Initial shocks and drifts in decadal climate predictions

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The problem

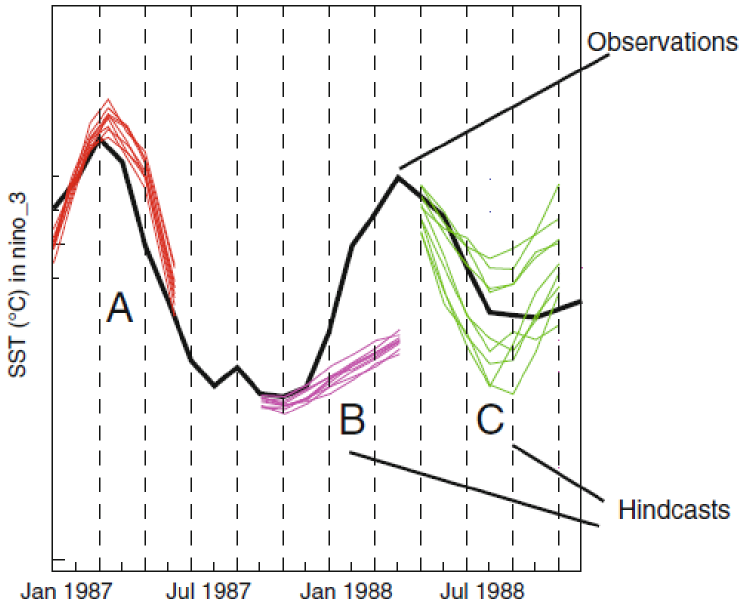
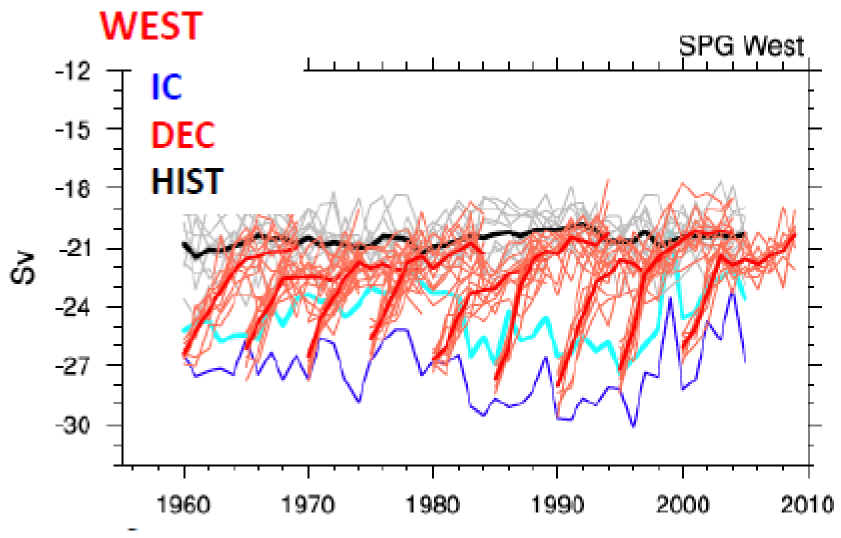


Fig. 1 Schematic of member behaviour in a seasonal forecast ensemble: (*A*) ideal forecast, (*B*) all members depart all together from observations is the signature of a systematic bias, (*C*) all members spread around the observations denote sensitivity to initial conditions

[Vannière et al., 2013]

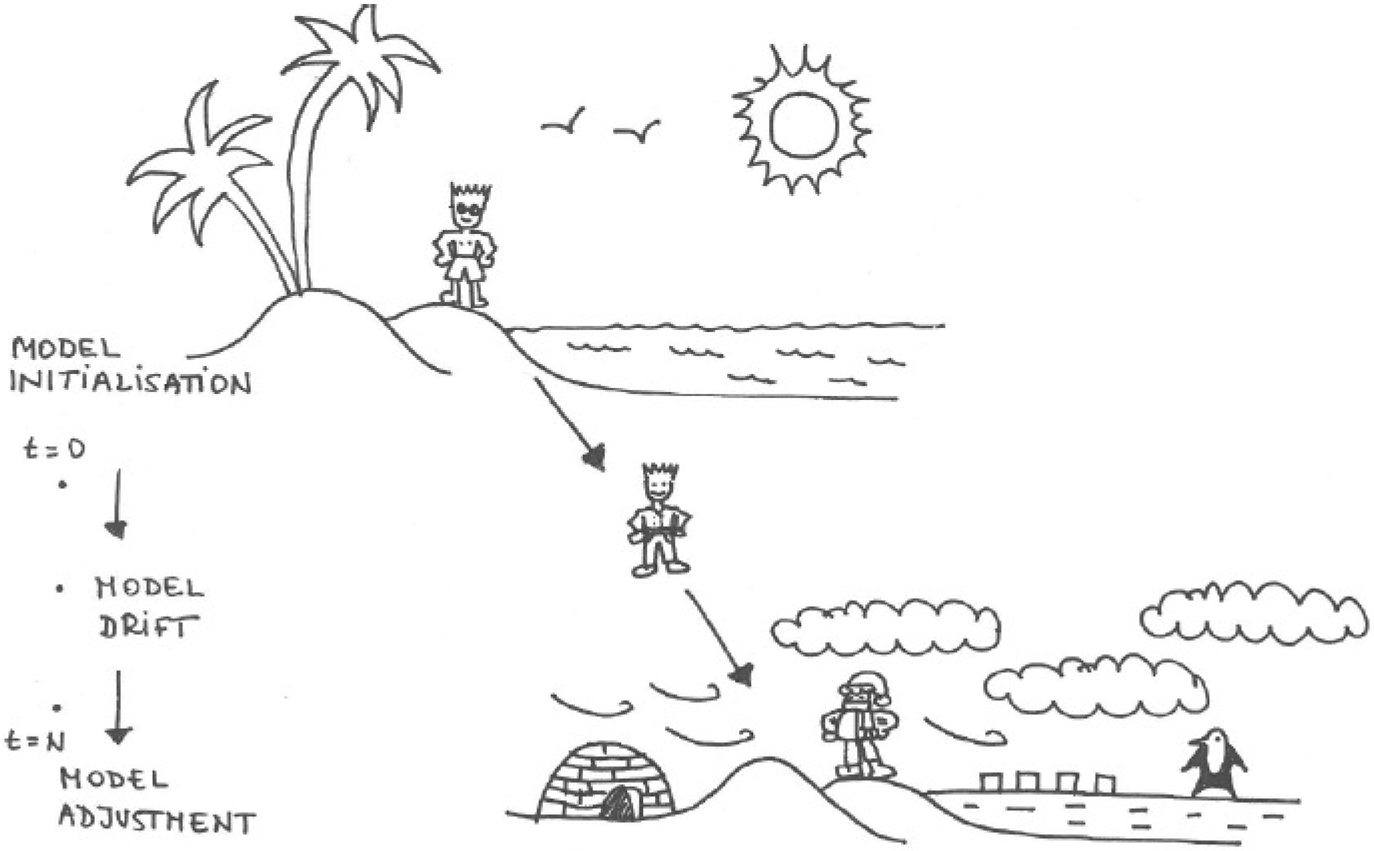


Strenght of the Northern Hemisphere subpolar gyre south of Greenland in the observations (blue curve) and in the Hist run (black curve) and initialized decadal predictions (red curves) from a given forecast system [Sánchez-Gómez et al., 2015].

