Please check our wiki for help on navigating the form.

Horizon 2020

Call: H2020-SPACE-2018-2020

(Space 2018-2020)

Topic: LC-SPACE-04-EO-2019-2020

Type of action: RIA

Proposal number: 870327

Proposal acronym: FRAMES

Deadline Id: H2020-SPACE-2019

Table of contents

How to fill in the forms

The administrative forms must be filled in for each proposal using the templates available in the submission system. Some data fields in the administrative forms are pre-filled based on the steps in the submission wizard.

1 - General information

Topic	LC-SPACE-04-EO-2019-2020	Type of Action	RIA
Call Identifier	H2020-SPACE-2018-2020	Deadline Id	H2020-SPACE-2019

Acronym	FRAMES
Proposal title	FiRe Across MultiplE Services

Note that for technical reasons, the following characters are not accepted in the Proposal Title and will be removed: < > " &

Duration in months	*36*
Fixed keyword 1	S1 - Atmosphere monitoring (Copernicus service)
Fixed keyword 2	S4 - Climate change monitoring (Copernicus service)
Fixed keyword 3	Environment, Pollution & Climate
Fixed keyword 4	S5 - Emergency response (Copernicus service)
Fixed keyword 5	Forestry
Fixed keyword 6	S3 - Land monitoring (Copernicus service)
Free keywords	*Fire prediction, fire emissions, fire radiative power assimilation, ignition modelling, burnt area modelling, fire weather indices*

Proposal ID **870327** *Acronym* **FRAMES**

Abstract

FRAMES revolves around a simple but still very ambitious idea: 'fire as an Earth-system process' which aims to create a consistent and coherent framework for treating fires across several Copernicus services. To this end FRAMES will develop novel physical models for the ignitions and burning processes based on inherent probabilistic methods, exploiting for the first time fire-related observations into a variational data assimilation framework and allowing to perform sensitivity analysis conducive to model optimisation for fire processes. FRAMES innovative ideas will be implemented into the Integrated Forecasting System (IFS) developed at ECMWF which is the core modelling system used for three Copernicus services (CAMS, CEMS, C3S). This approach will provide an end-to-end prototype system that will both maximise its sustainably and minimise risks of integration and operational uptake.
FRAMES also significantly invests in showcasing and facilitating the adoption of the new and improved products that have the potential to enrich and complement the portfolio of the Copernicus data. The cross-cutting nature of FRAMES establishes strong links with the fire-relevant Copernicus services including the Copernicus Land Monitoring Service (CLMS). FRAMES also reaches out to the broad international community represented by fire management programs, operational centres, academic institutions and international organizations. From this first endorsement stage, the project aims at defining the evolution pathway for ready-production services to be linked to the Copernicus programme and beyond.

Remaining characters 397

Has this proposal (or a very similar one) been submitted in the past 2 years in response to a call for proposals under Horizon 2020 or any other EU programme(s)? ○ Yes ◉ No

Please give the proposal reference or contract number.	
xxxxxx-x	

Declarations

1) The coordinator declares to have the explicit consent of all applicants on their participation and on the content of this proposal.	☒
2) The information contained in this proposal is correct and complete.	☒
3) This proposal complies with ethical principles (including the highest standards of research integrity — as set out, for instance, in the European Code of Conduct for Research Integrity — and including, in particular, avoiding fabrication, falsification, plagiarism or other research misconduct).	☒

4) The coordinator confirms:

- to have carried out the self-check of the financial capacity of the organisation on http://ec.europa.eu/research/participants/portal/desktop/en/organisations/lfv.html or to be covered by a financial viability check in an EU project for the last closed financial year. Where the result was "weak" or "insufficient", the coordinator confirms being aware of the measures that may be imposed in accordance with the H2020 Grants Manual (Chapter on Financial capacity check); or	○
- is exempt from the financial capacity check being a public body including international organisations, higher or secondary education establishment or a legal entity, whose viability is guaranteed by a Member State or associated country, as defined in the H2020 Grants Manual (Chapter on Financial capacity check); or	◉
- as sole participant in the proposal is exempt from the financial capacity check.	○

5) The coordinator hereby declares that each applicant has confirmed:

- they are fully eligible in accordance with the criteria set out in the specific call for proposals; and	☒
- they have the financial and operational capacity to carry out the proposed action.	☒
The coordinator is only responsible for the correctness of the information relating to his/her own organisation. Each applicant remains responsible for the correctness of the information related to him and declared above. Where the proposal to be retained for EU funding, the coordinator and each beneficiary applicant will be required to present a formal declaration in this respect.	

According to Article 131 of the Financial Regulation of 25 October 2012 on the financial rules applicable to the general budget of the Union (Official Journal L 298 of 26.10.2012, p. 1) and Article 145 of its Rules of Application (Official Journal L 362, 31.12.2012, p.1) applicants found guilty of misrepresentation may be subject to administrative and financial penalties under certain conditions.

Personal data protection

The assessment of your grant application will involve the collection and processing of personal data (such as your name, address and CV), which will be performed pursuant to Regulation (EC) No 45/2001 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data. Unless indicated otherwise, your replies to the questions in this form and any personal data requested are required to assess your grant application in accordance with the specifications of the call for proposals and will be processed solely for that purpose. Details concerning the purposes and means of the processing of your personal data as well as information on how to exercise your rights are available in the privacy statement. Applicants may lodge a complaint about the processing of their personal data with the European Data Protection Supervisor at any time.

Your personal data may be registered in the Early Detection and Exclusion system of the European Commission (EDES), the new system established by the Commission to reinforce the protection of the Union's financial interests and to ensure sound financial management, in accordance with the provisions of articles 105a and 108 of the revised EU Financial Regulation (FR) (Regulation (EU, EURATOM) 2015/1929 of the European Parliament and of the Council of 28 October 2015 amending Regulation (EU, EURATOM) No 966/2012) and articles 143 - 144 of the corresponding Rules of Application (RAP) (COMMISSION DELEGATED REGULATION (EU) 2015/2462 of 30 October 2015 amending Delegated Regulation (EU) No 1268/2012) for more information see the Privacy statement for the EDES Database.

2 - Participants & contacts

#	Participant Legal Name	Country	Action
1	EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	UK	
2	FCIENCIAS.ID - ASSOCIACAO PARA A INVESTIGACAO E DESENVOLVIMENTO DE CIENCIAS	PT	
3	KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT-KNMI	NL	
4	INSTITUTO PORTUGUES DO MAR E DA ATMOSFERA IP	PT	
5	CONSIGLIO NAZIONALE DELLE RICERCHE	IT	
6	NATIONAL OBSERVATORY OF ATHENS	EL	
7	ILMATIETEEN LAITOS	FI	
8	ASSIMILA LTD	UK	
9	Remy Samuel conseil scientifique	FR	
10	CLIMATE-KIC HOLDING BV	NL	
11	METEO-FRANCE	FR	
12	BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION	ES	

2 - Administrative data of participating organisations

PIC	***Legal name***
999916741	*EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS*

Short name: ECMWF

Address of the organisation

Street SHINFIELD PARK

Town READING

Postcode RG2 9AX

Country United Kingdom

Webpage www.ecmwf.int

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....yes

International organisation of European interest .....yes

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status..... unknown

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Forecast Department ☐ not applicable

☒ Same as proposing organisation's address

Street: SHINFIELD PARK

Town: READING

Postcode: RG2 9AX

Country: United Kingdom

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Francesca** Last name: **di Giuseppe**

E-Mail: **francesca.digiuseppe@ecmwf.int**

Position in org.: Principal Scientist

Department: Forecast Department ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: SHINFIELD PARK

Town: READING Post code: RG2 9AX

Country: United Kingdom

Website: www.ecmwf.int

Phone: +441189499605 Phone 2: +xxx xxxxxxxxx Fax: +44 118 986 9450

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Daniel	THIEMERT	daniel.thiemert@ecmwf.int	+xxx xxxxxxxxx
Ben	Brown	ben.brown@ecmwf.int	+xxx xxxxxxxxx

PIC	***Legal name***
915056194	*FCIENCIAS.ID - ASSOCIACAO PARA A INVESTIGACAO E DESENVOLVIMENTO DE CIENCIAS*

Short name: FC.ID

Address of the organisation

Street CAMPO GRANDE, EDIFICIO C1, PISO 3

Town LISBON

Postcode 1749 016

Country Portugal

Webpage http://www.fciencias-id.pt

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....10/01/2017 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Instituto Dom Luiz ☐ not applicable

☒ Same as proposing organisation's address

Street: CAMPO GRANDE, EDIFICIO C1, PISO 3

Town: LISBON

Postcode: 1749 016

Country: Portugal

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Emanuel** Last name: **Dutra**

E-Mail: **endutra@fc.ul.pt**

Position in org.: Researcher

Department: Instituto Dom Luiz ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: FCID Campo Grande Edifício C8, Piso 2,

Town: Lisbon Post code: 1749-016

Country: Portugal

Website: http://idl.campus.ciencias.ulisboa.pt/profiles/emanuel-dutra/

Phone: +351 217 500 357 Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Livia Maria	de Amorim Moreira	lmdmoreira@fciencias-id.pt	+xxx xxxxxxxxx

PIC	***Legal name***
999518944	*KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT-KNMI*

Short name: KNMI

Address of the organisation

Street UTRECHTSEWEG 297

Town DE BILT

Postcode 3731 GA

Country Netherlands

Webpage www.knmi.nl

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....15/05/2008 - no

SME self-assessment ..... unknown

SME validation sme.....15/05/2008 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: R&D Weather and Climate Modeling ☐ not applicable

☒ Same as proposing organisation's address

Street: UTRECHTSEWEG 297

Town: DE BILT

Postcode: 3731 GA

Country: Netherlands

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Vincent** Last name: **Huijnen**

E-Mail: **vincent.huijnen@knmi.nl**

Position in org.: senior scientist

Department: R&D Weather and Climate Modeling ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: UTRECHTSEWEG 297

Town: DE BILT Post code: 3731 GA

Country: Netherlands

Website: www.knmi.nl

Phone: +31 30 2206 301 Phone 2: +xxx xxxxxxxxx Fax: +31 30 2210 407

PIC	***Legal name***
953379924	*INSTITUTO PORTUGUES DO MAR E DA ATMOSFERA IP*

Short name: IPMA

Address of the organisation

Street RUA C AO AEROPORTO

Town LISBOA

Postcode 1749 077

Country Portugal

Webpage www.ipma.pt

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....30/04/2012 - yes

SME self-assessment ..... unknown

SME validation sme.....30/04/2012 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Meteorology and Geophysics Department ☐ not applicable

☒ Same as proposing organisation's address

Street: RUA C AO AEROPORTO

Town: LISBOA

Postcode: 1749 077

Country: Portugal

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: ○ Male ◉ Female

First name: **Isabel** Last name: **Trigo**

E-Mail: **isabel.trigo@ipma.pt**

Position in org.: Head of Remote Sensing Section

Department: Meteorology and Geophysics Department ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: RUA C AO AEROPORTO

Town: LISBOA Post code: 1749 077

Country: Portugal

Website: https://orcid.org/0000-0001-8640-9170

Phone: +351 218 447 108 Phone 2: *+xxx xxxxxxxxx* Fax: +351 218 402 370

PIC	***Legal name***
999979500	*CONSIGLIO NAZIONALE DELLE RICERCHE*

Short name: CNR

Address of the organisation

Street PIAZZALE ALDO MORO 7

Town ROMA

Postcode 00185

Country Italy

Webpage www.cnr.it

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....18/05/2016 - no

SME self-assessment ..... unknown

SME validation sme.....05/12/2008 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Istituto di Metodologie per l'Analisi Ambientale ☐ not applicable

☐ Same as proposing organisation's address

Street: C.da S. Loja

Town: Tito (PZ)

Postcode: 85050

Country: Italy

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: ○ Male ◉ Female

First name: **Lucia** Last name: **Mona**

E-Mail: **lucia.mona@imaa.cnr.it**

Position in org.: Researcher

Department: Istituto di Metodologie per l'Analisi Ambientale ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: C.da S. Loja

Town: Tito (PZ) Post code: 85050

Country: Italy

Website: www.imaa.cnr.it

Phone: +390971427257 Phone 2: *+xxx xxxxxxxxx* Fax: +3900971427271

PIC	***Legal name***
999653677	*NATIONAL OBSERVATORY OF ATHENS*

Short name: NOA

Address of the organisation

Street LOFOS NYMFON

Town ATHINA

Postcode 11810

Country Greece

Webpage www.noa.gr

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....22/04/2008 - no

SME self-assessment ..... unknown

SME validation sme.....22/04/2008 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: IAASARS ☐ not applicable

☐ Same as proposing organisation's address

Street: I. Metaxa and Vasileos Pavlou

Town: Athens

Postcode: 15236

Country: Greece

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr.

Sex: (•) Male ( ) Female

First name: **Vassilis**

Last name: **Amiridis**

E-Mail: **vamoir@noa.gr**

Position in org.: Research Director

Department: IAASARS ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: I. Metaxa and Vasileos Pavlou

Town: Athens Post code: 15236

Country: Greece

Website: https://www.astro.noa.gr/en/staff/cv.php?staff=researchers&id=ami

Phone: +30 2108109116 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

PIC	***Legal name***
999591306	*ILMATIETEEN LAITOS*

Short name: FMI

Address of the organisation

Street Erik Palmenin aukio 1

Town HELSINKI

Postcode 00560

Country Finland

Webpage www.fmi.fi

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status..... unknown

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

No department involved

Department name: *Name of the department/institute carrying out the work.* ☒ not applicable

☐ Same as proposing organisation's address

Street: *Please enter street name and number.*

Town: *Please enter the name of the town.*

Postcode: *Area code.*

Country: *Please select a country*

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Prof.

Sex: (•) Male ( ) Female

First name: **Mikhail**

Last name: **Sofiev**

E-Mail: **mikhail.sofiev@fmi.fi**

Position in org.: Atmospheric Composition Modelling group leader

Department: ILMATIETEEN LAITOS

☒ Same as organisation name

☒ Same as proposing organisation's address

Street: Erik Palmenin aukio 1

Town: HELSINKI

Post code: 00560

Country: Finland

Website: https://en.ilmatieteenlaitos.fi/

Phone: +358 29 539 5433

Phone 2: +xxx xxxxxxxxx

Fax: +358 29 539 5403

PIC	***Legal name***
952596067	*ASSIMILA LTD*

Short name: ASI

Address of the organisation

Street GREEN ROAD 45

Town READING

Postcode RG6 7BS

Country United Kingdom

Webpage www.assimila.eu

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....no

Non-profit .....no

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....no

Legal person .....yes

Industry (private for profit).....yes

Enterprise Data

SME self-declared status.....31/10/2012 - yes

SME self-assessment ..... unknown

SME validation sme.....31/10/2012 - yes

Based on the above details of the Beneficiary Registry the organisation is an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Assimila Ltd ☐ not applicable

☐ Same as proposing organisation's address

Street: Reading Enterprise Centre, University of

Town: Reading

Postcode: RG6 6BU

Country: United Kingdom

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Mr. Sex: (•) Male ( ) Female

First name: **Gerardo** Last name: **Lopez-Saldana**

E-Mail: **gerardo.lopezsaldana@assimila.eu**

Position in org.: Earth Observation Applications Scientist

Department: ASSIMILA LTD ☒ Same as organisation name

☐ Same as proposing organisation's address

Street: Reading Enterprise Centre, University of Reading, Earley Gate

Town: Reading Post code: RG6 6BU

Country: United Kingdom

Website: http://www.assimila.eu/

Phone: +44 1189 357338 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

PIC	***Legal name***
903906529	*Remy Samuel conseil scientifique*

Short name: SRS

Address of the organisation

Street 223 RUE ANDRE PHILIP

Town LYON

Postcode 69003

Country France

Webpage

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....unknown

Non-profit .....unknown

International organisation .....unknown

International organisation of European interest .....unknown

Secondary or Higher education establishment .....unknown

Research organisation .....unknown

Legal person .....no

Industry (private for profit).....unknown

Enterprise Data

SME self-declared status..... unknown

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

No department involved

Department name: *Name of the department/institute carrying out the work.* ☒ not applicable

☐ Same as proposing organisation's address

Street: *Please enter street name and number.*

Town: *Please enter the name of the town.*

Postcode: *Area code.*

Country: *Please select a country*

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr.

Sex: (•) Male ( ) Female

First name: **Samuel**

Last name: **Remy**

E-Mail: **remy.samuel@gmail.com**

Position in org.: CEO

Department: Remy Samuel conseil scientifique

☒ Same as organisation name

☒ Same as proposing organisation's address

Street: 223 RUE ANDRE PHILIP

Town: LYON

Post code: 69003

Country: France

Website: -

Phone: +33 6 28 25 13 60

Phone 2: *+xxx xxxxxxxxx*

Fax: *+xxx xxxxxxxxx*

PIC	***Legal name***
917561607	*CLIMATE-KIC HOLDING BV*

Short name: KIC

Address of the organisation

Street PADUALAAN 8 HIGO R KRUYTGEBOUW ROO

Town UTRECHT

Postcode 3584 CH

Country Netherlands

Webpage www.climate-kic.org

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....no

Non-profit .....no

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....no

Legal person .....yes

Industry (private for profit).....yes

Enterprise Data

SME self-declared status..... unknown

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

No department involved

Department name: *Name of the department/institute carrying out the work.* ☒ not applicable

☐ Same as proposing organisation's address

Street: *Please enter street name and number.*

Town: *Please enter the name of the town.*

Postcode: *Area code.*

Country: *Please select a country*

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Mr.

Sex: (•) Male ( ) Female

First name: **Rahul**

Last name: **Bansal**

E-Mail: **rahul.bansal@climate-kic.org**

Position in org.: Deputy Director of Education

Department: CLIMATE-KIC HOLDING BV ☒ Same as organisation name

☐ Same as proposing organisation's address

Street: Liverpool Street

Town: London

Post code: EC2M 7PP

Country: United Kingdom

Website: http://www.climate-kic.org/

Phone: +447909094812

Phone 2: *+xxx xxxxxxxxx*

Fax: *+xxx xxxxxxxxx*

PIC	***Legal name***
999578890	*METEO-FRANCE*

Short name: MF

Address of the organisation

Street AVENUE DE PARIS 73

Town SAINT MANDE CEDEX

Postcode 94165

Country France

Webpage www.meteo.fr

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....18/06/1993 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Study and Consultancy Department, End-user Meteorological Service ☐ not applicable

☐ Same as proposing organisation's address

Street: 42, avenue Coriolis

Town: TOULOUSE

Postcode: 31057

Country: France

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Mr. Sex: (•) Male ( ) Female

First name: **Mathieu** Last name: **Regimbeau**

E-Mail: **mathieu.regimbeau@meteo.fr**

Position in org.: Study Engineer at Agrometeorology Group

Department: Study and Consultancy Department, End-user Meteorological Services Direc ☐ Same as organisation name

☐ Same as proposing organisation's address

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Country: France

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Other contact persons

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Alain	Gradot	alain.gradot@meteo.fr	+xxx xxxxxxxxx

PIC	***Legal name***
999655520	*BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION*

Short name: BSC

Address of the organisation

Street Calle Jordi Girona 31

Town BARCELONA

Postcode 08034

Country Spain

Webpage www.bsc.es

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....01/03/2005 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Earth Science Department ☐ not applicable

☐ Same as proposing organisation's address

Street: NEXUS II building ,Jordi Girona 29

Town: Barcelona

Postcode: 08034

Country: Spain

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

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Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
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3 - Budget

No	Participant	Country	(A) Direct personnel costs/€	(B) Other direct costs/€	(C) Direct costs of sub-contracting/€	(D) Direct costs of providing financial support to third parties/€	(E) Costs of inkind contributions not used on the beneficiary's premises/€	(F) Indirect Costs / € (=0.25(A+B-E))	(G) Special unit costs covering direct & indirect costs / €	(H) Total estimated eligible costs / € (=A+B+C+D+F +G)	(I) Reimburse-ment rate (%)	(J) Max.EU Contribution / € (=H*I)	(K) Requested EU Contribution/ €
1	European Centre For Medium-range	UK	806491	78500	0	0	0	221247,75	0	1106238,75	100	1106238,75	1106238,75
2	Fciencias.id - Associacao Para A	PT	158400	15000	0	0	0	43350,00	0	216750,00	100	216750,00	216750,00
3	Koninklijk Nederlands Meteorologisc	NL	171947	15000	0	0	0	46736,75	0	233683,75	100	233683,75	233683,75
4	Instituto Portugues Do Mar E Da	PT	148500	10000	0	0	0	39625,00	0	198125,00	100	198125,00	198125,00
5	Consiglio Nazionale Delle Ricerche	IT	108000	10000	0	0	0	29500,00	0	147500,00	100	147500,00	147500,00
6	National Observatory Of Athens	EL	72000	10000	0	0	0	20500,00	0	102500,00	100	102500,00	102500,00
7	Ilmatieteen Laitos	FI	240000	15000	0	0	0	63750,00	0	318750,00	100	318750,00	318750,00
8	Assimila Ltd	UK	72000	10000	0	0	0	20500,00	0	102500,00	100	102500,00	102500,00
9	Remy Samuel Conseil Scientifique	FR	120000	10000	0	0	0	32500,00	0	162500,00	100	162500,00	162500,00
10	Climate-kic Holding Bv	NL	48000	44000	8000	0	0	23000,00	0	123000,00	100	123000,00	123000,00

11	Meteo-france	FR	96000	10000	0	0	0	26500,00	0	132500,00	100	132500,00	132500,00
12	Barcelona Supercomputing Center -	ES	108000	15000	0	0	0	30750,00	0	153750,00	100	153750,00	153750,00
	Total		2149338	242500	8000	0	0	597959,50	0	2997797,50		2997797,50	2997797,50

4 - Ethics

1. HUMAN EMBRYOS/FOETUSES		Page
Does your research involve Human Embryonic Stem Cells (hESCs)?	○ Yes ◉ No	
Does your research involve the use of human embryos?	○ Yes ◉ No	
Does your research involve the use of human foetal tissues / cells?	○ Yes ◉ No	
2. HUMANS		**Page**
Does your research involve human participants?	○ Yes ◉ No	
Does your research involve physical interventions on the study participants?	○ Yes ◉ No	
3. HUMAN CELLS / TISSUES		**Page**
Does your research involve human cells or tissues (other than from Human Embryos/ Foetuses, i.e. section 1)?	○ Yes ◉ No	
4. PERSONAL DATA		**Page**
Does your research involve personal data collection and/or processing?	○ Yes ◉ No	
Does your research involve further processing of previously collected personal data (secondary use)?	○ Yes ◉ No	
5. ANIMALS		**Page**
Does your research involve animals?	○ Yes ◉ No	
6. THIRD COUNTRIES		**Page**
In case non-EU countries are involved, do the research related activities undertaken in these countries raise potential ethics issues?	○ Yes ◉ No	
Do you plan to use local resources (e.g. animal and/or human tissue samples, genetic material, live animals, human remains, materials of historical value, endangered fauna or flora samples, etc.)?	○ Yes ◉ No	
Do you plan to import any material - including personal data - from non-EU countries into the EU?	○ Yes ◉ No	
Do you plan to export any material - including personal data - from the EU to non-EU countries?	○ Yes ◉ No	
In case your research involves low and/or lower middle income countries, are any benefits-sharing actions planned?	○ Yes ◉ No	
Could the situation in the country put the individuals taking part in the research at risk?	○ Yes ◉ No	

7. ENVIRONMENT & HEALTH and SAFETY		Page
Does your research involve the use of elements that may cause harm to the environment, to animals or plants?	○ Yes ◉ No	
Does your research deal with endangered fauna and/or flora and/or protected areas?	○ Yes ◉ No	
Does your research involve the use of elements that may cause harm to humans, including research staff?	○ Yes ◉ No	
8. DUAL USE		**Page**
Does your research involve dual-use items in the sense of Regulation 428/2009, or other items for which an authorisation is required?	○ Yes ◉ No	
9. EXCLUSIVE FOCUS ON CIVIL APPLICATIONS		**Page**
Could your research raise concerns regarding the exclusive focus on civil applications?	○ Yes ◉ No	
10. MISUSE		**Page**
Does your research have the potential for misuse of research results?	○ Yes ◉ No	
11. OTHER ETHICS ISSUES		**Page**
Are there any other ethics issues that should be taken into consideration? Please specify	○ Yes ◉ No	

I confirm that I have taken into account all ethics issues described above and that, if any ethics issues apply, I will complete the ethics self-assessment and attach the required documents. ☒

How to Complete your Ethics Self-Assessment

5 - Call-specific questions

Extended Open Research Data Pilot in Horizon 2020

If selected, applicants will by default participate in the Pilot on Open Research Data in Horizon 2020[1] , which aims to improve and maximise access to and re-use of research data generated by actions.

However, participation in the Pilot is flexible in the sense that it does not mean that all research data needs to be open. After the action has started, participants will formulate a Data Management Plan (DMP), which should address the relevant aspects of making data FAIR – findable, accessible, interoperable and re-usable, including what data the project will generate, whether and how it will be made accessible for verification and re-use, and how it will be curated and preserved. Through this DMP projects can define certain datasets to remain closed according to the principle "as open as possible, as closed as necessary". A Data Management Plan does not have to be submitted at the proposal stage.

Furthermore, applicants also have the possibility to opt out of this Pilot completely at any stage (before or after the grant signature). In this case, applicants must indicate a reason for this choice (see options below).

Please note that participation in this Pilot does not constitute part of the evaluation process. Proposals will not be penalised for opting out.

We wish to opt out of the Pilot on Open Research Data in Horizon 2020.	○ Yes	◉ No

Further guidance on open access and research data management is available on the participant portal: http://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/open-access-dissemination_en.htm and in general annex L of the Work Programme.

[1] *According to article 43.2 of Regulation (EU) No 1290/2013 of the European Parliament and of the Council, of 11 December 2013, laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" and repealing Regulation (EC) No 1906/2006.*

FIRE ACROSS MULTIPLE SERVICES

(FRAMES)

List of participants

Participant No.	Participant organisation name	Short name	Country
1 (Coordinator)	European Centre for Medium Range Weather Forecasts	ECMWF	International
2	FCiências.ID - Associação para a Investigação e Desenvolvimento de Ciências	FC.ID	Portugal
3	Koninklijk Nederlands Meteorologisch Instituut	KNMI	The Netherlands
4	Instituto Português do Mar e da Atmosfera	IPMA	Portugal
5	Consiglio Nazionale delle Ricerche	CNR	Italy
6	National Observatory of Athens	NOA	Greece
7	Finnish Meteorological Institute	FMI	Finland
8	Assimila-SME	ASI	United Kingdom
9	Samuel Remy -SME	SRS	France
10	EIT Climate-KIC	KIC	International
11	Meteo-France	MF	France
12	Barcelona Supercomputer Centre	BSC	Spain

(Coordinator: Dr Francesca Di Giuseppe, ECMWF)

Contents

1 Excellence

The "FiRe Across MultiplE Services" (FRAMES) project aims at developing a consistent and coherent framework for treating fires across several Copernicus services. The strength of FRAMES is that it will address aspects of the existing Copernicus services and related activities that are currently deficient. The success of the FRAMES project will be achieved by (i) the development of a fully consistent dynamical model and data assimilation system relying on a probabilistic approach ('fire as an Earth-system process') and (ii) direct access to the world leading ECMWF-Integrated Forecasting System, which currently is at the core of several Copernicus services, minimising research-to-operations and service transition efforts, and their sustainability.

Fire impacts occur over a wide range of temporal and spatial scales, from local to global, via many complex, interdependent, and poorly understood processes. For example, primary fire emissions are affected by a variety of factors including fuel conditions (type, structure, quantity, and moisture content), fire intensity, and fire-related weather variables (cumulative temperature, relative humidity, wind speed and precipitation) that in turn can be rapidly and heterogeneously modified by fires as they burn. Over the life cycle of a fire, combinations of flaming and smouldering combustion lead to different emissions at different times and at different locations within a fire. These variables also influence plume rise and the subsequent transport and chemical evolution of fire emissions, which determine the secondary products (e.g. evolved gases and aerosol species). Wildfire initiation can be natural (by lightning) or human-caused. Prescribed fires are also becoming a more frequent tool for land management (e.g., land clearing and agriculture).

In 2018, the European Commission published its 2017 annual report[1] on Forest Fires in Europe, the Middle East and North Africa. It showed that wildfires burned over 1.2 million hectares that year, more than the total surface area of the Mediterranean island of Cyprus. Wildfires also claimed the lives of 127 firefighters and civilians and caused economic damages estimated at almost €10 billion. The Mediterranean region was the hardest hit and, unfortunately, the majority of fires were human-caused, making prevention and early detection the most important ways to save lives and money. Because of their implied costs, the European Union has formulated a response which goes well beyond simply tracking wildfire activity.

For their relevance, **fires represent an aspect that is at the intersection of** four out the six existing Copernicus services (namely, **the Copernicus Emergency Management, Atmosphere Monitoring, Climate Change and Land Monitoring Services**). Fires also release between approximately 6 and 8 Gt per year of carbon dioxide (CO_2) globally in the atmosphere (values based on Global Fire Assimilation System, GFAS[5] calculations). Thus, they are also relevant for exploratory projects such as the **CO_2 Human Emissions** (CHE[2]) and its CHE-2 follow-on that has the potential to develop into a dedicated Copernicus CO_2 Service. **We will refer to these five existing and precursor Copernicus services as "fire-relevant Copernicus Services" in the remainder of this document.**

While fires are relevant to all Copernicus services listed above, they are not always accounted for. Even when they are, their treatment can vary substantially from one service to another, often using incomplete (e.g. deterministic as opposite to probabilistic) modelling approaches and exploiting the available observations only partially. For instance, fire danger metrics like the Fire Weather Index, used as the main product of the **Copernicus Emergency Management Service** (CEMS)[3], exclusively rely on semi-empirical relationship based on one prevailing vegetation type, its flammability characteristics and how these are impacted by meteorological conditions. However, they are then applied globally without accounting for the underlying available fuel and its amount. Fire emissions into the atmosphere have implications for air quality. Smoke (biomass burning particulate), a by-product of wildfires, is one of the most important aerosol types and it is often referred to as the "silent killer"[4]. This constituent is of interest for the **Copernicus Atmosphere Monitoring Service** (CAMS[5]) to initialise its air quality transport model. However, without a dynamical fire model able to predict the emission evolution from burning fires, **these initial estimates are kept constant for the whole forecast range currently delivered by CAMS (5 days)**. Despite having a large impact on changing the Earth's weather conditions and its

[1] https://ec.europa.eu/jrc/en/publication/forest-fires-europe-milddle-east-and-north-africa-2017
[2] https://www.che-project.eu/
[3] https://emergency.copernicus.eu/. Fire Weather Index (FWI) products are displayed in the European Forest Fire Information Service (EFFIS) platform (http://effis.jrc.ec.europa.eu/) and its global extension the Global Wildfire Information Service (GWIS, http://gwis.jrc.ec.europa.eu).
[4] https://www.health.ny.gov/publications/2826.pdf.
[5] https://atmosphere.copernicus.eu/.

climate through their impact on both the land component and the radiation budget, many models neither include the dynamical feedback between vegetation, fire emissions and meteorological variables nor do they exploit the available fire-related observations. These deficiencies affect for instance both the current climate reanalysis simulations, and the seasonal forecasting products provided by the **Copernicus Climate Change Service** (C3S[6]). The inconsistencies of approaches and methods applied by the various services derive from the fact that fires are not considered a dynamical physical process and, at best, only a description of their effects on other Earth system components is considered.

The ground-breaking idea proposed by FRAMES is to address the inconsistencies in the current approaches by treating fires as one of the Earth's processes. The ambition is **to develop a new fully interactive probabilistic fire component as part of a world-leading weather forecasting model, the ECMWF Integrated Forecasting System (IFS).** This choice is based on the consideration that the IFS is the core model used in several applications and products provided by the CEMS, CAMS and C3S, as well as the core Earth System Model used in the preparatory project CHE, potential precursor of a Copernicus service element to monitor the CO_2 anthropogenic emissions.
Using a step-wise approach, FRAMES aims at developing new modelling components and an integrated data assimilation system for fire-related products. FRAMES developments will be fit for an operational environment from the start as the prototype will use the backbone modelling component of three Copernicus services. This also means that the products envisaged in FRAMES will be automatically available in databases (e.g. the ECMWF meteorological archive, MARS) that can be easily interfaced through adaptors to data dissemination channels developed within the Copernicus program such as the Climate Data Store (CDS) and Atmospheric Data Store (ADS) platforms, as well as the Copernicus Data and Information Access Services (DIAS). Moreover, as **the FRAMES approach will be developed directly into the modelling system used by the Copernicus services, it will provide from the start an end-to-end prototype system that, on one hand, will maximise its sustainably, and, on the other hand, will virtually zero the risks of integration and operational uptake.**

1.1 Objectives

FRAMES will develop a coherent, probabilistic modelling and assimilation framework for fire related processes. Fire processes will be dynamically coupled to the other processes, e.g. the radiation, represented in the Earth System Model that is at the core of CAMS, C3S, and CEMS: the ECMWF IFS. By doing so, FRAMES will radiantly enhance the capabilities of the targeted Copernicus services and will benefit from the established links already existing for the distribution and sustainability of the services.

To achieve this goal, FRAMES has set five top-level objectives presented in Table 1.

Table 1: FRAMES top level objectives

Objective	Achieved by	Addressed in work package
1. Develop a fully integrated fire dynamical model adopting solutions suitable for a global and operational uptake, → to allow the coherent and probabilistic treatment of all effects related to fire events across the fire-relevant Copernicus services	→ implementing major upgrade in the vegetation representation in IFS by including new vegetation types such as peat, which is relevant for fire; → implementing new dynamical processes such as vegetation growth, regeneration and dynamical change in albedo; → Implementing a stochastic ignition model based on fuel status, lightning density probability, human impact and suppression measures; → Implementing a weather dependent emission conversion module for fires, an injection height parameterization that accounts for the sub-grid nature of fire processes; → incorporating all new fire, vegetation and emissions modules into the physical processes of ECMWF's Integrated Forecasting System (IFS) in a probabilistic way.	WP1

[6] https://climate.copernicus.eu/.

2. Develop a data assimilation framework for fire-related remote-sensing observations, → to initialize the fire related variables and define an initial state for the forecast evolution; → to allow the exploitation of observations related to fire that have not been assimilated before and are being made available through the Copernicus programme and new international observations program.	→ Linking the land model developments into the data assimilation system; → implementing an observation operator, and corresponding tangent linear and adjoint models for Fire Radiative Power (FRP) and CO in the IFS 4D-Var data assimilation system; → performing sensitivity studies to identify the set of most relevant fire/vegetation parameters to use in the data assimilation control vector.	WP1, WP2
3. Integrate FRAMES prototype products into the Copernicus services, → to address identified needs in the targeted Copernicus user communities → to enhance the exploitation of the Copernicus data → to guarantee homogenization and enhancement of products across the Copernicus services that deliver vital information for European society. → to Integrate all research within the European and international context	→ responding to the needs for CEMS, CAMS and C3S also highlighted in the endorsement letters attached to this proposal → integrating the model and assimilation components into the ECMWF's IFS model to guarantee they will be seamlessly accessible by all the Copernicus services that rely on IFS as their modelling component. → using a pragmatic approach to develop a full infrastructure that accounts for all fire-relevant processes even with simplified assumptions at the start, and suggesting aspects that could be further enhanced. An incremental and modular approach has the advantage to allow new products exploitation from a very early stage.	WP3, WP1, WP2
4. Develop new and improved products to the Copernicus user community → to enhance Copernicus services → To generate a broader Community of Copernicus users	→ Increasing the physical complexity of the fire process representation → Increase the realism through the exploitation of not yet exploited observations → Including the probabilistic components of the fire processes, which will allow for uncertainties analysis to be performed	WP1, WP2, WP3
5. Fulfil a comprehensive strategy for dissemination and exploitation of the results. → to understand the strengths and	→ involving a broad selection of key player that will benefit from the project new prototype products through a broad engagement program, testified by the significant range of endorsement letters attached to this proposal; → Hosting placement programs in collaboration with the Climate-KIC community	WP3, WP5

limitations of the proposed approach → to pave the way to a follow-on user engagement program	→ disseminating and providing training on novel code development concepts through direct public engagement, stakeholder communication and through the Climate-KIC.	

Several Copernicus services currently use or need fire information to provide their services. However, they have adopted different, and sometimes diverging strategies to address specific aims within their theme without attempting to homogenize these approaches. For example, CAMS uses daily estimates of emissions from wildfires and biomass burning, derived off-line from the CAMS Global Fire Assimilation System (GFAS[5]), as a critical input to its global and European air quality forecast models. GFAS uses satellite observations of Fire Radiative Power (FRP) to detect fires and estimate emissions of pyrogenic atmospheric pollutants, including trace gases, aerosols and greenhouse gases. While the GFAS emissions are appropriate for producing the initial state of the daily forecasts, **they are kept constant during the 5-day global and 4-day European forecasts provided by CAMS**. The assumption that fires observed at the analysis time are persistent during the forecast range is often not realistic, as most of fires have a life time shorter than 5 days[7]. Having a dynamical fire model within GFAS or potentially the CAMS global forecasting system itself would ensure significantly improved global and European forecasts of air quality around forest fires and biomass burning. This is especially relevant considering the impact that smoke from wildfires can have on pollution episodes and how these episodes are managed by national and local authorities.

Similarly, a missing link between vegetation and fires can be identified in CEMS. One of the main products developed to support fire management and control, and provided by CEMS is the Fire Weather Indices (FWI). This is produced daily at ECMWF[8] as a post processing calculation using the outputs of the IFS ensemble forecasting system in fire danger models. The latter diagnose weather conditions conducive of unmanageable fire conditions rather than modelling fire probability of ignition and spread. The FWI (developed in Canada[9]) is at the core of the modelling component of the **European Forest Fire Information System (EFFIS**), which, like other models used for fire forecasting, has two important limitations:

1. It does not include any information of the vegetation status and the actual fuel load availability, despite it could be available through establishing a relevant link with IFS evolving vegetation.
2. Its formulation is specifically calibrated to describe the fire behaviour in a jack pine stand Pinus banksiana typical of the Canadian forests, despite the driving numerical vegetation scheme allowing for vegetation representation and initialization to the current state.

Nonetheless, FWI is applied to different vegetations with very different burning characteristics. A consequence is that non-vegetated areas, where fire cannot occur due to unavailability of fuel (e.g. deserts), can be associated with high fire danger values. As a workaround, these areas are typically masked out using climatological land-vegetation maps. **Establishing the link with the actual fuel availability in these models is regarded as the most important single improvement to the field by the fire danger modelling community[10].**

Despite the relevance of biomass burning for climate[11], C3S provides limited information on fires consisting of gridded Burned Area (BA) and Fire Radiative Power (FRP) products retrieved from satellite measurements. Model-based products (like those from climate reanalysis and seasonal forecasting) do not exploit the potential benefits of coupling fires and atmospheric dynamic. Such a coupling could provide predictability skills at seasonal time scales[12] and possibly also benefit reanalysis products with the introduction of new variables such burned areas and planet albedo.

[7] Di Giuseppe, F., Rémy, S., Pappenberger, F., and Wetterhall, F.: Using the Fire Weather Index (FWI) to improve the estimation of fire emissions from fire radiative power (FRP) observations, Atmos. Chem. Phys., 18, 5359-5370, https://doi.org/10.5194/acp-18-5359-2018, 2018.

[8] http://gwis.jrc.ec.europa.eu/static/gwis_current_situation/public/index.html

[9] Van Wagner, C.E (1987). Development and structure of the Canadian Forest Fire Weather Index System. Canadian Forestry Service, Headquarters, Ottawa. Forestry Technical Report 35. 35 p, available at http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/19927.pdf. Last access 15 Feb 2019.

[10] Flannigan, M.D., Wotton, B.M., Marshall, G.A. et al. Climatic Change (2016) 134: 59. https://doi.org/10.1007/s10584-015-1521-0

[11] Hanson, C.; Wildfire in the Age of Climate Change, *BioScience*, Volume 68, Issue 2, 1 February 2018, Pages 146–148, https://doi.org/10.1093/biosci/bix166

[12] A Benedetti, F Vitart : Can the Direct Effect of Aerosols Improve Subseasonal Predictability? - Monthly Weather Review, 2018.

The key challenge is to establish the many missing links for the benefits of all the Copernicus services at once. By fulfilling its objectives, FRAMES will pave the way towards this goal through the combination of novel probabilistic modelling approaches and algorithms, and a new physical understanding of the interactions between fire and the other components of the Earth System. The FRAMES outcome will be the **foundation of a new concept for fire modelling** that will provide better characterized products than currently available. It will also harmonise the effects of fires into the Copernicus services minimizing the risk of inconsistent information. FRAMES will directly benefits CAMS, C3S and CEMS. Within this project, satellite-based products from the global component of the Copernicus Land Monitoring Service (CLMS) will be used to verify the model-based products that will be produced. In the future, in the light of an operational implementation of the FRAMES approach, these model-based products could complement the satellite-based equivalents provided by CLMS. Furthermore, we do not exclude that the approach proposed here could have a wider impact able to spin-off activities and applications that could be relevant for the Copernicus Service for Security (CSS) and the Copernicus Marine Environment Monitoring Service (CMEMS). Figure 1 summarises how FRAMES radiantly provides cross-cutting benefits across all the Copernicus services.

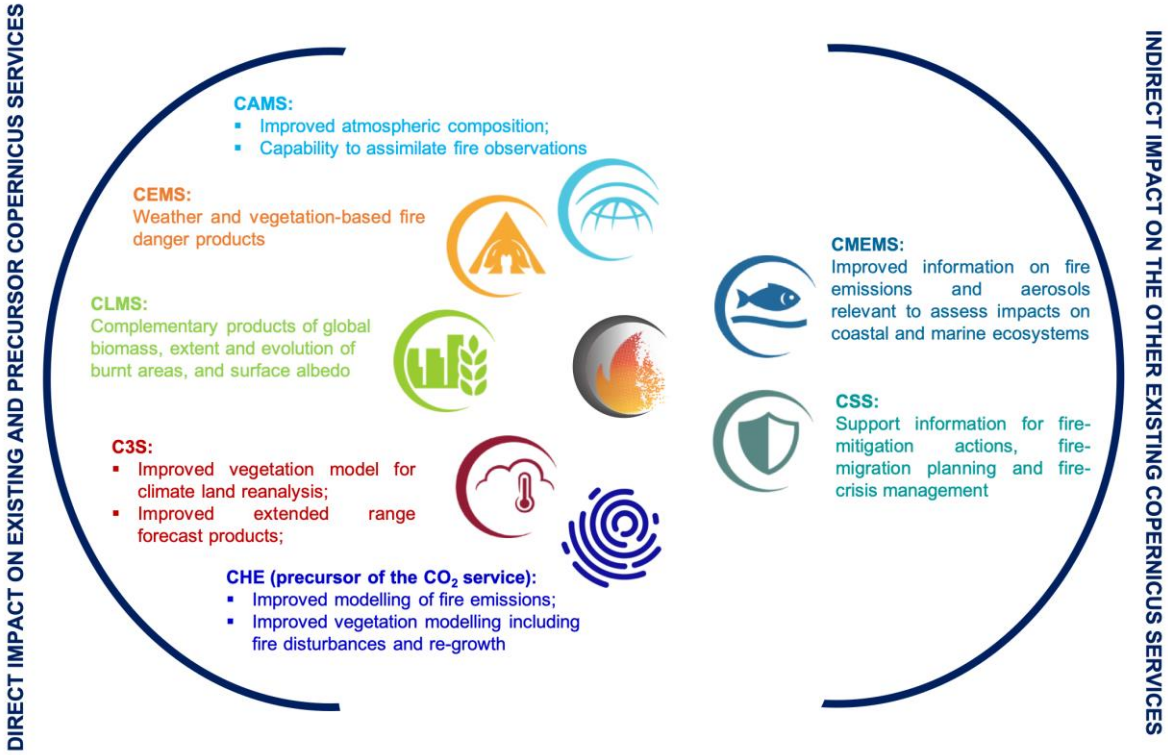

Figure 1: Cross-cutting nature of FRAMES within the Copernicus programme.

FRAMES builds on the significant involvement of the Consortium in the Copernicus programme with ECMWF being the entrusted entity to implement two services, CAMS and C3S, and being the computational centre and data provider of CEMS-Fire, and IPMA having a strong role in Copernicus-land. In addition, ECMWF coordinates the H2020 CHE Project, a preparatory project for a new Copernicus service element dedicated to the monitoring of anthropogenic CO_2 emissions. CHE and the already envisaged follow-on project, which will also be led by ECMWF, is putting in place a (inverse) modelling infrastructure with ECMWF's IFS as a central element to monitor anthropogenic emissions of CO2 using Earth observation data. This also requires a detailed modelling of the full carbon cycle, and wildfires and biomass burning are an important part of that cycle, both in terms of emissions and changes to the vegetation. FRAMES will therefore closely interact with CHE to exploit synergies and effectively contribute to the development of this new Copernicus service element without duplicating efforts.

FRAMES, by revolving around the IFS, directly feeds into the Copernicus infrastructures**. This important aspect makes it an already proved concept of operability and portability**.

1.2 Relation to the work programme

The FRAMES proposal responds to the LC-SPACE-04-EO-2019-2020 call ("Copernicus evolution – Research activities in support of cross-cutting applications between Copernicus services"), a Research and Innovation action (RIA) of the Horizon 2020 program "Building a low-carbon, climate resilient future (LC)". In response to this call, **the present proposal aims** at establishing a community of various players (such as research institutes, operators of in-situ measurement stations and of numerical weather prediction, leading experts for modelling and data assimilation) **to deliver the first prototype in which fire processes are described and treated in a consistent way across several Copernicus services**.

