

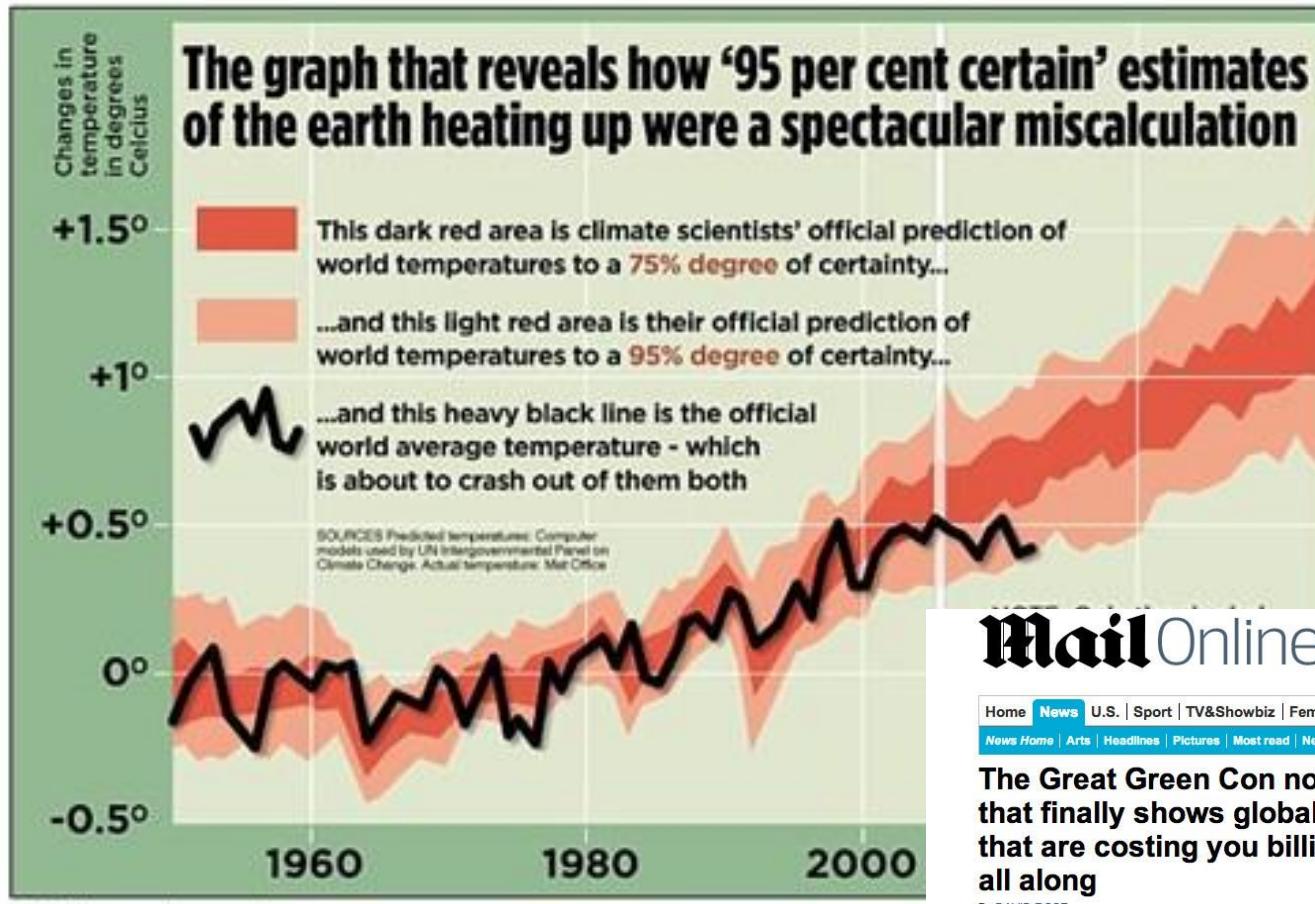
DEEPC: WP1 overview & rapid trawl through the literature...

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, 26th March 2014

Global Warming has stalled?



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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

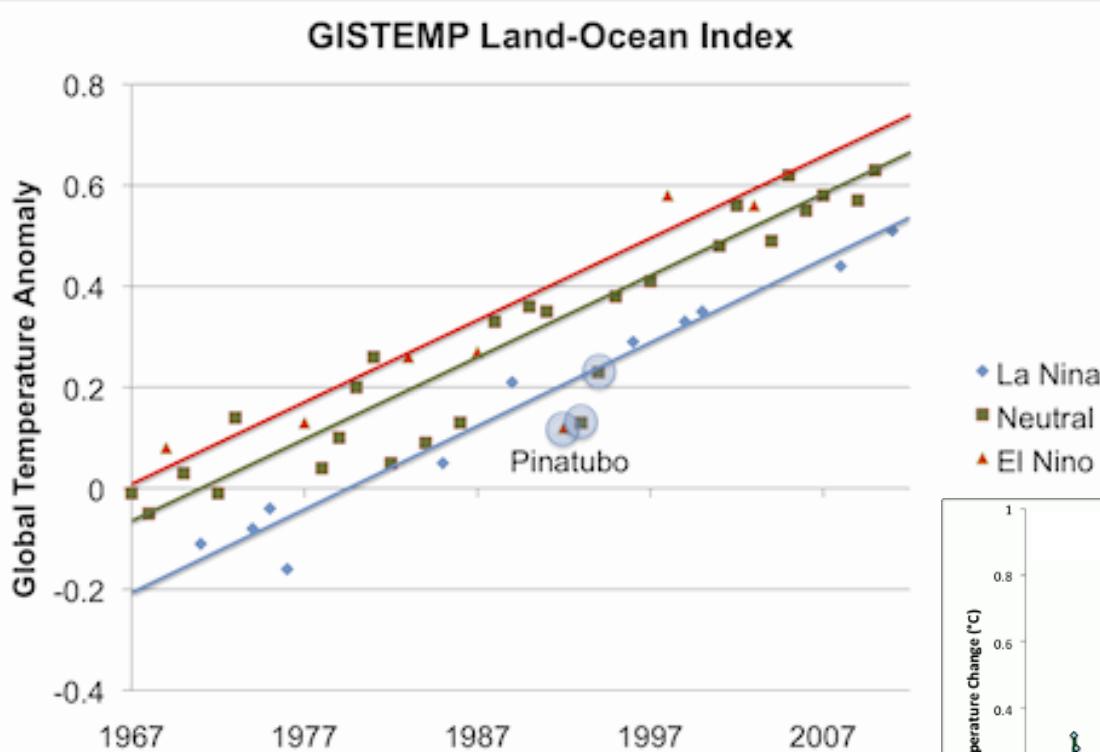
PUBLISHED: 23:37, 16 March 2013 | UPDATED: 13:41, 18 March 2013

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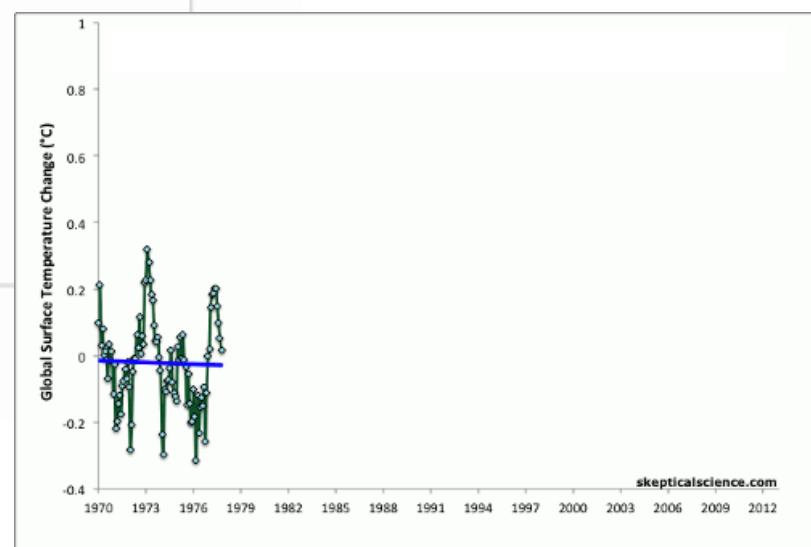
No, the world ISN'T getting warmer (as you may have noticed). Now we reveal the official data that's making scientists suddenly change their minds about climate doom. So will eco-funded MPs stop waging a green crusade with your money? Well... what do YOU think?

Mail on Sunday 16th March 2013

We've just had less El Niños?

