Dynamics and Predictability of the AMOC

Mojib Latif, Helmholtz Centre for Ocean Research and Kiel University
Co-workers: J. Ba, H. Ding, R. J. Greatbatch, S.K. Gulev, N.S. Keenlyside, M. Klöwer, T. Martin, W. Park

- New analysis of NA surface heat fluxes since 1880

  → ocean drives NA SST at decadal time scales

- Dynamical/statistical prediction of AMO/V
- → to account for model bias, strong NAO influence
- Southern Ocean variability and AMOC impact

  → at centennial time scales, hiatus in global warming

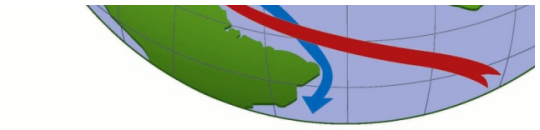
1. New analysis of North Atlantic surface heat fluxes since 1880

LETTER

doi:10.1038/nature12268

North Atlantic Ocean control on surface heat flux on multidecadal timescales

Sergey K. Gulev[1,2,3], Mojib Latif[2,4], Noel Keenlyside[5], Wonsun Park[2] & Klaus Peter Koltermann[3]



suggests that the ocean drives the SST at decadal time scales, the atmosphere damps the SST

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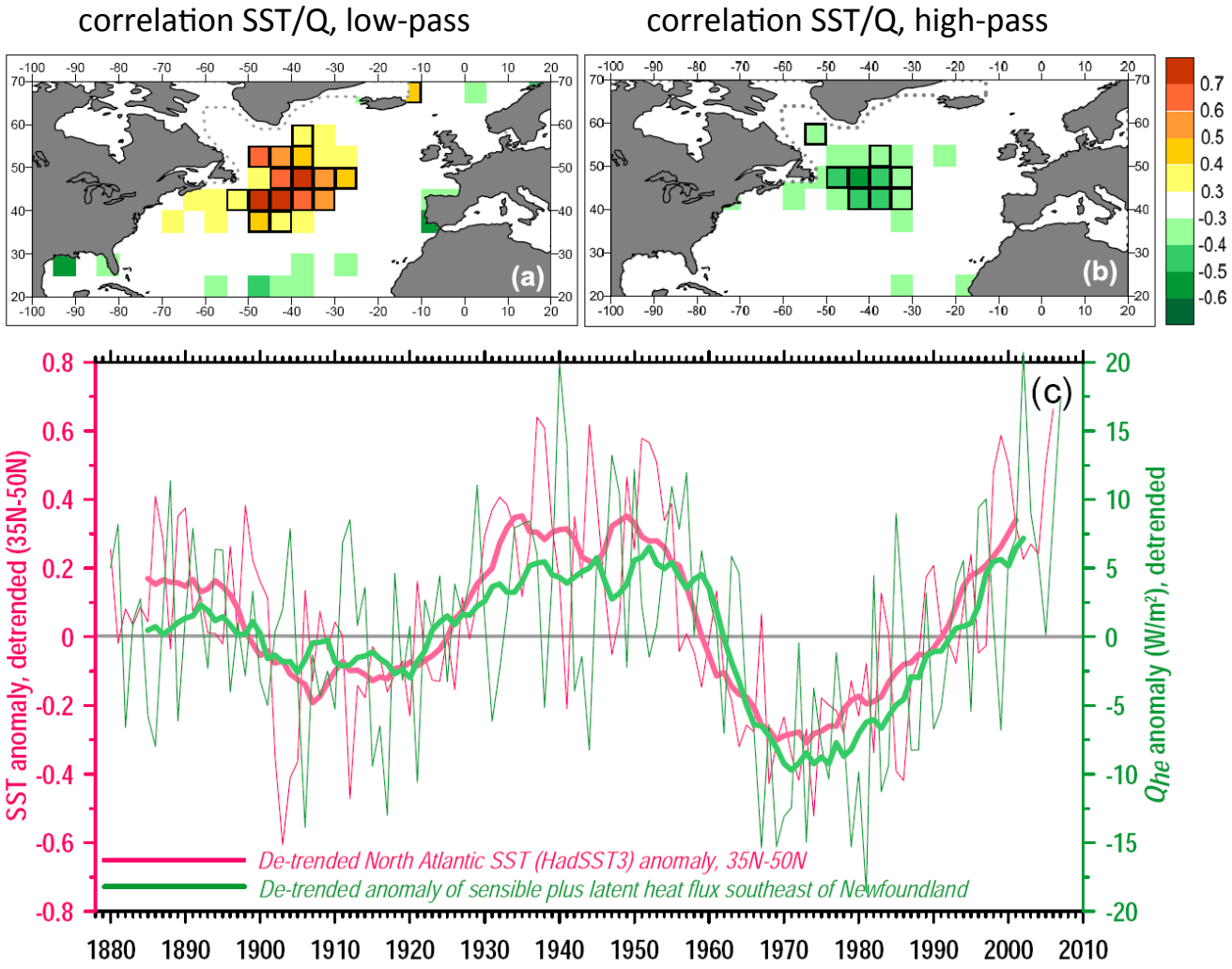
Verification of the Bjerknes hypothesis: atmosphere drives SST on short, ocean on long time scales



Gulev et al., Nature (2013)

