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Institut für Meteorologie
und Geophysik



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wien**

Bias Adjustments for the Upper Air Temperature and Wind Dataset

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4th Reanalysis Conference, Silver Spring, 10 May 2012

Outline

- Focus on T adjustments from 1958 onwards
- RAOBCORE/RICH homogenization system
- Some diagnostics of the adjustment system
 - Breaksize estimation
 - Adjustment ensembles, sensitivity experiments
 - Trend amplification
 - Comparison with satellite data
- Back to early 20th century -> Lorenzo R.
 - Early wind data

Observation Feedback

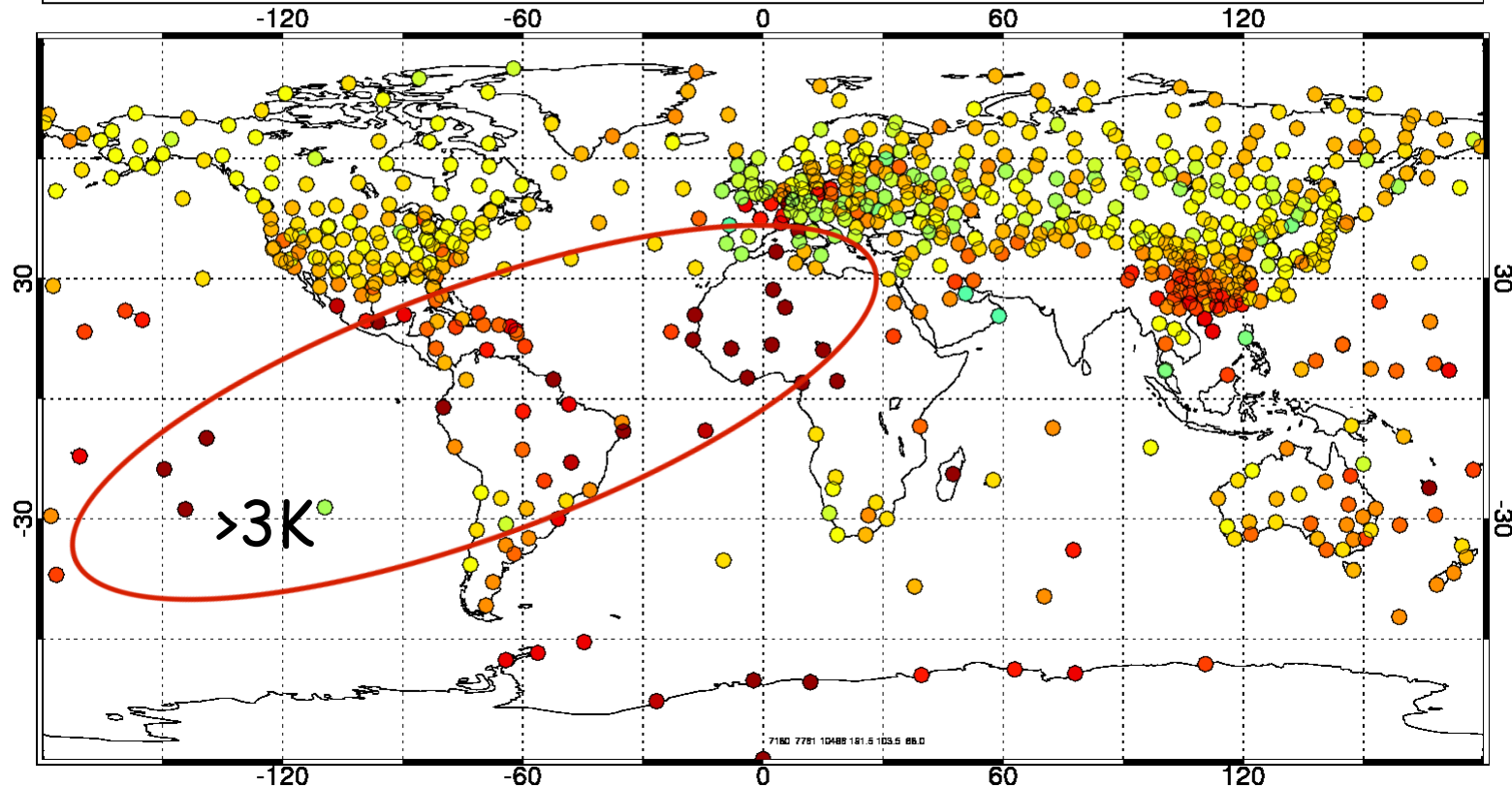
- Background ($y - Hx_b$) and analysis departure statistics from pilot assimilations and reanalyses
- **Credo: Departure statistics highly valuable for QC/BC**
- For RAOBCORE v1.5: departure statistics from
 - ERA-Interim (ODB files)
 - ERA-40 (BUFR files)
 - IGRA v1 (bg calculated „offline“ from interpolated gridded bg fields)
 - CHUAN v1 (bg calculated offline, z-level wind interpolated to p-levels)
 - **MERRA (first tests, a few years available)**
- Feedback from 20th Century Reanalyses v2
 - Obs from above archives
 - Departures from ensemble mean analysis interpolated to stations

1969-72 obs-bg at 100 hPa

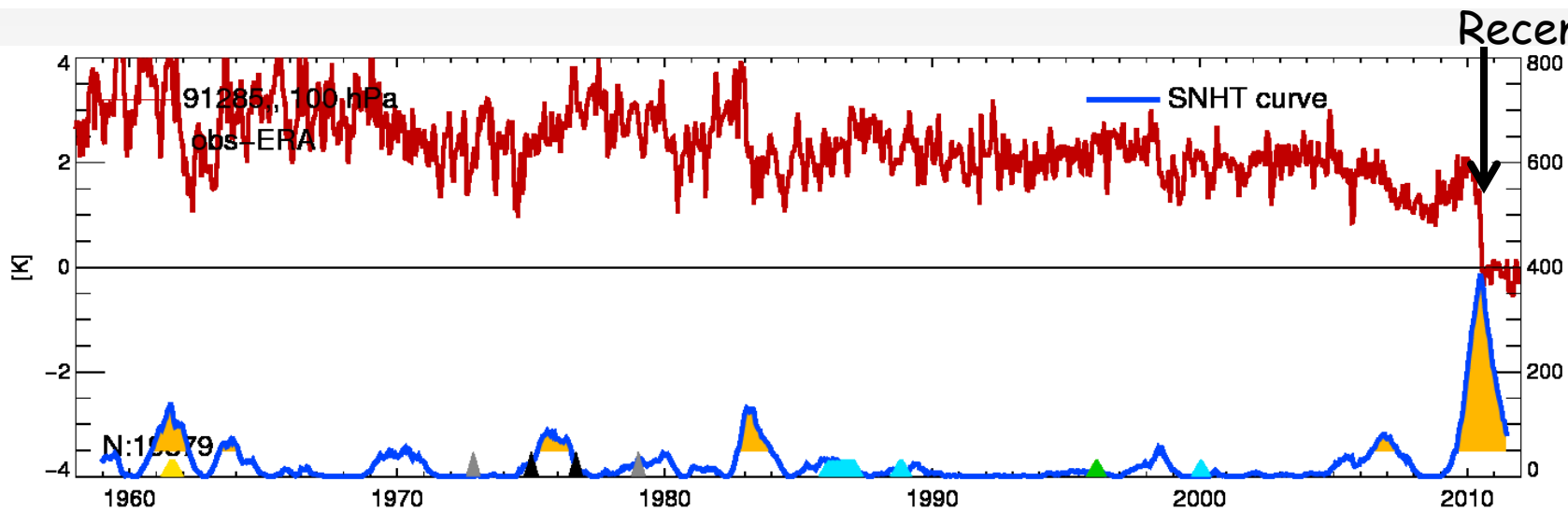
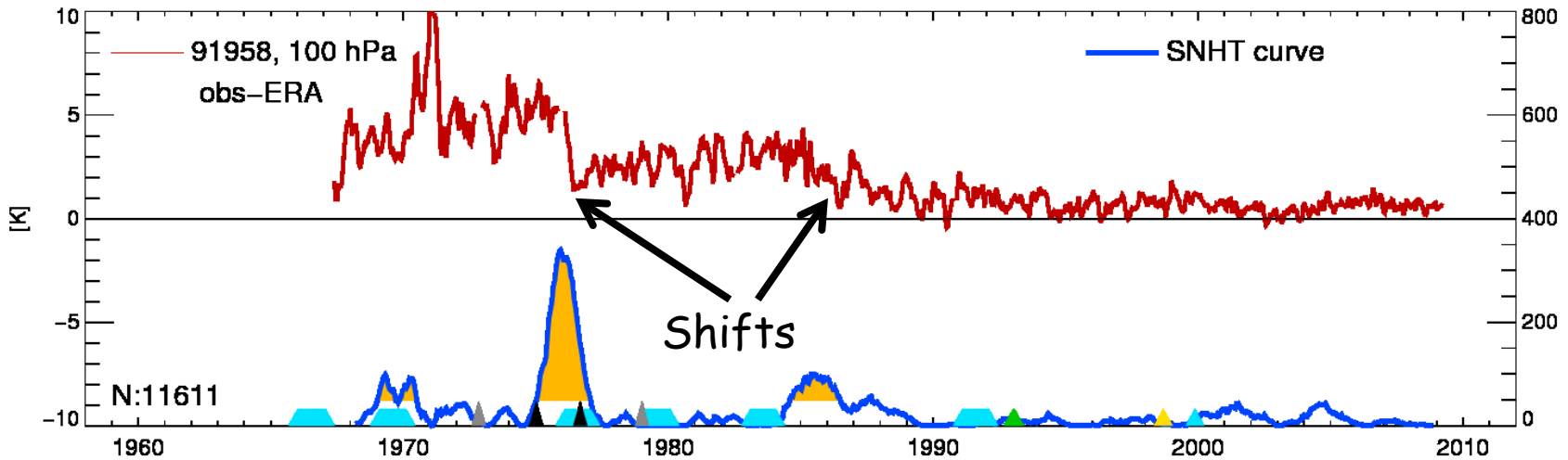
Temperature Difference 24h 1969-1972 100hPa, [K] Radiosondes, tm

Total monthly means: 35273 Evaluated Stations: 714 Cost:4063.21

-3.0 -2.7 -2.4 -2.1 -1.8 -1.5 -1.2 -0.9 -0.6 -0.3 0.0 0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0



Obs-bg (merged ERA-40/ERA-Interim)

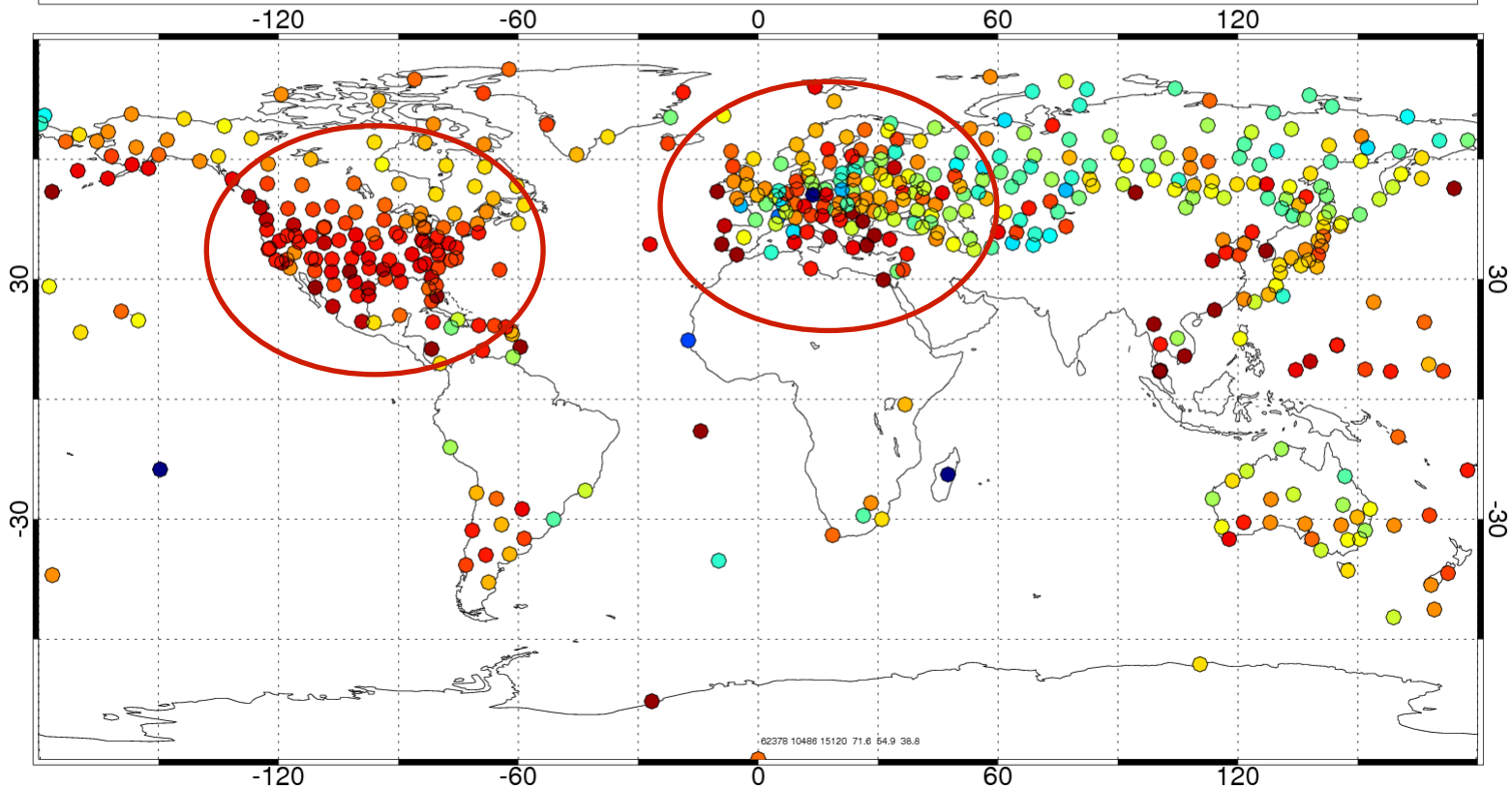


Trends 1964-1984, 100 hPa

Temperature Trend 24h 1964-1984 100hPa, [K/10a] Radiosondes, tm

Total monthly means: 123719 Evaluated Stations: 499 Cost:1564.42

-1.6 -1.5 -1.4 -1.3 -1.2 -1.1 -1.0 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3 0.4



Homogenisation methods

- **RAOBCORE „Radiosonde Observation Correction using Reanalysis“**
 - Detects inhomogeneities in observation records from $y-H(x)$ (obs-bg) time series
 - **Obs-bg time series also used for obs adjustment**
 - 1100 Stations, back to 1958
- **RICH „Radiosonde Innovation Composite Homogenization“**
 - Relies on breakpoints detected by RAOBCORE but **uses neighboring records for adjustment estimation**
 - RICH-obs compares 10-30 neighboring **obs** records
 - RICH- τ compares 10-30 neighboring **bg-obs** records

