Comparing climate signals in radiosonde and satellite temperature datasets

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Outline

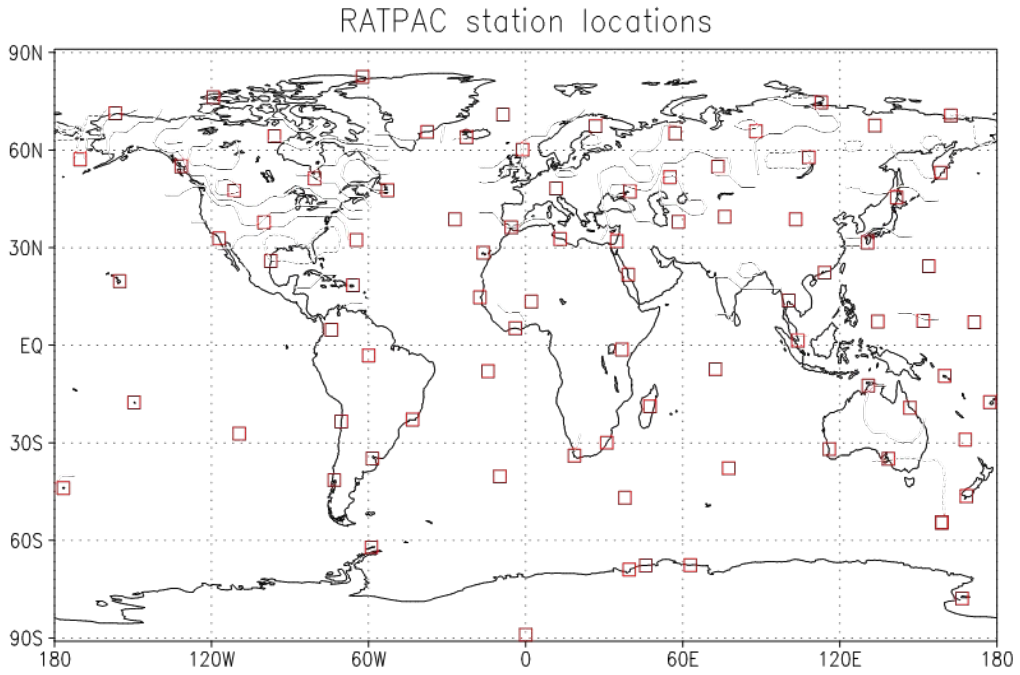
- Overview of radiosonde datasets
- Spatial sampling issues
- Problems with homogeneity adjustments
- How much difference does it make which sonde dataset we use?
- How similar are climate signals in radiosondes to those in satellite data?

Radiosonde datasets

Name	Source	Stations	Adjustment method
Angell	NOAA	63 (54)	None
RATPAC	NOAA	85	Manual, multiple indicators (pre-1995)+ first differences (post-1995)
HadAT2	UKMO	676	Automated, neighbor comparisons
IUK	Yale	527	Kriging
RAOBCORE	U. Vienna	>1000	Automated, reanalysis background as ref.
RICH	U. Vienna	>1000	Reanalysis to find changepoints Radiosondes to get adjustments

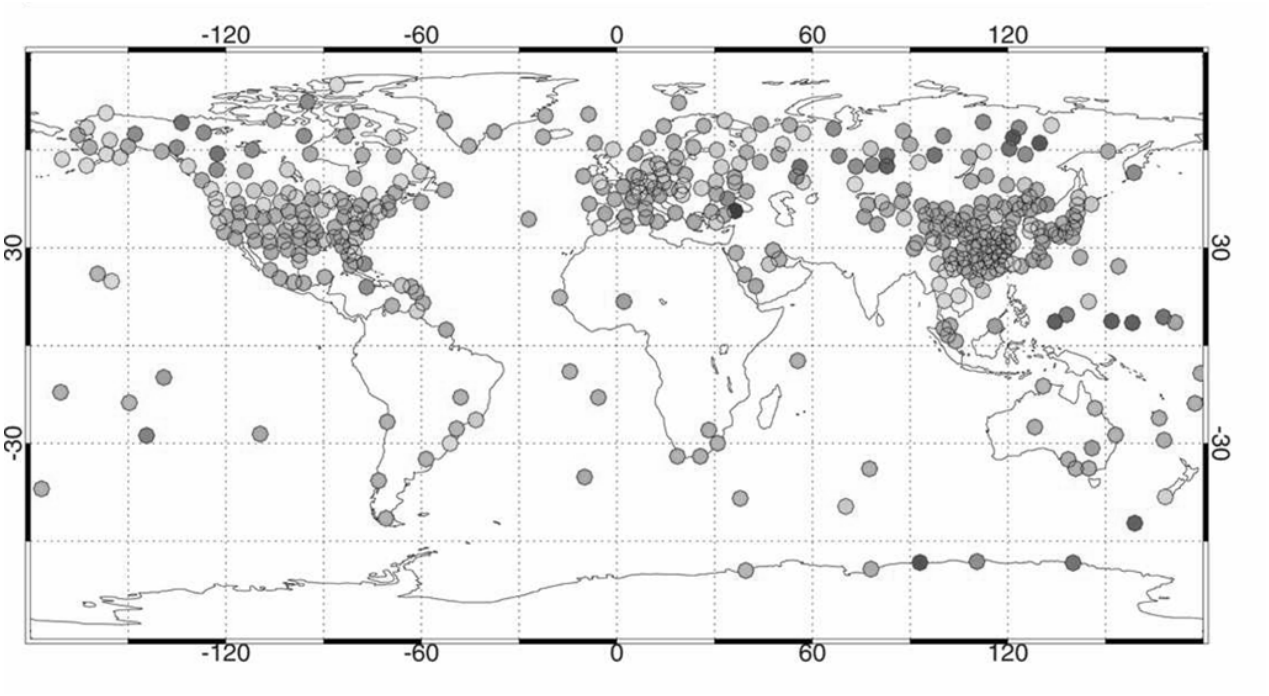
Name	Pro	Con
Angell	No errors introduced from adjustments	No adjustments Few stations
RATPAC	Conservative adjustments Independent of satellites.	Known jumps left. Few stations.
HadAT2	More stations. Smoother. Independent of satellites.	Some jumps still left.
IUK	Independent of satellites	Not updated Few levels in troposphere
RAOBCORE	Most stations.	Affected by problems in reanalysis?
RICH	"	"

(Not a complete list)

