The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
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IAEA
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1968-18

Conference on Teleconnections in the Atmosphere and Oceans

17 - 20 November 2008

North Atlantic teleconnections linking worlds apart.

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THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY

NORTH ATLANTIC TELECONNECTIONS LINKING WORLDS APART

Yochanan Kushnir

with

Richard Seager, Mingfang Ting and other members of the LDEO Climate Modeling Group

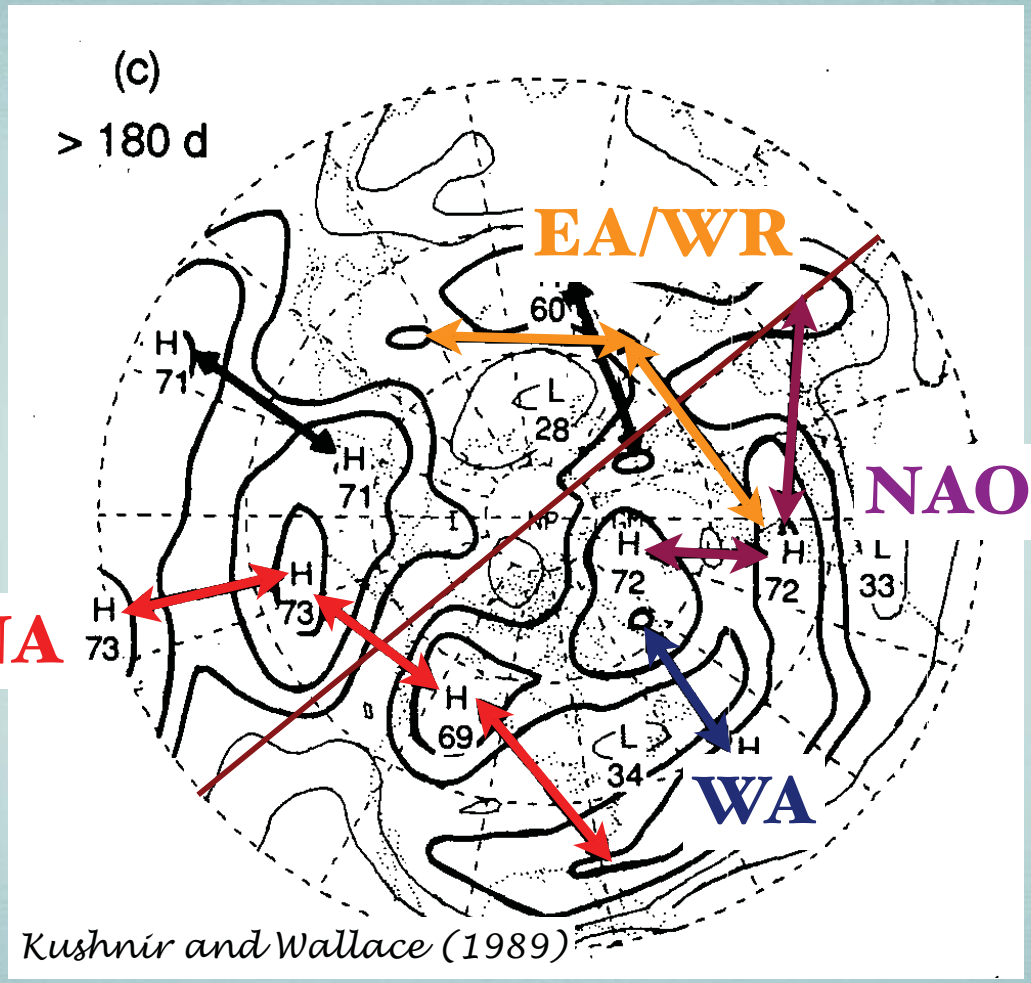
and

Mordechai Stein

Geological Survey of Israel, Jerusalem

Conference on Teleconnections in the Atmosphere and Oceans
ICTP - Trieste - Italy, 17 - 20 November 2008

Teleconnections in the NAtl

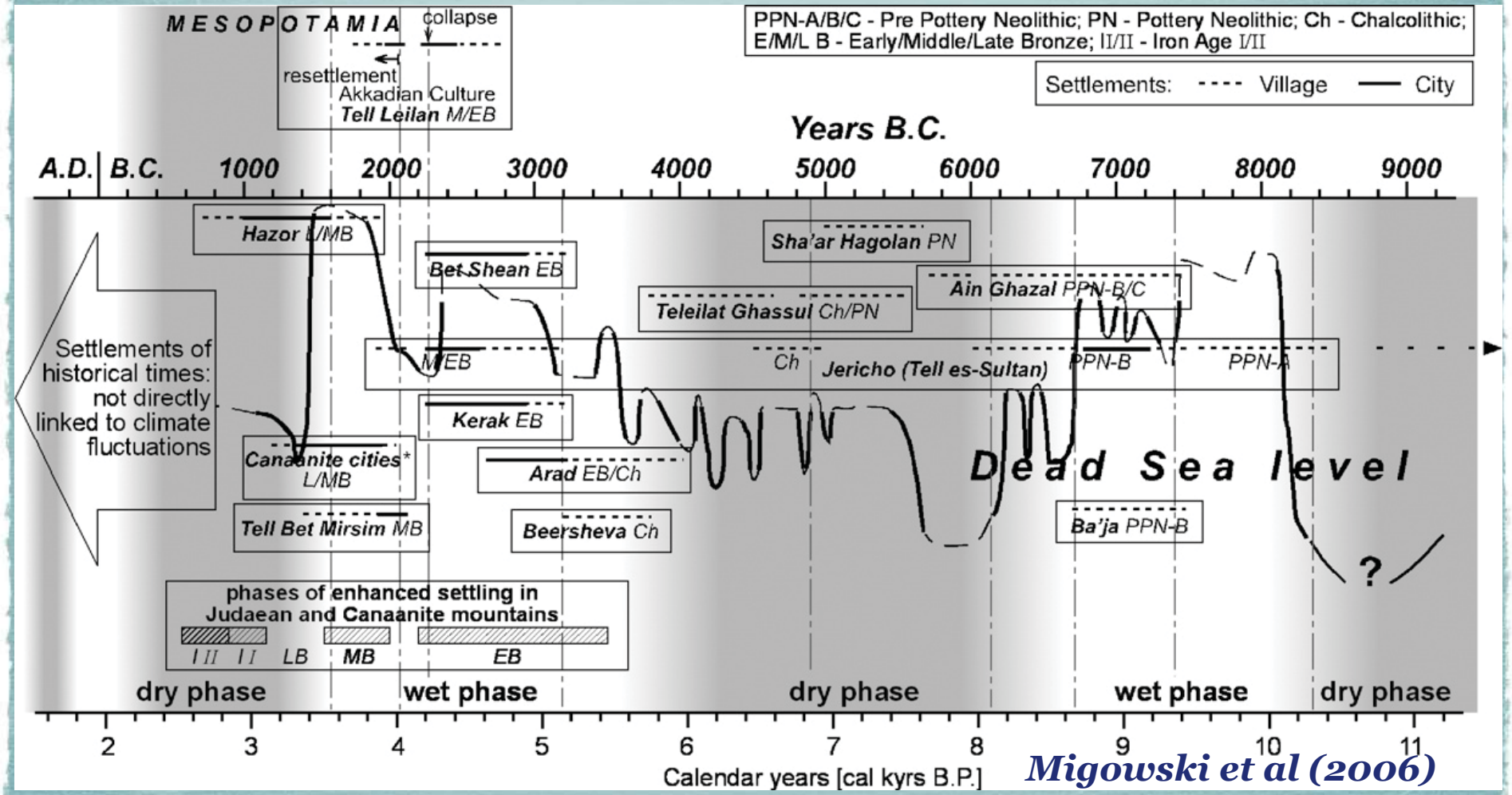


Response to (weak) surface boundary forcing

Outline

- Anti-phase relationship between North African and Levant hydroclimate - orchestrated by Atlantic Multidecadal SST Variability (AMV)
- AMV & North American Droughts
- The mechanisms
- AMV and "Global Warming"

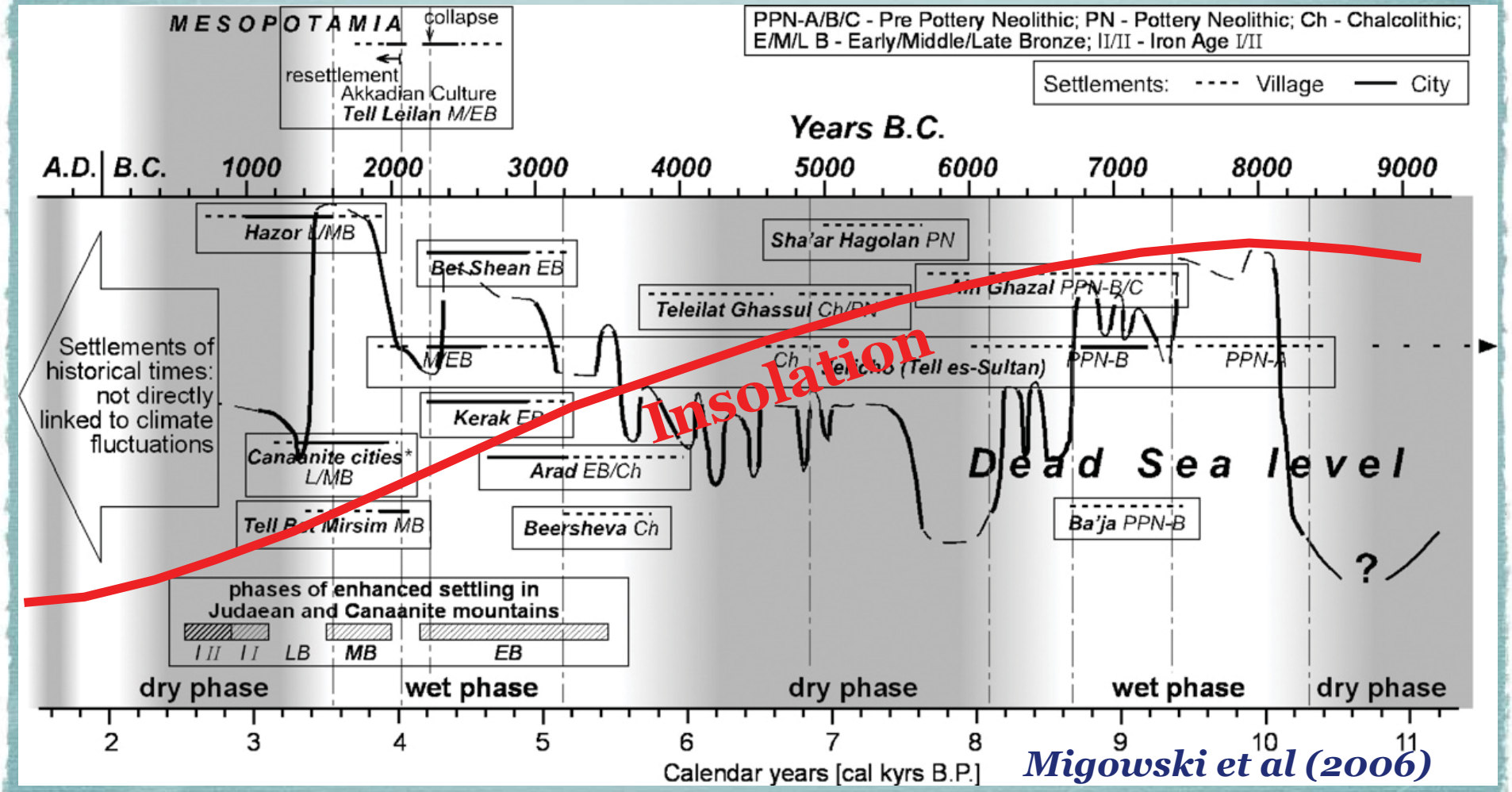
DS Level and Settlements



Migowski et al (2006)

