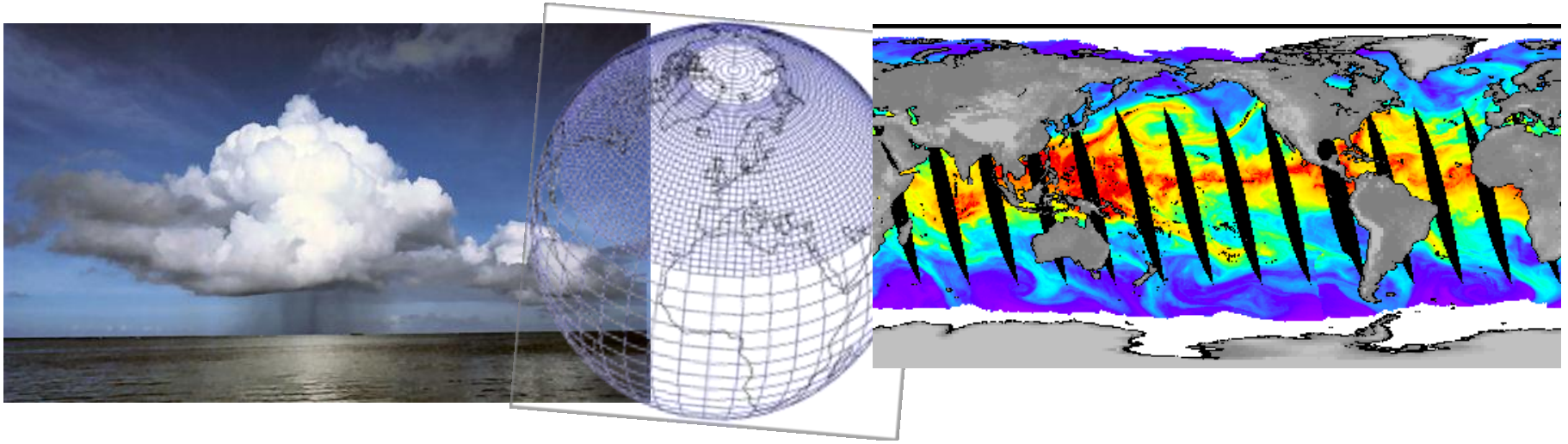

How and why is rainfall changing across the globe?

Richard Allan, David Lavers, Chunlei Liu, Matthias Zahn

Department of Meteorology, University of Reading

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How will global precipitation respond to climate change?

