RS41 / RS92 GRUAN Data Products Comparison (D3)

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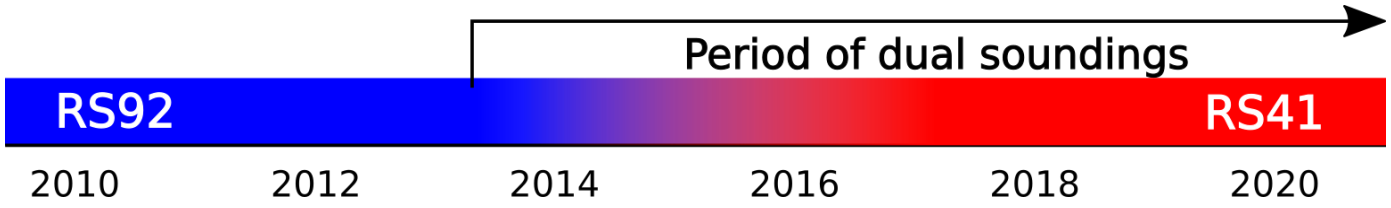
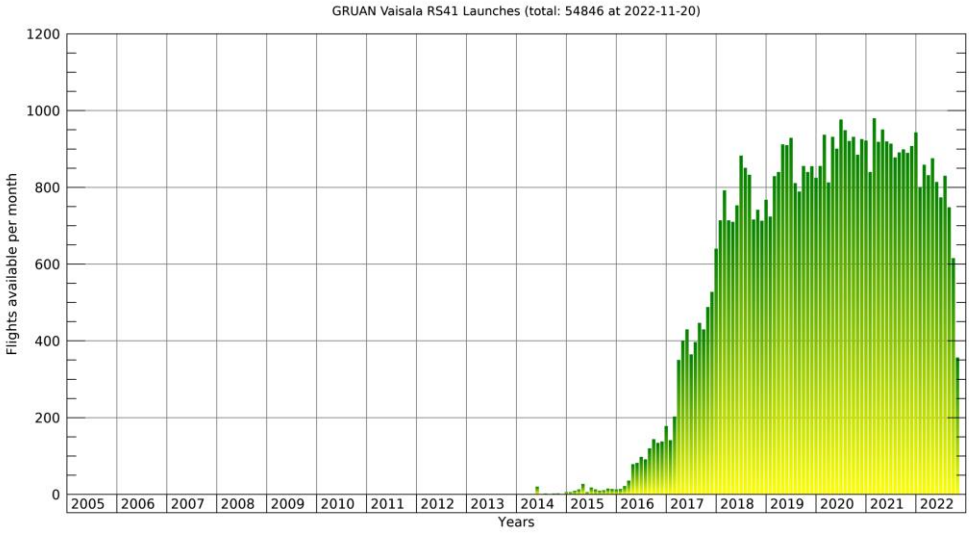
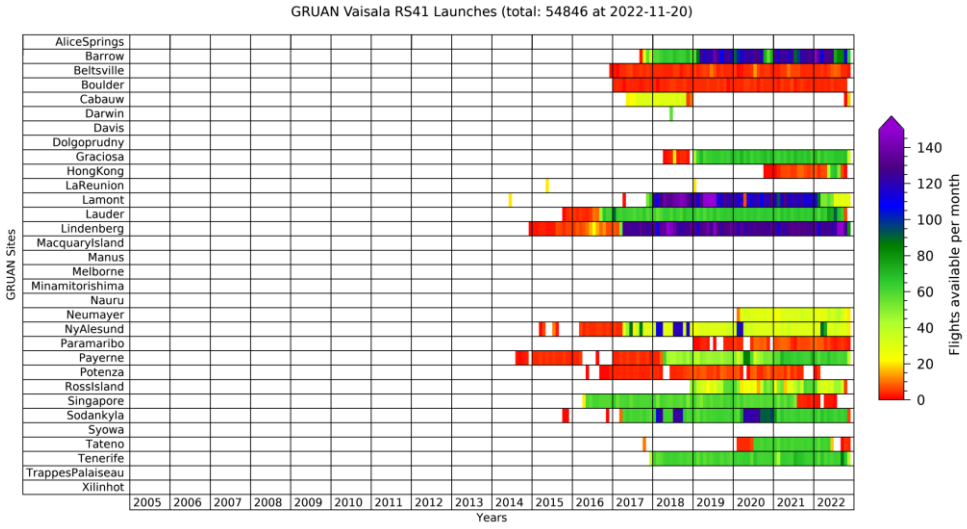
Why RS41 and RS92?



- RS41 is the follow-up radiosonde to the RS92
- RS92 used in 18/31 GRUAN sites
- RS41 used in 19/31 GRUAN sites
- For both sondes manufacturer created EDT products are available
- For both sondes GRUAN GDP's are created
- GDP's contain all measurements + estimated uncertainty budgets





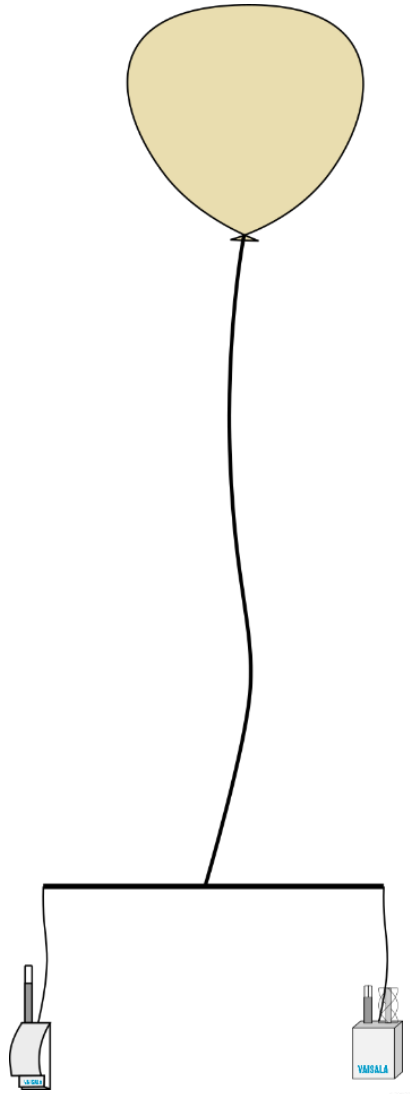
1133 flights from Tropics to Arctic

Temperate	N of flights
Beltsville, US	151
Camborne, UK	45
Graciosa, Azores	27
Kathmandu, Nepal	22
Lamont, US	53
Lauder, NZ	50
St. Helena island	45
Table Mountain, US	40
Tateno, Japan	8

Arctic	N of flights
NyAlesund	110
Neumayer	26

Continental	N of flights
Lindenberg, Germany	321
Payerne, Switzerland	110
Sodankyla, Finland	3

Tropical	N of flights
Darwin, Australia	52
Palau	14
La Reuinon	29



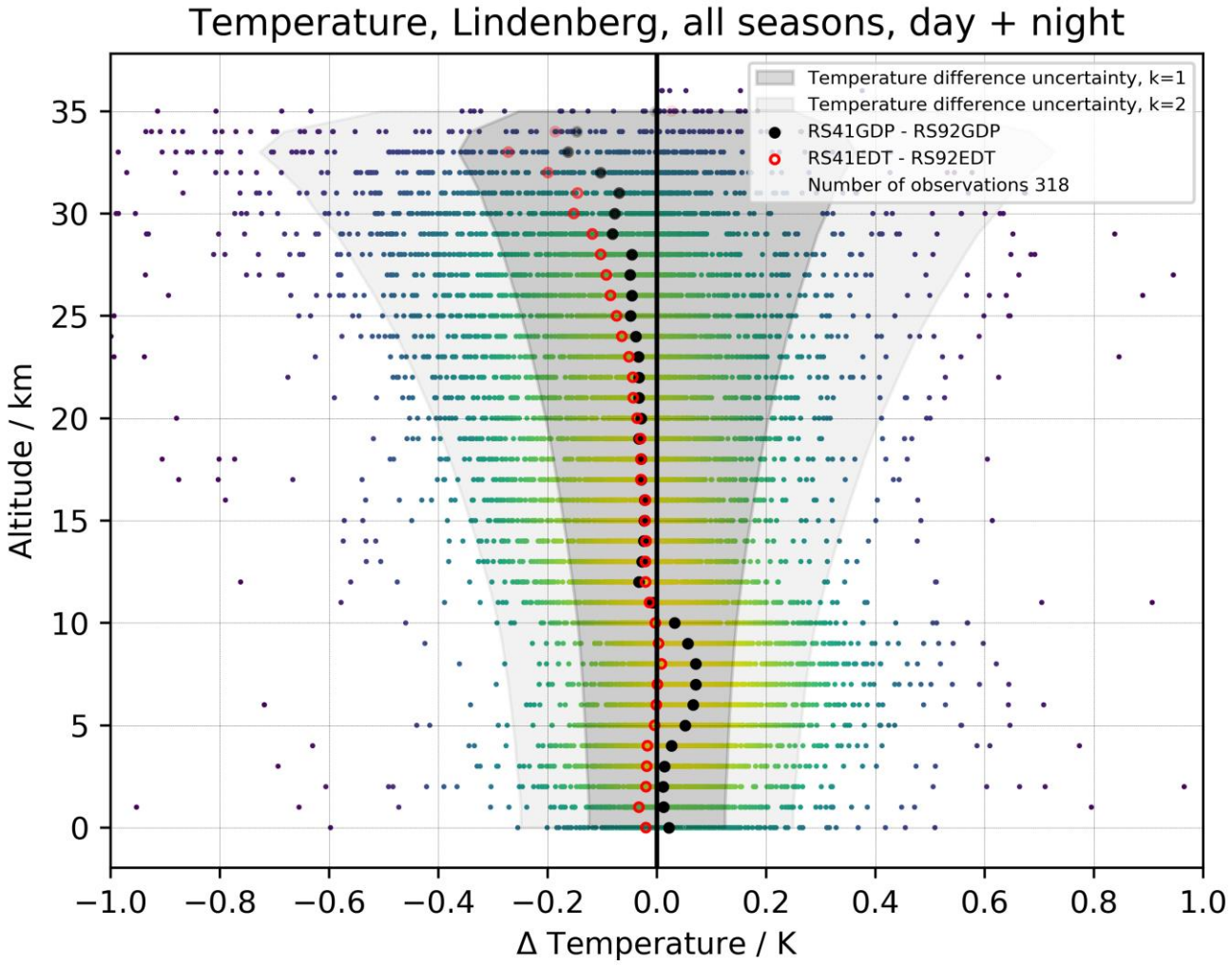
Simple scheme of uncertainties

	Point in profile	Layer in profile	All profiles
• uncorrelated (random)	u_{ucorr}	$u_{ucorr} = \sqrt{\sum u_{ucorr}^2}$	$u_{ucorr} = \sqrt{\sum u_{ucorr}^2}$
• correlated (systematic)	u_{corr}	$u_{corr} = \frac{1}{n}\sum_n u_{corr}$	$u_{corr} = \frac{1}{n}\sum_n u_{corr}$
• full	$u = \sqrt{u_{ucorr}^2 + u_{corr}^2}$	$u = \sqrt{u_{ucorr}^2 + u_{corr}^2}$	$u = \sqrt{u_{ucorr}^2 + u_{corr}^2}$

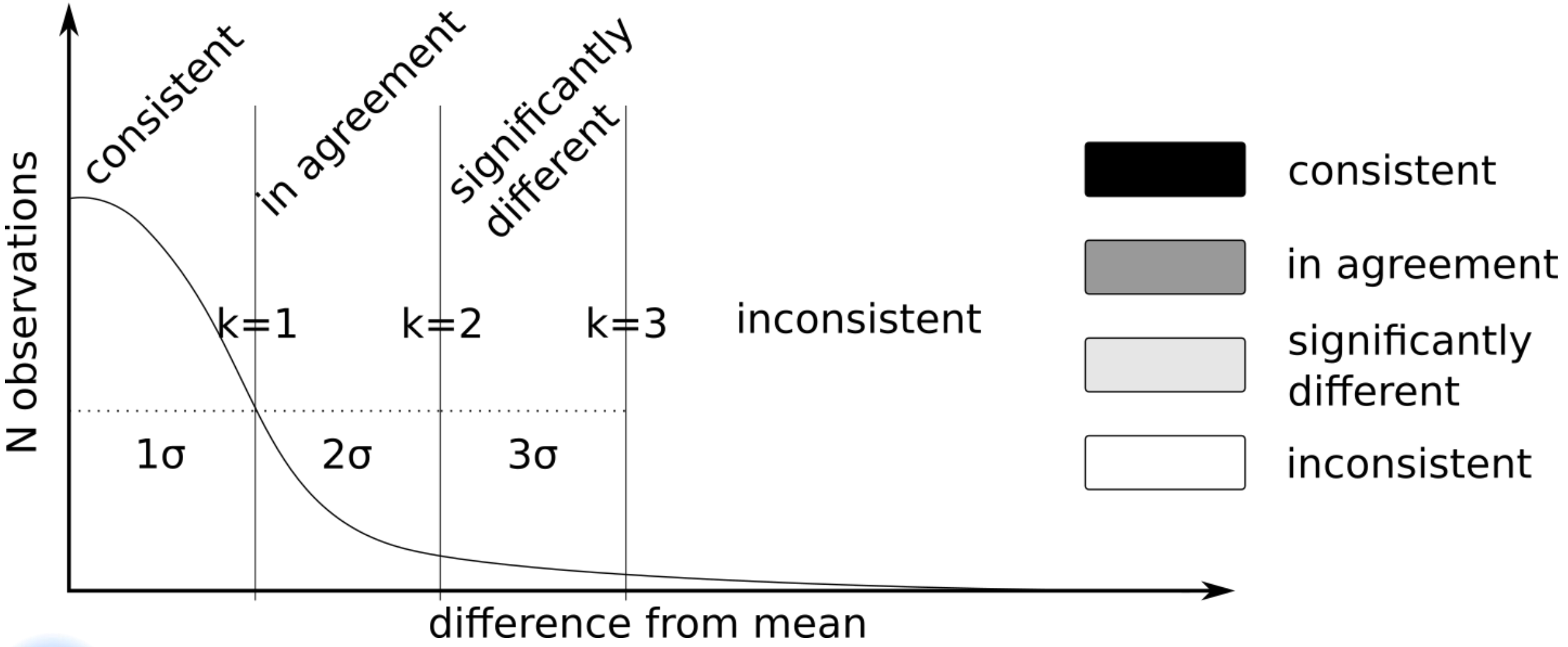
Only full uncertainties shown on plots

Statistics on consistency

- Each point represents a bin from a single profile
- Colours represent density of bins from individual profiles
- Most bins are within the calculated uncertainty thresholds
- Normal distributions can be expected