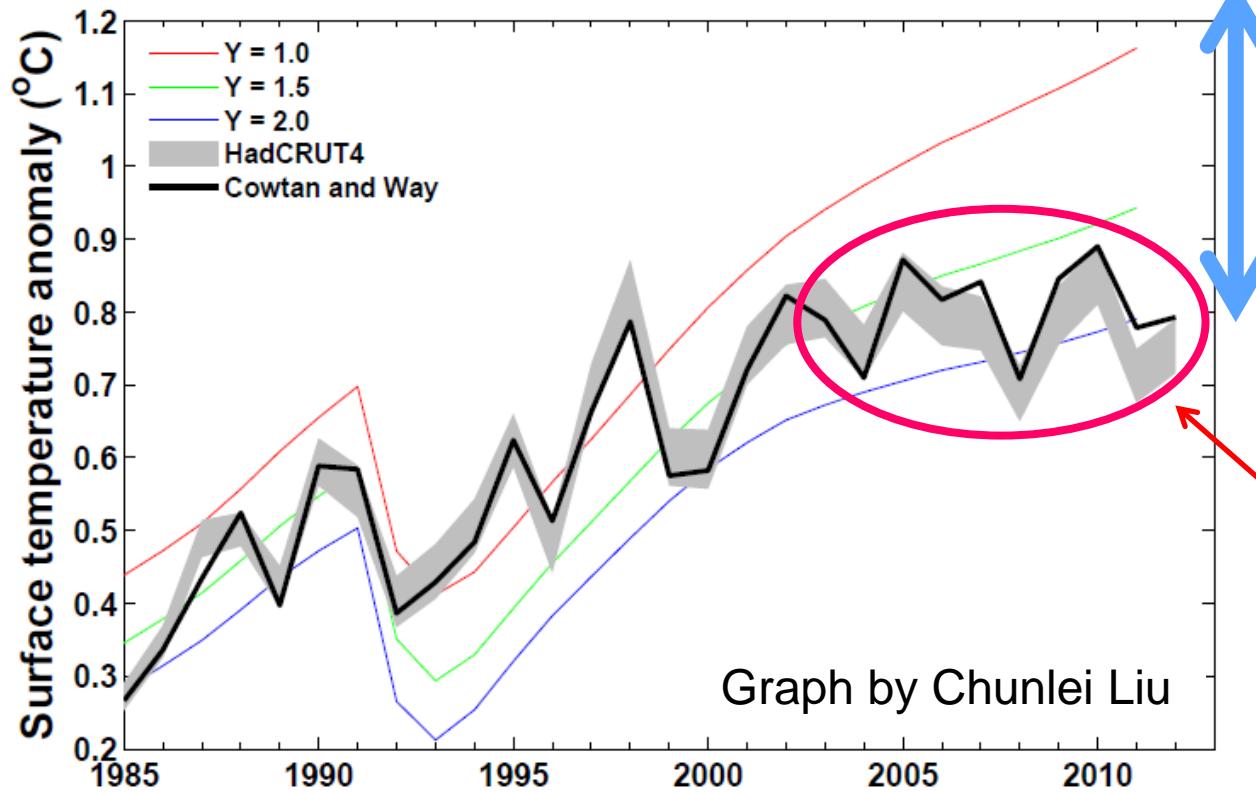


But why have there been more La Niñas recently and hasn't the slowdown in surface warming lasted a long time?



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

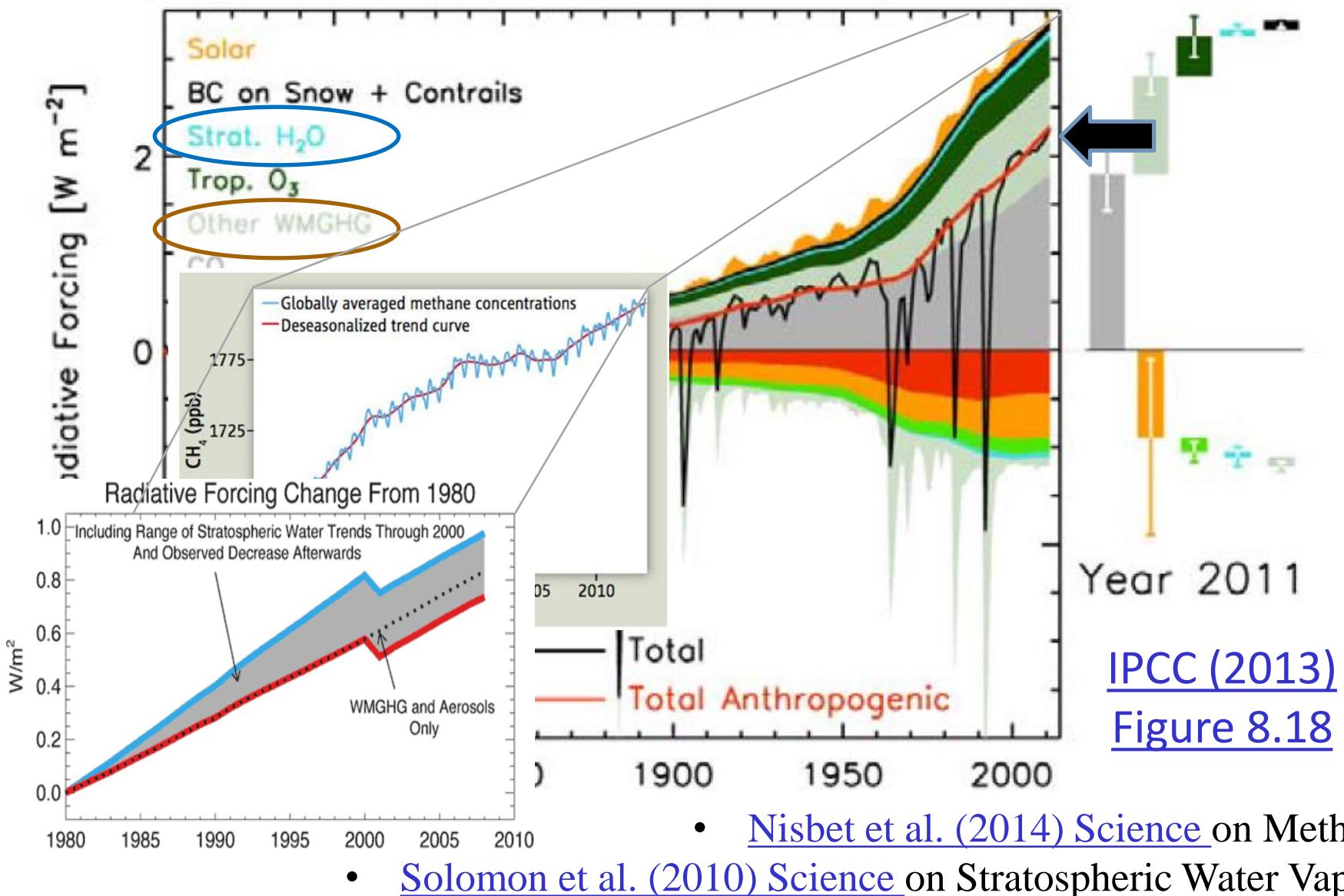
Is the temperature record wrong or are computer models inaccurate?



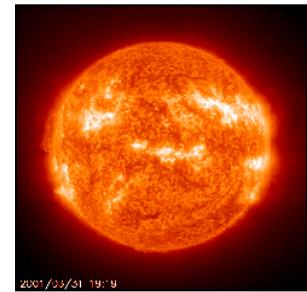
Can comparisons tell us about how sensitive climate is to radiative forcing?
e.g. [Otto et al. \(2013\) Nature Geosci](#)

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

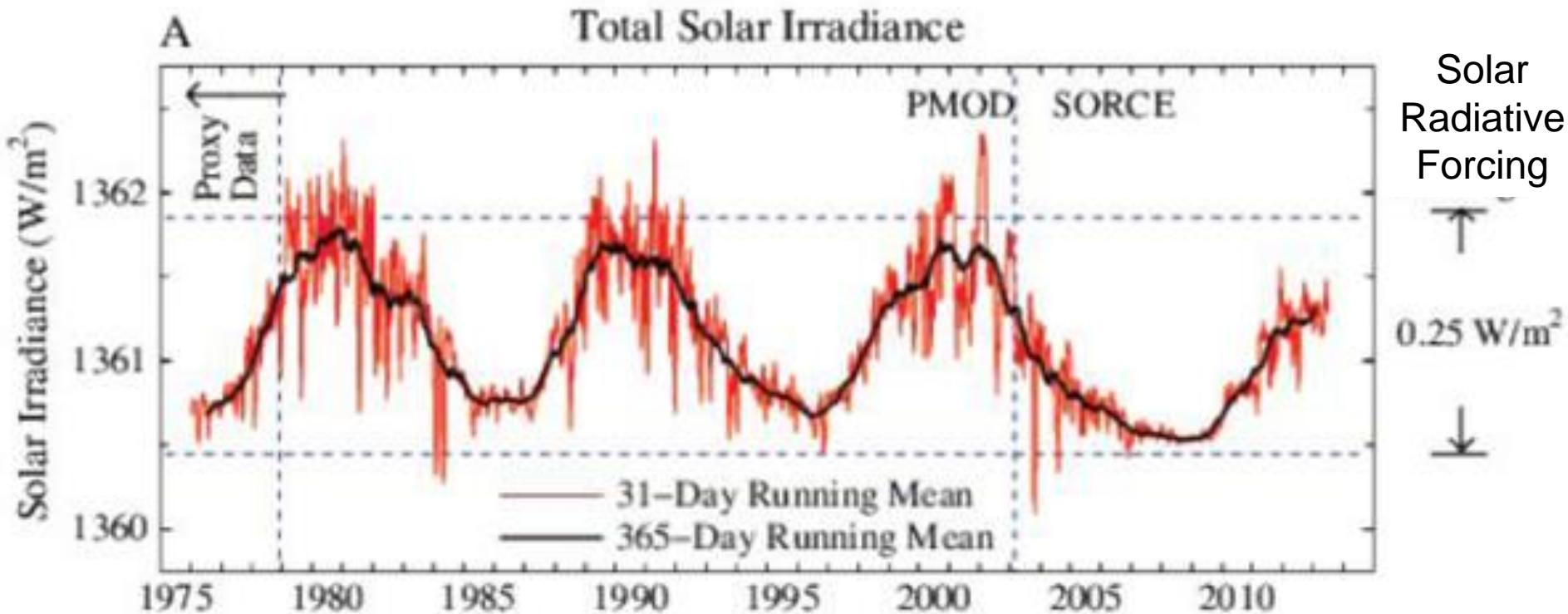
Drop in minor radiative forcings?



Weaker Solar Output?

