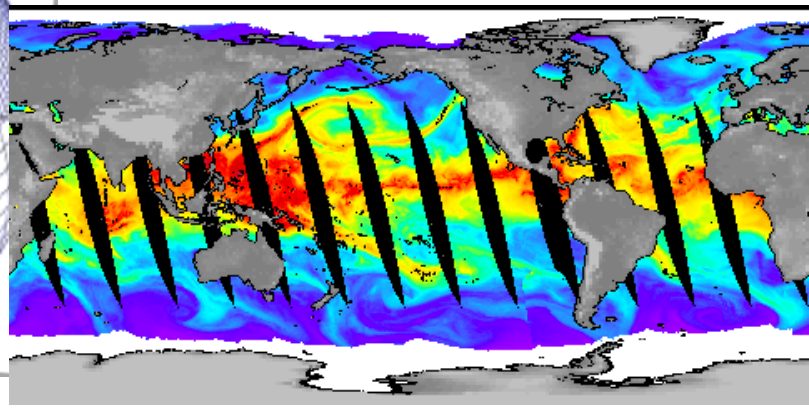

Current and future changes in precipitation and its extremes

Richard P. Allan, David Lavers, Chunlei Liu, Matthias Zahn
Department of Meteorology/NCAS, University of Reading
http://www.met.reading.ac.uk/~sgs02rpa r.p.allan@reading.ac.uk

Thanks to Brian Soden and Viju John

Climate model projections

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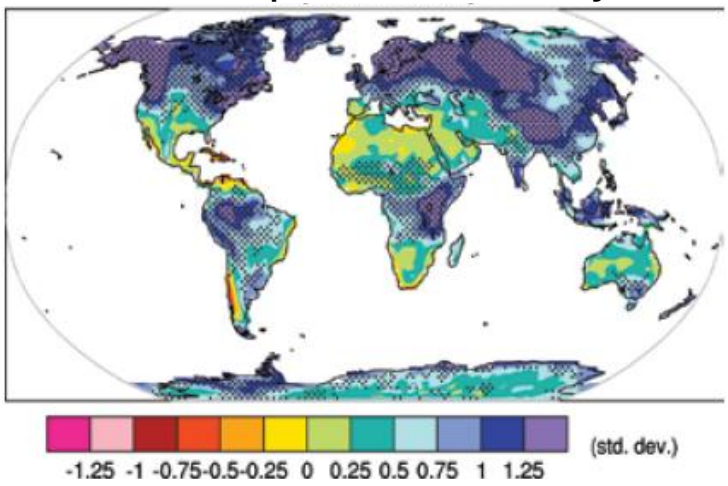
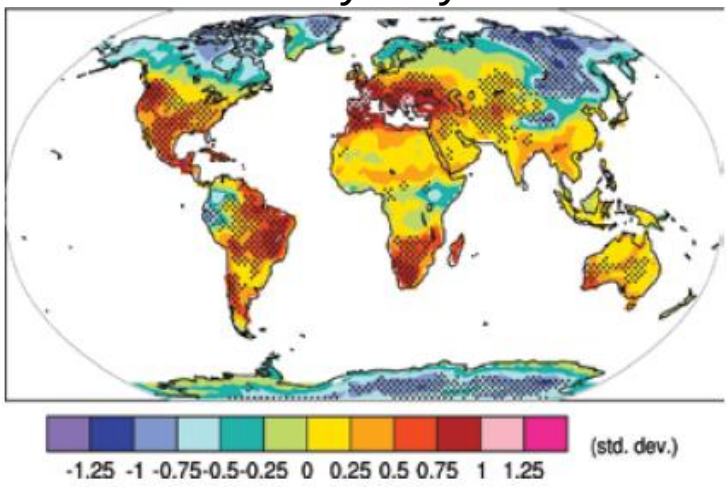
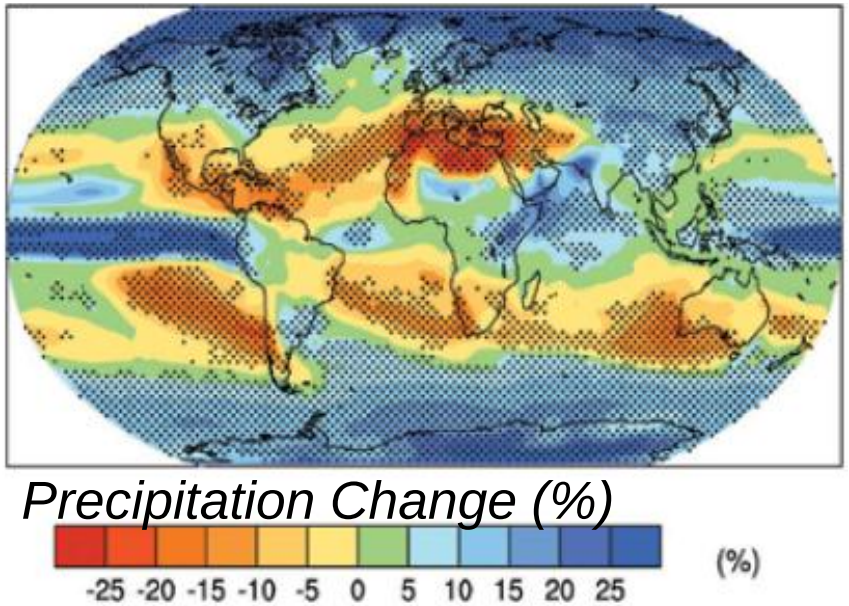
Precipitation Intensity



Dry Days

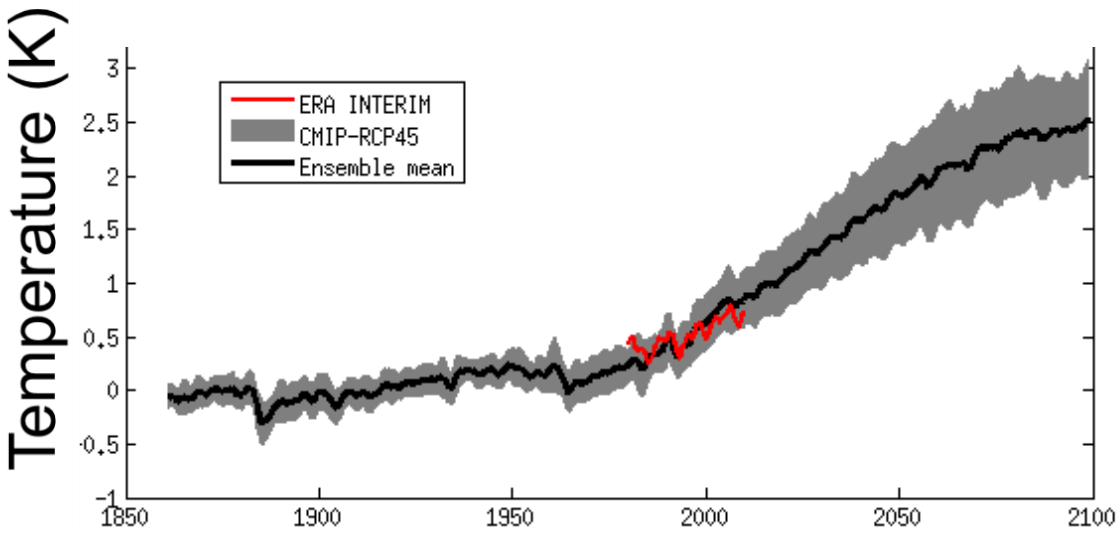


- Increased Precipitation
- More Intense Rainfall
- More droughts
- Wet regions get wetter, dry regions get drier?
- Regional projections??

