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Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Exeter, 6 October 2016

Climate prediction for Climate Services

Martin MÉNÉGOZ
BSC Earth Sciences Department, Barcelona, Spain

VOLCADEC

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

BSC Earth Sciences Department

What

Environmental modelling and forecasting

Why

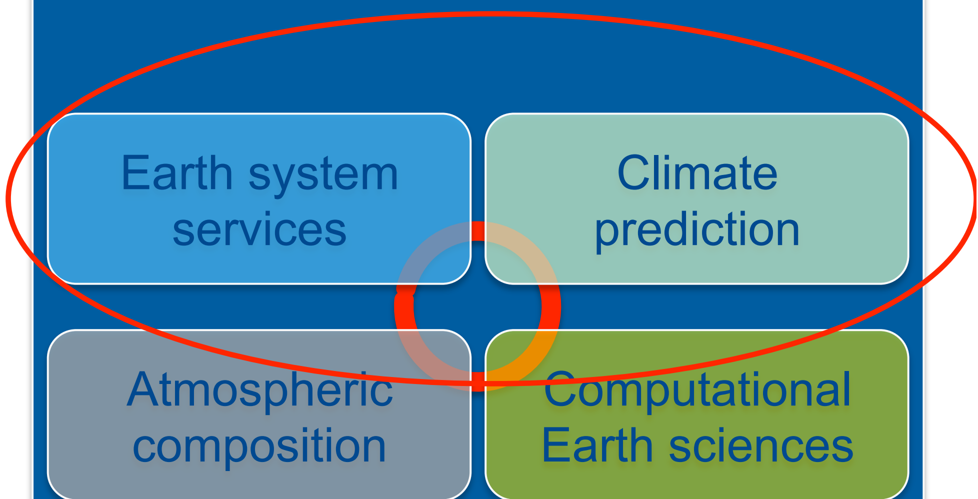
Our strength …

… research …
&
… services …

How

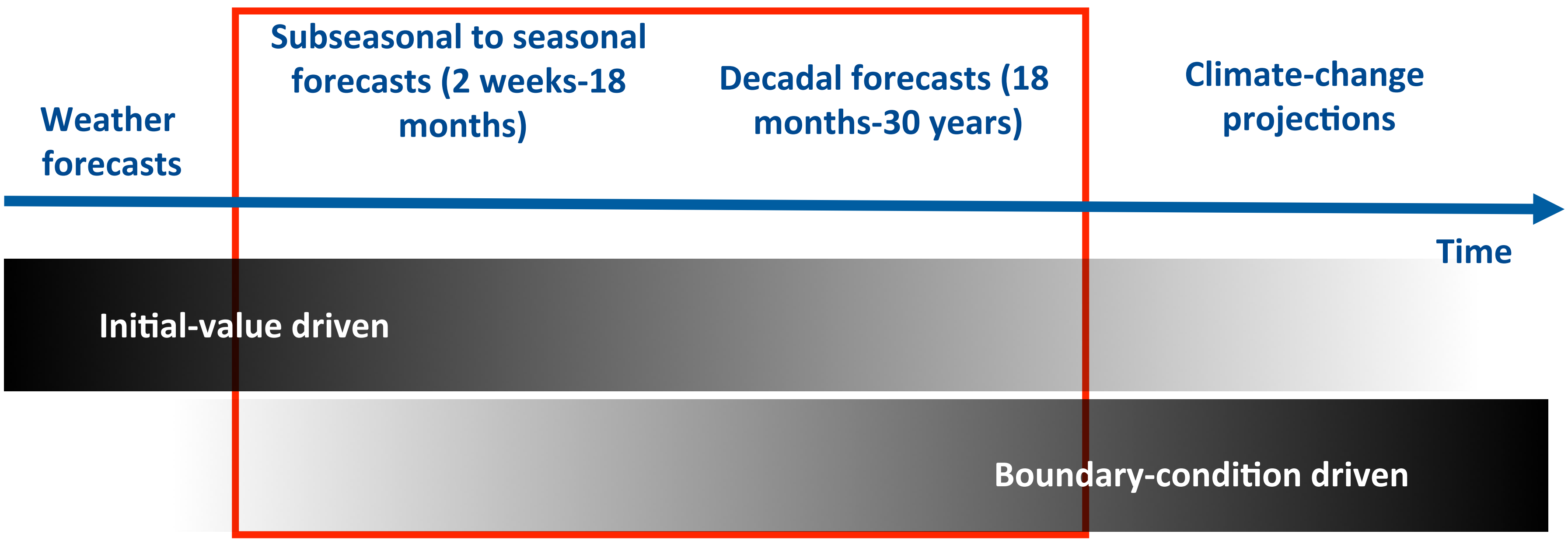
Implement a climate prediction system for subseasonal-to-decadal climate prediction

Develop user-oriented services that favour both technology transfer and adaptation



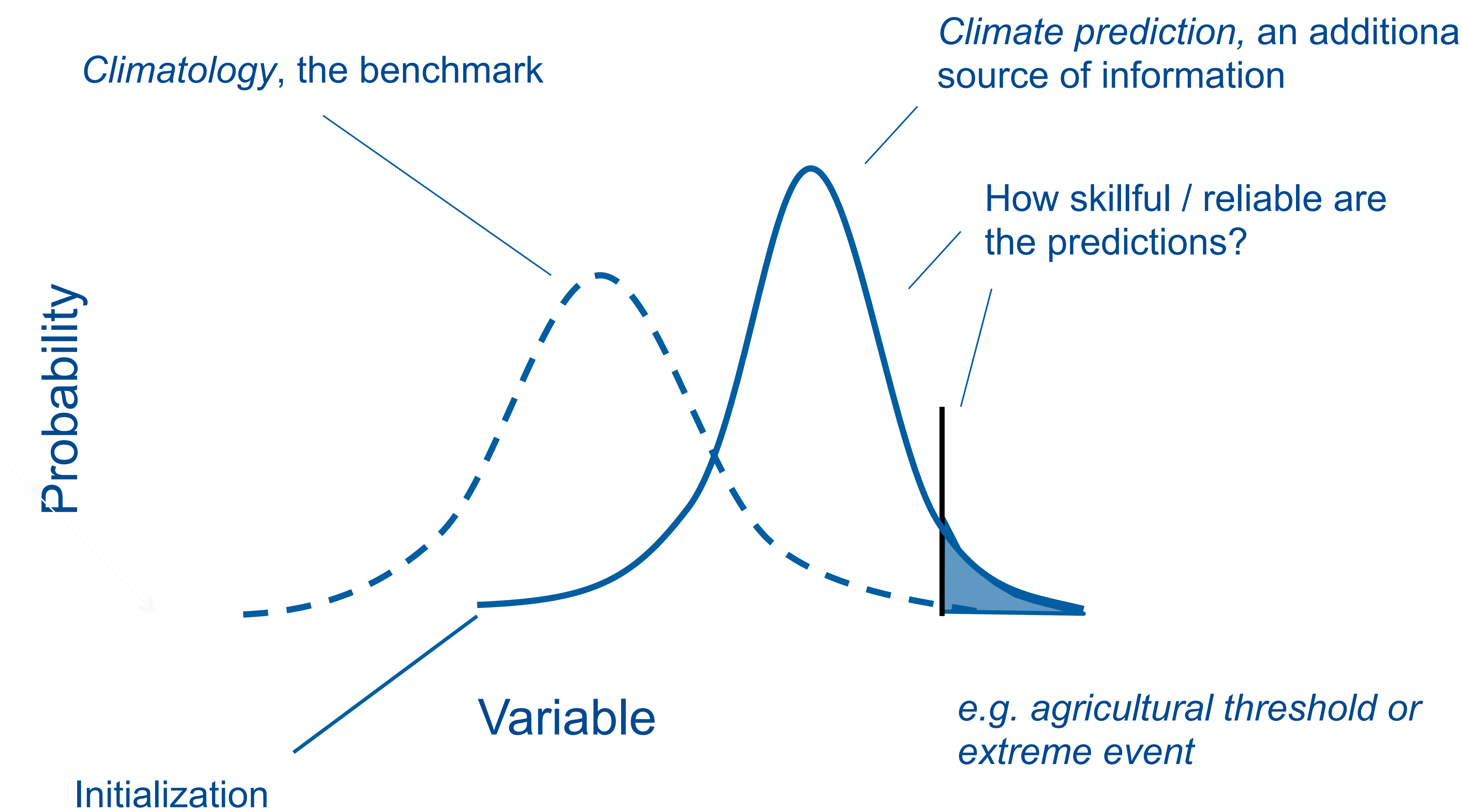
Climate prediction time scales

Between initial-value problems (weather forecasting) and multi-decadal to century projections as a forced boundary condition problem.

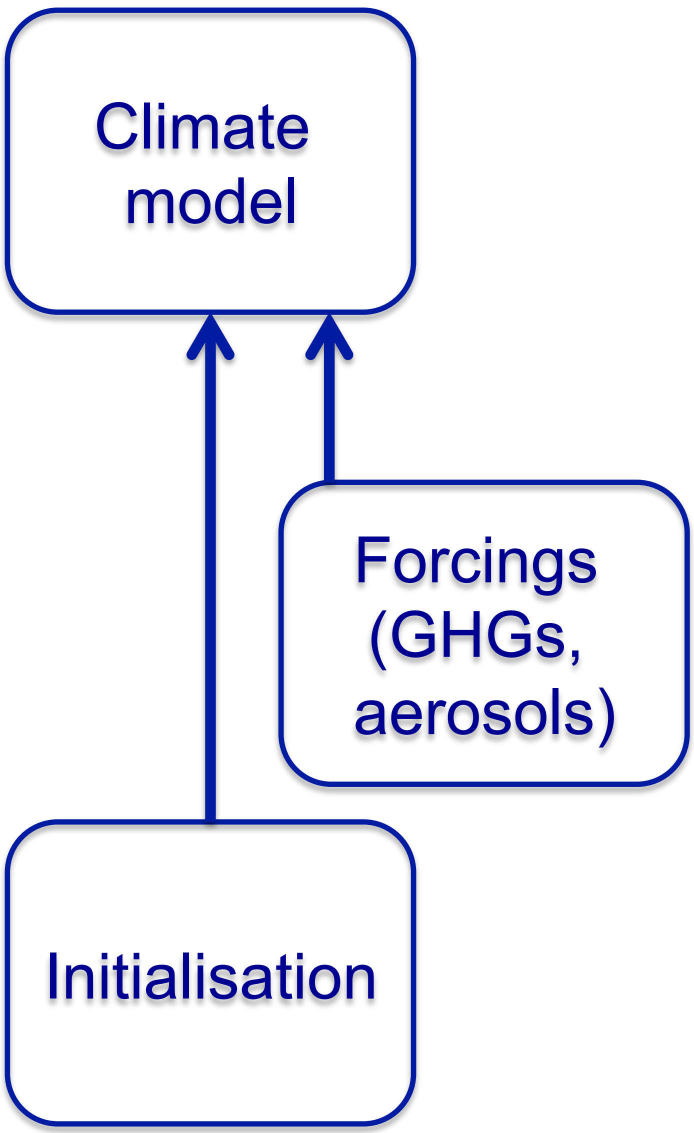


Adapted from Meehl et al. (2009)

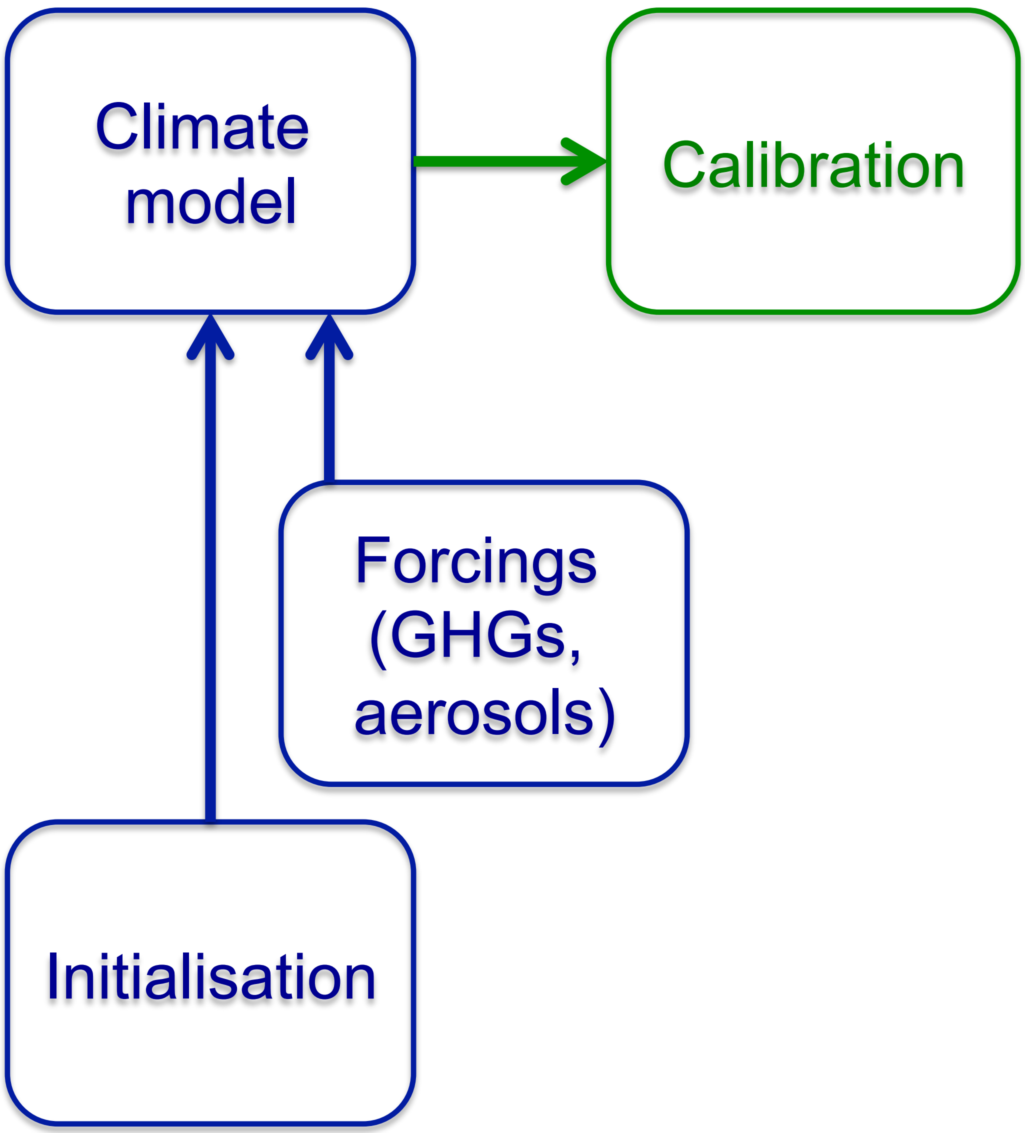
Climate prediction: concept



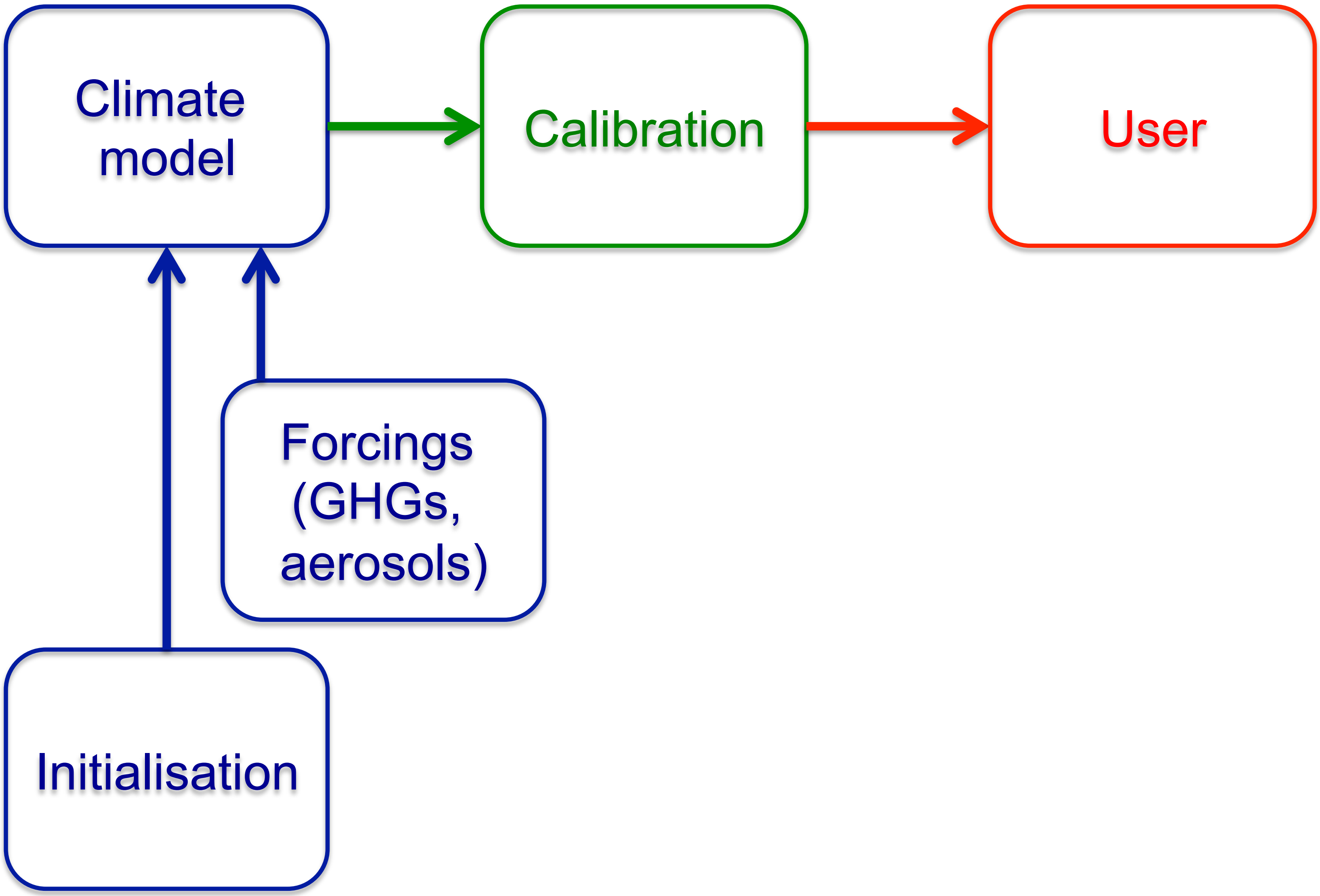
From climate science to user applications



