Comments on decadal prediction in the Atlantic Sector

Noel Keenlyside, Annika Reintges, Nour-Eddine Omrani
Jin Ba, and Thomas Martin

1. Uncertainties in AMOC prediction

2. Atmospheric response to AMV
   -- role of the stratosphere

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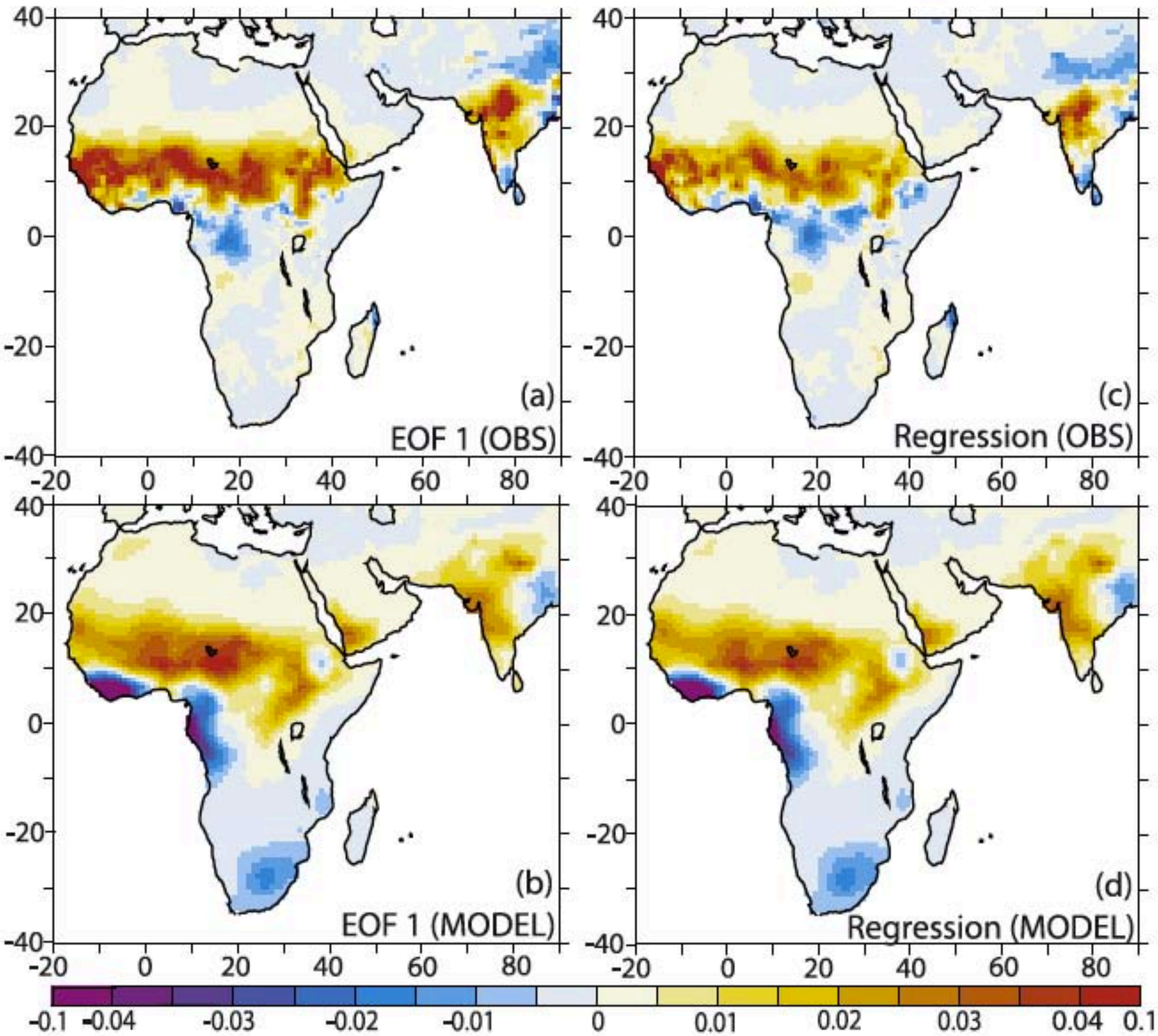
Major AMV impacts reproducible

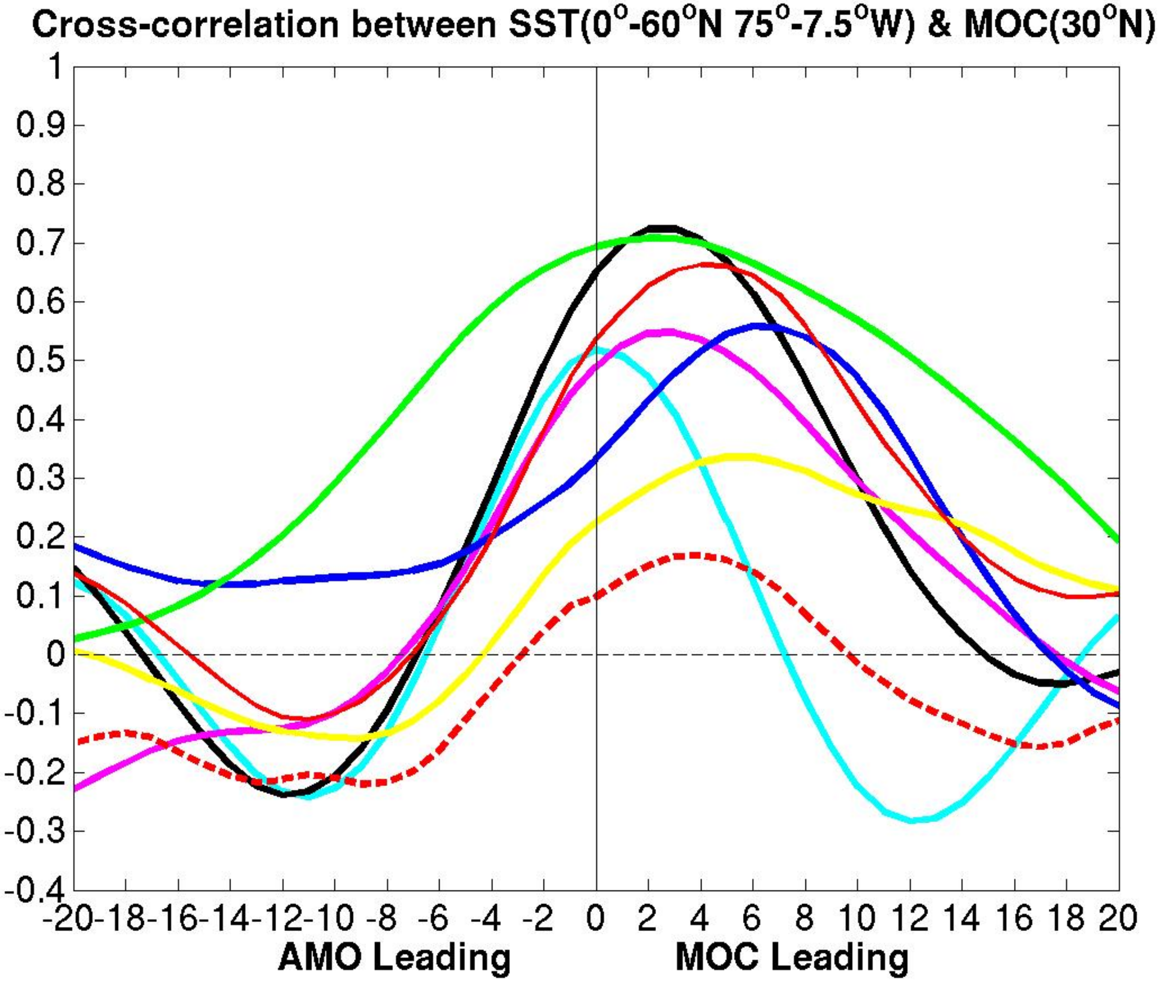


Precipitation

Zhang & Delworth (2006)

Evidence that AMOC drives AMV

CMIP3 pre-industrial control



But other (external) factors also contribute!

