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GRUAN Monitor MW41 and the Vaisala RS41 Additional Sensor Interface

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Abstract

This document describes the installation and operation of the GRUAN Monitor MW41 (GM41) software tool release 0.2.2. The GM41 tool displays decoded Xdata protocol frames of several instruments connected to the RS41 in a web browser. The purpose of GM41 is to verify that certain connected instruments are working properly while sounding preparation and data acquisition during laboratory experiments, and that the recorded data are within expected limits. GM41 is compatible with Microsoft Windows 7 or 10 and the Vaisala MW41 sounding software 2.6 to 2.15. Furthermore the connection of additional sensors with Xdata interface and protocol to the Vaisala RS41 type radiosondes is described as well.

Revision history

Version	Author / Editor	Description
1.4 (2024-04-11)	Peter Oelsner	Minor changes for PCFH V2.4 and GM41 V0.2.4
1.3 (2021-02-18)	Peter Oelsner	TEX template changed. Minor changes for PCFH V2.2, MW41 V2.15 and GM41 V0.2.2
1.2 (2019-06-18)	Peter Oelsner	GM41 uses gm41.ini in place of Windows Registry. Updated for GM41 V0.2.
1.1 (2019-05-15)	Peter Oelsner	Updated to GM41 release 0.1.21, MW41 v2.11 and Windows 10
1.0 (2017-03-10)	Peter Oelsner	First published version as GRUAN Technical Note 8
0.1.12 (2017-02-20)	Peter Oelsner, Rico Tietz	Draft version as GRUAN Technical Note 8 and title *GRUAN Monitor MW41*

Editor Remarks

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement by GRUAN.

Acknowledgements

Contacting GRUAN Lead Centre

Please contact the GRUAN Lead Centre (gruan.lc@dwd.de) if you have any questions or comments in relation to this document, or in relation to GRUAN's use of Vaisala RS41 Radiosonde data. If appropriate, the Lead Centre will redirect requests to the Task Team Radiosondes (tt-radiosondes@gruan.org).

Table of contents

1　Introduction

At the GCOS Reference Upper-Air Network (GRUAN) Lead Centre the software tool GRUAN Monitor MW41 (GM41) was developed as an extension to the Vaisala MW41 sounding software with the purpose of decoding Xdata protocol frames from additional sensors connected to Vaisala RS41 type radiosondes. This allows to monitor the performance of additional Xdata sensors during flight preparation and for data acquisition during laboratory experiments. Currently the supported Xdata sensors are Cryogenic Frost-Point Hygrometer (CFH), Compact Optical Backscatter Aerosol Detector (COBALD), Balloon Optical Fluorescent Hygrometer (FLASH-B), Vaisala MW41 Ozone Interface Board (OIF411), the ozone interface board on EN-SCI Model 2Z-V7 ozone sondes (V7), Peltier Cooled Frost point Hygrometer (PCFH) V2.2 and Meisei Peltier-based chilled-mirror hygrometer (SKYDEW). GM41 was tested for compatibility with Microsoft Windows 7 or 10 (English and German localization) and the Vaisala MW41 sounding software 2.6 to 2.15.

Please note that scientific analysis of sounding data should be based on Vaisala MW41 MWX archive or other generated file formats from the sounding system. The MWX file format is explained in *Vaisala* (2018). Beside GM41, the GruanToolRS92 (GT92) available from the GRUAN Lead Centre converts Vaisala archive files into Network Common Data Formats (NetCDFs) or American Standard Code for Information Interchanges (ASCIIs) files that might be entry points for a scientific post processing tool chain. This tool decodes Xdata protocol frames simultaneously. Please contact the GRUAN Lead Centre or visit https://www.gruan.org/data/software/ for obtaining GM41 and GT92. More information about connecting Xdata sensors to the RS41 radiosonde directly or by using the OIF411 while performing ozone soundings is given in Appendix D, *Vaisala* (2015) or *Vaisala* (2016).

The GM41 data flow scheme in short: a server takes care of data acquisition from the Vaisala MW41 sounding interface using IronPython scripts (Python is used as IronPython synonym). For the scientist, data visualization is performed by a client running in a web browser. The server can support multiple clients simultaneously, depending on a powerful server machine. More information on the design of the server and client structure is given in chapters 3 and 4.

Please note that the license to use this software does not allow distribution to third parties. In case of questions, please contact the GRUAN Lead Centre (gruan.lc@dwd.de).

2 Setup and operation

GM41 has to be installed beside the MW41 sounding software from that data is acquired. For a standard installation the following path and network settings are suggested: install directory `c:\tools\gm41`, webserver host name `localhost` or Internet Protocol address (IP-address) `127.0.0.1` and webservers network Transmission Control Protocol (TCP) port `8881`. If the accessibility of the website should also be expanded to a network, the webservers host name or IP-address has to be adjusted respectively. Firewall rules should also be configured. Since GM41 version 0.1.19 root privileges are needed to perform the installation steps described as follow:

Setup

1. Uninstall all existing GM41 installations on that computer using the Microsoft Windows uninstall option for GM41 from: `Control Panel` > `Programs` > `Programs and Features` > `Uninstall`. Delete older installations manually if there is no entry for GM41 in the `Uninstall` list.

2. Run the installer `gm41_setup_0.2.2.exe`. If you are in user mode the installer will request root account credentials that are needed to continue.

