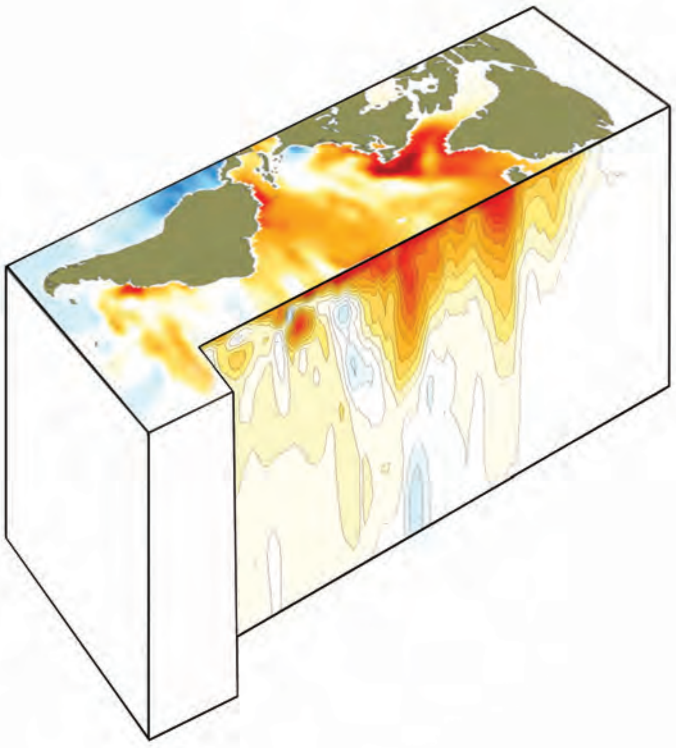
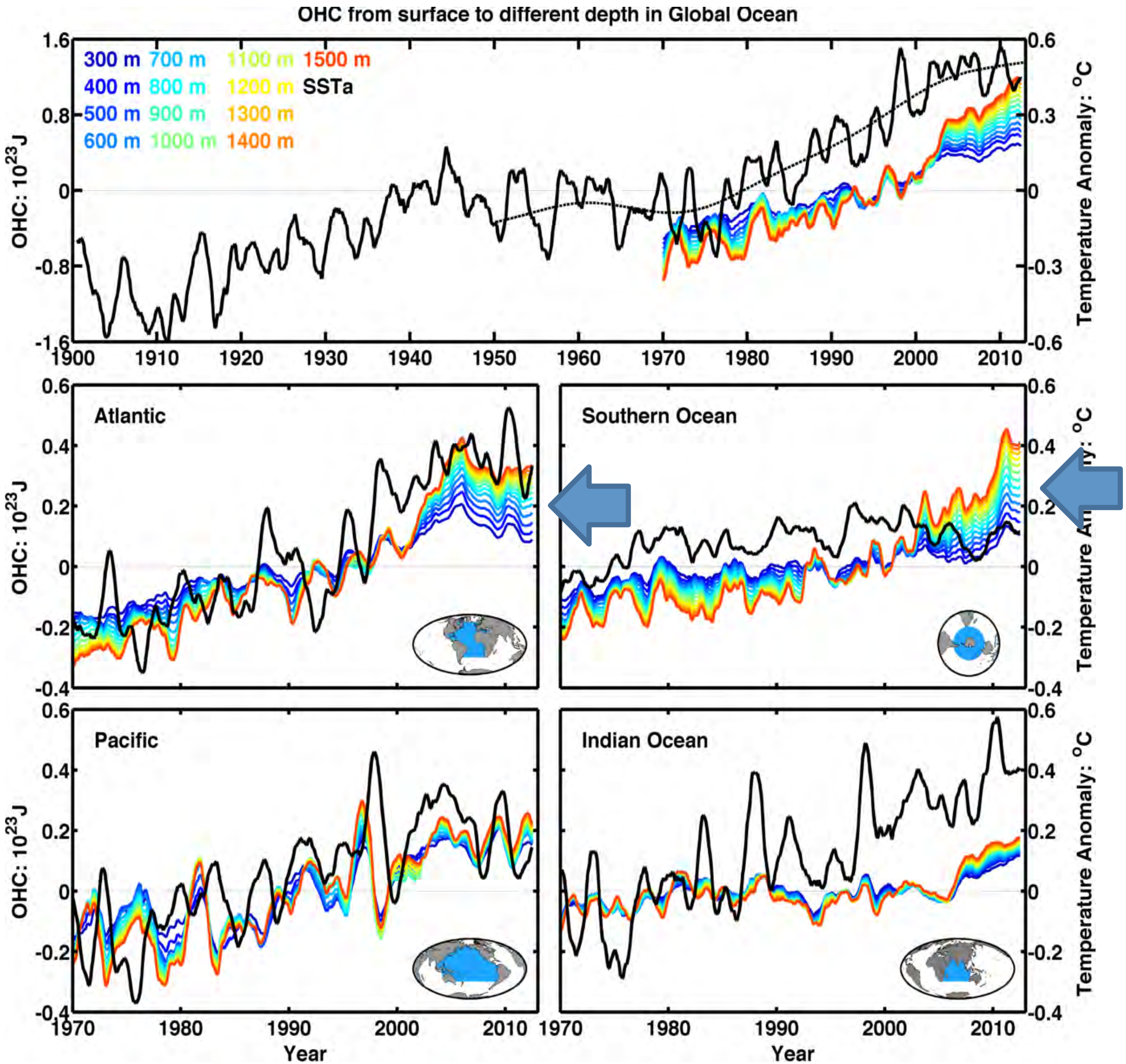
AMOC'S MULTI-DECADAL VARIABILITY & GLOBAL WARMING SLOWDOWN

