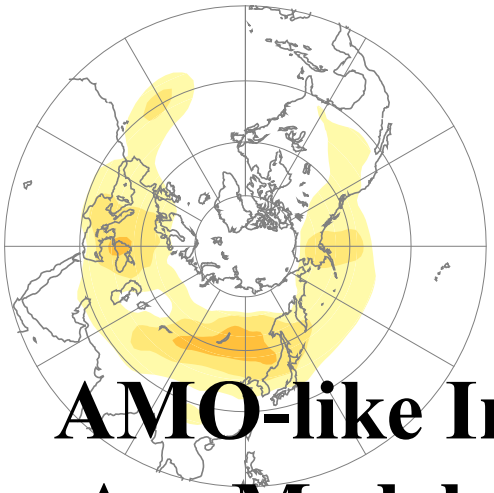

EAPMO and AMO
(and AMV in CMIP5)
AMO-like Interdecadal Variability in the CMIP5 - Are Models Oversensitive to Prescribed Forcing?

Huang-Hsiung Hsu[1], Ming-Ying Lee[2,3], Ren-Jie Wu[3]

[1]Research Center for Environmental Research, Academia Sinica

[2]Central Weather Bureau

[3]Department of Atmospheric Sciences, National Taiwan University

NTU International Science Conference on Climate Change: Multidecadal and Beyond

September 17-20, 2012

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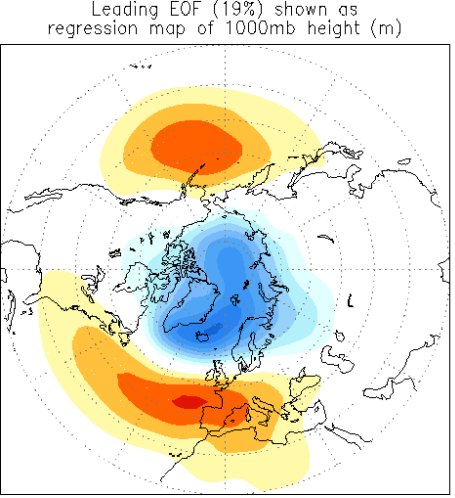
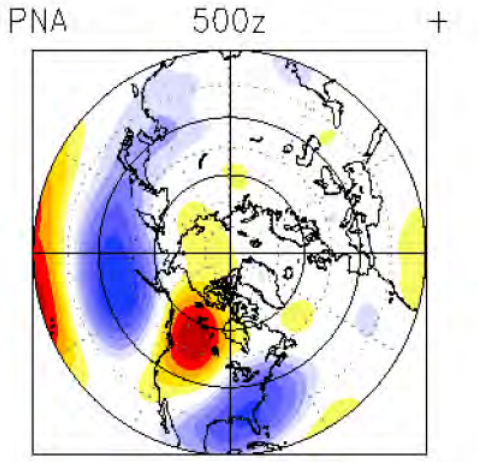


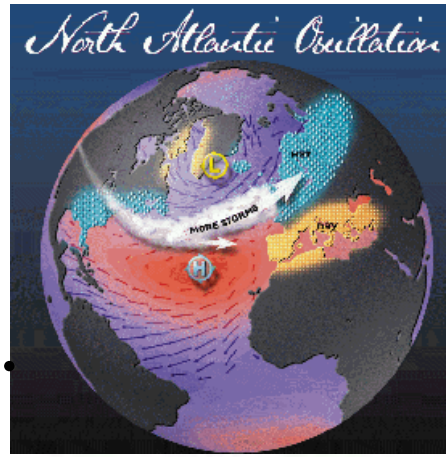
Teleconnection Families



Family of "P": EA, WP, PNA, EU, TNH, PJ, …

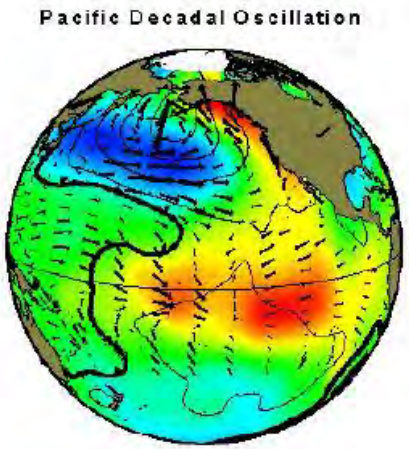
Family of "O": NAO, ENSO, PDO, IPO, AMO, …

Family of "M": IOZM(IOD), NAM, SAM, AMM, …

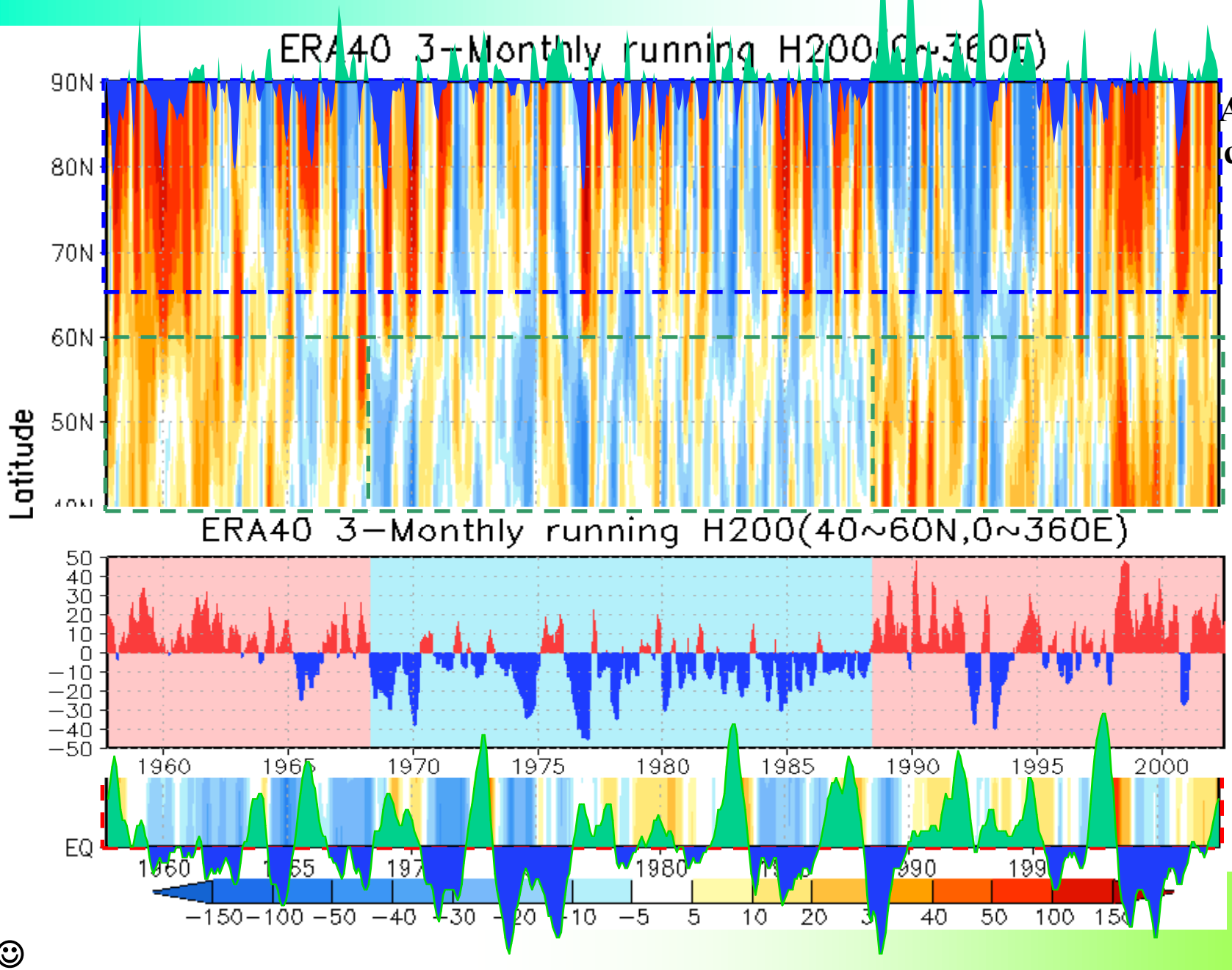


EurAsian Pacific Multidecadal "O" (EAPMO)
- A new baby in the family?

- **Location – Eurasia/North Pacific**
- **Time scale: multidecadal**



Zonally-symmetric structure in the NH upper troposphere



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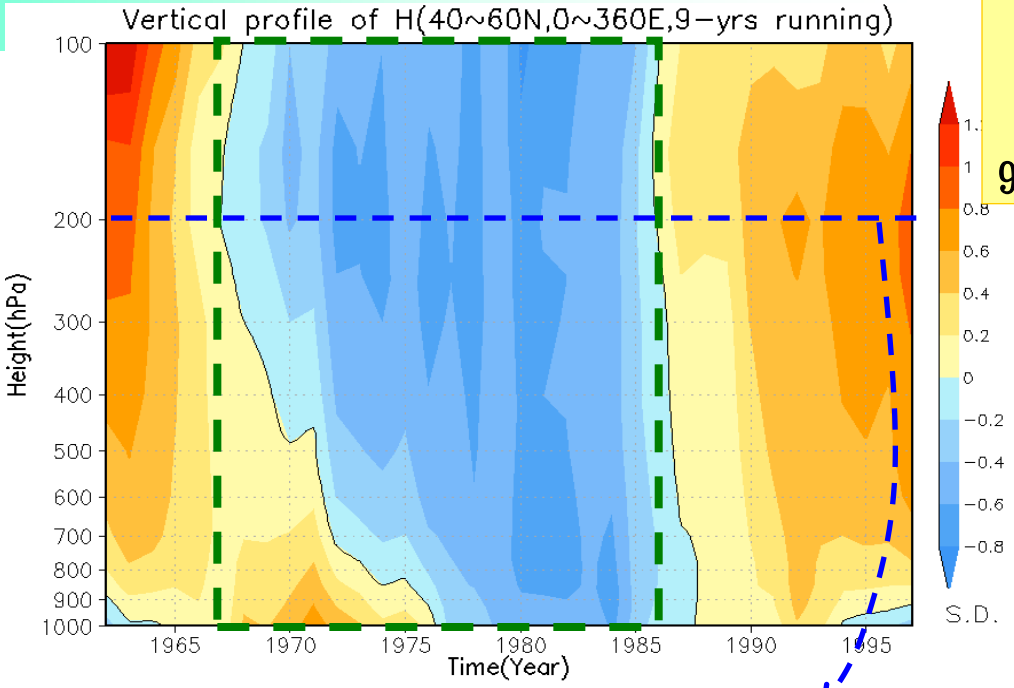
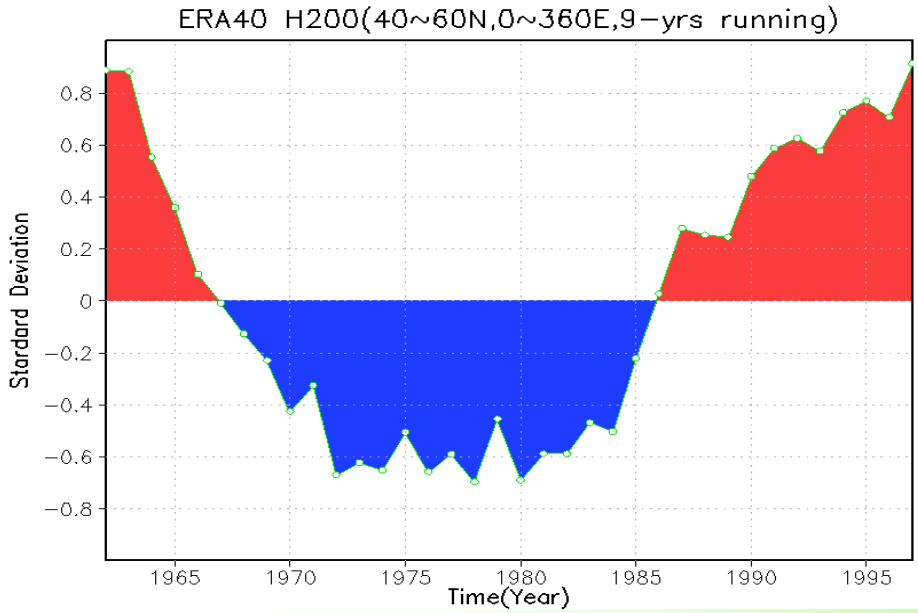


40N-60N

Zonal mean

9 Year running mean



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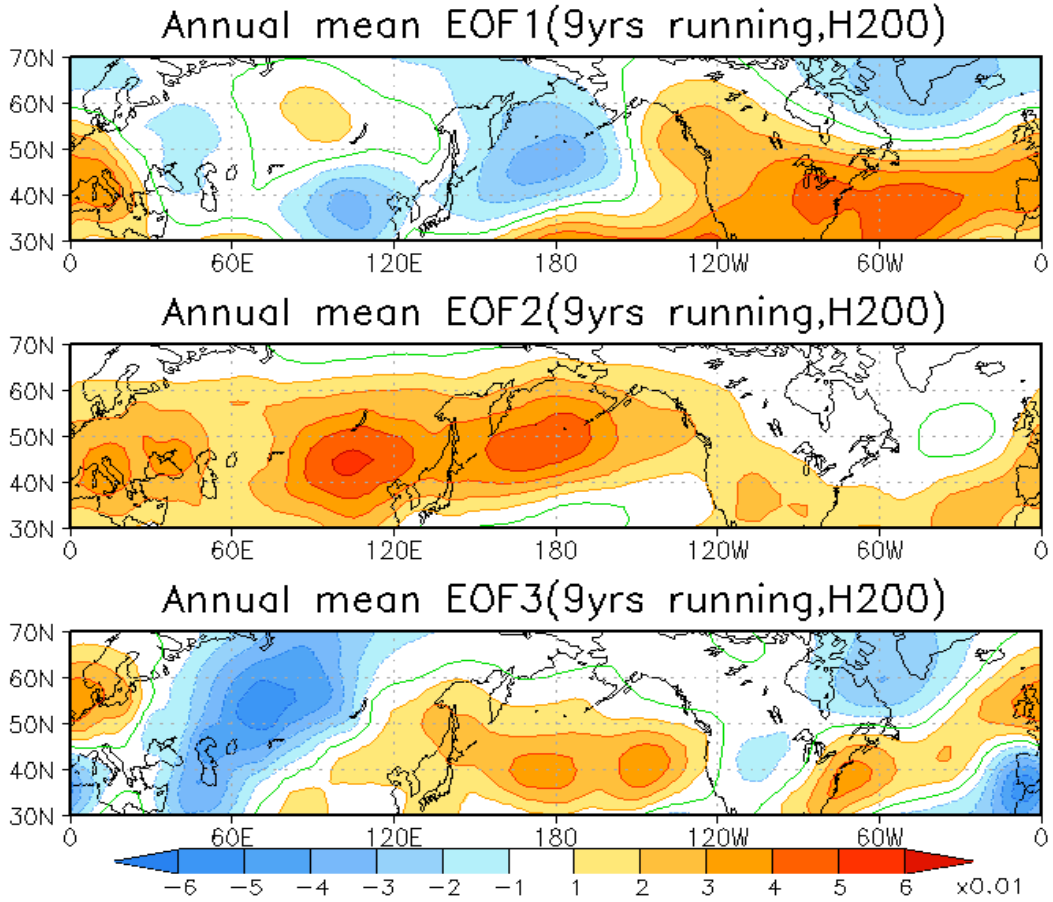
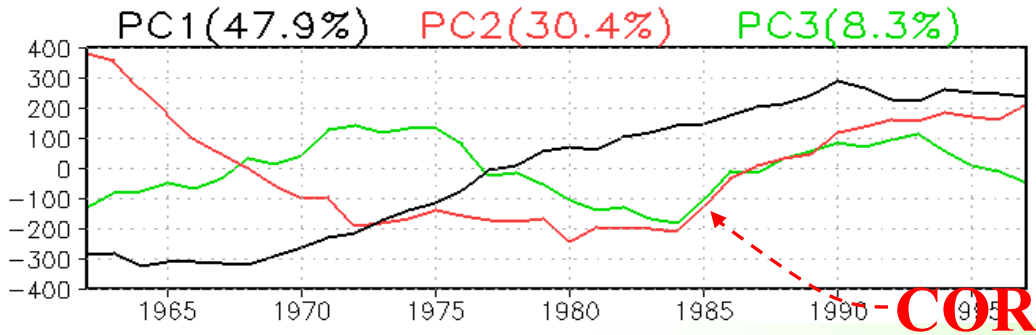
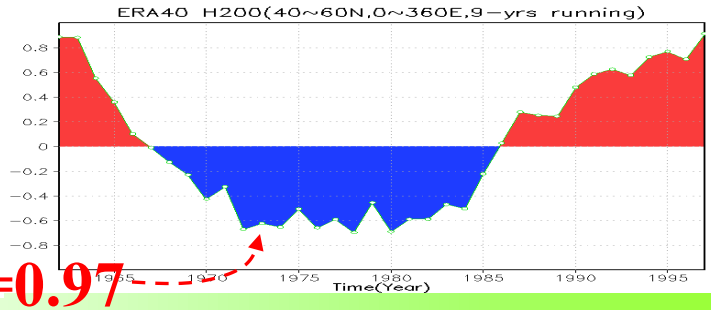
EOF analysis

Northern Hemisphere



What is EOF1?





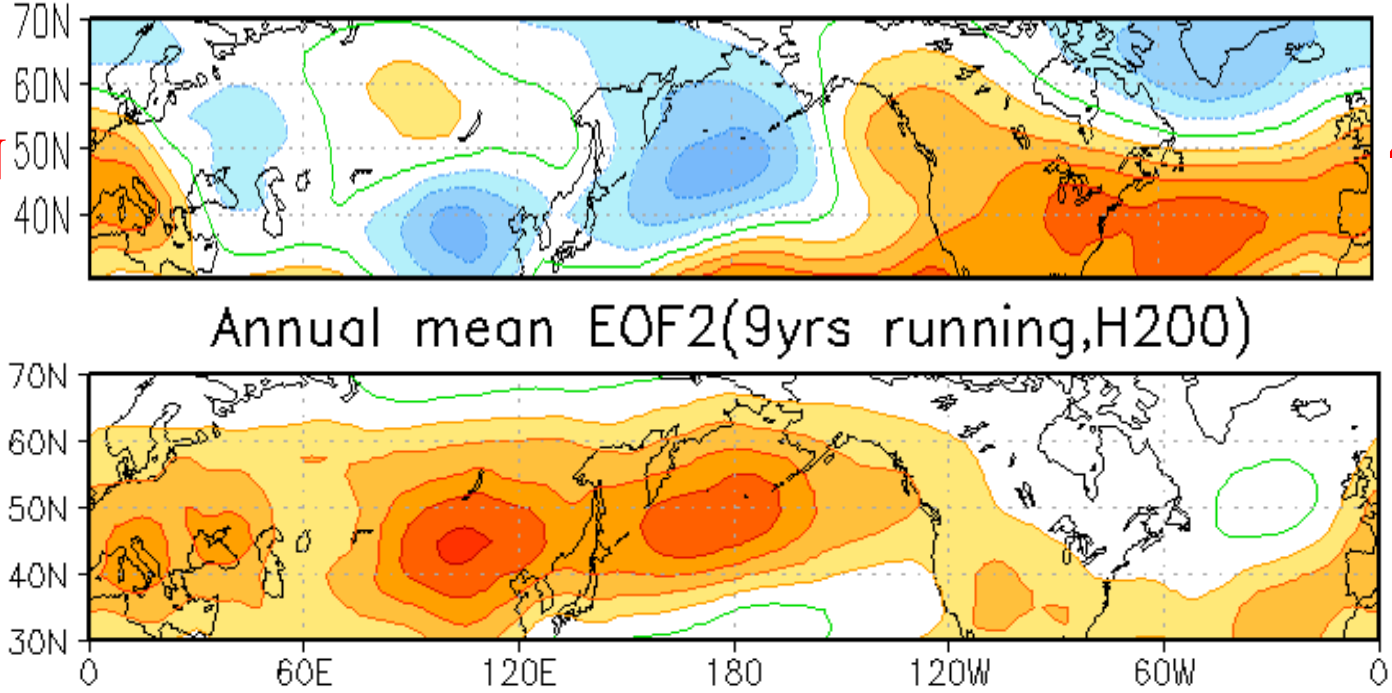
COR=0.97

☺

EOF analysis

EOF 1

30^0N~70^0N



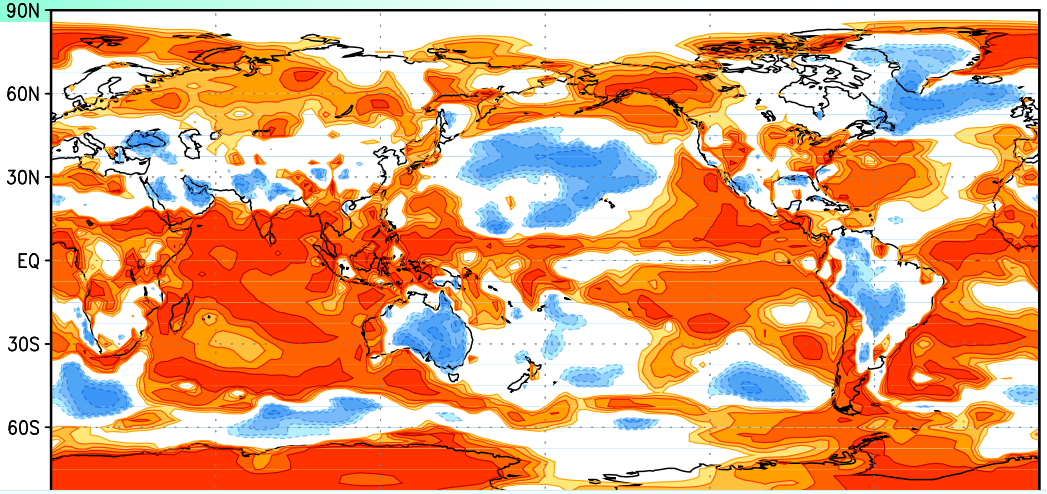
47.9%

30.4%

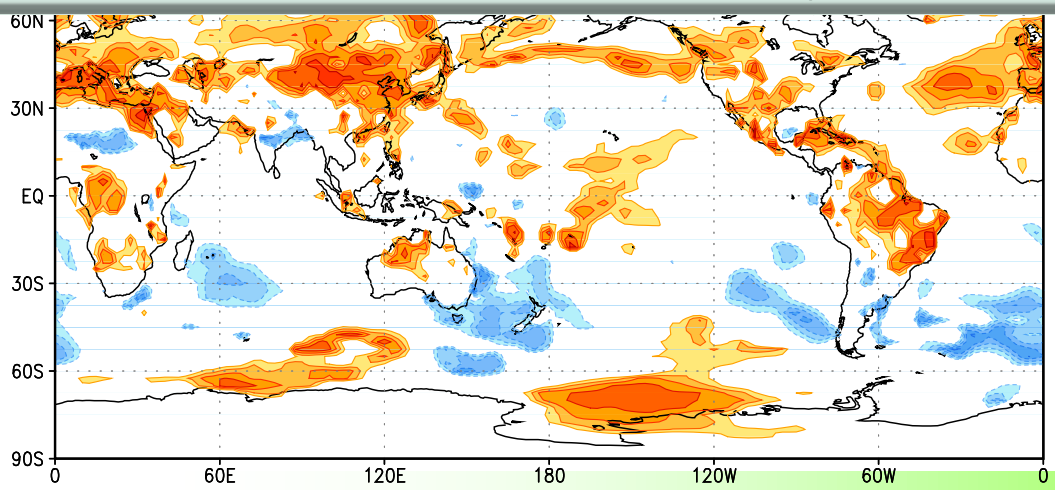
☺

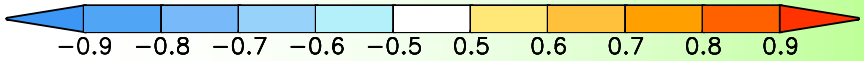
Correlation

Correlation EOF PC1 & ERA40 2mT *T2m vs. PC1*



It took two EOFs (modes?) to explain multidecadal variability in NH.