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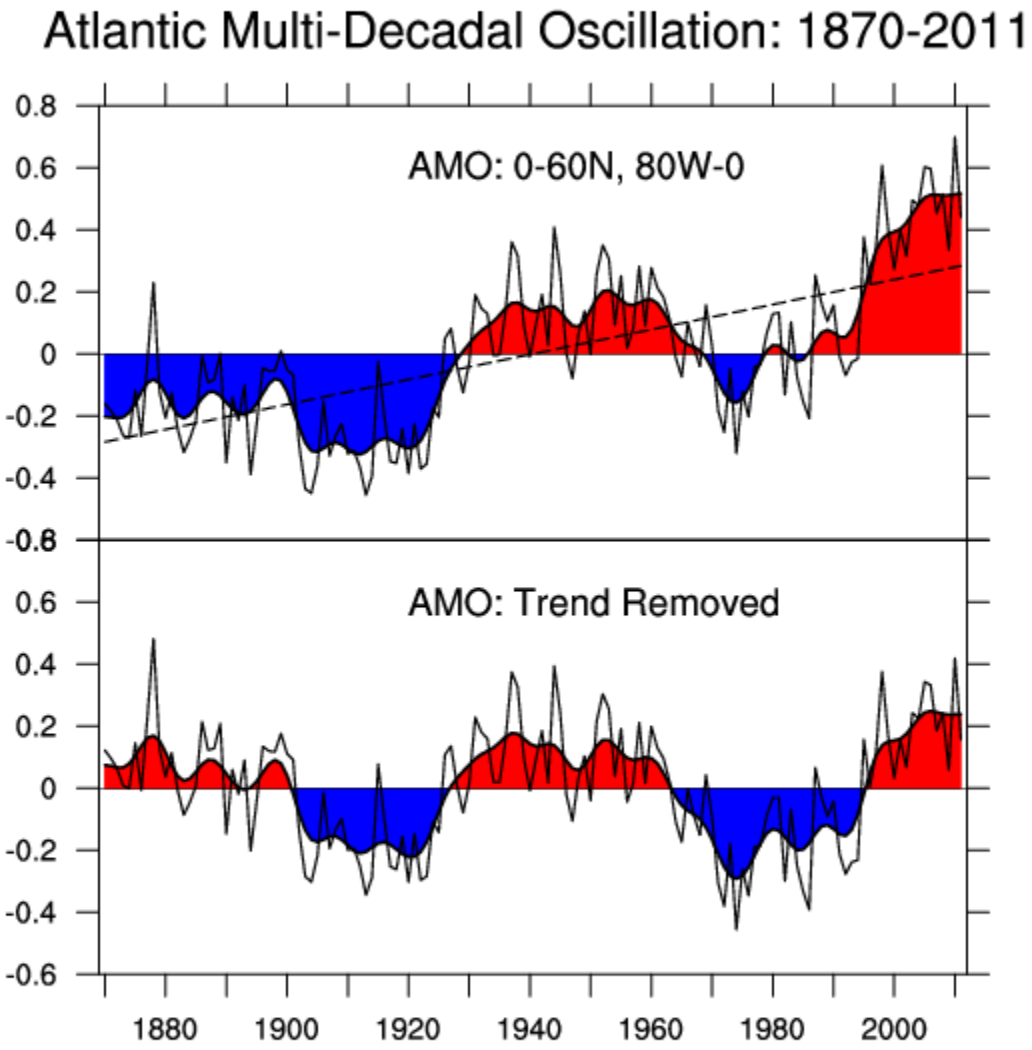
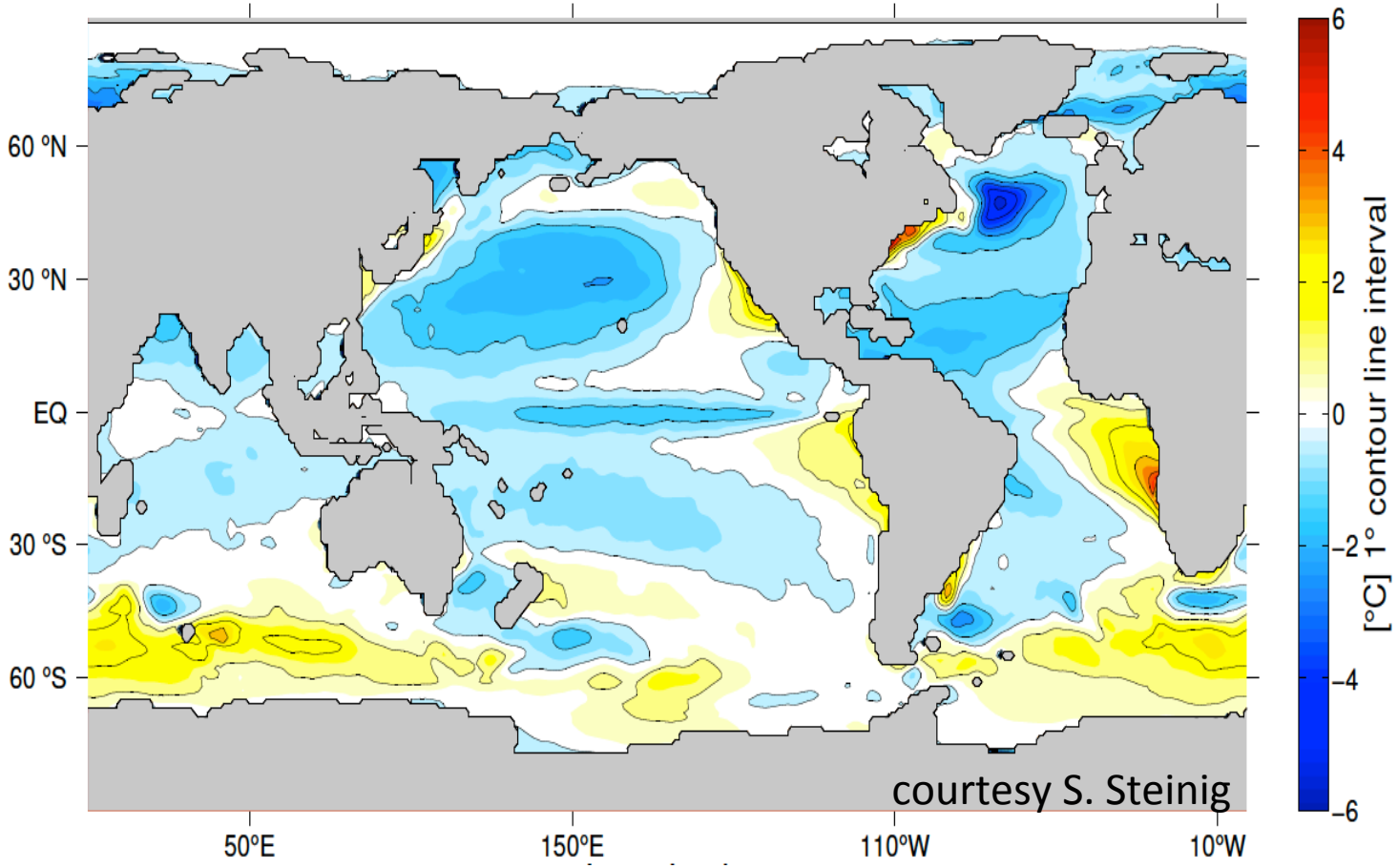
2. Dynamical/statistical AMO/V prediction



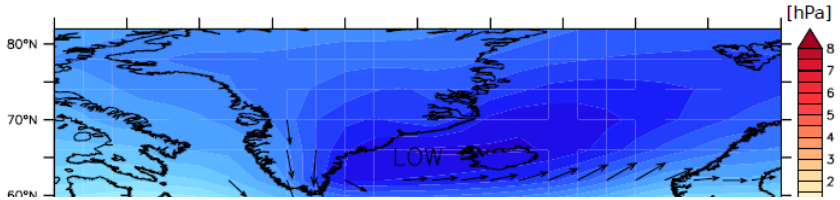
The issue of model bias

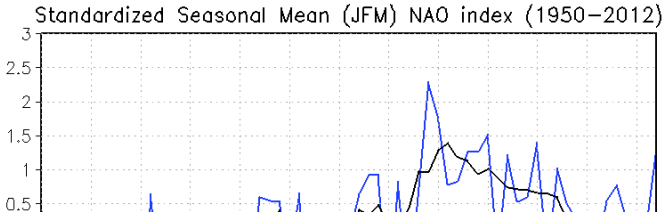
CMIP5 multi-model mean SST bias



incorrect path of North Atlantic Current inhibits realistic simulation of SST and its variability

Our forecast approach is entirely based on the NAO





testing the null hypothesis for AMOC variability (see also J. Mecking's talk)