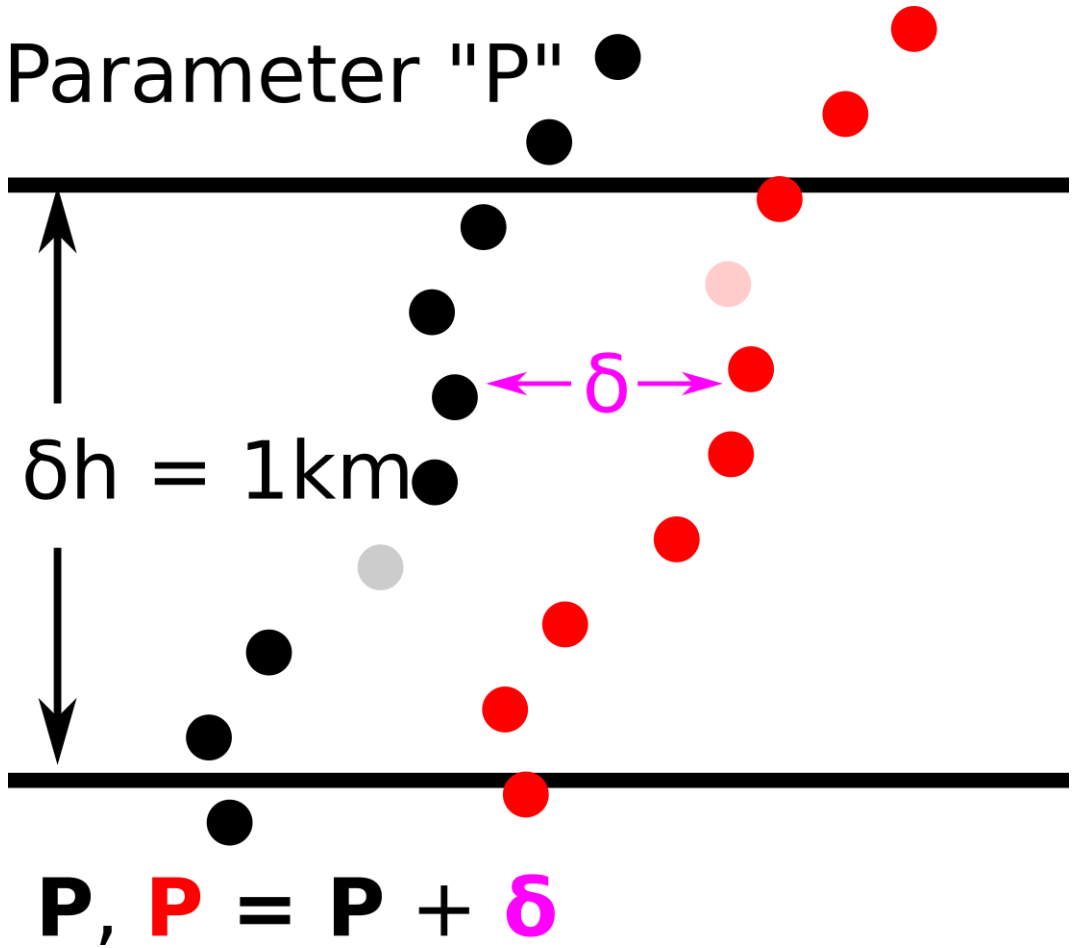


Consistency with uncertainties



Altitude binning

- **Profiles synchronized on GPS time**
- Each profile divided into layers 1km thick, based on RS41GDP
- Values averaged in each layer for base profile
- Values from pairs with gaps excluded
- Values for all profiles calculated from mean difference to base
- Values for all profiles for each station averaged for each layer
- Estimated uncertainties from GDP's



Black points and black uncertainties from GRUAN Data Products

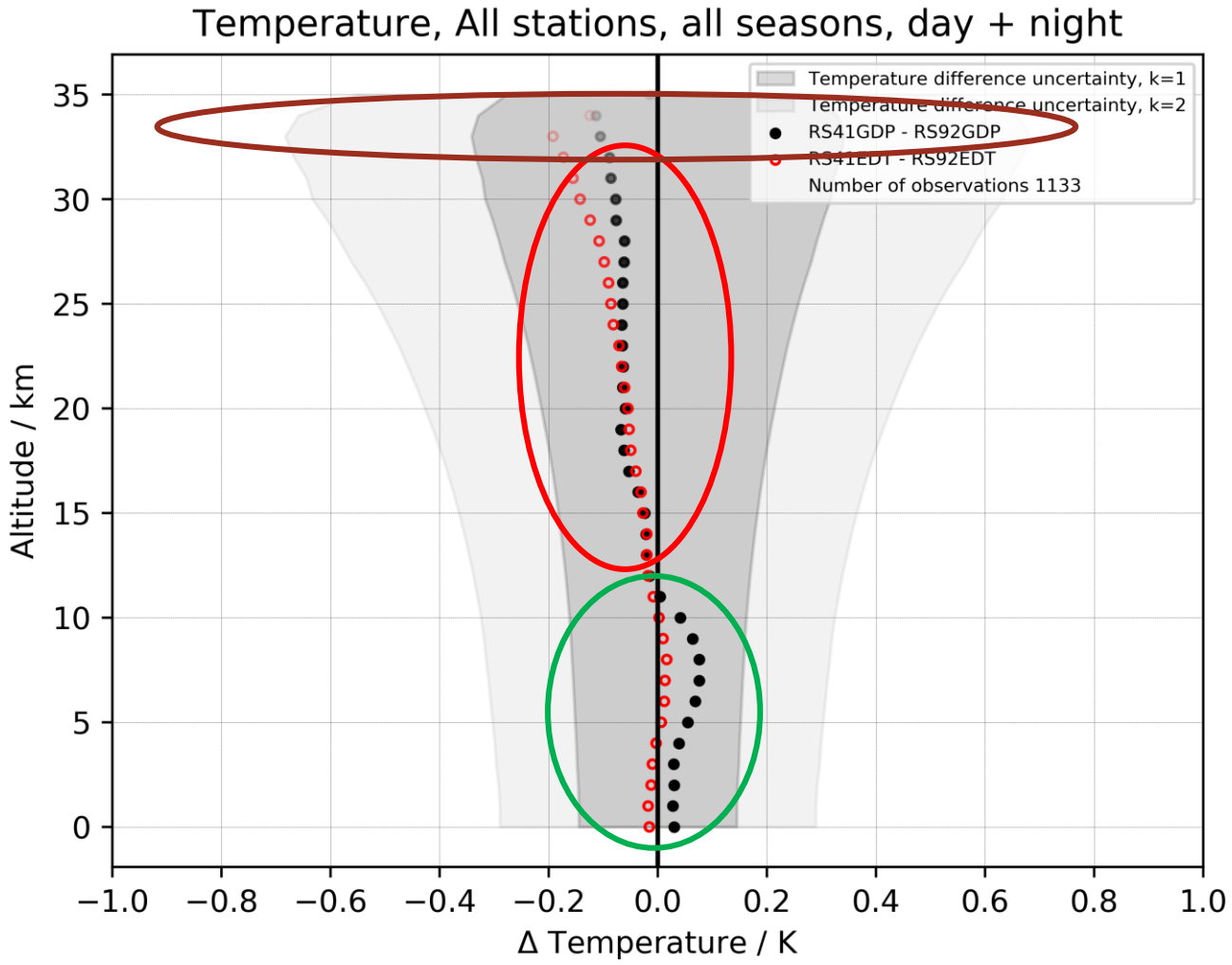
Red circles from Vaisala comparison

Always RS41-RS92

Effects on temperature

Observed features in the comparison:

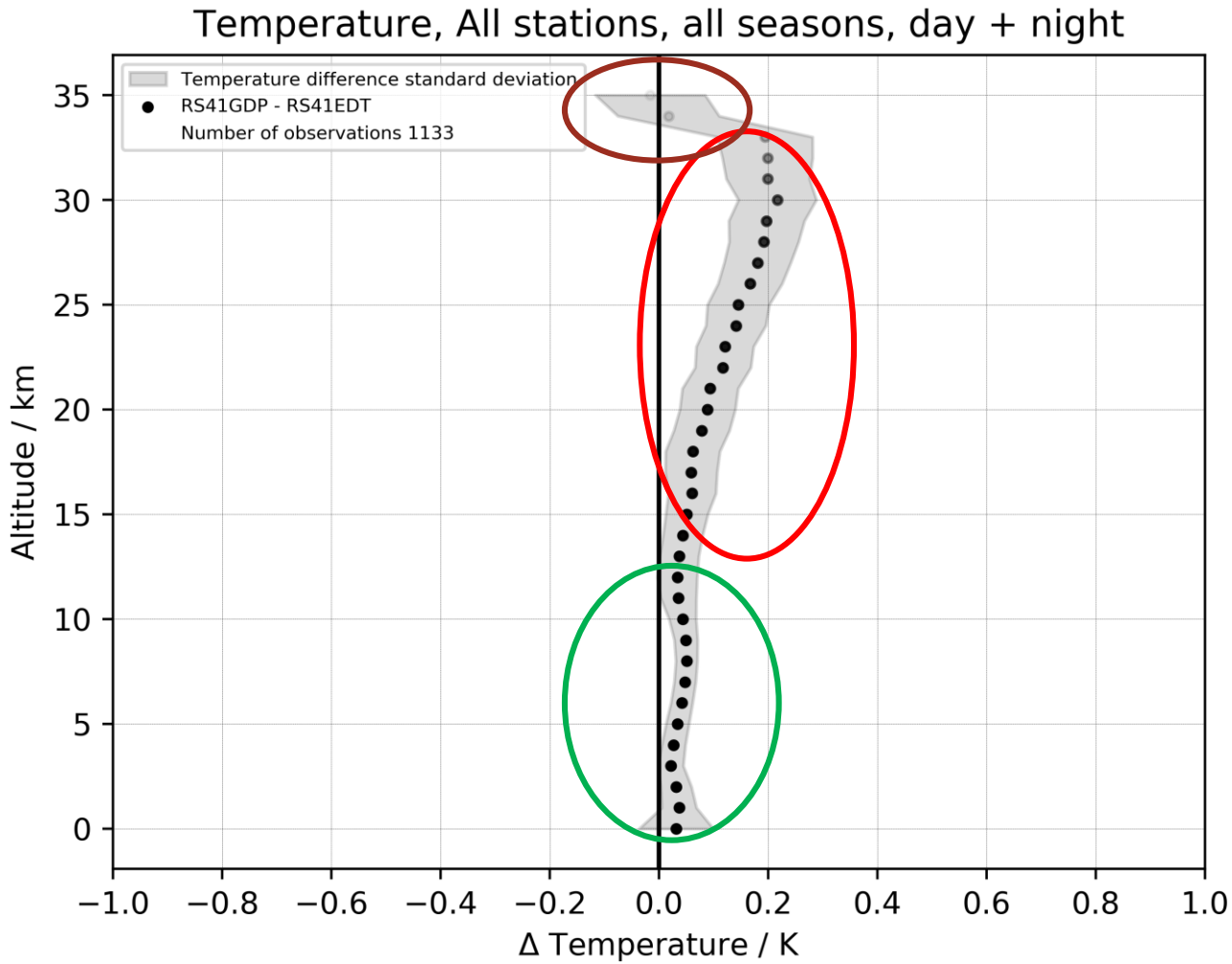
- Top of profiles – night flights reach higher altitudes more often, which decreases overall uncertainty
- Stratosphere – differences in radiation corrections across stations
- Troposphere – time lag difference between RS41 and RS92 temperature sensors



