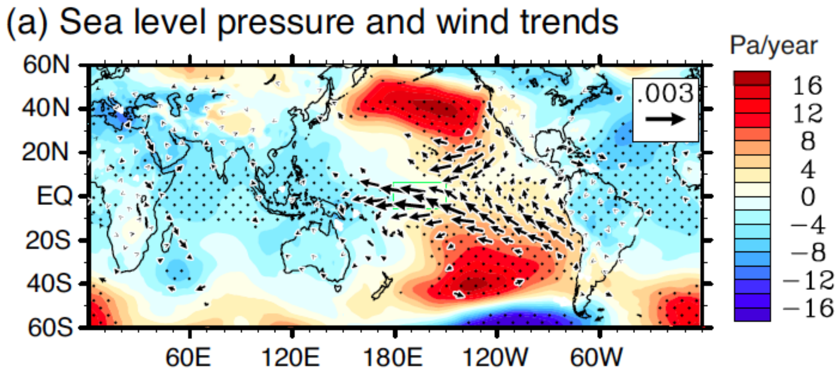
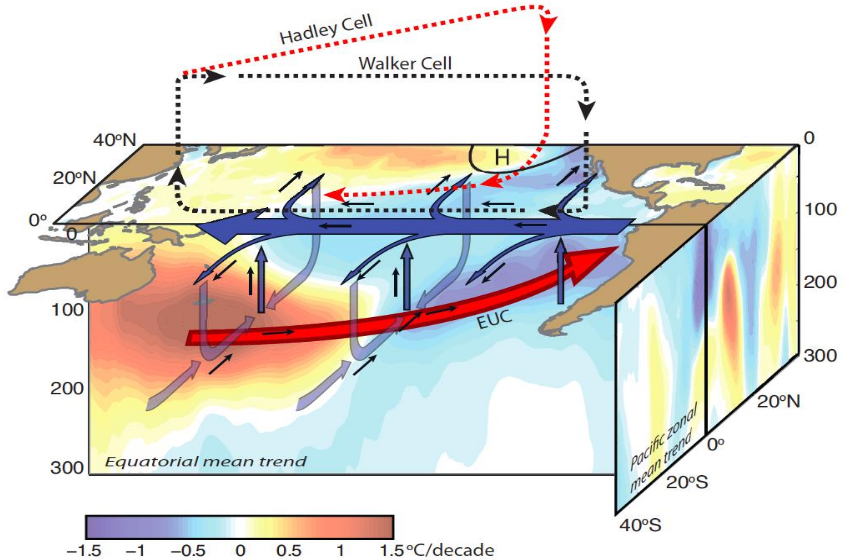
Pacific wind-driven circulation variability and its role in hiatus / accelerated warming decades





Matthew England
ARC Centre of Excellence for Climate System
The University of New South Wales
www.science.unsw.edu.au/~matthew

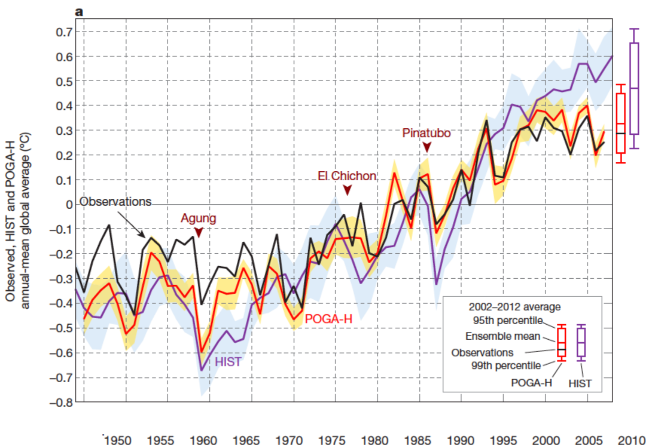
Coupled Modelling and Prediction :

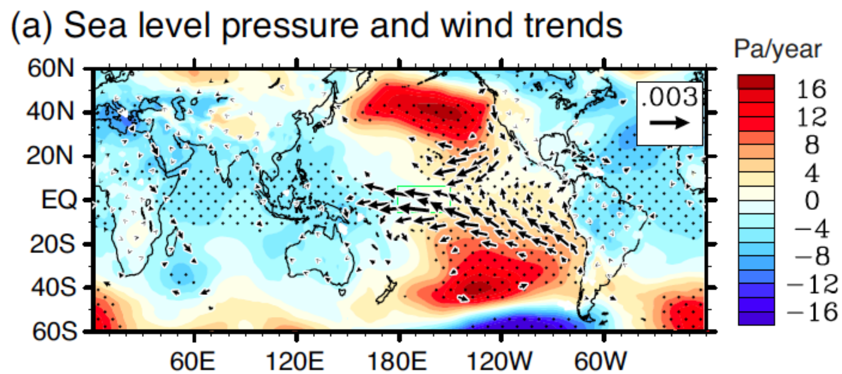
FROM WEATHER TO CLIMATE

Venue: Bureau of Meteorology, Melbourne, Australia
http://cawcr.gov.au/events/AWS9/

CAWCR 9th Annual Workshop
19-22 OCTOBER 2015

Pacemaker experiments for studying decadal climate variability





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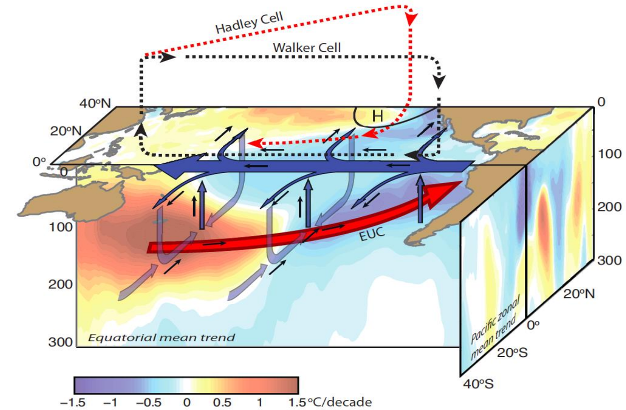

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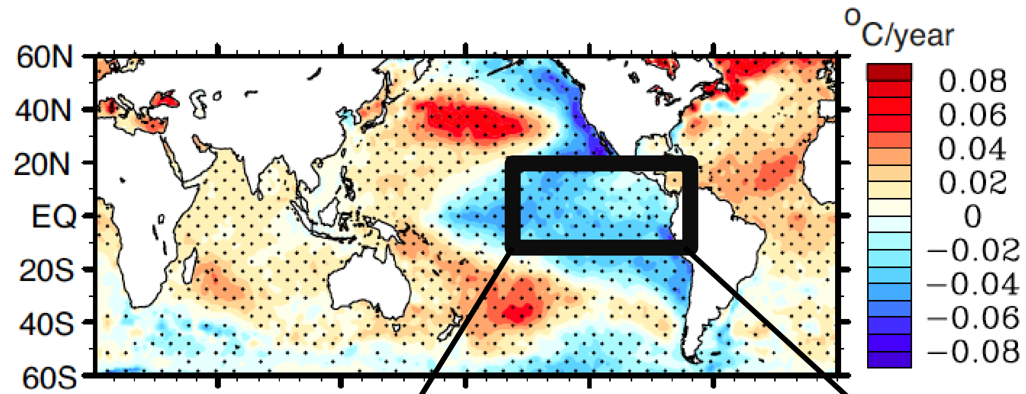
Pacemaker experiments – SST forcing – full coupled model

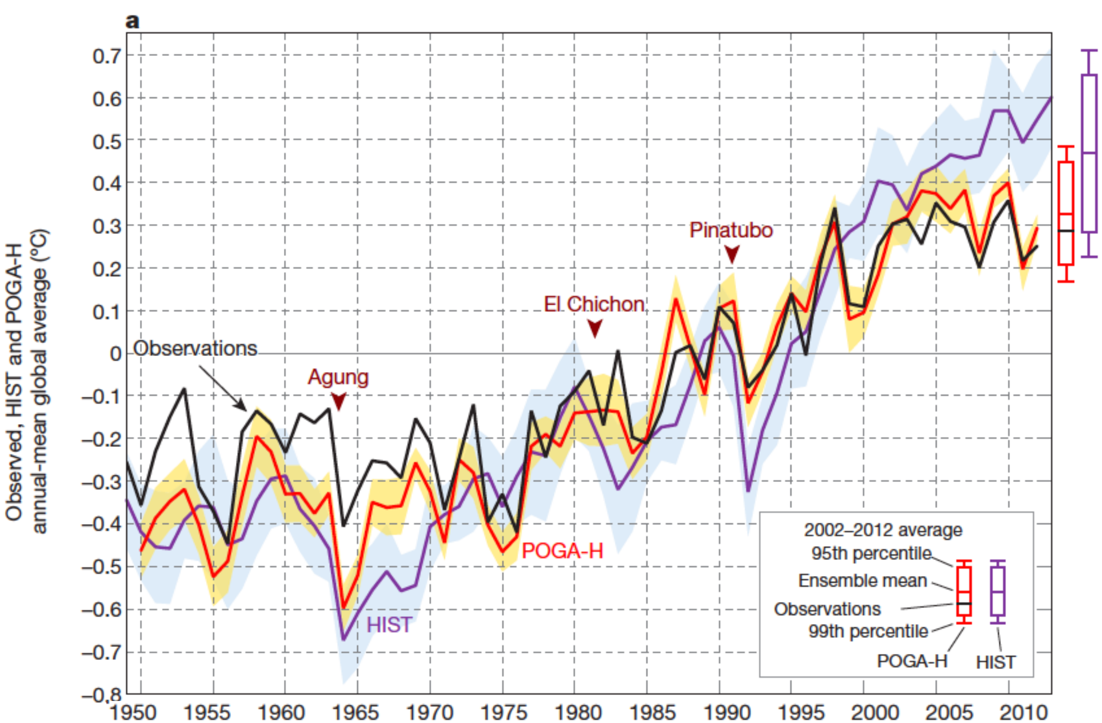
LETTER

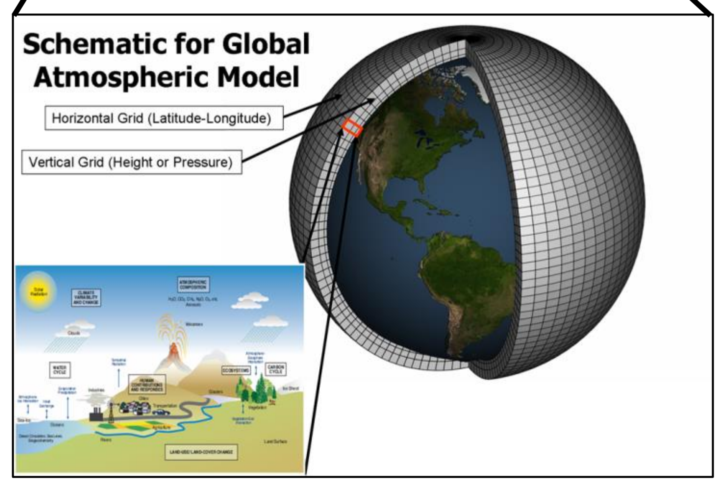
doi:10.1038/nature12534

Recent global-warming hiatus tied to equatorial Pacific surface cooling

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







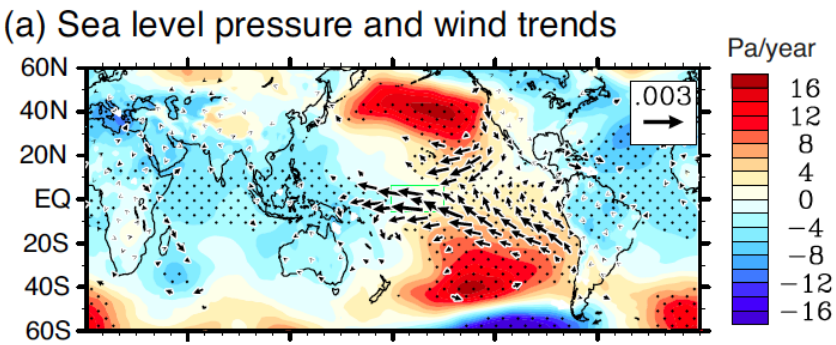
Kosaka and Xie (2013)

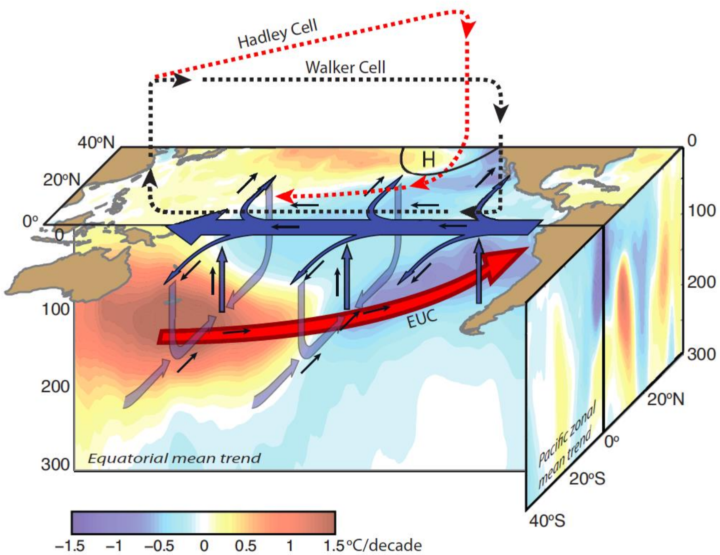
Pacemaker experiments – wind-driven forcing

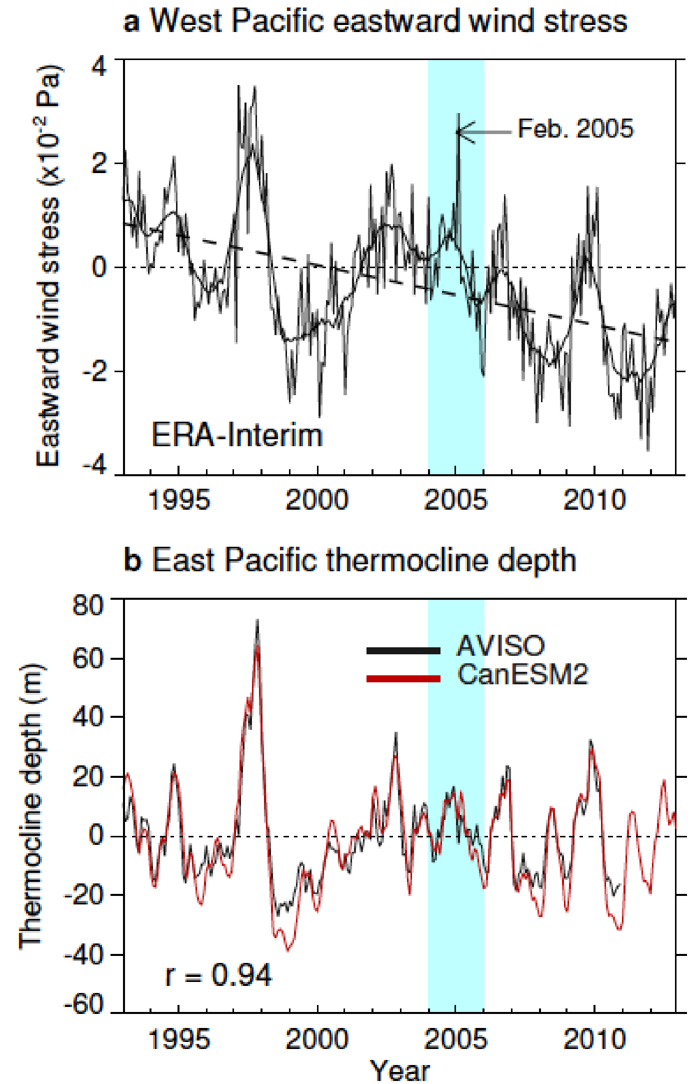
nature climate change
ARTICLES
PUBLISHED ONLINE: 9 FEBRUARY 2014 | DOI: 10.1038/NCLIMATE2106