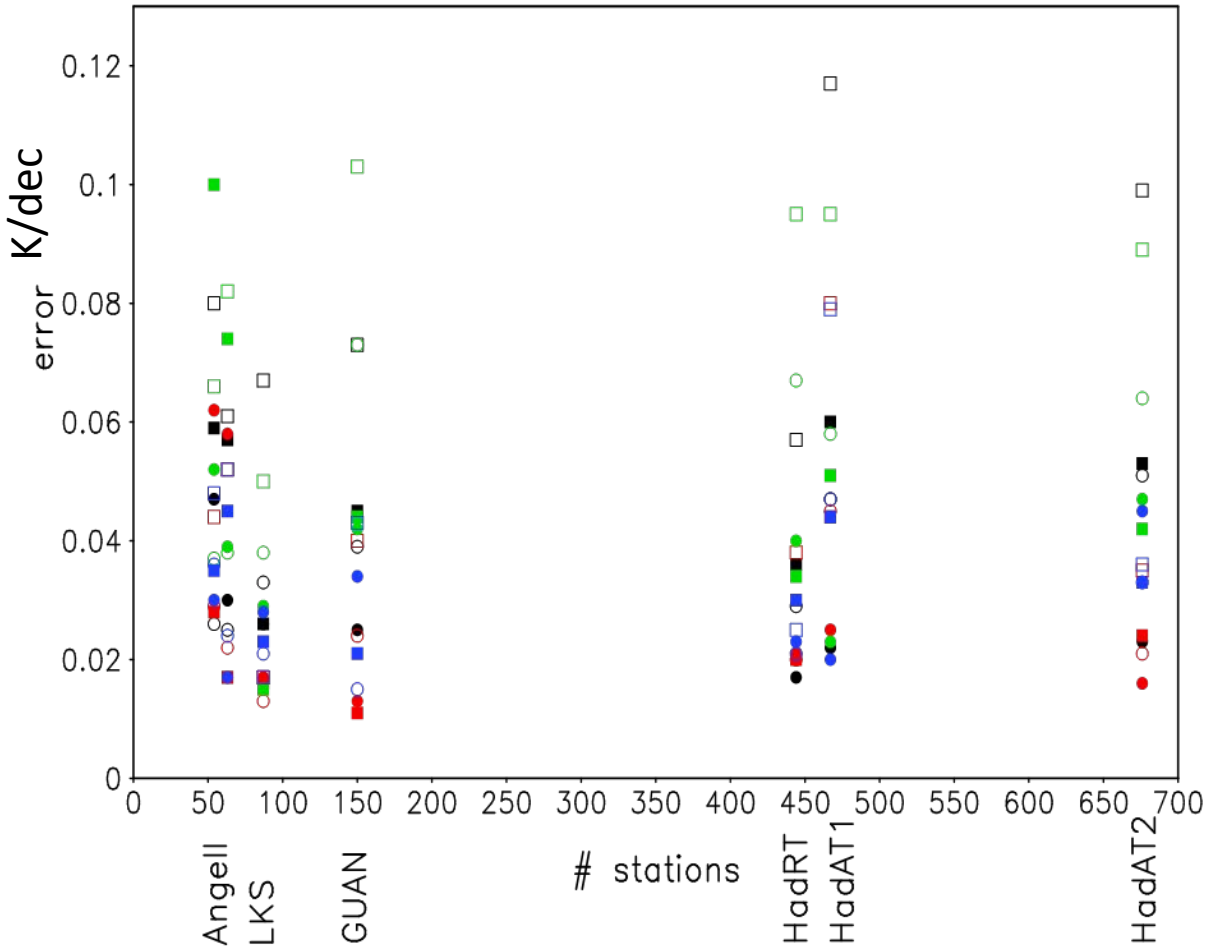


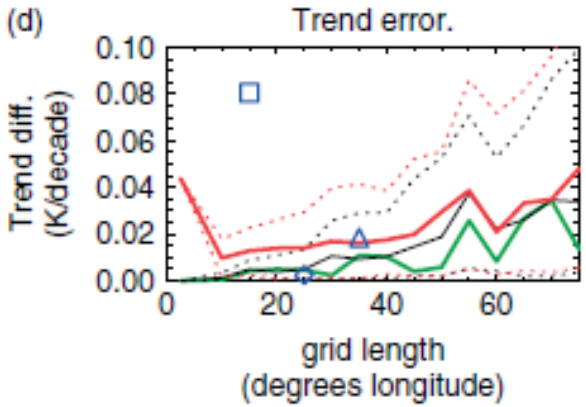
Despite larger number of stations, same large gaps over oceans, Africa, etc.

RAOBCORE station locations



Spatial sampling errors in trends from actual radiosonde networks using reanalysis- no decrease with increasing size





