Radiosonde Quality issues affecting climate and integration with remote sensing

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Upper Air development
Responsibilities- Met Office

- 3rd line support to resolving technical problems
- Developing and improving quality assurance techniques
- Testing the impact of changes in the radiosondes used in order to inform Met Office Users including the climate trends community.
- Investigate the use of alternative systems to reduce operational costs

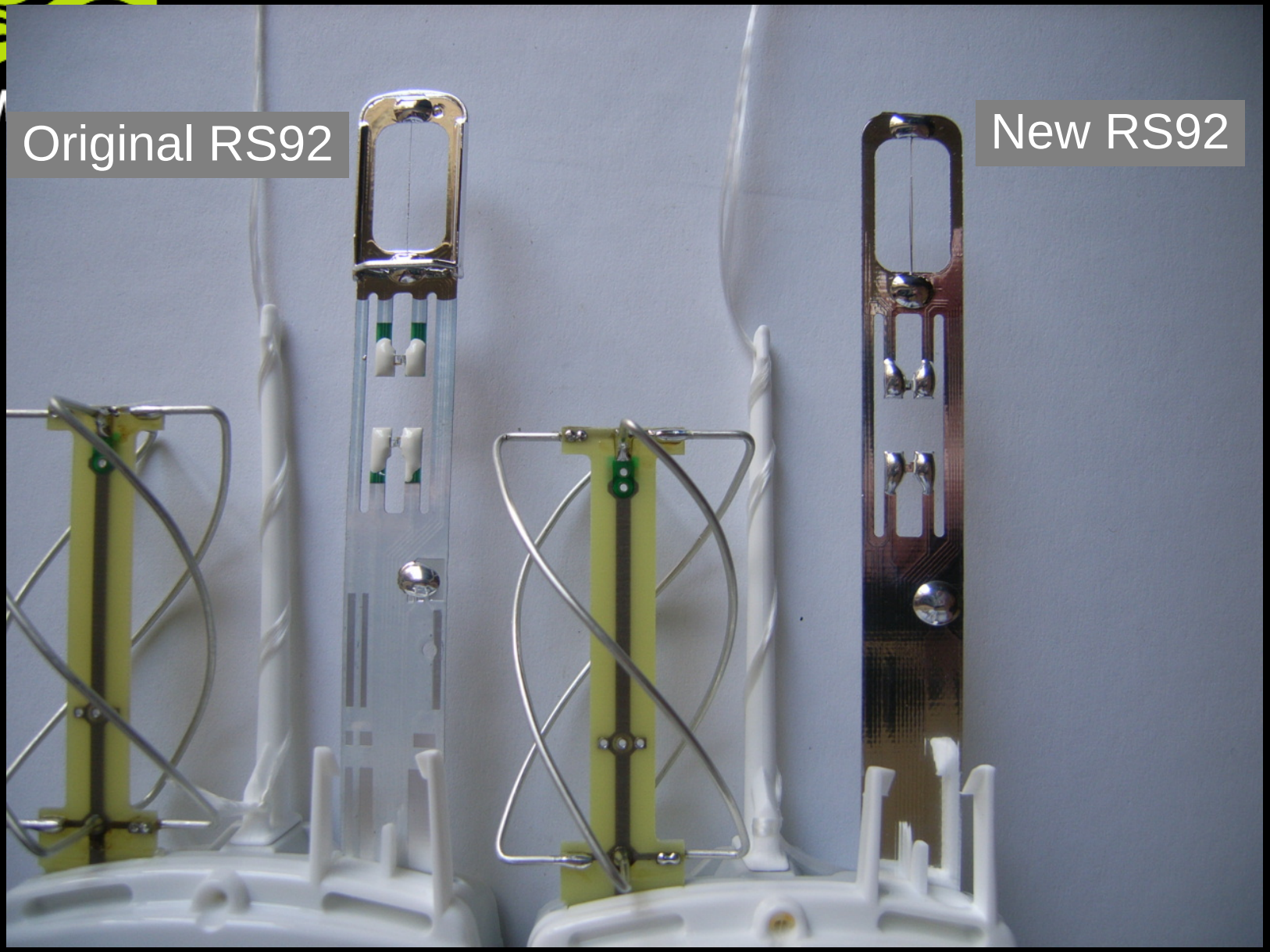
Upper Air development
Responsibilities- WMO

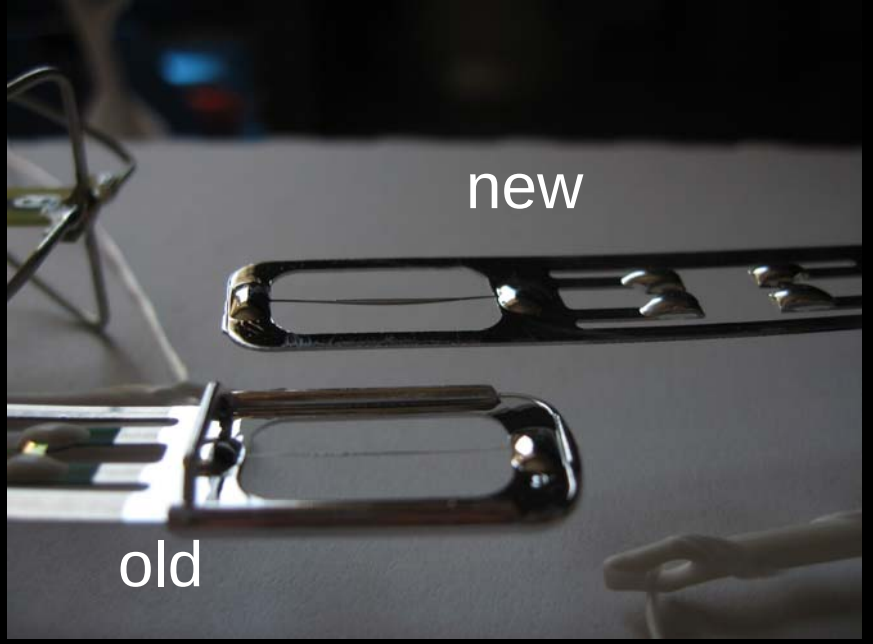
- Support resolution of technical problems on an international scale
- Developing and improving quality assurance techniques
- Supervision of testing the impact of changes in the radiosondes used globally.
- To collaborate in the development of the GCOS Reference Upper Air network
- Investigate the use of alternative systems to reduce operational costs
- Set the standards for operational measurements and ensure supporting documentation is accurate and understandable
- Provide training through International workshops as required by WMO members

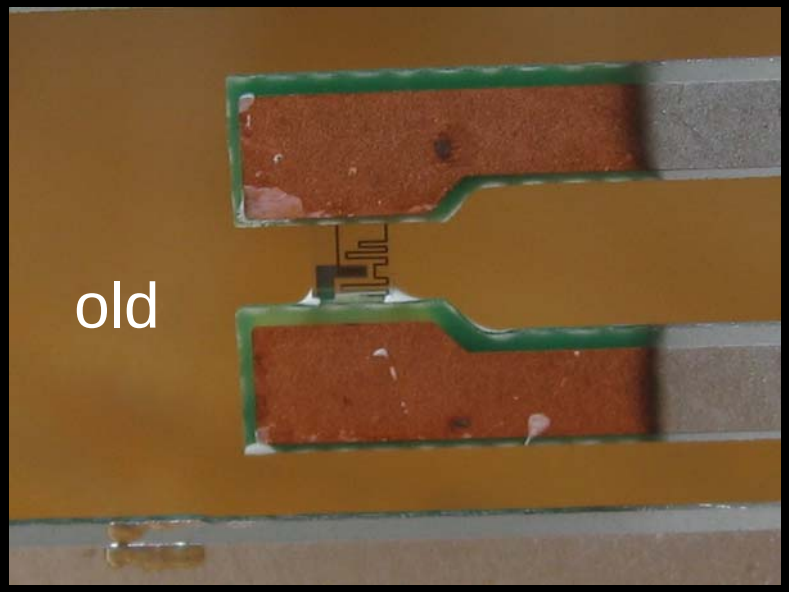
Testing of Latest developments in radiosondes

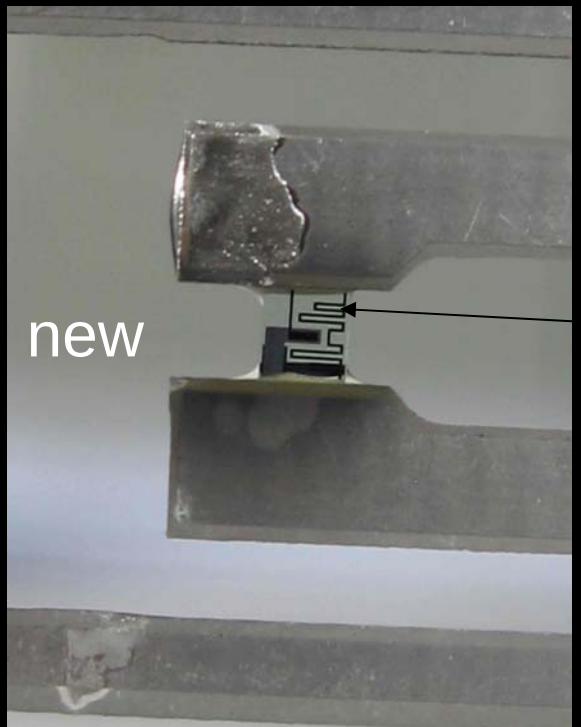
- New Sensors on Vaisala RS92
  - Thicker Temperature sensor
  - Thinner temp sensor housing
  - Humidity sensor aluminated

