Efficient driving of AMOC variability by North Atlantic buoyancy fluxes in CCSM4

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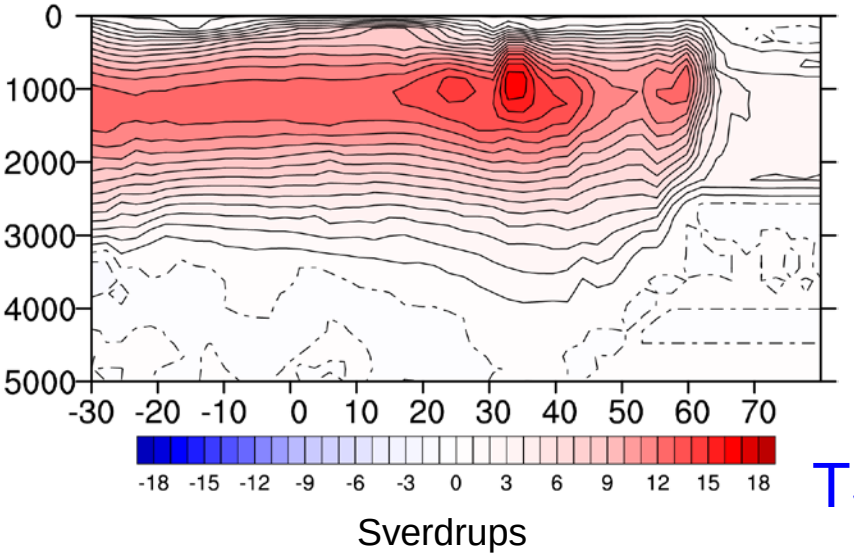
with help from Haiyan Teng, Andy Mai, Patrick Callaghan & Svetlana Karol



T31, 3deg CCSM4

Shields et al., 2012

Are there efficient alternatives to NAO buoyancy fluxes?

Fluctuation Dissipation Theorem

$$\left[AMOC(t)\right] = \hat{\mathbf{M}}_t F = \hat{\mathbf{M}}_t \begin{bmatrix} \dot{T} \\ \dot{S} \\ \dot{u} \\ \dot{v} \end{bmatrix}$$