From climate science to user applications



From climate science to user applications



From climate science to user applications

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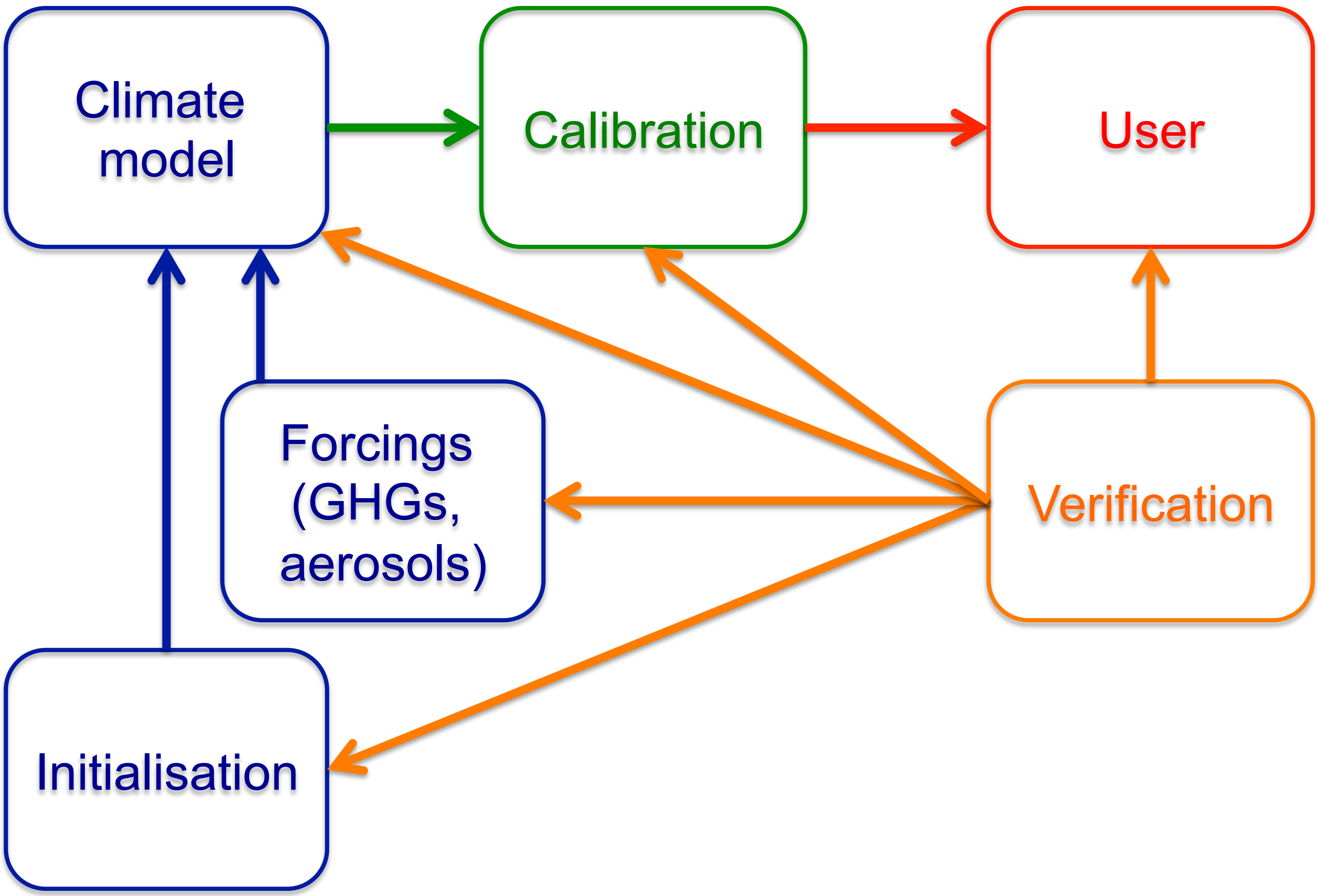
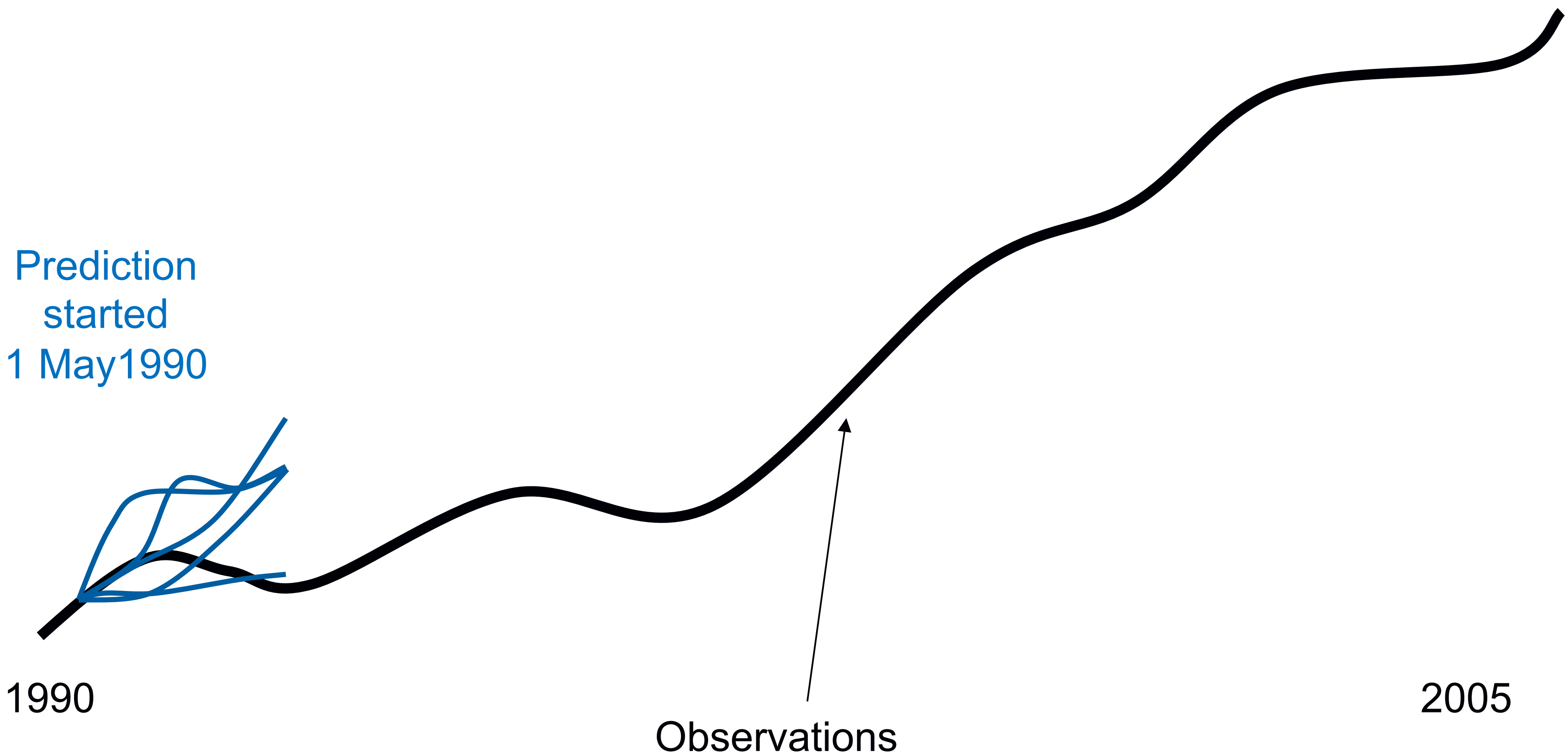
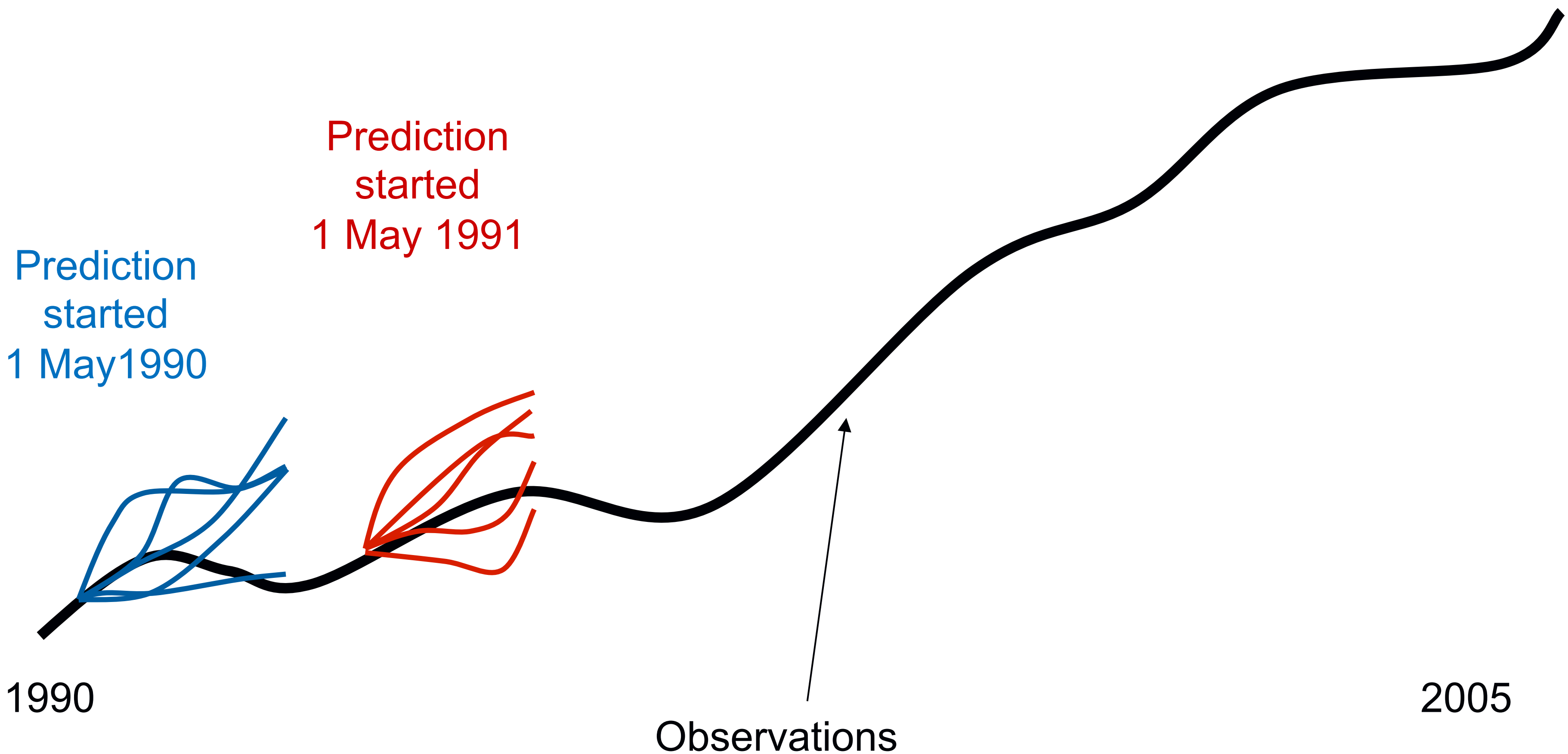


