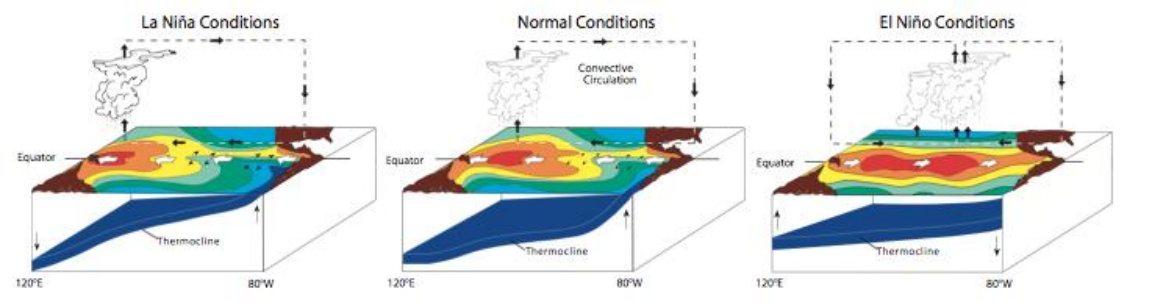
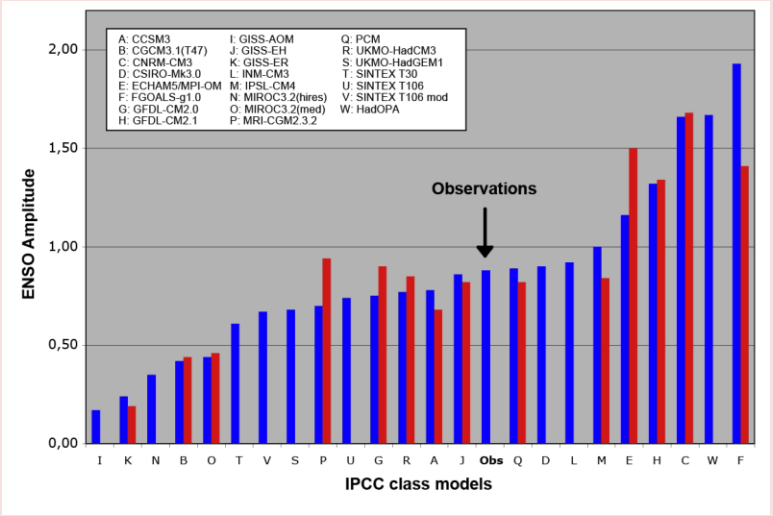
Understanding tropical pacific mean state and El Niño errors in climate models using seasonal forecasts techniques

Benoît Vannière and Eric Guilyardi

> El Niño : a case study

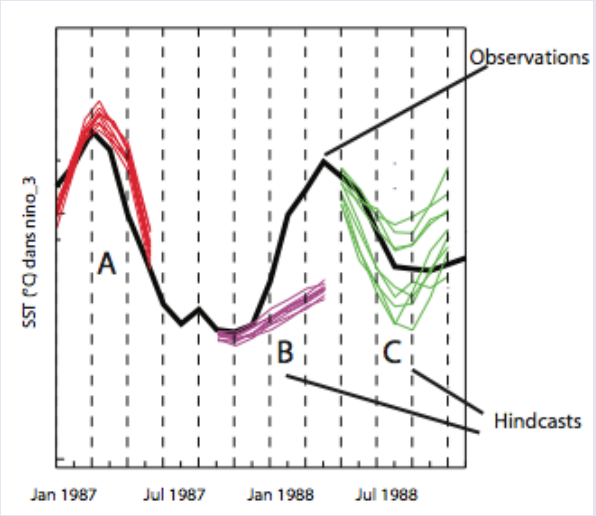


> Climate models still exhibit coupled errors



ENSO amplitude in CMIP3 CGCMs compared with the observations. Guilyardi (2009)

> Seasonal forecasts techniques : an alternative to long stabilized simulations to study the development of CGCMS biases



