FLASH FLOODS AND PLUVIAL FLOODING

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

REGIONE AUTONOMA DELLA SARDEGNA

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

Working Group F Thematic Workshop

ACCURACY OF RAIN INTENSITY MEASUREMENTS AND ITS INFLUENCE ON THE STATISTICS OF EXTREME EVENTS

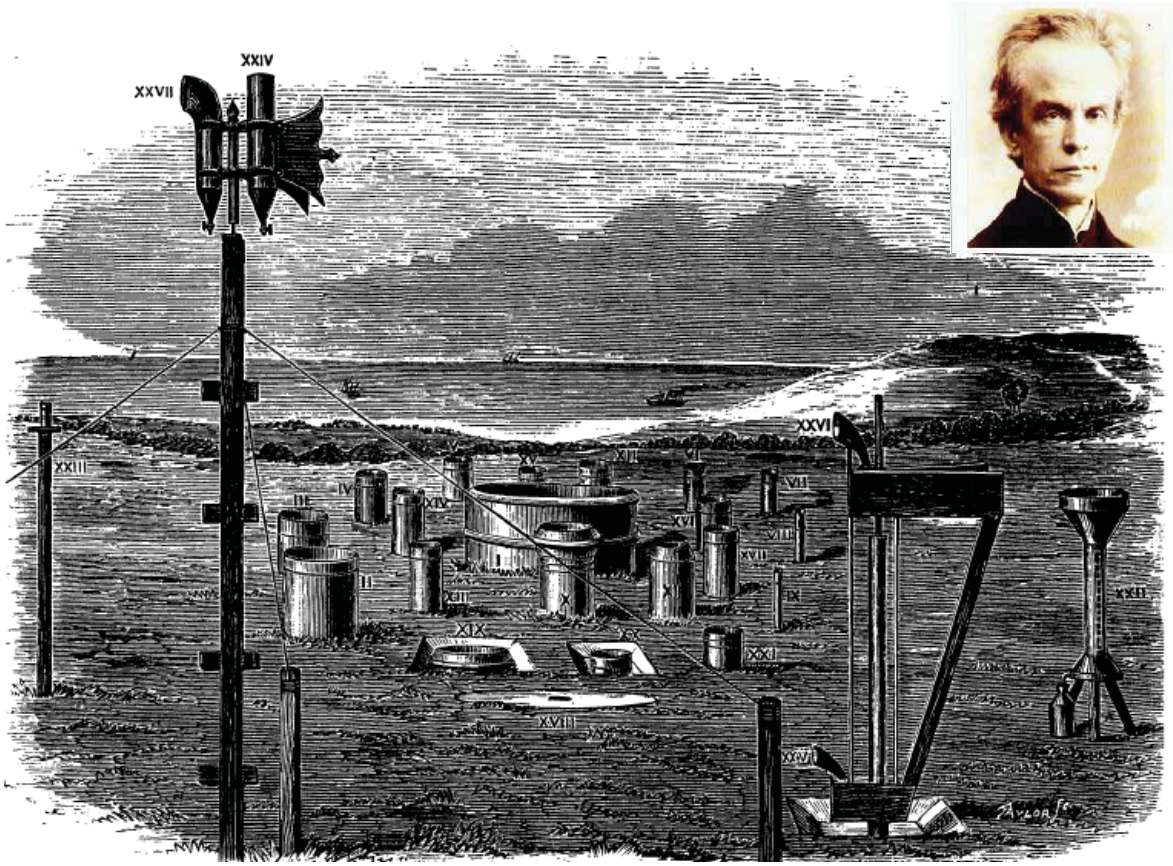
L.G. Lanza and E. Vuerich

University of Genova, Italian Air Force

26th-28th May 2010, Cagliari, Italy

The tradition of intercomparison studies …

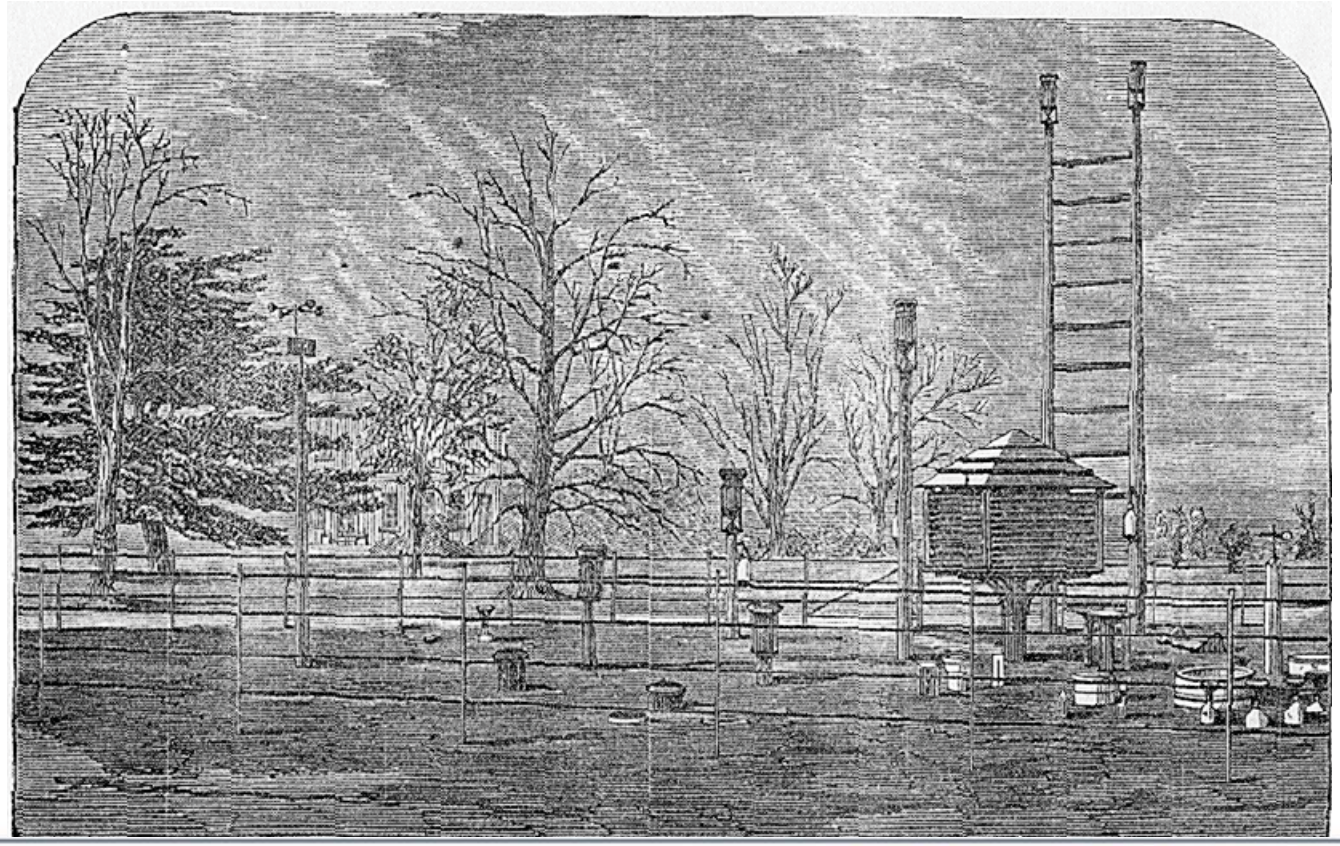
1871 – SYMONS PERFORMS THE FIRST INTERCOMPARISON OF RAIN GAUGES AT HAWSKERS (YORKSHIRE)



Father Francesco Denza (1872) Italian Meteorological Society

"….in order that meteorological studies produce advantages for human beings… it is not only necessary to have lots of observatories and observations / measurements be done with intelligence and accuracy, but it is moreover requested a meteorological investigation with same **methodology and with well compared instruments**".

EXPERIMENT TO INVESTIGATE THE EFFECT OF MEASUREMENT HEIGTH (SYMONS 1862)



Previous related WMO Intercomparisons:

. International Comparison of National Precipitation Gauges with a Reference Pit Gauge (Sevruk *et al.*, 1984).
. WMO Solid Precipitation Measurement Intercomparison (Goodison *et al.*, 1998).
Precipitation intensity was investigated for the first time in the assessment of present weather systems:
. WMO Intercomparison of Present Weather Sensors/Systems (Leroy *et al.*, 1998).
but only for qualitative information (light, moderate, heavy)

- focus on rainfall accumulation
- low intensity rainfall (snow)
- overall effect of counting and catching errors

Catching errors = The errors due to the weather conditions at the collector, as well as those related to wetting, splashing and evaporation processes. They indicate the ability of the instrument to collect the exact amount of water that applies from the definition of precipitation at the ground, i.e. the total water falling over the projection of the collector's area over the ground.

Counting errors = Counting errors are on the other hand related to the ability of the instrument to "sense" correctly the amount of water that is collected by the instrument.
They can be experienced both in catching and non-catching type of instruments, although in the latter case the assessment of such errors is very difficult, and is hard to be performed in laboratory conditions.

ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale
REGIONE AUTONOMA DELLA SARDEGNA
MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

From Laboratory to Field Tests

The main objective of the Laboratory Intercomparison was to **test the performances** of catchment type rainfall intensity gauges of different measuring principles **under documented conditions**.

Laboratory →

- controlled conditions
- constant flow rate
- known reference flow rate
- counting errors

Drawbacks:

- no real rainfall (variability, etc.)
- no catching errors
- no real operating conditions

→ Follow-up in the field

WMO Field Intercomparison of Rainfall Intensity Gauges

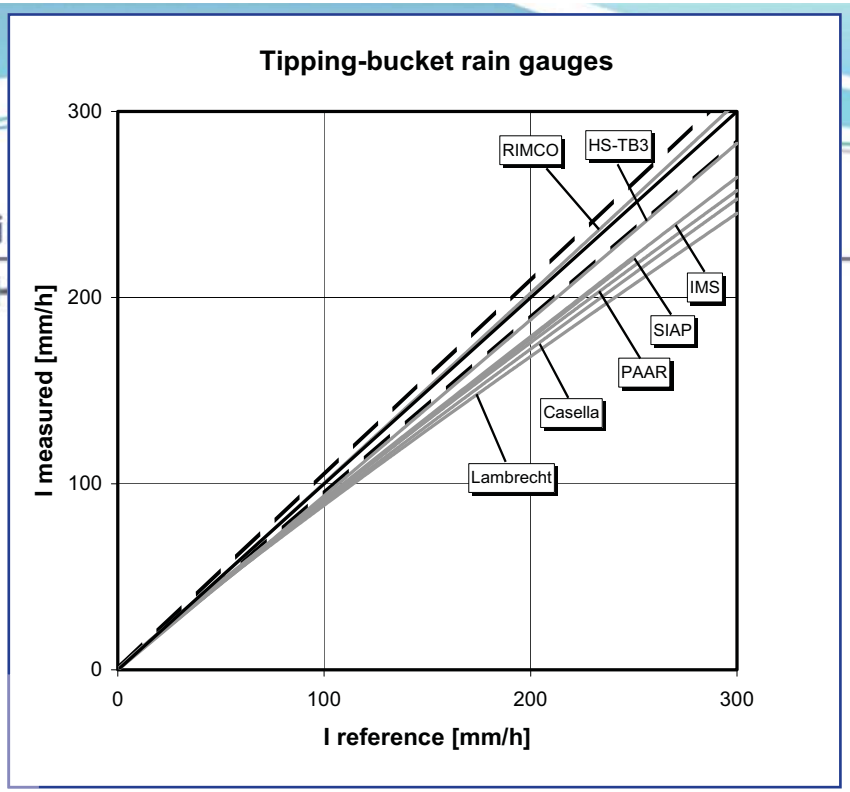
Vigna di Valle (Rome)