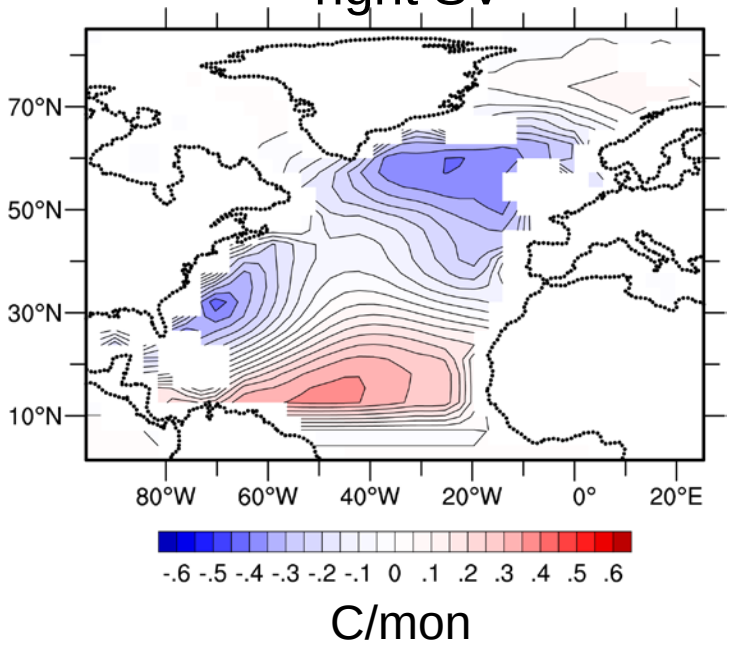
t = 5 yrs

singular value decomposition

SV1 for thermal forcing in top 110m

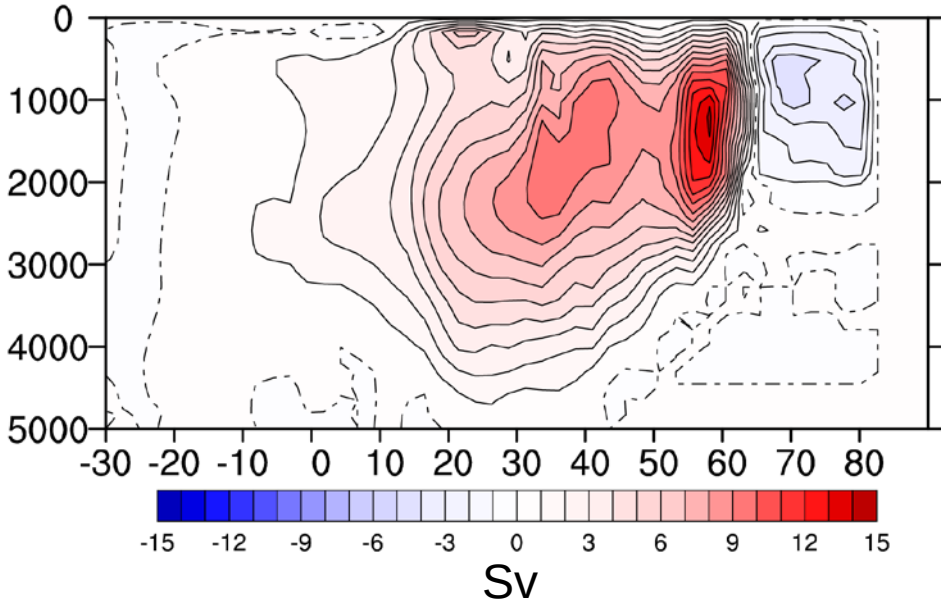
maximizing yr 5 response

right SV



C/mon

left SV

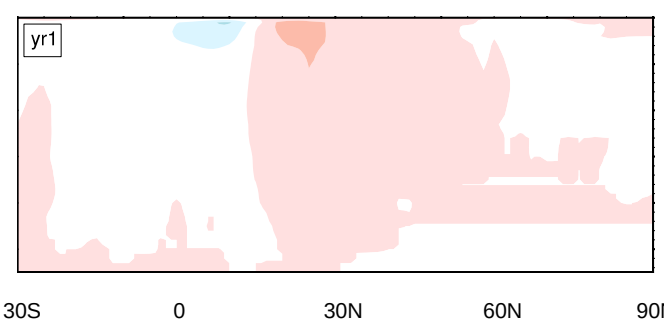


Sv

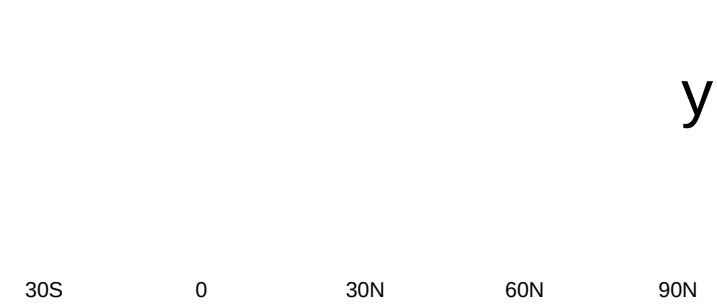
8 times average response to random forcing

CCSM4 AMOC response to thermal SV1
(pos-neg)