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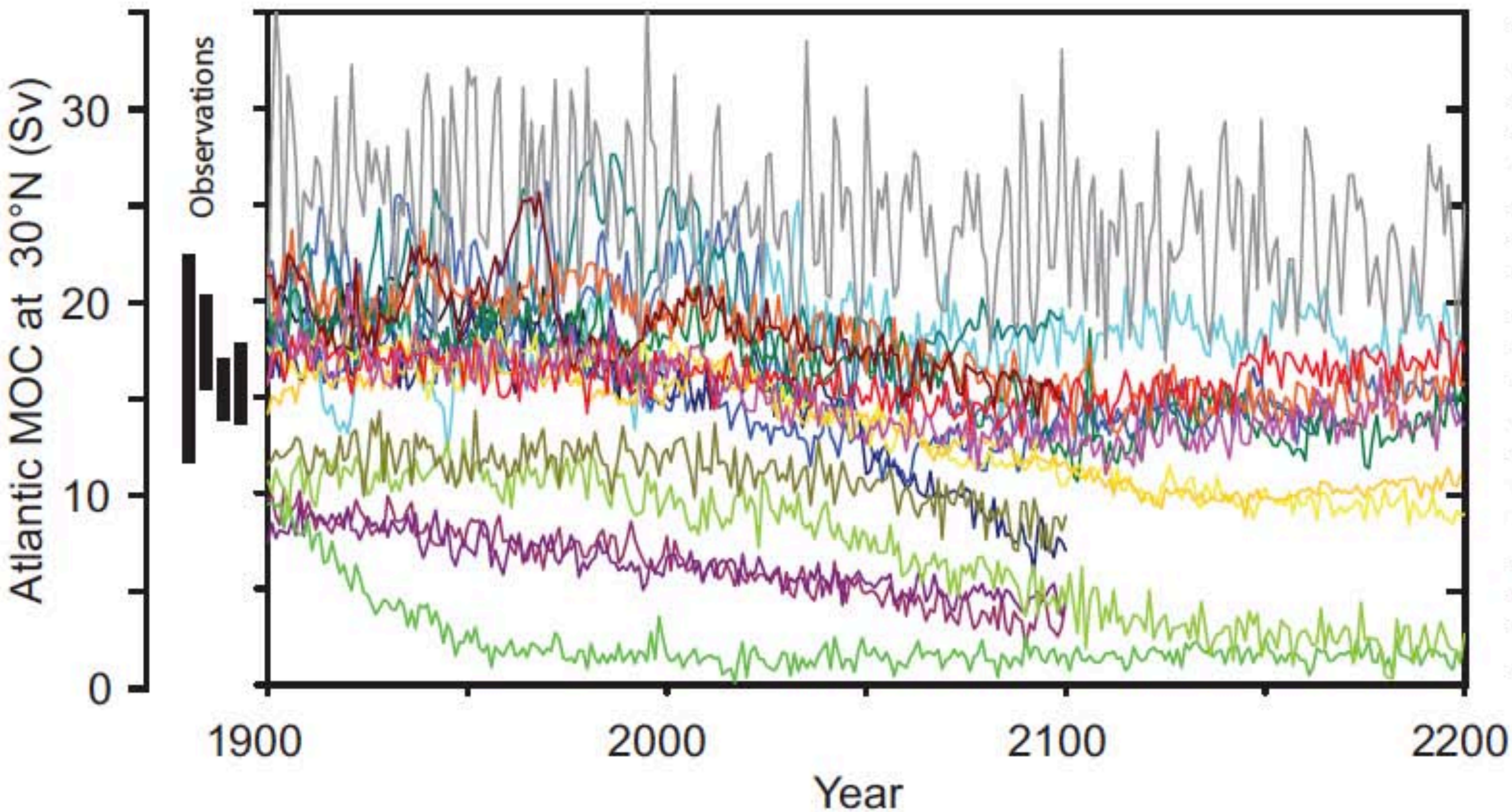
Uncertainty in model projections of AMOC

AMOC at 30N, CMIP3 models, 20C/A1B



Schmittner et al. (2005)

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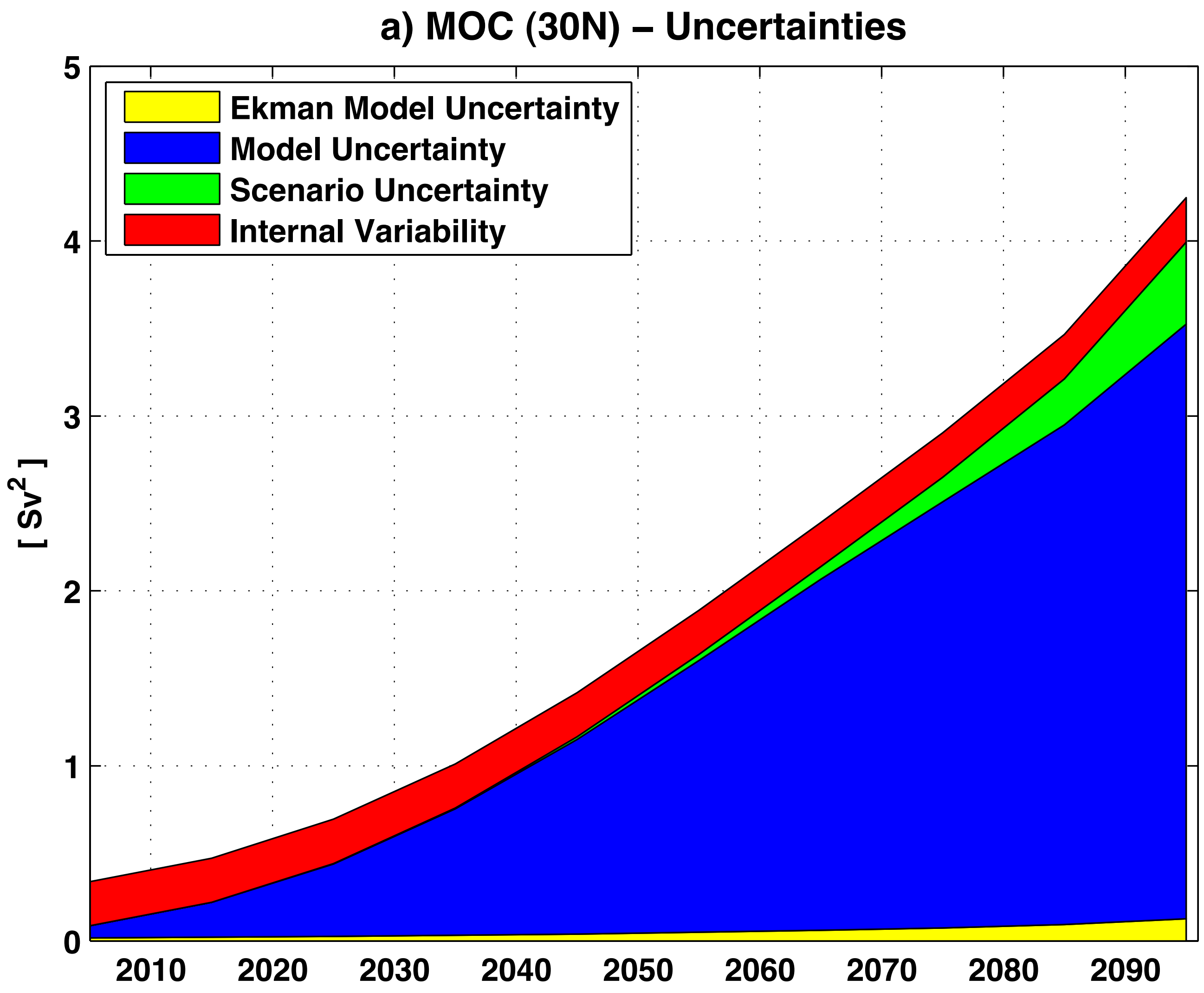
Quantifying uncertainty in decadal AMOC change

Following Hawkins and Sutton (2009)



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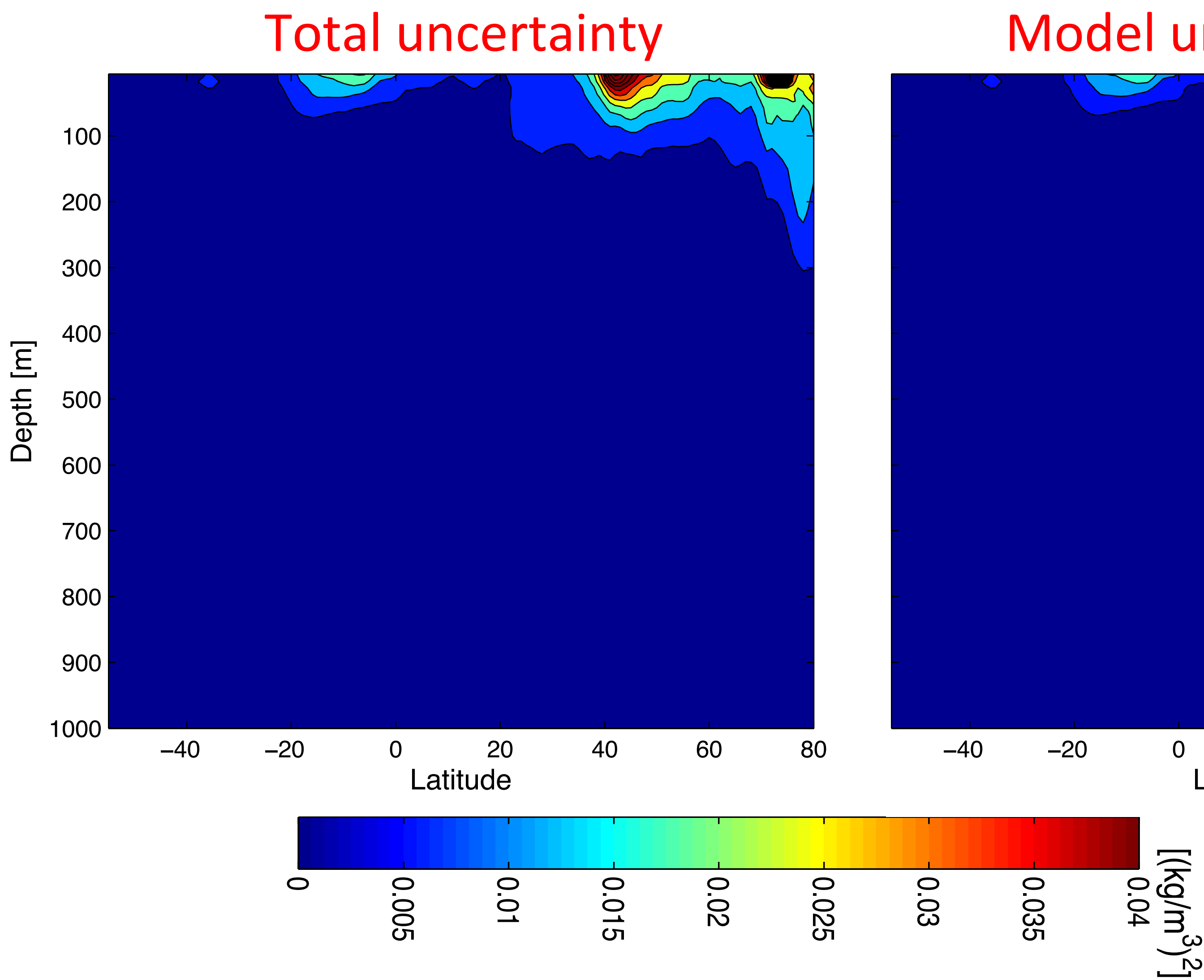
Uncertainties in zonal average density

