WMO Field Intercomparison of Rainfall Intensity Gauges

Vigna di Valle, Italy, Mid 2007–Mid 2008

Data Manager Report
N. **2**/*September 2007*

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Test Field in Vigna di Valle (Italy)
September 2007

Preface

The present report is devoted to the description of the start-up phase of the WMO/OMM Field Intercomparison of Rainfall Intensity (RI) Gauges (from here on RI-FI) of Vigna di Valle (Italy) and in particular, to the assessment of suitable strategies for data storing and data analysis following specific *Data Managing* duties (crf. the CIMO OPAG SURFACE ET-SBII & CM-3/IOC-3 Final report, 2007, section 3.6.6). The whole document has been revised according to the ET/IOC suggestions, following the CIMO OPAG SURFACE ET-SBII CM-5-IOC-5 Fifth (reduced) Session of 19-21 September 2007 in Vigna di valle (Italy).

The report is structured as follows:

I. Chapter 1 "**The WMO RI-FI: General Framework**" describes the general framework of RI-FI, focusing on aspects directly connected with data collection and analysis such as types of involved instruments, their positioning within the testing area, output records and native error codes. All information presented here was collected by the Site manager (SM) and data Manager (DM) both through direct claim to the manufacturers and from preliminary Laboratory/Field tests of the RI-FI gauges. Manuals, software and other technical documentations concerning the 26 typologies of instrument under test are available to the WMO RI-FI Staff at the internet address: `http://www.pro-testa.net/WMO_FIRII/`. Moreover, a copy of the documentation is present on the WMO ftp site, accessible by authentication to the ET/IOC;

II. Chapter 2 "**Designing the RI-FI Data Base**" is devoted to the identification of a *standard output record (SOR)* and the design of the data collection system for both the raw data and the whole campaign db. Moreover, Chapter 2 assesses

additional data storing issues, such as the coding of external (generated by the data acquisition system) and native (generated by sensors) error codes, sampling strategies, "ad posteriori" validation procedures (Quality Control) and the recording of control variables. The data collection procedure has been developed by the DM in concert with the SM (responsible for the RI-FI acquisition system) based on the output records described in Chapter 1; following the ET/IOC directions, an ensemble of procedures for data Quality Control (QC) and "Ad Posteriori validation" has been developed also basing on World Meteorological Organization (2006);

III. Chapter 3 "**Preliminary Data Analysis Specifications**" deals with the basic procedures for data analysis emphasizing the need for the preliminary application – at least in the course the RI-FI preliminary phase – of an ensemble of exploring statistics and methods before defining final Data Analysis procedure. These methods are therefore presented in "draft" form, highlighting the most relevant related issues/drawbacks.

Appendix A lastly reports specifications of the instruments involved in the RI-FI and links to the collected documentation now available on line at the address http://www.pro-testa.net/WMO_FIRII/.

Contents

Chapter 1

The WMO RI-FI: General Framework

The present chapter provides a general background of the WMO/OMM Field Intercomparison of Rainfall Intensity (RI) Gauges thorough the description of basic goals, characteristics of the involved instruments, installation scheme and procedures for both lab and field testing/manteinence of gauges. It is therefore propaedeutic to Chapter 2 and Chapter 3, mainly centered on the acqisition/managing/analisis of data.

As previuosly mentioned, all the information here presented has been collected by the SM and the DM both through direct claim to the manufacturers and Laboratory/Field functioning test of the RI-FI gauges. Manuals, software and other technical documentations concerning the 26 typologies of instruments under test are currently available for the WMO RI-FI Staff at the internet address `http://www.pro-testa.net/WMO_FIRII/`, while links to the specific folder of each RI gauge can be encountered along the text. Moreover, a copy of the documentation is present on the wmo ftp site, accessible by authentication to the ET/IOC.

The chapter opens with a presentation of the 30 (26 in field + 4 references) rainfall gauges involved in the RI-FI, categorized by nationality, functioning principle and actual output typology (namely the native data message generated from the instrument); then the transfer function from the actual to the Rainfall Intensity output is discussed in conjunction with a detailed illustration of the 26 native output records. Moreover, both lab and field calibration procedures are described in Section 1.5.

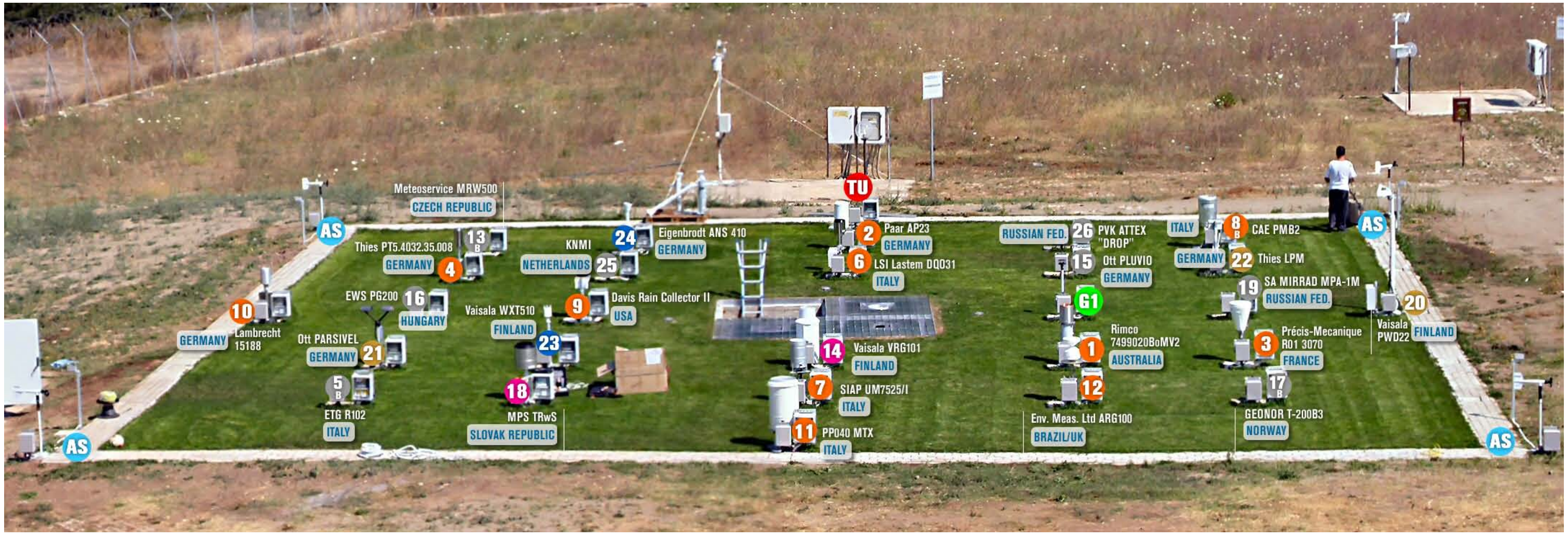

Figure 1.1: The test field of Vigna di Valle in Mid July, during the DM visit: Instruments location scheme

Figure 1.2: The test field of Vigna di Valle in late August

Figure 1.3: The test field of Vigna di Valle in late August

Figure 1.4: The test field of Vigna di Valle in late August

Figure 1.5: The test field of Vigna di Valle: detail of the data acquisition system

Figure 1.6: The test field of Vigna di Valle as installed in September 2007

Figure 1.7: The test field of Vigna di Valle as installed in September 2007

1.1 RI-FI basic goals and expected results

The WMO/OMM RI-FI follows the WMO Laboratory Intercomparison of Rainfall Intensity Gauges (Lanza, L.G., Leroy, M., Alexandropoulos, C., Stagi, L., Wauben, W., 2005) with the basic goal of analyze and compare the performance of different typologies of Rain gauges in measuring Rainfall intensity under several climatic conditions. During the RI-FI, 30 RI (26 in field + 4 references) gauges will undergo performance tests and will be compared with the 4 reference gauges selected basing on the Laboratory Intercomparison results, namely the ETG R102 and the CAE PMB2 tipping bucket rain gauges end the Meteoservis MRW500 and the Geonor T-200B weighing gauges.

The test field is located within the Italian Air Force Meteorological Research Center (RESMA) in Vigna di Valle (Italy) and is a square of 20.5 X 20.7 meters where testing instruments are equally distanced, while reference instruments are located in a central pit for the lowering of climatic effects. The Test Field, as showed up in mid July, is represented in Figure 1.1 while Figure 1.2 to Figure 1.5 reports the installation state in late August. In particular, Figure 1.5 shows a detail of the data acquisition system.

Finally in Figure 1.6 to Figure 1.7 the present state of the test field is shown. The ancillary sensors location is also represented in Figure 1.1, namely: the 4 propeller wind gauges in AS together with 4 rainfall sensors, an additional wind sensor in G1 and Temperature, Relative Humidity sensors in TU. As highlighted in the Final Report of the "WMO Laboratory Intercomparison of Rainfall Intensity Gauges", (2005):

> *"Precipitation intensity is defined by WMO as the amount of precipitation, collected per unit time interval. According to this definition, precipitation intensity data can be derived by the measurement of precipitation amount using an ordinary precipitation gauge. In that sense, precipitation intensity is a secondary parameter, derived from the primary parameter precipitation amount. However, precipitation intensity can also be measured directly. For instance, using a gauge and measuring the flow of the captured water, or the increase of collected water as a function of time. A number of measurement techniques for the determination of the amount of precipitation are based on these direct intensity measurements by integrating the measured intensity over a certain time interval. Typical examples are optical and electromagnetic sensing rain gauges. In fact, all remote sensing techniques measure intensity as primary variable. [...] It is important to evaluate these automatic gauges for measuring precipitation intensity."*

During the Laboratory Intercomparison of Rainfall Intensity Gauges, instruments have been then provided with constant water flows and the accuracy of their response has been assessed. In the three involved laboratories of De Bilt, Genoa and Trappes experiments have been led under controlled conditions, annulling so all those error components connected with:

1) the space-time characteristics of the measured rainfall event
2) other climatological quantities/factors – such as e.g. wind speed and direction – able to influence the RI measurements

Depending on the time aggregation on which the measurements are performed, rainfall field erratic structure and/or external climatic factors can be more or less influent as a function of the native sampling window of the instrument, its response interval and its sensitivity to external factors.

All these evidences have to be carefully considered during the present RI-FI, in order to:

1) assess the biases due to "external" climatic effects by the comparison of the instruments under test with 4 reference instruments positioned in a standard pit
2) learn as much as possible about the response of different typologies of RI measurement instruments to the space time structure of the rainfall process through the exact meteorological categorization of all measured rain events.

1.2 The 26 typologies of involved instruments

The RI-FI involves 26 "under test" and 4 reference instruments representing 15 nations. The most represented countries are Germany (with 6 different instruments and 4 manufacturers), Italy (with 5 different instruments and 5 manufacturers) and Finland (with 3 different instruments and 1 manufacturer). In Table 1.1 the instruments are listed by affiliation country. To the huge variety of nations represented corresponds also a great variety in functioning principles (12 Tipping bucket rain gauges, 7 Weighing gauges, 3 Optical disdrometers, 1 Acoustic gauge, 1 Pressure gauge, 1 Level Gauge and 1 Micro Doppler radar) and in native output. Different functioning schemes are summarized in Table 1.2, while in Table 1.3 is reported the native output list.

ID	MODEL/MANUFACTURER	NATIONALITY
1	7499020BoMV2/RIMCO	AUSTRALIA
2	AP23/PAAR	AUSTRIA
3	R01 3070/PRECIS-MECANIQUE	FRANCE
4	PT 5.4032.35.008/THIES	GERMANY
5	R 102 (REFERENCE GAUGE)/ETG	ITALY
6	DQA031/LSI LASTEM	ITALY
7	T-PLUV UM7525/I/SIAP-MICROS	ITALY
8	PM B2 (REFERENCE GAUGE)/CAE	ITALY
9	RAIN COLLECTOR II (7852)/DAVIS	USA
10	15188/LAMBRECHT	GERMANY
11	PP040/MTX	ITALY
12	ARG100/ENV. MEAS. Lmt.	BRAZIL/UK
13	MRW500(REFERENCE GAUGE)/METEOSERVIS	CZECH REPUBBLIC
14	VRG101/VAISALA	FINLAND
15	PLUVIO/OTT	GERMANY
16	PG200/EWS	HUNGARY
17	T-200B (REFERENCE GAUGE)/GEONOR	NORWAY
18	TRwS/MPS	SLOVAK REPUBBLIC
19	MPA-1M/SA "MIRRAD"	UCRAINE
20	PWD22/ VAISALA	FINLAND
21	PARSIVEL/OTT	GERMANY
22	LPM/THIES	GERMANY
23	WXT510/VAISALA	FINLAND
24	ANS 410-H/EIGENBRODT	GERMANY
25	Electrical raingauge/KNMI	NETHERLANDS
26	DROP/PVK-ATTEX	RUSSIAN FEDERATION

Table 1.1: List of RI-FI gauges by id, model/manufacturer and nationality

As evident from this last table, a first issue in RI data synchronization and aggregation on 1 minute just arises from the lack of homogeneity in actual outputs. Moreover, a part of the manufacturers has been not able to provide their gauges with a RI output

ID	MODEL/MANUFACTURER	TYPOLOGY
1	7499020BoMV2/RIMCO	Tipping bucket
2	AP23/PAAR	Tipping bucket
3	R01 3070/PRECIS-MECANIQUE	Tipping bucket
4	PT 5.4032.35.008/THIES	Tipping bucket
5	R 102 (REFERENCE GAUGE)/ETG	Tipping bucket
6	DQA031/LSI LASTEM	Tipping bucket
7	T-PLUV UM7525/I/SIAP-MICROS	Tipping bucket
8	PM B2 (REFERENCE GAUGE)/CAE	Tipping bucket
9	RAIN COLLECTOR II (7852)/DAVIS	Tipping bucket
10	15188/LAMBRECHT	Tipping bucket
11	PP040/MTX	Tipping bucket
12	ARG100/ENV. MEAS. Lmt.	Tipping bucket
13	MRW500(REFERENCE GAUGE)/METEOSERVIS	Weighing Gauge
14	VRG101/VAISALA	Weighing Gauge
15	PLUVIO/OTT	Weighing Gauge
16	PG200/EWS	Weighing Gauge
17	T-200B (REFERENCE GAUGE)/GEONOR	Weighing Gauge
18	TRwS/MPS	Weighing Gauge
19	MPA-1M/SA "MIRRAD"	Weighing Gauge
20	PWD22/ VAISALA	Optical Disdrometer
21	PARSIVEL/OTT	Optical Disdrometer
22	LPM/THIES	Optical Disdrometer
23	WXT510/VAISALA	Acoustic detection of individual rain drops
24	ANS 410-H/EIGENBRODT	Pressure sensor
25	Electrical raingauge/KNMI	Level sensor
26	DROP/PVK-ATTEX	Micro Doppler radar

Table 1.2: List of RI-FI gauges by id, model/manufacturer and functioning principle

ID	ACTUAL OUTPUT
1	Passive Reed Contact Switches (pulses) - RA
2	Passive Reed Contact Switches (pulses) - RA
3	Passive Reed Contact Switches (pulses) - RA
4	Passive Reed Contact Switches (pulses) - RA
5	(CORRECTED) RA, RI on 1-MINUTE
6	RA on 1 minute (but also at higher resolutions) (crf. manual and Appendix A)
7	RI, RA, RA corrected on 1-minute
8	RI[mm/h], RA corrected on 1-minute
9	Passive Reed Contact Switches (pulses) - RA
10	ACTIVE PULSE 0-5V with random additional pulse (300ms pulse interval) for corrections - RA (crf. manual and Appendix A
11	Passive Reed Contact Switches (pulses) - RA
12	Passive Reed Contact Switches (pulses) - RA
13	istantaneous weight [mm], avg weight [mm](on 1 minute), precipitation operating value [mm] (on 1 minute)
14	RA, RI, RA1[g] =MASS[g] on 1-minute
15	Real time RI (>threshold),Real time RI (no threshold), No realtime RI [(crf. manual and Appendix A)
16	difference between the actual and previous averages of total weight of container [mm];"real sum" [mm];average of the total weight of container [mm]; precipitation status.
17	RA, AVERAGE RA (crf. manual and Appendix A)
18	RA, ACCUMULATED WEIGHT, RAIN YES/NO on 1 minute (crf. manual and Appendix A)
19	RA, RI
20	RI,RA
21	RI,RA (Only when precipitation starts)
22	RI,RA
23	RI,RA (Only when precipitation starts)
24	RA [mm] on 1 minute (sampling between 1 to 999 seconds)
25	RI [micrometer/h]AND RAINFALL DURATION (crf. manual and Appendix A)
26	RA [mm]

Table 1.3: List of RI-FI gauges by id, model/manufacturer and actual output: where not specificated RI (Rainfall Intensity) is expressed in mm/h and RA (Rainfall Accumulation)in mm

on 1 minute so that the definition of suitable transfer functions became crucial. Problem connected with transfer function definitions are diffusely discussed in Section 1.3, while different actual outputs are described in detail in Section 1.4.

An important topic deriving from the analysis of actual output is error coding: also in dealing with diagnostic data and error codes in fact, we encounter a great variety of different data massages ranging between the total absence of a error encoding to instruments such as LPM THIES (crf. THIES LPM documentation) presenting 67 diagnostic quantities plus the precipitation spectrum. Different error encodings are always examined in Section 1.4 and their translation whitin the WMO RI-FI db will be deepened in Chapter 2. Table 1.5 summarizes where error codes are or are not present in the single instruments records.

1.3 Instruments without RI on 1 minute aggregation output: the Transfer Function

As reported in the the CIMO OPAG SURFACE ET-SBII & CM-3/IOC-3 Final report, (2007), section 3.5.5 of the "Procedures for installation and supervision of instruments", points *g)* to *i)*:

A) In case the RI (rainfall rate per 1 minute) is not directly provided as an output of the measurement, the transfer function shall be given by manufacturers to derive RI at 1-min time resolution.

B) Manufacturers shall provide a time-synchronized output with an update frequency of 1-minute. Therefore, the procedure to synchronise the observation interval to a reference has to be described.

C) Manufacturers shall provide the response time of their instrument and the delay time for the RI output.

In the following we will summarize the transformation law from native output to RI on 1 minute aggregation, time synchronization and native sampling in a unique function, namely the Global Transfer Function (GTF), able to code each instrument native output in a synchronized RI measurement in mm/h on 1 minute aggregation. Table 1.4 provides a summary of GTFs for the 25 RI-FI gages.