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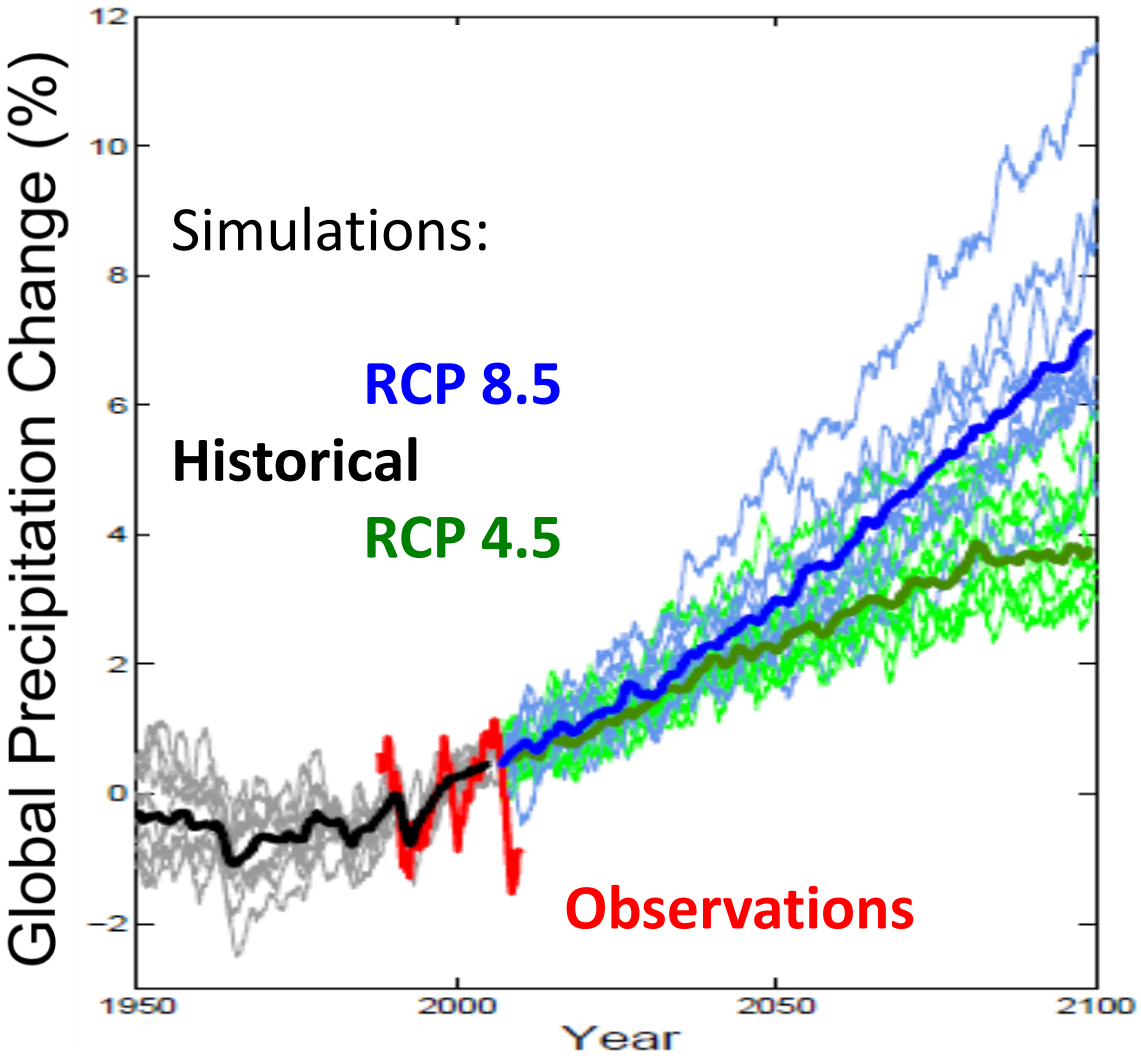
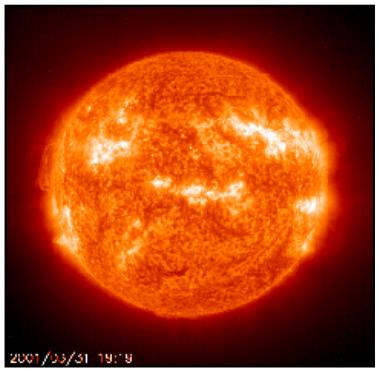
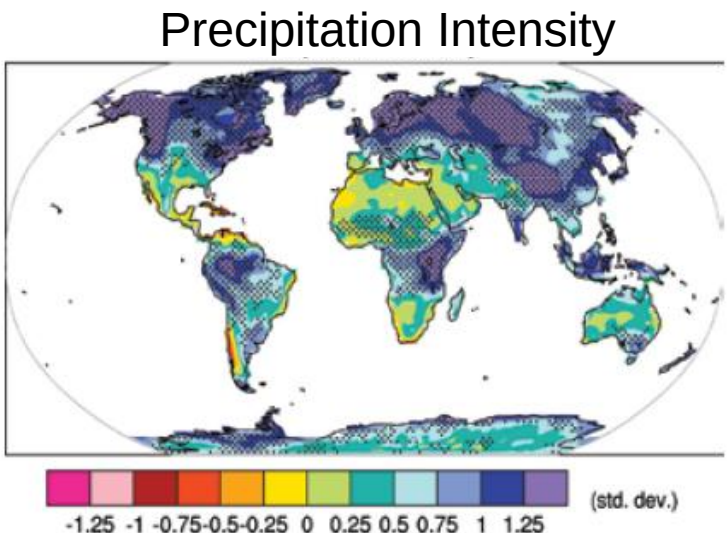