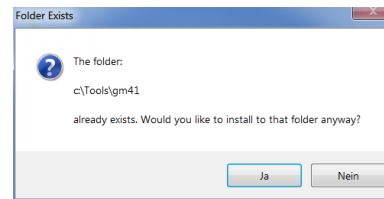3. Click next in the installers welcome page:

Figure 2.1: Installer welcome page.

4. Accept the default installation directory or select another, see Figure 2.2a. The value is stored in the applications launch configuration file `gm41.ini` as key `GM41_APP_DIR` in section `GM41_launch_config` that is later used for application start. Another window appears (Figure 2.2b), if the folder already exists. In that case select yes to continue.

5. The host name or IP-address and network TCP port to bind the webserver to are requested with another window, see Figure 2.3. Click next to accept the shown standard values or apply changes. These values will be stored in `gm41.ini`, keys `GM41_HOST` and `GM41_PORT` in section `GM41_launch_config` respectively, and used for **gm41** startup.
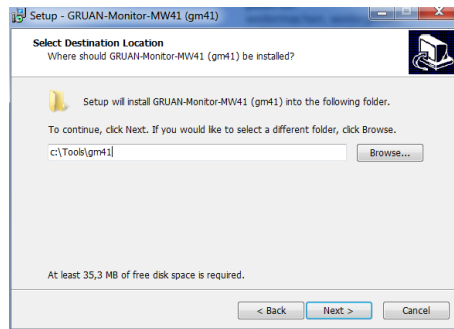
(a) Selection the destination location.   (b) Folder exists.

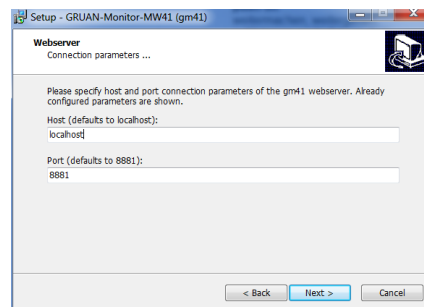Figure 2.2: Selection of destination folder where the app should be installed.

Figure 2.3: Input mask for webserver network settings.

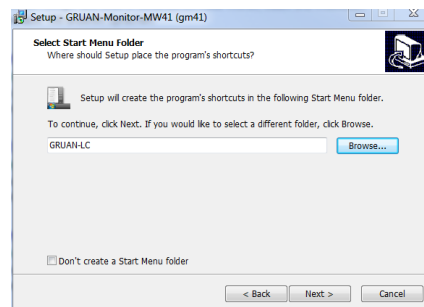6. Select the folder where the applications shortcuts should be stored ore disable this feature:

Figure 2.4: Select a folder for application shortcuts.

7. Configuring the setup has been finished. Click `Install` to perform the installation now:

8. Complete the setup process and reboot or login/logoff that all link changes can take effect.

Operation

9. The installer creates shortcuts for every user on the Windows-Desktop to make easy web-server and client access possible. The settings from steps 4 and 5 are used.

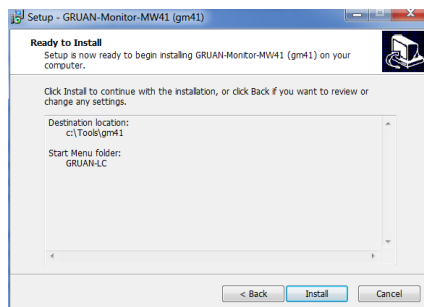10. Start a sounding preparation in the MW41 sounding software.

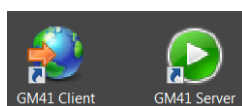Figure 2.5: Window to start performing the installation

Figure 2.6: Shortcuts of GM41 server and client on a Windows-Desktop.

11. Start the GRUAN Monitor MW41 server by clicking the server shortcut on the Windows-Desktop or directly by running `gm41.bat` from the command line in the applications root directory. A command prompt window should appear, showing some runtime information. Please wait some seconds until the application is fully loaded (see Figure 2.7).
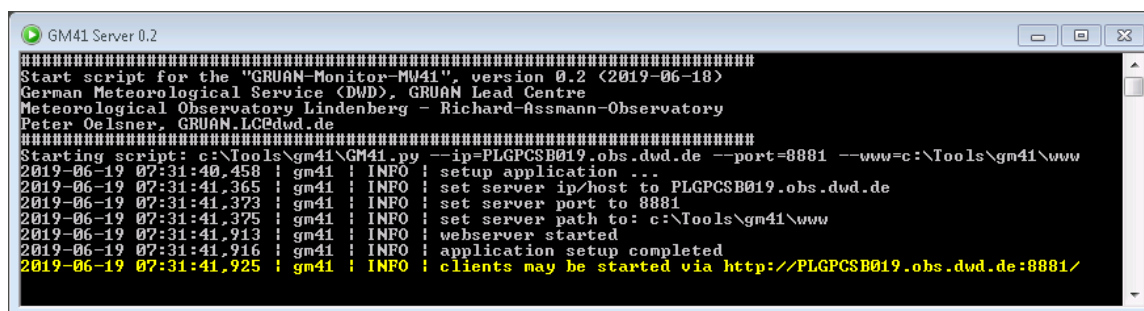

Figure 2.7: Window with runtime information of GM41 server using a non default host name (PLGPCSB019.obs.dwd.de).

12. Call the client website using the shortcut on the Windows-Desktop or visible from the server prompt window (see yellow text line in 2.7). The client website was successfully tested with Firefox version 60+ and new Google Chrome versions. Wait some seconds until the website is fully loaded. Please refresh the web page if it stays with a gray background color more than 15 s.

