CURRENT CHANGES IN EARTH’S ENERGY IMBALANCE 1985-2014

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CURRENT CLIMATE CHANGE THROUGH SURGE AND SLOWDOWN

Update from Allan et al. (2014) Surv. Geophys & Allan et al. (2014) GRL

Earth’s energy imbalance (Wm\(^{-2}\))

2.8
1.8
0.8
-0.2
-1.2
-2.2
Analysis using simple energy balance model
Allan et al. (2014) GRL supplementary

\[ \frac{d\Delta T_s}{dt} = \frac{N - D}{C_m} = \frac{\Delta F - Y\Delta T_s - D}{C_m} \]

\[ D = k(\Delta T_s - \Delta T_D) \]

See also Checa-Garcia et al. (2016) ERL
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

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

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


• Changes in energy fluxes 1986-2000 to 2001-2008
• Surface energy flux dominated by atmospheric transports
• Contrasting model pattern of change, realistic? e.g. He & Soden (2016) J. Clim
• Are reanalysis transports reliable?

Liu et al. (2015) JGR

see also Stephens et al. (2016)

• Observed inter-hemispheric imbalance in Earth’s energy budget
• Use asymmetric ocean heating observed by Roemmich et al. (2015) Nature Climate and Purkey & Johnson (2010)
• Derive implied ocean heat transport: smaller than Loeb et al. (2015) and Frierson et al. 2013 (0.44 PW) – unrealistically so?
CONCLUSIONS

• Heating of Earth continues at rate of ~0.6-0.8 Wm$^{-2}$
  • Manifest as positive imbalance in Southern Hemisphere
  • Variability from radiative forcings & ocean internal changes

• What are pathways/mechanisms for ocean heat uptake?

• Toward reconciled ocean heating & radiation budget changes
  • are realanalysis energy transports reliable?
  • do climate models capture internal variability & coupling?

• Do feedbacks amplify/extend hiatus/surge events?
  • e.g. Brown et al. (2016) J. Clim; Kosaka and Xie (2013) Nature, etc

See also posters on:

Chunlei Liu: The DEEP-C surface and TOA energy budget reconstruction

Peter Hill: Clouds, radiation and precipitation in west Africa (DACCIWA project)

See DEEP-C website for data and links to journal paper:

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