RADIOSONDE RS41 AND RS92 KEY DIFFERENCES AND COMPARISON TEST RESULTS IN DIFFERENT LOCATIONS AND CLIMATES

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ABSTRACT

The data obtained from synoptic radiosonde observations performed globally has a high impact on operational weather forecasting. Furthermore, the sounding data records are important for climate study. Vaisala has developed a new radiosonde for various atmospheric observation needs. In order to quantify the differences between Vaisala Radiosonde RS41 and the widely used Vaisala Radiosonde RS92, comparison flight campaigns have been performed in several selected locations, representing various climate conditions.

Radiosonde RS41 incorporates new technological concepts and improvements to the measurement of atmospheric temperature, humidity and pressure. It is of great importance to understand the possible changes the new instrumentation may introduce in the observation data. Test rigs with multiple radiosondes have been used for accurate characterization of differences between radiosonde models RS41 and RS92. Comparison test results from several locations, such as Finland, United Kindom, Czech Republic and Malaysia will be presented in this paper.

Vaisala Radiosonde RS41 shows consistent improvement of temperature and humidity measurement reproducibility in day and night time conditions. Based on the results of the performed flight test campaigns, the impact of the switch from RS92 to RS41 on climatological time series is estimated to be moderate. The most significant impact on average values will be seen in humidity measurements in tropical climates, in the humid conditions of the upper troposphere.

INTRODUCTION

Vaisala Radiosonde RS41 is a major new platform in the long continuum of the history of Vaisala radiosonde development. With the new technological solutions, Radiosonde RS41 delivers improved measurement accuracy on atmospheric temperature, humidity and pressure profile measurement. RS41 is operated with Vaisala DigiCORA® Sounding System MW41. RS41 pre-flight check and frequency setting is performed in a highly-automated process by using Ground Check Device RI41.

The paper presents the Radiosonde RS41 technology and expresses the key differences when compared to Radiosonde RS92. Comparison test results between Vaisala RS41 and RS92 Radiosonde models from tropical, mid-latitude and high-latitude locations are presented, with the emphasis on the temperature and humidity measurement results. The sounding test results demonstrate an improved temperature and humidity measurement reproducibility with RS41 during night and daytime conditions. The measured temperature differences are moderate in general. Greater differences between RS41 and RS92 radiosondes humidity measurment can be detected at daytime tropical tropopause region at very cold temperatures.

Vaisala Radiosonde RS41-SG uses the Global Positioning System (GPS) for observations of height, pressure, horizontal location and wind. The RS41 GPS-based and the RS92 pressure sensor-based techniques for measuring geopotential height and atmospheric pressure, as well as impact on temperature and humidity measurement are described in references [1] and [2].

VAISALA RADIOSONDE RS41 TECHNOLOGY AND COMPARISON WITH RS92

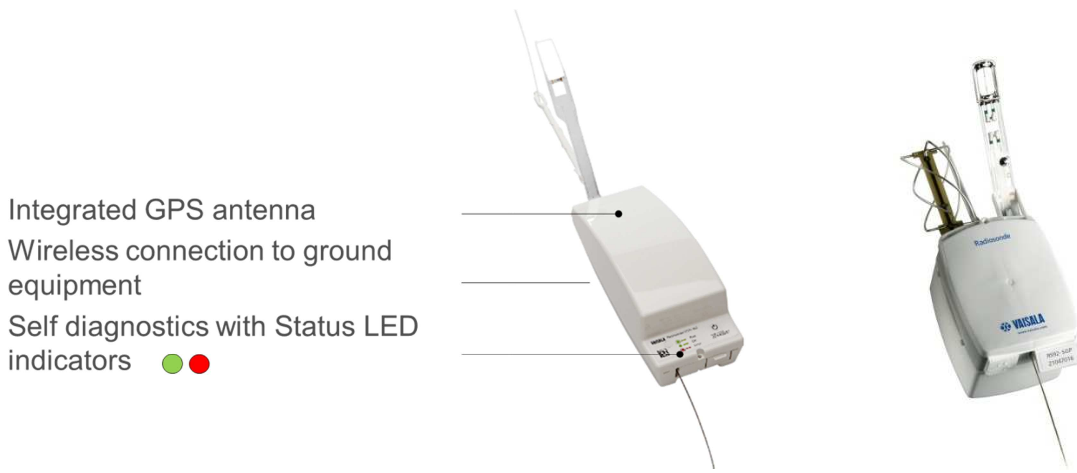

Figure 1. Vaisala Radiosonde RS41 and Vaisala Radiosonde RS92

Figure 1 presents the construction of RS41-SG, and, for reference, the construction of RS92. On the top of the radiosondes, the sensor boom serves as a support structure for the temperature and humidity sensors. For improved ruggedness, the RS41 Radiosonde GPS antenna is integrated to the radiosonde electronics board, residing in the radiosonde body. The radiosonde is powered with integrated batteries, contributing to the automated sounding preparations. During the preparation phase, RS41-SG gives a message on the radiosonde’s status, and the status of readiness is indicated with green and red LED lights. In case there is any need to discontinue the sounding operations, for example, for an external reason, it is possible to temporarily turn off and turn on the radiosonde transmission by pressing the radiosonde power switch. The solution eliminates the need for opening the radiosonde case for battery connection or disconnection, simplifying the use compared with RS92. In order to further improve the usability and reliability during the ground check phase, the galvanic contact currently used in RS92 is replaced with a short-range wireless link.

RS41 introduces a new type of unwinder concept. During radiosonde preparation and balloon filling phase, the radiosonde and the unwinder are separated, which eases the operation. The unwinder can be connected to the balloon as soon as the sounding preparations begin. When the radiosonde is ready for the launch, it is brought to the balloon shed and connected to the unwinder by attaching the unwinder connection stick to the radiosonde (**Figure 2**). The sensor boom is also bent automatically and reliably to the right flight position.

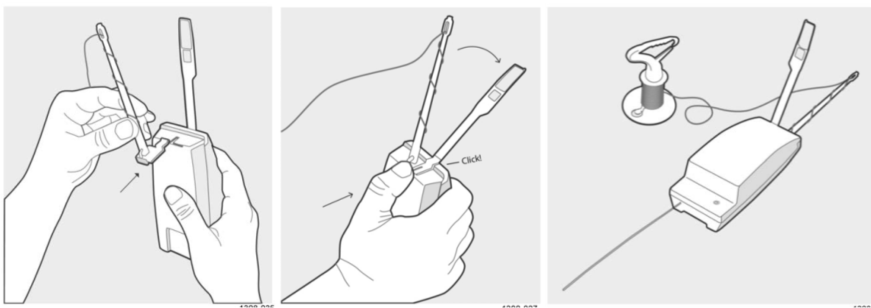

Figure 2. Vaisala RS41 Radiosonde unwider concept

Tables 1 and 2 summarize the key differences of the technical and usability-related issues/facts between RS41 and RS92 Radiosonde models.

Feature	RS41-SG	RS92-SGPD
Weight (1	109 g	280 g
Dimensions	272 x 63 x 46 mm	220 x 80 x 75 mm
Battery type	Lithium, nominal 3 V	Alkaline, nominal 9 V
Battery capacity	> 240 min	135 min
Transmitter standard	EN 302 054	EN 302 054
Transmitter power	Min. 60 mW	60 mW
Telemetry range (with RB31 antenna)	350 km	350 km
Measument cycle	1 s	1 s

1) Weight does not include unwinder and other possible extra rigging, such as parachute.

Table1. RS41-SG and RS92-SGPD technical features comparison

Usability features	RS41	RS92
Batteries	**Integrated low weight batteries** Makes preparation easy and fast. No need for batteries mechanical assembly. Reduced weight saves gas. Reduced environmental footprint	Separate battery package
Radiosonde power-on and power-off	**Automatic On-switching during ground check** **Additional On/Off button** Convenient operation also in case of delayed launch	Manually by connecting / disconnecting battery package.
Radiosonde launch readiness indication	**Status LED indicators** Radiosonde self-diagnostics information prior to launch	No self-diagnostics in radiosonde
Unwinder	**Radiosonde and unwinder separated during preparation phase.** Allows easy “string-free” radiosonde preparation indoors.	Unwinder fixed to radiosonde
GPS antenna	**Integrated antenna**	External helix antenna

Table 2: RS41-SG and RS92-SGPD usability features comparison

Radiosonde RS41 temperature measurement technology

Vaisala Radiosonde RS41-SG temperature measurement is based on a resistive platinum temperature sensor technology. Platinum resistor temperature sensors are characterized by linearity and excellent calibration stability. The sensor is specifically designed for the atmospheric temperature measurement in the radiosonde application. **Figure 3** presents the temperature sensor integrated to the sensor support structure. By this construction, the measurement noise in the higher part of the atmosphere is significantly reduced compared with Radiosonde RS92's design. The RS41 temperature sensor also incorporates effective protection from evaporating cooling, a phenomenon occasionally encountered when the radiosonde emerges from a cloud top.

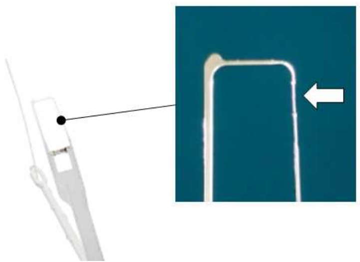

Figure 3. Vaisala Radiosonde RS41-SG temperature sensor

Vaisala RS41 temperature measurement is traceable to SI-standards. The measurement uncertainty has been characterized by following the recommendations of JCGM 100:2008. The measurement traceability and uncertainty analysis are described in more detail in reference [3].

RS41-SG Radiosonde temperature measurement specifications, as well as comparison to RS92-SGPD Radiosonde are presented in the **Table 3**.

Temperature	RS41-SG	RS92-SGPD
Sensor type	**Platinum Resistor**	**Capacitive wire**
Combined uncertainty in sounding 1)	0.3 ºC < 16 km 0.4 ºC > 16 km	0.5 ºC < 16 km 0.5 ºC > 16 km
Reproducibility in sounding 2)	0.15 ºC > 100 hPa 0.3 ºC < 100 hPa	0.2 ºC > 100 hPa 0.5 ºC < 100 hPa
Repeatability in calibration 3)	0.1 ºC	0.15 ºC
Response time (63.2 %, 6 m/s, 1000 hPa)	0.5 s Time lag correction applied, negligible residual errors	0.4 s No time lag correction
Ground check	No correction needed. In-built temperature check to find faulty units	Corrected against Pt100 reference

1) 2-sigma (k=2) confidence level (95.5%) cumulative uncertainty.
2) Standard deviation of differences in twin soundings, ascent rate above 3 m/s.
3) Standard deviation of differences between two successive repeated calibrations, k=2 confidence level.