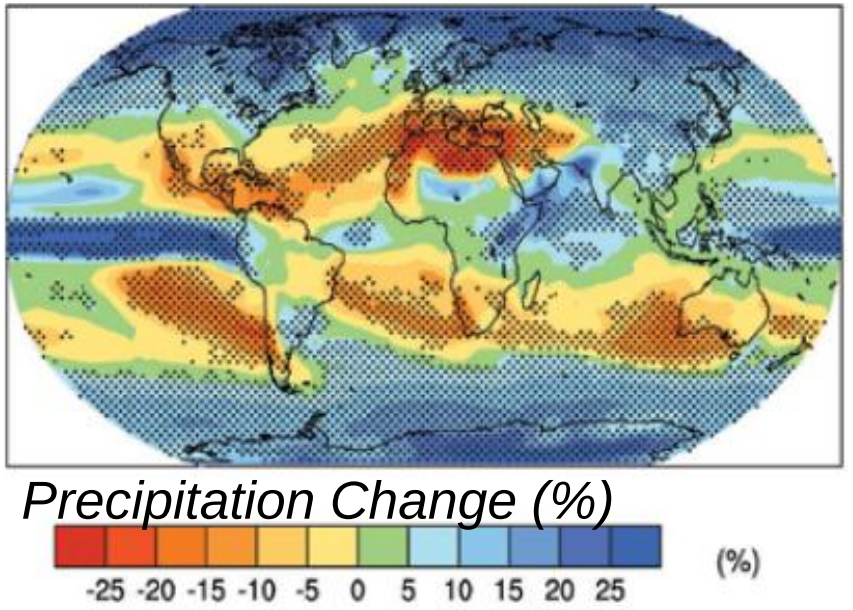


Allan et al. (2013) Surv. Geophys, see also Hawkins & Sutton (2010) Clim. Dyn

Climate model projections

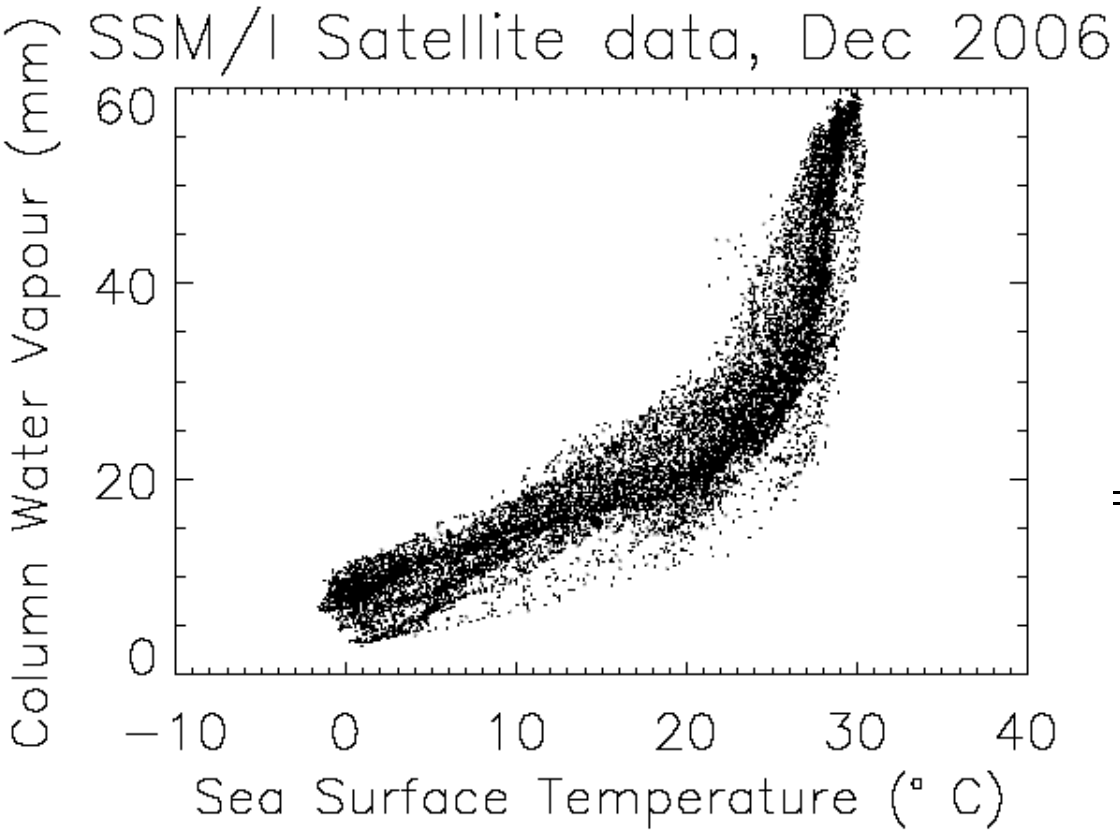


- Increased Precipitation
- More Intense Rainfall
- More droughts
- Wet regions get wetter, dry regions get drier?
- Regional projections??



IPCC WGI (2007)