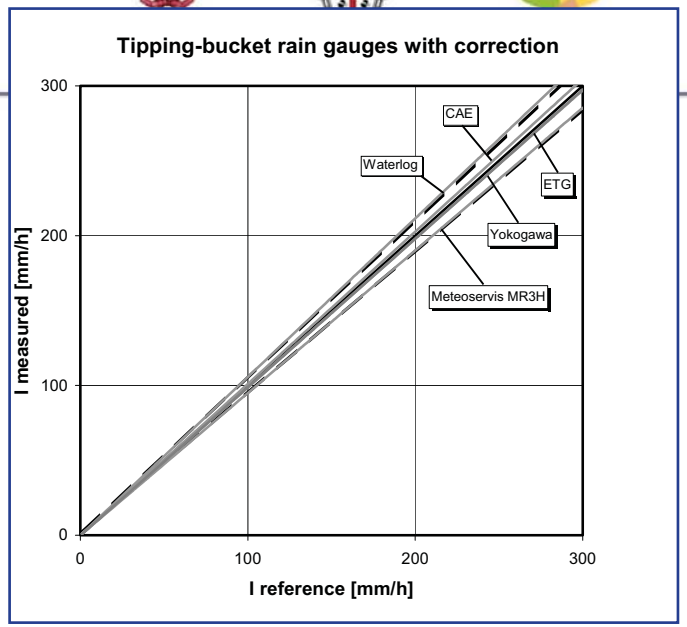
Started in October 2007

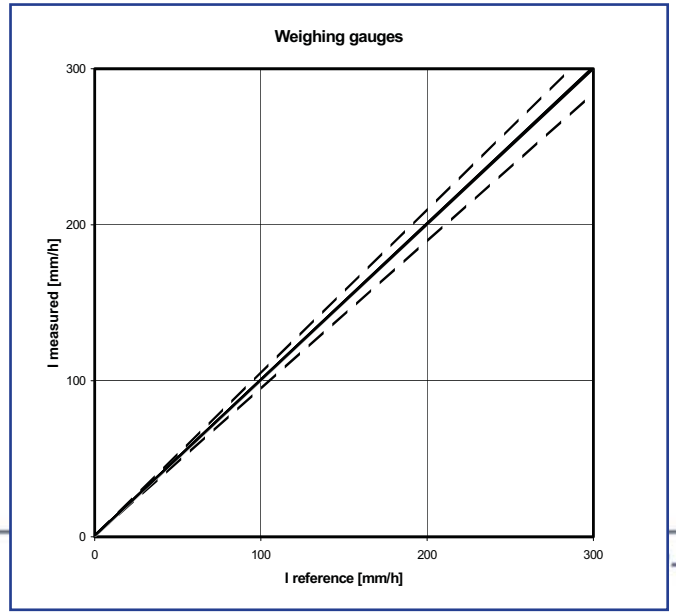
Worki

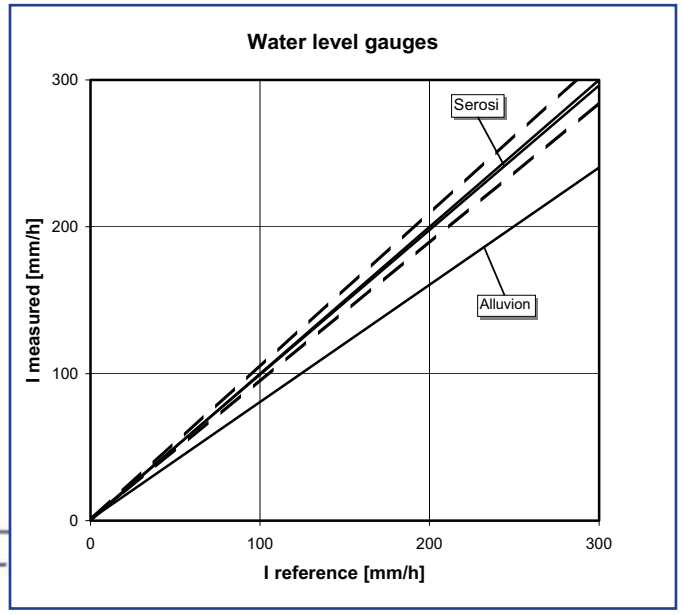
FLASH

Performances of each individual gauge









The WMO Field Intercomparison of RI gauges was started in October 2007 in Vigna di Valle, Rome (Italy). Installation of the instruments in the field was preceded by the laboratory calibration of all submitted catching type rain gauges at the University of Genova. Periodic testing of these gauges by means of dynamic calibration was performed throughout the measurement campaign, using a portable calibration device.

ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale
REGIONE AUTONOMA DELLA SARDEGNA
MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE
R.S.M.A.
WMO

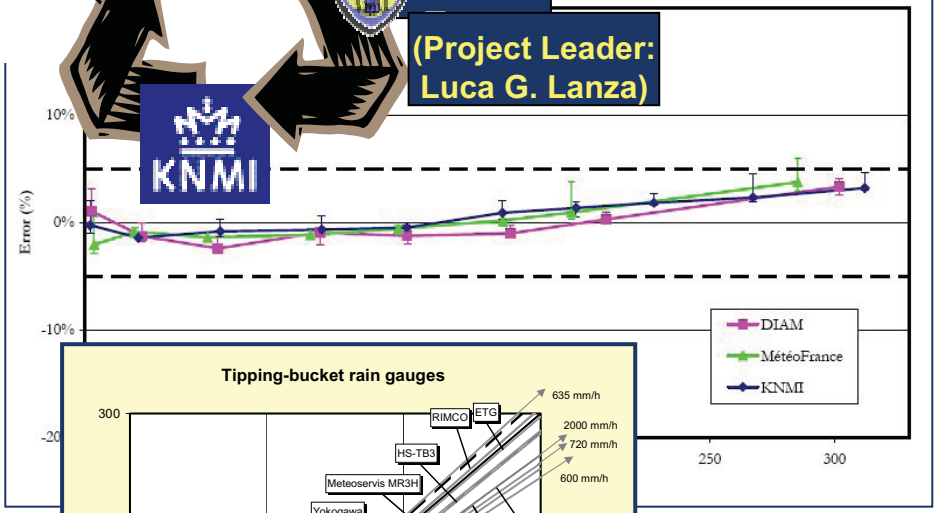
METEO FRANCE
DIAM UNIG
KNMI

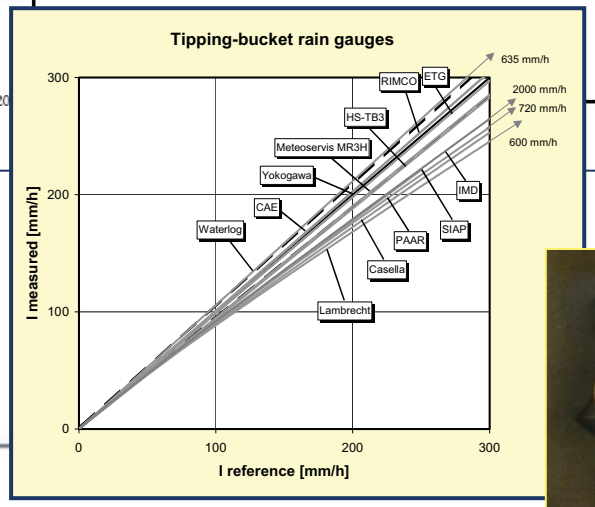
WMO LAB INT 2004-2005

(Project Leader: Luca G. Lanza)

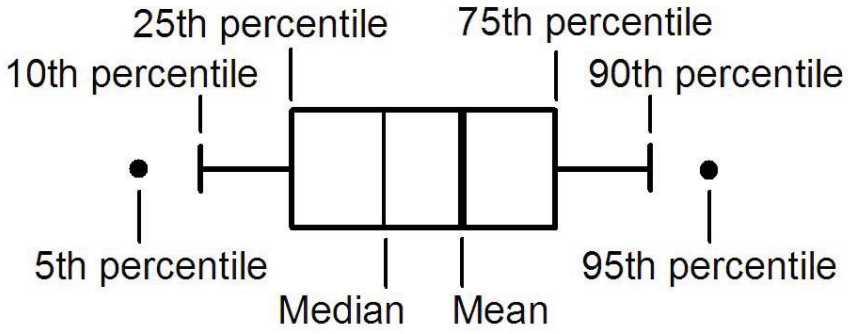
WMO FIELD INT 2007-2009

(Project Leader: E. Lanzinger)

