Introduction to upper air measurements with radiosondes and other in situ observing systems [3]

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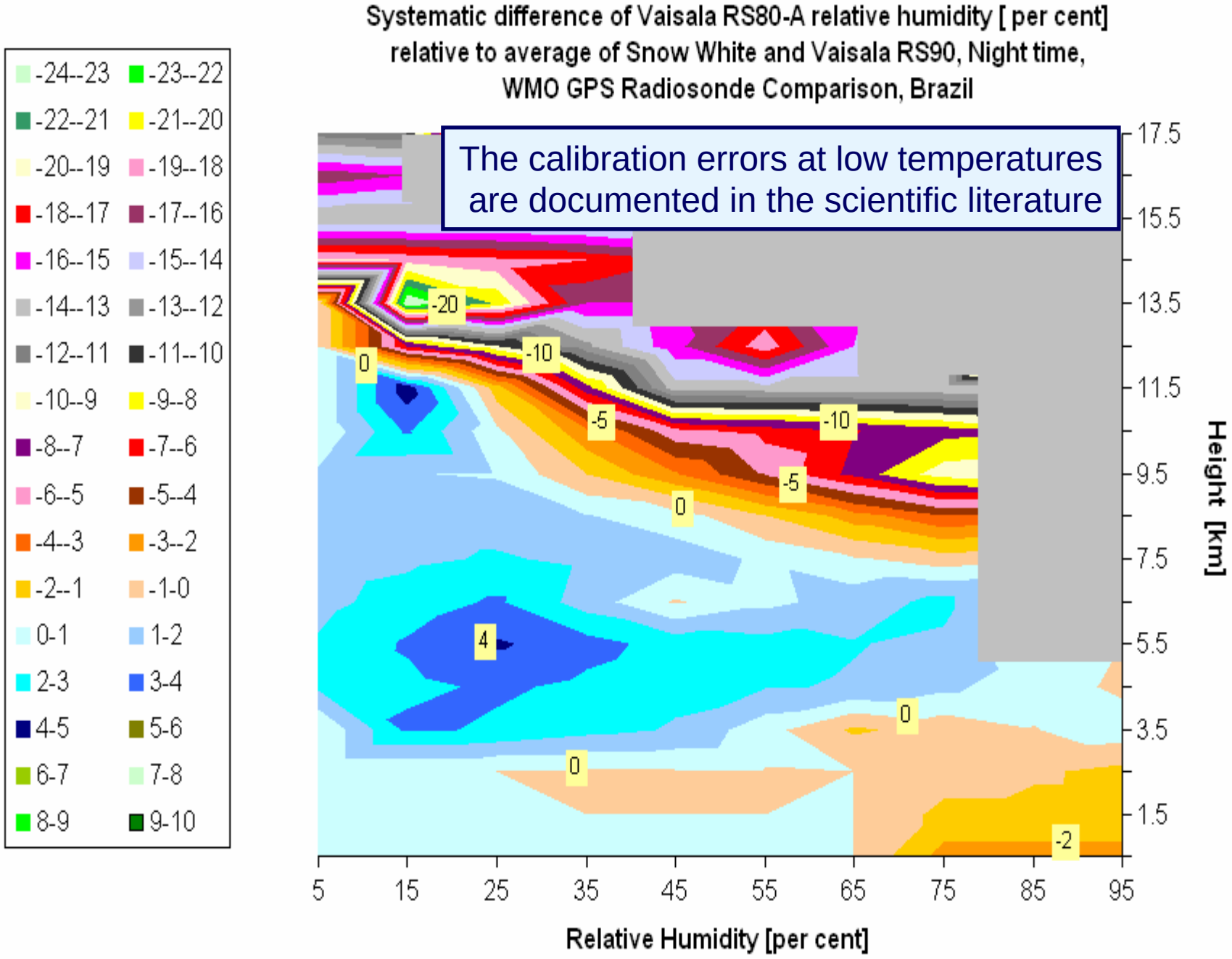
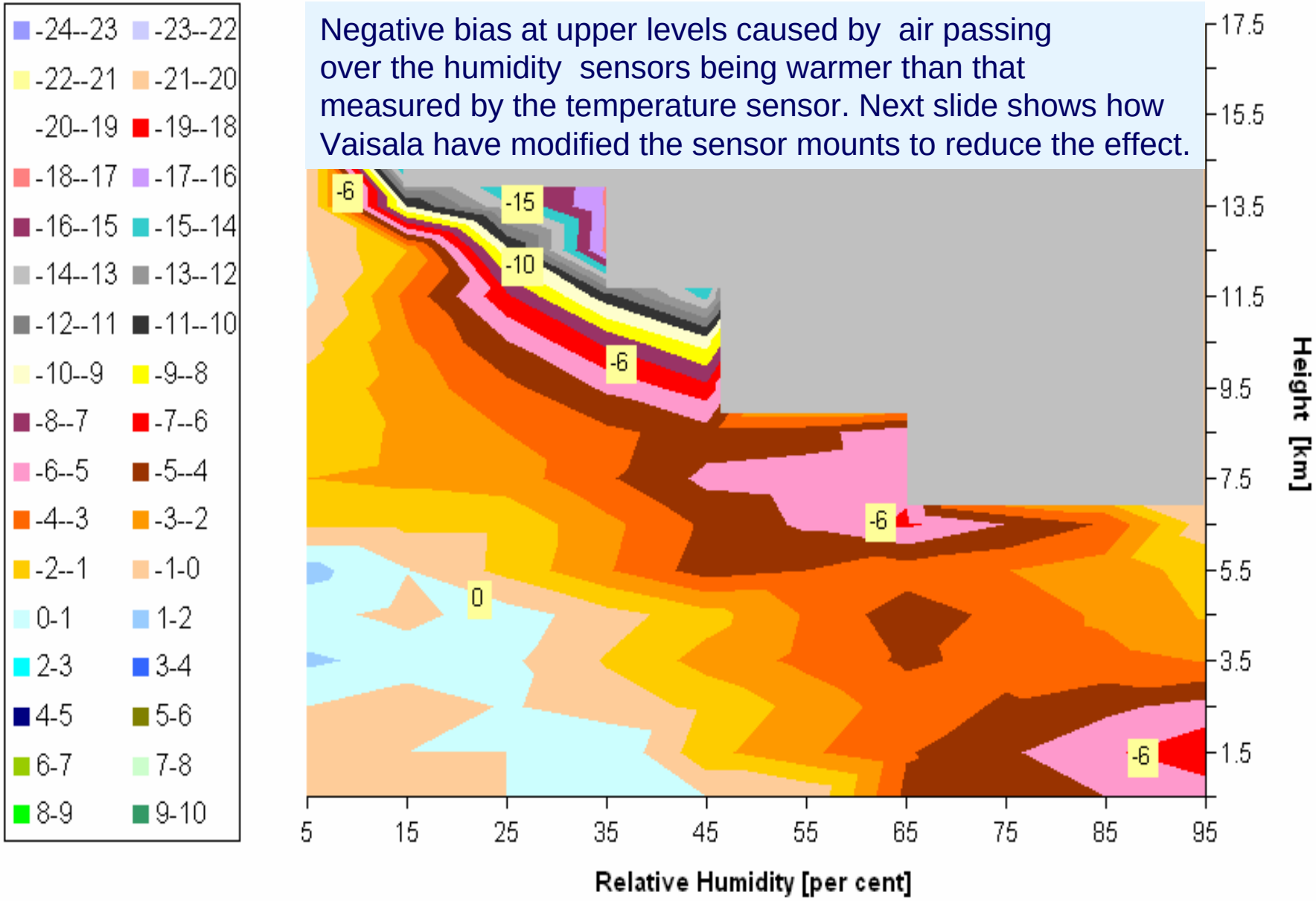