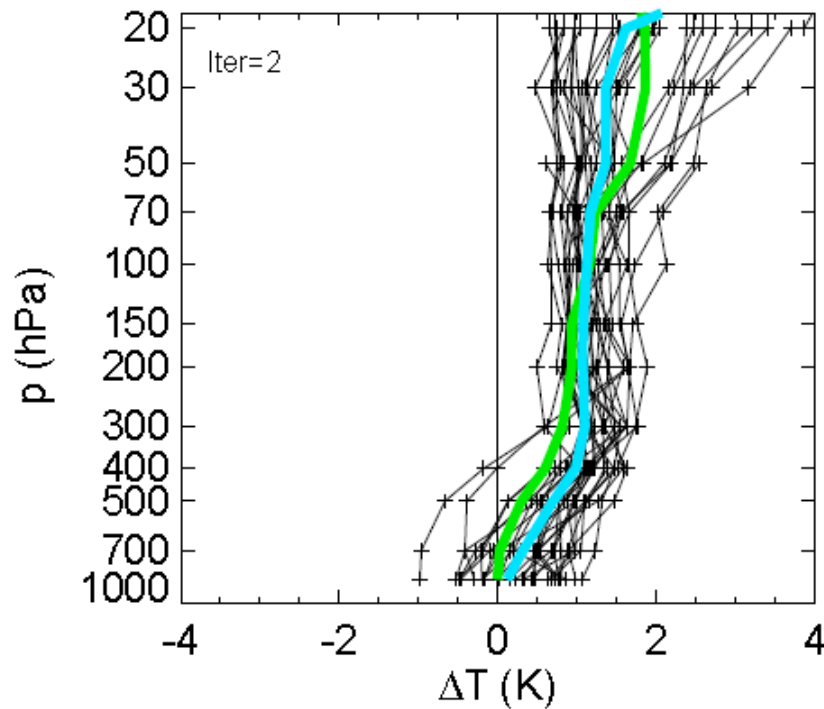
A breaksize estimation example

Bethel, Alaska, 198906

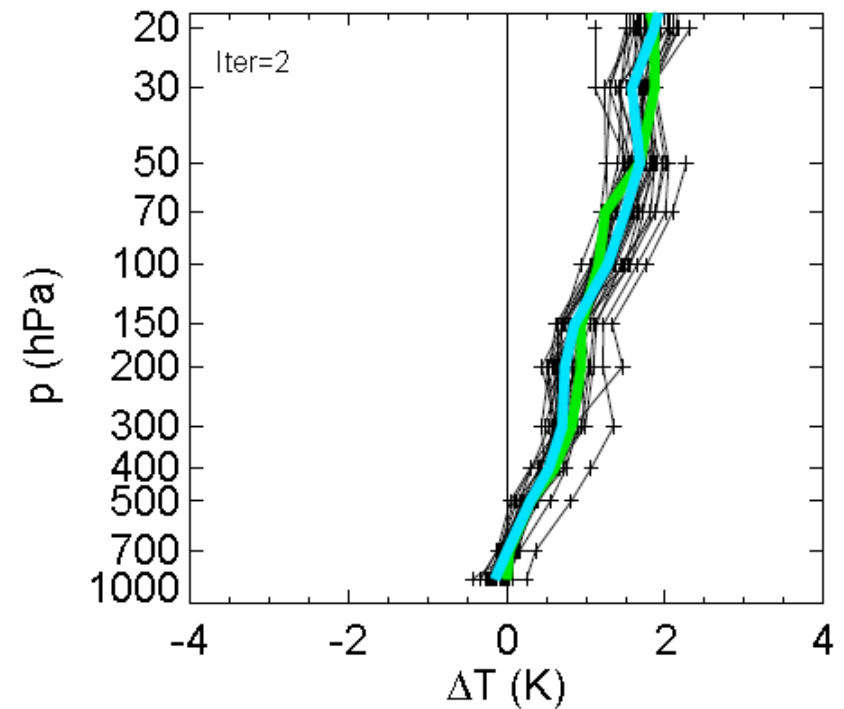
$$\Delta obs_{Test} - \Delta obs_{ref}$$

$$\Delta(obs - bg)_{Test} - \Delta(obs - bg)_{ref}$$

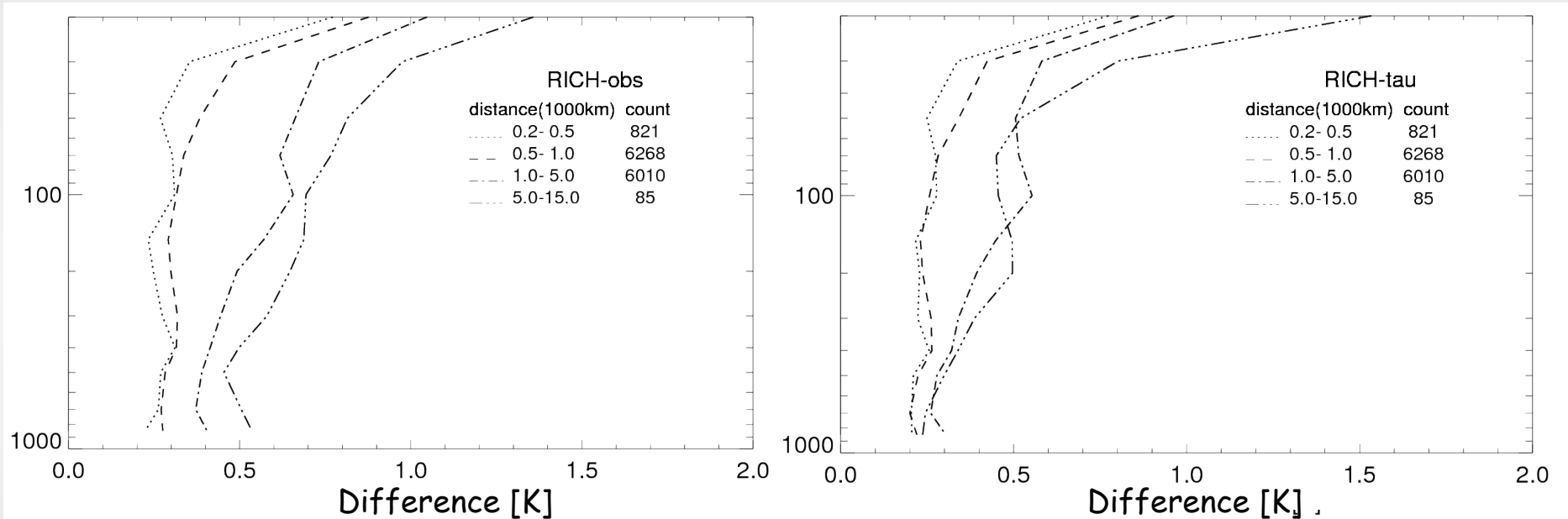
RICH-obs



RICH-tau

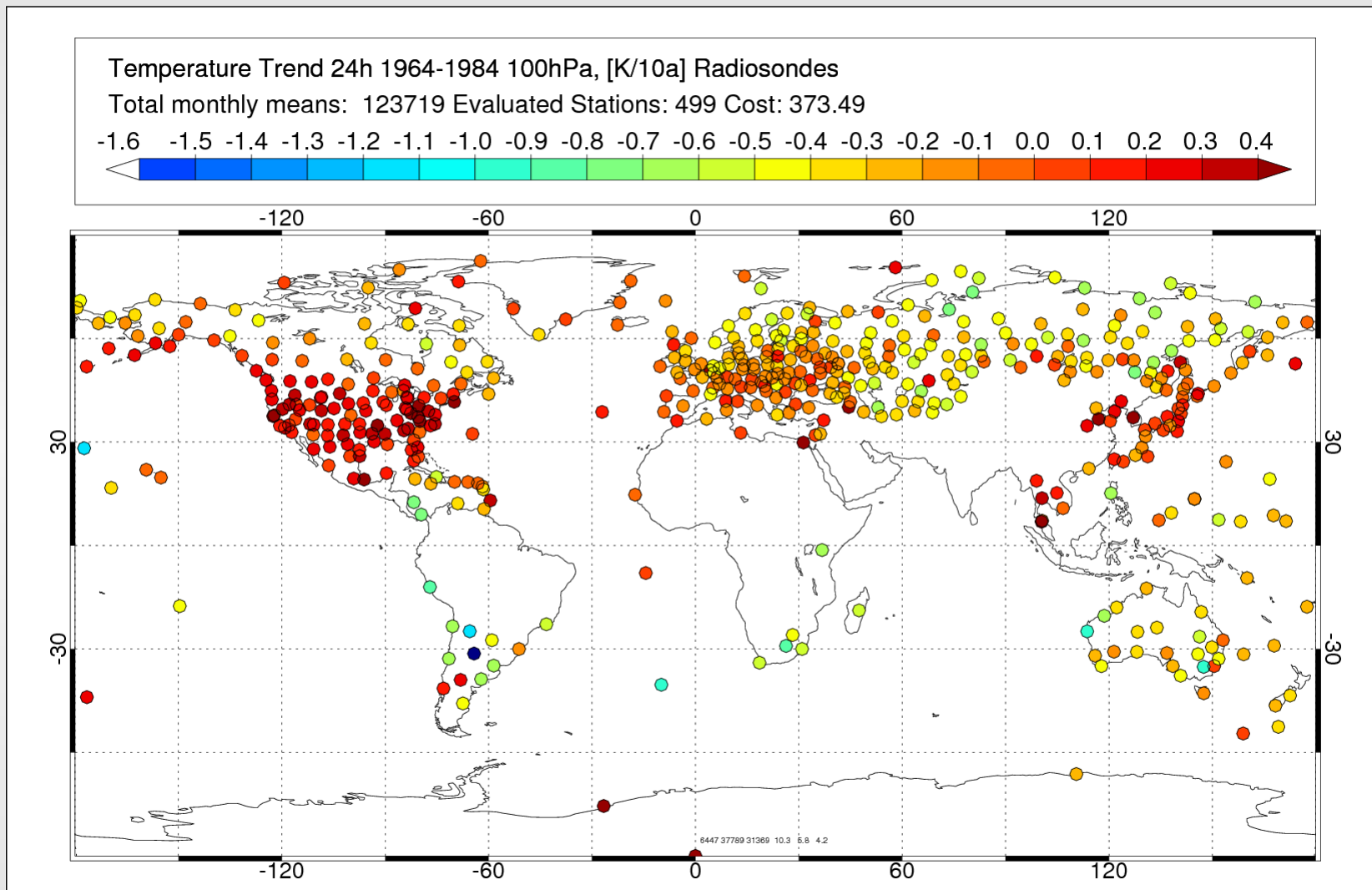


Difference between RAOBCORE and RICH breaksize estimates



- due to sampling differences
- due to undetected shifts in the reference series
- due to too little data for RICH mainly at high altitudes

RAOBCORE adjusted trends 1964-1984

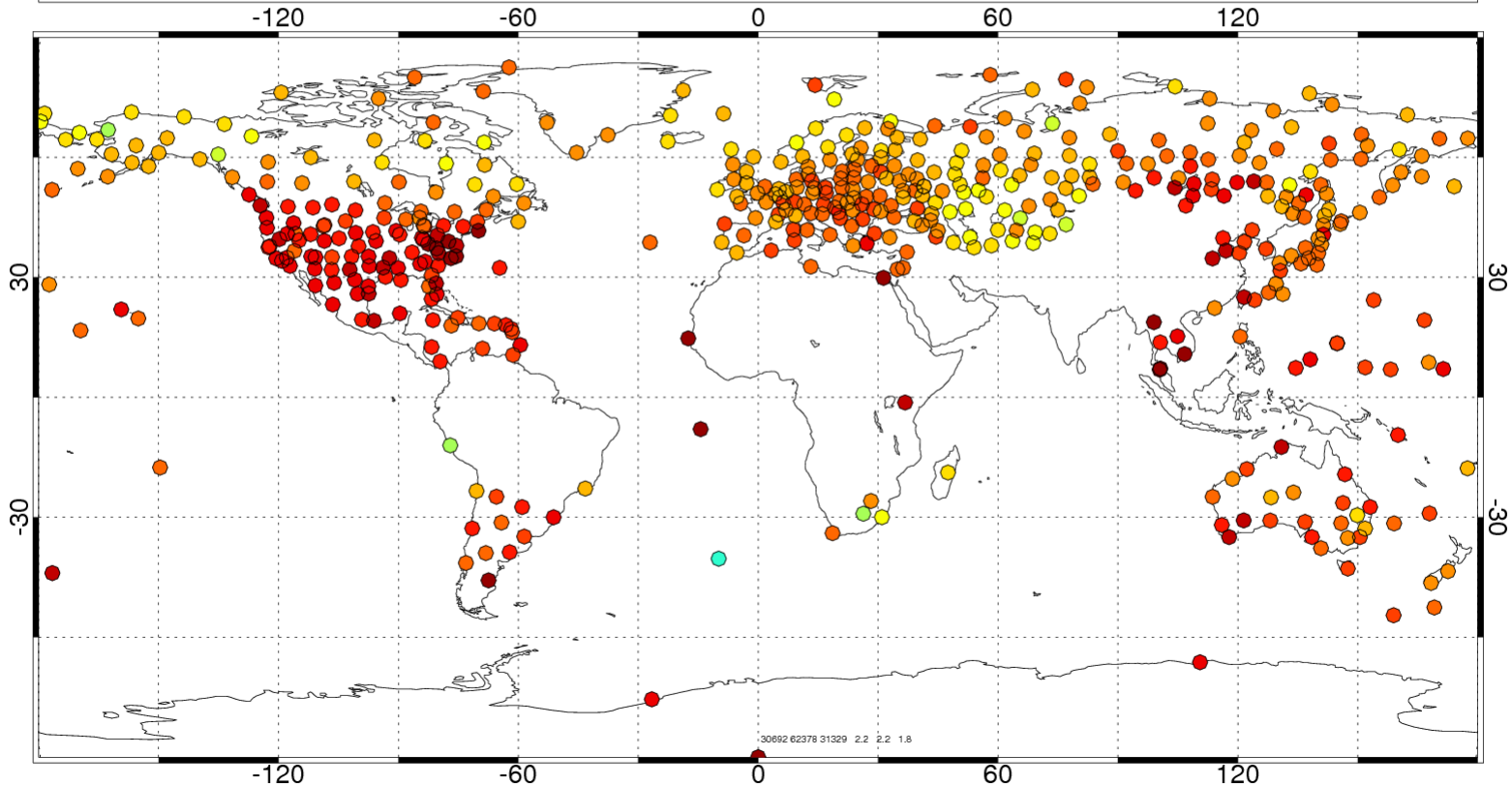


RICH-obs adjusted trends 1964-1984

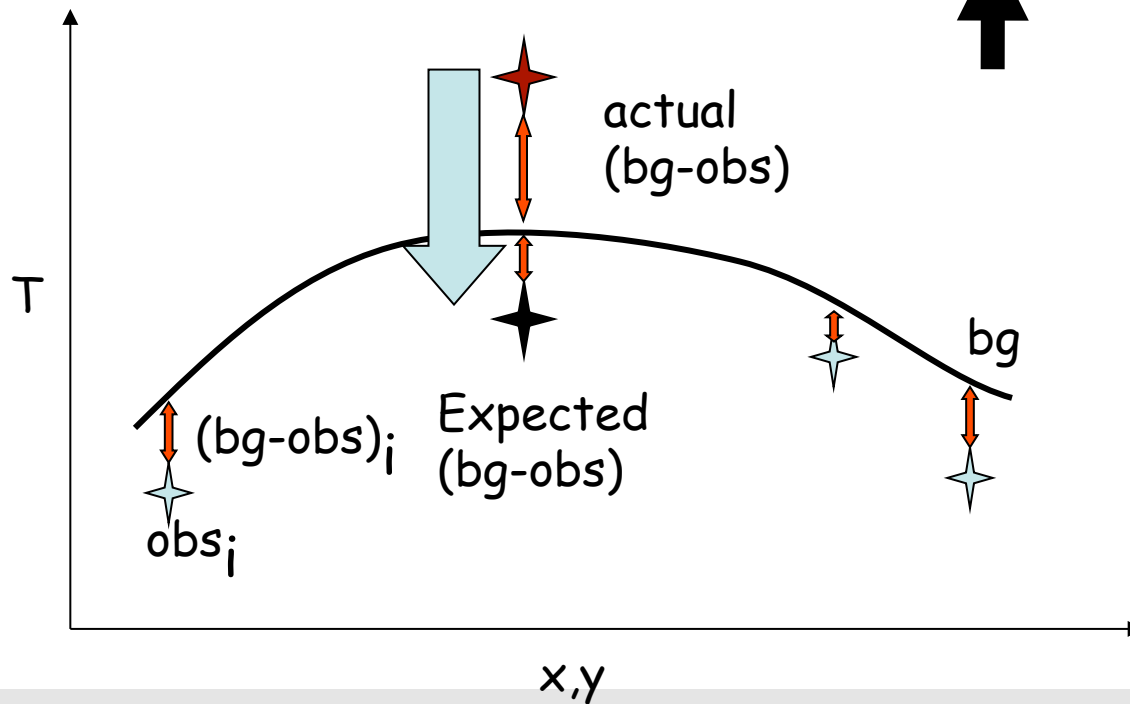
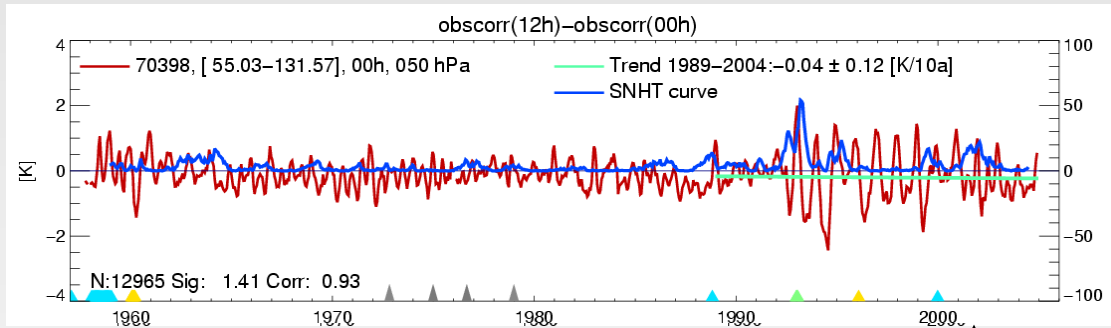
Temperature Trend 24h 1964-1984 100hPa, [K/10a] Radiosondes

Total monthly means: 123719 Evaluated Stations: 499 Cost: 181.35

-1.6 -1.5 -1.4 -1.3 -1.2 -1.1 -1.0 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3 0.4



