Understanding the quality of radiosonde descent data

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Overview

- Variability in radiosonde descents
- ECMWF O-B statistics for Sep-Nov 2019
  - Descent data monitored in operational system from June 2019
- Also some ascent-descent statistics for Czech station (no P sensor)
  - Correcting temperature biases
- Impact
- Summary

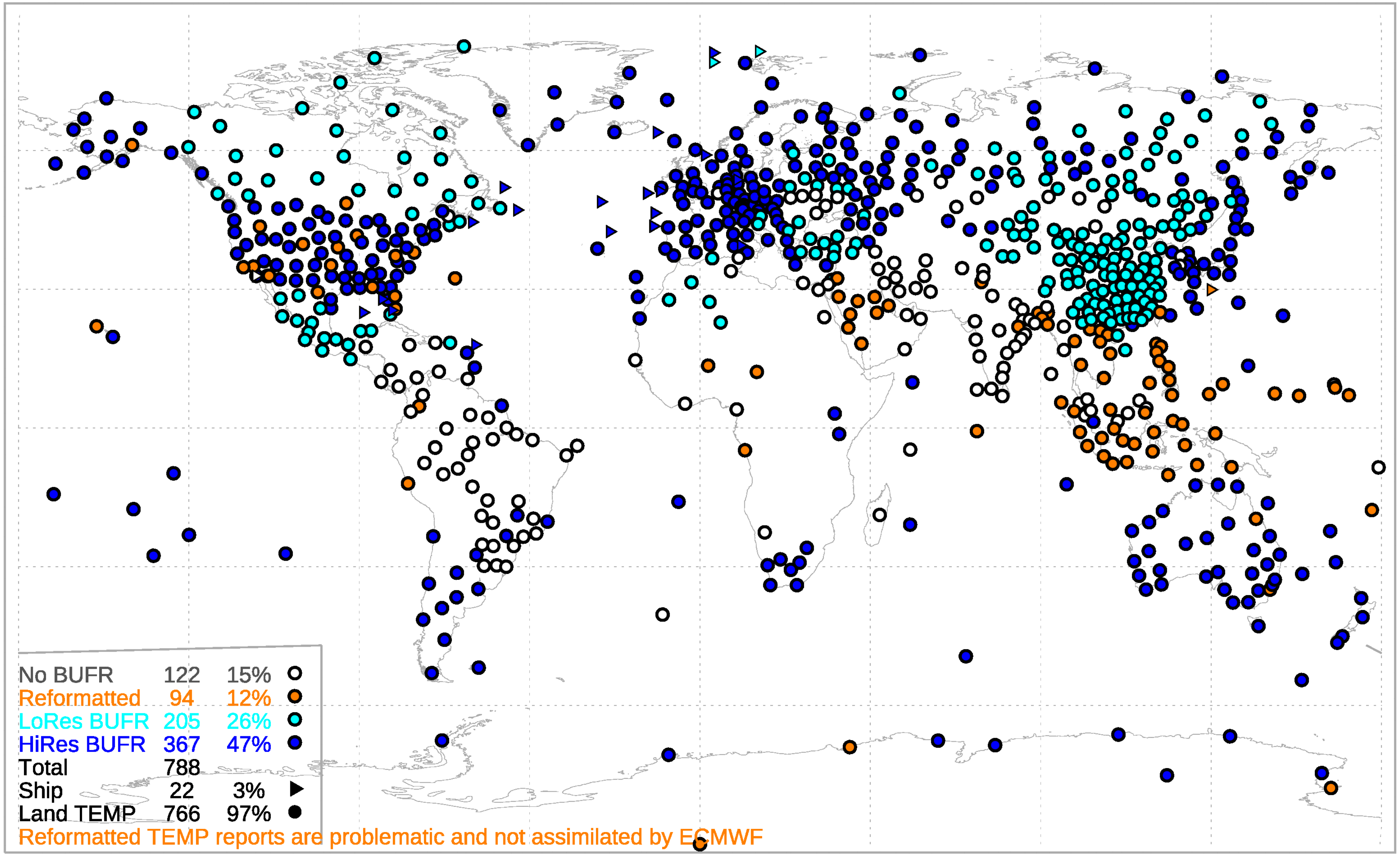
- *Upper level descent temperature higher than ascent T*
  - *ICM-11 – not sure which was better, now think we understand T and P biases*
- *Descent winds smoother than ascent winds, still not sure which is better*

Current status of radiosonde GOS (1 slide)

- 47% of stations send HiRes BUFR ☺☺
- 26% of stations send good LowRes BUFR ☺ (China started late 2019)
- 27% of stations: BUFR missing or converted from TAC ☹☹

- ECMWF (Nov ’14 onward) BUFR radiosonde ascent data now available from NCEI – item in next SPARC newsletter
- Add descent data?

October 2020: Radiosonde BUFR availability/type



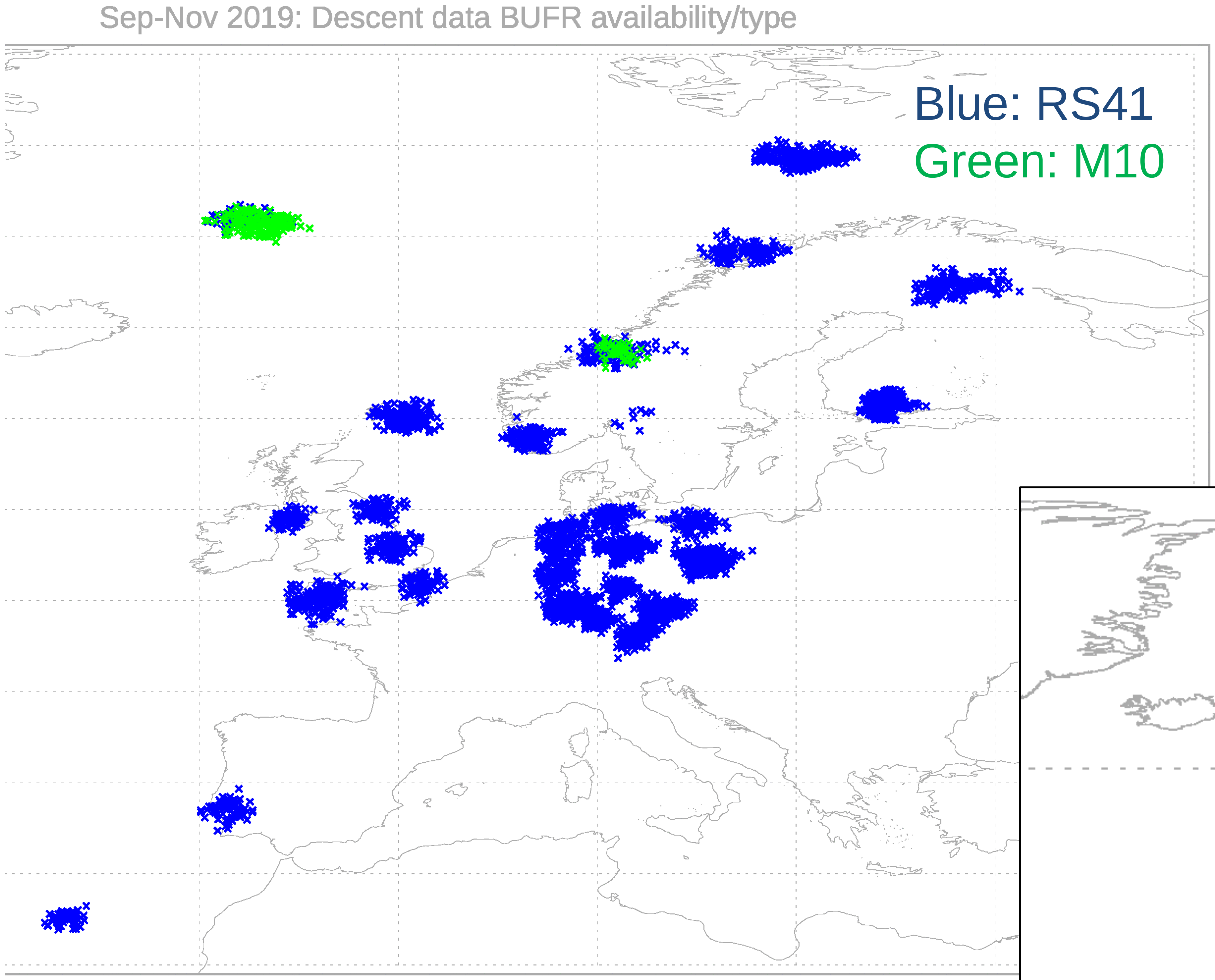
Radiosonde descent data at ECMWF (Sep-Nov 2019)

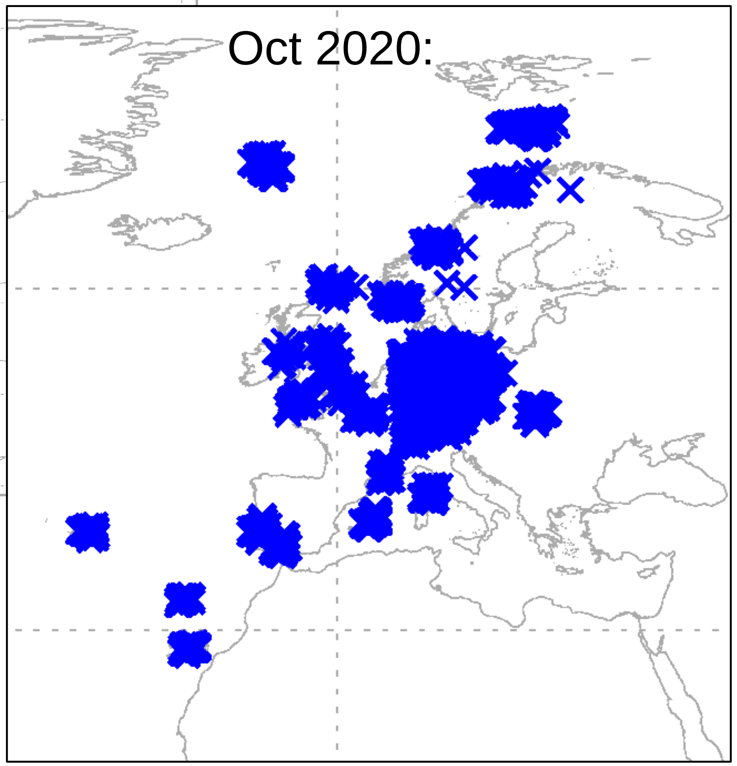
Sep-Nov data in BUFR DROP TEMP format. *Norwegian data useful addition to sample.*

Now DESCENT TM 309057 format in use by DE/PO/ES/CH/NO*.

New Zealand also sent descent data, and some examples from USA and EURECA expt.