The problem

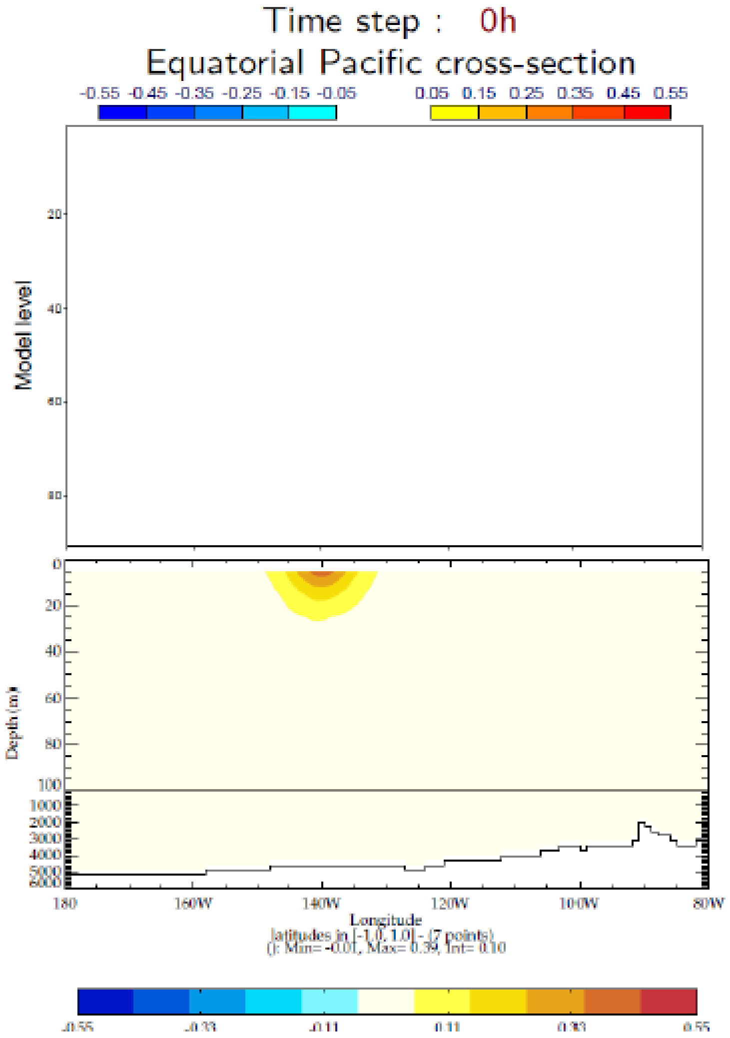
Observed Climate

Model Climate



[Sánchez-Gómez, 2016]

The problem

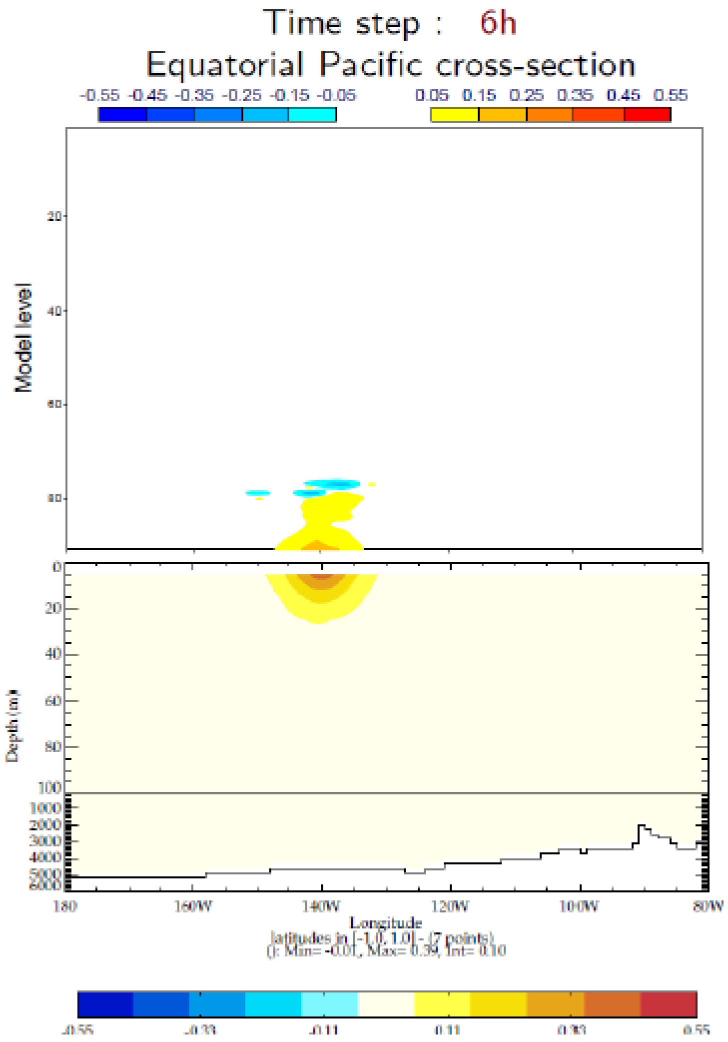


Assimilation of one SST observation at a depth of 5 meters, at 140°W and over the Equator.

Note how rapidly that information is transferred into the atmosphere within the assimilation window period.

[Laloyaux et al.,2016]

The problem



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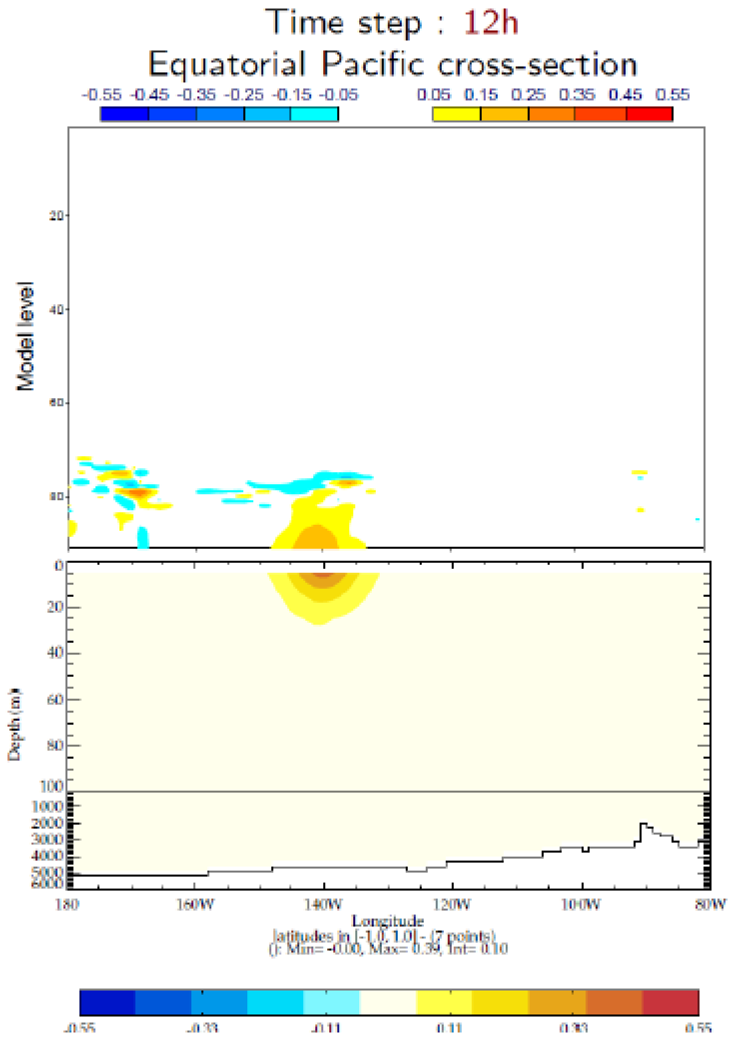