Effects on temperature in RS41

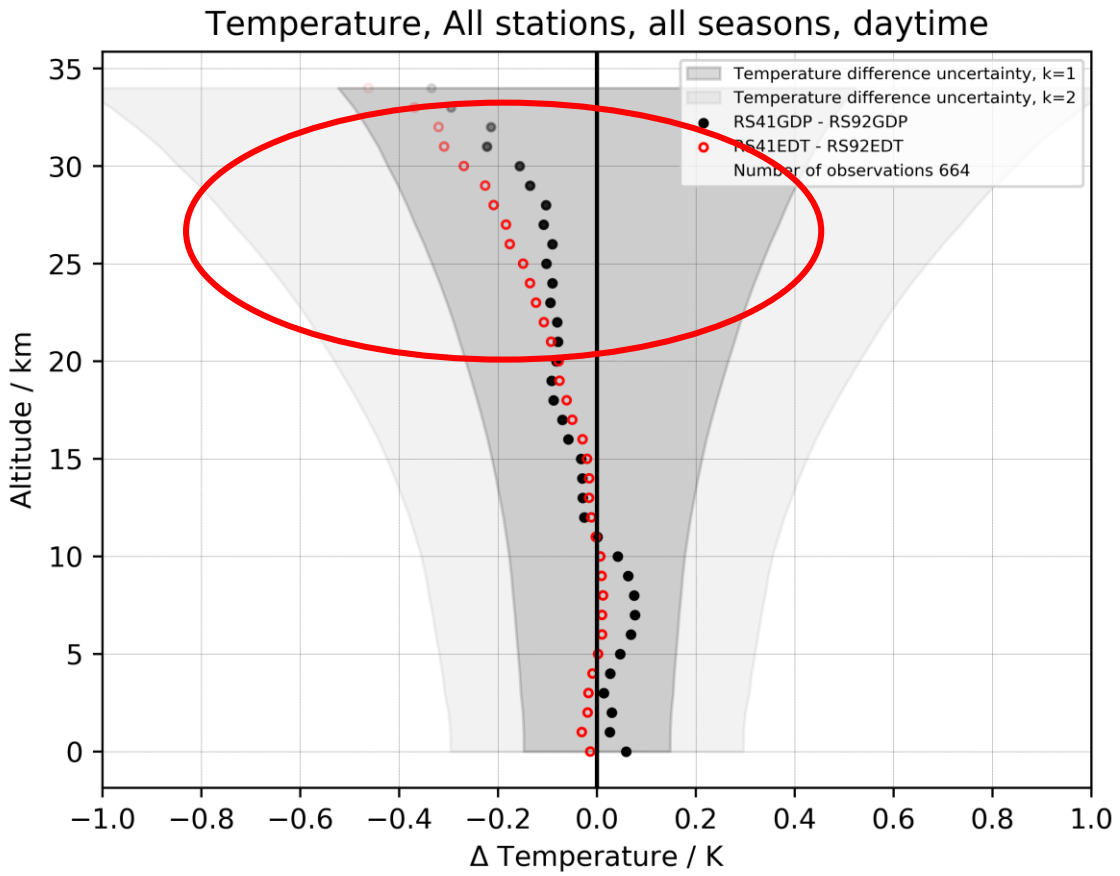
RS41 **GDP** vs Vaisala **EDT** product comparison:

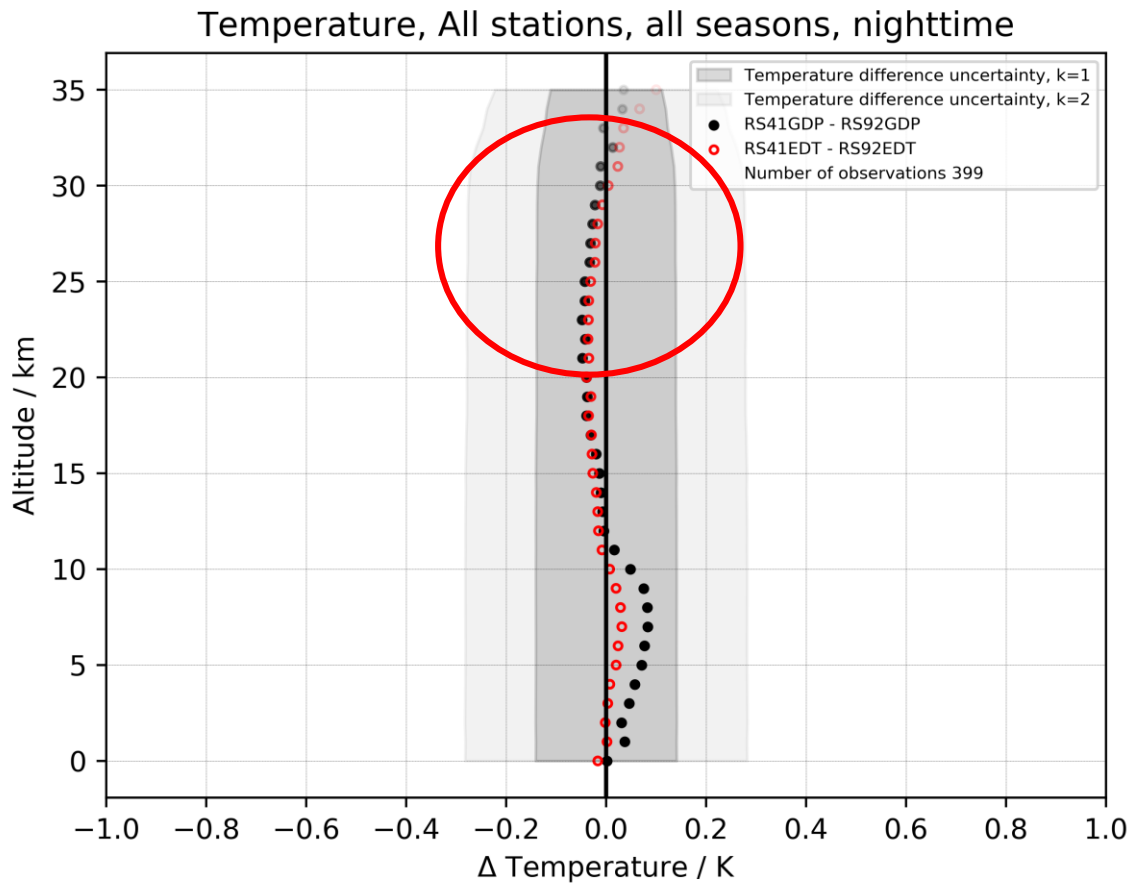
- Top of profiles – night flights without radiation correction
- Stratosphere – smaller GDP radiation correction, based on laboratory measurements
- Troposphere – time lag correction in the GDP dataset dependent on pressure, ventilation and thermal conditions



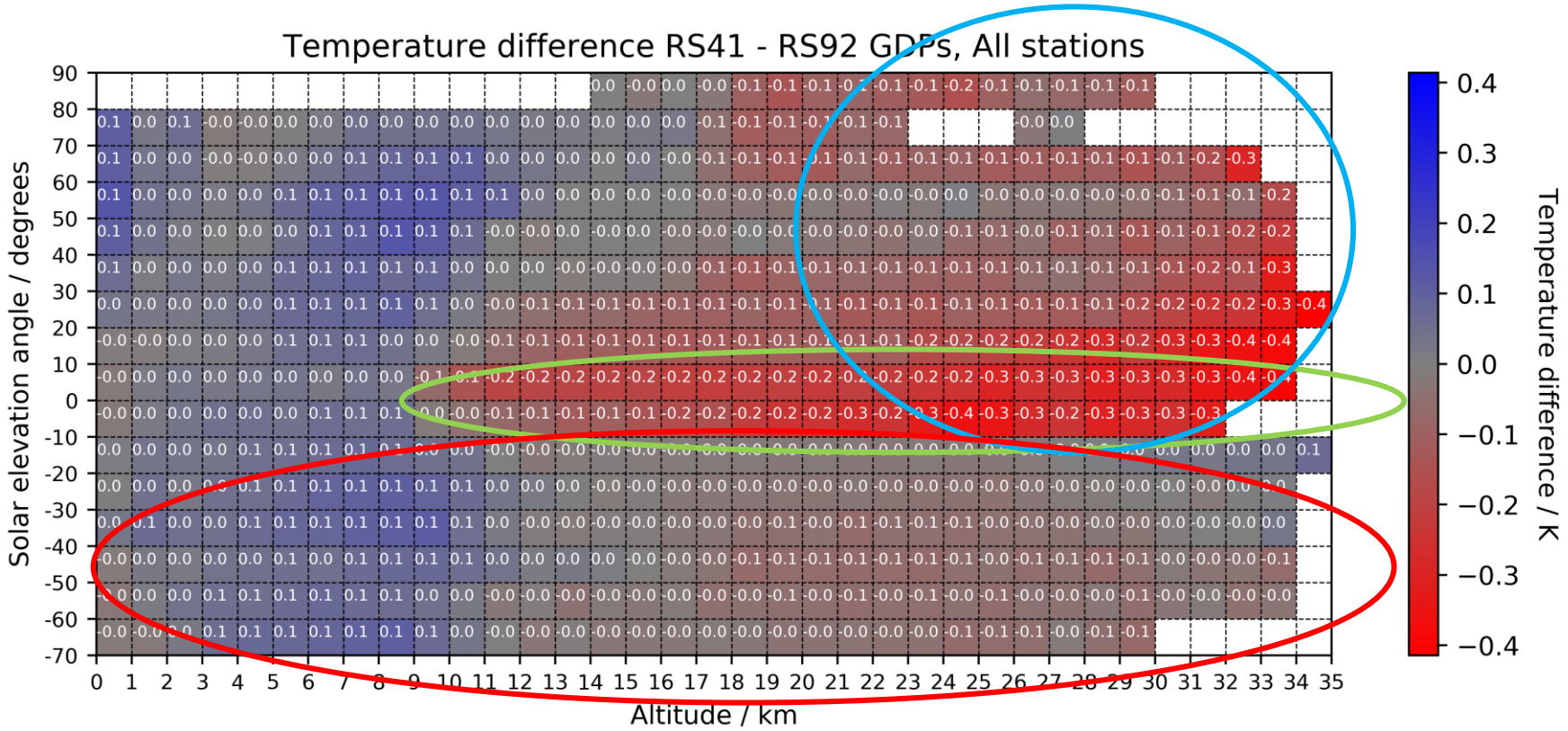
Radiation influence on temperature

- Larger radiation effect in both RS92 products, compared to the RS41 data



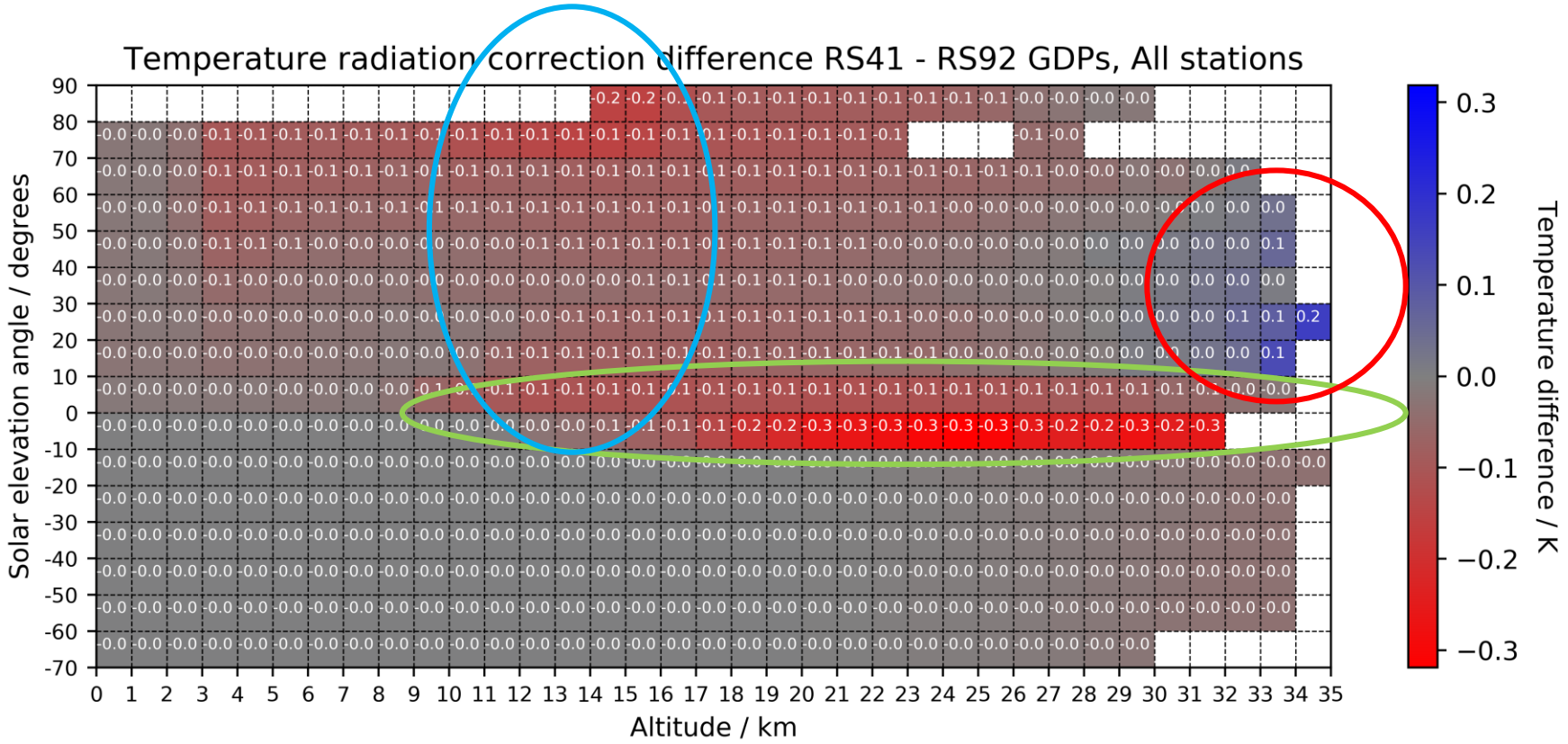


Radiation effect on temperature – GDP's



- RS92 temperature in stratosphere higher
- Largest difference close to sun at horizon
- No radiation influence during night

