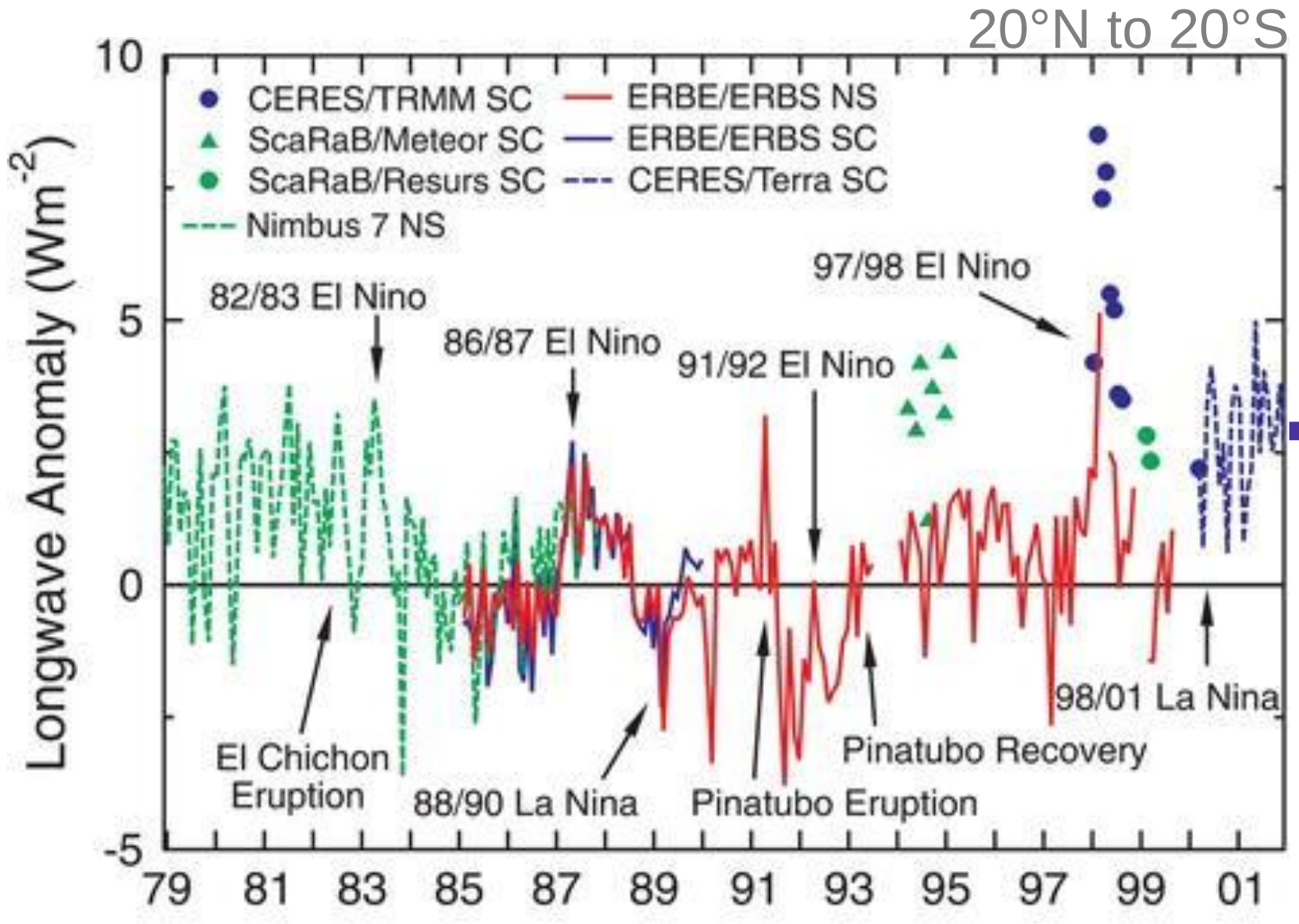
Reconciling Ocean Heating and Satellite Earth Radiation Budget estimates