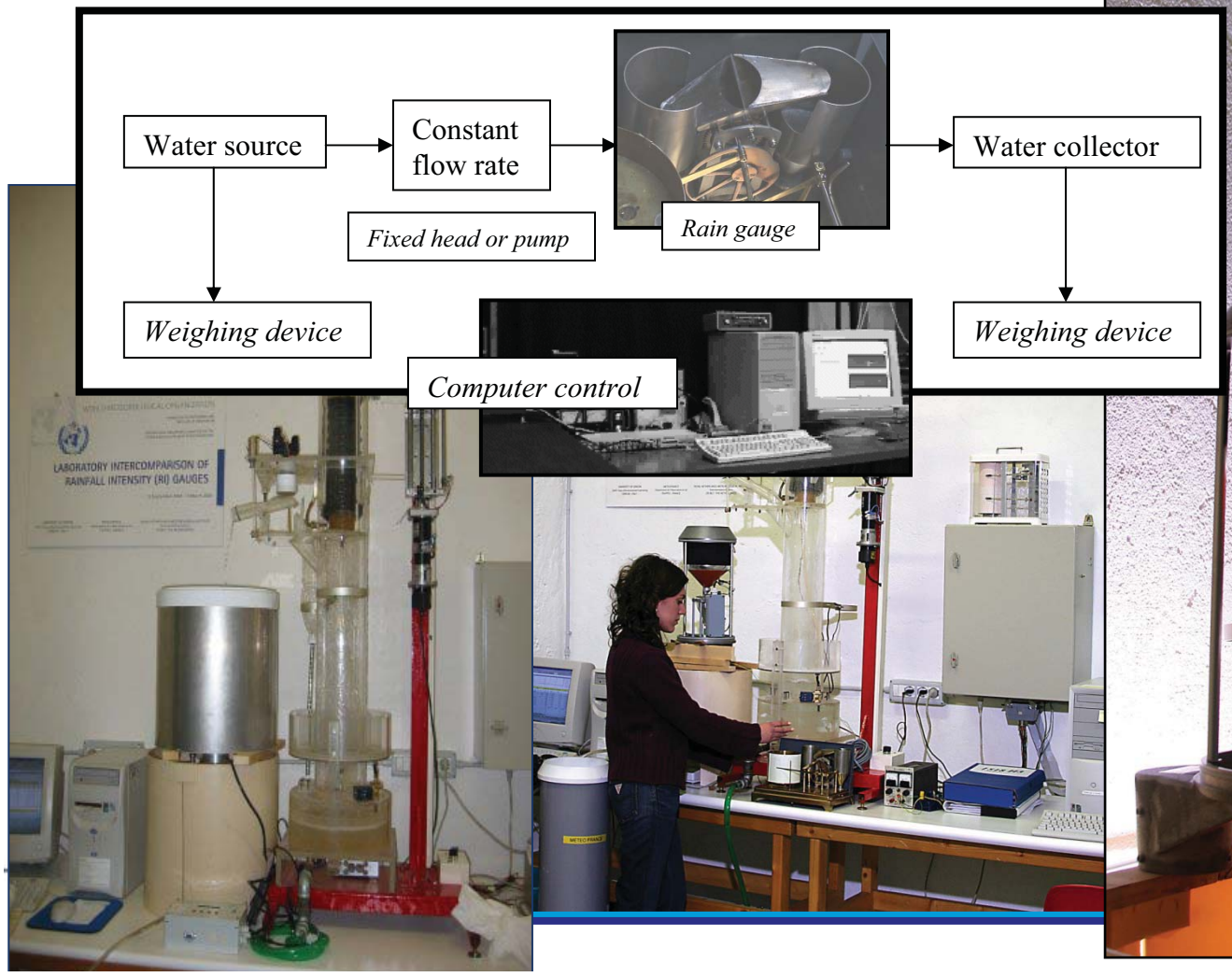


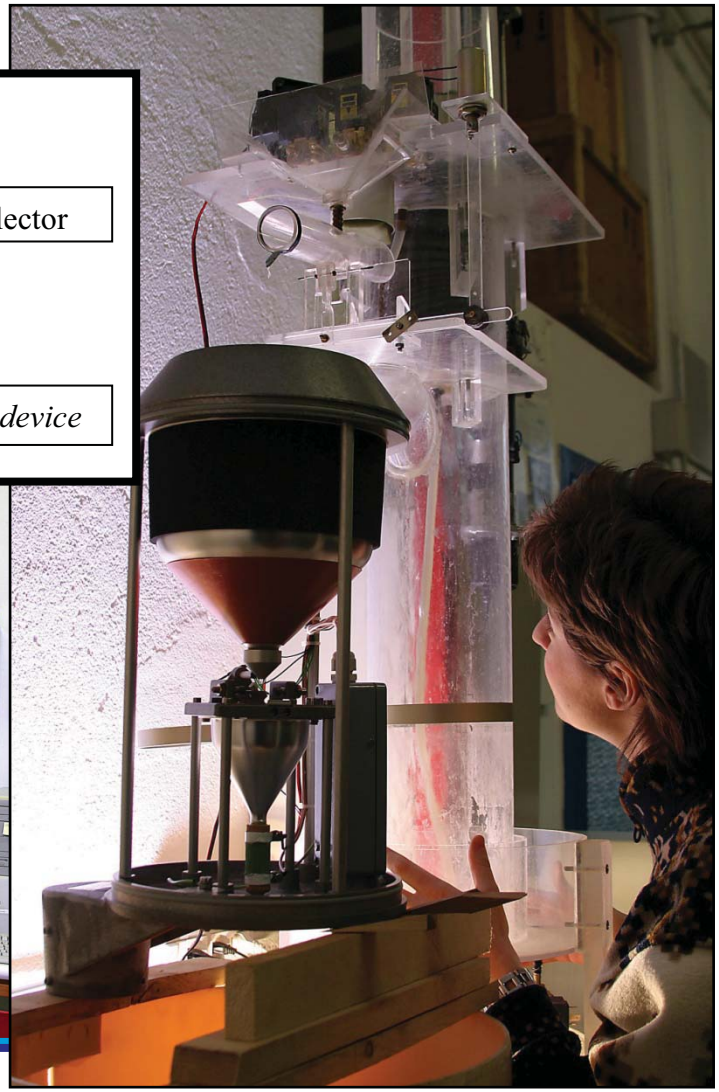


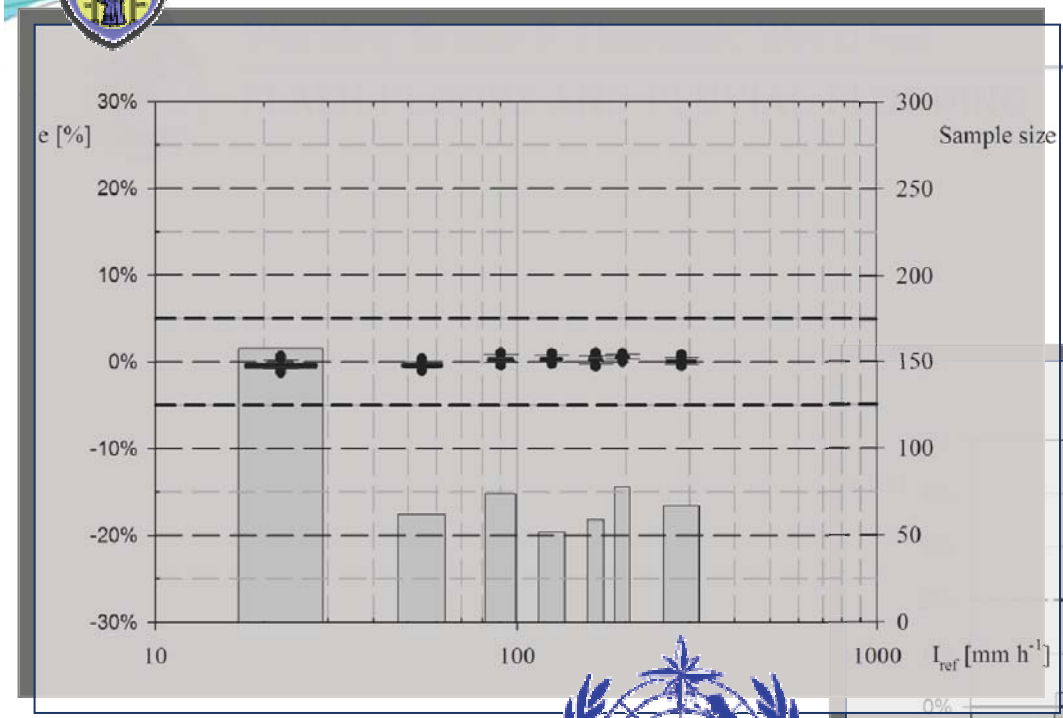
Novel approach:
tests are performed at one-minute resolution. "Instantaneous" RI rather than long term averages.