Systematic difference of Vaisala RS80-A relative humidity [per cent]
relative to average of Snow White and Vaisala RS90, Night time,
WMO GPS Radiosonde Comparison, Brazil
The calibration errors at low temperatures are documented in the scientific literature
-24--23
-23--22
-22--21
-21--20
-20--19
-19--18
-18--17
-17--16
-16--15
-15--14
-14--13
-13--12
-12--11
-11--10
-10--9
-9--8
-8--7
-7--6
-6--5
-5--4
-4--3
-3--2
-2--1
-1-0
0-1
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
9-10
-20
-10
0
-5
-10
-5
0
4
0
0
-2
17.5
15.5
13.5
11.5
9.5
7.5
5.5
3.5
1.5
Height [km]
5
15
25
35
45
55
65
75
85
95
Relative Humidity [per cent]

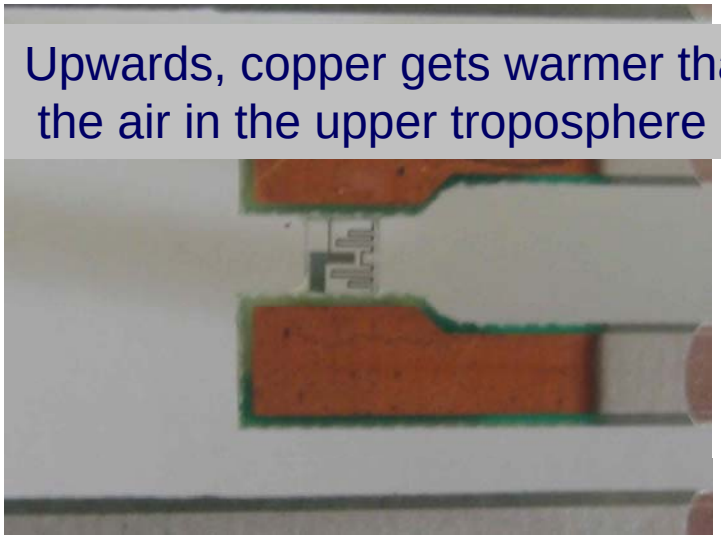
Systematic difference of Vaisala RS90 relative humdity [per cent] relative to average of Snow White and Vaisala RS90, Day time, WMO GPS Radiosonde Comparison, Brazil

Negative bias at upper levels caused by air passing over the humidity sensors being warmer than that measured by the temperature sensor. Next slide shows how Vaisala have modified the sensor mounts to reduce the effect.

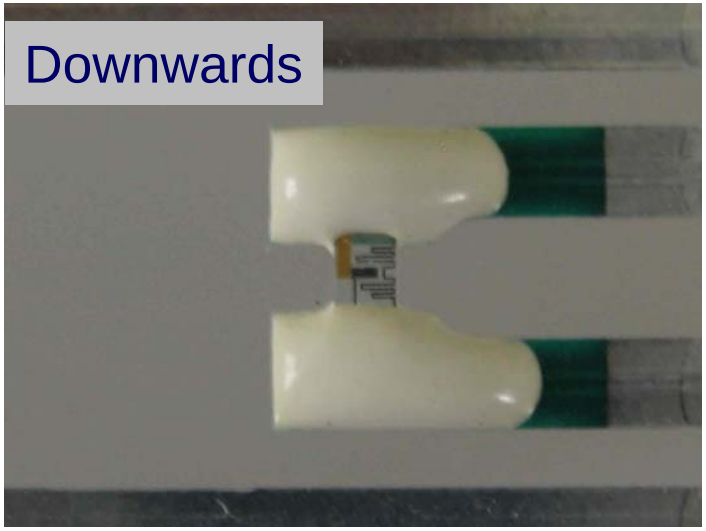


Changes to Vaisala RS92 sensor to reduce daytime heating errors in relative humidity

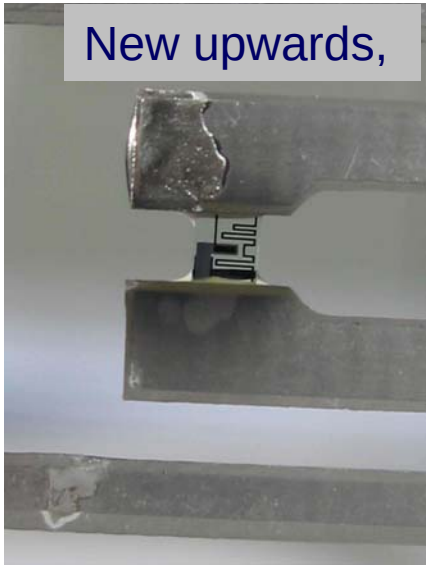
Upwards, copper gets warmer than the air in the upper troposphere