McCarthy et al. 2007

50

200

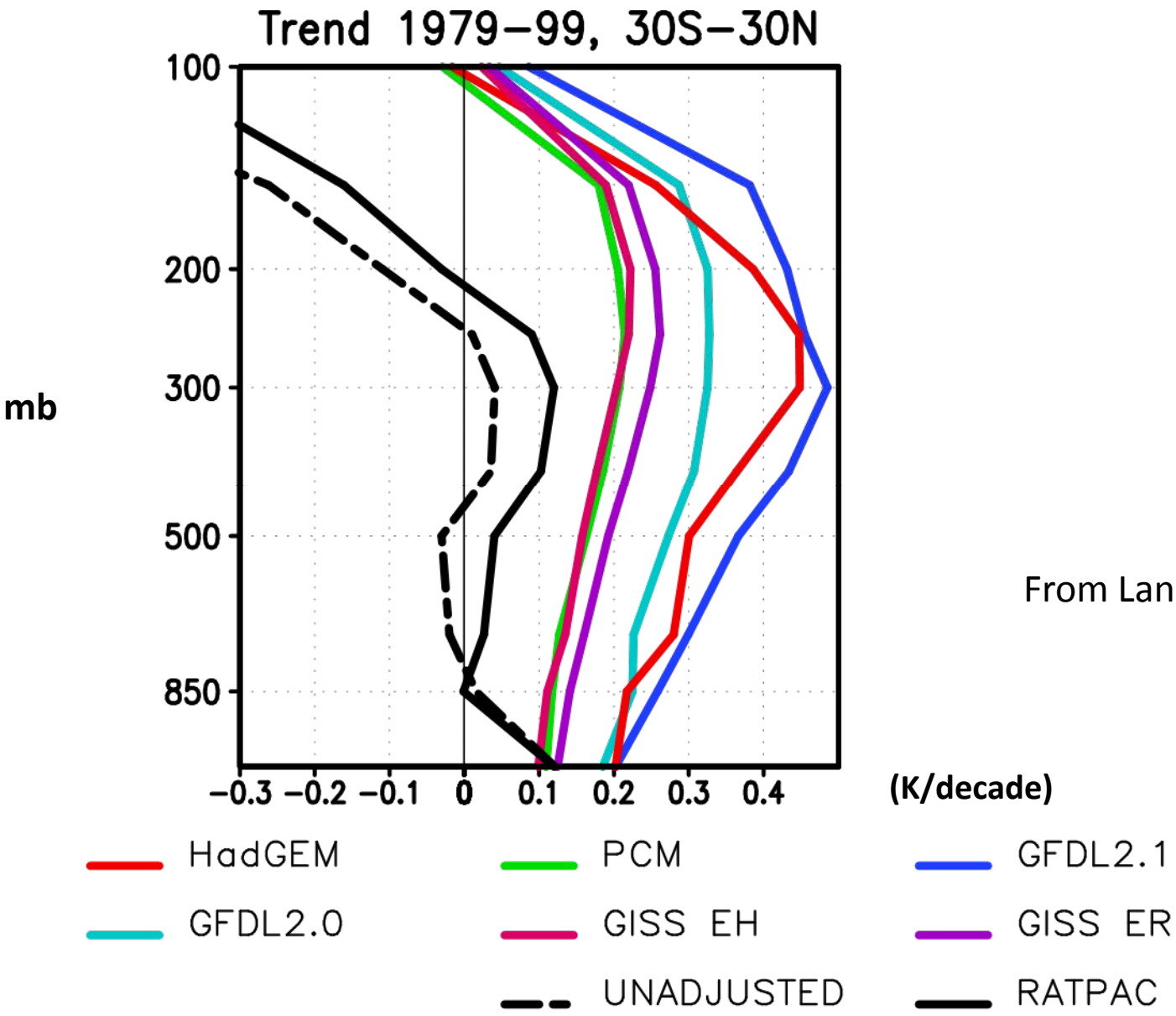
500

850

From Free and Seidel 2005

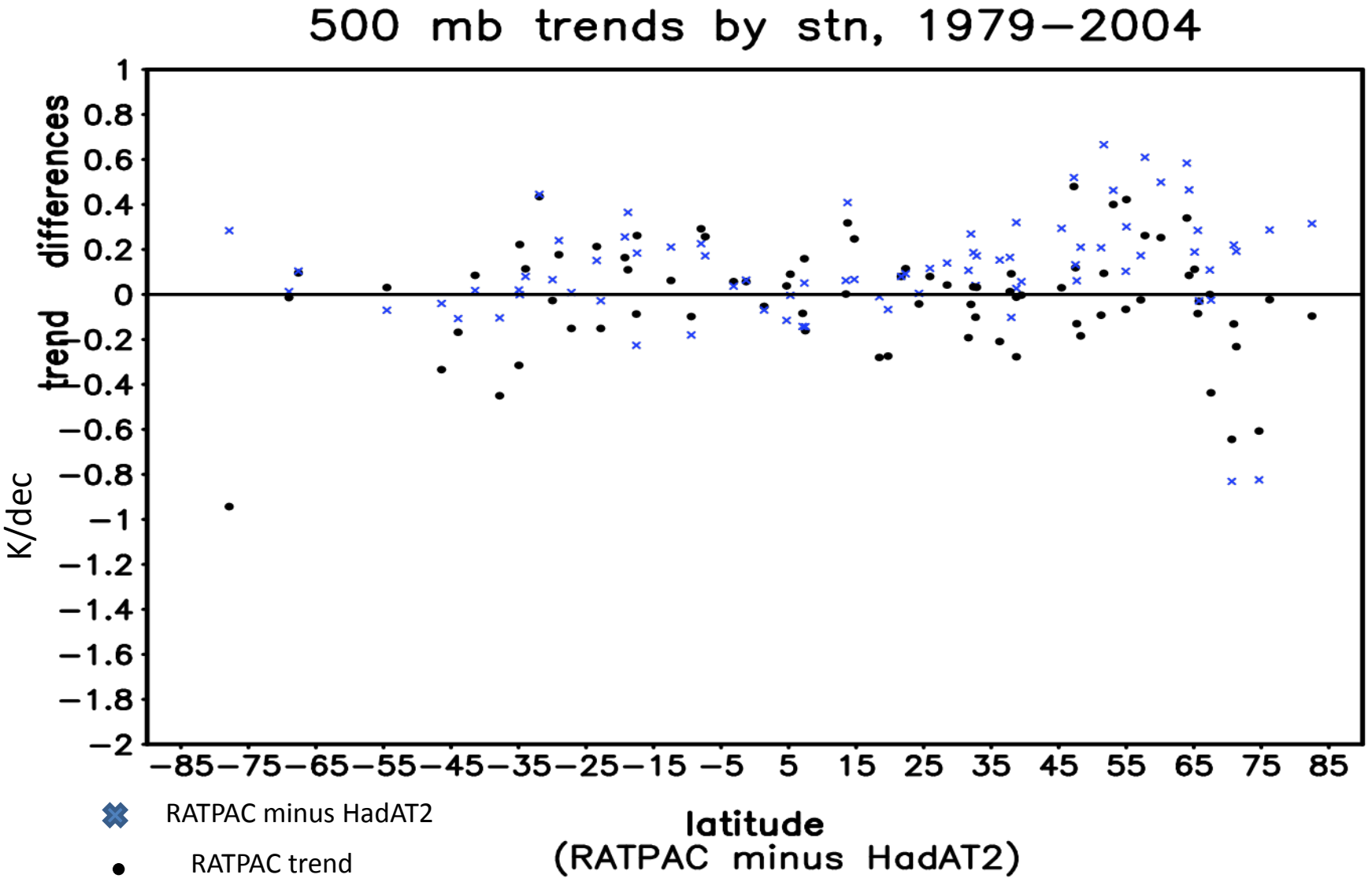
tropics SH NH Globe

Adjustment typically increases trend and brings it closer to models



From Lanzante and Free 2008

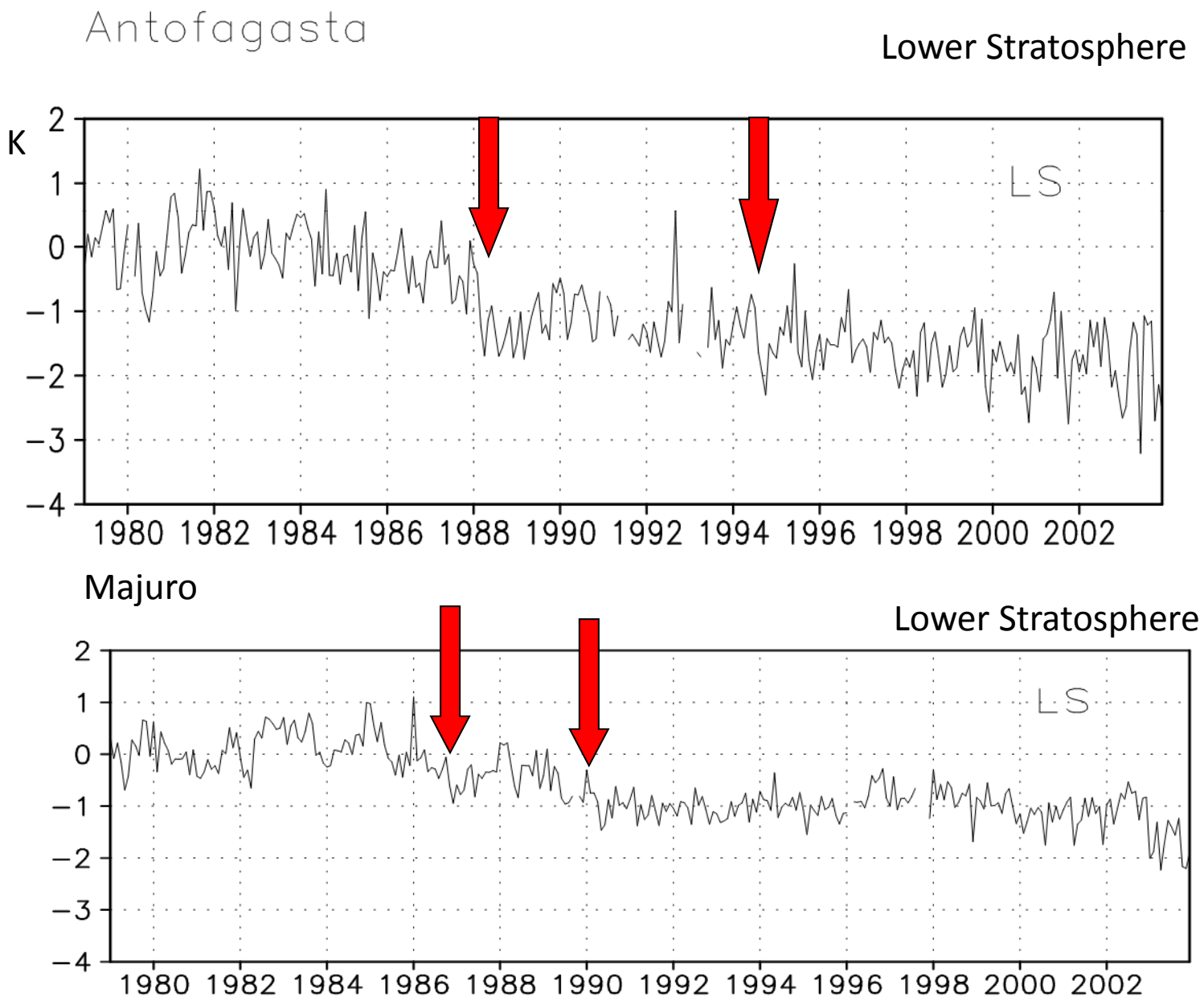
But even after adjustments, differences between trends at individual stations in different datasets can be comparable in size to the trends themselves.



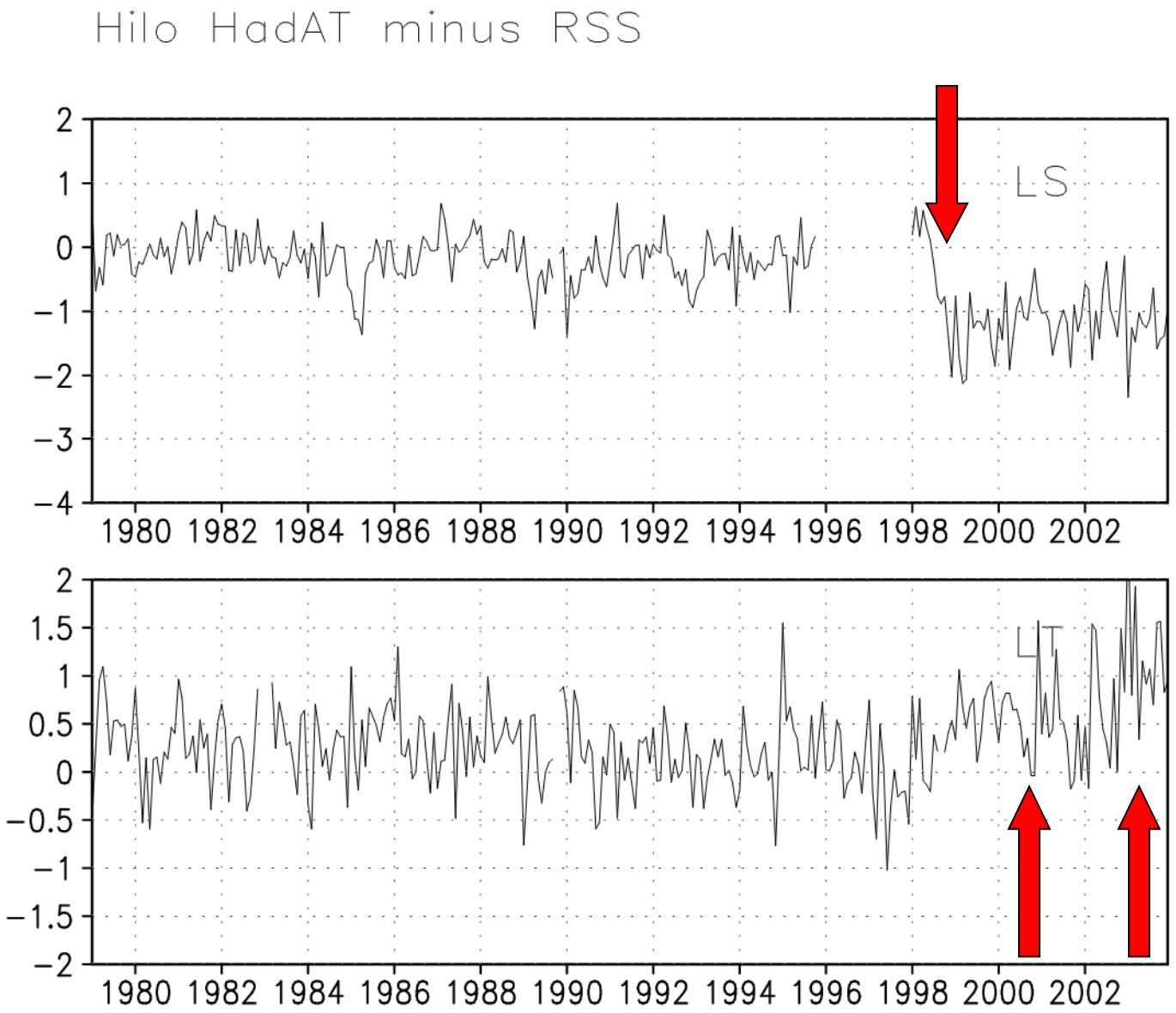
Adjusted datasets still contain apparent problems