Station climatology adjustment



★ Mean T of neighbouring homogenized „reliable” series

★ Mean T of most recent part of tested series

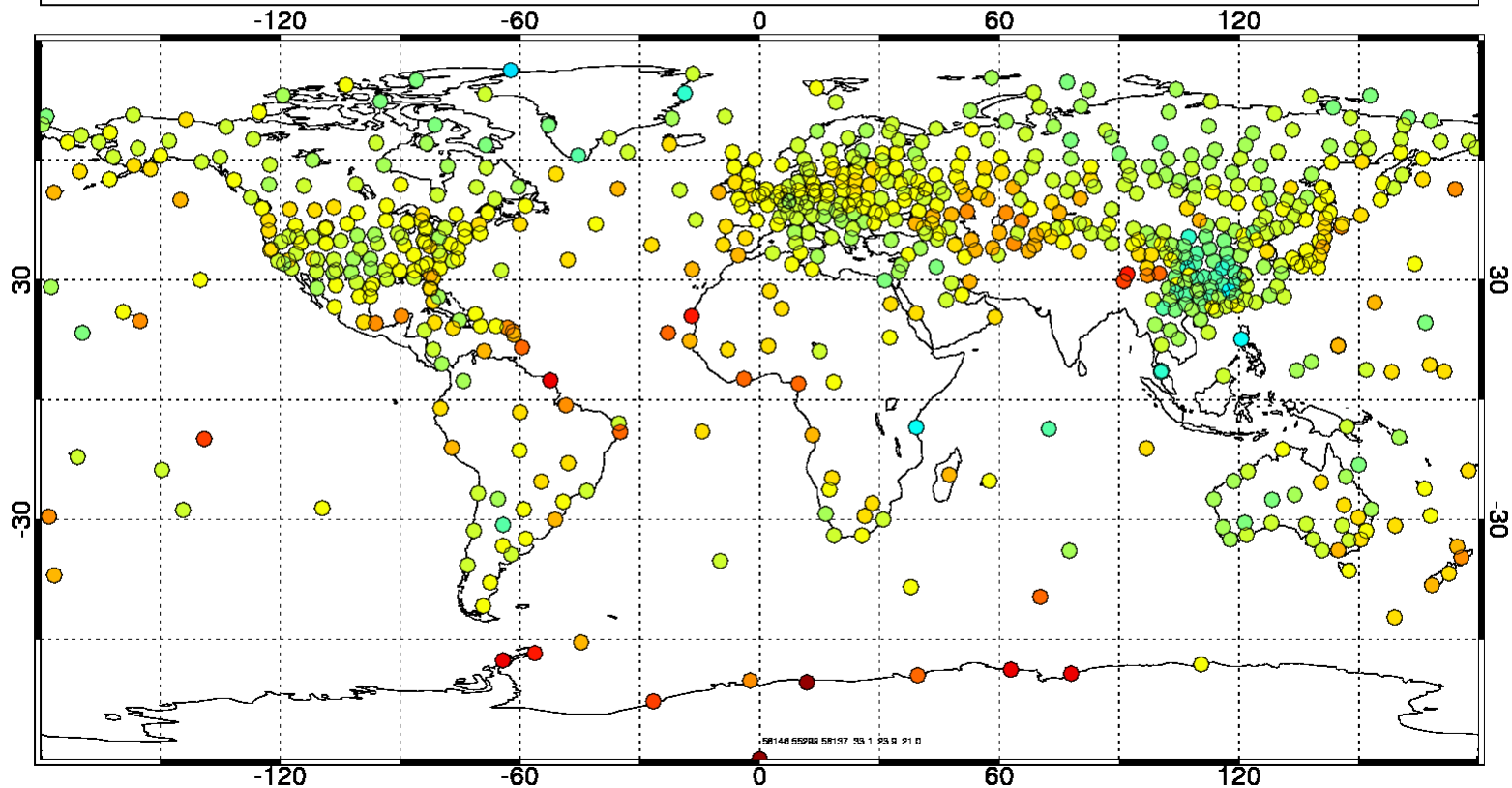
Bg used for interpolation

Obs-bg after adjustment

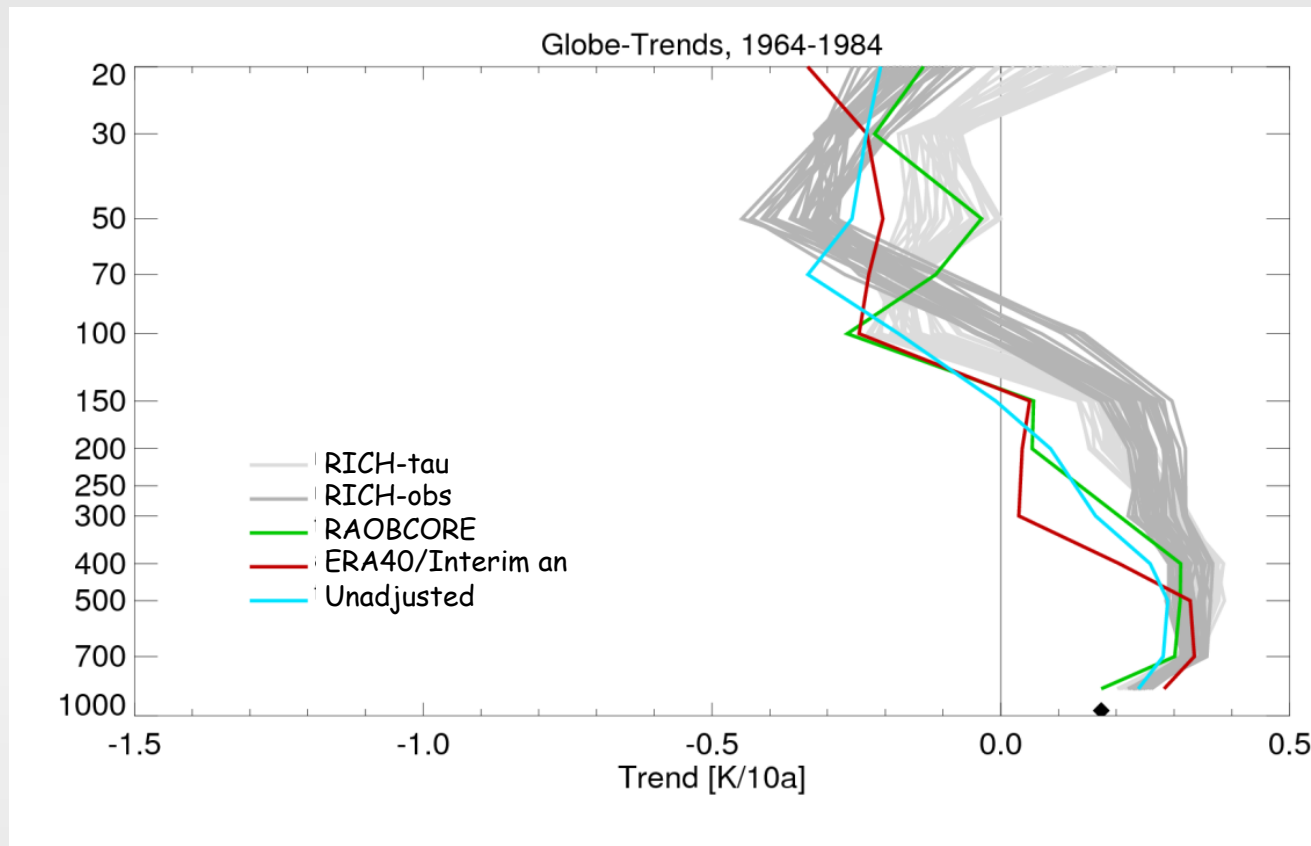
Temperature Difference 24h 1969-1972 100hPa, [K] Radiosondes

Total monthly means: 35273 Evaluated Stations: 714 Cost:1445.50

-3.0 -2.7 -2.4 -2.1 -1.8 -1.5 -1.2 -0.9 -0.6 -0.3 0.0 0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0

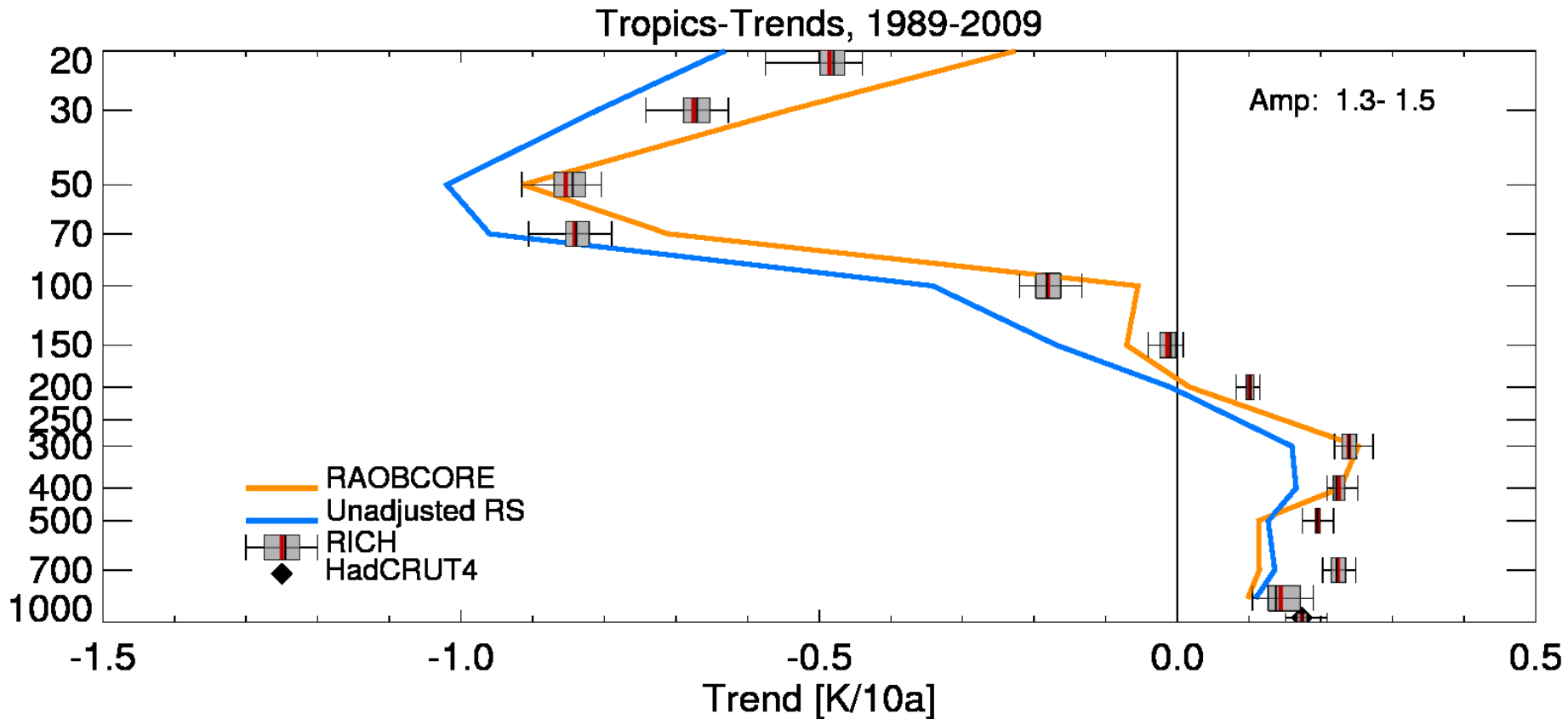


Ensemble of RICH adjustments



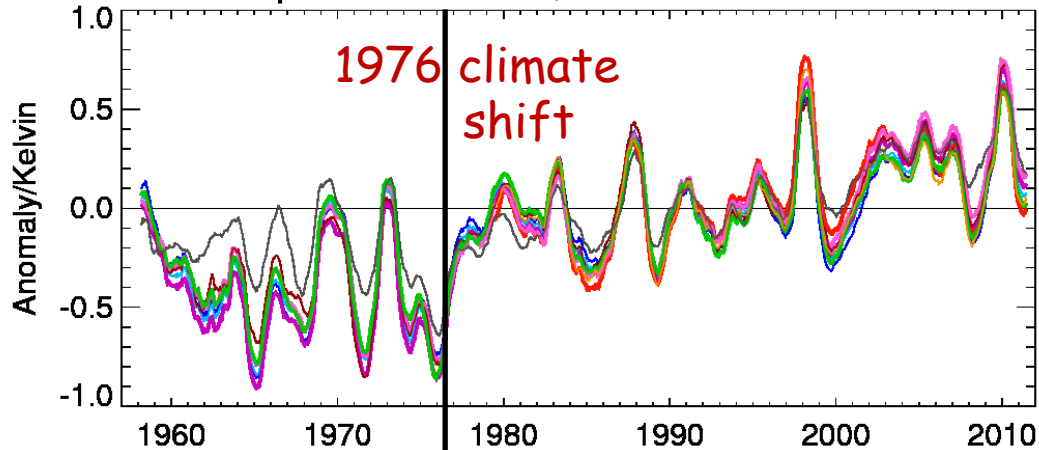
Spread through variation of parameters in RICH, e.g. number of neighbors, weighting with distance, minimum required good values for adjustment (Haimberger et al. JC 2012)

Trend amplification in the Tropics (20N-20S)