ID	MODEL/MANUFACTURER	RI OUTPUT	GTF (yes/no)
1	7499020BoMV2/RIMCO	NO	YES
2	AP23/PAAR	NO	YES
3	R01 3070/PRECIS-MECANIQUE	NO	YES
4	PT 5.4032.35.008/THIES	NO	YES
5	R 102 /ETG	YES	-
6	DQA031/LSI LASTEM	NO	YES
7	T- PLUV UM7525/I/SIAP-MICROS	YES	-
8	PM B2 /CAE	YES	-
9	RAIN COLLECTOR II (7852)/DAVIS	NO	YES
10	15188/LAMBRECHT	NO	YES
11	PP040/MTX	NO	YES
12	ARG100/ENV. MEAS. Lmt	NO	YES
13	MRW500 /METEOSERVIS	NO	YES
14	VRG101/VAISALA	YES	-
15	PLUVIO/OTT	YES	-
16	PG200/EWS	NO	YES
17	T-200B /GEONOR	NO	YES
18	TRwS/MPS	NO	YES
19	MPA-1M/SA "MIRRAD"	YES	-
20	PWD22/VAISALA	YES	-
21	PARSIVEL/OTT	YES	-
22	LPM/THIES	YES	-
23	WXT510/VAISALA	YES	-
24	ANS 410/H/EIGENBRODT	NO	YES
25	Electrical raingauge/KNMI	YES	-
26	PVK/ATTEX DROP	NO	YES

Table 1.4: GTFs status for the 26 typologies of RI-FI gages

ID	MODEL/MANUFACTURER	DIAGNOSTIC DATA AND/OR ERROR CODES
1	7499020BoMV2/RIMCO	No
2	AP23/PAAR	No
3	R01 3070/PRECIS-MECANIQUE	No
4	PT 5.4032.35.008/THIES	No
5	R 102 (REFERENCE GAUGE)/ETG	No
6	DQA031/LSI LASTEM	Yes (only through the manufacturer software)
7	T-PLUV UM7525/I/SIAP-MICROS	No
8	PM B2 (REFERENCE GAUGE)/CAE	Yes
9	RAIN COLLECTOR II (7852)/DAVIS	No
10	15188/LAMBRECHT	No
11	PP040/MTX	No
12	ARG100/ENV. MEAS. Lmt.	No
13	MRW500(REFERENCE GAUGE)/METEOSERVIS	Yes
14	VRG101/VAISALA	Yes
15	PLUVIO/OTT	Yes
16	PG200/EWS	Yes
17	T-200B (REFERENCE GAUGE)/GEONOR	No
18	TRwS/MPS	Yes
19	MPA-1M/SA "MIRRAD"	No
20	PWD22/ VAISALA	Yes
21	PARSIVEL/OTT	Yes
22	LPM/THIES	Yes
23	WXT510/VAISALA	Yes
24	ANS 410-H/EIGENBRODT	Yes
25	Electrical raingauge/KNMI	Yes
26	DROP/PVK-ATTEX	Yes

Table 1.5: List of RI-FI gauges by id, model/manufacturer and error codes (yes/no)

1.4 Output Record cathegories and GTFs

Native Output records of the 26 RI-FI instruments are listed below together with their interpretation and the relative GTFs (where provided). For a more in-depth coverage of the actual output translation and coding refer to the on-line documentation of the Intercomparison: http://www.pro-testa.net/WMO_FIRII/.

1.4.1 1 – 7499020BoMV2, RIMCO, AUSTRALIA

ACTUAL OUTPUT: Passive Reed Contact Switches (pulses) - RA [mm]
DATA TELEGRAM: -
GTF: $RI = p_{min} * 12$,
with: RI = rainfall intensity in mm/h
p_{min} = pulses per minute output from reed-contact.
Each tip of our instrument = $0,2$ mm of accumulated rainfall.
DIAGNOSTIC DATA AND/OR ERROR CODES: No diagnostic data or error codes

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1.4.2 2 – AP23, PAAR, AUSTRIA

ACTUAL OUTPUT: Passive Reed Contact Switches (pulses) - RA [mm]
DATA TELEGRAM: -
GTF: $RI = p_{min} * 6$,
with: RI = rainfall intensity in mm/h
p_{min} = pulses per minute output from reed-contact.
Each tip of our instrument = $0,1$ mm of accumulated rainfall.
DIAGNOSTIC DATA AND/OR ERROR CODES: No diagnostic data or error codes

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1.4.3 3 – R01 3070, PRECIS-MECANIQUE, FRANCE

ACTUAL OUTPUT: Passive Reed Contact Switches (pulses) - RA [mm]
DATA TELEGRAM: -
GTF: $RI = p_{min} * 12$,

with: RI = rainfall intensity in mm/h
p_{min} = pulses per minute output from reed-contact.
Each tip of our instrument = $0,2$ mm of accumulated rainfall.
DIAGNOSTIC DATA AND/OR ERROR CODES: No diagnostic data or error codes

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1.4.4 4 – PT 5.4032.35.008, THIES, GERMANY

ACTUAL OUTPUT: Passive Reed Contact Switches (pulses) - RA [mm]
DATA TELEGRAM: -
GTF: $RI = p_{min} * 6$,
with: RI = rainfall intensity in mm/h
p_{min} = pulses per minute output from reed-contact.
Each tip of our instrument = $0,1$ mm of accumulated rainfall.
DIAGNOSTIC DATA AND/OR ERROR CODES: No diagnostic data or error codes

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1.4.5 5 – R 102 (REFERENCE GAUGE), ETG, ITALY

ACTUAL OUTPUT:(CORRECTED) RA[mm], RI[mm/h] on 1 minute
DATA TELEGRAM:

```
17/07/07 11:55 26,33 128,23
17/07/07 11:56 30,70 262,44
17/07/07 11:57 35,03 259,92
17/07/07 11:58 39,38 260,72
```

GTF: -
DIAGNOSTIC DATA AND/OR ERROR CODES: Not specified

1.4.6 6 – DQA031, LSI LASTEM, ITALY

ACTUAL OUTPUT:RA[mm] on 1 minute (but also at higher resolutions), DATA RELIABILITY PERCENTAGE (only by using the software provided by the manufacturer

in support to E-log data logger and adopted during the Lab test @DICAT cfr. documentation)

DATA TELEGRAM:

Sample record after software processing:

```
08/05/2007 13.56.00 0000000.00 0000100.00 0000003.60 0000100.00
```

Date, Time (with 1 s resolution), RA for instrument n.1, reliability percentage for for instrument n.1, RA for instrument n.2, reliability percentage for for instrument n.2. Warning: the data of sensor 1 are validated at 100% even if the sensor is not connected.

Sample record from serial port connected to e-log:

```
1(3.0;)
```

1 means "sensor 1", RA on 1 minute is in brackets.

GTF: $RI[mm/h] = PCk60$,

RI = Rainfall intensity (mm/h) 1 minute;

PC = Pulses counted on one minute;

k = Rain gauge resolution = $0.2mm$

$(RA[mm/h]1minute = PCxk)$

DIAGNOSTIC DATA AND/OR ERROR CODES: Percentage of Reliability(only by using the software provided by the manufacturer in support to E-log data logger)

1.4.7 7 – T- PLUV UM7525/I, SIAP-MICROS, ITALY

ACTUAL OUTPUT:RI[mm/h], RA[mm], Corrected RA [mm], on 1-MINUTE

DATA TELEGRAM:

```
#1# 157.94#
#2# 926.39#
#3# 996.39#
```

where #1# indicates RI, #2# RA and #3# CRA. The data telegram is output every minute. **GTF:** -

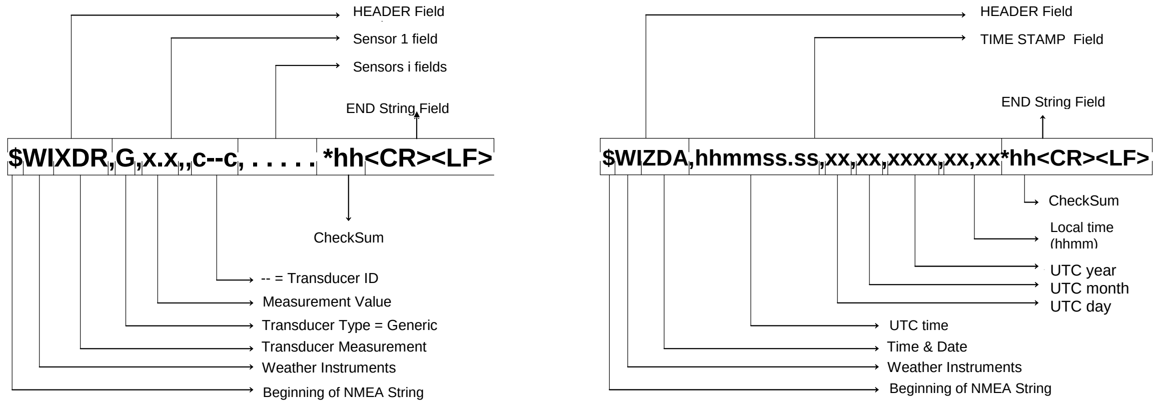
DIAGNOSTIC DATA AND/OR ERROR CODES: Not specified

1.4.8 8 – PM B2 (REFERENCE GAUGE), CAE, ITALY

ACTUAL OUTPUT: Corrected RI[mm/h], RA[mm] on 1 minute aggregation
DATA TELEGRAM:

```
$WIZDA,112400.00,09,01,2007,-01,00*48
$WIXDR,G,5.6,,c0c,G,0.0,,c1000c*62
$WIZDA,112500.00,09,01,2007,-01,00*49
$WIXDR,G,5.6,,c0c,G,0.0,,c1000c*62
```

whose explanation is reported in Figure 1.8 (crf. CAE PMB2 documentation) .
GTF: -



(a) Date/Time Record (b) Data Record

Figure 1.8: CAE Data telegram explanation

DIAGNOSTIC DATA AND/OR ERROR CODES: Data string check sum ($wixdr)

1.4.9 9 – RAIN COLLECTOR II (7852), DAVIS, USA

ACTUAL OUTPUT: Passive Reed Contact Switches (pulses) - RA [mm]
DATA TELEGRAM: -

GTF: $RI = p_{min} * 12$,
with: RI = rainfall intensity in mm/h
p_{min} = pulses per minute output from reed-contact.
Each tip of our instrument = $0,2$ mm of accumulated rainfall.
DIAGNOSTIC DATA AND/OR ERROR CODES: No diagnostic data or error codes

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1.4.10 10 – 15188, LAMBRECHT, GERMANY

ACTUAL OUTPUT: ACTIVE PULSE 0-5V with random additional pulse (300ms delay respect previous pulse) for correction - RA[mm]
DATA TELEGRAM: -
GTF: (crf. Intensity_Correction_procedure01.pdf by Lambrecht)

1) $RI[mm/h] = (p_{hr} * 0,1mm)/1hour$
   p_{hr} = pulses occurred in one hour
   Each tip of our instrument = 0,1mm of accumulated rainfall.

2) $RI[mm/min] = (p_{min} * 0,1mm)/1min$
   p_{min} = pulses occurred in one minute
   Each tip of our instrument = 0,1mm of accumulated rainfall.

Lambrecht warning: Please note that a pure extrapolation of rain intensities from the unit ”mm per minute” to the unit ”mm per hour” misleadingly may cause higher errors caused by a multiplication of single errors.
DIAGNOSTIC DATA AND/OR ERROR CODES: No diagnostic data or error codes

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1.4.11 11 – PP040, MTX, ITALY

ACTUAL OUTPUT: Passive Reed Contact Switches (pulses) - RA [mm]
DATA TELEGRAM: -
GTF: $RI[mm/min] = p_{min} * 0,2mm$ (from MTX manual)
p_{min} =pulses per minute output from reed-contact.
Authorization from MTX also for the mm/h output:

$RI[mm/h] = p_{min} * 12$

p_{min} =pulses per minute output from reed-contact.

Each tip of our instrument = 0,2 mm of accumulated rainfall.

DIAGNOSTIC DATA AND/OR ERROR CODES: No diagnostic data or error codes

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1.4.12 12 – ARG100, Environmental Measurements Limited, BRAZIL/UK

ACTUAL OUTPUT: Passive Reed Contact Switches (pulses) - RA [mm]

DATA TELEGRAM: -

GTF:$RI = p_{min} * 12$,

with: RI = rainfall intensity in mm/h

p_{min} = pulses per minute output from reed-contact.

Each tip of our instrument = $0,2$ mm of accumulated rainfall.

DIAGNOSTIC DATA AND/OR ERROR CODES: No diagnostic data or error codes

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1.4.13 13 – MRW500 (REFERENCE GAUGE), METEOSERVIS, CZECH REPUBLIC

Index				Description
01	0x10	0x11	0x12	Receiver's address (rain gauge)
02	0x01	0x01	0x01	Sender's address (PC)
03	0x22	0x22	0x22	Command code
04	0x04	0x04	0x04	Length (4+0)
05	0x45	0xB4	0xA5	CRC

Figure 1.9: Meteoservis MRW500 Data enquiry (0x22)

ACTUAL OUTPUT: ISTANTANEOUS WEIGHT[mm], AVG WEIGHT[mm](on 1 minute), PRECIPITATION OPERATING VALUE[mm] (on 1 minute)

DATA TELEGRAM: The data telegram is output after pooling: in Figure 1.9 and Figure 1.10 an example is shown, drawn from the MRV500 user manual. Lo means lower byte,H means upper byte; Analog values (voltage, level, temperature) are transmitted as 16-bit numbers (065535). It is necessary to divide these values by 100 for conversion to

Index	Data	Vah SR	
01	-	Addr Y	Receiver's address (PC)
02	-	Addr I	Sender's address (rain gauge)
03	-	Cmd	Command code
04	-	Length	Length of heading + data part
05	01	Volt Lo	Battery voltage
06	02	Volt Hi	
07	03	Level1 Lo	Instant level (weight) - „ **Iv** “ (###.##) [mm]
08	04	Level1 Hi	
09	05	Level Lo	Average level (weight) – „ **Av** “ (###.##) [mm]
10	06	Level Hi	
11	07	TempTenz1 Lo	Strain gauge tempereture (###.##) [°C]
12	08	TempTenz1 Hi	
13	09	-??-	
14	10	-??-	
15	11	Temp KTY Lo	Temperature below upper vessel (###.##) [°C]
16	12	Temp KTY Hi	
17	13	-??-	
18	14	-??-	
19	15	-??-	
20	16	-??-	
21	17	-??-	
22	18	-??-	
23	19	-??-	
24	20	-??-	
25	21	-??-	
26	22	-??-	
27	23	-??-	
28	24	-??-	
29	25	-??-	
30	26	-??-	
31	27	Rain Lo	Counter of precipitation by 0.1 mm (0-65535) - operaitional value of procipitation - „ **Ov** “
32	28	Rain Hi	
33	29	-??-	
34	30	-??-	
35	-	CRC	CRC

Figure 1.10: Meteoservis MRW500 Answer to enquiry 0x22

real values. Resulting range of vaules is then 0,00655,35.

GTF: For 10 seconds sampling time:

RI[mm/h]=((Ov7-Ov1)*0.1[mm/min])*60[min/h] where:

- Ov1Ov7: 7 samples of Ov=RA1 to calculate 1 min precipitation

- (Ov7-Ov1)*0.1=precipitation cumulated in 1 minute;

DIAGNOSTIC DATA AND/OR ERROR CODES:

1) Battery voltage
2) Strain gauge temperature $\#\#\#.\#\#\ C^o$

3) Temperature below upper vessel ###.## C^o

Complet_MRW500_2007_ENG.pdf manual

1.4.14 14 – VRG101, VAISALA, FINLAND

ACTUAL OUTPUT: RA[mm], RI[mm/h], RA1[g] =MASS[g] on 1 minute aggregation
DATA TELEGRAM:

```
AVRG // 000 39.78 23.58 -99.99 4703.0 28.5 11.8 CC
AVRG // 000 41.85 45.40 -99.99 4734.2 28.5 11.8 C4
AVRG // 000 41.85 42.27 -99.99 4736.1 28.4 11.8 C6
AVRG // 000 41.85 15.95 -99.99 4738.1 28.3 11.8 CC
```

whose interpretation is explained in Figure 1.11 and Figure 1.12 (crf. VAISALA VRG101 documentation) .

GTF: -

${}^{S}{}_{H}$VRG id${}^{S}{}_{X}$Message body${}^{E}{}_{X}$CC${}^{C}{}_{R}{}^{L}{}_{F}$

where

${}^{S}{}_{H}$	=	Start of heading (chr(1))
VRG	=	Sensor type, followed by one space
id	=	ID number 1 ... 99 in a two-character field
${}^{S}{}_{X}$	=	Start of text (chr(2))
${}^{E}{}_{X}$	=	End of text (chr(3))
CC	=	Two-hexadecimal character checksum from SOH to ETX (included)
${}^{C}{}_{R}{}^{L}{}_{F}$	=	New line

Figure 1.11: Vaisala VRG101 telegram structure

DIAGNOSTIC DATA AND/OR ERROR CODES: As illustrated in Figure 1.12, diagnostic data are given by:
HARDWARE STATUS: 0=hardware ok, 1=fail, 2=warning
HEATER STATUS: 0=heater OFF/none, 1=heater ON, 2=failure

```
000    0.94    0.00  -99.99  6923.0    7.4  0.4
                                             --.- VB
                                            - space
                                      ----.- Tcpu
                                     - space
                             ------.- mass g
                            - space
                     ----.- T PT100 (-99.99 = no sensor)
                    - space
             ----.-- precipitation intensity mm/h
            - space
     ----.-- precipitation accumulation mm
    - space
   - 0=hardware ok, 1=fail, 2=warning
  - 0=heater OFF/none, 1=heater ON, 2=failure
 - 0=data ok, 1=failure, 2=warning, 3=overflo, 4=draining



character positions

000    0.94    0.00  -99.99  6923.0    7.4  0.4
1234567890123456789012345678901234567890123456
```

Figure 1.12: Vaisala VRG101 Data telegram structure

DATA CHECK 0=data ok, 1=failure, 2=warning, 3=overflo, 4=draining, TEMP, TCPU, VB=supply voltage terminal, CHKSUM (crf. VAISALA VRG101 documentation) .