The Copernicus Regulation (EU 377/2014) established the Union Earth observation and monitoring programme. It contained service components ensuring delivery of information in the areas of atmosphere monitoring, marine environment monitoring, land monitoring, climate change, emergency management and security. The present research and innovation action aims at demonstrating the technical operational feasibility of a specific cross-cutting application that will use the available Copernicus infrastructure to provide an advance to their value, both in terms of quality and usability.

FRAMES has these ambitions at its core by foreseeing a completely new paradigm to handle fire-related processes across all the fire-relevant Copernicus services. To achieve this very ambitious plan, the project will develop a prototype fire model that will be fully integrated into the ECMWF weather forecasting system. As the ECMWF prediction system is the backbone of three of the Copernicus services targeted in this call, the inclusion of this new component and the interaction with the other model components will complement and broaden the panoply of information currently made available by those services.

By fulfilling its goals, FRAMES will allow to predict fire emissions for the most important chemical species (black carbon, organic matter, CO, CO_2, O_3 etc), enhancing the predictive capability of **CAMS with the possibility of extending the provided forecast products beyond the range of 5 days**. The new assimilation capabilities developed by FRAMES also has the potential to improve the future generation of reanalyses and the IFS-based long-range forecasts produced by C3S. This is because including the impact of fires on the Earth system will allow to monitor the climate evolution of fire-related variables. Moreover, allowing fires to influence the local and global circulation, the convection, and the planet energy balance through various feedbacks is expected to increase the predictive skills of the IFS[12].

FRAMES prototype products will also provide a series of fire danger information in support of fire management and control, such as probabilistic maps of fuel moisture content evolution (not available now), fire ignition probability, and burned area. While these products are comparable in their use to those obtained from classical fire danger systems used in **CEMS**, they address a specific identified need in the user community that is to establish a link between atmospheric fire danger and the state of the vegetation/fuel. **FRAMES prototype products will not be the result of weather forecast post-processing but the dynamical outcome of an evolving coupled vegetation-weather system.** This is a real paradigm shift in fire forecasting and will provide a new pathway for the development of systems that are not calibrated over specific ecosystems and have a better handling of the fuel status impact in fire danger. This development will especially benefit global fire danger products that ECMWF provides to the Global Wildfire Information System (GWIS[8]), a joint initiative of **the GEO and Copernicus program**. FRAMES has also the potential to complement Copernicus-Land products by providing new datasets for land monitoring and will benefit the CHE Project (precursor of a CO_2 service element) developments providing additional emissions from biomass burning. FRAMES possible evolutions also project into the other two services as information could be used to support mitigation measure in case of big fire events impacting human safety, social security and assets preservations addressed by CSS, and possibly also CMEMS, as anticipated in Figure 1.

Thus, **FRAMES addresses the aims and scopes of LC-SPACE-04-EO-2019-2020 through its top-level objectives** (Section 1.1), particularly advancing and complementing the Copernicus services within the already existing infrastructure. A detailed overview of how FRAMES targets the specific topics of the call - with reference to the project's work packages and tasks - is given in Table 2 below.

Given the complexity and innovative challenges of this project, FRAMES brings together a comprehensive consortium of key European players both from the private and public sectors to ensure that progress is made on designing and developing all elements required to realize the envisaged, more-consistent future system.

In addition to the expertise of its partners, FRAMES will engage with the Copernicus services through an advisory board, and the organization of a public workshop and placement programs. A special effort will be dedicated to

outreach aspects by engaging specific communities of users, e.g. by interfacing them to FRAMES thanks to the contribution that will be provided by the Knowledge and Innovation Communities (KIC)

Table 2: FRAMES relation to work programme topics of LC-SPACE-04-EO-2019-2020.

<table>
<tr><th>Call Text</th><th>How FRAMES responds.</th></tr>
<tr><td>[..] Specific and well-targeted applications involving the outcome from multiple core services need to be developed in the mid-term.</td><td>Figure 1 highlights how FRAMES provides direct benefits to 4 of the Copernicus services (C3S, CAMS, CEMS, CLMS) during the lifetime to the project. It also provides an opportunity for further evolutions, which could benefit the other two services (Security and Marine).</td></tr>
<tr><td>R&D activities are to be conducted such that results are available in a sufficiently timely manner to support an informed discussion, if and under which conditions the proposed new applications should be integrated into the operational service portfolio of the Copernicus programme. Furthermore, proposers should highlight where results could also be valuable for GEO, considering Copernicus as the European contribution to this global initiative.</td><td>Given the complexity and innovative challenges of this project, FRAMES will adopt an incremental and modular approach with the priority of creating a comprehensive infrastructure in IFS where all model components and initialization strategies are accounted for. In this sense FRAMES aims at creating all the building blocks where future improvements could be added modularly while allowing the links to the end-users to be established from an early stage.
The FRAMES developments will be fit for an operational environment from the start. This is because it will use the backbone modelling component of three Copernicus services. FRAMES prototype products will be automatically available in databases (e.g. the ECMWF MARS archive) that can be easily interfaced through adaptors to data dissemination channels developed within the targeted Copernicus services zeroing portability risks. The improvements to the GWIS platform, part of the GEO program, will translate into benefits to this global initiative. [WP1, WP2, WP3, WP4]</td></tr>
<tr><td>Proposals shall demonstrate the technical operational feasibility of one specific cross-cutting thematic application.</td><td>By enhancing the IFS capabilities, FRAMES provides the cascading effect of enhancing all the products connected to it. Moreover, by building into the operational core of IFS, it will create the premises to its integration into the already operational Copernicus services reducing to zero the risks of portability. The success of this strategy for the advanced development of model components used by the Copernicus services has already been tested in the CO_2 Human Emission project[2] that is designing the first complete infrastructure to monitor and predict anthropogenic CO_2 emission using IFS core modelling components. [WP1, WP2, WP3]</td></tr>
<tr><td>The proposers are expected to demonstrate that their proposal is relevant for the enhancement of Copernicus core services and capitalise from the corresponding product portfolio.</td><td>FRAMES has identified the missing links between the various Copernicus services and has defined a clear, comprehensive strategy to build the needed bridges to better “frame” all the services. FRAMES aims at capitalising the available infrastructures (i.e. modelling components and data dissemination) to enhance the quality and availability of products.
Examples of FRAMES equivalents to the current portfolio of available products is given in the following table, which also highlights the limitations of the state-of-the-art (a comprehensive list of products and service innovation will be provided in D3.1):
<table><tr><th>State-of-the-art</th><th>FRAMES approach</th></tr><tr><td>Fire Weather Index (FWI) does not include any information of the vegetation status and the</td><td>Fire Emission Potential (FEP) is the FRAMES equivalent. It is the combination of the fuel</td></tr></table></td></tr>
</table>

	<table><tr><td>actual fuel availability. FWI formulation is specifically calibrated to describe the fire behavior in a standard jack pine stand Pinus banksiana typical of the Canadian forests. It is however applied to different vegetations with very different burning characteristics.</td><td>load derived from the vegetation status and the ignition potential, it is therefore an extended risk indicator by accounting for a dynamical biomass load available for burning. As FEP is initialised through a data assimilation process (WP2), it has memory of the previous fire season.</td></tr><tr><td>Biomass burning emissions of main species (CO, CO_2, black carbon and organic matter) These emissions are currently generated by the GFAS data assimilation system after assimilating of FRP data and are kept constant during the 5 days forecast.</td><td>FRAMES equivalent Global, gridded product of fire emission evolutions obtained as output of the newly developed fire dynamical model.</td></tr></table> **[WP3]**
The output of this research and innovation action should provide a proof-of-concept or a prototype including a benchmarked selection of concurring methodological approaches, where feasible, that shall complement and broaden the panoply of information made currently available by the core services and which can act as reference for the independent assessment of Copernicus services evolution, in light of product extensions and service improvements.	FRAMES will provide a prototype system that will enhance the capabilities of many of the Copernicus services. Since the prototype will be built inside the forecasting system used by several services, it will automatically benefit from the already available infrastructure. FRAMES will be benchmarked against the existing services to showcase the enhancement and complementary with the products already existing. Moreover, FRAMES will implement a comprehensive validation strategy that mimics the validation activities performed as part of the Copernicus services. **[WP1, WP2, WP3, WP4]**
These applications may concern areas in relation to domains such as energy, agriculture and forestry, health, water resources, security, natural environments and manmade disasters, resilience of built environment, cultural heritage, coastal monitoring, urban planning, climate adaptation, biodiversity and eco-system preservation, exploration and mineral resources, and others.	FRAMES focuses on fires, hence it is perfectly aligned with the call targeted applications.
Proposals are encouraged to use the Copernicus Data and Information Access Services (DIAS), or other existing data access solutions instead	The FRAMES prototype will be developed inside the already existing modelling infrastructure of IFS so it will automatically benefit from the already established connections with the Copernicus services such as DIAS, CDS and ADS. **[WP3]**

of setting up their own download and processing infrastructure.	
They are also encouraged to integrate third-party data (including in-situ data) and envisage data assimilation into models and products made available on the Copernicus platform of the Copernicus services.	FRAMES builds on the outstanding experience of ECMWF and the consortium to exploit the information provided by diverse observational systems for the benefit of numerical simulations. FRAMES envisages the development of **a new data assimilation framework** for fire variables within an operational numerical weather prediction system. FRAMES will also interface itself with the ACTRIS (Aerosol, Clouds and Trace Gases Research Infrastructure) community through the ACTRIS partners involved in FRAMES (BSC, NOA, CNR). ACTRIS is a pan-European initiative consolidating actions amongst European institutes producing high-quality observations of aerosols, clouds and trace gases. FRAMES will use ACTRIS data to verify the developments of the aerosol model using variable fire emissions derived from the fire dynamical model. The assimilation outputs will also be assessed with the high-quality datasets available from ACTRIS. **[WP2, WP4]**
The proof-of-concept or prototype should allow demonstrating the relevance and suitability to implement the proposed application later on at European level in a cost-efficient manner, i.e. potentially with operational Copernicus funding.	FRAMES has reached out to a vast community of European and International institutional player related with several aspects of fire management, prediction and monitoring. This community will be engaged in a series of activities during the FRAMES lifetime. With these outreach and user engagement activities, we aim to showcase the enhancement that FRAMES products will provide to the vast and distributed Copernicus user communities. Attention will be paid in establishing a tangible outreach to different professional communities thanks to the activity of the Climate-Knowledge and Innovation Community, partner in the FRAMES consortium. **[WP5]**
To allow a discussion of such potential operational funding, the activity should also result in one or more possible scenarios on how this application could potentially be integrated into the existing service architecture.	FRAMES by construction builds into the operational core of the fire-relevant Copernicus services and for this reason it minimises the risk of sustainability and maximises the potential for operational portability.
Proposers are invited to investigate synergies with the Knowledge and Innovation Communities (KICs), in particular Raw Materials and Climate.	Members of the Climate Knowledge and Innovation Communities (KICs) are partners of the proposal and they will have a key contribution in establishing the links with a broader community of users.
The proposal should: → Demonstrate to what extent the proposed evolution could be a candidate for the operational Copernicus service in terms of cost-benefits, calendar and operational feasibility; → Specify the conditions for making available, for use and exploitation, the results (including IPR) to the entities	→ FRAMES builds on improvements to the IFS model and by construction solutions will be implemented to fit the constraints of an operational uptake. → FRAMES products will be available as soon as they are created with no further costs to operationalise them. FRAMES will be part of the Copernicus infrastructure as soon as it is implemented, therefore there are no IPR issues. → A set of new and i**mproved fire-related products** will also become available. These will offer the opportunity to spin-off new studies and research activities, and opportunities on aspects

implementing the EU Copernicus programme, including its contractors and service providers; → Foster innovation and enhance applications which exploit Copernicus service information from across the service domain.	not yet fully explored and understood, and sectors with non-obvious linkages to fire episodes and consequences.
For proposals under this topic: → Participation of industry, in particular SMEs, is encouraged; → Coordination and partnership with KICs is encouraged; → Involvement of post-graduate scientists, engineers and researchers is also encouraged, for example through professional work experience or through fellowships, scholarships as applicable.	→ FRAMES is supported by two SMEs. → The link with the EIT Climate-KIC has been established. → FRAMES will support a placement program to facilitate the involvement of professionals and early career scientists.

1.3 Concept and methodology

1.3.1 Concept

Major fire events are social-economic disasters that cause annually significant losses in lives and goods worldwide, and have consequences on human health, agriculture, tourism, security, resource availability, and climate to mention only a few relevant sectors. Thus, fire information is relevant to several Copernicus Services. Yet, the way such an information is used is not consistent across them and is often too simplistic to be effective. Although significant progress has been made to date, addressing fire-related emergencies, designing mitigation actions, and preparing for potential fire-related crisis still represent a major challenge that requires a fundamental shift in the approach fire information is produced and used by the relevant Copernicus services and presented to users.

The FRAMES project aims at facilitating that shift by proposing a new integrated modelling prototype for fire processes that has an encapsulated probabilistic approach at its core. The latter will be integrated and tested in an operational environment (TRL7 – system prototype demonstration in operational environment), namely the ECMWF's operational Numerical Weather Prediction (NWP) system, the Integrated Forecasting System (IFS). The IFS is the backbone Earth System Model (ESM) used to run many of the applications that feed into the Copernicus services, namely the fire-element of CEMS, CAMS, the C3S climate reanalysis and seasonal forecasting, and the Carbon Human Emission (CHE) project, precursor of a CO_2 monitoring service (Figure 2a). Furthermore, the IFS seasonal forecasting system is also used by the EC-Earth[13] community, a Europe-wide consortium that promotes international cooperation to address scientific hypothesis on climate and environmental changes. As such, EC-Earth is a major contributor to international efforts such as the World Climate Research Programme's (WCRP) Coupled Model Inter-comparison Project (CMIP).

Together with the paradigm shift in the way fire is threated, **FRAMES proposes a service cross-cutting approach**. By design, the FRAMES prototype is implemented in the ECMWF IFS irrespective of the applications and the services (Figure 2b), thus all fire-relevant Copernicus services but CLMS will benefit from the envisaged developments. **This approach enables a co-design of the innovations actions based on the Copernicus services' requirements and needs, and zeroes the risk associated to a follow-on up-take and provides already a solution for sustainability and portability**. The integration of fire processes into the IFS will lead to a more consistent treatment of fire across these services than currently available, and provide insights into the impact of wildfires on air quality, health and weather/climate at various time ranges for the benefits of various economic sectors. It

[13] https://www.ec-earth.org.

is worth mentioning that an additional advantage of the FRAMES strategy is represented by the potential positive feedback that the increased realism brought by the new processes in the IFS could have on the main meteorological fields at different forecast ranges from a few days to several months. A better meteorology means, for instance, a better transport of atmospheric composition, and a step closer to the (energy and carbon) budgets' closures. **However, FRAMES will not just bring a general improvement in the quality of what already exists but also new products that will be exploited by early warning systems, such as the ARISTOTLE-2 network, and an increased use of a probabilistic approach across the services.**

The FRAMES concept revolves around three pillars:

→ Research and Service Innovation
→ Service integration and adoption
→ Service Evolution

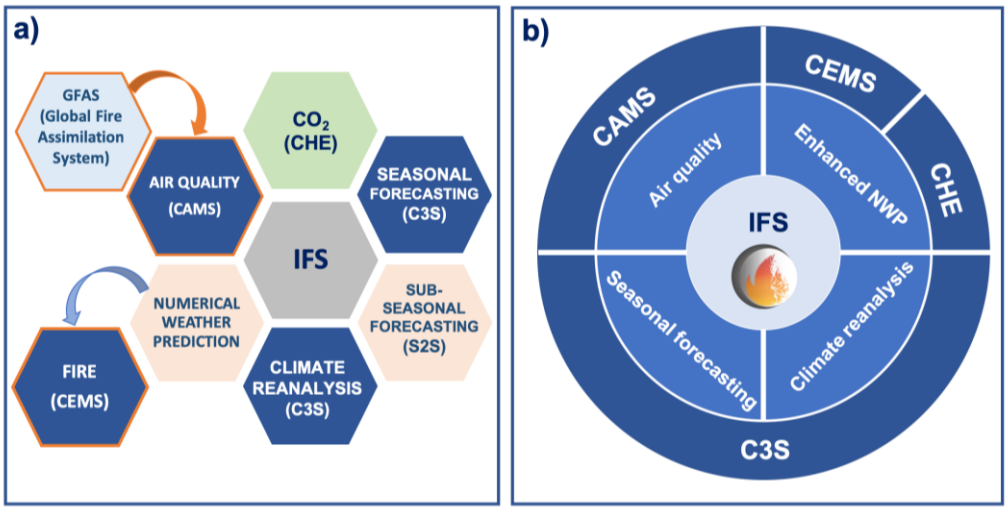

Figure 2 Panel a): State-of-the-art: link between the IFS and applications run as part of existing (blue hexagons) and precursor service (green hexagon) part of the Copernicus Programme. The NWP and the sub-seasonal forecasting (pale orange hexagons) refer to the other two applications that, although not part of the Copernicus services, have a wide user community. Orange-framed hexagons refer to model and applications in which fire information is currently either used or computed. Panel b): FRAMES innovation and integration concept provides the links for an integrated treatment of fire processes.

Pillar 1: Research and Service Innovation

This pillar focuses on how the science elements proposed by FRAMES can be developed and integrated in the IFS and in the operational chains of the fire-relevant Copernicus services.

Previous studies[14] have shown how fire parameterizations can be included in land-surface schemes for climate applications and the impact that they have on the surface energy budget. However, **the idea of considering fire processes as one of the earth-system components in a NWP system is innovative and challenging.** For the first time, the physical processes governing fire ignition, spread and suppression, and biomass burning emissions will be coupled with a global NWP system, allowing feedbacks from/on the meteorological variables and interaction at the interface between the atmosphere and the land/vegetation components. This will address the issue of the missing links between fire processes, vegetation conditions and meteorology, as discussed in section 1.1. Table 3 presents an account of the main envisaged innovation aspects brought by FRAMES in the fire-related Copernicus services.

Table 3 FRAMES envisaged main innovation aspects for the fire-relevant Copernicus services

Service	State-of-the-art for fire	Innovation delivered by FRAMES	Type of innovation
CAMS	CAMS provides off-line estimates of emissions from wildfires and biomass	1. **Improved emission as defined by a dynamical vegetation model**.	Increased quality of

[14] Pechony, O., and D. T. Shindell (2009), Fire parameterization on a global scale, J. Geophys. Res., 114, D16115, doi:10.1029/2009JD011927.

	burning through the Global Fire Assimilation System (GFAS) that assimilates satellite observations of Fire Radiative Power (FRP) to detect fires and estimate daily mean emissions of pyrogenic atmospheric pollutants, including trace gases, aerosols and greenhouse gases.	2. **Time varying estimation of fire emissions during the forecast** 3. **Uncertainty estimates** based on Ensemble Data Assimilation **for fire-emitted atmospheric composition variables** (CO, CO_2, black carbon and organic matter aerosols)	existing products (1-2), and a tool to define the priorities for the service evolution (3)
CEMS	CEMS provides Fire Weather Indices (FWI) produced as a post processing calculation based on products of ECMWF weather ensemble prediction system. FWI products are widely used in fire-forecasting despite two major limitations: It does not include any information of the vegetation status and the actual fuel load availability, and is calibrated to describe the fire behaviour of pine trees typical of the Canadian forests. Nonetheless, FWI is applied to different vegetations with very different burning characteristics.	1. **Improved products** (e.g. Fire Emission Potential, FEP, see Section 1.3.3**) equivalent to existing FWI codes** that overcome the limitation of the latter while representing a better probabilistic fire-risk indicator, being based on both the fuel load derived from the vegetation status and the ignition potential. 2. Paradigm shift from fire product obtained with simplified metrics calibrated on a specific ecosystem to **fire as a coupled process between the atmosphere and the vegetation.** 3. N**ew probabilistic and physically-based products** related to the probability of ignitions that cannot be derived from currently-used schemes.	New Products (1-3)
C3S	C3S provides limited information on fires. This comes mostly in form of fire monitoring e.g. of gridded Burned Area (BA) and Fire Radiative Power (FRP) products retrieved from satellite measurements. Both products will be distributed via the C3S Climate Data Store (CDS) in the forthcoming months. Fires is not accounted for in C3S modelling products e.g. reanalysis and seasonal forecast	1. **Increased realism** of the C3S climate reanalysis and (IFS-based) seasonal forecasting products by adding fire-related physical processes currently not accounted for; 2. **New era-land reanalysis, which includes model-based Burned areas (BA).**	Increased quality of existing products (1), and new Products (2)
CLMS	Copernicus Global Land Service, CGLS regularly provides a set of satellite-based bio-geophysical variables that are directly or indirectly linked to landscape fires as 10-daily maps of burned scars, parameters related to the vegetation state (e.g. LAI, FAPAR), vegetation growth (Dry Matter Productivity), and albedo.	1. **The system proposed in FRAMES,** with its integrated approach to forecast FEP and corresponding impact on vegetation cover and albedo, **can provide complementary information to that already envisaged within CGLS.**	New Products (1)
CO_2 CHE	CHE is building a monitoring capacity able to disentangle natural and anthropogenic CO_2 emissions. Natural and anthropogenic fires, for instance, contribute to both CO_2 and CO emissions. The CO_2 effects of fires is	1. **Improved** modelling of CO_2 and CO **emissions from fires through the use of an advanced assimilation framework exploiting fire radiative power observations.**	Improved quality of existing products (1-3)

	related to two aspects: 1) a reduced CO_2 photosynthetic uptake; and 2) direct emissions from burning forest's wood or smouldering peat fires. These aspects are currently neglected.	2. **Enhanced realism of the vegetation model**, which will include fire disturbances and re-growth.	

Pillar 2: Service Integration and adoption

Dedicated experiments will be run using the developed prototype. The FRAMES outputs (products) of these experiments will be available in the ECMWF MARS archive, which can be interfaced to both the C3S Climate Data Store (CDS) and the CAMS Atmosphere Data Store (ADS) through adaptors. This means that all downstream and sectorial applications, as well as any other users (from scientific, and public sectors, as well as policy makers) of the ECMWF Numerical Weather Prediction, C3S and CAMS services can benefit from the new or enhanced products. The FRAMES products will be also made available through the CEMS channels that are available to ECMWF for that service.

The FRAMES consortium is also well placed to exploit additional channels, for instance through the ARISTOTLE-2 network[15]. ARISTOTLE-2 is an on-going coordinated action to provide Multi – Hazard Advice to the European Response and Coordination Centre (ERCC) either in advance or through the activation of the EC Civil Protection Mechanism (CPM). IPMA and MF (partners in FRAMES) coordinates the ARISTOTLE-2 FIRE activities. At the time of writing the ARISTOTLE-2 project is funded until 2019 with the possibility of a two to three-year extension. If the extension is granted, a pilot assessment project to validate the quality and fitness-for-purpose of the new fire danger products in an operational context will be initiated.

Besides products' integration and dissemination, knowledge access will also be guaranteed to the wider scientific community. It has already been mentioned that the IFS is also the backbone model used by the EC-Earth community, whose studies and results significantly contribute to international efforts such as the WCRP CMIP initiative. Similarly, a wide research community has access to an open-access version of the IFS model, called OpenIFS[16]. Thus, the research methods used to describe the fire processes and land modifications once integrated in FRAMES can eventually be also made available to the OpenIFS community.

Pillar 3: Service Evolution

This pillar focuses on how additional aspects can be built-on the FRAMES proof-of-concept and added in the future to assist the evolution of the considered Copernicus services.

The integrated approach proposed within the timeframe of FRAMES will develop the main pathways to couple the atmosphere and land components of the IFS, and link the new fire-related processes to the dynamical core of the IFS (e.g. radiation). These will provide a necessary proof-of-concept of the FRAMES approach. Several improvements can be implemented on top of what is proposed here that cannot be considered within the envisaged 3-year period of FRAMES. These developments are regarded as a required evolution of the current proposal for the transition from a proof-of-concept phase to a (pre-)operational stage (Table 4).

Table 4: Future developments needed to take the FRAMES proof-of-concept closer to an operational stage. The list is not exhaustive.

WP in FRAMES	Addressed Component	FRAMES' development	Future evolution after FRAMES
WP1	Vegetation model	Enhanced vegetation model with fire processes, dynamical albedo, climatological biomass	Dynamical growth of vegetation and biomass load available for burning
WP1	Emissions	NO_2 modelled but not assimilated	NO_2 in data assimilation framework
WP1	Aerosol interaction with the physics	Direct effect due to aerosol-radiation interaction	Indirect effect due to aerosol-cloud interaction

[15] http://aristotle.ingv.it/tiki-index.php.

[16] https://www.ecmwf.int/en/research/projects/openifs.

WP2, WP3	Data assimilation	Short test using the fully integrated approach for the vegetation variables	Long-term experiments using the fully integrated approach with modelled vegetation in the DA scheme
WP5	Outreach and dissemination	Engagement with selected users	Systematic engagement of the main users of the fire-related Copernicus services

The evolution of the FRAMES approach summarized in Table 4 is designed to benefit the selected Copernicus services already targeted in the present proposal. Additional studies could kick-off independently and perhaps also interest the two remaining Copernicus services not targeted in this proposal: the Copernicus Security Service (CSS) and the Copernicus Marine Environment Monitoring Service (CMEMS). For instance, major fire events can cause migration-related issues well beyond the active-fire period. This is because, by changing the land cover, fires can seriously impact the most delicate economies whose gross domestic product is largely based on agriculture revenues. These economies certainly include Third World countries worldwide, as well as most southern European countries that have long and important agriculture-based traditions. As replacing a cultivation destroyed by a fire can take several years (e.g. olive trees take decades to reach full production), fires could lead to immigration issues just like political instabilities and wars.

Fires developing along coastal areas are also a potential threat for the marine ecosystems. These aspects have only recently received some attention and very little has been ascertained to date. In mid-December 2017 while California was devastated by the Thomas Fire with ash plumes reaching several miles off-shore and ashes deposited over the Santa Barbara channel, a team of specialists in geochemistry, optics, and microbiology from the University of California sailed through the channel.

Measurements were taken that provide the first real-time dataset of how ash from a wildfire affects everything from marine carbon storage to the health of sea life[17]. While the data analysis from that campaign is still on-going, it cannot be excluded that the marine ecosystems, and fishery industry in the proximity of the affected areas could be affected by the released ash. If the fishery industry is impacted, human health is in turn at potential risk.

Figure 3: The ash plume from the Thomas Fire could be seen from the International Space Station. Photo by NASA Photo/Alamy Stock Photo.

1.3.2 Links with national and international research activities

The members of the FRAMES consortium are and have been involved in several national, international and European projects that provide relevant input to FRAMES and its developments. FRAMES launches an innovative idea while building on methodologies, code, validation datasets and knowledge from a number of existing projects and initiatives listed below, in addition to the significant experience of the project partners in operating operational weather forecasting and Copernicus services.

Table 5: Recent projects with partner involvement relevant for FRAMES

Project	Outputs provided to FRAMES	FRAMES partners involved
Research activities		
FUME (EU-FP7)	FUME was an EU 7th Framework Programme funded project that evaluated which changes in the land or in other factors occurred in the last decades that affected forest fires in Europe and other fire-affected areas of the world.	FC.ID

[17] https://www.independent.com/news/2018/feb/12/thomas-fire-ash-sampled-santa-barbara-channel/.

	FRAMES will benefit from the developments achieved in FUME linking extreme weather (e.g. drought and heat waves) with fires.	
GEOLAND GEOLAND2 (EU-FP7)	GEOLAND I and II have been a joint initiative of European Commission (EC) and European Space Agency (ESA), aiming at building up a European capacity for Global Monitoring of Environment and Security. The projects were carried out in the context of GMES/GIO/Copernicus as precursors of the Copernicus Global Land Monitoring Service. FRAMES benefits from the land monitoring developments in those projects, which were further developed in ImagineS, and are now operational in the Copernicus land services, in particular for the global mapping of vegetation characteristics and albedo, which are relevant for the fire-land-surface interactions envisaged in FRAMES.	ECMWF, IPMA
SPFireSD - Seasonal Prediction of Fire danger using Statistical and Dynamical models (H2020 GA-748750)	EU funded project to develop and assess seasonal fire prediction capability through a variety of complementary and innovative methods, with a focus on Europe, the Amazonian basin and Indonesia. FRAMES will benefit from the developments of the long range component for fire danger that is used in EFFIS and GWIS. Outcomes from SPFireSD could be used to validate new FRAMES fire danger products at a time scale that is beyond the availability of the EFFIS platform	BSC
SERV-FORFIRE - Integrated Services and approaches for assessing effects of climate change and extreme events for fire and post fire risk prevention.	ERA4CS project to improve the quality of services and approaches for assessing effects of climate change on fire and post fire risk. The project tries to define suitable strategies for prevention and mitigation actions.	FMI, CNR
EXHAUSTION. Exposure to heat and air pollution in Europe – cardio-pulmonary impacts and benefits of mitigation and adaptation (H2020)	EU-funded project, expected to start in summer 2019, to evaluate future-climate health effects triggered by the extreme meteorological and air pollution events. Fire risk will receive the primary attention as one of the most-sensitive types of the emission sources with regard to climate change. From there, all the effect chain towards mortality and morbidity will be followed and the related risks quantified.	FMI
Copernicus Specific Activities		
Copernicus Global Land Service, CGLS (EU) – global component of the CLMS	Following the exploitation of GEOLAND2, FRAMES will benefit from the land monitoring activities in Copernicus Global Land, and of a deep knowledge of the uncertainty in the estimation of satellite estimates of vegetation products, albedo, burned areas, which are relevant for the assessment of fire-land-surface interactions envisaged in FRAMES.	IPMA, FC.ID
CAMS -Development of the global fire assimilation system (CAMS44) (EU)	CAMS44 is a contract awarded by CAMS for providing support for and further development of the global fire data assimilation system (GFAS) of CAMS operated by ECMWF. FRAMES benefits from the experience in using satellite-based fire radiative power to infer emission rates and knowledge of the respective uncertainty budgets.	IPMA
CAMS- Utilization of the current GFAS version for air quality forecasting in Europe.	CAMS50 is a contract awarded by CAMS for the operational delivery of the European-scale air quality component of CAMS. FRAMES benefits from the experience in using satellite-based fire radiative power to infer emission rates and knowledge of the respective uncertainty budgets.	FMI

(CAMS50) (EU)		
CAMS-Global aerosols aspects (CAMS43) (EU)	CAMS43 is a contract awarded by CAMS for providing support for and further development of the global production system of CAMS operated at ECMWF that delivers 3D distributions of aerosols in the troposphere and stratosphere through data assimilation and numerical modelling. Frames benefits from the involvement and the developments of the modelling components for fire emissions achieved under this ITT	SRS, KNMI
CEMS-Fire danger Computational centre (JRC-EU)	ECMWF, in collaboration with MF, is the Computational centre for the Copernicus fire forecasting data. It has the operational duty to provide fire weather indices to the EFFIS portal	ECMWF, MF
International programs and coordinated efforts		
ACTRIS-2 Aerosols, Clouds and Trace gases Research InfraStructure / ACTRIS PPP - Aerosols, Clouds and Trace gases Preparatory Phase Project	ACTRIS is the European Research Infrastructure for the observation of Aerosol, Clouds and Trace Gases. ACTRIS is composed of observing stations, exploratory platforms, instrument calibration centres, and a data centre. ACTRIS serves a vast community of users working on atmospheric research, climate and Earth system and air quality models. ACTRIS is developing towards becoming a European Research Infrastructure Consortium (ERIC). FRAMES directly links benefits from the availability of integrated state-of-the-art European ground-based stations for long-term observations of aerosols, clouds and short-lived gases.	BSC, CNR, ECMWF, NOA
Climate Change Initiative Programme Extension Phase 1 (CMUG-3)	The European Space Agency has established the "Climate Modelling User Group" (CMUG), to place a climate system perspective at the centre of its Climate Change Initiative (CCI) programme, and to provide a dedicated forum through which the Earth Observation Data Community and Climate Modelling Community can work closely together. FRAMES benefits from using the CCI products, which include fire data (burned area), for quality assessment.	ECMWF, BSC, MF
ARISTOTLE-2 European Natural Hazard Scientific Partnership (DG-ECHO)	ARISTOTLE-2- ENHSP is a project financed by the EC DG-ECHO that delivers world leading multi-hazard advice capability to the Emergency Response Coordination Centre (ERCC). Within ARISTOTLE 2-ENHSP, a collaborative network of scientific and operational experts has been established across Europe to exploit the available scientific and technological expertise and provide expert advice to ERCC. In the context of ARISTOTLE 2, FRAMES aims at building the Interface for show case 1 “FRAMES for CEMS”.	ECMWF, MF, IPMA, KNMI
Vegetation Fire and Smoke Pollution Warning and Advisory System (VFSP-WAS) (WMO)	In recognition of the problems related to biomass burning, WMO initiated development of the Vegetation Fire and Smoke Pollution Warning and Advisory System (VFSP-WAS) as an outcome of the international workshop on “Forecasting Emissions from Vegetation Fires and their Impacts on Human Health and Security in South-East Asia” which took place from 29 August to 1 September 2016 in Jakarta, Indonesia. In implementation of this concept, WMO relies on the national and international modelling centres and institutions that can develop the modelling capability to provide the warnings on different temporal and spatial scales. FRAMES will provide its prototype products for the scopes of the VFSP-WAS.	ECMWF
LSA-SAF (EUMETSAT)	The LSA SAF (Satellite Application Facility on Land Surface Analysis) is part of the distributed EUMETSAT (European Organization for the Exploitation of Meteorological Satellites) Application Ground Segment. It focuses on the development and processing of satellite products that characterize the continental surfaces, such as radiation products, vegetation, evapotranspiration and wild fires. FRAMES benefits from the experience in	IPMA, FC.ID

	the calibration and assessment of fire risk maps, using data records of fire frequency and intensity (emitted power) based on satellite observations.	

In addition to ongoing research activities, FRAMES has established a series of links to international organizations, civil protections, Meteorological Services and Copernicus services that have expressed a clear interest in the possible outcomes of FRAMES. The endorsement letters enclosed to this proposal also highlight specific user needs that FRAMES has the potential to fulfil, as summarized in Table 6.

Table 6 Summary of endorsement letters and interest expressed in the FRAMES outcome and products.

Entity	Type	Expressed User need and FRAMES products/developments adoption
World Meteorological Organisation	International coordination organization	FRAMES products related to fire and smoke forecasts will be used for the Fire and Smoke Pollution Warning and Advisory System (VFSP-WAS) forecasts. VFSP-WAS is run by the Singapore Met Service on behalf of WMO.
International Cooperative of Aerosol Prediction	International coordination consortium	FRAMES scientific developments will be used to obtain dynamical fire emissions and extend the forecasts range of the aerosol models that are part of ICAP.
Copernicus Climate Change Service	Copernicus Service	FRAMES developments in land surface modelling including fire and vegetation will support the improved monitoring, the past reconstruction and the future predictions of fire-related parameters such as for example the burned areas.
Copernicus Atmosphere Modelling Service	Copernicus Service	FRAMES developments in fire emissions will provide better estimates for the benefit of the CAMS global and regional users.
Meteorological Service Singapore	Operational Met Service	FRAMES products will support the forecasts of the Fire and Smoke Pollution Warning and Advisory System (VFSP-WAS).
Agencia Estalal de Meteorologia	Operational Met Service	FRAMES dynamical emission and aerosol forecasts will be used in support of measurement campaigns aimed at special events.
Chinese Academy of Meteorological Sciences	Operational Met Service	FRAMES and meteorological products will be used to provide support for fire management in collaboration with the State Forestry Administration in accordance with the National Forest Fire Emergency Plan.
Dipartimento di Protezione Civile Italiana	National Protection service	FRAMES prototype fire products will be assessed to improve fire risk prevention and management.
Australian Department of Environment and park Protection	National Protection service	Maps of fuel moisture content and fire ignition probability derived in FRAMES will be used to improve fire management outcomes.
Columbia University	Academic research institute	FRAMES fire and smoke aerosol products will be used to investigate climatic and air quality effects of biomass burning emissions, in developing early warning systems for severe fire episodes at synoptic, sub-seasonal and seasonal time scales, and in projecting fire activity under a changing climate..
ARISTOTLE-ENHSP	Consortium - European Natural Hazard Scientific Partnership	FRAMES fire forecasting products will be assessed and used in support of the consortium activities in the framework of its support to the ERCC
Hellenic National Meteorological Service	Operational Met Service	FRAMES prototype fire products will be assessed to improve fire risk prevention and management.

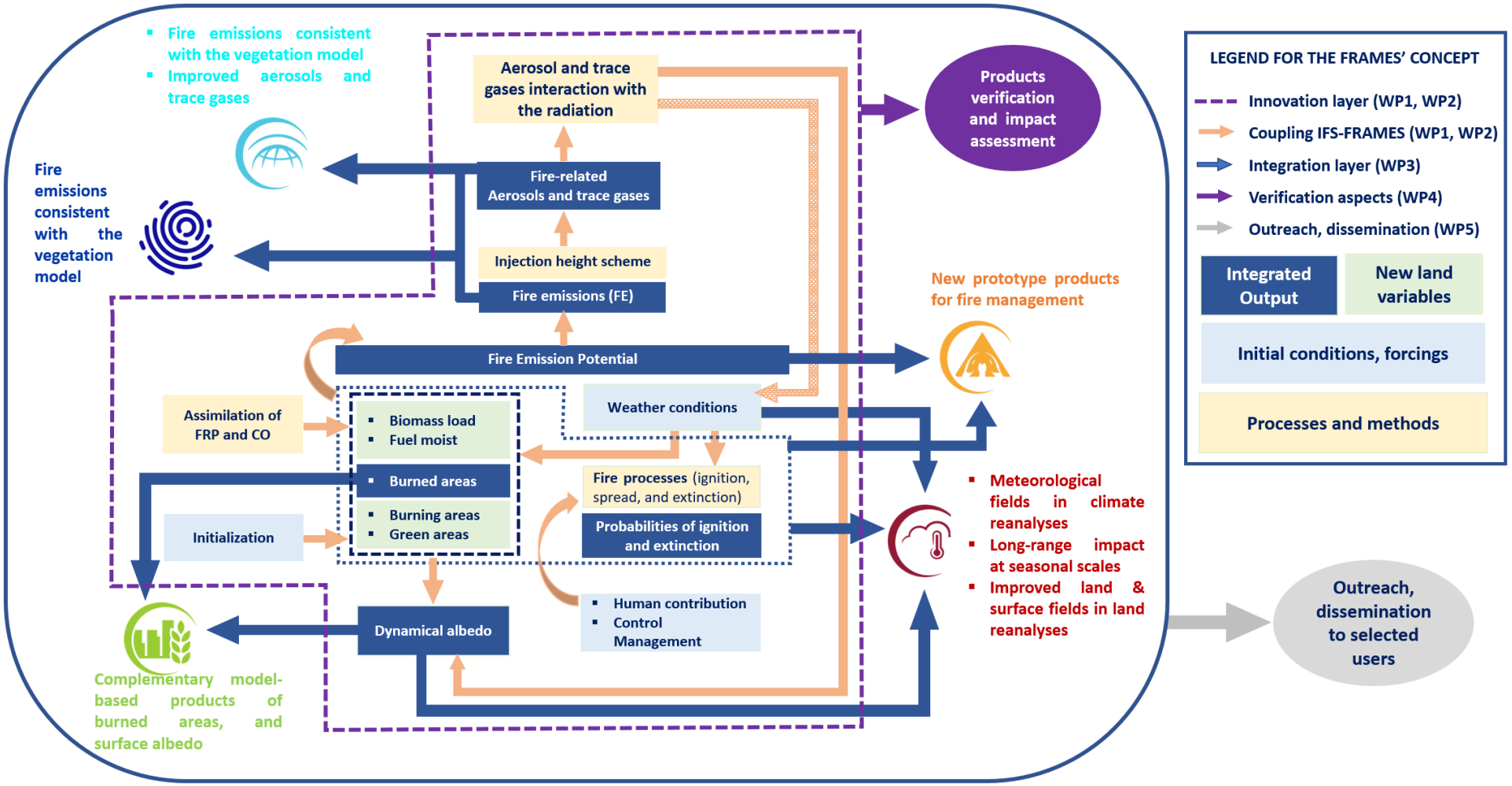

Figure 4: FRAMES diagram architectural concept. The modelling core lies with the definition of the evolving vegetation variables (Biomass load, Fuel moist, burned areas and burning areas) and the description of the fire processes (ignition, spread and extinction). The four prognostic variables will be initialised using satellite observations. In a second stage, FRAMES will also develop a data assimilation infrastructure to exploit the wealth of available Fire Radiative Power (FRP) and carbon monoxide (CO) observations. The interface to the atmosphere is defined through the Fire Emission Potential that is directly linked to the biomass burning emissions. These emissions will be coupled with the other components of the Earth System (e.g. radiation). An overarching verification framework will be developed for all components developed in the project. The diagram also highlights the exit points of the architectural concepts, i.e. what FRAMES will deliver into the targeted Copernicus Services, and for each the anticipated benefits.

1.3.3 Methodology

Overview

The adopted methodology will use a combination of dynamical and probabilistic modelling, diagnostic and verification tools to best characterize the initial state and evolution of fire events. To tackle this challenge on a global scale, identifying the complementarities between available observations, modelling and data assimilation methodologies, and establishing their limitations and strengths are paramount.

Figure 4 presents the project concept diagram highlighting the new elements that will be added to the IFS and how these interface each other (science and innovation layer). Improvements on existing data and new data products are envisaged. Some of them are of direct interest for the targeted Copernicus Services (blue arrows), some are meant for adoption by broader communities. Envisaged improvements to each fire-relevant Copernicus service are also indicated.

A collaboration between ECMWF, key research and operational partners, and the five fire-relevant Copernicus services (CEMS, CAMS, C3S, CLMS, CHE/CO2) is articulated in Figure 5 with a work breakdown structure that sees six work-packages interconnected and clustered in layers. The programmatic core of the project is interlinked with the Copernicus services targeted in this proposal. Their presence in form of supporting entities and WP coordination will guarantee the steering force needed to target the program key requirements.

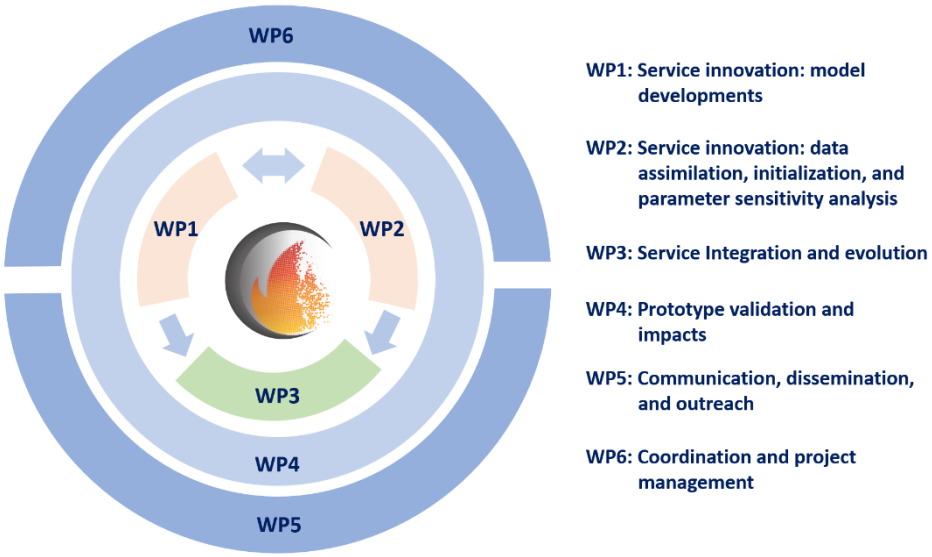

Figure 5: FRAMES Work-Package structure

A science and development layer, which consists of two work packages, aims at providing research-based answers and proposing solutions to the FRAMES challenges. Addressing the prediction of fires *per se* and the usability of these developments not only for the scope of air quality but also for weather and climate simulations, requires a new strategy regarding the modelling of fire emissions and the interaction of fires with other components of the Earth system. This will be performed mostly in **WP1**, with interlinked activities concerning initialization and data assimilation done in **WP2**. The implementation element where the proposed research solutions from WP1 and WP2 are tested for feasibility, adapted and integrated into the application-oriented systems is performed in **WP3**. **WP4** is devoted to the model evaluation, and product verification activities. It also defines the performance benchmarks based on the available observations and available products. The verification activities within this layer are expected to benefit from a strong connection with existing users of the climate, environmental and emergency response products under the Copernicus umbrella. FRAMES will also target a broader uptake of FRAMES prototype products through a broad spectrum of outreach and coordination activities, and through professional work experience facilitated by the cooperation with already existing positioning programs such as the “Climate-KIC's Pioneers into Practice” initiative (**WP5**).

FRAMES deliverables will report on a range of findings to support research advancements relevant for Europe and worldwide. In addition, the strongly innovative character of FRAMES outcomes has already received a significant interest testified by the significant number of endorsement statements attached to this proposal spanning from operational centres, research institutes and prestigious international organizations.

