The coupling between the AMOC and the atmosphere in CCSM3

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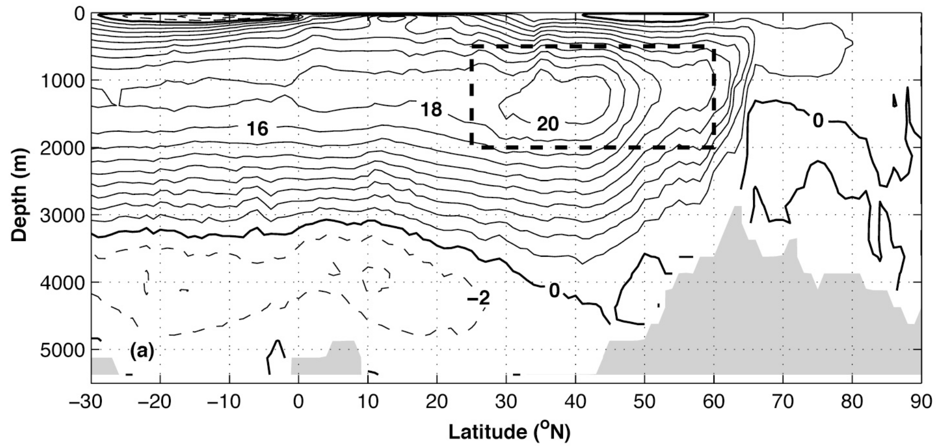
Does the AMOC significantly influence the atmospheric circulation?

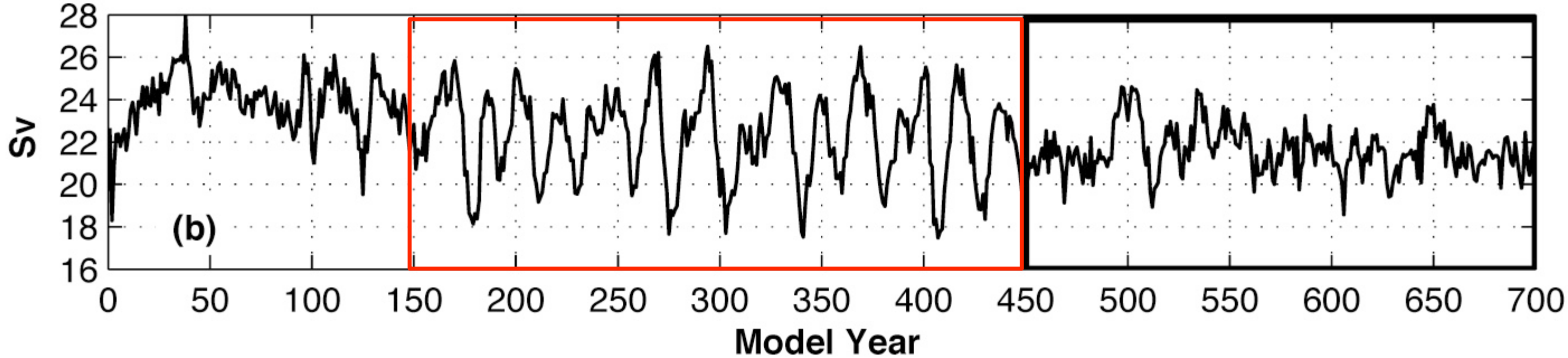
If so, is the impact realistic?