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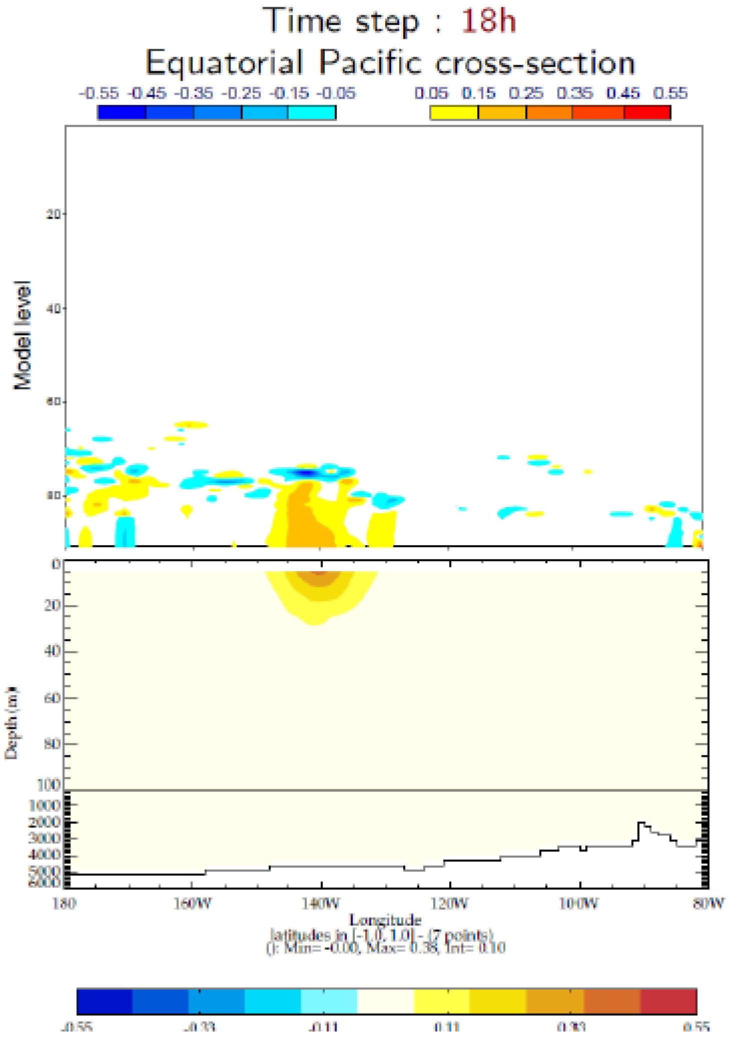

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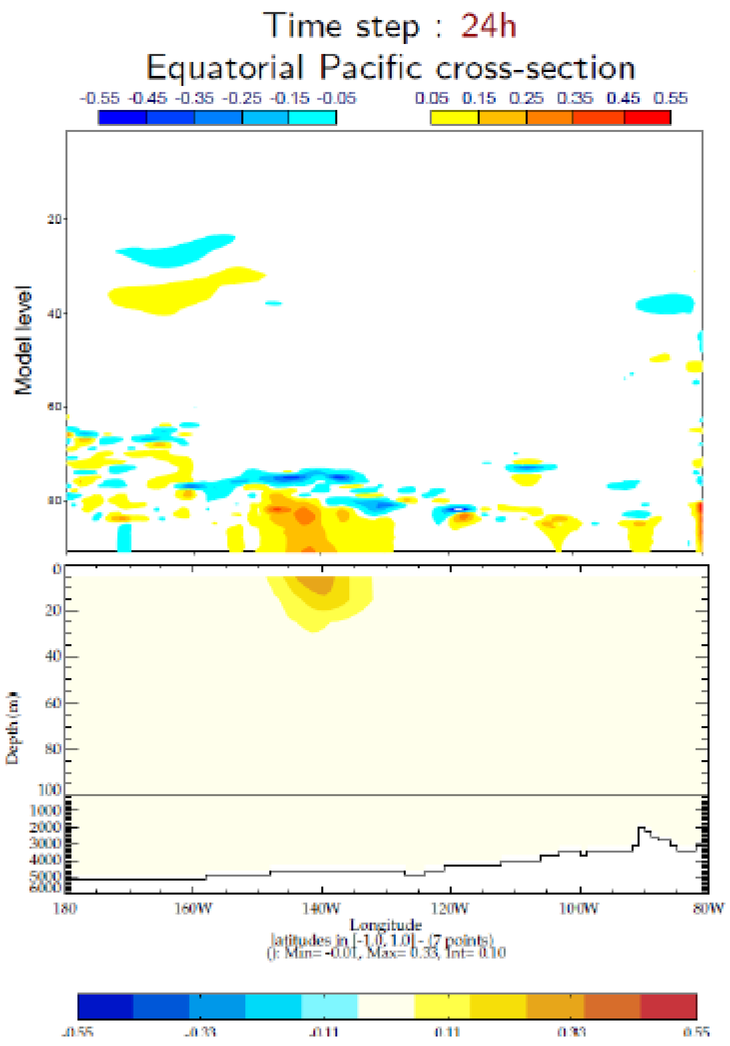

Assimilation of one SST observation at a depth of 5 meters, at 140°W and over the Equator.

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[Laloyaux et al.,2016]

The problem

“Drift” is the term we usually use to include all the physical processes that occur after initialization by which the model adjusts to its own attractor or climatology.

“Initial shock” is mostly used to refer to the fast response of the model to initialization.

(Is there a clear distinction between both?)

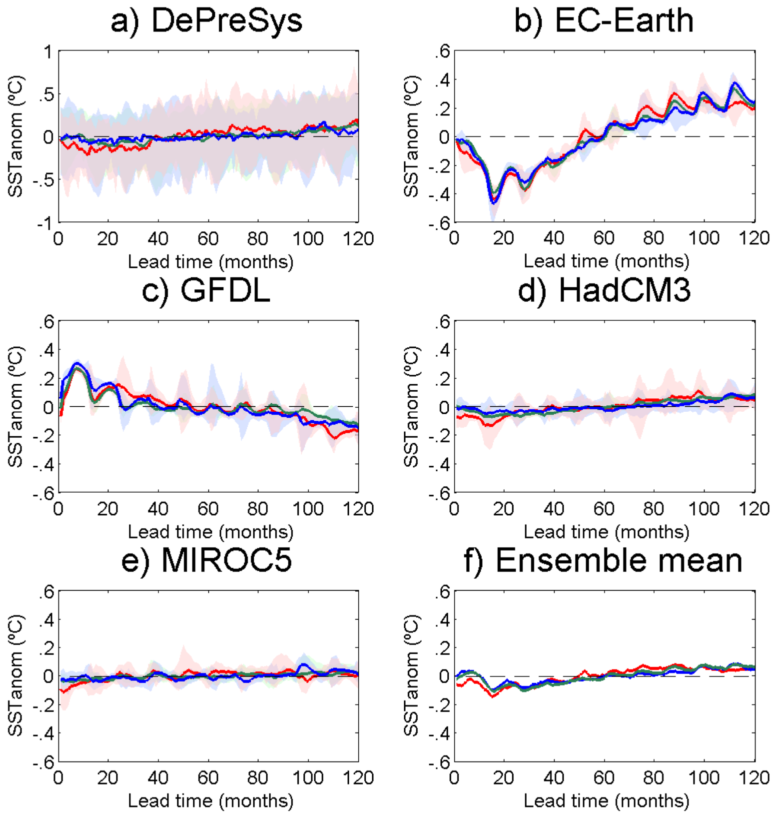
The problem

This problem is not just present in seasonal or decadal predictions, but also show up in climate change projections.
(what about weather predictions?)

Model drift usually leads to what we call "systematic errors" of the model (which can be partially solved *a posteriori*) + "noise" (or all those errors that cannot be modelled).

The problem

It might be useful to find links between the errors and other variables (e.g. circulation).



Evolution of SST anomalies in the South Pacific basin in different forecast systems as a function of El Niño phase (green for neutral, red for El Niño and blue for La Niña events). Note differences in the trends/drifts across models.