(Randel and Wu 2006, Free and Seidel 2007)

RATPAC sonde minus RSS satellite

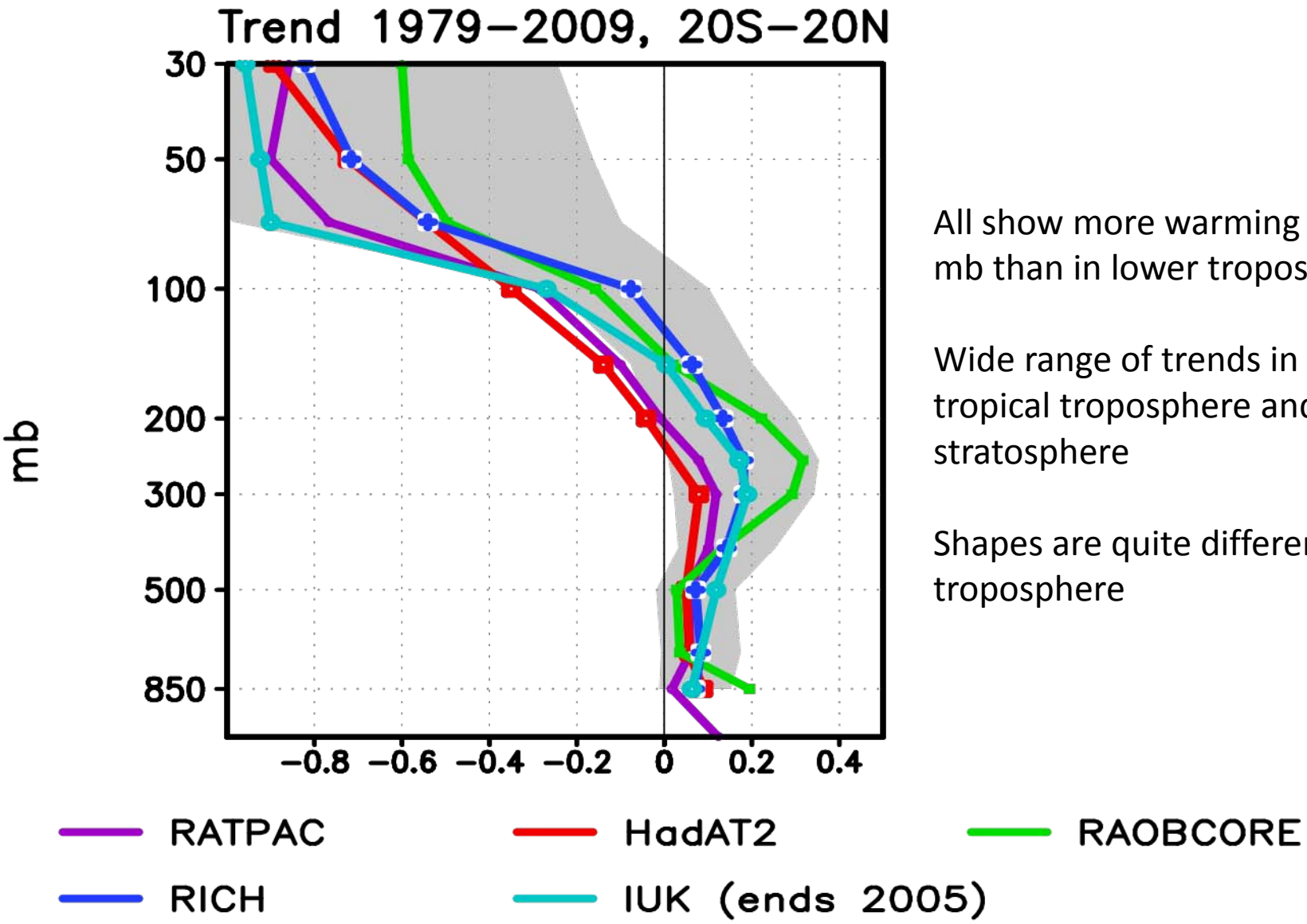


Suspicious events also occur in datasets other than RATPAC



Can we tell which set is best?

Possible criteria	Issues
Coverage/sampling	Are more stations always better?
Degree of spatial variability	Not clear if less means a better trend
Difference in day vs. night trends	Necessary but not sufficient
Comparisons to satellite data or reanalysis	Is the reference dataset homogeneous?
Physical plausibility of signals	Do we know what to expect?
Consistency with other climate variables	Are they known any better than temp?
Availability of updates	
Level of spatial or temporal resolution	



All show more warming at 300 mb than in lower troposphere

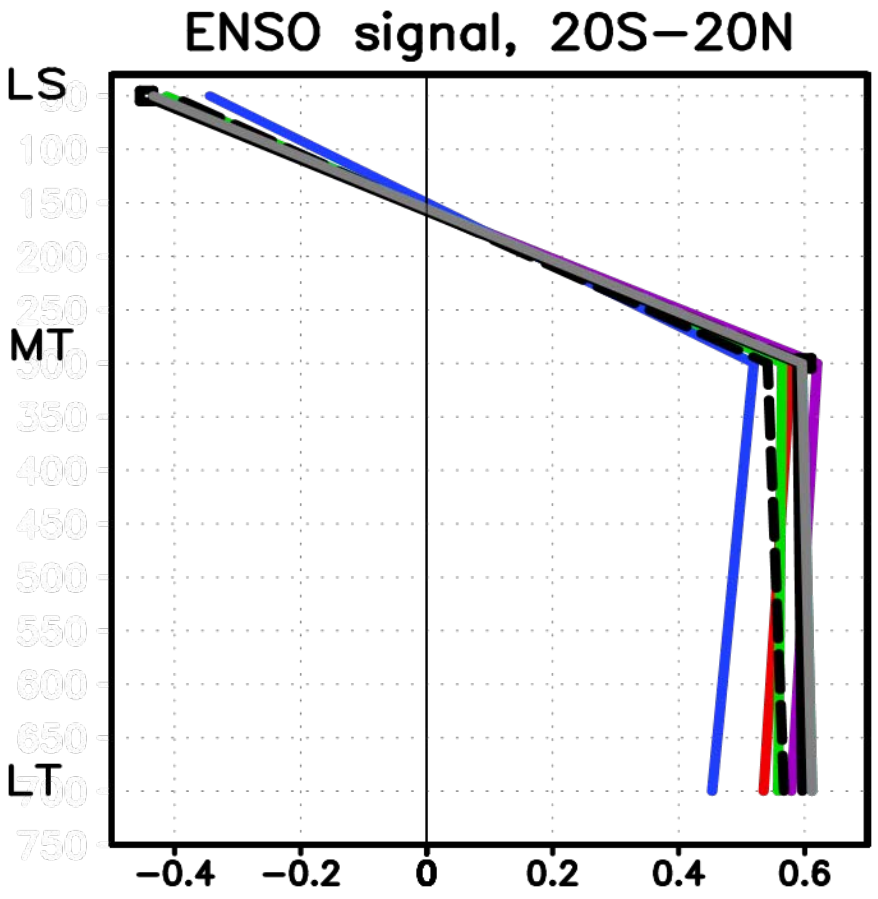
Wide range of trends in upper tropical troposphere and stratosphere

Shapes are quite different in troposphere

Shading= 95% confidence interval for RICH

How similar are climate signals in radiosondes to those in satellite data?

- ENSO
- Volcanic effects
- Trends
  - Latitudinal patterns
  - Seasonal patterns
  - Relation between levels