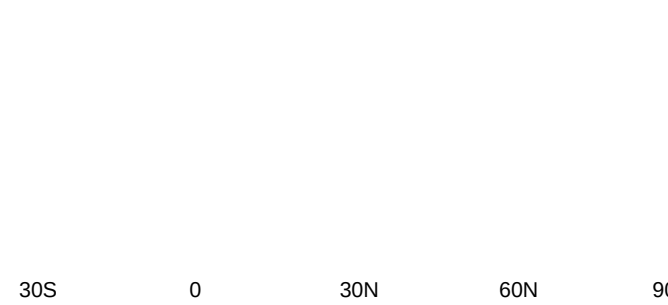
yr 1



yr 2



yr 3

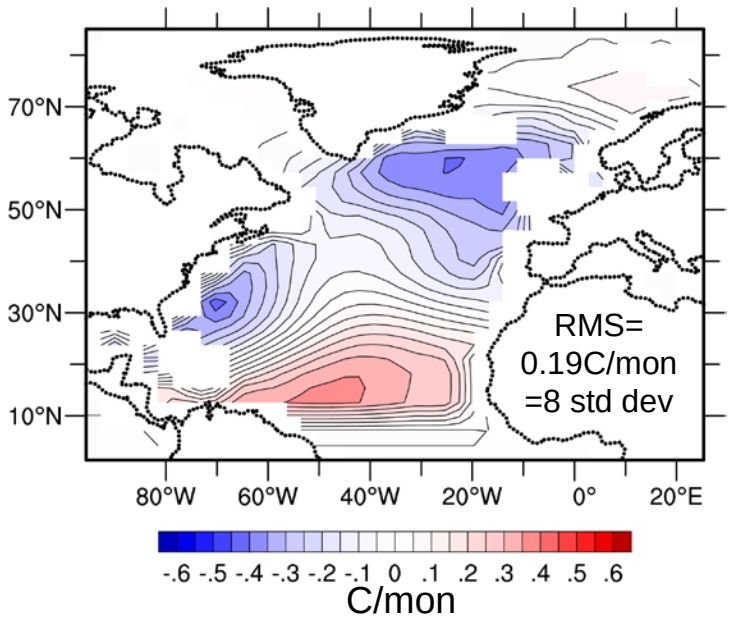


yr 4

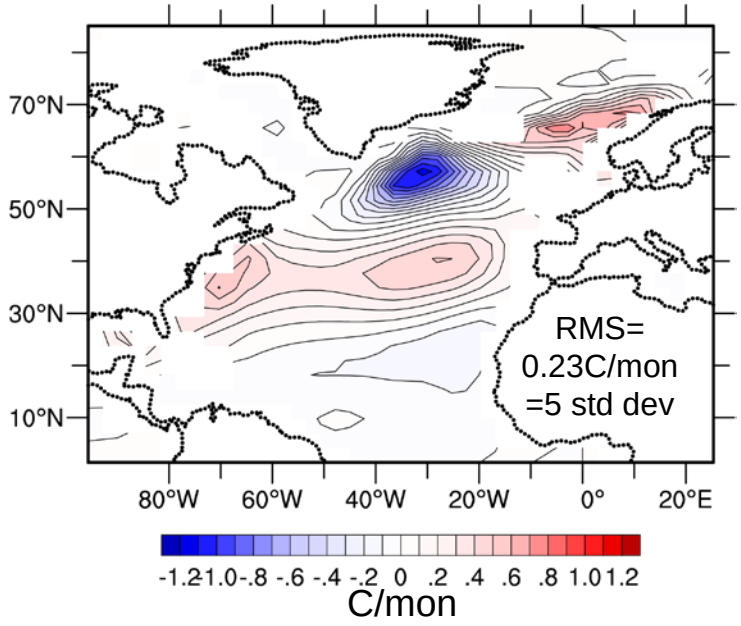
yr 5

Thermal forcing in top 110m

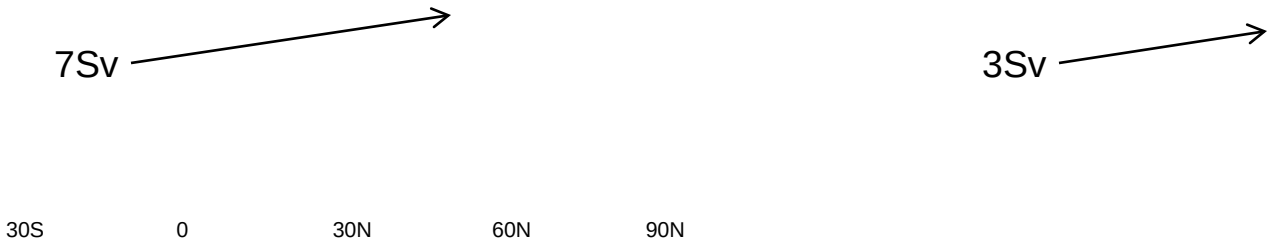
SV1



NAO

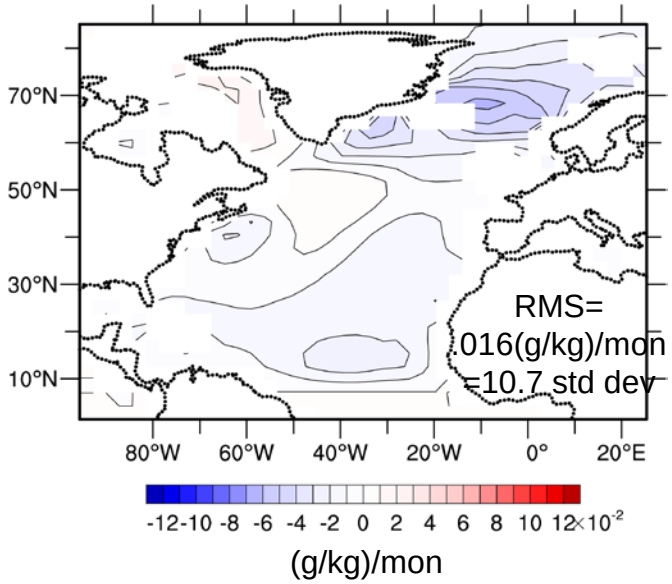