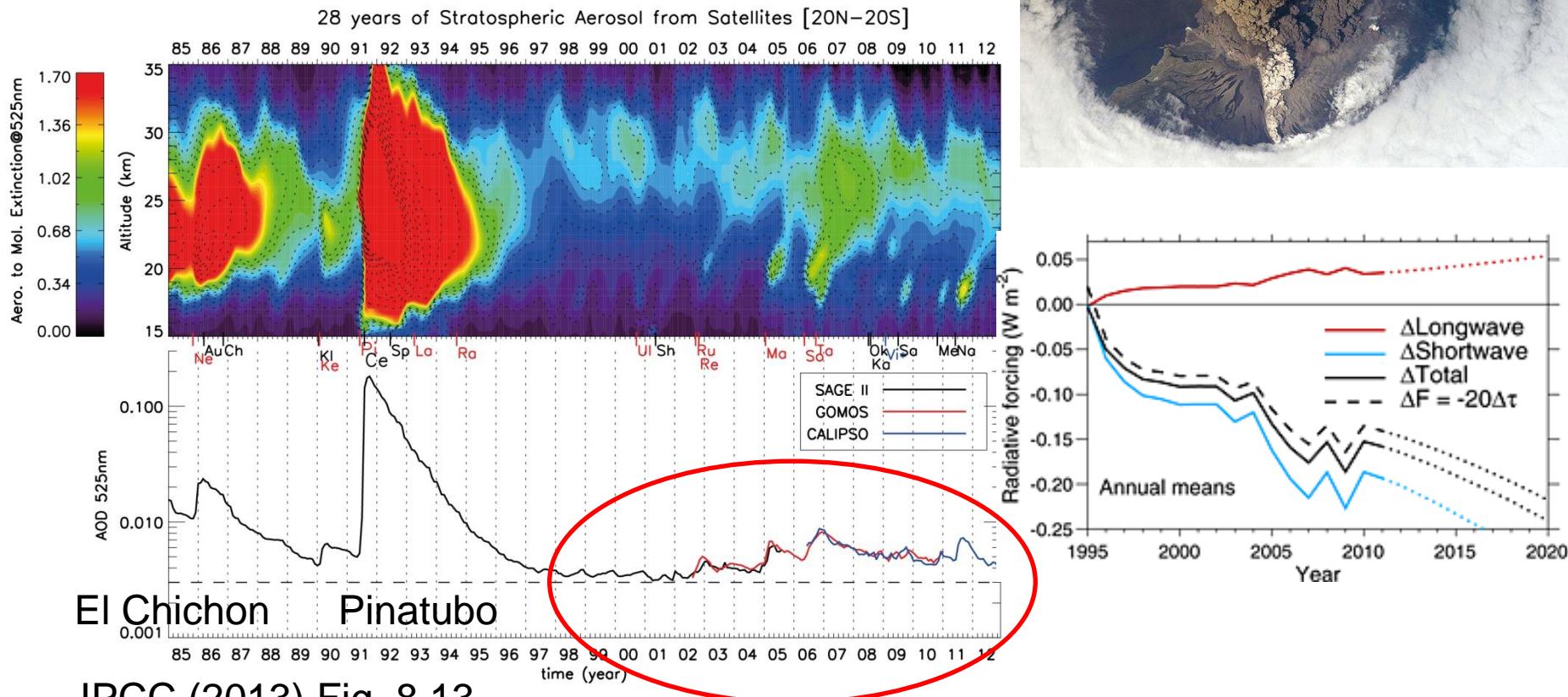


IPCC: Solar Radiative Forcing change
of -0.04 Wm^{-2} from 1986 to 2008



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

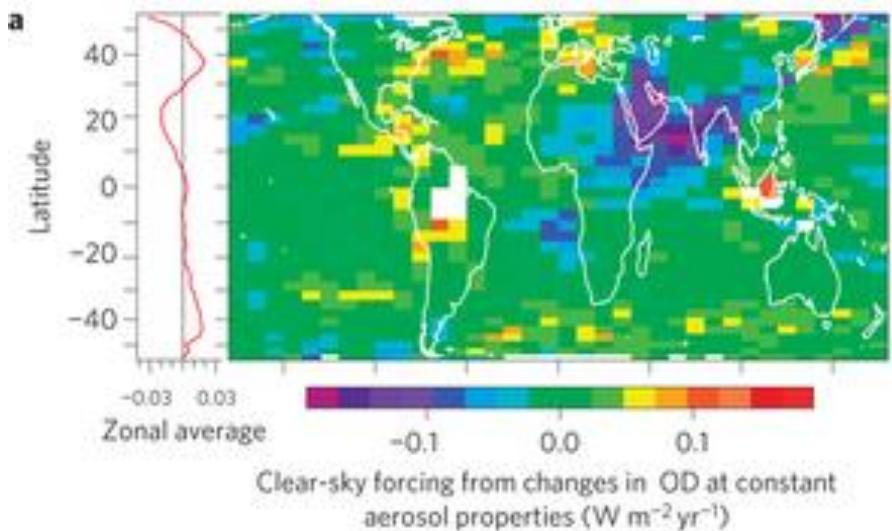
Cooling from small volcanos?



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

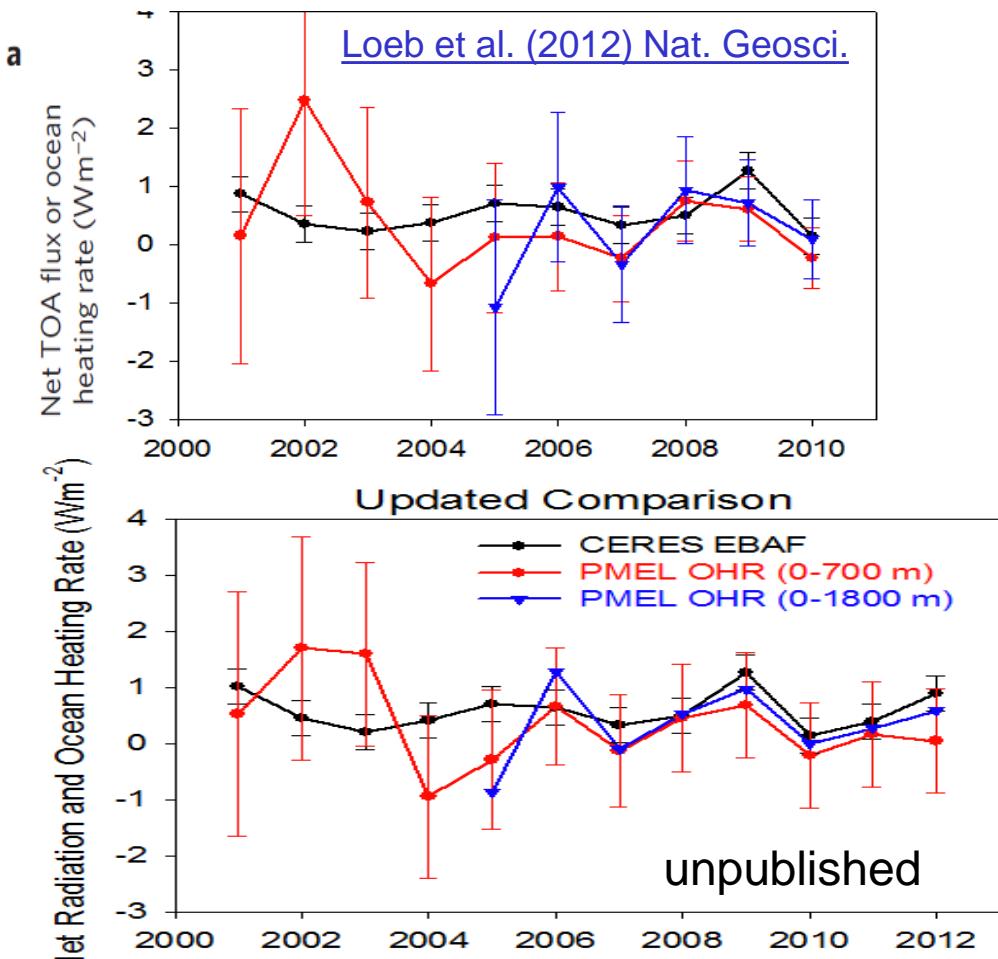
Cause	Estimated Change in Radiative Forcing (W per sq.m) ¹
Greenhouse gases	+ 0.48
Solar	- 0.16
Volcanoes	- 0.06
Other (e.g. aerosols)	± ?
TOTAL	+ 0.26 ± ?

