Attribution of Climate Change in the Presence of Unforced Variability

by John M. Wallace, Clara Deser and Brian Smoliak

Partitioning of the variability and trends

	thermodynamically induced	dynamically induced
Forced		
Free		

	thermodynamically induced	dynamically induced
Forced	radiative response to increasing GHG solar, volcanoes	
Free		COWL, NAO PNA, ENSO

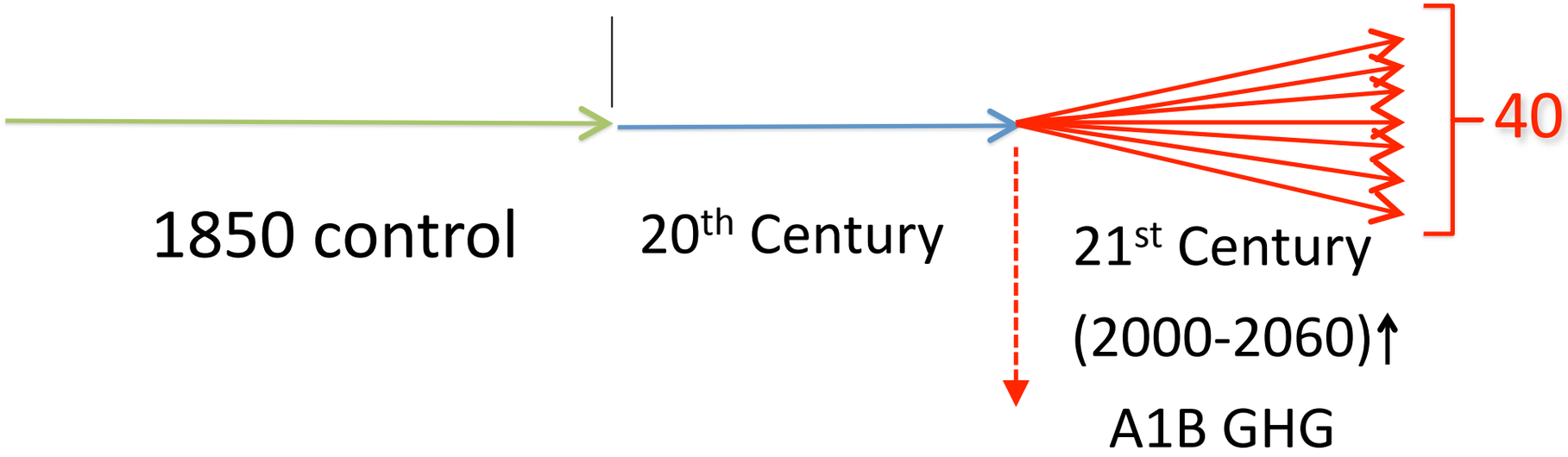
	thermodynamically induced	dynamically induced
Forced		ozone hole polar amplification heating gradients “robust responses”
Free	ENSO response to AMV	

In an Ensemble Model Simulation

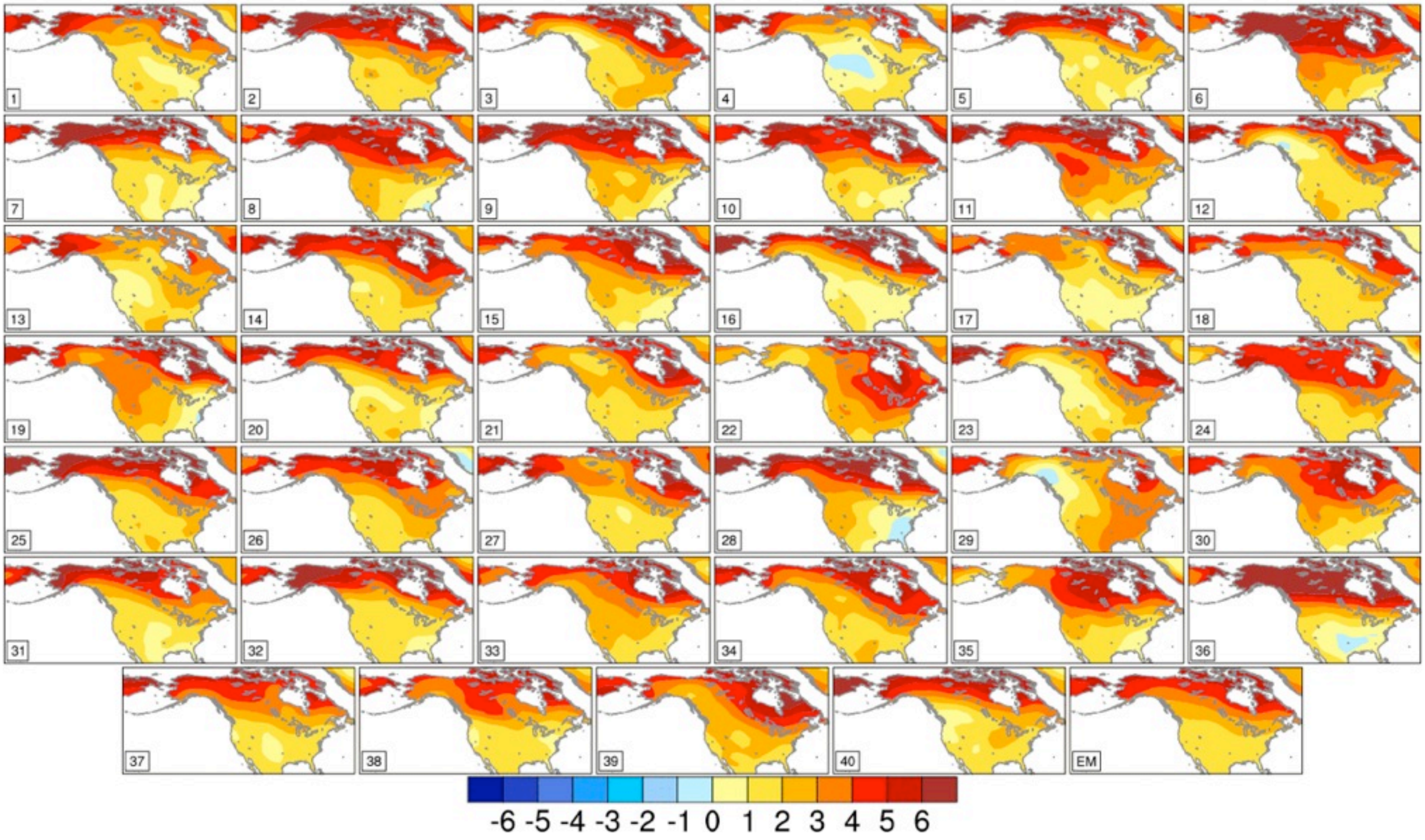
	thermodynamically induced	dynamically induced
Forced	ensemble mean	
Free	ensemble member — ensemble mean	

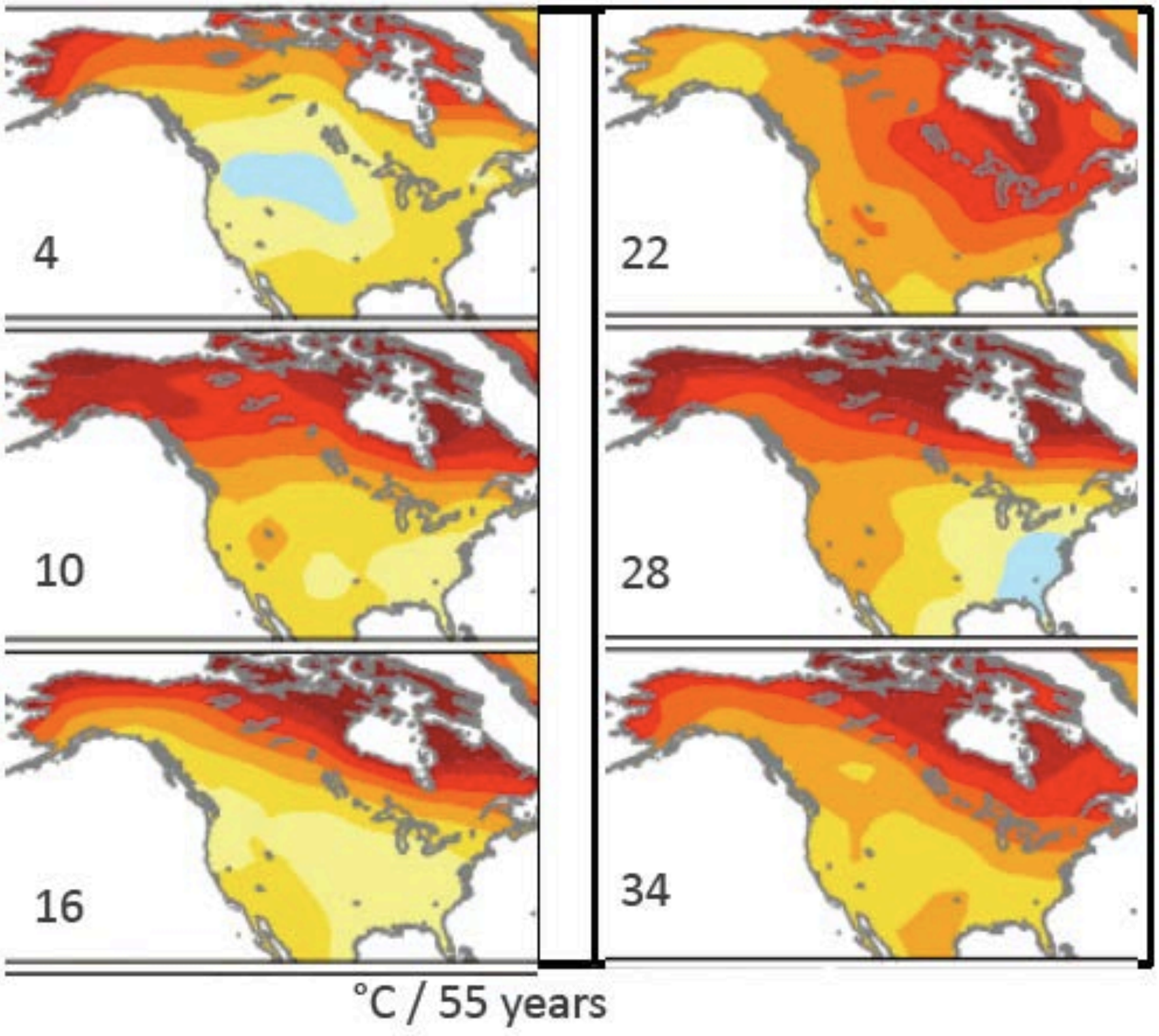
	thermodynamically induced	dynamically induced
Forced	residual	dynamical contribution
Free		

40 CCSM3 Integrations



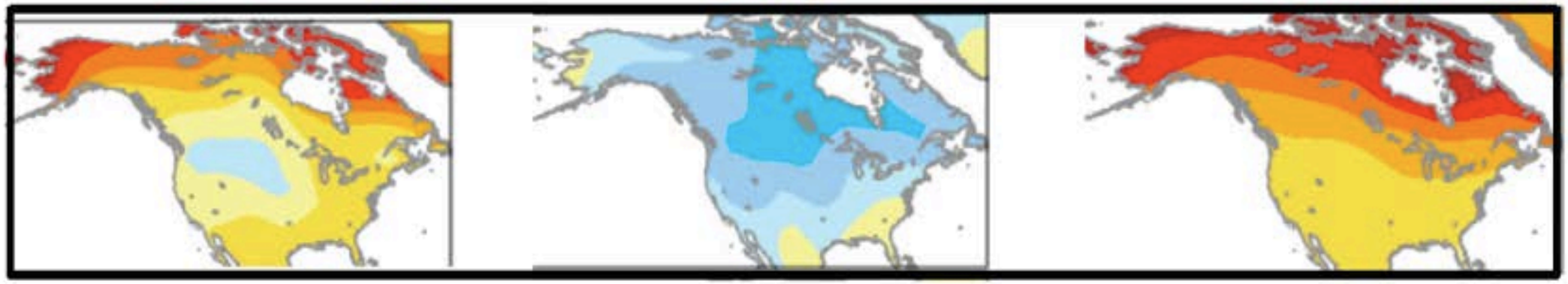
Raw DJF CCSM3 Lg. Ens. TREFHT 2005-2060 Trends

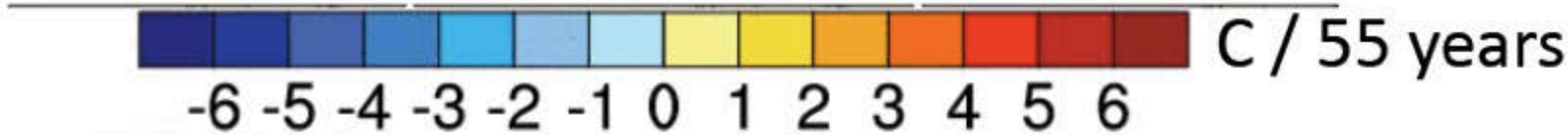



4
10
16
22
28
34
°C / 55 years
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6

