

# Homogenized radiosonde temperature data for climate reanalyses

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Thanks to H Hersbach, P Dahlgren S Brönnimann, S Jourdain, M. A. Valente, A. Sterin, F. Ladstätter A. Steiner

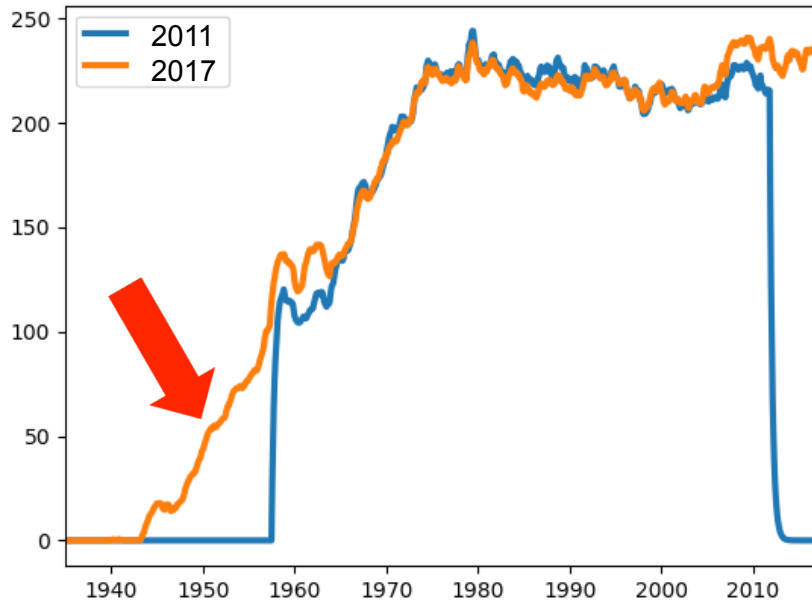
# Motivation for an update

- Radiosonde data need homogenization
  - RAOBCORE adjustments (Haimberger 2012) only back to 1958 up to 2011
- More early upper air data available since then
  - Many paper archives have been digitized
  - 5 year longer records
- New reference data for break detection/adj.
  - JRA55 (1958-), ERA-preSAT (1939-1966)
  - CERA20C (1900-2010)
- Improved homogenization methods
  - Annual cycle of bias

# Radiosonde temperature monthly records

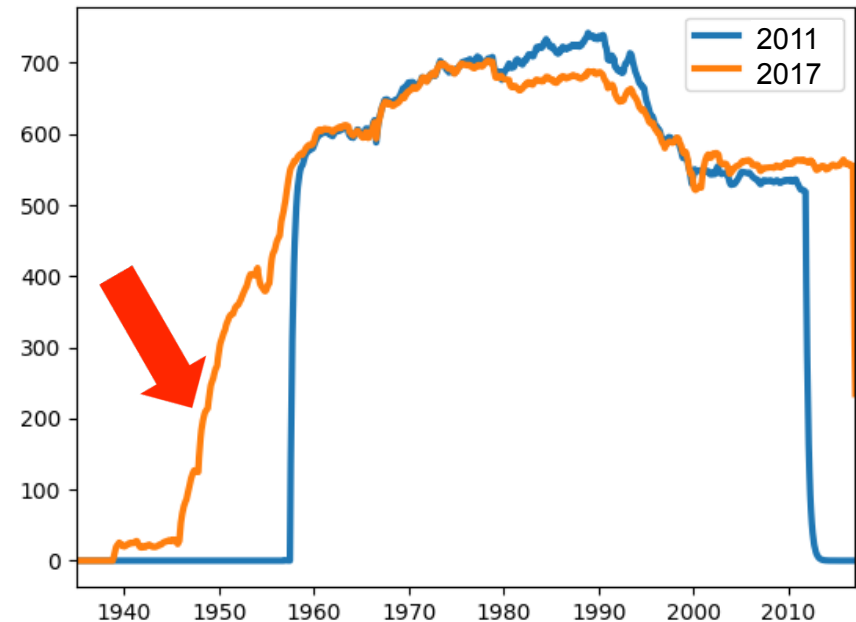
South of 20N

Monthly records, 500hPa



North of 20N

Monthly records, 500hPa

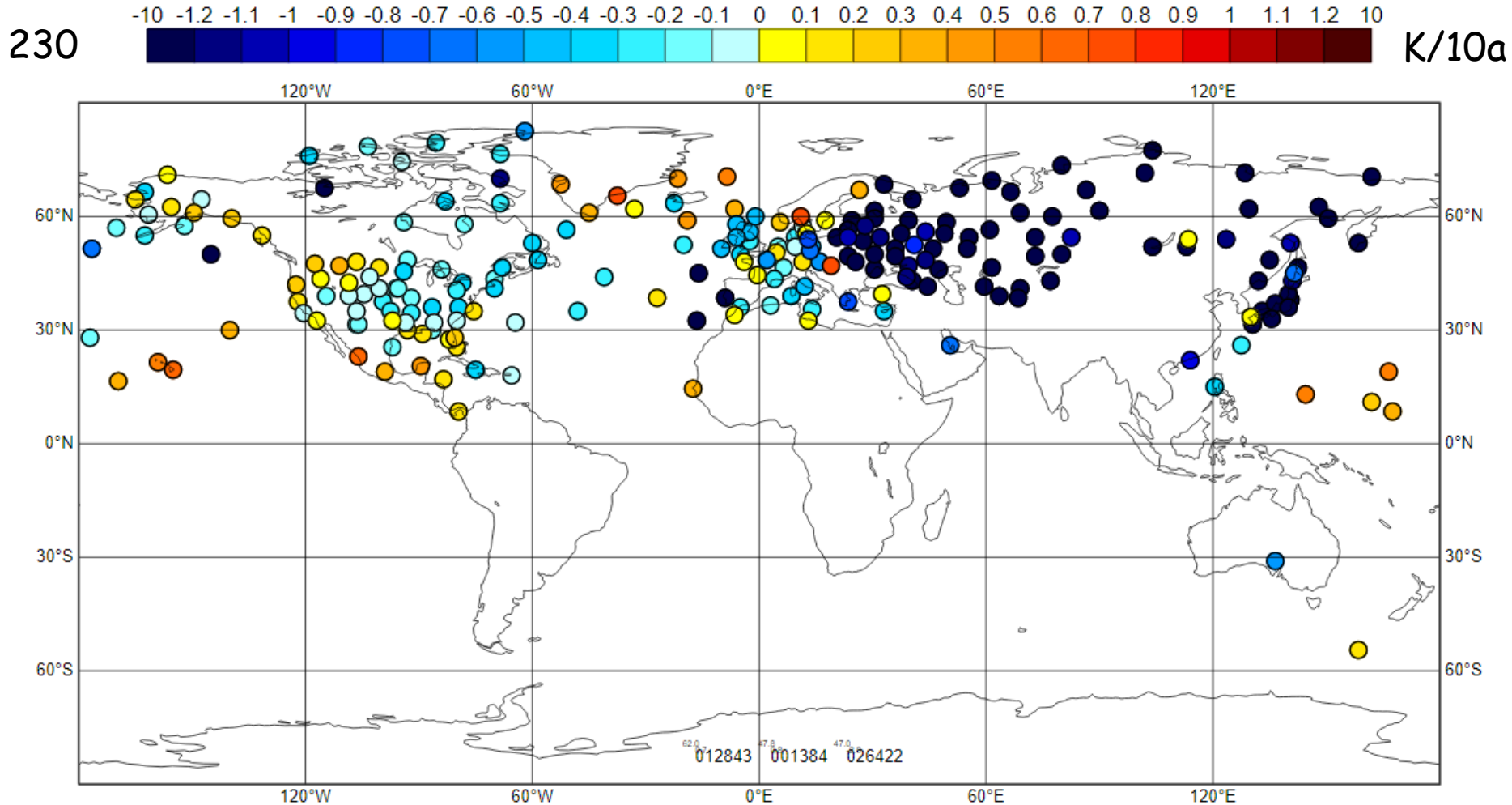


- Many of the pre-IGY data have been digitized only recently (ERA-CLIM(2))
- Are now in ODB format - ready for assimilation with Copernicus ERA5
- Homogeneity adjustments??

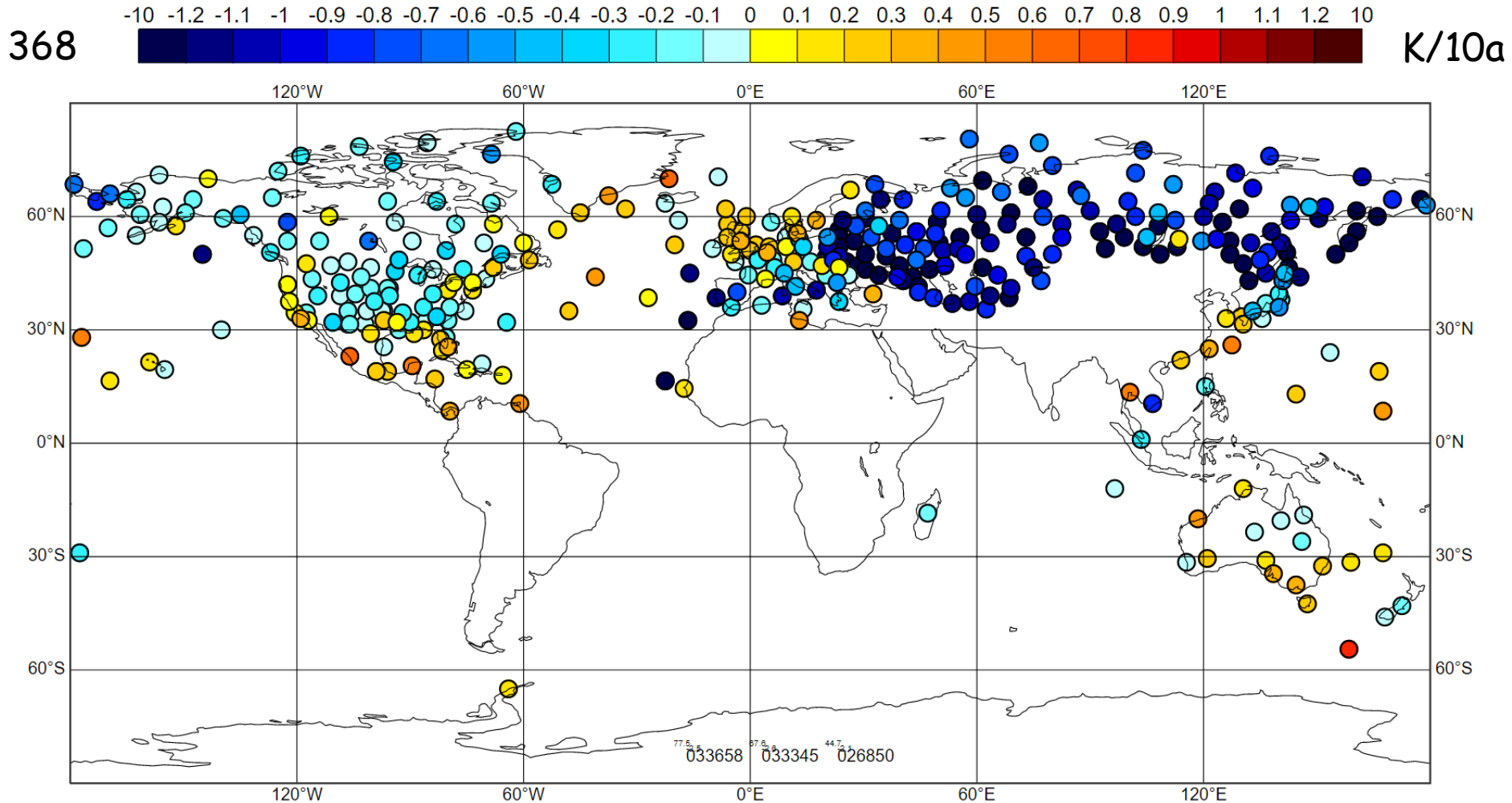
# 5 Highlights

- Pervasive biases in pre-satellite era
  - Data may nevertheless be of good quality
  - How do they influence the reference?
- Near-surface inhomogeneities
- Influence of GPS-RO data
- Adjustment of short records
- Annual cycle of bias

