Observed and simulated impact of the Atlantic Multidecadal Variability on the North Atlantic Oscillation (NAO)

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Introduction

the winter North Atlantic Oscillation (NAO) changes drive a significant portion of the Atlantic Multidecadal Variability (AMV). However, the role of external forcing, in particular solar forcing, in driving modulating the AMV is still unknown.
it is also controversial whether ocean-atmosphere interaction or other processes internal or external to the atmosphere force the multidecadal NAO viriability

Data and models

- NCEP reanalysis and HAD-SST and SLP
- Non-coupled experiment with low and high top ECHAM5
- Coupled control experiments using ECHAM6/MPIOM and uncoupled experiments usingECHAM6/

Fig. 1

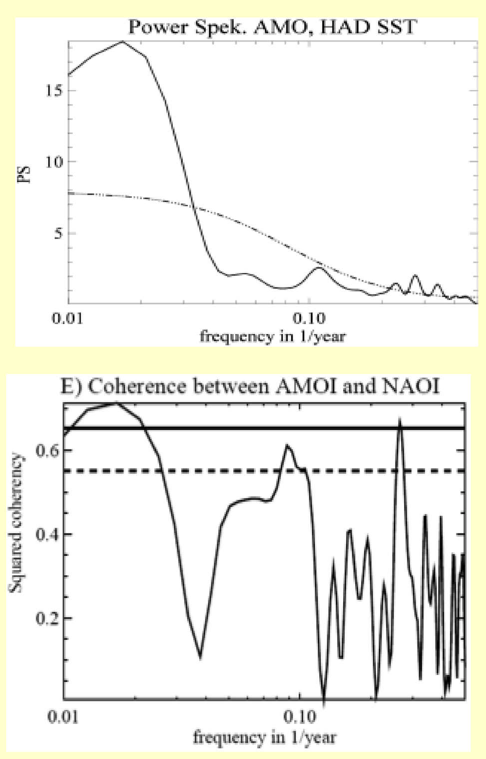
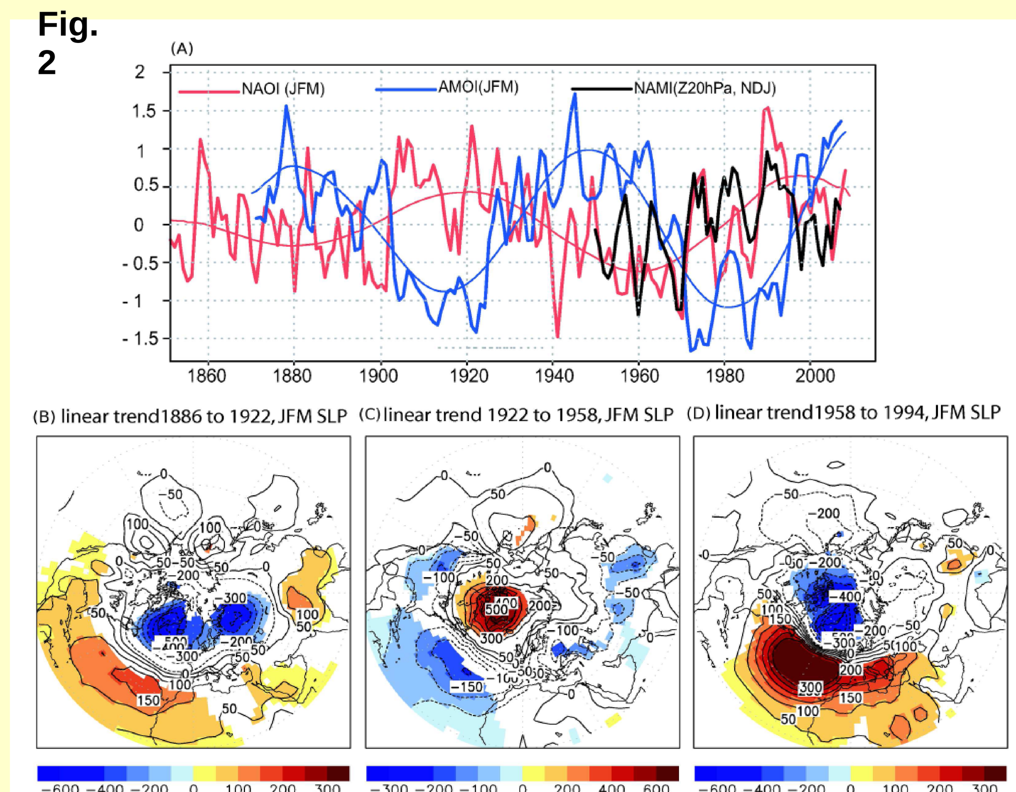