CESM yr 5 AMOC response

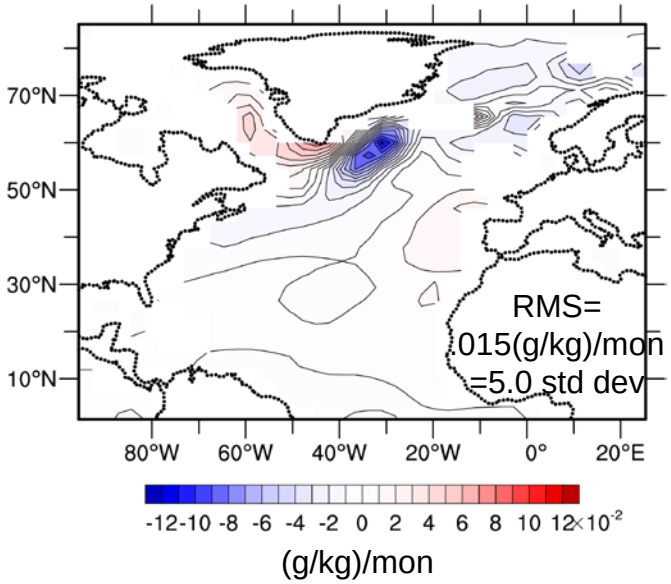


Salinity Forcing

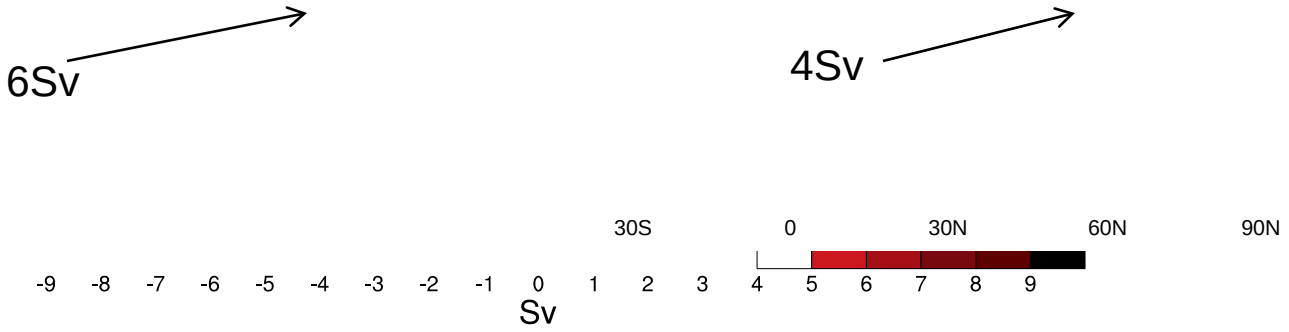
SV1(pos-neg)



NAO(pos-neg)

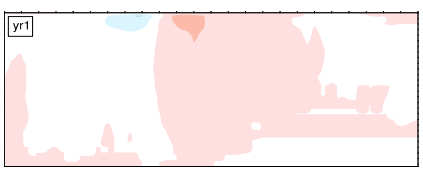


CCSM4 5yr AMOC response



What factors contribute to the growing response to constant forcing?