1.4.15 15 – PLUVIO, OTT, GERMANY

ACTUAL OUTPUT: Real-time Bucket content in mm, Non-real-time Accumulated Precipitation in mm, Non-real-time Precipitation Intensity in mm/h, rain trend sign, Real-time Precipitation Intensity (¿ threshold) in mm/h, Real-time Precipitation Intensity without threshold in mm/h, Smoothed Precipitation Intensity for lowest intensities in mm/h

DATA TELEGRAM:

```
RM01,#1#,170.09,129.30,0000.0,+27.0,0,0,0,0,0,0,0,0,#2#,000,034,
001,0000.0,0000.0,-000.0,0.00,0020,0033<CR><LF><ETX>
RM01,#1#,170.09,129.30,0000.0,+27.0,0,0,0,0,0,0,0,0,#2#,000,017,
```

```
001,0000.2,0000.2,0000.2,0.25,0028,0033<CR><LF><ETX>
RM01,#1#,170.09,129.30,0000.0,+27.0,0,0,0,0,0,0,0,0,#2#,000,047,
001,0000.0,-000.2,-000.2,0.16,0064,0033<CR><LF><ETX>
```

whose explanation is reported in Figure 1.13:

Notes and recommendations for intercomparison user:

2.2 Structure, data and field segmentation

00 ... 03	Device identification
04	,
05 ... 07	Mark 1. line: #1#
08	,
09 ... 14	**Real-time Bucket content in mm** (xxx.xx)
15	,
16 ... 21	**Non-real-time Accumulated Precipitation in mm** (xxx.xx reset at 500.00 in minute interval)
22	,
23 ... 28	**Non-real-time Precipitation Intensity in mm/h** (xxxx.x updated in 1 minute intervals)
29	,
30 ... 34	**Ambient temperature with sign** (xxx.x in minute interval)
35	,
36	α; trend sign 1 = open housing + = accumulated precipitation has increased 0 = accumulated precipitation without change
37	,
38	β; Status operating voltage 1 = Power supply has failed 0 = Uninterrupted power supply
39	,
40	γ; free
41	,
42	δ; 70 % of bucket content exceeded 1 = yes 0 = no
43	,
44	ε; restart of system 1 = system has failed 0 = system in continuous operation

45	,
46	η; level of operating voltage 1 = operating voltage < 10 Volt 0 = operating voltage ≥ 10 Volt
47	,
48	λ; Plausibility check 0 = no plausibility check (alternative field 54 ... 56)
49	,
50 ... 52	Mark of former 2. line in previous version 4.0; output: #2#
53	,
54 ... 56	Result of plausibility check 000 = O.K. 001 = Weight below minimum (missing bucket) 002 = Weight over maximum (over load) 003 = Force shunt (e.g. transportation lock not removed) 010 = AD converter defective 021 = Unidentified object (not water) 022 = Measurement out of range or definition (Values > bucket weight and no change in between 24 hours)
57	,
58 ... 60	Measuring dynamics of determined bucket weight raw values
61	,
62 ... 64	Status of rim heating, decimal coded
65	,
66 ... 71	**Real-time Precipitation Intensity (> threshold) in mm/h** (xxxx.x updated in 6 sec intervals)
72	,
73 ... 79	**Real-time Precipitation Intensity without threshold in mm/h** (xxxx.x or −xxx.x updated in 6 sec intervals)
80	,
81 ... 87	**Smoothed Precipitation Intensity for lowest intensities in mm/h** (xxxx.x or −xxx.x updated in 6 sec intervals)
88	,
89 ... 93	**Coefficient of determination R^2 for the above regression** (x.xx updated in 6 sec intervals)
94	,
95 ... 99	**30 Seconds dynamics** (xxxx updated in 6 sec intervals)
100	,
101 .. 105	**15 minutes dynamics** (xxxx updated in 6 sec intervals)
106	CR; Carriage return
107	LF; Line feed
108	ETX; End of Text

Figure 1.13: OTT Pluvio telegram structure

1) **Real-time Precipitation Intensity (> threshold)** Field position 66 ... 71
Output threshold: $PI \geq 4,2mm/h$.
These PI values are strictly representative for the past 60 s time interval. Do not accumulate these values for hourly or daily sums of precipitation. Depending on the synchronisation and the polling interval the update interval of 6 seconds can

introduce a delay between 0 to 6 seconds.

2) **Non-real-time Precipitation Intensity** Field Position 23 ... 28
Output threshold: $PI \geq 1,8mm/h$.
Resolution of PI: 0,6 mm/h. The maximum integration time for achieving 1,8 mm/h is 40 minutes. Therefore this measurement is representative for the time interval after the last PI output but maximum for the past 40 minutes time interval. The non-real-time PI data is affected by long term filtering processes and therefore shows an output delay of 336 s. Depending on the synchronisation and the polling interval the update interval of 60 seconds can introduce a delay between 0 to 60 seconds.

3) **Real-time Precipitation Intensity without threshold** Field position 73 ... 79
PI data without threshold limitation can be used for analysis purposes or postprocessing of PI data and duration of precipitation information below threshold.

4) **Smoothed Precipitation Intensity for lowest intensities** Field position 81 ... 87
Values are based on a regression over the past 90 seconds introducing a time constant of about 30 seconds. No output threshold is applied and output unit is mm/h. Smoothed PI are useful for analysis of small PI events (e.g. below the output threshold of real-time PI)

5) **All other data not defined here are dedicated to service purposes.**

As requested by the manufacturer, during WMO RI-FI, the quantity under test will be Real-time Precipitation Intensity, while both Real-time Precipitation Intensity and Non-real-time Precipitation Intensity will be tested in Lab. **GTF:** -
DIAGNOSTIC DATA AND/OR ERROR CODES:
see Ott Pluvio Germany_OTT_Pluvio_Supplement DWD Pluvio[1].pdf manual and Figure 1.13

1.4.16 16 – PG200, EWS, HUNGARY

ACTUAL OUTPUT: difference between the actual and previous averages of total weight of container [mm];"real sum" [mm];average of the total weight of container [mm]; precipitation status.
DATA TELEGRAM:

`"1Y=ss###.##ss###.##ss###.##ss###",CR,LF` (s means space)

where the first data is the difference between the actual and previous averages of total weight of container in mm; the second data is the "real sum" in mm; the third data is the average of the total weight of container in mm; the fourth data is the precipitation status [0,1,2]. RA[mm] defined as the difference between the actual and previous averages of total weight of container in [mm] on 1-minute (but if polled by data-logger on 1-minute sampling time).

GTF: For the elaboration @DICAT laboratory (data output on 1 minute aggregation through the pc software provided by the manufacturer) $RI[mm/h] = RA[mm/min] * 60[h/min]$, with:

$RA[mm]$ =the difference between the actual and previous averages of total weight of container in [mm] on 1-minute

For the elaboration @RESMA (polling mode every 10 seconds) Hungarian Met service recommended: Calculation of intensity on 1 minute resolution:

$RI[mm/h] = 60*(RA1[mm]+RA2[mm]+RA3[mm]+RA4[mm]+RA5[mm]+RA6[mm])$ with $RI[mm/h]$ = rainfall intensity in mm/h on 1 minute and $RAn[mm]$ = the difference between the actual and previous averages of total weight of container in [mm] on 10 seconds

DIAGNOSTIC DATA AND/OR ERROR CODES: 1) Precipitation status (0 - 1 - 2); 2)Load cell temperature (in polling mode (RESMA) only available with 2M command; For DICAT lab always available through the special software delivered).

Coding for precipitation status:

a) 0=no precipitation, no internal calculation of averages,
b) 1=changing 2-0 or 0-2 (calculations enabled),
c) 2=precipitation (calculations enabled)

1.4.17 17 – T-200B (REFERENCE GAUGE), GEONOR, NORWAY

ACTUAL OUTPUT: RA [mm], AVERAGE RA [mm]

DATA TELEGRAM:

```
"TOA5","CR200Series_2","CR2xx","","v02","1SEN1MIN.CR2","23729","min"
"TIMESTAMP","RECORD","Batt_Volt_Min","Freq","Depth","Freq_Avg","Depth_Avg"
"TS","RN","Volts","Hz","mm","Hz","mm" "","","Min","Smp","Smp","Avg","Avg"
"2007-07-12 09:55:00",1,12.05938,1041.444,0.07415808,"-INF","-INF"
```

```
"2007-07-12 09:56:00",2,12.06693,1041.104,0.01734738,1041.333,0.05559225
"2007-07-12 09:57:00",3,12.05938,1041.47,0.07839736,1041.287,0.04798479
"2007-07-12 09:58:00",4,12.06861,1041.208,0.03469676,1041.19,0.0317714
```

GTF: Calculation of RI on 10 seconds:
$RI[mm/10sec] = RA[mm]_t - RA[mm]_{t-10sec}$ with:
- RA[mm]= gauge total depth in [mm] every 10 seconds ("Geonor depth")
Then:
Calculation of intensity in [mm/h] on 1 minute resolution:
$RI[mm/h] = 60*[(RI1+RI2+RI3+RI4+RI5+RI6)/6] = AVERAGE_RI[mm/min]*60$
with:
- $RIn[mm/min] = (Geonor_depth[mm]_t - Geonordepth[mm]_{t-10sec}) * 6$
DIAGNOSTIC DATA AND/OR ERROR CODES: Not specified

1.4.18 18 – TRwS, MPS, SLOVAK REPUBLIC

ACTUAL OUTPUT: RA [mm], ACCUMULATED WEIGHT[gr], RAIN YES/NO on 1 minute with manufacturer software; rain indication yes/no and duration last minute + one minute sum of precipitation [mm] + total weigth [gr]+ sensor temperature [C]+ cumulated ([mm], max 99mm; to be requested with specific RS485 command). With rain duration in the last minute and RA on the same minute, RI mm/h could be retrieved. Comunication 485 protocol and commands on Manual 2007. Polling mode: to be polled for data trasmission. Software "TABLO" to make acquisition on 1 minute time resolution and data storage. Possibility of Pulse output (selectable precipitation increment 0,01...0,1...1mm/impulse).
DATA TELEGRAM, in field (by pooling mode):

```
77 0 60 3524 1022127 12116 1595
77 0 60 3525 1022127 12116 1595
```

whose complete explanation is given in Figure 1.14 and Figure 1.15:

in Lab by TABO software:

```
28.05.2007 11.09.39 0 1011.791
```

data	description	range	size
<PRCP1M>	*one minute sum of precipitation [μm]*	0÷60000	1÷5
<RD1M>	*rain duration in last minute [sec] (note 1)*	0÷60	1÷2
<TW1>	*sensor temperature in hundredths of Celsius*	-3500÷8000	1÷3
<WA1>	*total weight [mg]*	±20000000	1÷8
<US1>	*TRwS power supply voltage [mV]*	0÷25000	1÷5
<NS>	*ND (note 2)*	0÷25000	1÷5

Figure 1.14: TRwS MPS telegram structure

data	value	description
ADR	***11***	answer is from TRwS with address ‚**11**' hex
PRCP1M	***134***	one minute sum **0.134**mm
RD1M	***60***	it was raining **60**s in last minute or rain detector is not connected
TW1	***2148***	temperature sensor is **21.48**℃
WA1	***7995146***	total weight is **7995.146** gram
US1	***12000***	power supply is **12**V
UCN	***45***	-

Figure 1.15: Example of the TRwS MPS telegram interpretation

```
28.05.2007 11.10.30 0 1011.737
28.05.2007 11.11.31 0 1011.737
28.05.2007 11.12.32 0.016 1012.566
```

given by: date, time, RA, AW.

GTF: for sensor Nr. 18 . TRwS 503:

$RI[mm/h] = 60xRI[\mu m/min]$

$RI[mm/min]$ can be extracted by the TRwS record through rain duration in the last minute and RA on the same minute.

DIAGNOSTIC DATA AND/OR ERROR CODES: temperature of sensor, power supply, voltage on Cn input (see Figure 1.14 , Figure 1.15 and the MPS user manual)

1.4.19 19 – MPA-1M, SA "MIRRAD", UCRAINE

ACTUAL OUTPUT: RA [mm], RI [mm/h]
DATA TELEGRAM: - (The instrument has been not delivered yet)
GTF: -
DIAGNOSTIC DATA AND/OR ERROR CODES: Not Specified

1.4.20 20 – PWD22, VAISALA, FINLAND

ACTUAL OUTPUT: Present Weather, Visibility, RI [mm/h], RA [mm], snow accumulation on 1 minute aggregation
DATA TELEGRAM:

```
PW 1 00 275 2059 C 0 0 0 0.00 0.00 0 28.9 /////
PW 1 00 4325 1985 C 0 10 10 0.00 0.00 0 29.0 /////
```

record structure is not specified.
GTF: -
DIAGNOSTIC DATA AND/OR ERROR CODES:

a) 1=Status (00)
b) 2=Temperture of sensor electronics

Diagnostic data coding:

a) Status: 0=optics ok, 1=hardware error, 2= hardware warning, 3=backscatter alarm, 4=backscatter warning; 0=hardware/cleaning OK, 1=visibility allarm1, 2=visibility allarm2, 3=visibility allarm3 4 or 3 code = lens to be cleaned
b) Temperature: working limit=+55C

1.4.21 21 – PARSIVEL, OTT, GERMANY

ACTUAL OUTPUT (only when precipitation starts): RI [mm/h], Rain amount since start of device [mm], Weather code according to SYNOP (see appendix C of the manual: "Categorization of precipitation type by precipitation codes"), Radar reflectivity, MOR visibility in the precipitation.
Rainfall intensity is calculated as a running average on the previous 60 seconds, output every 30 seconds.

Meas. value No.	Meas. value	Definition
13	200248	Sensor serial number
01	000.000	Rain intensity
02	0000.00	Rain amount since start of device
03	00	Weather code according to SYNOP $w_a w_a$ (see appendix C "Categorization of precipiation type by precipitation codes")
07	-9.999	Radar reflectivity
08	9999	MOR visibility in the precipitation
12	025	Temperature in the sensor
10	15759	Signal amplitude of the laser strip
11	00000	Number of detected particles
18	0	Sensor status

Figure 1.16: Parsivel Ott data telegram

DATA TELEGRAM:
`00221944;0000.000;0020.78;00;-9.999;5000;036;12707;00000;0;`
`00221944;0000.000;0020.78;00;-9.999;5000;036;12709;00000;0;`
`00221944;0000.000;0020.78;00;-9.999;5000;035;12710;00000;0;`
whose explanation is reported in Figure 1.17: (crf. OTT PARSIVEL documentation) .
GTF: -
DIAGNOSTIC DATA AND/OR ERROR CODES: Temperature in the sensor, Signal amplitude of the laser strip, Number of detected particles, Sensor status (crf. OTT PARSIVEL documentation) .

1.4.22 22 – LPM, THIES, GERMANY

ACTUAL OUTPUT: RI [mm/h], RA [mm] (total 527 byte positions);
see manual Germany_Thies-DWD_LPM_Manual_5.4110.xx.x00_LNM_V2.2x_STD_eng_.pdf
DATA TELEGRAM: (crf. THIES LPM documentation) .
GTF:
DIAGNOSTIC DATA AND/OR ERROR CODES: A proposed selection of the available (67) diagnostic data is listed below:

1) 1 minute Measuring quality (0100

Example telegram 4:

```
  00;0072;1.16;24.01.05;14:01:00;71;71;-SN  ;000.035;71;71;-SN
;000.014;000.000;000.014;0012.52;16132;12.3;100;0.0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;0;+11;12;1494;4010;2574;189;174;17
3;-
01.0;201;0723;0441;0570;00054;00000.000;00000;00000.000;00000;00000.000;00000;00000.000;00003;00000.017;000
00;00000.000;00000;00000.000;00002;00001.469;00000;00000.000;00001;00001.428;00030;00004.857;00000;00000.00
0;00001;00000.118;00017;00000.192;00000;00000.000;000;000;001;001;001;003;001;001;001;001;000;000;000;001;000
;000;000;000;000;000;000;000;000;000;000;003;003;002;000;000;000;000;000;000;000;000;000;000;000;000;000;002;00
1;000;000;001;000;000;000;000;000;000;000;000;000;000;000;000;000;000;003;004;010;002;002;000;001;000;000;0
00;000;000;000;000;000;000;000;000;000;000;001;001;001;002;001;000;000;000;000;000;000;000;000;000;000;000;000;
000;000;000;000;000;001;001;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;00
0;001;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;0
00;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;00
0;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;0
00;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;00
0;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;0
00;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;00
0;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;0
00;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;
000;000;000;000;000;000;000;000;000;000;41;
```

Figure 1.17: LPM Thies data telegram

2) Status laser (0=ok; 1=off)
3) Status sensor supply (0=ok; 1=off)
4) Control Voltage[mV] (reference value 40105)
5) Optical contro output[mV] (2300...6500)

(crf. THIES LPM documentation) .

1.4.23 23 – WXT510, VAISALA, FINLAND

ACTUAL OUTPUT (only when precipitation starts): Rain Accumulation [mm], Rain Duration [s], Rain Intensity [mm/h], Rain Peak Intensity [mm/h] on 1 minute. Rainfall intensity is calculated as a running average on the previous 60 seconds, updated every 10 seconds

DATA TELEGRAM:

```
0R3,Rc=1.94M,Rd=4070s,Ri=1.1M,Rp=4.7M
0R3,Rc=1.95M,Rd=4080s,Ri=1.2M,Rp=4.7M
```

```
0R3,Rc=1.95M,Rd=4080s,Ri=1.2M,Rp=4.7M
0R3,Rc=1.95M,Rd=4080s,Ri=1.2M,Rp=4.7M
```

where Rc=Rain Accumulation (M=mm) on 1 minute, Rd=Rain Duration (s=s) on 1 minute, Ri=Rain Intensity (M=mm/h) on 1 minute, Rp=Rain Peak Intensity (M=mm/h) on 1 minute (crf. VAISALA WXT510 documentation) .
GTF: -
DIAGNOSTIC DATA AND/OR ERROR CODES: (crf. VAISALA WXT510 documentation) .

