Filling the gap of climate information on decadal timescales

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Outline

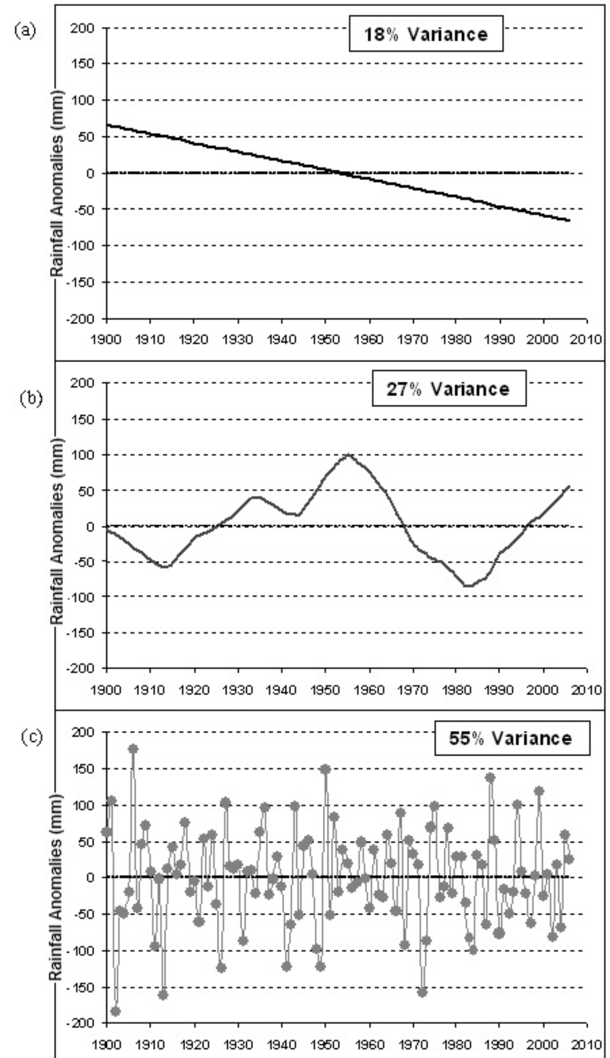
- Why decadal prediction are important?
- What are decadal predictions?
- How does climate variability and change jointly influence in South America?
- Which is the status of decadal prediction development?
- Why climate prediction are not enough for climate risk decision making?

(AR5-SYR) For many regions and sectors, enhanced capacities to **mitigate and adapt** are part of the foundation essential for **managing climate change risks**

Decision makers at developing countries typically operate in a **near to medium term decision space** (2–5 yr, sometimes up to 10 yr)

Need to improve knowledge and prediction of **natural variability and forced change from annual to decadal timescales**

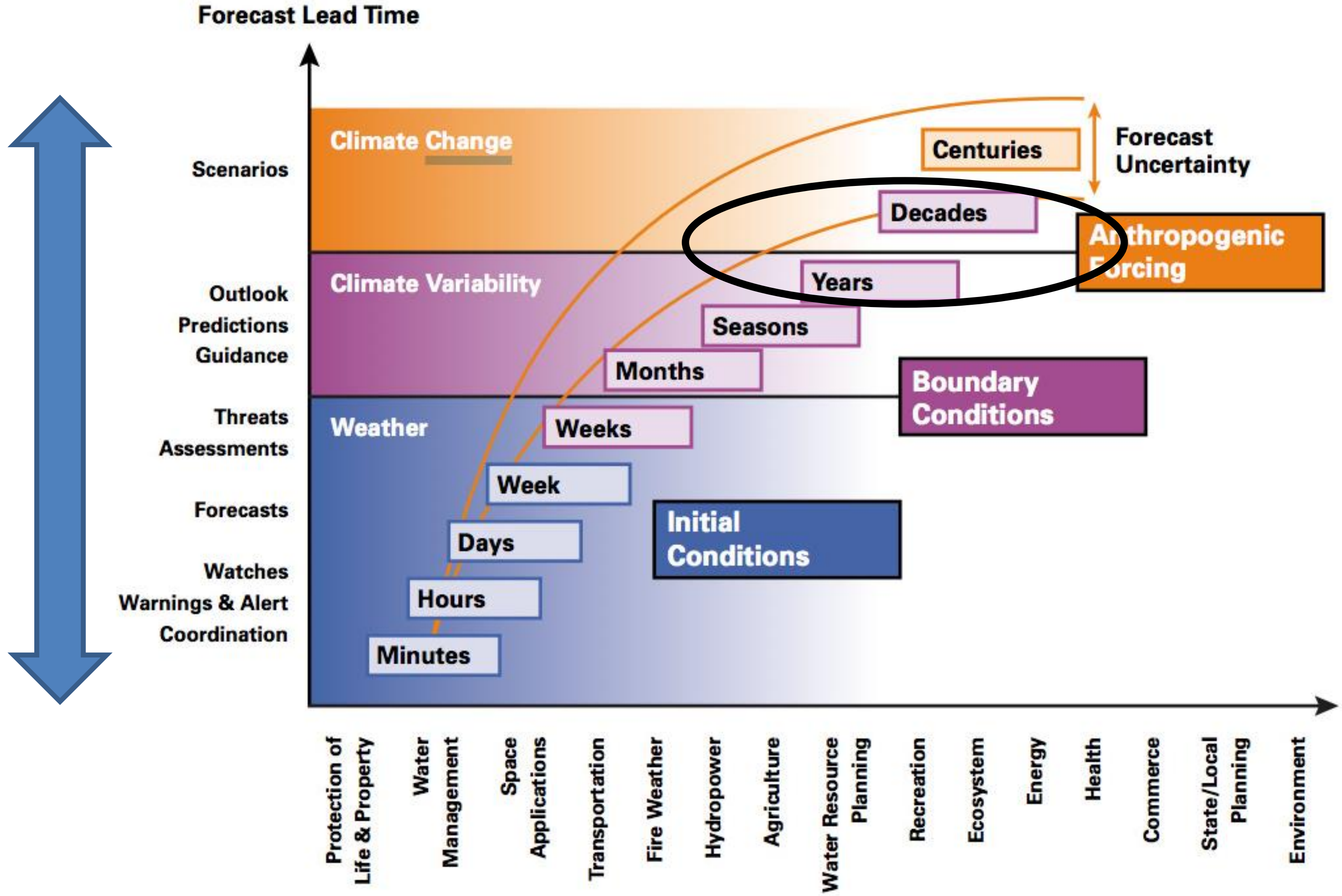
In South America while seasonal predictions and climate change projections are available, there is still no provision of climate decadal predictions



Baethgen (2010)

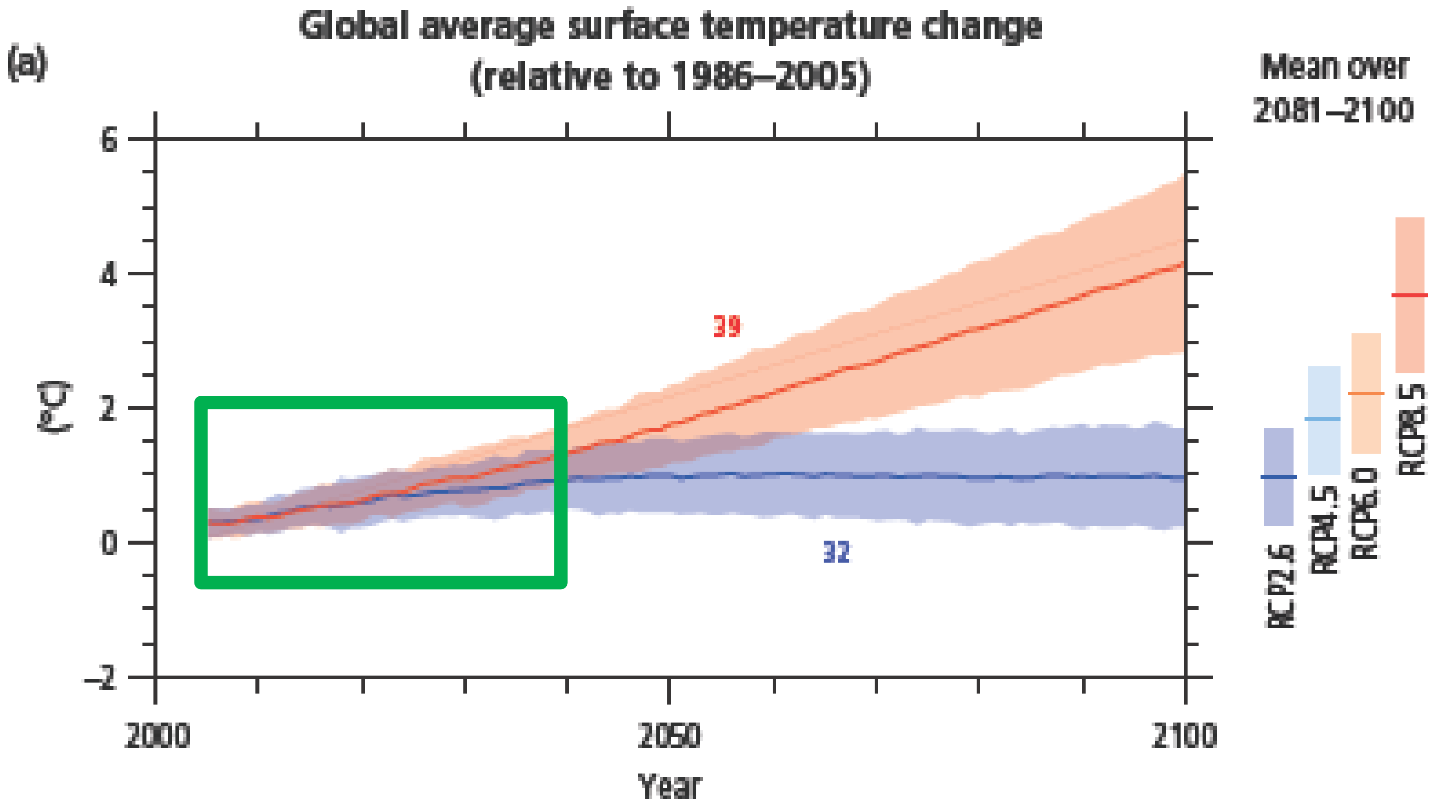
CLIMATE RELATED DECISIONS: CLIMATE SERVICES

Adaptation and Mitigation options should take in consideration the full range of climate variability and change



Essentially the same fundamental climate models are used to provide information at all time scales

The provision of year or decadal forecasts at regional scales is still at research-development phases



In the near term, differences in global mean surface air temperature change across RCP scenarios for a single climate model are typically smaller than differences between climate models under a single RCP scenario.

IPCC-AR5

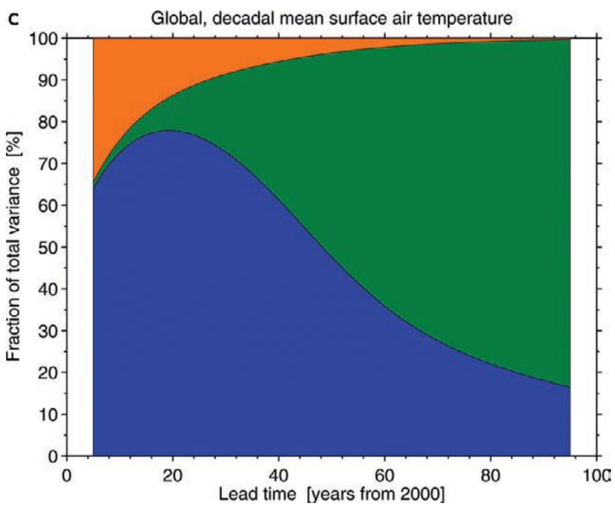
Relative importance of each source of uncertainty in decadal mean projections of surface air temperature and precipitation

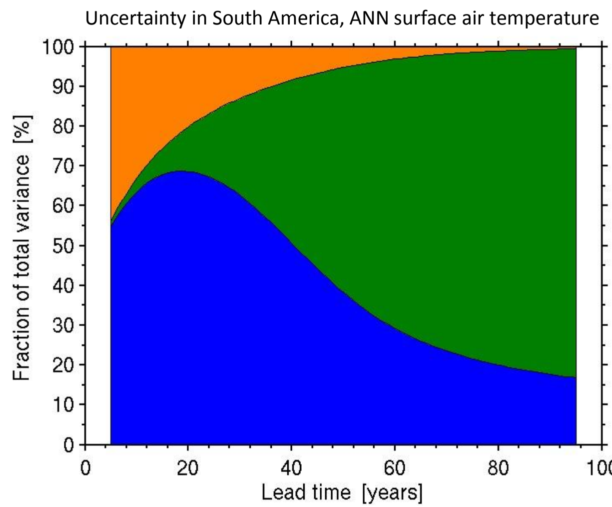
(scenario uncertainty, model uncertainty, internal climate variability uncertainty)