Richard Allan, University of Reading/NCAS Climate

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

Royal Society Hiatus meeting, Middle of nowhere, 2/4/2014

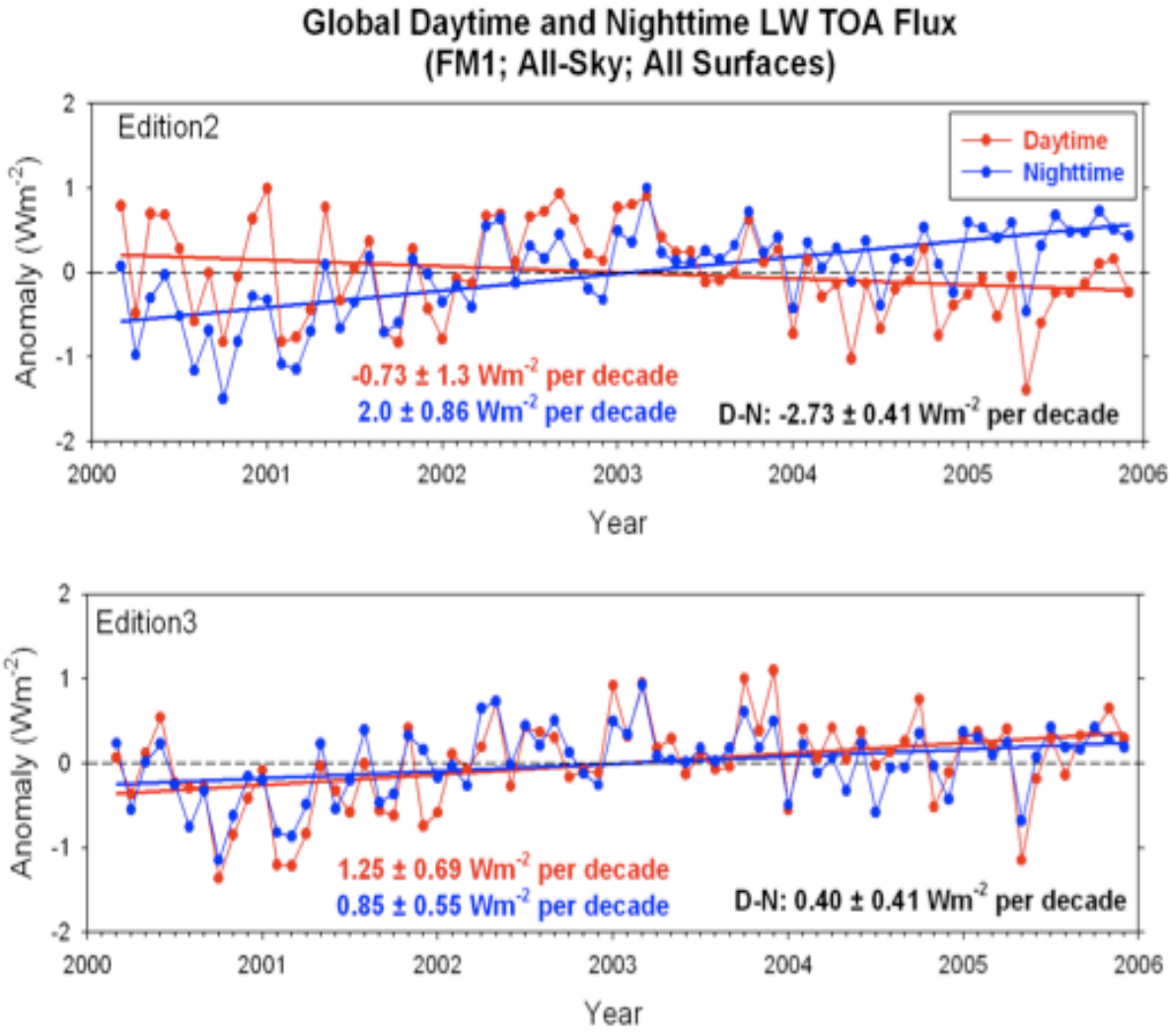
Earth Radiation Budget Satellite Data



Wong et al. (2006) J Clim; Wielicki et al. (2002) Science

Updated CERES satellite data

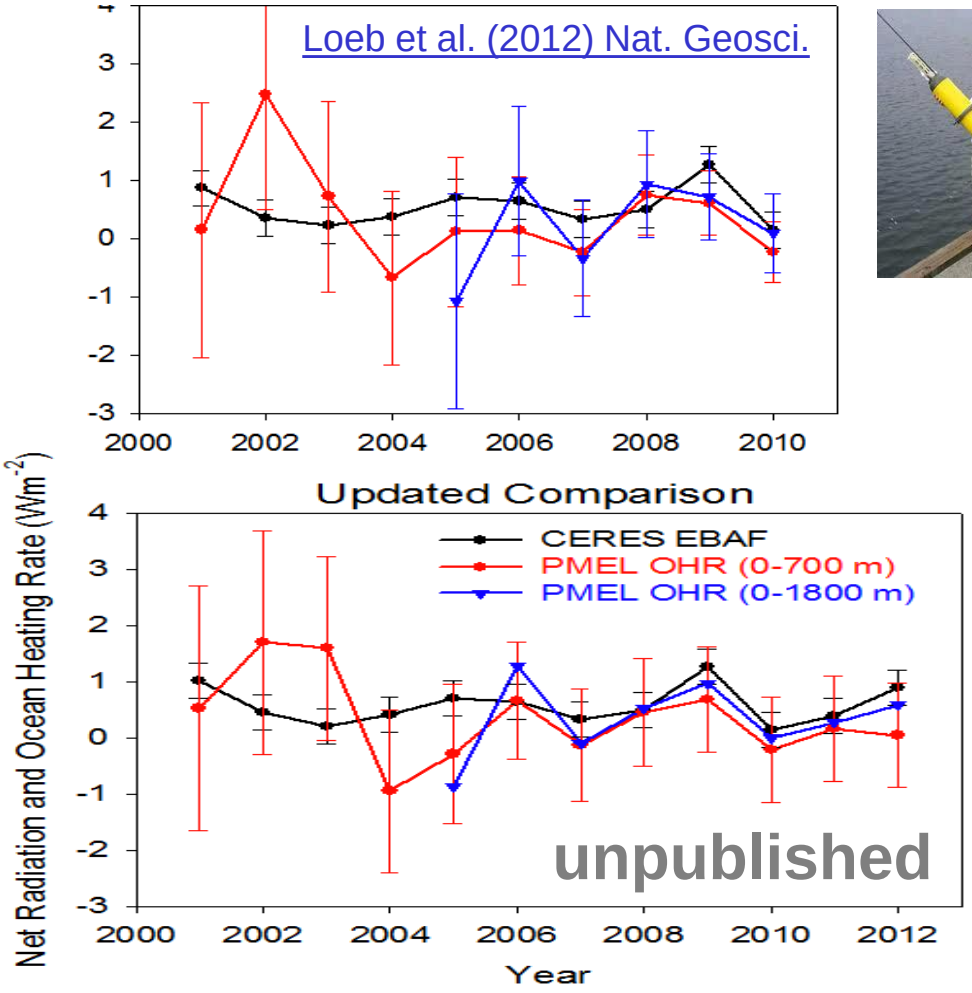
- Issues with sampling, radiance to flux conversion, calibration, etc
- Correction for degradation of shortwave filter
- Correction also improves physical consistency of trends in daytime longwave



