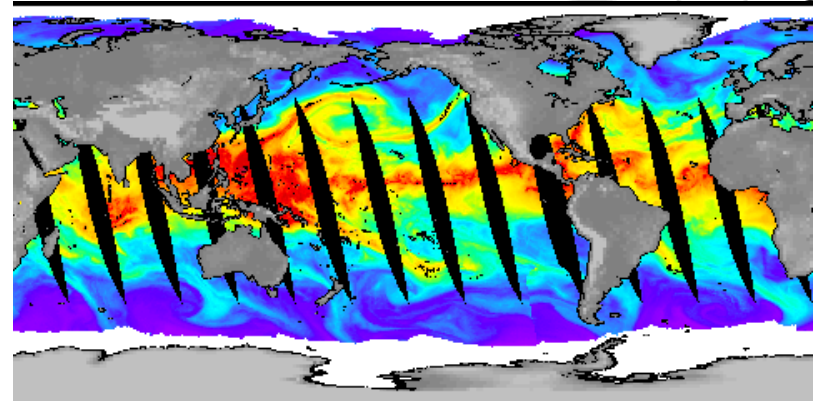
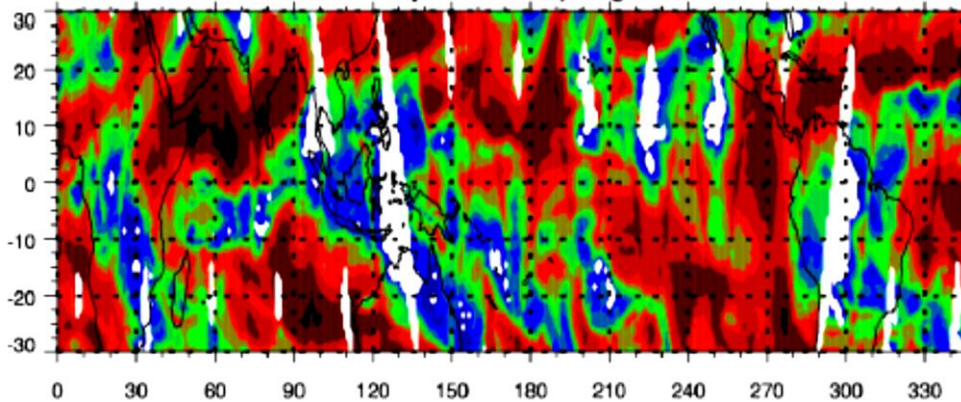


Daily MW Sampling - Jan



Satellite measurements of changes in column integrated water vapour and upper tropospheric humidity

Richard P. Allan¹, Viju O. John²

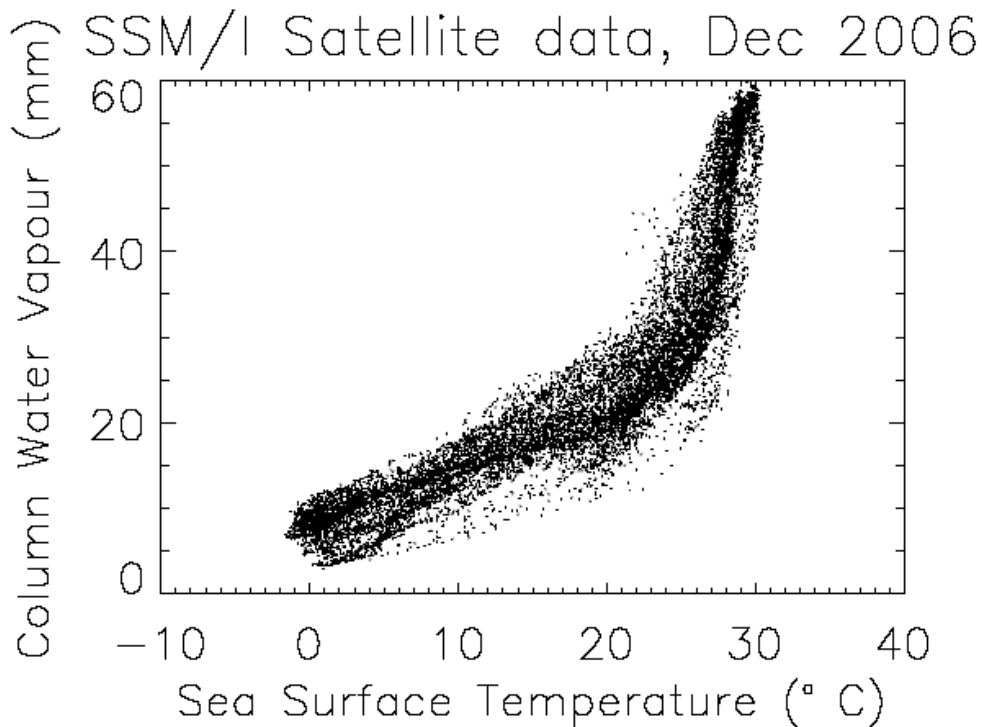
¹Department of Meteorology, University of Reading; ²Met Office

<http://www.met.reading.ac.uk/~sgs02rpa>

r.p.allan@reading.ac.uk

Clausius Clapeyron

$$\frac{1}{q_s} \frac{dq_s}{dT} \approx \frac{1}{e_s} \frac{de_s}{dT} = \frac{L}{R_v T^2} = \begin{cases} 0.14 K^{-1} & T = 200 K \\ 0.07 K^{-1} & T = 273 K \\ 0.06 K^{-1} & T = 300 K \end{cases}$$