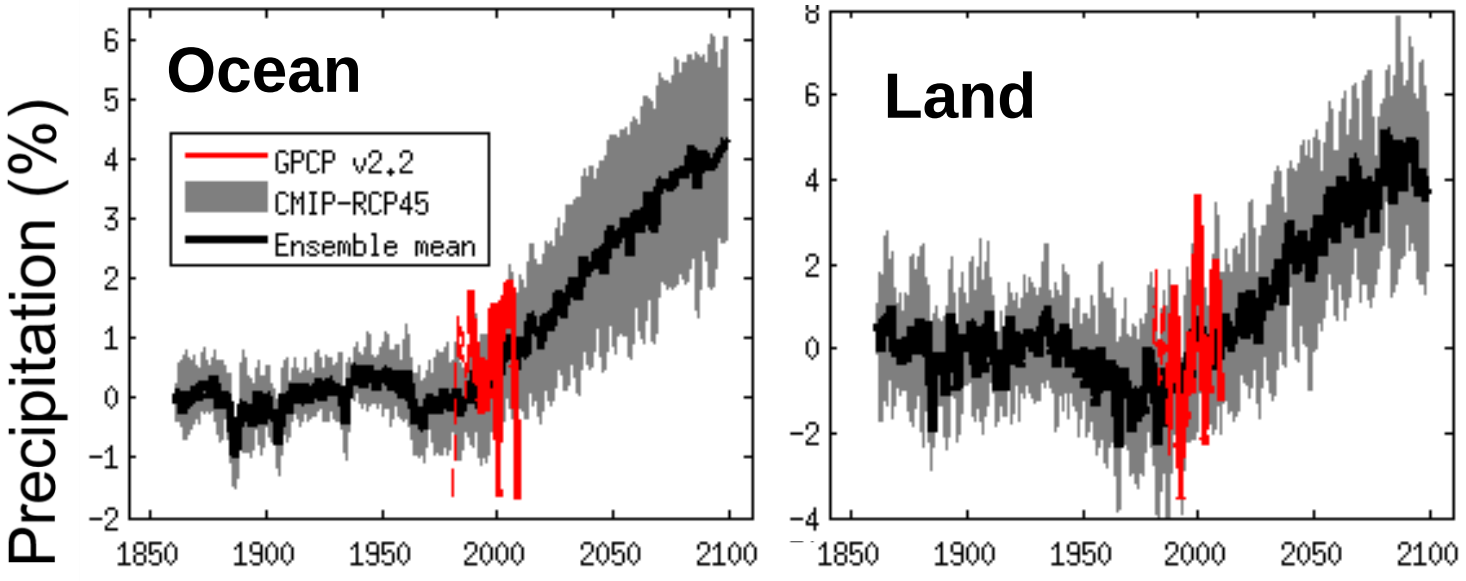


IPCC WGI (2007)

Projected precipitation response



Response
~2%/K



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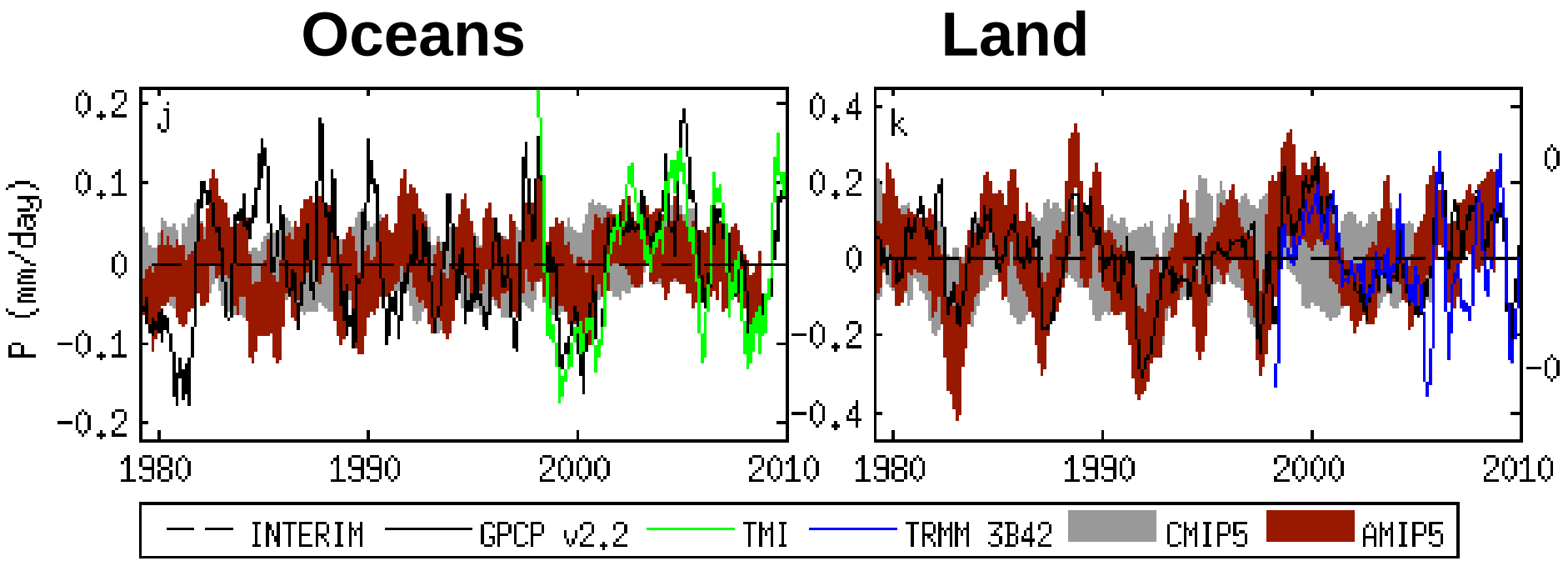
Changing water cycle

Horyuji PAGODA
HydrOlogical cYcle Understanding via Process-bAsed GlObal Detection, Attribution and prediction

Current observed & simulated changes

Note realism of atmosphere-only AMIP model simulations



Allan et al. (2010) ERL; Liu and Allan in prep…

Horyuji PAGODA
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Changing water cycle

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Global changes in water vapour