We used version CERES_EBAF-TOA_Ed2.6r; currently v2.8

Combining Earth Radiation Budget data and Ocean Heat Content measurements

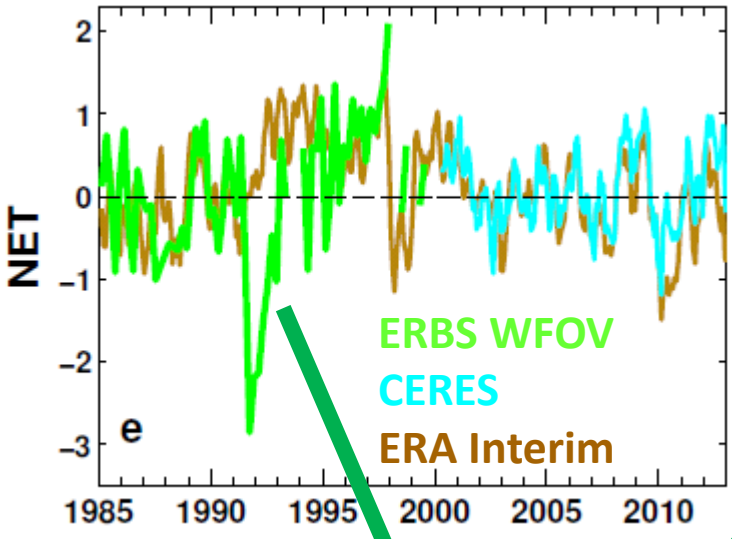
- Tie 10-year CERES record with SORCE TSI and ARGO-estimated heating rate 2005-2010 + minor additional storage terms
- Variability relating to ENSO reproduced by CERES and ERA Interim
- Updated estimate of net energy imbalance 2000/03-2013/03: **0.60±0.43 Wm^{-2}**



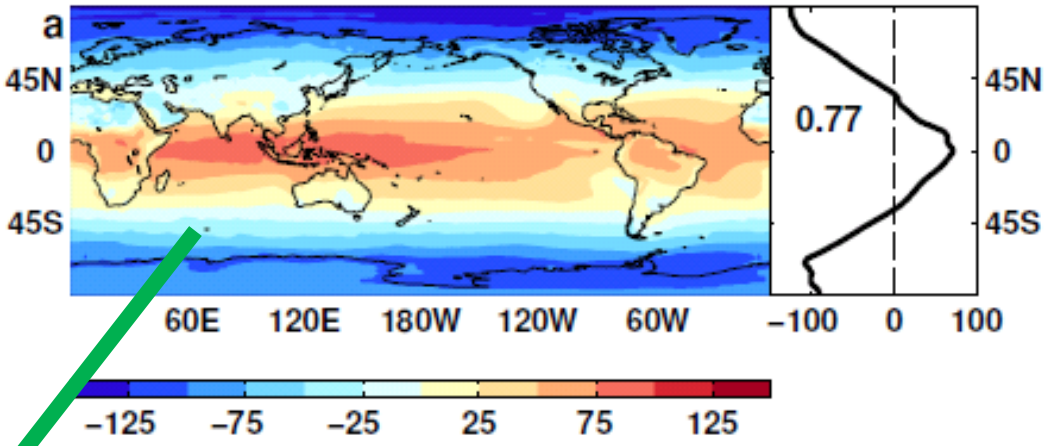
Loeb et al. (2012) Nat. Geosci. See also Hansen et al. (2011) ACP