Change in VaisalaRS92 sensor design







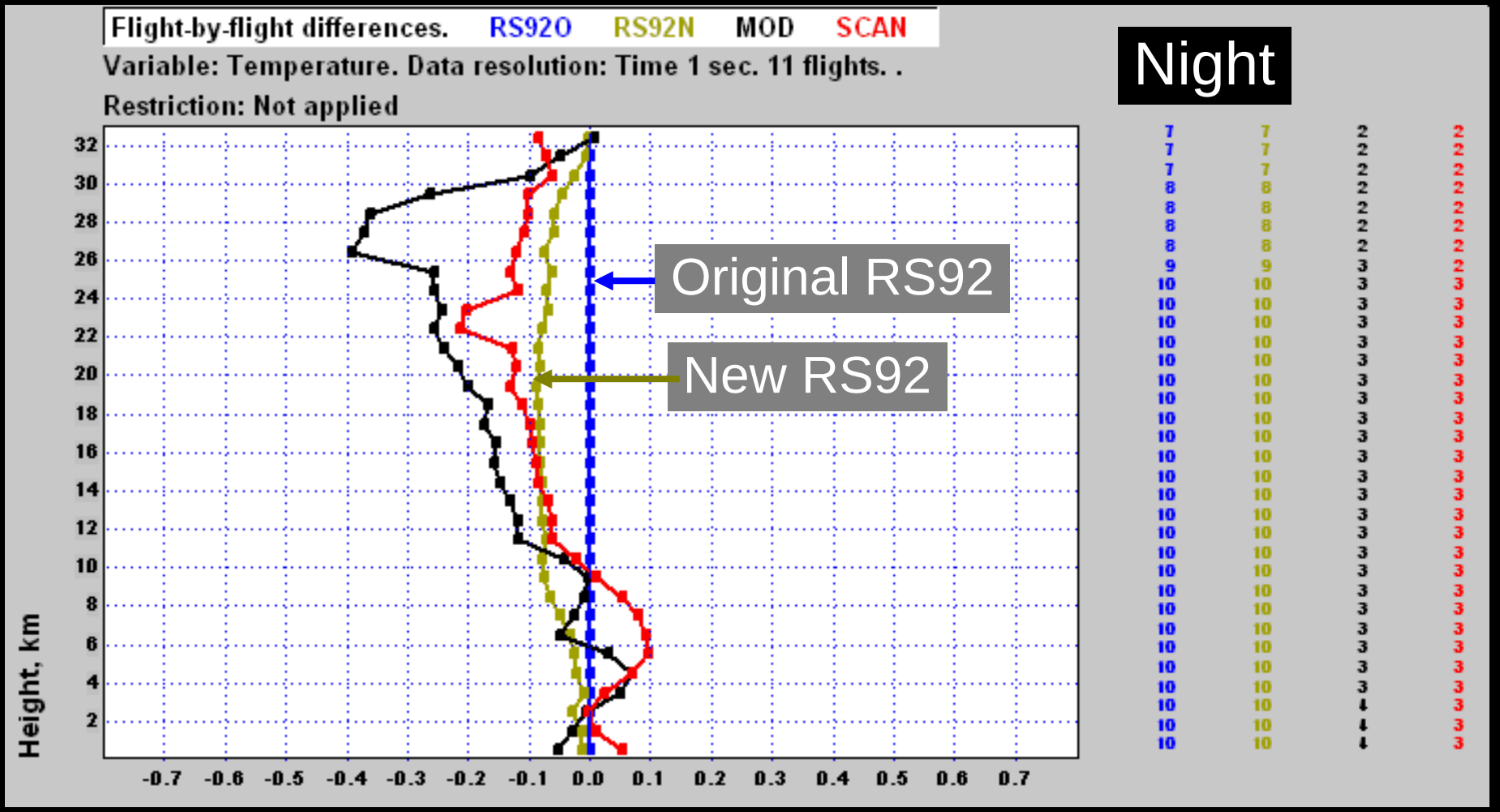


Results from radiosonde Intercomparison, Mauritius, 2005

- New and old radiosondes first compared at night
- This is to identify long term changes in batch performance, because in the short term temperature measurement reproducibility is good , about 0.1 K?

Night Temperature Bias Comparison

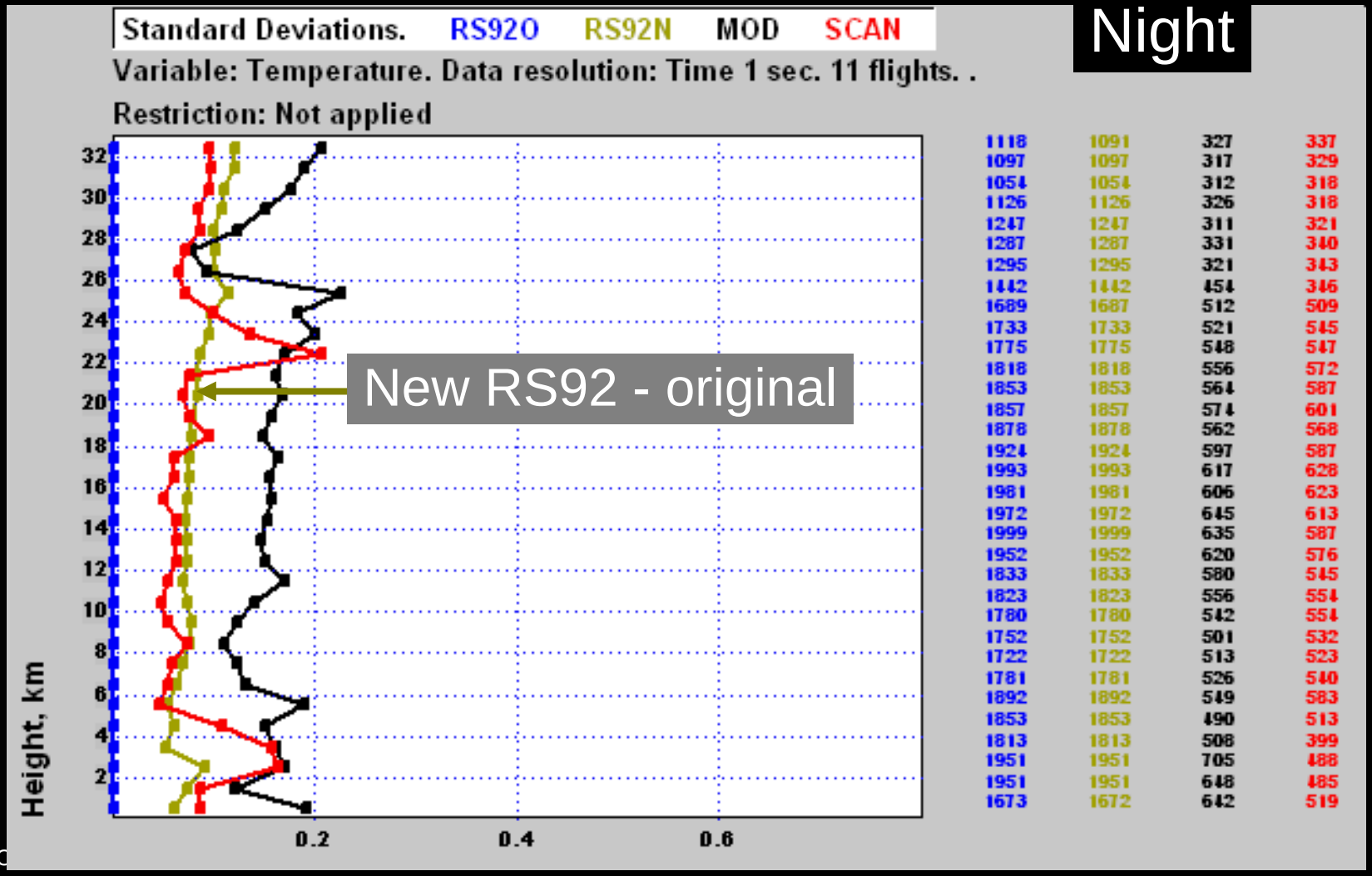
Modem and Sippican samples are low,
But show general agreement with Vaisala



Night Standard Deviation Comparison

Standard deviations of simultaneous samples relative to the original RS92 measurements

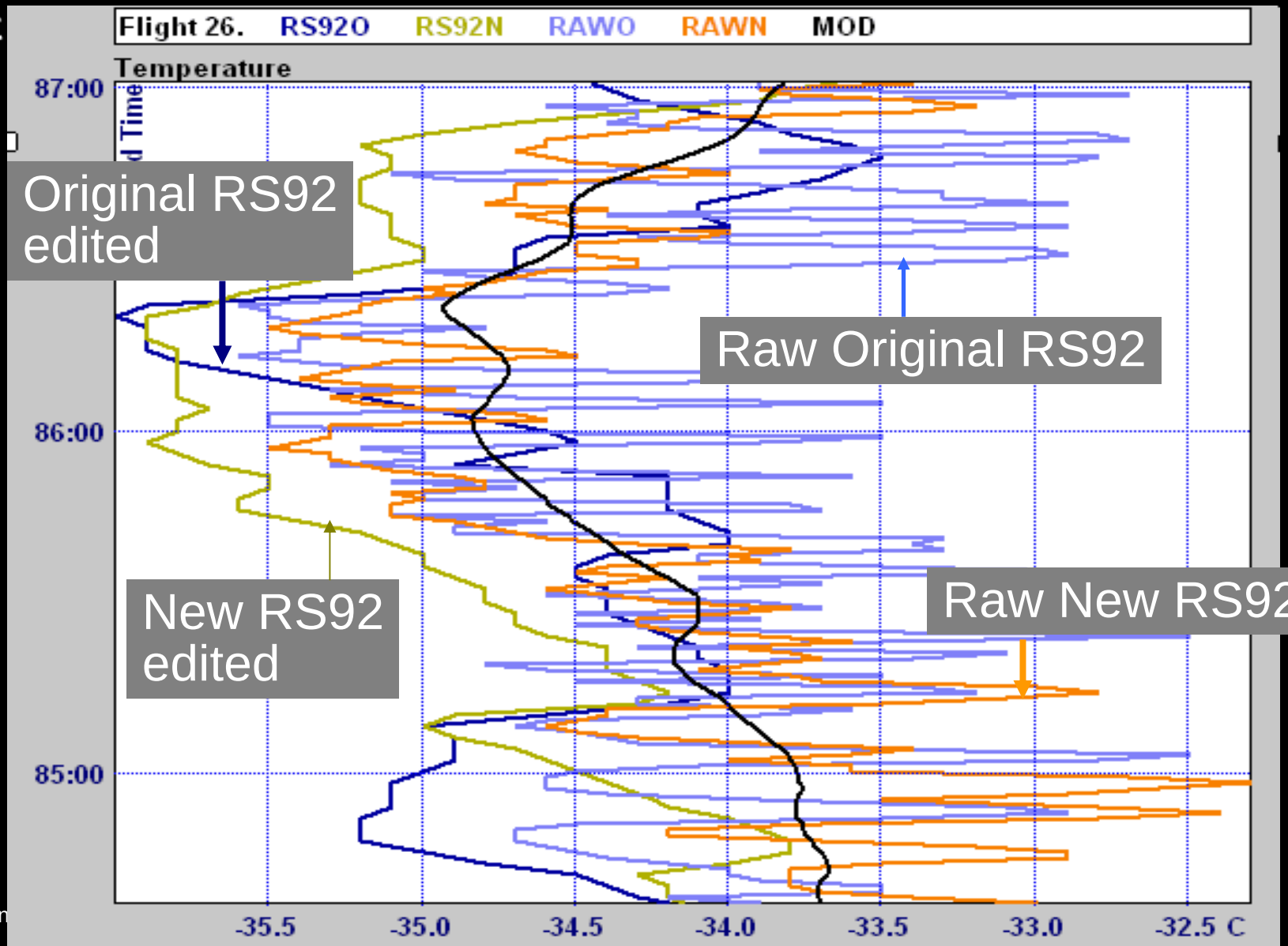
All temperature measurements have short term reproducibility of better than 0.2 K[1s.d.]



