

# DEEPC: WP1 overview

& rapid trawl through the literature...

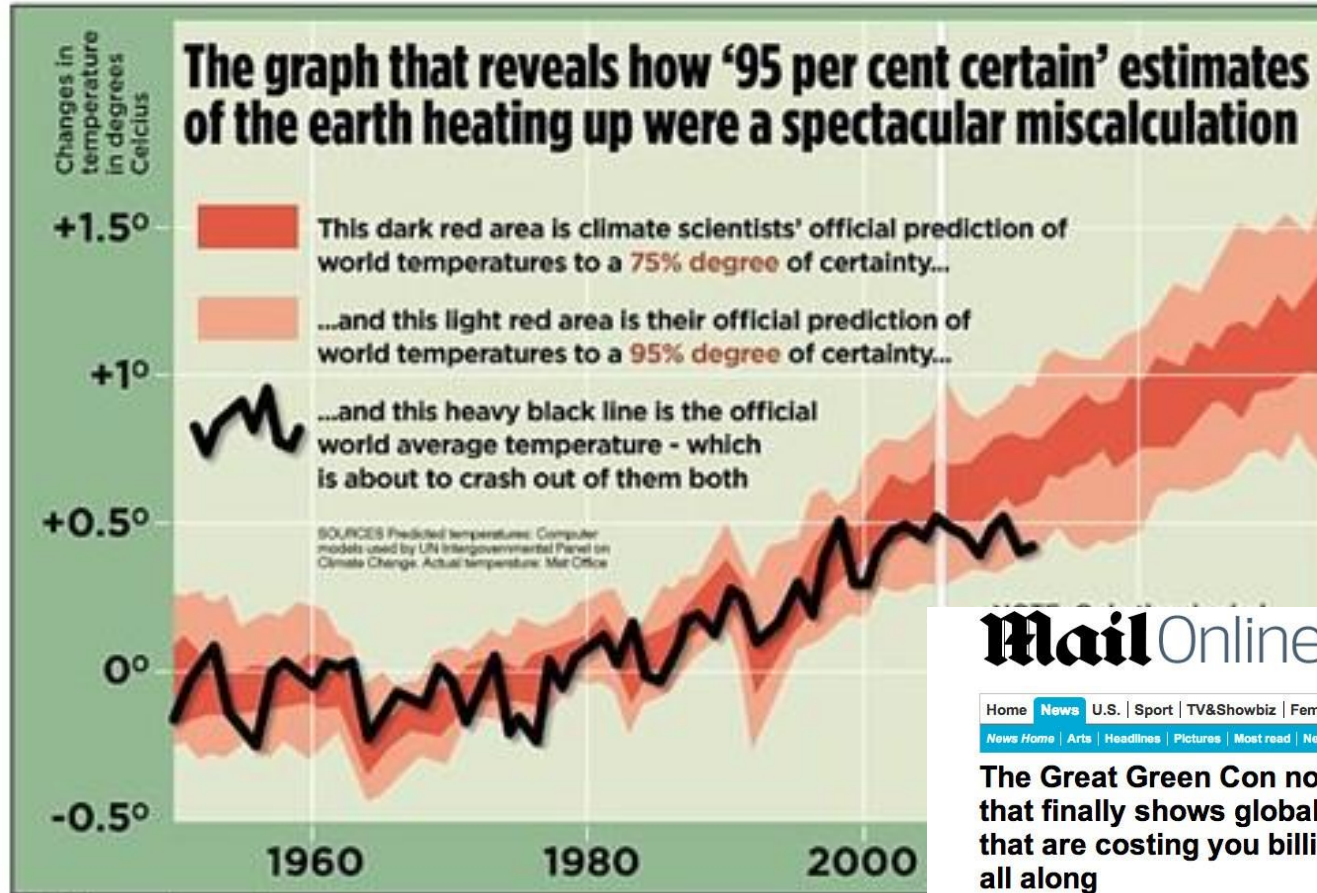
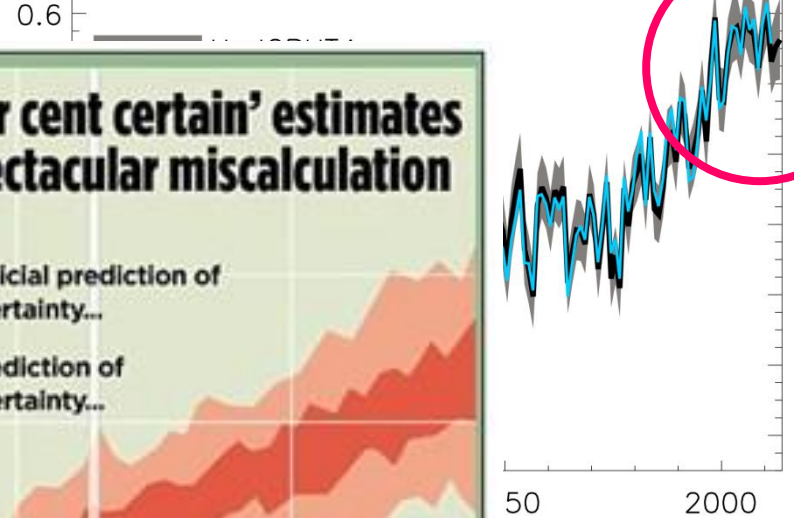
**Richard Allan, Chunlei Liu - University of Reading**

Thanks to: Norman Loeb, Matt Palmer, Doug Smith, Malcolm Roberts, Pier Luigi Vidale, Piers Forster

*DEEP-C Meeting, NOC-Southampton, 26<sup>th</sup> March 2014*

# Global Warming has stalled?

Global Annual Mean Temperature Anomaly



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## The Great Green Con no. 1: The hard proof that finally shows global warming forecasts that are costing you billions were WRONG all along

By DAVID ROSE

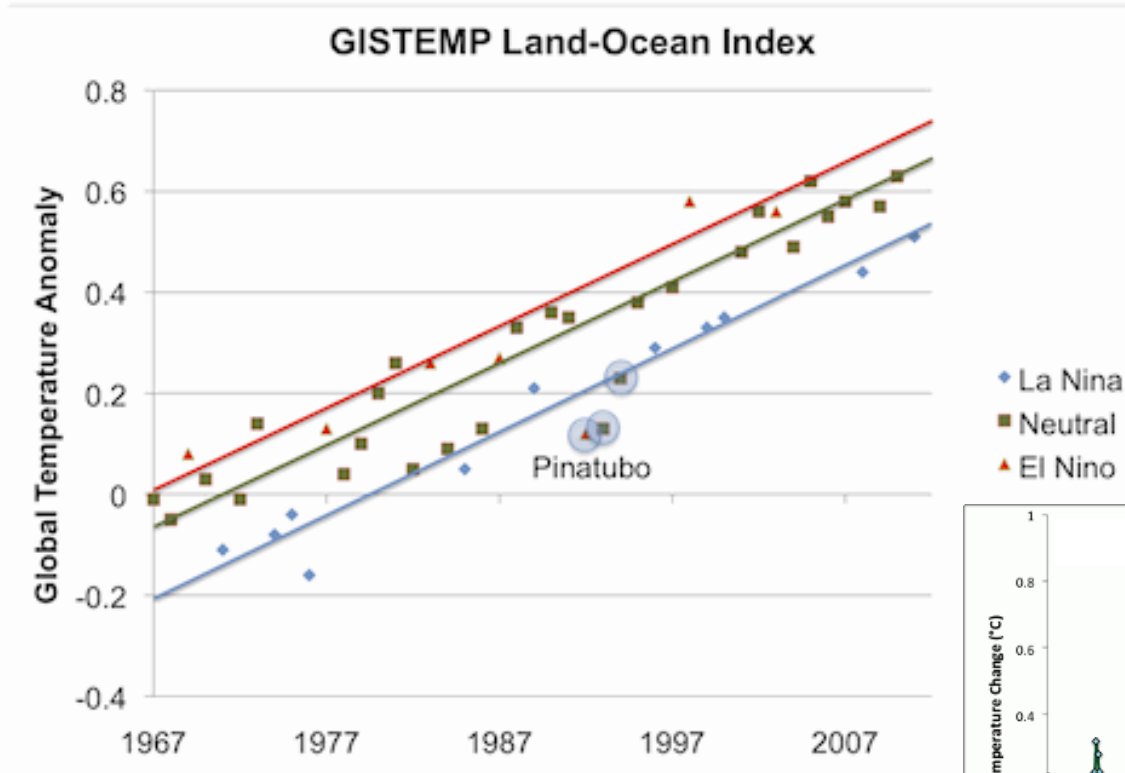
PUBLISHED: 23:37, 16 March 2013 | UPDATED: 13:41, 16 March 2013

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No, the world ISN'T getting warmer (as you may have noticed). Now we reveal the official data that's making scientists suddenly change their minds about climate doom. So will eco-funded MPs stop waging a green crusade with your money? Well... what do YOU think?

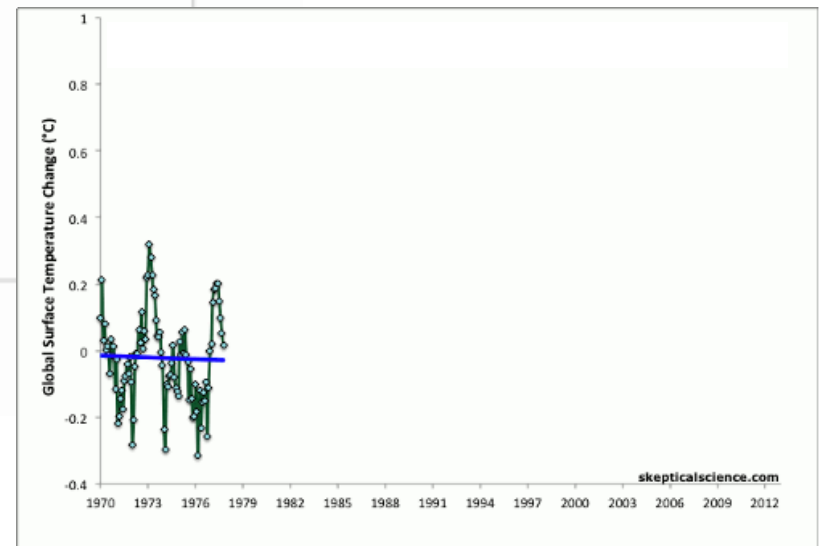
[Mail on Sunday 16<sup>th</sup> March 2013](#)