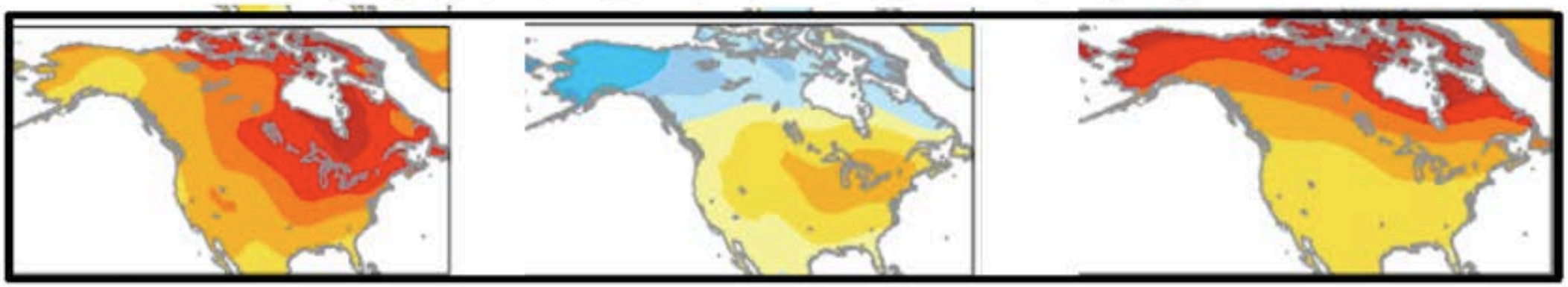
Total = Free + Forced

Run # 4

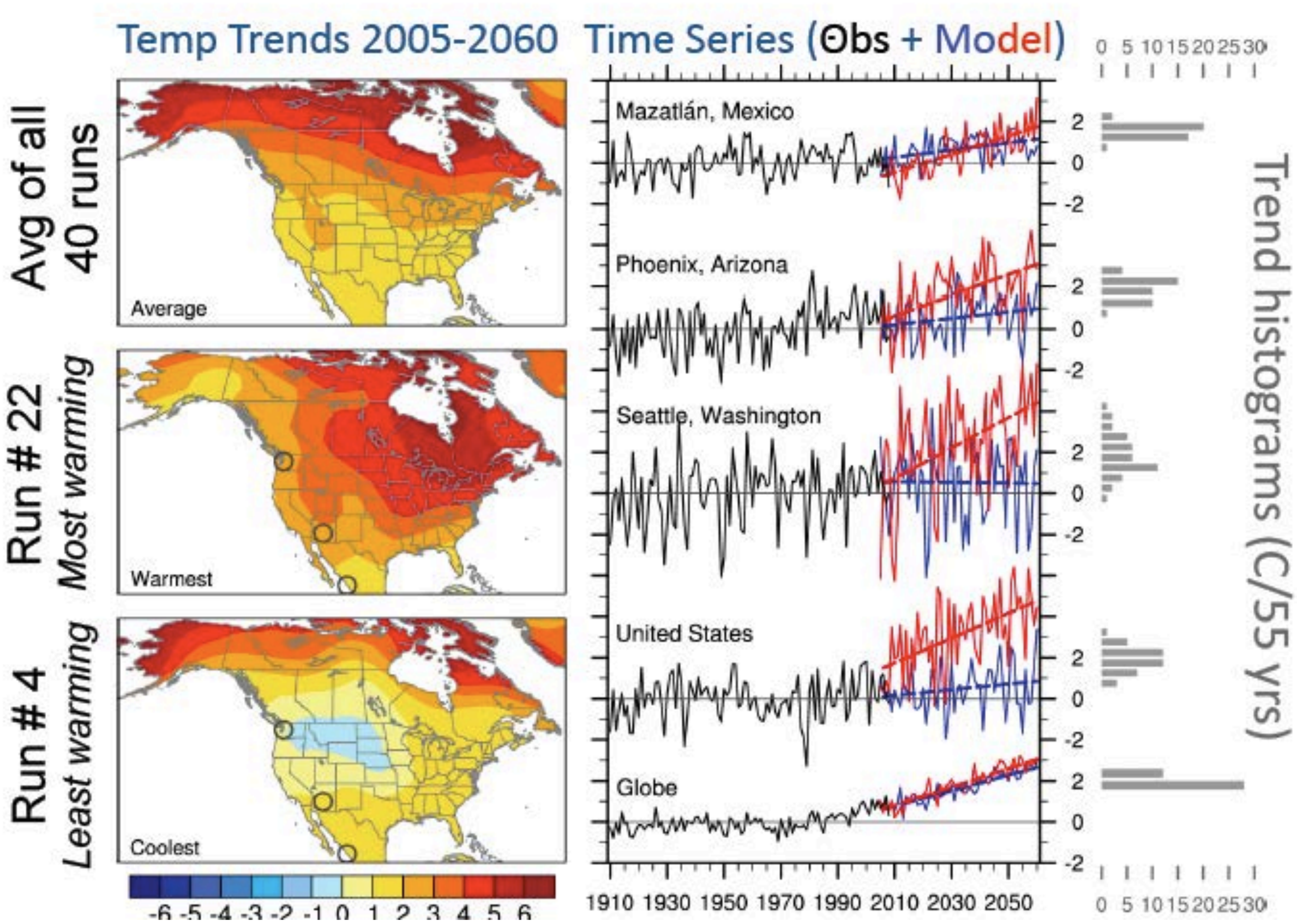




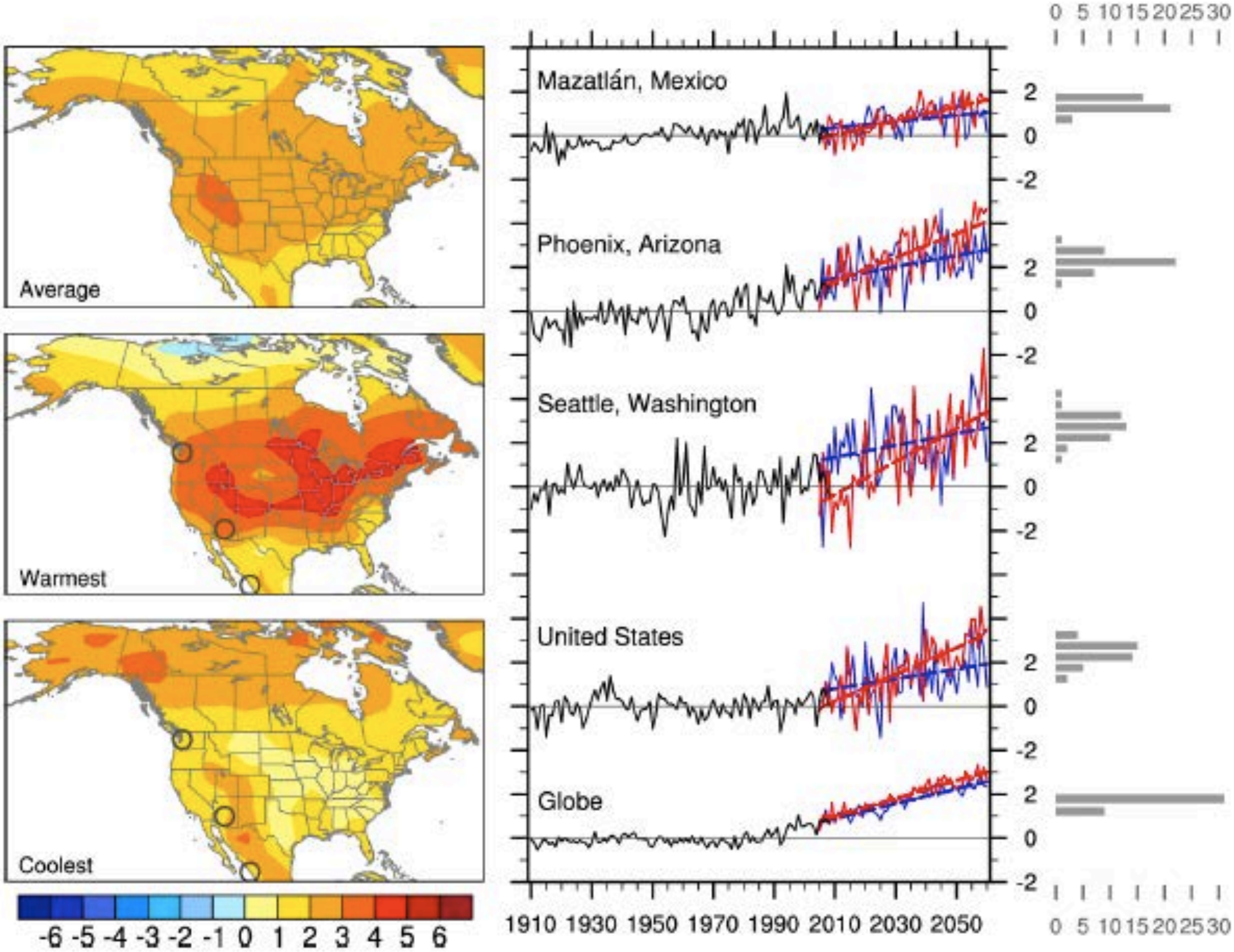
Run # 22



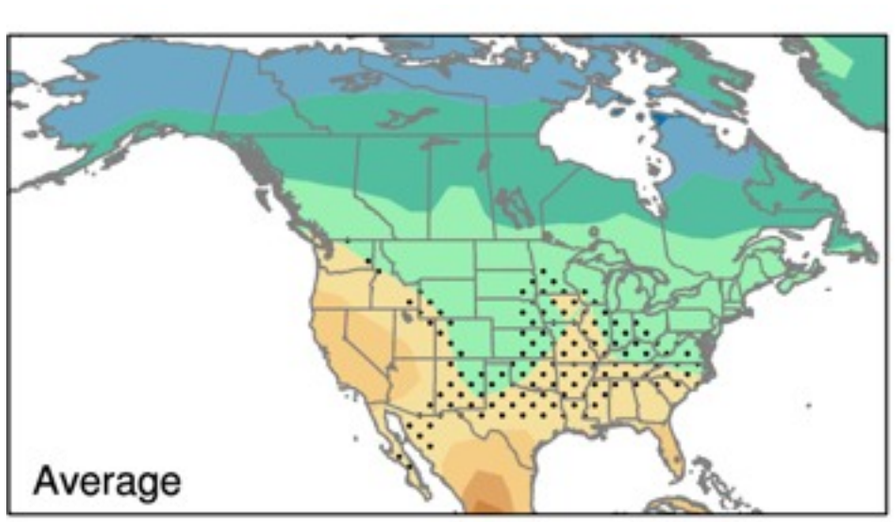
DJF SAT Trend 2005-2060

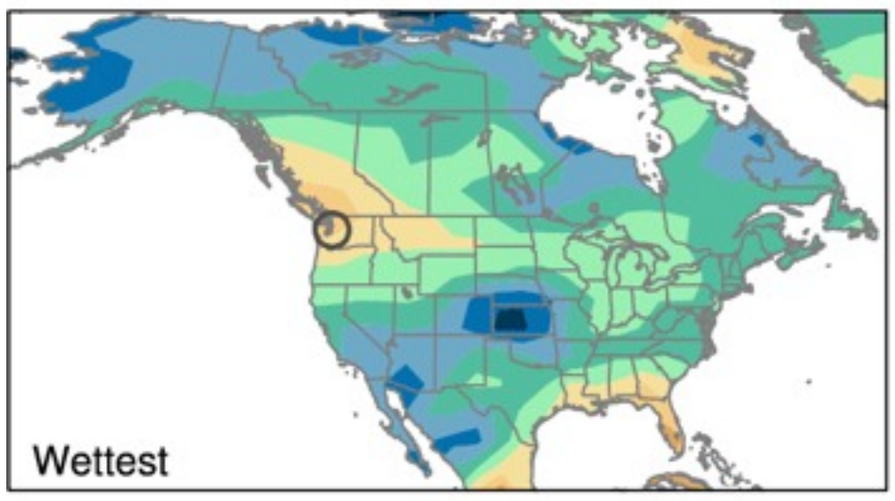


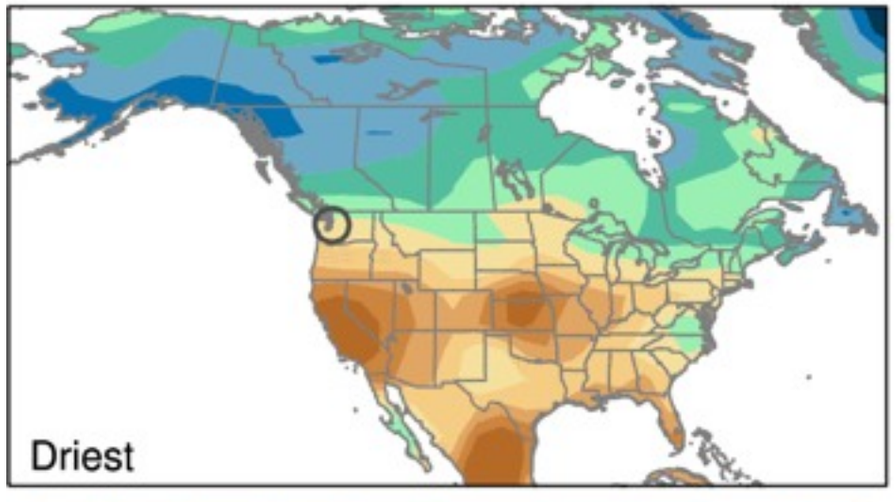
JJA SAT Trend 2005-2060

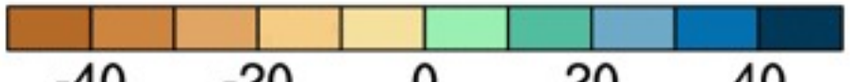


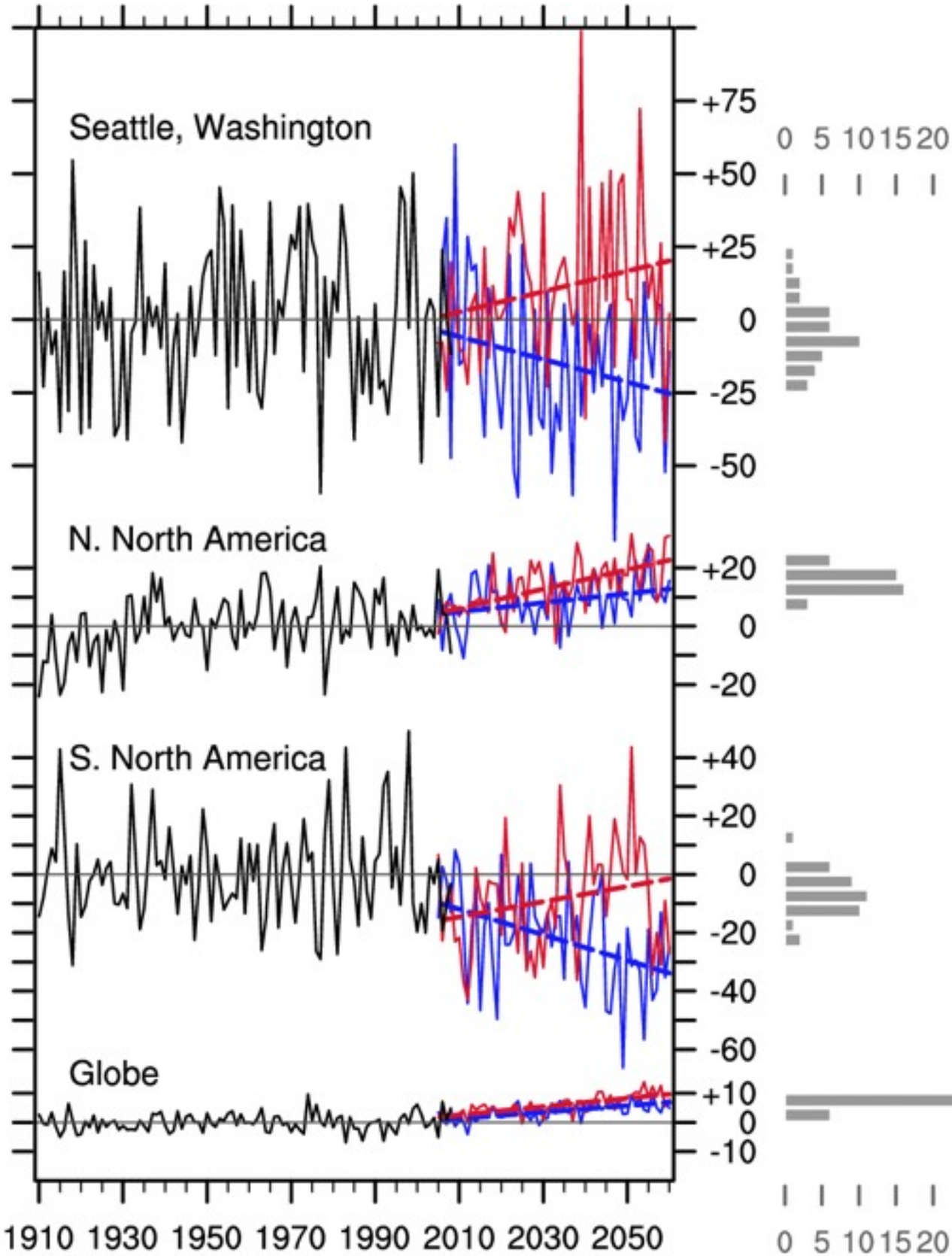