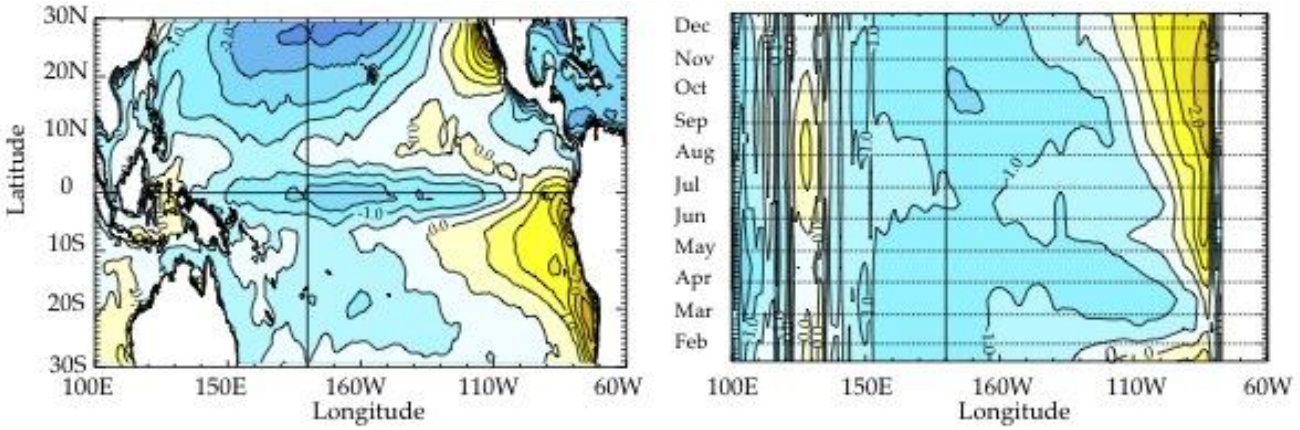
A. Perfect forecast.
B. Systematic bias.
C. Sensitivity to initial conditions.

2nd Part : Vanniere et al. 2012b A hindcast and partially coupled strategy to identify the source of tropical SST errors in coupled GCMs. (in preparation)

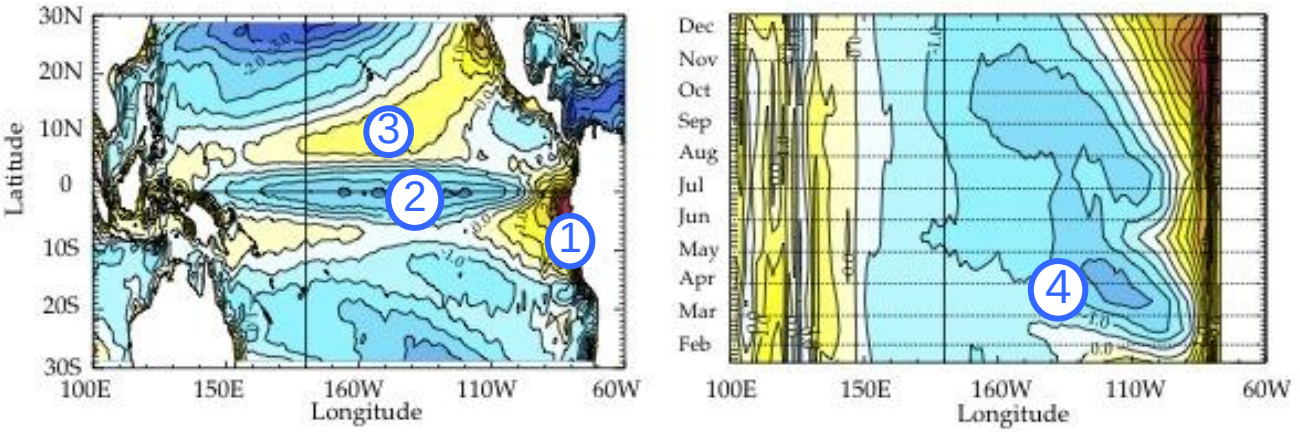
Strategy to identify tropical mean state biases. The strategy used in Vanniere et al. 2012a is developed, exploring lead time ranging from season to decade and completed by simulations with various degrees of coupling.

