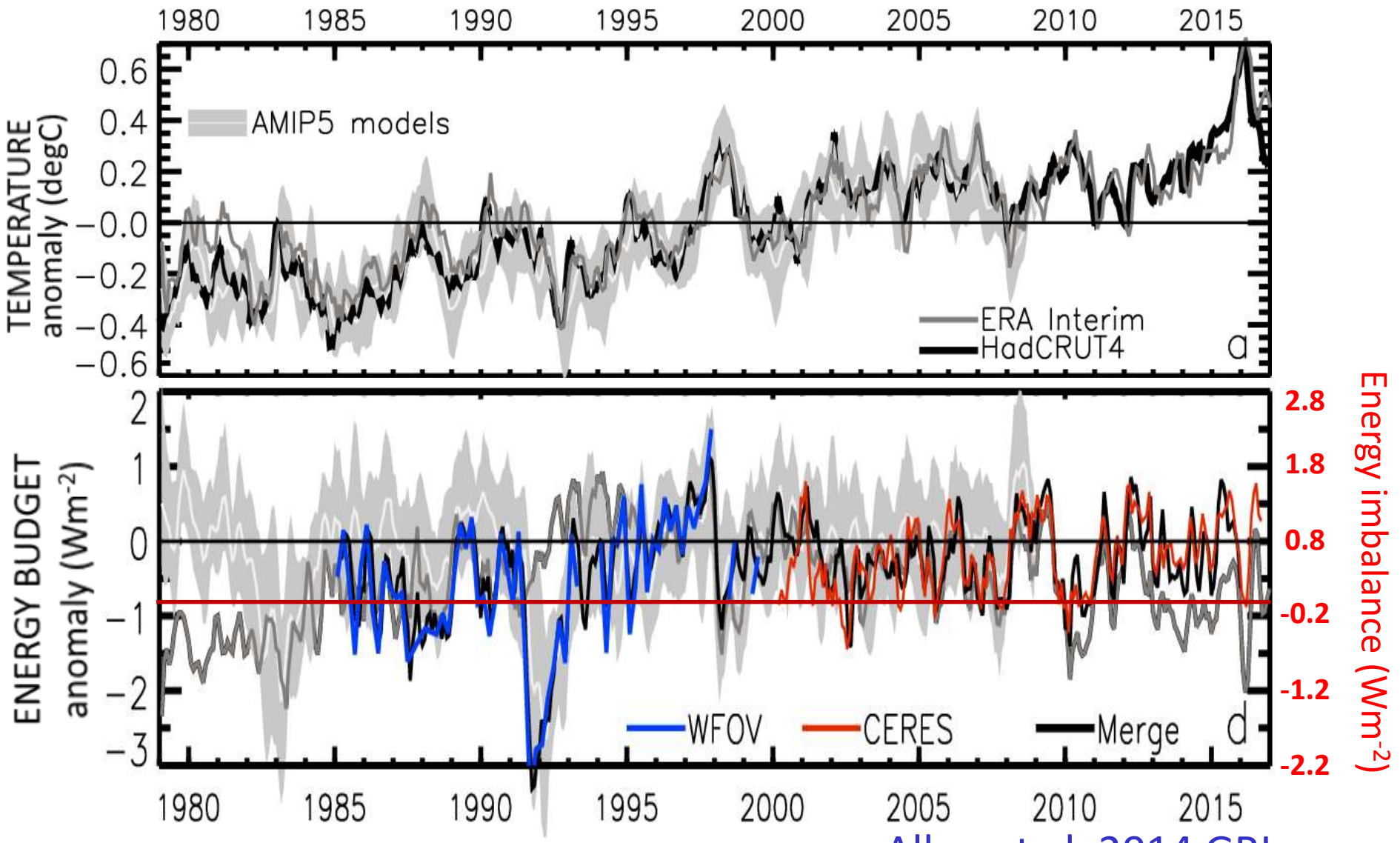
Influence of climate variability and volcanic forcing on Earth's energy balance