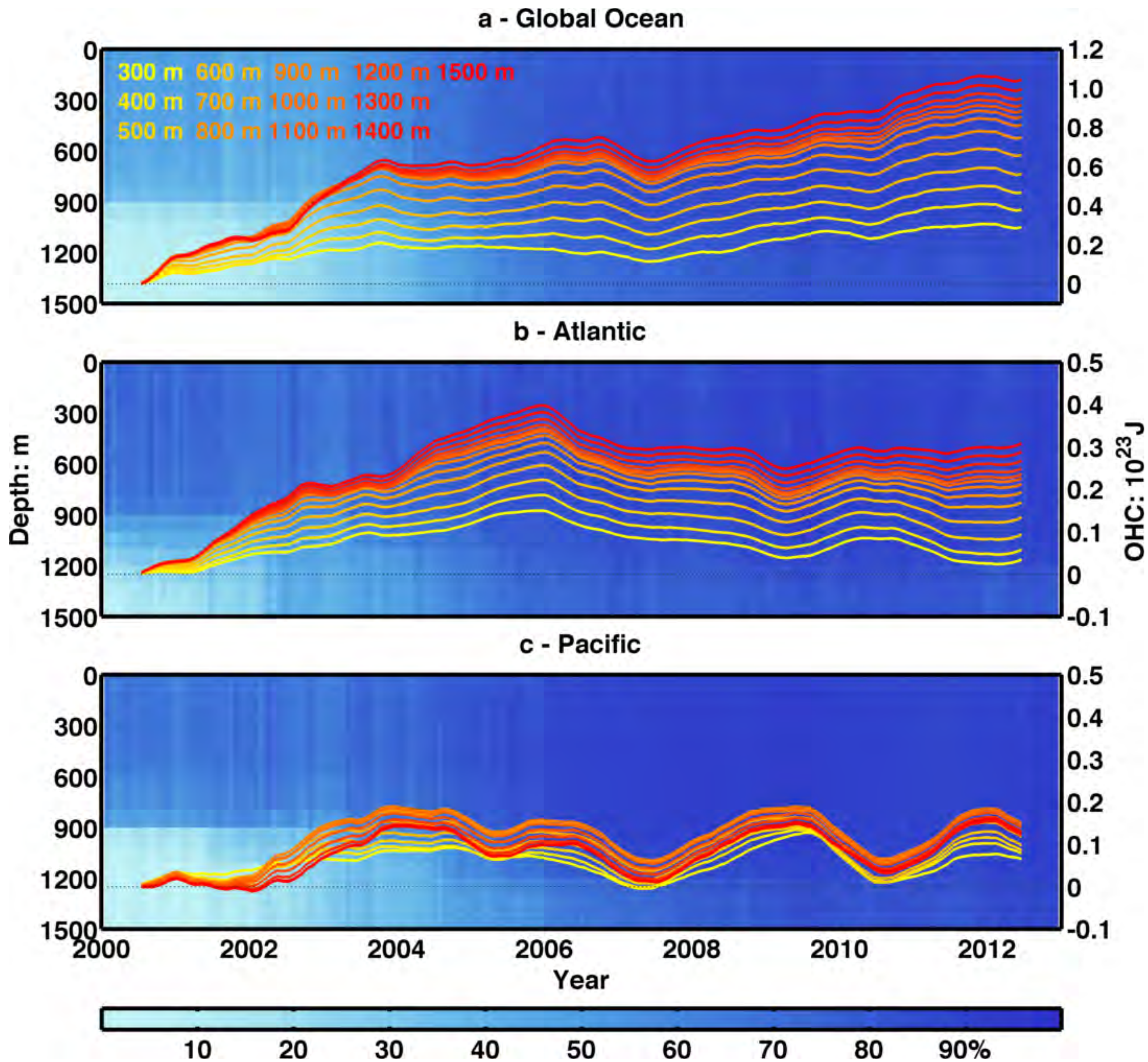


K.K. Tung
Department of Applied Mathematics
University of Washington

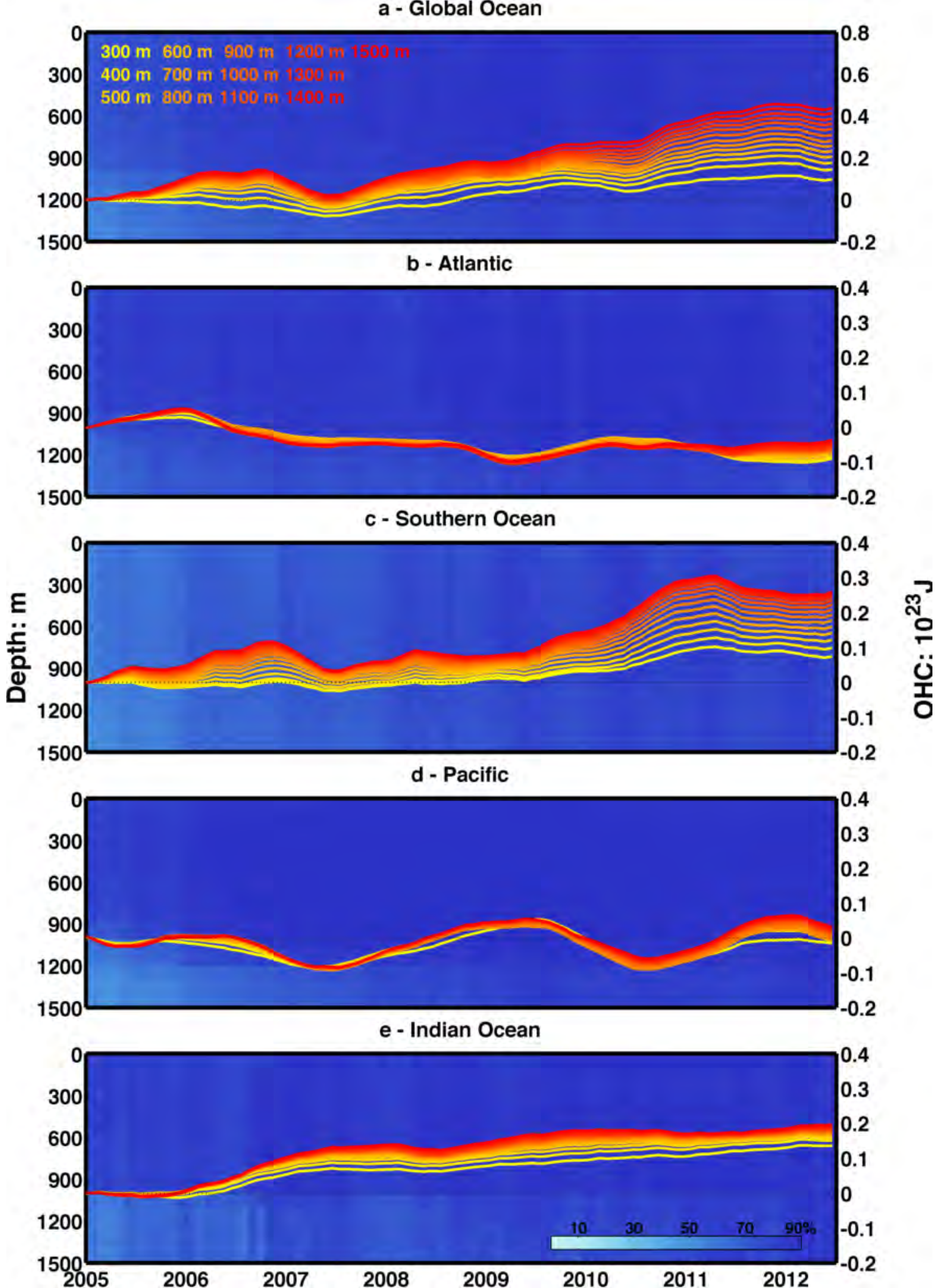
Reference: X. Chen and K.K. Tung (2014) "Varying planetary heat sink led to global warming slowdown and acceleration" , Science.



