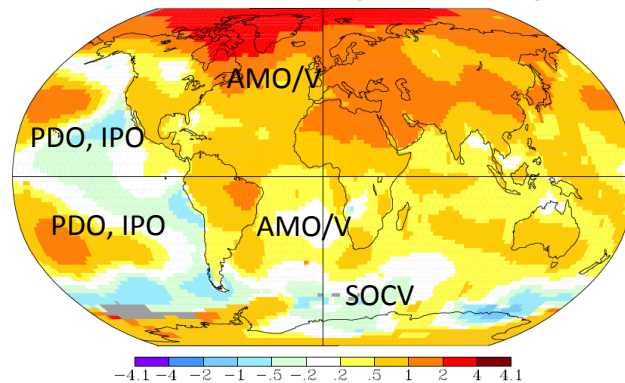


Decadal climate variability and predictability: Overview and challenges

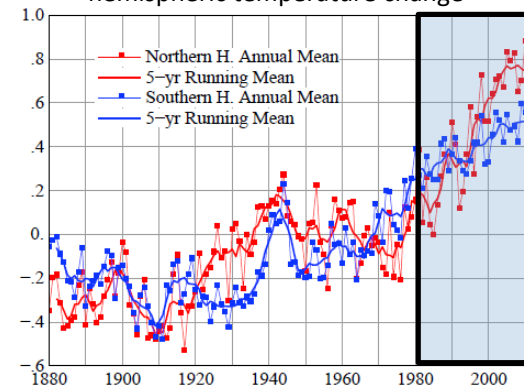
Mojib Latif, GEOMAR Helmholtz Centre for Ocean Research Kiel and Kiel University

surface air temperature (SAT) trend, 1980-2014

linear SAT trend, 1980-2014, global SAT change 0.5°C



hemispheric temperature change

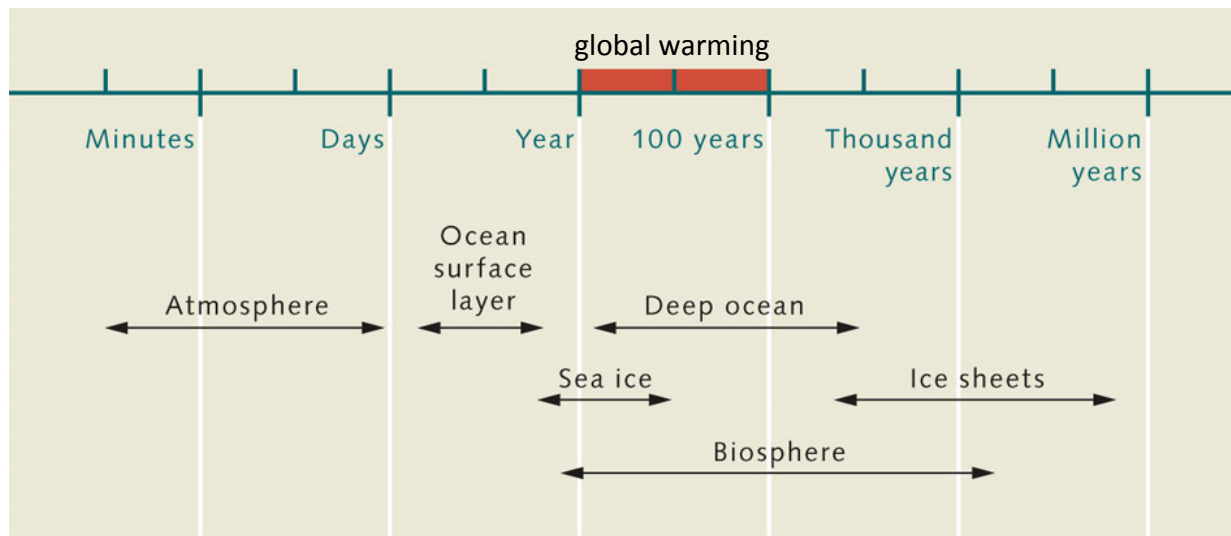


GISS Surface Temperature Analysis

Outline

1. Internal variability
2. External variability
3. The role of model bias
4. Decadal modulation of interannual variability
5. Decadal predictability