1.4.24 24 – ANS 410/H, EIGENBRODT, GERMANY

ACTUAL OUTPUT: RA [mm], pulses (1 pulse=0.01mm of precipitation) on 1 minute aggregation (but also aggregation from 1 to 999 seconds)
DATA TELEGRAM:

```
24.07.07;14:03:43;00001;00.0100;1
24.07.07;14:04:43;00215;02.1500;1
24.07.07;14:05:43;00437;04.3700;0
```

to be interpreted as follow: date, time, RA [mm], Pulse [mm], error code.
GTF: $RI[mm/h] = RA[mm/min] * 60[h/min]$, with:
- RI = rainfall intensity in mm/h
- RA[mm/min]= averaged rain rate from the previous time intervall=1 min
RA=also equal to Pulses*0.01mm
Each pulse is = 0,01mm

DIAGNOSTIC DATA AND/OR ERROR CODES: Error coding: 0=OK, 1=FAILURE

1.4.25 25 – Electrical raingauge, KNMI, NETHERLANDS

ACTUAL OUTPUT: RI [μ m/h] and RAINFALL DURATION (crf. KNMI documentation) : The Rainfall-SIAM transmits a message with a standard X-SIAM structure every

12 seconds (see specification ID-30-015, "X-SIAM Output specification Extended Protocol"). In the standard message, measurement values are incorporated for the rainfall intensity and rainfall duration.

DATA TELEGRAM: The length of a string is 95 characters plus ¡CR LF¿, the length of the total message is 295 characters (including control characters). The transmission time is approximately 2,7 seconds.

GTF: RI output is in $[\mu m/h]$ units and in exponential notation (X-SIAM specification manual v.1.8 pg15 par.5.16 and pg.8):

$RI[mm/h] = RI[\mu m/h] * 0.001$ where:

$RI[\mu m/h] = 0.BCD * 10^A[\mu m/h]$ and with ABCD = four numerals data into the output telegram

DIAGNOSTIC DATA AND/OR ERROR CODES:

Precipitation intensity diagnostic parameters:

0 ... Normal operation

1 ... SIAM test. Message displays hour counter and SIAM number

3 ... Sensor test. Message displays float level

A ... The SIAM is reset due to a voltage interruption or by a software error. The status A is always followed by status I

B ... Open line, no precipitation meter connected

C ... Fatal range error: the intensity is larger than 300 mm/hour (large float jump)

d ... Float position lower than 0.7 mm. Normally the float position cannot become lower than 1.0 mm

D ... Float position lower than 0.6 mm. Normally the float position cannot become lower than 1.0 mm

E ... Reduction of the float position larger than 0.05 mm in 60 minutes. This is an indication of a leaking discharge valve

I ... Post-reset status. After a reset (status A) or after a switched-off input (status Z) the SIAM requires a period of time to perform the first intensity measurements

K ... Float position is higher than 11.5 mm. Normally the float position is not higher than 11.0 mm, because then the valve will be opened. This status is an indication for a non-functioning discharge valve or for a very high rainfall intensity

P ... The valve is controlled "open" but the SIAM does not receive a message that the valve is actually open

W ... The emptying of the vessel takes longer than 20 seconds. Normally the time to empty is 12..15 seconds. When this status occurs, the discharge valve is probably soiled

with grass or earth
X ... SIAM process error. The process is not terminated in a correct manner
x ... SIAM board temperature too high
Y ... Recoil. No measurement value available because extrapolation is not possible due to fatal status of previous sample
y ... Recoil. Measurement value is not measured but extrapolated
Z ... Sensor switched-off at the front panel
Rainfall duration diagnostic parameters:
The status codes will be taken from the status of the NI-measurements because the ND measurements are derived from these.

1.4.26 26 – DROP, PVK-Attex, RUSSIAN FEDERATION

ACTUAL OUTPUT: RA [mm] on 1 minute aggregation
DATA TELEGRAM: crf. documentation
GTF: $RI[mm/h] = RA[mm] * 60$
DIAGNOSTIC DATA AND/OR ERROR CODES: Error counter.

1.5 the Lab Test framework

The RI-FI Laboratory Calibration phase precedes the installation of the instruments in field at the Vigna di Valle Site and has been performed at the DICAT Laboratory of the University of Genoa, following the CIMO OPAG SURFACE ET-SBII & CM-3/IOC-3 Final report regulations (crf. section 3.4 *Procedures for laboratory calibration phase before the field phase*).

The Lab test is aimed at verifying the correct functioning of instruments after transportation and collecting information about the instruments response to different constant RIs.

Always according to the CIMO OPAG SURFACE ET-SBII & CM-3/IOC-3 Final re-

ID	MODEL/MANUFACTURER	CATCHING (YES/NO)
1	7499020BoMV2/RIMCO	YES
2	AP23/PAAR	YES
3	R01 3070/PRECIS-MECANIQUE	YES
4	PT 5.4032.35.008/THIES	YES
5	R 102 (REFERENCE GAUGE)/ETG	YES
6	DQA031/LSI LASTEM	YES
7	T-PLUV UM7525/I/SIAP-MICROS	YES
8	PM B2 (REFERENCE GAUGE)/CAE	YES
9	RAIN COLLECTOR II (7852)/DAVIS	YES
10	15188/LAMBRECHT	YES
11	PP040/MTX	YES
12	ARG100/ENV. MEAS. Lmt.	YES
13	MRW500(REFERENCE GAUGE)/METEOSERVIS	YES
14	VRG101/VAISALA	YES
15	PLUVIO/OTT	YES
16	PG200/EWS	YES
17	T-200B (REFERENCE GAUGE)/GEONOR	YES
18	TRwS/MPS	YES
19	MPA-1M/SA "MIRRAD"	YES
20	PWD22/ VAISALA	NO
21	PARSIVEL/OTT	NO
22	LPM/THIES	NO
23	WXT510/VAISALA	NO
24	ANS 410-H/EIGENBRODT	YES
25	Electrical raingauge/KNMI	YES
26	DROP/PVK-ATTEX	NO

Table 1.6: List of RI-FI gauges by id, model/manufacturer and catching/not catching typology

ID	MODEL/MANUFACTURER	OPERATIONAL RANGE [mm/h]
1	7499020BoMV2/RIMCO	0–500
2	AP23/PAAR	0–720
3	R01 3070/PRECIS-MECANIQUE	0–450
4	PT 5.4032.35.008/THIES	0–420
5	R 102 (REFERENCE GAUGE)/ETG	0–300
6	DQA031/LSI LASTEM	Declared UNLIMITED by the Manufacturer
7	T-PLUV UM7525/I/SIAP-MICROS	0–250
8	PM B2 (REFERENCE GAUGE)/CAE	0–300
9	RAIN COLLECTOR II (7852)/DAVIS	0–2540 Declared by the Manufacturer
10	15188/LAMBRECHT	0–600
11	PP040/MTX	Declared UNLIMITED by the Manufacturer
12	ARG100/ENV. MEAS. Lmt.	Not Declared
13	MRW500(REFERENCE GAUGE)/METEOSERVIS	2–400
14	VRG101/VAISALA	0.5–2000
15	PLUVIO/OTT	0–1200
16	PG200/EWS	0.1 to infinite
17	T-200B (REFERENCE GAUGE)/GEONOR	0–600
18	TRwS/MPS	0–3600
19	MPA-1M/SA "MIRRAD"	0–1800 Declared by the Manufacturer
20	PWD22/ VAISALA	0.05–999.9
21	PARSIVEL/OTT	0.001–1200
22	LPM/THIES	0.005–250
23	WXT510/VAISALA	0–200
24	ANS 410-H/EIGENBRODT	0–1200 (broader range with reduced accuracy)
25	Electrical raingauge/KNMI	0–300
26	DROP/PVK-ATTEX	0.1–240

Table 1.7: List of RI-FI gauges by id, model/manufacturer and operational range

ID	MODEL/MANUFACTURER	DELIVERY DATE
1	7499020BoMV2/RIMCO	15/05/2007
2	AP23/PAAR	26/03/2007
3	R01 3070/PRECIS-MECANIQUE	22/06/2007
4	PT 5.4032.35.008/THIES	14/05/2007
5	R 102 (REFERENCE GAUGE)/ETG	15/06/2007
6	DQA031/LSI LASTEM	24/04/2007
7	T-PLUV UM7525/I/SIAP-MICROS	24/04/2007
8	PM B2 (REFERENCE GAUGE)/CAE	26/03/2007
9	RAIN COLLECTOR II (7852)/DAVIS	31/05/2007
10	15188/LAMBRECHT	10/04/2007
11	PP040/MTX	11/04/2007
12	ARG100/ENV. MEAS. Lmt.	01/06/2007
13	MRW500(REFERENCE GAUGE)/METEOSERVIS	05/06/2007
14	VRG101/VAISALA	03/04/2007
15	PLUVIO/OTT	09/07/2007
16	PG200/EWS	16/07/2007
17	T-200B (REFERENCE GAUGE)/GEONOR	31/05/2007
18	TRwS/MPS	08/05/2007
19	MPA-1M/SA "MIRRAD"	Not delivered
24	ANS 410-H/EIGENBRODT	02/05/2007
25	Electrical raingauge/KNMI	11/05/2007

Table 1.8: List of RI-FI gauges by id, model/manufacturer and delivery date @DICAT Lab

port, section 3.4.1:

> [...] results of the laboratory calibration would not be used for applying any correction or adjustment to the data during the field intercomparison period.

Only the 21 catching instruments plus 4 reference (as listed in Table 1.6), for a total of 25 instruments had to undergo the Lab Phase. The first batch of instruments is now terminating their calibration while spare instruments (duplicates) will be calibrated later with inferior priority. As evidenced in Table 1.8 the first instruments were delivered in Genoa at the end of March, while the last ones arrived in Mid July. This fact has affected the installation scheduling, that has been re-planned as a function of effective deliveries. Moreover, not always the delivery of instrumentation has coincided with the possibility of making gauges fully operational in Lab, due to delays in providing manuals and/or their translation, correction or integrations. At the present moment, only the gage n. 19 (MPA-1M/SA "MIRRAD") results not yet delivered.

1.5.1 Statistical methods for Lab test

All the procedures used in the framework of the WMO Laboratory Intercomparison of RI Gauges (De Bilt, Genova, Trappes) have been kept, with the following exceptions:

- **a)** A laboratory calibration has been done under constant flow rate condition but data evaluation has been performed for 1, 5, 10, 15 -minute time aggregations;
- **b)** Laboratory calibration also consisted of a measurement of step response and delay times;
- **c)** Following the decision to shorten the time for calibration it was used a RI of 5 mm/h as the lowest RI (instead of 2 mm/h as previously used in the WMO Laboratory Intercomparison of RI Gauges).

Always referring to Lanza, L.G., Leroy, M., Alexandropoulos, C., Stagi, L., Wauben, W. (2005), the calibration range and points for each instrument have been assessed. In case the range is declared unlimited by the Manufacturer, the 2000 mm/h Intensity (World Meteorological Organization, 1983) has been taken as maximum RI for the instruments (see Table 1.7), even if frequently lamination phenomena arise before this limit.

The test procedure consists of 3 repetitions of the prefixed calibration points logarithmically distributed on the gauge operational range. Then, for each calibration point, the

procedure for the statistical analysis of results has been designed by the Laboratory Test Site Manager (LTSM) together with the DM as follows;

1) Calculation of average Actual and Measured RIs on the 1, 5, 10, 15 -minute time aggregations (where the instrument does not output RI, the GTFs provided by manufacturers have been used),
2) Calculation of average relative errors (as defined in Lanza, L.G., Leroy, M., Alexandropoulos, C., Stagi, L., Wauben, W. (2005)) on the 1, 5, 10, 15 -minute time aggregations,
3) Extraction, for each time resolution, of the Mean Actual and Measured RIs relative to the considered calibration point, together with the average relative error (e%), standard deviation, standard error and coverage factor.

Finally, the procedure foresees the representation of results through the standard Calibration Curve (Measured versus reference RI) and Error Graph (e% versus reference RI).

1.5.2 In situ functioning test

With the aim of verifying "in field" the functioning conditions of the 30 installed instruments, a manual device just used in previous laboratory calibration (Lanza and Stagi (2002); Lombardo and Stagi (1997) and able to provide in field constant flows with an uncertainty within the 1% limit, has been tested in Vigna di Valle (see Figure 1.18 and Figure 1.19).

Figure 1.18: Functioning test in field at the Vigna di Valle Site

Figure 1.19: Functioning test in field at the Vigna di Valle Site

Chapter 2

Designing the RI-FI Data Base

Data storage strategies represents one of the crucial issues in the RI-FI framework, due to the need of conciliate, in a unique db architecture, both a direct access to coarse records and the practicalness in managing/analyzing data. During the February 2007 Meeting in Vigna di Valle:

> *the "ET/IOC agreed on a general design of the data storage, composed of the sequential DB of 10-second data with an external back-up data storage and Relational Database (RDB) of 1-minute data. The raw data will be taken every 10 seconds and will contain all data delivered by the instruments. The working database will be stored in a RDB outside ReSMA main complex and will have a restricted web access (FTP, internet) for the access by ET/IOC members and for regular monitoring by the Data Analysis Expert. This RDB will at least contain 1-minute data of the following parameters: 1-minute RI of all gauges, 1-minute averages of wind speed and wind direction, max. wind speed, temperature + standard deviation (STD), relative humidity + STD, output of wetness sensors and drop counters, and QC information (e.g. flags, specific for each instrument)"* (CIMO, 2007).

In this chapter we will analyze possible solutions for the management of data coming from the 30 (under test + reference) involved RI gauges and from ancillary sensors, besides external and native error codes interpretation, Quality Control and "Ad posteriori" Validation. The data acquisition system will be considered as consisting of a series of superposing information layers from the native output message of the instrument to a

standard measurement record on 1 minute aggregation common to all the instruments. In this prospective it is important to stress how the whole layers of information will result ultimate to the final data interpretation and analysis.

2.1 Data managing strategies:

In the following sections, possible solutions for the RI-FI data managing will be discussed. The first treated issue is the definition of records for the 10 seconds sequential data (*information layer 1*) and of a standard record (SR) for derived quantities recorded on 1 minute aggregation (*information layer 2*). Records will be defined for both RI instruments and Ancillary sensors trying to compress in a SR (with minimum information loss) data coming from *layer 1*.

Following the SRs definition, naming conventions for data files and output scheduling will be discussed. Finally, the coding of internal and external error messages will be assessed and the compatibility of output data with a commercial RDB importation procedure are analyzed.

2.2 Output Record structures for sequential data and 1 minute data

2.2.1 Record structure for coarse data

As pointed out in Section 1.4, the 30 instruments involved in the field intercomparison presents a great variety of native outputs and an error coding ranging between the total absence of diagnostic data and the presence of about 67 different error codes (crf. Section 1.4.1 to Section 1.4.26).

Such native records represent the most complete form of information coming from both RI and ancillary sensors and, sampled every 10 seconds, will constitute the first information layer of the RI-FI DB besides being a basic reference for data verification and validation. Sequential data (First layer data) will be collected in files following naming and output scheduling procedures illustrated in Section 2.3 and Section 2.3.1. Moreover, specific row data files will be output for sensors **15** and **22**, presenting a huge amount of diagnostic data.

FIELD NAME	UNIT/FORMAT
INSTRUMENT ID	-
INSTRUMENT SERIAL (or serial number coding)	-
DATE	yy/mm/dd
TIME	hh:mm
COUNTER	-
RI_1 on 1 minute aggregation	mm/h
RA_1 on 1 minute aggregation	mm
RI_2 on 1 minute aggregation (if available)	mm/h
RA_2 on 1 minute aggregation (if available)	mm
RAIN YES/NO (if available)	-
RAINFALL DURATION (if available)	minutes
$RI_1^{Validated}$ on 1 minute aggregation	mm/h
RI_1 Validation code	-
$RA_1^{Validated}$ on 1 minute aggregation	mm/h
RA_1 Validation code	-

Table 2.1: Rainfall Instruments sample record on 1 minute aggregation

2.2.2 Record structure for 1 minute data

Ri data collected on 1 minute time aggregation, their accuracy and their dependence from different field conditions constitute the central subject of RI-FI. A correct estimate of final results bases then on a suitable management of such 1 minute data. The second information layer has been designed to compress within a SR the maximum quantity of information coming from first level data. Possible data record for RI instruments and ancillary sensors are proposed in Table 2.1 to Table 2.7, while a possible coding for internal (native) and external error codes are sumarized in Table 2.8 and Table 2.9. External error codes are warnings that are directly generated by the acquisition system.

