Predictability based on initial conditions from prescribed wind-stress anomalies simulation

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1 Introduction

Wind-stress is an important driver of ocean variability, sometimes also with feedbacks to the atmosphere, like in the case of the El Niño / Southern Oscillation (ENSO, *Bjerknes 1969*). ENSO acts particularly on interannual timescales.
But wind also influences 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 tropical Pacific wind-stress (*Delworth et al. 2015*).
Furthermore, hindcasts initialized from coupled model runs driven by reanalysis wind-stress could predict decadal climate shifts for 1976/77 and 1998/99 in the Pacific (*Ding et al. 2013*).
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 (~2.8°), L19]
- ocean sea-ice model: NEMO (OPA9-LIM2) [2° horiz., 31 vert. levels]

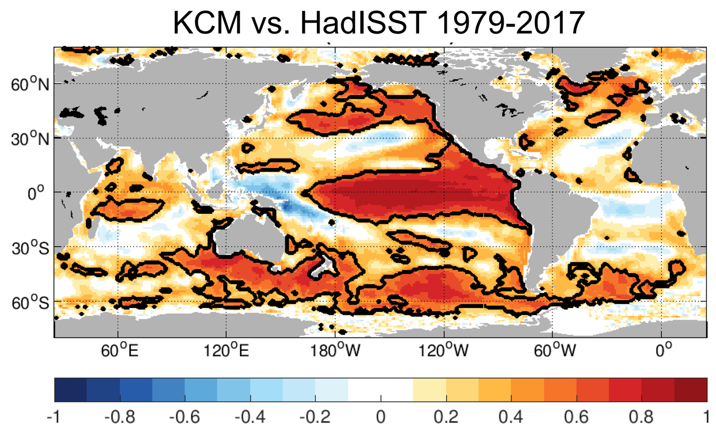
A Wind-stress experiments for the period 1979-2010
- daily ERA-interim (*Dee et al. 2011*) wind-stress anomalies are added to the KCM climatology
- 10 members differing in initial conditions but with same historical CO_2 forcing

B Hindcasts for the period 1988-2017
- no prescribed variables (except for historical external forcing)
- 10 members initialized from **A** - run for 10 years
- initialized every 3 months from Dec 1988 to Sep 2007

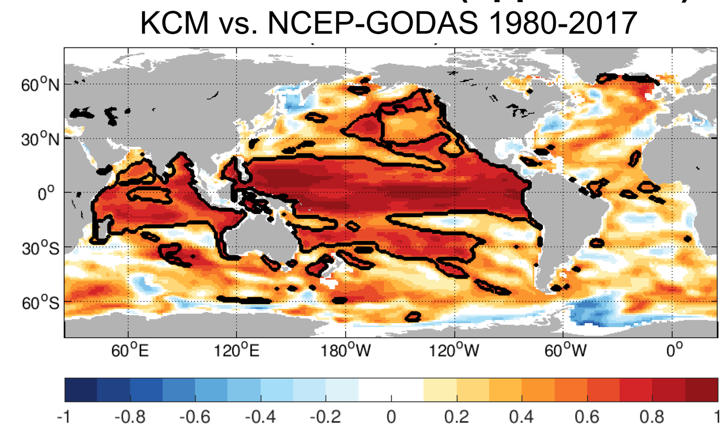
3 The role of the wind-stress in driving ocean variability (A experiments)

Anomaly Correlations – KCM vs. Observation (12 months averages, detrended)