yr 1

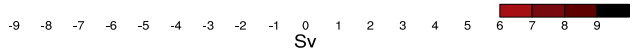


yr 2

yr 3

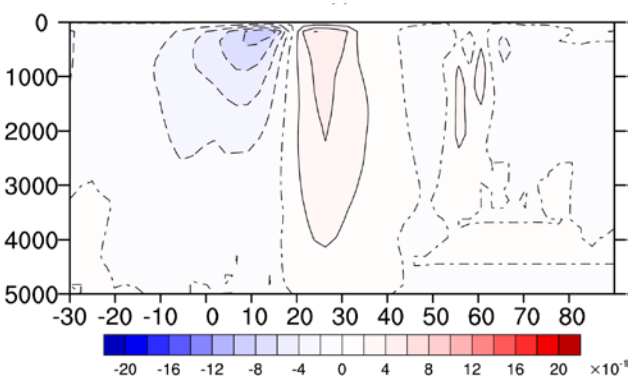
yr 4

yr 5

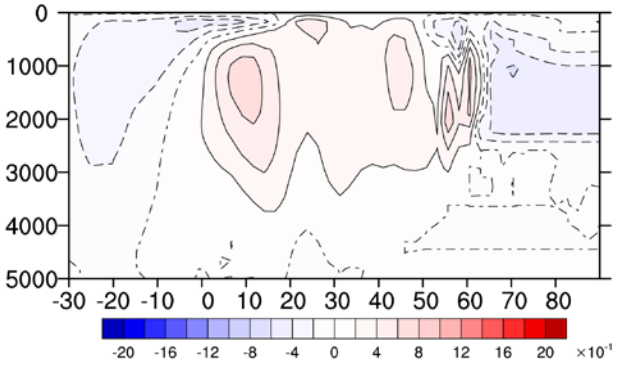


Response to forcing by SV1temp for 1 year

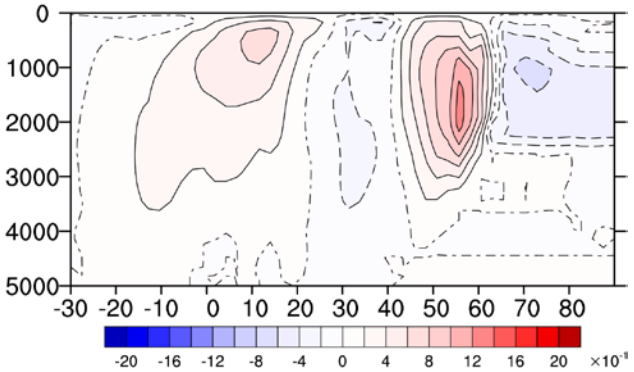
yr 1



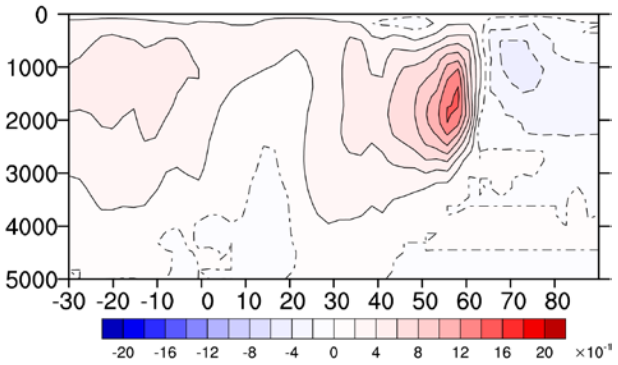
yr 2



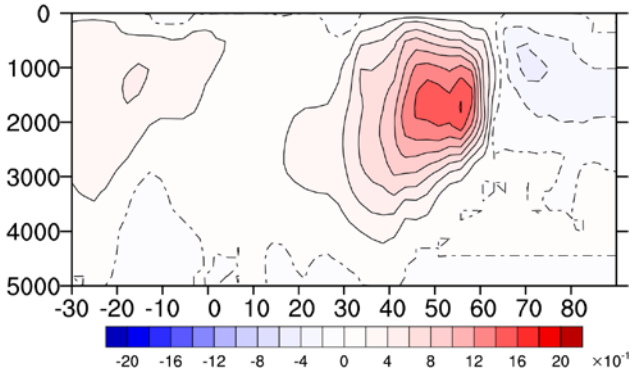