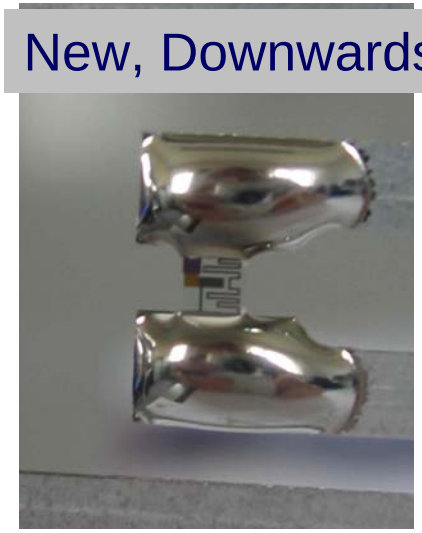
Downwards



New upwards,



New, Downwards



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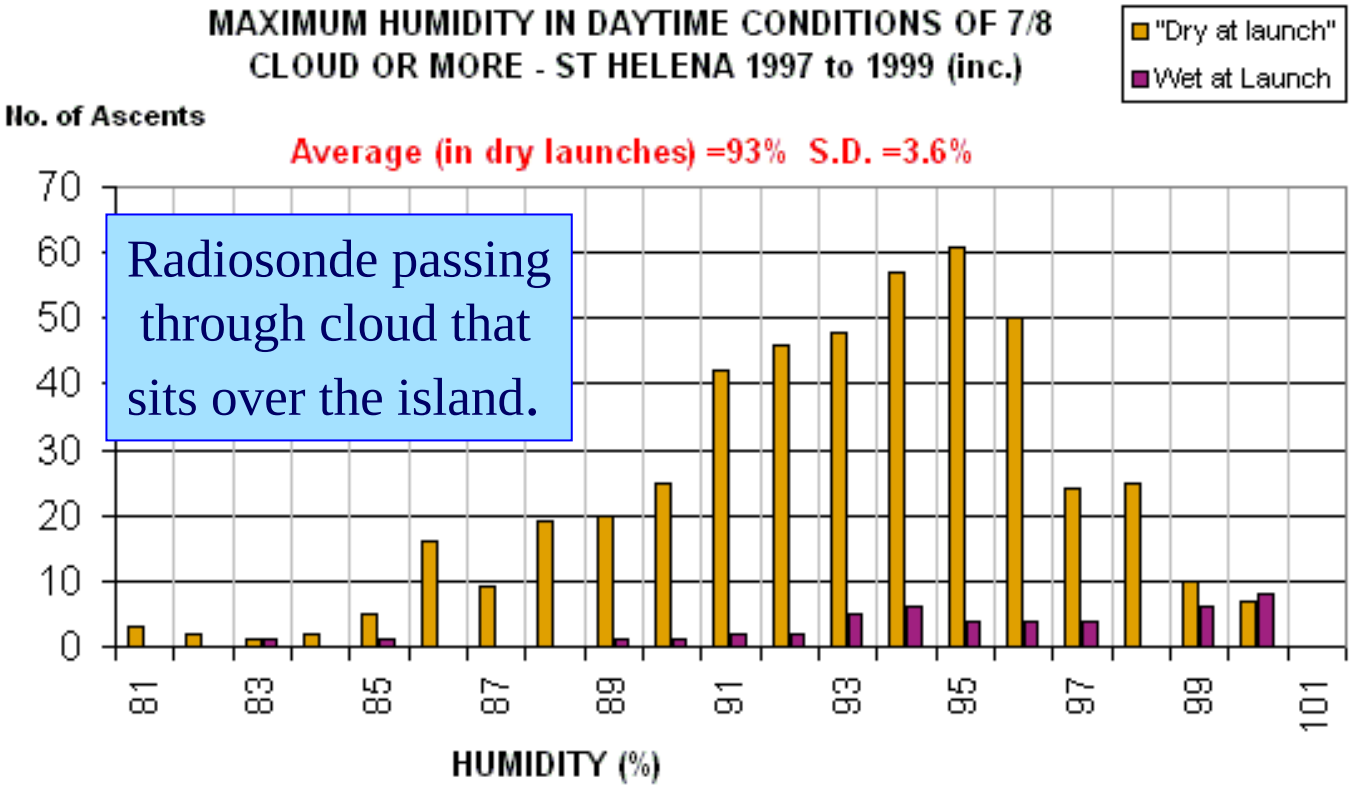
Operational monitoring of relative humidity in low cloud



Radiosonde passing through cloud that sits over the island.