4

DS Level and Settlements



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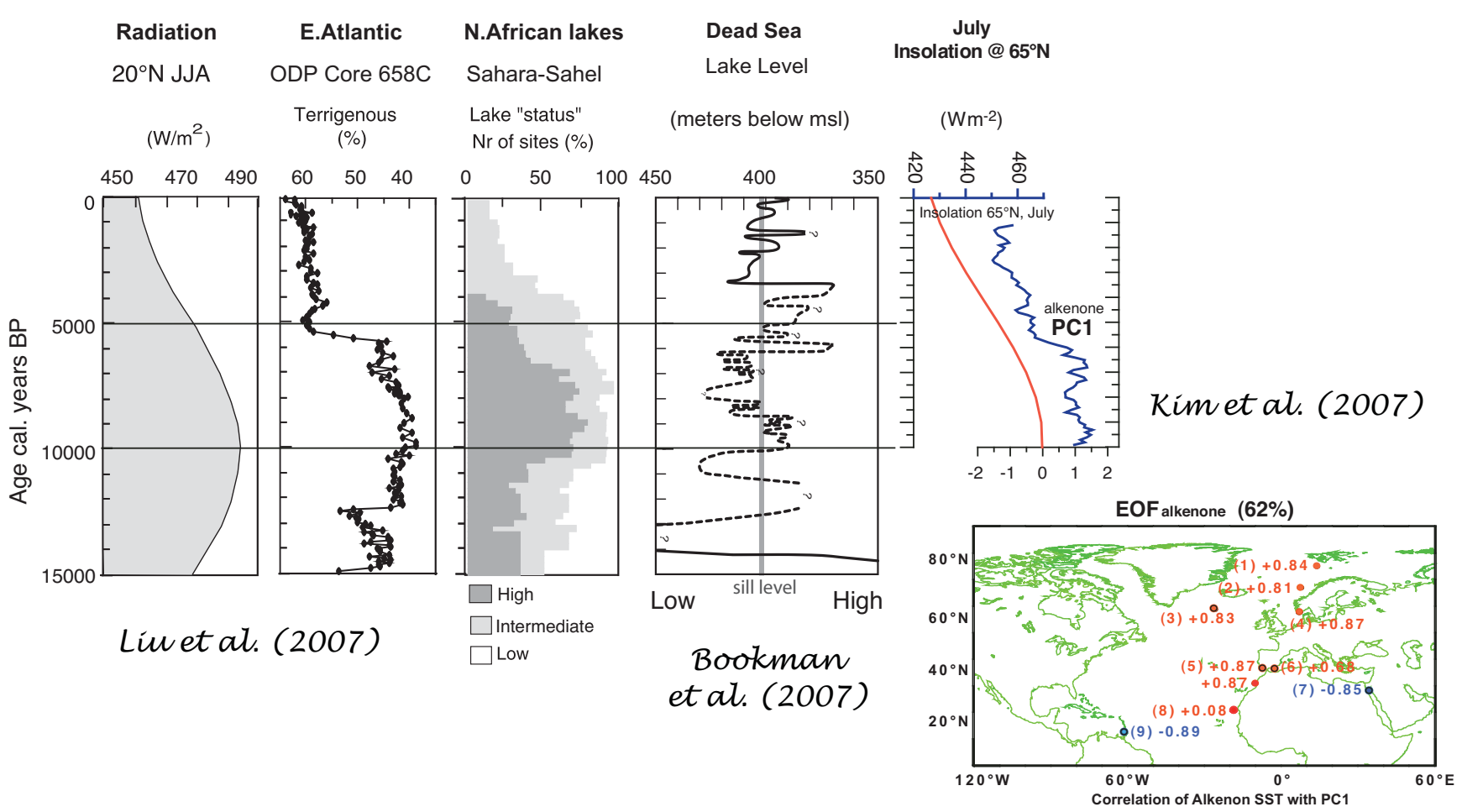
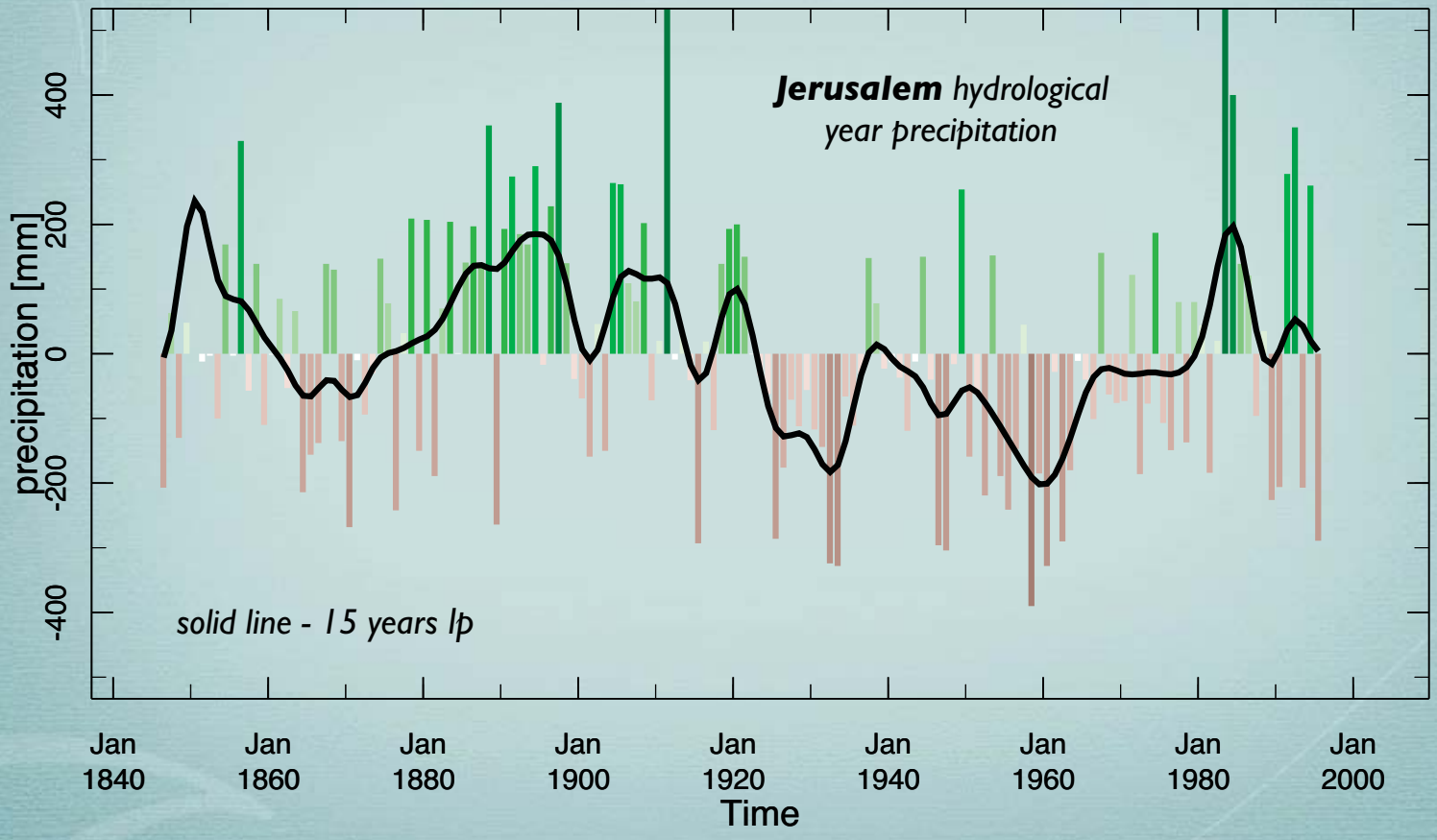
Holocene Sahel-Levant Connection



Levant Precipitation & N. Atlantic SST



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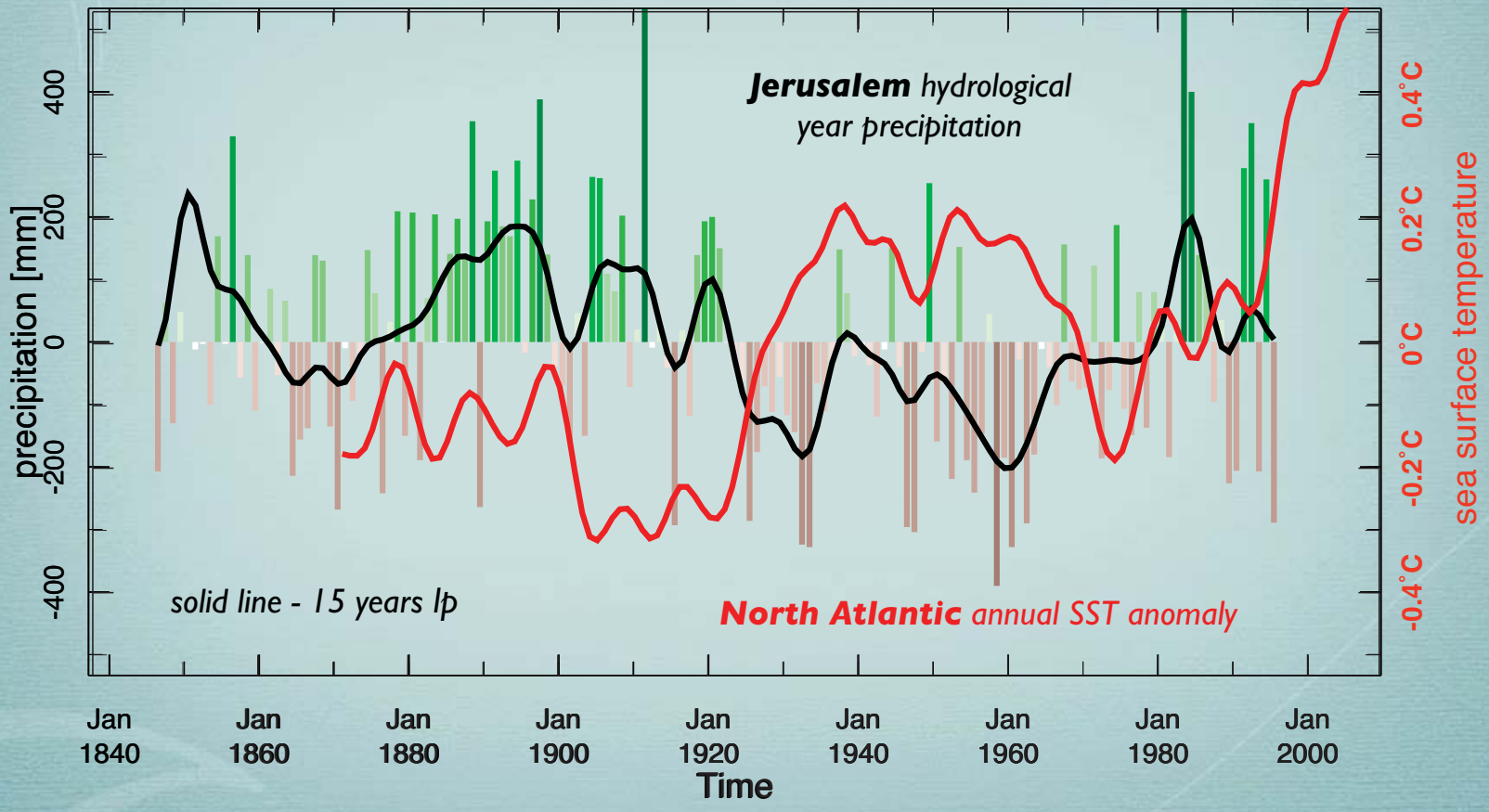
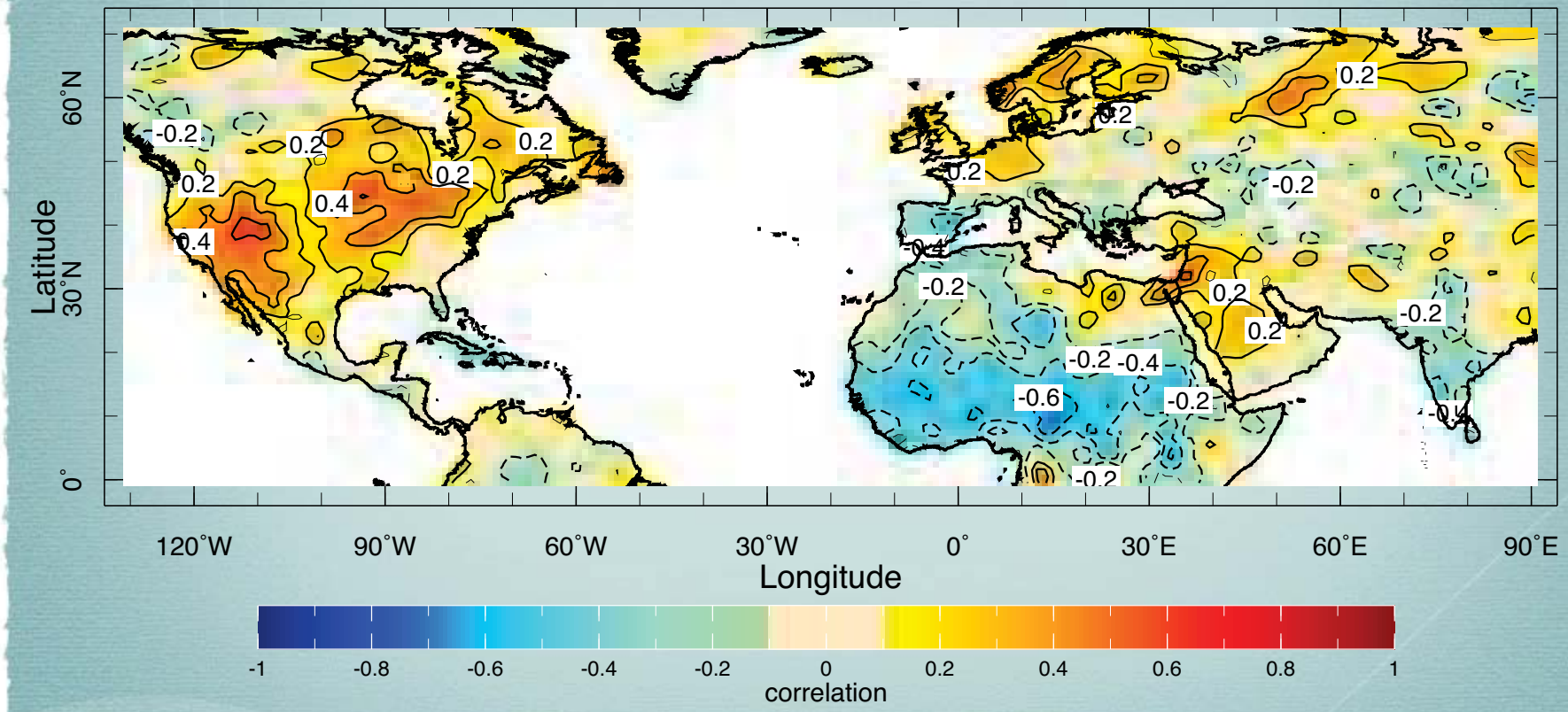


