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Lund, Oct. 26 2019

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Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Development of the EC-Earth offline land surface model and application to decadal prediction of wildfires using LPJ-Guess

EC-Earth C4MIP spinup status

Etienne Tourigny,
BSC Climate Prediction & Computational Earth Sciences groups
Emanuel Dutra
Lund University
KNMI

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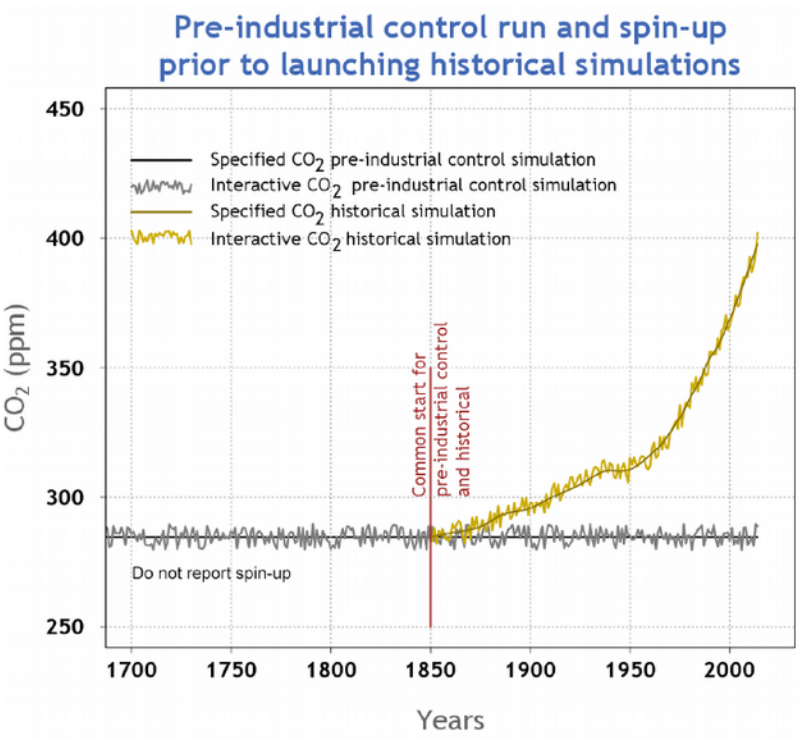
BSC's contribution to C4MIP With EC-Earth

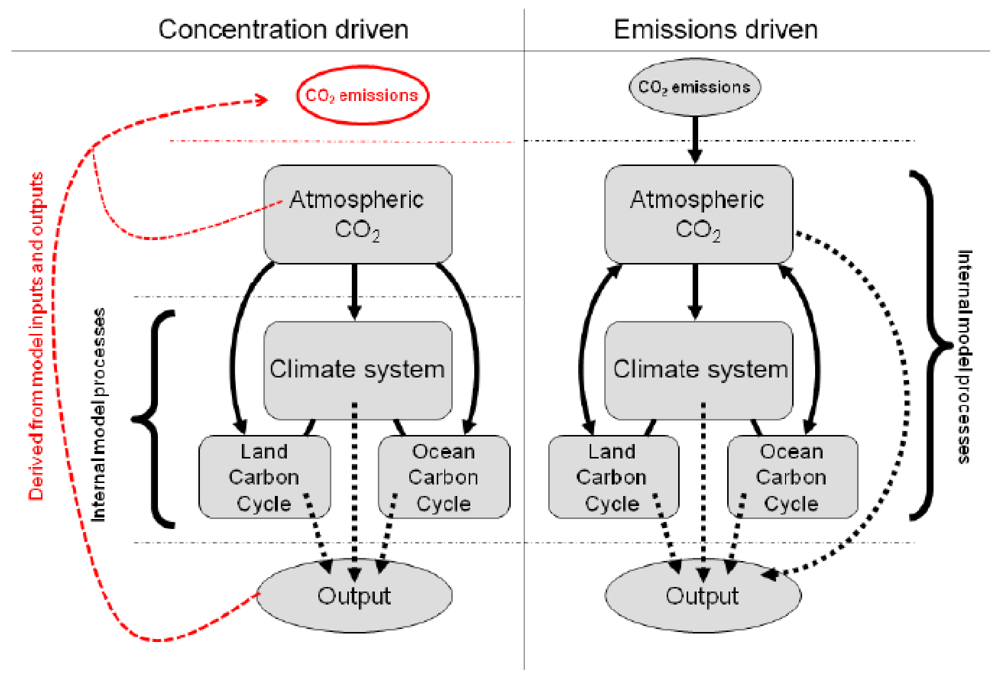
BSC - Etienne Tourigny, Raffaele Bernardello
Valentina Sicardi, Mario Acosta
Lund University
KNMI

C4MIP requirements

C4MIP – The Coupled Climate–Carbon Cycle Model Intercomparison Project: experimental protocol for CMIP6

Chris D. Jones et al. 2016 Geosci. Model Dev., 9, 2853–2880, 2016





Global carbon cycle: EC-Earth3-CC

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EC-Earth3-CC
Earth System Model

Model Components

Global Climate Model

IFS (Atmospheric Model):
T255 (0.75º) ~80km
L91 (top 0.01hPa) ~mesosphere
IFS-HTESSEL (Land Model)

NEMO (Ocean Model):
Nominal 1° Resolution
L75 levels (thousands km deep)

LIM (Sea-ice Model):
Multiple (5) ice category

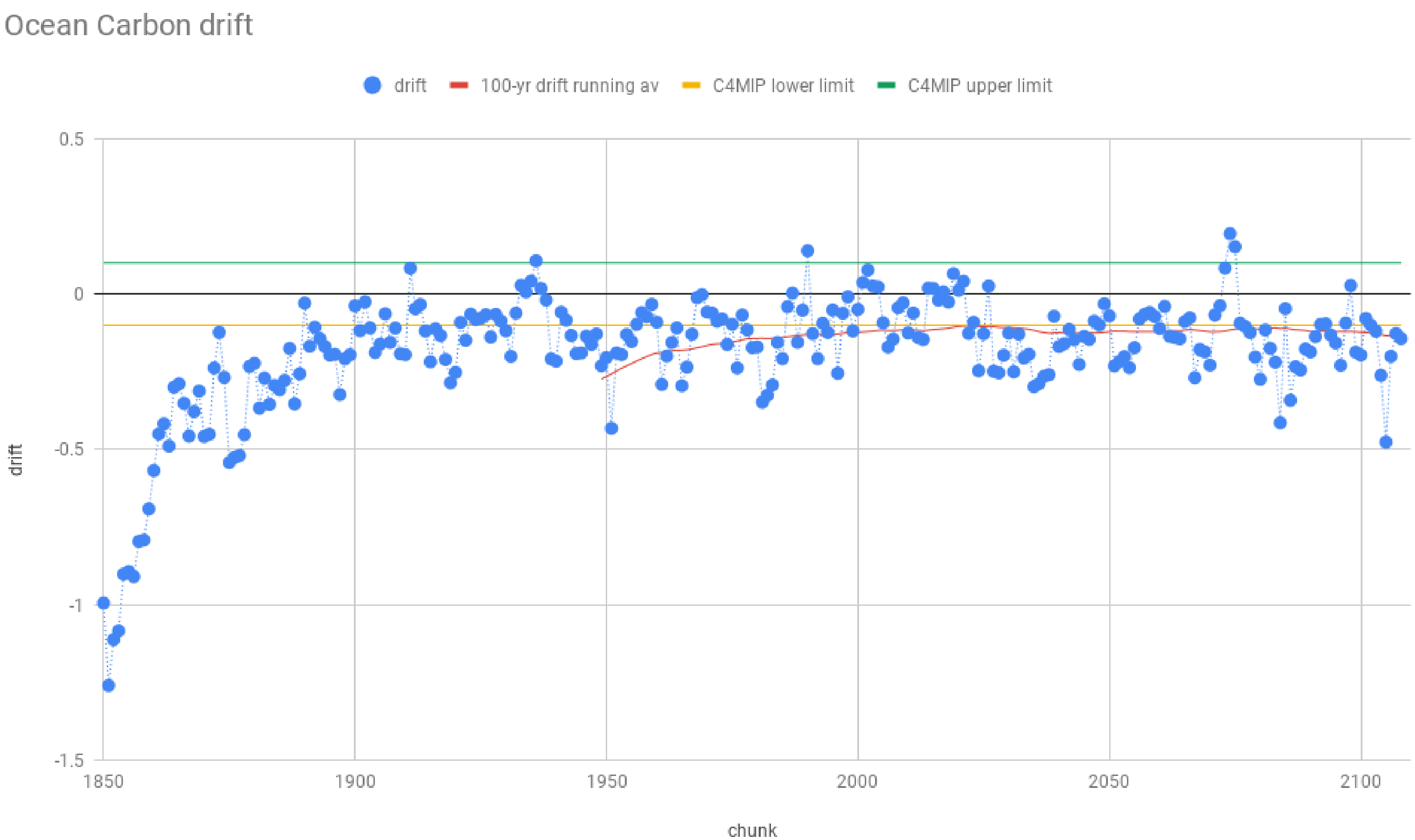
Global Carbon Cycle Model

PISCESv2 (Ocean Biogeochemical Model):
Lower trophic levels of marine ecosystems

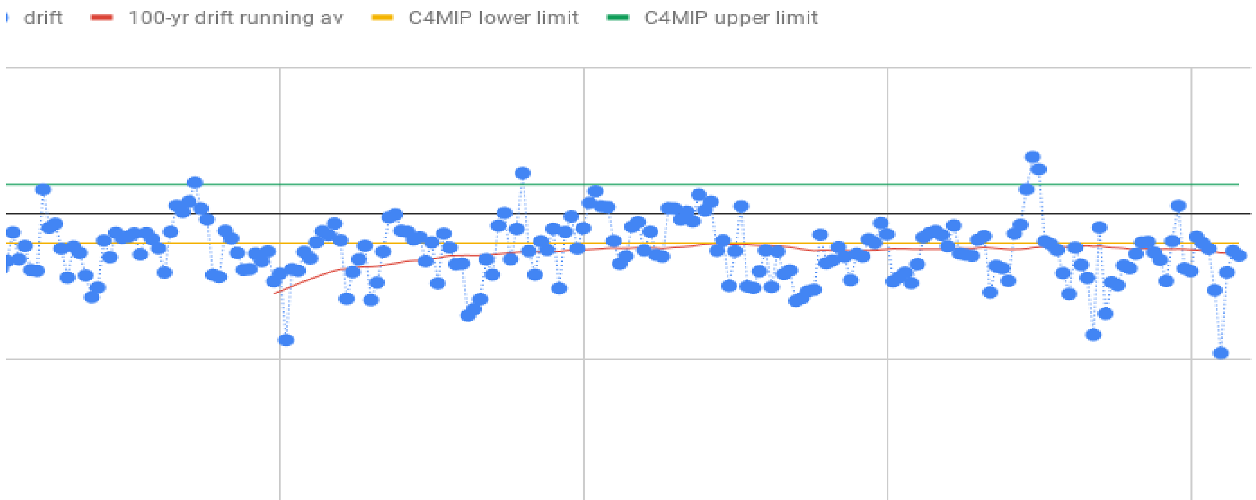
LPJ-GUESS (Dyn. Glob. Vegetation Model):
Process-based, plant functional types

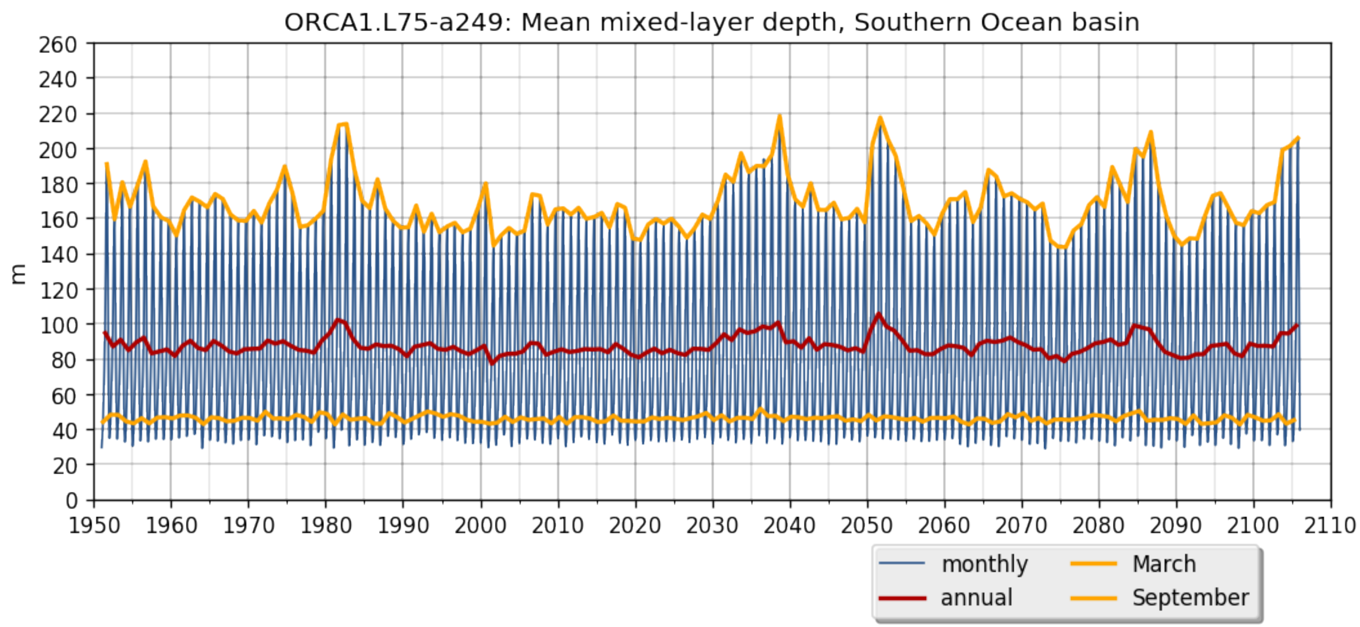
TM5-CO2 (Atm. Chem. Transport Model):
34 layers, single-tracer version (CO2)