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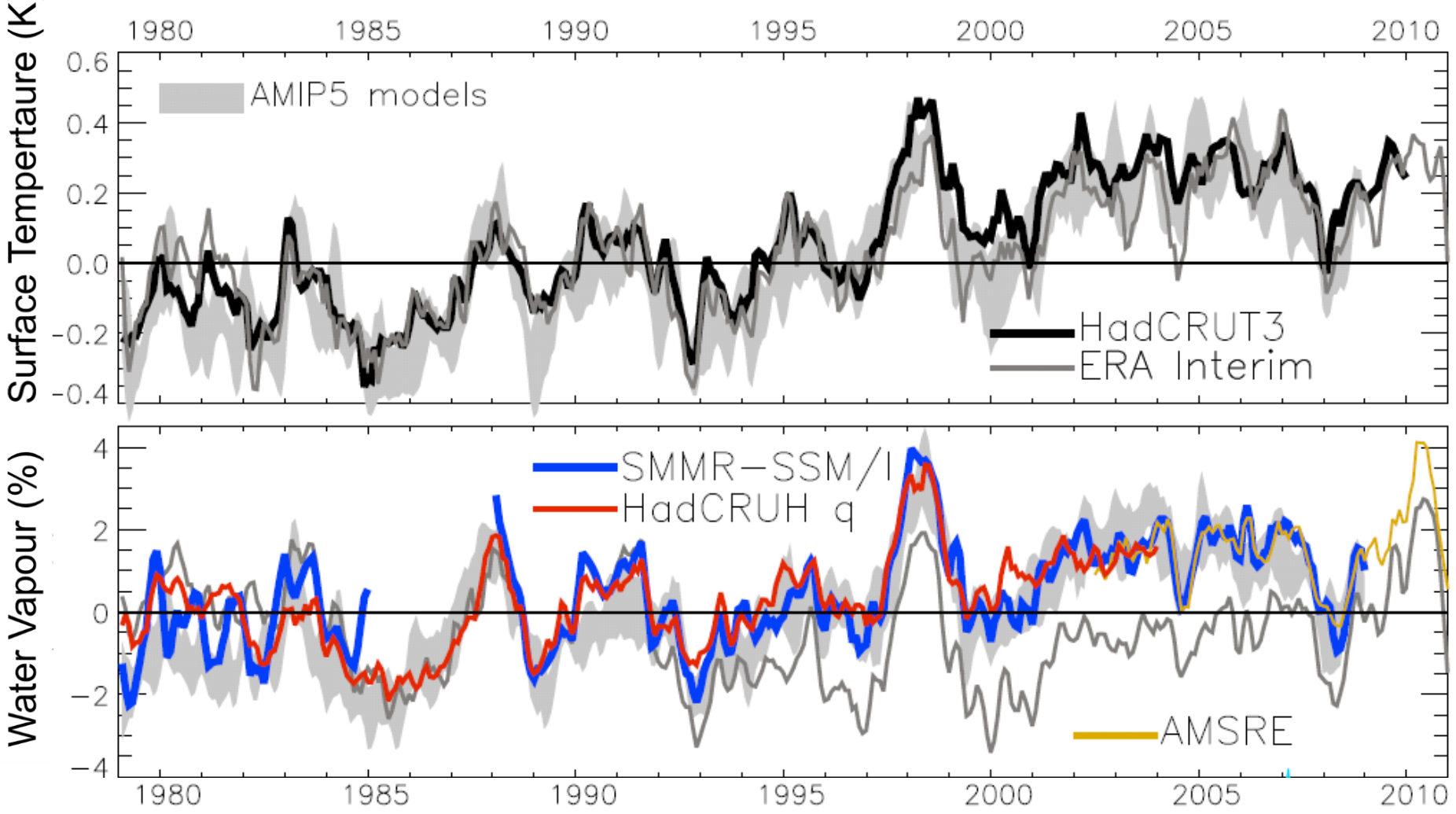
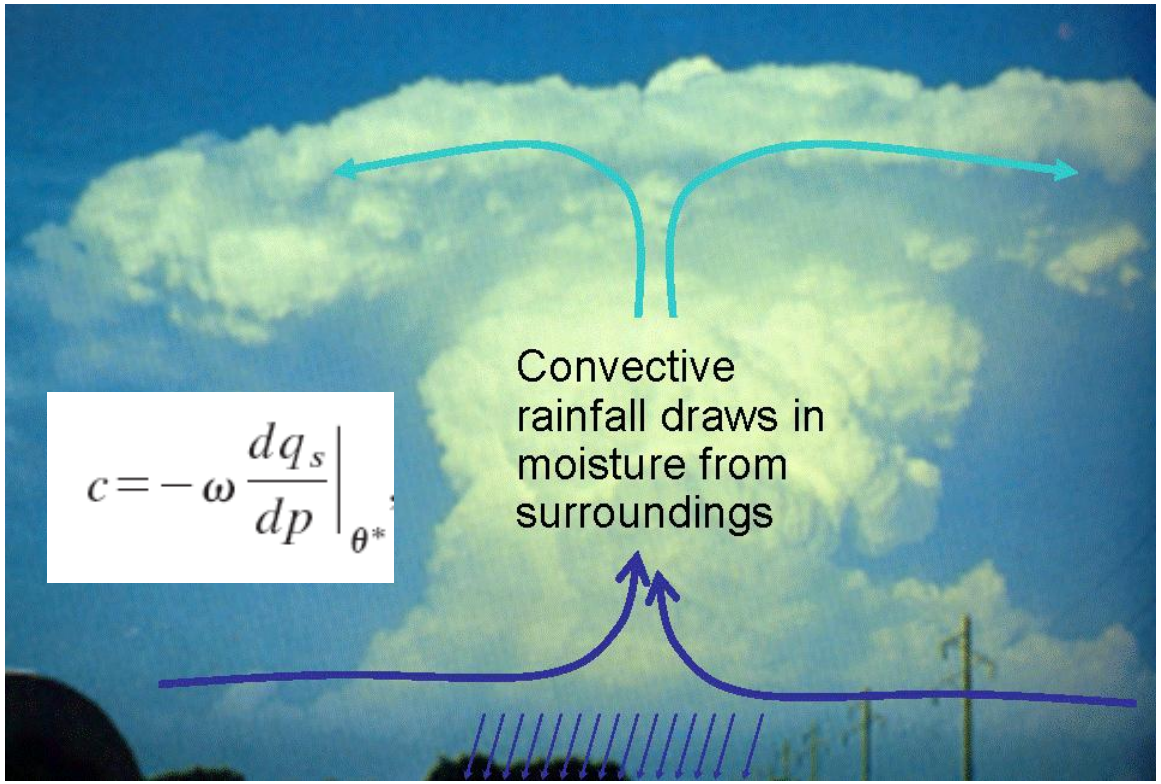


Updated from O'Gorman et al. (2012) Surv. Geophys; see also John et al. (2009) GRL

Extreme Precipitation



- Large-scale rainfall events fuelled by moisture convergence
  - e.g. Trenberth et al. (2003) *BAMS*. *But see also Wilson and Toumi (2005) GRL*

→ Intensification of rainfall (~7%/K?)

O'Gorman & Schneider (2009) *PNAS*; Gastineau and Soden (2009) *GRL*

- Is there a positive latent heating feedback on hourly intensities?