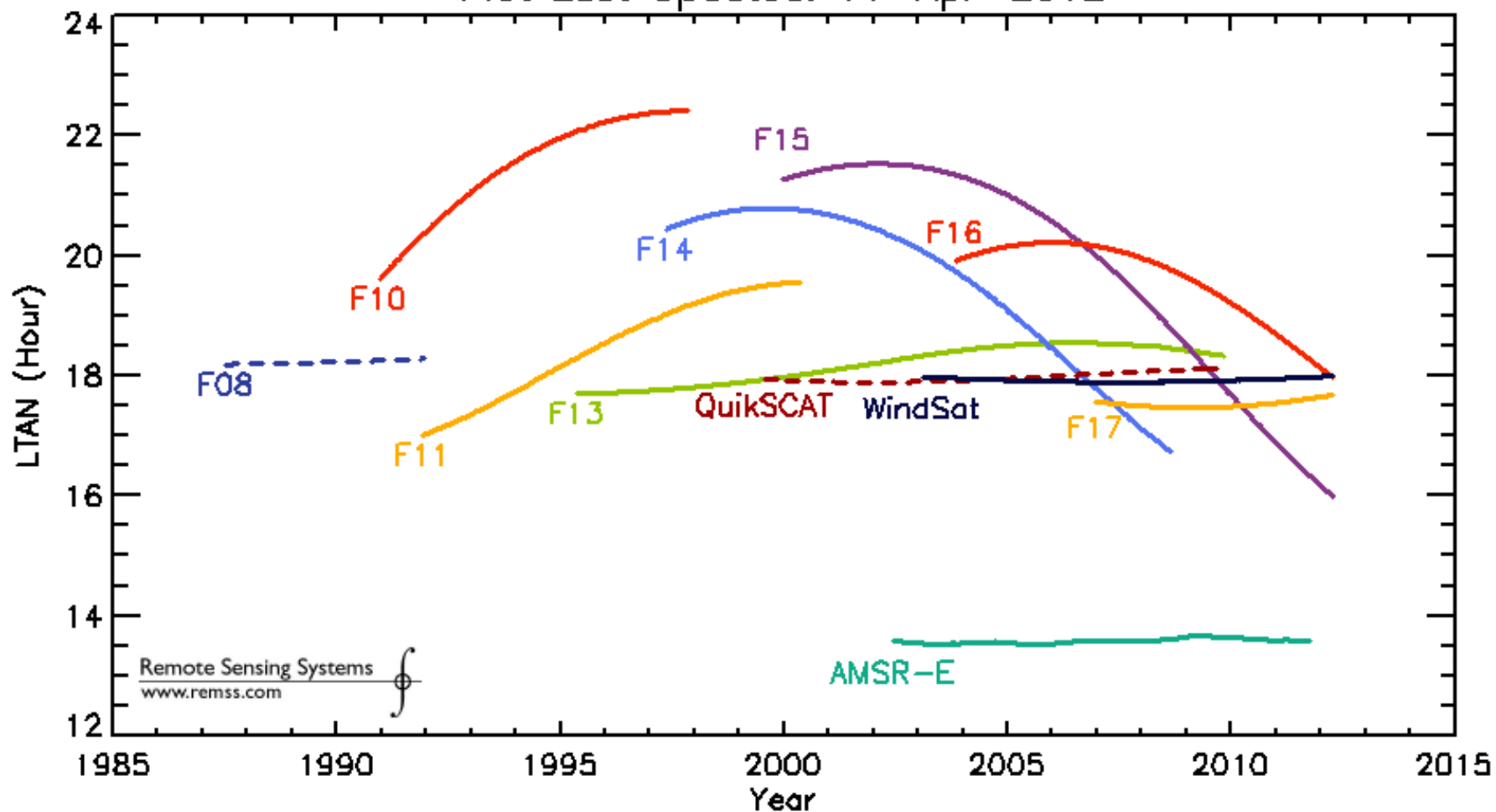


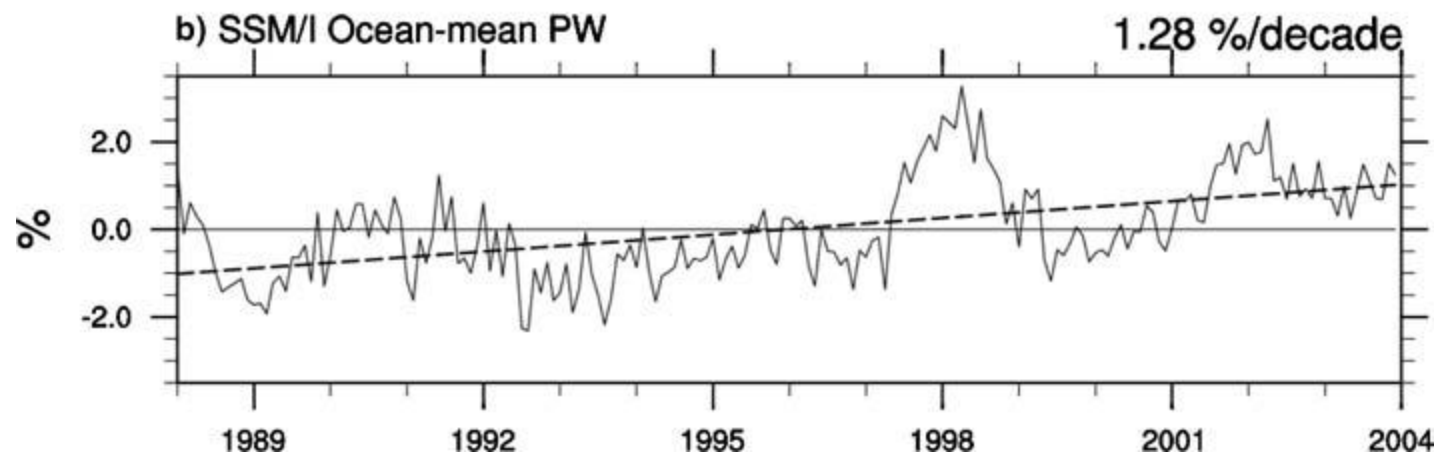
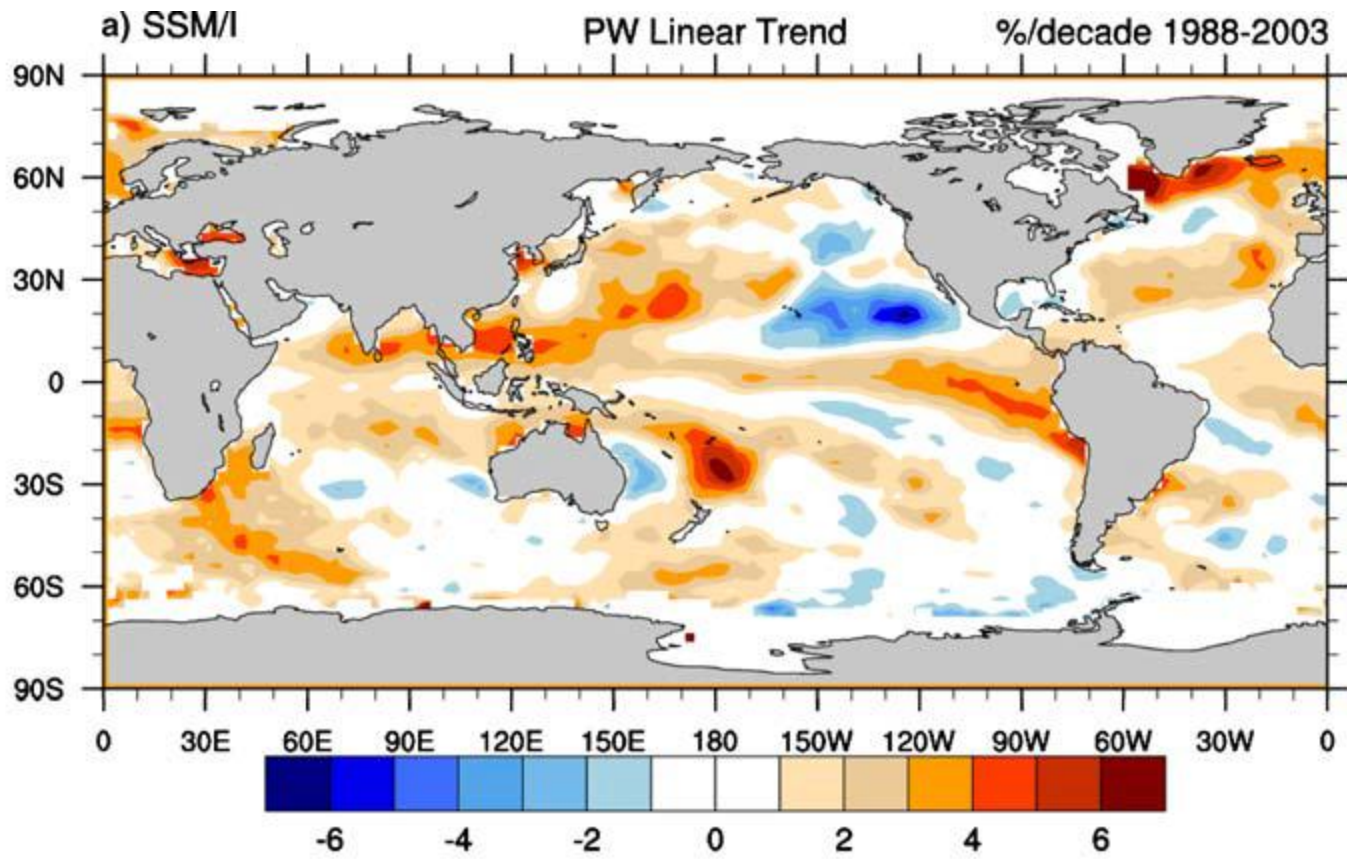
- Strong constraint upon low-altitude water vapour over the oceans
- Water vapour is a very forgiving climate variable!
- Land regions?
- Upper troposphere?

e.g. see [Allan \(2012\) Surv Geophys](#)