NAO

↓

Heat flux anomalies

↓

Deep convection

↓

Meridional Overturning Circulation

↓

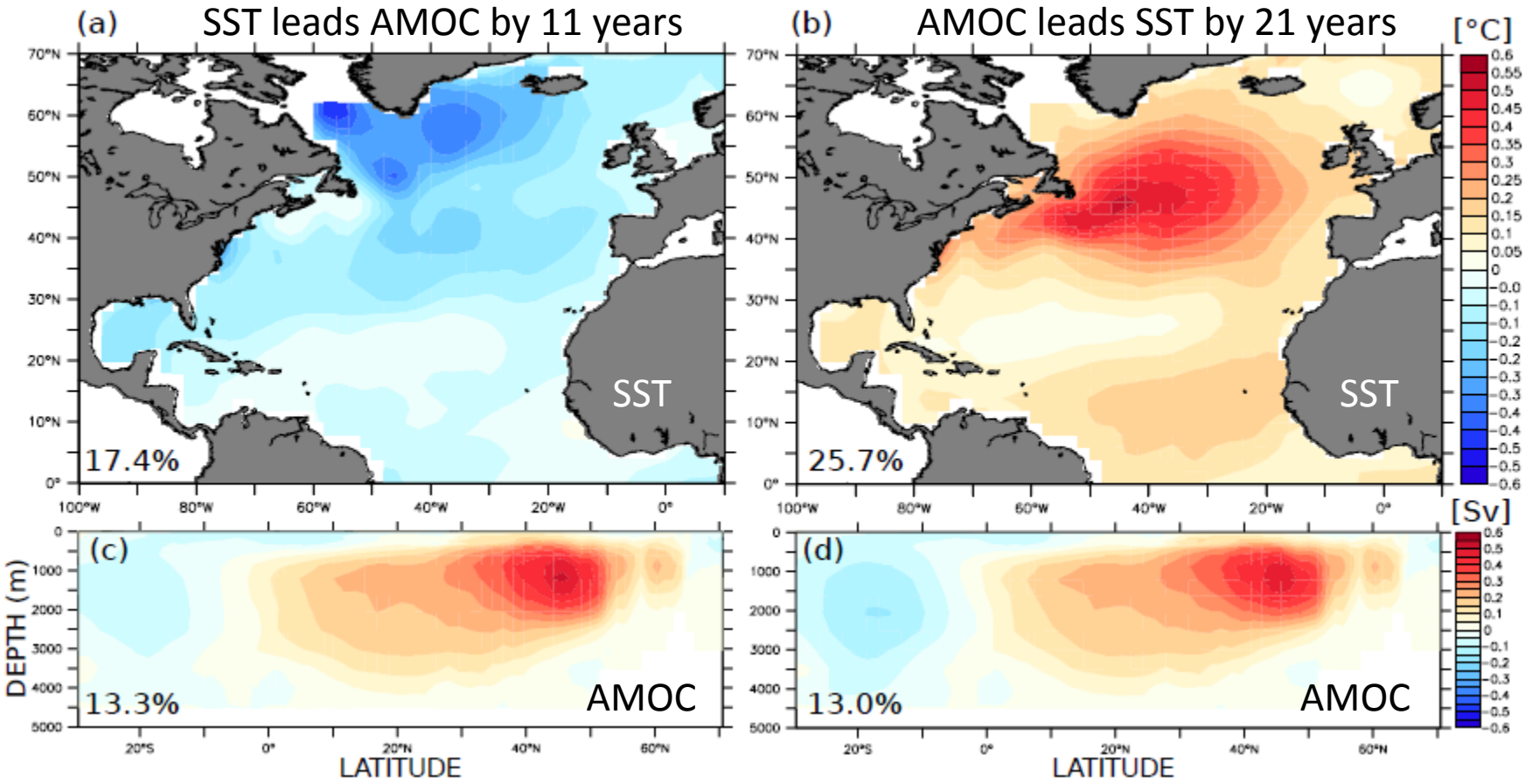
Oceanic heat transport

↓

SST anomalies

Ding et al., in prep.

Link between model (KCM) overturning and observed North Atlantic SST obtained from CCA



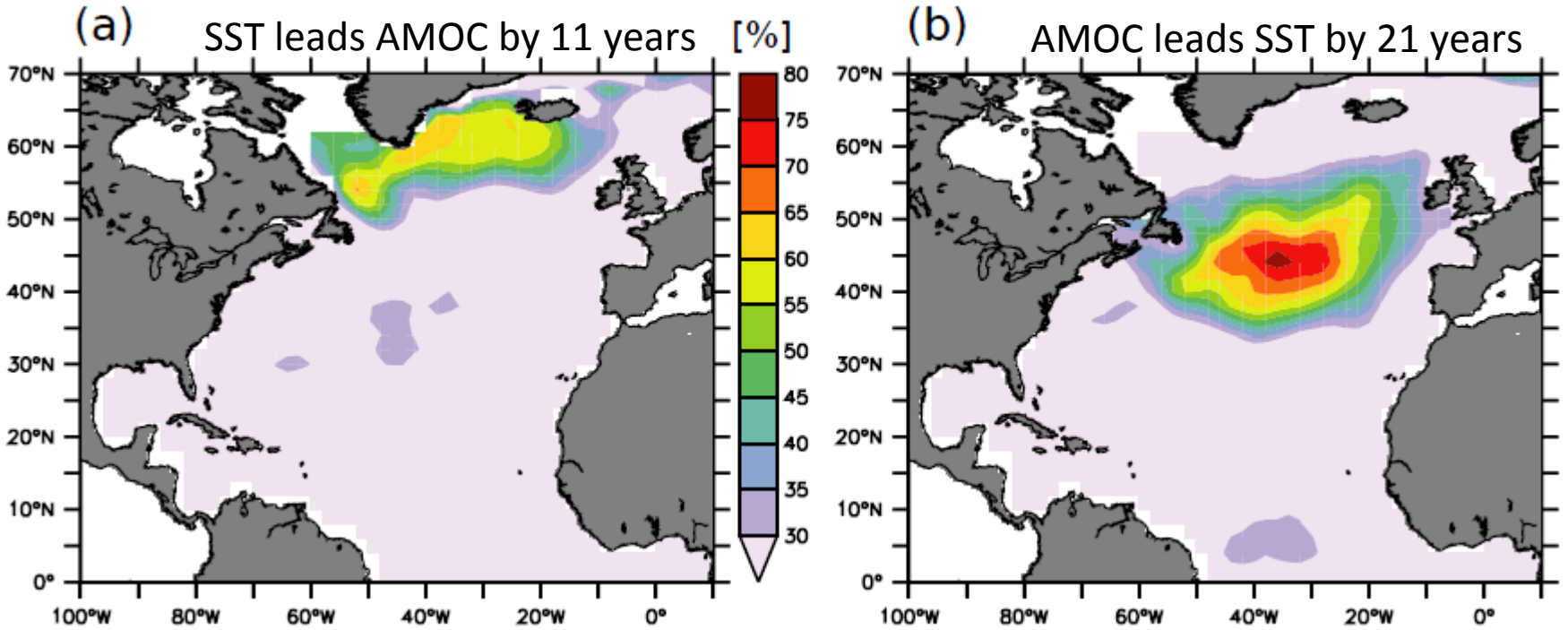
Bachelor thesis, M. Klöwer 2013

1. SST leads AMOC by a decade

2. AMOC leads SST by 2 decades

The connection between the model's AMOC and observed SST is pretty healthy

variances accounted for by the CCAs at the two lags



anomalies are relative to 1870-2000

Bachelor thesis, M. Klöwer 2013

NAO-related SST anomalies lead the model's AMOC, the latter in turn drives the SST with a time delay

