CURRENT CHANGES IN EARTH’S ENERGY IMBALANCE 1985-2014

Richard Allan  r.p.allan@reading.ac.uk  @rpallanuk

Thanks to Chunlei Liu, Norman Loeb and all co-authors
AT WHAT RATE IS EARTH HEATING?

What are implications for climate sensitivity and the global water cycle?

RECONSTRUCTING GLOBAL RADIATIVE FLUXES SINCE 1985

Combine CERES/ARGO accuracy, ERBS WFOV stability and reanalysis circulation patterns to reconstruct radiative fluxes.
EARTH CONTINUES TO HEAT UP

Imbalance: 0.23 0.00 0.78 0.63 0.63 (Wm$^{-2}$)

Allan et al. (2014) GRL

Volcano

El Niño

La Niña

0.34±0.67 Wm$^{-2}$

0.62±0.43 Wm$^{-2}$

Net Imbalance Anomaly (Wm$^{-2}$)
DISCREPANCY BETWEEN RADIATION BUDGET & OCEAN HEATING

- Large ocean heating anomaly in 2002
- Inconsistent with radiation budget observations and simulations
- Changing observing system influence?
- Slight drop in net flux 1999-2005?

Smith et al. (2015) GRL
WHERE IS THE HEAT GOING?
NEW ESTIMATES OF SURFACE ENERGY FLUX

\[ F_{\text{SFC}} = F_{\text{TOA}} - \frac{\partial T E}{\partial t} - \nabla \cdot \left( \frac{1}{g} \int_0^1 V (Lq + C_p T + \varphi_s + k) \frac{\partial p}{\partial \eta} d\eta \right) \]

Net surface downward energy flux (Wm\(^{-2}\))
Liu et al. (2015) JGR
WHERE IS THE HEAT GOING?

CHANGES IN SURFACE ENERGY FLUX

- Surface energy flux dominated by atmospheric transports
- Contrasting model pattern of change
- Are reanalysis transports reliable?

Liu et al. (2015) JGR
OBSERVED ASYMMETRY IN EARTH’S ENERGY BUDGET

- Observed inter-hemispheric imbalance in Earth’s energy budget
- Not explained by albedo: brighter NH surface but more clouds in SH (Stephens et al. 2015)
- Imbalance explains position of ITCZ (Frierson et al. 2013)

EQUATORIAL HEAT TRANSPORT AND MODEL PRECIPITATION BIAS

- Clear link between bias in cross-equatorial heat transport by atmosphere and inter-hemispheric precipitation asymmetry

CONCLUSIONS

- Heating of Earth continues at rate of ~0.6 Wm^{-2}
  - Manifest as positive imbalance in Southern Hemisphere
  - Energy transport by ocean to Northern Hemisphere offset by atmospheric energy transport to Southern Hemisphere
  - Variability from radiative forcings & ocean internal changes
- Where is the excess energy going in the oceans?
- Toward reconciled ocean heating & radiation budget changes
- Do feedbacks amplify/extend hiatus/surge events?
- Inter-hemispheric heating links to model precipitation biases

See posters on:
  - Changing water cycle and interhemispheric energy transports (Allan & Liu)
  - Recent changes in precipitation over Africa (Maidment et al.)
  - Clouds, radiation and precipitation in west Africa (DACCIWA; Hill et al.)