Aims and main features of the six work packages presented in Figure 5 are defined as follows:

WP1 - Service Innovation: modelling aspects

Aim: **WP1** will develop the modelling framework of FRAMES's fire model. It will use an incremental approach to allow WP2 and WP3, which are closely interlinked to WP1, to run in parallel. In the first phase, algorithms and solutions will be tested in an offline 1D environment. In the second phase, the developed fire model will be coupled with the full 4D atmospheric modelling system.

Approach and methodology:

Using an incremental approach WP1 will construct the innovative modelling framework of FRAMES going from the surface representation of fires to their interaction with the atmosphere.

Fire model development Fire activity is strongly influenced by available fuel, climate/weather conditions, ignition agents and social activities. Thus, an ideal strategy should focus on connecting meteorological and surface parameters from the vegetation scheme. These parameters include land use and cover, fuel load and fuel moisture content, but also others related to emission amounts. FRAMES modelling strategy relies on a novel variable defined at the interface between the fire interactive vegetation and the atmosphere, the **Fire Emission Potential (FEP)**. FEP provides an estimation of the biomass load available for burning and is linked to the probability of ignition as, intuitively, the drier and more abundant the fuel the more likely it is to ignite and to have sustained fires. As ignition will also depend on factors such as lightning probability, population density, and fire control measures, a value of **FEP larger than zero is not a condition for a fire to be activated. This will happen only when an ignition takes place**. Fire ignition is fundamentally a stochastic problem as it cannot be predicted exactly when a fire will start, but only what the probability of its occurrence is. The development of a new fire ignition scheme will therefore follow a stochastic approach. Once a fire is activated, it will be treated as a sub-grid scale process.

At the expected model resolutions (10 to 30 km), most fires occur at sub-grid scales, i.e. the active and burned area only covers a fraction of the model grid-cell. Furthermore, considering these resolutions, the effects of fire propagation (e.g. slopes in the topography) will not be resolved, as this would require topographic information available at much higher spatial resolutions (sub-kilometre). Strategies connecting large scale and sub-grid phenomena exist and are already well tested in physical model developments. For instance, they are often adopted to describe convection initiation, or cloud formation where a connection between the large-scale weather parameters, such as temperature and humidity, is established with smaller-scale phenomena, like convective storms.

In FRAMES, the following four evolving (prognostic) variables, which depend on large scale weather conditions and vegetation evolution, are defined: (a) **burning area**, i.e. fraction of the grid box with an active fire, (b) **fuel moisture content**, which is connected to the sustainability of fire, (c) **biomass load** available for burning, and (d) **burned area** (fraction of the grid box that experienced a fire). Burned area will evolve following the development of active fires (burning area) and vegetation recovery. It identifies the "fire scar" that is then used to modulate land surface characteristics, such as vegetation cover and albedo. A key component is the coupling between the fuel moisture content and the biomass load available to the FEP on the global scale. This coupling will be done via the land-surface scheme, which is already integrated into the ECMWF's model and will be expanded by adding new vegetation components (e.g. peat) to describe all processes that are relevant to fire.

A modular approach will guarantee the parallel developments of the various modelling components. The development and testing of the fire model will take place in the off-line version of the vegetation scheme. The first step will couple fuel load to land cover using the land cover and vegetation characteristics of the land surface model. This will require an update of the land cover database to include the recently developed ESA CCI land cover and a transfer function between land classification and fuel load. Vegetation and biomass recovery will be parameterized following land-cover dependent recovery time-scales, derived from satellite observations. This approach will allow a fast turn-over of the simulations, with a low computational footprint, enabling testing and verification. In addition to the global domain, several regional domains, identified in **WP4**, will be also considered. **This off-line phase will allow the testing and development of FEP and downstream interactions.** Following this first testing phase performed in **WP4**, a full 3D coupling with the other components of the IFS will follow.

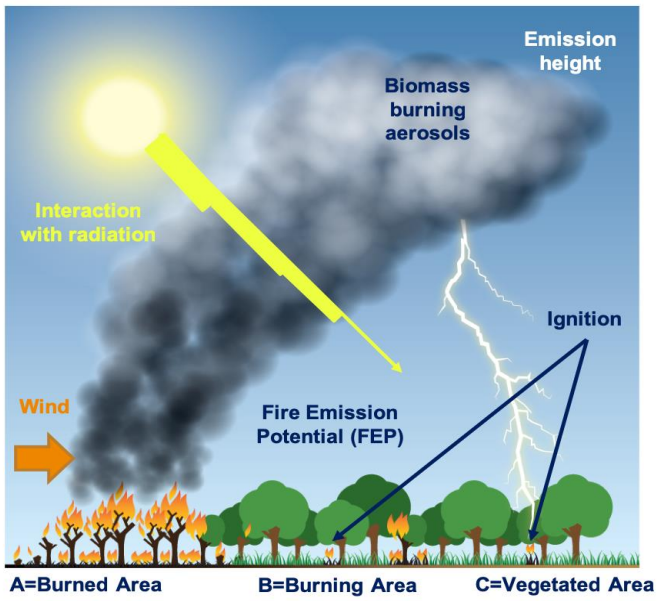

Figure 6 FRAMES modelling processes. The schematic represents the processes that are going to be considered in every IFS grid box. Three new vegetation tiles are going to be implemented: A- Burned area, B- Burning area and C =1-A-B vegetated area. An ignition scheme function of lightning, human behaviour and weather will provide the ignition probability. Fuel load and fuel moisture content will be used to define a Fire emission potential The FEP is the interface variable between the vegetation and the atmosphere and will be used to convert dry matter into emissions. An injection height scheme will correctly place emissions in the atmosphere to be then interfaced with the other earth system modelling components (e.g. transport and radiation).

Links with the atmospheric dynamics Based on our definition, FEP is the available dry matter for combustion, expressed in kg of Dry Matter per unit area. Hence, its rate of change depends on the fire ignition, evolution and extinction. It is directly proportional to the production of emissions of both chemical trace gases and aerosol. An advantage of treating FEP as a prognostic variable to derive atmospheric emissions is the potential to naturally **account for evolution of emissions as a function of the meteorological conditions**, hence to obtain weather-modulated emissions. This represents one of the prototype improvements for the CAMS service that will be tested in WP3 in a CAMS-dedicated show case. Within the scope of FRAMES, emissions of organic and black carbon, CO, CO_2 and NO_x (=NO+NO_2) will be computed. These will be inputs to the modelling of prognostic aerosol and trace gases in the IFS, and coupled to the data assimilation system developed in **WP2**. Emission estimates for other trace gases will be prescribed from the CAMS operational configuration to allow running the corresponding show case (**WP3**). It is noted that while aerosol, CO and CO_2 emissions will directly be applied, the emissions of NO_x are a special case. NO_2 is highly reactive and hence exhibits a variable, but comparatively short lifetime, which is dependent on chemical composition as well as meteorological variables like cloudiness, and incident solar radiation[18]. This requires a full description of tropospheric chemistry to be resolved, which is unfeasible for operational applications. Nevertheless, tropospheric NO_2 columns, including those from fires, are well observed from space, thus they have the potential to serve as a useful source of information to help attributing observed concentration increments to fire emissions[19], and distinguishing from those due to other, anthropogenic and natural, emission sources. With this perspective in mind, we propose here to develop a simplified NO_2 model that can run at the operational resolution targeted, like the existing linear CO model already available in the IFS[20]. The simplified NO_x model will be designed using a training set of data based on the full tropospheric chemistry model available within IFS developed for CAMS[20]. The use of such a dataset allows to identify a set of meteorological predictors that could be used to parametrize the NO_2 sources and sinks, possibly using machine learning methods. The tropospheric NO_2 concentrations based on this newly developed simplified model will be evaluated against TropOMI observations of NO_2 **(WP4)**, and benchmarked against a full-chemistry model version. Here, the focus is on its ability to represent fire emission plumes, both in terms of representation of the fire location, and NO_x emission strength. For instance, evaluation of NO_2 models has been shown to put constraints on the fire type (smouldering vs flaming), which in turn defines the CO/CO_2 ratio, a metric for the

[18] E.g. Stavrakou, T., Müller, J.-F., Boersma, K. F., van der A, R. J., Kurokawa, J., Ohara, T., and Zhang, Q.: Key chemical NOx sink uncertainties and how they influence top-down emissions of nitrogen oxides, Atmos. Chem. Phys., 13, 9057-9082, https://doi.org/10.5194/acp-13-9057-2013, 2013.

[19] E.g. Castellanos, P., Boersma, K. F., and van der Werf, G. R.: Satellite observations indicate substantial spatiotemporal variability in biomass burning NOx emission factors for South America, Atmos. Chem. Phys., 14, 3929-3943, https://doi.org/10.5194/acp-14-3929-2014, 2014.

[20] Flemming et al Tropospheric chemistry in the Integrated Forecasting System of ECMWF, Geosci. Model Dev., 8, 975–1003, doi: 10.5194

combustion completeness. Hence, evaluating the NO_2 model against satellite observations may provide further constraints on the fire carbon emissions (**WP4**).

Injection height or profile, i.e. the height at which the smoke constituents (aerosols, trace gases) are released, is also a crucial element in the simulation of the trajectory of a biomass burning plume. When fires are in the smouldering stage, emissions are usually released close to the surface. For fires affecting high vegetation in the flaming stage, emissions can be released in the boundary layer or in the free troposphere depending on the fire intensity, on the thermal stratification of the atmosphere and, for particularly strong fires, on the occurrence of pyro-convection. A large majority of fires release constituents in the boundary layer[21], but a few[22] can release aerosols and trace gases up to the upper troposphere-lower stratosphere (UTLS). In such cases, however, one must distinguish between the fire-induced plume rise and subsequent 3D transport of the emitted materials. Fires in the smouldering and flaming stages can be discriminated by their predicted FEP, which should be much lower for the former. There is a potential also by the fraction of low and high vegetation in the IFS land model tile: high vegetation is more prone to strong fires due to higher fuel density. The most-straightforward option of introducing the injection height is to provide the IFS with the vertical-resolving plumes. A second option is to implement an injection height module directly in the IFS. This second option has proved to be a quite robust one and has already been implemented in a climate model[23]. Several candidate models exist to simulate the injection height or profiles using fire and meteorological input such as IS4FIRES[24] or the Cloud-Resolving Model[25] Plume Rise Model (PRM)[26]. The algebraic solution of IS4FIRES would be quite easy to implement in the fire model, using FRP from the fire model (developed as part of FRAMES), the Planetary Boundary Layer Height (PBL) and atmospheric stability represented by the Brunt-Väisälä frequency in the free troposphere. As a first step, we propose to adapt and implement the IS4FIRES parameterization into the fire model to provide the IFS with an injection height.

Interaction with radiation**.** Once fire emissions are injected into the atmosphere, they interact with the other components of the Earth system. Interaction of the biomass burning components (organic matter, black carbon) with the radiation scheme (**direct effect**) is already accounted for in IFS using tabulated optical properties for the extinction coefficient and the single scattering albedo. In the interactive aerosol runs, the optical depth of the biomass burning aerosols can vary and is computed as the integral of the convolution of the prognostic mass mixing ratios and the extinction cross section over the whole atmosphere. The optical depth is updated at every time step in the radiation scheme to drive the direct radiative impacts of the fire-emitted particles. The impact of other aerosol species (e.g. dust, marine, sulphate aerosols) will be accounted for by using the operational aerosol climatology to isolate the direct impact of the biomass burning aerosols on the radiation fluxes and on the meteorological variables directly affected, such as surface temperature and winds. The verification and the impact of biomass burning aerosol on the radiation is part of the activities described in **WP4**. There are several ways in which clouds are susceptible to aerosols **(indirect effect).** Aerosol particles act as Cloud Condensation Nuclei (CCN) and can change the optical properties of clouds. For example, in presence of large amounts of aerosols, there will be a competing effect for the available water vapor that will most likely condense over a larger number of smaller droplets. These droplets will have different optical properties from their larger counterparts that will most likely form in a more pristine environment. The relative importance of these indirect aerosol effects in global models is still debated in the scientific community, and now this effect is entirely neglected in IFS. However, given the already heavy weight in model developments undertaken in this three-year project, an attempt to account for the indirect effect of aerosols will not be pursued in FRAMES and will be left for future developments (evolution aspects discussed in **WP3**).

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[21] Sofiev, M., Vankevich, R., Ermakova, T., Hakkarainen, J. (2013) Global mapping of maximum emission heights and resulting vertical profiles of wildfire emissions. *Atmos. Chem. Phys*., **13**, 7039-7052, doi. 10.5194/acp-13-7039-2013, http://www.atmos-chem-phys.net/13/7039/2013/.

[22] Fromm, M., Bevilacqua, R., Servranckx, R., Rosen, J., Thayer, J. P., Herman, J., and Larko, D.: Pyro-cumulonimbus injection of smoke to the stratosphere: observations and impact of a super blowup in northwestern Canada on 3–4 August 1998, J. Geophys. Res.-Atmos., 110, D08205, doi:10.1029/2004JD005350, 2005. 9771

[23] Turquety, S. (2013). Evaluating the Atmospheric Impact of Wildfires. In Fire Phenomena and the Earth System, C. M. Belcher (Ed.). doi:10.1002/9781118529539.ch13

[24] Sofiev, M., Ermakova, T., and Vankevich, R. (2012) Evaluation of the smoke injection height from wild-land fires using remote sensing data, Atmos. Chem. Phys., 12, 1995–2006, doi:10.5194/acp-12-1995-2012, www.atmos-chem-phys.net/12/1995/2012/

[25] Freitas, S. R., Longo, K. M., Chatfield, R., Latham, D., Silva Dias, M. A. F., Andreae, M. O., Prins, E., Santos, J. C., Gielow, R., and Carvalho Jr., J. A.: Including the sub-grid scale plume rise of vegetation fires in low resolution atmospheric transport models, Atmos. Chem. Phys., 7, 3385-3398, https://doi.org/10.5194/acp-7-3385-2007, 2007.

[26] Paugam, R., Wooster, M., Freitas, S., and Val Martin, M.: A review of approaches to estimate wildfire plume injection height within large-scale atmospheric chemical transport models, Atmos. Chem. Phys., 16, 907-925, https://doi.org/10.5194/acp-16-907-2016, 2016.

Suitability of the research approach: **WP1** will follow procedures and development methods closely related to the good practice and testing methods developed at ECMWF as part of its Research-to-Operations implementation procedure. In situ and remote sensing datasets have been identified to guarantee the robust benchmarking of the research innovation.

Measures for Success of the Work Package/ KPIs:

- Implementation of the fire module in the off-line 1D vegetation scheme delivered.
- Development of the links with the other earth-system components (3D model).
- Proof-of-concept of the fire dynamical integration approach.

WP2 - Service Innovation: Data Assimilation developments, initialization and parameter sensitivity analysis

Aim: **WP2** will develop the data assimilation and initialization framework of the FRAMES' fire model. The goal will be to build a fully integrated assimilation of fire radiative power in the IFS that is entirely consistent with the vegetation/fire/biomass burning aerosol model developed in **WP1**. The tasks will involve initialisation of the relevant physical processes as well as data assimilation for fire/vegetation related variables.

Approach and methodology:

WP2 will follow modular developments going from a simplified solution for the fire model initialization into a more complex and integrated solution envisaging the use of the 4D-VAR assimilation system.

Fire component initialization: A key component of **WP2** will be the initialization of the new prognostic variables defined in **WP1** (burning area, fuel moisture content, biomass load and burned area). Like **WP1**, also **WP2** will follow an incremental approach, where a temporary initialization strategy will be defined to work in the 1D off-line model environment. This **initialization** will mostly rely on independent satellite observations, of vegetation status (e.g. leaf area index) and burned area without employing an assimilation framework. Burned area is a direct component of the fire model and observations will be directly ingested given the well-established developments of satellite observations. Observations of vegetation status (e.g. leaf area index- LAI, normalized difference vegetation index – NDVI) will also be used to constrain fuel moisture content and biomass load using simplified empirical relationships[27].

Sensitivity of FRP to fire/vegetation parameters and FRP assimilation: Once the link between the fire dynamical model and the atmosphere has been established, the integration of the fire radiative power (FRP) assimilation into the ECMWF's four-dimensional variational system (4D-VAR) will be explored with **the goal of estimating directly the parameters of the fire/vegetation model developed in WP1**. The main advantage is these parameters will then be derived from FRP and consistently used to compute emissions for the atmospheric compositions forecasts.

The parameters of the fuel/fire model developed in **WP1** will be perturbed in the ensemble configuration of IFS and the resulting spread on the FRP will be assessed. This will assist in understanding which parameters FRP is mostly sensitive to, with the aim to inform the assimilation developments. Here, the most relevant parameters will be identified and their error characteristics will be determined with the aid of the ensemble approach. By building an integrated system, the parameters that drive the fuel/fire model will be used directly as *control variables* in the assimilation to match the model-equivalent of the observed FRP. An important step toward this achievement is represented by the definition of a model of FRP as a function of the fire/vegetation parameters as provided by the fire model.

This is a major development that will also allow to establish the link between the meteorological forcing and the biomass burning emissions which will be directly related to the relevant input parameters. Today, emissions only used in CAMS at the time of the forecast initialization are persisted for the full length of the forecast without any modulation; this is a known weakness of the system[7] that leads to the widespread adoption of corrective tuning parameters. Thus, currently most models scale biomass burning emissions of carbonaceous to match the observed climatology. These scaling factors ranges from 1.7 for the Met Office Unified Model limited area

[27] Baccini A, Goetz SJ, Walker WS, Laporte NT, Sun M, Sulla-Menashe D, et al. Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. Nat Clim Chang. Nature Publishing Group; 2012;2: 182. doi:10.1038/nclimate1354.

model[28] to 3.4 for CAMS[29]. **One of the benefits of FRAMES would be to reduce the need for these scaling factors by allowing the fire modulation through its interaction with the weather** conditions.

***Carbon monoxide assimilation*:** Carbon monoxide (CO) is one of the most relevant trace gasses from fire activities. FRAMES will allow for the first time to fully integrate fire-related observations and atmospheric composition observations in a variational data assimilation system. Observations available from various satellite platforms (IASI on MetopB and C, MOPITT, TropOMI) will be used to directly constrain CO 3D concentrations in 4D-VAR to support the parameter estimation exercise. A linear CO model is available in IFS and will be used to provide the initial model guess in the assimilation. Key to the success of this component will be the synergy between fire-related observations, which will constrain the fire/vegetation parameters, and the atmospheric composition observations, which will constrain CO. In future, this could be extended with additional components, for example through the development of a simplified NO_2 model as outlined in **WP1**.

Suitability of the research approach: WP2 will be developed following the consolidated approaches used at ECMWF for data assimilation and model initialization. Results will be benchmarked with the current GFAS system in the initial phase to ensure correct implementation of the observation operator for fire radiative power in the 4D-VAR. In the second part of the WP2 implementation, established, independently-derived emission inventories will be used to guarantee the quality of the emissions derived from the new fire/vegetation assimilation developments (in connection with **WP4**).

Measures for Success of the Work Package/ KPIs:

- Creation of a consistent approach to initialize vegetation and fire-related variables to work in the off-line 1D model framework.
- Understanding of what parameters of the vegetation/fire model biomass burning emissions are most sensitive to and characterize their uncertainties using the ensemble approach**.**
- Development of all necessary technical tools to fully integrate the FRP observations in IFS, including forward operator and tangent linear and adjoint operators (3D model).
- Joint use of FRP to estimate the fire/vegetation parameters and CO observations to estimate surface tracer concentrations in an integrated assimilation approach.

WP3: Service Integration and Evolution

Aim: **WP3** is mainly devoted to test the integration of the FRAMES approach within the targeted Copernicus services. To that end, the new or improved products, and the developments made in **WP1** and **WP2** will be tested and compared with the state-of-the-art used by the targeted Copernicus services. For this evaluation, several show cases (presented below), each addressing an innovation aspect of the targeted Copernicus service, will be performed. This WP is closely related to **WP4** where the assessment of the show cases' results is performed. As such, the service-targeted experimentation represents the integration layer in FRAMES. To provide a complete picture of how the FRAMES approach can benefit the targeted services, a technology mapping analysis will be performed. This will detail the innovation aspects anticipated through FRAMES. To complete the picture, a detailed roadmap analysis of how the services could evolve if the FRAMES approach is adopted will be performed. Thus, **WP3** will link the three pillars that constitute the FRAMES concept: innovation to the state-of-the-art, integration of the FRAMES approach through service-specific testing, and its evolution, i.e. aspects that cannot be developed and integrated within the project timeframe.

Approach and methodology:

WP3 will provide the tools and developments to link the service innovation into its integration and evolution.

Link to the Service innovation: **WP3** will first provide a technology mapping analysis that highlights the limitations and inconsistencies of the current fire approaches used within the fire-related Copernicus services, and then discusses the level of innovation FRAMES is expected to bring to each service. This analysis will also cover aspects that cannot be addressed in FRAMES and highlight the evolution potential of the targeted services.

Service integration. The service integration and adoption (pillar 2) will be illustrated by five show cases. In each show case, the classical Copernicus approach to fire is compared with that proposed in FRAMES. The

[28] Kolusu, S. R., Marsham, J. H., Mulcahy, J., Johnson, B., Dunning, C., Bush, M., and Spracklen, D. V.: Impacts of Amazonia biomass burning aerosols assessed from short-range weather forecasts, Atmos. Chem. Phys., 15, 12251–12266, https://doi.org/10.5194/acp-15-12251-2015, 2015.

[29] Kaiser, J.W., A. Heil, M.O. Andreae, A. Benedetti, N. Chubarova, L. Jones, J.-J.Morcrette, M. Razinger: Biomass burning emissions estimated with a global fire assimilation system based on observed fire radiative power, Biogeosciences, 9, 527-554, 2012.

configuration of each show case will be set-up to be as close as possible to the one used by applications run by the Copernicus services. Each show case will provide the FRAMES products to WP4 for the impact assessment. These experimental products will be made available to selected and interested service-related users that are either part of the consortium or have expressed an interest through endorsement letters attached to this proposal. The list of envisaged show cases is as follows:

Case 1: FRAMES for CEMS

Recent European and non-European fire events will be selected. For these fire events, classical fire products (FWI) provided by CEMS and the new products produced by FRAMES (Fire Emission Potential) will be contrasted using the tools and evaluation methods developed in **WP4**. A survey targeting selected users (e.g. ARISTOTLE-2 expert group, and WMO Vegetation Fire and Smoke Pollution Warning and Advisory System, VFSP-WAS[30]) will be used to identify the merits of the two approaches.

Case 2: FRAMES for CAMS

Fire emissions calculated on-line using the FRAMES developments will be used as inputs for CAMS runs. The outputs from the FRAMES runs will be contrasted with outputs obtained from equivalent CAMS experiments that used fire emissions provided by GFAS. The comparisons will focus on aerosols, relevant reactive gases and CO_2 and provide an assessment of the relative merits using the evaluation methods defined in **WP4.**

Case 3: FRAMES for C3S

The show case for C3S responds to two of the service streams: a) climate monitoring with its reanalysis products and b) climate prediction with its extended range forecasts.

a) The developments on the land and vegetation scheme provided by FRAMES will be showcased in a new ERA-Land-like reanalysis (referred to as **FRAMES ERA-Land**). The latter will be run using the new fire scheme and contrasted with the operational C3S ERA-Land products. FRAMES ERA-Land will use atmospheric forcings provided by ERA5, and the same configuration and general settings of the C3S ERA-Land production. Fields to be analysed and methodologies are defined in **WP4** and will include new parameters such as burned areas.
b) The enhanced IFS obtained after the main FRAMES concept has been implemented will be tested over an extended forecast range covering several months/seasons using interactive aerosols. The results will be contrasted with those using the classical set-up and configuration. These experiments will be run with the ECMWF's coupled Ensemble Prediction system including a set of re-forecasts (forecasts in the past) to perform calibration and bias correction. An adequate number of ensemble members will be used to allow for a statistically significant sample. Probabilistic scores will be calculated based on this ensemble. The most important atmospheric perturbations relevant at scales from weeks to several months (e.g. Madden-Julian Oscillation, MJO) will be analysed using the methodologies defined in **WP4.**

Case 4: FRAMES for CLMS

A potential future operational fire model built on FRAMES developments will pave the way to C3S to provide analysis and forecast products of biomass, burned areas and land surface albedo that could complement the satellite-based products of the Global Land service (CGLS), one of the CLMS elements. Furthermore, the satellite- and model-based datasets could be used synergistically in the future to routinely monitor the long-term changes of these essential climate variables. This requires building a framework system to compare the FRAMES-based biomass, burned areas and land surface albedo products with those made available from the CGLS. Such a framework will be tested using the FRAMES ERA-Land dataset created in Case 3a.

Case 5: FRAMES for ALL

This show case will highlight the intrinsic cross-cutting nature of FRAMES and the potential improvements brought by the FRAMES prototype to the targeted Copernicus services. For two/three fire events characterized by different level of predictability (e.g. Indonesian fire in 2015, Pedro Grande (Portugal) fire in 2016, Attica (Greece) fire in 2018), the predictive skills and the temporal/spatial consistency of the predictions provided by the targeted services using the FRAMES framework will be assessed and contrasted with those using the state-of-the-art systems. Comparisons will include but will not be limited to:

1. Long range forecasts with the FRAMES fire model to assess the limits of predictabilities for the various events and their impacts on the quality of the long-range forecast (C3S).

[30] https://www.wmo.int/pages/prog/arep/gaw/documents/Draft_GAW_235.pdf

2. Medium range forecasts with the FRAMES fire model to assess the quality of emission forecasts after 5 days and the prediction of fire danger and probability of ignitions compared to the standard fire danger metrics such as FWI (CEMS/CAMS).
3. Comparison of fire dynamical prediction with satellite-based products from CLMS.

All FRAMES' products will be made available through a web-portal that will be created and linked to the project web-site. The public availability of FRAMES products is envisaged for the last 3 months of the project. The exact details and characteristics of the show cases will be defined at the start of the project and presented in an Implementation Plan (D3.2).

Service evolution: The pragmatic approach employed here will allow the consortium to develop and implement the main pathways and missing links to provide a proof-of-concept of the FRAMES approach. A detailed analysis of future improvements that could be implemented on top of what has been proposed here will be produced in **WP3**. These developments are regarded as a required ***evolution*** of the current proposal that will take the level of integration of the fire processes in the relevant Copernicus Services from a proof-of-concept phase to an operationally-ready stage.

Suitability of the research approach: The proposed approach for the **WP3** show cases will make use of set-up and configurations as used by the corresponding services, and the same evaluation methods to ensure a swift transfer of the results and feedback to the Copernicus services.

Measures for Success of the Work Package/ KPIs:

- Delivery of show cases tailored to the relevant Copernicus service.

WP4: Prototype Verification, Validation, Impacts

Aim: **WP4** collects the activities related to the model and data validation and product verifications. It also defines the performance benchmarks based on the available observable truth, the state of the art assessment practices used in the operational services and studies of impacts. The complexity of the delivery chain in FRAMES that stems from research to innovation of new fire products to be linked to different sectors of the Copernicus system requires for a detailed and specific verifications linking methodology, model outputs and final products. The prototype verification will be performed at the level of each single component of the FRAMES system describing different phases of the investigated process. The methods described below provide the tools that will be used to assess the show cases defined in **WP3.**

Approach and methodology:

WP4 performs the overarching validation and verifications of all aspects of FRAMES, spanning model developments, quality assurance and service impact.

Conditions for fire ignition: The verification of the vegetation components included into the IFS and at the base of the fire model will be first validated against independent datasets (e.g. active fires and burned areas). At the same time, land properties, like the green mass available, will be evaluated (e.g. LAI, NDVI measurements). These aspects will be mostly linked to Show Cases 1 (FRAMES for CEMS), 3 (FRAMES for C3S), 4 (FRAMES for CLMS) and 5 (FRAMES for ALL).

Predicted fires: The evaluation of the FRAMES prototype capability to reproduce the observed burned area will provide a first qualitative assessment of the system. This verification has also impact in the feedback mechanism: when an area is burnt because of a fire, it becomes a potential source of new fires because the vegetation index is modified. A detailed verification of this aspect will be performed. Fire ignitions will be assessed using active fire measurements from remote sensing observations (e.g. FRP, hot spots). These aspects will be mostly linked to Show Cases 1 (FRAMES for CEMS), 3 (FRAMES for C3S), 4 (FRAMES for CLMS) and 5 (FRAMES for ALL).

Fire emissions: A relevant step is the validation of the injected burned material (both aerosol particles - mainly black carbon and organic matter -, and trace gases) into the atmosphere. The capability of FRAMES to predict and describe such emissions will be quantitatively assessed through detailed comparison with independent observations (e.g. ground-based, airborne and satellite borne measurements). An aspect that will need attention to assess the fire-based aerosol species is the aerosol speciation. This is because even in presence of an aerosol layer due to a forest fire, aerosol measurements could be "contaminated" by the presence of other aerosol species not directly related to fire emissions, e.g. the local background. The evaluation of the FRAMES aerosol products requires datasets of forest fire-related aerosol products. In recent years, single-species aerosol datasets and methods to subtract the background information have become available (e.g. Sayer et al., 2014). These

aspects will be considered when designing the verification procedure and documented in the corresponding WP deliverable. These assessments will be mostly relevant to Show Cases 2 (FRAMES for CAMS), 3a (FRAMES for C3S) and 5 (FRAMES for ALL).

Meteo impacts: The occurrence of wildfires impacts the Earth System evolution. On the one hand, emissions of biomass burning aerosols modify the atmospheric composition, affecting radiation and cloud formation; on the other hand, once the land surface is burnt, the surface characteristics, such as the albedo, change. These effects may last for days, weeks and years and should correctly be accounted for in numerical weather prediction. **WP4** will assess the dynamical impact of the links between the fire modules and the other components of the Earth System using long-range hindcast datasets and reanalysis as benchmarks. These activities will be linked to Show Cases 3 (FRAMES for C3S) and 5 (FRAMES for ALL).

Fires alerting system: FRAMES prototype will deliver fire-danger products to be potentially used by Civil Protection Agencies to forecast the occurrence of fires even during the activation phase. To evaluate the skill of the FRAMES approach compared to the one currently used, a set of fire events will be selected as example. The new products will be provided to selected users through a dedicated platform. The effectiveness of decision-making process based on the current and new set of products will be compared. These activities will be linked to Show Cases 1 (FRAMES for CEMS) and 5 (FRAMES for ALL).

Suitability of the research approach:

A two-way continuous exchange between WP4 and WP1-WP3 is anticipated to benefit from their respective expertise and allow the cross-disciplinary exchange of ideas and methodologies needed in model development and testing. The result is anticipated to benefit other research communities as data will be made available for studies of impact and predictability.

Measures for Success of the Work Package/ KPIs:

- Providing a comprehensive performance assessment of the "FRAMES for CEMS", "FRAMES for CAMS", "FRAMES for C3S", and "FRAMES for ALL" show cases.
- Providing a comprehensive evaluation of the FRAMES products versus the CLMS equivalent.

WP5 and WP6: Dissemination, Training, Project Management

Aim: Prompting a paradigm shift in the understanding and use of fire products across the Copernicus services, **WP5** will focus on training, support and dissemination activities. In addition, **WP5** will actively promote the dissemination and use of fire products and the exploitation of the model developments by the international community, as well as in training and education. **WP6** coordinates the project and ensures that its innovation actions, objectives and impacts will be delivered.

Approach and methodology: **WP5** will provide the public web portal where also the new FRAMES products will be made available at the end of the project, Confluence interactive development pages for remote working and exchange between partners, and the provision of a common software development and exchange platform suitable for rapid deployment and developments in a distributed environment. A particular focus of **WP5** is to ensure adequate training and dissemination of the novel concepts. Training of early-career scientists through use of novel concepts will foster community acceptance and showcase the benefit for further develop the concept of Earth-system model as opposite to atmospheric modelling.

The **WP6** management structures will coordinate and ensure to:

- set-up and maintain a structure, procedures and tools that will allow a coherent and efficient technical and administrative management of the project;
- keep the project on time and within the assigned budget;
- identify and manage risks and solve problems;
- identify opportunities for improved results and collaboration;
- coordinate the interactions between work packages and partners;
- provide and manage working procedures ensuring transparency within the team and for the EC;
- manage quality assurance.

Suitability of the research approach: The common software development platform based on Atlassian tools hosted at ECMWF has proven successful in many of the projects lead by ECMWF and especially CHE and will be

continued in this project. The additional benefit derives from the continued support and promotion of CHE outcomes together with the additional improvements in FRAMES in a common development environment. The early exposure of the novel development concepts based on FRAMES is crucial for domain scientists, data and product users.

Measures for Success of the Work Package/ KPIs:

- Successful provision of all relevant communication tools between project partners, stakeholders and the public.
- Successful interaction with domain-scientists and Copernicus data users in the form of dissemination and a discussion workshop and one placement program.

1.3.4 FRAMES gender dimension

Despite science, technology, engineering, maths and medicine (STEMM) subjects have a recognised large bias towards male scientists, FRAMES reverts this tendency right from the leadership layer with 50% of the project and Work-package leaders being women. All partners have working environments that welcome female candidates. Furthermore, BSC has been awarded the "Human Resources Excellence in Research" that identifies the institutions and organisations that act as providers and supporters of a stimulating and favourable working environment. Moreover, CNR has just join the GENERA programme – Gender Equality Network in the European Research Area. All partners are committed to the principles of the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers. Therefore, FRAMES will support researchers with children or other dependants, engagement with target audiences, and when designing information and services, it will be gender-neutral. European cultural richness is preserved involving a large number nationalities across public, and private sectors (10 Countries, 2 International organization and 2 SMEs).

1.4 Ambition

1.4.1 State-of-the-art

Figure 7 summarises the current state-of-the-art systems of fire modelling as a function of spatial and temporal scales. The three non-interlinked triangles highlight how different modelling approaches are used depending if fire is looked at (i.e. as a micro process, a regional or global scale phenomenon) and on which time scales (from hours to decades). Depending on the temporal and spatial scales they focus on, these models all require different inputs and produce only a limited set of information (e.g. heat released, fire behaviours and fire regimes). At very small spatial and temporal scales, the combustion process can be accurately described by a physical model, if fuel and oxygen are provided as input variables (initialization). Model of physical combustions can be used to understand the amount and type of particulate produced and how much heat is released during the burning. These models are at the foundation of the description of the burning process, however they are of limited use in an operational context when information such as, fire spread, fire sustainability and control efforts are the main information required. Thus, at the regional to global scale, the most relevant aspect is to be able to model the relationship between weather and fuel availability as this relationship is the one that ultimately controls fire behaviour and its sustainability on a larger scale.

Fire-atmosphere coupled models, which can predict fire behaviour, have been developed and applied to limited case studies[31]. These models consider environmental factors such as topography, wind conditions, and fuel characteristics, and describe the fire pattern with a set of numerical equations. However, the amount of information they require is often unavailable at global scale. This means that they are applied and tested only when a detailed post event knowledge of all environmental conditions become available. The difficulties of accessing global real-time observations of fuel amount and its dryness status to correctly initialise the prediction have led most of the semi-empirical models used in fire danger management to only consider weather conditions. These models only accounts for the weather danger that is conducive of fires while implicitly assuming a constant amount of fuel available everywhere on the globe. This is a crude approximation that neither allows to retain memory of the available fuel nor to link it with the danger of an ignition. These models are just initialised using the previous day conditions and have no information of the real-time fire activities (as it could be available from an on-line use of fire observations). Moreover, these models do not include ignition as a process. Climate simulations and studies on changing patterns in fire regimes are also possible. These mostly

[31] Coen J.L. et al, 2013 https://doi.org/10.1002/2013GL057868.

benefit from existing atmosphere-vegetation dynamical coupling in climate models. Still, ignition is a climatological input based on static maps of lightning density and past events. Additionally, climate models are used over years/decadal time-scale, thus they are neither able to support prompt responses (hours to days) nor able to support readiness and planning actions (days to months).

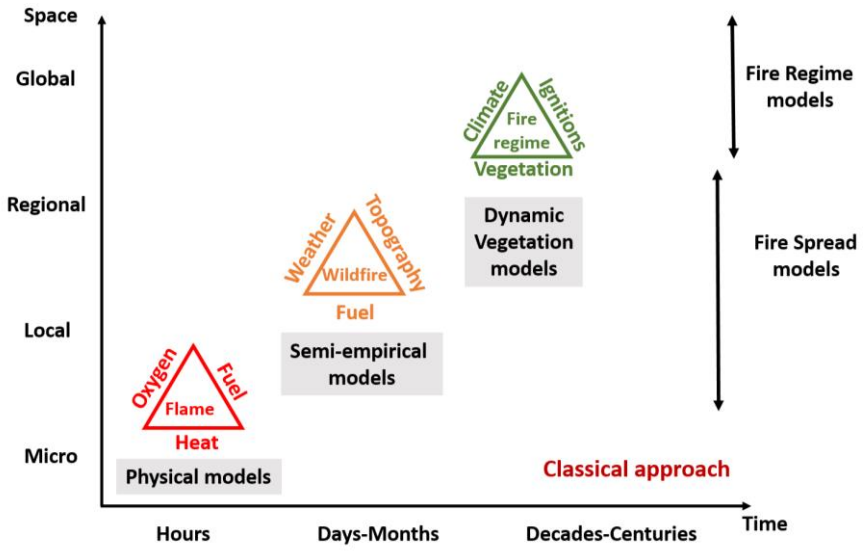


Figure 7: State-of-the-art approaches to model fires at different spatial and temporal scales[32].

All currently used approaches applied to fire modelling present important limitations as consequences of the missed links mentioned above and the poor exploitation of available observations. The state-of-the-art systems are also reflected in the operational applications that run as part of the Copernicus programme.

1.4.2 Going beyond the state-of-the-art

FRAMES creates a framework that works towards closing the gaps highlighted in Session 1.1 by considering fire as an Earth-system process. FRAMES achieves this goal by **using a holistic approach** and working its way up and linking the three modelling components highlighted in the previous section.

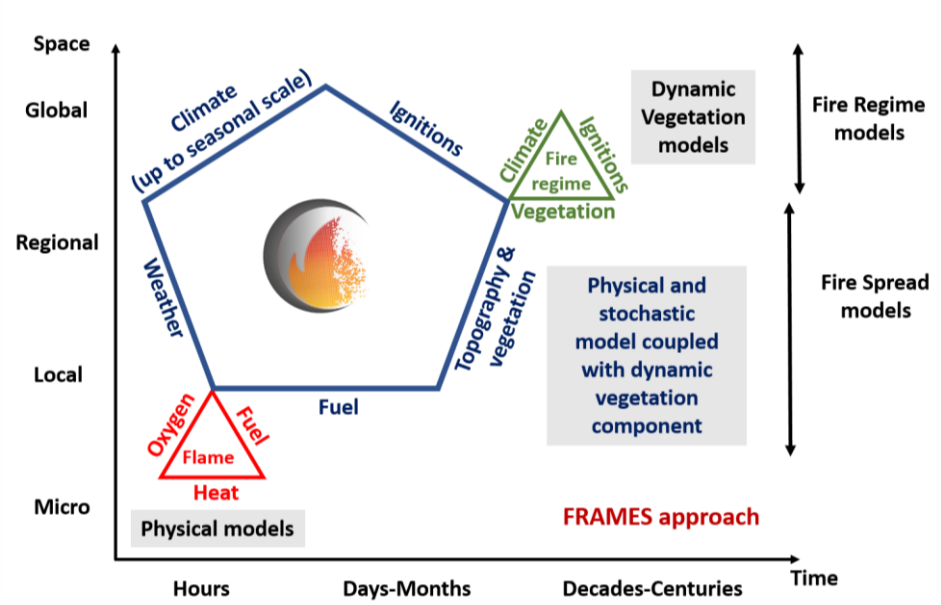


Figure 8: Approach proposed in FRAMES to model fires. The IFS versatility allows one to cover forecast scales ranging from day to months. The system is run globally at an operational spatial resolution of 9km at time of writing.

FRAMES will encompass most fire regimes from micro process (by linking in the IFS the combustion process to the vegetation status that will be achieved by allowing the modulation of the emission coefficients through the

[32] Figure adapted from figure 1 of Moritz, M.A., Morais, M.E., Summerell, L.A., Carlson, J.M., Doyle, J., 2005. Wildfires, complexity, and highly optimized tolerance. PNAS 102, 17912–17917.

Fire Emission Potential in WP1) to global scale phenomena over the seasonal time scale and beyond (through its dynamical fire evolution). Thus, FRAMES with its integrated approach will enhance both ends of the modelling chain by representing fire as a sub-grid scale process and coupling fire processes with all the other earth system components. The coupling between the vegetation, fuel availability and the stochastic probability of ignition will enable to translate the local information to the global level. These relationships and the strategies adopted to have a realistic initialisation of the vegetation status will provide the basis to create a fire dynamical model that will work at all temporal and spatial scales as graphically illustrated in Figure 8. The development of a dynamical fuel/fire model will also allow the exploitation of the available fire observations from remote sensing into an integrated modelling system.

Although FRAMES' approach is general and could enhance any model, a fundamental strength of this proposal is the use of the ECMWF IFS as the sole ESM in which all developments will be implemented. The IFS, a global NWP ensemble prediction system, is used as the backbone system for the CAMS global products, the CEMS/Fire products; the C3S climate reanalysis; one of the C3S seasonal forecasting systems; and the H2020 CHE project, precursor of a dedicated CO_2 monitoring service element that is anticipated to be created within the Copernicus Programme. **Also given the implicit stochasticity of the ignition process, the availability of the ensemble system provided by IFS is also fundamental to allow the probabilistic interpretation of the results.**

The scientific developments proposed within the given timeframe of three years will allow the consortium to develop the main pathways and links between the different components. The choice of focusing on one widely-used ESM maximizes the probability of a successful integration into the Copernicus services, and a smoother future transitions into their operational chains.

1.4.3 Innovation potential

Service innovation is one of the three pillars that constitute the FRAMES' concept. As such, the anticipated innovation that FRAMES will bring has been discussed in detail in section 1.3.1, and presented for each of the fire-relevant Copernicus services individually in Table 3. In here, we stress the **consistency that the holistic approach proposed by FRAMES will ensure**. The approach will ensure consistency between fire processes, land cover and vegetation classification, soil/canopy conditions and weather conditions. The latter are particularly important in case of extreme weather conditions conducive of fire-prone activities, such as droughts. The FRAMES' holistic approach will provide consistency between fire products at different temporal scales up to seasonal range and across all fire-relevant Copernicus services to support fire response and suppression, and readiness and fire prevention actions.

A set **of new and improved fire-related products** will also become available. These will offer the opportunity to spin-off new studies and research activities, and opportunities on aspects not yet fully explored and understood, and sectors with not obvious linkages to fire episodes and consequences. For instance, the impact of smoke and ash to air quality and human health is known, fire damages to homes and structures are broadcasted every time a new event occurs, and can be easily measured, impact on sectors like agriculture can also be quantified for fire-affected areas. However, what is the impact of ash in coastal areas? And on the marine life? What are the consequences for the fishery sector, and the quality of fish we eat?

FRAMES will focus on the research, development and integration of an innovative approach that has the potential to revolutionize future fire-related activities. To support the uptake of such an approach, it is recognised that special attention has to be paid on training and education of professionals. To this end and in addition to other activities, **FRAMES will promote a work placement that will help explore new professional venue for FRAMES products** thanks to the partnership with the Climate-KIC**.**

2 Impact

2.1 Expected impacts

FRAMES will impact European excellence by pushing our understanding of the Earth System mechanisms and increasing the quality of weather forecasts and climate products of the many sectors that relies on them as their main source of information. Wildfire is an essential part of the Earth system with natural fire cycles playing a vital role in local ecology, and the carbon and water cycles. Urban expansion into natural wildfire habitats, for example in parts of California, has significant economic impacts. Over the course of 2018, devastating wildfires in California in July and November burned 1.82 million acres, displaced more than 300,000 people, causing a record

$400 billion in damages and cost more than $1 billion for the California fire department to fight. In contrast, the US Forest Service spent $2.9 billion to fight fires across the country[33].

The economic costs of forest fires worldwide also increased significantly in 2018 to $24 billion against a 2000-2017 average of $7 billion. Similarly, the insured costs were $18 billion in 2018 against a 2000-2017 average of $2 billion. The economic and insured losses worldwide are comparable to those associated with winter weather[34]. More precise forecasts with uncertainty bounds in both time and space are critical for human activities and concerns sectors like travel/tourism, health, work, and safety. While there is no control about the fire-weather driving conditions, its impact on society through forecasting and preparation could be drastically reduced through advances in predictive skills that enable more timely decisions[35]. To this end, including fire processes in an operational context represents a top scientific challenge[36] to react to present disasters, and prepare for and mitigate their consequences in the future.

A new risk is the changing characteristics (frequency, location, severity) of weather and climate related hazards since natural climate variability is now exacerbated by long-term, human-induced climate changes. The increased socio-economic impact of fire-related disasters provided by changing climate forcings is very visible in recent mega-fire events. Another example is provided by the devastating 2015 fire season in Indonesia that was exacerbated by the use of fires as an agriculture clearing practice and the establishment of hot and dry conditions sustained by a strong El Niño-Southern Oscillation (ENSO)[37]. It began in August, and by September much of Sumatra, Kalimantan, Singapore, and parts of Malaysia and Thailand were covered in thick smoke, affecting the respiratory health of millions of people. Visibility was also reduced to less than 10% of normal over Borneo, and large parts of the region could not be seen from space. Greenhouse gas emissions from the burning (in CO equivalent) exceeded Japan's 2013 emissions from fossil fuel combustion[38]. Even after the worst of the 2015 Indonesian fires were no longer burning, the remaining pollution stretched halfway around the globe affecting people's health and the regional climate.

