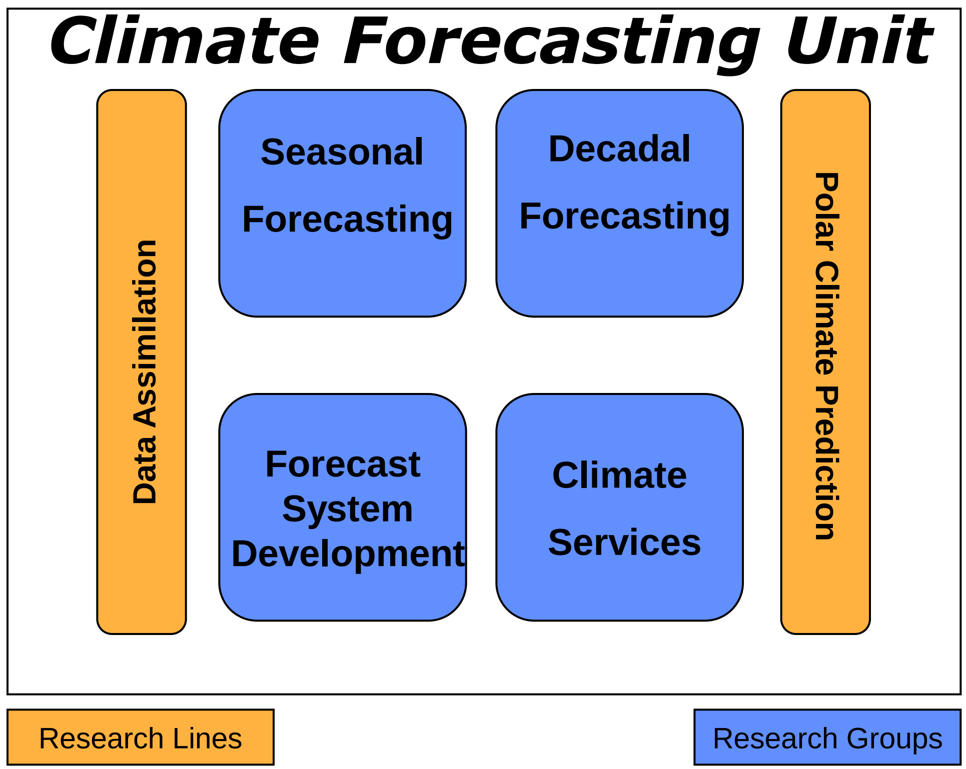
Climate prediction for climate services: a new road to climate adaptation

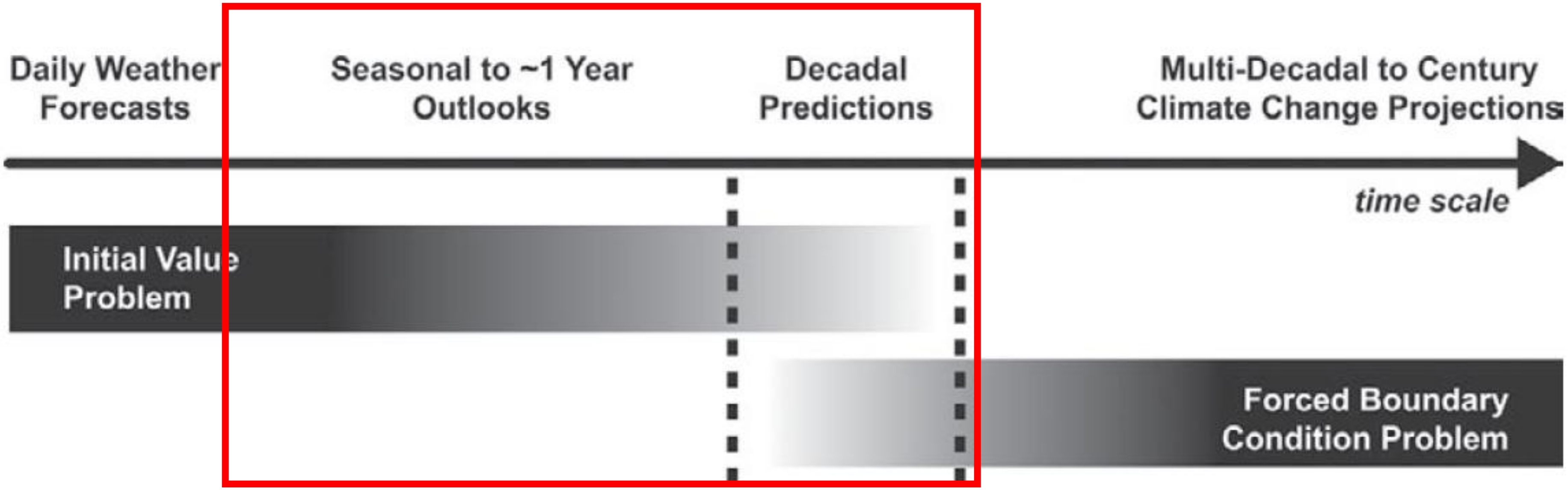
F.J. Doblas-Reyes, IC3 and ICREA, Barcelona



SEVENTH FRAMEWORK PROGRAMME

Climate time scales

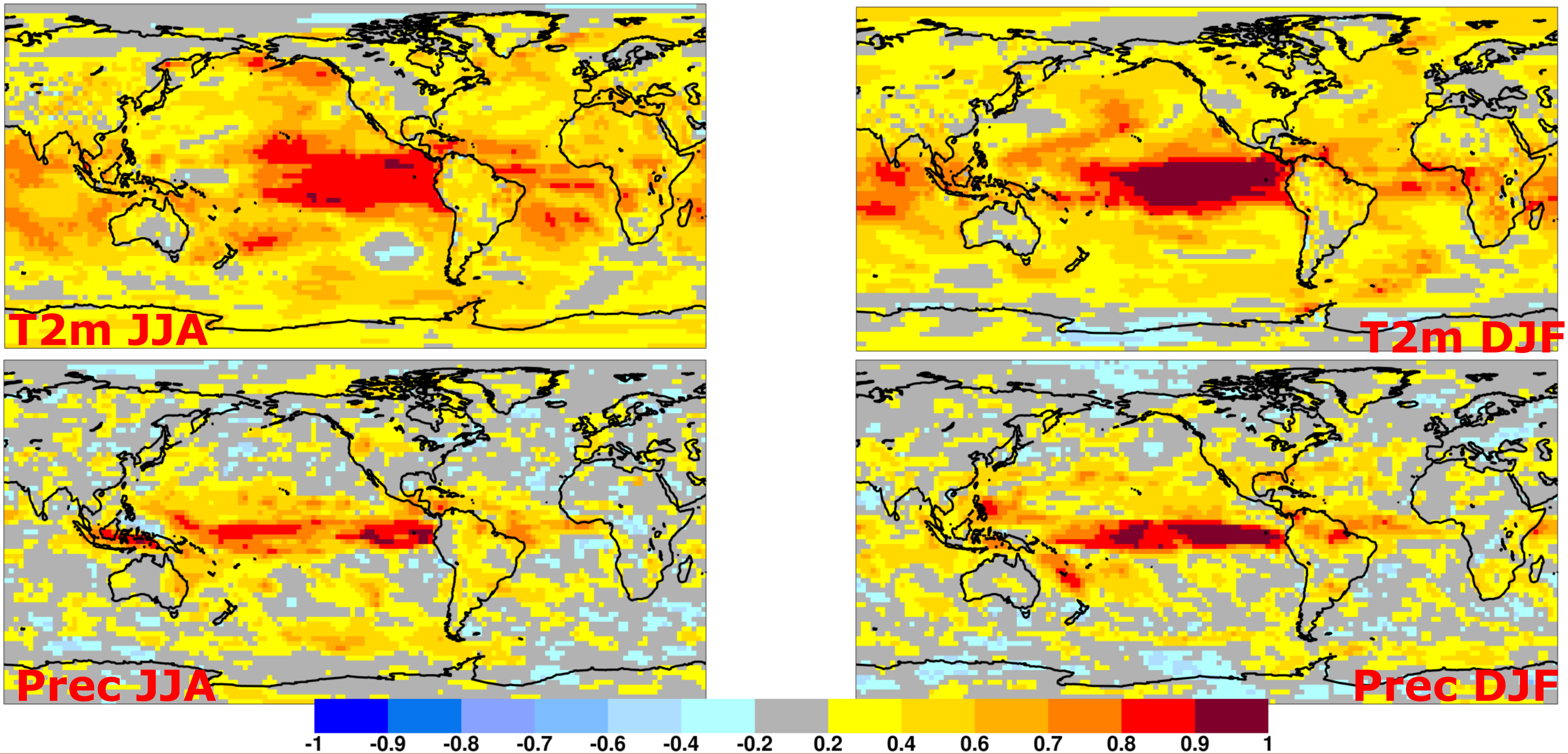
Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.



Meehl et al. (2009)

Typical seasonal forecast skill

Correlation of the ensemble mean for the ENSEMBLES multi-model (45 members) wrt ERA40-ERAInt (T2m over 1960-2005) and GPCP (precip over 1980-2005) with 1-month lead.



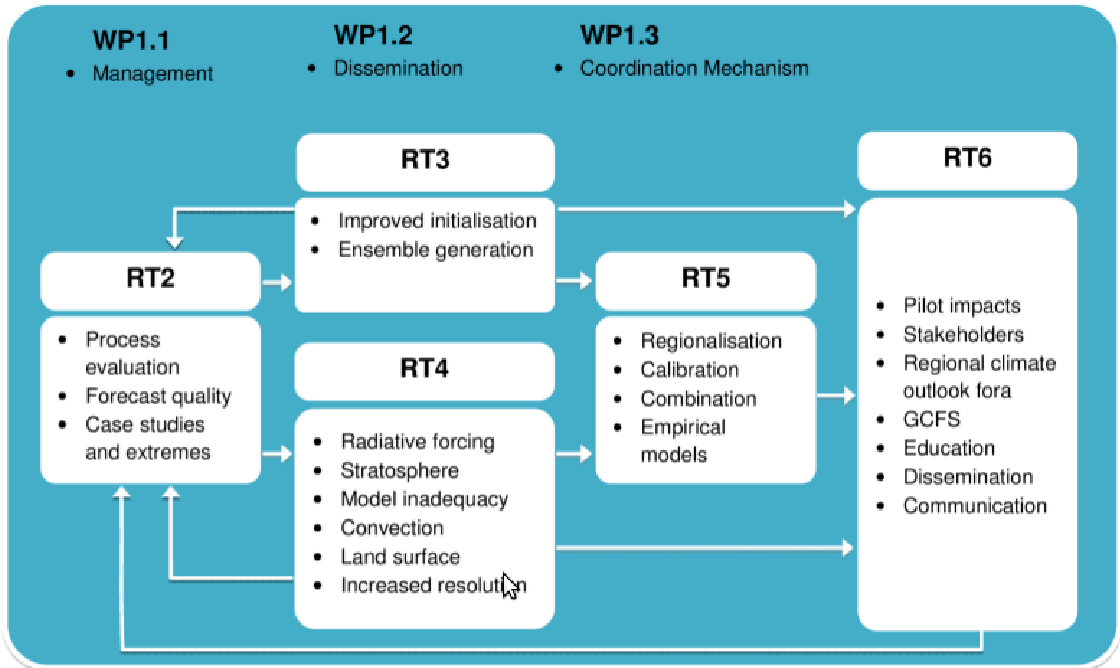
Some open fronts

- Work on initialisation: initial conditions for all components (including better ocean), better ensemble generation, etc. Link to observational and reanalysis efforts.
- Model improvement: leverage knowledge and resources from modelling at other time scales, drift reduction. More efficient codes and adequate computing resources.
- Calibration and combination: empirical prediction (better use of current benchmarks), local knowledge.
- Forecast quality assessment: scores closer to the user, reliability as a main target, process-based verification.
- Improving many processes: sea ice, projections of volcanic and anthropogenic aerosols, vegetation and land, …
- More sensitivity to the users' needs: going beyond downscaling, better documentation (e.g. use the IPCC language), demonstration of value and outreach.

SPECS FP7, overall strategy

SPECS will deliver *a new generation of European climate forecast systems*, *including initialised Earth System Models (ESMs) and efficient regionalisation tools to produce quasi-operational and actionable local climate information over land at seasonal-to-decadal time scales with improved forecast quality and a focus on extreme climate events, and provide an enhanced communication protocol and services to satisfy the climate information needs of a wide range of public and private stakeholders*.