Table 3. Comparison of RS41 and RS92 temperature measurement specifications

Radiosonde RS41 humidity measurement technology

The humidity measurement of RS41 Radiosonde is based on the capacitive Vaisala Humicap® polymer sensor technology. The sensor heating function enables an active and effective de-icing method when a radiosonde is flying through layers with freezing conditions. As a new feature, the sensor incorporates an on-chip temperature sensor. The function improves humidity measurement accuracy and can be utilized especially in the measurement of upper troposphere humidity at day time conditions, where solar radiation may cause additional sensor heating. By utilizing the temperature data of the chip as an integral part of the humidity calculation, the effect of solar radiation is eliminated, and no radiation corrections are needed. The heating and temperature measurement capability of the humidity sensor are also utilized during the radiosonde ground preparation phase for humidity sensor reconditioning and ground checking.

RS41-SG Radiosonde humidity measurement specifications, as well as comparison to RS92-SGPD Radiosonde are presented in **Table 4**.

Humidity	**RS41-SG**	**RS92-SGPD**
Sensor type	**Thin-film capacitor, integrated T sensor and heating functionality**	**Thin-film capacitor, heated twin sensor**
Combined uncertainty in sounding 1)	4 %RH	5 %RH
Reproducibility in sounding 2)	2 %RH	2 %RH
Repeatability in calibration 3)	2 %RH	2 %RH
Response time (63.2 %, 6 m/s flow, 1000 hPa)	< 0.3 s, +20 ºC < 10 s, -40 ºC	< 0.5 s, +20 ºC < 20 s, -40 ºC
Ground check	Corrected with RS41 in-built Physical Zero Humidity Check	Corrected against 0%RH humidity generated by desiccants

1) 2-sigma (k=2) confidence level (95.5%) cumulative uncertainty.
2) Standard deviation of differences in twin soundings, ascent rateabove 3 m/s.
3) Standard deviation of differences between two successive repeated calibrations, k=2 confidence level.

Table 4. Comparison of RS41 and RS92 humidity measurement specifications.

Pressure and height measurement

Pressure and height specifications for RS41-SG GPS-based measurement are presented in **Table 5**. Also the comparison to pressure-based RS92-SGPD is presented.

Pressure	**RS41-SG**	**RS92-SGPD**
Sensor type	**GPS derived**	**Silicon, Capacitive sensor**
Combined uncertainty in sounding 1)	1.0 hPa > 100 hPa 0.3 hPa < 100 hPa 0.04 hPa < 10 hPa	1.0 hPa > 100 hPa 0.6 hPa < 100 hPa 0.6 hPa < 10 hPa
Reproducibility in sounding 2)	0.5 hPa > 100 hPa 0.2 hPa < 100 hPa 0.04 hPa < 10 hPa	0.5 hPa > 100 hPa 0.3 hPa < 100 hPa 0.3 hPa < 10 hPa
Geopotential height		
Combined uncertainty in sounding 1)	10 gpm	Derived from pressure
Reproducibility in sounding 2)	6 gpm	Derived from pressure

1) 2-sigma (k=2) confidence level (95.5%) cumulative uncertainty.
2) Standard deviation of differences in twin soundings, ascent rate above 3 m/s.

Table 5. Comparison of RS41 and RS92 pressure measurement specifications

DigiCORA® SOUNDING SYSTEM MW41

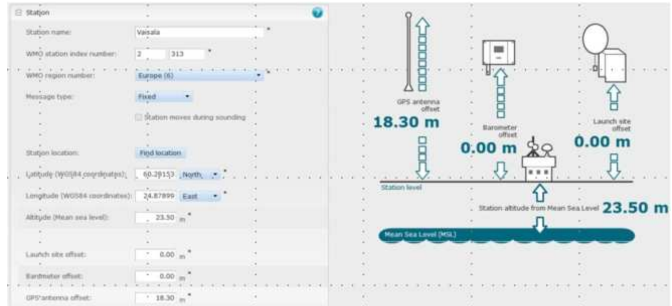

Figure 5. DigiCORA® Sounding System MW41 and example of MW41 user interface

Vaisala Radiosonde RS41 is used with DigiCORA® Sounding System MW41, presented in **Figure 5**. The sounding system consists of Sounding Processing Subsystem SPS311, a workstation running the DigiCORA® Sounding System software, and Ground Check Device RI41. The installation also includes antennas for the radiosonde signal and local GPS receiving. Sounding System MW41 can be connected to Vaisala Automatic Weather Stations (AWS), which provide surface weather information automatically.

The MW41 user interface is based on a web browser. The interface is designed to be intuitive for reducing human error, as well as reducing operator training time. **Figure 5** presents an example of the user interface screen with a visually-guided station setup.

The generation of meteorological messages in MW41 follows the latest WMO regulations, including TEMP, PILOT and BUFR coding. For specific purposes, the data is also available in XML format.

One of the features of DigiCORA® Sounding System MW41 is the capability to transfer the control of the system to a specified location. Such a configuration is presented in **Figure 6**. For example, configuring the MW41 system can be done remotely. The system gives ability to monitor and retrieve real-time sounding data in graphical and numerical format from a remote location, either through a local area network, or internet. If useful for the operations, a radiosonde can be released at a launch site, but the control of the rest of the sounding and reporting can be changed to the central observatory.

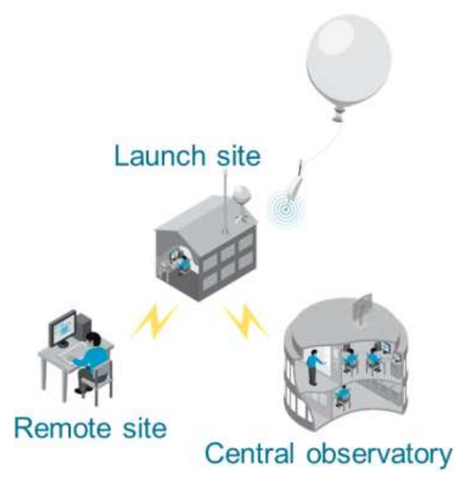

Figure 6.

Ground Check Device RI41 for Radiosonde RS41 and comparison to Ground Check Set GC25

RS41 Radiosonde ground preparations are performed by using Ground Check Device RI41 (**Figure 7)**. After placing RS41 Radiosonde on RI41, the radiosonde starts to communicate with MW41 software through a short-range wireless connection interface. The radiosonde humidity sensor is heated to an elevated temperature for removing any residual chemical contamination that might have occurred during transportation, thus purifying the sensor for accurate humidity measurement. During the heating phase also zero humidity check is conducted. The method enables an accurate and maintenance-free dry reference, with the residual humidity corrections typically in the order of some tenths of %RH.

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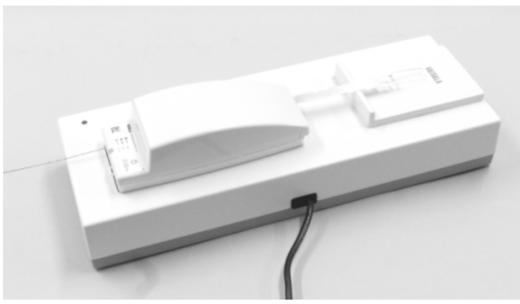

In addition to radiosonde electrical checks, the temperature element of the humidity sensor is used to check against RS41 temperature sensor, giving additional confidence. No temperature calibration fine-tuning is performed during the ground check. Table 6. summarizes the key differences between the use of ground check devices RI41 and GC25.

Figure 7. Ground Check Device RI41 and Radiosonde RS41

Radiosonde preparation	RS41 preparation with RI41	RS92 preparation with GC25
Communication link to ground system during the preparation phase	**Short range RF wireless connection** Makes preparation easy, reliable and maintenance-free	Galvanic communication with a cord and a connector
Humidity reference	**Physical zero reference** 0%RH condition is generated by sensor heating. No need for maintenance	Drying desiccants are used. Requires frequent regular maintenance
Temperature check	**Functional temperature sensor test** Platinum temperature sensor in radiosonde. No need for ground check correction	Temperature sensor ground check correction using platinum reference
Radiosonde frequency setting	**Automatic** MW41 can set radiosonde transmission automatically to pre-defined frequency	Manual through ground system user interface

Table 6. Comparison table for RS41 and RS92 Radiosondes ground check preparation

TEST FLIGHT CAMPAIGNS

Radiosonde RS41 has been tested in sounding test campaigns in several locations representing different climatological conditions. Mid-latitude test campaigns have been performed in Camborne, UK, and in Libus, Prague, Czech Republic. Higher latitude test flights have been done in Finland (Vantaa and Sodankylä). For tropical conditions tests, flights have been performed in Penang, Malaysia. In addition, a large number of concept-level and R&D soundings have been made in various locations in Finland, USA, and Australia. Earlier comparison test summaries have been published in references [4] and [5].

Figure 8 shows a commonly used test rig which carries four radiosondes; two RS41s and two RS92s. The setup enables a direct difference comparison between the RS41 and RS92 radiosonde models, and a characterization of radiosonde type-related reproducibility, by performing an RS41-RS41 and RS92-RS92 comparison.

Figure 8. Test flight rig in Camborne test campaign with two RS41 and two RS92 Radiosondes

In the following, temperature and humidity comparison data from several campaigns are presented with the main emphasis on instrument type data reproducibility and direct differences between RS41 and RS92 Radiosonde measurement.

TEMPERATURE MEASUREMENT RESULTS

Camborne test, temperature

Large-scale RS41/RS92 sounding test campaign was performed in Camborne, UK, in November 2013. 30 ascents, with four radiosondes each, two RS92s and two RS41s, were launched from the Met Office radiosonde station in Camborne during November 2013 in varying weather conditions. The RS92 software and model versions were the same as those used in the WMO intercomparison of high-quality radiosonde systems, Yangjiang, China, 2010 [6], and the design of the trial followed the methodology of WMO intercomparisons. The following presents some characteristic results from the data set. In addition, the UK Met Office has provided a scientifically independent report [7] from the data produced by the trial.