GLOBAL

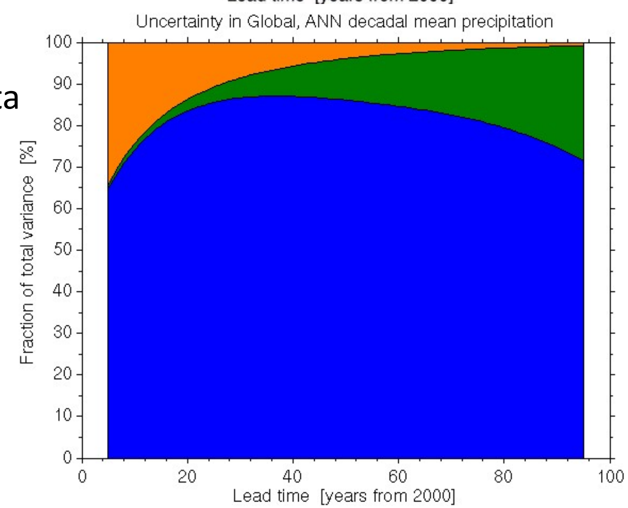
SOUTH AMERICA

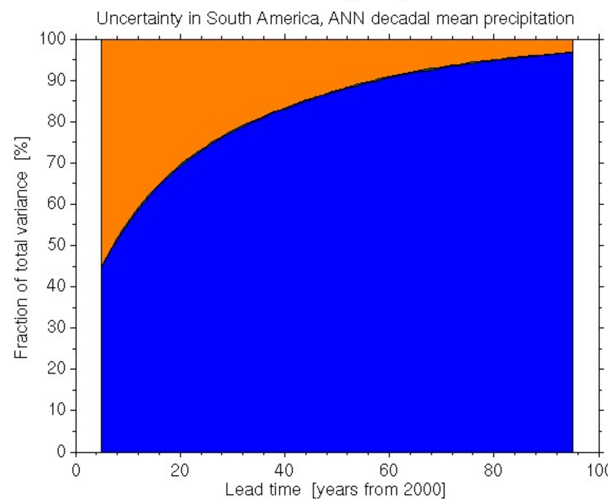
Surface air tempera ture





Precipita tion





Predictions of regional climate change for the next few decades are characterized by high uncertainty mainly associated with:

- Natural climate variability
- Model limitations

Hawkins and Sutton (2009, 2010)

Near-Term Climate:

Period from the present to mid-century, during which the climate response to different emissions scenarios is generally similar

(CMIP5: 2016-2035)

Climate Change Projections:

Models do not depend on initial condition but on the history and projection of climate external forcings (often referred to as 'uninitialized' or 'non-initialized' projections or 'NoInit')

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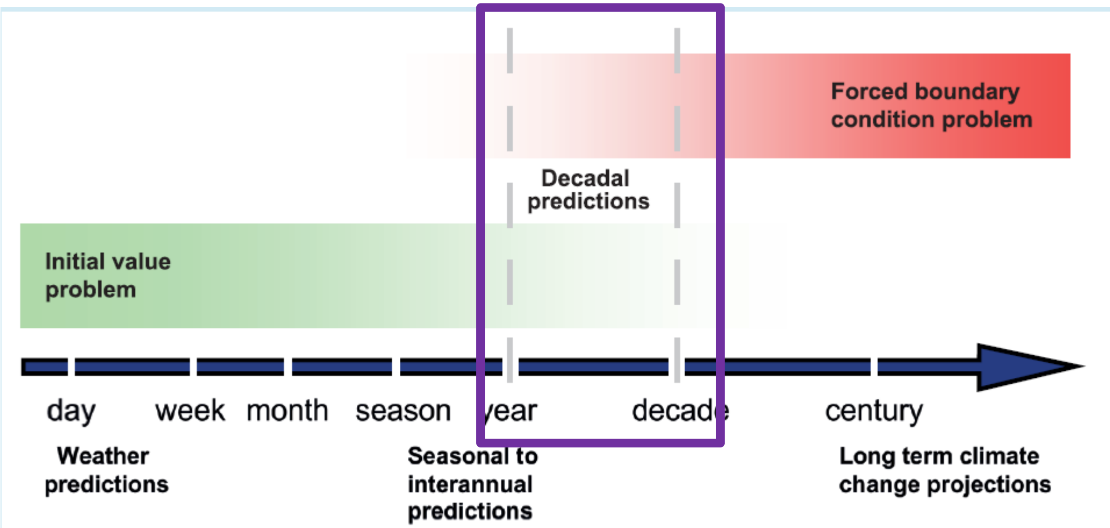
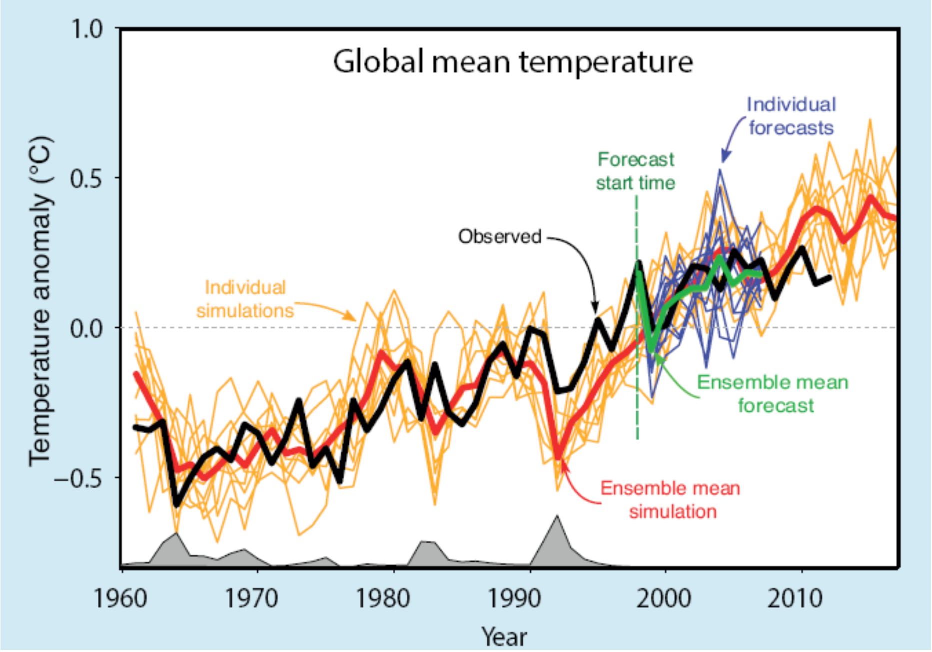
Climate Decadal Predictions:

Models depend on initial condition as well as on the projection of climate external forcings (often referred to as 'initialized' or "Init")



(Meehl et al. 2009)

CMIP5 included for the first time global climate predictions on decadal scales (10 an 30 years long, starting from 1960 to 2005)



Climate decadal predictions are expected to contribute to:

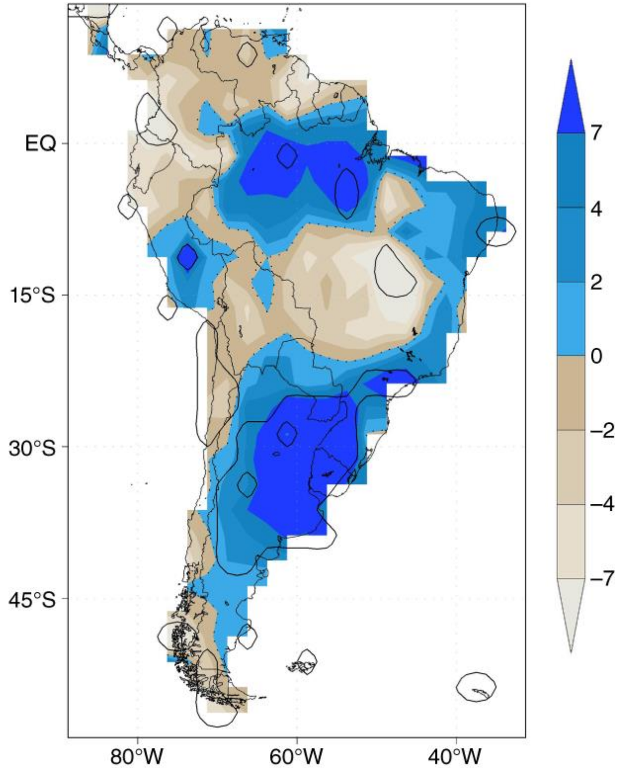
- **Reduce the uncertainties associated with the future natural variability**
- **predict the phases of the climate variability for the following years-decades.**

IPCC-AR5

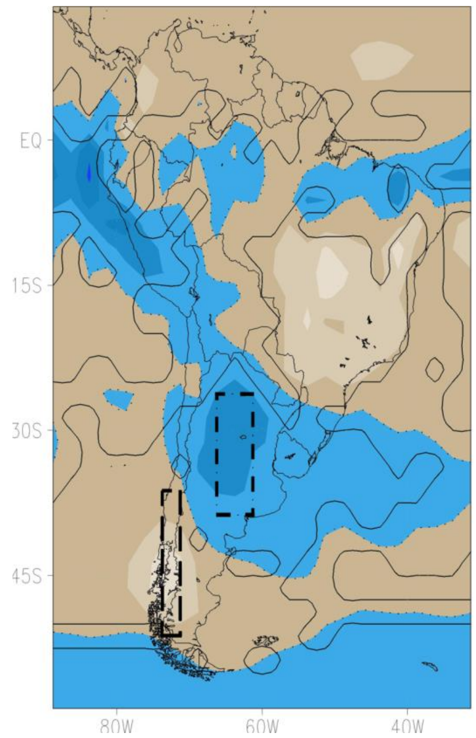
How is the multi-scale nature of the climate variability and change in South America?

DJF Rainfall linear trends
1902-2005 (mm/summer/decade)

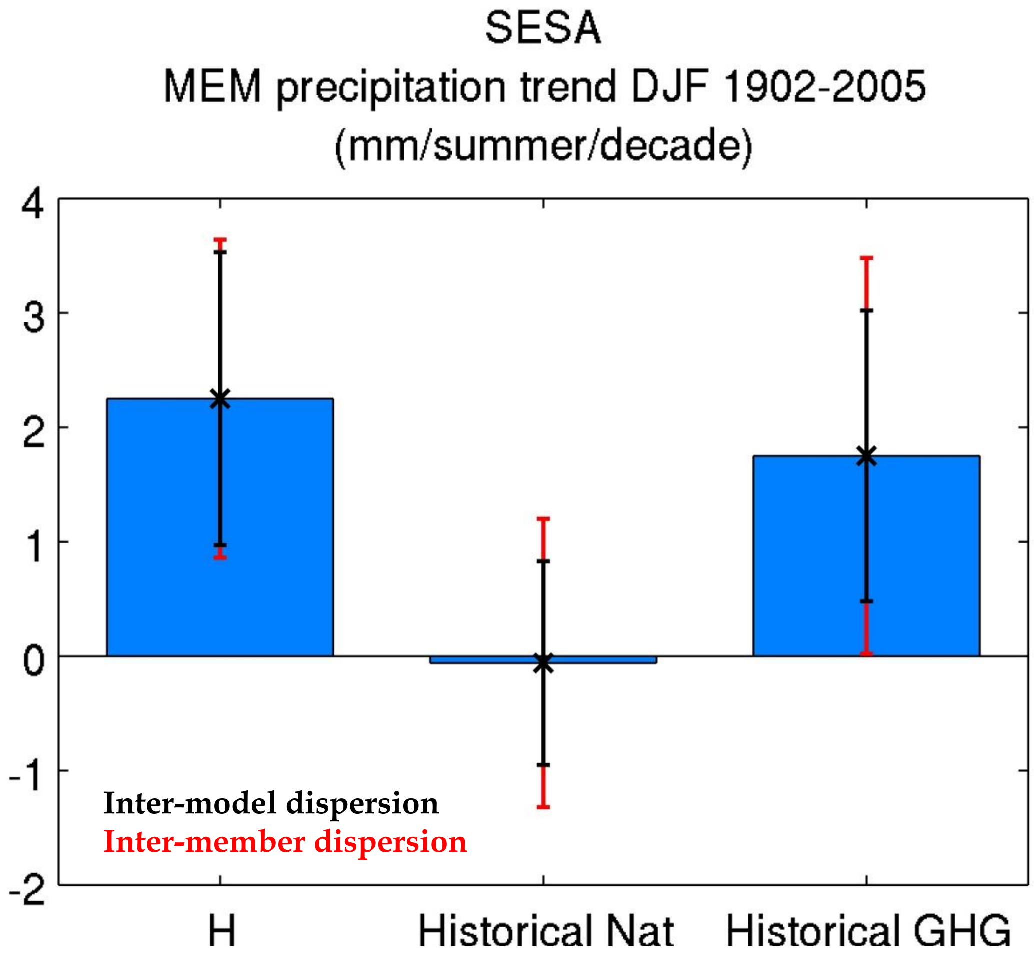
Observations (GPCC)



CMIP5 Historical simulations(H) Multi-model Ensemble (MEM)



Vera and Díaz (2015)