Internal error coding results strictly conditioned by the availability of suitable transfer function and/or effective ranges for each diagnostic quantity, while the external error coding is possible only for those instruments whose status can be pooled by the acquisition system through serial connections (native TBRs instrument 21 and 23 are then excluded). The RI_1 and RA_1 reported in Table 2.1 are the ones that will be primarily analyzed in the

FIELD NAME	UNIT/FORMAT
INSTRUMENT ID	-
INSTRUMENT SERIAL (or serial number coding)	-
DATE	yy/mm/dd
TIME	hh:mm
COUNTER	-
Average wind speed on 1 minute aggregation	m/s
Average wind direction on 1 minute aggregation (through vectorial scomposition)	degr
Wind speed Standard deviation on 1 minute aggregation	m/s
Wind direction standard deviation on 1 minute aggregation (through vectorial scomposition)	degr
Maximum Wind Speed on 1 minute	m/s
Wind Gust direction	m/s
Validated Average wind speed (AWS) on 1 minute aggregation	m/s
AWS Validation Code	-
Validated Average wind direction (AWD) on 1 minute aggregation	degr
AWD Validation Code	-
Validated Maximum Wind Speed on 1 minute	m/s
Maximum Wind Speed Validation Code	-
Validated Wind Gust direction	degr
Wind Gust direction Validation Code	-

Table 2.2: Wind sensors sample record on 1 minute aggregation

FIELD NAME	UNIT/FORMAT
INSTRUMENT ID	-
INSTRUMENT SERIAL (or serial number coding)	-
DATE	yy/mm/dd
TIME	hh:mm
COUNTER	-
Average Air Temperature on 1 minute aggregation	°C
Temperature standard deviation on 1 minute	°C
Maximum Air Temperature on 1 minute aggregation	°C
Minimum Air Temperature on 1 minute aggregation	°C
Validated Average Air Temperature on 1 minute	°C
Average Air Temperature Validation Code	-
Validated Maximum Air Temperature on 1 minute	°C
Maximum Air Temperature Validation Code	-

Table 2.3: Air Temperature sensor sample record on 1 minute aggregation

FIELD NAME	UNIT/FORMAT
INSTRUMENT ID	-
INSTRUMENT SERIAL (or serial number coding)	-
DATE	yy/mm/dd
TIME	hh:mm
COUNTER	-
Average Relative Humidity on 1 minute aggregation	%
Relative Humidity standard deviation on 1 minute	%
Maximum Relative Humidity on 1 minute aggregation	%
Minimum Relative Humidity on 1 minute aggregation	%
Validated Average Relative Humidity on 1 minute	%
Average Relative Humidity Validation Code	-
Validated Maximum Relative Humidity on 1 minute	%
Maximum Relative Humidity Validation Code	-

Table 2.4: Relative Humidity sensor sample record on 1 minute aggregation

FIELD NAME	UNIT/FORMAT
INSTRUMENT ID	-
INSTRUMENT SERIAL (or serial number coding)	-
DATE	yy/mm/dd
TIME	hh:mm
COUNTER	-
Rainfall Yes/No	-
Rain status	V

Table 2.5: Rainfall status sensors sample record on 1 minute aggregation

FIELD NAME	UNIT/FORMAT
INSTRUMENT ID	-
INSTRUMENT SERIAL (or serial number coding)	-
DATE	yy/mm/dd
TIME	hh:mm
COUNTER	-
Average Atmospheric Pressure on 1 minute aggregation	hPa
Atmospheric Pressure standard deviation on 1 minute	hPa
Validated Average Atmospheric Pressure on 1 minute	hPa
Average Atmospheric Pressure Validation Code	-

Table 2.6: Atmospheric Pressure sensor sample record on 1 minute aggregation

FIELD NAME	UNIT/FORMAT
INSTRUMENT ID	-
INSTRUMENT SERIAL (or serial number coding)	-
DATE	yy/mm/dd
TIME	hh:mm
COUNTER	-
Global Solar Radiation (Irradiance) on 1 minute aggregation	W/m2
Validated Global Solar Radiation (Irradiance) on 1 minute	W/m2
Global Solar Radiation Validation Code	-

Table 2.7: Solar Radiation sensor sample record on 1 minute aggregation

NATIVE ERRORS/DIAGNOSTIC DATA	ENCODING
No error detected	0
A warning code is detected almost 1 time in the considered 1 minute time spam	"doubtful"
An error code is detected almost 1 time in the considered 1 minute time spam	"erroneous"
None diagnostic data available	"None diagnostic data"

Table 2.8: Internal error encoding

EXTERNAL ERROR	ENCODING
No error detected	0
the "no signal" error code is detected at worst 2 times in the considered 1 minute time spam	"doubtful"
the "no signal" error code is detected more than 2 times in the considered 1 minute time spam	"missing"
Signal monitoring not available	"None acquisition data"

Table 2.9: External error encoding

RI-FI, while RI_2 and RA_2 (when available) will be considered as control quantities. For those instruments that output both corrected and not corrected RI/RA, for e.g., RI_1 will be the corrected one while RI_2 will correspond to the not corrected quantity. In addiction the record presents the following basic fields:

1) $RI_1^{Validated}$: Quality Checked version of RI_1, that will be primarily considered within the data analysis phase
2) RI_1 Validation code: Binary validation code summarizing the QC path of the RI_1 value, as described in Section 2.4
3) $RA_1^{Validated}$: Quality Checked version of RA_1, that will be primarily considered within the data analysis phase
4) RA_1 Validation code: Binary validation code summarizing the QC path of the RA_1 value, as described in Section 2.4

Moreover, missing data will be coded within the $RI_1^{Validated}$ and $RA_1^{Validated}$ fields as -9. Analogous quantities are defined for ancillary data too, as reported in Table 2.2 to Table 2.7.

2.2.3 Global Transfer Functions

An additional issue arise for those instruments whose output do not meet the WMO specifications for Rainfall Intensity output. The manufacturer of such gauges were asked to provide a GTF (cfr. Section 1.3) able to code each instrument native output in a synchronized RI measurement in mm/h on 1 minute aggregation. It is then evident how, in these cases, the passage from the sequential to 1 minute data will request an additional elaboration from the acquisition system that must be considered in order to avoid data desynchronizing.

2.3 Naming files and collecting data

2.3.1 Output files scheduling

For both RI instruments (under test and references) and ancillary sensor, the acquisition system will generate two different "second layer" (1 minute aggregation) textual (ASCII dos encoding) files, namely global files and daily files, obtained by append and so con-

stantly updated. Global file will contain all the given instrument data from the first instant of acquisition on, while daily files refer only to a specific acquisition date. At the present, first layer data concerning the whole RI instruments and all the ancillary sensors are collected in two distinct textual files (rows=sensors, columns=data fields), while two separate row data files are output for sensors 15 and 22, due to their huge amount of diagnostic data. The future implementation of the secondary information level could foresee a global and a daily data for each sensor output according to data record listed in tables Table 2.1 to Table 2.7.

Different and/or additional output aggregations, further than files nomenclature strategies will be discussed with the ET/IOC, PL and SM.

2.4 Quality Control of Data

Following the WMO - Guide No. 8 to Meteorological Instruments and Methods of Observation (2006):

> *"Quality control is the best known component of quality management systems, and it is the irreducible minimum of any system. It consists of examination of data at stations and at data centres to detect errors so that the data may be either corrected or deleted. A quality control system should include procedures for returning to the source of the data to verify them and to prevent recurrence of the errors. Quality control is applied in real time, but it also operates in non-real time, as delayed quality control. Real time quality control is usually performed at the station and at meteorological analysis centres. Delayed quality control may be performed at analysis centres for compilation of a re-checked database, and at climate centres or data banks for archiving. In all cases, the results should be returned to the observations managers for follow -up. Quality monitoring or performance monitoring is a non-real time activity in which the performance of the network or observation system is examined for trends and systematic deficiencies. It is typically performed by the office that manages and takes responsibility for the network or system; and which can prescribe changes to equipment or procedures. Quality management in general includes the above, and it also includes control of the other factors that directly affect data quality, such as equipment, exposure, procedures, maintenance, inspection, data processing and training. These are usually the responsibility of the network manager, in collaboration with other specialists, where appropriate."*

The Quality Control Procedures (QCP) will be carried out during and before the data analysis (namely QC must be able to provide validated data to DM). Time and detail of any intervention during the intercomparison that could cause erroneous or suspicious data shall be noted so that such data will not be used in data analysis. The QCP will be divided in two basic steps:

1) **REAL-TIME QUALITY CONTROL**;
2) **NEAR-REAL TIME QUALITY CONTROL OR "AD POSTERIORI" VALIDATION**;

ID	MODEL/MANUFACTURER	EXPECTED SAMPLES	MINIMUM SAMPLES
1	7499020BoMV2/RIMCO	6	4
2	AP23/PAAR	6	4
3	R01 3070/PRECIS-MECANIQUE	6	4
4	PT 5.4032.35.008/THIES	6	4
5	R 102 /ETG	1	1
6	DQA031/LSI LASTEM	1	1
7	T- PLUV UM7525/I/SIAP-MICROS	1	1
8	PM B2 /CAE	1	1
9	RAIN COLLECTOR II (7852)/DAVIS	6	4
10	15188/LAMBRECHT	6	4
11	PP040/MTX	6	4
12	ARG100/ENV. MEAS. Lmt	6	4
13	MRW500 /METEOSERVIS	6	4
14	VRG101/VAISALA	1	1
15	PLUVIO/OTT	6	4
16	PG200/EWS	6	4
17	T-200B /GEONOR	6	4
18	TRwS/MPS	6	4
19	MPA-1M/SA "MIRRAD"	-	-
20	PWD22/VAISALA	1	1
21	PARSIVEL/OTT	6	4
22	LPM/THIES	1	1
23	WXT510/VAISALA	6	4
24	ANS 410/H/EIGENBRODT	1	1
25	Electrical raingauge/KNMI	5	3
26	PVK/ATTEX DROP	6	4

Table 2.10: Expected and minimum number of samples for each gauge

According to the WMO Manual 485 "on the Global Data-processing System" (1992) (Appendix II-1, Table 1 "Minimum standards for quality control of data - both real time and not real time"). In both real time and not real time QC possible error codings will be inspired to BUFR table 033020, "Quality control indication of following values" (crf. BUFR Reference manual of ECMWF, 2006):

1) good (accurate; data with errors less than or equal to a specified value);
2) inconsistent (one or more parameters are inconsistent; the relationship between different elements does not satisfy defined criteria);
3) doubtful (suspect)
4) erroneous (wrong; data with errors exceeding a specific value);
5) missing data (external error or "to be checked" during the event);
6) under maintenance (data missing due to a maintenance action).

even if the whole Quality Control Information will be summarized, within each data record, through a *Binary validation Code*, whose structure is illustrated in Section 2.7. The following automatic real-time and near-real-time QC procedures of all measured data will be implemented in the Data Acquisition System:

2.5 Real Time Quality Control

2.5.1 Quality Control of Rainfall Data

A) QC of 1-minute data

Rainfall Intensity and Accumulation on 1 minute time scale are obtained basing on the 10 seconds row data acquired by the intercomparison data logging system, so that most of the quality checks exposed below will be performed relying on such coarse data. Moreover, since the number of the output samples varies from one instrument to another as a function of the output/acquisition method (pooling, automatic output, direct serial output...) QC procedures need to be integrated with a few simple rules for sampling and aggregation and have to take in account the different number of expected samples on 1 minute such as reported in Table 2.10. A basic rule for the aggregation of sensors 5, 6, 7, 8, 14, 20 and 24 (automatic 1 minute output) is the following:

> *if no sample is detected on 1 minute time spam, then also the 10 seconds following the given minute must be checked and if a sample is here detected must be attributed to the previous minute.*

This rule can also be extended to all the instruments presenting automatic output as follow:

> *if, on 1 minute time spam, is detected a number of samples equal to (expected number of samples - 1), then also the 10 seconds following the given minute must be checked and if a sample is here detected must be attributed to the previous minute.*

On the other hand, for sensors 18, 21, 22 and 26 a check of the age of the sample is necessary (in pooling with an internal update cycle comparable with the aggregation time)

RAINFALL INTENSITY

1) **NUMBER OF SAMPLES QC (FLAG=MISSING):** it varies with the number of samples naturally output by each instrument: referring to Table 2.10, if the number of samples collected in a minute is less than the Minimum Number of Samples of the considered gauge, such minute is flagged as missing and the flag is coded both directly in the "validated RI" field by -99 and in the correct position within the corresponding validation code (cfr. Section 2.7)
2) **ACQUISITION ERROR CHECK QC:** this check is performed basing on the external error codes provided by the acquisition system and is summarized in Table 2.9
   - **A)** if the "no signal" error code is detected at worst 2 times in the considered 1 minute time spam, the minute is flagged as "DOUBTFUL" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)
   - **B)** if the "no signal" error code is detected more than 2 times in the considered 1 minute time spam, the minute is flagged as "MISSING" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

if acquisition monitoring is not available for the considered instrument, the minute is flagged as "NONE ACQUISITION DATA" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

3) **NATIVE ERRORS QC:** it derives from native errors codings and is represented in Table 2.8:

   A) if a native warning code is detected almost 1 time in the considered 1 minute time spam, the minute is flagged as "DOUBTFUL" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

   B) if a native error code is detected almost 1 time in the considered 1 minute time spam, the minute is flagged as "ERRONEOUS" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

   if diagnostic data are not available for the considered instrument, the minute is flagged as "NONE DIAGNOSTIC DATA" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

4) **PLAUSIBLE VALUE CHECK (GROSS LIMIT CHECK):** This check will be performed on the 1 minute aggregated values. moreover, it will be assumed as plausible the instrument operational range declared by the manufacturer and where it is not declared or declared unlimited the WMO upper limit of 2000 mm/h will be assumed (World Meteorological Organization, 2006):

   A) if the RI value on 1 minute exceeds the upper limit of the functioning range declared by the manufacturer (or the 2000 mm/h limit for undeclared or declared unlimited ranges) , such minute is flagged as "DOUBTFUL" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

   B) if the RI value on 1 minute is negative, such minute is flagged as "ERRONEOUS" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

RAINFALL ACCUMULATION

1) **NUMBER OF SAMPLES QC (FLAG=MISSING):** it varies with the number of samples naturally output by each instrument: referring to Table 2.10, if the number of samples collected in a minute is less than the Minimum Number of Samples of

the considered gauge, such minute is flagged as missing and the flag is coded both directly in the "validated RA" field by -99 and in the correct position within the corresponding validation code (cfr. Section 2.7)

2) **ACQUISITION ERROR CHECK QC:** this check is performed basing on the external error codes provided by the acquisition system and is summarized in Table 2.9

   A) if the "no signal" error code is detected at worst 2 times in the considered 1 minute time spam, the minute is flagged as "DOUBTFUL" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

   B) if the "no signal" error code is detected more than 2 times in the considered 1 minute time spam, the minute is flagged as "MISSING" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

   if acquisition monitoring is not available for the considered instrument, the minute is flagged as "NONE ACQUISITION DATA" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

3) **NATIVE ERRORS QC:** it derives from native errors codings and is represented in Table 2.8:

   A) if a native warning code is detected almost 1 time in the considered 1 minute time spam, the minute is flagged as "DOUBTFUL" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

   B) if a native error code is detected almost 1 time in the considered 1 minute time spam, the minute is flagged as "ERRONEOUS" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

   if diagnostic data are not available for the considered instrument, the minute is flagged as "NONE DIAGNOSTIC DATA" and the flag is coded in the correct position within the corresponding validation code (cfr. Section 2.7)

CHECKS TO BE PERFORMED ON THE ENSEMBLE OF ALL RAINFALL QUANTITIES

INTERNAL CONSISTENCY CHECK : A possible check could be based on the

equation:

$$\int_{-\Delta t/2}^{+\Delta t/2} RI\ dRI = RA_{\Delta t} \tag{2.1}$$

considering also that some gauges apply a correction in the passage from RA to RI. The assigned flag is "INCONSISTENT" and no recovery action is foreseen.

Basing on Quality control data, erroneous value statistics will be performed along the whole RI-FI.

2.5.2 Quality Control of Ancillary data

C) QC of 1-minute data

a) **Plausible value check:** The limit values implemented will be as follows (basing on instrumental limits provided by the manufacturer and climatic limits):

Air temperature: -40 °C – +60 °C;
Relative Humidity: 0 – 100%;
Atmospheric Pressure: 600 – 1100 hPa;
Wind direction: 0 – 360 degrees;
Wind speed: 0 – 100 m/s (1-minute, 10-minute average);
Wind gust: 0 – 100 m/s;
Global solar radiation (irradiance): 0 - 1600 Wm^{-2}. (LYCOR model LI200X);

If the value is outside the acceptable range limit it should be flagged as erroneous.

b) **Time consistency check:**

i. **Check on a maximum allowed variability of an one-minute value (a step test):** if the current one-minute value differs from the prior one by more than a specific limit (step), then the current one-minute value fails the check and it should be flagged as doubtful (suspect). Possible limits of a maximum variability (the absolute value of the difference between the successive values) are reported in Table 2.11.

ii. **Check on a minimum required variability of one-minute values during a certain period (a persistence test):** once the measurement of the

Parameter	Limit for suspect	Limit for erroneous
Air Temperature	5 °C	10 °C
Relative Humidity	10%	15%
Wind Speed (2-minutes average)	10 m/s	20 m/s
Global Solar radiation (Irradiance)	800 Wm^{-2}	1000 Wm^{-2}

Table 2.11: Limits of maximum variability for the time consistency check of ancillary data

parameter has been done for at least 60 minutes. If the one-minute values do not vary over the past at least 60 minutes by more than the specified limit (a threshold value) then the current one-minute value fails the check. Possible limits of minimum required variability can be as follows:

Air temperature: above or equal to 0.1 °C over the past 60 minutes;
Relative Humidity: above or equal to 1% over the past 60 minutes when RH is above 50% and below 90%;
Wind direction: above or equal to 10 degrees over the past 60 minutes (limited to periods with wind speed greater than 0);
Wind speed: above or equal to 1 m/s over the past 60 minutes;

If the value fails the time consistency checks it should be flagged as doubtful (suspect).

c) **Internal consistency check:** The following conditions shall be true:

wind speed = 00 and wind direction = 00
wind speed ≠ 00 and wind direction ≠ 00
wind gust (speed) ≥ wind speed

If the value fails the internal consistency checks it should be flagged as inconsistent.

2.6 Log book format

All the maintenance action performed during the RI-FI will be recorded in the Intercomparison Logbook, in order to exclude from data Analysis and error statistics missing or erroneous data deriving from common repairs procedures. Moreover, a digitalized summary of the logbook will be holden with the following record format:

S / Start date / start time / instrument id / maintenance action description
E / End date / End time / instrument id / maintenance action description

Possible maintenance action are for example:

1) Gauge Emptying;
2) Functioning check;
3) Field calibration;
4) Cleaning;
5) Power disconnection

and so on. Information derived from the log book summary will be used for the automatic assignment of "UNDER MAINTENANCE" flag, directly coded within the "validated data" records through a -1 value. Also maintenance stats have to be carry out in order to assess the global performance of the gauges under test.

2.7 Validation Codes format

As highlighted in Table 2.1 to Table 2.9 and in Section 2.2.2 to each validated quantity is also assigned a *Validation Code*, summarizing the whole QC history of the considered data. The validation code is a 18 bit number whose bit positions (left to right) represent different validation checks, ranging from "missing" to "inconsistent" flag plus the last 2 position assigned to the "None diagnostic data" and "None Acquisition data" flags. An example related to the RI value validation is shown in Figure 2.1 The validation code is than a number with an increasing value passing from inconsistent to missing data.

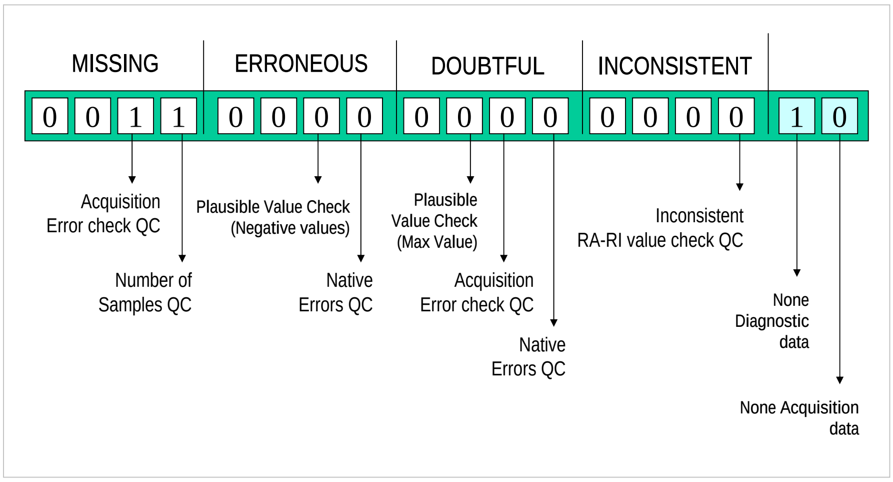


Figure 2.1: Validation Code structure: the RI value validation example

2.8 Near-Real Time Quality Control

Both Internal and External error coding and Real Time QC can be enhanced by the adoption of an "Ad posteriori" data validation (APDV) for RI gauges and ancillary sensors. Such validation procedure is often named "Near-Real Time Quality control" (NRTQC) and in the following of this report we will consider the two terms interchangeable.