SST
KCM vs. HadISST 1979-2017

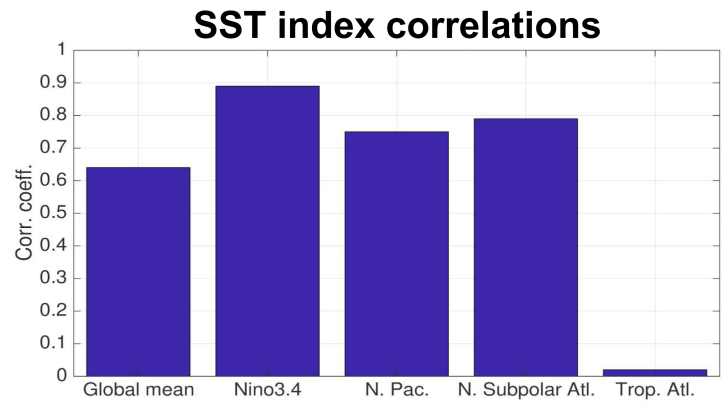


Ocean Heat Content (upper 700m)
KCM vs. NCEP-GODAS 1980-2017



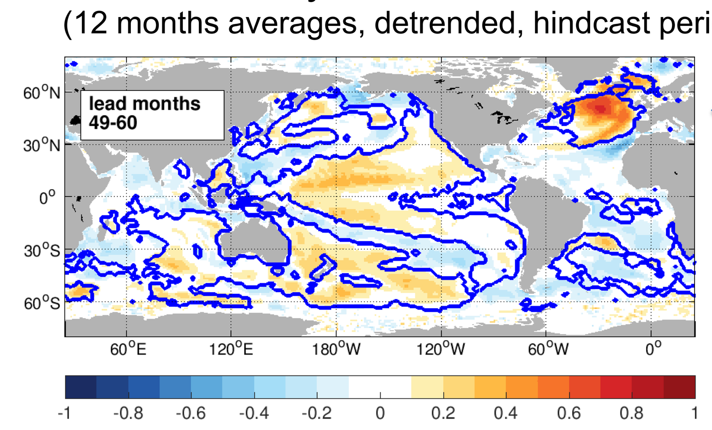
Black contour line: 95% confidence level

SST index correlations



4 Predictability through wind-stress initialization? (B experiments)

SST Anomaly Correlations with HadISST
(12 months averages, detrended, hindcast period 1988-2017)



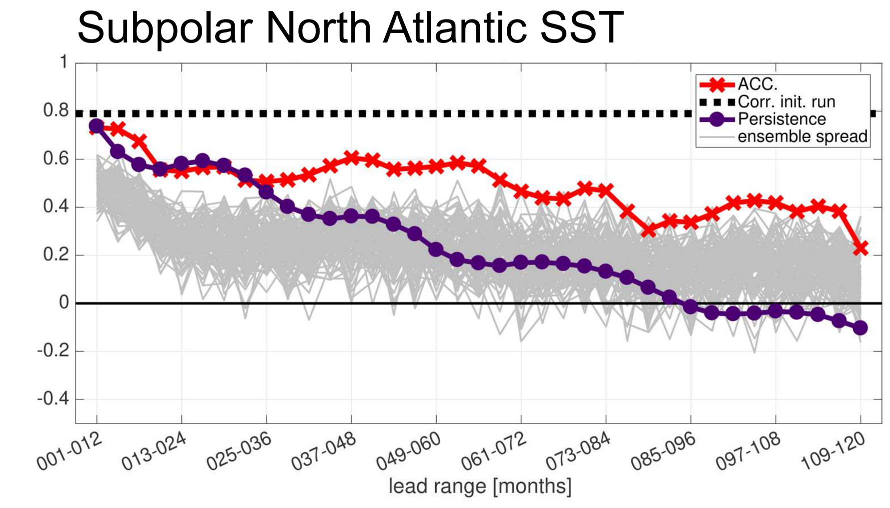
Prediction year 5

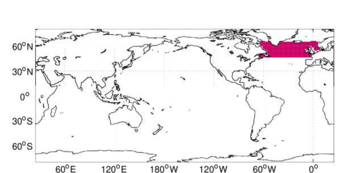
For futher lead times see

Scan me

Blue contour line:
Persistence (obs. auto-corr.)

