Madrid, 25 Abril 2019

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Servicios climáticos para la agricultura, de la modelización del clima al usuario

F.J. Doblas-Reyes
Barcelona Supercomputing Center

ICREA

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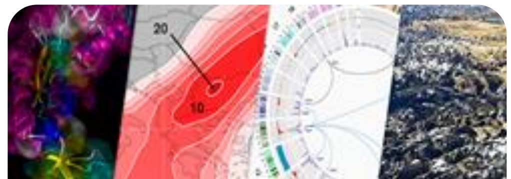
BSC-CNS objectives

Supercomputing services to Spanish and EU researchers



R&D in Computer, Life, Earth and Engineering Sciences

PhD programme, technology transfer, public engagement

BSC-CNS is a consortium that includes

Spanish Government	60%	Gobierno de España, Ministerio de Economía, Industria y Competitividad
Catalan Government	30%	Generalitat de Catalunya, Departament d'Empresa i Coneixement
Univ. Politècnica de Catalunya (UPC)	10%	Universitat Politècnica de Catalunya, BarcelonaTech

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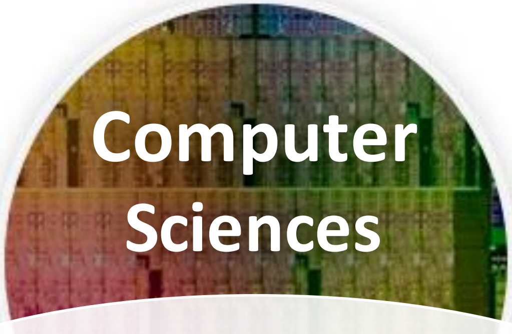
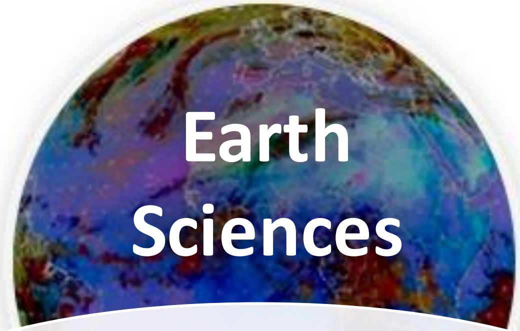
BSC scientific departments



To influence the way machines are built, programmed and used: programming models, performance tools, Big Data, computer architecture, energy efficiency



To develop and implement global and regional state-of-the-art models for short-term air quality forecast and long-term climate applications

To understand living organisms by means of theoretical and computational methods (molecular modeling, genomics, proteomics)

To develop scientific and engineering software to efficiently exploit super-computing capabilities (biomedical, geophysics, atmospheric, energy, social and economic simulations)

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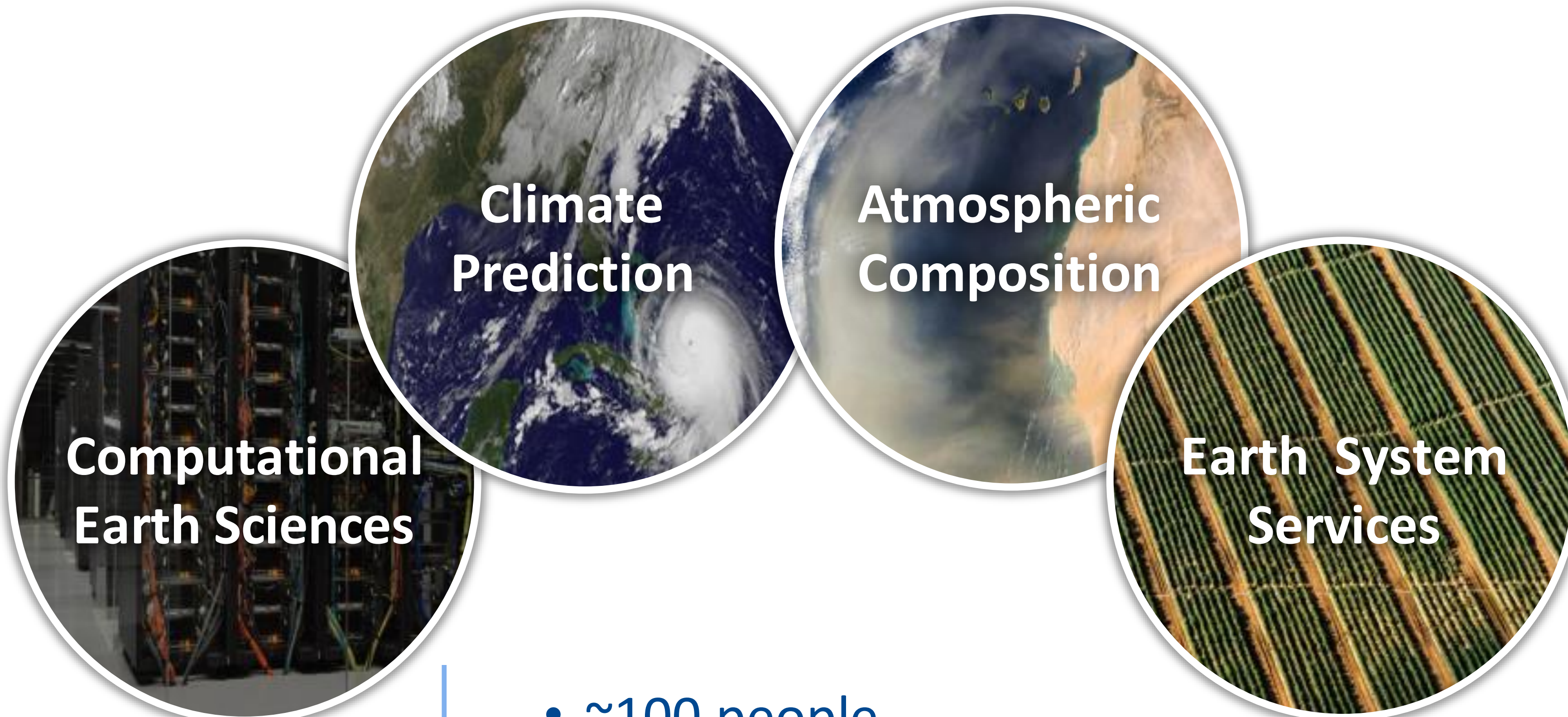
~600 people

Earth Sciences Department

Environmental modelling and forecasting, with a particular focus on weather, climate and air quality



- ~100 people
- Funding from H2020, COPERNICUS, private contracts, ESA, Spanish and regional governments

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From research to services

Research field

- Climate
- Mineral Dust
- Air Quality

Service user sectors

Climate

- Renewable energy
- Agriculture
- Insurance
- Water management
- Forest fires

Mineral Dust

- Solar energy
- Aviation
- Health

Air Quality

- Air quality and mobility planning
- Health
- Heavy industry

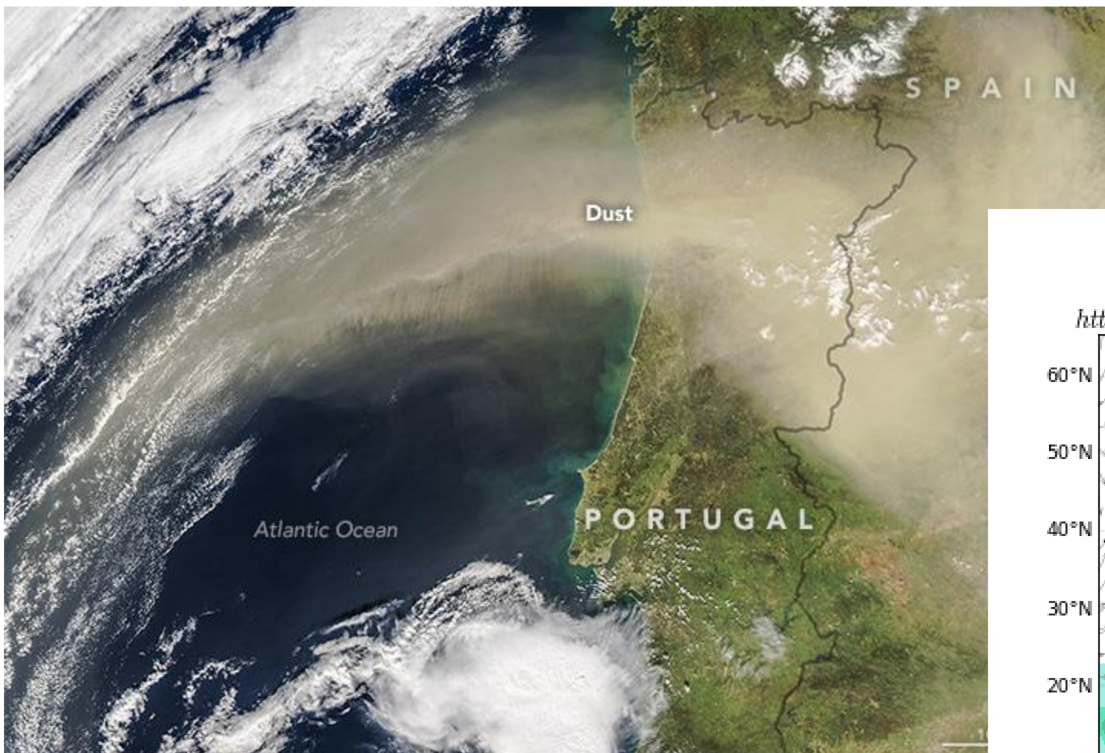
The Earth System Services group facilitates technology transfer of state-of-the-art research from local, national to international levels

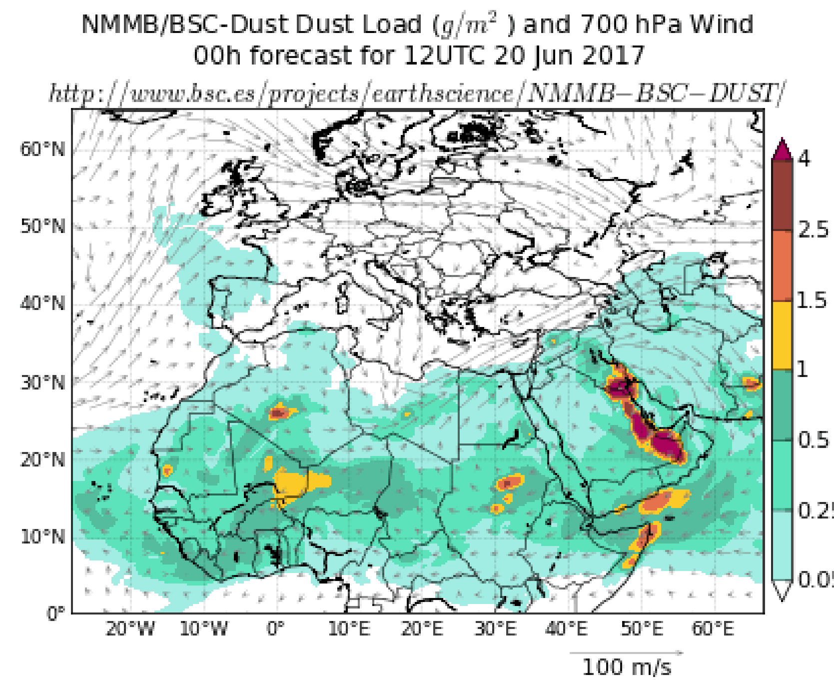
BSC

Air quality

Public resources (using the open data philosophy)