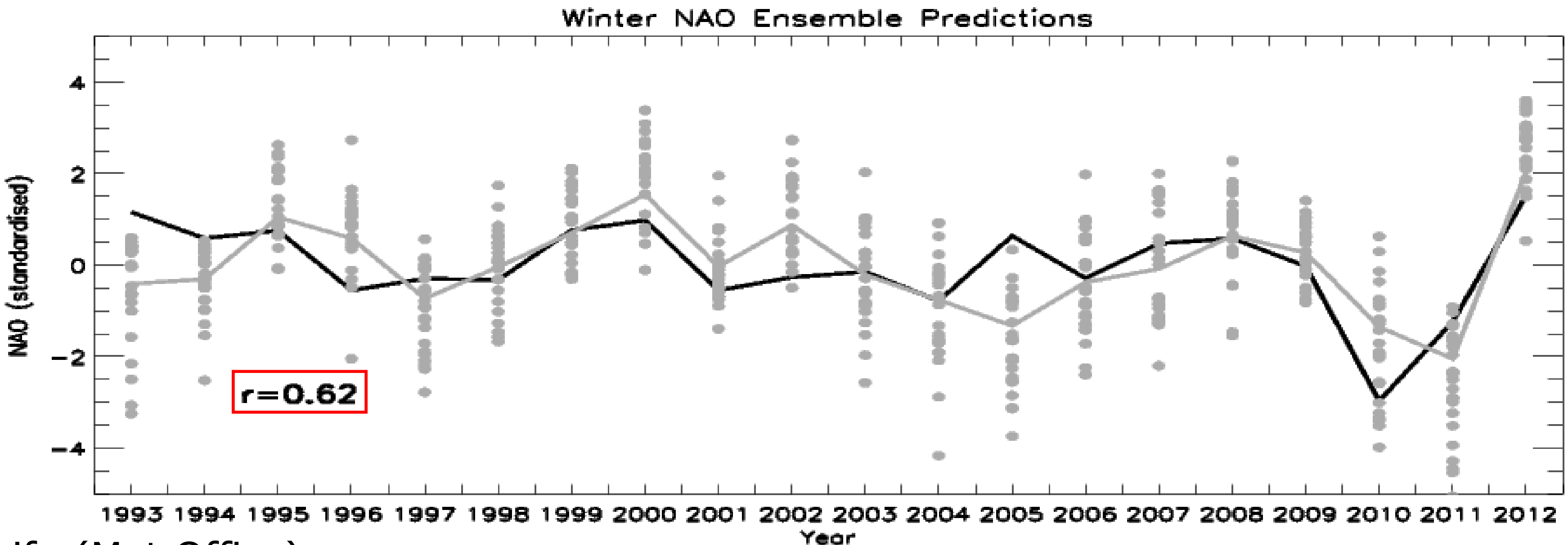
Forecast System	Project Partners
CNRM-CM5	CNRM, CERFACS
EC-Earth	KNMI, SMHI, IC3, ENEA
IFS/NEMO	ECMWF, UOXF
IPSL-CM5	CNRS
MPI-ESM	MPG, UniHH
UM	UKMET



WP1.1: Management
WP1.2: Dissemination
WP1.3: Coordination across EUPORIAS, NACLIM & SPECS
RT2: Evaluation of current s2d forecast systems
RT3: Forecast strategies
RT4: Improved systems
RT5: Calibrated predictions at the local scale

Predicting NA atmospheric circulation

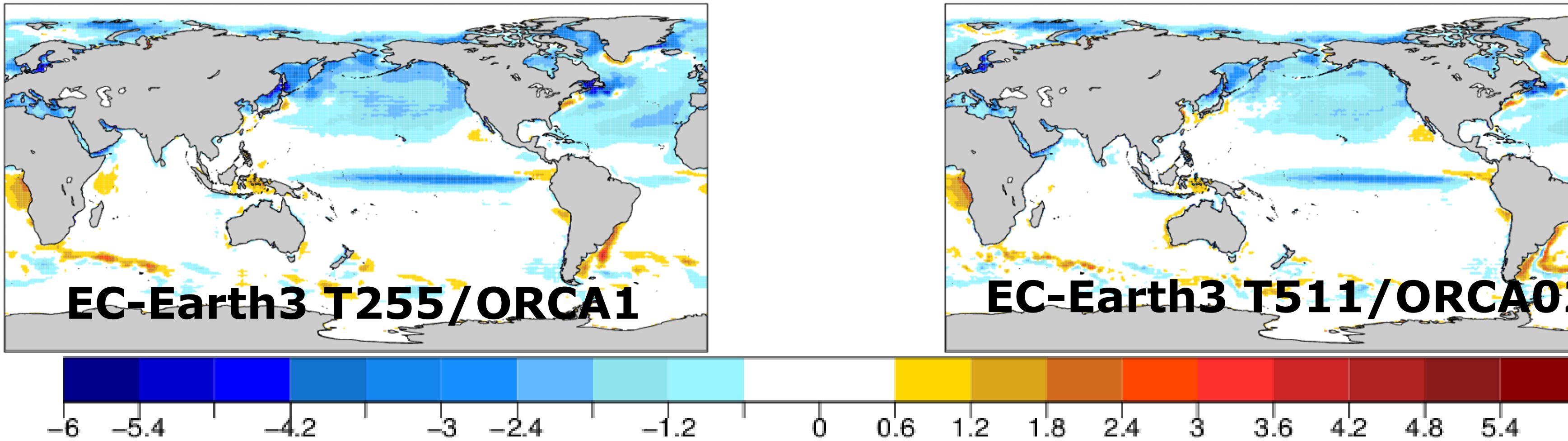
DJF NAO Met Office operational seasonal forecasts with HadGEM3H N216L85O(0.25) with initial conditions from operational atmospheric analyses and NEMOVAR, 24 members, start date around the 1st of November (lagged method). Winter NAO correlation significant at the 98% confidence level.

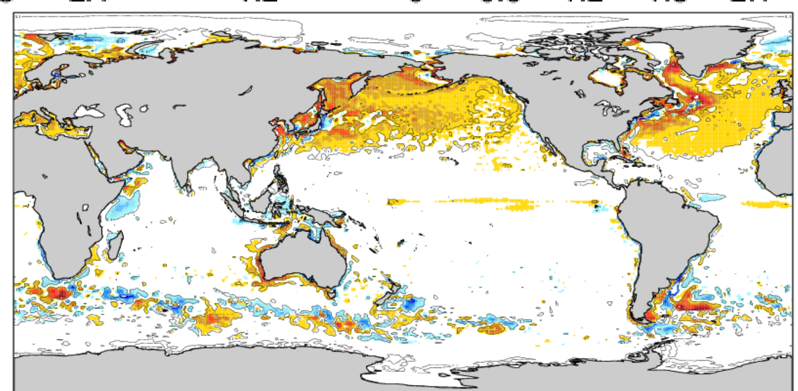


A. Scaife (Met Office)

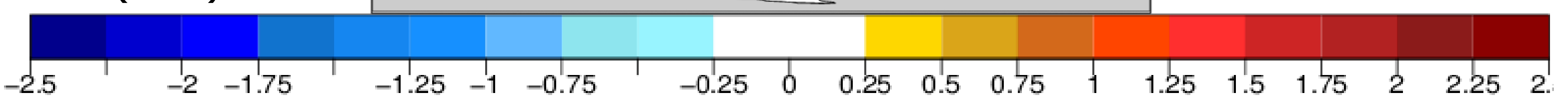
Increase in resolution: mean climate

Mean SST (K) systematic error versus ERAInt for JJA one-month lead predictions of EC-Earth3 T255/ORCA1 and T511/ORCA025. May start dates over 1993-2009 using ERA-Interim and GLORYS initial conditions.





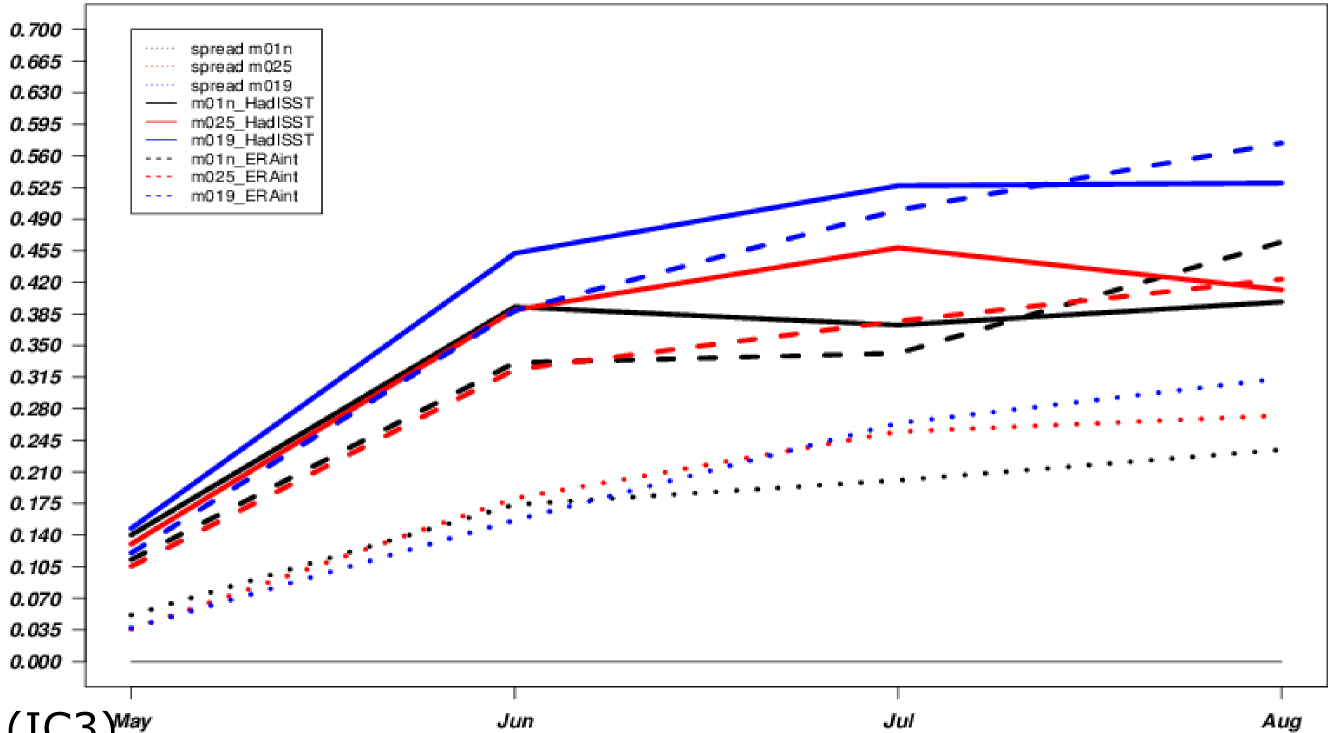
C. Prodhomme (IC3)



HiResClim

Increase in resolution: ENSO skill

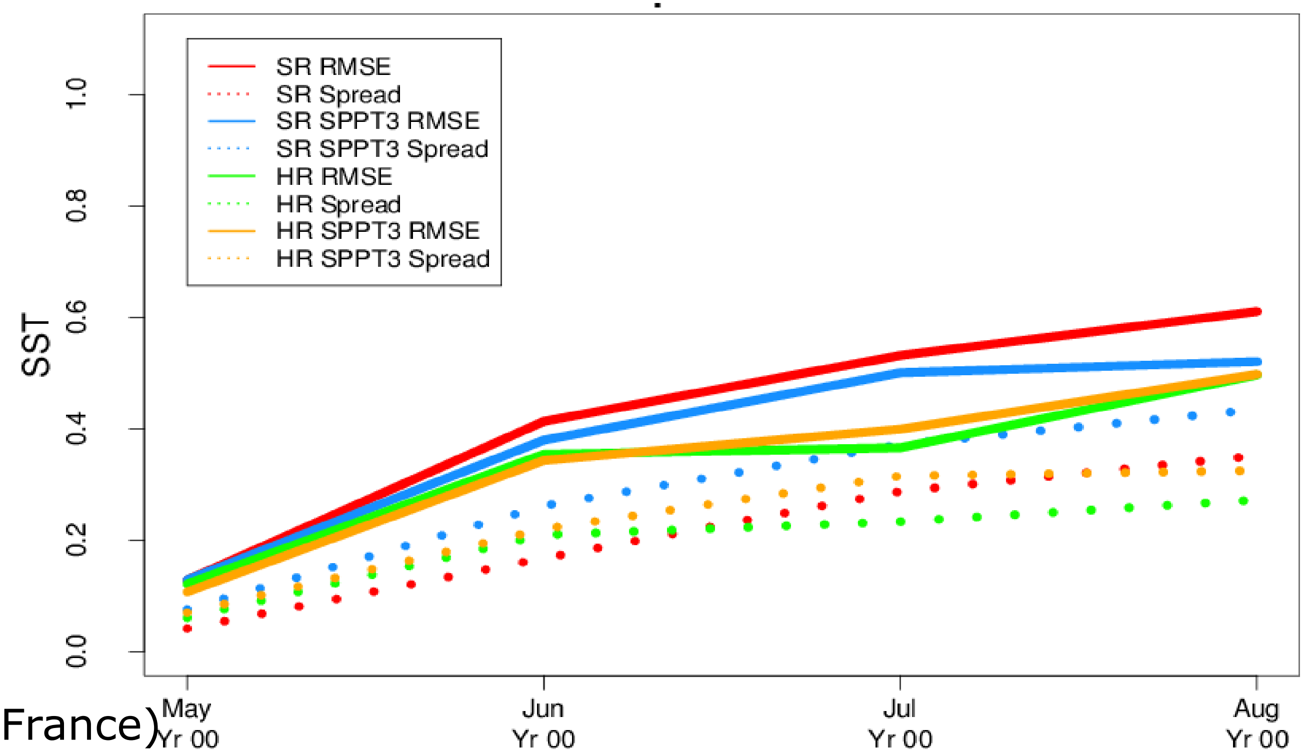
RMSE and spread of Niño3.4 SST (versus HadISST-solid and ERAInt-dashed) from four-month EC-Earth3 simulations: **T255/ORCA1**, **T255/ORCA025** and **T511/ORCA025**. May start dates over 1993-2009 using ERA-Interim and GLORYS initial conditions and ten-member ensembles.



C. Prodhomme (IC3)

Increase in resolution: ENSO skill

RMSE and spread of Niño3.4 SST (versus ERSST) from EC-Earth3 simulations: standard resolution (**SR**, **T255/ORCA1**), high resolution (**HR**, **T511/ORCA025**) without and with stochastic physics (**SPPT3**). May start dates over 1993-2009 using ERA-Interim and GLORYS and ten-member ensembles.