C4MIP spinup status

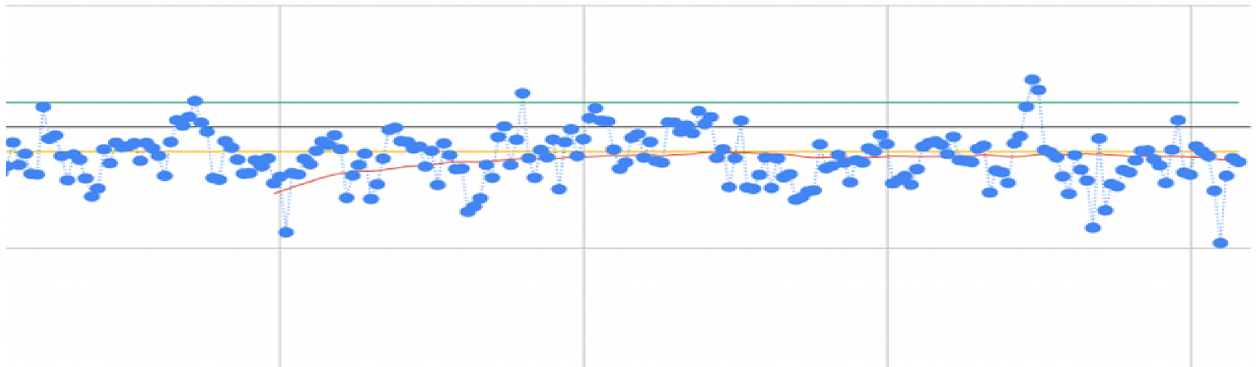


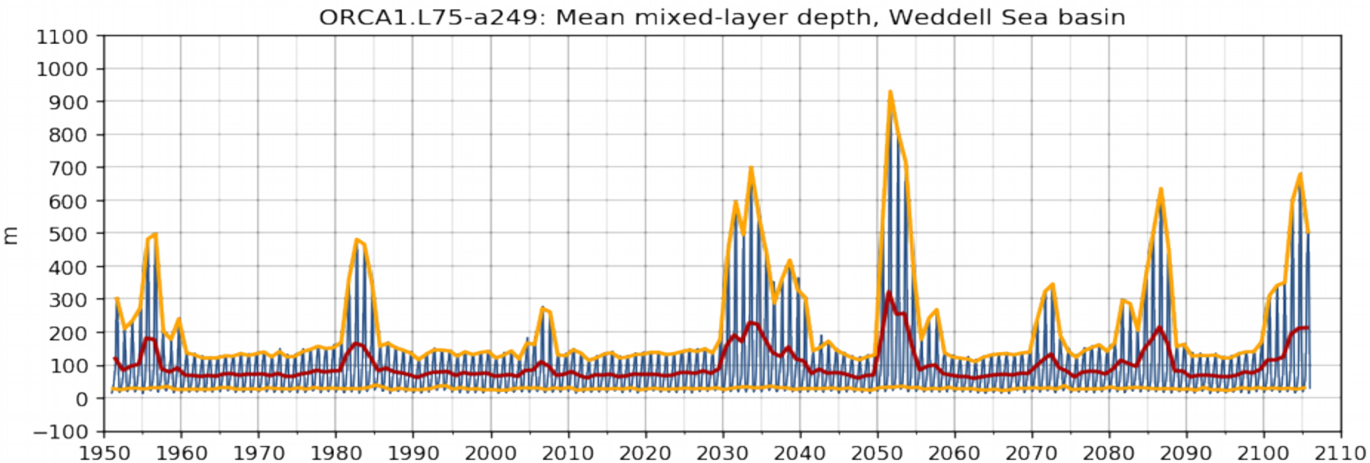
C4MIP spinup status

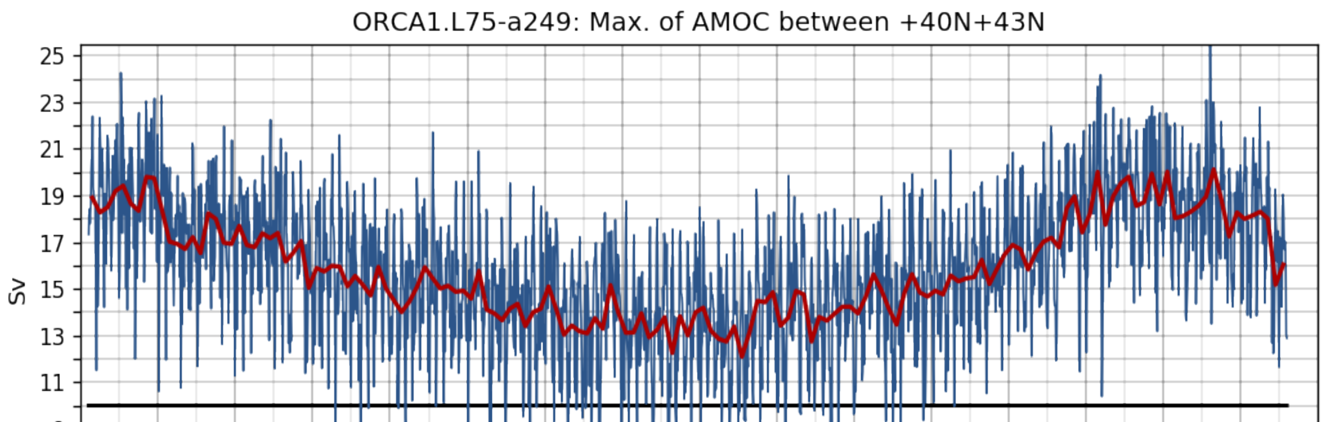




C4MIP spinup status

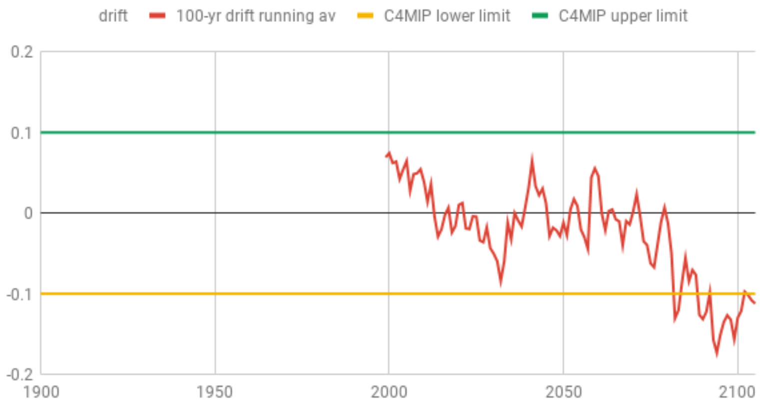




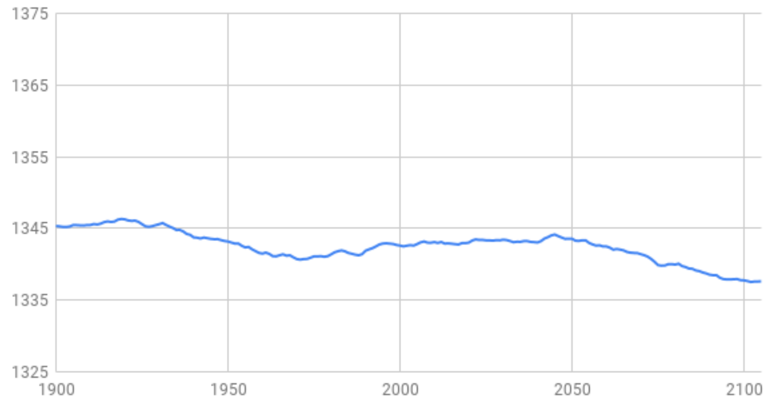


C4MIP spinup status

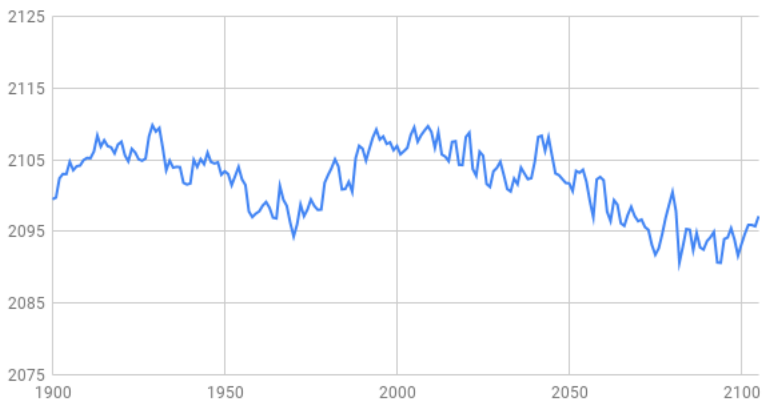
Land carbon drift (Pg/yr)



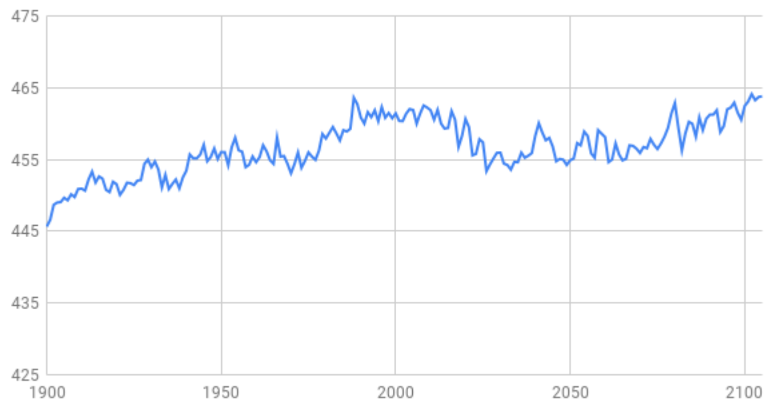
soilC (Pg)



Total C (Pg)



vegC (Pg)



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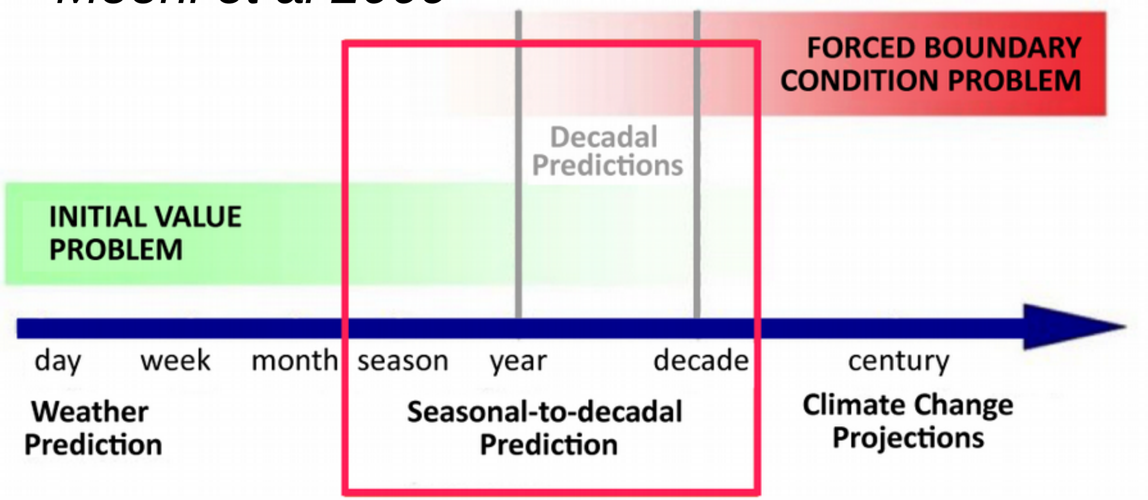
An update of the current climate prediction activities at BSC with EC-Earth