- Air quality forecast system CALIOPE
- Barcelona Dust Forecast Centre





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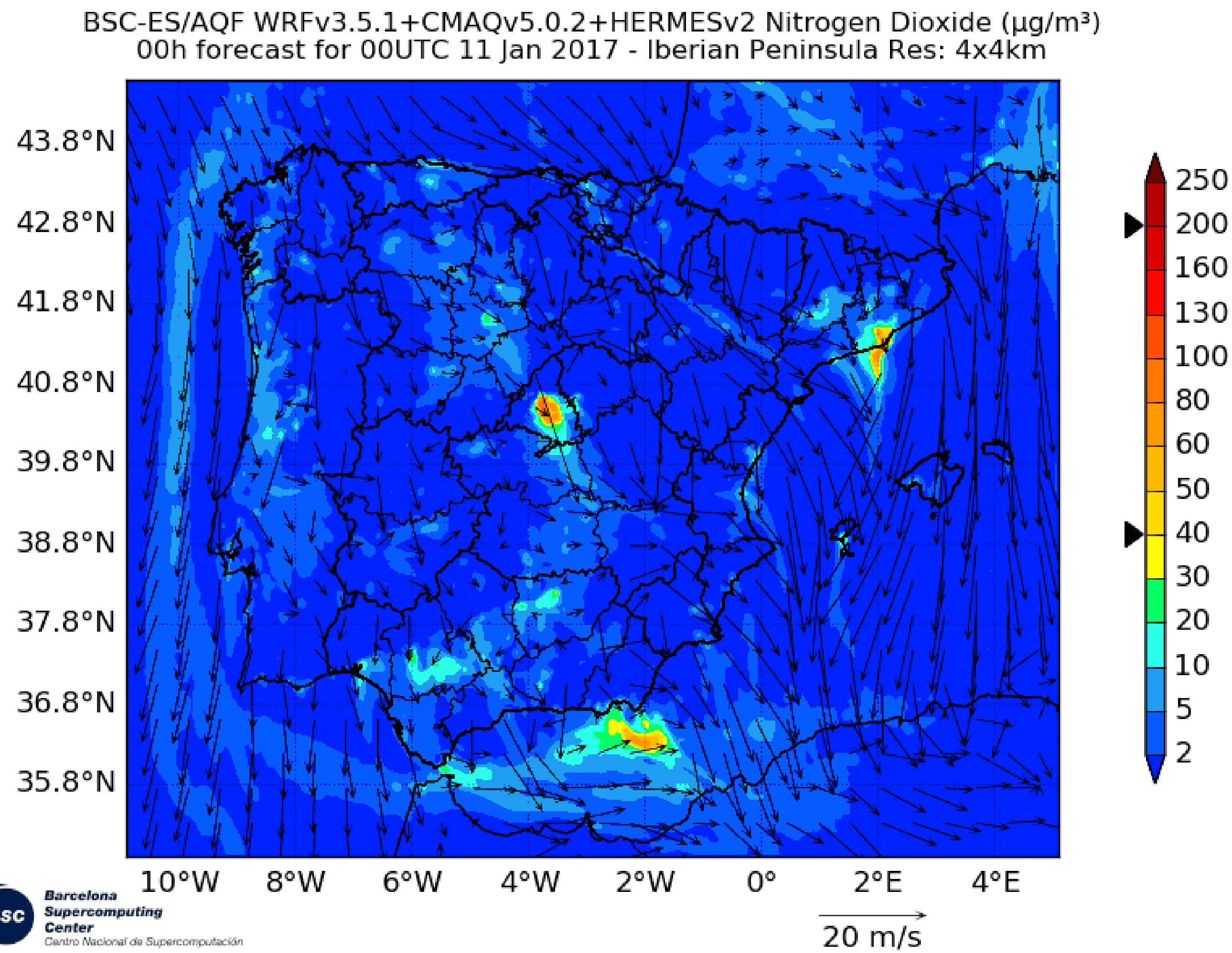
Air quality

Public resources (using the open data philosophy)

- Air quality forecast system CALIOPE
- Barcelona Dust Forecast Centre

www.bsc.es/caliope



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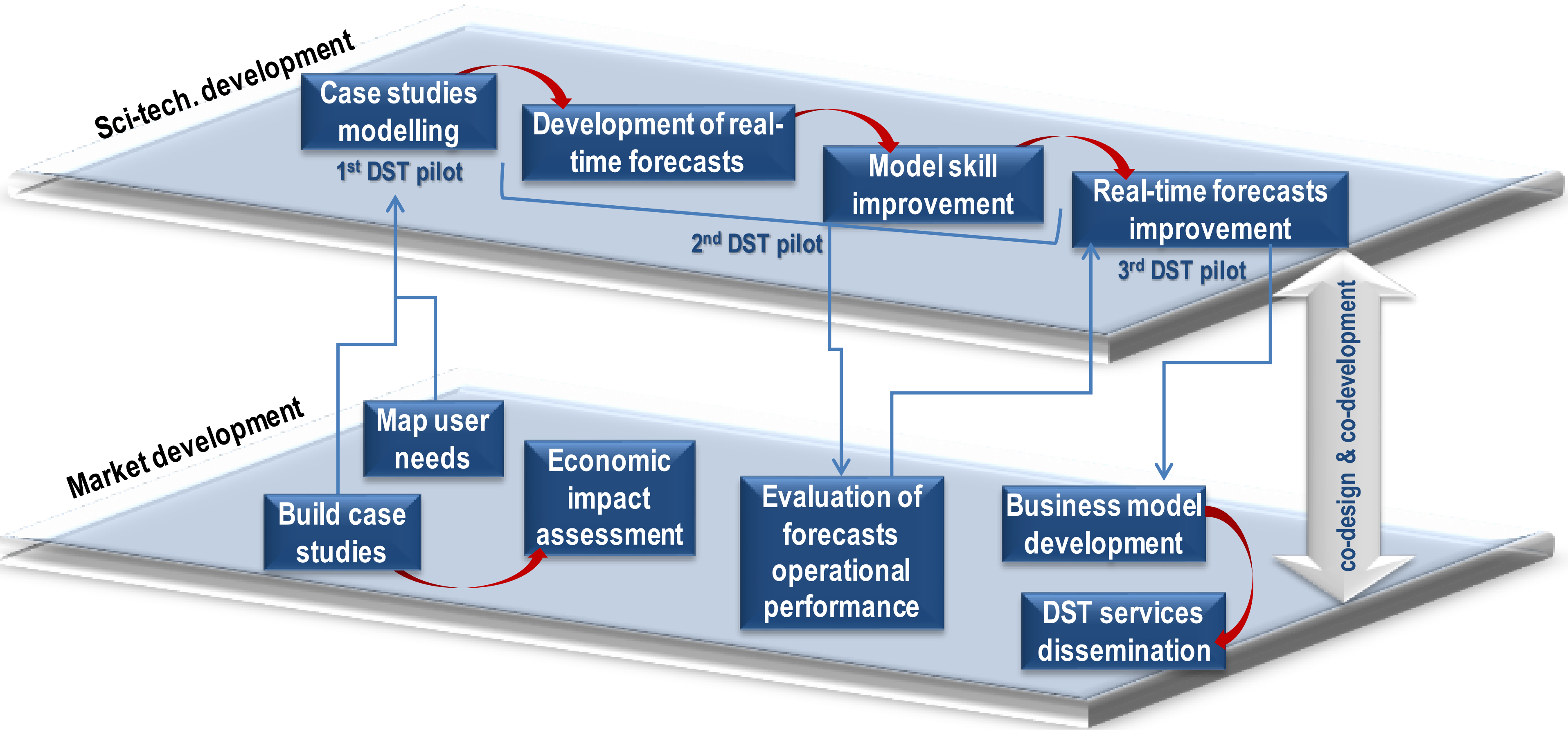
Prototypical climate services



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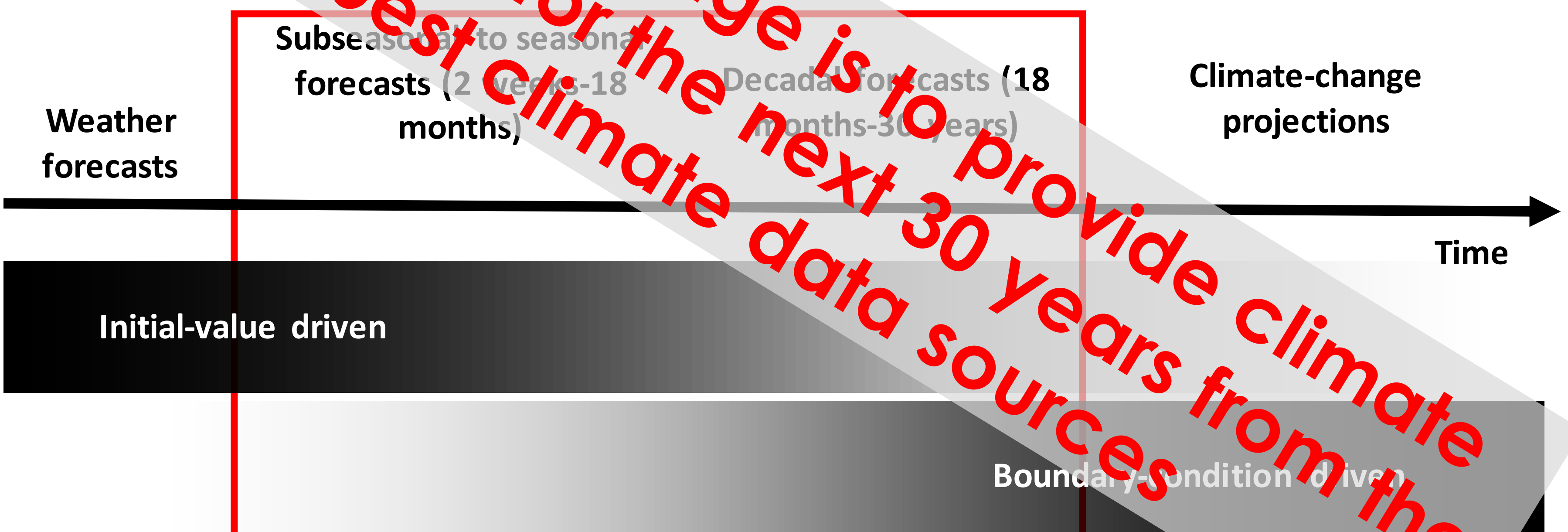
S2S4E
Climate Services for Clean Energy

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.

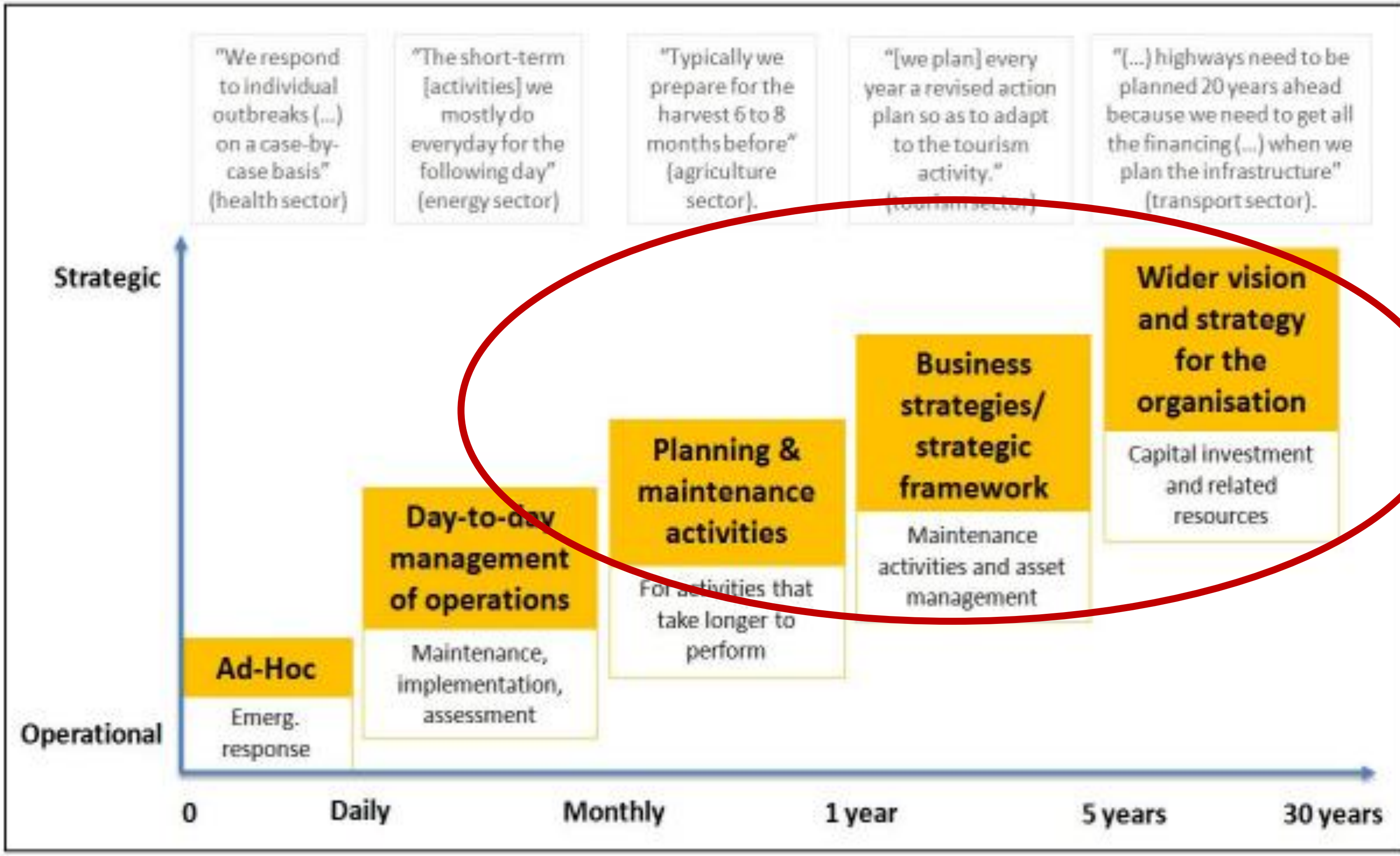
The big challenge is to provide climate information for the next 30 years from the best climate data sources



Adapted from Meehl et al. (2009)

Uses of climate information

The interest of the Department is mainly in sub-seasonal, seasonal and decadal time scales



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Dessai and Bruno-Soares (2013)

Uses of climate information

Maturity of climate-vulnerable sectors: In all sectors there are potential applications but in some sectors the decision making processes that would benefit from decadal predictions are better defined.