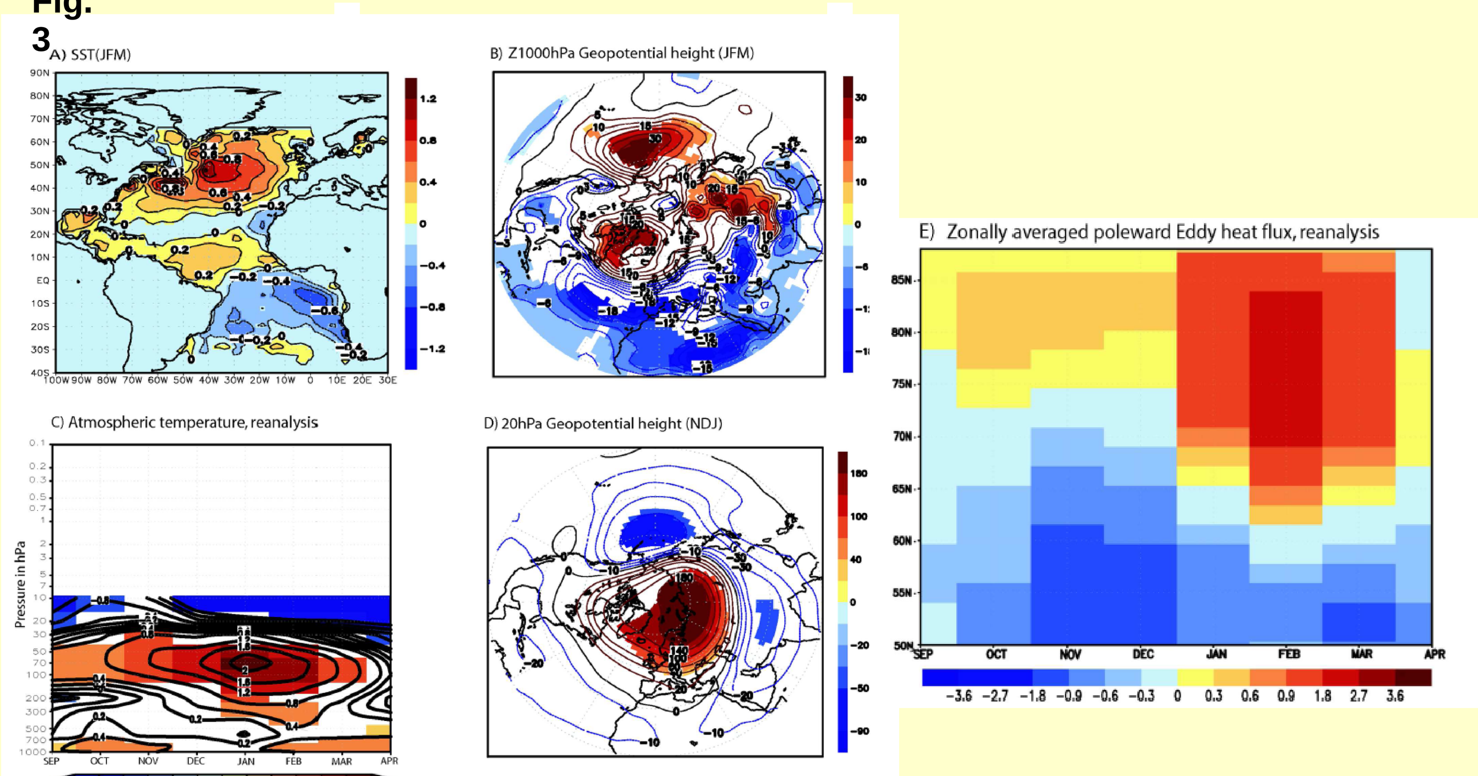
Fig. 2



- Observed warm (cold) AMV was associated with negative (positive) NAO (Fig. 1 and Fig.2 A)
- Multidecadal fluctuations (Fig. 2A) constitute the first SSA-mode of both AMV and NAO variability
- The highest coherence between NAO and AMV is seen in multidecadal timescales (not shown)
- Multidecadal NAO-trend from 1958 to 1994 can be seen as part of multidecadal NAO fluctuation (Fig.2 B-C)

Warm conditions of 1950s, NCEP and observation

Fig. 3



AMV-warming in 1950s is associated with precursory stratospheric warming and vortex weakening. The stratospheric warming propagates downward and reach the troposphere in form of a negative NAO in late winter.