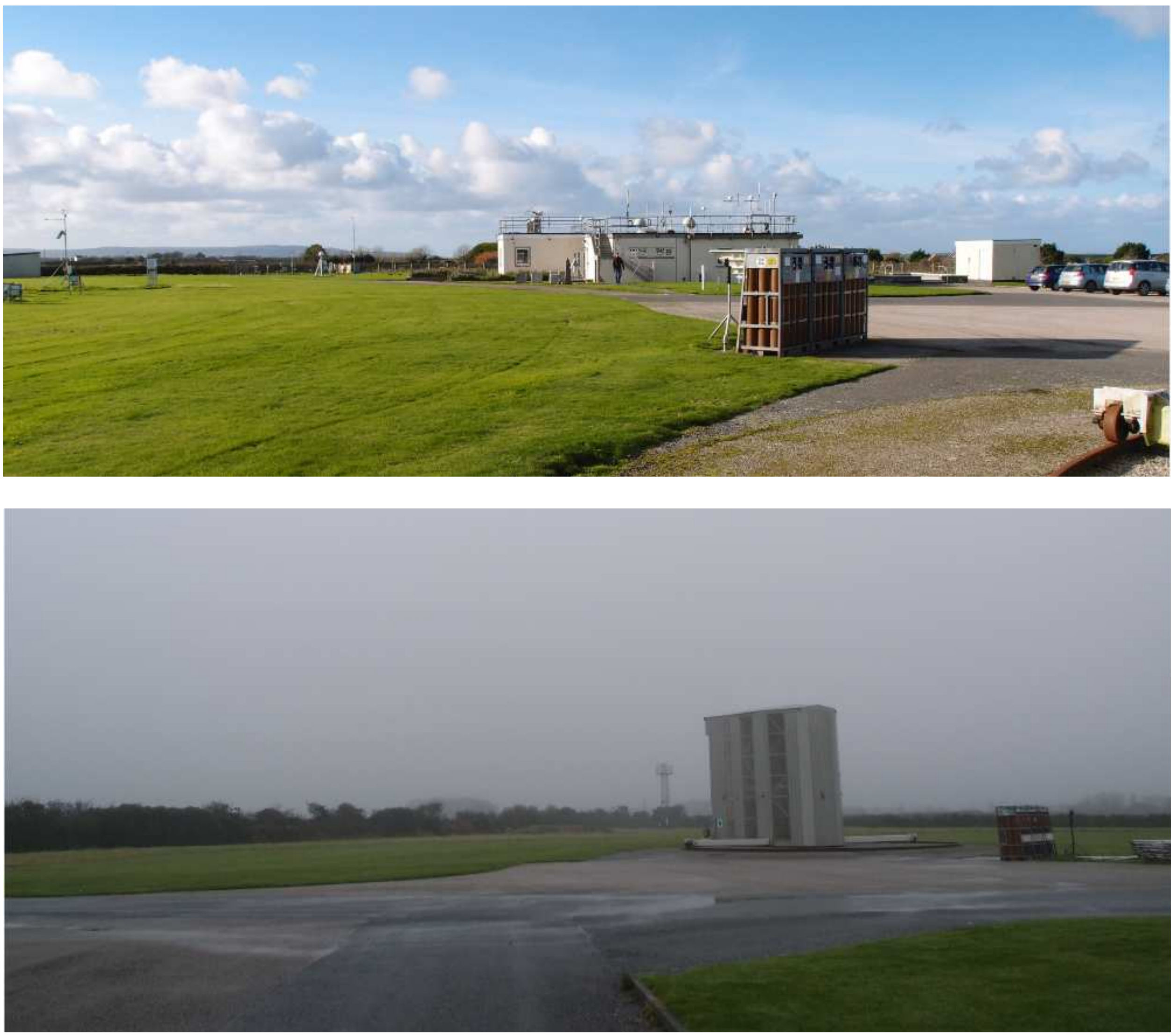

Figure 9. Camborne Observatory

Temperature measurement reproducibility (Camborne)

Figure 10 presents a night time sounding example of temperature differences between four radiosondes, RS41, RS41_2, RS92, and RS92_2. For the analysis, RS41 was used as a reference. Throughout the flight, the difference between the two RS41 Radiosondes was generally small, not exceeding 0.1 ºC at any second in this sounding. Result for RS92 radiosondes also shows good agreement, but with less precision than RS41 at lower altitudes.

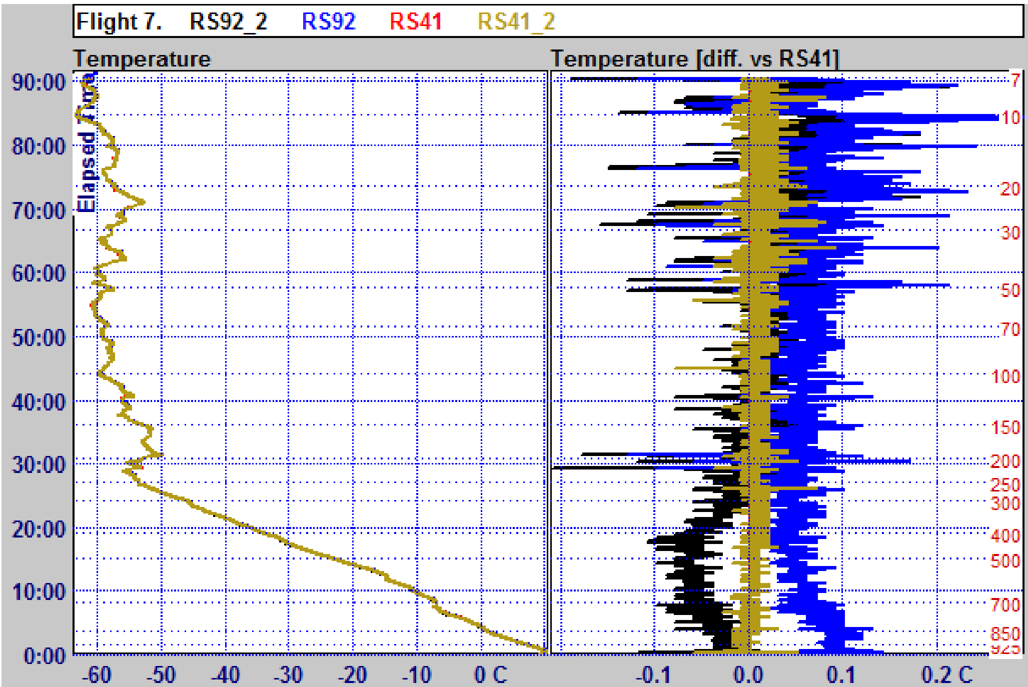

Figure 10. Night time sounding example, Camborne test

Statistics for RS41-RS41 and RS92-RS92 pairs in ten night time soundings are presented in **Figure 11**. The average difference between the two radiosondes is indicated by the bold line and the standard deviation of difference by the thin lines. The standard deviation between differences for RS41-RS41 pairs at 30 km is 0.025 ºC, and at 10 km 0.015 ºC. This is about 60% of the deviation for RS92.

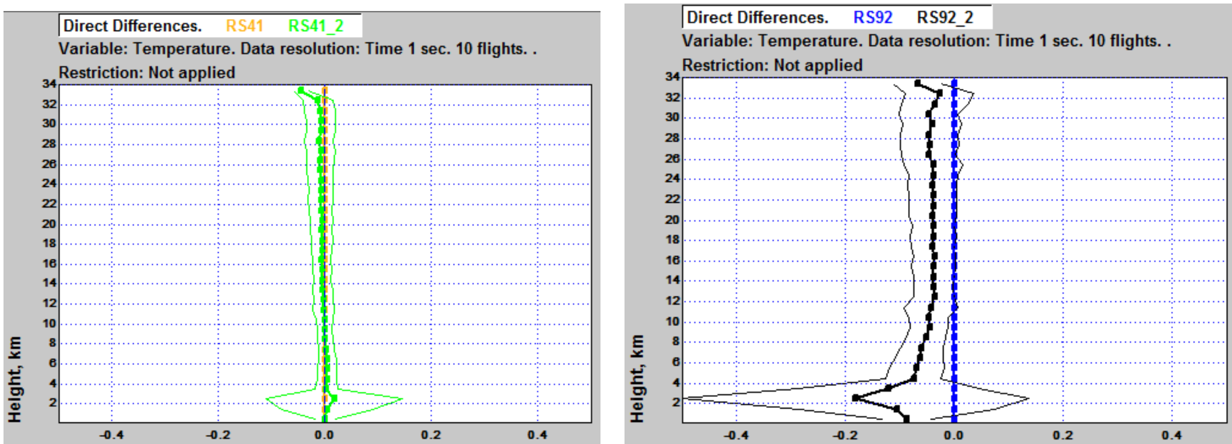

Figure 11. RS41 (left) and RS92 (right) direct differences and standard deviation, night time, Camborne test.

In daytime, the temperature sensor is exposed to intense solar radiation in a thin air at high altitudes, causing sensor heating and need for solar radiation error compensation in the ground system calculation. **Figure 12** shows the results of RS41 and RS92 temperature measurement reproducibility in Camborne day time soundings. At 30 km altitude, RS41 demonstrates improved measurement reproducibility, about two thirds of what is measured with RS92. At lower altitudes the relative difference is bigger, the reproducibility of RS41 being about one third of what is measured with RS92.