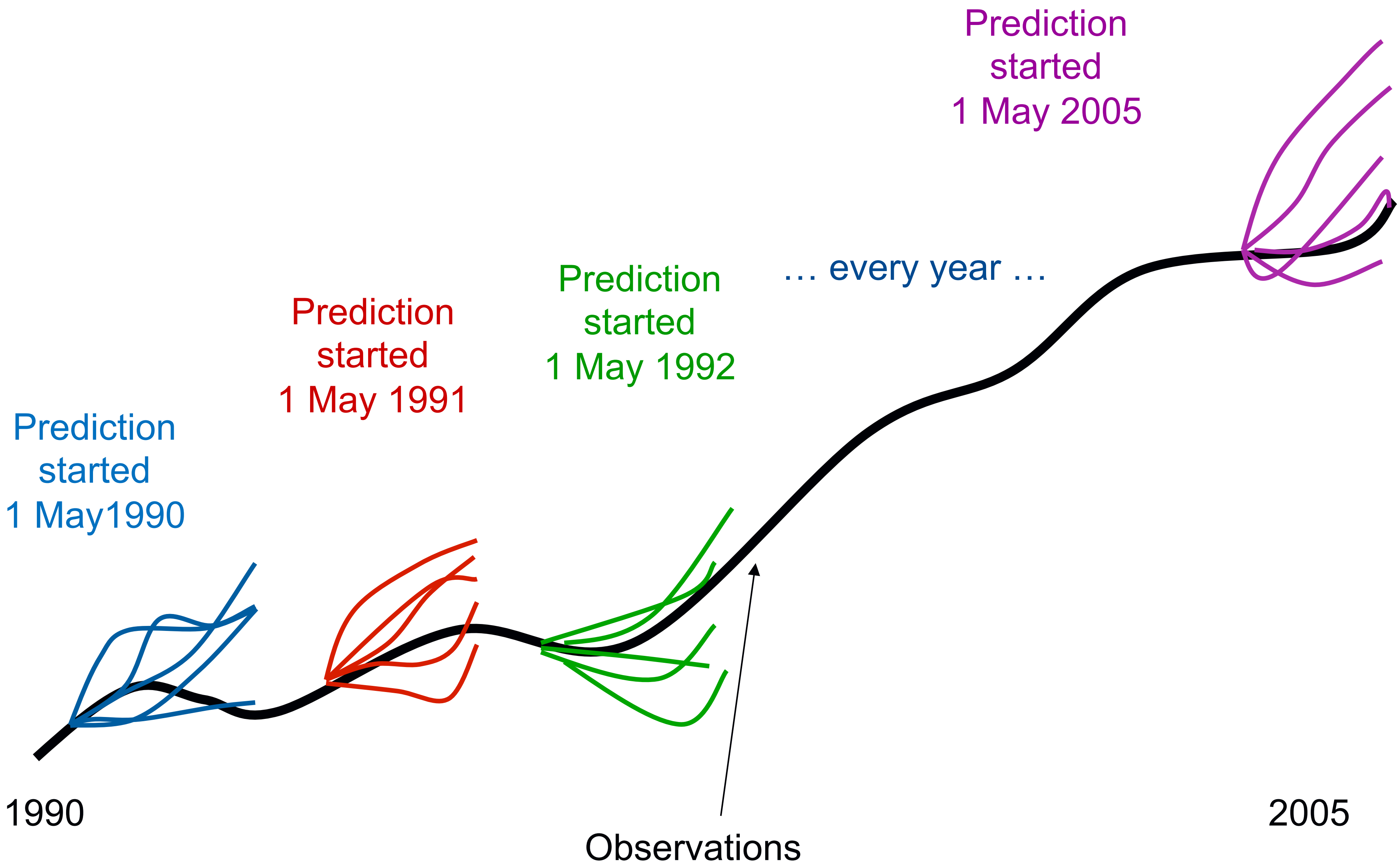
Climate prediction hindcasts



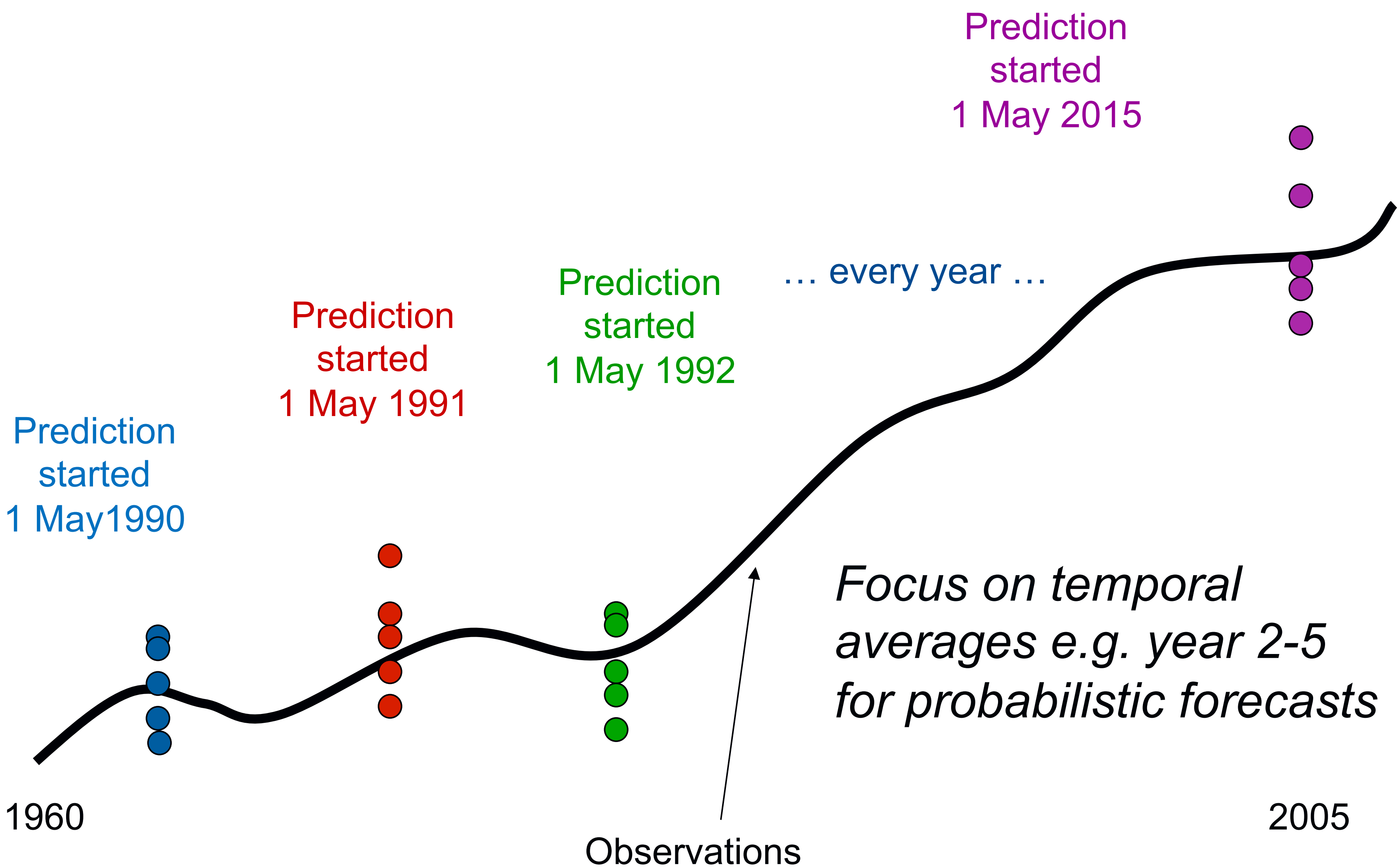
Climate prediction hindcasts



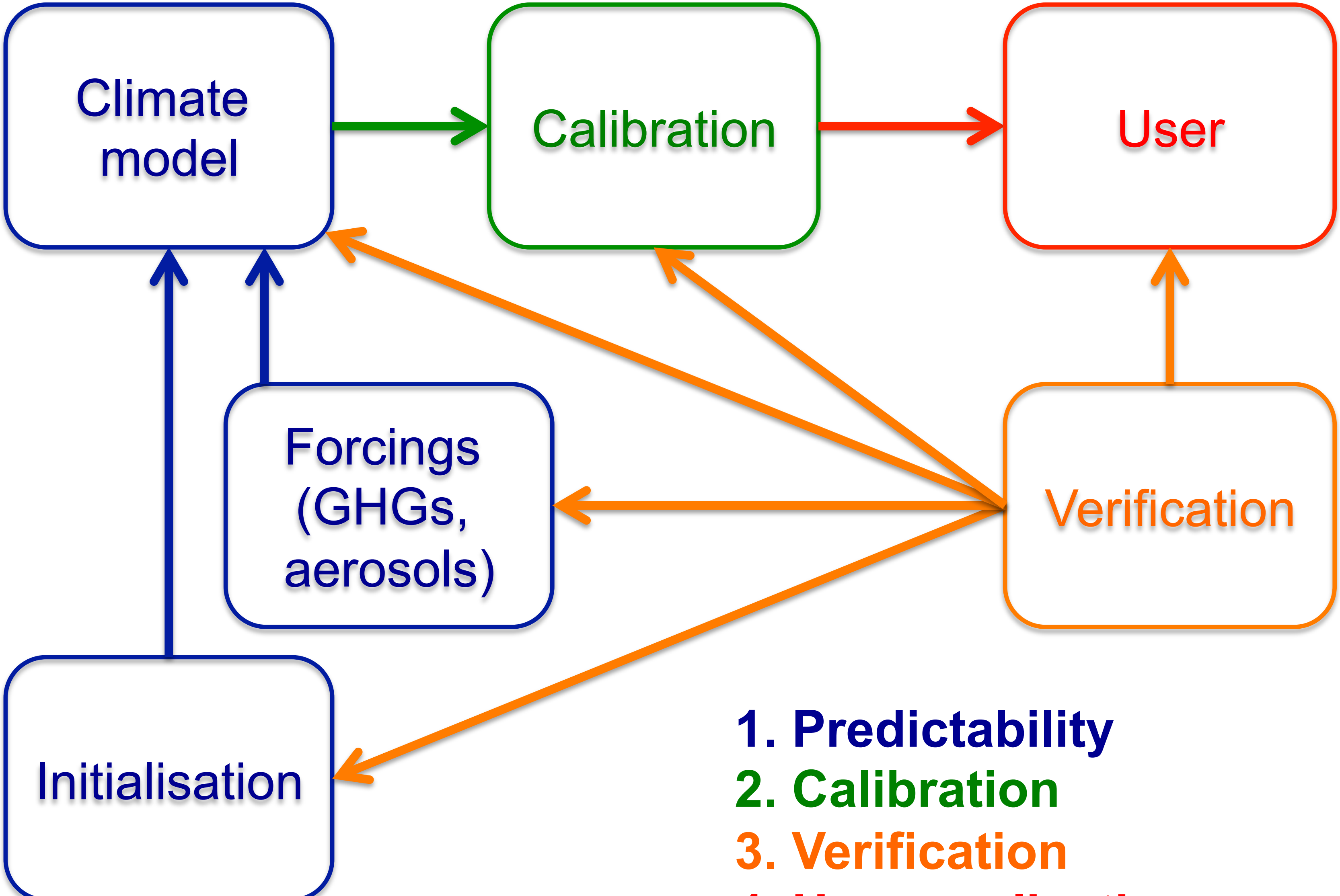
Climate prediction hindcasts



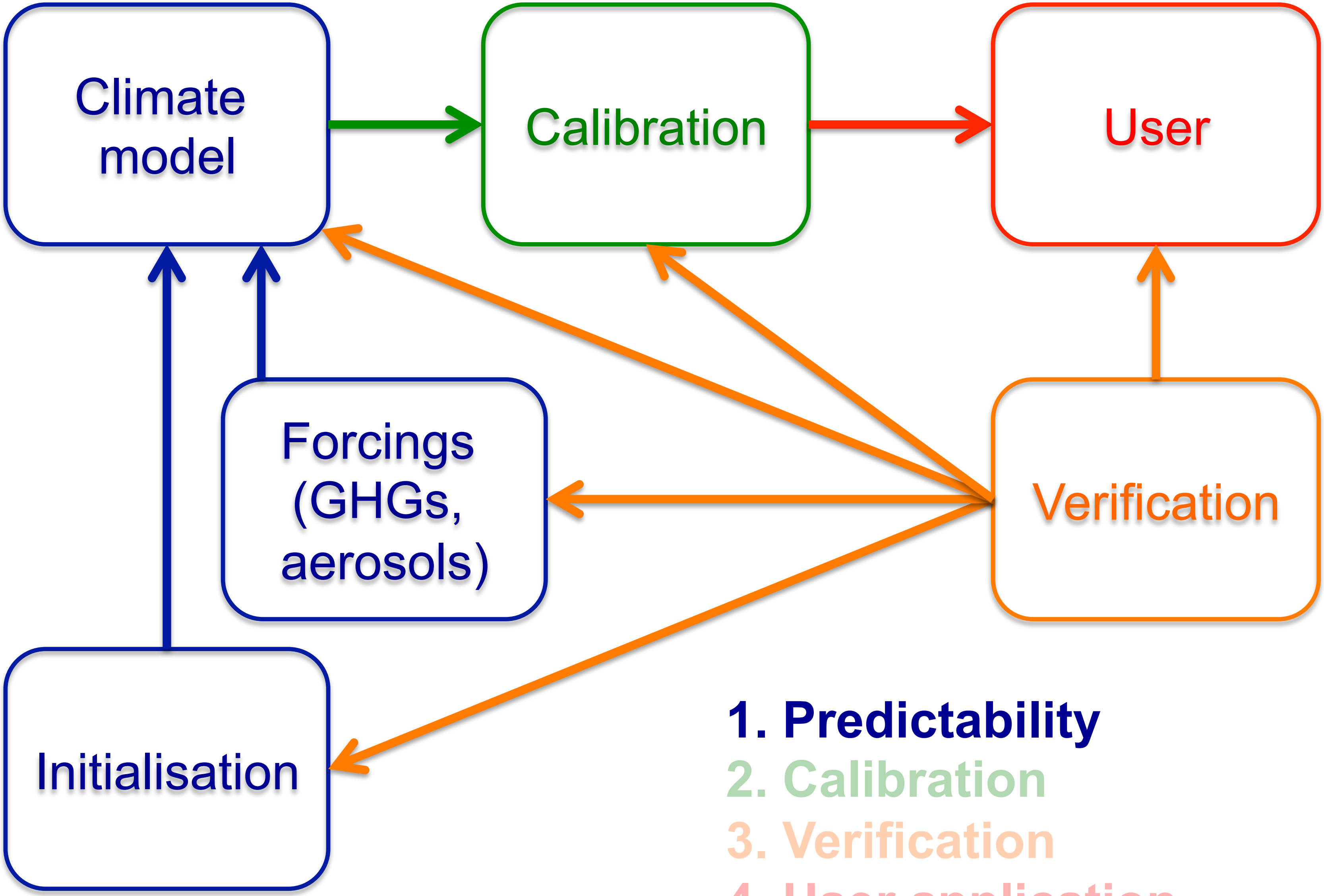
Climate prediction hindcasts



Outline



1. **Predictability**
2. **Calibration**
3. **Verification**
4. **User application**



1. Predictability
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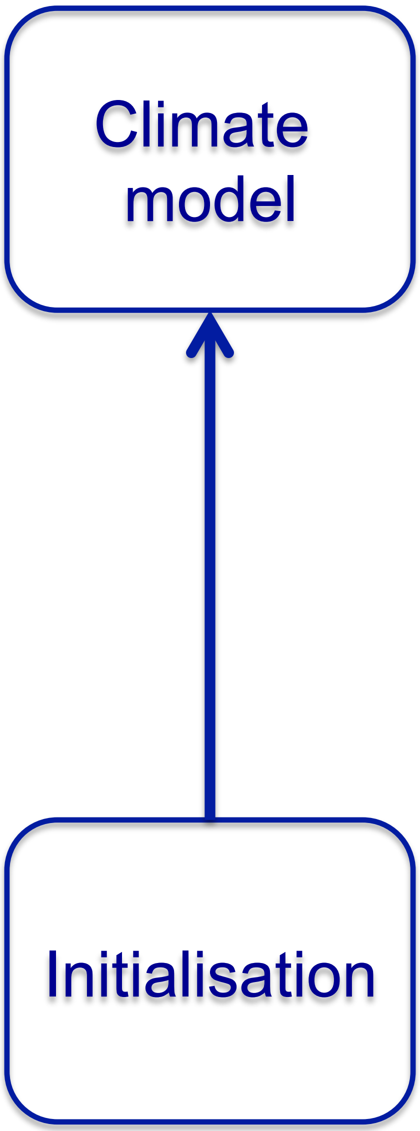
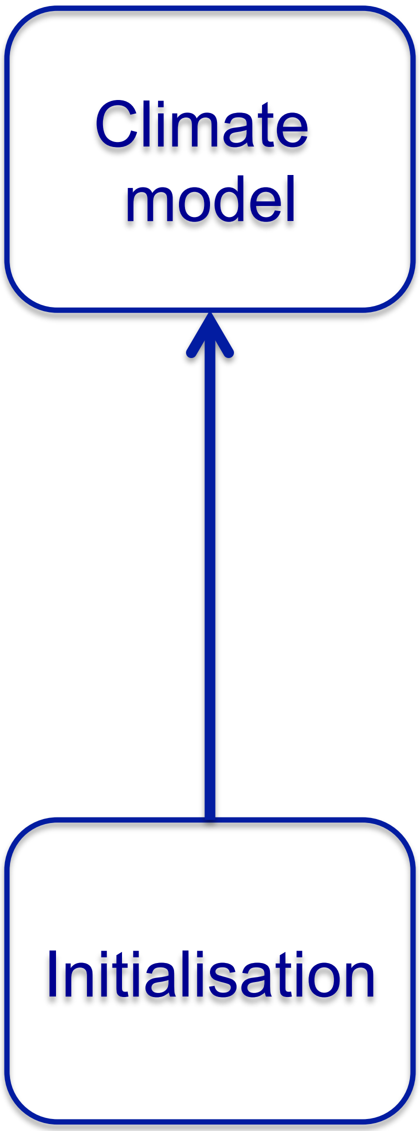
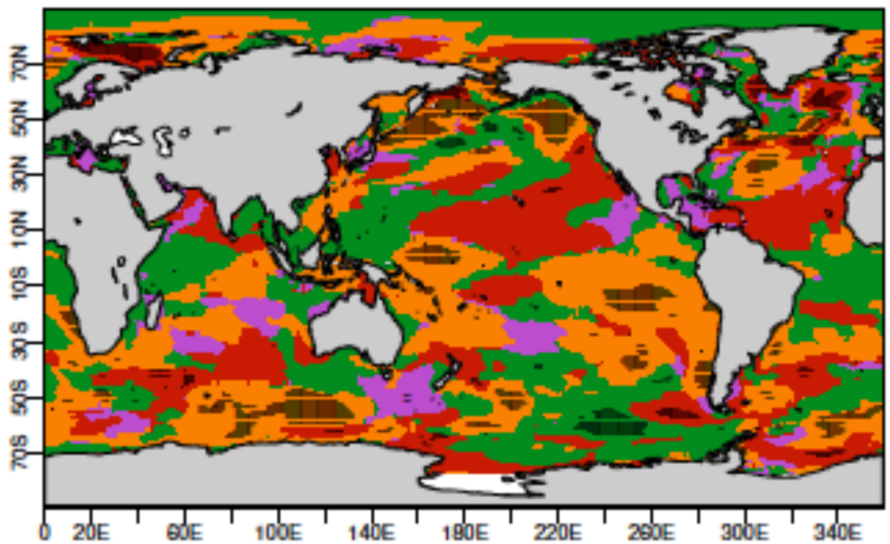
Internal variability



- FFI — Full Field initialisation
- OSI-AI — Ocean-Sea-Ice Anomaly initialisation
- ρ-OSI-wAI — OSI weighted anomalies
- NOINI — No Initialisation

Internal variability



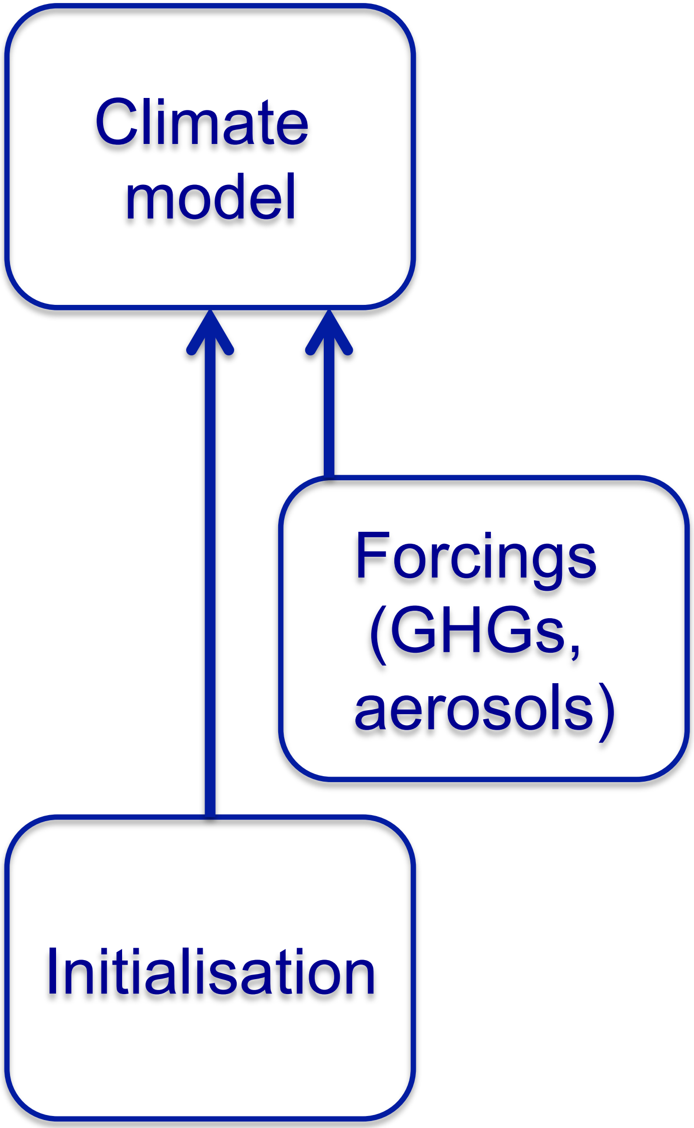


Minimum RMSE of the SST for the forecast years 2-5, get with different initialisation

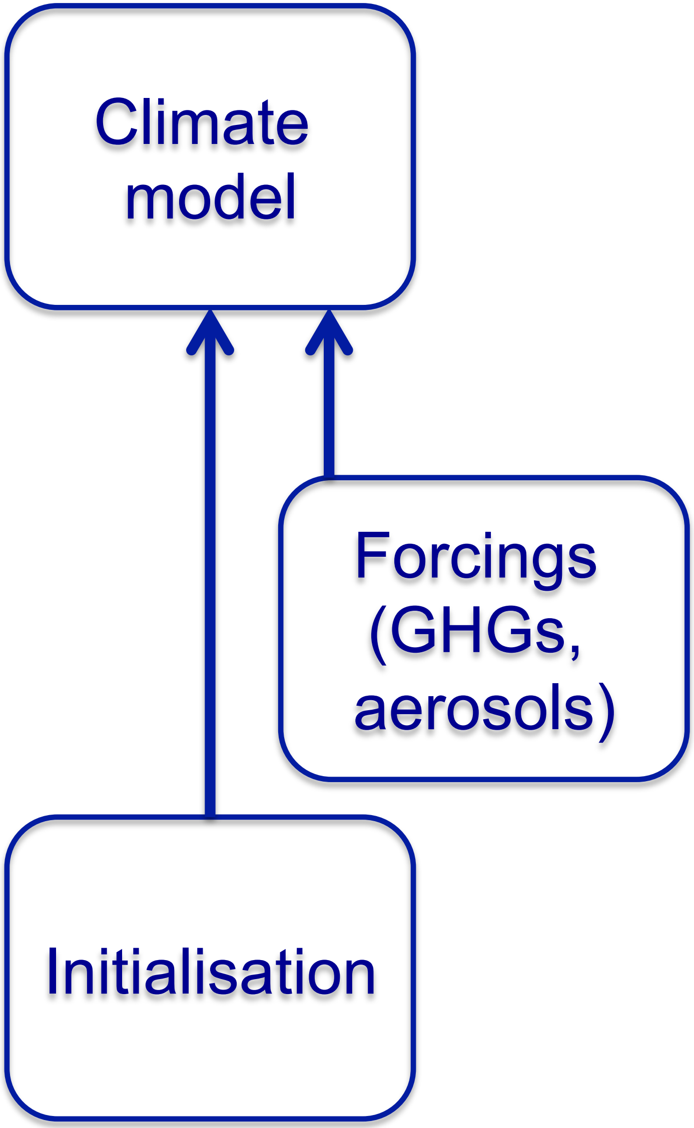
Volpi et al. 2016

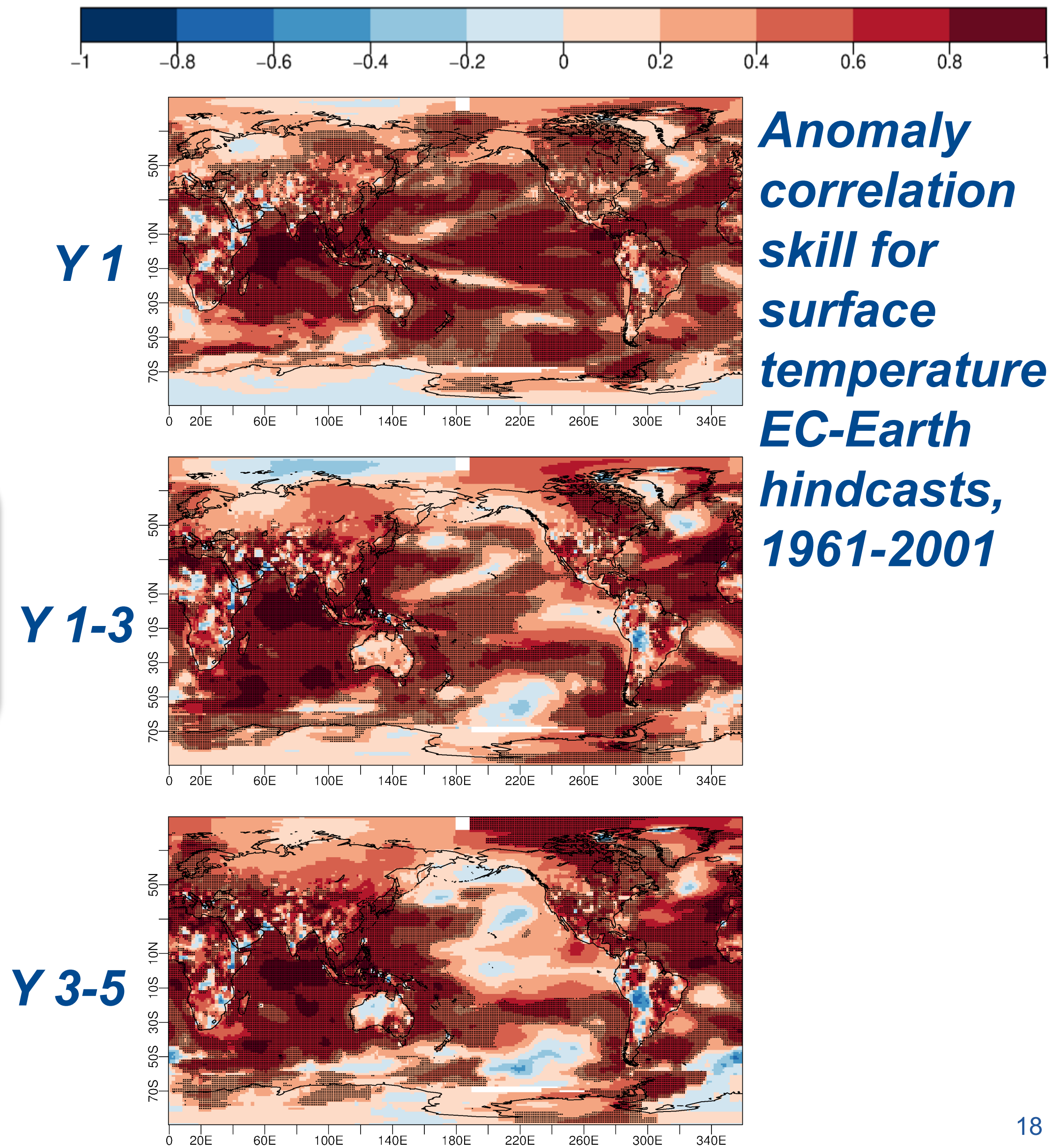
FFI	**Full Field initialisation**
OSI-AI	**Ocean-Sea-Ice Anomaly initialisation**
ρ-OSI-wAI	**OSI weighted anomalies**
NOINI	**No Initialisation**

Internal variability and external forcings



Internal variability and external forcings

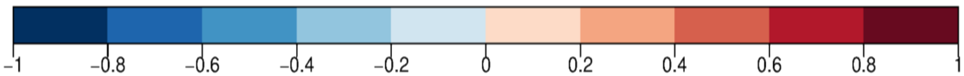




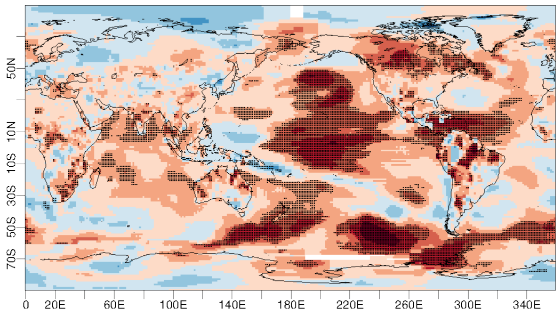
Anomaly correlation skill for surface temperature EC-Earth hindcasts, 1961-2001