Investment in forecasting systems that provide reliable and timely warning is therefore critical. It is accepted[39] that future improvements in predictive skill for weather induced disasters will arise from an improved representation of more complex physical and chemical processes, from the coupling between atmosphere, land surface and oceans, cryosphere and biosphere, and from a better characterization of forecast uncertainty through ensembles and stochastic approaches. This is especially true for processes that have an inherent human component in it, such as fire ignition.

All these conceptual improvements are addressed in FRAMES starting from the inner layer of its programmatic core. Moreover, FRAMES takes on a new challenge **foreseeing the integration of socio-economic-based data related to population density and control measures into a purely weather and climate framework**, which is used for operational services.

The development of new paradigms, such as the one presented in FRAMES, is outside the realm of individual operational services and requires internationally coordinated research and funding, a need that is addressed by FRAMES's research focus and constellation of partners.

FRAMES will directly benefit the consortia representing the countries shown Figure 12, but most of all FRAMES will produce a strong direct impact on CAMS, C3S and CEMS as they rely on the IFS world-leading European modelling system for their applications.

2.1.1 Impacts listed in the work programme

The following table lists the anticipated impacts of FRAMES with respect to the specific topics outlined in the work programme.

Table 7: Anticipated impacts listed in the work programme

Enable Copernicus services to better serve cross-cutting applications on European scale;

[33] https://www.thebalance.com/wildfires-economic-impact-4160764 accessed on 05.02.2019
[34] [AON report; http://thoughtleadership.aonbenfield.com/Documents/20190122-ab-if-annual-weather-climate-report-2018.pdf).
[35] https://www.unisdr.org/files/46796_cop21weatherdisastersreport2015.pdf
[36] https://doi.org/10.1126/science.275.5299.502
[37] https://www.pnas.org/content/early/2016/07/27/1524888113
[38] https://journals.ametsoc.org/doi/pdf/10.1175/2016BAMSStateoftheClimate.1
[39] https://www.nature.com/articles/nature14956

ECMWF is the operator of the Copernicus Atmospheric Monitoring Service (CAMS) and the Copernicus Climate Change (C3S) by delegation agreement with the EC. The IFS model is used in the CAMS global monitoring and forecasting component, and for the C3S global climate reanalysis and the ECMWF contribution to the seasonal multi-model forecast production. IFS is also the atmosphere component in EC-Earth. Further, operational ECMWF model output supports the product chain established by the European Flood Awareness System (EFAS) and the European Forest Fire Information System (EFFIS) in the Copernicus Emergency Management Service (CEMS). The development of key components in the future IFS through FRAMES will thus benefit and strongly impact the user communities behind CAMS, and C3S as well as CEMS. Furthermore, the IFS is also at the core of a preparatory H2020 project, CO2 Human Emission (CHE) that has the potential to develop into an operational Copernicus service element for the monitoring of anthropogenic CO2. In addition, the enhanced IFS that would be developed within FRAMES could generate model-based products of some of the variables provided by the Copernicus Land Monitoring Service (CLMS) as satellite-based products.

Enhance European industry's potential to take advantage of emerging market opportunities and capacity to establish leadership in the field;

According to Morgan Stanley Capital International Emerging Market Index, which lists the 23 emerging markets, the two power houses are China and India. Together, these two countries are home to 40% of the world's labour force and population. In 2017, their combined economic output ($32.6 trillion) was greater than either the European Union ($20.9 trillion) or the United States ($19.4 trillion). Despite their economic output figures, these economies are characterised by high volatility due to three factors: natural disasters, external price shocks, and domestic policy instability. Developing countries and/or countries with economies that traditionally rely on agriculture are especially vulnerable to natural disasters like fires (for instance the Indonesian fire season of 2015 was particularly severe). Several reasons contribute to this vulnerability, for instance:

- people often live in areas characterized by high risks, and the risk of fires increases with the population size;
- building industry often uses poor quality or flammable materials (e.g. wood, straw, etc);
- building methods do not often use techniques that would make buildings more resilient to natural disasters, including fires;
- countries in emerging markets do not often benefit from early warning systems to prepare both the population and the authorities to cope with a natural disaster when the risk is high (i.e. **lack of medium to short-time readiness**);
- These countries also have limited access to resources and assets to cope with the consequences of those disasters in the immediate aftermath (i.e. **lack of resources for short-medium time crisis management**).
- They have limited or no long-term fire-related regulations for disaster prevention (e.g. **lack of long-term prevention planning**);

Thus, the availability of improved Copernicus data related to natural disasters brings clear opportunities for the exploitation of downstream services or the creation of new products that could benefits European economies. Several sectors could take advantage from the new datasets especially in emerging countries for instance:

→ **services related to early warning systems** down to local level monitoring – e.g. development of downscale services and applications to derive high resolution information (sub-kilometre) from global coarser resolution datasets;
→ **services to support environmental governance**;
→ **services related to forest management, policy and regulation**;
→ services and industries linked **to fire prevention and peatland restoration**;
→ services and industries linked **to fire prevention action at local level**;
→ **services providing training and municipality advice** to develop appropriate normative and good practices, e.g. services designing and supporting local, regional and national governments to adopt **new agriculture practices for land clearing** that do not rely on fires and services to monitor that those practices are correctly used, and that the local economies are based on sustainable and transparent methodologies (to ensure the above practices are followed);
→ **services analysing scenarios to improve product value chain governance**;
→ **emergency-related industries**, i.e. those providing e.g. food, clean water, cloths, medical supplies, mobile structures in support of affected populations could all benefit from the availability of new and better

datasets. This is because their **production chains could be modulated** based **on the probability of fire occurrence** or based on extreme weather conditions particularly those that are most conducive of fires;

→ **building industry to create/provide new fire-proof building products** to reconstruct houses and buildings; **or even to design fire-protective structures for plantations** (e.g. Venice is protected from the seasonal water level rising with a mobile mega-structure that is engaged when there is a significant risk for the lagoon water level of exceeding safe thresholds, similar structures could be built to protect vulnerable countries from fire occurrence);

→ **bio-engineering industry**, e.g. to "design" plants that grow and reach their full production stage faster than normal plants (to speed up vegetation recovery).

The above (not exhaustive) list and considerations suggest that accessing high quality data and information as those that could be provided by the FRAMES approach has the potential to offer a variety of opportunities for commercial developments in those emerging markets.

Reinforce the link with academic and scientific sector for scientific exploitation of Copernicus data;

FRAMES, as a Research and Innovation Action, clearly focuses on the earlier stages, namely "activities aiming to establish new knowledge and/or to explore the feasibility of a new or improved technology, product, process, service or solution[40]". Consequently, an important deliverable of FRAMES is **dissemination and training**, which will ensure the anticipated **paradigm shift in the way fire processes are treated and represented** on the Earth-system model design and applications. It is very important "to channel knowledge, creativity, and technology into innovative, internationally competitive products and services that respond to societal needs[41]". This remains particularly true for the activities related to the Copernicus services in Europe.

The multi-lateral engagement of cutting-edge developments in FRAMES is supported by the strong partnership between world leading global weather centres, universities and national research centres. Moreover, the number of letters of support (attached) indicate the significant interest around the project and the large potential FRAMES offers to the European community and the interest of the non-European, international community in supporting FRAMES. The outcomes of FRAMES will produce models with higher complexity than have ever been used before in an operational context. The FRAMES prototype will feed directly into the prediction systems of ECMWF and thus into the CAMS model core, the C3S global climate reanalyses and the ECMWF contribution to the C3S multi-model seasonal forecasting system, as well as the CEMS fire prediction capability. ECMWF's key role in these activities makes FRAMES an investment into the future of the Copernicus services and an effective vehicle of cross-benefits between programmes across Europe and beyond.

The FRAMES strategy also provides a template for the wider weather and climate prediction communities as the solution adopted and the innovative aspects will become part of the relevant bibliography accessible to the scientific community worldwide. Other projects and modelling groups will be able to build upon the advances made by FRAMES, which will strengthen the innovation capacity of Europe in modelling and data assimilation.

FRAMES will further contribute to the integration of new knowledge by training the next generation of scientists accordingly using the well-established ECMWF training courses and the placement programs organised by Climate -KIC. Selected young scientists will be offered the opportunity to participate in working visits at ECMWF, project meetings, workshops and general assemblies, present their results, prepare discussions and chair sessions. Involving early-career scientists in FRAMES will guarantee a safe transfer of knowledge and prepare the ground for ambitious projects in the future.

Boost competitiveness of the industrial actors in EU and national procurements;

Natural hazard prediction capability sits at the beginning of the socio-economic value and decision-making chain, with downstream beneficiaries in water, agriculture, food and energy resource management, disaster prevention and risk mitigation. Given the anticipated climate change effects and the increasing probability of global weather extremes with unprecedented effects on Europe, significantly enhancing prediction capabilities through the establishment of missing links are vital for European society. The emerging markets for adaptation technology at national and European level will inevitably benefit from these capabilities. Therefore, sustaining and advancing the existing Copernicus services to a level that it is fit for the upcoming decades where climate change impacts will fundamentally influence European economies is paramount for ensuring sufficient growth and competitiveness.

[40] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016-2017/annexes/h2020-wp1617-annex-ga_en.pdf

[41] European Commission's Director General Report on Research and Innovation, http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2012/innovation_union_progress_at_country_level_2013.pdf

2.1.2 Impacts not listed in the work programme

Improvements for the global model used in European Commission Copernicus services:
ECMWF is the operator of the Copernicus Atmospheric Monitoring Service (CAMS) and the Copernicus Climate Change (C3S) by delegation agreement with the EC. The IFS model is used in the CAMS global monitoring and forecasting component, and the ECMWF contribution to the C3S global reanalysis and seasonal forecast production. IFS is also the atmosphere component in EC-Earth. Further, operational ECMWF model output supports the product chain established by European Fire Forecasting Information Service (EFFIS) EC-Earth will participate in future Coupled Model Inter-comparison Projects (CMIP) that form the foundation of the assessments of the Intergovernmental Panel on Climate Change (IPCC). The CMIP climate projections also provide key input for C3S. The development of key components in the future IFS will thus benefit and strongly impact the user communities spanned by both CAMS and C3S as well as EFFIS.
Impact on other relevant international research
The most relevant international research programmes supporting weather and climate prediction are WWRP and WCRP, which are administered by WMO. WWRP aims to advance society's ability to cope with high impact weather through research focused on improving the accuracy, lead time and utilization of weather prediction while the WCRP mission is to facilitate analysis and prediction of Earth-system variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society. The recently published WWRP strategy includes fires and its long-term prediction as one of the achievable goals given the advances in numerical weather predictions. Similarly, the need for an integration of process was highlighted among the five key themes considered central to the developments of future research strategy identified in the WCRP summit in October 2017.
Long term sustainability of FRAMES developments
FRAMES is designed to enhance the capabilities of the Copernicus services by working on its operational core. The challenges of having to define solutions fit for an operational environment from the very early stage of FRAMES brings the inherent added benefit of their long-term sustainability both technical and financial. Any new feature in the IFS code which brings measurable improvements to ECMWF product will be up taken by ECMWF itself and its user minimising the risk of a waste of resources.

2.1.3 Barriers, obstacles and other conditions with relevance to the impact

Integration of a new modelling process in the weather and climate prediction provides invaluable societal and economic benefits and a step forward towards the development of the next-generation forecasting systems. Considering the innovative aspects of this undertaking, the success of FRAMES will crucially depend on the ability of the consortium to build innovative solutions that could be fit for an operational up-take. The innovative aspects of this proposal require a broad engagement of operational services, academia and cutting-edge research supported by the EC.

FRAMES is the first concerted effort to address this challenge in the operational weather community at European level. To-date, projects like the Global and regional Earth-system Monitoring using Satellite and in-situ data (GEMS) and more recently the CO_2 Human Emission (CHE) have showcased an incremental approach and a longer-term commitment to provide a sustained return for the European society.

2.2 Measures to maximise impact

To maximise the impact of the project results, we have chosen a combination of measures for: **Dissemination**, **Communication, Training and Exploitation**. These activities will involve **all consortium partners** and their respective staff, including researchers.

- A **Dissemination and Communication strategy** will be fully developed in the early stage of the project (**WP5**). Focus on dissemination and communication activities in all work packages ensures that the full impact of the project is achieved. An online platform - an integral part of the plan - will be complemented with a comprehensive programme of offline activities, training, and dissemination activities to ensure the **maximum engagement with public and private sector** representatives of a full range of users and uses both within the scientific community and beyond this, in a wider European context. **Communication** foresees **a number of**

tools for the implementation of our strategy. **Suitably framed messages delivered through suitable dissemination tools** will help us publicize our work in such a way that the consortium will profit and help us to generate interest in the project and its outcomes; encourage scientists to join our partner institutes, companies and activities, draw the attention of national and regional governments and other public and private funding sources to the needs of long-sustainability of our researches and innovation plans. We have planned to tailor our messages for a full range of potential users and uses: for each audience, we will work on a distinct strategy using targeted messages, means and language, working at the right level according to the identified needs.

- **Exploitation (WP6)** will involve the development of suitable exploitation routes within **WP6** combined with a pro-active innovation management approach. The exploitation plan will be developed early in the project (**M12**) with the aim to inform the further development in terms of focus, also informed through the community interaction. The exploitation plan will be revisited towards the end of the project to identify and refine the activities to be implemented beyond the lifetime of the project.

Table 8: Overview of strategic plans for dissemination, exploitation, communication

	Plan for Dissemination and Communication	**Project Portal and Software Collaboration Platform**	**Exploitation Plan**
Objective	Enable and facilitate implementation of FRAMES prototype products	Provide metrics, data and software to facilitate numerical experimentation in off-line mode, i.e. outside IFS and on-line mode, i.e. coupled with IFS	Enable long-term sustainability and uptake of FRAMES' results as will create a platform that can be used for development
Target audiences	**Dissemination:** - FRAMES project partners - EC-Earth community - Open IFS community - CHE project - CAMS - C3S - CEMS - Scientific Community - EC (as a multiplier) **Communication:** - General public - Scientific community - WMO programmes - EC (as a multiplier)	FRAMES project partners Copernicus Services	- FRAMES project partners - CAMS - CEMS - C3S - CHE - ARISTOTLE-2 project - WMO programmes
Instruments	FRAMES website FRAMES reports FRAMES Wiki FRAMES workshop Training events, placement programs Scientific publications	FRAMES website FRAMES software collaboration platform FRAMES suites, data	FRAMES website FRAMES software collaboration platform
Access	Public	2-tier (project, public)	2-tier (project, public)
Responsibility	WP5	WP5	WP6

Since FRAMES develops novel enhanced products for fire emissions and danger forecasting, the communication, dissemination and output management activities will be shared by ECMWF and Climate-KIC, representing the numerical developer and application communities, respectively. Additionally, we can count on institutions with **in-house capacity** for science communication within the consortium.

2.2.1 Dissemination and exploitation of results

Scientific and technical results of FRAMES will be made available to the public and disseminated regularly through project reports and technical documentation, publications in the scientific literature and conference proceedings, and most importantly publications on the project website. Engagement with the university and

education sector will be crucial both for promoting the work of FRAMES and for FRAMES to benefit from scientific and technical developments taking place outside the consortium. Dissemination, output management and exploitation will use a set of key instruments. These instruments support a dialogue rather than a unilateral distribution of information. Within the project, the interplay between development and application with strong involvement from the industrial partners will be crucial.

- ***FRAMES community portal***: A dedicated portal will be implemented comprising public and project compartments. The public compartment will represent a showcase for information on key results and demonstration projects produced by FRAMES. The Plan for Dissemination and Communication (**D5.1**) will define milestones for public dissemination. The public site will also include a blog-function allowing external users to communicate with the team. The project compartment will provide limited access for project partners as well as the EC, and direct access to all material generated during the project as well as quick looks at the project status. The project site will also include an online exchange function to track the communication between partners on global project topics. Further, a project Wiki will be established as the central documentation tool. Further, a branch maintained by students will be established to link to classes, relevant course material, and training events organized in the framework of FRAMES, to be integrated in the established ECMWF training courses[42].
- ***Dissemination workshops***: ECMWF has established a strong engagement with its member states in the fields of meteorological applications in the latest years with a strong partnership in both feasibility projects (e.g. ARISTOTLE-2) and services (e.g. CEMS-Fire). An annual user seminar is run at ECMWF with the objective of assisting Member States and Cooperating States in advanced training on the operational aspects of the ECMWF forecasting system and its products designed for specific applications such as the one planned in FRAMES. FRAMES activities will feature prominently in these workshops through separate sessions (dissemination workshop). The working groups represent a forum for interaction between the FRAMES team and the community.
- ***Training courses***: The training effort in FRAMES will be organized around the already existing infrastructure of ECMWF training course that provides centralized European facilities to the community. The program concerning Parametrization of sub-grid physical processes and Data assimilation will be extended by modules concerning FRAMES advancements (**WP1, WP2**).
- ***Placement program:*** To explore the potential into new products and new markets provided by the new prototype, FRAMES will reach into the Climate-KIC's professional mobility programme Pioneers into Practice. The Pioneers programme consists of a 4 to 6-week placement (domestic or international), bespoke transitions thinking & systems innovation mentoring delivered through a structured workshop programme and online training.
- ***Committees***: The representation of ECMWF and project partners in international committees will be used as a channel for disseminating FRAMES results and output in the weather and climate prediction communities (mostly through WMO programmes, European Geophysical Union and European Meteorological Society). ECMWF and its partners are strongly represented in these communities. This ensures an efficient push-through of the FRAMES outcome to the relevant target groups.

Dissemination and exploitation within FRAMES*:* This will be managed in **WP5** and **WP6**. The central platform will be the FRAMES project website and its interactive facilities for the exchange of information, software and data. Repositories for project documentation (plans, progress tracking, reports, financial information), scientific outcome (papers, reports, documentation, conference proceedings), data (sample input and output), and general Wiki-type interactive tools will be established. Exchange forums for discussion between partners will be linked to the respective repositories.

WP5 will establish a technical and scientific collaboration platform comprising a source code repository and a bug tracking system to facilitate distributed software development. The planned workflow model for software development collaboration is illustrated in Figure 9. The central web-platform, collaboration tools such as the wiki, and the collaboration platform on software development will be maintained by ECMWF.

[42] https://www.ecmwf.int/en/learning/training

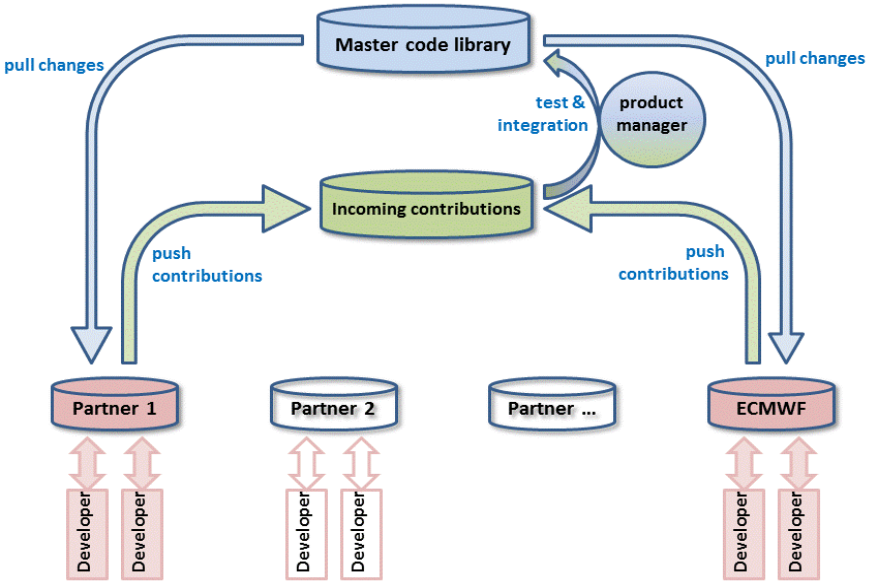


Figure 9: Project collaboration platform on software development.

Dissemination and exploitation beyond FRAMES: The products of FRAMES will comprise reports, scientific publications, graphical displays and datasets. Reports will be viewable and downloadable from the public pages of the central FRAMES website. Graphical products will be publicly viewable either directly from the central website or from partner websites to which users will be directed from the central site. Many of the pages served by partners will be given look-and-feel similar to that of those served by the central site. The central site will be hosted by ECMWF to ensure that the site benefits from the resilience built into the ECMWF web system.

A shortened version of the project plan suitable for a more general readership will be prepared based on the contractual Description of Action that, in turn, will be based on this proposal document. It will be made publicly available on the project website. The regular project reports will include accessible, self-contained summaries of progress, and these too will be made available as separate publicly available documents on the website. A 'news' item on the project website will draw attention to recent results and their potential impact on stakeholders.

Data/software policy and management of intellectual property rights (IPR): A key objective of publicly-funded research is that it should lead to the exploitation of results, which goes one step further than the mere production and dissemination of new scientific knowledge. Innovation is understood as any activity aiming to promote not only the dissemination, but crucially the subsequent exploitation of the results of the research and development projects. The strategic use and management of Intellectual Property (IP) in international research initiatives and in business is essential for strengthening the European scientific and technological base, boosting innovation and ensuring growth in the EU. In this context, our consortium is aware that Horizon 2020 places much emphasis on systematic Intellectual Property exploitation strategies as means to better protect innovation initiatives, and to reap commercial and economic benefits from EU-funded research.

- **Open access to peer-reviewed scientific publications**: Open access will be granted to all scientific publications resulting from FRAMES with a combination of golden and green open access. We will make use of institutional and topic repositories for making our publications available. FRAMES scientists, as EC grant recipients, will make their best efforts to ensure that electronic copies of **peer-reviewed scientific publications** become freely available to anyone as soon as possible and in all cases no later than six months after publication.
- **Open access to software and tools**: Following the developments in FRAMES and their implementation in the operational IFS, it is foreseen that results will also be made available via the OpenIFS license. This licence is limited in time, only permits non-commercial research use, and limits redistribution. The OpenIFS software licence also regulates that any further developments on OpenIFS regulated software may be commercially exploited by ECMWF or its member states in future. The OpenIFS software license has been drafted in agreement with the ECMWF Member States. These software elements are already subject to multiple ownership rights in several instances and thus sufficient experience exists within the consortium to resolve any issues that might arise.

- **Open access to data**: FRAMES prototype data will be made available. A Data Management Plan will be developed early on the project to outline what data will be made available and how. Data will be available in in the ECMWF meteorological archive (MARS), which can be interfaced to both the C3S Climate Data Store (CDS) and the CAMS Atmosphere Data Store (ADS) through adaptors.

The procedures above will be monitored by the Project Office. This will ensure coordination and standardization through a code exchange inventory and licensing register. The code management will monitor the availability of software to all project partners and ensure that formats and documentation are in line with the established guidelines. The code management protocol will be established at the kick-off General Assembly and will include representatives from each work package. It will collect and maintain the required code documentation. All partners will share the knowledge and methodologies developed within the project for achieving the expected results during the project. IPR protection will be addressed in the Consortium Agreement with a strong emphasis on open access data policies.

Dissemination measures *in the closing phase* of the project: The final report of the project (**D6.3**) will include a plan for the use and dissemination of foreground, to demonstrate the added value and positive impact of the project on the European Union. A final publishable summary of the results will be made available to the EC for dissemination in the public domain. This will include information on expected results, and their wider societal implications. The text will be drafted in a way to be understandable for a lay audience. A final project booklet collecting all project publications will be produced at the end of the project. The booklet will be made available for download on the website.

Dissemination measures *after the closure* of the project: After the official end of the project, the foreground of the project will be available as a web-based archive for all interested actors. The domain name of the project website will be assigned to ECMWF. The website archives all documentation related to the project, including publications, and will be accessible for 5 years after the end of the project.

2.2.2 Communication activities

Defining the target audience is important to produce impact outside FRAMES. The following audiences have been identified:

- The first audience are the scientific project users, who are potentially direct beneficiaries of the project and are represented for instance by other weather centres inside and outside Europe.
- The second category comprises the potential Copernicus downstream users and the Copernicus Services themselves. These are organisations that can benefit from using the outputs that FRAMES will develop. Examples of this are the several sectors that have commercial interest in fire and related effect prediction customer requirements.
- The third audience contains more general stakeholders such as ECMWF member states, academia, international committees, and the general public. The online platform and the social media managed by **WP5** will provide the tools to build and maintain an engaged community around the project.
- The general public, a wider audience with a non-scientific background.

The communication with these target audiences will be managed as shown in Table 9.

Table 9: Overview of FRAMES communication target groups and tools (this list is not exhaustive).

Target audience	Communication	Responsibility
Scientific project users	- Peer-reviewed scientific papers (Geophys. Research Letters, Bull. Amer. Meteor. Soc.) - Project workshop, conferences (ECMWF) - Copernicus communication events - FRAMES portal - Link with related H2020 activities (e.g. CHE)	All partners
Potential downstream Copernicus users and Copernicus Services	- Targeted publication material - Presence at inter-disciplinary conferences (AGU, EGU, AMS) - Participation in advisory boards (e.g. WMO) - FRAMES website - Link with related H2020 activities (CHE)	ECMWF.IPMA

ECMWF Member States, International committees	- ECMWF committee documents - Strategy papers, white papers - FRAMES website	ECMWF
General public	- General information material - Demonstration examples - FRAMES website	All partners

3 Implementation

3.1 Work plan — Work packages, deliverables

3.1.1 Overall Work Plan and Structure

The work plan builds on the interaction between the different work packages by further extending and applying the concept of fire across multiple services and underpinning these developments. Existing and novel mathematical and algorithmic developments are foreseen in **WP1** to provide the modelling foundations for fire processes. Initialization and assimilation strategies for the new fire, vegetation and emissions variables are defined in **WP2.** The definition of the new and improved products to be released by FRAMES across the Copernicus services is defined in **WP3**, where show cases are defined to help the full exploitation of the FRAMES potential. A broad and comprehensive strategy for validation (**WP4**) will insure the full assessment of the FRAMES outcome, at every level. Results and FRAMES outcomes are disseminated to selected parties identified in the show cases and through outreach and training activities (**WP5**). Finally, appropriate project planning and management is ensured (**WP6**).

The PERT diagram for the FRAMES project is shown below in Figure 10.

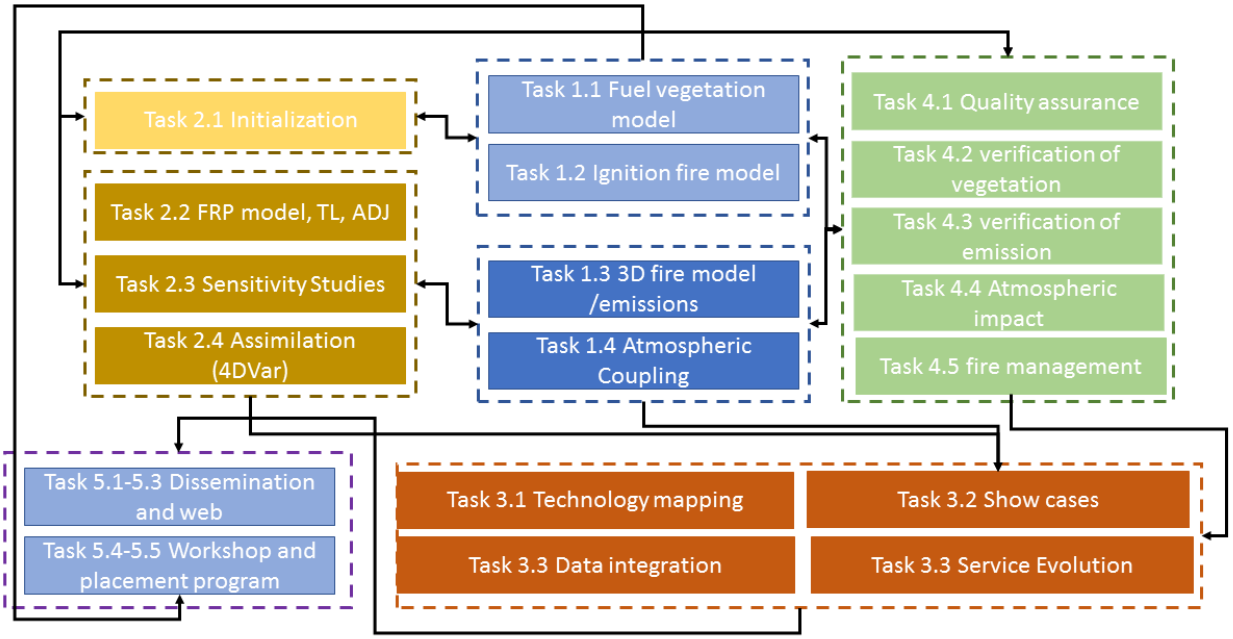


Figure 10: FRAMES PERT Diagram

3.1.2 Timing of the Work packages

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36
WP1 Service Innovation: Model Developments																																				
Task 1.1 Land cover and vegetation /fuel developments																																				
Task 1.2 Definition and implementation of the fire model																																				
Task 1.3 Coupling with the atmosphere: Fire emissions and injection height																																				
Task 1.4 Fire emission interaction with radiation																																				
WP1 Deliverables						1.1												1.2						1.3						1.4						
WP2 Service Innovation: Data Assimilation, Initialisation, and Parameter Sensitivity Analysis																																				
Task 2.1 Surface process initialization																																				
Task 2.2 Development of an observation operator for fire radiative power																																				
Task 2.3 Sensitivity Analysis																																				
Task 2.4 Assimilation FRP + CO																																				
WP2 Deliverables												2.1						2.2								2.3							2.4			
WP3 Service Integration and Evolution																																				
Task 3.1 Technology mapping analysis																																				
Task 3.2 Show cases																																				
Task 3.3 Data integration																																				
Task 3.4 Service evolution																																				
WP3 Deliverables						3.1			3.2											3.3													3.4			3.5
WP4 Prototype Validation and Impacts																																				
Task 4.1 Quality assurance and verification																																				
Task 4.2 Evaluation of fire and vegetation model components																																				
Task 4.3 Evaluation of biomass burning aerosols and trace g ases																																				
Task 4.4 Evaluation of the meteorological impact and forecast skill																																				
Task 4.5 Evaluation of fire danger products																																				
WP4 Deliverables									4.1											4.2							4.3							4.4			4.5
WP5 Communication, Dissemination and Outreach																																				
Task 5.1 Dissemination and Communication																																				
Task 5.2 Gender Balance																																				
Task 5.3 Website and Infrastructure																																				
Task 5.4 Fellowships																																				
T5.5 Outreach and Liaison																																				
WP5 Deliverables		5.1		5.2		5.4												5.5																		5.6
				5.3																																5.7
WP6 Coordination and Project Management																																				
Task 6.1 Project Management and Coordination																																				
Task 6.2 Risk and Quality Management																																				
Task 6.3 Administrative and Financial Management																																				
Task 6.4 Exploitation, Innovation and IPR management																																				
WP6 Deliverables		6.1				6.4						6.2																								6.3
Project Milestones				M1								M2								M3							M4							M5			M6

3.1.3 List of work packages

Work package No	Work Package Title	Lead Participant No	Lead Participant Short Name	Person-Months	Start Month	End month
WP1	Service Innovation: Model Developments	02	FC.ID	78	1	30
WP2	Service Innovation: Data Assimilation, Initialisation, and Parameter Sensitivity Analysis	01	ECMWF	48	1	33
WP3	Service Integration and Evolution	01	ECMWF	67	1	36
WP4	Prototype Validation and Impacts	04	IPMA	72	1	36
WP5	Communication, Dissemination and Outreach	01	ECMWF	26	1	36
WP6	Coordination and Project Management	01	ECMWF	23	1	36
			Total	314		

3.1.4 Work Package descriptions

Work package number	1		**Lead beneficiary**							FC.ID			
Work package title	Service Innovation: Model Developments												
Participant number	1	2	3	4	5	6	7	8	9	10	11	12	
Short name of participant	ECMWF	FC.ID	KNMI	IMPA	CNR	NOA	FMI	ASI	SRS	KIC	MF	BSC	**TOTAL**
Person months/ participant:	20	18	18	0	0	0	20	0	2	0	0	0	**78**
Start month	1						**End month**			30			

Objectives

WP1 is related to **FRAMES key objectives no. 1, 2 and 4**, and to **WP2**, **WP3** and **WP4**. The overarching aim of **WP1** is to implement all the modelling aspects foreseen in FRAMES. This is achieved by:

1. Improving the land and vegetation model;
2. designing and implementing fire modules for ignition, fuel consumption and fire extinction;
3. implementing a dedicated module for the calculation of fire emissions and of their injection height;
4. establishing the appropriate links between fire processes and the radiation scheme.

Description of Work

WP1 is led by **FC.ID** (Emanuel Dutra) and co-led by **FMI** (Mikhail Sofiev) and **KNMI** (Vincent Huijnen)

Task 1.1 Land cover and vegetation developments (Lead: FC.ID, Partners: ECMWF)

This task covers the developments associated with land-surface processes required for the definition of the Fire Emission Potential (FEP) and the feedbacks of fire process on surface characteristics (e.g. dynamical albedo). The FEP will require information regarding fuel moisture content, and biomass load as well as meteorological conditions. During an active fire, the burning area will lead to changes in biomass

load, which could lead to the fire extinction once all the available biomass is consumed. The burned area fraction, and the burning area will then be updated during an active fire while the vegetated fraction will be diagnosed. A vegetation recovery scheme will be implemented. The burned area fraction will be a key indicator for validation purposes but also to allow feedback into vegetation cover and surface albedo.

Within the FRAMES project, the developments on the land component will rely on static biomass load estimates based on land cover, and on vegetation recovery time-scales also depending on land cover. Including feedbacks from the burned area in the land surface characteristics, namely vegetation fraction and surface albedo, and allowing for a time varying biomass evolution and recovery are acknowledged to be important aspects to implement for an operational uptake, but not achievable within the timeframe of the current proof-of-concept.

Offline simulations (or surface simulations) with the land-surface model forced by ERA5 reanalysis near-surface meteorology will be performed to provide early validation data for data assimilation in **WP2**, validation activities in **WP4** as well as to provide consistent land-surface initial conditions to the coupled model. The activities to be performed in this task are as follows:

- Update of vegetation and land cover characteristics used by the ECMWF surface model. This will include the processing and adaptation of the annual ESA CCI land cover dataset to the specific land cover types used by ECMWF. This will allow to account for land cover and land use changes over time.
- Definition of biomass load depending on land cover;
- Calculation of fuel moisture content as a diagnostic variable based on biomass load and surface soil moisture evolution
- Calculation of the Fire Emission Potential based on the above developments, and current weather conditions (e.g. air temperature, humidity, wind-speed, following a similar approach to that of the FWI);
- Implementation of biomass recovery after a fire event based on land-cover dependent recovery time-scales;
- Perform surface simulations including part and all of the above developments for early validation, data assimilation and coupled initialization;

Task 1.2 Definition and implementation of the fire model (Lead: ECMWF, Partners: FC.ID/FMI)

In this task, a mathematical formulation for the fire modules will be derived and implemented in the IFS. The model will be composed of two main modules as follows:

- a stochastic fire ignition model, and
- a fuel consumption parameterization.

Both components are based on the definition of a variable describing the **fire emission potential** (FEP), computed in T1.1 as a function of the fuel load and the fuel moisture content, and quantified in terms of kg of dry matter per unit area available for combustion).

The **stochastic fire ignition model** will be built around a probabilistic formulation where at every time step and grid point the probability of ignition ($\mathbf{P_i}$) is calculated as the combined probability of:

1. **Lightning ($\mathbf{P_l}$)**: the probability of fire ignition due to lightning depends on the occurrence of cloud-to-ground flashes. In its current version implemented in the operational IFS in June 2018, the IFS lightning parameterization[43] can diagnose total (i.e. cloud-to-ground plus cloud-to-cloud) lightning flash densities from convection-related predictors coming from the forecast model, namely the convective available potential energy (CAPE), the contents in convective hydrometeors and convective cloud-base height. Thus, a first development step will be to split the existing parameterization output into its cloud-to-ground and cloud-to-cloud components. A validation of the resulting cloud-to-cloud flash densities should be possible using observations from

[43] Lopez, P., 2016: A Lightning Parameterization for the ECMWF Integrated Forecasting System. Mon. Wea. Rev., 144, 3057–3075, https://doi.org/10.1175/MWR-D-16-0026.1

continental-scale networks of ground-based lightning sensors. The probability of ignition will be expressed as a function of the cloud-to-ground lightning flash density predicted by the model.

2. **Human factors (P_h):** Using static maps of population density and a gravity model based on the road system and the distance of the urban centres from the forested area, we will derive a static layer for P_h which for the initial implementation will be used as a climatology over the period under study.
3. **Fire control factors (P_c):** The higher fire control actions, the lower the probability of fires. In some countries measure are in place to control and extinguish fires. These too need to be parameterised as climatological maps to compute the probability of fire extinction by human control. A gravity model approach based on available fire control data will be employed.
4. **Fuel emission potential (P_{FEP}):** This is the most variable component as it depends on the weather and vegetation conditions. As a first approach, P_{FEP} will be derived from FEP using a diagnostic approach only depending on a $FEP_{critical}$ critical value determined as a function of the vegetation type.

For each i-th grid cell with a probability of ignition $\mathbf{P_i}$, ignition will take place when a random number uniformly distributed between [0,1], *r*, will be larger than the ignition probability ($r > \mathbf{P_i}$).

Once a fire is triggered, it will be treated as a sub-grid scale process with the definition of a "fire fractional coverage" (FFC) per grid box that will depend on FEP because the drier the fuel, the faster the fire will spread and the fuel will burn. By linking FFC to FEP, one can retain memory of the total amount of fuel available at every time step and ensure that a box will not burn beyond its potential. Fire activity will decrease as a function of weather conditions. When FEP decreases to zero the fire ceases unless it has already been extinguished, e.g. by changed weather conditions (**extinguish scheme**). **Considering the stochasticity of fire ignition, the use of an ensemble forecast system as provided by the ECMWF model is essential. Every ensemble members will have different ignitions according to their unique weather conditions.** The combined use of the ignition spots from the ensemble prediction system will effectively provide maps of ignition probability (or flammability) that could be compared to more classical flammability measurements such as the fine fuel moisture content (FFMC) of the FWI.

Task 1.3 Fire emissions and injection height (Lead: FMI, Partners: KNMI/ECMWF/SRS)

This task aims at calculating the fire emissions obtained from the fire-related processes developed in T1.2. This requires the following developments and steps:

- interpretation of the FEP rate of change in terms of *burned dry matter* and its evolution in time, which is determined by the ignition, spread, and extinction processes.
- Correlate the burned dry matter to FRP. This step is required to obtain the model equivalent of the observations that will be assimilated in the data assimilation system (**WP2**) and to allow the product verification.
- Map the land-use classes defined in GFAS to those available in the IFS land model.
- Introduce baseline emission factors for the considered land use classes that relate the burned dry matter to different species and trace gas emissions.
- Introduce a model for injection height (e.g. IS4FIRES[24] as a function of FRP and the local meteorological conditions.
- Couple the fire emissions to the trace gases and aerosol prognostic fields.
- Introduce exploratory simplified NO_2 model exploiting full chemistry available in CAMS.

Two aspects will require attention prior the development of the injection height model as they could lead to inconsistencies whose impact on the injection height output will need to be evaluate (e.g. against independent observations from instruments like MISR and CALIOP). Based on that evaluation, harmonization / adaptation measures will need to be determined. The two aspects are:

1. inconsistencies in the grid resolution: that required by an injection height model is only limited by the satellite pixel size (i.e. 0.3 km - 3 km) while that of the IFS is at best about 9 km as used for the ECMWF weather forecasting, and about 40 km in the configuration used by CAMS;

2. inconsistencies in the definition of the boundary layer height: the one defined in the IS4FIRES model follows[44] and differs from the one available in the IFS.

Including a dynamical injection height model, which depends on the fractional high vegetation versus low vegetation, and weather dependent emission factors are interesting further developments, but are not achievable within the timeframe of the current proof-of-concept.

Task 1.4 Fire emission interaction with radiation (Lead: ECMWF, Partners: SRS/KNMI)

This task aims at coupling the fire-related variables to the other components of the Earth system by accounting for the direct radiative effect of the prognostic fire-induced aerosols, instead of using climatological values. In contrast, the other aerosol species will still be accounted in the radiation scheme as provided by the climatological distributions, as they are not part of the prognostic variables of the Earth system because that would be too computationally costly. This will involve accounting for both prognostic and climatological aerosols in the IFS radiation scheme while currently this scheme is able only to use either fully prognostic or full climatological aerosol input.

Assessing the indirect effects associated with the interaction of aerosols with clouds, although interesting, cannot be achieved within the timeframe of this project and is considered an important future development.

Deliverables

D1.1 Detailed design of the modelling implementations (ECMWF, R, PU, M6): The report will describe the strategy and connections between the various modelling components. Identifying the initialization strategy and indication on the verification

D1.2 Description of the new vegetation scheme with revised land cover and static fuel load (FC.ID, Report, PU, M18): The report will describe the implementation of the new vegetation scheme which accounts for new variables relevant for fire processes

D1.3 Description of the fire model components including ignition and emissions (ECMWF, R, PU, M24): The report will describe the fire model and its interaction with the atmosphere in terms of emissions and injection height

D1.4 Description of interaction processes between the biomass burning aerosols and the radiation scheme (ECMWF, R, PU, M30): The report will describe the interaction between the evolving aerosols and the radiation scheme.

Partner Roles	
ECMWF	Contributor to T1.1, and T1.3; T1.2 and T1.4 task leader
FC.ID	WP leader, T1.1 task leader and contributor to T1.2
KNMI	WP leader and contributor to T1.3, and T1.4
FMI	WP leader, and T1.2 task leader
SRS	Contributor to T1.4

WP Dependencies	
WP2	WP1 develops the model infrastructure required by the data assimilation system
WP3	WP1 develops the model infrastructure tested and integrated into the showcases in WP3
WP4	WP1 develops the model infrastructure verified in WP4
WP5	The model developments of WP1 will be promoted to the wider scientific community.

[44] Sofiev M., SILAM Team (2010) Aerosol Species in the Air Quality Forecasting System of FMI: Possibilities for Coupling with NWP Models. In: Baklanov A., Alexander M., Sokhi R. (eds) Integrated Systems of Meso-Meteorological and Chemical Transport Models. Springer, Berlin, Heidelberg. https://link.springer.com/chapter/10.1007/978-3-642-13980-2_15

Work package number	2		Lead beneficiary						ECMWF				
Work package title	Service innovation: data assimilation, initialization, and parameter sensitivity analysis												
Participant number	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
Short name of participant	ECMWF	FC.ID	KNMI	IMPA	CNR	NOA	FMI	ASI	SRS	KIC	MF	BSC	
Person months/ participant:	20	5	0	5	2	2	0	5	9	0	0	0	48
Start month	1						End month			33			

Objectives

WP2 is related to FRAMES key objectives no. **1, 2 and 4**, and to **WP1**, **WP3** and **WP4**.

WP2 aims to:

1. Create a consistent approach to initialize vegetation and fire-related variables which are part of the WP1 developments (i.e. burning area, burned areas, fuel moisture content and biomass load).
2. Perform a sensitivity analyses and identify which parameters of the vegetation/fire model are likely to have the largest impact in the FRP calculations.
3. Develop an assimilation framework for fire-related observations suitable to exploit the ECMWF 4D-Var architecture already in place. This will imply the development of forward, tangent linear and adjoint operators to estimate fire/vegetation parameters and tracer concentrations.
4. Test the developments of point 3 using the Fire Radiative Power and CO measurements available from various observing platforms.

Description of Work

WP2 is led by ECMWF (Angela Benedetti) and co-led by SRS (Samuel Rémy)

Task 2.1 Surface process initialization (Lead: FC.ID, Partners: ECMWF/IPMA/CNR/NOA)

This task aims at developing a consistent approach to initialize the new vegetation and fire-related variables (burning area, fuel moisture content and biomass load and burned area). This modelling initialization will rely on independent satellite observations of leaf area index and burned area. Burned areas are the most available variable due to the long-term developments of satellite observations however they are not available in real-time therefore an estimation of burnt-scar based on hot spots and FRP will need to be implemented. Vegetation status, will be a key component to constrain fuel moisture content and biomass load. This will be based on available measurements of leaf area index- LAI, normalized difference vegetation index (NDVI). Burning area initialization will be based on active fire estimates. The fuel/fire variable initialization will be tightly connected with the fire model developments in WP1. It is anticipated that the initialization will be based on the direct use of some of the measurements (e.g. burned area) while vegetation related conditions will rely on empirical relationships[27].