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

¹ 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 **$0.60 \pm 0.43 \text{ Wm}^{-2}$**

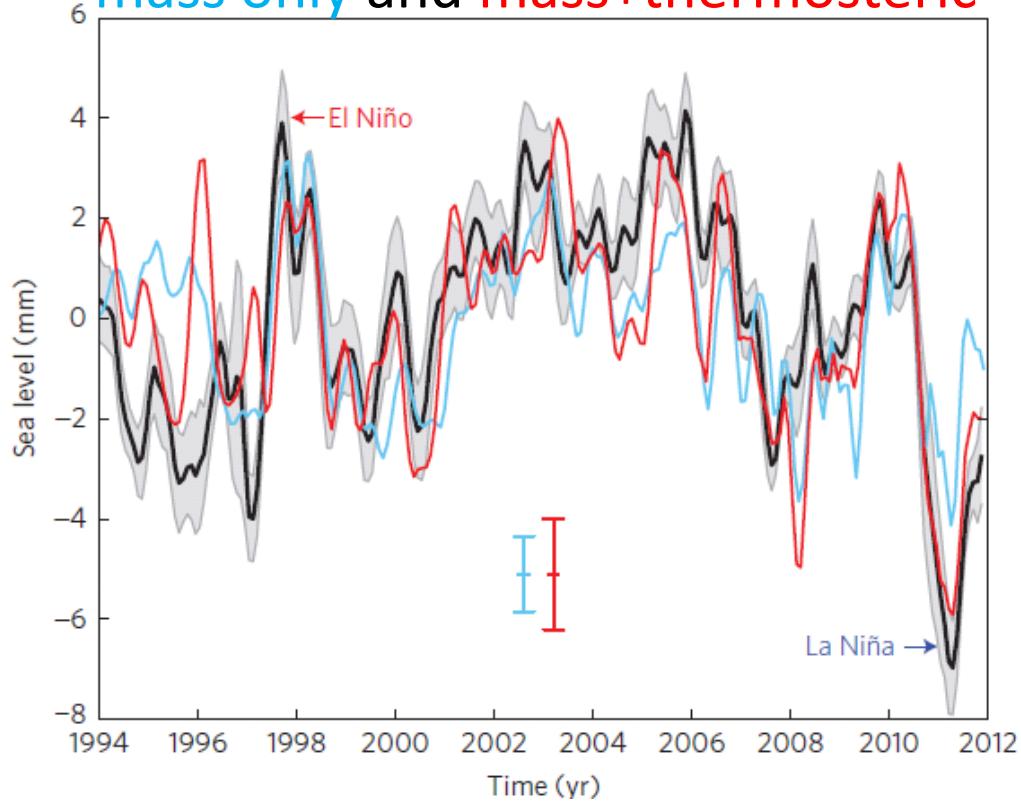


Increased heat flux to deeper layers of the ocean: [Watanabe et al. \(2013\) GRL](#); [Balmaseda et al. \(2013\) GRL](#)

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

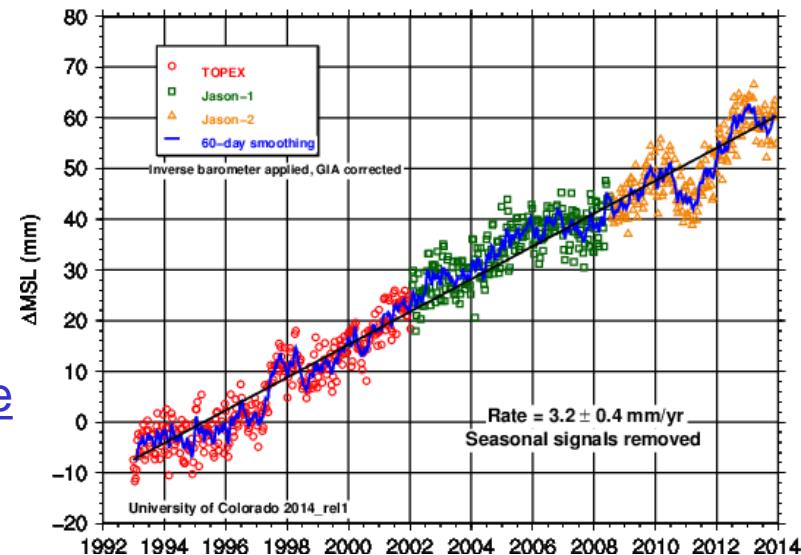
Reduced rate of sea level rise?

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

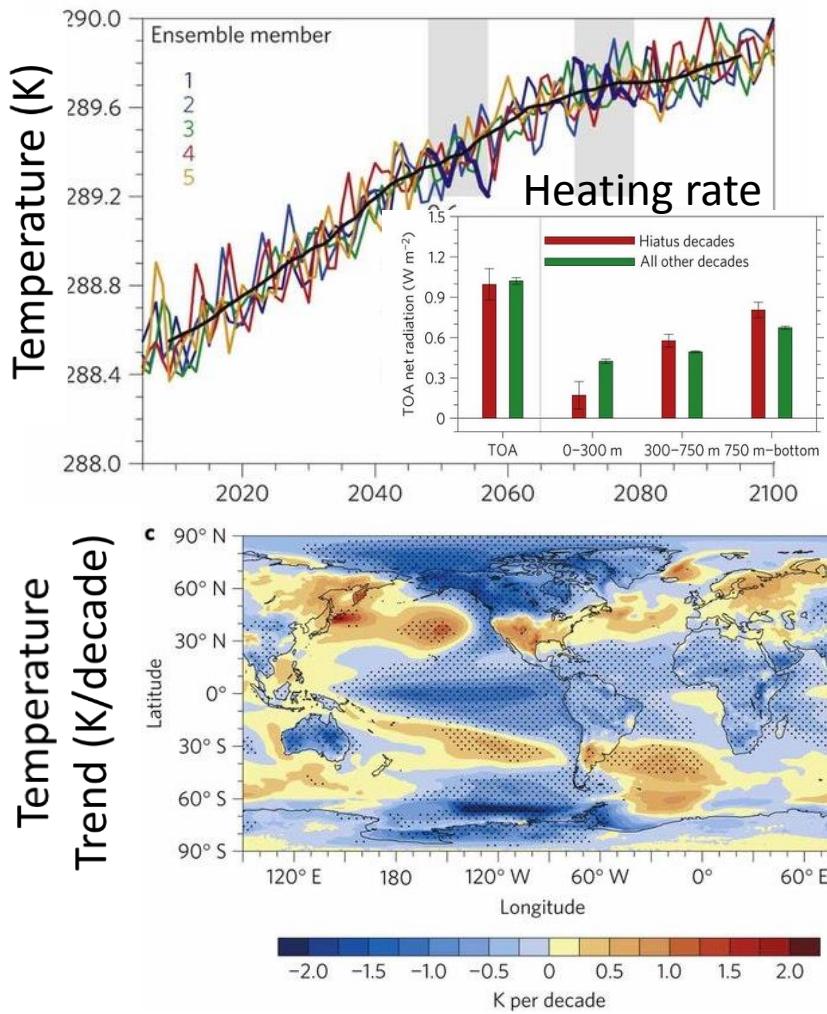


Cazenave et al. (2014) Nature Climate Change

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.

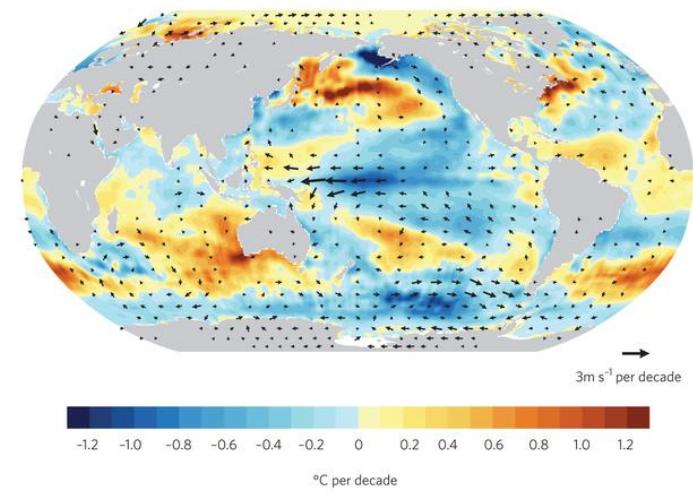


Climate models simulate decades with little surface warming despite CO₂ increases



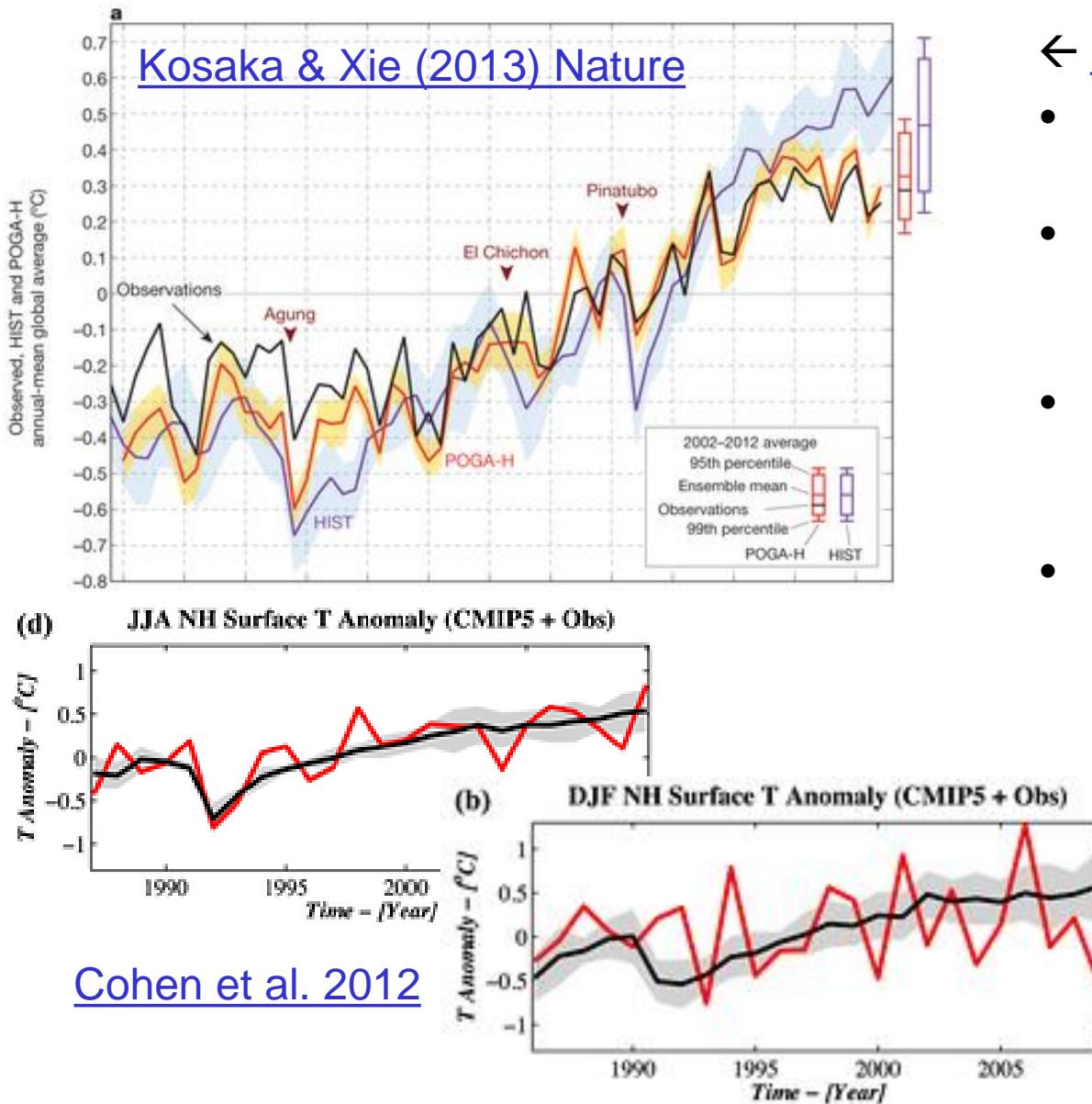
Model ([Meehl et al. 2011, 2013](#))