Equator Crossing Times

Plot Last Updated: 11-Apr-2012

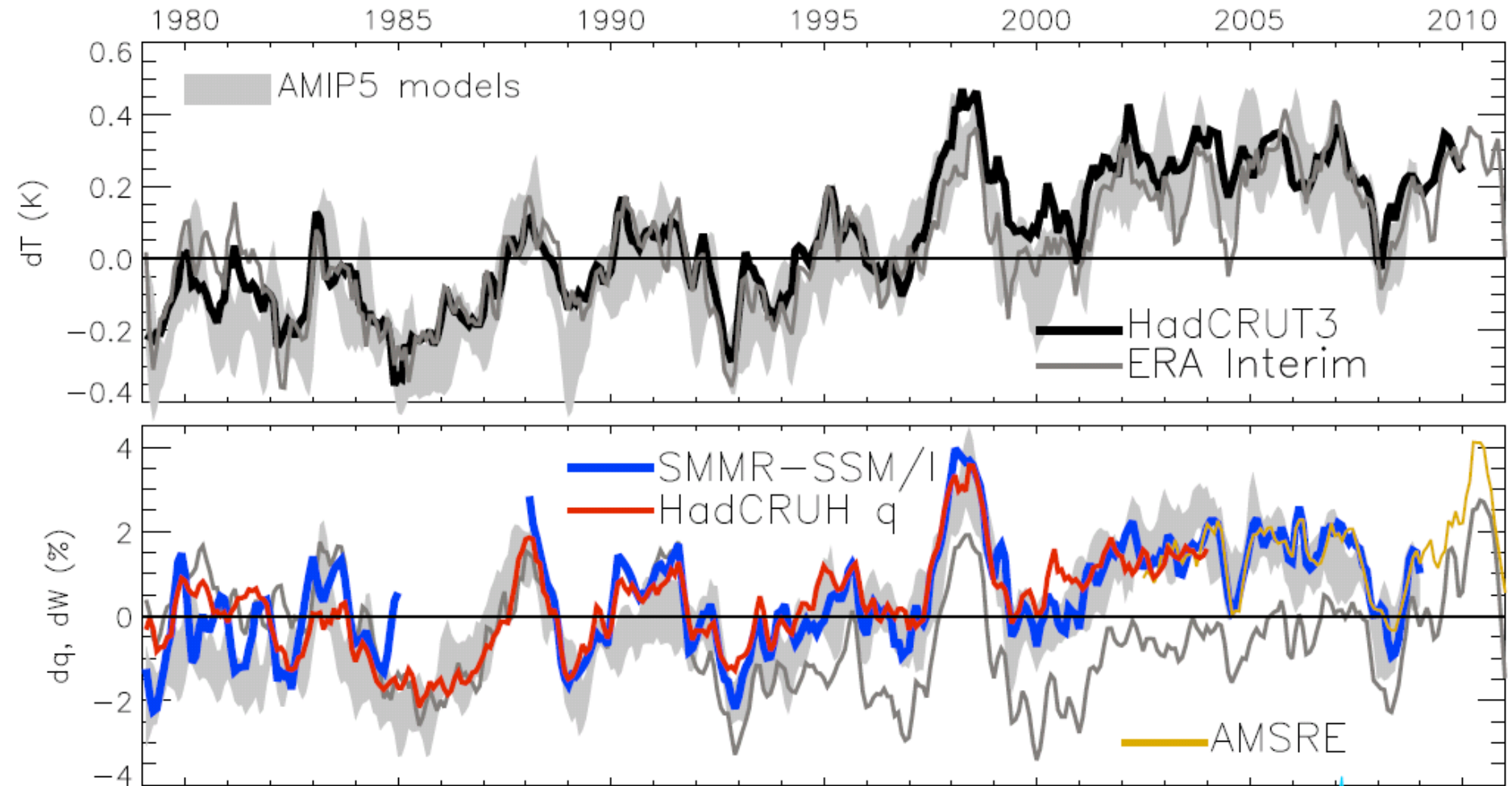




Trenberth et al.
(2005) *Clim Dyn*

See also:
Wentz and Schabel (2000)
Nature;
Soden (2000) *J Clim*;
[Allan et al. \(2003\) QJRMS](#)

Global changes in water vapour

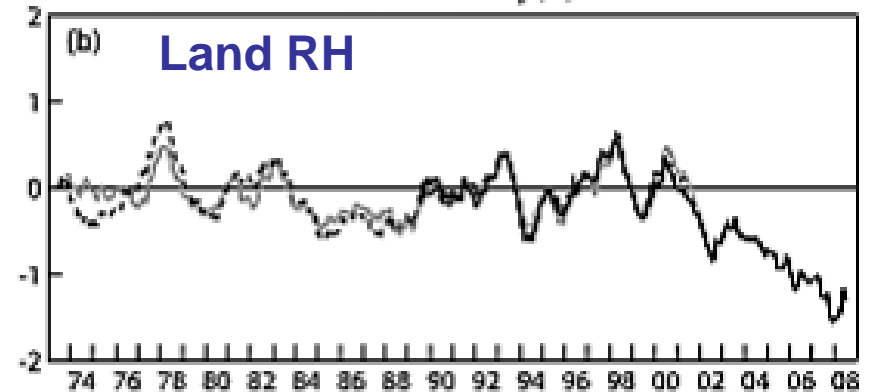
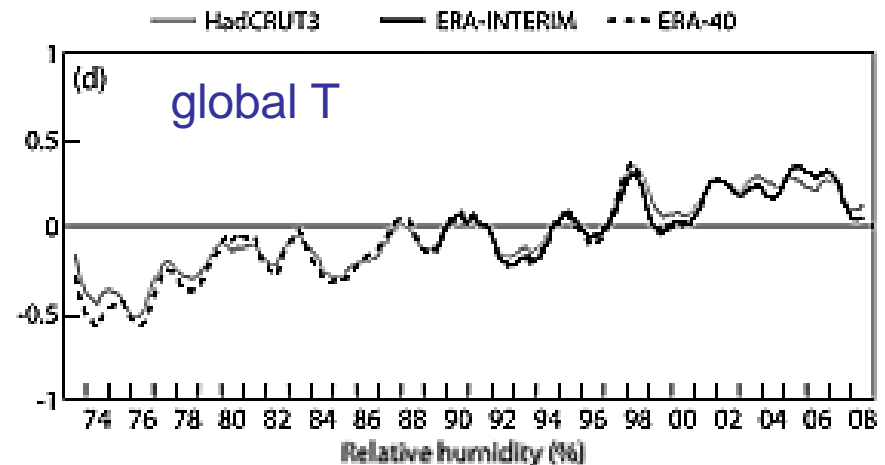
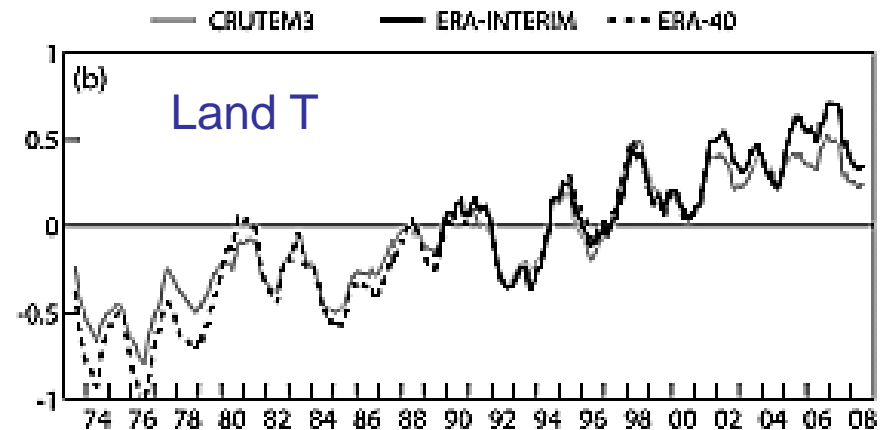


Updated from [O'Gorman et al. \(2012\) Surv. Geophys](#); see also John et al. (2009) GRL