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]



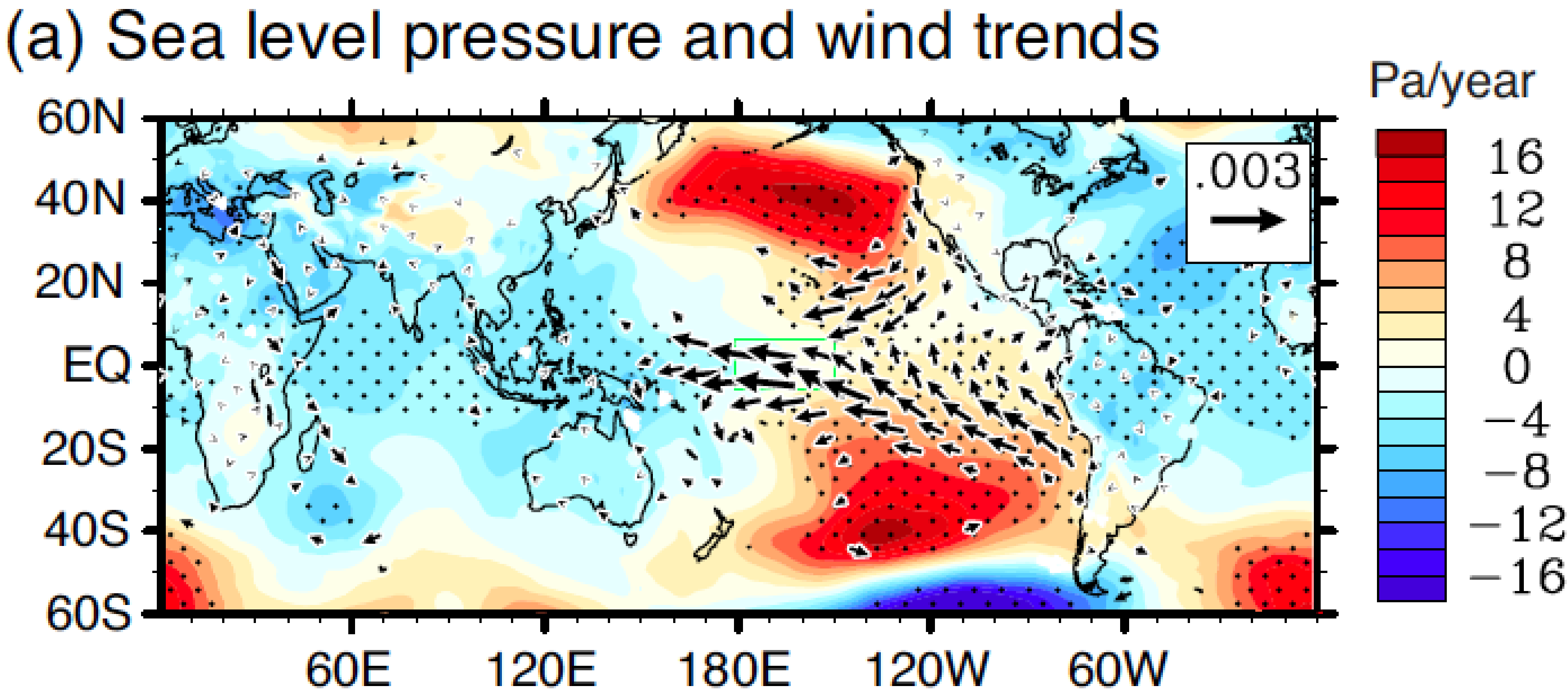




Influence of tropical wind on global temperature from months to decades

Oleg A. Saenko[1,2] · John C. Fyfe[1] · Neil C. Swart[1] · Warren G. Lee[1] · Matthew H. England[2,3]

Recent climate trends….

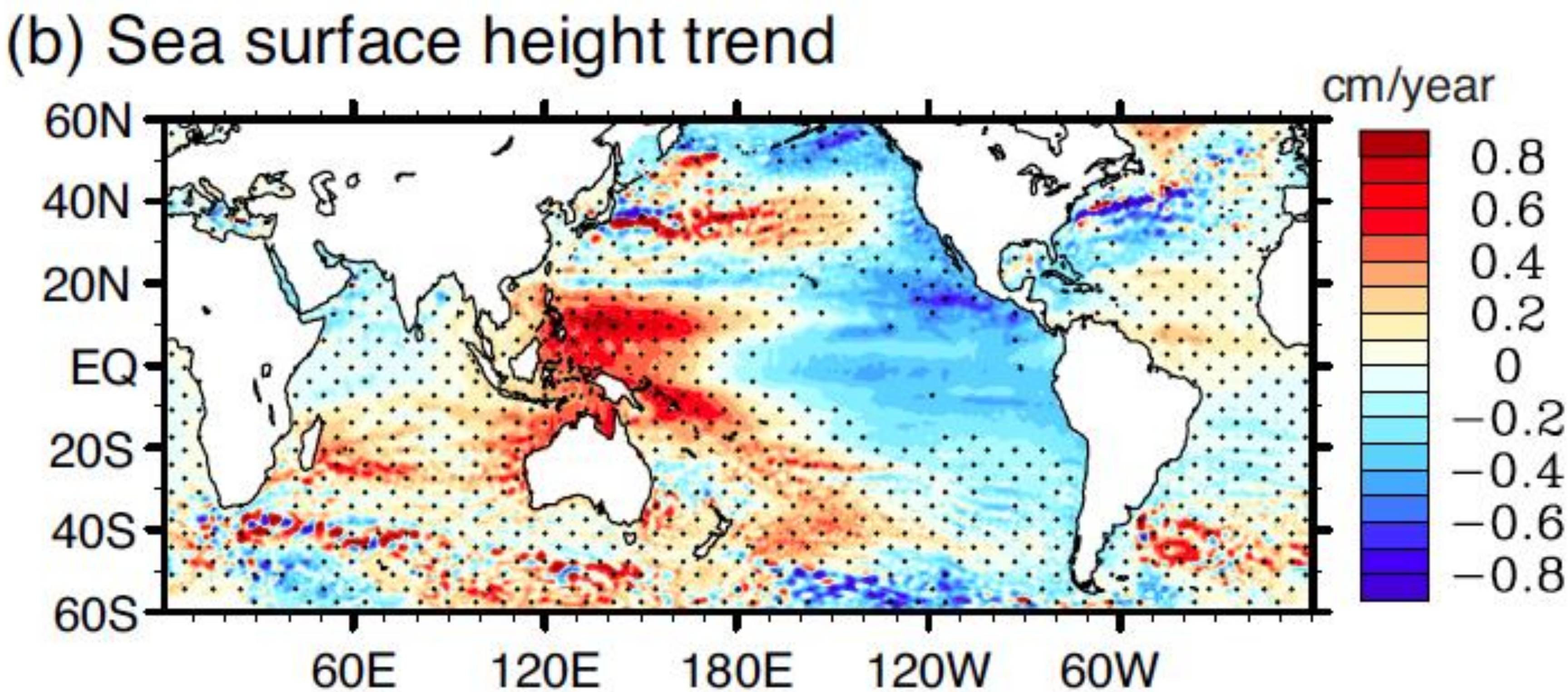


ERA-Interim SLP and wind stress trends

1992-2011

England et al. 2014

Recent climate trends….

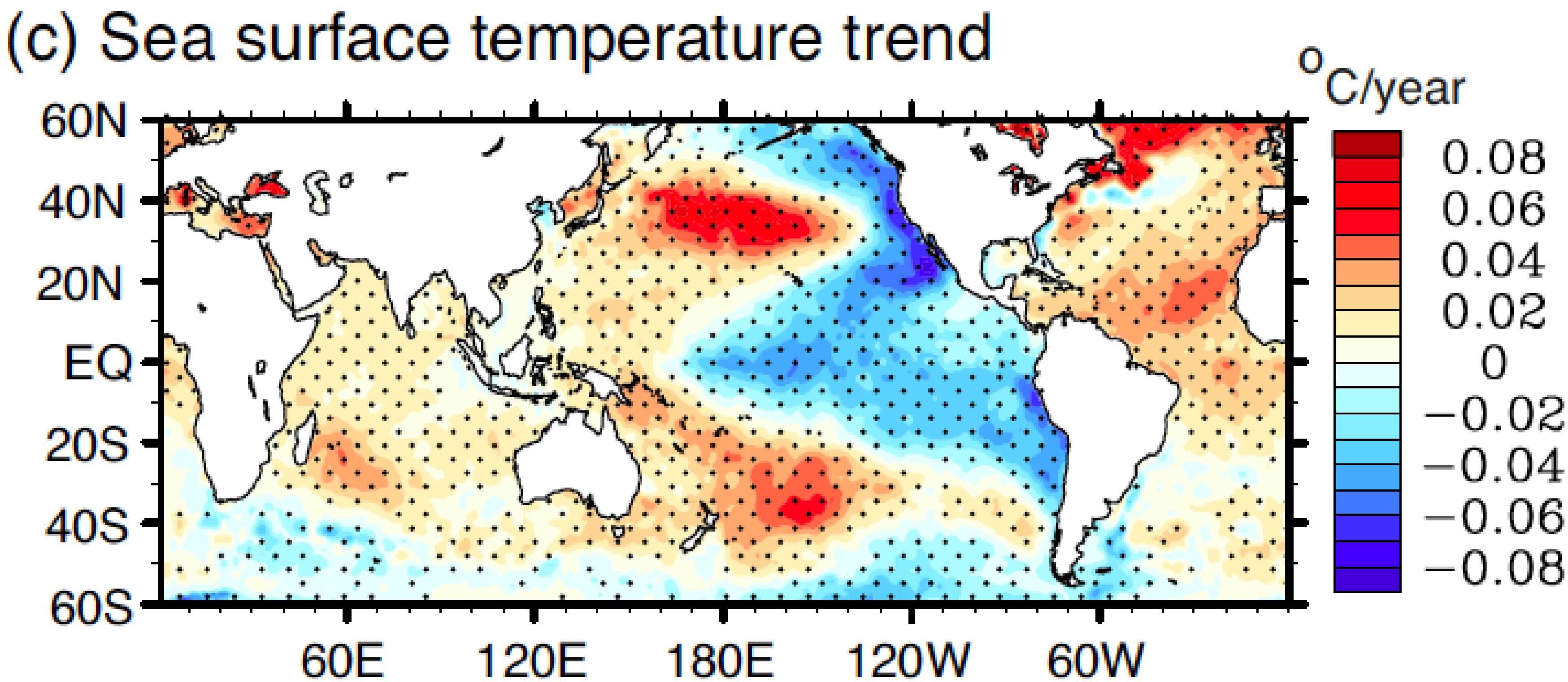


AVISO sea surface height trends

1992-2011

England et al. 2014

Recent climate trends....

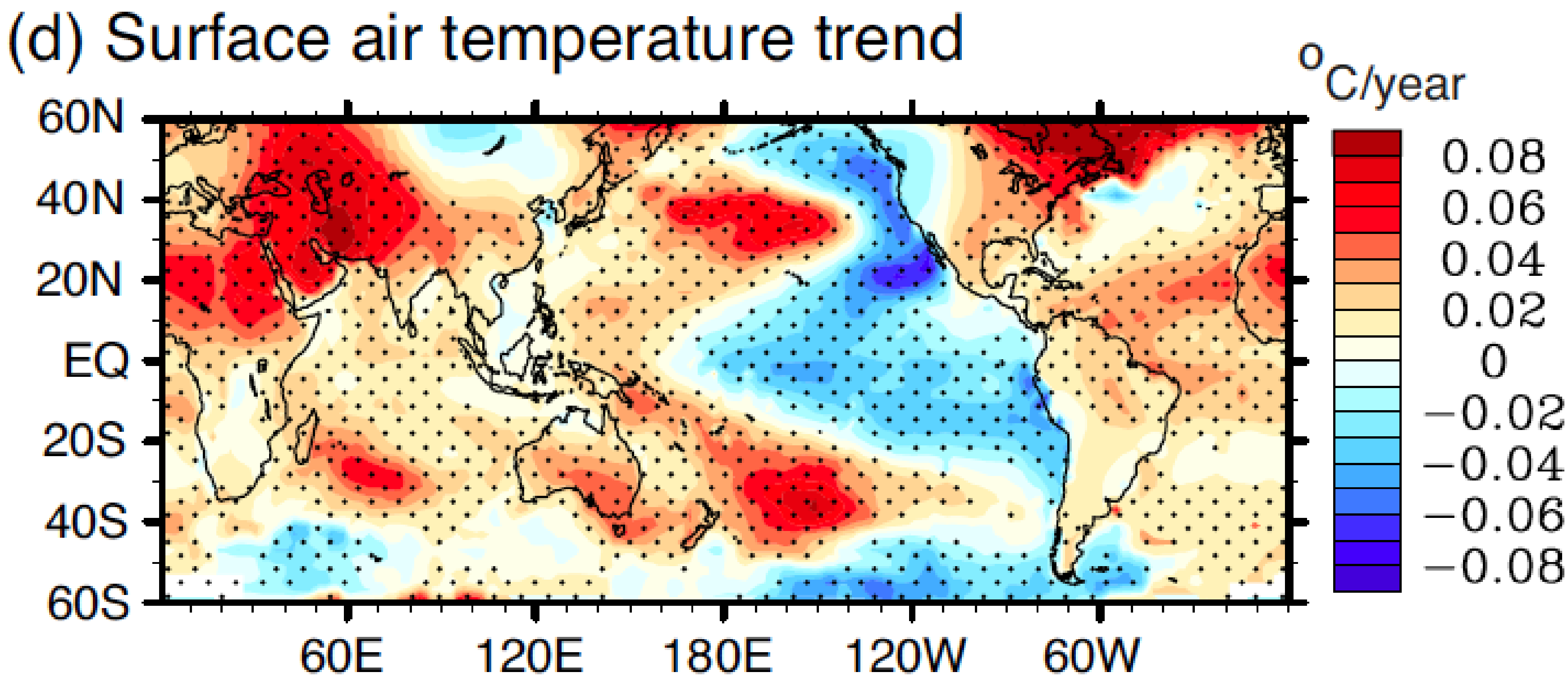


HadISST sea surface temperature trends

England et al. 2014

1992-2011

Recent climate trends….