Temperature radiation corrections*



- Largest difference around tropopause
- RS41 temperature correction higher at high altitudes
- No radiation correction for ground night in RS92

Temperature processing differences

RS92GDP:

- Sensitivity estimated from experiments in radiation chamber at various ***p*** and ***v***
- Solar radiation from RTM, based on **solar elevation**
- Use of a look-up table with pre-computed (simulated) cases -- but only a few different cases

RS41GDP:

- Sensitivity of T-sensor to solar radiation measured with SISTER as function of ***p,v***, the combination of ***boom angle*** and **solar elevation**, and as averaged effect over a **rotating sonde**
- Solar radiation from RTM
- online simulation of each flight case (up to 100 simulations per flight because change of time and solar angles)

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Atmospheric Measurement Techniques Discussions

Laboratory characterisation of the radiation temperature error of radiosondes and its application to the GRUAN data processing for the Vaisala RS41

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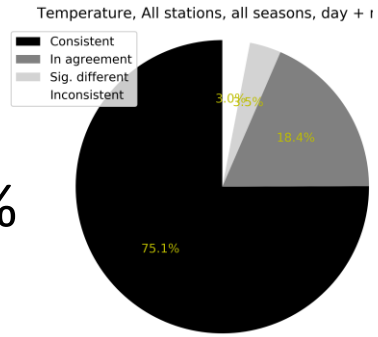
Abstract.

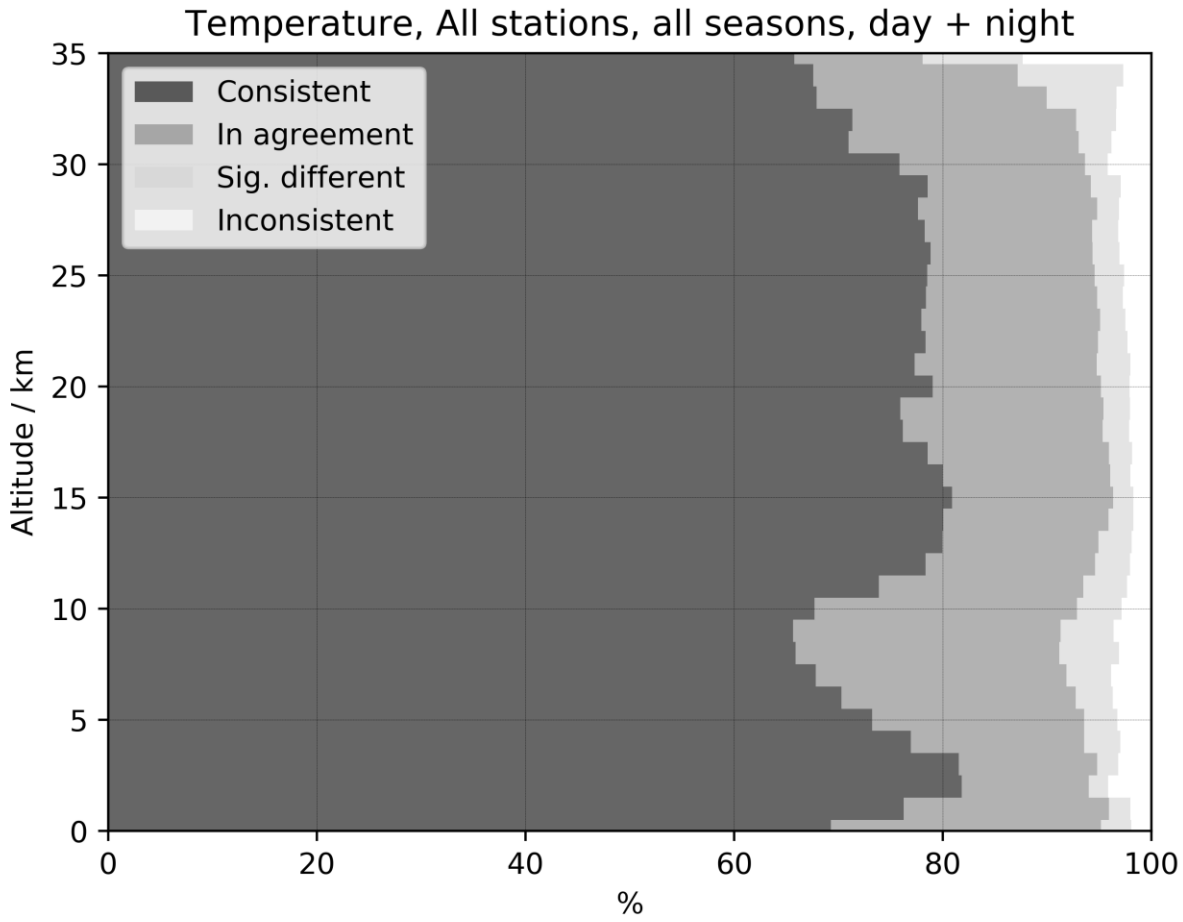
The paper presents the Simulator for Investigation of Solar Temperature Error of Radiosondes (SISTER), a setup that was developed to quantify the solar heating of the temperature sensor of radiosondes under laboratory conditions by recreating as closely as possible the atmospheric and illumination conditions that are encountered during a daytime radiosounding ascent. SISTER controls the pressure (3 hPa to 1020 hPa) and ventilation speed of the air inside the windtunnel-like setup to simulate the conditions between the surface and 35 km altitude, to determine the dependence of the radiation temperature error on the irradiance and the convective cooling. The radiosonde is mounted inside a quartz tube, while the complete sensor boom is illuminated by an external light source to include the conductive heat transfer between sensor and boom. A special feature of SISTER is that the radiosonde is rotated around its axis to imitate the spinning of the radiosonde in flight. The characterisation of the radiation temperature error is performed for various pressures, ventilation speeds and illumination angles, yielding a 2D-parameterisation of the radiation error for each illumination angle, with an uncertainty smaller than 0.2 K ($k = 2$) for typical ascend speeds. This parameterisation is applied in the GRUAN processing for radiosonde data, which relies on the extensive characterisation of the sensor properties to produce a traceable reference data product which is free of manufacturer

Effects on temperature - consistency

Observed features in the comparison:

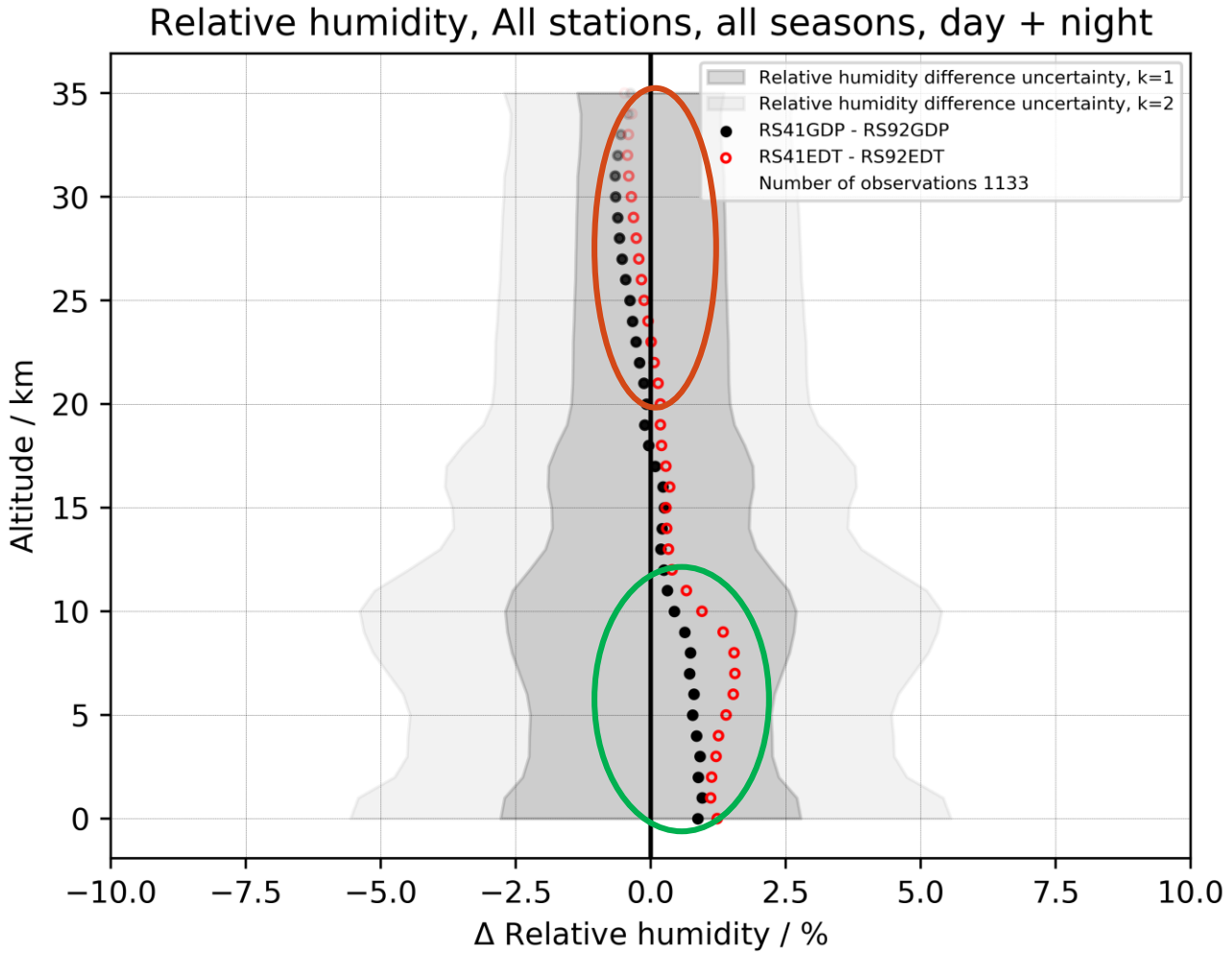
- 75.1% of the observed bins are consistent with uncertainties
- Daytime and local summer show higher consistencies at ~ 77%
- Lowest consistency observed in twilight conditions when Sun is at horizon ~ 64%
- Arctic stations show lowest consistencies ~ 67%



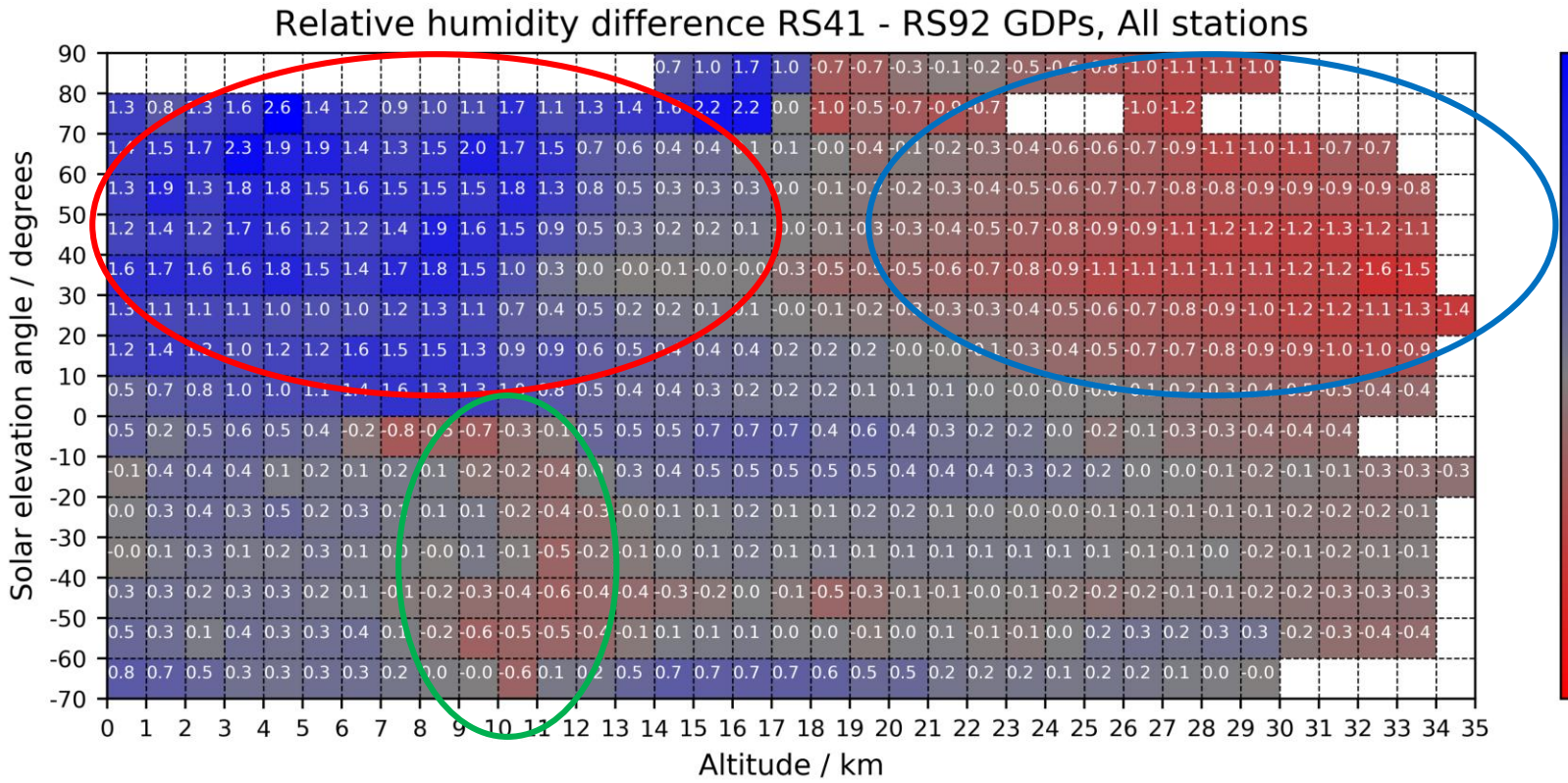


Relative humidity comparisons

- RS92 – two heated, independent thin-film polymer capacitors with solar radiation correction
- RS41 – single heated polymer capacitor, no solar radiation correction
- Stratosphere – observed residual humidity values
- Troposphere – time lag of the RH sensors



