Comparison of Radiosonde Data from Vaisala Sounding Systems MW41 and MW21/MW31

WHITE PAPER

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Chapter 1

Introduction

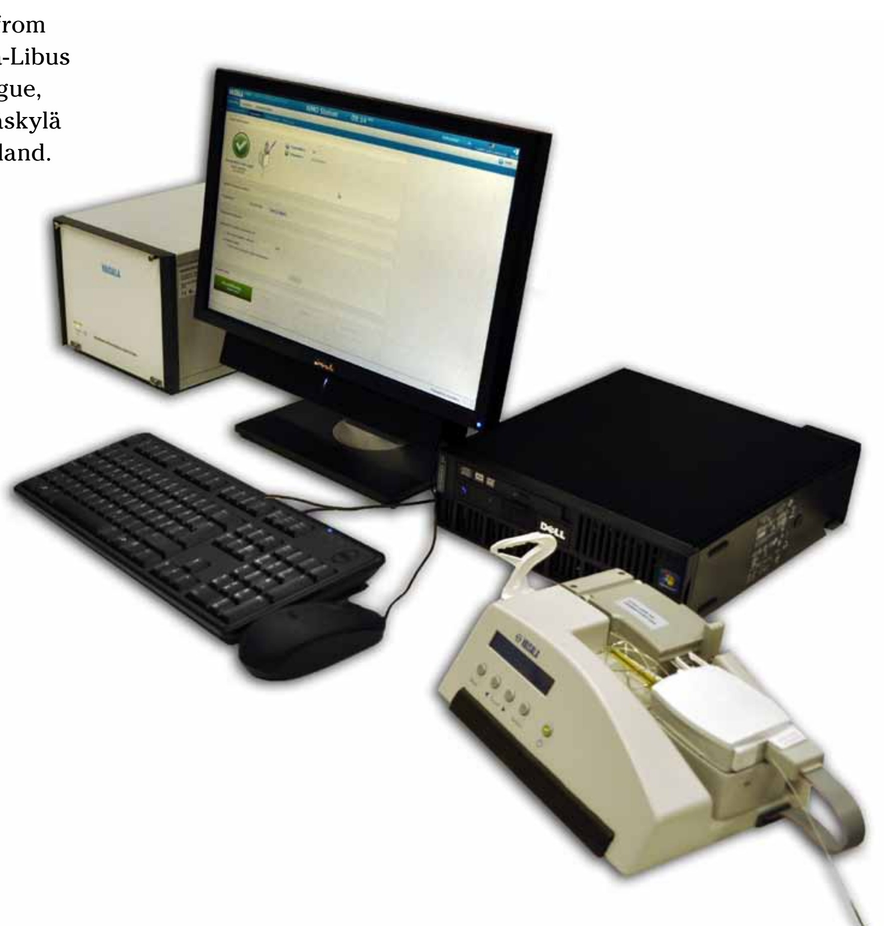
The purpose of this document is to report the results of comparison soundings for the new Vaisala DigiCORA® Sounding System MW41 and the current Vaisala DigiCORA® Sounding System. The MW41 sounding system is designed to ensure consistent high-quality measurements using the RS92-SGP sounding series, and a smooth upgrade path from current Vaisala sounding systems.

The MW41 implements the same advanced algorithms for computing pressure, temperature, humidity, and wind observations, but with a new software platform and a different programming language. The Vaisala DigiCORA® Sounding System MW21 was used as a reference model in the tests. The results are also applicable to comparisons with the MW31, which runs the same software as the MW21.

The datasets were obtained from two upper air stations: Praha-Libus station (WMO #11520) in Prague, the Czech Republic, and Jyväskylä station (WMO #02935) in Finland.

The soundings were carried out during the summer and fall of 2012 by staff from the Czech Meteorological and Hydrological Institute and the Finnish Meteorological Institute at their local stations.

The test method and system setup are described in Chapter 3. Individual results for pressure, temperature, humidity, and wind observations are described in the following sections.