> SST mean state bias in the tropical Pacific

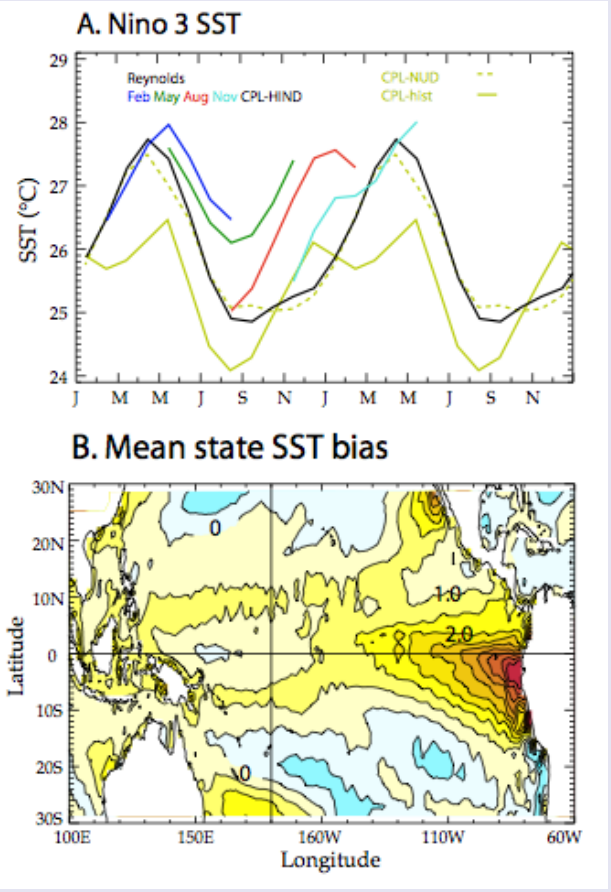
CMIP3+CMIP5



IPSL-CM5A

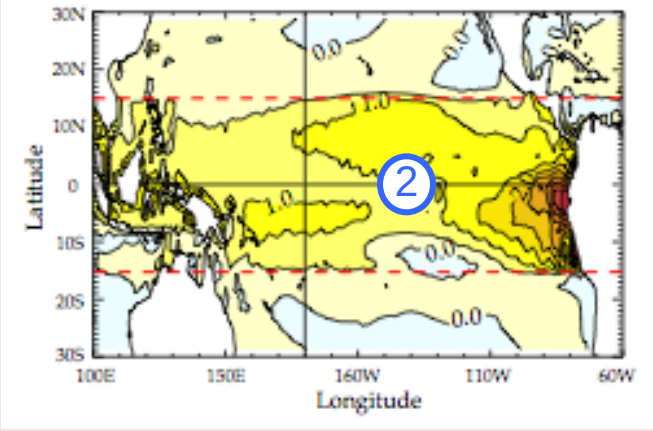


> At seasonal time scale, development of the East Pacific warm bias (1) and ITCZ and SPCZ warm biases (3).



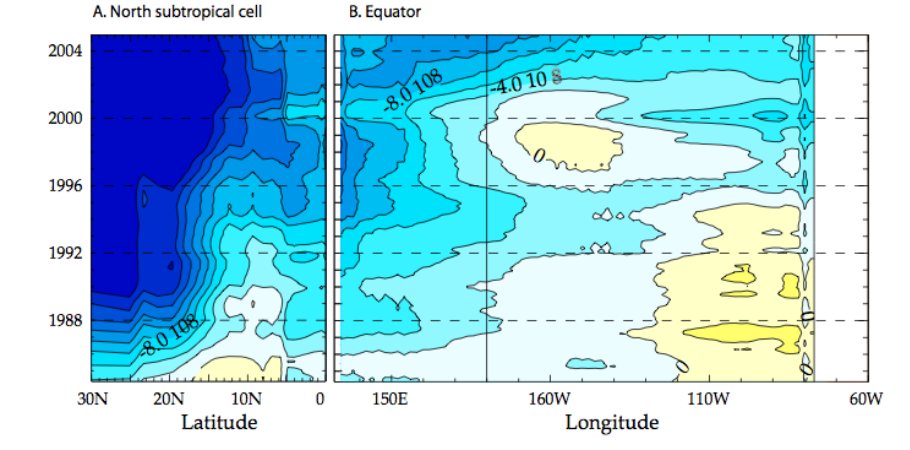
> Partially restored experiment allow to identify the geographical origin of SST bias.

