Radiosonde uncertainty estimates

GRUAN, ICM-10, 25 April 2018

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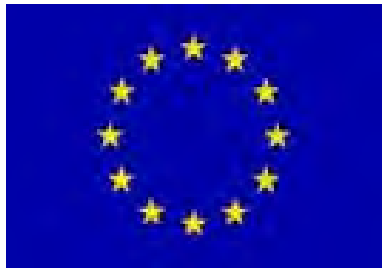
Overview

- Data assimilation diagnostics of vertical radiosonde uncertainty correlation
  - Results for Vaisala data
  - Detection of a radiosonde error (China)
- Short topics
  - Diurnal cycle of GRUAN u at LIN and SGP
  - Variation within operational RS92 data (DE+NL)
  - Preliminary radiosonde descent results (DE)
- Summary

Acknowledgements

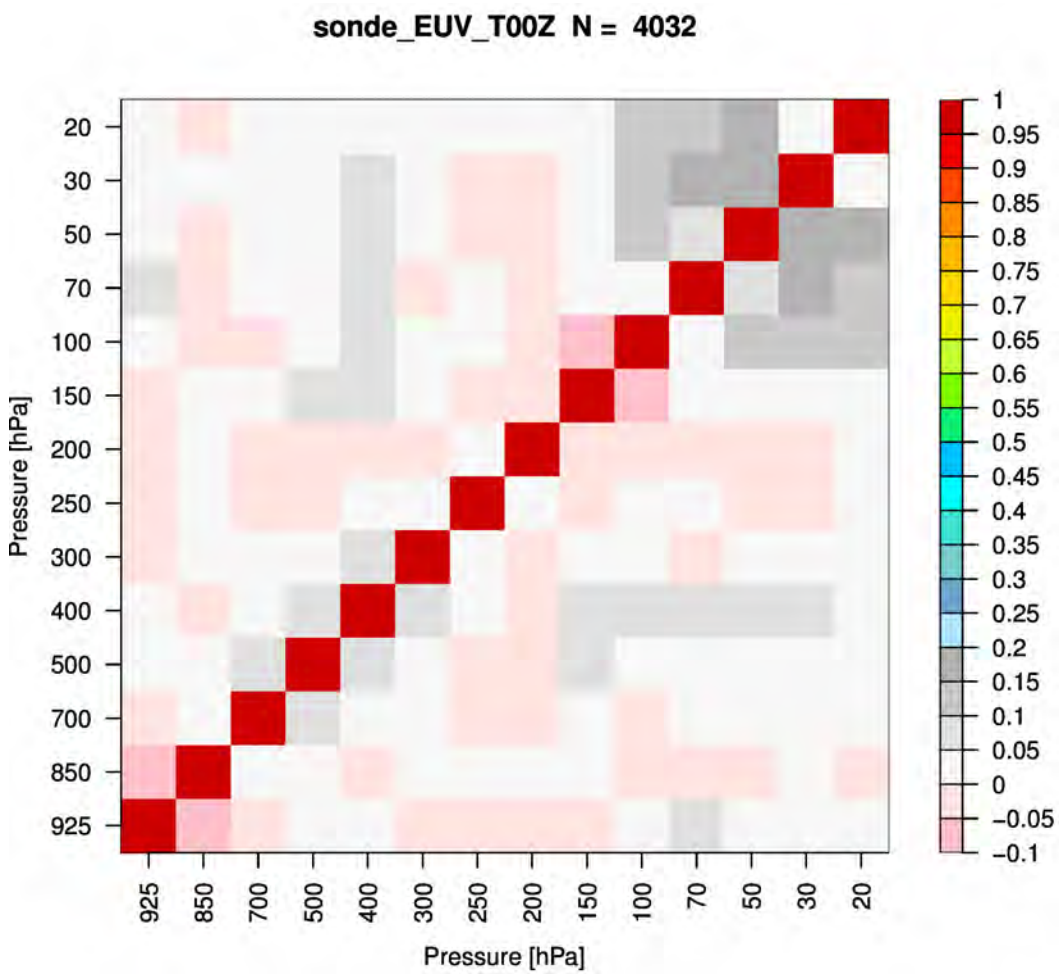
- Thanks to Lars Isaksen and Niels Bormann (ECMWF), Fabien Carminati (MetO), Aki Lilja (Vaisala).
- Part of work done for EU H2020 GAIA-CLIM project
- WP4: using in situ reference data (GRUAN radiosondes) and NWP fields to improve the calibration of satellite data

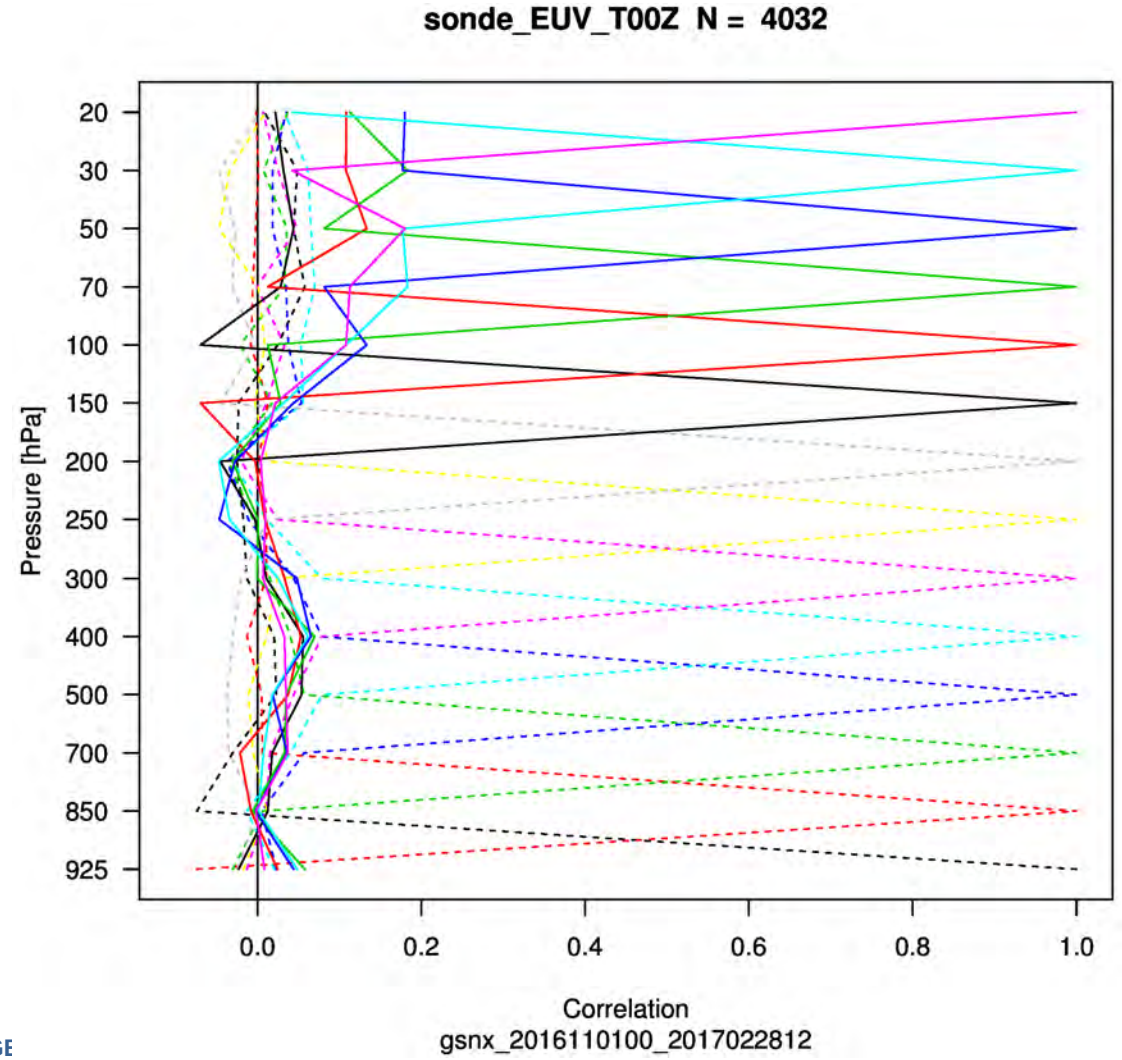


Operational uncertainty vertical correlations

- Using <(o-b)(o-a)> as suggested by Desroziers et al (2005, QJ)
  - Assumes that analysis weights are correct!
  - Can only use for data assimilated operationally
  - Niels Bormann has used this method for satellite channels (and I am using his programs)
  - Expect useful results (not exact answers given the assumptions)
  - NWP convolves measurement and representativeness uncertainty to give σ_o
- Using radiosonde standard levels from 925 to 20 hPa (adding 1000 and 10 hPa would cut the sample size)
- Results shown from radiosonde drift experiment
- Generally small correlations for wind, temperature biases in stratosphere give positive correlations there (next slide)

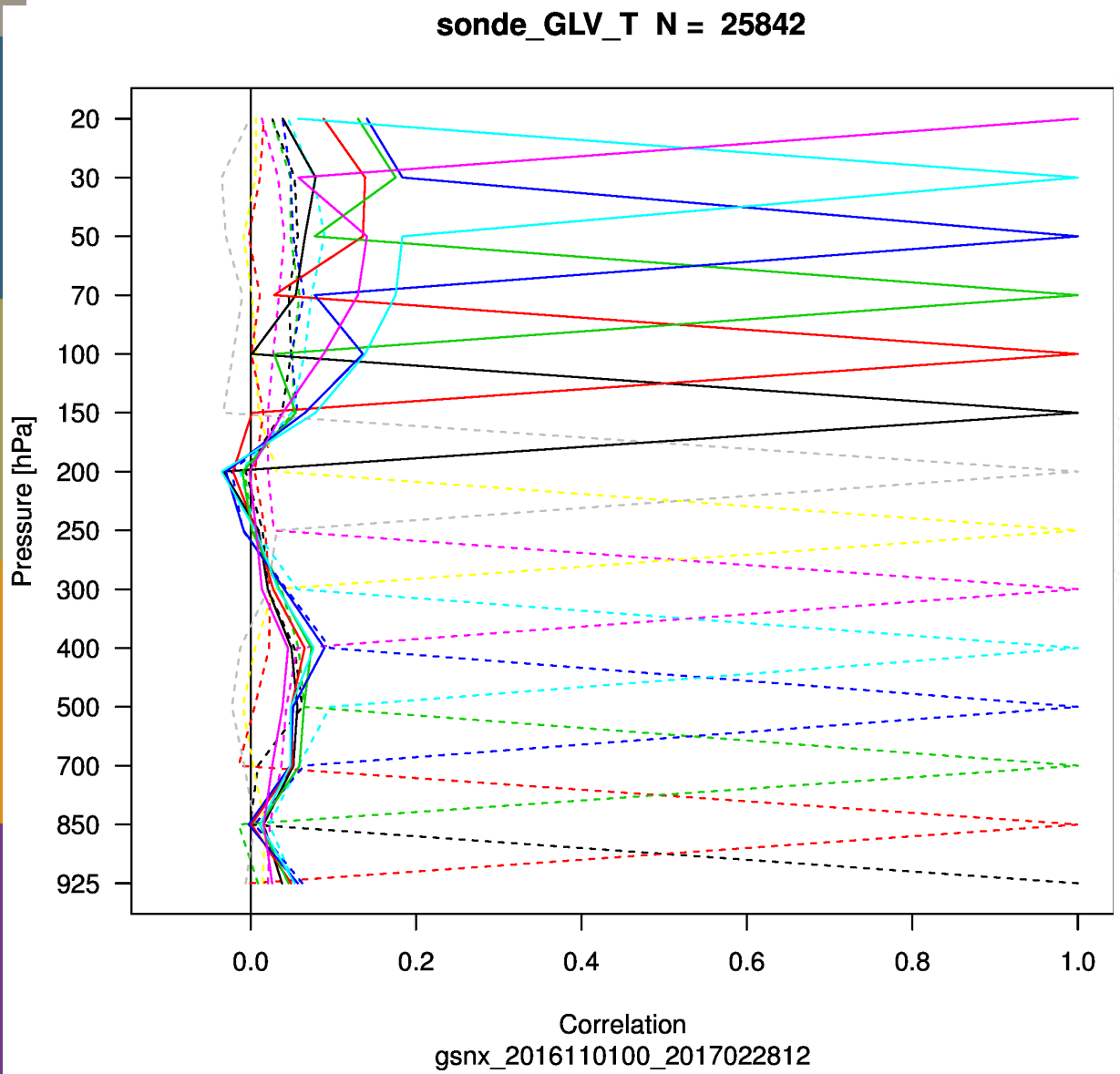
Alternative ways of showing the correlations (here for T)