Chapter 2

Executive Summary

The summary of the performance evaluation is presented in Table 1. The results show that there are no evident differences between the data processing streams of the two sounding systems, despite the significant changes in implementation technologies. The average and random differences are very small compared to the radiosonde measurement accuracy. A sounding system upgrade will not cause significant changes in observed data.

The results also apply to the Vaisala DigiCORA® Sounding System MW31. The MW31 uses the same software as the MW21 with the sounding processing subsystem of the MW41.

Measurement	Accuracy of RS92-SGP	System comparison: average difference	System comparison: random differences
Temperature	0.5 °C[1]	< 0.03 °C	<0.07 °C
Humidity	5 %RH	< 0.05 %RH	< 0.7 %RH
Pressure	1 hPa (1080-100 hPa)	< 0.1 hPa	< 0.05 hPa
	0.6 hPa (100 hPa – 3 hPa)	< 0.04 hPa	< 0.02 hPa
Wind	0.15 m/s (reproducibility)[2]	< 0.05 m/s	< 0.15 m/s (reproducibility)

Table 1. Summary of comparison results between MW41 and MW21 Sounding Systems.

[1] 2-sigma (k=2) confidence level (95.5%)

[2] standard deviation of differences in twin soundings

Figure 1. Performing a comparison sounding in Jyväskylä, Finland

The test results can be affected by factors including different ground check corrections, different receiver systems, timing differences between the systems, and the resolution of the statistical analysis software. There will therefore be small differences between the resulting measurement values caused by the test setup.

We would like to thank everyone involved from both meteorological services, especially the operators at Praha-Libus and Jyväskylä stations for their helpful assistance.

Chapter 3

Method of Comparison and System Setup

The two sounding systems were used in parallel and received the data from the same RS92-SGP radiosonde at the same time. In this way the comparison was about the difference between the two systems and not about the repeatability of the radiosonde data. Both systems used the same UHF and GPS antennas. The MW21 controlled the antenna direction. In addition, the systems shared the same GC25 ground check set so that the differences in data due to ground check were minimized. The exact procedure is explained in Reference [1].

Table 2 summarizes the system configurations during the test. The MW21 was deployed with software version 3.64.1 and used the SPS220G receiving system with UPP210A receiver processor and MWG210 GPS receiver. The software and data processing is identical to that of an MW31 sounding system with the same software version, as indicated in the third column of Table 2.

The MW41 was used with software version 1.0 and a SPS311G sounding processing subsystem with MRP111 receiver processor and MRG113 GPS receiver.

	MW41	MW21	MW31
Software version	1.0	3.64.1	3.64.1
Sounding processing subsystem	SPS311G	SPS220G	SPS311G
GPS receiver	MRG113	MWG210	MRG113
Receiver processor	MRP111	UPP210A	MRP111

Table 2. Configuration of the tested MW41 and MW21 sounding systems and a *comparable MW31 sounding system.*

The connections are shown in Figure 2. The test setup is explored in more detail in Reference [1], available through Vaisala.

The analysis consists of 35 soundings in total. 23 soundings were obtained from Praha-Libus station and 12 soundings from Jyväskylä. After the data were collected, the DC3DB files from the MW21 and the MWX archive files from the MW41 were extracted into text files, and the data were syncronized using GPS time stamps.

Statistical analyses were made using a WIN32 version of RSKOMP radiosonde comparison software, approved and recommended by WMO / CIMO [3]. The results of the RSKOMP analysis are shown in graphs in the following chapters. The average differences (="Direct Difference" in RSKOMP figures) as a function of height are shown on the left panel of each figure, and random differences described with the standard deviation on the right.