# Trends 1949-1969, 300 hPa



# Trends 1954-1974, 300 hPa



# RAOBCORE/RICH Homogenization

- Break Detection
  - analyzes differences between radiosonde temperature time series and existing reanalysis time series as well as HadCRUT(EM)4 temperatures
  - Automatic break detection with SNHT
- Break Adjustments using
  - Reanalyses time series as reference (**RAOBCORE**)
  - Neighbouring RS time series as reference (**RICH**)
- Adjustment of whole series if most recent part is biased - also short records adjusted

# Reference series

- There is no perfect reference series
  - `eijra_fgdep`:
    - ERA-preSAT 1939-66, JRA55 1967-78, ERA-Interim 1979-
    - Transition adjustments: 4yr parallel (1963-66, 1979-83, adjustments for each month)
  - `eice20c_andep`:
    - Ensemble mean CERA20C analyses 1939-78, ERA-Interim 1979-
  - `jrace20c_andep`:
    - CERA20C analyses 1939-1978, JRA55 1979-
  - Radiosonde composites (RICH)

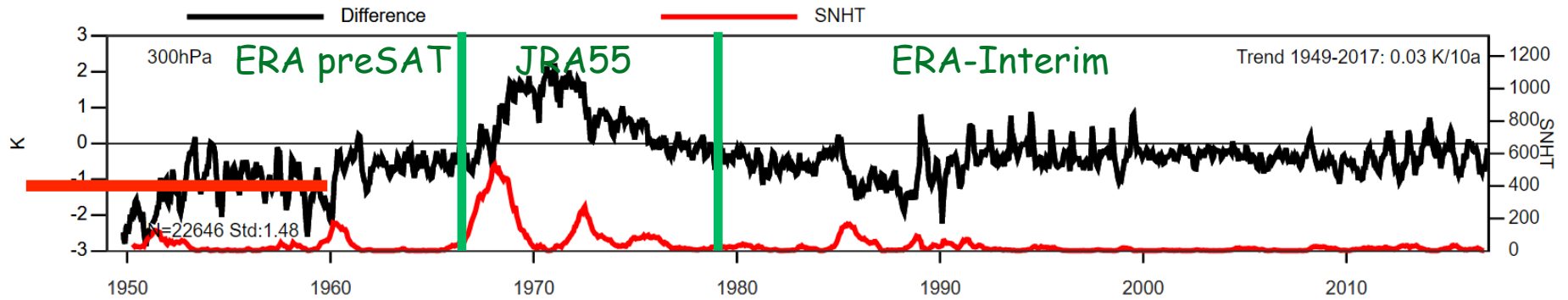


# RAOBCORE/RICH

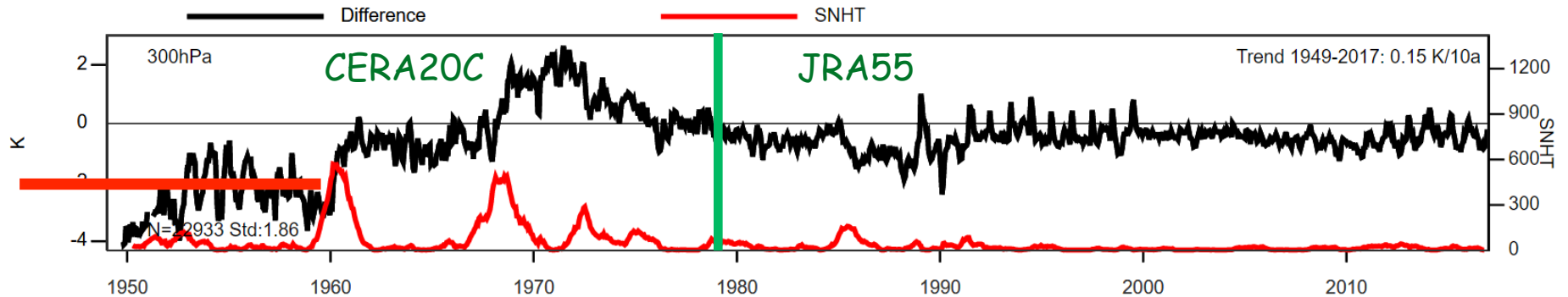
- Reference *eijra*: EI+JRA55+preSAT
- Reference *jrace20c*: JRA55+CERA20C

SONDES	260630RZ049	194501009941
SONDES	260630A22	1959030099 1
SONDES	260630RKZ-1	1962050099 1
SONDES	260630RKZ-2	1972110099 1
SONDES	260630MARS	1985020099
SONDES	260630MRZ	1991010099 1

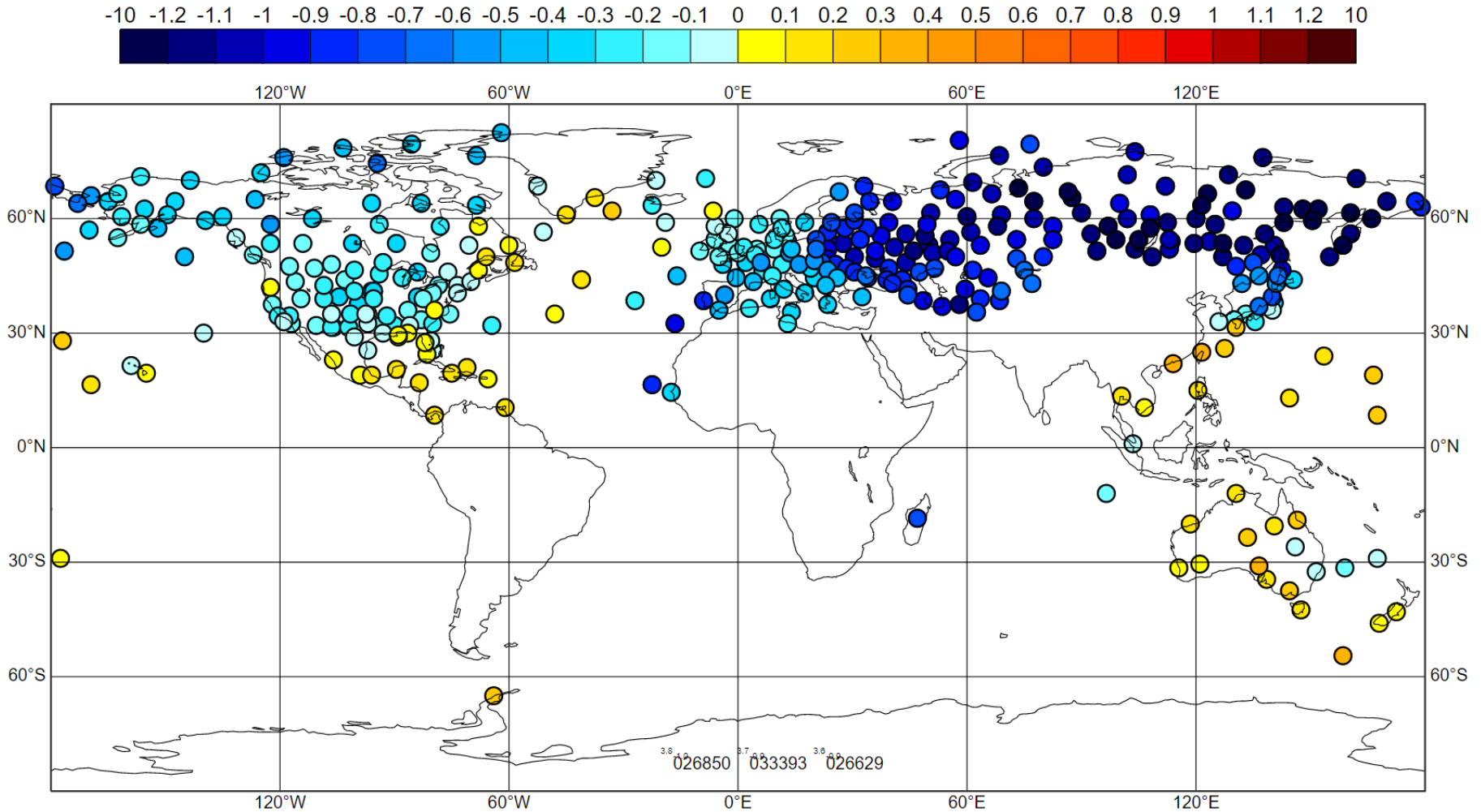
*eijra\_fg* departures, 026063 ST.PETERSBURG (VOEJKOVO) , 59.95N, 30.70E, 00h, exp03