OHC from surface to different depth in Global Ocean
300 m 700 m 1100 m 1500 m
400 m 800 m 1200 m SSTa
500 m 900 m 1300 m
600 m 1000 m 1400 m
OHC: 10^{23}J
Temperature Anomaly: °C
Year
Atlantic
Southern Ocean
Pacific
Indian Ocean



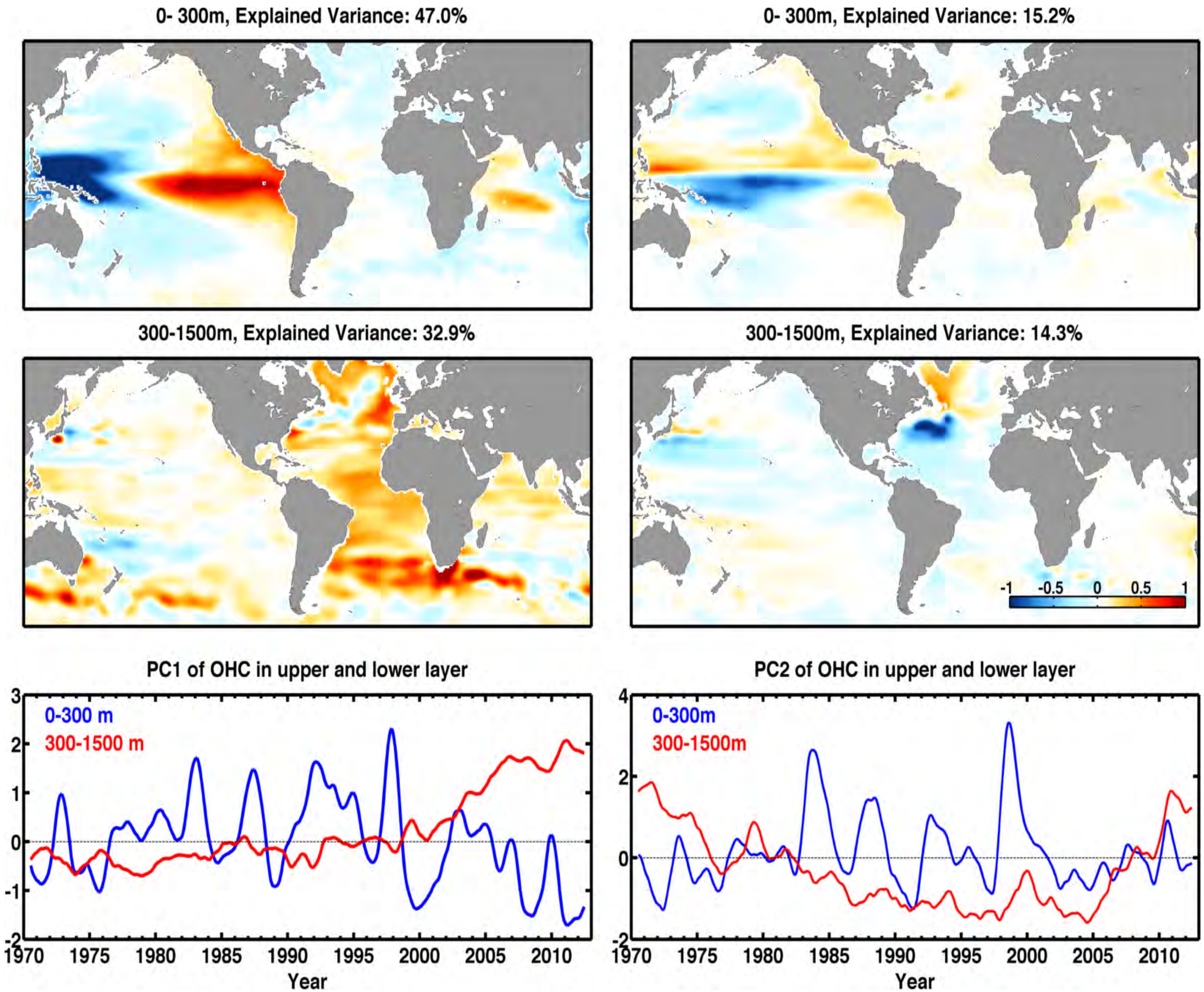
Percentage of data coverage (in 5x5 degrees) in each ocean as a function of depth. The result of not much heat storage in the Pacific is robust.


a - Global Ocean
b - Atlantic
c - Southern Ocean
d - Pacific
e - Indian Ocean
300 m 600 m 900 m 1200 m 1500 m
400 m 700 m 1000 m 1300 m
500 m 800 m 1100 m 1400 m
Depth: m
OHC: 10^{23} J
10 30 50 70 90%
2005 2006 2007 2008 2009 2010 2011 2012

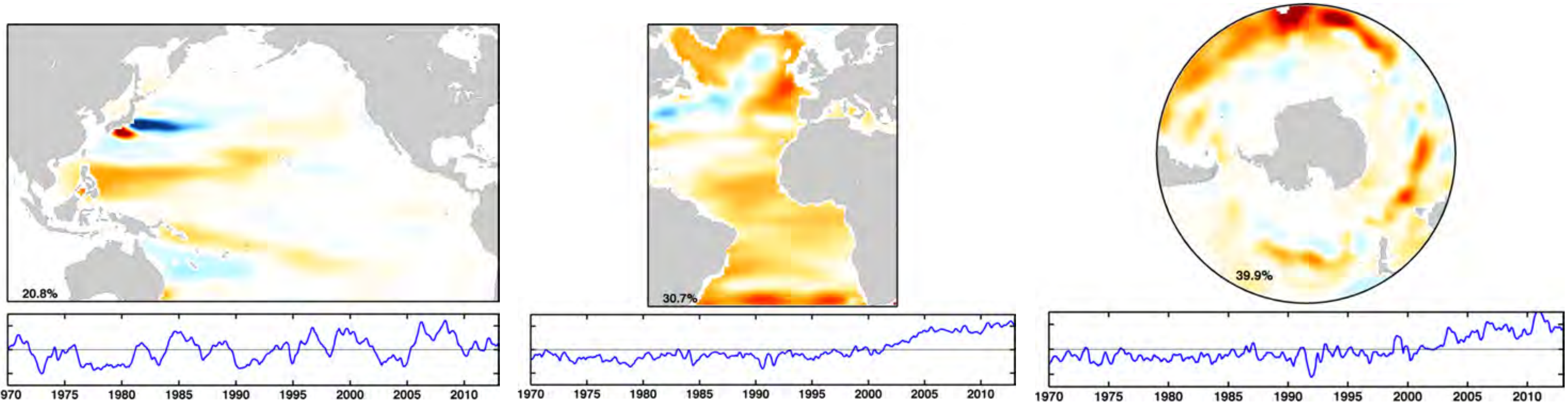
The EOF patterns containing most of the Variance

