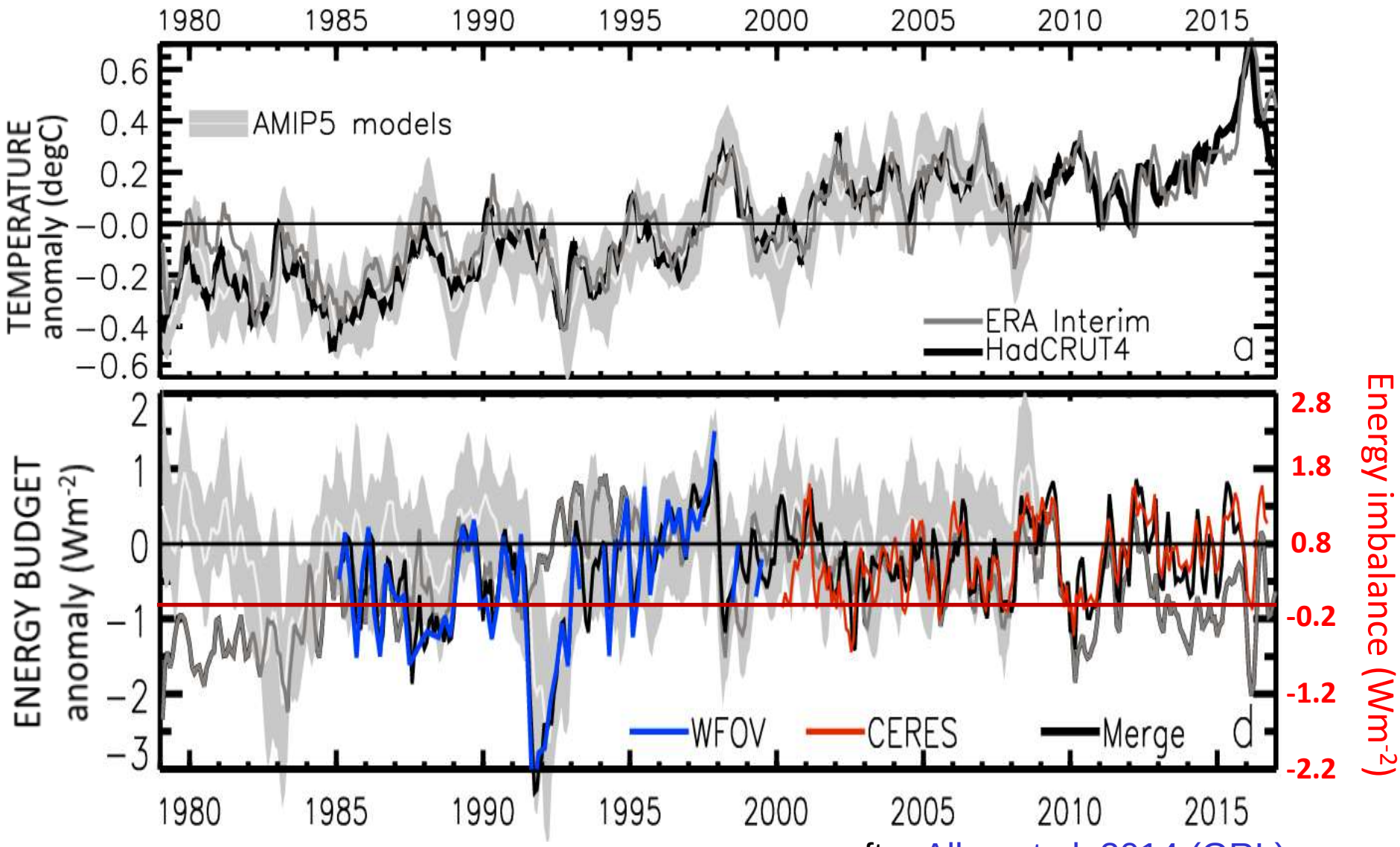
Earth's global surface temperature & energy imbalance variability since the 1980s