CCSM3 T85 version, 700-yr control run



Mean AMOC

AMOC strength



Oscillatory regime

time scale 20 yr

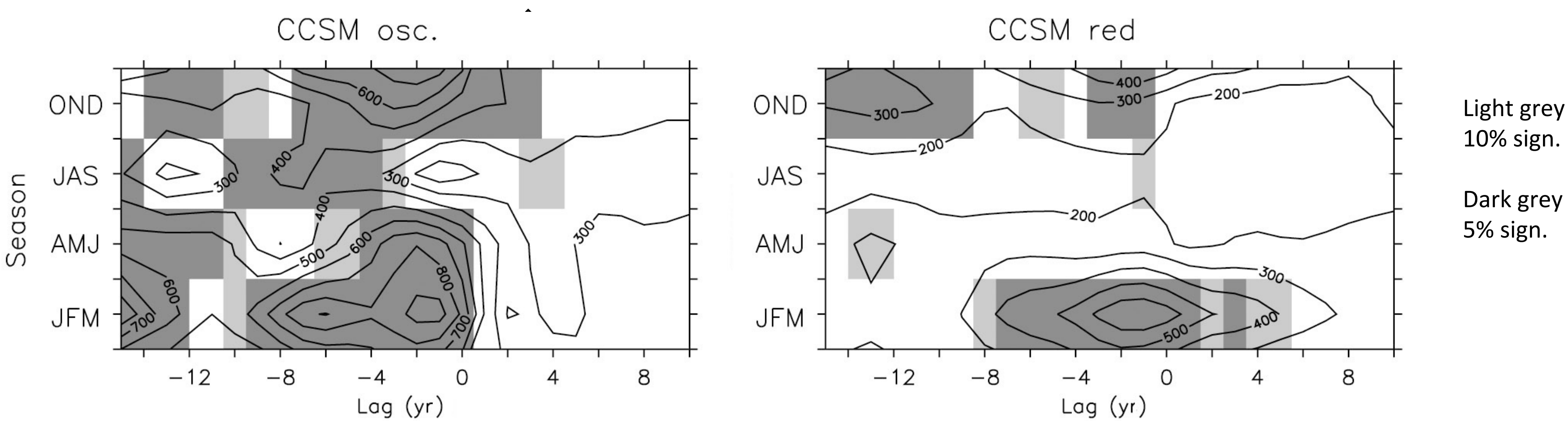
Red noise-like regime

30 – 40 yr

Sligthly weaker westerlies
GS/NAC shifted south

Maximum covariance analysis of AMOC (yearly) and SLP (3-month averages)

¼ ½ ¼ smoothing, ENSO subtracted



AMOC follows AMOC leads

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Oscillatory regime

Red noise regime

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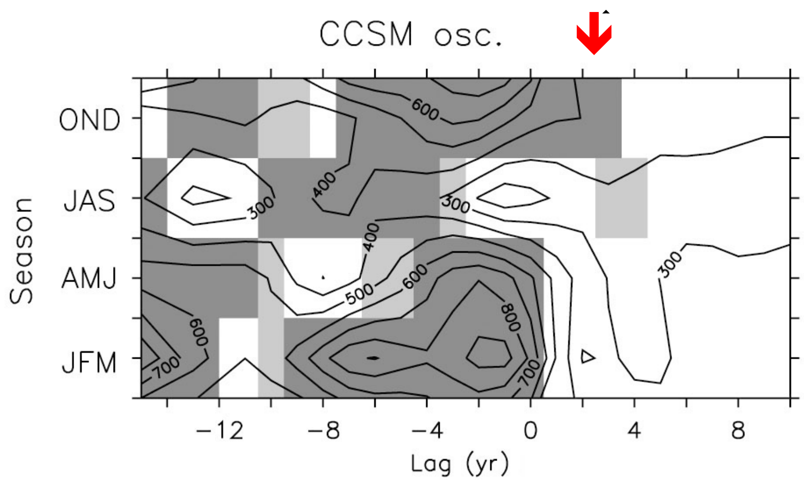
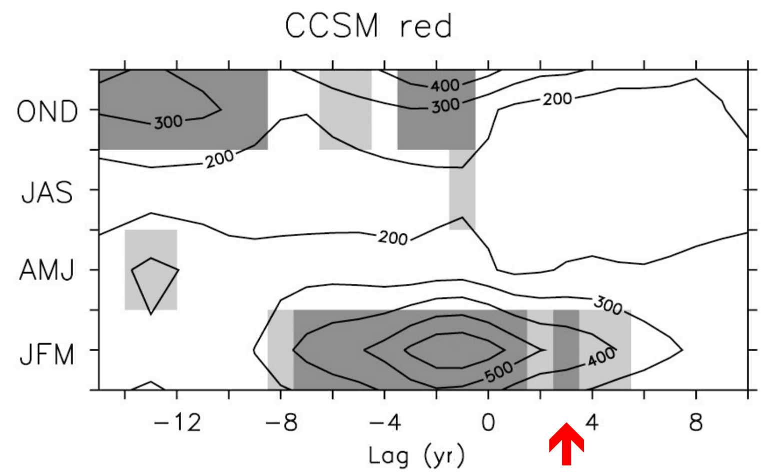




Light grey
10% sign.

Dark grey
5% sign.