# We've just had less El Niños?

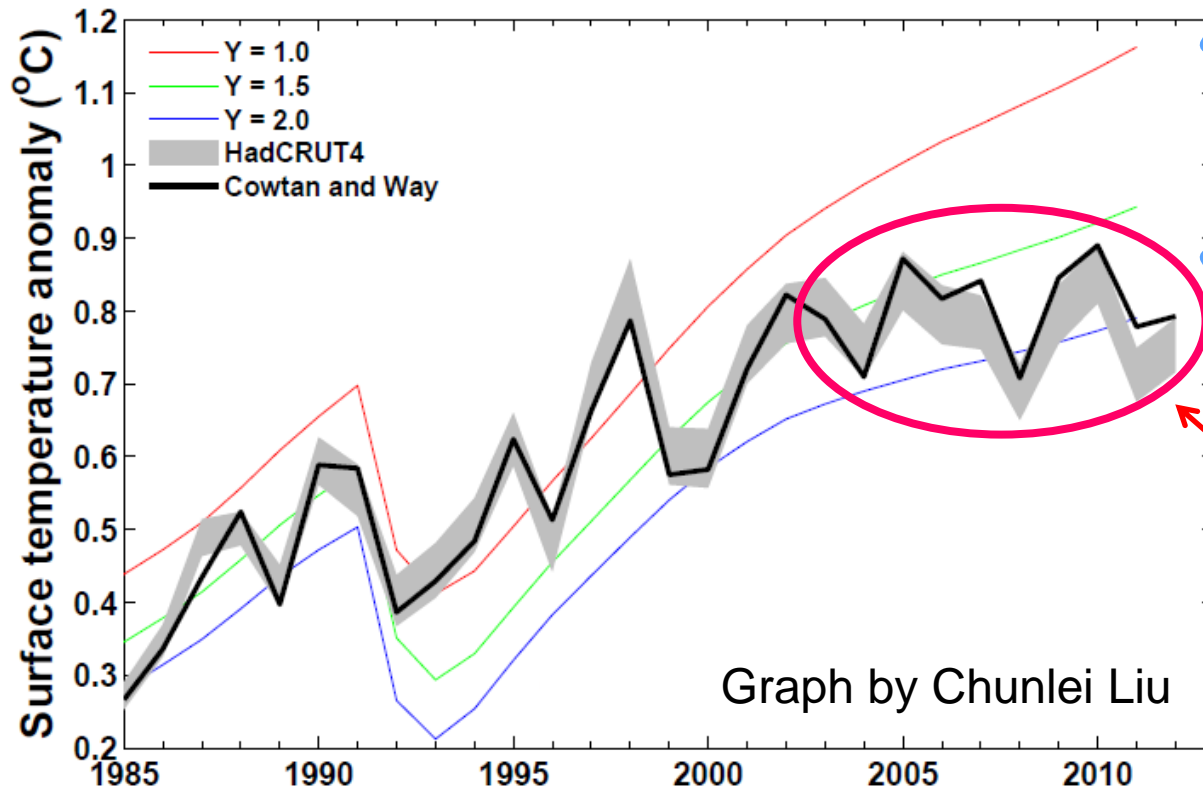


But why have there been more La Niñas recently and hasn't the slowdown in surface warming lasted a long time?

John Nielsen-Gammon, Texas A&M University  
see [Foster & Rahmstorf \(2012\) Environ. Res. Lett.](#)



# Is the temperature record wrong or are computer models inaccurate?

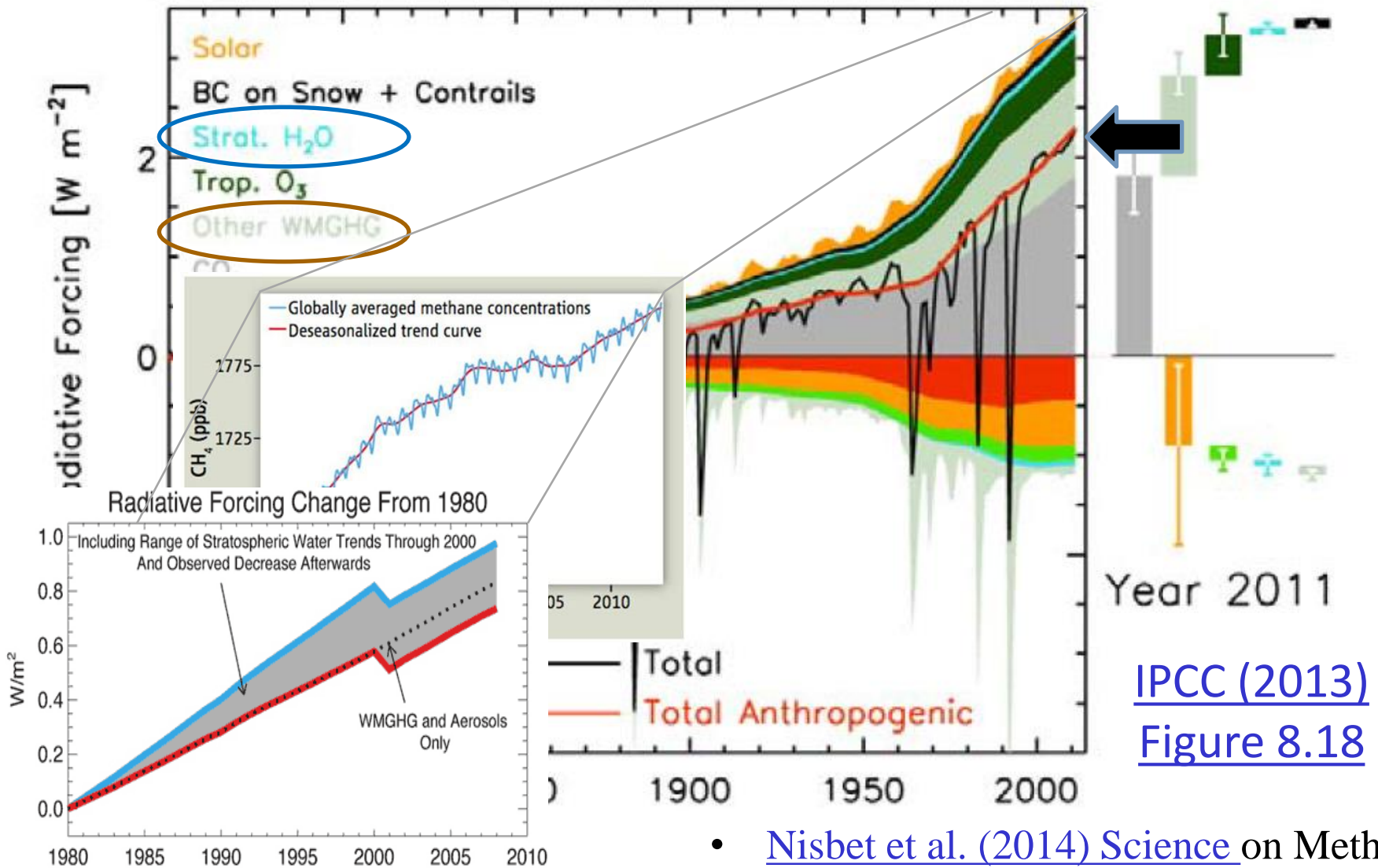


Can comparisons tell us about how sensitive climate is to radiative forcing?  
e.g. [Otto et al. \(2013\) Nature Geosci](#)

Spatial infilling of data gaps influences trends in surface temperature  
([Cowtan & Way, 2013 QJRMS](#)) and ocean heat content  
([Lyman & Johnson 2014 J. Clim.](#))



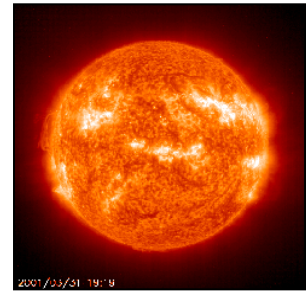
# Drop in minor radiative forcings?



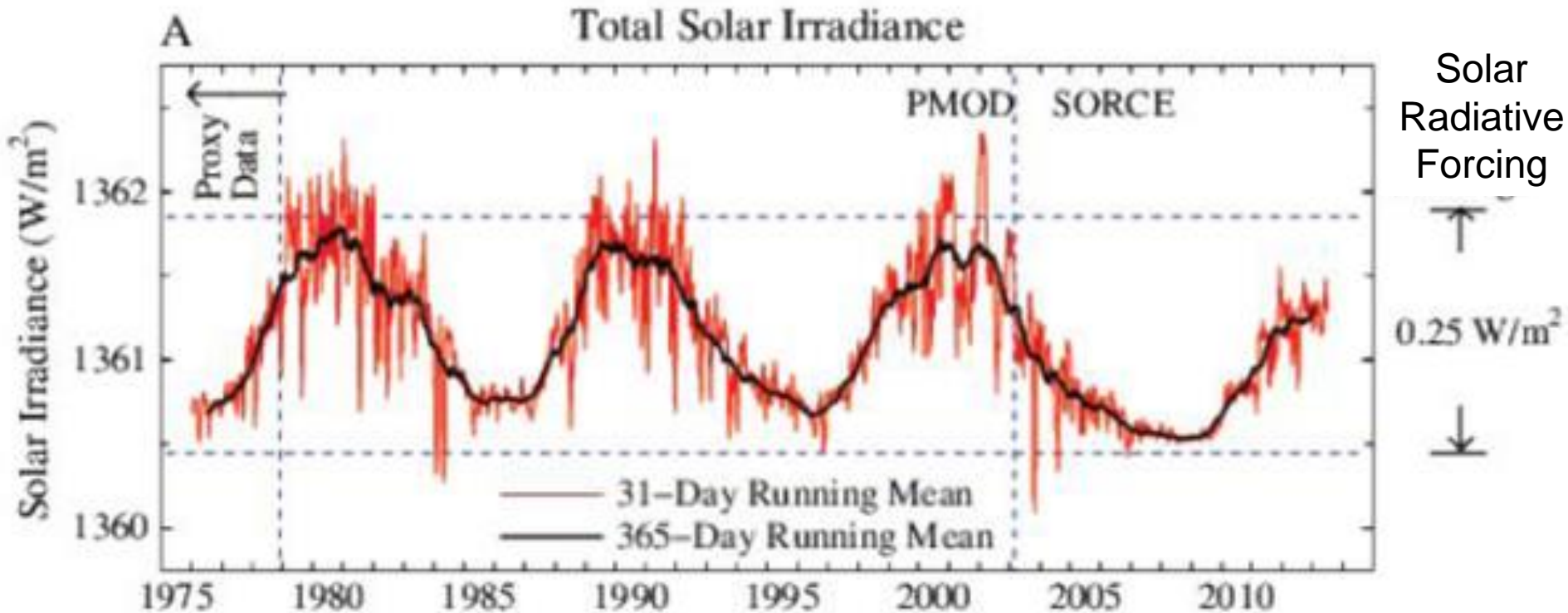
IPCC (2013)  
Figure 8.18

- [Nisbet et al. \(2014\) Science](#) on Methane
- [Solomon et al. \(2010\) Science](#) on Stratospheric Water Vapour