1. Internal variability



Stochastically-driven internal decadal variability

stochastic climate model hierarchy

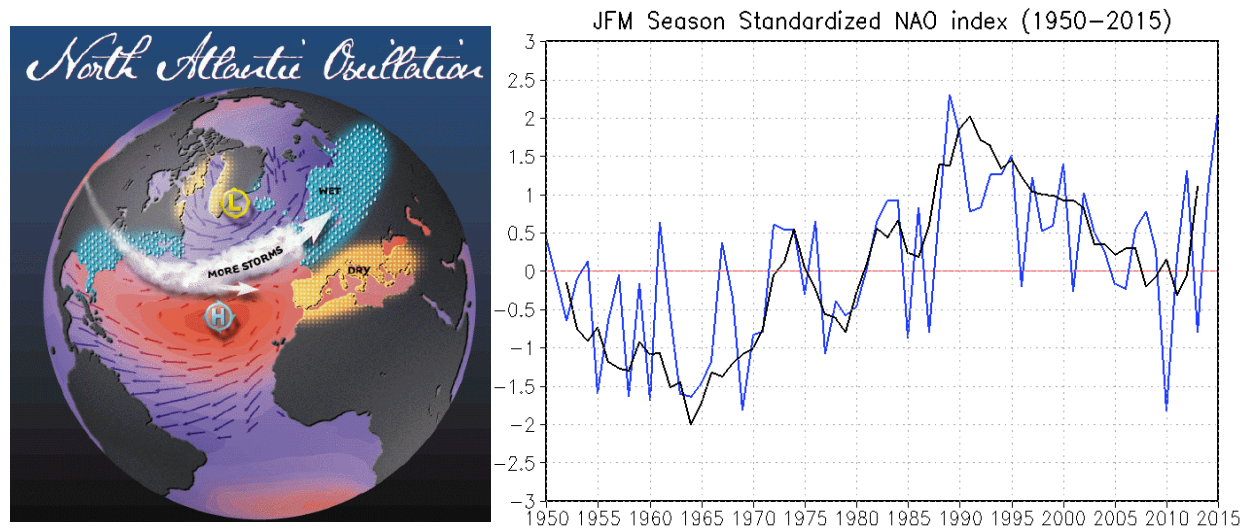
Atmosphere drives the ocean, but a feedback from the ocean on the atmosphere can be included

Local model (heat flux and momentum)

Spatial coherence in atmosphere, with and without oceanic advection

Spatial coherence in atmosphere, dynamical ocean models (wind-driven or thermohaline)

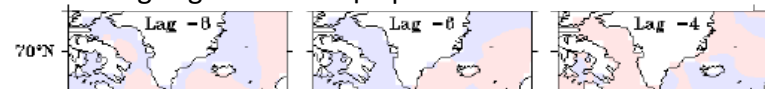
The North Atlantic Oscillation (NAO), the leading mode of atmospheric variability in winter



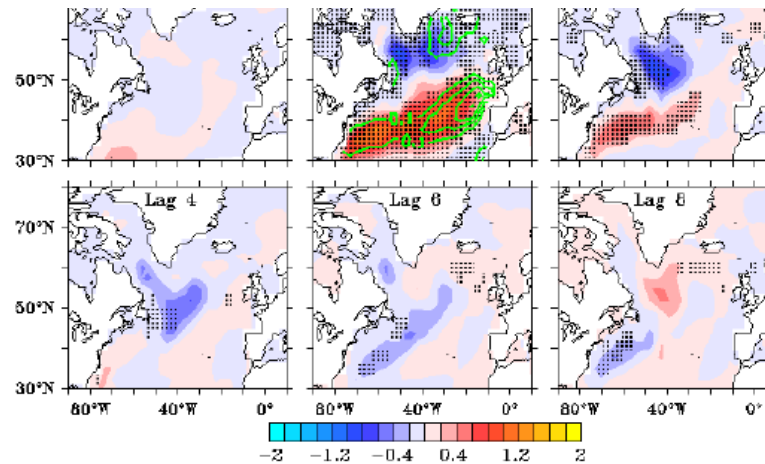
...has the potential to drive both gyre (through wind stress curl) *and* overturning circulation (through heat fluxes)

NAO-forcing of the barotropic streamfunction ψ , a measure of the (wind-driven) gyre circulation