Here the subtropical cold bias is suppressed by nudging SST and the cold bias at the equator (2) disappears.

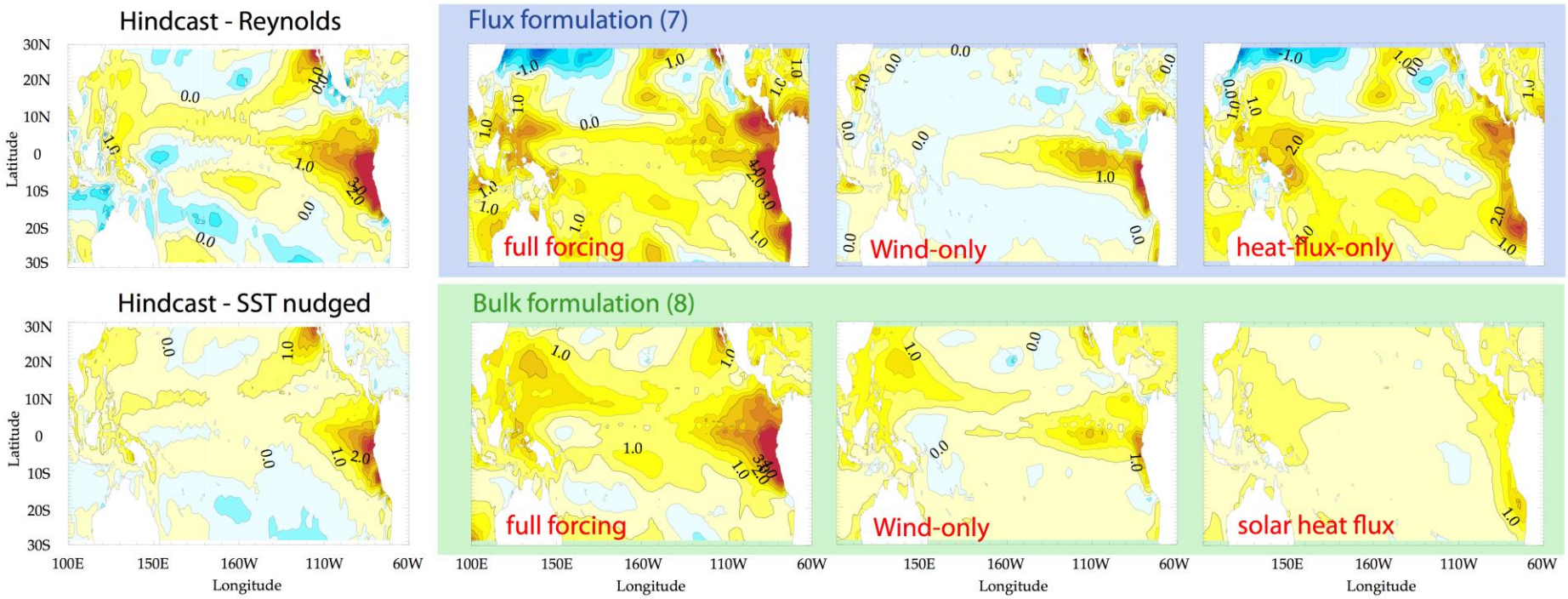


The cold tongue bias has both a long time scale and remote origin.