- Anthropogenic forcing in CMIP5 models has a detectable influence in explaining the precipitation trends in SESA.
- Uncertainties associated with model differences and internal climate variability are large

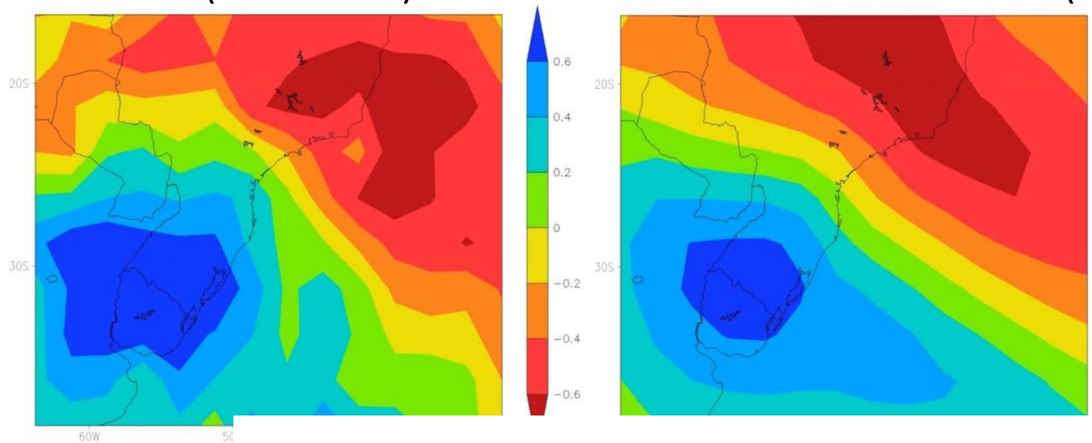
Vera and Díaz (2015)

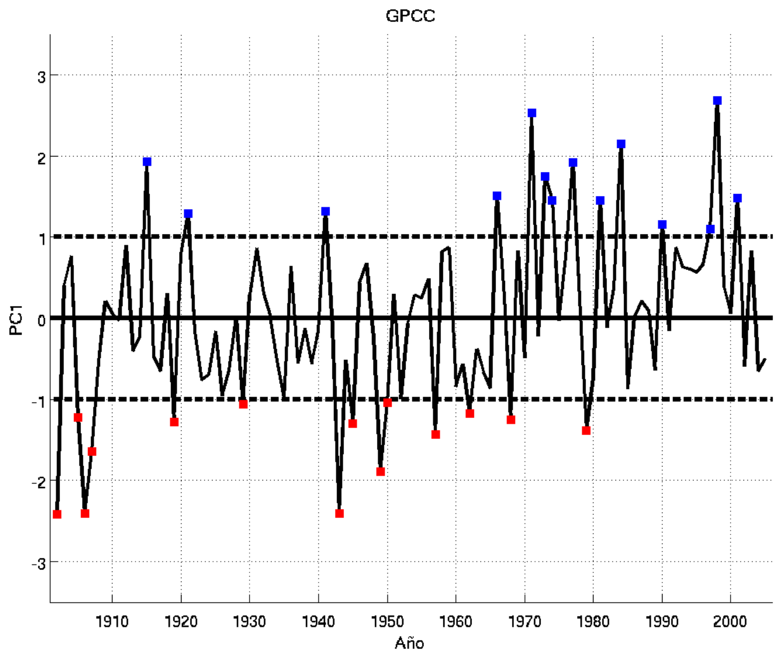
Internal variability and forced trends at present climate

Leading pattern of summer precipitation variability (EOF1)

CMAP (1980-2005)

CMIP5 MEM Historical runs (1902-2005)



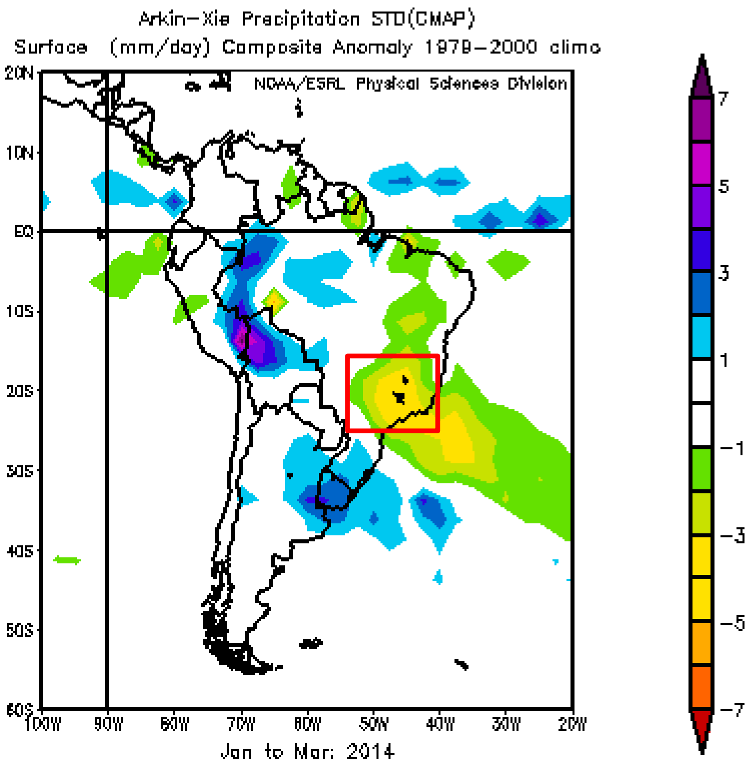


Observations and most of the models exhibit an **increase** of the **frequency** of **EOF1 positive phase** (wetter conditions in SESA and drier conditions in SACZ)
since early XX century to present

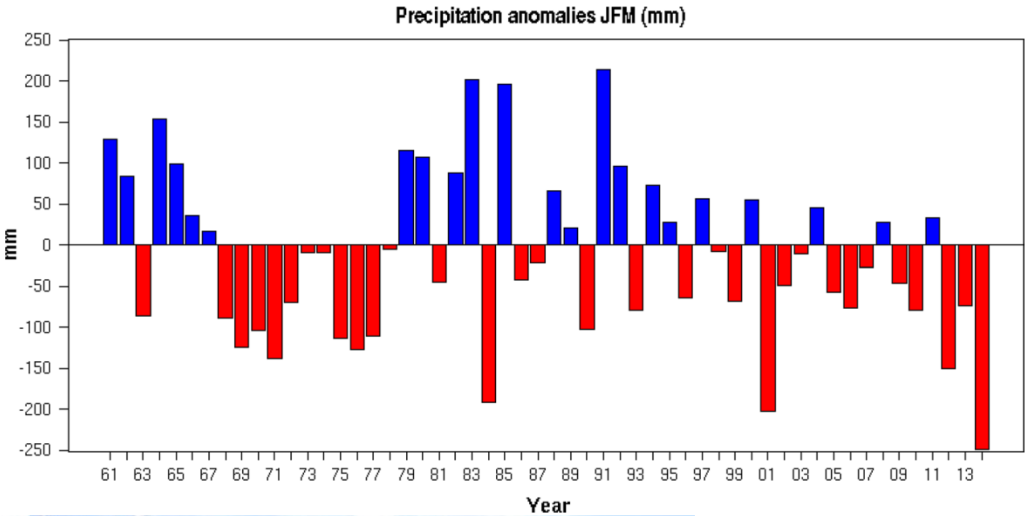
Díaz and Vera (2016)

The 2014 southeast Brazil summer drought: Extreme case of a positive EOF1 phase

JFM Precipitation anomaly in 2014



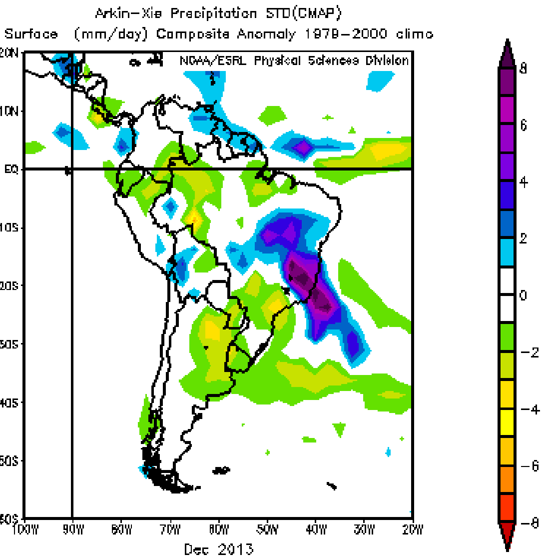
Observed JFM Precipitation anomalies averaged over southeast Brazil from 1961 to 2014



Coelho et al. (2015)

2013 December: Extreme case of a negative EOF1 phase

2013 December
Precipitation anomaly



Extreme heat wave in Argentina

- More than 15 days with extreme hot conditions
- Collapse of the energy system of Buenos Aires

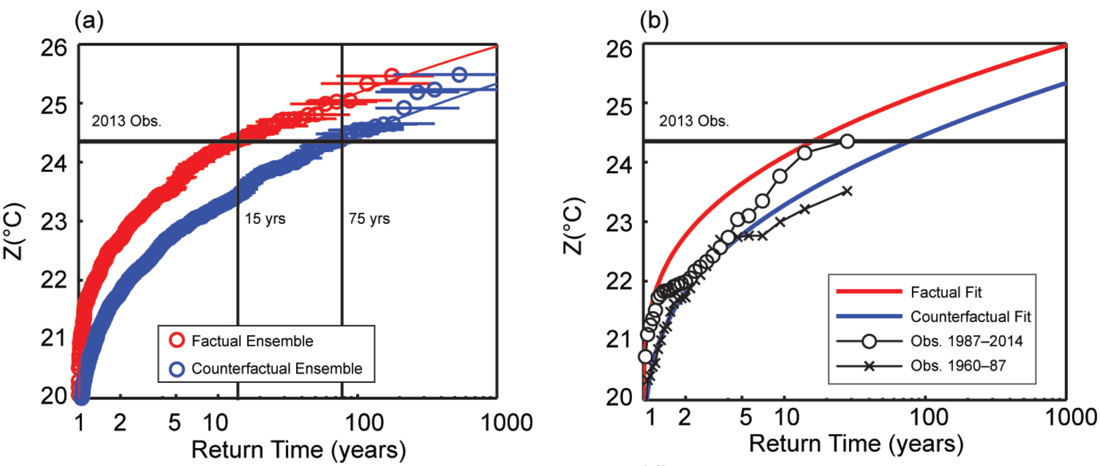
Extreme precipitation and floods in Southeast Brazil

- More than 15 days with extreme rainfall conditions
- Emergency at many states, serious and large socio-economic impacts

2013 Argentina heat wave attribution study

The Argentina heat wave of December 2013 was likely caused in part by anthropogenic forcings.

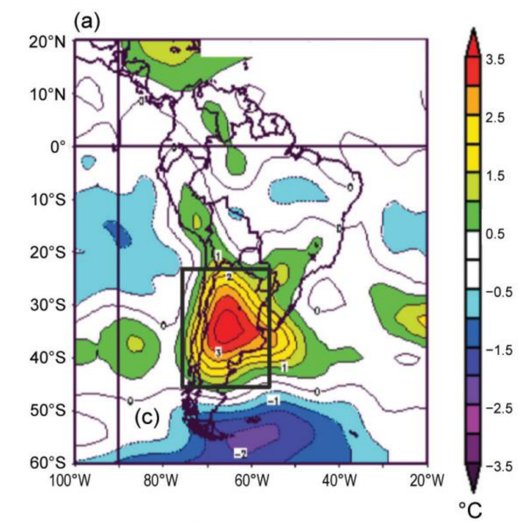
These forcings have increased the risk of such an event occurring by a factor of five



(a) Return level curves simulated by HADAM3P: factual values (red dots) and counterfactual values (blue dots), observed Dec 2013 value

(b) Same as (a) with superimposed observations over the 1960–87 (black line with crosses) and 1987–2014 (black line with circles) periods