Provided that the added value of predictions-projections is illustrated to the users.

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From project deliverables of EUCP (D 6.4), PRIMAVERA (D11.6) and EUPORIAS (D12.3). Additional sectoral comments in user engagement by S2S4E, APPLICATE, MED-GOLD, HIATUS and VISCA.

Uses of climate information

Bodegas Torres (a Spanish winery) is looking for new locations for its vineyards (and it is 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 needs local climate information (including appropriate uncertainty assessments) for the vegetative cycle of the vine, which lasts around 30 years.

The user needs to make the decision now.

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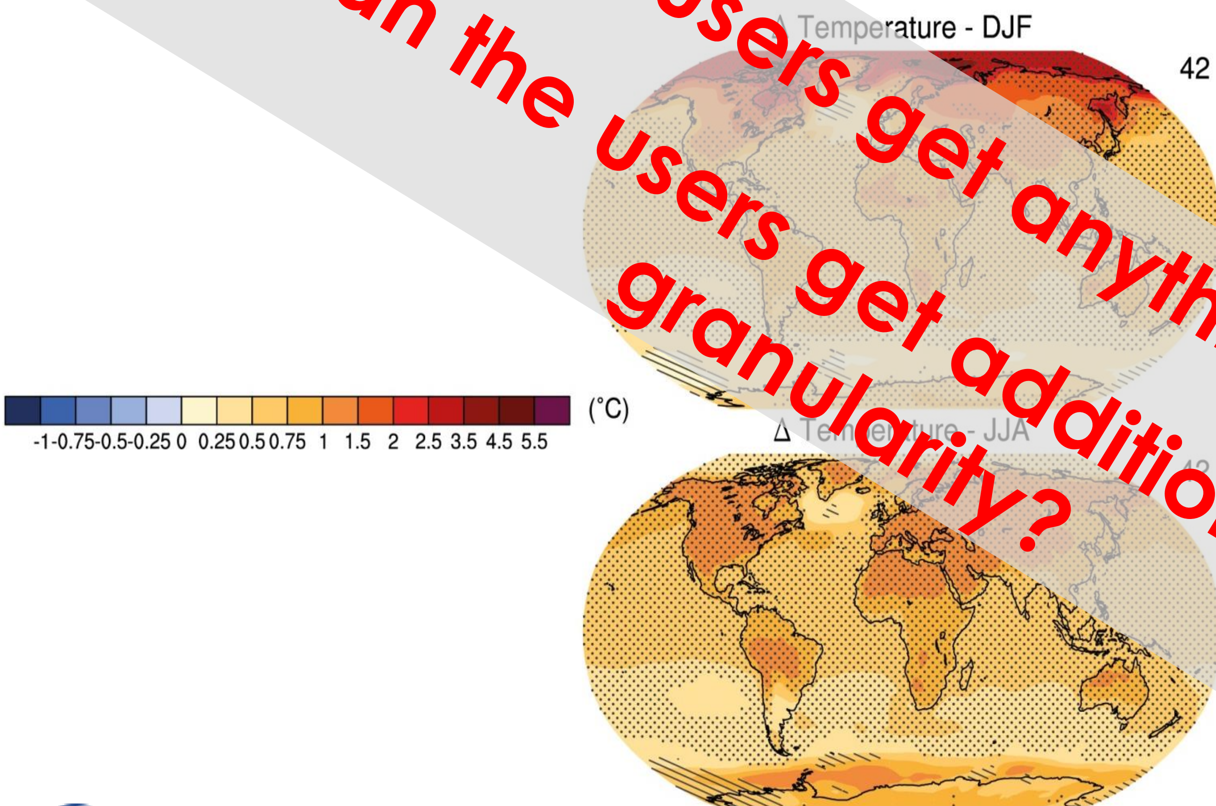
Climate information available

Seasonal-mean air temperature change for the RCP4.5 scenario over 2016-2035 (wrt 1986-2005). Stippling for significant changes, hatching for non significant.

Can the users get anything better?

Can the users get additional time granularity?



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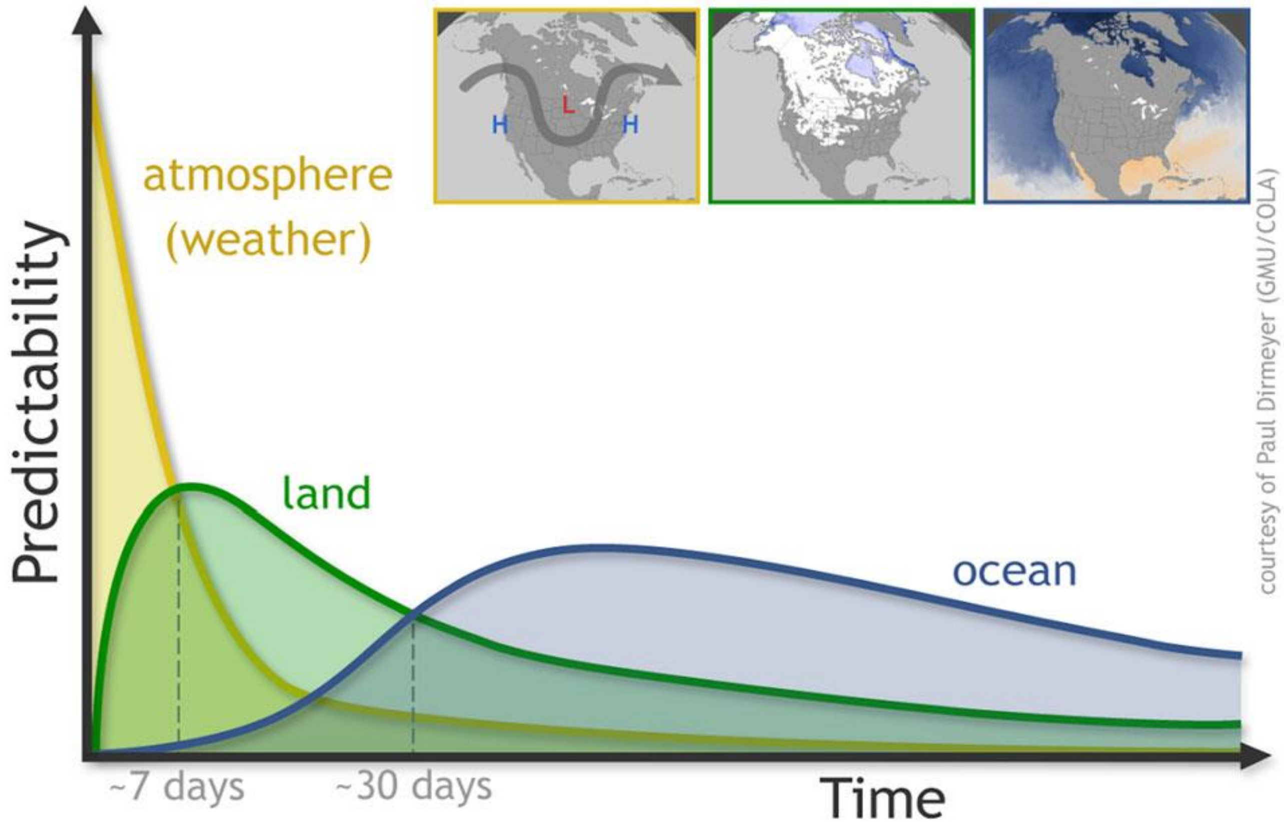
IPCC AR5 WGI (2013)

Predictability sources

Different components of the climate system act as predictability sources depending on the time scale.

However, converting predictability into actual forecast ability (skill) is not a trivial task.



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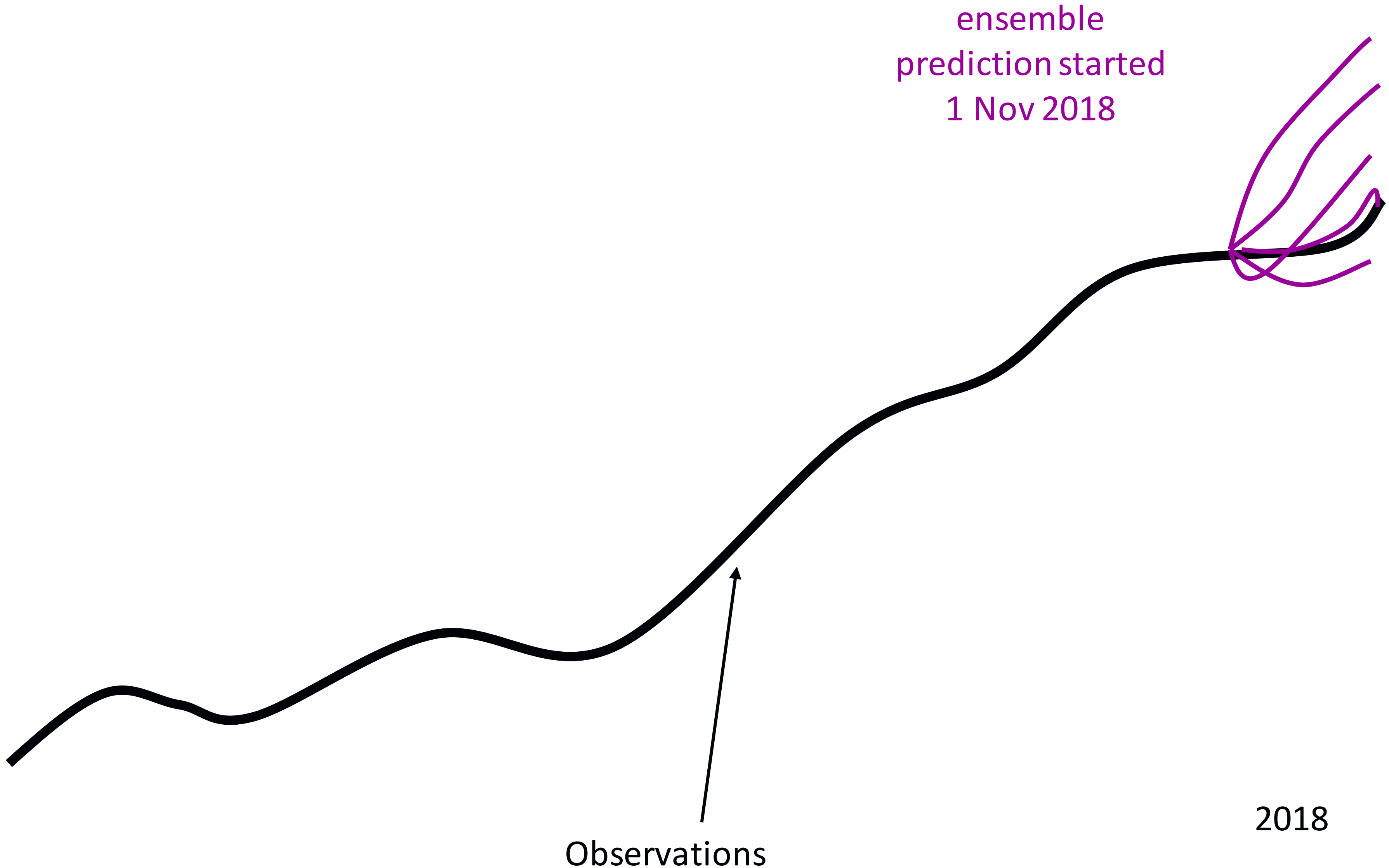
Predicting climate