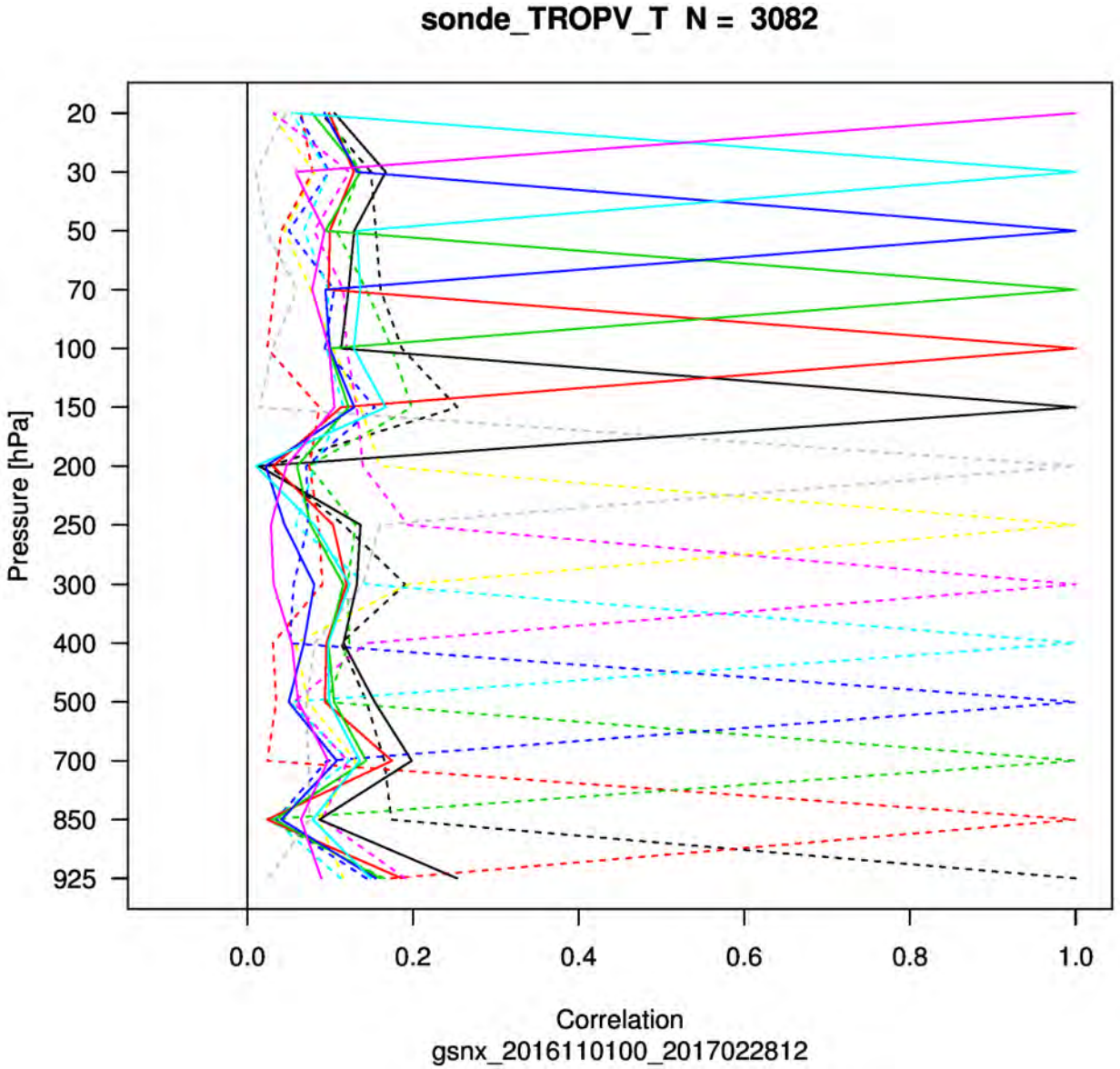




Global vs tropical temperature correlations

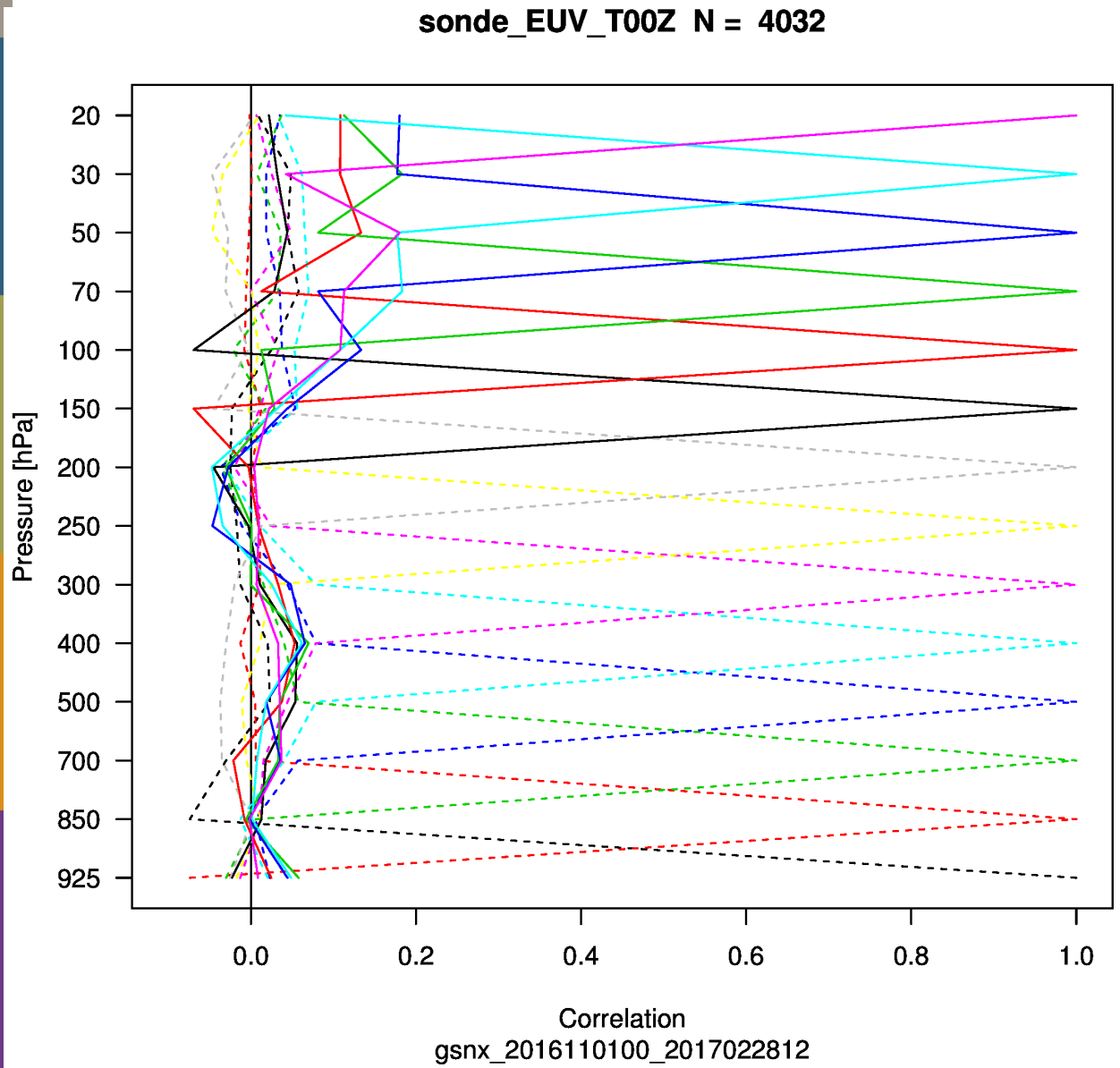
- GL corr up to 0.2 in strat, TR corr ~0.1 at all levels (smallish sample, calibration?)

