Reconciling Ocean Heating and Satellite Earth Radiation Budget estimates

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Royal Society Hiatus meeting, Middle of nowhere, 2/4/2014
Earth Radiation Budget Satellite Data

20°N to 20°S

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: $0.60 \pm 0.43$ Wm$^{-2}$

Loeb et al. (2012) Nat. Geosci. See also Hansen et al. (2011) ACP
Reconstructing global radiative fluxes prior to 2000

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) “\text{OBS}_B”
- Net less sensitive to method than OLR/ASR

![Outgoing Longwave Radiation Anomalies (Wm$^{-2}$)](image)
Reconstructed Net Flux (Wm$^{-2}$)

Net Imbalance Anomaly (Wm$^{-2}$)

- OBS$_B$
- UPSCALE
- AMIP5
- CMIP5


0.25  0.02  0.91  0.51  0.55

0.6 Wm$^{-2}$
Outgoing Longwave Radiation


Zonal mean

OBS

AMIP5

CMIP5

Wm^{-2}

-25 -15 -5 5 15 25

a

b

c

60E 120E 180W 120W 60W -1 0 1 2

45N 45S

0 0.27 0.34

45N 45S

0 0.27 0.34

45N 45S

0 0.27 0.34
Absorbed Shortwave Radiation


Zonal mean

OBS

AMIP5

CMIP5
Use AR5 RF

\[ N = \Delta F - Y \Delta T \]

Analysis using simple energy balance model

\[ \Delta T \]

\[ \Delta T_d \]
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