# Weaker Solar Output?

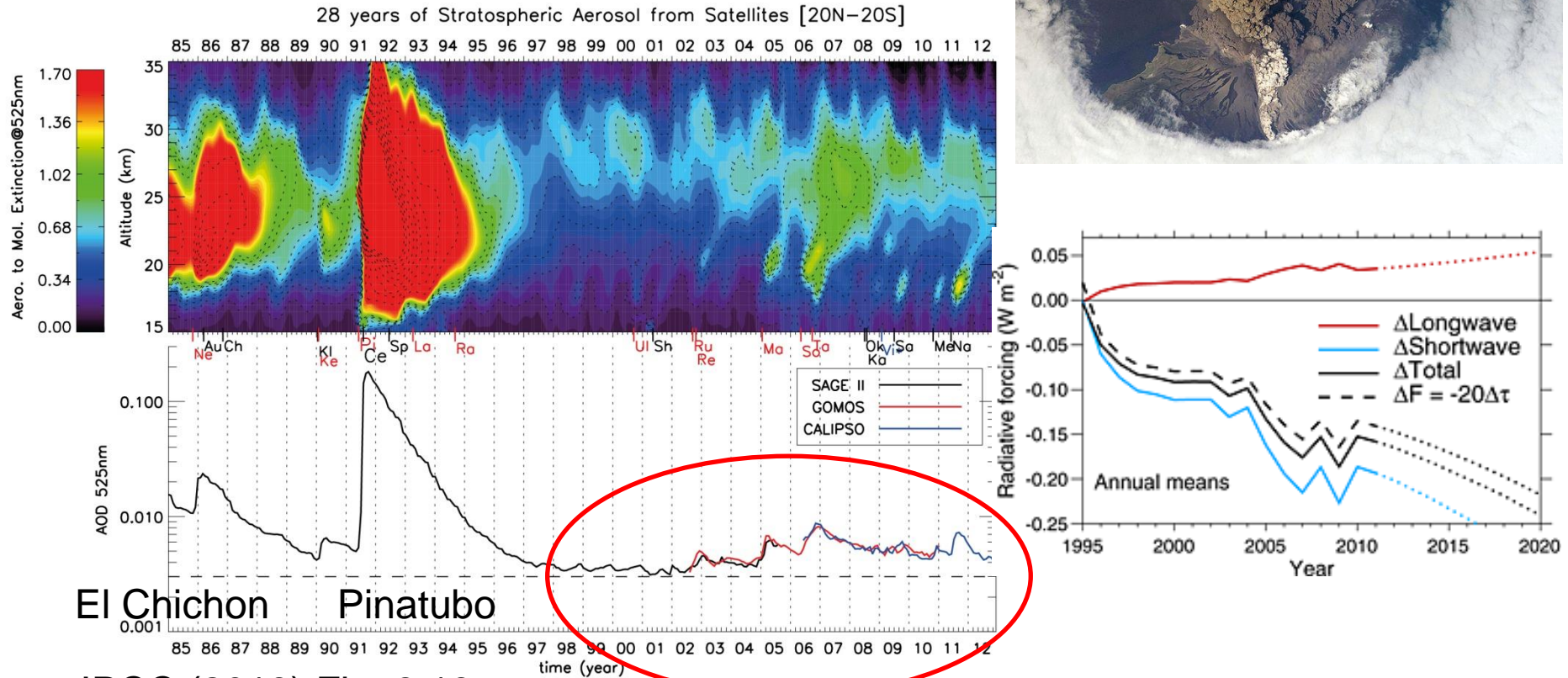


**IPCC:** Solar Radiative Forcing change of  $-0.04 \text{ Wm}^{-2}$  from 1986 to 2008



[Hansen et al. \(2013\) PLOS ONE](#); see also [Kaufmann et al. \(2011\) PNAS](#)

# Cooling from small volcanos?



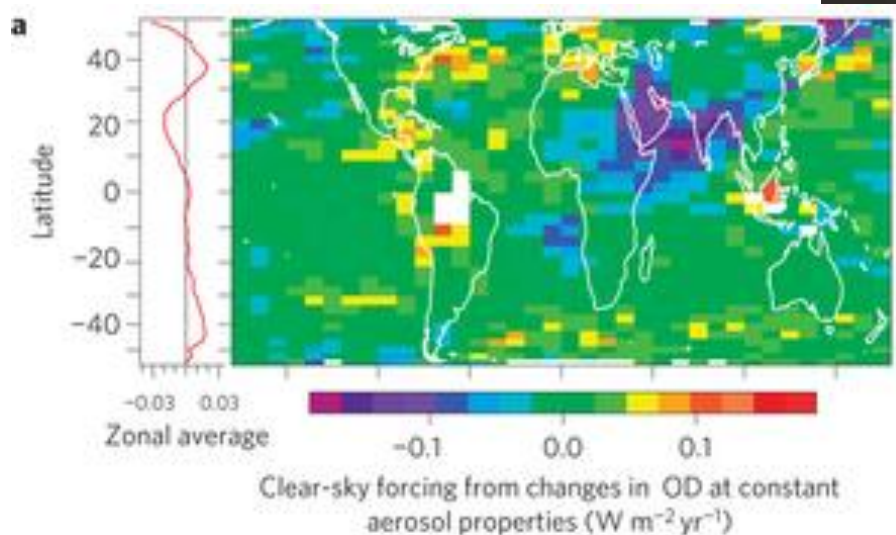
IPCC (2013) Fig. 8.13

Work by [Solomon et al. \(2011\) Science](#); [Vernier et al. \(2011\) GRL](#); [Fyfe et al. \(2013\) GRL](#); [Schmidt et al. \(2014\) Nature Geosci](#); [Santer et al. \(2014\) Nature Geosci](#).



# Increased aerosol pollution over Asia?

Increased Asian aerosol offset by decreases elsewhere – little change in 2000s: [Murphy \(2013\) Nature Geosci](#) (below)





# Causes of Climate Change 1998-2012

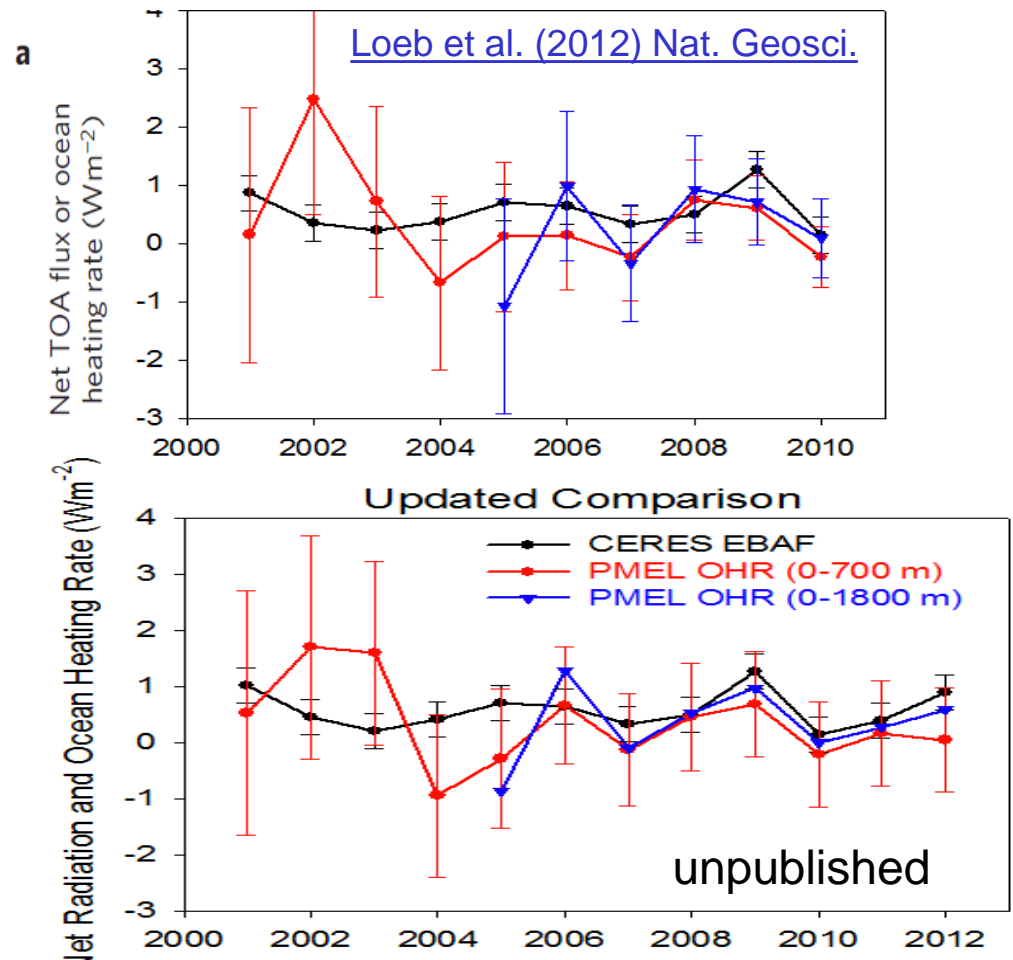
Cause	Estimated Change in Radiative Forcing (W per sq.m) <sup>1</sup>
Greenhouse gases	+ 0.48
Solar	- 0.16
Volcanoes	- 0.06
Other (e.g. aerosols)	± ?
<b>TOTAL</b>	<b>+ 0.26 ± ?</b>

1. Since 1998 natural factors have **masked** some of the greenhouse gas warming influence
2. In the 1990s natural factors (especially recovery from Mt. Pinatubo) **added** to the greenhouse warming influence
3. Little overall influence of natural factors since the 1950s

<sup>1</sup>Quantifying other forcings and uncertainties is ongoing research

# Combining Earth Radiation Budget and Ocean Heat Content data

- Tie 10-year CERES record with SORCE TSI and ARGO-estimated heating rate 2005-2010 + minor additional storage terms
- Variability relating to ENSO reproduced by CERES and ERA Interim
- Updated estimate of net energy imbalance of  $0.60 \pm 0.43 \text{ Wm}^{-2}$