Internal variability and external forcings

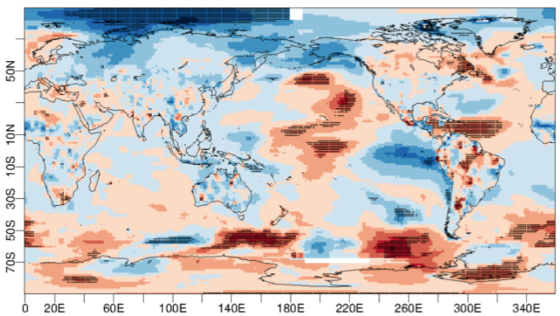
Ménégoz et al., in prep



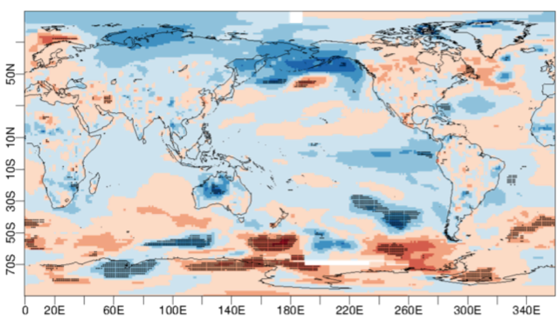
Anomaly correlation skill (T°)



Y 1



Y 1-3

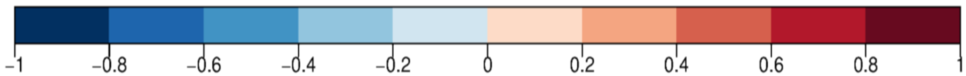


Y 3-5

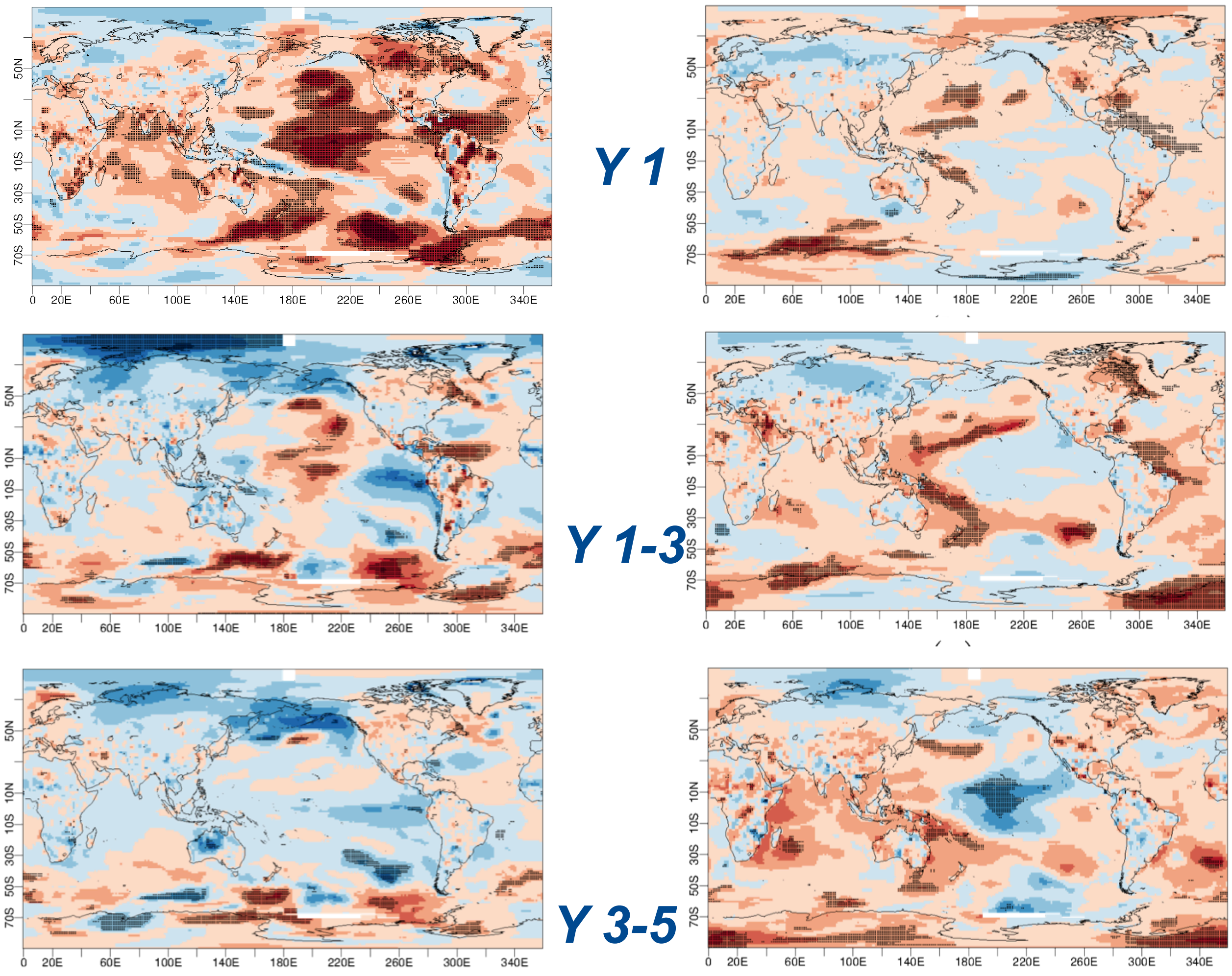
Initialisation

Internal variability and external forcings

Ménégoz et al., in prep



Anomaly correlation skill (T°)



Initialisation **Volcanic forcing**

Internal variability and external forcings

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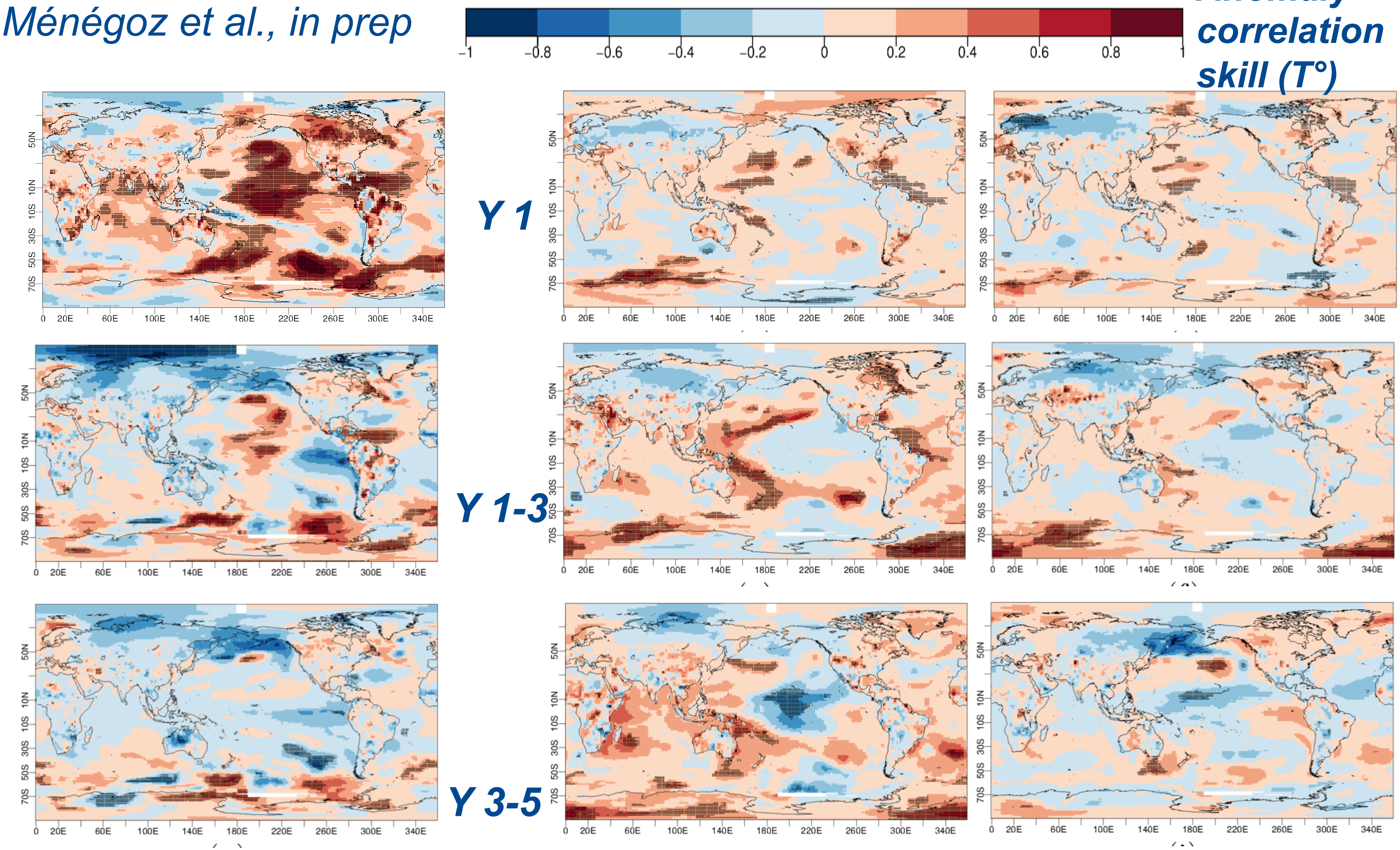
Ménégoz et al., in prep

Anomaly correlation skill (T°)

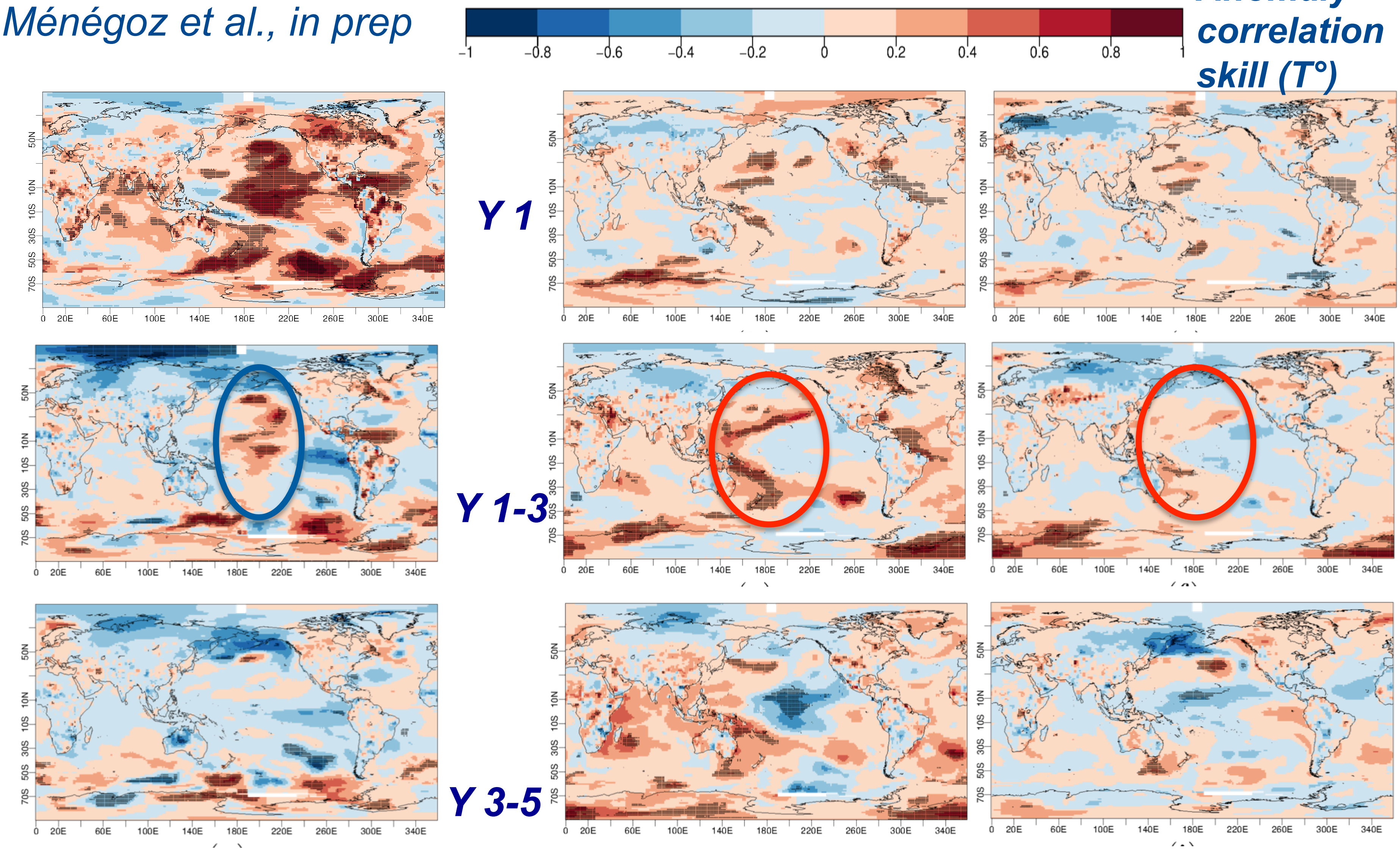


Initialisation ***Volcanic forcing*** ***Idealized forcing***

Internal variability and external forcings

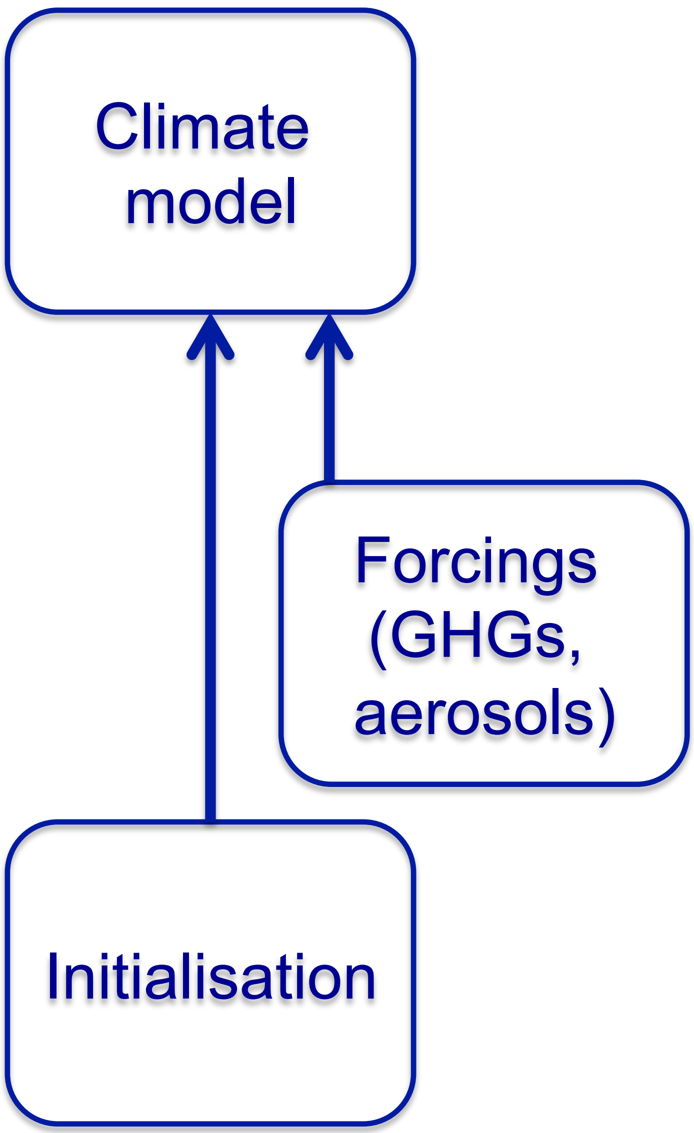
Ménégoz et al., in prep

Anomaly correlation skill (T°)

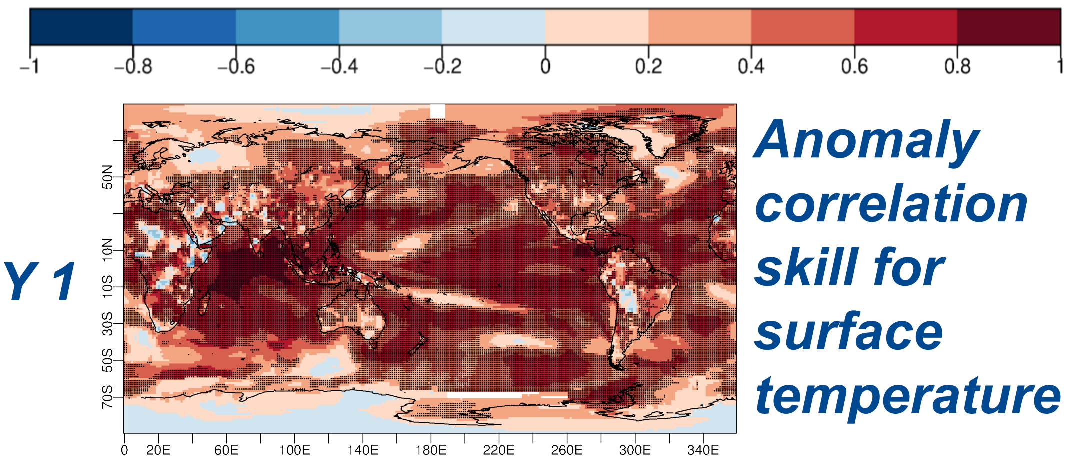


Initialisation **Volcanic forcing** **Idealized forcing**

Internal variability and external forcings



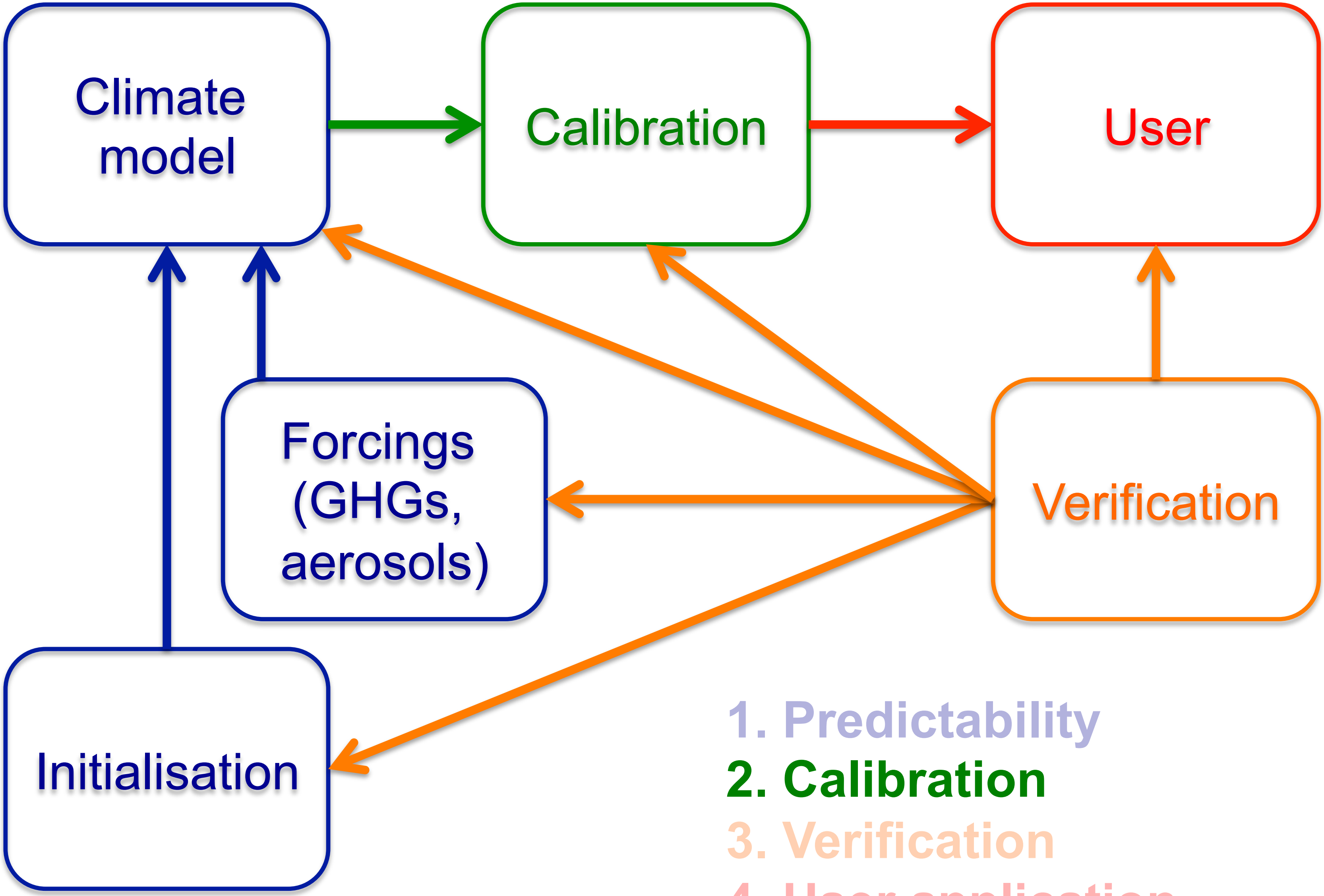
Y 1



Anomaly correlation skill for surface temperature

=> Contributions of initialization and external forcings to the forecast skill depends on the variable, the areas and the forecast time