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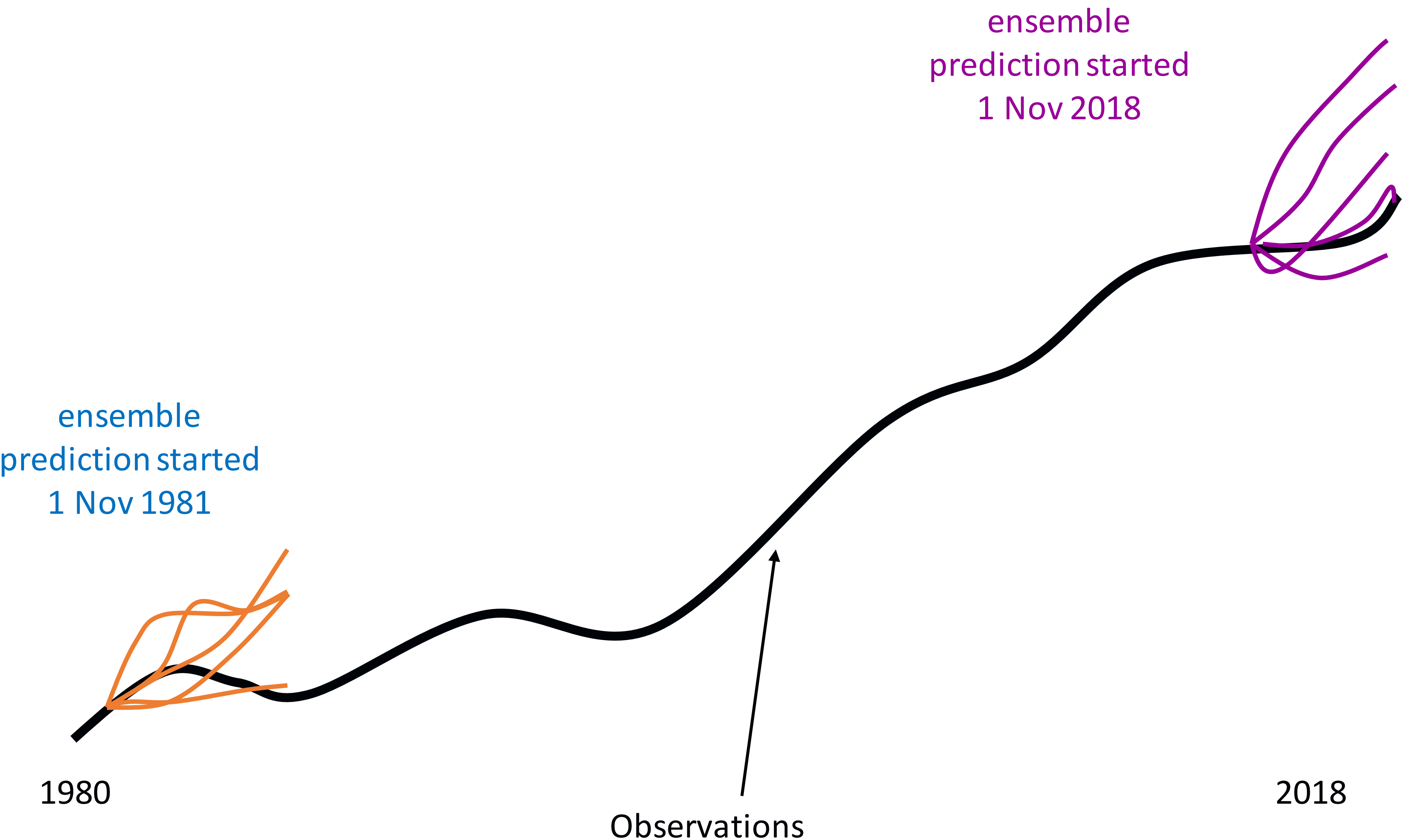
Predicting climate



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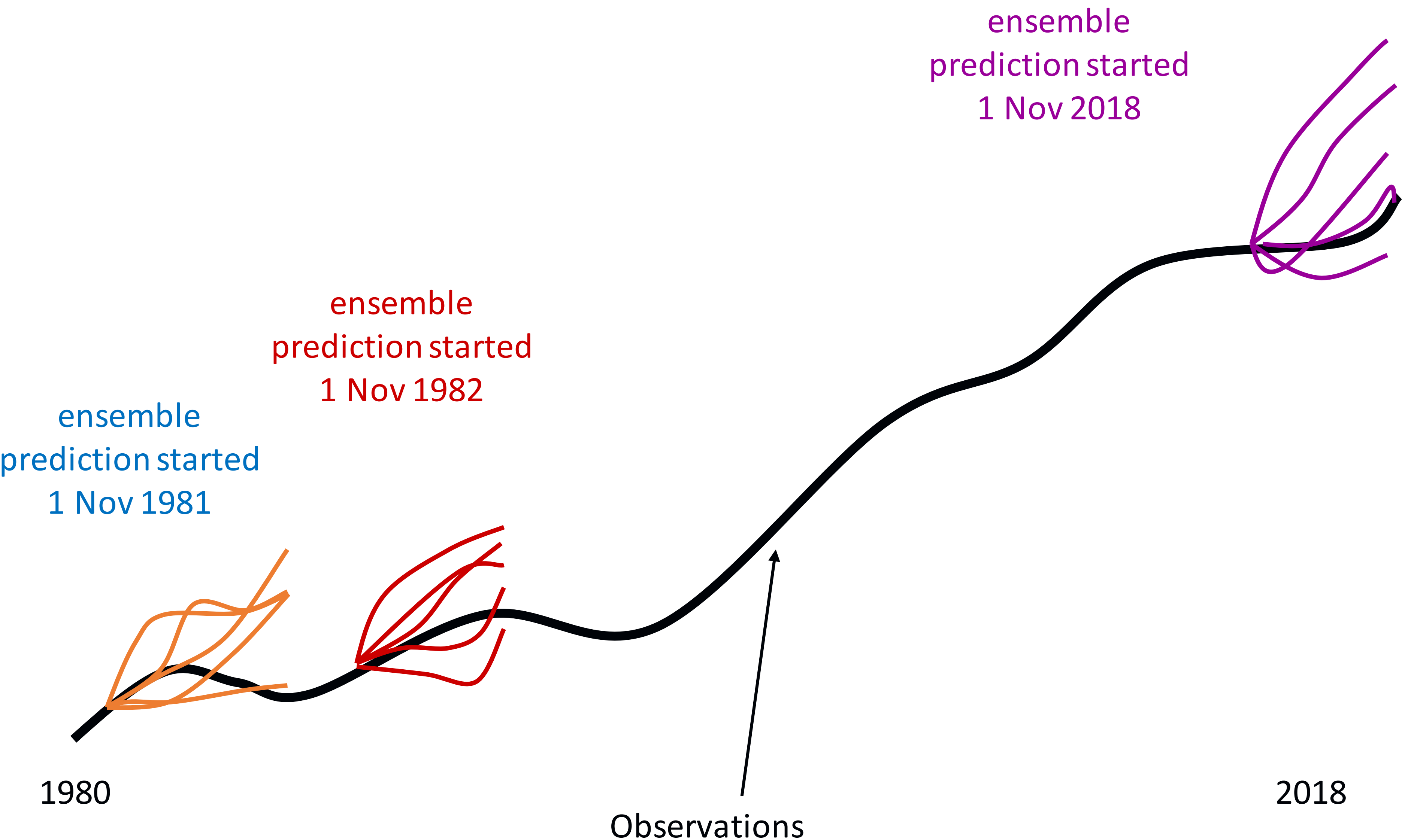
Predicting climate



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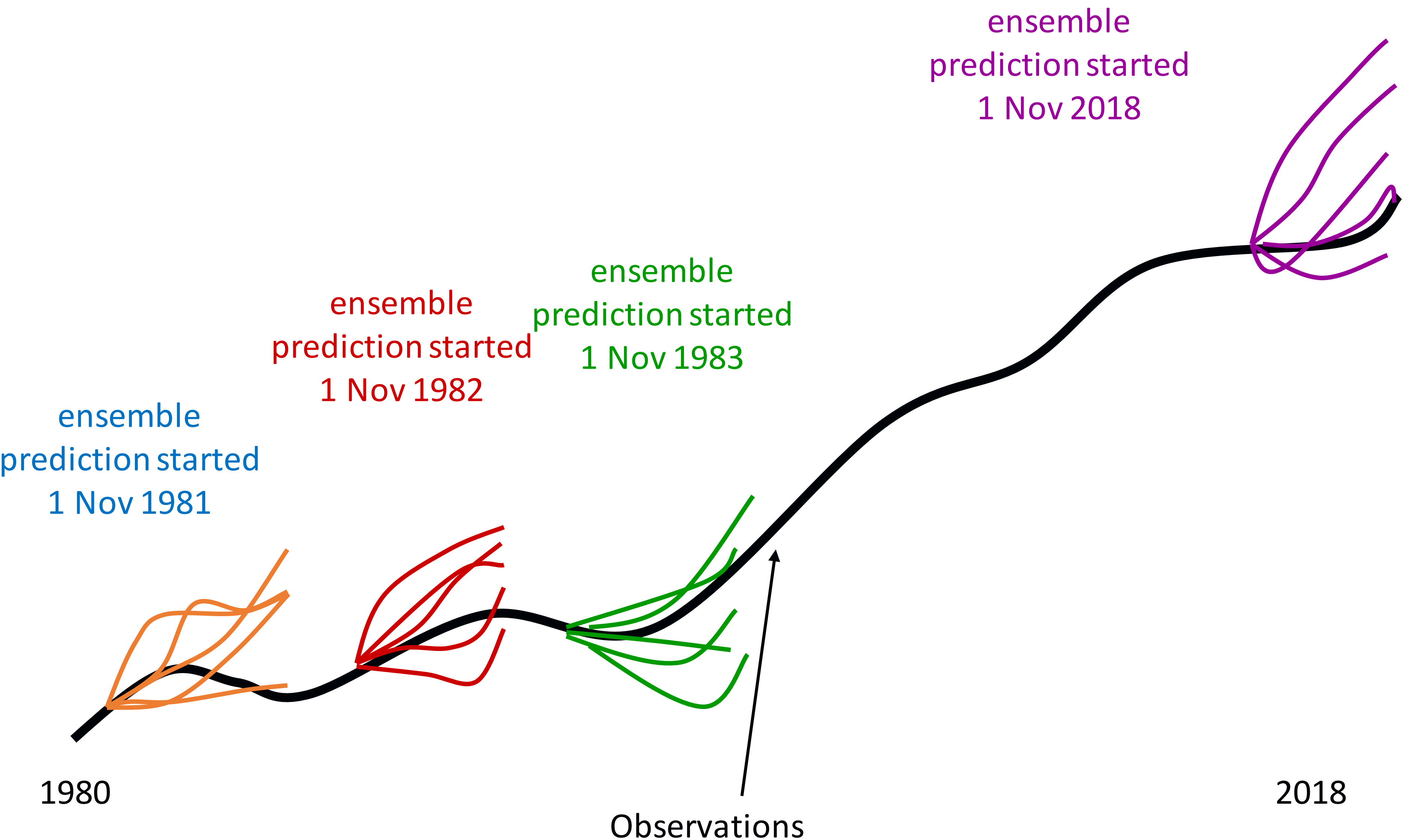
Predicting climate