2013 December
surface air temperature anomaly

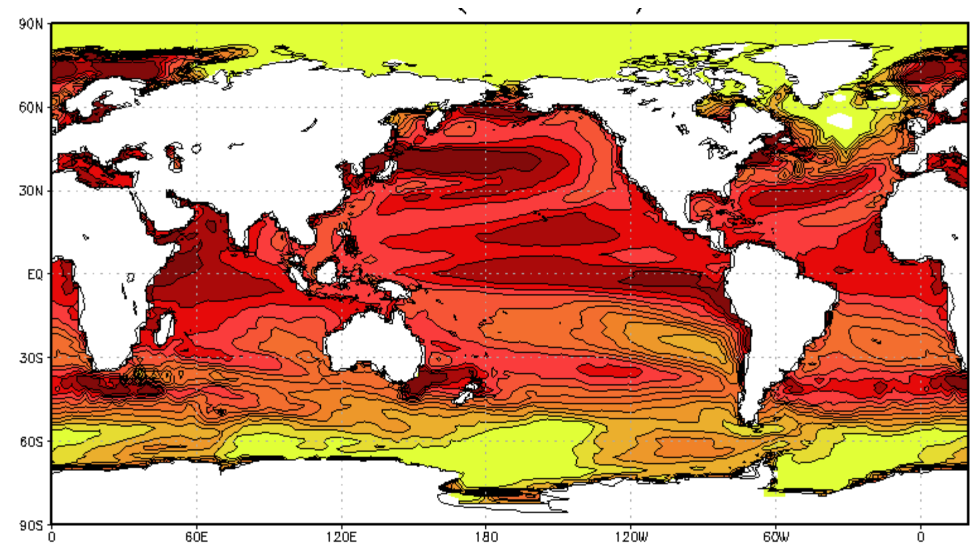


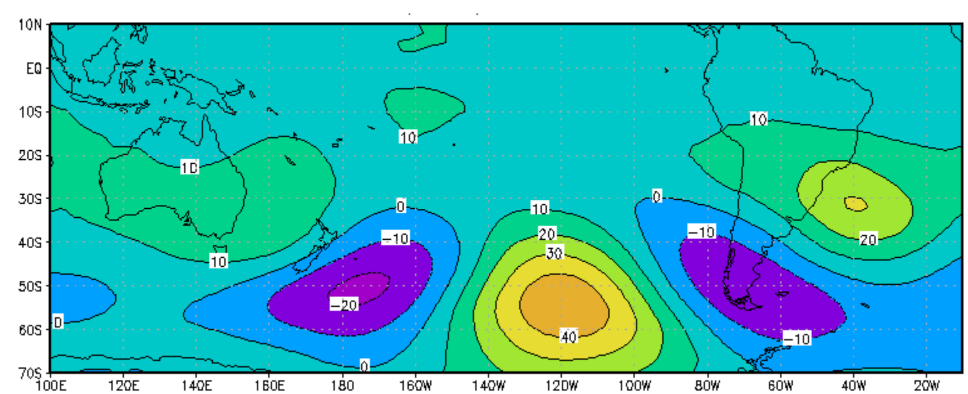
Hannart, Vera, Otto and Cerne (BAMS,2015)

Internal variability and forced trends at future climate

Most of CMIP3 models project for the rest of the 21st century an **increase** of the **frequency** of **EOF1 positive phase** (wetter conditions in SESA and drier conditions in SACZ)

in association with
changes of tropical SST
and
circulation in the Southern Hemisphere





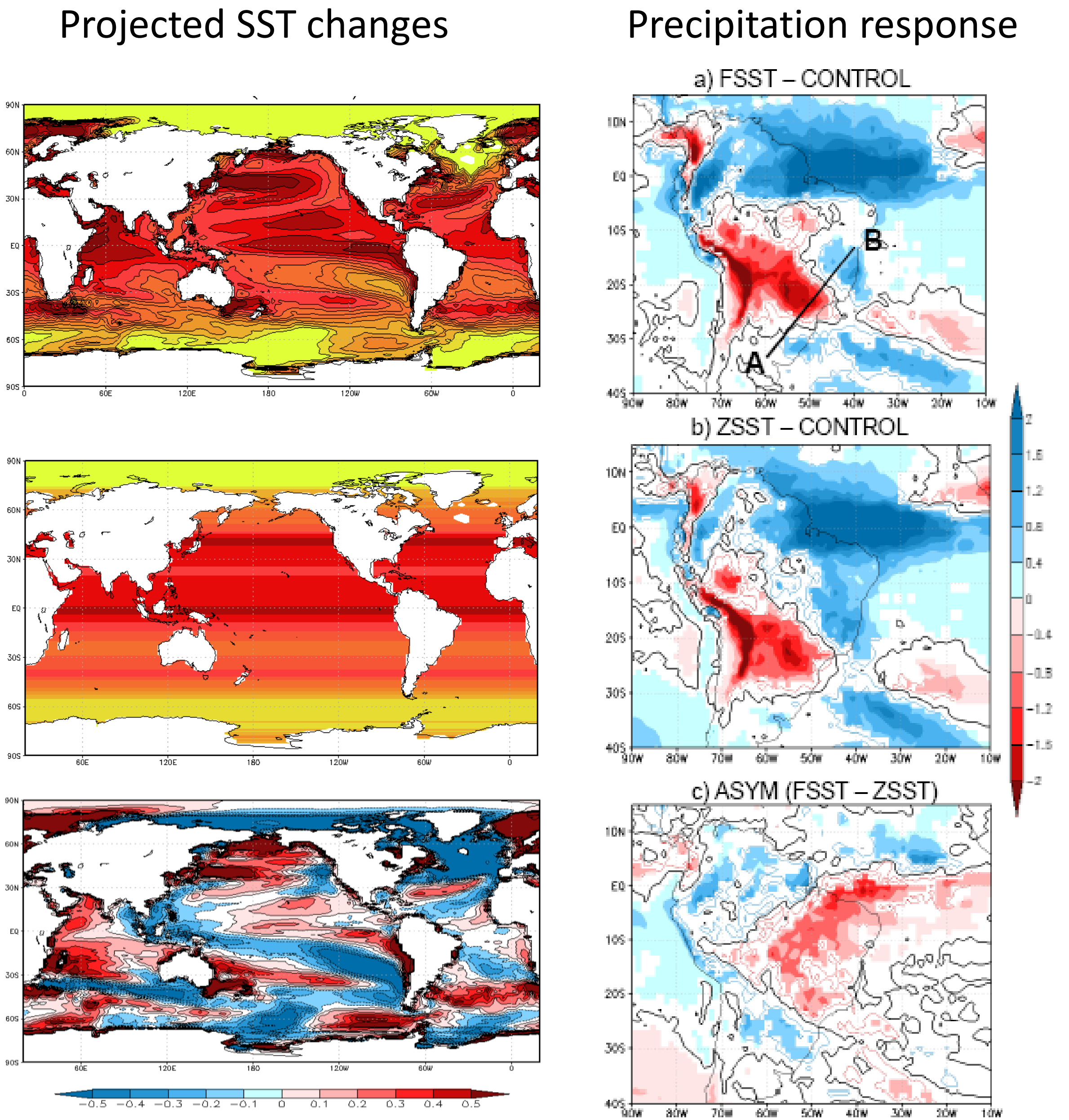
Junquas, Vera, Le Treut and Li (2012)

Sensitivity experiments performed with LMDZ model show that rainfall projected changes in eastern South America by the end of 21 century is strongly influenced by:

- the response to the zonally-asymmetric component of the SST change that induces precipitation increase at SESA and a decrease over the SACZ region. Differential tropical SST increase is associated with Indian-Pacific warming larger than that in the Atlantic

- The response to zonally symmetric component of SST induces opposite precipitation behavior.

- Uncertainties are large.



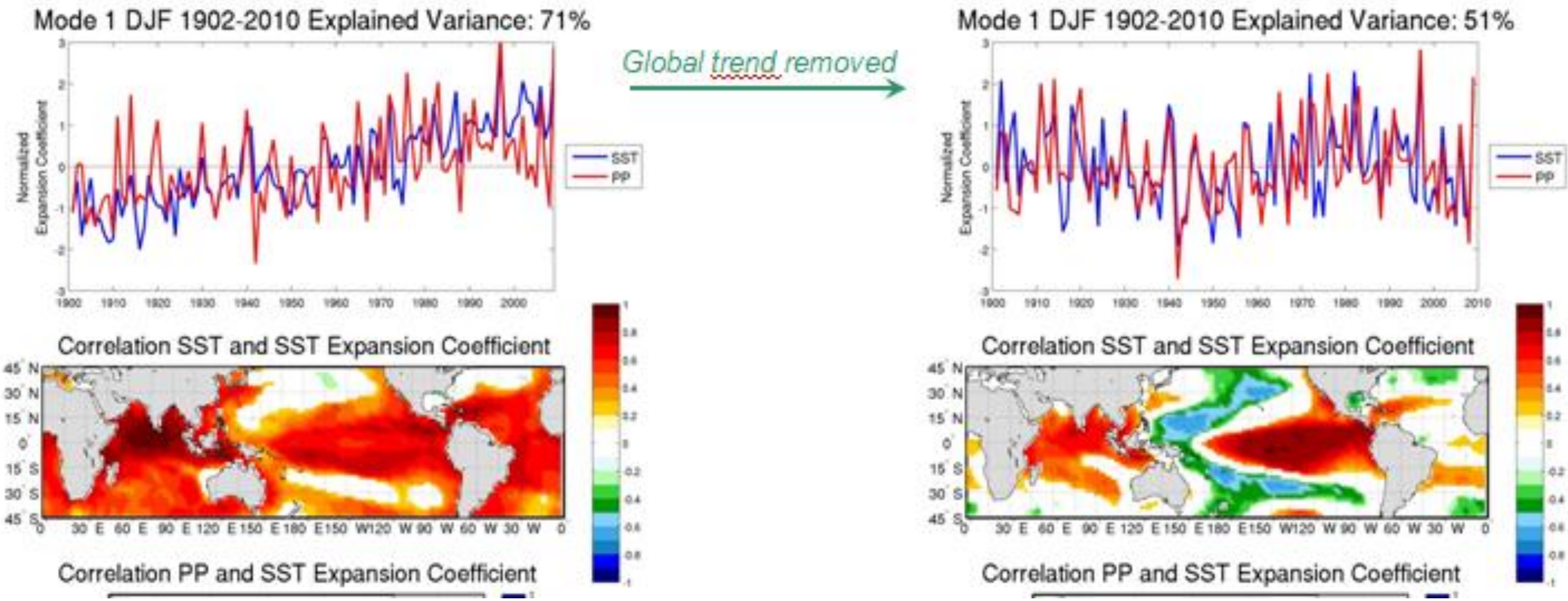
Junquas, Vera, Le Treut and Li (2012)

How the regional climate variability in South America will evolve in the next years-decades largely depends on:

- the internal natural variability mostly associated with the tropical ocean evolution

- The external climate forcing associated with both natural and anthropogenic sources

The interannual and decadal variability of EOF1 is associated with that of the tropical oceans

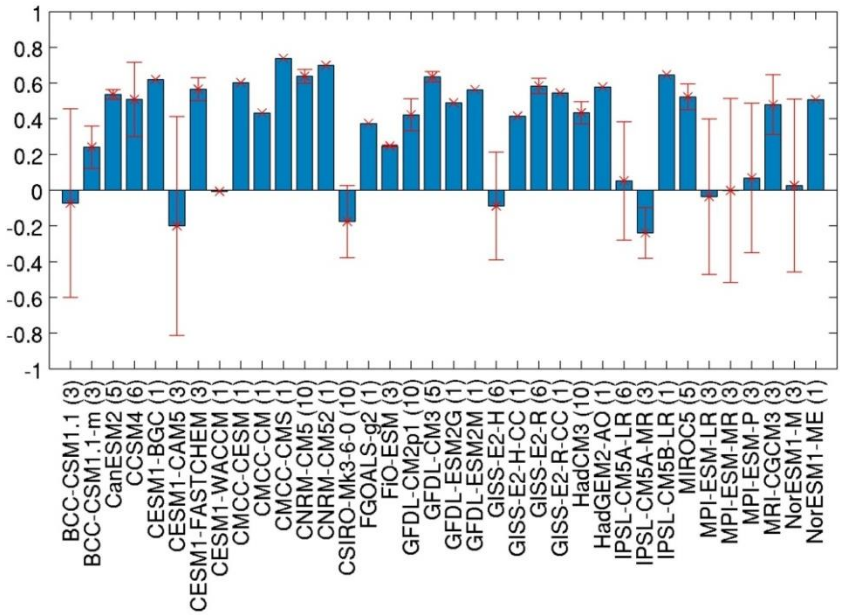


Previous studies confirm that climate patterns as ENSO, Pacific Decadal Oscillation (PDO), as well as those related with the Indian and Atlantic Oceans influence the climate variability in eastern South America

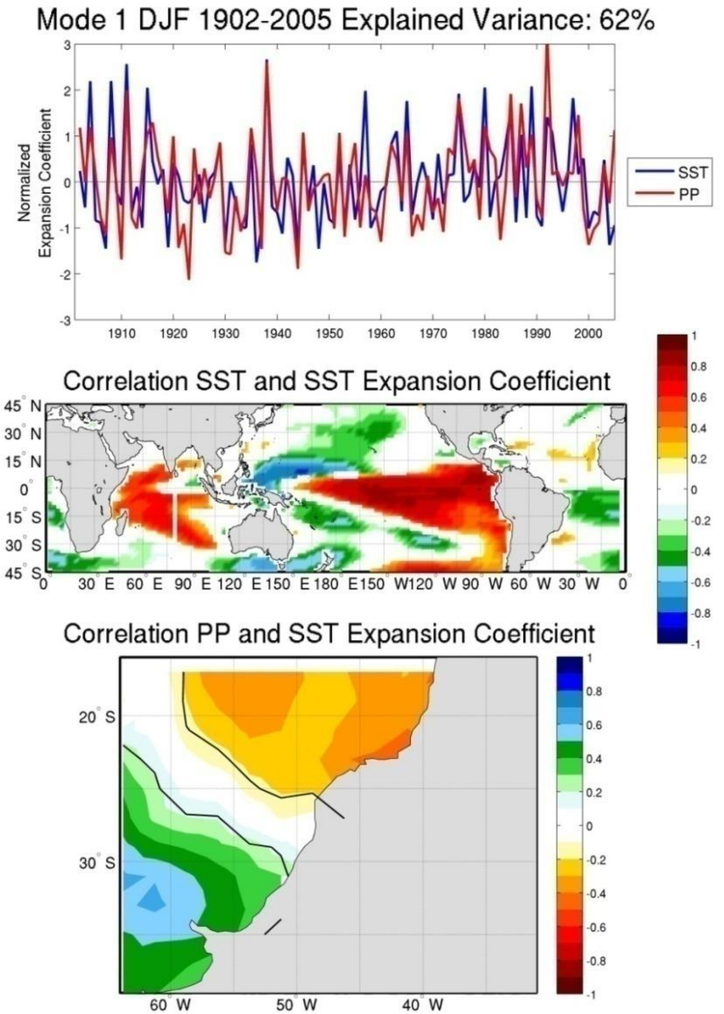
Díaz Vera, and Saurral (2016)

Can CMIP5 historical runs reproduce the main features of climate variability in South America?