13. GM41 will stop automatically when a sounding is terminated. Start the tool again for static data display. GM41 also stops when the terminal is closed. A running sounding will not be affected by closing the GM41 server or client.

During runtime debug information and errors are logged into the working directory (files with extension .log[0-9]). Please report bugs to the author including these log files.

3 Description of server site

A couple of Python script files together make the server site. They are partly compiled to `dll` library files. The Python standard library in the MW41 scripting environment is limited and extended by a compiled version. The main Python script is `GM41.py` and implements the MW41 `IExecutableScript` interface. It is called as argument of the Vaisala MW41 `ScriptExecutor.exe` tool *Vaisala* (2019). By that interface the main script is receiving requested notifications from the sounding system and has also limited access to the sounding database by MW41 `ISounding` methods. In Appendix B a scheme of the Vaisala MW41 Scripting Architecture is shown including both interfaces. GM41 selects sounding software events as well as Xdata sensor messages and radiosonde data from the notifications payload and decodes sensor-specific Xdata as needed. A parallel webserver thread for file distribution to clients is started from the main script.

4 Description of client site

The client is a Hypertext markup Language (HTML) website with some style sheets and java script code. Figure 4.1 gives an example displaying some RS41, OIF411 and COBALD readings. With automatic file requests measurement and control data are acquired from the webserver. Other repeating processes updates the visualization of the websites tabbing, header and footer sections. The parameters are refreshed in 2-5 second intervals.
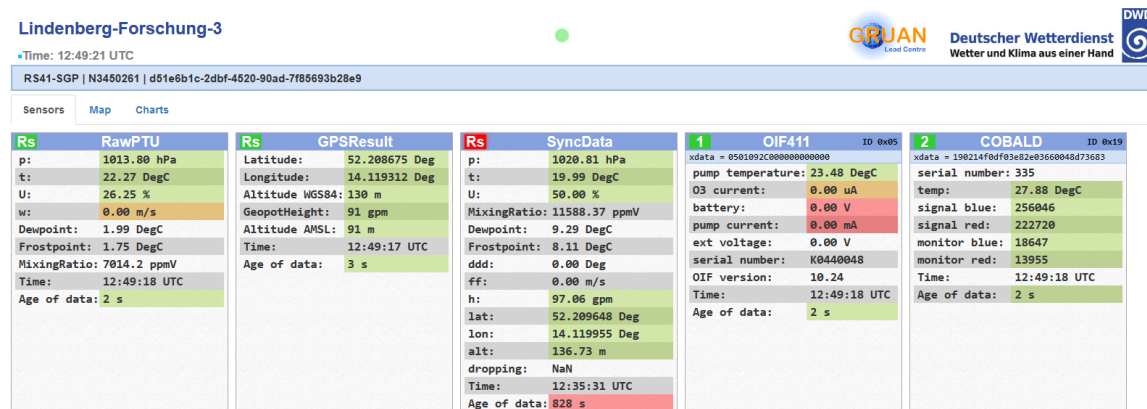

Figure 4.1: Screenshot of the client website, showing the *Sensors* tab.

4.1 Header section

The header section (shown in Figure 4.2) displays the station name, as configured in the MW41 sounding software, the client time, the radiosonde type, the radiosonde serial number and the MW41 sounding identifier. A solid green circle indicates data transfer between client and server.
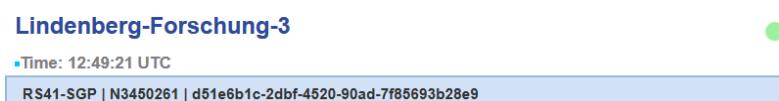

Figure 4.2: The header section.

4.2 Tabbing section

4.2.1 Sensors

In the *Sensors* tab separate boxes of decoded Xdata protocol frames and available radiosonde data types are displayed (see Figure 4.3).

The additional sensor position, so the daisy chain index *Wendell and Jordan* (2016), is indicated in the upper left of the boxes as integer values. For radiosonde data 'Rs' is displayed instead. If GM41 decodes more than one specific protocol frame per instrument, a packet identifier is added to the daisy chain index. As example: '2' and '2.1' would indicate the specific protocol frames 0 and 1 of the additional sensor with daisy chain index 2. A changing background color shows the age of data. Green means new data is arriving regularly, whereas red means the displayed data was received 10 seconds ago or more. The sensor name or data branch is displayed in the center and the Xdata sensor ID is shown on the right.

Measurement values of the radiosonde as also the raw Xdata frame, decoded Xdata frame variables, calculated parameters and times are shown as table entries. A conditional value coloring for some variables tries to help the operator to assess the instrument situation during sounding preparation. See appendix C for used limits. The background color green refers to a normal instrument operation. In amber coloring the user should check the instrument performance more intensively, where red indicates possible instrument errors. In no coloring (white or gray background color) no conditional coloring is applied.

4.2.2 Map

After launch, the radiosonde's position and simplified flight track is displayed on a map, as shown in Figure 4.4. The radiosonde's coordinates (latitude, longitude, and altitude) are displayed by clicking on the balloon burst point or last received position icon. The map is scaleable and print-able. Two check-boxes above the map control data refresh and radiosonde location centering. Different maps can be selected with radio buttons on the map. For operation without internet access an offline map source is also select-able. In that case necessary mapdata have to be copied into the webservers image path. Contact the GRUAN Lead Centre for support (gruan.lc@dwd.de).