Reconstructing global radiative fluxes prior to 2000

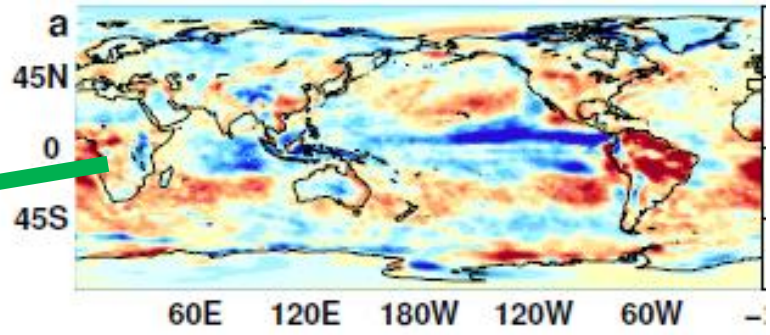
ERBS/CERES variability



CERES monthly climatology



ERA Interim spatial anomalies

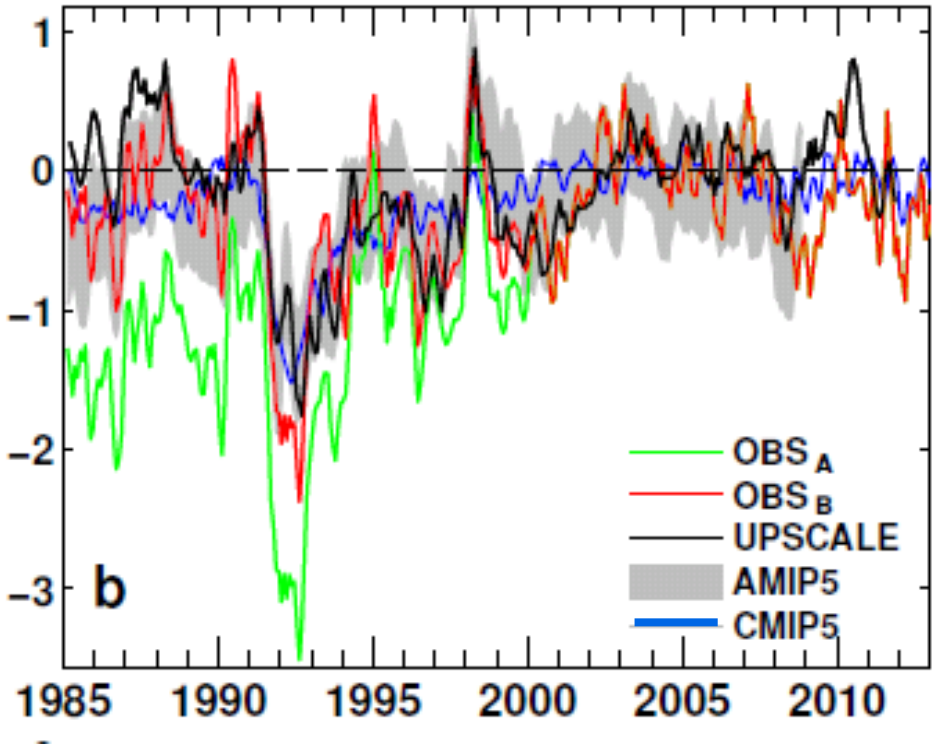


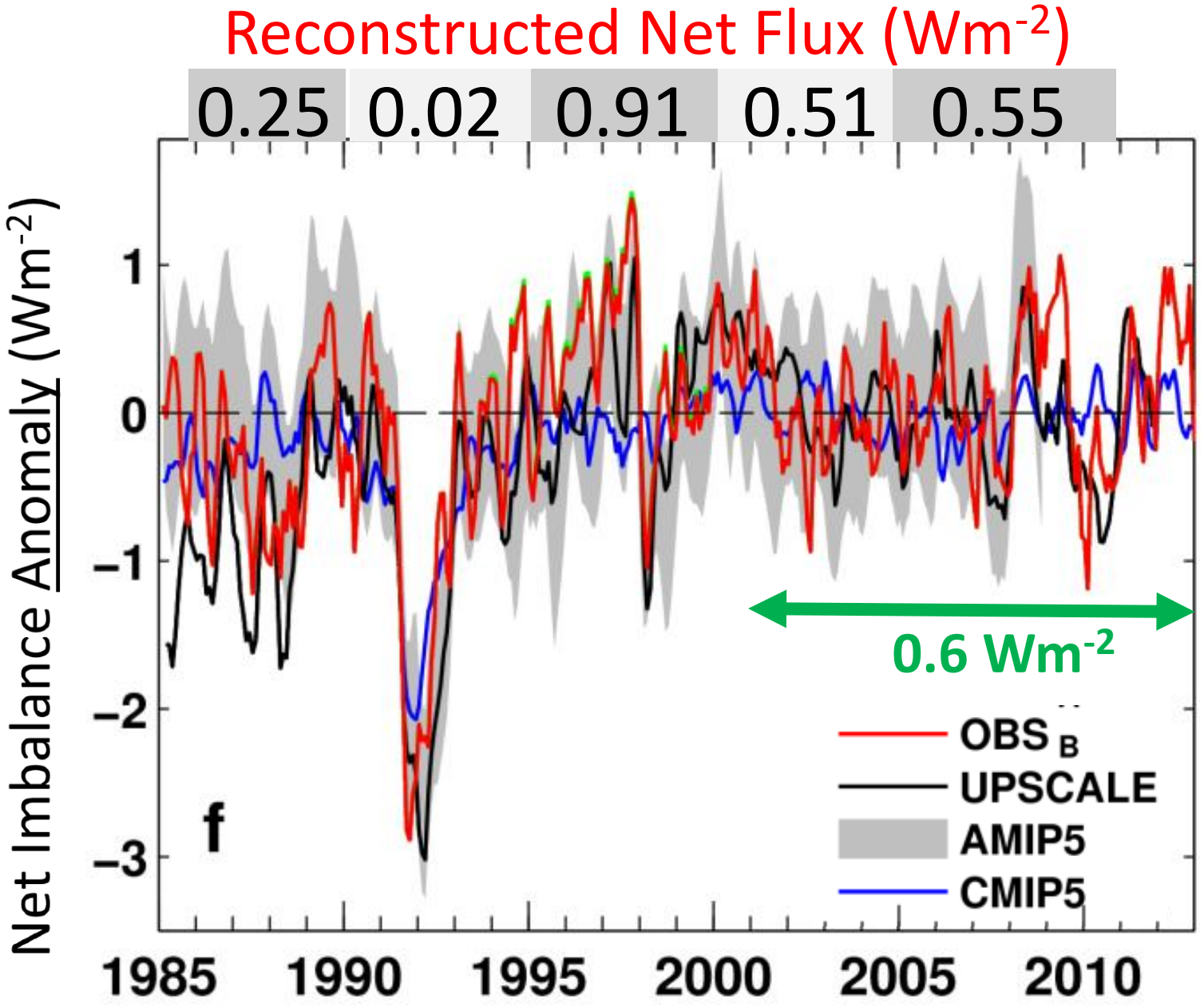
Combine CERES/ARGO accuracy, ERBS WFOV stability and reanalysis circulation patterns to reconstruct radiative fluxes