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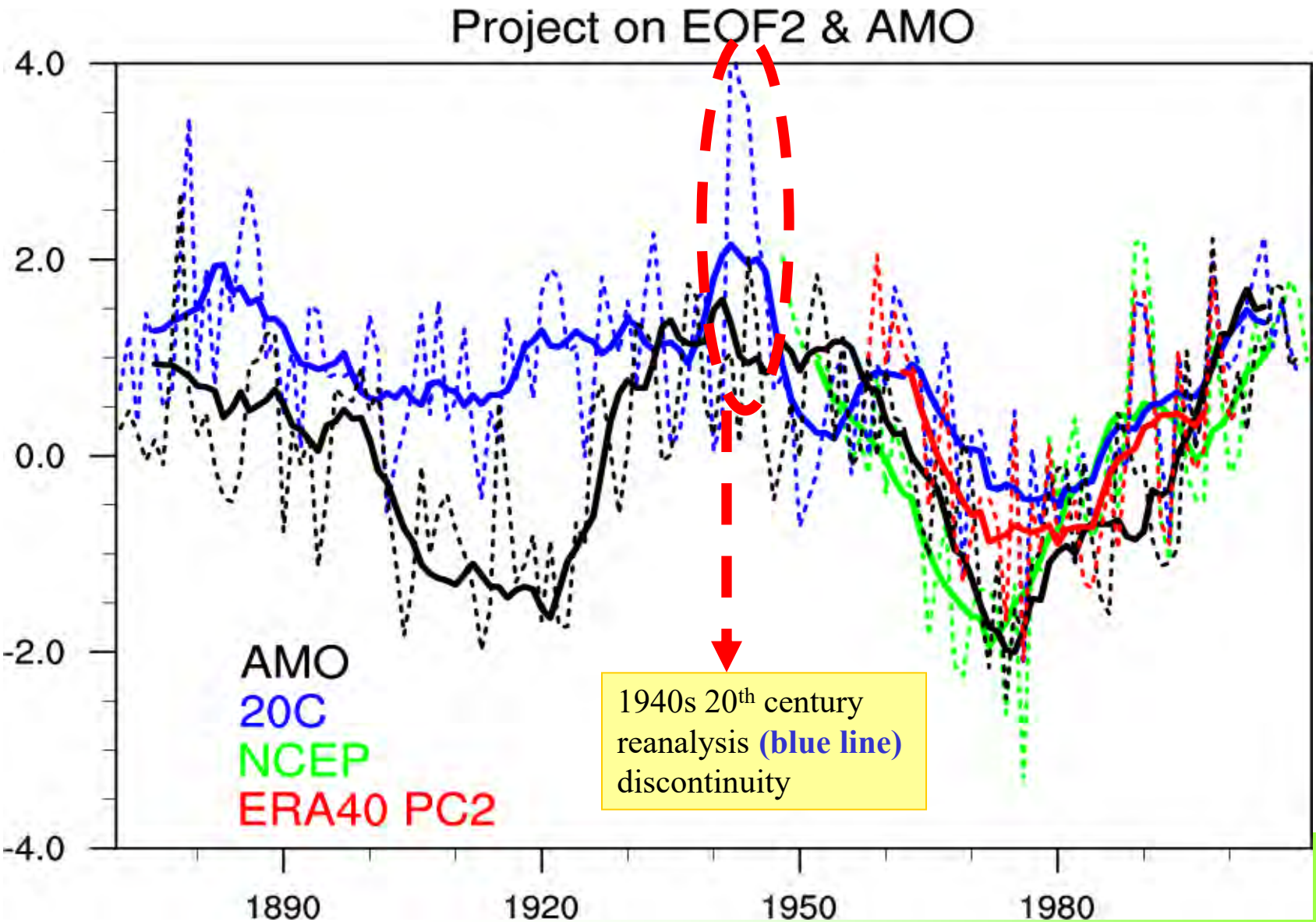
Existing in other datasets? - Projection of 20C Reanalysis on EOF 2



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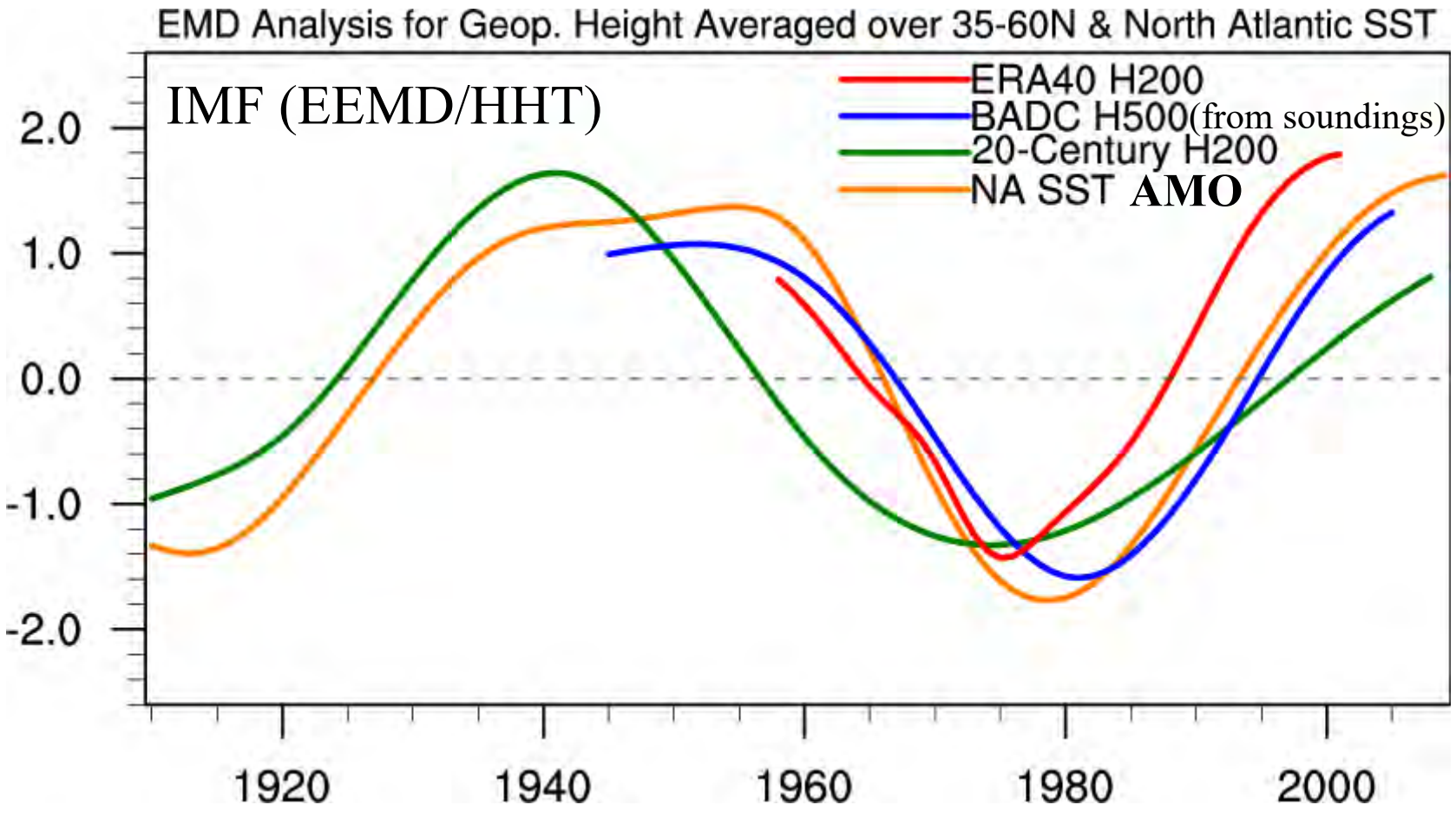
Existing in other datasets?



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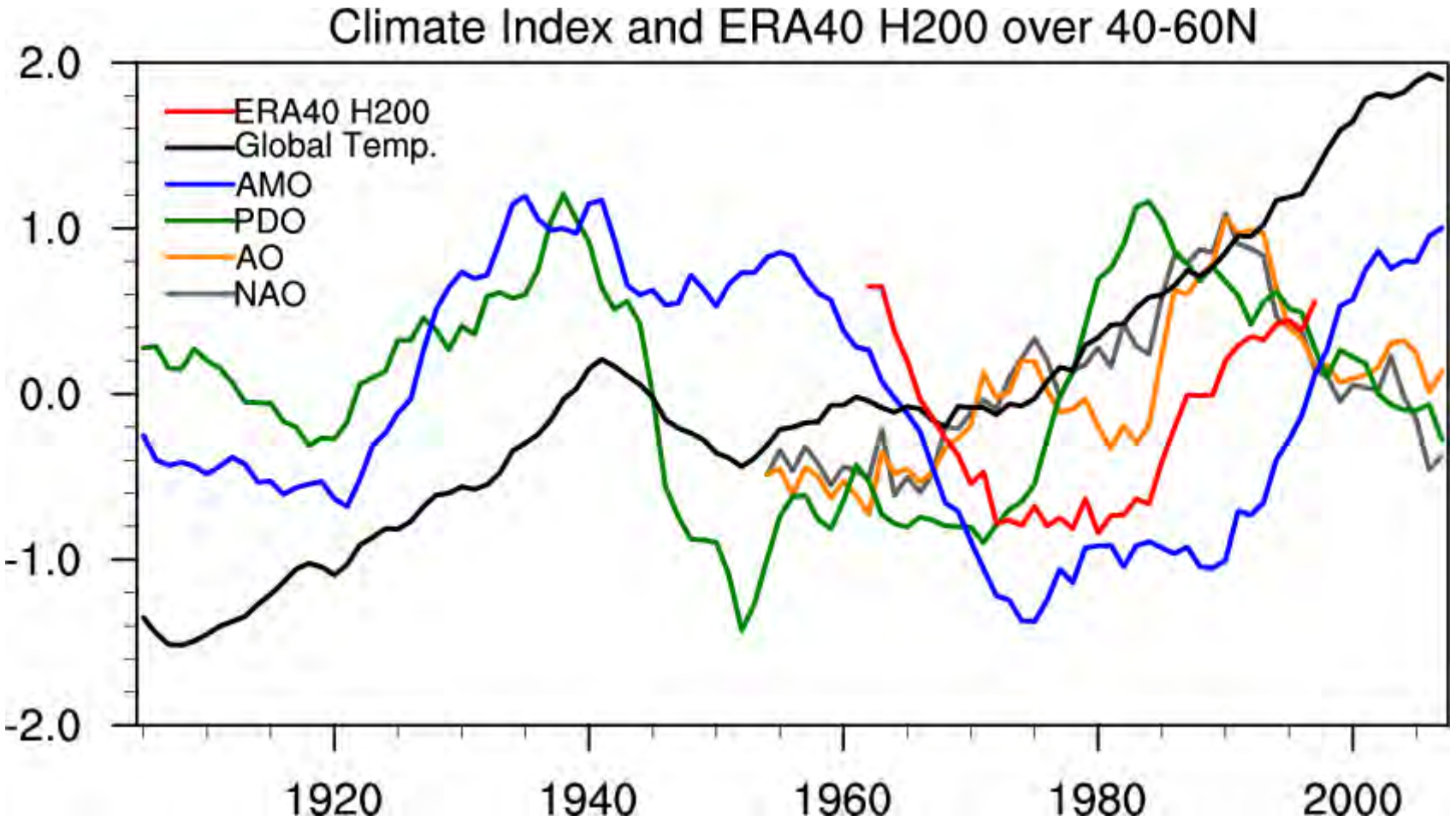
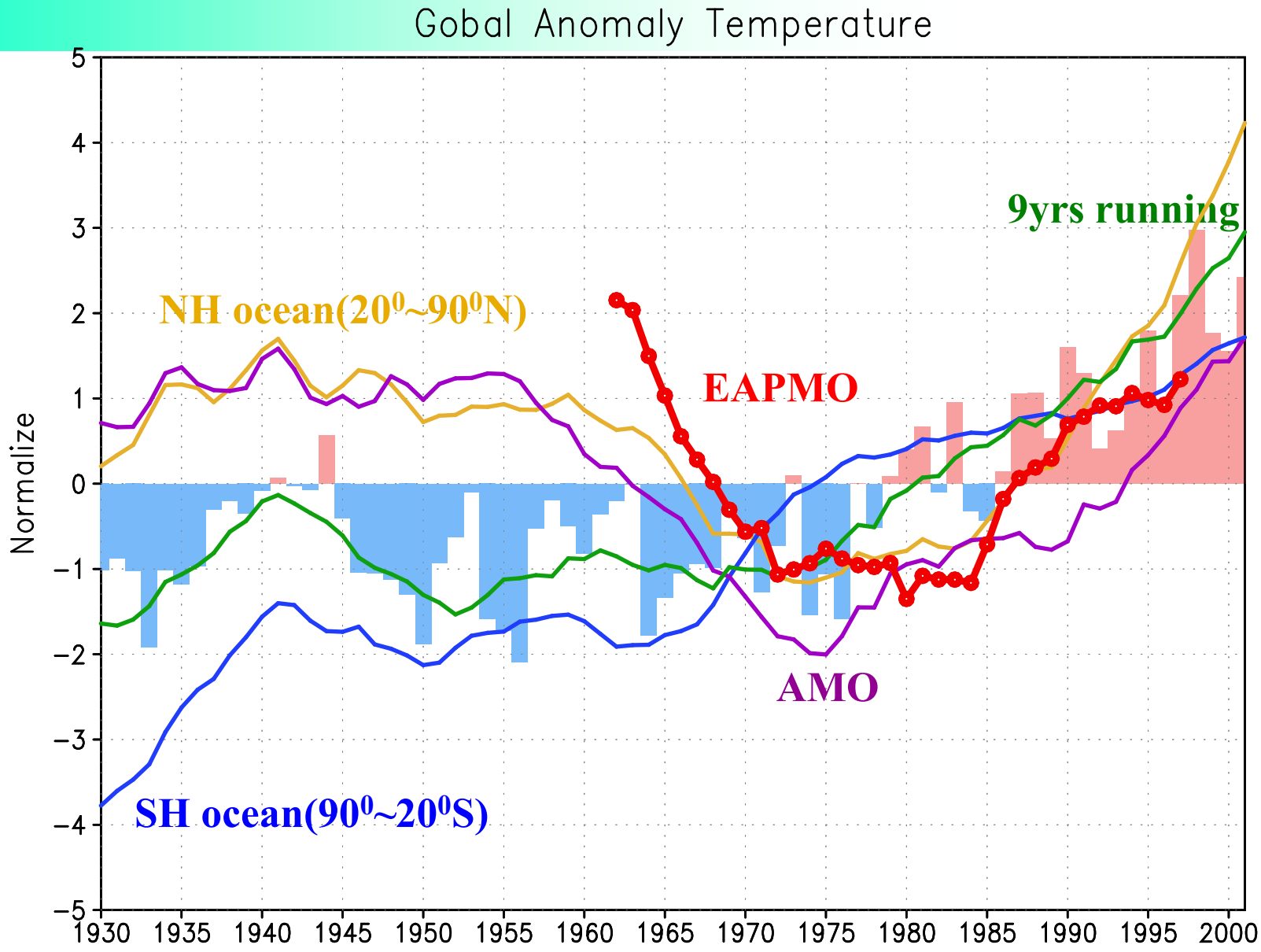
Relationship with Climate Indices?

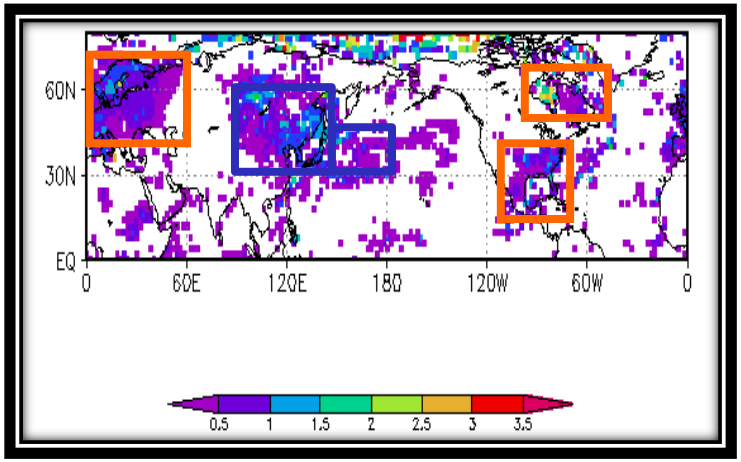


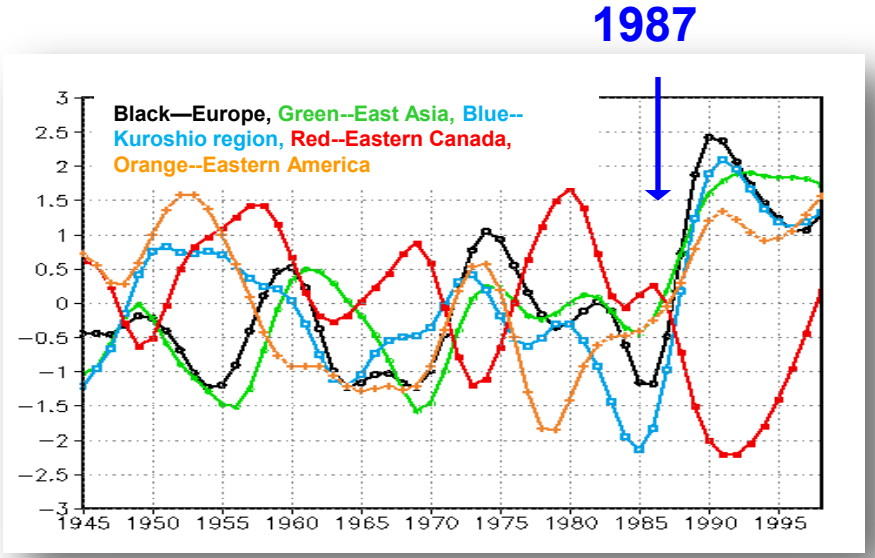


Data from: NCDC (ftp://ftp.ncdc.noaa.gov)

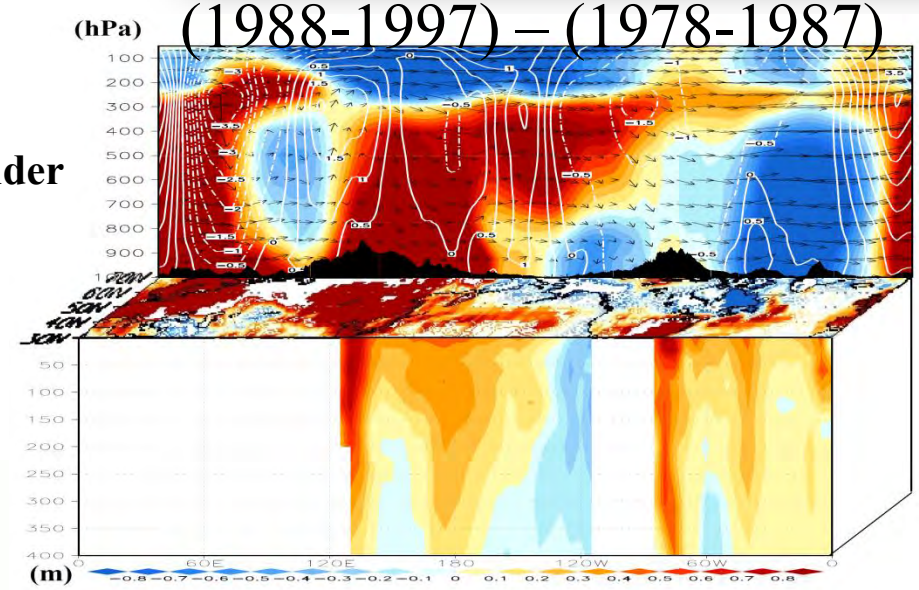
Related to Synchronous Climate Shift in northern winter SAT around 1987? (Lo and Hsu 2010)

Regime Shift Index (SAT) around 1987





(1988-1997) – (1978-1987)



40 ˚ -70 ˚ N average

Synchronous regime shift occurred in the whole troposphere, on and under ocean surface.

Lo, T.-T., and H.-H. Hsu, 2010: Change in Dominant Decadal Modes and the Late 1980s Abrupt Warming in the Extratropical Northern Hemisphere. *Atmos. Sci. Let.*, DOI: 10.1002/asl.275.

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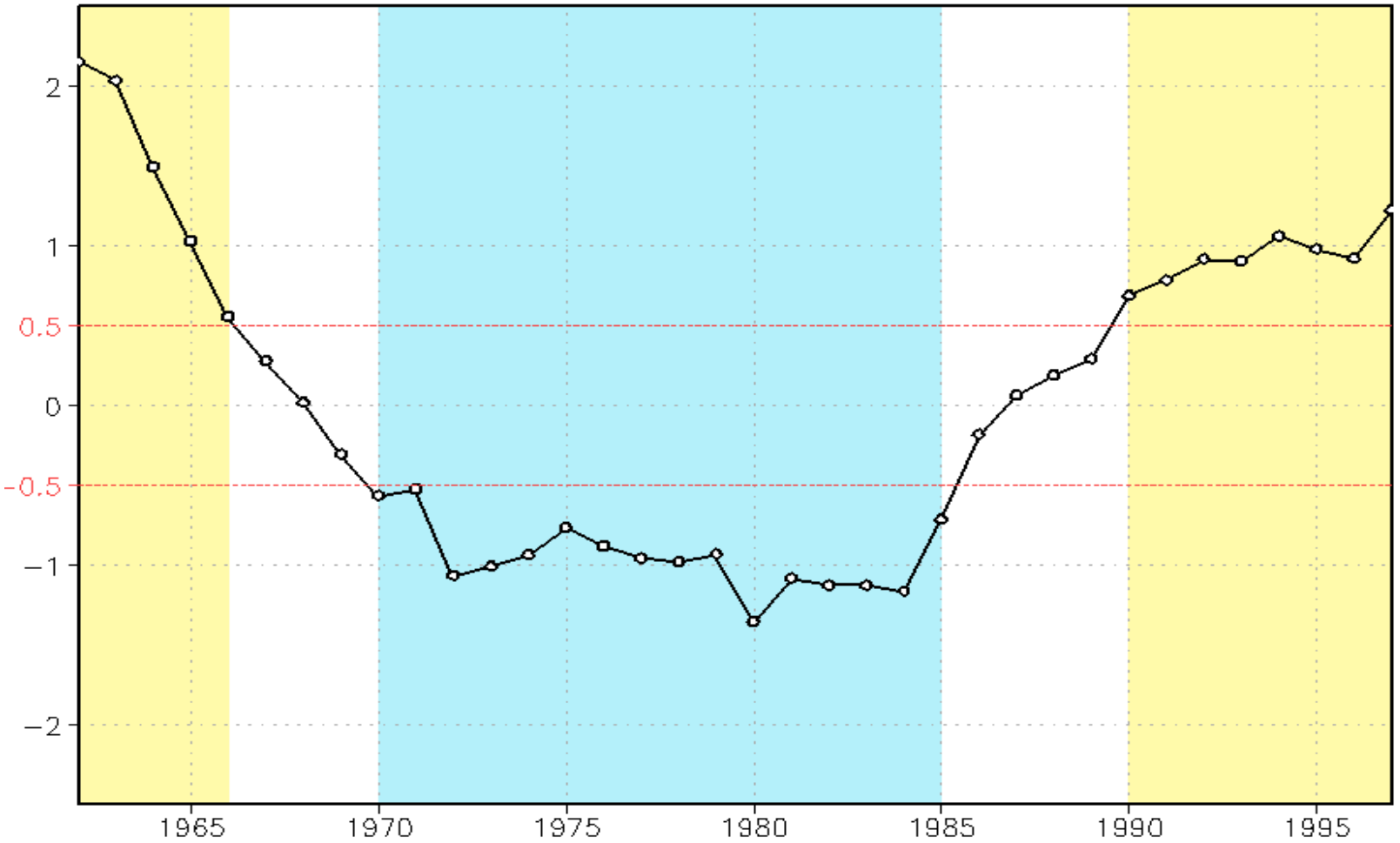
Normalized PC2



P1(1958~66) (9yrs)