The values in this histogram ought to be centred close to 100 per cent , not 93 per cent

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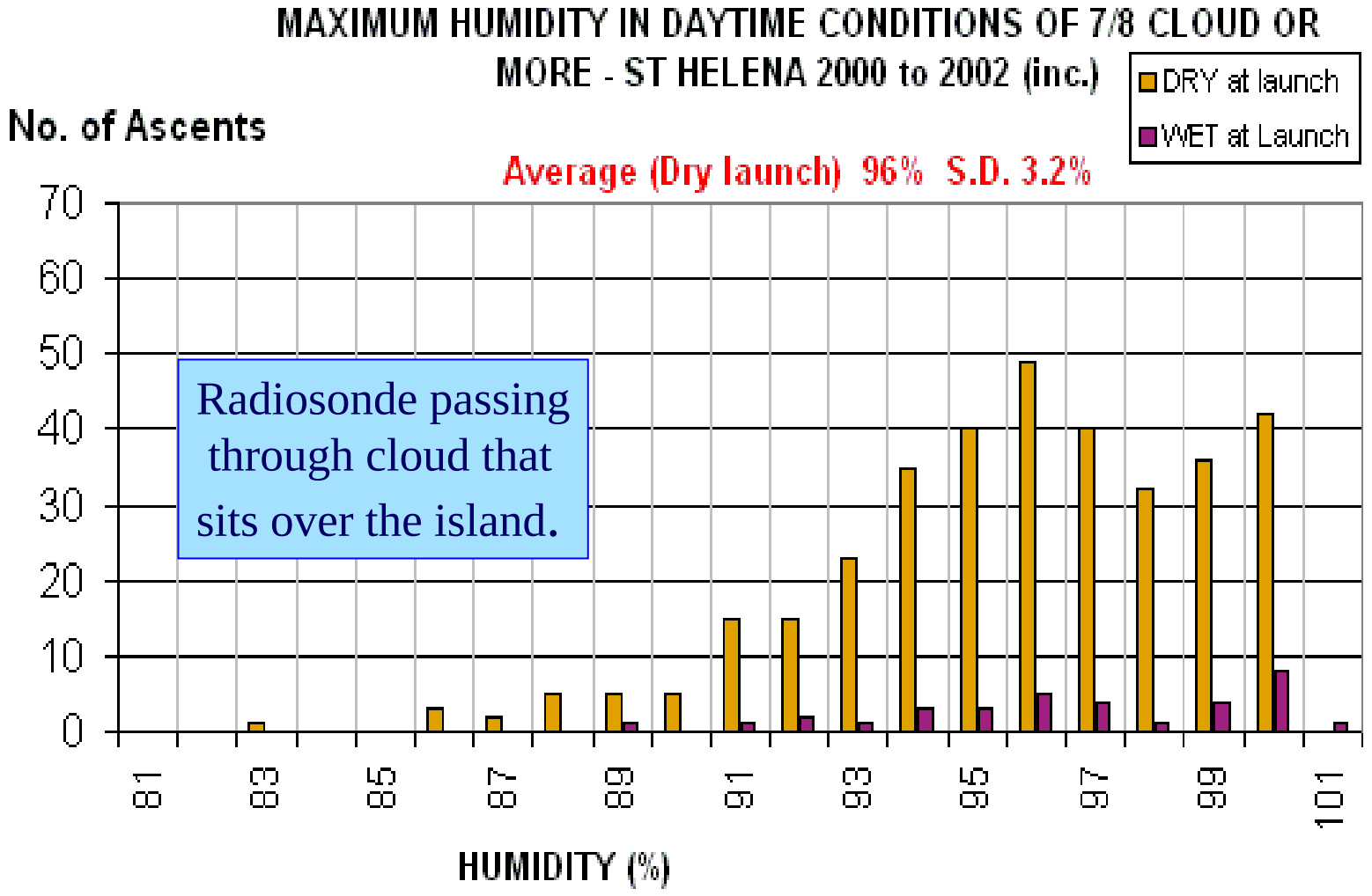
Many Vaisala RS80 measurements suffer dry bias because of chemical contamination.