> In hindcast, the slow equatorward propagation of cold heat content error, suggested an advection by subtropical cells.



> Ocean-only experiments using a blended forcing, made of one atmospheric model output (Q, Taux,…) and observations otherwise, allow to identify the field responsible for the SST error.



The legend in red identifies the field coming from the atmospheric model.
The forcing strategy (either bulk forcing and fixed-flux forcing) is indicated at top of each colored panel.

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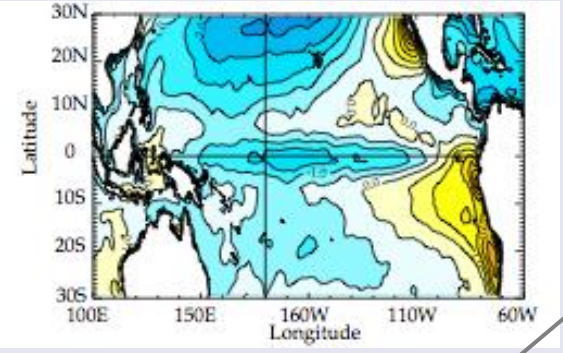
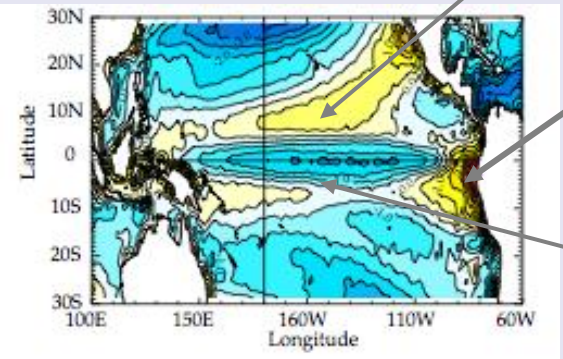
> SST mean state bias in the tropical Pacific

CMIP3+CMIP5



IPSLCM5A



➢Main results

The combination of **leadtime analysis** with **partially restored** experiments and **ocean-only** experiments gives information that is not given by stabilized long simulations, allowing us *to determine errors time scale*, *to distinguish pre-existing biases from errors responding to these biases*, and *to evaluate the role of the coupling in the development of the errors*.

the **off equatorial warm bias in ITCZ and SPCZ region,** develops in 6 months and involves both wind-induced Qlatent errors and Qsw errors.

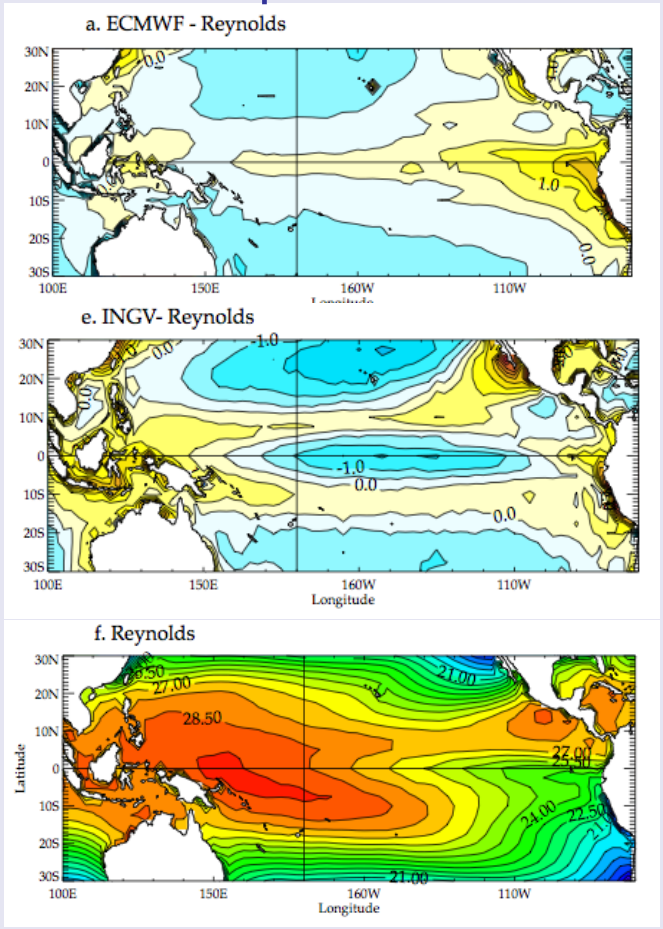
the **East Pacific warm bias** develops in 6 months and is reproduced in ocean only experiments using models 10-wind. It is due to the understimated coastal meridional winds that drive a too weak coastal upwelling.