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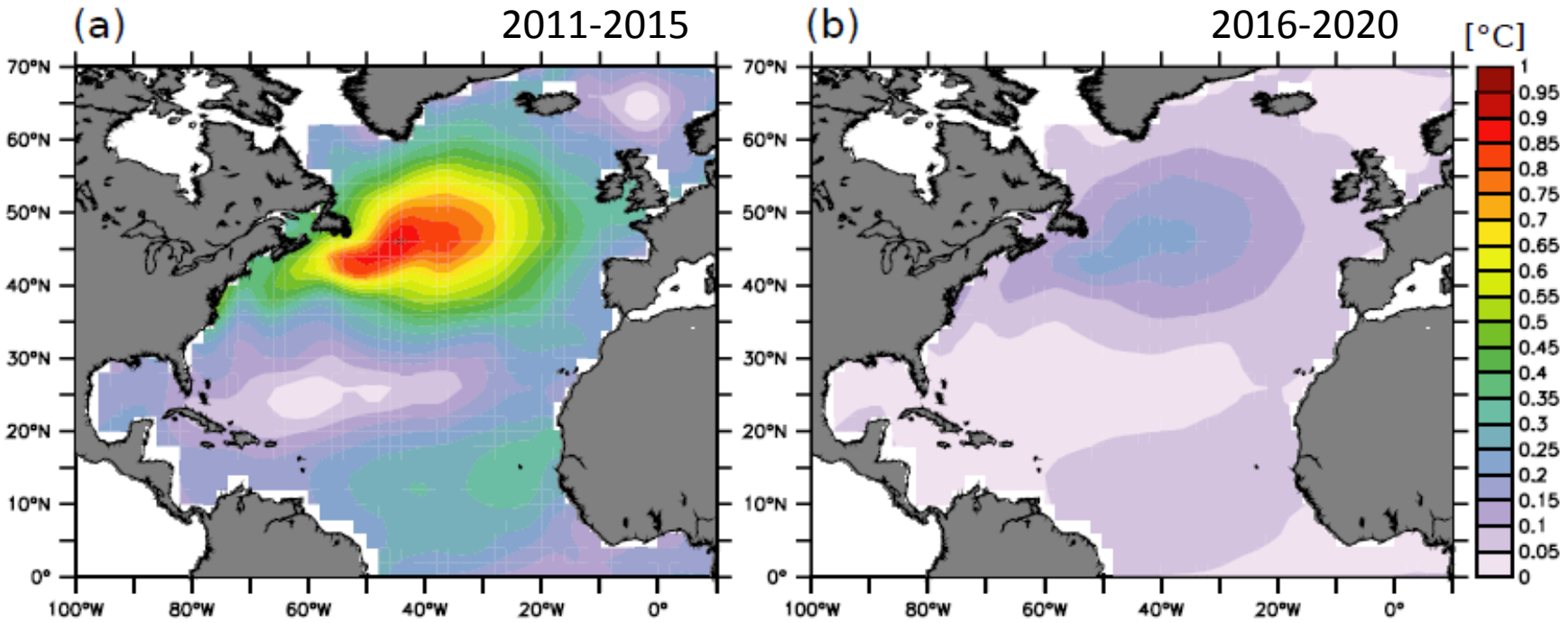
Forecast of NAO-forced SST anomalies until 2020 using the KCM's AMOC as a predictor



Bachelor thesis, M. Klöwer 2013

forecast based on the leading CCA mode at lag-21yr: the warm phase of the AMO/V may terminate soon

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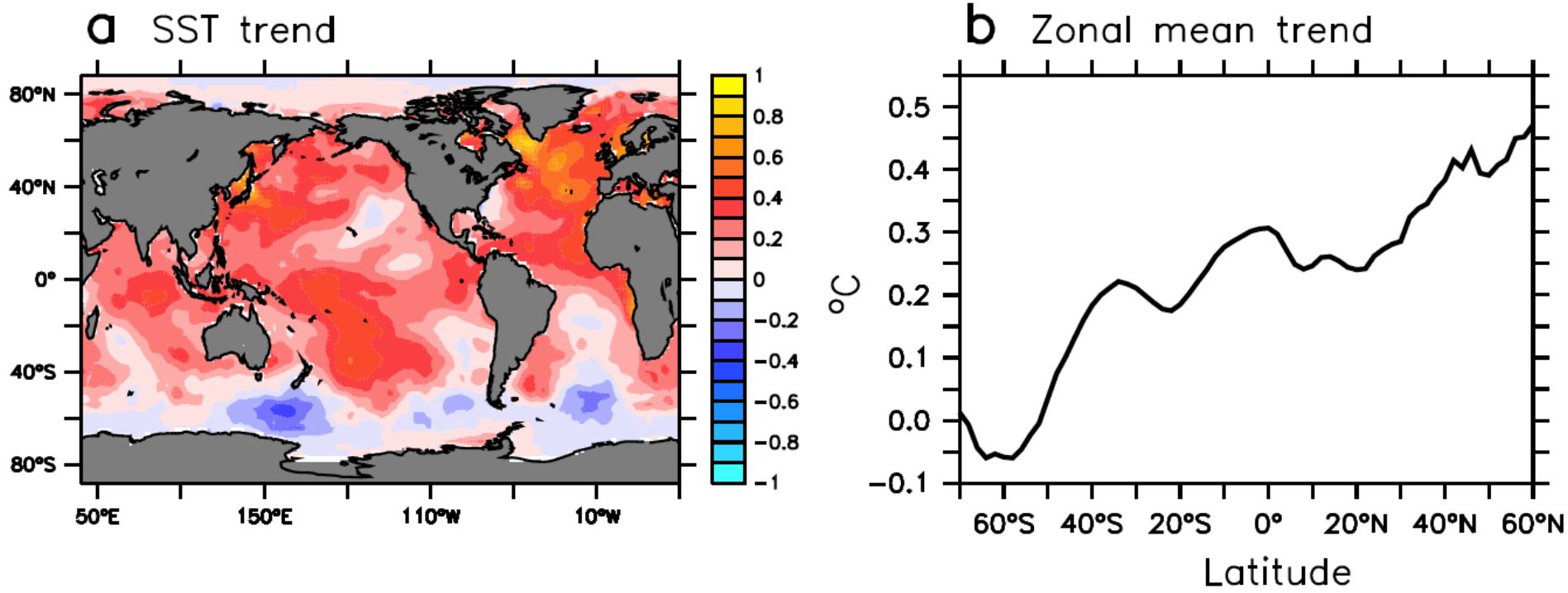
3. Southern Ocean variability and AMOC impact

linear trend in SST 1971-2010



the Southern Ocean did not warm, which could be due to internal centennial variability

Martin et al. (2012), Latif et al. (2013), Martin et al. (2013, in revision)