Data being evaluated but not assimilated at time



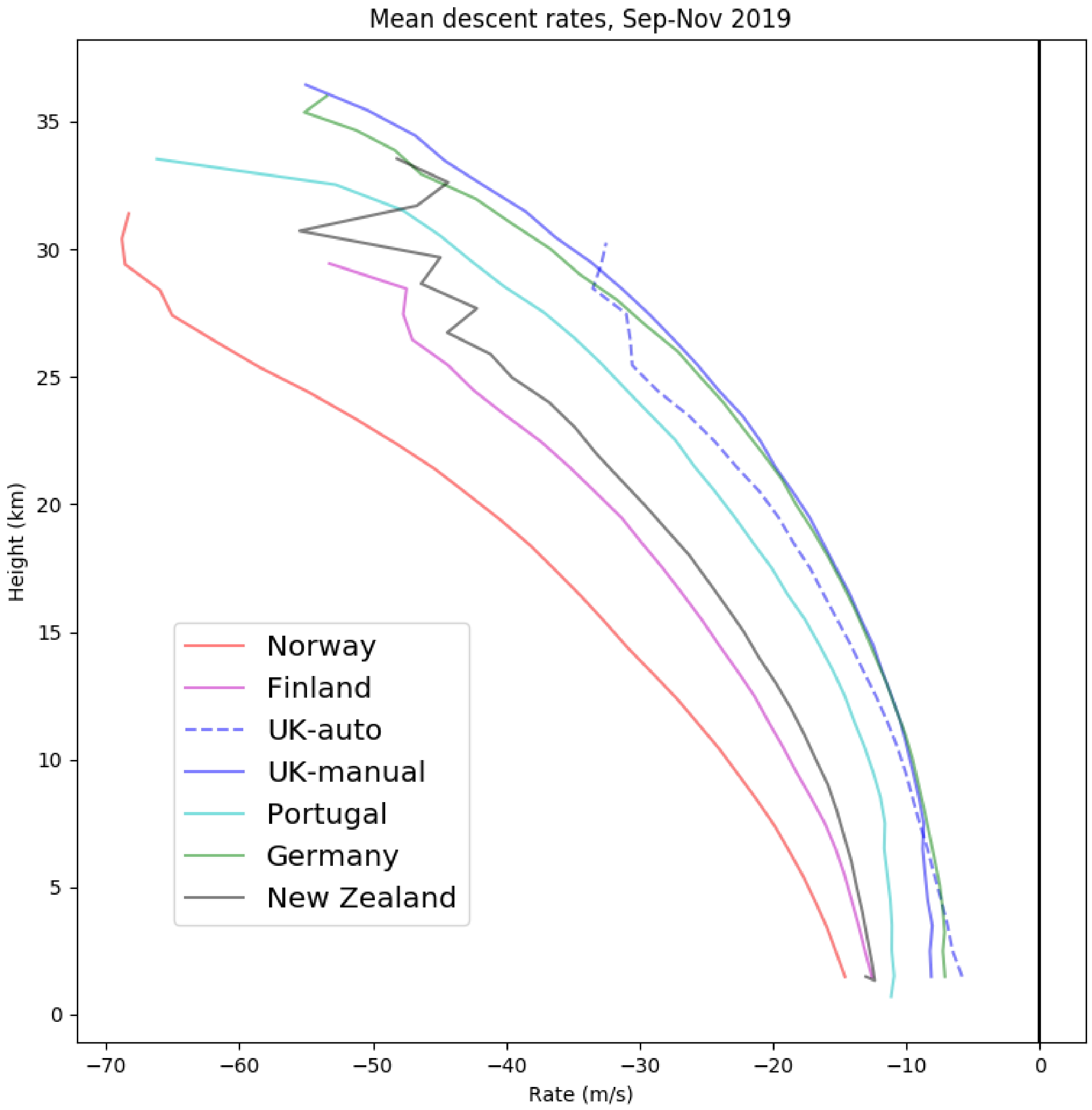


Mean descent rates

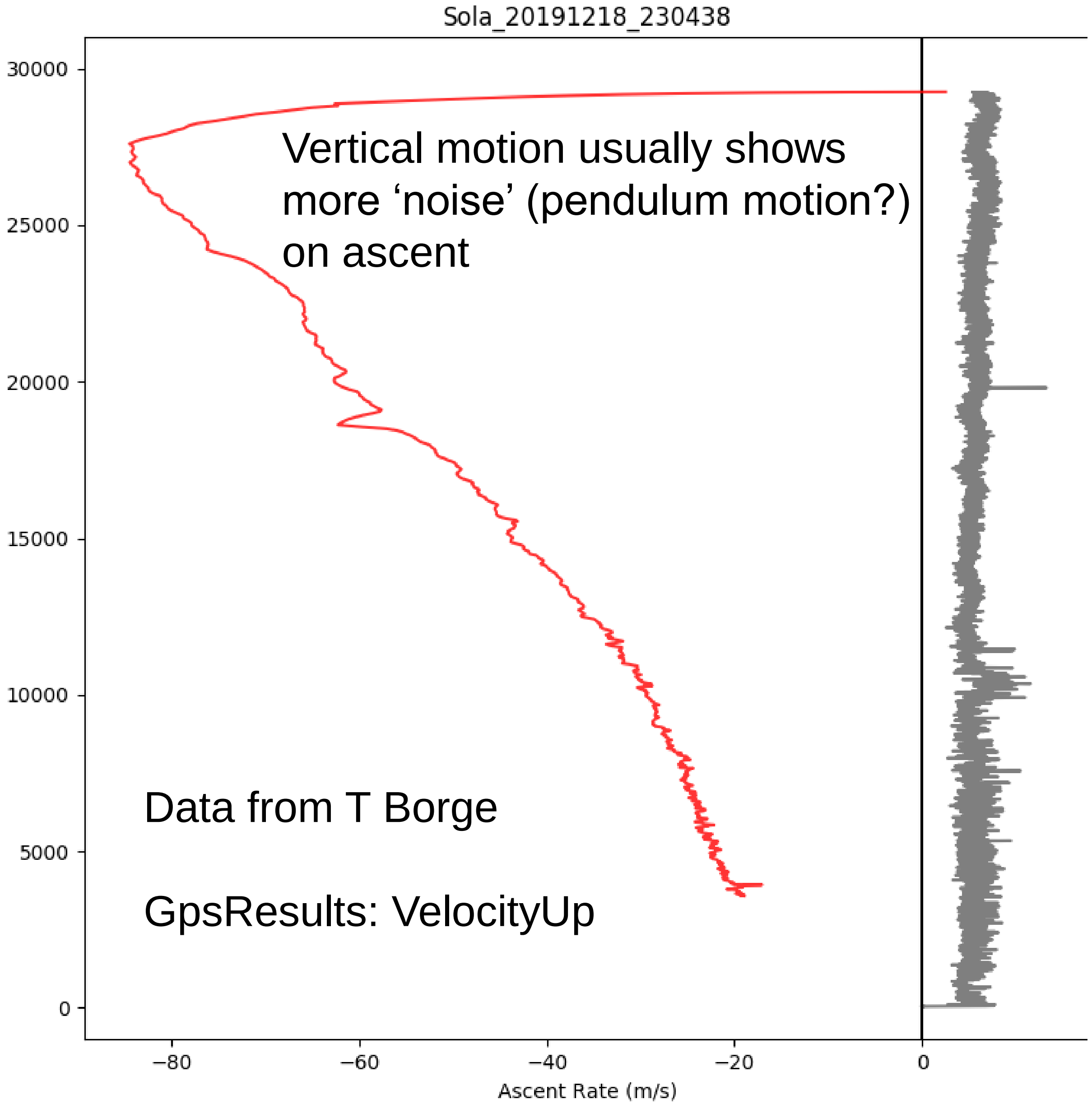
Germany and UK use parachutes => slower fall rates, others don't AFAIK.

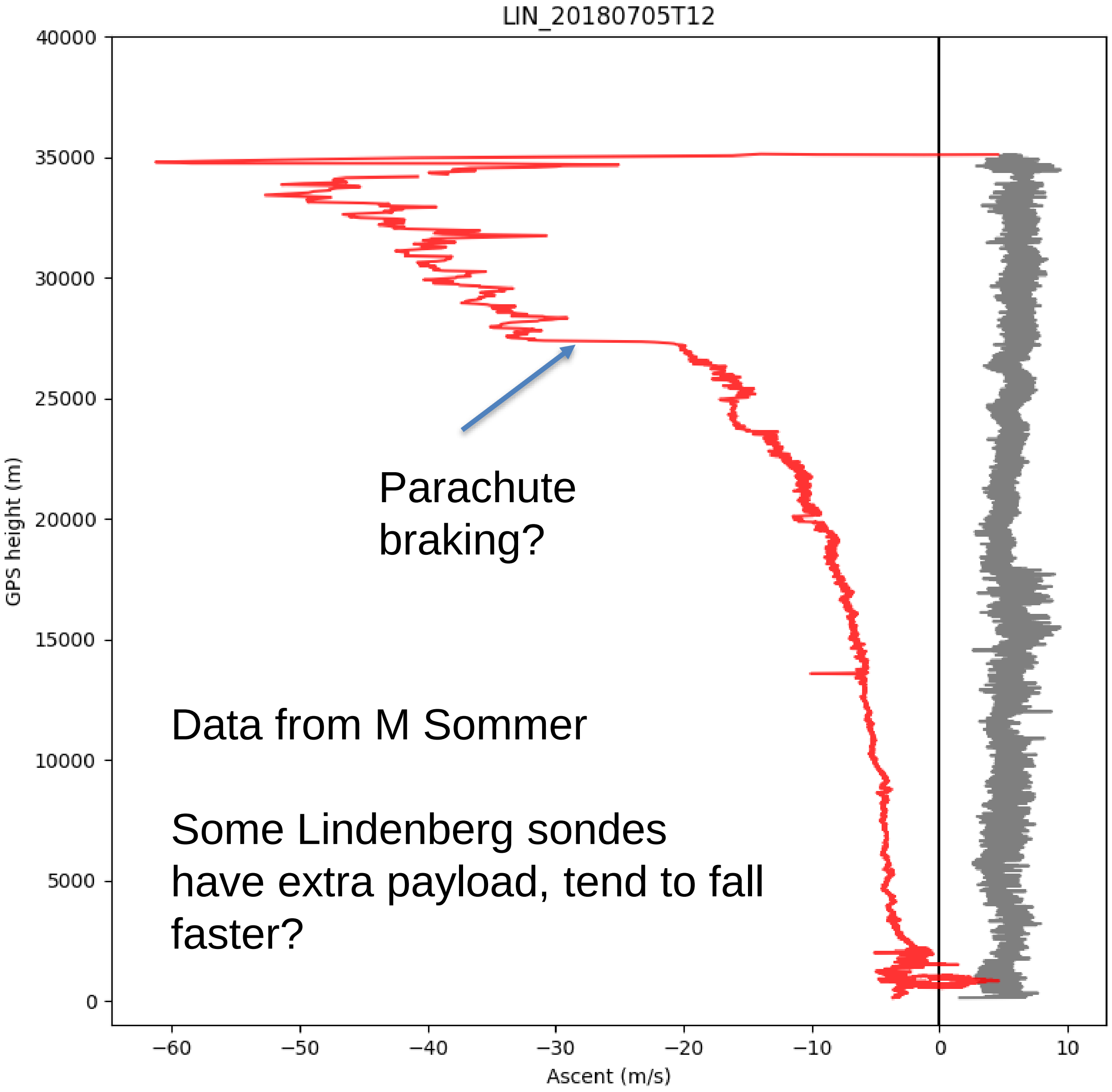
In some cases bigger balloons => faster fall rates (still remnants attached) but there are poorly understood aspects (eg intermediate rates for Portuguese)

Given large samples the mean profile looks smooth but this hides a lot of variability – next slides.