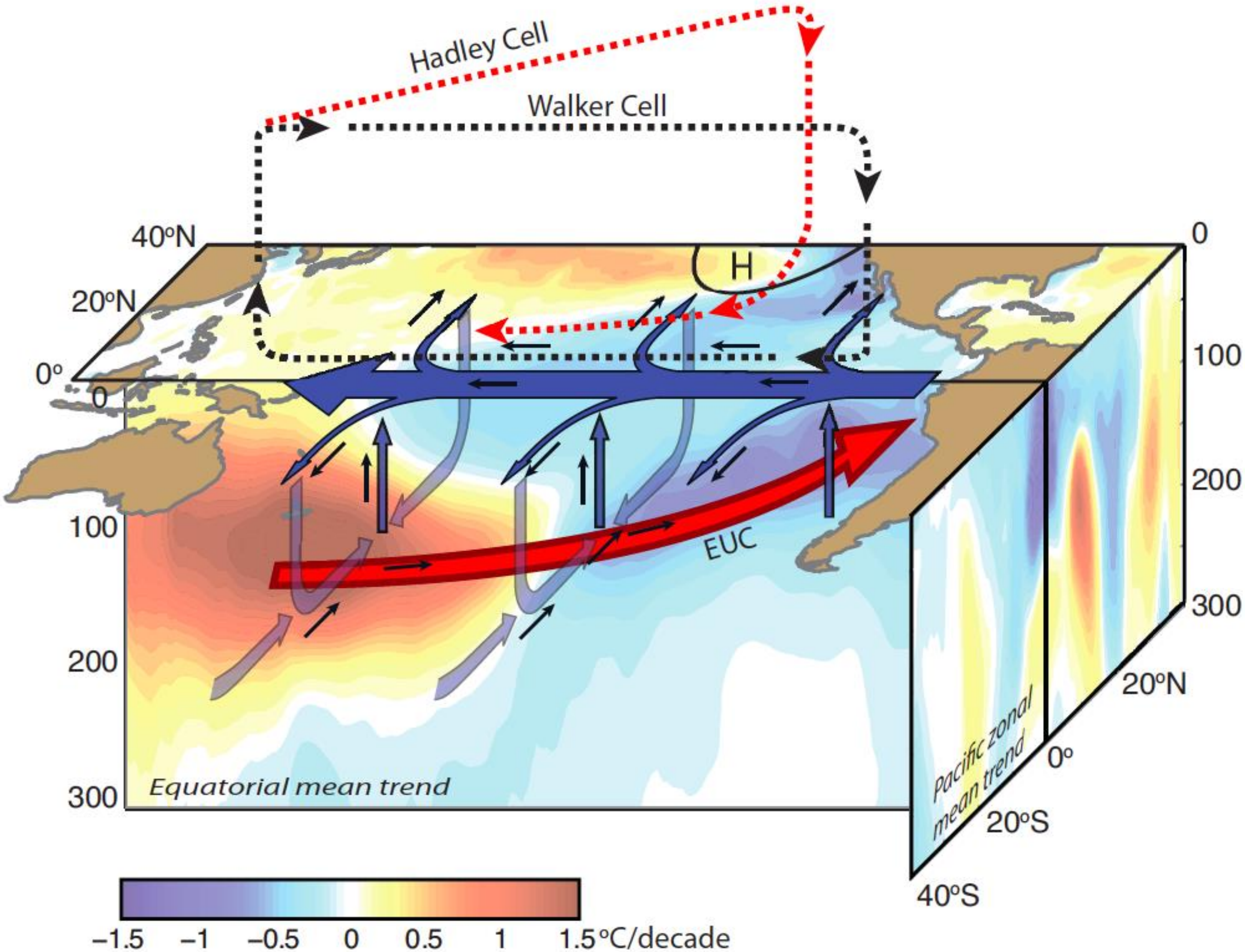


GISS surface air temperature trends

1992-2011

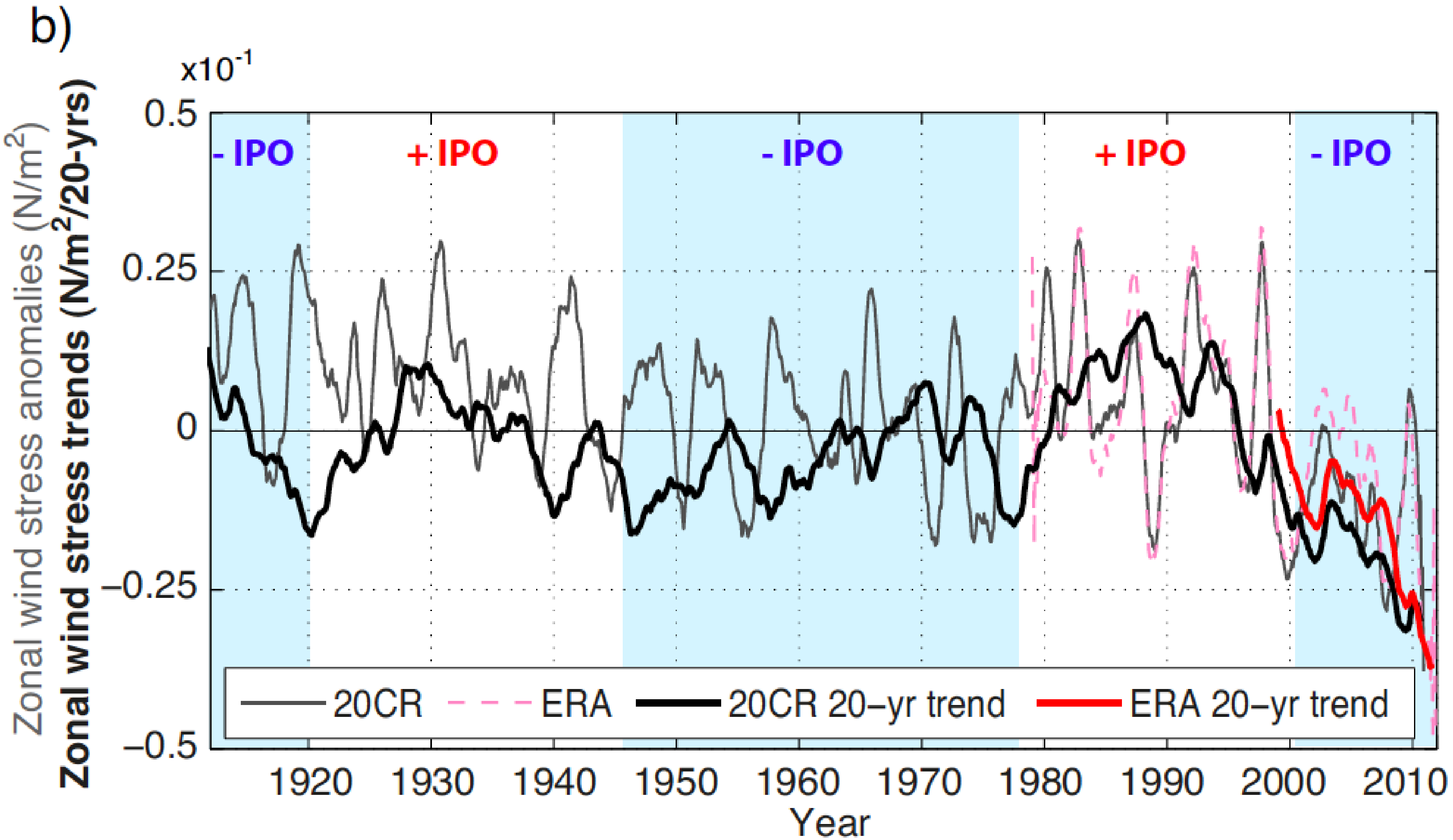
England et al. 2014

Recent Pacific Ocean trends....



England et al. 2014

How anomalous is the trade wind acceleration….?



England et al. 2014

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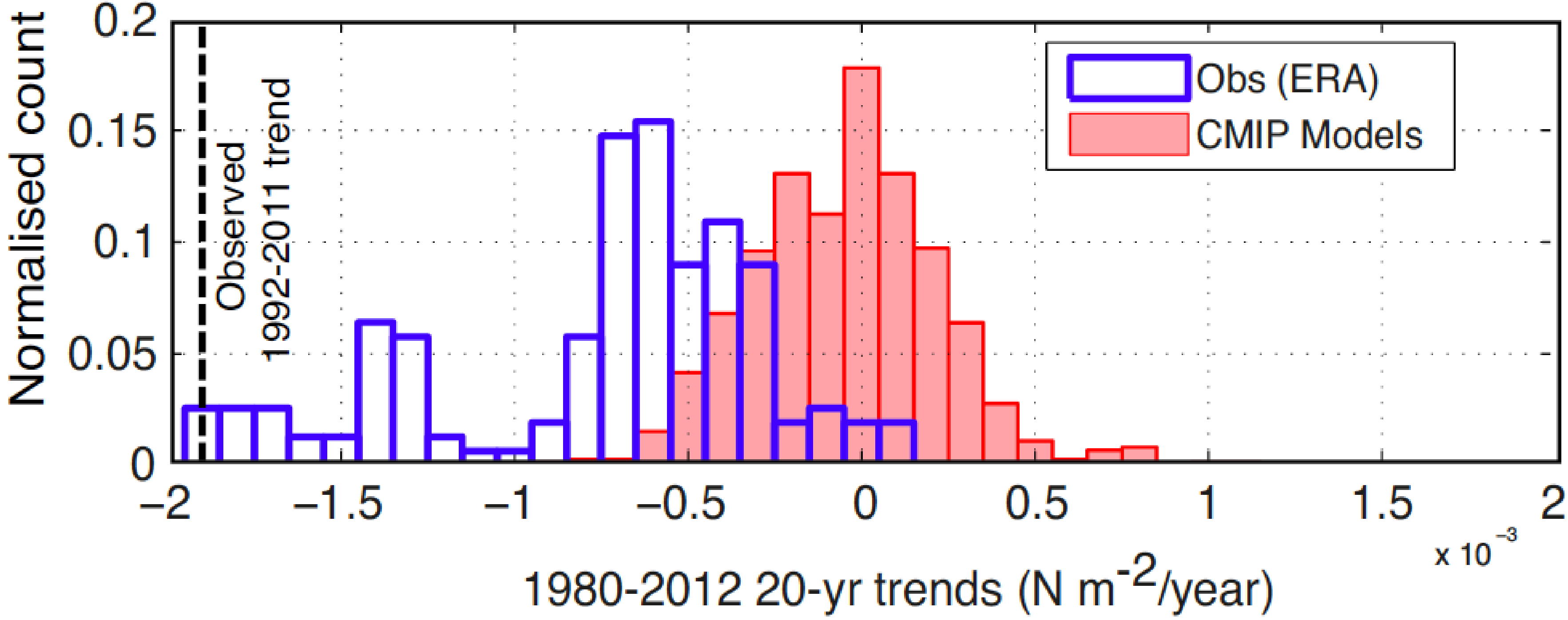
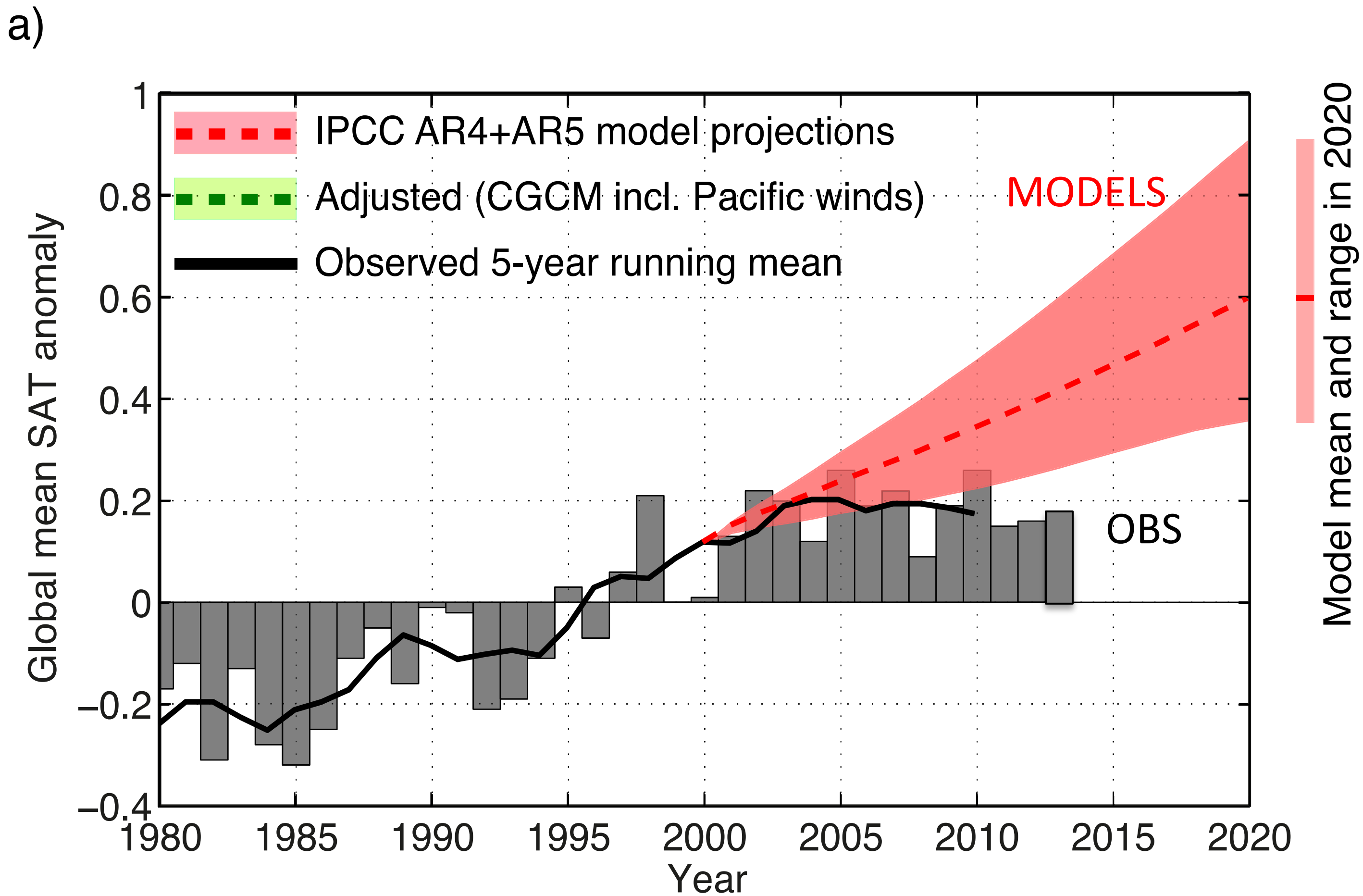