2030-2040, CMIP3, A1B



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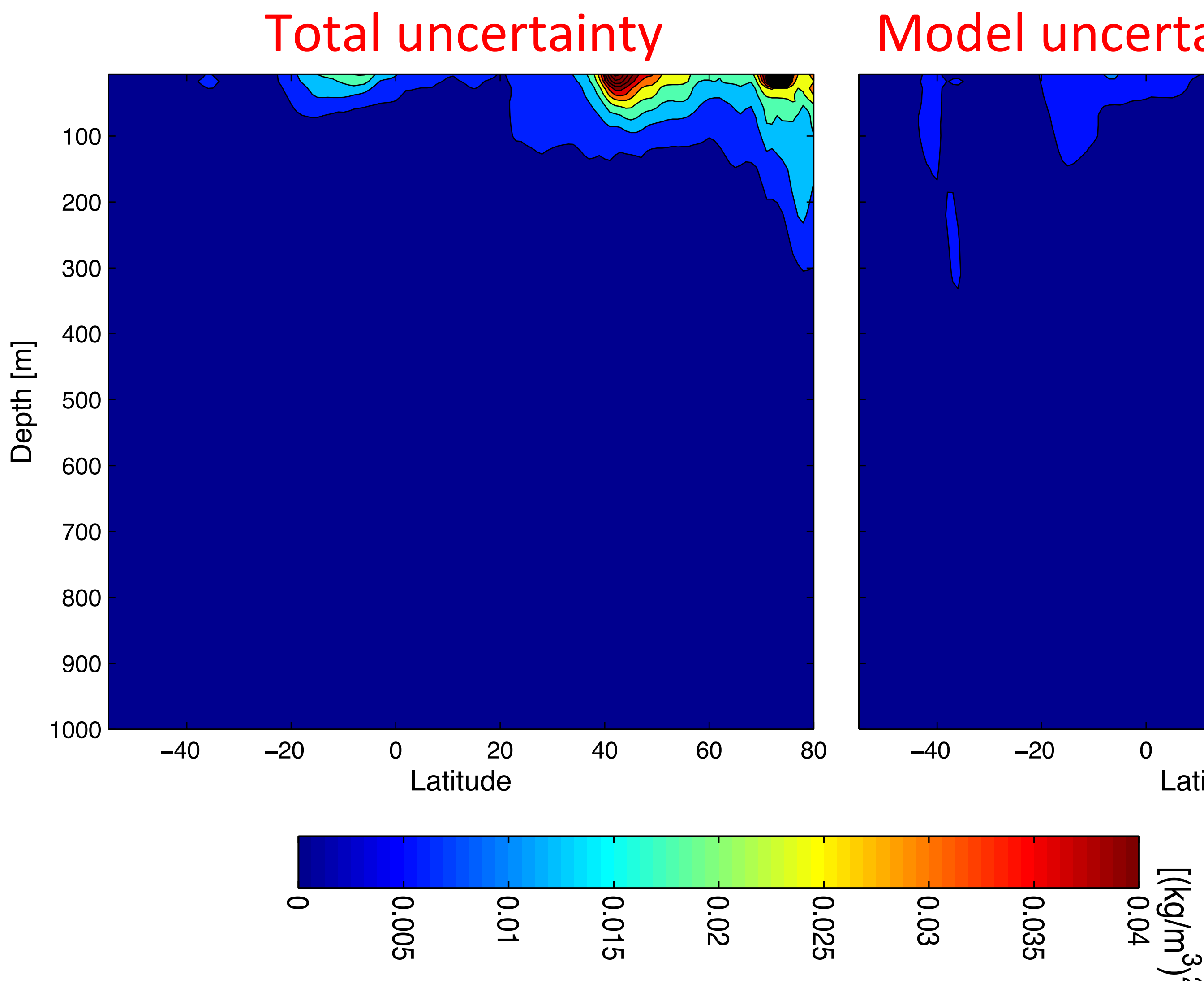
Salinity dominates model density uncertainty

2030-2040, CMIP3, A1B



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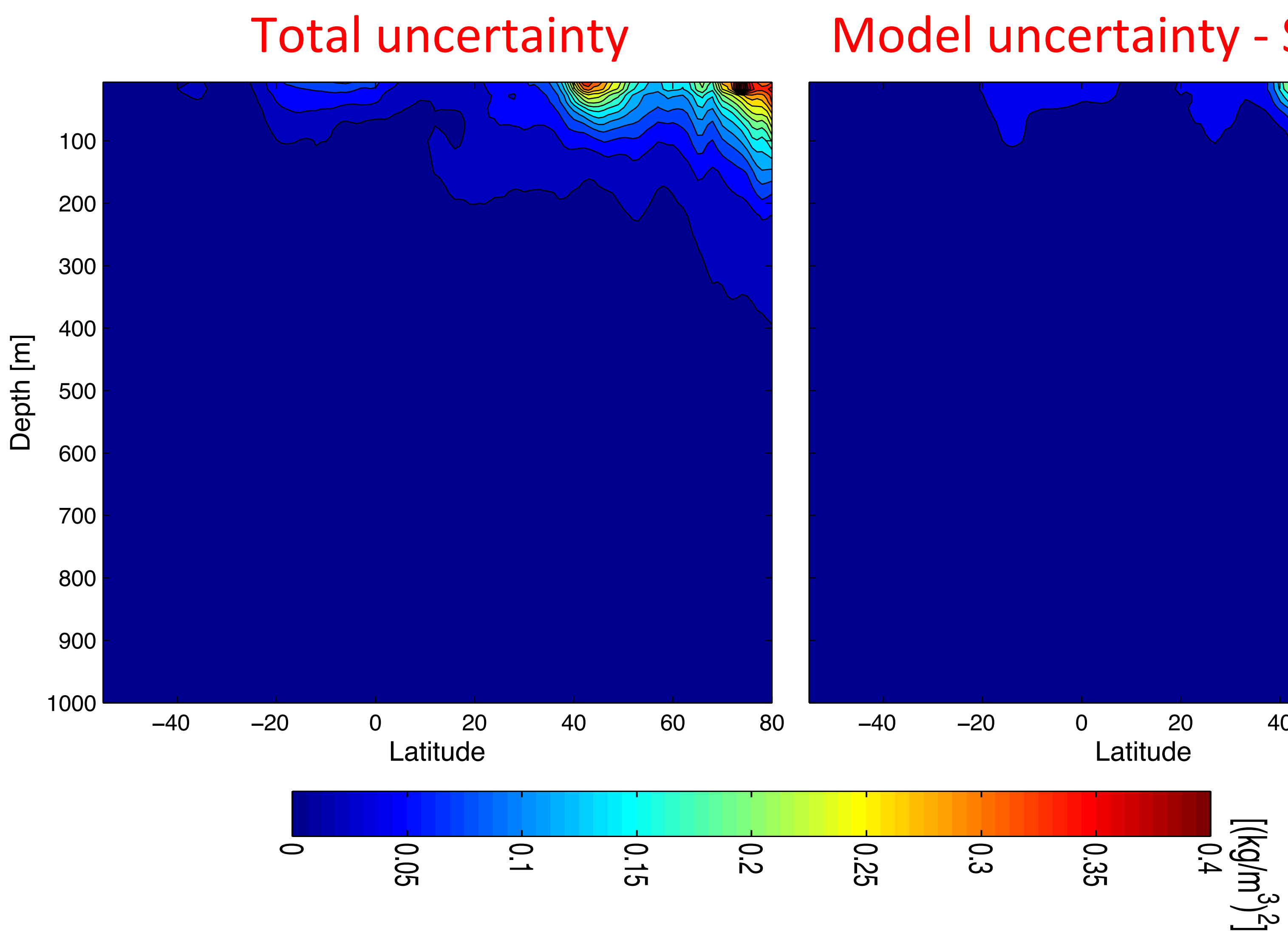
Salinity dominates model density uncertainty

2090-2100, CMIP3, A1B



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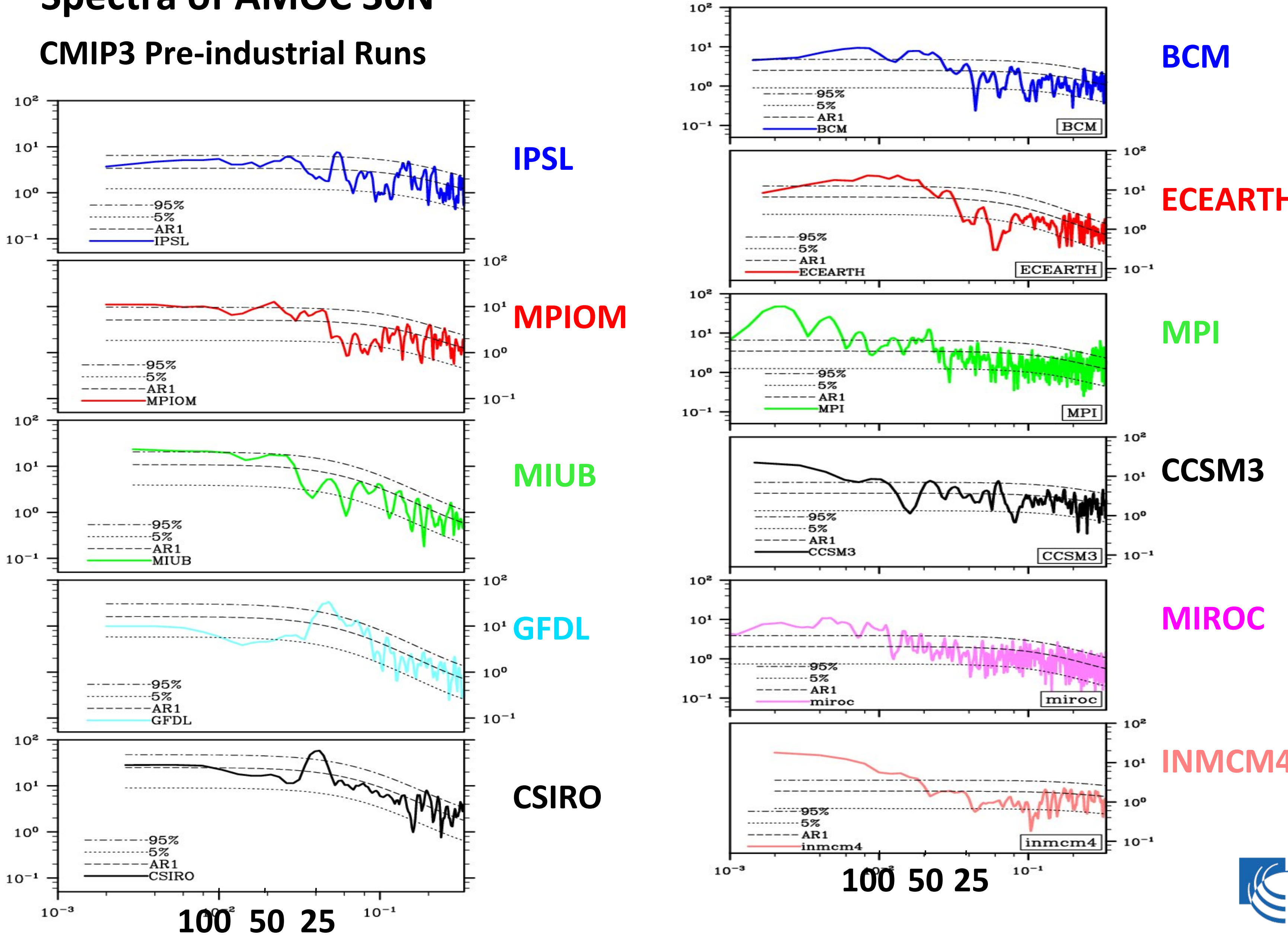
Uncertainties in internal variability