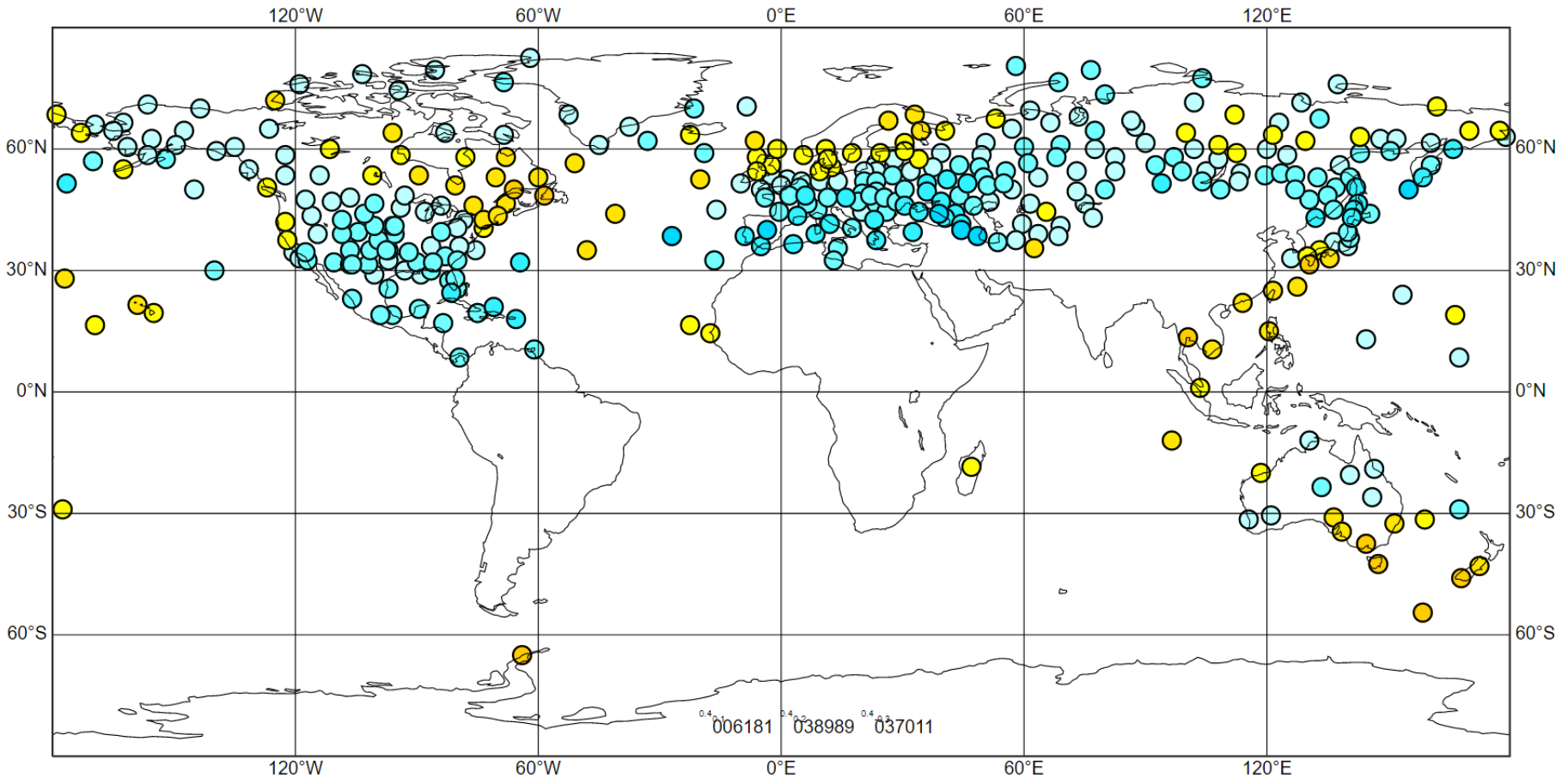
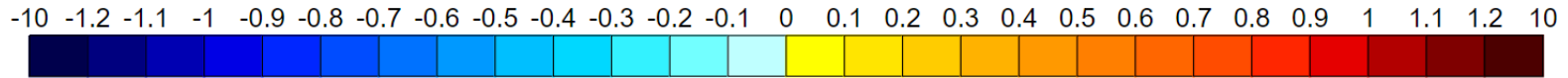
*jrace20c\_an* departures, 026063 ST.PETERSBURG (VOEJKOVO) , 59.95N, 30.70E, 00h, exp03



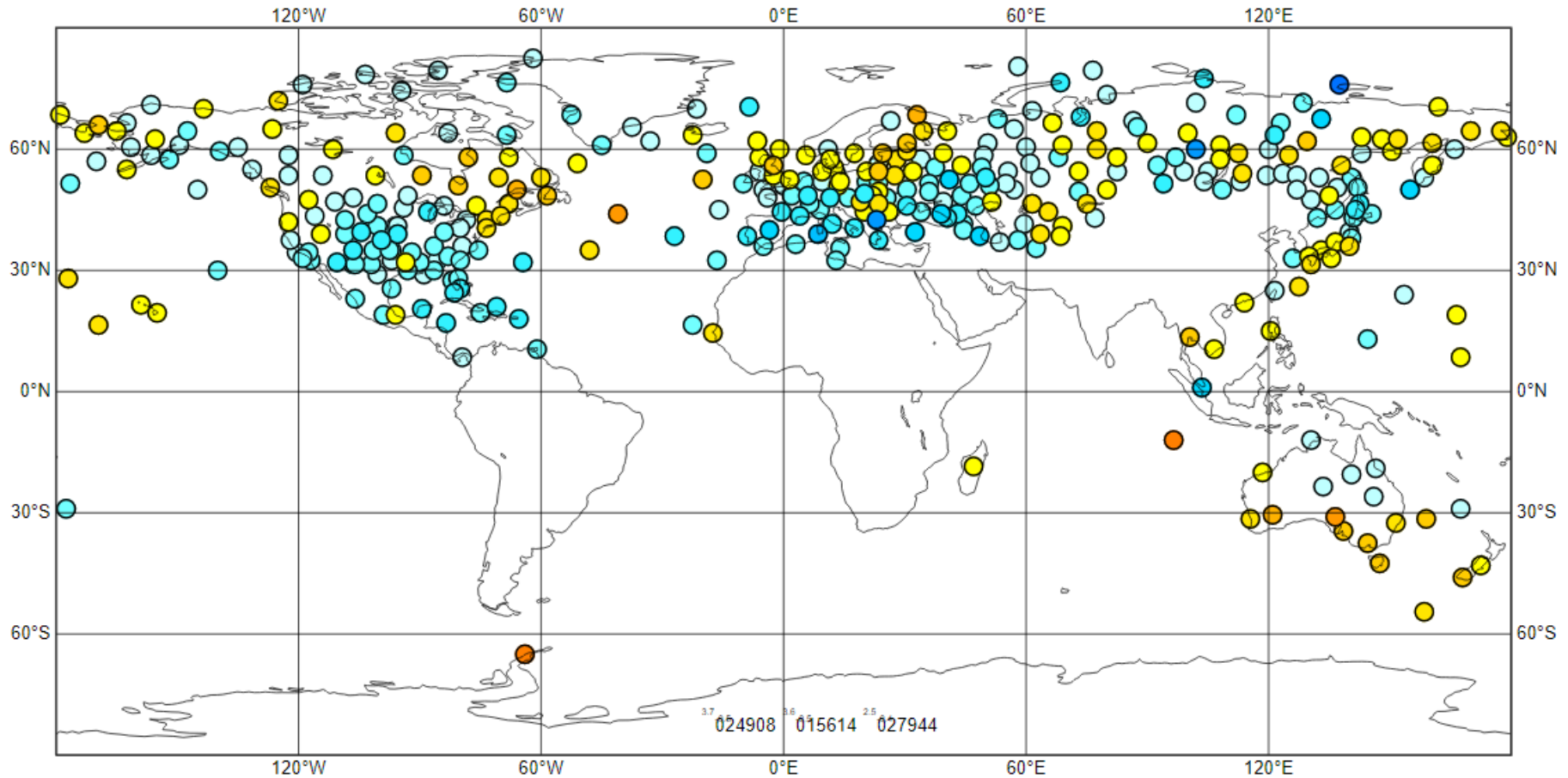
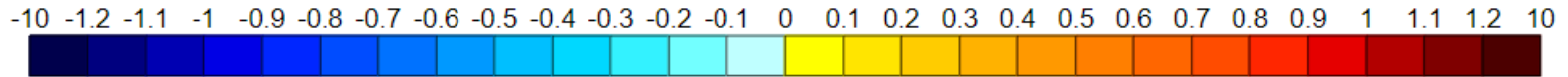
# Trend ERA-preSAT+JRA55 1954-1974



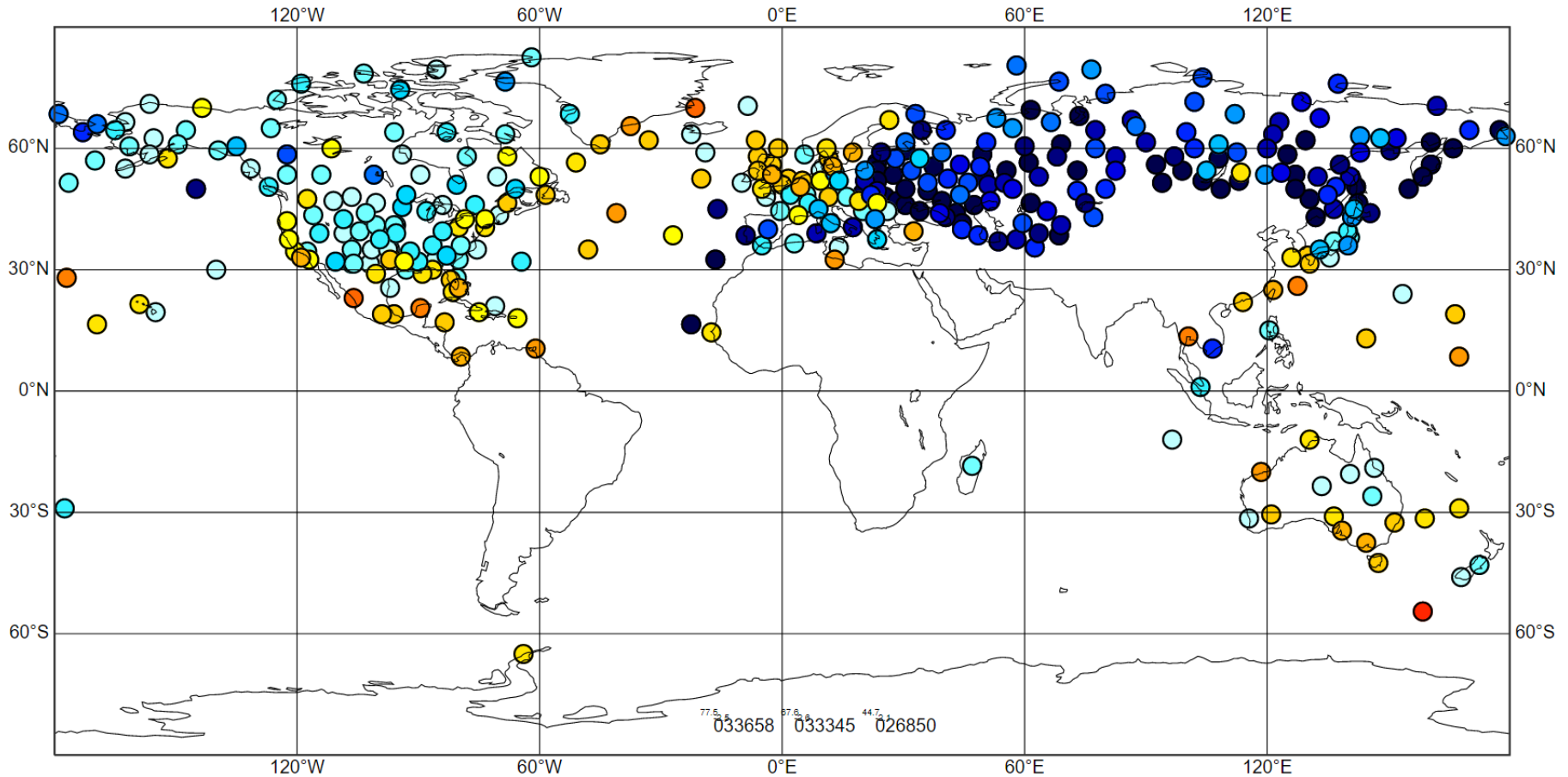
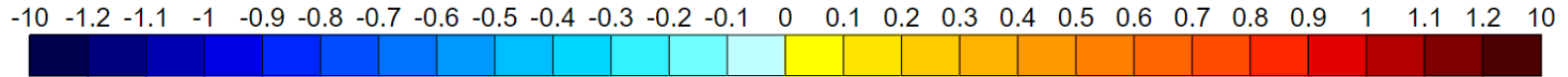
# Trends CERA20C 1954-1974