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

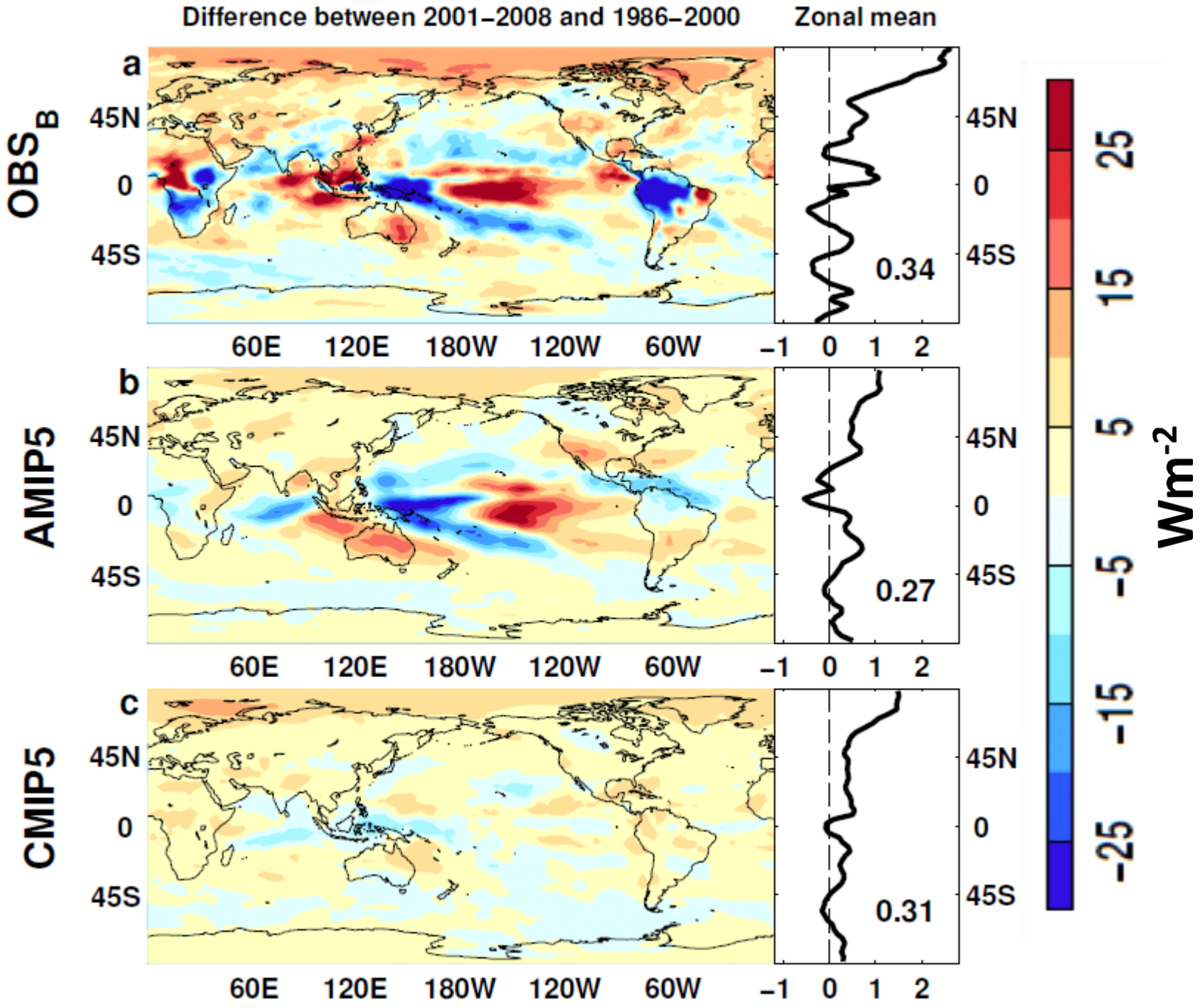
- ERA Interim trends suspect. Use model…
- **UPSCALE** simulations (obs. SST, sea ice & realistic radiative forcings) "**OBS_B**"
- Net less sensitive to method than OLR/ASR