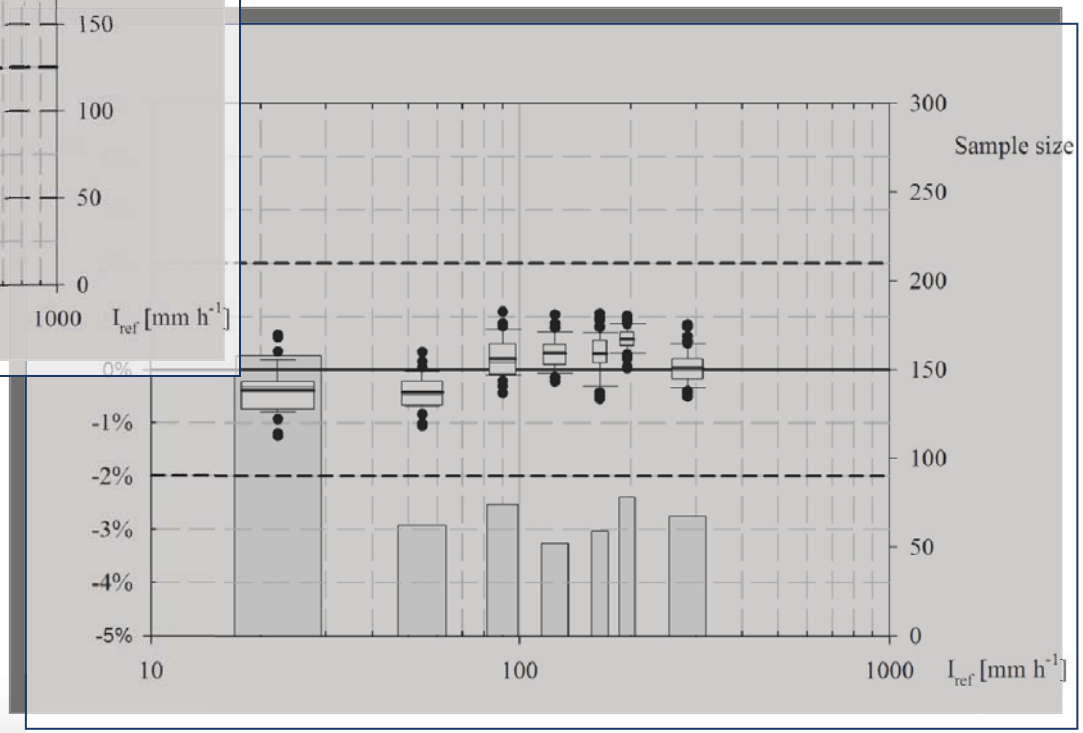
Preliminary tests in the laboratory





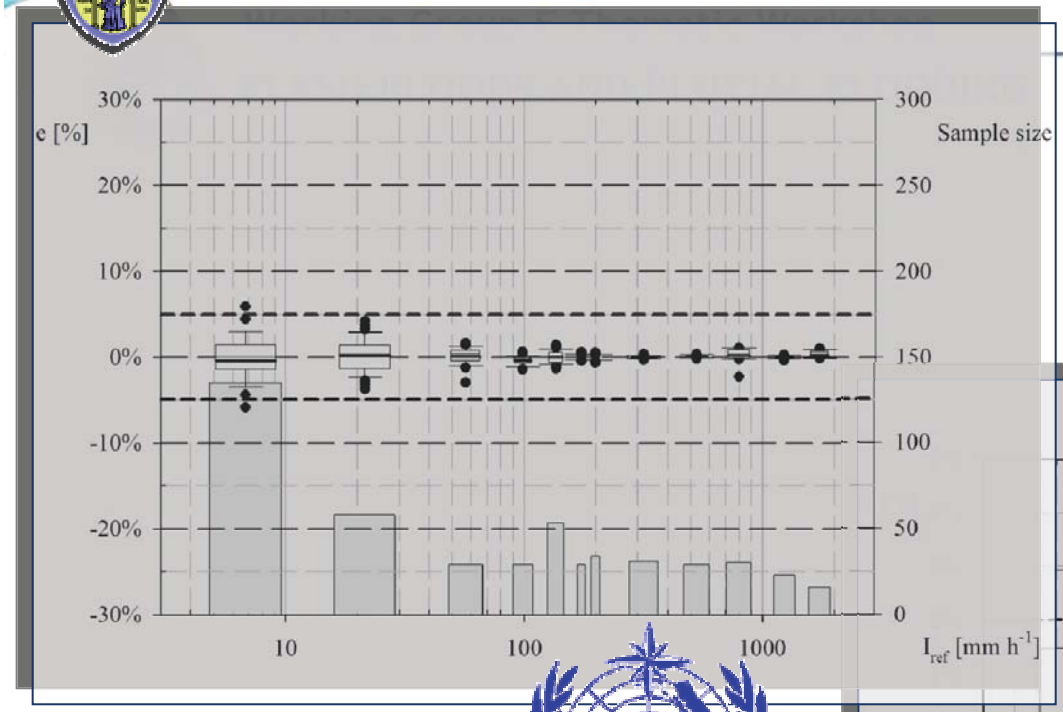


Best performing tipping-bucket rain gauge

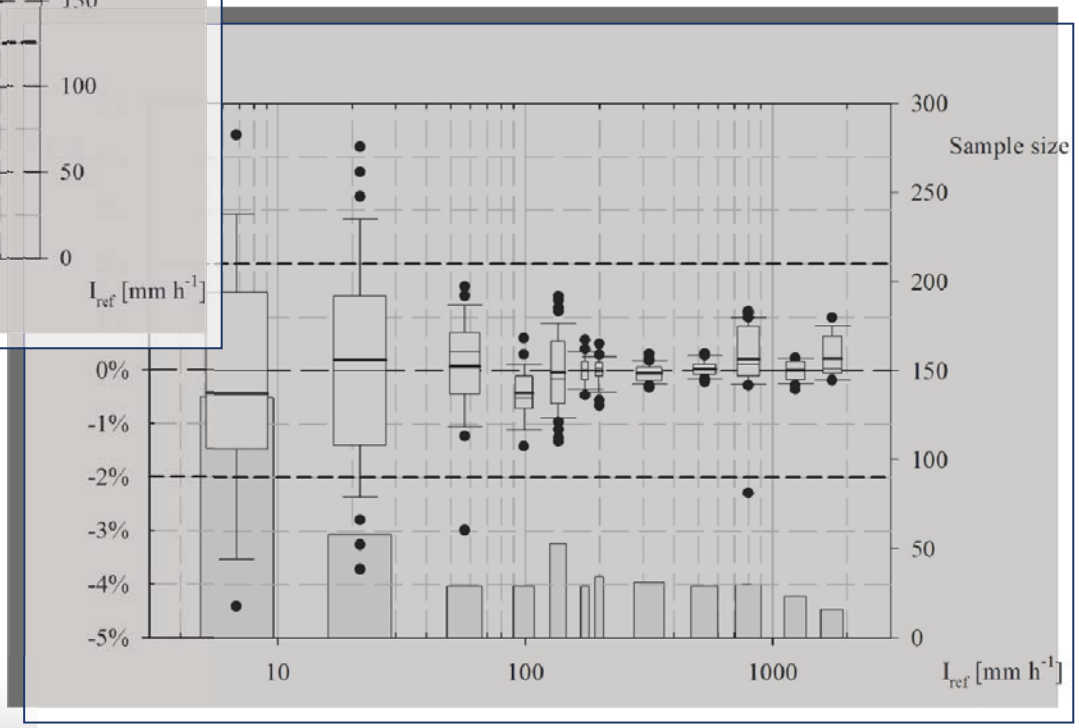


WMO

Box-plots indicate the mean (solid line), median (thin line), 25-75th percentiles (box limits), 10-90th percentiles (whisker caps) and outliers (black circles).

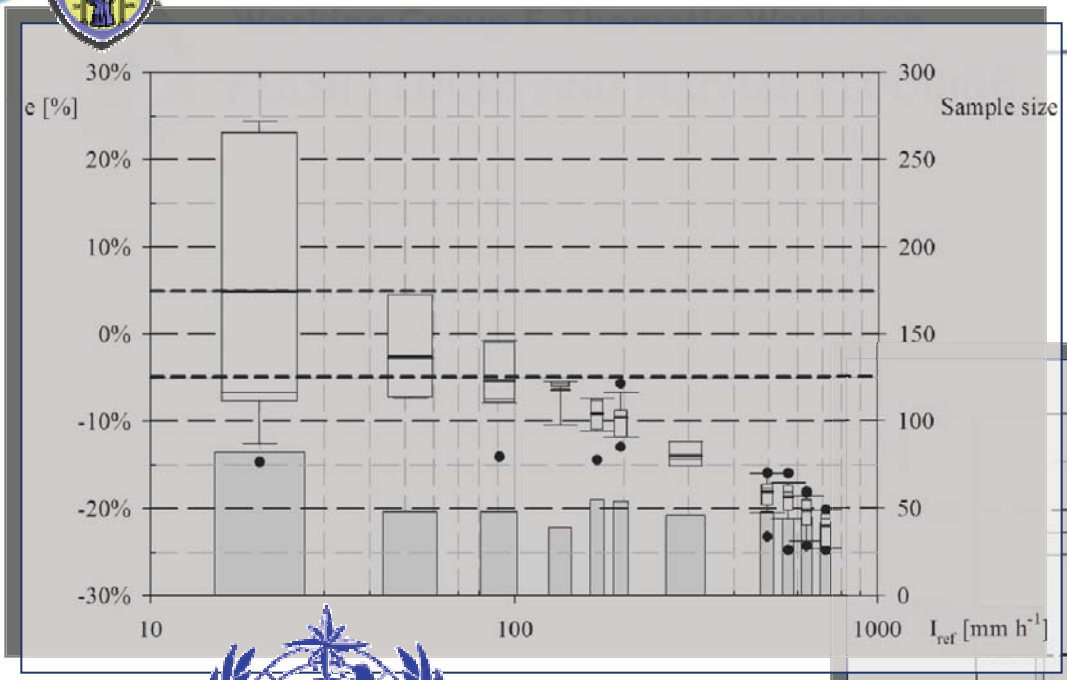


Best performing weighing gauge

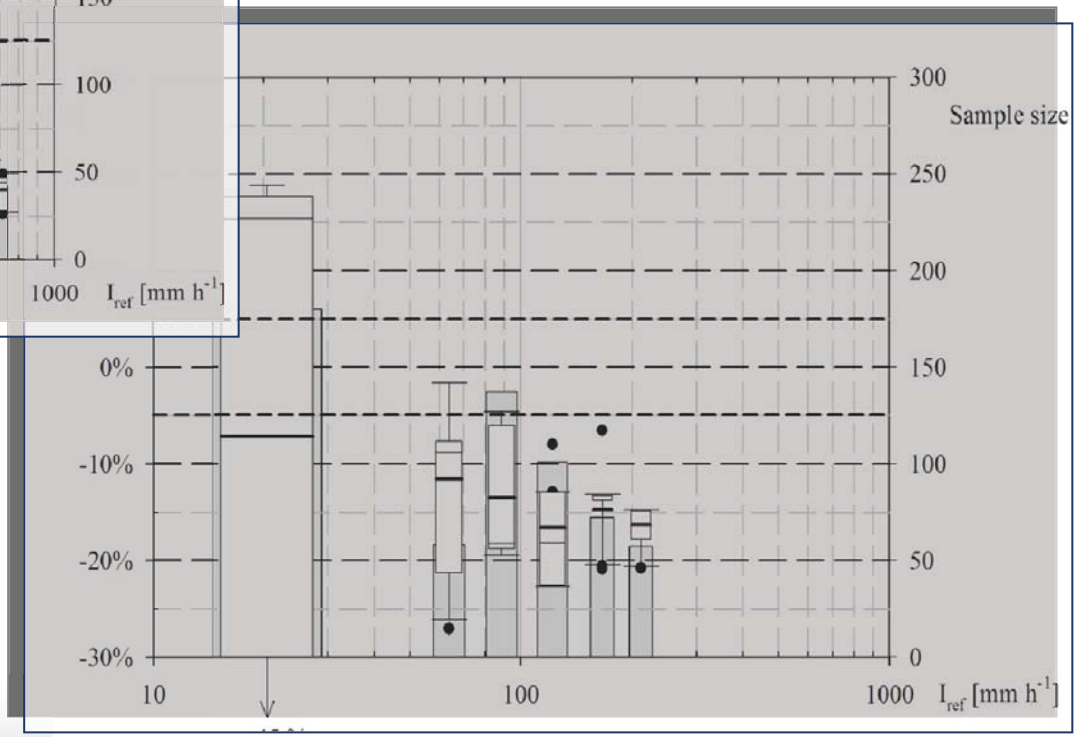


WMO

Box-plots indicate the mean (solid line), median (thin line), 25-75th percentiles (box limits), 10-90th percentiles (whisker caps) and outliers (black circles).



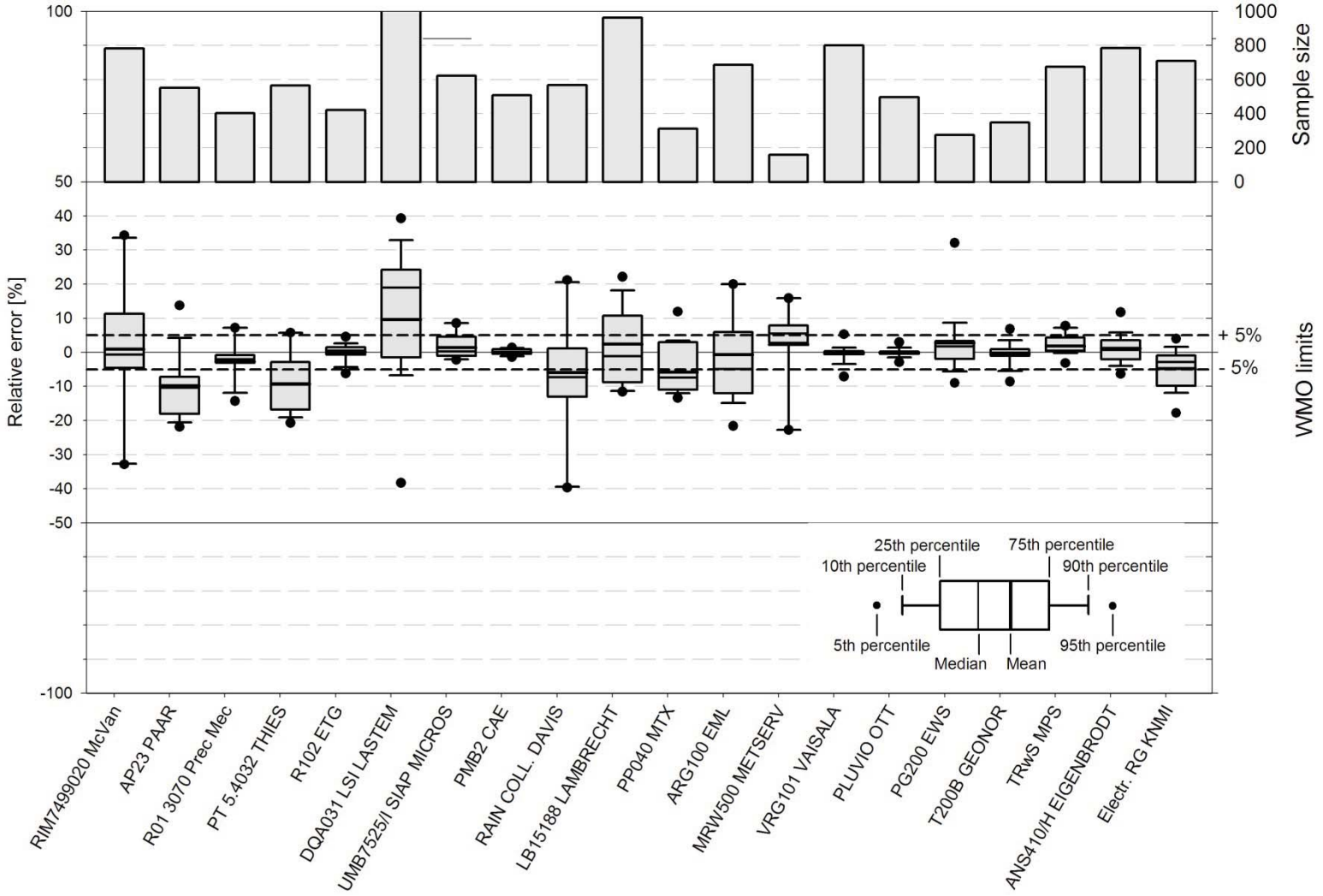
Typical (left) and bad (below) tipping-bucket rain gauges