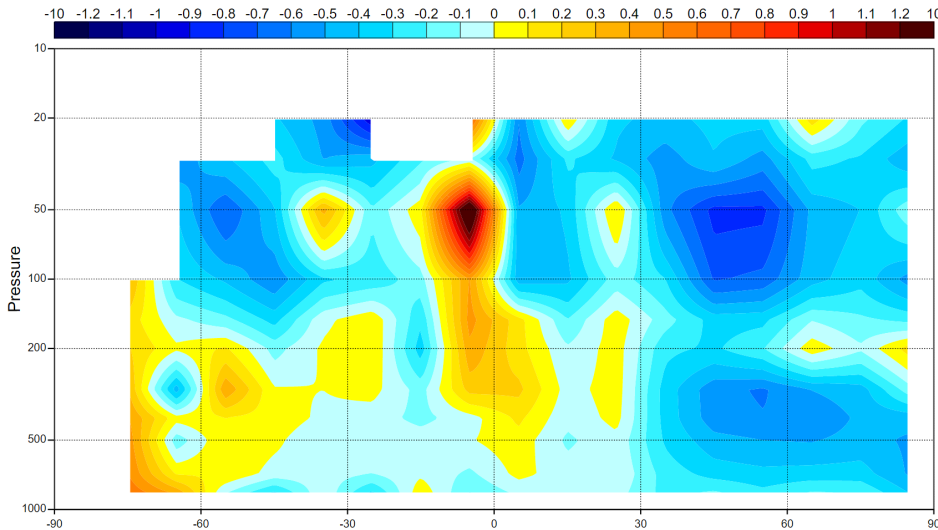
# Adjusted trends 1954-1974



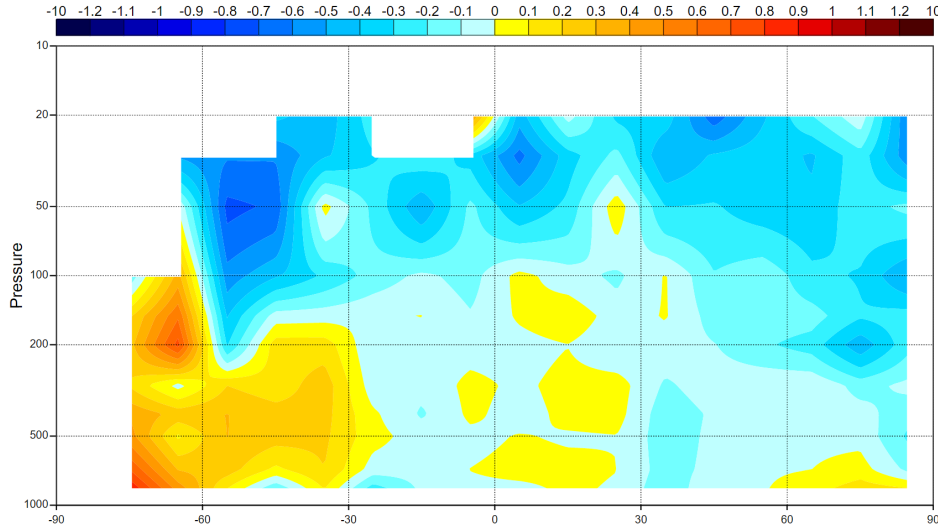
# Unadj. Trends 1954-1974, 300 hPa



# Effect on zonal mean trends



1954-1974  
before adjustment

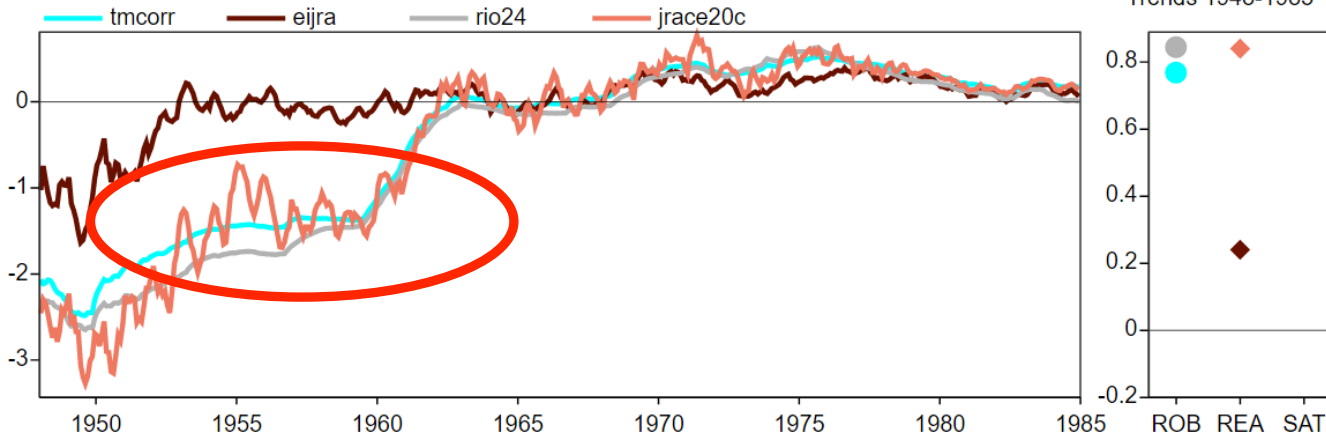


1954-1974  
after adjustment



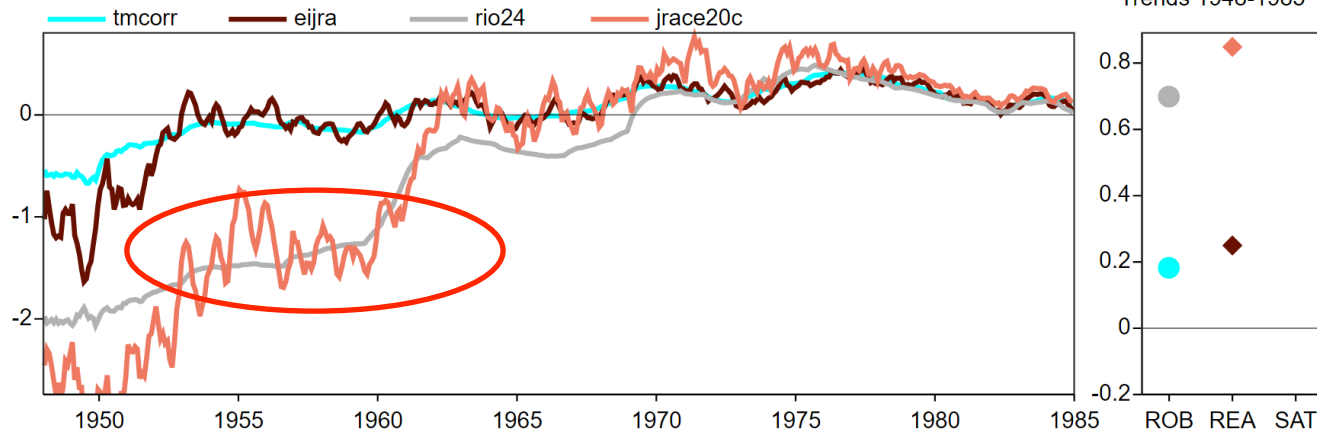
# Adjustment FSU using different reference series

Anomaly Differences [K] to tm, NHEX, 300 hPa, (1981-2010 Clim), Version exp02



- FSU 1948-1985
- Difference series to unadjusted radiosondes
- 1.5K bias!
- Adjustment suggested both by CERA20C, RICH

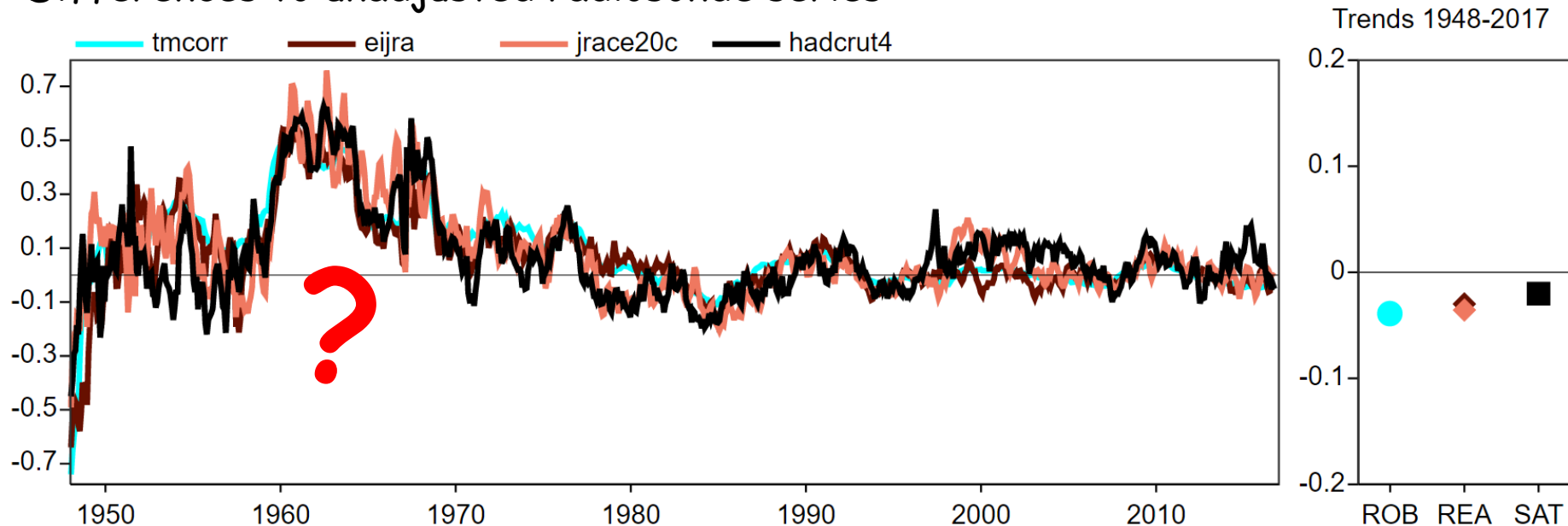
Anomaly Differences [K] to tm, NHEX, 300 hPa, (1981-2010 Clim), Version exp03



- JRA55/ERA-preSAT as reference
- Breaks detected but not adjusted!
- RICH still works here!