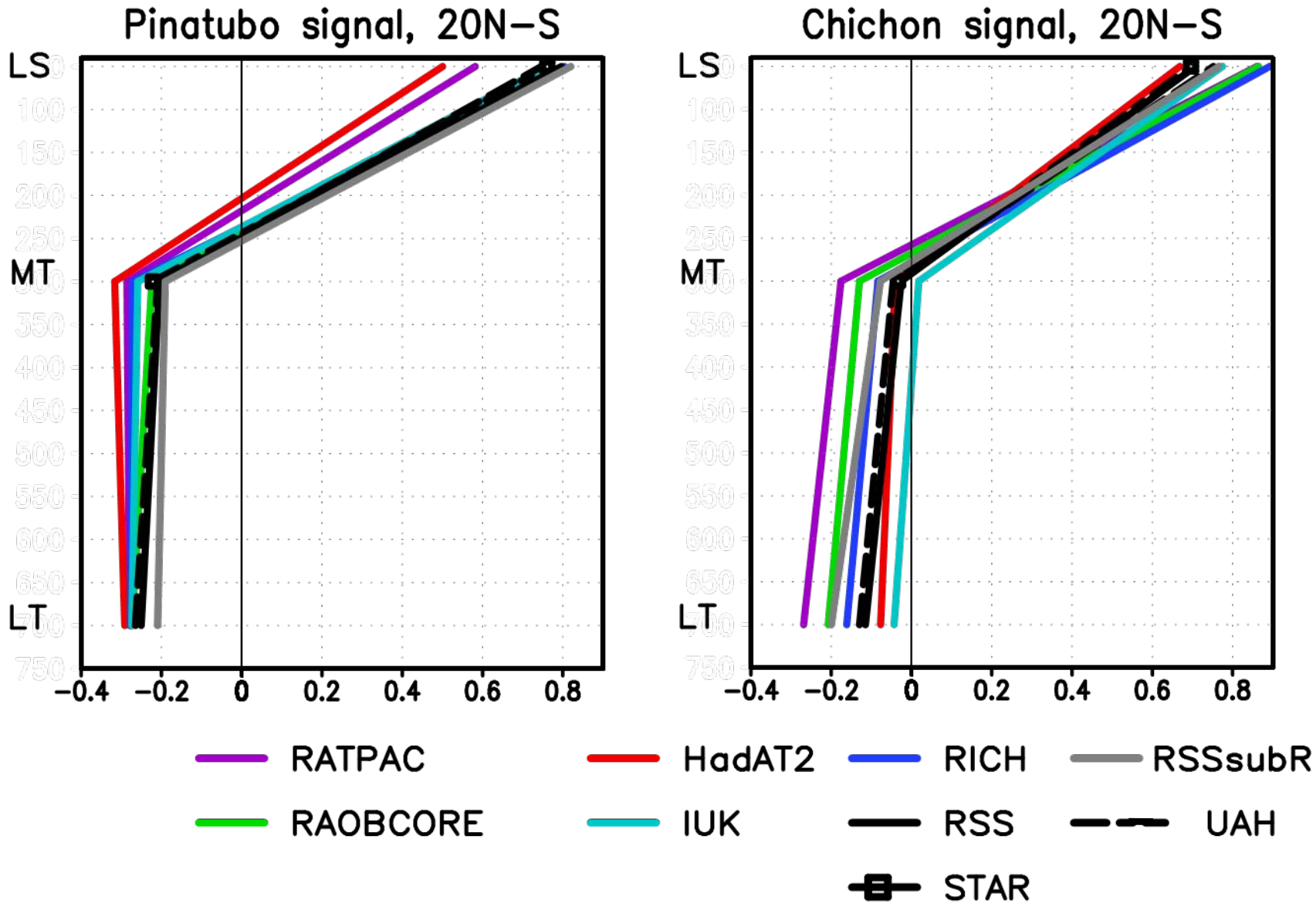
From linear regression using Nino3.4 SSTs

Signals similar overall
Less response in UAH than others

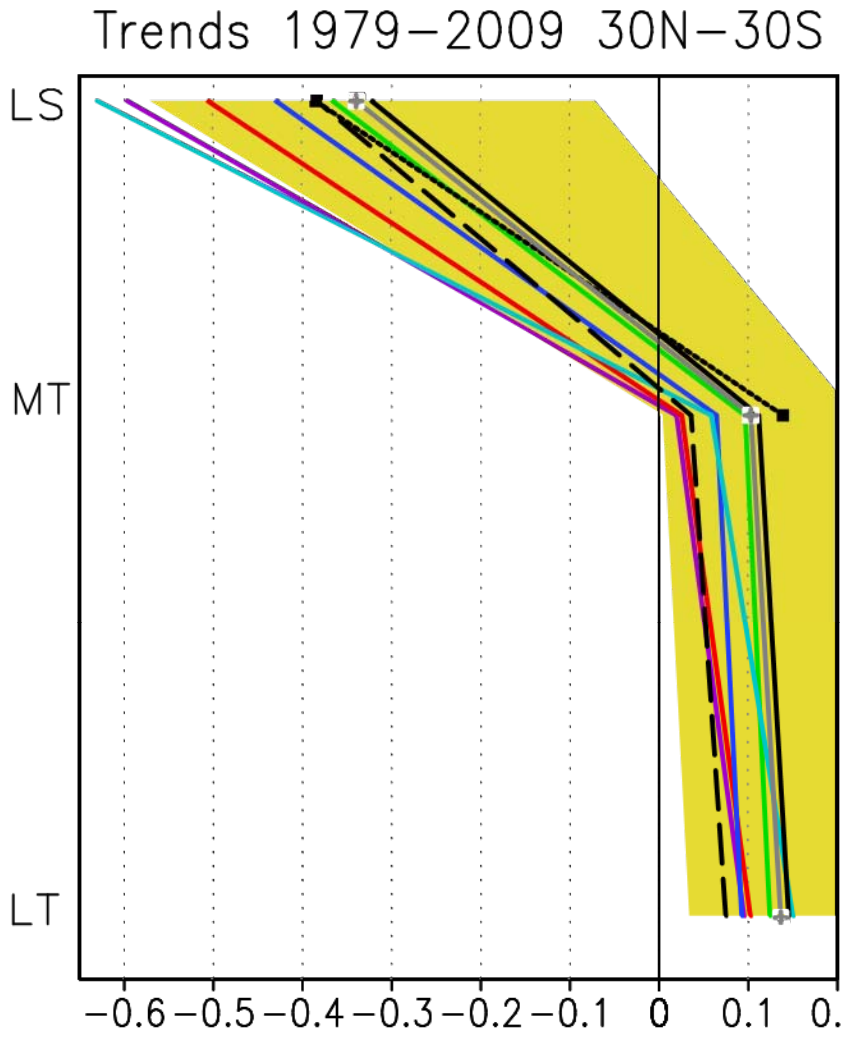
RATPAC
RAOBCORE
HadAT2
IUK
RICH
RSS
STAR
RSSsubR
UAH

2 years after minus 2 years before eruption

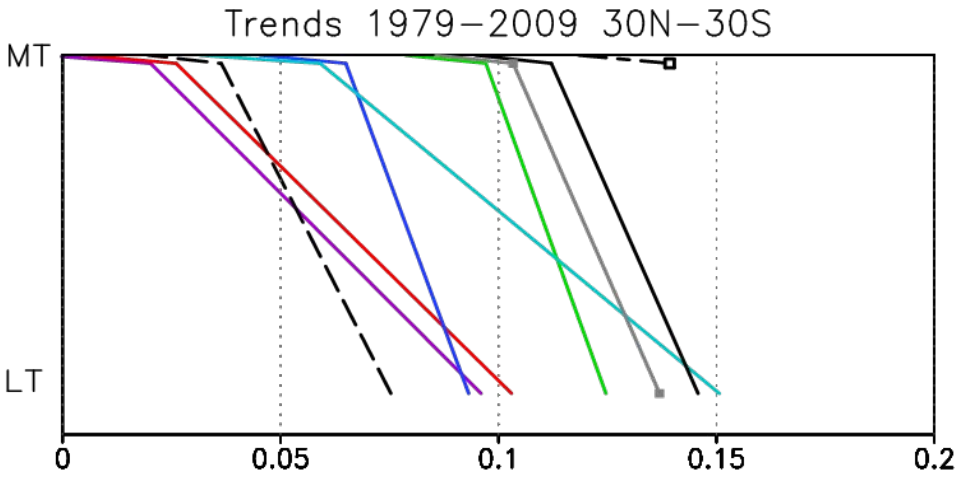
Satellites have ~ same signal; more spread for sondes