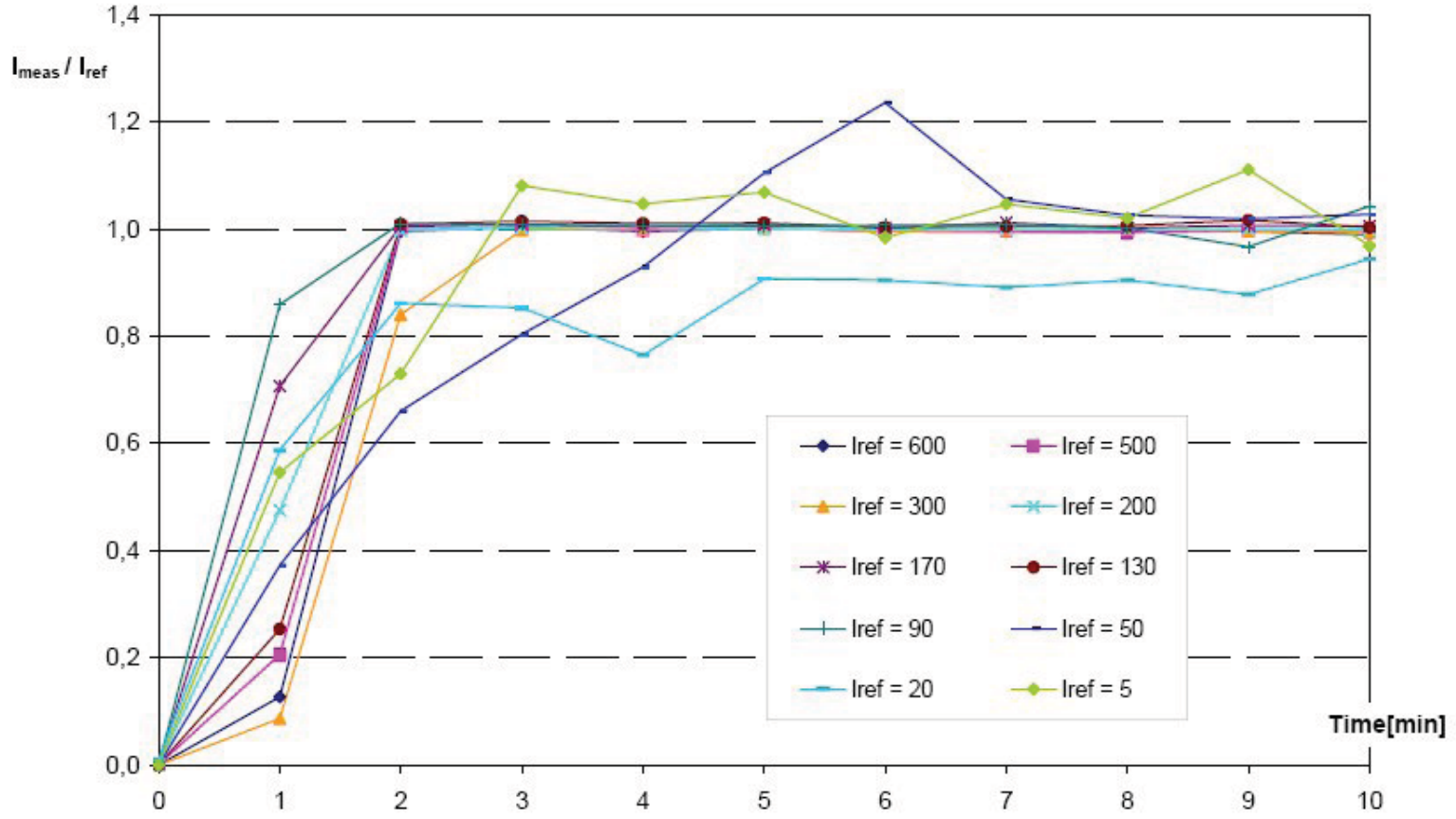
WMO

Box-plots indicate the mean (solid line), median (thin line), 25-75th percentiles (box limits), 10-90th percentiles (whisker caps) and outliers (black circles).

COMPARED LAB PERFORMANCE (CATCHING TYPE)



NORMALIZED STEP RESPONSE



Working Group F Thematic Workshop

FLASH FLOODS AND PLUVIAL FLOODING

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

REGIONE AUTONOMA DELLA SARDEGNA

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

ITALIAN AIR FORCE
METEOROLOGICAL SERVICE

RESMA

University of Genova

WMO

26th-28th May 2010, Cagliari, Italy

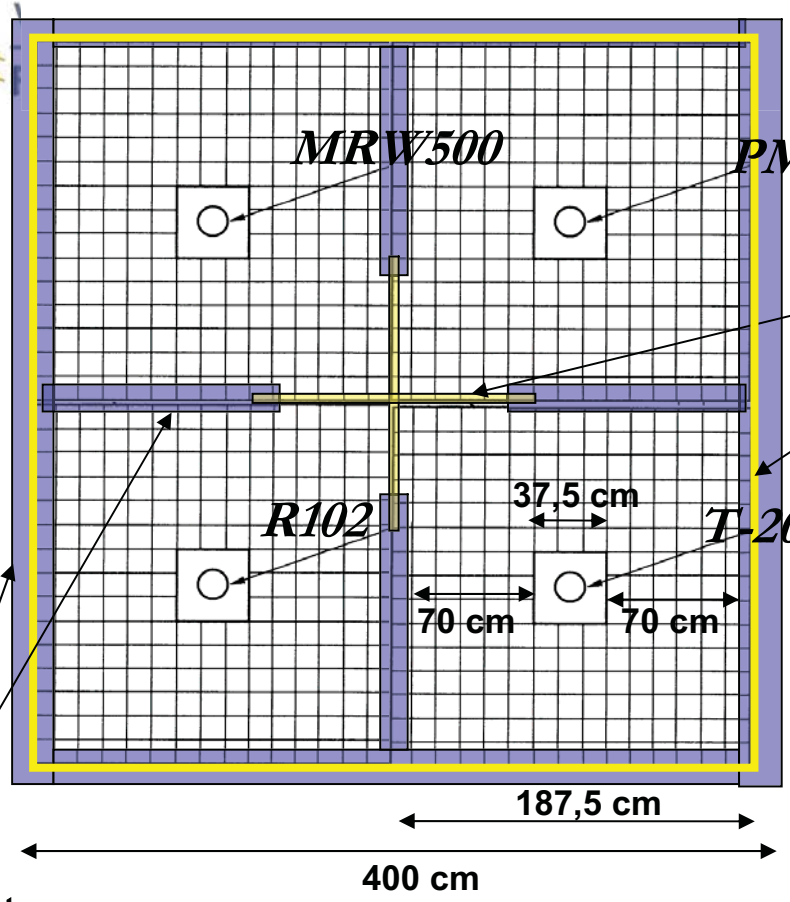
ID	MODEL/MANUFACTURER	TYPOLOGY
1	7499020BoMV2/RIMCO	Tipping bucket
2	AP23/PAAR	Tipping bucket
3	R01 3070/PRECIS-MECANIQUE	Tipping bucket
4	PT 5.4032.35.008/THIES	Tipping bucket
5	R 102 (REFERENCE GAUGE)/ETG	Tipping bucket
6	DQA031/LSI LASTEM	Tipping bucket
7	T-PLUV UM7525/I/SIAP-MICROS	Tipping bucket
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

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

REGIONE AUTONOMA DELLA SARDEGNA

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

WMO REFERENCE RAIN GAUGE
PITS – ITALY - EN13798:2002

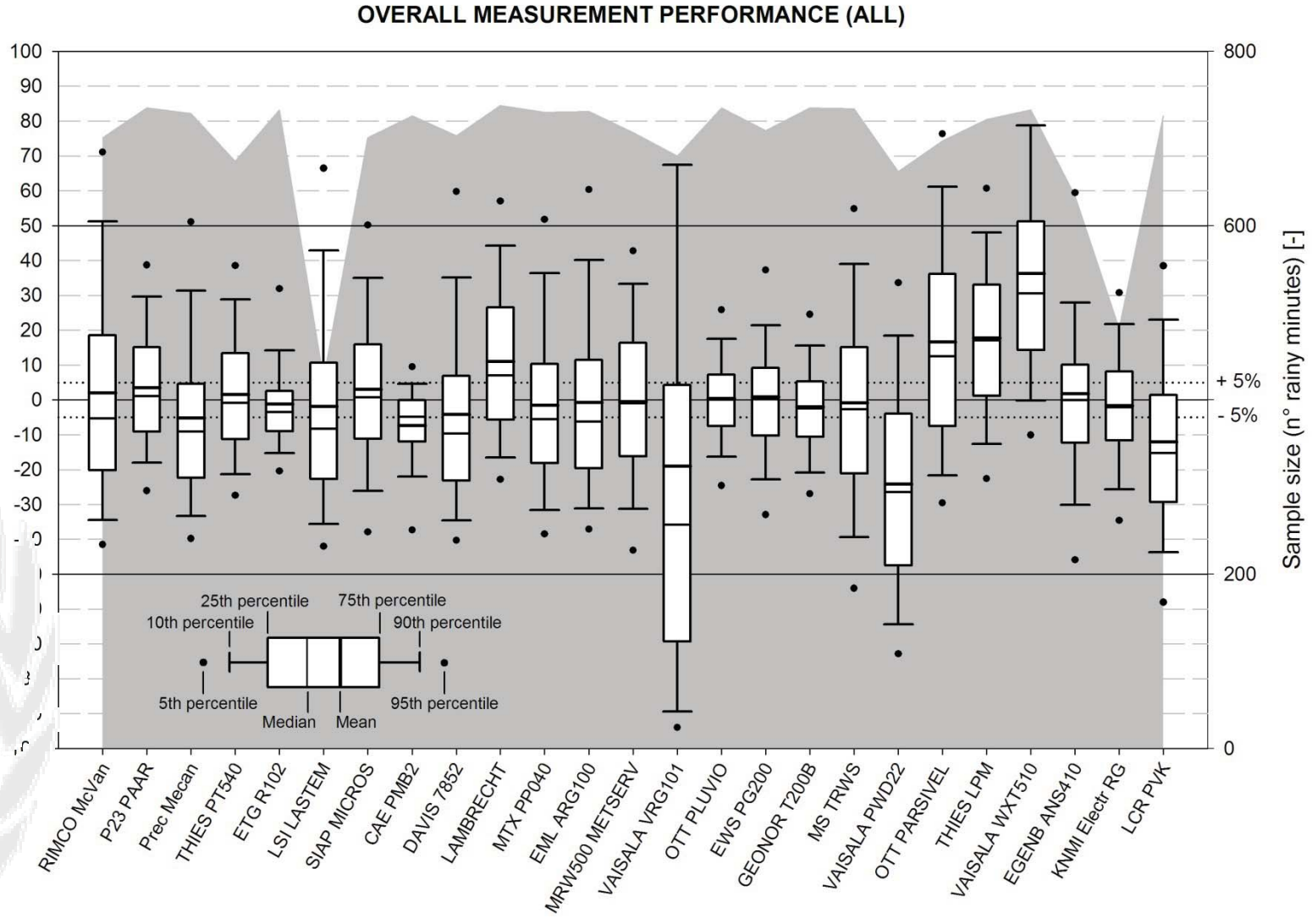


- ✓ A large Pit 1,7 meters deep was built and divided in 4 parts (**4 pits**) for hosting the working reference (4 different instruments).
- ✓ 4 standard galvanized steel gratings **187,5 x 187,5 x 12,0 cm** (LxWxH) will be positioned on pit walls. Spaces: **12,5 x 12,5 cm**. Accuracy: ±5mm; Strips:**3mm**