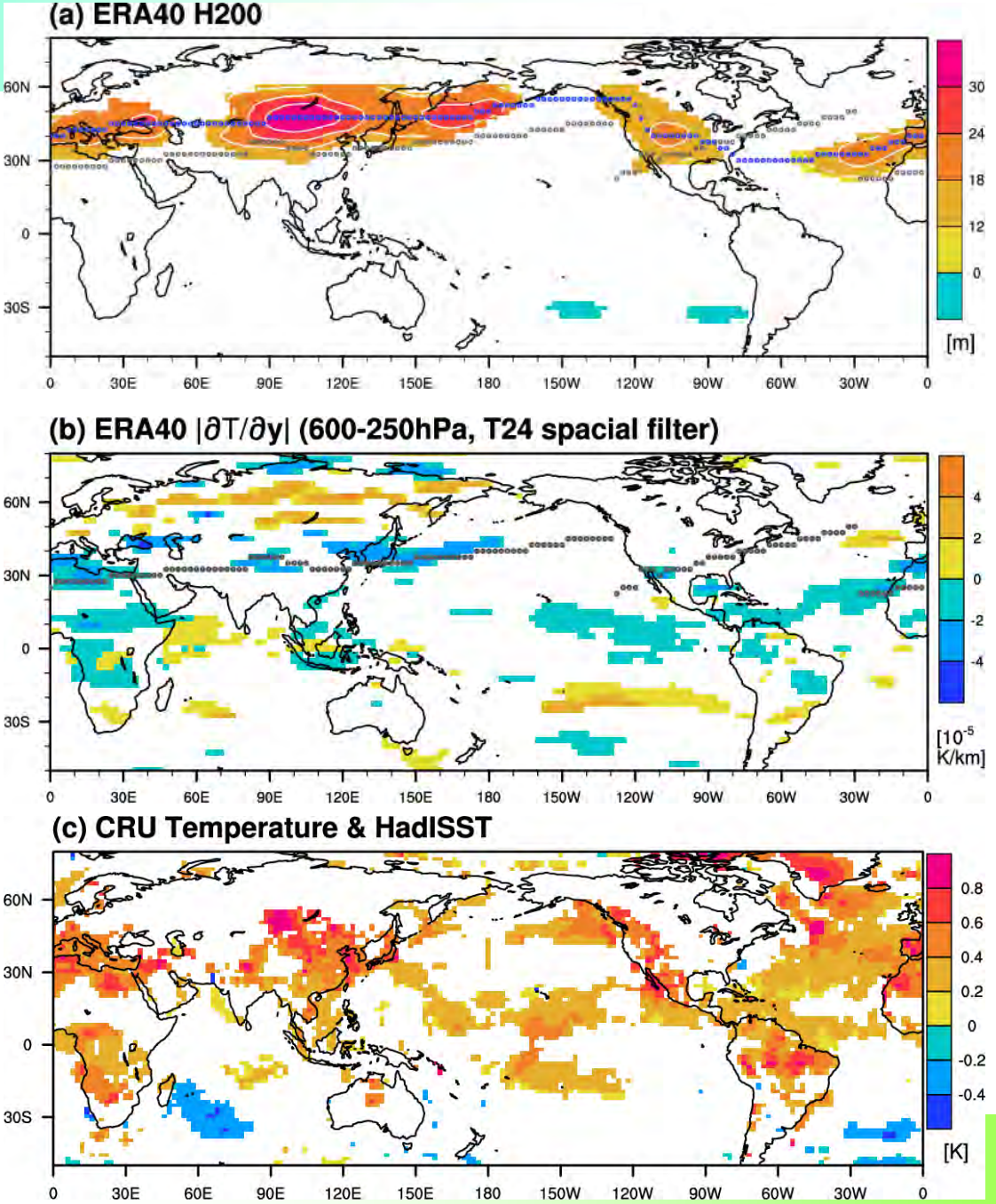
N(1970~85) (16yrs)

P2(1990~2001) (12yrs)

→ Composite:P1&P2 minus N

☺

Composite

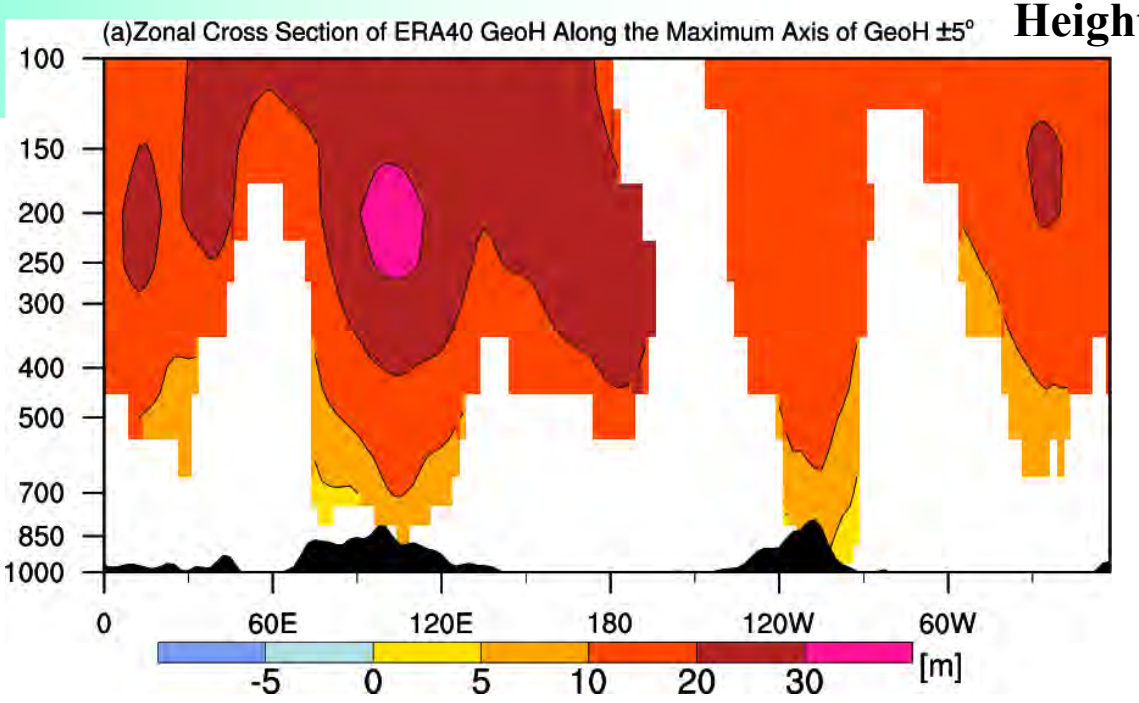

(a) ERA40 H200
60N
30N
0
30S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
30
24
18
12
0
[m]
(b) ERA40 |∂T/∂y| (600-250hPa, T24 spacial filter)
4
2
0
-2
-4
[10-5 K/km]
(c) CRU Temperature & HadISST
0.8
0.6
0.4
0.2
0
-0.2
-0.4
[K]

☺

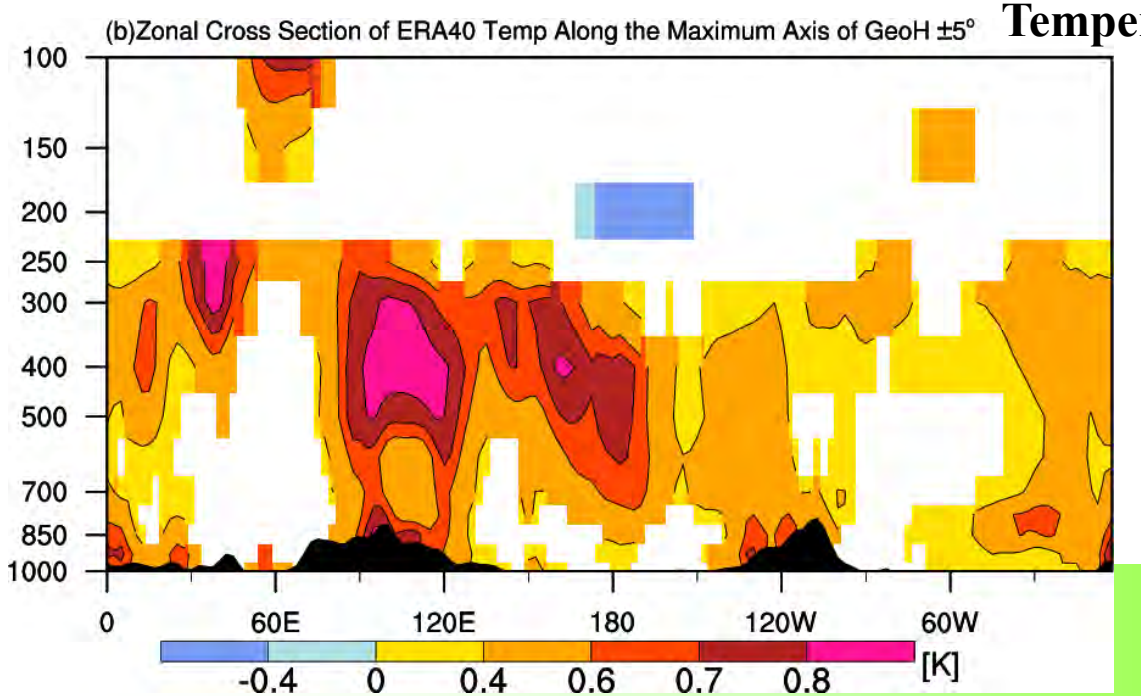
Composite

Meridional average over a 10-degree region centered along maximum H200a

Height



Temperature



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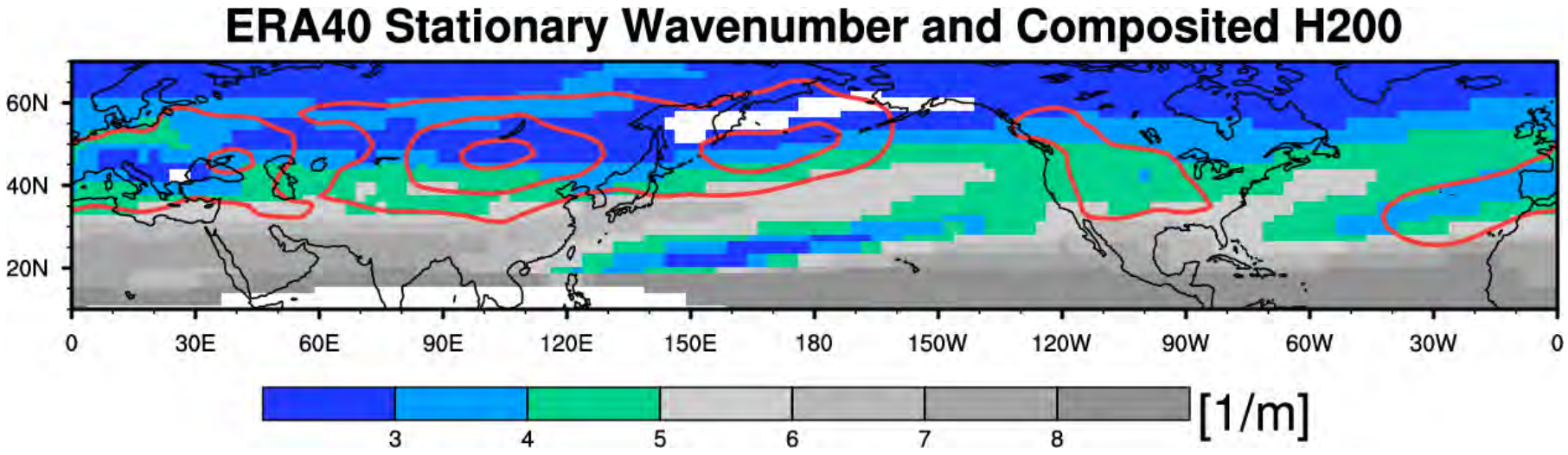
Why eddies north of 40N?

Effect of Mean Flow?



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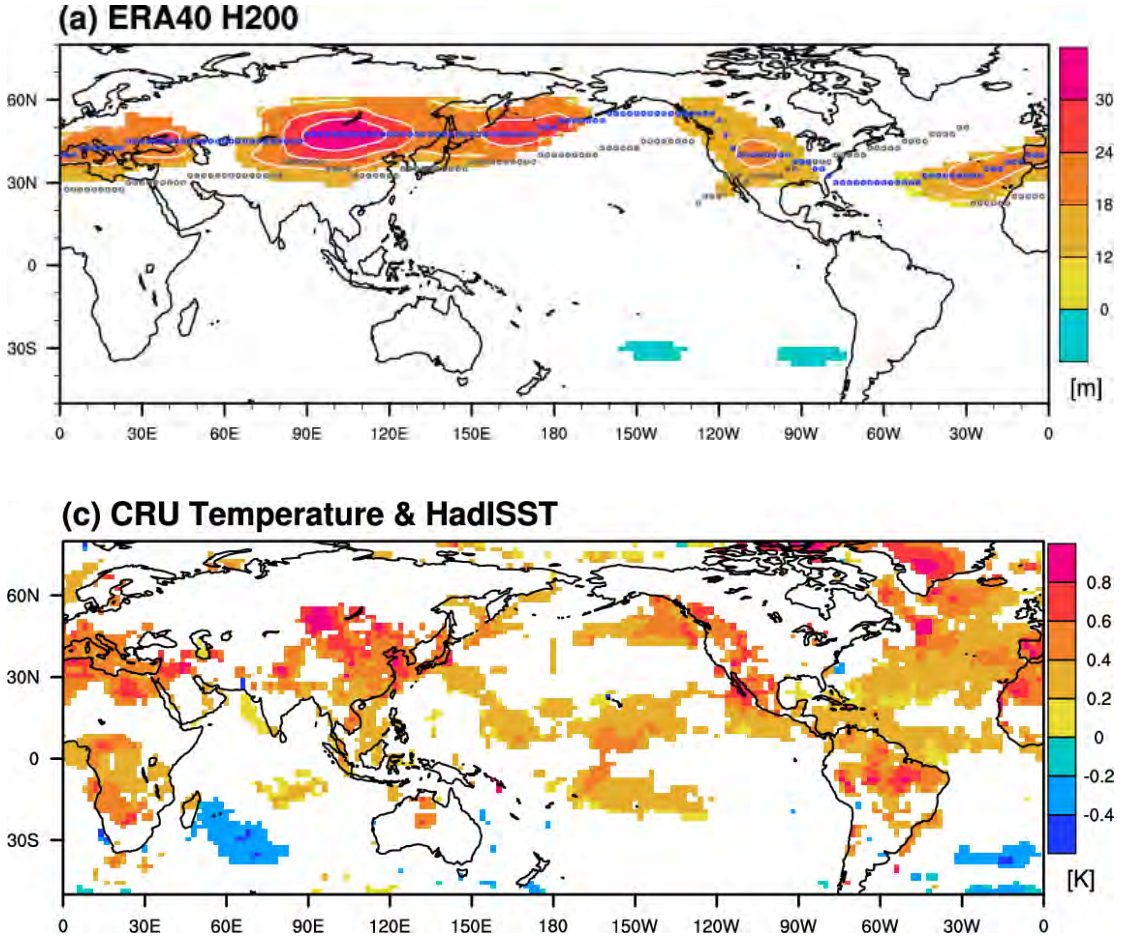
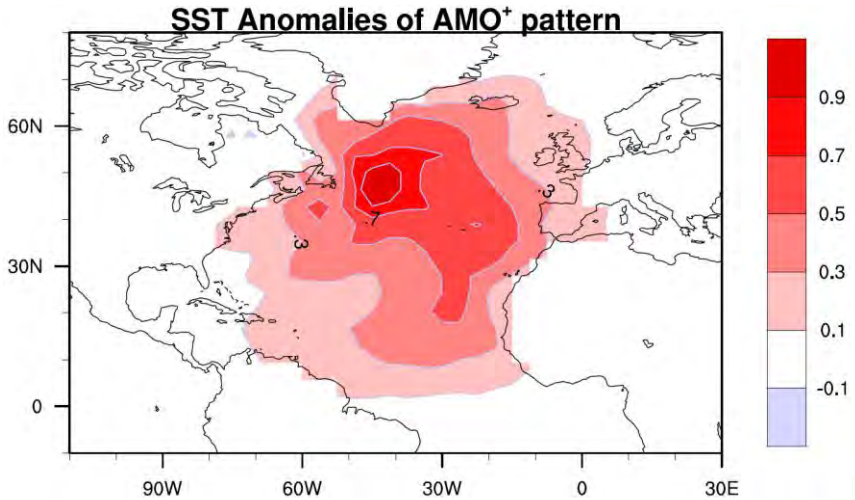
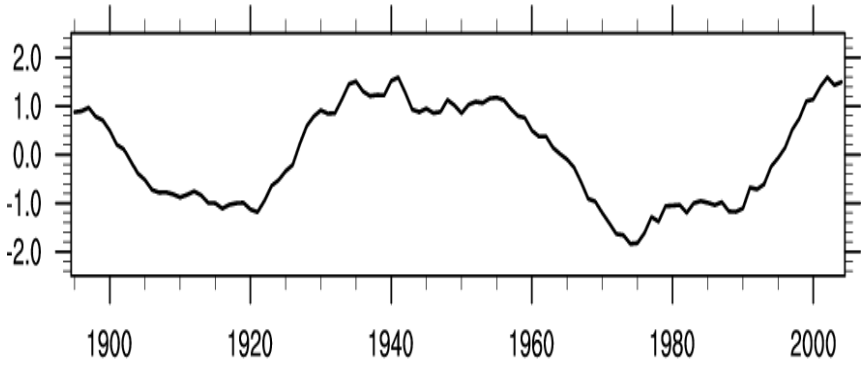
Was the EAPMO forced by AMO-like SST Anomaly?



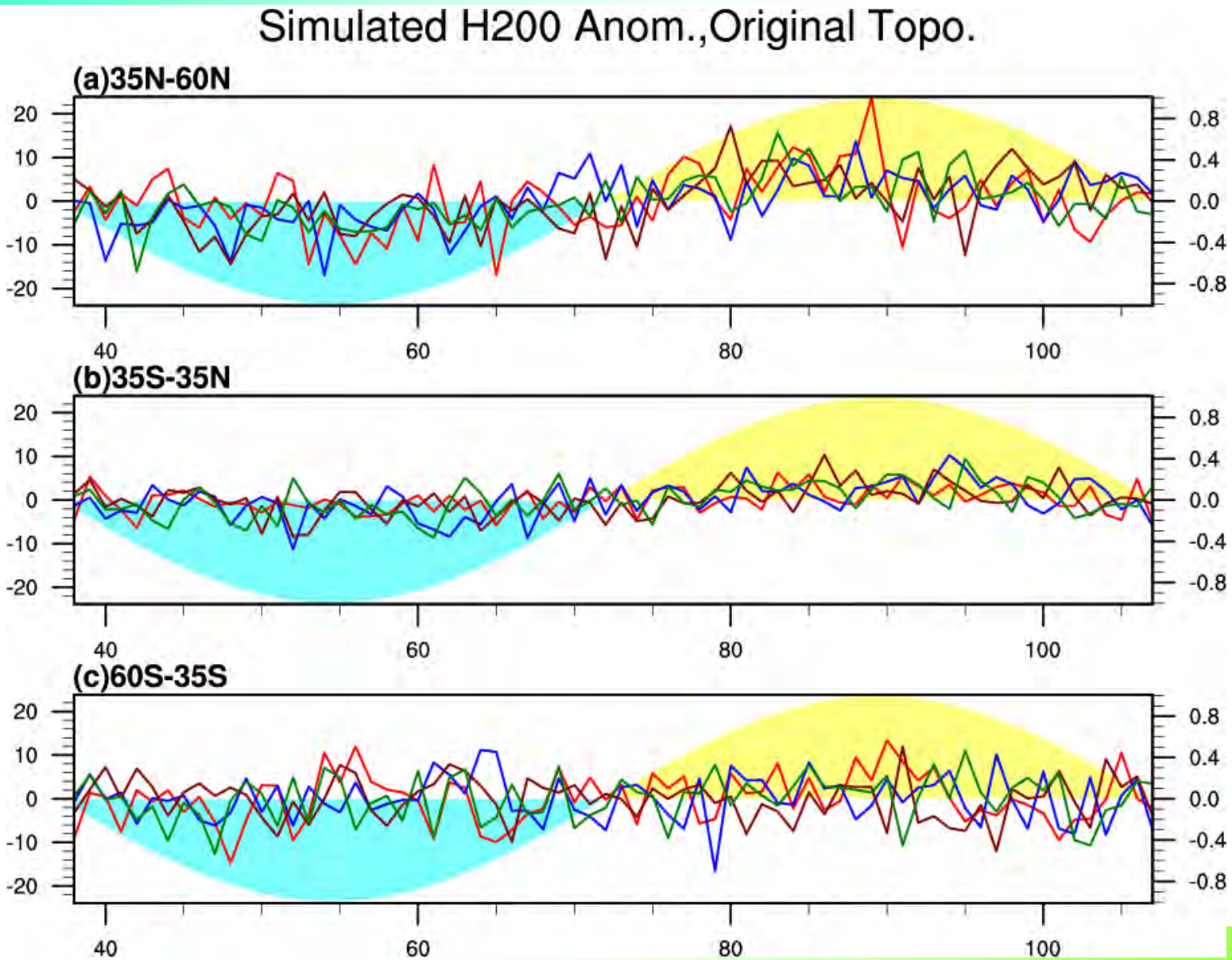
Numerical Experiments

- ECHAM5: T42L19
- Control experiments: climatological SST (monthly, no interannual)
- Forcing experiments: forcing - idealized AMO SSTA (x4), oscillating in 70-year period
- 4(↑) members, 105-year simulation each





Numerical Experiments



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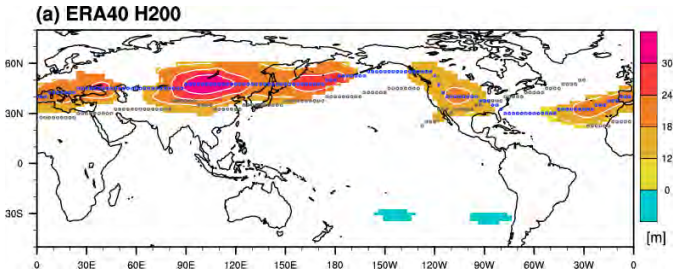
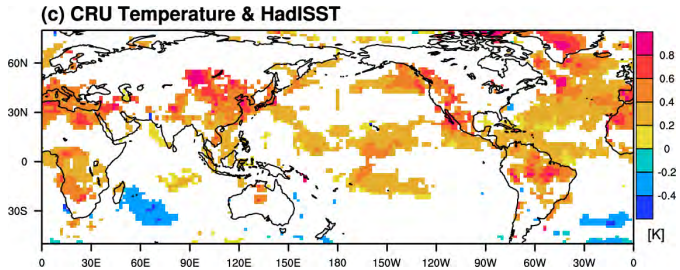
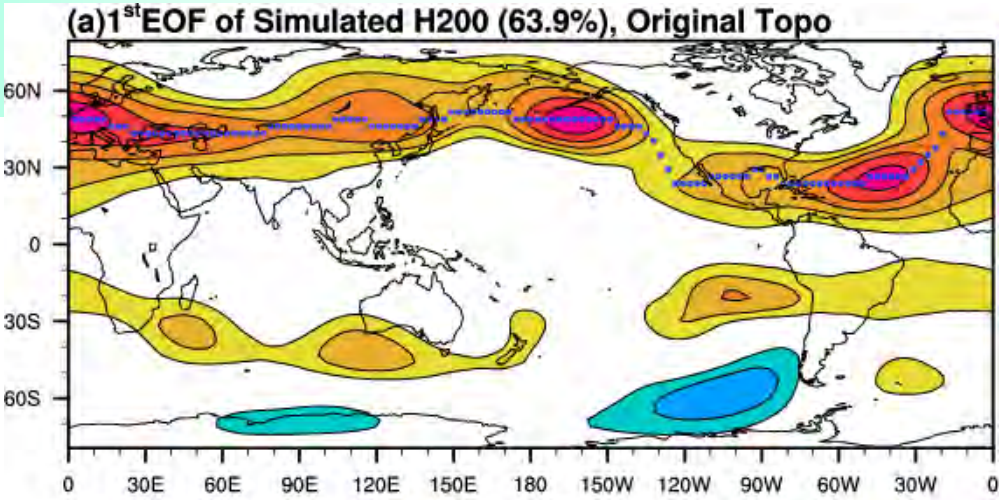
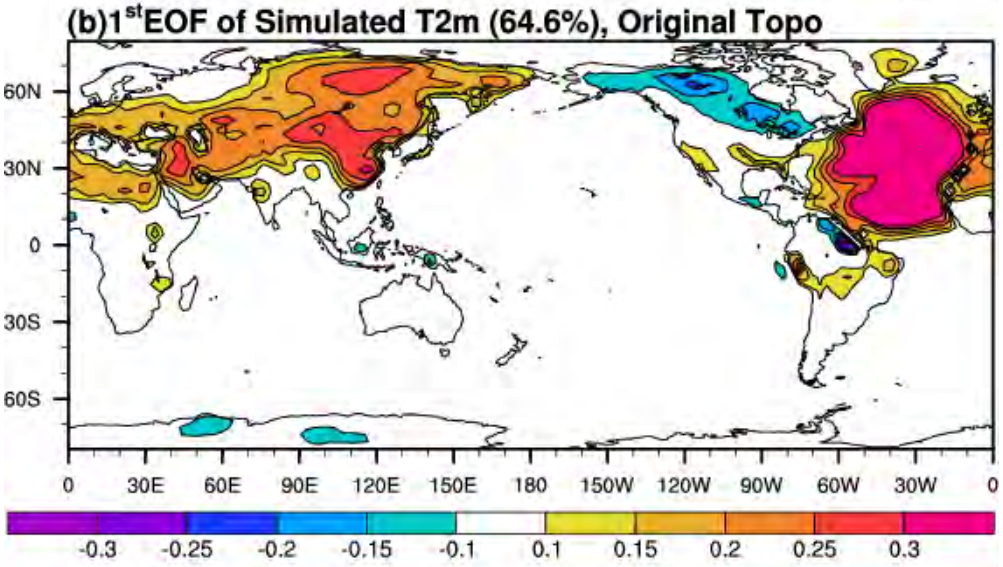
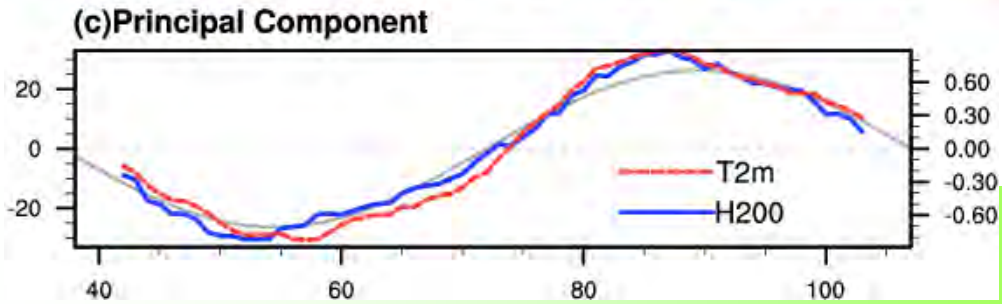
Numerical Experiments