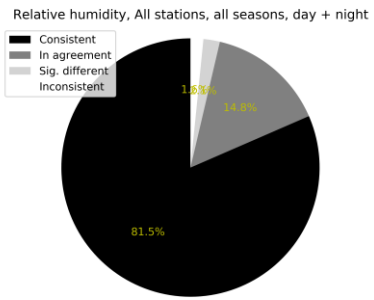
Relative humidity radiation

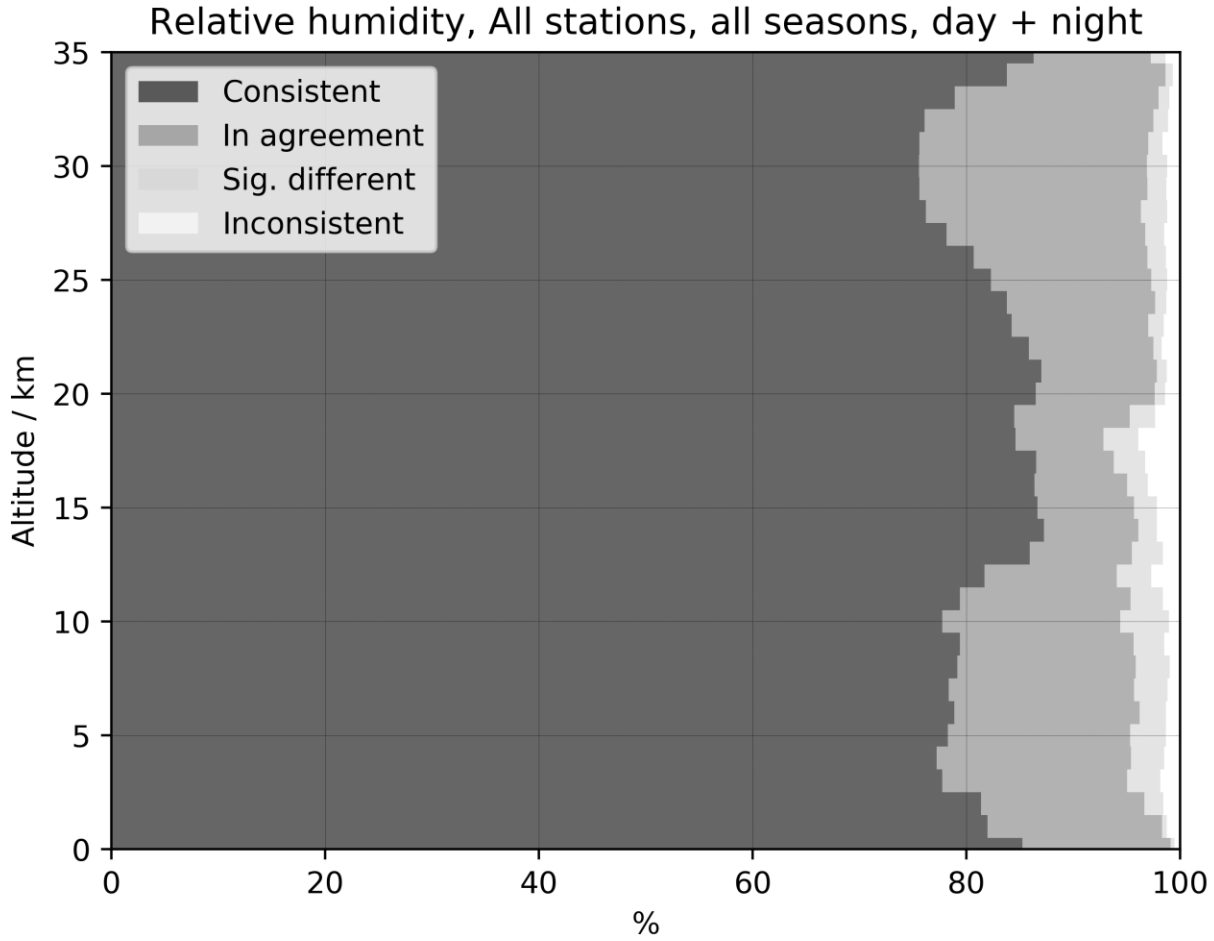


- RS41 wet bias in Troposphere during day-time
- RS92 wet bias in Stratosphere during day-time
- Small RS92 wet bias below Tropopause during night

Relative humidity consistency

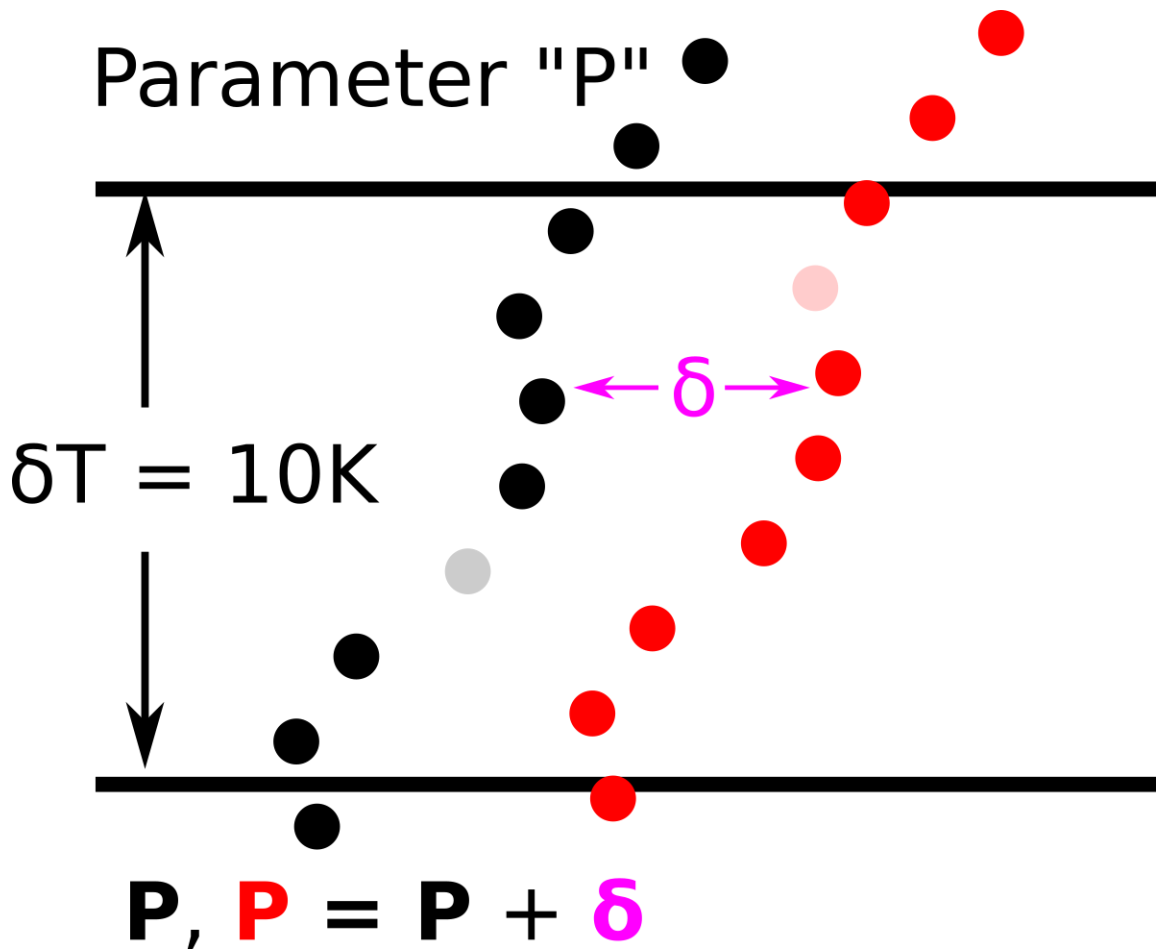
- 81.5% of observations consistent with uncertainties
- Highest consistencies in night-time at 88%
- Lowest consistencies in Arctic and Tropical stations between 71-78%
- Higher consistency in Summer, compared to Winter



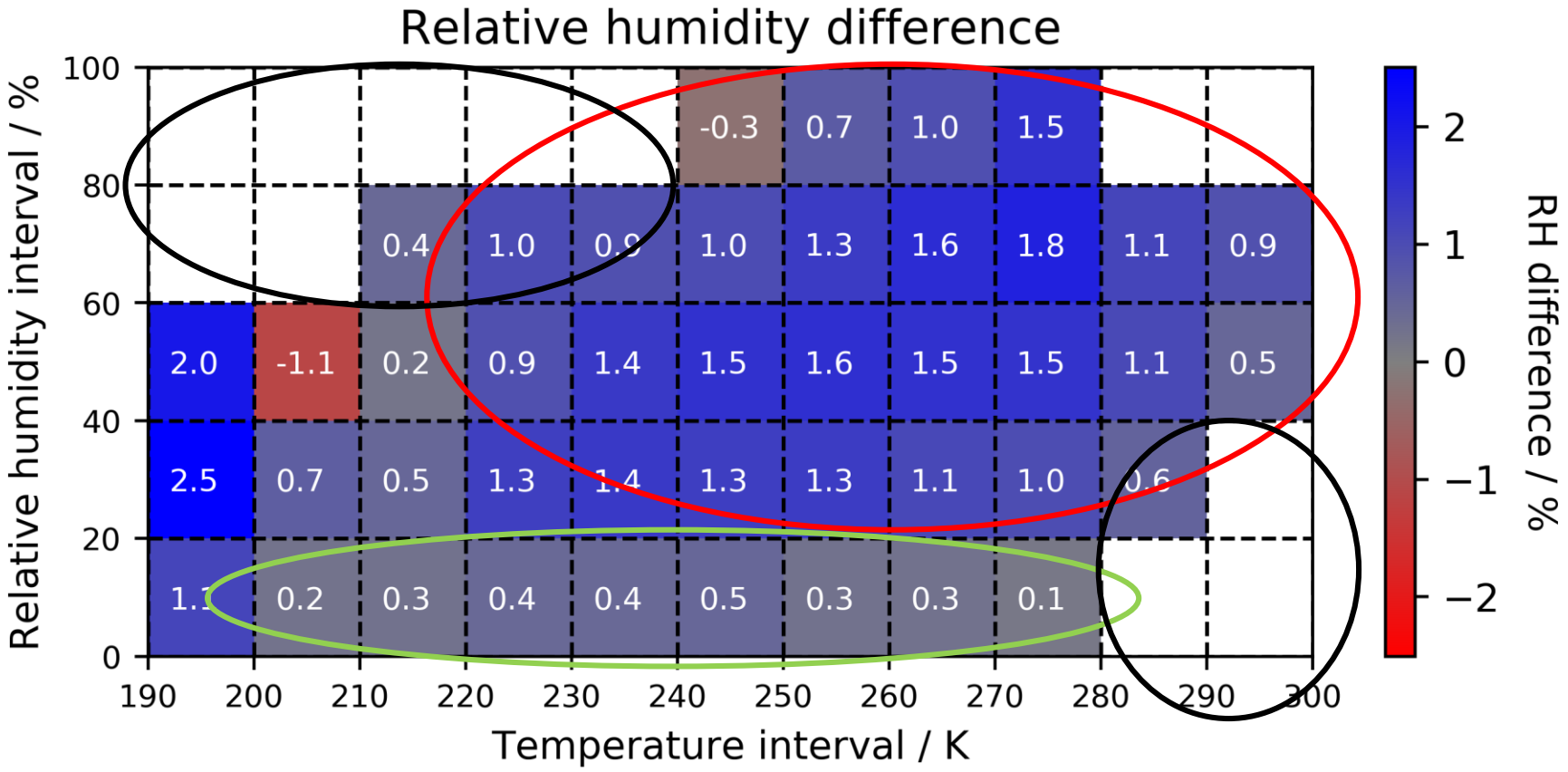


Temperature binning

- Each **Troposphere** profile divided into layers 10K thick, based on RS41GDP
- Values averaged in each layer for base profile
- Values for all profiles calculated from mean difference to base
- Values for all profiles for each station averaged for each layer
- Estimated uncertainties from GDP's