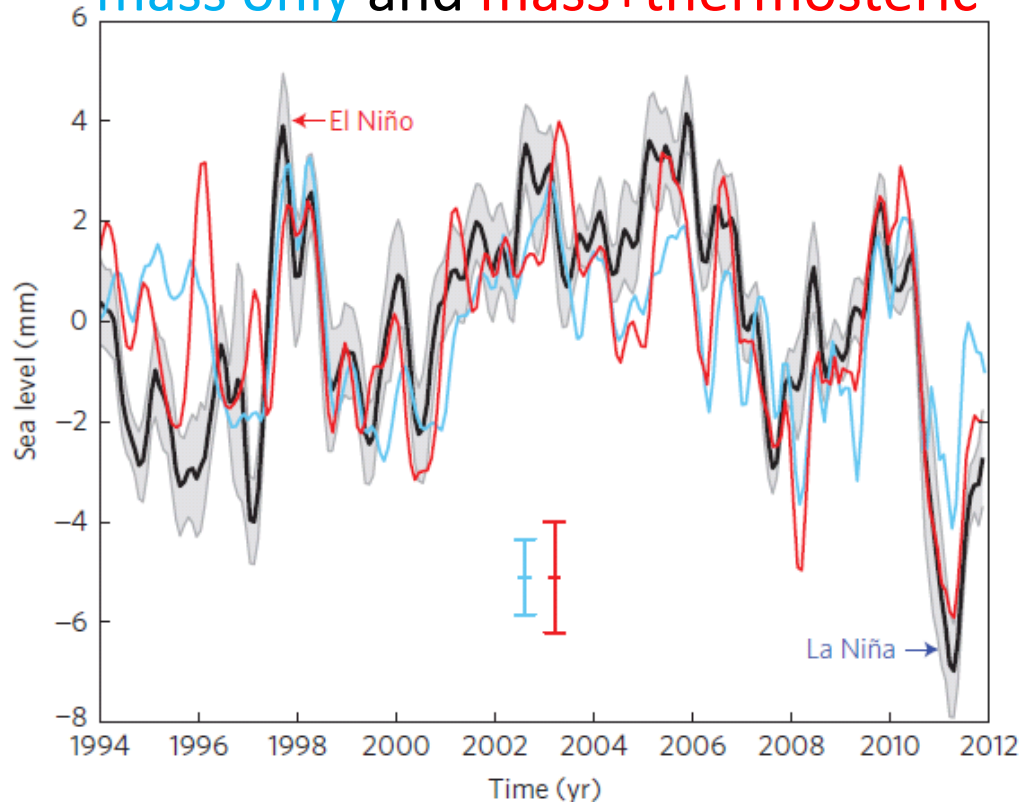


Increased heat flux to deeper layers of the ocean: [Watanabe et al. \(2013\) GRL](#); [Balmaseda et al. \(2013\) GRL](#)

[Loeb et al. \(2012\) Nat. Geosci.](#)  
 See also [Hansen et al. \(2011\) ACP](#);  
[Trenberth et al. \(2014\) J. Climate](#)

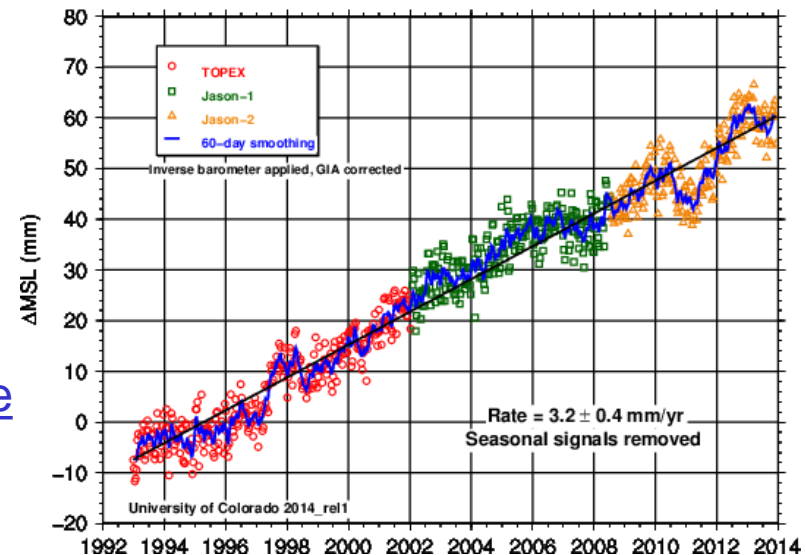
# Reduced rate of sea level rise?

Detrended global sea level changes:  
**mass only** and **mass+thermosteric**



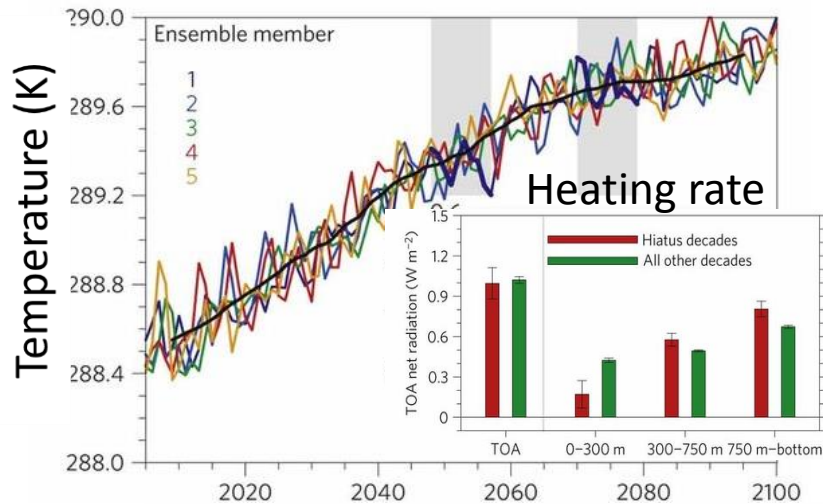
[Cazenave et al. \(2014\) Nature Climate Change](#)

Slowing in sea level rise?  
Not in recent data. Variability expected from movement of water mass over land & redistribution of heat in ocean during La Niña.

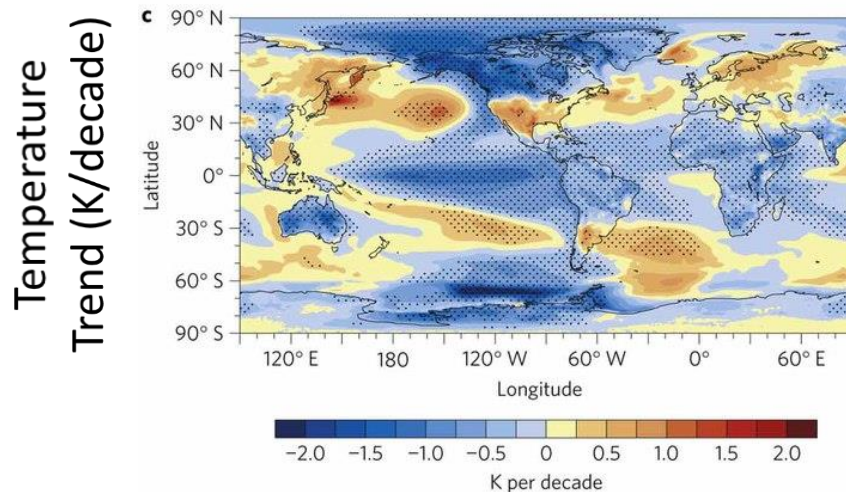




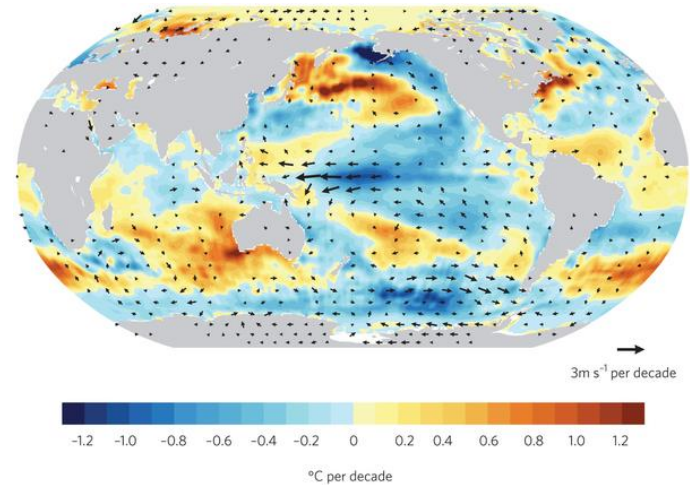
# Climate models simulate decades with little surface warming despite CO<sub>2</sub> increases



- Ocean variability causes heat to mix to deeper levels in some decades
- Associated pattern of sea surface temperature trends match current observations

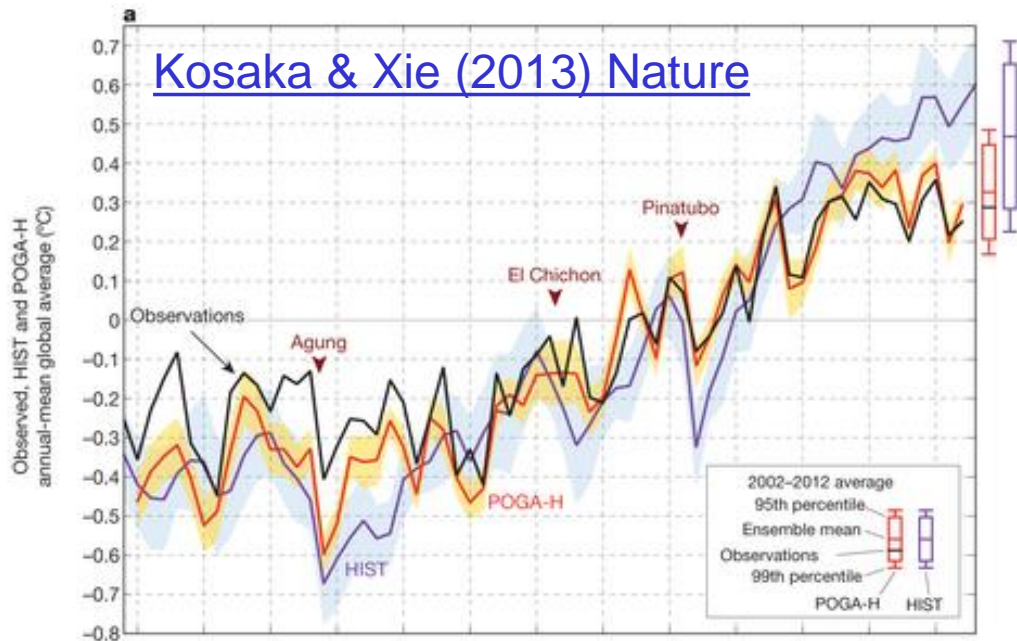


Model ([Meehl et al. 2011](#), [2013](#))