yr 3



yr 4



yr 5



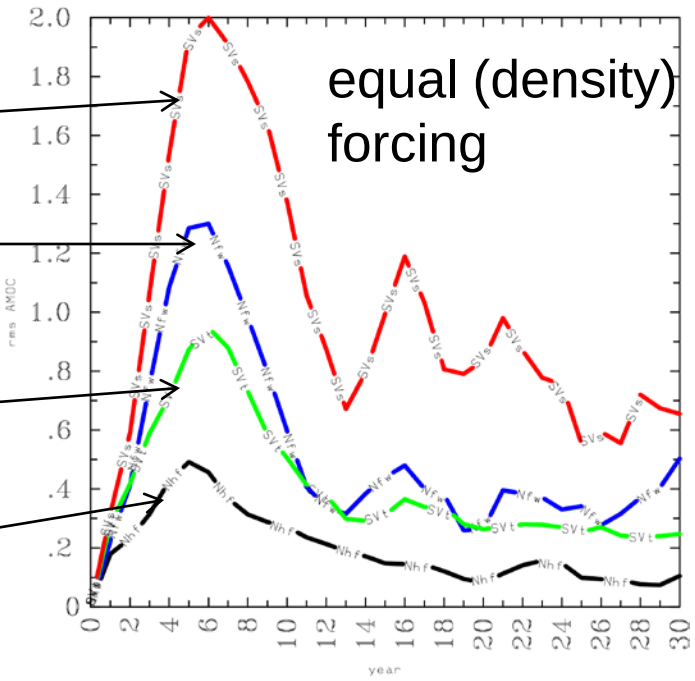
RMS AMOC response to 1 yr pulses

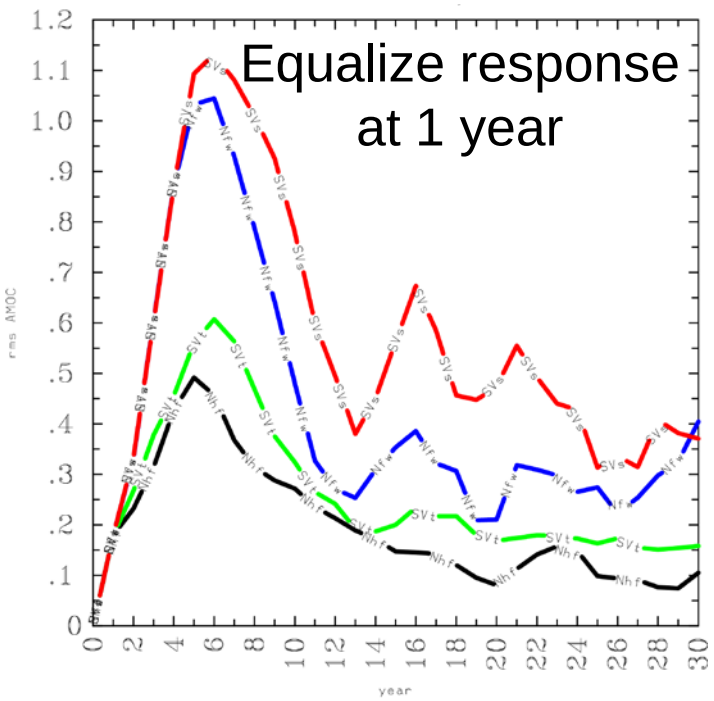
SV1salt

NAOsfwf

SV1temp

NAOshf

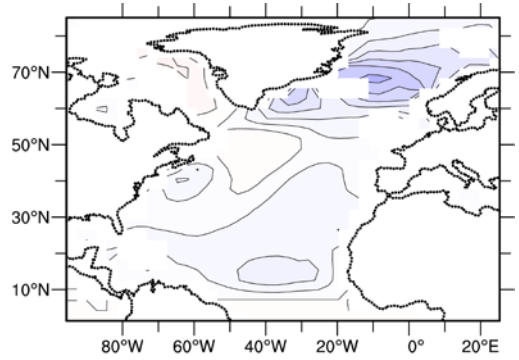




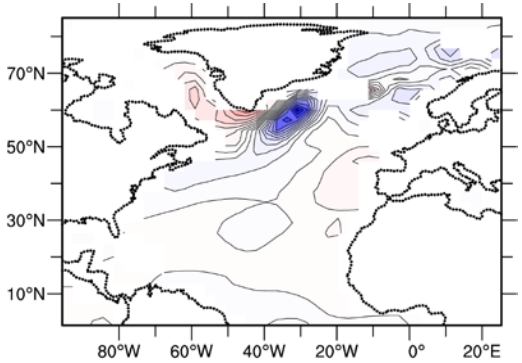
pltAMOC+SST1yrforce.newcontrol.various.unx1