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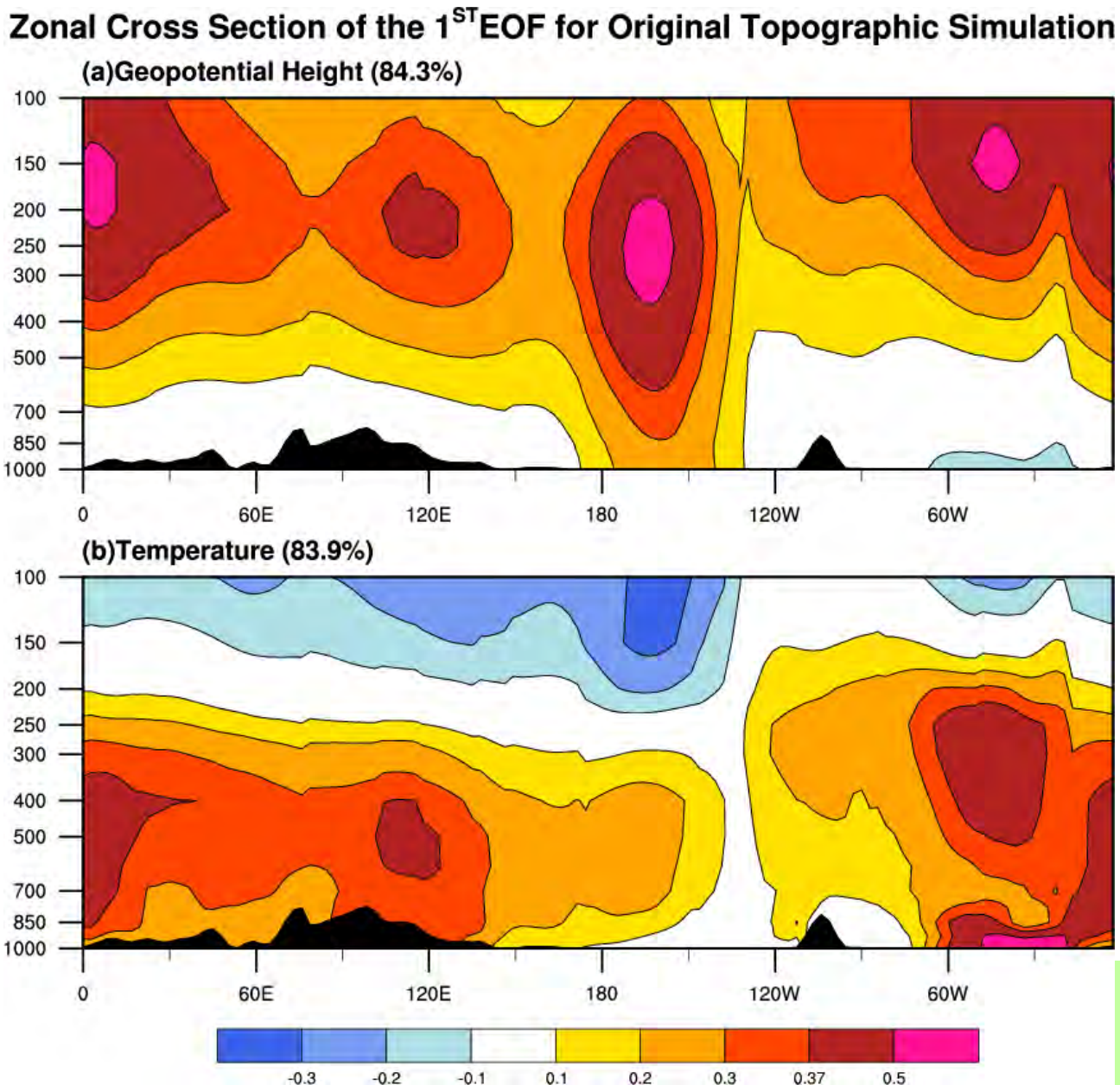
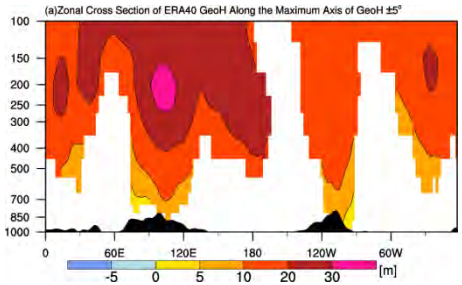
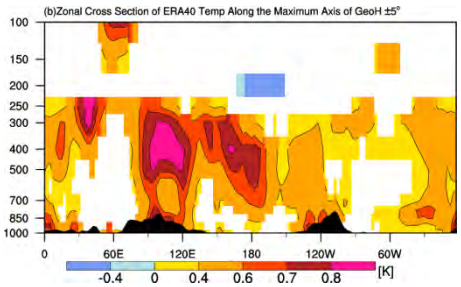
Numerical Experiments







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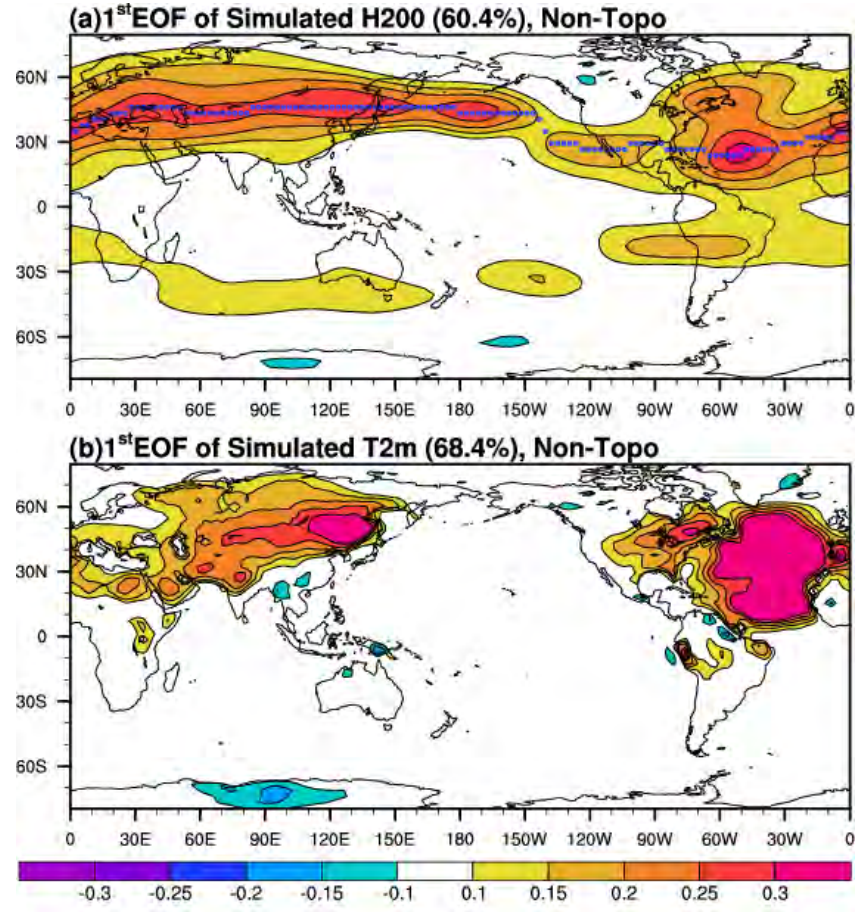
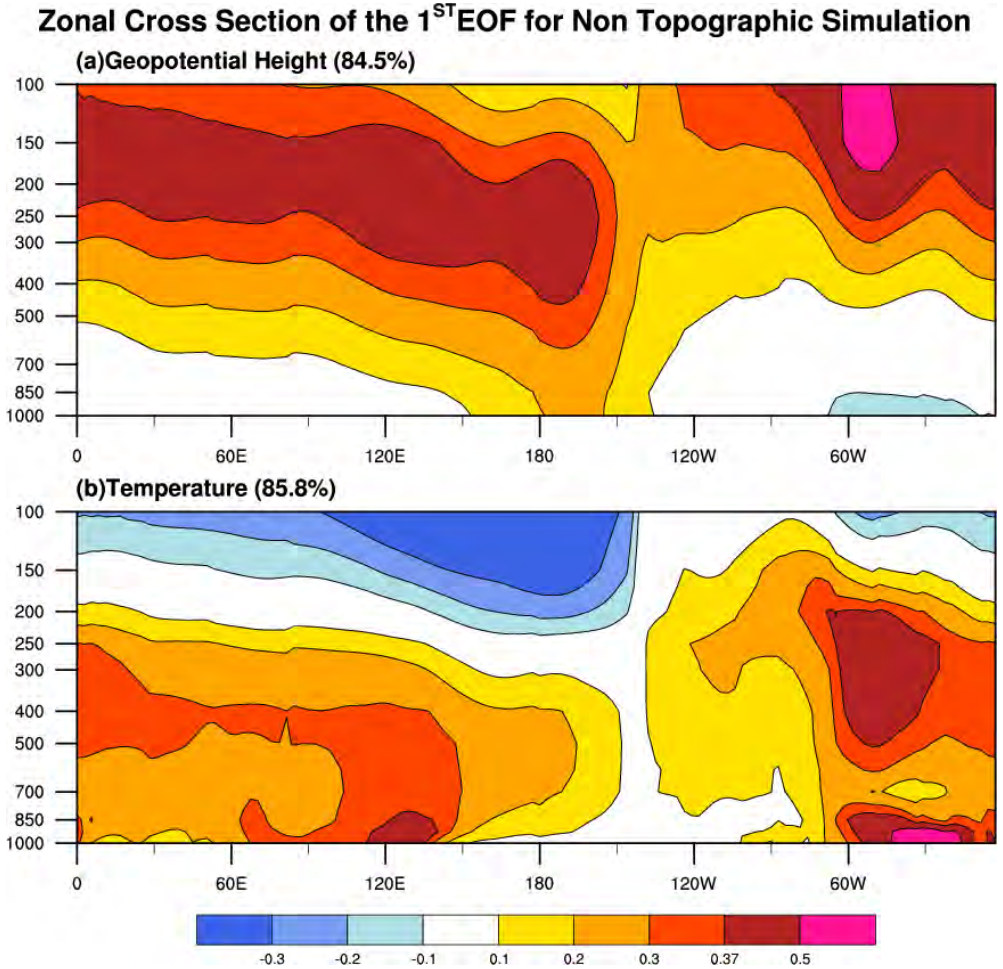
Numerical Experiments with No Topography





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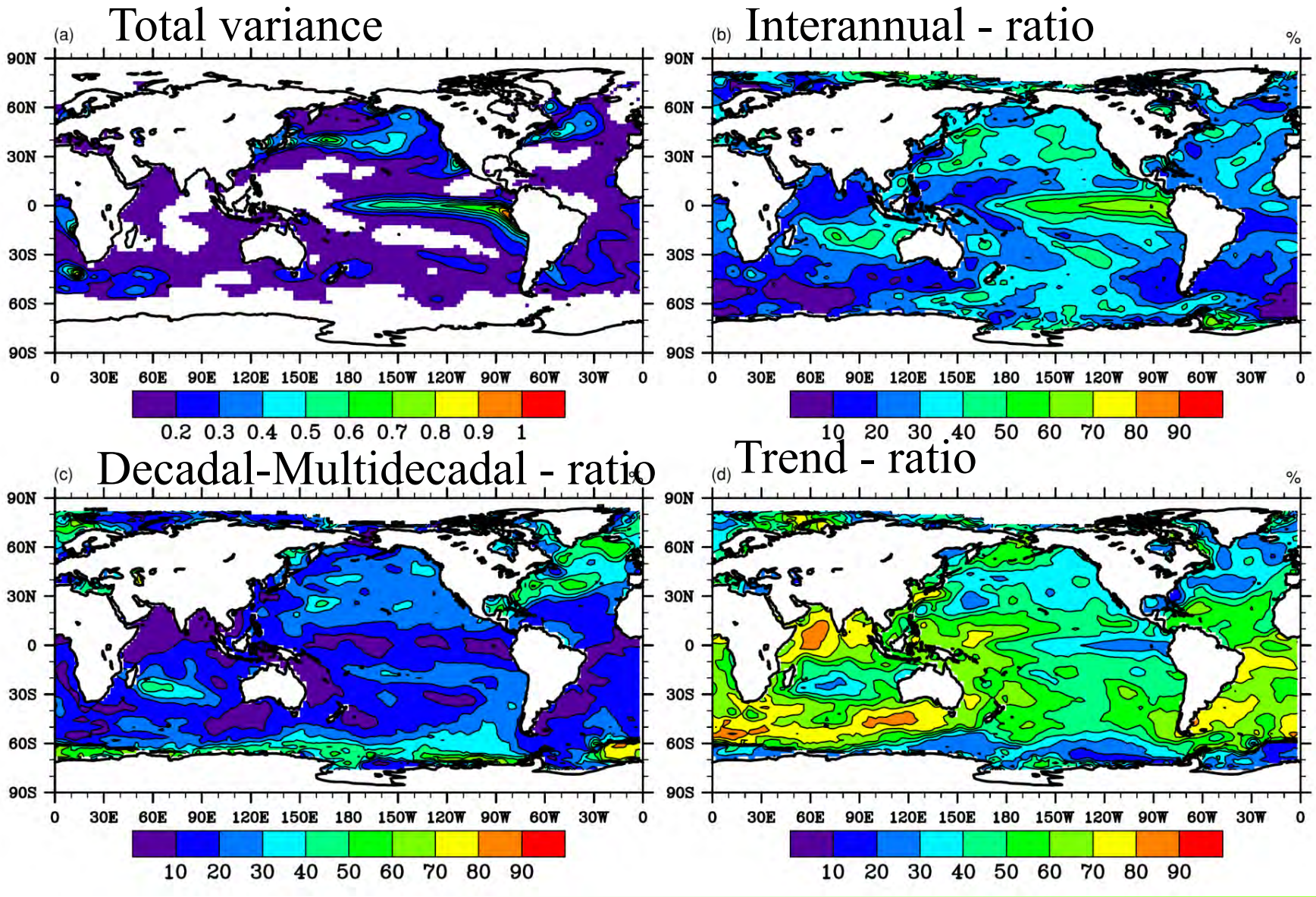
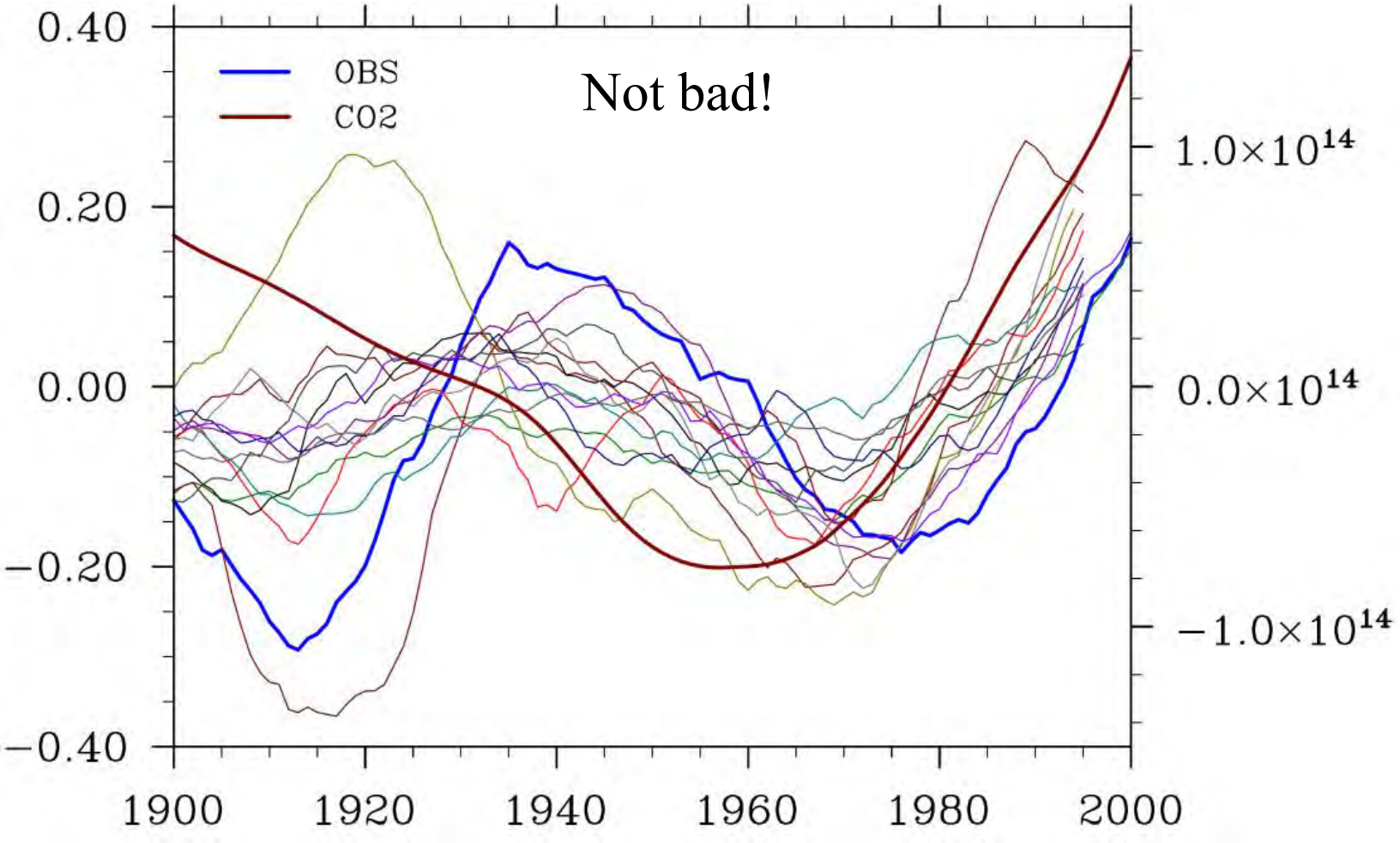
How was AMV simulated in CMIP5?

SST Variance



Area-mean SSTA in the N. Atlantic: Obs. and CMIP5



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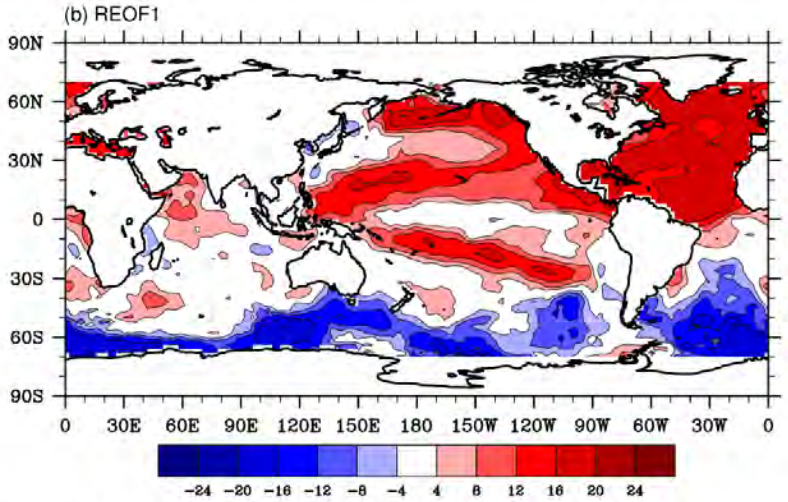
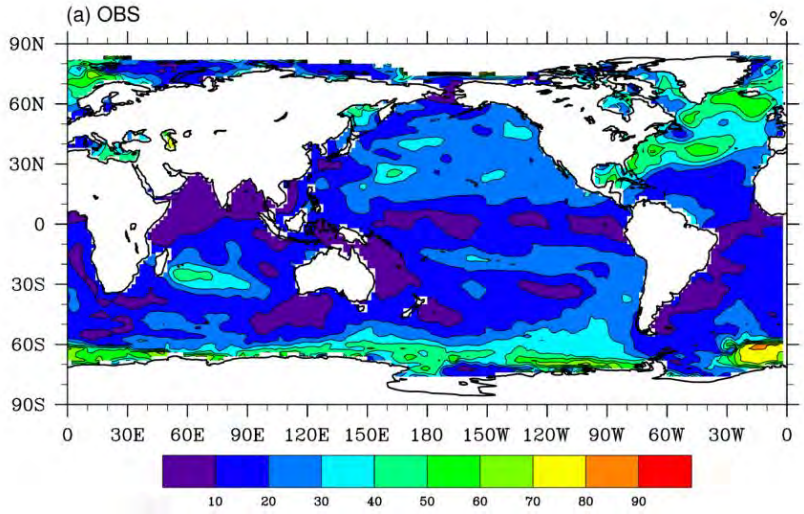
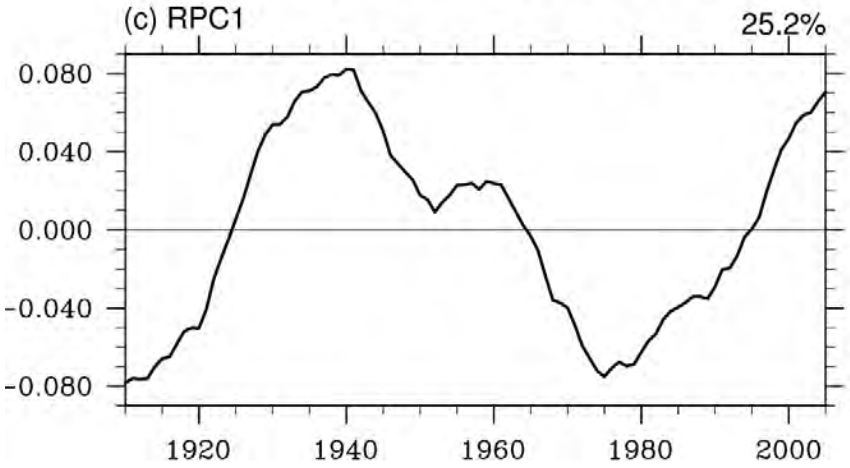
1st Rotated EOF (AMO-like) of 9-year detrended SST

How about a more stringent test based on rotated EOF?