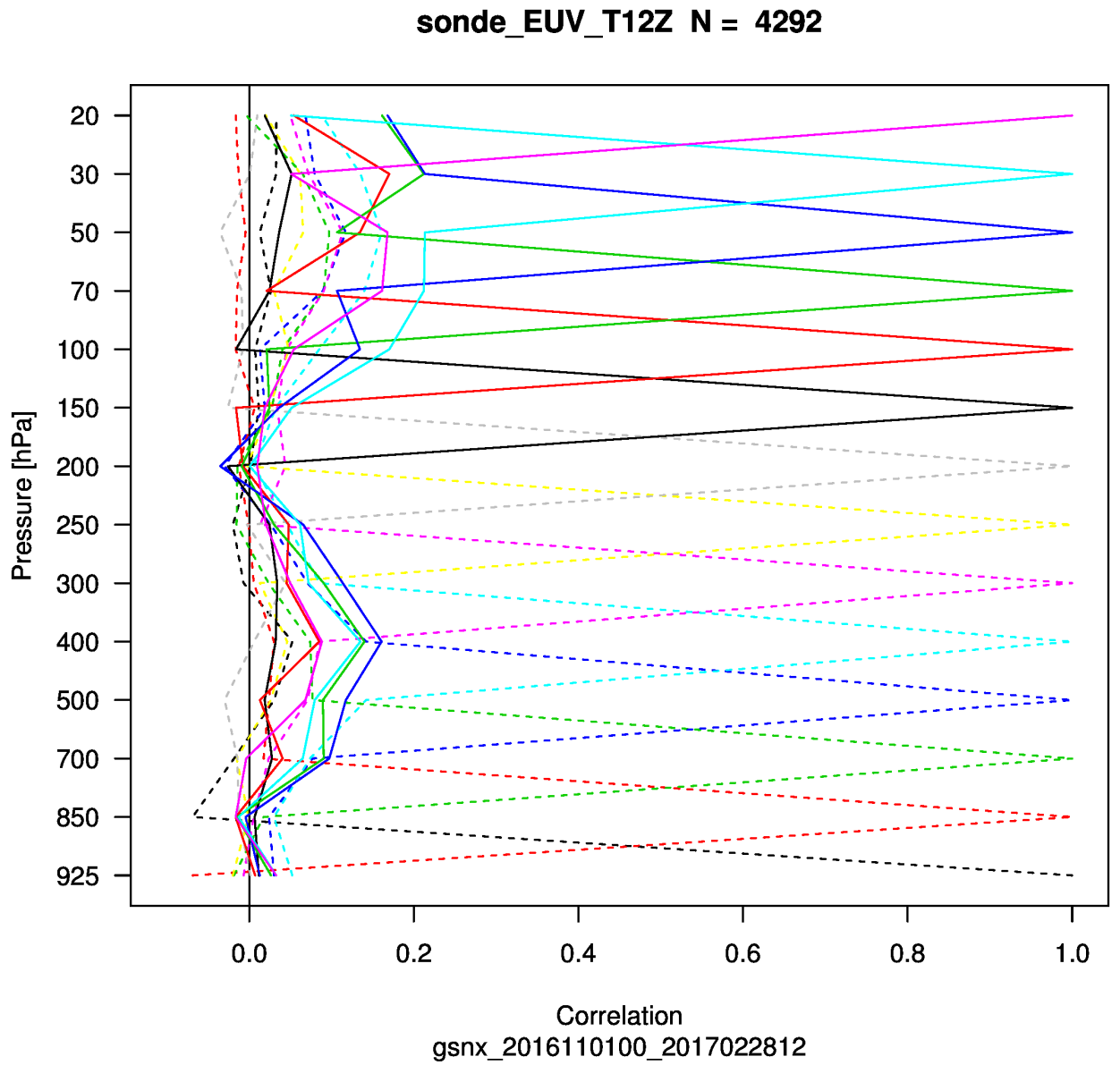




Night vs day T correlations, Europe

- 12Z (right) – slightly larger strat correlations, also larger x-corr with mid-troposphere



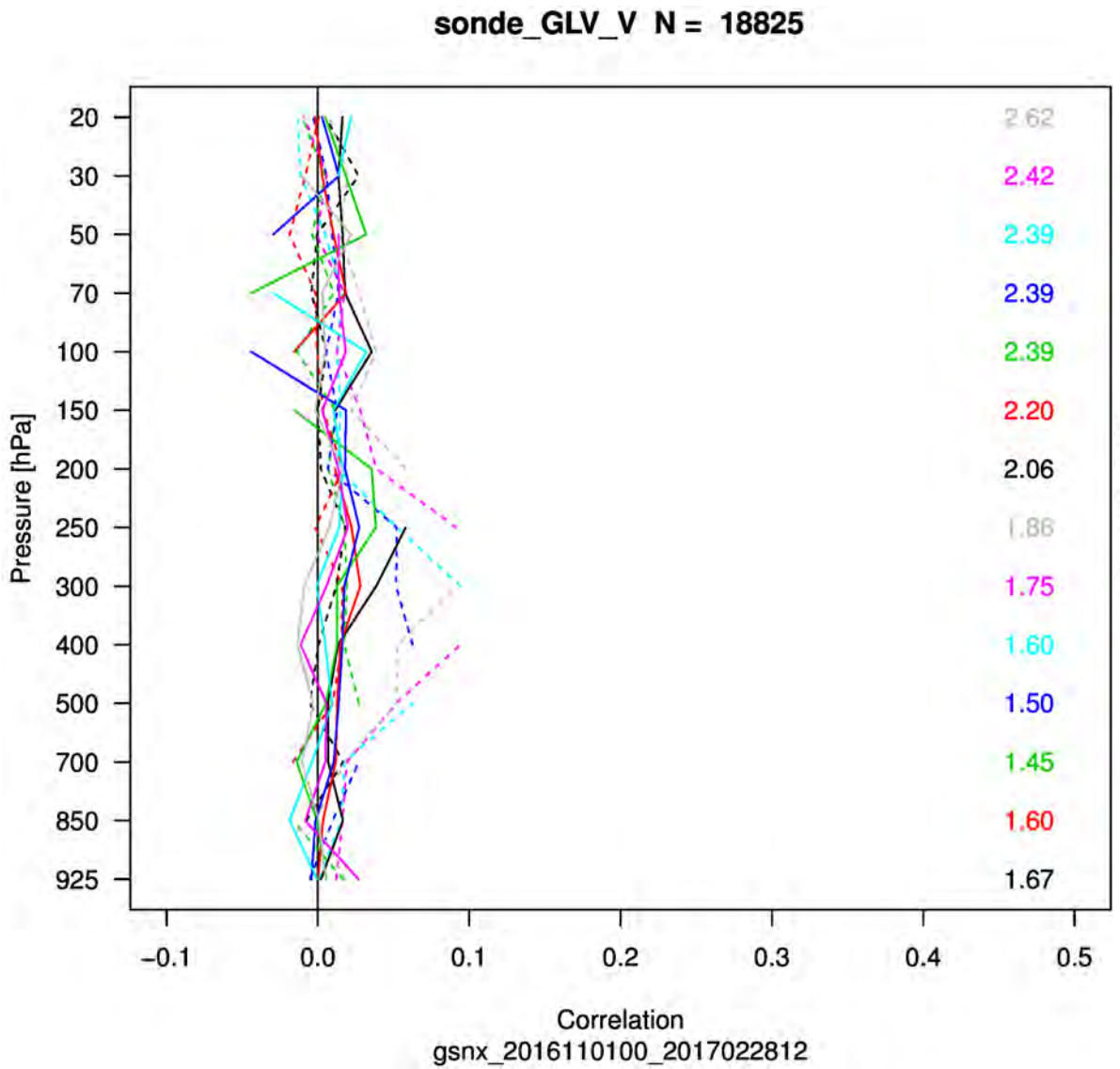


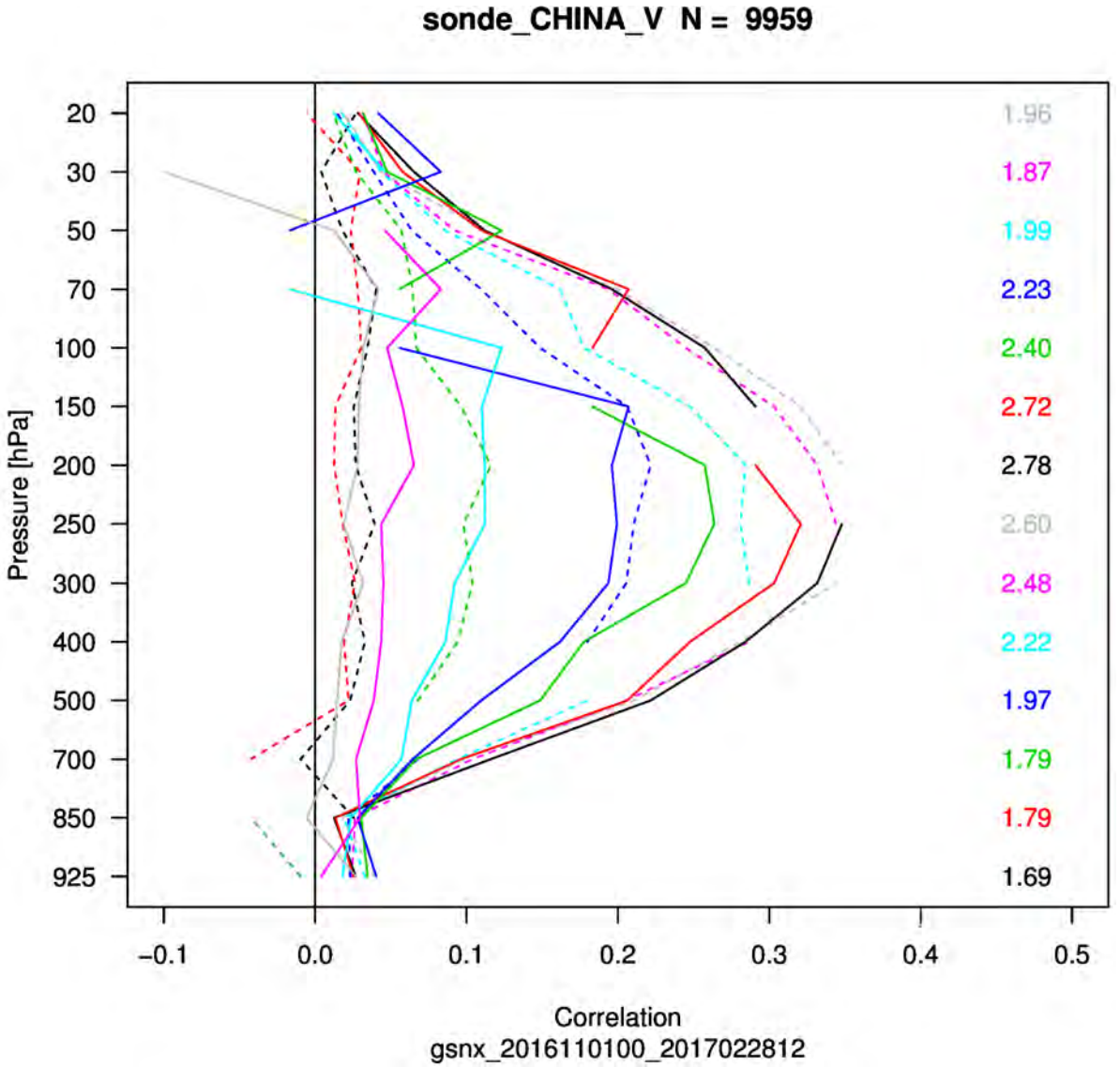
Temperature correlations

- Affected by stratospheric bias in B
- Off-diagonal correlations small in troposphere
- Tropics: off-diagonal correlations small at all levels
  - Baseline o-d correlation of ~0.1 (Calibration? Noise?)
- Some diurnal signal in mid-troposphere as well as stratosphere
  - 200 hPa statistics affected by (biased) aircraft data

Off-diagonal correlations for v-wind: l) Vaisala r) Chinese sondes

- Vaisala very “clean” almost uncorrelated (GPS winds), problem with Chinese winds