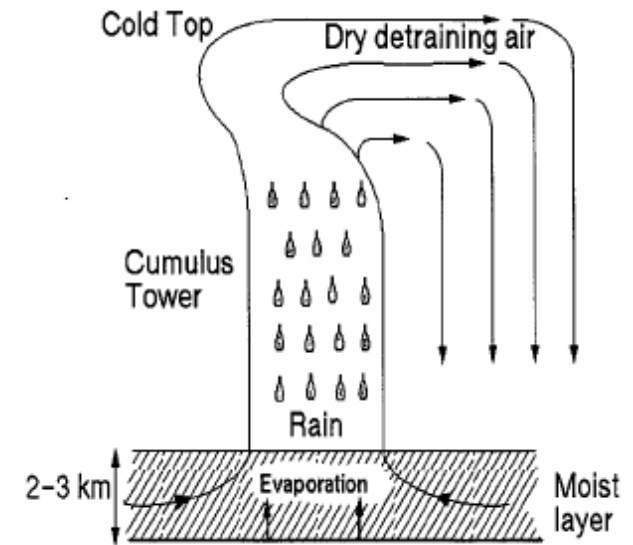
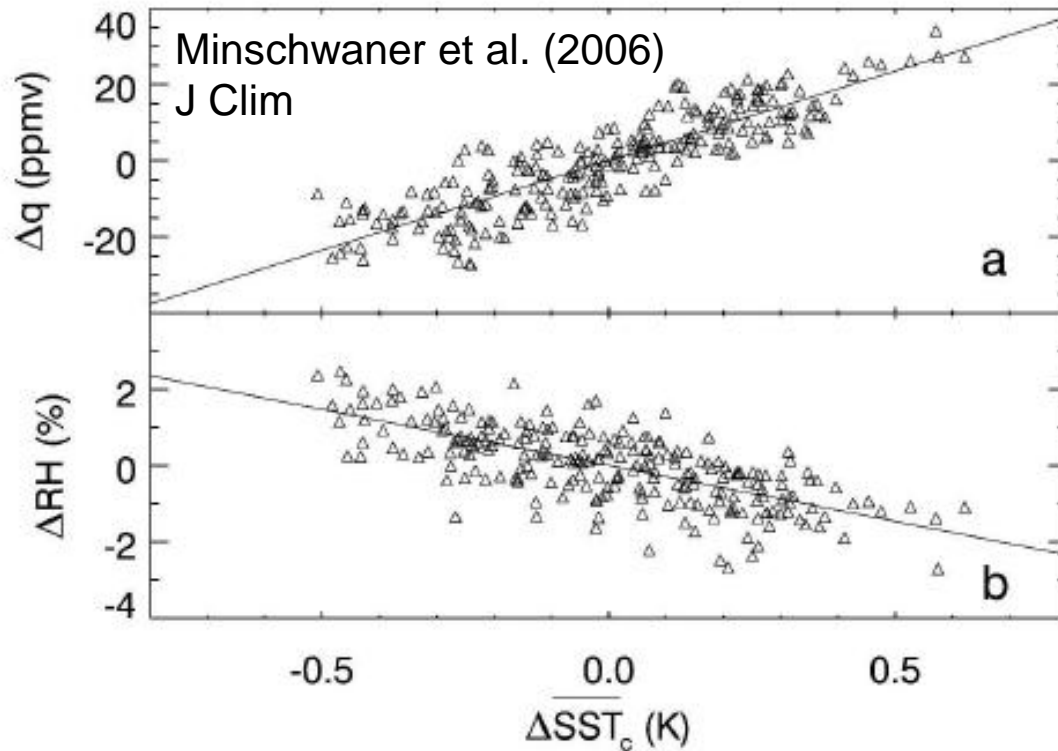
Declining RH over land?

- Stalling of ocean temperatures in 2000s
- Continued warming of land
- Reduced relative humidity over land?
- Implications for hydrological cycle

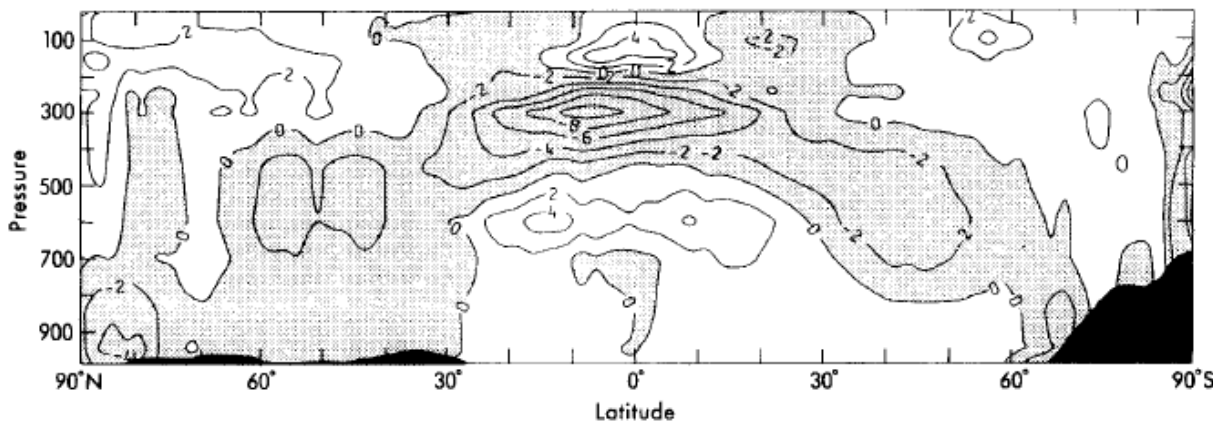
Simmons et al. (2010) JGR



Reduction in UTH* with warming?