Observations 2001-2013 ([Kosaka 2014](#))

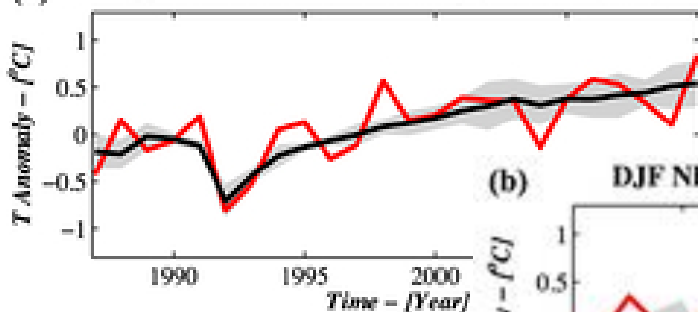
# Role of Pacific Ocean Natural Variability



← [Kosaka & Xie \(2013\) Nature](#)

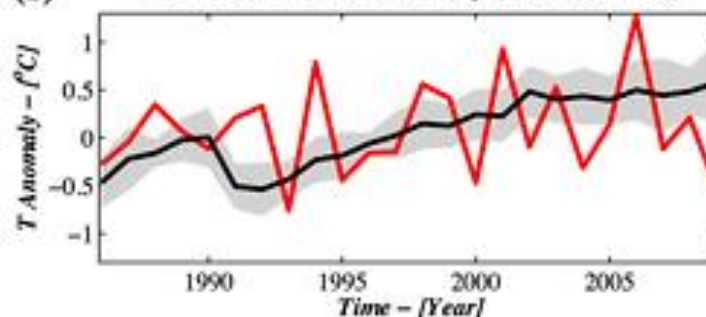
- Adjust heating in E Pacific to agree with obs SST
- Simulations reproduces hiatus and some regional climate anomalies
- Also explains why hiatus dominates NH winter (e.g. [Cohen et al. 2012](#), below)
- Note, some models do not simulate natural variability well e.g. CNRM, CanCM4; [Watanabe et al. 2013](#))

(d) JJA NH Surface T Anomaly (CMIP5 + Obs)

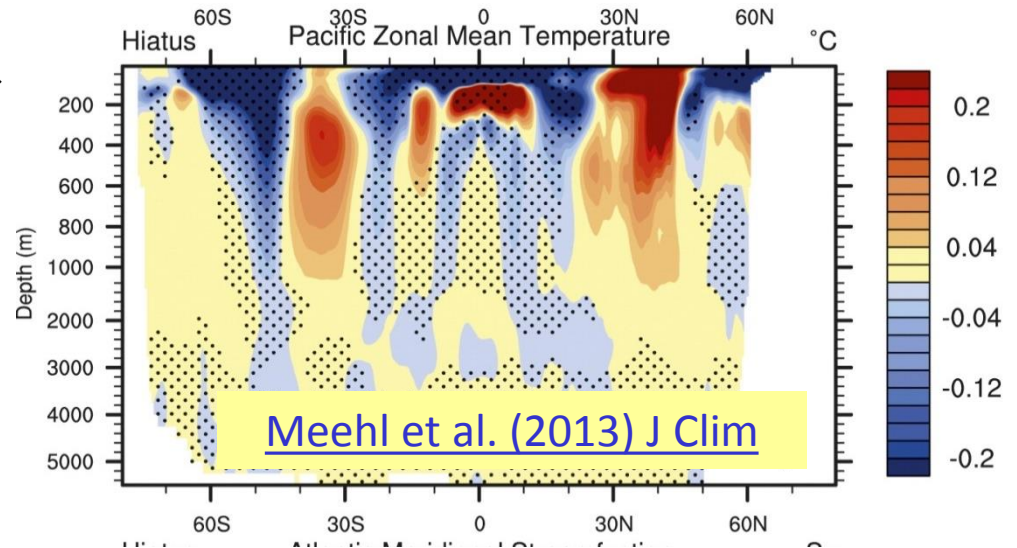
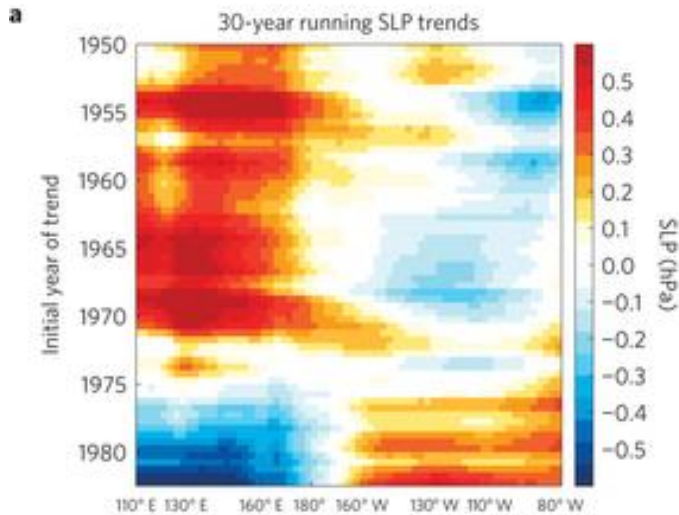


[Cohen et al. 2012](#)

(b) DJF NH Surface T Anomaly (CMIP5 + Obs)

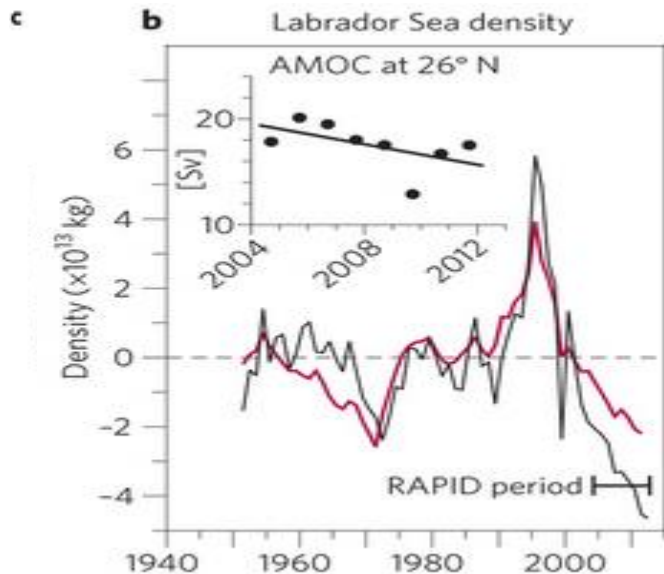


Vertical profiles of heating in Pacific during hiatus decades →



← Trends in SLP and decadal ENSO signal ([L'Heureux et al. 2013](#); [Sohn et al. 2012](#); [Merrifield 2011](#); [England et al. 2014](#))

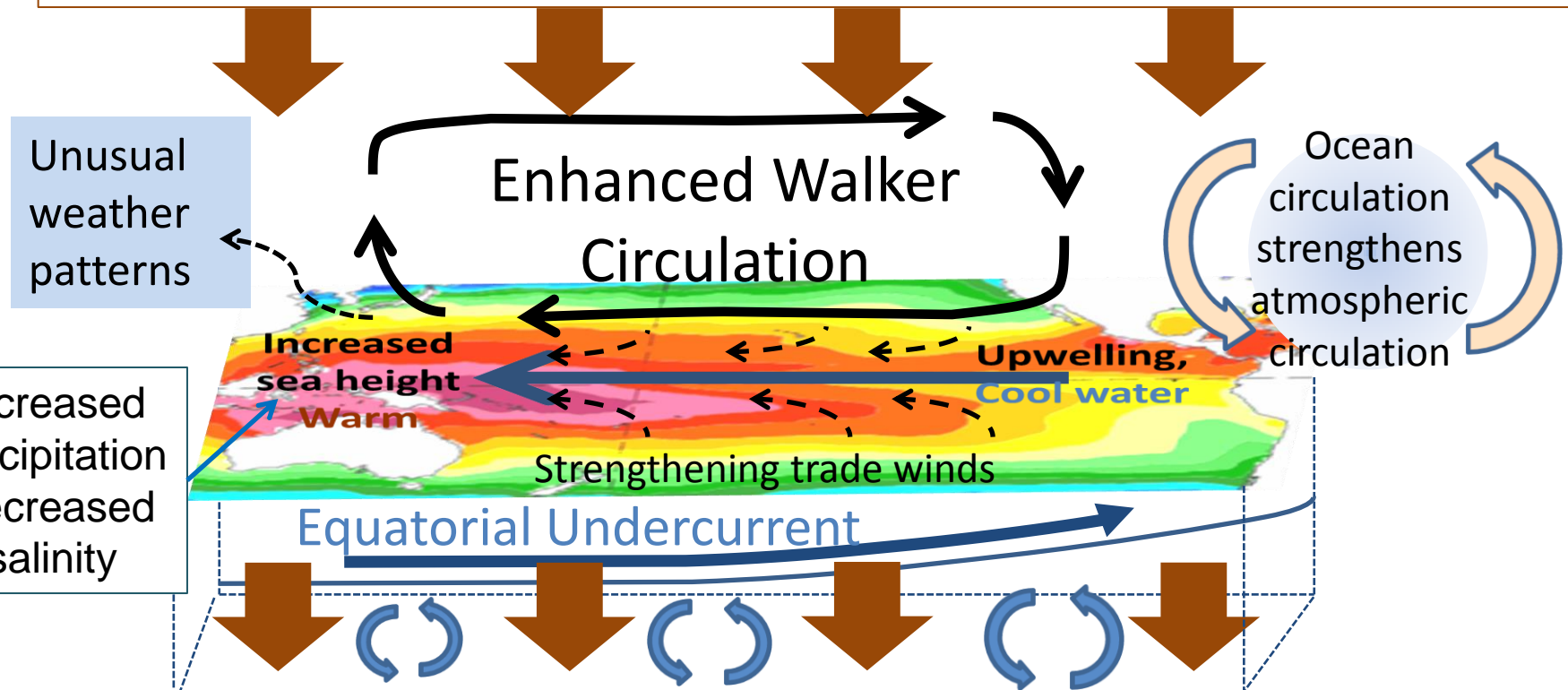
- Strengthening of Walker circulation in response to IPO pattern? Or has change in wind stress increased heat uptake below 700m ([Balmaseda et al. 2013](#))?
- Slowdown predicted with initialisation ([Guemas et al. 2013](#); [Smith 2013](#))
- Other notable changes: freshening of Antarctic bottom waters since 1980s ([Purkey & Johnson 2013](#)); slowing of AMOC? ([Robson et al. 2014](#))