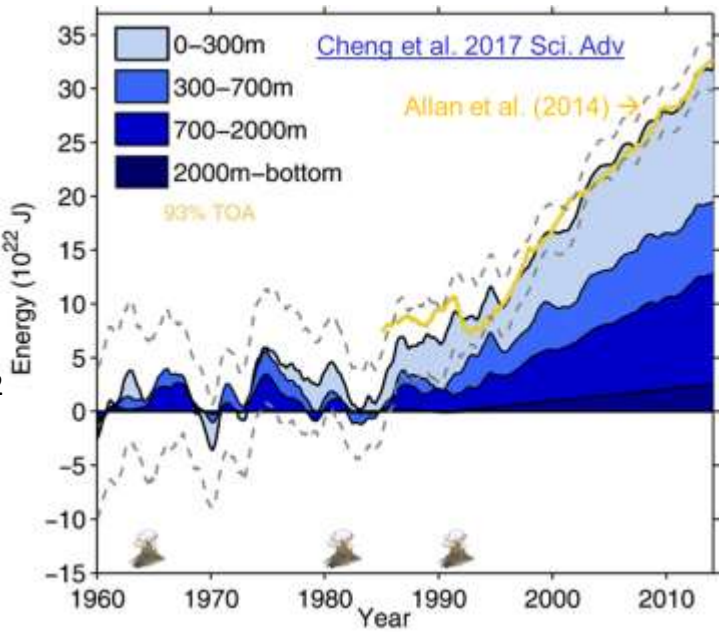
after Allan et al. 2014 (GRL)

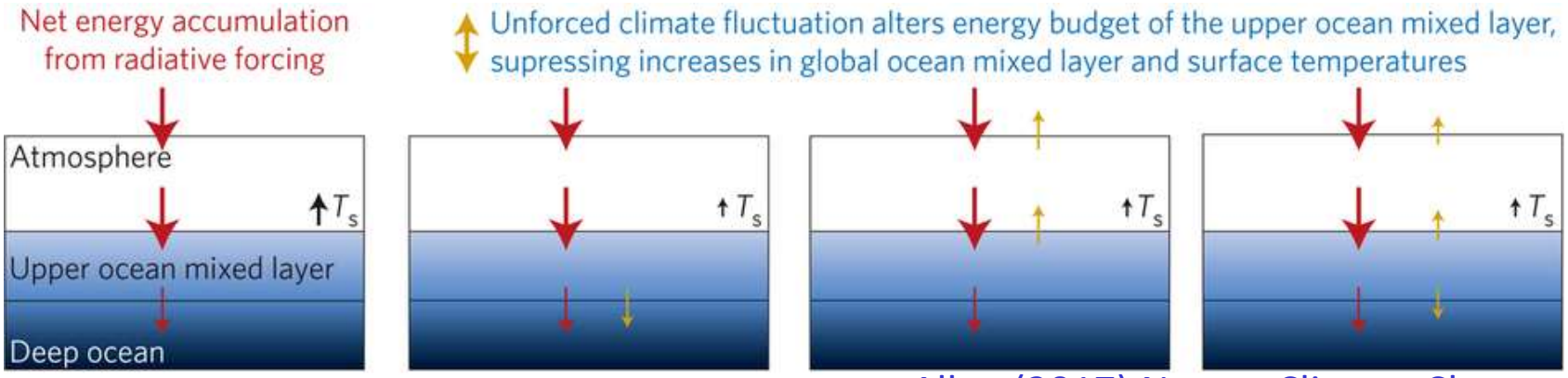
Role of energy imbalance in “hiatus” decades

- Steady decadal ocean heating since 2000:

0.6-0.8 Wm^{-2} (Johnson et al. 2016; Cheng et al. 2017)