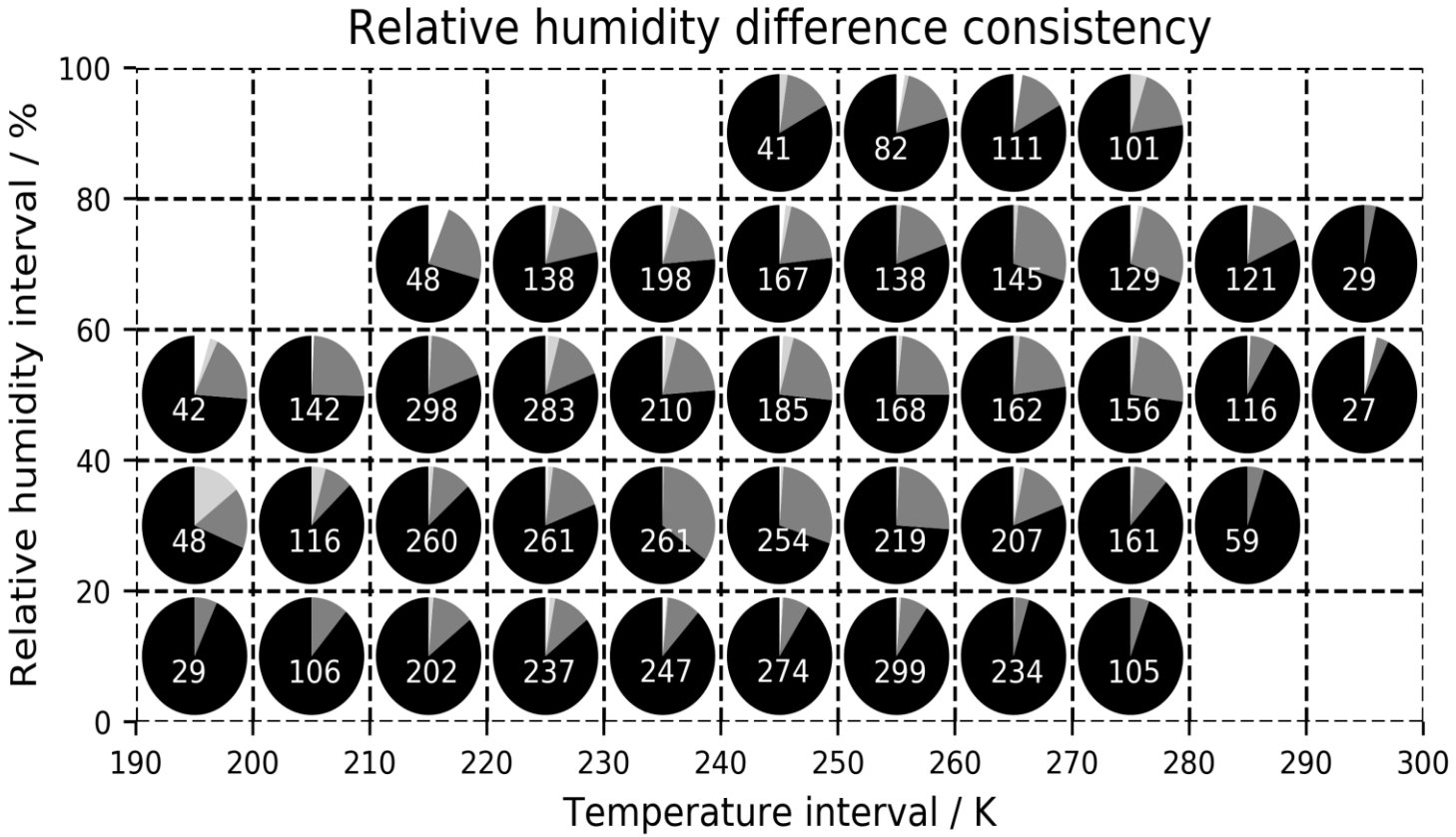


Temperature binning biases RS41-RS92



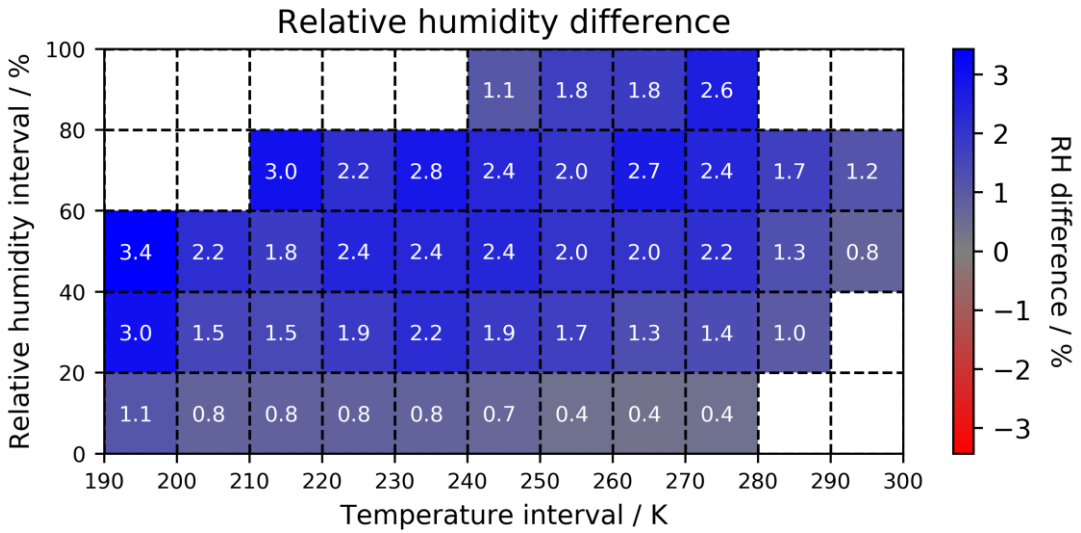
- RS41GDP wet bias above 220K and 20%
- Low difference in RH below 20%
- Few observations at extreme RH

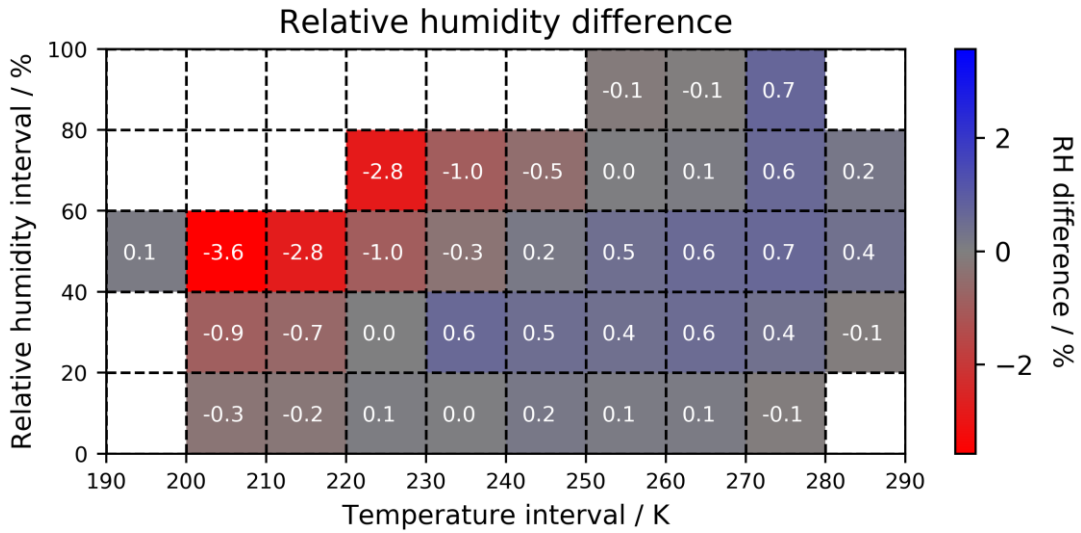
Temperature binning - consistency



- RS41GDP wet bias above 220K and 20%
- Low difference in RH below 20%
- Few observations at extreme RH

Biases RS41-RS92 day/night



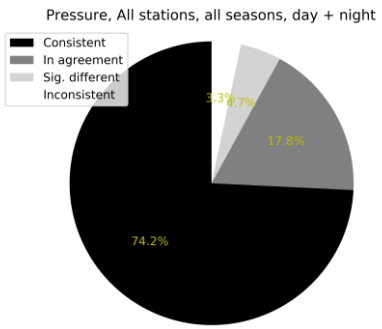


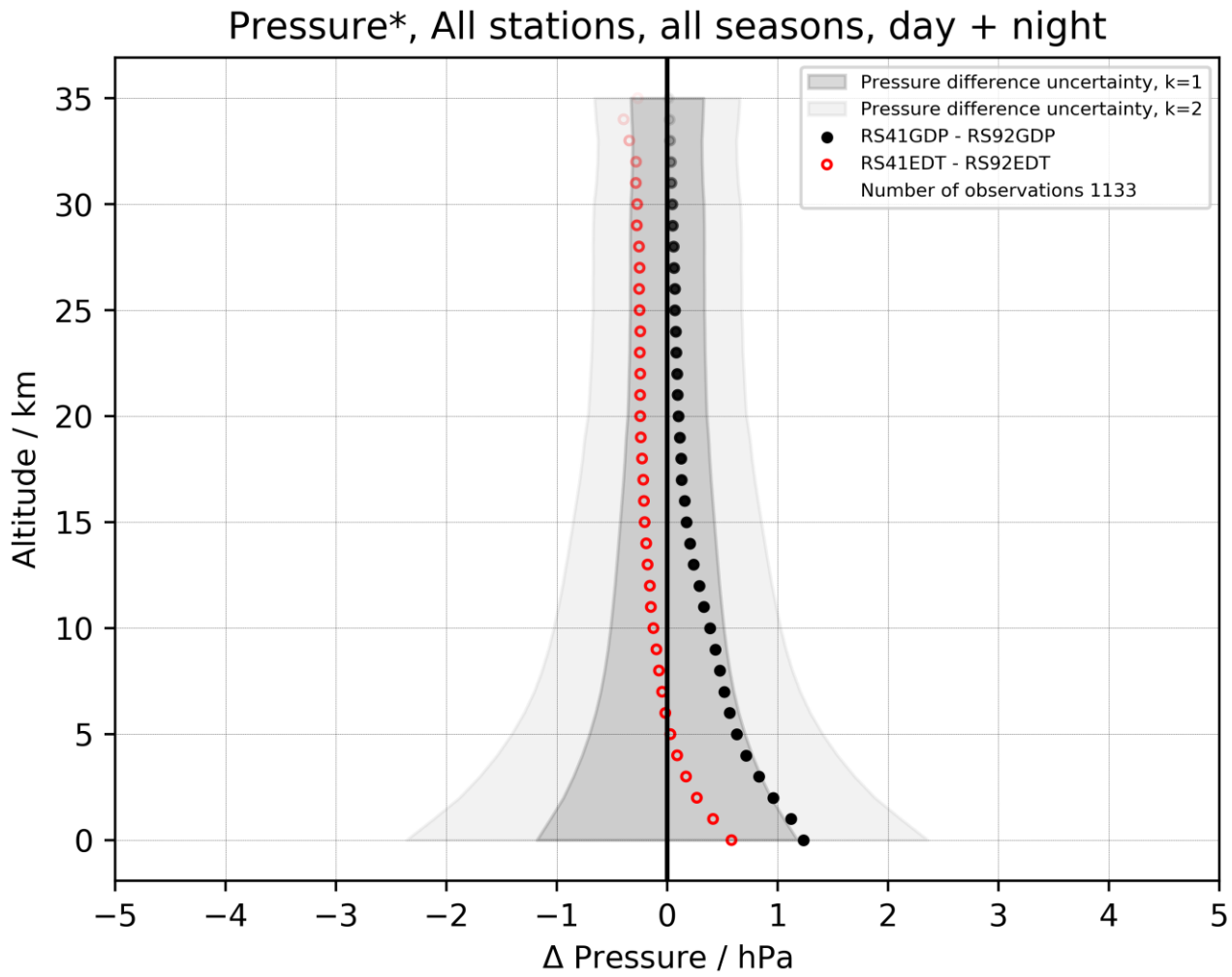
- Day-time
- RS41GDP higher RH in all pixels

- Night-time
- RS92GDP higher at low temperatures

Altitude and Pressure differences

- RS41 pressure from GPS only
- RS92 pressure combined from GPS and pressure sensor
- RS41GDP data uses independent pressure sensor during ground check
- RS41 higher pressure from altitude differences
- 74.2% consistent, agreement