Lenderink & van Meijgaard (2010) *ERL*; Haerter et (2010) *GRL*

Observed and Simulated responses in extreme daily Precipitation

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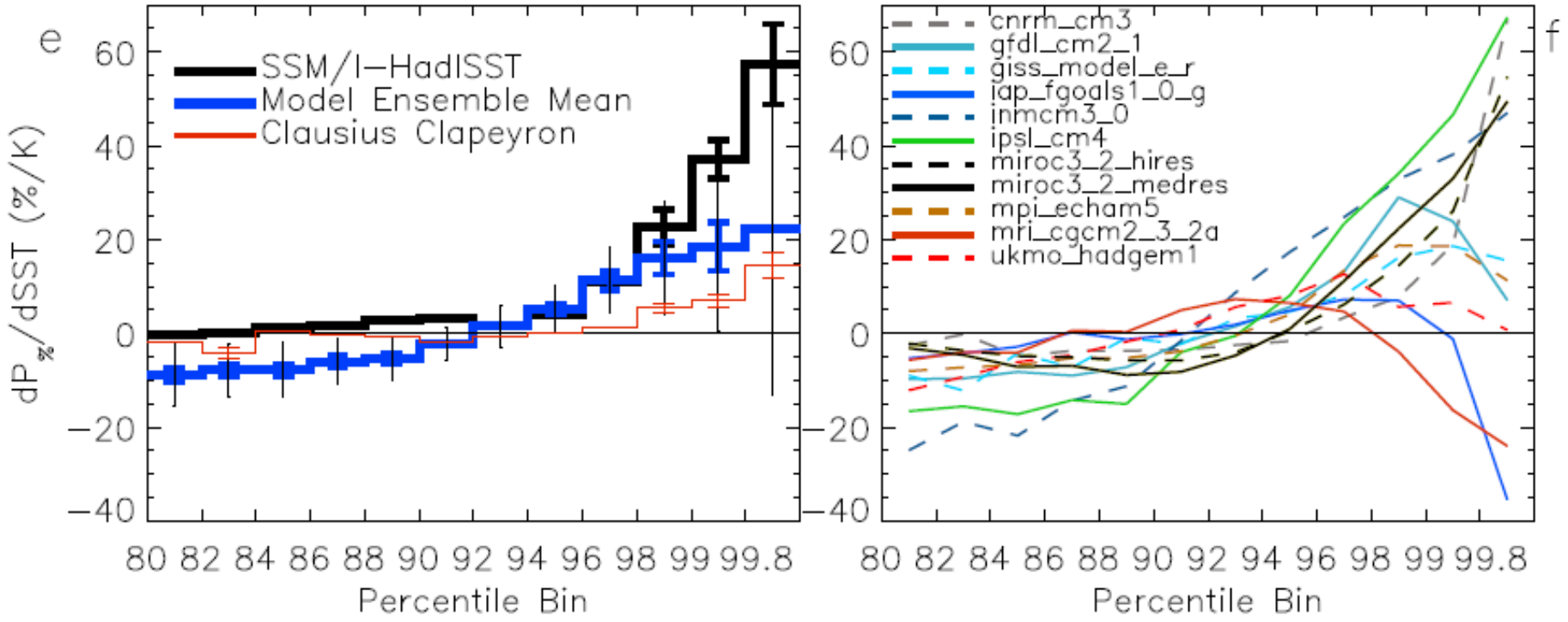
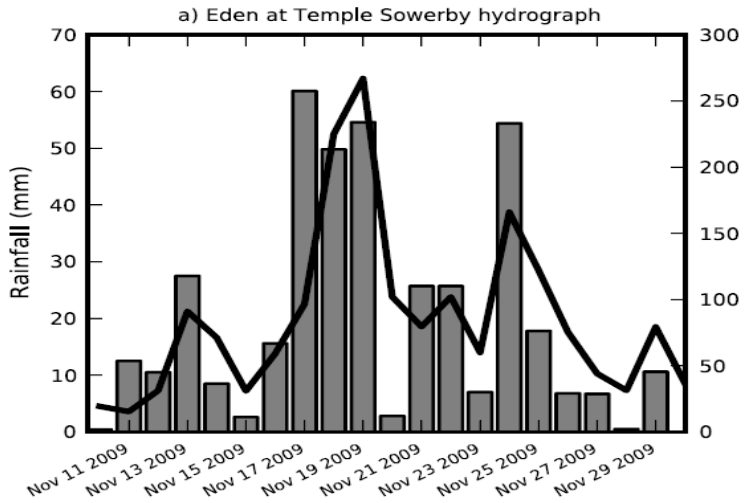
- Increase in intense rainfall with tropical ocean warming
- SSM/I satellite observations at upper range of models