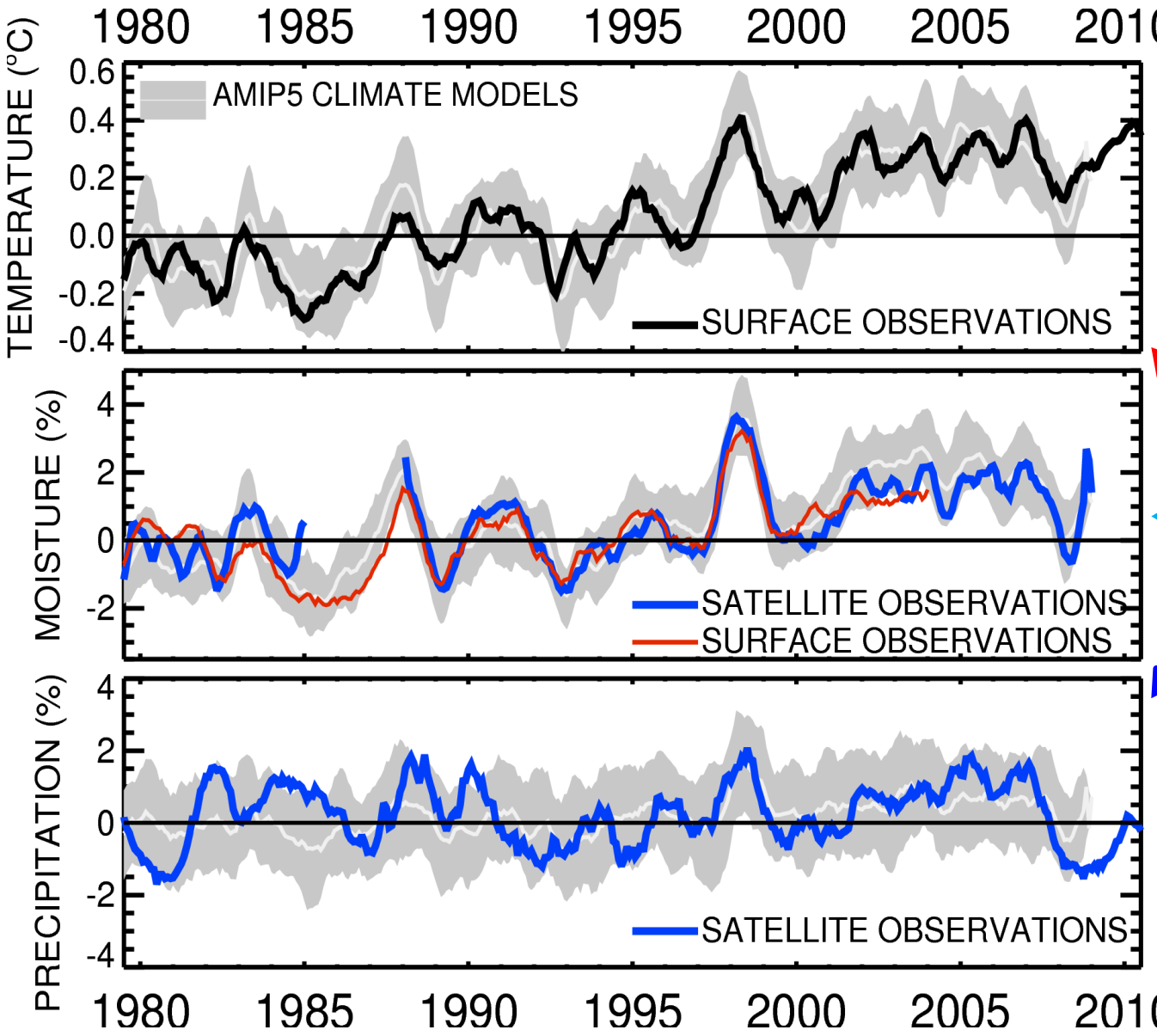
The role of water vapour



$$\frac{1}{e_s}\frac{de_s}{dT} = \frac{L}{R_v T^2}$$

$$= \begin{cases} 0.14K^{-1} & T = 200K \\ 0.07K^{-1} & T = 273K \\ 0.06K^{-1} & T = 300K \end{cases}$$

- Physics: Clausius-Clapeyron
- Low-level water vapour concentrations increase with atmospheric warming at about 6-7%/K
  - Wentz and Shabel (2000) *Nature*; Raval and Ramanathan (1989) *Nature*



Globally, in the present-day climate, temperature, moisture and precipitation are strongly coupled

See poster by Chunlei Liu

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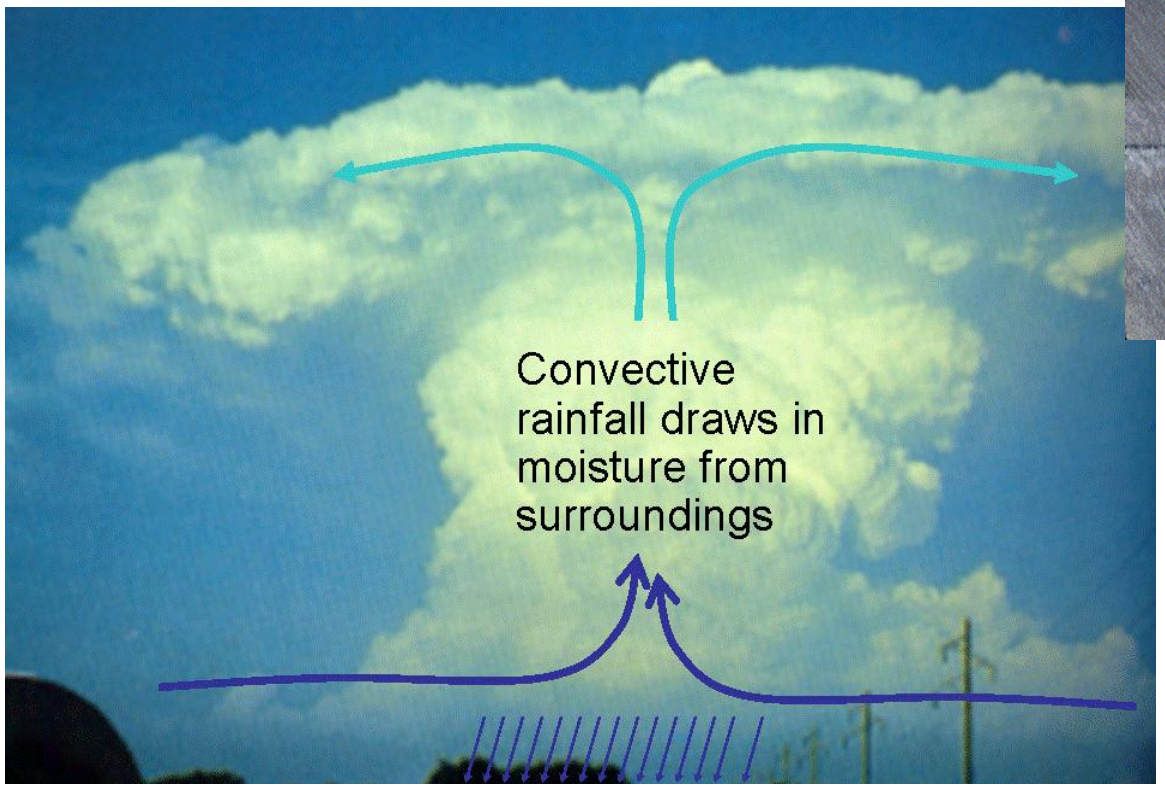
Horyuji PAGODA
HydrOlogical cYcle Understanding via Process-bAsed GlObal Detection, Attribution and prediction