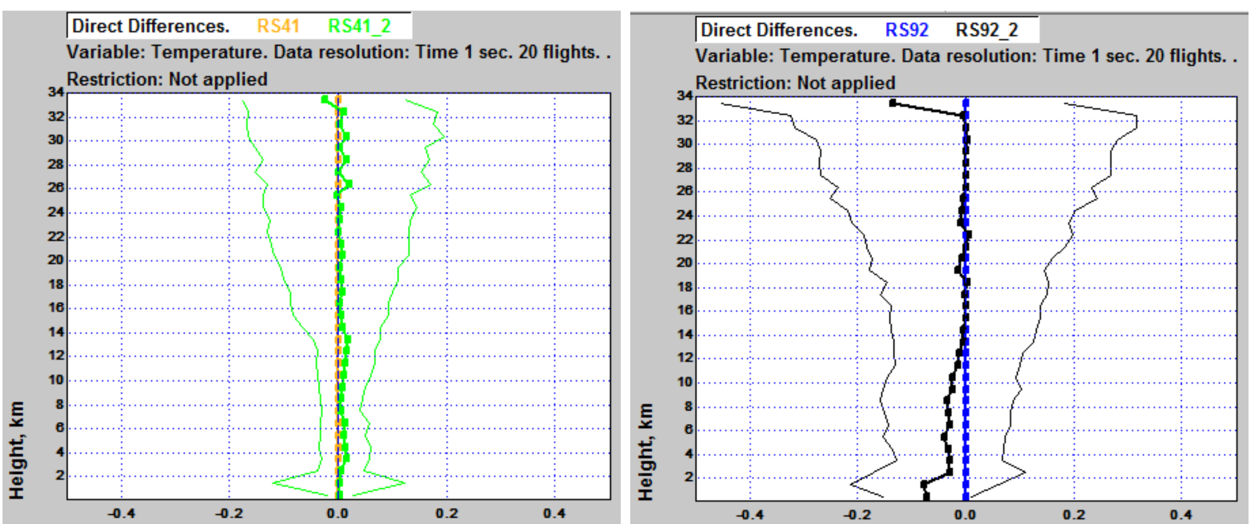

Figure 12: RS41 (left) and RS92 (right) direct differences and standard deviation, daytime, Camborne test

Temperature direct differences, RS92 - RS41(Camborne)

Direct differences of temperatures between RS41 and RS92 radiosondes were compared in 10 night time soundings and 20 daytime soundings. **Figure 13** presents the differences calculated from the night time soundings (left), and from the daytime soundings (right). At night time, the difference between two RS41 radiosondes was very small. RS92 radiosondes deviate from RS41 and from each other a bit more, differences being typically less than 0.05 °C and at low cloud region less than 0.2 °C. At daytime, the direct differences between RS41 and RS92 radiosondes were typically less than 0.1 °C.

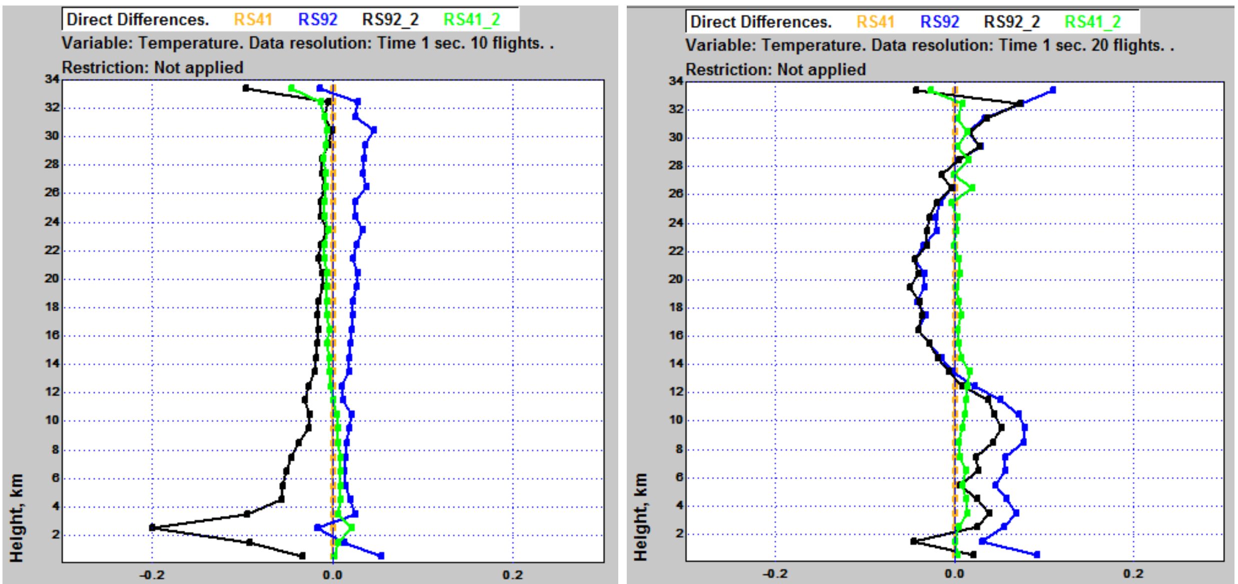

Figure 13. RS92-RS41 direct differences, night time (left) and daytime (right), Camborne

Libus, Chech Republic, CHMI campaign temperature measurement results

RS41 – RS92 Radiosonde comparison flight test campaign was performed in Libus Observatory in Prague, in August 2014. **Figure 14** presents the test rig setup with four radiosondes.

The campaign results are presented in detail in reference [8] In night time soundings, the temperature measurement reproducibility was within 0.1 ℃ throughout the profile, RS41 Radiosonde demonstrating about 0.02 ℃ standard deviation in compared to 0.04 ℃ of RS92 in most part of the profile. At daytime the deviation was larger, as expected. Daytime temperature reproducibility of RS41 and RS92 are presented in **Figure 15**. Daytime standard deviations progressed from 0.02 ℃ on surface up to 0.2 ℃ in 34 km for RS41 radiosonde, and from 0.08 ℃ to 0.4 ℃ for RS92 radiosonde.

Figure 14. Test flight arrangement in Libus Observatory test

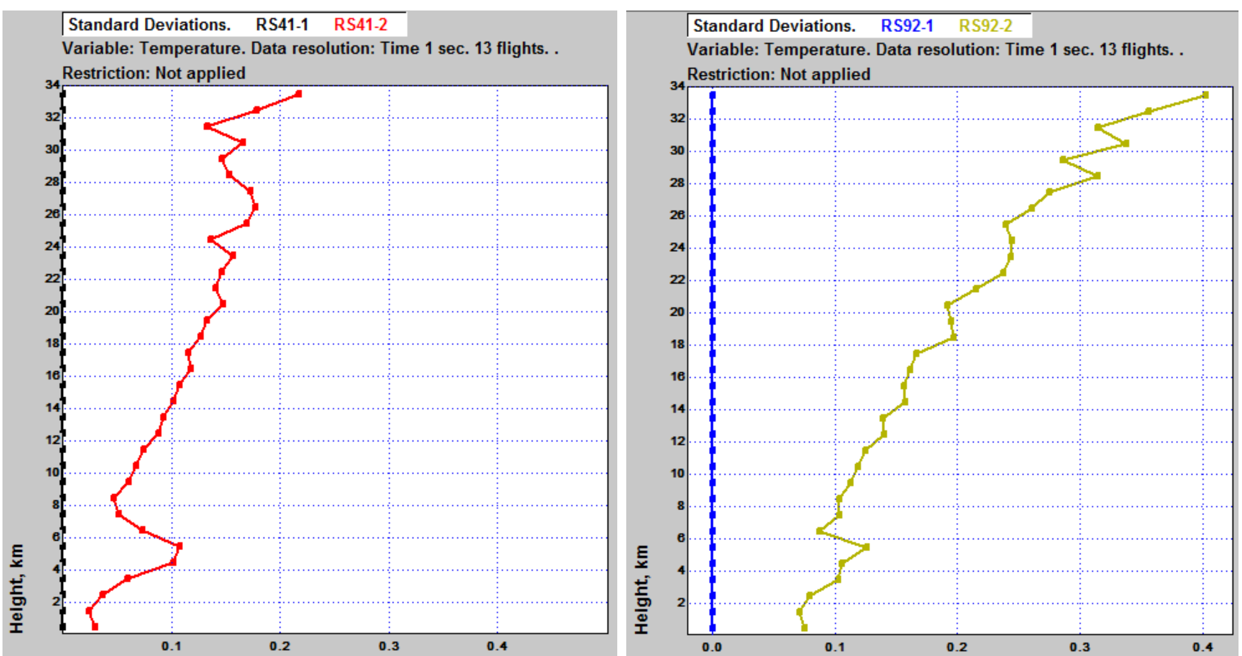

Figure 15. Temperature reproducibility, Libus test, daytime.

Direct temperature differences between RS92 and RS41 were within 0.1 ℃ in night time conditions (**Figure 16).** In daytime, the direct differences were higher than at night, but still lower than 0.2 ℃ (**Figure 17**.)