Task 2.2 Modular developments: an observation operator for fire radiative power and CO observations (Lead: SRS, Partners: ECMWF/ASI)

a) One of the most relevant remote observation of fire activity is the Fire Radiative Power (FRP). FRP is available in real time and from several multisensory platforms (e.g. VIIRS, Sentinel-3, MODIS, SEVIRI) making it suitable for operational use. To be ingested into IFS 4D-var system, an observation operator (linear model, tangent linear and adjoint) for FRP will be designed using as an input the fire/vegetation parameters of the model developed in Task 1.3.

b) Recognising that CO is one of the most important constituents emitted by wildfires and that it can be used as a proxy for fire activity, observations of CO available from various satellite platforms (IASI on MetopB and C, MOPITT, TropOMI) will be used to directly constrain CO concentrations in the model. For example, the MOPITT multispectral product provides profile information in the troposphere with enhanced sensitivity near the surface. An observation operator for CO and both a chemical mechanism and a linear model for the CO chemistry are already available in the IFS. The adjoint and tangent linear model of a representation of the CO chemical sources and sinks and of the CO injection process will be developed in this task. A key aspect of this development will be the synergy between fire-related observations (Task2.2a), which will indirectly constrain the tracer emissions via the fire/vegetation parameters, and the atmospheric composition observations which will constrain the atmospheric concentrations of CO, ensuring full consistency. FRAMES will leverage on developments already available in IFS from CAMS (linear CO tracer, CO2 and bulk aerosol scheme) and develop missing components, such as the inclusion of the (linear) chemistry in the assimilation and the separation of the contributions to emissions and tracer concentrations due exclusively to wildfires. In the future, this approach could be extended using additional components, such as the simplified NO2 model outlined in WP1**. If successful, this will be the first time that a fully integrate fire-related observations and atmospheric composition observations are integrated in a four-dimensional variational system.**

Task 2.3 Sensitivity experiments based on ensemble runs (Lead: ECMWF, Partners: ASI/FC.ID)

Parameters perturbations in the fuel/fire model developed in WP1 using the ensemble configuration of IFS will result in the spread of possible fire radiative power values through the relationships established in Task 1.3. Using the observation operator developed in Task2.2a this can be translated into spread in Fire Radiative Power. This analysis will assist in understanding which are the fire/vegetation model parameters to which FRP is mostly sensitive to and what their error characteristics are. The identified parameters of the fire/vegetation model will be then used as control parameters in the FRP assimilation.

Task 2.4 Technical developments and adaptations of the ECMWF 4D-Var system for fire related observations (Lead: ECMWF)

For any new observation that is deemed to be used into ECMWF data assimilation system, a series of technical developments need to be planned. The FRP observations will be transformed in the Binary Universal Form for the Representation of meteorological data (BUFR) format and then decoded into the Observation Data Base (ODB) format to be visible by the 4D-Var assimilation interface. Observation operators (see Task 2.3) linking the model prognostic variables to the fire relevant observation will be integrated into the assimilation routines. The Ensemble Data Assimilation (EDA) system will be used to compute flow-dependent background error covariance matrices for the CO and fire-related control variables. Thus, in this task the creation of the needed infrastructure to exploit fire related observations in a 4D-var framework will be provided. Task 2.3. works in close connection with Task 2.3 where modular developments of this whole infrastructure take place.

Deliverables

D2.1 Description of initialization approach for surface variables (ECMWF, R, PU, M12): The report will present results on the initialization for the new fuel/fire scheme variables (e.g. burning areas, fuel load).
D2.2 Description of observation operator for FRP and interface with the 4D-system (SRS, R, PU, M18): The report will present the newly developed observation operator, tangent linear and adjoin for FRP observations, as well as the 4D-Var infrastructure developments.
D2.3 Sensitivity analysis based on the assimilation framework (ECMWF, R, PU, M26): The report will present results highlighting the sensitivity of the fuel/fire parameter to FRP observations and will provide feedback on the evolution strategy.
D2.4 Description of use of the combined FRP and CO observation operators in the IFS 4D-Var system (ECMWF, R, PU, M33): The report will present results on the new assimilation scheme for CO and its impact when joined with the FRP assimilation.

Partner Roles

ECMWF	WP leader, task leader of T2.3, T2.4; contributor to T2.1, T2.2
FC.ID	Task leader of T2.1, and contributor to T2.4
IPMA, CNR, NOA	Contributor to T2.1
ASI	Contributor to T2.2 and T2.4
SRS	WP leader and task leader of T2.2

WP Dependencies	
WP1	WP2 develops the data assimilation infrastructure that uses the model developments (WP1)
WP3	WP2 develops the data assimilation infrastructure tested in the Show cases (WP3) whose results are assessed in WP4
WP4	
WP5	The data assimilation developments of WP2 will be promoted to the wider scientific community.

Work package number	3		**Lead beneficiary**						ECMWF			
Work package title	Service Integration and Evolution											
Participant number	1	2	3	4	5	6	7	8	9	10	11	12	**TOTAL**
Short name of participant	ECMWF	FC.ID	KNMI	IPMA	CNR	NOA	FMI	ASI	SRS	KIC	MF	BSC	
Person months/ participant:	12	6	2	8	10	10	0	3	0	1	5	8	**67**
Start month	1						**End month**			36			

Objectives

WP3 is related to **FRAMES key objectives no. 1, 2 and 3** and **4** and to **WP1**, **WP2** and **WP4**. **WP3** bridges the development (**WP1** and **WP2**), experimentation, verification (**WP4**) activities and the fire-relevant Copernicus services. **WP3** aims to:

1. Provide a technology mapping analysis
2. Perform five show cases, each designed to address a specific fire-relevant Copernicus service
3. Perform a Service evolution analysis based on the prior knowledge of what this proposal cannot address due to time constraints revisited in the light of the WP4 impact assessment of the show cases.

Description of Work

WP3 is led by ECMWF (Rossana Dragani and Mark Parrington)

Task 3.1 Technology mapping analysis (Lead: ECMWF, Partners: IPMA)

In this task, we provide a detailed analysis of the limitations and inconsistencies of the current fire approaches used within the fire-related Copernicus services, and of the innovative aspects that the new strategy proposed in FRAMES is anticipated to contribute to. This will address both methodological aspects and the fitness-for-purpose of the fire-related products provided by the Copernicus services and contrast it to the potential benefit the FRAMES-based equivalent can bring to the Copernicus programme.

Task 3.2 Show cases (Lead: ECMWF, Partners: FC.ID/IPMA/MF/NOA/CNR/ASI/BSC)

This task aims at facilitating the Service integration by designing and implemented five show cases. Each of them will refer to the specific needs and requirements of the Copernicus Service it addresses, thus exploiting configurations that are as close as possible to the operational ones.

Show case 1: FRAMES for CEMS

This show case is used to assess the value of the FRAMES approach in the CEMS context. A number of recent, major fires event will be selected. For these fire events, classical fire products provided by CEMS and their FRAMES equivalent will be contrasted using the tools and evaluation methods developed in **WP4**.

A survey targeting selected users that have expressed an interest in FRAMES (see endorsement letters attached to this proposal) will be used to identify the merits and fitness-for-purpose of the two approaches.

Show case 2: FRAMES for CAMS

This show case is used to assess the value of the FRAMES approach in the CAMS context. Fire emissions derived through the FRAMES developments will be used to run the CAMS system. The impact on the aerosol, relevant reactive gases and CO_2 will be assessed and contrasted with the quality of the same composition products derived from the CAMS system forced by the classical GFAS-derived fire emissions. The tools and evaluation methods developed in **WP4**, and the standard CAMS assessment tools will be applied.

Show case 3: FRAMES for C3S

This consists of two cases. The first one (case 3a) uses the off-line 1D vegetation model to run a FRAMES-equivalent of the C3S ERA-Land reanalysis. Comparisons between the two productions will provide insights on the potential added value brought by the FRAMES approach. The second one (case 3b) is used to assess the value of the FRAMES approach over the extended forecast range. The FRAMES-enhanced IFS will be tested over an extended forecast range using interactive aerosols. The ECMWF's ensemble coupled system will be used for these simulations. The impact of the new integrated approach will be analysed using the methodology defined in **WP4**, and contrasted with the impact of using the classical approach based on climatological aerosols, which is the standard of current service.

Show Case 4: FRAMES for CLMS

This show case is used to assess the value of the FRAMES approach to provide complementary products of biomass, burned areas and land surface albedo to those available as part of the global element of CLMS, namely the Copernicus Global Land service (CGLS). The currently CGLS products are satellite-based datasets. In this task, a framework for comparing the CGLS and FRAMES-equivalent products of biomass, burned areas and land surface albedo will be developed.

Show Case 5: FRAMES for ALL

This show case is used to assess the cross-cutting nature of the FRAMES prototype. It will be engineered around few recent fire events with different predictability characterises in terms of extent, duration and spatial extent. These events that might have been already analysed in the previous show cases will be revisited with the prospective interest of all fire-relevant Copernicus services to understand the added benefit of the FRAMES approach across the Copernicus services.

Task 3.3 Data integration (Lead: ECMWF)

This task is devoted to design prototypes for data integration in the main Copernicus data stores and dissemination channels, namely the C3S CDS, the CAMS ADS, and the CEMS fire catalogue, using the products generated in the show cases (**T3.2**).

Task 3.4 Service evolution (Lead: ECMWF, Partners: All)

This task is devoted to identifying those aspects and further refinements that cannot be considered in **WP1** and **WP2** but will need considerations before an actual uptake from the Copernicus services. The analysis will account for the outcome of the product verification and impact assessment performed in **WP4**. It will provide a roadmap for future evolution of the Copernicus Services that will also account for the anticipated evolution of the Copernicus services at the time this task will be performed.

Deliverables

D3.1 Fire information in the Copernicus Services: state-of-the-art and service innovation through FRAMES (ECMWF, R, PU, M6): The report will highlight in detail the expected service innovations in terms of existing products, their limitations and the improvements brought by FRAMES.

D3.2 Show cases Implementation Plan (ECMWF, R, PU, M9): This report will provide the characteristics of the show cases' design and how the experiments will be run.

D3.3 FRAMES integration and show cases (ECMWF, R, PU, M20): This is an interim report which will present the co-designed experiments solutions adopted to provide the show cases for those ones that have reached a good level of maturity

D3.4 FRAMES updates on integration and show cases (ECMWF, R, PU, M33): This is the updated and final report summarising the results from the show cases and highlighting the cross-cutting nature of the results.

D3.5 Fire developments for the Copernicus Services' evolution (ECMWF, R, PU, M36): The report will summarise the recommendation for the service evolution.

Partner Roles	
ECMWF	WP and task leader of T3.1, T3.2, T3.3, T3.4
FC.ID/CNR/NOA/ASI/KIC/MF	Contributor to T3.2
IPMA	Contributor to T3.1, T3.2, T3.4
BSC	Contributor to T3.2, T3.4

WP Dependencies	
WP1	The developments of WP1 will be used in the user cases (T3.2), and will be the basis to provide a technology mapping analysis (T3.1) and a service evolution roadmap (T3.3) on model development.
WP2	The developments of WP2 will be used in the show cases (T3.2), and will be the basis to provide a technology mapping analysis (T3.1) and a service evolution roadmap (T3.3) on data assimilation, and initialization aspects.
WP4	The show cases (T3.2) will be analysed in WP4.
WP5	The products and the conclusions from the show cases will be used to engage targeted potential users and promote the FRAMES approach to the wider scientific community.

Work package number	4		**Lead beneficiary**			IPMA						
Work package title	Prototype validation and impacts											
Participant number	1	2	3	4	5	6	7	8	9	10	11	12	**TOTAL**
Short name of participant	ECMWF	FC.ID	KNMI	IMPA	CNR	NOA	FMI	ASI	SRS	KIC	MF	BSC	
Person months/ participant:	6	5	4	18	10	10	2	0	0	0	5	12	**72**
Start month	1						**End month**			36			

Objectives

WP4 is related to **FRAMES key objectives no. 3 and 4**, and to **WP1**, **WP2** and **WP3**. **WP4** aims to perform a detailed product verification for the fire, aerosol and land/vegetation component resulting from the developments of **WP1** and **WP2**, as well as an impact assessment of the FRAMES approach using the show cases run in **WP3**.

Description of Work

WP4 is led by IPMA (Isabel Trigo) and co-led by CNR (Lucia Mona)

Task 4.1 Quality assurance and verification protocol (Lead: CNR, Partners: IPMA/ECMWF/BSC/FC.ID/NOA/ASI/MF)

The task will revise the available datasets for verification and will define a protocol and quality assurance for the verification of the various components of the FRAMES project

Task 4.2 Quality assurance and evaluation of fire and vegetation model components and assessment of relevant show cases (Lead: IPMA, Partners: ECMWF/FC.ID/ASI/FMI)

The evaluation of the main fire products will be based on available ground-based, aircraft and satellite observations. For example, the burned area to be produced by the future dynamical model will be validated using observations from ESA Fire_CCI, Copernicus-Land, MODIS, and L3JRC. We will also evaluate the impact of the fire dynamical model on land-surface variables such as albedo, or green biomass (e.g. provided by SMOS). The corresponding model variables will be validated with satellite products available, for example, from the ESA LandCover_CCI, the EUMETSAT-LSA-SAF, Copernicus-Land, and JRC-Land mapping. Some of these products are already used routinely for the evaluation of the surface fields at ECMWF. Relevant surface parameters will be also included in the ECMWF's Diagnostic Toolbox[45]. The FRP provided by the assimilation system will be compared against independent FRP data, for example from Sentinel-3. **Task 4.2 defines the verification strategy for show cases: 1,3a,4,5**

Task 4.3 Evaluation of biomass burning aerosols, trace gases and assessment of relevant show cases (Lead: CNR, Partners: NOA/ECMWF/KNMI)

During a forest fires, a significant amount of aerosol particles together with trace gases related to the combustion process is released. The emitted particles are mainly black carbon and organic matter, leading to the presence of highly absorbing aerosol typically small and spherical (for fresh smoke close to the source even larger and aspherical particles can be observed). With the view of an uptake of the FRAMES approach by CAMS, this task aims at assessing the quality of the fire-released aerosols and trace gases using the FRAMES approach and contrasting it to those obtained from the current CAMS system. Special attention will be paid to removing any contamination affecting the verifying datasets (e.g. the local background or the simultaneous presence of other, not fire-related aerosol particles.

Datasets that will be considered are **in-situ Aerosol Optical Depth** (AOD) observations from the AEORNET network (for AOD greater than 0.4 and Angstrom exponent greater than 1.4 that can be associated to scenes strongly affected by the presence of forest fire plumes), **aerosol profiling from lidars** from ground-based (e.g. EARLINET/ACTRIS), aircrafts and satellites (e.g. CALIOP on CALIPSO). The potentialities of using ICOS (Integrated Carbon Observation System research infrastructure) harmonised and high-precision scientific data on carbon cycle and greenhouse gas budget and perturbations will be investigated. Furthermore, depending on the simulated periods, available **datasets from** dedicated **campaigns** will be considered. These could include, for instance, SAMBBA (South AMerican Biomass Burning Analyses), aerosol products from ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS), and ASKOS (planned for Summer 2020 in Cape Verde for testing the ADM Aeolus aerosol products) are particularly suited for such kind of investigation. Existing satellite-based datasets (GFAS[46]; QFED[47]; FLAMBE[48]; and GFED[49]) will also be used for evaluation. The **AEROCOM** interface will also be used for the assessment. Satellite observations from the TropOMI instrument will be used to provide further constraints on the modelled CO concentrations, and, in turn, its fire emissions. Likewise, the TropOMI NO_2 observations will be used to validate the simplified NO_2 model.

This task will include the following activities:

- Definition of suitable verifying datasets

[45] https://www.ecmwf.int/sites/default/files/elibrary/2015/15255-new-developments-diagnosis-and-verification-high-impact-weather-forecasts.pdf

[46] Kaiser, J. W., Heil, A., Andreae, M. O., Benedetti, A., Chubarova, N., Jones, L., Morcrette, J.-J., Razinger, M., Schultz, M. G., Suttie, M., and van der Werf, G. R.: Biomass burning emissions estimated with a global fire assimilation system based on observed fire radiative power, Biogeosciences, 9, 527-554, https://doi.org/10.5194/bg-9-527-2012, 2012.

[47] Darmenov A., and da Silva, A. 2015. The Quick Fire Emissions Dataset (QFED): Documentation of versions 2.1, 2.2 and 2.4. (R. D. Koster, Ed.) (Vol. 38). USA.

[48] Reid J.S., E.J. Hyer, E.M. Prins, D.L. Westphal, J.L. Zhang, J. Wang, S.A. Christopher, C.A. Curtis, C.C. Schmidt, D.P. Eleuterio, K.A. Richardson, J.P. Hoffman, Global monitoring and forecasting of biomass-burning smoke: description of and lessons from the Fire Locating and Modeling of Burning Emissions (FLAMBE) Program, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2 (3) (2009), pp. 144-162, 10.1109/JSTARS.2009.2027443.

[49] van der Werf, G. R., Randerson, J. T., Giglio, L., Collatz, G. J., Mu, M., Kasibhatla, P. S., Morton, D. C., DeFries, R. S., Jin, Y., and van Leeuwen, T. T.: Global fire emissions and the contribution of deforestation, savanna, forest, agricultural, and peat fires (1997–2009), Atmos. Chem. Phys., 10, 11707-11735, https://doi.org/10.5194/acp-10-11707-2010, 2010.

- Definition of methodologies for
  i) extracting the forest fire contribution to the total content;
  ii) harmonizing concurrent datasets;
  iii) accounting for the observation uncertainty in the FRAMES system evaluation.
- Review and harmonization of data format and provision.
- Quantitative verification of the FRAMES system in terms of emitted aerosol concentrations.

The evaluation will include both standard metrics, and maps/time series as well as more advanced probabilistic scores applied to the ensemble output. The evaluation of the aerosol fields, which is routinely done in CAMS, will be expanded to include probabilistic metrics. **Task4.3 defines the verification strategy for show cases: 2, 5.**

Task 4.4 Evaluation of the meteorological impact and forecast skill and assessment of relevant show cases (Lead: BSC, Partners: ECMWF)

The potential benefits of including a fire modelling module in the IFS on meteorological surface fields at sub-seasonal timescales will be analysed. For this purpose, the hindcast runs produced in **WP3 (show case 3b)** will be evaluated against the ERA5 reanalysis product. The analysis will consist on a probabilistic forecast skill assessment of surface variables at the global scale (such as temperature, windspeed, precipitation and solar downwelling radiation). The forecast skill of the predictions with the interactive fire model will be compared to the forecast skill of a control run which uses a fire emission climatology. A combination of deterministic (correlation of the ensemble mean) and probabilistic (fair ranked probability skill score fairRPSS, continuous ranked probability skill score fairCRPSS) will be used for a complete assessment. Also, the ECMWF score cards will be used to assess the impact of including wildfires on several atmospheric variables.

The Madden-Julian Oscillation (MJO) has been shown to modulates wildfire activity[12]. Its impacts can be observed not only over tropical area such as Indonesia[50] but also in remote areas, such as Africa, and as far away as Northern Canada and Alaska[51]. We will first evaluate the skill of the coupled model at reproducing the phases of the MJO. We will repeat the sub-seasonal evaluation with forecasts composited by MJO phase. This will allow an understanding of how the phases of the MJO affect fire activity in the IFS model as well as which phases of the MJO provide enhanced (degraded) predictability. We will also explore whether the inclusion of fires impacts the strength and/or propagation of the MJO. **This task will define the verification strategy for show cases: 3b, 5.**

Task 4.5 Evaluation of fire danger products and assessment of the FRAMES for CEMS show case (Lead: MF, Partners: ECMWF/IPMA)

ECMWF, MF and IPMA have established solid collaborations and a series of cross-cutting European-wide activities in the fields of fire danger prevention and control.

As part of the CEMS contract for the Copernicus fire danger computation, MF is subcontracted by ECMWF (main contractor) to provide every year an objective and independent evaluation of the EFFIS products. The latter are produced by ECMWF and consist of Fire Weather Indices. As part of their operational data quality control, skill scores and expert analysis of fire events occurring in Europe are produced. Within the FRAMES context, products equivalent to the CEMS/Fire FWI will be generated and made available through a dedicated web portal. Using the same procedure and methodology applied to the assessment of the operational CEMS/Fire products, this task aims at assessing the new products generated within FRAMES and any added value of using the FRAMES prototype. EFFIS standard products will be used as benchmark in this validation exercise.

ECMWF, IPMA and MF are also part of the **ARISTOTLE 2-ENHSP project** as representatives of the forest fire expert group. **ARISTOTLE 2 provides a 24/7** collaborative network of scientific and operational expert across Europe to enhance the information provided to the European Response and Coordination Centre.

[50] Reid, J. S., Xian, P., Hyer, E. J., Flatau, M. K., Ramirez, E. M., Turk, F. J., ... Maloney, E. D. (2012). Multi-scale meteorological conceptual analysis of observed active fire hotspot activity and smoke optical depth in the Maritime Continent. Atmospheric Chemistry and Physics, 12(4), 2117-2147. https://doi.org/10.5194/acp-12-2117-2012.

[51] Zhang, C., 2013: Madden–Julian Oscillation: Bridging Weather and Climate. Bull. Amer. Meteor. Soc., 94, 1849–1870, https://doi.org/10.1175/BAMS-D-12-00026.1.

The forest fire expert team uses EFFIS platform as the main source of model-based information. FRAMES responds to a need from this community to create a stronger link between the weather-based fire danger and the vegetation status. Products from FRAMES will then be made available and will be tested in such a framework by national meteorological services expert in dealing forest fire assistances to civil protection authorities. At the time of writing the service is secured until the end of 2019 but it is likely to be extended for further two years so to cover at least one entire fire season of the FRAMES project. **This task defines the verification strategy for show cases: 1,5.**

References for the datasets referred to in WP4:

- Fire_CCI: http://www.esa-fire-cci.org/, last access: 2018-12-24
- Copernicus-Land: https://land.copernicus.eu/, last access: 2018-12-19
- MODIS: http://modis-fire.umd.edu/index.php, last access: 2018-11-24
- L3JRC: http://gfmc.online/inventory/burnt-area.html, last access: 2018-11-24
- LandCover_CCI: www.esa-landcover-cci.org/ Last access: 2018-12-19
- LSA-SAF: www.eumetsat.int/website/home/Satellites/GroundSegment/Safs/LandSurfaceAnalysis/index.html, last access: 2018-12-19
- JRC-Land: http://data.jrc.ec.europa.eu/dataset/jrc-luisa-land-use-ref-2014, last access 2018-12-19.
- CAMS:https://atmosphere.copernicus.eu/user-support/validation/verification-global-services#aerosols, last access: 2018-12-23
- AEROCOM: http://aerocom.met.no/tools.html, last access: 2019-01-23.
- AERONET: www.aeronet.gsfc.nasa.gov, last access: 2019-01-23.
- ACTRIS: http://actris.nilu.no/Data, last access: 2019-01-23.
- NASA Atmospheric data Centre: https://eosweb.larc.nasa.gov/HORDERBIN/HTML_Start.cgi, last access: 2019-01-23.
- LIVAS: http://lidar.space.noa.gr:8080/livas/, last access: 2019-01-23.

Deliverables

D4.1 Quality assurance (IPMA, R, PU, M9): The report will set the specification for the verification of the various aspects of the FRAMES products.

D4.2 Assessment of the new fire scheme: burned areas, fire activity, surface albedo (IPMA, R, PU, M20): The report will look at the overall capability of the fire scheme to reproduce the expected mean statistics of the surface variables. It will use CGML products in the assessment and will set the diagnostics used to provide an assessment of the FRAMES for CLSM and FRAMES for C3S a) show cases.

D4.3 Assessment of the new fire scheme: emissions (trace gases and aerosols) (CNR, R, PU, M26): The report will look at the overall capability of the fire scheme to reproduce the expected mean statistics for emissions. It will use CAMS/GFAS simulations for benchmarking and will set the diagnostics used to provide an assessment of the FRAMES for CAMS show case.

D4.4 Long range integration forecast skills (BSC, R, PU, M33): The report will look at the improved skills of the new FRAMES prototype in long range simulations. It will use C3S products as benchmarks and will set the tools used to provide an assessment of the FRAMES for C3S show case b).

D4.5 Evaluation of FRAMES simulations of fire activity within the context of operational forecast and monitoring of fire danger in Europe (MF, R, PU, M36): The report will present the benefit of FRAMES products for fire management and control. It will use the CEMS fire forecast products (e.g. FWI) as a benchmark and will set the tools used to provide an assessment of the FRAMES for CEMS show case.

All deliverables will provide the diagnostics to assess FRAMES for ALL show case.

Partner Roles	
ECMWF	Contributor to T4.1, T4.2, T4.3, T4.4, T4.5
FC.ID	Contributor to T4.1 e T4.2

IPMA	WP leader, T4.1 task leader, and contributor to T4.5
CNR	WP co-leader, and T4.1 and T4.3 task leader
NOA/FMI/KNMI	Contributor to T4.3
FMI	Contributor to T4.2
MF	T4.5 task leader
BSC	T4.4 task leader and contributor to T4.1

WP Dependencies	
WP1	WP4 performs a product verification of the fire and vegetation components developed in WP1
WP2	WP4 performs a product verification of the aerosol and trace gases analyses from the data assimilation system developed in WP2
WP3	WP4 performs quality assessment of the products and impact evaluation of the FRAMES approach using the show cases run in WP3
WP5	The outcome of the verification and impact assessment will be used for outreach and FRAMES communications

Work package number	5		**Lead beneficiary**						ECMWF			
Work package title	Communication, Dissemination and Outreach												
Participant number	1	2	3	4	5	6	7	8	9	10	11	12	
Short name of participant	ECMWF	FC.ID	KNMI	IMPA	CNR	NOA	FMI	ASI	SRS	KIC	MF	BSC	**TOTAL**
Person months/ participant:	12	1	1	1	1	1	1	0	0	6	1	1	**26**
Start month	1						**End month**			36			

Objectives

WP5 is related to **FRAMES key objective no. 5**, and to **all work packages**. **WP5** aims to:

- Prompt a paradigm shift in the understanding and use of novel fire modelling approach and their impact on Copernicus Services and wider communities.
- Promote the dissemination and use of products, model development, as well as in training and education.

Description of Work

WP5 is led by ECMWF (Daniel Thiemert) and co-led by KIC (Pamela Ragazzi).

Key tasks of FRAMES comprise **outreach, support, dissemination and communication activities**. The aim of **WP5** is to promote the understanding and use of novel technologies and their impact on the respective Copernicus Services and related communities.

To achieve a large audience, **outreach, dissemination and communication beyond the project network and lifetime**, the project will promote the dissemination of models and data resulting from the FRAMES project through the FRAMES project website. The project partners ECMWF and KIC will develop a fellowship programme and will ensure close liaison with the Copernicus Services and other projects in the Copernicus Evolution call. An important objective is thus to **facilitate FRAMES' dissemination and communication** established through five tasks:

Task 5.1 Dissemination and Communication (Lead: ECMWF)

In the first stage, **Task 5.1** will develop the plan for Dissemination and Communications including Media Outreach **(D5.1, ECMWF).** The plan will identify avenues and targets for communication, dissemination

and exploitation both within and outside the FRAMES Consortium including communication strategy and brand guidelines.

The second stage of this task will then see the implementation of this plan, including publications, webinars, talks, fairs, newsletters, press releases, etc. Further details on the dissemination and communication activities are already presented in Section 2.2.

Task 5.2 Gender Balance (Lead: KIC)

Task 5.2 will develop and implement the plan to ensure women's participation in the developments and applications as active members of research/engineering teams (**WP1** - **WP4**). It will ensure promotion of gender equality and diversity in the activities involved in the outreach and training activities that will be built in **WP5** by ensuring equal gender participation in training videos and webinars, by promoting success stories about women through the project website, and, by promoting partner activities that implement equal opportunity policies in their organisations (**D5.2, KIC**).

Task 5.3 Website and Infrastructure (Lead: ECMWF)

To establish efficient interaction between project partners and for communicating with external stakeholders**,** this task will establish the **web portal, the software collaboration platform** including bug tracking facilities, **and the software repository**. In addition, **collaborative tools** such as a wiki will be established and maintained (**D5.3, ECMWF**).

T5.3 will also realise the FRAMES data portal (**D5.4**, **ECMWF**) as part of the project website. The portal will provide an interface to the distributed data made available through the project, either as input datasets or as resulting datasets. The portal will be based on existing technology at ECMWF so as to minimise the costs to the project, with the focus being on releasing the portal early in the project.

Task 5.4 Pioneering program (Lead: KIC)

This task will generate the interface between FRAMES and the KIC Pioneers Programme. Pioneer is one of the KIC flagship programme for professional development running in over 15 European countries, and designed on an innovative pedagogic framework. Pioneers identifies and connects actors from across systems, equips participants with systems innovation understanding and skills, whilst also providing fresh perspectives and expertise for innovation to happen. It includes professionals and organisations from industry, small companies, universities, research institutes, municipalities, governance, and not-for-profit. In this task, the program will be run for 8 to 10 participants which will be hosted by interested organization that could benefits from the FRAMES developments. It is foreseen that having dedicated Pioneer "chairs" will provide an excellent base for dissemination and adoption of FRAMES outside the boundaries of the established users.

T5.5 Outreach and Liaison (Lead: ECMWF)

This task will ensure a dedicated regular interaction and feedback with the relevant Copernicus services and communities. This will include specific newsletters with the opportunity for Services to comment on the developments and provide feedback to guide the direction of the developments. Furthermore, the task will seek to foster synergies with other projects selected for this call and/ or dealing with fire modelling, to exchange knowledge and increase impact. The task will also realise the final dissemination workshop (D5.7, ECMWF) that will present the results of the FRAMES project to the communities including the Copernicus services.

Deliverables

D5.1 Plan for Dissemination and Communication (ECMWF, R, PU, M2): Outlines the plan for dissemination and communication activities including brand guidelines.

D5.2 Plan for Gender Balance (PGB) (KIC, R, PU, M4): Outlines the activities of FRAMES to support Gender Balance.

D5.3 Web Portal including Software Collaboration Platform (ECMWF, DEC, PU, M4): Website including internal and external sections as well as software collaboration tools.

D5.4 Data Portal (ECMWF, DEC, PU, M6): Portal to the distributed data of the project for public.

D5.5 Dissemination and Fellowship Programme Report 1 (ECMWF, R, PU, M18): Intermediate report on the results of the dissemination activities and the fellowship programme.
D5.6 Dissemination & Fellowship Programme Report 2 (KIC, R, PU, M36): Final report on the results of the dissemination activities and the fellowship programme.
D5.7 Final Dissemination workshop (ECMWF, R, PU, M36): Report on the final dissemination workshop presenting the results of the FRAMES project.

Partner Roles	
ECMWF	will lead this work package and is responsible for delivering Tasks 5.1, 5.3 and 5.5
KIC	Will lead tasks 5.2 and 5.4
All partners	Will contribute to the dissemination and communication activities

WP Dependencies	
WP1-4	All technical WPs provide input to the dissemination, communication and training activities.

Work package number	6		**Lead beneficiary**						ECMWF			
Work package title	Coordination and Project Management											
Participant number	1	2	3	4	5	6	7	8	9	10	11	12	**TOTAL**
Short name of participant	ECMWF	FC.ID	KNMI	IMPA	CNR	NOA	FMI	ASI	SRS	KIC	MF	BSC	
Person months/ participant:	12	1	1	1	1	1	1	1	1	1	1	1	**23**
Start month	1						**End month**			36			

Objectives

The general objective of **WP6** is to coordinate the project and ensure that its innovation actions, objectives and impacts will be delivered. Specific project management objectives are:

- to set-up and maintain a structure, procedures and tools that will allow a coherent and efficient technical and administrative management of the project;
- to keep the project on time and within the assigned budget;
- to identify and manage risks and to solve problems;
- to identify opportunities for improved results and collaboration;
- to coordinate the interactions between work packages and partners;
- to provide and manage working procedures ensuring transparency within the team and for the EC;
- to manage quality assurance.

Description of Work

WP6 is led by ECMWF (Francesca Di Giuseppe - Coordinator and Daniel Thiemert - Project Manager).

Task 6.1 Project Management and Coordination (Lead: ECMWF)

Task 6.1 will provide the project management and coordination for the FRAMES project. The work will comprise project initiation, including setting up the management structure such as General Assembly, Executive Board, project office etc. The necessary communication channels including mailing lists, and document management system will be implemented to support the project work.

The task will also be responsible for the organisation of project meetings including kick-off meeting and annual project board meetings.

In addition, progress monitoring will occur through regular Executive Board meetings (online, monthly) as well as quarterly progress reports from partners and work packages which will also aid the risk and quality management (see **Task 6.2**).

Finally, **Task 6.1** will also serve the scientific coordination of the project, ensuring that all partners and work packages are aligned and working towards the goal of the project.

Task 6.2 Risk and Quality Management (Lead: ECMWF)

Based on the initial risk table already identified in Table 11, this task will maintain a risk register (part of **D6.1, ECMWF**) that is regularly updated (through quarterly progress reports described in **Task 6.1**) or on an ad-hoc basis, as required. The task will thus actively monitor existing and emerging risks and identify mitigation measures.

Task 6.2 will also perform the quality management. A quality manual (also part of **D6.1, ECMWF**) will detail the Key Performance Indicators and will provide target measures for these. The manual will also provide the quality review process for each deliverable of the project, through a rigorous internal review process (at least two reviewers for each deliverable). The quality manual will also contain templates for the project, including deliverables, presentations, posters, etc.

Task 6.3 Administrative and Financial Management (Lead: ECMWF, M1-M36)

Task 6.3 provides the administrative and financial management for the FRAMES project. This includes management of potential amendments to Grant Agreement and Consortium Agreement, periodic reporting, management of the project finances (distribution of funds, financial claims, etc.) as well as organisation of periodic reviews. The task will also ensure liaison and communication with the European Commission.

Task 6.4 Exploitation, Innovation and IPR management (Lead: ECMWF)

Management of knowledge and innovation is an integral part of our project. We will focus on the role and synergies between the areas of competence of the partners, their experience, capabilities, and on how partners will protect, share, manage IPR capital actual exploitation.

The **consortium agreement** will be set up for regulating the ownership and access to key knowledge (IPR, data etc.) and scientific foreground, among other things, after the communication of the approval of the project by the EC and **before the signature of the Grant Agreement with the EC**.

A strategy for the knowledge management, protection and for the exploitation of results, the **Exploitation Plan** (**D6.2, ECMWF**), will be defined for the consortium in the early stage of the project based on the principles explained in Section 2.2. The strategy will be regularly updated during the entire project. Updates will be submitted to the EC as an integral part of the Project Periodic Reports.

At the *end of the project* a **revised version of the Exploitation plan** (**D6.3, ECMWF**) will be drafted for providing best practices in capturing and assessing the Intellectual Property and providing measures for exploitation for the phase after the closure of the project.

FRAMES will provide **open access to peer-reviewed scientific publications** through a combination of golden open access and green open access (cf. Section 2.2 for details on software IPR and data).

The task will also develop and maintain the Data Management Plan according to the Open Research Data Pilot of H2020 (**D6.4, ECMWF**).

Deliverables

D6.1 Quality Manual, Risks Register (ECMWF, R, CO, 2): Manual describing procedures for managing quality during project. Risk register tracking type, level, responsibility, mitigation measures.
D6.2 Exploitation Plan (EP) (ECMWF, R, CO, 12): Plan identifying types of potential pathways of market-oriented exploitation, converting or transforming knowledge will be identified, together with key factors for a successful innovation management.
D6.3 Exploitation Plan after closure (ECMWF, R, PU, 36): Strategy for defining measures for exploitation "after the project" phase, providing evidence of best practices in capturing and assessing IPR.
D6.4 Data Management Plan (Lead: ECMWF, M6, R PU): Outline of the Data Management Principles of the FRAMES Project.

Partner Roles	
ECMWF	Will lead the work package and deliver all its tasks
Partners	Will contribute to the management of the project and their WPs

WP Dependencies	
All	WP6 ensures that all WPs perform according to contract.

3.1.5 List of Deliverables

Deliverable (number)	Deliverable name	Work package number	Short name of lead participant	Type	Dissemination level	Delivery date (in months)
D1.1	Detailed design of the modelling implementations	WP1	ECMWF	R	PU	M6
D1.2	Description of the new vegetation scheme with revised land cover and static fuel load	WP1	FC.ID	R	PU	M18
D1.3	Description of the fire model components including ignition and emissions	WP1	ECMWF	R	PU	M24
D1.4	Description of interaction processes between the biomass burning aerosols and the radiation scheme	WP1	ECMWF	R	PU	M30
D2.1	Description of initialization approach for surface variables	WP2	ECMWF	R	PU	M12
D2.2	Description of observation operator for FRP and interface with the 4D-system	WP2	SRS	R	PU	M18
D2.3	Sensitivity analysis based on the assimilation framework	WP2	ECMWF	R	PU	M26
D2.4	Description of use of the combined FRP and CO observation operators in the IFS 4D-Var system	WP2	ECMWF	R	PU	M33
D3.1	Fire information in the Copernicus Services: state-of-the-art and service innovation through FRAMES	WP3	ECMWF	R	PU	M6
D3.2	Show cases Implementation Plan	WP3	ECMWF	R	PU	M9
D3.3	FRAMES integration and show cases	WP3	ECMWF	R	PU	M20
D3.4	FRAMES updates on integration and show cases	WP3	ECMWF	R	PU	M33
D3.5	Fire developments for the Copernicus Services' evolution	WP3	ECMWF	R	PU	M36
D4.1	Quality assurance	WP3	IPMA	R	PU	M9
D4.2	Assessment of the new fire scheme: burned areas, fire activity, surface albedo	WP4	IPMA	R	PU	M20
D4.3	Assessment of the new fire scheme: emissions (trace gases and aerosols)	WP4	CNR	R	PU	M26
D4.4	Long range integration forecast skills	WP4	BSC	R	PU	M33
D4.5	Evaluation of FRAMES simulations of fire activity within the context of operational forecast and monitoring of fire danger in Europe	WP4	MF	R	PU	M36
D5.1	Plan for Dissemination and Communication	WP5	ECMWF	R	PU	M2
D5.2	Plan for Gender Balance	WP5	KIC	R	PU	M4
D5.3	Web Portal including Software Collaboration Platform	WP5	ECMWF	DEC	PU	M4
D5.4	Data Portal	WP5	ECMWF	DEC	PU	M6

D5.5	Dissemination and Fellowship Programme Report 1	WP5	ECMWF	R	PU	M18
D5.6	Dissemination & Fellowship Programme Report 2	WP5	KIC	R	PU	M36
D5.7	Final Dissemination workshop	WP5	ECMWF	R	PU	M36
D6.1	Quality Manual, Risks Register	WP6	ECMWF	R	CO	M2
D6.2	Exploitation Plan	WP6	ECMWF	R	CO	M12
D6.3	Exploitation Plan after closure	WP6	ECMWF	R	PU	M36
D6.4	Data Management Plan	WP6	ECMWF	R	PU	M6

3.2 Management structure, milestones and procedures

3.2.1 Project organisation

This section describes the management of the project at the Consortium level. The objective is to keep the project on-track by defining and applying control and reporting procedures. At the same time, the consistency of and the cooperation among the activities in different work packages will be ensured.

A **Consortium Agreement** (CA) will define and complete any points not covered by the EC Grant Agreement. The CA will be signed before the project commences. The CA includes details about:

- The organisation of the consortium, as described below.
- The financial distribution based on each participant's effort and activity type.
- Procedures for changes in the consortium composition.
- IPR and exploitation: definition of the background brought by all participants and related access.
- Rights and rules for joint ownership, and access rights to project results for participants and 3rd parties.
- Dissemination rules for managing confidentiality and approving public presentations and publications.

The structure that has been adopted for FRAMES follows the DESCA Model Consortium Agreement for Horizon 2020 projects, and specific roles and decision-making responsibilities have been assigned accordingly here. Further details about all components are given below and in Figure 11.

The management body of FRAMES is composed of the General Assembly, the Executive Board, and the Project Office, aiming to:

- stay transparent and flexible at each stage,
- keep the structure as light as possible,
- provide working procedures offering full transparency for the participants and the EC,
- support the efficient cooperation between WPs,
- ensure a good link between technology, science and application,
- maintain control of the overall project while exploring synergies and encouraging creativity.

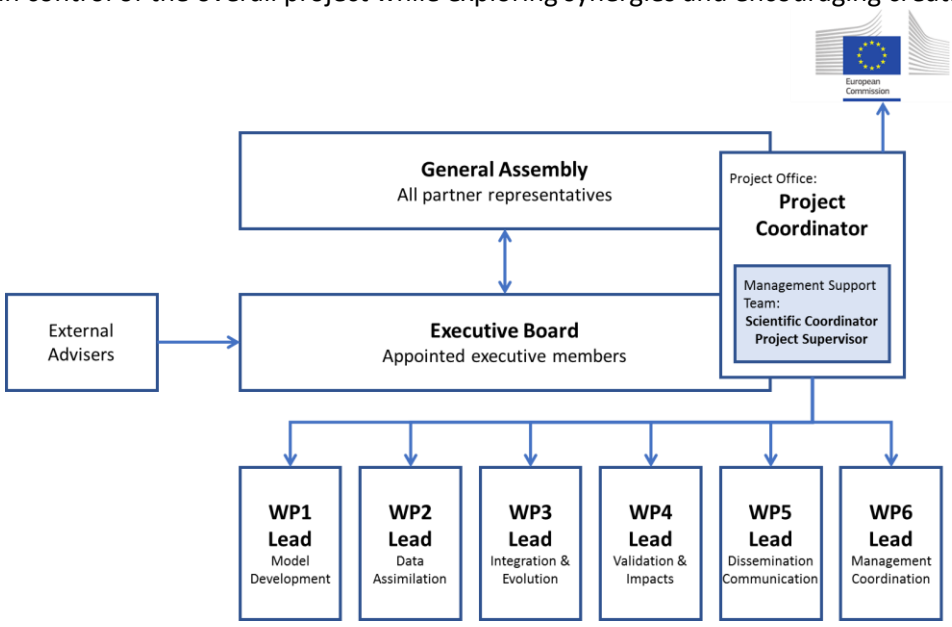


Figure 11: FRAMES project management structure.

The **General Assembly** (GA) is the ultimate decision-making body for FRAMES. This will be chaired by the Project Coordinator and will be composed of representatives from all partner organisations. The GA is the decision-making body. The responsibilities of the GA include:

- making the strategic decisions about the progress of the project,
- making the strategic decisions in case of conflict between beneficiaries,
- making the strategic decisions concerning IPR,
- modifying the Consortium Agreement if necessary,
- modifying the composition of the Consortium, according to the provisions of the Consortium Agreement and the rules imposed by the EC, if necessary,
- and approving major redistributions of budget if necessary.

The GA will convene, when necessary, during the bi-annual meetings of the Executive Board or on request by one third of its members. The members of the GA are the official representatives of the beneficiaries as appointed by their organisation. They are responsible for the management of the technical and/or scientific team working in their organisation and the timely production of the reports and results for which they have responsibility. The partner representatives report to the management of their organisation, to the GA for overall contractual and technical issues and to the WP leaders for issues specific to the progress of the WP's involving their organisation.

The **Executive Board** (EB) will be the supervisory body ensuring successful execution of the project, and will be accountable to the GA. The board will be chaired by the Project Coordinator. The EB is the coordination body and its members will be appointed by the GA. The EB will convene twice per year. EB meetings will be chaired by the Project Coordinator. Responsibilities of the EB include the:

- monitoring of the effective and efficient implementation of the project,
- preparation of meetings, proposal of decisions and preparation of the agenda for GA meetings,
- assurance that the project is compliant with the CA and, if required, proposal of modifications of the CA,
- provision of advice to the GA on rearrangement of tasks and budget, if applicable.

The EB will be supported by an **External Expert Advisory Board** composed of members of the Copernicus Services, namely:

1. Dr Jean-Noel Thepaut (head of C3S)
2. Dr Vincent-Henri Peuch (head of CAMS)
3. Dr Jesus San-Miguel (head of CEMS-Fire)
4. Dr. Roselyne Lacaze (highly involved in CLMS production of fire related products)

This review function will be enabled on demand by the EB.

The **Project Office** (PO) will conduct the day-to-day management of FRAMES on behalf of the GA. The PO executes the decision made by the EB to which it reports. Members are the Project Coordinator, the Scientific Coordinator and the Project Supervisor. The PO is supported by the administrative staff of the Coordinator's organisation. The Project Office is responsible for the:

- management of planning and practical decision making on the progress of the project,
- submission of deliverables to the EC and coordination of follow-up actions,
- supervision of the dissemination of project output within the consortium and the external communication,
- organisation of committee meetings,
- coordination of activities between the WPs,
- management of dissemination activities and IPR issues,
- management of the budget,
- management of the risks,
- management of the quality control.

The members of the PO are contributed by the lead partner ECMWF. ECMWF has an extensive track-record in coordinating and participating in complex multidisciplinary projects.

The **Project Coordinator** (PC) is responsible for the overall coordination of the project and will act as the point of contact for the EC. The PC has ultimate responsibility for ensuring that the project delivers what is

expected. The PC is also in charge of the management of innovations originating from the project. The Project Coordinator will be Dr Francesca Di Giuseppe (ECMWF).

The **Scientific Coordinator** (SC) is responsible for overseeing the scientific content of the project and ensuring that all work packages are contributing to the outcomes and scientific excellence of FRAMES. The Scientific Coordinator will be Dr Rossana Dragani (ECMWF).

The **Project Supervisor** (PS) will have overall responsibility for the efficient coordination of the project in terms of resources and time schedule, risks, quality, and innovation management. The PS acts on behalf of the PC and makes all the decisions relating to the contractual provisions. The PS's role is to ensure the smooth operation of the project in accordance with the provisions of the CA. The PS reports to EC (via the PC) and GA for financial and contractual issues, and to the EB for technical and management issues. The PS is also responsible for the maintenance of the risks register. The PS will organise the project reviews in collaboration with the partners and will be responsible for compiling the final report. From the first review onwards, the PS will be responsible for issuing the "cross-reference" document, which will trace how recommendations made by the EC's Project Officer and the reviewers are taken into account. The Project Supervisor will be Dr. Daniel Thiemert (ECMWF).