4.2.3 Charts

Plotting functionality is rudimentary implemented in the *Charts* tab, as shown in Figure 4.5. After selecting a data source and the x and y parameters, the plot is generated by pushing the "request plot" button. If the *automatic update* checkbox is selected, the plot is updated every few seconds. Changes in the data selection or switching to other tabs terminates the automatic update functionality.

Figure 4.3: An example of the *Sensors* tab is showing boxes with decoded Xdata protocol frames from OIF411, COBALD, CFH and SKYDEW instruments that were connected to the additional sensor interface of a RS41. Also results of the radiosonde data types `RawPTU`, `GPSResult` and `SyncData` (synchronized data or edited data) are visible.
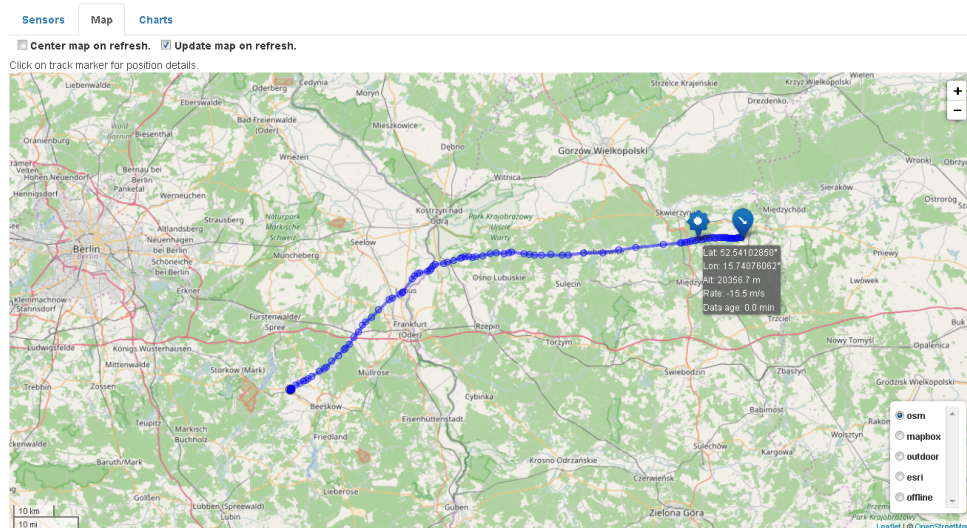
Figure 4.4: Visualization of the radiosondes flight track and station location on an interactive map. Different map-sources can be selected.
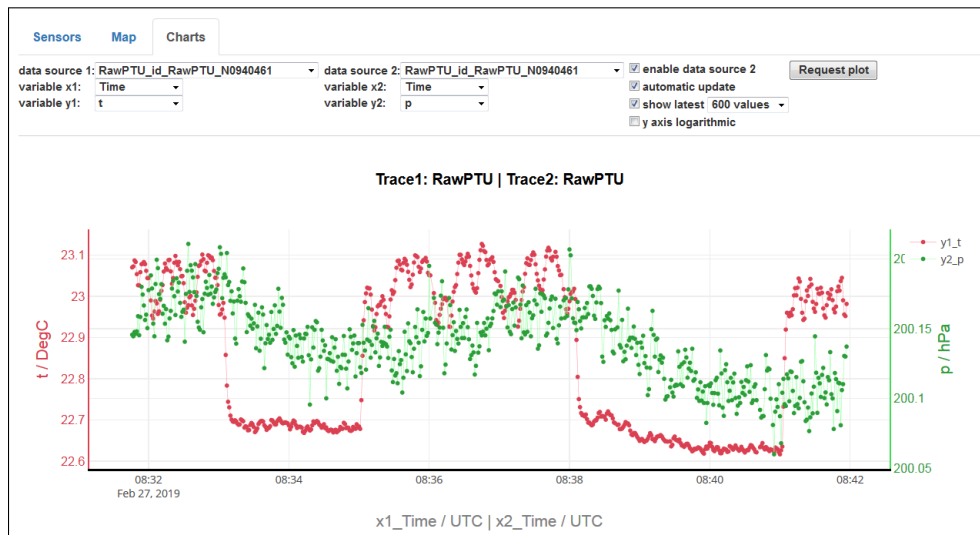
Figure 4.5: GM41 has a simple charting functionality. Hovering the plot, additional control elements appears in the top right of the chart for zooming, moving, storing and other possibilities. A tool tip will explain the controls.

4.3 Known issues

- The background color of the Xdata sensor position stays red while the data lines are getting updated: The real time clock of the webserver and client computer are out of sync. A synchronization of both clocks is needed.

- If a connection is closed by the browser before answered from the webserver, the webserver throws an exception. The exception is catched, but displayed in the terminal session. The server stays online.

Appendix

A Directory listing

```
 1  c:\
 2    tools\
 3      gm41\
 4          icons\
 5          simplejson\
 6        www\
 7          doc\...
 8          images\
 9            offline_charts\
10              osm\...
11          lib\...
12          index.html
13          ...
14        version
15        gm41.bat
16        gm41.ini
17        gm41.pdf
18        gm41_config.json
19        mw41gm.dll
20        std.dll
21        License.pdf
22        GM41.py
23        *.log
24        ...
```

B MW41 Scripting Architecture

Figure B.1: Scheme of the Vaisala MW41 Scripting Architecture (taken from *Vaisala*, 2019).