Richard Allan

Andy Sayer meeting, July 19th 2017

Variation in Earth's global energy imbalance since the 1980s

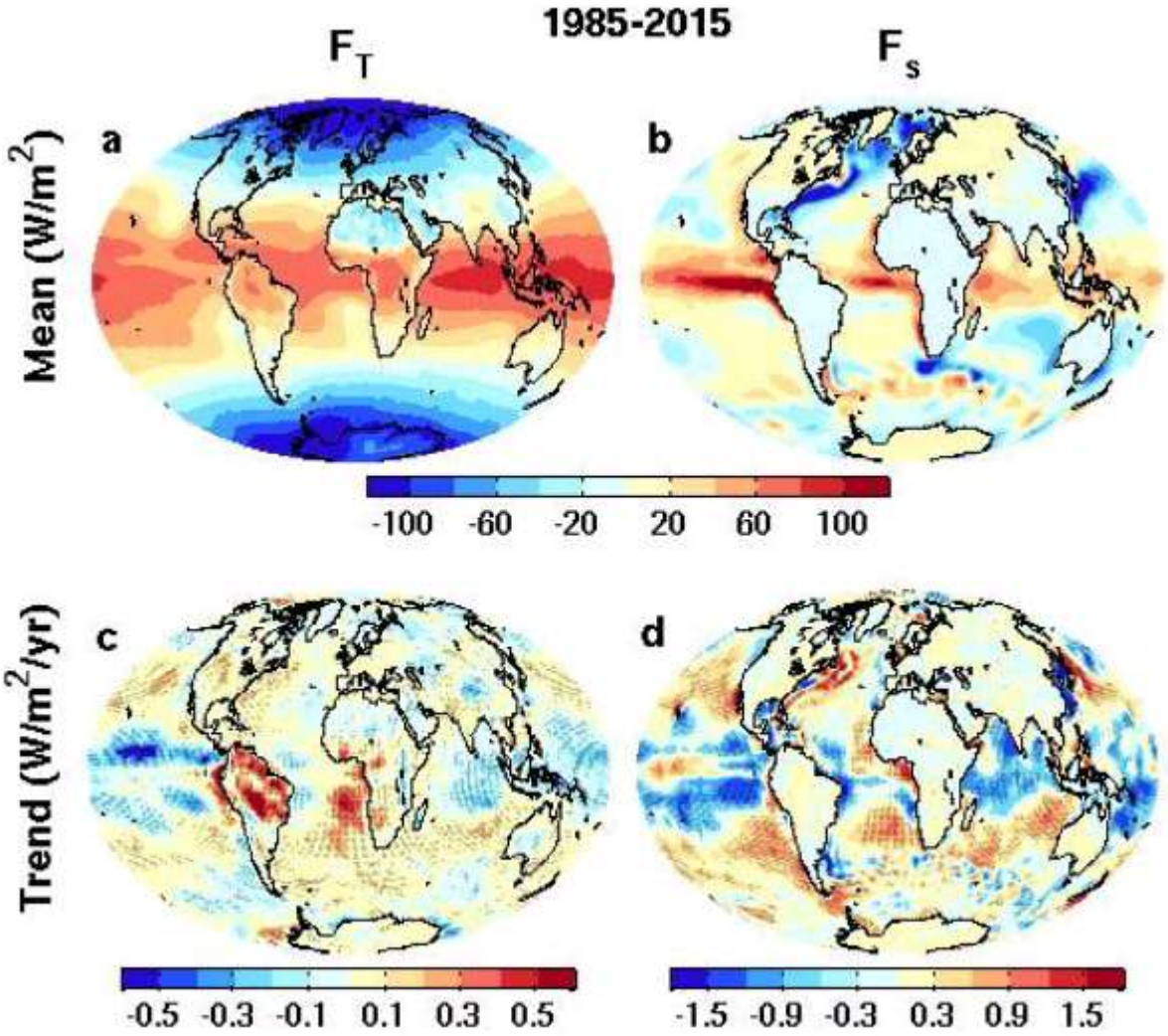
National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL



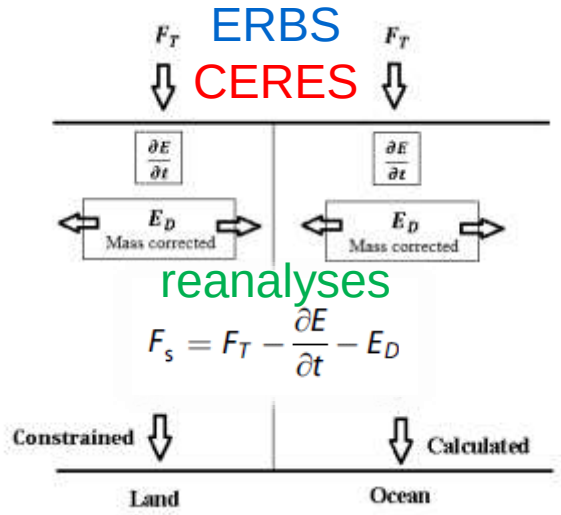
Allan et al. 2014 GRL

Surface/TOA energy fluxes & trends

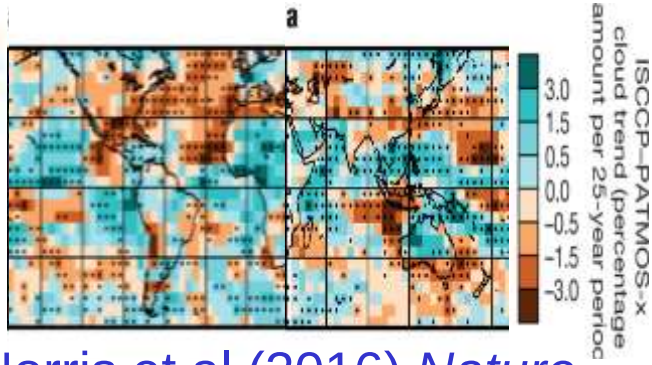
top of atmosphere surface



Liu et al. (2017) JGR Data: http://dx.doi.org/10.17864/1947.111



Surface energy flux dataset combining TOA reconstruction with reanalysis energy transports: Liu et al. (2015) JGR

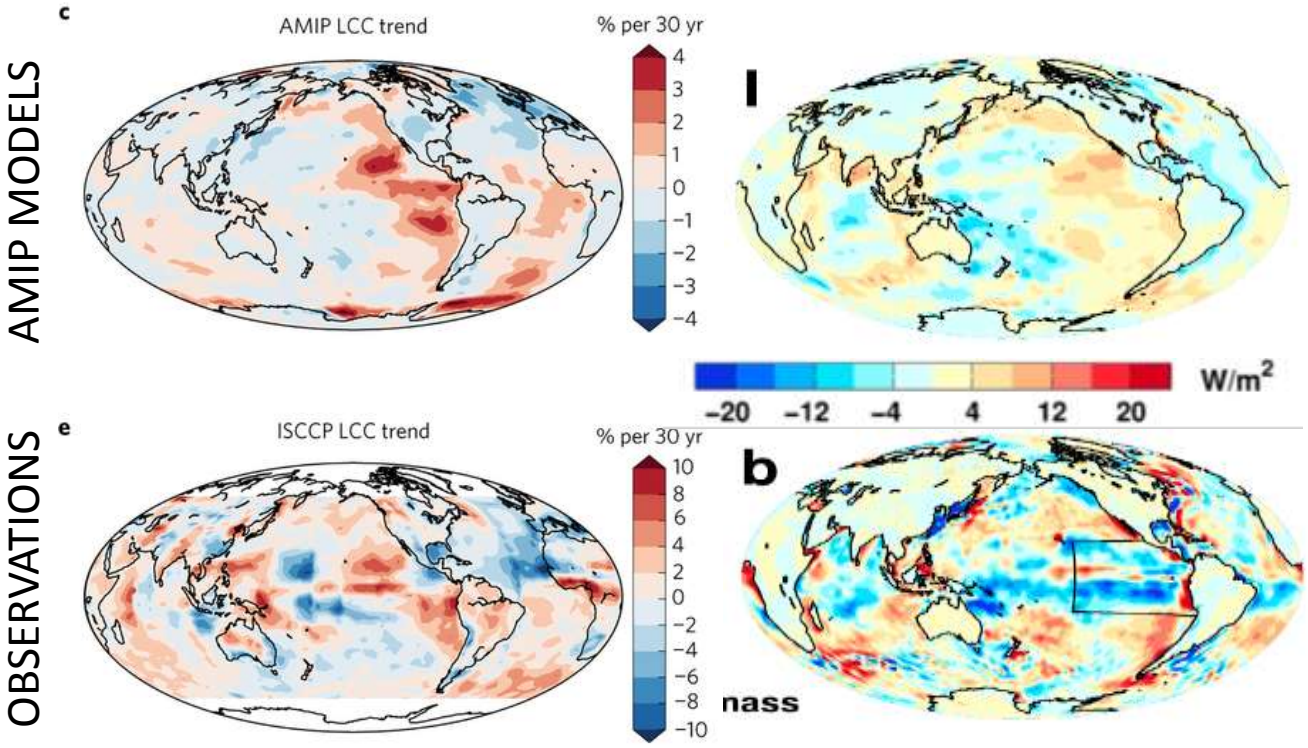


Norris et al (2016) *Nature*

Changes in cloudiness

Do cloud feedbacks in E. Pacific amplify decadal internal variability?