Lots of flight-to-flight variability (next page), Lindenberg sometimes shows “abrupt braking” – from parachute? Hardly seen at Sola (left, no parachute) – more vertical noise in general?





Three weeks of profiles from Sola

Data for 14 Dec 2019 – 5 Jan 2020

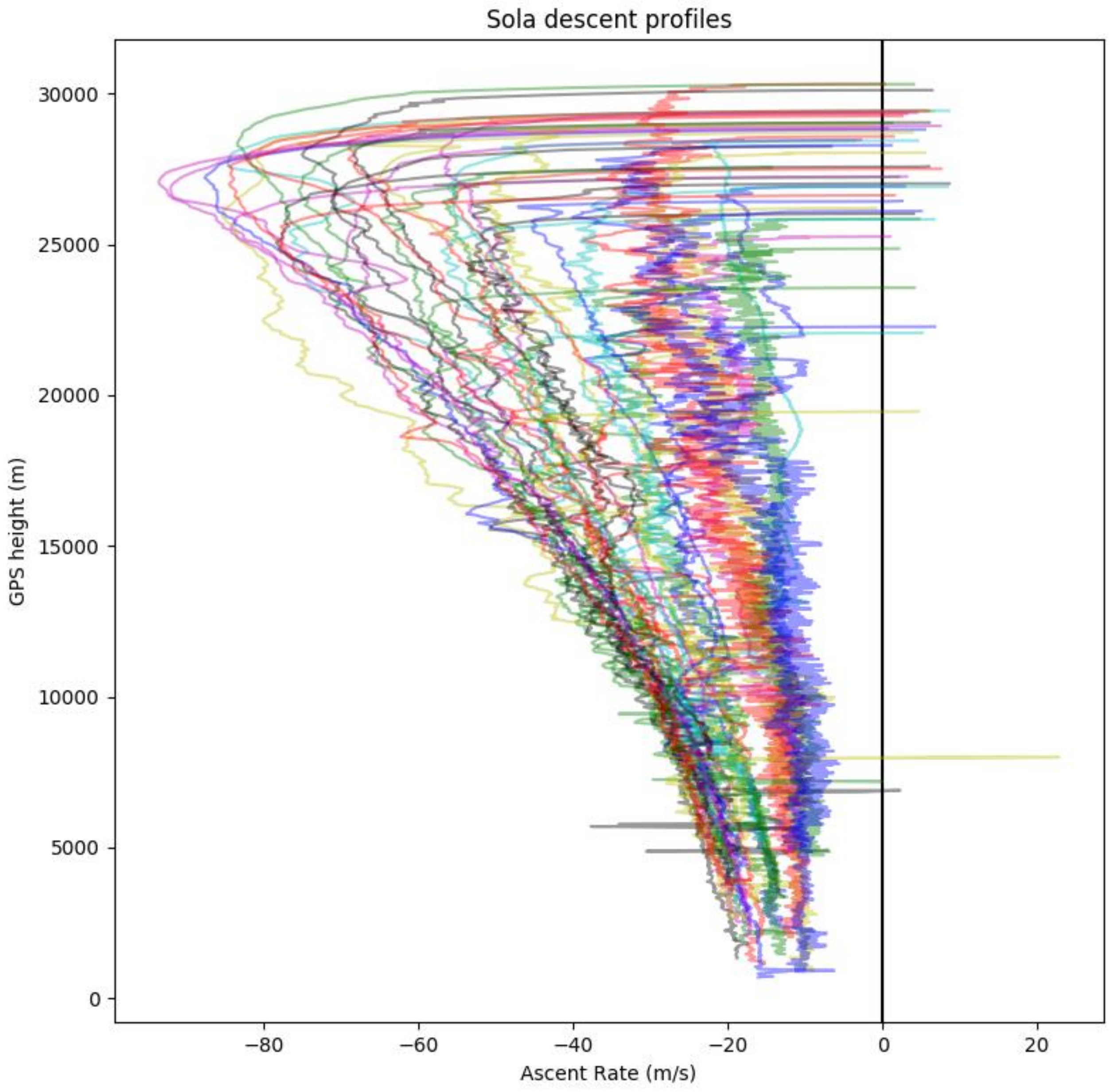
Faster fall rates: relatively smooth curves

Slower fall rates: high frequency ‘noise’
  Is this external (eg turbulence) or related to the sonde (something sticking out, sonde tumbling as it falls)?
  Latter explanations seem more likely given the vertical extent of the ‘noise’.

Q1. Is any of the balloon still attached?
 - usually yes

Q2. Orientation(s) of the falling sonde?

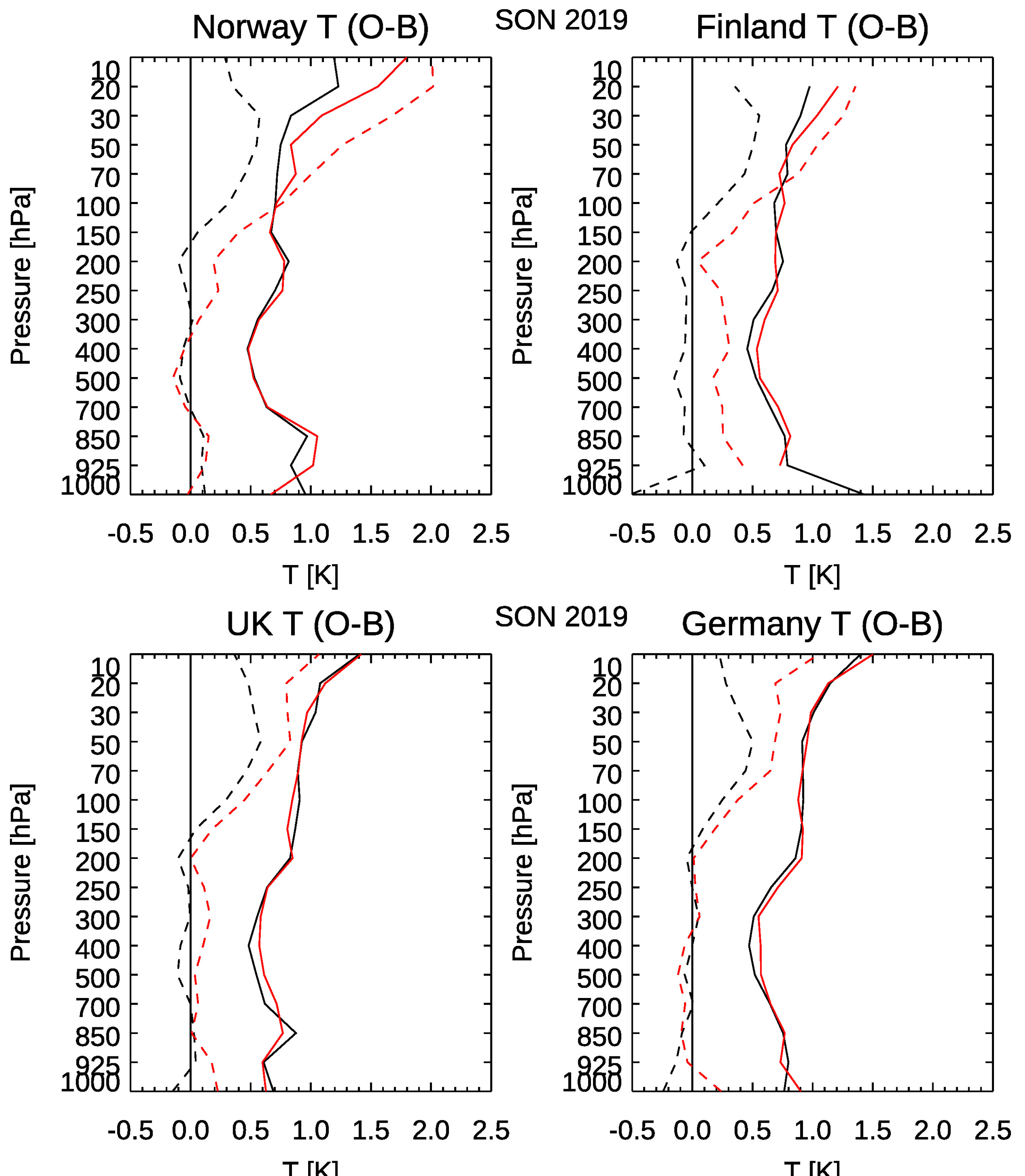
Q3. Are the balloon remains sometimes acting as a parachute?



Mean (dashed) and SD O-B stats: std levels
Black: ascent, Red: descent

Germany: best results, SDs very similar, descent warmer in stratosphere (note background bias – largest at 50 hPa).
UK: similar, but slight descent bias in troposphere
Finland: larger descent bias at top and 0.3 offset in troposphere
Norway: largest descent bias at top (almost 2 K) but no offset below 300 hPa, SDs worse in stratosphere

Link to fall speed?
Why is Finnish data better than Nowegian at top but worse in the troposphere? *See later.*



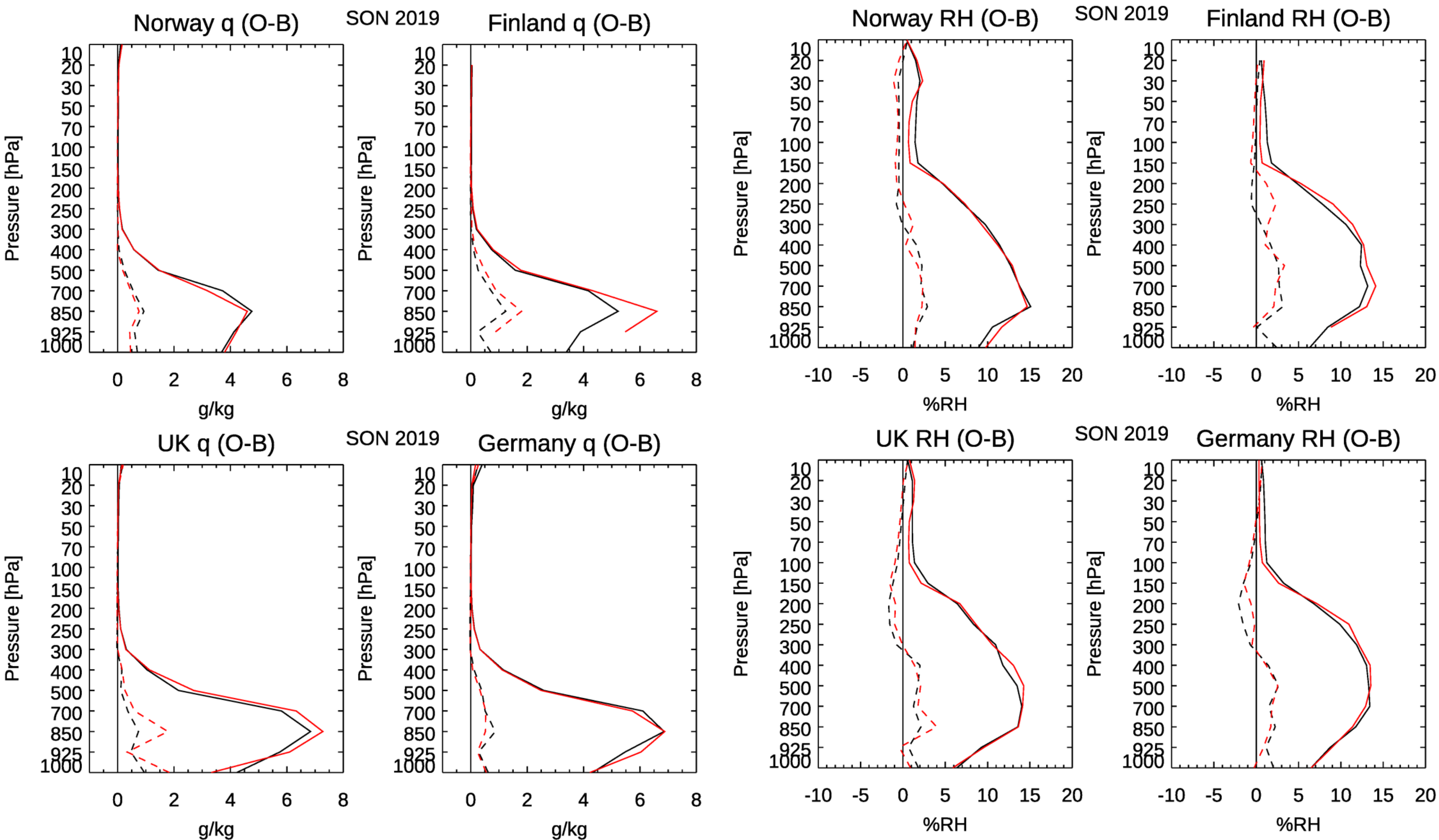
Check vs independent data (GPS-RO “dry temperatures”)