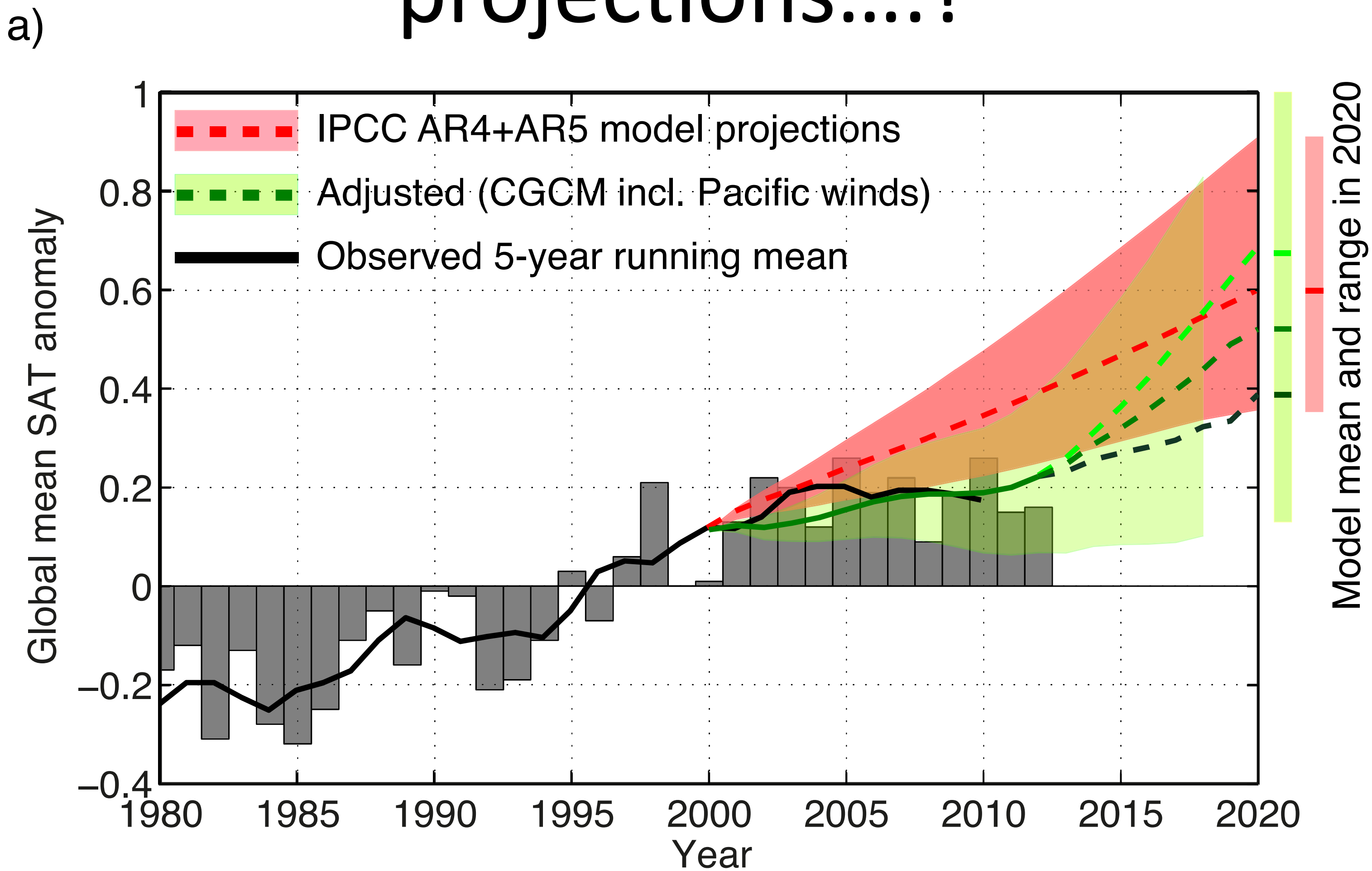
England et al. 2014

CMIP projections vs. observations



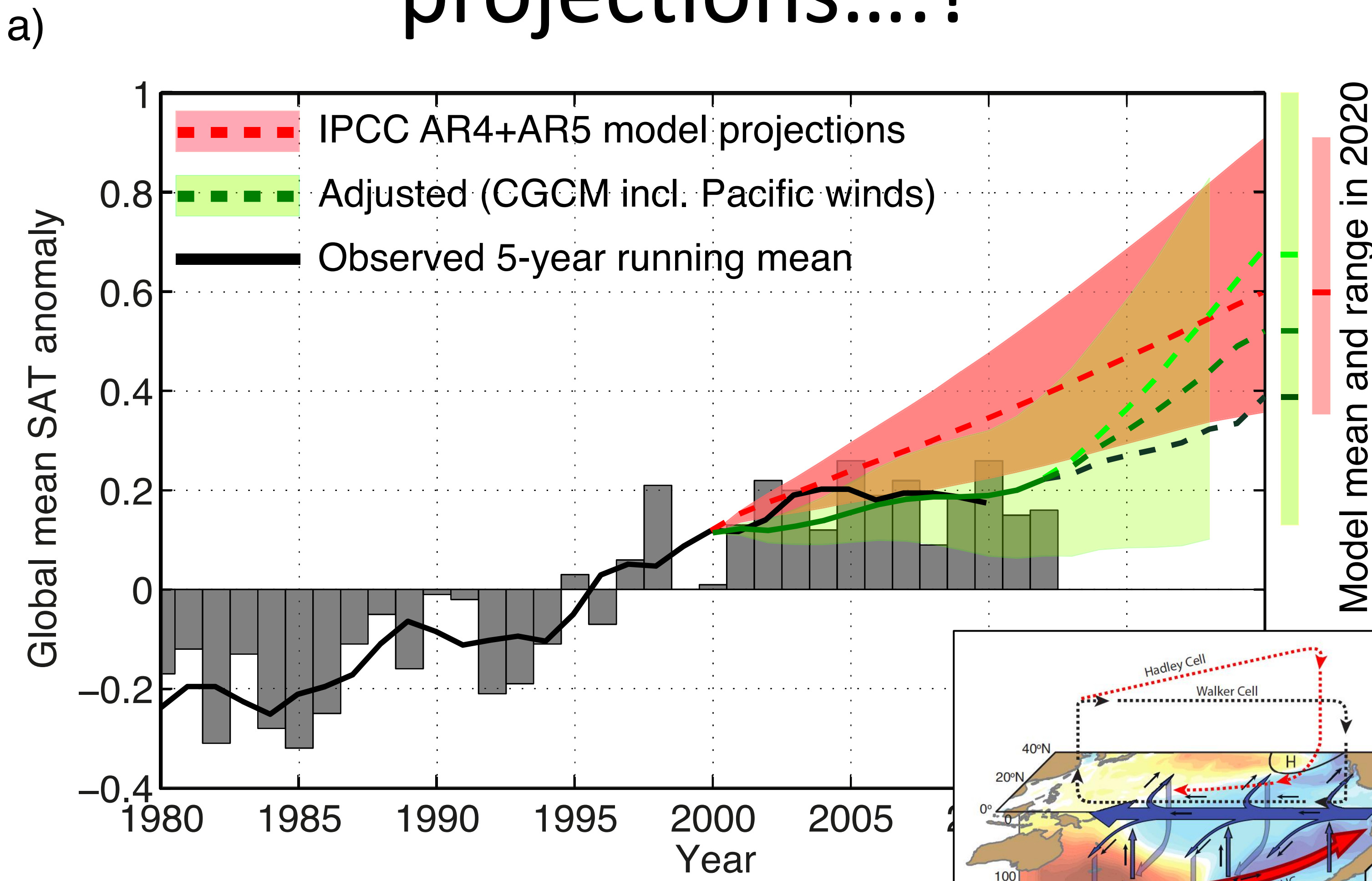
Comparison of MMM CMIP3+5 simulations with GISS SAT data

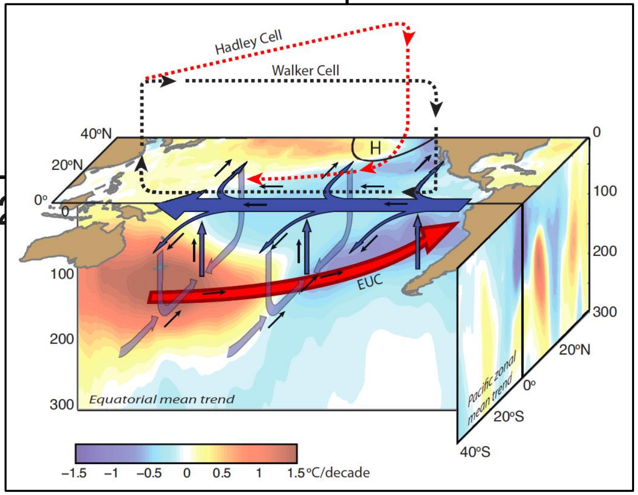
What does this mean for climate projections….?



England et al. 2014

What does this mean for climate projections….?