[Saurral et al.,2016]

Commonly-used “solutions”

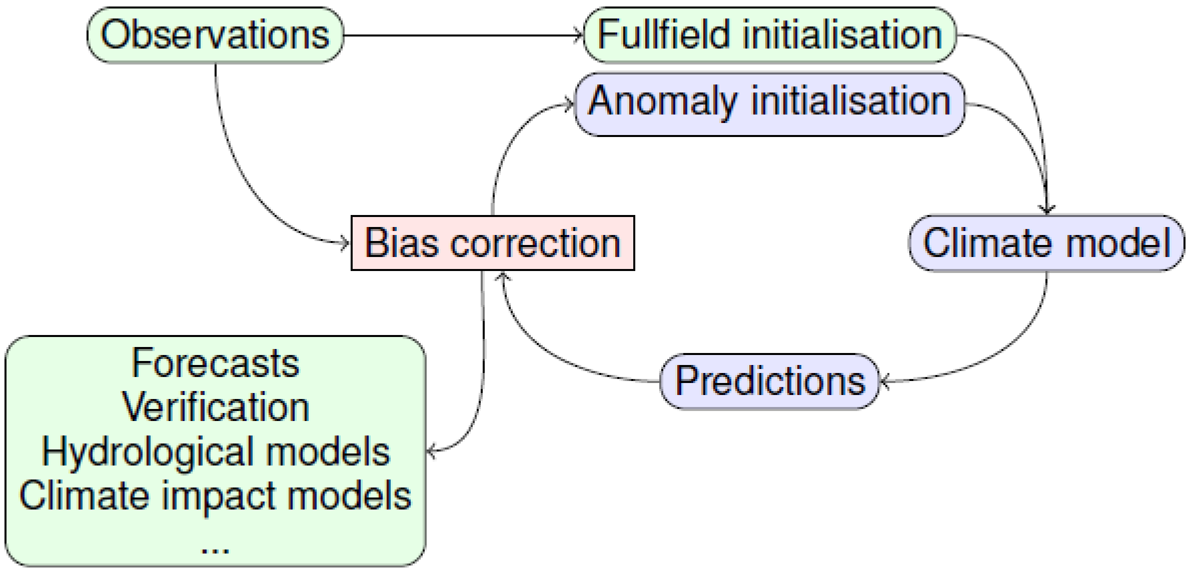
Common practice in most of the studies dealing with models:

-compute long-term means from OBS and from the model at different time scales (seasonal, monthly, annual).

-compute the (time-dependent) adjustment factors that need to be applied to the raw model outputs in order to obtain more reliable information [what are the limitations+assumptions of doing this?]

-correct the raw outputs and keep on working, usually forgetting about all these weird terms such as “bias”, “drift” and “shock”.

Commonly-used “solutions”



Observations

Fullfield initialisation

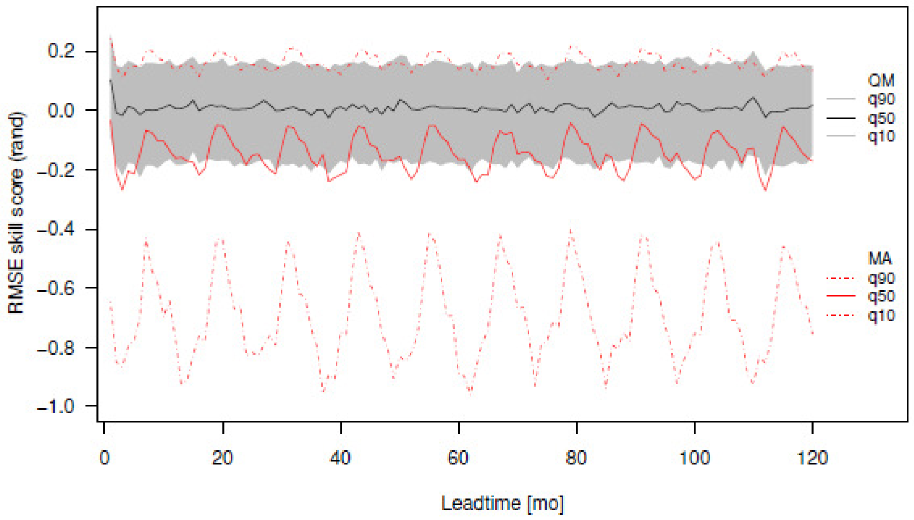
Anomaly initialisation

Bias correction

Climate model

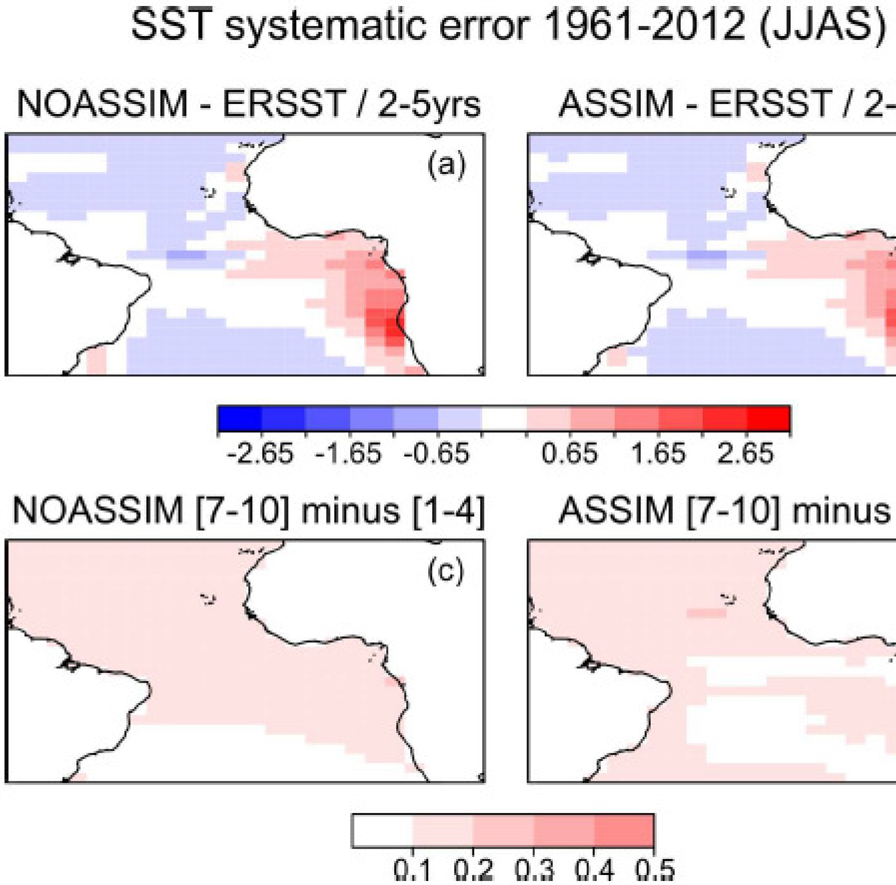
Predictions

Forecasts
Verification
Hydrological models
Climate impact models
...



[Sienz et al.,2016]

Commonly-used “solutions”



[García-Serrano et al.,2013]

Commonly-used “solutions”

Several strategies currently exist to remove the systematic bias: some based on statistics (e.g. QM, delta-change, …) and others, on dynamical downscaling.