JJA Precipitation Trend 2005-2060



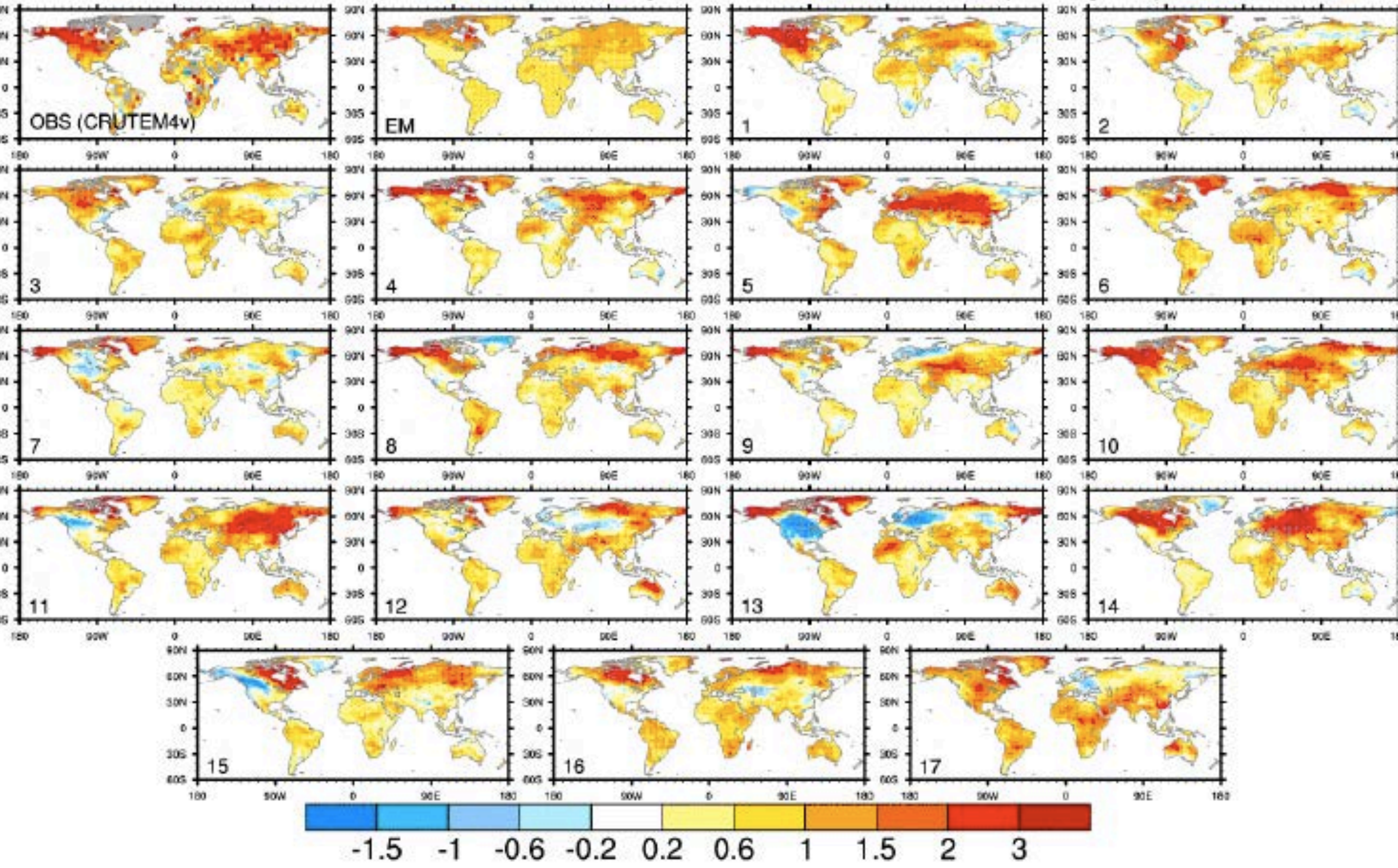








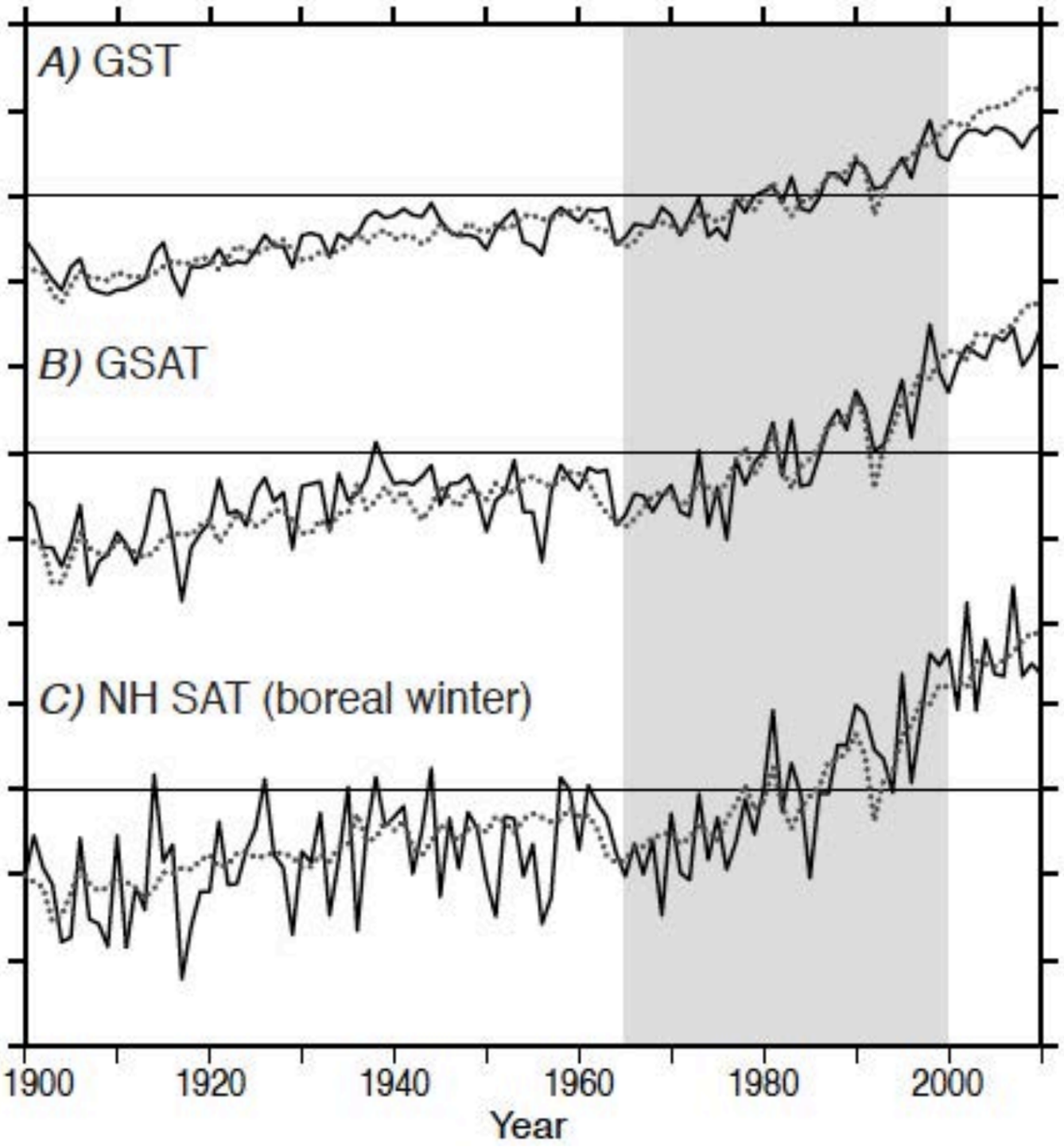
NDJFMA ESSENCE temp2 Trend 1970-2005 (K 36yr-1)



ECHAM Model

Simulated versus observed patterns of warming over the extratropical Northern Hemisphere continents during the cold season

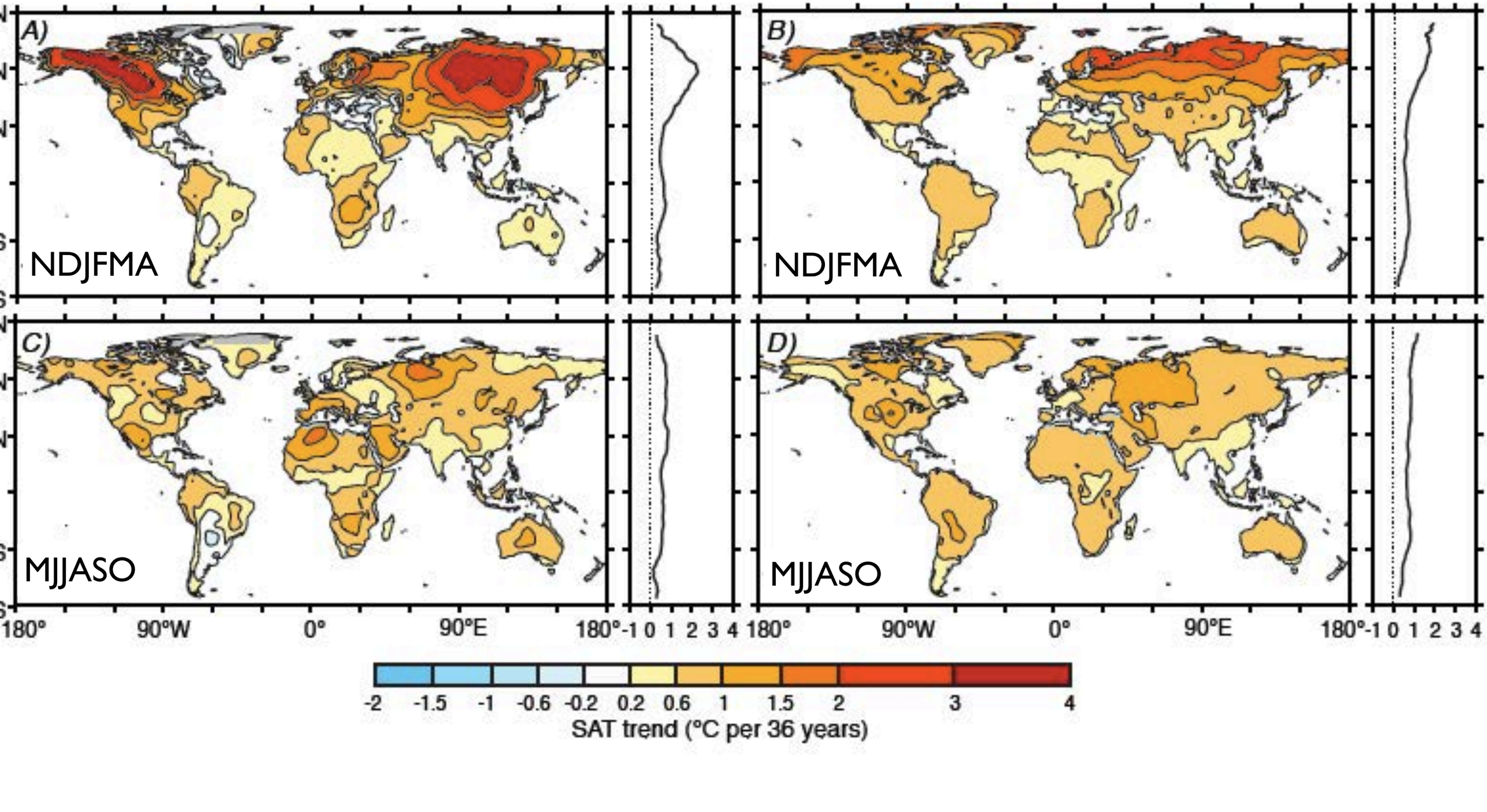
John M. Wallace[a,1], Qiang Fu[a,b], Brian V. Smoliak[a], Pu Lin[a], and Celeste M. Johanson[a]