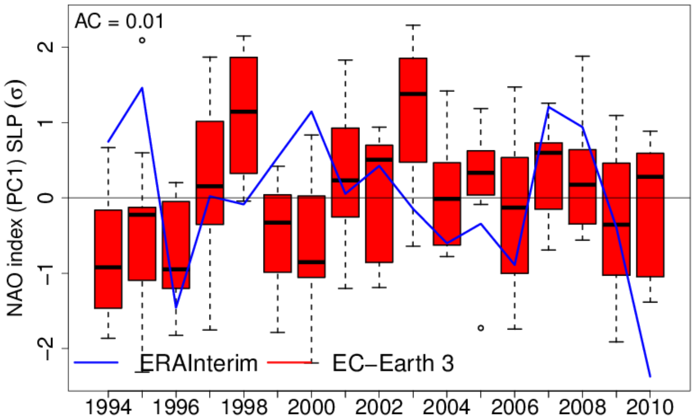


L. Batté (Météo-France)

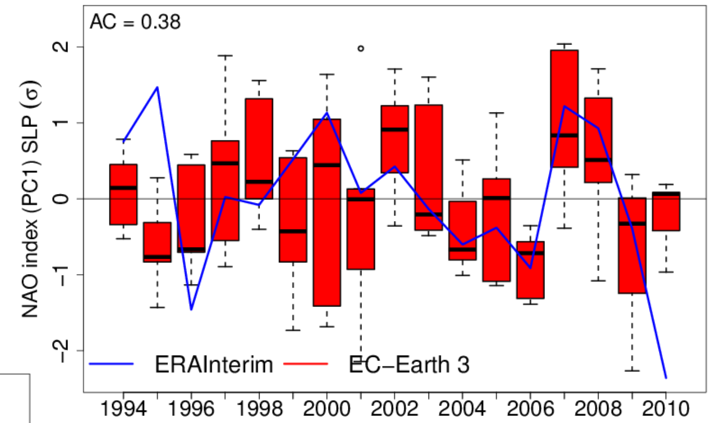
Predicting NA atmospheric circulation

Predictions of DJF NAO with **EC-Earth3 low and high resolution** and ECMWF S4 started in November over 1993-2009 with ERA-Interim and GLORYS initial conditions and five-member ensembles. Correlation of the ensemble mean on top left.

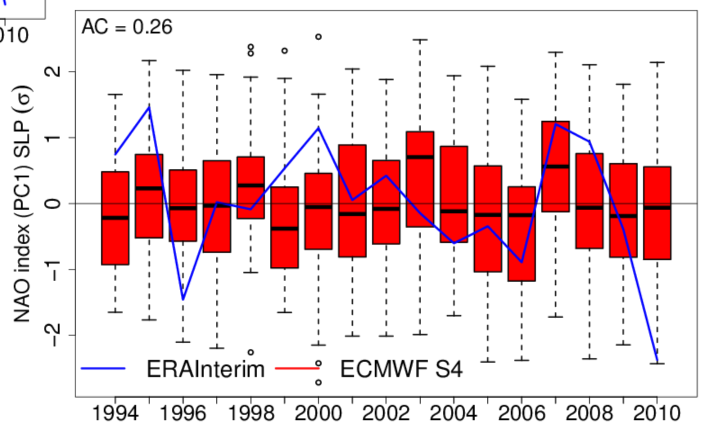
EC-Earth3 T255/ORCA1



EC-Earth3 T511/ORCA025



ECMWF S4

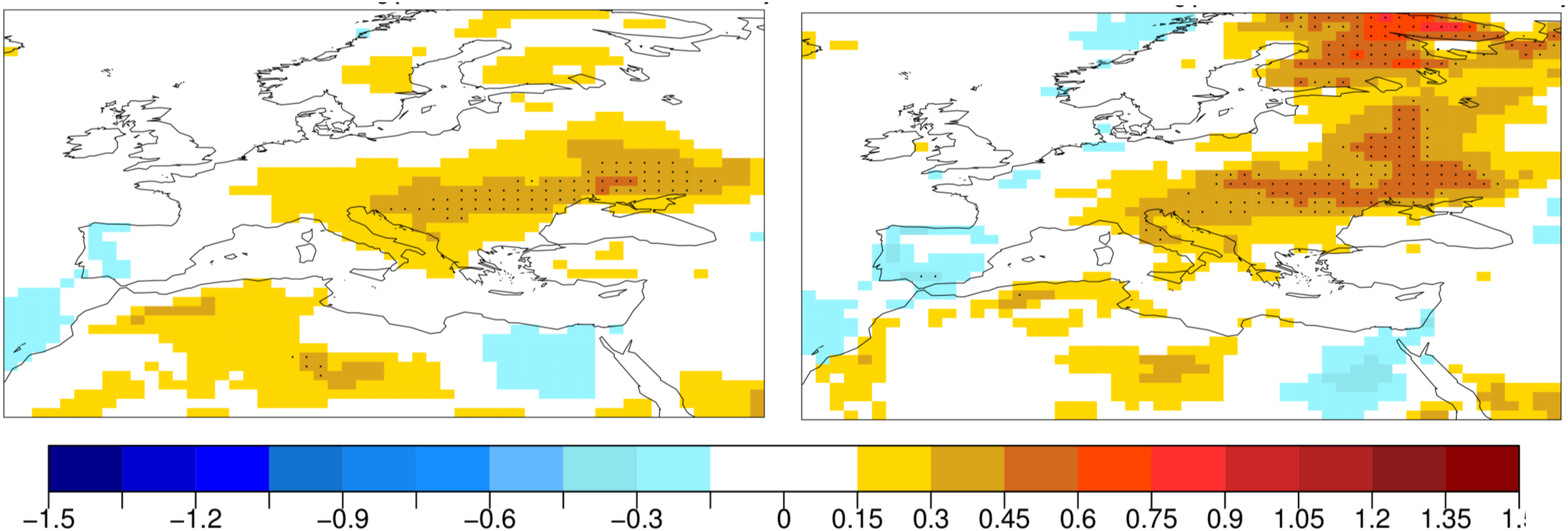


Batté et al. (2014)

Impact of initialisation: Land surface

Difference in the correlation of the ensemble-mean near-surface temperature from two experiments, one using a realistic and another a climatological land-surface initialisation. Results for EC-Earth2.3 started every May over 1979-2010 with ERAInt and ORAS4 initial conditions and a sea-ice reconstruction.

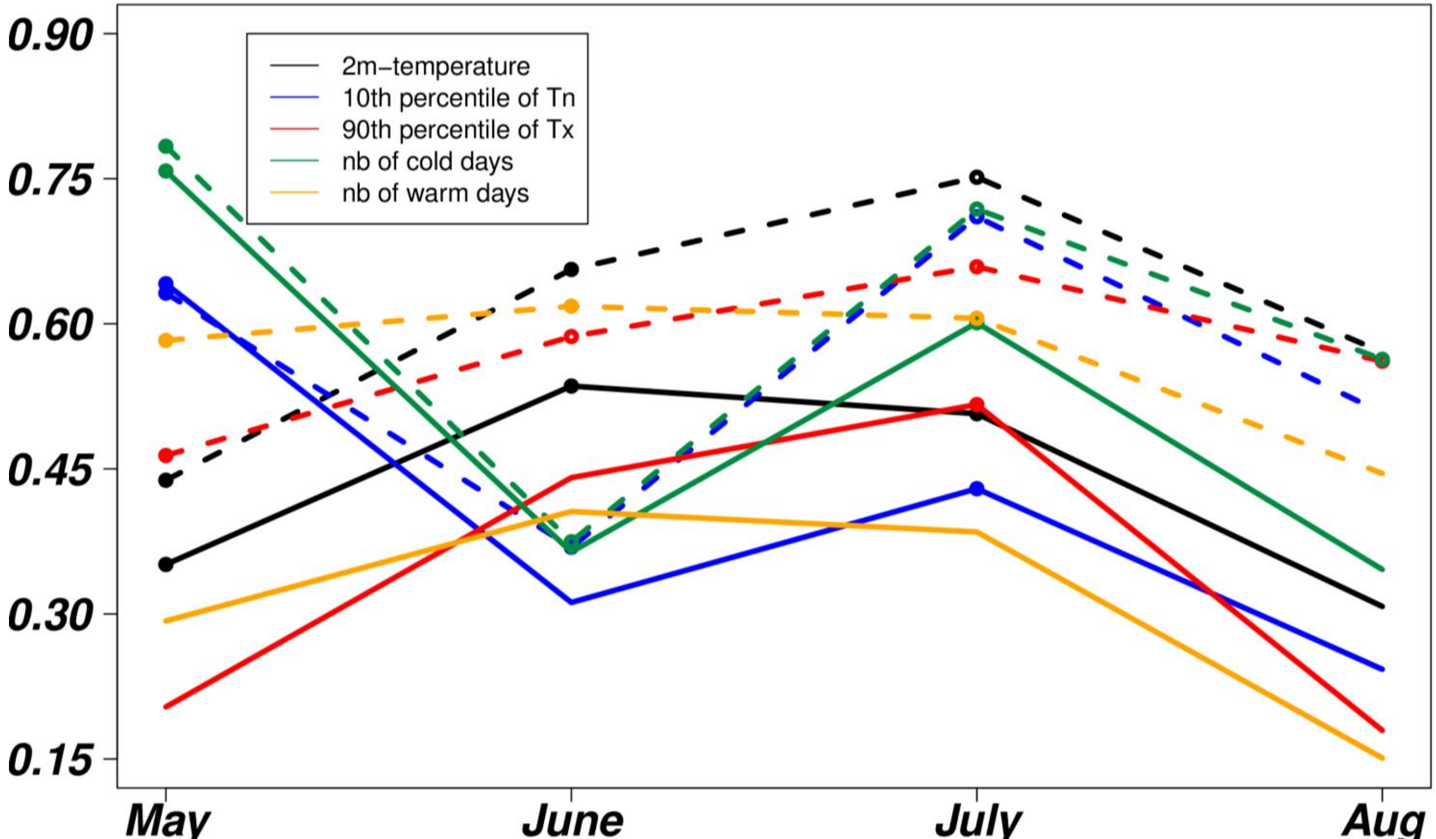
Difference for mean T | **Difference for T max**



C. Prodhomme (IC3)

Impact of initialisation: Land surface

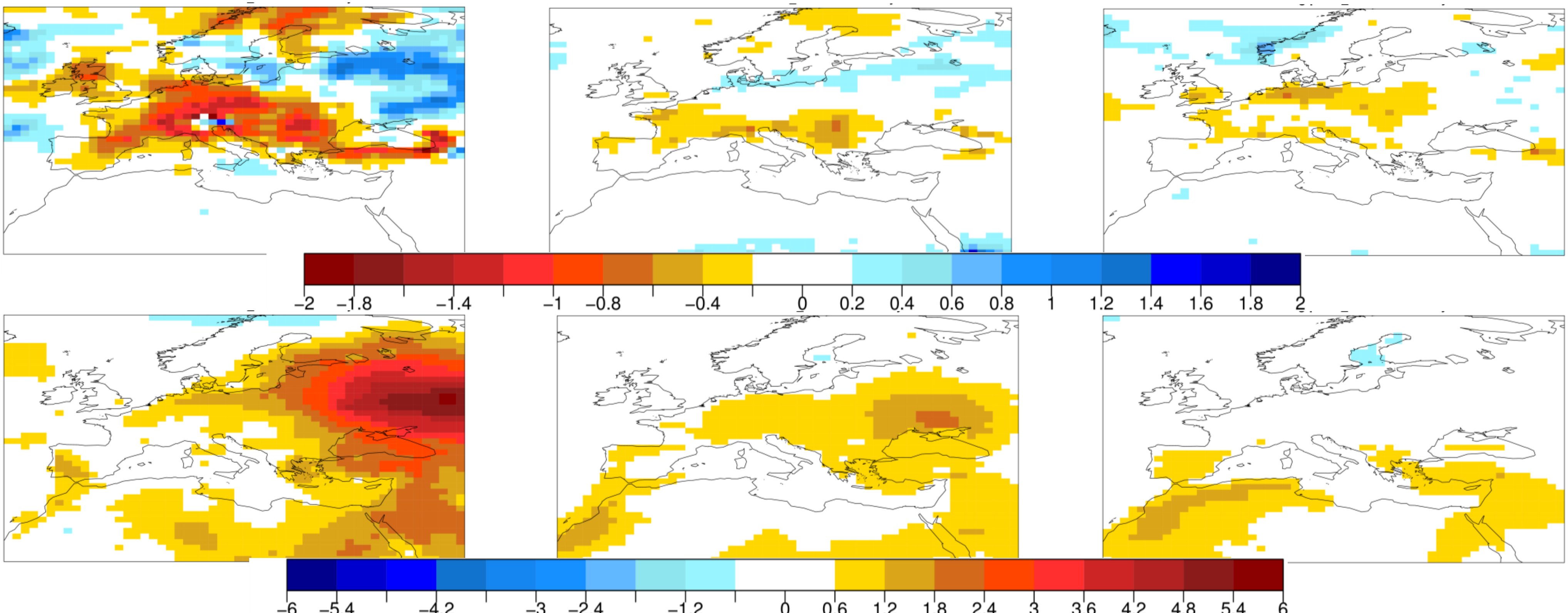
Correlation of the ensemble-mean for several temperature variables from experiments with a realistic (dashed) and a climatological (solid) land-surface initialisation. Results for EC-Earth2.3 started in May with initial conditions from ERAInt, ORAS4 and a sea-ice reconstruction over 1979-2010.



C. Prodhomme (IC3)

Impact of initialisation: Land surface

JJA precipitation in 2003 (top row) and near-surface temperature in 2010 (bottom row) anomalies from ERAInt (left) and experiments with a realistic (centre) and a climatological (right) land-surface initialisation. Results for EC-Earth2.3 started in May with initial conditions from ERAInt, ORAS4 and a sea-ice reconstruction over 1979-2010.



