Comparing RS41 ascent and descent data

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ECMWF

Overview

- Background
- Ascent and descent rate
- Results for January and <u>June</u> 2018
- Summary and work required
- Global radiosonde network May 2019 (1 slide)

- Initially treated ascent data as reference but there is evidence that in some respects descent data may be better so:
- Look at ascent+descent data together and compare to ECMWF B and try to understand the strengths and weaknesses

Background

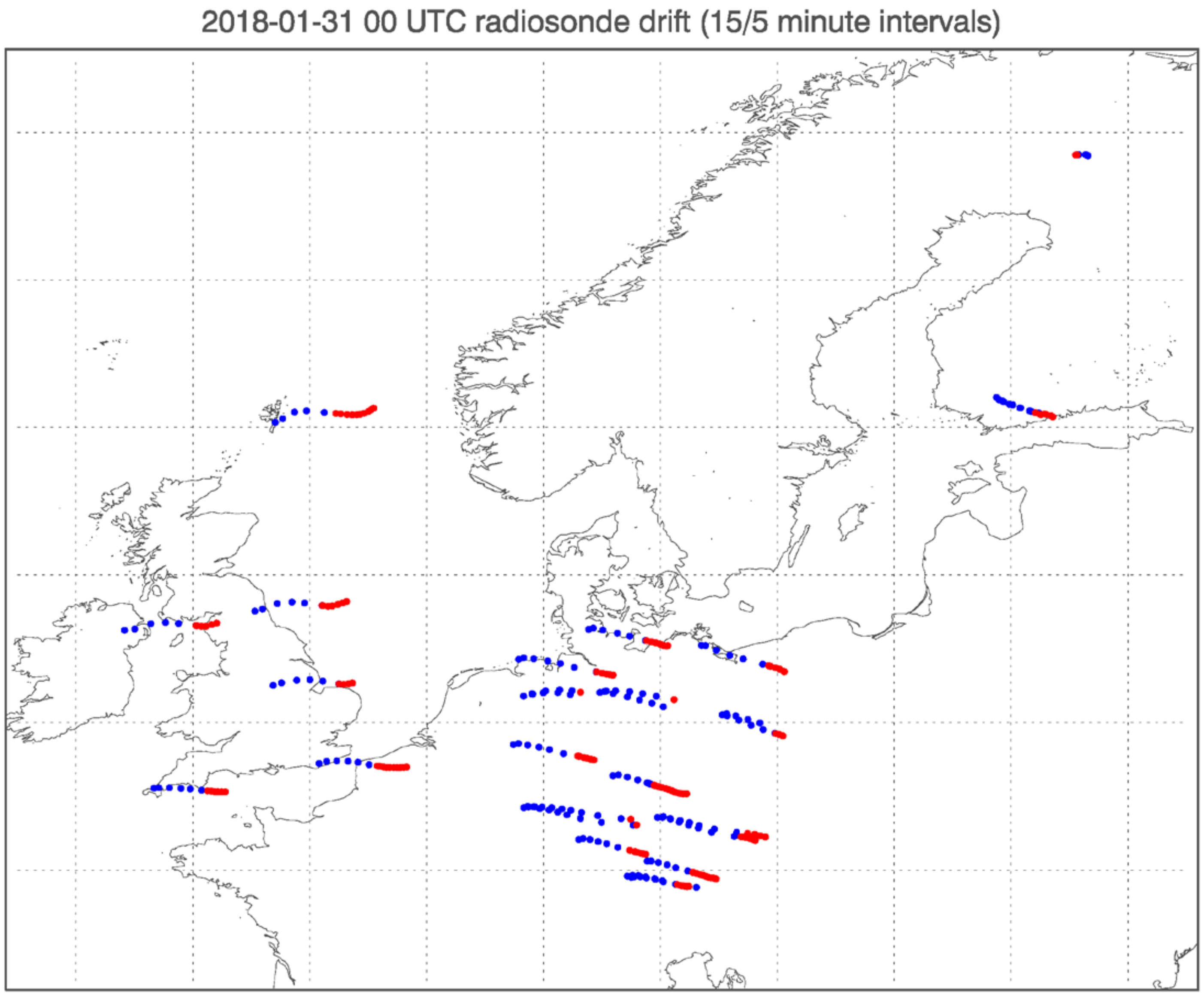
- Currently radiosonde reports stop when balloon bursts
- But radiosonde keeps measuring/transmitting on the way down
  - Receipt of data stops when sonde below horizon
- Little/no extra cost to making descent data available ☺

- Vaisala MW41 software (used with RS41) has option to generate separate descent reports using BUFR dropsonde template
  - Identifier set to missing unfortunately
  - New BUFR template (309056) approved – on GTS in 2019?
- Descent reports being produced by Germany, Finland and UK