C Conditional parameter coloring

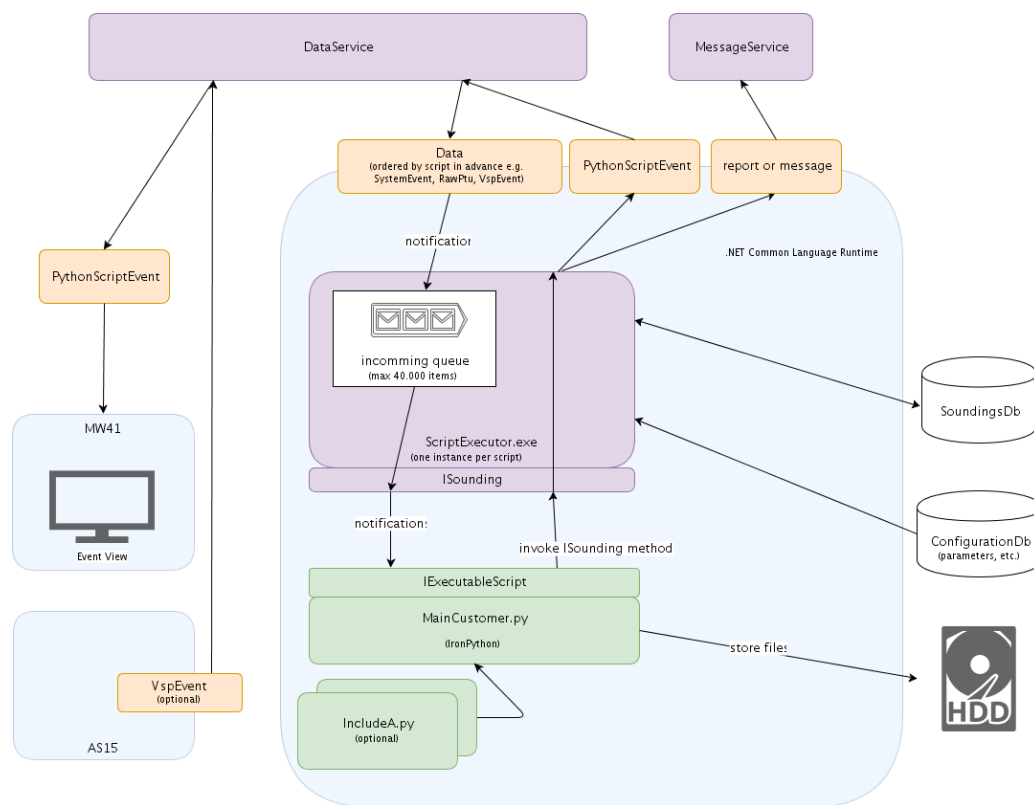| Instrument/DataType	Parameter	Index	green	amber	red
CFH (0x08)	frostpoint	0	[-100, 20)	[-120, -100)	[-99999, -120)
		1		[20, 30)	[30, 99999)
	testpoint	0	[2.45, 2.65)	[2.4, 2.45)	[-99999, 2.4)
		1		[2.65, 2.85)	[2.85, 99999)
	TOptik	0	[28, 35)	[20, 28)	[-99999, 20)
		1		[35, 49)	[49, 99999)
	Batt	0	[11, 12)	[9.5, 11)	[-99999, 9.5)
		1		[12, 13)	[13, 99999)
	Age of data	0	[0, 10)	[10, 12)	[-99999, 0)
		1			[12, 99999)
CFH (0x16)	frostpoint	0	[-100, 20)	[-120, -100)	[-99999, -120)
		1		[20, 30)	[30, 99999)
	testpoint	0	[2.45, 2.65)	[2.4, 2.45)	[-99999, 2.4)
		1		[2.65, 2.85)	[2.85, 99999)
	TOptik	0	[28, 35)	[20, 28)	[-99999, 20)
		1		[35, 49)	[49, 99999)
	Batt	0	[11, 12)	[9.5, 11)	[-99999, 9.5)
		1		[12, 13)	[13, 99999)
	Age of data	0	[0, 10)	[10, 12)	[-99999, 0)
		1			[12, 99999)
COBALD (0x19)	CobaldTemp	0	[0, 40)	[-40, 0)	[-256, -40)
		1		[40, 50)	[50, 255.875)
	CobaldSigBlue	0	[0, 1000000)	[-8388608, 0)	
		1		[1000000, 8388607)	
	CobaldSigRed	0	[0, 1000000)	[-8388608, 0)	
		1		[1000000, 8388607)	
	CobaldMonBlue	0	[-32768, 32767.1)	[-99999, -32768)	
		1		[32767.1, 99999)	
	CobaldMonRed	0	[-32768, 32767.1)	[-99999, -32768)	
		1		[32767.1, 99999)	
	Age of data	0	[0, 10)	[10, 12)	[-99999, 0)
		1			[12, 99999)

Figure C.1: Conditional parameter coloring for CFH and COBALD.