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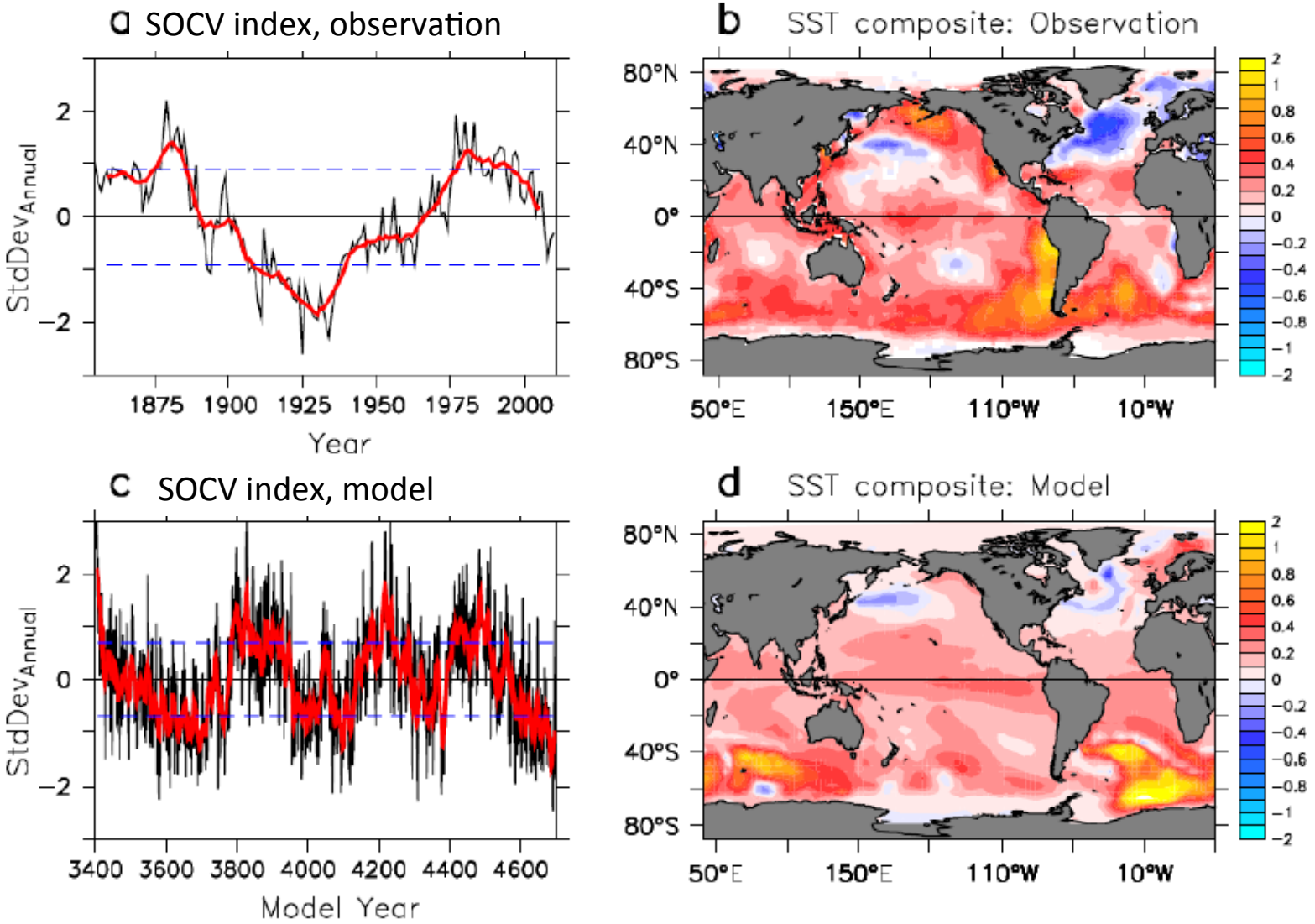
Southern Ocean centennial variability (SOCV)



the time scale is sensitive to model formulation, ranging from multidecadal to multicentennial

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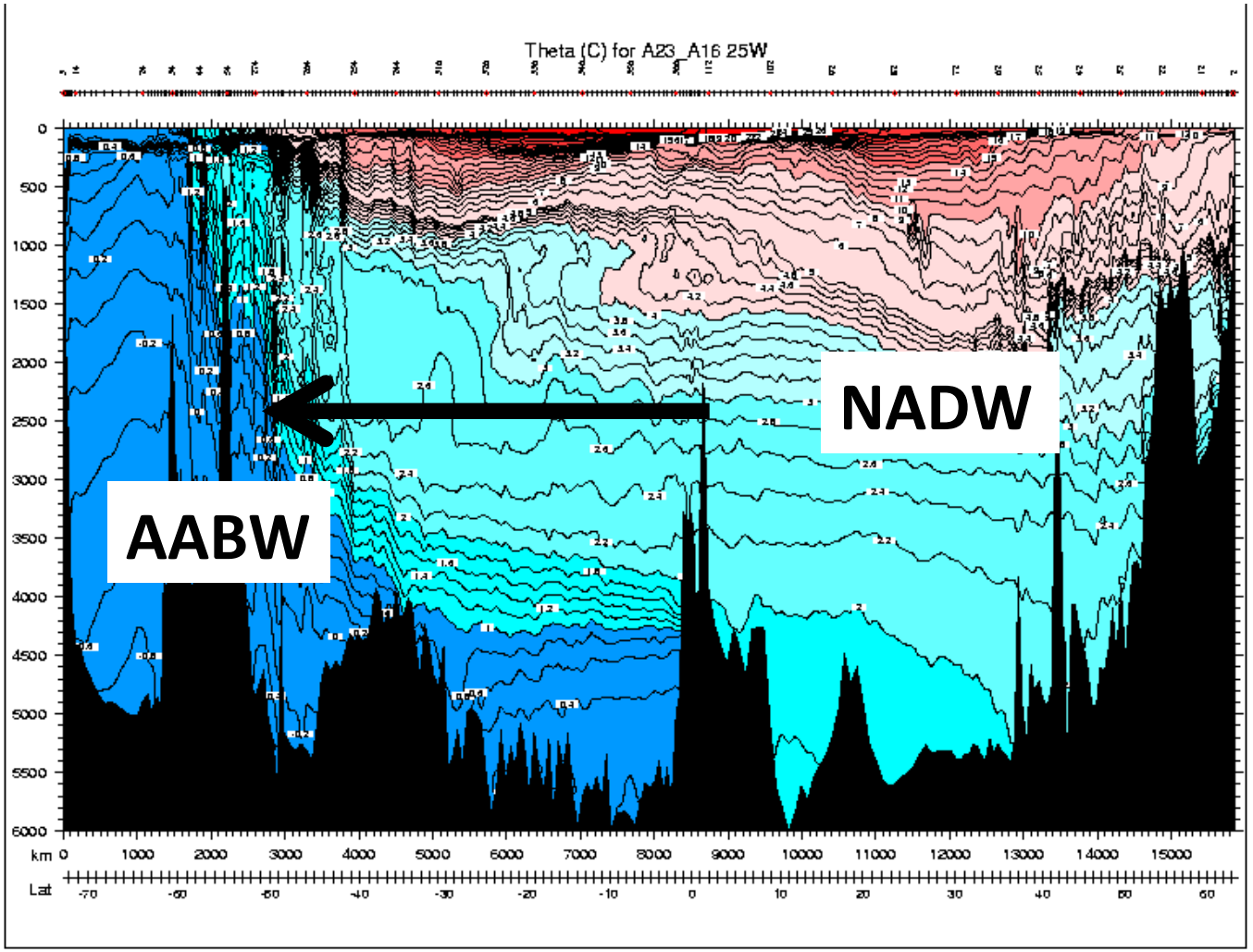
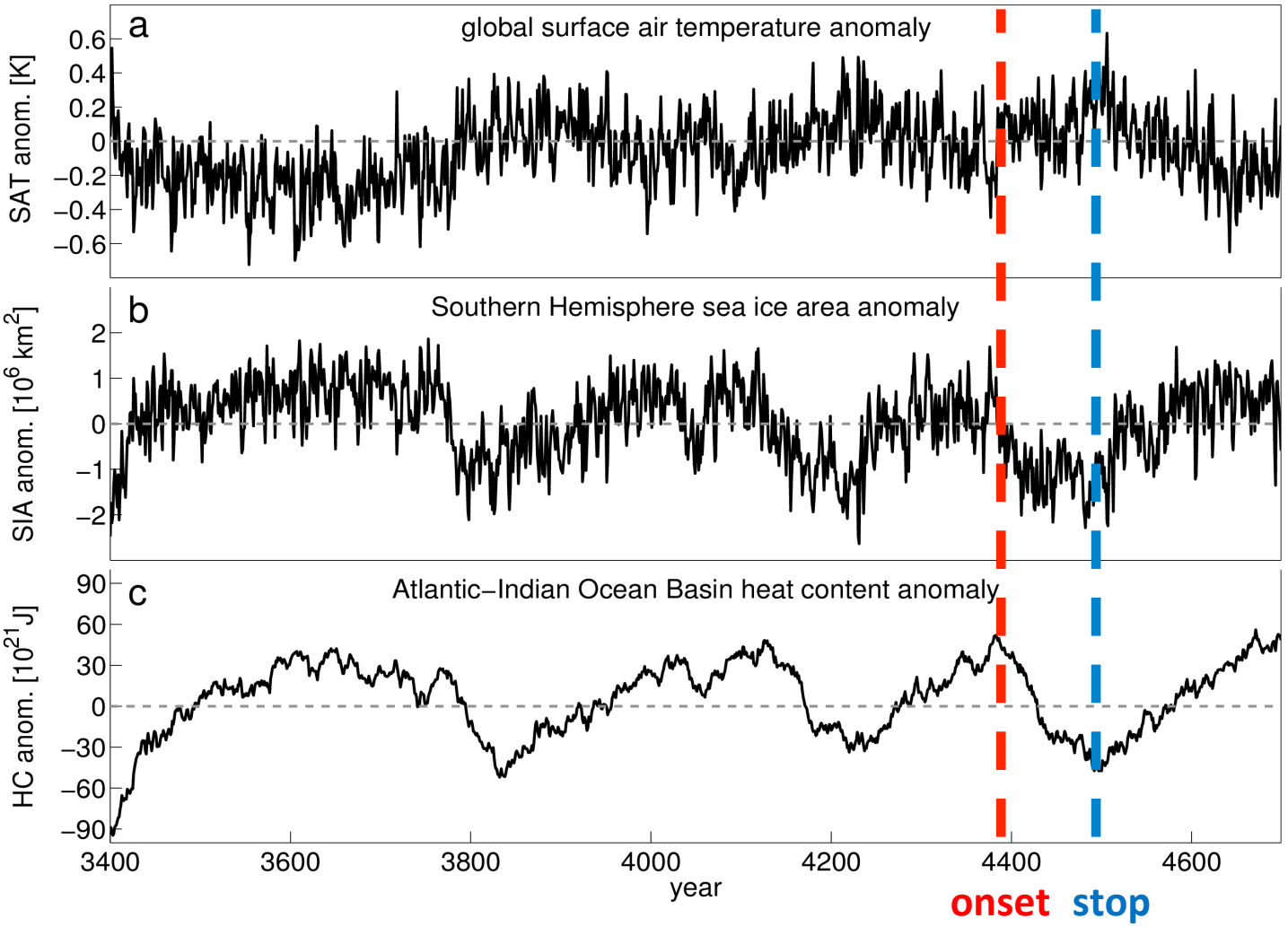
Potential temperature in the Atlantic