Effect of changing the Vaisala sensor mounts in daytime

- This is not straightforward since :-
- It should be expected that the enlarged sensor in the new version would have higher solar heating errors
- The support frame of the new version is smaller and thus should shed less heated air onto the temperature sensor
- The heating contamination often appears as pulses [positive temperature offsets of about 1 K at pressures lower than 20 hPa] so the effect of the quality control software on the raw reported temperatures also influences the result.

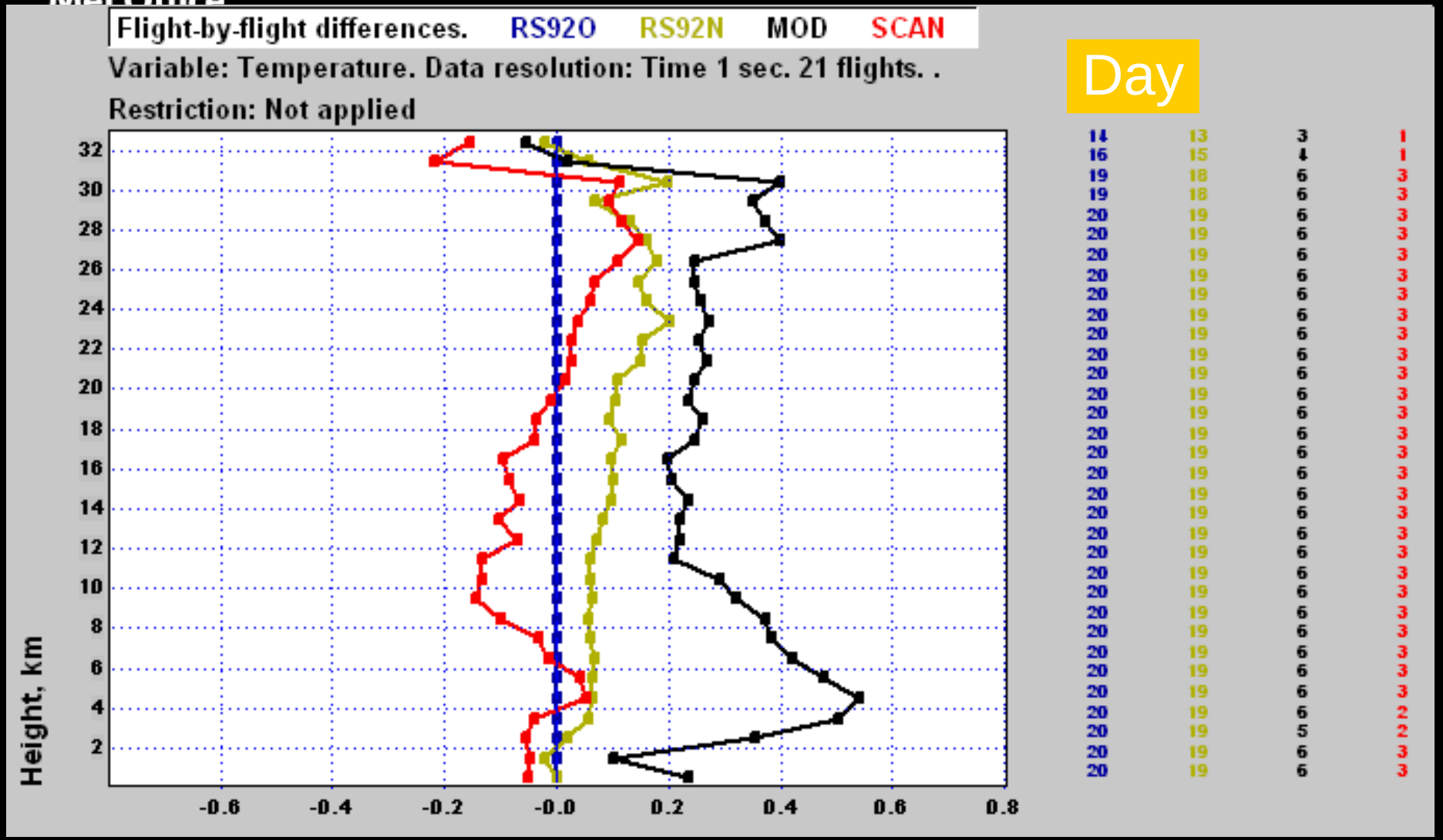
Comparison of raw and processed temperatures at about 15 hPa during the day



Method of suspension

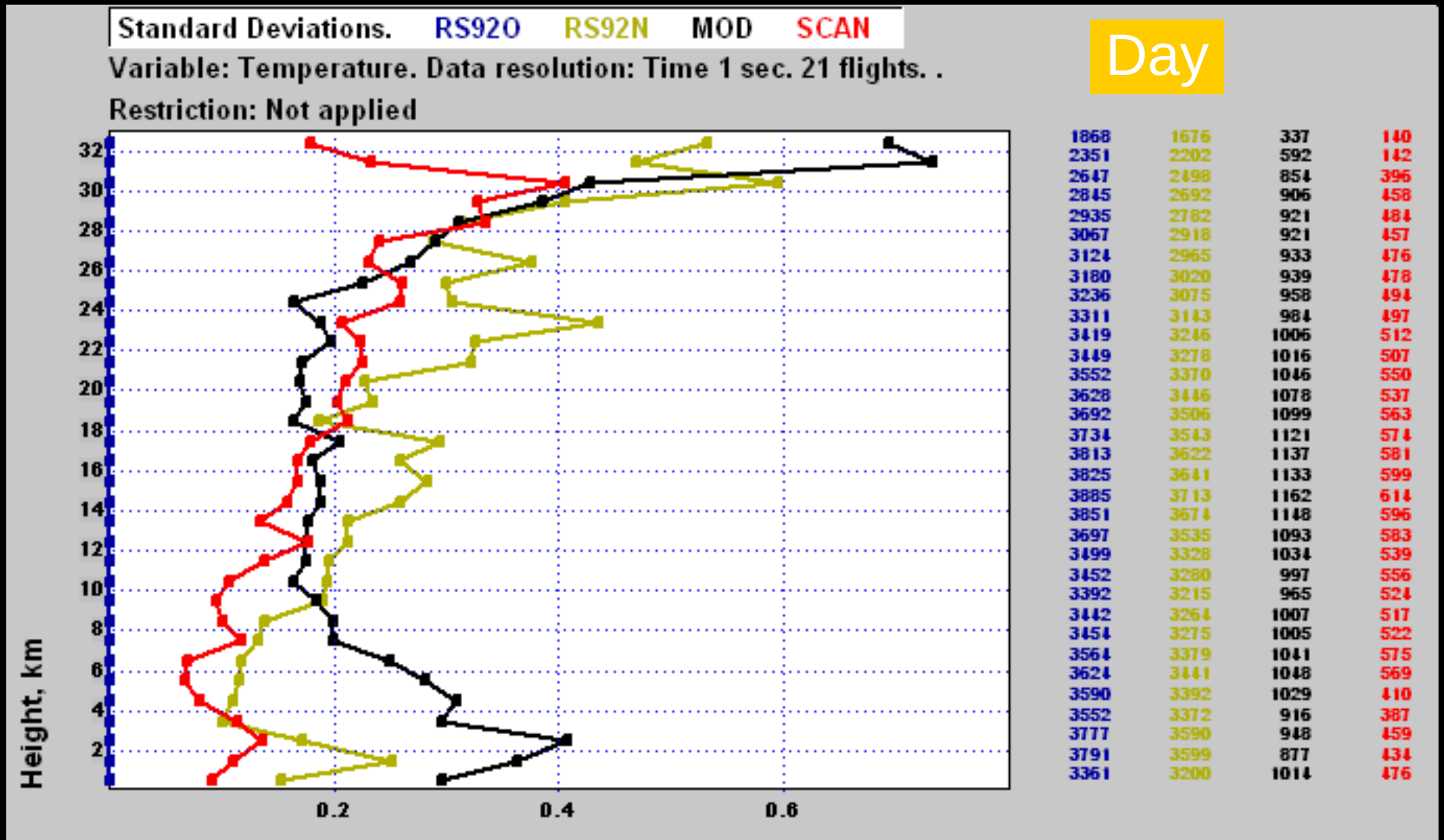
- In the results presented here in about half the test flights the radiosondes were flown with the radiosondes hanging on about 1.5 m of string from a bamboo cane and about half with the radiosondes both hanging from at least 10 m suspension, more similar to normal flight conditions.
- The radiosondes on the longer suspensions twist about in a more irregular fashion than the radiosondes hanging from the bamboo.
- Therefore the temperature offsets from heat contamination are more irregular for the longer suspensions.
- This means that the editing software may eliminate more of the regular heating contamination under the bamboo than the irregular heating on the long suspensions.