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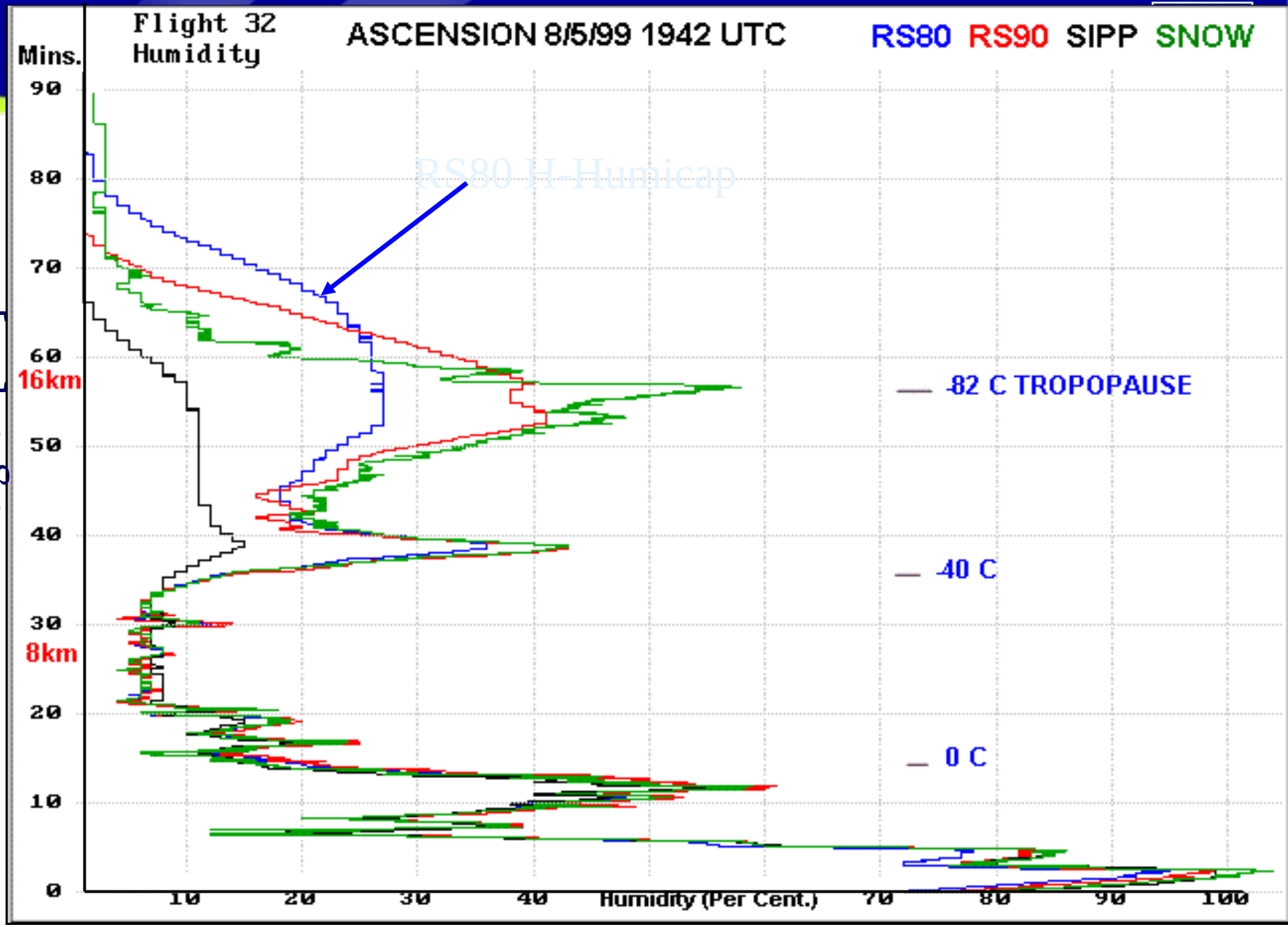

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Summary of Relative humidity sensors.

- Modern [capacitative] sensors can measure reliably to much lower temperatures than older sensors.. to as low as -70 deg C, with humidity errors probably lower than 5 per cent at high humidity at night and probably in the range 10 to 15 per cent relative humidity at the lowest temperature.
- Daytime measurements may have significant negative bias especially in the upper troposphere, and designs are in the process of being optimised for daytime work.
- Water or ice contamination can be a significant problem at night if ventilation of the sensors is poor, giving positive biases of up to 10 per cent on average after emerging from cloud.
- Chemical contamination can be eliminated by careful preparation of the radiosonde before flight.

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Pressure sensor errors

- In the UK, pressure sensor errors before 1978 were often quite large [5 to 10 hPa] in the stratosphere, with radar tracking commonly used to provide height at pressures lower than 100 hPa.

- 1 hPa error gives 220 m height error at 30 hPa,
  667 m height error at 10 hPa

- This magnitude of error was probably common on many older types of radiosondes, and errors larger than 4 hPa were found on two radiosondes in the early Phases of the WMO Radiosonde Comparisons .

- For India and China, the performance of the sensor did not appear reproducible to a better accuracy than 2 hPa even though the results actually submitted may have been within 1 hPa on average from the best estimate of truth .

- Best modern radiosondes have pressure errors much lower than 1 hPa in the stratosphere.