Low Cloud Cover trend **1980s-2000s** Surface energy flux change



Zhou et al. (2016) Nature Geosci

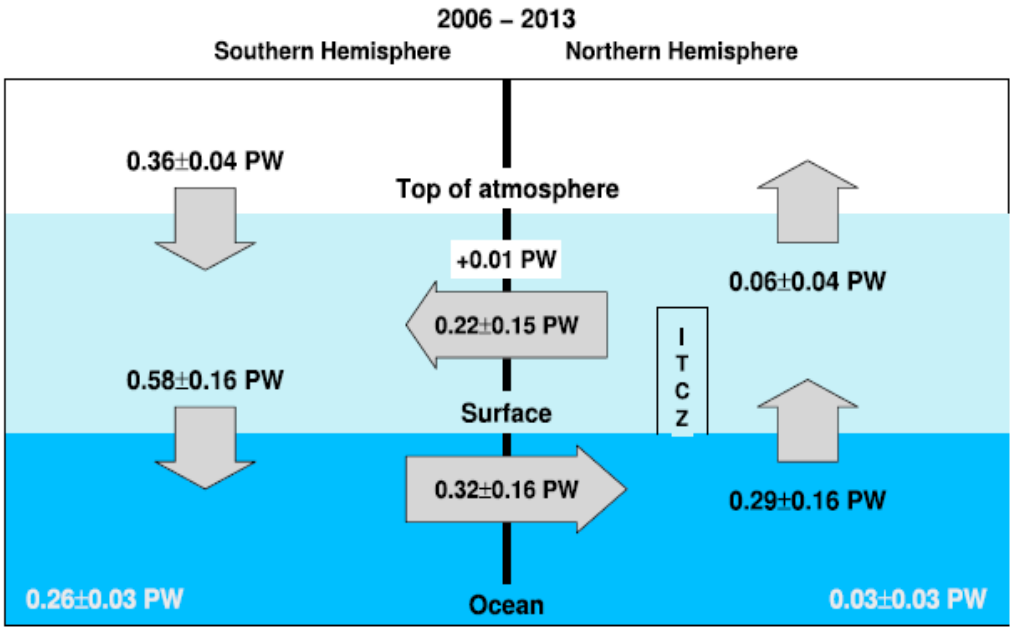
Liu et al. (2015) JGR

What explains decreased heating of E Pacific; is it realistic?

Distinct feedbacks on internal variability & forced change e.g. Brown et al. 2016 J. Clim; Xie et al. 2015 Nature Geosci; England et al. (2014) Nature Clim

Spatial patterns of warming crucial for feedbacks & climate sensitivity e.g. He & Soden (2016) J. Clim; Richardson et al. (2016) Nature Clim Change; Gregory & Andrews (2016) GRL

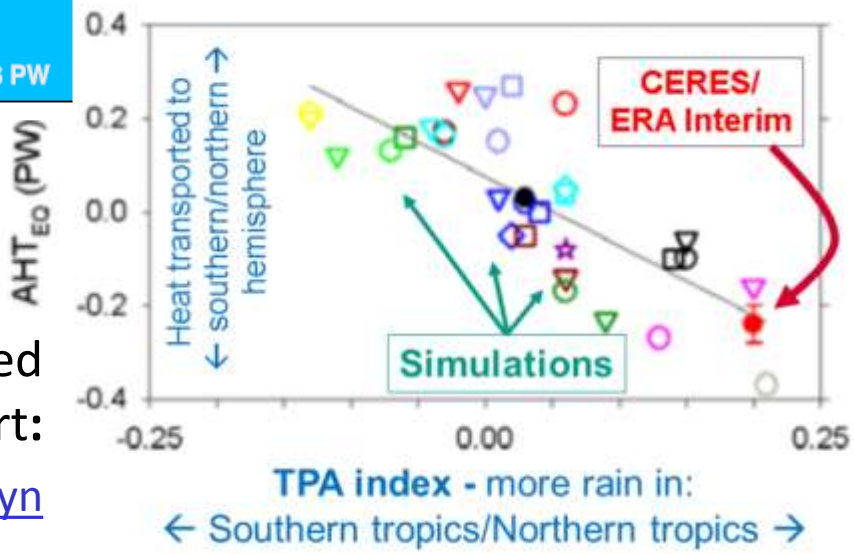
Cross-hemispheric energy transport & precipitation biases