Pablo Ortega

Climate Prediction Group, Earth Sciences Department

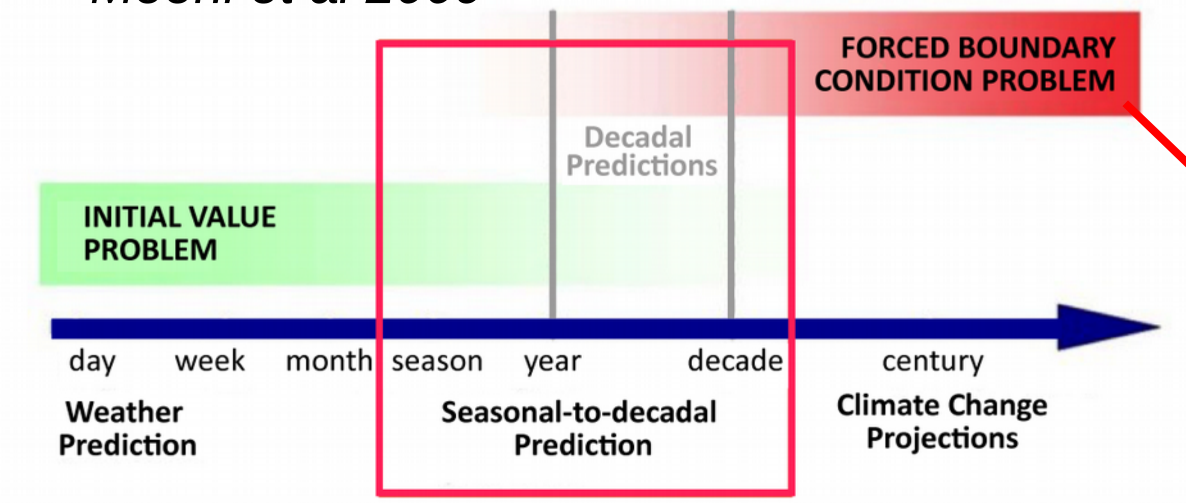
Cornerstones of climate prediction

Meehl et al 2009



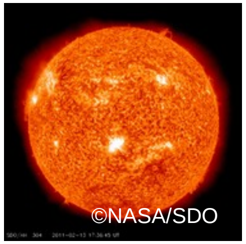
Cornerstones of climate prediction

Meehl et al 2009



Predictability relying on good guess of future changes in the forcing

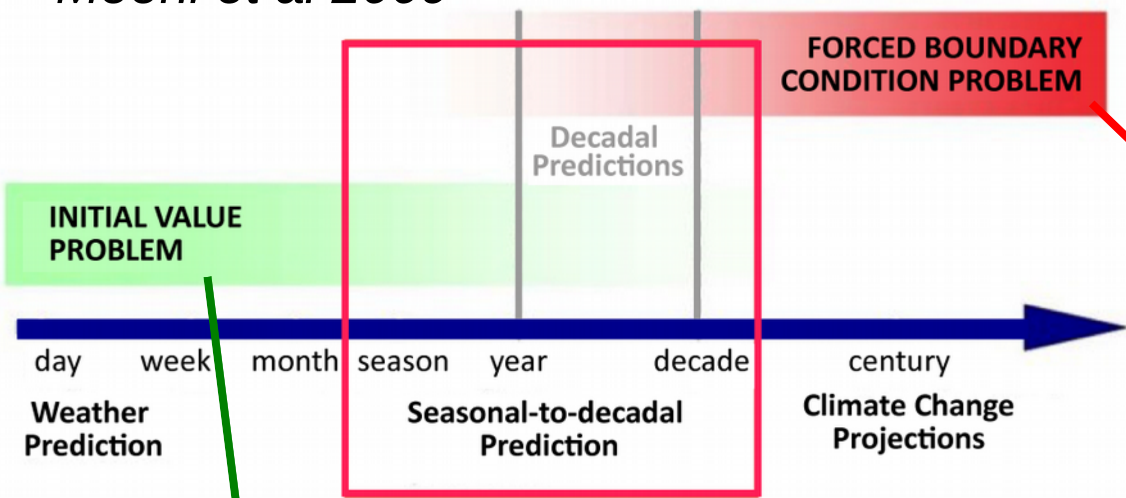
Solar Activity



Volcanic Aerosols

GHGs

Meehl et al 2009

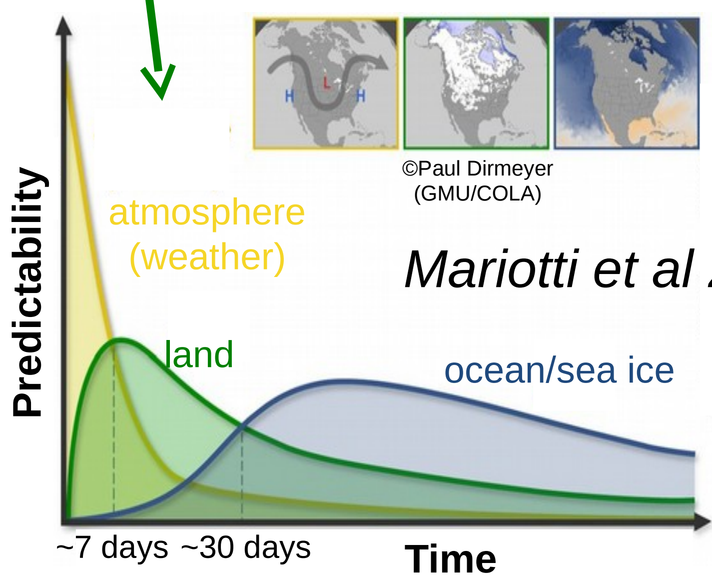


Predictability relying on good guess of future changes in the forcing

Solar Activity

Volcanic Aerosols

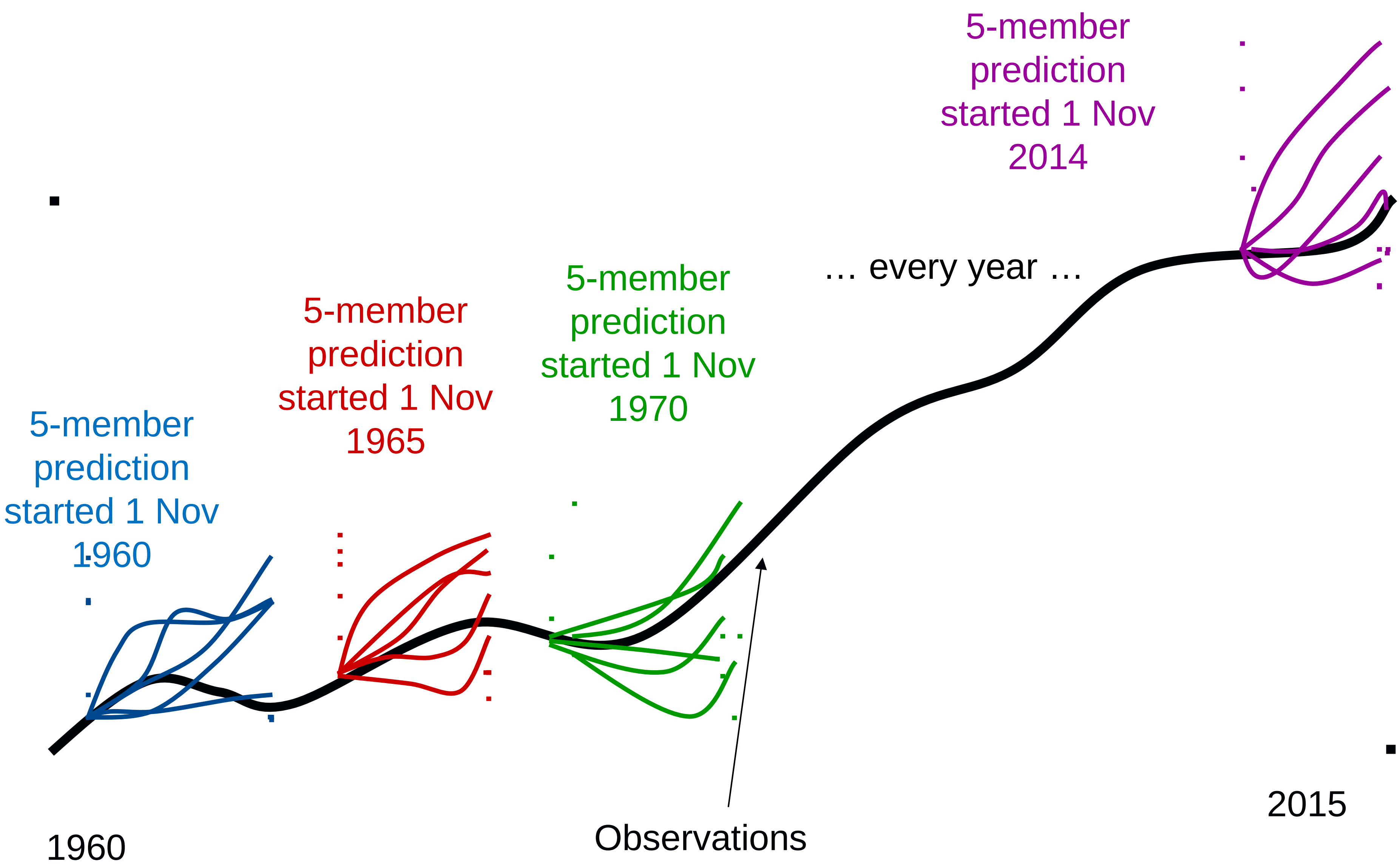
GHGs



Mariotti et al 2018

Predictability arising from the memory of slow processes/components in the climate system

Climate prediction experiments



Initial Conditions

ATM:
Interpolated to model grid with OpenIFS (now performed locally at BSC)

Atmosphere reanalysis (**ERA 40 + Interim**)

Land reanalysis (**ERA-Land**)

Ocean reanalysis (**ORAS4**)

Sea Ice reanalysis

Produced at BSC

LAND:
Offline land-surface simulation with near-surface meteorology and corrected fluxes from ERA-Interim

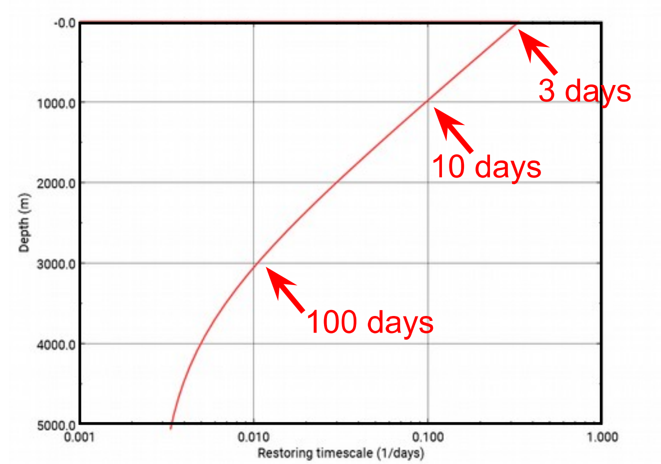
OCE+ SI:
Historical reconstruction with NEMO-LIM stand alone, forced with ERA-40/Interim fluxes, and nudged globally towards 3D T and S from ORAS4

Default surface restoring coefficients

γ_T = -40W/m^2/K

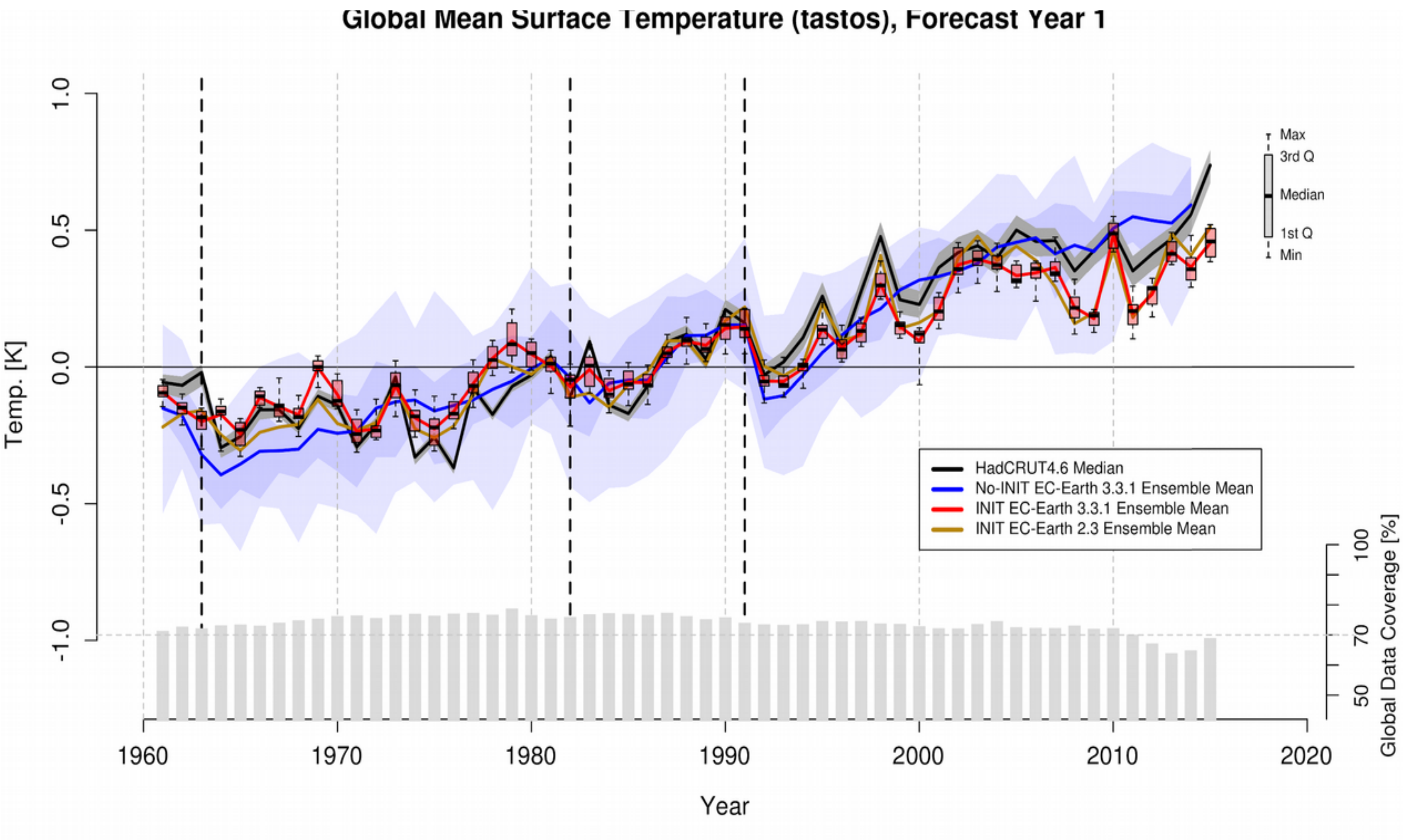
γ_S = -150 kg/m2/s/psu

Default 3D restoring timescales



Global Mean Surface Temperature

Forecast Year 1 (M3-14)
Combination of 2m temperature over land and SST over ocean



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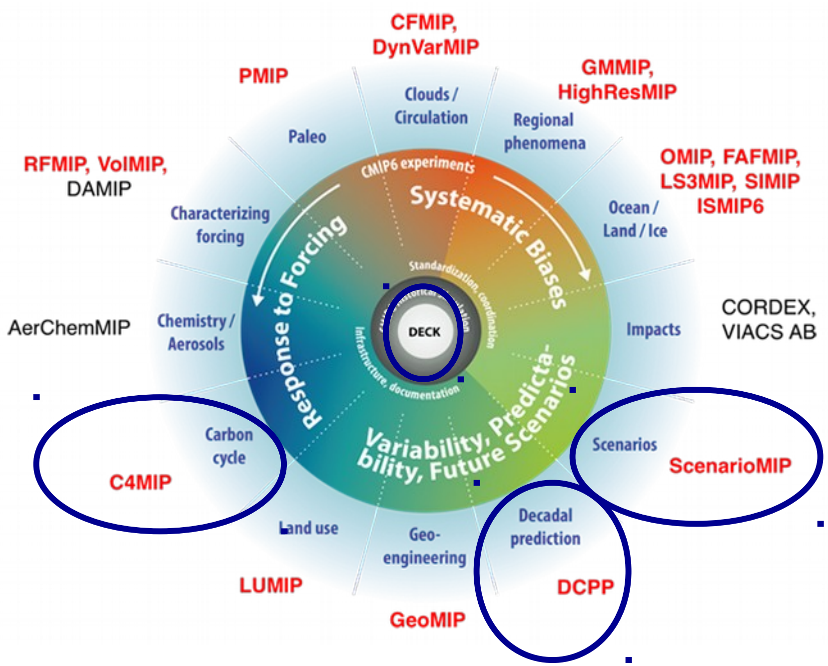

WCRP CMIP6
World Climate Research Programme

Contributions to CMIP6

EC-Earth 3.3.1 in standard resolution (~1°)

DCPP Component A:
Retrospective Predictions [1960-2017]

DCPP Component B:
Near-real time Forecasts [2018 onwards]

DECK+ScenarioMIP:
Historical+SPSS2-4.5 [1850-2100]

C4MIP

Other H2020 activities

With EC-Earth 3.3.1 in high resolution (~0.25°)

EUCP
European Climate Prediction system

DCPP Component A-like:
Retrospective Predictions [1960-2017]

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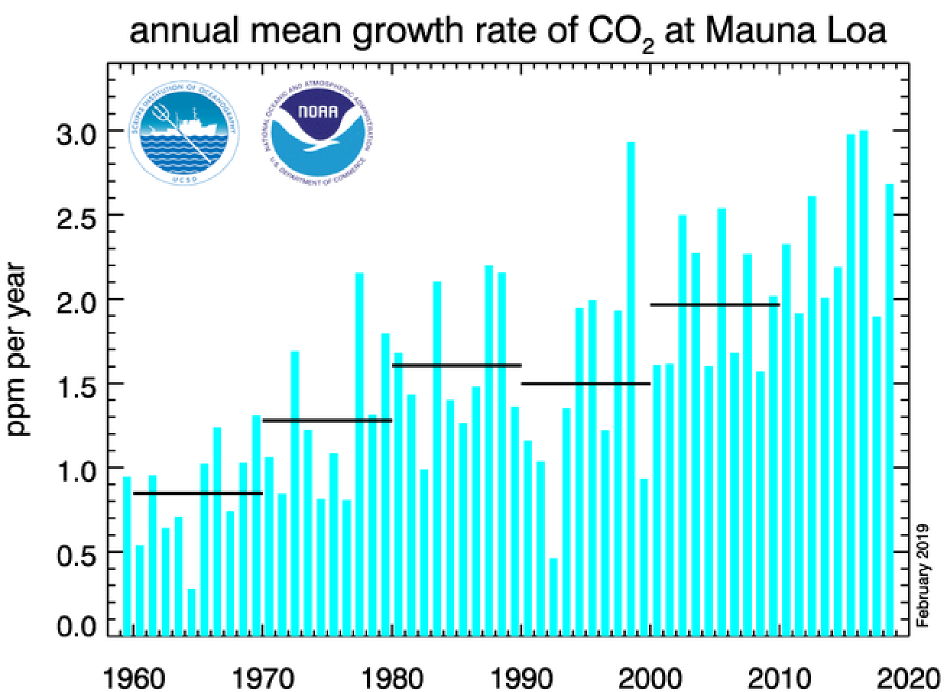
CCiCC