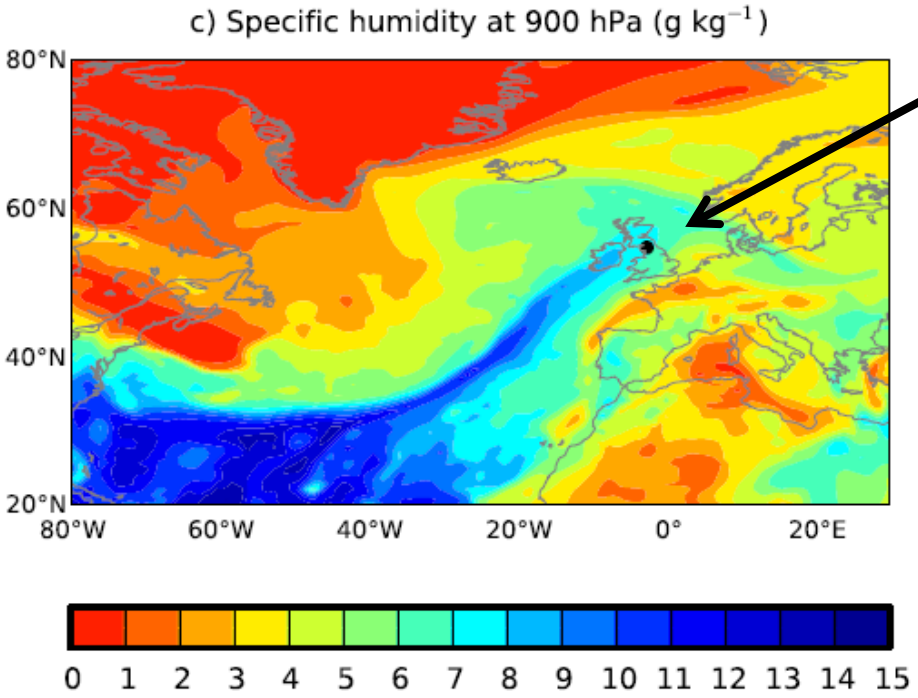
Extreme Precipitation

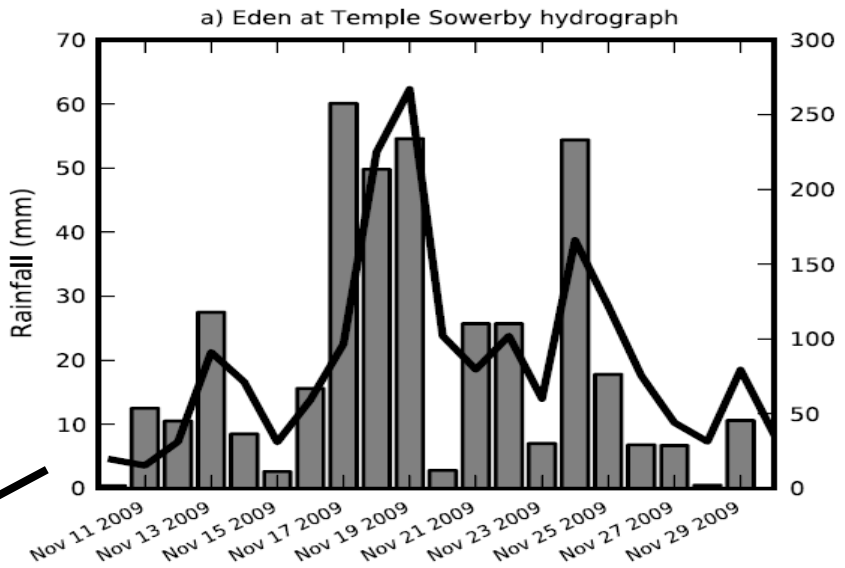


- Large-scale rainfall events fuelled by moisture convergence
  - e.g. Trenberth et al. (2003) *BAMS*
- Intensification of rainfall with global warming
  - *e.g. Allan and Soden (2008) Science*

Water vapour and mid-latitude flooding

- Linking UK winter flooding to Atmospheric Rivers
  - e.g. Nov 2009 Cumbria floods