CMIP5 Model skill in representing EOF1



GFDL-CM3 Model historical run



(Assessment of CMIP5 decadal predictions is in progress)

Díaz Vera, and Saurral (2016)

Can climate models predict the ocean variability influencing South America?

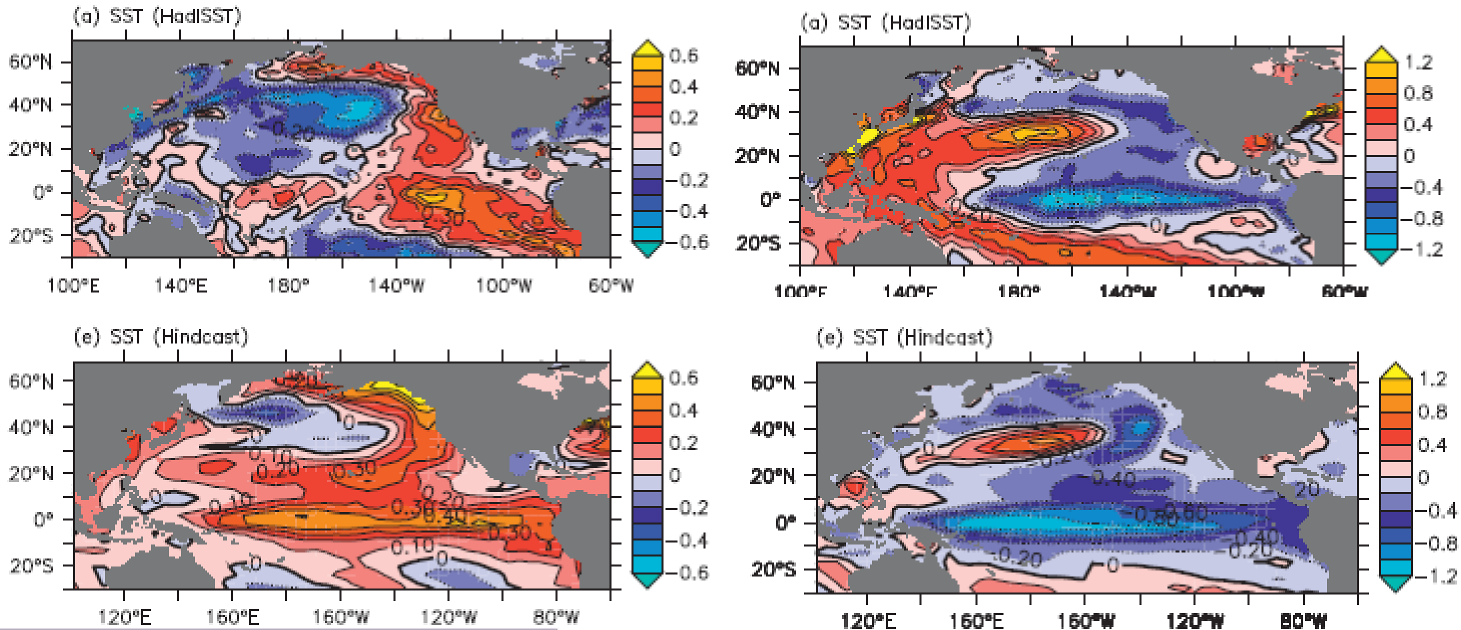
- Pacific Decadal Oscillation
- ENSO
- Tropical Indian Ocean

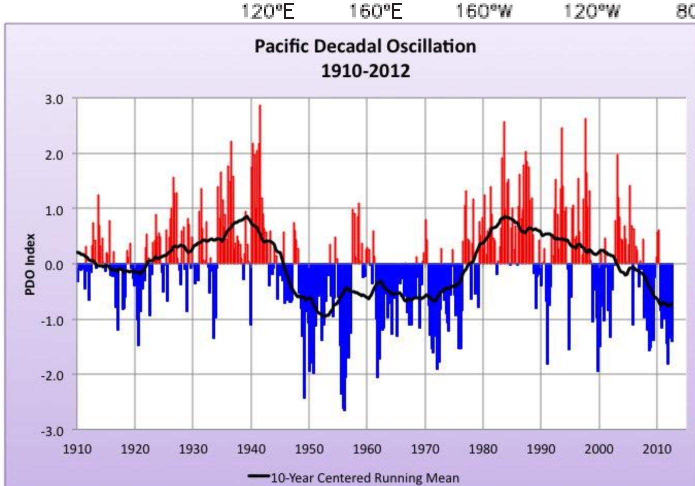
Decadal Predictions of the Pacific Decadal Oscillation (PDO)

PDO Positive Phase (1976-1985) | PDO negative Phase (1998-2002)

Observations

Decadal prediction by Kiel Climate Model





Observed evolution of the PDO index (detrended)

Ding et al. (2013)

Decadal Predictions of the Pacific Decadal Oscillation (PDO)

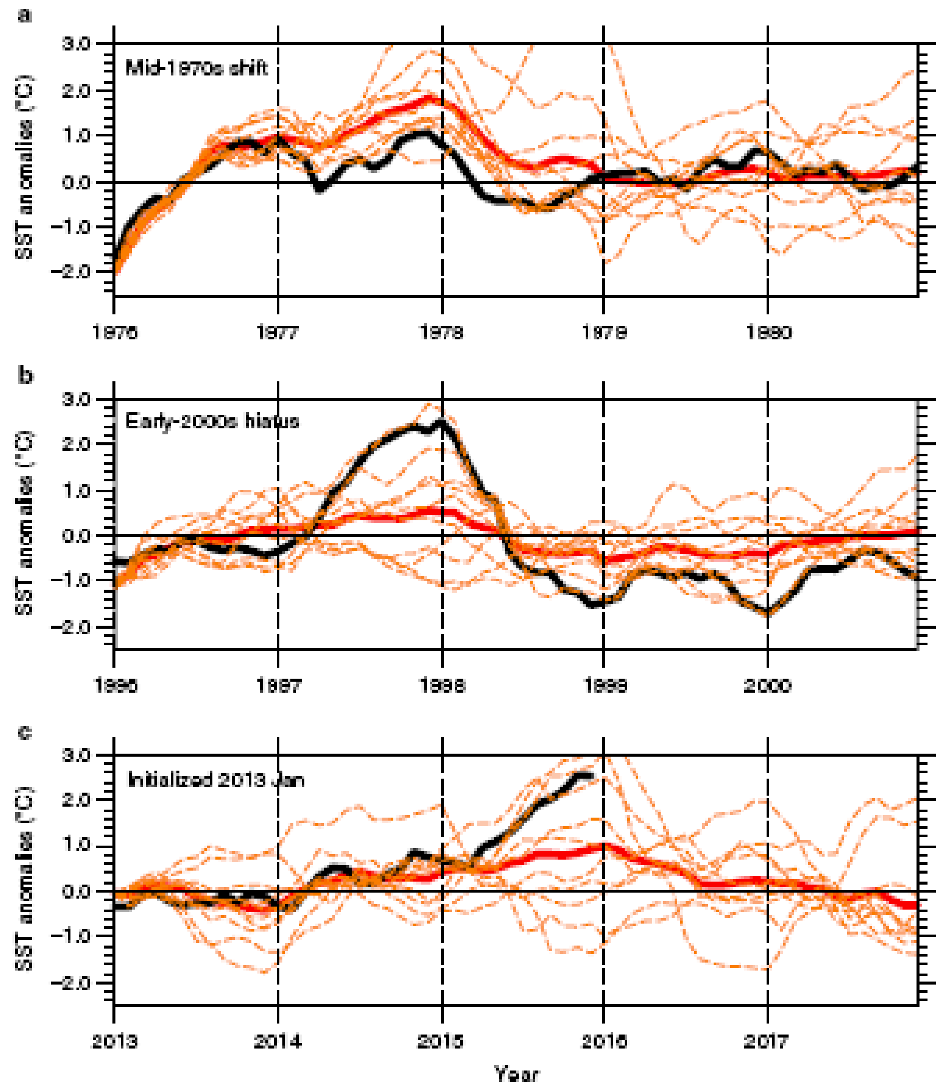
Initialized predictions of eastern equatorial Pacific sea surface temperatures.

Observations

Individual model ensemble members

Model ensemble mean

(NCAR/CCSM4 Model)

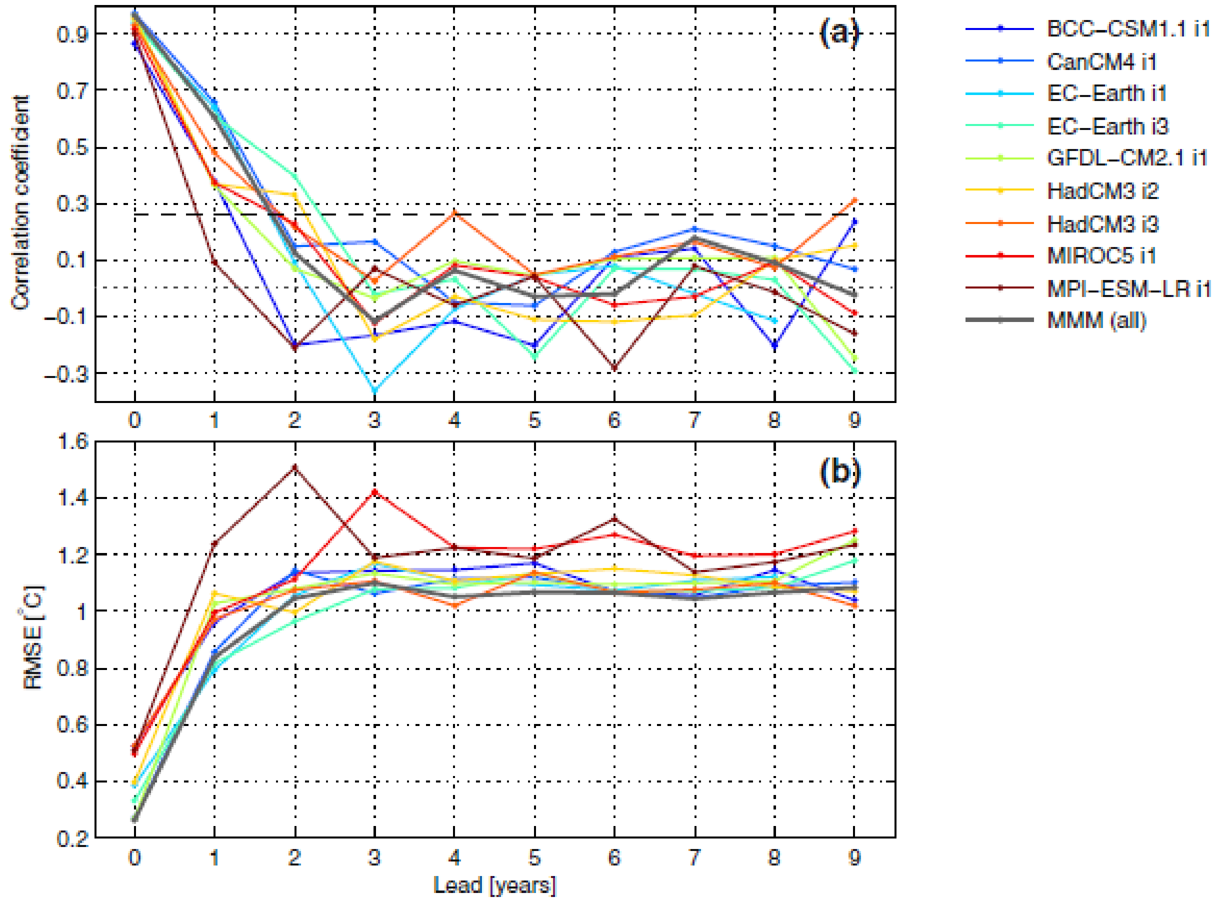


Meehl et al. (2016)