Towards a near-term prediction of the climate and carbon cycle interactions in response to Paris Agreement emission trajectories

Variability in atm CO2 growth rate is mostly due to natural variability

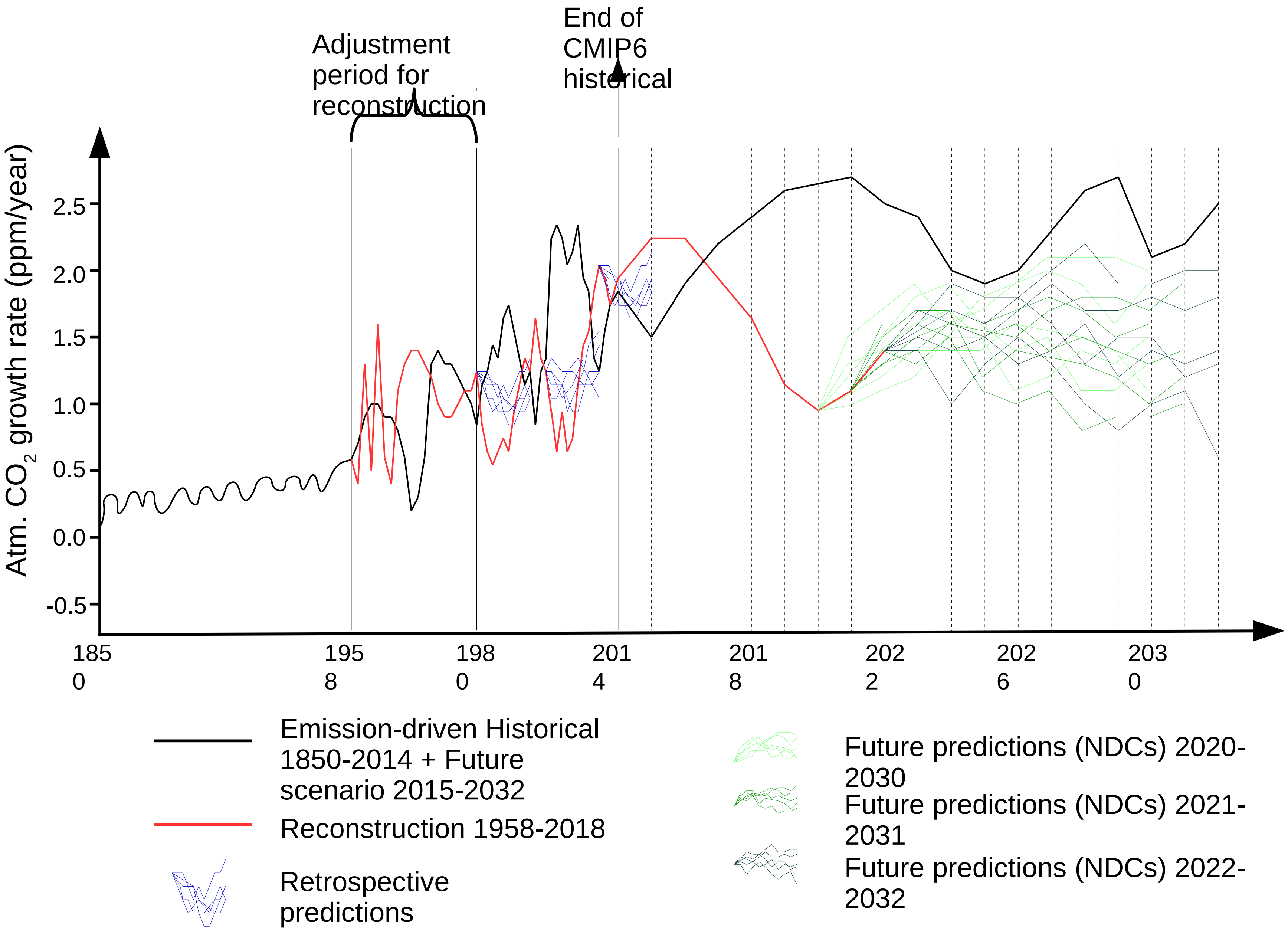


Testing different ocean biogeochemical reconstructions as initial conditions

Retrospective decadal predictions of ocean and land carbon uptake

Idealized perfect-model experiments to investigate mechanisms of C uptake predictability in the ocean.

Future Carbon – Climate interactions



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EXCELENCIA SEVERO OCHOA

EC-Earth land surface model : development of the offline configuration and application to decadal prediction of wildfires

Etienne Tourigny,
BSC Climate Prediction & Computational Earth Sciences groups
Emanuel Dutra
Lund University partners

Introduction

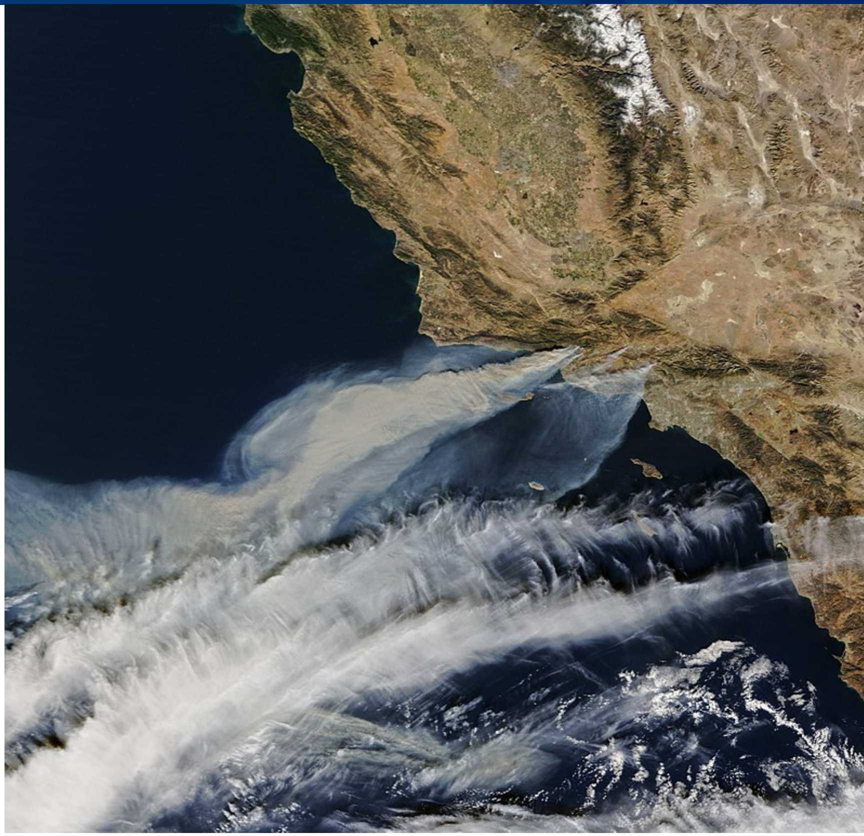
The 2017 fire season in California WAS the costliest on record, with 18 Billion US$ in damages, and deadliest with 43 casualties on record.

2018 wildfire season was even worse...

REX/Shutterstock

California 2017 wildfires

In October, around the Napa valley in Northern California, the Tubbs fire was the most destructive in US history. Warm temperatures and strong winds are thought to be responsible for the severity of these wildfires.



In December, Southern California was plagued by severe wildfires and the Thomas fire near Los Angeles became the largest in California history. It was thought to be fueled by sever Santa Ana winds and warmer than average temperatures.

Iberia 2017 wildfires

In June 2017, the infamous “Pedrogão Grande” wildfires (in central Portugal) killed 62 people trapped in their cars are they fled the intense wildfires.

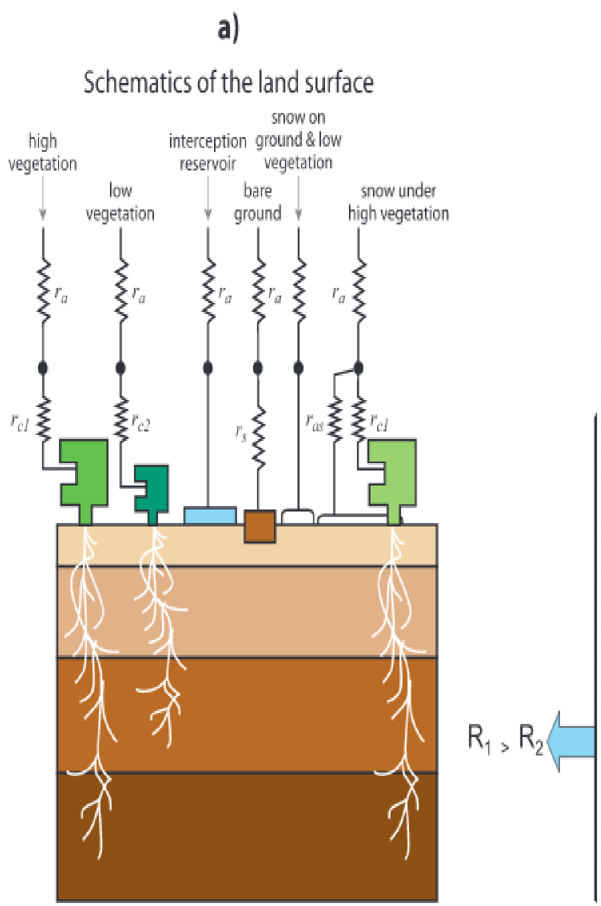
https://www.cnn.com/2017/06/18/europe/portugal-fire/index.html

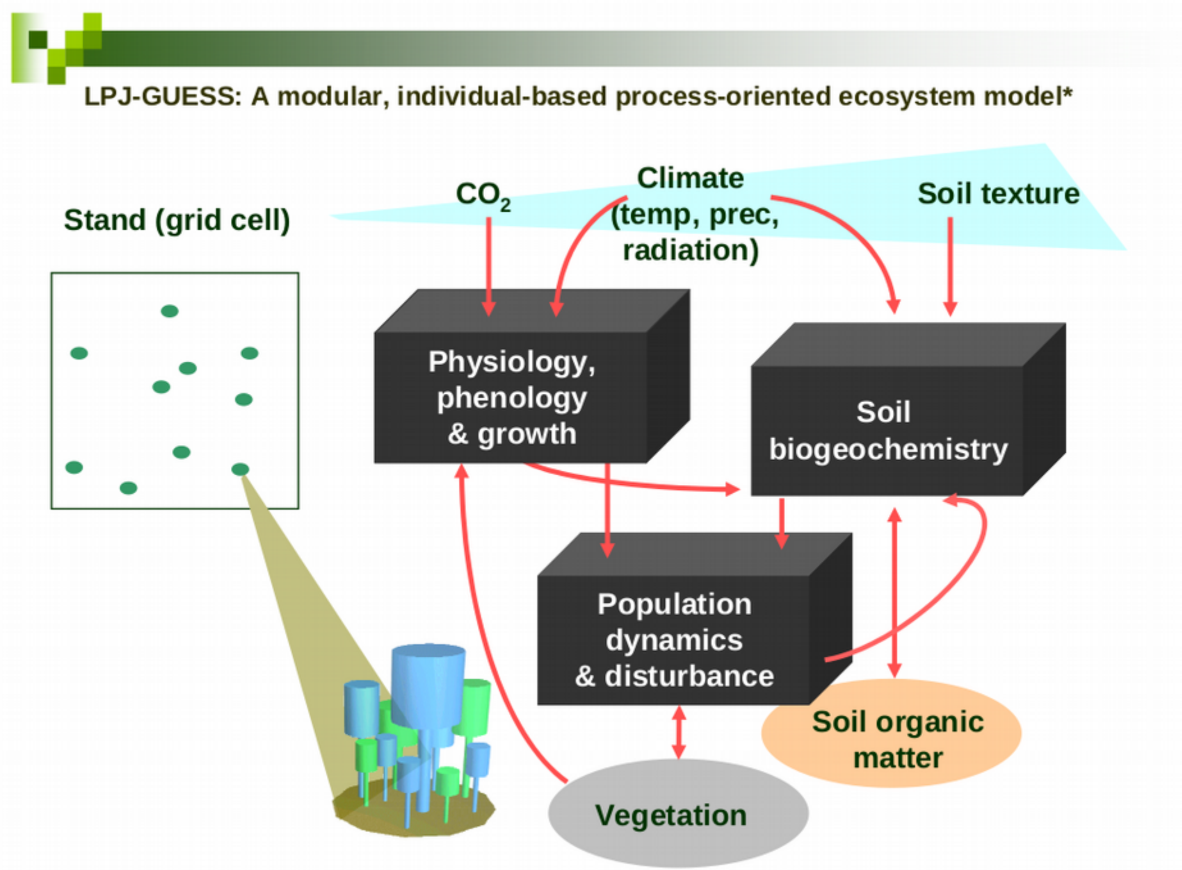
Iberia 2017 wildfires

In October 2017, wildfires raged across northern Portugal and Galicia (Spain). The wildfires were made possible due to an intense drought and fueled by intense winds from Hurricane Ophelia. Arson is believed to be responsible for igniting many fires.

https://www.nytimes.com/2017/10/16/world/europe/portugal-spain-fires.html

LSM : H-TESSEL + LPJ-GUESS





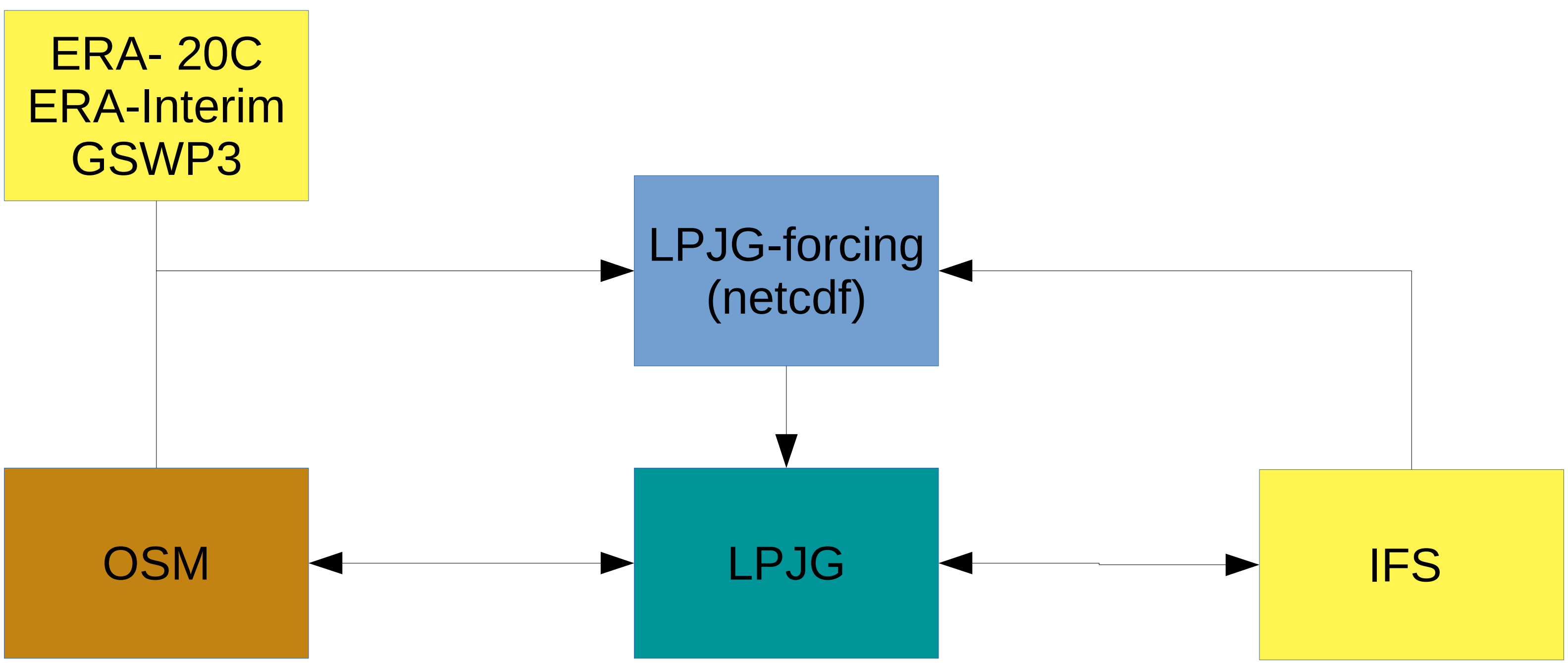
*Smith et al. 2001 *Global Ecology and Biogeography* 10: 621

