



Radiosonde Quality issues affecting climate and integration with remote sensing

Radiosonde Testing Group, Upper Air Development, Met Office - John Nash, Catherine Gaffard, Richard Smout, Mark Smees and Jonathan Jones

Vaisala Workshop, Reading 2 April, 2008



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

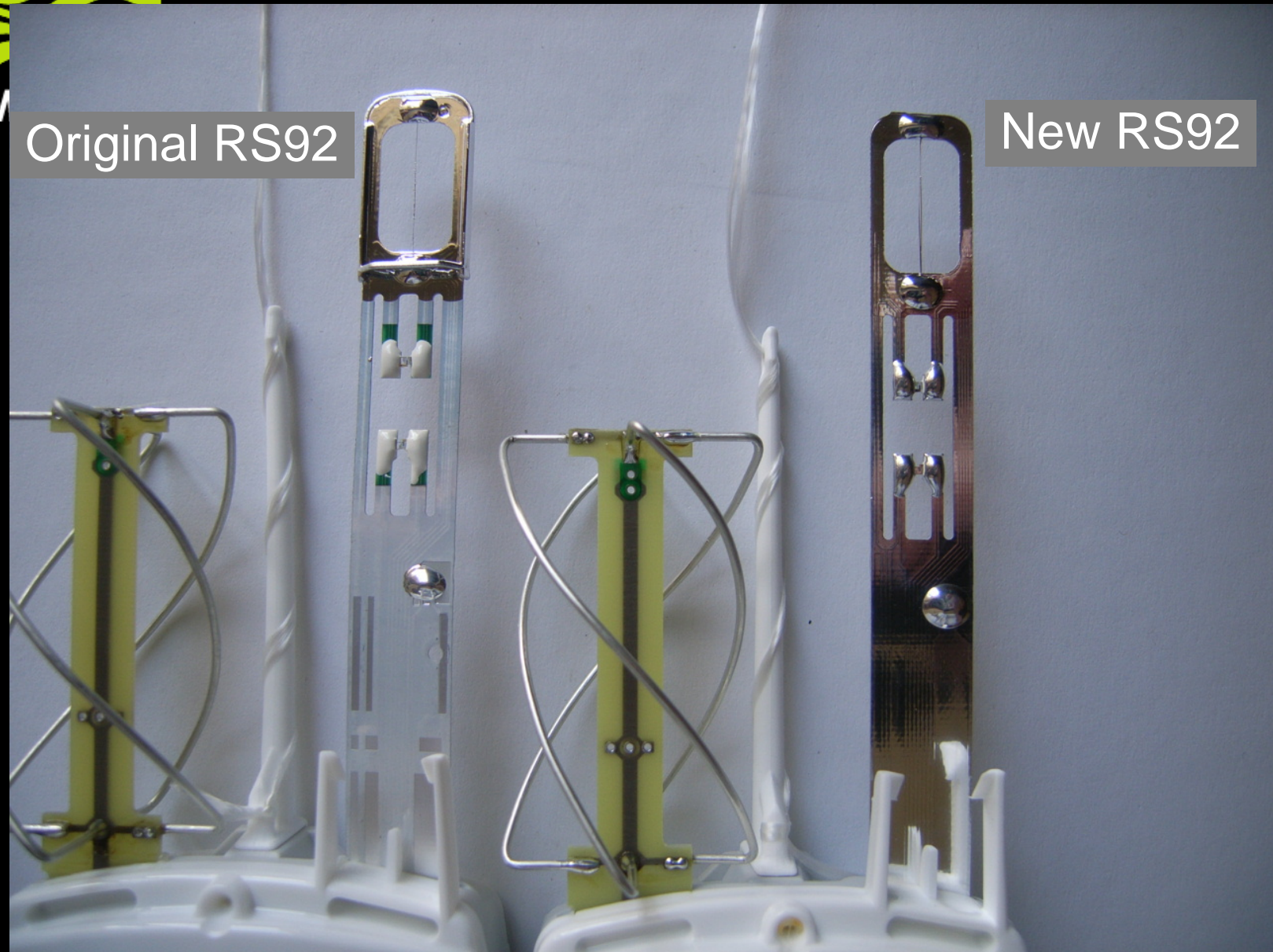
- Support resolution of technical problems on an international scale
- Developing and improving quality assurance techniques
- Supervision of testing the impact of changes in the radiosondes used globally.
- To collaborate in the development of the GCOS Reference Upper Air network
- Investigate the use 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

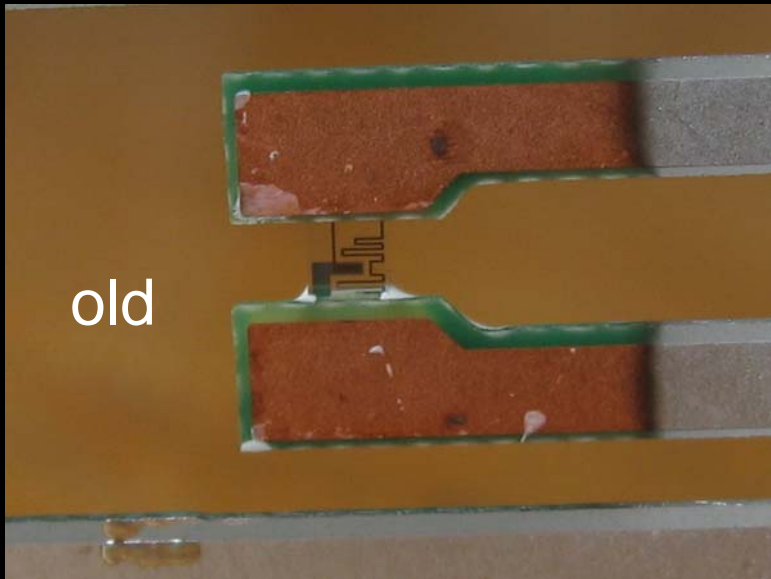


Testing of Latest developments in radiosondes

- 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?



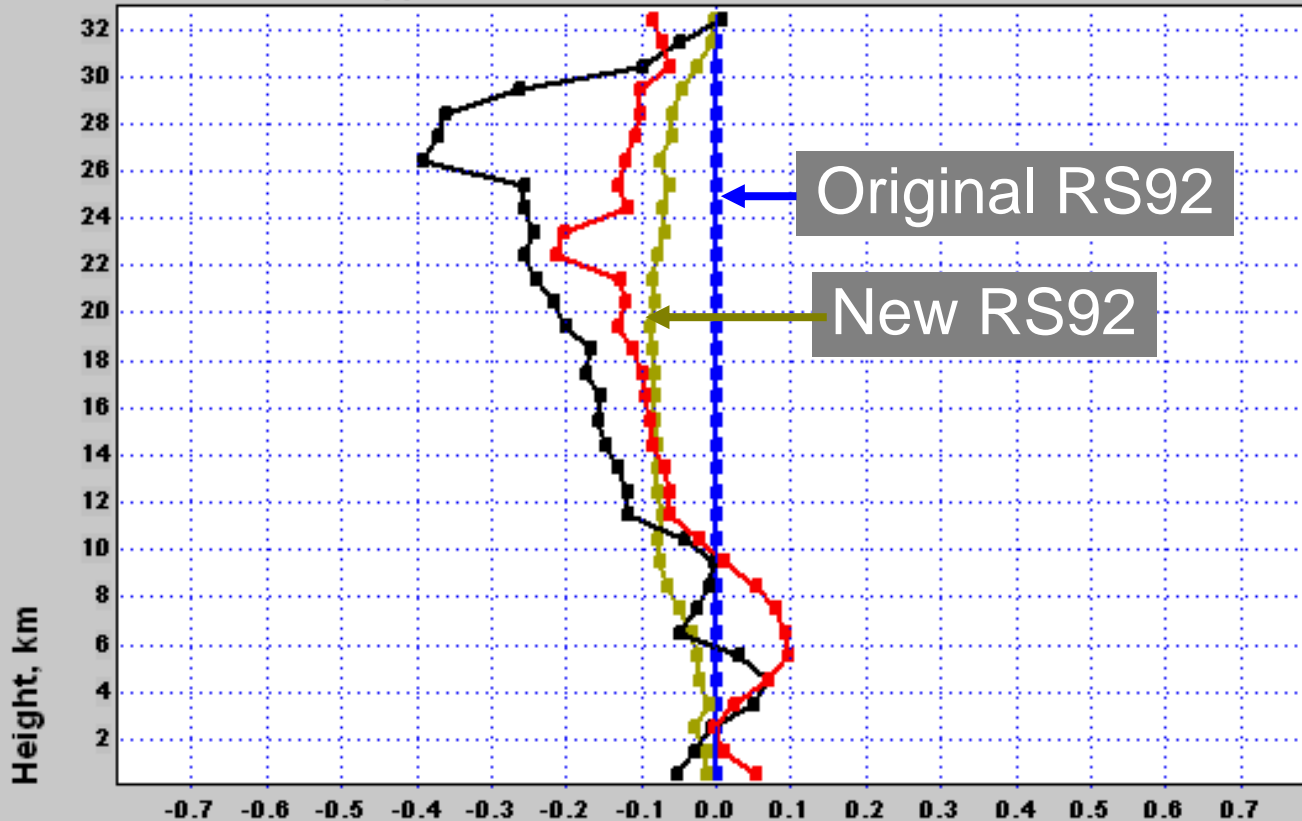
Night Temperature Bias Comparison

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

Flight-by-flight differences. **RS920** **RS92N** **MOD** **SCAN**

Variable: Temperature. Data resolution: Time 1 sec. 11 flights. .