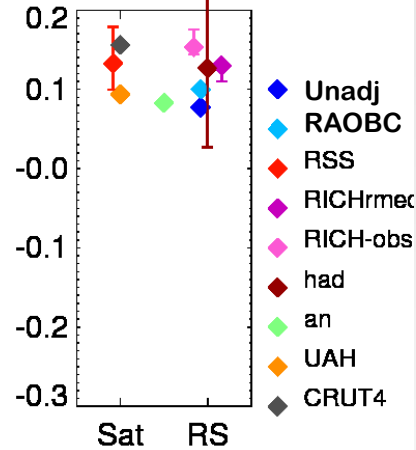


Lower tropospheric series, Tropics

Tropics 1979-2011, TLT - 1957-2011 cru

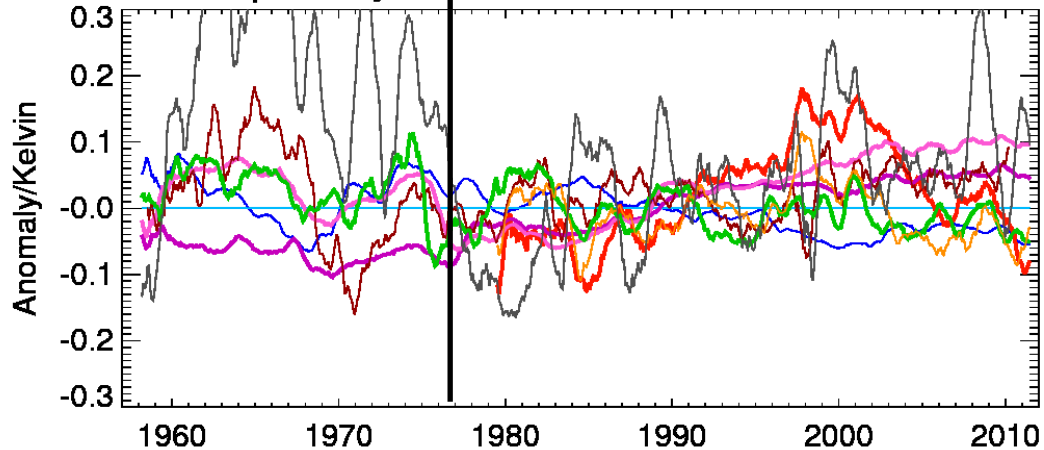


1979 - 2011

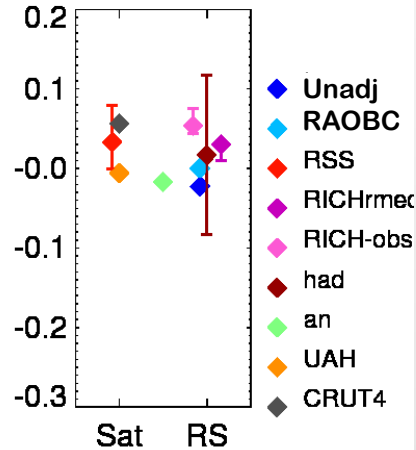


Full series

Tropics adj 1979-2011, TLT - 1957-2011 cru

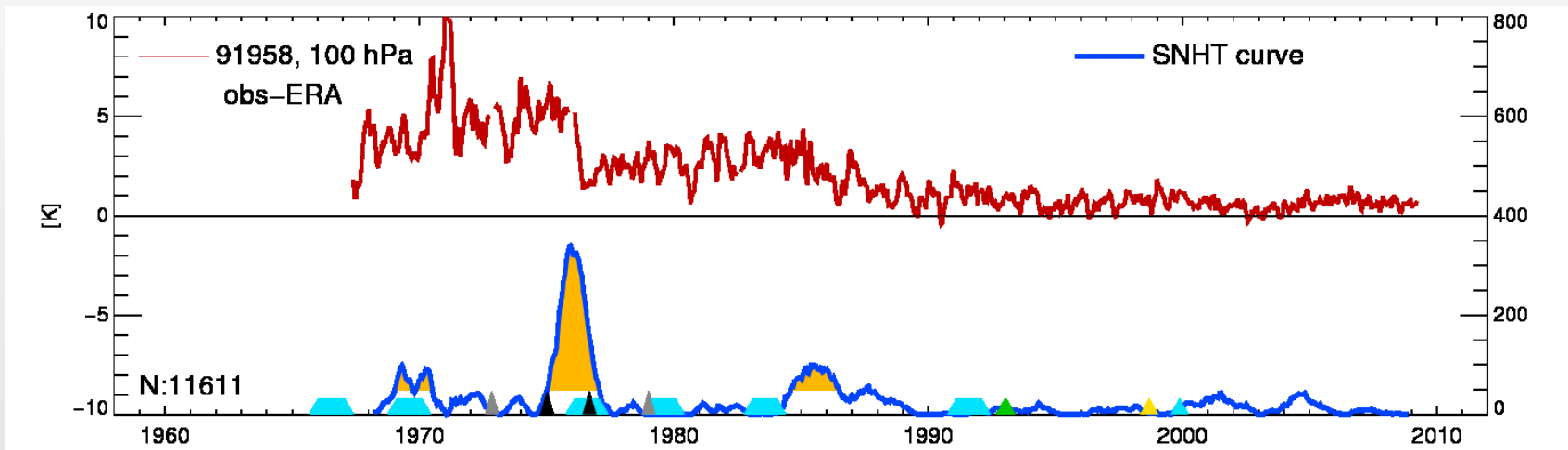
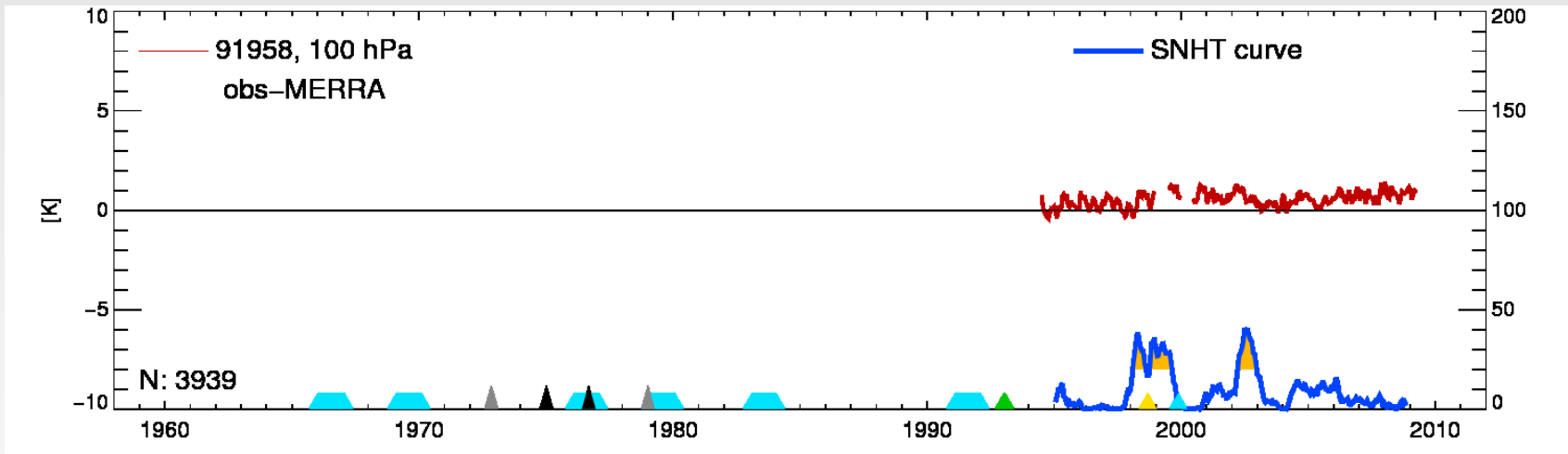


1979 - 2011



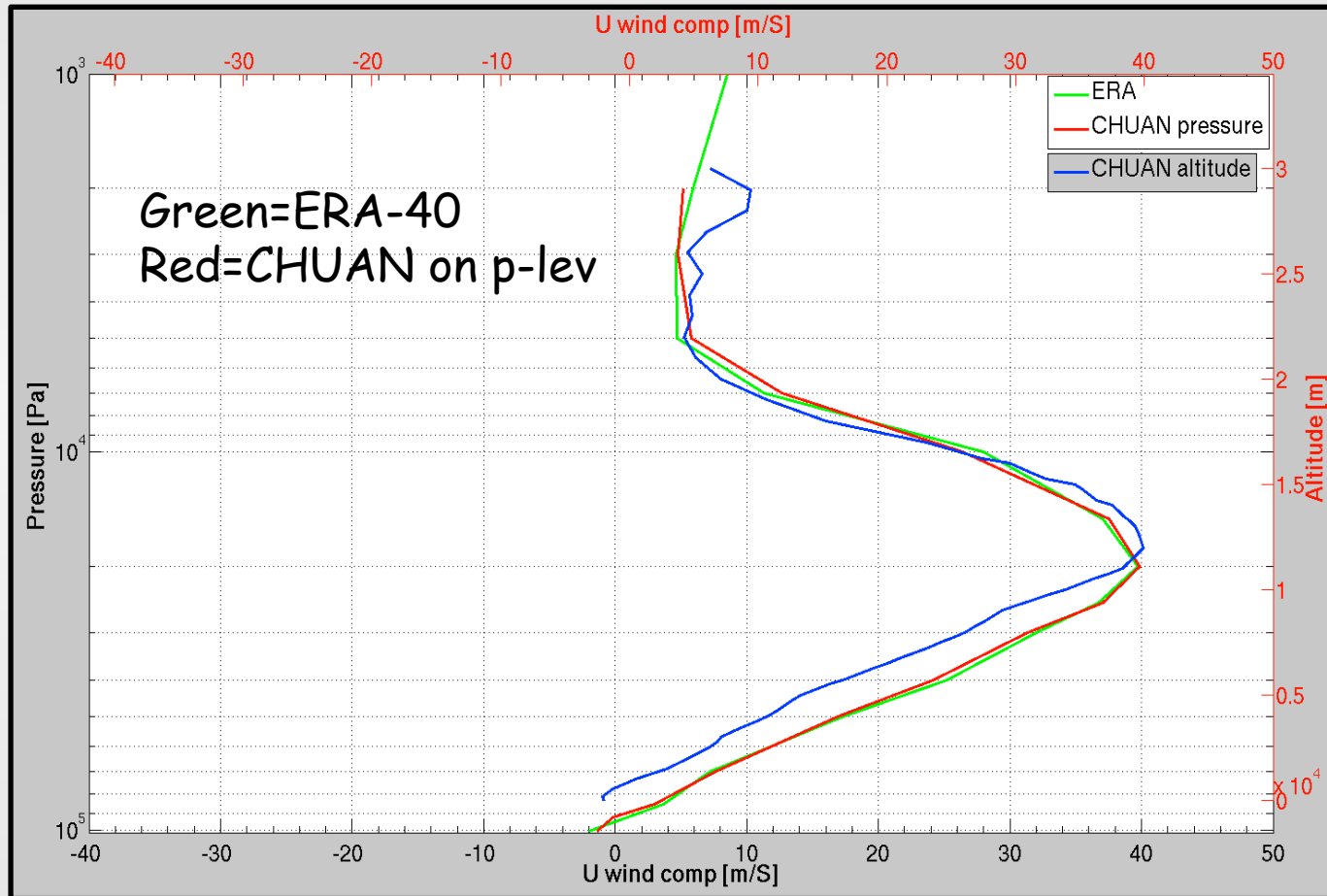
Difference Series with respect to RAOBCORE

Alternative background records



Altitude wind data on pressure levels

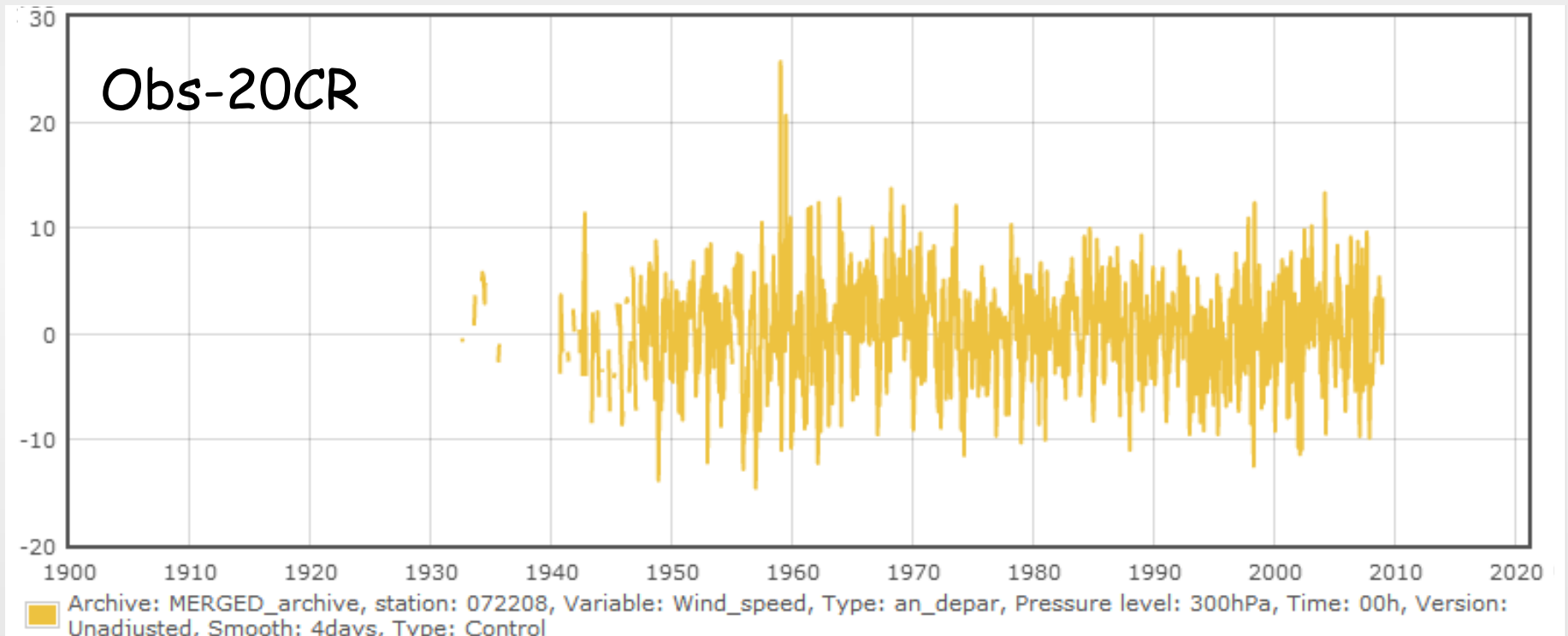
U wind at US station, January 1963, log(p) vs altitude



The conversion
altitude =>
pressure uses
20CR
temperature
to get height
of pressure
levels.

Wind speed at Charleston, SC

Sources: CHUAN, ERA-40, ERA-Interim



Conclusions

- Some progress since past IRC in RAOBCORE/RICH
 - better spatiotemporal consistency, particularly RICH-obs
 - uncertainty estimates of adjusted series
- Amplification of surface trends in Tropics
 - only in adjusted radiosonde data, improved consistency with MSU
 - 1976 climate shift stronger in upper air data?
- Homogenization of pre-1958 data using 20CR obs-an appears feasible (see **L. Ramella-Pralungos poster**)
 - T, wind - humidity will be tried in satellite era
- Sampling bias in early wind speed data. Variational estimation of wind direction feasible (**M. Milan**)
- Use GSICS to check RS-T bias adjustments in SAT era.
- Provide breakpoint information to assist VarBC



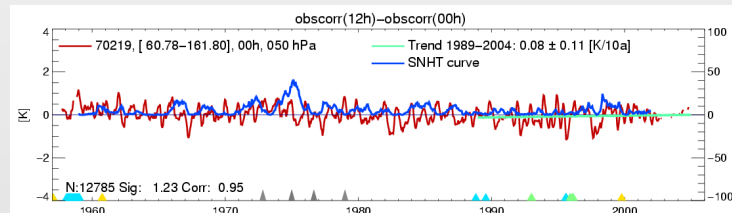
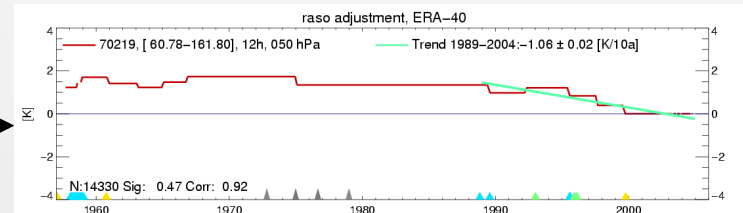
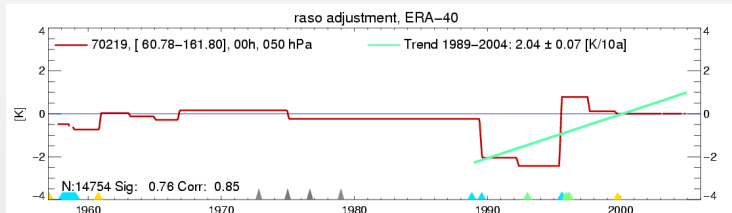
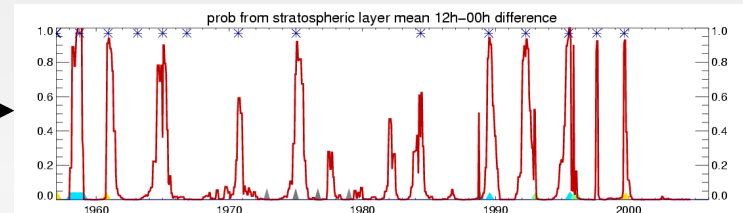
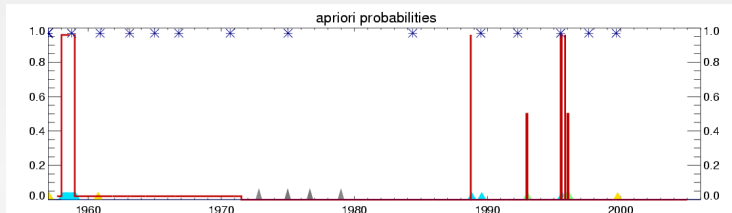
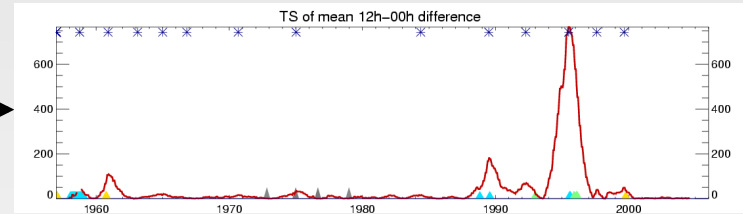
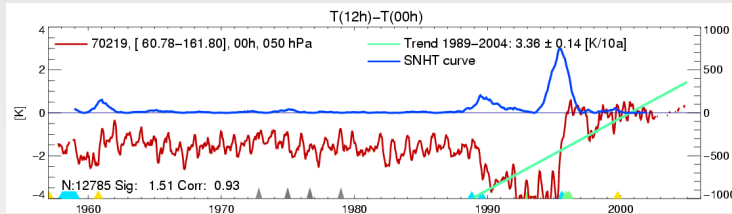
4th WCRP conference on reanalyses, 7-11 May 2012