England et al. 2014

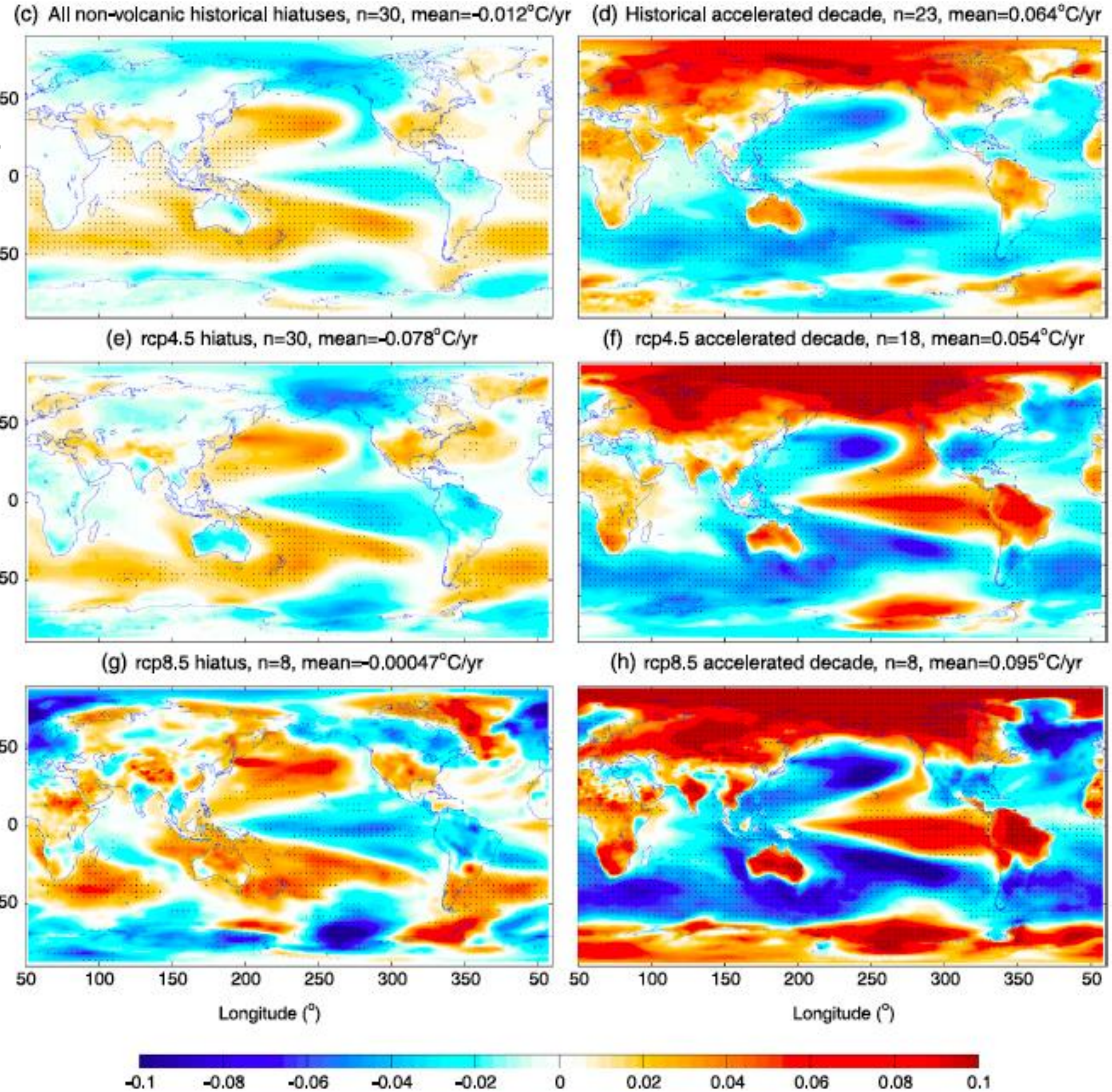
Hiatus decades

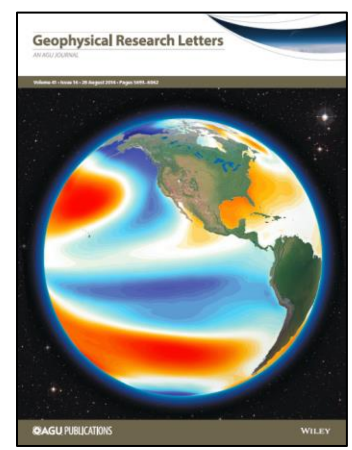
Warming decades

HIST’L

RCP4.5

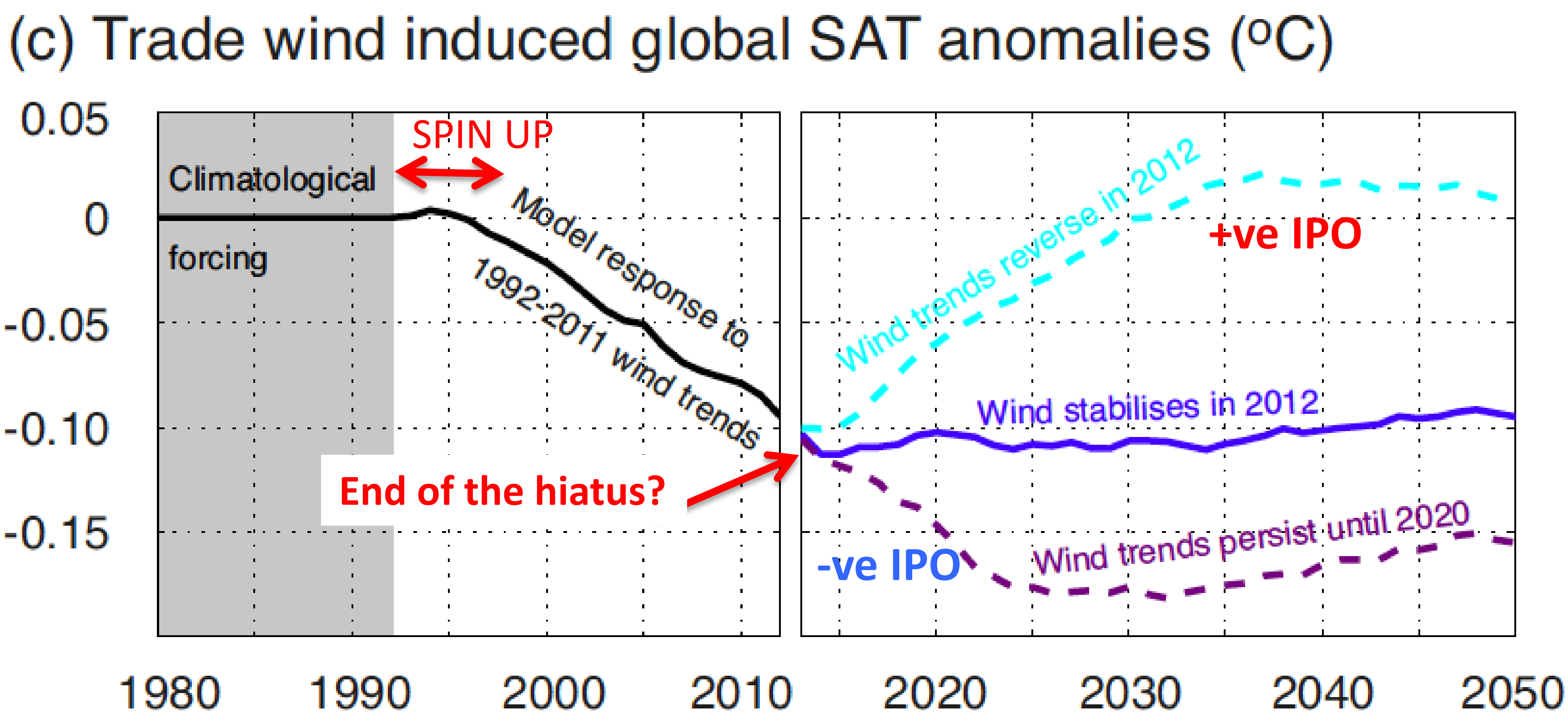
RCP8.5





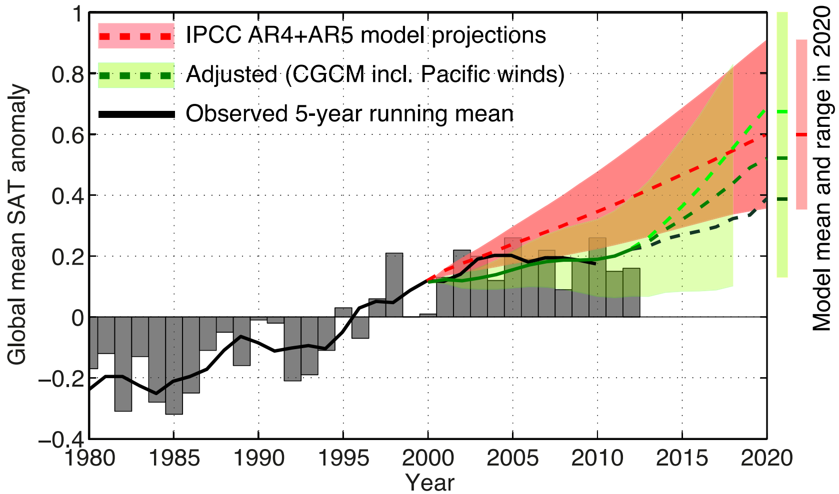
Maher et al. 2014

What next....?

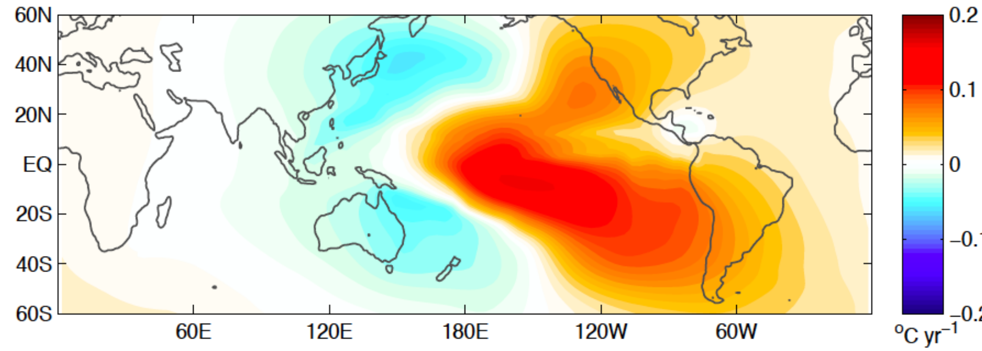


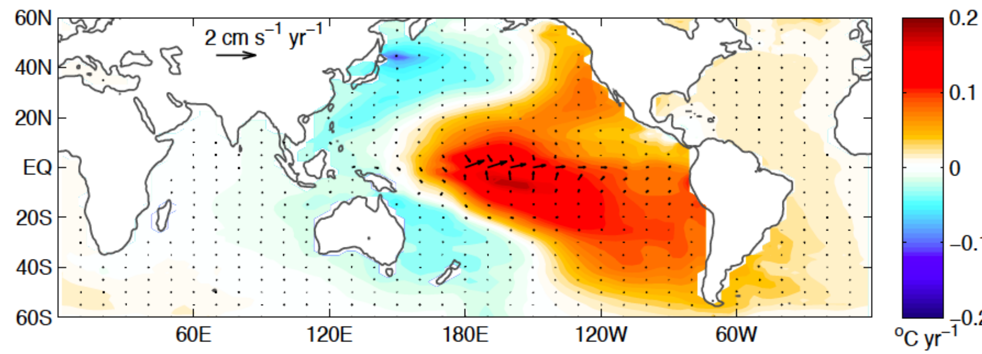
OCEAN GCM, SIMPLE ATMOSPHERE

a)

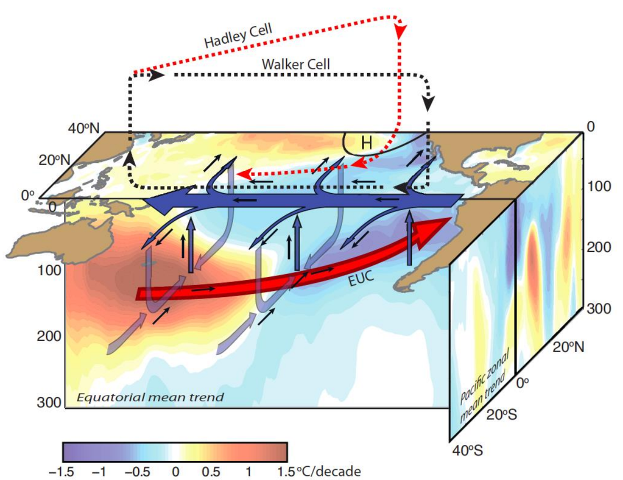


SAT and SST TRENDS 2013-2030

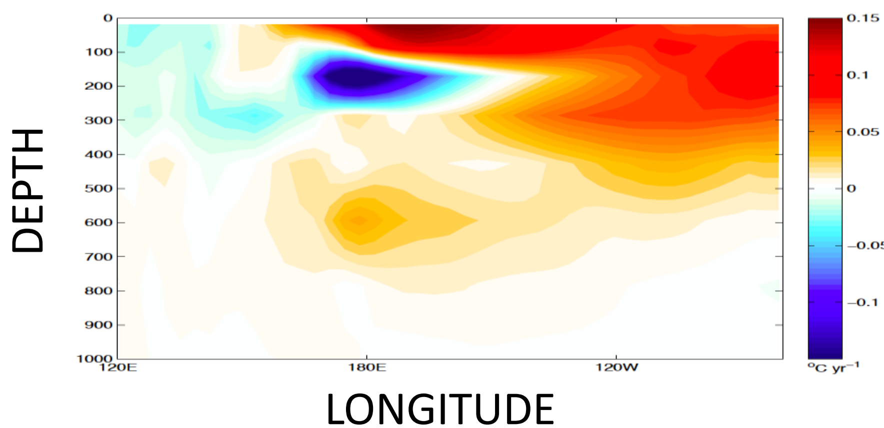




A REVERSAL OF CIRCULATION AND T ANOMALIES SEEN DURING THE HIATUS



PACIFIC TEMPERATURE TRENDS 2013-2030



What about the role of the Atlantic?

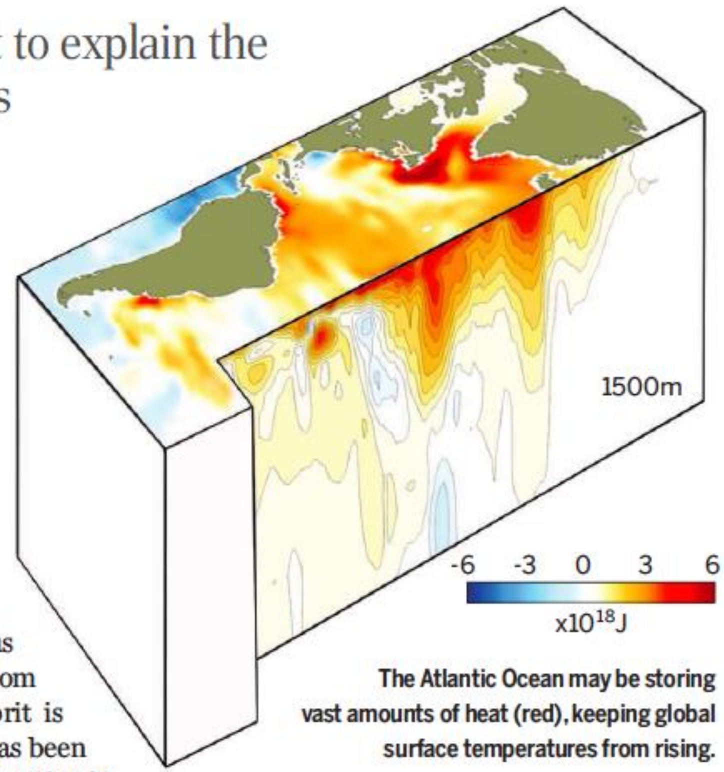
CLIMATE CHANGE

Is Atlantic holding Earth's missing heat?

New leads in the hunt to explain the global warming hiatus

By **Eli Kintisch**

Armchair detectives might call it the case of Earth's missing heat: Why have average global surface air temperatures remained essentially steady since 2000, even as greenhouse gases have continued to accumulate in the atmosphere? The suspects include changes in atmospheric water vapor, a strong greenhouse gas, or the noxious sunshade of haze emanating from factories. Others believe the culprit is the mighty Pacific Ocean, which has been sending vast slugs of cold bottom water to



The Atlantic Ocean may be storing vast amounts of heat (red), keeping global surface temperatures from rising.

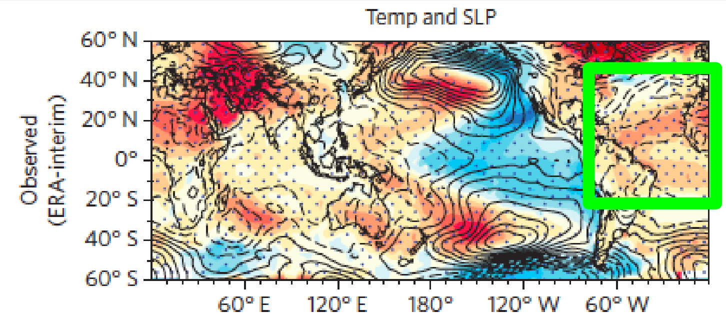
Perspective on Chen and Tung (2014) Science

Pacemaker experiments – SST forcing – AGCM – slab ocean

nature climate change
LETTERS
PUBLISHED ONLINE: 3 AUGUST 2014 | DOI: 10.1038/NCLIMATE2330

Recent Walker circulation strengthening and Pacific cooling amplified by Atlantic warming

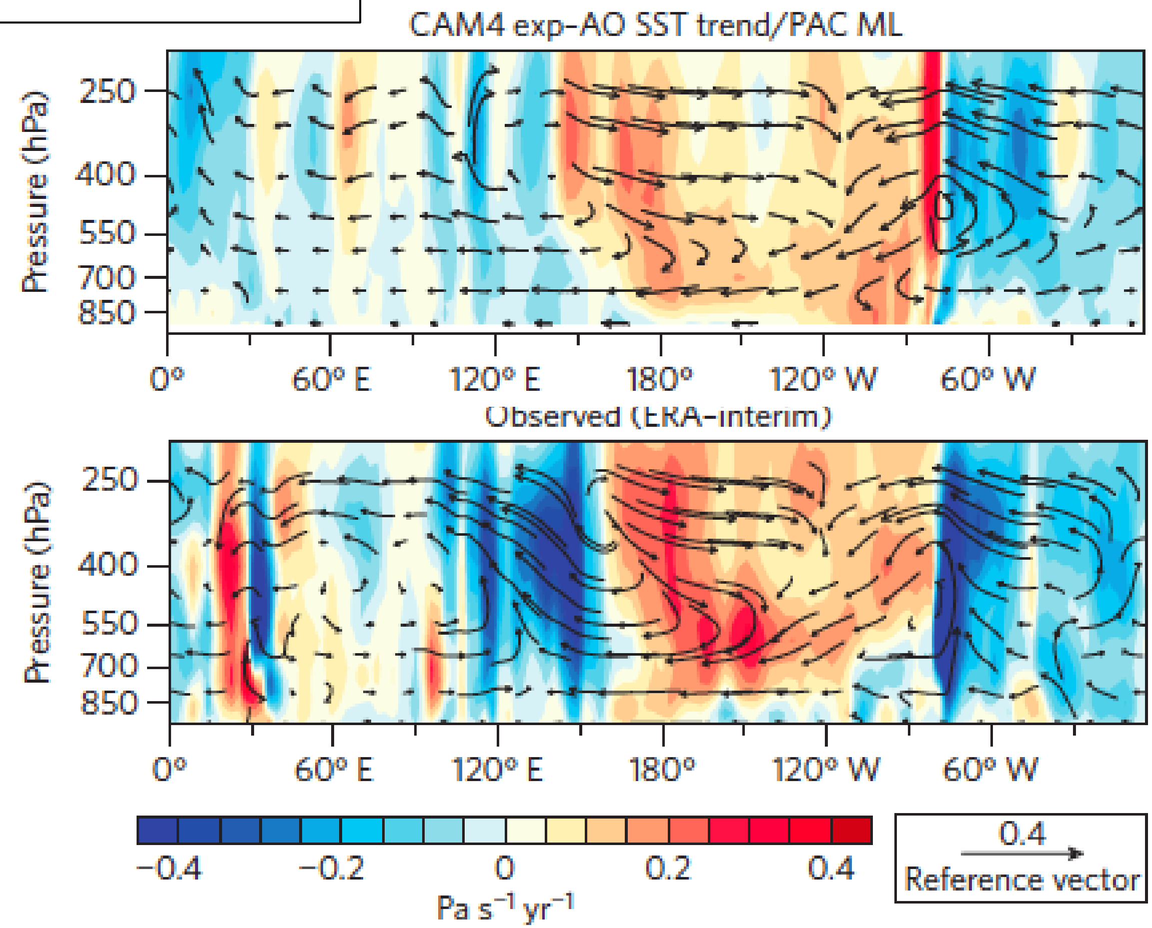
Shayne McGregor[1], Axel Timmermann[2*], Malte F. Stuecker[3], Matthew H. England[1], Mark Merrifield[4], Fei-Fei Jin[3] and Yoshimitsu Chikamoto[2]