Modem and Sippican samples are low,
But show general agreement with Vaisala
Implies new daytime error has increased by 0.3K at 24 km



Standard deviations of simultaneous samples relative to the original RS92 measurements. Number of samples on right.

All day temperature measurements have short term reproducibility which increase to higher than 0.2 K [1s.d.] at upper levels



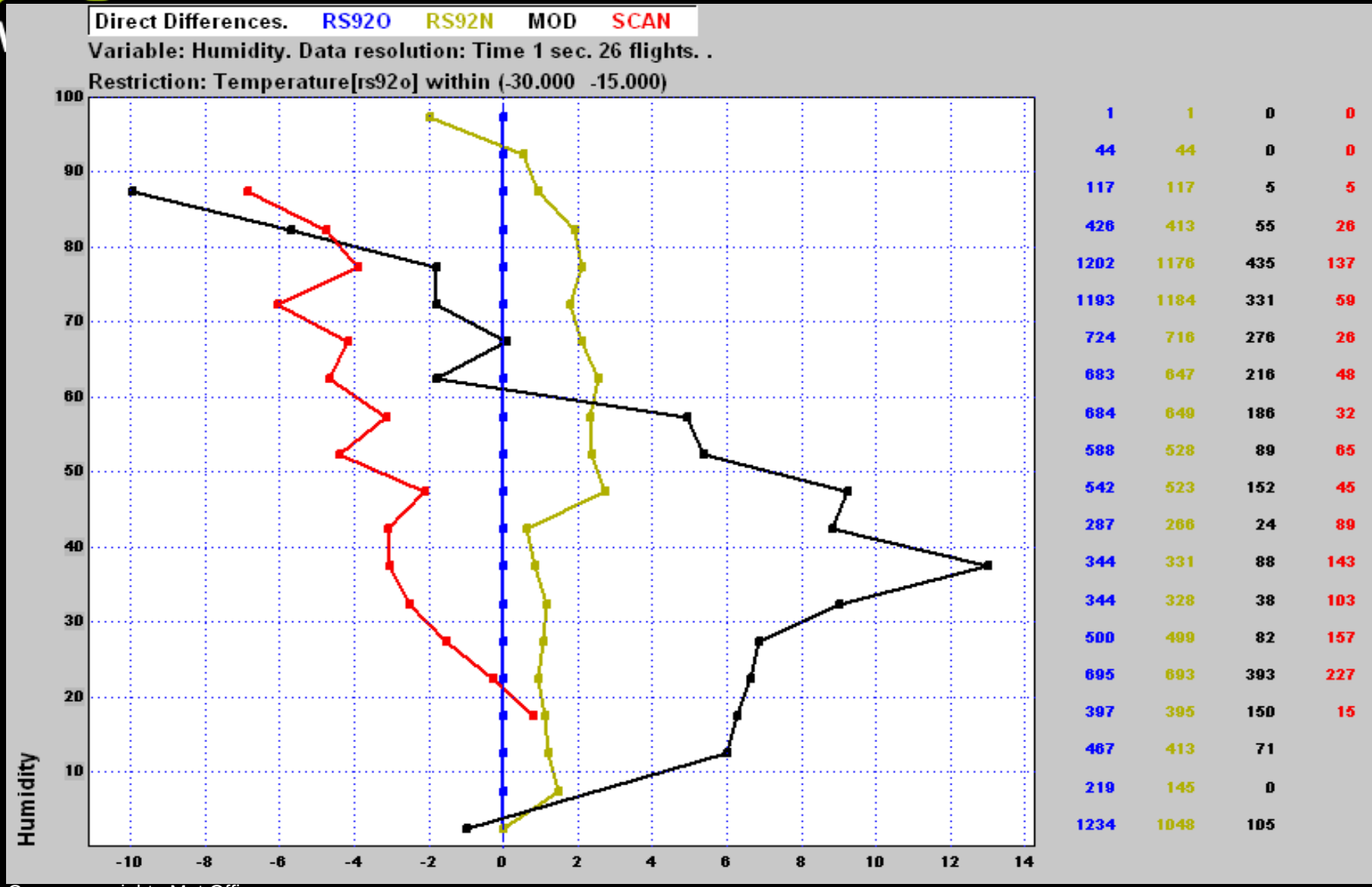
Conclusion

- For some Met Office customers changes of this magnitude [0.2 to 0.3K] matter and there needs to be a better description of the problem and the potential changes than has currently been issued by Vaisala

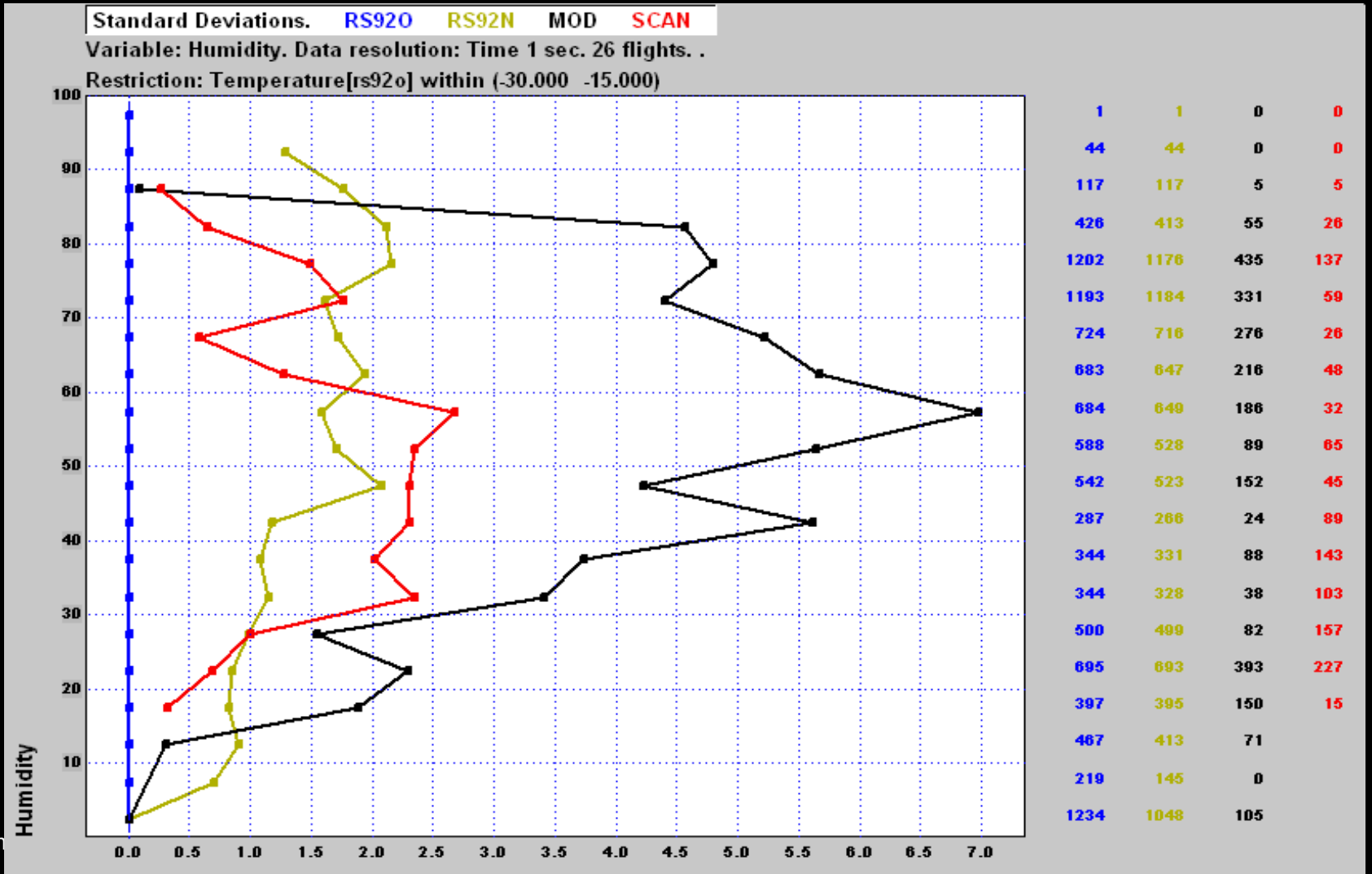
Water vapour and relative humidity

- Readily available water vapour measurements (microwave radiometer, GPS water vapour and radiosonde) have different error limitations.
- So operating the systems together should improve the knowledge of the errors and allow better exploitation by users.
- Calibration errors in RS92 RH have been identified in Vaisala RS92 measurements by checking against FN type Vaisala radiosonde in Lindenberg.
- Trials indicate the RS92 is ~4% too high between 10 and 30% relative humidity but little error above 40% relative humidity.

Temperatures from -15 to -30deg C, Day, two batches of Vaisala RS92 agree to around 2 per cent



Temperatures from -15 to -30deg C, Daytime.
Standard deviations calculated with respect to the original RS92 measurements. This implies reproducibility of Vaisala RS92 measurements better than 2 per cent and a limited sample of Sippican showing similar values.