Offline LSM status

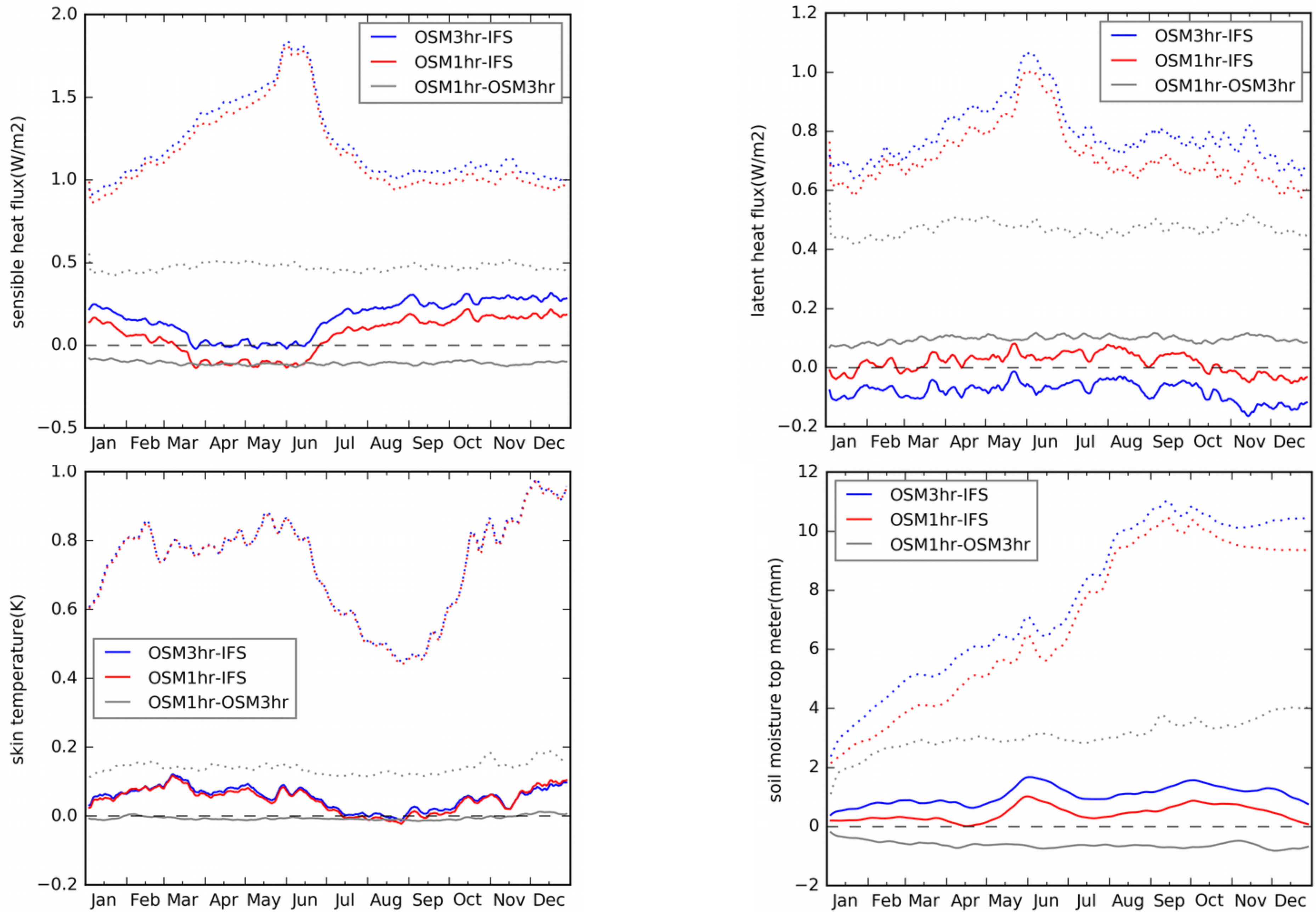
LSM (Land Surface Model) contains 3 components:

- **LPJG**, as used in the ESM configuration
- **LPJG-forcing** (aka Sparring), used to send atmospheric forcings to LPJG
- **OSM** (Offline Surface Model), offline version of the IFS surface model (H-TESSEL)

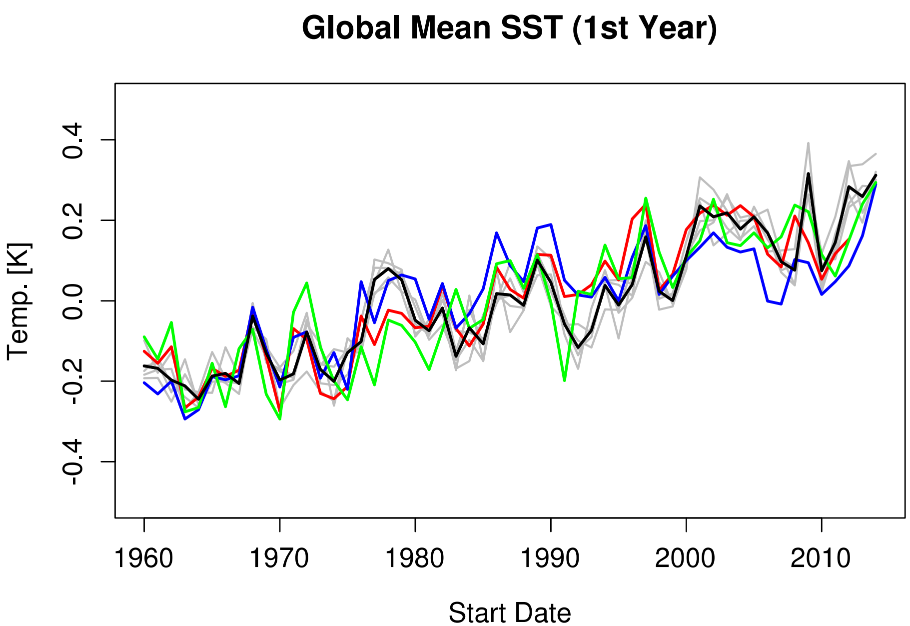
Forcings can be either From Reanalyses or IFS output

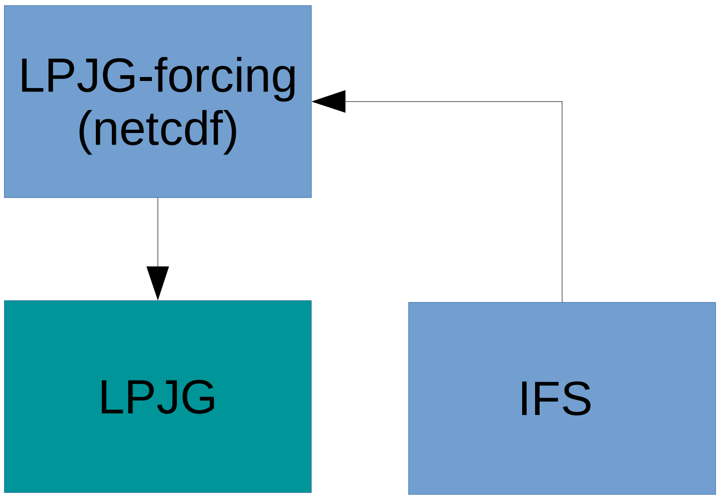


OSM validation – using IFS output



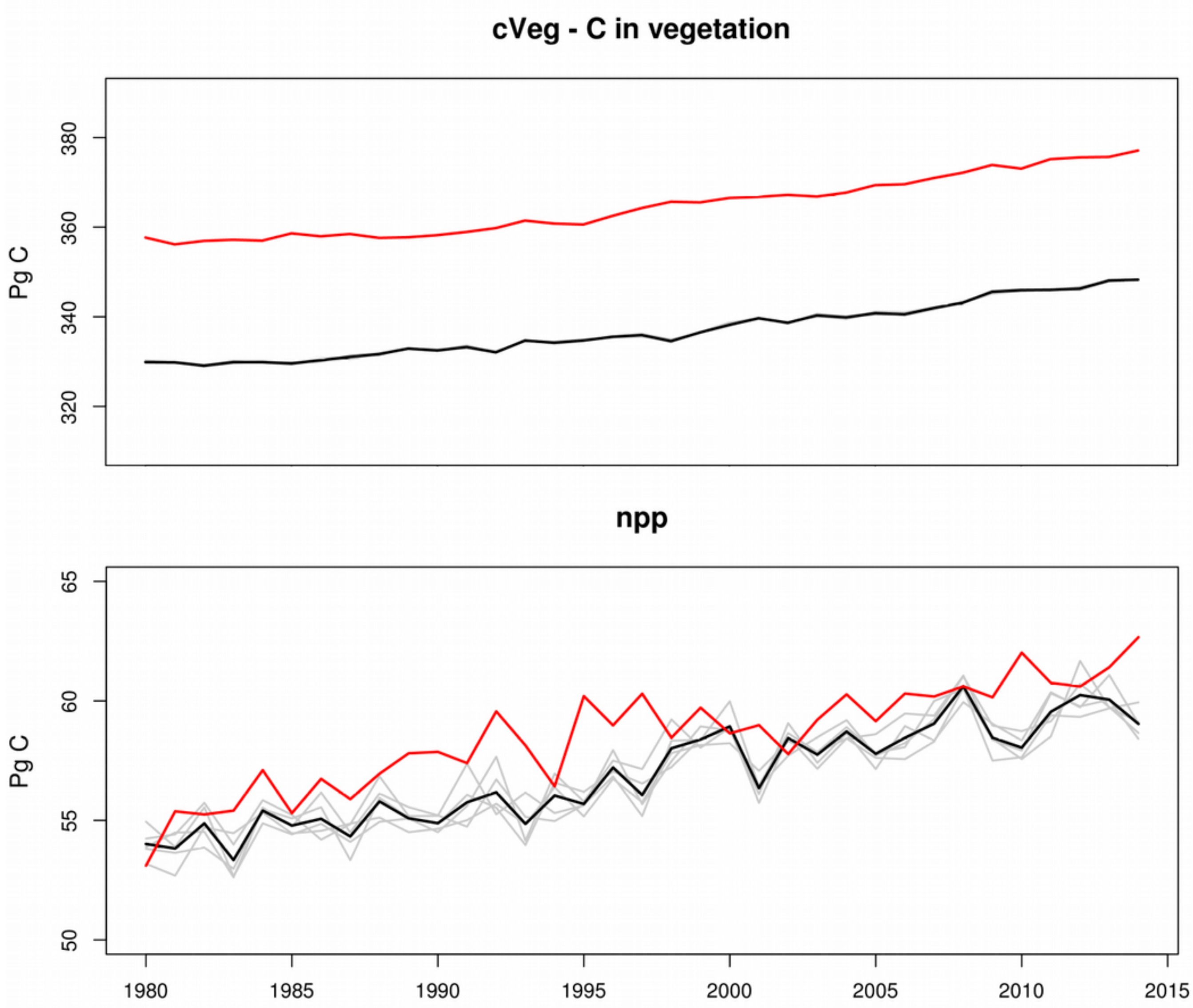
- DCPP LPJG-offline experiment :
  - **LPJG initial states** from Klaus' t613 run (EC_Earth-Veg)
  - Daily output from BSC's DCPP hindcasts (1960-2015), 5 years, 5 members
  - Allows to test the fire model before doing fully-coupled decadal hindcasts of the carbon cycle (CCiCC)





1st year DCPP vs ERA-Interim

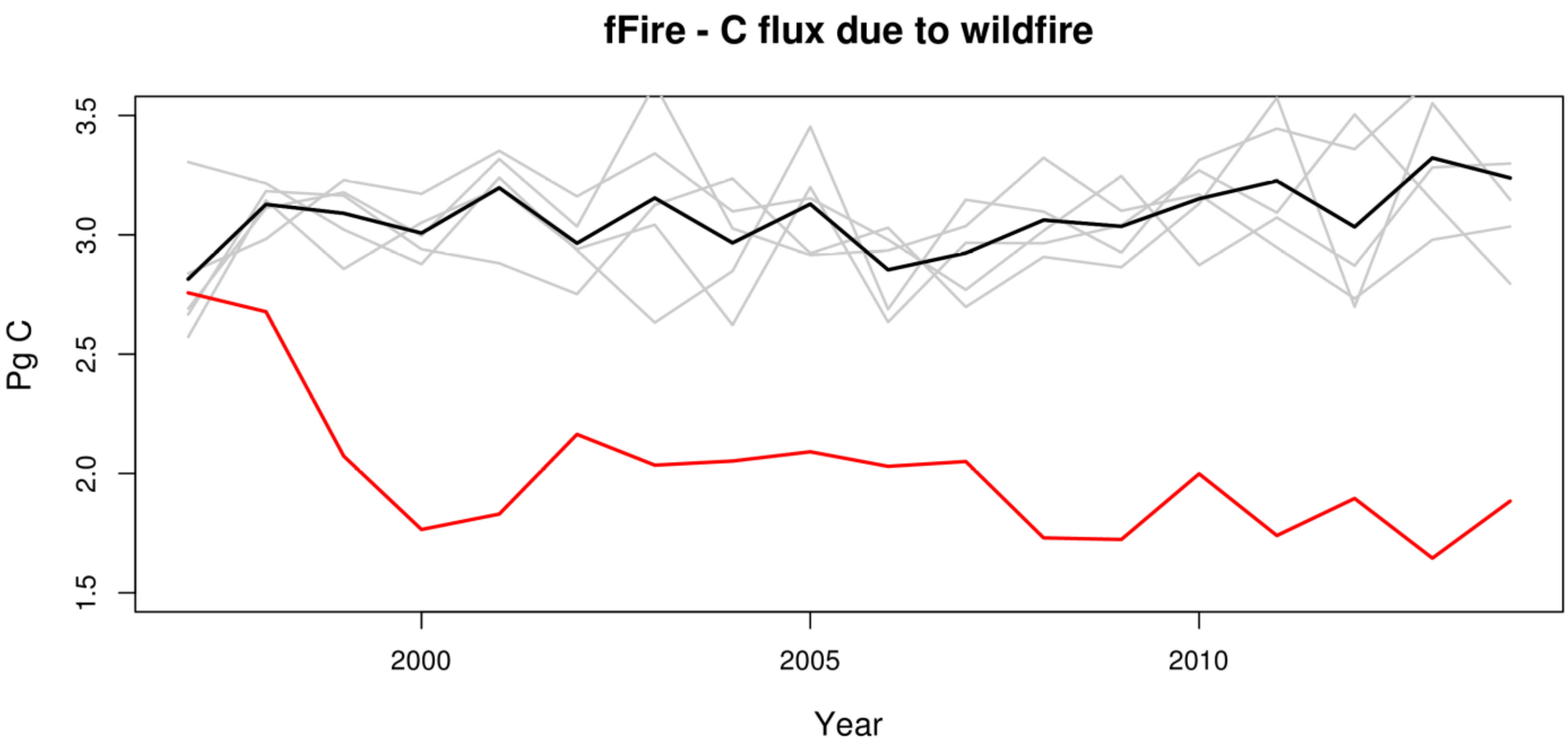
LPJG initial states from EC-Earth historical run,
Initialized with less vegetation Carbon than ERA-Interim forced offline run



1st year DCPP vs. GFED emissions

Fluxes from the GlobFIRM fire model are higher than GFED emissions,
Despite lower burned area (not shown). Large variability among ensemble members.