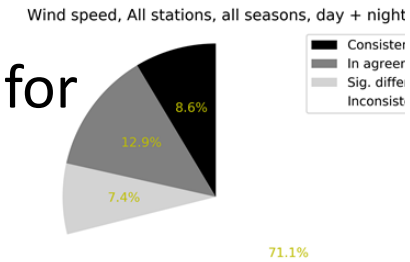


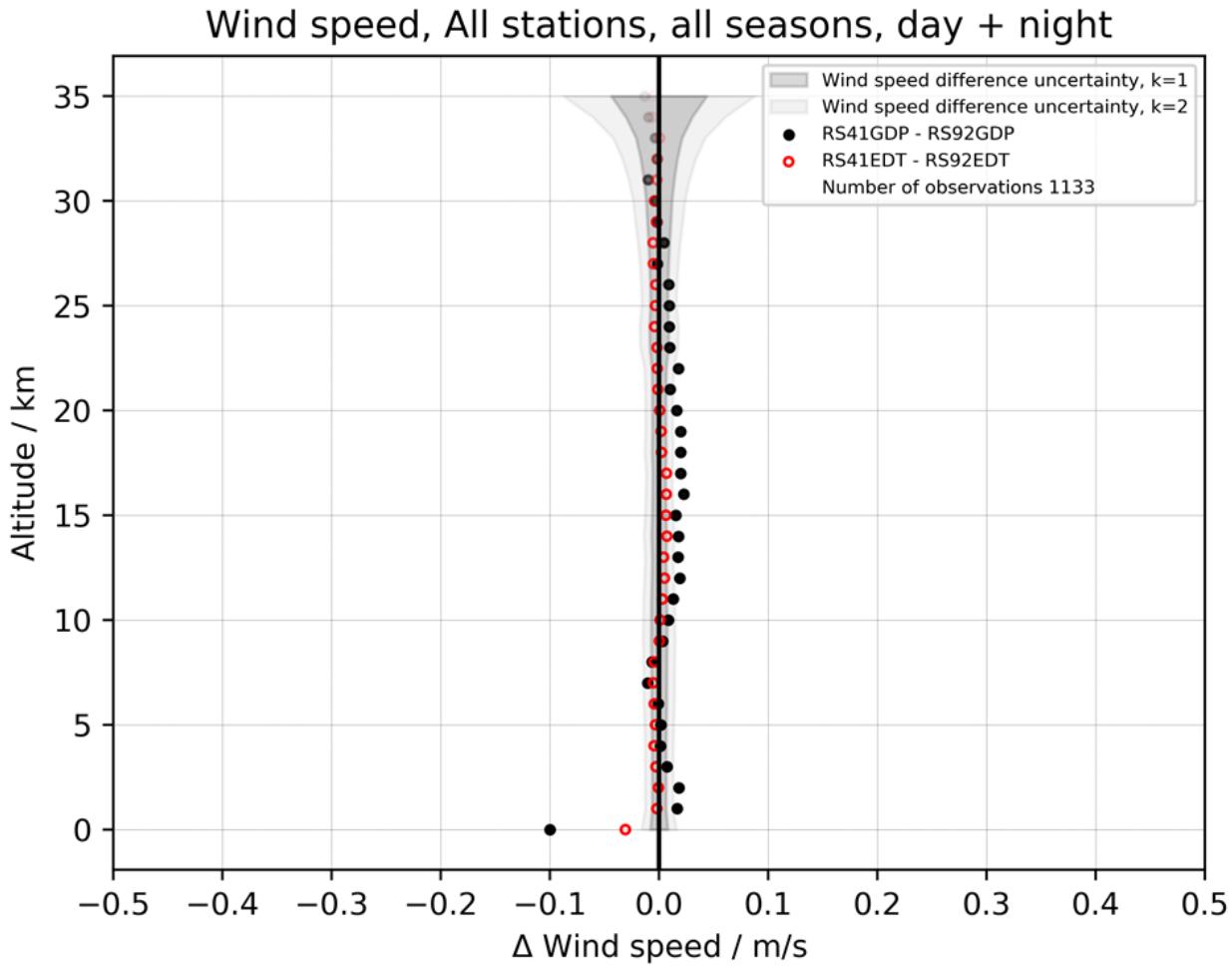


Wind speed comparisons

Observed features in the comparison:

- Small uncertainties, since all uncertainties are uncorrelated
- Both EDT wind speed calculated from Doppler GPS observations
- Both GDP wind speed calculated from differences between absolute positions
- Small differences in results for all sites and all seasons
- Below 10% consistency

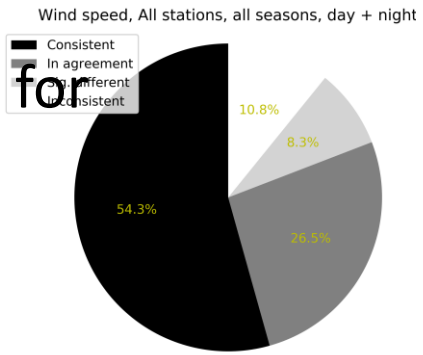


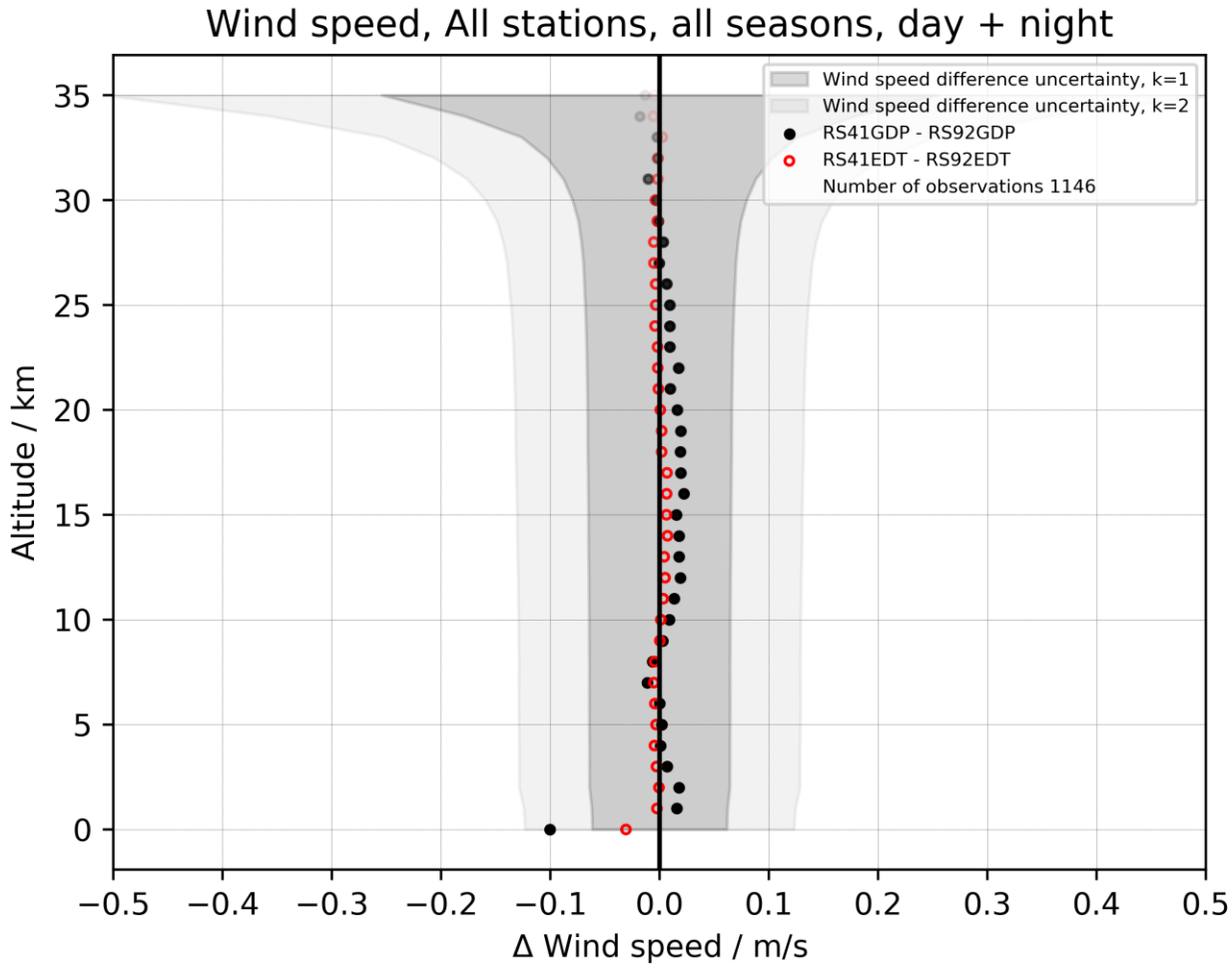


Wind speed*** comparisons

Observed features in the comparison:

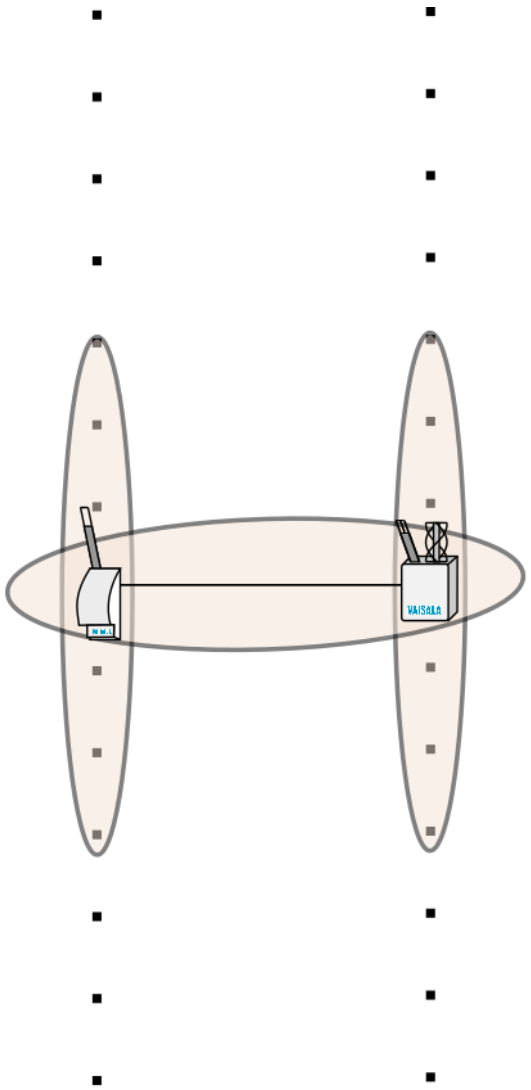
- Small uncertainties, since all uncertainties are uncorrelated***
- Both EDT wind speed calculated from Doppler GPS observations
- Both GDP wind speed calculated from differences between absolute positions
- Small differences in results for all sites and all seasons
- Below 60% consistency





Wind speed uc components

RS41GDP:
wspeed_uc_ucor_sm
wspeed_uc_ucor_gnss

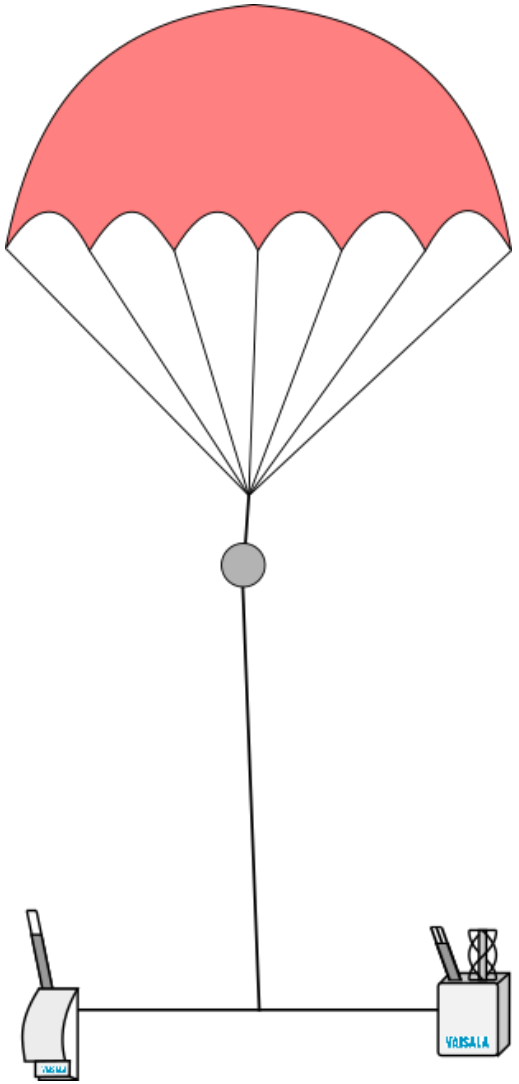


RS92GDP v2:
u_wspeed (smoothing)
RS92GDP v3:
wspeed_uc_ucor_sm
wspeed_uc_ucor_gnss

We need to store all individual uncertainty components in the GDP's!!!