P (hPa)	#	Asc-RO	Desc-RO	Asc-B	Desc-B
5	22	-0.07	1.05	-0.37	0.90
7	36	0.53	1.63	0.25	1.25
10	77	0.35	1.28	0.22	1.12
20	125	0.13	1.04	0.37	1.33
30	130	0.15	0.92	0.45	1.24
50	135	0.02	0.37	0.44	0.84
70	137	-0.11	0.17	0.39	0.68
100	136	0.28	0.41	0.31	0.51

Retrievals performed by Mohamed Dahoui with code from Sean Healy
Number of collocations with GPS-RO (within 100 km and 2 hours): 144
Sample size small but results are similar to those vs B: Descent is too warm
(Broadly similar for subsets too, but samples even smaller.)

This uses matched Descent-Ascent pairs (earlier stats use all data), a few % of Descents weren’t matched due to lack of station identifier.

Humidity results: surprisingly good, but they look a bit worse for q than RH (esp. Finland)



Wind results

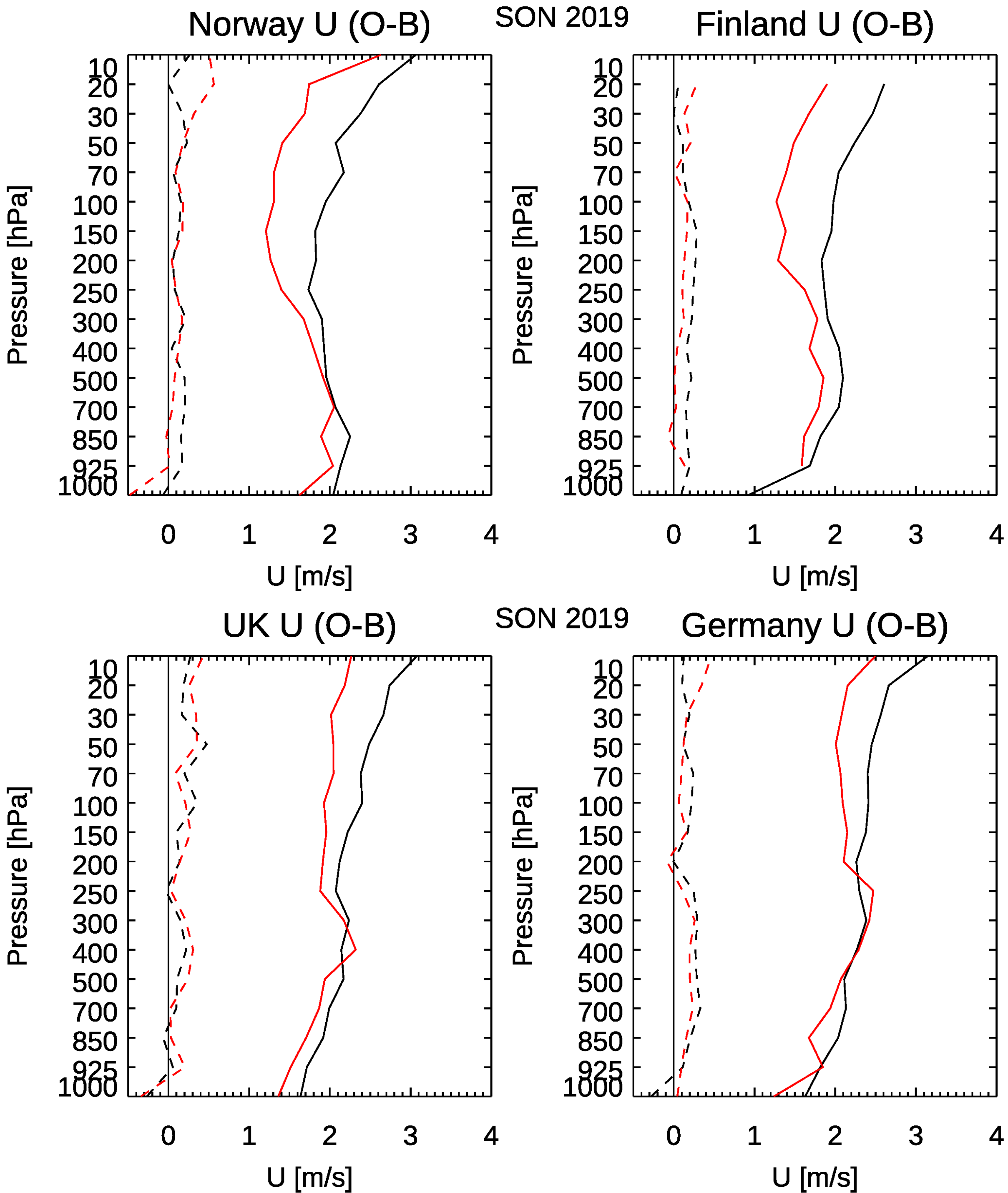
U shown (V similar, not shown)

Descent winds are generally closer to the background than the ascent winds – especially at upper levels!

It seems that the descent winds are generally good quality and less susceptible to pendulum motion than ascent winds.

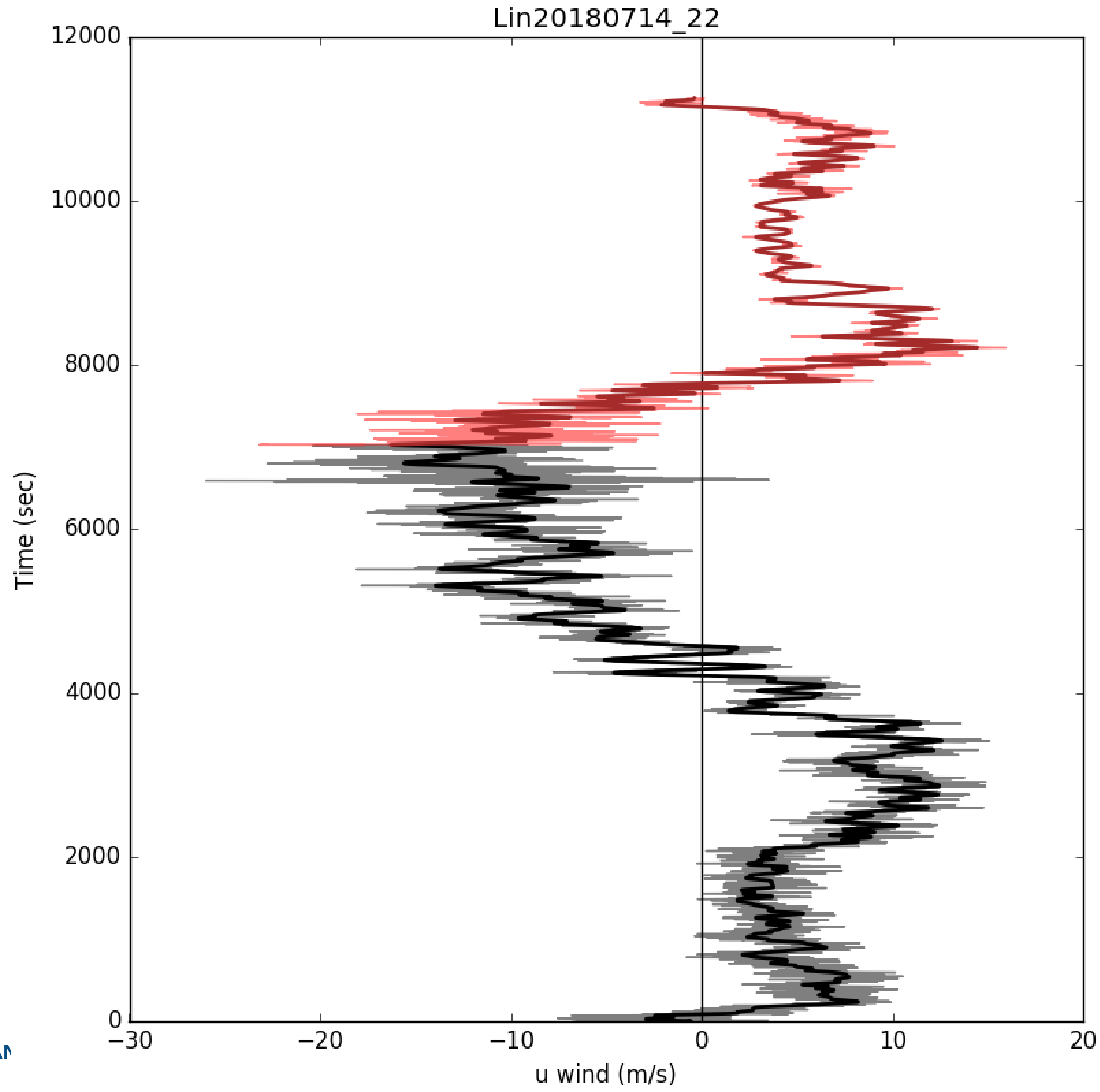
Vaisala software applies smoothing (fn(time)) in the same way as for ascent – oversmooths the profile, especially in stratosphere.