the so-called **cold tongue bias** develops in 30 years and is the result of the advection of subtropical cold SST bias by subtropical cells.

1st Part : Vanniere et al. 2012 Clim. Dyn.

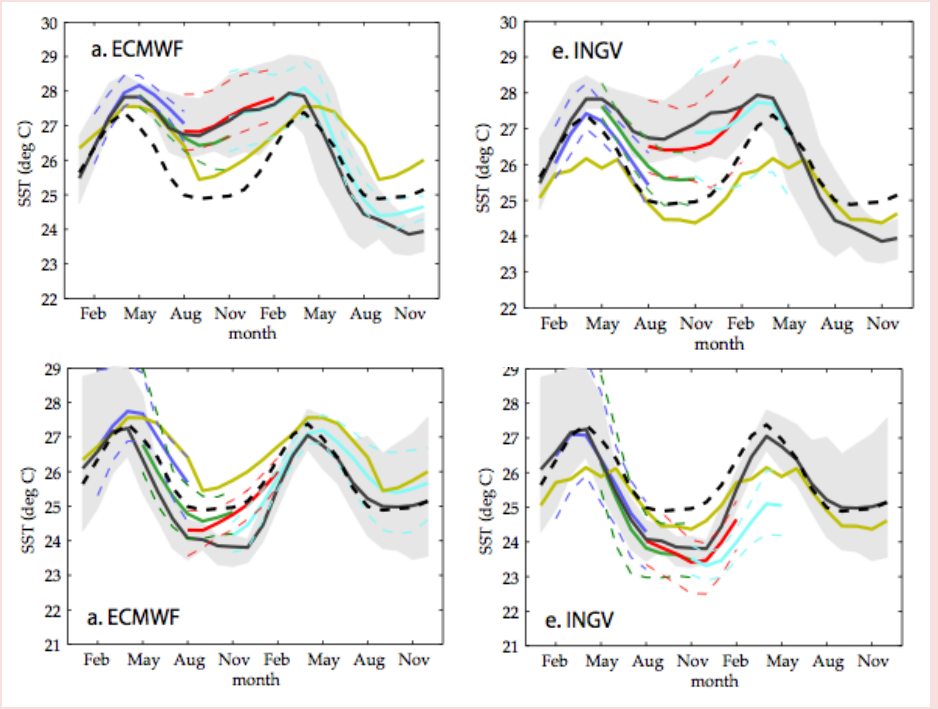
The strategy is applied to the seasonal hindcasts of 5 european CGCMs participating to ENSEMBLES EU-project (ECMWF, IFM-Kiel, Meteo-France, MetOffice and INGV)