The **Work Package Leaders** (WPL; and their co-leaders) have a responsibility to ensure delivery of their WP objectives and deliverables, working closely with PC and SC to support the outcomes of FRAMES as a whole. They are the coordinators of the different work packages. Each WP has its own leader, objectives and resources. The WPL will define the "Quality Plan" (QP) for the work of the teams involved. This QP will define the acceptance criteria for each deliverable. These activities are part of the WP's in terms of resources and responsibility and are conducted by the partners contractually involved in each WP. The WPLs control the progress of the WP.

Milestones relevant to the FRAMES project have been identified in Table 10 below.

Table 10: List of milestones

Milestone number	Milestone name	Related work package(s)	Due date (in month)	Means of verification
M1	Project initiated	WP5, WP6	4	D5.1, D5.2, D5.3, D6.1 quality approved and submitted
M2	Detailed architectural description of the modelling and initialization strategy and verification assurance plan	WP1, WP2, WP3, WP4	12	D1.1, D2.1, D3.1, D3.2, D4.1 quality approved and submitted
M3	First prototype of fire dynamical model with relevant initialization and off-line verification including outcomes from show cases (e.g. Case 3a)	WP1, WP2, WP3, WP4	20	D1.2, D2.2, D3.3, D4.2 quality approved and submitted
M4	Integration of the fire model into the earth system modelling and deployment of relevant show cases	WP1, WP2, WP4	26	D1.3, D2.3, D4.3 quality approved and submitted
M5	Consolidation of show cases impact	WP2, WP3, WP4	33	D2.4, D3.4, D4.4 quality approved and submitted
M6	Service Evolution defined, project completed	WP3, WP5, WP4, WP6	36	D3.5, D4.5, D5.6, D6.3 quality approved and submitted

3.2.2 Project management procedures

Decision-making process and conflict resolution

The project is steered and guided following a top-down approach, while issues are raised and problems resolved following a bottom-up approach. The details of the procedures will be described in the CA. Its general principles are:

- The GA is the ultimate decision-making body.
- Unless otherwise specified decisions are made by applying a simple majority of the members. In case of equal votes, the vote of the Chairman is decisive.
- In case of serious failing of one participant to fulfil their commitments to the extent that the project is jeopardized, the GA will have the right to expel this participant. This decision, as well as the one to include a new partner, will be made requiring approval by 2/3 of the GA members.
- The project could be affected by conflicts of various types: strategic, technical, shortage of resources, and others. WP Leaders, PC and PS should anticipate the emergence of such conflicts, and discuss the best way to resolve them with the partners. The project employs a multi-level escalation strategy. Conflicts at work level should first be reported to WPLs. If not resolved at this level, problems and possible solutions will be formally discussed at the EB-level, moderated by the PS, where, if necessary, a vote could take place. If no unanimous decision can be found, the EB will report the issue to the GA where the final decision will be taken in a meeting moderated by the PS.

Risk Management

The EB is in charge of managing the risks while the PS maintains the risks register, in order to prevent any deviation from the plans. The risks register contains the following information for each risk identified:

- risk description (fact or event which could jeopardize the correct functioning of the project),
- work package/task involved,
- probability (almost certain, likely, moderate, unlikely, rare),
- impact (insignificant, minor, moderate, major, catastrophic),
- risk response (type and description),
- responsibility,
- due date,
- status (open, closed).

At each EB meeting, the register will be analysed and the values of each parameter updated. With the help of this information, the EB will be able to make the most appropriate decisions. The PS will ensure that the risks register is permanently up to date and that the recommended measures are in place in due time.

The FRAMES project risks and appropriate mitigation measures are listed in Table 11.

Table 11: Critical risks for implementation

Description of risk (indicate level of likelihood: Low/Medium/High)	Work package(s) affected	Proposed risk-mitigation measures
Unavailability or resignation of key staff (low)	All WP	Reduce; Recruit new staff quickly; The coordinator will work with respective partners to provide a solution. Some of the competencies are partially overlapping, introduction of new partner.
Spin-up of new recruits and external partners in working with the IFS (low)	WP1, WP2, WP3	Consortium members involved in the development tasks have years of experience working with the IFS. They are also senior scientists with long records of supervision of new recruits.
Personnel involved or recruited not able to fulfil tasks (low).	All WP	Monitoring by the PO, and implementing adjustments within each organisation through GA.
Underperforming partners (medium).	WP6	Close contact between WP Leaders and Project Leader, short feedback loops and personal contact.
Fire/vegetation model not ready in time for sensitivity studies	WP2	Use climatological values of relevant parameters.

involving Fire Radiative Power (low)		
Slow development of observation operator for Fire Radiative Power and linear CO (including tangent linear and adjoint) (low)	WP2	Work Package leaders are senior scientists that have several years of experience in developing observation operators and tangent linear and adjoint codes.
Developments in 4D-Var (extended control vector) not ready for assimilation tests with fire/vegetation model parameters (medium)	WP2	Close collaboration with CHE scientists who are working on a similar development for the anthropogenic component of the CO2 emissions.
Delays in the availability of the first prototype version of the fire modelling (low)	WP1, WP2, WP3, WP4	The consortium includes partners and personnel that have a long-established experience in working in an operational context and with the complexity of IFS. The adoption of a stepwise approach will minimise failures
Delays in the implementation of modelling and assimilation elements for the show cases (low)	WP3, WP4	The project timetable has been carefully designed to allow a small margin for delay / error. Timing has been based on previous project experience. Activities have also been designed to run in parallel as much as possible.
Problems with the integration of the different aspects to allow the show cases (medium)	WP3	FRAMES concept will be implemented in the ECMWF IFS. The strong contribution of several ECMWF senior scientists, and of partners that are former ECMWF employees and still contributes to the ECMWF-led services (e.g. CAMS) minimizes this risk. Also, a detailed Implementation Plan will be prepared at the start of the project. Special attention will be paid during the project to the communication at the interfaces between the modelling, assimilation, experimentation and validation activities to align activities and detect any risk related to the integration.
Incompatibilities between components during integration (low)	WP3	The different components will be gradually integrated. The consortium members have long experience in designing modelling and data assimilation aspects of land variables and atmospheric composition species, and will draw solutions from similar activities currently being run in other projects (e.g. CHE).
Implementation of aspects not aligned with the target services' evolutions (low)	WP3	The consortium includes partners and personnel that also have relevant roles in all the targeted Copernicus services to guarantee a continuous interaction with them so as to stay aligned to their envisaged plans. Members of the target Copernicus services' senior managements will be invited as members of FRAMES' advisory board.

Innovation Management: Effective innovation management within this project will require an overview of the project in its entirety and for this reason the PC will be responsible for the process of innovation management. The management of innovation activities is integral to FRAMES. By nature of the structure of the consortium and the work packages within the project, the technical, scientific and application aspects of innovation are addressed and combined. There is expertise regarding all these aspects represented in the consortium. Through the PC and within the management structure already identified above these elements

will be brought together and will ensure that innovative products are developed and exploited as a result of the project.

The PC, with support from the SC will produce an overview of the WPs and the outcomes of FRAMES to provide effective management and therefore exploitation of these both during and after the project.

At each stage of the project, the tasks associated with innovation management will be slightly different. The interfaces between elements of the proposed system and uptake form critical stages of innovation management because they define the proposed integration with and benefit for the Copernicus Services addressed**.**

- The innovation management will form an integral part of the Exploitation Plan (**D6.2**) which will be defined at an early stage in the project.
- At a more mature stage of the project, this plan will be adapted to take into account best practice methods of maximising the value of intellectual property, for dealing with technology transfer/exploitation/protection, and with the assessment of IP and research results.
- Finally, towards the end of the project, the focus will be on defining a strategy for the intellectual property exploitation after the project.

WP1, **WP2**, **WP3** and **WP4** include feedback options to other work packages. To ensure that the project responds to feedback in the most efficient way, the timings of the deliverables and milestones of the work packages have been planned to allow sufficient time to incorporate feedback and development. In this way, the project will be responsive to any opportunities that may arise. The EB will also ensure that any opportunities are addressed and incorporated if applicable.

Quality Management: The quality control management involves the product description and quality expectations of key deliverables, and a review and acceptance procedure. In case of software, the quality control process also comprises output from code testing and validation of results. The procedures for the quality control process of deliverables will be described in the Quality Manual (**D6.1**) taking into account Technology Readiness Levels (TRL). When a deliverable is ready for review, it will be forwarded to the PO, which will verify its general compliance before forwarding it to the EB. The EB can request revision of the deliverable before approval.

Intellectual Property Management: The CA that will be produced and signed after acceptance of the project will define and complete any points not covered by the EC Grant Agreement. It will formalize project management procedures but will also consider Intellectual Property Rights (IPR).

The innovation management will manage the strategy and the concrete actions of the consortium for the protection, exploitation and dissemination (Section 2.2) of the results of the project.

Based on the agreement outlined in the project's CA, a structured strategy for the protection of intellectual property arising from the project will be updated and implemented with consensus of all parties. The innovation management will be in charge of tracking and proposing commercialisation and exploitation strategies to the whole consortium. When needed, he/she will give advice to the parties concerned about the ownership, access rights, legal and commercial implications, patents, publications, copyrights, etc.

Administrative management: To ensure the transparency of the project management, all reports will be made available on the internal FRAMES website. Only documents or part of documents concerning individuals will be kept confidential. Two main reporting types are identified:

- *Reporting to the EC*: contractually, regular management and financial reports have to be submitted to the EC. The PS will draft the reports in due time and submit them to the PC for approval.
- *Internal Reporting*: to control the project, each partner will submit a monthly performance sheet to the PS. The PO will publish a monthly dashboard displaying the progress of the project and a management report will be presented during each EB meeting and annexed to the minutes.

Financial management: The budgets and advance payments will be distributed according to the provisions of the CA and the decisions of the GA. Budget forecasts will be established as an input for EB meetings. The information on participant expenses will be gathered following the reporting procedure and information from the management report.

3.3 Consortium as a whole

The FRAMES Consortium (Figure 12) is comprised of 12 partners from 8 European countries (United Kingdom, Netherlands, Finland, France, Italy, Greece, Spain and Portugal). Through ECMWF, the reach is extended beyond these 8 countries due to the member and cooperating states of the international organisations.

The partnership presents a well-balanced mixture of research organisations (FC.ID, CNR, NOA) very active SMEs (ASI and SRS), operational national forecast centres (IMPA, KNMI, FMI, MF), an International Organisations (ECMWF) as well as a community organisation (KIC). All partners have experience in collaborative research on a European level and have previously been engaged in FP projects.

The FRAMES Consortium makes for an excellent multi-disciplinary partnership able to produce the envisaged results presented above and with the requisite industrial involvement to ensure exploitation of the results after the end of the project. Figure 13 presents the balance between partner expertise as required by the FRAMES project. This shows that the partners provide all the requisite expertise to cover the objectives of the project.

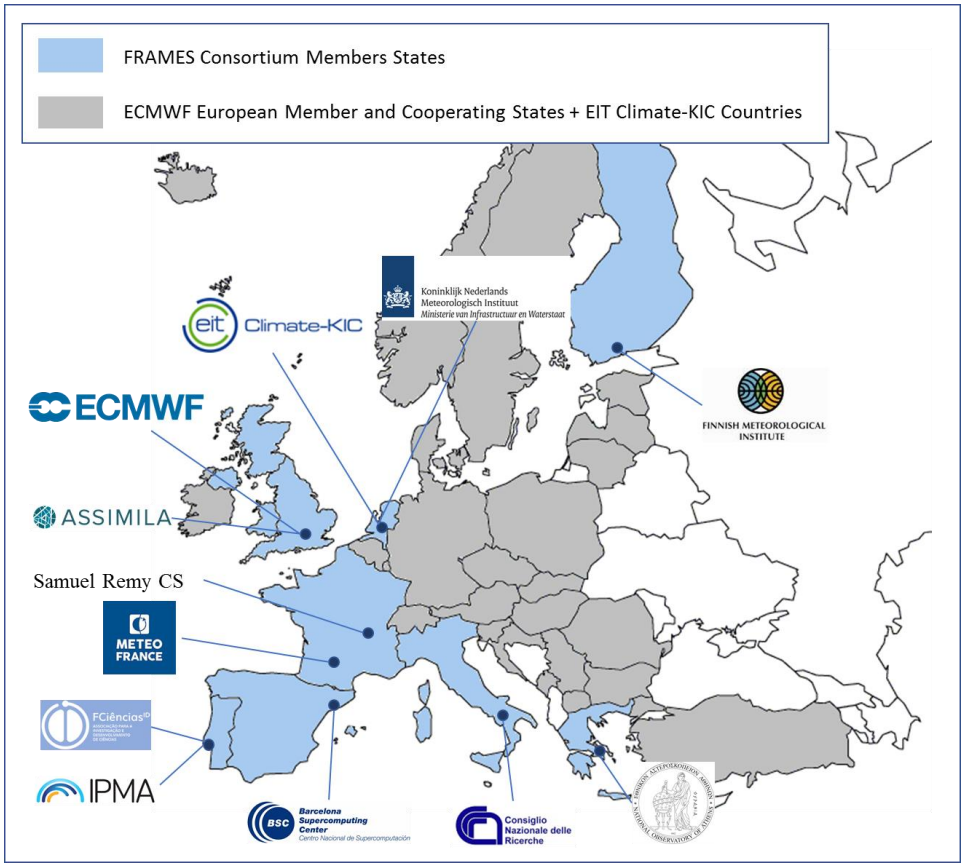


Figure 12: FRAMES Consortium

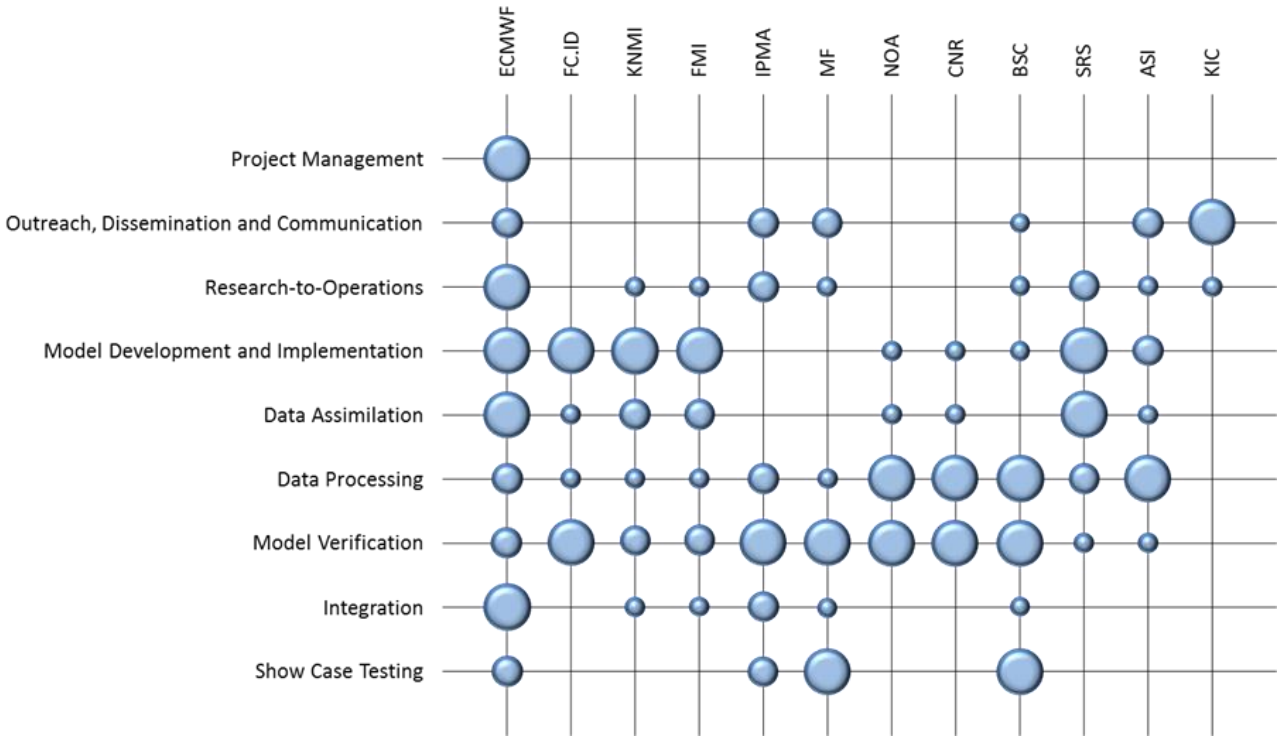


Figure 13: FRAMES Complementarity Matrix

3.4 Resources to be committed

The overall budget is outlined in the table below. In total, 314 Person Months (PM) will be deployed during the 3 years project time, averaging 8.72 persons per project month. The budget of €2,997,797.50 requested EC contribution is in line with the budget expectations indicated by the European Commission in the Call text. The Consortium considers this appropriate due to the complexity of the project and the uniqueness of its offerings requiring the involvement of a variety of partners. In addition, the FRAMES coordinator will provide in-kind contributions to support the management (WP6) of this challenging project, which will amount to an additional 9-12 person months.

	Personnel	*Travel*	*Audit*	*Workshops*	*Conferences/ Publications/ Website*	Total Other	Sub-contracting	Total Direct	Indirect	Total
ECMWF	806,491.00	*21,000.00*	*9,000.00*	*15,000.00*	*33,500.00*	78,500.00		884,991.00	221,247.75	**1,106,238.75**
FC.ID	158,400.00	*15,000.00*				15,000.00		173,400.00	43,350.00	**216,750.00**
KNMI	171,947.00	*15,000.00*				15,000.00		186,947.00	46,736.75	**233,683.75**
IPMA	148,500.00	*10,000.00*				10,000.00		158,500.00	39,625.00	**198,125.00**
CNR	108,000.00	*10,000.00*				10,000.00		118,000.00	29,500.00	**147,500.00**
NOA	72,000.00	*10,000.00*				10,000.00		82,000.00	20,500.00	**102,500.00**
FMI	240,000.00	*15,000.00*				15,000.00		255,000.00	63,750.00	**318,750.00**
ASI	72,000.00	*10,000.00*				10,000.00		82,000.00	20,500.00	**102,500.00**
SRS	120,000.00	*10,000.00*				10,000.00		130,000.00	32,500.00	**162,500.00**
KIC	48,000.00	*20,000.00*			*24,000.00*	44,000.00	8,000.00	100,000.00	23,000.00	**123,000.00**
MF	96,000.00	*10,000.00*				10,000.00		106,000.00	26,500.00	**132,500.00**
BSC	108,000.00	*15,000.00*				15,000.00		123,000.00	30,750.00	**153,750.00**
	2,149,338.00	**161,000.00**	**9,000.00**	**15,000.00**	**57,500.00**	**242,500.00**		**2,399,838.00**	**597,959.50**	**2,997,797.50**

Table 12 and Table 13 outline the efforts allocated to each partner and WP as well as the breakdown of "Other Direct Cost" for partners whose Other Direct Cost exceed 15% of the Personnel Cost.

Table 12: Summary of staff effort

	WP1	WP2	WP3	WP4	WP5	WP6	Total
01 ECMWF	20	20	12	6	12	12	82
02 FC.ID	18	5	6	5	1	1	36
03 KNMI	18	0	2	4	1	1	26
04 IPMA	0	5	8	18	1	1	33
05 CNR	0	2	10	10	1	1	24
06 NOA	0	2	10	10	1	1	24
07 FMI	20	0	0	2	1	1	24
08 ASI	0	5	3	0	0	1	9
09 SRS	2	9	0	0	0	1	12
10 KIC	0	0	1	0	6	1	8
11 MF	0	0	5	5	1	1	12
12 BSC	0	0	10	12	1	1	24
Total	**78**	**48**	**67**	**72**	**26**	**23**	**314**

Table 13: Other direct cost' items (travel, equipment, other goods and services, large research infrastructure)

10 - KIC	Cost (€)	Justification
Travel	20,000	Travel to Consortium Meetings
Equipment	-	
Other goods and services	24,000 16,000	Catering, venue hire, platform updates, communications, for fellowship programme Grants for participants to the fellowship programme
Total	60,000	

Figure **14** shows that research partners make up 34% of the effort which shows the scientific baseline of the FRAMES proposal. Nevertheless, industry (SMEs) represent 7% of the effort, while International Organisations and Operational centres are responsible for 59%. 7% has been attributed to Project Management, which will ensure that the project will successfully integrate the various stakeholders in the consortium.

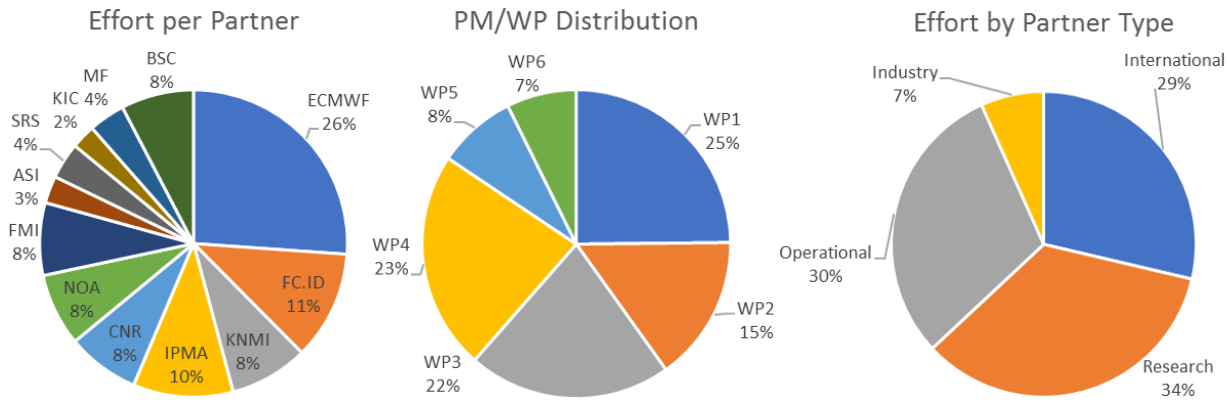


Figure 14: Effort Distributions

FIRE ACROSS MULTIPLE SERVICES

(FRAMES)

This proposal version was submitted by **Daniel THIEMERT** on **12/03/2019 14:32:07** Brussels Local Time. Issued by the Participant Portal Submission Service.

Contents

4 Members of the consortium

4.1 Participants (applicants)

4.1.1 ECMWF

European Centre for Medium-Range Weather Forecasts	ECMWF

About the Organisation

The European Centre for Medium-Range Weather Forecasts (ECMWF) is an international organization supported by 34 States: 22 Members (Austria, Belgium, Croatia, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom) and 12 Co-operating Members (Bulgaria, Czech Republic, Estonia, the former Yugoslav Republic of Macedonia, Hungary, Israel, Latvia, Lithuania, Montenegro, Morocco, Romania and Slovakia). ECMWF's principal objectives are the preparation, on a regular basis, of medium-range and long-range weather forecasts for distribution to the meteorological services of the Member States, the development of scientific and technical research directed to the improvement of these forecasts, and the collection and storage of appropriate meteorological data ECMWF's strategy includes the principal goals to provide reliable forecasts of severe weather across the medium-range and high-quality, near-surface forecast products focusing on areas such as precipitation, wind and temperature. ECMWF's computer facility includes supercomputers, archiving systems and networks.

ECMWF is the entrusted entity for the Copernicus Climate Change Service and the Copernicus Atmosphere Monitoring Service. The Copernicus Climate Change Service responds to environmental and societal challenges associated with human-induced climate change. The service will give access to information for monitoring and predicting climate change and will, therefore, help to support adaptation and mitigation. It benefits from a sustained network of in situ and satellite-based observations, re-analysis of the Earth climate and modelling scenarios, based on a variety of climate projections. The service will provide access to several climate indicators and climate indices for both the identified climate drivers and the expected climate impacts. The Copernicus Atmosphere Monitoring Service provides continuous data and information on atmospheric composition. The service consists of daily global forecasts of atmospheric composition, daily forecasts of European air quality, global and regional reanalyses, as well as services on solar radiation, greenhouse gases and emissions.

ECMWF is also the operational computational centre for the Copernicus Emergency Management Service (CEMS) for floods and fire. In its daily duties ECMWF provides daily fire danger forecast that are used by the Copernicus European Fire Forecast Information System (EFFIS) platform and its global counterpart, the Global Wildfire Information System (GWIS) which is part of the GEO program. ECMWF contributes also as a data provider to activities related to fire management and control in support of the European Response Coordination Centre (e.g Aristotle-2)

Role in this Project

ECMWF is FRAMES project coordinator and will be strongly involved in all aspects of the project from the inner research layers through all the aspects related to the service innovation, dissemination and outreach. ECMWF will achieve this through the renowned scientific excellence of its personnel and its high technical and operational capability.

Expertise with Relevance to this Project and Role

ECMWF is the operator of the Copernicus Atmospheric Monitoring Service (CAMS) and the Copernicus Climate Change (C3S) by delegation agreement with the EC. The Integrated Forecasting System (IFS) model is used in the CAMS global monitoring and forecasting component, and for the C3S global climate reanalysis and the ECMWF contribution to the seasonal multi-model forecast production. Further, operational ECMWF model output supports the product chain established by the European Flood Awareness System (EFAS) and the European Forest Fire Information System (EFFIS) in the Copernicus Emergency Management Service (CEMS). Furthermore, ECMWF is also project coordinator of a preparatory H2020 project, CO_2 Human Emission (CHE) that has the potential to develop into an operational Copernicus service element for the monitoring of

anthropogenic CO_2. Given the above ECMWF has a very strong expertise on all aspects related to the Copernicus services

Key Persons

Dr Francesca Di Giuseppe (female) joined ECMWF in 2011 as a scientist in the Research department. She holds a physics Degree from the University of Bologna (Italy) and a PhD in Meteorology from the University of Reading (UK). She is currently a Principal scientist leading the fire forecasting group which is responsible for the operation of the Copernicus Emergency Management Service fire. She is the ECMWF PI of several projects, e.g. SMOS-E, ARISTOTLE-2 that are devoted to both the scientific developments of new fire products as well as their operational uptake. In FRAMES, she acts as Project Coordinator, and WP 6 leader. Furthermore, given her established link with the CEMS community she e will make sure that the CEMS-related show case meets the user needs and requirements.

Dr Rossana Dragani (female) joined ECMWF in April 2006 as scientist in the Research Department. She holds a Master Degree in Physics from the University of L'Aquila (Italy), and a PhD in Meteorology from the University of Reading (UK). She is currently senior scientist at ECMWF and serves in both the Research Department where she leads the Atmospheric Composition team, and the Copernicus Department as Technical Officer for the Copernicus Climate Change Service. In 2018, she has coordinated the ECMWF roadmap for *Atmospheric Composition priorities for NWP*, and currently its implementation. She is the ECMWF PI of several projects, e.g. CMUG, which is part of the ESA CCI, and the H2020 AURORA. In FRAMES, she acts as Scientific Coordinator, and WP 3 leader. Furthermore, she will make sure that the C3S-related show cases meet the C3S needs and requirements.

Dr Mark Parrington (male) joined ECMWF in the summer of 2013 to work on assimilation of atmospheric composition profiles observed by satellite and aircraft measurements under the MACC-II and IGAS projects. He is currently a senior scientist in the Copernicus Atmosphere Monitoring Service (CAMS) Development Section working on wildfire emissions, and emissions from anthropogenic and natural sources, and their influence on global atmospheric composition. In FRAMES, he acts as WP 3 leader and he will make sure that the CAMS-related show cases meet the user need and requirements.

Dr Angela Benedetti (female) is a senior scientist in the Atmospheric Composition team of the Earth System Predictability section (Research Department). She joined ECMWF in October 2002 as a research consultant in cloud radar data assimilation. She was the main architect of the aerosol analysis that is now operational at ECMWF as part of the Copernicus Atmospheric Monitoring Service (CAMS) and she continues to pioneer the assimilation of new observations, such as satellite and ground-based lidar profiles of aerosol backscatter. Her most recent research focuses on the radiative impact of atmospheric aerosols on weather at the monthly and seasonal scales. In FRAMES, she acts a WP2 leader.

Dr Daniel Thiemert (male) joined ECMWF in 2015 as Project Manager in the Research Department. Before joining ECMWF, he was working for the University of Reading as Senior Researcher and Project Manager, being responsible for the management and coordinator of large scale European and national projects in the area of intelligent systems. He obtained his masters in computer science from the Anhalt University of Applied Sciences, Germany, and his PhD in Computer Science from the University of Reading, UK. At ECMWF he is responsible for the project management of the EU-funded projects CHE, ESCAPE and ESCPAE-2, as well as for managing externally funded project acquisition. Daniel will be the project supervisor/ manager for FRAMES.

Relevant Publications (up to 5)

1. **Di Giuseppe, F**., Rémy, S., Pappenberger, F., and Wetterhall, F.: Using the Fire Weather Index (FWI) to improve the estimation of fire emissions from fire radiative power (FRP) observations, Atmos. Chem. Phys., 18, 5359-5370, https://doi.org/10.5194/acp-18-5359-2018, 2018.
2. **Benedetti**, A. and F. Vitart, 2018: Can the Direct Effect of Aerosols Improve Subseasonal Predictability?. Mon. Wea. Rev., 146, 3481–3498, https://doi.org/10.1175/MWR-D-17-0282.1
3. **Benedetti, A**., Reid, J. S., Knippertz, P., Marsham, J. H., **Di Giuseppe**, F., **Rémy**, S., Basart, S., Boucher, O., Brooks, I. M., Menut, L., **Mona**, L., Laj, P., Pappalardo, G., Wiedensohler, A., Baklanov, A., Brooks, M., Colarco, P. R., Cuevas, E., da Silva, A., Escribano, J., Flemming, J., Huneeus, N., Jorba, O., Kazadzis, S., Kinne, S., Popp, T., Quinn, P. K., Sekiyama, T. T., Tanaka, T., and Terradellas, E.: Status and future of numerical atmospheric aerosol prediction with a focus on data requirements, Atmos. Chem. Phys., 18, 10615-10643, https://doi.org/10.5194/acp-18-10615-2018, 2018.

4. Flemming, J., **Benedetti, A.**, Inness, A., Engelen, R. J., Jones, L., Huijnen, V., **Remy, S.**, **Parrington, M.**, Suttie, M., Bozzo, A., Peuch, V.-H., Akritidis, D., and Katragkou, E.: The CAMS interim Reanalysis of Carbon Monoxide, Ozone and Aerosol for 2003–2015, Atmos. Chem. Phys., 17, 1945-1983, https://doi.org/10.5194/acp-17-1945-2017, 2017.
5. **Di Giuseppe, F.,** F. Pappenberger, F. Wetterhall, B. Krzeminski, A. Camia, G. Libertá, and J. San Miguel, 2016: The Potential Predictability of Fire Danger Provided by Numerical Weather Prediction. J. Appl. Meteor. Climatol., 55, 2469–2491, https://doi.org/10.1175/JAMC-D-15-0297.1

Recent Projects (up to 5)

- Copernicus - Fire Danger Forecast Computation Contract (933720)
- CHE CO2 Human Emissions - EU H2020 776186
- Computational Centre for the Copernicus Emergency Service European Flood Awareness System
- Entrusted Entity for the implementation of the Copernicus Atmosphere Monitoring Service CAMS
- Entrusted Entity for the implementation of the Copernicus Climate Change Service C3S

Major Hardware/ Infrastructure available

ECMWF maintains a multi-petaflops supercomputer facility which is designed for operational resiliency featuring two Cray XC40 systems and independent Cray Sonexion storage systems. Each subsystem consists of 20 Cray XC40 cabinets equipped with Intel Broadwell processors and around 3,600 dual-socket compute nodes per system, a number of Cray Development and Login nodes and around 10 petabytes of Lustre storage with the ability to cross mount the Lustre file systems between the halls.

4.1.2 FC.ID

FCiências.ID - Associação para a Investigação e Desenvolvimento de Ciências

About the Organisation

FCiências.ID – Associação para a Investigação e Desenvolvimento de Ciências (FC.ID), is a Non-Profit Private Association, endowed with legal personality. It was created in 2017 as an common initiative of Faculdade de Ciências da Universidade de Lisboa (FCUL) - a Higher Education institution - and 6 private companies, in order to support, potentiate and develop Research and Development (R&D) and innovation activities of its seven associates, while, simultaneously enhancing FCUL strategic partnerships with market and services companies, therefore creating a more challenging environment for research and innovation. FCiências.ID is the legal representative of 20 research centres, in several scientific fields. FCiências.ID responsibilities are related to the administrative, financial and scientific management of the research centres R&D projects, and also to performing research work. Many of these R&D activities are developed together with international teams and are funded both at National and European levels.

Faculdade de Ciências da Universidade de Lisboa (FCUL), based on a third party agreement, acts as a third party of FC.ID carrying out its own share of work, notwithstanding the full responsibility of FC.ID for the contracted scientific and technical work under specific R&D projects. At European level, FC.ID is currently managing 6 FP7 projects, 30 H2020 projects, including 3 projects coordinated by FC.ID and 2 ERC Grants, and one COST Action as Grant Holder.

IDL, a FCUL based Associate Laboratory, is focused on quantitative Earth Science research, combining analytical studies, data analysis, observational activities and modelling, relevant for Atmospheric, Ocean and Solid Earth processes, and Renewable Energy applications. As an integrated Earth System Science institute, IDL supports cross-discipline interactions, most relevant for the understanding of Earth processes driven by the interaction of different Earth components. At FCUL, IDL leads the FCT Doctoral Program on Earth System Science (EARTHSYSTEMS), and is a partner of the nationwide FCT Doctoral Program on Sustainable Energy Systems (MIT-Portugal), offering its researchers excellent opportunities to attract young gifted students to new areas of research.IDL operates a modern High Performance Computing system, and several state of the art laboratories in different domains of Geosciences and Applications.

Role in this Project

In FRAMES FC.ID will especially contribute to WP 1 focusing on the representation of vegetation on the model as well as its evolution following fires and its impact on other land surface characteristics such as surface albedo.

Expertise with Relevance to this Project and Role

IDL has a long-term experience in wildfires risk assessment and forecast as well as land-surface modelling which are two key components of the project.

Key Persons

Emanuel Dutra (Male) is a researcher at IDL/FCUL. Emanuel Dutra (1983) expertise encompasses land surface processes, large-scale hydrology and drought monitoring and forecasting. After his PhD in 2011 he joined ECMWF for 6 years where he worked in several EU FP7 projects related with water resources and seasonal forecasting. He (co)-authored more than 50 publications in international peer-reviewed journals.

Ricardo Trigo (Male) – is an associate professor in Climatology and Climate Variability and Change at FCUL, and IDL director. Ricardo Trigo (1967) is an expert in climate variability and climate change topics particularly in southern Europe, with a large contribution to the analysis and characterization of atmospheric circulation tools. In recent years he has focused preferentially on the occurrence of extreme events including: heatwaves, floods, droughts, landslides, wildfires. He (co)-authored over 150 publications in international peer-reviewed journals.

Carlos C. DaCamara (Male) – is an associate professor at FCUL and a senior researcher at IDL. Research by Carlos C. DaCamara (1957) encompasses a variety of fields that include remote sensing of active fires and burned areas by satellite, the short and medium range assessment of meteorological fire risk, the recovery of vegetation after large wild fires, the retrieval of land surface temperature and emissivity using information from satellite, the meteorological conditions associated to extreme (droughts, heat waves, etc.) and the activity of planetary waves in the atmosphere and its impact on climate variability. He (co)-authored 60 publications in international peer-reviewed journals and has supervised 18 PhD theses.

Relevant Publications (up to 5)

6. Boussetta, S., Balsamo, G., **Dutra, E.**, Beljaars, A., & Albergel, C. (2015). Assimilation of surface albedo and vegetation states from satellite observations and their impact on numerical weather prediction. Remote Sensing of Environment, 163, 111–126. doi: 10.1016/j.rse.2015.03.009.
7. Bastos A., Gouveia C.M., **DaCamara C.C., Trigo R.M**. (2011) Modelling post-fire vegetation recovery in Portugal. Biogeosciences, 8, 3593-3607, 2011, doi:10.5194/bg-8-3593-2011
8. Pinto MM, **DaCamara CC**, Trigo IF, **Trigo RM**, Turkman KF (2018) Fire danger rating over Mediterranean Europe based on fire radiative power derived from Meteosat. Natural Hazards and Earth System Sciences 18, 515–529. doi:10.5194/nhess-18-515-2018
9. Turco M., von Hardenberg J., AghaKouchak A., Llasat M., Provenzale A., **Trigo, R.M**., Espirito-Santo F. (2017) "On the key role of droughts in the dynamics of summer fires in Mediterranean Europe". Scientific Reports, 7, 81, doi: 10.1038/s41598-017-00116-9
10. Agustí-Panareda, A., Massart, S., Chevallier, F., Balsamo, G., Boussetta, S., **Dutra, E.**, & Beljaars, A. (2016). A biogenic CO2 flux adjustment scheme for the mitigation of large-scale biases in global atmospheric CO2 analyses and forecasts. *Atmospheric Chemistry and Physics*, *16*, 10399–10418. doi: 10.5194/acp-16-10399-2016

Recent Projects (up to 5)

- ERA-CLIM2: EU FP7 607029
- EUPORIAS: EU FP7 308291
- FUME: EU FP7 243888
- FAPESP/FCT Project Brazilian Fire-Land- Atmosphere System (BrFLAS) (FCT 2015/01389-4 and FAPESP/1389/2014) (FCT- Portuguese National Science Foundation)

Major Hardware/ Infrastructure available

Linux based high performance computing system with 800 cores and 400TB of data storage.

4.1.3 KNMI

Royal Netherlands Meteorological Institute

Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat

About the Organisation

KNMI is the Dutch national weather service and centre for climate research. The institute combines in house operational as well as strategic research tasks. As an integral part of the Ministry of Infrastructure and Environment KNMI provides on a day-to-day basis advice on weather and climate to national, regional and local authorities. KNMI is participating in many European projects on both climate and space research and keeps close ties with many of its stakeholders.

Role in this Project

KNMI will bring in its expertise on the modelling of tropospheric chemistry, and NO2 observations from the TropOMI satellite instrument. It will contribute to the modelling of simplified atmospheric chemistry that can be used in the operational model configuration to develop a method for the optimization of emissions. KNMI has extensively contributed in the past to the modelling setup of the CAMS modelling chains going from the scientific investigation of solutions into the designing innovative strategies for the operational. KNMI long standing expertise in working with IFS will be an asset through the challenging tasks of FRAMES

Expertise with Relevance to this Project and Role

Within the division Research and Development, Weather and Climate Modelling, the TM5 chemistry and aerosol model has been developed and maintained, which forms an important building block in many modelling and retrieval applications. KNMI is leading the tender on the development of reactive gases modelling within the Copernicus Atmosphere Monitoring Service (CAMS). Furthermore, as part of a Europe-wide consortium KNMI is contributing to the development of EC-Earth, an Earth System Model to study future climate. The coupling to the TM5 chemistry and aerosol model is investigated.

The KNMI space research division has a long-standing experience and expertise with satellite missions observing atmospheric composition. In particular, KNMI hosts also the PI for the Sentinel-5 Precursor (TROPOMI) which delivers crucial data to be assimilated by CAMS in the near future.

Key Persons

Vincent Huijnen (Male) - Vincent has built up over a decade of research experience in the field of atmospheric chemistry. He is one of the main co-developers of the integrated chemistry in the IFS system, which is currently operational in CAMS. Vincent currently coordinates the CAMS tender on global reactive gases modelling. As such he has established close collaborations with other elements in the CAMS service (particularly global aerosol modelling, emissions) and also has worked in the past on a-posteriori validation. Amongst his research interests have been in particular large fire events in Russia (2010) and Indonesia (2015).

Relevant Publications (up to 5)

1. **Huijnen** *et al.*, Fire carbon emissions over maritime southeast Asia in 2015 largest since 1997, Sci. Rep. 2016
2. Flemming, … **Huijnen**, *et al.,* The CAMS interim Reanalysis of Carbon Monoxide, Ozone and Aerosol for 2003-2015. ACP 2017.
3. Flemming, **Huijnen**, *et al.,* Tropospheric chemistry in the integrated forecasting system of ECMWF. GMD 2015.
4. **Huijnen** *et al.,* Hindcast experiments of tropospheric composition during the summer 2010 fires over western Russia. ACP 2012.
5. **Huijnen** *et al.*, The global chemistry transport model TM5: Description and evaluation of the tropospheric chemistry version 3.0, GMD 2010

Recent Projects (up to 5)

- CAMS_42: Tender on global reactive gases modelling within CAMS (2016-2019)
- CAMS_84: First tender on Global a-posteriori Validation (2015-2016)

- MACC (Monitoring Atmospheric Composition and Climate, 2009-2015)

Major Hardware/ Infrastructure available

KNMI key infrastructure entails modern IT and research infrastructure; a 4752 core Bull B500 supercomputer with 396 nodes, each containing 2 Intel Xeon X5675 processors. Also KNMI has large experience with ECMWF supercomputers.

4.1.4 IPMA

Instituto Português do Mar e da Atmosfera

About the Organisation

IPMA is the Portuguese National Meteorological Service, therefore responsible for monitoring weather and climate in Portugal, issuing weather forecasts and, when appropriate, meteorological warnings, operating and maintaining the network of national meteorological stations, monitoring the seismic activity, and for developing R&D in the fields of meteorology, climatology, earth observation and seismology. IPMA staff include, amongst others, technical staff, forecasters and researchers. Remote sensing projects and services are under IPMA's Scientific Coordination together with the Remote Sensing Section. While the former supervises the overall scientific and technical requirements of projects, the latter ensures the necessary infrastructure (input data and hardware) are in place for the project development and respective service implementation, when applicable.

As part of its operational commitments and R&D initiatives, IPMA makes extensive use of remote sensing data, mostly obtained from meteorological satellites. In particular, IPMA is the leading entity for the EUMETSAT Satellite Applications Facility on Land Surface Analysis (LSA SAF). The LSA SAF is focused on the development of remote sensing applications to characterize land surfaces, evaluate the surface radiation budget, and monitor vegetation and wild fires. Given Portugal's location in an area which is particularly vulnerable to forest and landscape fires, IPMA has a long experience in evaluating fire risk and in monitoring fire events. Within projects, such as the LSA-SAF, Copernicus Global Land, CAMS, and ARISTOTLE-2, such activities are maintained at different scales, ranging from regional to global.

As part of the LSA SAF and Copernicus-related initiatives, IPMA implemented and maintains a set of chains for processing, archiving and near-real time/off-line dissemination of remote sensing products.

Role in this Project

IPMA leads the verification aspects related to the fuel/ vegetation representation. Given its strong connection with the Copernicus Global Land service and its institutional role in fire early warning in Portugal, IPMA also acts as the connection point for the uptake of FRAMES products and the validation in an operational contest (WP3)

Expertise with Relevance to this Project and Role

Within WP4 and WP3, IPMA's contribution will be built on its experience in the generation and evaluation of remotely sensed products over land surfaces, together with expertise in the use of such data to evaluate model outputs. The involvement of IPMA in several Copernicus activities will be an asset to bridge the work developed within FRAMES and Copernicus services.

Key Persons

Isabel F. Trigo (female) graduated in Geophysical Sciences from the University of Lisbon (Portugal) and received her the Ph.D. degree from the University of East Anglia (UK). Dr Trigo initiated her research career in the area of climate variability and gradually moved into the use of satellite data to monitor land surfaces. Currently, Dr Trigo is a senior researcher at *Instituto Português do Mar e da Atmosfera*, IPMA (Portugal), where she leads the Remote Sensing Group. Her research focuses on applications of remote sensing observations to derive land surface variables, and on their use to better understand and model land surface processes. She is the Scientific Coordinator for the EUMETSAT Satellite Applications Facility on Land Surface Analysis (LSA SAF) and has acted as local PI for several international products funded by ESA, and by Copernicus and European Programmes.

Célia Gouveia (female) graduated in Geophysics (Meteorology/Oceanography) and in 2008 she got her PhD degree in Geophysical and Geoinformation Sciences (Remote Sensing) at the Faculty of Sciences, University of Lisbon. Dr. Gouveia PhD subject was related with the impact of climate variability on vegetation dynamics, using remote sensing information. During the last years she has focused in the climate impacts on vegetation status, namely in the case of extreme events, such as droughts, heat waves and wildfires. Dr Gouveia was an Assistant Professor at Instituto Politecnico de Setubal (1999 to 2014) and a researcher at Faculty of Science University of Lisbon (2014-2017) and currently is an assistant research at *Instituto Português do Mar e da Atmosfera*, IPMA (Portugal) and an invited assistant professor at Faculty of Sciences, University of Lisbon. She has participated as member of the research team of several national projects and EU funded projects and is now a researcher for the EUMETSAT Satellite Applications Facility on Land Surface Analysis (LSA SAF).