Restriction: Not applied



Night

7	7	2	2
7	7	2	2
8	8	2	2
8	8	2	2
8	8	2	2
9	9	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	3	3
10	10	4	4
10	10	4	4



Night Standard Deviation Comparison

Standard deviations of simultaneous samples relative to the original RS92 measurements

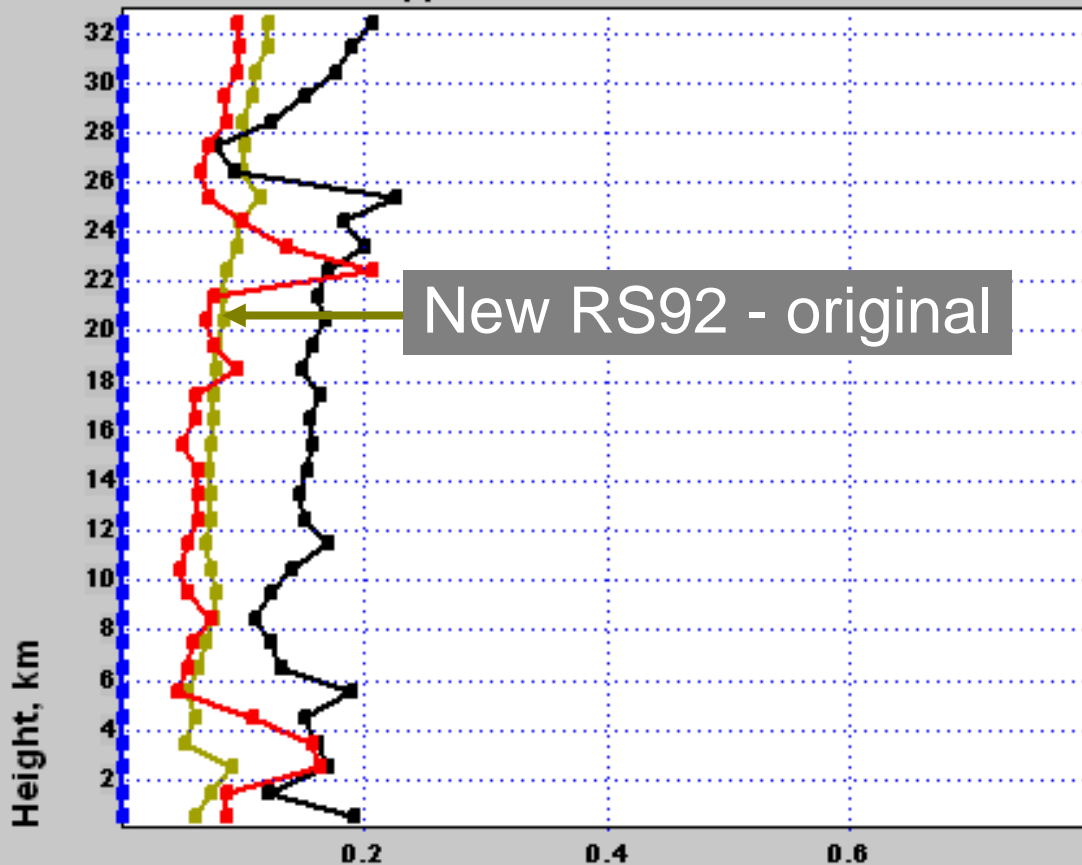
All temperature measurements have short term reproducibility of better than 0.2 K[1s.d.]

Night

Standard Deviations. **RS920** **RS92N** **MOD** **SCAN**

Variable: Temperature. Data resolution: Time 1 sec. 11 flights. .

Restriction: Not applied



1118	1091	327	337
1097	1097	317	329
1054	1054	312	318
1126	1126	326	318
1247	1247	311	321
1287	1287	331	340
1295	1295	321	343
1442	1442	454	346
1689	1687	512	509
1733	1733	521	545
1775	1775	548	547
1818	1818	556	572
1853	1853	564	587
1857	1857	574	601
1878	1878	562	568
1924	1924	597	587
1993	1993	617	628
1981	1981	606	623
1972	1972	645	613
1999	1999	635	587
1952	1952	620	576
1833	1833	580	545
1823	1823	556	554
1780	1780	542	554
1752	1752	501	532
1722	1722	513	523
1781	1781	526	540
1892	1892	549	583
1853	1853	490	513
1813	1813	508	399
1951	1951	705	488
1951	1951	648	485
1673	1672	642	519



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

Met

Flight 26. RS920 RS92N RAWO RAWN MOD

Temperature

87:00

Time

Original RS92
edited

Raw Original RS92

86:00

New RS92
edited

Raw New RS92

85:00

-35.5 -35.0 -34.5 -34.0 -33.5 -33.0 -32.5 C



Met Office

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.



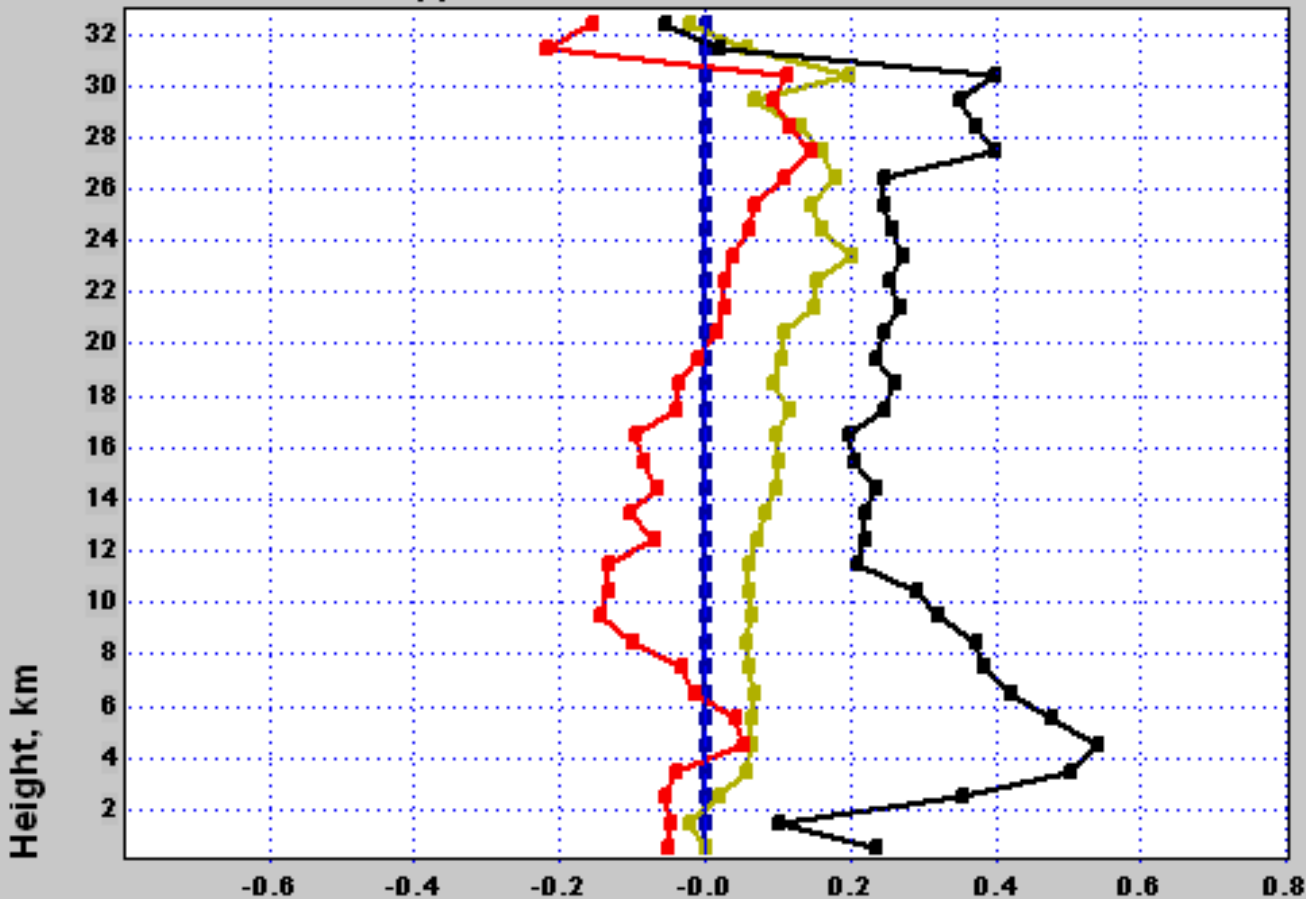
Met Office

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

Flight-by-flight differences. RS920 RS92N MOD SCAN

Variable: Temperature. Data resolution: Time 1 sec. 21 flights. .