Warm conditions of 1950s model simulations

Fig. 4

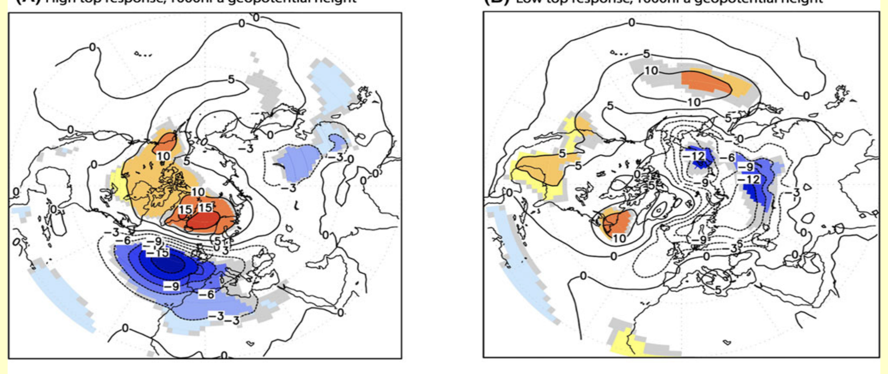
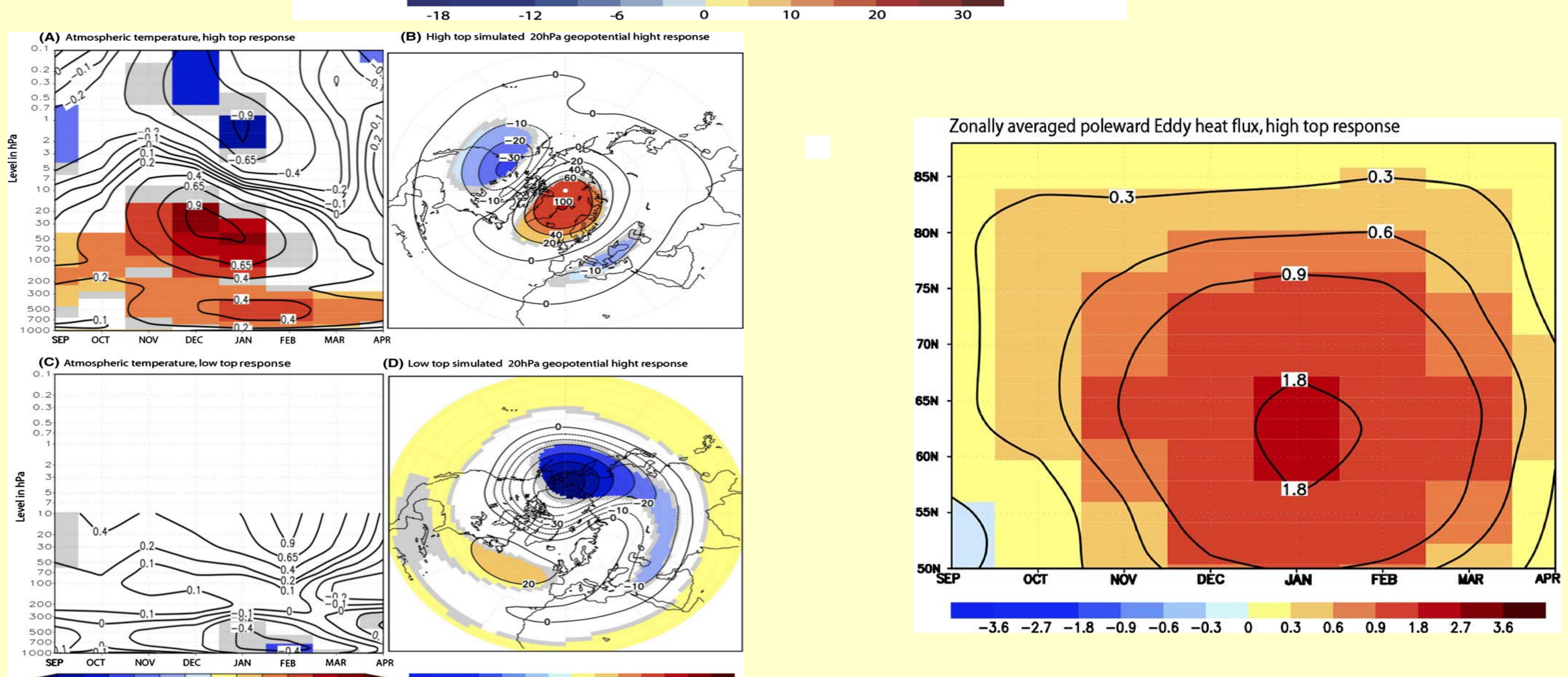