AMOC follows AMOC leads

AMOC follows AMOC leads

Oscillatory regime

SLP response in fall

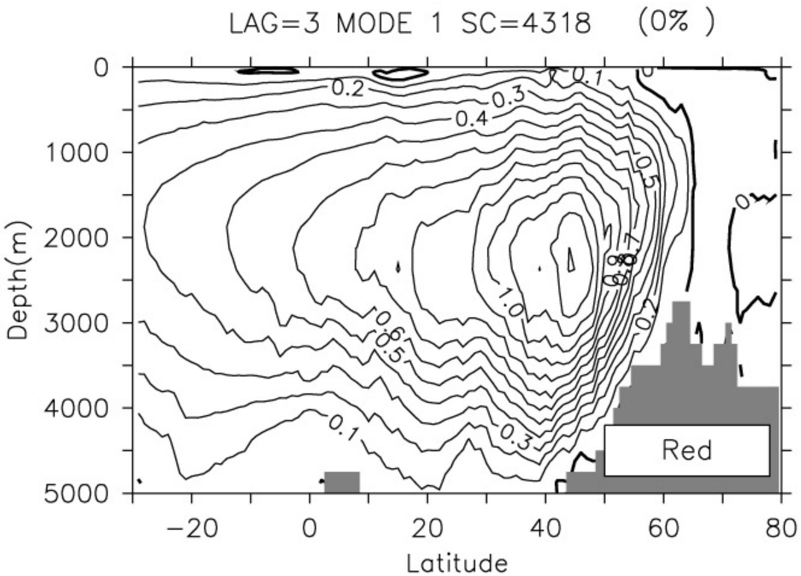
Less robust signal

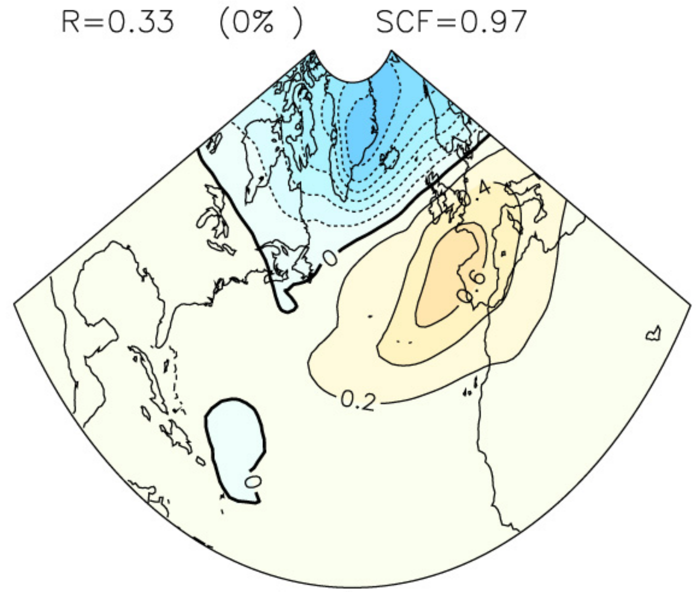
Red noise regime

SLP response in winter

strongest signal in FMA
5% significant until lag 10 (in year)

Red noise regime, late winter response





AMOC (in Sv) leads SLP (in hPa) by 3 years

AMOC intensitfication (EOF1)

Positive NAO

20% of seasonal NAO amplitude
(more at lower frequencies)

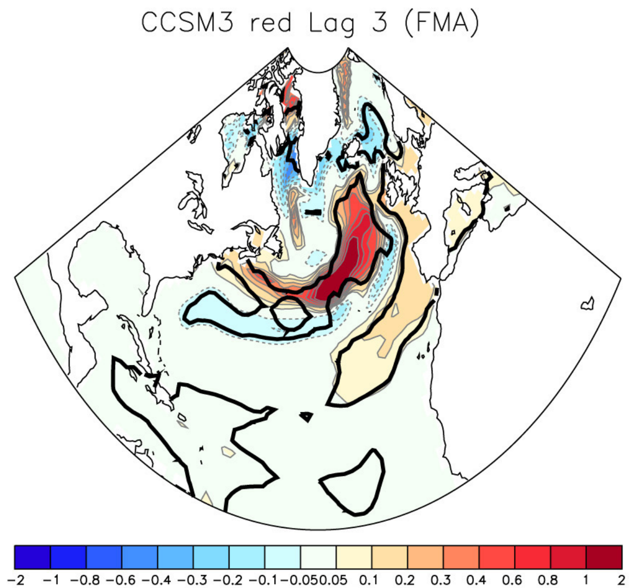
cross-validated correlation 0.29

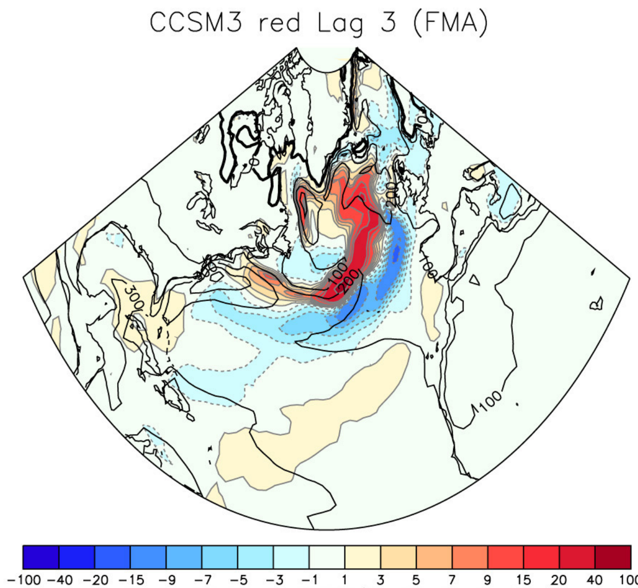
AMOC mostly driven by the NAO

weak positive feedback on the AMOC

Regression on AMOC time series (lagged to be in phase with maximum SLP response)