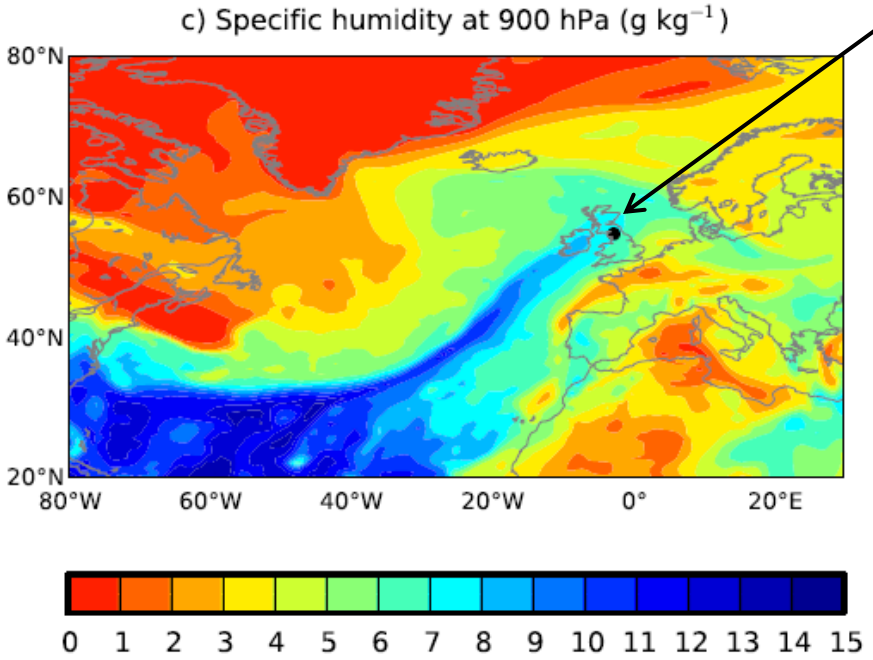


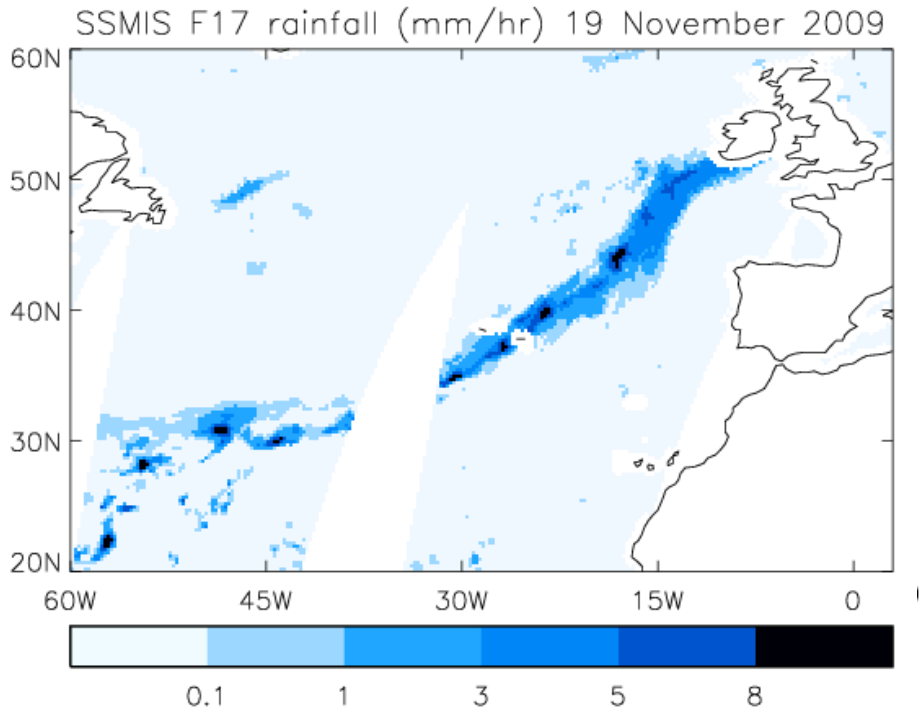
Allan et al. (2010) Environ. Res. Lett.; Liu and Allan (2012) *JGR*

Extreme precipitation & mid-latitude flooding

- Links UK winter flooding to moisture conveyor events
  e.g. Nov 2009 Cumbria floods



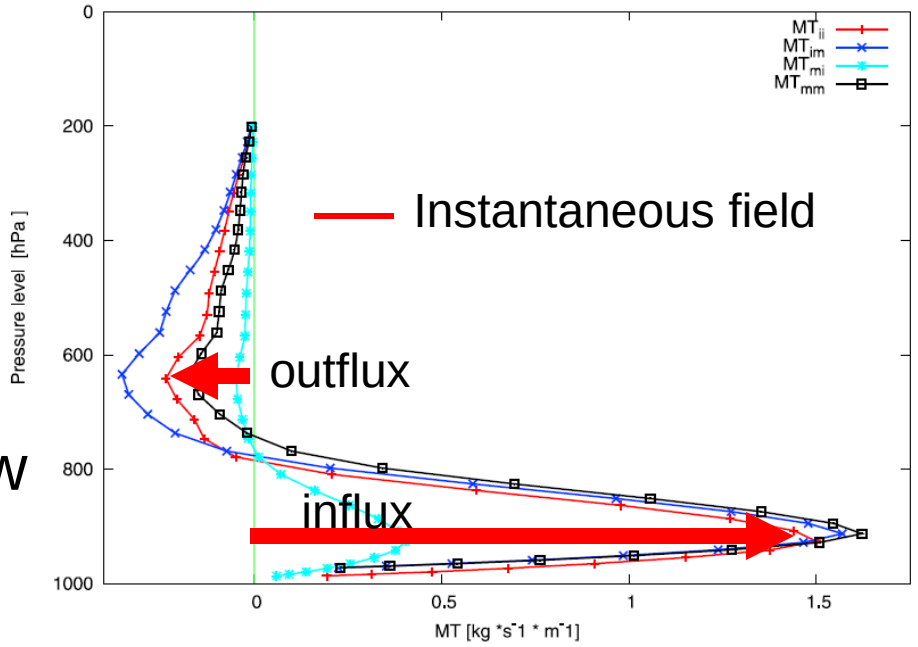


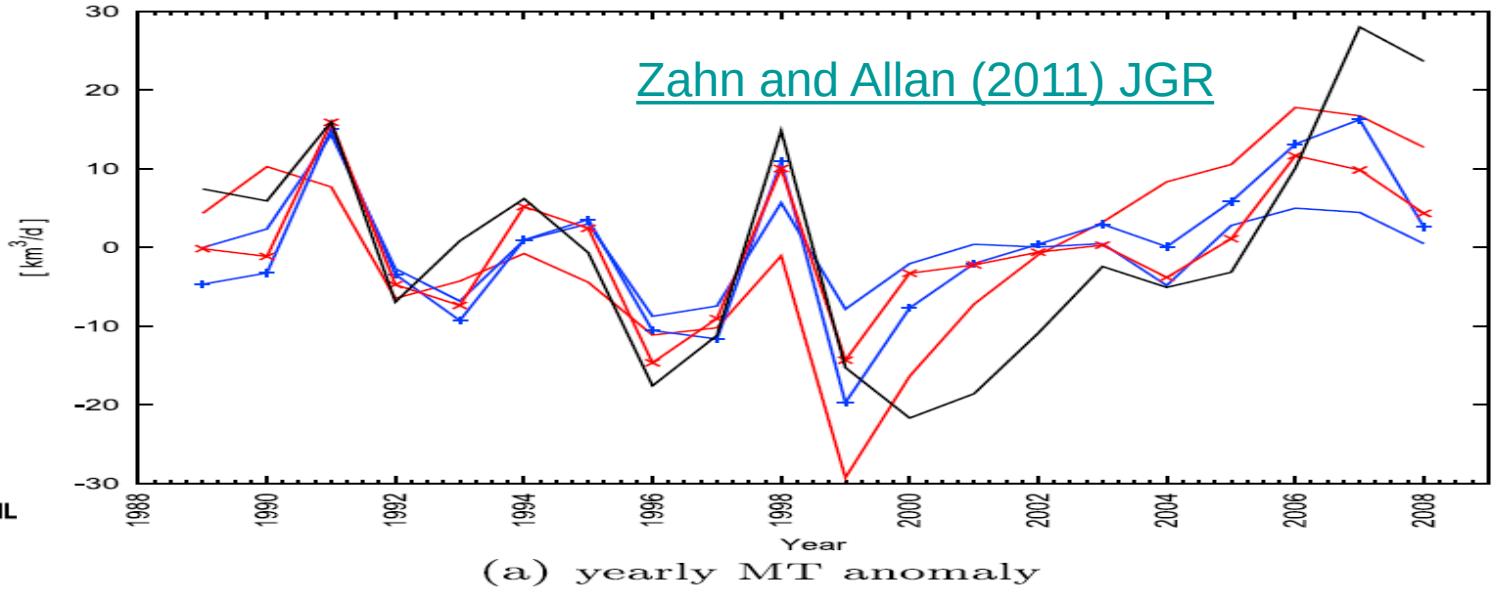


Lavers et al. (2011) Geophys. Res. Lett.

Enhanced tropical moisture transports

- Moisture transport into tropical ascent region
- Significant mid-level outflow
- 2000s: increases in inflow or drift in ERA Interim?