Relevant Publications (up to 5)

1. **Trigo**, I.F., S. Boussetta, P. Viterbo, G. Balsamo, A. Beljaars, I. Sandu, 2015: Comparison of model land skin temperature with remotely sensed estimates and assessment of surface-atmosphere coupling, J. Geophys. Res., 120, doi: 10.1002/2015JD023812
2. Balsamo, G.; Agusti-Panareda, A.; Albergel, C.; Arduini, G.; Beljaars, A.; Bidlot, J.; Bousserez, N.; Boussetta, S.; Brown, A.; Buizza, R.; Buontempo, C.; Chevallier, F.; Choulga, M.; Cloke, H.; Cronin, M.F.; Dahoui, M.; De Rosnay, P.; Dirmeyer, P.A.; Dutra, M.D.E.; Ek, M.B.; Gentine, P.; Hewitt, H.; Keeley, S.P.E.; Kerr, Y.; Kumar, S.; Lupu, C.; Mahfouf, J.-F.; McNorton, J.; Mecklenburg, S.; Mogensen, K.; Muñoz-Sabater, J.; Orth, R.; Rabier, F.; Reichle, R.; Ruston, B.; Pappenberger, F.; Sandu, I.; Seneviratne, S.I.; Tietsche, S.; **Trigo**, I.F.; Uijlenhoet, R.; Wedi, N.; Woolway, R.I.; Zeng, X. (2018) Satellite and In Situ Observations for Advancing Global Earth Surface Modelling: A Review. *Remote Sens*., 10, 2038, doi: 10.3390/rs1012203.
3. **Trigo**, I. F., C. C. DaCamara, P. Viterbo, J.-L. Roujean, F. Olesen, C. Barroso, F. Camacho-de Coca, D. Carrer, S. C. Freitas, J. García-Haro, B. Geiger, F. Gellens-Meulenberghs, N. Ghilain, J. Meliá, L. Pessanha, N. Siljamo, and A. Arboleda, 2011: The Satellite Application Facility on Land Surface Analysis. Int. J. Remote Sens., 32, 2725-2744, doi: 10.1080/01431161003743199
4. **Gouveia** C. M., Bistinas I. Liberato M.L.R., Bastos A., Koutsias N., and Trigo R. M., 2016. The combined effect of drought and heat waves on the 2007 Southern Greece exceptional fire season, Journal of Agriculture and Forest Meteorology, 218-219: 135-145 http://http://dx.doi.org/10.1016/j.agrformet.2015.11.023.
5. **Gouveia**, C.M., Páscoa, P. and DaCamara C. (2017) Postfire vegetation recovery in Iberia based on remote. doi.org/10.5772/intechopen.72594

Recent Projects (up to 5)

- EUMETSAT Satellite Applications Facility on Land Surface Analysis CDOP-3 (2017–2022)
- Copernicus Atmospheric Monitoring Service – Development of the global fire assimilation system (CAMS_44) (2015 – 2019)
- Copernicus Global Land Service – Operational Phase Lot 1 (C-GLOPS-1) (2015 – 2019)
- ARISTOTLE-2 (All Risk Integrated System TOwards The hoListic Early-warning) European Natural Hazard Scientific Partnership (2018-2020)
- BrFLAS (Brazilian Fire-Land-Atmosphere System), FAPESP/1389/2014 (2016-2019).

Major Hardware/ Infrastructure available

IPMA headquarters have an array of IT equipment typical of a National Meteorological Service, ranging from communications to computing facilities. Several no-break services guarantee the resilience of the crucial systems in case of power failure. Dedicated lines ensure 24/7 communications with the WMO communications system. As part of the LSA SAF and Copernicus-related initiatives, IPMA implemented a set of chains for processing, archiving and near-real time/off-line dissemination of remote sensing products.

4.1.5 CNR

Consiglio Nazionale delle Ricerche

About the Organisation

The National Research Council (CNR) is the largest public research institution in Italy, and the only one under the Research Ministry performing multidisciplinary activities.

CNR-IMAA (Istituto di Metodologie per l'Analisi Ambientale) is one of the CNR institutes. Its research activities involve more than 100 researchers and make use of laboratories and facilities of international relevance in the field of the Earth Observation. The expertise of CNR-IMAA staff in atmospheric studies covers a large range of aspects, from aerosols to clouds using in-situ measurements and satellite monitoring. The CNR-IMAA plays an ever-increasing role of excellence in the international community for observationally-based atmospheric studies.

Role in this Project

CNR will bring in this project its expertise with ACTRIS RI data and methods for aerosol remote sensing observations and characterization.

The CNR efforts in FRAMES will be related mainly to the evaluation of the methods developed during the projectand the co-design of the show cases

Expertise with Relevance to this Project and Role

CNR-IMAA has a leadership role in the remote sensing community, characterized by a high scientific productivity and by the proven capability to provide support and technological transfer to end users. CNR-IMAA has coordinated and participated in a large number of national, European and international projects. The CNR-IMAA is currently involved in research projects and initiatives related to the application of ACTRIS/EARLINET observations for model assimilation, verification and evaluation.

CNR will also contribute to the leadership of WP4

Key Persons

Lucia Mona (female) – Researcher

Dr. Lucia Mona is responsible of the EARLINET (European Aerosol Research Lidar NETwork)/ACTRIS database and is working on exploitation of EARLINET database for comparison/integration with other ground-based and satellite measurements and models and model evaluation/integration studies for peculiar long-range transport cases and for multi-year observation. Dr Mona has a researcher profile that combines expertise on developments of lidar systems, instruments integration/combination, analysis methodologies, exploitation of state-of-the-art measurements for different application fields and integrated studies with models.

The high level of Dr. Mona's research to date has been recognized at international level by the large number of participations in working groups as a key scientist and by the number of oral presentations and citations to her papers. She has participated in international measurement campaigns, (such as EAQUATE and SAMUM) and in many national and international projects during FP5, FP6 and FP7.

Currently she is participating in international current projects: DustClim (ERA4CS), ACTRIS PPP (H2020), EUNADICS-AV (H2020), ECARS (H2020), ACTRIS2 (H2020), ENVRIplus (H2020). She is currently leading the WP3 of EUNADICS-AV about the Observational infrastructure and the WG4 of the InDust COST action.

She is leading the AEROSAT (International Satellite Aerosol Science Network) Working Group on Aerosol Typing. She is member of the Regional Steering Group of the SDS-WAS (Sand and Dust Storm Warning Advisory and Assessment System) of the WMO.

Nikolaos Papagiannopoulos (male) – Researcher

Dr Nikolaos Papagiannopoulos is strongly involved in EARLINET/ACTRIS and his research makes use of the network's database in diverse applications. His expertise includes satellite validation studies, automated aerosol classification, and development of methodologies for lidar applications. Moreover, he has participated in measurement campaigns (i.e., ATHL16, THELI18, ACTRIS IOP 2012). Overall, Dr Papagiannopoulos experience has demonstrated the ability to integrate different instrumentation, to operate aerosol models, and to develop analysis methodologies.

Currently, Dr Papagiannopoulos participates in several international projects H2020 EUNADICS-AV, H2020 ACTRIS-2, H2020 EnvriPlus, and H2020 GAIA-CLIM

Serena Trippetta (female) – Researcher

Dr. Serena Trippetta is working on the integration of in-situ and remote sensing techniques for the study of the atmospheric aerosols and on the application of multivariate statistical techniques (e.g., Principal Component Analysis, Cluster Analysis) for the identification of their emission sources, both natural and anthopogenic.

Currently she is participating in international projects - such as DustClim (ERA4CS) and InDust COST action - dealing with the study of atmospheric dust and their impact on key economic sectors such as air quality/health, energy and aviation.

Relevant Publications (up to 5)

1. Pappalardo, G., Amodeo, A., Apituley, A., Comeron, A., Freudenthaler, V., Linné, H., Ansmann, A., Bösenberg, J., D'Amico, G., Mattis, I., **Mona**, L., Wandinger, U., Amiridis, V., Alados-Arboledas, L., Nicolae, D., and Wiegner, M.: EARLINET: towards an advanced sustainable European aerosol lidar network, Atmos. Meas. Tech., 7, 2389-2409, https://doi.org/10.5194/amt-7-2389-2014, 2014.
2. **Mona**, L., Papagiannopoulos, N., Basart, S., Baldasano, J., Binietoglou, I., Cornacchia, C., and Pappalardo, G.: EARLINET dust observations vs. BSC-DREAM8b modeled profiles: 12-year-long systematic comparison at Potenza, Italy, Atmos. Chem. Phys., 14, 8781-8793, https://doi.org/10.5194/acp-14-8781-2014, 2014.
3. Papagiannopoulos, N., **Mona**, L., Amodeo, A., D'Amico, G., Gumà Claramunt, P., Pappalardo, G., Alados-Arboledas, L., Guerrero-Rascado, J. L., Amiridis, V., Kokkalis, P., Apituley, A., Baars, H., Schwarz, A., Wandinger, U., Binietoglou, I., Nicolae, D., Bortoli, D., Comerón, A., Rodríguez-Gómez, A., Sicard, M., Papayannis, A., and Wiegner, M.: An automatic observation-based aerosol typing method for EARLINET, Atmos. Chem. Phys., 18, 15879-15901, https://doi.org/10.5194/acp-18-15879-2018, 2018.
4. Binietoglou, I., Basart, S., Alados-Arboledas, L., Amiridis, V., Argyrouli, A., Baars, H., Baldasano, J. M., Balis, D., Belegante, L., Bravo-Aranda, J. A., Burlizzi, P., Carrasco, V., Chaikovsky, A., Comerón, A., D'Amico, G., Filioglou, M., Granados-Muñoz, M. J., Guerrero-Rascado, J. L., Ilic, L., Kokkalis, P., Maurizi, A., **Mona**, L., Monti, F., Muñoz-Porcar, C., Nicolae, D., Papayannis, A., Pappalardo, G., Pejanovic, G., Pereira, S. N., Perrone, M. R., Pietruczuk, A., Posyniak, M., Rocadenbosch, F., Rodríguez-Gómez, A., Sicard, M., Siomos, N., Szkop, A., Terradellas, E., Tsekeri, A., Vukovic, A., Wandinger, U., and Wagner, J.: A methodology for investigating dust model performance using synergistic EARLINET/AERONET dust concentration retrievals, Atmos. Meas. Tech., 8, 3577-3600, https://doi.org/10.5194/amt-8-3577-2015, 2015.
5. D'Amico, G., Amodeo, A., Baars, H., Binietoglou, I., Freudenthaler, V., Mattis, I., Wandinger, U., and Pappalardo, G.: EARLINET Single Calculus Chain – overview on methodology and strategy, Atmos. Meas. Tech., 8, 4891-4916, https://doi.org/10.5194/amt-8-4891-2015, 2015.

Recent Projects (up to 5)

- DustClim
- EUNADICS-AV
- ACTRIS2
- ACTRIS PPP
- COST InDust

Major Hardware/ Infrastructure available

ACTRIS/EARLINET database and processing chain

4.1.6 NOA

National Observatory of Athens

About the Organisation

The National Observatory of Athens (NOA - http://www.noa.gr) has a constant presence in Science and education activities at international level for more than 170 years, being the first research Institute that was founded in Greece (1842). The activities in NOA are organized around 3 institutes: the Institute of Astronomy, Astrophysics, Space Applications and Remote Sensing (**IAASARS**) (participating in this proposal), the Institute of Environmental Research and Sustainable Development (IERSD), and the Geodynamics Institute (GI).

IAASARS/NOA has been actively involved in Space Applications and Earth Observation (EO) with remarkable achievements in leading research, and operational activities in the context of EU flagship programs/initiatives namely COPERNICUS, GALILEO and GEO. On operational level the Institute employs a strong ground-based remote sensing component, participating in ACTRIS Research Infrastructure, including state-of-the-art monitoring facilities like the advanced Polly ^{XT} lidar and the AERONET sunphotometric station in the island of Antikythera, Greece. Taking advantage of the existing EO receiving infrastructures, and the secured access to space agencies as ESA and NASA, as well as the use of ground-based infrastructure and advanced models, the Institute provides near real time observations and services to operational program frameworks of EU, ESA and to authorities and entities, at national and European level (e.g. ministries, civil protection authorities, municipalities, regional services, environmental organizations).

Regarding its contributions in international activities and networks, the Institute:

a) Hosts the Focal Point on the Global Earth Observing System of Systems (GEOSS) that is one of the four national GEO Offices in the World (Canada, Germany, USA, and Greece).

b) Hosts the UNESCO Chair for Natural Disasters, established within the framework of UNESCO-BRESCE

c) Is member of international monitoring networks such as the NASA-AERONET global sunphotometric network (http://aeronet.gsfc.nasa.gov/), the EARLINET lidar network (http://earlinet.org/), the ACTRIS (http://www.actris.eu/), the Direct Broadcast community of NASA (http://directreadout.sci.gsfc.nasa.gov/), and the European Fire Monitoring Center.

d) Is part of Product Validation and Evolution Teams related to CalVal activities of future ESA missions such as ADM-Aeolus and EarthCARE.

Role in this Project

NOA will mostly contribute to WP4 focusing on evaluating aerosol products by providing NRT optical properties such as the aerosol extinction, backscatter and absorption coefficients as well as aerosol concentration profiles from the synergy of ground-based lidar and sunphotometric observations (ACTRIS Aerosol Remote Sensing National Facility). The measurements are systematically obtained with the multi-wavelength lidar system Polly ^{XT} and the CIMEL sunphotometer, both located in NOA's background remote sensing station for climate research PANGEA, frequently affected by smoke from forest fires in Greece.

Expertise with Relevance to this Project and Role

Implementation of sophisticated ground-based active and passive remote sensing techniques for the characterization of the optical, microphysical and chemical properties of atmospheric aerosols. Aerosol/Cloud interactions. Investigating atmospheric aerosol radiative impact and climatic role. Space borne lidar validation/ calibration studies. Model validation with the use of remote sensing measurements.

Key Persons

Vassilis Amiridis (Male)

Vassilis Amiridis (VA) is a Research Director of the National Observatory of Athens (NOA/IAASARS). He is working on climate research and he focuses on the impact of atmospheric aerosols and clouds on radiation and extreme weather. His research is mainly based on advanced ground-based and space-borne remote sensing observations (passive and active remote sensing techniques) and theoretical models. VA has participated in 32 research projects and experimental campaigns, in 6 of which as coordinator and 4 as Principal Investigator for IAASARS/NOA. He has more than 90 publications in peer-reviewed scientific journals and his work received more than 2200 citations from third-party (h-index = 30, source: ISI Web of Knowledge). VA is leading the Atmospheric Remote Sensing group in IAASARS/NOA, currently composed of 15 members (7 Postdocs, 7 PhDs and 2 support staff). He is a member of the editorial board of EGU's

Atmospheric Measurement Techniques Journal (Copernicus Publications, Impact Factor = 3.2) and he is active reviewer in ~25 scientific Journals in his field.

VA is responsible for the operation and data exploitation of the 24/7 PollyXT sophisticated lidar system, part of the European Aerosol Research Lidar Network (EARLINET). His lidar-related activities have been acknowledged by the European Aerosol Research Lidar Network (EARLINET), which has elected VA as a council member for the periods 2012-2016 and 2016-2020. Moreover, VA acted as the Greek National Delegate for the GMES/COPERNICUS Committee for the period 2014-2017 and National Representative in Interim ACTRIS council, as well as member of the General Assembly of the Hellenic Foundation for Research & Innovation (ELIDEK). In 2016, VA received the ERC Consolidator Grant for establishing high level atmospheric research in the geophysical observatory of Antikythera, a unique infrastructure that is developed to study desert dust dynamics, transport and interaction with radiation.

Eleni Marinou (Female)

Eleni Marinou graduated from the Applied Physics at the Applied Sciences Department of the National Technical University of Athens in 2010. She received her M.Sc. in the field of "Environmental Physics" from the Physics Department of the Kapodistrian University of Athens (2013). She acquired her PhD diploma from the Aristotle University of Thessaloniki (2017). She has been contacting research at the IAASARS Institute of the National Observatory of Athens since 2010, focusing on the retrieval of atmospheric parameters using passive and active remote sensing techniques. Her main accomplishment is the development of desert dust climatologies, focusing on the vertical distribution of desert dust extinction and concentration, as well as dust-related cloud condensation nuclei and ice nuclei concentration over the Mediterranean, using synergistically active and passive remote sensing techniques. She has participated in six international and national projects related to aerosol and cloud processes. She has 18 publications in peer review journals and more than 50 presentations in scientific conferences.

Anna Gialitaki (Female)

Anna Gialitaki got her BSc degree in Physics from the National Kapodistrian University of Athens in 2016 and received her M.Sc. in Applied Physics with specialization in "Enviromental Physics" from the same department in 2018. She is currently a PhD candidate focusing on the retrieval of physical, optical and chemical properties of smoke using remote sensing techniques and in-situ measurements. She has experience with the operation of the ground based lidar system of NOA. She participated in three experimental campaigns as well as national and international conferences.

Relevant Publications (up to 5)

1. **Amiridis** et al., 2015, LIVAS: a 3-D multi-wavelength aerosol/cloud database based on CALIPSO and EARLINET, *Atmospheric Chemistry and Physics*, 15, 7127–7153
2. **Amiridis** et al., 2012, impact of the 2009 Attica wildfires on the air quality in urban Athens, *Atmospheric Environment*, 46, 536-544
3. **Amiridis** et al., 2010, Smoke injection heights from agricultural burning in Eastern Europe as seen by CALIPSO, *Atmospheric Chemistry and Physics*, 10, 11567-11576
4. **Amiridis** et al., 2009, Optical characteristics of biomass burning aerosols over Southeastern Europe determined from UV-Raman lidar measurements, *Atmospheric Chemistry and Physics*, 9, 2431–2440
5. Marinou et al., 2017, Three-dimensional evolution of Saharan dust transport towards Europe based on a 9-year EARLINET-optimized CALIPSO dataset, *Atmospheric Chemistry and Physics*, 17, 5893–5919

Recent Projects (up to 5)

- **D-TECT _ ERC Consolidator Grant 2016** *(Does dust **T**ribo**E**lectrification affect our **C**lima**T**e?)*
- **MarcoPolo _ FP7 project** (*Monitoring and Assessment of Regional air quality in China using space Observations, Project Of Long-term sino-european co-Operation*).
- **DEDICATE _ ESA project** (*Development of a dual-channel Depolarization lidar technique for the derivation of CALIPSO/ Aeolus/ EarthCARE-related conversion factors*).
- **LIVAS _ ESA project** (*Lidar Climatology of Vertical Aerosol Structure for Space-Based Lidar Simulation Studies*) (http://lidar.space.noa.gr:8080/livas/).

Major Hardware/ Infrastructure available

Multi-wavelength Raman/polarization lidar Polly [XT]

CIMEL sunphotometer, part of the NASA-AERONET network

4.1.7 FMI

Finnish Meteorological Institute

About the Organisation

The Finnish Meteorological Institute (FMI) as a research and service agency is working under Ministry of Transport and Communications. FMI performs advanced scientific research and provides a wide variety of information services relating to weather, air quality, sea and climate. FMI has a strong background in meteorological observation, remote sensing, atmospheric modelling, meteorological applications and end-user applications as well as climate research and application development. Both research and operative units of FMI actively participate in national and international collaborative projects and development. The Modelling Group of the Atmospheric Composition Department has developed the Integrated System for wild-land fires IF4FIRES and chemistry transport model SILAM. The SILAM team is involved in many international co-operative, research and assessment efforts (e.g. UN/ECE EMEP, HELCOM/MONAS, WMO/GAW) as well as research projects and services (e.g., CAMS-50).

Role in this Project

The FMI team will be responsible for development of the plume injection algorithm and lead the corresponding task. It will also contribute to the data assimilation WP with its expertise on variational assimilation.

Expertise with Relevance to this Project and Role

The FMI SILAM team is the core developer of the IS4FIRES system. The group coordinator Prof.M.Sofiev has developed one of the widely used the plume injection formula, which will form the basis for the FRAMES construction.

Key Persons

Prof. Dr. Mikhail Sofiev (male)

Prof. Dr. Mikhail Sofiev is a Research Professor in Atmospheric Composition Research department at the FMI and an Adjunct Professor at University of Helsinki. He has 27 years of experience in development and application of air pollution models at various scales – from mesoscale to global for a wide range of tasks. M.Sofiev if a member of WMO Scientific Advisory Group on Applications, Finnish Emergency Response team. He is coordinator of SILAM modelling team, fire information system IS4IRES, and a national forecasting system for allergenic pollution. M.Sofiev is an author of 216 scientific publications; 119 of them are published in refereed international and national journals and series (h-index=36, Google Scholar, 2018.08.20). M.Sofiev is a supervisor of 15 academic theses (14 completed). He participated in over 40 international research and application projects (was a project PI in 6), in particular led the development of global fire emission assessment system IS4FIRES.

Relevant Publications (up to 5)

1. **Sofiev**, M., Ermakova, T., and Vankevich, R. (2012) Evaluation of the smoke injection height from wild-land fires using remote sensing data, *Atmos. Chem. Phys.*, **12**, 1995–2006, doi:10.5194/acp-12-1995-2012
2. **Sofiev**,M., Vankevich,R., Lotjonen,M., Prank,M., Petukhov,V., Ermakova,T., Koskinen, J. Kukkonen,J. (2009). An operational system for the assimilation of satellite information on wild-land fires for the needs of air quality modelling and forecasting. *Atmos. Chem. Phys.*, **9**, 6833-6847
3. **Sofiev**, M. (2013) Wildland Fires: Monitoring, Plume Modelling, Impact on Atmospheric Composition and Climate. Chapter 21 in *Matyssek, R., Clarke, N., Cudlin, P., Mikkelsen, T.N., Tuovinen, J.-P. Wieser, G., Paoletti, E. Climate Change, Air Pollution and Global Challenges. Developments in Environmental Science, vol. 13*. ISBN: 978-0-08-098349-3 ISSN: 1474-8177, Elsevier & Book Aid Intern., pp.451-474

4. Soares, J., **Sofiev**, M., Hakkarainen, J. (2015) Uncertainties of wild-land fires emission in AQMEII phase 2 case study. *Atmosph.Environ.*, doi:10.1016/j.atmosenv.2015.01.068
5. Kollanus, V., Prank, M., Gens, A., Soares, J., Vira, J., Kukkonen, J., **Sofiev**, M., Salonen, R.O., Lanki, T. (2016) Mortality due to vegetation-fire originated PM2.5 exposure in Europe – assessment for the years 2005 and 2008. *Environ. health prospective.* DOI: 10.1289/EHP194

Recent Projects (up to 5)

- ServForFires (2018-2021) Integrated services and approaches for Assessing effects of climate change and extreme events for fire and post fire risk prevention, ERA4CS, 259 kEuro (FMI)
- GLORIA (2017-2020) Global health risks related to atmospheric composition and weather. Finnish Academy, WP leader, FMI funding ~300kEuro.
- EUNADICS-AV (2016-2019) European Natural Airborne Disaster Information and Coordination System for Aviation. EU Horison 2020, Workpackage leader, co-coordinator of FMI team. FMI funding 630 kEuro.
- ADHIW / NordicWelFair (2015-2019). Understanding the link between Air pollution and Distribution of related Health Impacts and Welfare in the Nordic countries. NordForsk. Resp. for FMI regional modelling. 140 kEuro
- CAMS-50 (2015-2020) Copernicus Atmospheric Monitoring Service, regional AQ forecasting ensemble, task leader, FMI SILAM team funding 190 kEuro

Major Hardware/ Infrastructure available

FMI has over 25 years of global, regional and urban-scale air quality modelling, has developed a series of CTMs, including SILAM used in PAPILA, and 10 years of experience in satellite remote sensing of aerosols. FMI possesses own supercomputer and all related infrastructure, as well as an access to the Finnish Centre of Scientific Computing and ECMWF facilities and data storage

4.1.8 ASI

Assimila Ltd

About the Organisation

Assimila is an independent company (SME), founded in 2006, with the aim of bridging the gap between the academic, business and government worlds to support the uptake of new technology, particularly space based Earth Observation (EO), in environmental management.

Assimila's focus in EO applications is on land surface processes. For example, in association with UCL, Assimila has worked for several years on an EO land surface data assimilation system (EO-LDAS) to generate physically consistent retrievals of vegetation parameters (LAI, fAPAR) from heterogeneous EO data inputs. As part of the H2020-funded Multiply project, Assimila and UCL have developed a consistent multi-sensor coarse resolution framework to go from Top-of-the-atmosphere reflectances data to a consistent BRDF descriptors that allow to characterise the land surface including abrupt changes in reflectance due to fire or flooding events. Working with CABI for several years, Assimila has developed a range of crop pathogen growth models which are driven by open source environmental data - including Earth observation data, global re-analyses and NWP forecasts. These model developments are complemented by website development to deliver results to users.

Assimila has previously undertaken applications development work in the climate area, albeit using a very different approach. We worked with Universities of Reading and Edinburgh for Airbus on the development of a system to enhance GHG inventories. The method relied on measuring atmospheric concentrations of GHGs using in situ and satellite sensors and using advanced data assimilation techniques to calculate emissions and net fluxes.

Role in this Project

In order to initialze vegetation and fire-related variables into the IFS model, Assimila will support the development of a dynamic vegetation status product that can take into account land cover type, vegetation

health, fuel moisture content, and biomass load. Additionally, Assimila will look into the long-term impacts of fire in terms of radiative forcing of biomass burning events.

Expertise with Relevance to this Project and Role

Assimila's expertise in fire science includes the development of a probabilistic wildfire risk index for Chile using the TIGGE dataset, the work was funded by the Newton fund as was carried out together with the University of Reading (UK). Some additional work includes a global analysis of radiative forcing exerted by albedo changes due to biomass burning using the whole MODIS data record.

Key Persons

Gerardo López-Saldaña (male) has almost 20 years of experience working with EO data to create products that allow a better characterisation of the land surface. His fire expertise includes the development of an active fire detection algorithm using direct-readout AVHRR data, mapping burnt areas using MODIS and AVHRR and the global analysis of radiative forcing from fire-induced shortwave albedo changes using MODIS data. Some additional work includes, the development of an optimal estimation framework to create the longest albedo data record as part of the GlobAlbedo project, land cover monitoring for UNFCCC reporting in North America and the UK (MELODIES project), the development of an EO Data Cube for environmental applications and the use of Data Assimilation techniques.

Relevant Publications (up to 5)

1. Dacre, H.F., Crawford B.R., Charlton-Perez, A.J., **Lopez-Saldana**, G., Griffiths G.H., Vicencio Veloso, J. (2018). Chilean wildfires - Probabilistic Prediction, Emergency Response, and Public Communication. *Bulletin of the American Meteorological Society*, (November), 2259–2274. https://doi.org/10.1175/BAMS-D-17-0111.1
2. **López-Saldaña**, G., Bistinas, I., & Pereira, J. M. C. (2015). Global analysis of radiative forcing from fire-induced shortwave albedo change. *Biogeosciences*, *12*(2), 557–565. https://doi.org/10.5194/bg-12-557-2015
3. Ressl, R**., Lopez-Saldana**, G., Cruz, I., Colditz, R. R., Schmidt, M., Ressl, S., & Jiménez, R. (2009). Operational active fire mapping and burnt area identification applicable to Mexican Nature Protection Areas using MODIS and NOAA-AVHRR direct readout data. *Remote Sensing of Environment*, *113*(6), 1113–1126. https://doi.org/10.1016/j.rse.2008.10.016
4. Colditz, R. R**., López Saldaña**, G., Maeda, P., Espinoza, J. A., Tovar, C. M., Hernández, A. V., … Ressl, R. (2012). Generation and analysis of the 2005 land cover map for Mexico using 250m MODIS data. *Remote Sensing of Environment*, *123*, 541–552. https://doi.org/10.1016/j.rse.2012.04.021
5. Blanco, P. D., Colditz, R. R**., López Saldaña**, G., Hardtke, L. a., Llamas, R. M., Mari, N. a., … Arroyo, V. B. (2013). A land cover map of Latin America and the Caribbean in the framework of the SERENA project. *Remote Sensing of Environment*, *132*, 13–31. https://doi.org/10.1016/j.rse.2012.12.025

Recent Projects (up to 5)

- MULTIscale SENTINEL land surface information retrieval Platform (MULTIPLY). http://www.multiply-h2020.eu/
- Sentinel 2/3 Synergy Products. http://www.virtualsensor.org/
- Maximising the Exploitation of Linked Open Data In Enterprise and Science (MELODIES). https://www.melodiesproject.eu/node/190

Major Hardware/ Infrastructure available

n/a

4.1.9 SRS

Samuel Remy conseil scientifique	Samuel Remy CS

About the Organisation

Samuel Remy CS is an independent SME that has been founded in 2017. Its expertise lies in modelling in atmospheric composition forecasting systems, with a focus on global aerosol modelling and fire emissions.

While SRCS is a new company, it can draw on the expertise of its key personnel, Samuel Remy, in modelling, data assimilation and project management. Samuel has been involved in several past or present European projects that deal with aerosol modelling, such as the Monitoring Atmospheric Composition and Climate (MACC) –II and III projects, as well as being the service manager of the global aerosol aspects component of the Copernicus Atmospheric Monitoring Services (CAMS). Within MACC, Samuel was also responsible for the maintenance and development of the Global Fire Assimilation System (GFAS), which provides estimates of biomass burning emissions of aerosols and trace/greenhouse gases to the global atmospheric composition forecasting system of the ECMWF. During this time, a Plume Rise Model (PRM) which provides estimates of the injection height of biomass burning emissions was integrated into GFAS.

Role in this Project

Samuel Remy CS will assist in developing the biomass burning injection height parameterization in the Integrated Forecasting System (IFS) of ECMWF in WP1. The company will also co-lead WP 2 and will contribute in developing the observation operator that will provide estimates of Fire Radiative Power (FRP) land surface parameters

Expertise with Relevance to this Project and Role

Expertise in fire emissions and deriving fire emissions from satellite products in the Global Fire Assimilation System (GFAS). Samuel Remy CS has also been involved in developing the aerosol forecasting capabilities of the IFS for several years; this expertise will be very useful for both work packages 1 and 2.

Key Persons

Samuel Remy (male) –Samuel obtained a PhD in Atmospheric Sciences in 2009, with a specialization in data assimilation, and has been working in operations at Météo-France from 2009 to 2012. In 2013 and 2014, Samuel was part of the Atmospheric Composition team at ECMWF, and since 2014 he is working at CNRS/IPSL on improving the operational aerosol models of the IFS within the framework of the Copernicus Atmospheric Monitoring Services (CAMS).

Relevant Publications (up to 5)

1. **Rémy, S., Benedetti, A.,** Haiden, T., Jones, L., Razinger, M., Flemming, J., Engelen, R.J., Peuch, V.H. and J.N. Thepaut, 2015: Feedbacks of dust and boundary layer meteorology during a dust storm in the Eastern Mediterranean. Atmos.Chem.Phys., 15, 12909-12933, link
2. **Rémy, S.,** Veira, A. and couthors, 2017 : Two global datasets of daily fire emission injection heights since 2003, Atmos.Chem.Phys., 17, 2921-2942, link
3. **Rémy, S., Benedetti, A.** and Boucher, O., 2016, 2017, 2018: Aerosols [in "State of the Climate in 2015, 2016, 2017"], Bull. Amer. Soc., link (for 2017)
4. **Benedetti, A. and Rémy S.**, 2015: Aerosols [in "State of the Climate in 2014"], Bull. Amer. Soc., 96(7), S43-44 . link

Recent Projects (up to 5)

- Copernicus Atmospheric Monitoring Services (CAMS) 43: global aerosol aspects; service manager and main contributor
- MACC 2 and 3: researcher in the AER and FIRE teams, responsible for developments in the IFS and GFAS.

Major Hardware/ Infrastructure available

n/a

4.1.10 KIC

EIT Climate-KIC

About the Organisation

EIT Climate-KIC (Knowledge and Innovation Community) is the EU's largest public-private partnership addressing climate change through innovation. Our community consists of over 300 leading partners from

business, academia, the public sector and NGOs. Our purpose is to help create a prosperous, inclusive, climate resilient society founded on a circular, zero-carbon economy.

We identify and support innovation that helps society mitigate and adapt to climate change. We believe that a decarbonised, sustainable economy is not only necessary to prevent catastrophic climate change, but presents a wealth of opportunities for business and society.

We focus on levers of systemic change, looking for where innovation is most needed to accelerate deep decarbonisation (elimination of fossil fuels and negative carbon) and effective adaptation. EIT Climate-KIC is predominantly grant-funded by the European Institute for Innovation and Technology, a body of the European Union and acts as a platform to work across boundaries and across sectors, fostering innovation as a catalyst for transformation.

EIT Climate-KIC is a European knowledge and innovation community, working to accelerate the transition to a zero-carbon economy.

Role in this Project

Climate-KIC will be the key partner for the activities working across work packages and supporting the project with long-term sustainability, with an active role as well in the development of the strategy, deployment of the portfolio of training material and dissemination strategy. In particular Climate-KIC will lead on activities related to the exploitation of FRAMES products portfolio by professional through the design and running of a dedicated placement program in the framework of its mainstream Pioneering into practice program (WP5). Additional activities will occur including the knowledge sharing with other existing projects and transfer of know-how towards DG GROW.

Expertise with Relevance to this Project and Role

Convening networks of expertise

We bring together partners in the worlds of business, academia, and the public and non-profit sectors to create networks of expertise, through which innovative products, services and systems can be developed, brought to market and scaled-up for impact.

Through our convening power, EIT Climate-KIC brings together the most effective groups to create the innovation that can lead to systemic change.

Leveraging grants smartly and effectively

We identify, source and place public and private funds that stimulate innovation. We track progress and outcomes and draw out learning and insight so that our funding partners can effectively invest their resources for maximum impact.

By bringing together those with vision, with ideas, with low-carbon products and services, and with finance, we generate the critical mass needed to tackle climate change.

Developing people and capacity

EIT Climate-KIC runs a range of inspirational education programmes across Europe and online, for students, postgraduates and professionals. These programmes develop their participants' skills and capacities, empowering them with up-to-date knowledge and best practice.

In this way, we are fostering a new generation of entrepreneurs and climate leaders to realise a zero-carbon economy.

Catalysing innovation

We catalyse and nurture innovation, whatever its source: from large corporations, research institutes and public bodies, through to start-ups and individual entrepreneurs. We encourage fresh new thinking from beyond the mainstream through initiatives like our 24-hour hackathon Climathon, or our cleantech ideas platform Climate Launchpad.

Our incubator programme, Accelerator, gives seed funding, structure and assistance to start-ups and SMEs. We drive innovation in established organisations through our range of innovation programmes, specifically for our partners.

Key Persons

Pamela Ragazzi (Female) – Pamela Ragazzi graduate at the University of Ferrara in BA Applied Economics and International Institutions and MSc in Applied Economics and Economic Policies. During her studies she

had experiences in the UK (Erasmus at the University of Birmingham) and Germany (internship at the UNEP/Wuppertal Institute Collaborating Centre on Sustainable Consumption and Production). After the involvement in an EU-funded project on Sustainable Tourism with the Regional Authority of Emilia-Romagna (Italy), she has joined Aster in 2013 working on a number of EIT Climate-KIC activities such as Pioneers into Practice, The Journey Summer School, Outreach/Regional Innovation Scheme focusing on the collaboration with Slovenia. Since 2016 she works as a Programme Manager at Climate-KIC Italy, supporting the partners in the Pioneers, Journey and the Climathon, among other activities. In 2018 she coordinated the InnoSpace Journey.

Daniel Zimmer (Male) - Daniel Zimmer has a background in Agricultural Engineering and in Hydrology. He spent the first 15 years of his career at Cemagref, the French Agricultural and Environmental Engineering Research Centre (today IRSTEA). Daniel became the Director of the World Water Council for eight years, an international institution based in Marseilles, France. After a short period of work as a Consultant for the UN and other international institutions, he joined EIT Climate-KIC in 2010.

Tom Mitchell (Male) - Tom Mitchell has joined EIT Climate-KIC's executive team as Director for the UK and Ireland. Previously, he was Head of Climate and Environment at the Overseas Development Institute, and a Research Fellow at the Institute of Development Studies. He was a senior advisor to the Climate and Development Knowledge Network, in which he oversaw the research and knowledge management components. Tom also served on the Intergovernmental Panel on Climate Change (IPCC) Working Group II Coordinating Lead Author of the Special Report on Extreme Events and Disasters; and a Lead Author of the IPCC 5th Assessment Report. He has a PhD from University College London on national level strategy planning for strengthening resilience to extreme events.

Thanh-Tam Le (Male) – A classical concert violinist, mathematician and engineer, Thanh-Tâm joined EIT Climate-KIC in 2013 as Director for France and, since 2016, for the Mediterranean. He had previously set up the Ecole Polytechnique's Graduate School (Doctoral and Master's Directorates, Careers, Internships & Academic counselling) and become its first Director. Prior experience includes a Ph.D. in 4D topology, followed with positions as Lecturer and Dean at SUPAERO (Toulouse).

Line Gry Knudsen (Female) - As acting Director of Education, Line is focusing on ensuring competence development opportunities for students, professionals and innovators and support future climate entrepreneurs in addressing climate change challenges. Line holds a PhD degree in University-Industry collaboration from Copenhagen Business School where she is affiliated as external lecturer. With a background as senior consultant in the Copenhagen based education think tank, DEA, she has gained a deep insight in the European educational landscape and its dynamics.

Emilie Normann (Female) – Extensive work with European research and innovation, business support and entrepreneurship, primarily in strategic and managerial positions. She is responsible for all start-up activities at EIT Climate-KIC, including our Accelerators programmes that run from 32 locations in 24 different Europe countries.

Rahul Bansal (Male) - Rahul Bansal (MBA, Imperial College London) is the Deputy Director of Education at EIT Climate-KIC which is Europe's biggest initiative on driving climate innovation. Rahul has extensive experience in corporate development, strategy, start-ups and investments across various industrial sectors (Education, CleanTech, Healthcare etc.). He has been working with the Imperial College London, one of world's most dynamic centres for innovation and entrepreneurship, which has provided him an academic platform with cutting-edge research, a living entrepreneurship lab and an invaluable global network of expertise and experience. Currently, Rahul is leading the downstream application of Earth Observation data application for Copernicus.

Kate Martin (Female) – Kate Martin is the Pioneers Lead at EIT Climate-KIC and has overall responsibility for the development & delivery of this climate change professional mobility programme. Kate has been involved in the Pioneers program since 2013 where she managed the UK & Ireland programme for three years before moving into the central management of the programme. In her central role she now oversees the development and implementation of the programme in 16+ locations across Europe. Under her leadership the programme has grown not only geographically but also in number and diversity of applicants from both Individuals and host organisations, 2018 saw 360 individual and 186 Host organisations applying from across public, private, research and not for profit sectors. Spanning over 12 years, her background is in project and programme management at both a regional and European level. She has a BA (Hons) in International

Tourism Management and PG Cert in Destination Management, and also successfully qualified as a PRINCE2 Practitioner for project management.

Erik Chavez (Male) - Erik is a research fellow working on EIT Climate-KIC led project WiNners which offers risk management services to build resilient supply chains from the smallholder to the global retailer. His research activity focuses in the areas of climate dynamics, risk modelling, supply chain analysis and agricultural development. He has worked for 6 years as a short-term consultant of the Agricultural Risk Management Team at the World Bank. He is the winner of the 2015 Lloyd's Science of Risk Prize in the "big data and analytics" category and is a member the Aspen Institute Food Security Strategy Group, and of the UK-US Taskforce on Extreme Weather and Global Food System. He completed his Ph.D. in climate dynamics and economics between Imperial College London and the ENS Paris (Ecole Normale Supérieure).

Fabrizio Rossi (Male) - Fabrizio Rossi joined EIT Climate-KIC in 2016 as Business Development Lead with a specific focus on sustainable land use. He works in Brussels on a daily basis and travels across Europe to connect CKIC and its portfolio of projects on forestry, food and sustainable agriculture with the international funding and donor community. This work allows him to combine his interest for international cooperation with his passion for trees and forestry. Previously, he has founded a Belgian start-up implementing reforestation projects in Africa and South America. He has worked in Valencia with the European Commission and developed a platform for improving synergies among EU funding programmes in the Mediterranean area. In its first assignment in Brussels, he was responsible for the management of an international organization for territorial cooperation integrated by 25 provinces from 6 EU countries.

Kevin Ramirez (Male) – Kevin Ramirez serves as the Copernicus Programme Coordinator at the EIT Climate-KIC. He holds a bachelor's degree in chemical engineering and a master's degree in Eco-Innovation from the University of Versailles. Previously he worked in the United Nations Environment Programme as a consultant in projects related to Corporate Sustainability Reporting and Eco-innovation. He is now responsible to coordinate all the Copernicus projects in which the Climate-KIC is involved.

Relevant Programs run by KIC

1. pioneers-into-practice https://learning.climate-kic.org/en/programmes/pioneers-into-practice

Recent Projects (up to 5)

1. **RiskFP** – Better Monitoring & Management of Natural Risks for Forest Projects

Due to unmanaged or mismanaged fire risk, forest projects have a high potential of profitability. The RiskFP team works on an integrated fire risk assessment tool, dedicated to measure fire impacts.

Among the three major economic activities in the forest sector, timber production, ecological conservation/protection and climate change mitigation, the last two have strongly grown thanks to to climate change mitigation related investments. Meanwhile, this growth appears to be hampered by the fire risk, inherent in forestry projects.

ONFI, ARIA and South Pole Carbon Asset Management, all RiskFP members and experts in forest lands and carbon finance, have identified a global need for precise fire risk assessment tools, at different levels in the market chain. The RiskFP tools will allow a better understanding of the nature of the risk, so as its geographic and temporal distribution. As such, the tools could address several needs in the forestry sector.

RiskFP partners focus on those needs, discussing with four types of market players:

- Forest carbon projects management
- Forest logging market
- Insurance market
- Forest protection market

2. INNOSPACE

Our vision spans and integrates the 'innovation pyramid', which brings together education, research, business, and government/society in order to address complex challenges and to deliver world-class solutions. The Copernicus collaboration, through **InnoSpace**, is an opportunity for Climate-KIC to disseminate this good practice to a wider community and create synergies and brand visibility for the Copernicus ecosystem. It is an opportunity to combine the impactful education formats and outreach dissemination platforms of Climate-KIC, with the freely and openly available data from Copernicus and the stakeholders of Copernicus Academy.

- **Journey: 5-week summer school in 3 locations of Europe** - Since 2010, The Journey has been one of the most successful products of the Climate-KIC portfolio, recognised by OECD HEinnovate as best exemplar for innovation training. An intensive 5-week innovation and entrepreneurship residential school based in 3 locations. We envisage running Space-specific Journey for 40 high talent graduates. The Journey would bring together highly motivated students (Masters and PhDs) as well as young professionals from a large variety of backgrounds and disciplines.
- **Climathons: 24 hours non-stop education programme on ideation in 10 cities of Europe -** The Climathon, launched in 2015, is a low-cost, high impact global profile-raising 24-hour climate change event organised by Climate-KIC with the goal to develop city-level solutions to climate change challenges. Climathon was awarded Guardian Sustainability Award for initiating a global movement with the ambition to bring together the brightest minds to solve climate challenges. It has grown tremendously, encouraging more innovators across the globe to drive climate action. We are now in over 100 cities, with 100 million outreach on social media last year in over 70 countries.

3. Professional, online and executive education

Climate-KIC has built significant expertise in professional, online and executive education. These cover six main topics, including development capacity to support the impacts goals associated with Climate-KIC's four Themes.

- **Pedagogies and education formats**: developing our portfolio of training formats and our pedagogic approaches, balancing research into respective training needs with piloting of newly conceptualised formats and methods. We are contributing to the discourse on the future of learning, particularly in respect of training for innovation, entrepreneurship, and leadership in complexity and systems thinking in support of transformational change;
- **Online education platform**: Climate-KIC has developed a cutting-edge online learning platform that enables application of innovative blended learning formats that facilitate all aspects of our education programme. The platform has integrated learning management system with the content management system (an intelligent library of all learning materials) and ensuring appropriate data management and security, preparing the platform for use by tens of thousands of users. In addition, new e-learning content and nuggets will be developed. Programmes are developed in English, but translations will be developed where appropriate. For example, French and German versions of the Climate Smart Agriculture MOOC are in progress, and a Chinese version is under consideration;
- **Network of coaches**: To achieve our target of training thousands of practitioners each year we rely on a network of trainers. To ensure harmonisation of training across Climate-KIC we have piloted competency and quality standards, and developed a training-the-trainers programme
- **Certified Professional**: Having developed and validated the first two competency frameworks on 'Accelerating Transitions' and 'Promoting Innovation', we launched the certification framework officially in 2018. This programme has attracted considerable interest within the Commission and with other KICs and some companies (https://www.certifiedprofessional.eu);
- **Knowledge products and teaching case studies**: Climate-KIC has developed a database of knowledge products, learning materials and case studies.
- **Pioneers Programme:** Operating in over twenty European locations, the Pioneers programme runs from May through to November and consists of a 4-6 week placement (domestic or international), bespoke transitions thinking & systems innovation mentoring delivered through a structured workshop programme and online training.