SST
in K





Heat flux
in Wm^{-2}

Climatology
in grey

Northward shift of GS/NAC
cooling to the south

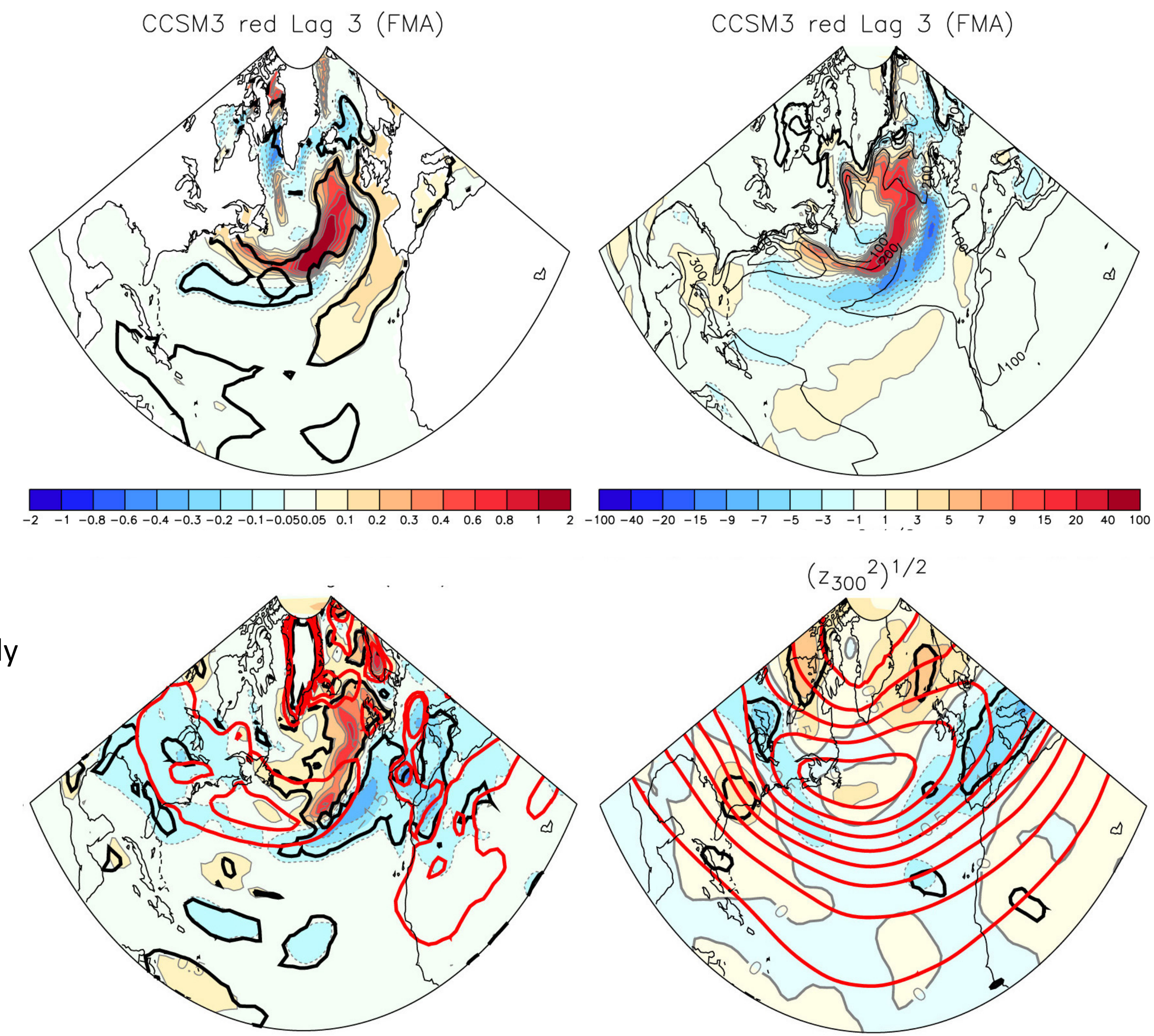
Negative heat flux feedback
northward shift of maximum heating of atmosphere

Regression on AMOC time series (lagged to be in phase with maximum SLP response)

SST
in K

Heat flux
in Wm^{-2}

Climatology
in grey



(2.2–6 days)