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

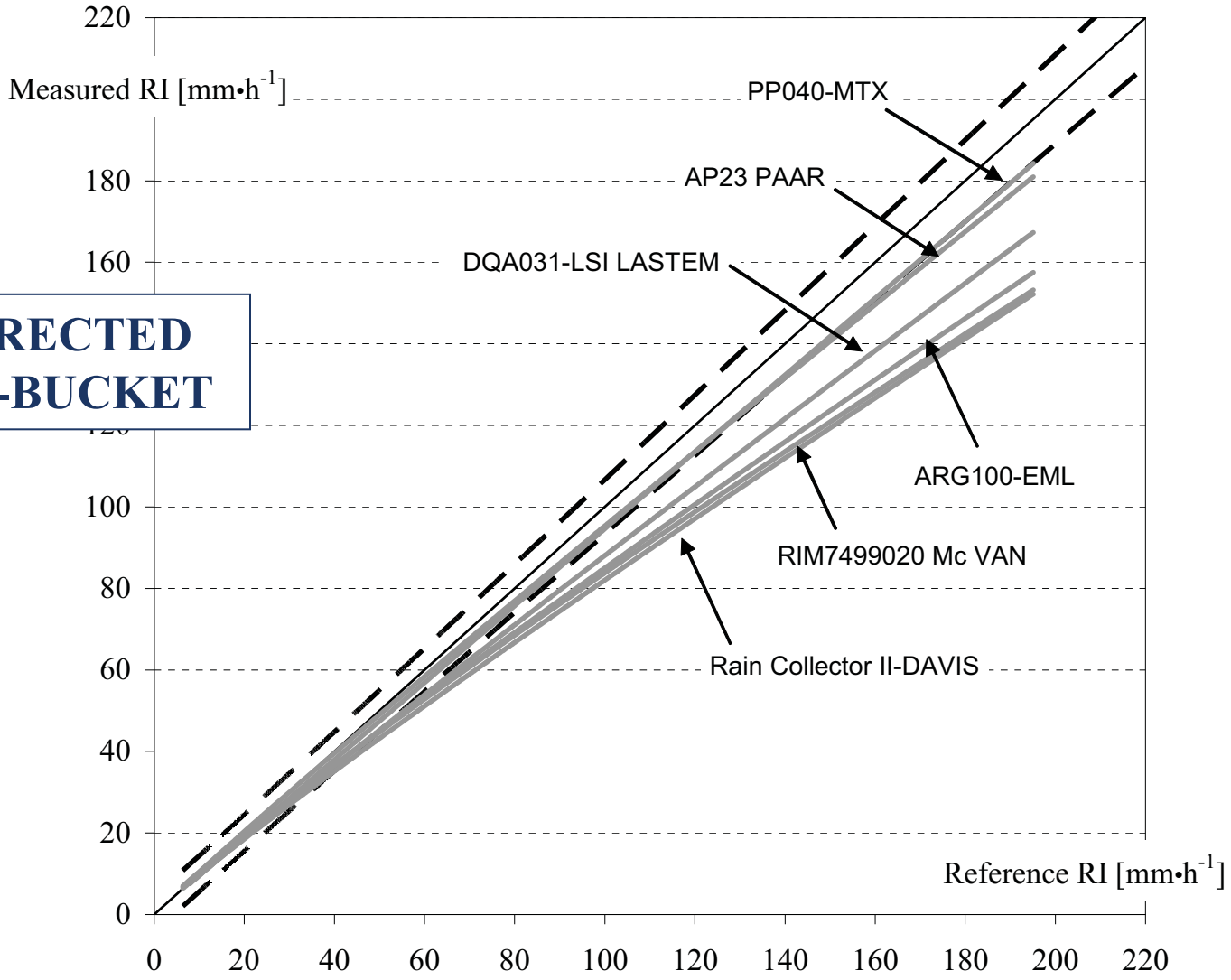
REGIONE AUTONOMA DELLA SARDEGNA

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE



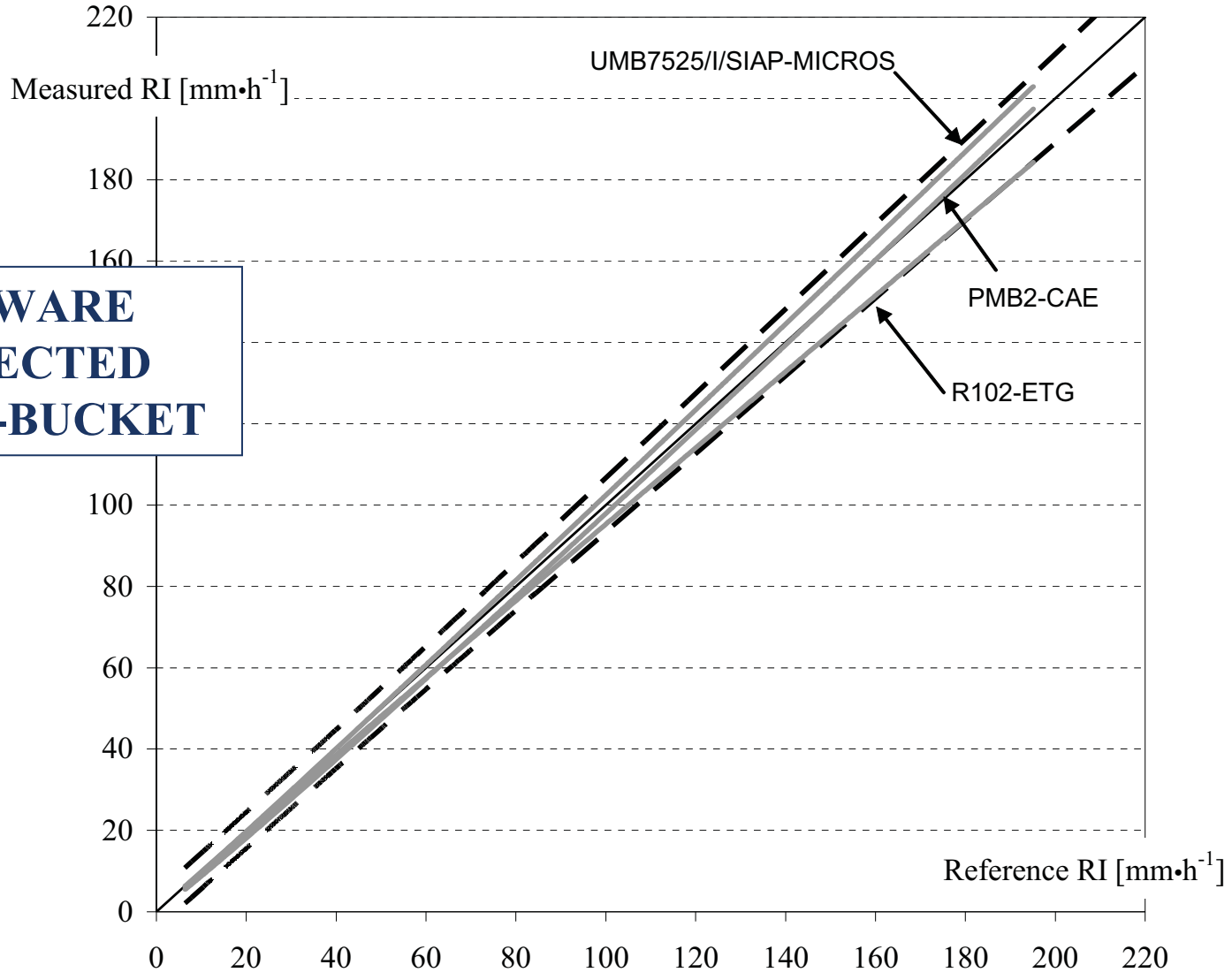
WMO

UNCORRECTED TIPPING-BUCKET



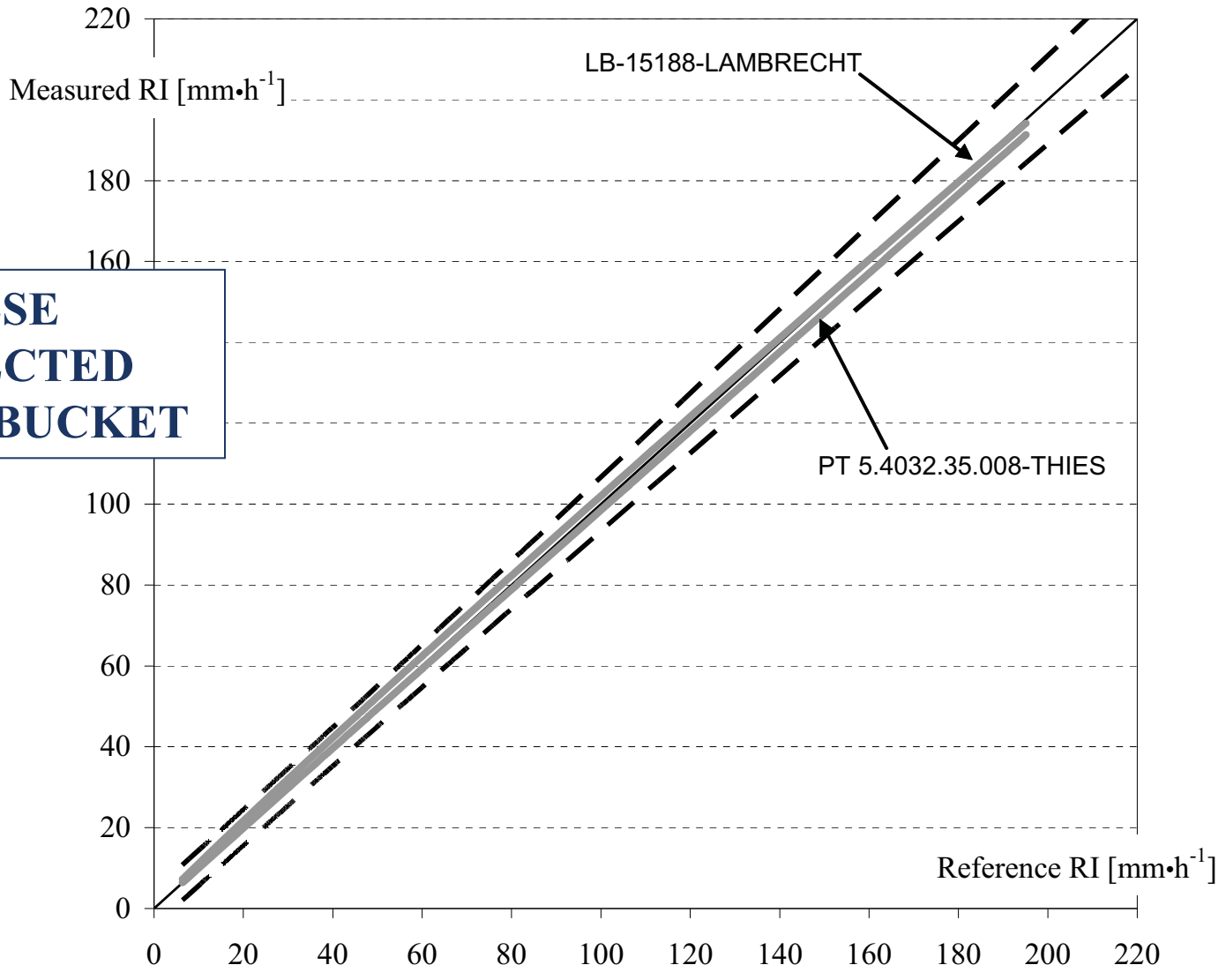
WMO

SOFTWARE CORRECTED TIPPING-BUCKET

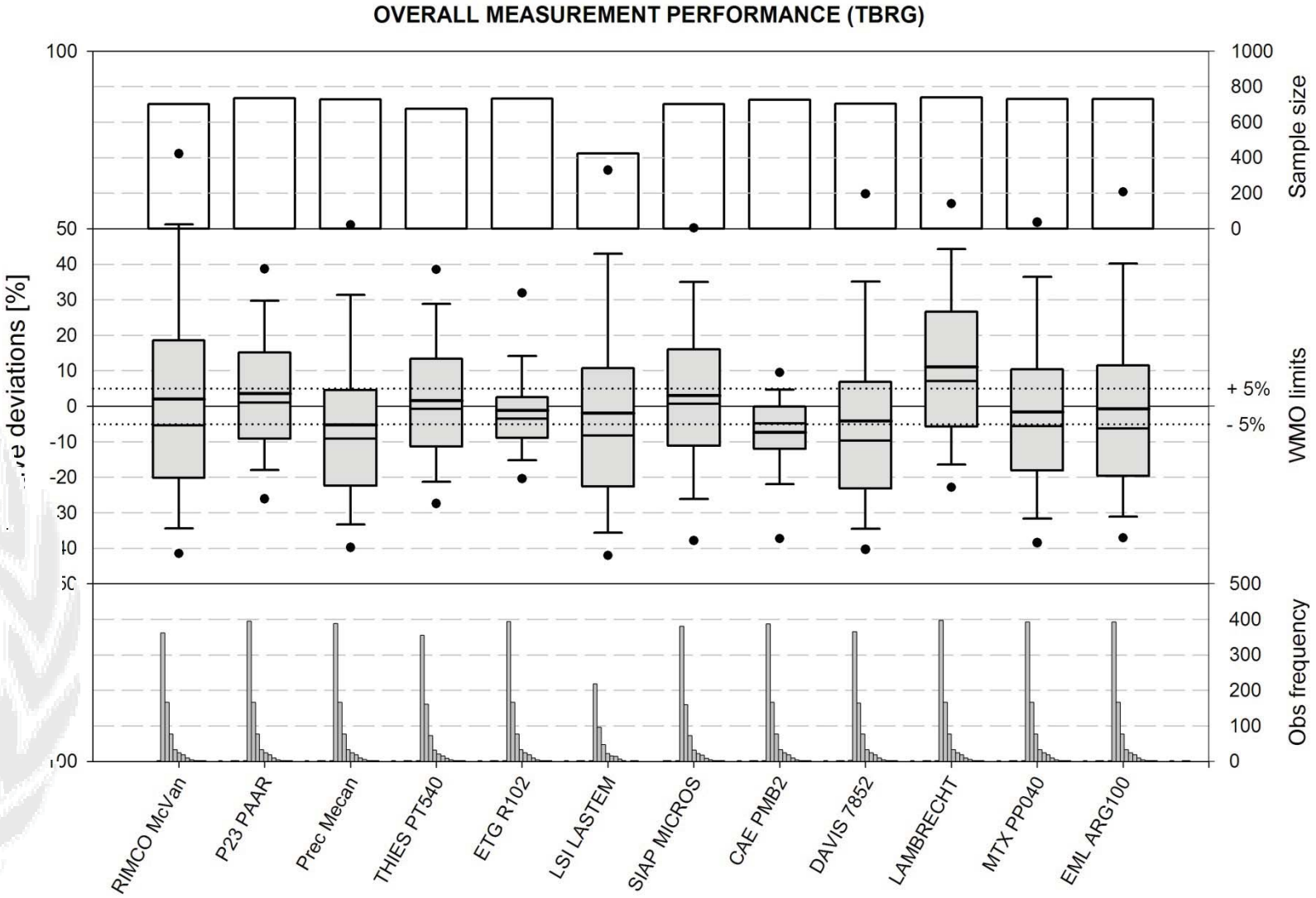


WMO