# 850 hPa temperatures in Tropics

Differences to unadjusted radiosonde series

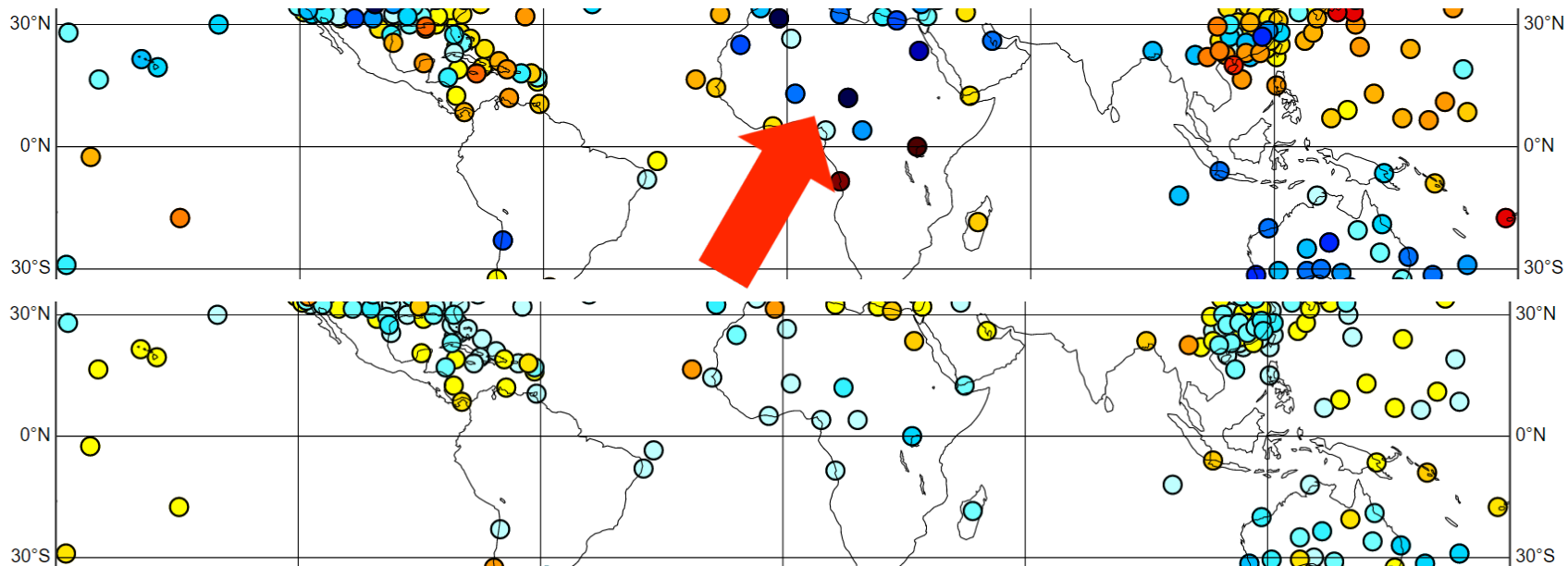
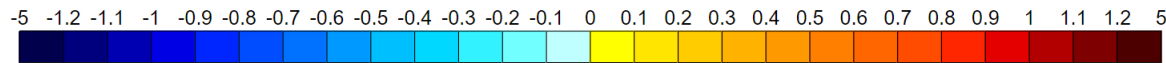


- RS 850 hPa temperature 0.5K too cool in Tropics?
- Not only vs. Reanalyses but also vs. HadCRUT4



# Some very cool temperatures over Africa?

Difference radiosonde-reanalysis 1959-1960, 850 hPa

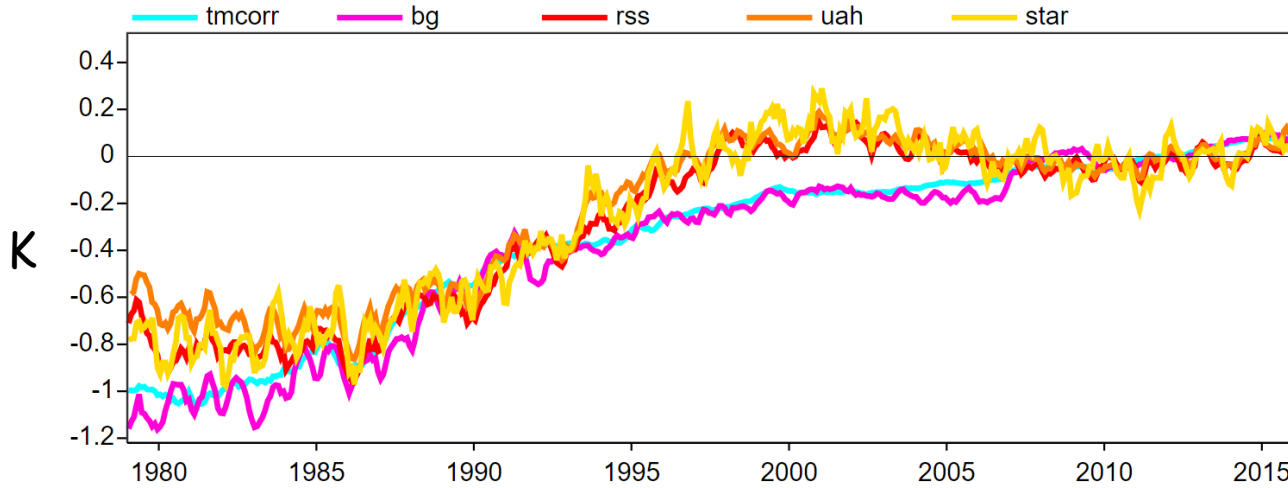


Unadj.

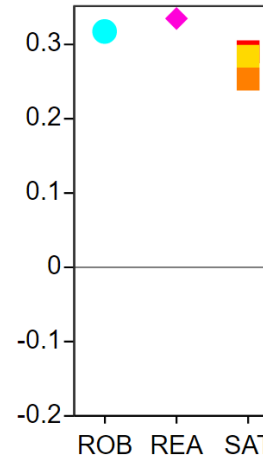
Adj.

# Comparisons for Satellite Era: MSU TLS

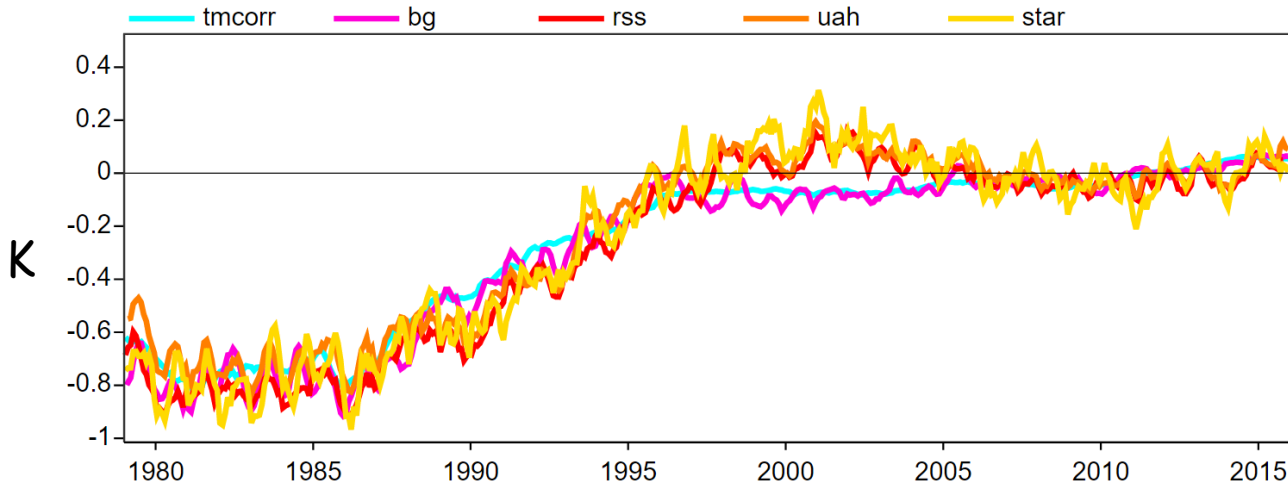
Anomaly Differences [K] to tm, Globe, TLS, (2006-2016 Clim), Version exp01