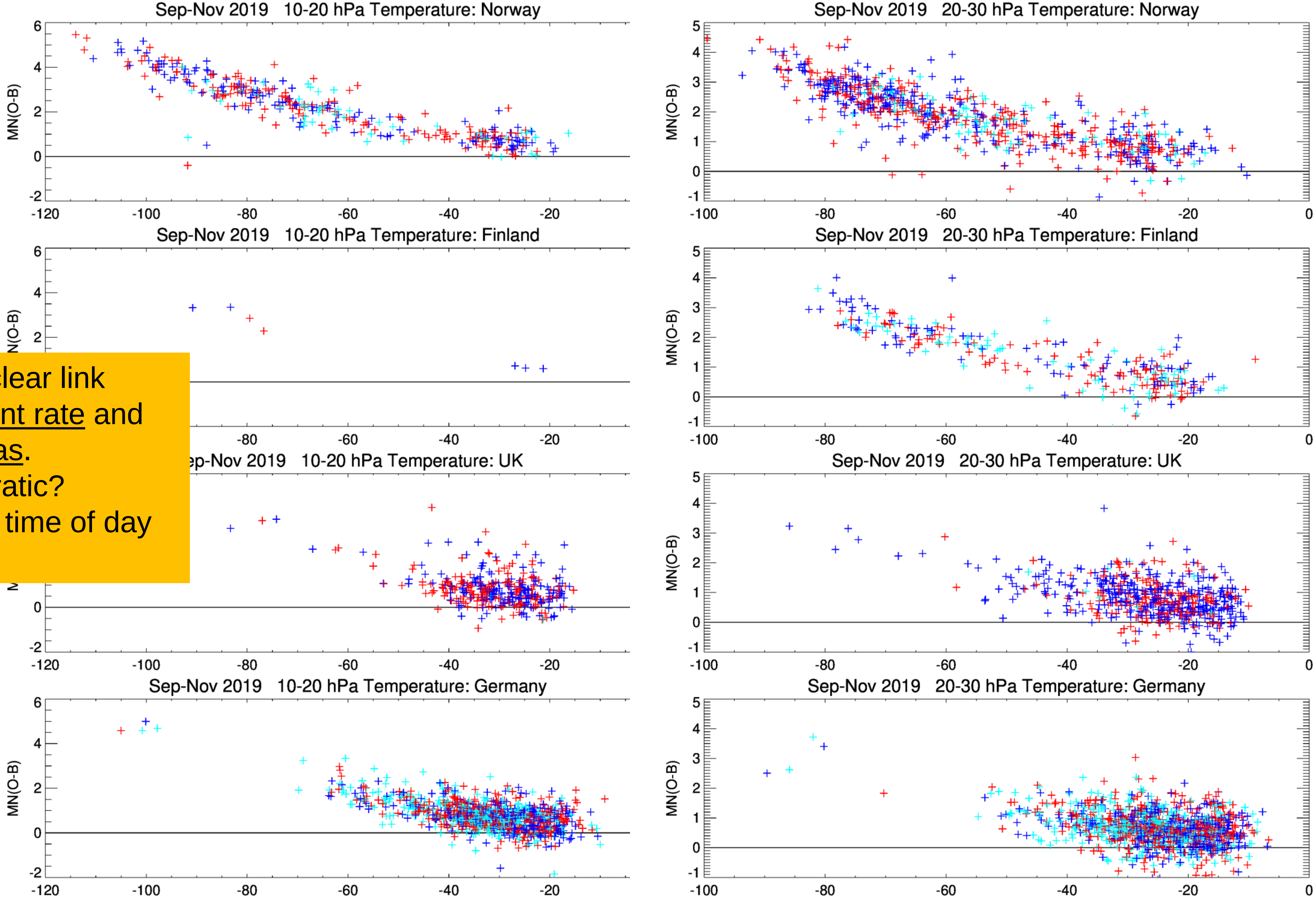
We don't have other observed wind profiles to compare with ☹ (radar wind profilers too coarse)



Pendulum motion and wind filtering

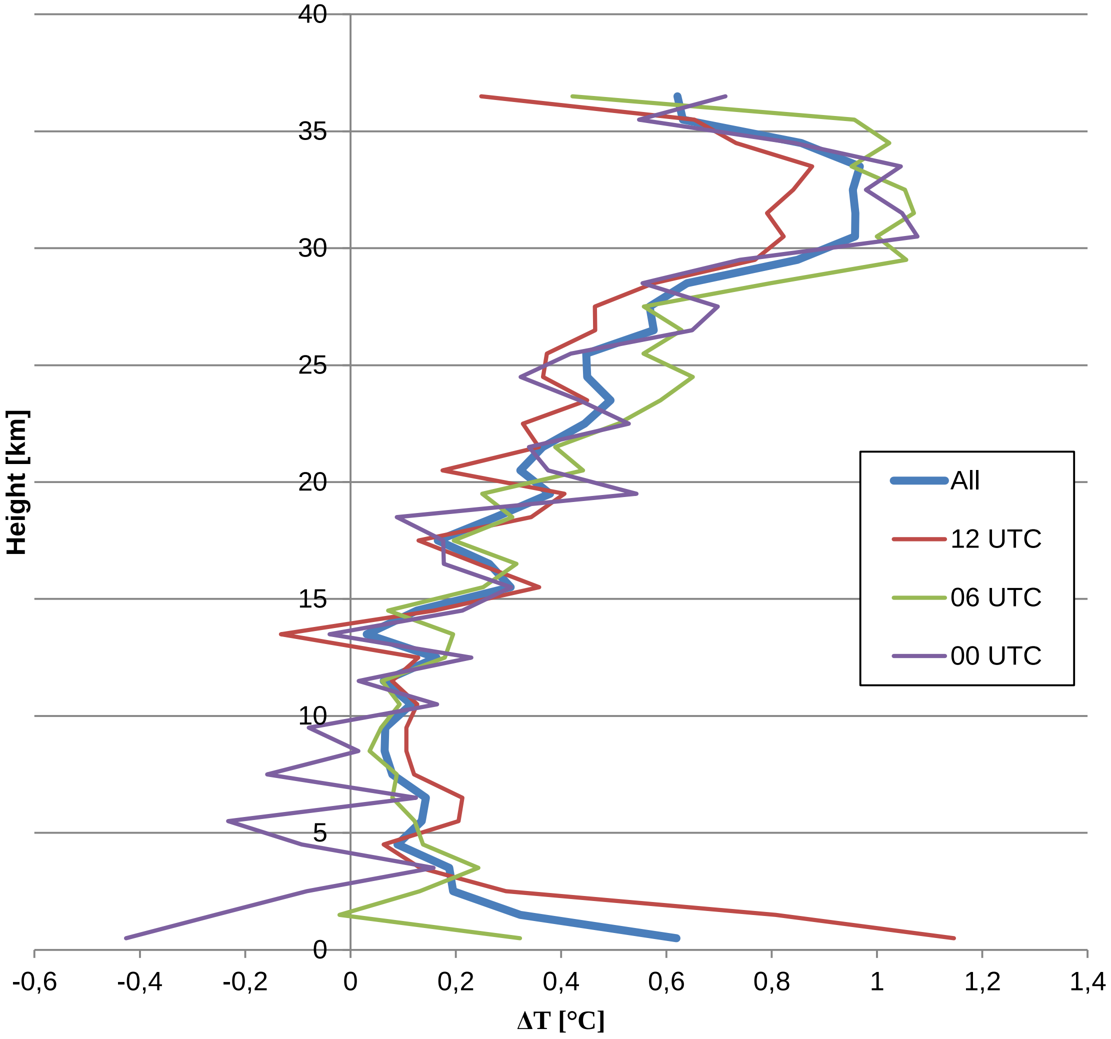
- Radiosonde swings under the balloon
- This adds high frequency noise to the GPS-derived winds – removed by filtering (eg Dirksen et al, 2014) – thin line raw data, **bold curves show filtered u wind** (data from Lindenberg)
- The noise varies …
- How much is signal?
- Some operational radiosondes seem to over-smooth.
- Less noise in troposphere for descents? Fits with w results.
- G Marlton: parachute descents have less pendulum motion

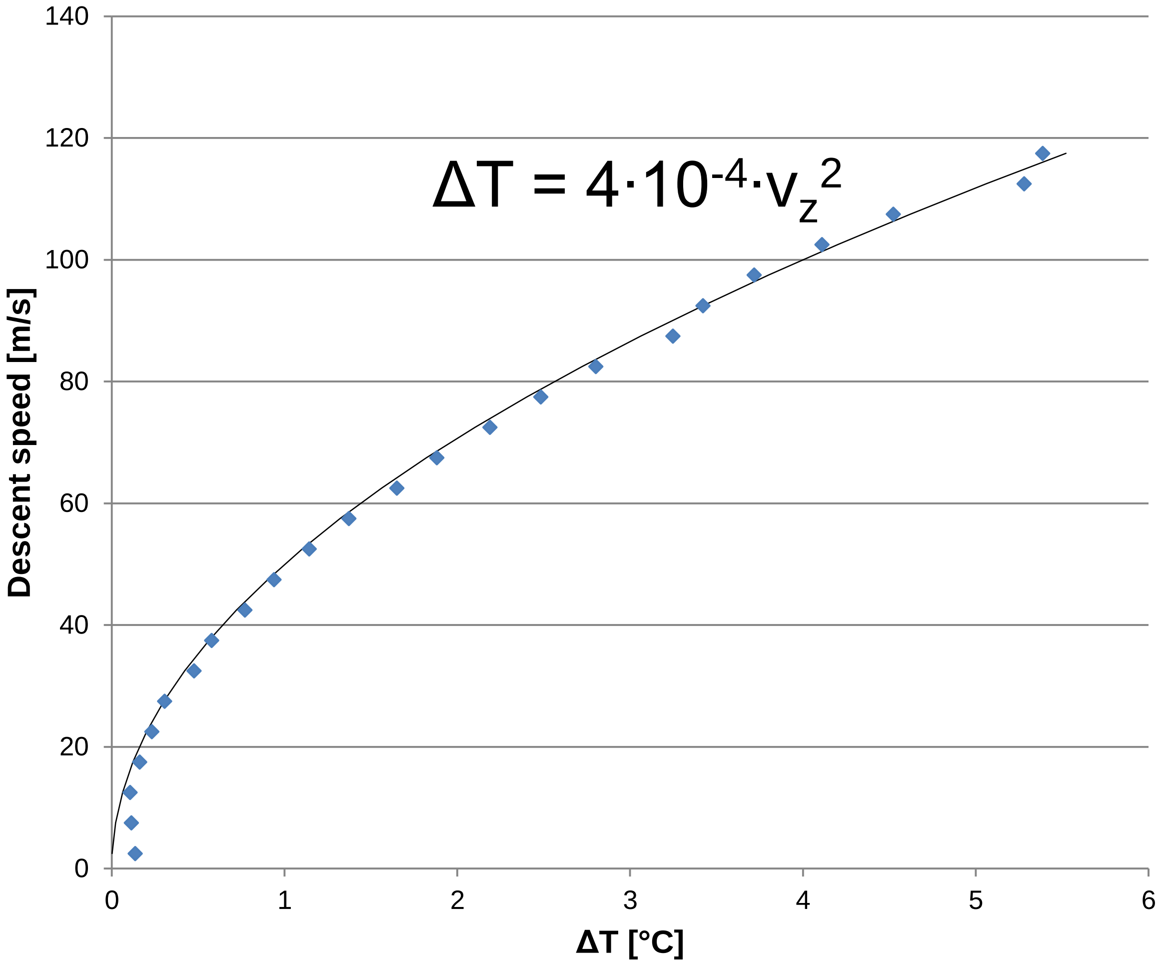




Stratosphere: clear link between descent rate and temperature bias.
Linear or quadratic?
No clear link to time of day (colours)