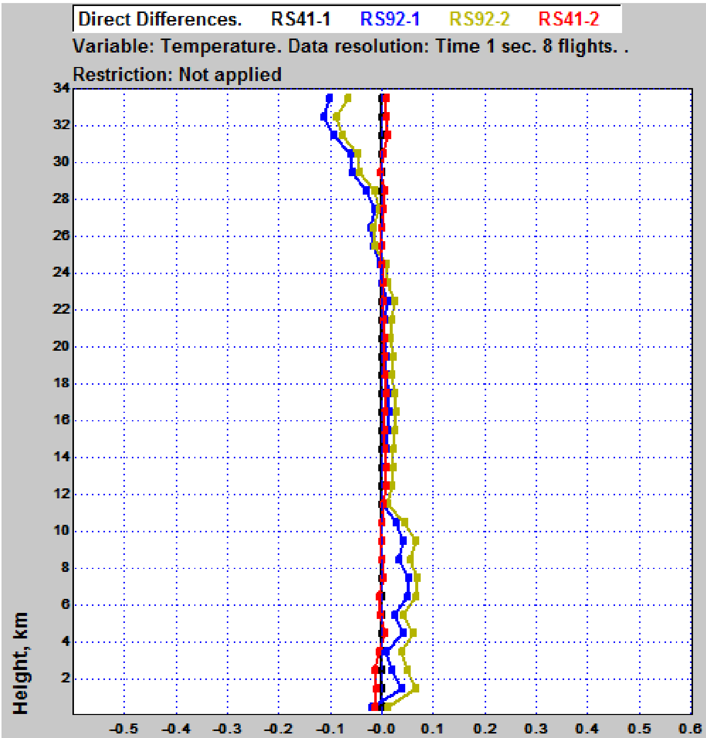

Figure 16. Temperature direct differences, night time, Libus

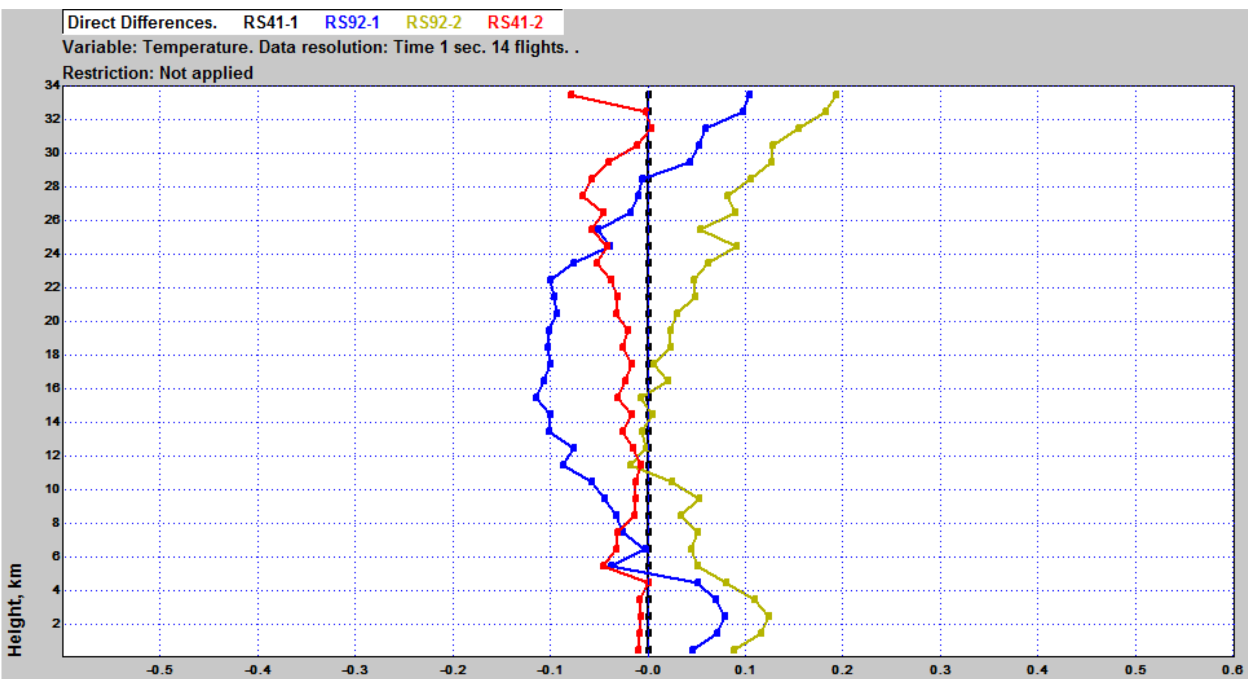

Figure 17. Temperature direct differences, daytime, Libus

Tropical atmosphere soundings, Malaysia, temperature measurement results

In tropics, the tropopause is located at high altitude and its temperature is low. During the day high solar radiation angle for the testing can be reached. RS41-RS92 Radiosonde comparison test soundings were performed in March, 2013. The rig carried up two RS41 and two RS92 Radiosondes. Figure 19. show an example of temperature and humidity profiles during the test.

Figure 18. Preparing the four-radiosonde test rig release in Penang, Malaysia

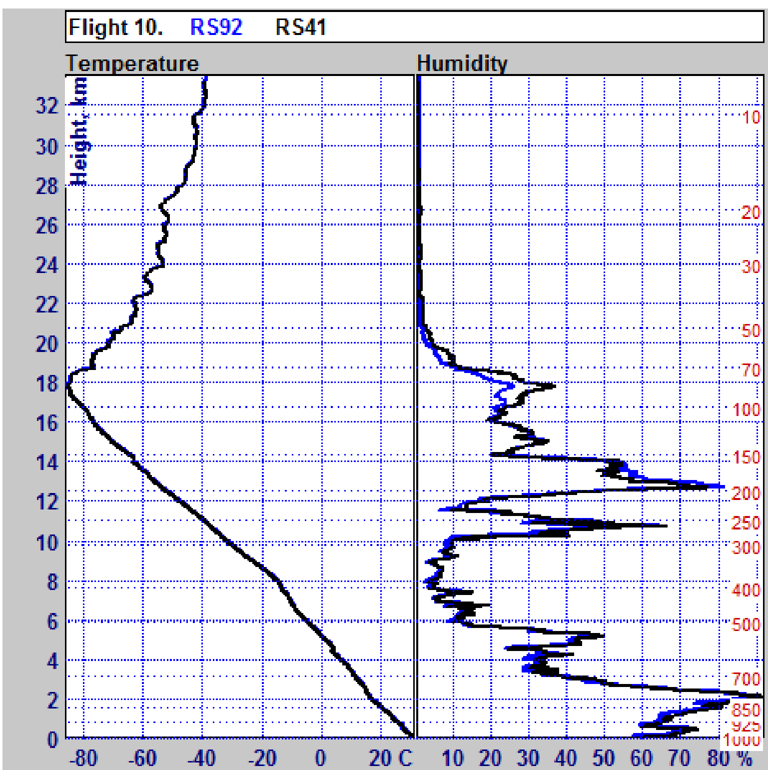

Figure 19. Example of temperature and humidity profiles during the tropical sounding test

Temperature reproducibility and direct differences, RS92-RS41 (Tropics)

Figures 20 and 21 present the temperature measurement reproducibility results for the RS41 and RS92 Radiosondes, shown as standard deviation of differences (thin lines). **Figure 20** presents the result in the night time. Compared to RS92, RS41 measurement demonstrates smaller measurement deviation. In the daytime (**Figure 21**), when the deviation is larger in general, results indicate smaller temperature deviation with RS41, especially at altitudes above the tropopause region.

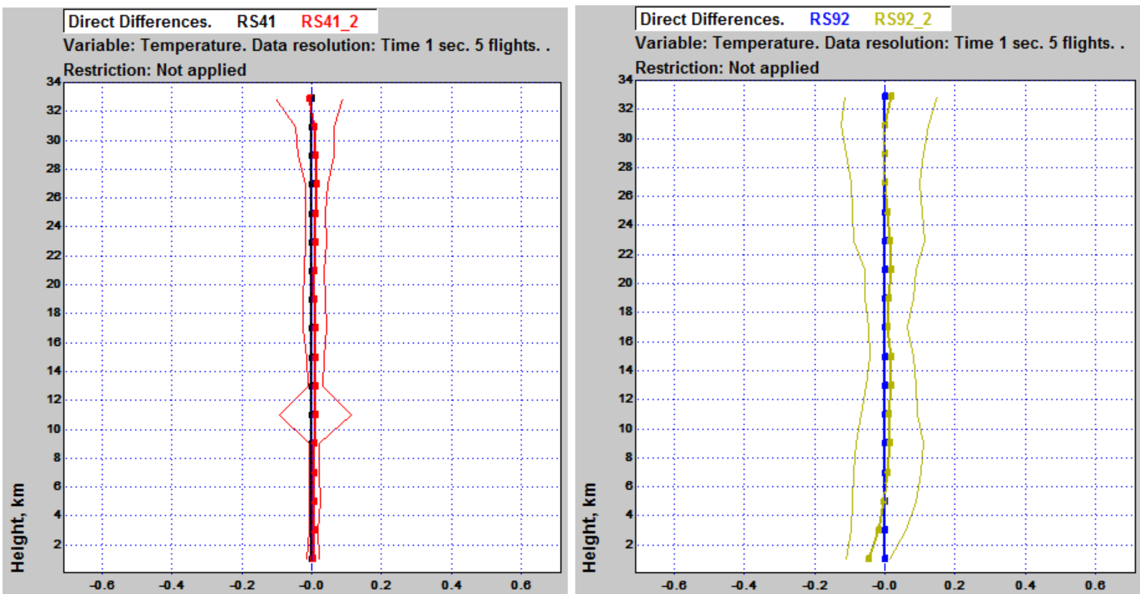

Figure 20. RS41-RS41 (left) and RS92-RS92 (right) temperature reproducibility in tropical night time atmosphere

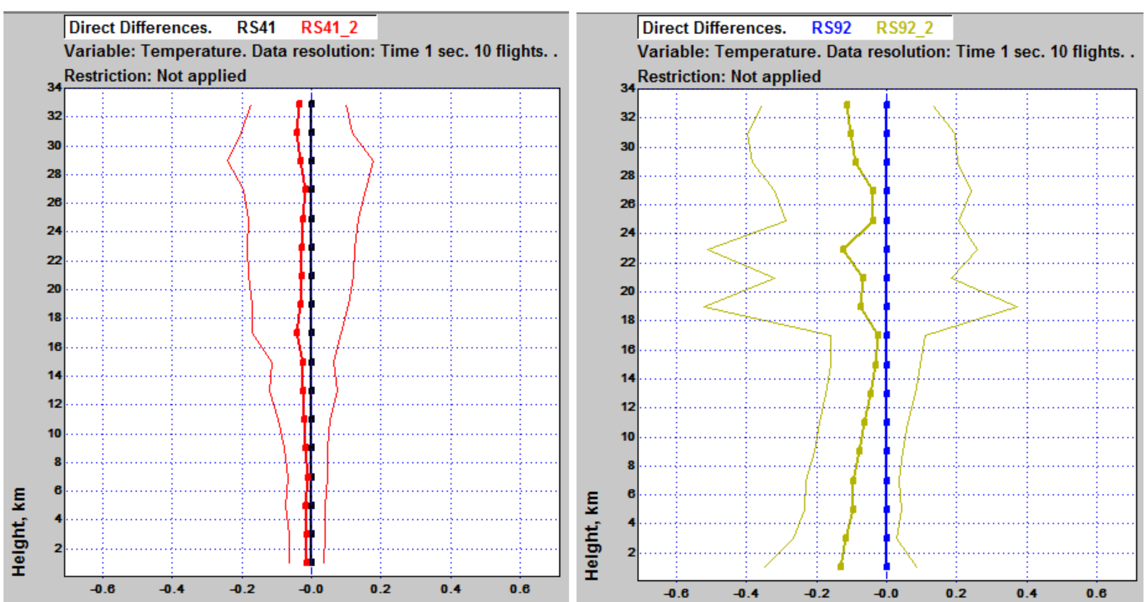

Figure 21. RS41-RS41 (left) and RS92-RS92 (right) temperature reproducibility in tropical day time atmosphere

Figure 22. shows RS41 and RS92 average differences in tropical night time and daytime atmosphere using RS92 as reference. The average temperature differences between RS41 Radiosonde and RS92 Radiosonde were in night time < 0.1 ℃ and in daytime < 0.2 ℃.