Ménégoz et al., in prep



1. Predictability
2. **Calibration**
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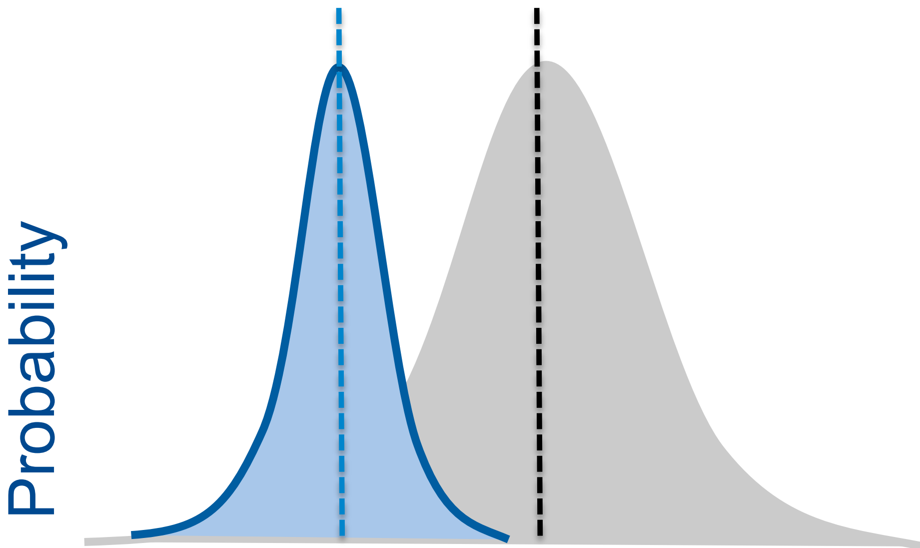
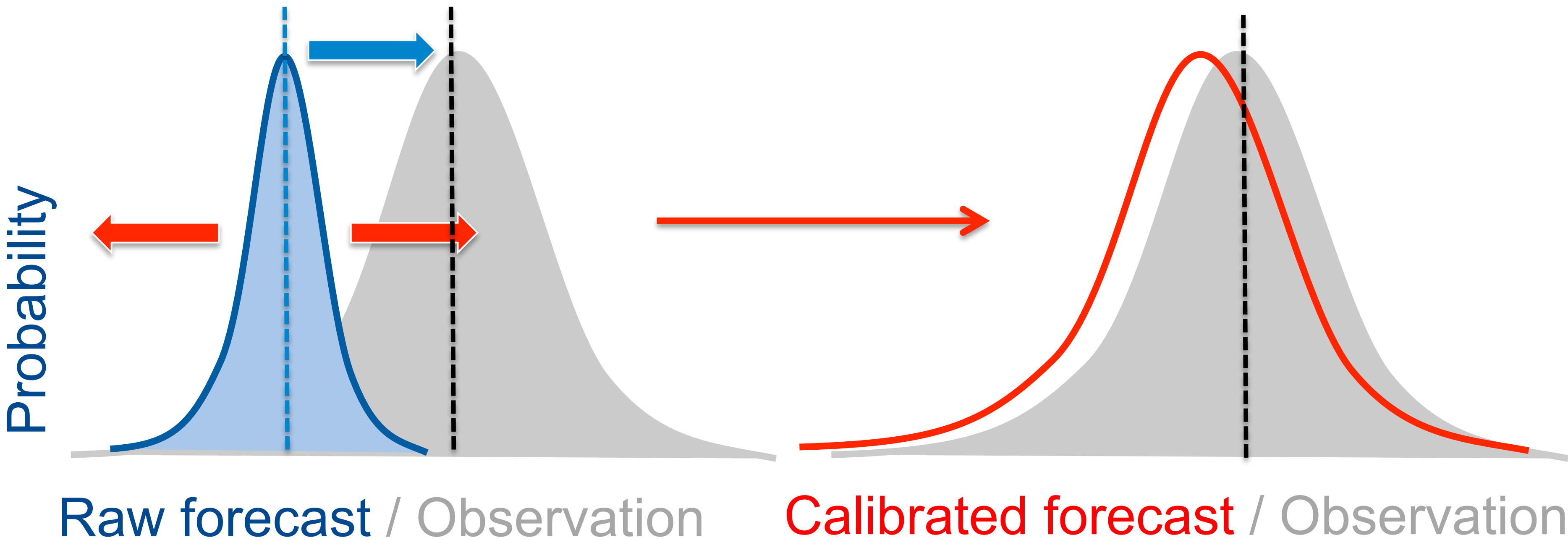
Calibration



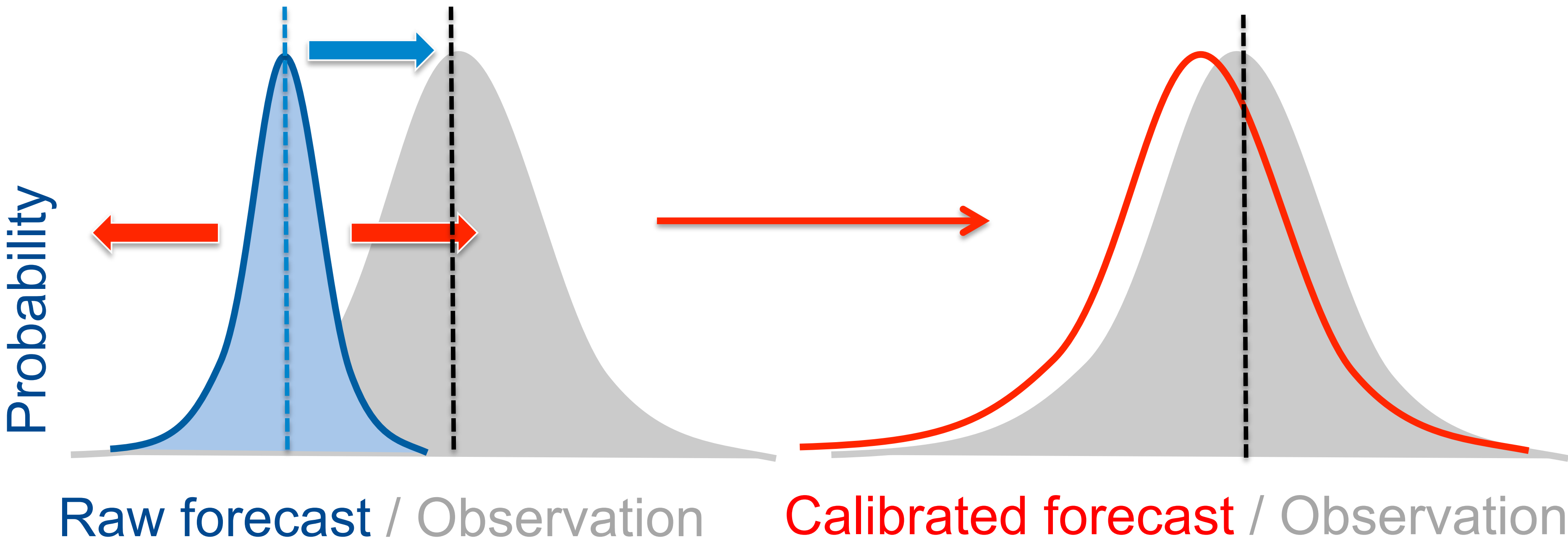
Raw forecast – Observation

Calibration



- Simple bias correction
- Distribution adjustment (inflation)
- Quantile mapping

Calibration

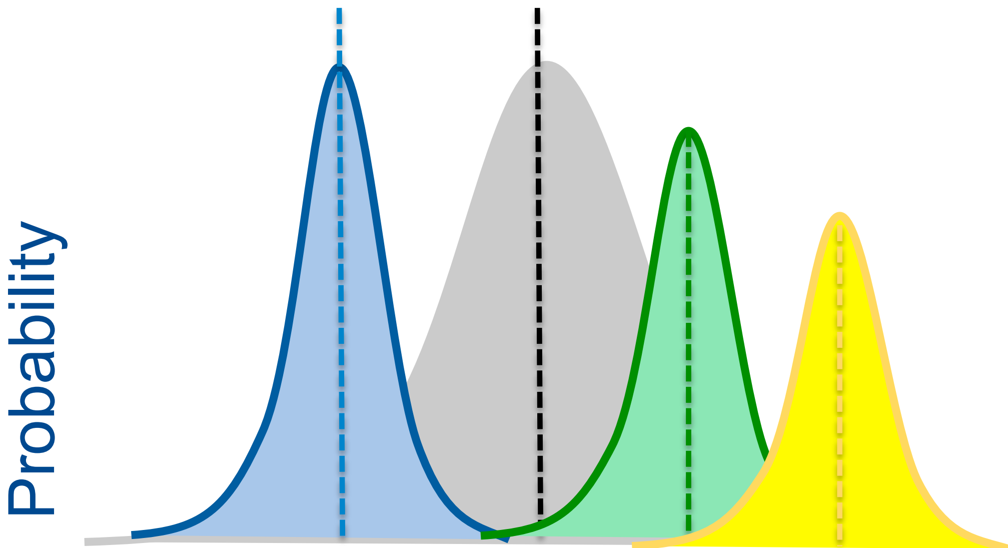


- Simple bias correction
- Distribution adjustment (inflation)
- Quantile mapping

V. Torralba, BSC

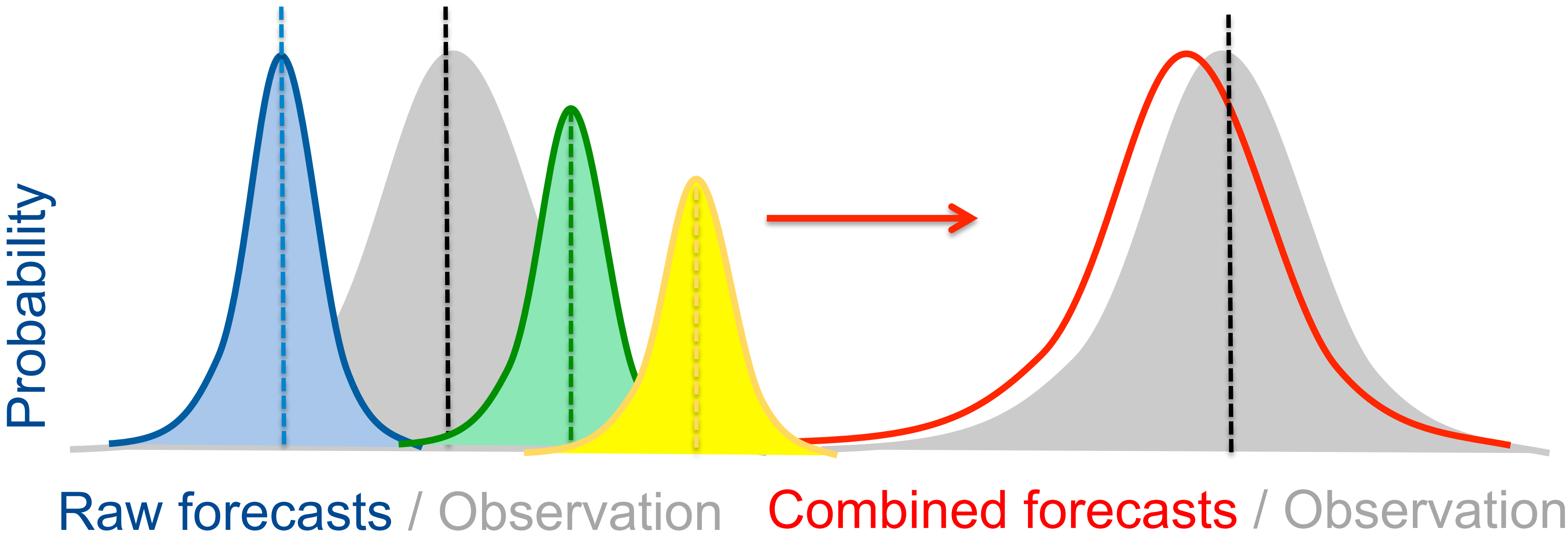
=> The benefits of each method depend on: the variable, the areas and the forecast time

Combination



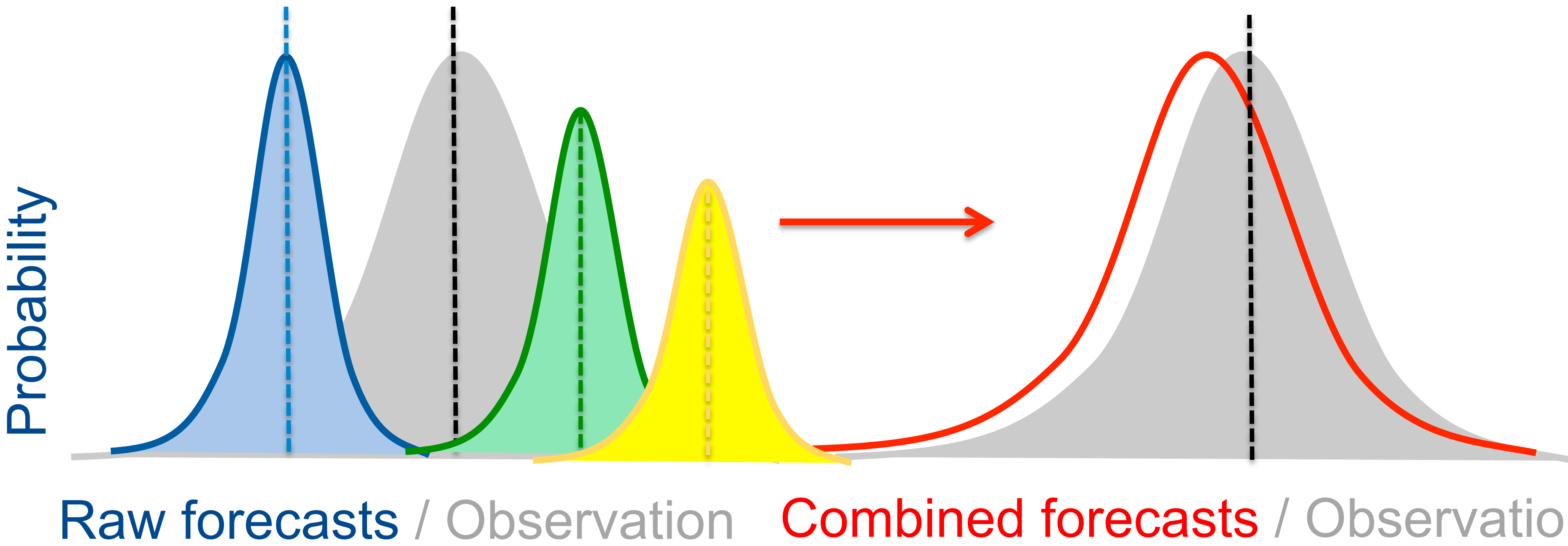
Raw forecasts / Observation

Combination



- Simple Multi-model
- Forecast Assimilation (models weighted according to their skill)

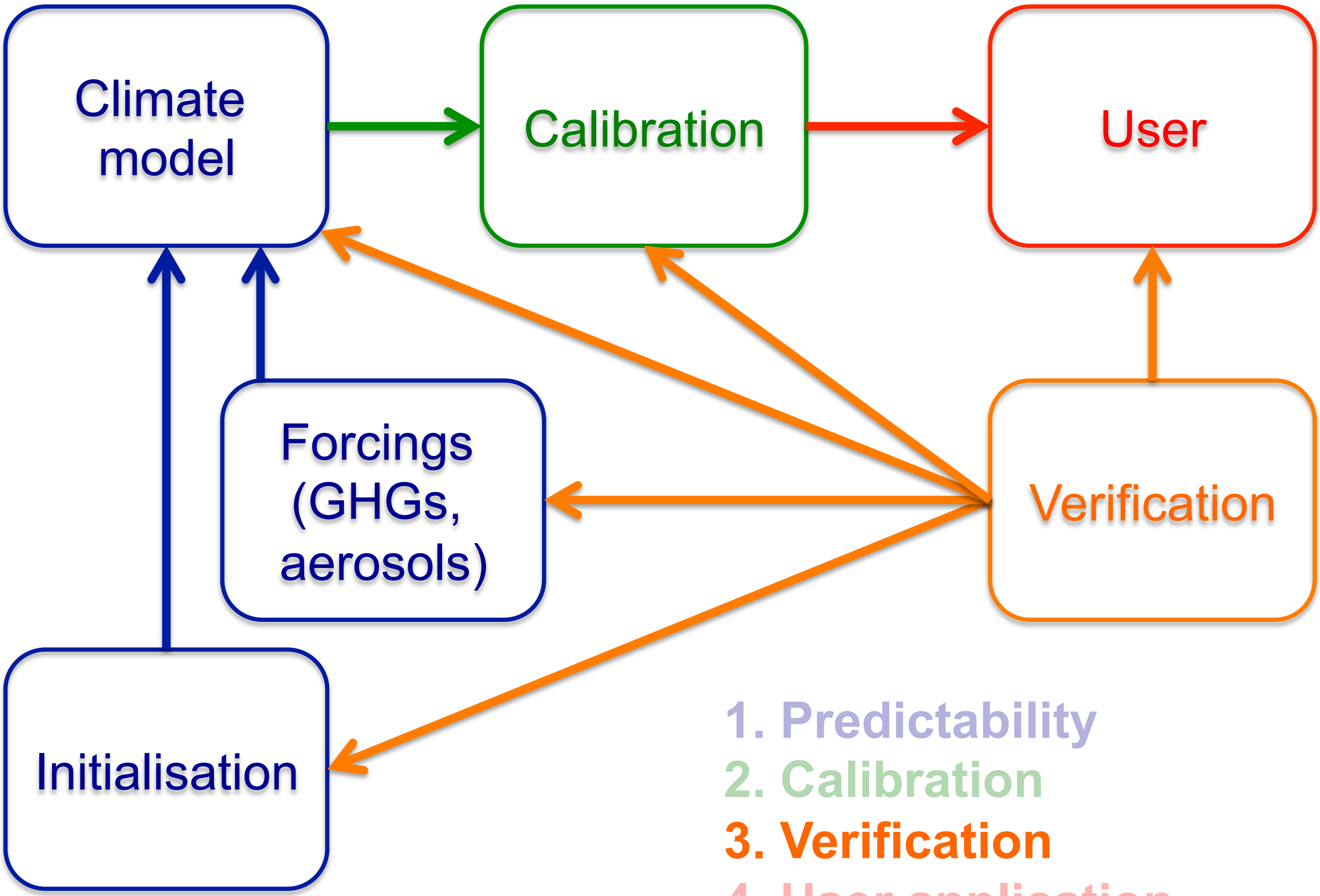
Combination



- Simple Multi-model
- Forecast Assimilation (models weighted according to their skill)

=> The combination of model forecast is often the best forecast, but not systematically. The benefits of each method depend on: the variable, the areas and the forecast time