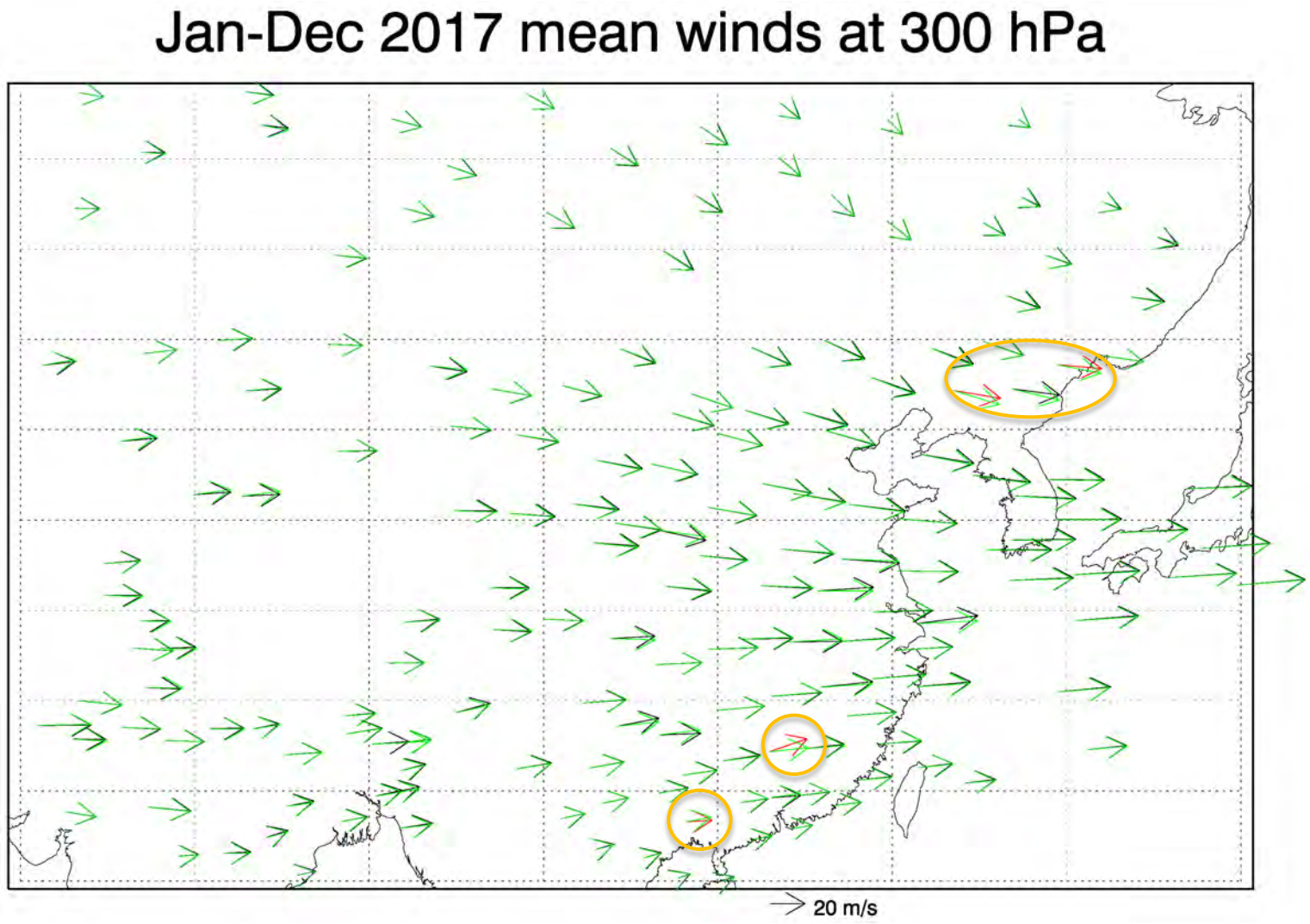




Chinese (radar) winds: some direction problems?

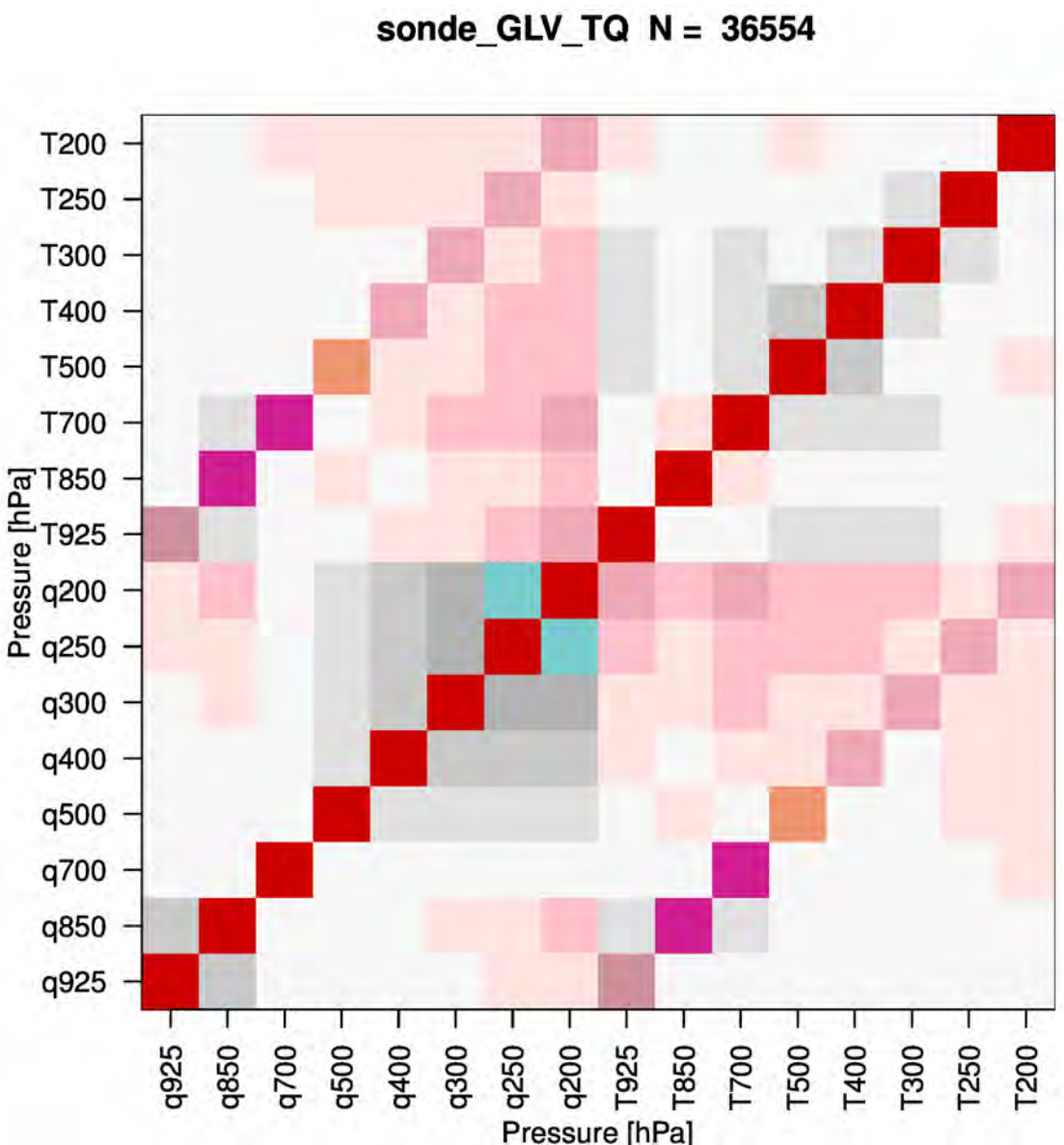
- One station has 10° offset vs B, three others have 5° offset
- Fairly consistent in vertical
- Problem with radar orientation?
- CMA informed

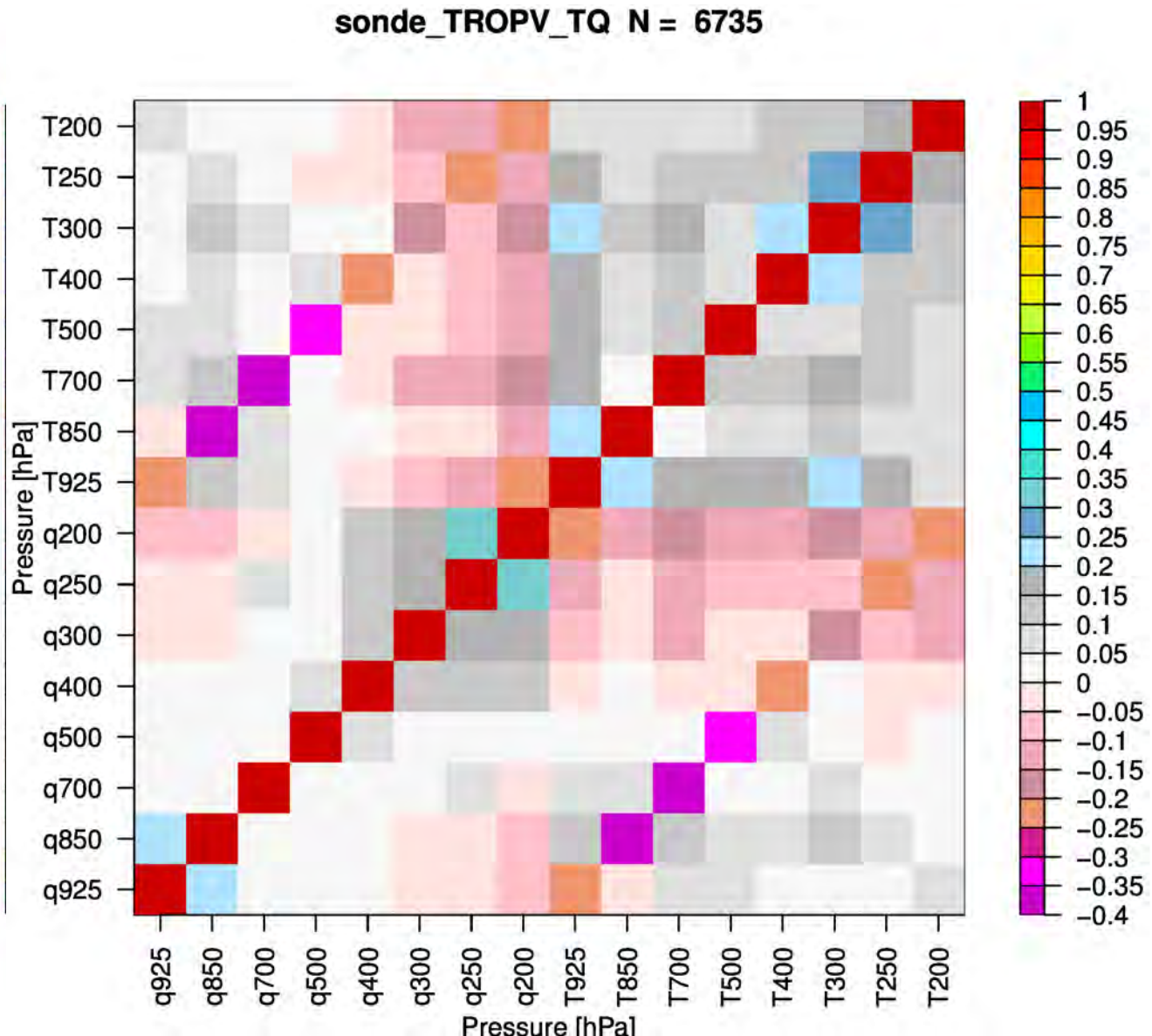
- Diagnostic very sensitive to small errors



Specific humidity vs temperature correlations (GL and TR)