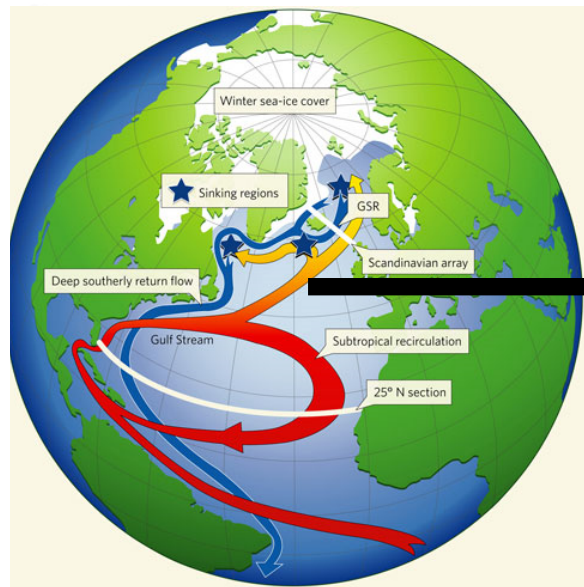
Lag-regressions of ψ upon NAO index in the KCM



Gyre response is “short-lived” and leads to multiyear variability

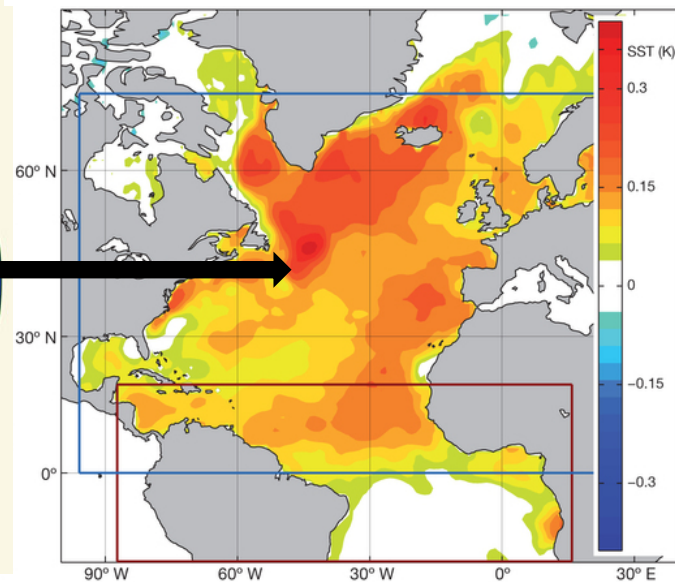


The AMOC has the potential to drive longer timescale decadal to multidecadal variability



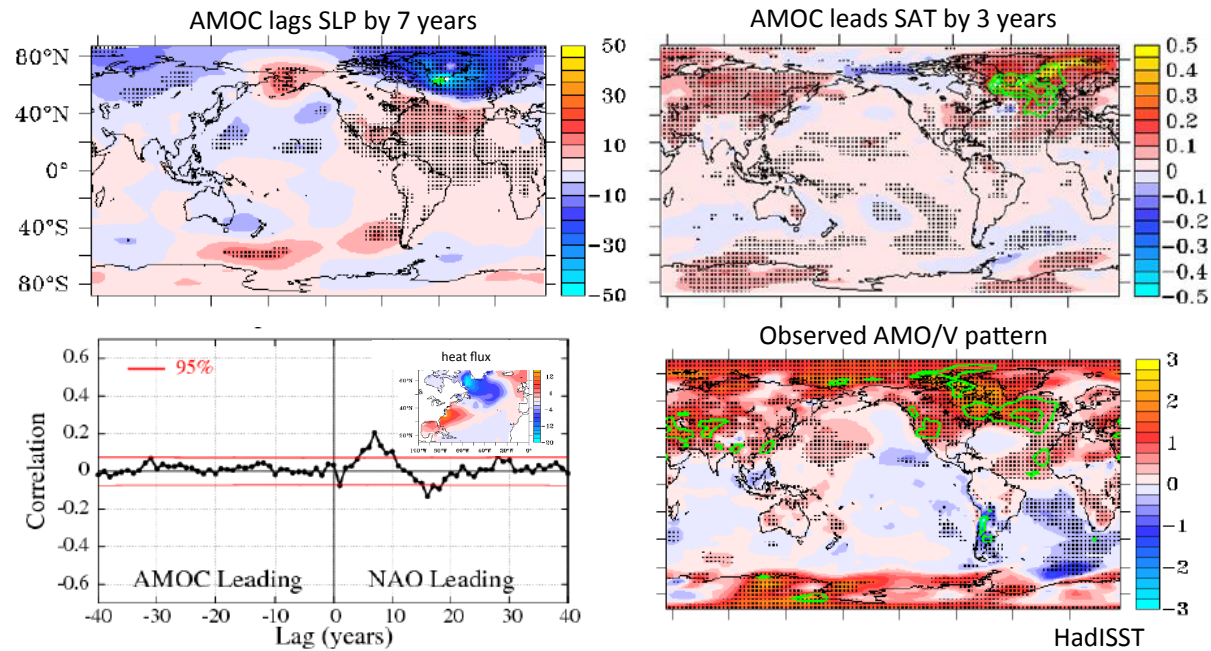
Atlantic Meridional Overturning Circulation (AMOC)

monopolar AMO/V pattern (from observations)