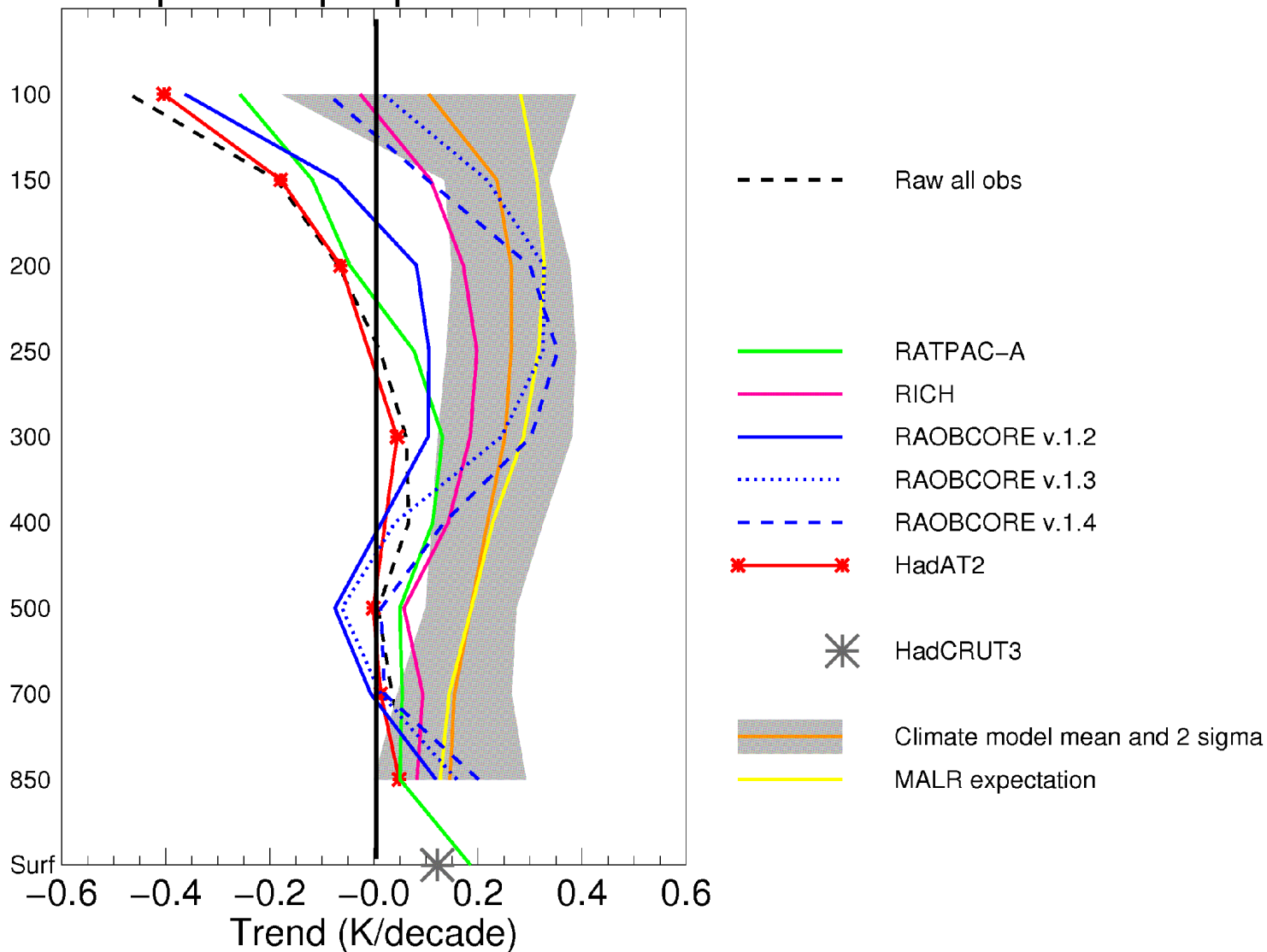
Parameters of the adjustment system

- Break detection efficiency (How many breaks)
- Selection of neighbors (How many)
- Weighting of neighbors with distance
- Minimum number of good values
- RICH-obs or RICH-tau
- Condition of high spatiotemporal consistency of trends limits range of parameters, spread of trends
- Not yet a probabilistic approach but a start
- See Haimberger et al. (2012, rev, JC)
- For future: Vary background (20CR, MERRA, JRA55?)