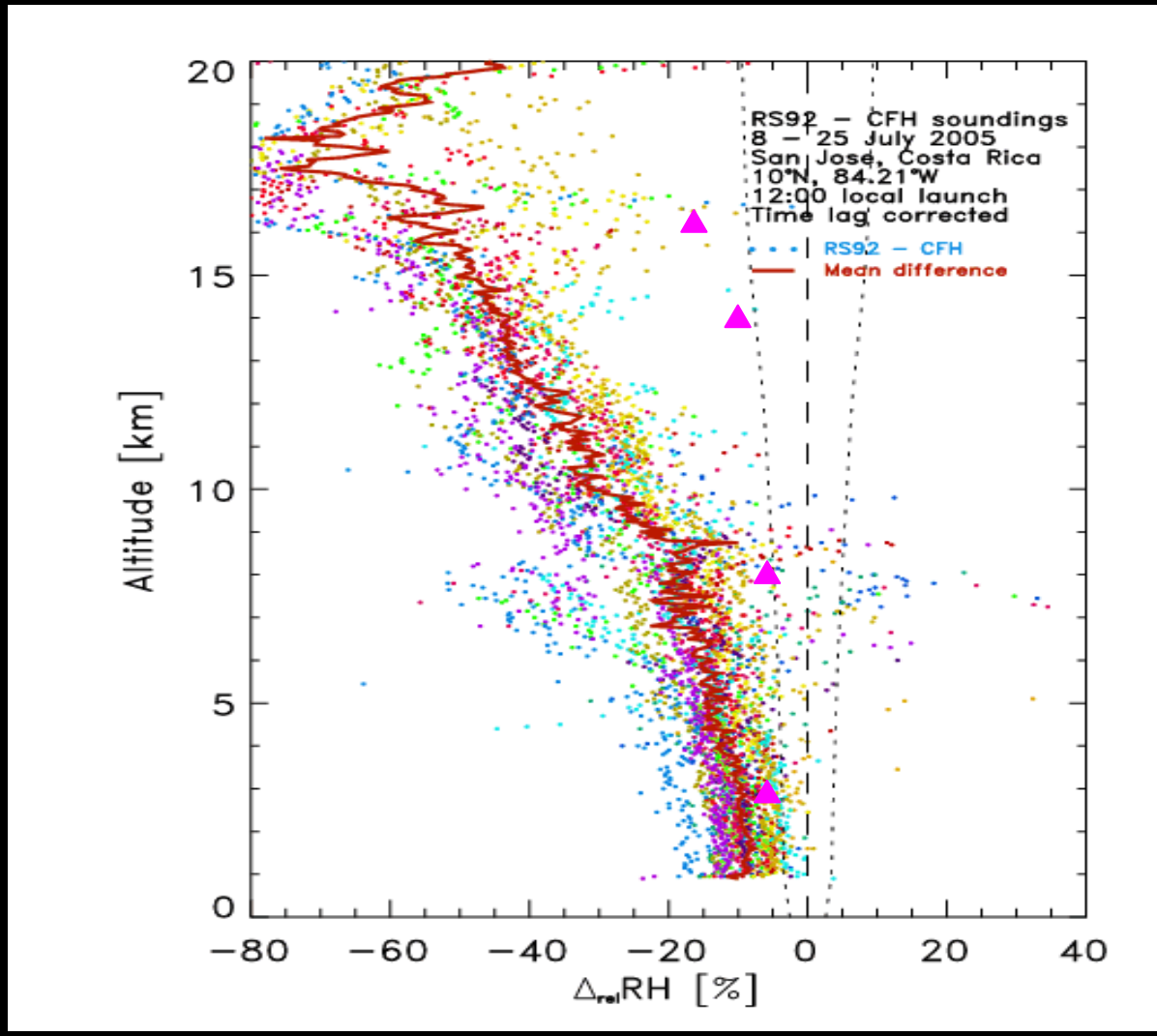


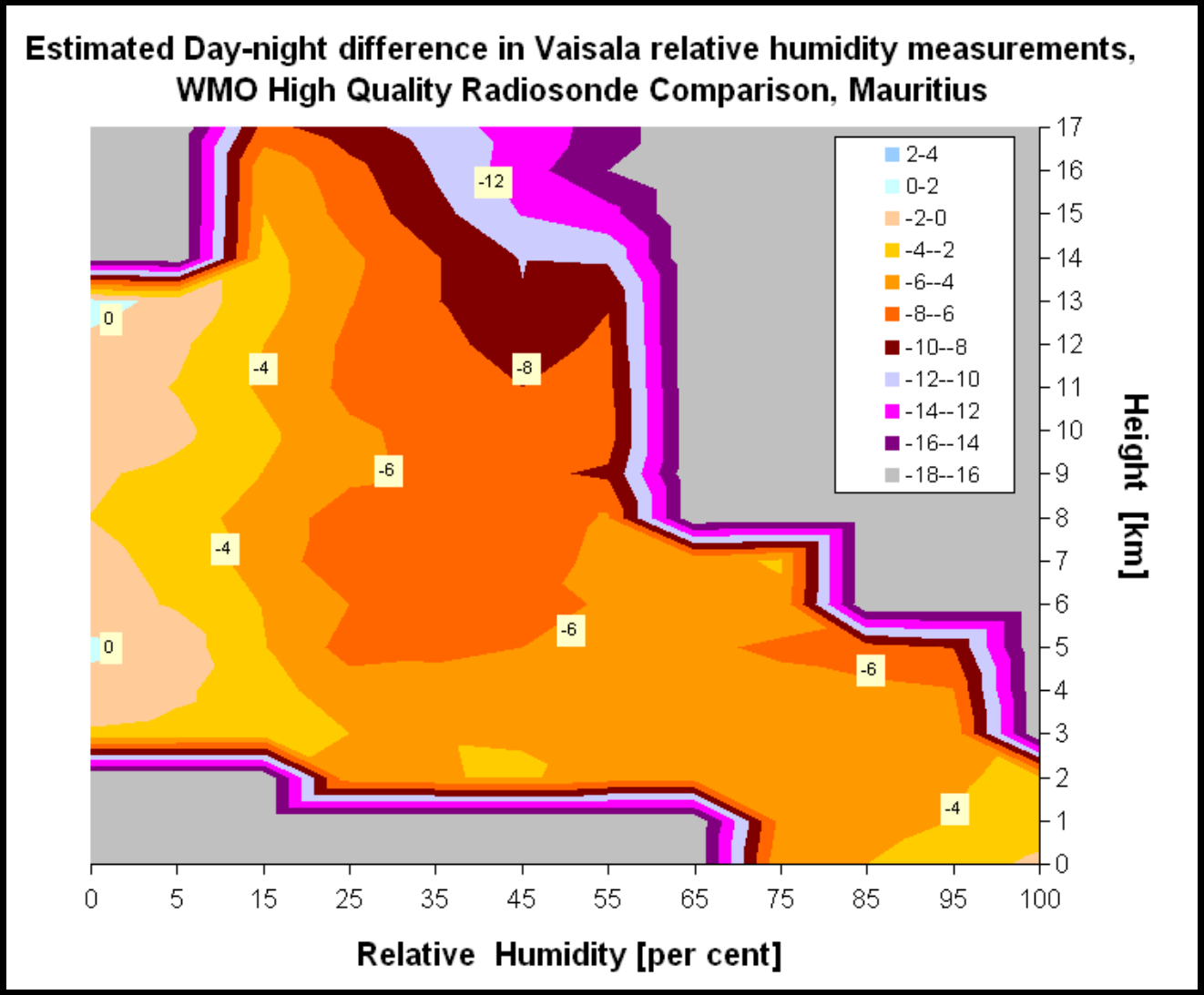
But how consistent are the day/night measurements?

Results
Published by H. Voemel

Are these differences correct or was the radiosonde suspended in a way which prevented it ventilating in the manner it would operate on an individual flight?

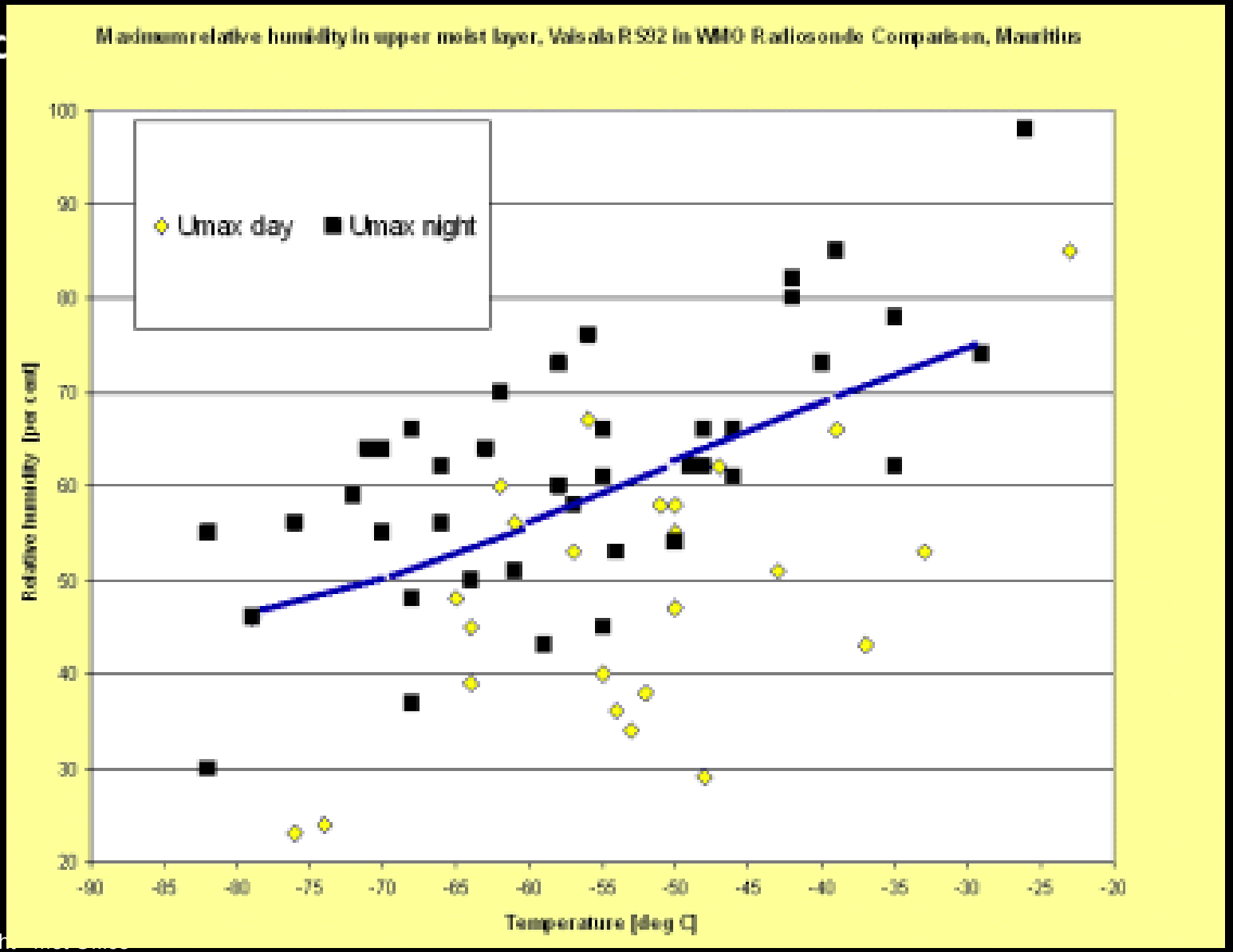
▲ Daytime RS92, high RH
If CFH= Nighttime RS92
Results from Mauritius