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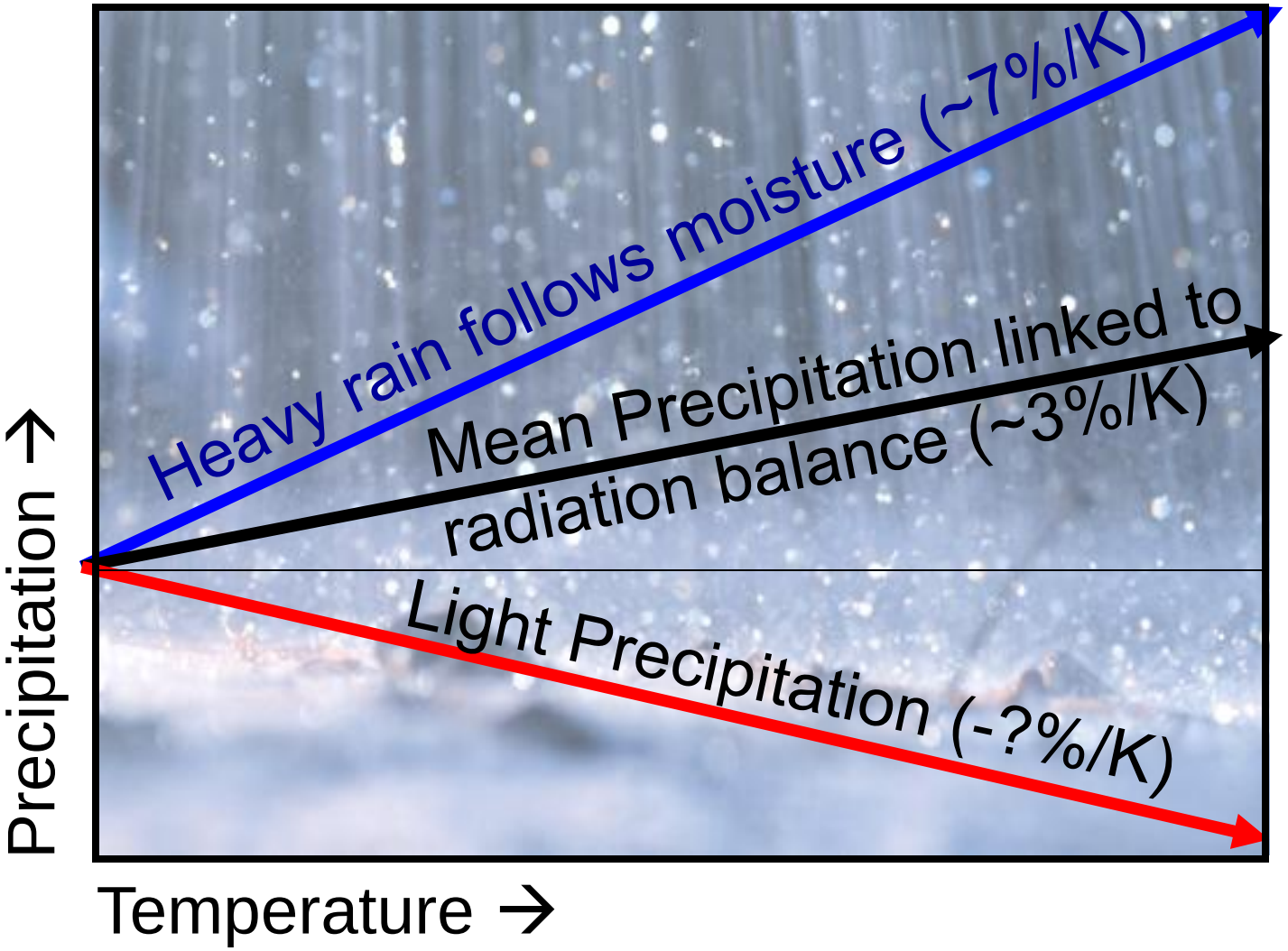
PREPARE project

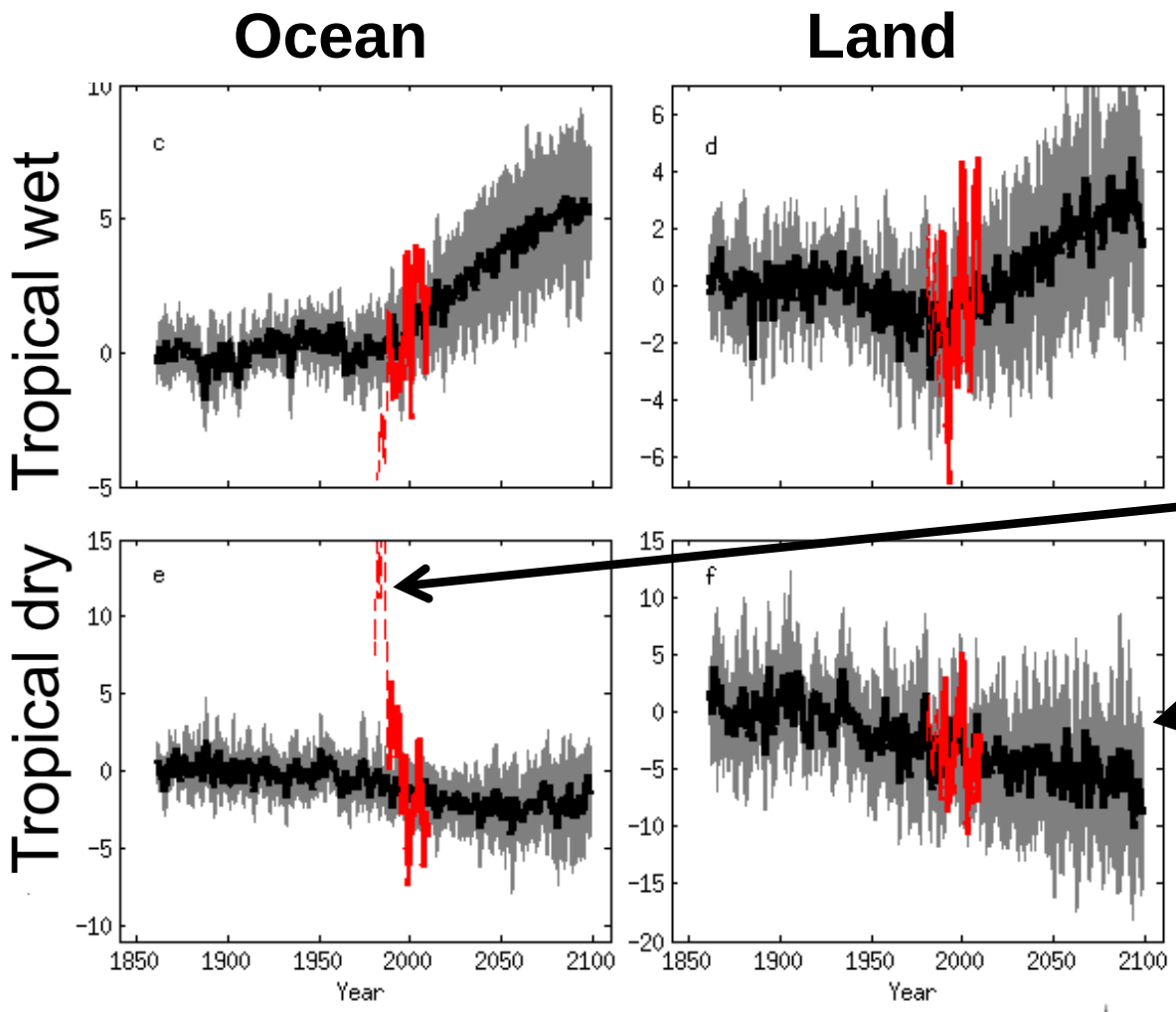
See poster A203 (CL2.10), Hall A Friday AM (Matthias Zahn)

Contrasting precipitation response expected



e.g. Allen and Ingram (2002) *Nature;* Allan and Soden (2008) *Science*

Wet regions get wetter, dry regions get drier



Pre 1988 GPCP ocean data does not contain microwave data

Robust drying of dry tropical land

More at poster A204
Friday AM: (Liu & Allan)

Allan et al. (2010) ERL.; Liu and Allan *in prep*

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HydrOlogical cYcle Understanding via Process-bAsed GlObal Detection, Attribution and prediction

Conclusions

- Global rises in precipitation ~2%/K
  - Relate to energetics (Allen and Ingram 2002)
  - **Regional projections a challenge**
- Robust increases in water vapour (~7%/K) →

Fuels comparable rise in precipitation intensity

  - Possible positive feedbacks on hourly time-scales

Enhances moisture transport: wet get wetter, dry get drier

  - Moisture feedbacks over land?