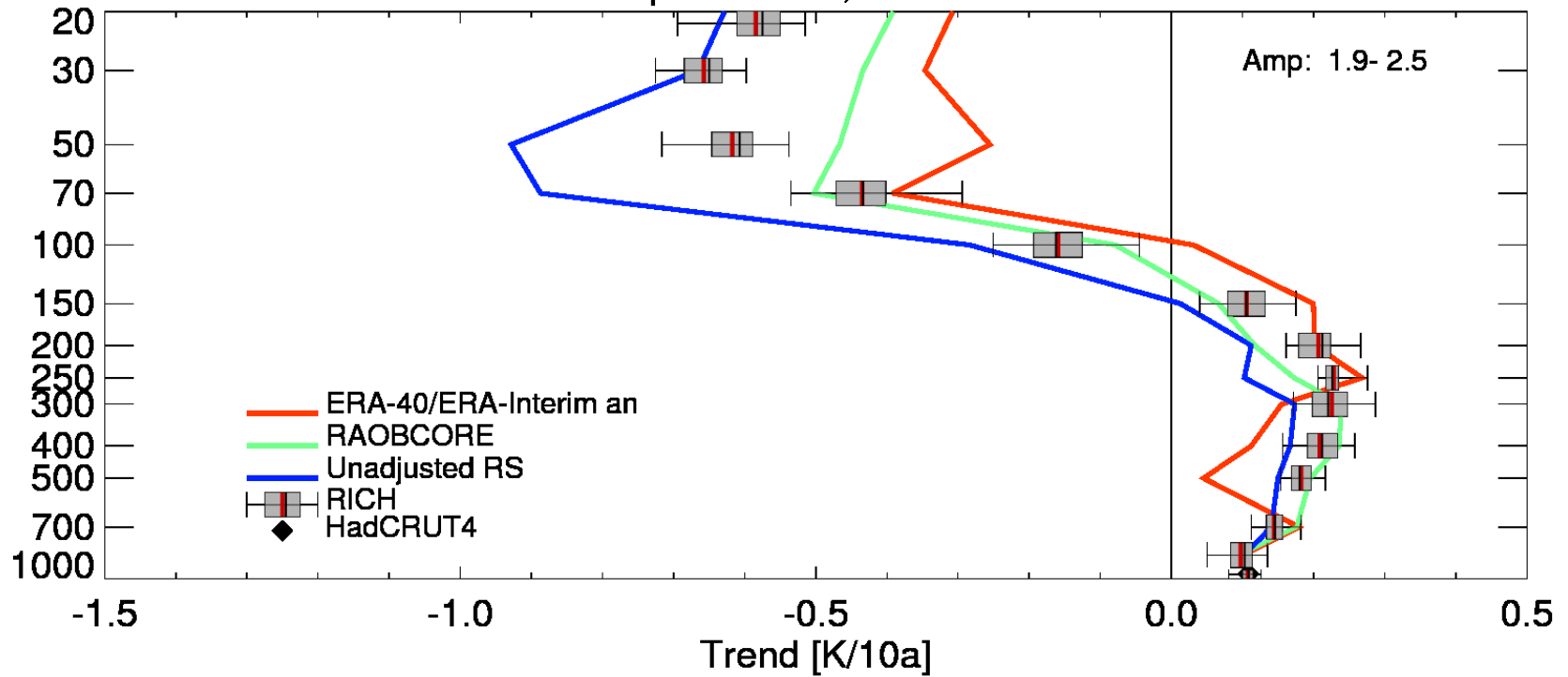
RAOBCORE break detection



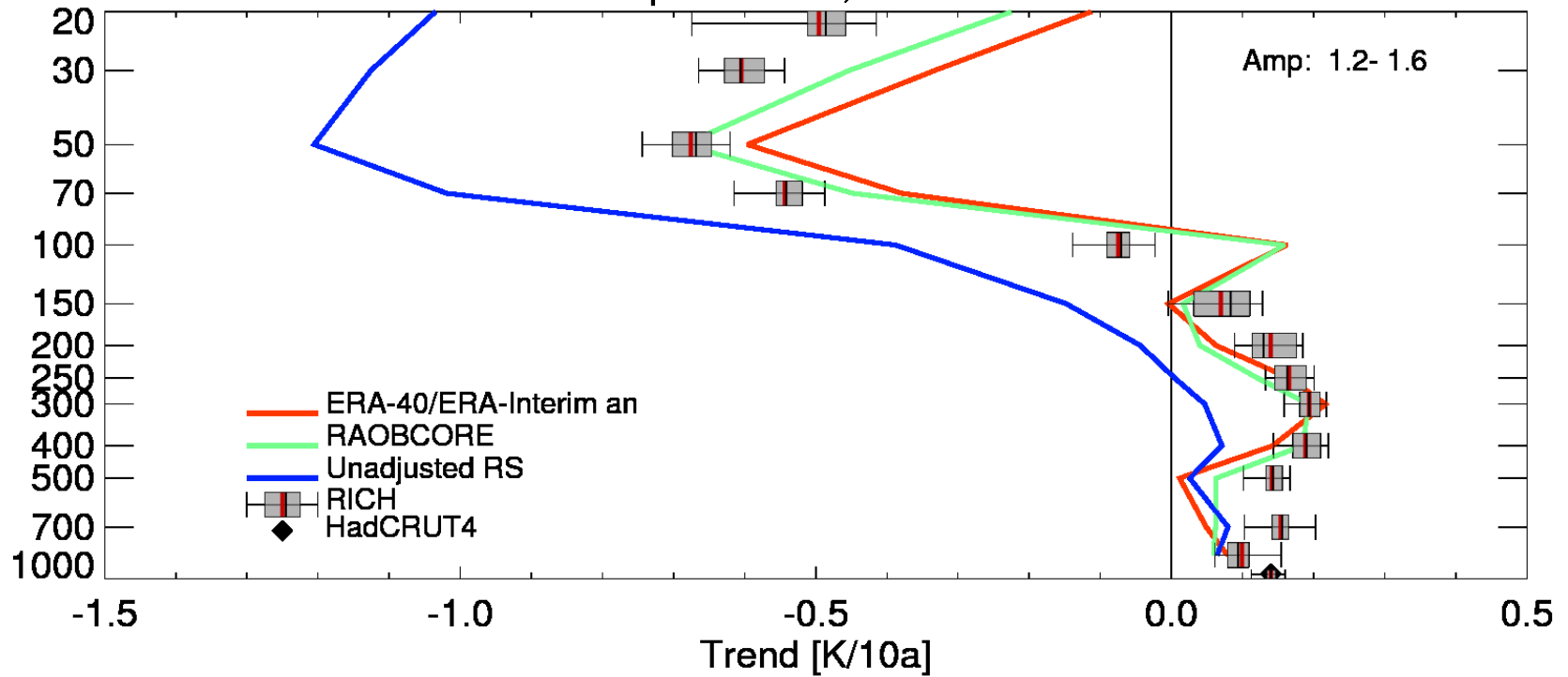
Tropical tropospheric trends



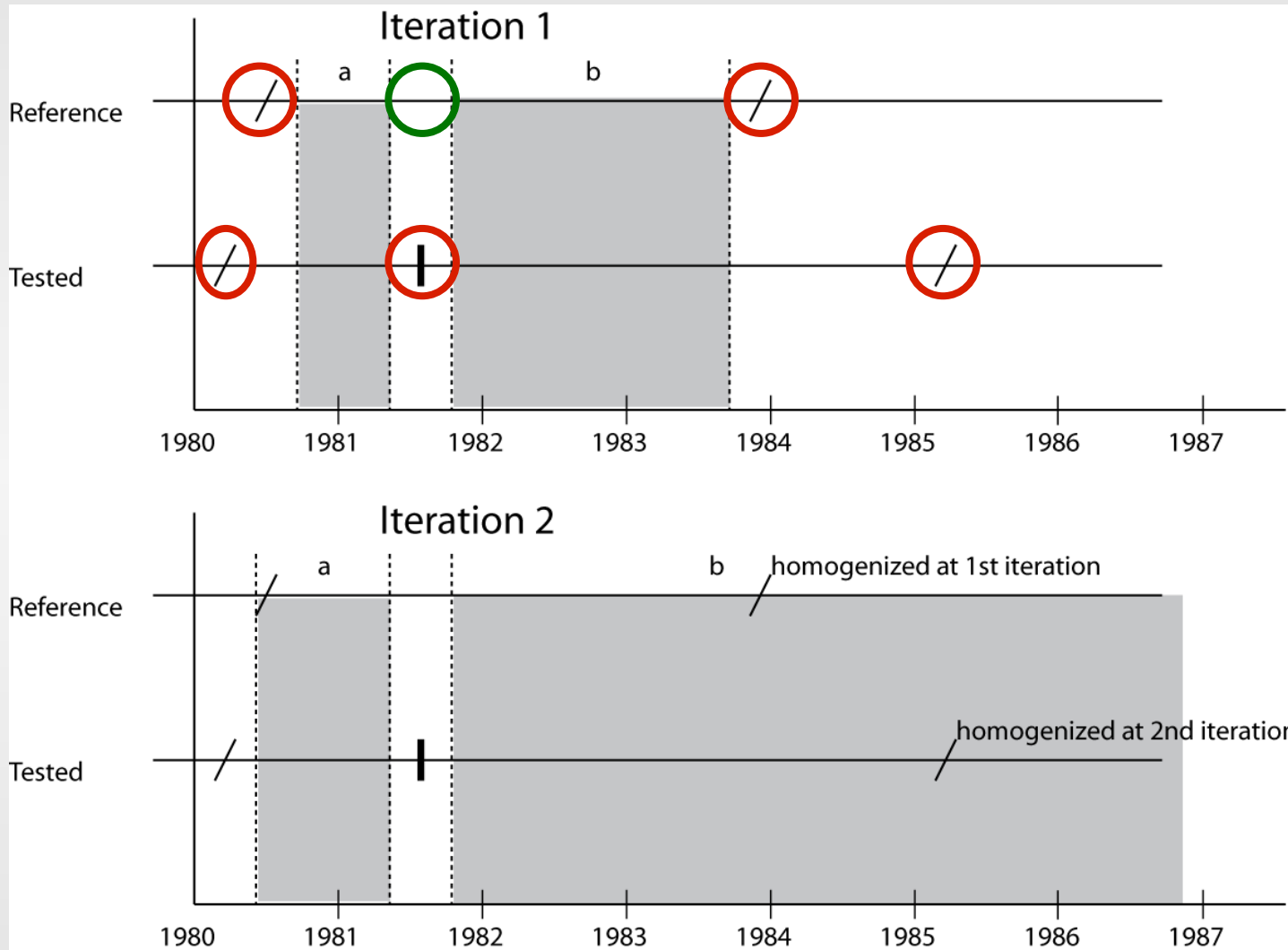
Tropics-Trends, 1958-2010



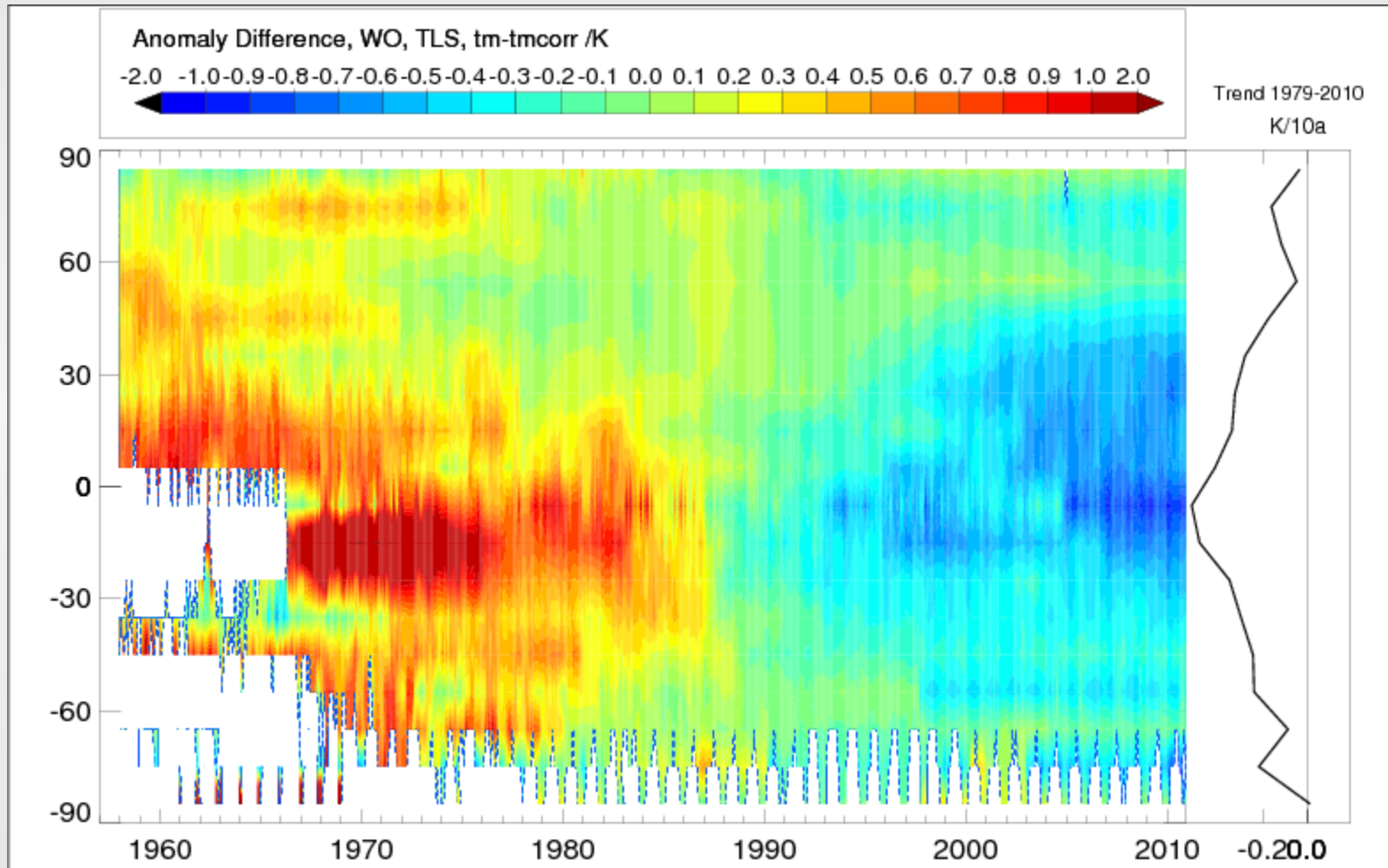
Tropics-Trends, 1979-2010



Choice of segments for breaksize estimation in RICH



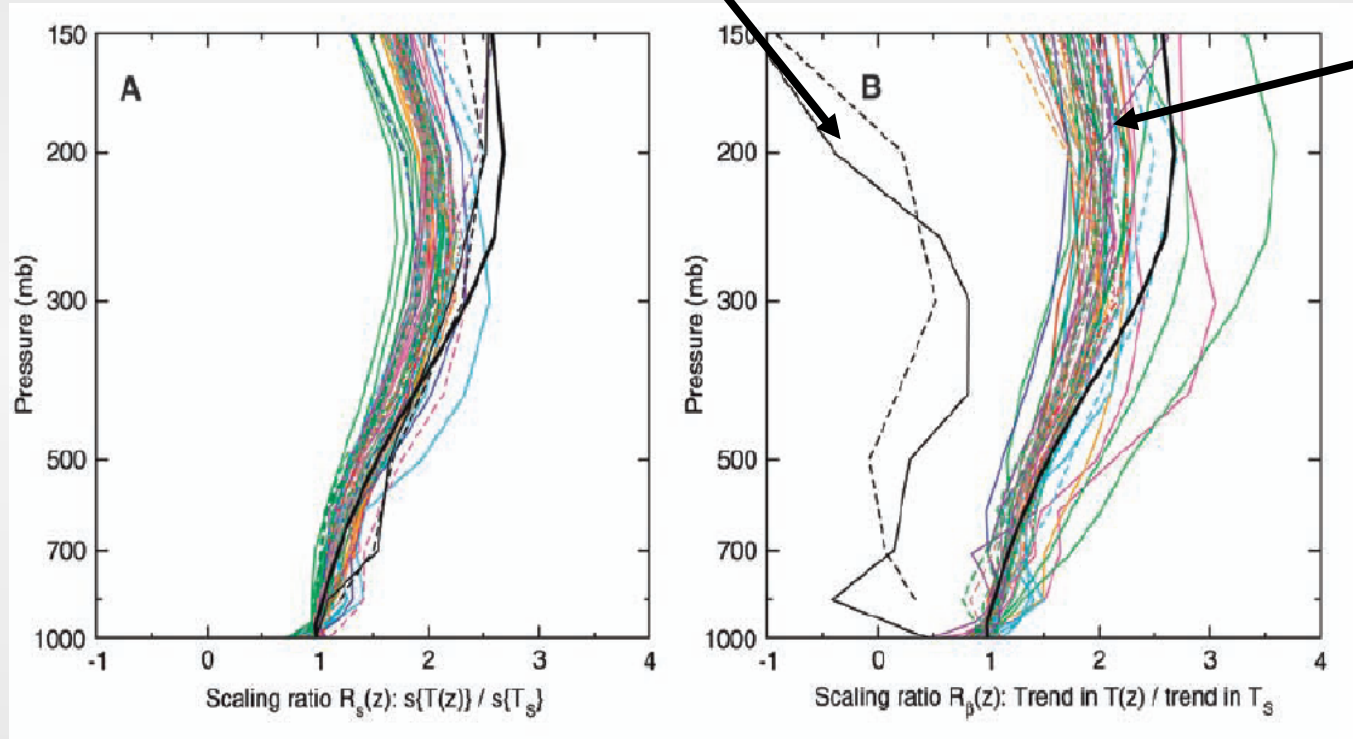
Hovmöller plot unadjusted-adjusted RS, LS



Tropical temperature variability

Santer et al.
(2005), Science

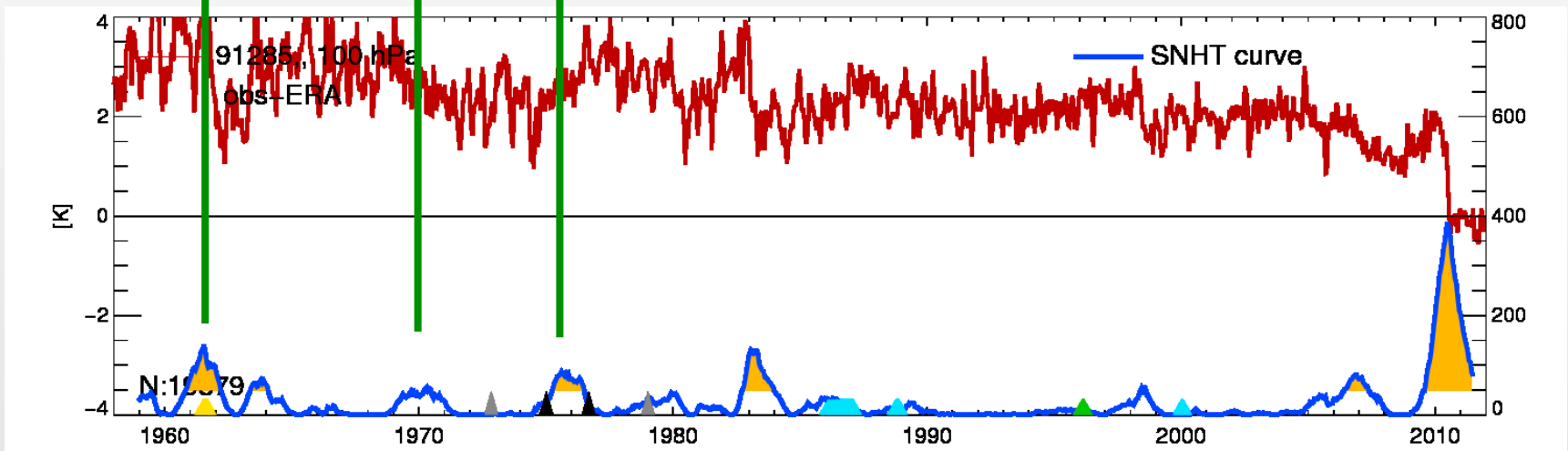
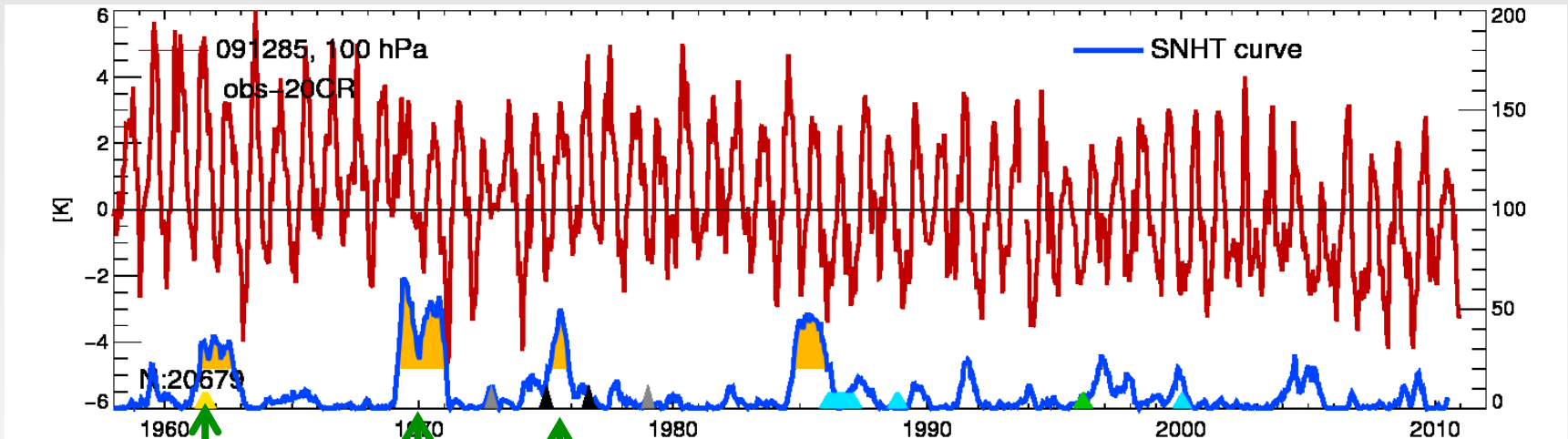
RATPAC, HadAT
1979-1999



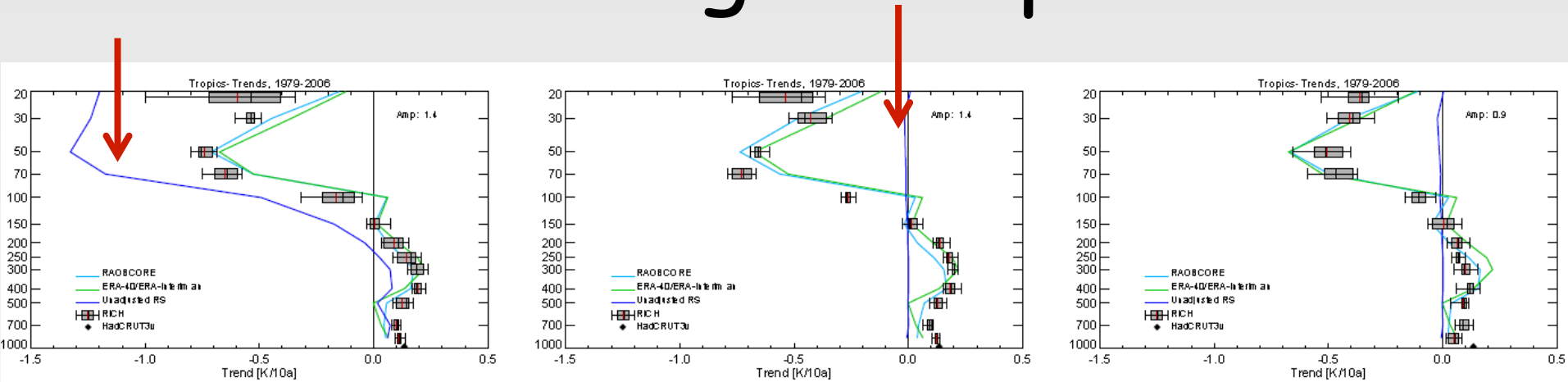
AR4 climate
models

Temperature variability

Trends, $1=0.12\text{K}/10\text{a}$



Removal of signal experiments

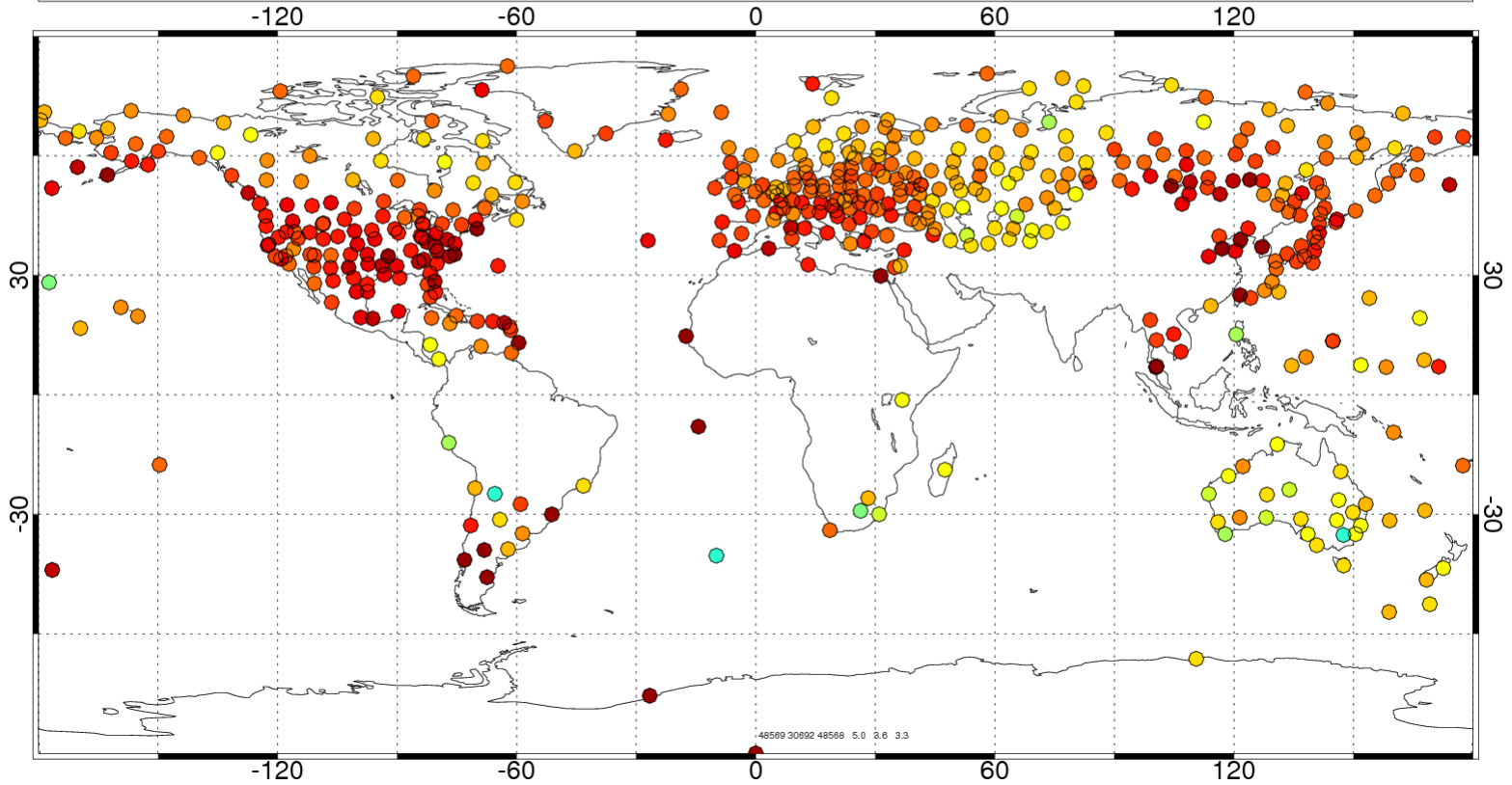
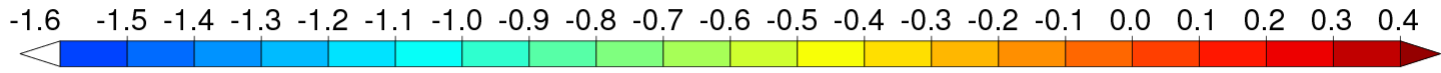


- Shifts introduced in all time series such that climate signal (blue line) is reduced to zero
- RAOBCORE/RICH can recover climate signal in the tropics if breakpoints are known