Lindzen (1990) BAMS



Mitchell et al. (1987)
QJRMS

* 'upper' tropospheric humidity or relative humidity above the boundary layer

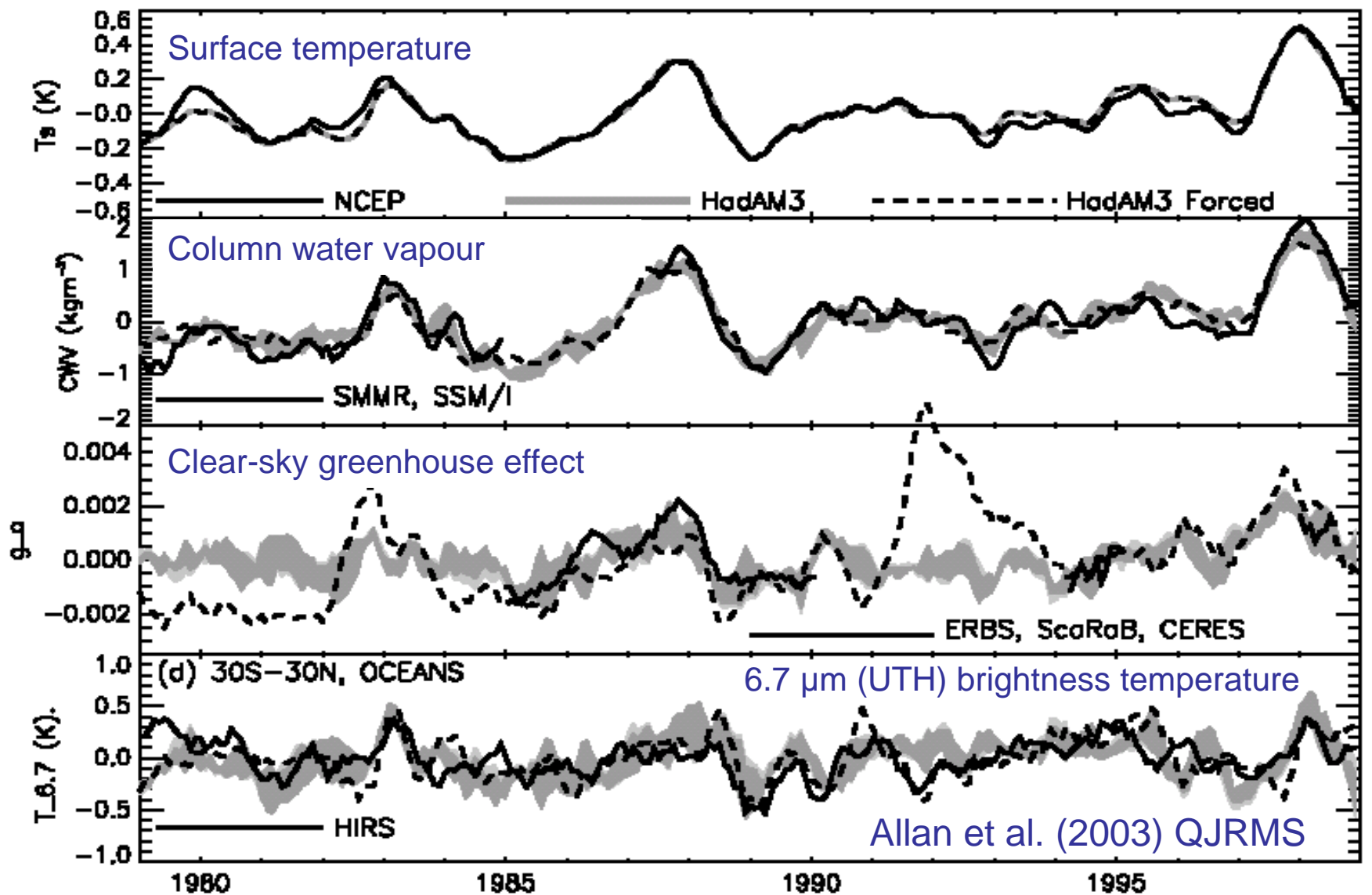
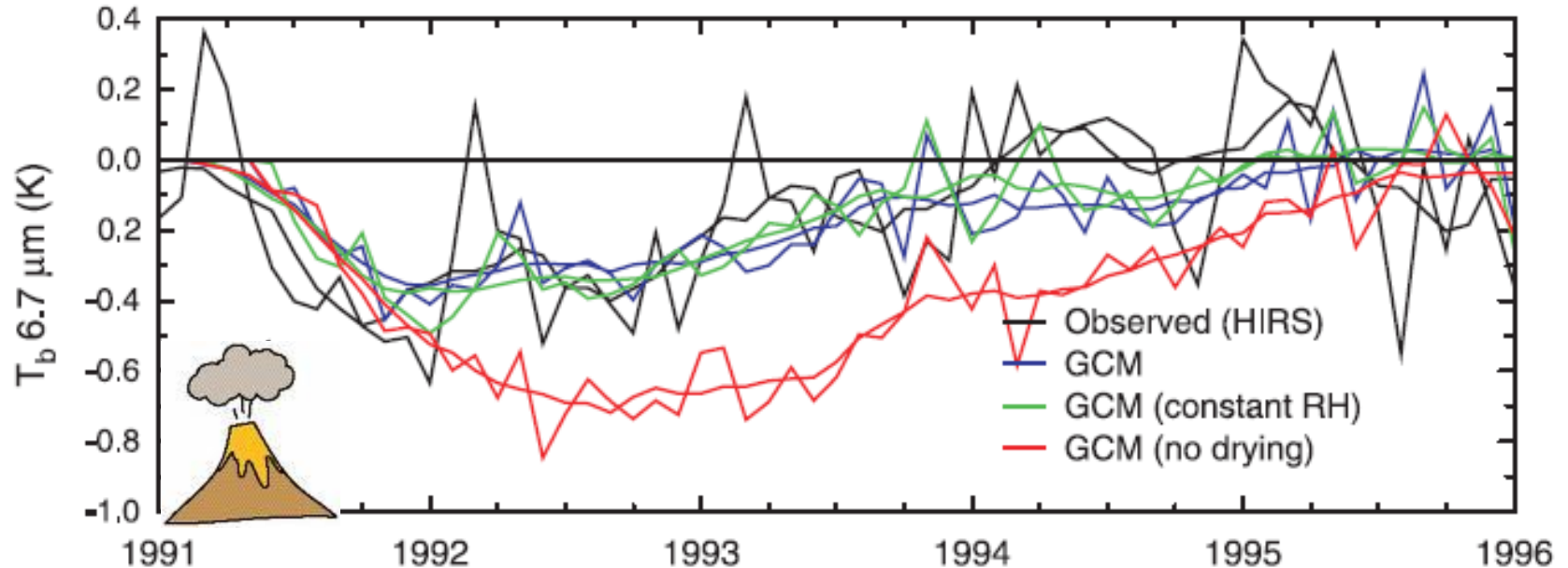


Figure 6. Interannual anomalies of (a) surface temperature, (b) column water vapour, (c) normalized greenhouse trapping and (d) $6.7 \mu\text{m}$ brightness temperature for area-weighted means over the tropical oceans. Anomalies are formed by removing the monthly climatology displayed in Fig. 5. The shaded region denotes inter-ensemble spread for HadAM3 SST-only forcing. Dark and light shading denote Type I and Type II diagnostics, respectively (see text). The dashed line denotes the ‘all-forcings’ HadAM3 experiment.