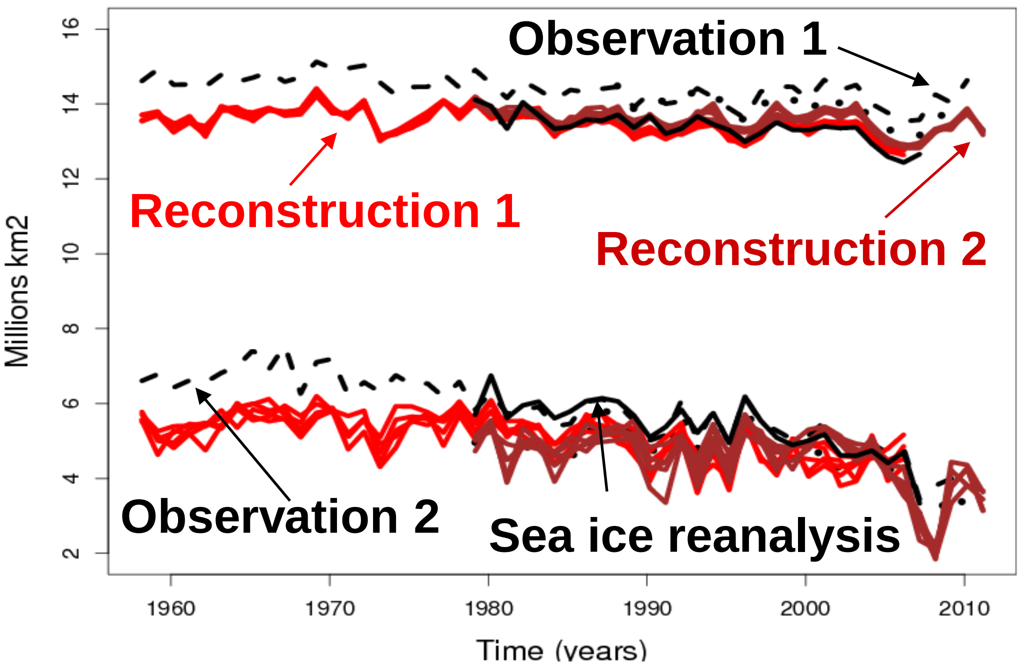
C. Prodhomme (IC3)

Initial conditions: sea-ice reconstructions

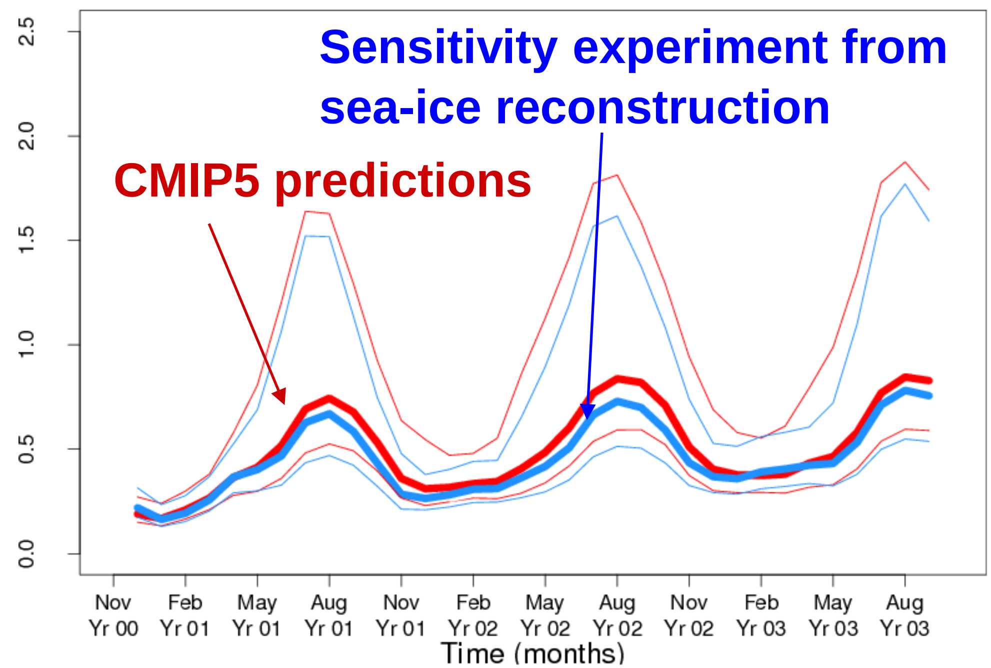
Sea ice simulation constrained by ocean and atmosphere observational data

Arctic sea ice area

March and September reconstruction



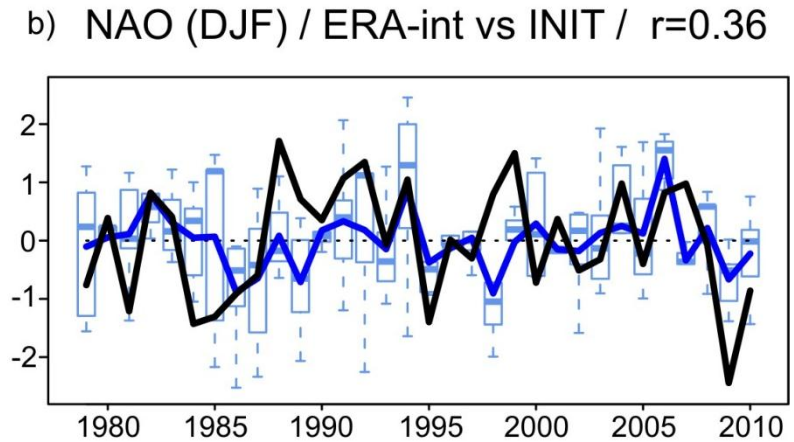
Root Mean Square Error of predictions

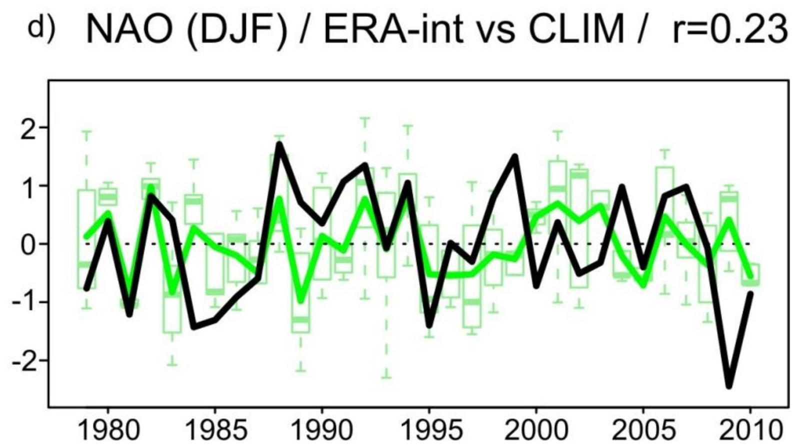


Guemas et al. (2014)

Predicting NA atmospheric circulation

Predictions of DJF NAO with EC-Earth2.3 started in November over 1979-2010 with ERAInt and ORAS4 initial conditions. Two sets, one initialised **with realistic (top) and one with climatological (bottom) sea-ice initial conditions**.



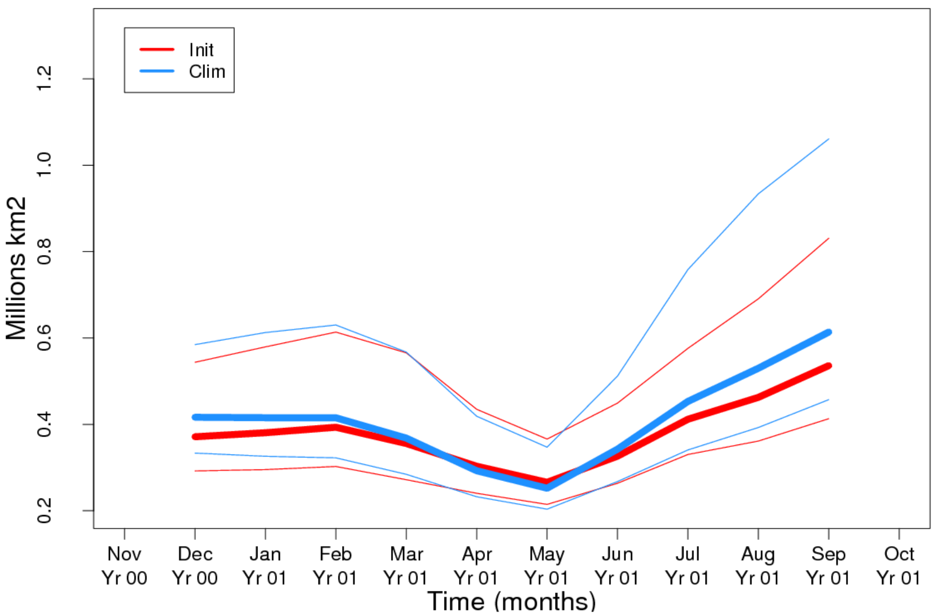


J. García-Serrano (IPSL)

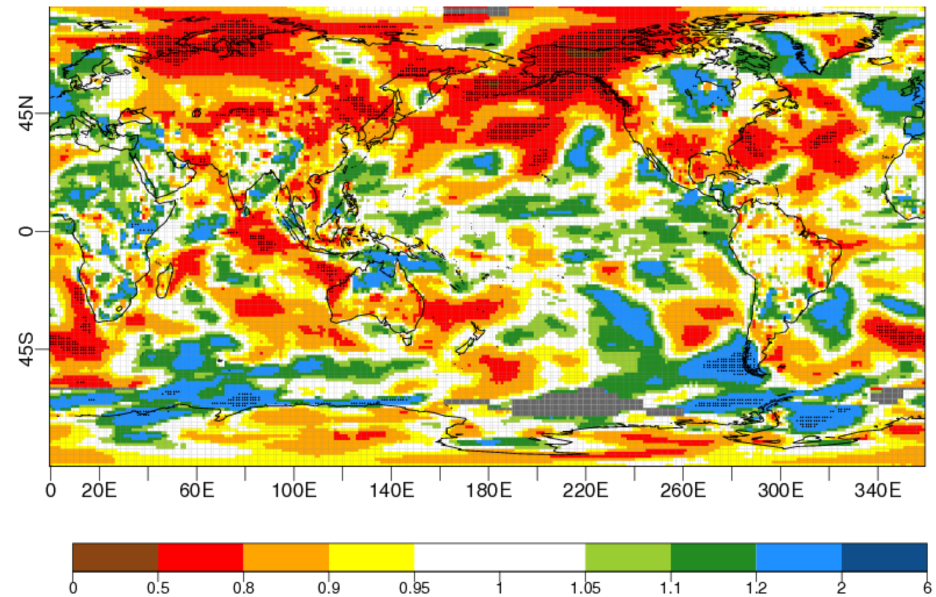
Impact of initialisation: Sea ice

Predictions with EC-Earth2.3 started every November over 1979-2010 with ERAInt and ORAS4 initial conditions, and a sea-ice reconstruction. Two sets, one initialised with realistic and another one with climatological sea-ice initial conditions. Substantial reduction of temperature RMSE in the northern high latitudes when using realistic sea-ice initialisation.

RMSE Arctic sea-ice area



Ratio RMSE Init/Clim hindcasts 2-metre temperature (months 2-4)



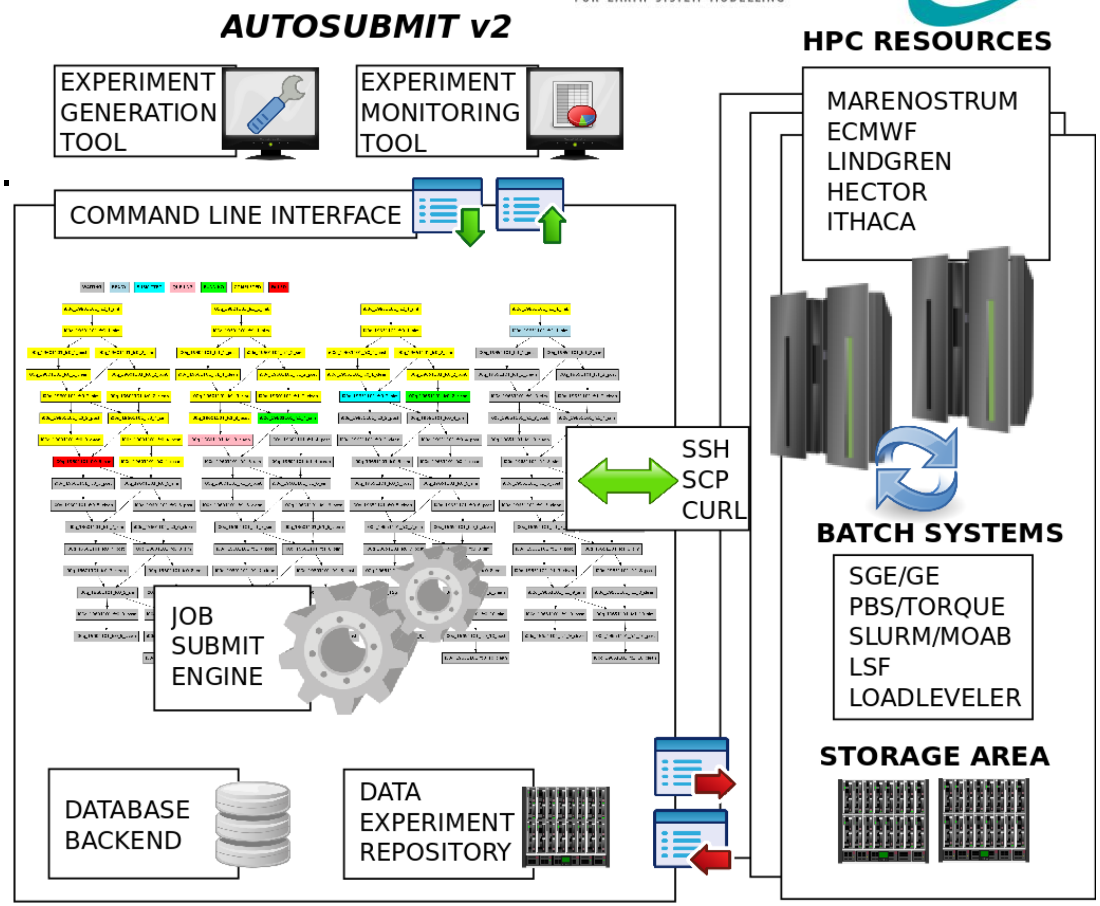
Guemas et al. (2014)

Autosubmit

Autosubmit acts as a wrapper to run a climate experiment on a HPC. The experiment is a sequence of jobs that it submits, manages and monitors. When a job is complete, the next one can be executed.