CMIP5 decadal prediction skill for DJF ENSO index

Anomaly correlation (ACC)

Root mean square error (RMSE)



(dashed line indicates 95% significant threshold)

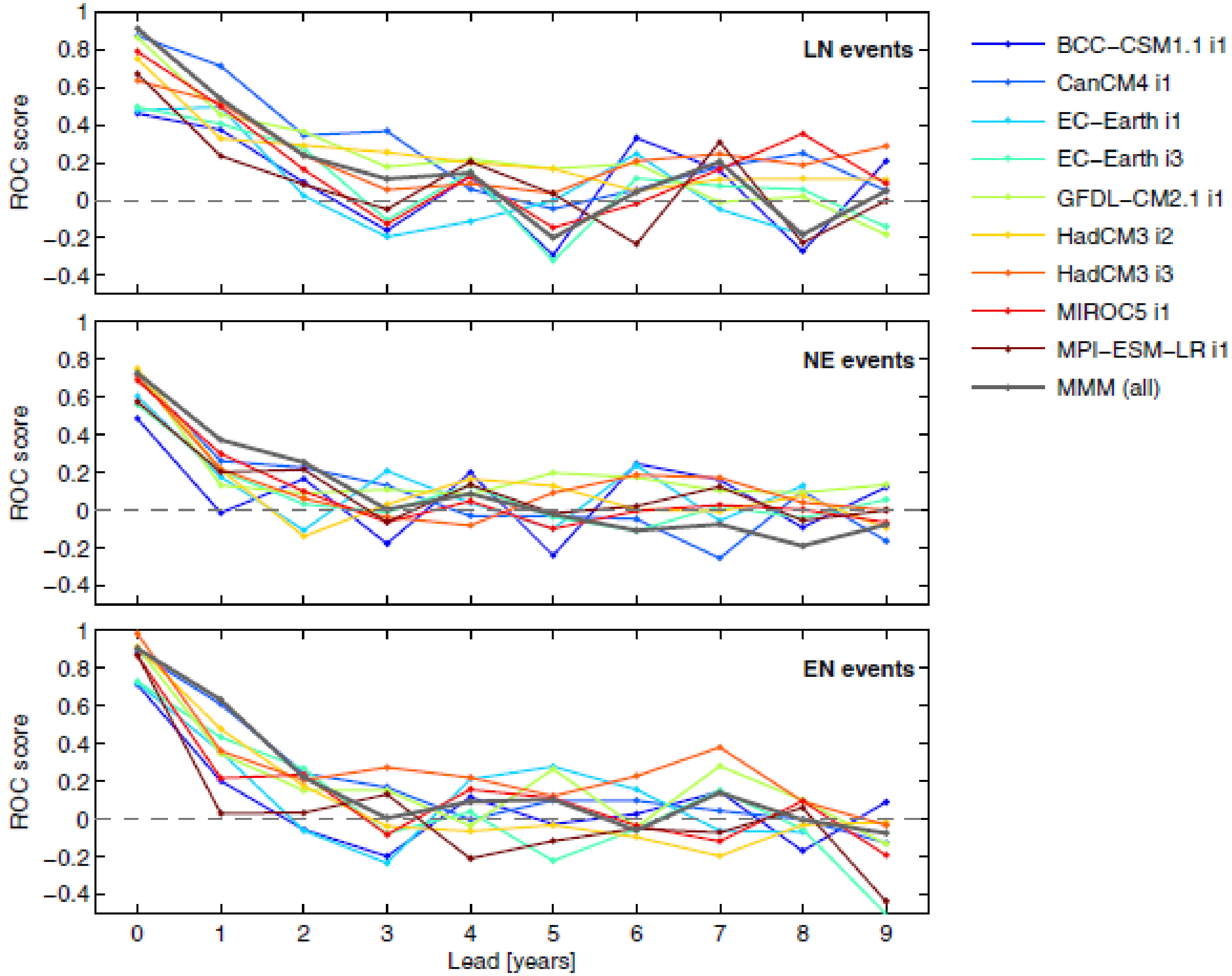
Gonzalez and Goddard (2016)

CMIP5 decadal probabilistic prediction skill for ENSO phases

La Niña

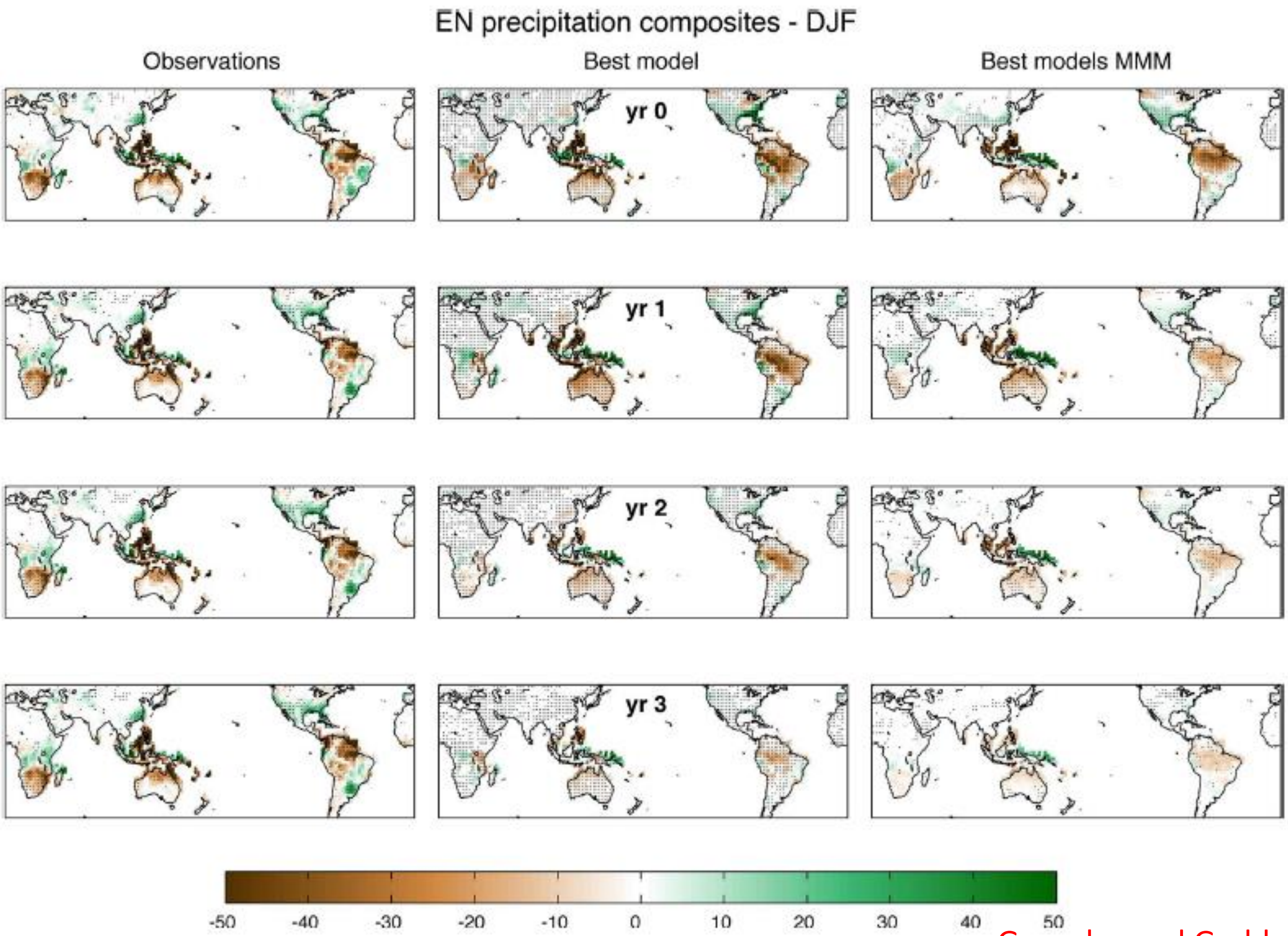
ENSO-Neutral

El Niño



Gonzalez and Goddard (2016)

Composites of precipitations anomalies for El Niño events

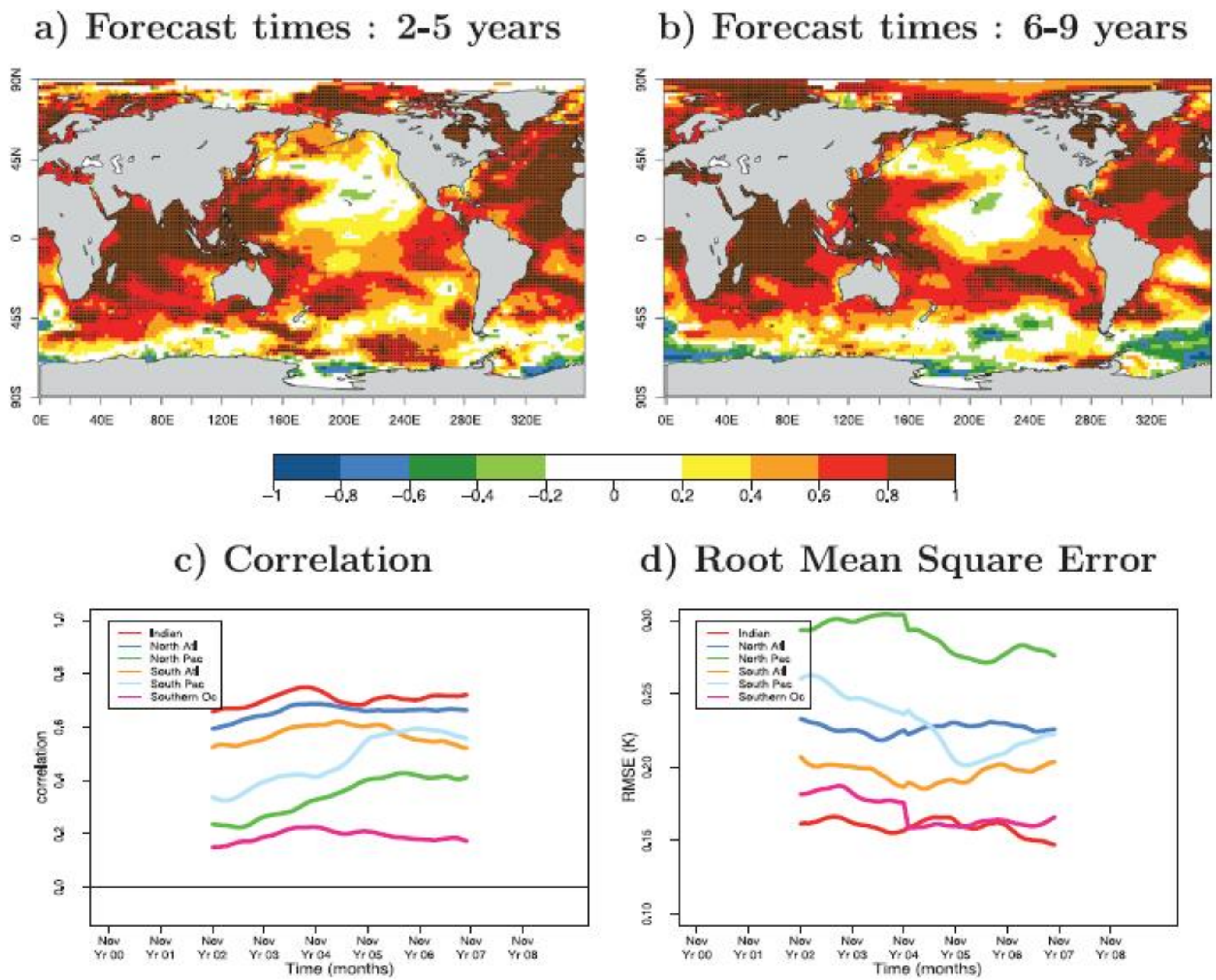


Gonzalez and Goddard (2016)

The Indian Ocean: The Region of Highest Skill Worldwide in Decadal Climate Prediction

Correlation between the ensemble-mean predicted and ERSST sea surface temperature anomalies in the CMIP5 Init decadal hindcasts.