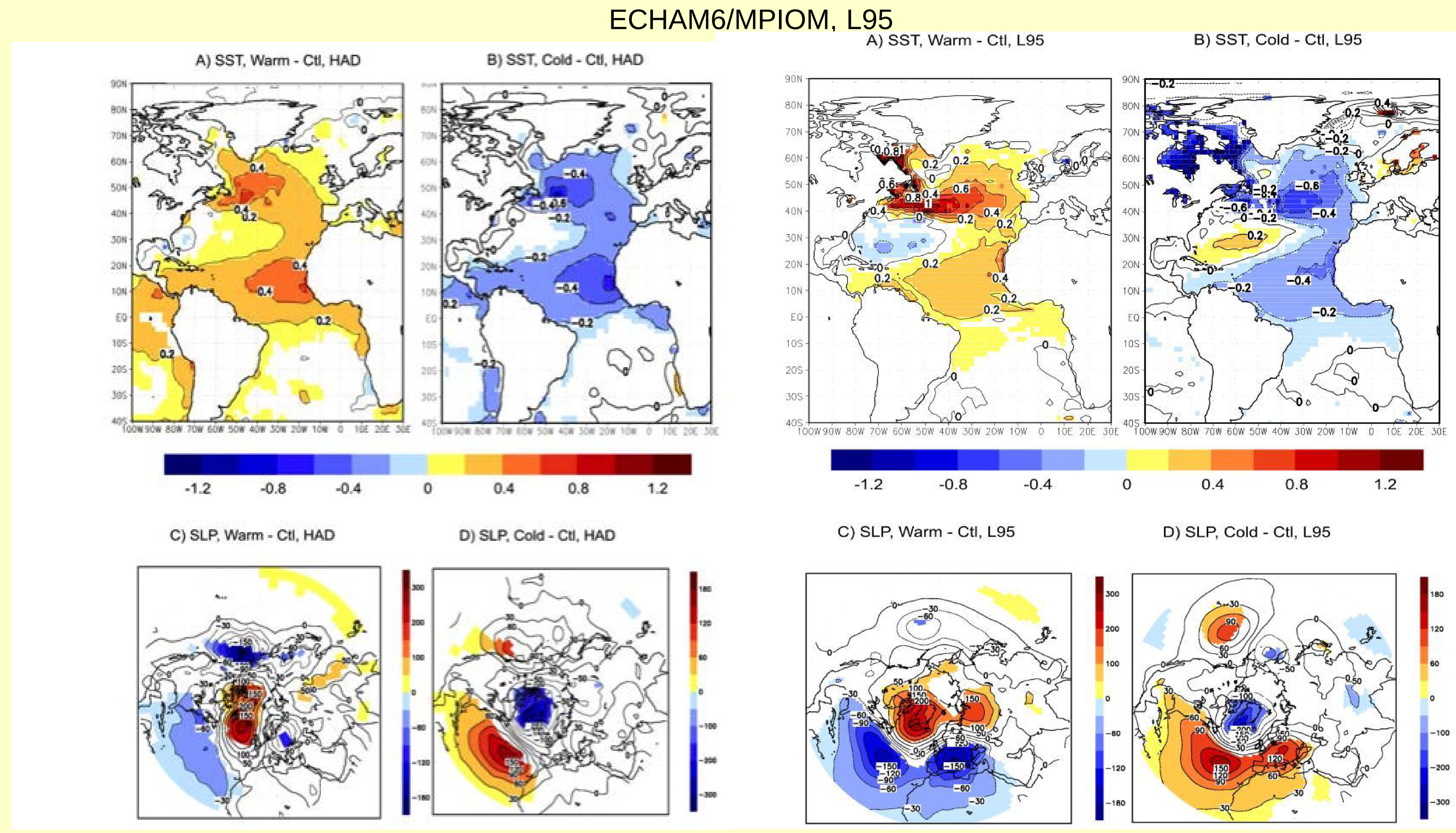
Fig. 5



The negative NAO caused by AMV, the associated precursory change in the stratosphere and the downward propagation of stratospheric warming can be simulated only by stratosphere-resolving models.