Spectra of AMOC 30N

CMIP3 Pre-industrial Runs



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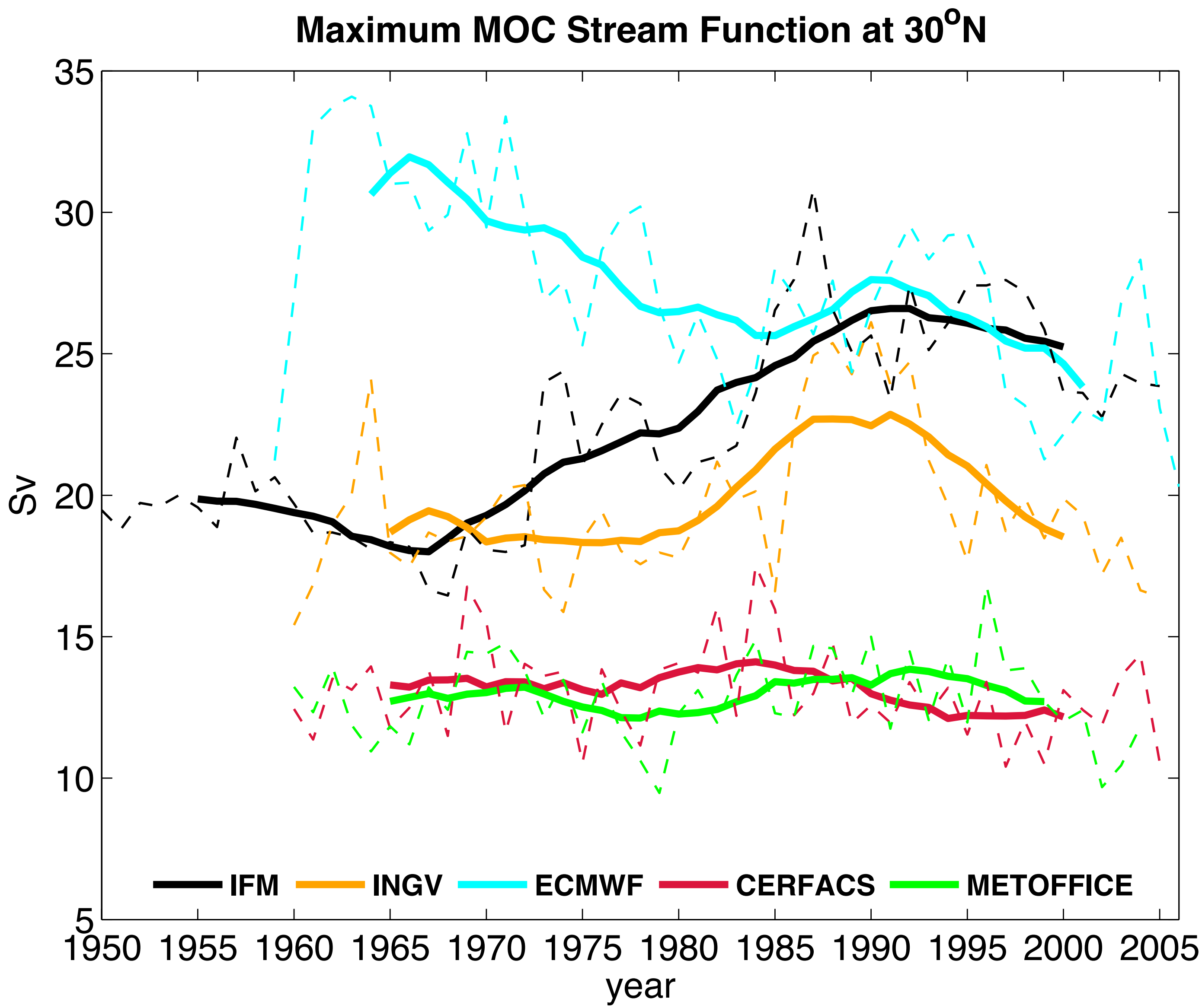
Uncertainties in initial conditions



Keenlyside & Ba (2010)

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Atmospheric response to AMV
-- role of the stratosphere

Omrani and Keenlyside, to be submitted

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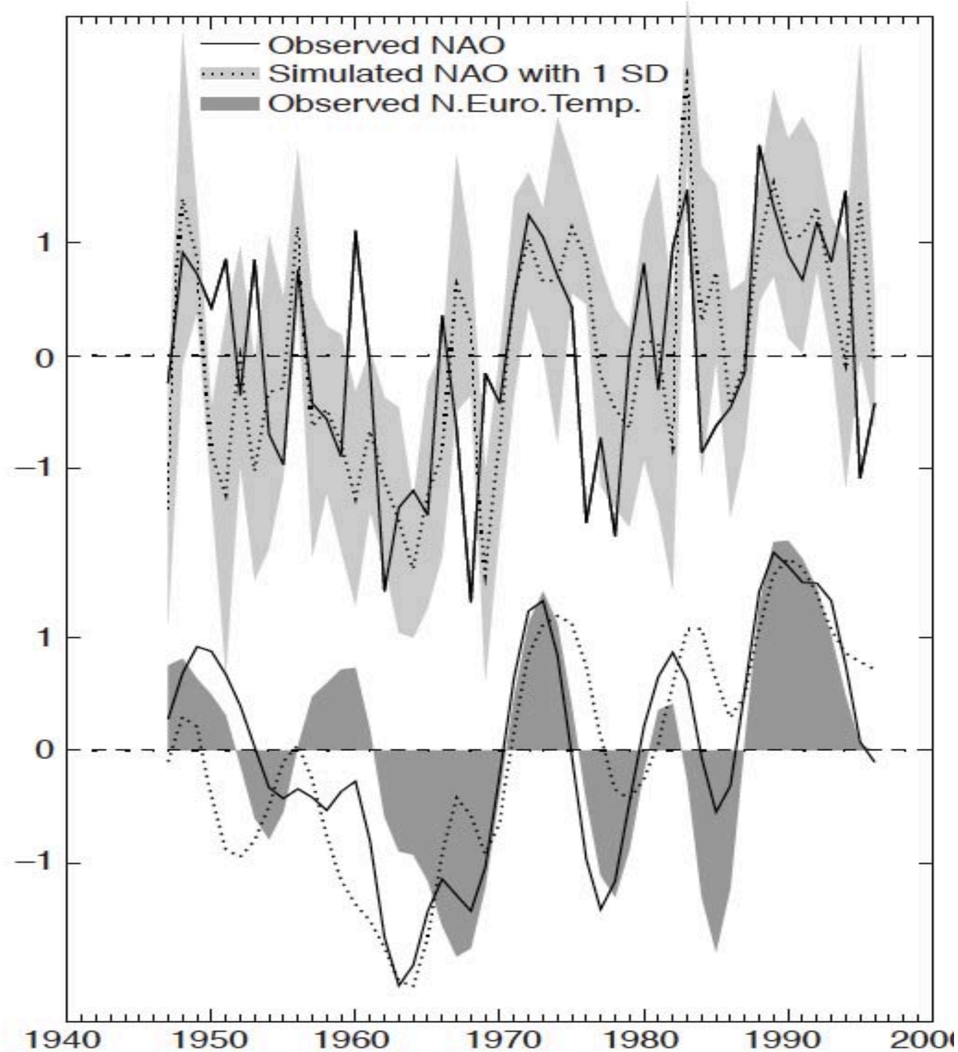
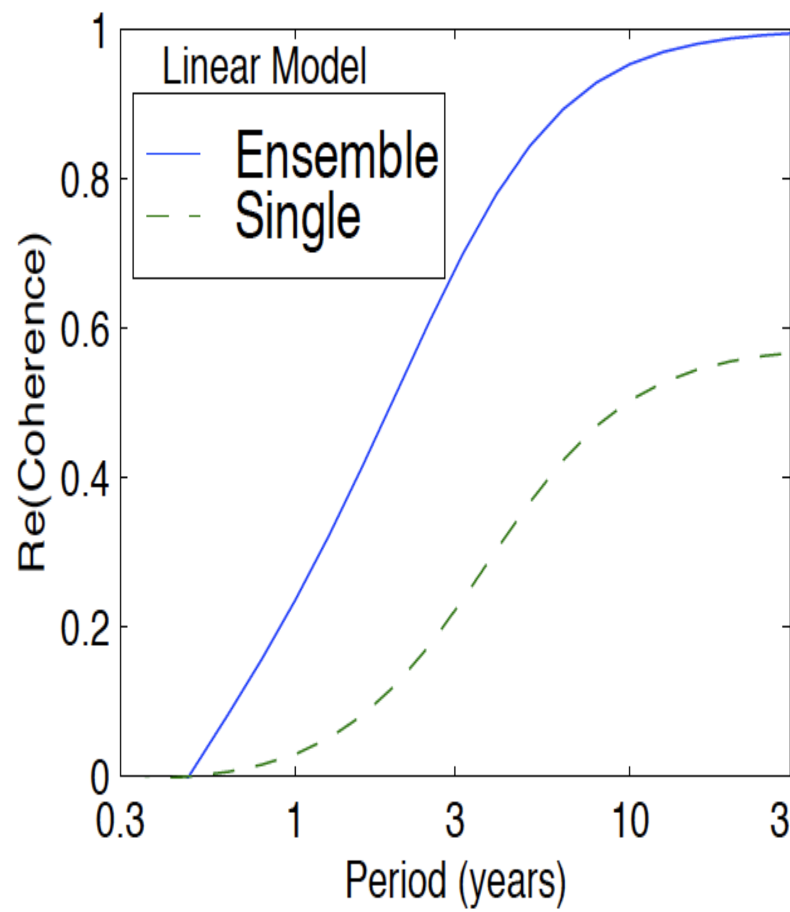
Does the atmosphere respond to mid-latidude SST ?