Maximum Eady
growth rate

Climatology
in red

NE shift

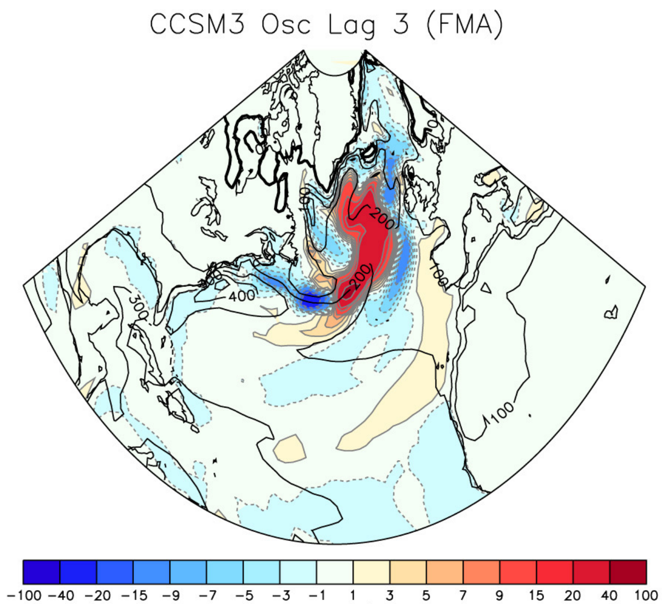
Storm track
shifted NE

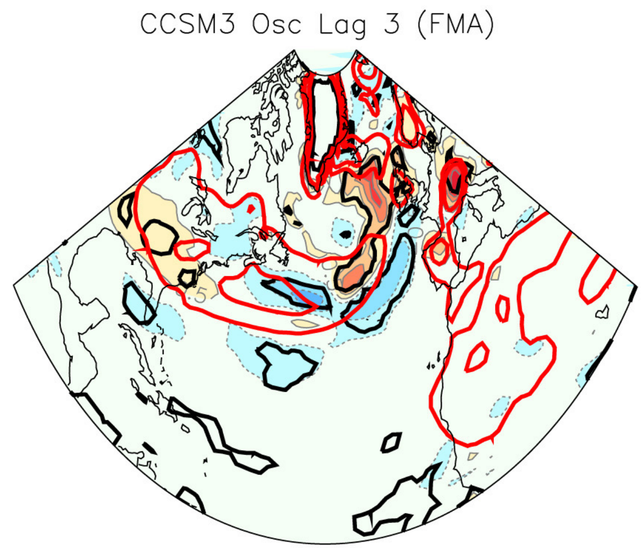
(NAO+)

Why isn't there a FMA response in the oscillatory regime?

Regression on AMOC PC1 3 years earlier

Surface heat flux





Maximum Eady growth rate

Climatology in grey

Climatology in red

GS shifts south and NAC shifts north when AMOC intensifies

baroclinic growth reduced and shifted S in the west increased and shifted north in the east

Conflicting influences?

Opposite NAO response (NAO-) to AMOC intensification in 6 THOR climate models

Gastineau and Frankignoul 2012

Need to establish degree of realism of climate models

AMOC not observed

SST influence detected in observations at the seasonal scale
can be used for model validation

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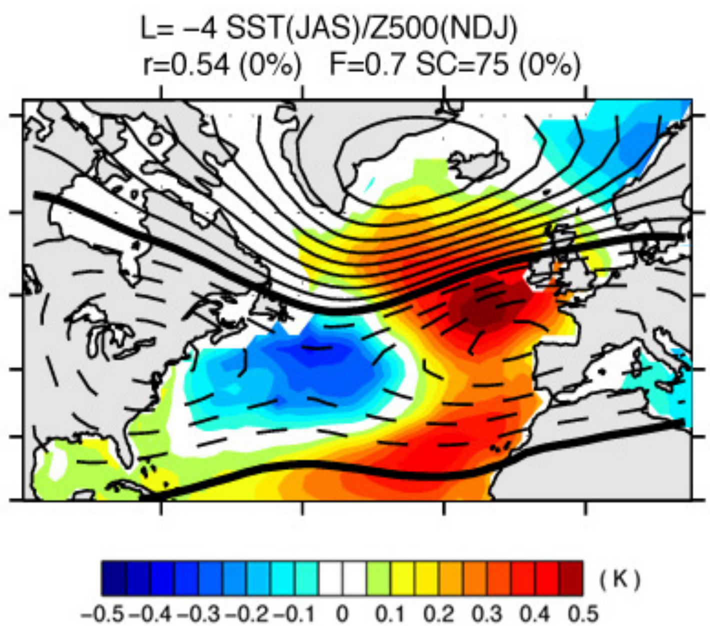


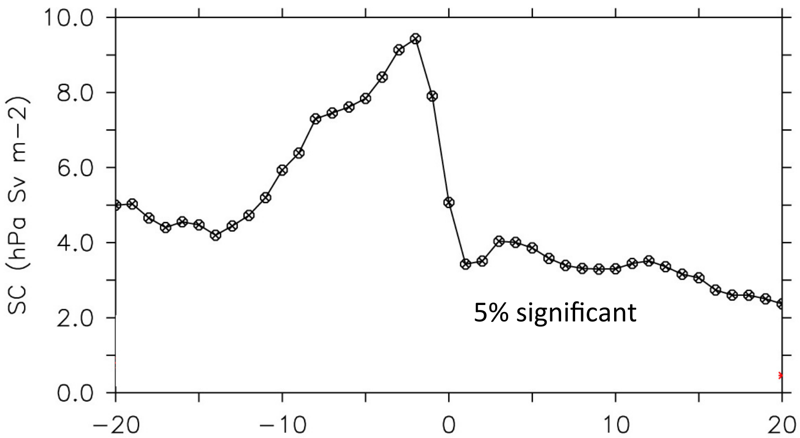
North Atlantic horseshoe
SST leads NAO by 3 to 4 mo
in early winter