Data examined

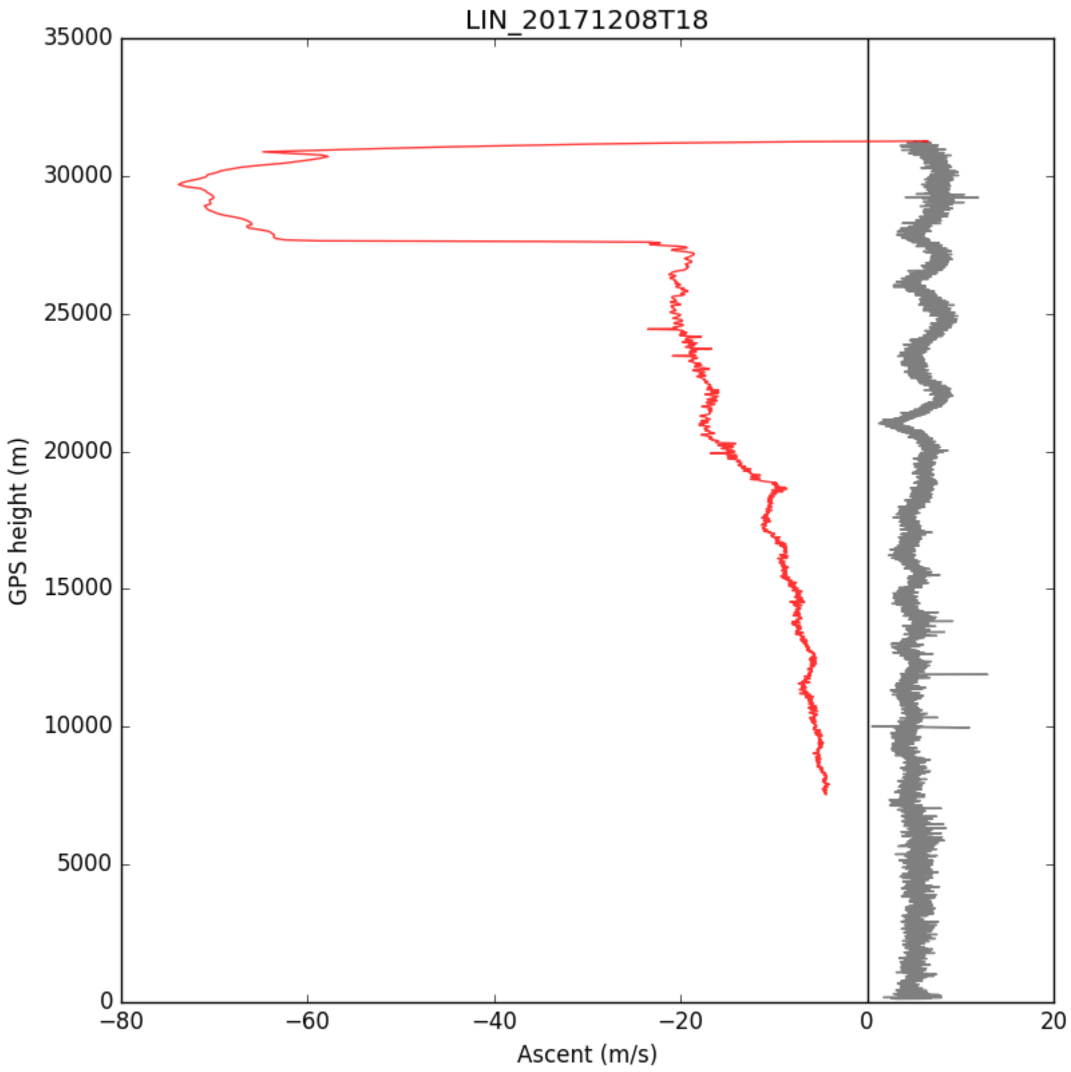
- DWD: 14 stations
- UK: 6 stations (+2 remote)
- FMI: 2 stations

- Plot shows case in Jan 2018 – ascents blue (15 min dots), descents red (5 min dots), other radiosondes not shown
- January and June 2018 processed, results similar will mainly show those for June



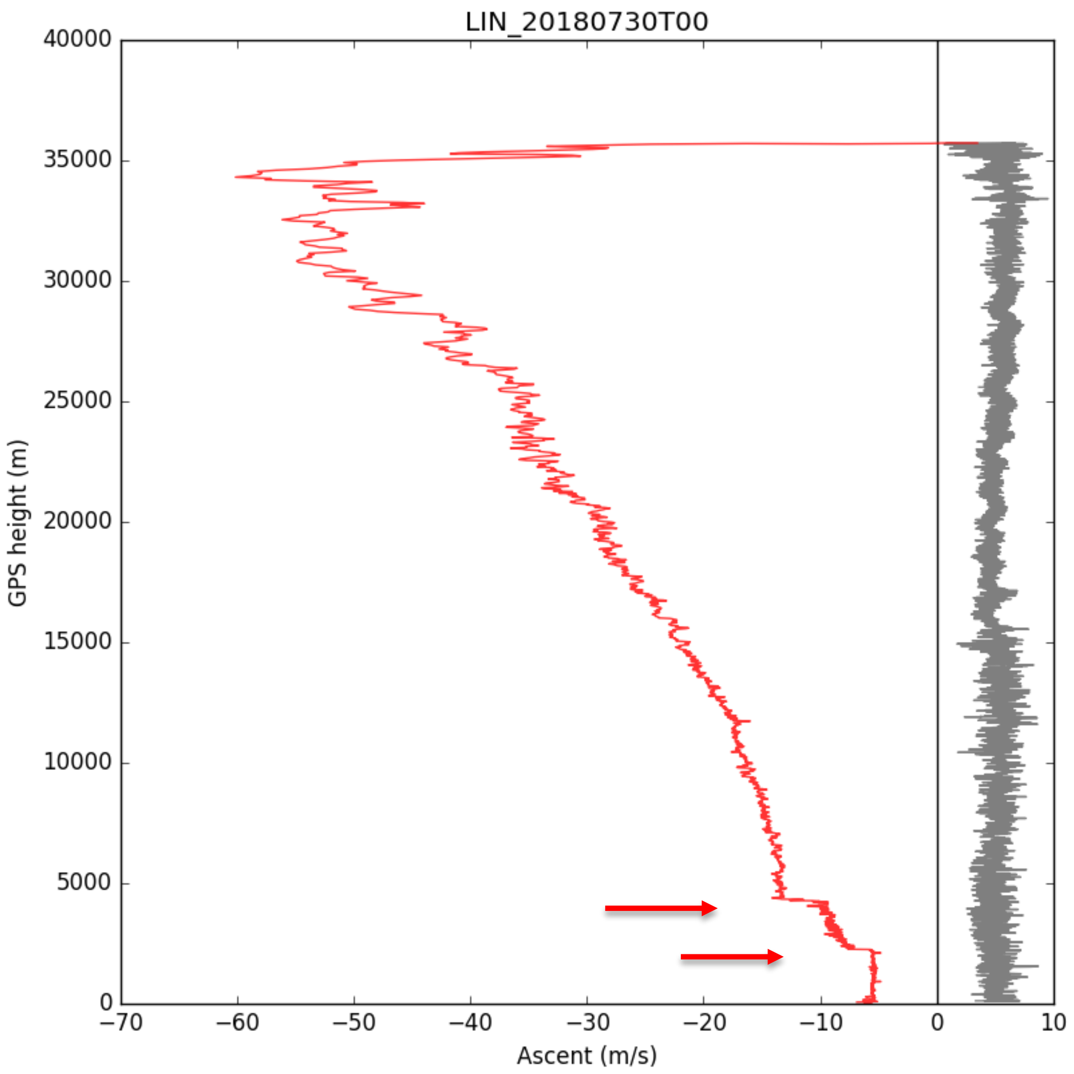
Ascent/descent rates: Lindenberg example 1