Temperature differences





Temperature

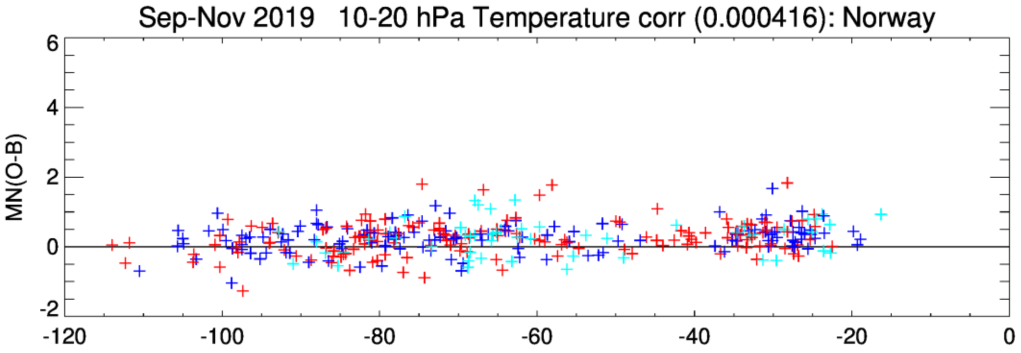
- $\Delta T = 4{,}16 \cdot 10^{-4} \cdot v_z^2$
- explains 33,1 % of variance
- Tested for:
  - $\Delta T = A \cdot v_z^2 + B \cdot v_z + C$

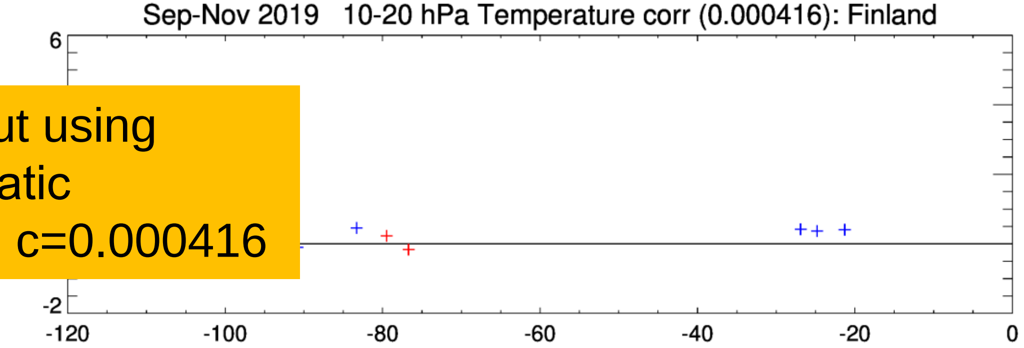
    improvement only to 33,2 %
  - data under 4 km excluded

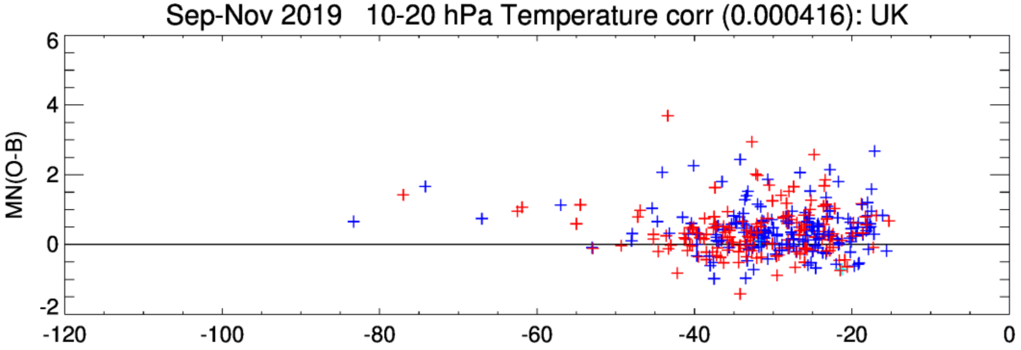
    $\Delta T = 4{,}18 \cdot 10^{-4} \cdot v_z^2$
  - each term (00, 06, 12) separately

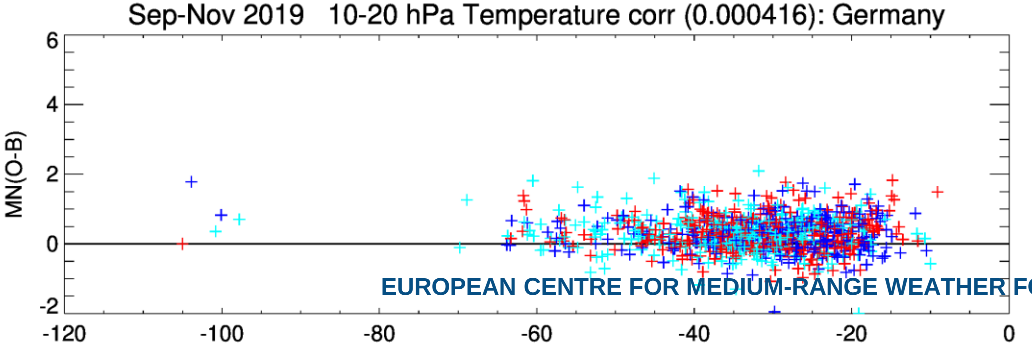
    coefficients from $3{,}94 \cdot 10^{-4}$ to $4{,}39 \cdot 10^{-4}$

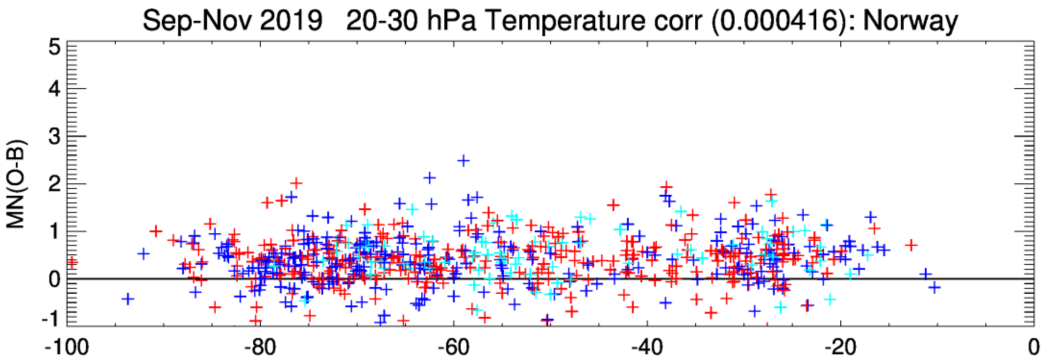
As last slide but using Martin’s quadratic correction with c=0.000416