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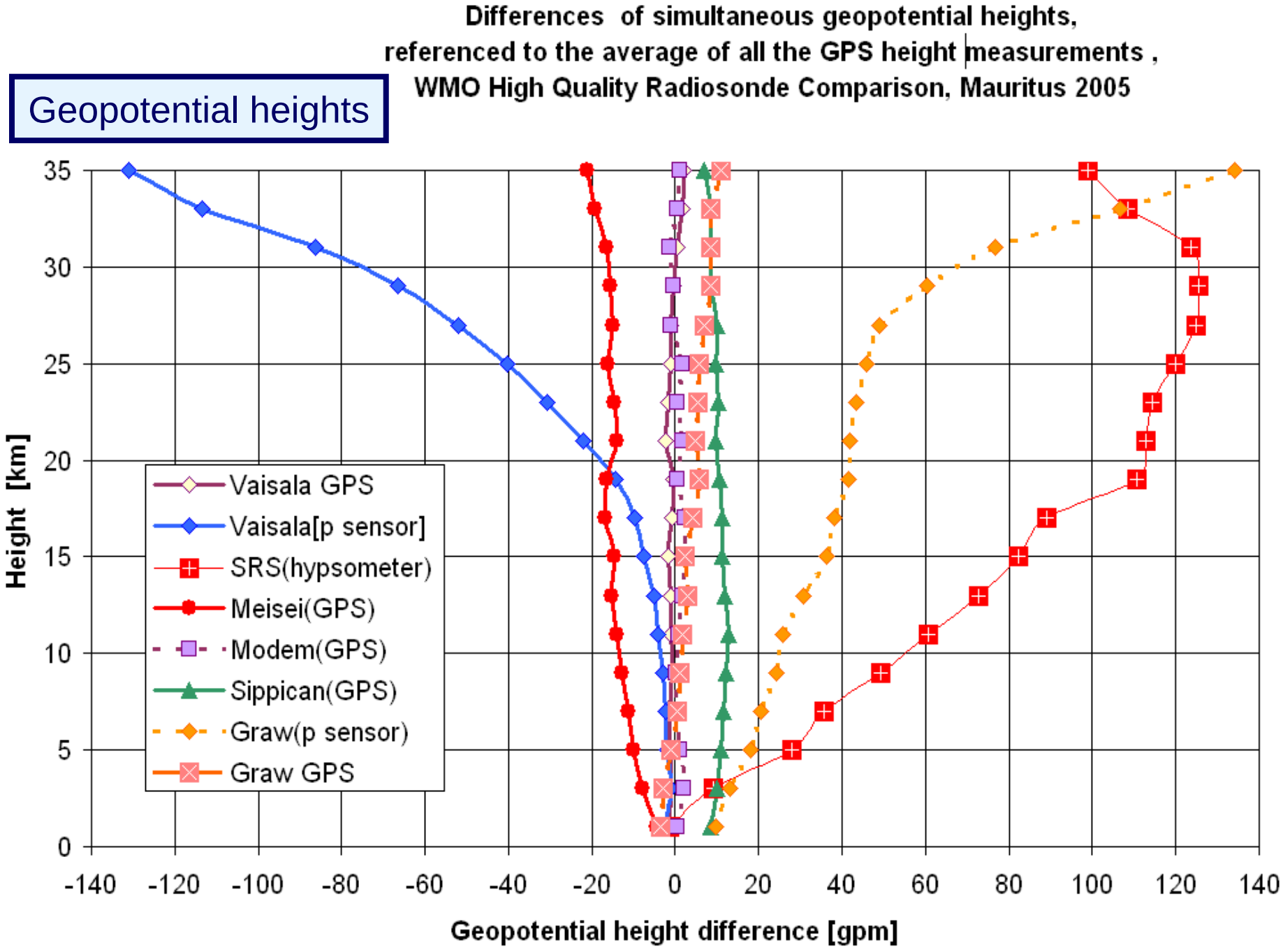
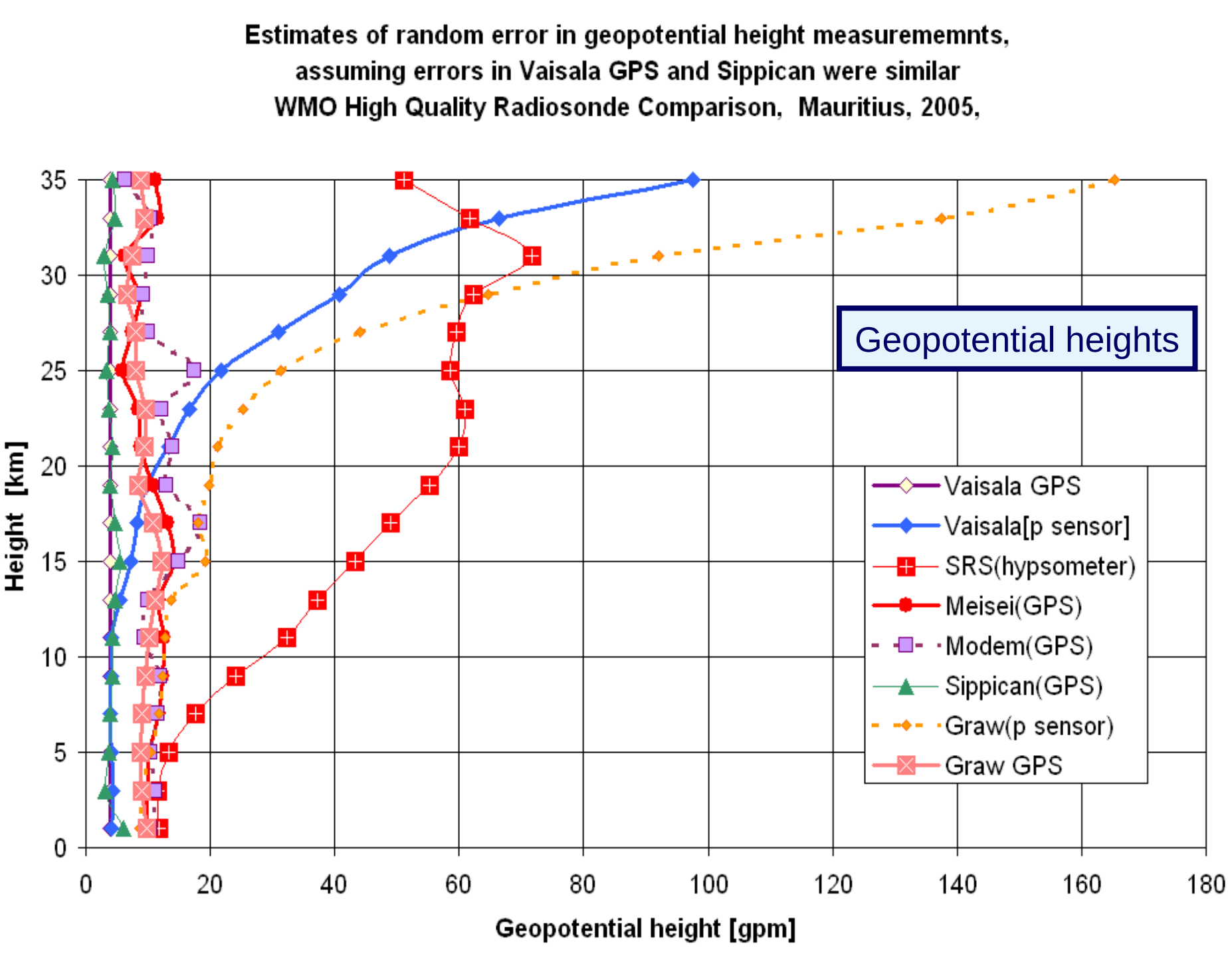
Geopotential heights




Estimates of random error in geopotential height measurememnts,
assuming errors in Vaisala GPS and Sippican were similar
WMO High Quality Radiosonde Comparison, Mauritius, 2005,
Geopotential heights
Vaisala GPS
Vaisala[p sensor]
SRS(hypsometer)
Meisei(GPS)
Modem(GPS)
Sippican(GPS)
Graw(p sensor)
Graw GPS
Height [km]
0
5
10
15
20
25
30
35
0
20
40
60
80
100
120
140
160
180
Geopotential height [gpm]

Basic source on aircraft measurements

- Guide to Meteorological Instruments and Methods of Observation
  Seventh Edition [revised 2006]
  WMO- No8

Should be available in electronic form from WMO by end of 2007???

Part II

chapter 3 Aircraft observations

Temperature random errors depend on aircraft speed and are in the range 0.3 to 0.4 deg C.

Wind random errors 2-3 ms^{-1}

Presssure errors 2 hPa at cruise level

Heights defined by the International standard atmosphere.

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Questions & Answers