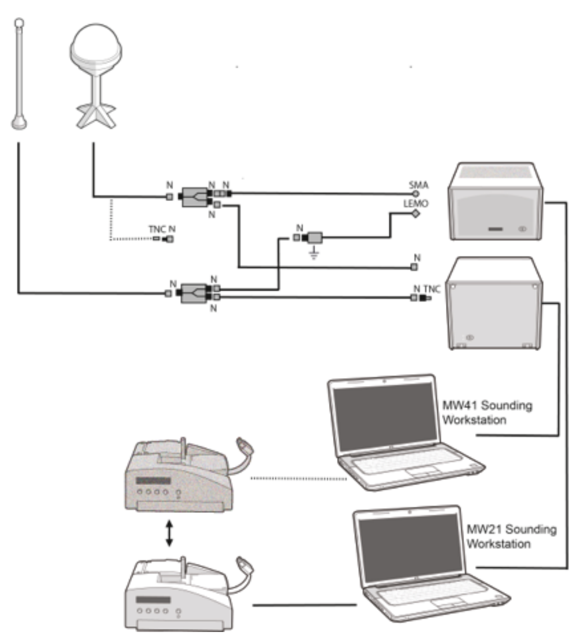


Figure 2. Sounding system, ground check, and antenna connections for the parallel comparison.

Chapter 4

Temperature Measurement

Calculation Algorithms

The temperature measurements in the comparison were taken from the thin-wire temperature sensor in the RS92-SGP. The Vaisala Sounding System MW41 implements the same advanced algorithms for temperature calculation as the MW21 and MW31 sounding systems. These include the algorithms implemented for the WMO China Intercomparison, i.e. the revised temperature sensor solar radiation correction RSN2010. Differences are explored in detail in References [2] and [4].

Comparison Results

The temperature comparison results are shown in Figure 3. The graphs show the average difference (left) and the standard deviation of the differences (right) as a function of height for all flights[3]. These indicate, respectively, the level of persistent differences and random variations between the two sounding systems. The average differences were 0.03°C or less and the standard deviations 0.07°C or less at all heights. The total uncertainty in the sounding of the RS92-SGP temperature measurement is 0.5°C. There are therefore no significant differences between the temperature results of the two systems.

The small differences observed were mostly caused by the test setup, such as the resolution of matching the time axes of the two data sets in the statistical analysis. A small bias effect resulted from the ground check. Although both systems used the same GC25 ground check set and the same reference temperature, the reading of the sonde temperature measurements did not occur at the same instant, which caused small differences in the corrections. Another minor factor may be the small numerical differences between software implementations.

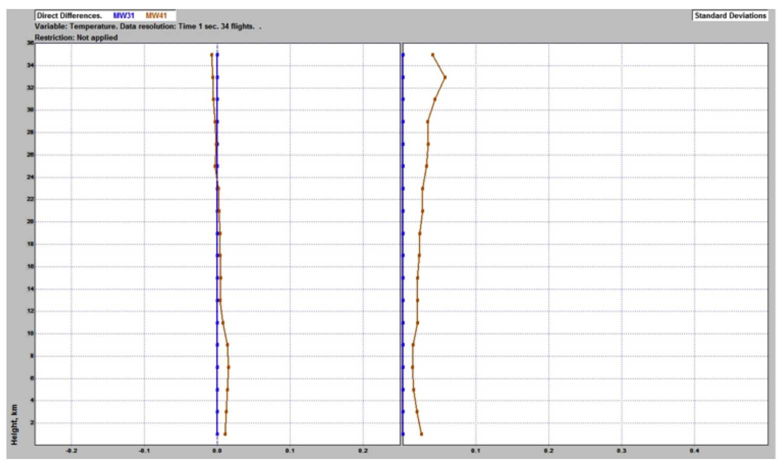


Figure 3a. Results of the temperature comparison.