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



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

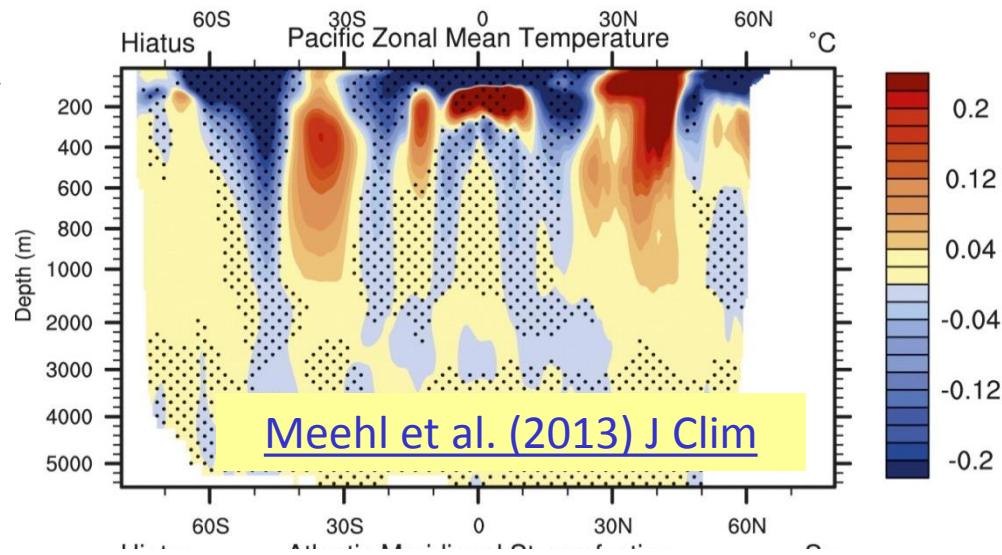
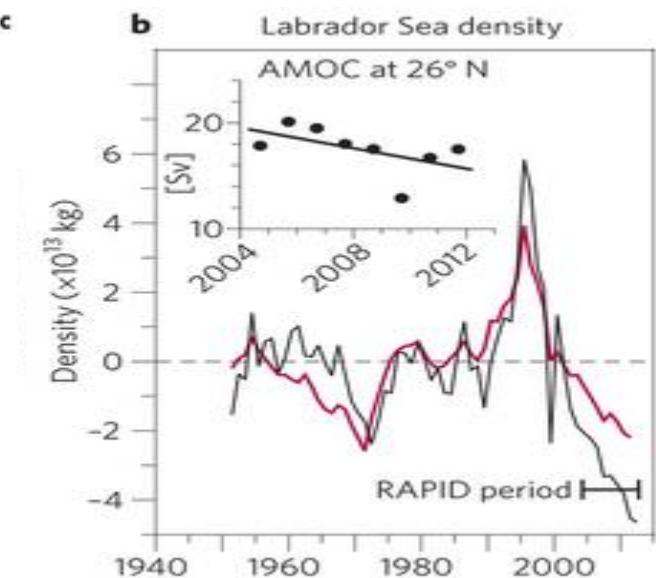
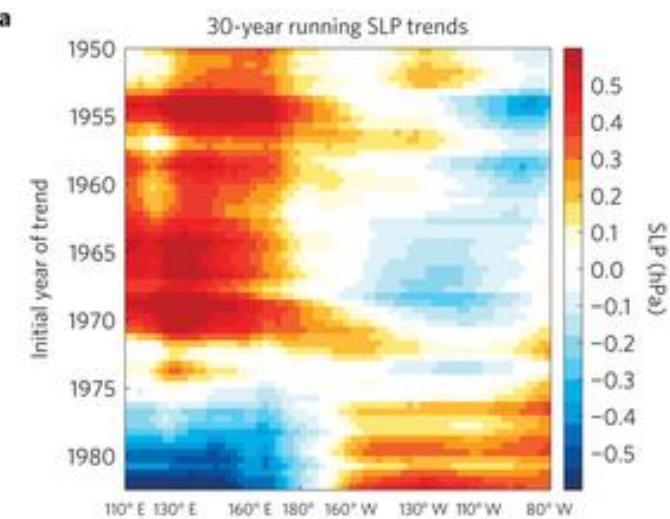
Role of Pacific Ocean Natural Variability



← [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](#))

Vertical profiles of heating in Pacific during hiatus decades →

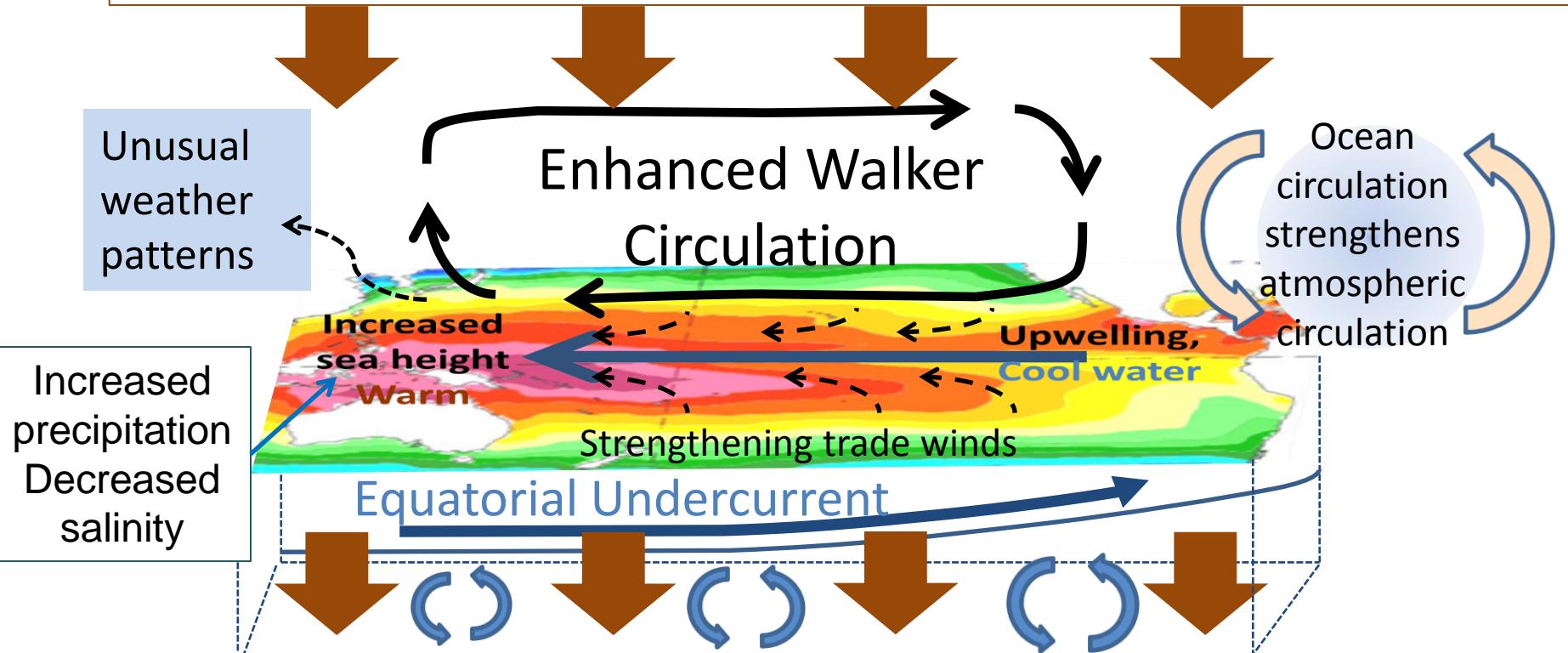


← Trends in SLP and decadal ENSO signal ([L'Heureux et al. 2013](#); [Sohn et al. 2012](#); [Merrifield 2011](#); [England et al. 2014](#))

- 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

Work by [Merrifield \(2010\) J. Climate](#); [Sohn et al. \(2013\) Clim. Dyn.](#); [L'Heureux et al. \(2013\) Nature Climate Change](#); [Kosaka and Xie \(2013\) Nature](#); [England et al. \(2014\) Nature Climate Change](#)

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		
WP3 (Met Office)	O3	D3 McDonagh, King		
WP4 (All)	Recruitment, Integration, KO meeting	O4-O5-O6 Kuhlbrodt, Gregory	D4,D5	Synthesis
Partners				

Table 2 - Management timeline for DEEP-C.