- Ascent rate ~5 m/s (WMO rules)
- High frequency noise – pendulum motion
- Lower frequency fluctuations at upper levels (gravity waves?)
- Descent rate: very fast just after balloon burst, can be 70+ m/s
- Sometimes abrupt slow down
  - Balloon torn off (less weight)?
  - Parachute opens fully?
- Less high frequency noise in descent
- Signal lost at ~7.5 km in this case



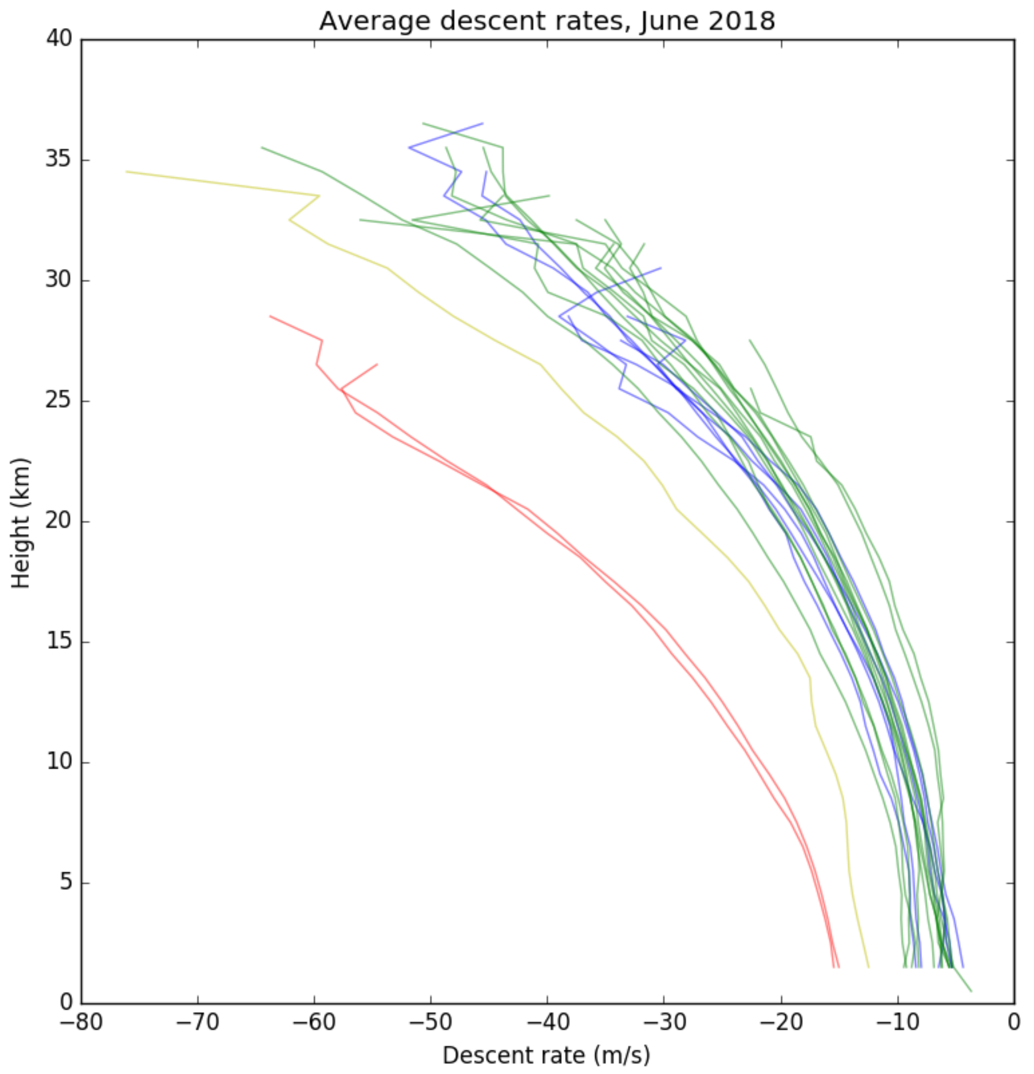
Ascent/descent rates: Lindenberg example 2

- Ascent ~5 m/s
- Less evidence of waves
- Descent: “smoothish” decrease of fall rate with increasing air density
- Two abrupt slow downs at fairly low levels (parts of balloon tearing off?)
- Again less evidence of high frequency noise in descent (also affects horizontal winds?)