4. **EO4GEO** –

"Towards an innovative strategy for skills development and capacity builiding in the space geo-information sector supporting Copernicus User Uptake" EACEA/04/2017 ERASMUS+ Sector Skills Alliances. The project gathers 26 partners most of the from the Copernicus Academy Network, from 16 countries active in the education/training and space/geospatial sectors. Climate-KIC is a member of the Steering Committee of EO4GEO, an Eramus+ Sector Skills Alliance gathering 26 partners from 212 countries from academia, private and public sector active in the education/training and space/geospatial sectors. EO4GEO aims to help bridging the skills gap between supply and demand of education and training in the space/geospatial sector by reinforcing the existing ecosystem and fostering the uptake and integration of space/geospatial data and services in end-user applications. EO4GEO will work in an multi- and interdisciplinary way and apply innovative solutions for education and training actions including case based and collaborative learning scenarios, learning-while-doing in a living lab environment, on-the-job training, the co-creation of knowledge and the development of skills and competencies.
Major Hardware/ Infrastructure available n/a

4.1.11 MF

Météo-France
About the Organisation Météo-France is the French National Meteorological Service. It has the responsibility of observing weather and climate over the country. Its primary mission consists of observing and forecasting the evolution of the atmosphere, of the snow and the surface oceanic characteristics and so ensuring the security of people and property. Among its operational activities, Météo-France is concerned by carrying out the forest fires assistance to french national and regional civil protection authorities.
Role in this Project Meteo France leads the validation of the show case FRAMES for CEMS and will be involved in the validation of the new fire products in an operational framework.
Expertise with Relevance to this Project and Role As part of the Copernicus Fire Management Service contract for the Copernicus fire danger computation, Météo-France is subcontracted by ECMWF (main contractor) to provide every year an objective and independent evaluation of the EFFIS products. The latter are produced by ECMWF and consist of Fire Weather Indices. As part of their operational data quality control, skill scores and expert analysis of fire events occurring in Europe are produced. Within the FRAMES context, products equivalent to the CEMS/Fire FWI will be generated and made available through a dedicated web portal. Using the same procedure and methodology applied to the assessment of the operational CEMS/Fire products, this task aims at assessing the new products generated within FRAMES and any added value of using the FRAMES prototype.
Key Persons **M. Mathieu Regimbeau (male)** ▪ Coordinator and technical responsible for operational forest fires activities at Météo-France (including operational computation over Western Europe and overseas regions) ▪ Expertise in Forest Fire Danger assessment : in charge of the coordination of the services provided by Météo-France to the Civil Protection Authorities by the different regional centres. ▪ Expertise in Forest Fire Indices Calculation : being responsible for setting up the operational fire indices computation tasks over France (Western Europe & overseas)

▪ Studies and productions in « Forest Fires and Climate Change », Expertise for French ministries, publications of operational indicators dealing with Climate Change

Relevant Publications

- **M Regiembau**: EFFIS validation for the fire season 2018. Technical memo submitted as R1 report to JRC as part of the Copernicus management service activities
- Presentation of fire activities in France: **M. REGIMBEAU** - Le réchauffement climatique https://www.youtube.com/watch?v=f47wtfVDTzM

Relevant Recent Projects (up to 5)

- Operational Fire danger assistance to French Civil Protection Authorities
- **EFFIS-GWIS** - Fire danger forecast computation at global level for Copernicus Early Management Service
- **ARISTOTLE2 -** multi-hazard advice capability to the Emergency Response Coordination Centre (ERCC).

Major Hardware/ Infrastructure available

n/a

4.1.12 BSC

Barcelona Supercomputing Center-Centro Nacional de Supercomputación

About the Organisation

The Barcelona Supercomputing Center-Centro Nacional de Supercomputación (BSC, https://www.bsc.es) combines unique high performance computing facilities and in-house top research departments on Computer, Life, and Earth sciences, and in computational applications in science and engineering. It is the main provider of public supercomputing services in Spain, coordinating the Red Española de Supercomputación and representing Spain in international initiatives such as PRACE (http://www.prace-ri.eu/). The Earth Sciences (BSC-ES) Department focuses on the atmosphere-ocean biosphere system and is structured around four groups with more than 85 researchers and support staff. It is a highly productive scientific entity that has published more than 160 research peer-reviewed articles over the last 5 years, many in high-impact journals. Two of these groups are participating in this proposal.

The Climate Prediction Group (CPG) aims at developing a climate forecast system based on the Earth System Model EC-Earth. The CPG also performs regular assessments of the system's predictive capacity and compares it with other operational and quasi-operational systems in the world. The CPG has a long experience in seasonal to decadal climate prediction, which has been reflected in its active participation to several European projects with a strong component on climate prediction (see list below). The CPG currently participates to 10 European and 4 national projects. The group has been expanding its research activities on prediction, and is contributing to the development of the CMIP6 version of EC-Earth. With the final model version, the group will strongly contribute to DCPP (Decadal Climate Prediction Project), and C4MIP (Coupled Climate-Carbon Cycle Model Intercomparison Project). In addition, members of the group are currently testing several techniques to produce optimal initial conditions for decadal predictions of climate and global carbon cycle.

Also within the ES Department, the Earth System Services group (ESS) aims at demonstrating the ongoing value of climate prediction services, atmospheric composition and weather forecasting to society and the economy. The group actively works in identifying user needs that will partly guide research in the BSC-ES Department and aims to quantify the impact of weather, climate, aerosols and gaseous pollutants upon socio-economic sectors through the development of user-oriented services that ensure the transfer of the technology developed and the adaptation to a rapidly changing environment, especially of those highly vulnerable. This group is coordinating the H2020 project S2S4E-776787 “Subseasonal to seasonal climate

predictions for energy" and has a key role in other European and national projects on climate services. The ESS has an interdisciplinary approach closely collaborating with research groups and general support groups at the BSC (technology transfer, communications, visualisation, education and outreach). The Atmospheric Composition (AC) group aims at better understanding the chemical composition of the atmosphere and its effects upon air quality, weather and climate, while improving predictions from local to global scales. The AC group develops the Multiscale Online Non-hydrostatic AtmospheRe CHemistry model (MONARCH; previously known as NMMB/BSC-CTM). MONARCH contains advanced chemistry and aerosol packages, and is coupled online with the Non-hydrostatic Multiscale Model (NMMB), which allows for running either global or high-resolution (convection-allowing) regional simulations, and is coupled with an aerosol data assimilation system based on the Local Ensemble Transform Kalman Filter (LETKF).

The Atmospheric Composition group (AC) contributes to a variety of forecasting activities. The dust component of MONARCH runs operationally at the first WMO Regional Specialized Meteorological Center for Atmospheric Sand and Dust Forecast (i.e., the Barcelona Dust Forecast Center, BDFC), and contributes to multi-model ensemble forecasts both at the WMO Sand and Dust Storm Warning Advisory and Assessment System Regional Center (WMO SDS-WAS RC) for Northern Africa, the Middle East and Europe, and the International Cooperative for Aerosol Prediction (ICAP). Both WMO Regional Centers are co-hosted by BSC and the Spanish Meteorological Agency (AEMET). The group also develops and maintains the CALIOPE air quality system ("CALIdad del aire Operacional Para España"), which provides high-resolution air quality forecasts over Europe and Spain using the in-house emission model HERMES.

Role in this Project

BSC is leading the validation of the FRAMES for C3S b showcase and will be involved in understanding the impact that the advancement of FRAMES can bring into long range forecast simulations

Expertise with Relevance to this Project and Role

The CPG and ESS groups at the BSC have a long experience in sub-seasonal to decadal climate prediction, reflected in its active participation in several European projects with a strong component on climate prediction (see list below).

Key Persons

Dr. Etienne Tourigny (Male) has a PhD in Meteorology from the Instituto Nacional de Pesquisas Espaciais (INPE-CPTEC, Brasil) and a M.Sc. in Atmospheric Science from the Université du Québec à Montréal (UQAM). Dr. Tourigny has a strong multi-disciplinary background, having studied physics, computer science, atmospheric science and biosphere-atmosphere interactions. He has professional experience in the Information Technology sector, before transitioning to the climate research field where he developed his expertise in the field of climate seasonal prediction, having studied the impacts of ENSO on precipitation anomalies in the tropical Americas. He contributed to the development of the Brazilian Earth System Model (BESM) at INPE – CCST acquiring in the process a very strong expertise in vegetation and fire modelling as well as in high-performance computing. After joining the climate prediction group at BSC, he obtained a Marie-Curie fellowship. Dr. Tourigny is developing a new research line on seasonal predictions of wildfires while, at the same time, actively contributing to the development of the CMIP6 version of the EC-Earth ESM.

Dr. Andrea Manrique-Suñén (Female) has a degree in Physics at Universidad Complutense de Madrid (Spain), specialising in atmospheric physics and holds a PhD in Meteorology from the University of Reading (UK). For her PhD she evaluated land-atmosphere energy and carbon exchange of two land surface models, acquiring expertise in land surface modelling and vegetation processes. She currently works in forecast quality assessment of sub-seasonal forecasts including implementing and testing bias adjustment techniques. She is involved in H2020 projects IMPREX and S2S4E.

Dr. Albert Soret (Male) holds a PhD in Environmental Engineering from the Polytechnic University of Catalonia (Barcelona). He is head of the Services group at the Earth Sciences Department of the BSC. He is a postdoc researcher with 10 years of experience in the areas of Air Quality and Climate. His main expertise includes emission modelling, meteorological modelling, air quality modelling and climate services. His research facilitates technology transfer from local, national to international levels to advance sustainable development in key sectors such as energy, urban development, infrastructure, transport, health, and agriculture and water management. He is the principal investigator of the S2S4E project (EC-H2020). Member of the External Advisory Board of Clim2Power (ERA4CS).Work Package leader within Clim4Energy (Copernicus), VISCA (H2020) and MAGIC (Copernicus) and he is also involved in EC-FP7 and H2020 projects:

NEWA, EUPORIAS, SPECS, IMPREX, PRIMAVERA and APPRAISAL. He coordinated the development of an air quality forecast systems for Southern Spain-Andalucia and Canary Islands. He has participated in the Spanish air quality-related CALIOPE for the Spanish Ministry and the air quality forecast system for the Mexico City's Environment Secretary.

Dr. Markus Donat (Male)

Dr. Markus Donat is an expert in studying climate extremes and climate variability, mechanisms driving or amplifying extremes, and climate model evaluation focussing on their fidelity to simulate climate extremes. He is now co-leader of the Climate Prediction group at the BSC, after holding Postdoctoral and Senior Research Fellow positions over the past eight years at the University of New South Wales in Sydney (Australia). Markus has published more than 60 peer-reviewed journal articles since 2010, seven of these in *Nature*-family journals, and has contributed to the IPCC 5th Assessment Report. He is Associated Investigator with the Australian Research Council Centre of Excellence for Climate Extremes, and Associated expert with the World Meteorological Organization (WMO) Commission of Climatology (CCl) Expert Team on Data Development and Stewardship. Based on his achievements he has been awarded the World Climate Research Program (WCRP) / Global Climate Observing System (GCOS) International Data Prize 2017.

Relevant Publications (up to 5)

1. Turco, M., S. Jerez, F.J. Doblas-Reyes, A. AghaKouchak, M. Carmen Llasat and A. Provenzale (2018). Skilful forecasting of global fire activity using seasonal climate predictions. Nature Communications, 9, 2718, doi:10.1038/s41467-018-05250-0 .
2. Prodhomme, C., F.J. Doblas-Reyes, O. Bellprat and E**. Dutra** (2016). Impact of land-surface initialization on sub-seasonal to seasonal forecasts over Europe. Climate Dynamics, 47, 919-935, doi:10.1007/s00382-015-2879-4 .
3. Lledó, Ll., O. Bellprat, F.J. Doblas-Reyes and A. **Soret** (2018). Investigating the effects of Pacific sea surface temperatures on the wind drought of 2015 over the United States. Journal of Geophysical Research Atmospheres, 123, 4837-4849, doi: 10.1029/2017JD028019 .
4. Torralba, V., F.J. Doblas-Reyes, D. MacLeod, I. Christel and M. Davis (2017). Seasonal climate prediction: a new source of information for the management of wind energy resources. Journal of Applied Meteorology and Climatology, 56, 1231-1247, doi:10.1175/JAMC-D-16-0204.1 .
5. Doblas-Reyes, F.J., J. García-Serrano, F. Lienert, A. Pintó Biescas and L.R.L. Rodrigues (2013). Seasonal climate predictability and forecasting: status and prospects. WIREs Climate Change, 4, 245-268, doi:10.1002/WCC.217 .

Recent Projects (up to 5)

- **IMPREX** *IMproving PRedictions and management of hydrological EXtremes (*GA 641811) This project will improve forecast skill of meteorological and hydrological extremes in Europe and their impacts, by applying dynamic model ensembles, process studies, new data assimilation techniques and high resolution modeling.
- **S2S4E** *Sub-seasonal to Seasonal climate forecasting for Energy* (GA 776787) will offer an innovative service to improve RE variability management by developing new research methods exploring the frontiers of weather conditions for future weeks and months. The main output will be a user co-designed Decision Support Tool (DST) that for the first time integrates sub-seasonal to seasonal (S2S) climate predictions with RE production and electricity demand.
- **ACTRIS-2** *Aerosols, Clouds, and Trace gases Research InfraStructure* (GA- 654109) https://www.actris.eu/Projects/ACTRIS-2IAinH2020(2015-2019).aspx). It addresses the scope of integrating state-of-the-art European ground-based stations for long-term observations of aerosols, clouds and short lived gases. It consolidates and improves services offered within FP7 funded Integrated Infrastructures Initiative ACTRIS (2011-2015).
- **SPFireSD** *Seasonal Prediction of Fire danger using Statistical and Dynamical mode*ls (GA-748750). The goal of this project is to develop and assess seasonal fire prediction capability through a variety of complementary and innovative methods, with a focus on Europe, the Amazonian basin and Indonesia.
- **Climate Change Initiative Programme Extension Phase 1** undertakes to support integration by building appropriate interfaces, to foster the exploitation of global satellite data products within the

Climate Modelling Community and to assess the quality and impact of individual/combined global of global satellite data products in climate model and data assimilation context.

Major Hardware/ Infrastructure available

BSC is a key element of and coordinates the Spanish Supercomputing Network, which is the main framework for granting competitive HPC time to Spanish research institutions. Furthermore, BSC is one of six hosting nodes in France, Germany, Italy and Spain that form the core of the Partnership for Advanced Computing in Europe (PRACE) network. PRACE provides competitive computing time on world-class supercomputers to researchers in the 25 European member countries. BSC operates MareNostrum, the most powerful supercomputer in Spain since its inception In March 2004.

The latest version, MareNostrum 4 (since July 2017) has a performance capacity of 13,7 Petaflop/s and is composed of two distinct parts. The general-purpose element, provided by Lenovo, has 48 racks with more than 3,400 nodes with next generation Intel Xeon processors and a central memory of 390 Terabytes. Its peak power is over 11 Petaflop/s, i.e. it is able to perform more than 11,000 trillion operations per second, ten times more than MareNostrum 3 despite costing only a 30% increase in energy consumption. The second element of MareNostrum 4 is formed of clusters of three different technologies that will be added and updated as they become available. These are technologies currently being developed in the USA and Japan to accelerate the arrival of the new generation of pre-exascale supercomputers. MareNostrum 4 will have a disk storage capacity exceeding 10 Petabytes and will be connected to the Big Data infrastructures of BSC, which have a total capacity of 24.6 Petabytes. BSC has also other cutting-edge computing infrastructure based on latest available technology like FPGA boards, small clusters based on ARM SoCs, GPUs, etc.

4.2 Third parties involved in the project (including use of third party resources)

02 - FC.ID

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	**N**
If yes, please describe and justify the tasks to be subcontracted.	
Does the participant envisage that part of its work is performed by linked third parties (Article 14 of the Model Grant Agreement)	**Y**
If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party. *FCUL – foreseen task includes scientific supervision of the model developments* The Faculty of Sciences at the University of Lisbon (FCUL), is the basis a large community of students and researchers, involved in scientific and technological research. FCUL offers under to post graduate degrees and PhD programs in many basic and applied science fields, hosting groups in Mathematics, Statistics, Physics, Chemistry and Biochemistry, Biology, Geology, Geophysics, Computer Science, Astronomy, Environmental and Marine Sciences, and in Science History and Philosophy. FCUL offers its members a modern set of shared infrastructures. Faculdade de Ciências da Universidade de Lisboa (FCUL), based on a third party agreement, acts as a third party of FC.ID carrying out its own share of work, notwithstanding the full responsibility of FC.ID for the contracted scientific and technical work under specific R&D projects.	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Agreement)	**Y**
If yes, please describe the third party and their contributions. *FCUL – 6PM contribution on model development (Reason: E. Dutra cannot commit PM to the project due to exclusivity contract)*	

10 - KIC

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	**Yes**
If yes, please describe and justify the tasks to be subcontracted. The core tasks of the project will be delivered by Climate-KIC. However, we foresee subcontracting certain activities such as market designing, hiring specialist coaches, hiring venue etc.	
Does the participant envisage that part of its work is performed by linked third parties (Article 14 of the Model Grant Agreement)	**Yes**
If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party. Climate-KIC is a group structure with a Dutch holding company (Climate-KIC Holding .B.V) 12 subsidiaries established in all our major European geographies for employment of staff, cored function activities and project delivery for all our EIT and non EIT funded work. This structure means that Climate-KIC can delivery initiatives on a pan -European basis and has intimate knowledge and networks of regional and national innovation ecosystems. For the purposes of this project, Climate-KIC Holding BV will be the lead applicant. Our subsidiaries in the UK, France and Italy are affiliated legal entities – Linked Third Party **Climate-KIC S.r.l. (ITALY)** Registration No.: BO-524957 PIC Code – 917194365 Add: Via P. Gobetti 101, 40129 Bologna, Italy **Climate-KIC SASU (FRANCE)** Registration No.: 817 505936 PIC Code – 921160113 Add: 24 Avenue Marceau, 75008 Paris, France **Climate-KIC GmbH (Germany)** Registration No.: HRB 171530 PIC Code – 920740103 Add: Torgauer Str. 12-15, Euref-campus 16, 10829 Berlin, Germany **Climate-KIC ApS (Denmark)** Registration No.: 38151088 PIC Code - 915896893 Add: Nils Koppels Allé Building 402, 2800 Kongens Lyngby, Denmark While this project will have a pan-European remit, this proposed delivery structure will allow the project to focus its central delivery and replication efforts on the geographies which have the highest concentration of earth observation industry stakeholders.	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Agreement)	**No**
If yes, please describe the third party and their contributions.	

No other third parties involved

5 Ethics and Security

5.1 Ethics

No ethical issues have been identified.

5.2 Security

Please indicate if your project will involve:

- activities or results raising security issues: NO
- 'EU-classified information' as background or results: NO

6 Letters of Support

6.1 World Meteorological Organisation

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale
Organización Meteorológica Mundial
Всемирная метеорологическая организация
المنظمة العالمية للأرصاد الجوية
世界气象组织

Secrétariat
7 bis, avenue de la Paix – Case postale 2300
CH 1211 Genève 2 – Suisse
Tél.: +41 (0) 22 730 81 11
Fax: +41 (0) 22 730 81 81
wmo@wmo.int – public.wmo.int

Ref.: 03656/2019-1.2 RES-ARE

Our ref.: 03656/2019-RES/ARE

Francesca Di Giuseppe
The European Centre for Medium-Range
Weather Forecasts (ECMWF)
Shinfield Park, Reading
RG2 9AX, United Kingdom

6 February 2019, GENEVA

Subject: letter of support for the "FRAME - FiRe Across MultiplE Services" project

Dear Dr Di Giuseppe,

With this letter I would like to express our support to the "FRAME - FiRe Across MultiplE Services" project proposal to be submitted to the H2020 programme in response to the call "Copernicus evolution – Research activities in support of cross-cutting applications between Copernicus services". If implemented, this project will bring multiple benefits to the Members of the World Meteorological Organization (WMO).

The World Meteorological Organization is the UN system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources. The activities of WMO Members are guided by the developments in the atmospheric sciences which are regularly reviewed by the WMO Commission for Atmospheric Sciences and supported by the Research Department of WMO.

The WMO's Commission for Atmospheric Science (CAS-17) met in Geneva, Switzerland on 23-24 October 2017 and made several recommendations to the WMO Constituent Bodies and Members in relation to the scientific priorities for the organization. The CAS-17 session built on the outcomes of the preceding "Science Summit on Seamless Research for Weather, Climate, Water, and Environment" those recommendations are published in the comment in the Nature magazine on 13 December 2017. One of the outcomes of the CAS-17 session is a call for the new generation of modelling and observing systems that would support advances in seamless predictions within next 5-year horizon and provide services in multiple environmental domains and time scales. Such capacity could be built on the Earth System modelling approach which is the approach underling the FRAME project.

The FRAME project addresses an important environmental phenomenon, namely fire, which is associated with degraded air quality, related health impacts and ecosystem degradation. In recognition of the problems related to biomass burning, WMO initiated development of the Vegetation Fire and Smoke Pollution Warning and Advisory System (VFSP-WAS) as an outcome of the international workshop on "Forecasting Emissions from Vegetation Fires and their Impacts on Human Health and Security in South-East Asia" which took place from 29 August to 1 September 2016 in Jakarta, Indonesia. In implementation of this concept, WMO relies on the national and international modelling centres and institutions that can develop the modelling capability to provide the warnings on different temporal and spatial scales.

At the moment such capabilities are based on the Fire danger metrics (the Canadian Fire Weather Index, the US Forest Service National Fire-Danger Rating System and the Australian McArthur system are example) that rely on semi-empirical relationship based on prevailing vegetation type, its flammability characteristics and meteorological conditions.

The FRAME project proposes the more "natural" though more challenging approach, that treats fires as one of the processes in an Earth system model developed for weather forecasting. By doing so it will harmonise the way fire is treated across the various Copernicus services and will create a real opportunity to enhance all of the services by providing consistent and cross-cutting new Copernicus products. Moreover, focus on this hazard demonstrates the social orientations of the proposal, that if fully implemented, will provide multiple benefits (e.g. increased resilience) to WMO Members and address one of the WMO Strategic Priorities on Disaster Risk Reduction as described in the WMO Strategic Plan for 2019-2023.

Considering the alignment of the proposal with articulated above priorities of WMO, I am happy to provide the support to this activity and looking forward to its contribution to the WMO coordinated activities.

Yours sincerely,

(O.Tarasova)
Atmospheric Environment Research Division
Research Department

6.2 International Cooperative of Aerosol Prediction

Monterey, CA USA
February 6, 2019

RE: Copernicus evolution submission-FRAMES

Dear Dr. Di Giuseppe,
We are writing today on behalf of members of the International Cooperative of Aerosol Prediction (ICAP) in support of the proposed FiRe Across MultiplE Services (FRAMES) initiative. ICAP is a grassroots style community/trade organization to advance global aerosol prediction and analysis through the open exchange of best practices between developers for global aerosol forecasting systems. All of the world's centers that generate a global aerosol forecast have representation in ICAP (e.g., BSC, Copernicus/ECMWF, FMI, JMA, MeteoFrance, NASA GMAO, NOAA NCEP, UKMO, US Navy NRL/FNMOC) as well as numerous agencies supporting satellite observations. ICAP members are at the forefront of aerosol technology and are greatly concerned with the future of aerosol related systems, their application, and the supporting data that are used for initialization, assimilation and verification. While we do not officially speak for our respective agencies, we are writing today to present a consensus opinion by ICAP scientists and developers on the community wide benefit of the FRAMES program, should it be funded.

ICAP members are well acquainted with both the basic science and applications of the field of aerosol research. An area of long standing concern is seasonal forecasting of biomass burning. With climate applications of direct and indirect forcing and real world applications for natural disaster preparedness, biomass burning forecasting is a priority at all major global aerosol forecast centers. Compared to other aerosol sources, biomass burning has the most interdisciplinary relationships with meteorology across fields. For example, major dust and sea salt events can be predicted with moderate skill using land surface maps coupled with wind forecasts. Anthropogenic and biogenic emissions can be treated with seasonal and temperature inputs. Biomass burning, however, is a result of a complex set of relationships between weather and ignition opportunity. In some places, such as central Africa and South America, seasonal burning has predictable patterns. But, in more temperate to boreal environments, the relationships between weather, fuel conditions and ignition become more complex. As a case in point, last year significant burning activity in Scandinavia took the scientific community by surprise. Was this an isolated incident or an indicator of climate change? Such a question and many others related to biomass burning can be addressed in a probabilistic framework.

As colleagues of the FRAMES co-PI, Dr. Benedetti, we are writing in support of this effort and recognize the importance of the biomass burning challenges FRAMES will address. While there are several fire hazard products available from the US and Canadian forest services, moving from "immediate" fire conditions to the full forecast on medium to seasonal scales will require a high quality meteorological ensemble coupled with an earth system model. We believe that the ECMWF ensemble coupled with

Copernicus earth science components will provide the necessary framework. *Indeed, the probabilistic ensemble approach followed by ECMWF for weather prediction provides a natural way to deal with an inherently stochastic problem, and this is the approach that will be applied in FRAMES. By using dynamical emissions from an integrated fire dynamical model, the aerosol prediction and its downstream impacts will be greatly enhanced in the sub seasonal-to-seasonal scale.* Such forecasts are in their infancy in the community, and some of the most respected work thus far has been led by Dr. Benedetti.

As a community we are excited about the possibilities and the many potential benefits this work could offer. It is an innovative plan. We wish the project well in its scientific endeavours, and if selected, ICAP members across the globe look forward to actively collaborating with the FRAMES team.

Very Best Regards,

Peter R. Colarco, NASA
Co-Chair of ICAP

Jeffrey S. Reid, NRL
Co-Chair of ICAP

Taichu Y. Tanaka

Taichu Y. Tanaka, JMA
Co-Chair of ICAP

6.3 Agencia Estalal de Meteorologia

Centro de Investigación Atmosférica de Izaña

Santa Cruz de Tenerife, February 13th, 2019

To whom it may concern,

In my capacity of Director of the Izaña Atmospheric Research Center (IARC) from the State Meteorological Agency –AEMET-, Spain, which manages the Izaña Observatory, part of the World Meteorological Organization (WMO) Global Atmospheric Watch (GAW) Programme, I declare my interest in the proposal titled **"FRAME - FiRe Across MultiplE Services"**, led by ECMWF.

This project is aimed to modify completely the way fire information is modelled and used across several Copernicus services (namely CAMS, C3S, CEMS, CLMS, CO2/CHE).

The IARCs observation and research programmes are envisaged to greenhouse and carbon cycle gases, reactive gases and aerosols using in-situ and ground based remote sensing techniques. For this reason, the ECMWF's proposal is very interesting for our center because the new FRAME system will be able to predict fire emissions for the most important chemical species (black carbon, organic matter, CO, CO2, O3 etc). This new and unique information will help us to understand atmospheric background data and the atmospheric/terrestrial mechanisms explains its variability, and warn us about interesting atmospheric events, helping to adequately schedule special measurement programs.

Yours faithfully,

Dr. Emilio Cuevas
ecuevasa@aemet.es
Izaña Atmospheric Research Center
State Meteorological Agency of Spain (AEMET)
C/ La Marina, 20, Planta 6
38071 Santa Cruz de Tenerife, SPAIN
Phone: +34-922-151718; Fax: +34-922-574475
http://izana.aemet.es

CORREO ELECTRONICO
ecuevasa@aemet.es

C/ La Marina, 20-6ª planta
Tel. 922-151718
Fax. 922-574475

6.4 Protecione Civile Italiana

DPC
Prot. U. n. 9851 del 21 febbraio 2019

MODULARIO P.C.M. - P.C. - 9

Presidenza del Consiglio dei Ministri
DIPARTIMENTO DELLA PROTEZIONE CIVILE

Presidenza del Consiglio dei Ministri Mod. 9
DIPARTIMENTO PROTEZIONE CIVILE
Prot n° PRE/0009851
Roma, del 21/02/2019
USCITA 21

Prot. N°
Risposta al Foglio del
N°

Dott.ssa Francesca Di Giuseppe

FRAMES-Coordinator

ECMWF

Shinfield Park - Reading RG2 9AX

e-mail: Francesca.digiuseppe@ecmwf.int

Subject: Letter of support of Italian Civil Protection Department to the project FRAMES (coordinated by ECMWF).

I hereby undersigned dott. Angelo Borrelli, Head of Italian Department of Civil Protection, confirm our interest in the proposal project "FiRe Across Multiple Services (FRAMES)", coordinated by the European Centre for Medium Range Weather Forecast (ECMWF) that will be submitted to the "EU Research and Innovation program Horizon 2020".

The Italian Department of Civil Protection considers the products that will be developed in FRAMES project as an important contribution for improving the capabilities of the system to support fire and weather risk assessment. The new prototype products that could be made available through FRAMES promise to address specifically a need for integrated information that are missing at the moment and hopefully will improve the risk prevention and management. For these reasons, considering the benefits that this proposal could bring to the available European products, we believe that the main expected results of the project may provide important contributions also to Civil Protection issues.

In each case, we will not raise any financial request from the project FRAMES and/or the beneficiaries. At the same time, our organization will not be requested to overpower any economic participation to the project

THE HEAD OF THE DEPARTMENT
Angelo Borrelli

6.5 Chinese Academy of Meteorological Sciences

中国气象科学研究院
Chinese Academy of Meteorological Sciences
46 Zhong Guan Cun S. Ave., Beijing, 100081, China
Tel：86-10-68406216；Fax：86-10-62175931

To: Francesca Di Giuseppe
FRAMES-Coordinator
ECMWF
Shinfield Park
Reading RG2 9AX

Subject: letter of support for the "FRAMES - FiRe Across MultiplE Services" project

Dear Dr Di Giuseppe,

I am writing on behalf of WMO SDS WAS

In 2012, the General Office of the State Council released the National Forest Fire Emergency Plan to further promote the working mechanism of responding to forest fire disaster and take effective forest fire emergency by law so as to minimize casualties and property loss caused by forest fire. This plan defines the work of meteorological department in warning release, measures of emergency response, communication and information support and etc. In the future, meteorological department will play a more important role in national forest fire emergency work.

The plan also emphasizes that forestry and meteorological departments should provide analysis data of weather trend, satellite forest fire monitoring cloud image, live picture and image of fire, electronic map and other information so as to provide support for putting out the fire. CMA and State Forestry Administration always keep good cooperation relation. CMA monitors the heat source points of the whole country every day and the conditions of forest fire as well as releases forest fire weather rating forecast.

In view of these points, I welcome and support ECMWF's proposal to build an integrated global fire/biomass burning aerosol forecasting system in the FRAMES proposal to be submitted to the European Union's H2020 Research and Innovation programme.

CMA has an history of collaboration with ECMWF on many areas. As you know, I personally worked with Dr Benedetti who is one of the Work Package leaders, on aerosol analysis and

forecasting. The dust forecasts from CAMS contribute to the WMO Sand and Dust Storm-Warning and Assessment System Asian Node, of which I am the chairperson. In view of these productive collaborations, I wish you a successful proposal and I look forward to a continued collaboration.

Sincerely yours

(Xiaoye Zhang)
Chair of WMO SDS WAS SC

6.6 Meteorological Service Singapore

METEOROLOGICAL SERVICE SINGAPORE
P O Box 8 Singapore Changi Airport
Singapore 918141

Tel: +65 6488 1859
Fax: +65 6289 9313

18 February 2019

Dr Francesca Di Giuseppe
European Centre for Medium-Range Weather Forecasts
Reading RG2 9AX, United Kingdom

Dear Dr Di Giuseppe,

Proposal for FRAMES (FiRe Across MultiplE Services)

1 The Meteorological Service Singapore (MSS) is supportive of the objectives outlined in the FRAMES proposal by the European Centre for Medium-Range Weather Forecasts (ECMWF) to be submitted to the European Union's Horizon 2020 Research and Innovation programme.

2 MSS hosts the ASEAN Specialised Meteorological Centre (ASMC), which is the official centre for monitoring and alerting of fires and transboundary haze in the Southeast Asia region. This service is provided to the Association of South East Asian Nations (ASEAN) comprising Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam). ASMC also provides seasonal climate predictions for the region, using information from the Copernicus Climate Change Service (C3S). In addition, ASMC aims to host the first regional centre under the new WMO Vegetation Fire and Smoke Pollution Warning and Advisory System (VFSP-WAS).

3 MSS has been developing a haze dispersion modelling system to improve assessment of transboundary haze. Key inputs to the model are pollutant emissions from fires, which are based on information from the Copernicus Atmosphere Monitoring Service (CAMS). The development of a dynamical fire model in FRAMES and establishment of relevant feedbacks to ECMWF's Integrated Forecasting System (IFS) will provide improved estimates of fire emissions. Incorporating the impact of fires could also help enhance C3S seasonal products.

4 With our operational and research expertise that is tailored to the region, we would be happy to collaborate and contribute to the development and testing of relevant fire products for Southeast Asia. We look forward to the enhanced CAMS and C3S products arising from developments under the FRAMES proposal which will benefit our services to the ASEAN region.

Yours sincerely,

Wong Chin Ling (Ms)
Director-General
Meteorological Service Singapore

6.7 Columbia University

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Francesca Di Giuseppe
FRAMES-Coordinator
ECMWF
Shinfield Park
Reading RG2 9AX

February 12, 2019

Dear Dr. Di Giuseppe:

Subject: Letter of support for the "FRAMES - FiRe Across MultiplE Services" project

I write in support of your proposed project 'FiRe Across MultiplE Services', which is directly relevant to my NASA-supported projects in estimating the climatic and air quality effects of biomass burning emissions, in developing early warning systems for severe fire episodes at synoptic, sub-seasonal and seasonal time scales, and in projecting fire activity under a changing climate. The proposed approach of integrating fire within ECMWF's Earth system modeling components represents a major advance in all areas.

A new risk is the changing characteristics (frequency, location, severity) of weather and climate related hazards since natural climate variability is now exacerbated by long-term, human-induced climate change. The increased socio-economic impact of fire related disasters provided by changing climate forcings is very visible in recent mega-fire events. Another example is provided by the 2015 Indonesian devastating fire seasons which was exacerbated by the resilient human practice of using fire to clear land and the establishment of hot and dry conditions sustained by a strong ENSO. Our previous work on this topic has demonstrated the potential for useful long-lead forecasts of such events, but only in an 'off-line' sense which does not account for the climatic effects of aerosol emissions.

Investment in forecasting systems that provide reliable and timely warning is therefore critical. It is accepted that future improvements in predictive skill for weather induced disasters will arise from an improved representation of more complex physical and chemical processes, This is especially true for process that have an inherent human component in it such as fire ignition.

I therefore welcome the conceptual improvements addressed in FRAMES as they take on a new challenge of also integrating socio-economic based data related to population density and control measures into a purely weather and climate framework which is used for operational services. This will represent a real opportunity to extend the predictive range of the forecasting models and will provide a good way to improve our understanding of the process that regulate fire ignition and spread.

For these reasons I support this project and would very much look forward to further collaboration.

Sincerely,

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Dr. Robert Field
Robert Field
NASA Goddard Institute for Space Studies
Columbia University, Dept. of Applied Physics and Applied Mathematics
2880 Broadway, New York, NY, 10025
robert.field@columbia.edu, Tel: 212-678-5600

6.8 ACT Parks and Conservation Service

ACT Government
Environment, Planning and Sustainable Development

Dr Francesca Di Guiseppe
European Centre for Medium-Range Forecasts
Reading
RG2 9AX
United Kingdom

Dear Dr Di Guiseppe,

Support for FRAME – FiRe Across MultiplE Services project proposal

Thank you for bringing the H2020 FRAME project proposal to the attention of ACT Parks and Conservation Service. The treatment of fire as an integral part of the earth system and the development of new prediction systems that are enabled to feedback its effects on the weather and other fire-related metrics represents a significant advancement on the present modular approaches. I agree with the statement in the proposal abstract that this is a ground-breaking concept.

Smoke production from fires is a key issue for fire managers in Australia following the Hazlewood Mine Fire of 2014 which was subject of a Government inquiry. Consequently, improved understanding and prediction of smoke dispersion and its affects is an active field of research and operational evolution. Wildfires are usually the primary cause of smoke issues, and this is a most important aspect for improvement, but for land managers such as ourselves attention is focussed on the smoke produced by prescribed burns. We see potential for significant improvement in both cases. Predictions of the most important chemical species within emissions is also important due to the potential it may deliver, to improve public health outcomes.

GPO Box 158 Canberra ACT 2601 | phone: 132281 | www.environment.act.gov.au

Other aspects of the proposal which are of great importance to Australian land and fire managers are maps of fuel moisture content and fire ignition probability. Better prediction of the likelihood of ignitions, the behaviour of fires and the opportunities to conduct prescribed burns are all topics with strong potential to improve fire management outcomes. In remote regions of Australia burnt area mapping is also valuable, particularly for reporting functions.

I strongly support the FRAME project proposal and would be pleased to see it funded. I also stand available to contribute to evaluation or trials if required.

Dr Adam Leavesley
Bushfire Research Utilisation Manager
ACT Parks and Conservation Service
500 Cotter Road,
Weston, ACT, 2611,
AUSTRALIA

5 March 2019

6.9 Copernicus Climate Change Service

FRAMES
06/03/2019

0118-949-9166
Carlo.buontempo@ecmwf.int

To: Dr. Francesca Di Giuseppe,

coordinator of FRAMES proposal

Dear Coordinator,

Given the importance that biomass burning and forest fire have in controlling local CO2 concentrations and changing the surface albedo, Copernicus Climate Change Service is supportive of any initiative designed to improve the monitoring, the past reconstruction and the future predictions of fire related parameters such as for example the burned areas.

More specifically C3S is particularly keen to engage with all those projects which link to the experience of the Sectoral Information System and aim to develop or improve the provision of downstream impact data.

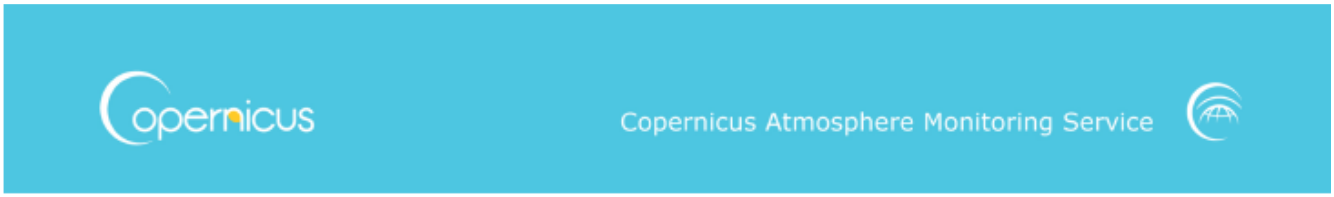
The FRAMES proposal clearly falls in this category.

For this reason, should FRAMES be funded, we would be more than happy to work with the project team to ensure a smooth interaction with or climate monitoring and operational activities.

Yours sincerely,

Carlo Buontempo

6.10 Copernicus Atmosphere Monitoring Service



Dr. Vincent-Henri Peuch
Deputy Director Copernicus Services
Head of the Copernicus Atmosphere Monitoring Service (CAMS)
European Centre for Medium-Range Weather Forecasts
Tel +44 118 949 9102
Fax +44 118 986 9450

11 March 2019

Reference: Letter of Support for the FRAMES H2020 proposal

Dear Dr. Di Giuseppe, dear Francesca

This letter is in support of the FRAMES (FiRe Across MultiplE Sercices) proposal that you are sending in response to Call LC-SPACE-04-EO-2019-2020 in my capacity as Head of the Copernicus Atmosphere Monitoring Service (CAMS). We've had several exchanges throughout the preparation of the proposal and, from the CAMS point of view, I reckon it meets perfectly well the Call's key objectives "to demonstrate the technical operational feasibility of one specific cross-cutting thematic application [... and that the] proposal is relevant for the enhancement of Copernicus core services [...]".

Fires are an important component of the Earth-System and, as you mention, are at the intersection of four of the six thematic Copernicus Services and are also relevant for current precursor activities developing new Copernicus products relative to CO2 emissions. Regarding CAMS specifically, the fire-related products in the portfolio pertain to the detection of currently active fires (based on Fire Radiative Power remote-sensing from different low-earth orbiting and geostationary platforms) and to the quantitative estimation of emissions of gases, particles and greenhouse gases from the combustion of biomass. These fire emissions, besides being products in their own right with an active and growing user community, are also used by our main global and European air quality forecasting systems. As you know, the CAMS forecasts reach a very large audience as they are used by leading apps and websites such as The Weather Channel, Euronews or Windy and effectively reach millions of individuals. On-going fires generally lead to adverse air quality and it is thus very important that our systems are able to account for them accurately.

FRAMES will bring improvements to the CAMS fire products as they stand now. To focus on the most important aspect, the proposal will look into the forecasting of the evolution of fires. Currently, we make the crude assumption in the CAMS forecasts that fires continue to burn and emit throughout out forecast horizon of 5 days ahead. This is obviously not realistic, especially if weather conditions are changing from fire-prone to fire-suppressing. By looking into the forecasting of fire evolution and liking this to fire danger forecasts of the Copernicus Emergency Management Service (CEMS), FRAMES will not only address this shortcoming, but it will also allow building in some degree of continuity between the CAMS fire emissions

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and CEMS fire danger forecasts. I can clearly see a benefit for the users of both products and also for the users of the CAMS air quality forecasts to have a much more realistic handling of how fires may evolve, given the forecast of meteorological conditions. Importantly, because the FRAMES developments will be in the software framework of ECMWF's land surface model, it will minimise the effort needed for picking up later the FRAMES developments into CAMS operations.

I wish you all the best for the FRAMES proposal and hope very much that it will be selected.

Yours sincerely,

Dr. Vincent-Henri Peuch, Head of CAMS

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6.11 ARISTOTLE European Natural Hazard Scientific Partnership

Rome, March 6th 2018

Subject: Letter of interest for the proposal FRAMES (FiRe Across Multiple Services) - Call H2020-SPACE-2018-2020

To whom it may concern,

As Representative of the Group Leader of the project ARISTOTLE-ENHSP "European Natural Hazard Scientific Partnership", I hereby express the interest to follow the activities of the proposal FRAMES "*FiRe Across Multiple Services*", submitted in response to the Call H2020-SPACE-2018-2020 launched by the European Programme Horizon 2020.

ARISTOTLE-ENHSP is envisaged as a long-term cooperation plan building onto the expertise, partnership and deliverables of the ARISTOTLE pilot project to deliver to the ERCC and to the ERCC Analytical Team world leading multi-hazard scientific advice through the implementation of the ENHSP which consists of a flexible and scalable operational service complemented by a permanent set of knowledge based pillars to support the operational activities with science and research, technological innovation, service quality assessment.

As such, ARISTOTLE-ENHSP is strongly interested to evaluate new products for fire forecasting that the FRAMES initiative might develop throughout the project. The expected results of FRAMES should foster the innovation and the development inside the Forest Fires' Expert Group of the ARISTOTLE-ENHSP as well as promote the linkages between the research community of FRAMES and the multi-hazard operational partnership of ARISTOTLE-ENHSP.

Your sincerely,

Alberto Michelini

Representative of the Group Leader

on behalf of the ARISTOTLE-ENHSP Consortium

6.12 Hellenic National Meteorological Service

HELLENIC NATIONAL METEOROLOGICAL SERVICE (HNMS)
El. Venizelou Street 14, 167 77 Helliniko, Athens, GREECE
Tel.: +30 210 9699002, +30 210 9699000
Fax: +30 210 9629415, +30 210 9628952, +30 210 9629408

Athens, March, 8, 2019

Project Coordinator of FRAMES

Letter of Support for FRAMES Program

Dear Project Coordinator,

I am writing on behalf of Hellenic National Meteorological Service (HNMS) in order to express our Service's support for the activities which are proposed to be carried out under the auspices of the FRAMES project.

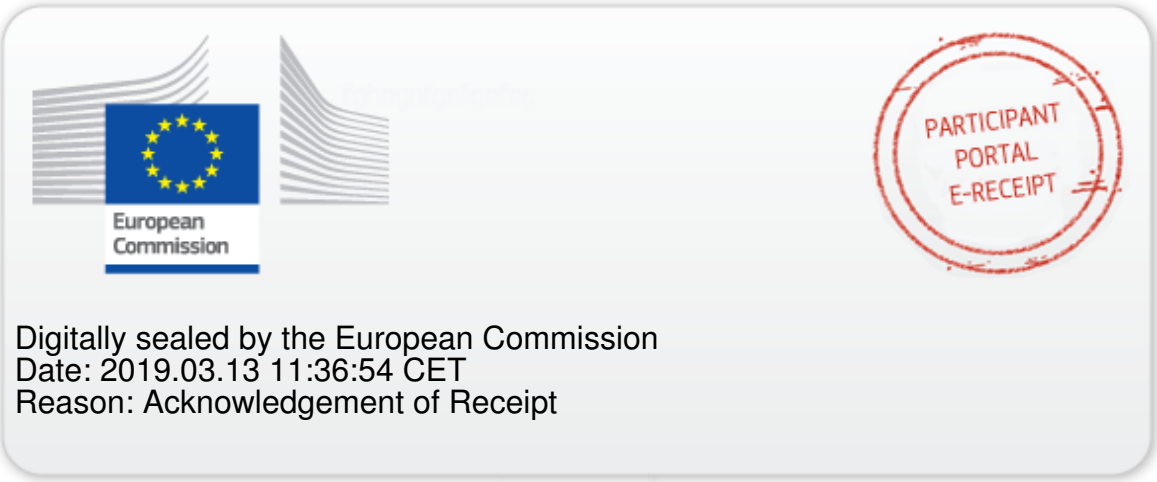
Acknowledging the importance of forest fires for Greece and their impacts on the economy, ecosystems, heritage and the society, HNMS welcomes the proposed efforts in FRAMES first for the incorporation of a dynamical fire model in the new ECMWF numerical weather forecasting model and then the fire-weather-air quality ensembles forecasts, in order to better understand the fire impacts on the Earth System as a whole.

Therefore, we are very interested in following FRAMES advancements and use the project's outcomes, which will be of obvious benefit for weather forecasting but also for the climate services.

We hereby declare that should the FRAMES project be chosen for funding, we have strong interest on using the fire danger products of FRAMES for Greece (e.g. fuel moisture content, fire ignition probability and burnt area). In addition, the exploitation of FRAMES's project deliverables by HNMS, as an official operational tool, will contribute to a fire risk assessment system for all related Greek authorities.

Yours sincerely,

Brigadier General (MT) Nikolaos Vogiatzis
Director General of HNMS



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