Top layer: ENSO pattern

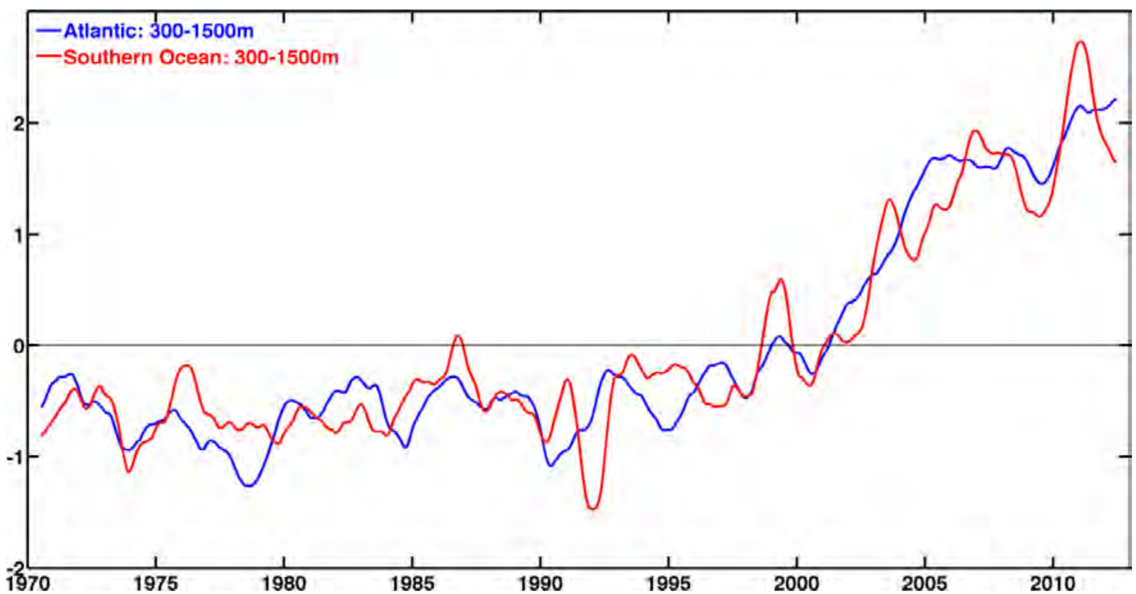
Lower layer: Atlantic and ACC in the S. Ocean.