DEEPC: WP1

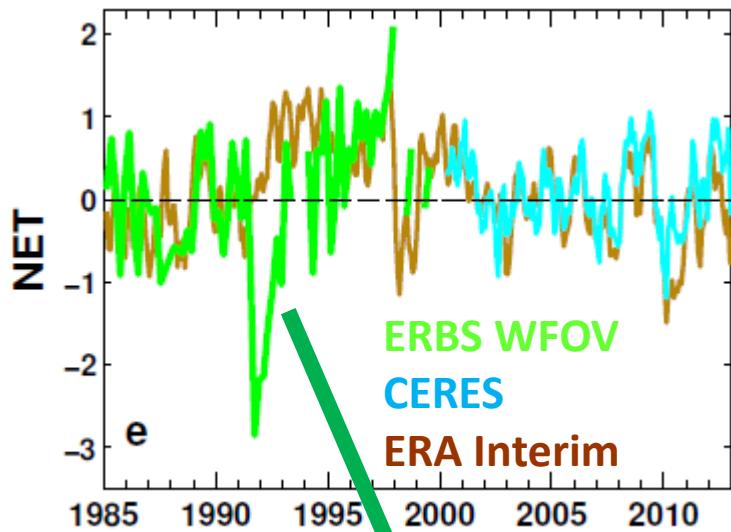
Earth's energy imbalance 1985-2012

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

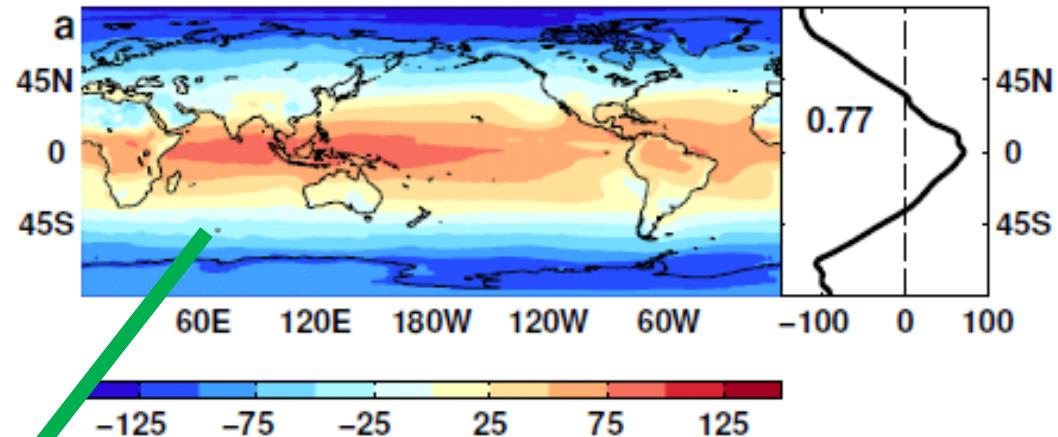
DEEP-C Meeting, NOC-Southampton, 26th March 2014

Reconstructing global radiative fluxes prior to 2000

ERBS WFOV variability

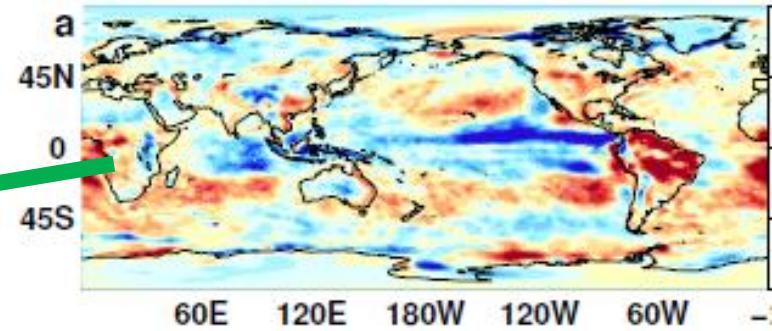


CERES monthly climatology



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

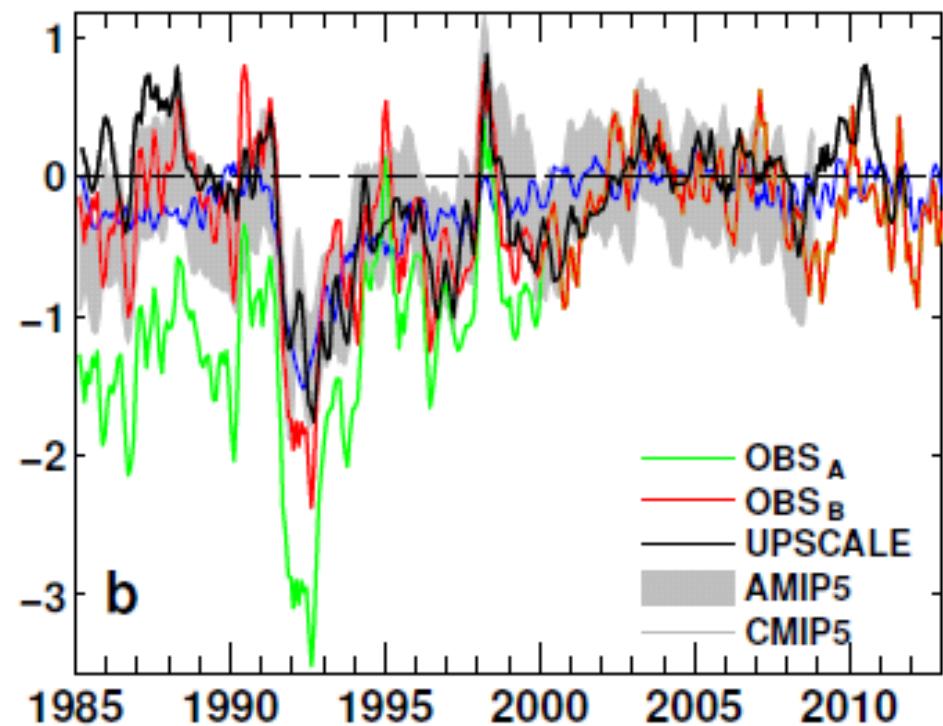
ERA Interim spatial anomalies

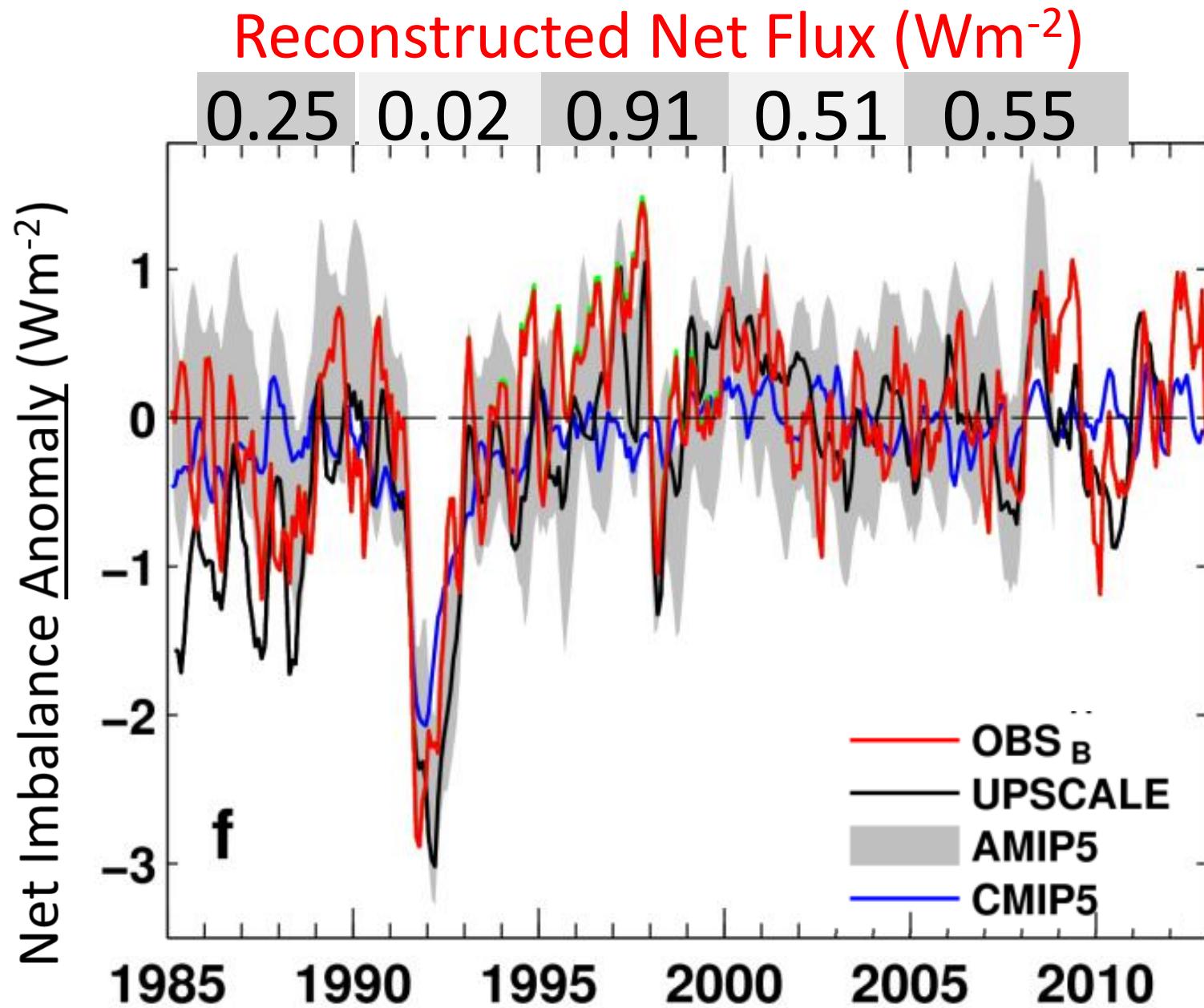


Use reanalyses or models to bridge gaps in record (1993 and 1999/2000)