MODELLED

CAM4 experiment forced by observed Atlantic Ocean SST trends (includes a Pacific mixed layer)

OBSERVED



McGregor et al. 2014

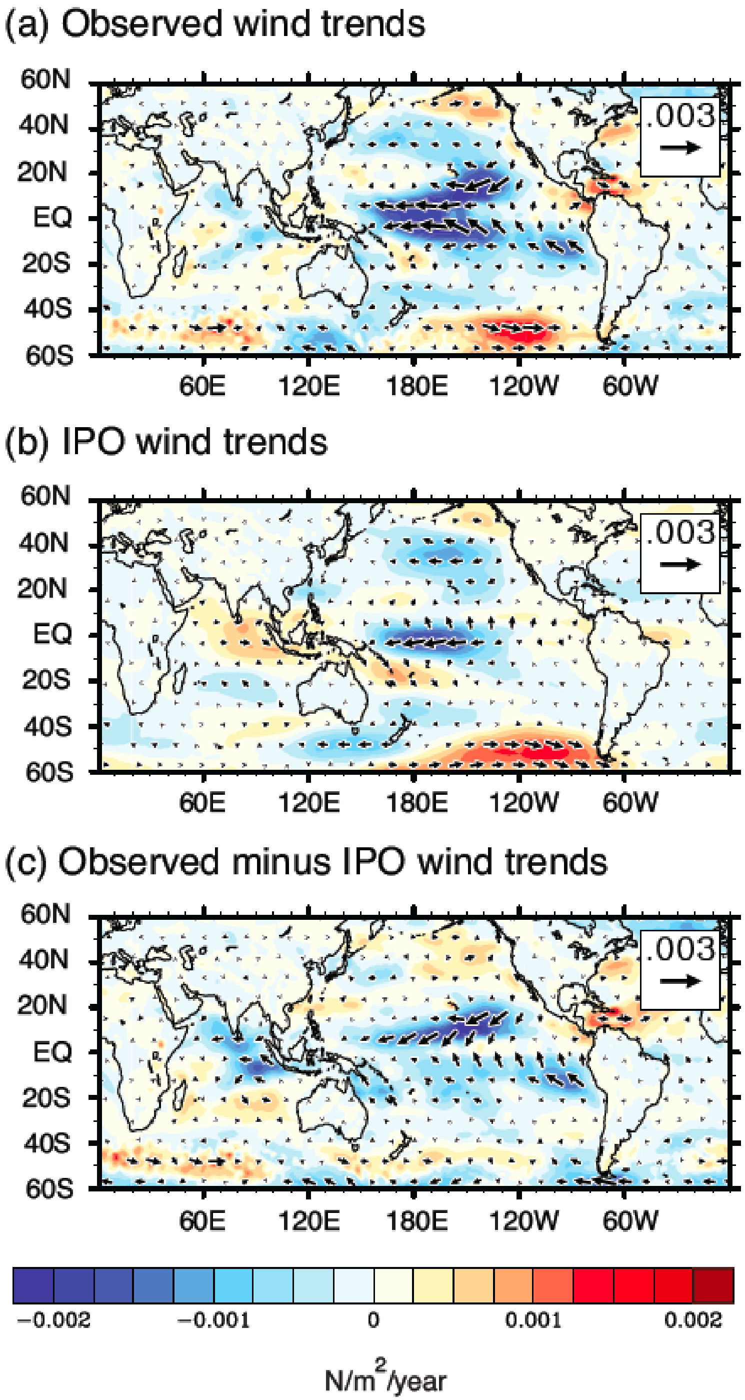
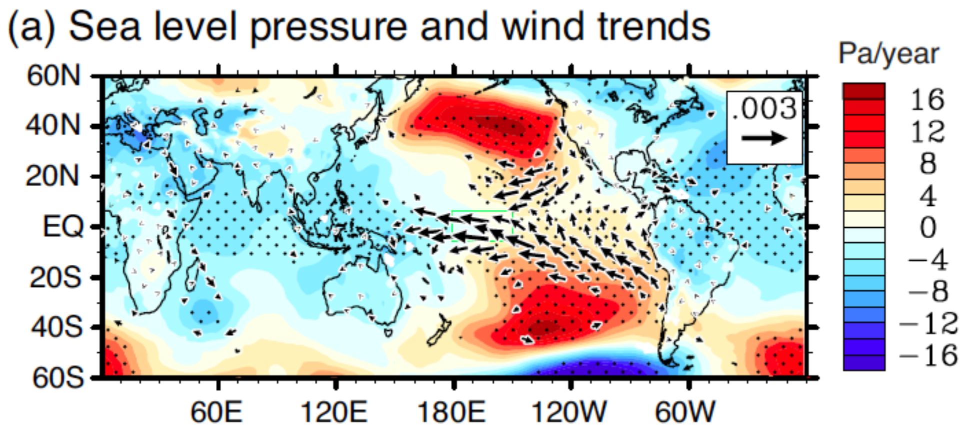
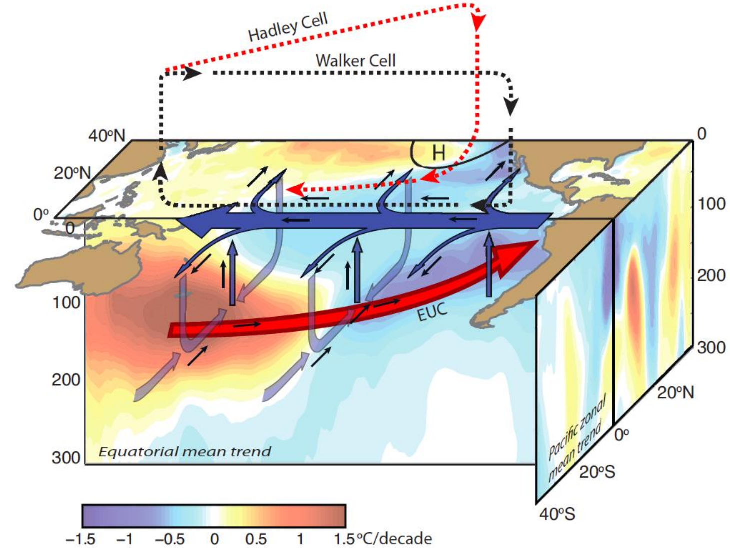


Figure S1 | Observed wind trends during 1992-2011. (a) Observed trends in surface wind stress (N/m^2/year) shown as vectors with the strength of the zonal wind stress trend overlaid in colour shading (N/m^2/year). Maximum vector scale is indicated. (b) As in (a) but showing the wind stress trends derived from a regression of the Interdecadal Pacific Oscillation (IPO) index. (c) As in (a), but showing the component of the 1992-2011 wind stress trends not accounted for by typical IPO variability (i.e., panel (a) minus panel (b)). The recent observed wind trends (panel (a)) are thus seen to be significantly stronger than those typically associated with the IPO (panel (b)).

England et al. 2014

Pacemaker experiments – wind-driven forcing





nature climate change
ARTICLES
PUBLISHED ONLINE: 9 FEBRUARY 2014 | DOI: 10.1038/NCLIMATE2106

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] Wenju Cai[5], Alex Sen Gupta[1,2], Michael J. McPhaden[6], Ariaan Purich[5] and Agus

nature climate change
LETTERS
PUBLISHED ONLINE: 31 AUGUST 2014 | DOI: 10.1038/NCLIMATE2355

Contribution of natural decadal variability to global warming acceleration and hiatus

Masahiro Watanabe[1]*, Hideo Shiogama[2], Hiroaki Tatebe[3], Michiya Hayashi[1], Masayoshi Ishii[4] and Masahide Kimoto[1]

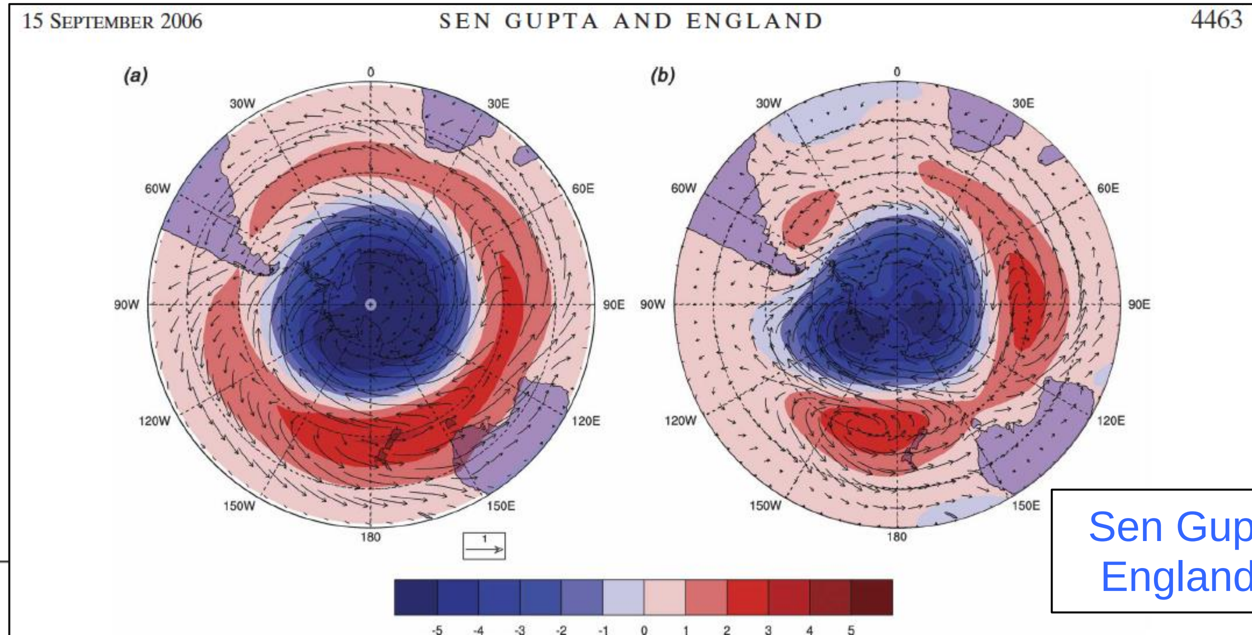
AGU PUBLICATIONS
Geophysical Research Letters
RESEARCH LETTER
10.1002/2014GL062775

The recent global warming hiatus: What is the role of Pacific variability?

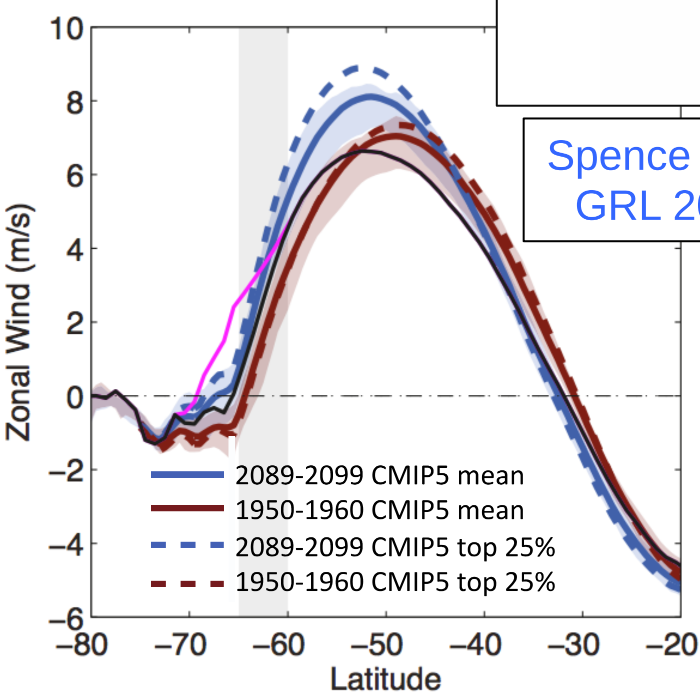
H. Douville[1], A. Voldoire[1], and O. Geoffroy[1]
[1]CNRM-GAME, Toulouse CEDEX 01, France

Key Points:
- Many models overestimate the Pacific influence on global mean temperature
- The recent hiatus is only partly due to the internal Pacific variability

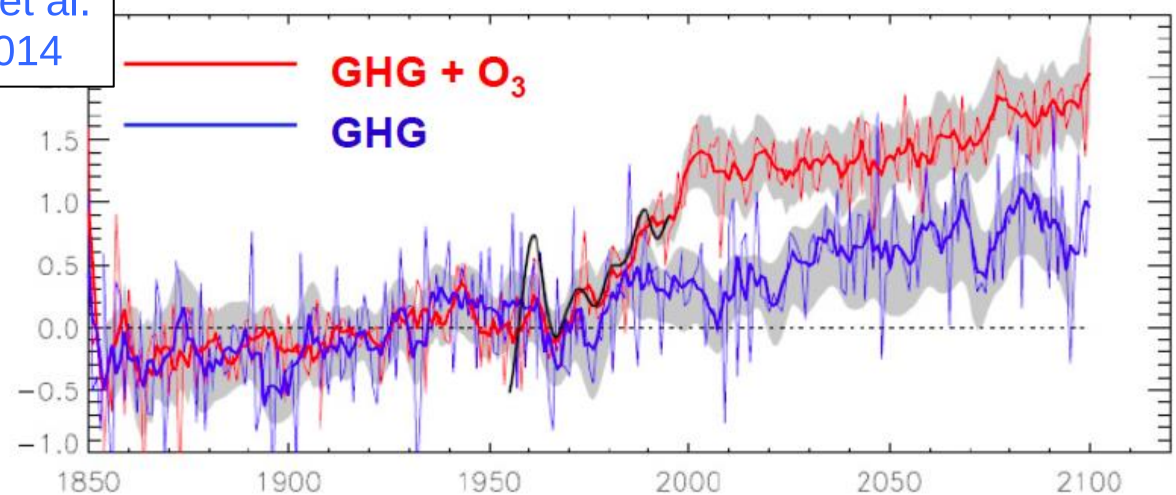
Pacemaker experiments – SO wind-driven forcing