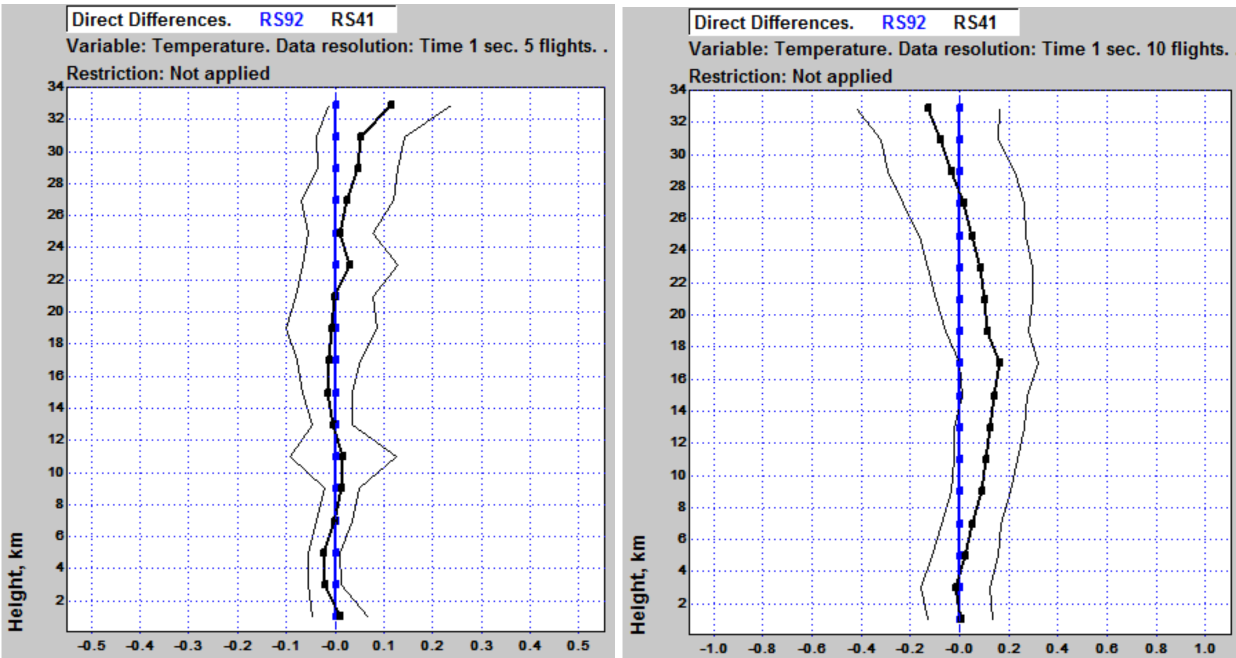

Figure 22. RS92 vs. RS41 temperature differences in tropical night time (left) and daytime (right) atmosphere

Polar winter atmosphere, Sodankylä, temperature measurement

A smaller scale test campaign was performed in polar winter, cold stratosphere conditions in Sodankylä, Finland, in February 2014.

Figure 23. Sodankylä observatory and a balloon being prepared for a flight with research instruments

A temperature profile example is presented in figure 24. Direct temperature differences between the RS41 and RS92 sondes were generally within 0.2 ℃ (**Figure 25**). However the sample size in this test was limited for further conclusions.

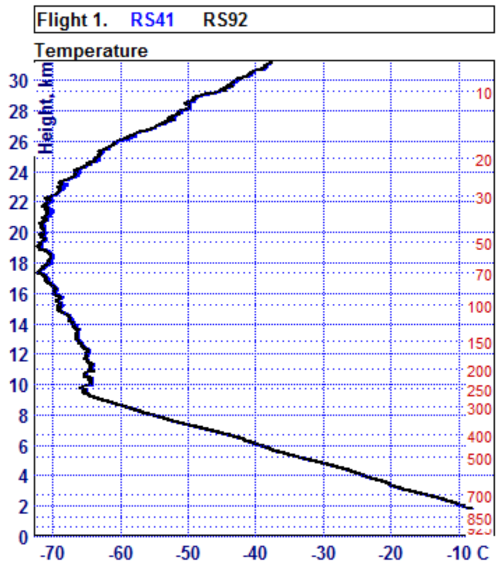

Figure 24. Typical temperature profile during time of the test flights

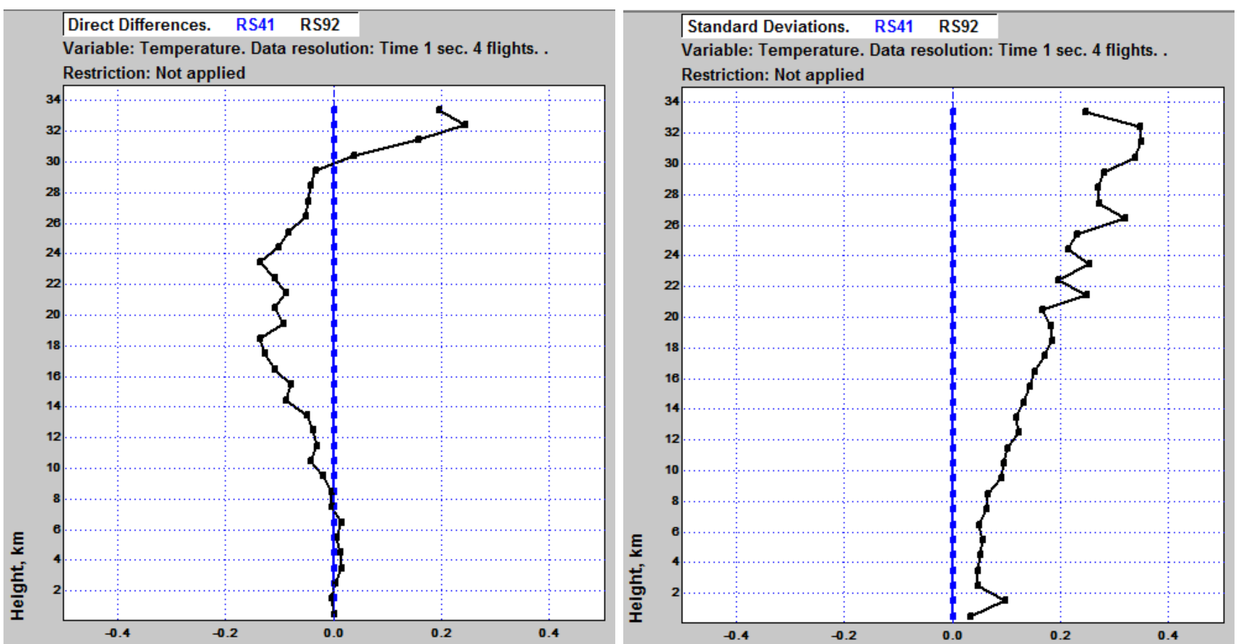

Figure 25. Temperature direct differences and standard deviation, polar winter profile

HUMIDITY MEASUREMENT RESULTS

Sounding campaigns for RS41/RS92 humidity comparison have been conducted in various climatological conditions. In the following test results from Camborne - UK, Penang - Malaysia and Sodankylä - Finland are presented.

Camborne test, humidity

Humidity measurement reproducibility (Camborne)

Figure 26 presents an example of four sonde humidity data on Camborne campaign. At right hand side pane a zoomed view reveals the profile detailed structure. As typically to test results, two RS41 Radisonde humidity curves follow each other very closely. RS92 humidity agrees well in general, but with slightly higher temporal deviation.

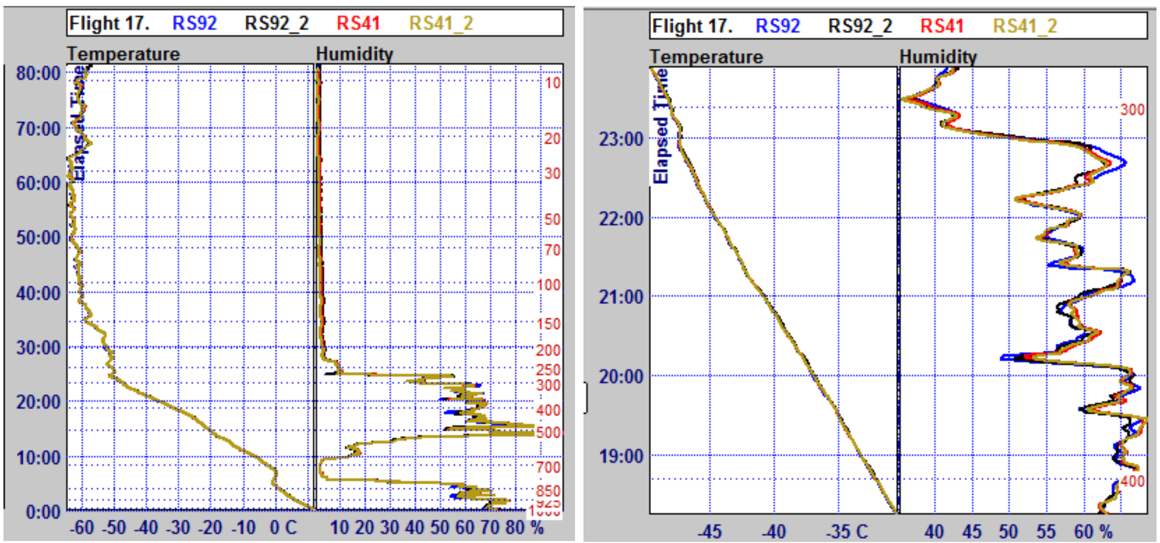

Figure 26. Humidity measurement profile example, Camborne. The whole profile and the time interval of 20 – 24 min

The difference in measurement performance can also be seen in humidity measurement reproducibility statistics in **Figures 27 and 28**. The measurement deviation of RS41 is almost half of the RS92 deviation in night time and in daytime conditions.