Left: New observational estimates of inter-hemispheric energy budget (peta watts):

Liu et al. (2017) JGR

- see also Stephens et al. 2016 CCCR

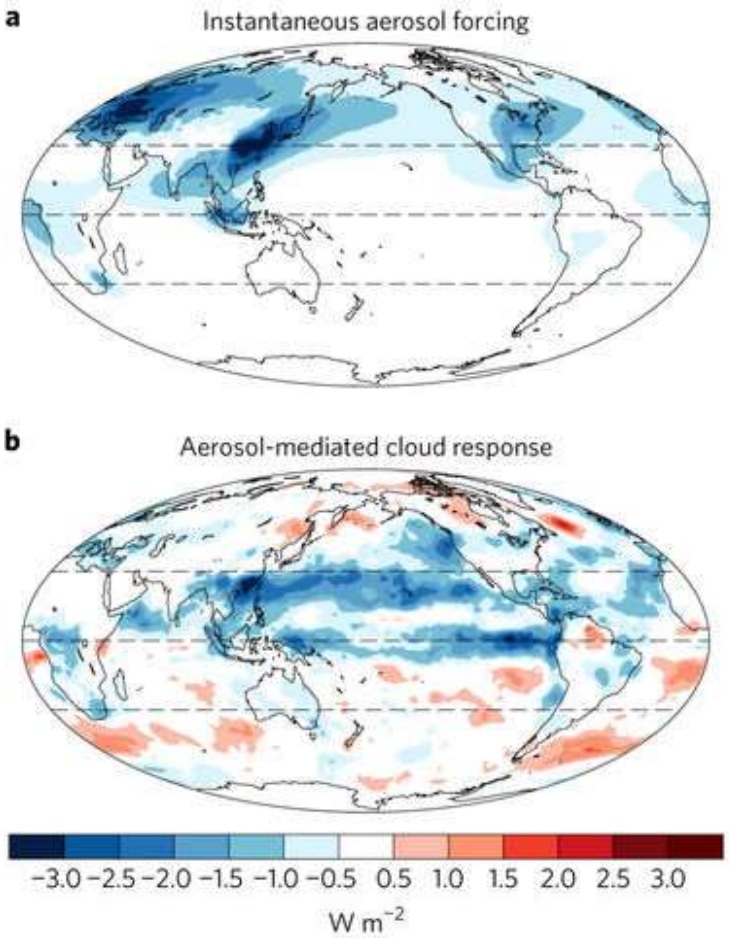


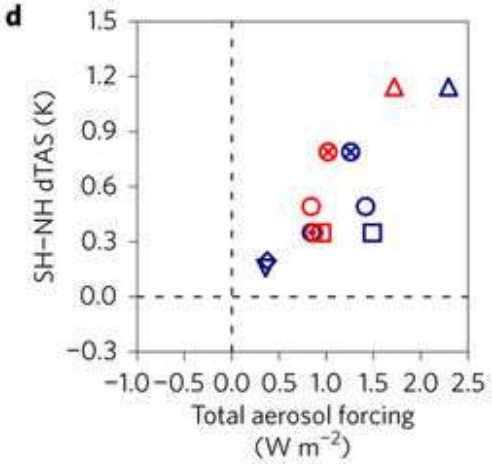
Right: Model precipitation biases linked to cross-equatorial heat transport**:**