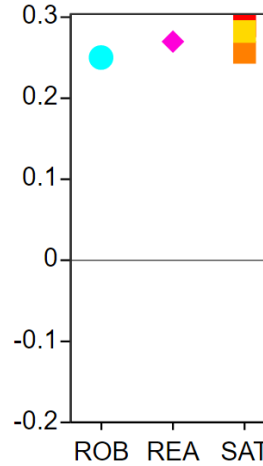
Trends 1979-2016



ERAI bg  
reference



Trends 1979-2016

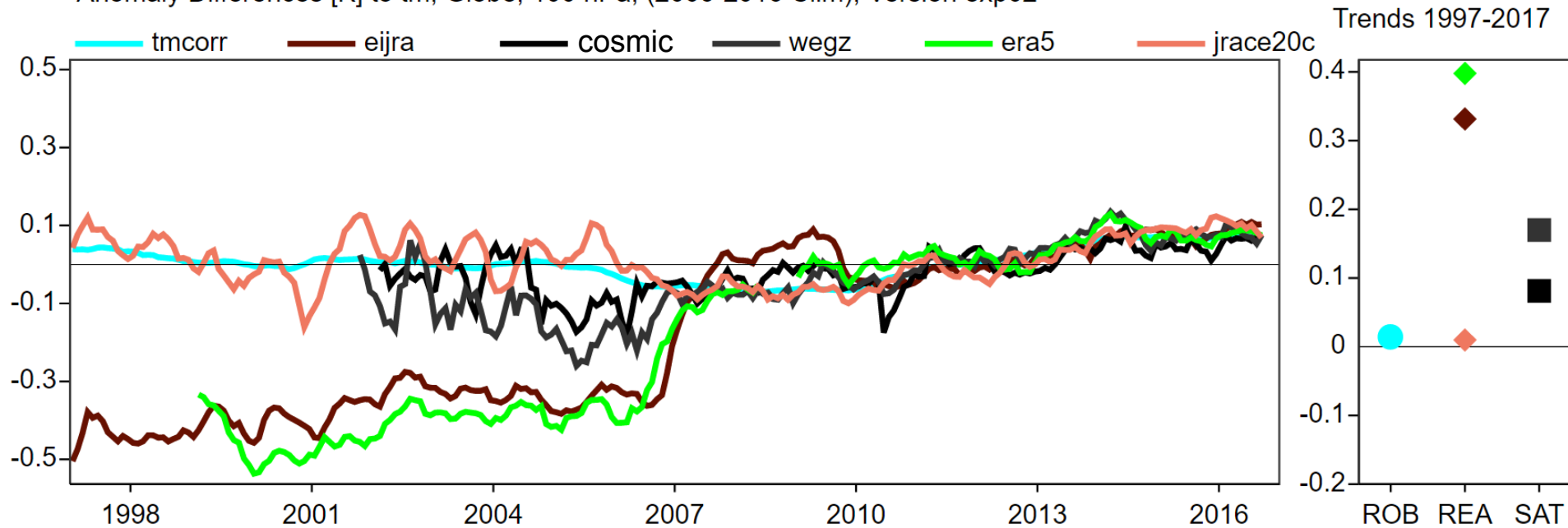


JRA bg  
reference

**Better fit!**

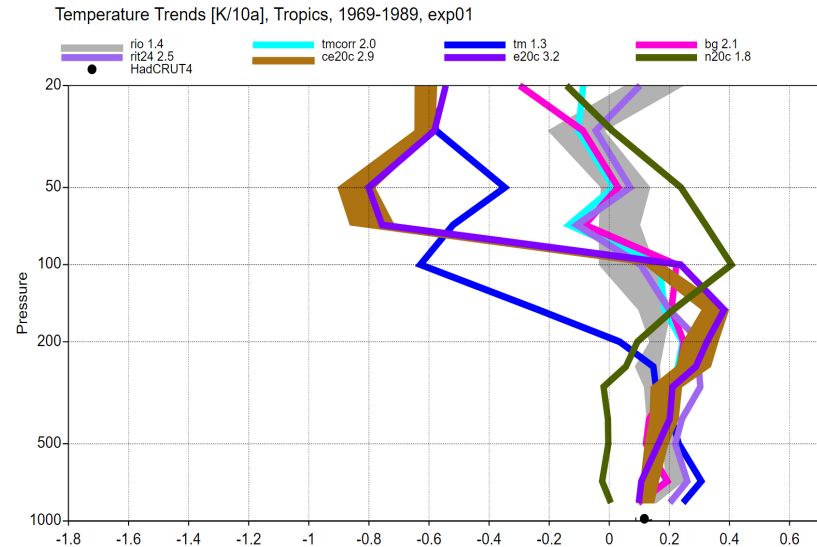
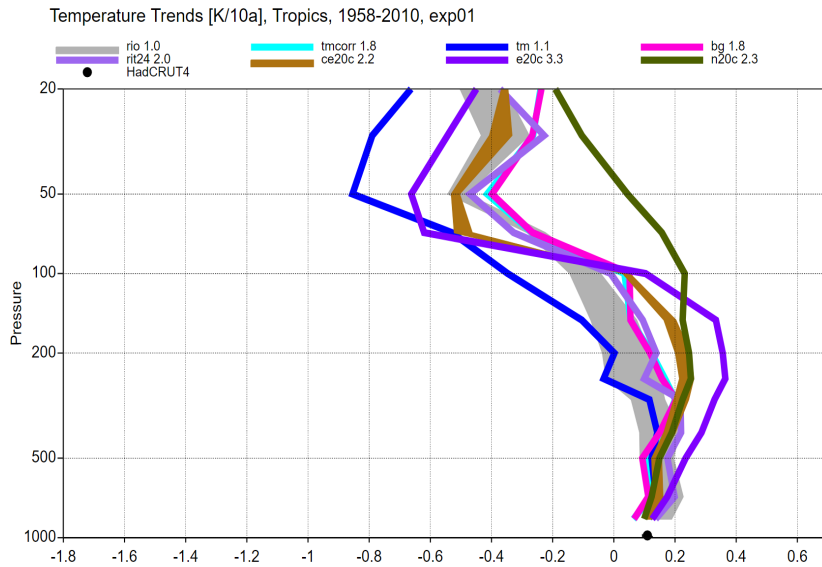
# Pre-COSMIC to COSMIC, 100 hPa

Anomaly Differences [K] to tm, Globe, 100 hPa, (2006-2016 Clim), Version exp02



- GPS-RO from CDAAC (Boulder) and Wegener Center (Graz)
- ERAI cooler than CHAMP RO data until 2007, ERA5 has the same problem
- JRA55 slightly warmer than RO during CHAMP period
- Excellent agreement after 2007

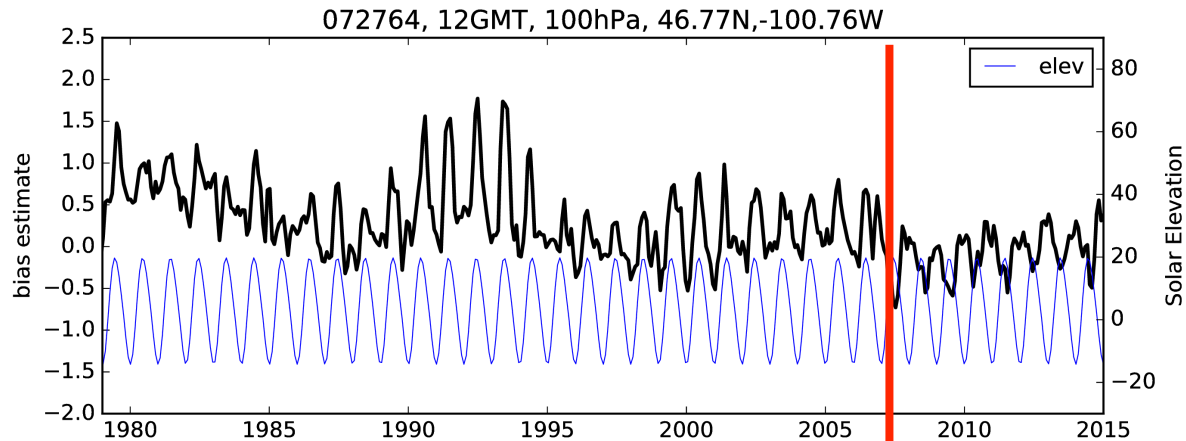
# 20S-20N T-Trends 1958-2010



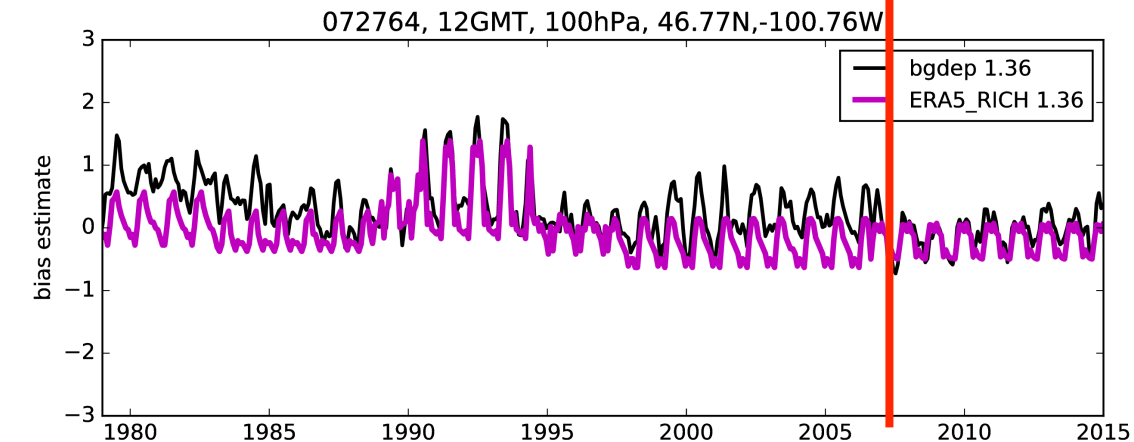
- Good agreement for 1958-2010
- Large uncertainty 1969-1989 in stratosphere.

# Annual cycle of radiation error

- At high latitudes, regions around 100W, 80E
- Estimate radiation error as function of solar elevation




Different radiosonde types have different annual cycles of bias



Mostly in phase with solar elevation.

# Outlook

- More reliable homogeneity adjustments, 1939-
  - Some large biases could be addressed
  - Consistency with GPS-RO
- Different references tried
  - CERA20C+JRA55 best compromise
  - Other choices help assessing uncertainties involved
-  Deliverable, to be used in ERA5
- <http://srvx1.img.univie.ac.at/raobvis/>
- Humidity - M. Blaschek's talk
- Revisit wind - many new PILOTs in early period