NADW (warm water) accumulation in the Southern Ocean by the lower limb of the AMOC

Heat accumulation in the Weddell Sea preconditions deep convection



during Weddell Sea convection the global SAT warms and Antarctic sea ice retreats, and vice versa

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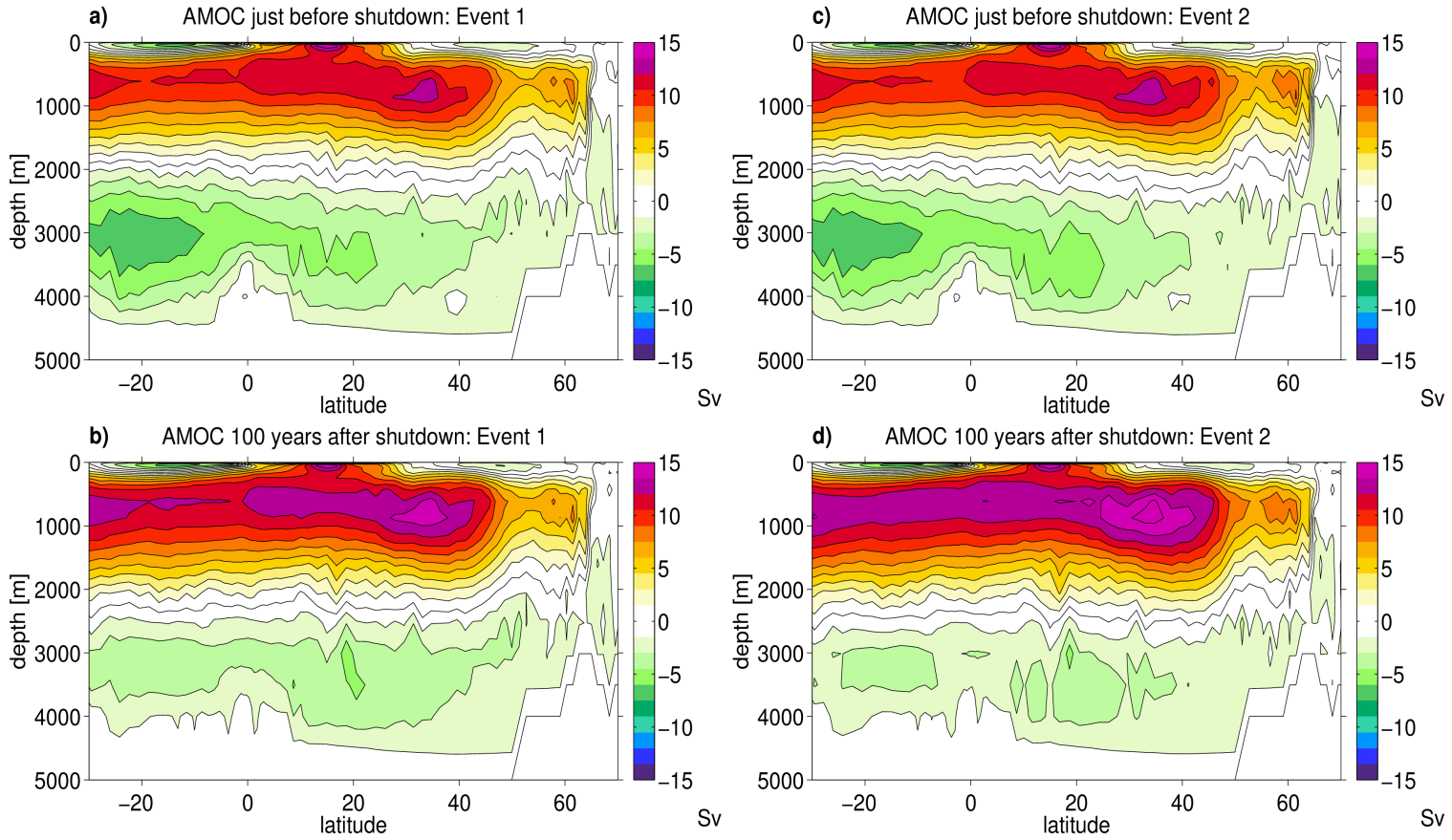
Southern Ocean centennial variability (SOCV) impact on the AMOC in the KCM