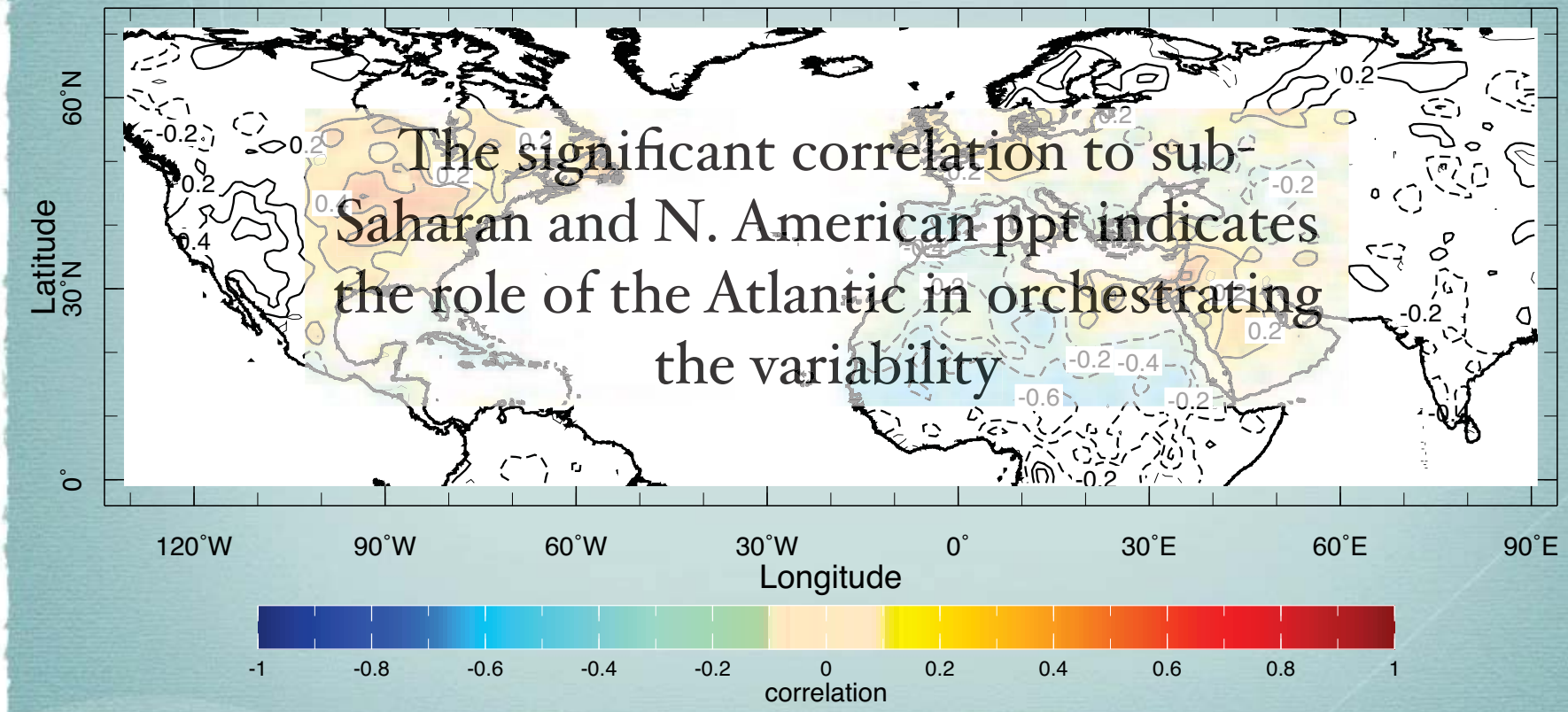
Intercontinental links to Jerusalem ppt



Annual (Oct-Sep) Jerusalem precipitation correlated with precipitation elsewhere. Time series were smoothed by 1 pass of a 2-nd order binomial filter. Precipitation from GPCC 1930-1995.

7

Intercontinental links to Jerusalem ppt



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7

North American Droughts

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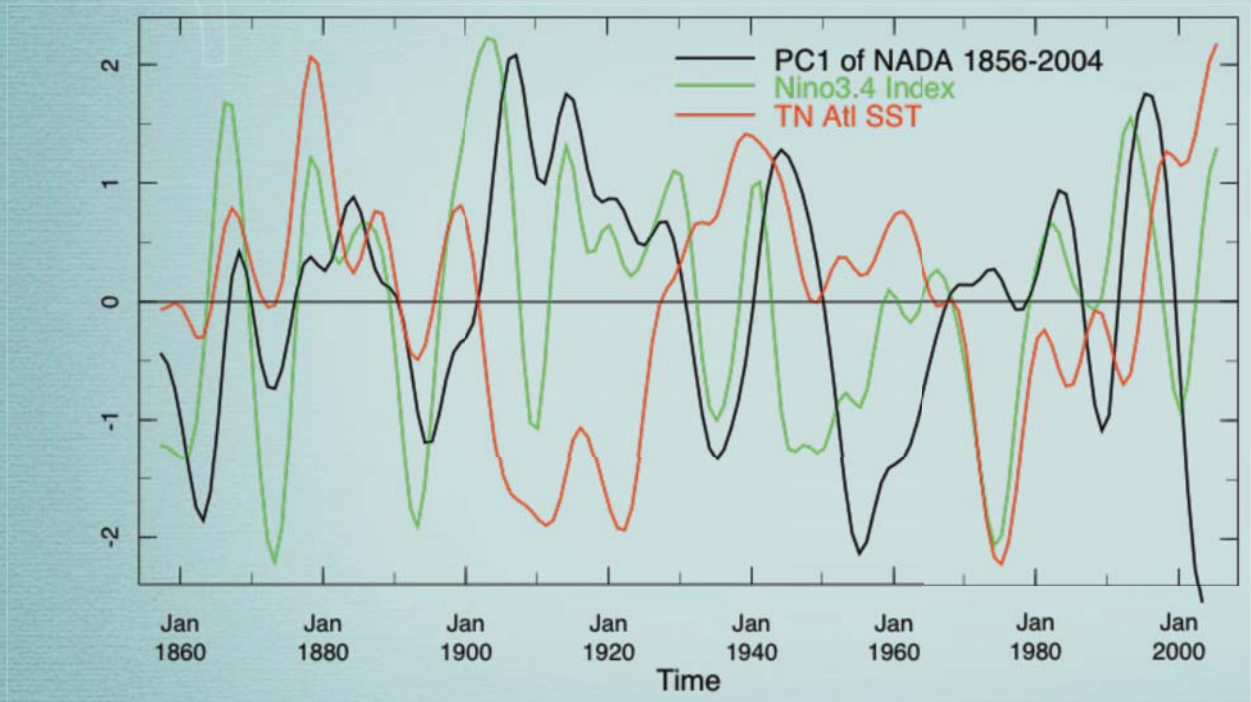

First PC of annual Palmer Drought Severity Index (PDSI) for the years 1857 to 2004 (black solid line), tropical North Atlantic (tNAtl) SST (0-30°N, red line), and Nino3.4 (green line). All time series are derived from annual mean data, linearly detrended in time & low pass filtered to emphasize fluctuations with periods longer than a decade.

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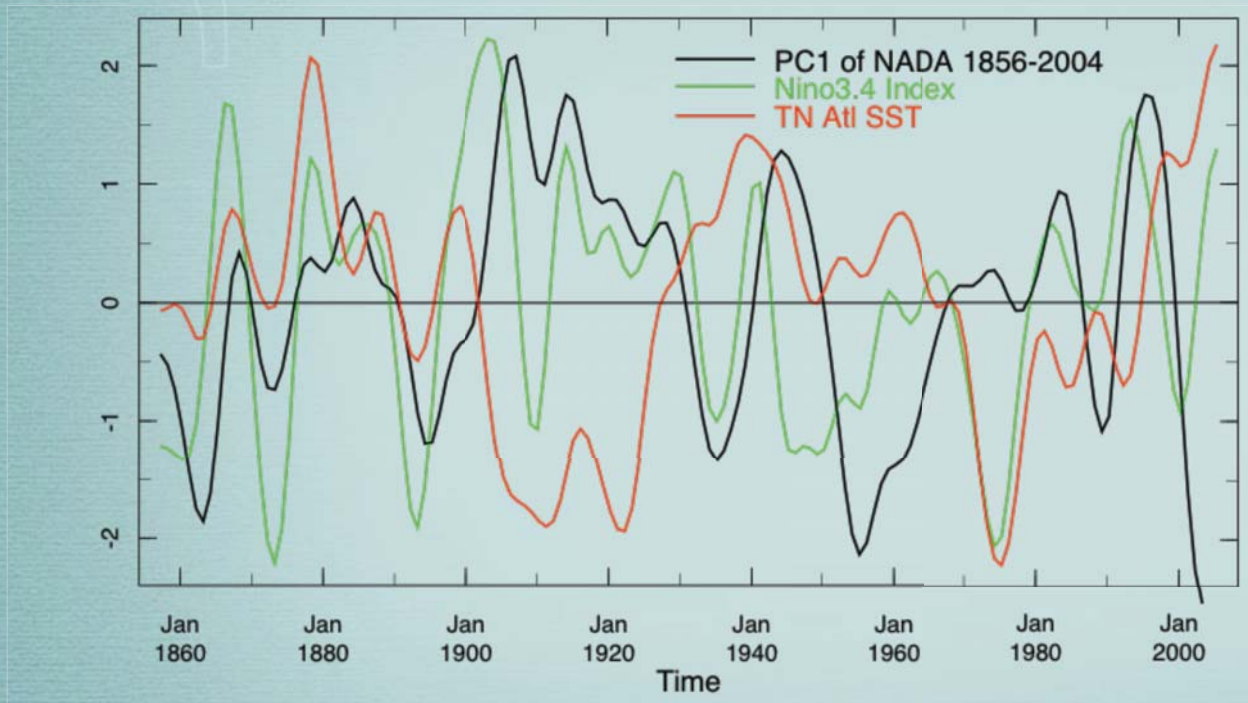

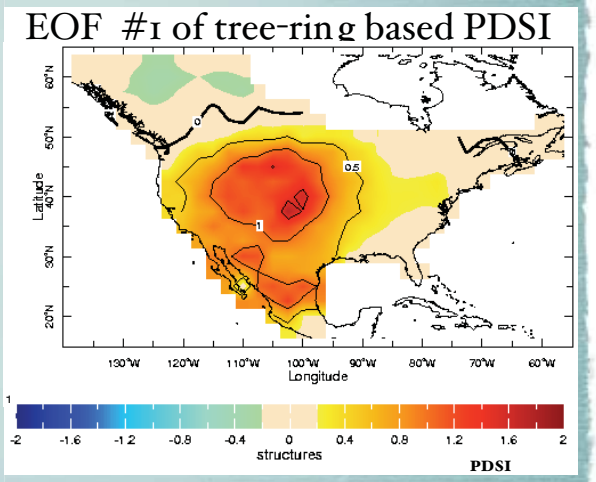

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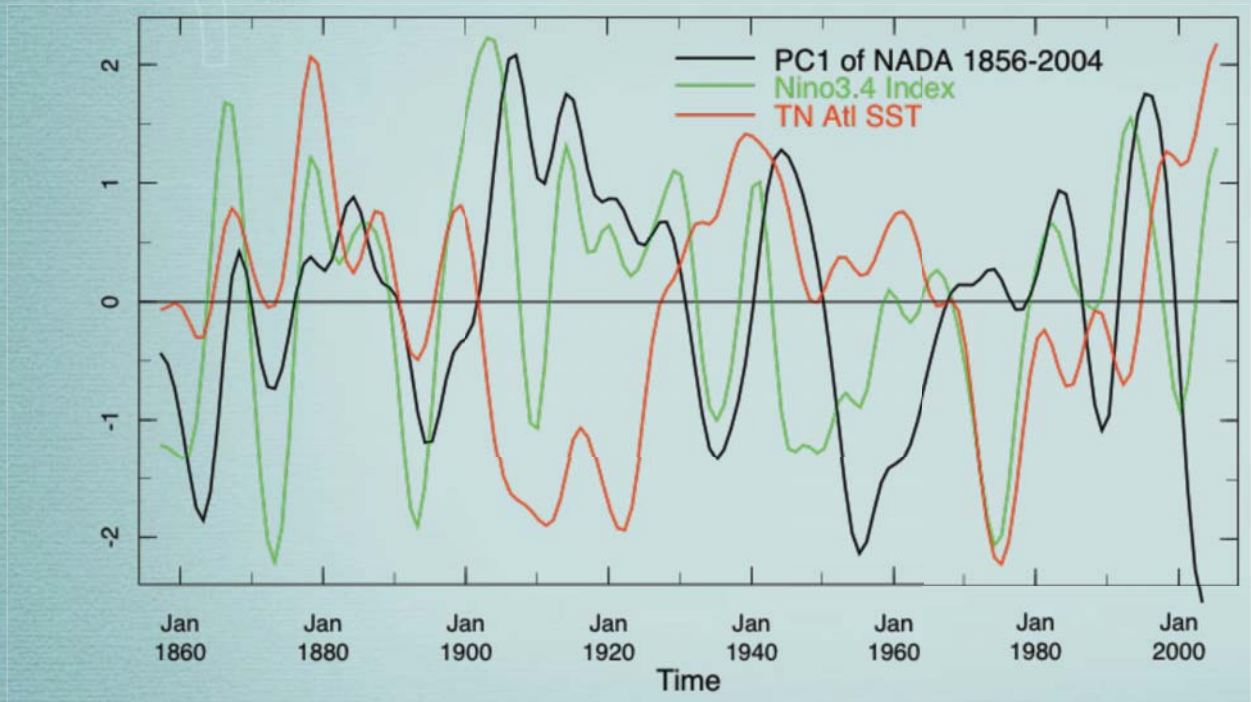

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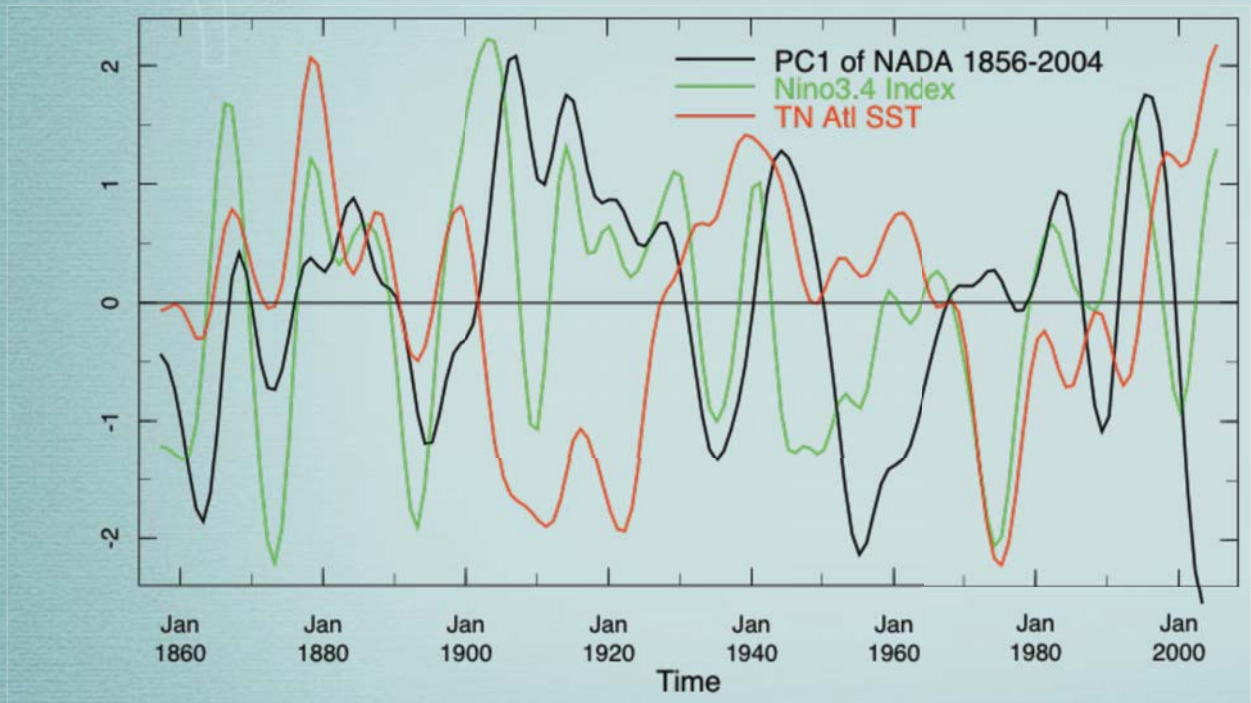

- The correlation of PC1 & the time series of tNTal SST is -0.34 (significant at the 5% level).
- With Niño3.4 the corr. is 0.38.
- A time series reconstructed from a multiple regression of PC1 on both the Niño3.4 and tNTal SST correlates with PC1 series at a level of 0.69.
- The correlation between the two low-pass filtered SST indices in only 0.15.