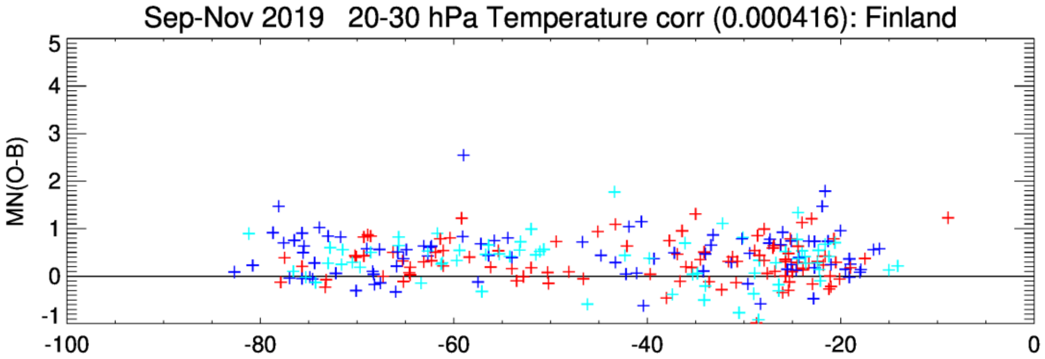


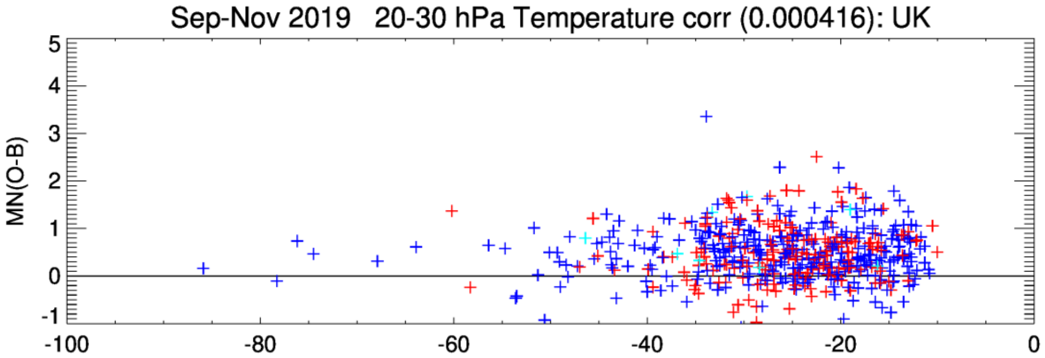


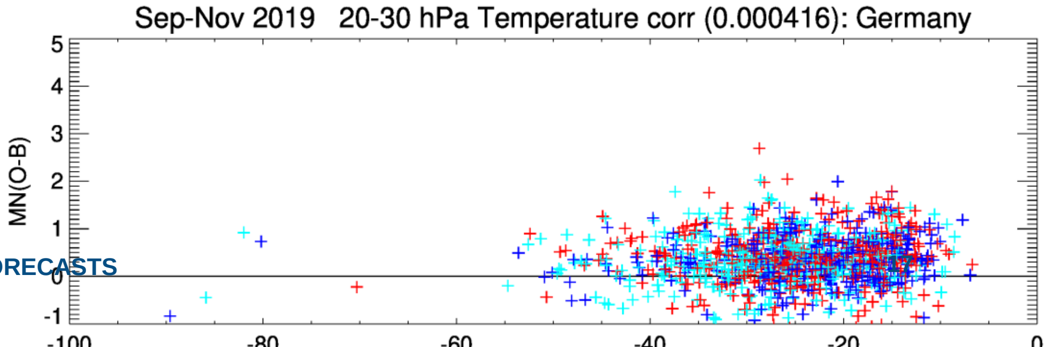








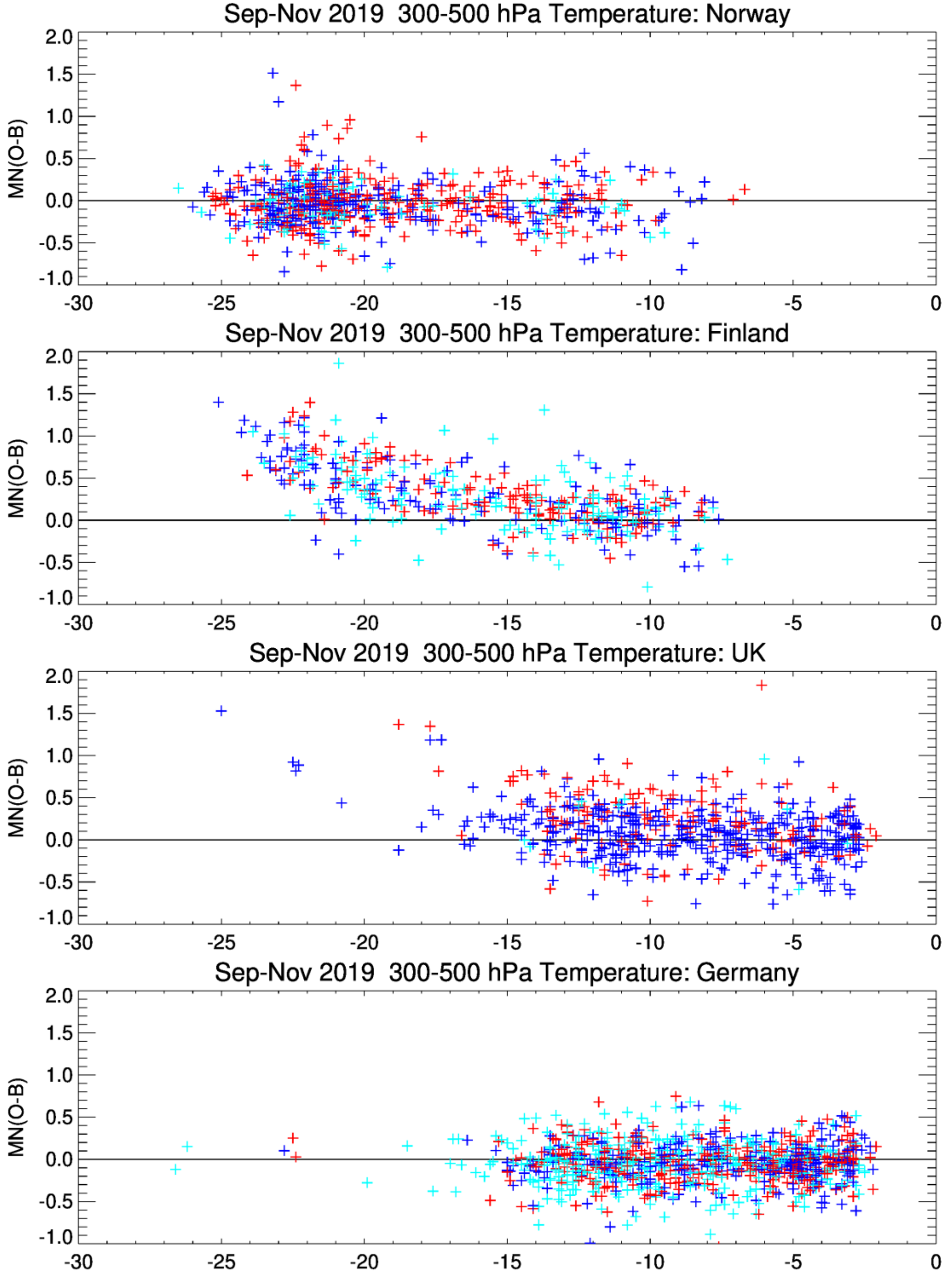




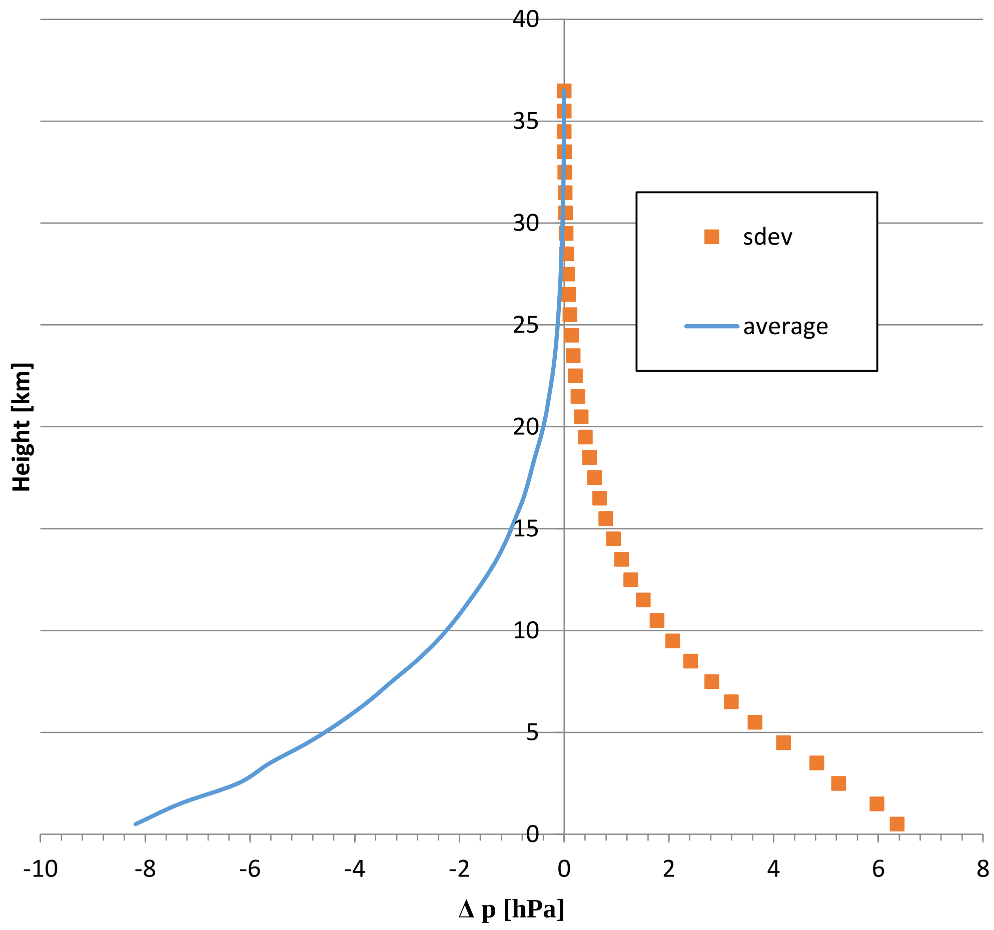
Troposphere (300-500 hPa)

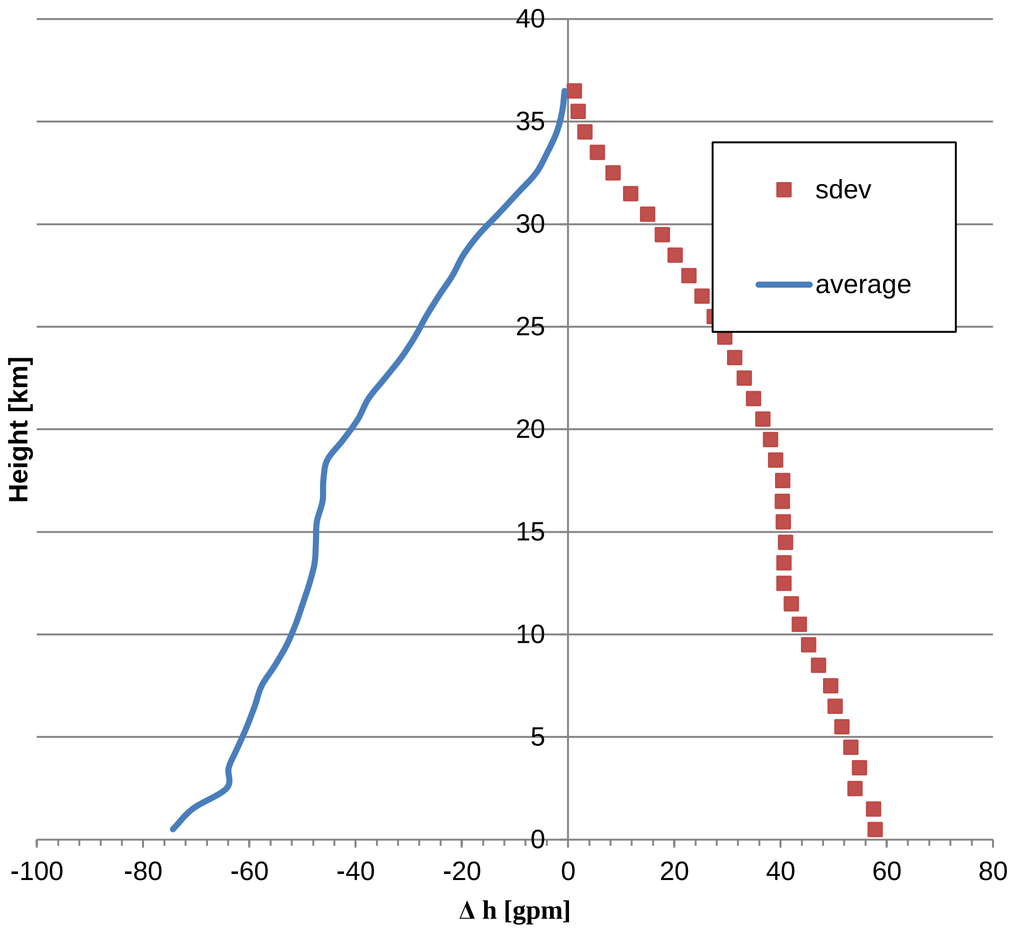
- T bias seems independent of descent rate (up to ~25 m/s) for Norwegian and German data but not Finnish?! UK also shows ‘biased tail’ – small sample
- UK/Finnish radiosondes don’t have pressure sensor, German and Norwegian RS41 do
- Without P sensor pressure is calculated from (biased) temperatures higher in profile: gives apparent T bias in troposphere – insight from M Motl

- German results best (P sensor and parachute)
  – Although P sensor accuracy is worse at high fall rates, recent result
- Finnish results ~worst (no P sensor and no parachute)