PNAS
2012

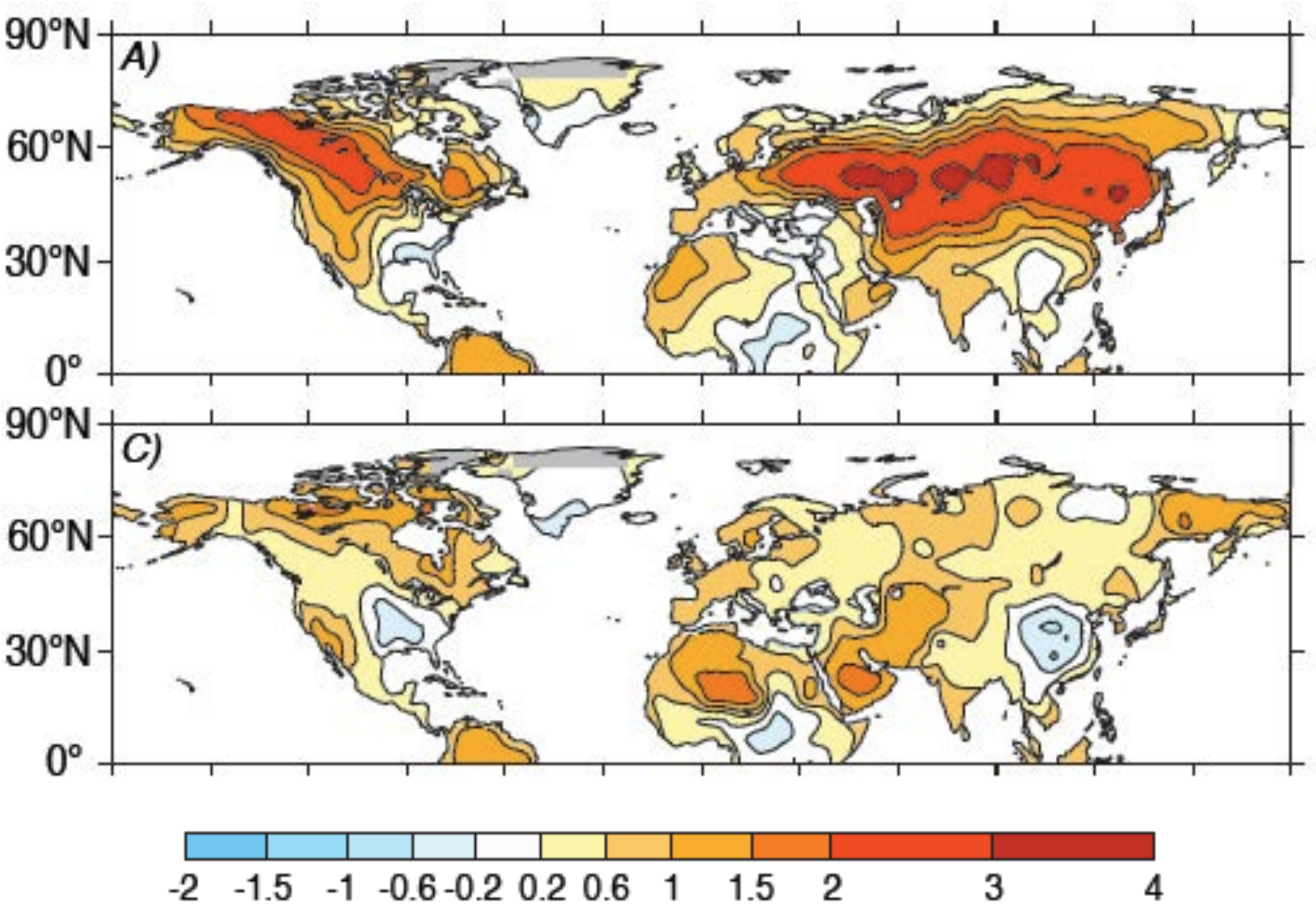
Observations (NOAA MLOST)

AR4 Models Ensemble Mean



NDJFMA

SAT Trends 1920-2008

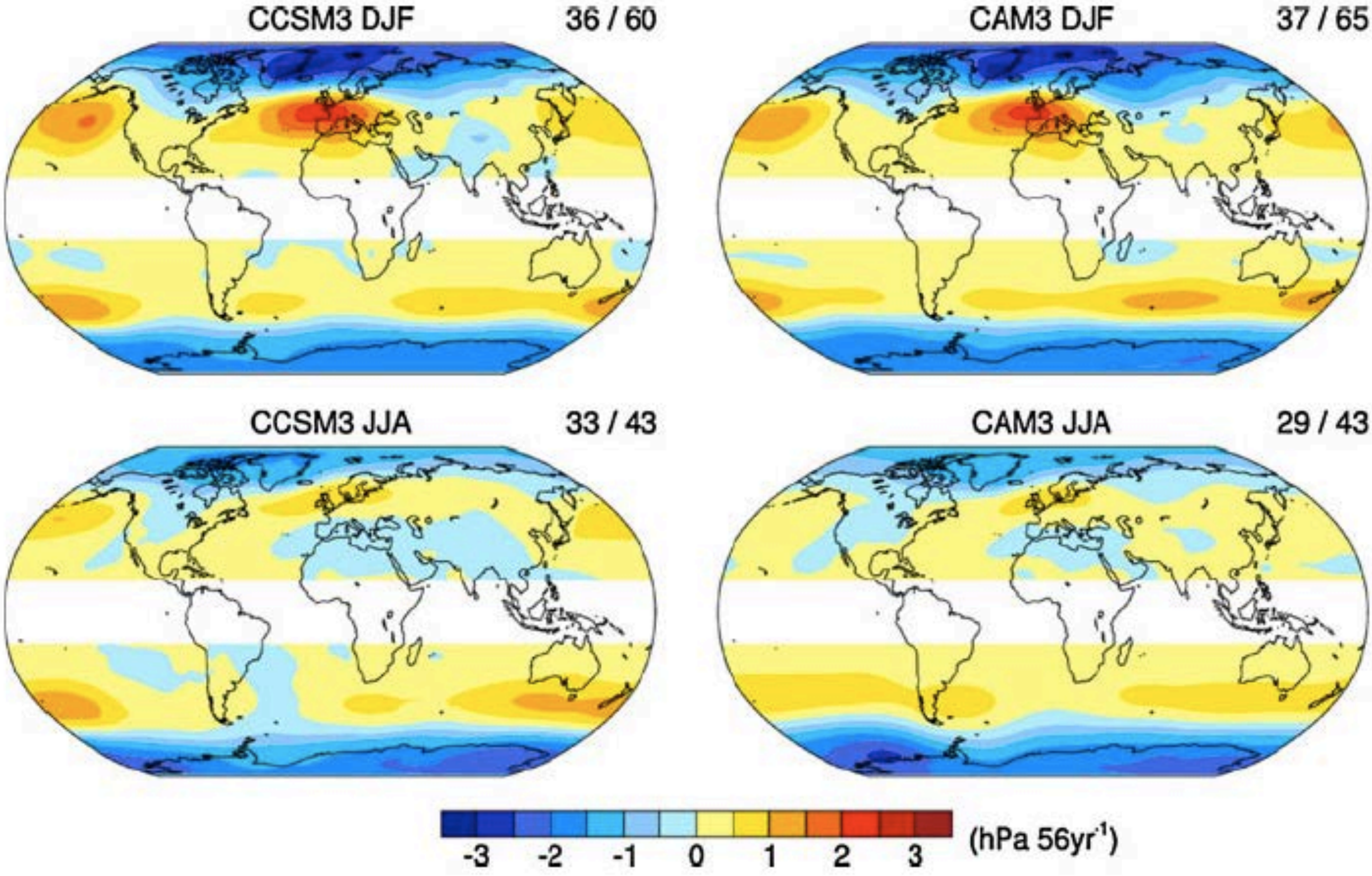


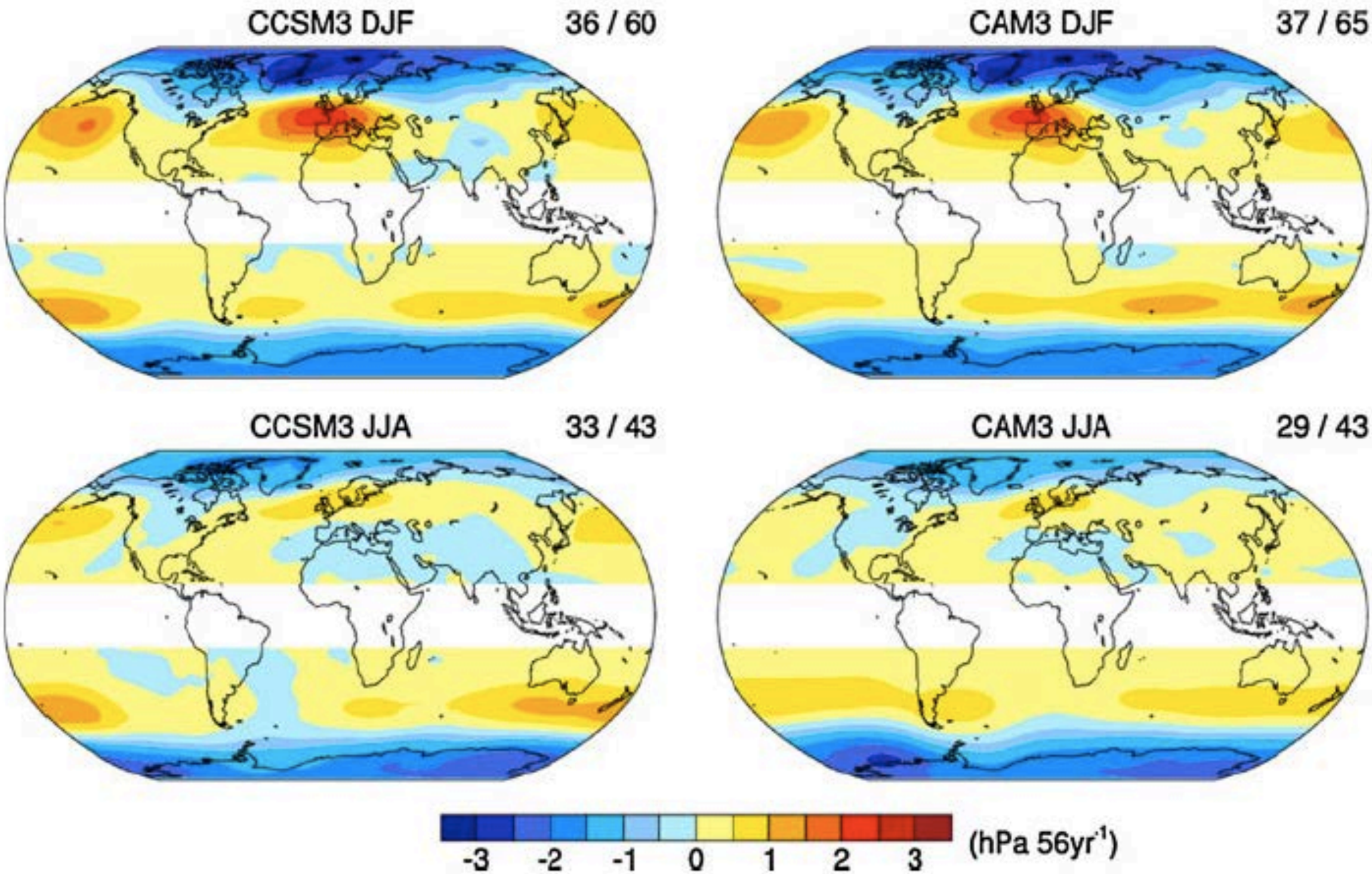
Uncertainty in climate change projections: the role of internal variability