Restriction: Not applied



Day

14	13	3	1
16	15	4	1
19	18	6	3
19	18	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	3
20	19	6	2
20	19	5	2
20	19	6	3
20	19	6	3



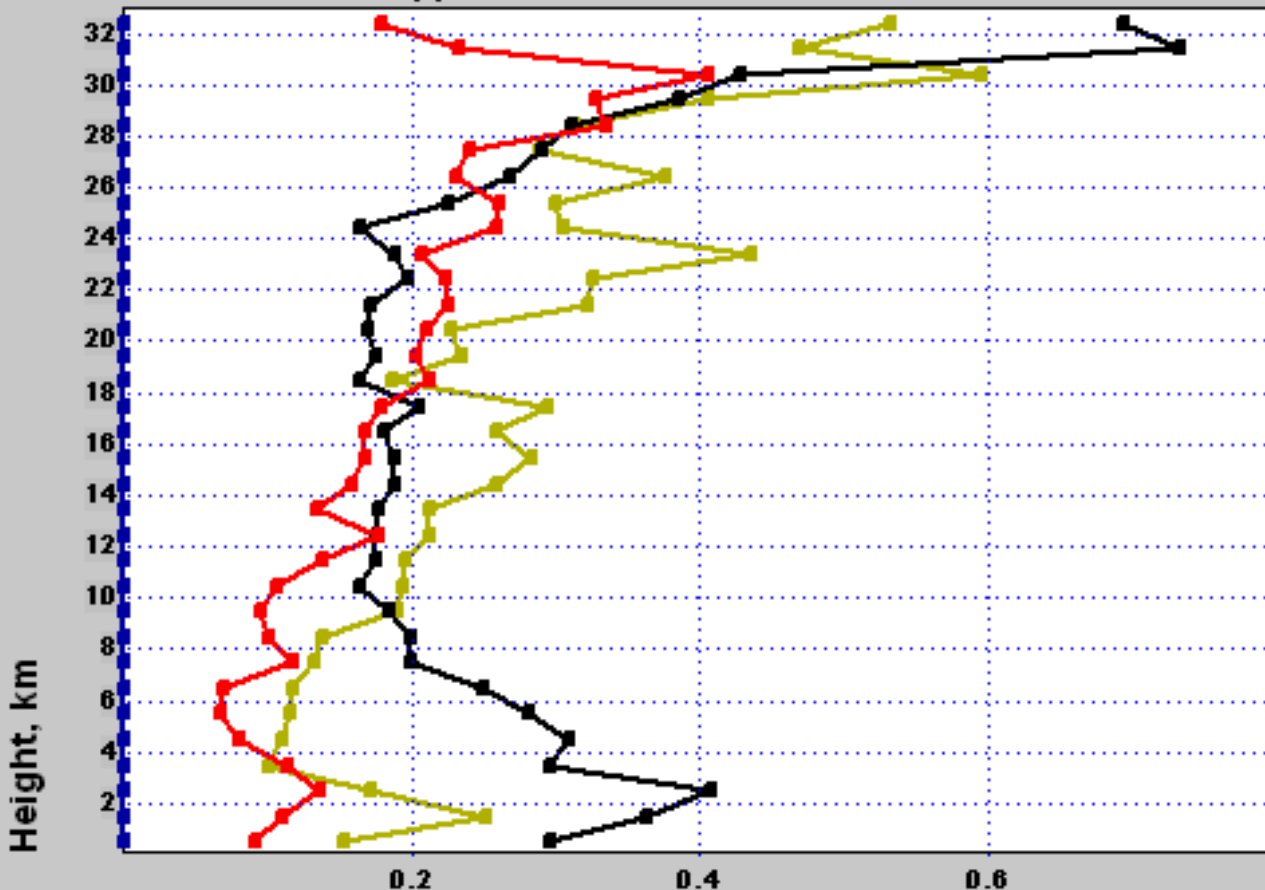
Standard deviations of simultaneous samples relative to the original RS92 measurements. Number of samples on right.

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

Standard Deviations. RS920 RS92N MOD SCAN

Variable: Temperature. Data resolution: Time 1 sec. 21 flights. .

Restriction: Not applied



Day

1868	1676	337	140
2351	2202	592	142
2647	2498	854	396
2845	2692	906	458
2935	2782	921	484
3067	2918	921	457
3124	2965	933	476
3180	3020	939	478
3236	3075	958	494
3311	3143	984	497
3419	3246	1006	512
3449	3278	1016	507
3552	3370	1046	550
3628	3446	1078	537
3692	3506	1099	563
3734	3543	1121	574
3813	3622	1137	581
3825	3641	1133	599
3885	3713	1162	614
3851	3674	1148	596
3697	3535	1093	583
3499	3328	1034	539
3452	3280	997	556
3392	3215	965	524
3442	3264	1007	517
3454	3275	1005	522
3564	3379	1041	575
3624	3441	1048	569
3590	3392	1029	410
3552	3372	916	387
3777	3590	948	459
3791	3599	877	434
3361	3200	1014	476



Met Office

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



Met Office

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.

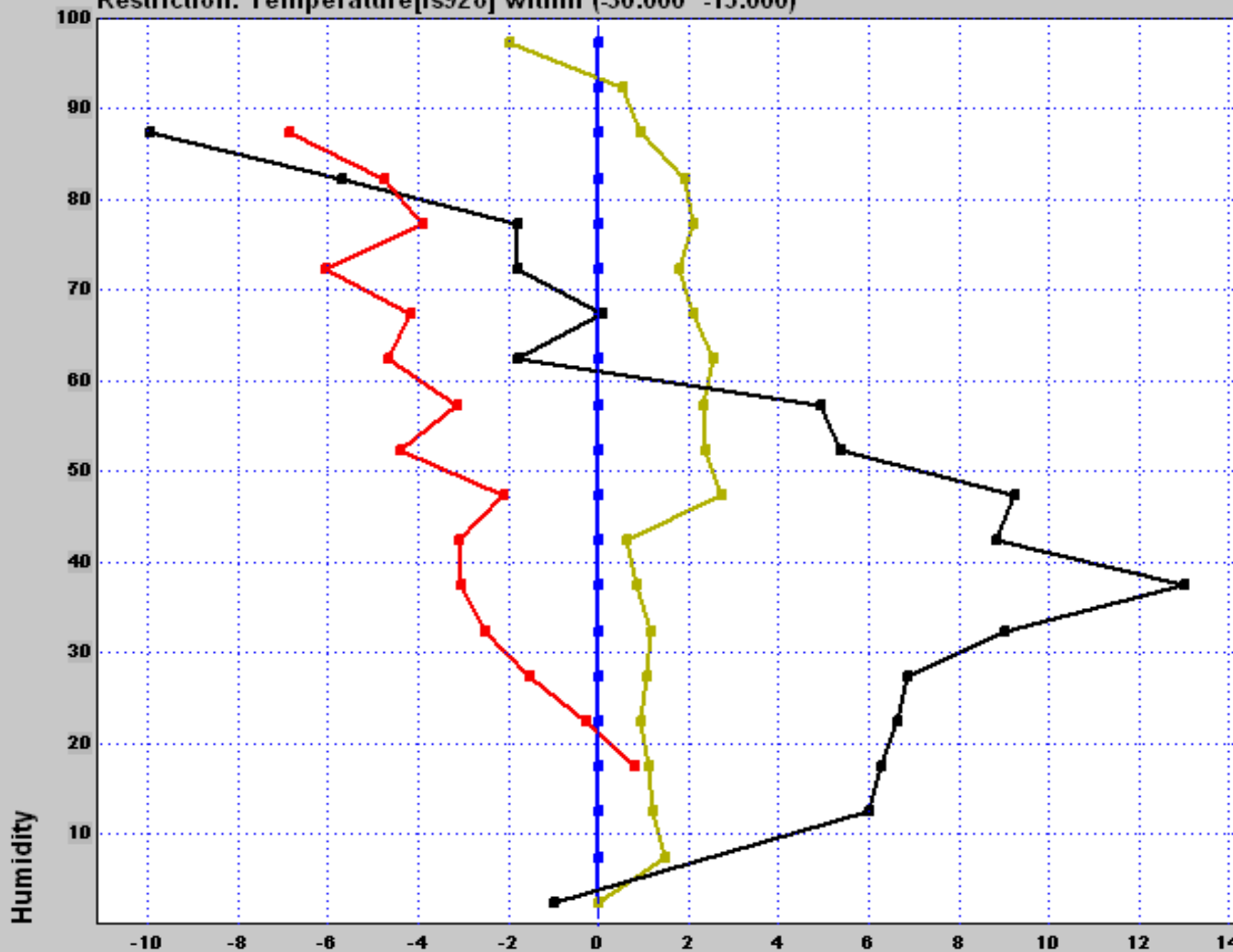


Temperatures from -15 to -30deg C, Day, two batches of Vaisala RS92 agree to around 2 per cent

Direct Differences. RS920 RS92N MOD SCAN

Variable: Humidity. Data resolution: Time 1 sec. 26 flights. .