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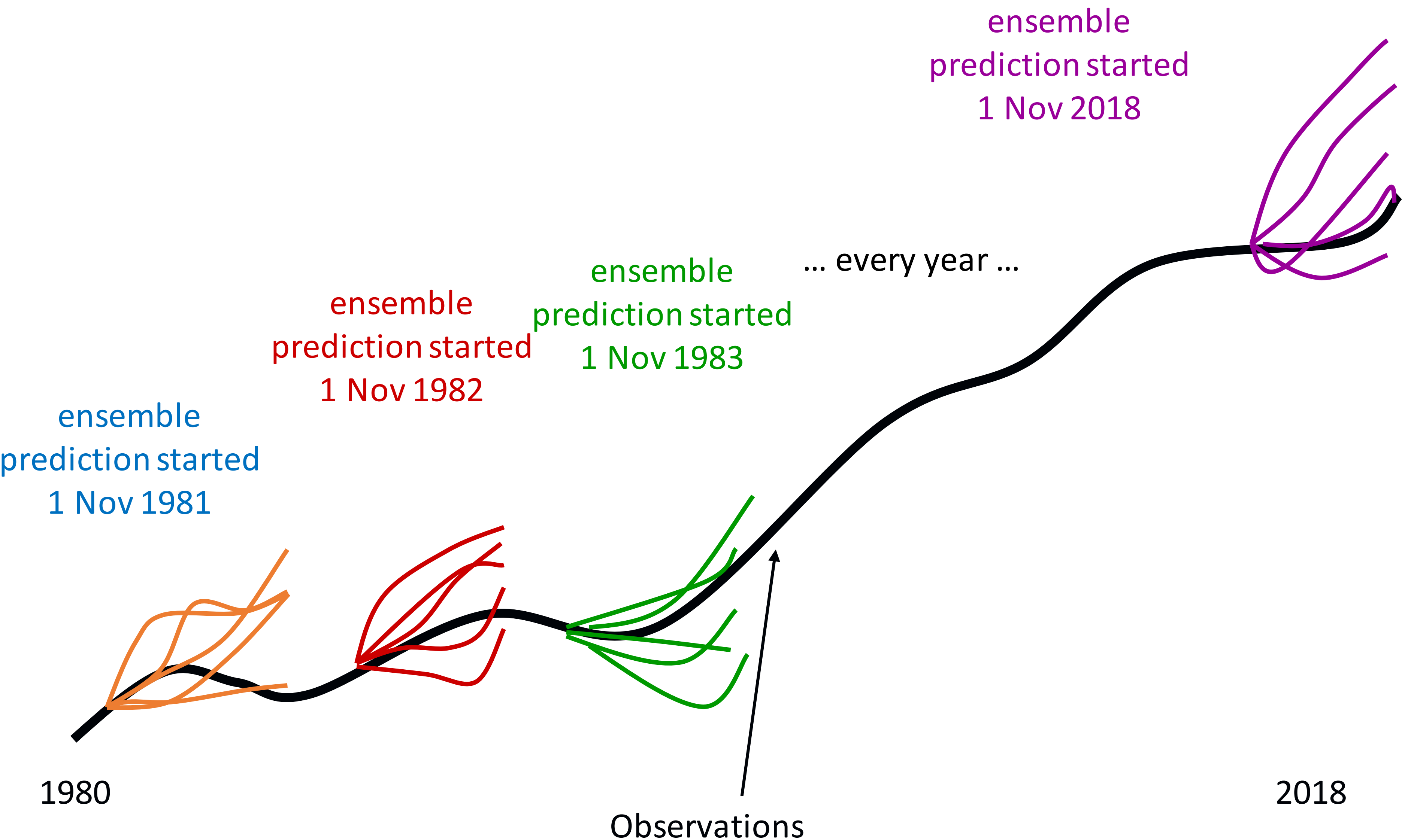
Predicting climate



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EC-Earth as the main climate tool

Model Components

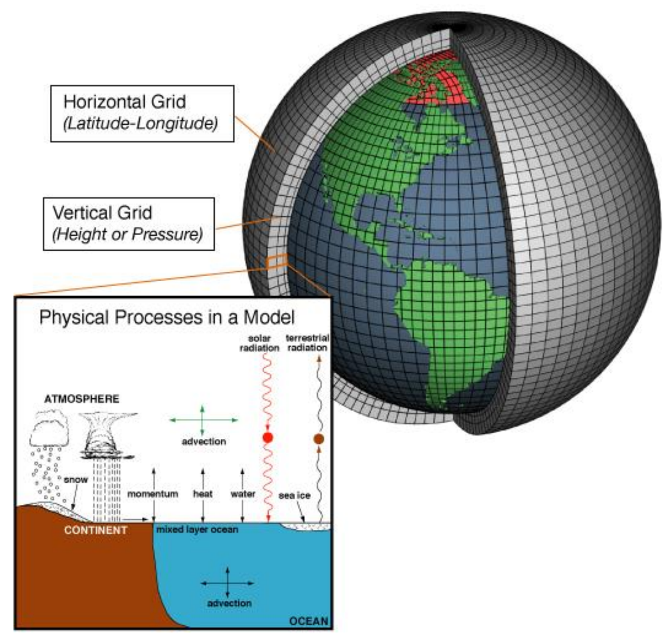
IFS (Atmospheric Model):
- T255 (0.75º) ~80km
- L91 (top 0.01hPa) ~mesosphere
- *IFS-HTESSEL (Land Model)*

NEMO (Ocean Model):
- Nominal 1° Resolution
- L75 levels (thousands km deep)
- *PISCES (Biogeochemistry Model)*

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

IFS-HTESSEL

EC-EARTH
Global Coupled model



produced in-house

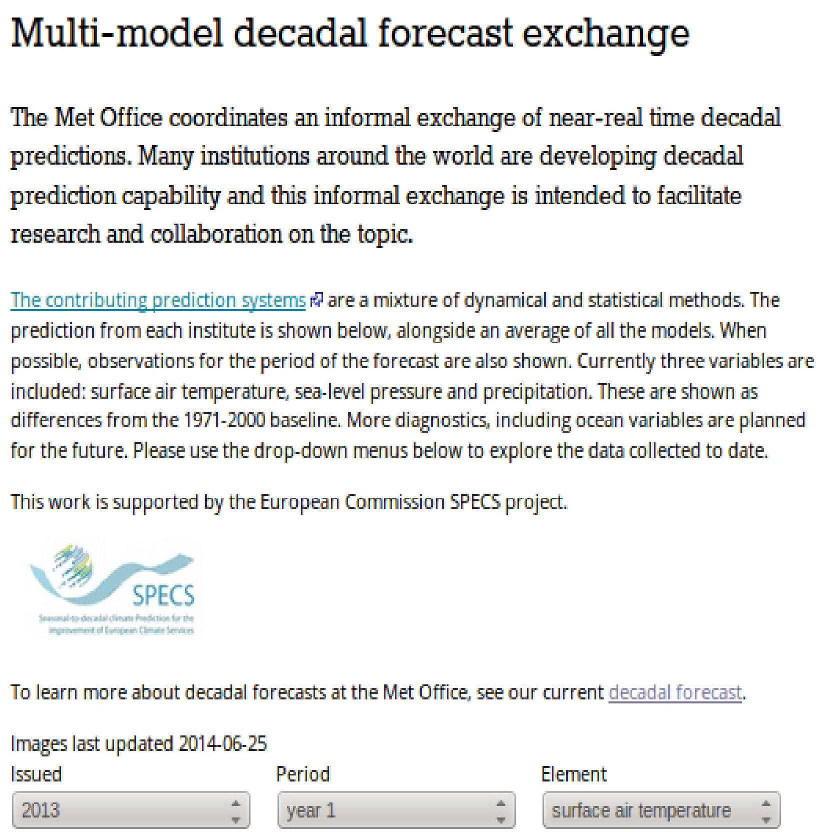
Initial Conditions

Sea Ice reanalysis **(ESA)**	Atmosphere reanalysis **(ERA-Interim)**
Ocean reanalysis **(ORAS4)**	Land reanalysis **(ERA-Land)**

BSC as a climate provider: decadal prediction

The multi-model real-time decadal prediction exchange is a research exercise that guarantees equal ownership to the contributors.

BSC is one of the four centres recognised as global producers of decadal climate predictions by WMO-CCl.



Multi-model decadal forecast exchange

The Met Office coordinates an informal exchange of near-real time decadal predictions. Many institutions around the world are developing decadal prediction capability and this informal exchange is intended to facilitate research and collaboration on the topic.

The contributing prediction systems are a mixture of dynamical and statistical methods. The prediction from each institute is shown below, alongside an average of all the models. When possible, observations for the period of the forecast are also shown. Currently three variables are included: surface air temperature, sea-level pressure and precipitation. These are shown as differences from the 1971-2000 baseline. More diagnostics, including ocean variables are planned for the future. Please use the drop-down menus below to explore the data collected to date.

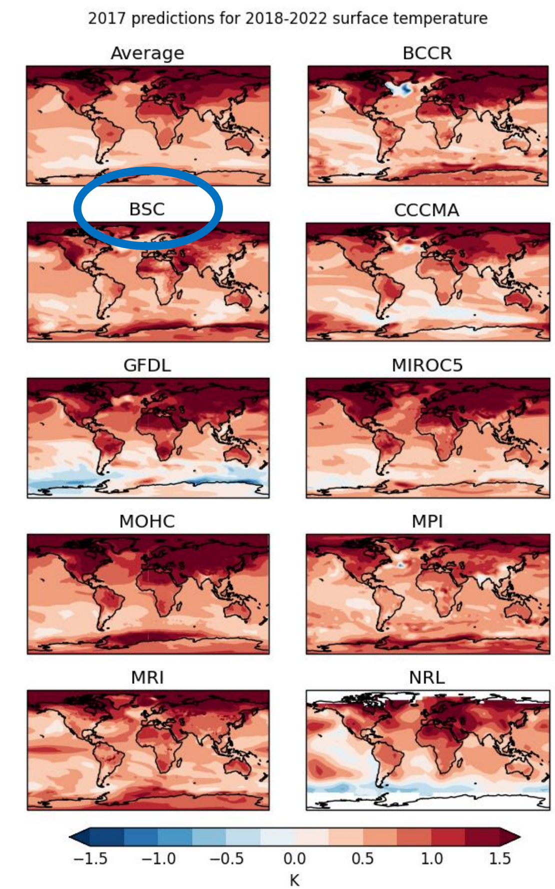
This work is supported by the European Commission SPECS project.

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

To learn more about decadal forecasts at the Met Office, see our current decadal forecast.

Images last updated 2014-06-25

Issued	Period	Element
2013	year 1	surface air temperature



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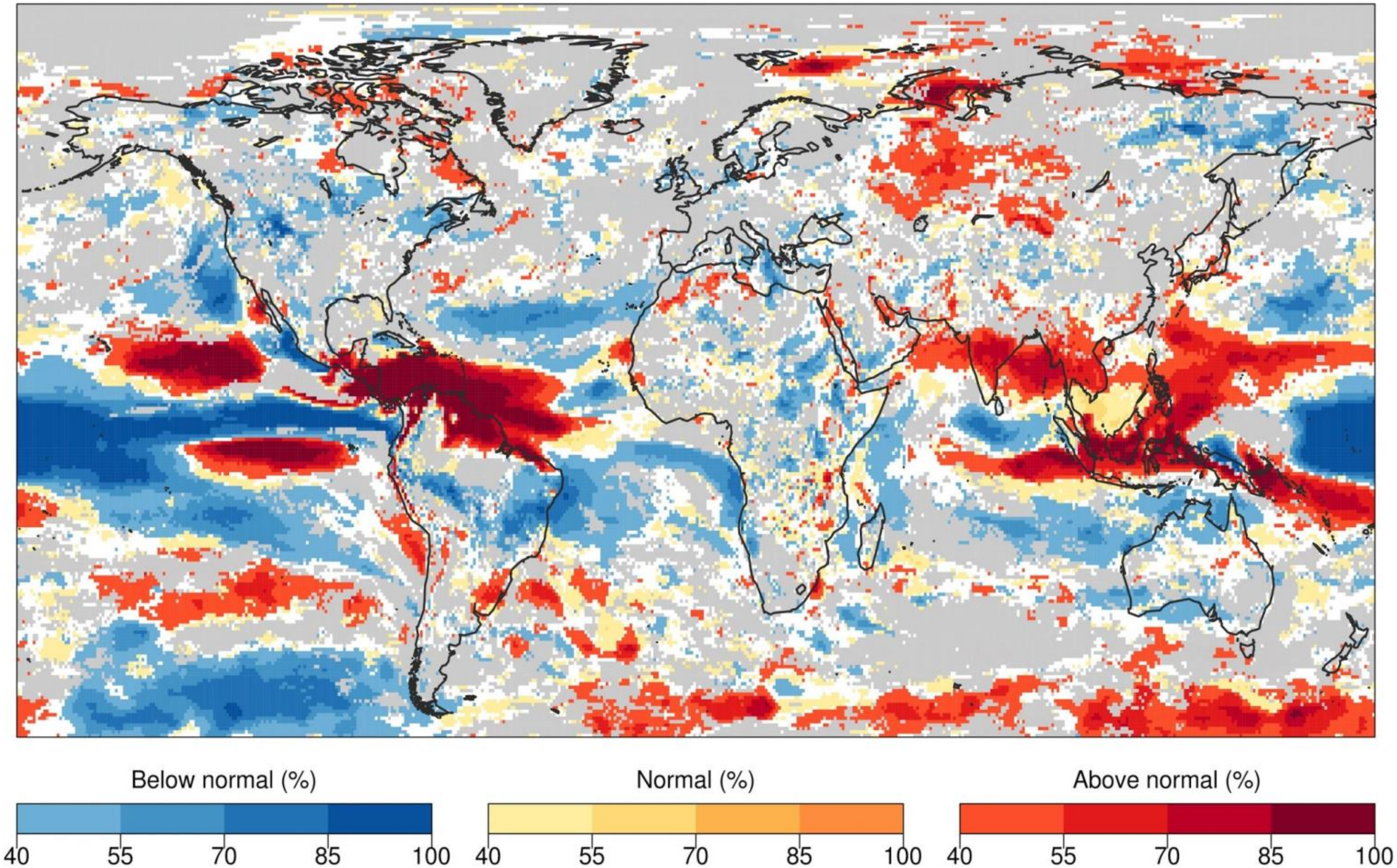
World Meteorological Organization

Climate forecast products and their quality

The prediction process follows a series of steps:

- Formulate a prediction from a forecast system. The exact definition of the prediction is very important.
- Select the verification metrics of the prediction to adequately represent the attributes of interest and an observational reference.
- Choose a comparison standard that provides a reference level (persistence, climatology or a previous forecast system).
- A prediction is of high quality if it predicts the conditions observed according to some objective criterion better than a reference prediction.
- The prediction has value if it helps the user to obtain some kind of benefit from the decisions he has to make.
- Note that the forecast quality is valid for a specific forecast product. Different products from the same forecast system will show different forecast quality.