Ensemble AGCM prescribed SST experiments



Rodwell et al., 1999

Theoretical results



Bretherton & Battisti 2000

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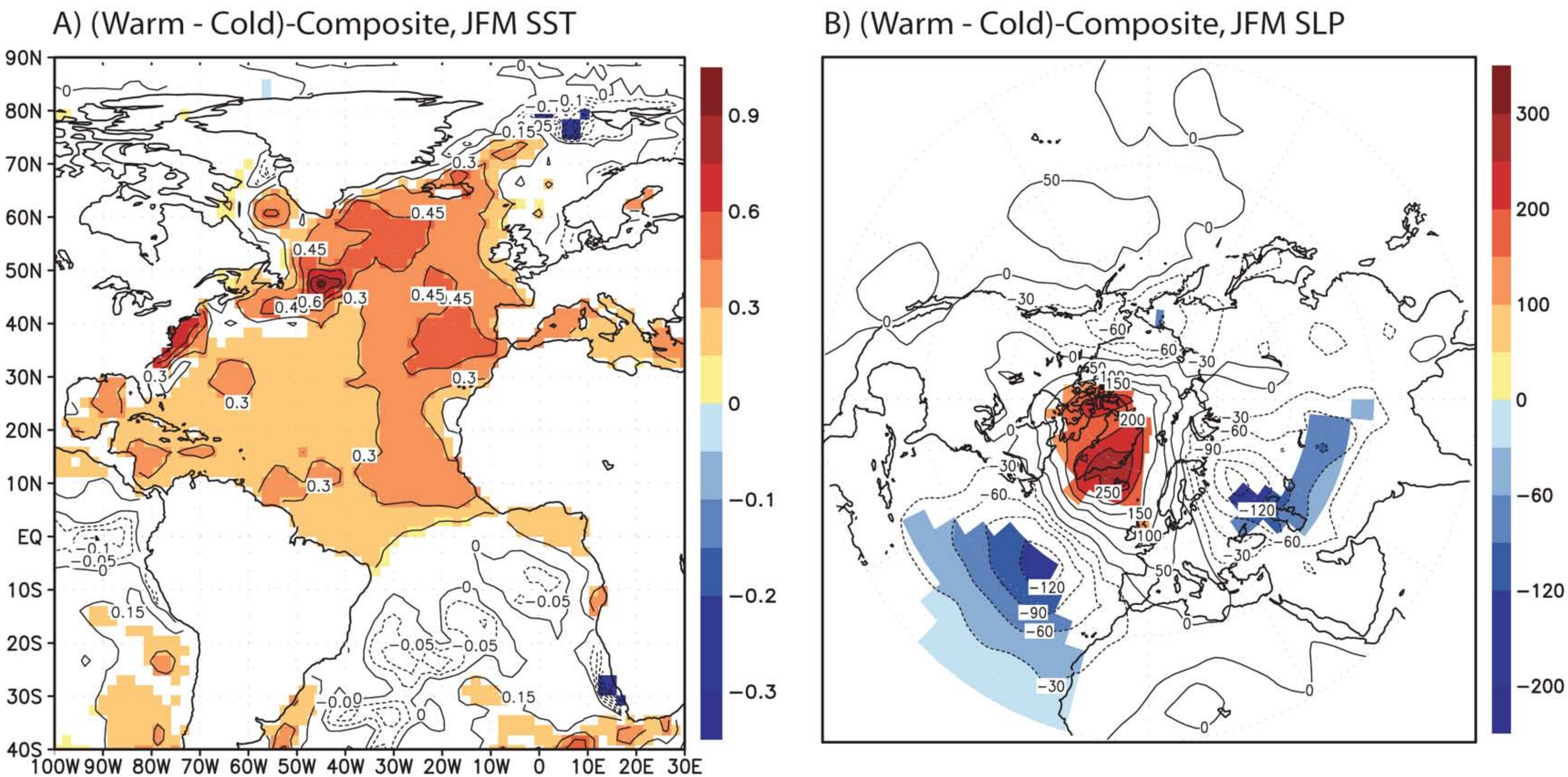
Warm AMV and negative winter (JFM) NAO

Composite analysis of 10yr running mean AMV-index, 1870-2010



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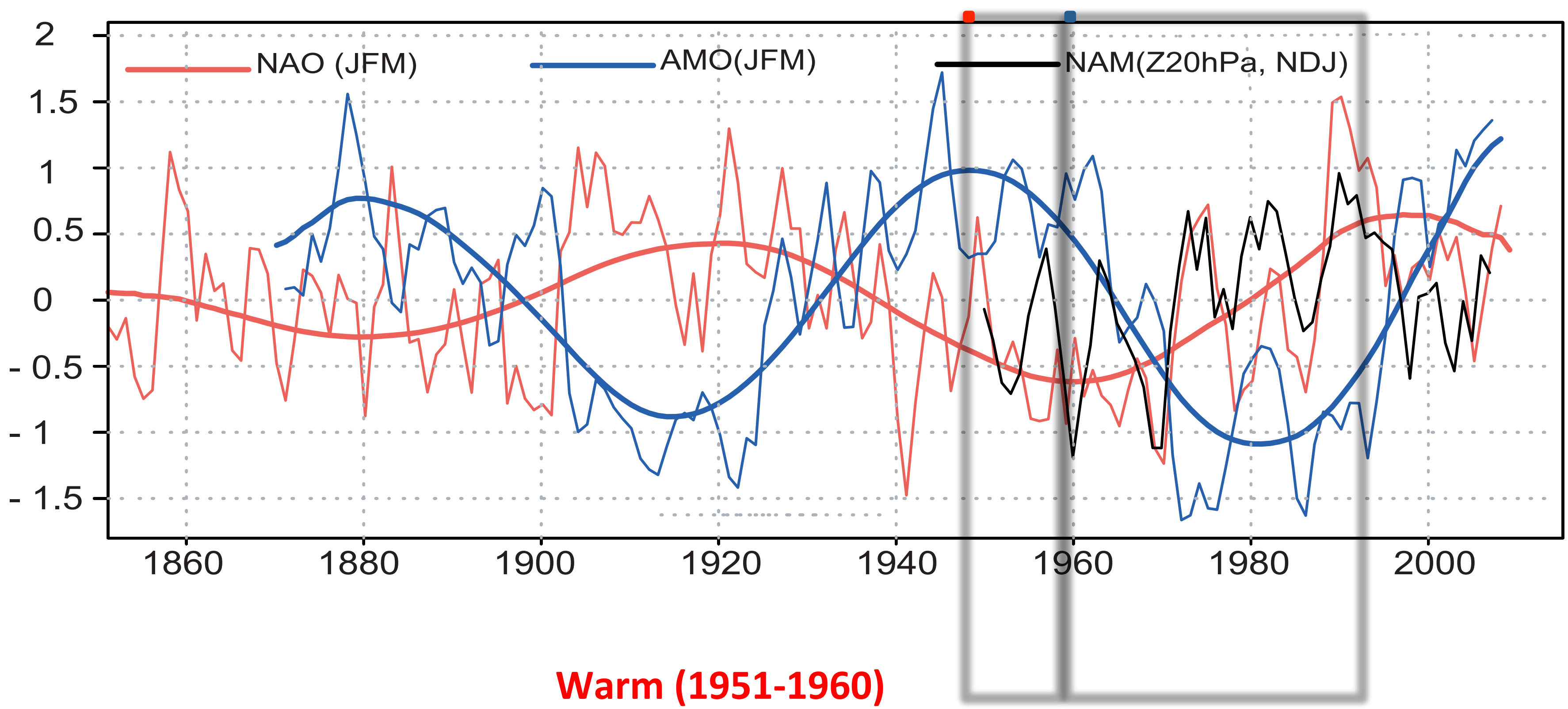
AMV(JFM), NAO(JFM), and stratospheric NAM (NDJ)

AMV partly forced by NAO, could the converse be true?



