Wind-Driven Hindcasts with the Kiel Climate Model: Variability and Teleconnections

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1 Introduction

Wind stress is an important driver of ocean variability, sometimes involving also a feedback to the atmosphere. A prominent example is the El Niño/Southern Oscillation (ENSO, *Bjerknes 1969*) where wind stress anomalies are one crucial element establishing this recurring mode of climate variability: linking the atmosphere, the surface, and sub-surface ocean. ENSO acts particularly on interannual timescales.

But wind driven processes operate also on decadal timescales, as, for example, during the recent global warming hiatus. The hiatus was shown to be reproduced by a coupled model when forced by observed wind stress in the tropical Pacific (*Delworth et al. 2015).*

Thus, wind stress forcing of the ocean circulation is important to understand climate predictability on a wide range of timescales, from seasonal to decadal.

2 Model and experiments

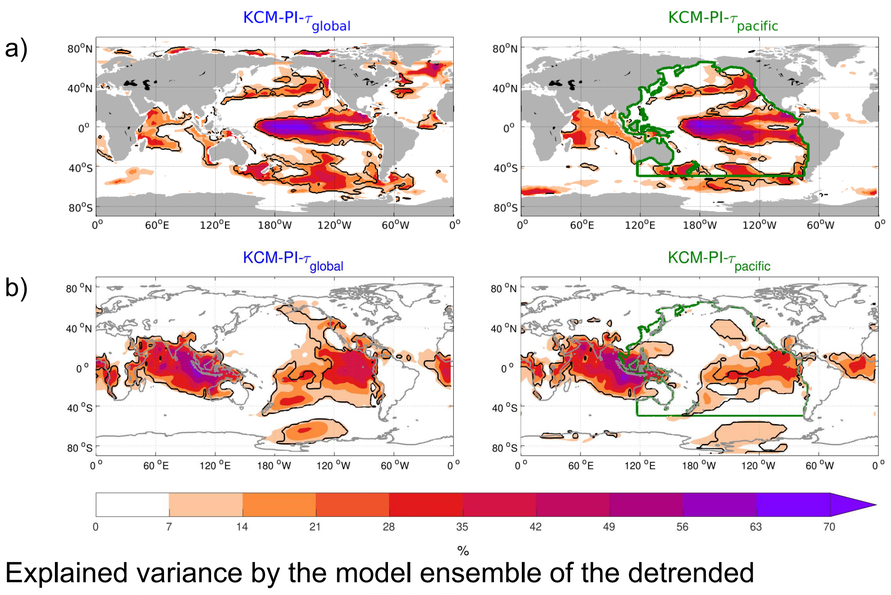
Kiel Climate Model (KCM) - *Park et al. 2009*

- atmosphere model: ECHAM5 [T42, L19]
- ocean sea-ice model: NEMO (OPA9-LIM2) [2° horiz., 31 vert. levels]

Wind stress experiments for the period 1900-2010

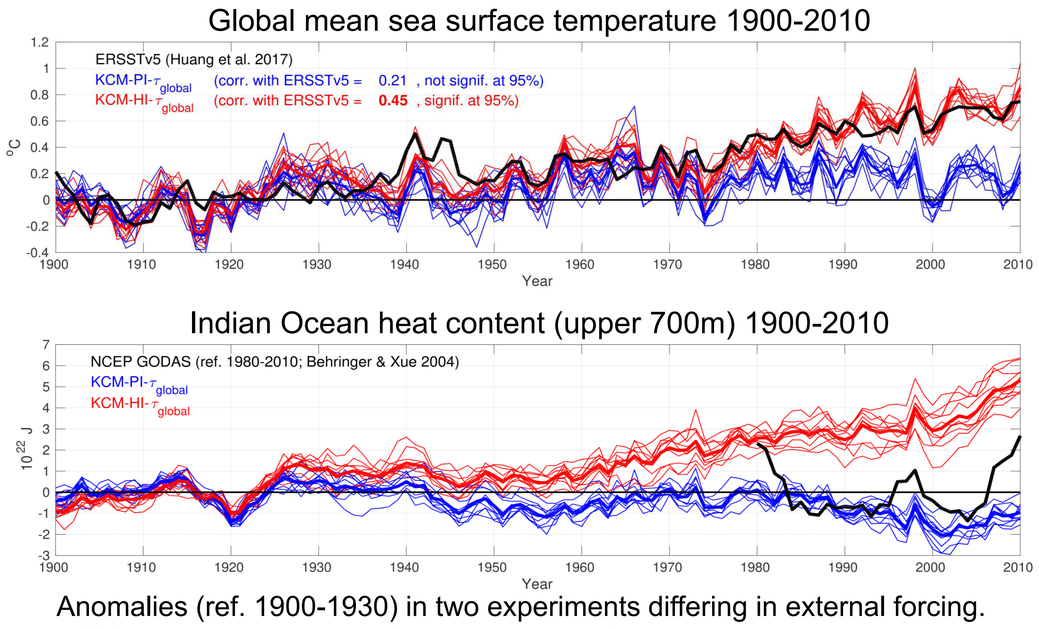
- daily anomalies of the ERA-20C reanalysis (*Poli et al. 2016*) wind stress are added to the KCM
- each experiment is defined as the average over 10 ensemble members differing in initial conditions
- external forcing: constant pre-industrial (**PI**) vs. historical (**HI**) forcing
- to identify teleconnections the wind stress forcing was applied globally, but also limited to different ocean areas