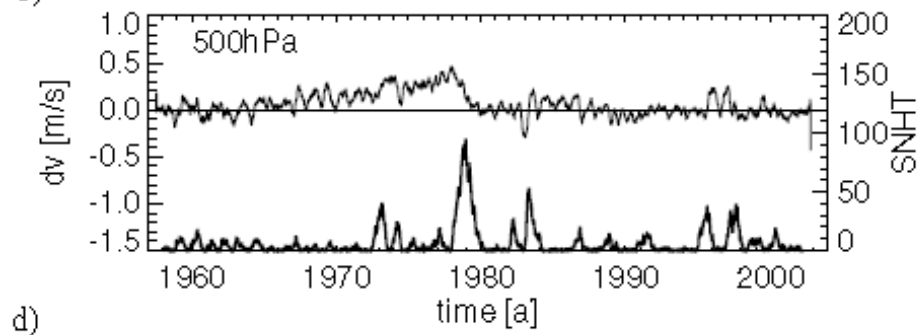
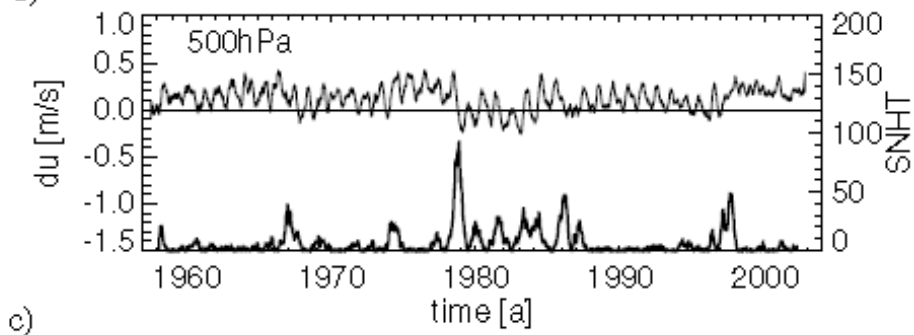
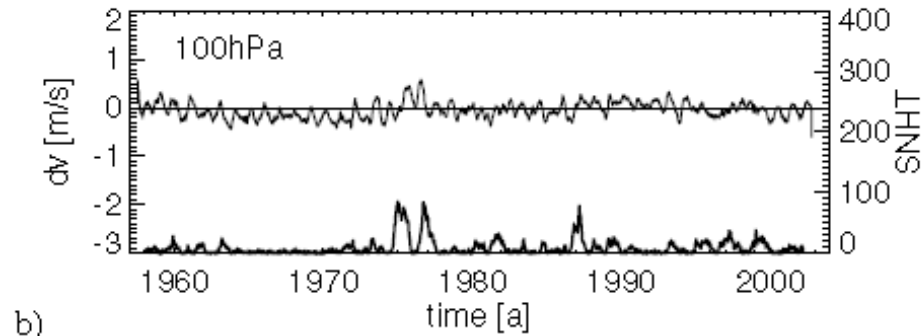
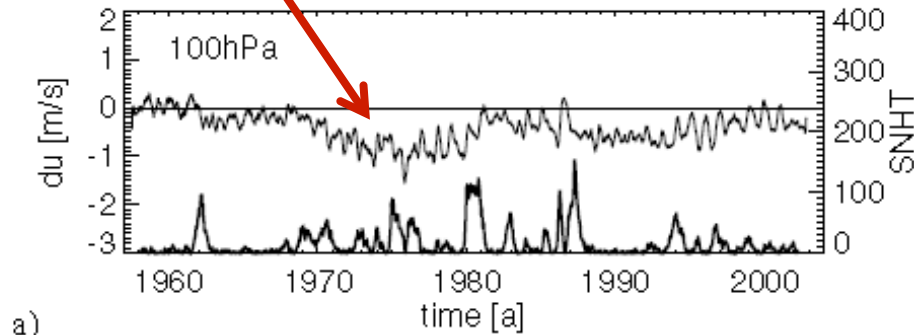
RICH-tau adjusted trends 1964-84

Temperature Trend 24h 1964-1984 100hPa, [K/10a] Radiosondes, rit24_

Total monthly means: 123719 Evaluated Stations: 499 Cost: 229.78

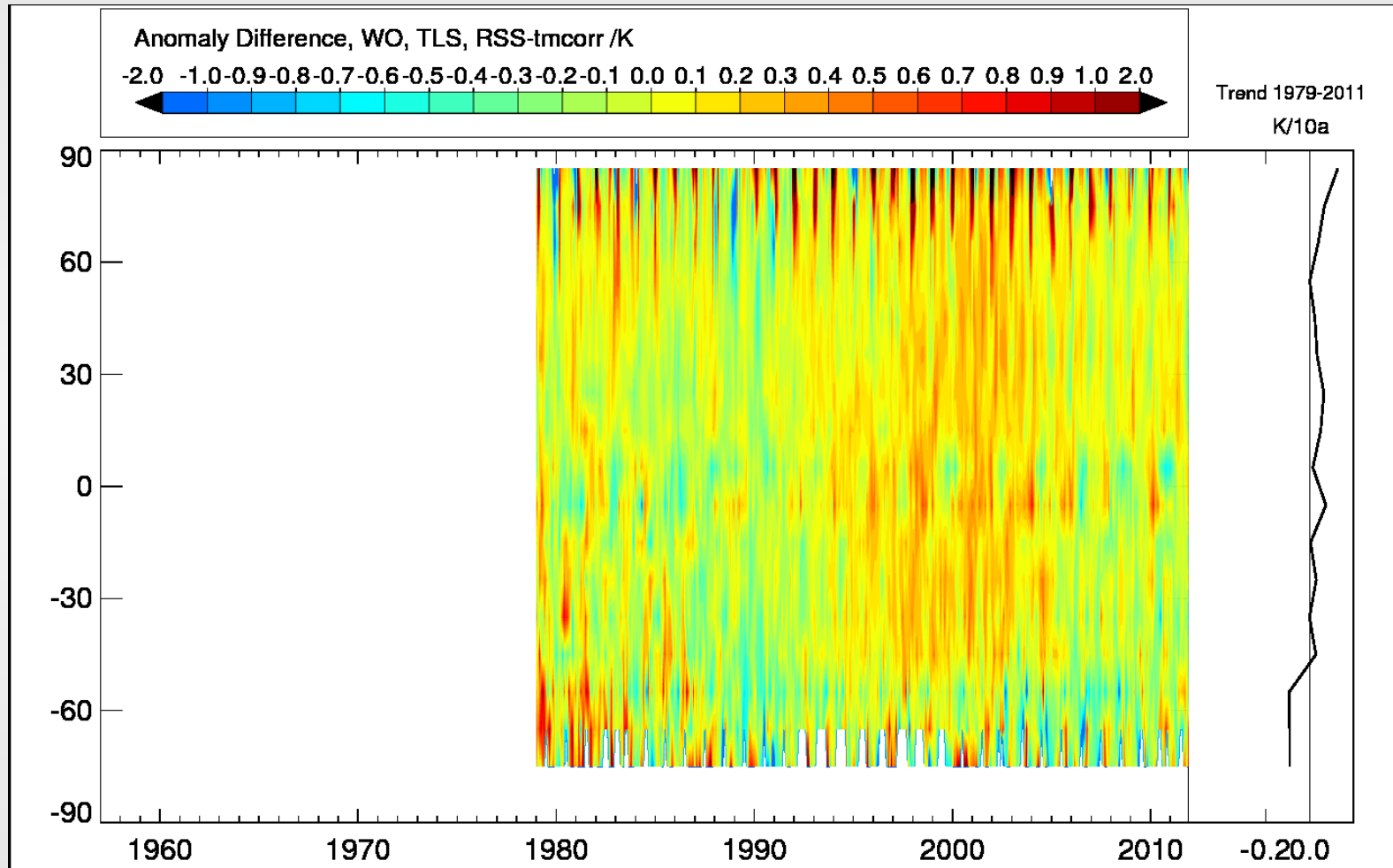


Wind speed biases

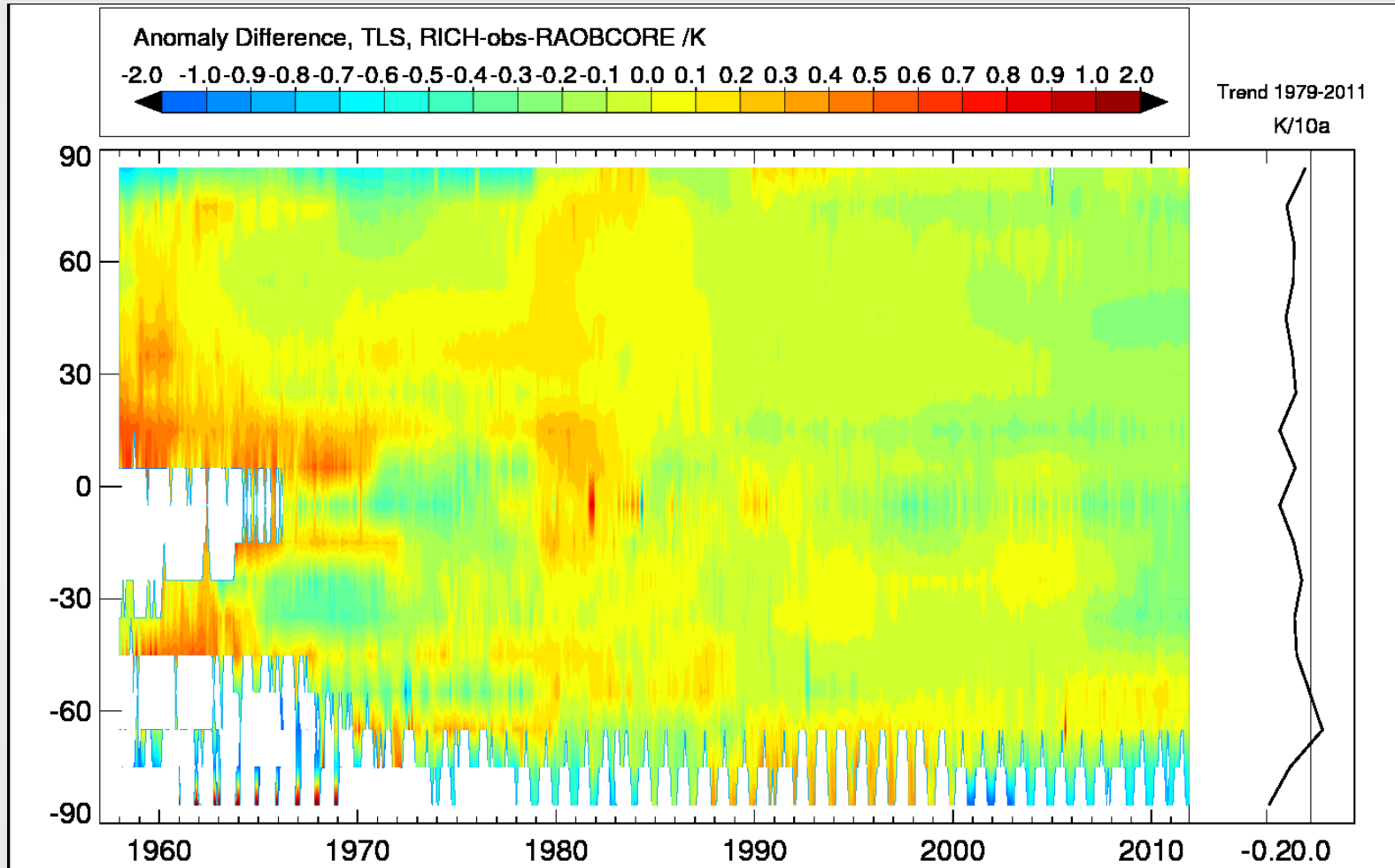


Obs-bg, USA/Canada composite

RSS-RAOBCORE

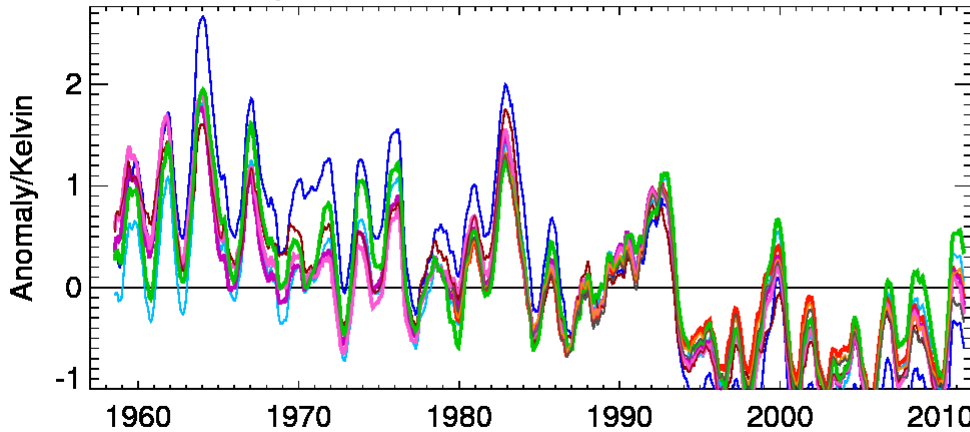


RICHobs-RAOBCORE

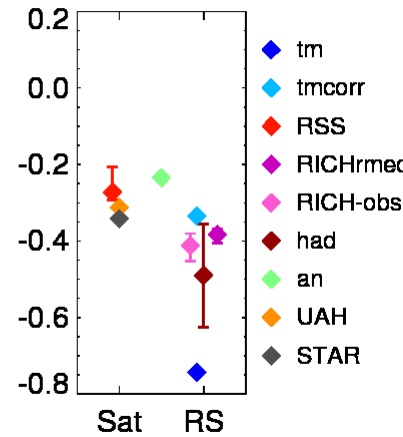


Lower stratospheric series, Tropics

Tropics 1979-2011, TLS - 1957-2011

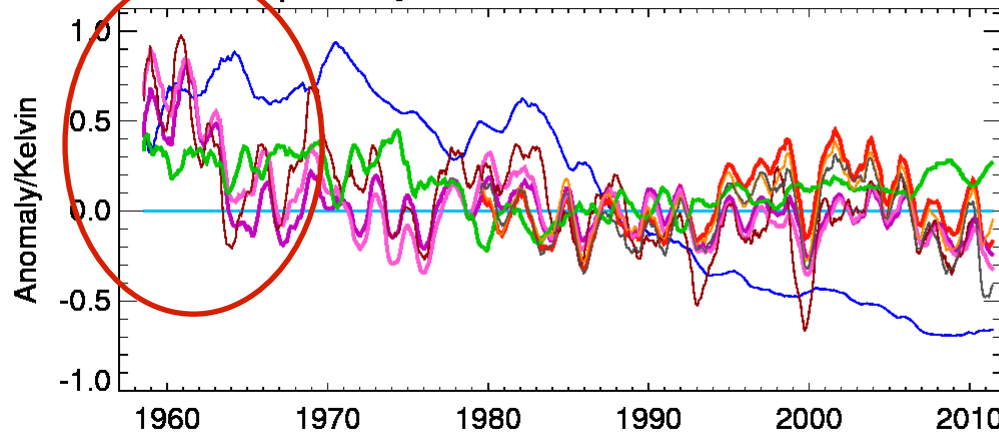


1979-2011

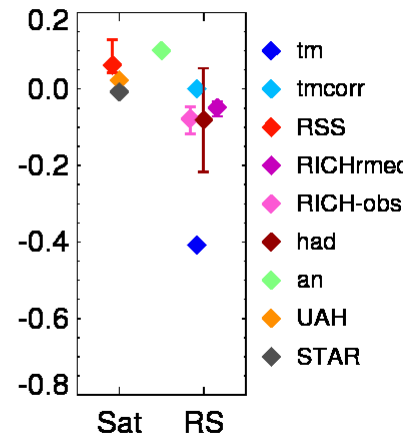


Full series

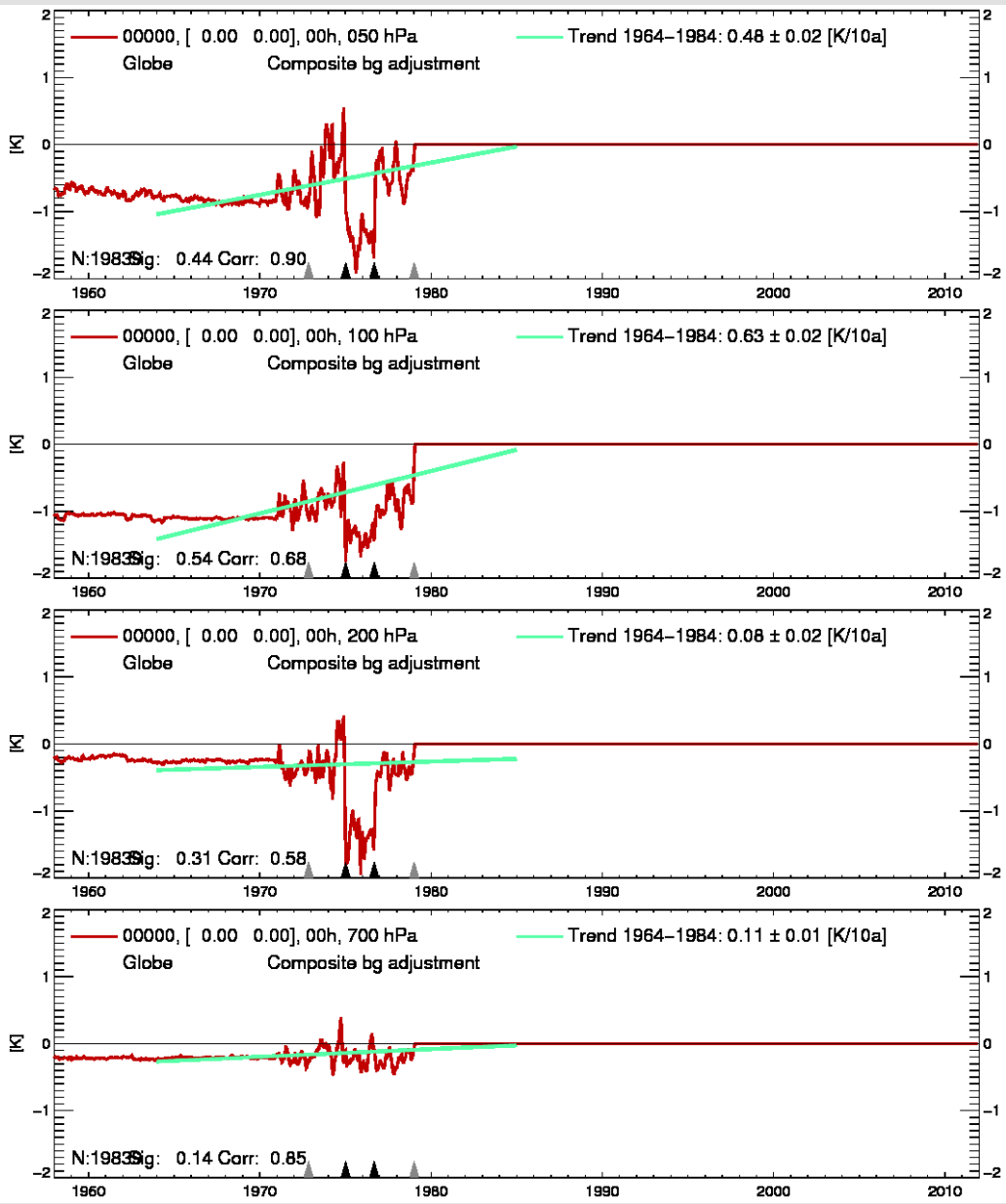
Tropics adj 1979-2011, TLS - 1957-2011



1979-2011



Difference series



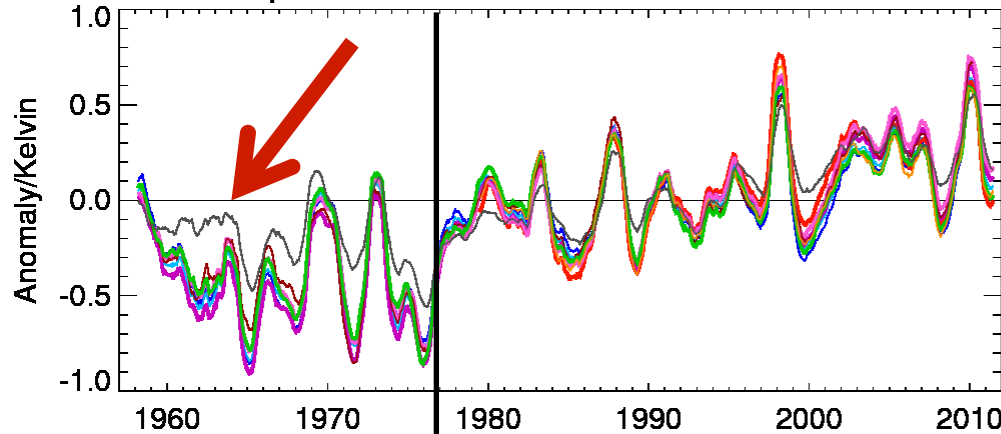
Adjustment of ERA-40 background

Transition from ERA-40 to ERA-Interim in 1979 coincides with FGGE, Satellite introduction. Makes estimate of shift difficult