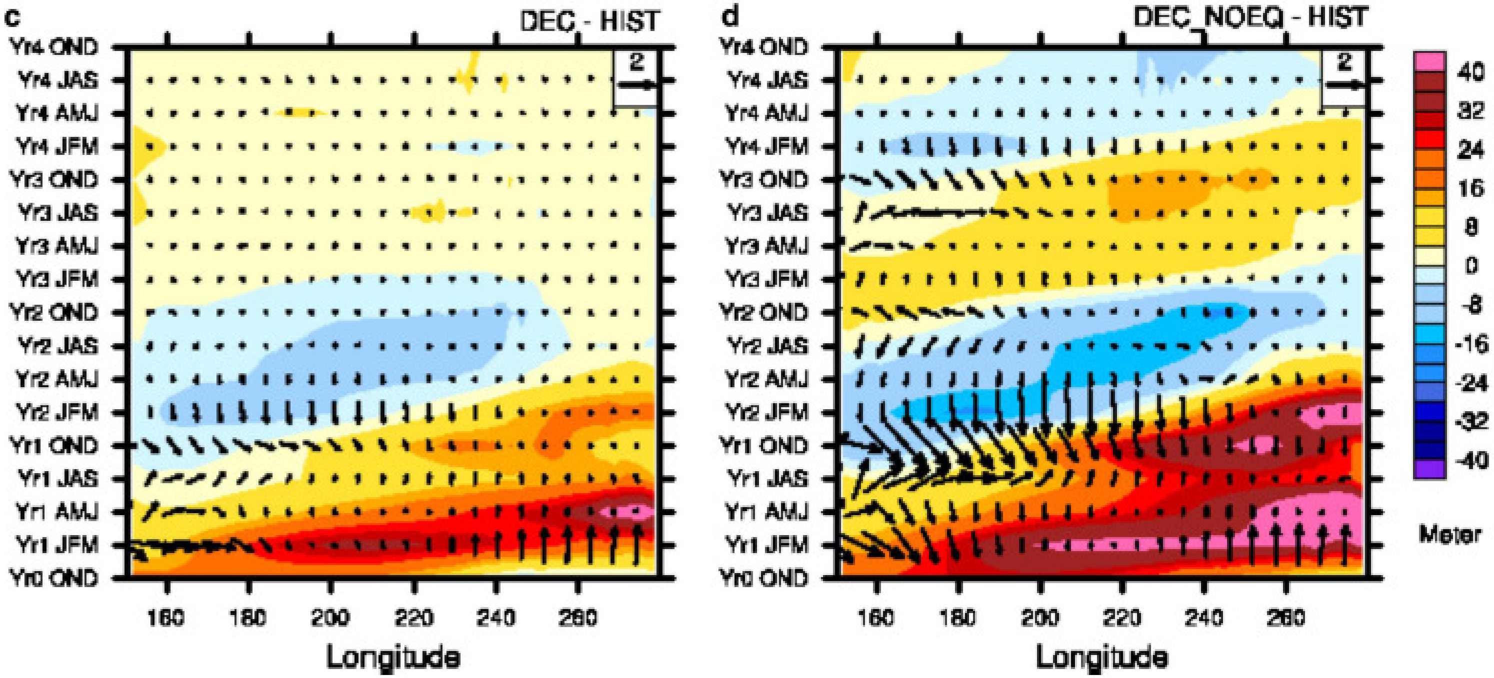
Still, most of them rely on huge assumptions of stationarity, which usually does not hold or is unknown (climate change scenarios).

Commonly-used “solutions”

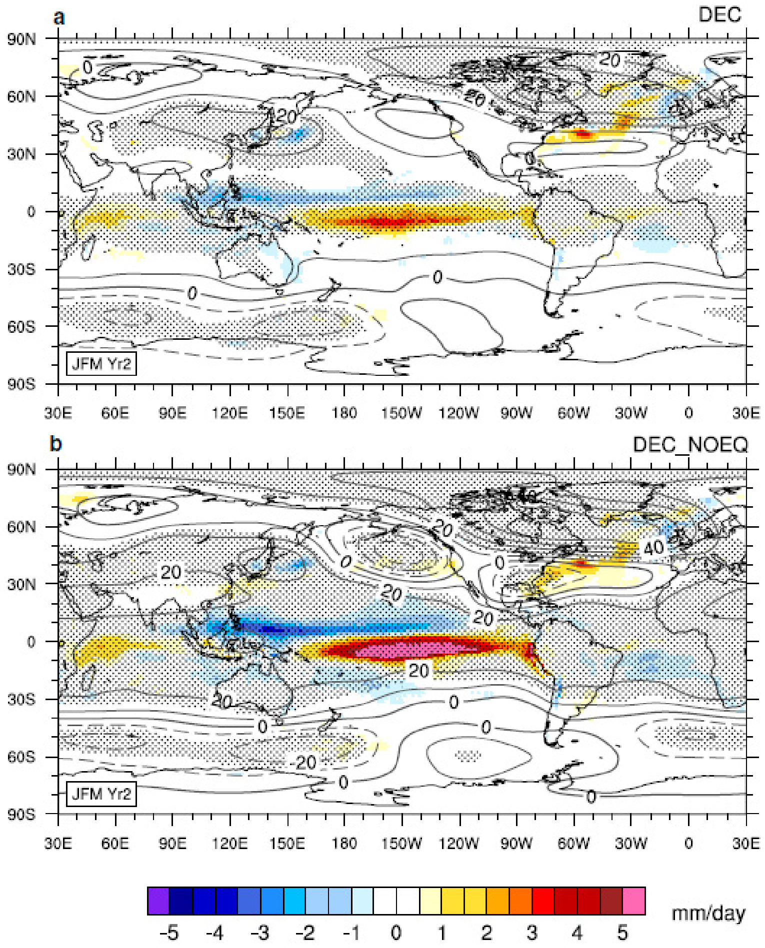
Bias correction must be done carefully, since it may easily lead to inconsistencies between variables (e.g. when correction is done separately) or may cause under- or over-estimations of the actual relationship between variables.

Diving into the mechanisms

Some studies have focused on the physical mechanisms behind drifts and shocks. Sánchez-Gómez et al. (2015) analyzed the biases in the North Atlantic region.



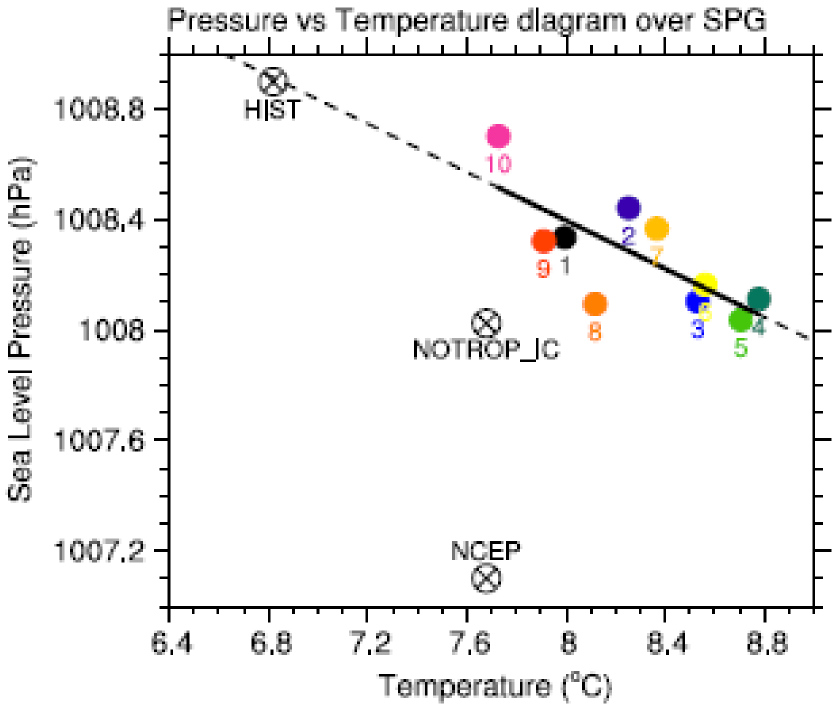
Diving into the mechanisms



[Sánchez-Gómez et al., 2015]

Differences in Z500 (contours) and precip (shading) in decadal predictions with a given forecast system, 2 years after initialization, with nudging applied everywhere except over 15°S/15°N (top) and over 1°S/1°N (bottom).