- Divided in 3 phases: ExpID assign, experiment creation, run.
- Separation experiment/autosubmit codes.
- Config files for autosubmit and experiment.
- Database to store experiment information.
- Common templates for all platforms.
- Recovery after crashes.
- Dealing with a list of schedulers and communication protocols.

Each job has a colour in the monitoring tool: yellow=completed, green=running, blue=pending, etc.



Subseasonal-to-seasonal prediction

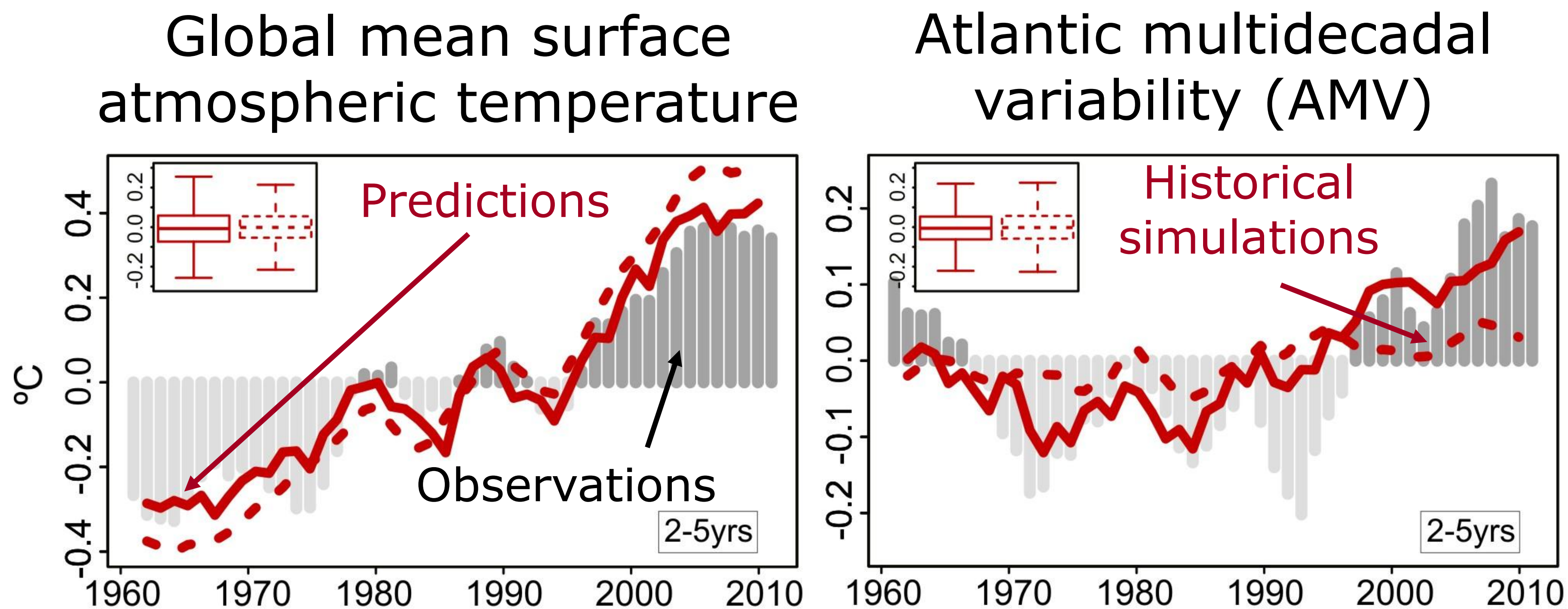
The subseasonal-to-seasonal (S2S) prediction initiative is a WWRP/WCRP joint initiative with objectives:

- To improve forecast skill and understanding on the sub-seasonal to seasonal timescale with special emphasis on high-impact weather events
- To promote the initiative's uptake by operational centres and exploitation by the applications community
- To capitalize on the expertise of the weather and climate research communities to address issues of importance to the Global Framework for Climate Services

	Time-range	Resolution	Ens. Size	Frequency	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	d 0-32	T639/319L62	51	2/week	On the fly	Past 18y	weekly	5
UKMO	d 0-60	N96L85	4	daily	On the fly	1989-2003	4/month	3
NCEP	d 0-60	T126L64	16	daily	Fix	1999-2010	Once a day	4
EC (exp)	d 0-35	0.6x0.6 L40	21	weekly	On the fly	Past 18y	weekly	4
CAWCR	d 0-120	T47L17	33	2/week	Fix	1989-2010	3/month	33
JMA	d 0-34	T159L60	50	weekly	Fix	1979-2010	3/month	5
KMA	d 0-30	T106L21	20	3/month	Fix	1979-2010	3/month	20
CMA	d 0-45	T63L16	40	6/month	Fix	1982-now	monthly	48
CPTEC	d 0-30	T126L28	1	daily	No	-	-	-
Met-Fr	d 0-60	T127L31	51	monthly	Fix	1981-2005	monthly	11
SAWS	d 0-60	T42L19	6	monthly	Fix	1981-2001	monthly	6
HMCR	d 0-60	1.1x1.4 L28	10	weekly	Fix	1979-2003	monthly	10

CMIP5 decadal predictions

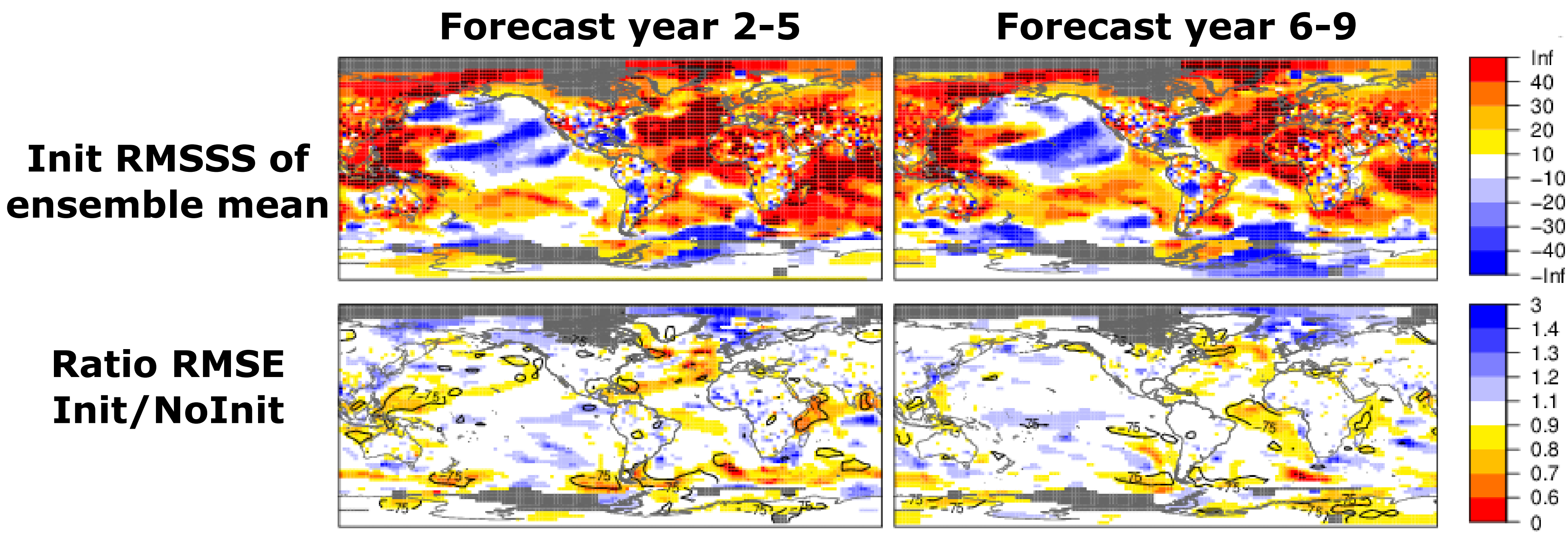
CMIP5 decadal predictions. Global-mean t2m and AMV against GHCN/ERSST3b for forecast years 2-5. **The initialised experiments reproduce the GMST trends and the AMV variability and suggest that initialisation corrects the forced model trend and phases in some of the internal variability.**



Doblas-Reyes et al. (2013)

Impact of initialisation in CMIP5

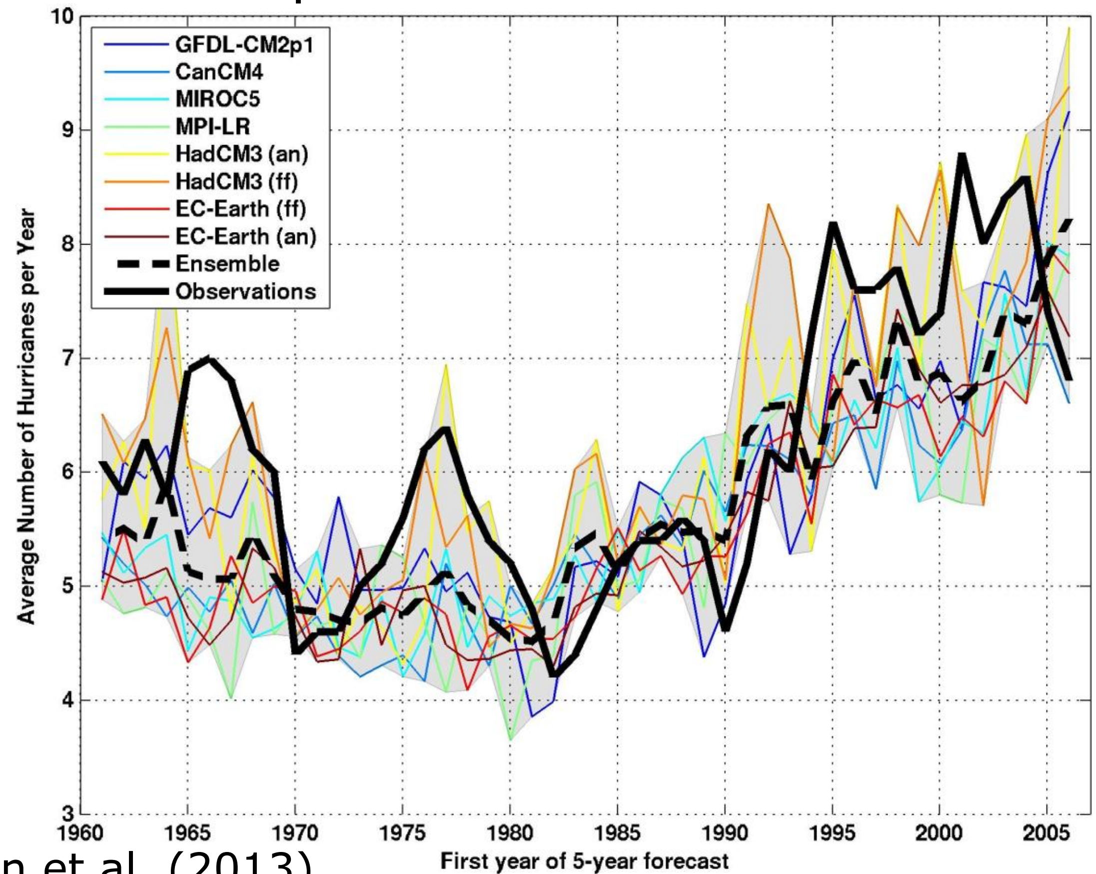
(Top row) Root mean square skill score (RMSSS) of the ensemble mean of the initialised predictions and (bottom row) ratio of the root mean square error (RMSE) of the initialised and uninitialised predictions for the near-surface temperature from the multi-model CMIP5 experiment (1960-2005) for (left) 2-5 and (right) 6-9 forecast years. Five-year start date interval.