What does a prediction look like



Wind speed prediction for June 1st - August 31st 2015, issued on May 1st 2005.

The most likely wind power category (below normal, normal or above normal), and its percentage probability to occur is shown. "Normal" represents the average of the past. White areas show where the probability is <40% and approximately equal for all three categories. Grey areas show where the climate prediction model does not improve upon the standard and current approach, which projects past climate data into the future.

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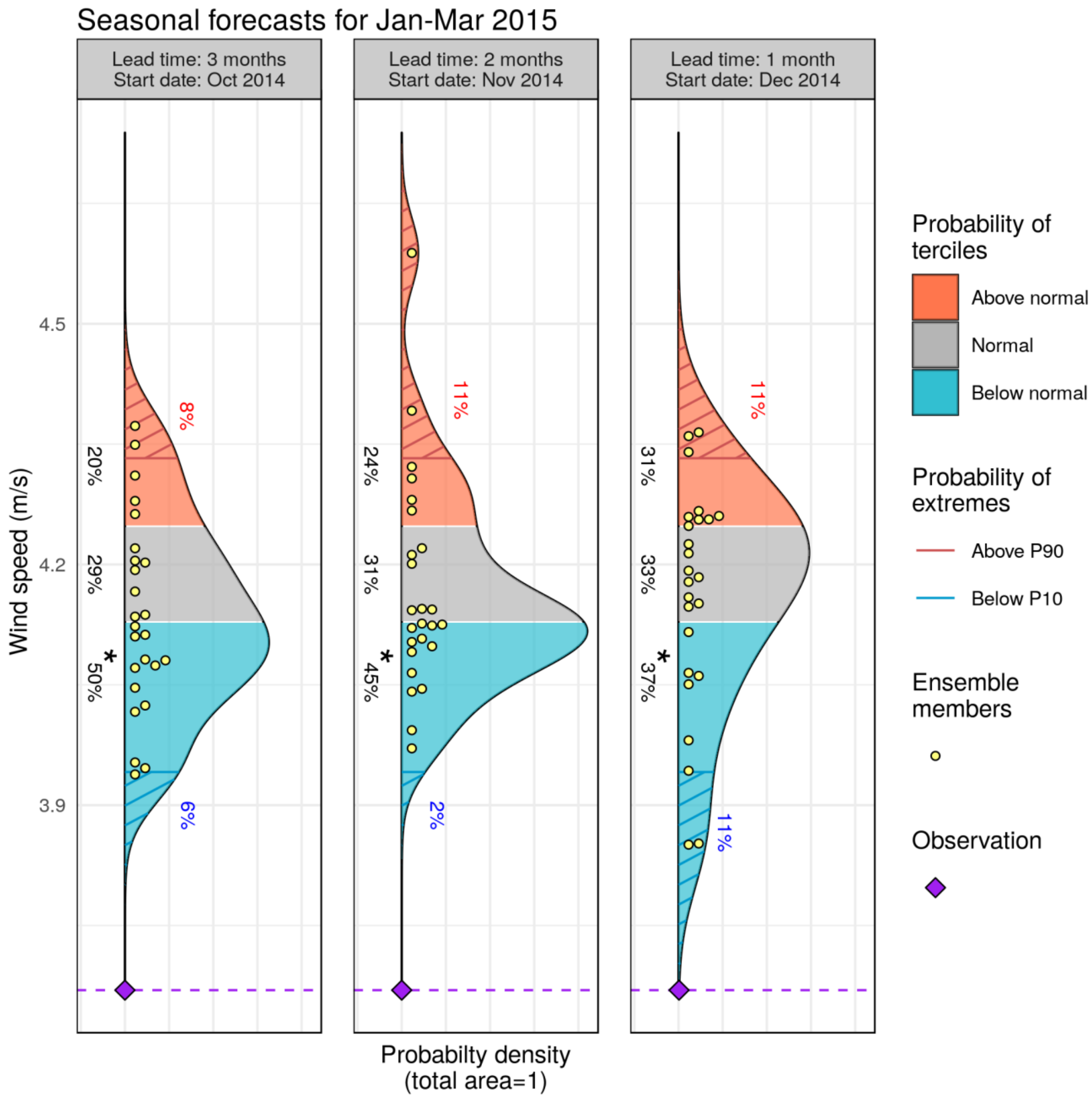
What does a prediction look like



DJF wind speed predictions starting on the first of October, November and December for the first trimester of 2015, ECMWF SEAS5, reanalysis: ERA-Interim, hindcasts over 1993-2015.

	Start Date		
	Oct	**Nov**	**Dec**
RPSS	0.35	0.39	0.35
CRPSS	0.14	0.11	0.14
Corr	0.55	0.54	0.51

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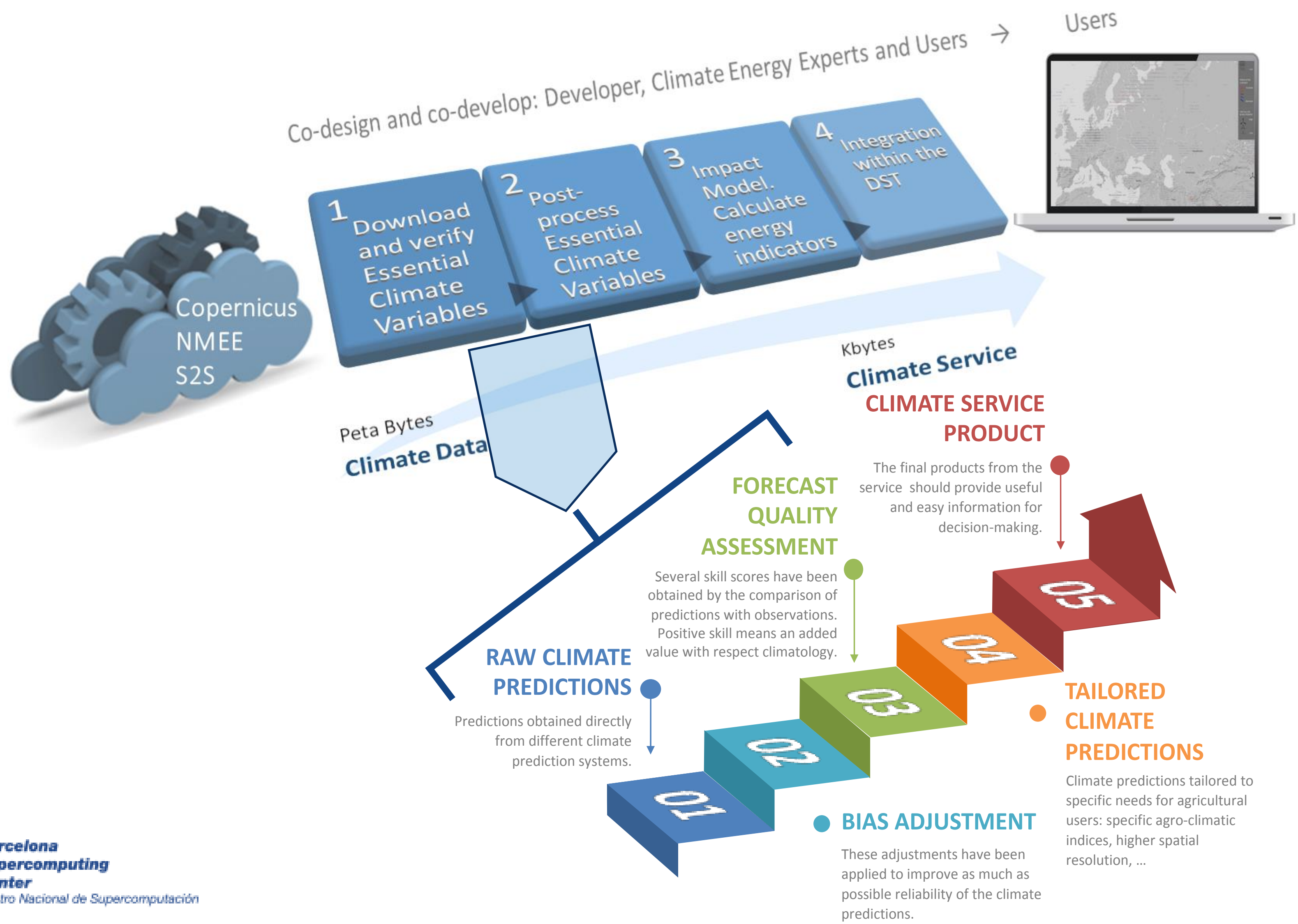
But the chain goes well beyond climate

Even when there is skill in the climate variables, converting it into proven usefulness for a specific application involves a complex chain.



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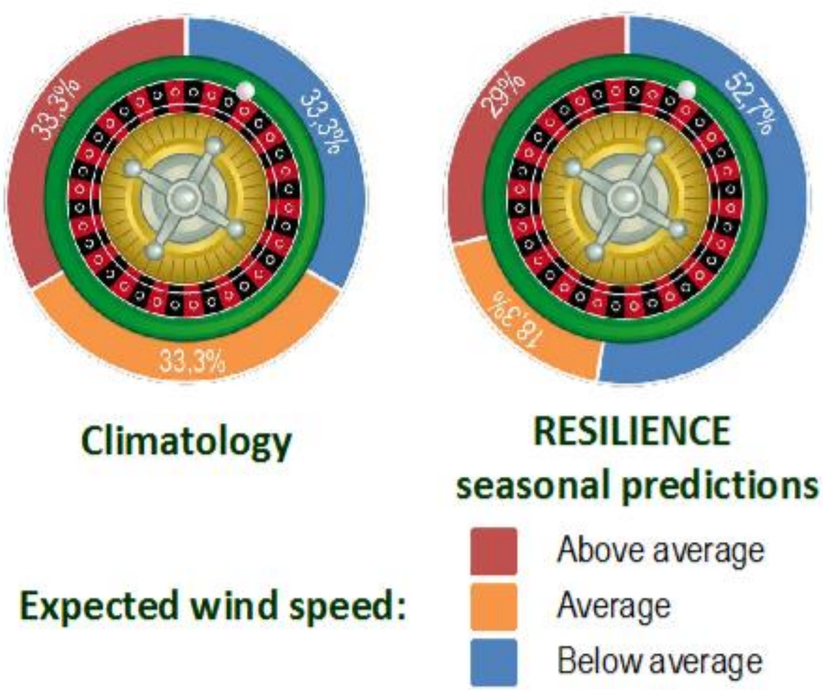
Illustrating prediction value

Gamification is useful to illustrate the challenges of using and the value of seasonal climate predictions:

- Play against a reference taken from climatological frequencies.
- The bets are proportional to the predicted probabilities.
- The amount invested in the observed category is multiplied by 3.