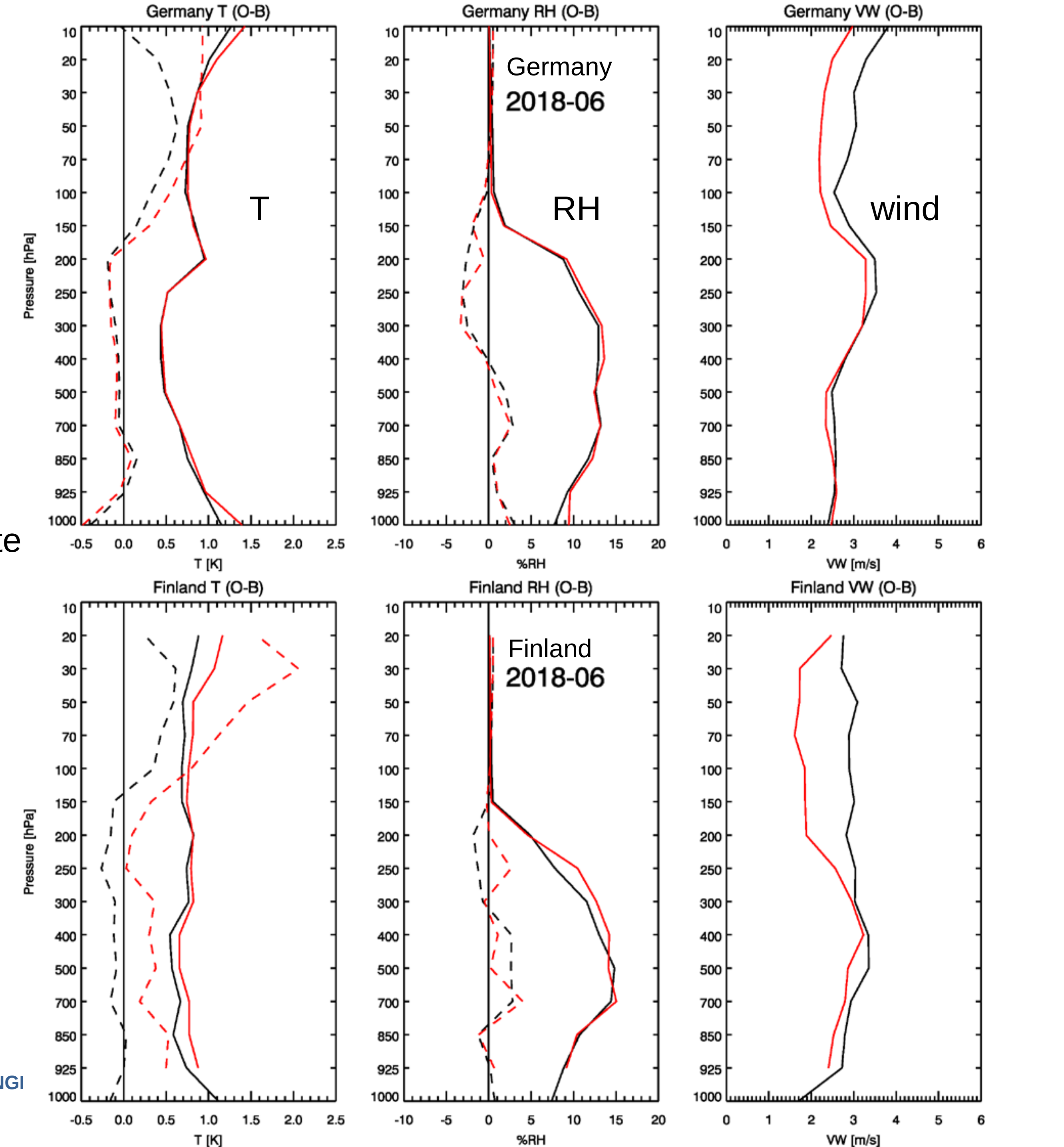
Average descent rates: overview

- One line per station
- Finland: smaller balloons, no parachutes (~15m/s at bottom)
- St Helena: no parachute (~12 m/s)
- UK: different sizes of balloon (6-8 m/s at bottom)
- Germany: different sizes of balloon? (5-9 m/s at bottom)
- Radiosondes ascend ~30 km taking ~2 hours and drifting 40-200 km, descent ~30 mins depends on:
  - Parachute or not? Balloon remains.
  - Density – much faster in stratosphere