Martin et al. 2013 (in revision)

AMOC intensifies with a time delay of several decades to a century and expands vertically after halt in Weddell Sea convection

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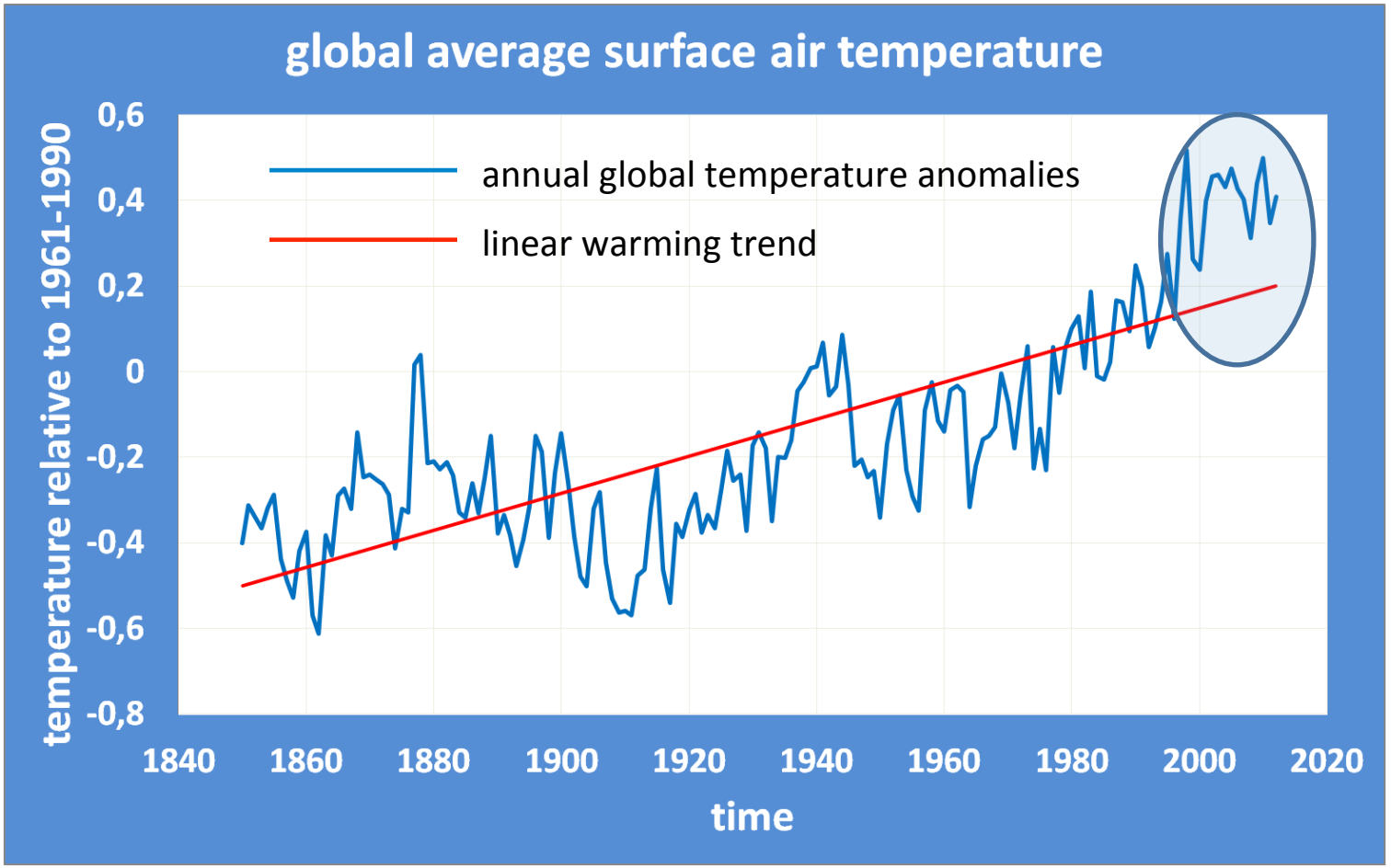
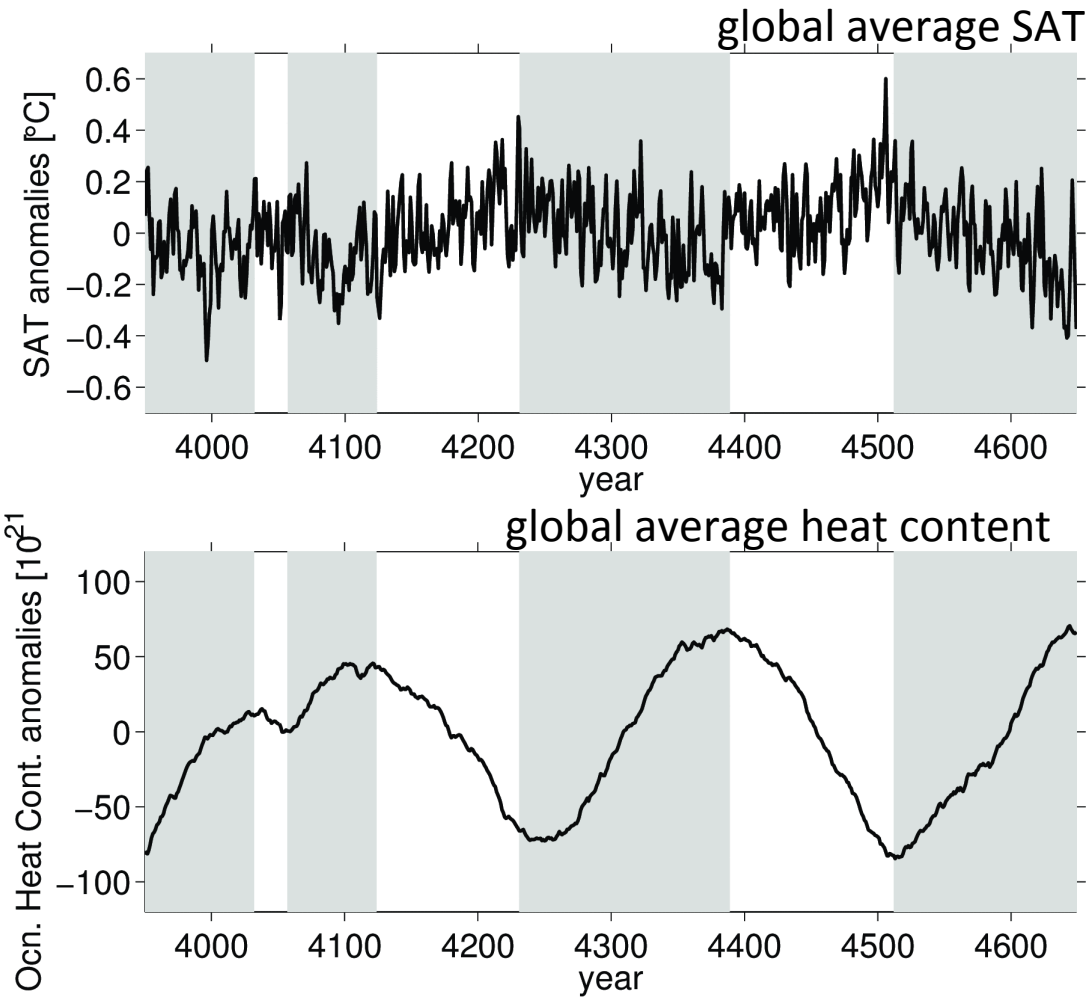
Possible implications for global warming



can the SOCV be the reason for the current hiatus in global warming?