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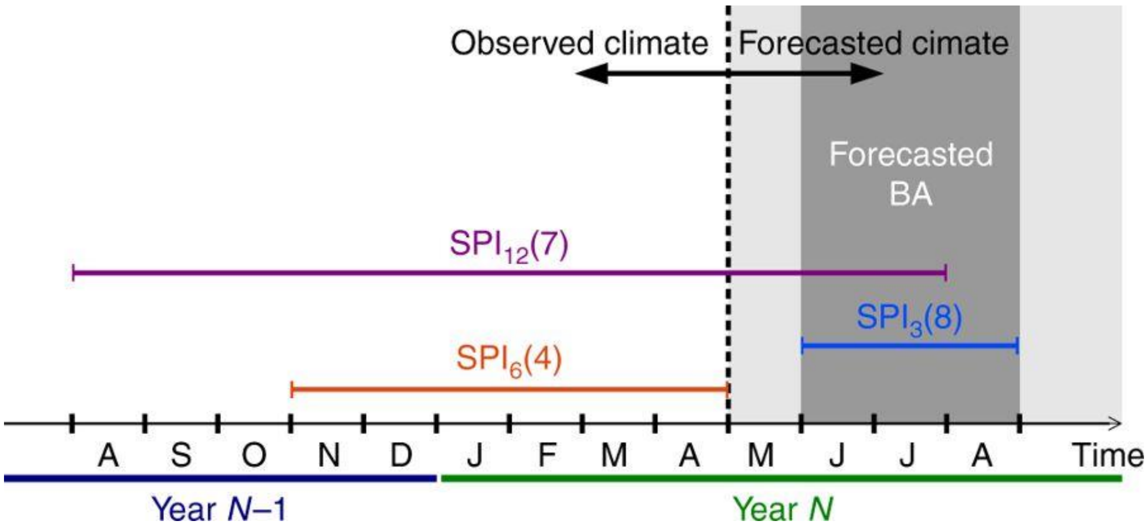
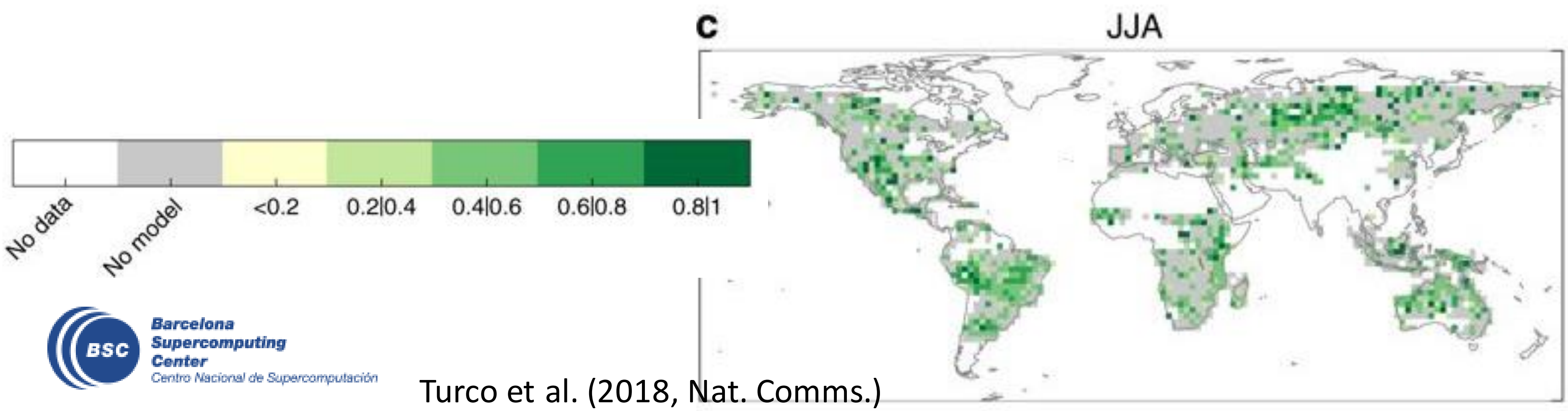
play.google.com/store/apps

Seasonal predictions of burned area

Summer burned area predictions using observations of temperature and precipitation (ERA Interim and GPCP) and a multi-model of seasonal forecasts initialized at the beginning of May over 1995-2016.





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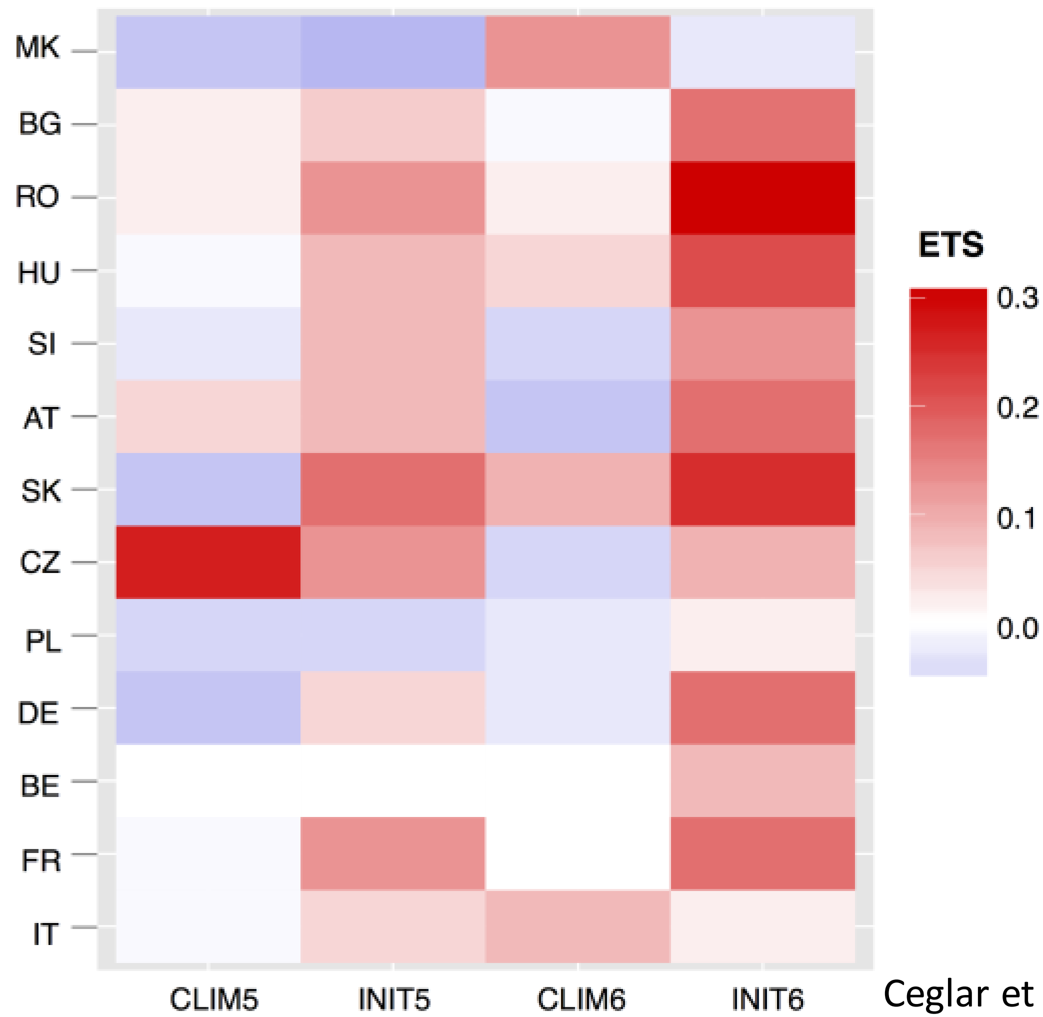
Turco et al. (2018, Nat. Comms.)

Improved seasonal predictions of crop yield

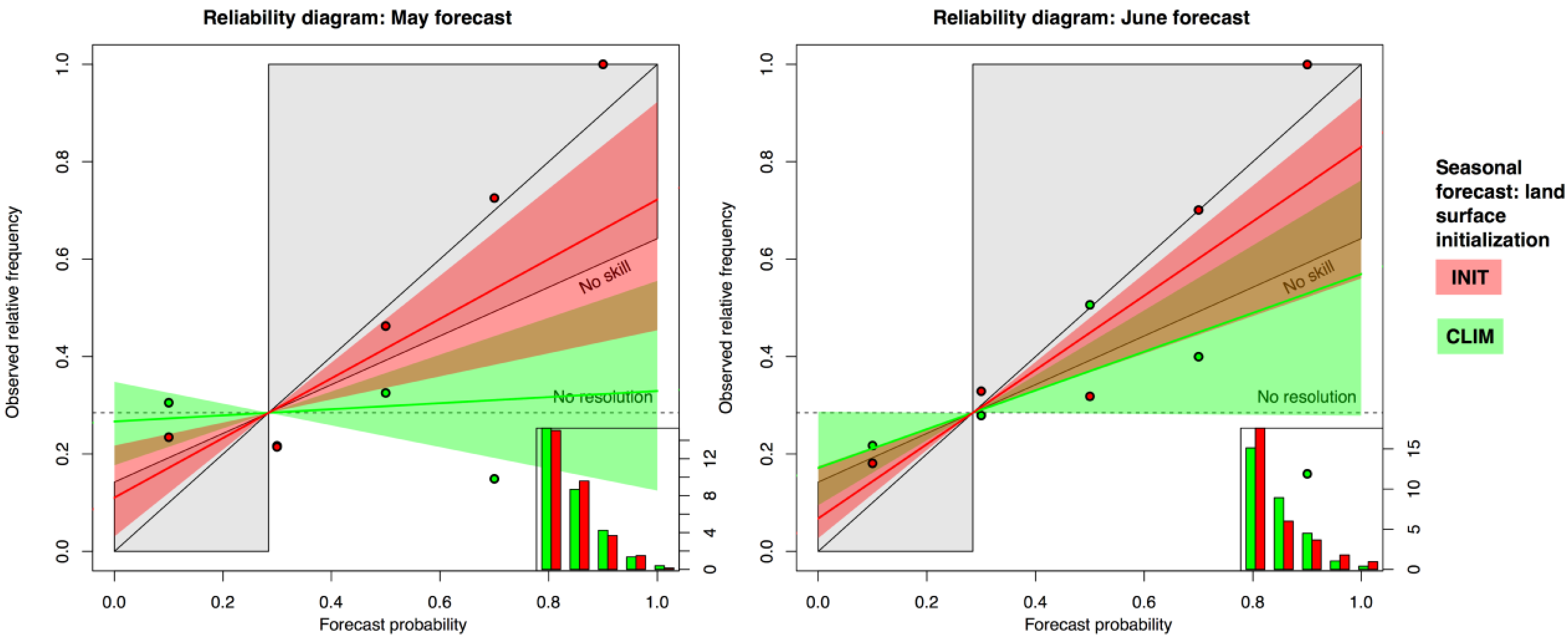
Equitable threat score (ETS) of predictions of poor maize yield (lower quartile) from EC-Earth when the land-surface uses realistic initial conditions (INIT) wrt conditions with no interannual information (CLIM).



Ceglar et al. (2018, Sci. Rep.)

Improved seasonal predictions of crop yield

Reliability diagram of predictions of poor maize yield (lower quartile) from EC-Earth seasonal predictions when land-surface is initialised with realistic (INIT) and climatological (CLIM) initial conditions with May and June start dates.