Descent O-B statistics

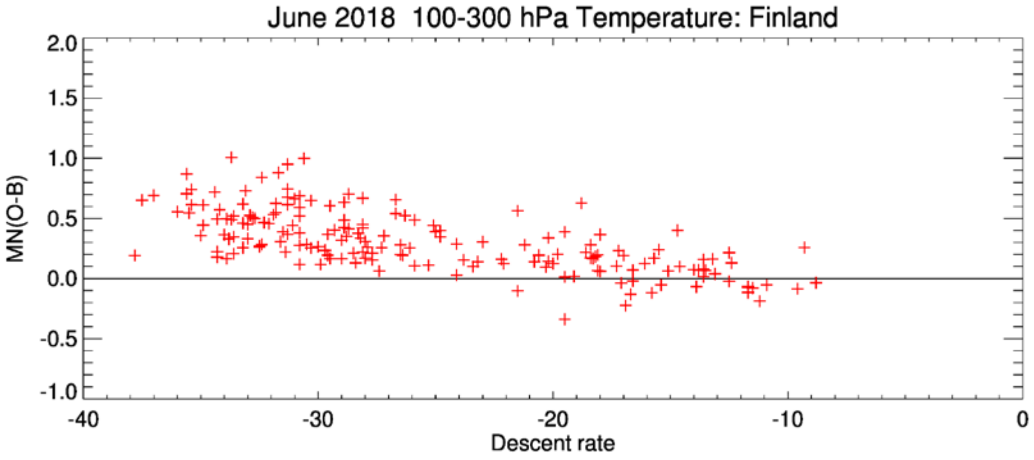
- Encouraging O-B statistics (red – descent)
  - Observation minus Background (Forecast), mean (dashed) and standard deviation
  - Temperature, RH, Vector Wind (rms)
  - Germany (top) has best/smoothest results
  - But warm bias at upper levels
  - Warm bias (and SD) worse without parachute bias extends to troposphere – Finland, (bottom), also seen for St Helena ☹
  - Wind rms(O-B) smaller?? Descent oversmoothed or ascent undersmoothed? (Filtered to remove pendulum motion.)
  - UK statistics intermediate (not shown)
  - Check day-to-day variability (next)

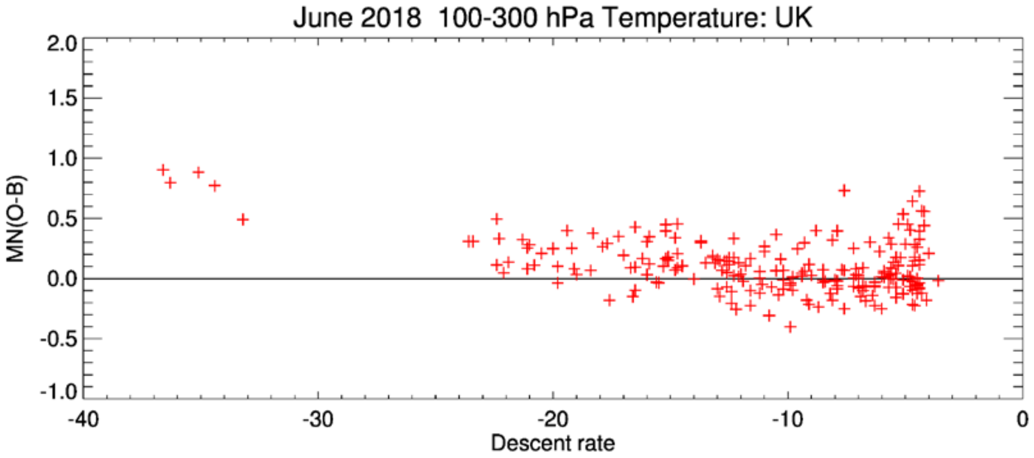


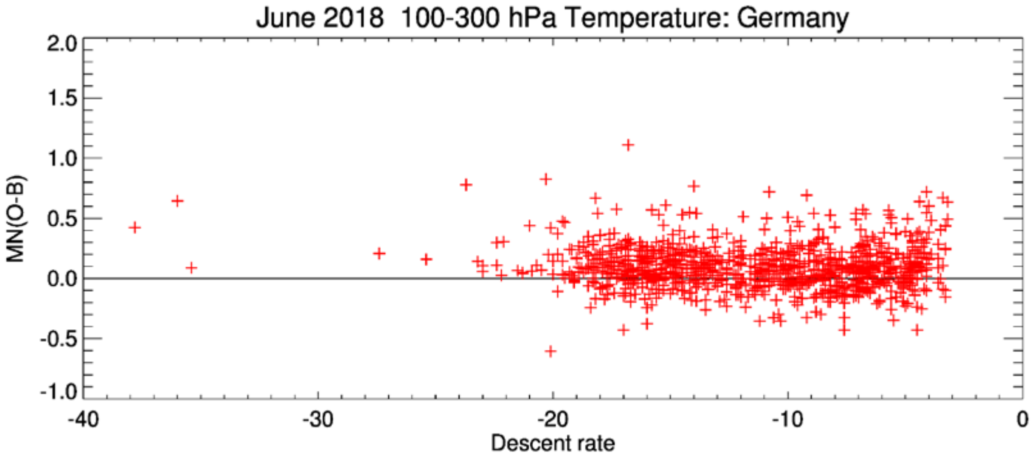
T bias vs descent rate

- Individual descents shown for 100-300 hPa
- Some association between fast descent and larger biases. Clearest for Finland (top), least clear for Germany (bottom). Also seen for other layers.
- SD(O-B): no clear link to descent rate (not shown).

- Possible explanations:
- Frictional heating?
- Air flows over slightly warm radiosonde case and then over sensor?