Subpolar North Atlantic SST

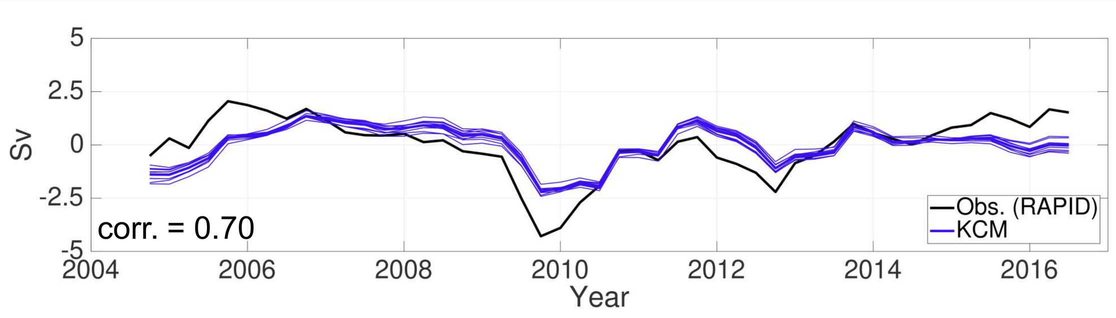




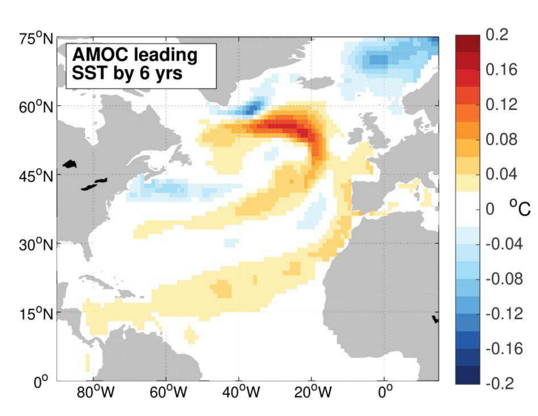
ACC (Anomaly Correlation Coefficient). Ensemble spread from randomly chosen ensemble members each time step.

5 Sources for predictability?

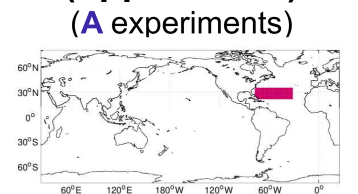
AMOC index at 26°N
(**A** experiments)

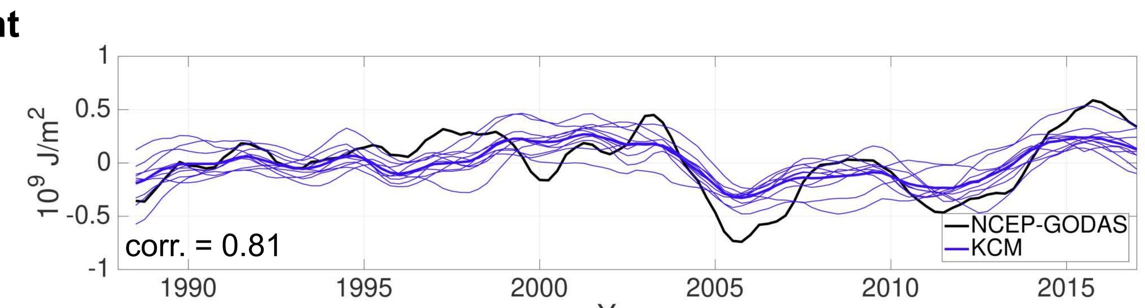


Regression:
AMOC 26°N leading SST by 6 years
(KCM control run)



Ocean Heat Content (upper 700m)
(**A** experiments)





6 Summary

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

3 The wind-stress is very important for interannual SST and Ocean Heat Content variability, especially, in the tropical Pacific, the North Pacific, and the subpolar North Atlantic, but not in the tropical Atlantic.

4 There is predictability for the SST in the Subpolar North Atlantic for a lead time of several years (anomaly correlation coefficients are high ~0.6 and larger than persistence). Initialization was achieved purely through wind-stress forcing.

5 Sources for the SST predictability in the Subpolar North Atlantic could be the wind-driven response of the deep ocean circulation like the AMOC (Atlantic Meridional Overturning Circulation), but also other effects that influence the Oceanic Heat Content (e.g., wind-driven anomalous heat advection or Ekman pumping).

References

Bjerknes 1969: Atmospheric teleconnections from the tropical Pacific; Mon Weather Rev 97

Dee et al. 2011: The ERA-Interim reanalysis: configuration and performance … ; QJR Met Soc 137

Ding et al. 2013: Hindcast of the 1976/77 and 1998/99 Climate Shifts in the Pacific; J Clim 26(19)

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