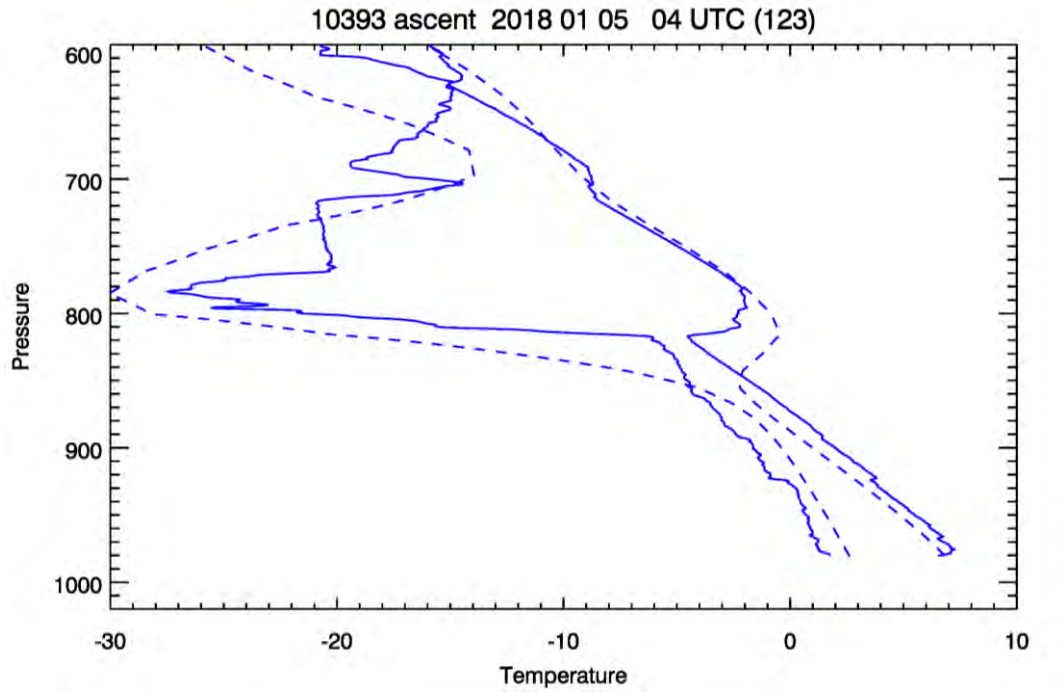
- -ve Tq correlation at same level, esp 850 hPa Europe, 850-500 hPa Tropics





Negative T-q correlation

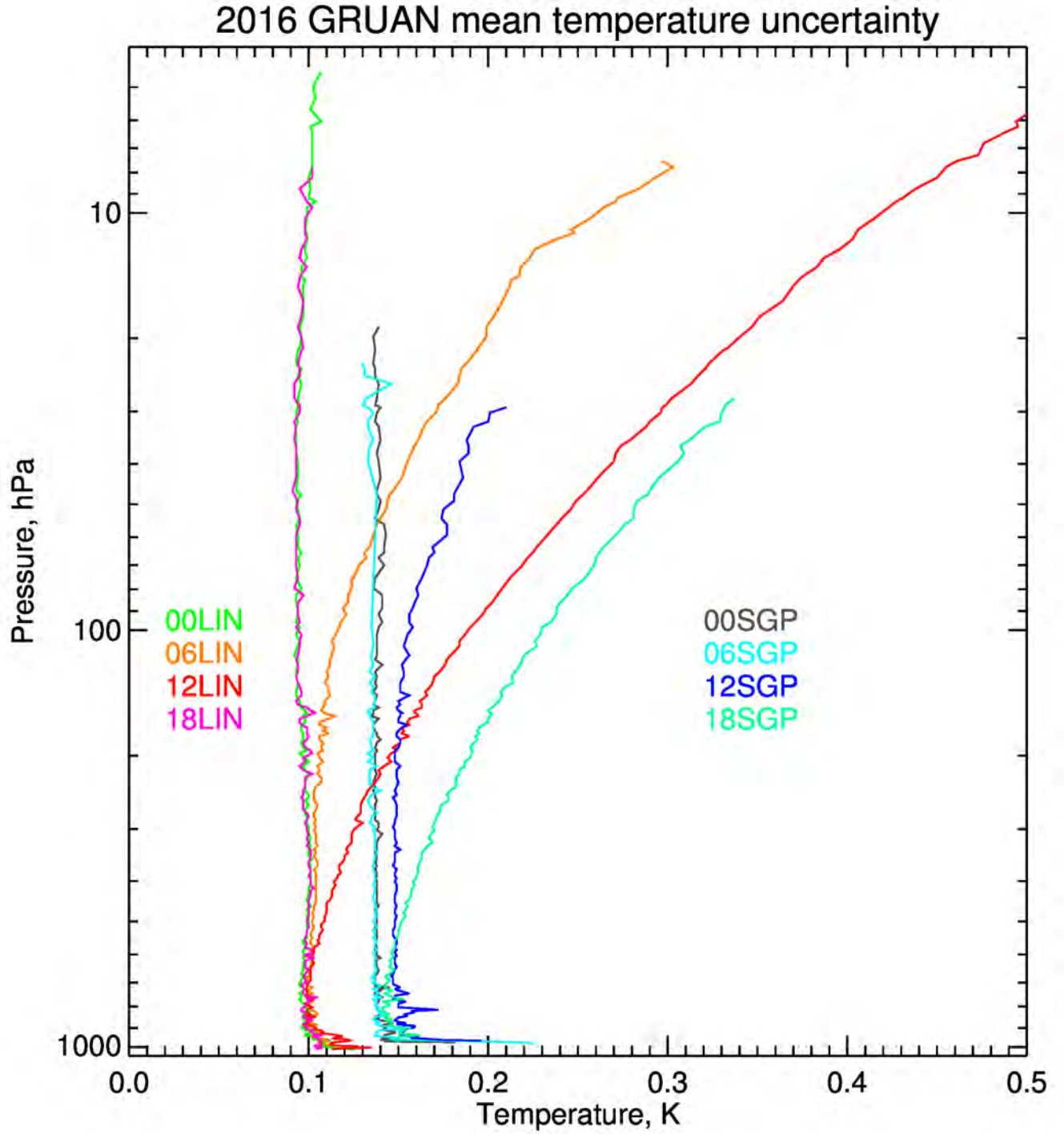
- Unlikely to be (mainly) measurement error
  - Sensor wetting not usually a problem for Vaisala radiosondes
- Representativeness error
- Background error (not in B)
- Probably linked to errors in BL top:
- BL top higher in tropics

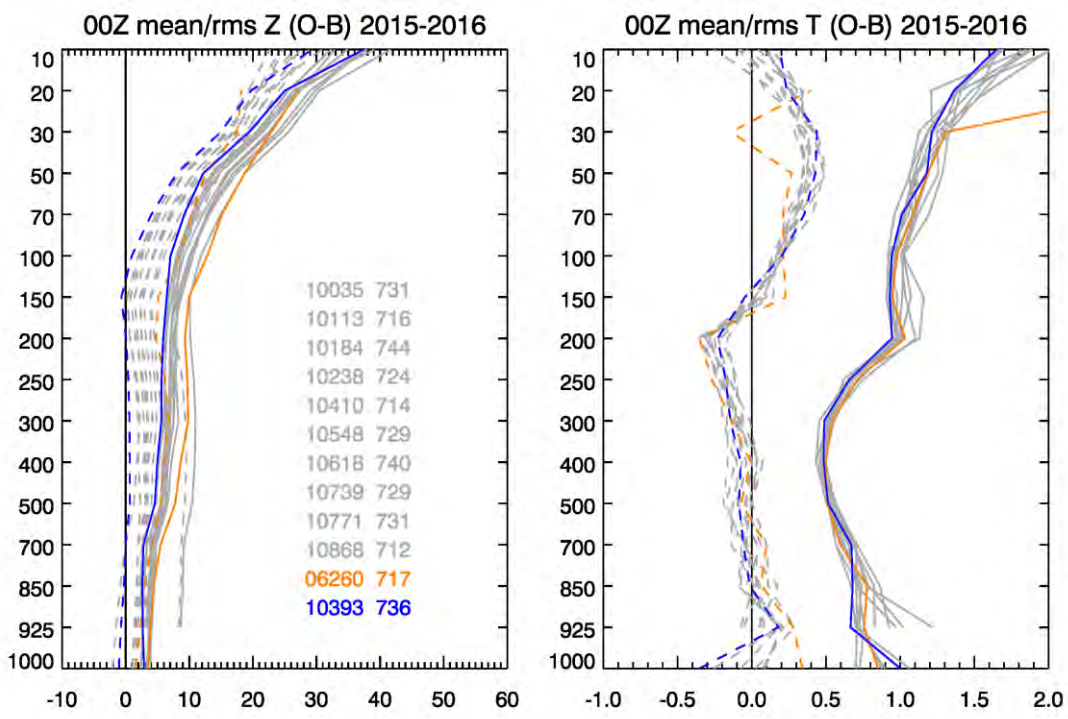


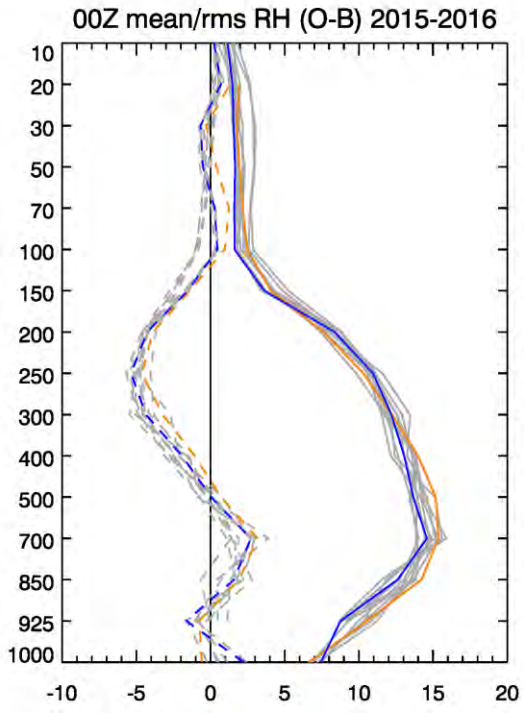
- Small –ve correlation between lower tropospheric T and upper tropospheric q (previous slide)?

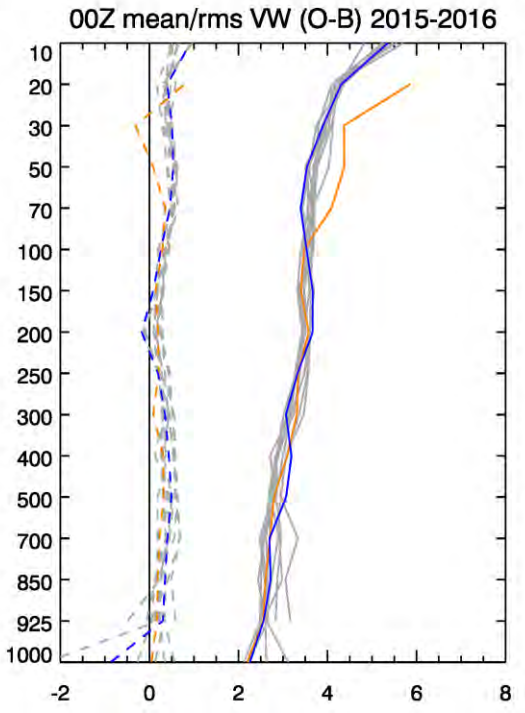
Diurnal cycle at 2 GRUAN stations

- LIN and SGP report 4x per day: look at cycle of |u_temp| from NetCDF reports
- Night-time (00LIN and 06SGP) almost constant 0.1 for LIN, 0.13 for SGP (k=1)
- Why is SGP u_temp larger?
- Apparently due to ground check.
- Daytime uncertainties larger (need to check SZA for whole profile not just launch), little effect at 700-800 hPa
- NetCDF also gives u_press (~0.5 hPa), should we multiply by local |dT/dp| and add to u_temp when comparing with model values matched by pressure??