Instrument/DataType	Parameter	Index	green	amber	red
V7 (0x01)	PumpT	0	[10, 35)	[5, 10)	[-99999, 5)
		1			[35, 99999)
	CurrV7	0	[40, 90)	[30, 40)	[-99999, 30)
		1		[90, 110)	[110, 99999)
	BatV7	0	[16, 18)	[14, 16)	[-99999, 14)
		1		[18, 19)	[19, 99999)
	Age of data	0	[0, 10)	[10, 12)	[-99999, 0)
		1			[12, 99999)
OIF411 (0x05)	TPump	0	[10, 35)	[5, 10)	[-99999, 5)
		1			[35, 99999)
	o3Current	0	[0.01, 20)	[0, 0.01)	[-99999, 0)
		1		[20, 30)	[30, 99999)
	batteryVoltage	0	[16, 18)	[14, 16)	[-99999, 14)
		1		[18, 19)	[19, 99999)
	pumpCurrent	0	[40, 90)	[30, 40)	[-99999, 30)
		1		[90, 110)	[110, 99999)
	Age of data	0	[0, 10)	[10, 12)	[-99999, 0)
		1			[12, 99999)
SKYDEW (0x3F)	Temp	0	[-100, 20)	[-120, -100)	[-99999, -120)
		1		[20, 30)	[30, 99999)
	PT100	0	[60, 120)	[-99999, 60)	
		1		[120, 99999)	
	DEW	0	[1, 1.8)	[0.5, 1)	[0, 0.5)
		1		[1.8, 2)	[2, 99999)
	SCA_Base	0	[21000, 22000)	[-99999, 21000)	
		1		[22000, 99999)	
	PT_Current	0	[0, 2.5)	[-0.4, 0)	[-99999, -0.4)
		1		[2.5, 2.6)	[2.6, 99999)
	HS	0	[-90, 40)		[-99999, -90)
		1			[40, 99999)
	CB	0	[-40, 40)		[-99999, -40)
		1			[40, 99999)
	PID	0	[0.6, 200)	[-99999, 0.6)	
		1		[200, 99999)	
	Batt	0	[4.5, 7.0)	[4, 4.5)	[-99999, 4)
		1		[7, 8)	[8, 99999)
	Age of data	0	[0, 10)	[10, 12)	[-99999, 0)
		1			[12, 99999)

Figure C.2: Conditional parameter coloring for V7, OIF411 and SKYDEW.

| Instrument/DataType	Parameter	Index	green	amber	red
RawPTU	p	0	[4, 1060)	[1060, 1080)	[-99999, 4)
		1		[1, 4)	[1080, 99999)
	t	0	[-95, 60)		[-99999, -95)
		1			[60, 99999)
	U	0	[1, 100)	[0, 1)	[-99999, 0)
		1		[100, 105)	[105, 99999)
	w	0	[5, 8)	[-60, 5)	[-99999, -8)
		1		[8, 12)	[12, 99999)
	Age of data	0	[0, 10)	[10, 12)	[-99999, 0)
		1			[12, 99999)
GPSResult	Latitude	0	[-90, 90)		[-99999, -90)
		1			[90, 99999)
	Longitude	0	[-180, 180)		[-99999, -180)
		1			[180, 99999)
	Altitude	0	[0, 50000)	[-100, 0)	[-99999, -100)
		1			[50000, 99999)
	GeopotHeight	0	[0, 50000)	[-100, 0)	[-99999, -100)
		1			[50000, 99999)
	GeometricHeightFromSeaLevel	0	[0, 50000)	[-100, 0)	[-99999, -100)
		1			[50000, 99999)
	Age of data	0	[0, 10)	[10, 12)	[-99999, 0)
		1			[12, 99999)
SyncData	p	0	[4, 1060)	[1060, 1080)	[-99999, 4)
		1		[1, 4)	[1080, 99999)
	t	0	[-95, 60)		[-99999, -95)
		1			[60, 99999)
	U	0	[1, 100)	[0, 1)	[-99999, 0)
		1		[100, 105)	[105, 99999)
	h	0	[0, 50000)	[-100, 0)	[-99999, -100)
		1			[50000, 99999)
	lat	0	[-90, 90)		[-99999, -90)
		1			[90, 99999)
	lon	0	[-180, 180)		[-99999, -180)
		1			[180, 99999)
	alt	0	[0, 50000)	[-100, 0)	[-99999, -100)
		1			[50000, 99999)
	Age of data	0	[0, 10)	[10, 180)	[-99999, 0)
		1			[180, 99999)

Figure C.3: Conditional parameter coloring for several RS41 data types.

D Additional Sensor connection to RS41

After describing the RS41 additional sensor interface with Figures D.1 and D.2, two approaches for connecting additional Xdata sensors to the RS41 without and with the Vaisala MW41 Ozone Interface Board (OIF411) are shown in appendix D.2 and D.1.


(a) Vaisala RS41 radiosonde with opened additional sensor interface port right hand from the antenna (marked with a black circle).
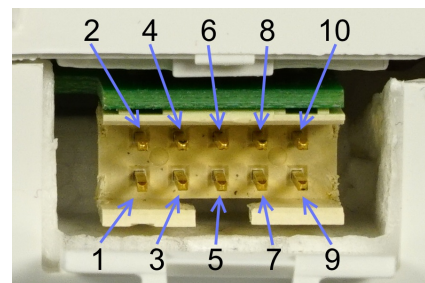
(b) Close view to the Vaisala RS41 radiosonde additional sensor interface port with labeled pin order.

Figure D.1: RS41 additional sensor Interface location and pin order. The pin function is: **1** and **10** GND, **2** RXD (from additional sensor), **3** TXD (to additional sensor), **4** reserved, **5** supply voltage to additional sensor (3.7 V, ± 3 %), **6** to **10** reserved.
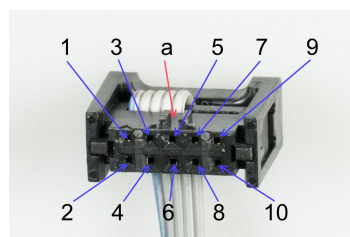
(a) Wire housing with pin numbers. See Figure D.1 for a the pin function description. The orientation pin is marked with "a".