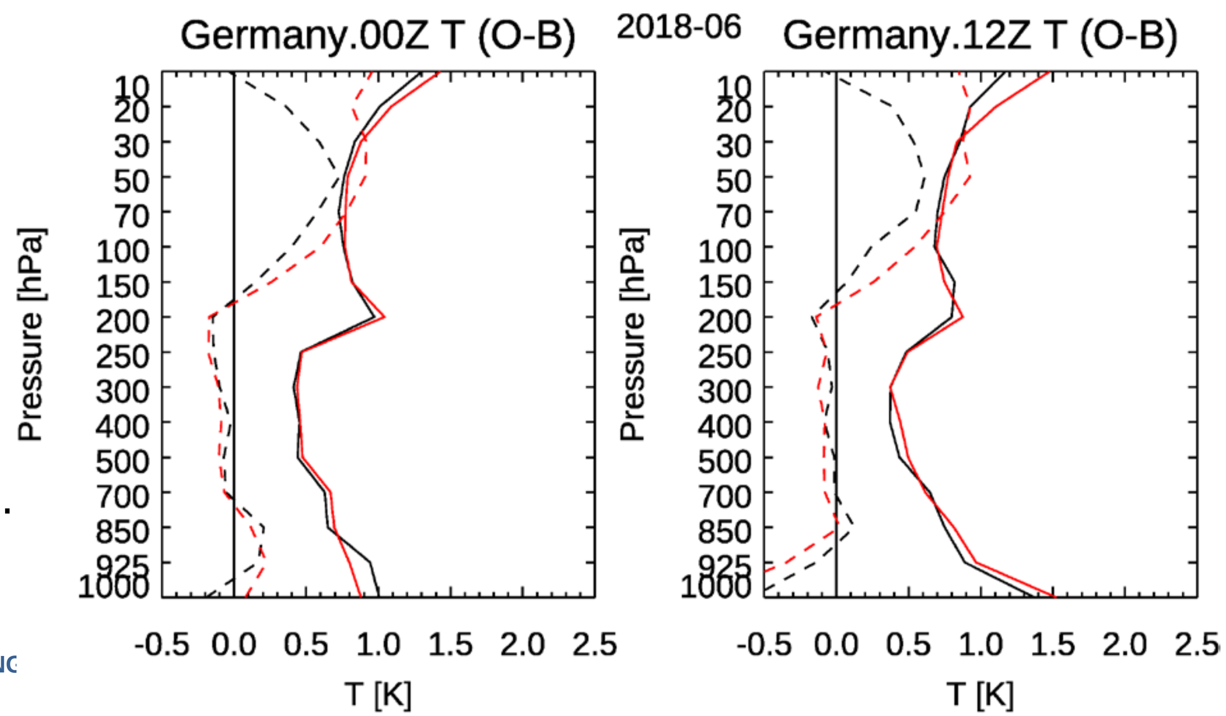






What happens in mid-stratosphere?

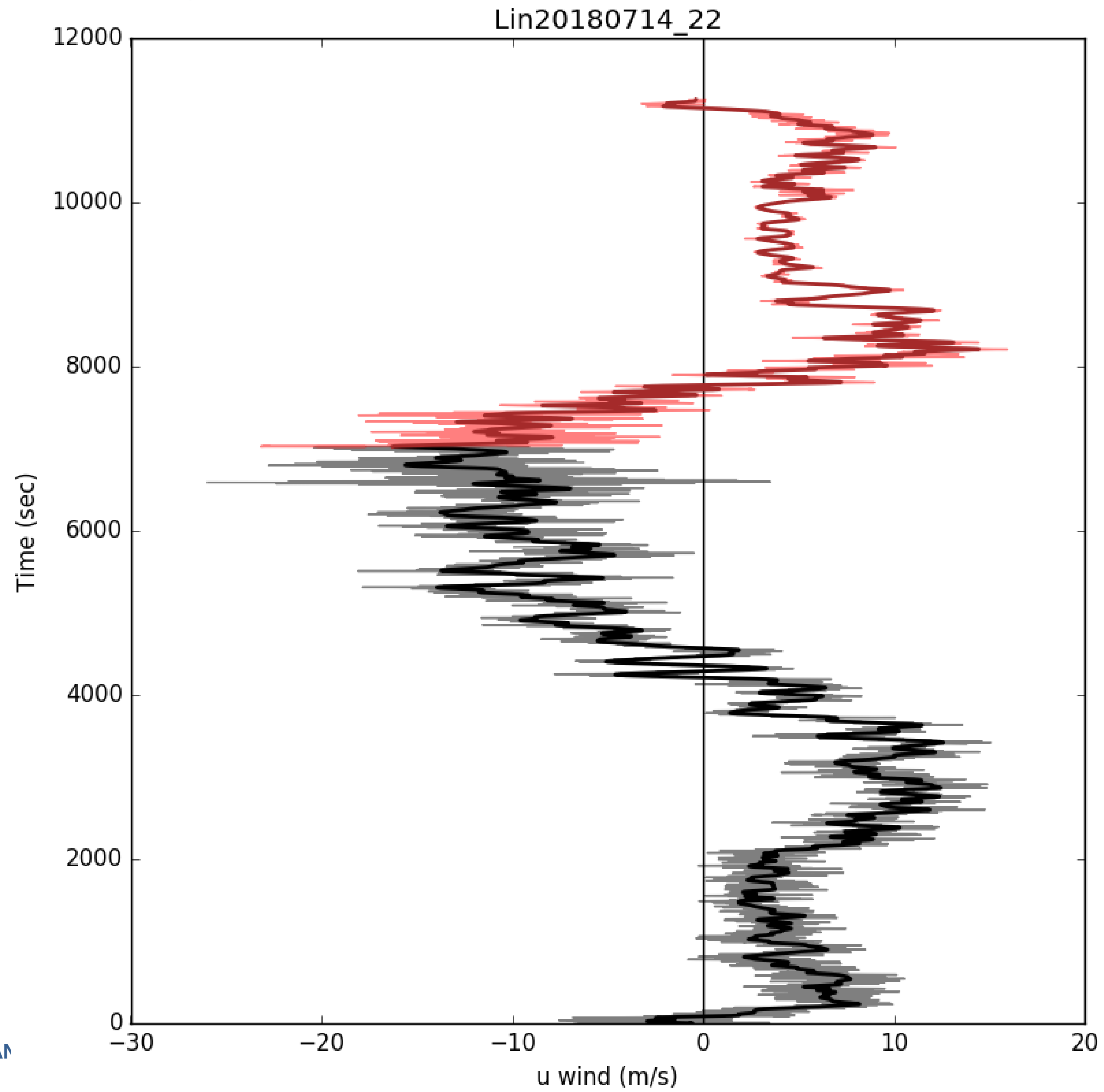
- Sonde temperature uncertainty at 20 or 10 hPa is large compared to that at lower levels (especially in daytime)
- Tiefenau and Gebbeken (1989, JTech) suggested that ascending sonde is within balloon wake most of the time and adiabatic expansion of balloon means that wake is cooler than ambient air => descent is better at night! Used 30 m string.
- Daytime extra complication from solar heating of balloon …
- Elms et al (TECO-1994) said that 40 m string OK (better than 10 m)
- Contradicts T&G?
- Shimizu and Hasebe (2010, AMT)
- More work needed!
- Little diurnal variation of O-B bias ..