Warm (1951-1960)

Reference (1961-1990)

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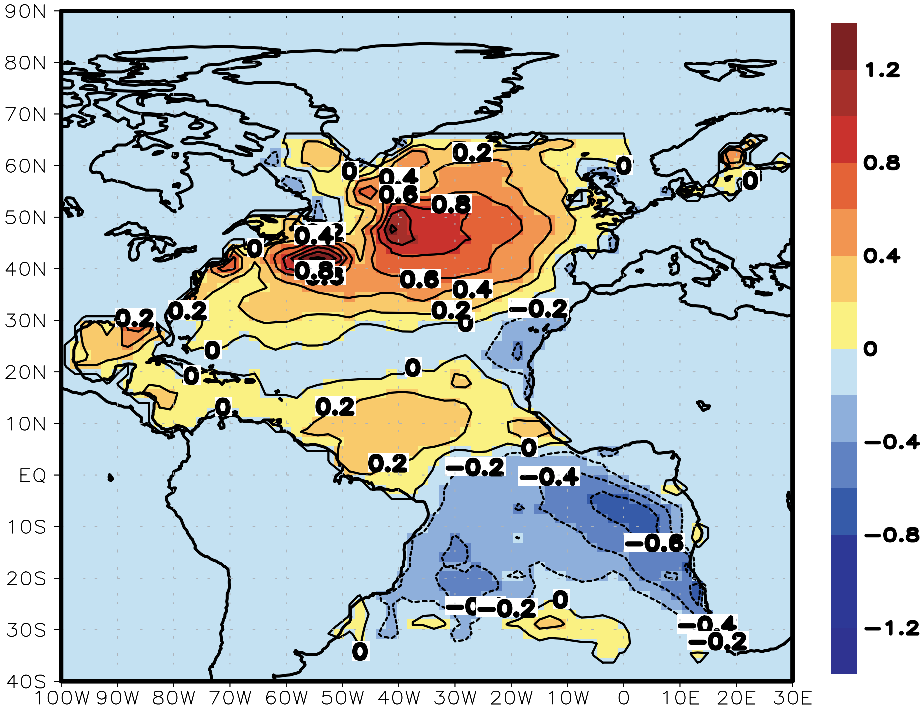
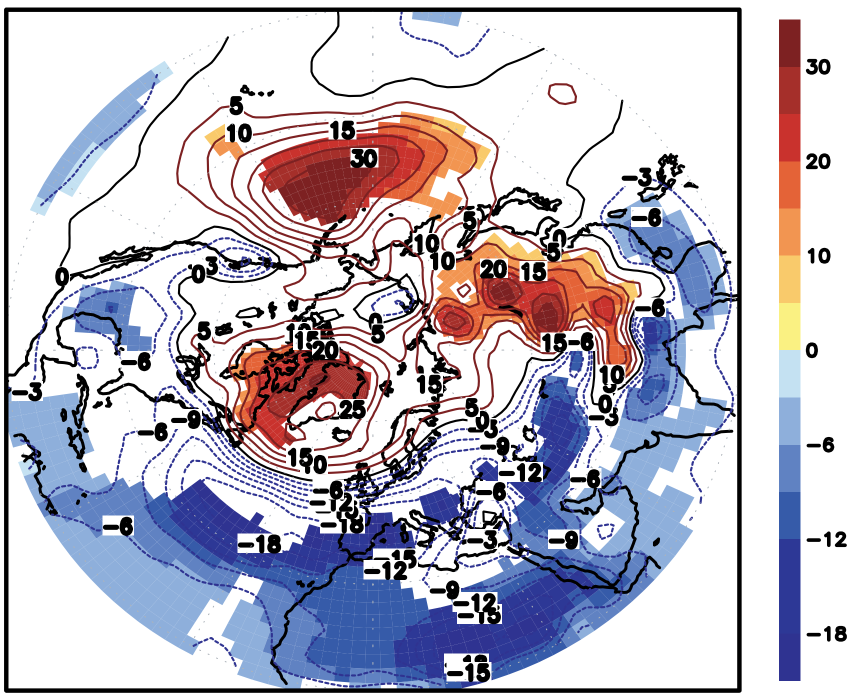
Observed (JFM) changes for 1951-1960

B) SST(JFM)



C) 1000hPa Geopotential height (JFM)



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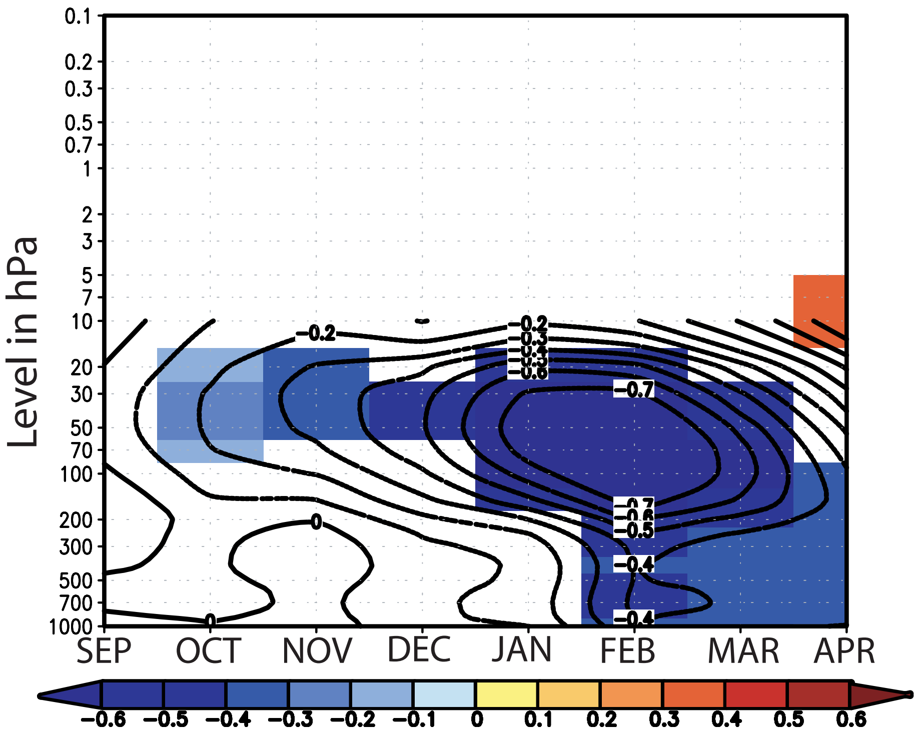
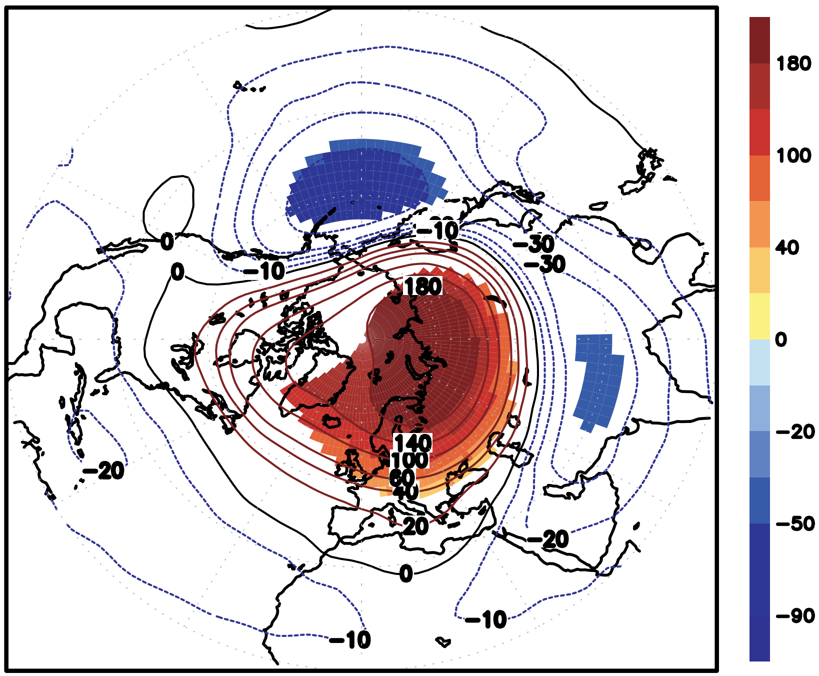
Observed stratosphere precursor, 1951-1960

D) Atmospheric NAO index



E) 20hPa Geopotential height (NDJ)



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Experiments

- **High top warm (Atl.)**: MAECHAM5 at T63L39 with stratosphere and lower mesosphere (from surface to 0.001hPa)

- **Low top warm (Atl.)**: standard ECHAM5 at T63L19 without middle and upper stratosphere (from surface to 10hPa)