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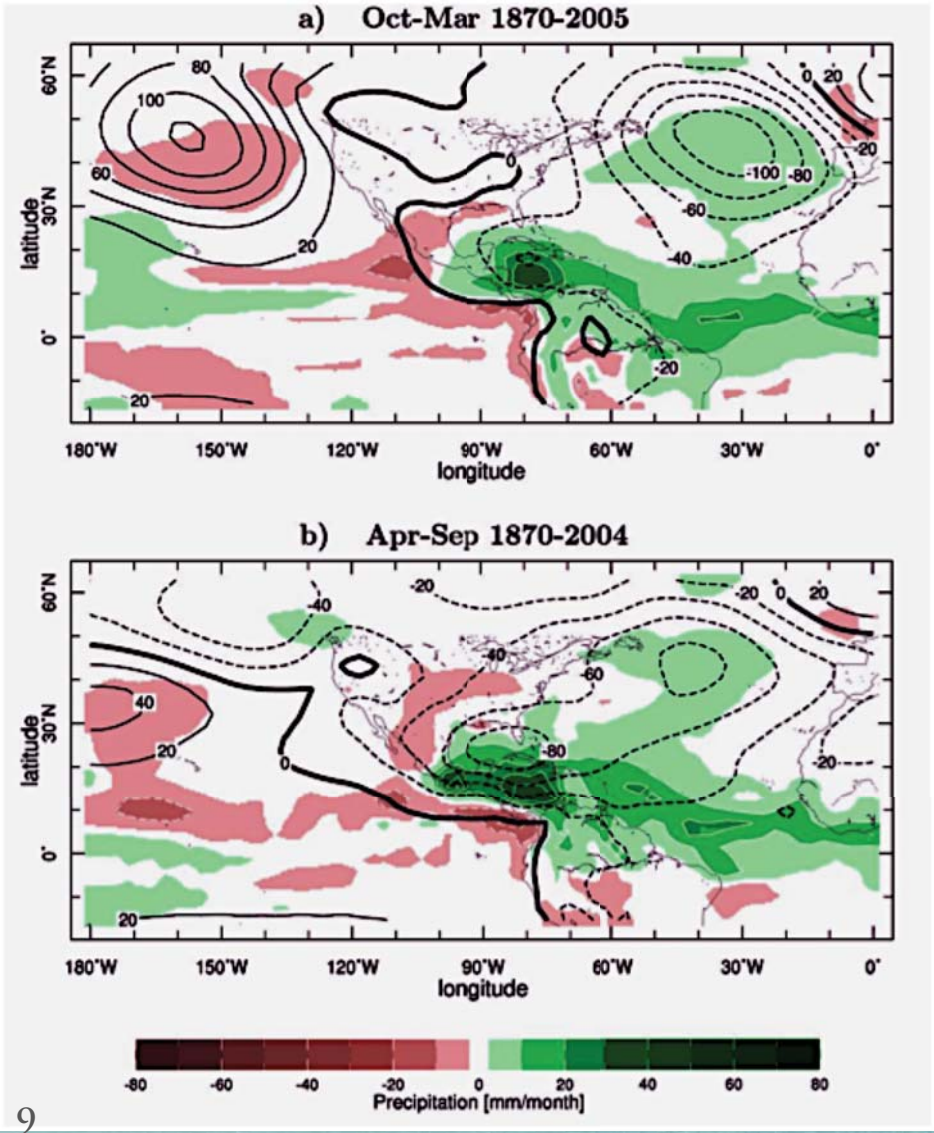
Trop. Atl. Teleconnections

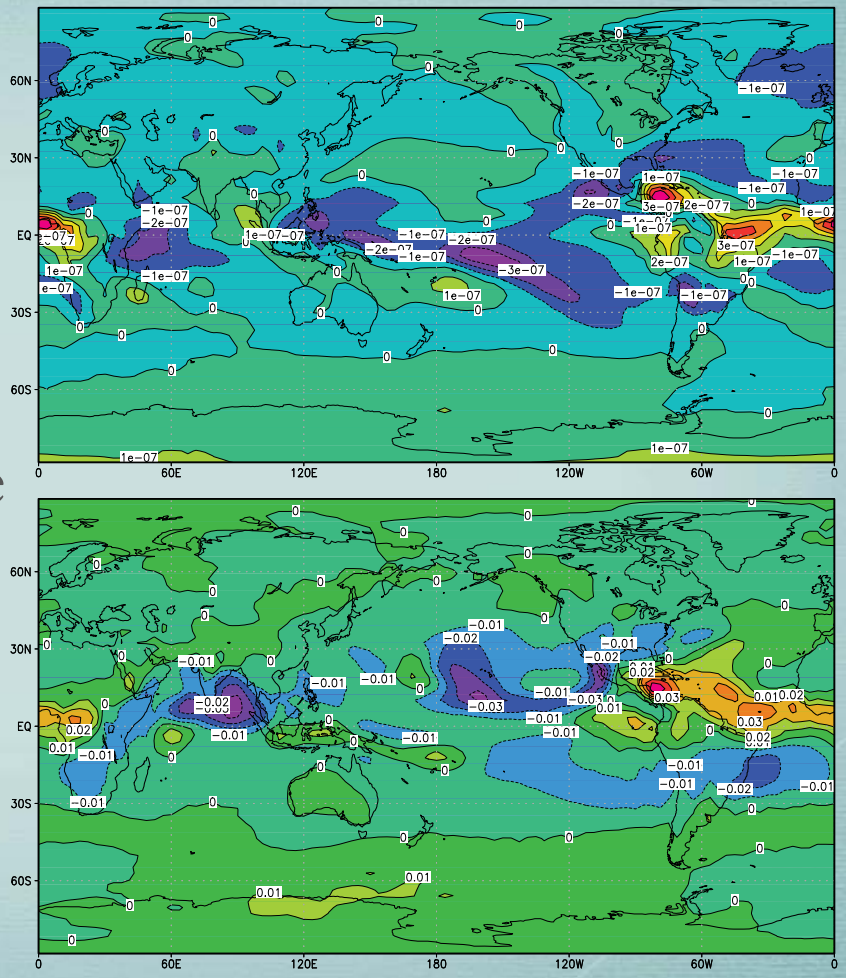
- TAGA exp: 16 member ensemble with 30°S-30°N Atl. SST prescribed from obs. 1970-2005)
- ***Figure: Ensemble mean SLP & PPT, regressed on trop. No. Atl. SST***
- Drying over US Southwest when trop. No. Atl. is warm
- Low pressure over No. Atl. in both seasons. High pressure over No. Pac. in winter.



9

TAGA Diabatic Heatinbg

- Total column heating in K/s derived from TAGA AGCM integrations
- Center of heating is the Caribbean.
- There is broad cooling over the Pacific, especially in winter.