- Aerosols
  - Alter energetically driven global response (e.g. Andrews et al. 2010 ERL); implications for mitigation and geoengineering
  - Associated changes in atmospheric circulation

See also posters Friday AM:

A203-4, Hall A (Zahn & Allan; Liu & Allan); Z96, HallZ (Williams et al.)

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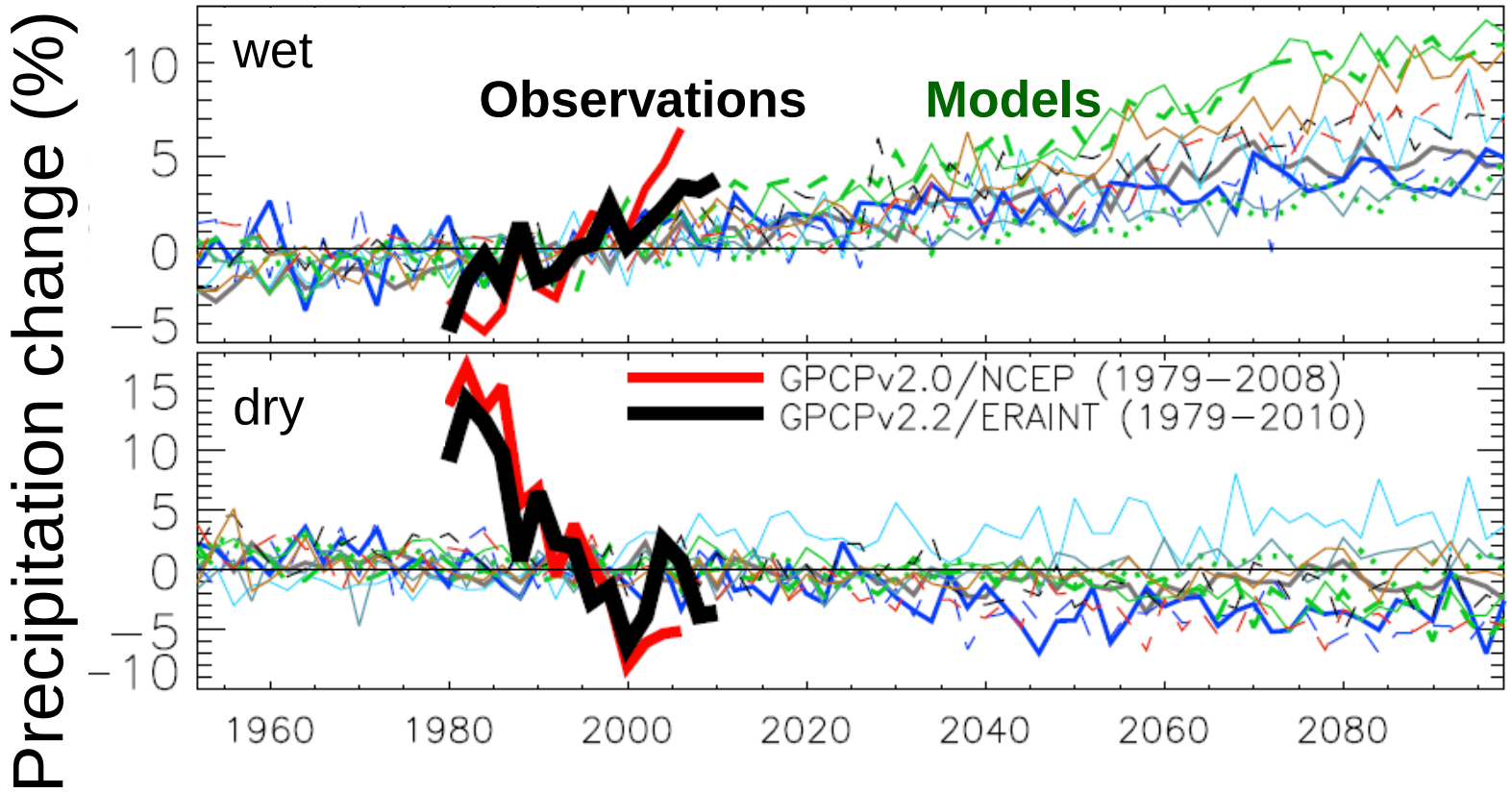
Extra slides