Salinity Forcing

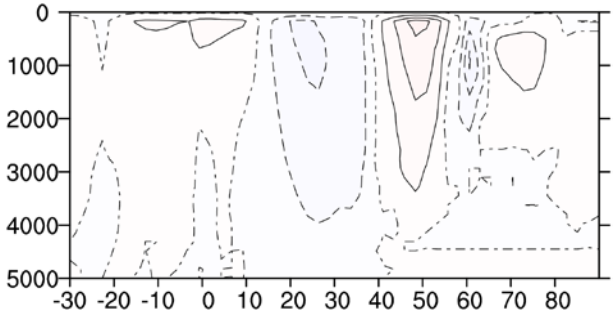
SV1salt

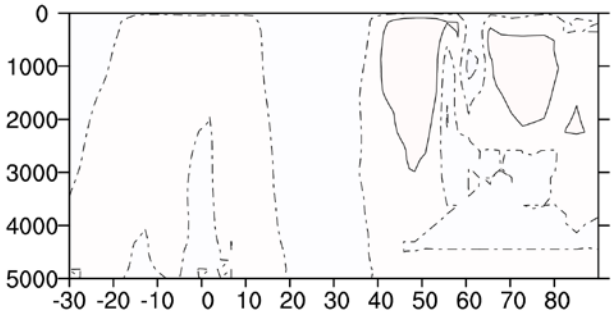


NAO(neg-sfwf)

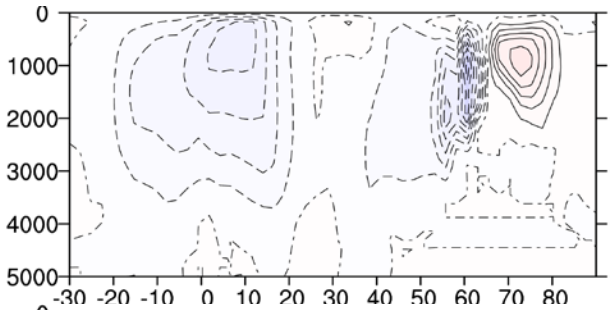


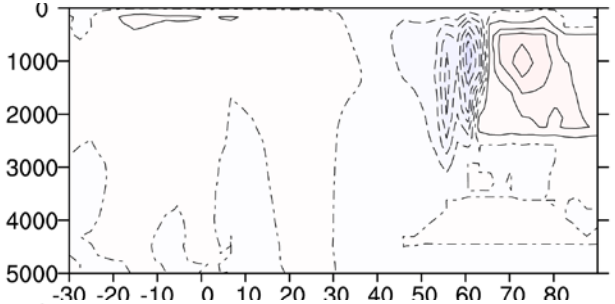
yr 1



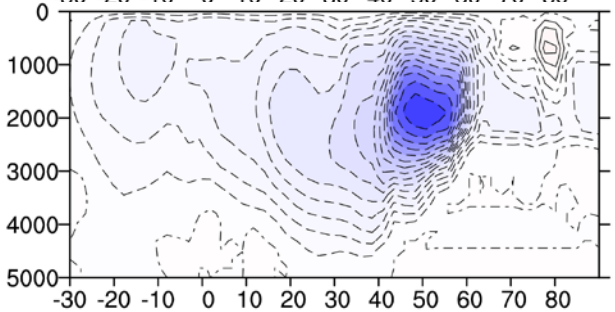


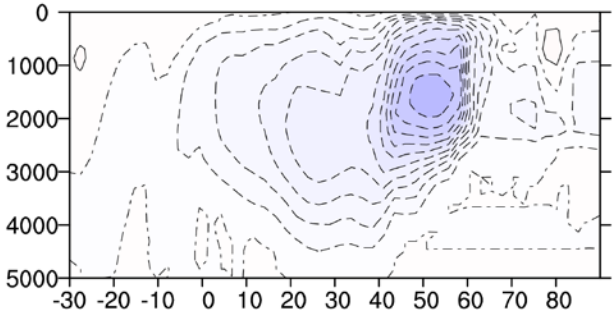
yr 2





yr 5





Do the alternative flux patterns have a detectable impact on internal AMOC variability?