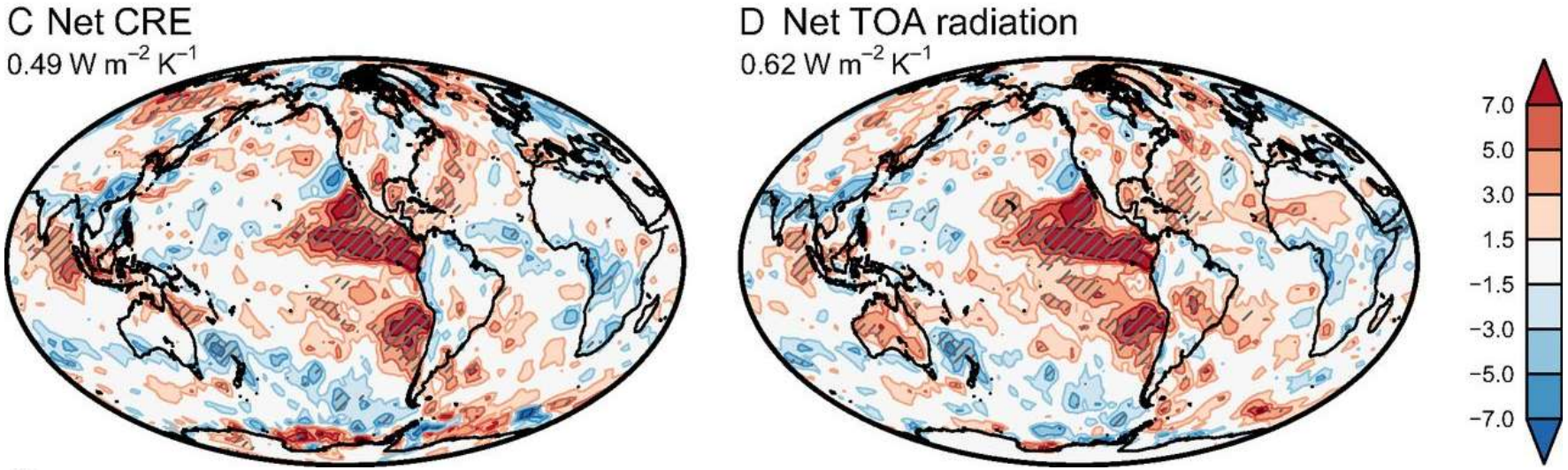
- Radiative forcing/internal variability influence TOA radiation (Palmer & McNeall 2014; Allan et al. 2014; Huber & Knutti 2014; Xie & Kosaka 2017)
- Upper ocean heat budget explains surface temperature: hiatus events explained by < 0.1 Wm^{-2} anomaly, Hedemann et al. 2017 NatureCC

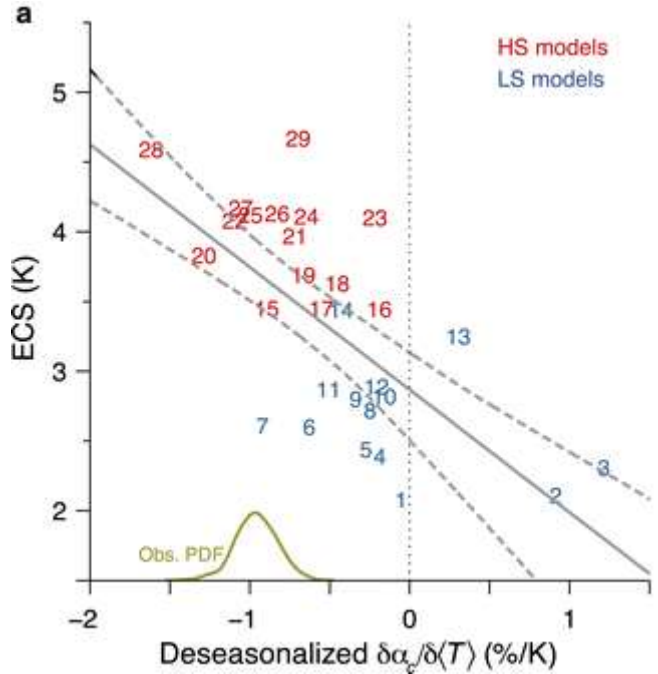




Allan (2017) Nature Climate Change

Climate sensitivity





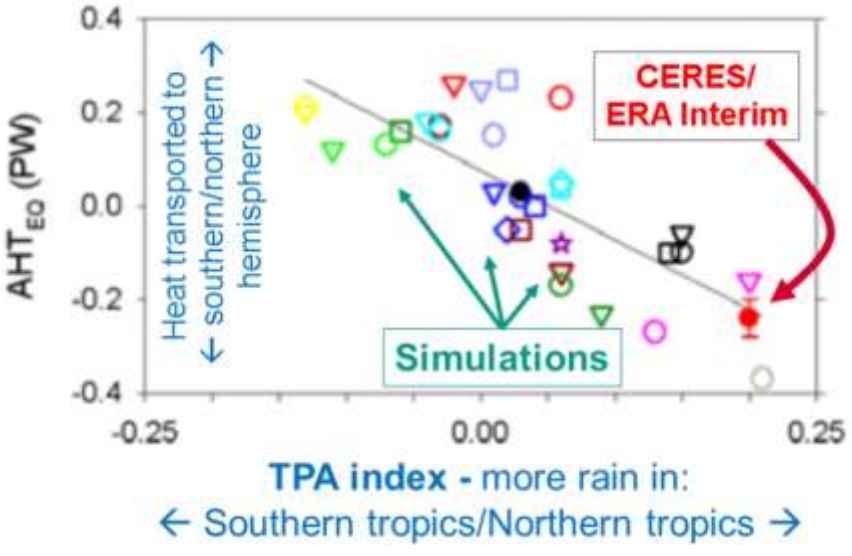
Using observed interannual energy balance variability as proxy for low-cloud climate feedbacks