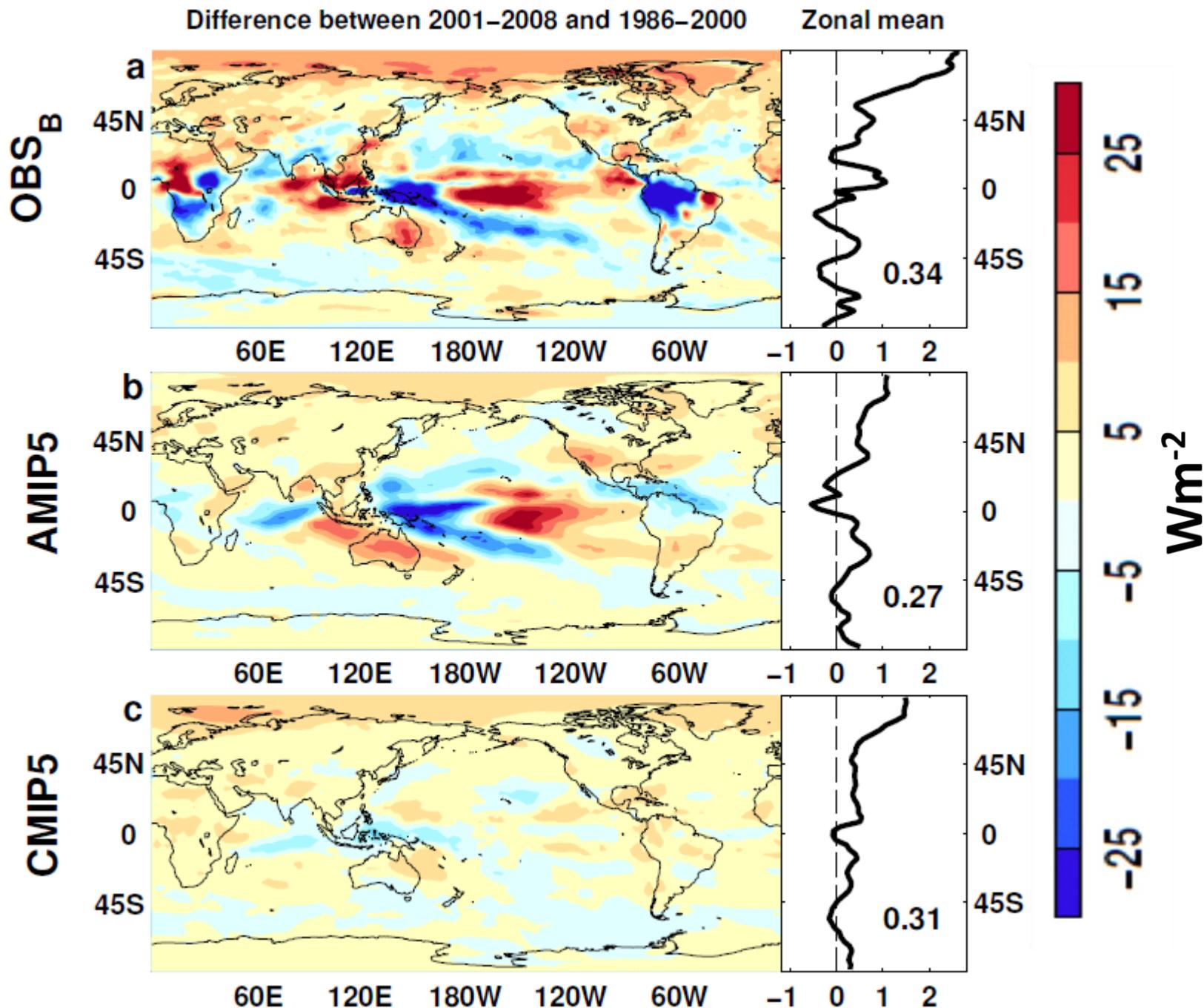
- ERA Interim trends suspect. Use model...
- **UPSCALE** simulations (obs. SST, sea ice & realistic radiative forcings) “**OBS_B**”
- Net less sensitive to method than OLR/ASR

Outgoing Longwave Radiation Anomalies (Wm^{-2})



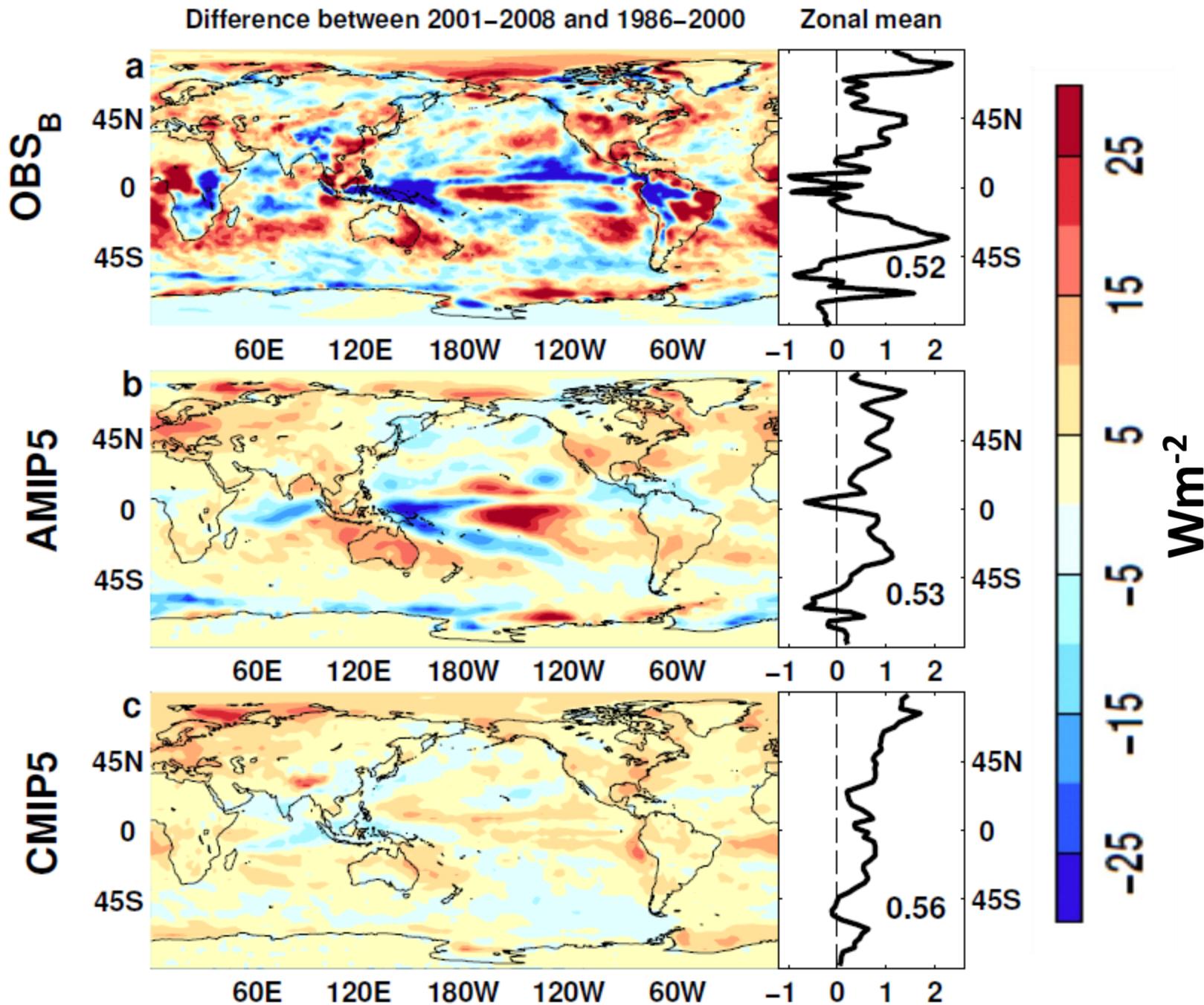


Outgoing Longwave Radiation



Absorbed Shortwave Radiation

Difference between 2001–2008 and 1986–2000



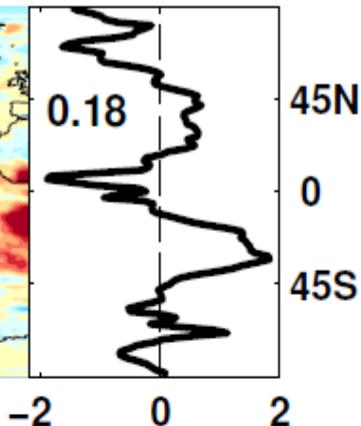
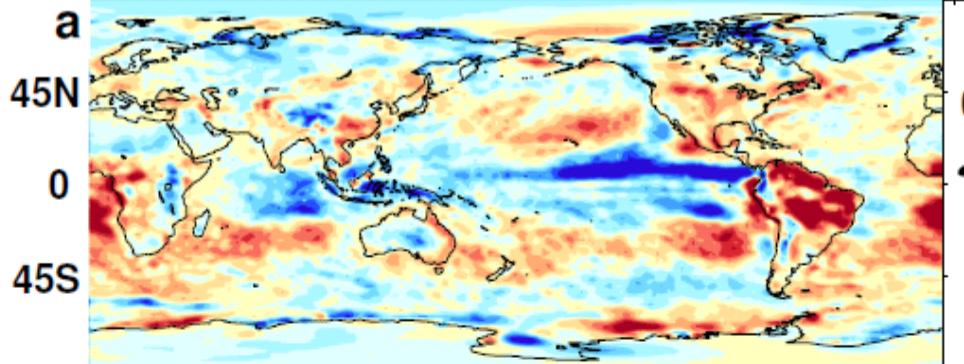
NET