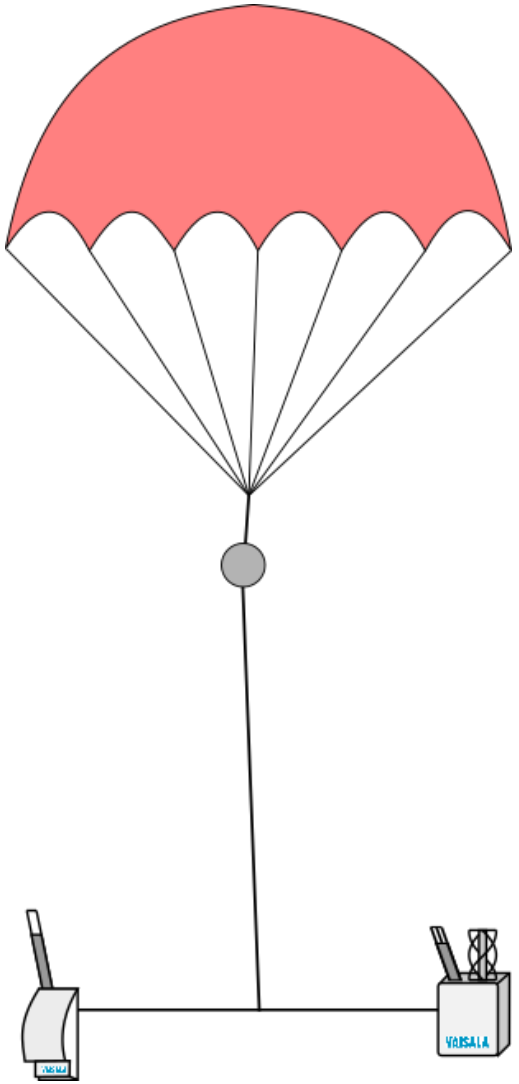
Conclusion

- **Biases** between individual RS41 and RS92 GDP profiles **are** appropriately **consistent** with the estimated uncertainties
- **Mean biases** between RS41 and RS92 GDP's are almost always **within k=1** uncertainties for all stations / seasons / climates



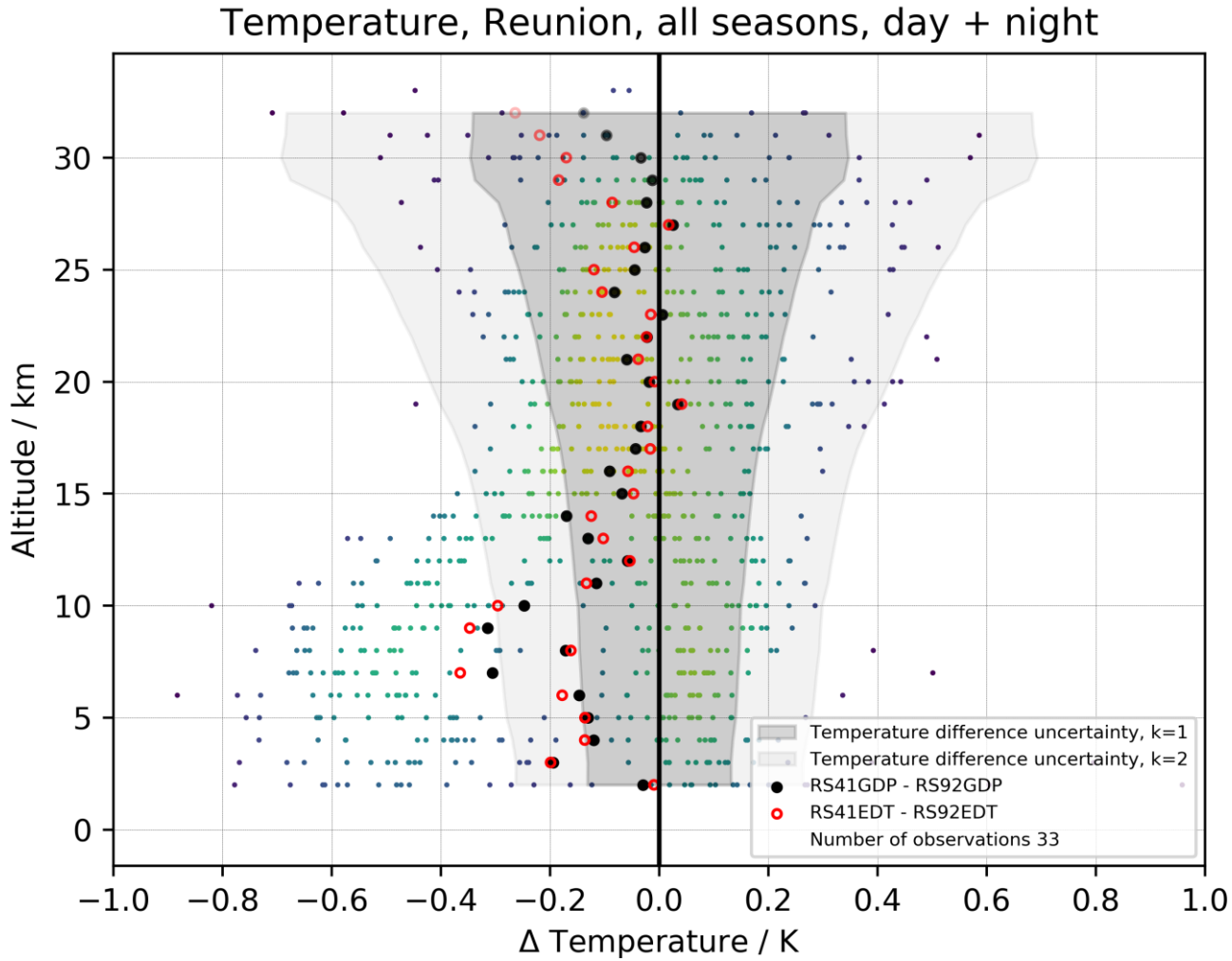
Summary and outlook

- Temperature and relative humidity comparisons paper in final stage before submission
- Paper on pressure, coordinates and wind in preparation
- Results used for the preparation of the next iterations of RS41 and RS92 GDP's

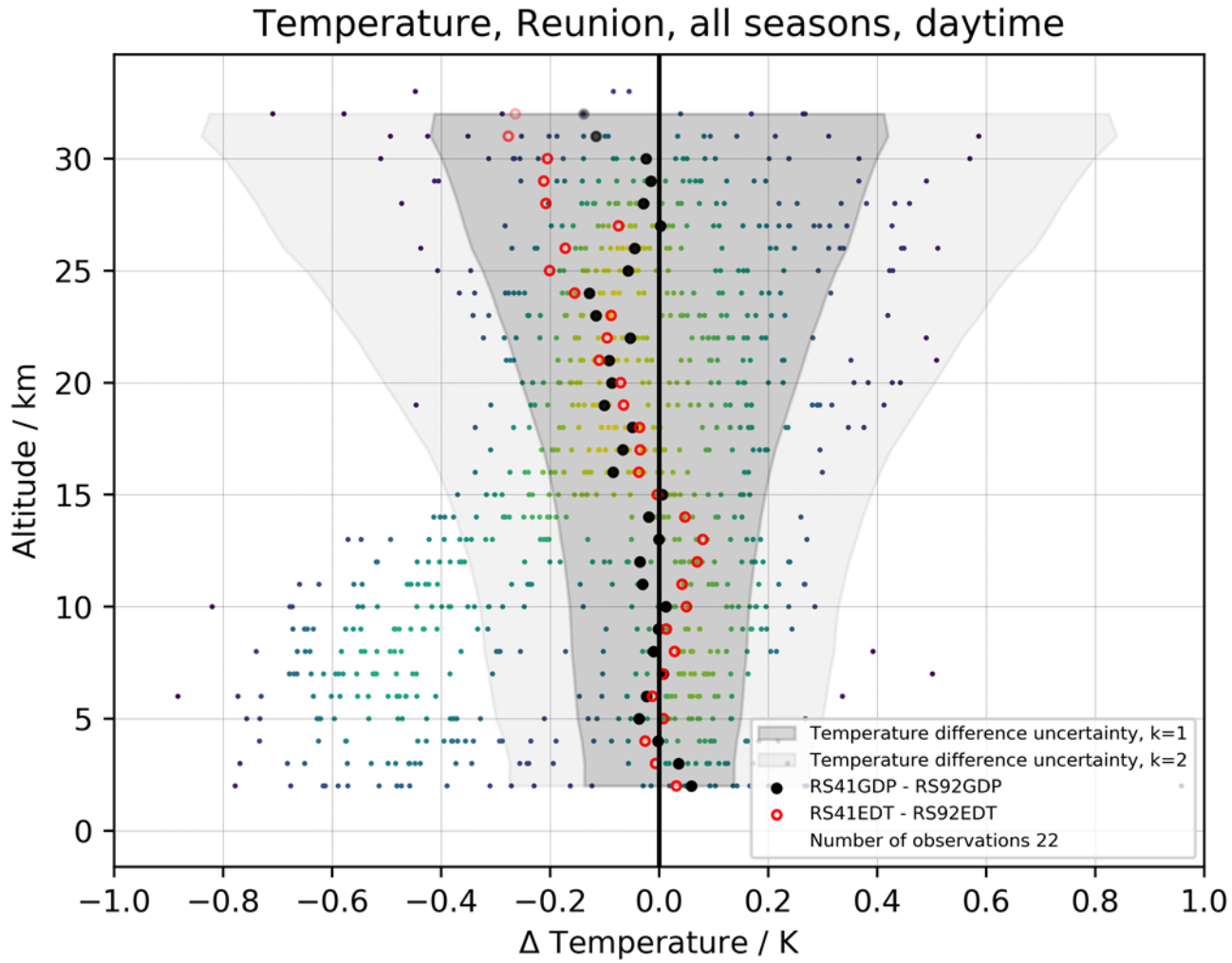



00:09:01:11
Thank you for your attention !

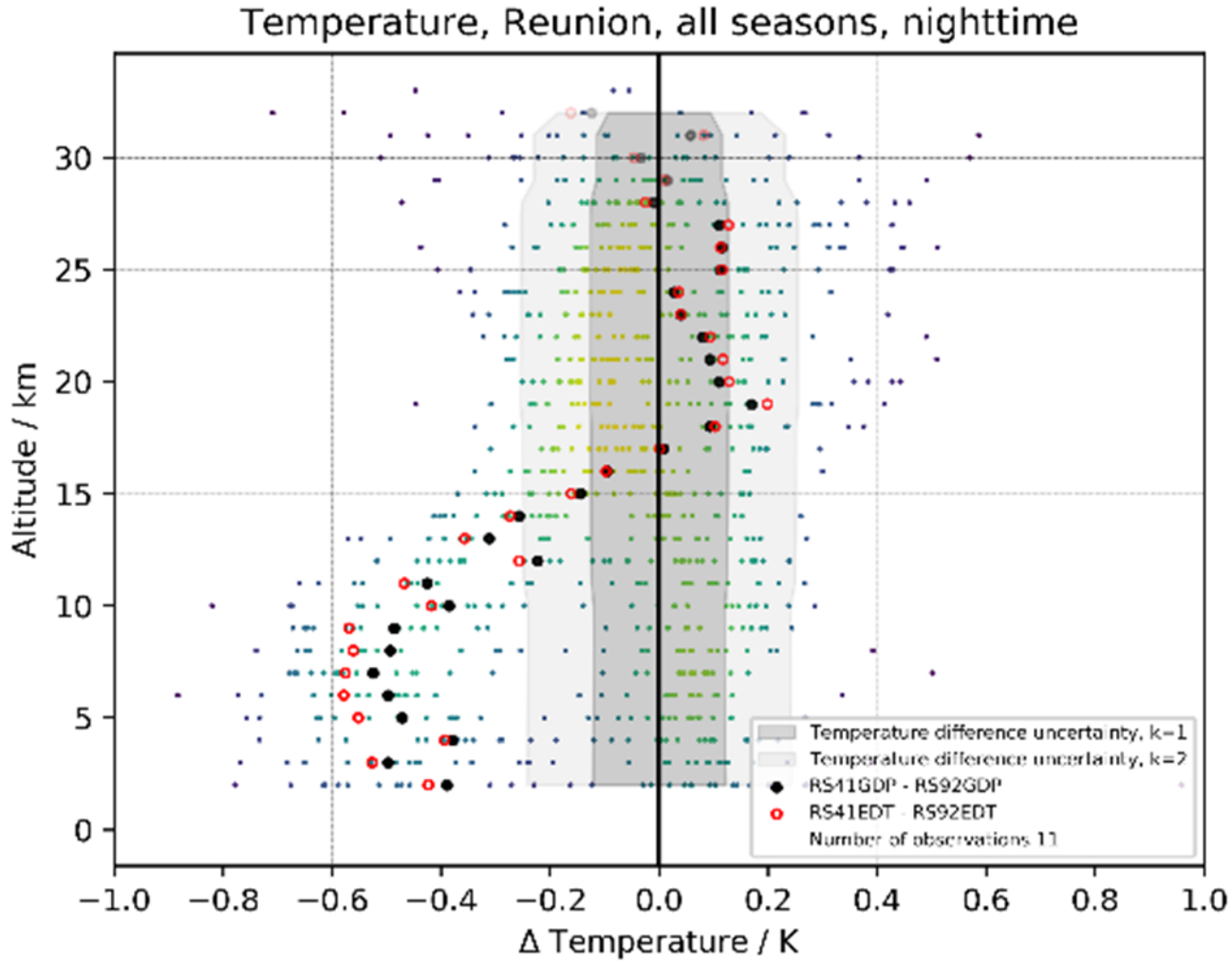
Reunion Temperature



Reunion Temperature



Reunion Temperature



Altitude profile, date 20201005, time 08 UTC