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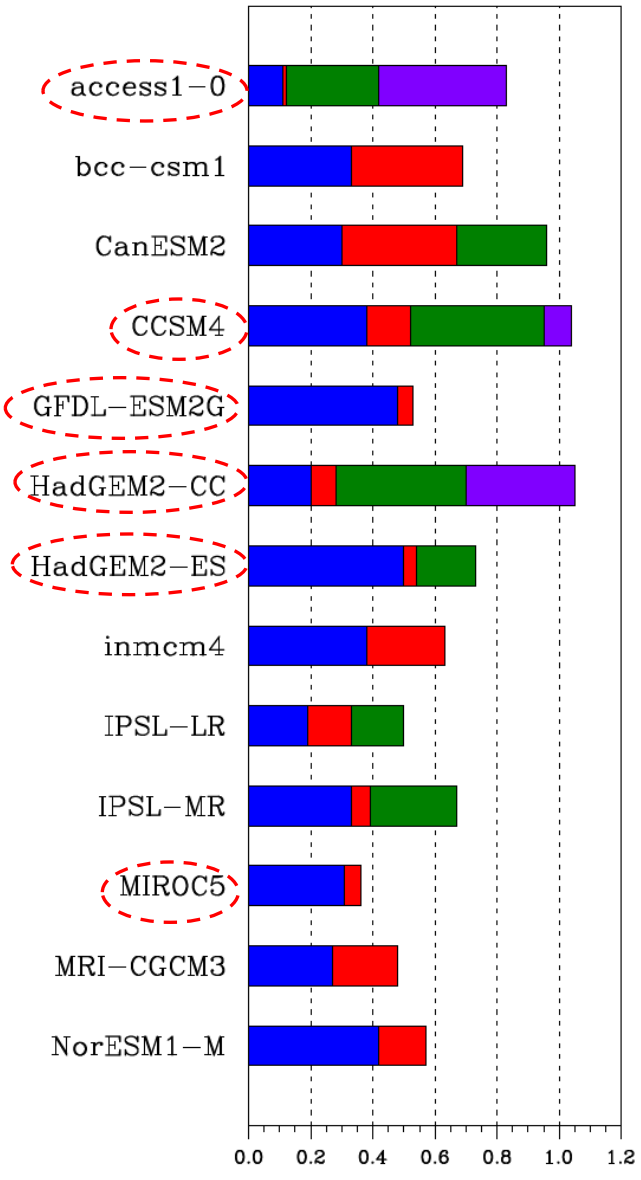
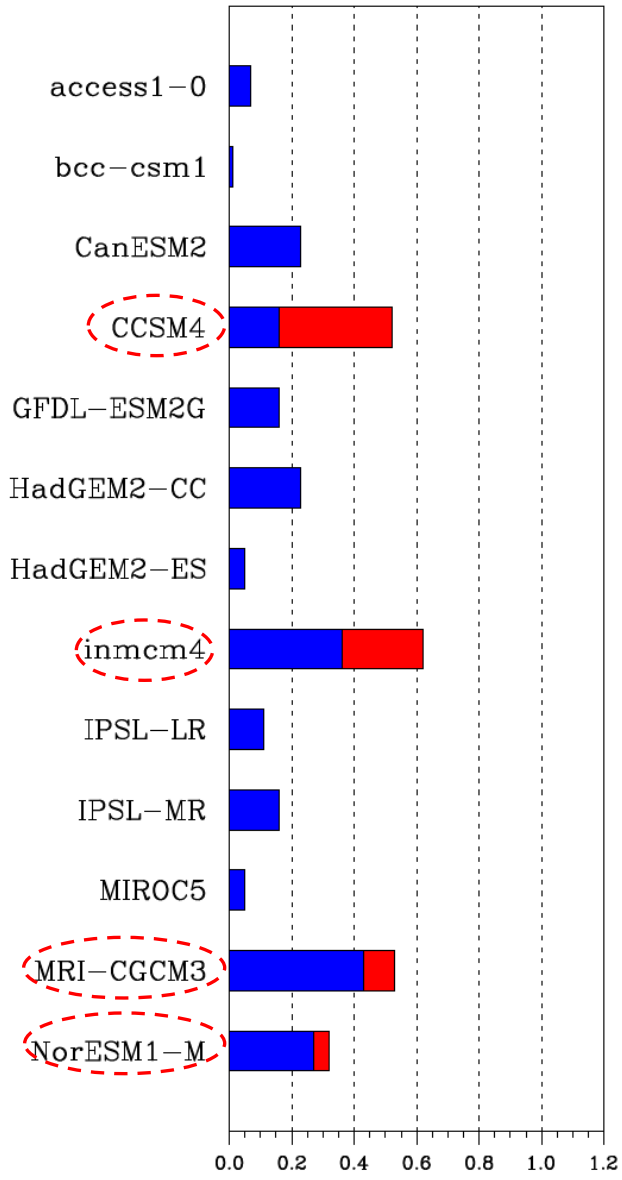
Pattern correlation: obs. AMO pattern vs. simulated leading EOFs

Historical



Pre-industrial



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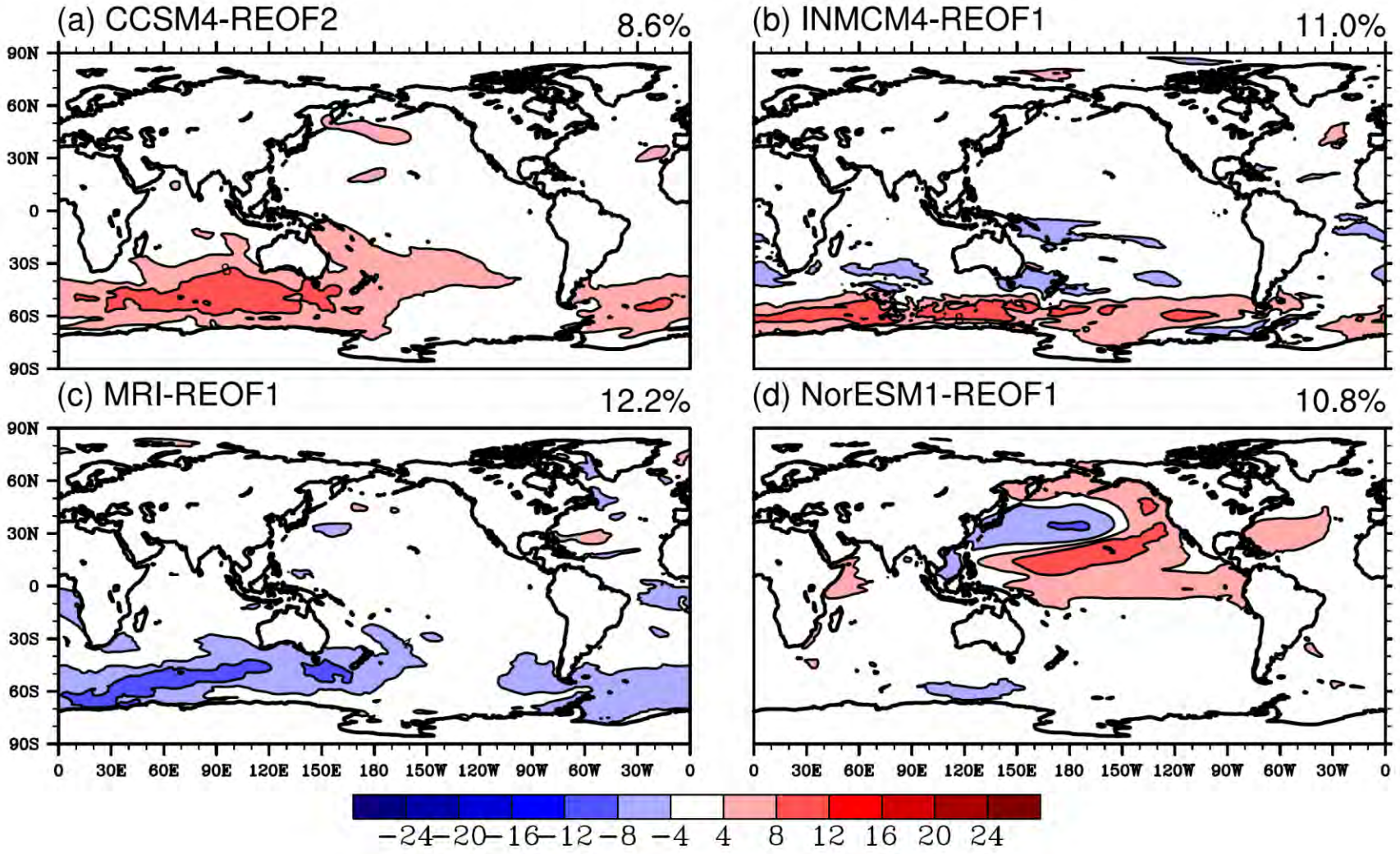
Pre-industrial Simulation
no clear AMO-like pattern found (SSO?)



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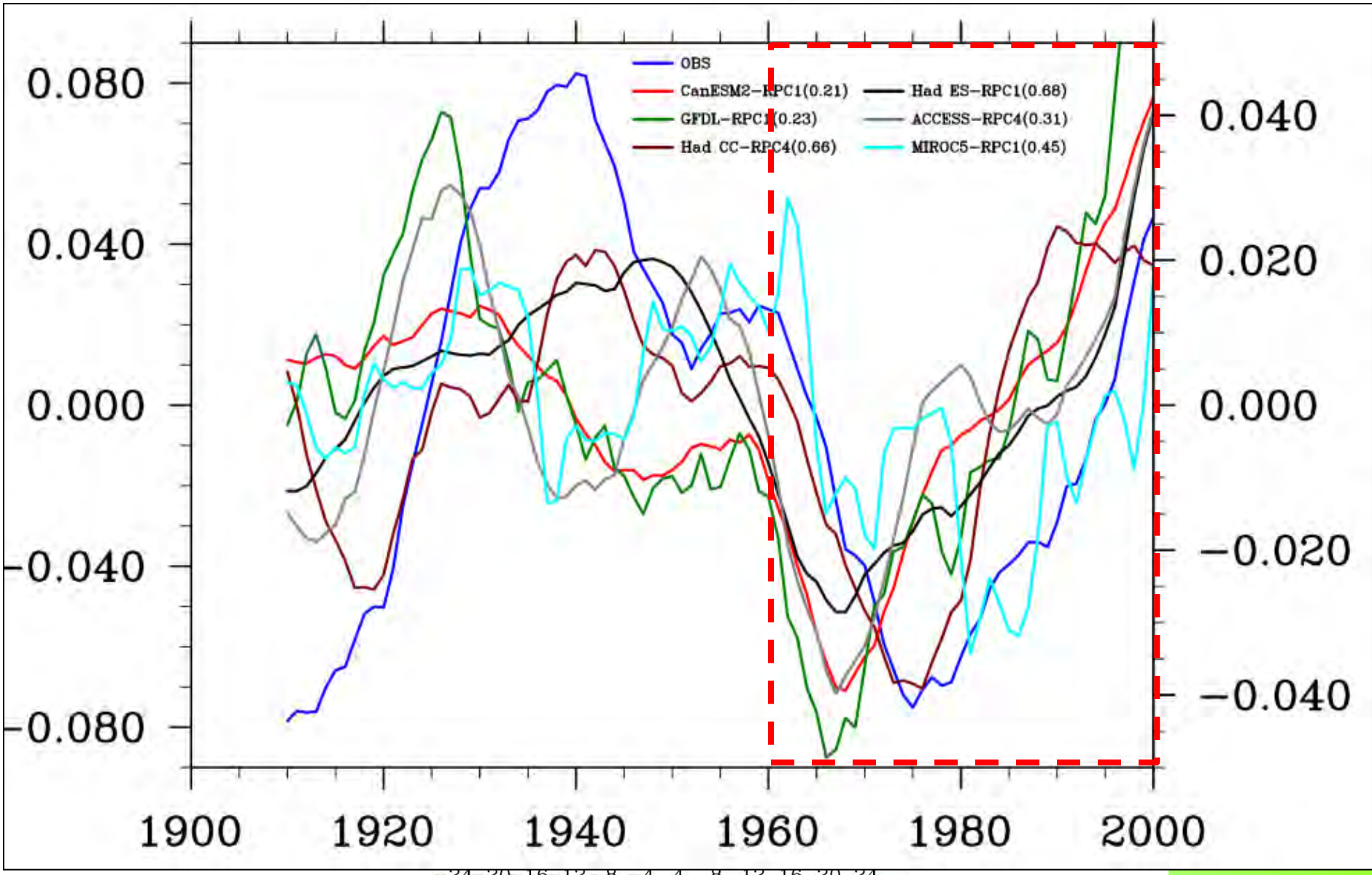
Historical Simulation: better simulated in some models



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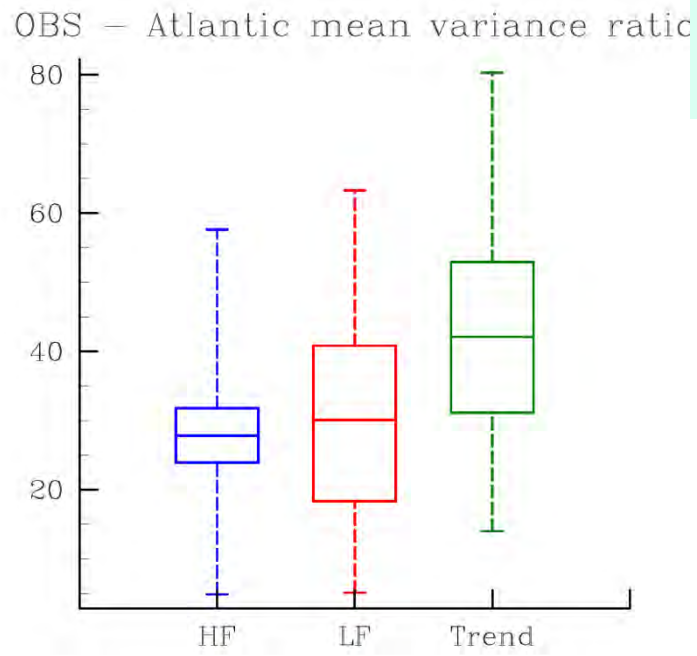
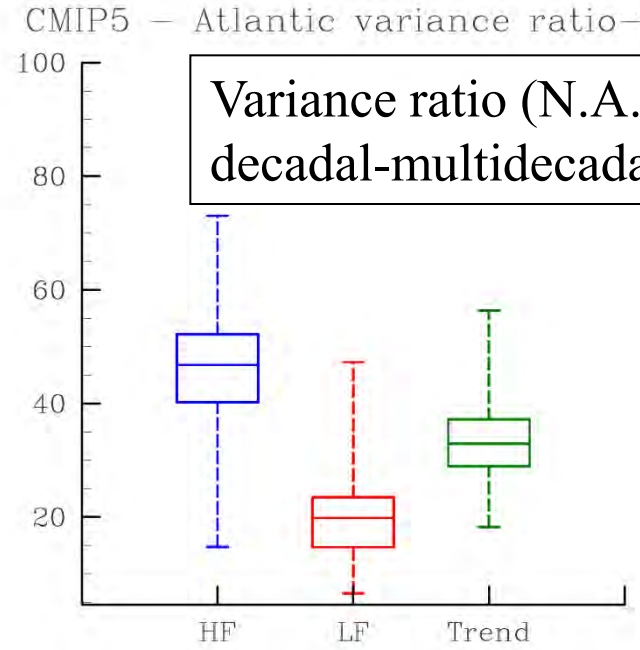
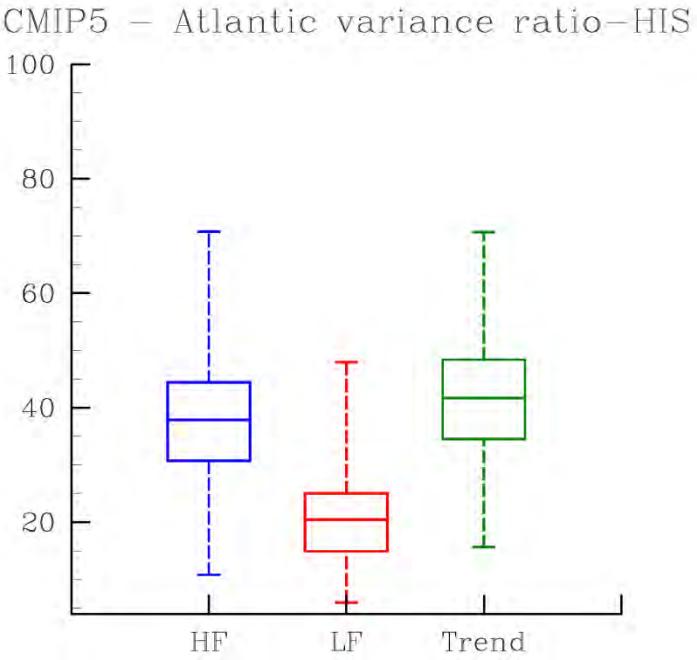
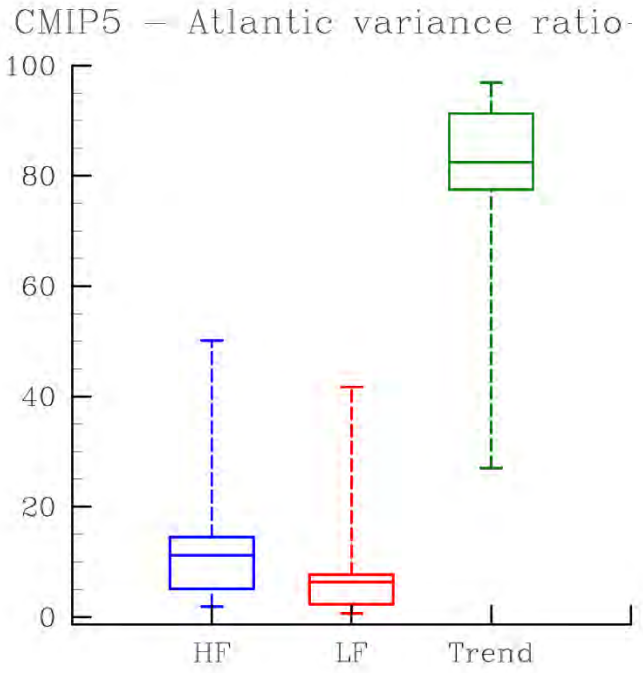




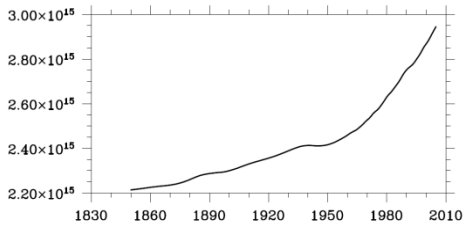
Variance ratio (N.A.): interannual, decadal-multidecadal, trend

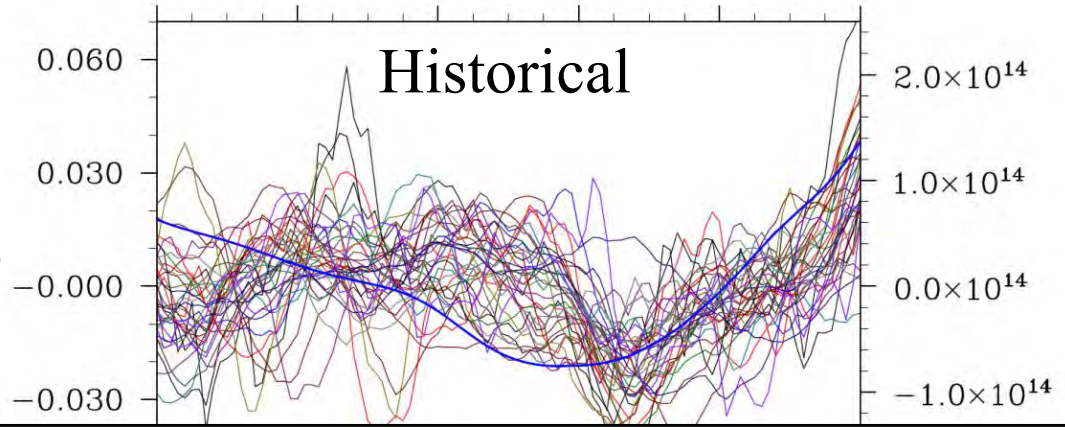




RCP8.5

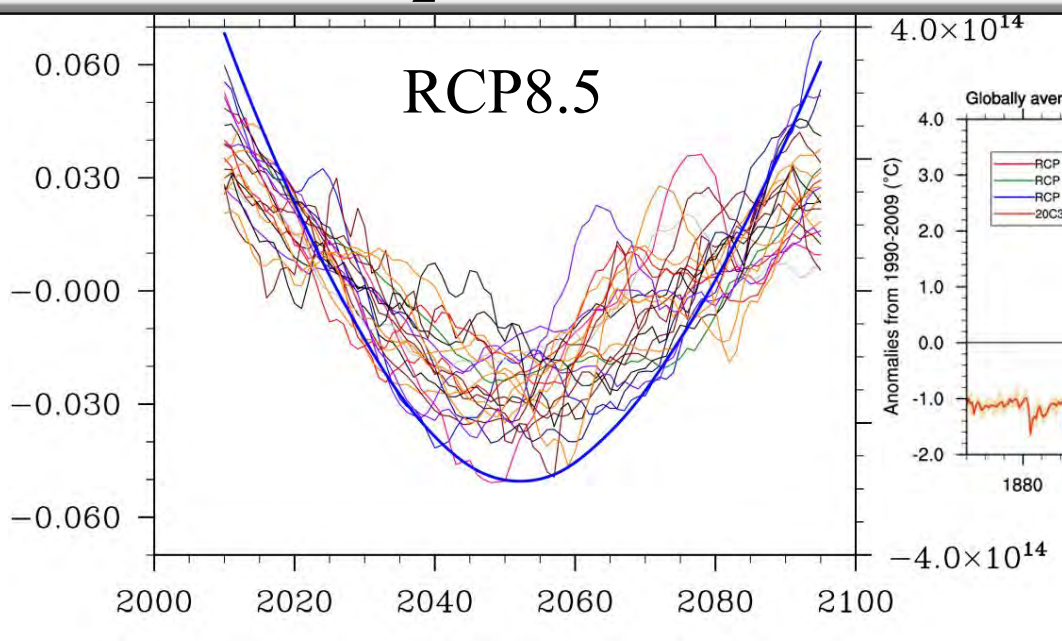
Leading PCs vs. CO_2 Concentration Curve (detrended)

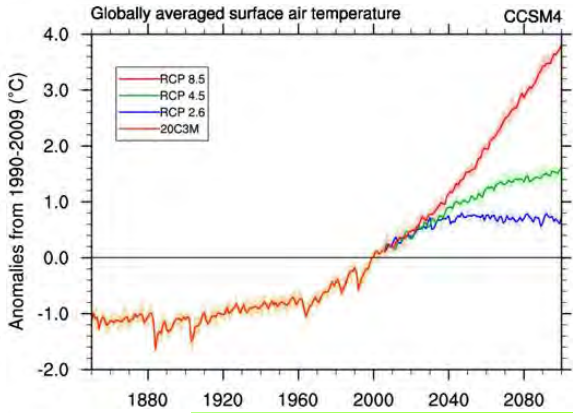




Are models oversensitive to prescribed CO_2 forcing?

Very weak multidecadal signals in CO_2 and SST, but





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Summary I

- A multi-decadal pattern over Eurasia/North Pacific is identified.
- Barotropic, most apparent in the upper troposphere
- Second most important pattern in explaining climate variation in the past several decades
- Can be forced by AMO-like SSTA
- Enhanced near mountains
- Is it truly an oscillation?
- Simulation suggests that warming in NA led to climate shift in the late 1980s.

Summary II

- AMO-like SST pattern is not well simulated in pre-industrial experiments.
- But better simulated by some models in the historical experiments. Effects of prescribed forcing?
- Overall enhancement of multidecadal variability in models by prescribed forcing in CMIP5 was limited.
- Models may be oversensitive to prescribed GHG forcing?