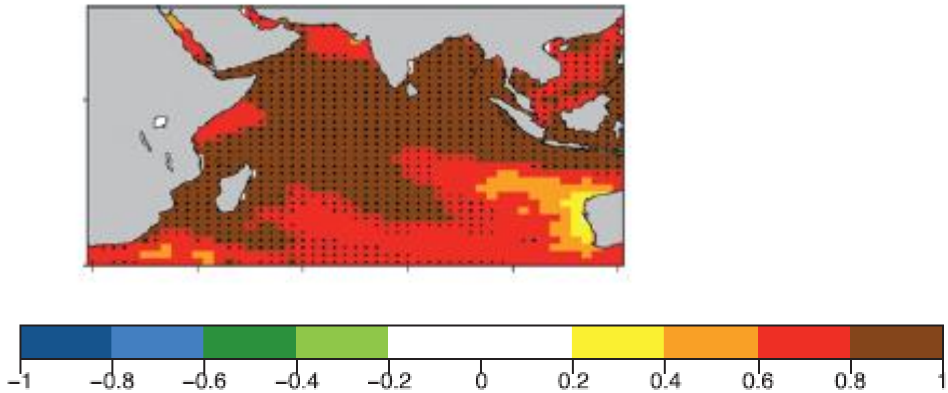
Skill metrics per basin



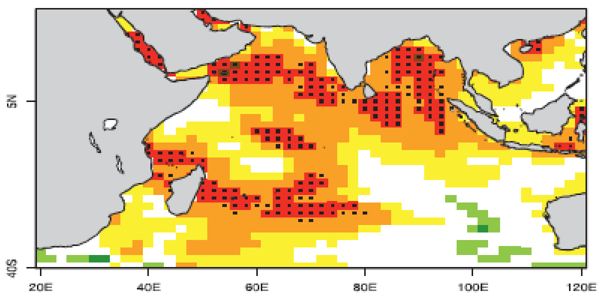
Guemas et al. (2016)

A high SST skill in the Indian Ocean: Contribution of the external forcings

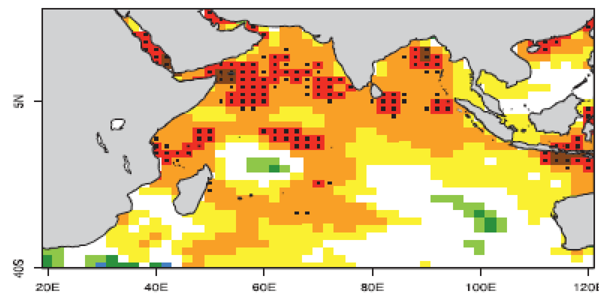
Correlation between the ensemble-mean predicted and ERSST sea surface temperature anomalies for CMIP5 Init predictions



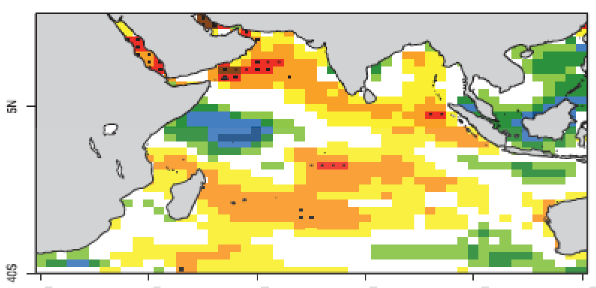
a) CO2 effect
filtered out by linear regression



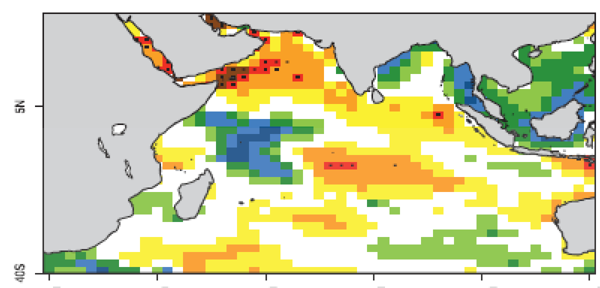
b) CO2 + Solar activity
filtered out by multiple linear regression



c) CO2 + volcanic eruptions
filtered out by multiple linear regression



d) CO2 + Solar + Volcanoes
filtered out by multiple linear regression

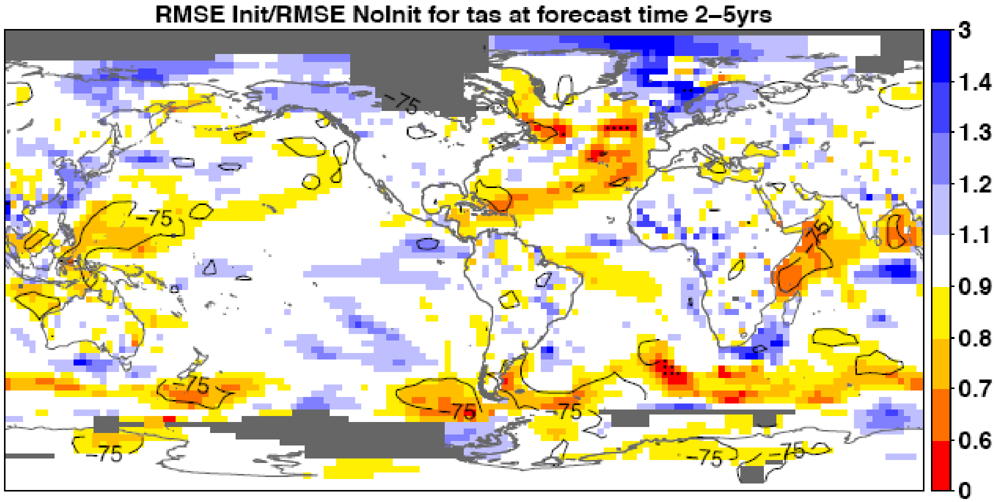


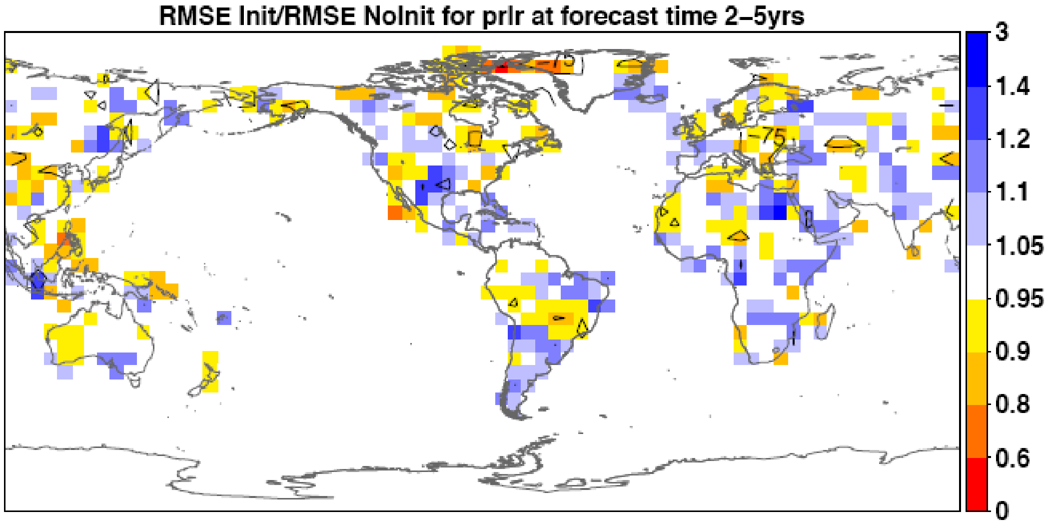
Guemas et al. (2016)

How is the current skill of decadal climate predictions at regional scales?

Ratio between the Root Mean Square Error of the CMIP5 Ensemble mean for Init and No Init

Surface air temperature

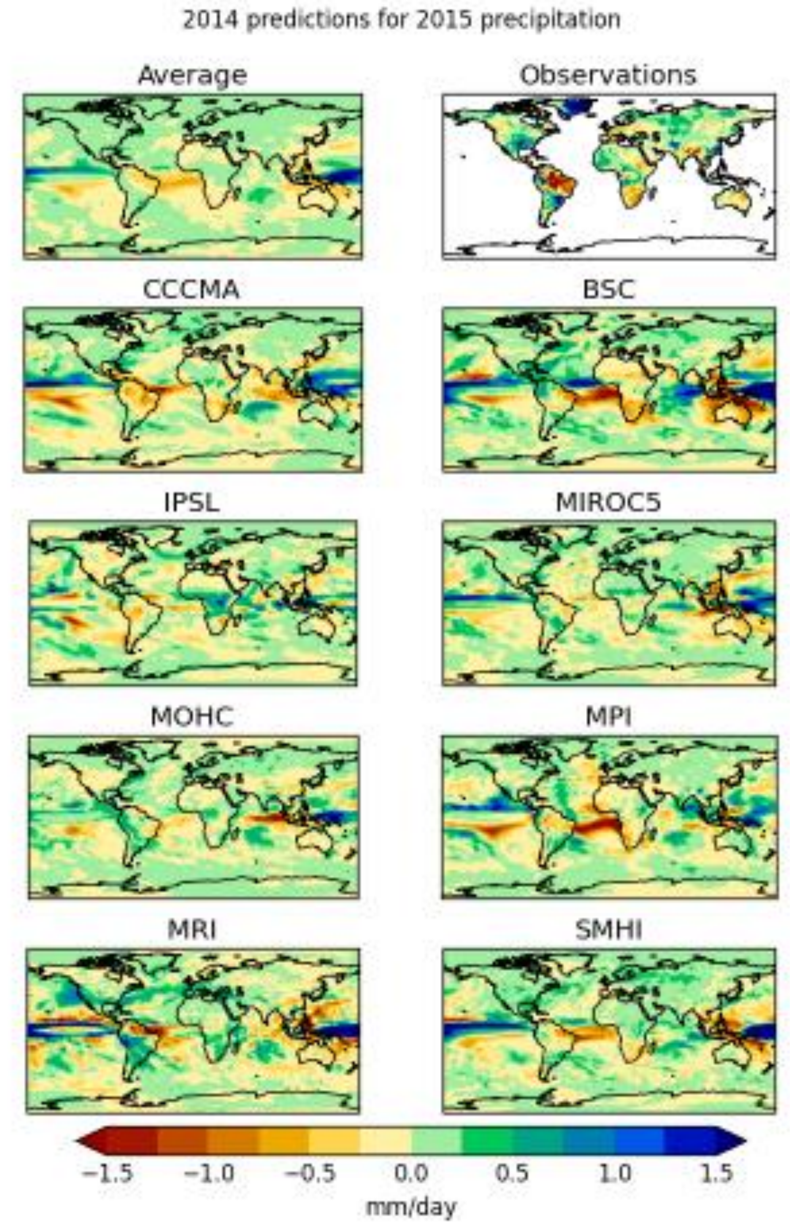




Precipitation

IPCC-AR5 (Chap 11, WG1)

Real-time decadal predictions

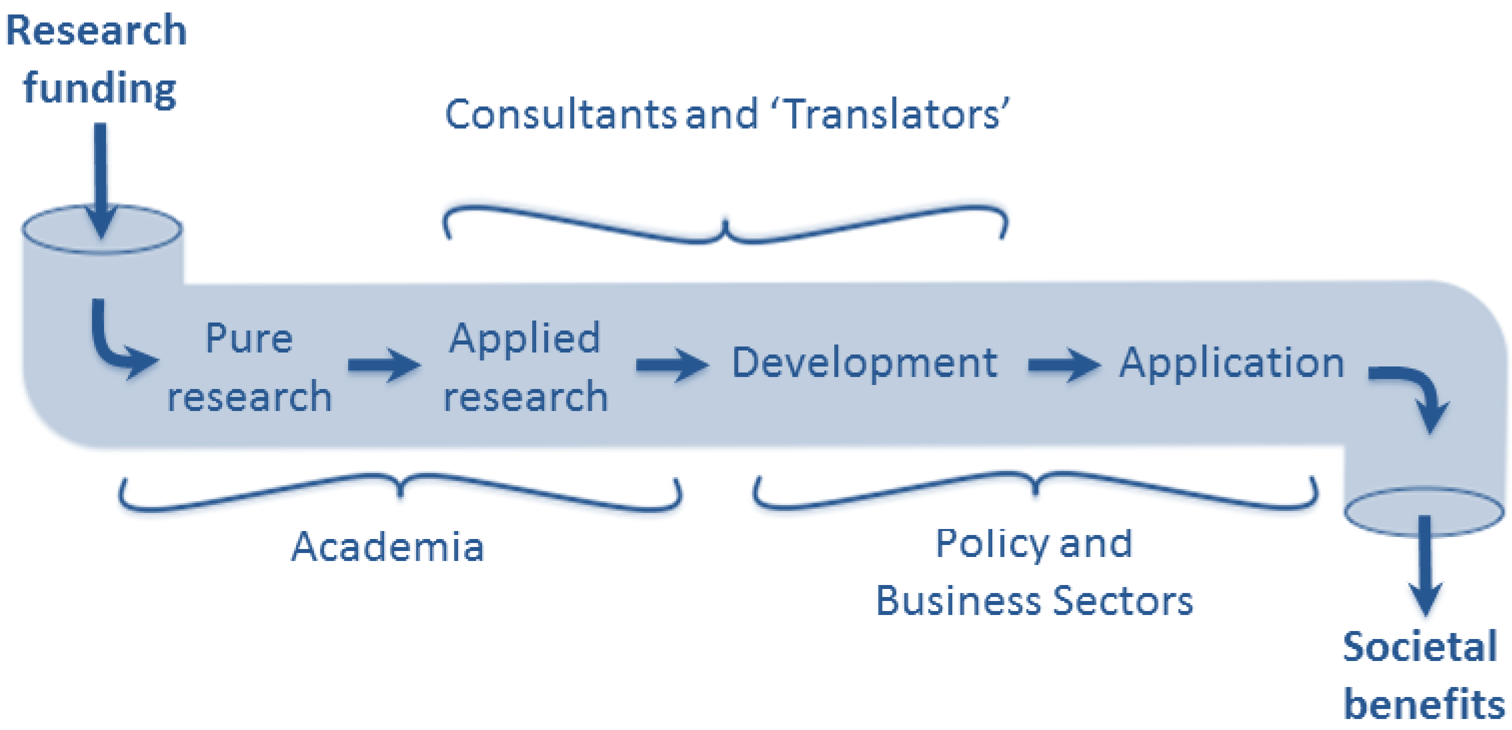


SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

- **There are concrete possibilities to develop climate information on yearly and decadal timescales to support the development of mitigation and adaptation options**

- **How is the climate information currently being delivered?**

Climate information is usually being provided through the 'linear model' of science and society



•Some critics have argued that current climate forecasts and the way they are presented and disseminated are many times ineffective.