Results from Mauritius show significant differences but much smaller than Voemel. Here the radiosondes used did not have bare copper faces near the sensors, as with the new tested at Camborne.

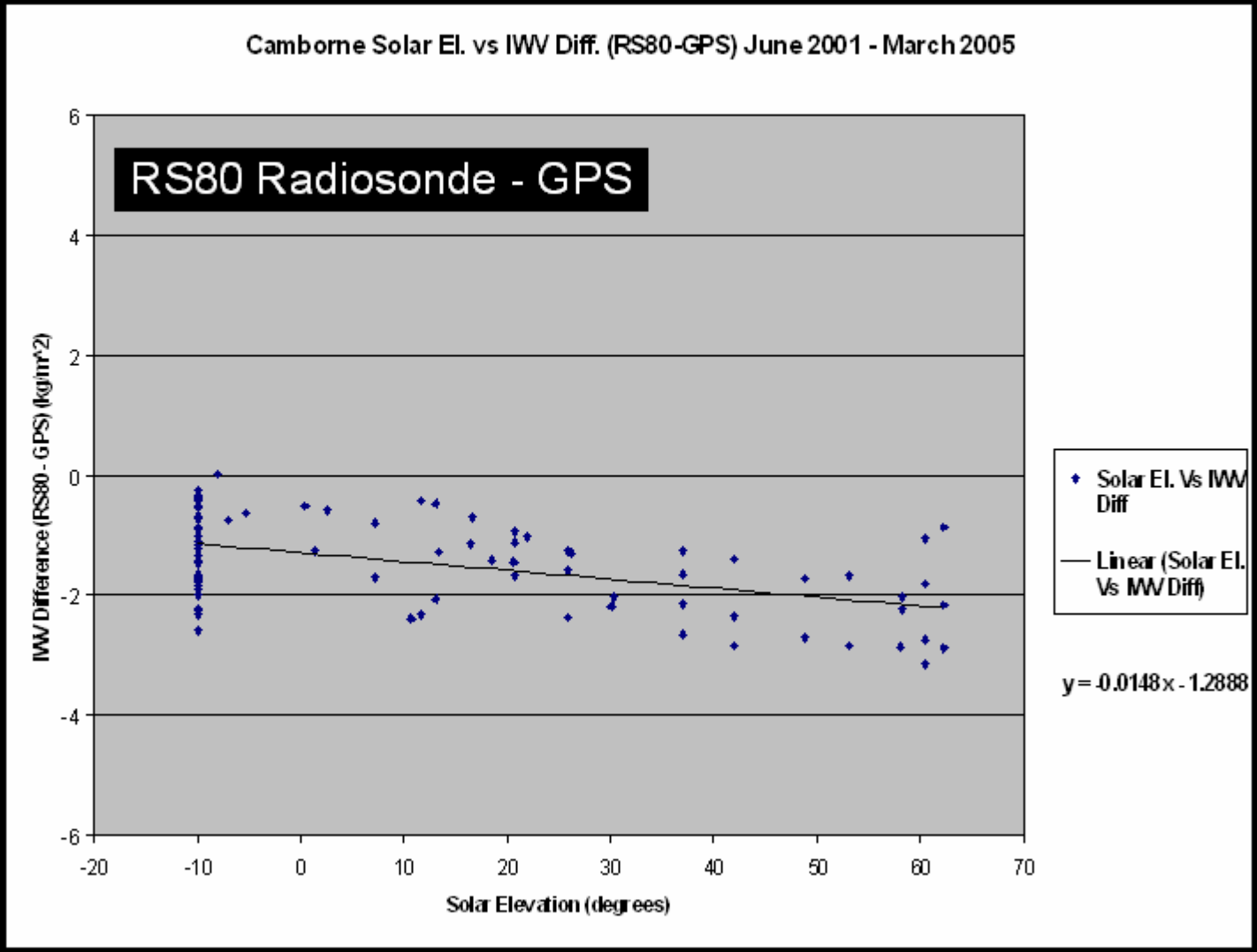
Check absolute values against saturation with respect to ice, from WMO Comparison , Mauritius



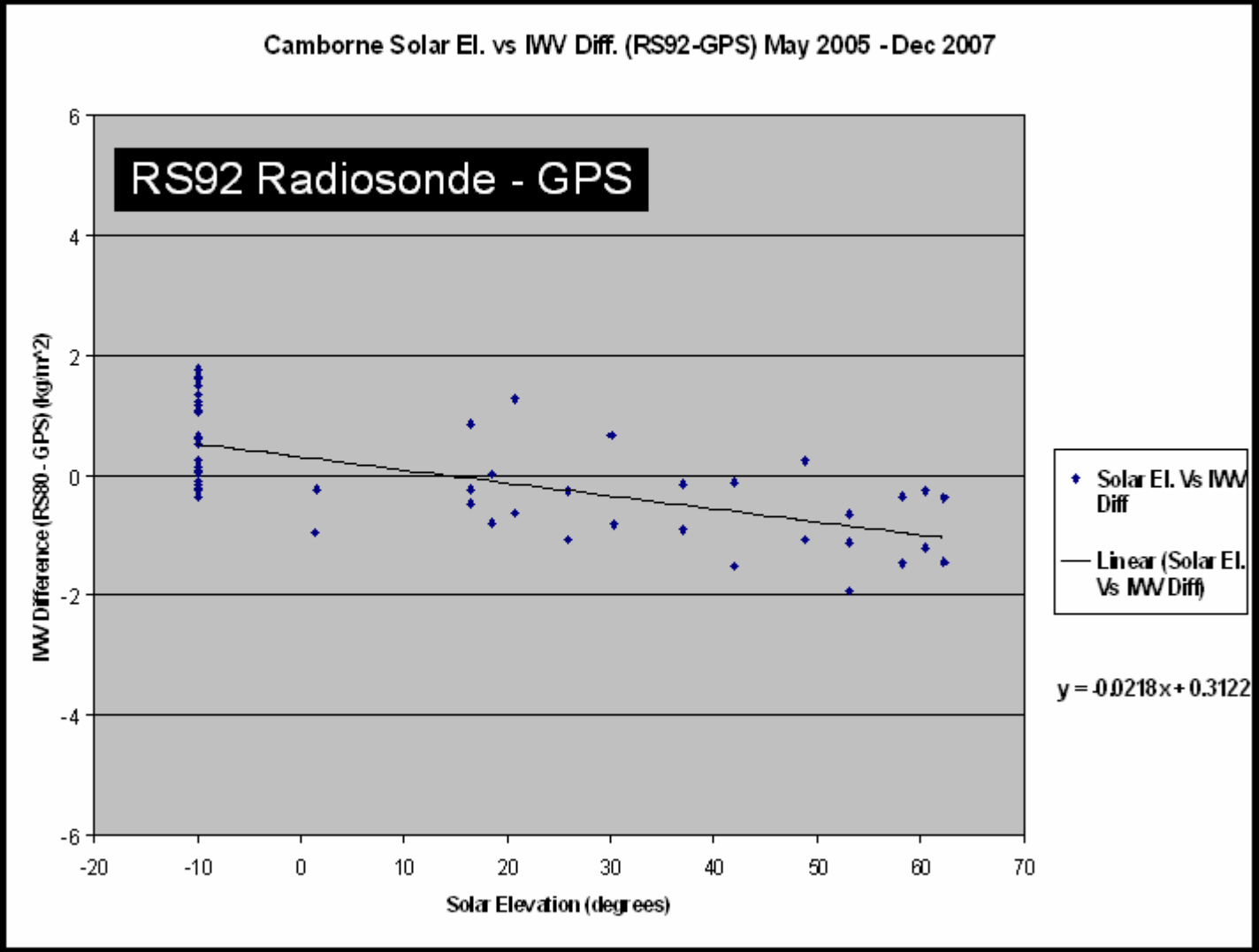
Investigation of day-night RS92 RH consistency at lower levels by comparing with GPS water vapour measurements in the UK

- Solar Elevations
  - Increasing solar elevation = increased RS – GPS bias
  - Greater slope of trend line with GPS vs. RS92 compared to RS80 but less of an offset
  - At high IWV a bias of 1.1kg.m^{-2} between low and high solar elevation for an average of about 25 kg.m^{-2} might be equivalent to about 4% in day-night difference in relative humidity day to night
  - GPS errors not expected to depend on solar elevation