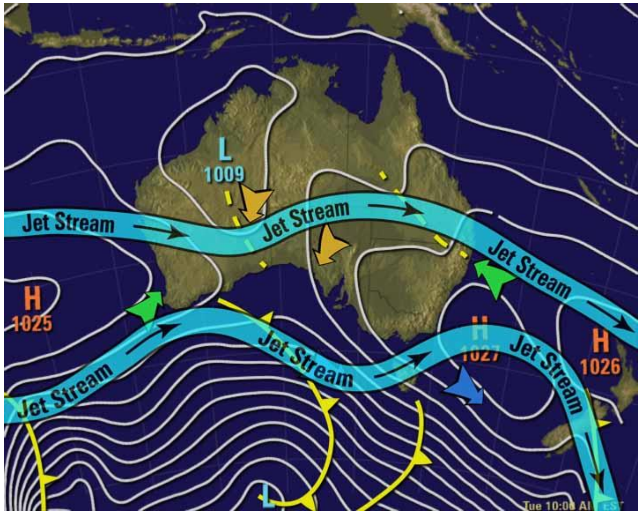
Sen Gupta and England 2006



Spence et al. GRL 2014

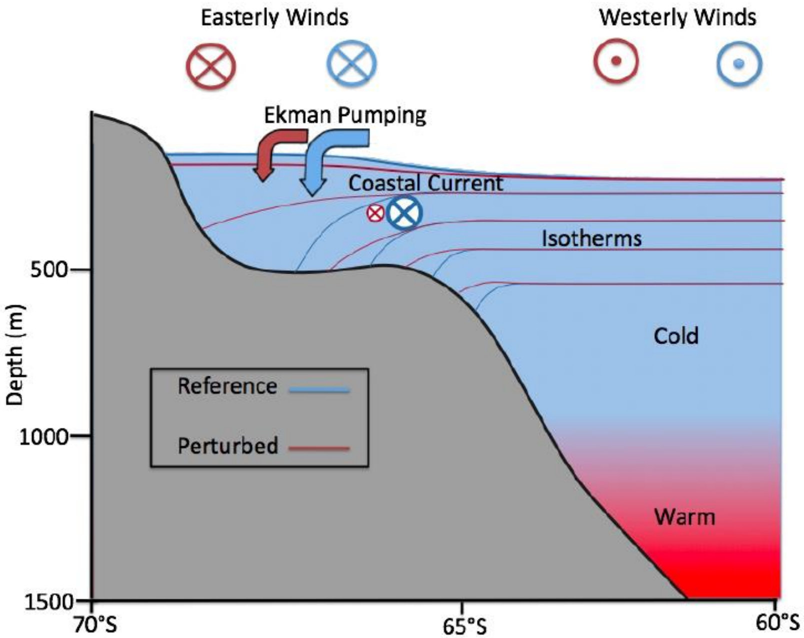


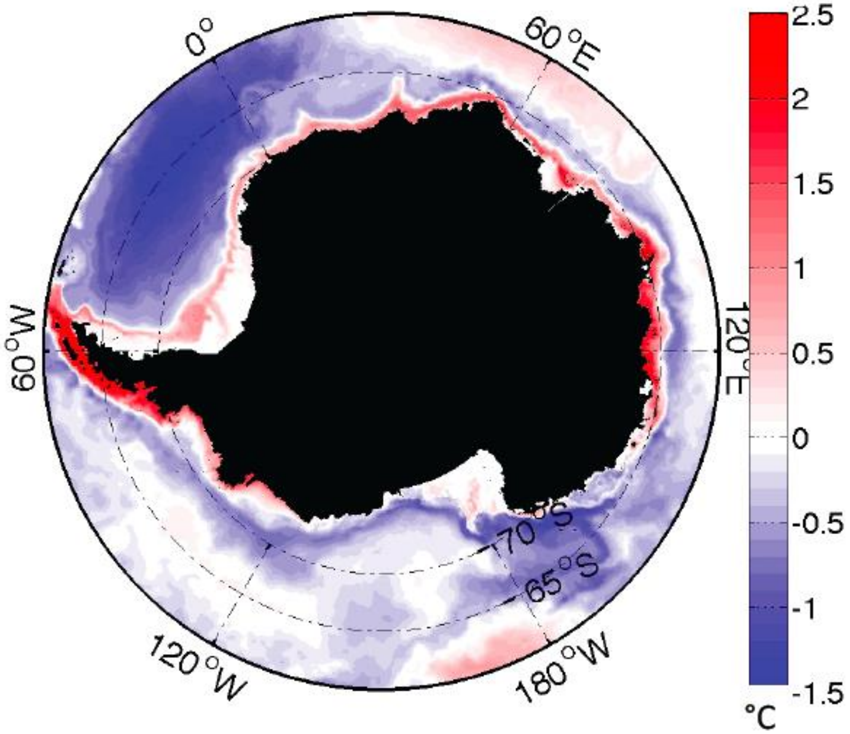
Mechanism for circulation changes and rapid warming in the Southern Ocean



Spence et al. GRL 2014

SH WESTERLY WINDS
15% increase and 4^{o} shift





Rapid subsurface warming driven by wind changes around Antarctica

Spence et al. GRL 2014

Pacemaker experiments – other variables

Arctic sea-ice trends / variations

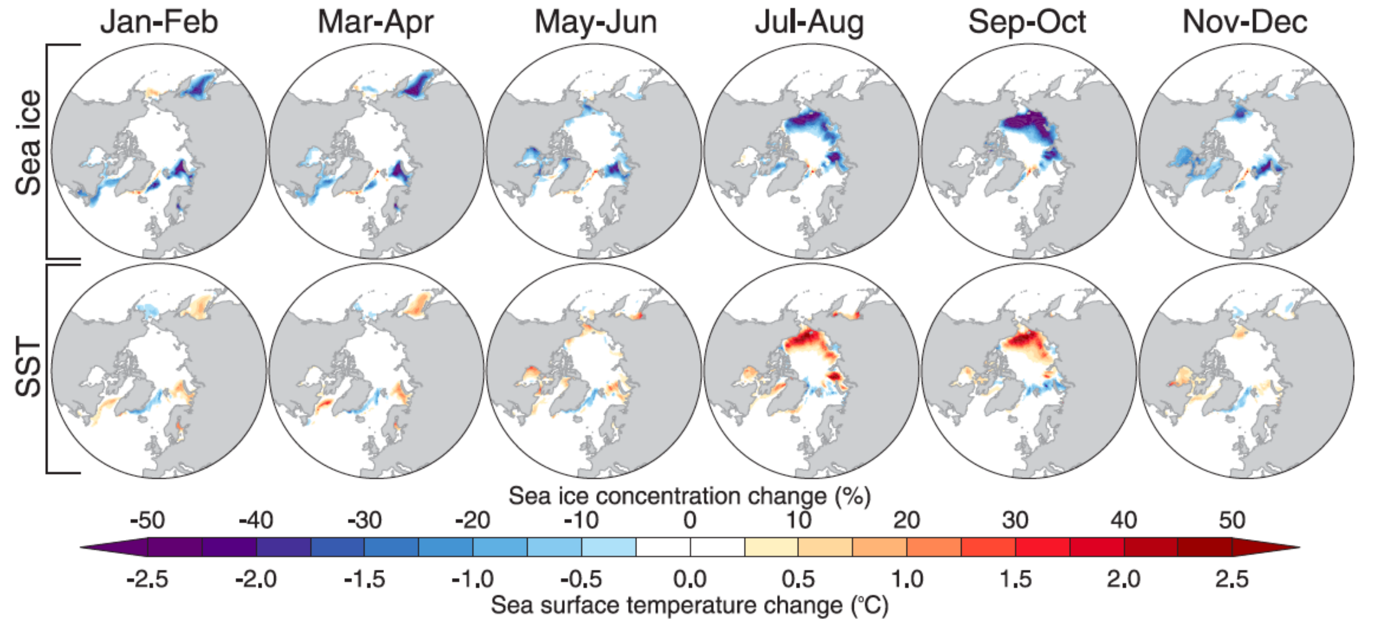


FIG. 1. Linear changes from 1979 to 2009 in (top) sea ice concentrations and (bottom) sea surface temperatures. SST changes are confined to areas of sea ice change by design (see text).

Screen et al. 2013

Pacemaker experiments – other variables

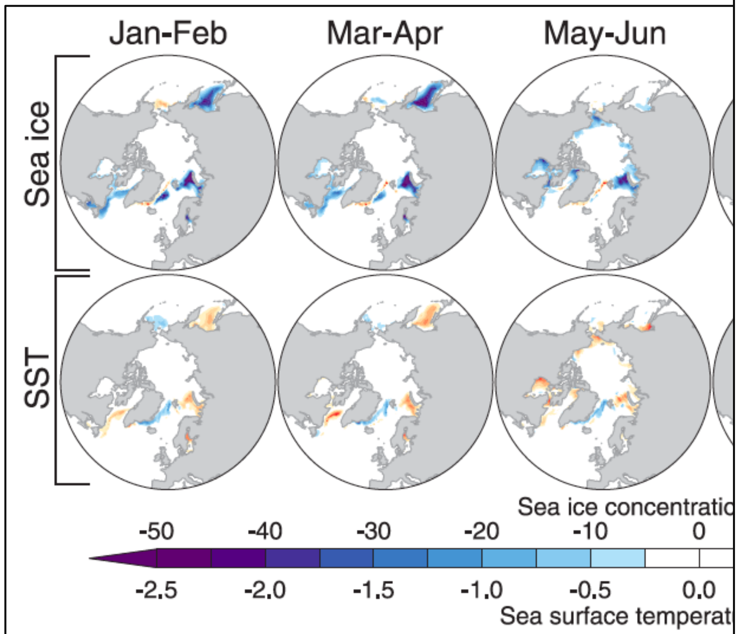
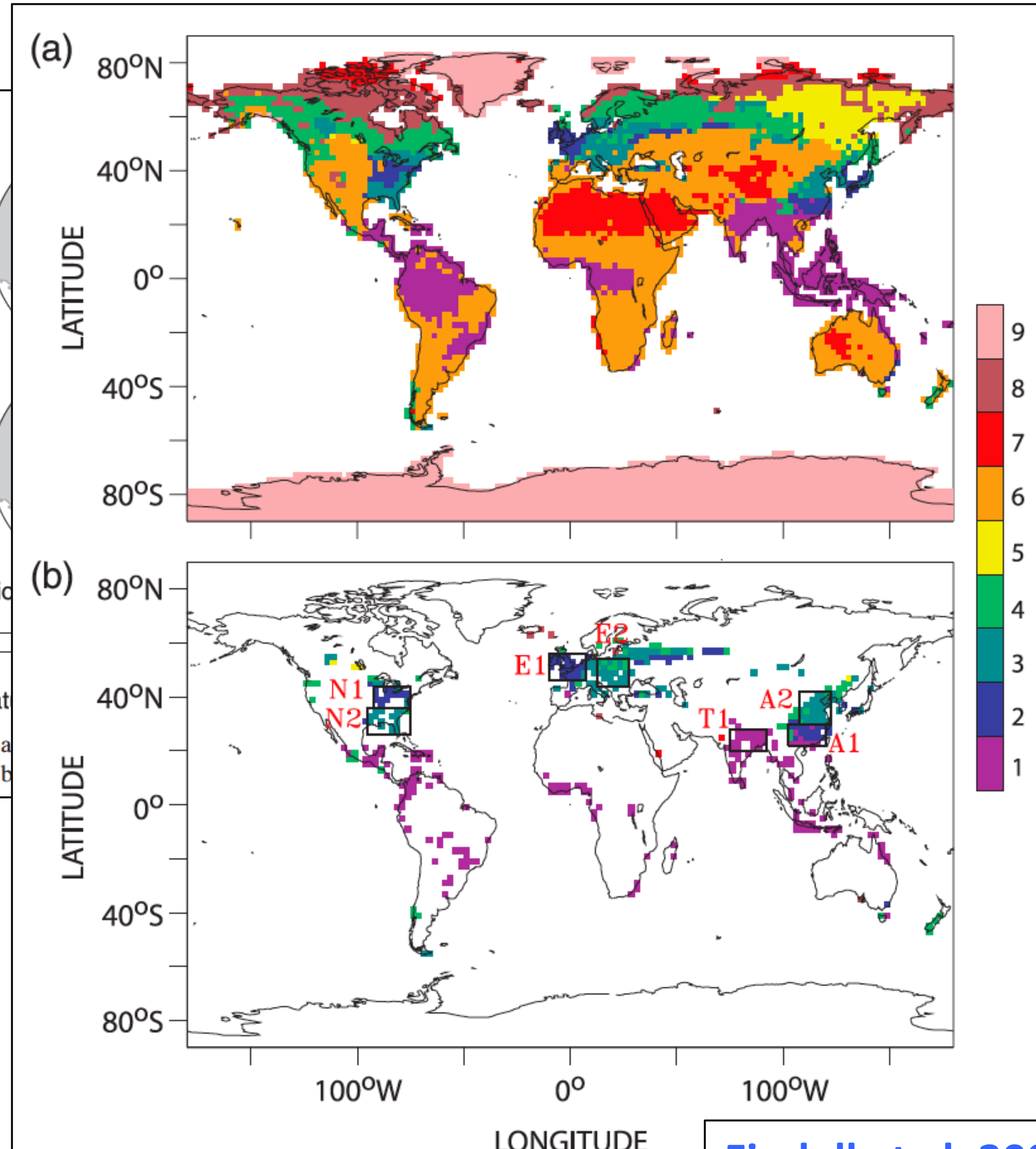


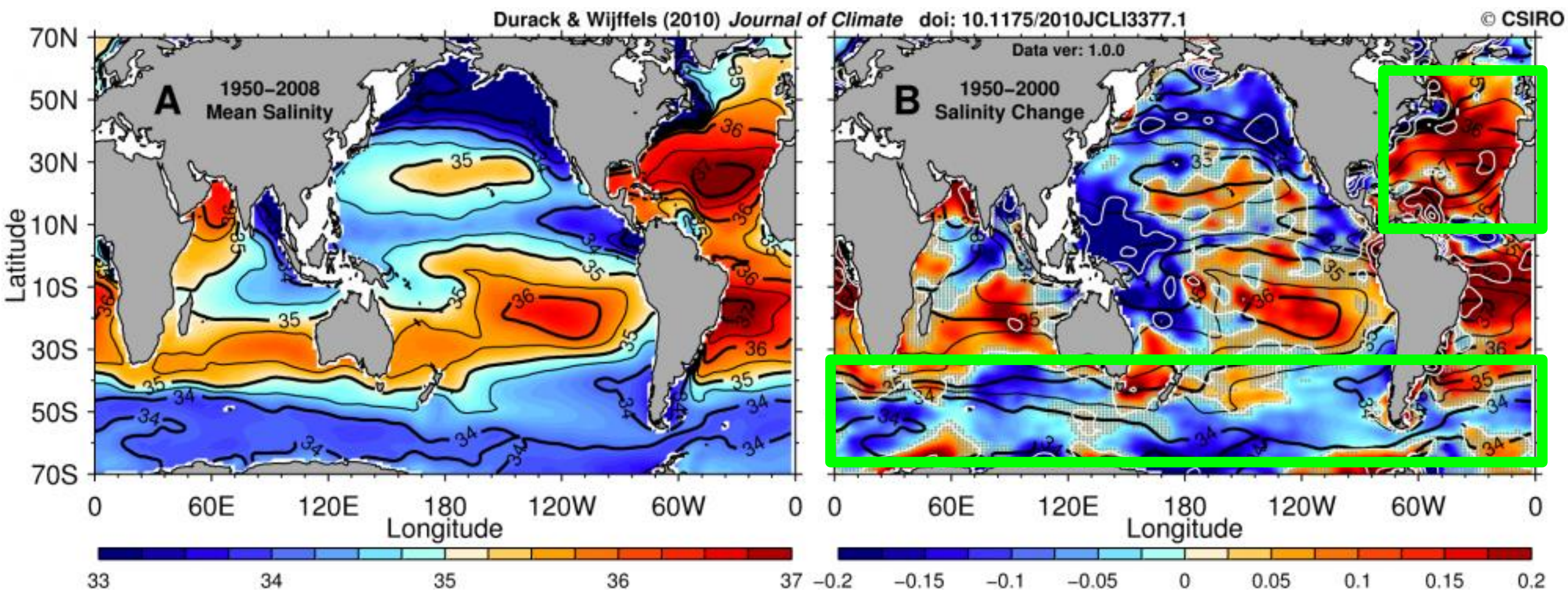
FIG. 1. Linear changes from 1979 to 2009 in (top) sea ice concentrations a
to areas of sea ice change b