NRTQC can consist of several procedures, among which:

1) **missing/erroneous data analysis;**
2) **time-series plots of all measured parameters on a daily (24-hour) basis;**
3) **detection of potential anomalies (extreme values of differences);**
4) **error data analysis.**

according to WMO Manual 485 "on the Global Data-processing System" (1992) (Appendix II-1, Table 1 "Minimum standards for quality control of data - both real time and not real time"). Thresholds and procedures for the NRTQC of both reference and under test gauges will be selected on the base of the explorative preliminary analysis described in Chapter 3. Possible validation criteria can for example base on given homogeneity conditions for ancillary sensors during the rain event.

2.8.1 Ad posteriori detection of the erroneous functioning of an instrument

In many cases the erroneous functioning of an instruments can become evident only after "ad posteriori validation" and/or data analysis. Where the near-real time quality control is not sufficient to assess the beginning of the malfunction, it will be extrapolated through data analysis. Moreover, if some anomaly is detected in data analysis and no maintenance cause is evident, this anomalies have to be attributed to the instrument itself.

2.9 From the RI-FI DB to a Relational DB (RDB)

The textual files described in Section 2.3.1 are fully compatible with the importation in most common commercial relational data base, which could allow the construction of "ad hoc" queries in support to the data analysis procedures described in Chapter 3.

Chapter 3

Preliminary Data Analysis Specifications

The goal of this chapter is the assessment of basic guidelines for the data analysis to be performed in Vigna di Valle during the field Intercomparison of rainfall intensity (RI) instruments. All the procedures are here presented in a "draft" form, trying to stress the most relevant issues/drawbacks that could arise in the start-up phase of the field Intercomparison. Primary RI-FI goals are twofold:

a) To learn as much as possible about the behavior/response of different typologies of Rain gauges in field conditions,
b) To develop standard tools aimed to the comparison of the different instrumental responses at a diversified range of actual rainfall events.

We have than to provide specific statistical/probabilistic tools for these two "strictly connected" objectives, always taking in account the complex nature of the observed phenomenon. To this aim, we will ideally divide data analysis in two parts:

1) **Pre-processing and validation:** basically aimed at producing reliable reference RIs from the 4 reference gauges and acquiring – in the most effective way – comparable RI data from the 26 typologies of gauge under test,
2) **Data Investigation:** devoted to the assessment of the performance and the accuracy of the gauges under test through the determination of the reference intensity/intensities and its/their accuracies, error and error functions definition, integration of RI measurements with ancillary data, correlation of space-time patterns with climatological quantities

Dealing with Data Acquisition, Pre-processing and validation, we have to consider:

1) Issues connected with the positioning of gauges within the test field: particular installation geometries could in fact produce spurious correlation between the instruments. In this context, the main challenge is represented from our necessity of distinguish between instrumental errors, noise and test field climatologic /orographic patterns.
2) Reference Intensities validation issues (as exposed in Section 2.8): we need in fact to define in which range or through which criteria is possible consider the reference RI acceptable for our analysis (Ad posteriori validation of reference gauges). This validation phase will also rely on ancillary data, such as rainfall sensors in AS positions (see Figure 1.1) and external/non instrumental observations provided by RESMA;
3) Intensities validation issues: basically based on the Reference RI validation (crf. Section 2.8) and on ancillary data, such as rainfall sensors in AS positions (see Figure 1.1) and external/non instrumental observations provided by RESMA (Ad posteriori validation of the instruments under test);

Besides, in performing Data Investigation and Performance evaluation we have to answer the following questions:

1) Dealing with the basic issue of assessing the reference RI, starting from the 4 reference gauges data: Should be the reference RI a summary value or a function of boundary conditions (RI intensity and ancillary data values), or both? And more, should it be unique?
2) How could we define (relative) error? Contrary to Laboratory Intercomparison the relative error definition "in field" is not trivial: Could be the relative error a combination of residuals probabilistic characteristics (distribution parameters and type) and statistical summaries (mean, mode, median, standard error)?
3) Performance is an univocal value or a function of more parameters? How can we obtain an accuracy as a function of RI value, ancillary measurements values, readiness and so on. Do we need a unique performance index?

For both the phases of data processing and analysis of results, it could be important to foreseen a *"running in" period* (concentred on the analysis of **almost 5 significative rain events**), devoted to the test of different elaboration procedures.

In the following session we will then describe an ensemble of draft analysis procedures to be performed within such "calibration phase". It will be a duty of data manager to select most effective statistical survey procedures and eventually design/perform additional

QUANTITY	UNIT OF MEASURE
RI_1 on 1 minute aggregation	mm/h
RA_1 on 1 minute aggregation	mm
RI_2 on 1 minute aggregation (if available)	mm/h
RA_2 on 1 minute aggregation (if available)	mm
RAIN YES/NO (if available)	-
RAINFALL DURATION (if available)	minutes
Average wind speed on 1 minute aggregation	m/s
Average wind direction on 1 minute aggregation	degr
Maximum Wind Speed on 1 minute aggregation	m/s
Average Air Temperature on 1 minute aggregation	°C
Temperature standard deviation on 1 minute	°C
Maximum Air Temperature on 1 minute aggregation	°C
Minimum Air Temperature on 1 minute aggregation	°C
Average Relative Humidity on 1 minute aggregation	%
Relative Humidity standard deviation on 1 minute	%
Maximum Relative Humidity on 1 minute aggregation	%
Minimum Relative Humidity on 1 minute aggregation	%
Average Atmospheric Pressure on 1 minute aggregation	hPa
Atmospheric Pressure standard deviation on 1 minute	hPa
Global Solar Radiation on 1 minute aggregation	W/m^2

Table 3.1: Investigated quantities

data analysis according to guidance of the ET/IOC, PL and FI-SM.

3.1 The analyzed quantities

As highlighted in Chapter 2 the RI-FI will preponderantly focus on the Rainfall Intensity measurement on the 1 minute aggregation. Moreover, basing on the Standard measurement record described in Section 2.9, the quantities here investigated are summarized in Table 3.1. In the following, in considering the quantities “Rainfall intensity” and “Rainfall Accumulation” we always refer to RI_1 and RA_1, if not differently specified. Moreover,

when we will speak about gauges "under test" we will refer to the instruments in field to distinguish them from the reference one (under test too but within the pit).

We will then consider the RA and RI measured at a given location in space i and at the instant t with time aggregation A as a multidimensional space-time stochastic process, given by:

$$RA_A(i,t) = \int_{t-A/2}^{t+A/2} RA(i,\tau)\, d\tau \tag{3.1}$$

and:

$$RI_A(i,t) = \frac{1}{A} RA_A(i,t) \tag{3.2}$$

Besides we will refer to

1) $RI^{(T)}_{1\ min}(i,t) = RI^{(T)}_i(t)$ as the rainfall intensity measured on 1 minute aggregation from a generic instrument under test at location i;
2) $RI^{(R)}_{1\ min}(i,t) = RI^{(R)}_i(t)$ as the rainfall intensity measured on 1 minute aggregation from a generic reference instrument at location i;
3) $RA^{(T)}_{1\ min}(i,t) = RA^{(T)}_i(t)$ as the rainfall accumulation measured on 1 minute aggregation from a generic instrument under test at location i (control quantity);
4) $RA^{(R)}_{1\ min}(i,t) = RA^{(R)}_i(t)$ as the rainfall accumulation measured on 1 minute aggregation from a generic reference instrument at location i (control quantity);
5) $\Delta RI^{(RT)}_{ij} = (RI^{(R)}_i - RI^{(T)}_j)$ as the RI difference on 1 minute aggregation between a reference gauge at location i and an instrument under test at location j (and similarly for $\Delta RA^{(RT)}_{ij}$);
6) $\Delta RI^{(RR)}_{ij} = (RI^{(R)}_i - RI^{(R)}_j)$ as the RI difference on 1 minute aggregation between two reference gauges respectively located in i and j (and similarly for $\Delta RA^{(RR)}_{ij}$);
7) $\Delta RI^{(TT)}_{ij} = (RI^{(T)}_i - RI^{(T)}_j)$ as the RI difference on 1 minute aggregation between two gauges under test and respectively located in i and j (and similarly for $\Delta RA^{(TT)}_{ij}$);
8) $\Delta RI^{(RO)}_{ij} = (RI^{(R)}_i - RI^{(O)}_j)$ as the RI difference on 1 minute aggregation between a reference gauge and its homologous in field (respectively located in i and j) – similarly for $\Delta RA^{(RO)}_{ij}$;
9) $\varrho^{(RT)}_{ij}(\tau)$ as the cross-correlation function at lag τ (the lag is assumed measured in minutes) between a reference gauge at i and a test gauge at j;
10) $\varrho^{(RR)}_{ij}(\tau)$ as the cross-correlation function at lag τ (the lag is assumed measured in

minutes) between two reference gauges respectively located in i and j;

11) $\varrho_{ij}^{(TT)}(\tau)$ as the cross-correlation function at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j;

12) $\hat{I}_{ij}^{(RT)}(\tau)$ as the Average Mutual Information function at lag τ (the lag is assumed measured in minutes) between a reference gauge at i and a test gauge at j;

13) $\hat{I}_{ij}^{(RR)}(\tau)$ as the Average Mutual Information function at lag τ (the lag is assumed measured in minutes) between two reference gauges respectively located in i and j;

14) $\hat{I}_{ij}^{(TT)}(\tau)$ as the Average Mutual Information function at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j;

where the Cross correlation function and Mutual information for e.g. the RI process X are respectively defined as:

$$\varrho_{ij}(\tau) \simeq \cdot \frac{\frac{1}{N-\tau} \cdot \sum_{k=1}^{N-\tau} [RI_i(k) - \hat{\mu}_{RI_i}] \cdot \left[RI_j(k+\tau) - \hat{\mu}_{RI_j}\right]}{\hat{\sigma}_{RI_i} \cdot \hat{\sigma}_{RI_j}} \tag{3.3}$$

where N is the sample size, $\hat{\mu}_{RI_i}$ and $\hat{\mu}_{RI_i}$ the RIs expected values estimated at locations i and j and $\hat{\sigma}_{RI_i}$ and $\hat{\sigma}_{RI_i}$ the the standard deviation estimates and:

$$\hat{I}_{ij}(\tau) = \sum_{ij} p_{ij}^{\tau} \log \left(\frac{p_{ij}^{\tau}}{p_{i\cdot}\, p_{\cdot j}} \right) \tag{3.4}$$

the former describing the spatial linear correlations within the rainfall process and the latter the global correlation structure (linear and not linear) as illustrated in the following section.

3.1.1 A few notes on Global correlation measures

Mutual information is strictly related to Information Transfer Theory and the concept of entropy. However, while mutual information is essentially a tool for the description and the analysis of regular patterns –namely is a structure measure– entropy is an uncertainty and disorder statistic. Often mutual information is also considered a global correlation measure, given its property of inferring both linear and not linear correlations (Molini et al., 2006). Consider the probability distribution $p_1, \dots, p_k$ (where $\sum_{i=1}^{k} p_i = 1$ and $p_i \geq 0 \; \forall \; i$) of a generic random variable X (e.g. the rainfall depth recorded at some

rain gage station in space). In our case the distribution turns out to be discretized due to the sampling filter of measurements, but an analogous derivation can be made for a continuous process.

If we sample this distribution N times to find n_i events of each type i, the number of distinct ways the vector $\mathbf{n} = (n_i)$ may be observed is $\binom{N}{\mathbf{n}}$.

Since entropy can be defined as the logarithmic asymptotic average of the total number of ways in which the process can occur (Wolf, 1996), after exploiting Stirling's approximation the following well-known expression for information entropy is obtained:

$$S(\mathbf{p}) = -\sum_{i=1}^{k} p_i \log(p_i) \tag{3.5}$$

$S(\mathbf{p})$ is also called the Shannon entropy. Natural logarithms are used here, although the choice is completely arbitrary since the log-base only defines the unit of measure for information (e.g., when using base 2 logarithms, the unit is the "bit"). The joint process of two random variables X and Y (that in the specific case of rain field would e.g. represent two trajectories of the process at two different locations in space) can be described with the same procedure. With some algebra the expression for the joint entropy is obtained in the form:

$$S(X,Y) = -\sum_{ij} p_{ij} \log(p_{ij}) \tag{3.6}$$

where $p_{ij} = P\,(X = x_i, Y = y_j)$. For the conditional variables *Equation 3.6* yields:

$$S(X \mid Y) = -\sum_{ij} p_{ij} \log(p_{ij}/p_{\cdot j}) \tag{3.7}$$

$$S(Y \mid X) = -\sum_{ij} p_{ij} \log(p_{ij}/p_{i\cdot}) \tag{3.8}$$

where $p_{i\cdot} = \sum_j p_{ij}$ and $p_{j\cdot} = \sum_i p_{ij}$.

Similarly, an expression for the m-variable entropy $H(\mathbf{X})$ (often called block entropy) can be derived:

$$H(\mathbf{X}) = -\sum_{all\ m} p_{i\ldots m} \log\left(p_{i\ldots m}\right) \tag{3.9}$$

If a partition size δ is chosen, corresponding to the accuracy of the considered measurements, we may define the information dimension D as:

$$D = \lim_{\delta \to 0} \frac{-H(\mathbf{X}, \delta)}{\log(\delta)} \tag{3.10}$$

The variable:

$$I(X, Y) = S(X) - S(X \mid Y) \tag{3.11}$$

represents the difference of the degree of uncertainty on X that derives from knowing or knowing not Y "a priori", namely the mutual information between X and Y. It is symmetric in its arguments and considering that:

$$S(X, Y) = S(X \mid Y) + S(Y) = S(Y \mid X) + S(X) \tag{3.12}$$

by substituting in *Eq.3.11* we have

$$I(X, Y) = S(X) + S(Y) - S(X, Y) = S(X, Y) - S(X \mid Y) - S(Y \mid X) \tag{3.13}$$

Before making use of such concepts in our analysis, a few remarks on the method used to estimate mutual information are necessary. Mutual information can be indeed estimated in several ways. Here, one of the most popular methods for the estimation of mutual information is addressed. It consists of partitioning the event spaces of X and Y into bins of finite size and obtaining, from *Eqs.3.6-3.8* and some algebra, a simple expression for the estimation of mutual information:

$$\begin{gathered}
\hat{I}_{ij}(\tau) = -\sum_{ij} p_{ij}^{\tau} \log(p_{ij}^{\tau}) + \sum_{ij} p_{ij}^{\tau} \log(p_{ij}^{\tau}/p_{\cdot j}) + \sum_{ij} p_{ij}^{\tau} \log(p_{ij}^{\tau}/p_{i \cdot}) = \\
= \sum_{ij} p_{ij}^{\tau} \left[-\log(p_{ij}^{\tau}) + \log(p_{ij}^{\tau}/p_{\cdot j}) + \log(p_{ij}^{\tau}/p_{i \cdot}) \right] = \\
= \sum_{ij} p_{ij}^{\tau} \left[-\log(p_{ij}^{\tau}) + \log(p_{ij}^{\tau}) - \log(p_{\cdot j}) + \log(p_{ij}^{\tau}) - \log(p_{i \cdot}) \right] = \\
= \sum_{ij} p_{ij}^{\tau} \log\left(\frac{p_{ij}^{\tau}}{p_{i \cdot} \cdot p_{\cdot j}} \right)
\end{gathered} \tag{3.14}$$

where $p_{ij}^{\tau} = P\left(X_t = x_i, Y_{t+\tau} = y_j\right)$.

3.2 The preliminary data analysis procedure

In the next four sections, it will be described a simple ensemble of descrittive/explorative statistical tools aimed at the preliminary assessment of the RI-FI data analysis framework. A selection of such statistics will be applied to the *first 5 significative rainfall events* of the RI-FI in order to calibrate validation procedures/criteria and to gain maximum information on RI data variability in space and time. The The final data analysis procedure will be selected basing on results of the start-up phase and ET/IOC, PL and SM requested integrations/exclusions. First we will review basic descriptive statistical tools; then the (one-dimensional and bi-dimensional) probabilistic structure of most significative field quantities is discussed together with global and linear correlation analysis and basic cluster analysis.