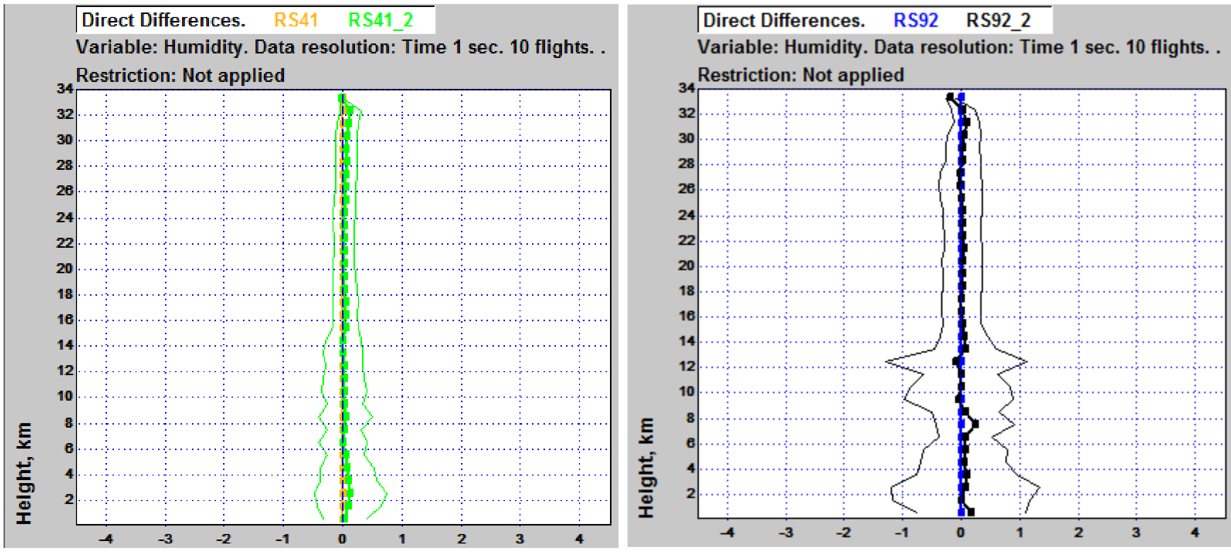

Figure 27. Humidity reproducibility, night time, Camborne 2013

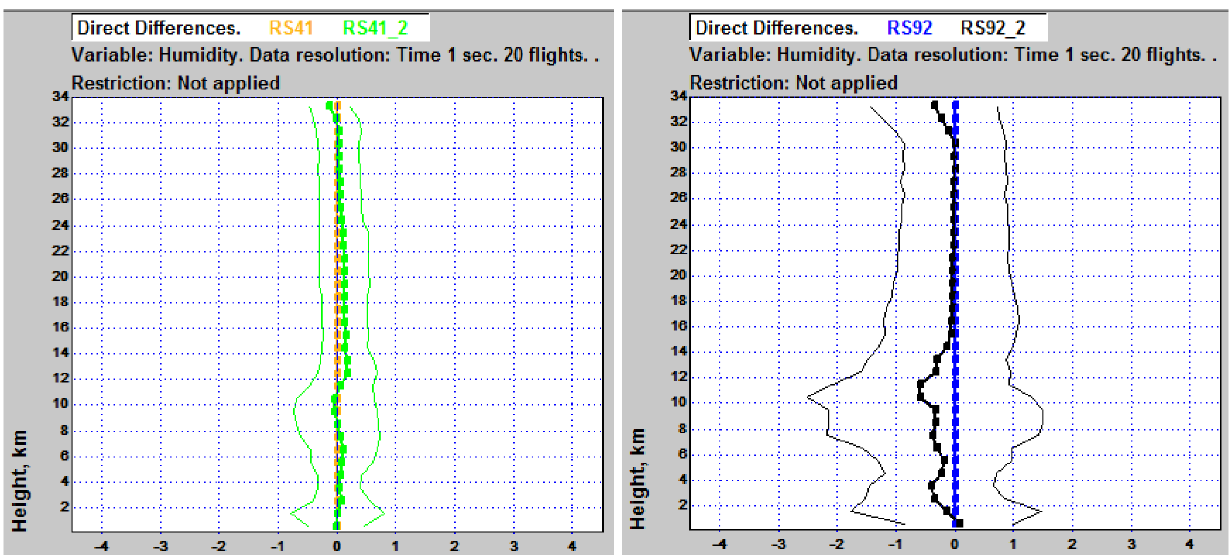

Figure 28. Humidity reproducibility, daytime, Camborne 2013

Humidity direct differences, RS92-RS41 (Camborne)

Figure 29 shows the average direct differences between RS41 and RS92 sondes in Camborne test, presented against height. The difference between the sonde types is typically within 1 %RH and somewhat similar during night time and daytime. In the day time RS92 measured about 2 %RH lower humidity at ground level. Detailed analysis on the differences, also against temperature scale is presented in the reference [7]. Humidity measurement results of Camborne test are well aligned with the results of Libus test, reported in reference [8].

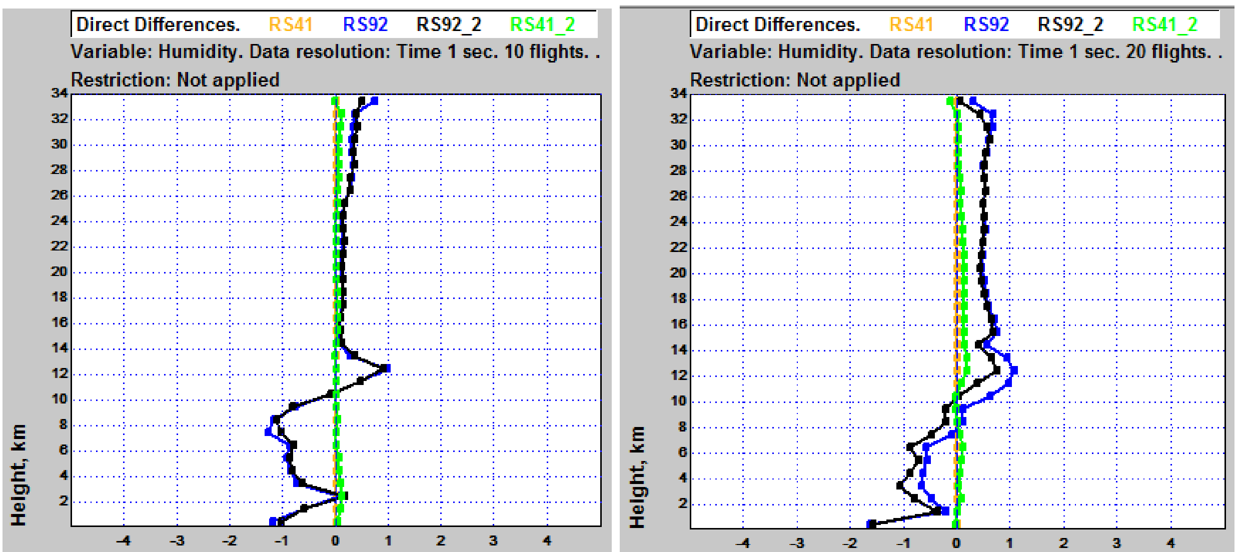

Figure 29. Humidity direct differences between RS92-RS41, night time (left) and day time (right), Camborne 2013

Tropical atmosphere soundings, Malaysia, humidity measurement results

Humidity measurement reproducibility (Tropics)

For testing radiosonde humidity measurement, tropical atmosphere probably offers the most challenging environment, covering a wide range of water vapour pressure, temperature, and solar radiation. **Figure 19** shows example of the tropical atmosphere temperature and humidity profiles.

Statistics for RS41-RS41 night time and daytime soundings in tropics are presented in **Figures 30 and 31**. In night time the biggest difference in measurement deviation can be seen at the ground level, RS92 showing larger deviation up to 1 %RH. In day time the differences are smaller, both sonde types having highest deviation at 10 to 20 km region.

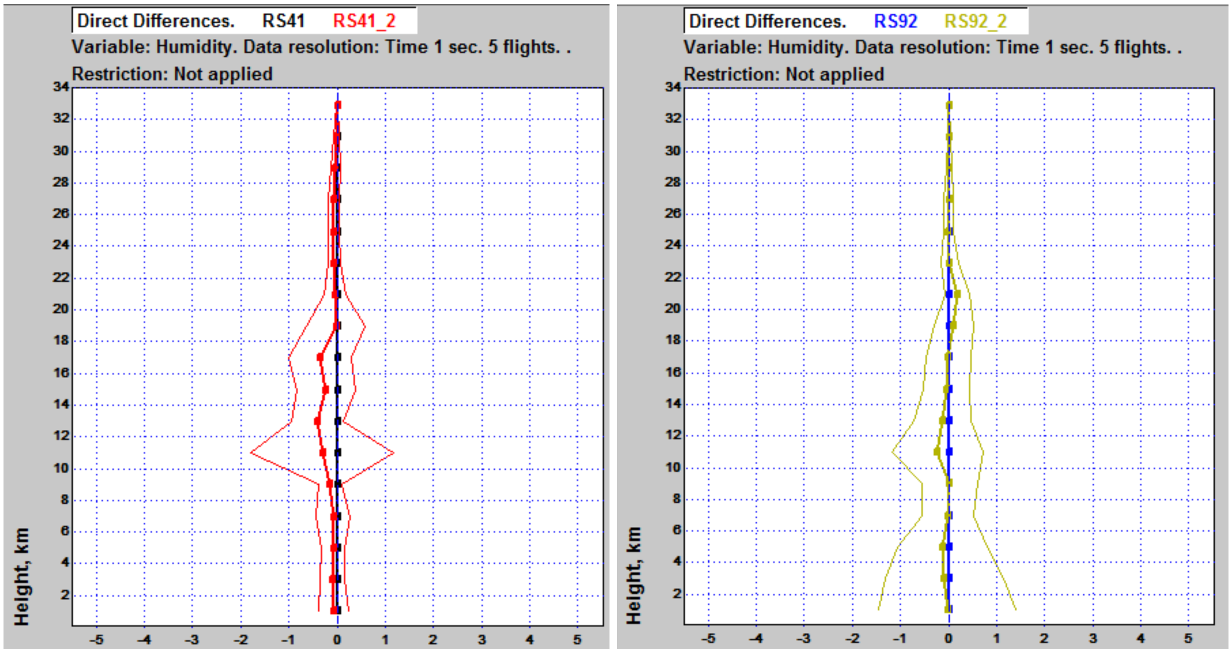

Figure 30. RS41-RS41 (left) and RS92-RS92 (right) humidity reproducibility in tropical night time atmosphere