Maximum covariance analysis of SST in JAS and SLP in NDJ

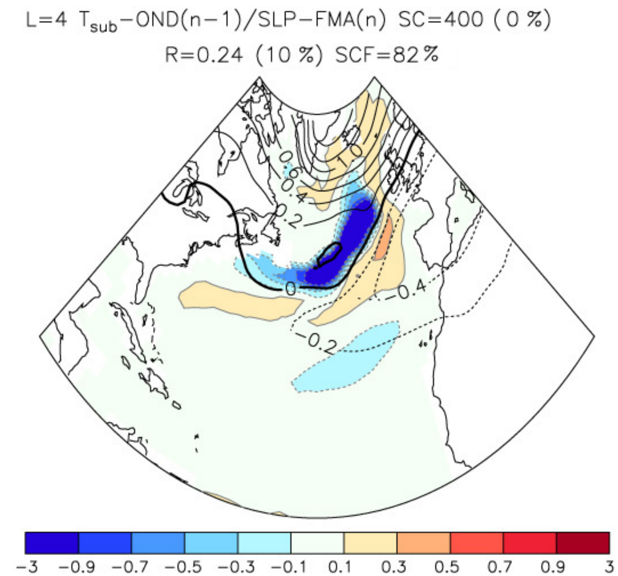
Czaja and Frankignoul 2002

Seasonal air-sea coupling in CCSM3, red noise regime

Maximum covariance analysis between $T_{0\text{-}200\ m}$ and SLP in late winter (FMA)



$T_{0\text{-}200\ m}$ lags (in mo) $T_{0\text{-}200\ m}$ leads (in mo)



$T_{0\text{-}200\ m}$

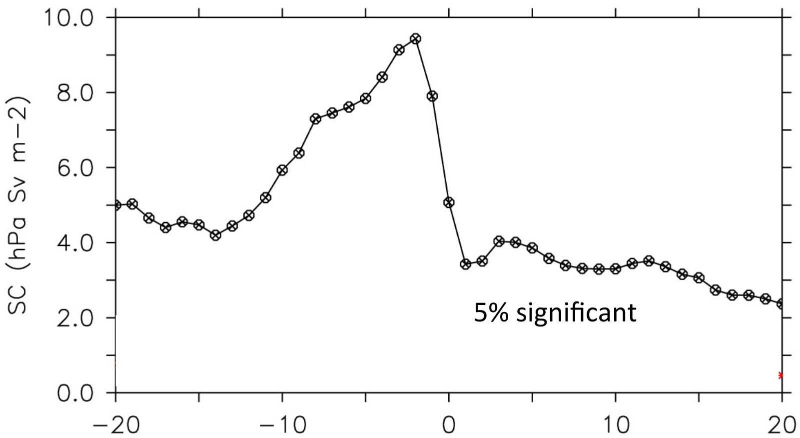
corresponding to AMOC decrease

leads NAO-

Similar patterns with SST, but less significant

Seasonal air-sea coupling in CCSM3, red noise regime

Maximum covariance analysis between $T_{0\text{-}200\ m}$ and SLP in late winter (FMA)



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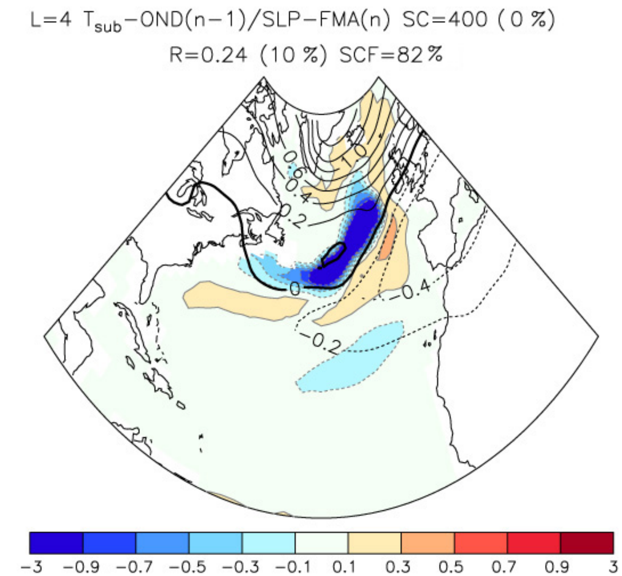