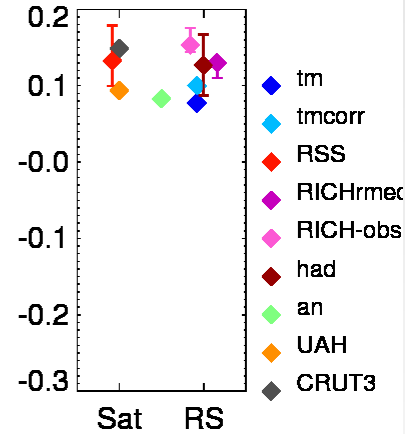
Uncertainty $\Delta T \sim 0.1-0.5K$

Lower tropospheric series, Tropics

Tropics 1979-2011, TLT - 1957-2011 cru



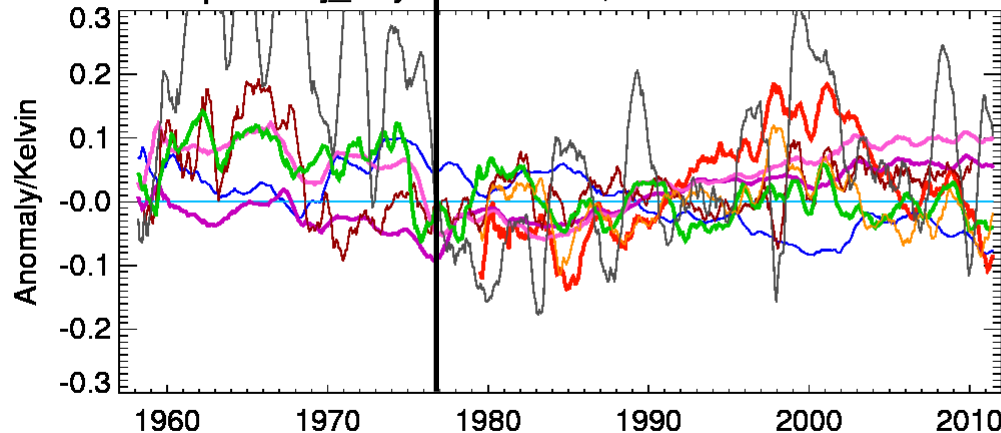
1979 - 2011



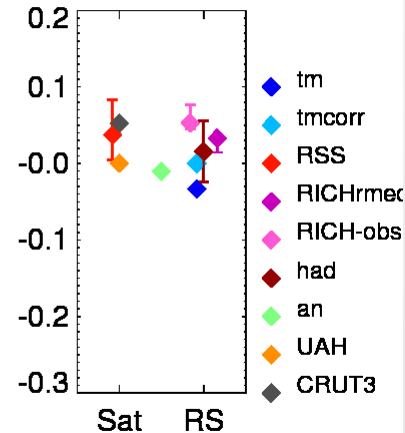
Full series

Black is HadCRUT3

Tropics adj_day 1979-2011, TLT - 1957-2011 cru



1979 - 2011

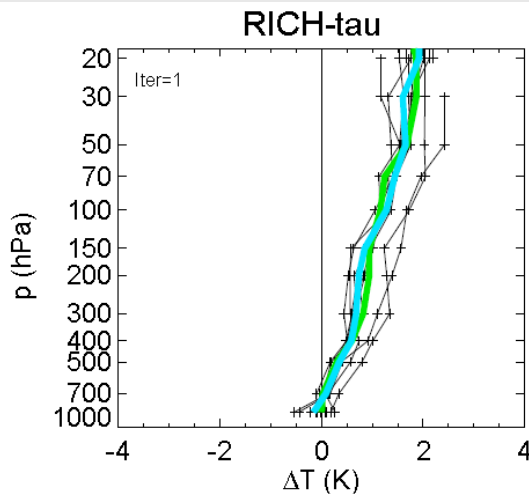
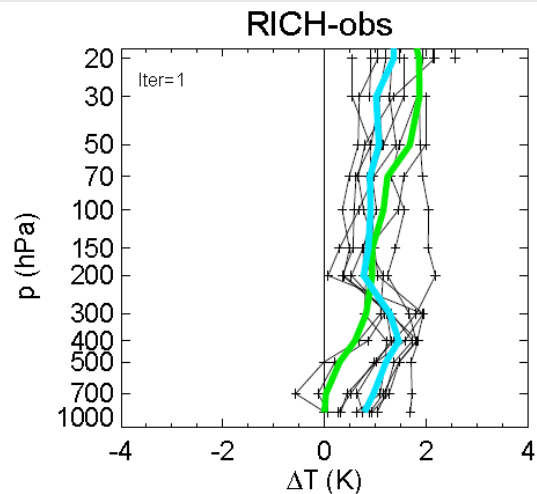


Difference series

A breaksize estimation example

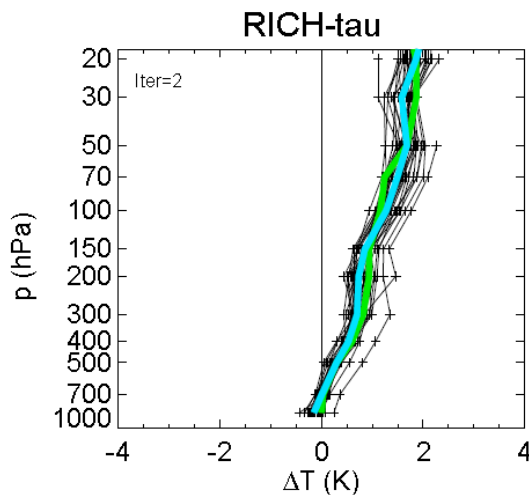
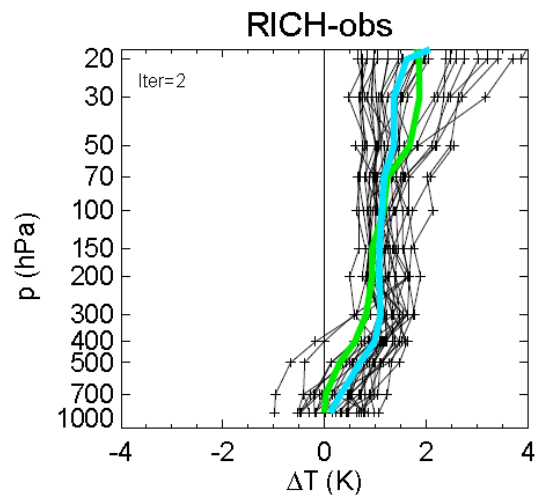
$$\Delta obs_{Test} - \Delta obs_{ref}$$

$$\Delta(obs - bg)_{Test} - \Delta(obs - bg)_{ref}$$



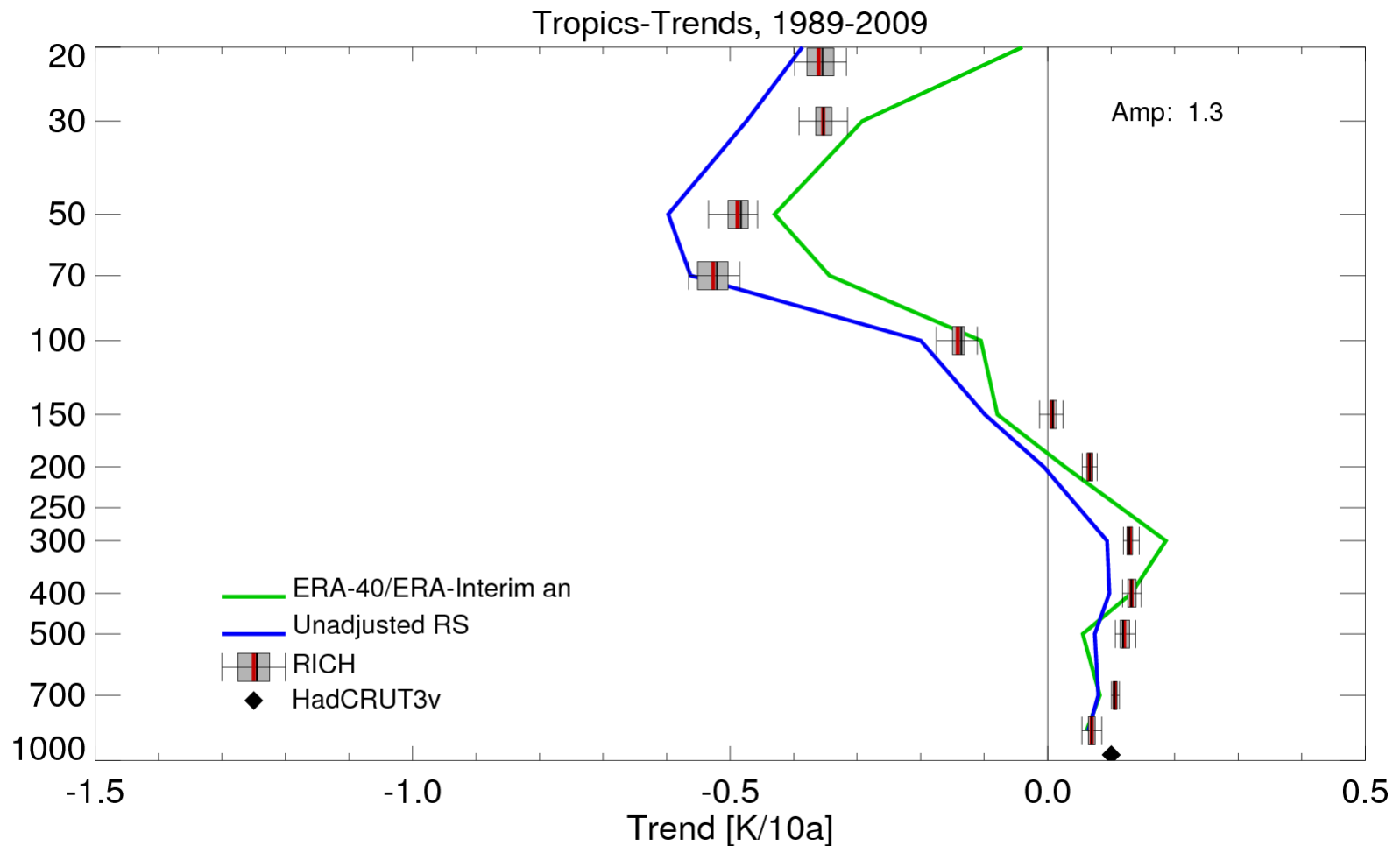
Bethel, Alaska, 198906

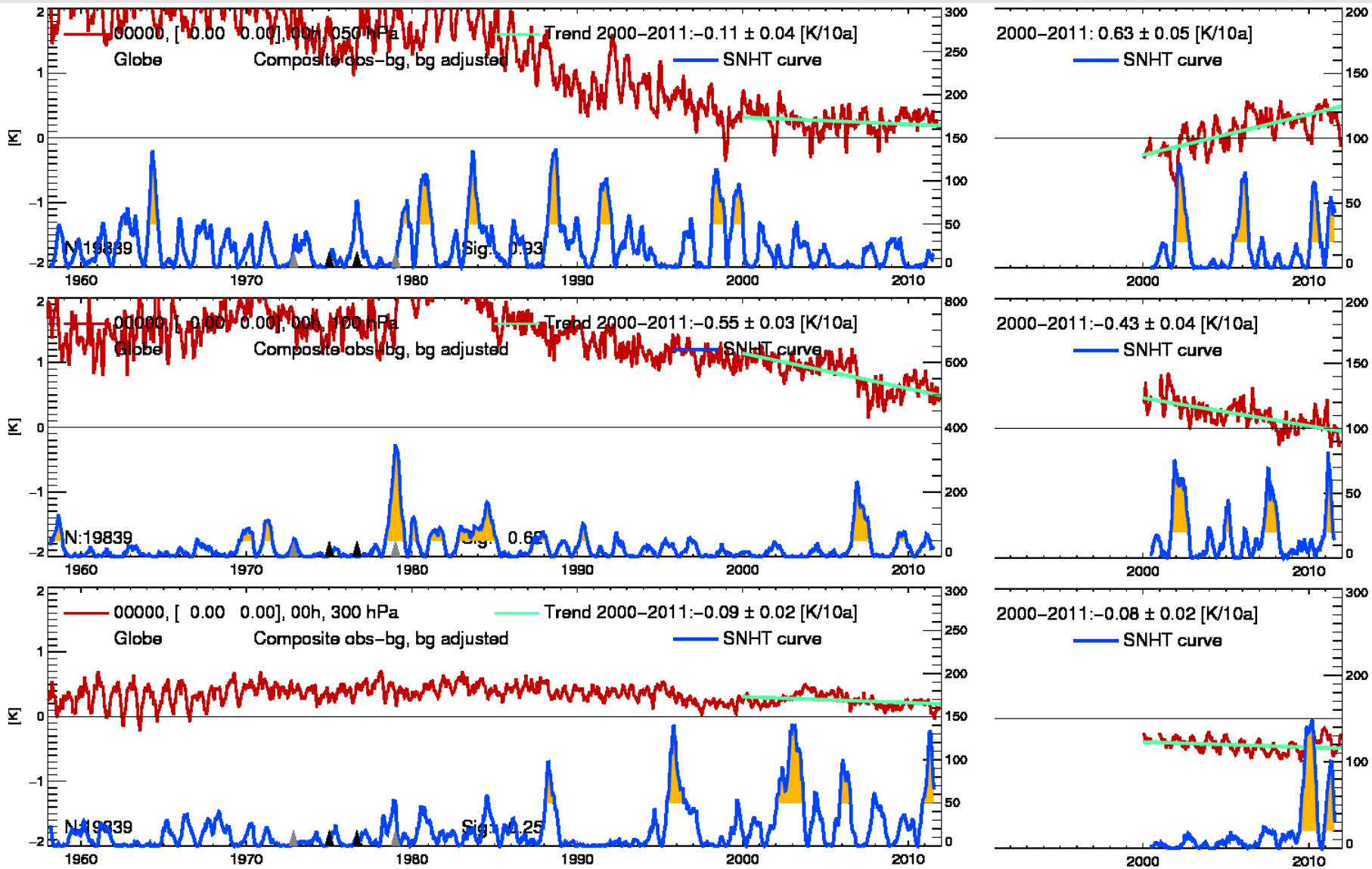
1st Iteration (9 neighbors)



2nd Iteration (30 neighbors)

Warming in Tropics (20S-20N)





4th WCRP conference on reanalyses, 7-11 May 2012