Global average SAT and global average mid to deep ocean heat content (below 1000m)



as heat is taken up by the deep ocean, global average SAT cools

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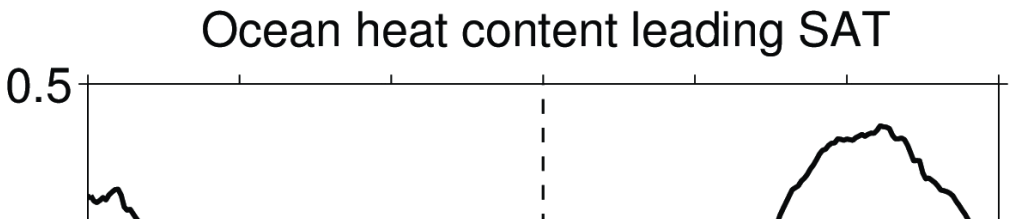
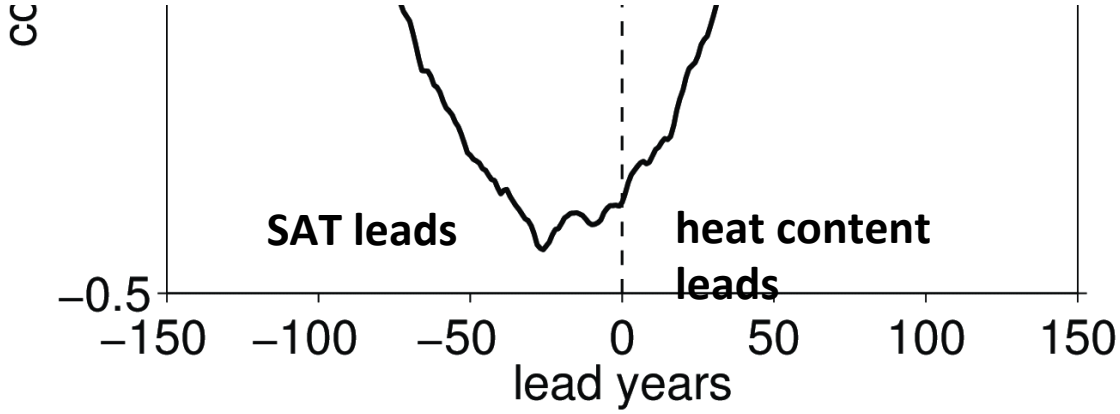
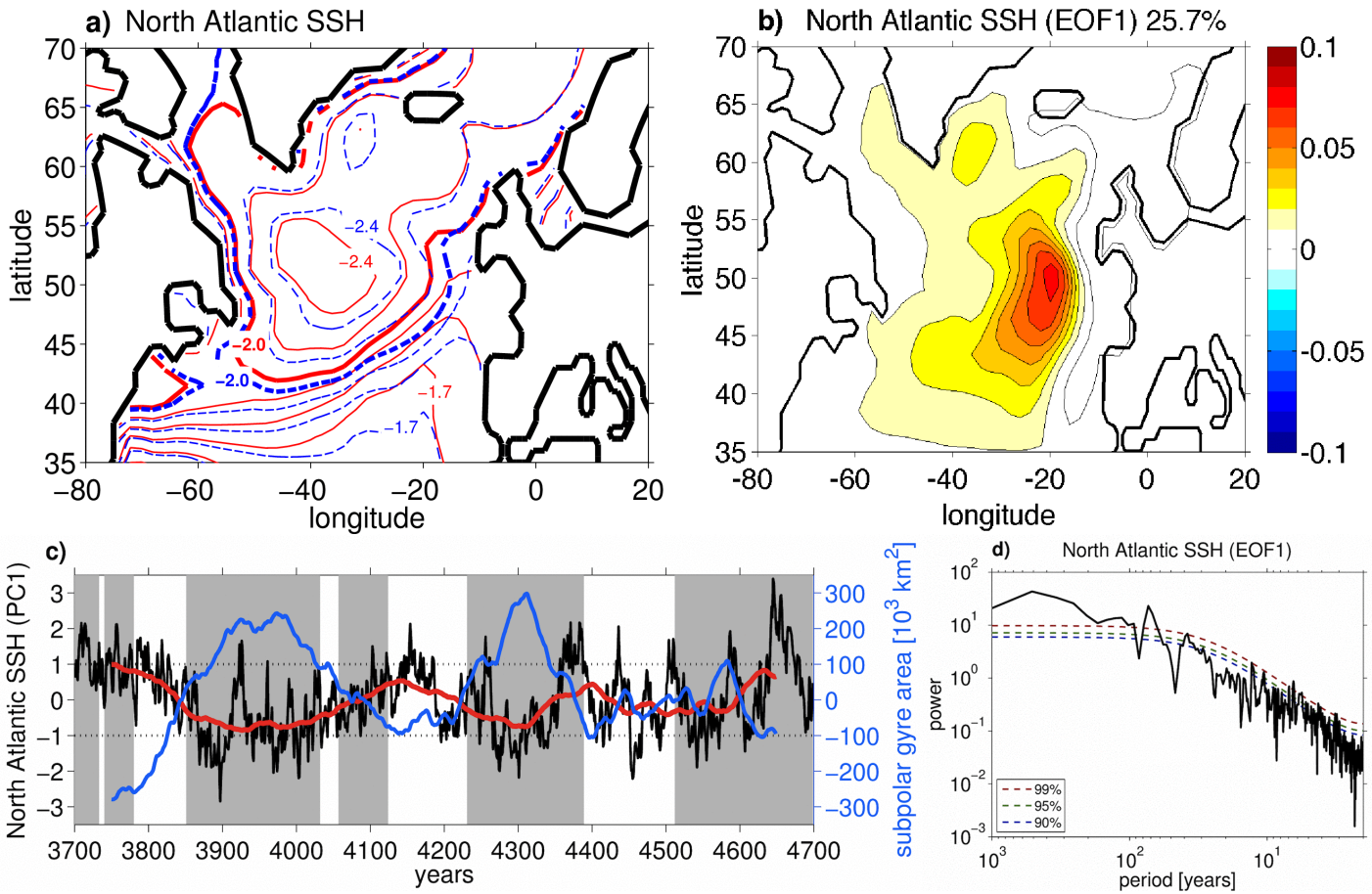
Correlation global average SAT with global average heat content



Is the current hiatus in global warming due to an enhanced heat uptake of the Southern Ocean?



Southern Ocean centennial variability (SOCV) impact on North Atlantic sea level in the KCM



Martin et al. 2013 (in revision)

Time scale dependence of the heat flux/SST link in the observations (solid) and in the KCM (dotted)

coherence and phase spectra: ocean drives SST at decadal time scales

spectra: enhanced variability at decadal time scales

Gulev et al., Nature (2013)