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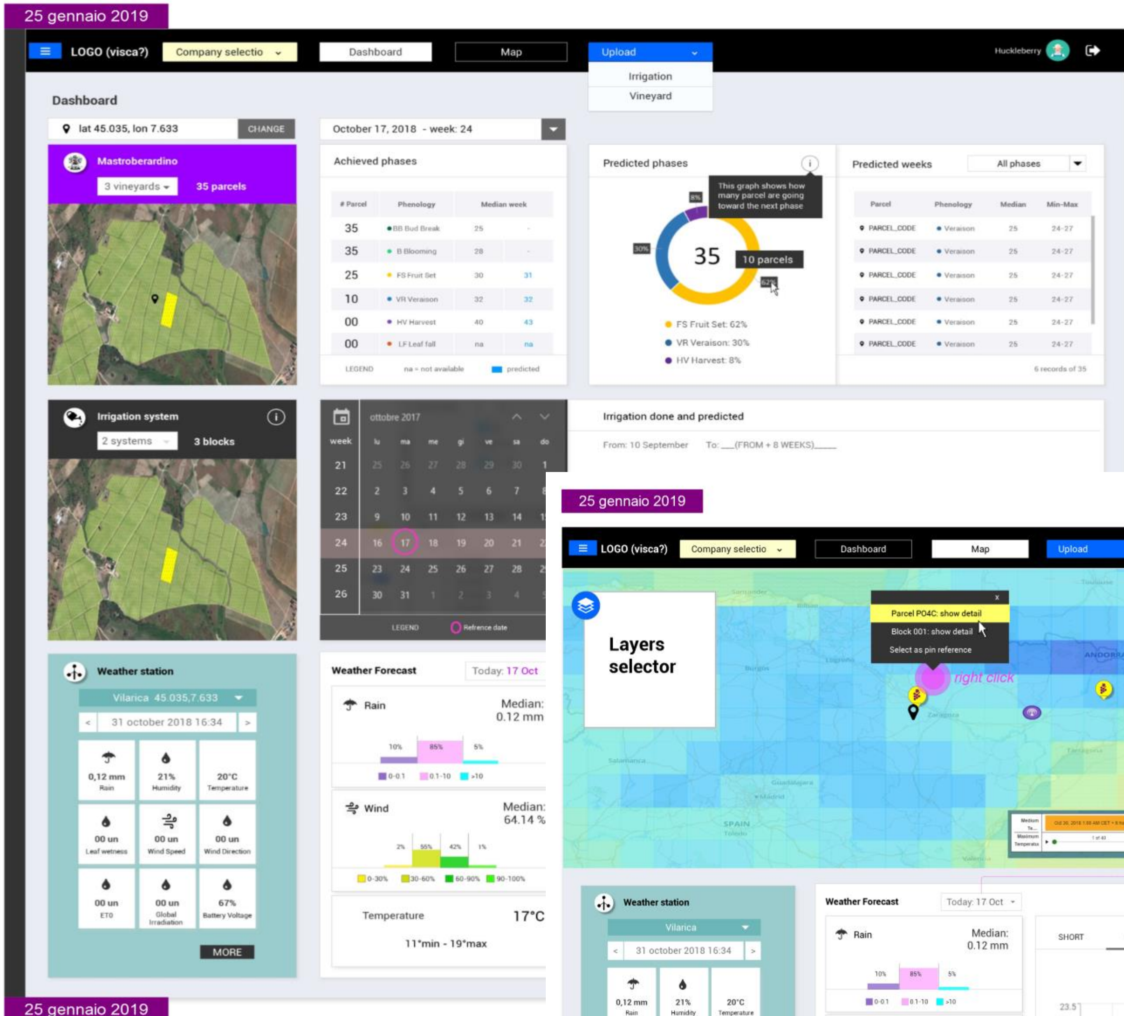
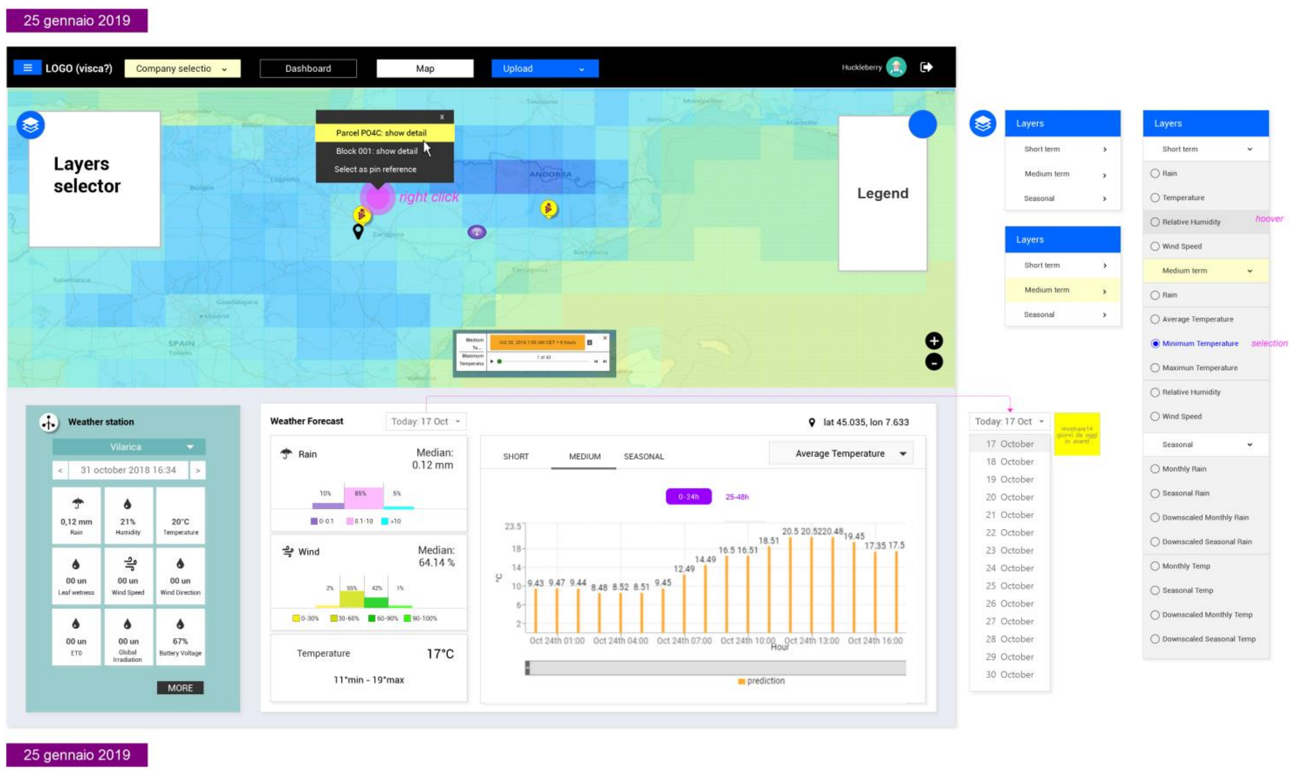
Ceglar et al. (2018, Sci. Rep.)

Prototype service for wine production





VISCA
VINEYARDS INTEGRATED SMART CLIMATE APPLICATION

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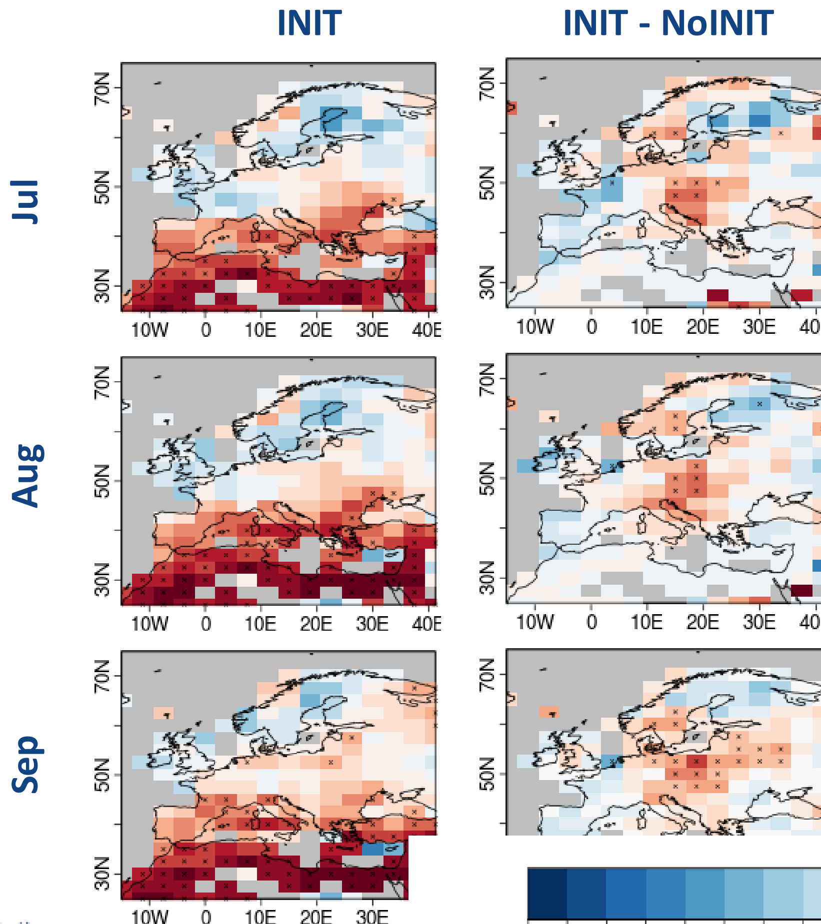
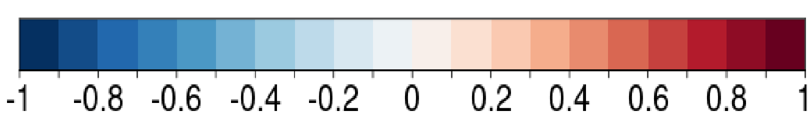
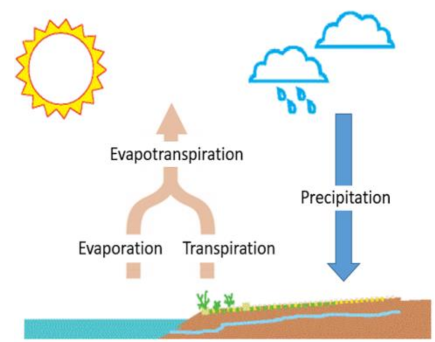
Multiannual prediction of crop yield

Multi-model correlation between the predicted ensemble mean and reference (from GHCN and GPCC) standardised precipitation evapotranspiration index of the previous six months (SPEI6) for the boreal summer averaged over forecast years 2 to 5.





INIT: Initialized decadal prediction
NoINIT: Non initialized climate projection



Solaraju Murali (BSC)

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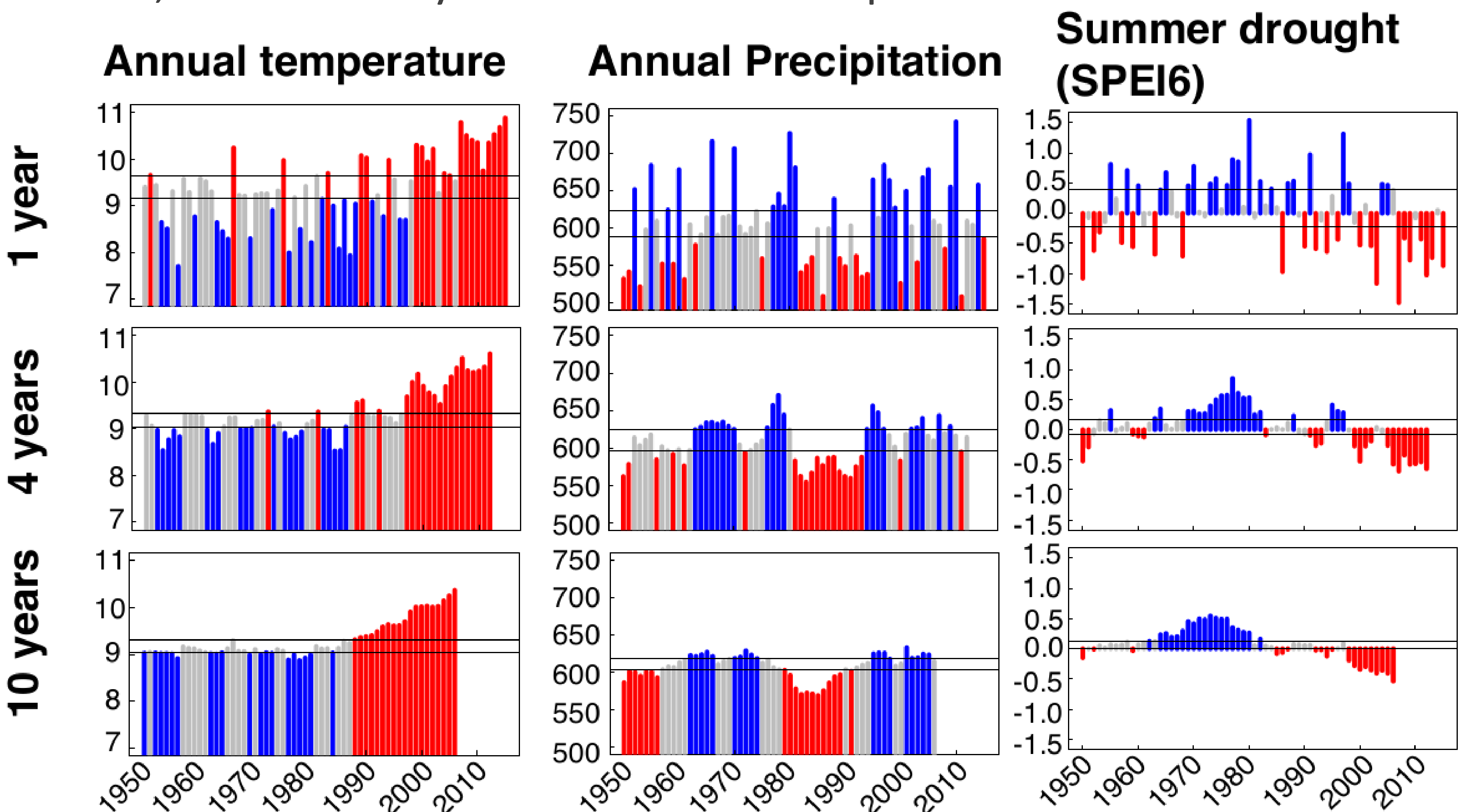
Multiannual prediction of crop yield

Time series of temperature, precipitation and August SPEI6 averaged over one, four and 10 years in Eastern Europe.



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Marco Turco (BSC)

Summary

- Requests for climate information for the next 30 years comes from a broadening range of users and should be addressed from a climate services perspective. Addressing this requirement require a new paradigm for climate research.
- Different tools are available to provide climate information (global and regional projections, predictions, empirical systems, etc.). Merging all this information into a reliable, unique source is a problem still not solved.
- Standards for verification, data dissemination, quality control need to be established.
- Climate services start with an appropriate user engagement.
- None of this will materialise without appropriate investment in observational networks, increased collaboration reduction of all aspects of model error.