Vertical trend pattern

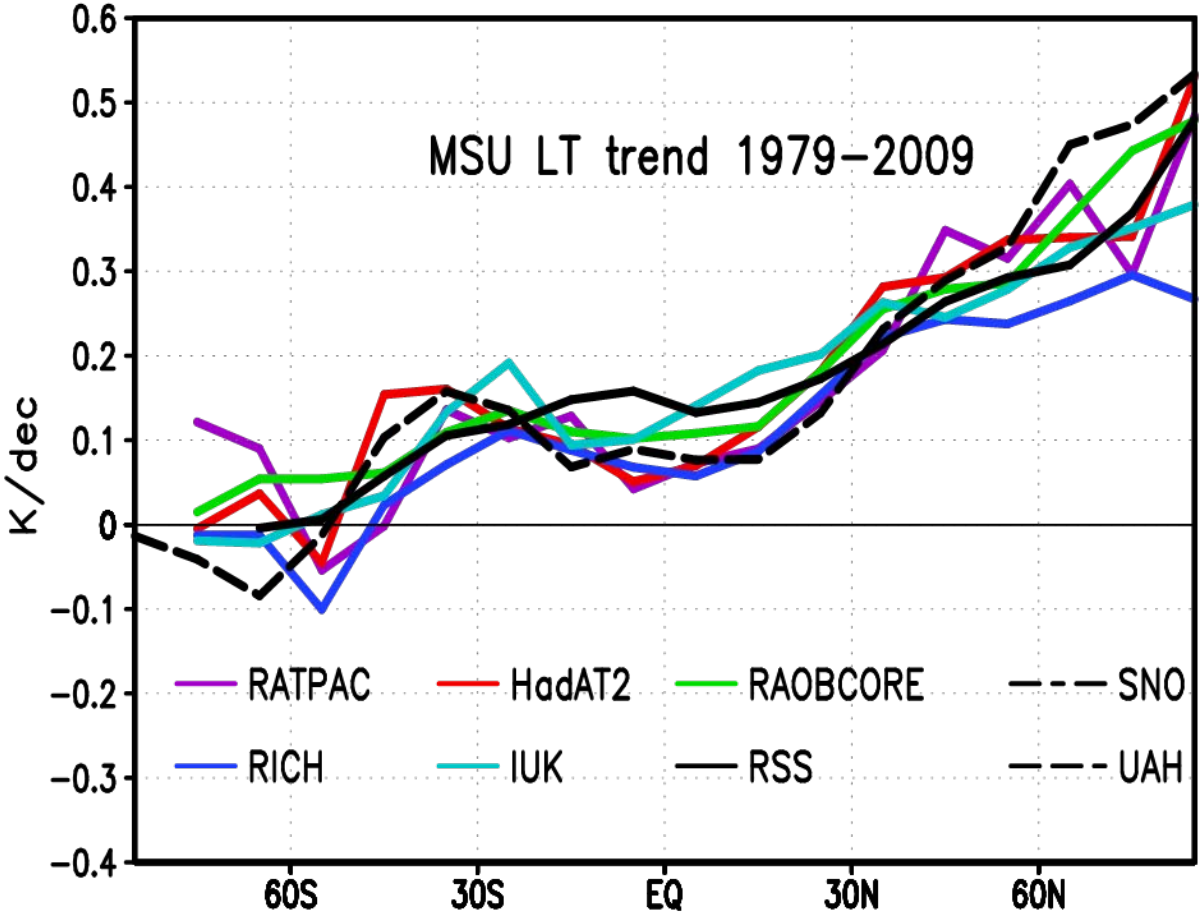


LT > MT for all sets
Relation similar for UAH and RSS



RATPAC
HadAT2
RICH
RSSsubR
RAOBCORE
IUK
RSS
UAH
STAR

Trends:
Latitudinal trend patterns

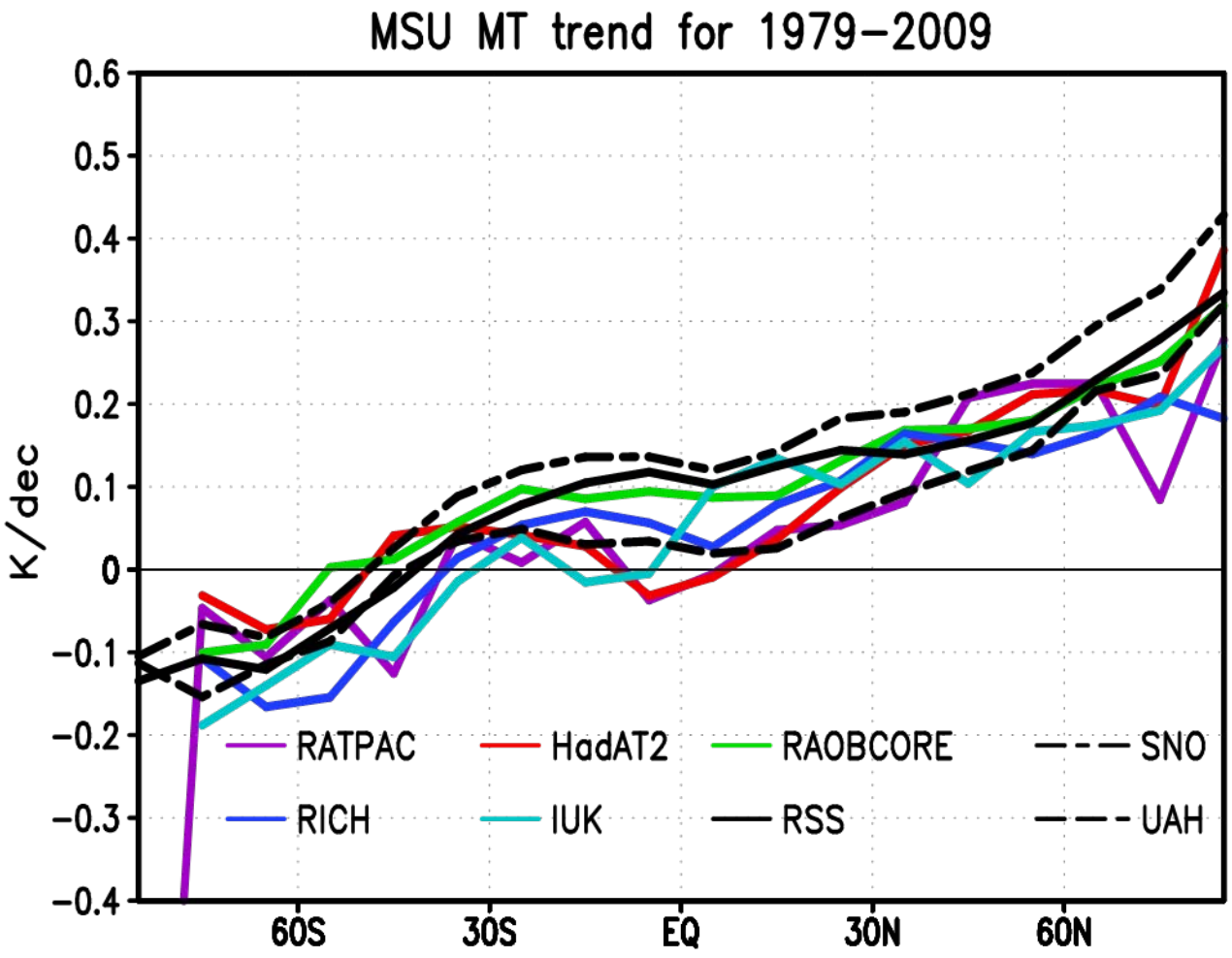


Common: increasing trend from S Pole to N Pole

Satellites differ most in tropics and Arctic

Sonde trends mostly at low end of satellite trends

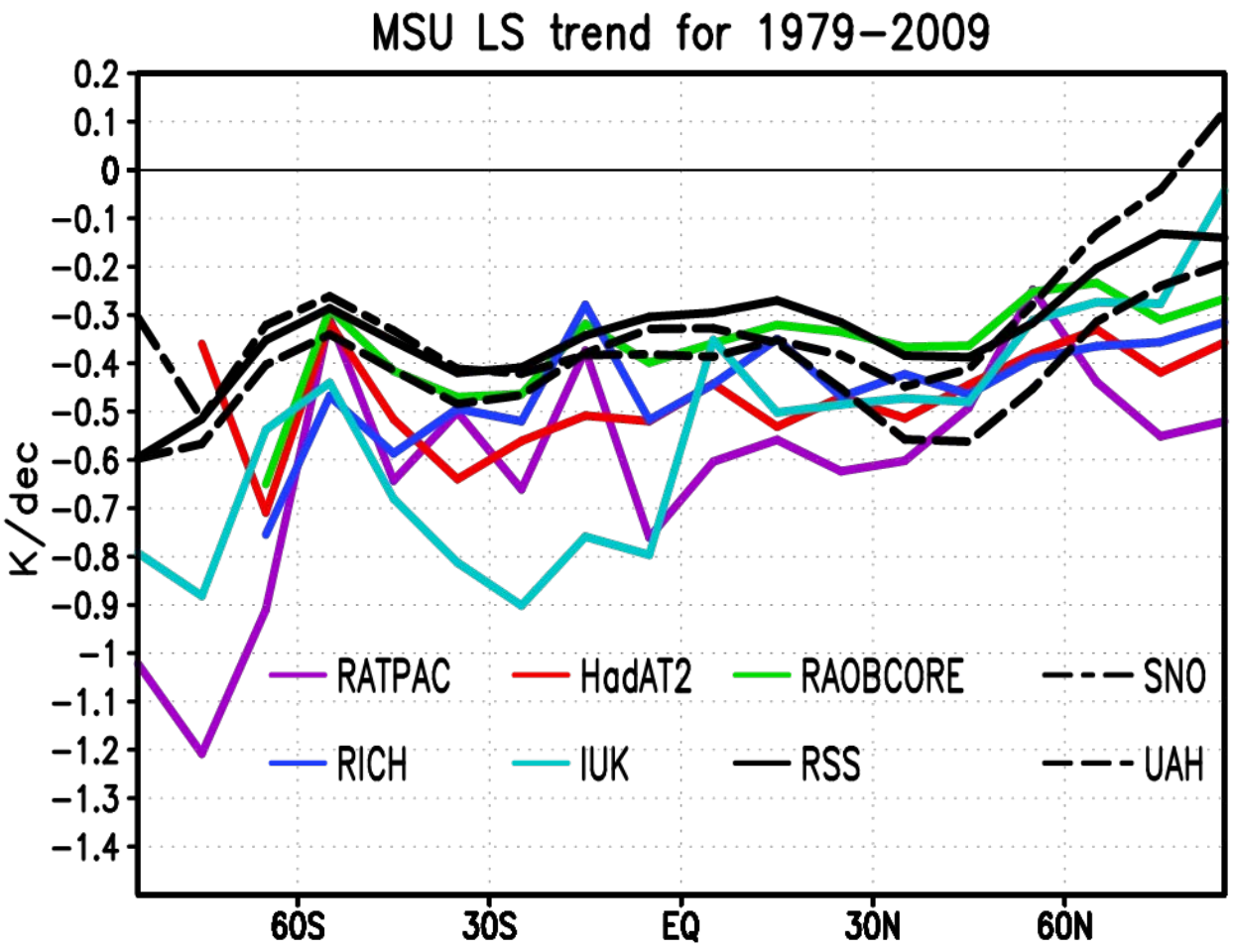
Sonde trends much noisier



SH-NH gradient again

STAR-RSS closest in tropics

UAH-RSS farthest apart in tropics

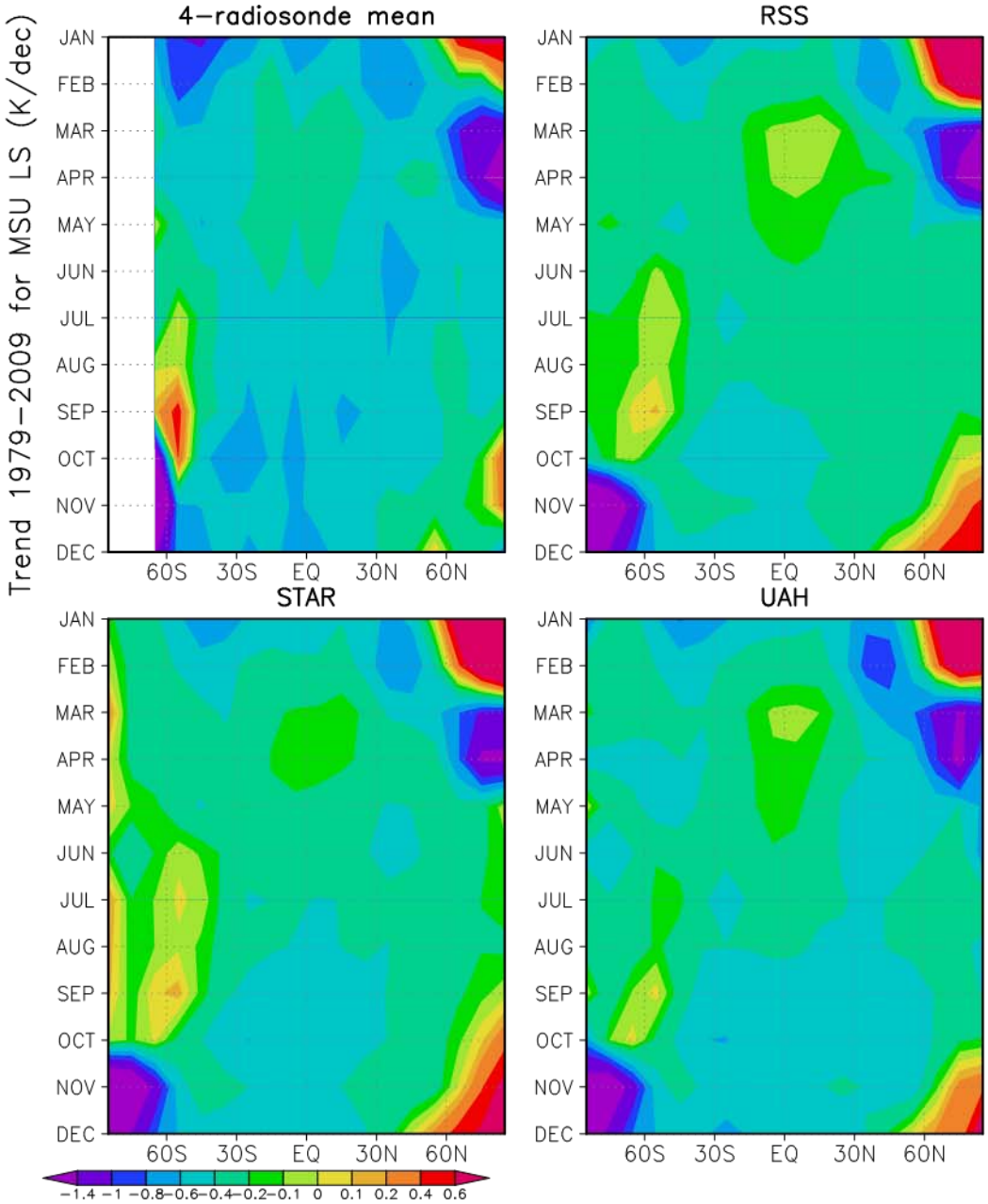