☺

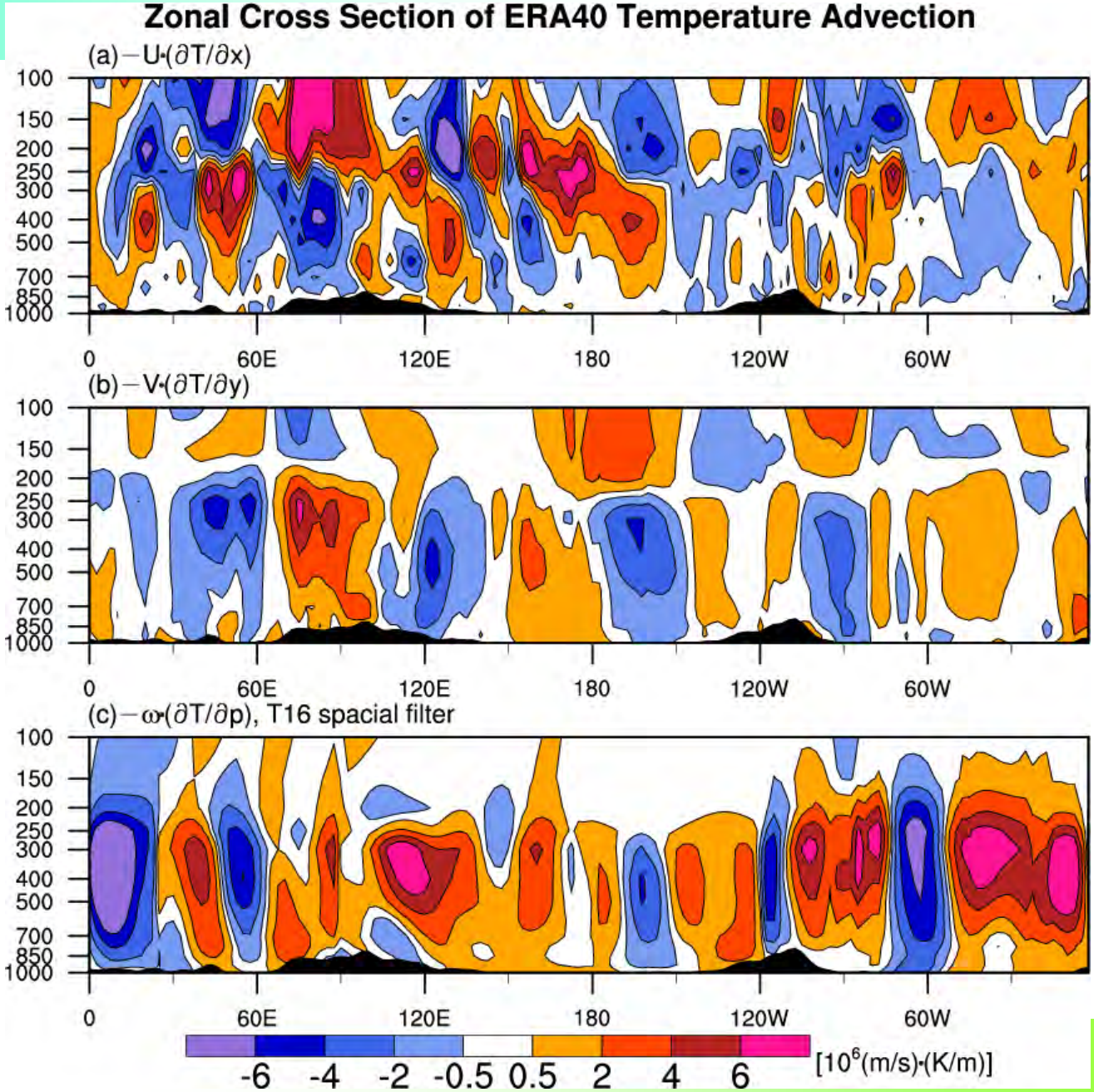
Thank You for Your Attention

☺

Composite

3-D Temperature Advection

No diabatic effect is considered!



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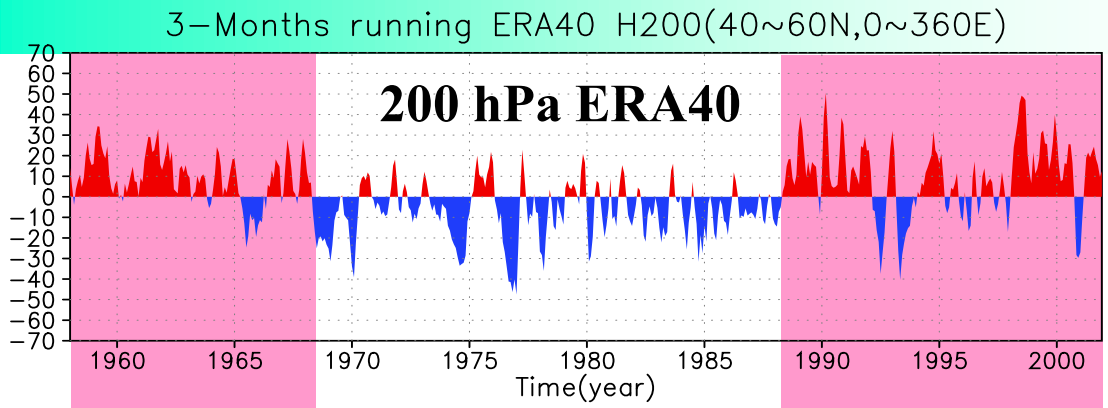
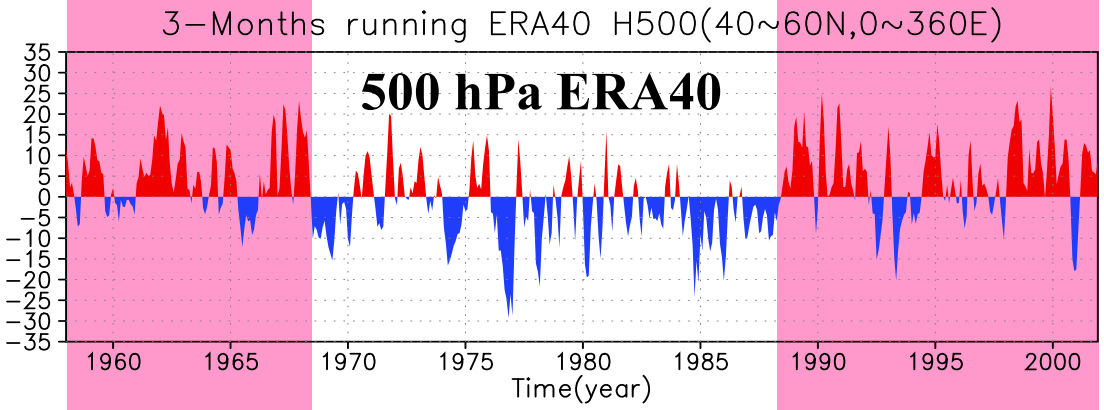
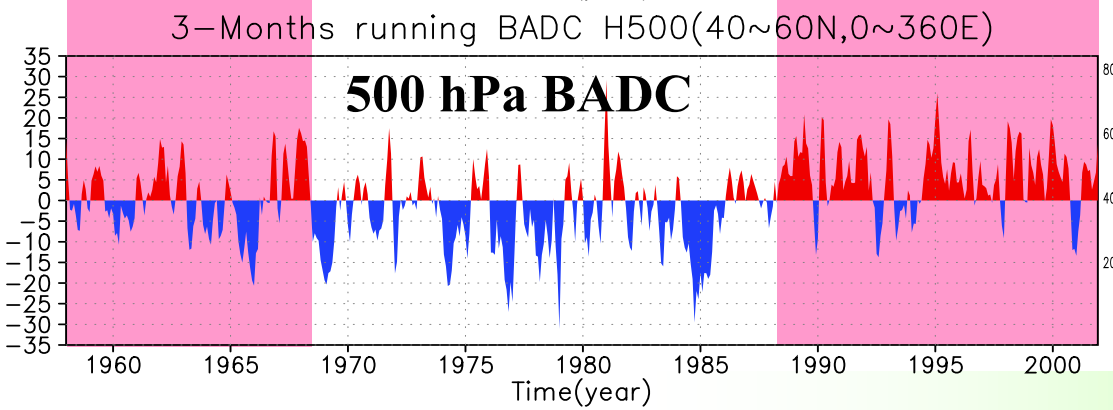
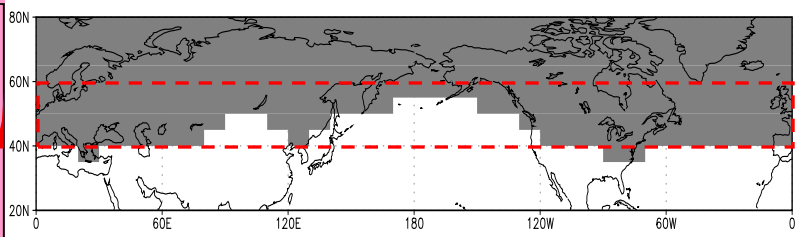






Also seen at other levels and in BADC 500hPa height (sounding) data



BADC (Britich Atmospheric Data Centre)

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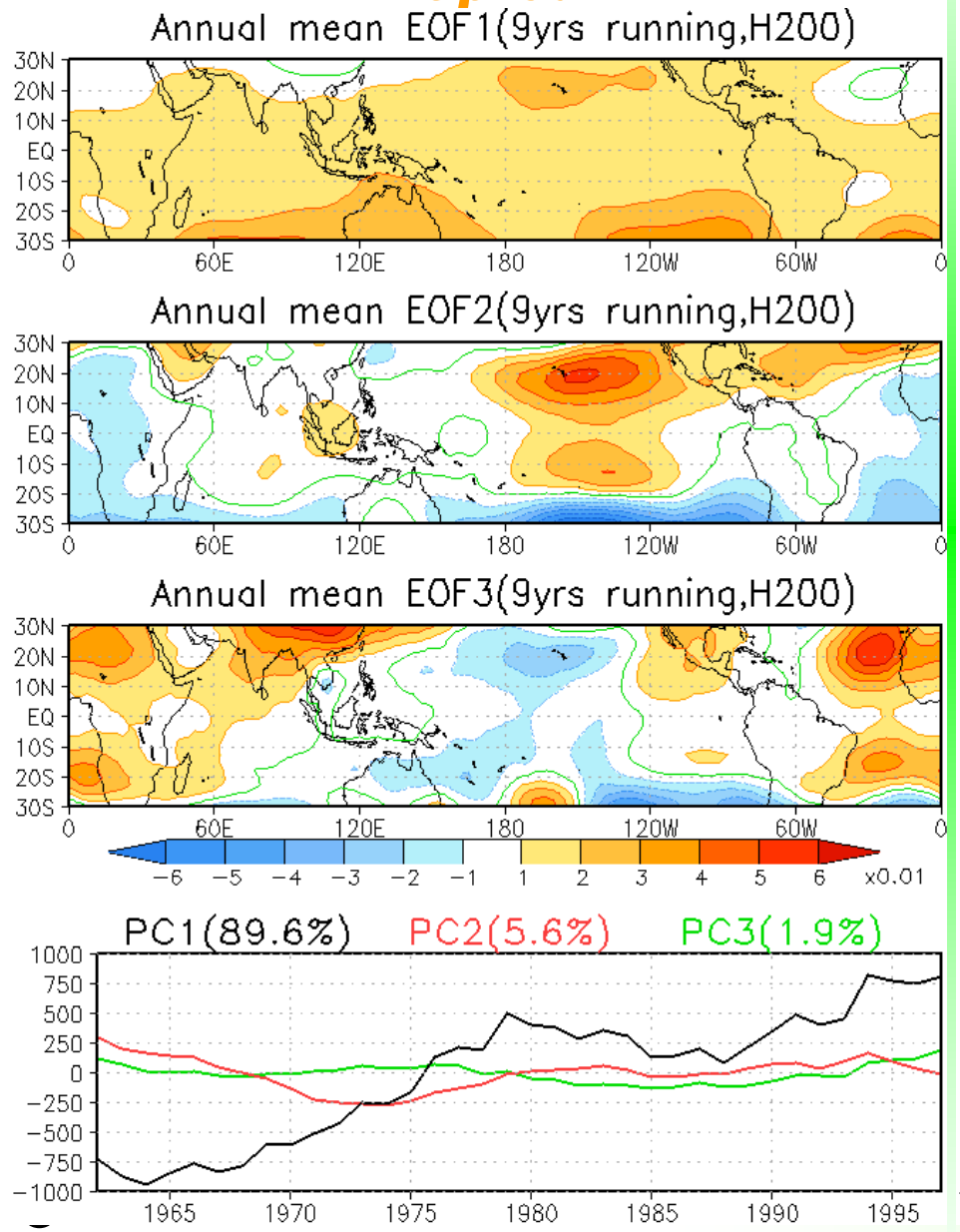
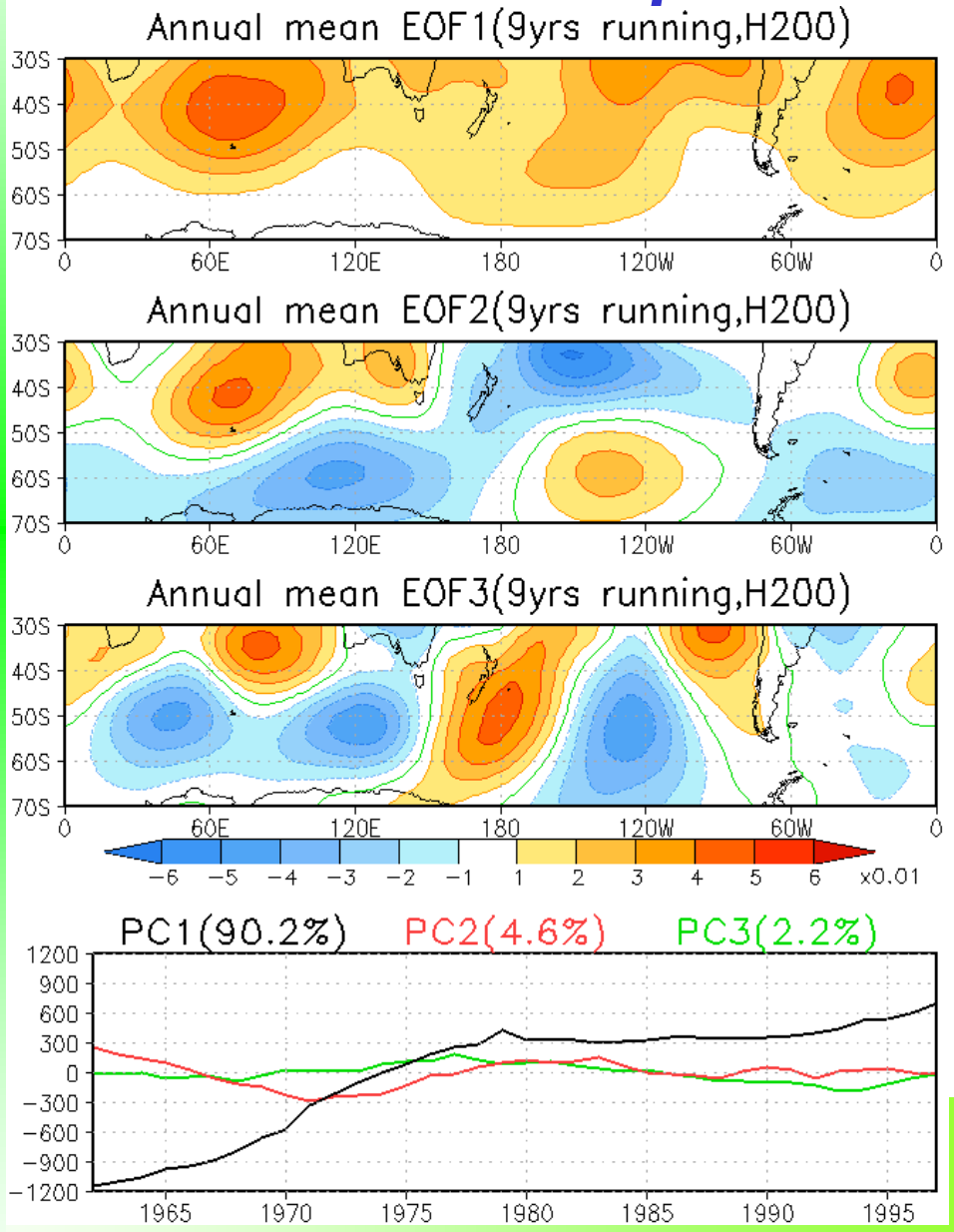
EOF analysis

Tropical

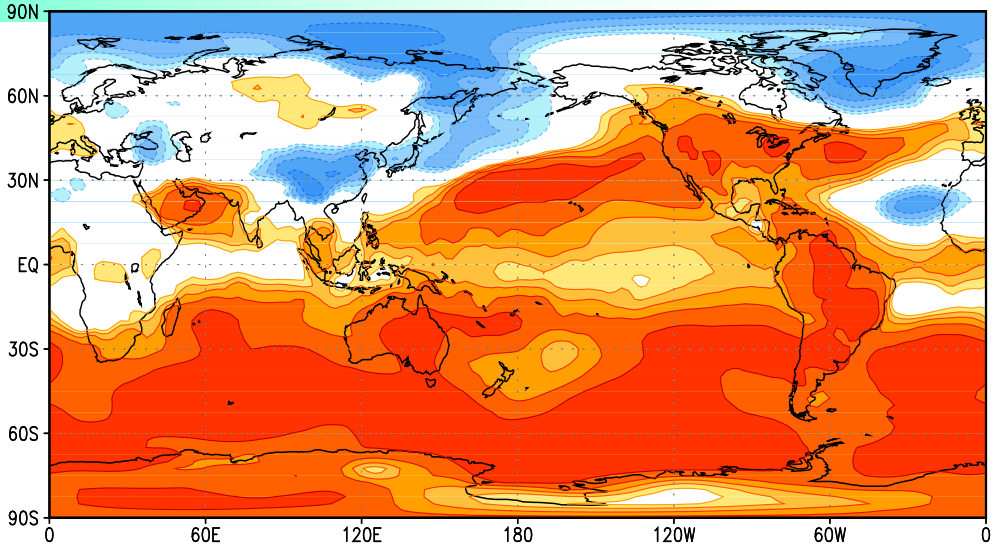


Southern Hemisphere



Correlation

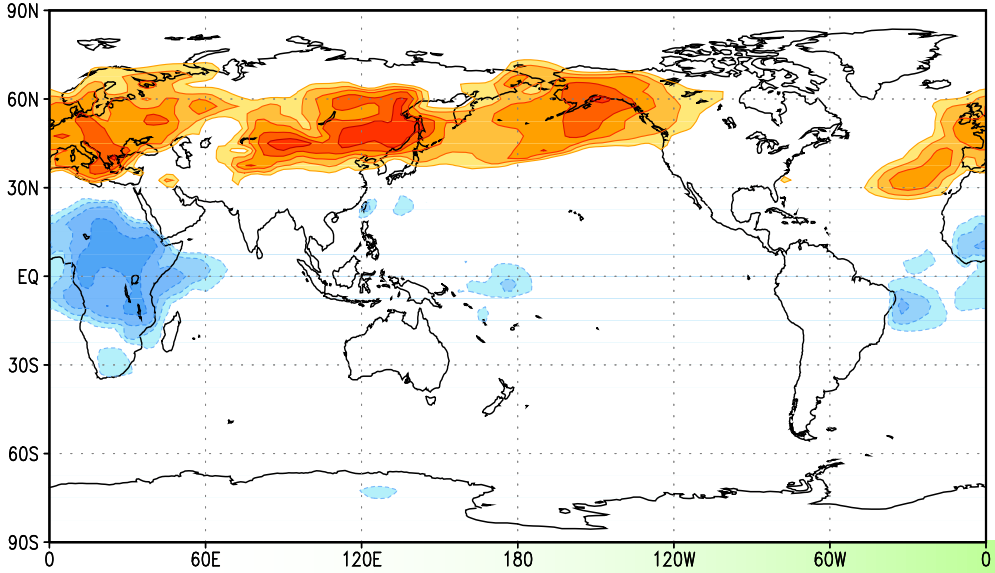
Correlation EOF PC1 & ERA40 t700200



T700~200

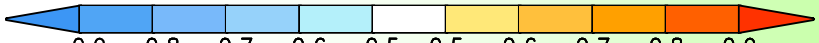
.vs. PC1

Correlation EOF PC2 & ERA40 t700200



T700~200

.vs. PC2



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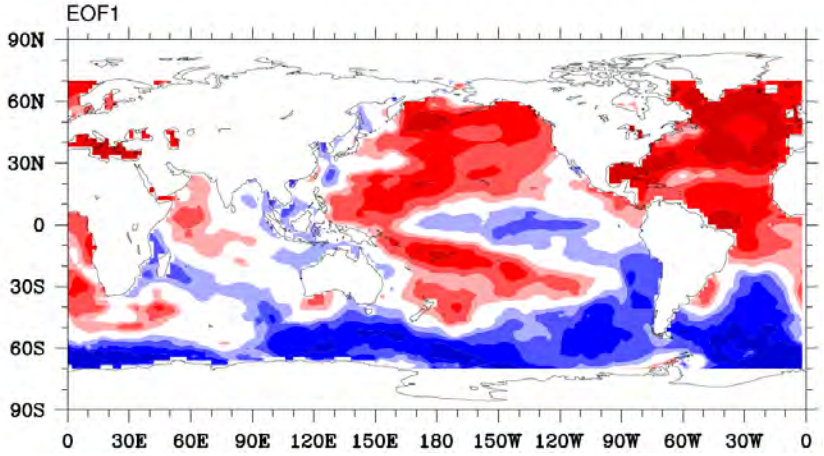
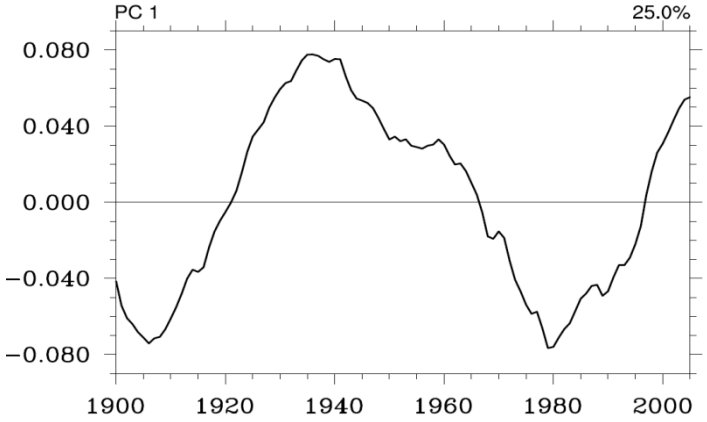
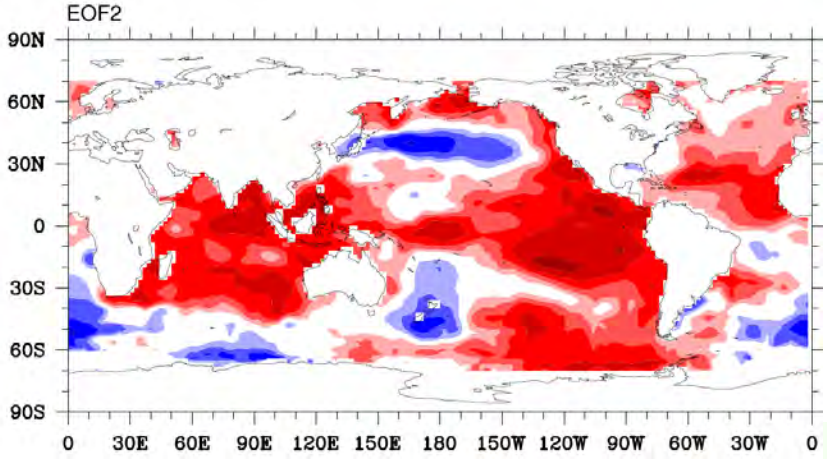
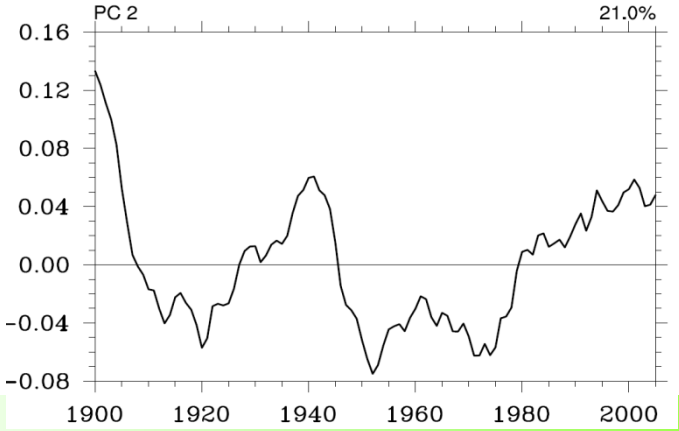
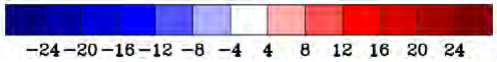
Detrended EOF