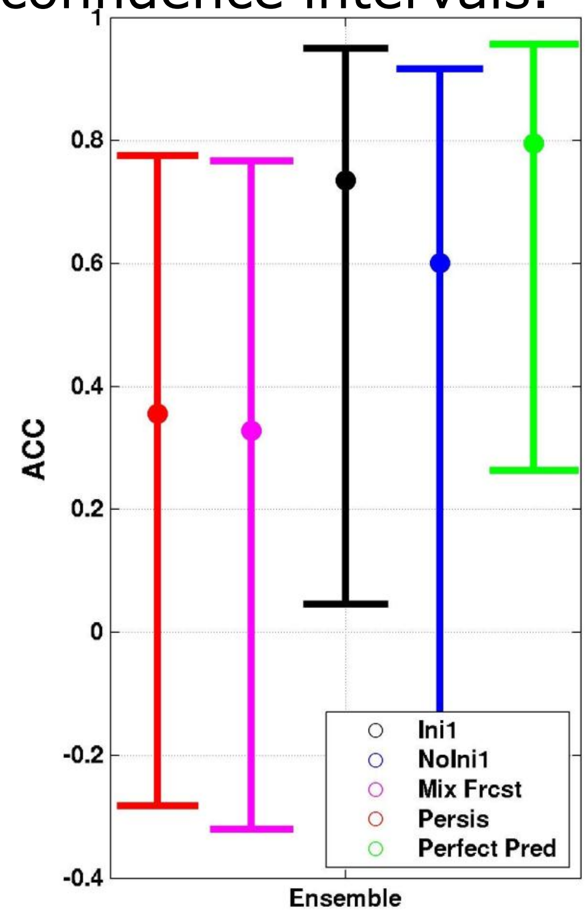


Doblas-Reyes et al. (2013)

Hurricane frequency prediction

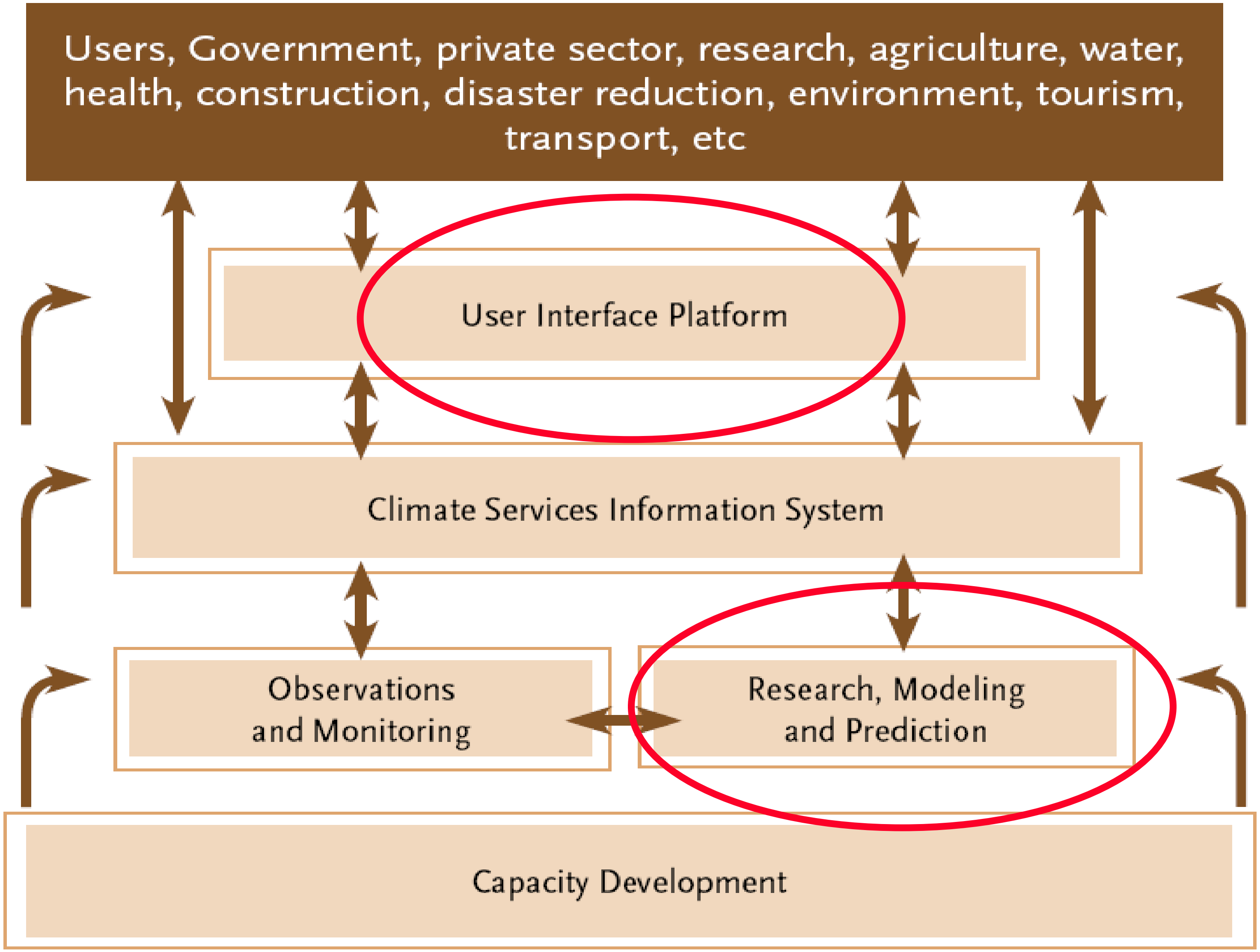
Average number of hurricanes per year estimated from observations and from the CMIP5 multi-model decadal prediction ensemble (forecast years 1-5). The correlation of the ensemble mean for the initialized, uninitialized and statistical predictions are shown with the 95% confidence intervals.





Caron et al. (2013)

Global framework on climate services



Some of the things missing

- Understanding of the impact models, and the best way to adapt them to the useful climate information available
- Bias correction
- Calibration and combination
- Downscaling, when necessary
- Documentation (follow the IPCC calibrated language), demonstration of value and outreach
- The EUPORIAS project, working alongside SPECS, is considering solutions to address some of these problems.

EUPORIAS

- EUPORIAS intends to improve our ability to maximise the societal benefit of climate prediction technologies.
- The project wants to develop a few fully working prototypes of climate services addressing the need of specific users.
- The time horizon is set between a month and a year ahead with the aim of extending it towards the more challenging decadal scale.
- This will increase the resilience of European society to climate change by demonstrating how climate information becomes usable by decision makers in different sectors.
- SPECS and EUPORIAS are part of ECOMS.

EUPORIAS

EUPORIAS

Three main blocks:

RT1: understand

- Users needs and current use of s2d
- Sector specific vulnerability

RT2: improve

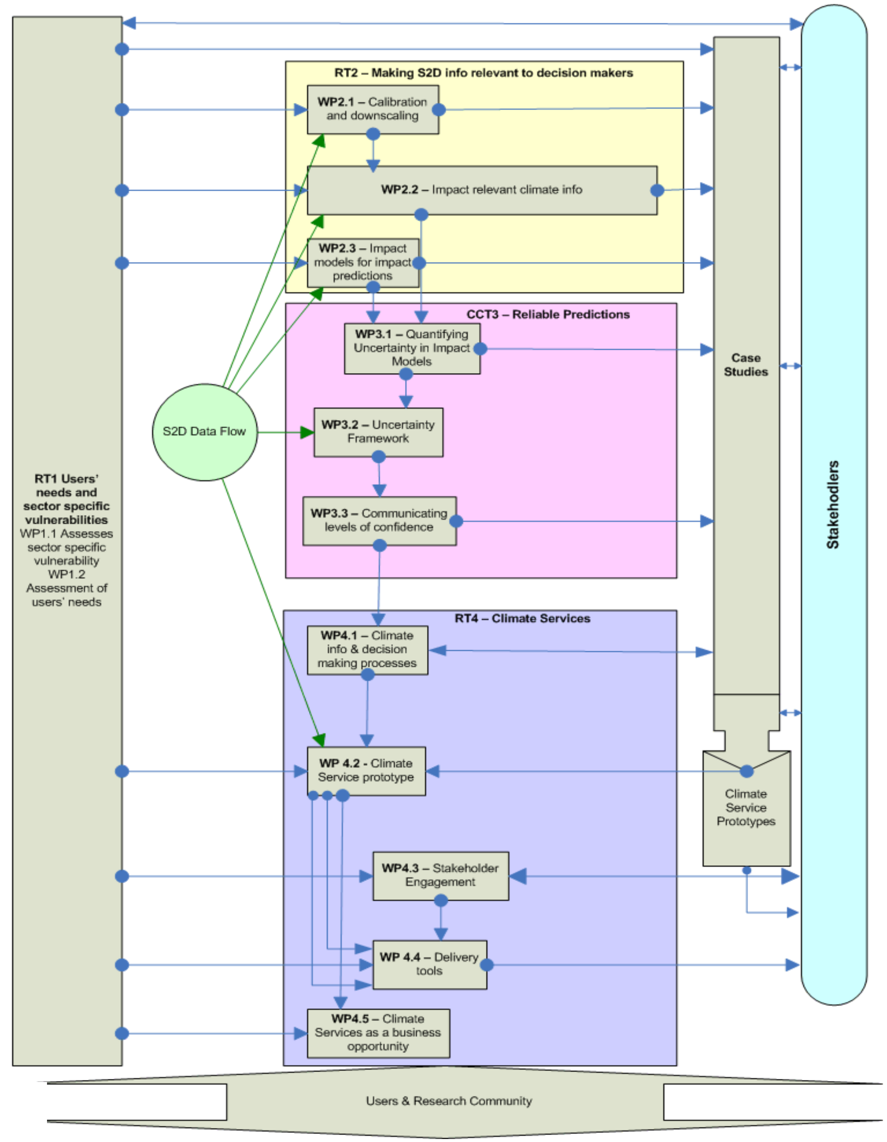
- Decision-relevant scales: downscale
- Decision-relevant parameters: impact models and post-processing

CCT3: uncertainty

- Impact models' uncertainties
- Combining uncertainties
- Communicating level of confidence

RT4: engage and demonstrate

- Decision making process
- Climate service prototypes
- Delivery and engagement
- Business opportunity

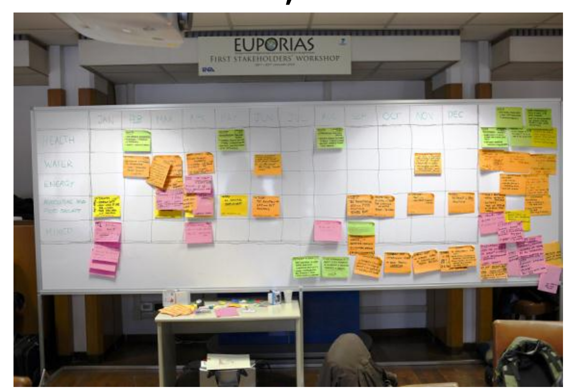


EUPORIAS: some activities

- Stakeholder workshop:
  - User-relevant parameters differ from sector to sector, but temperature and precipitation among the most required
  - Seasonality of the requirements
  - Appetite to improve large-scale predictability rather than granularity
  - Huge need for *education and training*
- Workshop on “Climate services providers & users’ needs”:
  - Current users (operational/strategic level) related to the energy, insurance, or transport sectors
  - Majority use predictions with lead time of a month up to a season
  - Barriers: Low skill, limited capacity and usability of data available, accessibility/communication of information
  - Solutions to overcome barriers:

    training and communication, improve skill,

    public funding

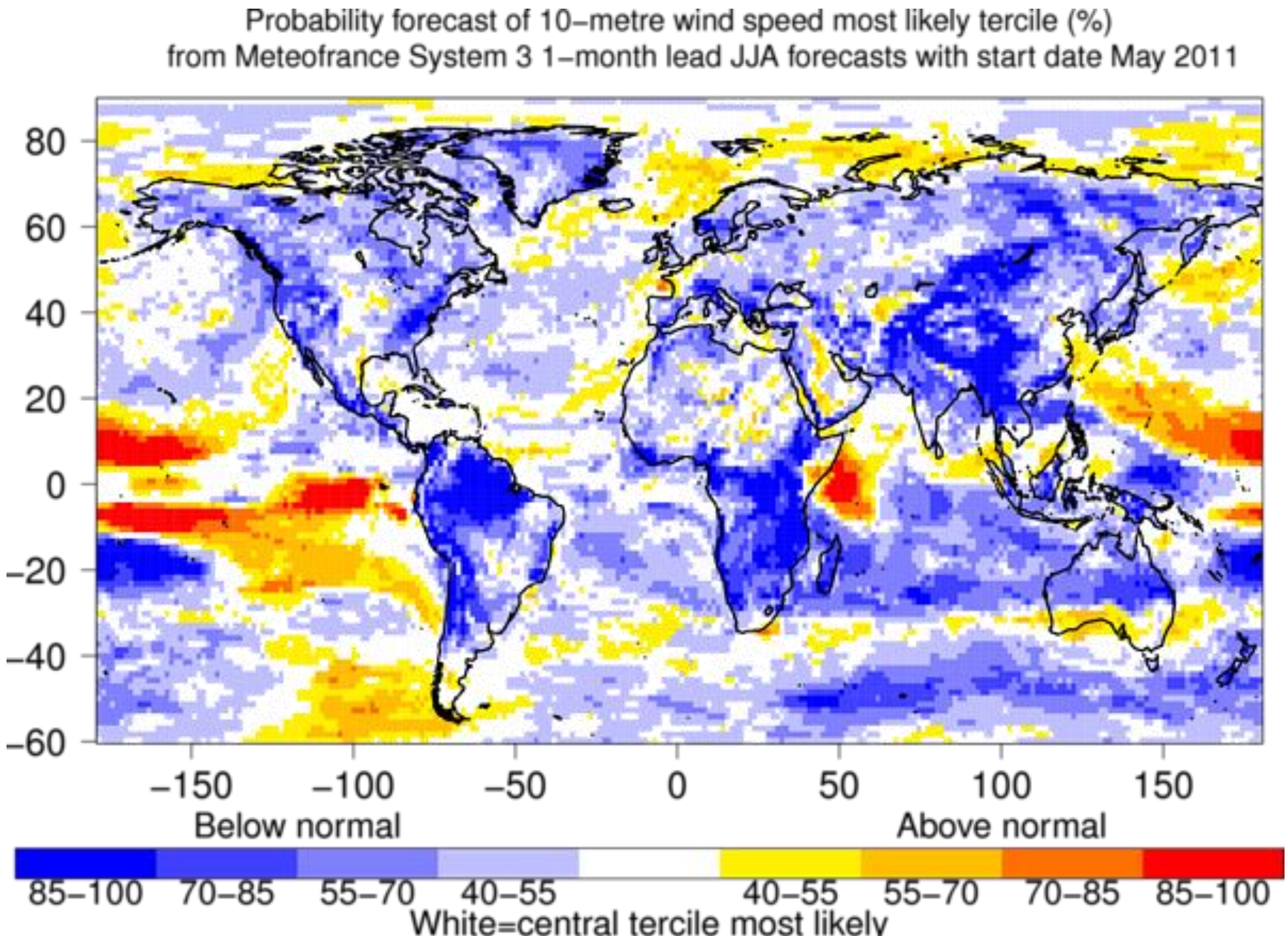


EUPORIAS

EUPORIAS: prototypes

- The prototypes will represent the main outcome of the project, providing a real example of what a climate service may look like for s2d time scales in Europe.
- Six proposals selected by an external panel based on value to the users, skill in the predictions, stakeholder engagement, robustness of the impact model.
  - Outlook for UK winter conditions to inform transport industry
  - Food security in East Africa for WFP
  - Winter land management for Clinton Devon Estate
  - Renewable energy management
  - River management in two French catchment areas
  - Hydroelectric production in Sweden
- From March 2014 a monthly update is provided.
- Next general assembly along with SPECS in October in Toulouse.