Land clearing prescribed expts

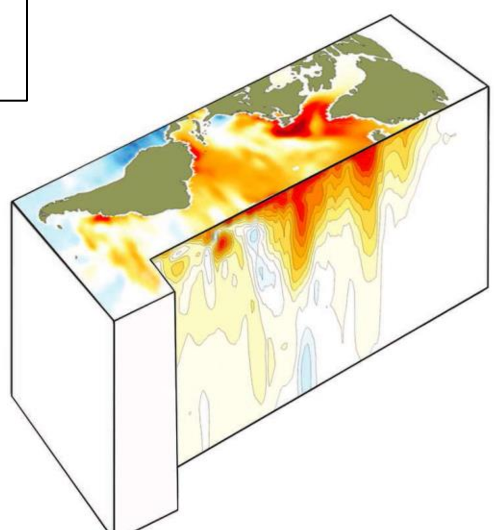


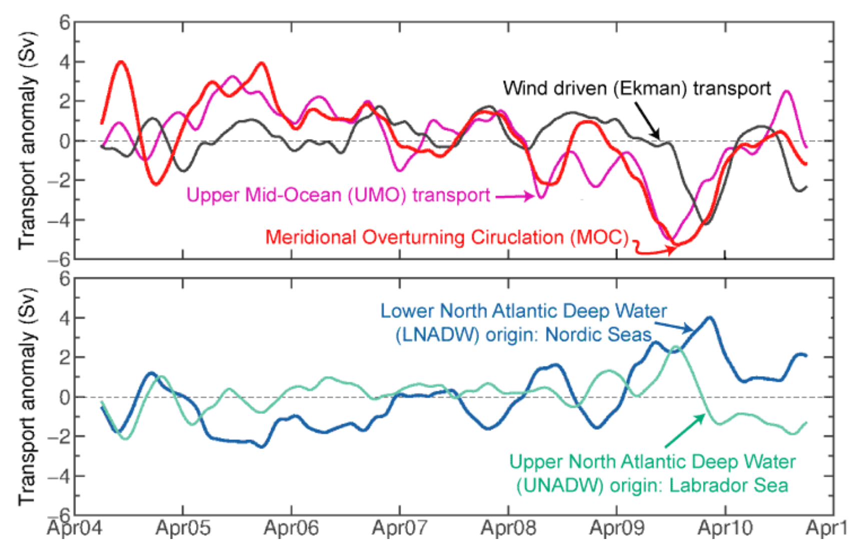
Findell et al. 2009

Pacemaker experiments – surface salinity / E-P forcing



Durack and Wijffels SSS





Pacemaker experiments for studying decadal climate variability

Motivations:

- Improving mechanistic understanding of OBS
- Improving understanding of models, model biases
- Improve understanding of interbasin forcing
- Improved prediction skills

Toward Pacemaker MIPs:

- Start as ad-hoc simulations
- Something interesting is found
- Community interest gathers
- Coordinated experiments get discussed
- MIPs formally proposed

So many options….

- Full coupled model
- AGCM coupled to slab ocean
- OGCM coupled to ‘slab’ atmosphere

Pacemaker specified via

- SST override / SST restoring / SST via fluxes
- wind stress / wind impact on fluxes…
- SSS restoring / E-P / MW perturbations
- Sea-ice
- Combinations of the above // regional selection

Additional Pacific wind pacemaker experiments?

SST pacemaker……

- \- heat / energy not conserved
- \- GMST oversensitivity to E-Pac SST?
- \+ well-observed
- \+ atmospheric response
- • SST restoring / override / enter via fluxes

WIND pacemaker……

- \+ heat / energy conservation
- • sensitivity to E-Pac winds
- \- less well-observed
- \+ oceanic response
- • wind stress / evaporative fluxes, ML deepening etc?

DCPP Component C: Predictability, Mechanisms and Case Studies

Table 1.

Component C1: Haitus+: Accelerated and retarded rates of global temperature change

Objectives: To investigate the role of eastern Pacific and North Atlantic sea surface temperatures in the modulation of global surface temperature trends and in driving regional climate variations.

#	TIER	Experiment	Notes	# of years
		Pacemaker experiments		
C1.1	1	Coupled model restored to observed anomalies of sea surface temperature in the tropical Pacific	Follow the experimental design of Kosaka and Xie (2013). Time period: 1950 to 2015 Ensemble size: 10 members Restoring timescales: 10 days for 50m deep mixed layer suggested Climatological period for computing anomalies: 1950-2015	66x10=660 years IPO
C1.2	1	As above but for the North Atlantic	As C1.1 but restored to observed sea surface temperature anomalies in the North Atlantic, 0°N to 60°N Time period: 1950 to 2015 Ensemble size: 10 members Restoring timescales: as for C1.1	66x10=660 years AMO

DCPP Component C: Predictability, Mechanisms and Case Studies

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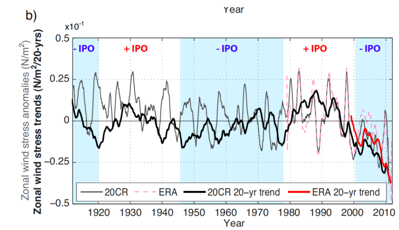
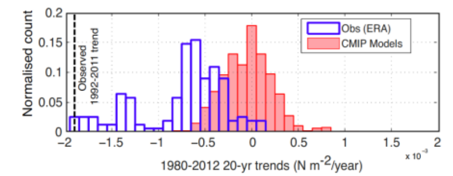
& 1920 – 2015 runs

& different start years
(mid 1990s subpolar NA warming)

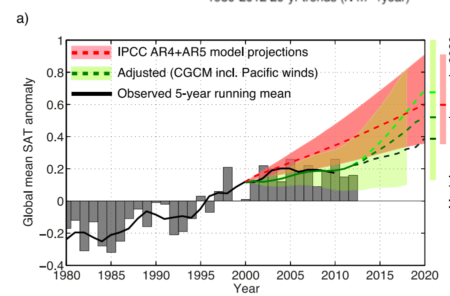
Conclusions



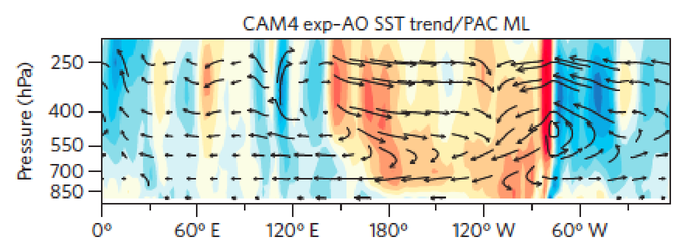
- Recent observed trade wind trend unprecedented



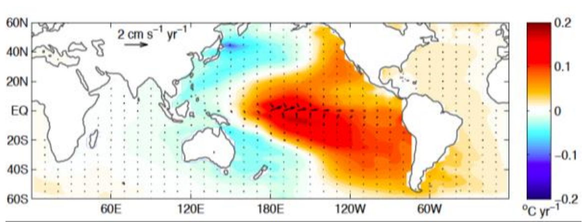
- Beyond the variability seen in CMIP models



- Cooling impact can account for the hiatus
  - Ocean heat uptake
  - Teleconnections from cool East Pacific SST
- The Atlantic plays a role – but via a teleconnection to PO



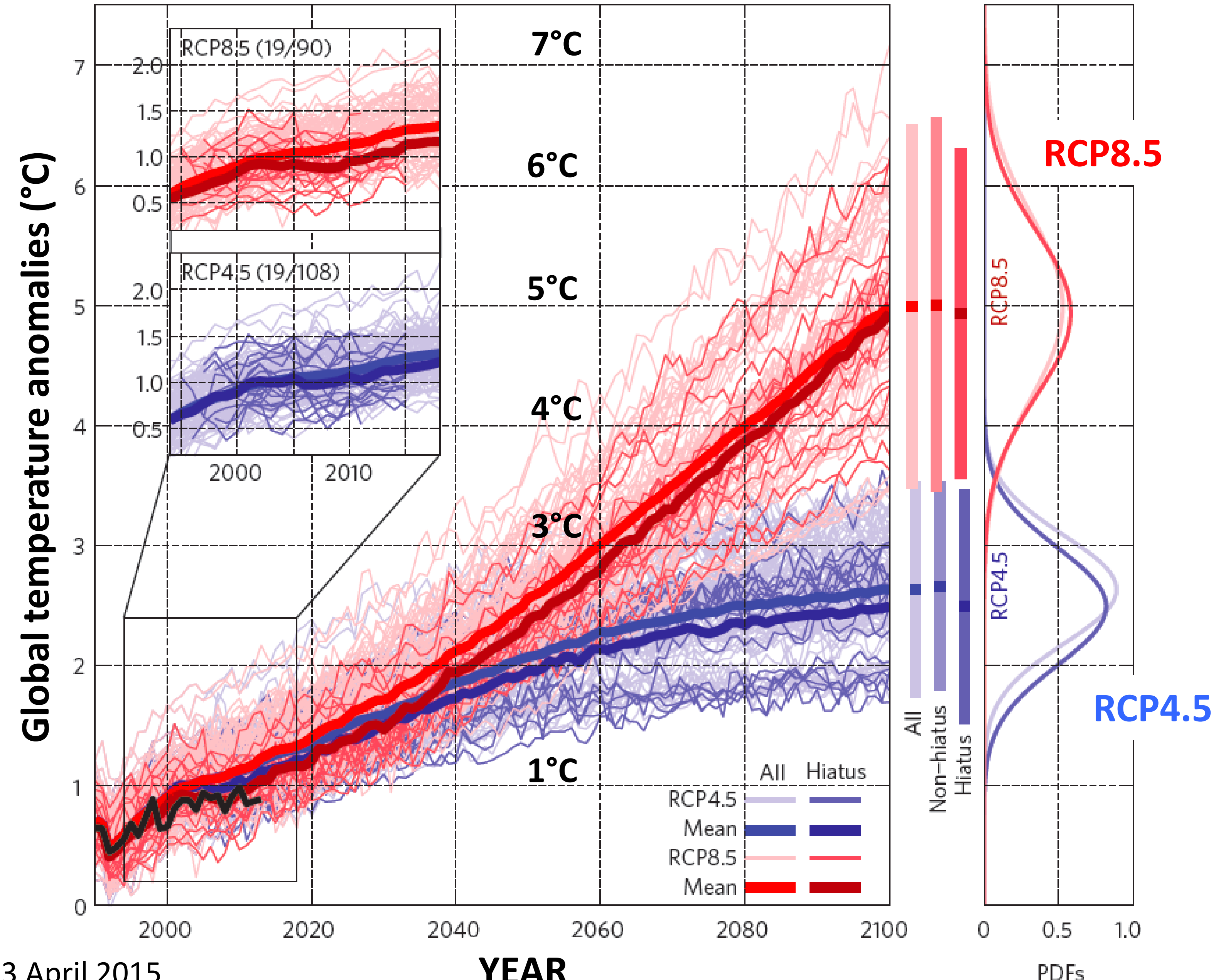
- Warming out of hiatus likely rapid
  and likely to be +ve IPO-like



nature climate change

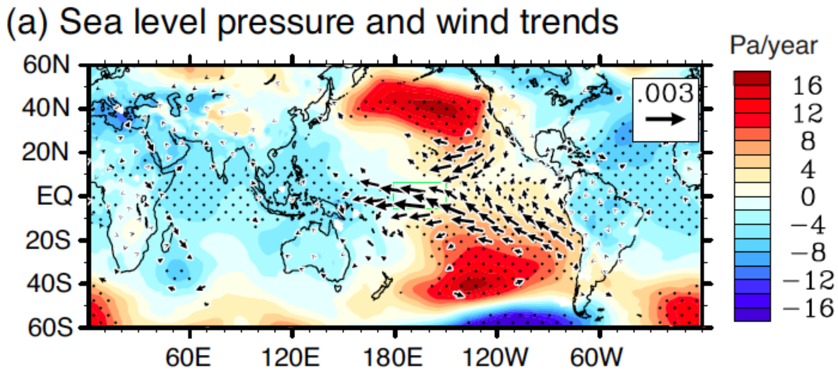
Robust warming projections despite the recent hiatus

Matthew H. England, Jules B. Kajtar and Nicola Maher

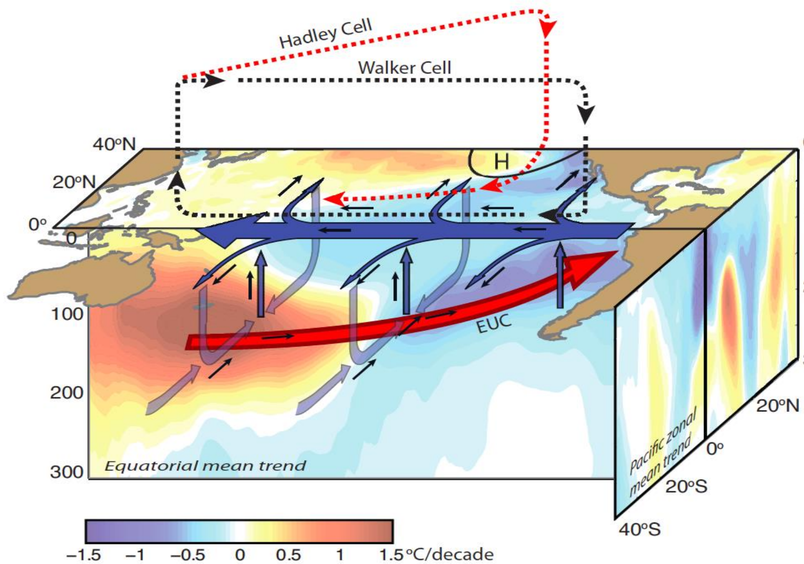


Appeared 23 April 2015

Pacific wind-driven circulation variability and its role in hiatus / accelerated warming decades



Matthew England
ARC Centre of Excellence for Climate System
The University of New South Wales
www.science.unsw.edu.au/~matthew



Coupled Modelling and Prediction :

FROM WEATHER TO CLIMATE

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