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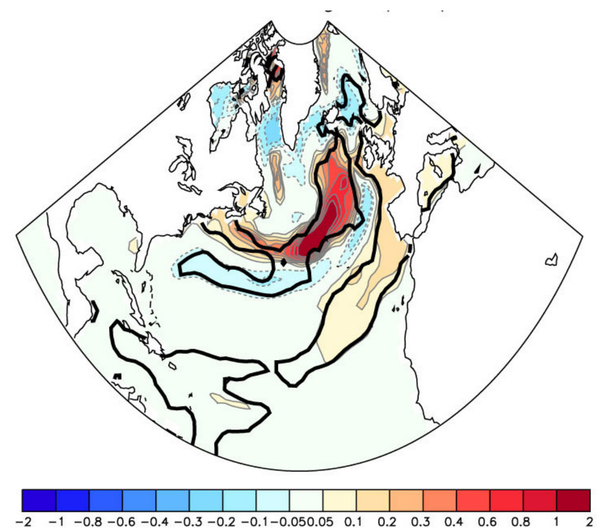
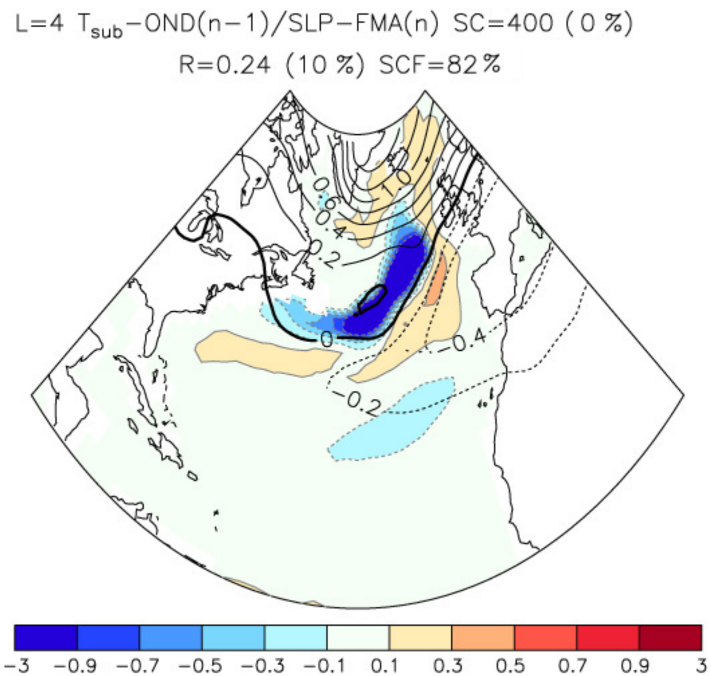


SST driven by AMOC increase

AMOC impact is seen
in relation between SST or $T_{0\text{-}200\ m}$
the atmosphere

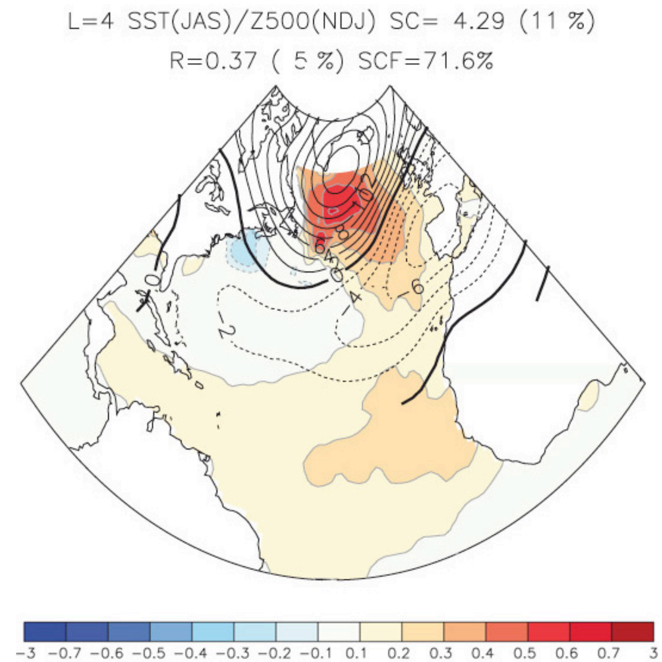
Comparison with the observations

CCSM3 red noise regime



Late winter NAO- response to NAC cooling

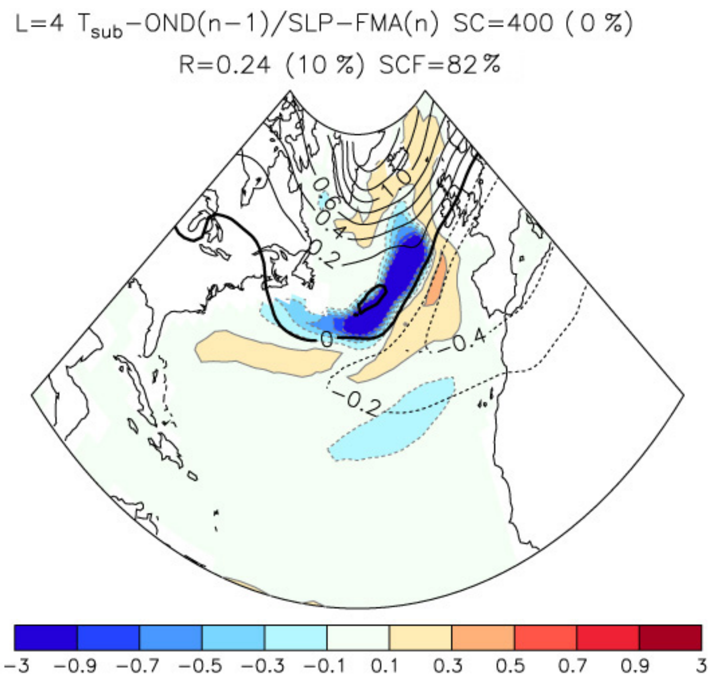
20th century reanalysis (1901-2005)



Early winter NAO- response to NAH (subpolar warming)