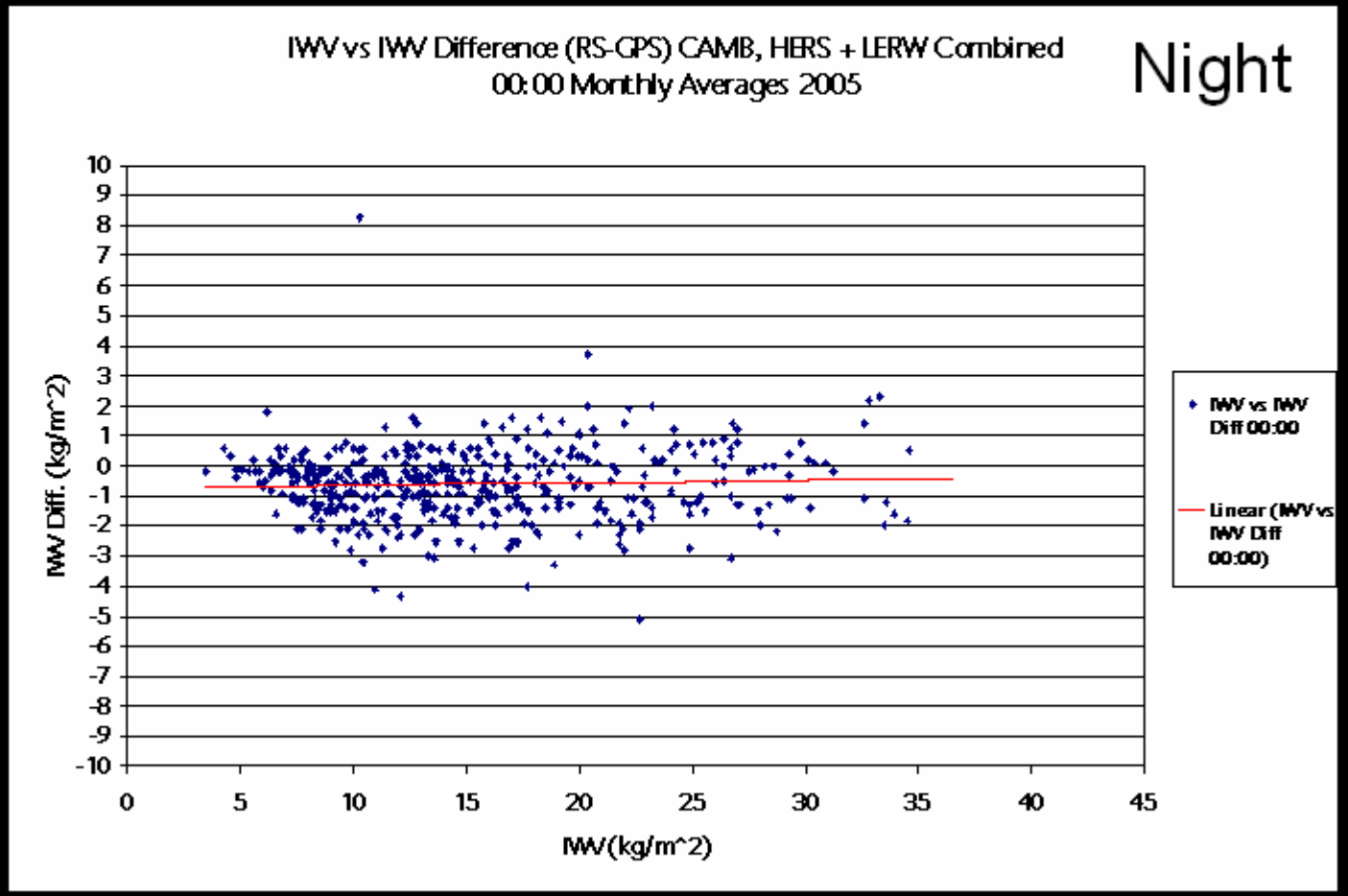
Radiosonde lower at higher solar elevations

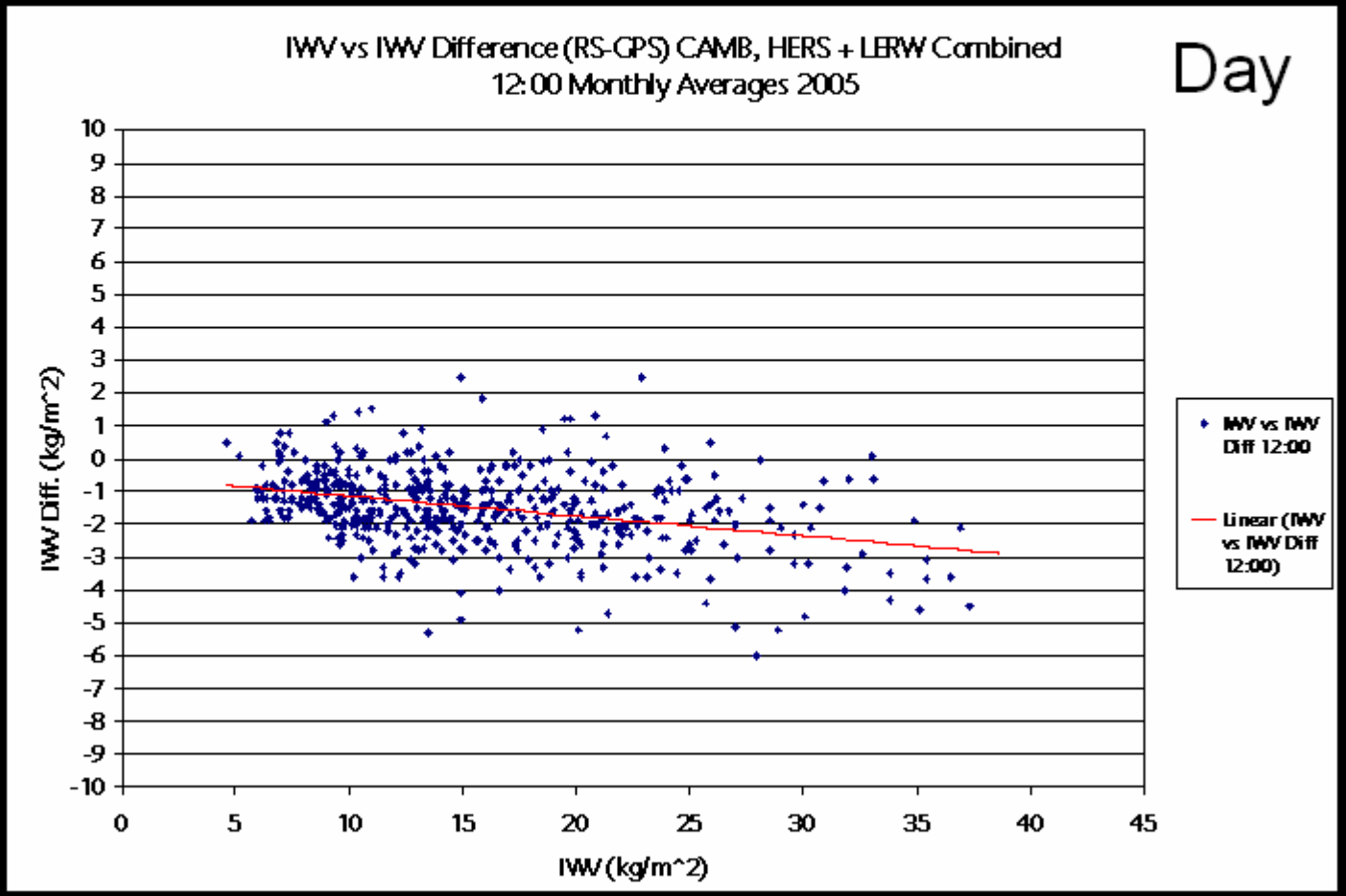


Radiosonde lower at higher solar elevations



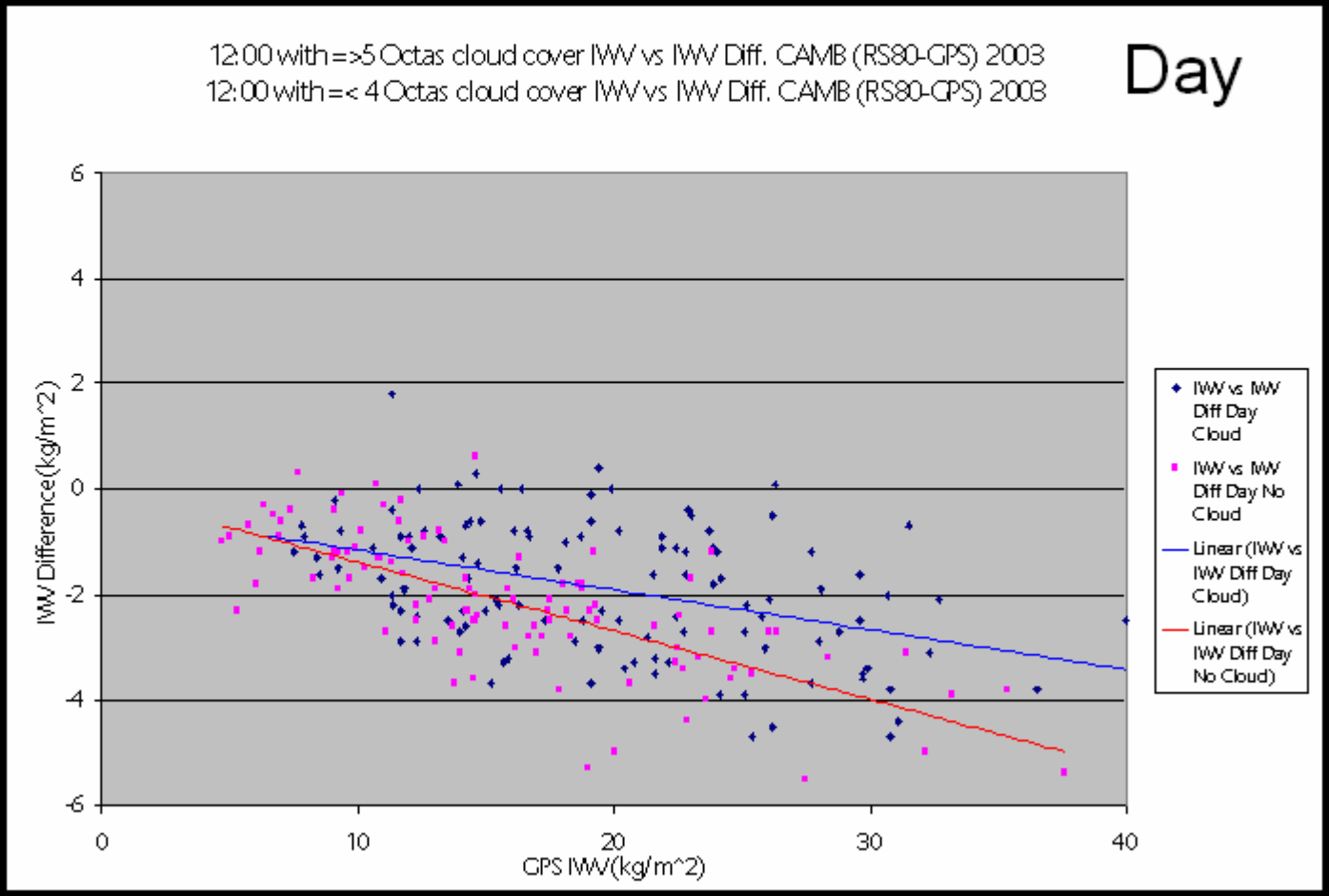
- Day vs. Night Biases for all 3 UK sites (Lerwick, Herstmonceux and Camborne combined) for 2005
  - Show more of a RS-GPS difference in the daytime than the night time