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

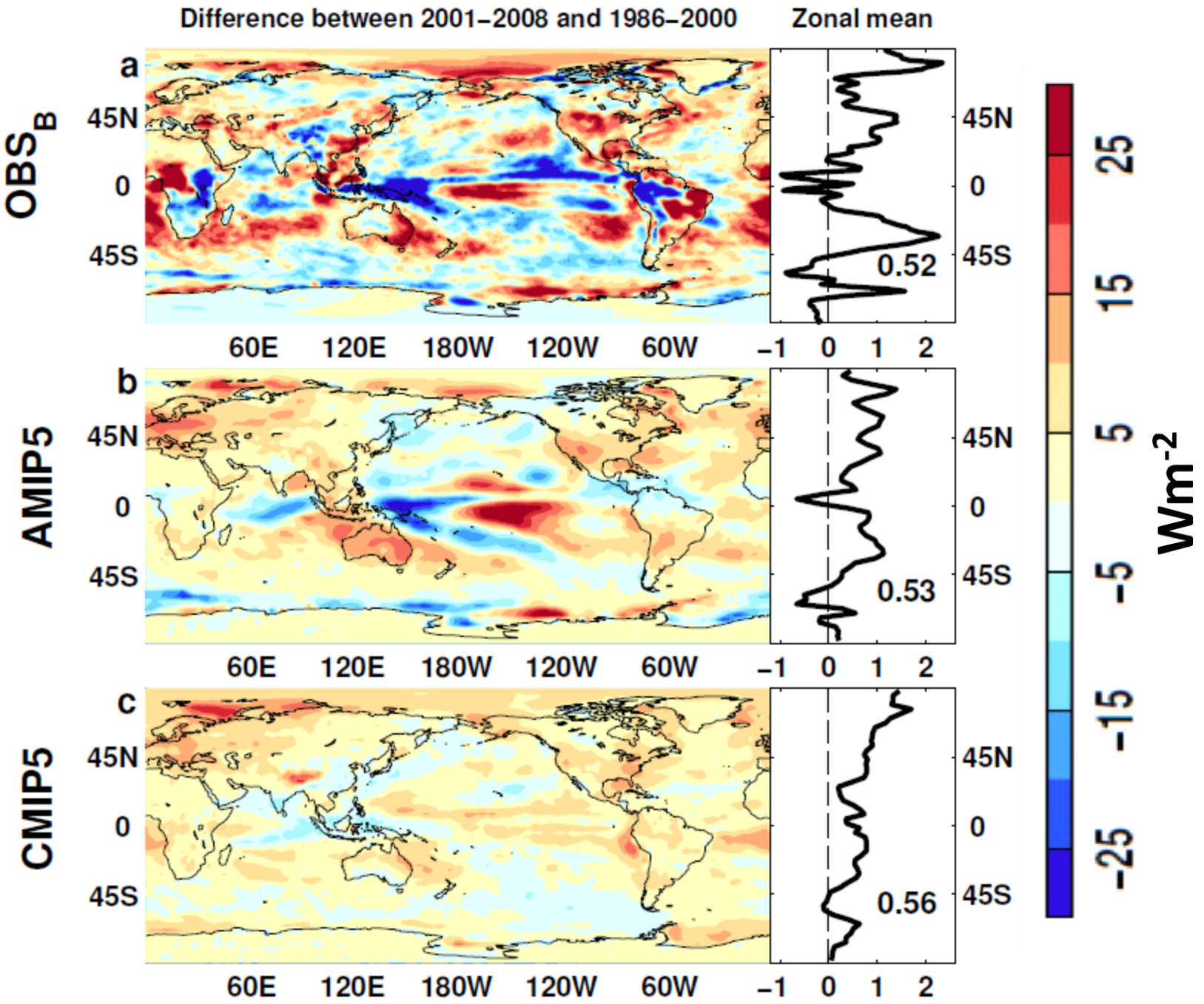



Reconstructed Net Flux (Wm-2)
0.25
0.02
0.91
0.51
0.55
Net Imbalance Anomaly (Wm-2)
1
0
−1
−2
−3
1985
1990
1995
2000
2005
2010
f
0.6 Wm-2
OBS B
UPSCALE
AMIP5
CMIP5