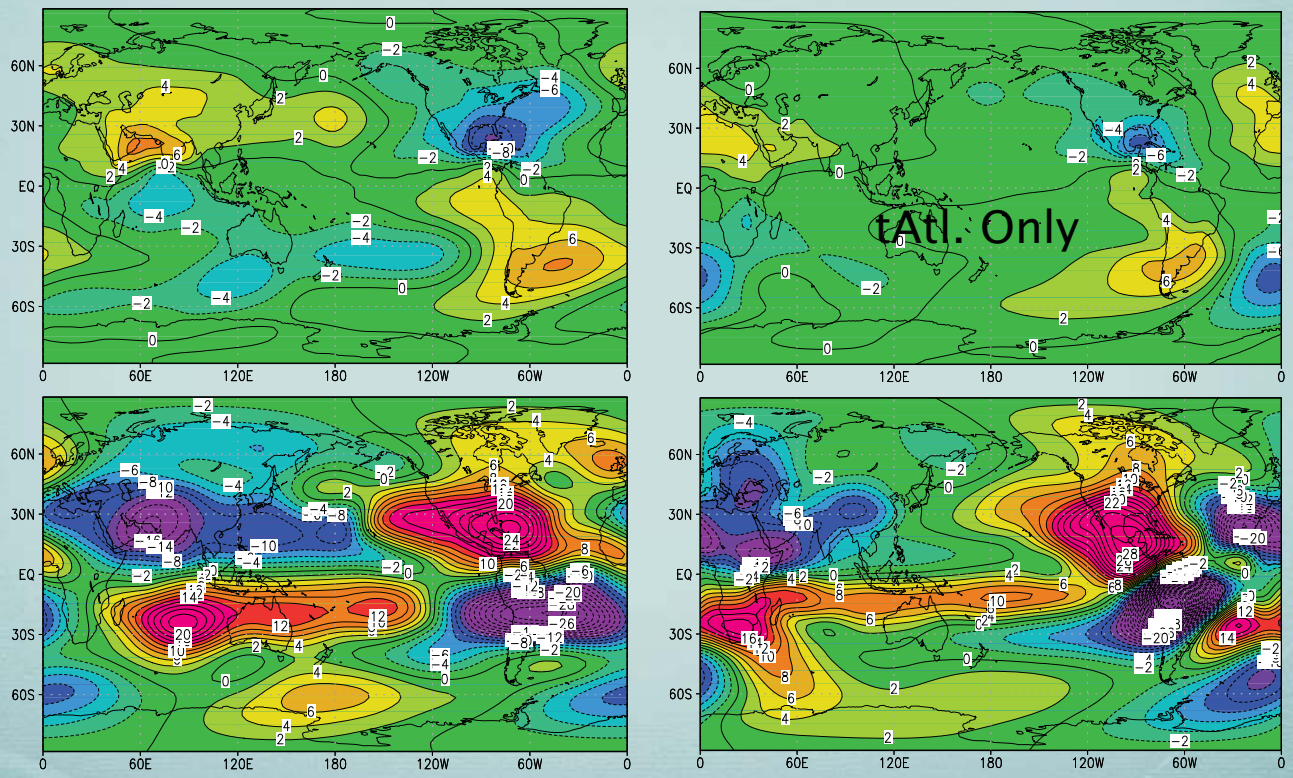


10

Linear AGCM forced w. TAGA heating: summer

~850 hPa

~150 hPa



Full GCM regression on tNAtl SST

Linear GCM response to summer heating

Linear AGCM forced w. TAGA heating: summer

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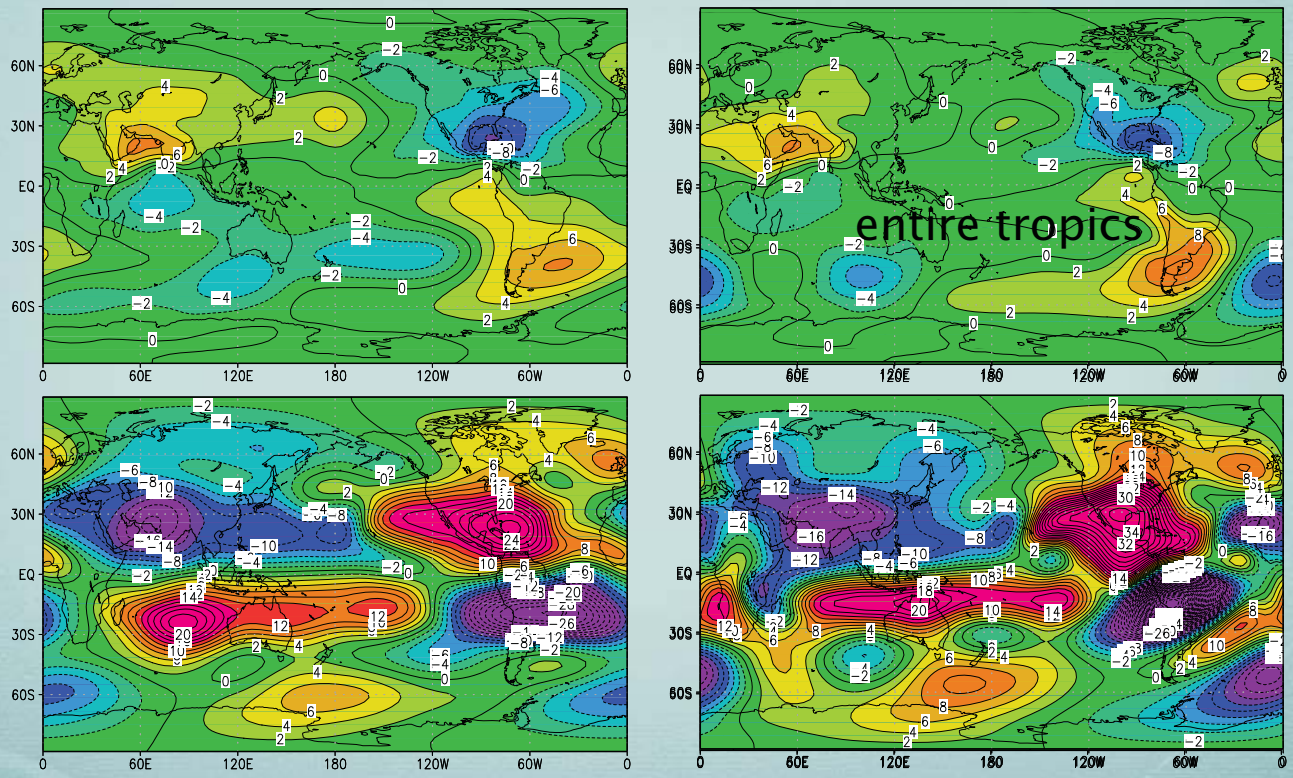
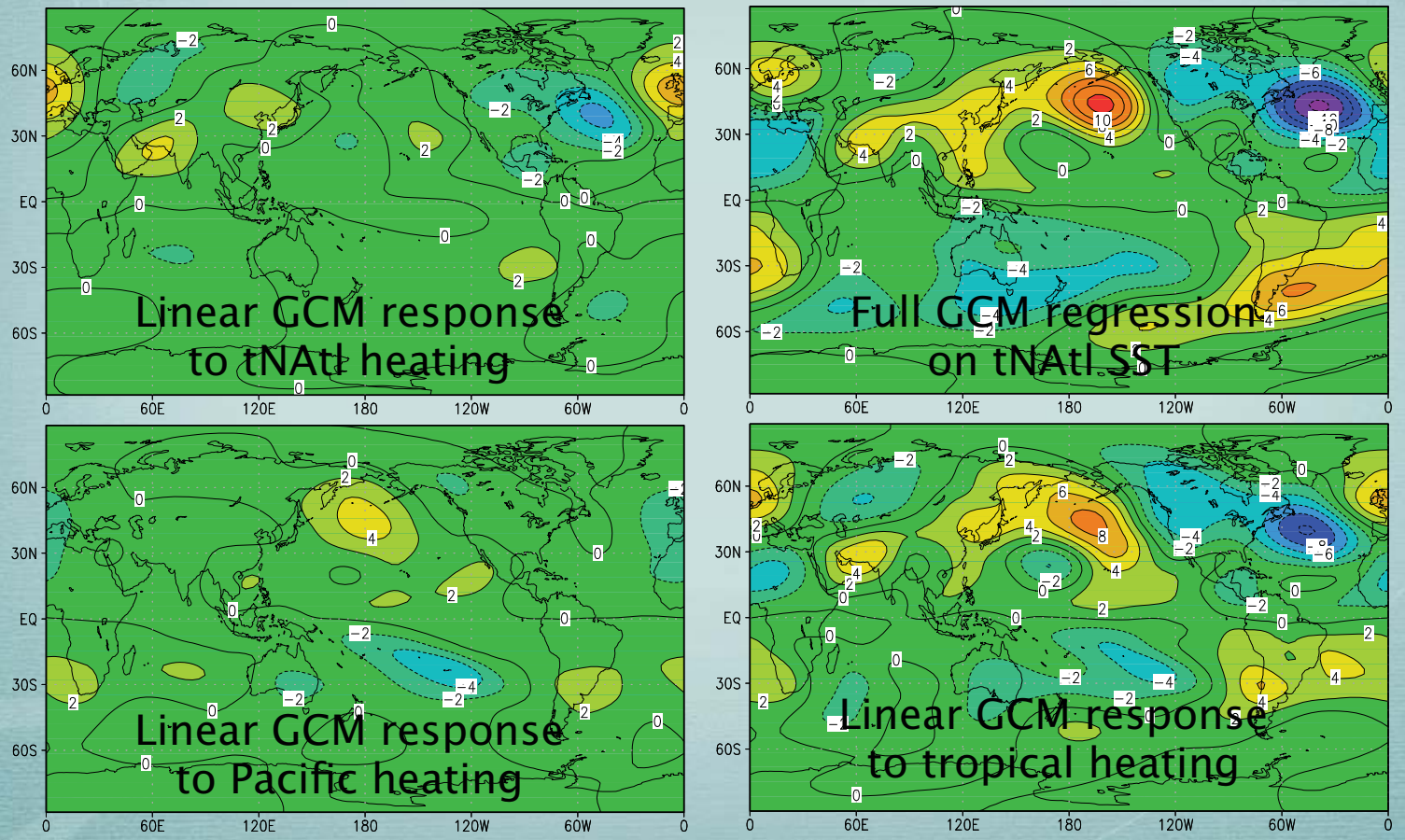


Full GCM regression on tNAtl SST

Linear GCM response to summer heating

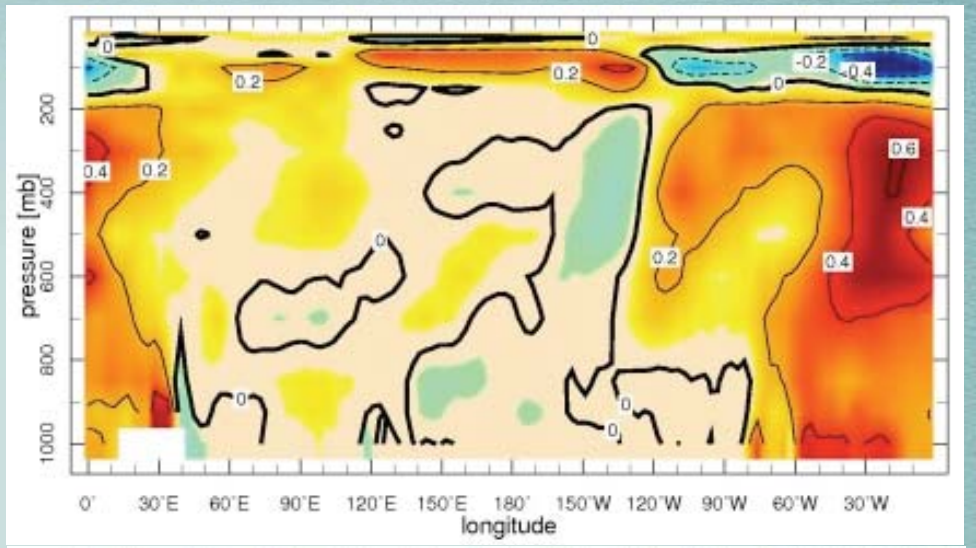
Winter response to tropical heating



12

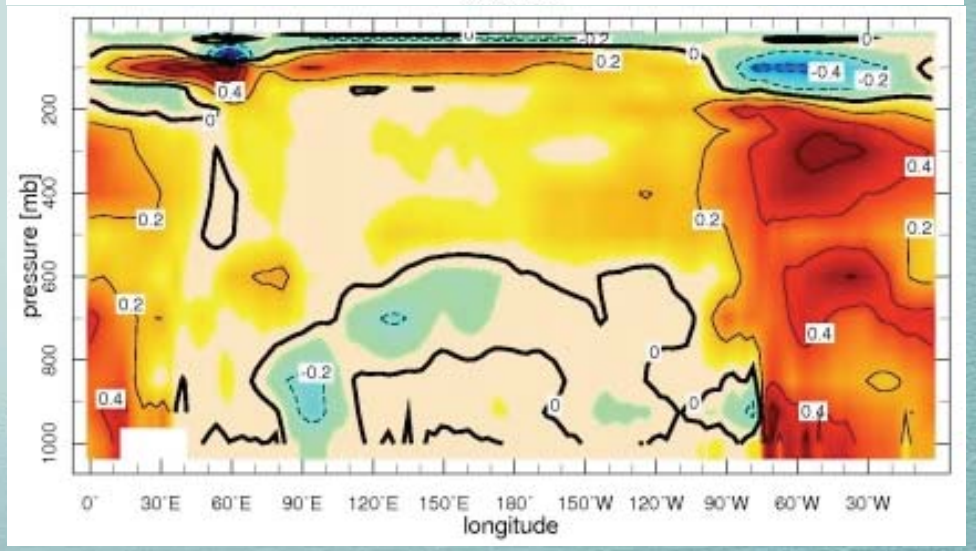
Spreading of tNAtl heating

1 Dec start



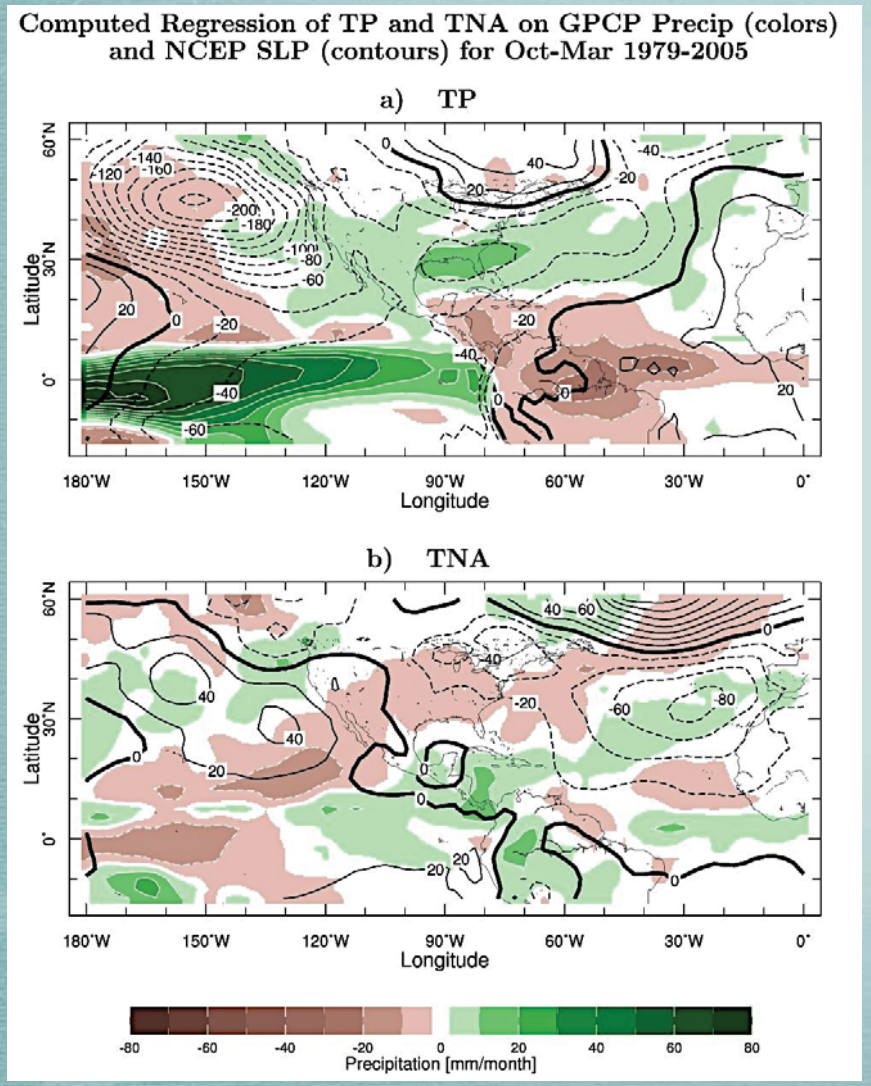
The change in the vertical temperature distribution 10°S-10°N, in a 100-member ensemble of a 100-day integration with a fixed, realistic tNAtl SSTA. Shown is average for days 31-50.