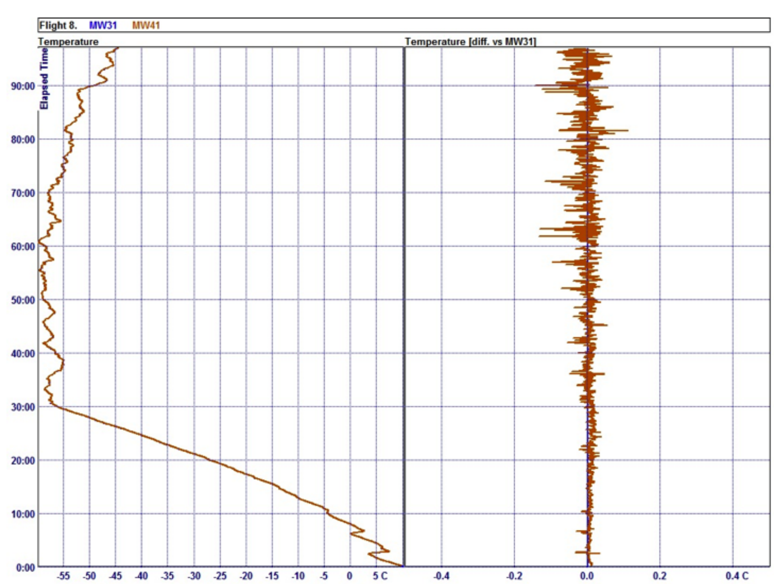


Figure 3b. Example temperature profile and difference between systems.

[3] One Jyväskylä flight was left out from the dataset due to a 5-minute data break in the MW21's temperature profile.

Chapter 5

Humidity Measurement

Calculation Algorithms

The humidity measurements were taken from the two thin-film polymer humidity sensors in RS92-SGP. The humidity calculations in the MW41 and MW21 sounding systems use the same advanced algorithms developed for the WMO China Intercomparison, i.e. the time lag and solar radiation corrections for observed relative humidity. Differences are explored in detail in Reference [2].

Comparison Results

The humidity comparison results are shown in Figure 4. The average differences were 0.05% RH or less for all heights, and the standard deviations were 0.3% RH or less through most of the heights. There was a small change in the upper troposphere, where the random differences between the two systems went up to 0.7% RH, while the average difference – the bias – remained at 0.05% RH or less.

Further investigation indicated a small difference in the outcome of the time lag correction algorithms in the two implementations. The test does not indicate which of the algorithm implementations would be more accurate, but mainly indicates a small random difference in the region where the impact of the time lag correction is largest. The total uncertainty in the sounding of the RS92-SGP humidity measurement is 5% RH, and the observed differences are therefore not significant.

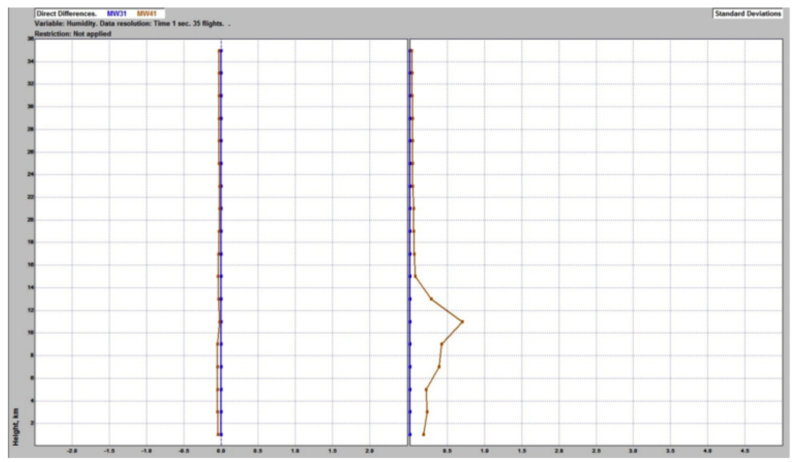


Figure 4a. Results of the humidity comparison.