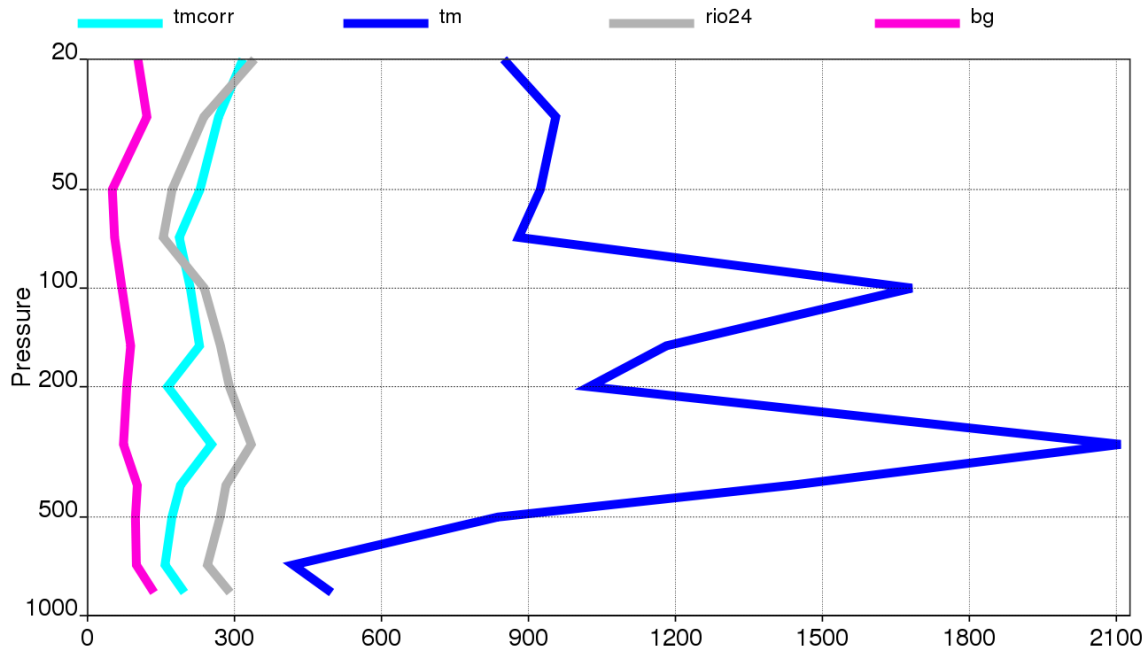


5th ICR, Rome, Nov 2017



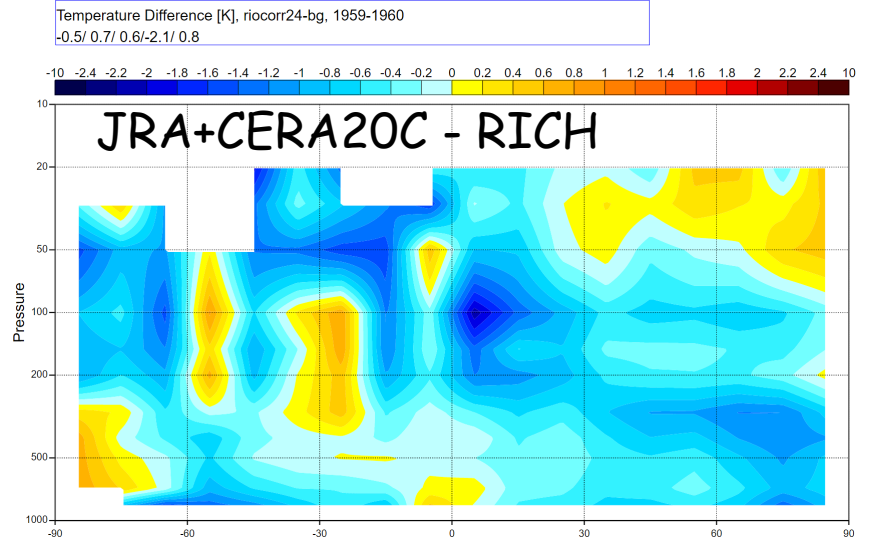
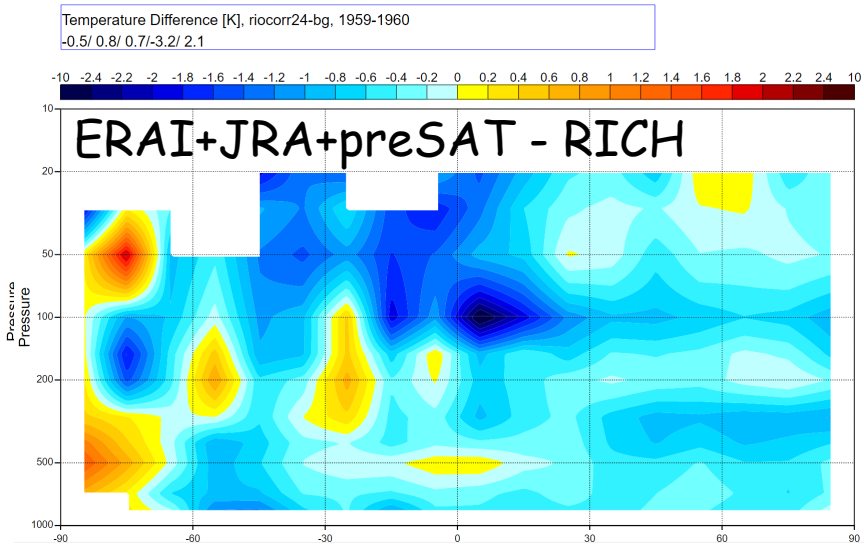
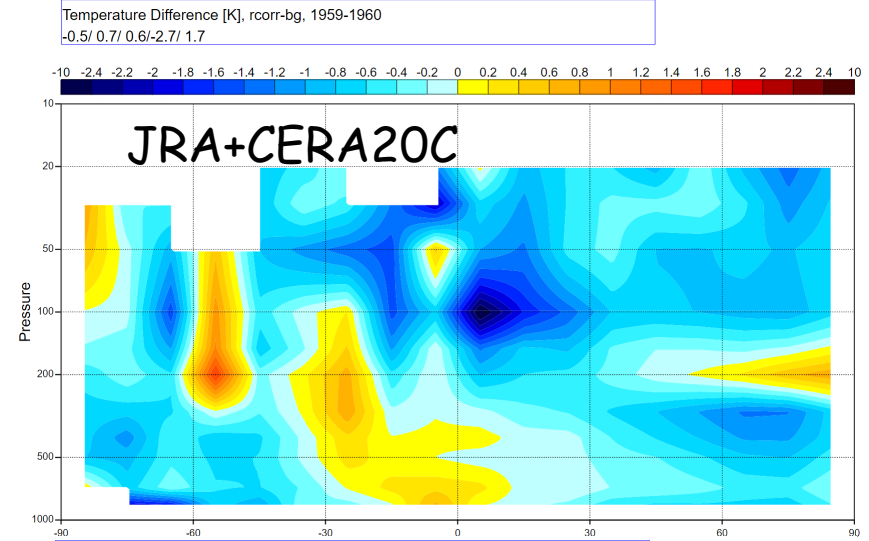
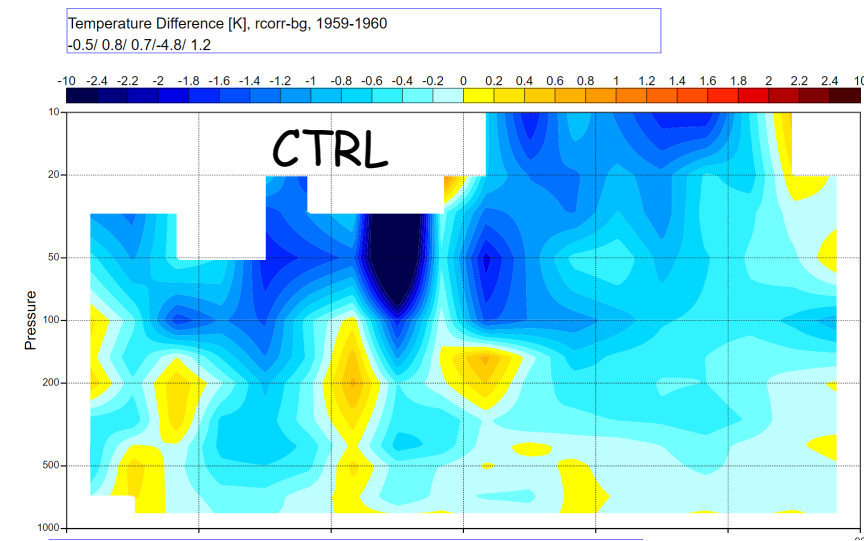
# Spatial trend consistency

Temperature Trend Cost, , 1959-1979  
1.0, exp02



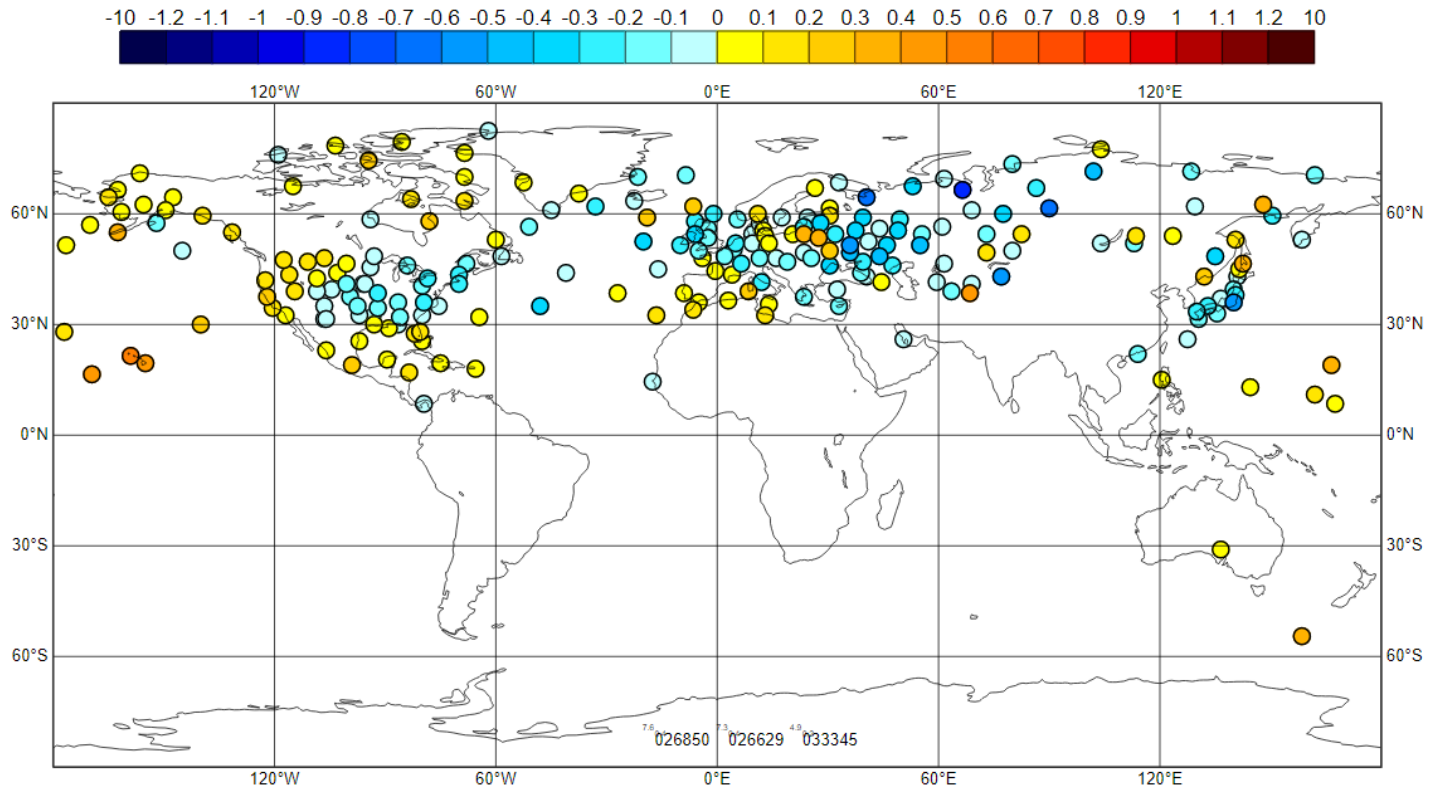


# Overall adjustments 1959-1960



# Adjusted Trends 1949-69, 300 hPa

Temperature Trends [K/10a], tmcrr, 1949-1969, 24h, 300 hPa  
230 Stations, Cost: 173.63, 1.0, eice20c\_andep



# Results from radiosonde intercomparisons

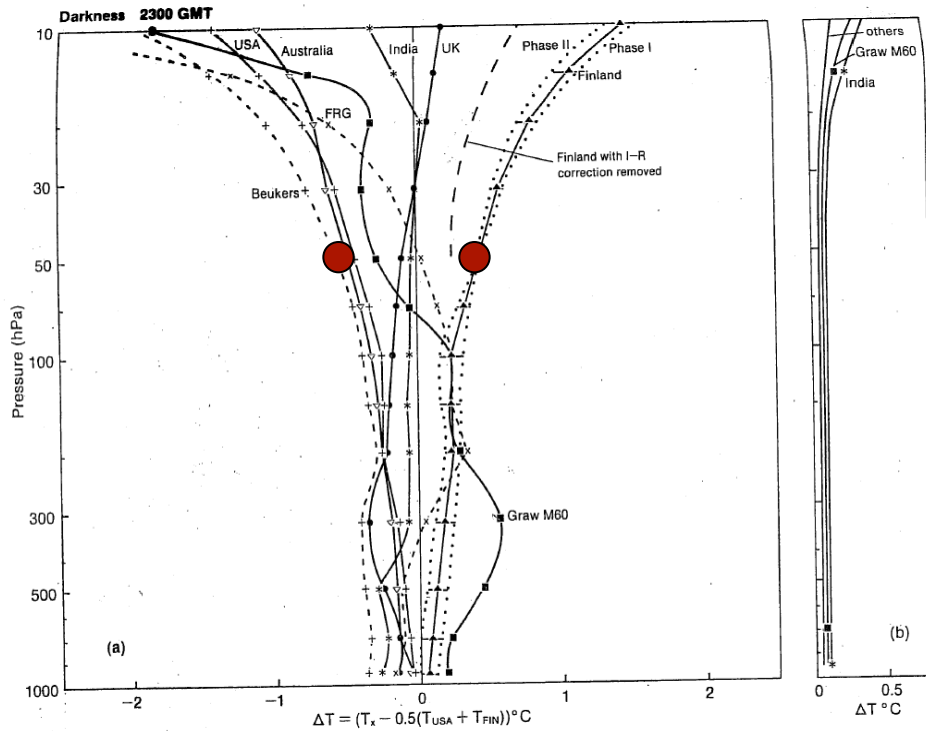


Fig. 5.3 Combination of simultaneous temperature comparison data from Phases I and II for dark conditions. (a) consistent differences; (b) standard error (1 S.D. level) estimates.