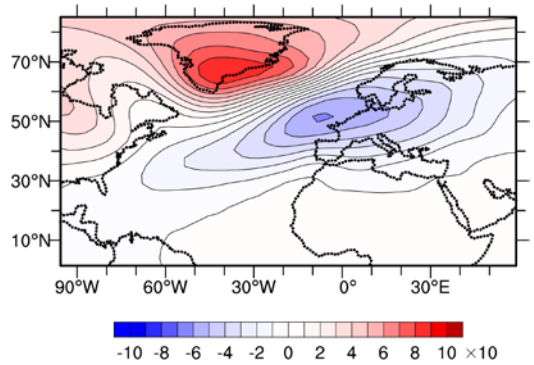
Regression wrt 5yr mean NAtl PSL indices

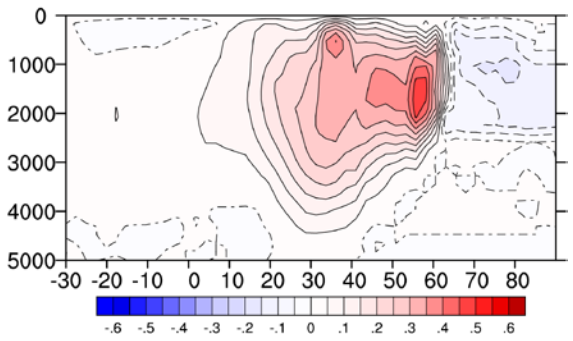
5yr mean PSL

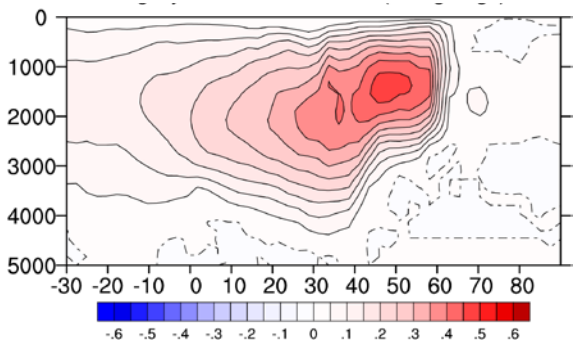
1yr mean AMOC (1yr delay)

1yr mean AMOC (5yr delay)

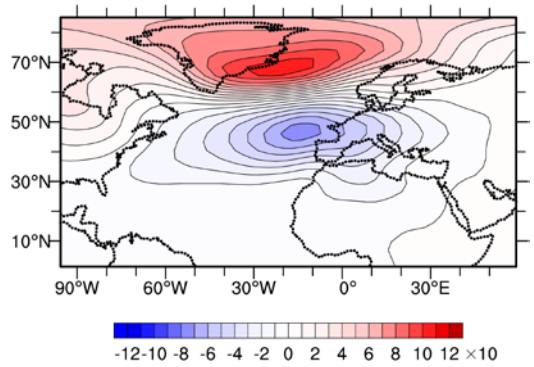
PSL from SV1temp

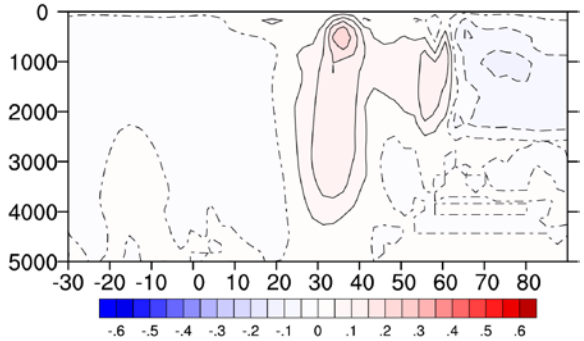


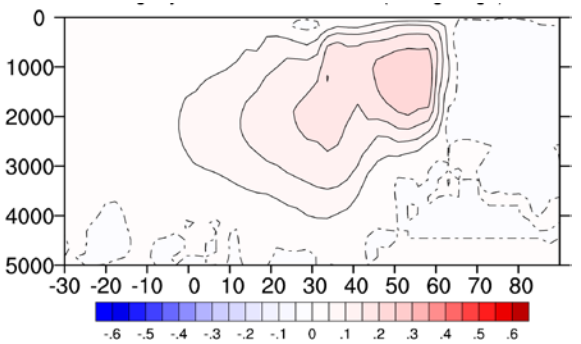




NAtl PSL EOF1-







- There are more efficient patterns than the NAO for forcing AMOC anomalies
- These patterns produce a response that grows for 5-6 years
- SV structures are imbedded in the response to NAO
- Small changes in atmos variability can have large effects on AMOC variability