Diving into the mechanisms

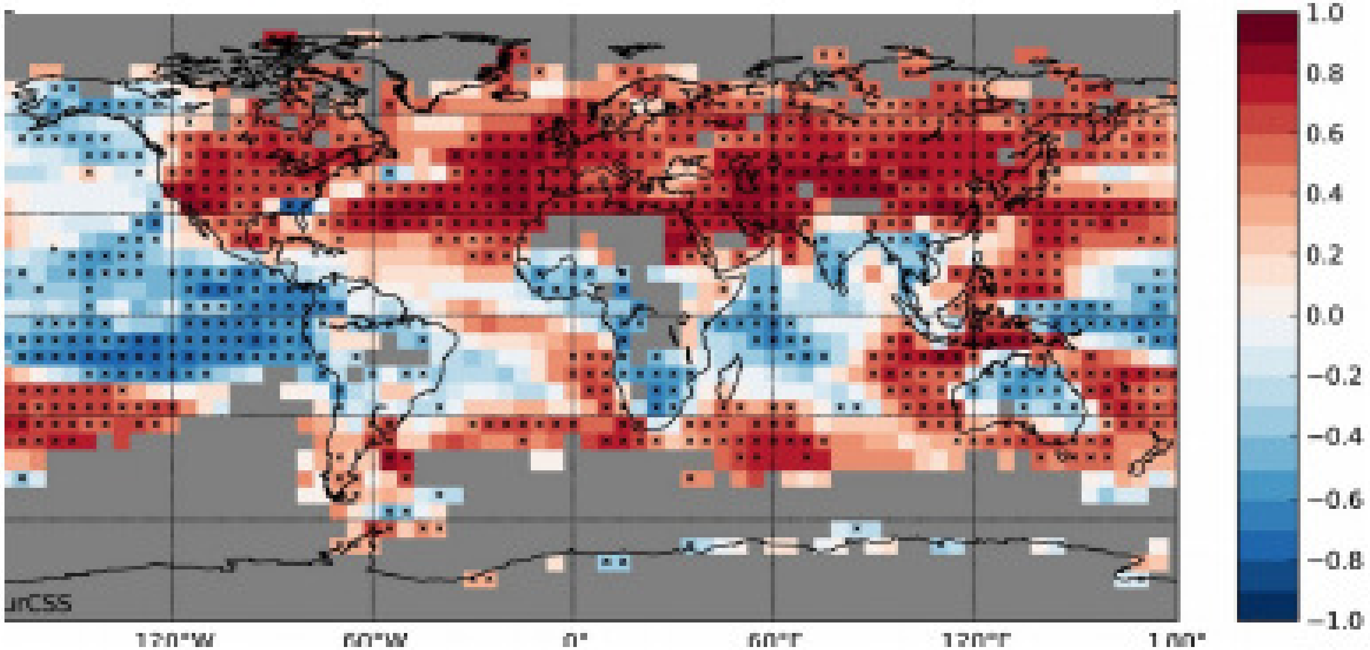


A positive feedback is reported by the authors between SST and SLP forecasts over the North Atlantic region. Note how both variables vary simultaneously as a function of the lead time.

[Sánchez-Gómez et al., 2015]

Diving into the mechanisms

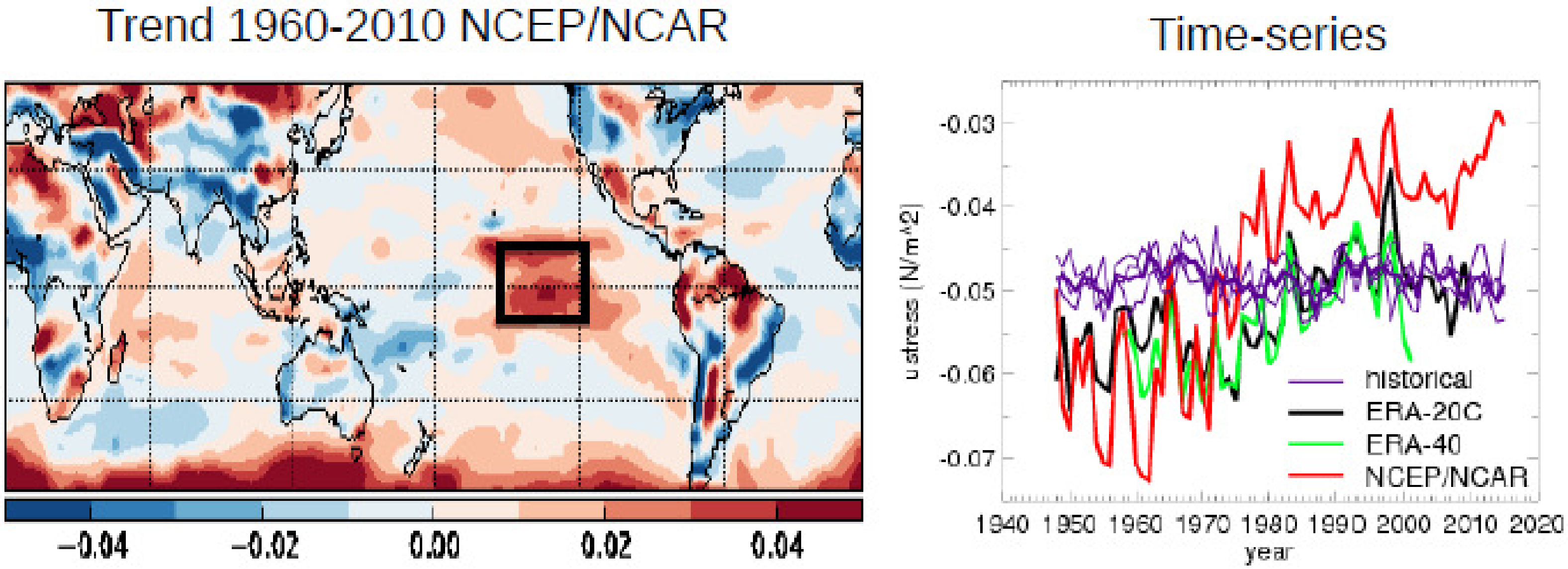
MPI-ESM / CMIP5



[Pohlmann et al., 2016]

Interannual prediction skill is particularly low in the tropics. These authors report that drifts in the predictions are caused by biases in the strenght of the surface wind stress at low latitudes.

Diving into the mechanisms

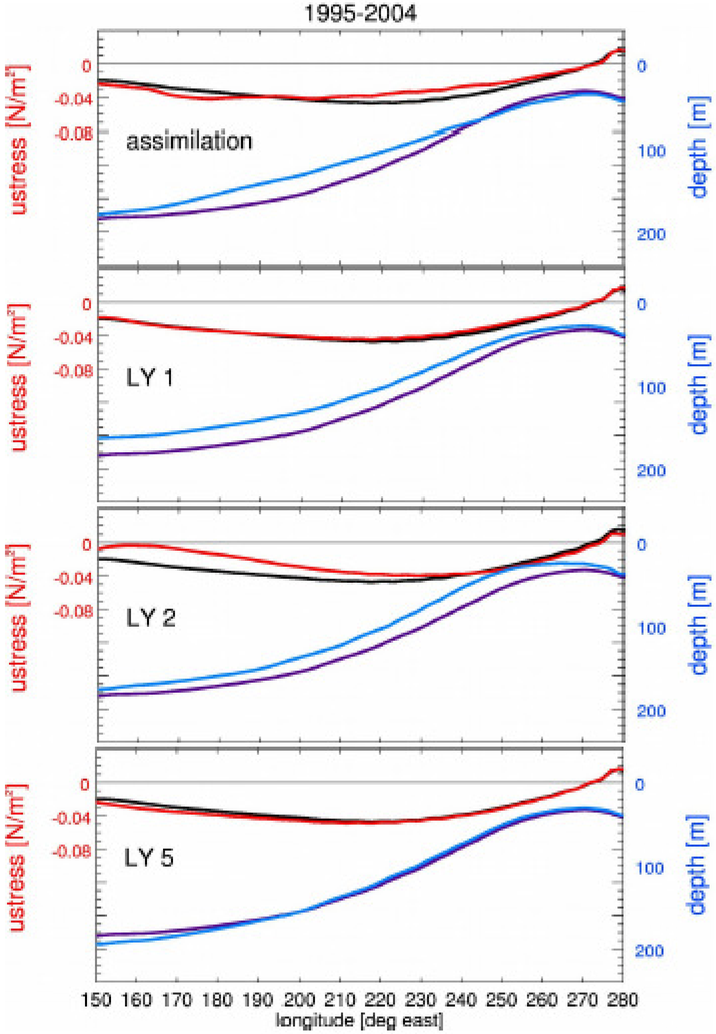

Trend 1960-2010 NCEP/NCAR

Time-series

[Pohlmann et al., 2016]

Trends in surface wind stress in NCEP/NCAR (left) and time series of surface wind stress in the reanalysis and in Hist simulations.