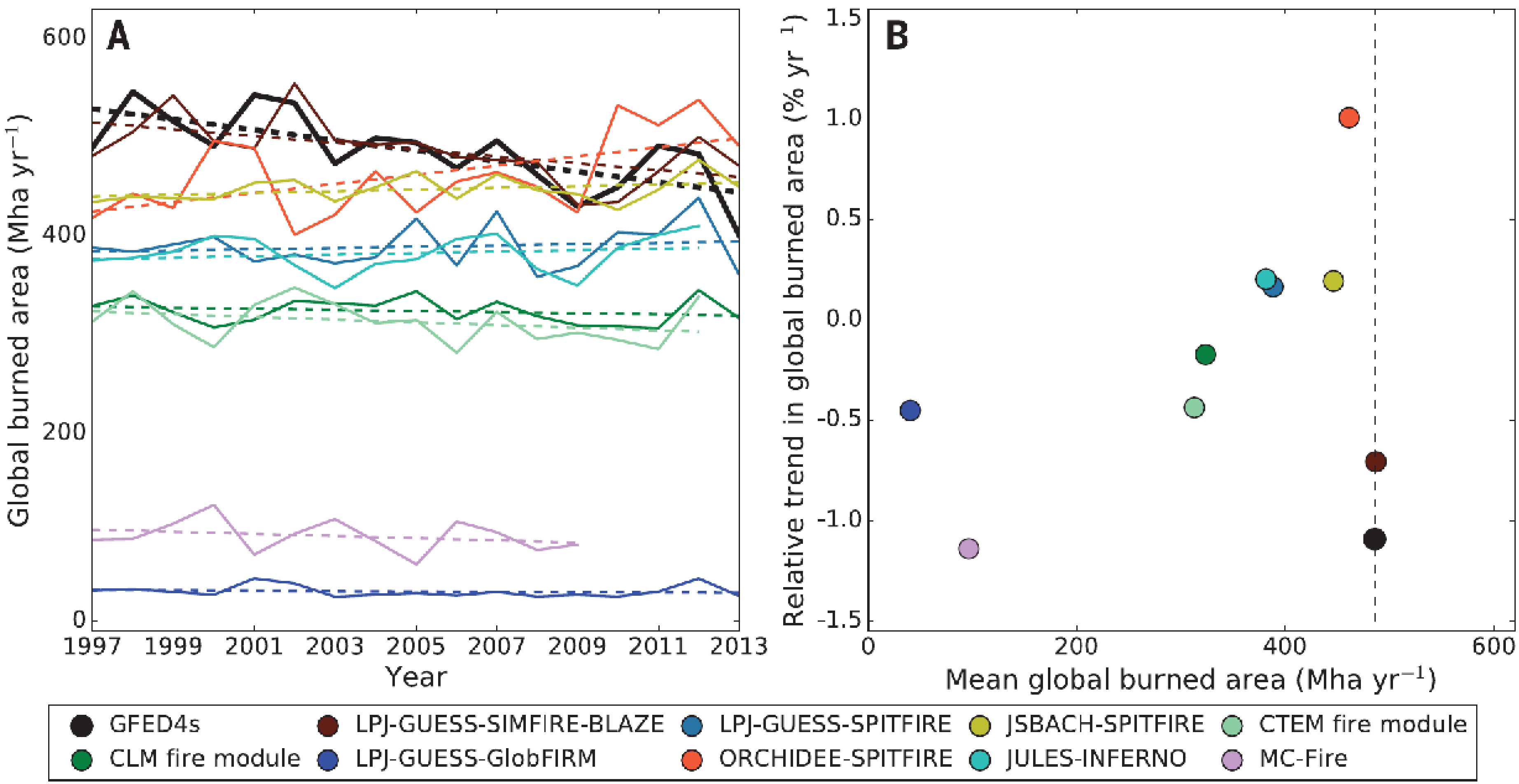
Hope is that better fire models (SIMFIRE/BLAZE, SPITFIRE) will perform better.



State of the art Wildfire models

Comparison of burned area simulated by several offline fire models (FIREMIP)

Current model in LPJG is the worst – GlobFIRM
The best is SIMFIRE-BLAZE – soon in our LPJG version!



Offline LSM status

- Uses of the EC-Earth offline LSM
  - Easy generation of Spinup / piControl / historical runs forced by reanalyses
  - Forcings from ERA20C / ERA-Interim / ERA5 / GSWP3
  - Can be used to generated ERA-Land initial conditions for IFS, using the same land model
  - Use in CMIP6 : LS3MIP, LUMIP & DCPP
- Contributions to LPJ-GUESS
  - Compressed output of text files – much faster offline runs, used by Paul Miller for GSWP3
  - Testing and improvement of fire models (SIMFIRE/BLAZE, SPITFIRE) in the EC-Earth framework
  - Development of “full” restarts in the middle of the year

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Thank you!

etienne.tourigny@bsc.es

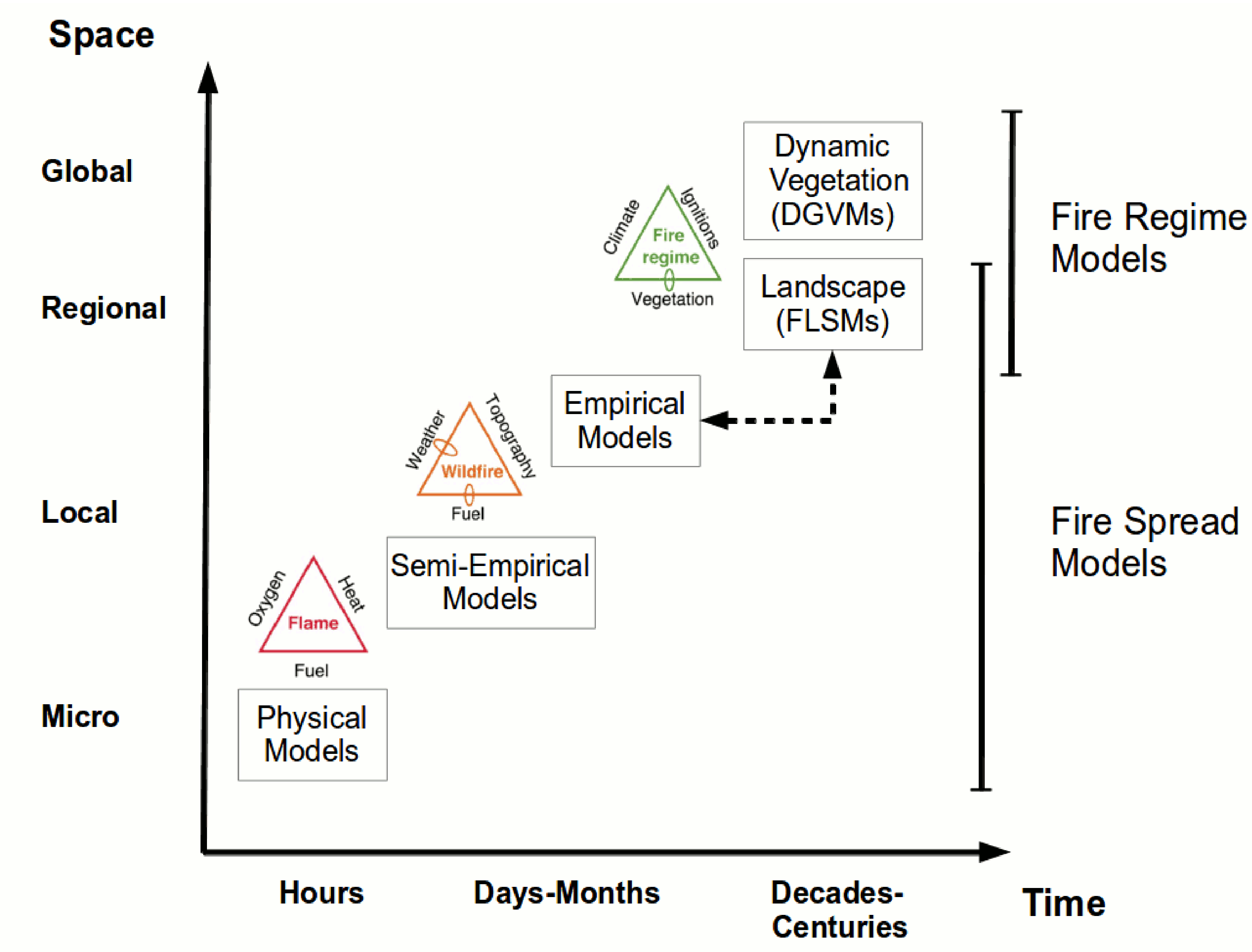
MARIE CURIE ACTIONS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 748750 "SPFireSD" - Seasonal Prediction of Fire danger using Statistical and Dynamical models

SPFireSD

- Seasonal Prediction of Fire danger using Statistical and Dynamical models (SPFireSD) is a MARIE SkŁodowska-CURIE ACTIONS Individual Fellowship (MSCA-IF)
- SPFireSD proposes to develop and assess seasonal fire prediction capability through a variety of complementary and innovative methods using statistical and dynamical models, with a focus on Europe, the Amazonian basin and Indonesia.
- This project will develop and assess seasonal prediction capability of wildfire danger using three complementary approaches:
  - 1) **Fire danger indices approach**: simple fire danger indices computed from seasonal dynamical climate prediction systems
  - 2) **Statistical approach**: statistical fire danger models using a combination of past observational data and seasonal dynamical climate forecasts
  - 3) **Dynamical approach: ensemble dynamical predictions** using state-of-the-art fire models within Earth System Models (LPJ-Guess part of the EC-Earth Earth System Model)