PULSE CORRECTED TIPPING-BUCKET

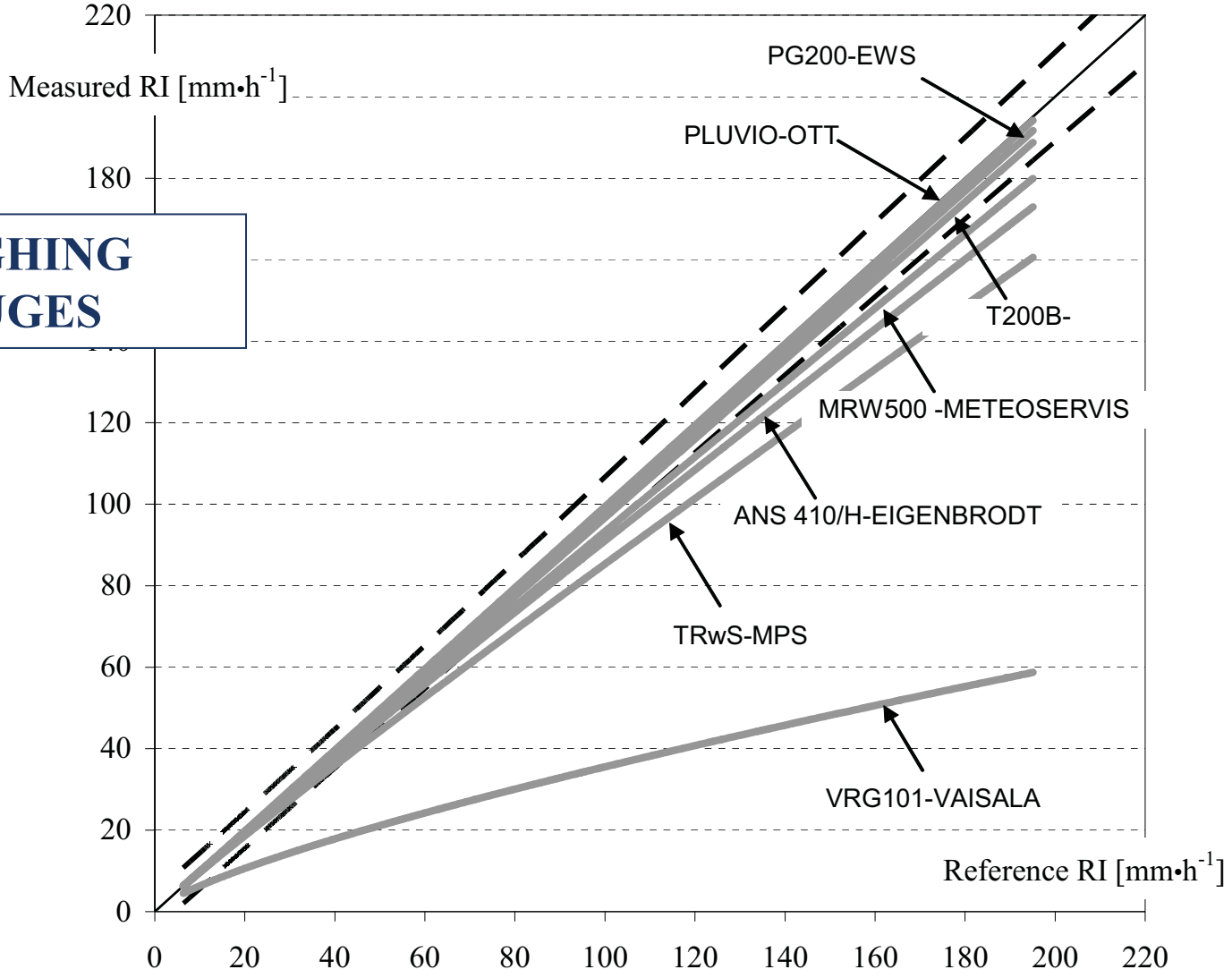


WMO

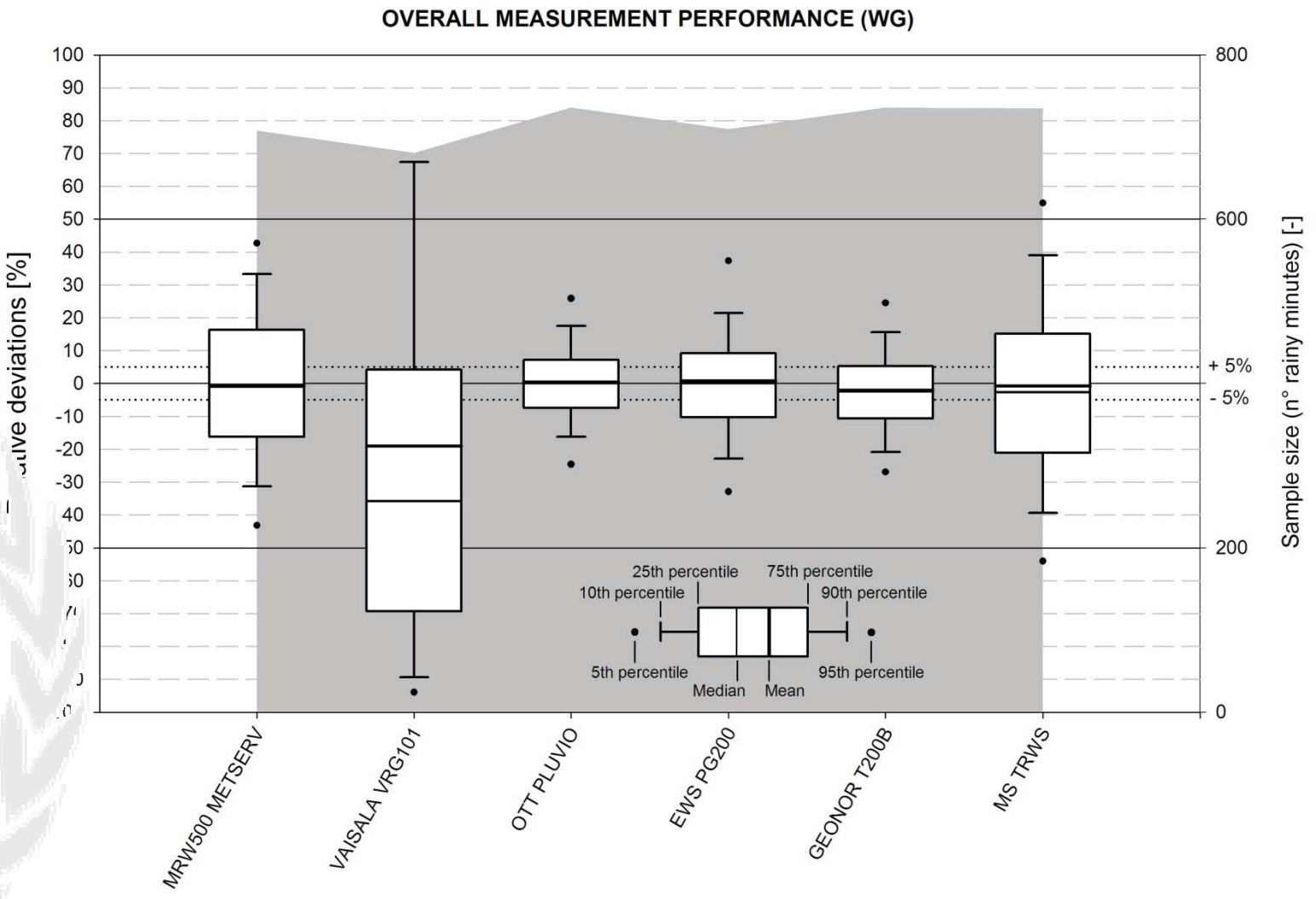

OVERALL MEASUREMENT PERFORMANCE (TBRG)
100
50
40
30
20
10
0
-10
-20
30
40
50
100
1000
800
600
400
200
0
Sample size
+ 5%
- 5%
WMO limits
500
400
300
200
100
0
Obs frequency
RIMCO McVan
P23 PAAR
Prec Mecan
THIES PT540
ETG R102
LSI LASTEM
SIAP MICROS
CAE PMB2
DAVIS 7852
LAMBRECHT
MTX PP040
EML ARG100