Clara Deser · Adam Phillips · Vincent Bourdette · Haiyan Teng

Clim Dyn (2012) 38:527–546

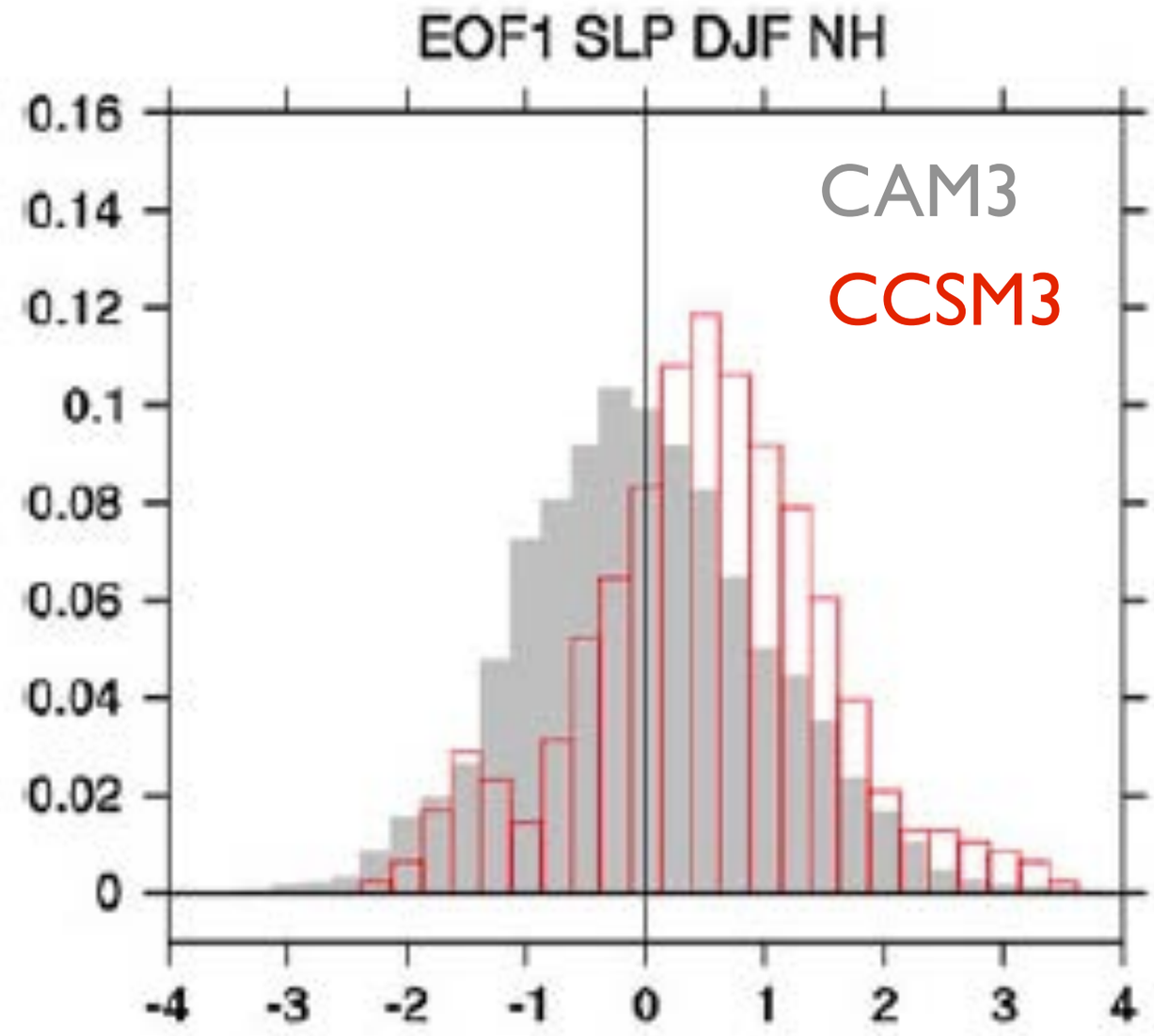
Leading EOF of 2005-2060 SLP Trends

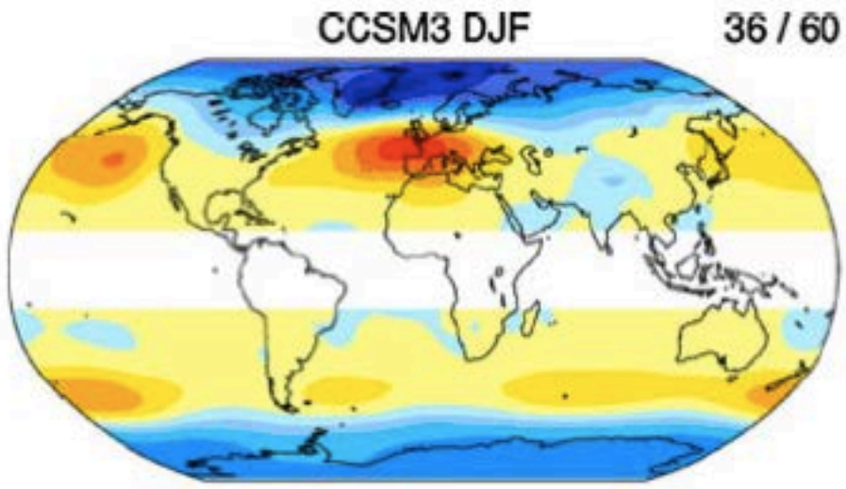


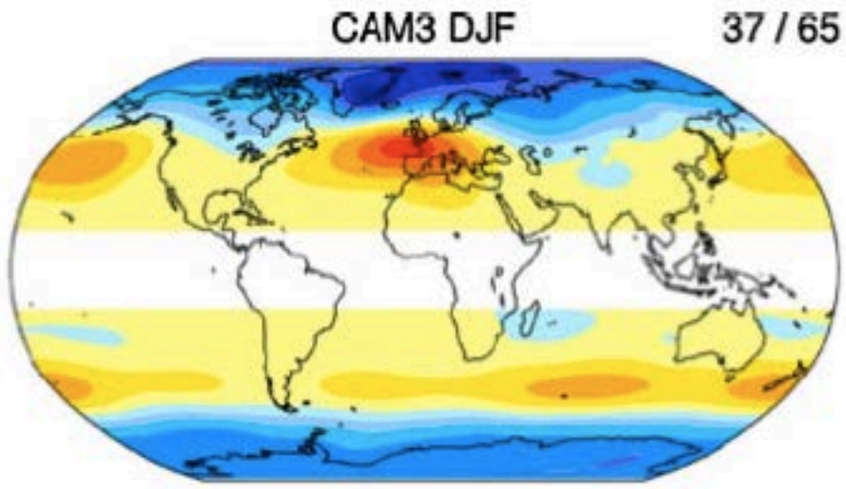


Note that amplitudes in CCSM3 and CAM3 are comparable

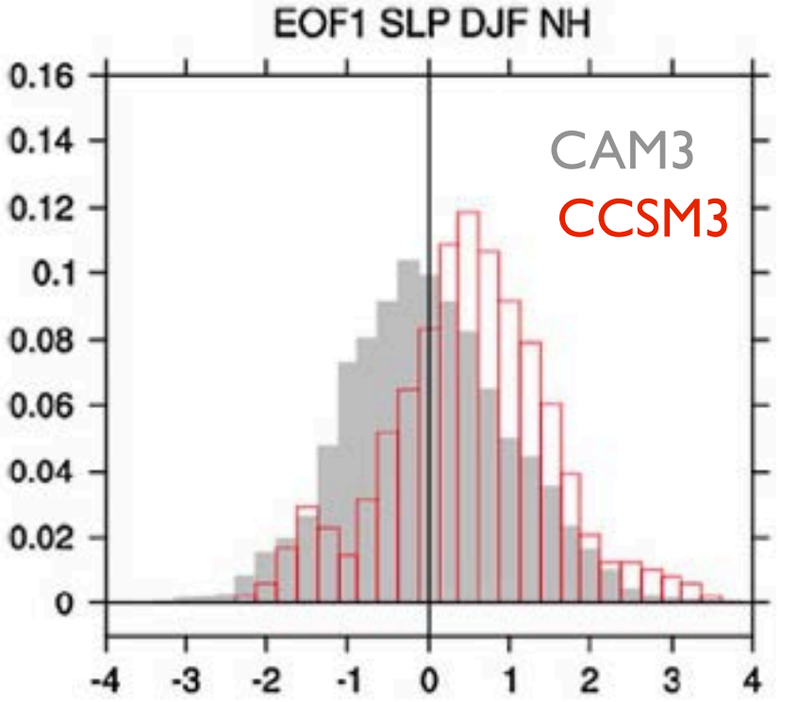
2005-2060 SLP Trends

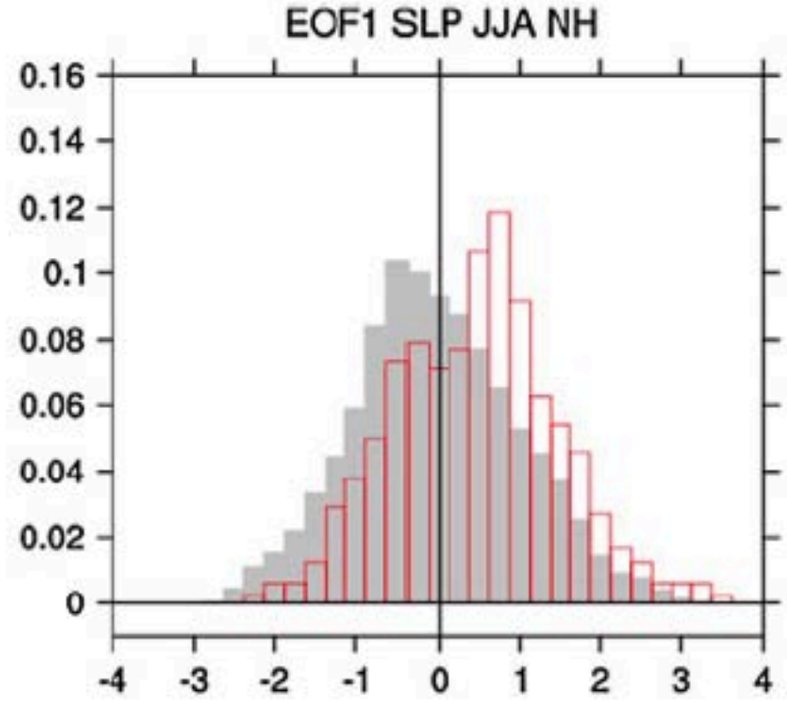


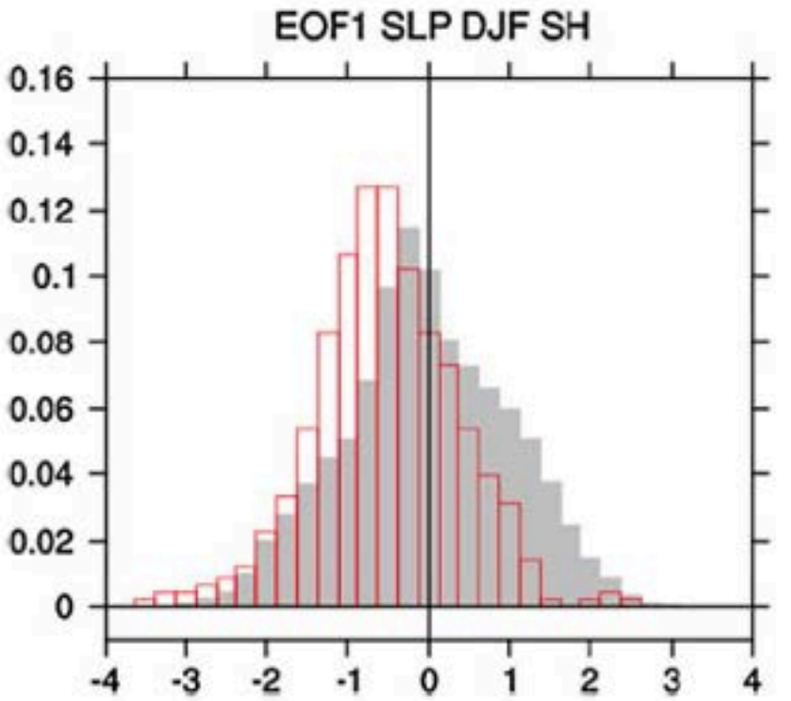


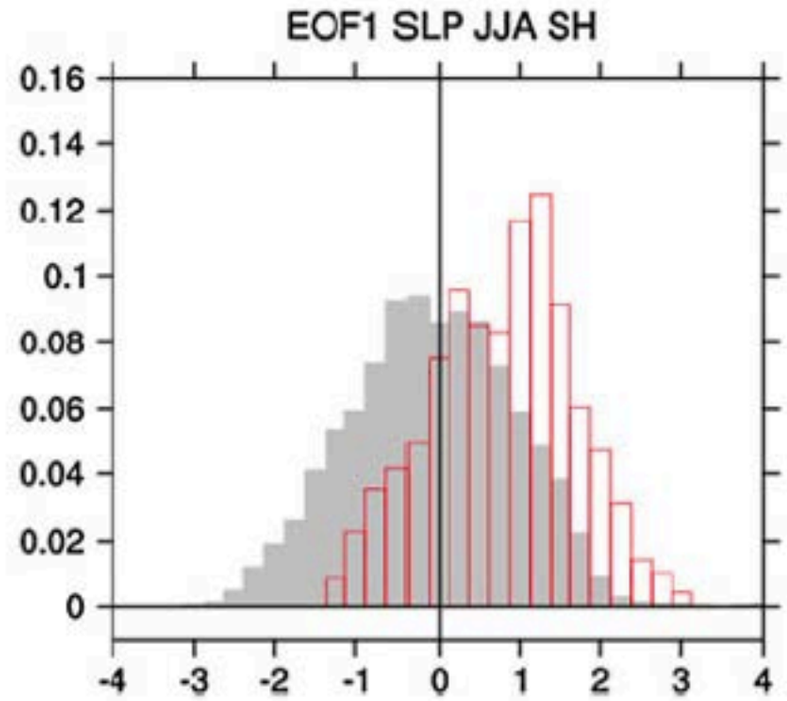


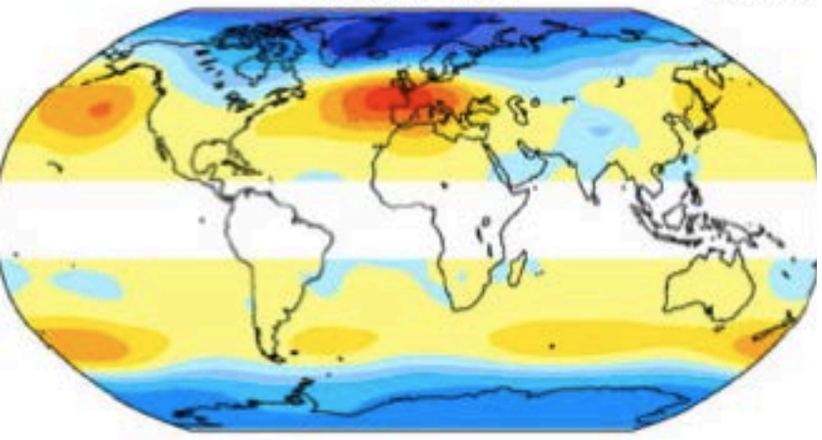