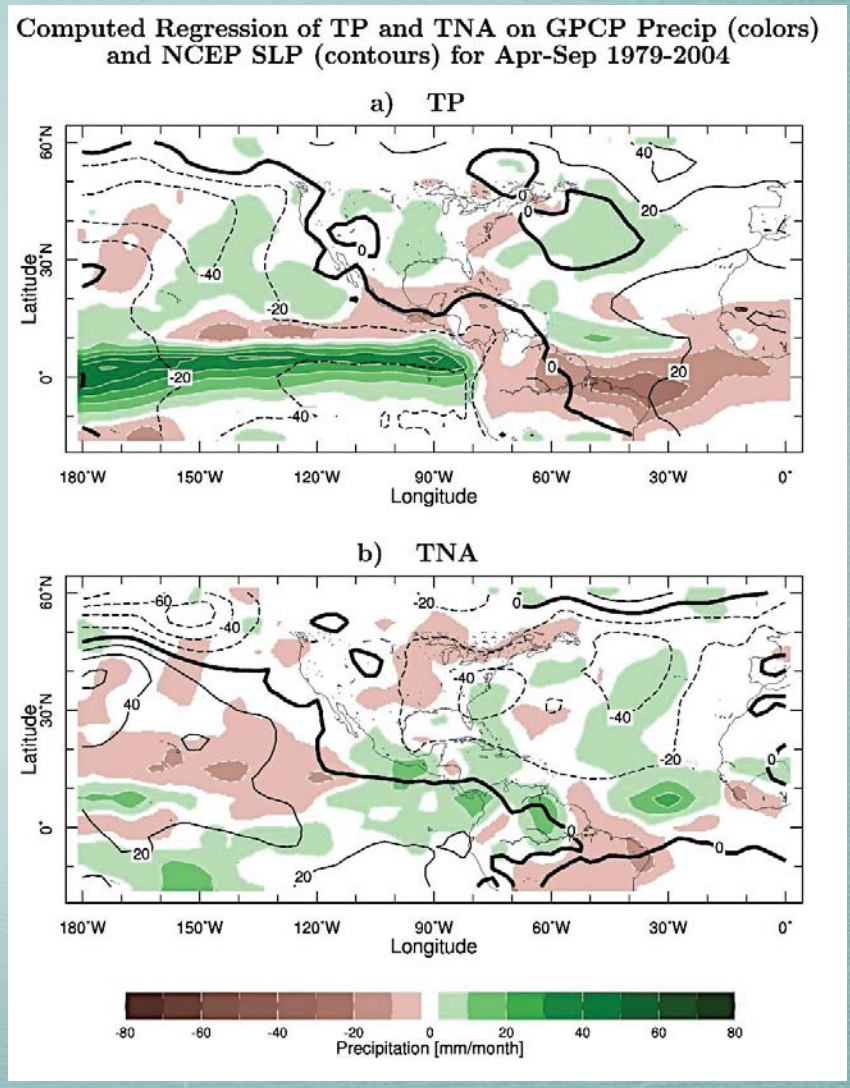
1 Jun start



13

Evidence from Observations





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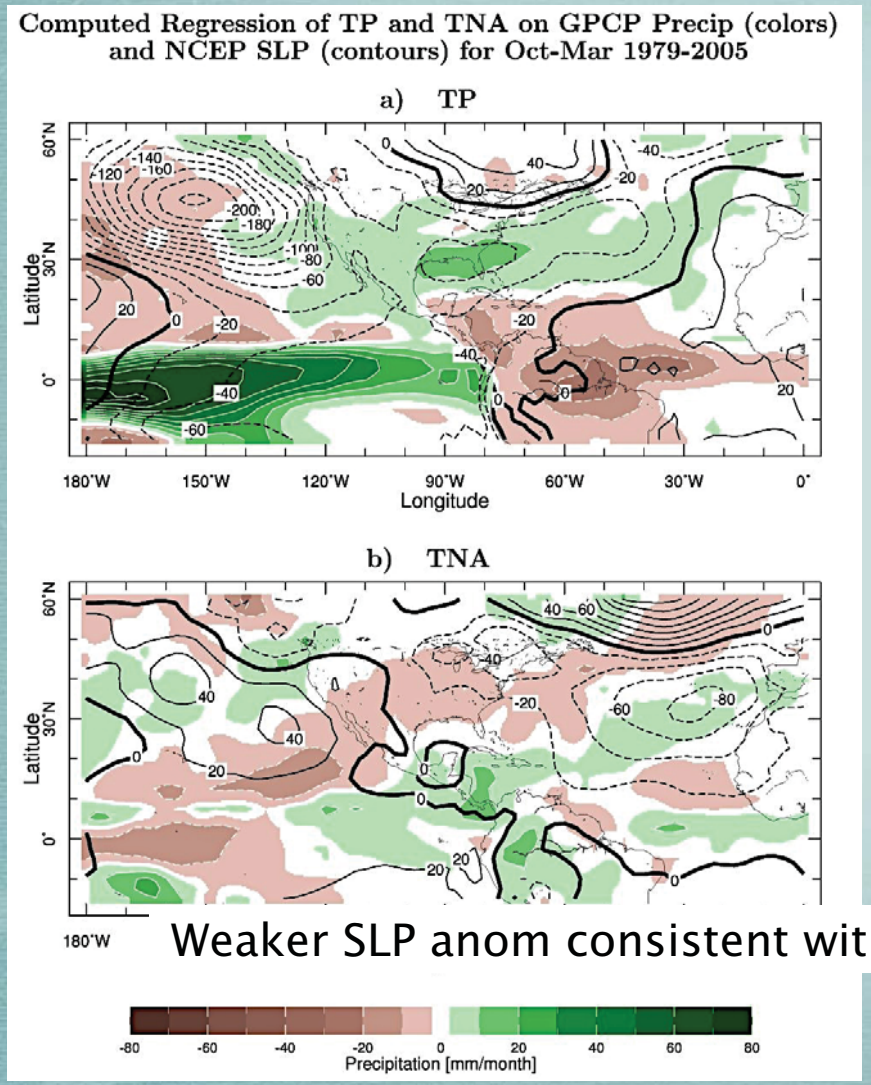
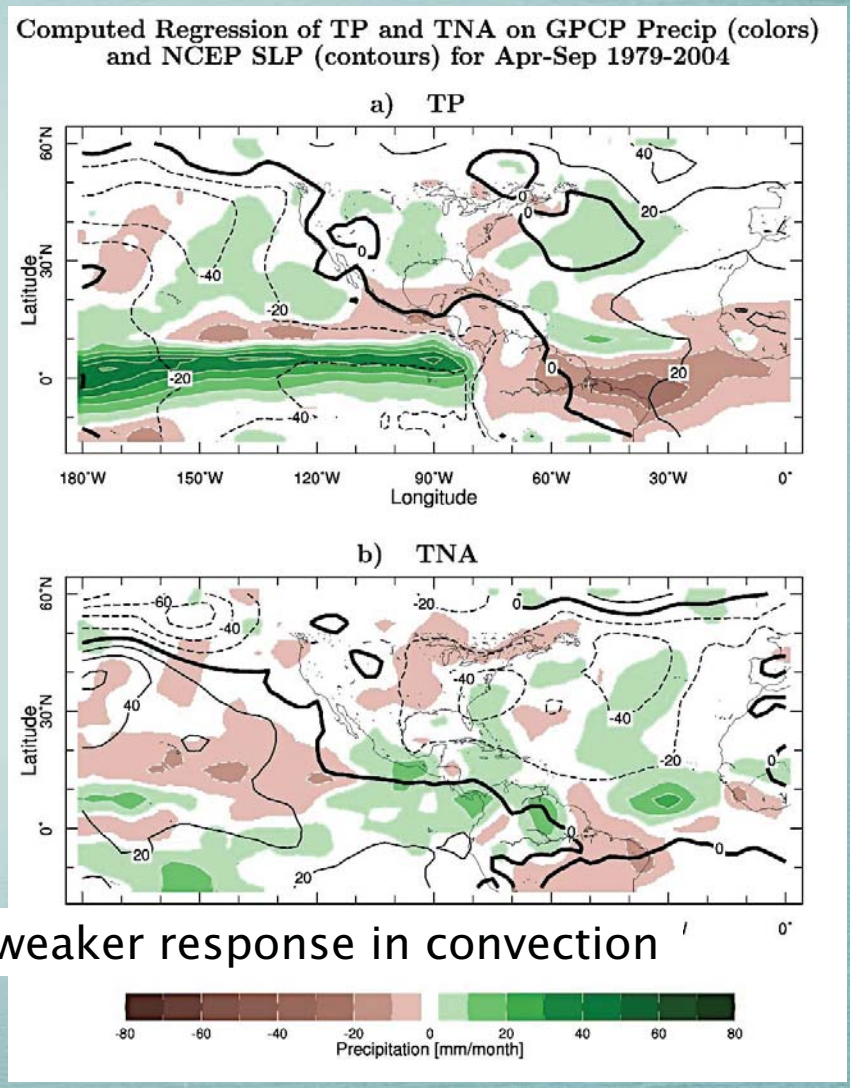
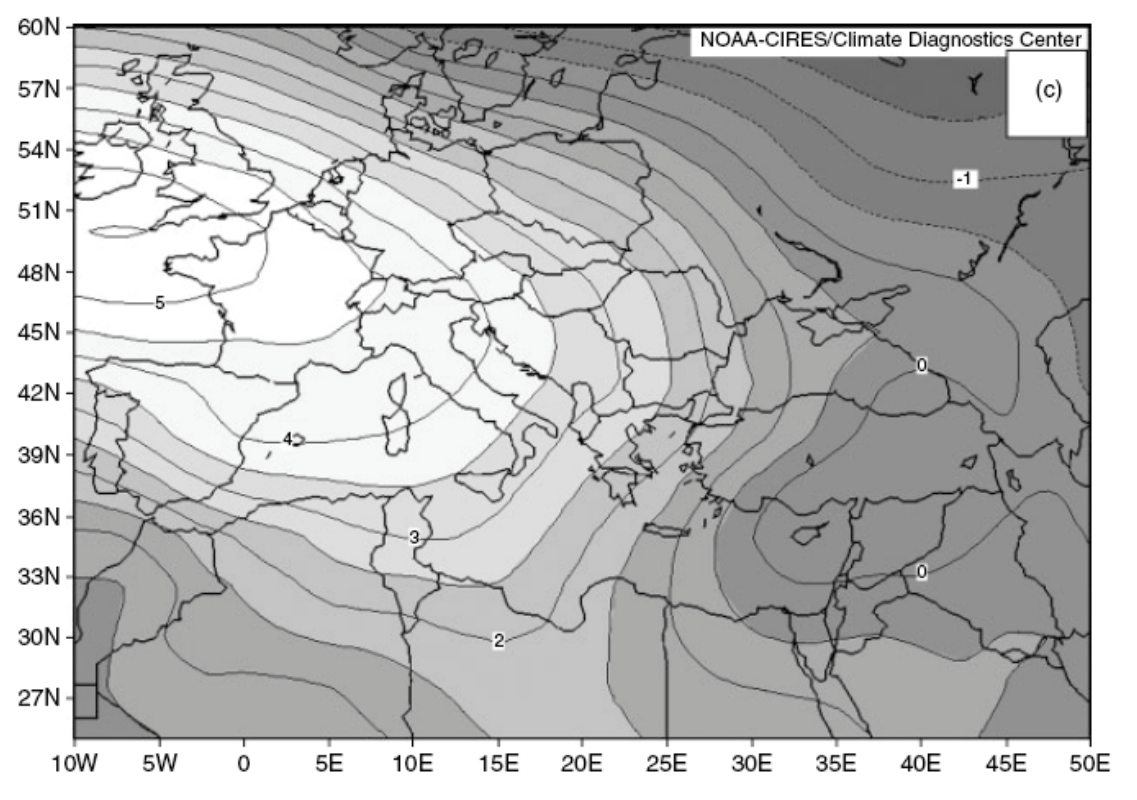




Weaker SLP anom consistent with weaker response in convection

East Atlantic - Levant Teleconnections

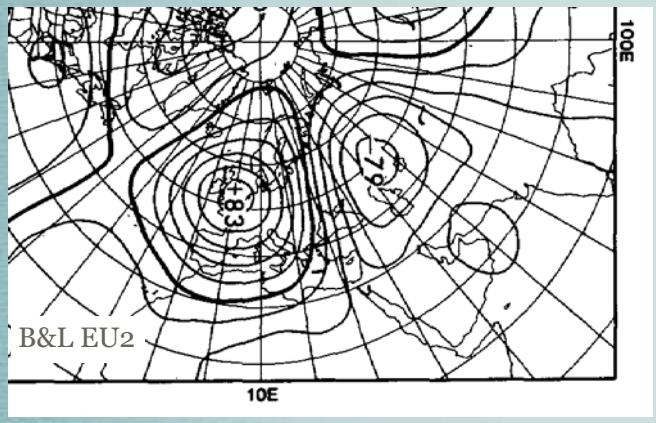


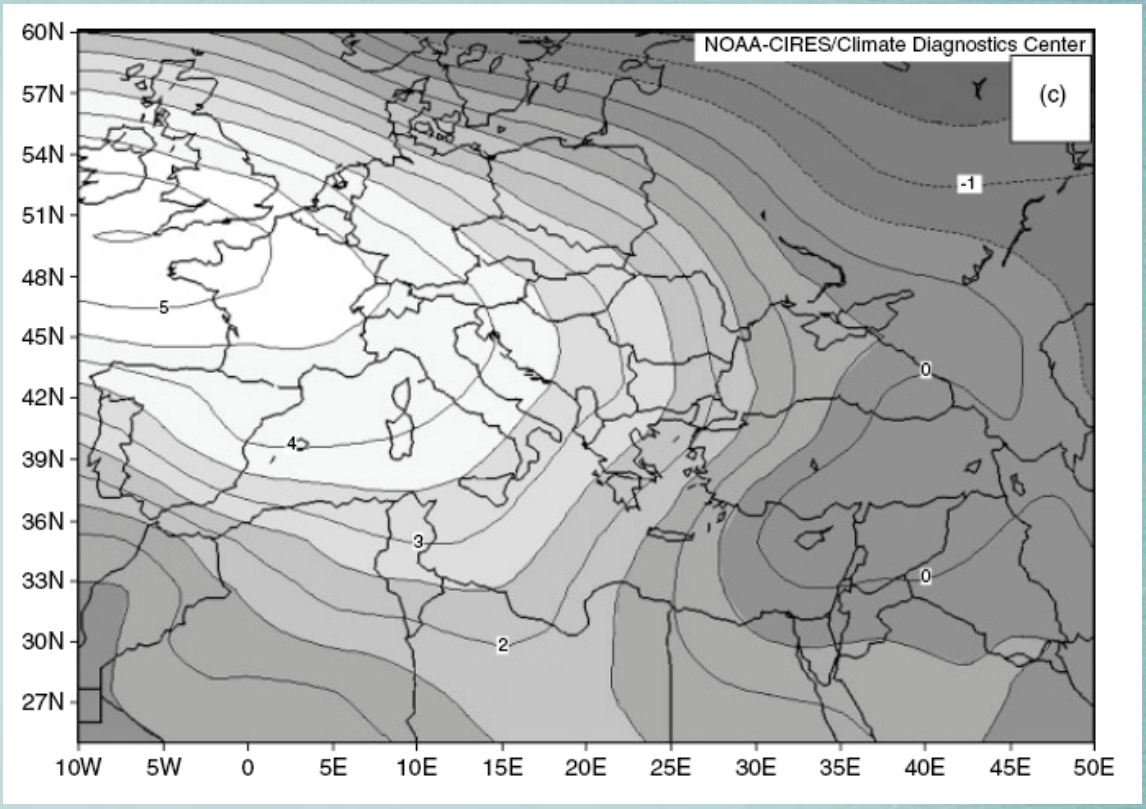
The SLP difference between wet and dry years points at a seesaw between the Eastern Atlantic and the Eastern Mediterranean.