Restriction: Temperature[rs92o] within (-30.000 -15.000)

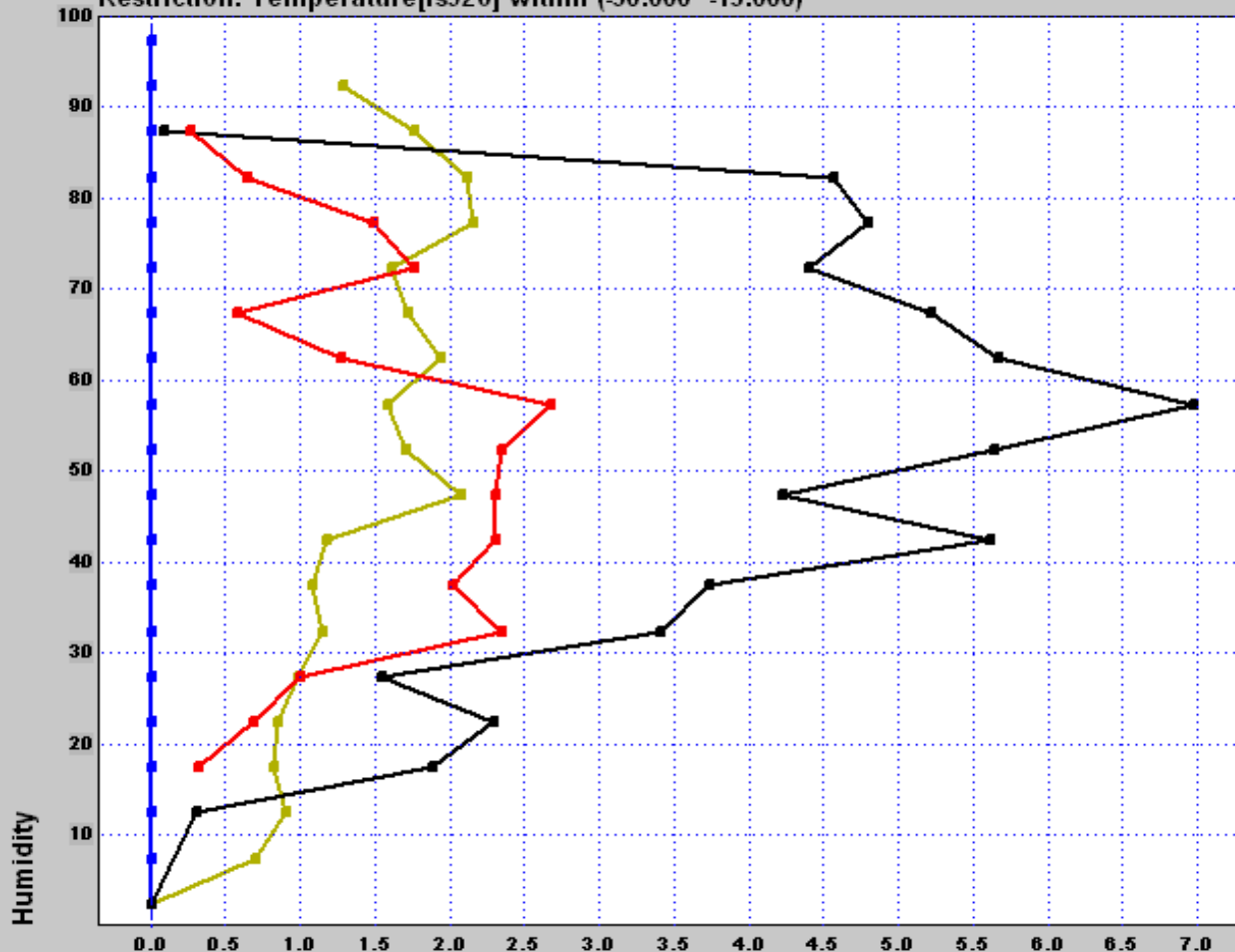


1	1	0	0
44	44	0	0
117	117	5	5
426	413	55	26
1202	1176	435	137
1193	1184	331	59
724	716	276	26
683	647	216	48
684	649	186	32
588	528	89	65
542	523	152	45
287	266	24	89
344	331	88	143
344	328	38	103
500	499	82	157
695	693	393	227
397	395	150	15
467	413	71	
219	145	0	
1234	1048	105	



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.

Standard Deviations. **RS920** **RS92N** MOD **SCAN**
 Variable: Humidity. Data resolution: Time 1 sec. 26 flights. .
 Restriction: Temperature[rs92o] within (-30.000 -15.000)



1	1	0	0
44	44	0	0
117	117	5	5
426	413	55	26
1202	1176	435	137
1193	1184	331	59
724	716	276	26
683	647	216	48
684	649	186	32
588	528	89	65
542	523	152	45
287	266	24	89
344	331	88	143
344	328	38	103
500	499	82	157
695	693	393	227
397	395	150	15
467	413	71	
219	145	0	
1234	1048	105	

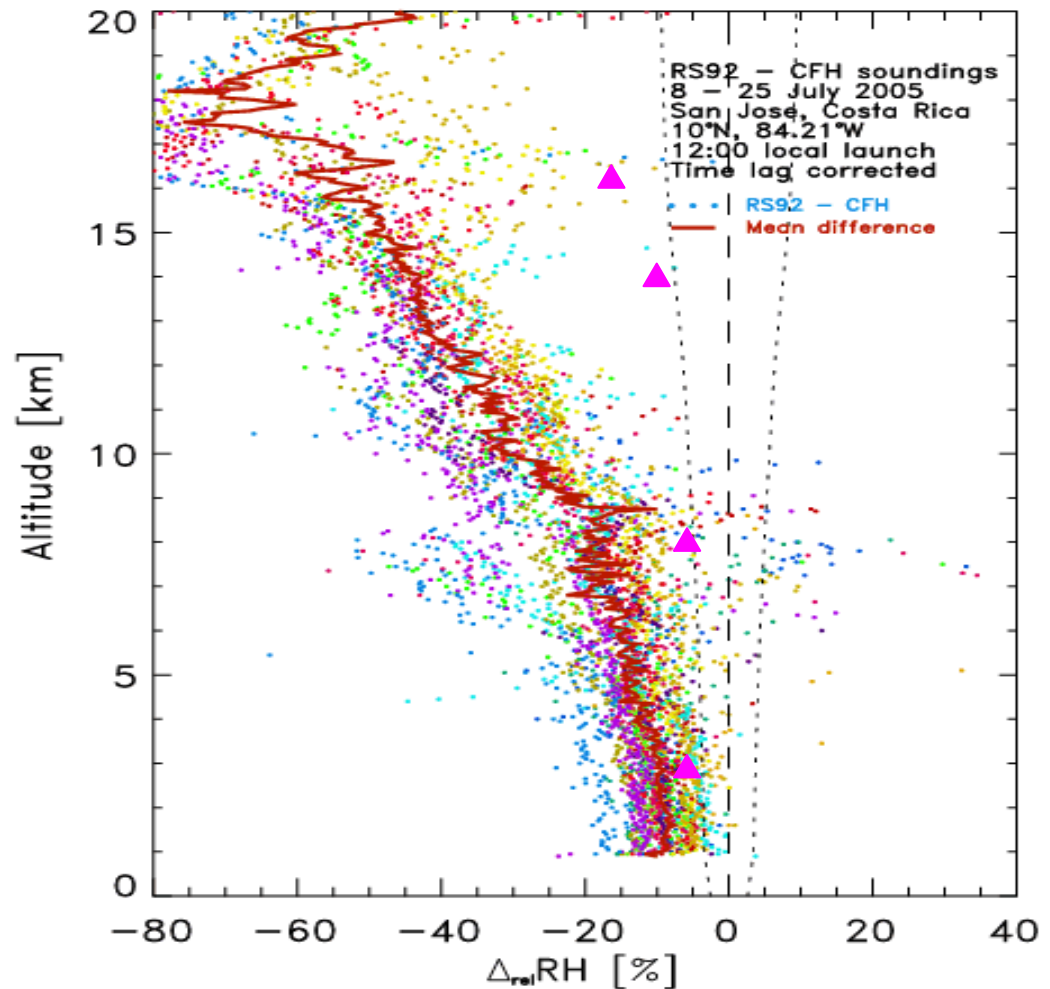
But how consistent are the day/night measurements?