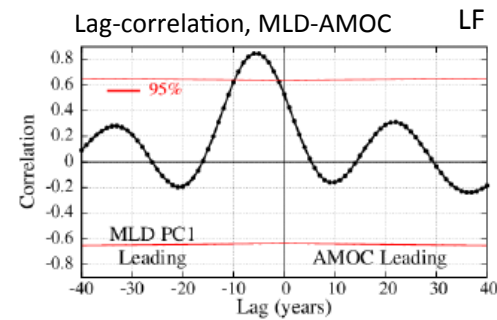
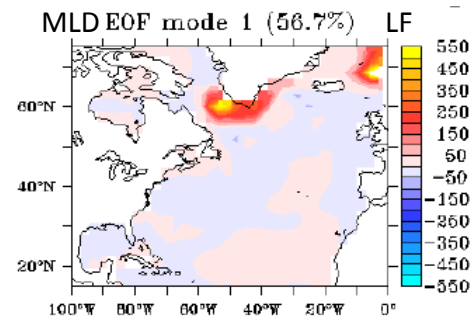
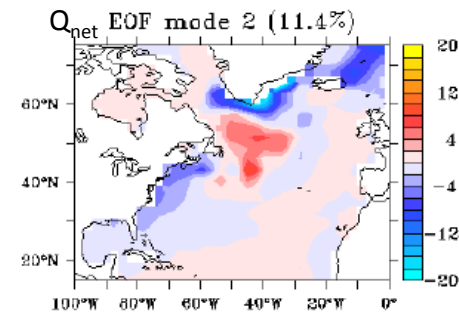
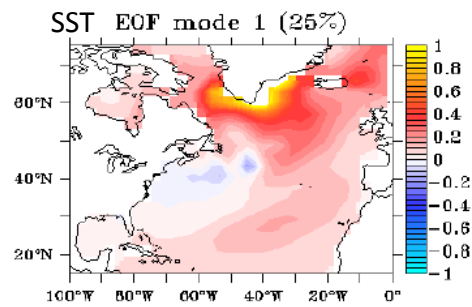
Atlantic Multidecadal Oscillation/Variability (AMO/V), Li et al. (2014)

The NAO drives the AMOC in the KCM, which in turn drives the AMV



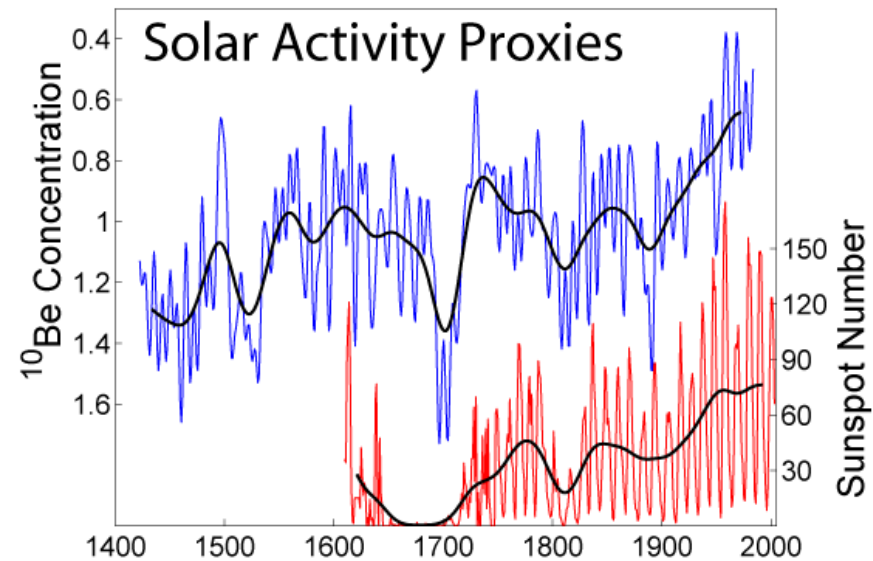
AMOC-related multidecadal variability in the KCM