PhD L. Rodrigues, IC3



1. Predictability
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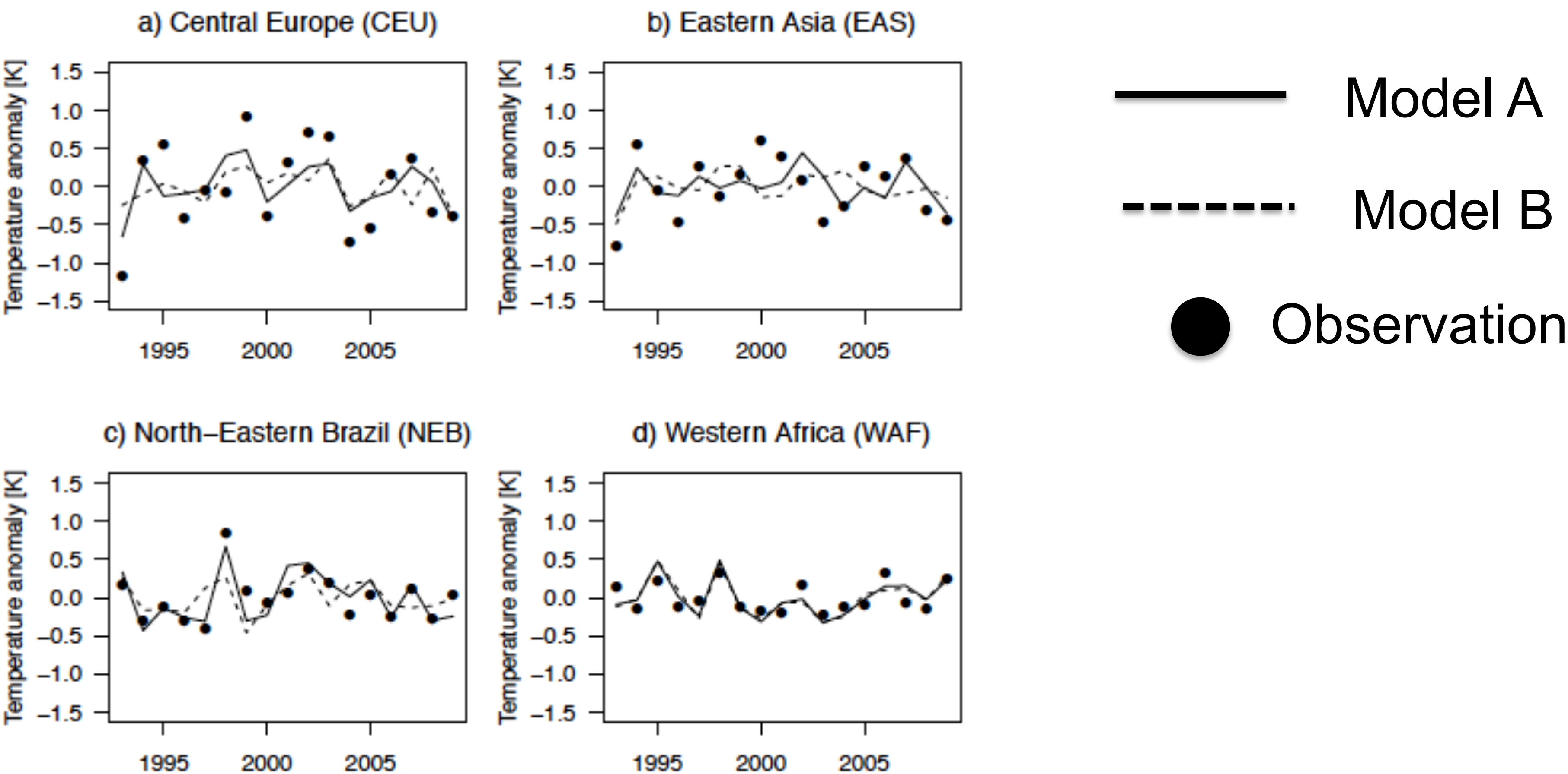
Verification



Surface temperature in different regions

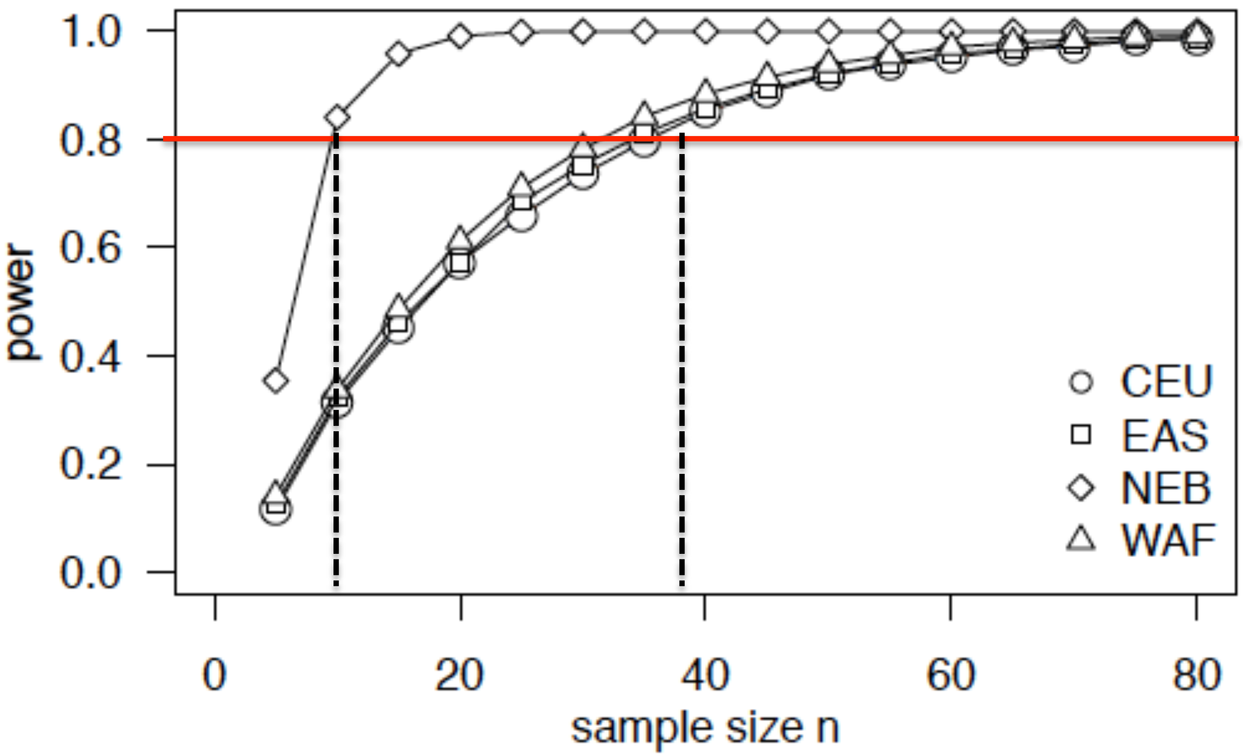
Is model B better than model A?

Verification

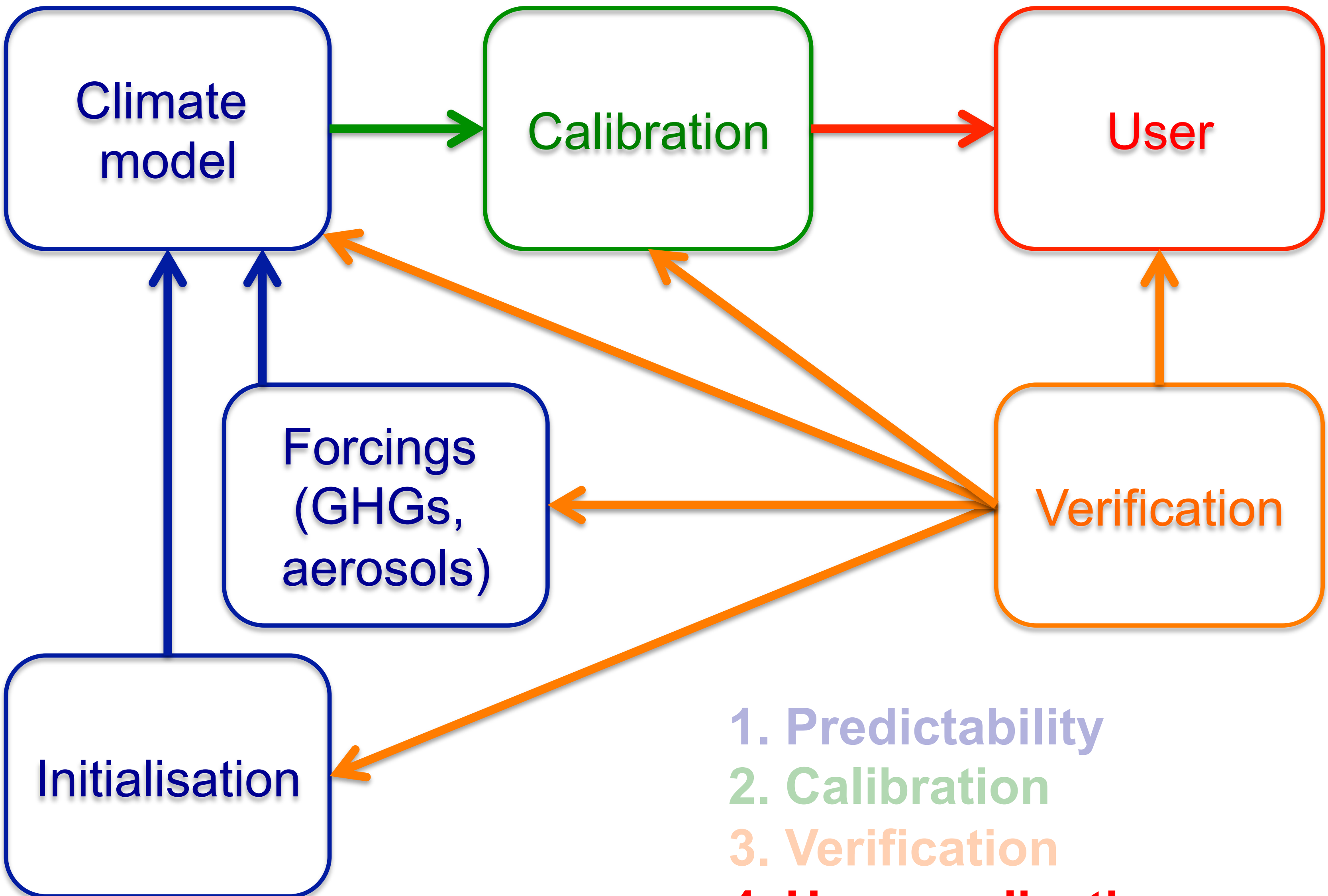
- Skill scores
- Tests consistent with the samples properties

Verification

- Skill scores
- Tests consistent with the samples properties
- Power of the test > 80%



Siegert et al., 2016



1. Predictability
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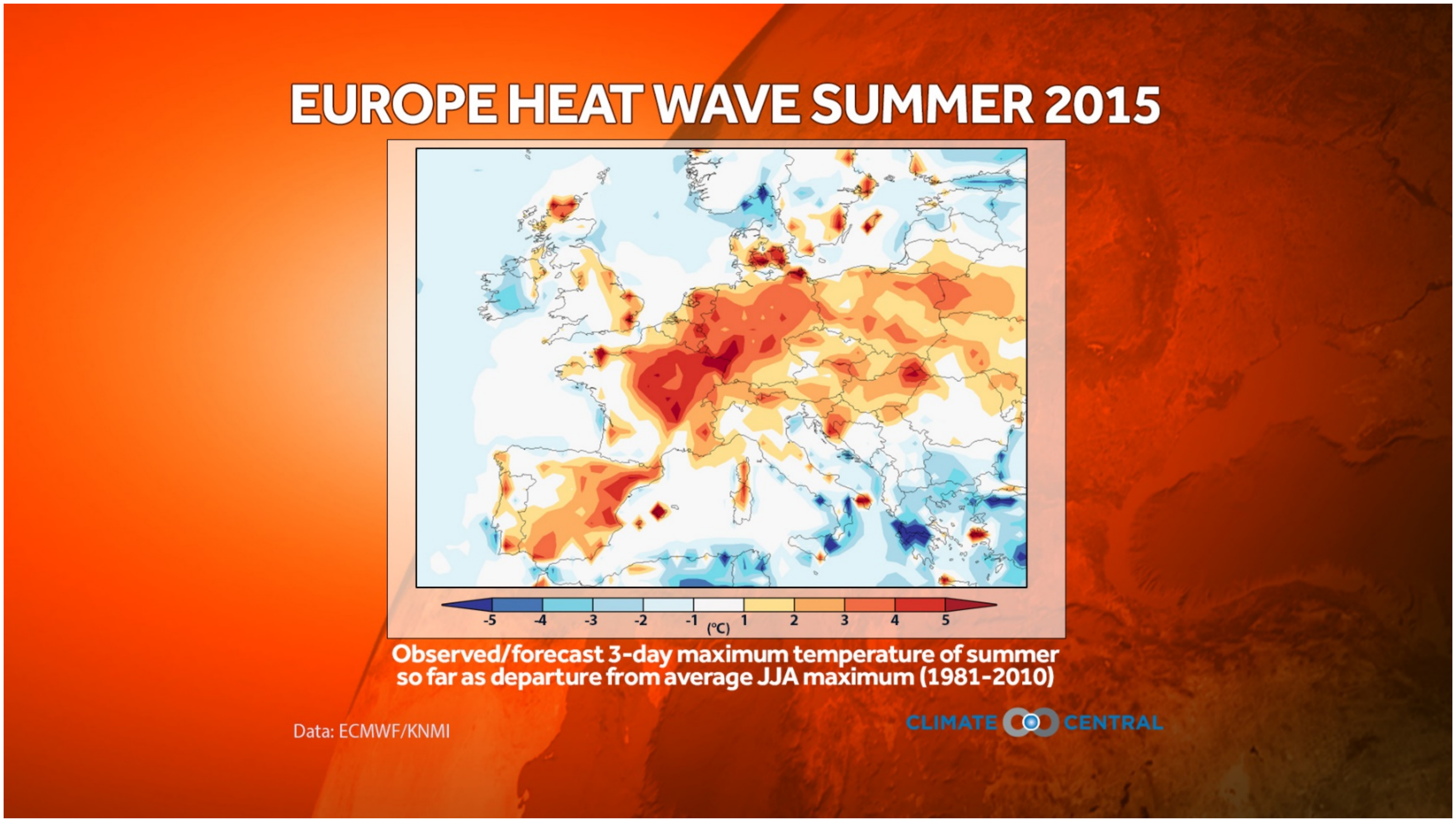
Last years European heat wave has become twice as likely.