Results

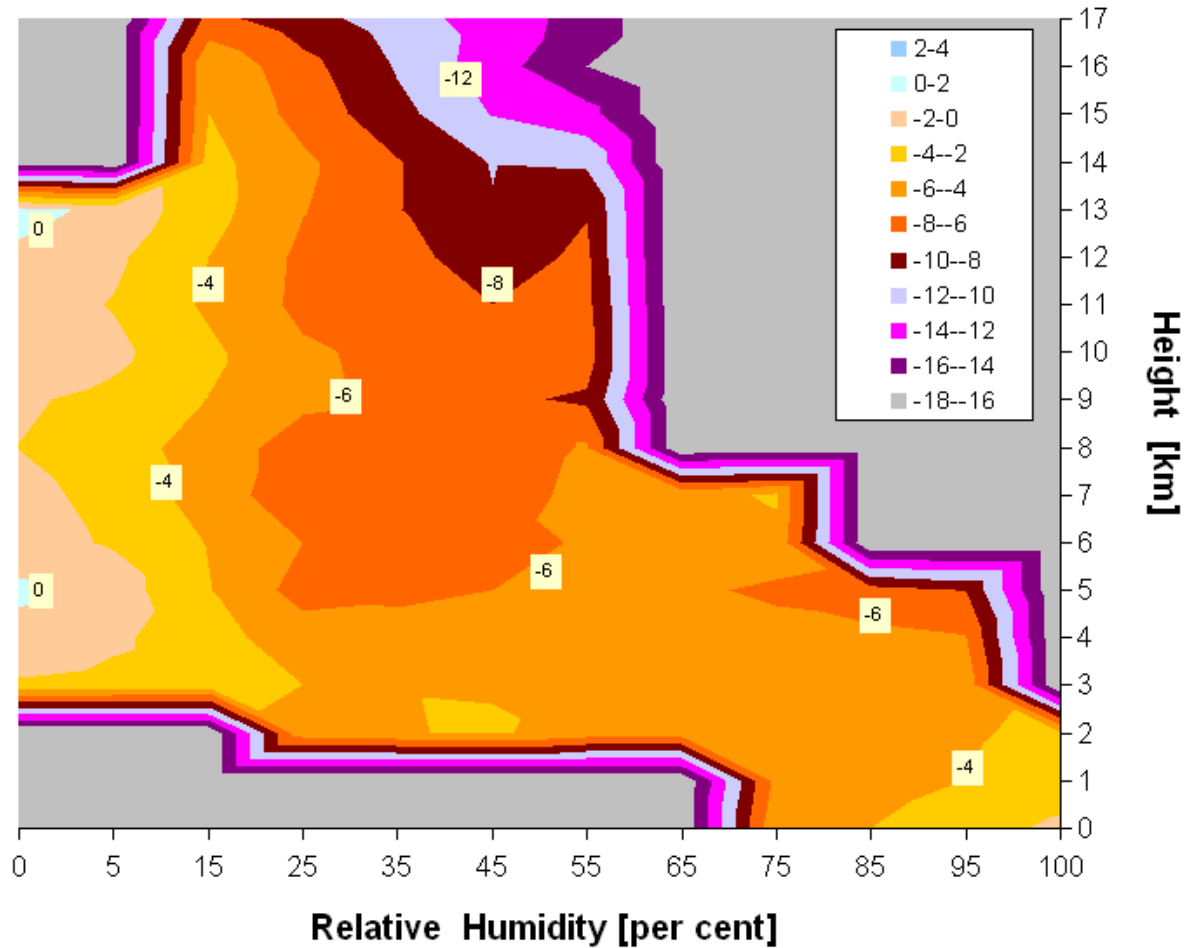
Published by H. Voemel

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



Estimated Day-night difference in Vaisala relative humidity measurements, WMO High Quality Radiosonde Comparison, Mauritius



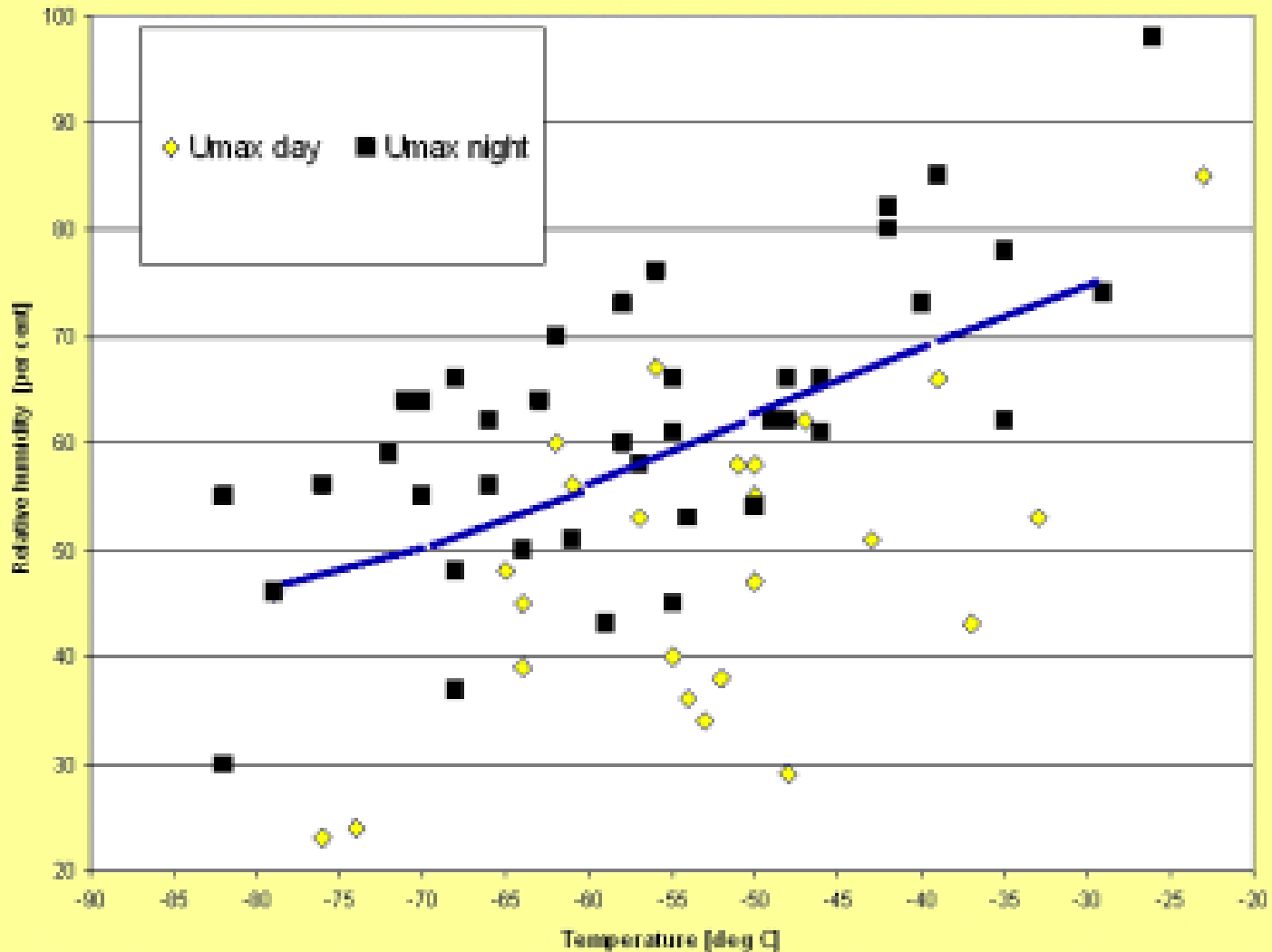
Results from Mauritius show significant differences but much smaller than Voemel. Here the radiosondes used did not have bare copper faces near the sensors, as with the new tested at Camborne.