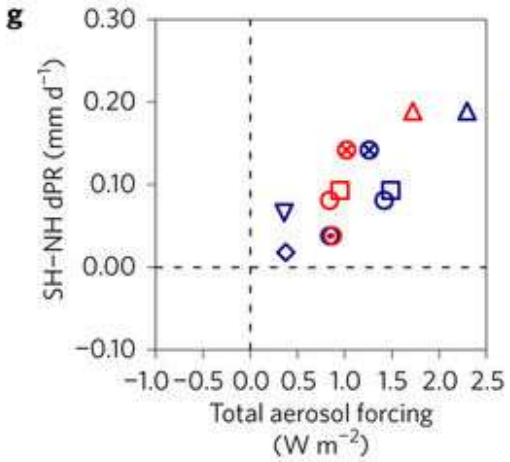
Loeb et al. (2016) Clim. Dyn

Aerosol-cloud forcing drives hemispheric climate response in simulations

Chung & Soden (2017) Nature Geosci

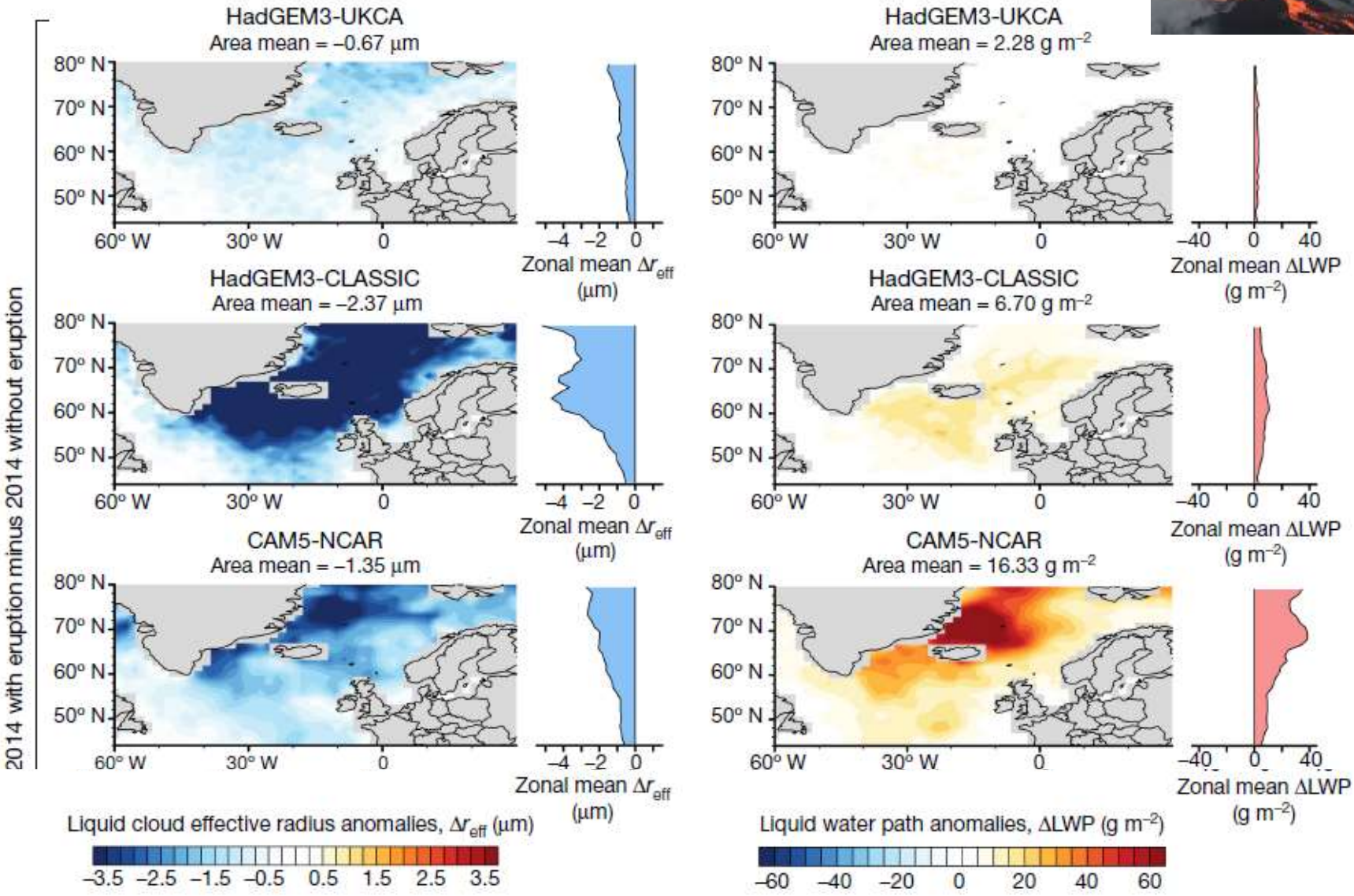






To test aspects of anthropogenic aerosol-cloud interactions we use comparable SO_2 emissions from massive fissure eruption of Holuhraun, Iceland.