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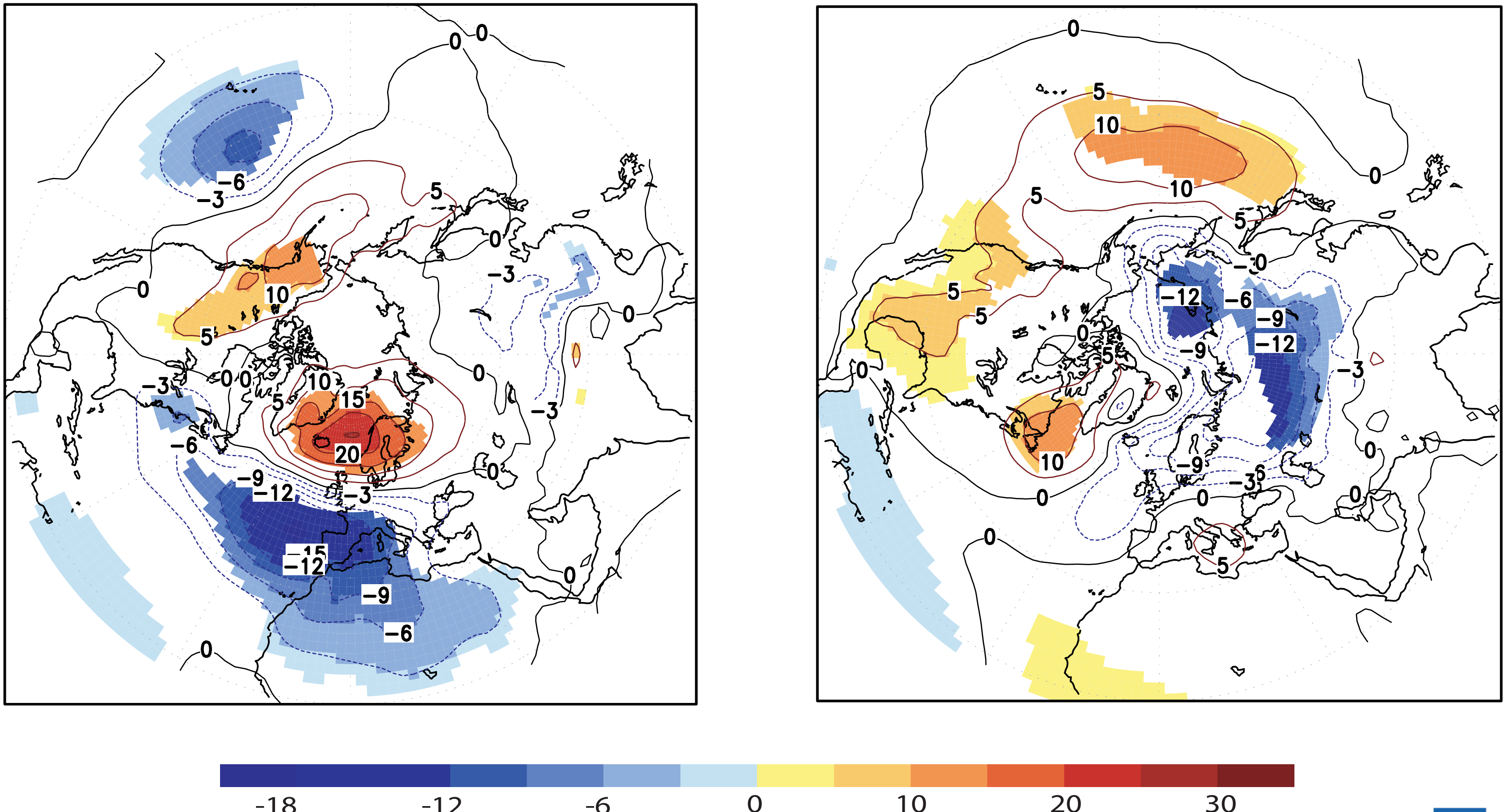
Stratosphere required to capture observed winter (JFM) response

High-top model

A) High top response, 1000hPa geopotential height

Low-top model

B) Low top response, 1000hPa geopotential height



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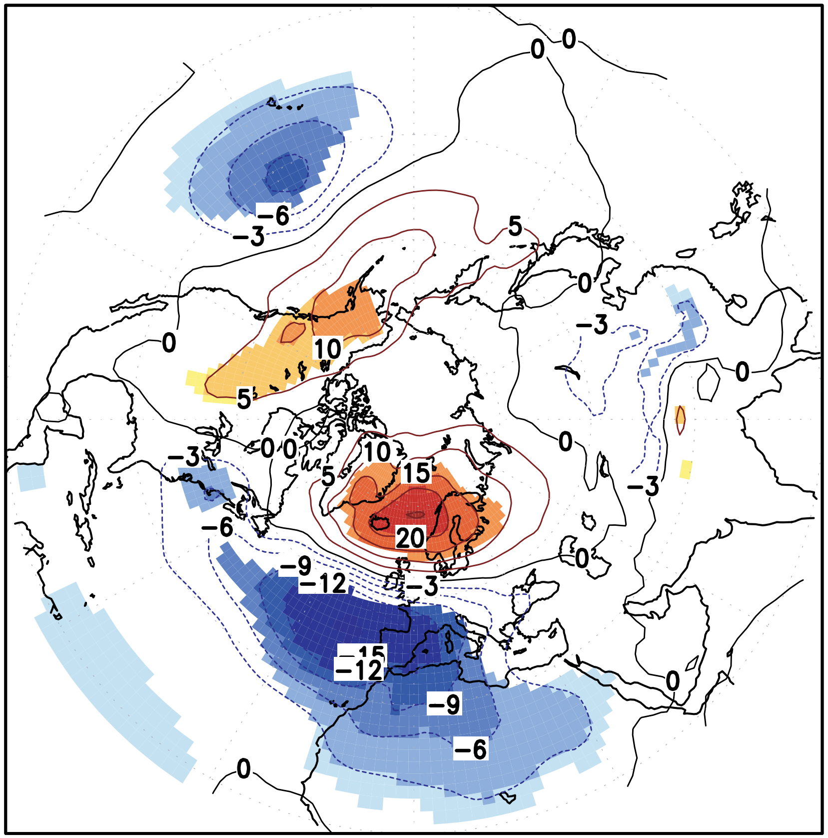
Stratosphere required to capture observed winter (JFM) response

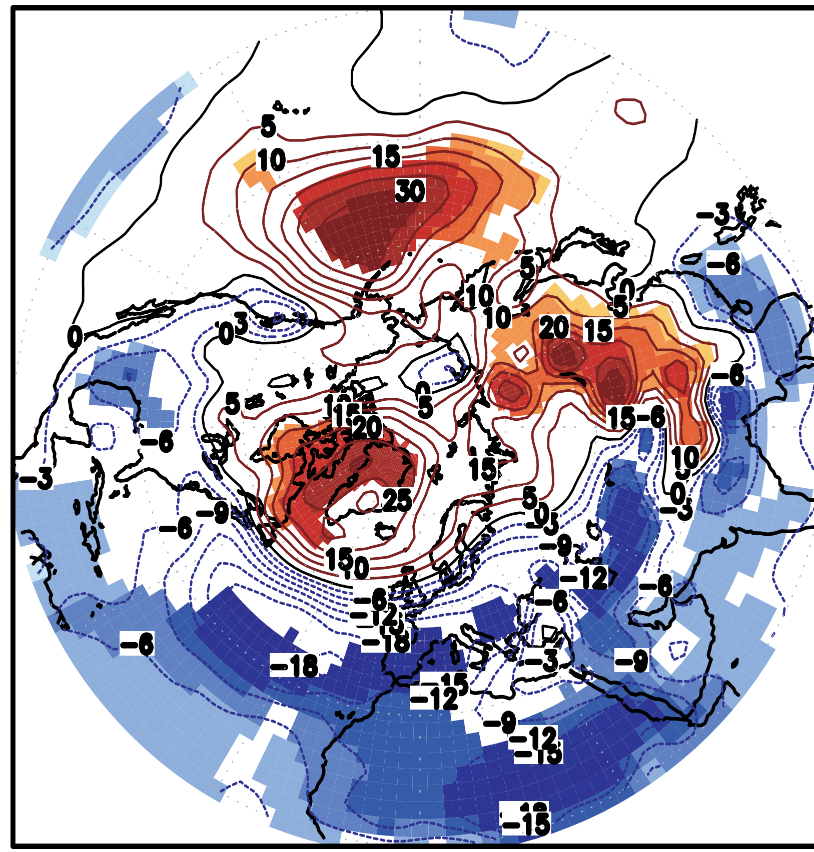
High-top model

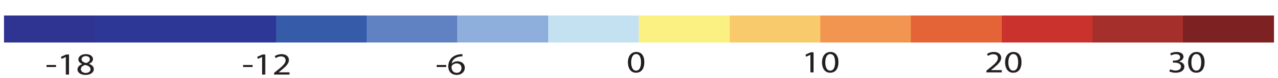
A) High top response, 1000hPa geopotential height



NCEP/NCAR

C) 1000hPa Geopotential height (JFM)





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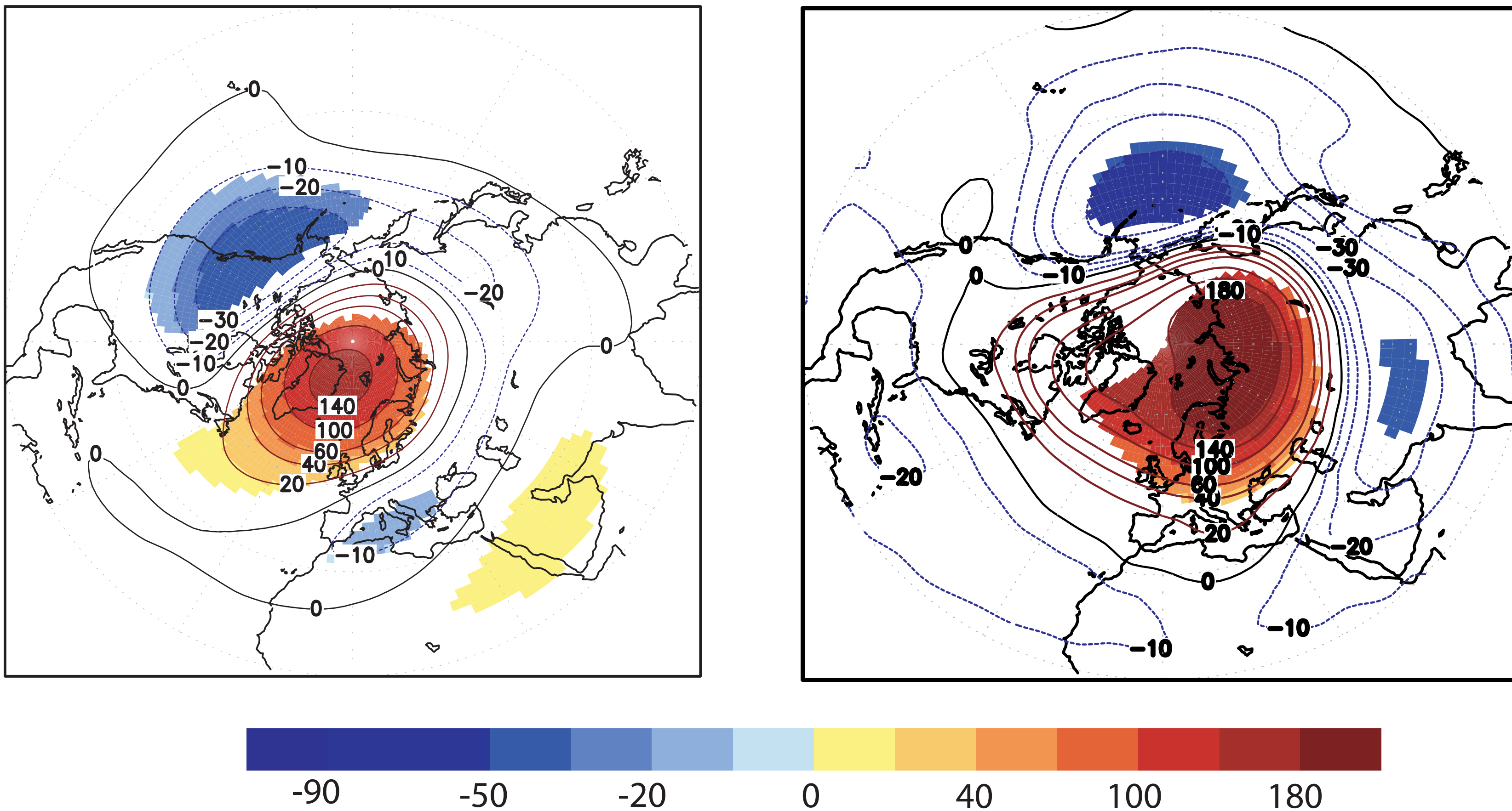
Simulated and observed weakening of early winter stratospheric polar vortex