# Role of Pacific ocean variability

Continued heating from rising greenhouse gas concentrations



Enhanced mixing of heat below 100 metres depth by accelerating shallow overturning cells and equatorial undercurrent

# WP1 - Planned work

1. Analyse and update observed variability in TOA radiation balance (under review)
2. *Investigate lags in climate system* (in preparation)
3. Combine ERA Interim and CERES to provide new estimate of surface heating (in preparation)
  - Wider use of flux products by Pat Hyder et al. (Met Office)
4. *Monitoring of changes in energy balance*
5. *Reconcile TOA radiation balance and ocean heating*

# WP1 Objectives/Deliverables

- O1.** Combine satellite radiation budget measurements with atmospheric reanalyses, providing improved 2D estimates of surface heat fluxes across the ocean surface (WP1)
- O5.** Monitor co-variations in net radiative energy imbalance and ocean heating (from O1,O2,O4); quantify and understand lags between OHC and TOA radiation (WP1-4)
- O6.** Characterise spatial signatures/mechanisms of ocean and atmospheric heat re-distribution (from O4-5) during the hiatus period 2000-2015 using observations and simulations (WP1-4)
- D1.** Combined satellite-reanalysis atmosphere/surface energy flows: methodology, uncertainty and exploring lags in the climate system (paper 1,2; WP1, O1,4)



# DEEP-C Work Plan

Start date: March 2013; Project Ends February 2017

Workpackage	Year 1	Year 2	Year 3	Year 4
WP1 (Reading)	O1	D1 PDRA1		
		Allan		
WP2 (Southampton)	O2	D2 PDRA2		
		McDonagh, King		
WP3 (Met Office)	O3	D3 Palmer		
WP4 (All)	Recruitment, Integration, KO meeting	O4-O5-O6 Kuhlbrodt, Gregory		D4,D5 Synthesis
Partners				

Table 2 - Management timeline for DEEP-C.

# DEEPC: WP1

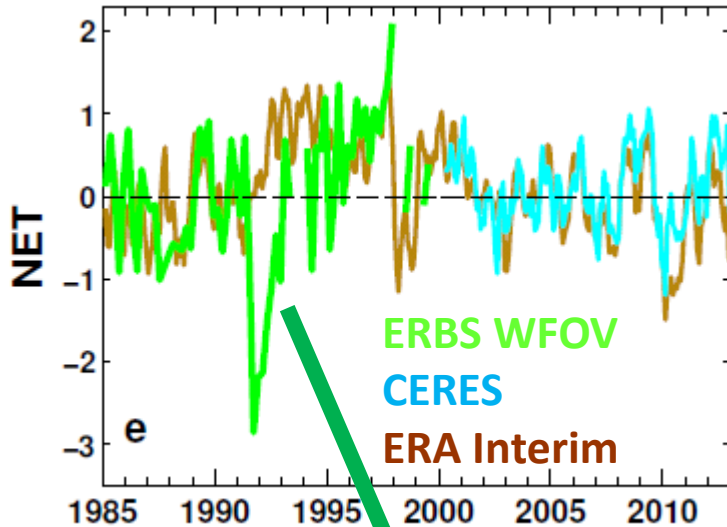
## Earth's energy imbalance 1985-2012

**Richard Allan, Chunlei Liu (University of Reading);  
Norman Loeb (NASA Langley); Matt Palmer, Doug Smith,  
Malcolm Roberts (Met Office); Pier Luigi Vidale (Reading/NCAS)**

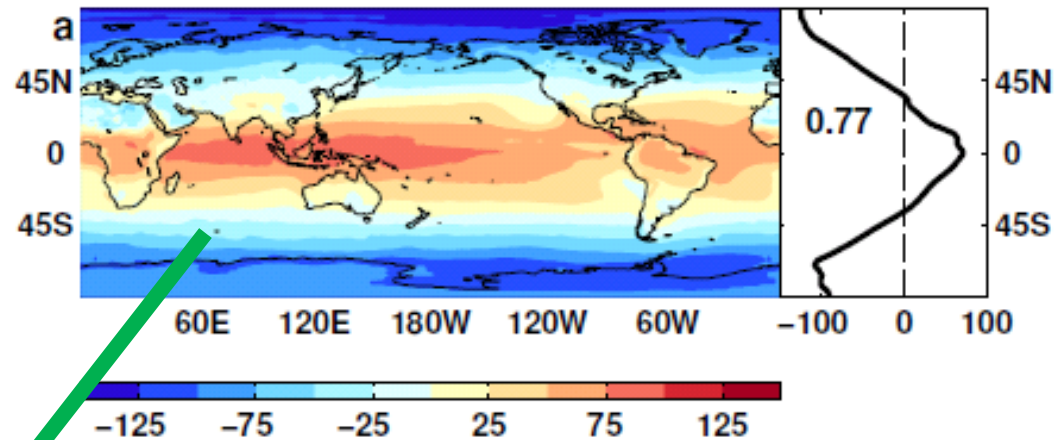
*DEEP-C Meeting, NOC-Southampton, 26<sup>th</sup> March 2014*

# Reconstructing global radiative fluxes prior to 2000

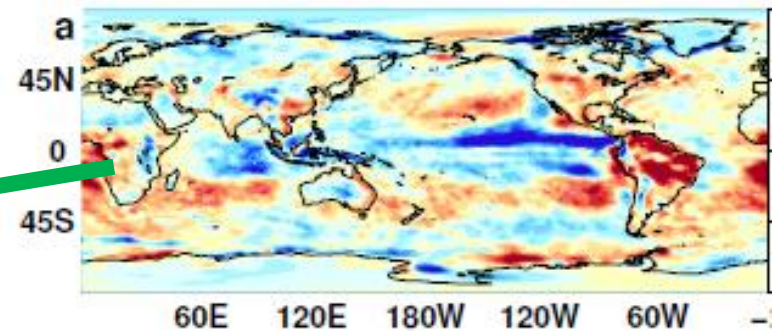
ERBS WFOV variability



CERES monthly climatology



ERA Interim spatial anomalies

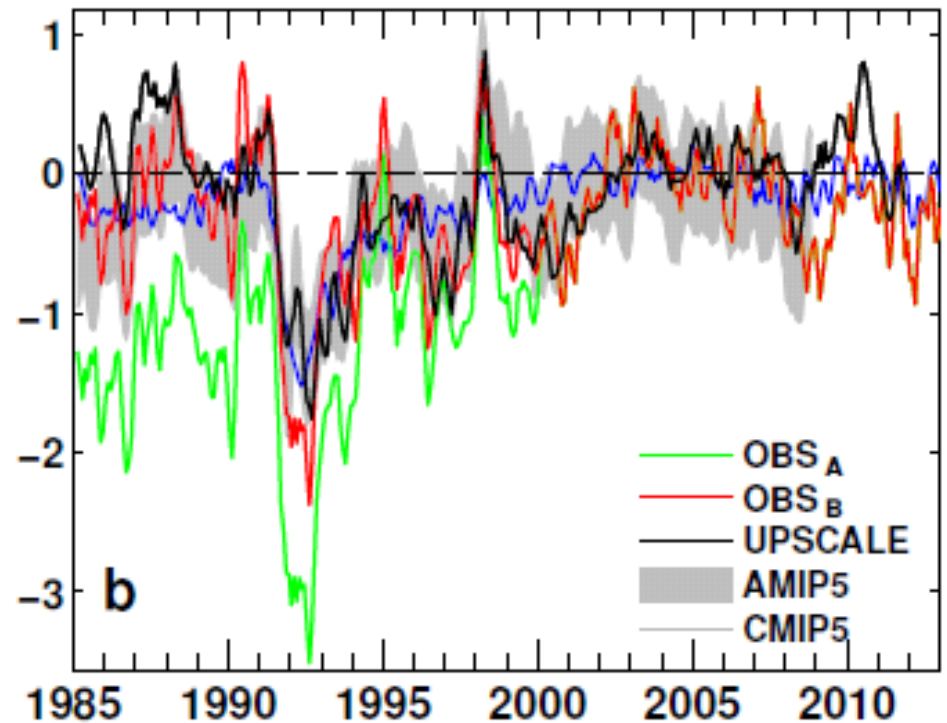


Combine CERES/ARGO accuracy, ERBS WFOV stability and reanalysis circulation patterns to reconstruct radiative fluxes

# Use reanalyses or models to bridge gaps in record (1993 and 1999/2000)

- ERA Interim trends suspect. Use model...
- **UPSCALE** simulations (obs. SST, sea ice & realistic radiative forcings) “**OBS<sub>B</sub>**”
- Net less sensitive to method than OLR/ASR