leading EOFs of selected quantities which all are linked to the AMOC



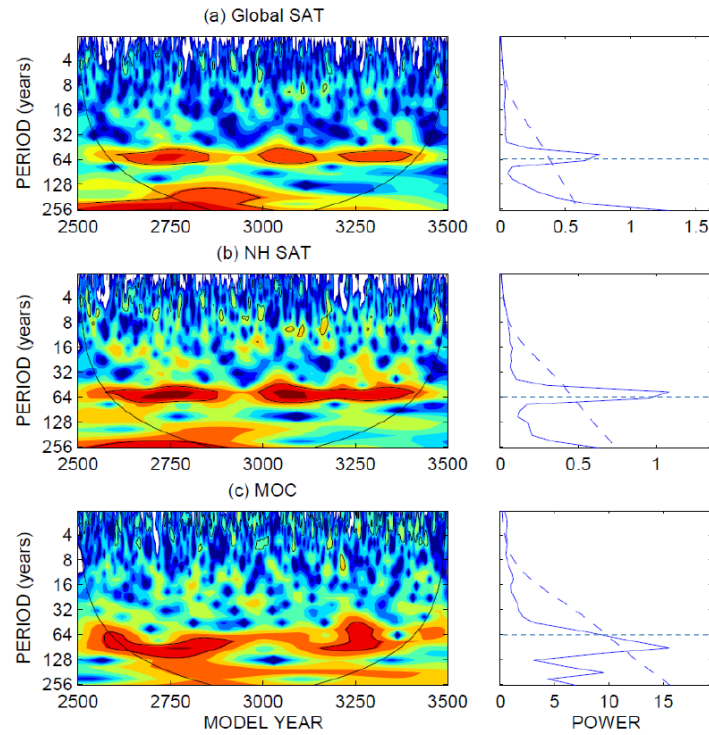
2. External variability

Multidecadal to centennial variability in solar forcing is obvious



...but how does the climate system respond to solar forcing,
especially on regional scales?

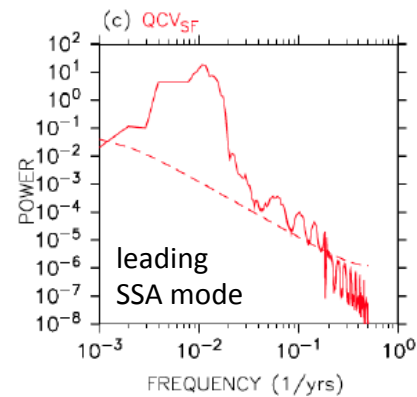
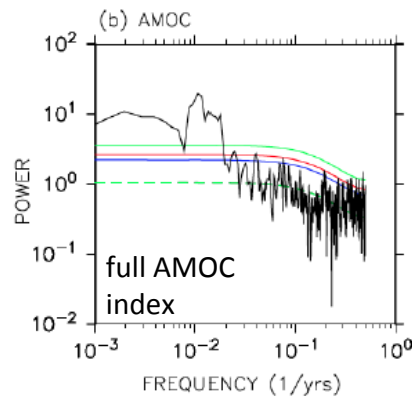
Kiel Climate Model forced by periodically varying solar constant ($\pm 2 \text{ Wm}^{-2}$), $P=60$ years



Park and Latif (2012)

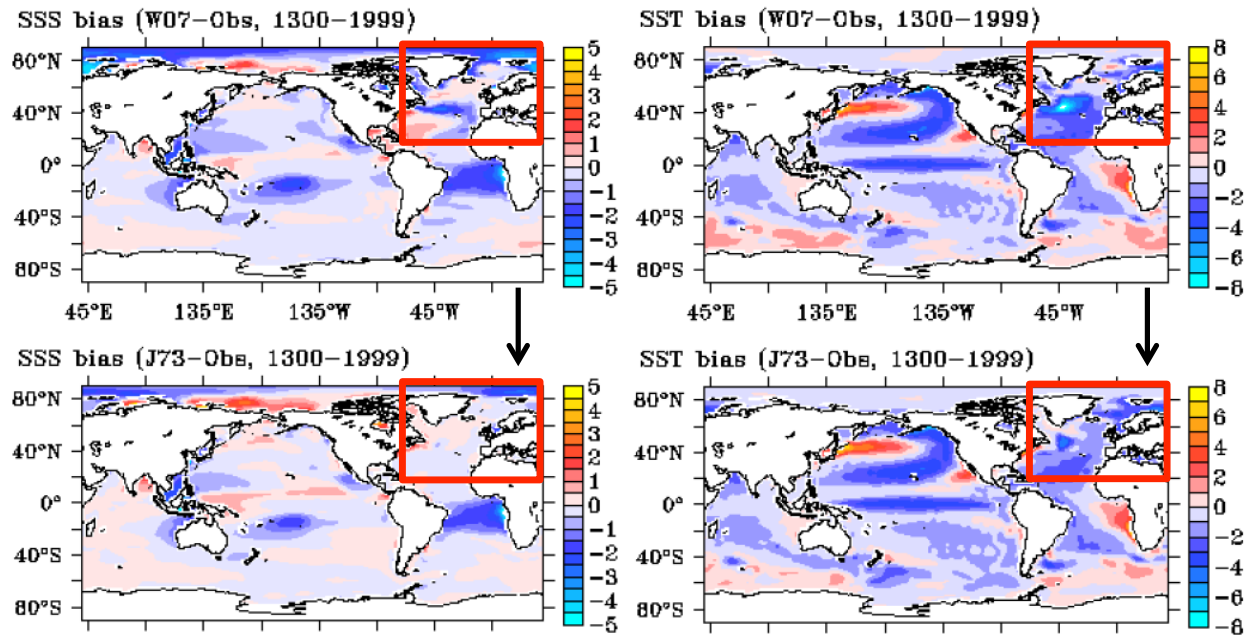
Response of the AMOC to solar forcing (P=60 years), the AMOC response is quasi-centennial