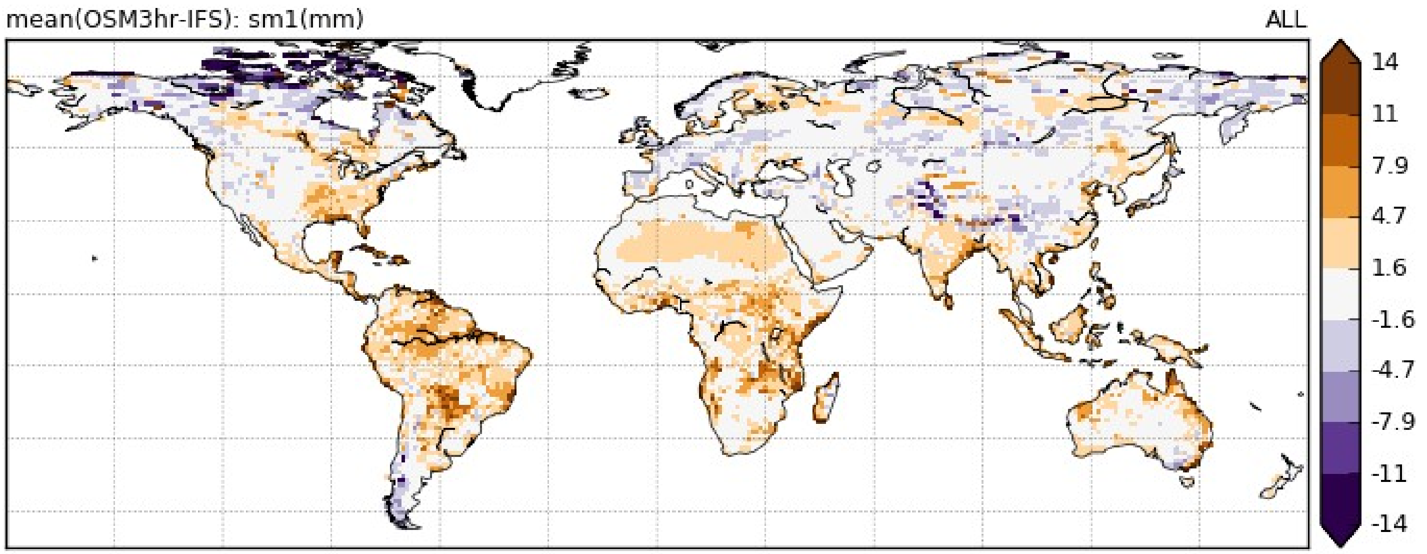
Fire modeling across scales

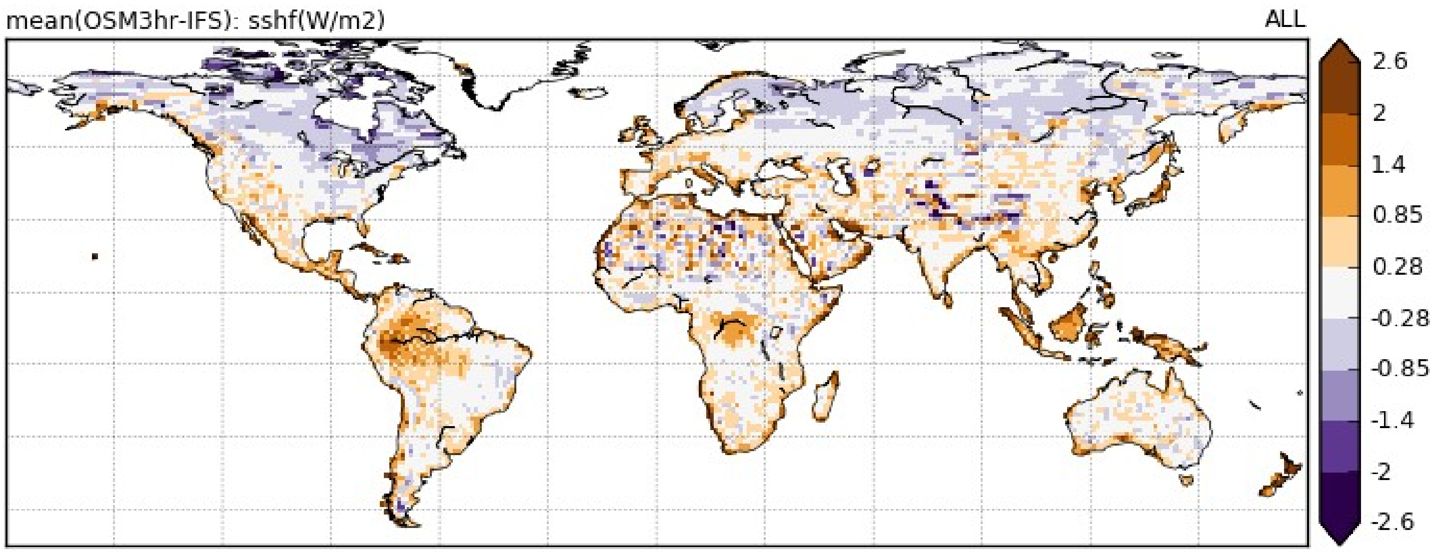


Offline LSM status

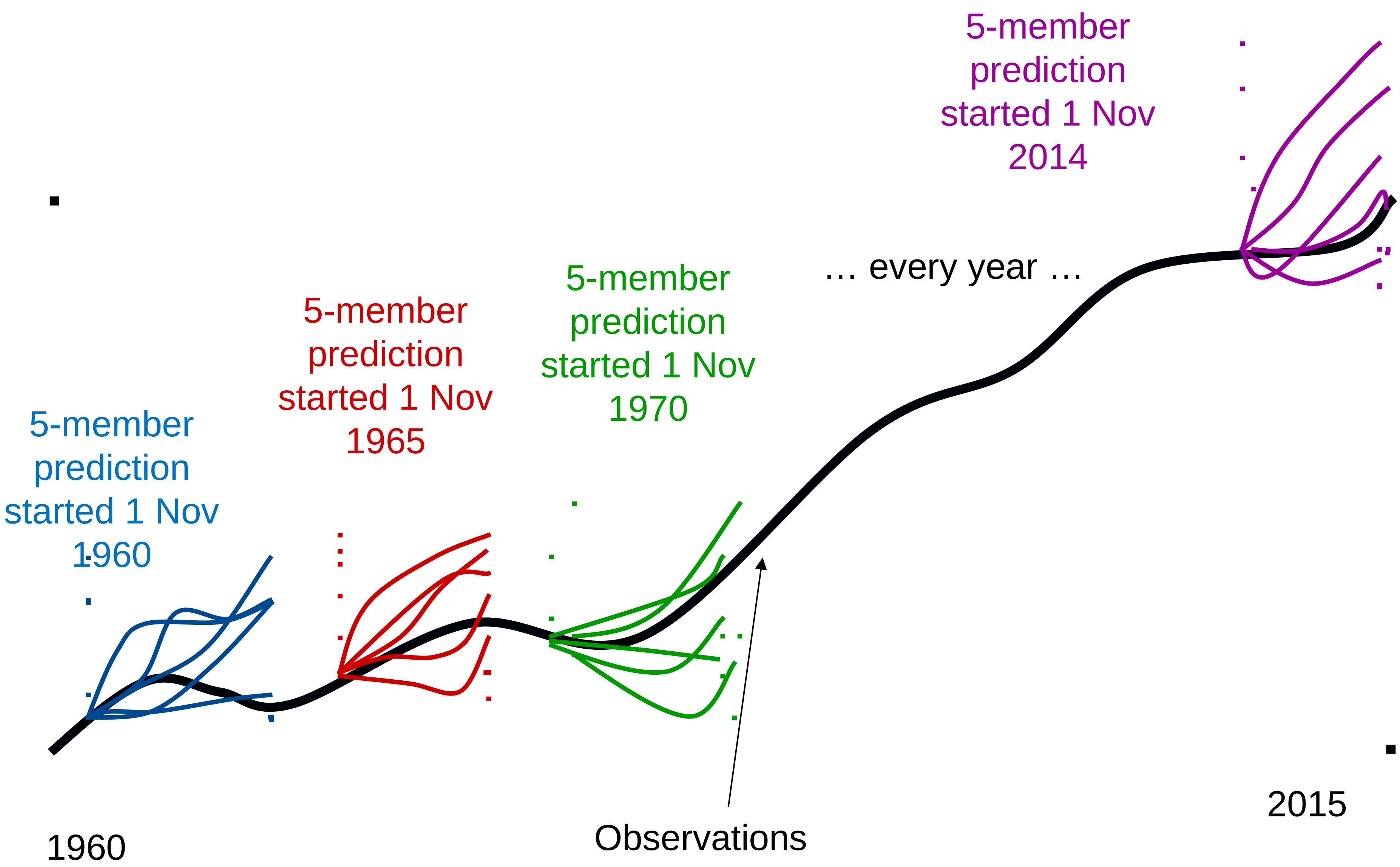
- WHY?
  - Easy tool for quick testing & validation
  - Requirements for CMIP6 (LUMIP, LS3MIP, etc.) & other projects
  - Development of new codes quick & easy
- History:
  - ??? Uwe, Paul Miller develop the Sparring, which simulates the IFS by sending and receiving data to LPJG via OASIS calls, Klaus develops script to convert IFS output to daily netcdf files
  - July 2017 – Dec 2017 : development of the initial ece-lsm.sh script by Etienne, with help from Paul, Lars & Peter Anthoni, merged into the initial ESM branch (issue #412)
  - Nov. 2017 – Jan 2018 : Development of the OSM by Emanuel Dutra “off-line HTESSEL model downgraded from openIFS (cy43r1)” (issues #380 #458)
  - July 2018 – Nov. 2018 : coupling htessel and lpjg by Emanuel Dutra (issue #572)
  - Nov. 2018 – today : bugfixes and optimizations, synced with 3.3.1 by Etienne, multiple resolution support (issues #555, #596)
  - Sept. 2018 – used by Paul Miller for GSWP3 runs, KNMI for H-TESSEL studies

OSM validation – using IFS output





Climate prediction experiments



Climate prediction experiments

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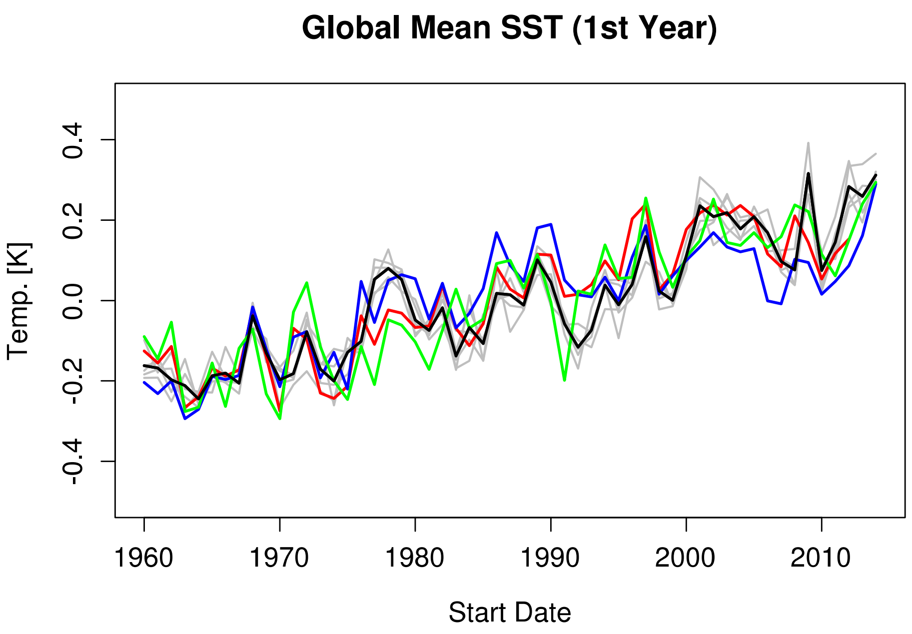
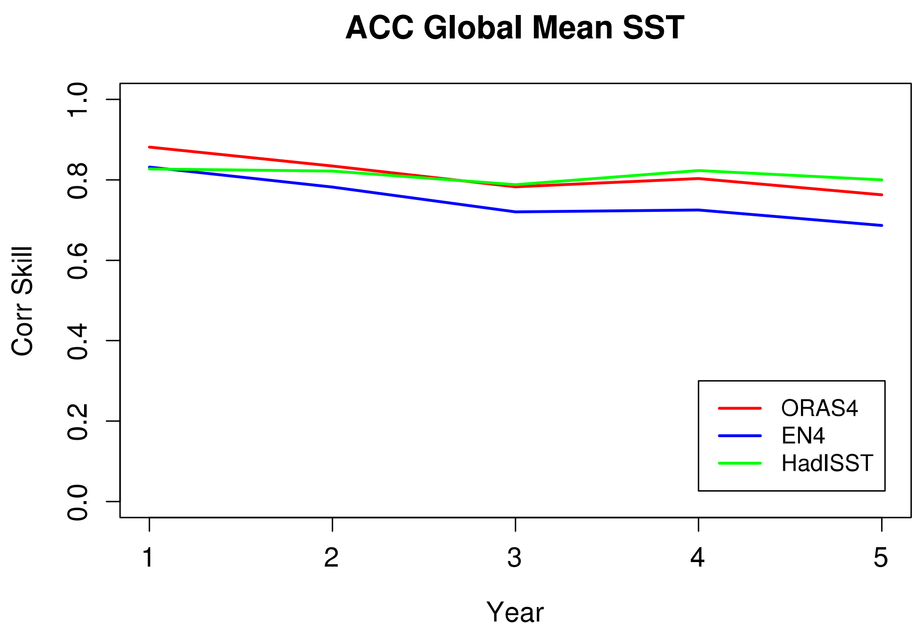
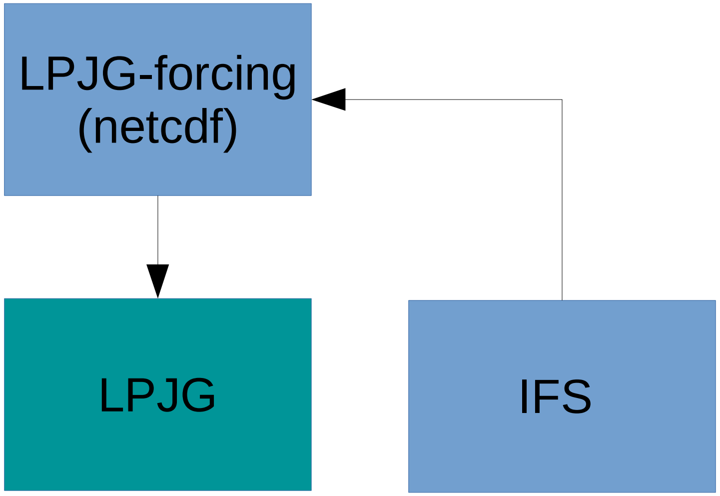


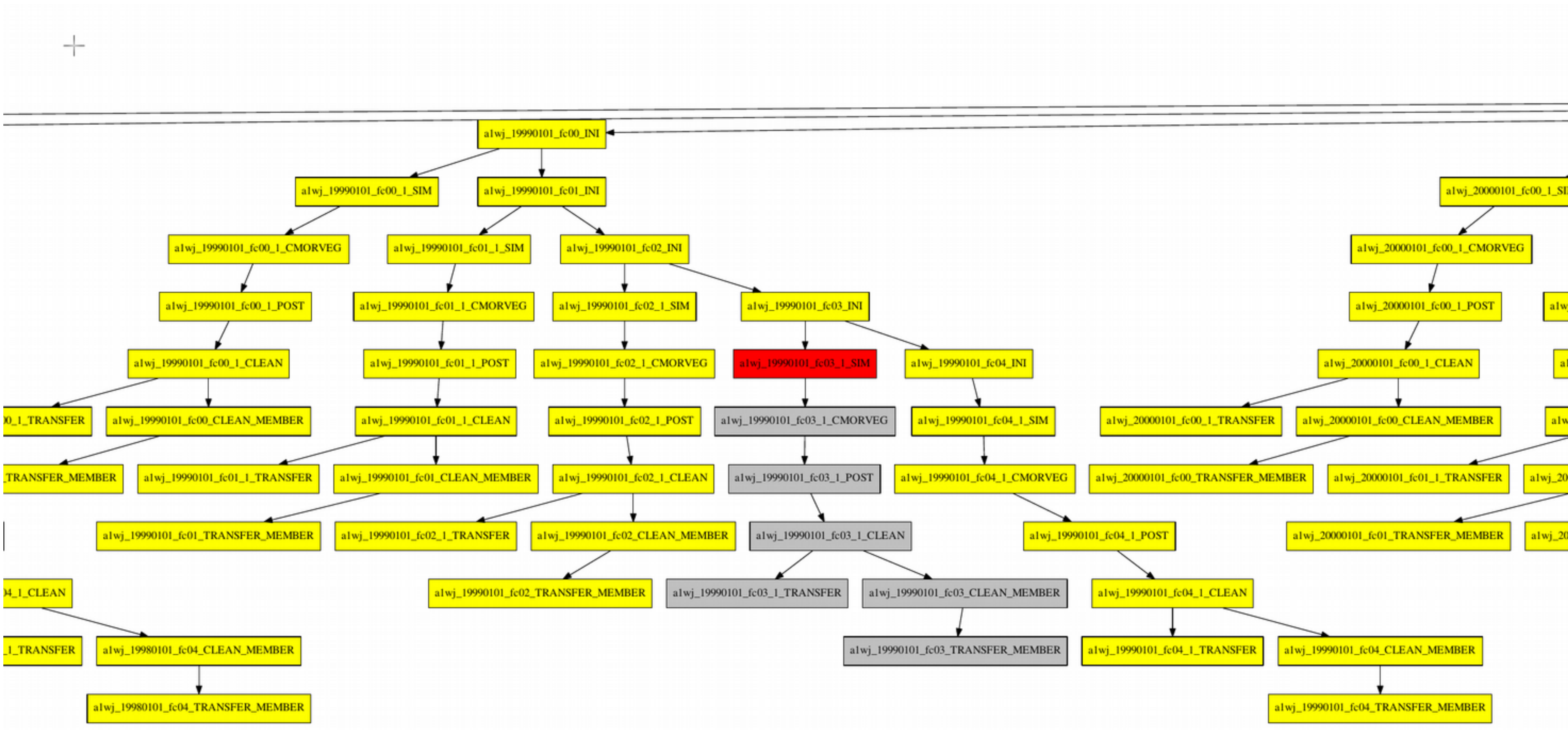


- DCPP LPJG-offline experiment (a1wj):
  - LPJG states from Klaus' t613 run (EC_Earth-Veg)
  - Daily output from BSC's DCPP hindcasts (1960-2015), 5 years, 5 members
  - 1 hour to run 5 years on 2 nodes
  - 1 hour to CMORize on 1 node!!!