Met Office

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

Maximum relative humidity in upper moist layer, Vaisala RS92 in WMO Radiosonde Comparison, Mauritius



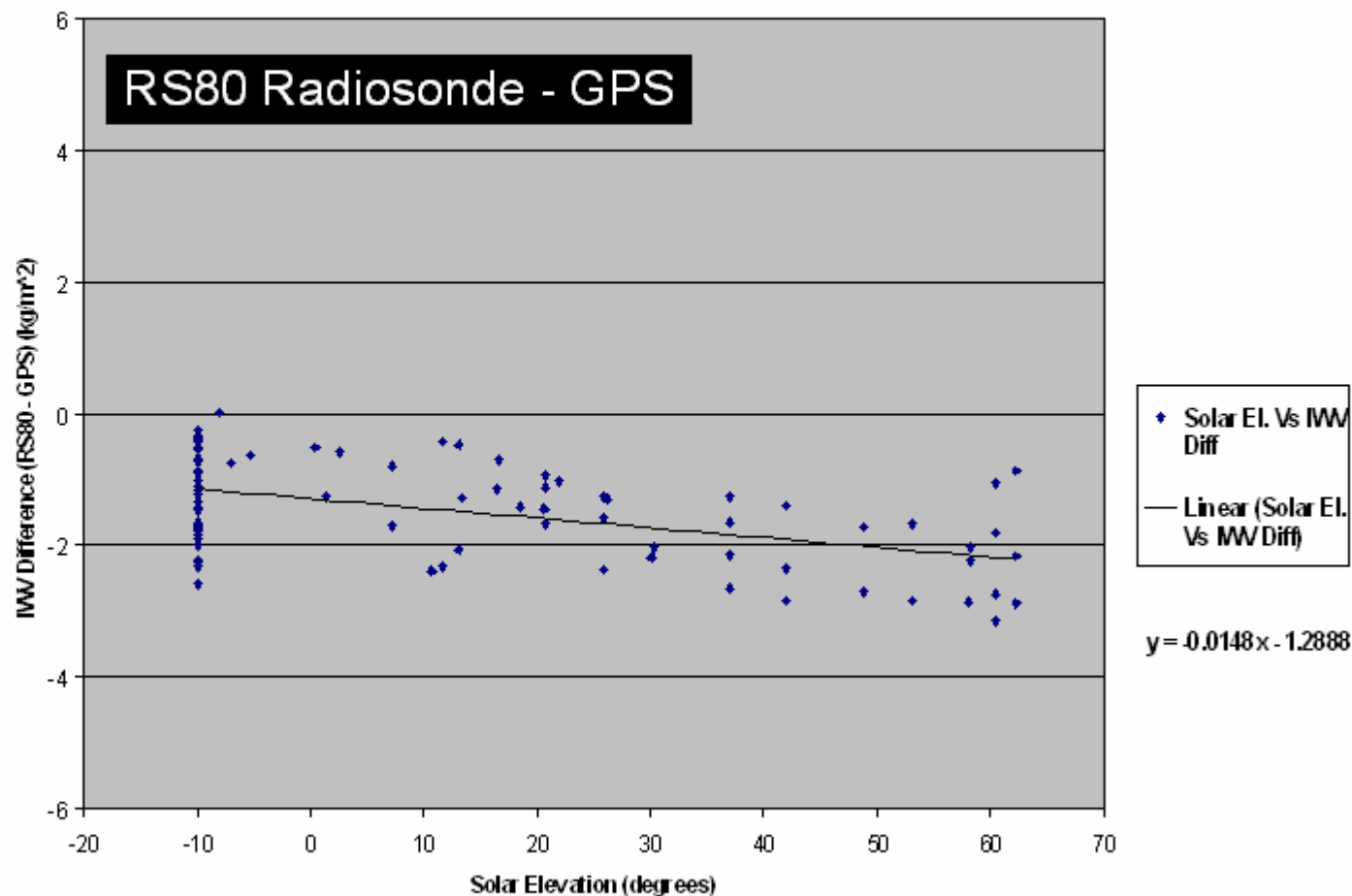


Investigation of day-night RS92 RH consistency at lower levels by comparing with GPS water vapour measurements in the UK

- 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 1.1 kg.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

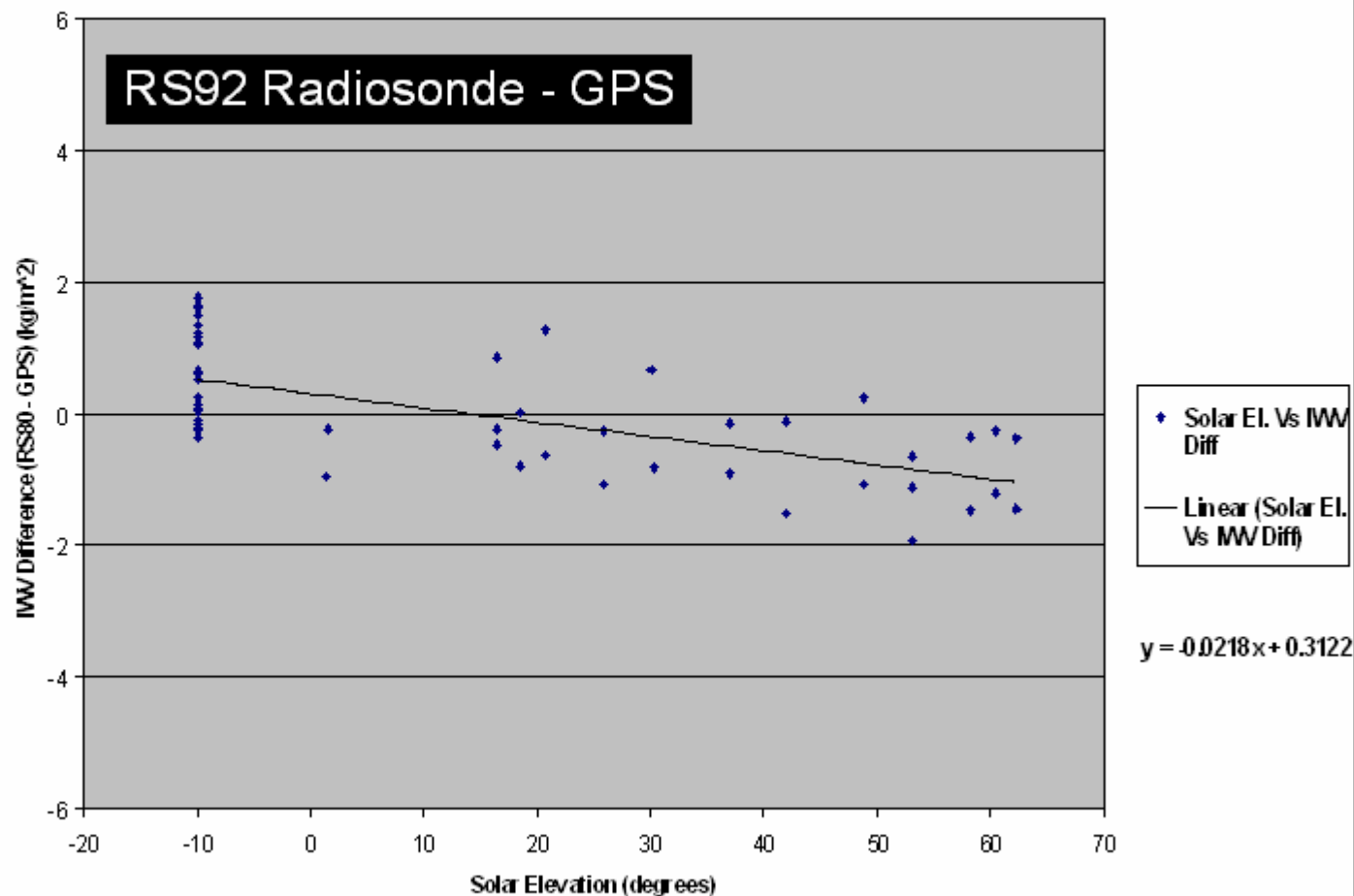
Radiosonde lower at higher solar elevations