> SST mean state bias in the tropical Pacific



El Nino

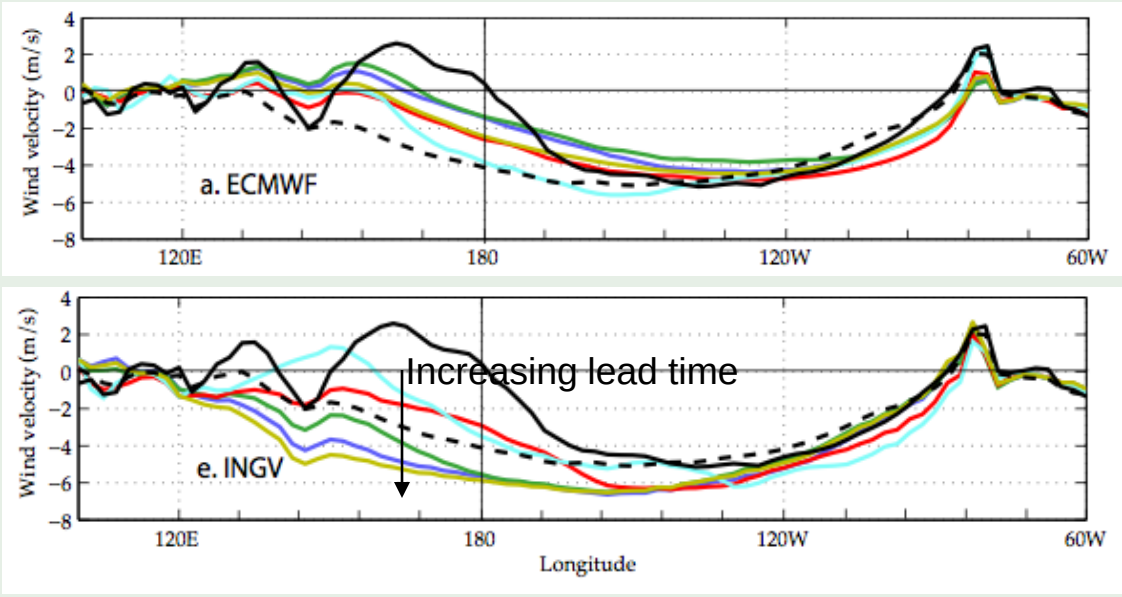
La Nina



- CGCMs simulate correctly either El Nino or La Nina but not both
- CGCMs rapidly converge toward their own seasonal cycle (in brown)
- In models affected by cold bias : how much do errors in the El Nino simulation contribute to the mean state cold bias ?

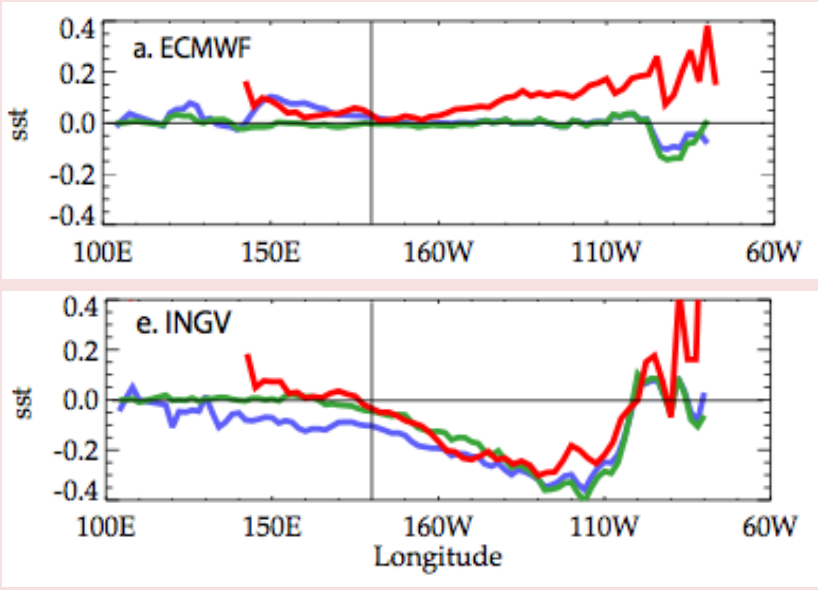
> Lead time analysis reveals the role of zonal wind at the equator in setting the SST biases

Zonal wind along the equator, composite of El Nino events



➢ When the atmospheric field responsible for the SST bias has been identified, its impact on SST bias is tested with an ocean-only simulation.

➢ Ocean-only simulations forced with the coupled models 10m winds reproduce the cold bias in INGV



Ocean only, both dynamical and heat flux effects

Ocean only, dynamical effect

ENSEMBLES