The AMOC is not entrained by the forcing frequency
and responds with one its quasi-centennial mode
which is not the leading mode of the control run; the
spatial surface forcing pattern matters



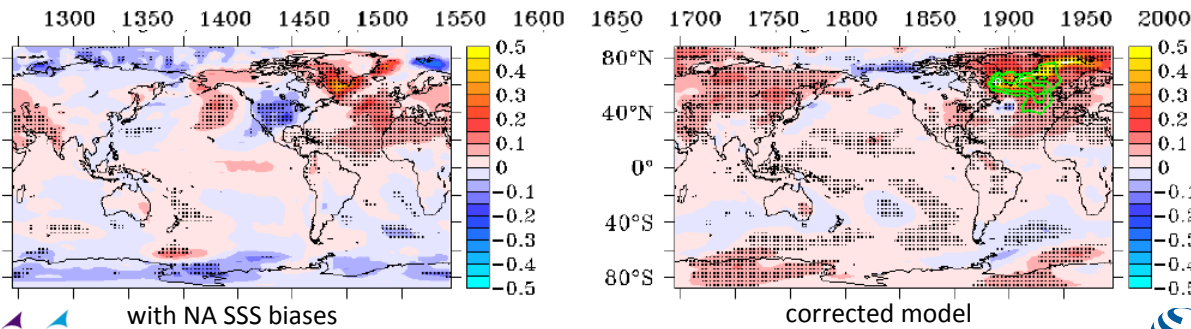
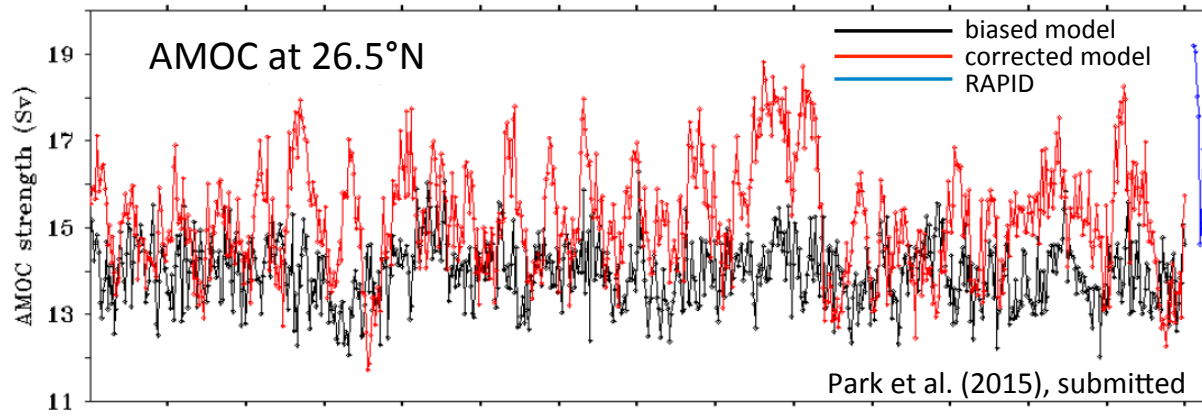
Park and Latif (2012)