Satellites show much less cooling in Arctic than elsewhere; not so clear in sondes

Large variability in sonde trends

Satellite trend range is larger for 30-60 N than tropics; sonde trends are most consistent there

Seasonal trend patterns in the stratosphere



Antarctic spring warming and cooling
Lin et al., Hu and Fu 2009

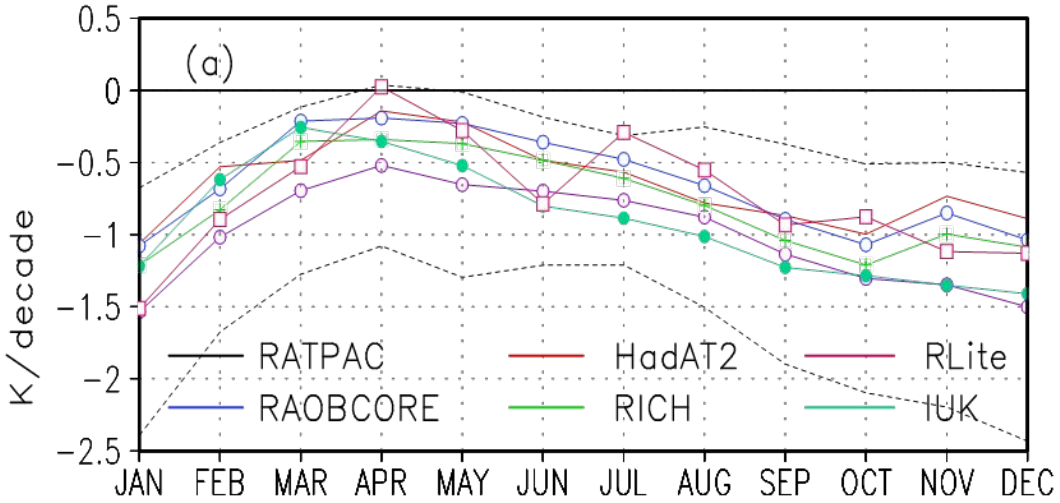
Arctic winter warming and spring cooling

Greater cooling in tropics in boreal winter

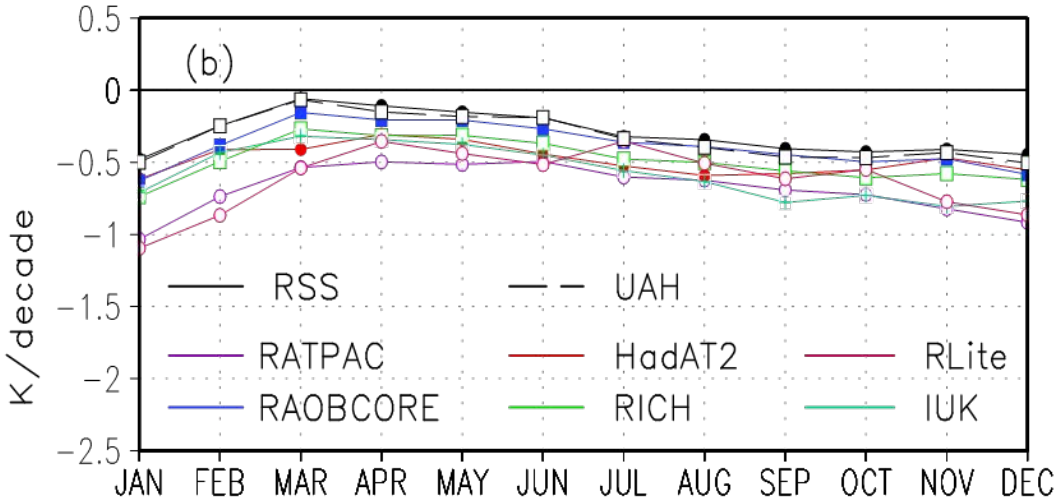
Patterns mostly similar among datasets despite spatial coverage differences