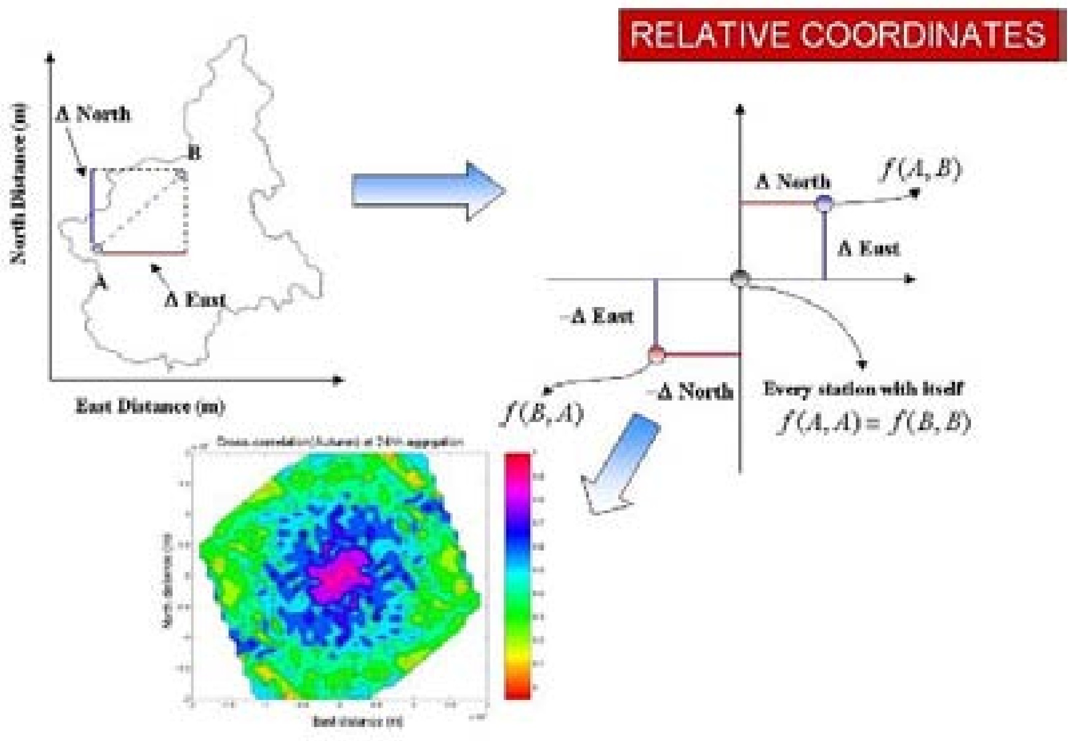


Figure 3.1: Relative coordinates representation scheme: an example applied to Piemonte region in Italy

3.2.1 Descriptive statistics for the start-up phase

In the start-up phase of the RI-FI a choice of the following descriptive statistic tools will be applied to most significant events following the ET/IOC indications:

1) **Comparative hyetographs – RI (for reference gauges):** Comparative hyetographs report on the same temporal x-axis a specular representation of the two RI time series generated, allowing the event structure analysis, the identification of similitude and the quantification of the time delay (if it exists) beetween the two instuments; In the case of two reference gauges this type of representation permits to collect useful information for the identification of reliable statistical summaries of reference data;
2) **Comparative scatter plots – RA (for reference gauges):** control statistic,
3) **Comparative hyetographs – RI (reference versus test gauges) :** aimed to highlight time structure differences and delays between reference and under test gauges,
4) **Comparative scatter plots – RA (reference versus test gauges) :** control statistic,
5) **Rain event box plot as a function of each test gauge from one given reference (1 for each reference):** Graphical representation of data summaries and variability,
6) **Rain event box plot as a function time, compared with the four references hyetograms** ,
7) **Average event rainfall field (RI) as a contour plot:** Space representation of data at a given time t; different types of interpolation method will be compared,
8) **Average event rainfall field (RA) as a contour plot:** control statistic,
9) **Animated representation of the rainfall field (RI) in space and time as a contour plot:** Animated representation of the event in space and time,
10) **Animated representation of the rainfall field (RA) in space and time as a contour plot:** control statistic,
11) $\Delta RI_{ij}^{(RT)}$ **Representation in relative coordinates** an example of relative coordinate representation is given in Figure 3.1; Roughly speaking, relative coordinates represent a quantity recorded at different locations as a function of the relative distances between the locations themselfes;
12) $\Delta RI_{ij}^{(RR)}$ **Representation in relative coordinates**,
13) $\Delta RI_{ij}^{(TT)}$ **Representation in relative coordinates**,

14) **Scatter plots of $\Delta RI_{ij}^{(RT)}$ versus ancillary data:** this type of graphical representation is able to qualitatively represent dependence law between residuals and different ancillary data,
15) **Scatter plots of $\Delta RI_{ij}^{(RR)}$ versus ancillary data**,
16) **Scatter plots of $\Delta RI_{ij}^{(TT)}$ versus ancillary data**,
17) **Scatter plot of under test gauges Time delays respect Rain Sensors data as a function of the distance of the instrument from the side of the test field from which wind comes from**,
18) **Scatter plot of under test gauges Time delays respect Rain Sensors data versus $\Delta RI_{ij}^{(RT)}$**,

The analysis cold be performed on the 1, 5, 10 and 15 time aggregation and on additional time scales when necessary for the accurate comprehension of the process. For a deeper discussion of explorative and descriptive methods see N. T. Kottegoda (1997).

3.2.2 Probabilistic tools

The following histograms, comparative histograms, and empirical Cumulated Density functions (CDFs) represent a list of probabilistic tools among which is possible to draw according to the specific analysis requirements;

1) Comparative event histogram – RI (for reference gauges):
2) Comparative event histogram – RA (for reference gauges)
3) Comparative event histogram – RI (reference versus test gauges)
4) Comparative event histogram – RA (reference versus test gauges)
5) Histograms of reference gauges both on event aggregation and in append (namely both on single events and on the whole series) – RA:
6) Histograms of reference gauges both on event aggregation and in append – RI:
7) Histograms of under test gauges both on event aggregation and in append – RA:
8) Histograms of under test gauges both on event aggregation and in append – RI:
9) Histograms of ancillary data both on event aggregation and in append: ,
10) Inference of the references RIs CDFs with the most common probability distributions and Goodness of fit tests,
11) $\Delta RI_{ij}^{(RT)}$ Histograms, both on event aggregation and in append,
12) $\Delta RI_{ij}^{(RR)}$ Histograms, both on event aggregation and in append,
13) $\Delta RI_{ij}^{(TT)}$ Histograms, both on event aggregation and in append,

14) Joint histograms of $\Delta RI_{ij}^{(RT)}$ versus ancillary data,
15) Joint histograms of $\Delta RI_{ij}^{(RR)}$ versus ancillary data,
16) Joint histograms of $\Delta RI_{ij}^{(TT)}$ versus ancillary data,
17) time delays histograms

3.2.3 Linear and global correlation analysis

Linear correlation analysis of the rainfall intensity process in space and time will base on one or more of the following survey scheme:

1) Cross-correlation function $\varrho_{ij}^{(RT)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between a reference gauge at i and a test gauge at j, represented in relative coordinates, as a function of the longitudinal (d_{ij}^{Long}) and latitudinal (d_{ij}^{Lat}) distance between sensors,
2) Cross-correlation function $\varrho_{ij}^{(RR)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between two reference gauges respectively located in i and j, represented in relative coordinates, as a function of the longitudinal (d_{ij}^{Long}) and latitudinal (d_{ij}^{Lat}) distance between sensors,,
3) Cross-correlation function $\varrho_{ij}^{(TT)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the longitudinal (d_{ij}^{Long}) and latitudinal (d_{ij}^{Lat}) distance between sensors,,
4) Cross-correlation functions between ancillary quantities and Reference RIs at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the longitudinal (d_{ij}^{Long}) and latitudinal (d_{ij}^{Lat}) distance between sensors,
5) Cross-correlation functions between ancillary quantities and under test RIs at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the longitudinal (d_{ij}^{Long}) and latitudinal (d_{ij}^{Lat}) distance between sensors,
6) Average Cross-correlation function $\varrho_{ij}^{(RT)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between a reference gauge at i and a test gauge at j, represented in relative coordinates, as a function of the absolute distance between sensors,
7) Average Cross-correlation function $\varrho_{ij}^{(RR)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between two reference gauges respectively located in i and j, rep-

resented in relative coordinates, as a function of the absolute distance between sensors,

8) Average Cross-correlation function $\varrho_{ij}^{(TT)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the absolute distance between sensors,
9) Average Cross-correlation functions between ancillary quantities and Reference RIs at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the absolute distance between sensors,
10) Average Cross-correlation functions between ancillary quantities and under test RIs at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the absolute distance between sensors,

while the untangling of global (linear and not-linear) correlations, where this statistic will be considered significant, will relay on a selection of the following tools:

1) Average Mutual Information function $\hat{I}_{ij}^{(RT)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between a reference gauge at i and a test gauge at j, represented in relative coordinates, as a function of the longitudinal (d_{ij}^{Long}) and latitudinal (d_{ij}^{Lat}) distance between sensors,
2) Average Mutual Information function $\hat{I}_{ij}^{(RR)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between two reference gauges respectively located in i and j, represented in relative coordinates, as a function of the longitudinal (d_{ij}^{Long}) and latitudinal (d_{ij}^{Lat}) distance between sensors,,
3) Average Mutual Information function $\hat{I}_{ij}^{(TT)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the longitudinal (d_{ij}^{Long}) and latitudinal (d_{ij}^{Lat}) distance between sensors,,
4) Average Mutual Information functions between ancillary quantities and Reference RIs at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the longitudinal (d_{ij}^{Long}) and latitudinal (d_{ij}^{Lat}) distance between sensors,
5) Average Mutual Information functions between ancillary quantities and under test RIs at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of

the longitudinal (d_{ij}^{Long}) and latitudinal (d_{ij}^{Lat}) distance between sensors,

6) Average Mutual Information function $\hat{I}_{ij}^{(RT)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between a reference gauge at i and a test gauge at j, represented in relative coordinates, as a function of the absolute distance between sensors,

7) Average Mutual Information function $\hat{I}_{ij}^{(RR)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between two reference gauges respectively located in i and j, represented in relative coordinates, as a function of the absolute distance between sensors,

8) Average Mutual Information function $\hat{I}_{ij}^{(TT)}(\tau)$ at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the absolute distance between sensors,

9) Average Mutual Information functions between ancillary quantities and Reference RIs at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the absolute distance between sensors,

10) Average Mutual Information functions between ancillary quantities and under test RIs at lag τ (the lag is assumed measured in minutes) between two test gauges respectively located in i and j, represented in relative coordinates, as a function of the absolute distance between sensors,

Both the methods are aimed to learn as much as possible about the correlation structure of the testing field and try to filter spurious correlation effects. The RI gauges installation must in fact avoid spurious correlation effects due to the instruments positioning and correlation analysis represent an affordable tool for both spurious patterns and clustering effects. Moreover, the correlation between weighing gauges measurements and air temperature will be analyzed.

3.3 Conclusions

The present chapter presents a selection of possible statistical methods applicable to the RI-FI data set during its start-up phase. As evident, after a correct characterization of different instruments behaviors and their responses to different climatological conditions, such ensemble of statistics could be resized or intergraded with additional statistics. What is relevant is the basic goal of the start up phase, namely the acquisition of a series of

information fundamental in the assessment of instrumental responses to different field conditions. From this point of view the proposed methods must be intended as explorative only and loose their real significance in absence of a successive critical elaboration of the obtained information.

Appendix A

Appendix A: Documents and specifications of the Involved RI Gauges

A.1 7499020BoMV2, RIMCO, AUSTRALIA

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.1: Gauge 7499020BoMV2, RIMCO, AUSTRALIA

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/1_RIMCO_7499020BoMV2_AUSTRIA/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/1_RIMCO_7499020BoMV2_AUSTRIA/

SERIAL NUMBERS

Instrument Serial Number: 90184

Spare Instrument Serial Number: 90191

TECHNICAL DATA

Functioning principle: Tipping Bucket

Operational Range [mm/h]: 0–500

Catching (YES/NO): YES

Collecting Surface [cm^2]: 223.6

Bucket capacity [gr]: 20

Resolution on 1 minute aggregation [mm/h]: 12

Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: passive reed contact swiches (pulses), sampled every 10 s
Expected number of samples for minute: 6
Internal Up-date Cycle: random
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): No

A.2 AP23, PAAR, AUSTRIA

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.2: Gauge AP23, PAAR, AUSTRIA

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/2_PAAR_AP23_AUSTRIA/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/2_PAAR_AP23_AUSTRIA/

SERIAL NUMBERS

Instrument Serial Number: 183246

Spare Instrument Serial Number: X24

TECHNICAL DATA

Functioning principle: Tipping Bucket

Operational Range [mm/h]: 0–720

Catching (YES/NO): YES

Collecting Surface [cm^2]: 500

Bucket capacity [gr]: 5

Resolution on 1 minute aggregation [mm/h]: 6

Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: passive reed contact swiches (pulses), sampled every 10 s
Expected number of samples for minute: 6
Internal Up-date Cycle: random
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): No

A.3 R01 3070, PRECIS-MECANIQUE, FRANCE

Figure A.3: Gauge R01 3070, PRECIS-MECANIQUE, FRANCE as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/3_PRECISE_MECANIQUE_R013070_FRANCE/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/3_PRECISE_MECANIQUE_R013070_FRANCE/

SERIAL NUMBERS

Instrument Serial Number: 19425

Spare Instrument Serial Number: 19426

TECHNICAL DATA

Functioning principle: Tipping Bucket

Operational Range [mm/h]: 0–450

Catching (YES/NO): YES

Collecting Surface [cm^2]: 1000

Bucket capacity [gr]: 20
Resolution on 1 minute aggregation [mm/h]: 12
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) No

ACQUISITION SPECIFICATIONS

Acquisition Method: passive reed contact swiches (pulses), sampled every 10 s
Expected number of samples for minute: 6
Internal Up-date Cycle: random
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): No

A.4 PT 5.4032.35.008, THIES, GERMANY

Figure A.4: Gauge PT 5.4032.35.008, THIES, GERMANY as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/4_THIES_PT5.4032.35.008_GERMANY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/4_THIES_PT5.4032.35.008_GERMANY/

SERIAL NUMBERS

Instrument Serial Number: 507650

Spare Instrument Serial Number: 507649

TECHNICAL DATA

Functioning principle: Tipping Bucket

Operational Range [mm/h]: 0–420

Catching (YES/NO): YES

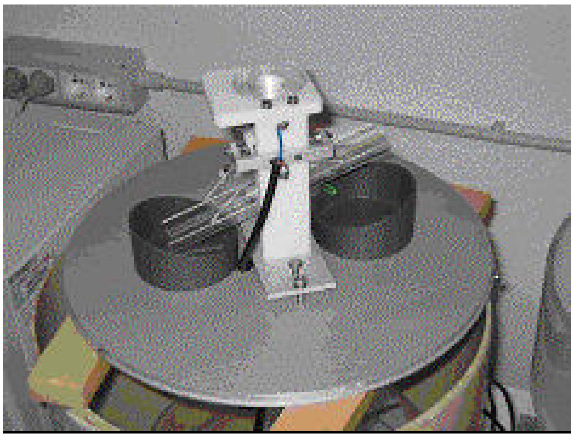
Collecting Surface [cm^2]: 200

Bucket capacity [gr]: 2
Resolution on 1 minute aggregation [mm/h]: 6
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) No

ACQUISITION SPECIFICATIONS

Acquisition Method: passive reed contact swiches (pulses), sampled every 10 s
Expected number of samples for minute: 6
Internal Up-date Cycle: random
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): No

A.5 R 102 (REFERENCE GAUGE), ETG, ITALY



(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.5: Gauge R 102 (REFERENCE GAUGE), ETG, ITALY

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/5_ETG_R102_ITALY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/5_ETG_R102_ITALY/

SERIAL NUMBERS

REFERENCE Instrument Serial Number: GB1010

Instrument Serial Number: GB1011

Spare Instrument Serial Number: GB1012

TECHNICAL DATA

Functioning principle: Tipping Bucket (corrected)

Operational Range [mm/h]: 0–300

Catching (YES/NO): YES

Collecting Surface [cm^2]: 1000

Bucket capacity [gr]: 20

Resolution on 1 minute aggregation [mm/h]: 0.6 (from manufacturer questionnaire)
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: Automatic output on 1 minute aggregation
Expected number of samples for minute: 1
Internal Up-date Cycle: -
RI Output (YES/NO): Yes
Internal diagnostic data/error codes (YES/NO): No

A.6 DQA031, LSI LASTEM, ITALY

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.6: Gauge DQA031, LSI LASTEM, ITALY

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/6_LSILASTEM_DQ031_ITALY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/6_LSILASTEM_DQ031_ITALY/

SERIAL NUMBERS

Instrument Serial Number: P704626

Spare Instrument Serial Number: P764625

TECHNICAL DATA

Functioning principle: Tipping Bucket

Operational Range [mm/h]: declared UNLIMITED by the manufacturer

Catching (YES/NO): YES

Collecting Surface [cm^2]: 324

Bucket capacity [gr]: 6.48

Resolution on 1 minute aggregation [mm/h]: 12

Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: Automatic output on 1 minute aggregation
Expected number of samples for minute: 1
Internal Up-date Cycle: 1 minute
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): No

A.7 T- PLUV UM7525/I, SIAP-MICROS, ITALY

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.7: Gauge T- PLUV UM7525/I, SIAP-MICROS, ITALY

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/7_SIAP_UM7525I_ITALY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/7_SIAP_UM7525I_ITALY/

SERIAL NUMBERS

Instrument Serial Number: 333

Spare Instrument Serial Number: 335

TECHNICAL DATA

Functioning principle: Tipping Bucket (corrected)

Operational Range [mm/h]: 0-250

Catching (YES/NO): YES

Collecting Surface [cm^2]: 1000

Bucket capacity [gr]: 20

Resolution on 1 minute aggregation [mm/h]: 0.2 (from manufacturer questionnaire)

Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: Automatic output on 1 minute aggregation
Expected number of samples for minute: 1
Internal Up-date Cycle: 10 seconds
RI Output (YES/NO): Yes
Internal diagnostic data/error codes (YES/NO): No

A.8 PM B2 (REFERENCE GAUGE), CAE, ITALY

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.8: Gauge PM B2 (REFERENCE GAUGE), CAE, ITALY

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/8_CAE_PMB2_ITALY/

INSTRUMENT MANUALS/TECHNICAL REPORTS URL:

http://www.pro-testa.net/WMO_FIRII/8_CAE_PMB2_ITALY/

SERIAL NUMBERS

REFERENCE Instrument Serial Number: 21876

Instrument Serial Number: 21858

Spare Instrument Serial Number: 21869

TECHNICAL DATA

Functioning principle: Tipping Bucket (corrected)

Operational Range [mm/h]: 0–300

Catching (YES/NO): YES

Collecting Surface [cm^2]: 1000

Bucket capacity [gr]: 20

Resolution on 1 minute aggregation [mm/h]: 0.1
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: Automatic output on 1 minute aggregation
Expected number of samples for minute: 1
Internal Up-date Cycle: 1 second
RI Output (YES/NO): Yes
Internal diagnostic data/error codes (YES/NO): Yes

A.9 RAIN COLLECTOR II (7852), DAVIS, USA

Figure A.9: Gauge RAIN COLLECTOR II (7852), DAVIS, USA as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/9_DAVIS_RAINCOLLECTORII_USA/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/9_DAVIS_RAINCOLLECTORII_USA/

SERIAL NUMBERS

Instrument Serial Number: PN7752

Spare Instrument Serial Number: -

TECHNICAL DATA

Functioning principle: Tipping Bucket

Operational Range [mm/h]: 0–2540

Catching (YES/NO): YES

Collecting Surface [cm^2]: 214
Bucket capacity [gr]: 5.43 (equivalent to 1 inch of RA)
Resolution on 1 minute aggregation [mm/h]: 15.24
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) No

ACQUISITION SPECIFICATIONS

Acquisition Method: passive reed contact swiches (pulses), sampled every 10 s
Expected number of samples for minute: 6
Internal Up-date Cycle: random
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): No