(b) Assembled wire housing and wire with one turn on a ferrite tube.

Figure D.2: Wire housing (Mfr. Amphenol FCI, part no. 89361-710SLF) for RS41 additional sensor Interface cable - radiosonde site. Visible in (b) is also a suitable ferrite tube (Mfr. Wurth Elektronik, part no. 74270032) and wire (Mfr. 3M, part no. HF625/10). Pitch space is 2 mm.

D.1 Connections with using OIF411

The OIF411 ozone board is technically an additional Xdata sensor with ozone sonde measurement / supply ports and the option for connecting one additional Xdata sensor. Figure D.3 shows the pin connection of OIF411 to RS41 and one next additional Xdata sensor. Xdata messages are forwarded to the RS41 (daisy chaining). The OIF411 is a part of the Vaisala RSA411 Ozone Interface Kit with cables to radiosonde and ozone sonde. Therefore no adapter cable to the radiosonde must be assembled in this approach. Only the cable to the additional Xdata sensor is needed and often included with the additional Xdata sensors.
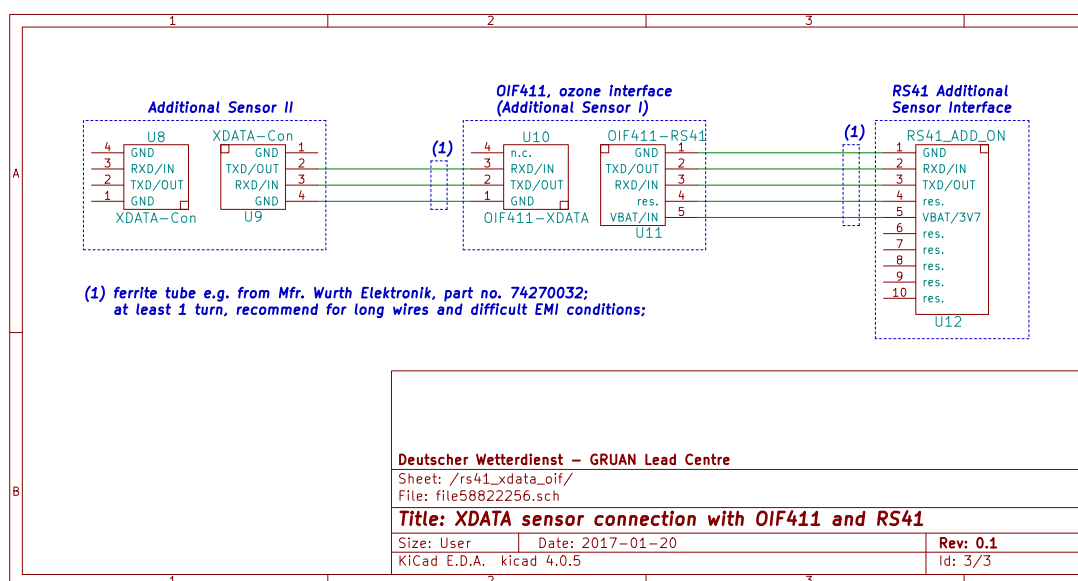

Figure D.3: Pin configuration scheme for two additional sensors (daisy-chain configuration) using the OIF411 (see Figure D.4) connected to the RS41 additional sensor interface. Connector details as also manufacturer and order codes can be gathered from Figures D.1, D.2 and D.6 or from *Vaisala* (2015).