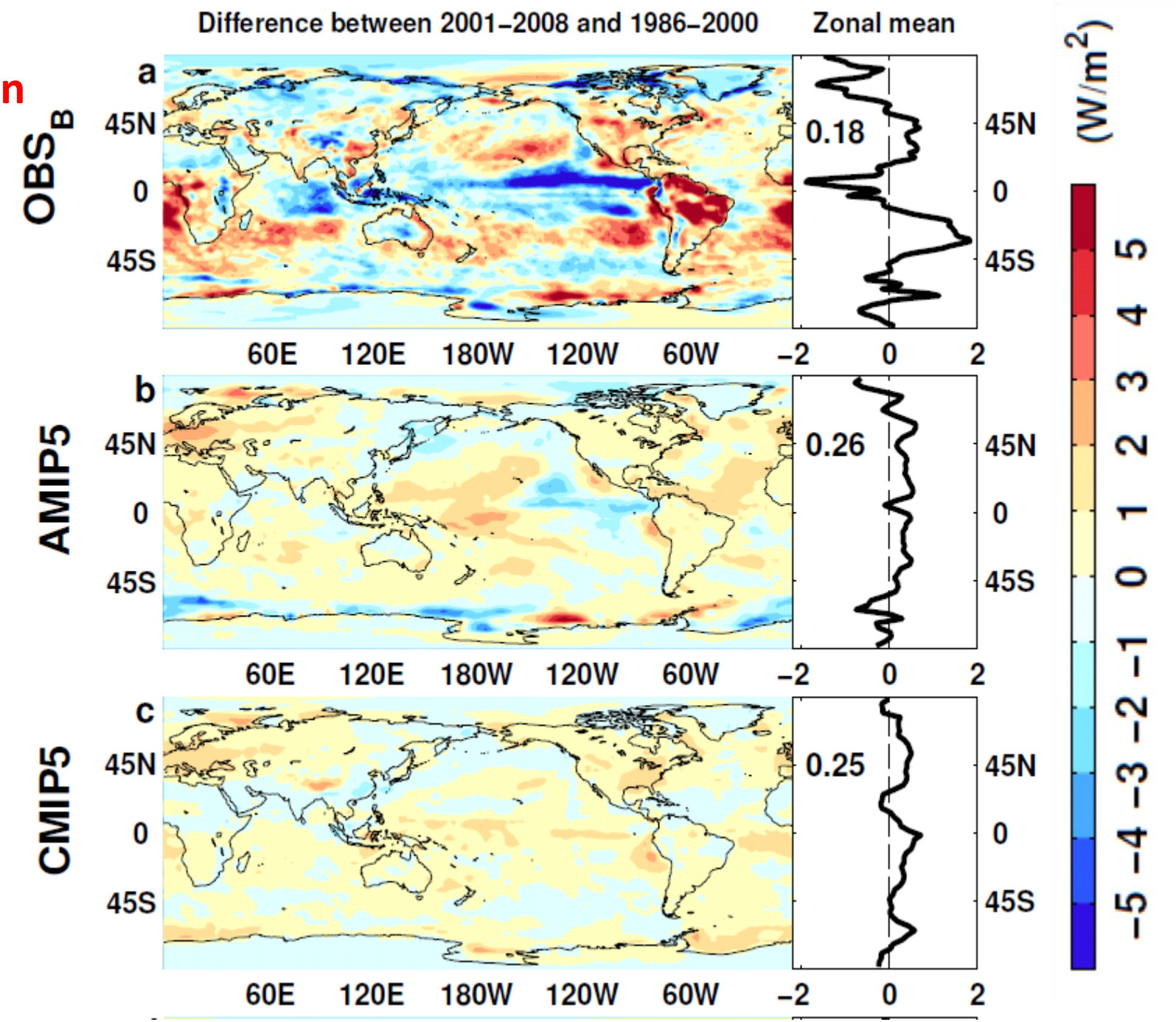
Outgoing Longwave Radiation



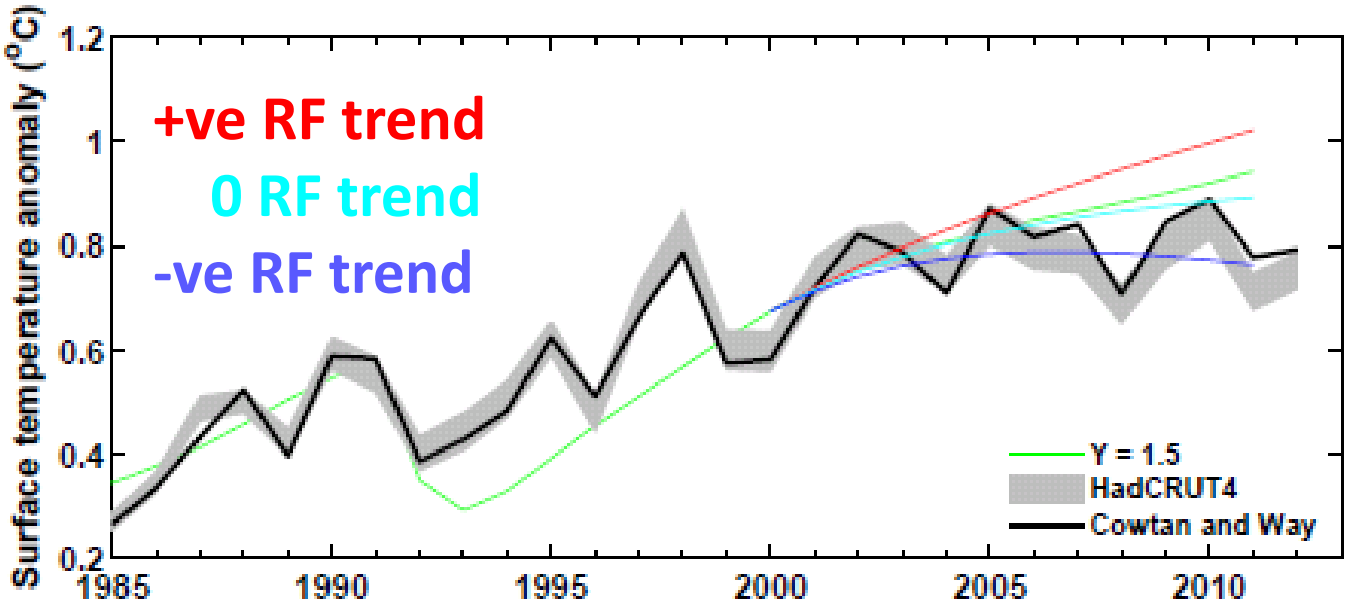
Absorbed Shortwave Radiation



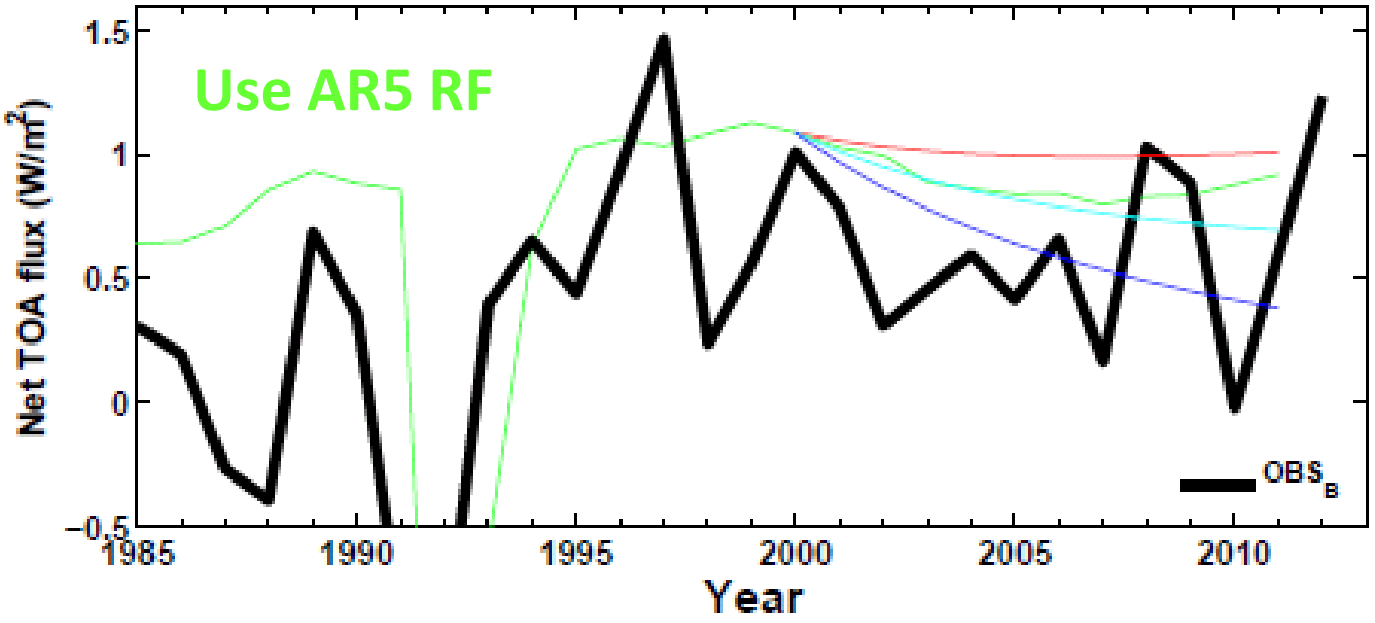
NET Radiation



ΔT

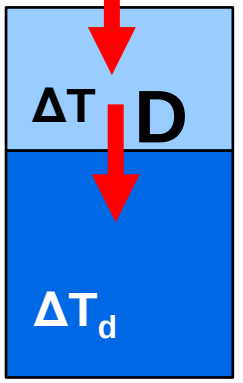


N



Analysis using simple energy balance model

$N = \Delta F - Y\Delta T$



Preliminary results

- Heating of Earth continues at rate of ~0.6 Wm-2
- Current variability in TOA radiation (1985-2013)
- Net radiative flux imbalance fairly stable
  - Requires anchoring to ARGO ocean heating rate + minor terms
  - Influence of Pinatubo and ENSO
  - ~0.3 Wm^{-2} higher in 1995-1999 than 2000-2013 period
- Distinct East Pacific signal in ΔT and ΔN
- Radiative forcing alone can't explain surface warming slowdown: internal variability important
- Next steps: combining with reanalyses energy transports to estimate surface fluxes