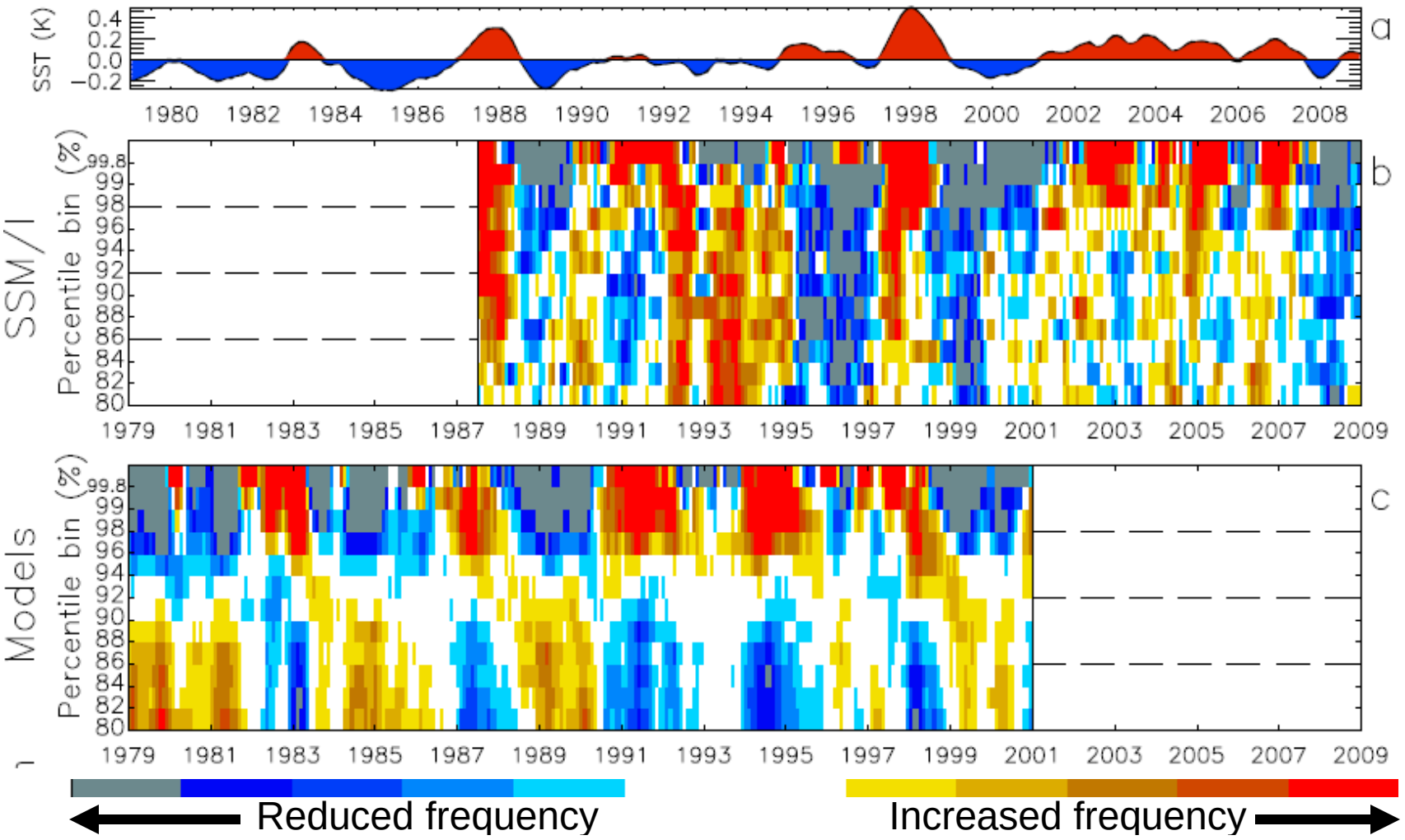
Contrasting precipitation response in wet and dry regions of the tropical circulation



Sensitivity to reanalysis dataset used to define wet/dry regions

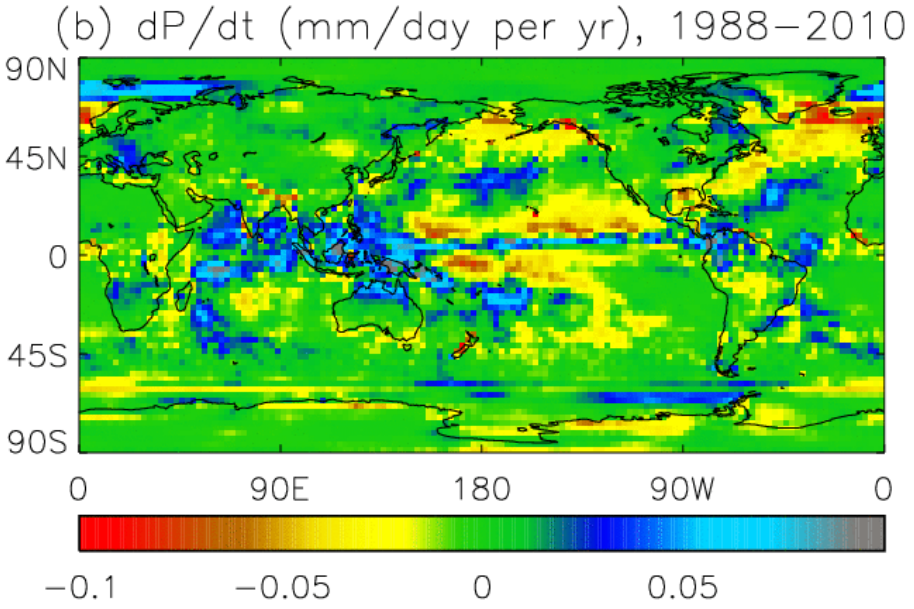
Updated from Allan *et al.* (2010) *Environ. Res. Lett.*

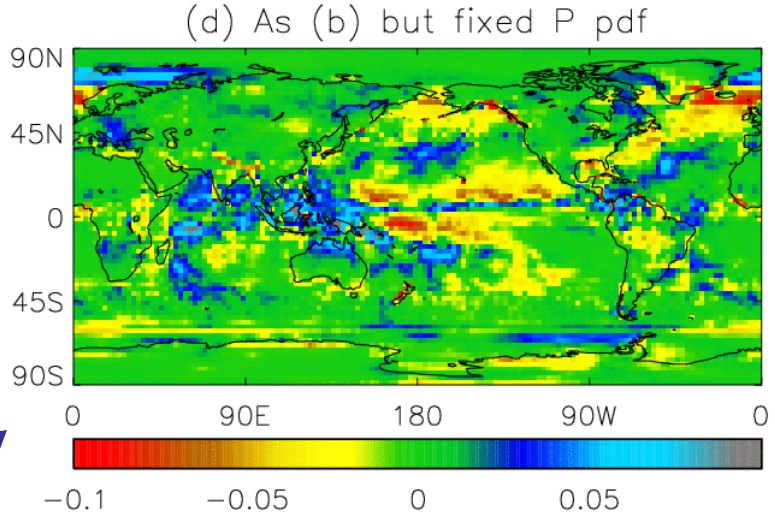
Increases in the frequency of the heaviest rainfall with warming: daily data from models and microwave satellite data (SSM/I)



Allan and Soden (2008) Science; Allan et al. (2010) Environ. Res. Lett.

Separating dynamical thermodynamic trends

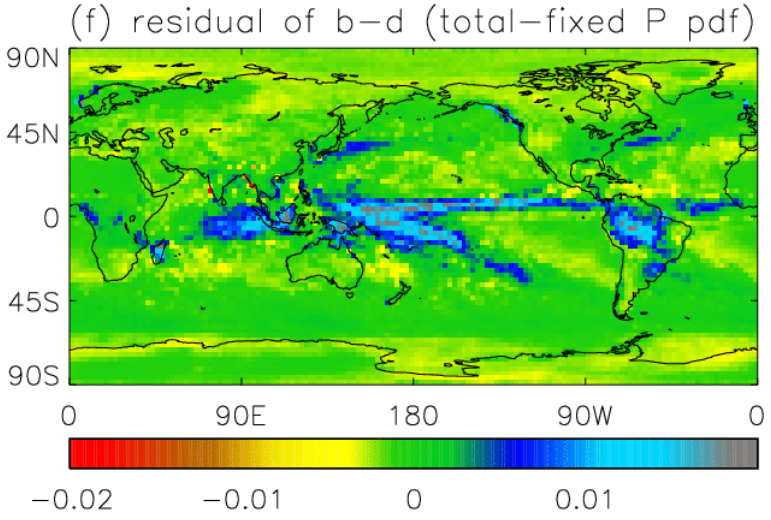




Top: fixed P intensity PDF

Bottom: residual (total trend minus fixed PDF)

We are currently applying this technique to CMIP5 models



Precipitation bias and response binned by dynamical regime

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- Model biases in warm, dry regime
- Strong wet/dry fingerprint in model projections (below)

Allan (2012) Clim. Dyn.