Seasonal pattern of trends in tropical stratosphere

50 mb
10NS

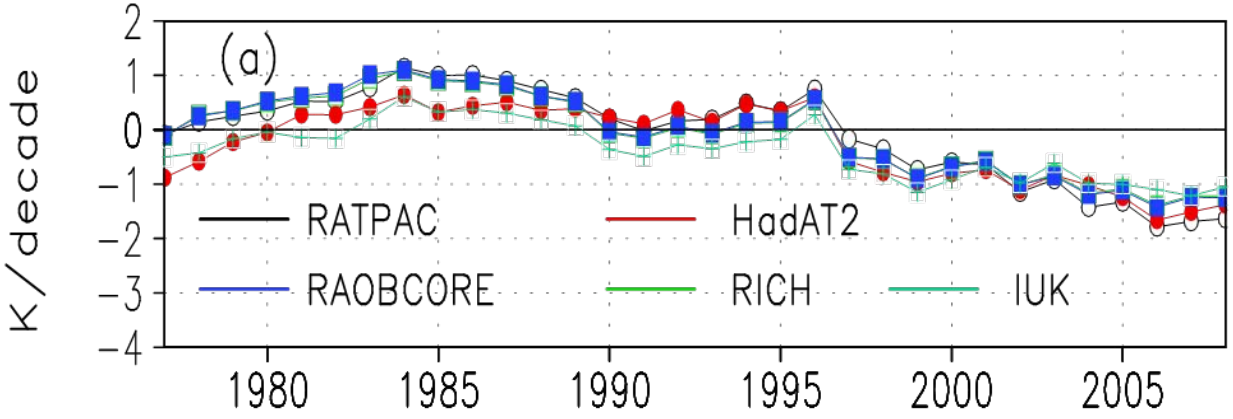


MSU LS
10NS



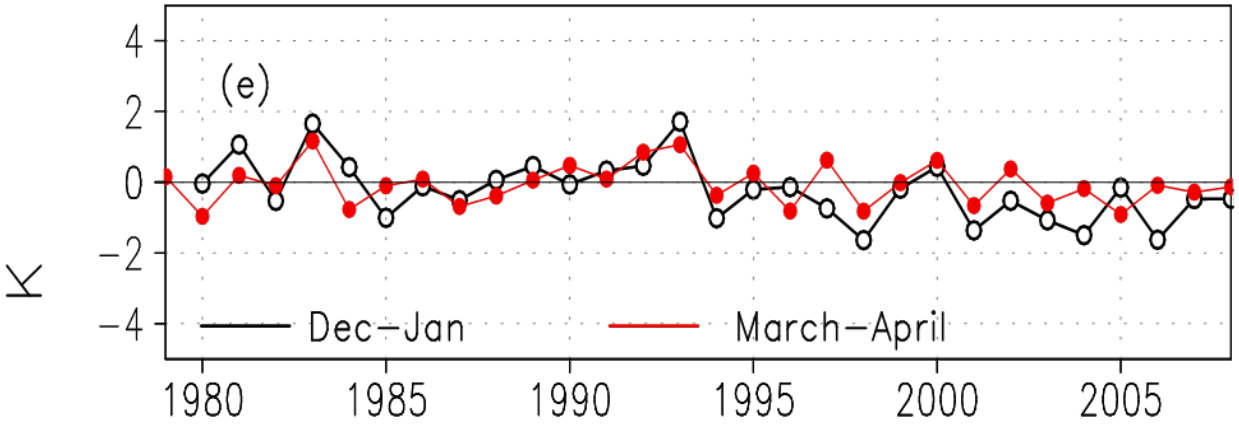
The tropical seasonal pattern seems to be a recent development (mid-90s)

Jan minus April Trends for 20-year periods, 50 mb, 10NS



Seasonal difference is not negative until after 1995

RSS LS, 10NS



Winter T declines more sharply in mid-90s than Spring T does

Conclusions

- Adjusted sonde datasets still have problems.

- Not clear which sonde datasets are best.

- It is hard to use sondes to evaluate long-term changes in satellite records because sondes have large uncertainties.

- Short-term signals are generally similar in most datasets, and many patterns in the trends are also similar.

- Radiosonde trends still usually on low side in comparison with satellites

- Trend patterns in the stratosphere are subject of new work, but large interannual variability increases uncertainties there.

Santer et al. International J. of Climatology 2008

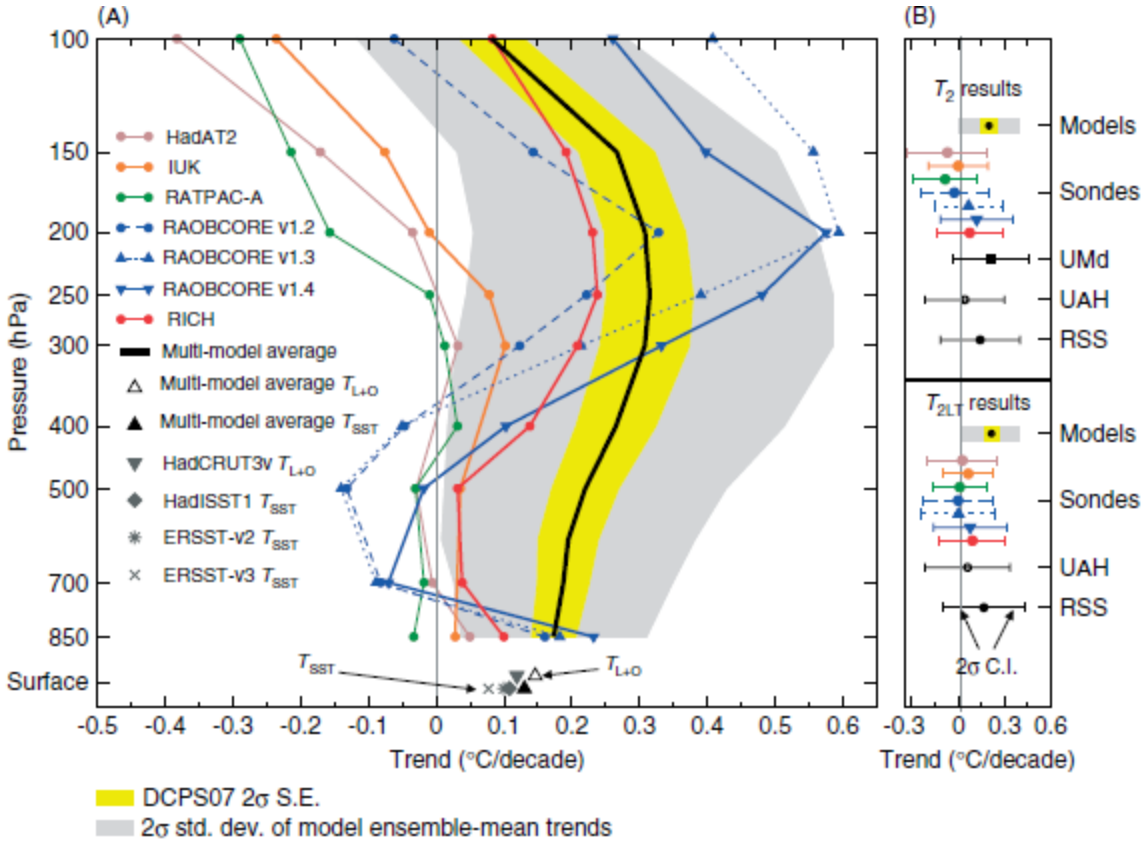


Figure 6. Vertical profiles of trends in atmospheric temperature (panel A) and in actual and synthetic MSU temperatures (panel B). All trends were calculated using monthly-mean anomaly data, spatially averaged over 20°N–20°S. Results in panel A are from seven radiosonde datasets (RATPAC-A, RICH, HadAT2, IUK, and three versions of RAOBCORE; see Section 2.1.2) and 19 different climate models. Tropical T_{SST} and T_{L+O} trends from the same climate models and four different observational datasets (Section 2.1.3) are also shown. The multi-model average trend at a discrete pressure level, $\ll b_m(z) \gg$, was calculated from the ensemble-mean trends of individual models [see Equation (7)]. The grey-shaded envelope is $s\{<b_m(z)>\}$, the 2σ standard deviation of the ensemble-mean trends at discrete pressure levels. The yellow envelope represents $2\sigma_{SE}$, DCPS07's estimate of uncertainty in the mean trend. For visual display purposes, T_{L+O} results have been offset vertically to make it easier to discriminate between trends in T_{L+O} and T_{SST}. Satellite and radiosonde trends in panel B are plotted with their respective adjusted 2σ confidence intervals (see Section 4.1). Model results are the multi-model average trend and the standard deviation of the ensemble-mean trends, and grey- and yellow-shaded areas represent the same uncertainty estimates described in panel A (but now for layer-averaged temperatures rather than temperatures at discrete pressure levels). The y-axis in panel B is nominal, and bears no relation to the pressure coordinates in panel A. The analysis period is January 1979 through December 1999, the period of maximum overlap between the observations and most of the model 20CEN simulations. Note that DCPS07 used the same analysis period for model data, but calculated all observed trends over 1979–2004.