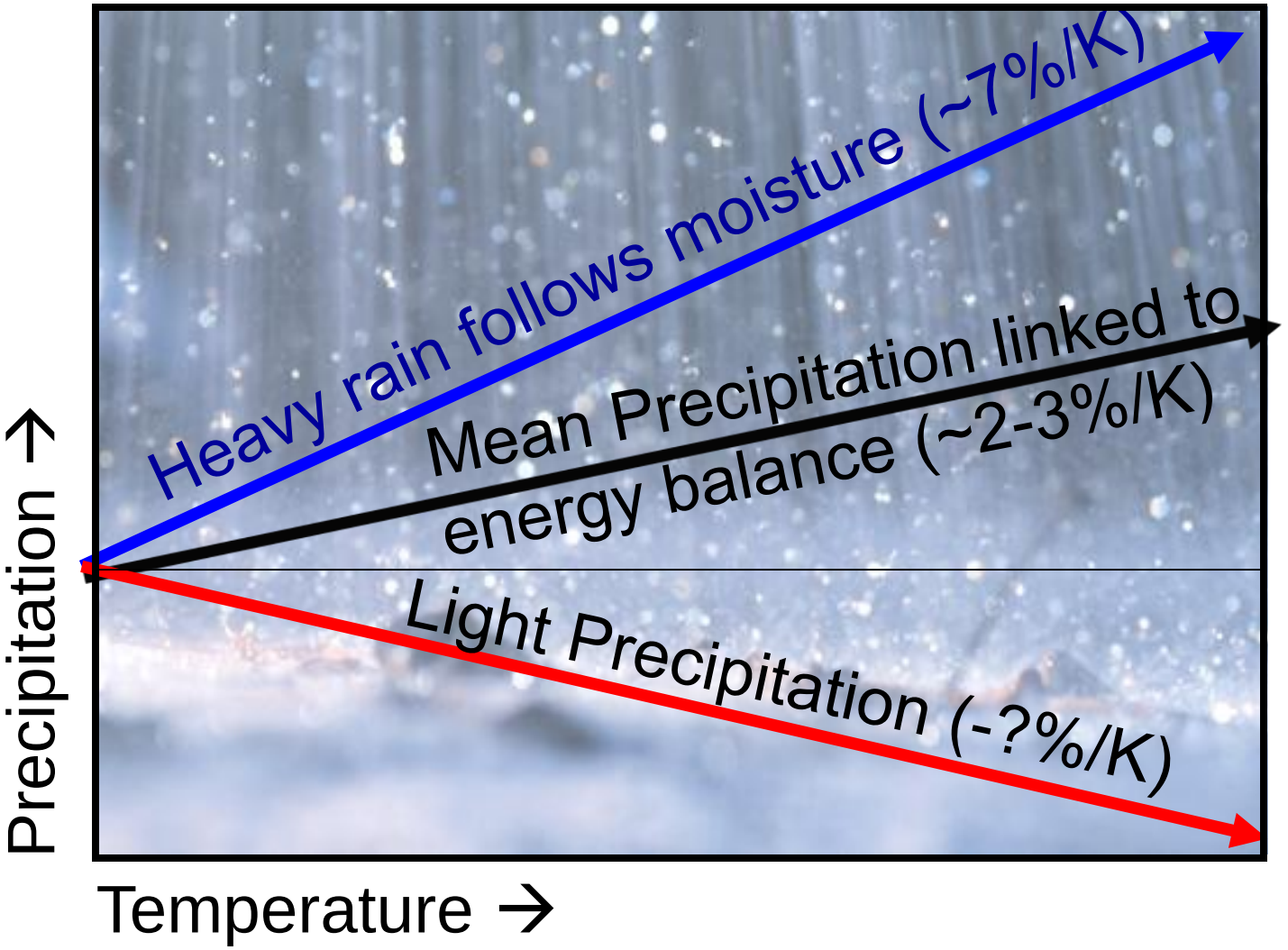


NERC HydEF project

See poster by David Lavers

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

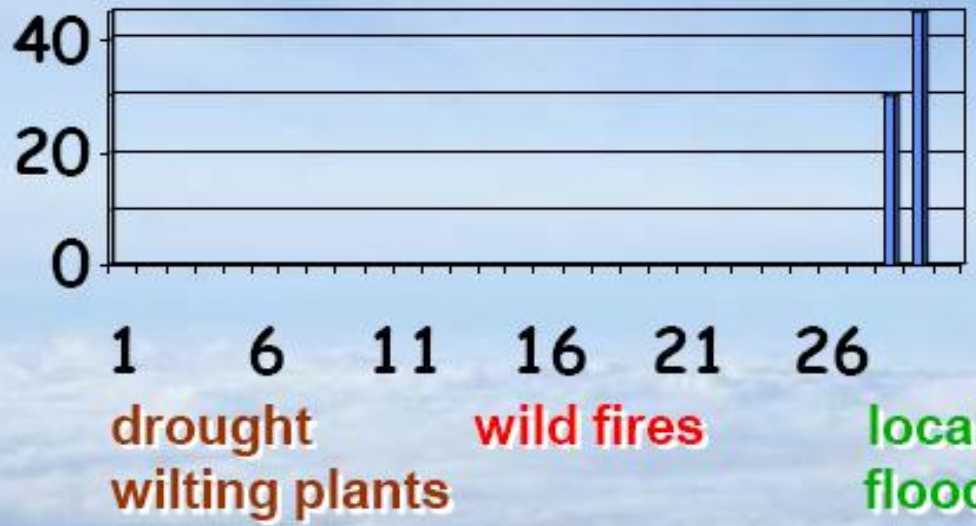
Contrasting precipitation response expected