2005-2060 SLP Trends

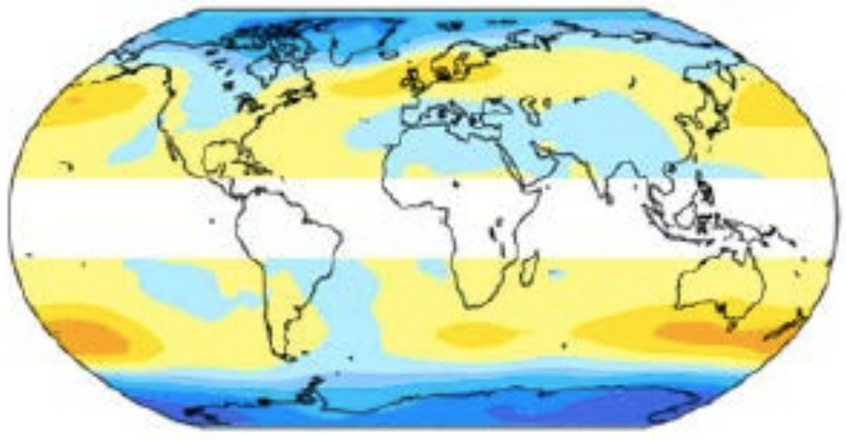






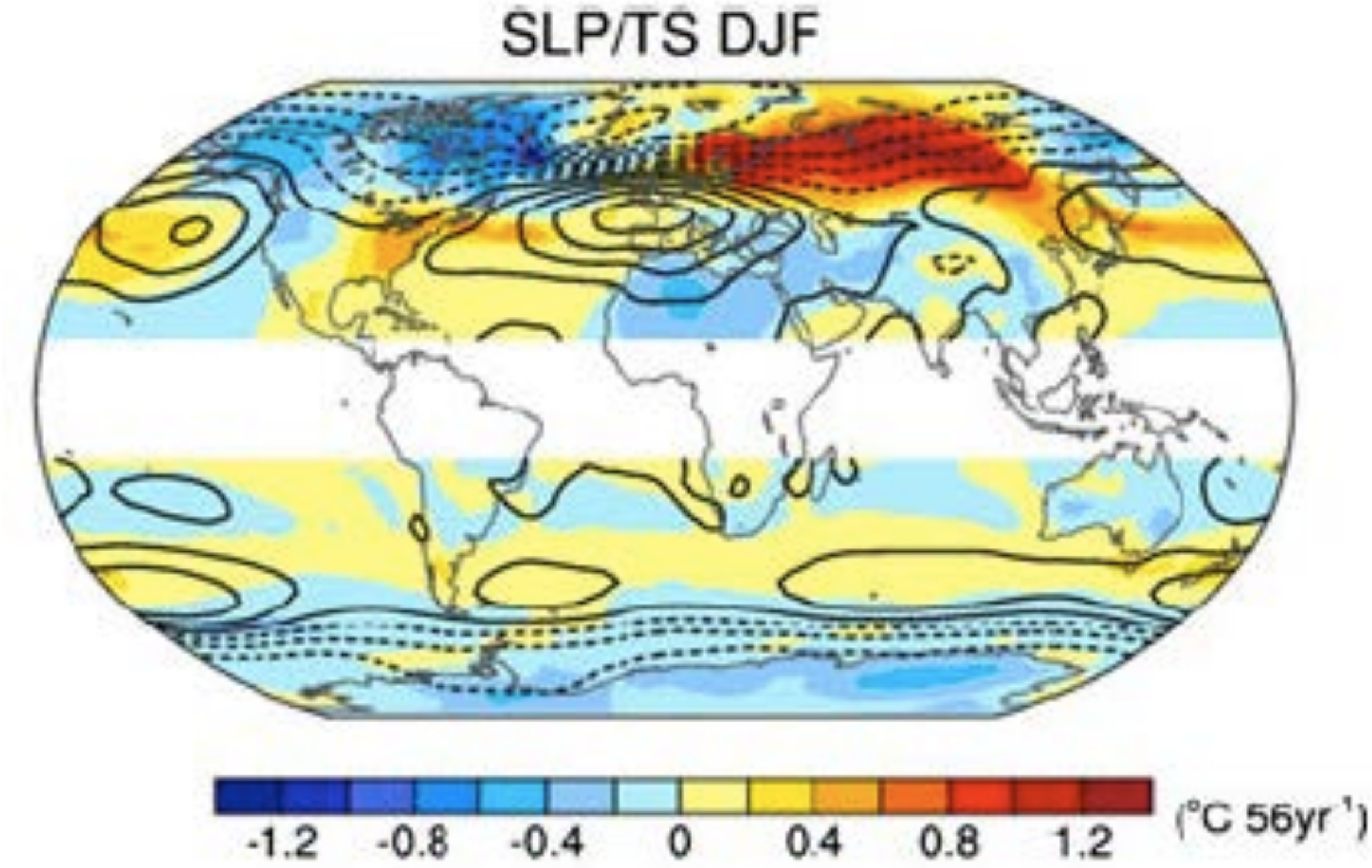




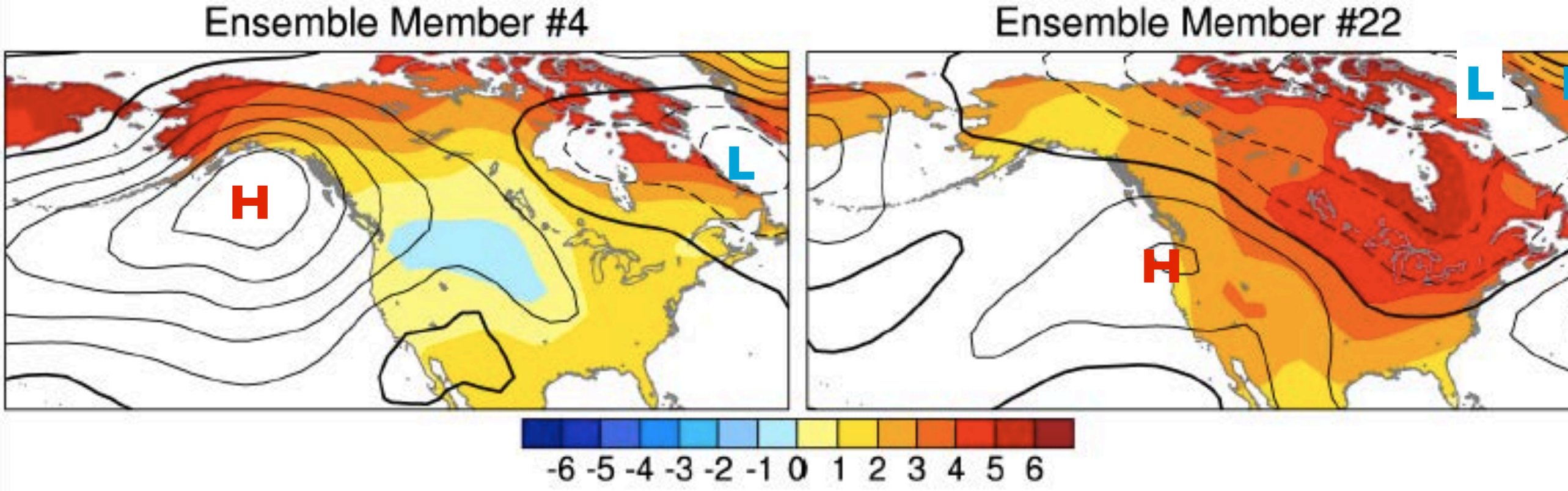


	thermodynamically induced	dynamically induced
Forced		shift toward higher values
Free		spread

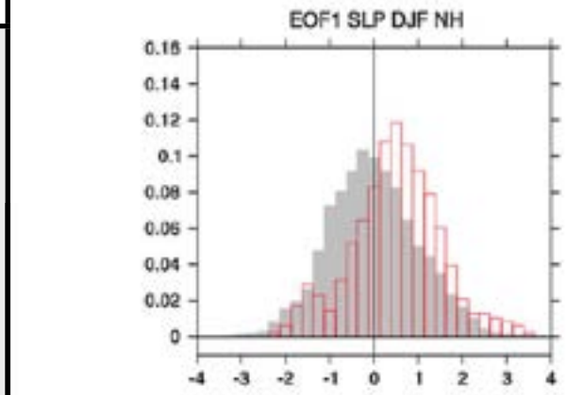
CCSM3 40-member ensemble mean

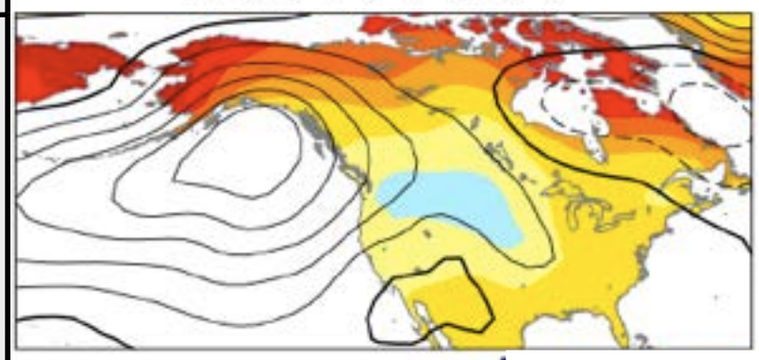


DJF 2005-2060 Departures from MEM Trends

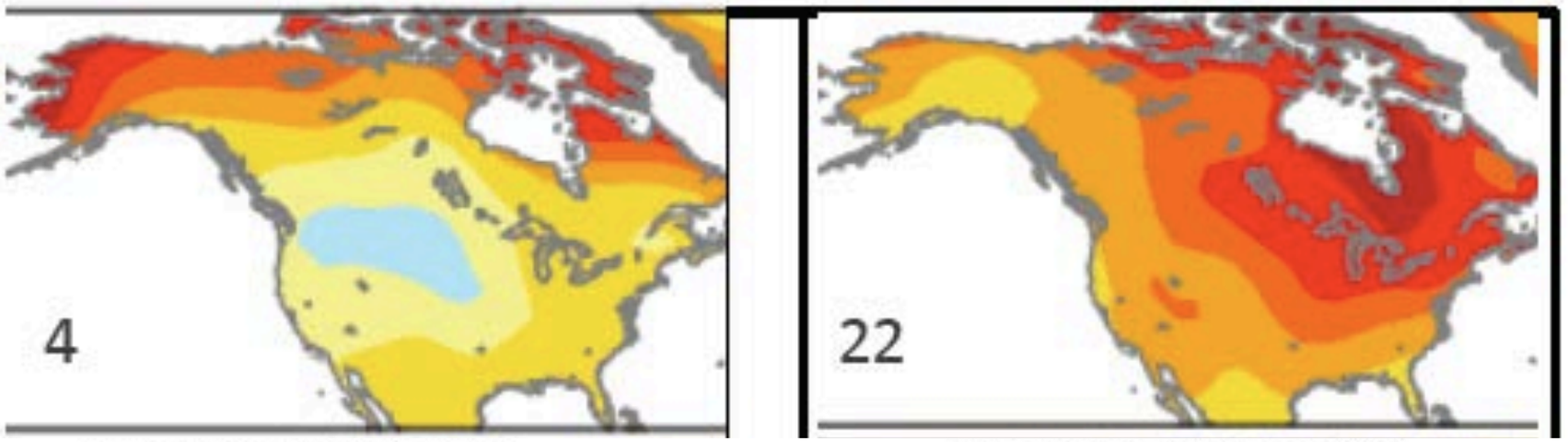


	thermodynamically induced	dynamically induced
Forced		MEM
Free		departures from MEM