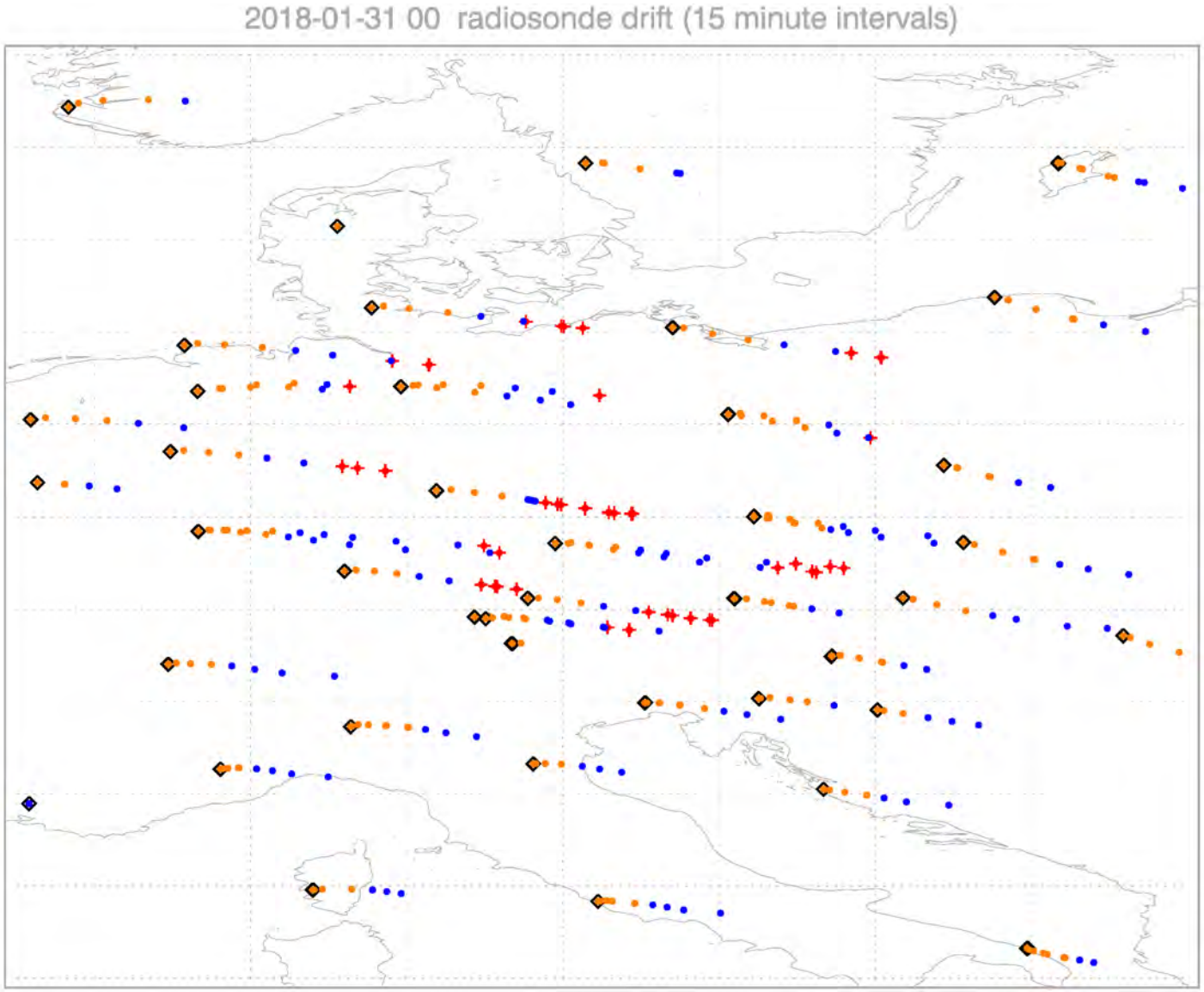
RS92 variation between stations?

- 00 UTC O-B results
- Operational reports from Germany + NL
- Generally tight cluster of results, Lindenberg slightly closer to B for heights (extra near-surface scatter for T and wind)
- Cabauw similar – slightly worse fit for height and RH (B could be worse closer to Atlantic)
- One station appears to have height bias (from station height error?) of about 8 m.
- At 12 UTC (next slide) the height and temperature fits are somewhat worse (expected)
- At 12 UTC the UTLS RH bias falls into two clusters – probably due to the processing version

Ascent/descent data (Germany) example

- Black diamonds – launch
- Levels to 100 hPa
- Levels above 100 hPa
- + Descent
- ~14 stations with descent data

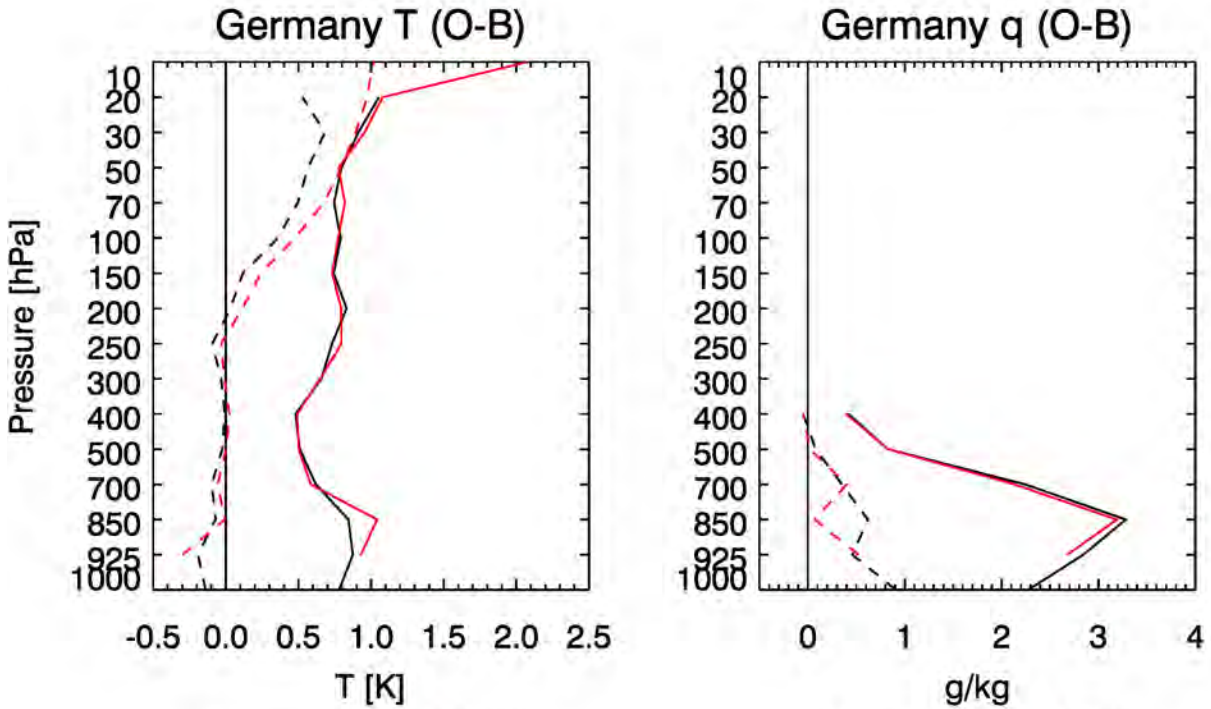
- Split profiles into 15 minute intervals (may shorten)

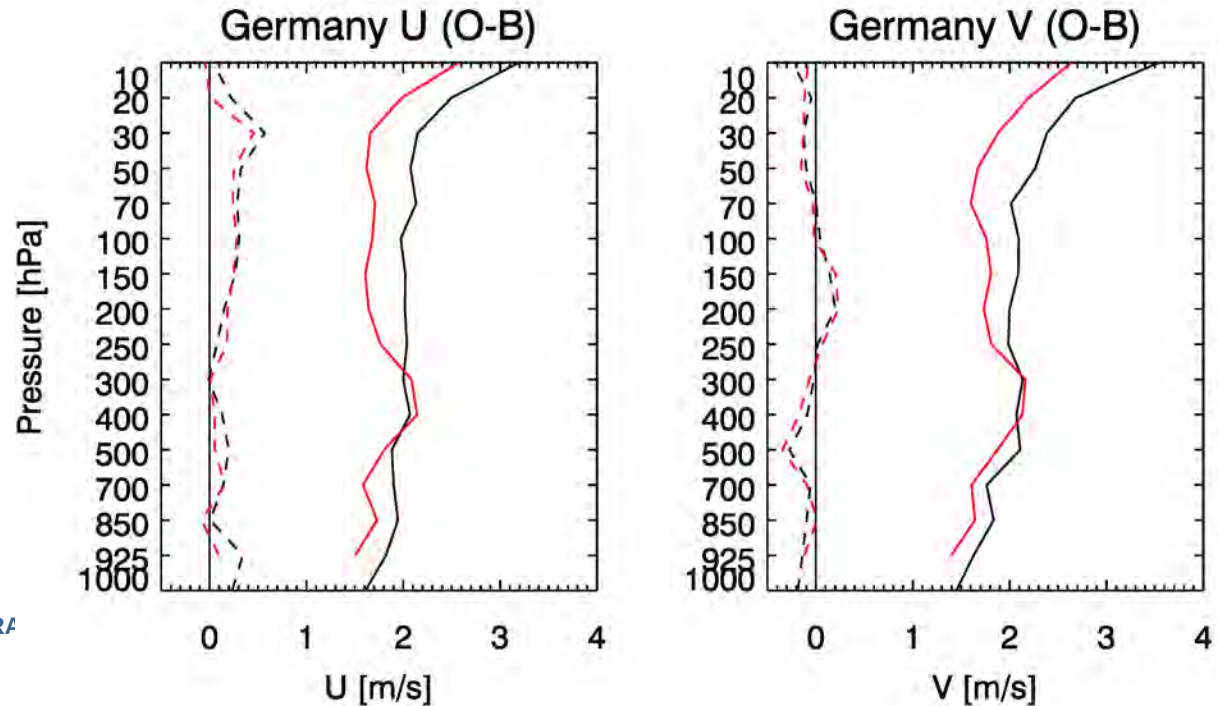


German statistics

- Mean O-B (dashed) and standard deviation, SD, (solid)
- Used data
- T and q: SDs similar, larger T bias in stratosphere (partly bias in B)
- U and V: SDs *smaller* at most levels (except ~300 hPa), esp. in stratosphere!? ☺