Camborne Solar El. vs IWV Diff. (RS80-GPS) June 2001 - March 2005



Radiosonde lower at higher solar elevations

Camborne Solar El. vs IWV Diff. (RS92-GPS) May 2005 - Dec 2007

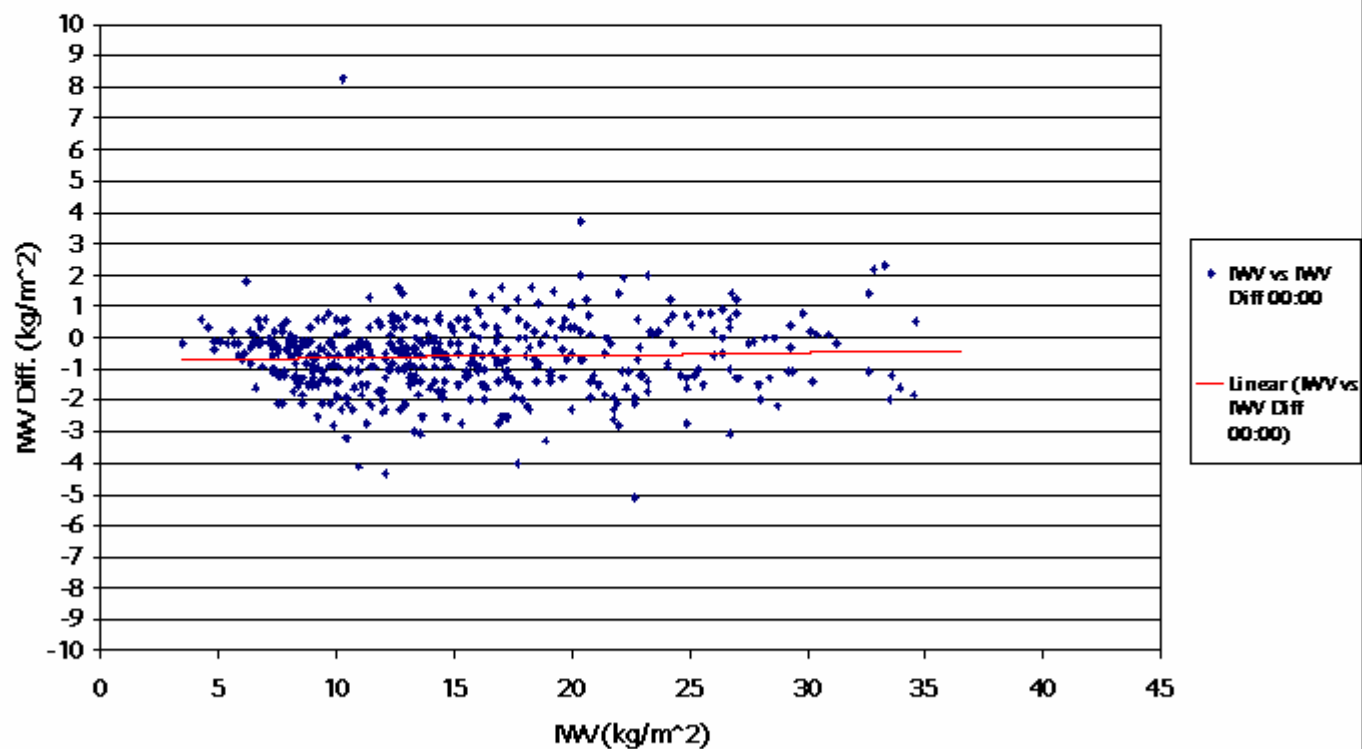




- Day vs. Night Biases for all 3 UK sites (Lerwick, Herstmonceux and Camborne combined) for 2005
 - Show more of a RS-GPS difference in the daytime than the night time

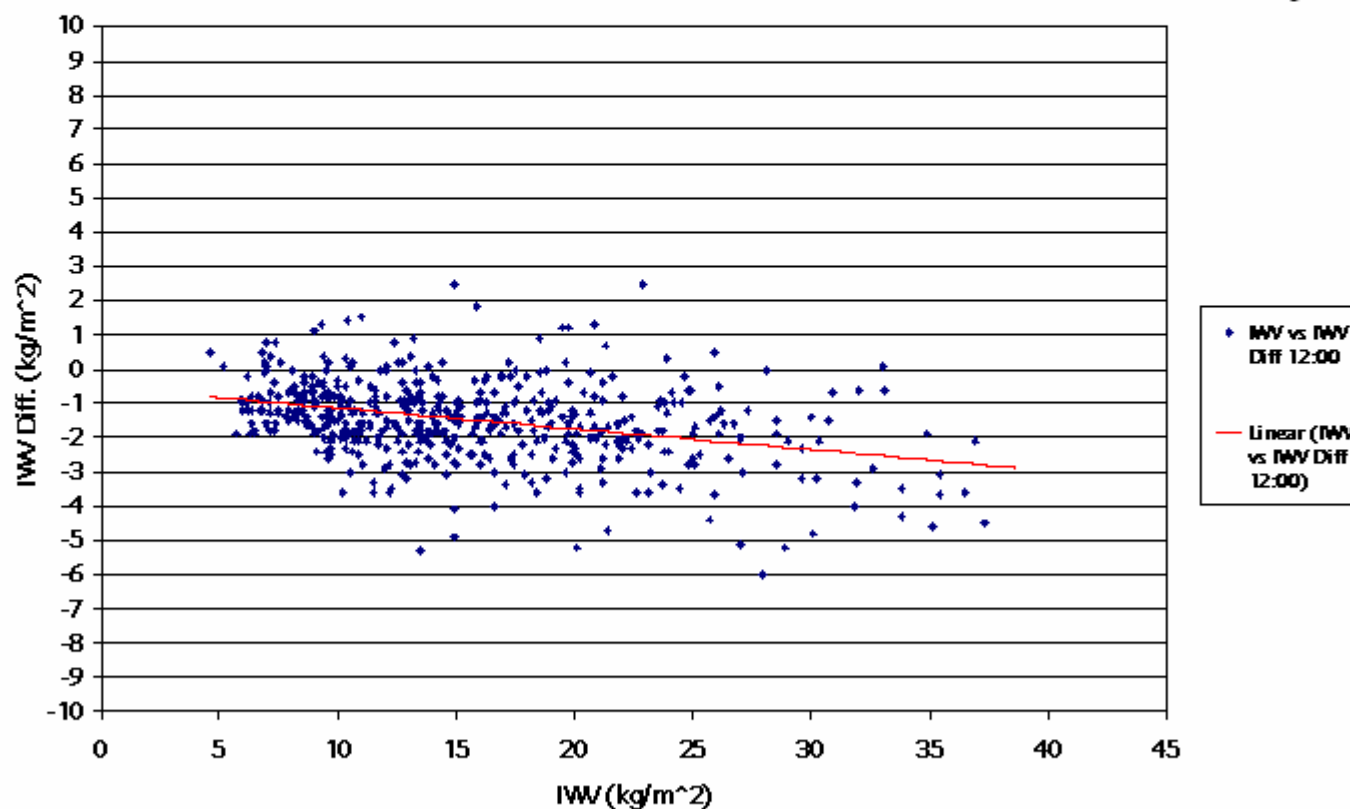
IWV vs IWV Difference (RS-GPS) CAMB, HERS + LERW Combined
00:00 Monthly Averages 2005

Night



IWV vs IWV Difference (RS-GPS) CAMB, HERS + LERW Combined
12:00 Monthly Averages 2005

Day



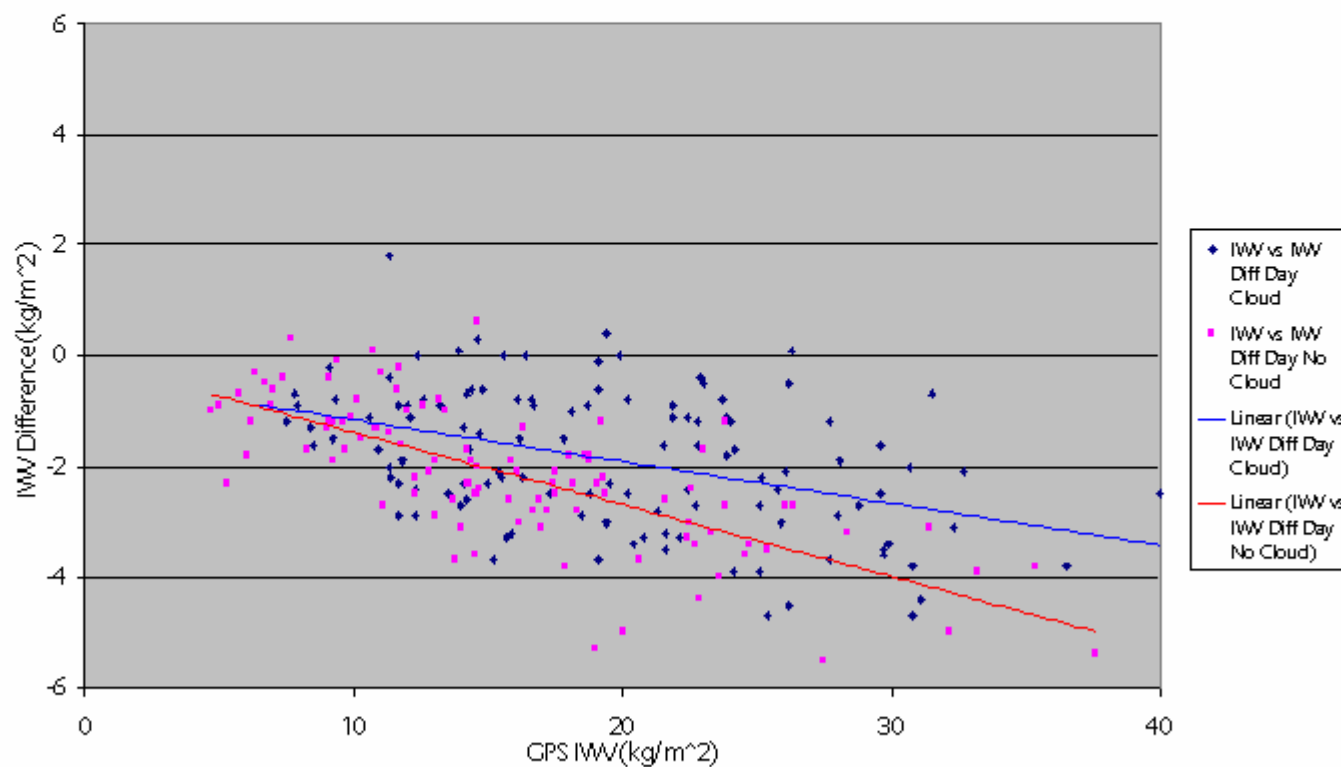


- Day vs. night, cloud vs. no-cloud plots, Camborne 2003
- Plots show that there is the greatest bias in the daytime when there is no cloud (solar heating of RS80 humidity sensor)
- However, there still exists a bias of cloud vs. no cloud in the night time which needs to be investigated further with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