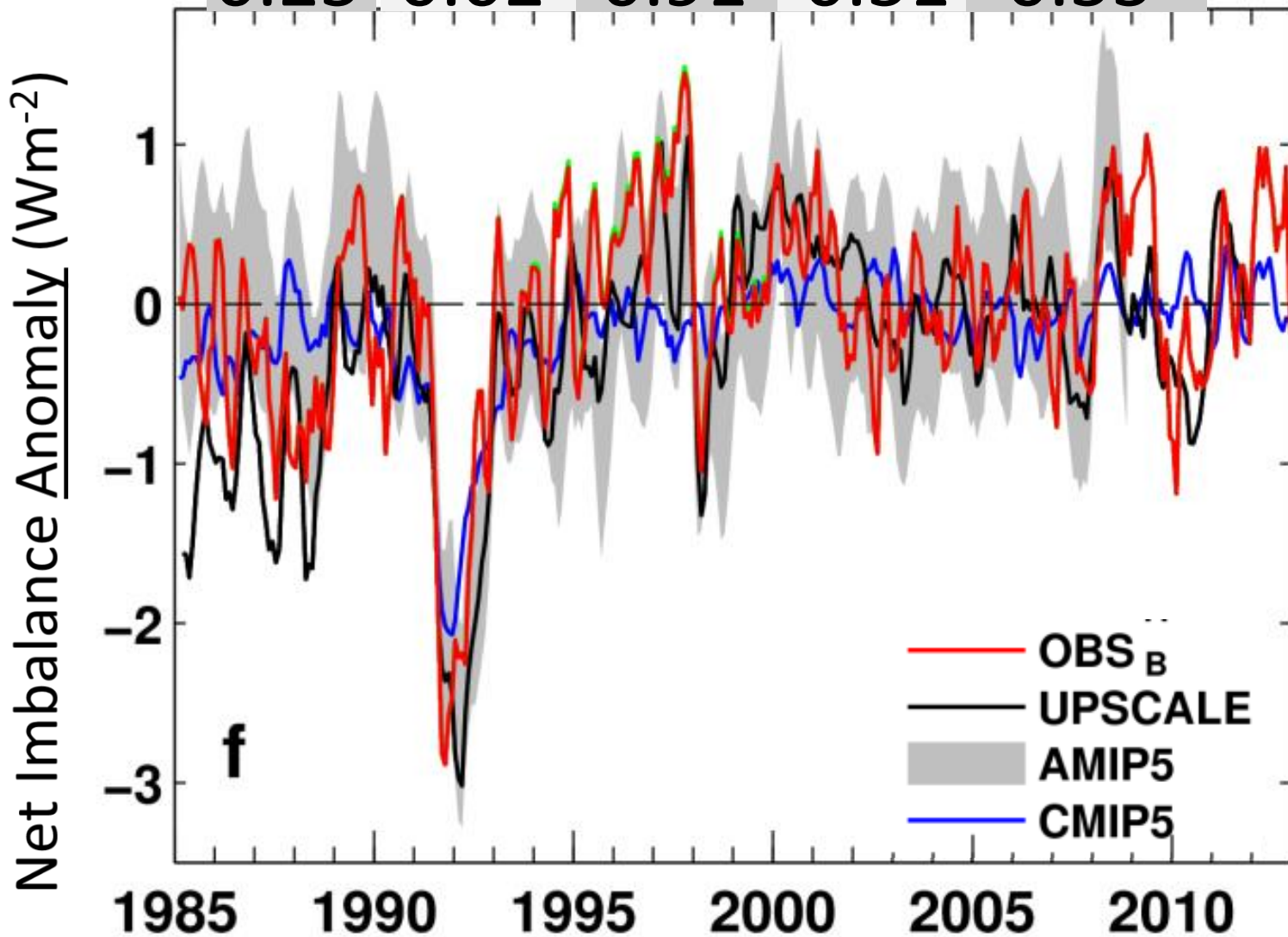
## Outgoing Longwave Radiation Anomalies ( $\text{Wm}^{-2}$ )