Ziv et al. (2006)

15

East Atlantic - Levant Teleconnections





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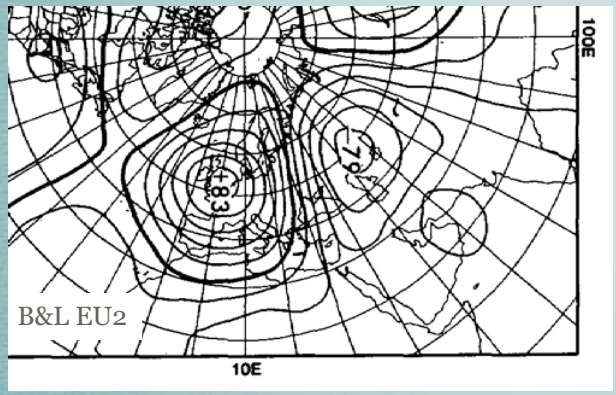

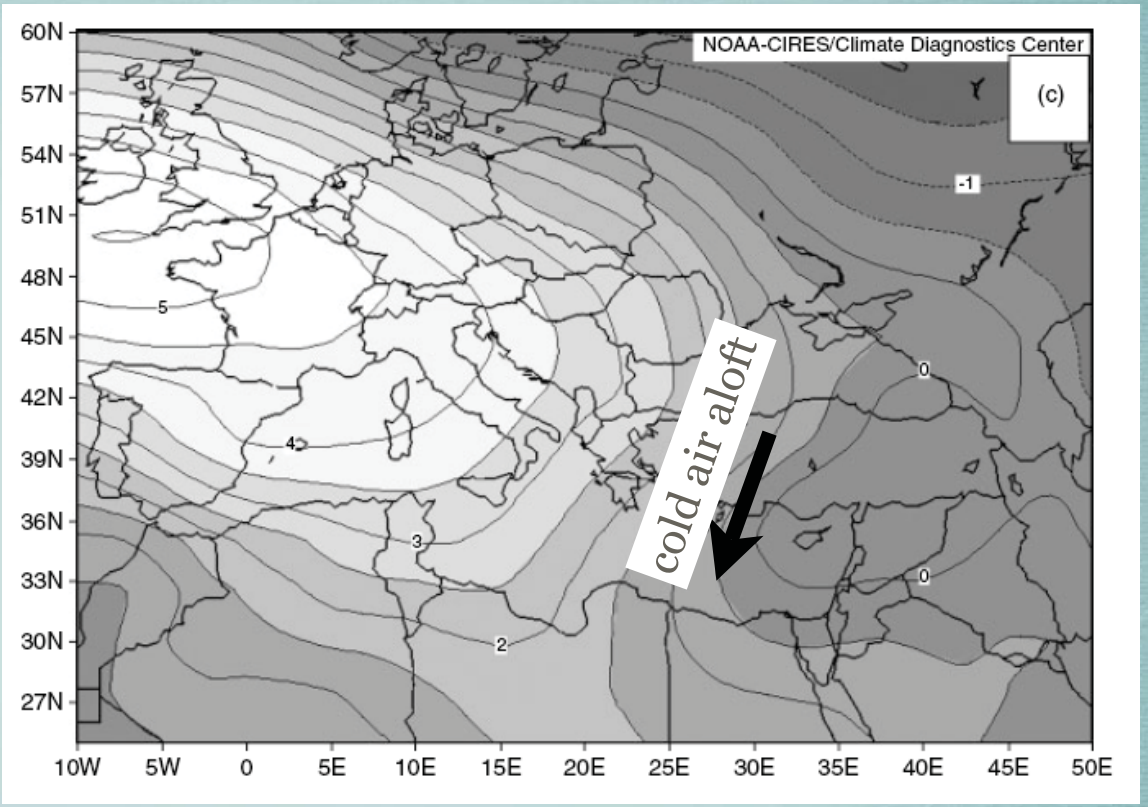

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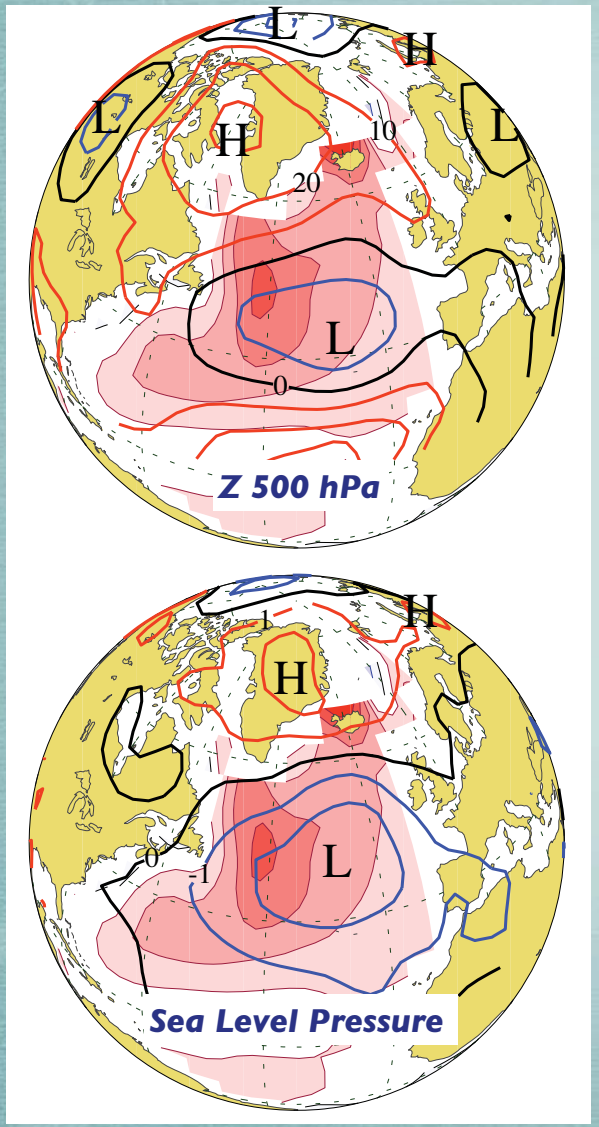
1950-1965 (warm Atlantic)
minus
1970-1985 (cold Atlantic)
Kushnir (1994)



Simulation of orbital forcing

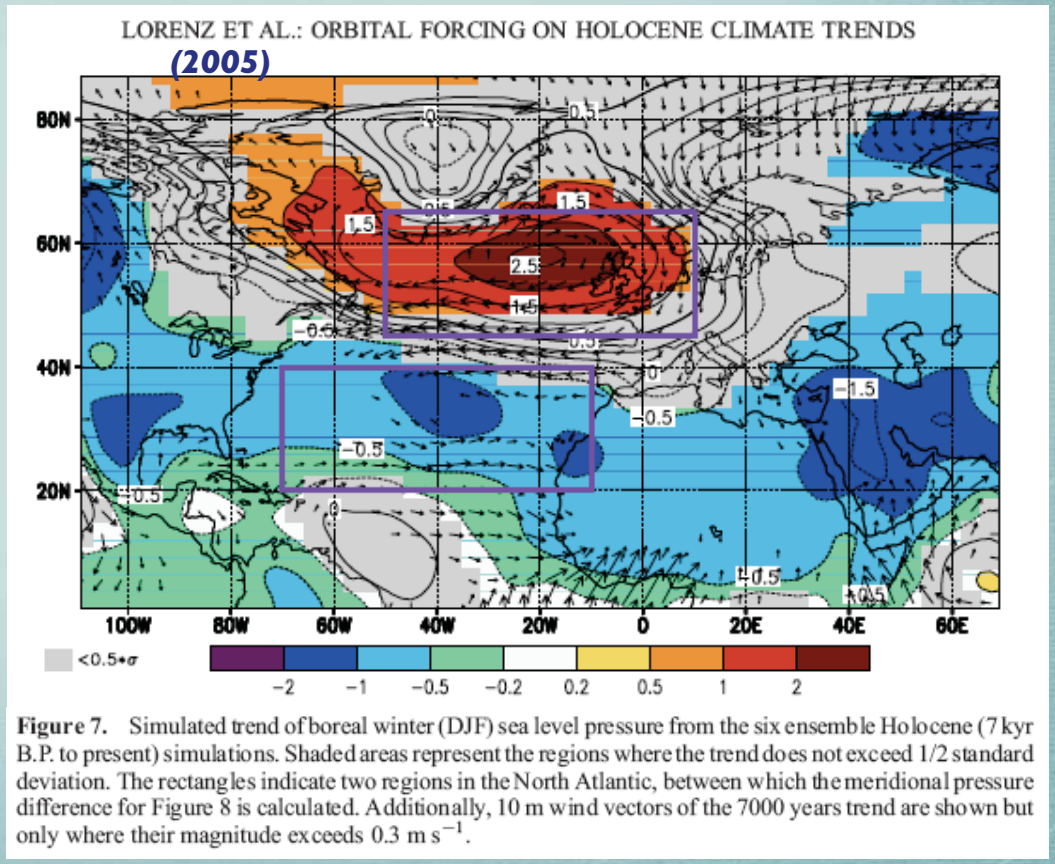


Figure 7. Simulated trend of boreal winter (DJF) sea level pressure from the six ensemble Holocene (7 kyr B.P. to present) simulations. Shaded areas represent the regions where the trend does not exceed 1/2 standard deviation. The rectangles indicate two regions in the North Atlantic, between which the meridional pressure difference for Figure 8 is calculated. Additionally, 10 m wind vectors of the 7000 years trend are shown but only where their magnitude exceeds 0.3 m s^{-1}.

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Summary

- The relatively weak forcing of the AMV can modulate multidecadal variability on five continents (recall links to the Indian monsoon or NE Brazil wet season)
- The mechanism of spreading the influence appears to be the well-known set of NH atmospheric teleconnection patterns
- The critical region in the ocean is the tNAtl
- For the near future AMV has to be accounted for in Global Warming projections

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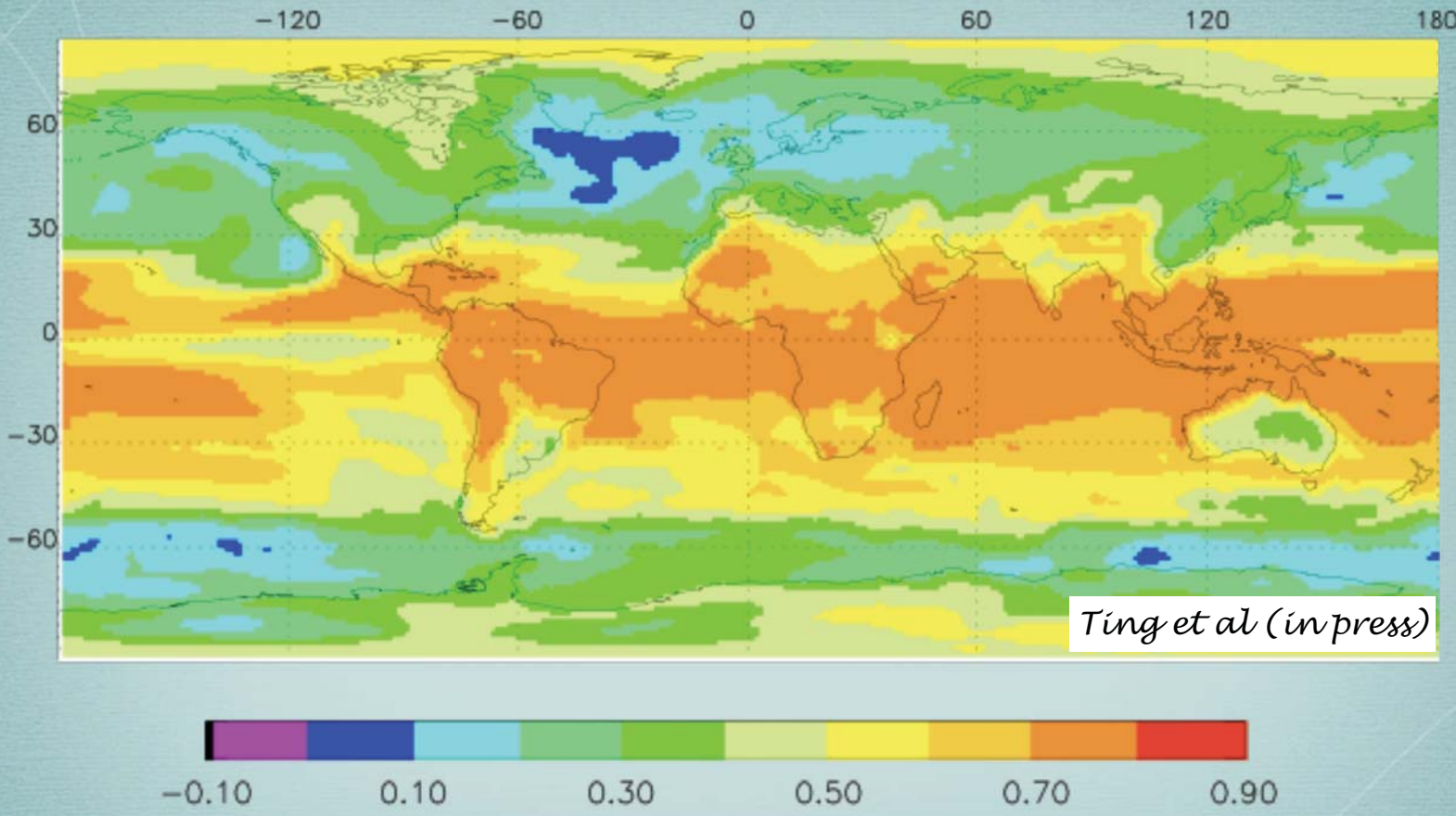
Ratio of Variance



Forced/Total variability in IPCC AR4 models (CMIP5 runs).
Results are based on 6 model ensemble with # members ≥ 4.