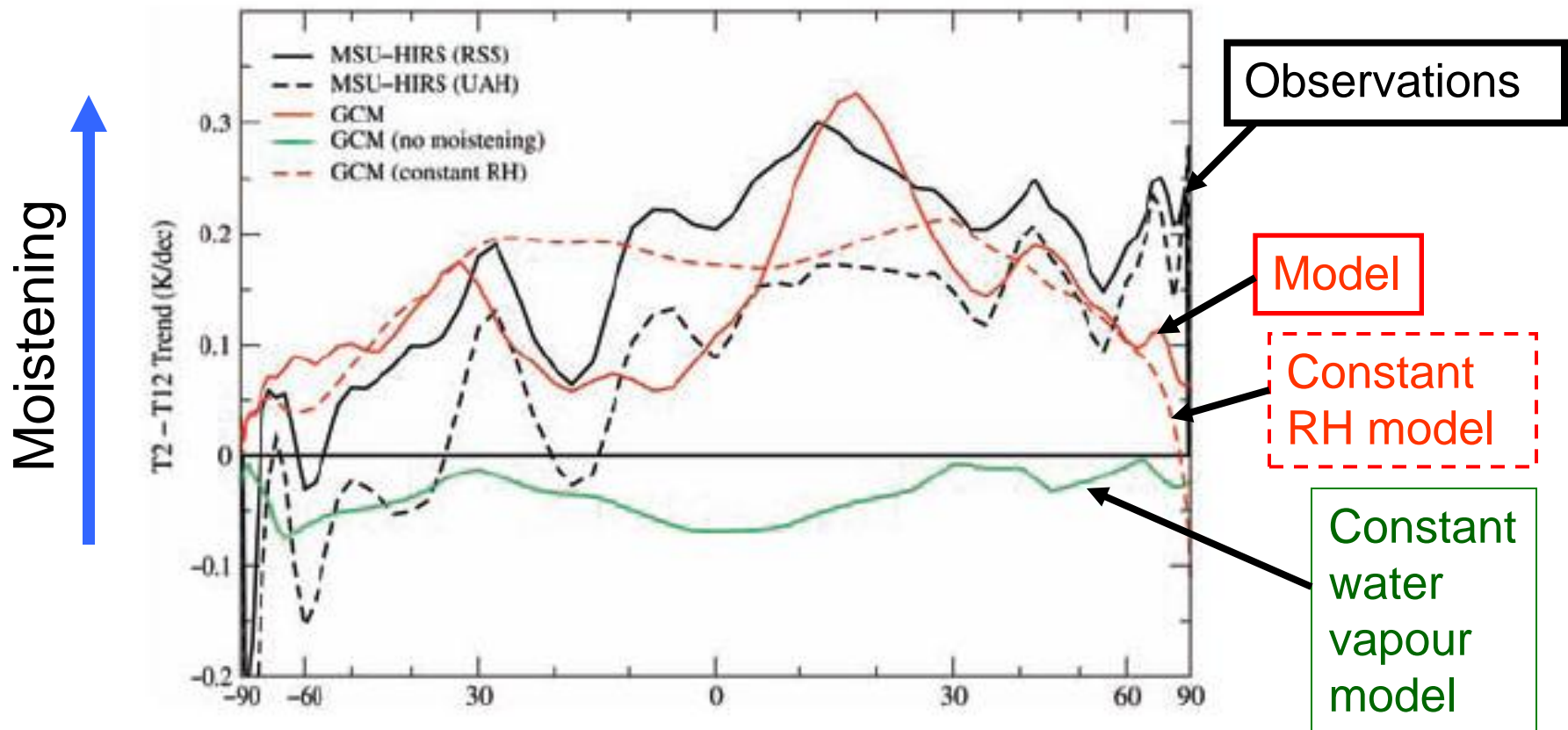
Time-scale dependence?



Soden et al. (2002) *Science*; Forster/Collins (2004) *Clim Dyn*; Harries/Futyan (2006) *GRL*

Trends in Upper Tropospheric Humidity (UTH)

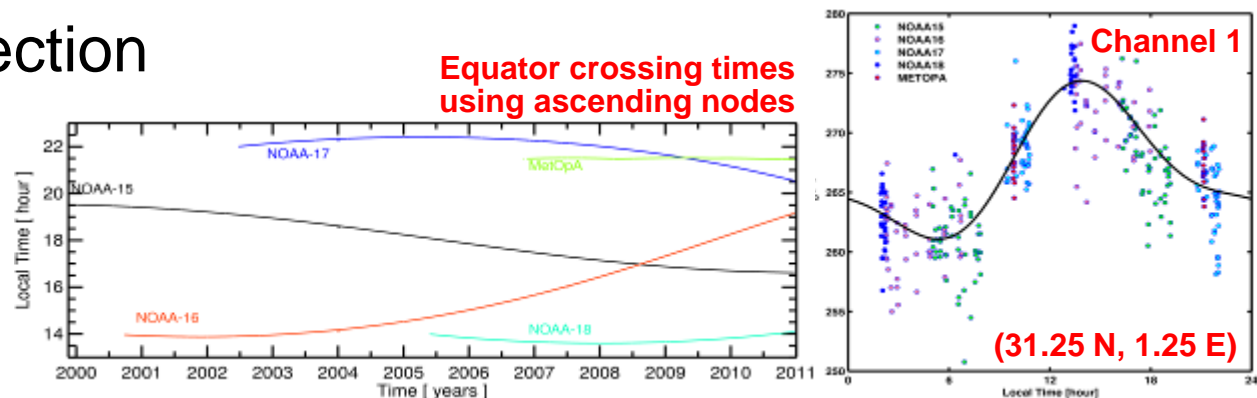
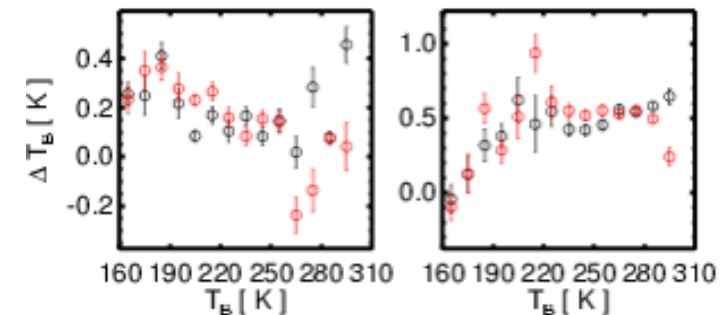
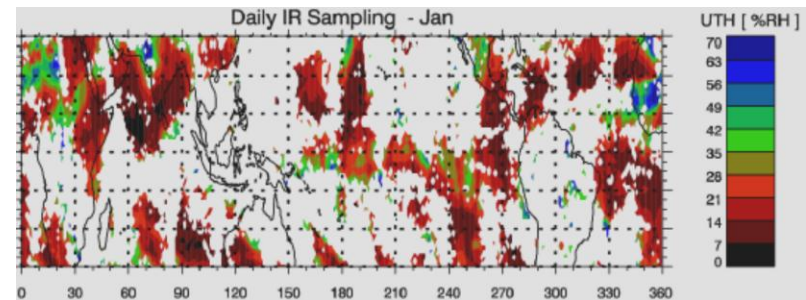
Trend in brightness temperature difference: 1983-2004



Soden et al. (2005) *Science*

Intercalibration of satellite UTH data HadIR project (HadMW?)