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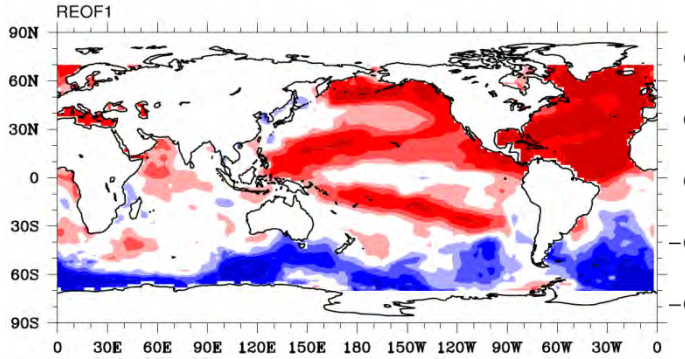
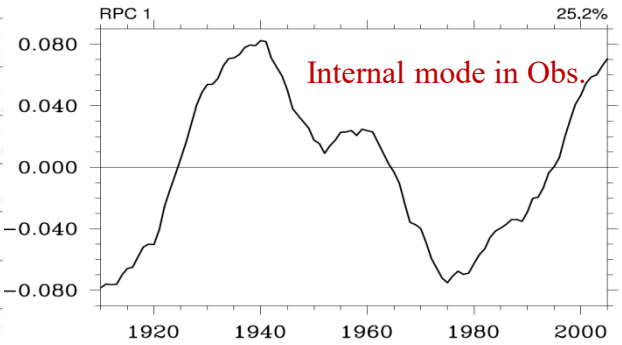
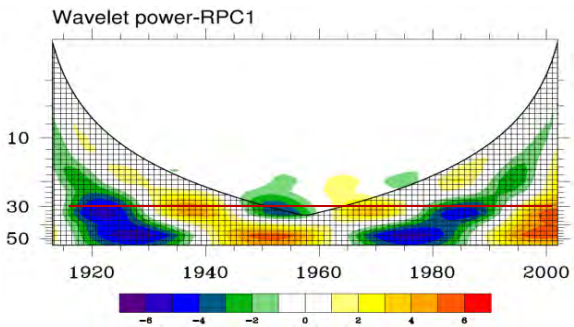
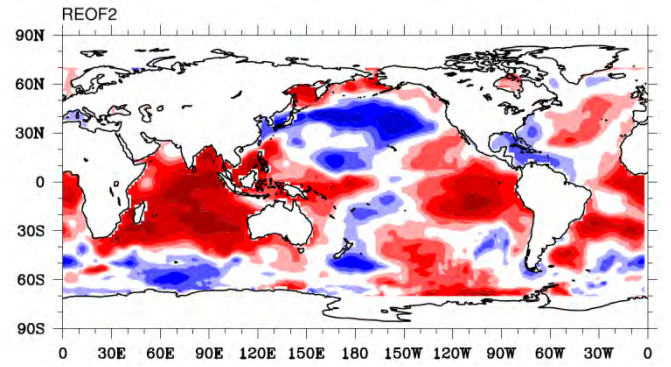
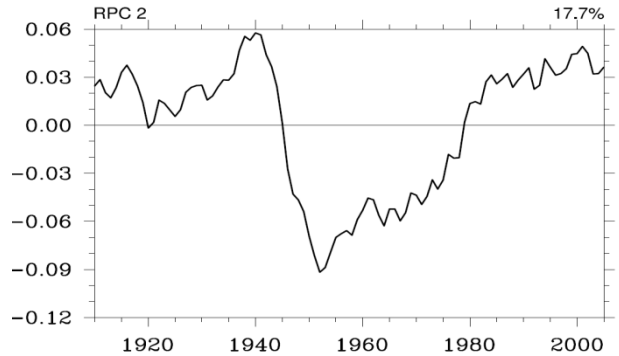
Detrended REOF

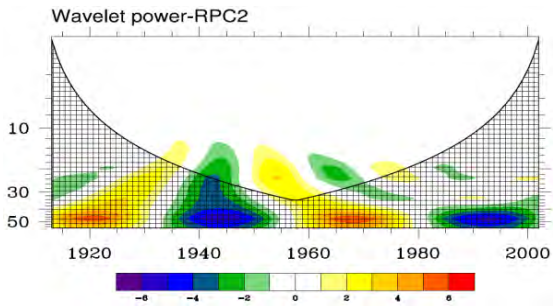


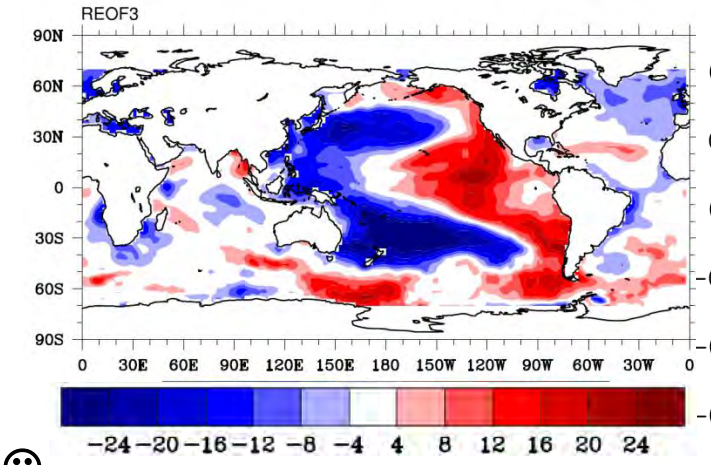


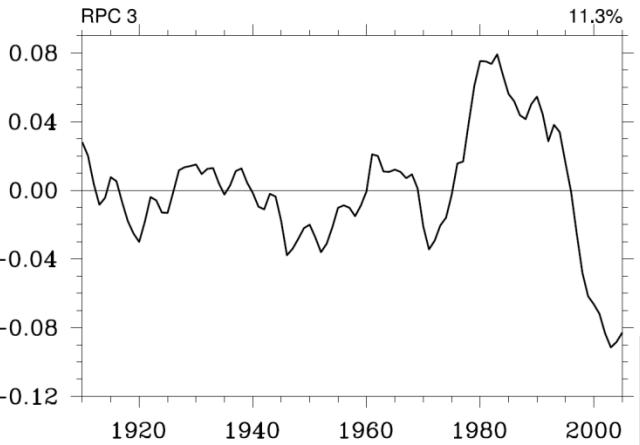


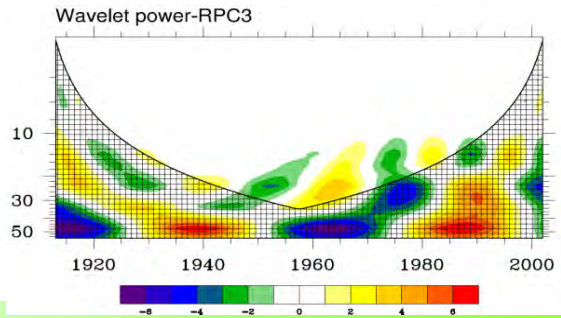




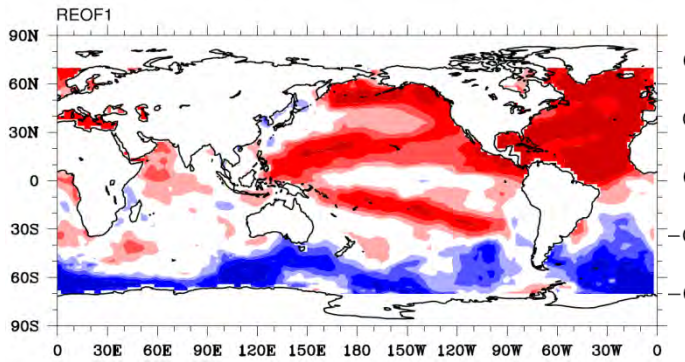


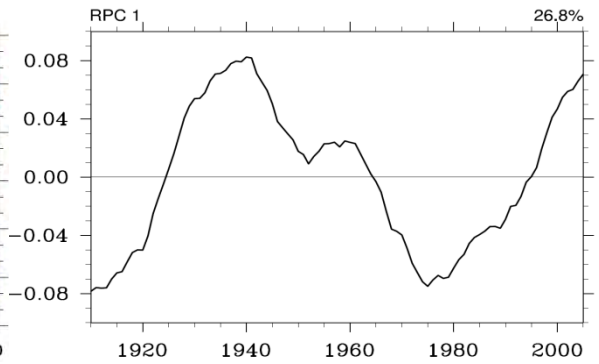


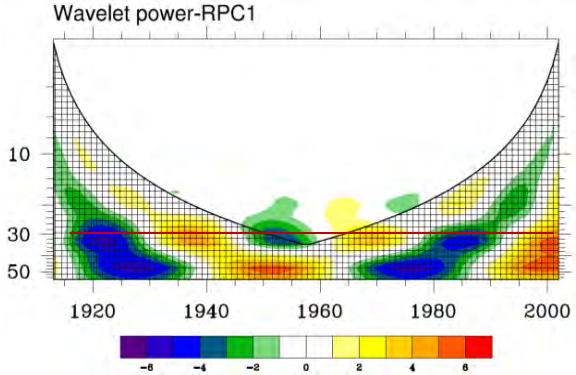


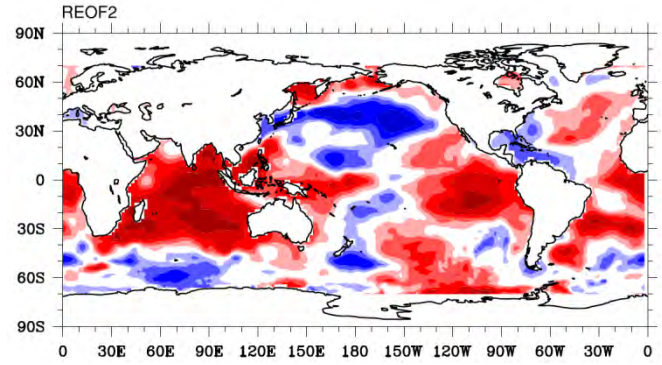


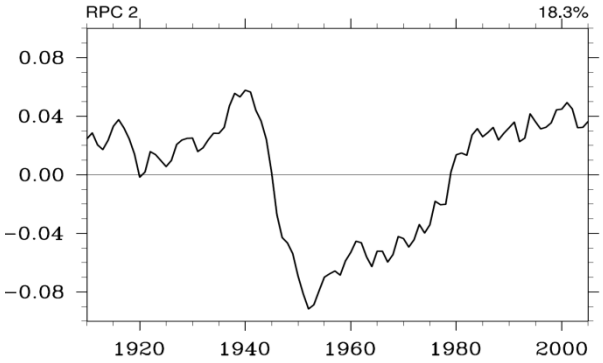
OBS result : De-trended REOF

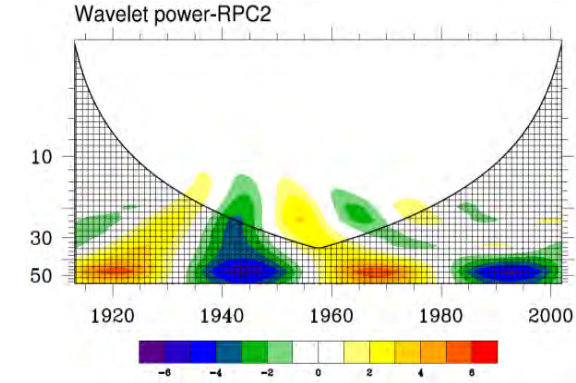


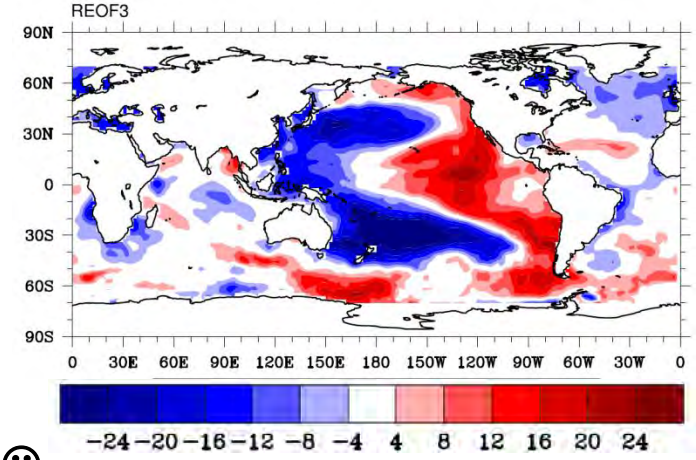


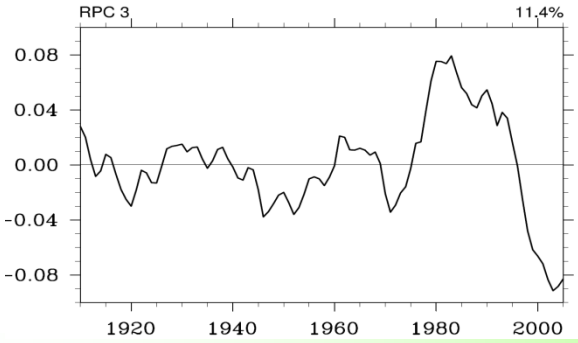


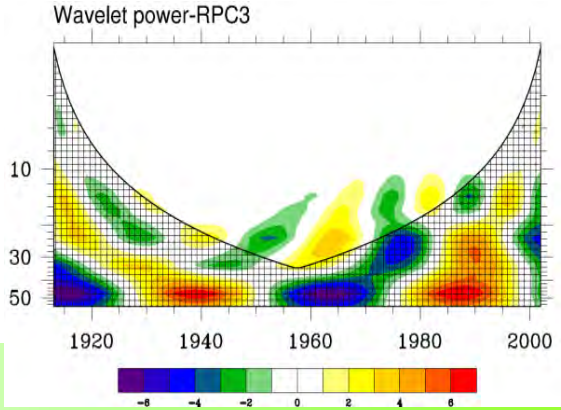




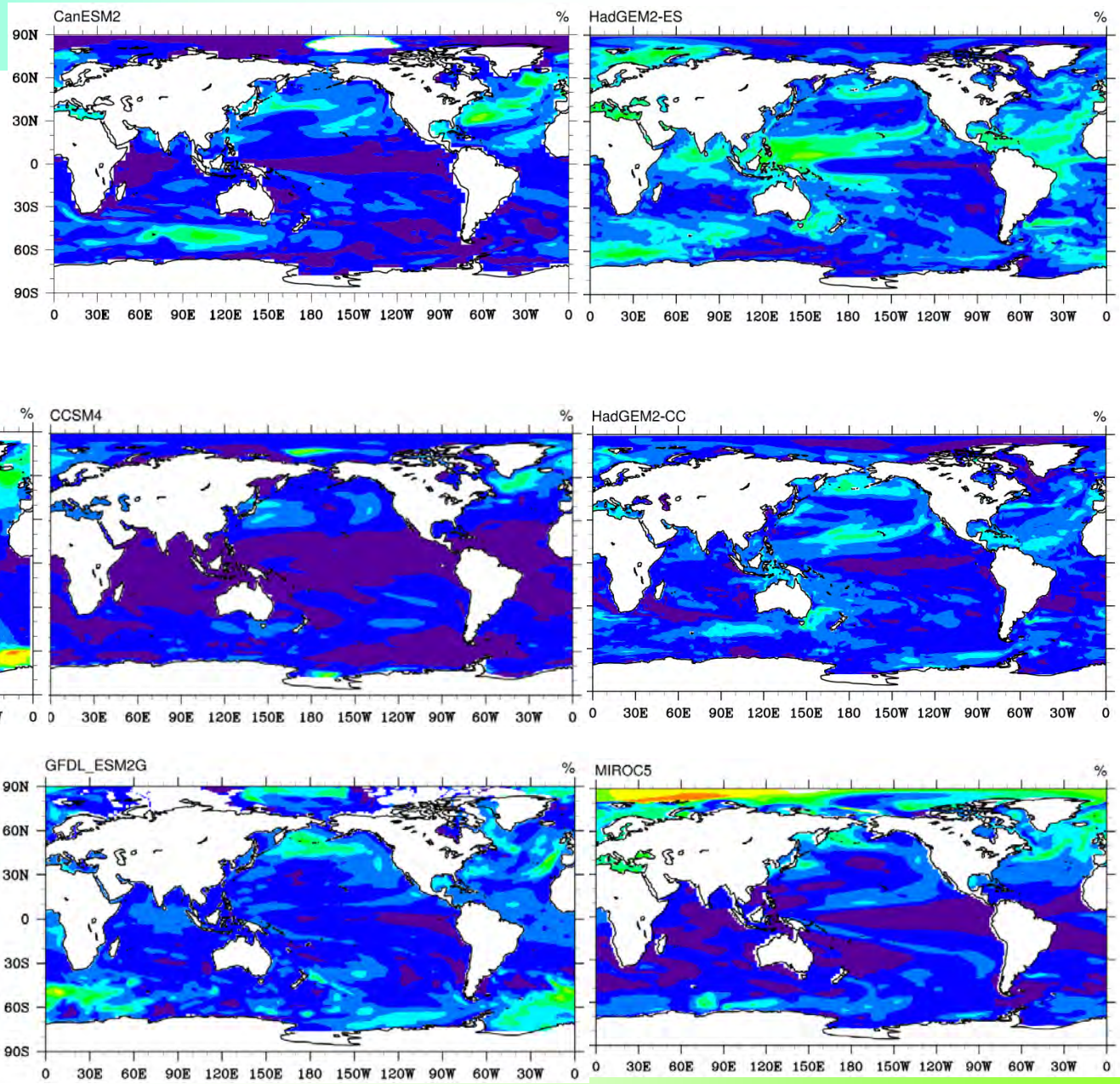








Decadal variability ratio



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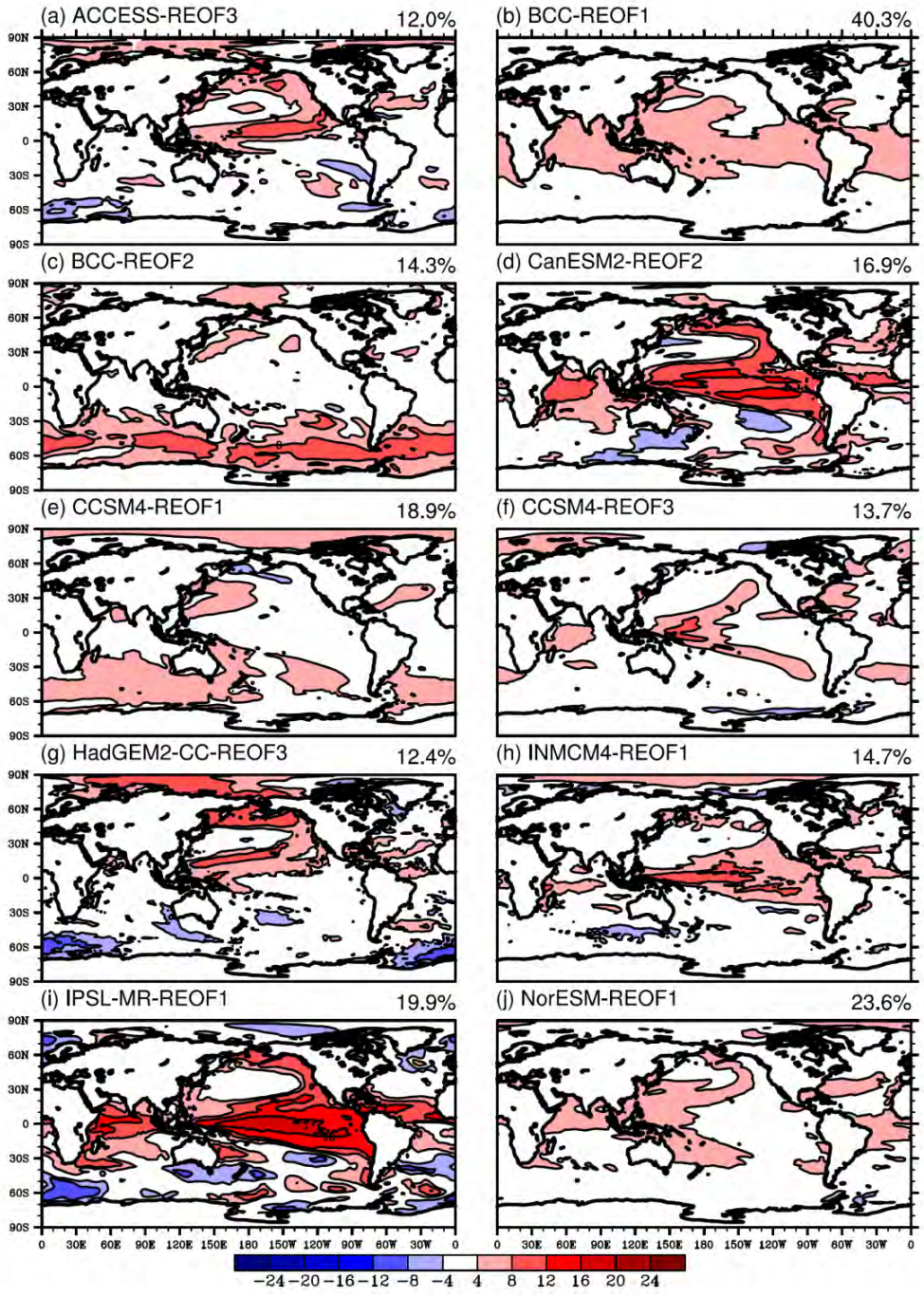
Not-so-good ones but with pattern correlation > 0.3