20 hPa geopotential height (NDJ)

High-top | NCEP/NCAR



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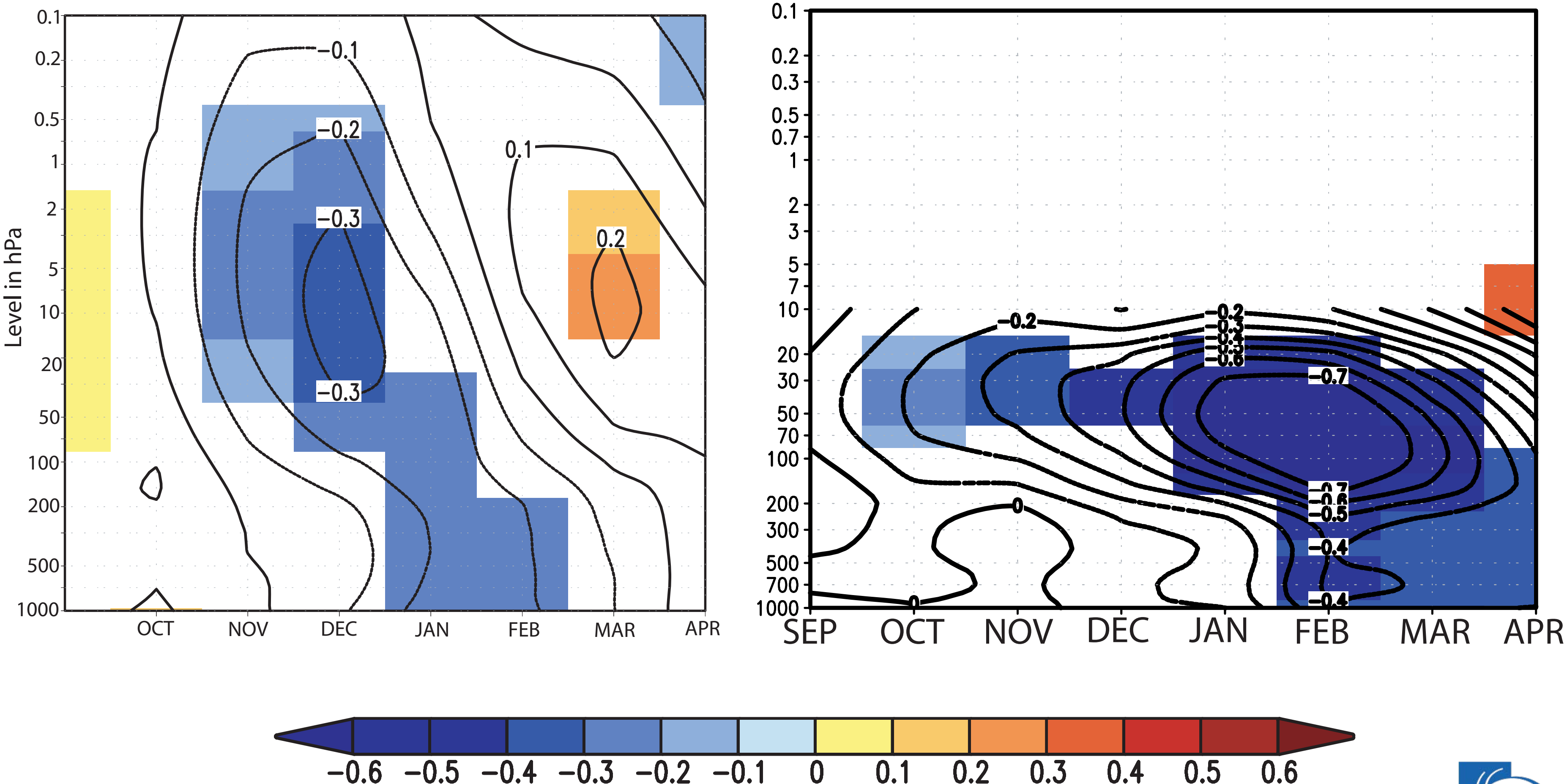
Simulated and observed downward propagation of weakened westerlies

High-top

NCEP/NCAR



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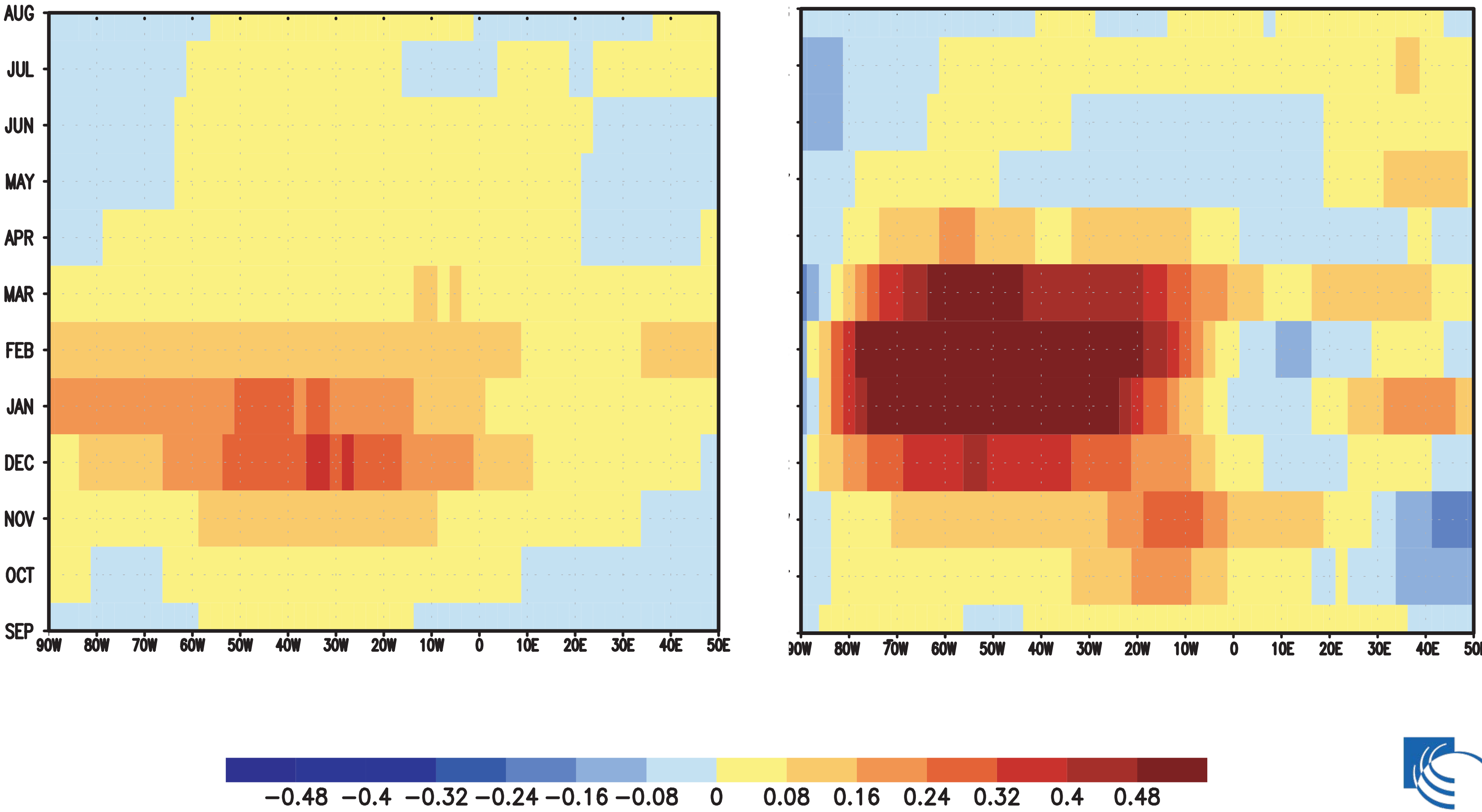
AMV drives upward propagating quasi-stationary waves that weaken polar vortex

High-top

NCEP/NCAR



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Summary

1. Uncertainties in AMOC prediction
   - Model uncertainty dominates on decadal (centennial)
   - Salinity in high-latitudes is large uncertainty

2. Observations and model indicate warm AMV drives negative NAO, with stratosphere playing a key role

   Caveat: One model & one case