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) – thin line raw data, **bold curves show filtered u wind** (data from Lindenberg)
- The noise varies …
- How much is signal?
- Some operational radiosondes seem to over-smooth.

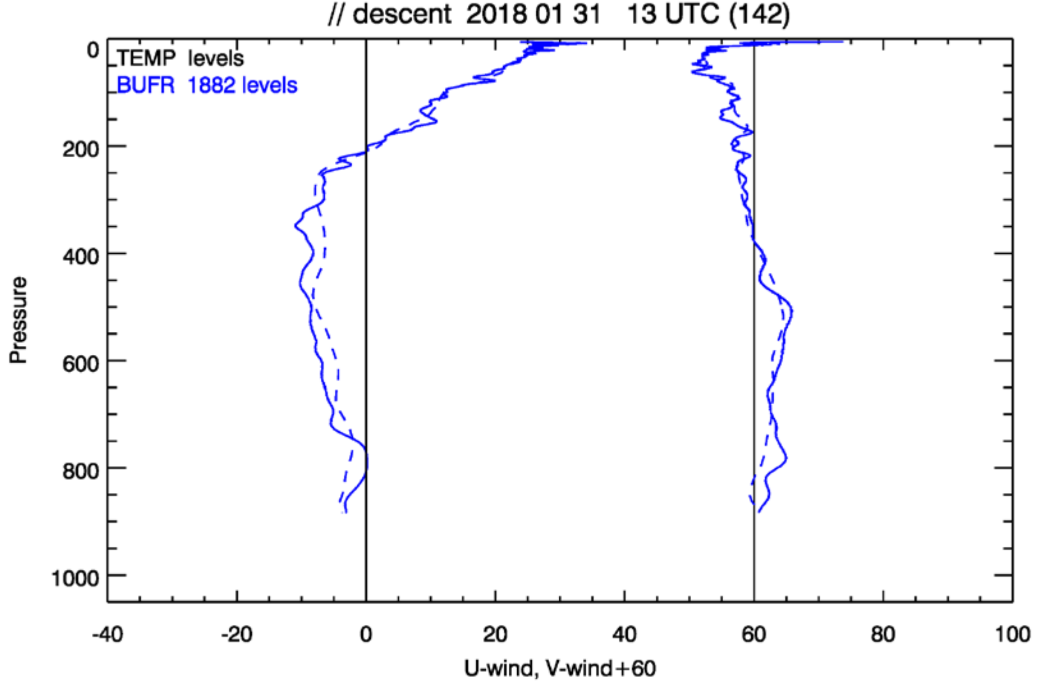
- Less noise in troposphere for descents? Fits with w results.

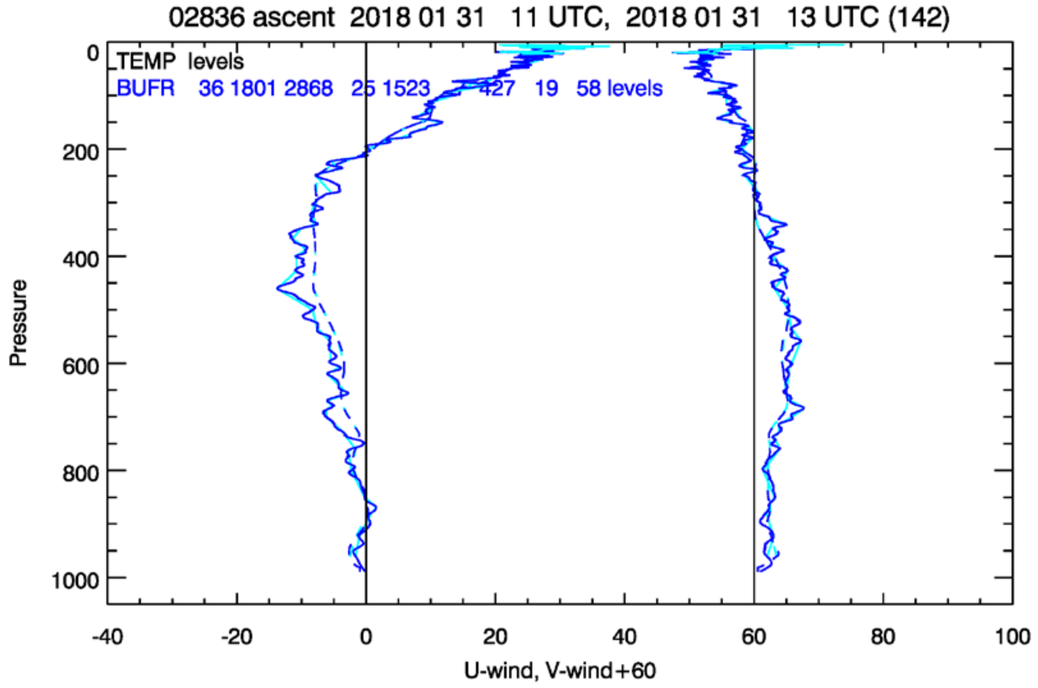


Example wind profile

- 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” (function of time)
- Vertical scale larger when radiosonde falling faster