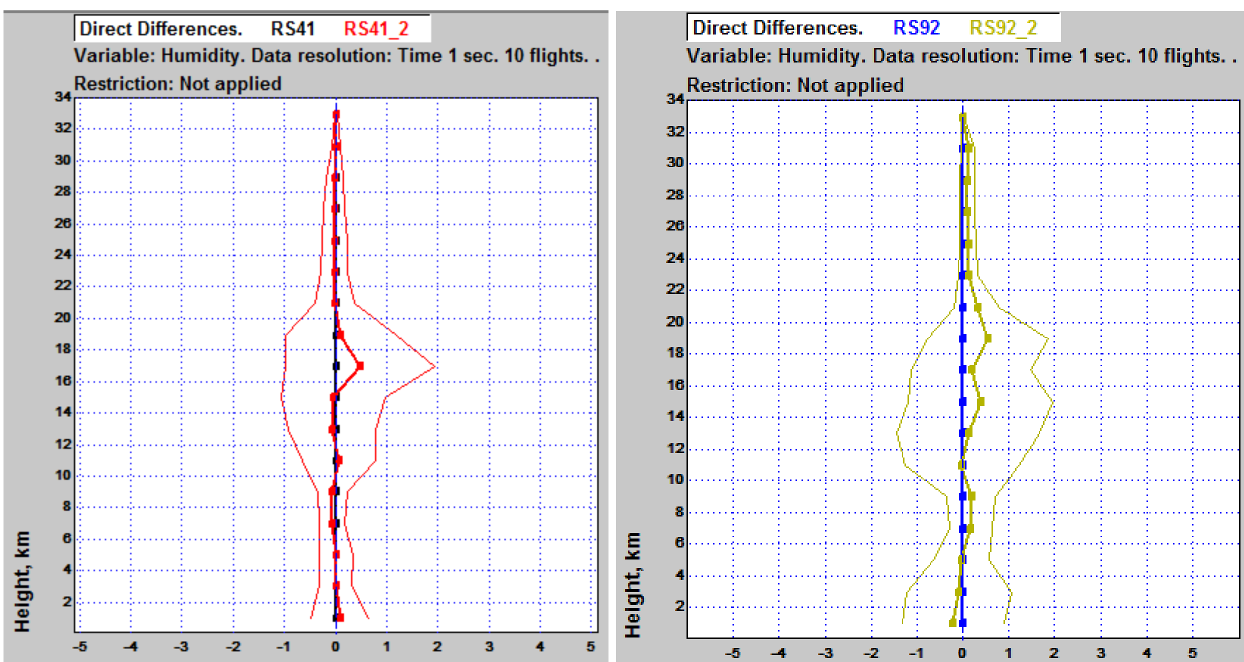

Figure 31. RS41-RS41 (left) and RS92-RS92 (right) humidity reproducibility in tropical daytime atmosphere

Humidity direct differences, RS41-RS92 (Tropics)

The largest mean differences between RS41 and RS92 humidity measurement can be seen in tropical conditions. **Figure 32** presents direct difference result for night time and daytime flights. In night time the difference between the sonde models is at highest about 2.5 %RH. In daytime in a tropopause region at 17 km, RS41 sondes measured about 5 to 6 %RH higher relative humidity mean difference when compared to RS92 sondes. In individual flights the differences can be much higher. The difference is largely due to the dissimilar approaches in compensating the heating effect of solar radiation on humidity sensor. RS92 Radiosonde relies on SW correction, whereas in RS41 Radiosonde the measurement of actual humidity sensor temperature produces accurate humidity result directly, without a need for SW-based solar radiation correction

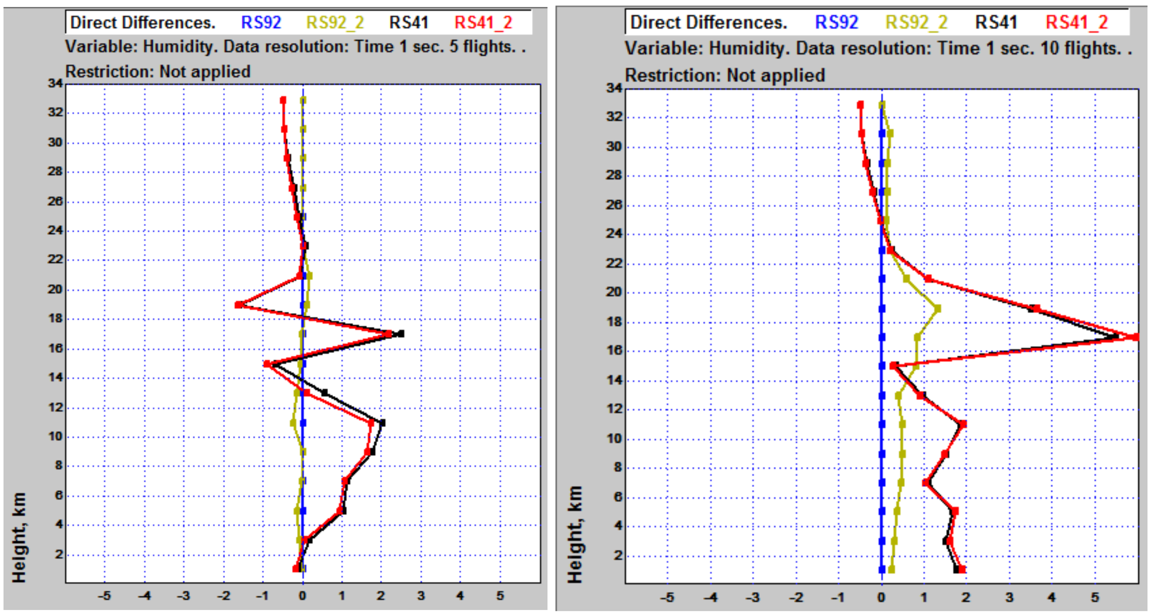

Figure 32. RS41-RS92 direct differences in tropical atmosphere, at night time (left) and daytime right (right)

Polar winter atmosphere, Sodankylä, humidity measurement

Small series of test flights were performed in Sodankylä observatory during the period with cold stratospheric temperatures. Figure 33 shows a sounding example. Small difference between RS41 and RS92 humidity measurement can be seen at 70 – 30 hPa region, RS41 measuring higher humidity.

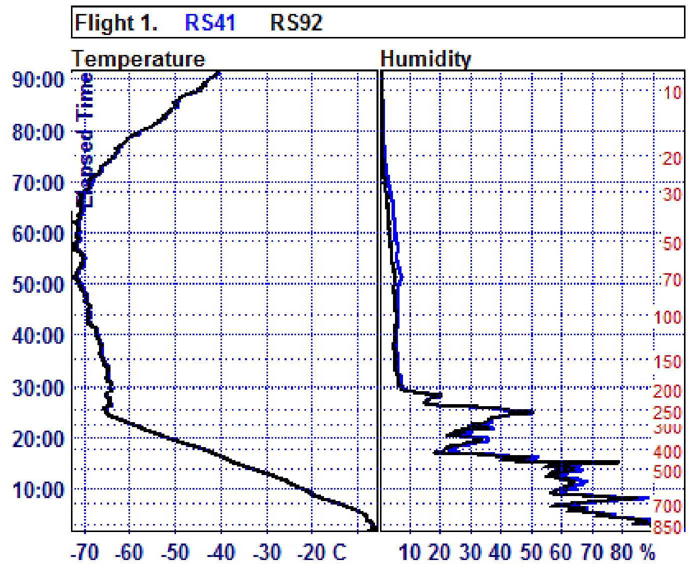

Figure 33. RS41, RS92 sounding in polar winter atmosphere, Sodankylä

Statistics of the four flights show about 2 %RH difference at 20 km (Figure 35). However, it is good notice the limited sample size of test set for firm conclusions.

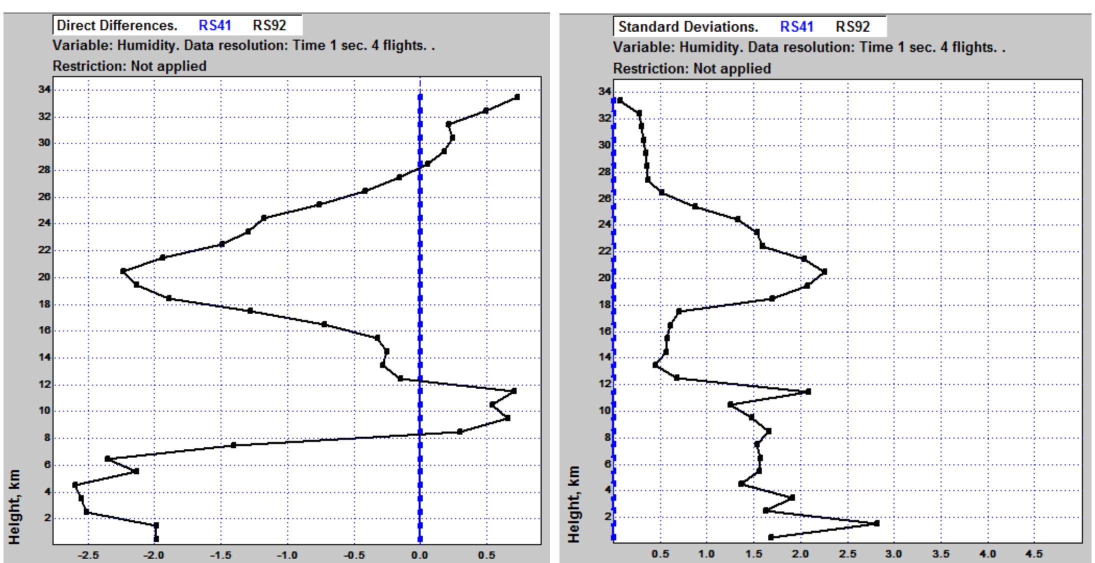

Figure 35. Polar winter, Sodankylä, humidity direct difference and standard deviation

SUMMARY

Vaisala Radiosonde RS41 and Vaisala DigiCORA® Sounding System MW41 introduce a new generation of sounding products. With the new sensor technology of RS41 Radiosonde the atmospheric temperature and humidity profiles can be measured with increased accuracy.

Test results from different locations and climatological conditions are consistent and demonstrate improved temperature and humidity measurement precision / reproduciblity in night and daytime conditions.

The observed mean direct differences between RS41 Radiosonde and RS92 Radiosonde temperatures are moderate, typically in the order of 0.1 ℃, up to 0.2 ℃.

The observed mean direct differences between RS41 Radiosonde and RS92 Radiosonde humidity are < 2 %RH at high latitude conditions. In tropical night time conditions the differences are in the order of 1 – 3 %RH. The largest differences between RS41 and RS92 Radiosondes can be detected at daytime in tropical tropopause region at very cold temperatures, RS41 measuring on average 5-6 %RH higher humidity. The difference is related much to the improved humidity measurement technology in RS41 Radiosonde.

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