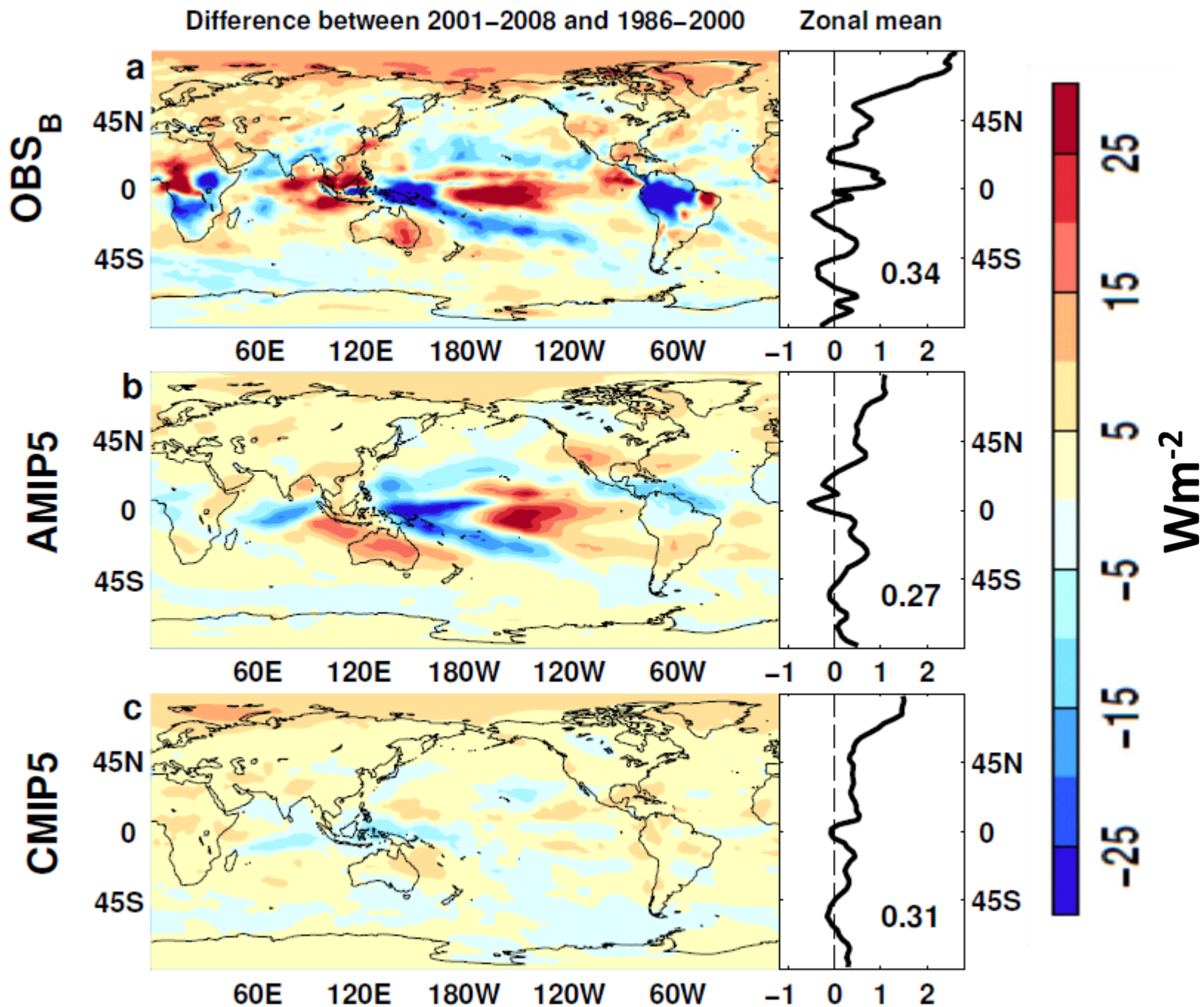


# Reconstructed Net Flux ( $\text{Wm}^{-2}$ )

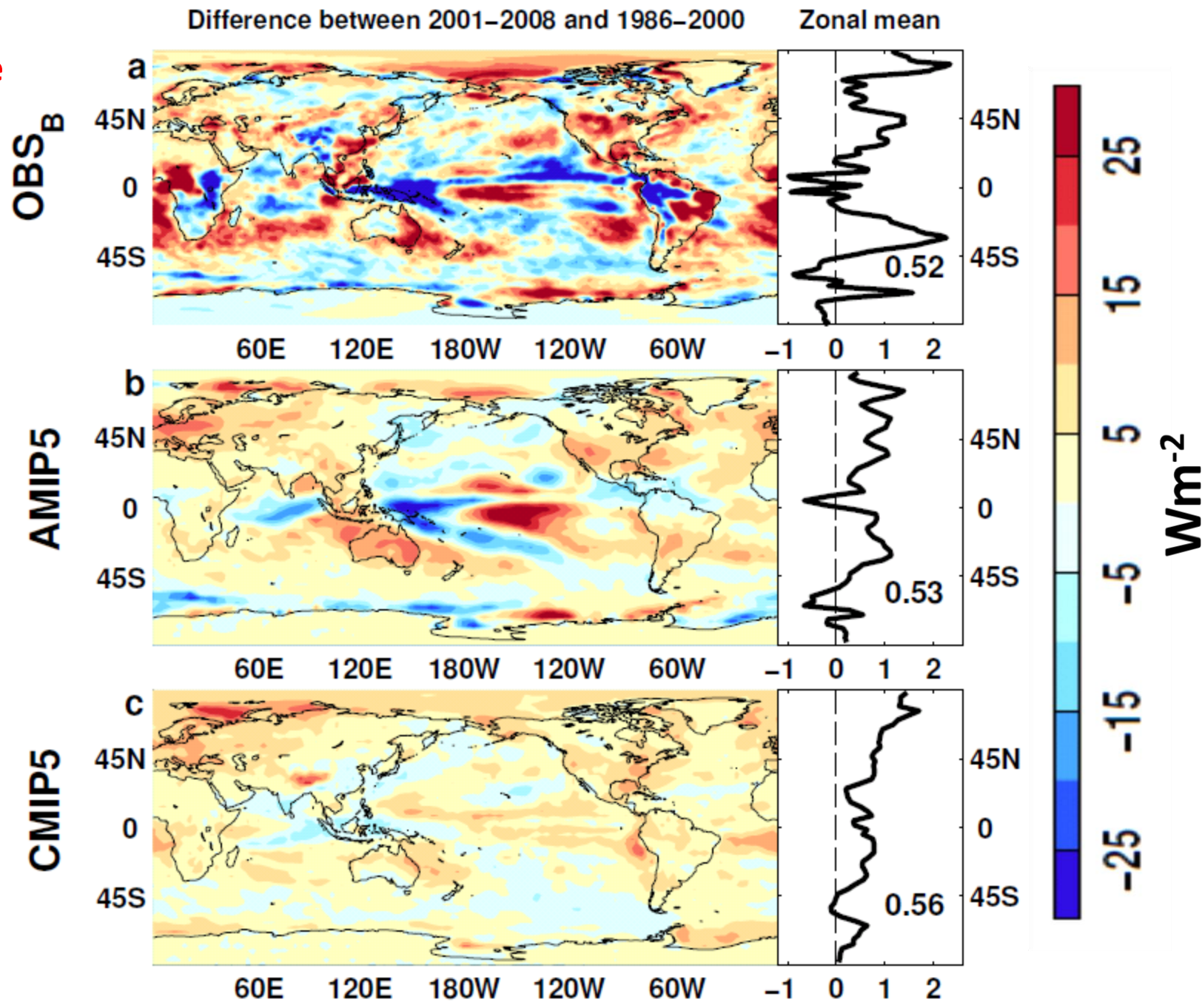
0.25 0.02 0.91 0.51 0.55



**Outgoing  
Longwave  
Radiation**

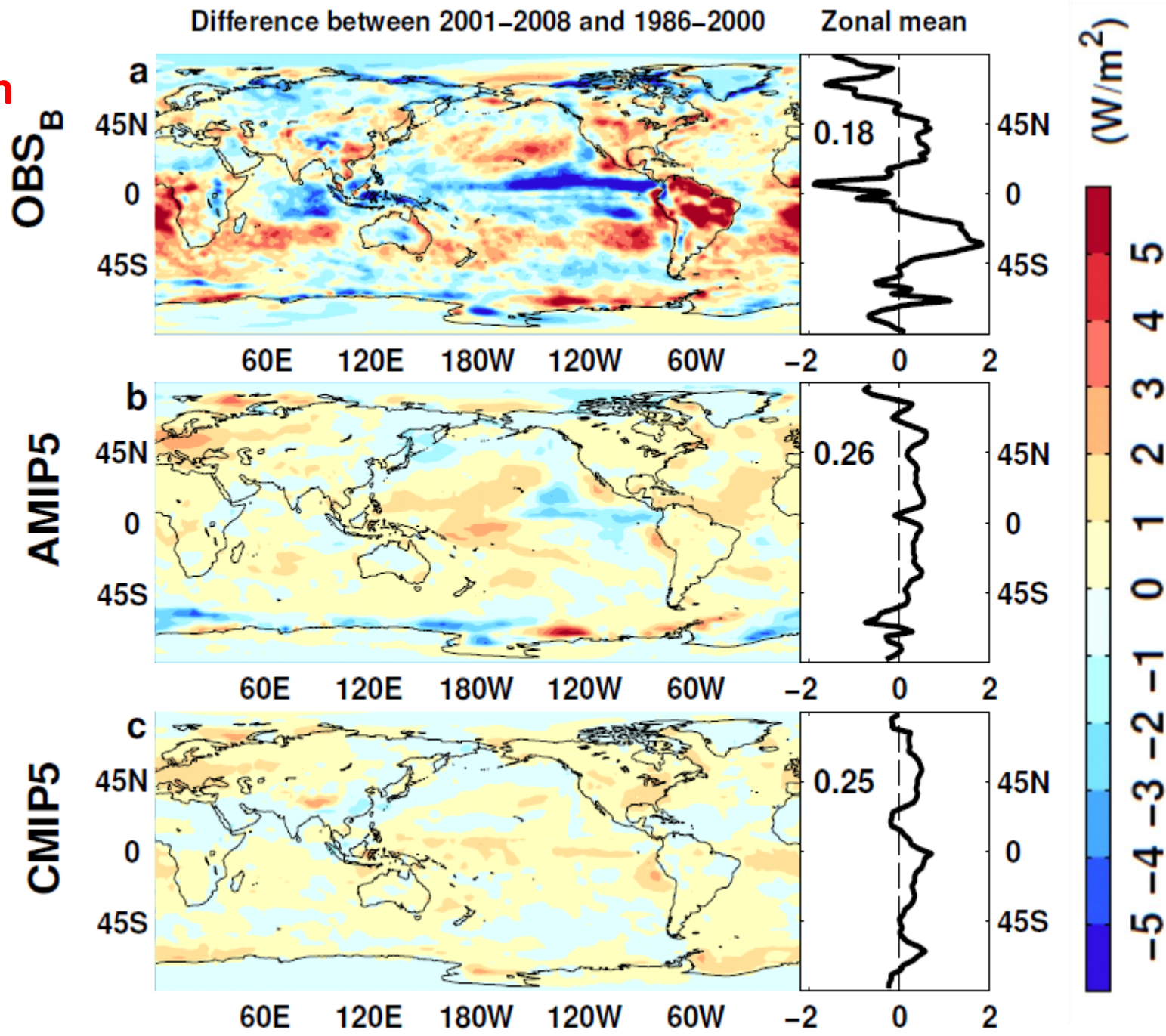


**Absorbed  
Shortwave  
Radiation**

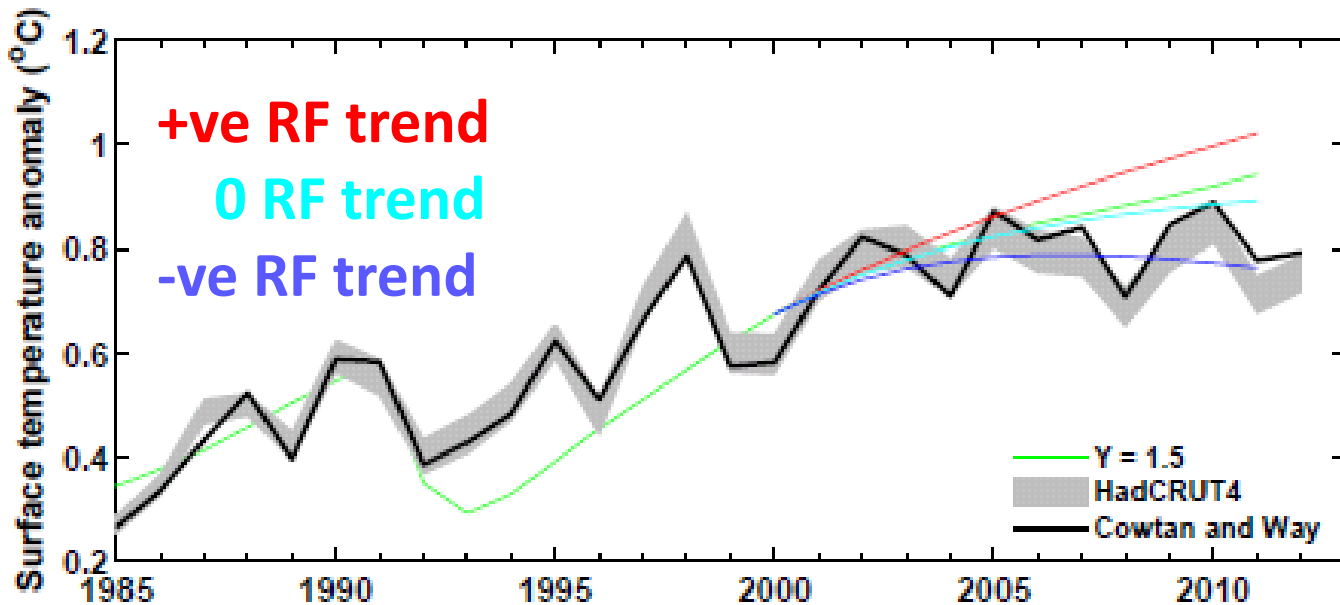




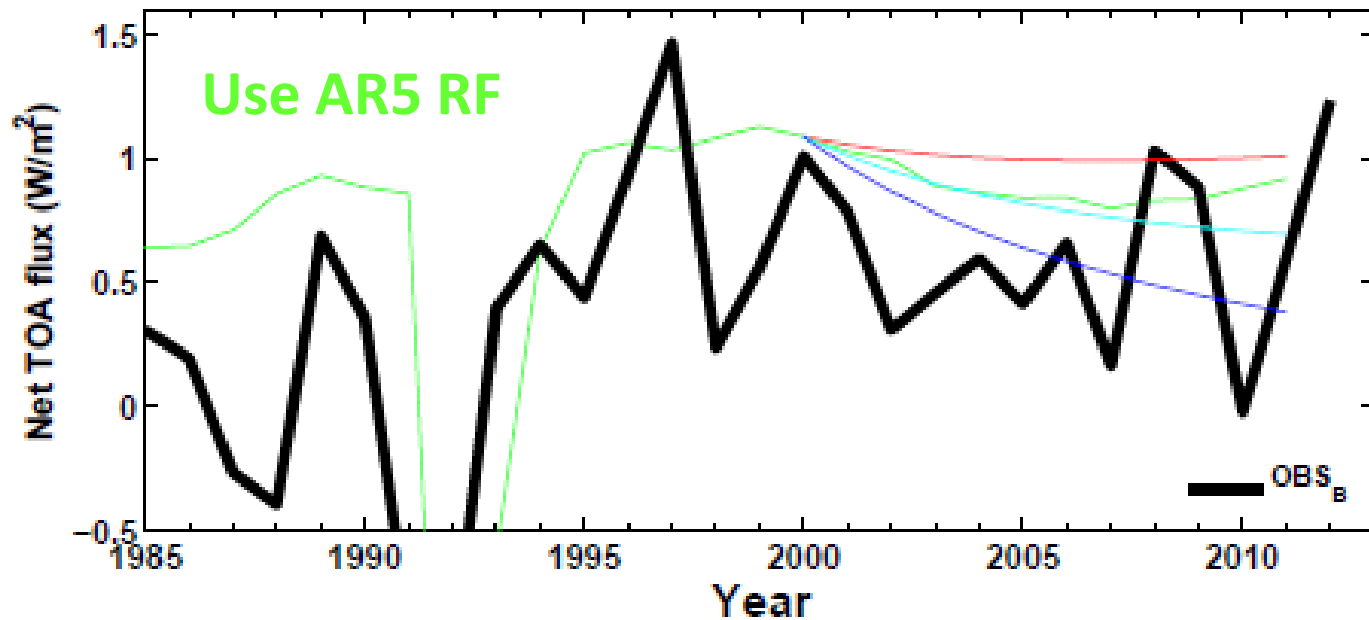
**NET  
Radiation**







Analysis using simple energy balance model



# Preliminary results

- Heating of Earth continues at rate of  $\sim 0.6 \text{ Wm}^{-2}$
- Radiative forcing alone can't explain surface warming slowdown: internal variability important
- Current variability in TOA radiation (1985-2013)
- Net flux higher in 1995-1999 than 2000-2012 period
- Distinct East Pacific signal in  $\Delta T$  and  $\Delta N$
- Plans:
  - Development of surface flux dataset (next)
  - Lag-lead analysis (some preliminary work)
  - Work with WP2 (surface fluxes) and WP3 (simulations) and use/comparison of surface fluxes (Met Office)

# Dissemination Activities

- April 2014 – Royal Society “Hiatus” discussion meeting
- February 2014 - ["Where has the warming gone?"](#) talk to the Royal Meteorological Society South East Group
- February 2014 - [Comment on recent Nature Climate Change paper by England et al.](#) (see also [Guardian](#) article).
- August 2013 - [Comment on recent Nature paper by Kosaka and Xie](#) (see also [BBC](#) and [Independent](#) articles).
- July 2013 - Science Media Centre [briefing](#) on “slowdown”
- May 2013: [Carbon Brief](#) article on DEEP-C temperature obs.
- April 2013 - Meeting with DECC partners in London

**Also:** twitter, Walker Institute, media interaction

Links to journal papers on website: Google “DEEP-C Climate”

<http://www.met.reading.ac.uk/~sgs02rpa/research/DEEP-C.html>