3. The role of model bias

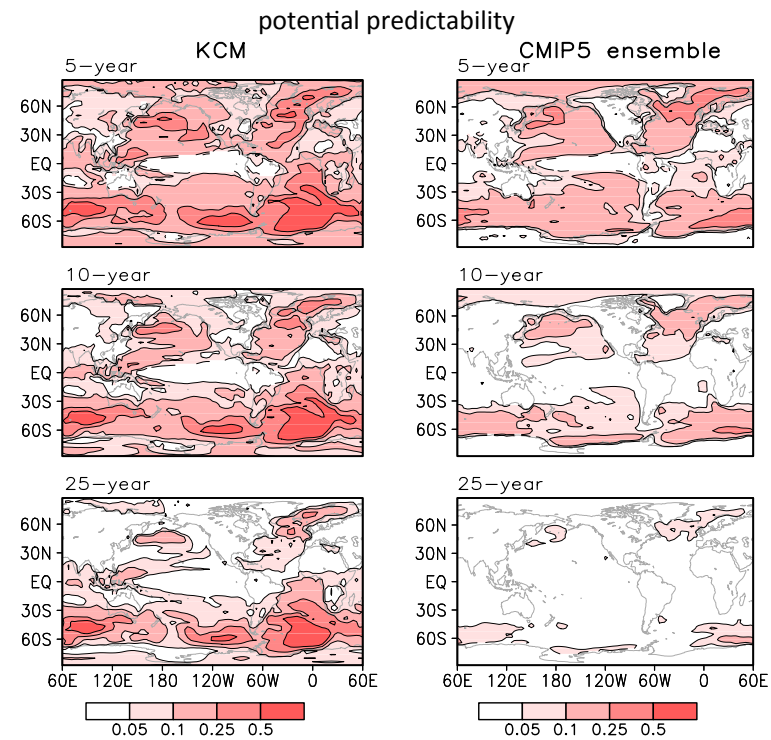


Impact of correcting North Atlantic sea surface salinity (which also improves North Atlantic SST) on the character of North Atlantic multidecadal variability