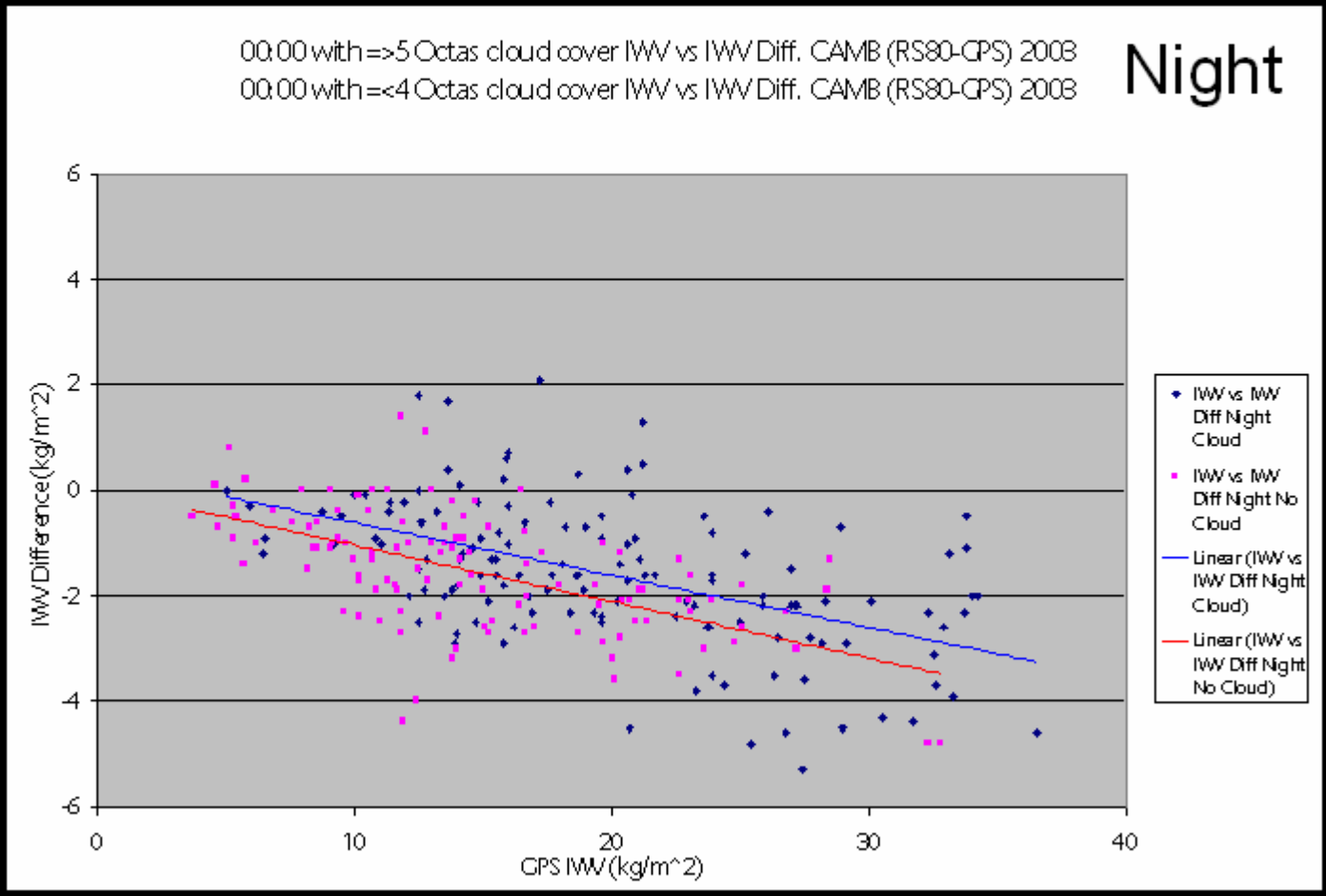


- Day vs. night, cloud vs. no-cloud plots, Camborne 2003
- Plots show that there is the greatest bias in the daytime when there is no cloud (solar heating of RS80 humidity sensor)
- However, there still exists a bias of cloud vs. no cloud in the night time which needs to be investigated further with additional data.

Day, Cloud vs. No Cloud



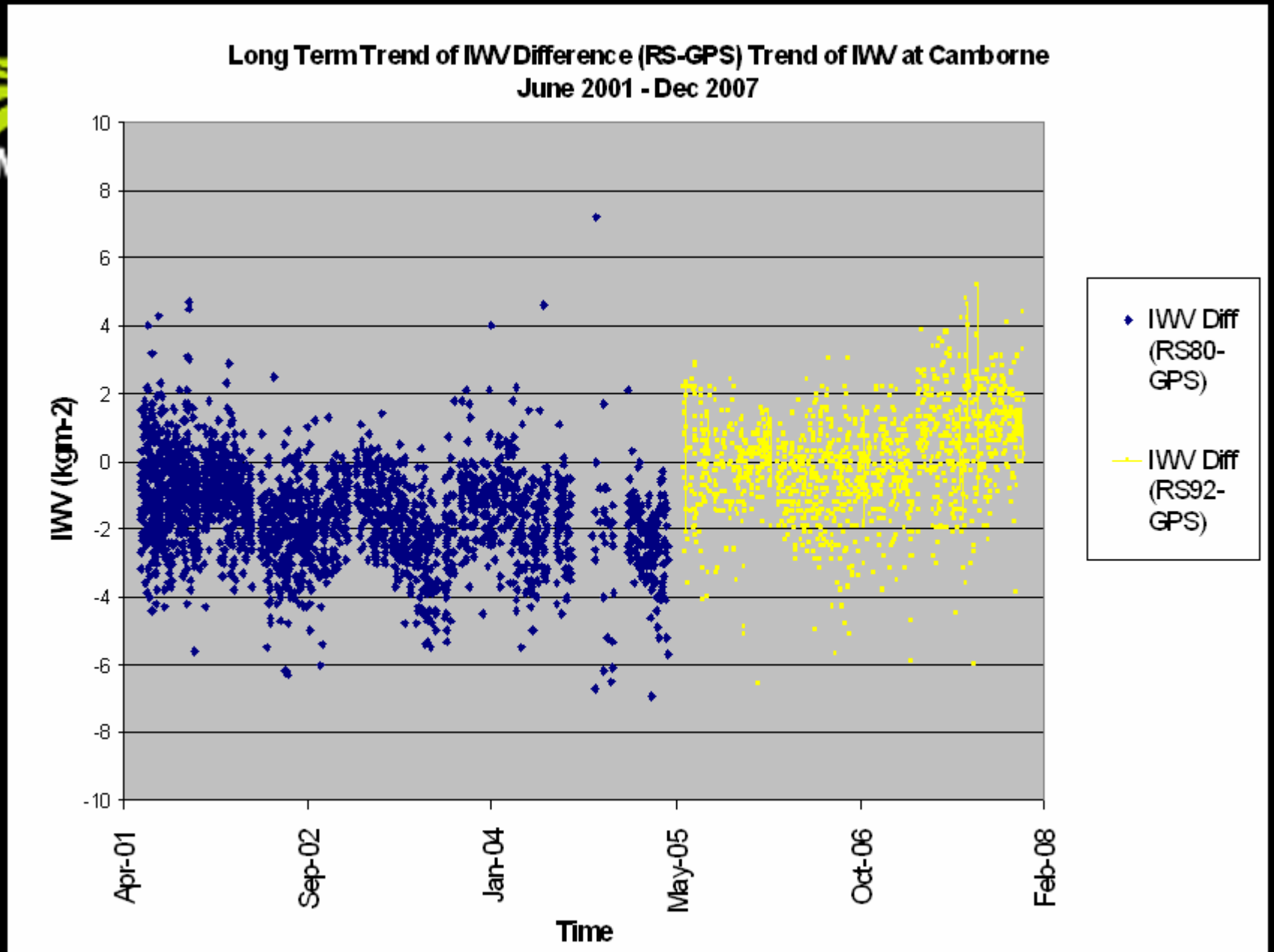
Night, Cloud vs. No Cloud



- The following plot identifies Long term RS-GPS bias plot at Camborne
  - Clearly showing introduction of RS92's
  - Thus far seeing less seasonal variability than with RS80's

Do the users want to correct these biases in relative humidity?

- Yes…
- Especially the much larger errors suggested at upper levels in the tropics, where the errors do matter.
- Does Vaisala intend to make any modifications regarding the persisting day-night differences in the relative humidity measurements?



Questions & answers