•This is not an intrinsic deficiency of scientifically based climate knowledge; it is more likely a consequence of the complexity of the decision making process and the difficulties of decision makers and scientists to recognize that the knowledge of managing risk resides with both communities.

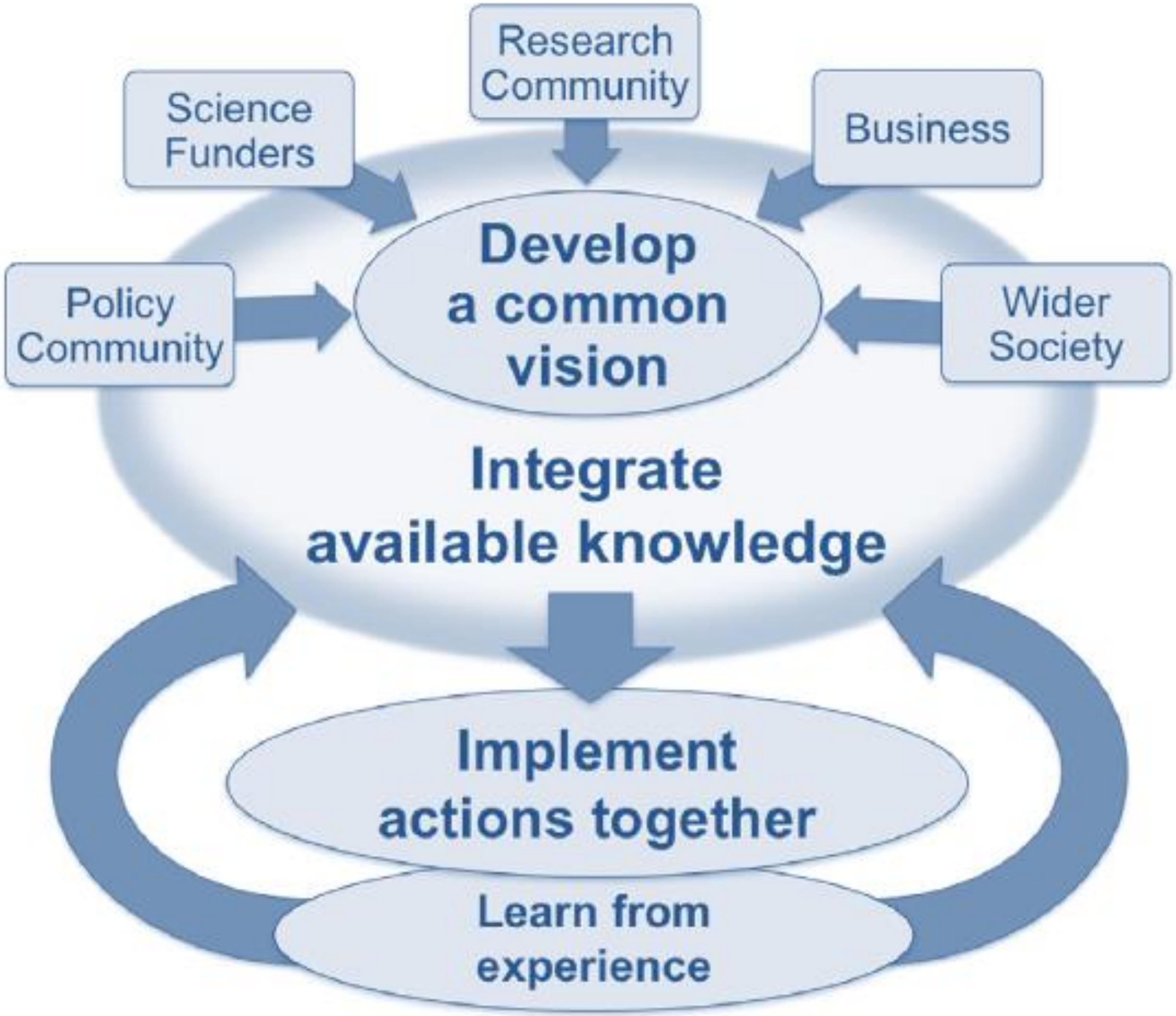
•Climate information to translate into real-life action requires:

- **•Salience** (is the information provided that the users think they need, in a form and at a time that they can use it?)
- **•Credibility** (is the information perceived as technically valid?)
- **•Legitimacy** (is the information aligned with the interest of the users?)

•Alternative ways of engagement between scientists and decision makers are needed

(Meinke et al. 2006)

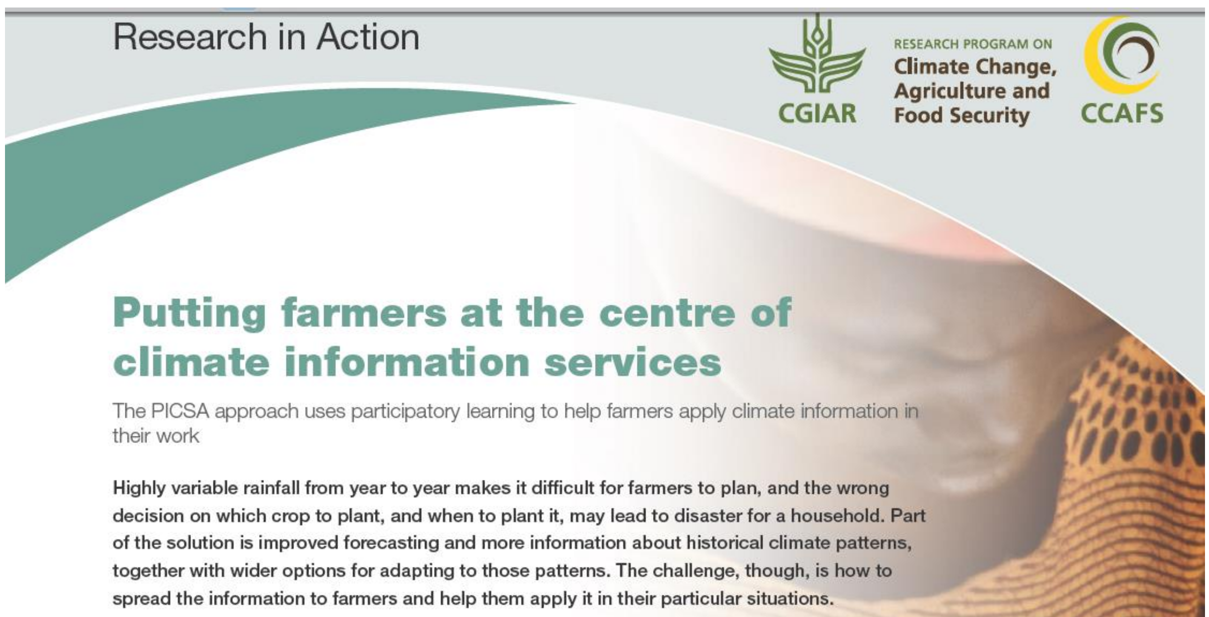
Co-design and co-production of knowledge



- Co-production not only expands the available expertise and knowledge that can be harnessed for problem solving;

- but helps to make informed judgments about the uncertainty and the probabilistic nature of future weather and climate conditions, which are inherently uncertain.

- Joint accountability for the generation and use of probabilistic information is fundamental.


Research in Action

CGIAR

RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

CCAFS

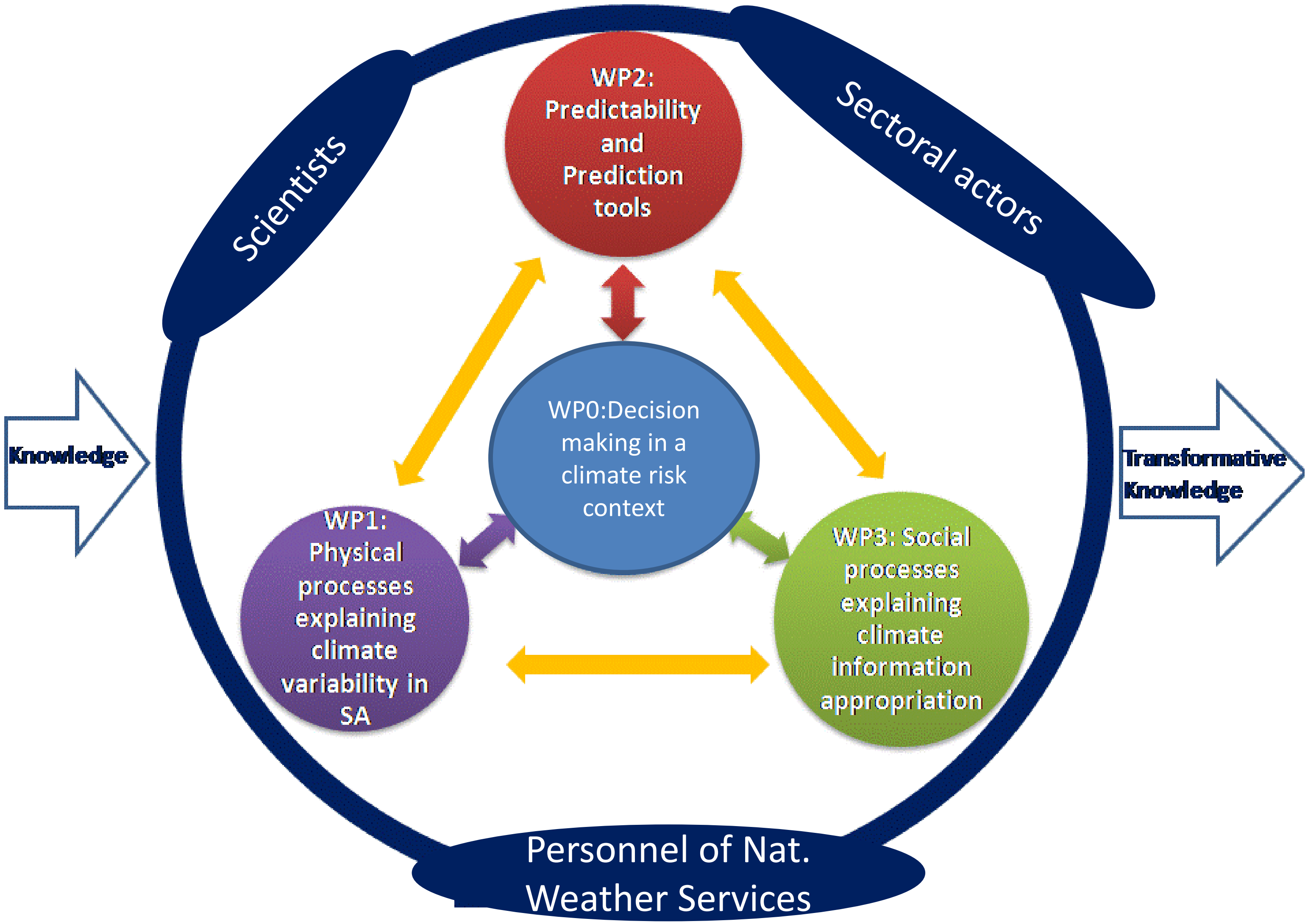
Putting farmers at the centre of climate information services

The PICSA approach uses participatory learning to help farmers apply climate information in their work

Highly variable rainfall from year to year makes it difficult for farmers to plan, and the wrong decision on which crop to plant, and when to plant it, may lead to disaster for a household. Part of the solution is improved forecasting and more information about historical climate patterns, together with wider options for adapting to those patterns. The challenge, though, is how to spread the information to farmers and help them apply it in their particular situations.

Belmont Forum funded Project: CLIMAX

An inter- and trans-disciplinary framework based on a European-South American research cooperation to underpin climate services in **southern South America**



CONCLUSIONS

•There is a need of climate information at all timescales to underpin decision making of many socio-economic sectors in South America

•Decadal variability is important. Decadal predictions are new and still don´t have much skill on regional scales but skills on predicting large-scale climate patterns are promising

•Climate variations at yearly and decadal timescales can be characterized integrating historical climate variability knowledge with climate predictions.

•Experience shows that the transfer of climate information does not necessarily mean that it is going to be automatically adopted by decision makers.

•The climate risk management requires holistic solutions derived from inter-disciplinary research made in the context of co-design and co-production