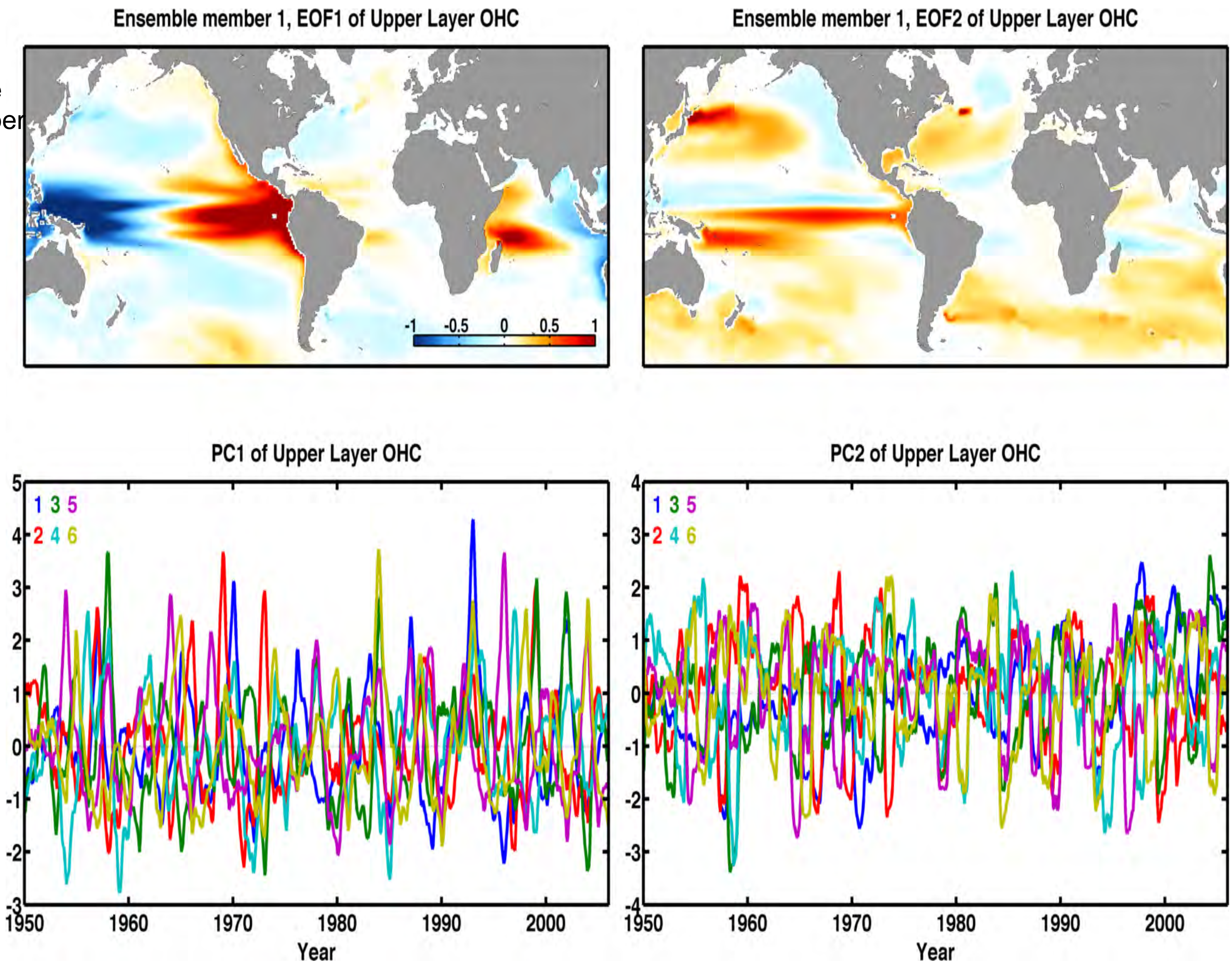
EOF1 of OHC in 300-1500m

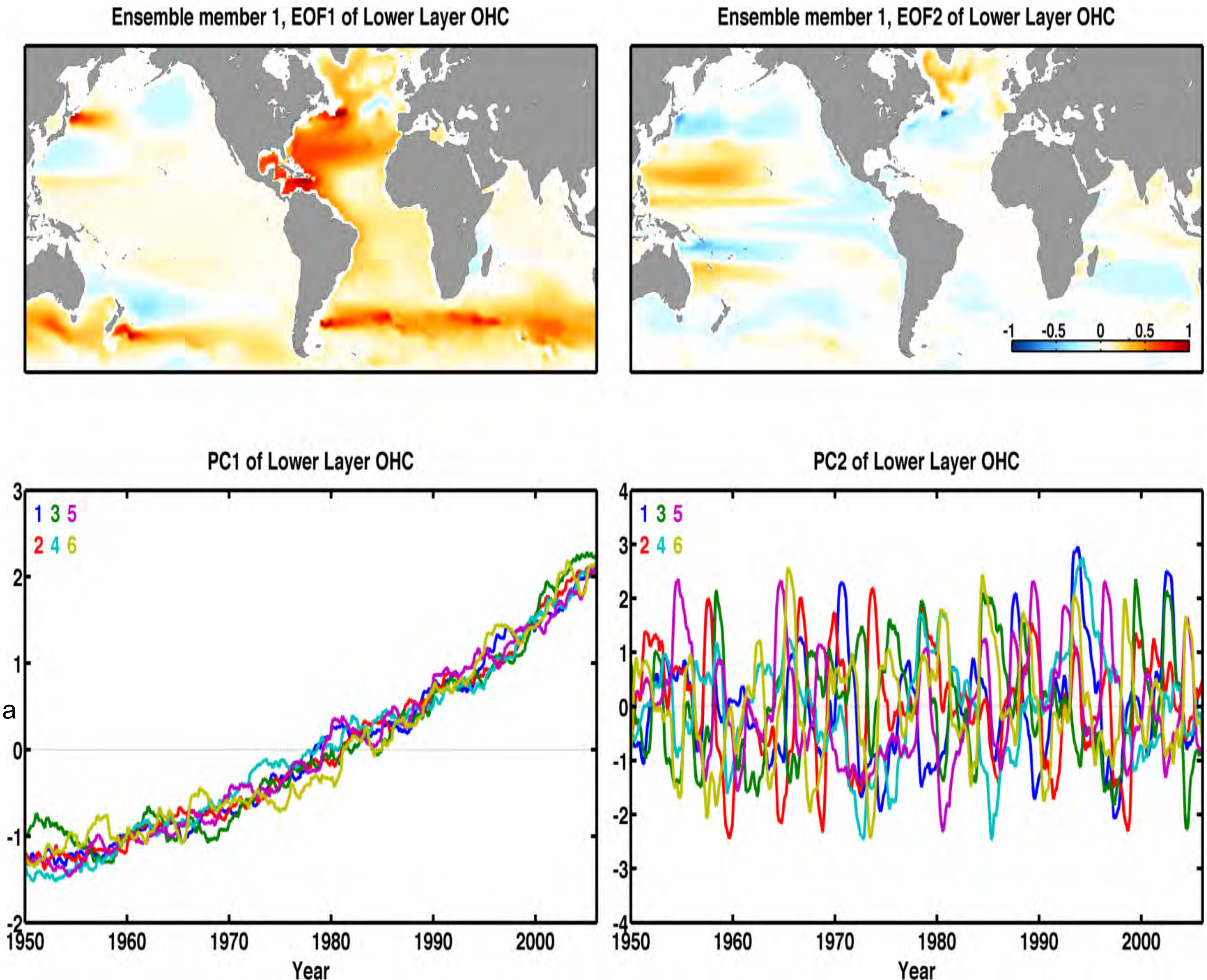


PC1 of OHC in 300-1500m in Atlantic and Southern Ocean



Single
member



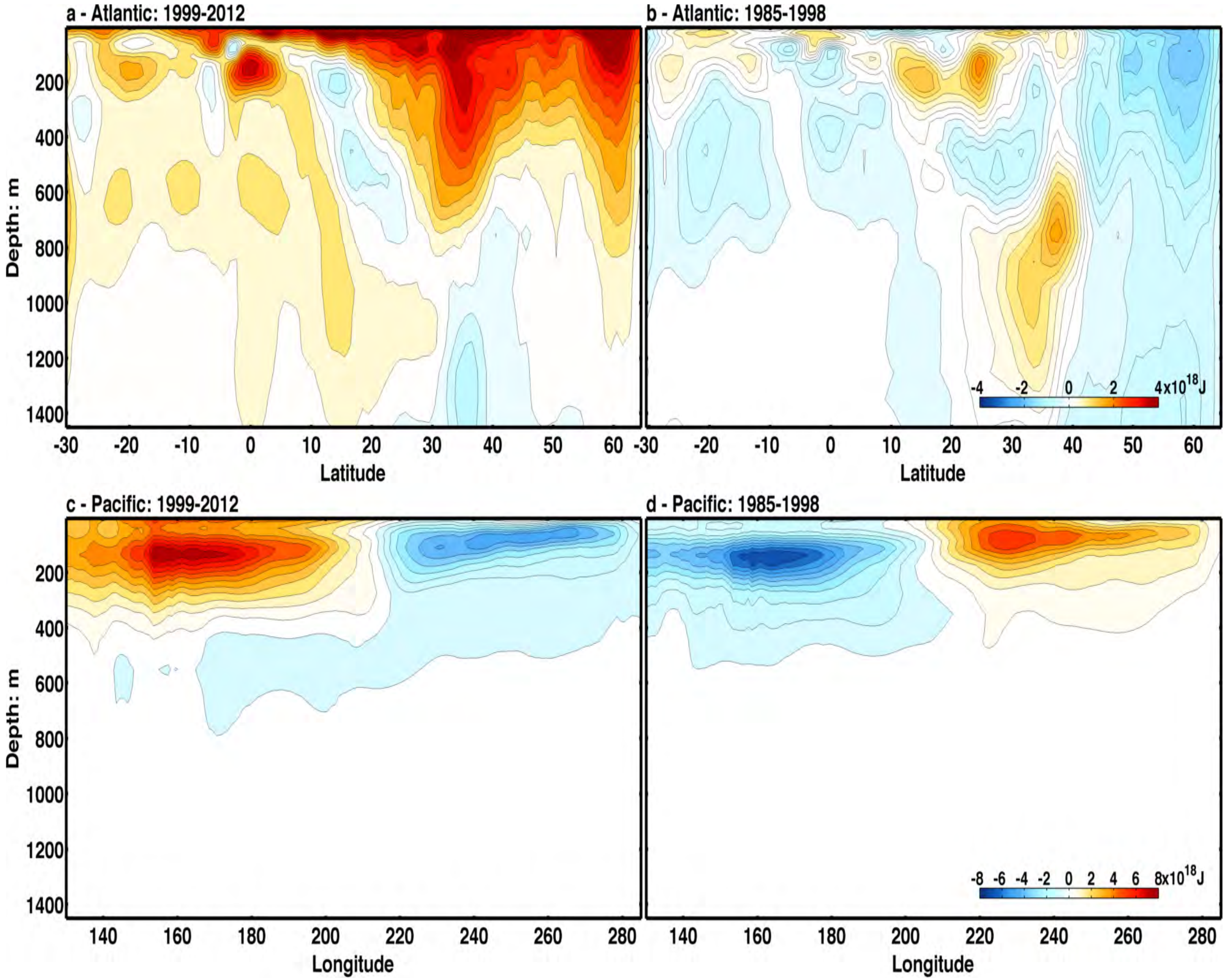