- Finnish statistics (no parachute) similar except that descent T worse

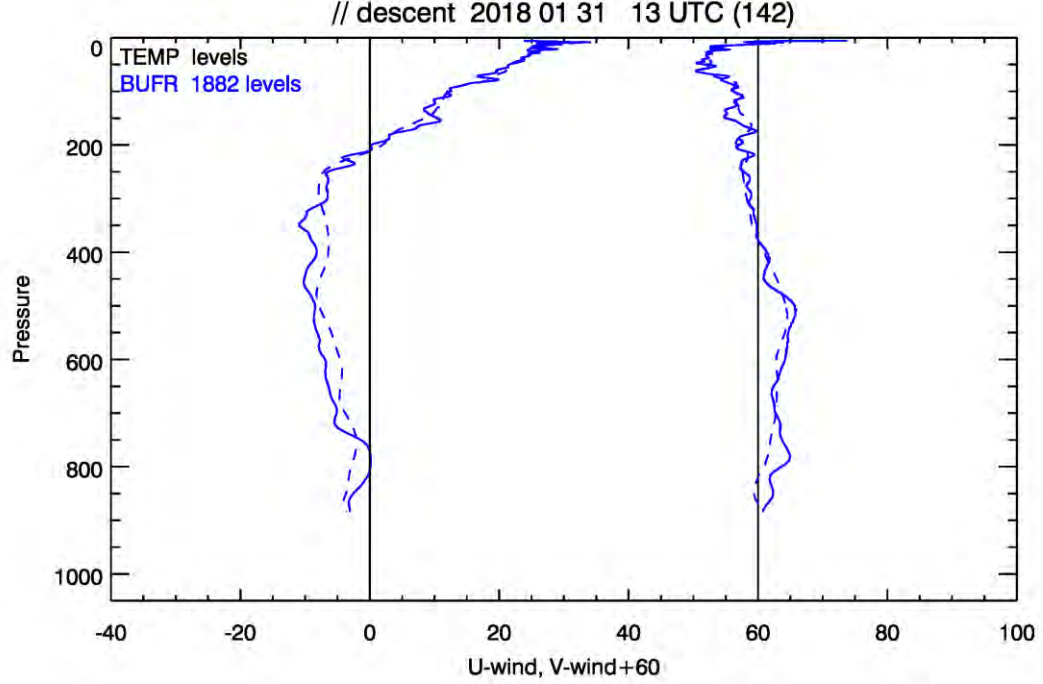


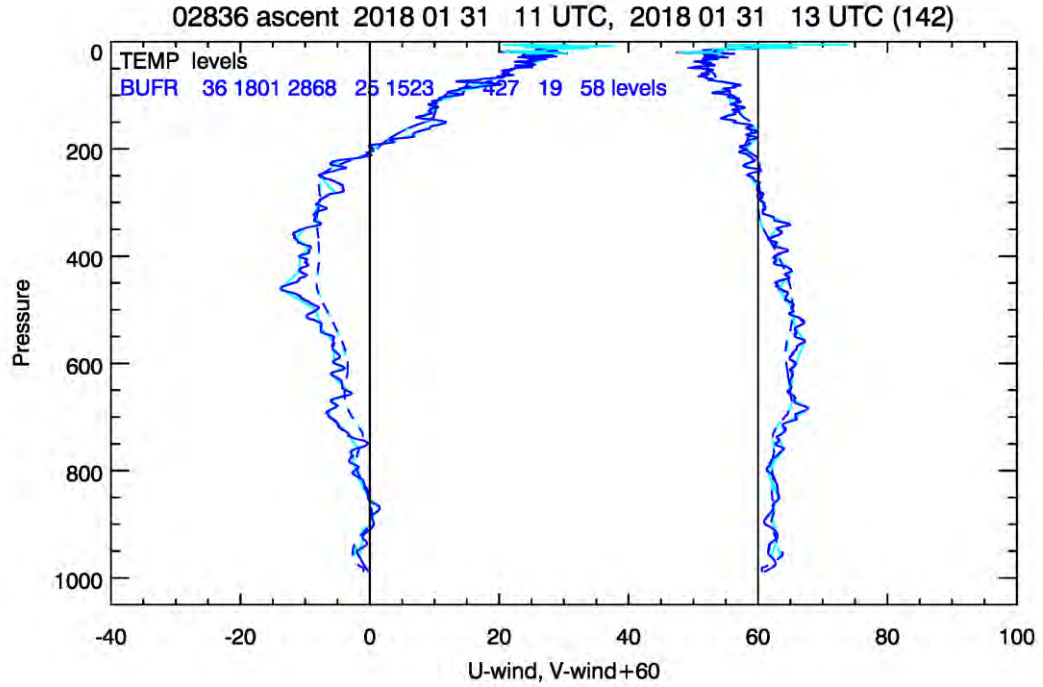


Example wind profile

- Reported – solid, background – dashed
- Descent (top) is clearly smoother than ascent (bottom), is this due to:
- Less pendulum motion? ☺
- Too much smoothing? ☹
- Balloon “catches” small-scale wind more?
- Other?

- Vaisala: “filtering the same for ascent and descent but fn(time): vertical scale ~ vertical speed”



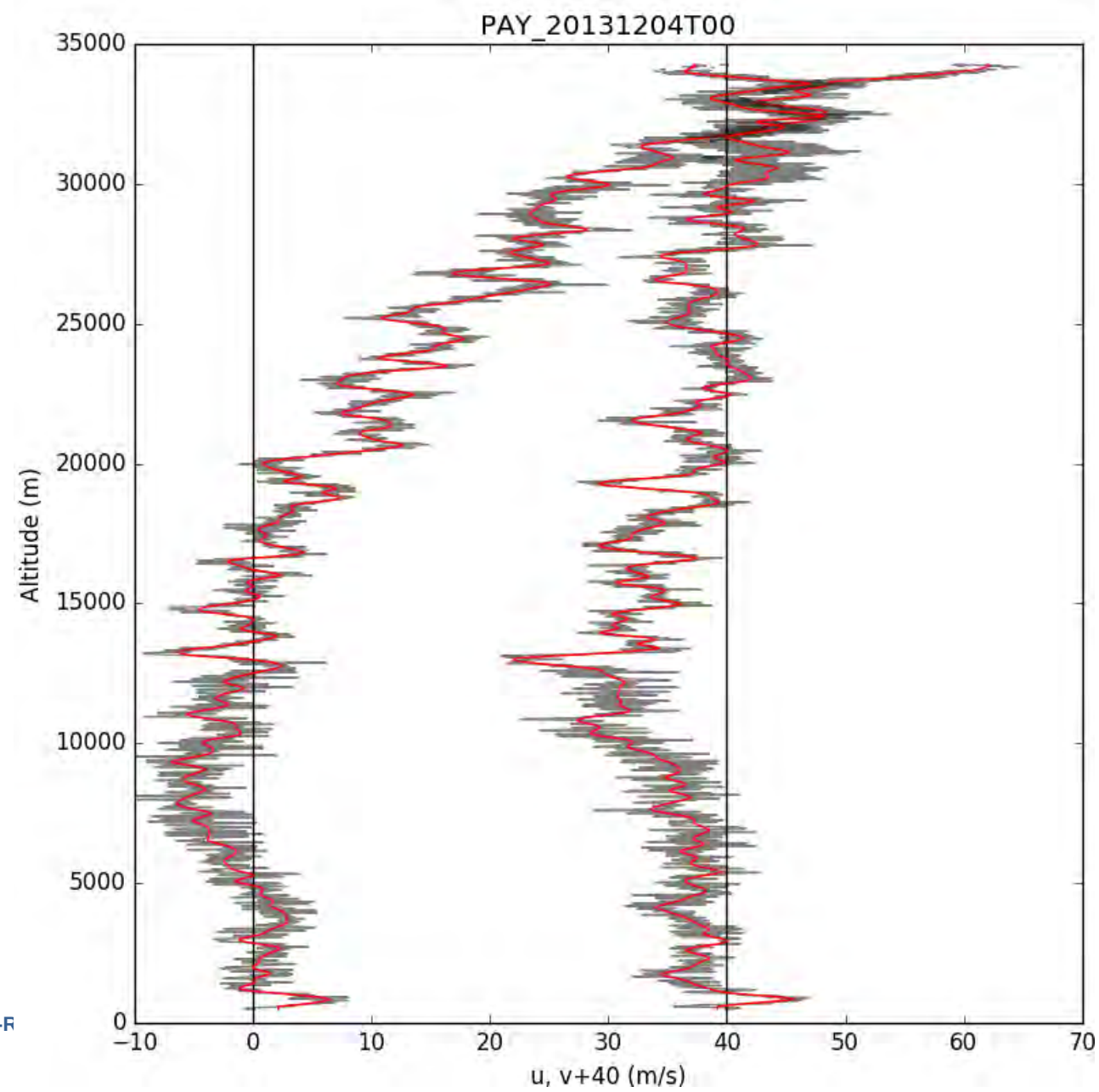


Summary

- Uncertainty estimates from <(O-A)(O-B)> useful
  - Little correlation of uncertainty in the vertical
  - Can see some diurnal cycle and some analysis problems
  - Wind direction error showed up very clearly
- GRUAN temperature uncertainty 40% larger at SGP than LIN
- RS92 data similar at different German stations
- Radiosonde descent data: encouraging results
  - Wind (O-B) better for descent data – less pendulum motion or more smoothing?
  - Look at raw data
- More work needed