e.g. Allen and Ingram (2002) *Nature*; Allan (2011) *Nature*

Daily Precipitation at 2 stations

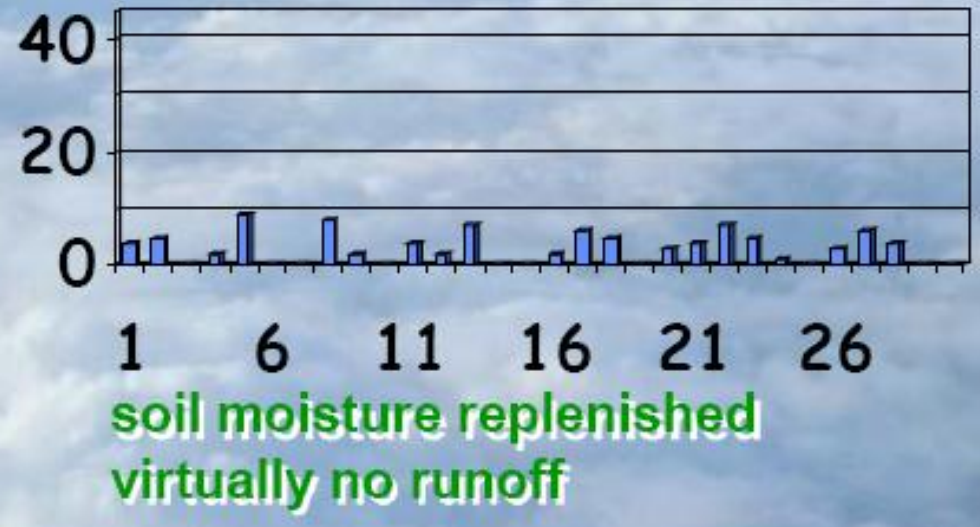
A



Monthly
Amount 75 mm

Frequency 6.7%
Intensity 37.5 mm

B



Amount 75 mm

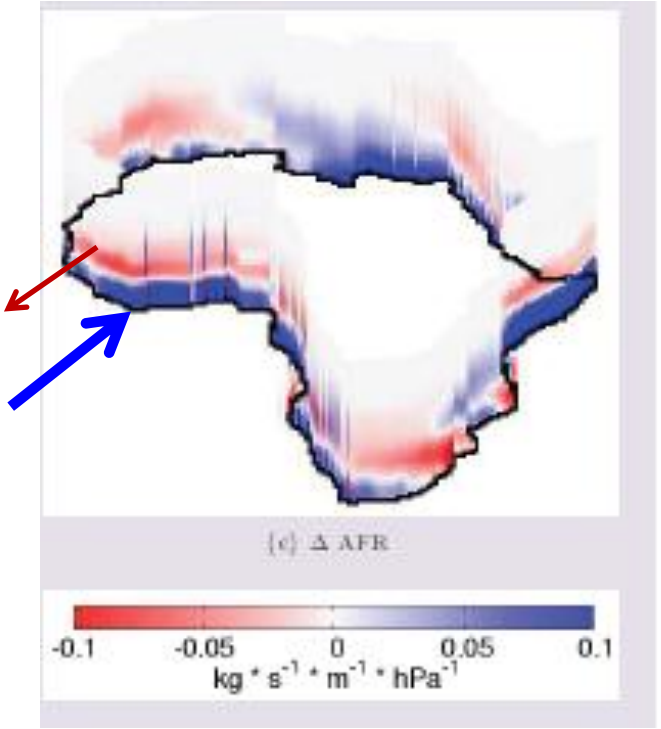
Frequency 67%
Intensity 3.75 mm

Courtesy of Dr Kevin Trenberth, Head of the Climate Analysis Section at the USA National Center for Atmospheric Research

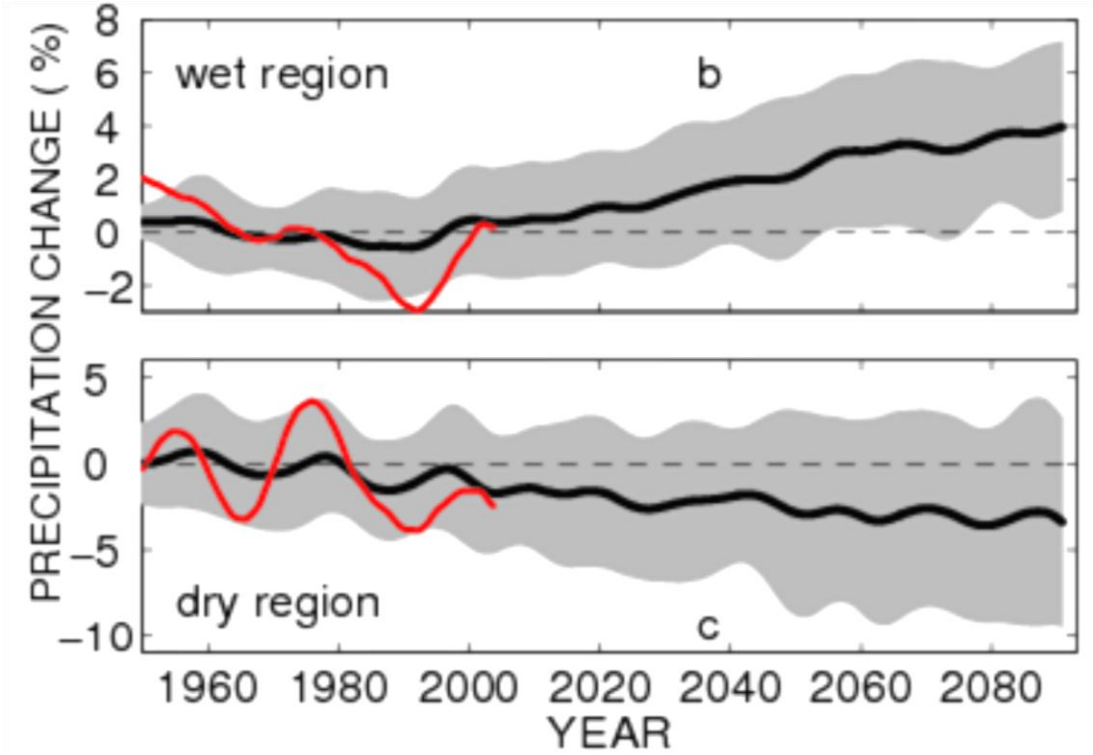
Contrasting precipitation response in wet and dry regions of the tropics