18

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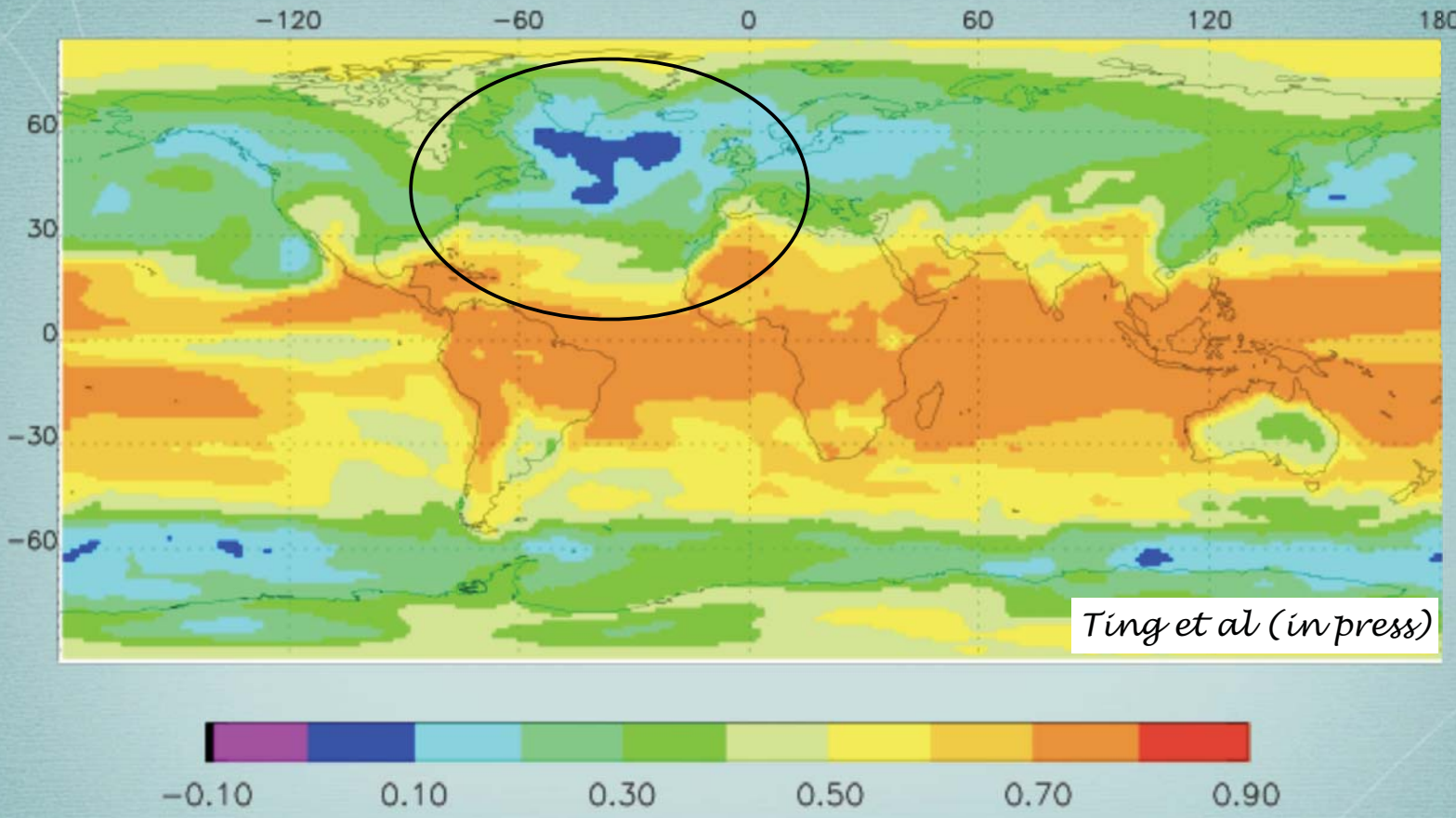

Forced/Total variability in IPCC AR4 models (CMIP5 runs).
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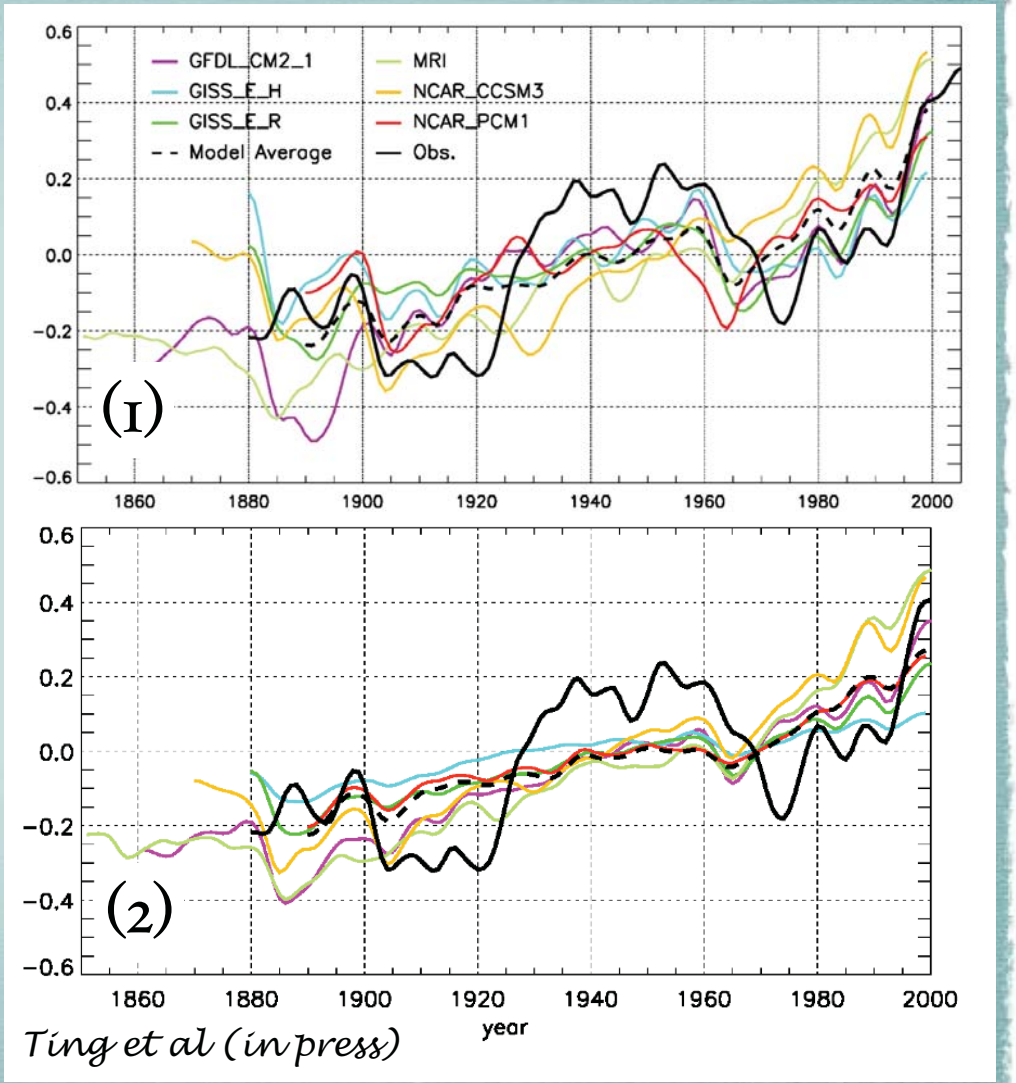
18

AMV and Global Warming

1. Annual SST anom. averaged over the N. Atl. in observations (solid black) and 6 CGCMs ensembles. Dashed line is the multi-model average.

2. Solid line is the same as above. Colored lines are the projections of N. Atl. SST on each model's S/N maximizing PCs of global surface air temperatures (the externally forced signal).



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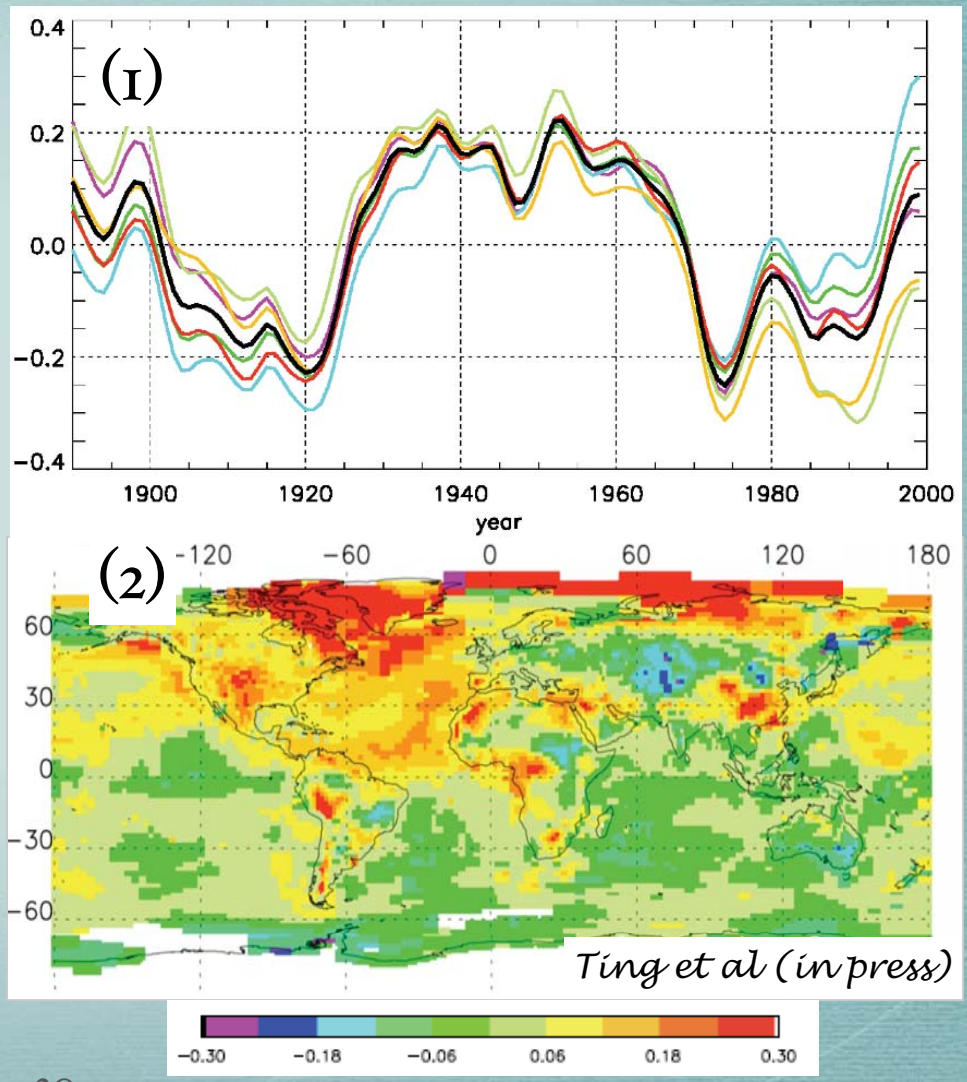
Pattern of AMV

1. Time series of annual mean SST averaged over the N. Atl. minus the externally forced signal estimated using S/N maximizing PC analysis (each color represents a different model estimate of the forced signal).

2. The projection of annual mean surface air temperature on the time series in (1).



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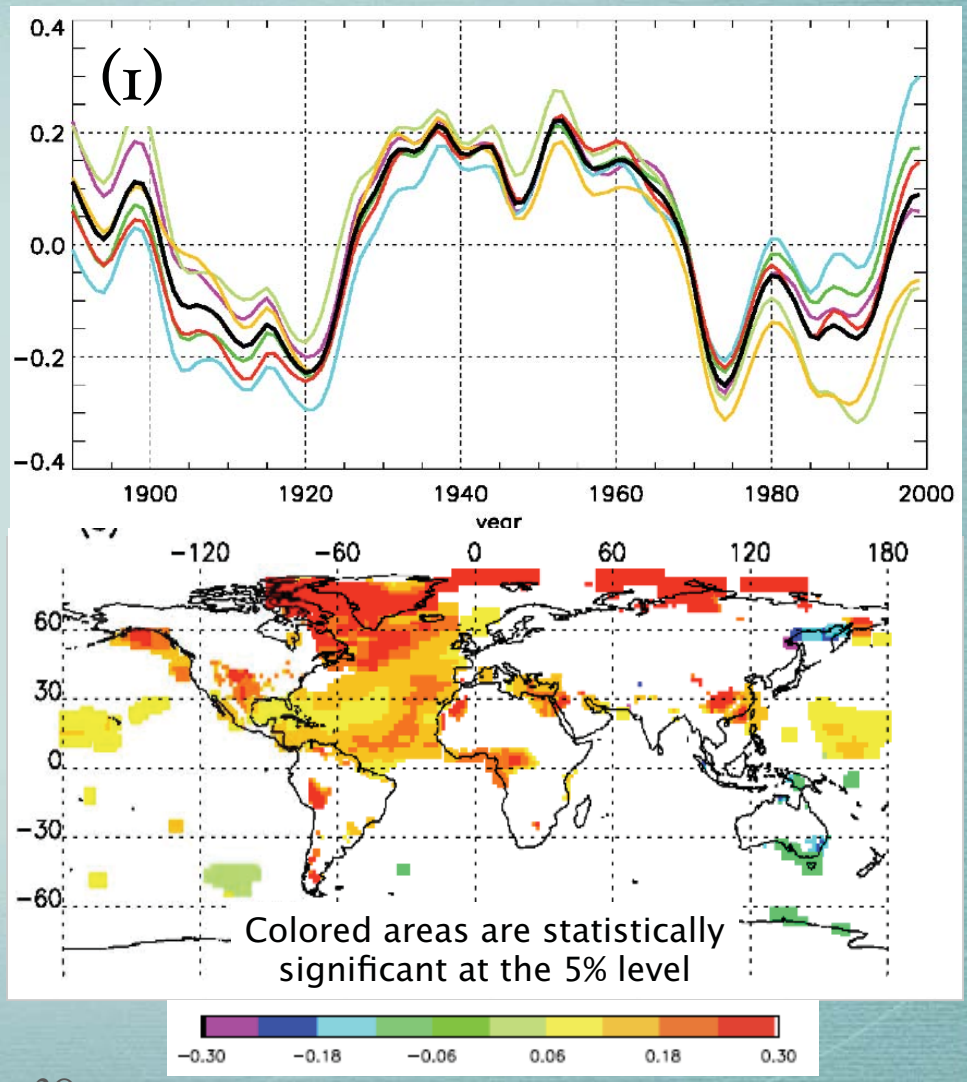

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