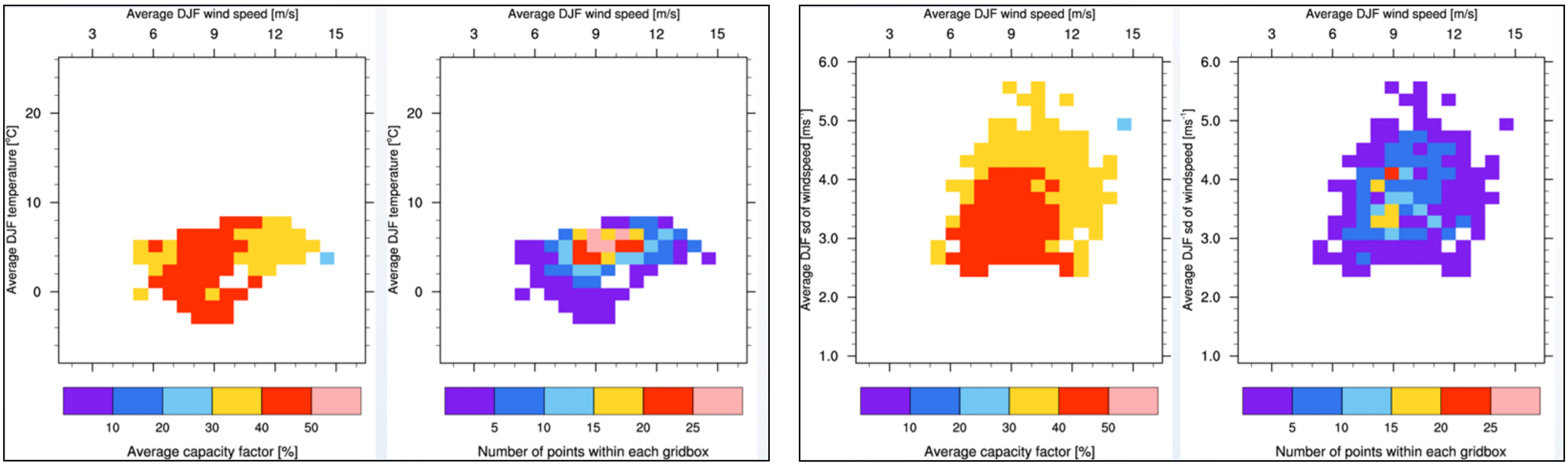
Climate services: renewable energy



Doblas-Reyes et al. (2013)

Climate services: impact models adapt

Impact surfaces of a simple wind-energy model over the North Sea for DJF as a function of the mean seasonal wind and the wind intraseasonal variability. Capacity factor (average power generated divided by the maximum power of the specific turbine) estimates obtained using the XXth Century Reanalysis, a Rayleigh function to estimate high-frequency winds from mean daily values and a wind profile power law to obtain 100 m winds from 10 m winds.



D. MacLeod (Univ. Oxford)

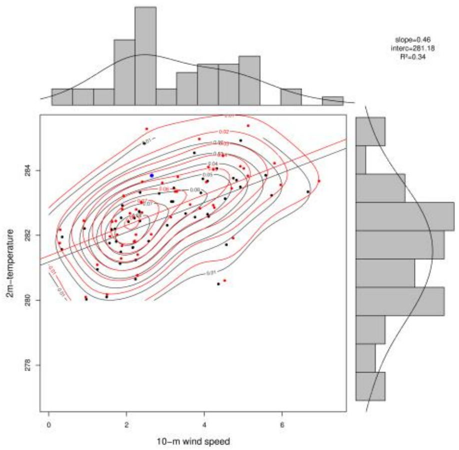
Bias correction

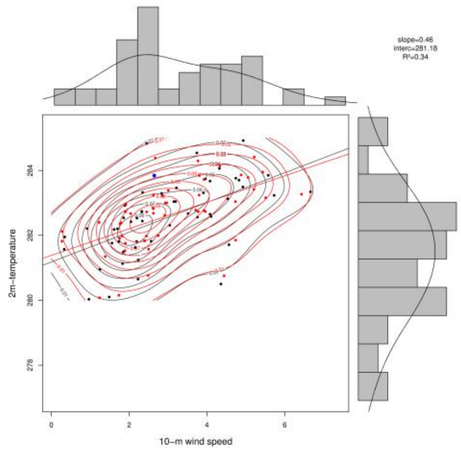
Bias correction is necessary, but it can also impact the skill. Bias-corrected ECMWF S4 forecasts for November with start date in November over 1981-2012. One-year-out cross-validation applied.

SIMPLE BIAS CORRECTION

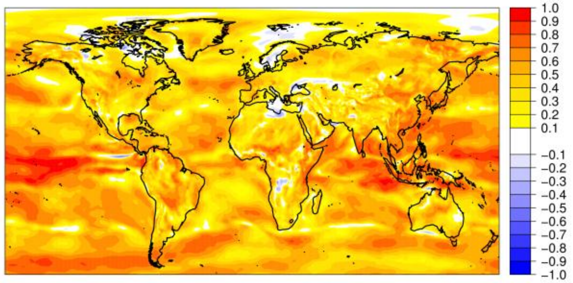
PERCENTILE BIAS CORRECTION

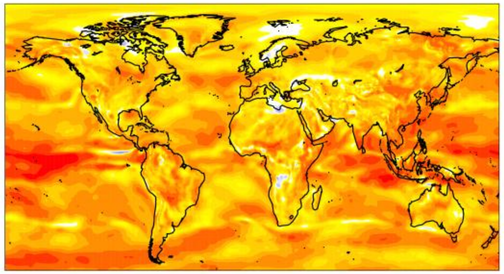
SCATTER PLOTS WITH MARGINAL DISTRIBUTIONS. 10-m wind speed and 2-m temperature for ECMWF S4 with 0-lead. November (2011). London





CORRELATION SKILL
10-m wind speed between ECMWF S4 ensemble mean and ERA INTERIM for November with start dates once a year on first of November from 1981 to 2012

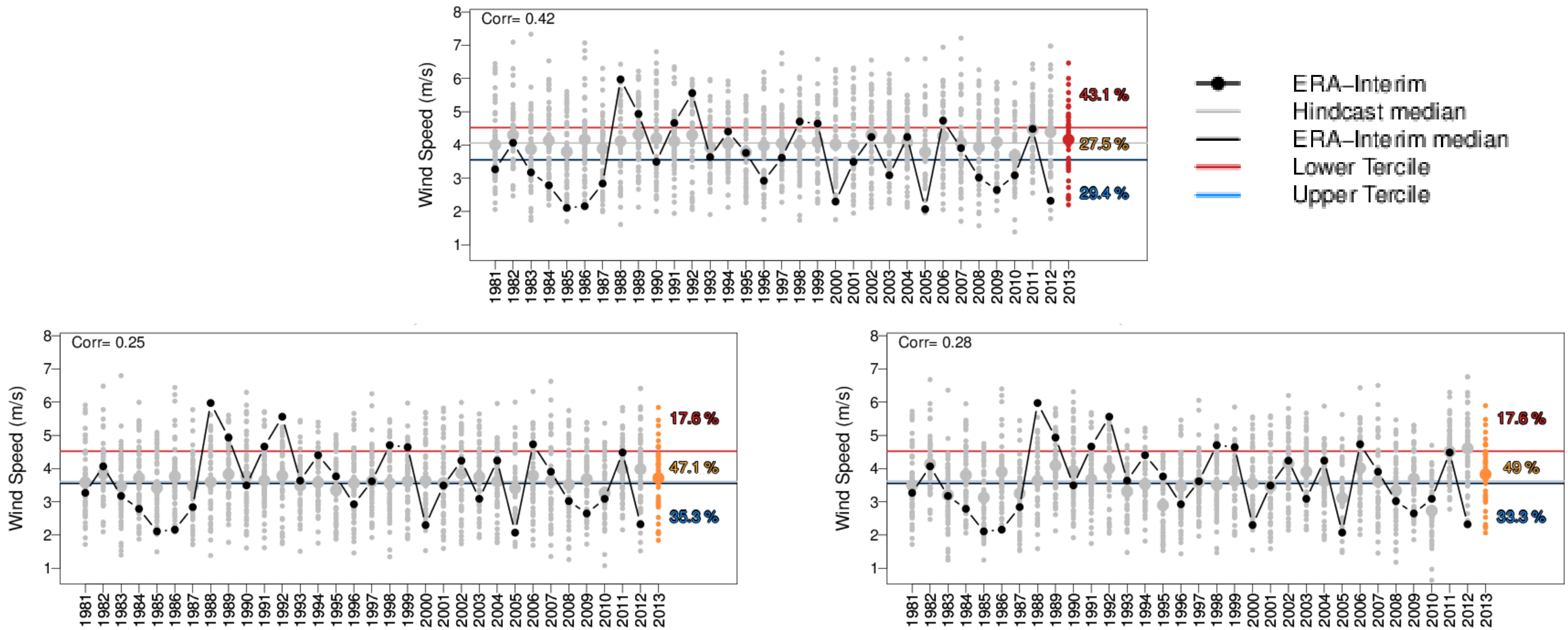




V. Torralba (IC3)

Bias correction and calibration

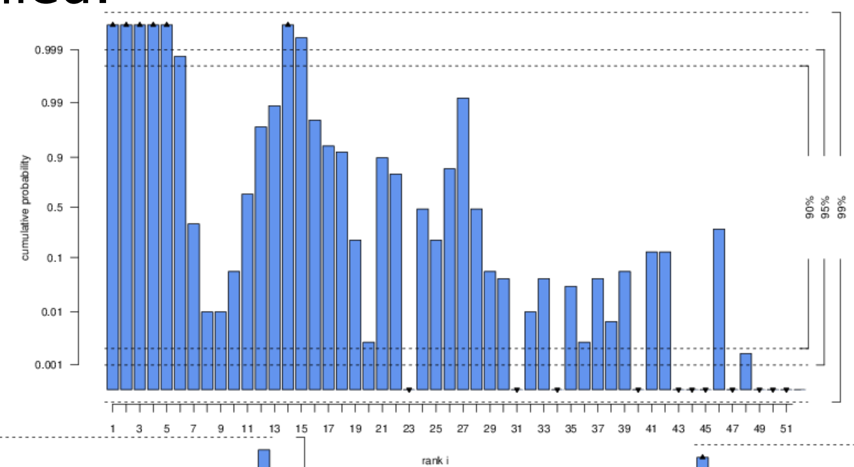
Bias correction and calibration have different effects. ECMWF S4 predictions of 10 m wind speed over the North Sea for DJF starting in November. Raw output (top), bias corrected (simple scaling, left) and ensemble calibration (right). One-year-out cross-validation applied.

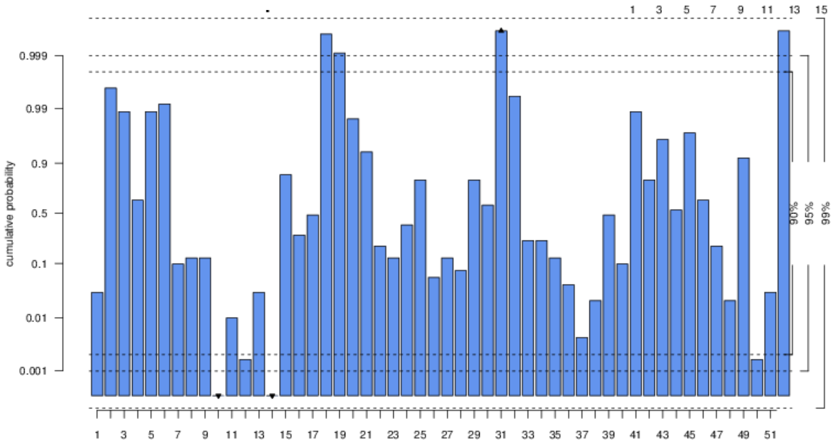


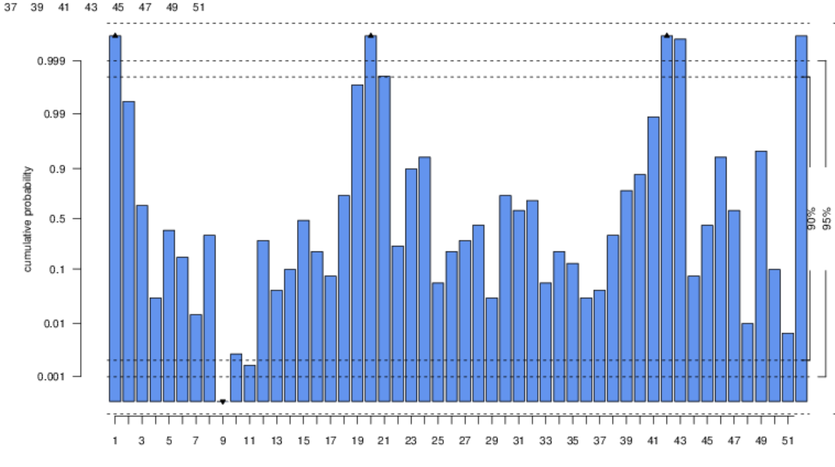
V. Torralba (IC3)

Bias correction and calibration

Rank histogram for ECMWF S4 predictions of 10 m wind speed over the North Sea for DJF starting in November. Raw output (top), bias corrected (simple scaling, left) and ensemble calibration (right). One-year-out cross-validation applied.