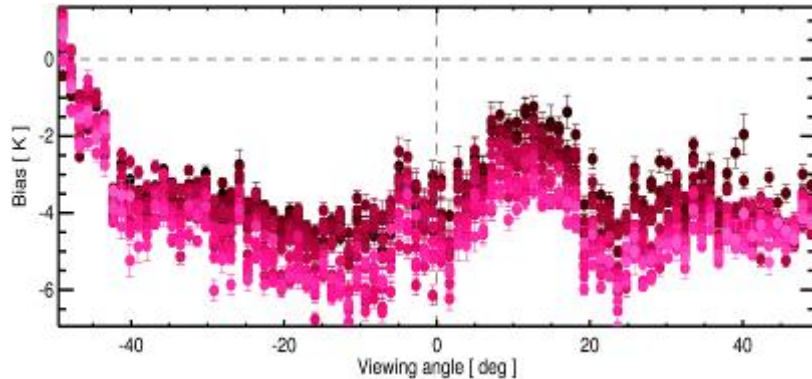
- Sampling issues
 - Infra-red vs microwave
- Inter-Calibration using satellite nadir overpasses
 - Polar overpasses
 - Satellite drift overpasses
- Correction for orbit drift
 - Diurnal correction



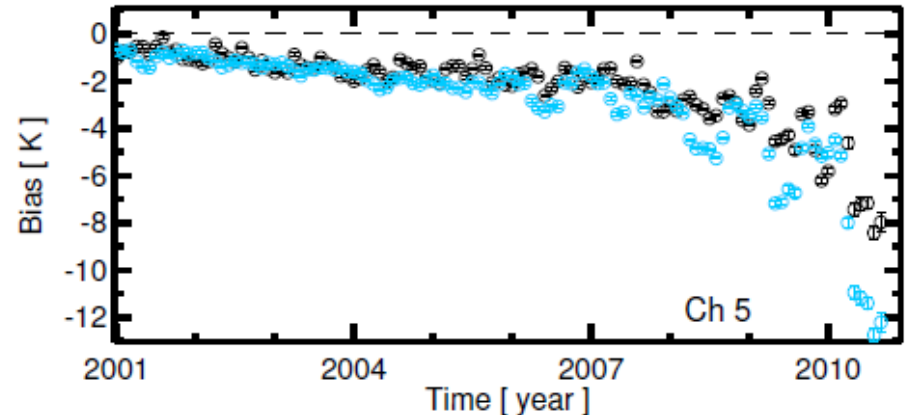
Viju John and
HadIR project

Ongoing work and future plans

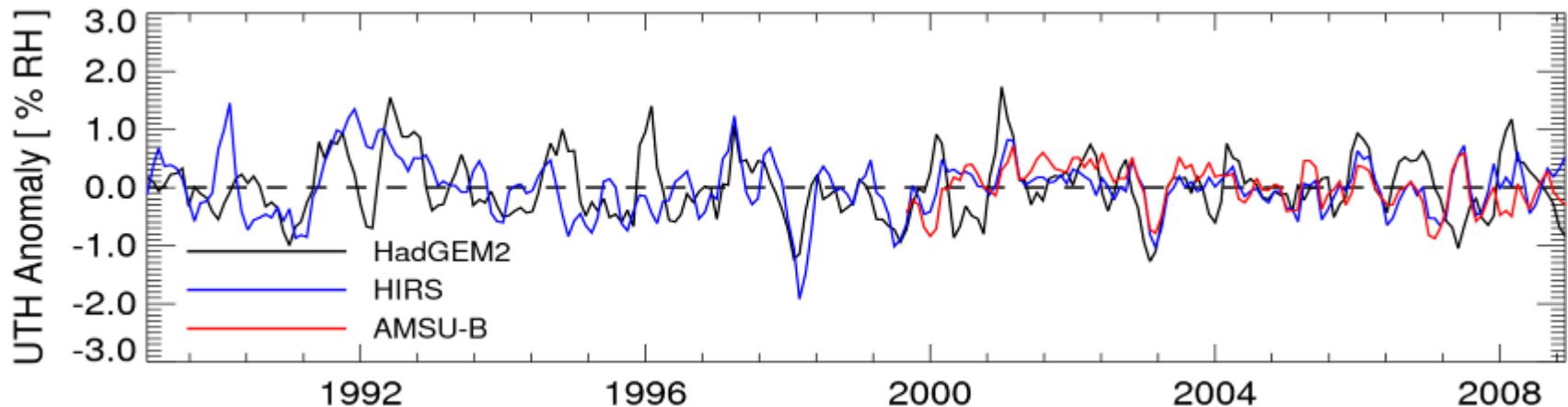
Correct for scan-dependent biases



Correct for time-dependent biases



Evaluate climate model processes using the generated data sets



Extend the comparisons to other CMIP5 models and ERA-Interim

Satellite record of water vapour

- Physically well understood
 - ...at least, at low levels over oceans
 - changes over land and upper troposphere?
- Maturing observing system
 - CWV record over oceans (SMMR, SSM/I, SSMIS)
 - Agreement with ground based observations (e.g. Willett et al.)
 - Infra-red UTH sampling an issue → microwave?
- Reanalyses?
 - Limitations: trends in large-scale ocean averages inaccurate
 - Strengths: dynamical fields/transport?
- Regional changes:
 - Dynamical vs thermodynamic drivers
- Constraints on extreme precipitation & cloud feedbacks?