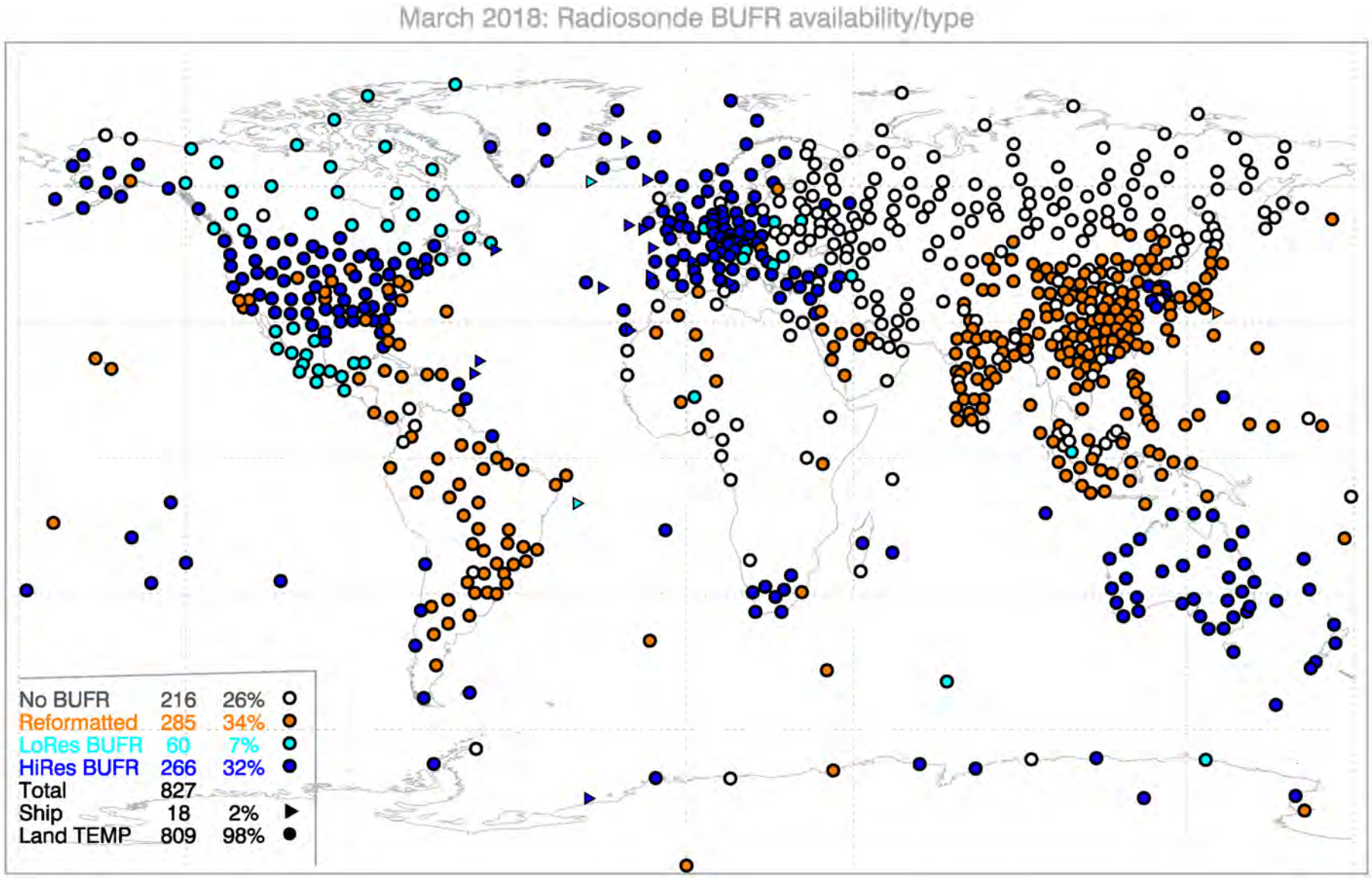
Pendulum motion and wind filtering

- Radiosonde swings under the balloon
- This adds high frequency noise to the GPS-derived winds – removed by filtering (eg Dirksen et al, 2014) – red curve shows filtered wind
- The noise varies within ascent and from day to day
- How much is noise and how much is signal?
- Some operational radiosondes seem to over-smooth.

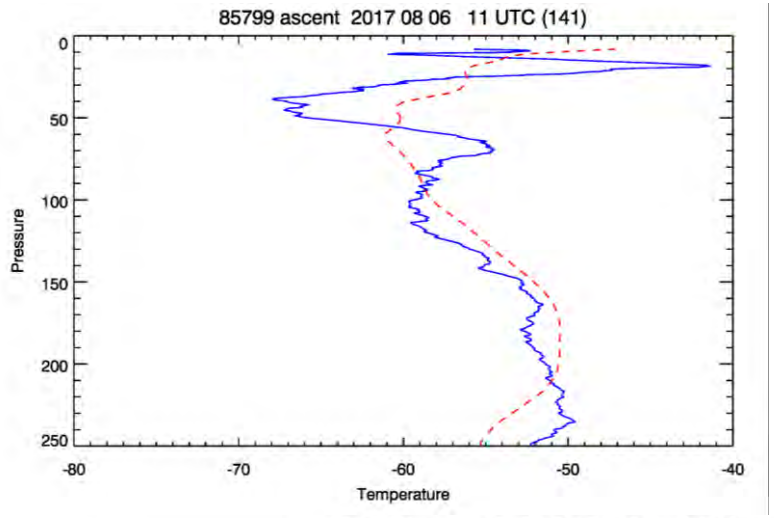


BUFR and high-resolution report availability March 2018

- HiRes was mainly from Europe, Australia/NZ but others now. Most of USA in 2017.



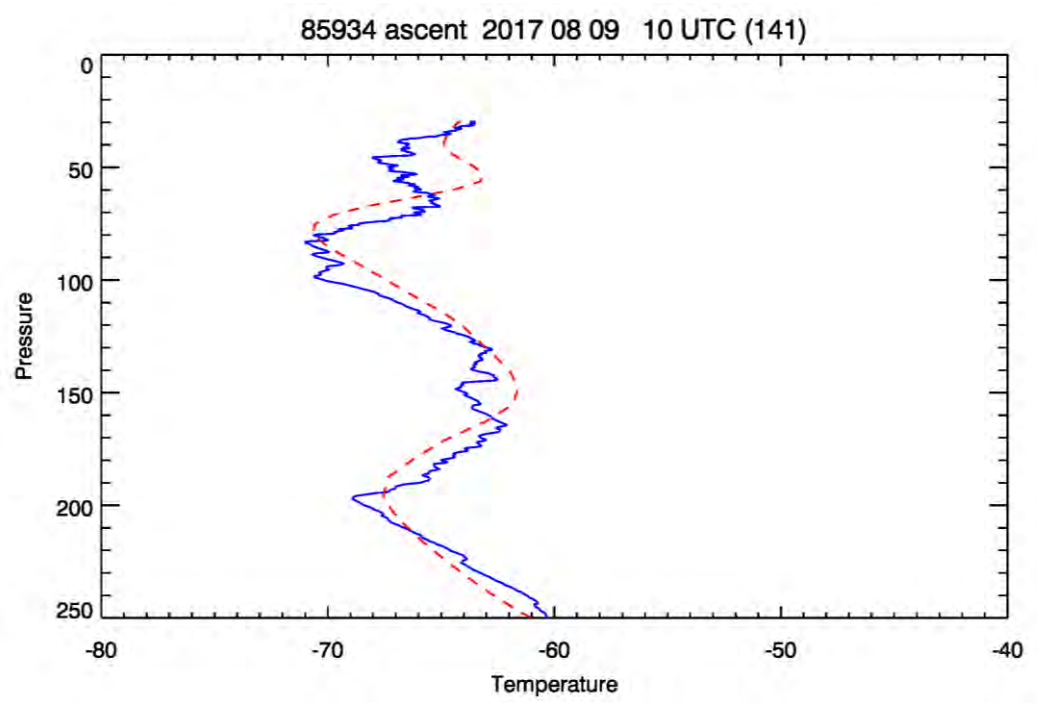
Gravity wave T cases - Chile

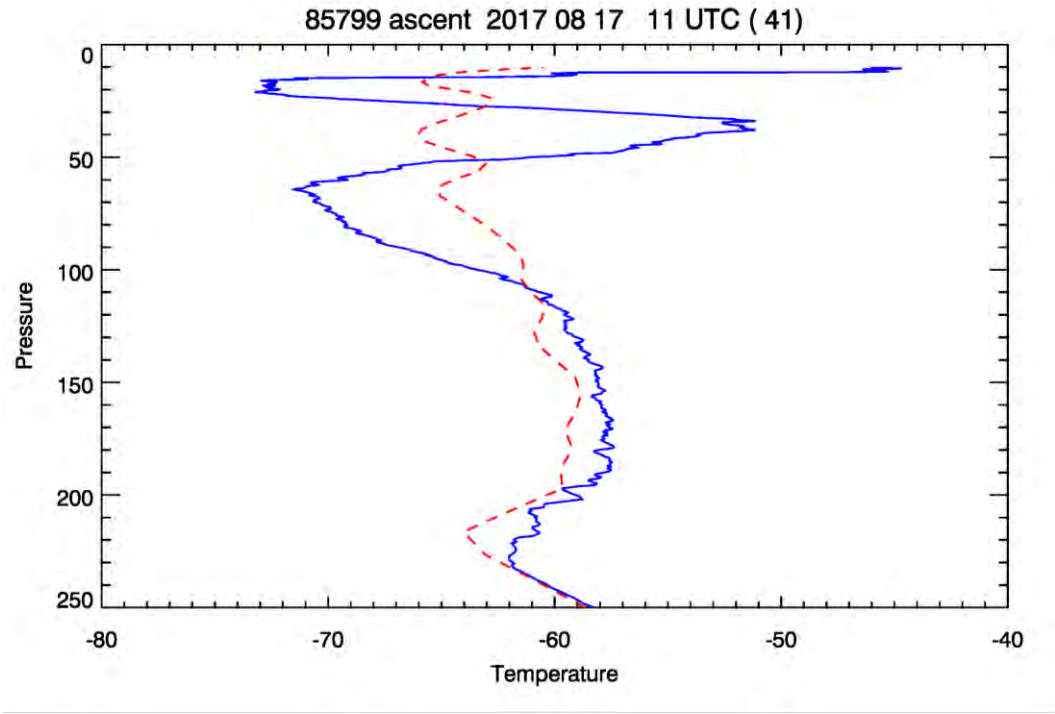


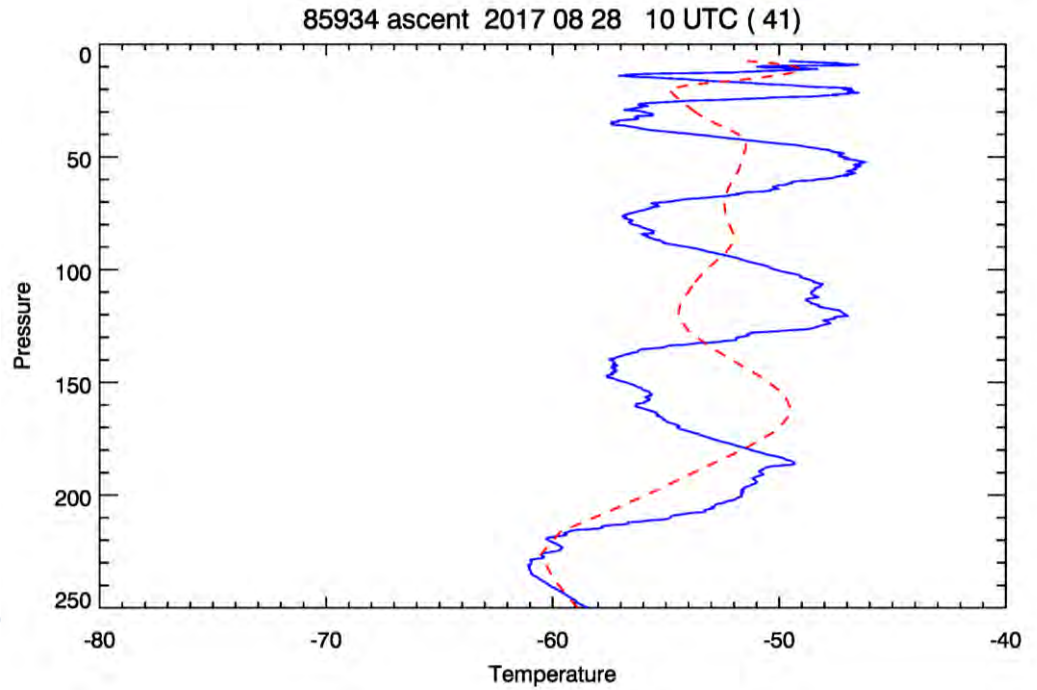
< 41°S

53°S >

HiRes sonde
Background







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Result from GRUAN processor

- 2013 data for Lindenberg (near Berlin) – GRUAN lead centre, typical of Northern Extratropics
- Note: B-O! for MetOffice and ECMWF
- Red: GRUAN uncertainty
- Obvious feature is ECMWF cold bias between 100 and 10 hPa (due to excess water vapour there?)
- *This is also seen in operational O-B statistics, with slightly lower magnitude*
- Lower panel: values in ATMS radiance space
- Heather Lawrence gave recent seminar