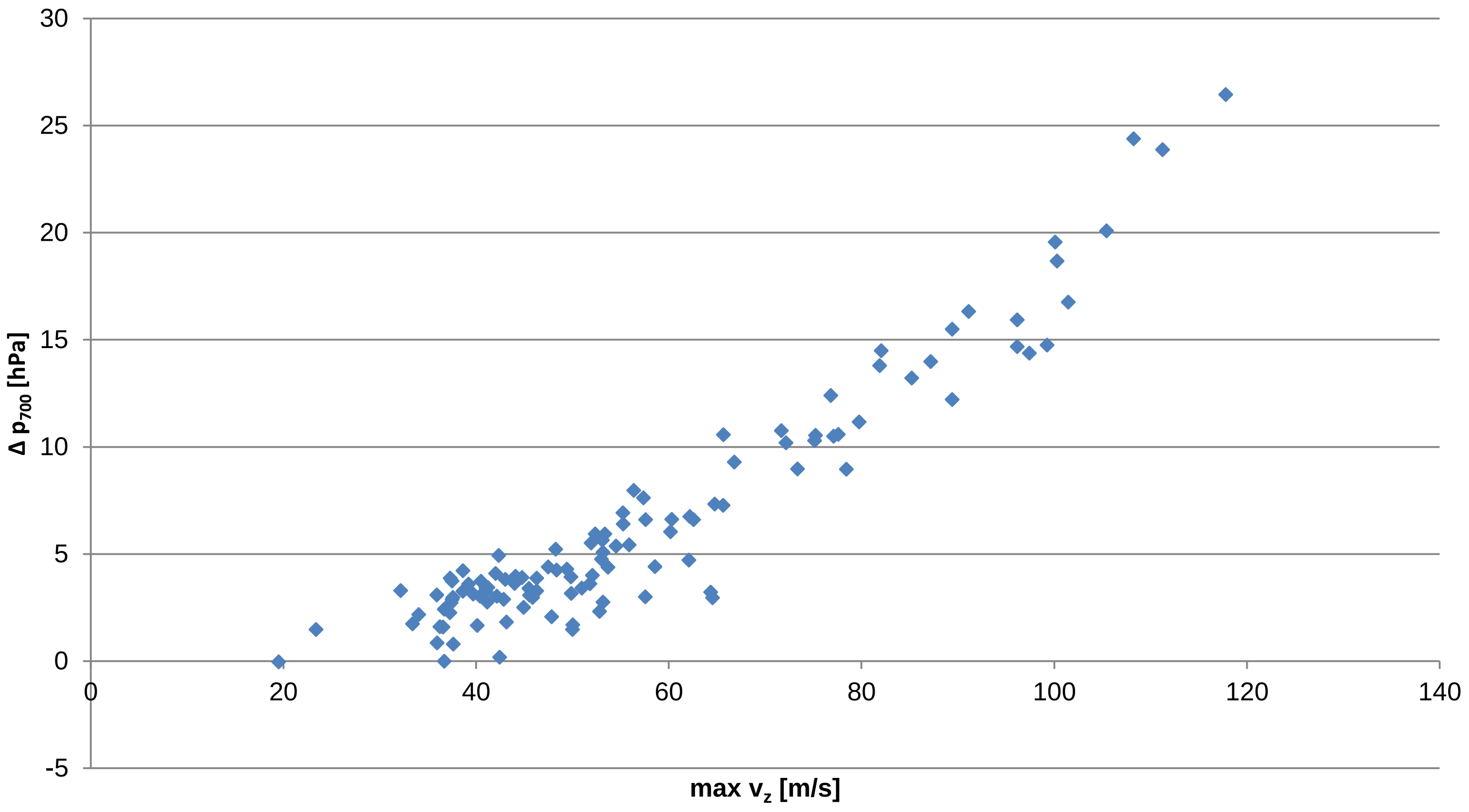


Pressure differences





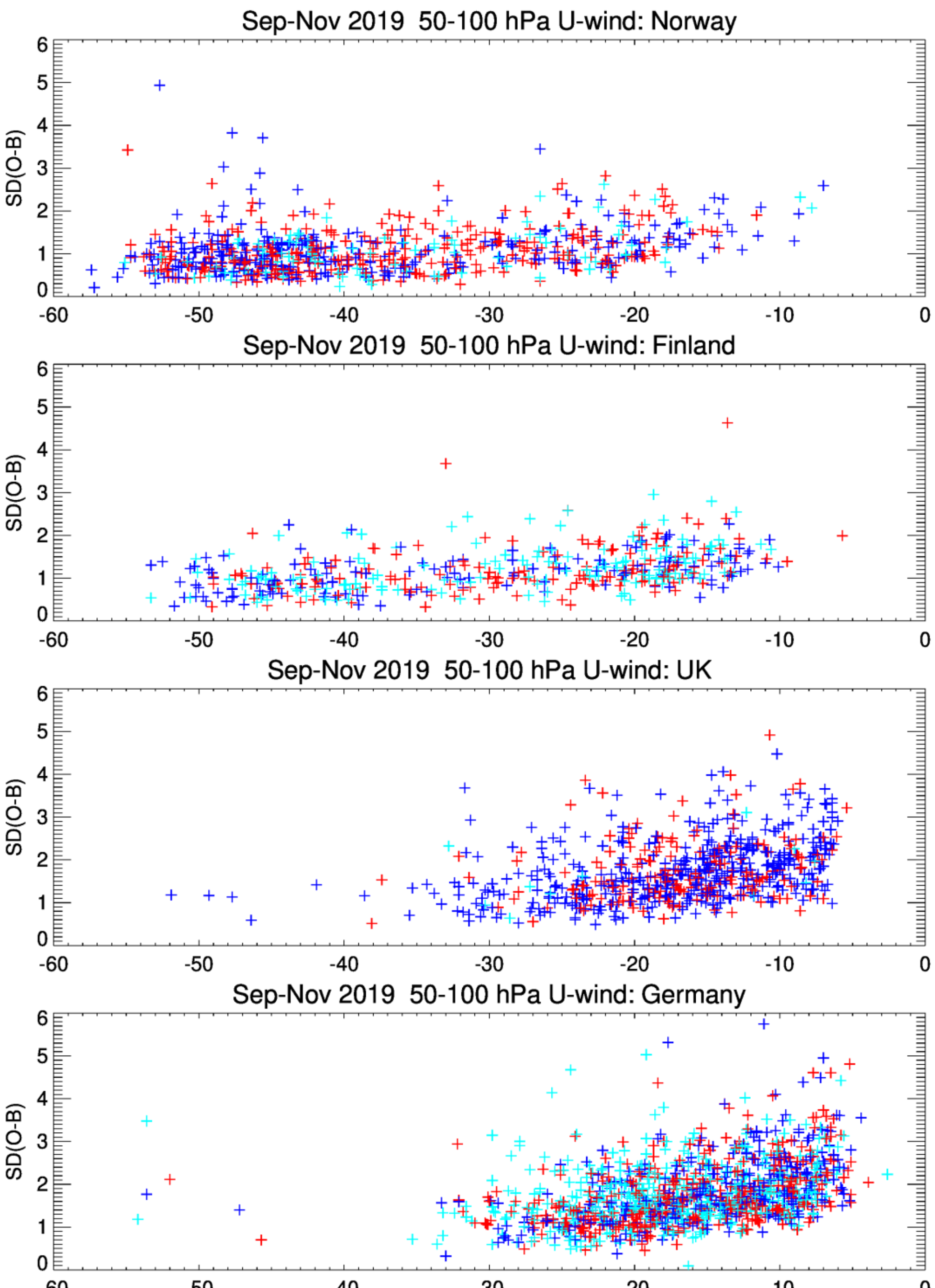
p error is connected with descent speed



Wind diffs vs descent rate

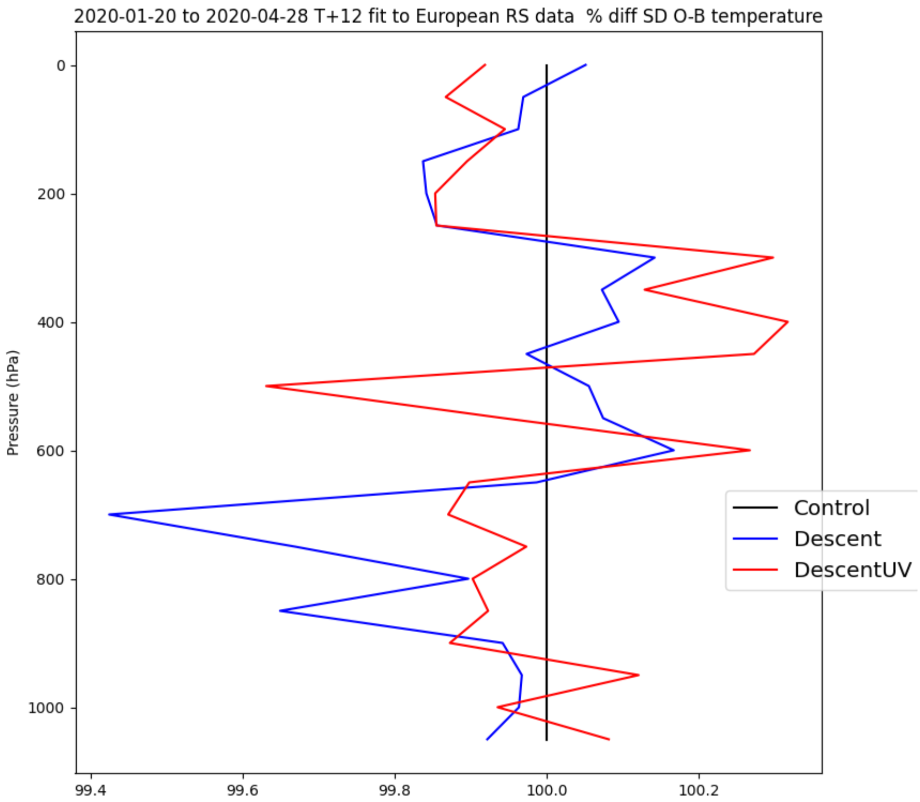
- No clear biases linked to fall rate (unlike T)
- But some increase in SD(O-B) for <u>smaller</u> fall rate
  - Data probably still usable for NWP
- Clearer for UK and Germany
- Linked to ‘noisier’ fall rate for slower descents?

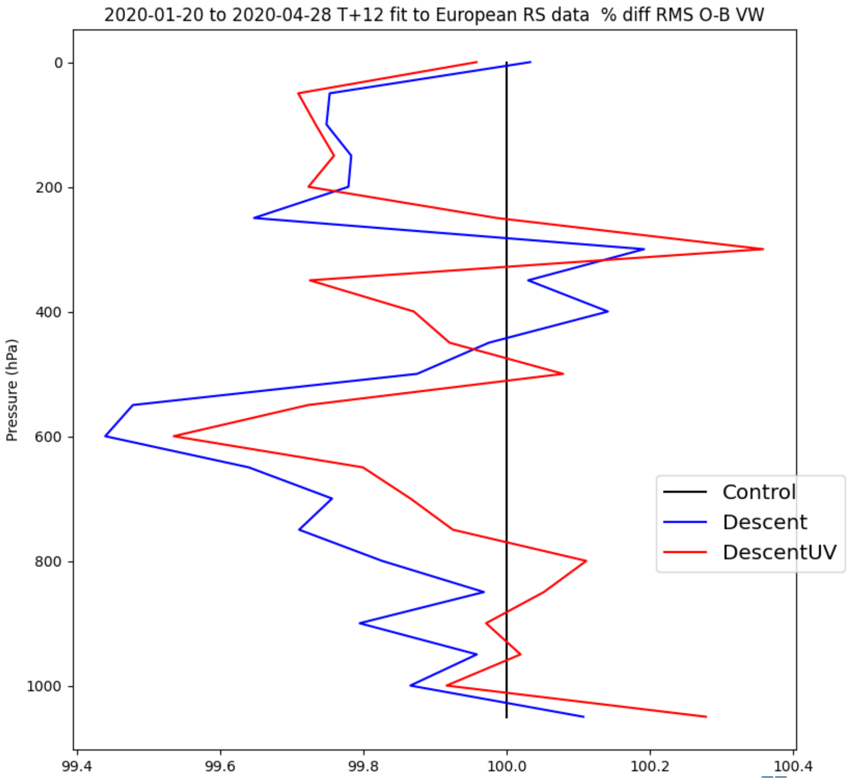
- Is sonde tumbling, waggling or spinning more in slower descents?
- Tumbling more likely without parachute?



Impact

- Trials run 20 Jan – 28 April 2020
- Large scale impact mixed, ~neutral
- Over Europe T+12 slightly improved vs radiosonde ascents, esp. wind (right)
- Better over Germany, worse over Norway, mixed over UK
- ECMWF started assimilation of German descent data on 17 June 2020
  - Best subset less subject to pressure offset, data with P<150 hPa





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Summary of descent results

- At upper levels descent **T** is too high (vs ascent, background and GPS-RO)
- Evidence that this is linked to descent rate (KE converted to T)
- With P sensor fast descent reduces P accuracy locally ☹
- Without P sensor subsequent descent pressures can be offset
- Q. To what extent can the biases be corrected? (When? Vaisala processing?)
- Rms(O-B) is mostly smaller for descent **winds** ! => better?
  - Less pendulum motion on descent, also descent winds oversmoothed?
- Working on publication
- **What is reference for wind?** Without pendulum motion.
  - Jimsphere (still available or not?)
  - Radiosonde with two balloons (Krauchi et al, 2016)?
  - Wind profiler? Relatively coarse vertical resolution
  - Try radiosonde attached directly to balloon?