3 Hindcasts of sea surface temperature and sea level pressure 1970-2010



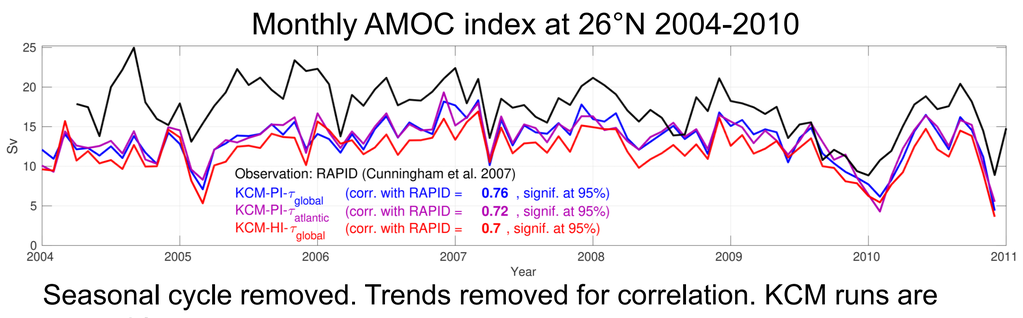
Explained variance by the model ensemble of the detrended
a) sea surface temperature: ERSSTv5 (*Huang et al. 2017*)
b) annual sea level pressure: HadSLP2r (*Allan and Ansell 2006*)
Black line: 95% confidence level.

4 Indian Ocean warming during the hiatus period

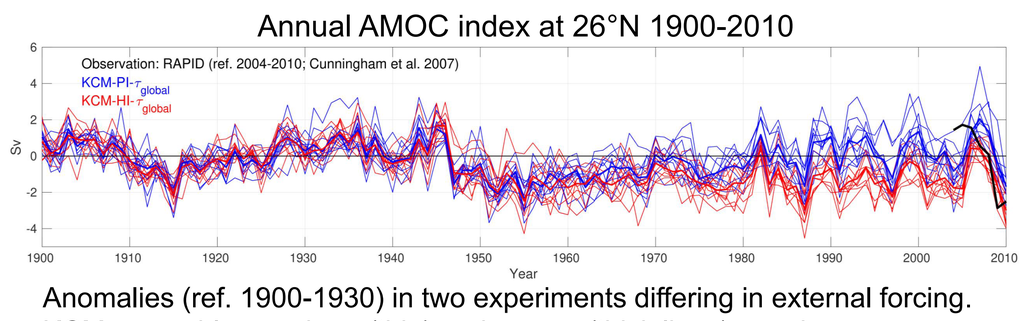


Anomalies (ref. 1900-1930) in two experiments differing in external forcing.
KCM ensemble members (thin) and means (thick lines) are shown.
Trends removed for correlation.

5 Atlantic Meridional Overturning (AMOC) variability



Seasonal cycle removed. Trends removed for correlation. KCM runs are ensemble means.



Anomalies (ref. 1900-1930) in two experiments differing in external forcing.
KCM ensemble members (thin) and means (thick lines) are shown.

6 Summary

The Kiel Climate Model (KCM) was forced by the wind stress of the ERA-20C reanalysis to investigate the role of wind forcing for different timescales of variability.

3 Over large parts of the tropics more than half of the observed annual variability in sea surface temperature and sea level pressure can be explained by the wind stress. Pacific-only wind stress significantly contributes to the variability also outside the Pacific ocean.

4 The timing of the global warming hiatus period along with the accelerated Indian Ocean warming is reproduced, suggesting a wind driven mechanism associated with a negative phase of the Interdecadal Pacific Oscillation (IPO).

5 The Atlantic wind stress explains 52% of the monthly variability of the observed AMOC index at 26°N.
Adding greenhouse gas forcing causes a slight deceleration of the annual AMOC until the year 2010, but interannual variability due to the wind stress is dominating.

References

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