Mostly a forced linear trend

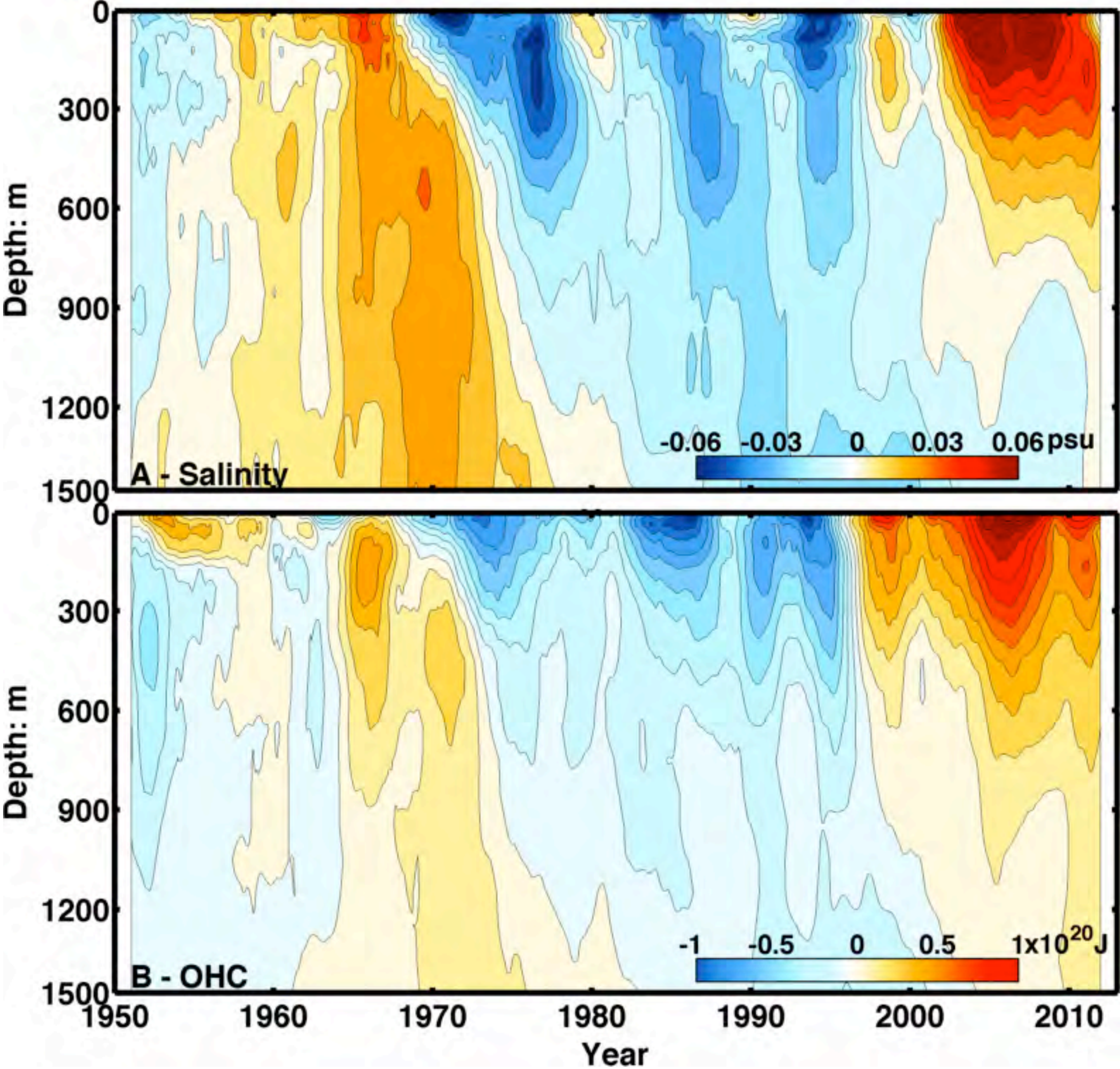
Current 14 years of hiatus vs previous 14 years

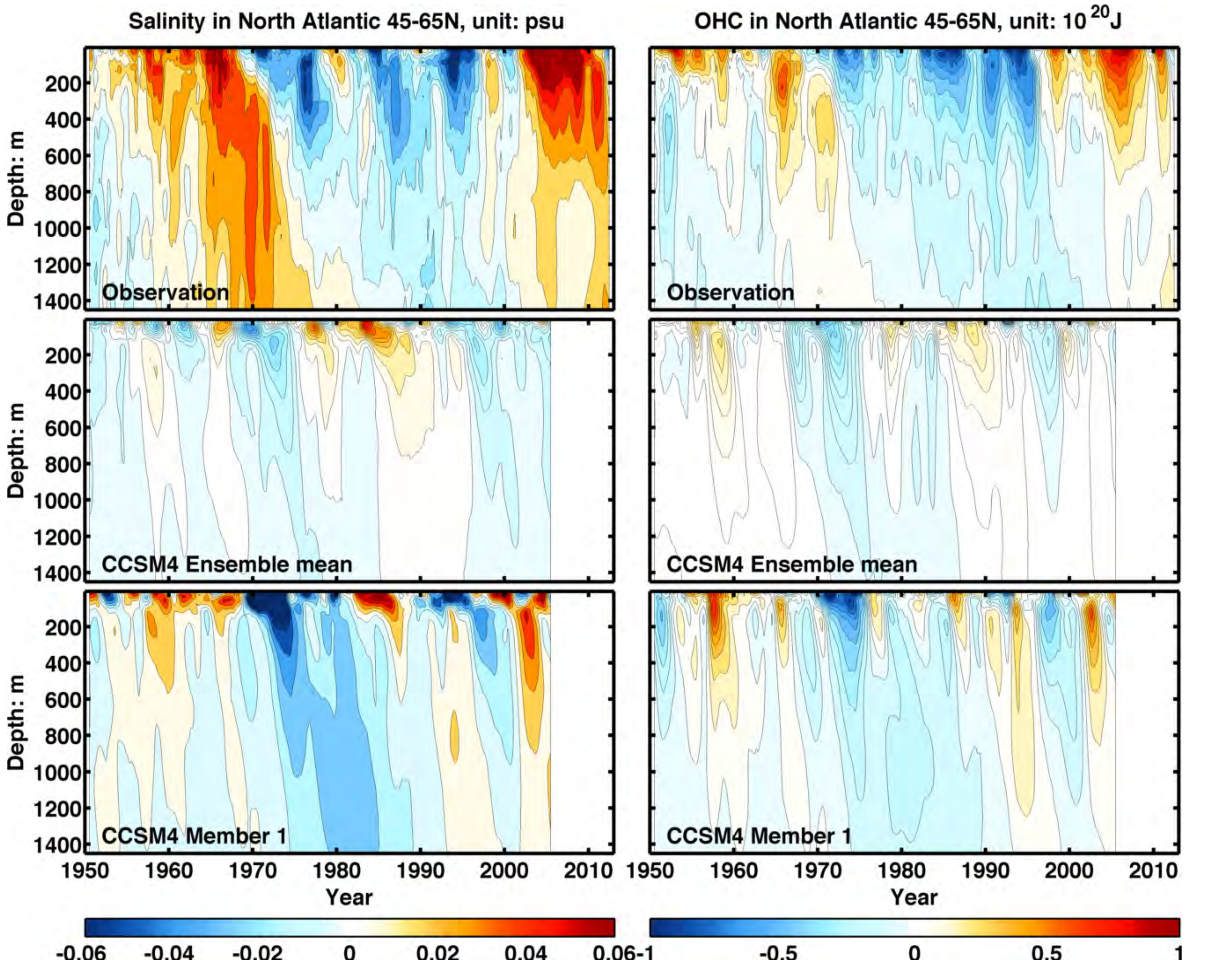
Atlantic zonal mean as a function of latitude