The impact of SSS biases on the AMOC and the AMV

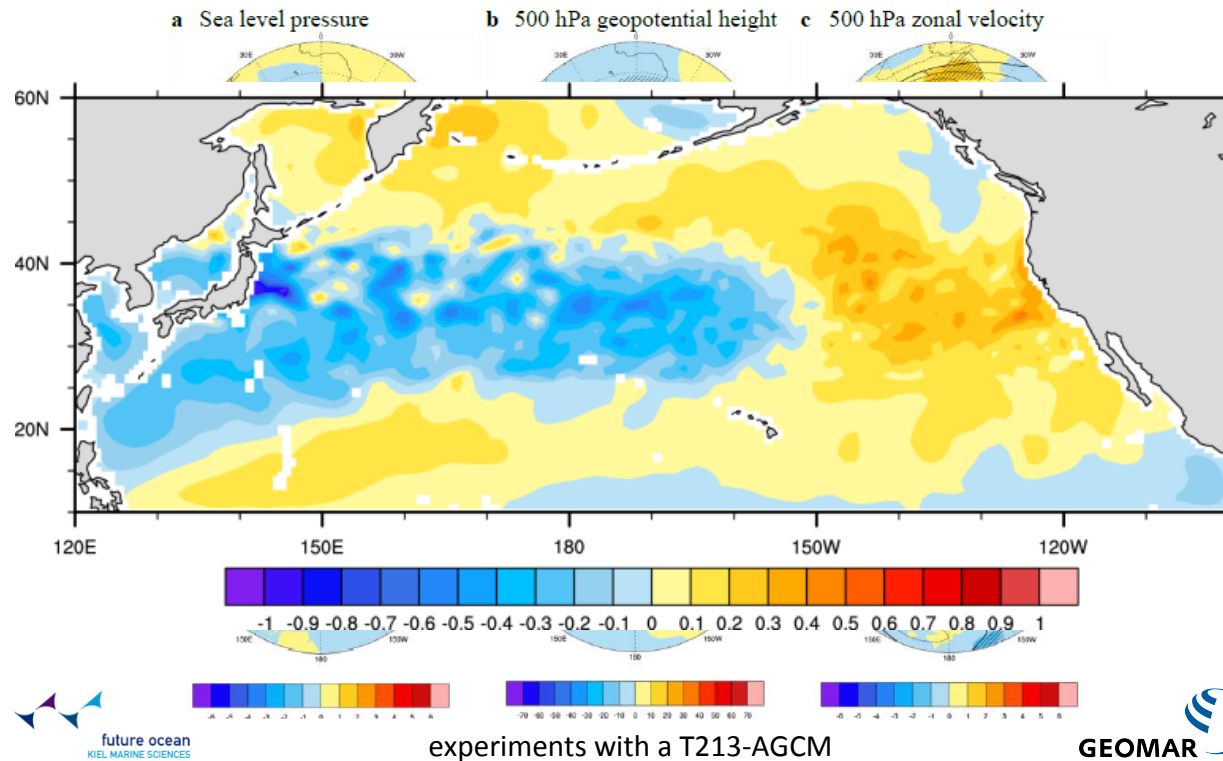


4. Decadal predictability

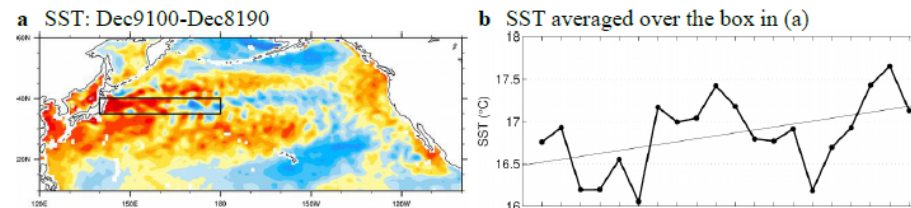


Wu et al. (2015)

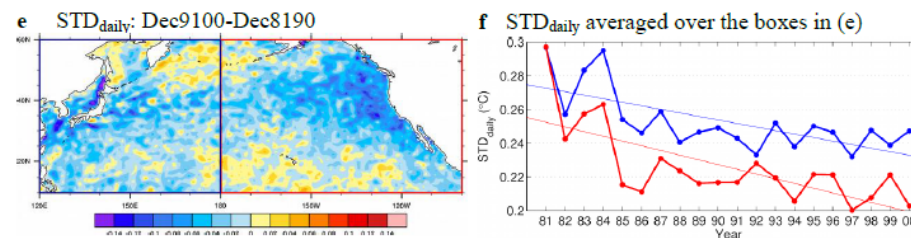
The atmospheric response to SST anomalies depends on the background SST on which it is superimposed



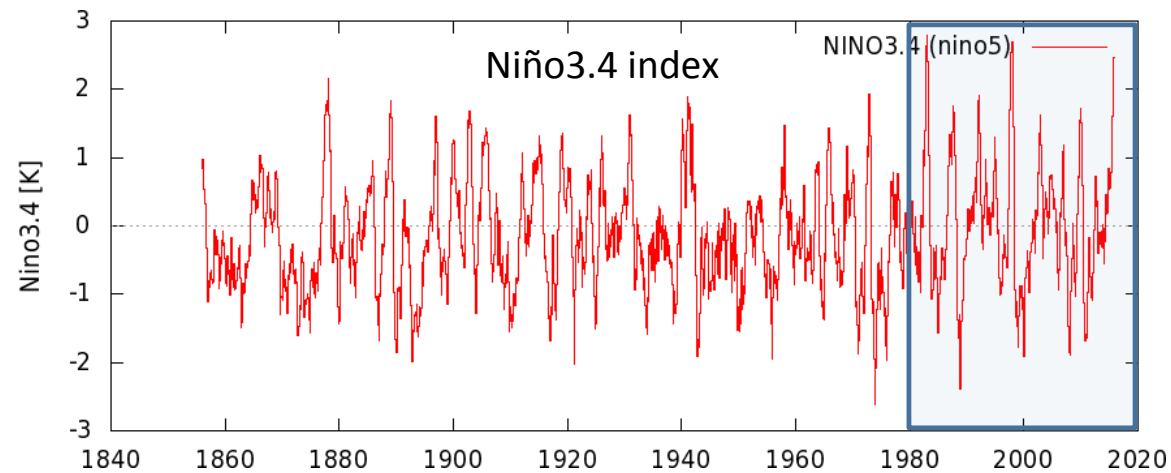
Statistics of the background SSTs matter, among others the level of daily SST variability



small-scale daily variability in the background SST matters, which requires that such variability is simulated by the ocean component and resolved by the atmospheric component of climate models



Decadal modulation of interannual variability: ENSO is an example



Is ENSO changing in response to global warming or are we just seeing decadal variability of ENSO strength? If we are seeing the latter, what is the mechanism and the impact on seasonal forecast skill?

Scientific questions

- Understand better mechanisms of internal variability
- What is the climate response to decadal variability in external forcing?
- Relative roles of internally and externally driven decadal variability
- The role of model bias in decadal variability and predictability
- Decadal modulation of interannual variability, role of interactions between the extratropics and the tropics
- Quantification of decadal predictability potential is pending,

estimates are very model-dependent