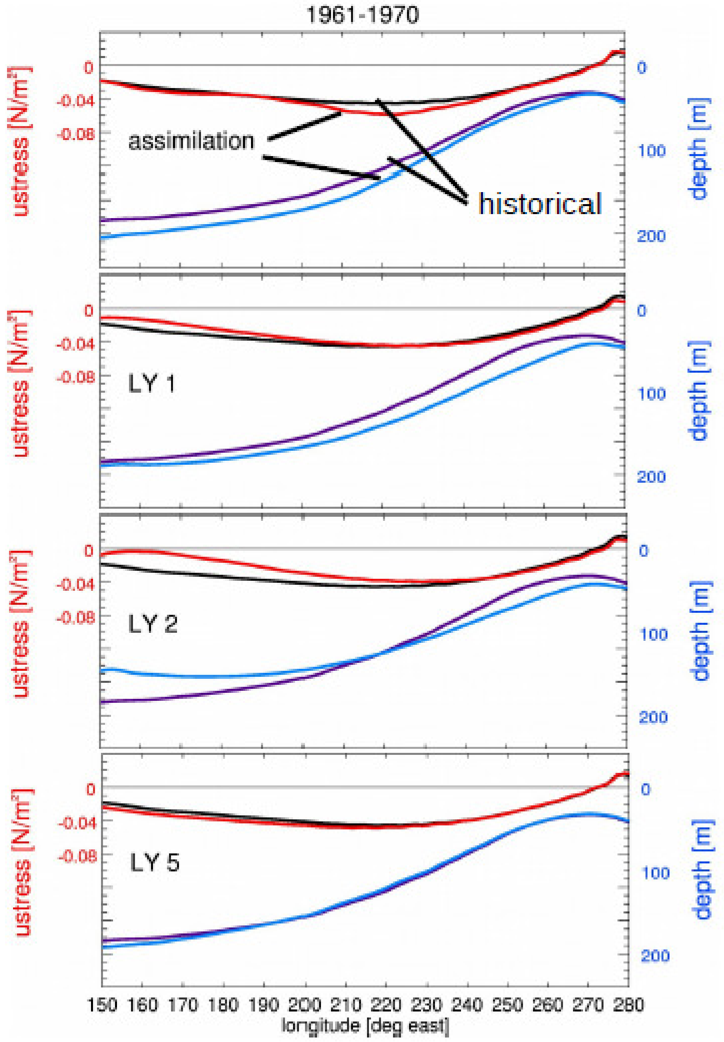
Diving into the mechanisms



[Pohlmann et al., 2016]

- Thermocline is displaced from its preferred state during the initialization.
- Recovery process triggers La Niñas during 1995-2004.

Diving into the mechanisms

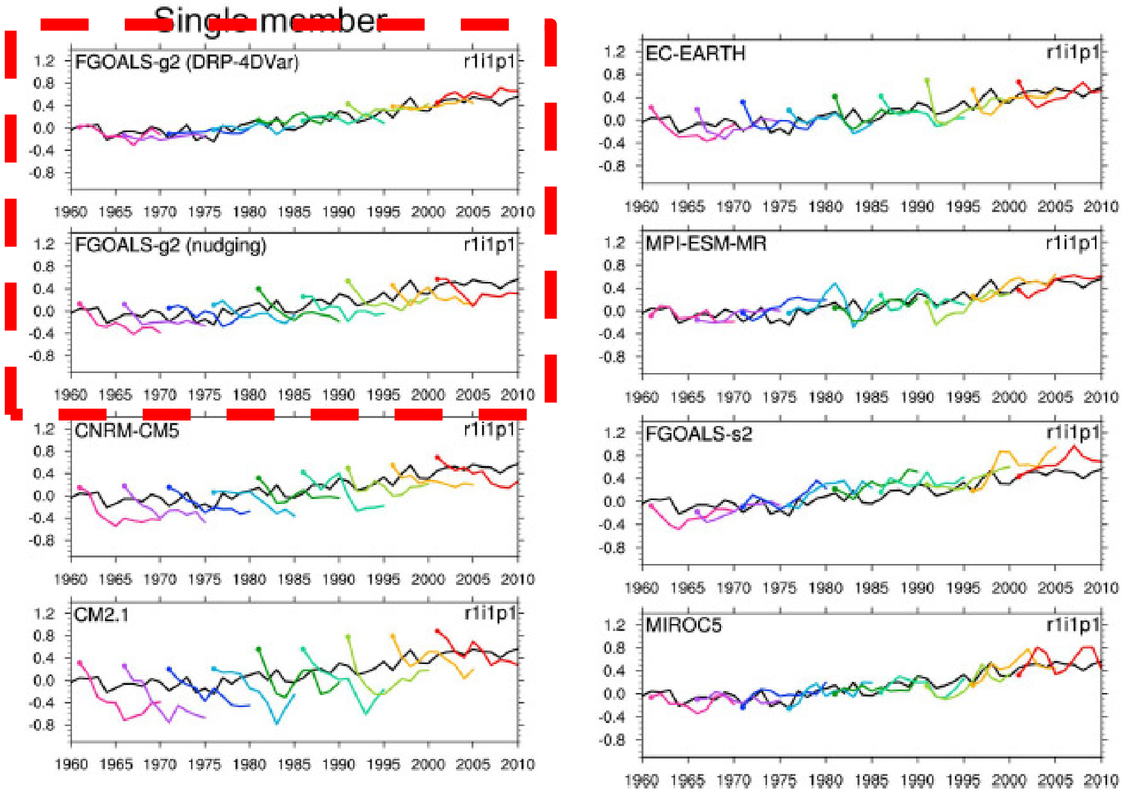


[Pohlmann et al., 2016]

- Thermocline is displaced from its preferred state during the initialization.
- Recovery process triggers El Niños during 1961-1970.