Radiation

Difference between 2001–2008 and 1986–2000

Zonal mean

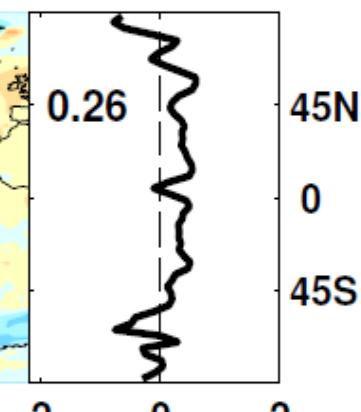
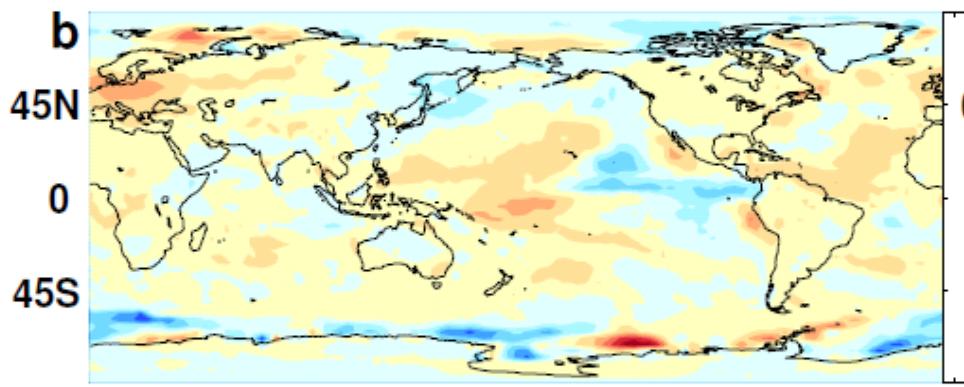
OBS_B



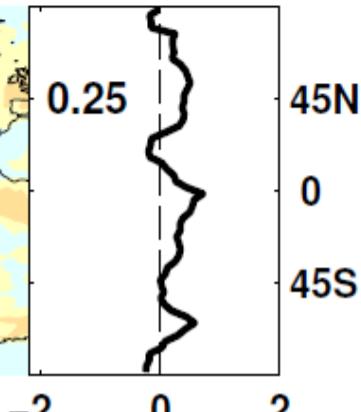
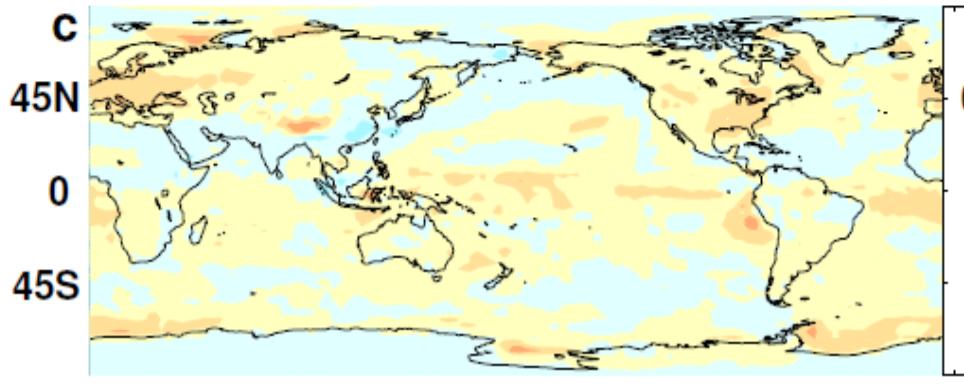
(W/m²)

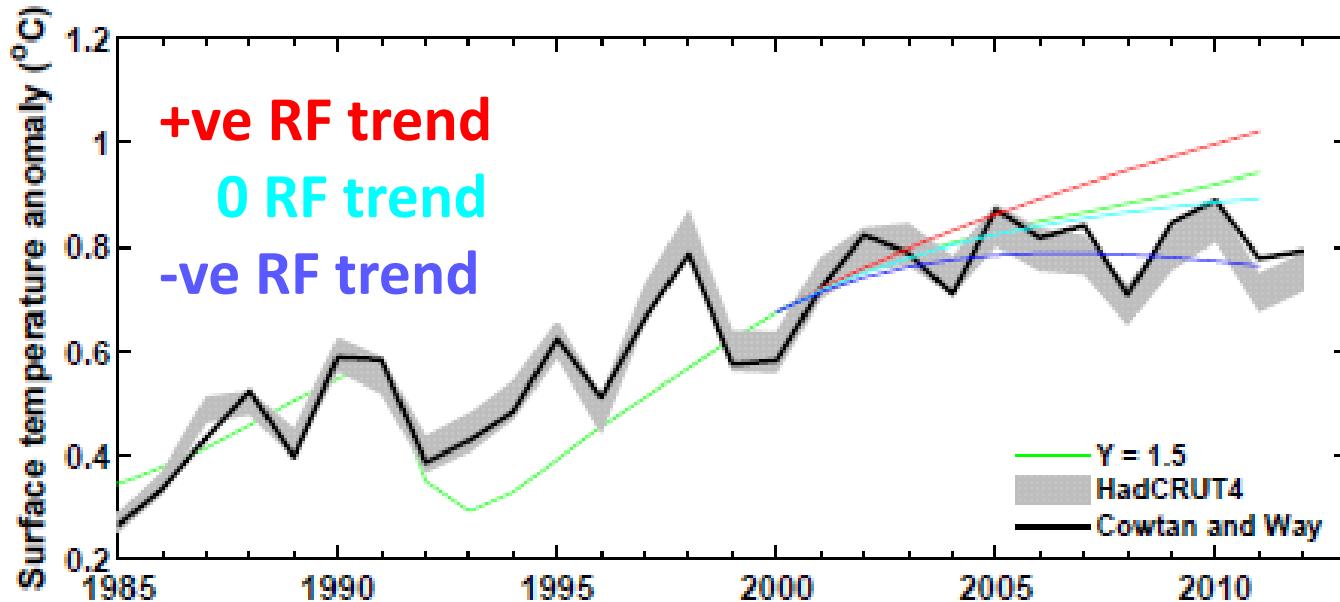
-5 -4 -3 -2 -1 0 1 2 3 4 5

AMIP5

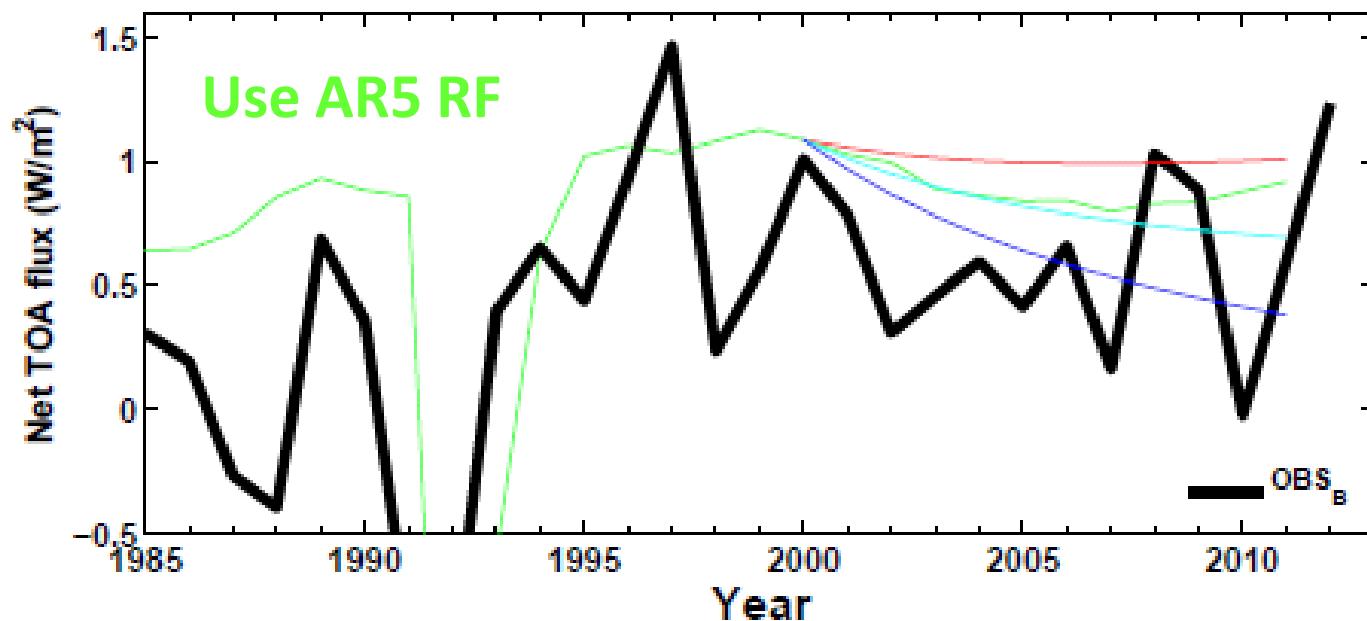


CMIP5





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 ΔT and ΔN
- 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>