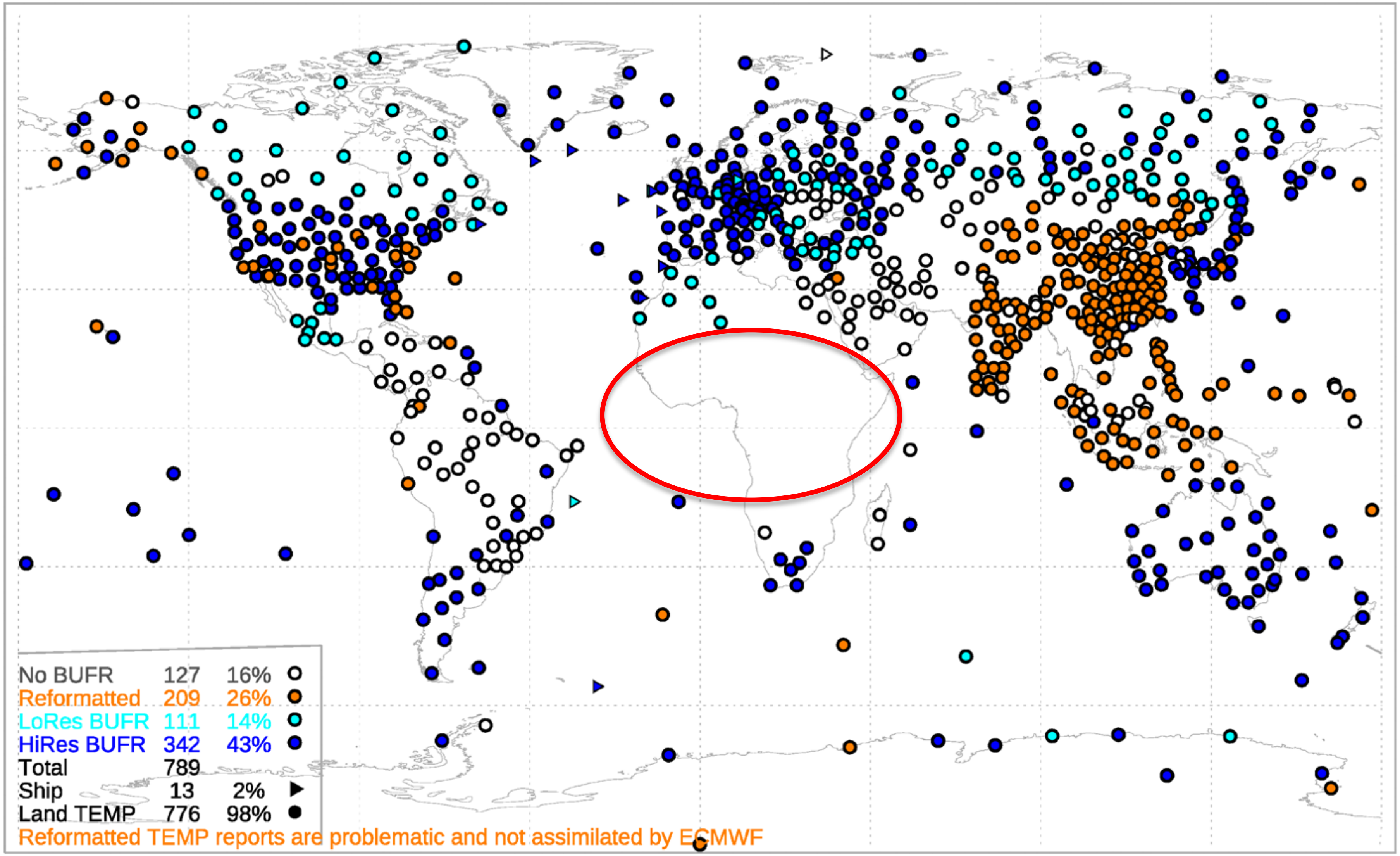
Summary

- Preliminary O-B statistics for January and June 2018
  - German/UK T and RH look OK (similar to ascent) ☺ except for T bias at top ☹
  - Finnish T looks worse than ascent – faster fall rate? ☹
  - Effect of balloon wake on ascent T in mid/upper stratosphere??
  - Both sets of wind look good ☺ – descent wind smoother than ascent ☺/☹?
    - Is this real or are descent winds oversmoothed? Seems to be real!
  - Results encourage further work, move towards operational monitoring
- To do (ECMWF)
  - Operational processing from June 2019
  - Look at extra QC checks (reject T when falling fast?), estimated errors
  - Data from more NMSs? Use parachutes to improve descent data?
  - New, lighter RS41? Assimilation tests
- Future: more use of raw radiosonde data in NWP?

Global radiosonde network in May 2019

- ~43% of stations now send HiRes BUFR ☺
- New in last 12 months: Japan, South America*, Russia* (* partial)
- Still many stations without good BUFR (China, India, ….) ☹☹
- 3 stations in East Africa were 'lost' last year ☹
- ~8 'lost' in West Africa recently ☹☹
- Some may come back – consumables?

01-12may2019: Radiosonde BUFR availability/type



Status in May 2018