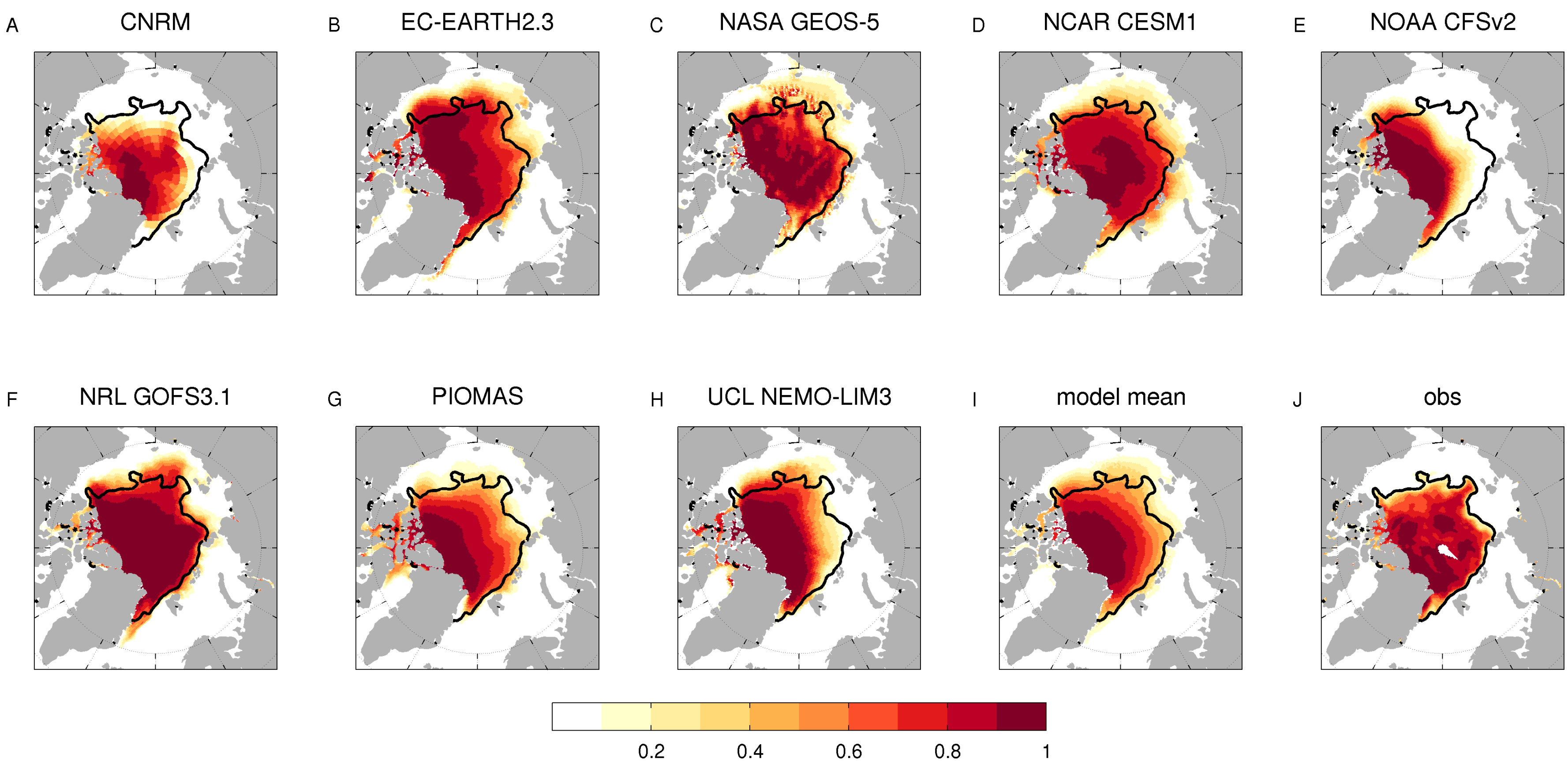
CLIMATE CENTRAL

RED CROSS/RED CRESCENT CLIMATE CENTRE

International Federation of Red Cross and Red Crescent Societies

The Netherlands Red Cross

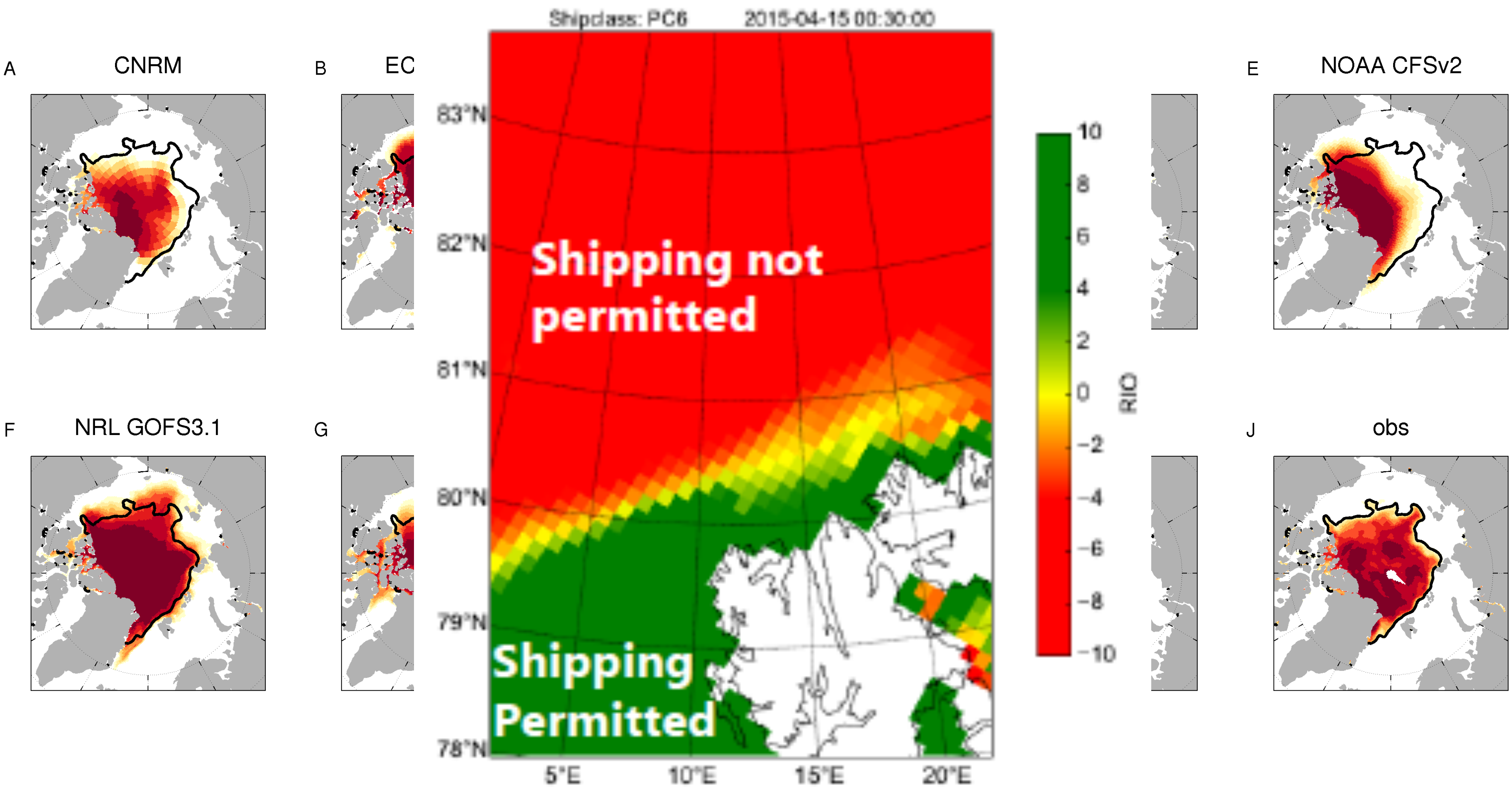
Making usable products



September 2015 sea-ice forecast, from 8 models initialized in May

Courtesy of E. Blanchard and A.Gierisch

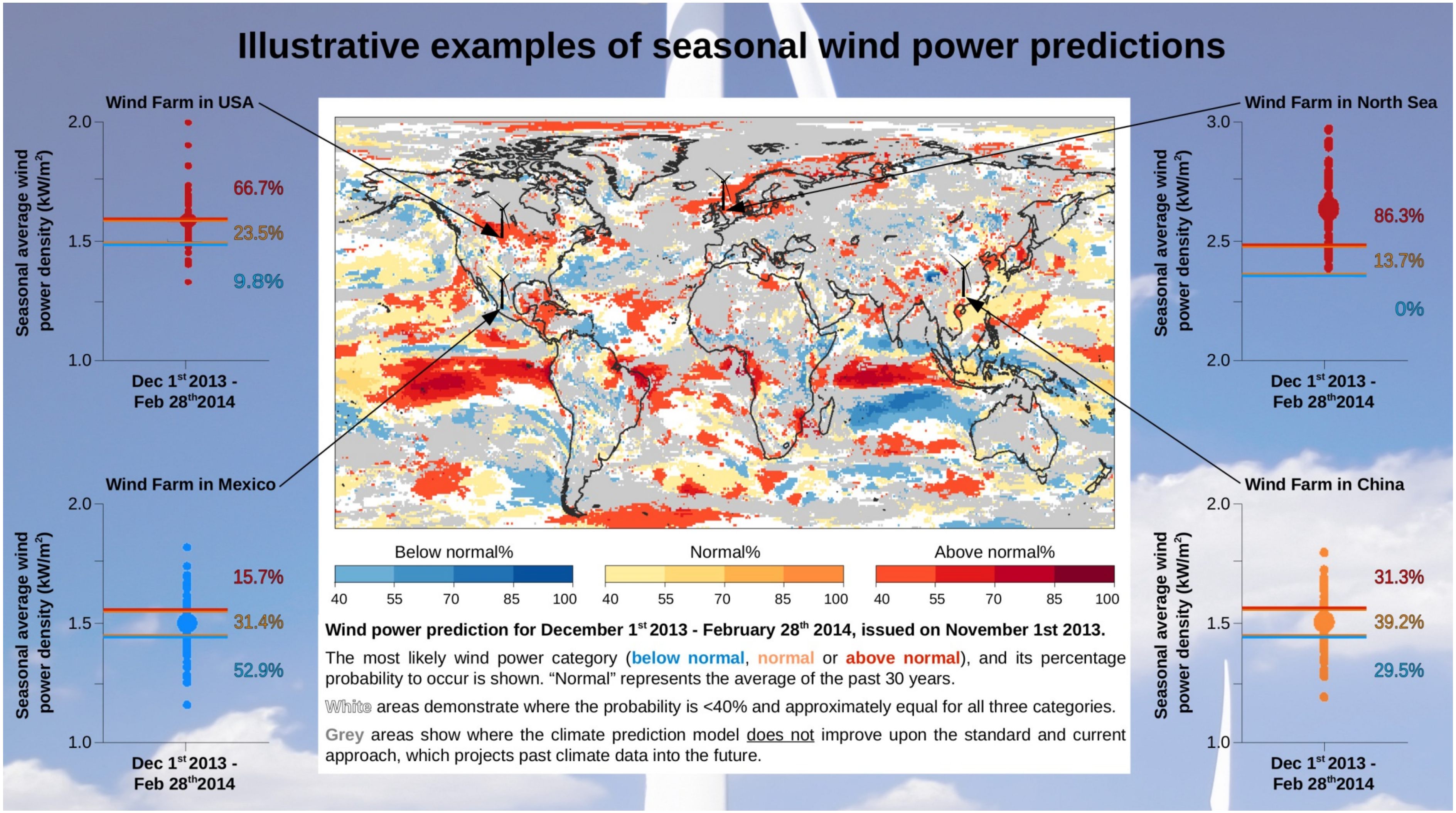
Making usable products



September 2015 sea-ice forecast, from 8 models initialized in May

Courtesy of E. Blanchard and A.Gierisch

Climate data for wind energy



Climate services group, BSC

Take home messages

✓ **User applications**

→ Energy sector, health, agriculture, insurance, water resources, transport, tourism...

Take home messages

✓ User applications

→ Energy sector, health, agriculture, insurance, water resources, transport, tourism...

✓ Looking for predictability sources

→ Model physics
→ Need for improved initialization strategies
→ Estimates of external forcings for real-time forecasts

Take home messages

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✓ **User applications**

→ Energy sector, health, agriculture, insurance, water resources, transport, tourism...

✓ **Looking for predictability sources**

→ Model physics
→ Need for improved initialization strategies
→ Estimates of external forcings for real-time forecasts

✓ **Calibration adapted to applications (variable, region, forecast time)**

Take home messages

✓ **User applications**

→ Energy sector, health, agriculture, insurance, water resources, transport, tourism...

✓ **Looking for predictability sources**

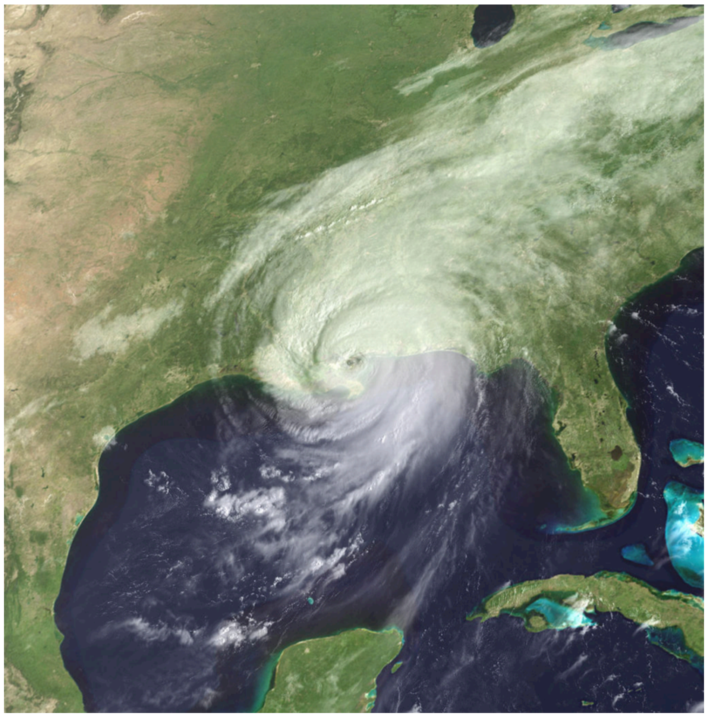
→ Model physics
→ Need for improved initialization strategies
→ Estimates of external forcings for real-time forecasts

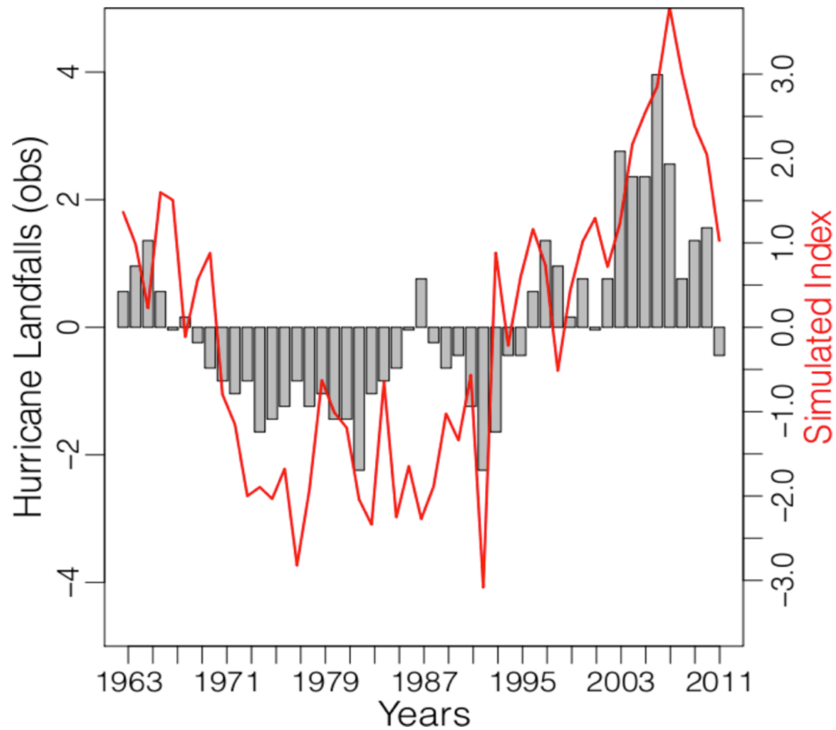
✓ **Calibration adapted to applications (variable, region, forecast time)**

✓ **The power of verification tests need to be above 80%**

Thank you

AMV is a decadal predictor for tropical cyclone activity in the Atlantic. Decadal predictions over forecast years 1-5.



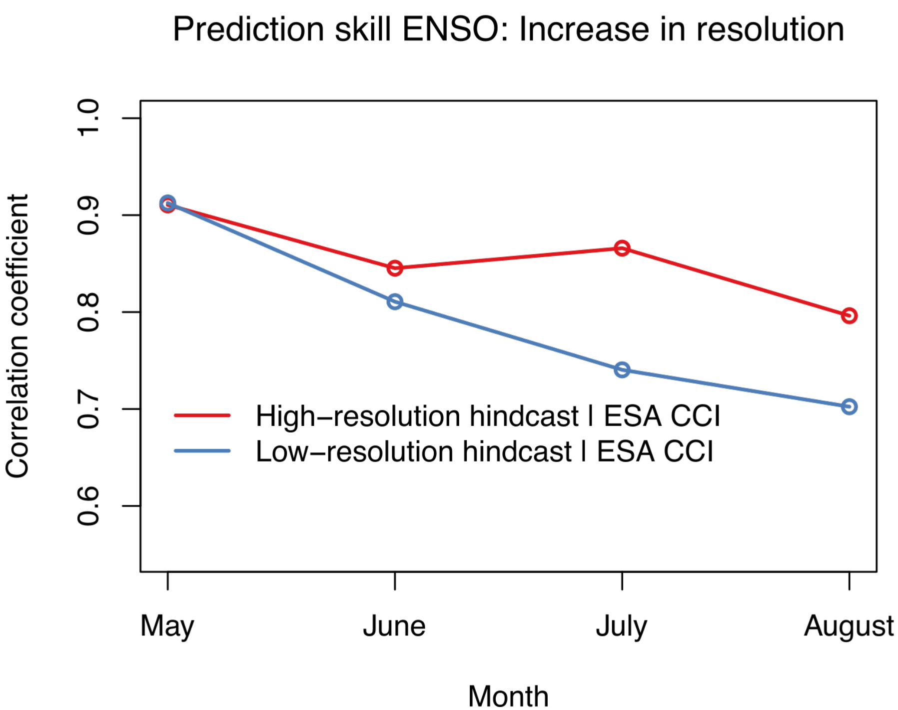


L. Caron (BSC)

High-resolution forecasting

High horizontal resolution improves ENSO predictions.

Observational uncertainty similar magnitude as improvements.



Difference in correlation surprisingly systematic

C. Prodhomme, O. Bellprat (BSC)

Impact of Arctic sea ice initialisation

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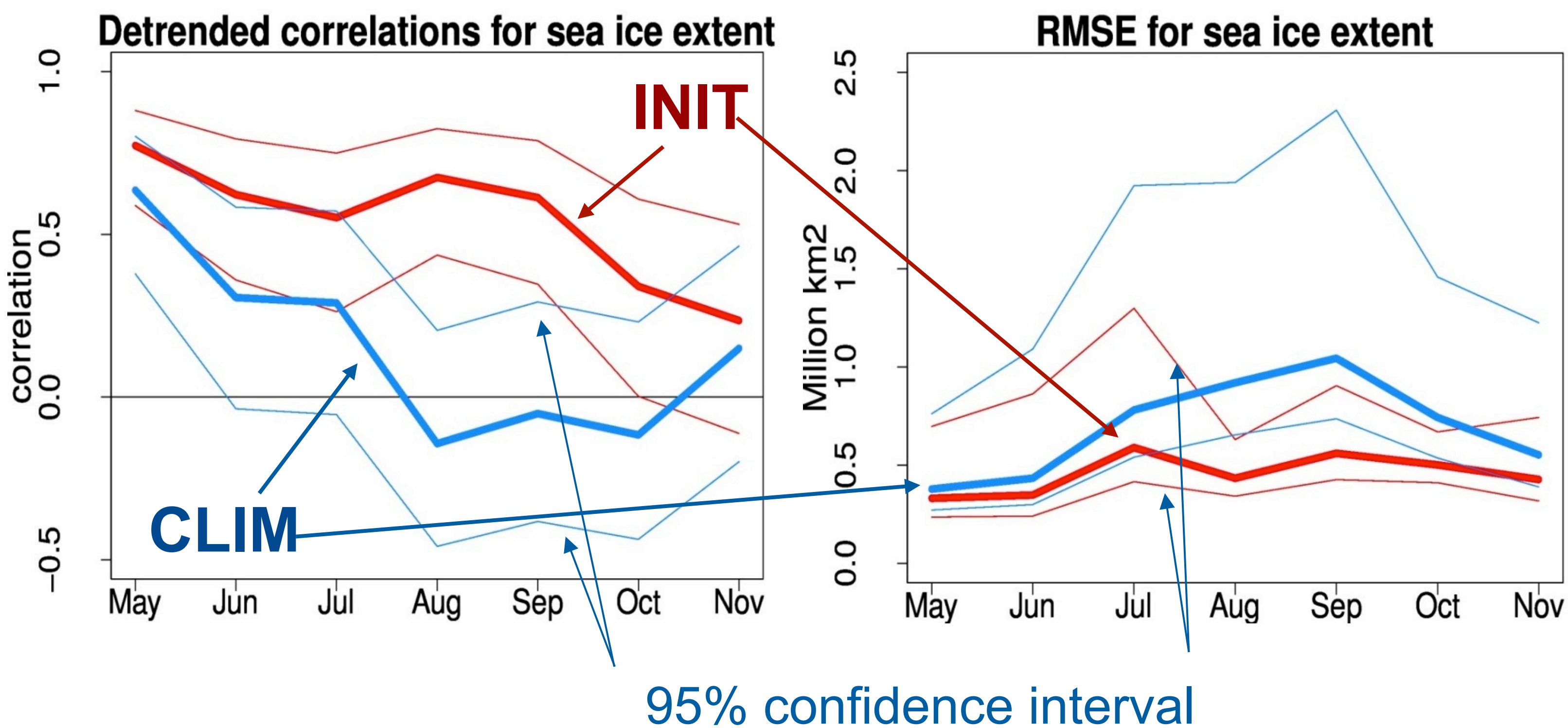
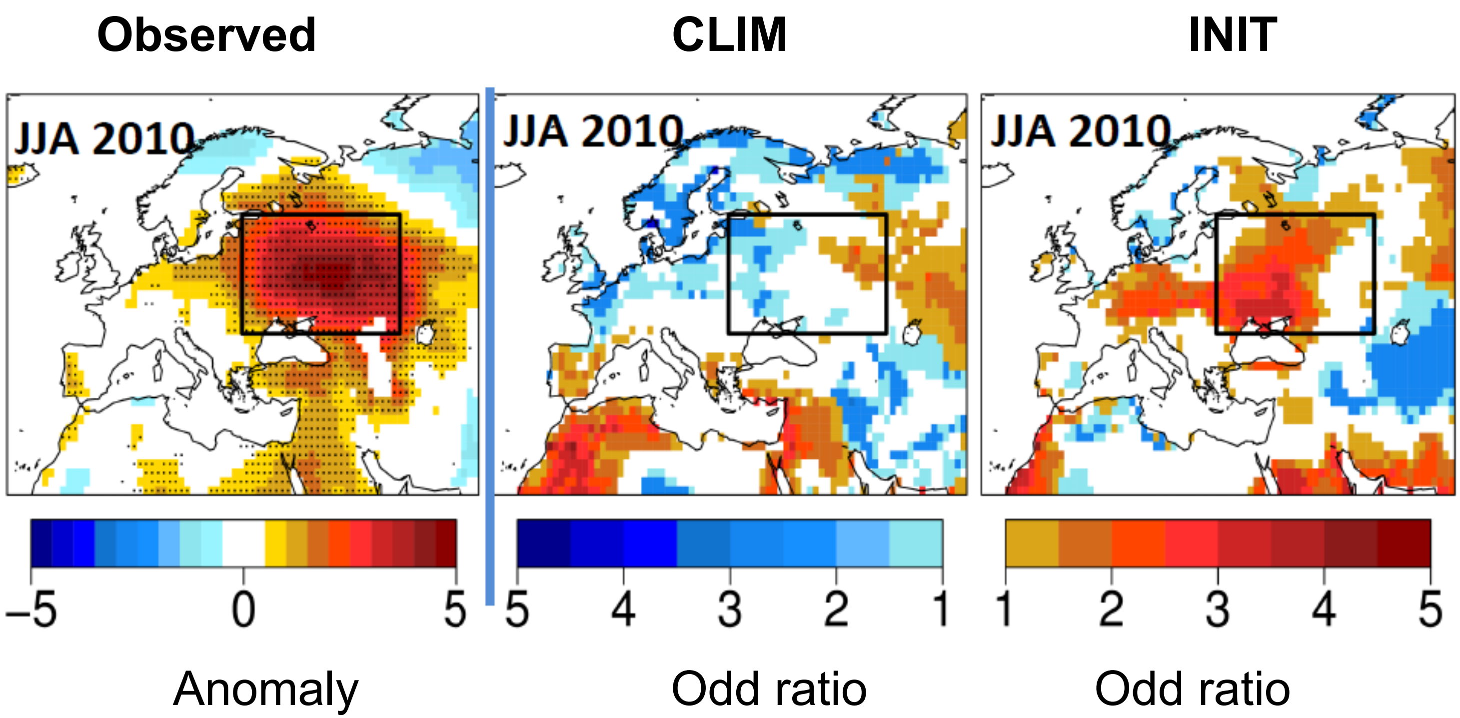
Seasonal climate forecasts initializing sea ice reconstruction (INIT) or a climatology of this reconstruction (CLIM). No impact on the atmosphere prediction skill



Beyond means: Extreme events

Seasonal prediction of Russian heat wave initializing observed land-surface (INIT) conditions and climatological (CLIM) conditions. Land-surface initialisation matters.



European climate services

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Copernicus
Europe's eyes on Earth

Climate Change Service

Copernicus Climate Change Service (C3S)

C3S Vision

How is climate changing?