Diverse simulated cloud response to volcanic aerosol emissions



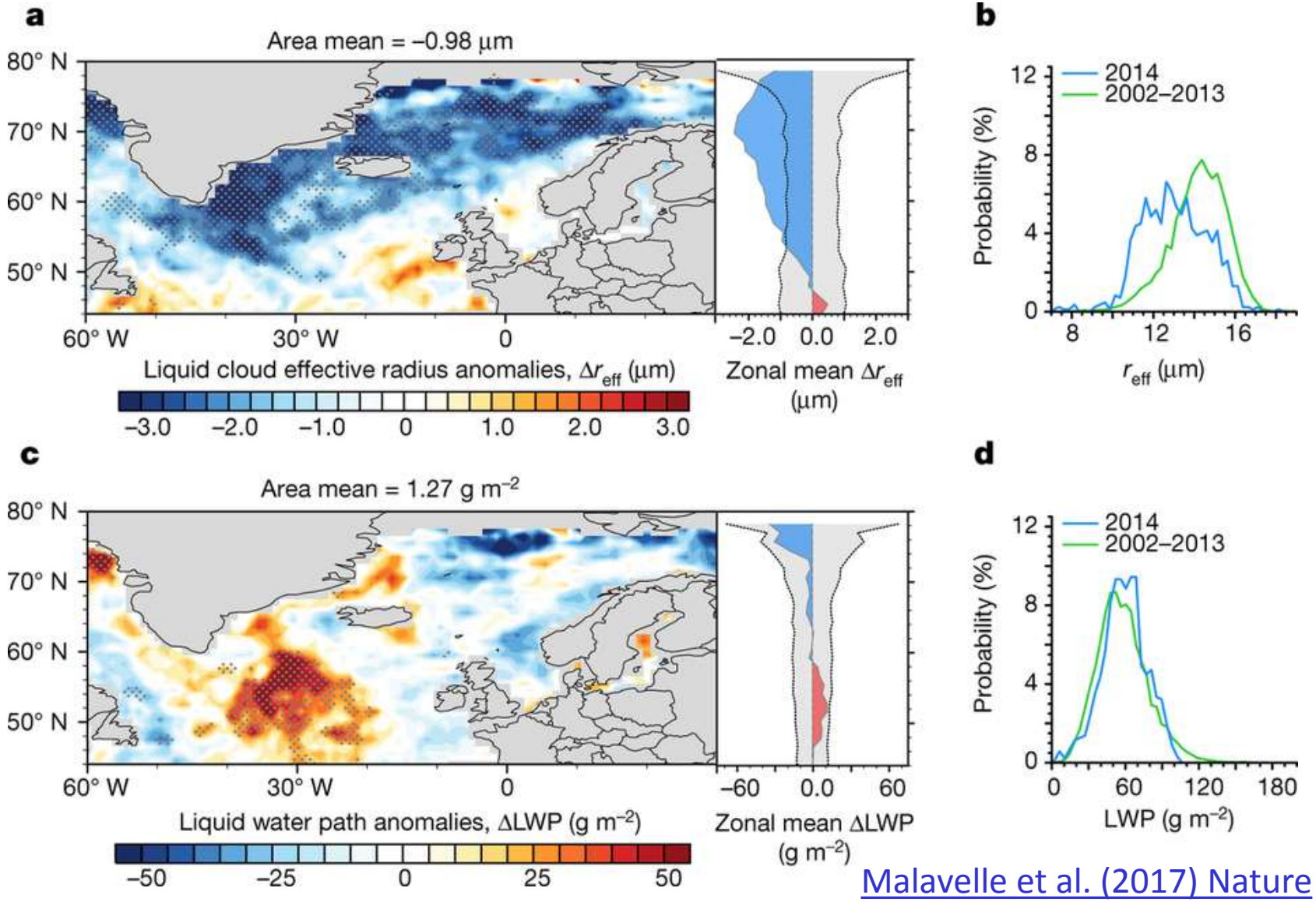
Malavelle et al. (2017) Nature

Volcanic aerosol haze causes noticeable expected decrease in cloud drop size

MODIS-Aqua Observations

Droplet size

Cloud water

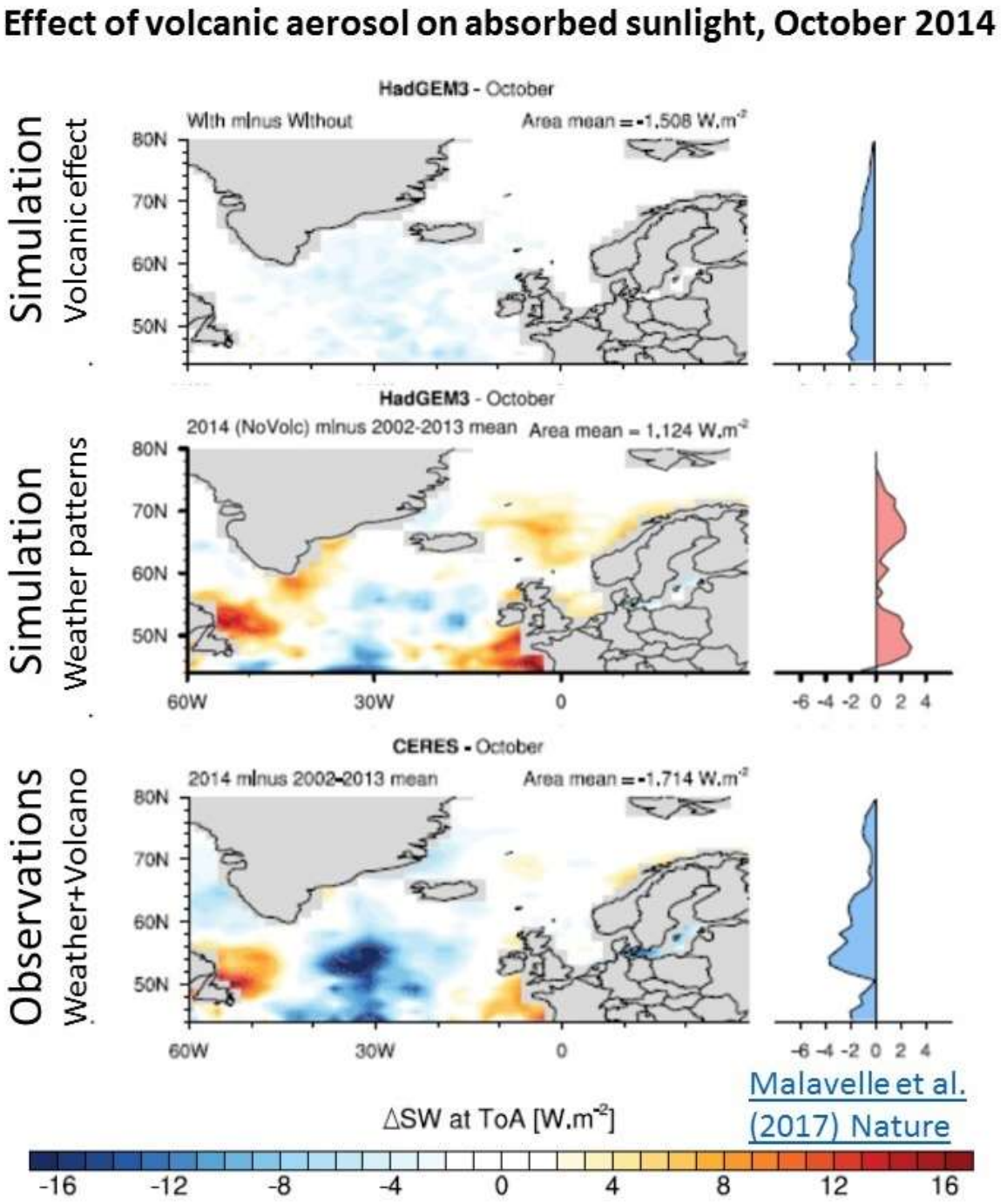


Malavelle et al. (2017) Nature

Further indirect effects of aerosol haze on cloud water undetectable

TOA irradiance

- Influence of cloud/aerosol interaction on TOA shortwave undetectable above weather noise
- Can swath level measurements show signal?



Malavelle et al. (2017) Nature

Conclusions

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- Extended Top of atmosphere radiation dataset (Allan et al. 2014 GRL)
  - Earth's energy imbalance relatively stable (~0.7 Wm^{-2}), increased since 1980s?
- New method for deriving surface energy flux (Liu et al. 2017 JGR)
  - How do clouds and surface fluxes determine decadal climate variability?
  - Link between hemispheric energy balance and climate
- Observed constraint on aerosol-cloud interactions (Malavelle et al. 2017 Nature)
  - Use volcano to mimic aerosol pollution haze
  - Decrease in cloud droplet size detectable
  - Further indirect effects on cloud and the radiation budget not distinguishable from weather noise