Pacific Mean 35S-65N

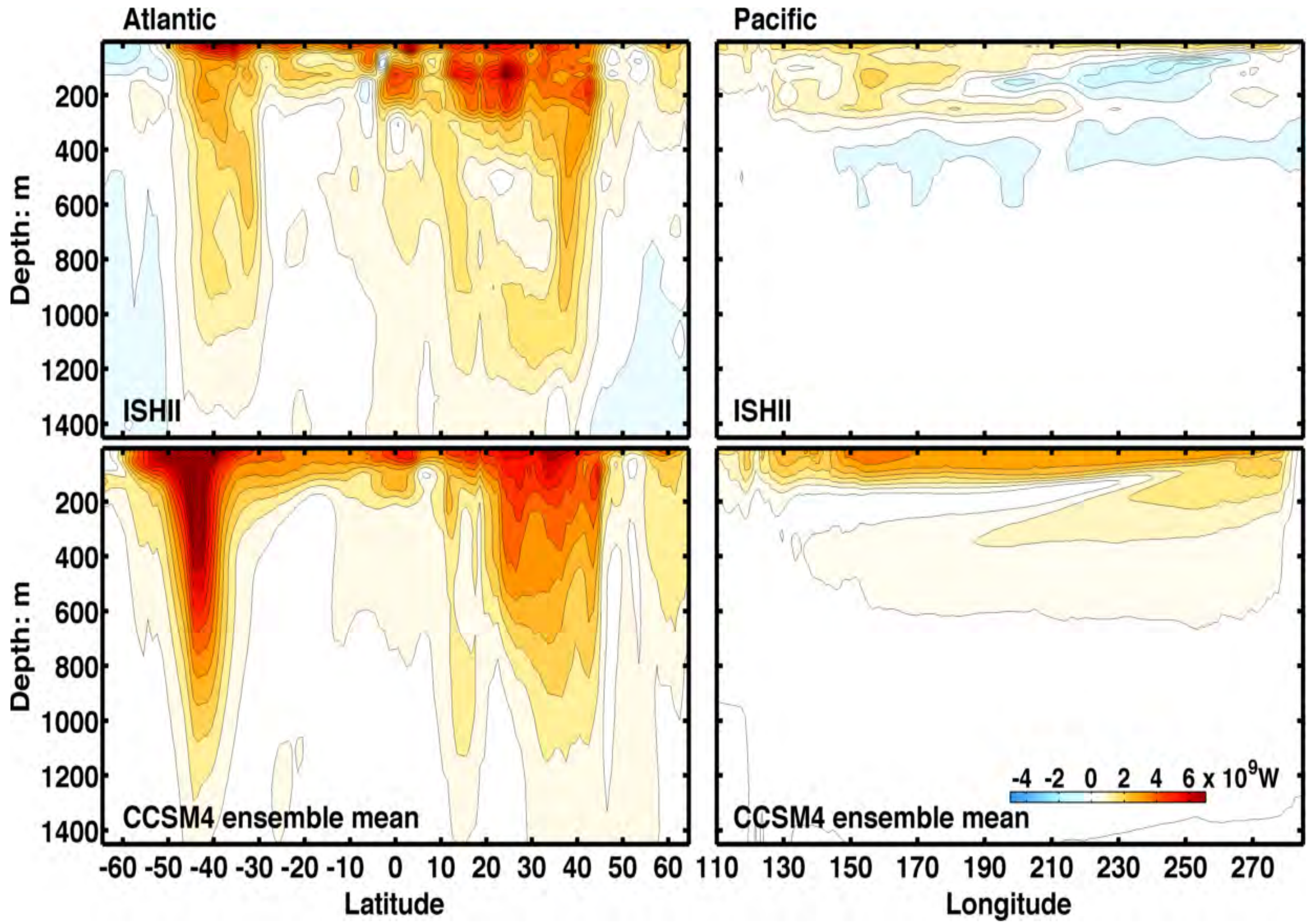


Climate shifts in Salinity and OHC: North Atlantic subpolar (45-65 N) mean salinity (top) and layer OHC (bottom), 12-month running mean, as a function of years; not detrended but 1950-2012 climatology removed.





Salinity in North Atlantic 45-65N, unit: psu
OHC in North Atlantic 45-65N, unit: 10^{20}J
Depth: m
200
400
600
800
1000
1200
1400
Observation
CCSM4 Ensemble mean
CCSM4 Member 1
1950
1960
1970
1980
1990
2000
2010
Year
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
-1
-0.5
0
0.5
1



Not much
Heat
Storage
In Pacific

Forced
Linear
trend

Spatial patterns associated with the linear trend in the Atlantic sector (left) as a function of latitude, and in the Pacific (right) as a function of longitude, for the period 1950-2012. Top: Ishii data; bottom: CCSM4 ensemble mean.

MECHANISMS OF OCEAN HEAT TRANSPORT VARIABILITY

Pacific Basin

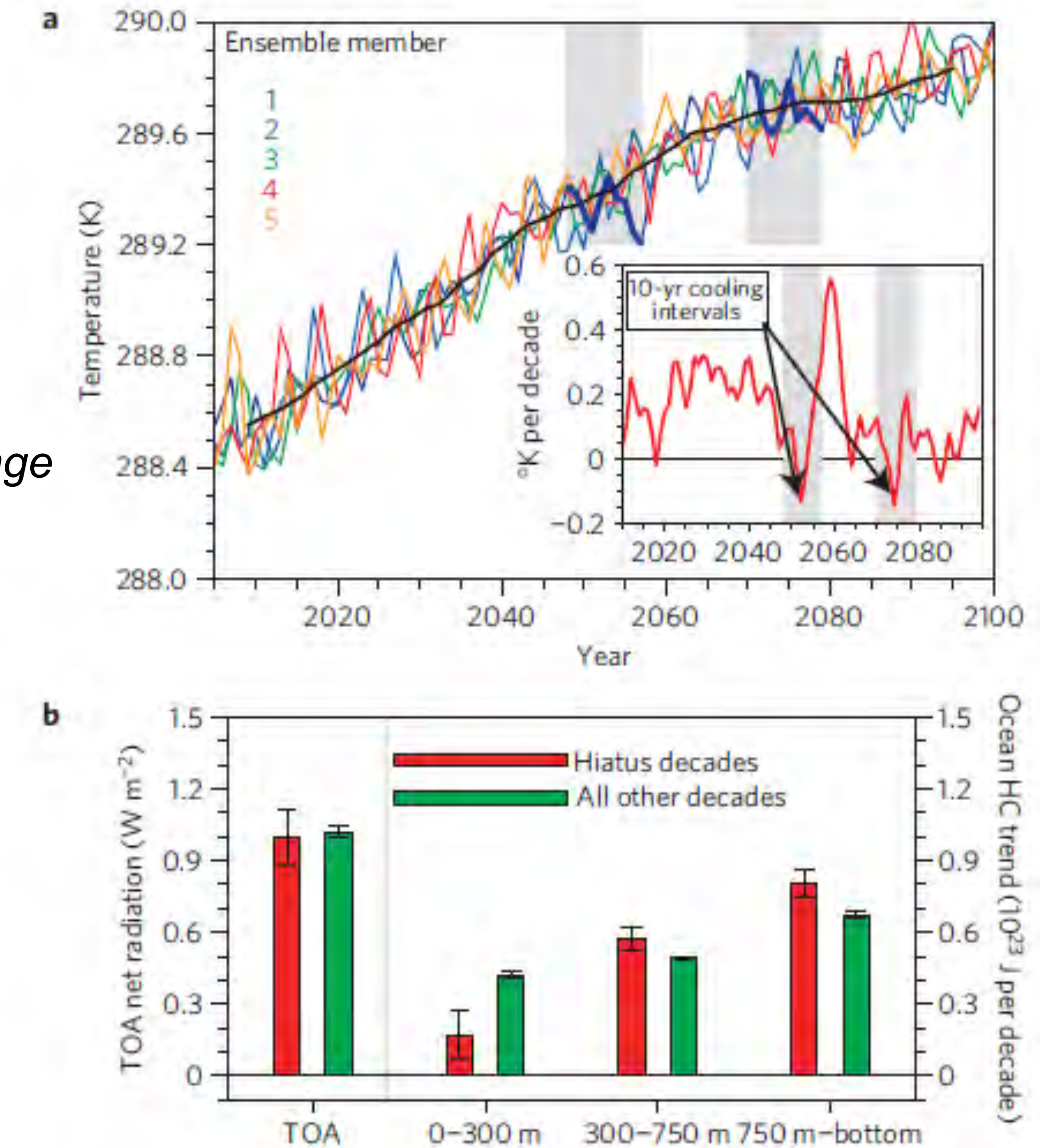
- *Mainly wind-driven*
- *Coupled SST-trade winds*
- *Shallow*
- *ENSO timescales*