A.10 15188, LAMBRECHT, GERMANY

Figure A.10: Gauge 15188, LAMBRECHT, GERMANY as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/10_LAMBRECHT_15188_GERMANY/

INSTRUMENT MANUALS/TECHNICAL REPORTS URL: http://www.pro-testa.net/WMO_FIRII/10_LAMBRECHT_15188_GERMANY/

SERIAL NUMBERS

Instrument Serial Number: 740621.0002

Spare Instrument Serial Number: - ; Bucket substituted for demagnetization and shipped at Dicat on 18/06/2007

TECHNICAL DATA

Functioning principle: Tipping Bucket

Operational Range [mm/h]: 0–600

Catching (YES/NO): YES

Collecting Surface [cm^2]: 200
Bucket capacity [gr]: 2
Resolution on 1 minute aggregation [mm/h]: 6
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: ACTIVE PULSE 0-5V, sampled every 10 s, with random additional pulse (300ms after previous pulse) for corrections
Expected number of samples for minute: 6
Internal Up-date Cycle: random
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): No

A.11 PP040, MTX, ITALY

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.11: Gauge PP040, MTX, ITALY

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/11_MTX_PP040_ITALY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/11_MTX_PP040_ITALY/

SERIAL NUMBERS

Instrument Serial Number: 70/074

Spare Instrument Serial Number: -

TECHNICAL DATA

Functioning principle: Tipping Bucket

Operational Range [mm/h]: The range was declared UNLIMITED by the manufacturer

Catching (YES/NO): YES

Collecting Surface [cm^2]: 1000

Bucket capacity [gr]: 20

Resolution on 1 minute aggregation [mm/h]: 12

Previously calibrated during the WMO Lab Intercomparison: (YES/NO) No

ACQUISITION SPECIFICATIONS

Acquisition Method: passive reed contact swiches (pulses), sampled every 10 s
Expected number of samples for minute: 6
Internal Up-date Cycle: random
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): No

A.12 ARG100, Environmental Measurements Limited, BRAZIL/UK

Figure A.12: Gauge ARG100, Environmental Measurements Limited, BRAZIL/UK as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/12_ENVMEASLTD_ARG100_BRAZIL_UK/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/12_ENVMEASLTD_ARG100_BRAZIL_UK/

SERIAL NUMBERS

Instrument Serial Number: 071608

Spare Instrument Serial Number: 071607

TECHNICAL DATA

Functioning principle: Tipping Bucket

Operational Range [mm/h]: Undeclared

Catching (YES/NO): YES
Collecting Surface [cm^2]: 254
Bucket capacity [gr]: 5.08
Resolution on 1 minute aggregation [mm/h]: 12
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) No

ACQUISITION SPECIFICATIONS

Acquisition Method: passive reed contact swiches (pulses), sampled every 10 s
Expected number of samples for minute: 6
Internal Up-date Cycle: random
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): No

A.13 MRW500 (REFERENCE GAUGE), METEOSERVIS, CZECH REPUBLIC

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.13: Gauge MRW500 (REFERENCE GAUGE), METEOSERVIS, CZECH REPUBLIC

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/13_METEOSERVIS_MRV500_CZECHREPUBLIC/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/13_METEOSERVIS_MRV500_CZECHREPUBLIC/

REFERENCE Instrument Serial Number: 34

SERIAL NUMBERS

Instrument Serial Number: 41

Spare Instrument Serial Number: 35

TECHNICAL DATA

Functioning principle: Weighing Gauge

Operational Range [mm/h]: 2–400

Catching (YES/NO): Yes

Collecting Surface [cm^2]: 500
Resolution on 1 minute aggregation [mm/h]: 6
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: In pooling every 10 seconds
Expected number of samples for minute: 0.1 declared by the manufacturer
Internal Up-date Cycle: 30 seconds (declared by the manufacturer)even if from manual it seems similar to a TBR and constrained to .1 mm resolution in RA; output cycle depends on the precipitation duration, max reaction time = 1 minute
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): Yes

A.14 VRG101, VAISALA, FINLAND

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.14: Gauge VRG101, VAISALA, FINLAND

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/14_VAISALA_VRG101_FINLAND/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/14_VAISALA_VRG101_FINLAND/

SERIAL NUMBERS

Instrument Serial Number: C0620011

Spare Instrument Serial Number: C0620012

TECHNICAL DATA

Functioning principle: Weighing Gauge

Operational Range [mm/h]: 0.5–2000

Catching (YES/NO): Yes

Collecting Surface [cm^2]: 400

Resolution on 1 minute aggregation [mm/h]: 0.1 (from manufacturer manual, but from the data telegram resolution seems 0.01, probably due to calculation performed on

the weight, res=0.1 gr)
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: Automatic output on 1 minute aggregation
Expected number of samples for minute: 1
Internal Up-date Cycle: 54 seconds
RI Output (YES/NO): Yes
Internal diagnostic data/error codes (YES/NO): Yes

A.15 PLUVIO, OTT, GERMANY

Figure A.15: PLUVIO, OTT, GERMANY as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/15_OTT_PLUVIO_GERMANY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/15_OTT_PLUVIO_GERMANY/

SERIAL NUMBERS

Instrument Serial Number: 220331

Spare Instrument Serial Number: 220332

TECHNICAL DATA

Functioning principle: Weighing Gauge

Operational Range [mm/h]: 0–1200

Catching (YES/NO): Yes

Collecting Surface [cm^2]: 200
Resolution on 1 minute aggregation [mm/h]: 0.6 (declared by manufacturer)
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS
Acquisition Method: In pooling every 10 seconds
Expected number of samples for minute: 6
Internal Up-date Cycle: 6 seconds
RI Output (YES/NO): Yes
Internal diagnostic data/error codes (YES/NO): Yes

A.16 PG200, EWS, HUNGARY

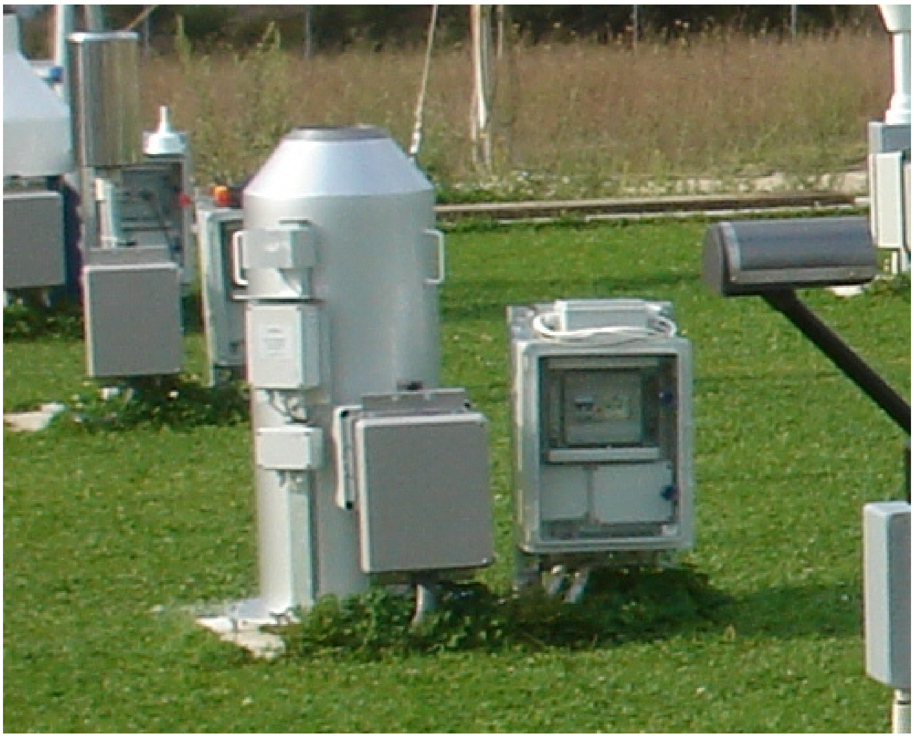


Figure A.16: Gauge PG200, EWS, HUNGARY as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/16_EWS_PG200_HUNGARY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/16_EWS_PG200_HUNGARY/

SERIAL NUMBERS

Instrument Serial Number: CSM001107

Spare Instrument Serial Number: CSM001207

TECHNICAL DATA

Functioning principle: Weighing Gauge

Operational Range [mm/h]: 0.1 to “no practice limit”

Catching (YES/NO): Yes

Collecting Surface [cm^2]: 200
Resolution on 1 minute aggregation [mm/h]: 0.1 declared by the manufacturer, although from the original configuration file RA resolution results 0.05 mm and so, the RI Resolution on 1 minute aggregation should be 3 mm/h
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) No

ACQUISITION SPECIFICATIONS

Acquisition Method: In pooling every 10 seconds (the device recalculate data at the pooling instant)
Expected number of samples for minute: 6
Internal Up-date Cycle: internal sampling frequency =1 s; data output cicle = pooling time
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): Yes

A.17 T-200B (REFERENCE GAUGE), GEONOR, NORWAY

(a) As installed in the pit of @RESMA Test Field in Vigna di Valle (Italy) (1)

(b) As installed in the pit of @RESMA Test Field in Vigna di Valle (Italy)(2)

Figure A.17: Gauge T-200B (REFERENCE GAUGE), GEONOR, NORWAY

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/17_GEONOR_T200B3_NORWAY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/17_GEONOR_T200B3_NORWAY/

SERIAL NUMBERS

REFERENCE Instrument Serial Number: 14607

Instrument Serial Number: 14707

Spare Instrument Serial Number: 14507, only Spare electronics plus vibrating wire

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TECHNICAL DATA

Functioning principle: Weighing Gauge

Operational Range [mm/h]: 0–600

Catching (YES/NO): Yes

Collecting Surface [cm^2]: 200

Resolution on 1 minute aggregation [mm/h]: 0.1 mm sensitivity leading to a RI resolution of 6 mm/h (from manufacturer manual)
Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: Direct acquisition from the data logger – 6 synchronized samples
Expected number of samples for minute: 6
Internal Up-date Cycle: 1 second
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): No

A.18 TRwS, MPS, SLOVAK REPUBLIC

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.18: Gauge TRwS, MPS, SLOVAK REPUBLIC

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/18_MPS_TRWS_SLOVAK_REPUBLIC/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/18_MPS_TRWS_SLOVAK_REPUBLIC/

SERIAL NUMBERS

Instrument Serial Number: 189

Spare Instrument Serial Number: 191

TECHNICAL DATA

Functioning principle: Weighing Gauge

Operational Range [mm/h]: 0–3600

Catching (YES/NO): Yes

Collecting Surface [cm^2]: 500

Resolution on 1 minute aggregation [mm/h]: 0.06

Previously calibrated during the WMO Lab Intercomparison: (YES/NO) Yes

ACQUISITION SPECIFICATIONS

Acquisition Method: In pooling every 10 seconds

Expected number of samples for minute: 6

Internal Up-date Cycle: 1 minute (from manufacturer questionnaire); the manufacturer suggests a 57" synchronization for pooling

RI Output (YES/NO): No

Internal diagnostic data/error codes (YES/NO): Yes

A.19 MPA-1M, SA "MIRRAD", UCRAINE

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/19_SAMIRRAD_MPA-1M_UKRAINE/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/19_SAMIRRAD_MPA-1M_UKRAINE/

SERIAL NUMBERS

Instrument Serial Number: -

Spare Instrument Serial Number: -

TECHNICAL DATA

Functioning principle: -

Operational Range [mm/h]: -

Catching (YES/NO): -

Collecting Surface [cm^2]: -

Bucket capacity [gr]: -

Resolution on 1 minute aggregation [mm/h]: -

Previously calibrated during the WMO Lab Intercomparison: (YES/NO) -

ACQUISITION SPECIFICATIONS

Acquisition Method: -

Expected number of samples for minute: -

Internal Up-date Cycle: -

RI Output (YES/NO): -

Internal diagnostic data/error codes (YES/NO): -

A.20 PWD22, VAISALA, FINLAND

Figure A.19: Gauge PWD22, VAISALA, FINLAND as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/20_VAISALA_PWD22_FINLAND/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/20_VAISALA_PWD22_FINLAND/

SERIAL NUMBERS

Instrument Serial Number: C15506

Spare Instrument Serial Number: C15505

TECHNICAL DATA

Functioning principle: Optical Gauge

Operational Range [mm/h]: 0.05–999.99

Catching (YES/NO): No

Resolution on 1 minute aggregation [mm/h]: 0.01

ACQUISITION SPECIFICATIONS

Acquisition Method: Automatic output on 1 minute aggregation
Expected number of samples for minute: 1
Internal Up-date Cycle: 15 seconds (from manufacturer questionnaire)
RI Output (YES/NO): Yes
Internal diagnostic data/error codes (YES/NO): Yes

A.21 PARSIVEL, OTT, GERMANY

Figure A.20: Gauge PARSIVEL, OTT, GERMANY as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/21_OTT_PARSIVEL_GERMANY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/21_OTT_PARSIVEL_GERMANY/

SERIAL NUMBERS

Instrument Serial Number: 221944

Spare Instrument Serial Number: 221945

TECHNICAL DATA

Functioning principle: Optical disdrometer

Operational Range [mm/h]: 0.001–1200

Catching (YES/NO): No

Resolution on 1 minute aggregation [mm/h]: 0.001

ACQUISITION SPECIFICATIONS

Acquisition Method: In pooling every 10 seconds

Expected number of samples for minute: 6

Internal Up-date Cycle: Unknown

RI Output (YES/NO): Yes

Internal diagnostic data/error codes (YES/NO): Yes

A.22 LPM, THIES, GERMANY

Figure A.21: Gauge LPM, THIES, GERMANY as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/22_THIES_LPM_GERMANY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/22_THIES_LPM_GERMANY/

SERIAL NUMBERS

Instrument Serial Number: 294

Spare Instrument Serial Number: 295

TECHNICAL DATA

Functioning principle: Optical disdrometer

Operational Range [mm/h]: 0.005–250

Catching (YES/NO): No

Resolution on 1 minute aggregation [mm/h]: 0.001

ACQUISITION SPECIFICATIONS

Acquisition Method: Automatic output on 1 minute aggregation
Expected number of samples for minute: 1
Internal Up-date Cycle: 1 minute
RI Output (YES/NO): Yes
Internal diagnostic data/error codes (YES/NO): Yes

A.23 WXT510, VAISALA, FINLAND

Figure A.22: Gauge WXT510, VAISALA, FINLAND as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/23_VAISALA_WXT510_FINLAND/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/23_VAISALA_WXT510_FINLAND/

SERIAL NUMBERS

Instrument Serial Number: 1620016

Spare Instrument Serial Number: 1620017

TECHNICAL DATA

Functioning principle: Acoustic Gauge

Operational Range [mm/h]: 0–200

Catching (YES/NO): No

Resolution on 1 minute aggregation [mm/h]: 0.01

ACQUISITION SPECIFICATIONS

Acquisition Method: Automatic output on 10 seconds aggregation
Expected number of samples for minute: 6
Internal Up-date Cycle: 10 seconds
RI Output (YES/NO): Yes
Internal diagnostic data/error codes (YES/NO): No

A.24 ANS 410/H, EIGENBRODT, GERMANY

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.23: Gauge ANS 410/H, EIGENBRODT, GERMANY

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/24_EIGENBRODT_ANS410_GERMANY/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/24_EIGENBRODT_ANS410_GERMANY/

SERIAL NUMBERS

Instrument Serial Number: 9767

Spare Instrument Serial Number: 9766

TECHNICAL DATA

Functioning principle: Pressure Sensor

Operational Range [mm/h]: 0–1200

Catching (YES/NO): Yes

Collecting Surface [cm^2]: 200 **Resolution on 1 minute aggregation [mm/h]:** 0.01 from Manufacturer questionnaire, even if from data telegram RA resolution seems to be 0.01 mm too, leading to a RI res of 0.6 mm/h

Previously calibrated during the WMO Lab Intercomparison: (YES/NO) No

ACQUISITION SPECIFICATIONS

Acquisition Method: Automatic output on 1 minute aggregation
Expected number of samples for minute: 1
Internal Up-date Cycle: 0.05 seconds (from manufacturer questionnaire)
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): Yes

A.25 Electrical raingauge, KNMI, NETHERLANDS

(a) During the Laboratory test @DICAT in Genoa (Italy)

(b) As installed @RESMA Test Field in Vigna di Valle (Italy)

Figure A.24: Gauge Electrical raingauge, KNMI, NETHERLANDS

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/25_KNMI_NETHERLANDS/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/25_KNMI_NETHERLANDS/

SERIAL NUMBERS

Instrument Serial Number: 01.08.061-026

Spare Instrument Serial Number: 01.08.061-016

TECHNICAL DATA

Functioning principle: Level Gauge

Operational Range [mm/h]: 0–300

Catching (YES/NO): Yes

Collecting Surface [cm^2]: 400

Resolution on 1 minute aggregation [mm/h]: 0.1 (from manufacturer questionnaire, even if data telegram RA resolution seems to leed to a 0.06 mm/h RI res)

Previously calibrated during the WMO Lab Intercomparison: (YES/NO) No

ACQUISITION SPECIFICATIONS

Acquisition Method: Automatic output on 12 seconds aggregation (running average)
Expected number of samples for minute: 5
Internal Up-date Cycle: 12 seconds
RI Output (YES/NO): Yes
Internal diagnostic data/error codes (YES/NO): yes

A.26 DROP, PVK-ATTEX, RUSSIAN FEDERATION

Figure A.25: Gauge DROP, PVK-ATTEX, RUSSIAN FEDERATION as installed @RESMA Test Field in Vigna di Valle (Italy)

DOCUMENTATION URLS

Instrument Documentation URL: http://www.pro-testa.net/WMO_FIRII/26_PVKATTEX_DROP_RUSSIANFED/

Instrument Manuals/Technical Reports URL: http://www.pro-testa.net/WMO_FIRII/26_PVKATTEX_DROP_RUSSIANFED/

SERIAL NUMBERS

Instrument Serial Number: -

Spare Instrument Serial Number: -

TECHNICAL DATA

Functioning principle: Radar Sensor

Operational Range [mm/h]: 0.1–240

Catching (YES/NO): No

Resolution on 1 minute aggregation [mm/h]: 0.06

ACQUISITION SPECIFICATIONS

Acquisition Method: In pooling every 10 seconds
Expected number of samples for minute: 6
Internal Up-date Cycle: 0.1 seconds
RI Output (YES/NO): No
Internal diagnostic data/error codes (YES/NO): Yes

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