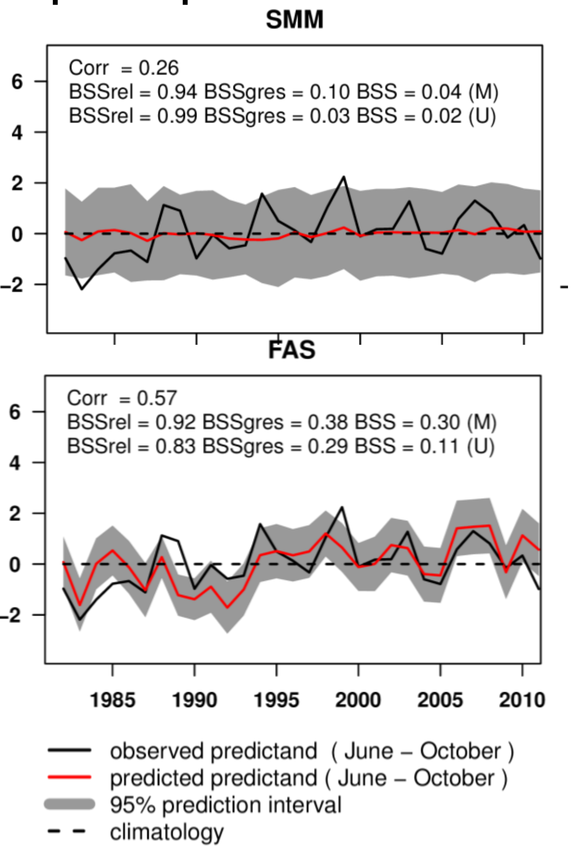


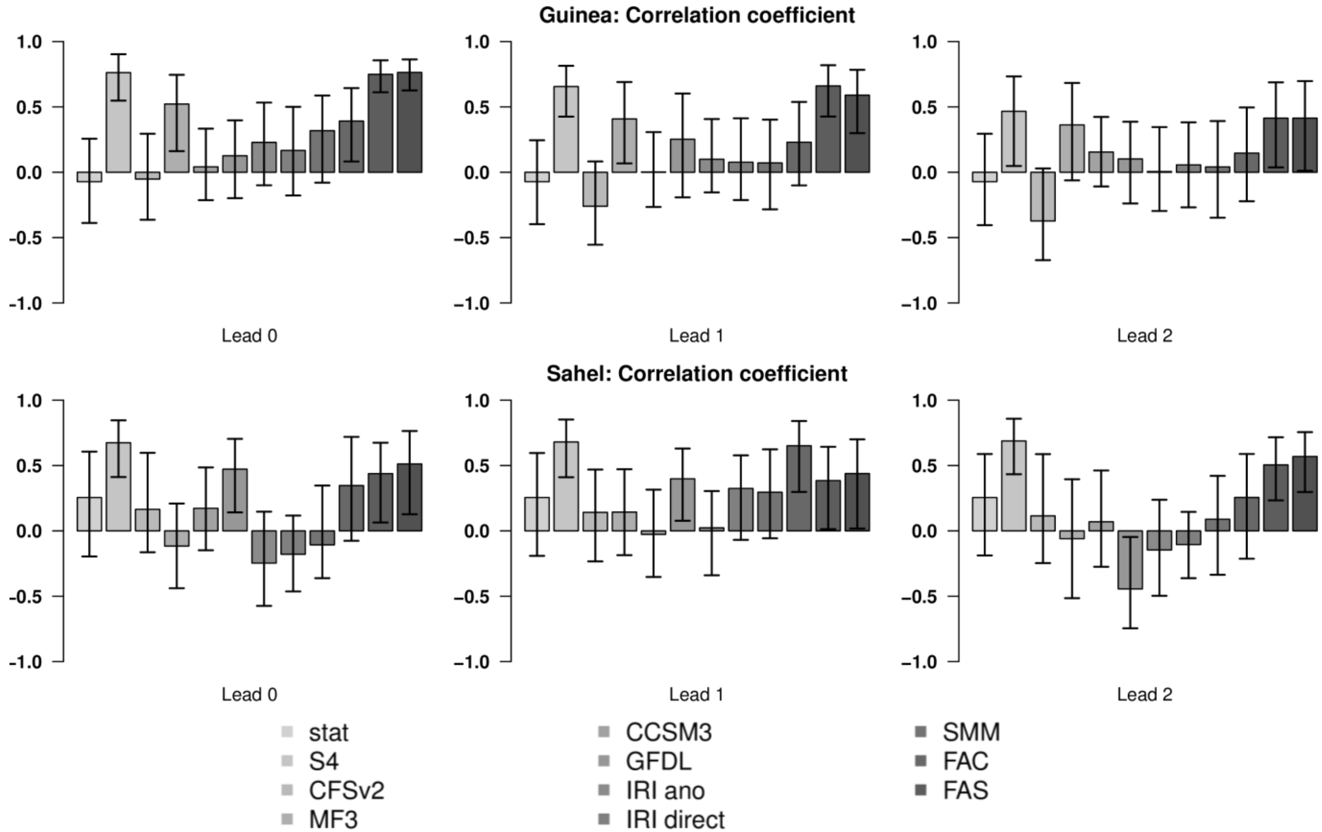


V. Torralba (IC3)

Calibration and combination: WAM

(Left) Multi-model seasonal predictions of Sahel precipitation, including its intraseasonal variability from June to October, started in April. (Right) Correlation of the ensemble mean prediction for Guinean and Sahel precipitation. *Reliability is fundamental for climate services.*





Rodrigues et al. (2014)

Downscaling for seasonal predictions

Publications applying any form of statistical downscaling to seasonal forecast products. TAO means “temporal aggregation of the output”.

Reference	Country	Affiliation	Source model(s)	Approach[1]	Technique[2]	Var	Region	TAO[3]
Landman and Tennant (2000)	S. Africa	S. Africa Weather Bureau	COLA GCM	MOS-E	G-D (CCA)	P	South Africa	M
Robertson et al. (2004)	USA	Columbia University	ECHAM 4.5	MOS-D	G-S (HMM)	P	Brazil	D
Díez et al. (2005)	Spain	National Institute of Meteorology	DEMETER (2 models)	PP-E (ERA-40)	NG-D (Analogs)	P	Spain	D
Pavan et al. (2005)	Italy	ARPA-SIMC	DEMETER (6 models)	PP-E (ERA-40)	G-D (MLR)	T, P	Italy	M
Gutiérrez et al. (2005)	Spain	University of Cantabria	DEMETER (4 models)	PP-E (ERA-40)	NG-D (Analogs)	P	Northern Peru	S
Frías et al. (2005)	Spain	University of Cantabria	DEMETER (7 models)	PP-E (ERA-40, NNR)	G-D (CCA)	T	Iberian Peninsula	M
Feddersen and Andersen (2005)	Denmark	Danish Meteorological Institute	DEMETER	MOS-E	G/NG-D (SVD+WT)	P, T	Europe, N America, Australia	S
Chu et al. (2008)	Taiwan	National Taiwan Normal University	SMIP (6 GCMs)	MOS-E	G-D (SVD)	P	N Taiwan	S
Sordo et al. (2008)	Spain	University of Cantabria	ECMWF's System2	PP-E (ERA-40)	NG-D (Analogs)	P	Spain	D
Landman et al. (2009)	S. Africa	South African Weather Service	ECHAM4.5	MOS-E	G-D (CCA)	P	S Africa	S
Juneng et al. (2010)	Malaysia	Universiti Kebangsaan	APCC-MME (7 models)	MOS-E	G-D (CCA)	P	Malaysia	M
Frías et al. (2010)	Spain	University of Cantabria	DEMETER	PP-E (ERA-40)	NG-D (Analogs)	P, T	Spain	D
Min et al. (2011)	S. Korea	APEC Climate Center	APCC MME (6 models)	MOS-E	G-D (LR)	P, T	S Korea	S
Wu et al. (2012)	USA	NCAR	CFS	MOS-E	NG-D (Analogs-KNN)	P	SE Mediterranean	M
Sun and Chen (2012)	China	Institute of Atmospheric Physics	DEMETER (7 models)	MOS-E	G-D (LR)	P	Global (CRU data)	S
Kryzhov (2012)	Russia	Hydrometeorological Research Center	SLAV GCM	MOS-E	G-D (LR)	T	N Eurasia	M
Robertson et al. (2012)	USA	International Research Institute for Climate and Society	RegCM3 / ECHAM4.5	MOS-E	G-D (PC-LR)	P	Philippines	D
Ying and Ke (2012)	China	Institute of Atmospheric Physics	DEMETER (3 models)	PP-E (ERA-40)	G-D (LR)	P	SE China	S
Johnson (2012)	USA	Florida State University	DEMETER (and others)	MOS-E	G-D (LR)	P	S America	M
Tian and Martinez (2012)	USA	University of Florida	GFS / DOE	PP-E (NARR)	NG-D (Analogs)	ET_0	Florida	D
Shao and Li (2013)	Australia	CSIRO	POAMA	PP-E (NNR)	NG-D (Analogs)	P	SE Australia	D
Sinha et al. (2013)	India	Indian Institute of Technology	In-GLM1 (NCMRWF)	PP-E (NNR)	G-D (CCA)	P	India	S
de Castro et al. (2013)	Brazil	Federal University of Ceara	RSM / ECHAM4.5	MOS-E	G-D (ANN)	P	Brazil	M
Charles et al. (2013)	Australia	Bureau of Meteorology	POAMA	MOS-E	NG-D (Analogs)	P	SE Australia	D
Sohn et al. (2013)	Korea	APCC	APCC MME (10 models)	MOS-E	G-D (LR)	P	S Korea	M
Silva and Mendes (2013)	Brazil	University Federal of Rio Grande do Norte	CFS	MOS-E	G-D (ANN)	P	NE Brazil	M
Tung et al. (2013)	China	City University of Hong Kong	APCC MME	MOS-E	G-D (SVD)	P	S China	S
Pavan and Doblas-Reyes (2013)	Italy	ARPA-SIMC	ENSEMBLES (5 models)	MOS-E	G-D (MLR)	T	Italy	M

J.M. Gutiérrez (Univ. Cantabria)

How are some predictions communicated?

Alarm in Europe: 2013's summer predicted as the closest to 1816, the year without summer. Canal Météo used external sources.

Actualité > **Société**

Météo : l'été sera-t-il vraiment «pourri» ?

Publié le 28.05.2013

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Hiver froid, printemps frais, été gâché ? A en croire certains prévisionnistes, le temps maussade qui s'est abattu sur la France depuis plusieurs mois... ne devrait pas être chassé par les doux rayons du soleil estival. Pis, Météo Consult table carrément sur «un été pourri» en France.

AUDIO. Du soleil en été ? «Il y a de l'espoir» pour Frédéric Decker, de Météo News.

Le Parisien, 28 May 2013

Météo 2013 : une année sans été ?

France

Dernière modification le samedi 25 mai 2013 à 16h29

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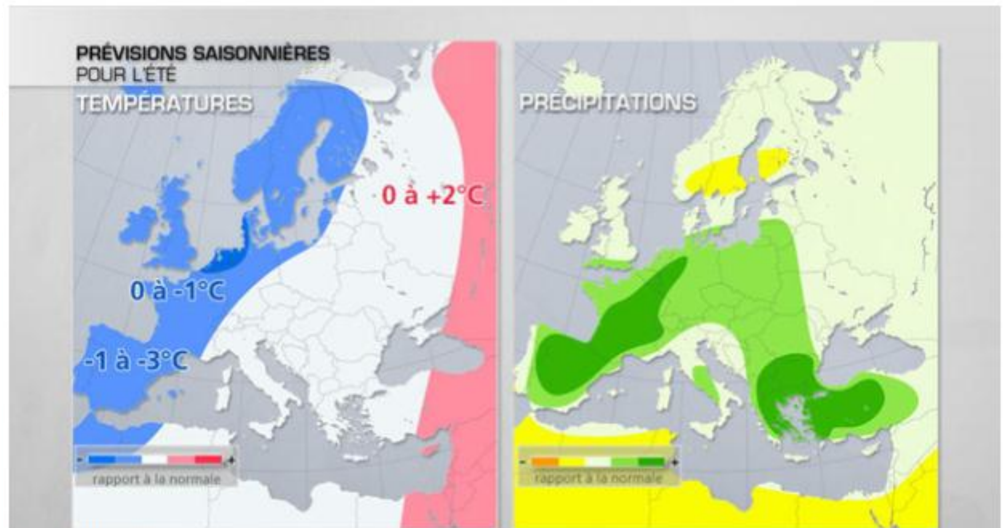
Climat



Crédit Photo :

Canal Météo, 25 May 2013

Progress on the open fronts

- Work on initialisation: initial conditions for all components (including better ocean), better ensemble generation, etc. Link to observational and reanalysis efforts.
- Model improvement: leverage knowledge and resources from modelling at other time scales, drift reduction. More efficient codes and adequate computing resources.
- Calibration and combination: empirical prediction (better use of current benchmarks), local knowledge.
- Forecast quality assessment: scores closer to the user, reliability as a main target, process-based verification.
- Improving many processes: sea ice, projections of volcanic and anthropogenic aerosols, vegetation and land, …
- More sensitivity to the users' needs: going beyond downscaling, better documentation (e.g. use the IPCC language), demonstration of value and outreach.