- *"Global climate shift" Multidecadal "memory" in the atmosphere, the Pacific Decadal Oscillation*

Atlantic Basin

- *Atlantic Meridional Overturning Circulation (AMOC)*
- *(The climatological part is probably driven by ACC region winds; we are interested in the variability)*
- *Density driven; salinity and fresh water.*
- *Deep convection*
- *Multidecadal timescales*
- *Variation in northward surface heat transport by the conveyor belt changes what the global atmosphere needs to transport*

Meehl et al 2011
Nature Climate Change



LETTER

doi:10.1038/nature12534

Recent global-warming hiatus tied to equatorial Pacific surface cooling

Yu Kosaka[1] & Shang-Ping Xie[1,2,3]

nature climate change

ARTICLES

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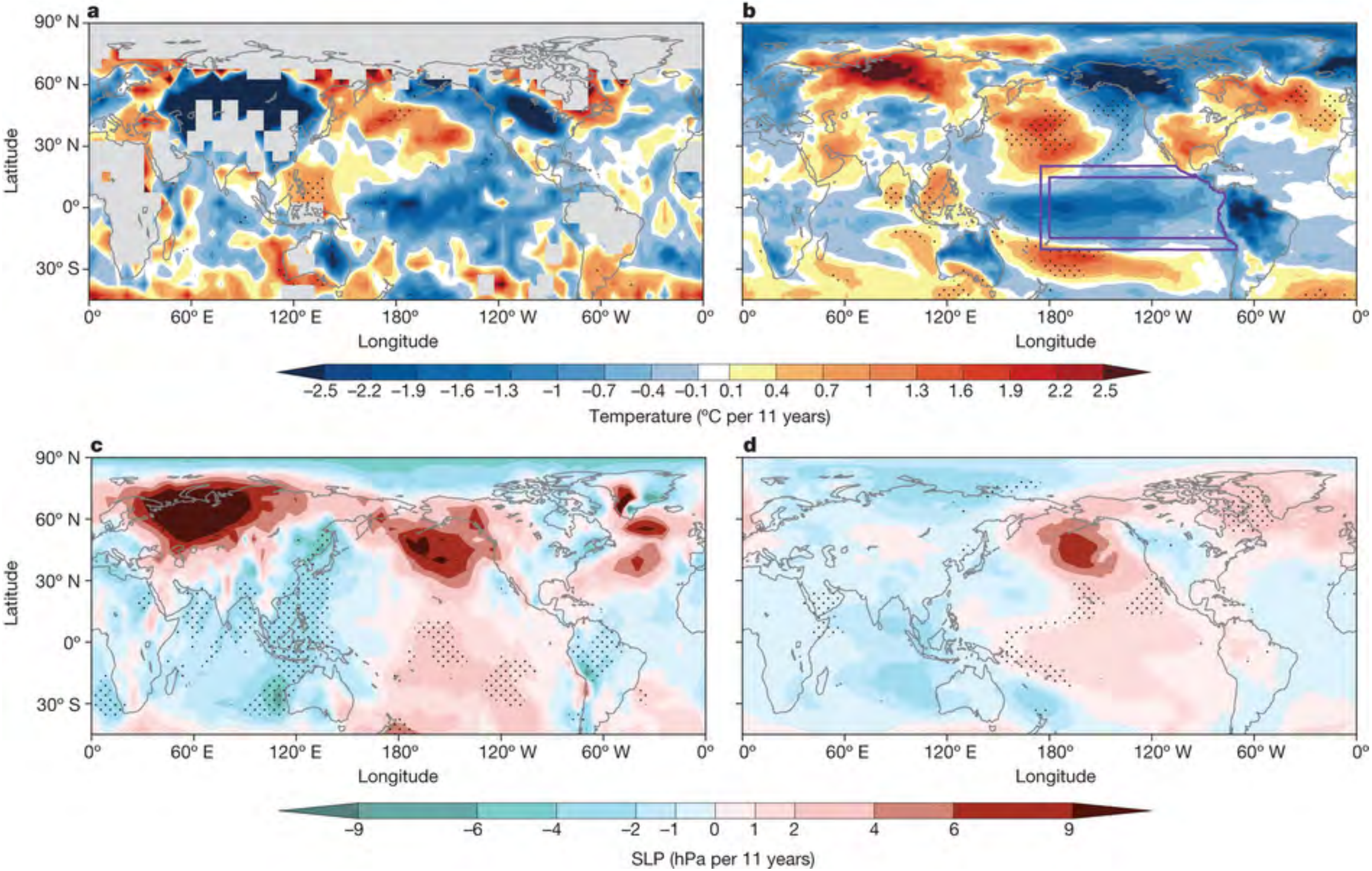
Recent intensification of wind-driven circulation in the Pacific and the ongoing warming hiatus

Matthew H. England[1,2*], Shayne McGregor[1,2], Paul Spence[1,2], Gerald A. Meehl[3], Axel Timmermann[4], Wenju Cai[5], Alex Sen Gupta[1,2], Michael J. McPhaden[6], Ariaan Purich[5] and Agus Santoso[1,2]


a
b
c
d
90° N
60° N
30° N
0°
30° S
Latitude
0°
60° E
120° E
180°
120° W
60° W
Longitude
−2.5 −2.2 −1.9 −1.6 −1.3 −1 −0.7 −0.4 −0.1 0.1 0.4 0.7 1 1.3 1.6 1.9 2.2 2.5
Temperature (°C per 11 years)
−9 −6 −4 −2 −1 0 1 2 4 6 9
SLP (hPa per 11 years)