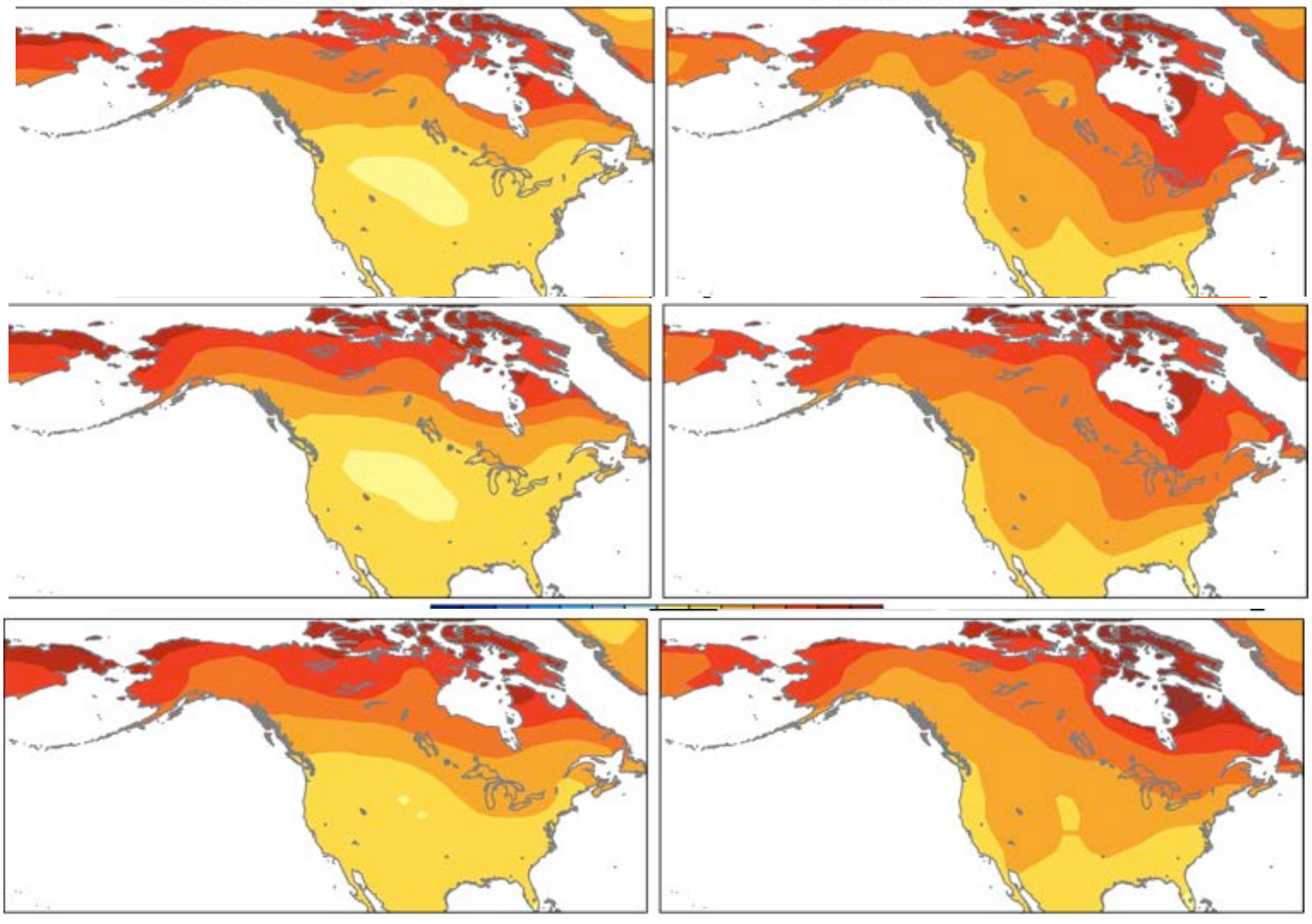




	thermodynamically induced	dynamically induced
Forced	residual	dynamical contribution
Free		



raw



residuals

5 SLP EOFs

10

20

Questions about how to perform the dynamical adjustment

- Is SLP the best variable to use?
- How best to avoid overfitting? PLS?
- How to adapt to historical record?

Simulated versus observed patterns of warming over the extratropical Northern Hemisphere continents during the cold season

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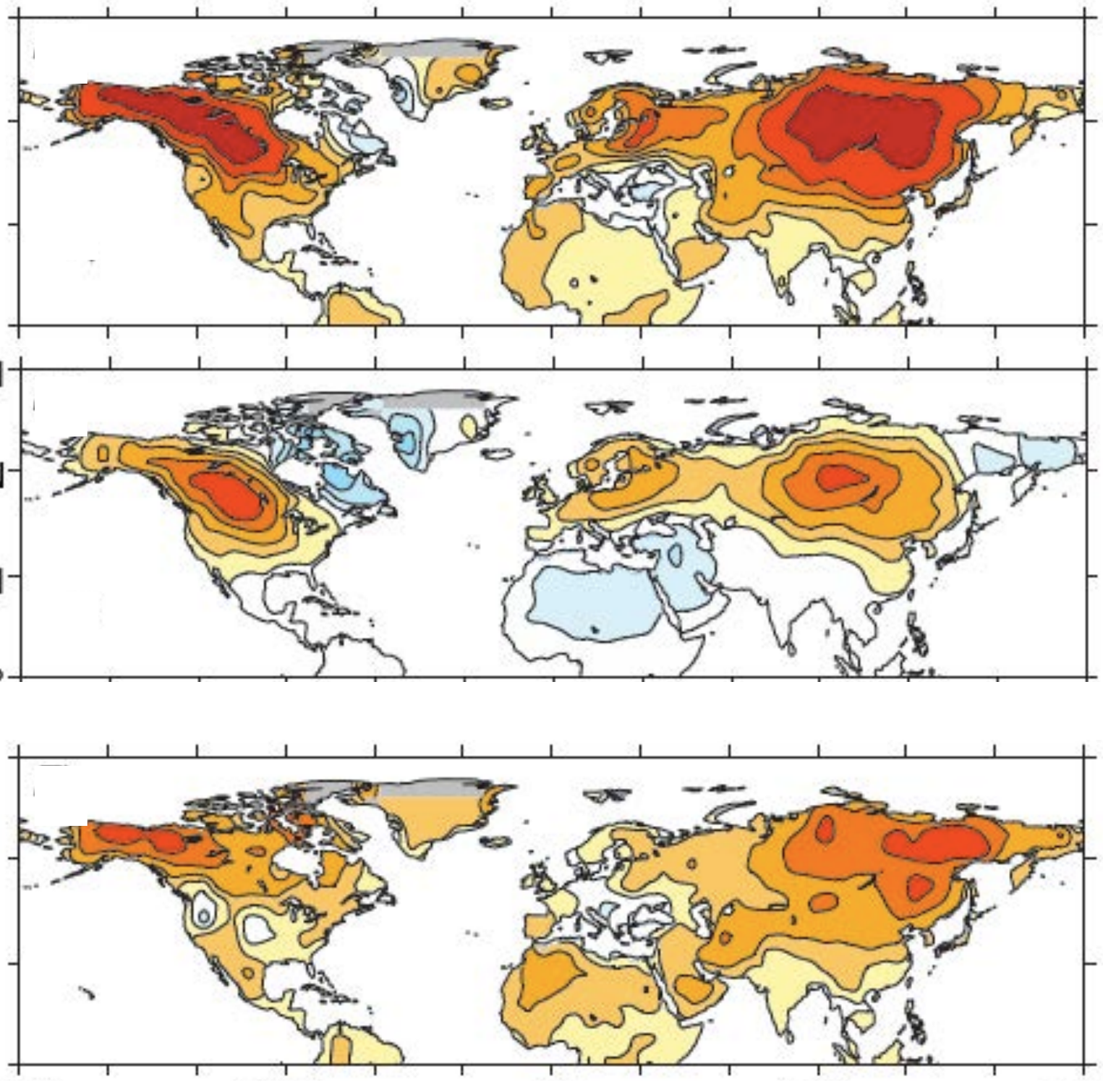
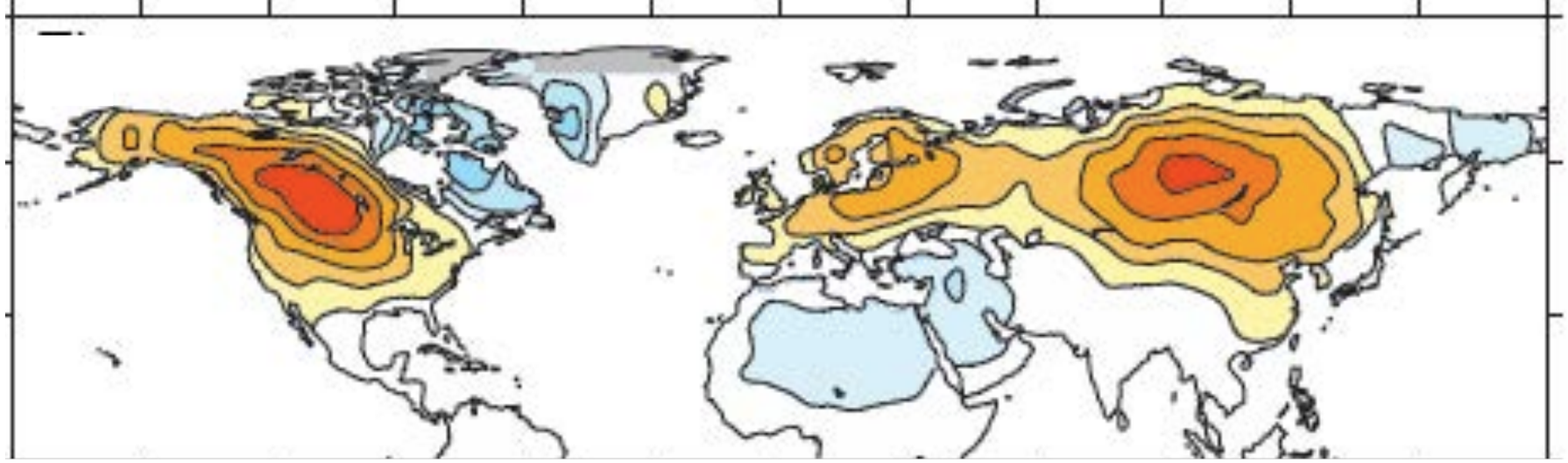