Different ways to deal with model drift

1) Improve initialization strategies (e.g. He et al., 2017)



Different ways to deal with model drift

2) Improve initial conditions (e.g. Pohlmann et al., 2016; Hawkins et al., 2014, …)

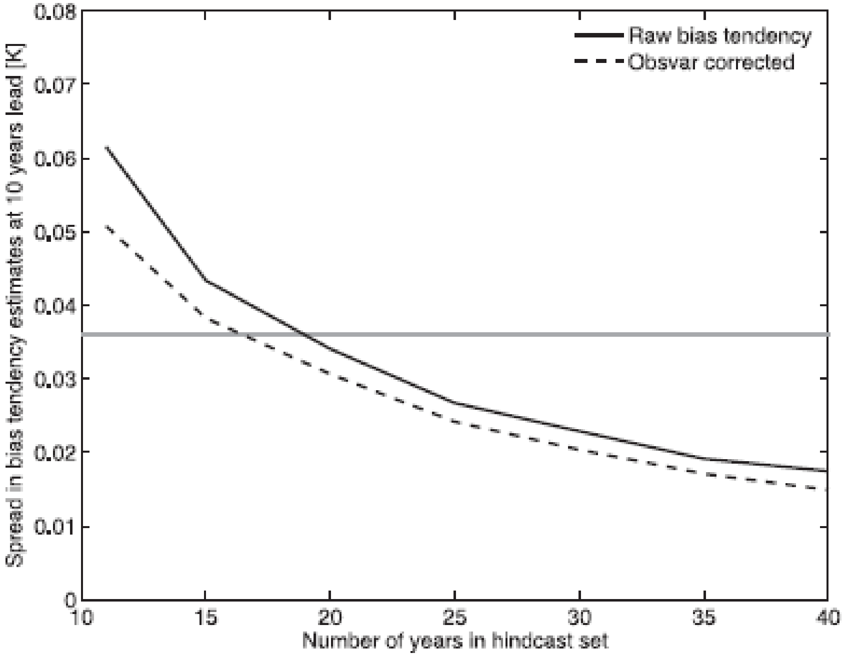


FIG. 3. The spread in 1000 realizations of the bias tendency estimates, an example of which is shown in Fig. 2, for the raw bias tendency (solid black) and corrected bias tendency (dashed black) at a lead time of 10 yr. The magnitude of the true bias is shown in gray, indicating that, for this choice of toy model parameters, the bias could be detected with $L \approx 16$ (20) hindcast start dates if the correction is made (not made).

Different ways to deal with model drift

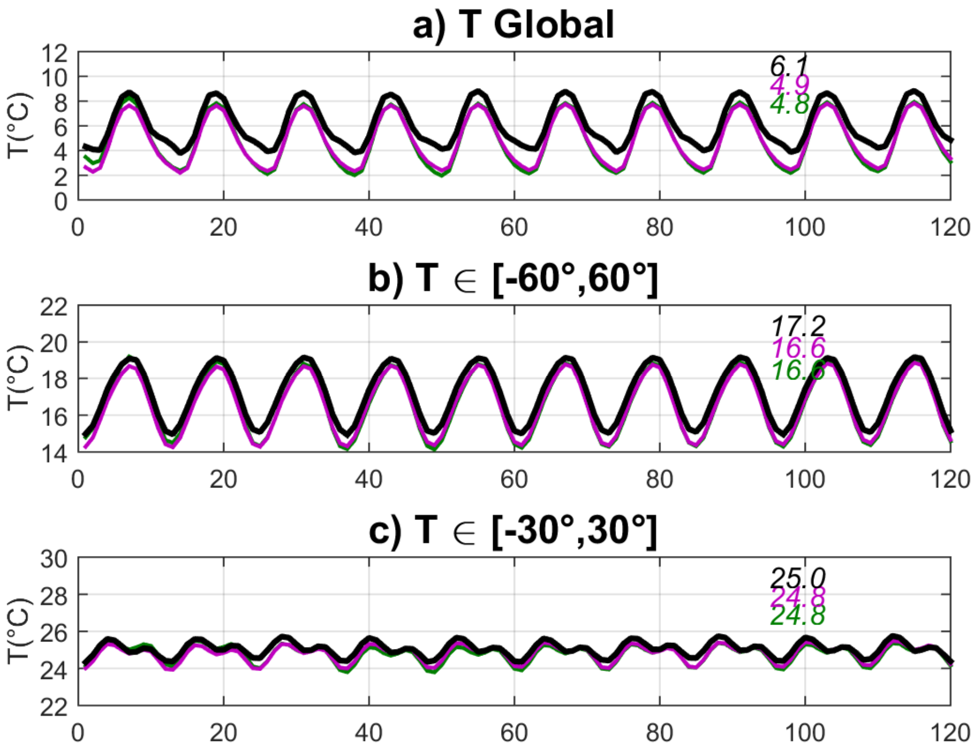
3) Improve our understanding of the processes beneath the drift (e.g. Sánchez-Gómez et al., 2016)

Ways forward

WGSIP's Long-Range Forecast Transient Intercomparison Project (**LRFTIP**)

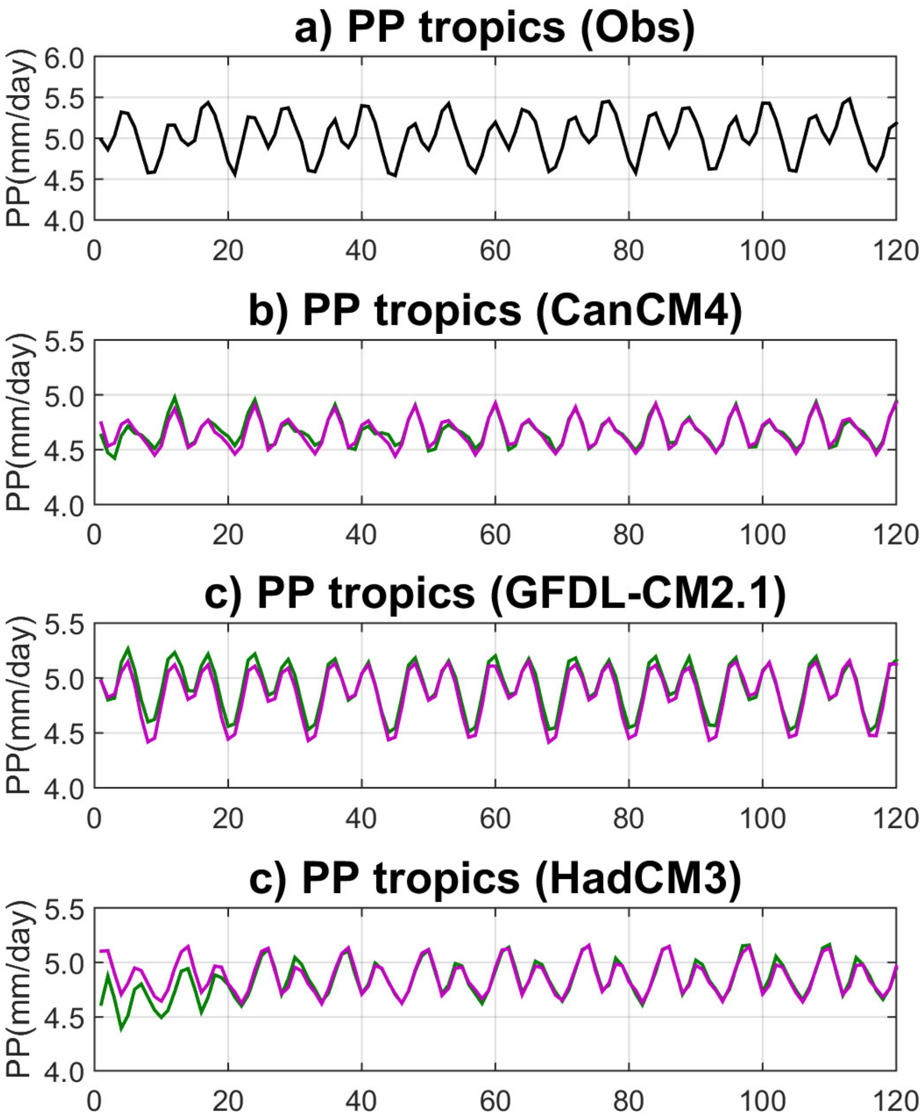
[Led by Bill Merryfield and Mikhail Tolstykh]

ftp://dapp2p.cccma.ec.gc.ca/pub/goapp/LRFTIP/



Ways forward

Mean precipitation in the tropics (15°S to 15°N), after averaging across start times (every 5 years, 1961-2006)



Ways forward

There are a lot of variables available for download at the LRFTIP website. This will naturally help to understand the physical mechanisms underlying the documented drifts.

Thank you!
Questions?