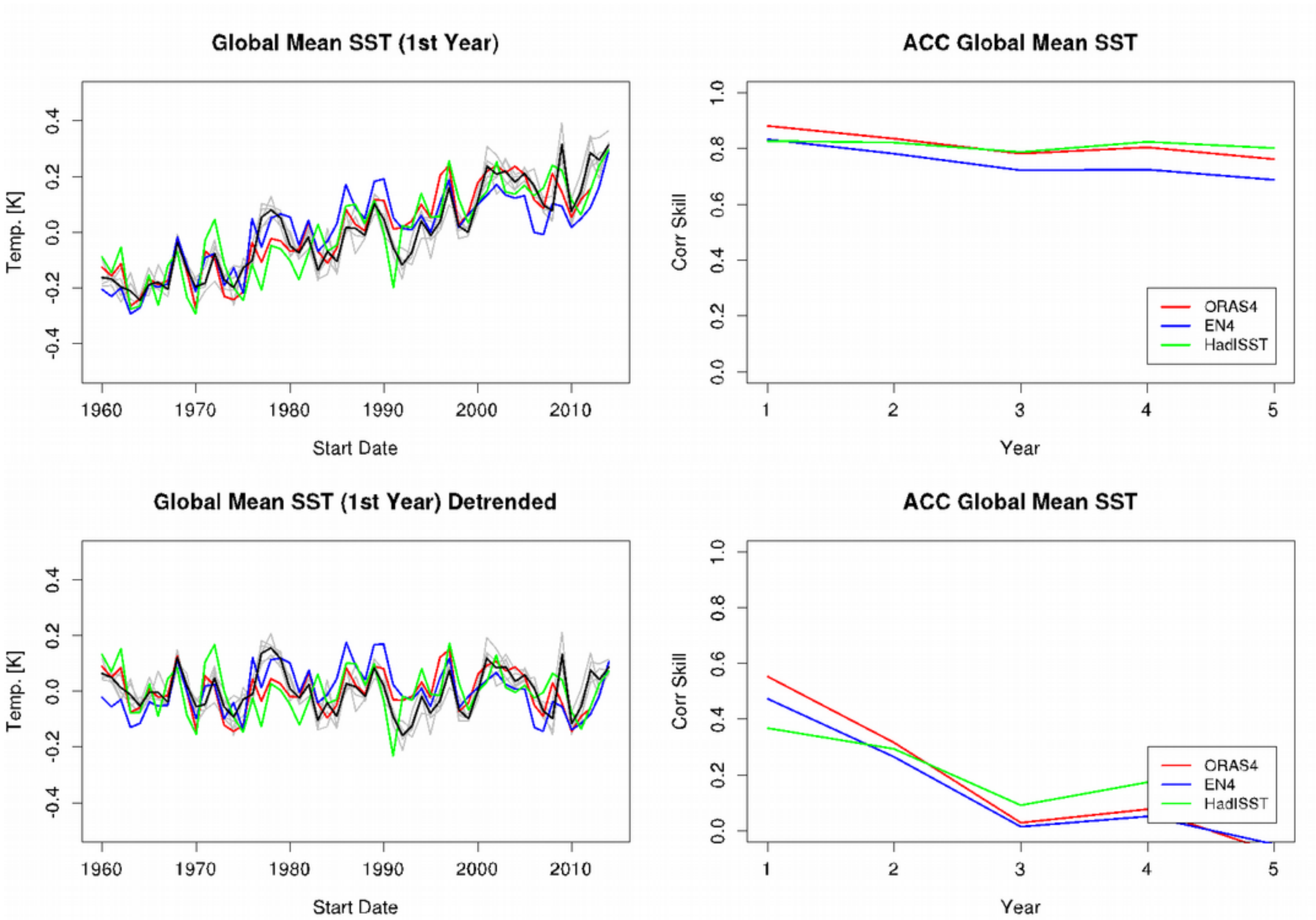
Climate prediction experiments

UNKNOWN | WAITING | READY | SUBMITTED | QUEUING | RUNNING | COMPLETED | FAILED | SUSPENDED



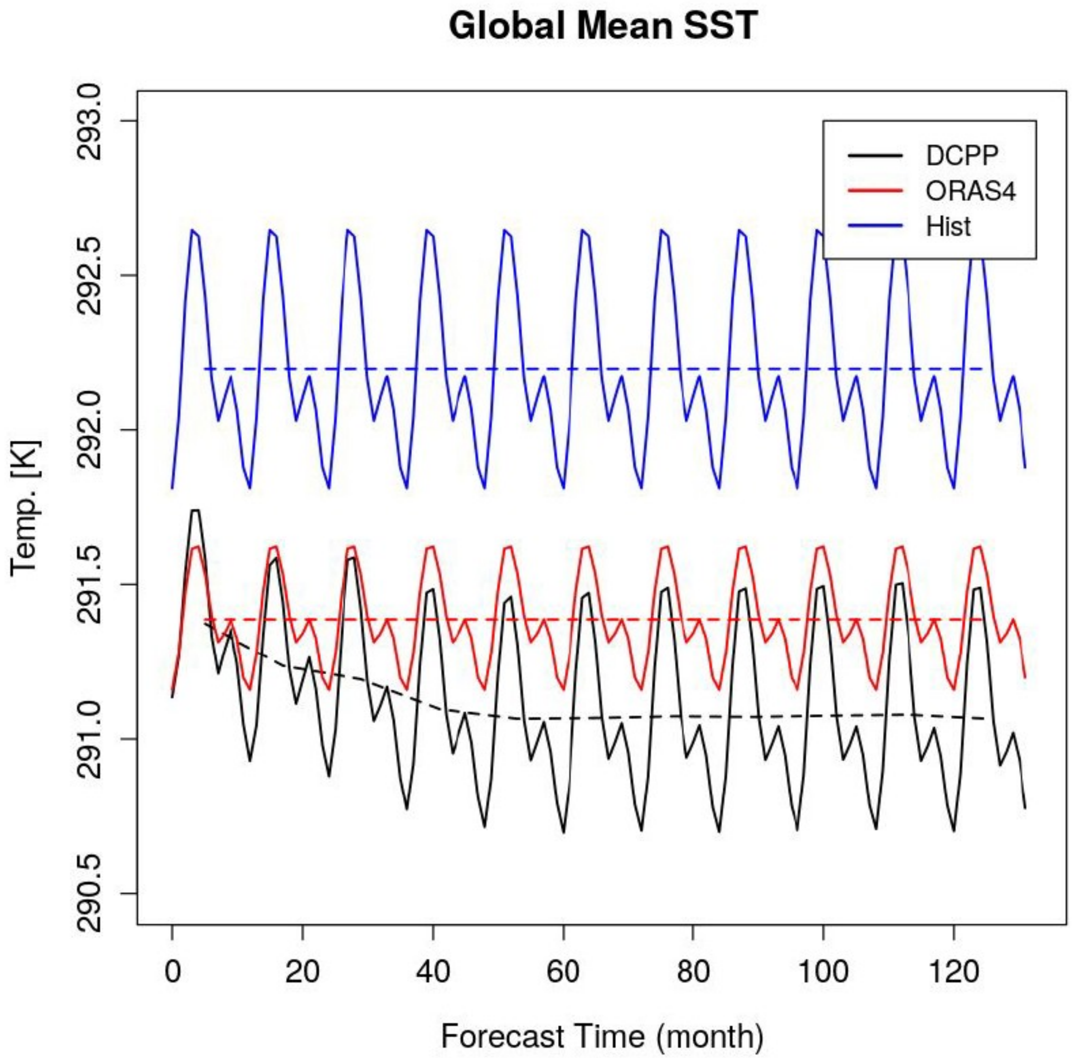
Predictability of ocean variables

Global Mean SST



Global mean temperature is also largely predictable due to global warming trend.

Drift in Decadal Predictions



- Stronger seasonal cycle in model
- Predictions drift away from historicals
- Different attractor in historical and decadal experiments

Offline LSM status

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- History:
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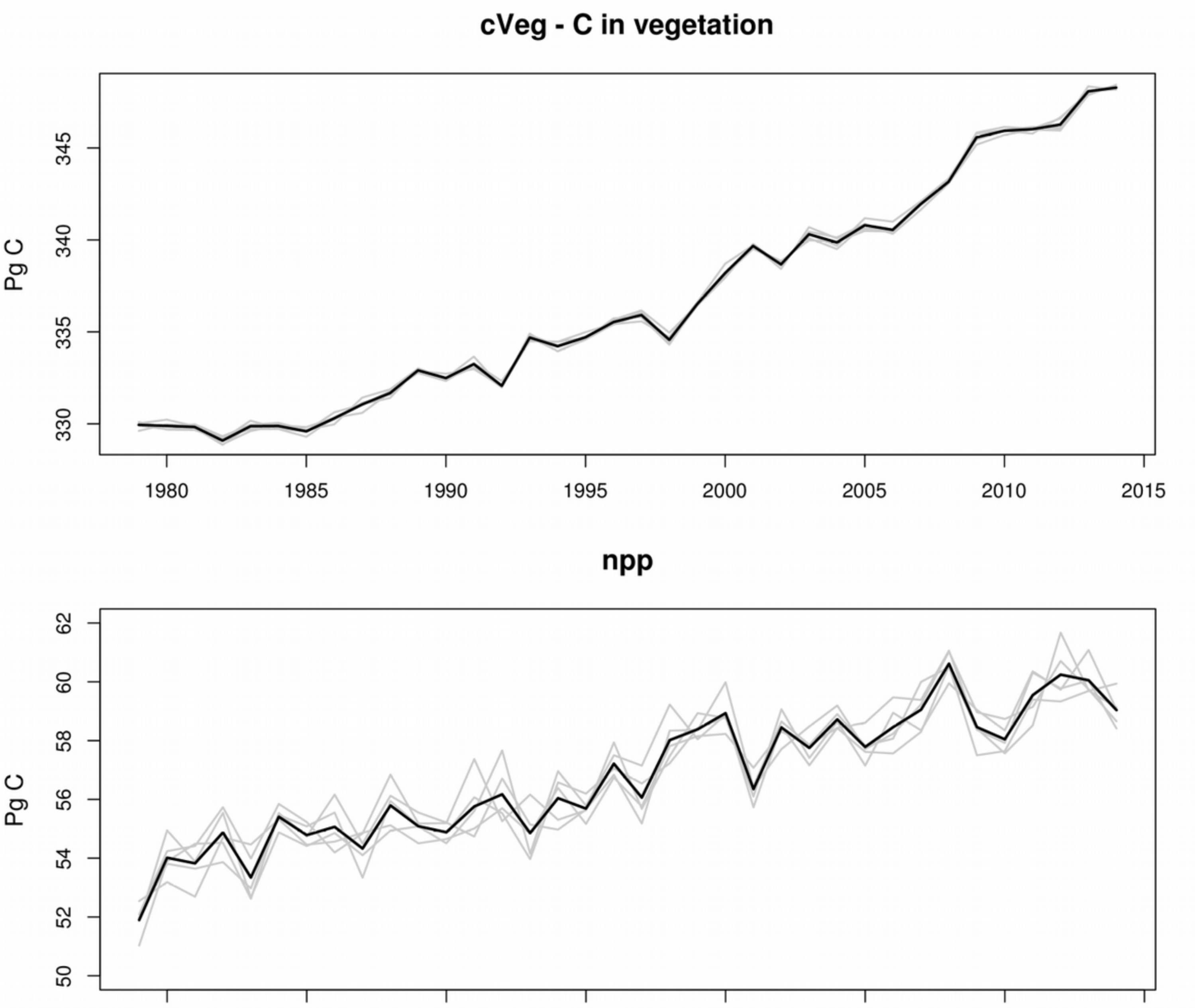
- The Future?
  - Pending merge into trunk: LPJG vendor drop for compressed output, correct bug found in forcing?
  - scientific validation & testing by others
  - Integration of LS3MIP
  - Use in LS3MIP, LUMIP & DCPP

Offline LSM status

- The Future of LSM development
  - Pending merge into trunk: LPJG vendor drop for compressed output, correct bug found in OSM→ LPJG
  - scientific validation & testing by others
  - Integration of LS3MIP changes into surf/offline
  - Use in CMIP6 & beyond : LS3MIP, LUMIP & DCPP/CCiCC
- Future work in wildfire modeling
  - In-depth analysis of results, compared to (few) observations
  - Compare to offline runs driven by reanalyses
  - Integrate better fire models with help from partners in Lund University - SIMFIRE/BLAZE
  - Use these new models in offline decadal hindcast runs – very cheap!

LPJG-offline runs - 1st year DCPP



Offline LSM status

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EXCELENCIA SEVERO OCHOA

- History:
  - ??? Uwe, Paul Miller develop the Sparring, which simulates the IFS by sending and receiving data to LPJG via OASIS calls, Klaus develops script to convert IFS output to daily netcdf files
  - July 2017 – Dec 2017 : development of the initial ece-lsm.sh script by Etienne, with help from Paul, Lars & Peter Anthoni, merged into the initial ESM branch (issue #412)
  - Nov. 2017 – Jan 2018 : Development of the OSM by Emanuel Dutra “off-line HTESSEL model downgraded from openIFS (cy43r1)” (issues #380 #458)
  - July 2018 – Nov. 2018 : coupling htessel and lpjg by Emanuel Dutra (issue #572)
  - Nov. 2018 – today : bugfixes and optimizations, synced with 3.3.1 by Etienne, multiple resolution support (issues #555, #596)

Offline LSM status

- Performance (on Marenostrum4):
  - LPJG only:
    - 30 minutes/year initially
    - 7 minutes/year after I/O opt + compressed output
  - OSM only: 10 minutes/year
  - LPJG + OSM : 15 minutes/year
- Configurations:
  - IFS → OSM (for testing)
  - ERA-20C/Interim → OSM → LPJG-forcing → LPJG
  - ERA-20C/Interim → OSM ↔ LPJG
  - IFS → LPJG-forcing → LPJG (e.g. DCPP)

Offline LSM status

- ERA-Interim LPJG-offline experiment (a1xx):
  - LPJG states from Klaus' t613 run (EC_Earth-Veg)
  - Yearly forcings from ERA-Interim, processed by OSM with the cmip6 (t613) ifs_vegetation_source
- DCPP LPJG-offline experiment (a1wj):
  - Same states as a1xx
  - Daily output from DCPP hindcasts (1960-2015), 5 years, 5 members
  - 1 hour to run 5 years on 2 nodes
  - 1 hour to CMORize on 1 node!!!

Offline LSM status

- Performance (on Marenostrum4):
  - LPJG only:
    - 30 minutes/year initially
    - 7 minutes/year after I/O opt + compressed output
  - OSM only: 10 minutes/year
  - LPJG + OSM : 15 minutes/year
- The Future of LSM development
  - Pending merge into trunk: LPJG vendor drop for compressed output, correct bug found in OSM → LPJG
  - scientific validation & testing by others
  - Integration of LS3MIP changes into surf/offline
  - Use in CMIP6 : LS3MIP, LUMIP & DCPP/CCiCC