- Earth observations
- Reanalysis

Will climate change continue/accelerate?

- Predictions
- Projections

What are the societal impacts?

- Climate indicators
- Sectoral information

BSC-ES Ongoing projects:

-QA4Seas: Forecast quality assessment of climate predictions.

-MAGIC: Evaluation of historical climate simulations

-SECTEUR: Climate indicators for the public sector

Extreme event attribution not yet part

Seasonal wind power predictions

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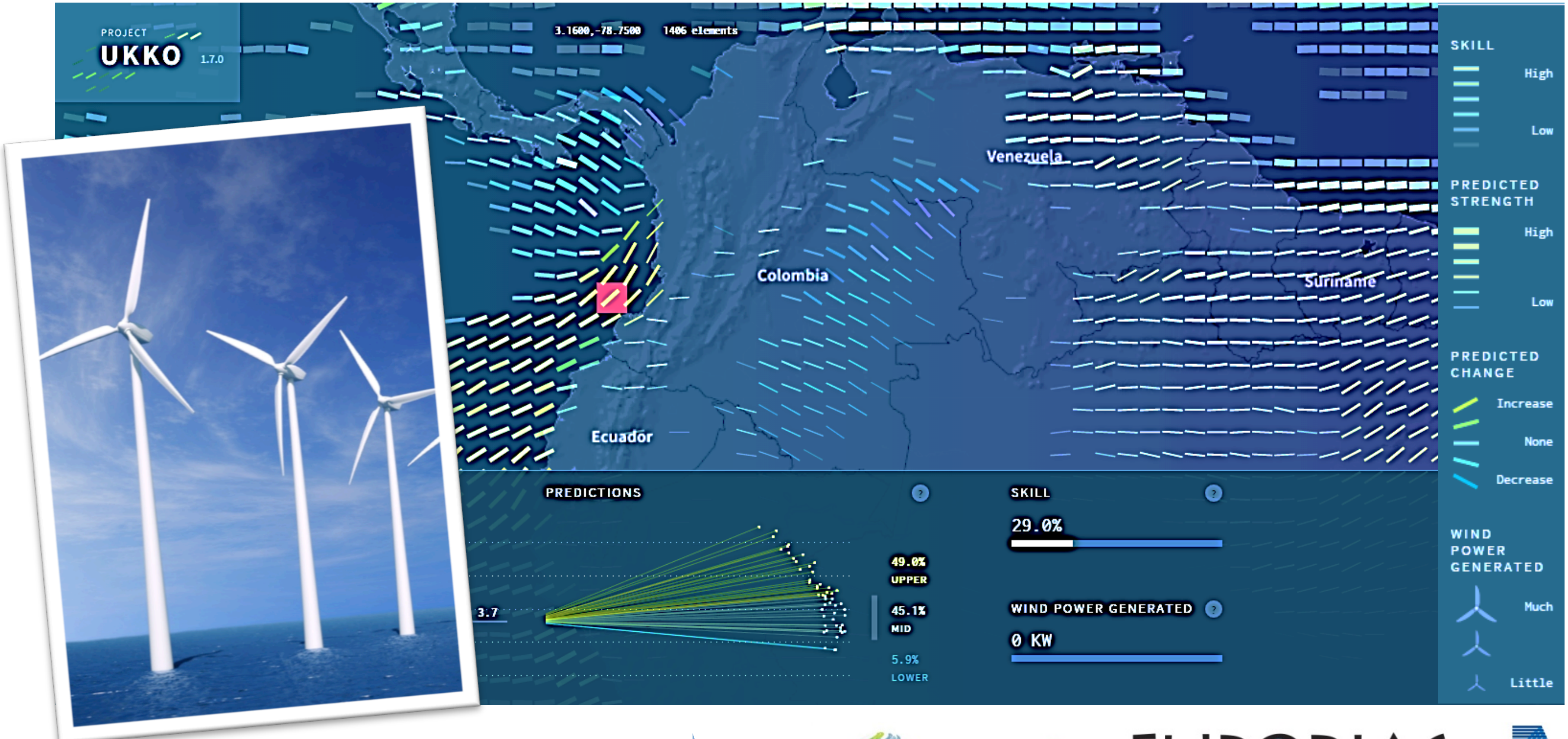

RESILIENCE PROTOTYPE

SPECS
EUPORIAS
SEVENTH FRAMEWORK PROGRAMME
Clim4Energy
NEWA
EDF
edp renewables
ALSTOM
VORTEX
natural power
EnBW

Another service case

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Bodegas Torres (a Spanish winery) is looking for new locations for its vineyards (and it's not the only one doing it).

Land is being purchased closer to the Pyrenees, at higher elevation. They are considering acquiring land in South America too, in areas where wine is currently not produced.

Bodegas Torres requests local climate information (including appropriate uncertainty assessments) for the vegetative cycle of the vine, which lasts 30-40 years.

VIÑAS DEL VERO
SOGRAPE VINHOS
CODORNÍU
RAIMAT
TORRES
1870

Seasonal predictions of hurricanes

First comprehensive service of predictions of tropical cyclone seasonal frequency. www.seasonalhurricanepredictions.org

L-P Caron, BSC

Where we are heading to

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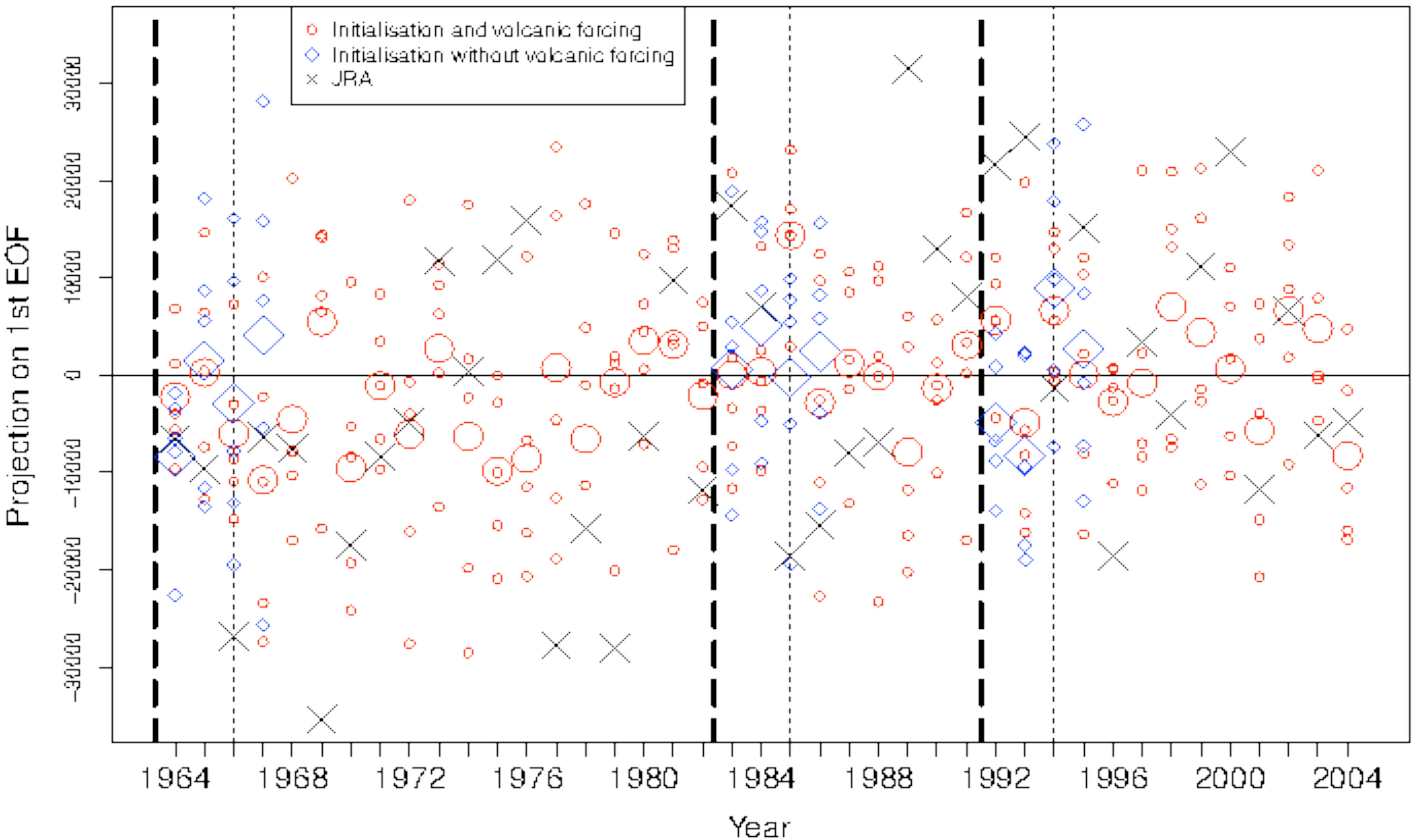
- **Improve our forecast systems** with better land use estimates, data assimilation (better use of the existing observations), high resolution, ensembles, better knowledge of the physical processes, etc.
- Address **services for specific users**: renewable energy, health, transport, agriculture, etc.
- **Visualization and dissemination** of predictions of air quality, weather and climate using international standards; influence those standards.
- Foster **open research** (both data and knowledge).

→ DJF forecasts: NAO+ signal the third winter after eruptions



Winter NAO forecasted three year in advance (1st EOF of SLP) in simulations initialised each year from 1961 to 2001, including (red) and excluding (blue) the volcanic forcing. Bold lines indicate the timing of the eruptions, light lines the third winter following the eruptions. Black crosses show the JRA NAO index.

Calibration

Method	Equation	Description
Simple bias correction	$y_{j,i} = (x_{ij} - \bar{x})\frac{\sigma_{ref}}{\sigma e} - \bar{o}$	Based on the assumption that both the reference and forecasted distribution are well approximated by a Gaussian distribution.
Calibration method	$y_{j,i} = \alpha x_i + \beta z_{ij}$	Variance inflation modifies the predictions to have the same interannual variance as the reference dataset and corrects the ensemble spread to improve the reliability.
Quantile mapping	$y_{j,i} = (ecdf^{ref})^{-1} ecdf^{mod}(x_{ij})$	It determines for each forecast to which quantile of the forecast climatology it corresponds, and then they are mapped to the corresponding quantile of the observational climatology.

Combination

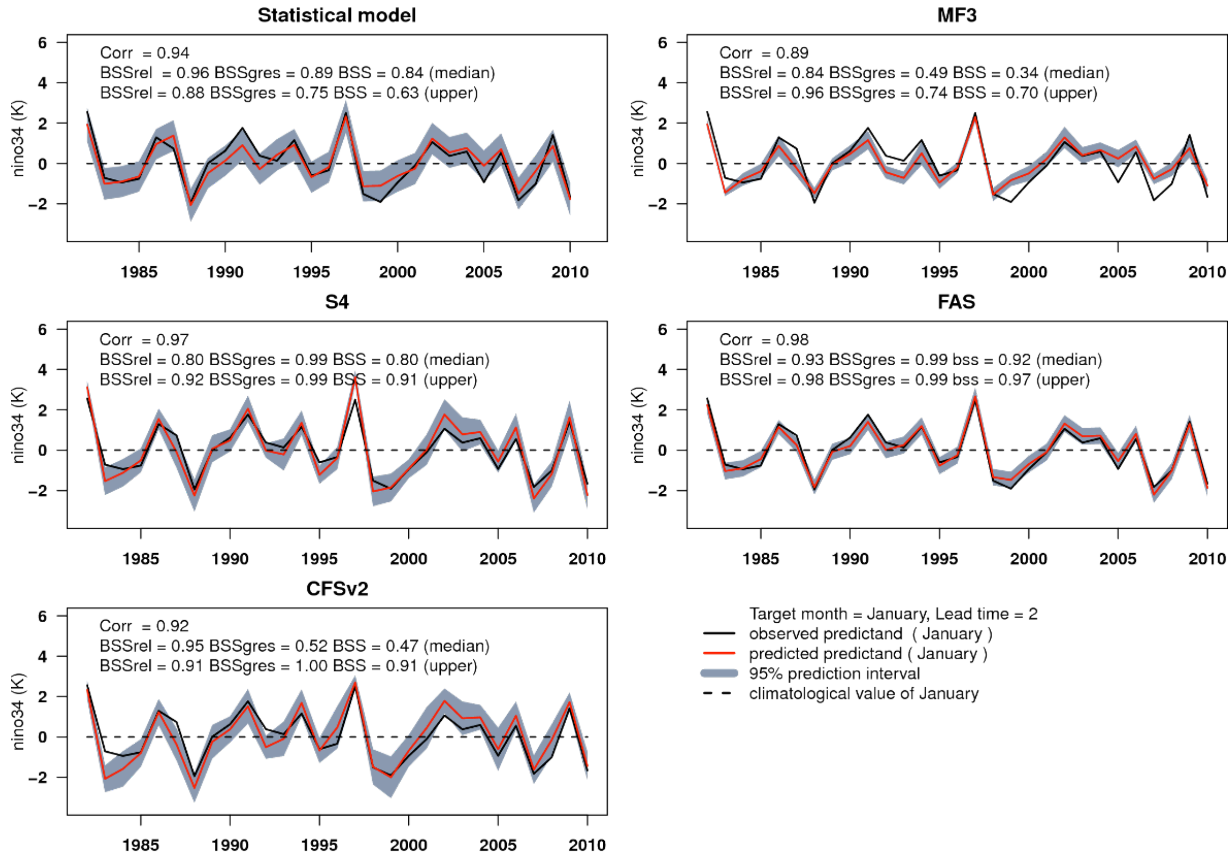


Figure 1XX: Monthly forecast anomalies of Niño3.4 index for the statistical model, S4, CFSv2, MF3 and FAS. Forecasts are for the target month of January with lead time two. Observed values (black solid line), predicted values (red solid line), 95% predicted interval (grey area) and the climatology value of January (black dashed line). Several scores are displayed in each panel: the correlation coefficient, and the Brier skill score and its reliability and resolution components for dichotomous events of SST anomalies exceeding the median and the upper quartile.

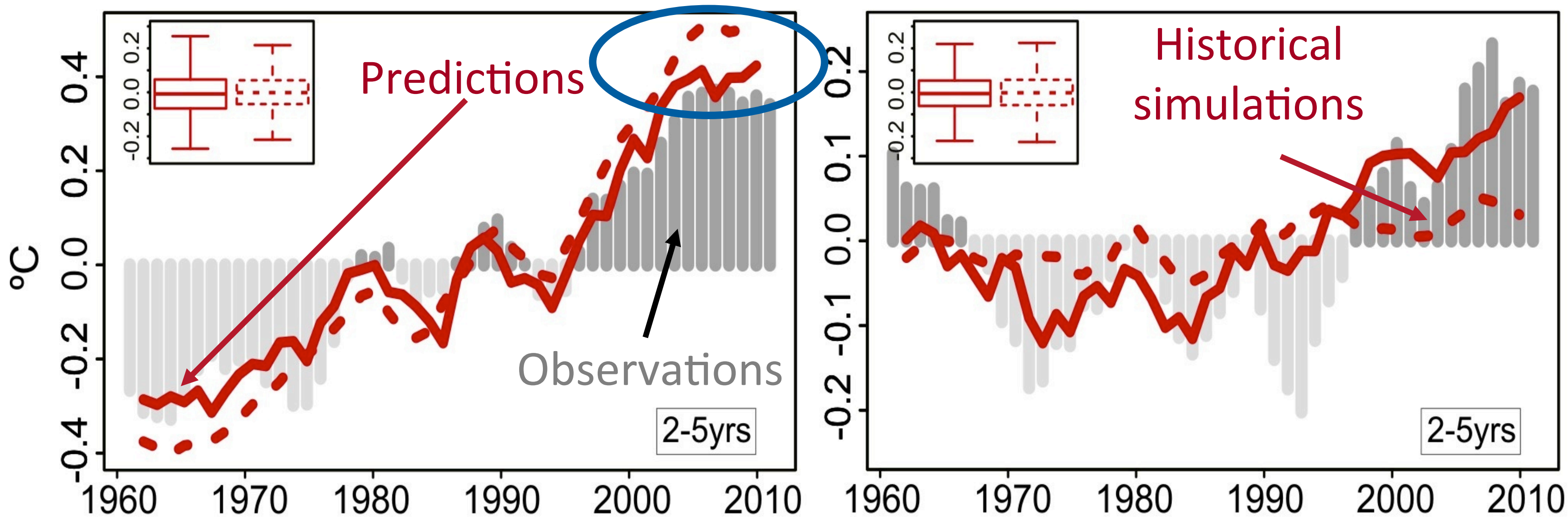
Decadal climate predictions

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Global-mean near-surface air temperature and AMV for forecast years 2-5

Global mean surface air temperature (GMST)

Atlantic multidecadal variability (AMV)



Initialised simulations reproduce the global temperature and some of the AMV tendencies and suggest that initialization corrects the forced model response and phases in internal variability.

Doblas-Reyes et al. 2013 (Nature Comm.)

Climate response to volcanoes

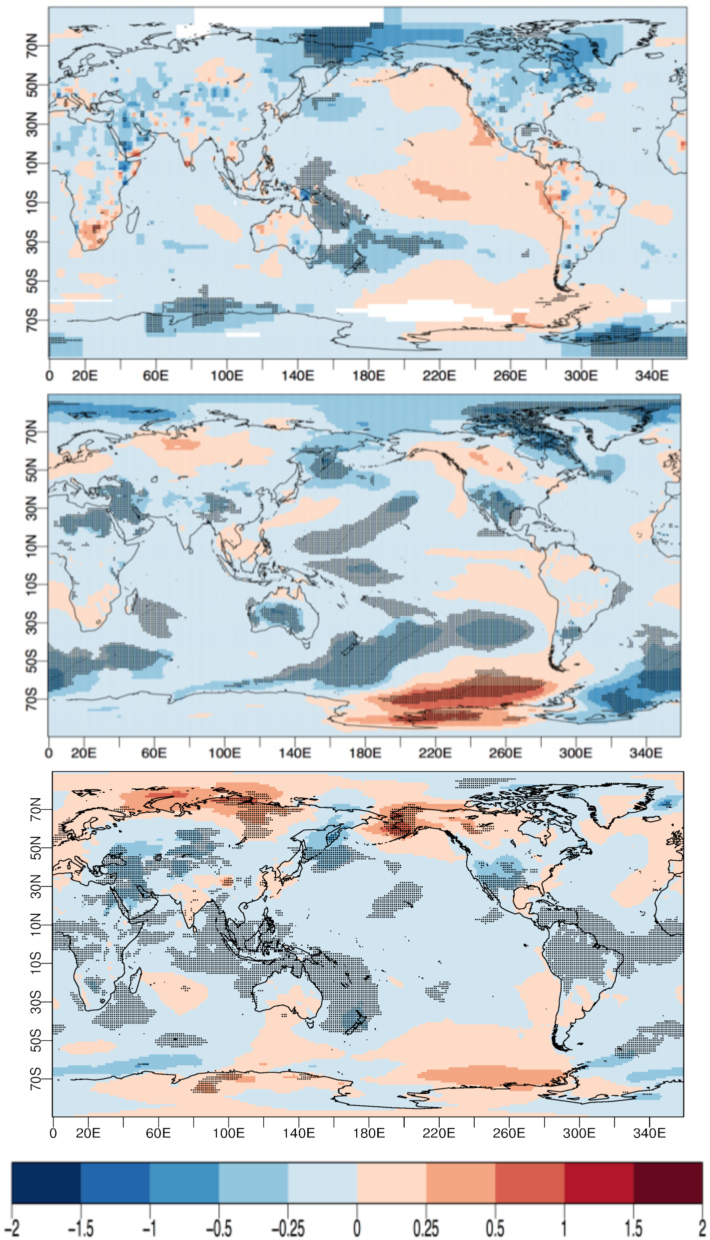
Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Surface temperature anomaly averaged over forecast years 1-3 averaged over forecasts initialized right before the Pinatubo, Agung and Chichon volcanic eruptions

Observation

Hindcast using observed volcanic forcing

Forecast using idealized volcanic forcing



M. Ménégoz (BSC)