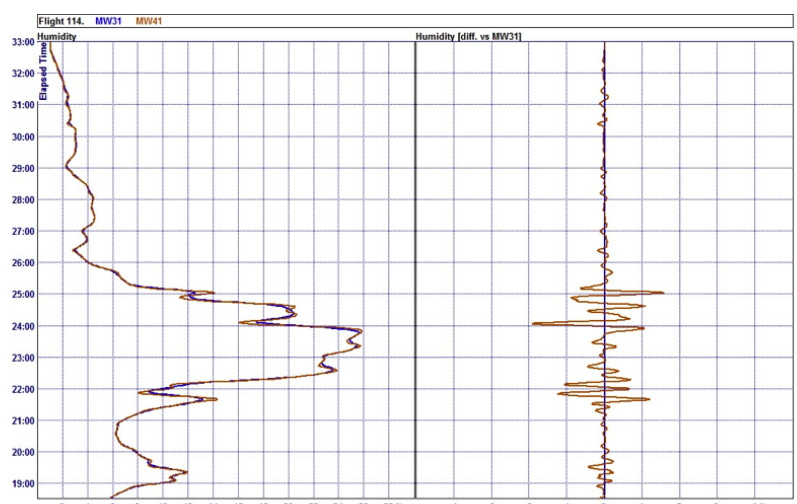


Figure 4b. Example of a humidity profile around the tropopause.

Chapter 6

Pressure Measurement

Calculation Algorithms

The pressure observations in this comparison were taken from the silicon pressure sensor in RS92-SGP. The same algorithms are used in the MW41 and MW21 sounding systems.

Comparison Results

The pressure comparison results are shown in Figure 5. The average differences were less than 0.1hPa and the standard deviations were 0.05hPa or less near the surface. The differences decrease as the altitude increases. The total uncertainty in the sounding of the RS92-SGP pressure measurement is 1.0hPa in the pressure range 1080-100hPa, reducing to 0.6hPa in the pressure range 100-3hPa. There are no significant differences between the pressure results of the two systems.

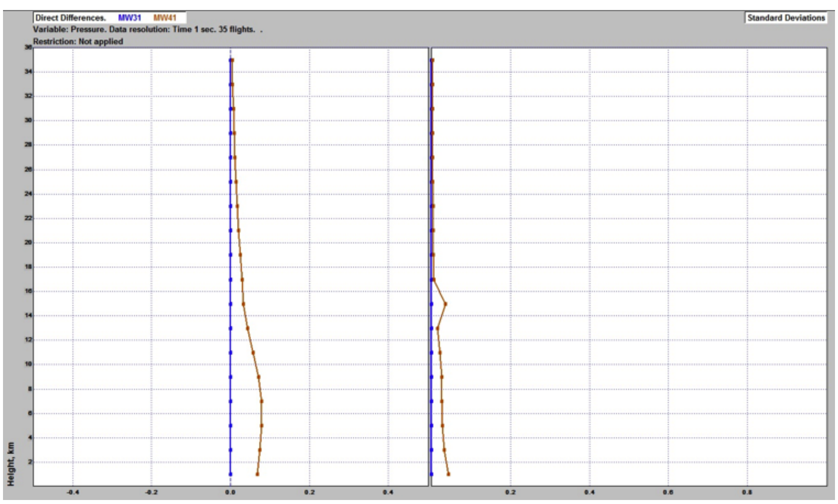


Figure 5. Results of the pressure comparison.

Chapter 7
Wind Measurement

Calculation Algorithms

Both of the systems use the differential GPS method for calculating wind measurements. This method uses satellites observed both by the radiosonde and the local GPS receiver to produce wind data. It is worth noting that although the systems share the same GPS antenna, both systems have their own GPS receivers. This can potentially cause some differences in the calculated values as the systems may not be tracking the same locally observed satellites.

Comparison Results

The comparisons of north-south and east-west wind components are shown in Figure 6 and Figure 7. The average difference in each wind component is less than 0.05 m/s and the standard deviation less than 0.15 m/s for all heights after the immediate launch period. The comparison shows good agreement between the systems.