University of Reading

21C-20C



Tropical land



NERC PREPARE project

See posters by Matthias Zahn and Chunlei Liu

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Changing water cycle

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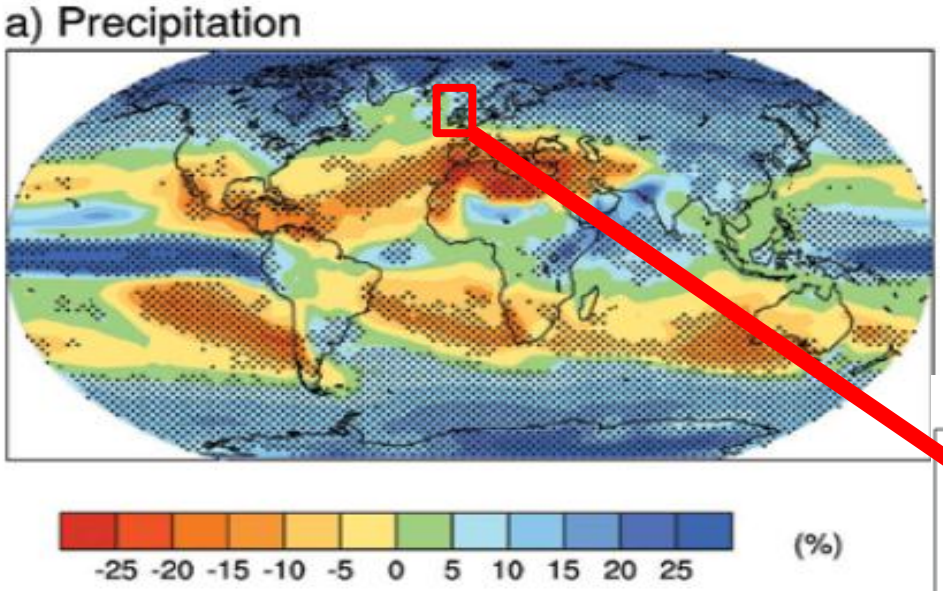
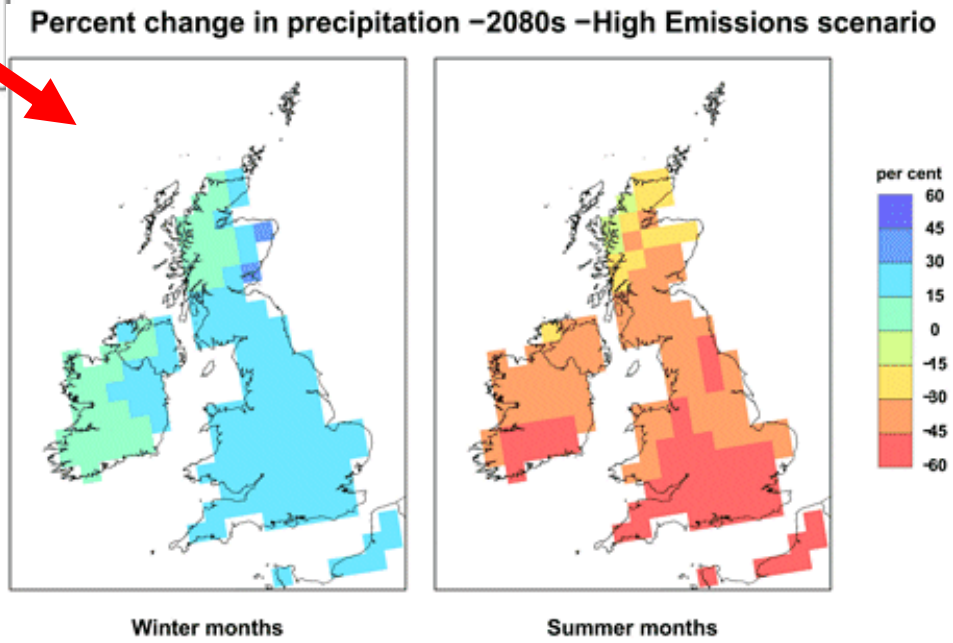
HydrOlogical cYcle Understanding via Process-bAsed GlObal Detection, Attribution and prediction

Allan *et al.* (2010) *Environ. Res. Lett.*,
Zahn & Allan (2013) J Clim

Robust predictions of regional changes in the water cycle: a great challenge



Shifts in circulation patterns are crucial to regional changes in water resources and risk yet predictability is often poor.



How will monsoons and jet stream positions respond to warming?

How will primary land-surface and ocean-atmosphere feedbacks affect the local response to global warming?

Conclusions


- Global precipitation will rise with warming ~2%/K
  - Constrained by energy budget of atmosphere
- Heavy rainfall becomes more intense
  - Fuelled by increased water vapour (~7%/K)
- Wet get wetter, dry get drier
  - More flooding, more drought ?
  - But wet and dry regions don't stay still…
- Regional projections are a challenge
  - Sensitive to small changes in atmospheric circulation