Comparison with the observations

CCSM3 red noise regime



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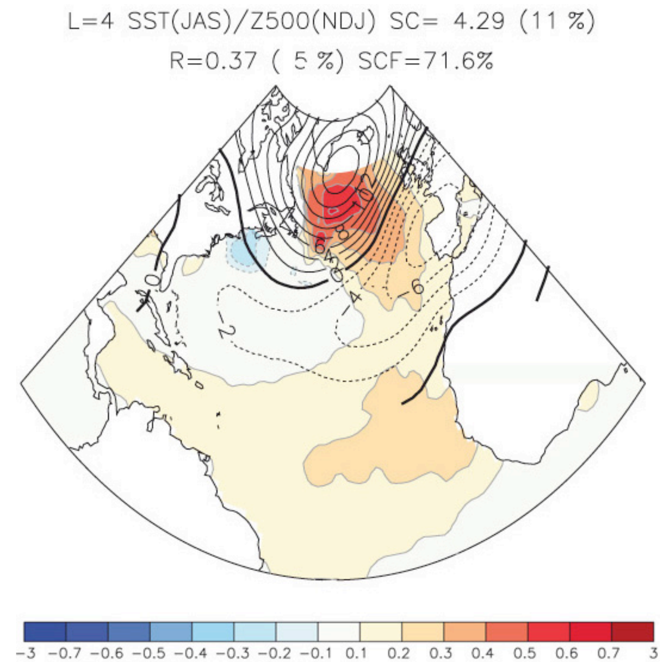


Early winter NAO- response to NAH (subpolar warming)

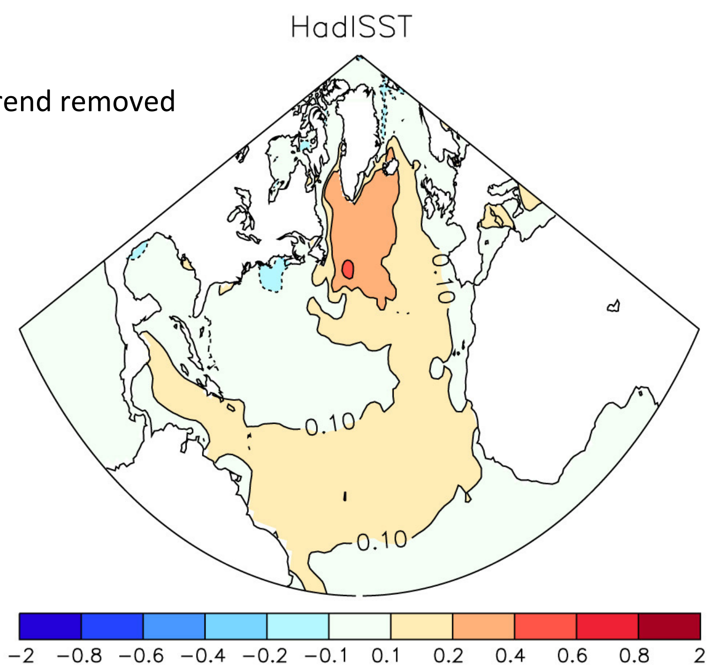
Atmospheric response to N. Atlantic SST is not realistic in CCSM3 (too strong GS/NAC shifts)

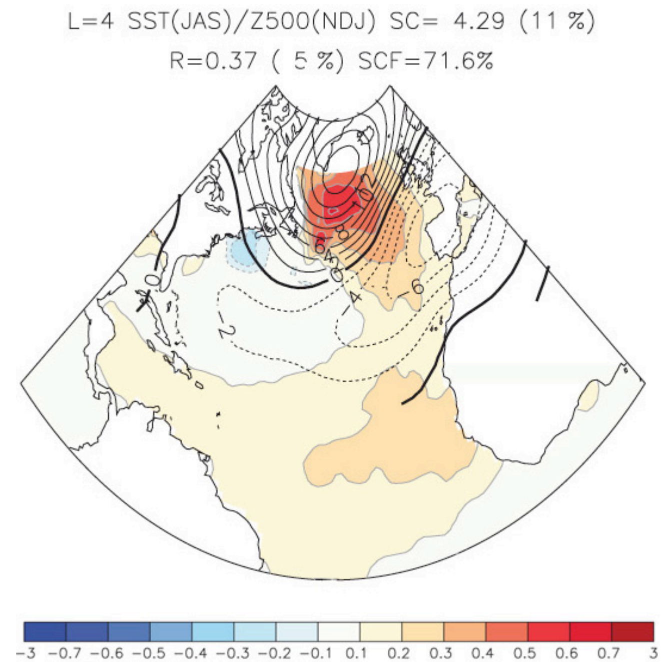
Winter climate predictability expected from AMOC changes in CCSM3 useful?

The NAH SST anomaly is correlated with the AMO at low frequency

20th century reanalysis (1901-2005)

Global trend removed
by LIM





Early winter NAO- response to NAH (subpolar warming)

The AMO influences the early winter NAO

Gastineau et al. 2012