There is a small increase in the standard deviation at the lowest heights, while the average difference remains negligible. This arises from occasional variations during some flights in the first tens of seconds, that are explained by small differences in the signal processing of the two GPS systems, such as different rejection limits for weak GPS reception. An example of such a case is shown in Figure 8.

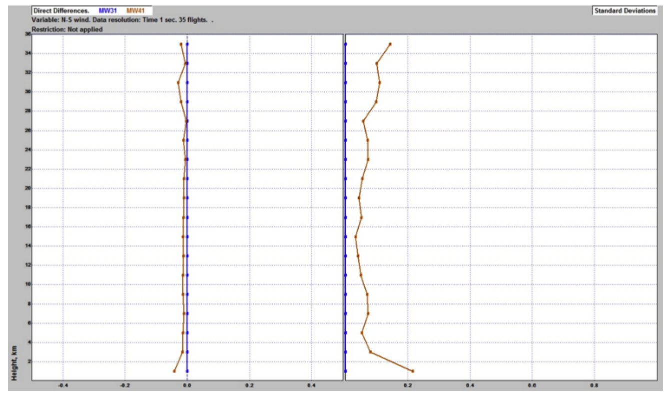


Figure 6. Results of the wind comparison, north-south component.

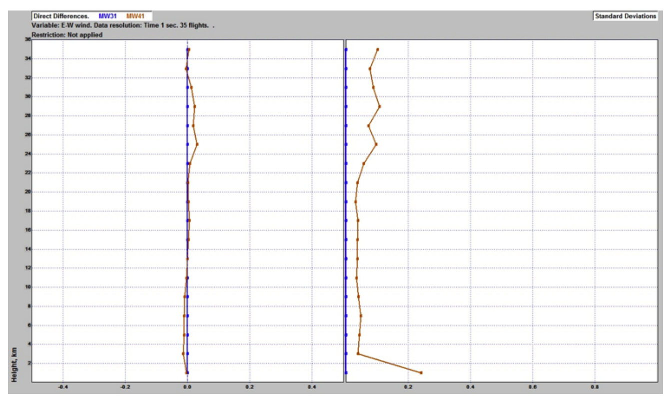


Figure 7. Results of the wind comparison, east-west component.

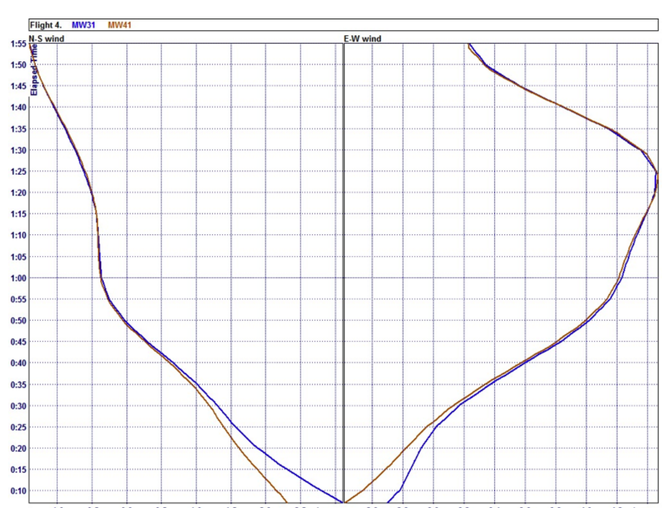


Figure 8. Example of N-S and E-W wind components during the first two minutes of a flight.

References

[1] Comparison sounding technical note, Vaisala reference M211577EN

[2] WMO Intercomparison of Radiosonde Systems in China, Vaisala News 184, pages 16-17

[3] Description and User Guide for the Radiosonde Comparison and Evaluation Software Package, WMO, 1996

[4] Improved Measurement Accuracy of Vaisala Radiosonde RS92, Vaisala News 185, pages 4-7

Ref.B211283EN-A ©Vaisala 2013