1965-2000 SLP Trends

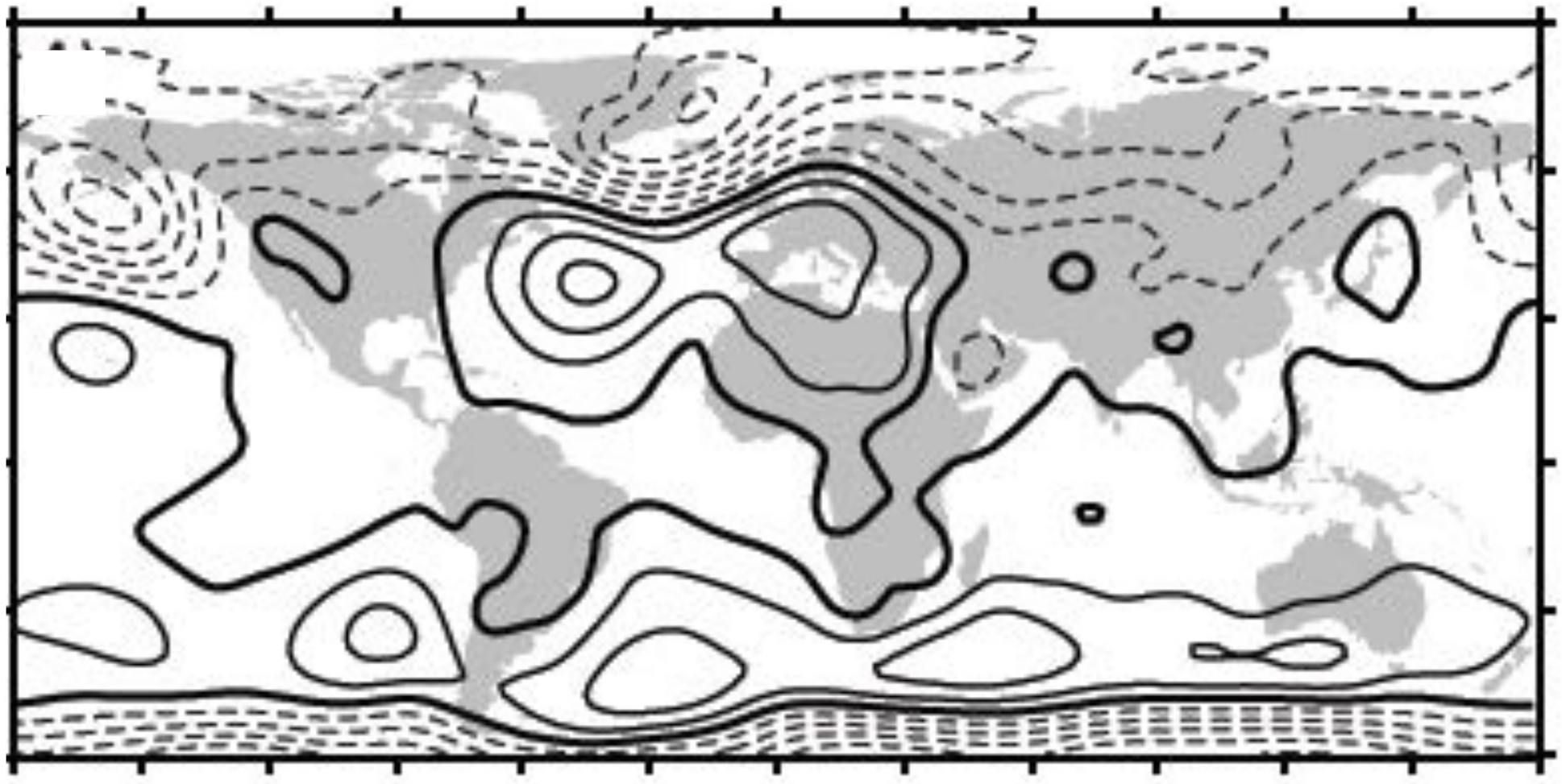
dynamical contribution

high frequency SLP: 2 passes PLS

residual



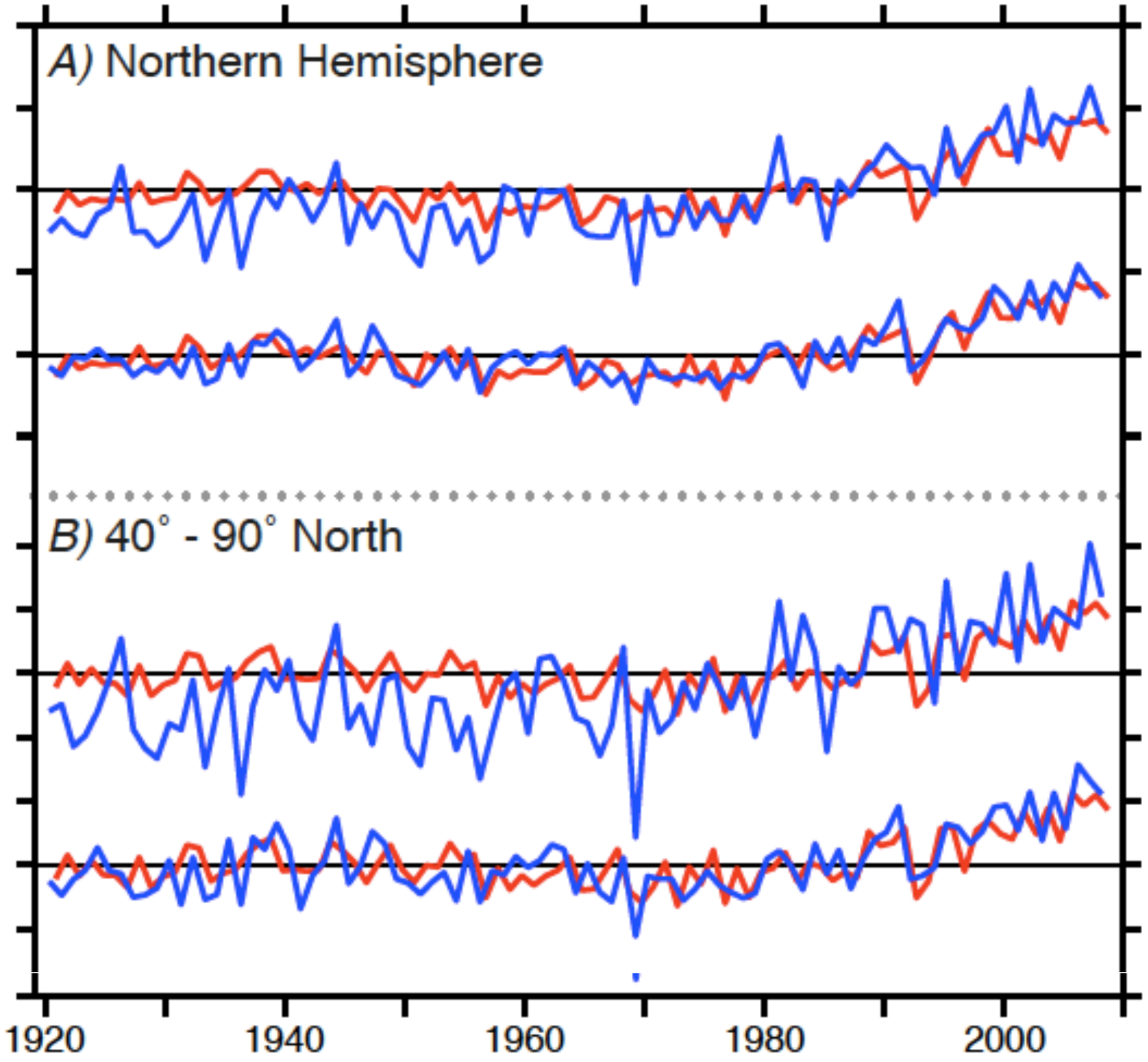
dynamical contribution



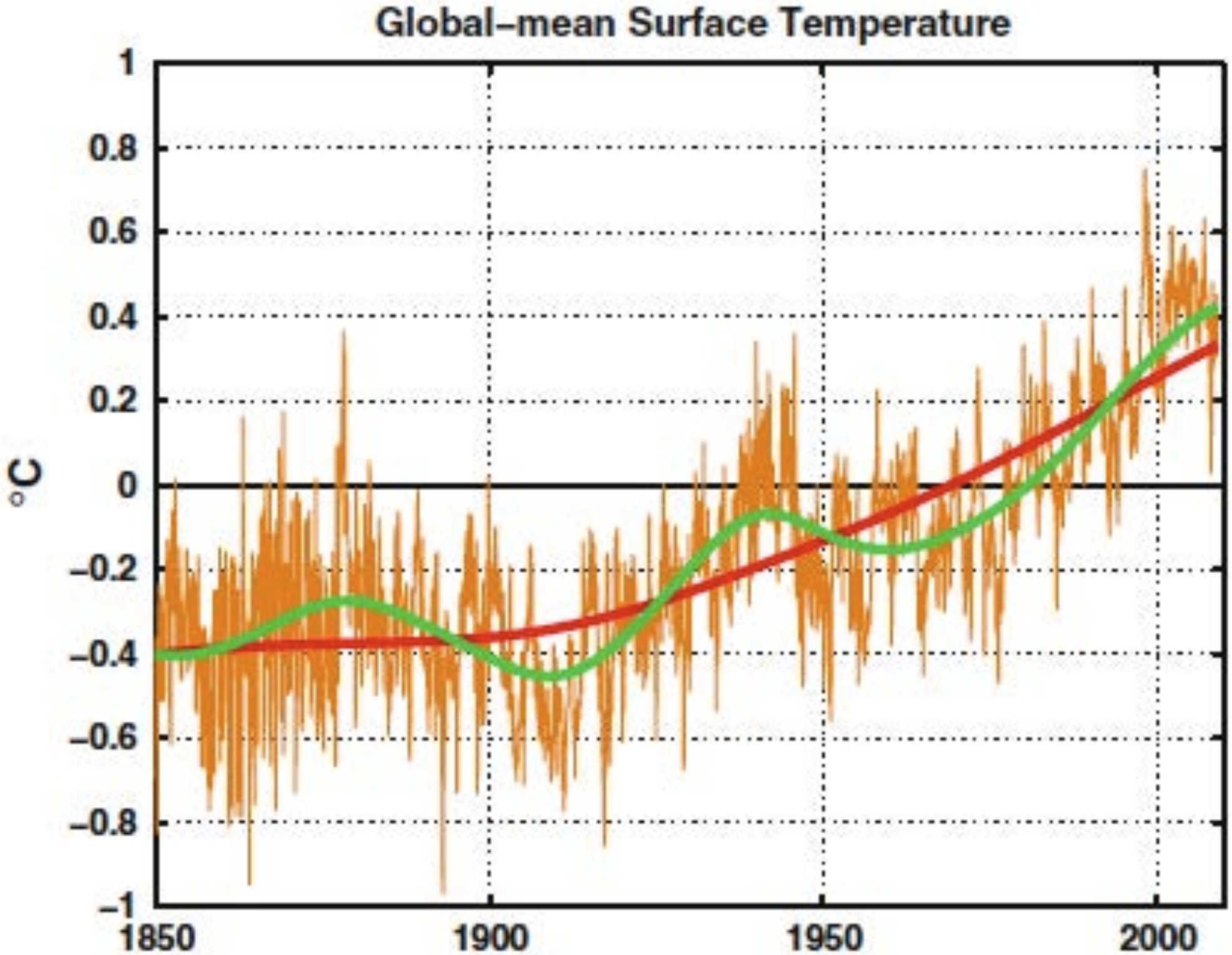
Observed SLP trends 1965-2000

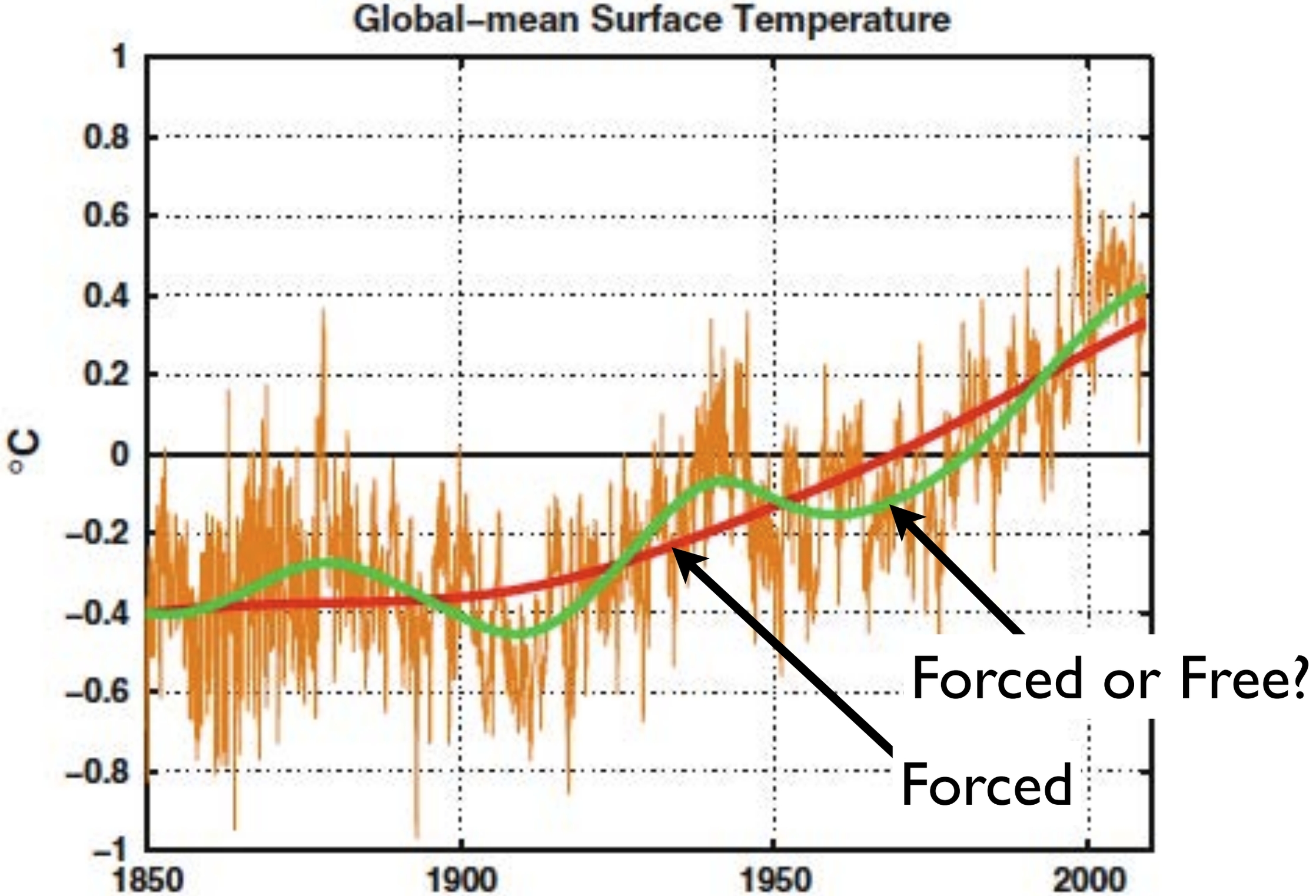
SAT Trends 1965-2000

	NDJFMA	MJJASO
N: 40ºN–90ºN	1.72 (*1.02*)	0.79
S: 60ºS–40ºN	0.70	0.69
GSAT (Land)	1.03 (*0.80*)	0.72
GSST (Ocean)	0.35	0.37
GST	0.57 (*0.49*)	0.48


A) Northern Hemisphere
B) 40° - 90° North
1920
1940
1960
1980
2000

Concluding Remarks


Global–mean Surface Temperature
°C
1
0.8
0.6
0.4
0.2
0
–0.2
–0.4
–0.6
–0.8
–1
1850
1900
1950
2000


Global–mean Surface Temperature
°C
1
0.8
0.6
0.4
0.2
0
–0.2
–0.4
–0.6
–0.8
–1
1850
1900
1950
2000
Forced or Free?
Forced

Role of Atlantic Multidecadal Variability

	thermodynamically induced	dynamically induced
Forced		
Free	Wu and Huang 2008 Wu et al. 2011 Semenov et al 2010 Delsole et al. 2011 Tung and Zhou 2012	

	thermodynamically induced	dynamically induced
Forced		
Free		

	thermodynamically induced	dynamically induced
Forced		
Free		

	thermodynamically induced	dynamically induced
Forced		
Free		