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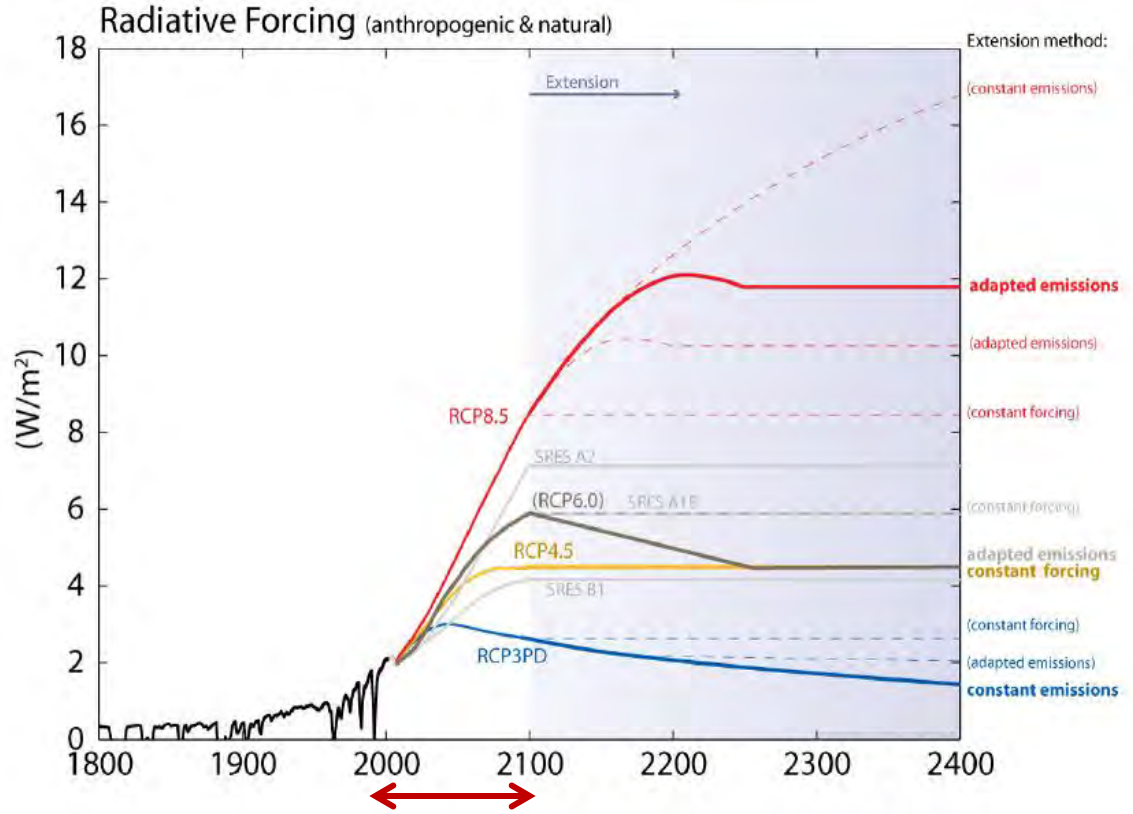
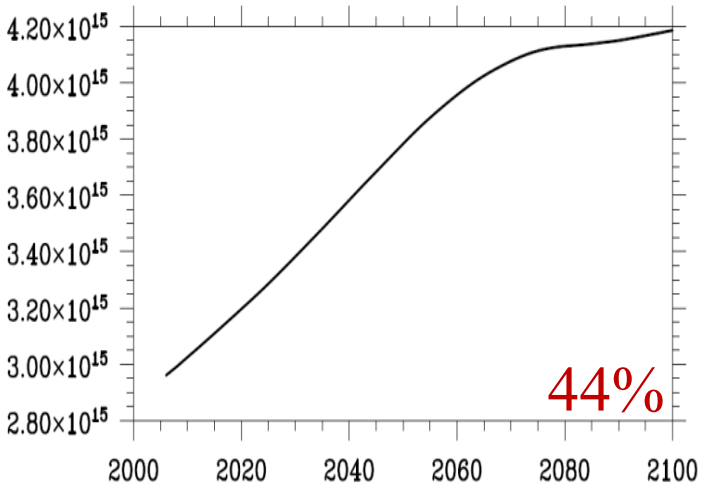
Key diagnostics- Future

- RCP4.5 (2006~2100)





Between B1 and A1B

Taylor et al., 2009

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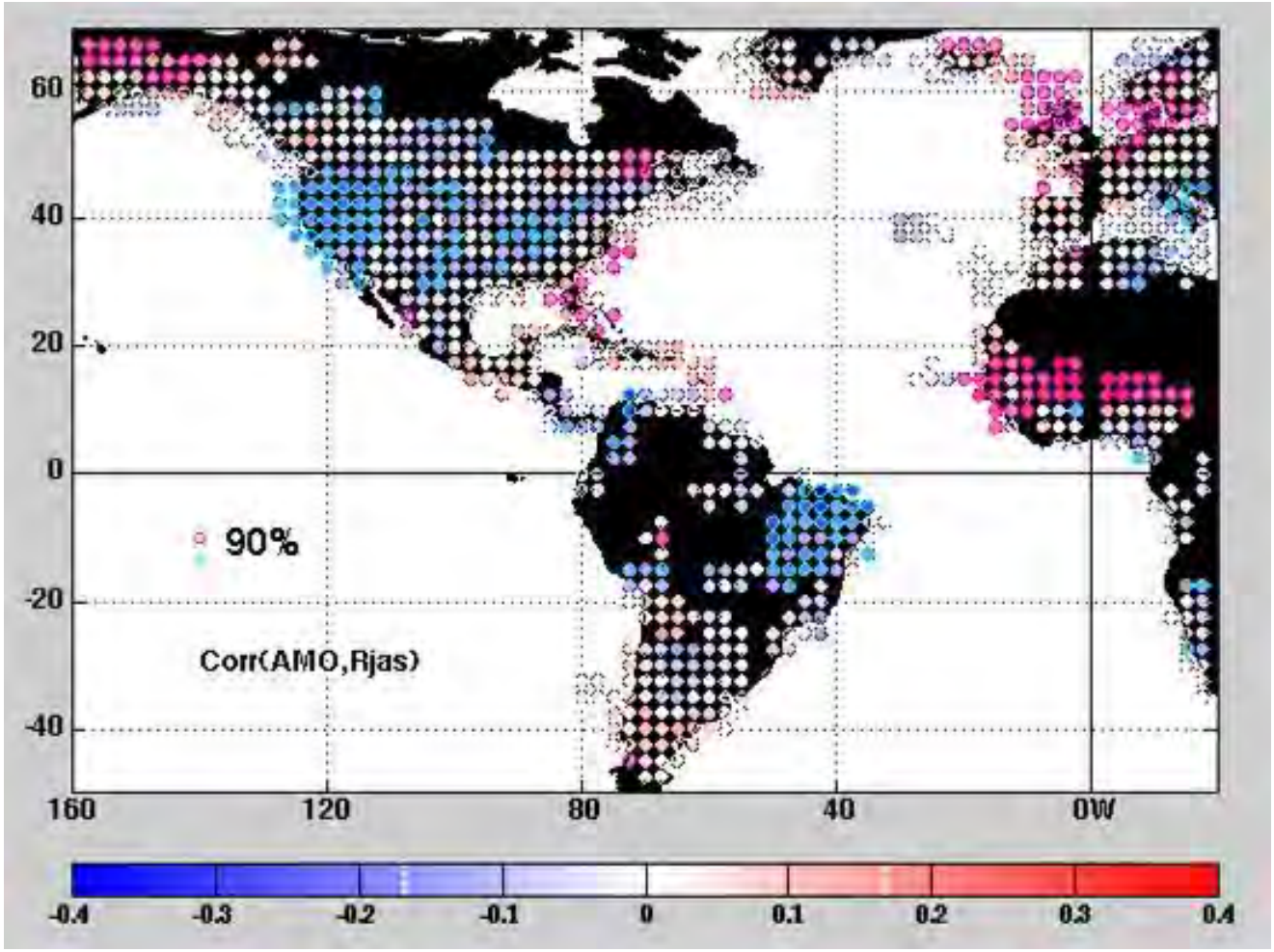
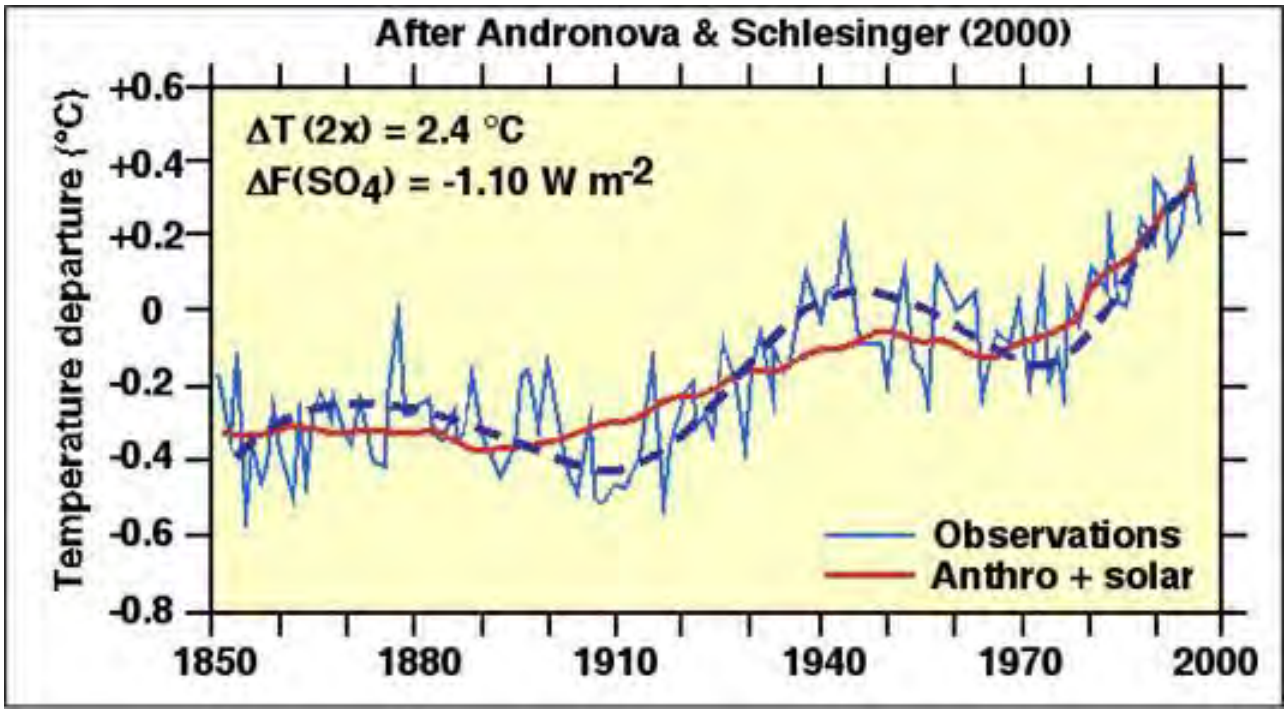
What are the impacts of the AMO?



Red and blue colored dots represent positive and negative correlations of Northern Hemisphere summer rainfall with the AMO index. When the AMO is positive (warm Atlantic) there is less rainfall over most of the United States and northeastern South America, and more rainfall in southern Alaska, northern Europe, west Africa and Florida.

Form:http://www.aoml.noaa.gov/phod/amo_fig.php

What are the impacts of the AMO?



The solid blue curve shows the observed northern Hemisphere temperatures and the dashed blue curve is a smoothed version. The red curve is the temperature history for a model that responds to the external forcing of greenhouse gases and solar variability but not to natural climate variations. The blue alternations about the red curve represent the natural AMO oscillations. When the AMO decreases, as from 1950 to 1975, global warming may appear to be reversed. When the AMO increases, as from 1975 to the present, the global warming (red) is exaggerated.

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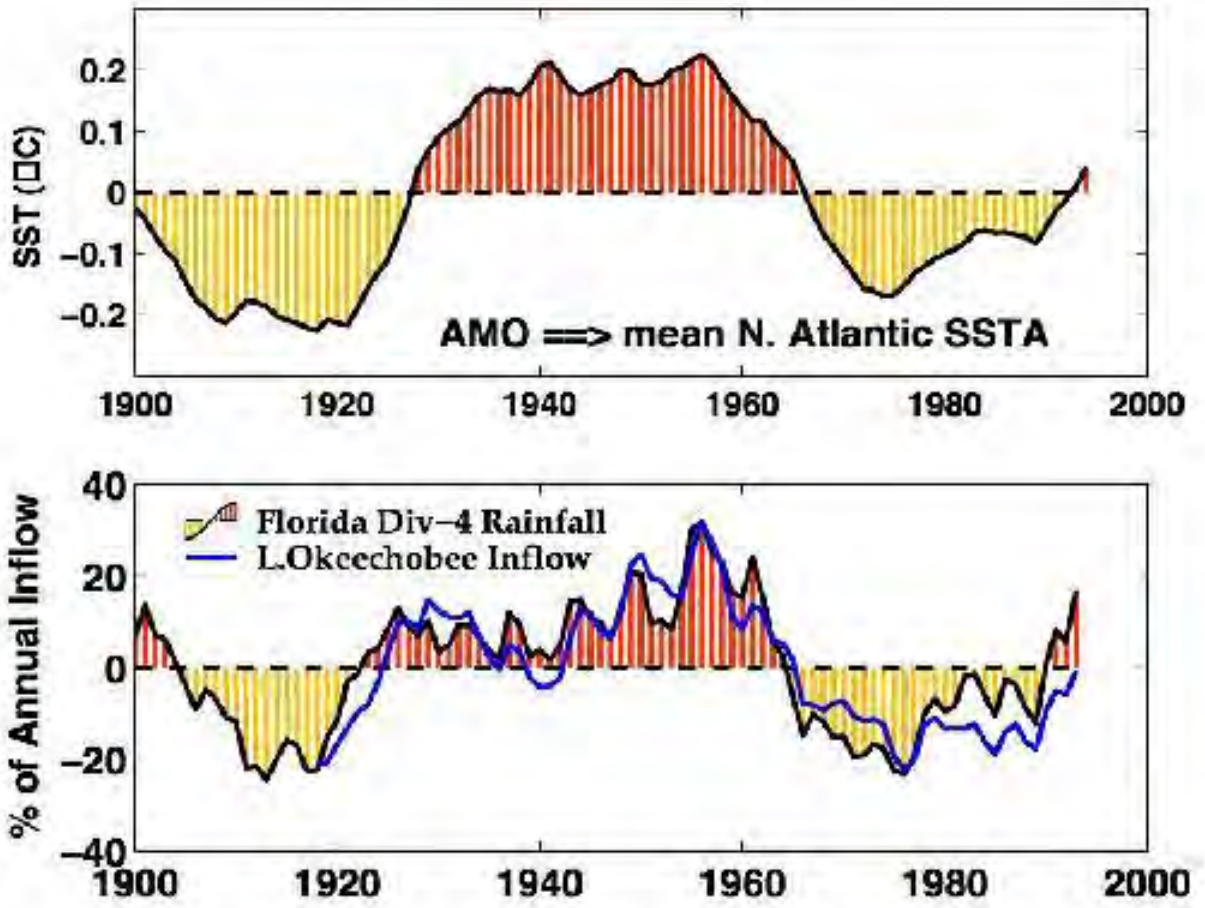
Form:http://www.aoml.noaa.gov/phod/amo_fig.php

How does the AMO affect Florida?



The upper panel shows the AMO index since 1860 (°C). The lower panel shows the smoothed anomaly of central Florida rainfall (shaded curve) and the amount of water flowing into Florida Lake Okeechobee. Both are expressed as a percentage of their long-term average

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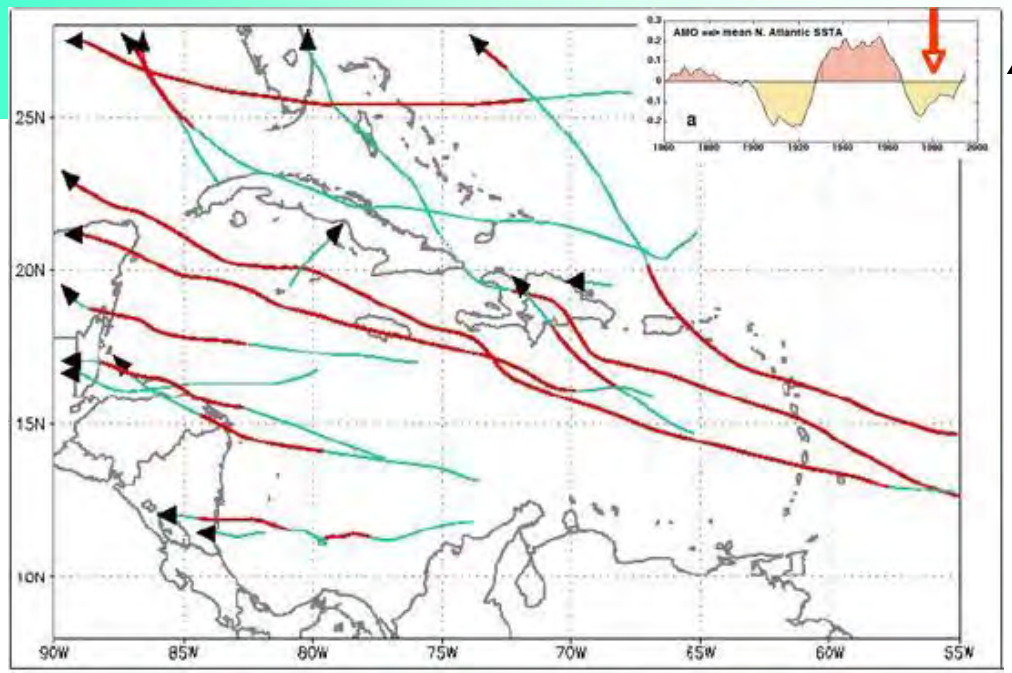
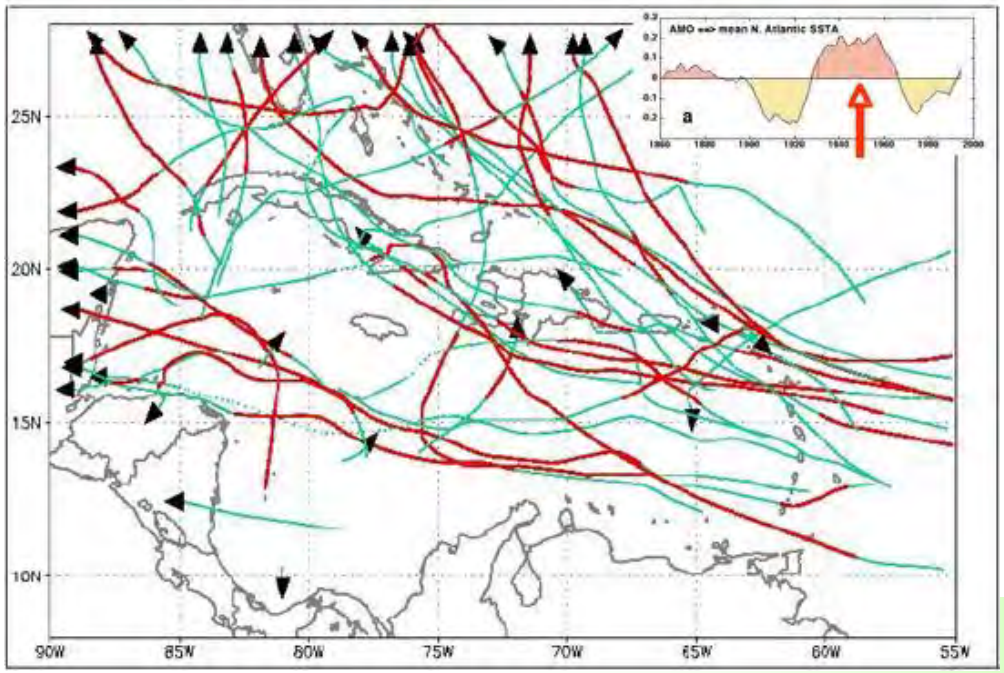
Form:http://www.aoml.noaa.gov/phod/amo_fig.php

AMO & hurricanes





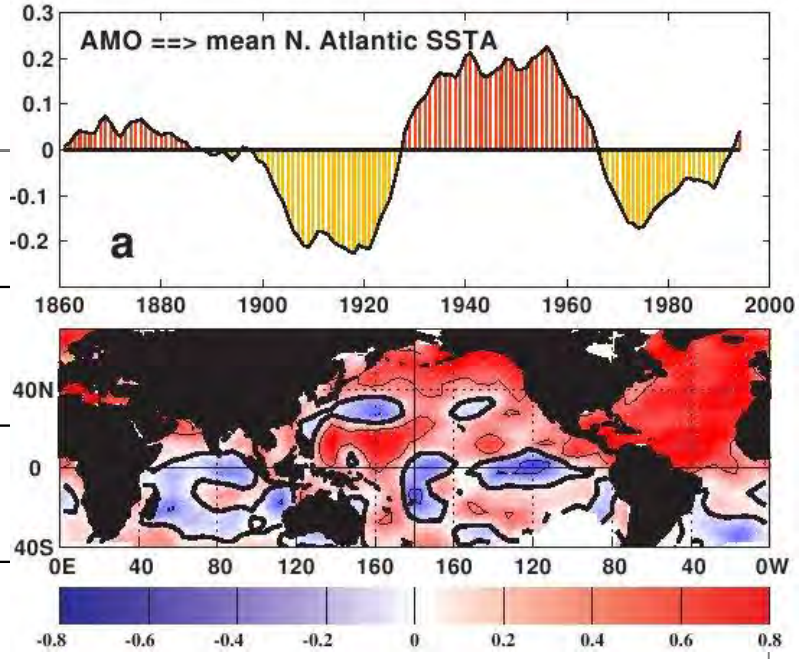
During warm phases of the AMO, the numbers of tropical storms that mature into severe hurricanes is much greater than during cool phases, at least twice as many. Since the AMO switched to its warm phase around 1995, severe hurricanes have become much more frequent and this has led to a crisis in the insurance industry.

Form:http://www.aoml.noaa.gov/phod/amo_fig.php

JJA surface temperature in Taiwan and AMO?
21-year running means

Influence of AMO?

七站平均



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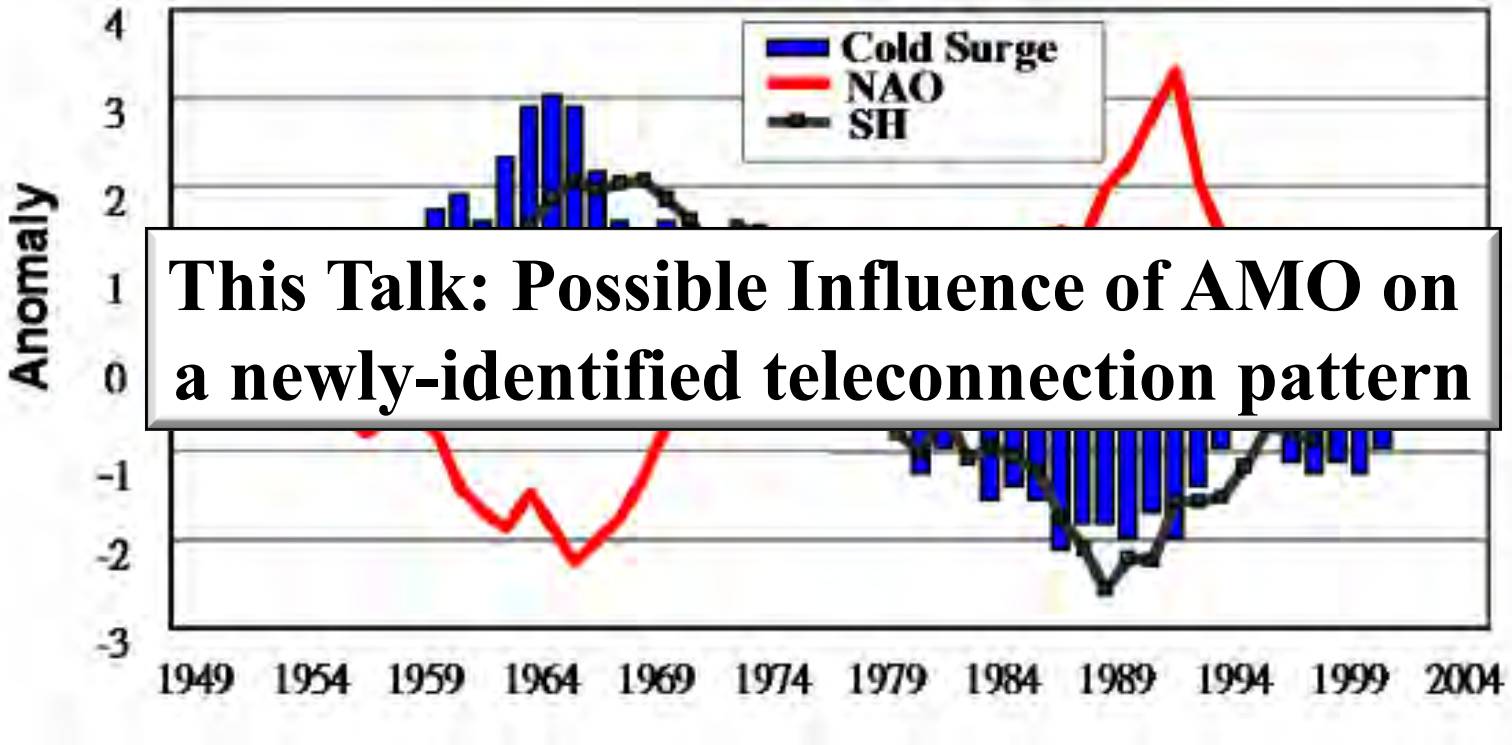
NAO (AMO?) vs. Cold Surge in Taiwan



This Talk: Possible Influence of AMO on a newly-identified teleconnection pattern

Hong, C.-C., H.-H. Hsu, H.-H. Chia, and C.-Y. Wu (2008), Decadal relationship between the North Atlantic Oscillation and cold surge frequency in Taiwan, Geophys. Res. Lett., 35, L24707, doi:10.1029/2008GL034766.

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