Day, Cloud vs. No Cloud

12:00 with =>5 Octas cloud cover IWW vs IWW Diff. CAMB (RS80-GPS) 2003
 12:00 with =<4 Octas cloud cover IWW vs IWW Diff. CAMB (RS80-GPS) 2003

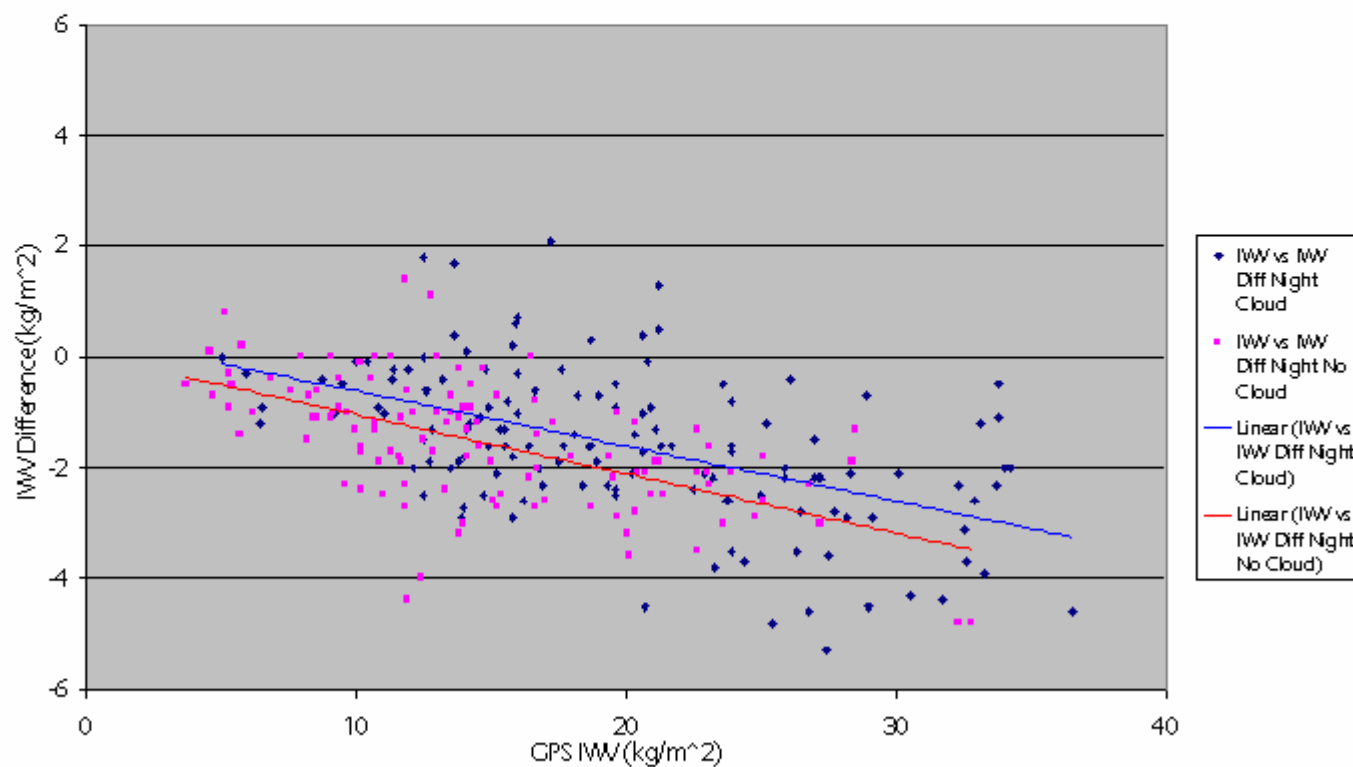
Day



Night, Cloud vs. No Cloud

00:00 with \Rightarrow 5 Octas cloud cover IWW vs IWW Diff. CAMB (RS80-GPS) 2003
 00:00 with \leq 4 Octas cloud cover IWW vs IWW Diff. CAMB (RS80-GPS) 2003

Night





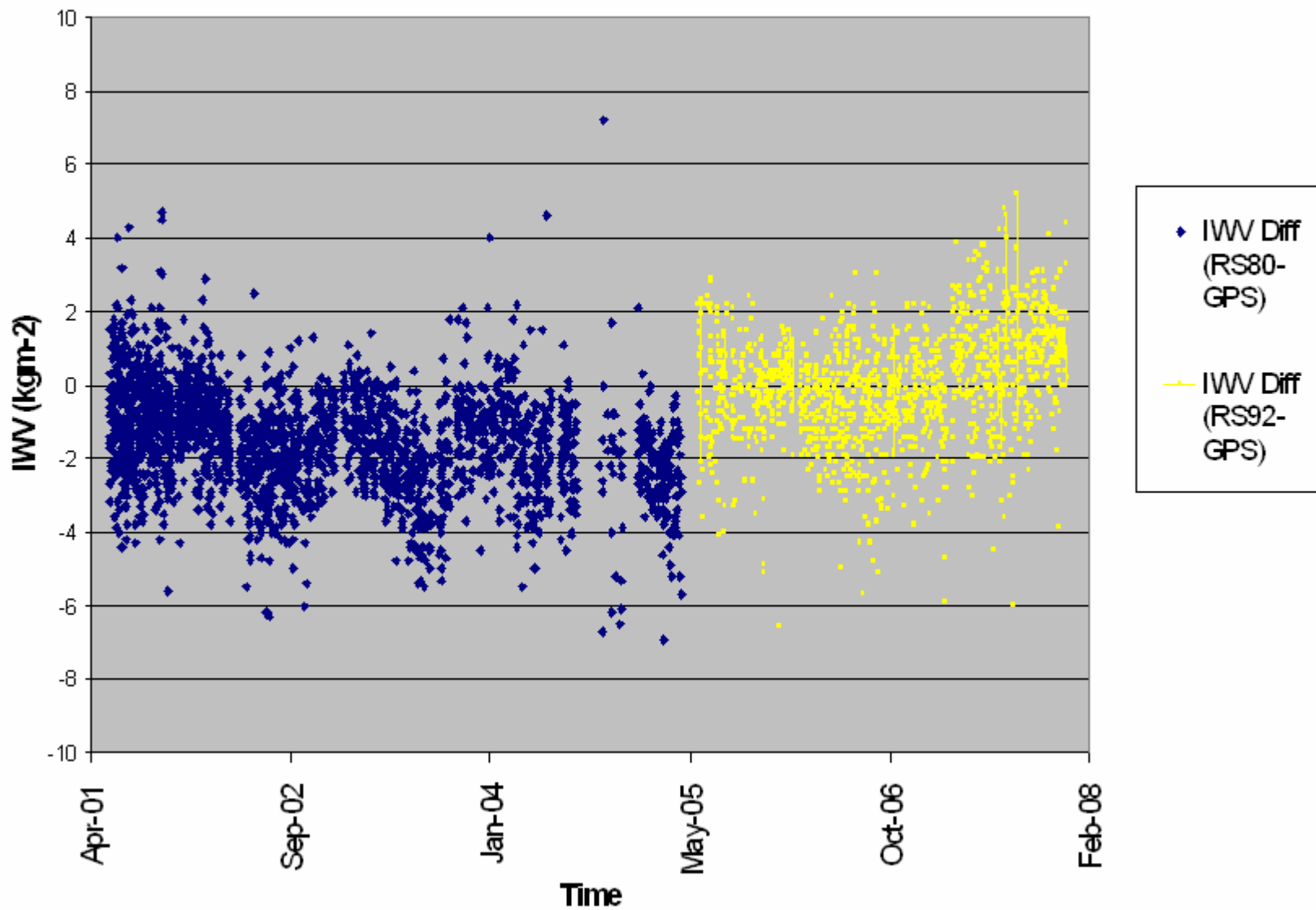
- The following plot identifies Long term RS-GPS bias plot at Camborne
 - Clearly showing introduction of RS92's
 - Thus far seeing less seasonal variability than with RS80's



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?

Long Term Trend of IWV Difference (RS-GPS) Trend of IWV at Camborne June 2001 - Dec 2007





Questions & answers