D.2 Connections without using OIF411

When no ozone sonde is used on the payload or connected through other Xdata compatible ozone interface board respectively (e.g. V7), additional Xdata sensors can also be connected with their Xdata port directly to the RS41. Only an adapter cable without active components is needed as described in Figure D.5.
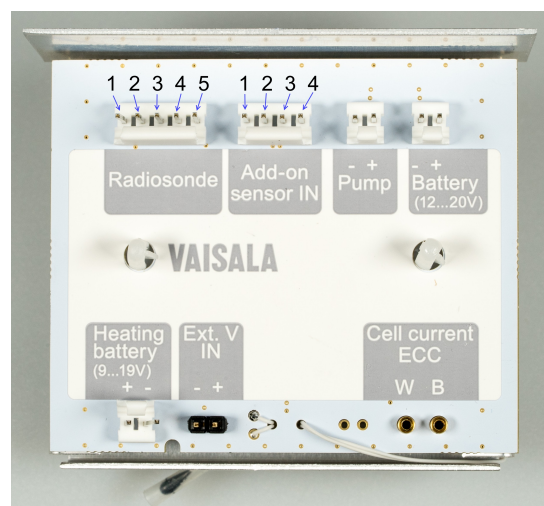
Figure D.4: Vaisala MW41 Ozone Interface Board (OIF411) for connecting additional Xdata sensors (through connector "Add-on sensor IN") and an ECC ozone sonde with the RS41 radiosonde. The interface is powered by the radiosonde connected to port "Radiosonde". Note that board and cables to radiosonde and ozone sonde are already included with the Vaisala RSA411 Ozone Interface Kit.
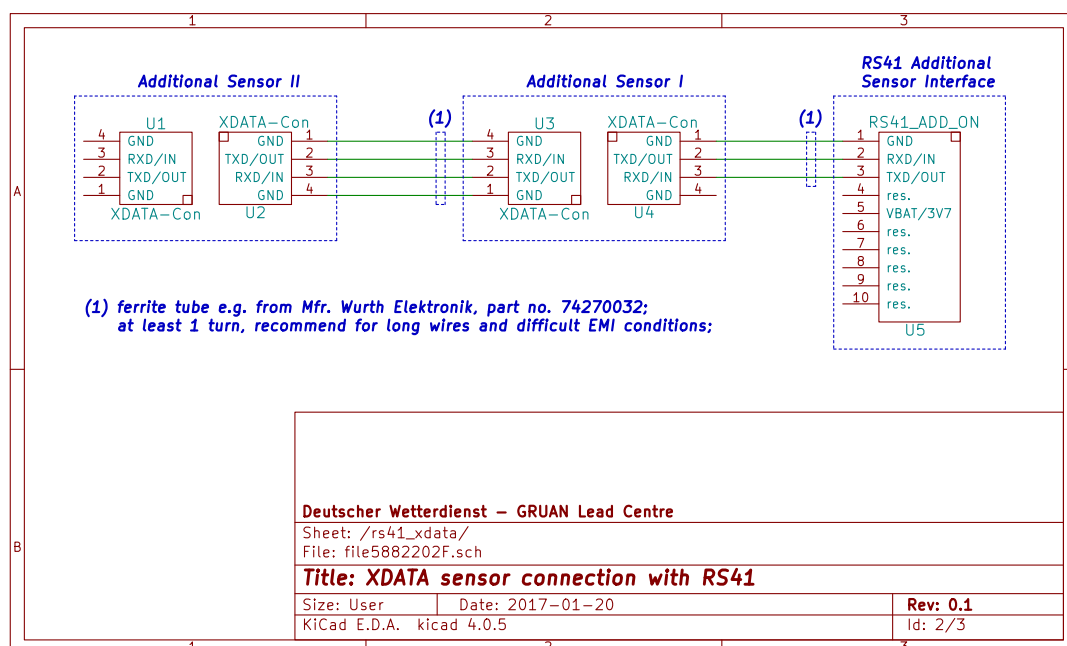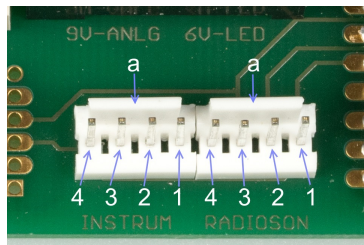

Figure D.5: Pin configuration scheme for two additional sensors (in daisy-chain configuration) connected directly to the RS41 additional sensor interface. Connector details as also manufacturer and order codes can be gathered from Figures D.1, D.2 and D.6 or from *Vaisala* (2015).

(a) Headers (Mfr. TE Connectivity, part no. 640456-4, MTA100 series) on COBALD electronics board for connection to next additional Xdata sensor (left) and to radiosonde (right).
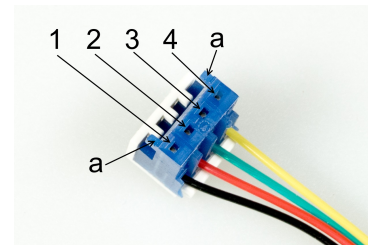
(b) Wire housing (Mfr. TE Connectivity, part no. 3-643816-4, MTA100 series) for cables between additional Xdata sensors.

Figure D.6: Header (a) and wire housing (b) mostly used for Xdata additional sensor connections. **1** to **4** are pin numbers. Orientation pins are indicated with **a**.

Acronyms

ASCII	American Standard Code for Information Interchange
CFH	Cryogenic Frost-Point Hygrometer
COBALD	Compact Optical Backscatter Aerosol Detector
GM41	GRUAN Monitor MW41
GRUAN	GCOS Reference Upper-Air Network
GT92	GruanToolRS92
HTML	Hypertext markup Language
FLASH-B	Balloon Optical Fluorescent Hygrometer
SKYDEW	Meisei Peltier-based chilled-mirror hygrometer
NetCDF	Network Common Data Format
OIF411	Vaisala MW41 Ozone Interface Board
PCFH	Peltier Cooled Frost point Hygrometer
V7	the ozone interface board on EN-SCI Model 2Z-V7 ozone sondes
TCP	Transmission Control Protocol
IP-address	Internet Protocol address

Bibliography

Vaisala, *Vaisala Radiosonde RS41 Additional Sensor Interface*, Vaisala Oyi, P.O. Box 26 FI 00421 Helsinki Finland, 2015, users Guide, filename M211604EN-C.pdf.

Vaisala, *Ozone Sounding with Vaisala Radiosonde RS41*, Vaisala Oyi, P.O. Box 26 FI 00421 Helsinki Finland, 2016, users Guide, filename M211486EN-B.pdf.

Vaisala, *Vaisala DigiCORA Sounding System MW41*, Vaisala Oyi, P.O. Box 26 Fl 00421 Helsinki Finland, 2018, technical Reference, filenmame M211415EN-R.pdf.

Vaisala, Ironpython scripts in the sounding system, Vaisala MW41 v2.11 DVD, 2019, folder /UserDocumentation/Scripting/architecture.htm on MW41 sounding software DVD.

Wendell, J. and A. Jordan, imet-1-rsb radiosonde xdata protocol & daisy chaining, 2016.