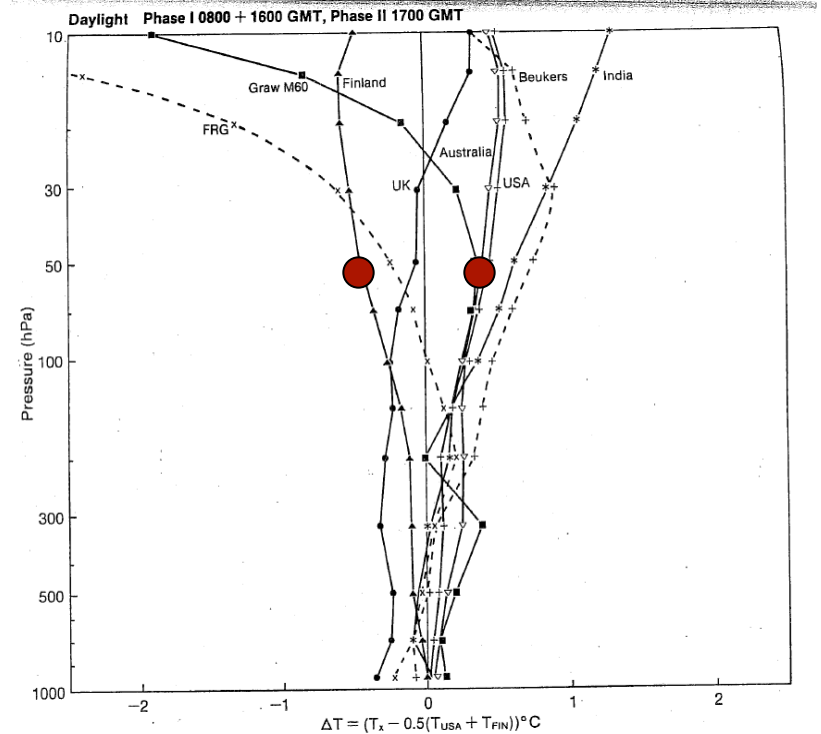
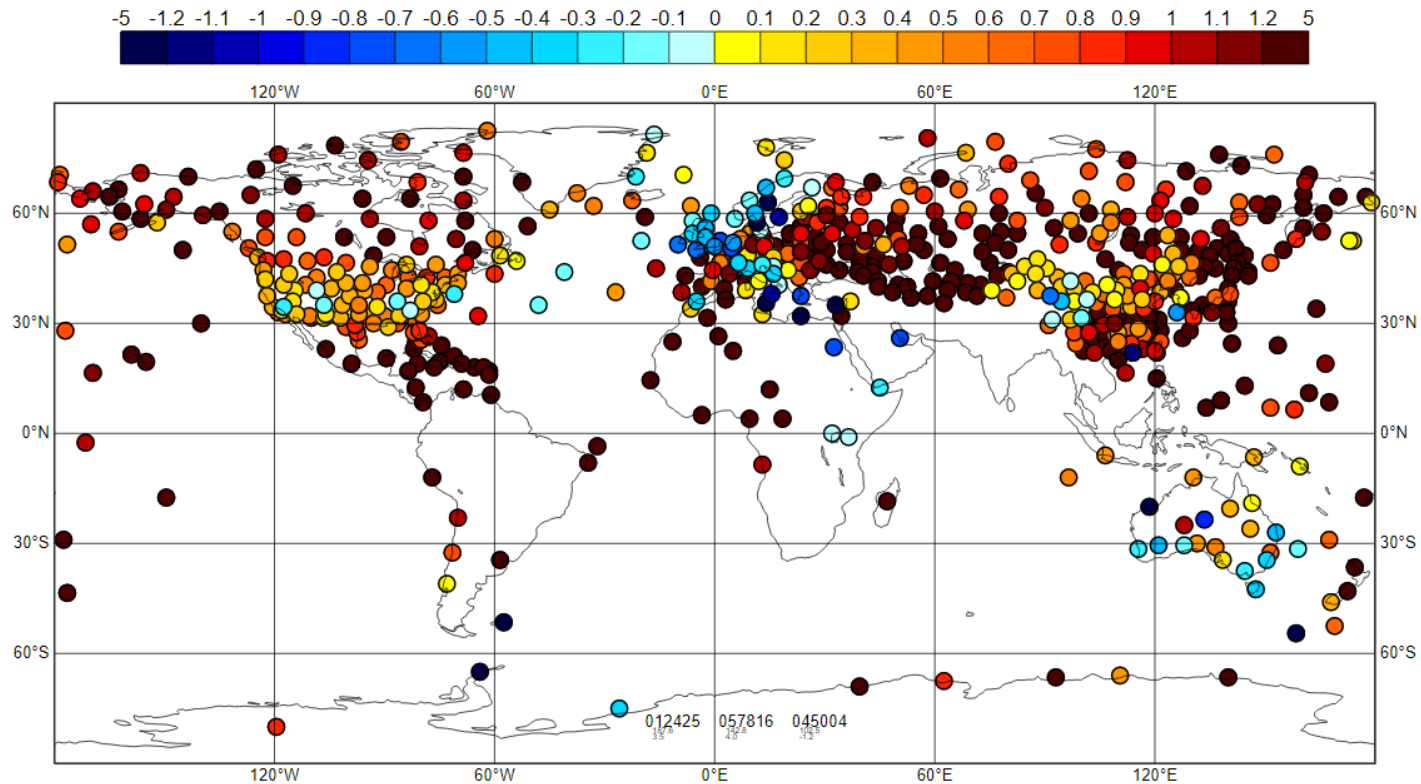


Fig. 5.4 Combination of simultaneous temperature comparison data from Phases I and II for daylight conditions.

Nash and Schmidlin, 1987

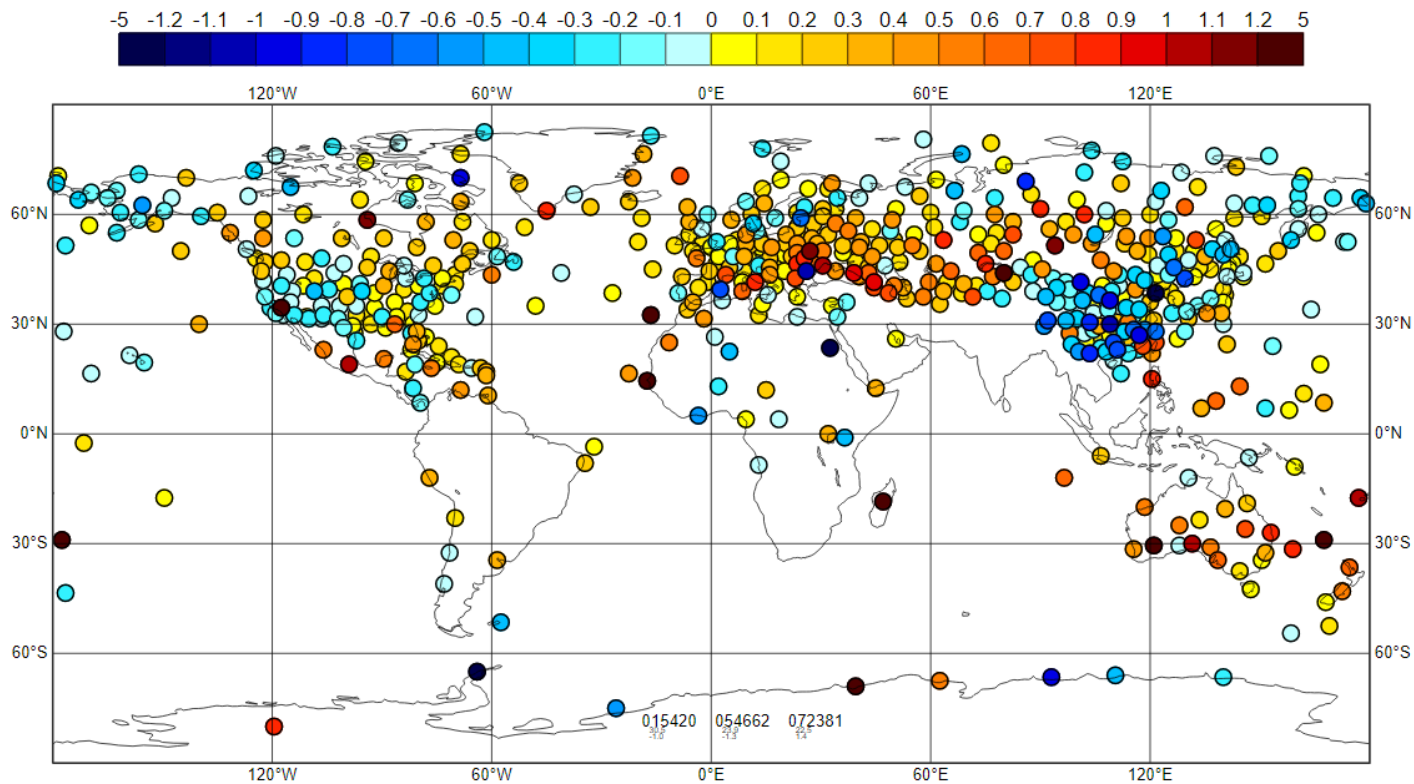
# Temperature Differences

Temperature Difference [K], tm-bg, 1959-1960, 24h, 100 hPa  
605 Stations, Cost: 5808.67, 1.0



# Temperature Difference ce20c

Temperature Difference [K], tmcrr-bg, 1959-1960, 24h, 100 hPa  
605 Stations, Cost: 1232.16, 1.0



# Temperature Differences ERA-preSAT

Temperature Difference [K], tmcrr-bg, 1959-1960, 24h, 100 hPa  
609 Stations, Cost: 536.69, 1.0