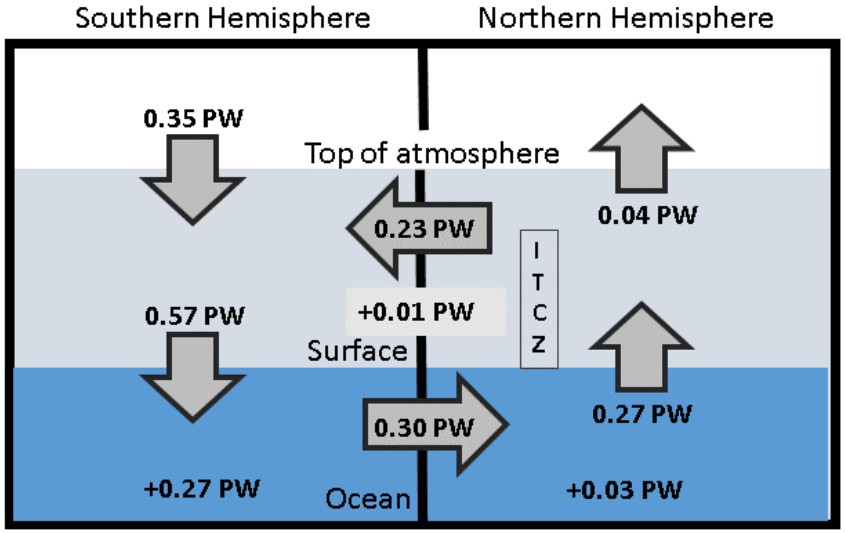
Above: Ceppi & Gregory, 2017 PNAS

Left: Brient and Schneider (2016) J. Clim.

Few tenths of %/K albedo or Wm^{-2}K^{-1} net radiation

Inter-hemispheric energy imbalance/transport and precipitation biases in CMIP5 models





- Cross-equatorial heat transport by atmosphere & hemispheric precipitation asymmetry linked

(Loeb et al. (2016) Clim. Dyn)

See also: Haywood et al. (2016) GRL; Hawcroft et al. (2016) Clim. Dyn.

- Can infer cross equatorial heat flux from observed inter-hemispheric imbalance in Earth's energy budget (Liu et al. 2017 JGR 2000-15 update of Loeb et al. (2016) Clim. Dyn using Roemmich et al. (2015) Nature Climate ocean heating)
- Also ocean heat transports? Trenberth & Fasullo (2017)

Science questions & requirements

- Energy imbalance since 2000: 0.6-0.8 Wm^{-2} (Loeb et al. 2012; Johnson et al. 2016); trend requirements of ~0.1 Wm^{-2}/decade (Loeb et al. 2018)
- Upper mixed ocean layer energy budget deviation within ~0.1 Wm^{-2} required to attribute hiatus decades (e.g. Hedemann et al. 2017)
- Distinct feedbacks on internal variability/forced change, few tenths of $Wm^{-2}K^{-1}$ (Brown et al. 2016 J. Clim; Zhou et al. 2016)
  - <0.5%CRF/decade (Wielicki et al. 2013)
- Inter-hemispheric energy imbalance as constraint on heat transport simulated precipitation (Frierson et al. 2013; Loeb et al. 2016 Clim. Dyn; Stephens et al. 2016 CCCR Haywood et al. (2016) GRL)
  - 0.1 PW/hemisphere → 0.4 Wm^{-2}
- assimilation of energy balance data to constrain ocean heat content data: Storto et al. (2017) GRL
- Sampling e.g. diurnal (CERES, Loeb et al. 2018); spatial (Gristey et al. 2017)

Richard Allan (University of Reading) r.p.allan@reading.ac.uk @rpallanuk

List of journal articles: www.met.reading.ac.uk/~sgs02rpa/research/DEEP-C.html#PAPERS