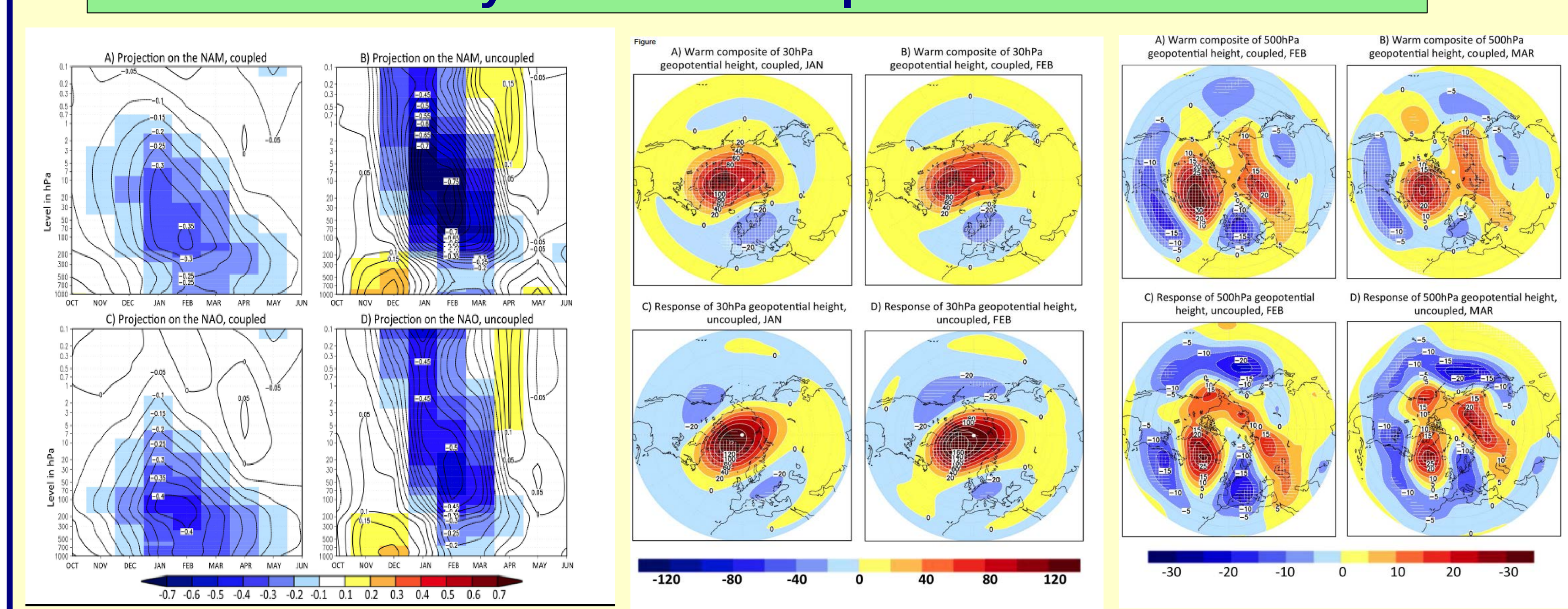
AMV/NAO coupling in stratosphere-resolving atmosphere/ocean coupled models

ECHAM6/MPIOM, L95



- The observed AMV/NAO relationship can also be captured in long-term simulations using the ECHAM6/MPIOM model.

Response to ward AMV using standalone Model driven by SST from coupled model



- The standalone atmospheric model can also respond to warm AMV with stratosphere playing important role

Conclusions

- Observed warm (cold) AMV conditions was associated with negative (positive) NAO
- The NAO responds to the AMV warm conditions with the stratosphere acting like atmospheric glasses to see and therefore feel the large-scale Atlantic warming
- The mechanisms of NAO-rsponse to Atlantic warming involve the wave-induced stratospheric/troposphere coupling, in which the AMV-induced stratospheric warming propagates into the high-latitude troposphere decreasing the meridional temperature gradient and thus low level baroclinicity
- Since it is widely accepted that the AMV is, to a large extent, the delayed NAO-response, the response of NAO to AMV support a self-maintained oscillatory behavior between AMV and NAO
- The observed AMV/NAO relationship can be captured in ECHAM6/MPIOM long-term simulation
- The standalone atmospheric model can also respond to large scale Atlantic Warming with stratosphere playing important role

Reference:

- Omrani, N.-E., N. S. Keenlyside, J. Bader, and E. Manzini, 2014: Stratospheric key for wintertime atmospheric response to warm Atlantic decadal conditions. Climate Dyn., 42, 649–663, doi 10.1007/s00382-013-1860-3
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