WMO

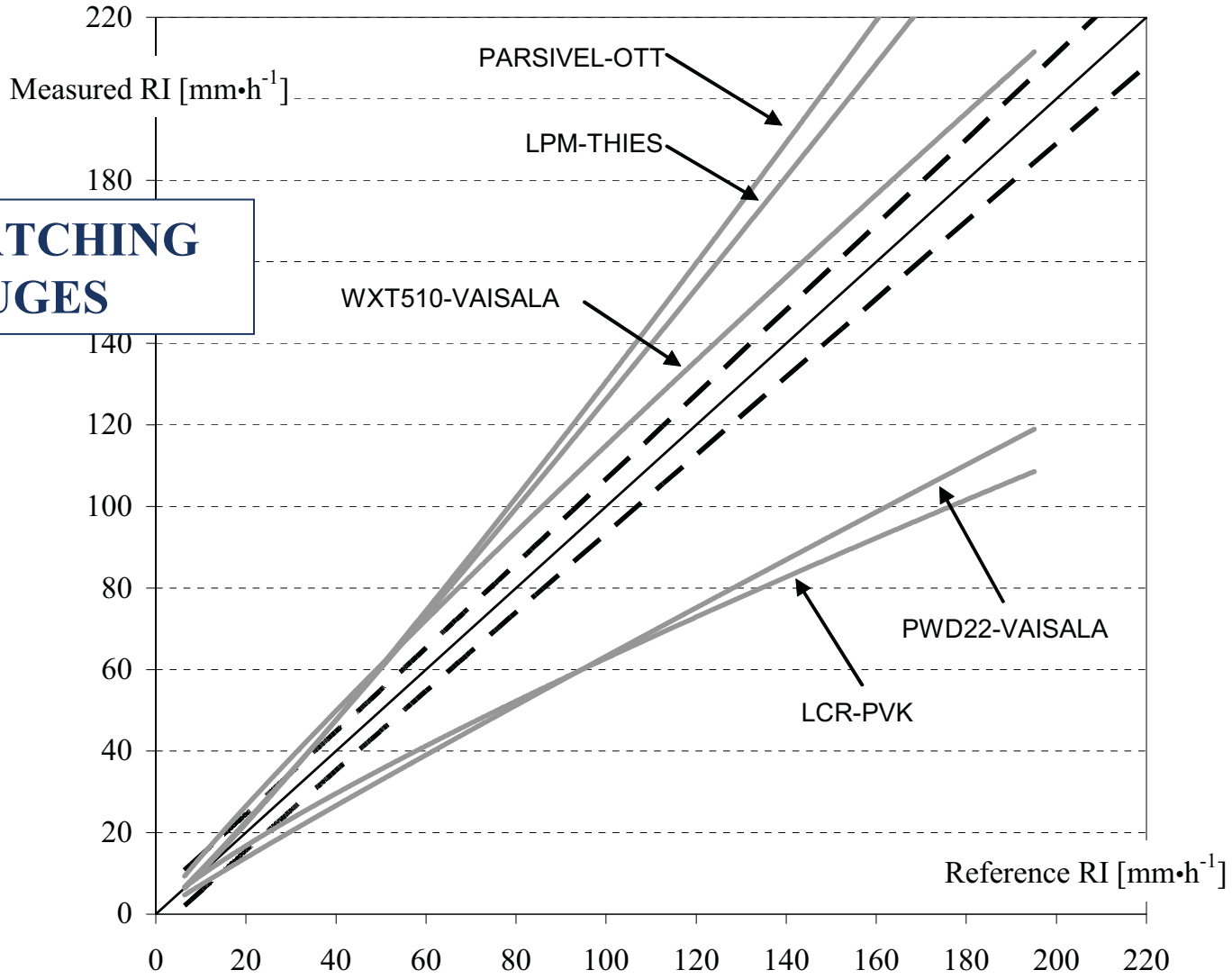
WEIGHING GAUGES



WMO


OVERALL MEASUREMENT PERFORMANCE (WG)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
800
600
200
0
+ 5%
- 5%
Sample size (n° rainy minutes) [-]
25th percentile
75th percentile
10th percentile
90th percentile
5th percentile
95th percentile
Median
Mean
MRW500 METSERV
VAISALA VRG101
OTT PLUVIO
EWS PG200
GEONOR T200B
MS TRWS

NON CATCHING GAUGES



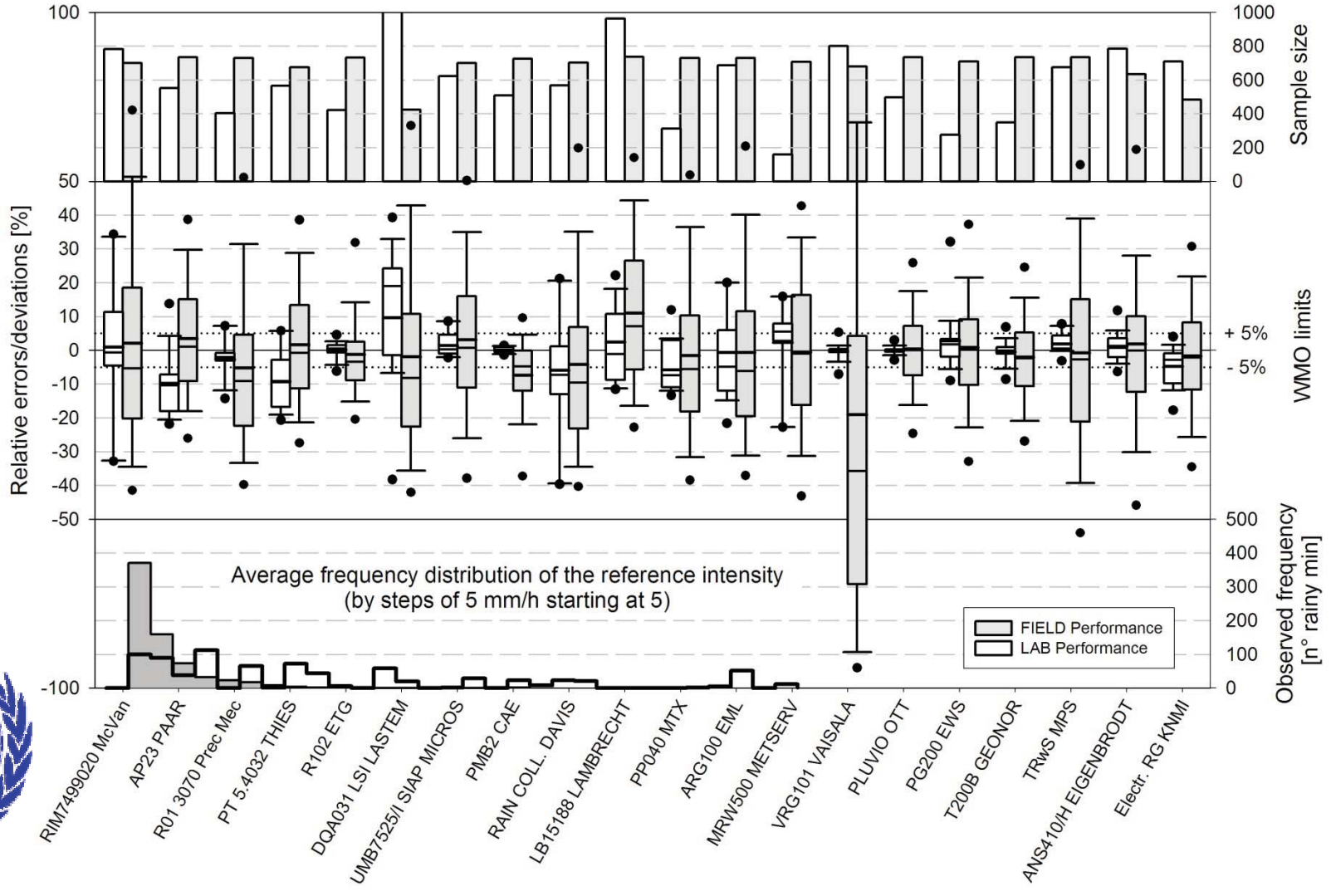
WMO

ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale

REGIONE AUTONOMA DELLA SARDEGNA

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

COMPARED LAB AND FIELD PERFORMANCE (CATCHING TYPE GAUGES)



WMO

WORLD METEOROLOGICAL ORGANIZATION

INSTRUMENTS AND OBSERVING METHODS
REPORT No. 99

WMO FIELD INTERCOMPARISON OF RAINFALL INTENSITY GAUGES

(Vigna die Valle, Italy)
October 2007 - April 2009

E. Vuerich (Italy)
C. Monesi (Italy)
L.G. Lanza (Italy)
L. Stagi (Italy)
E. Lanzinger (Germany)

WMO/TD-No. 1504
2009

#5,27-R 102 - ETG

R 102-ETG
- Italy -

Technical Specifications

- Provided by the manufacturer -

- Physical principle: Tipping bucket with correction algorithm
- Collector area: 1000 cm^2
- Range of measurement : 0-300 mm/h
- 1-minute resolution: 0.6 mm/h.

Data output

- Output: data message by serial interface RS485 in ASCII protocol - Automatic mode (every minute). (*Software: MicroRec_OS ver 2.00*)
- Data update cycle : 1 min
- Rainfall parameters: 1 min RI [mm/h], corrected rainfall accumulation RA [mm].
- Transfer function for 1-min RI: none.

#5 - R 102 -ETG in the field
(s/n 1011)

#27 R 102- ETG
Reference Pit Gauge
(s/n 1010)

WORLD METEOROLOGICAL ORGANIZATION

INSTRUMENTS AND OBSERVING METHODS
REPORT No. 99

WMO FIELD INTERCOMPARISON OF RAINFALL INTENSITY GAUGES

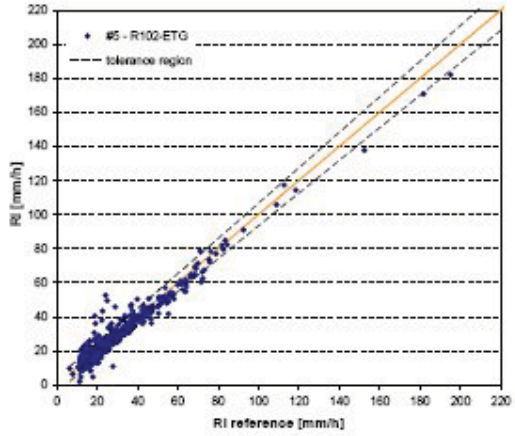
(Vigna die Valle, Italy)
October 2007 - April 2009

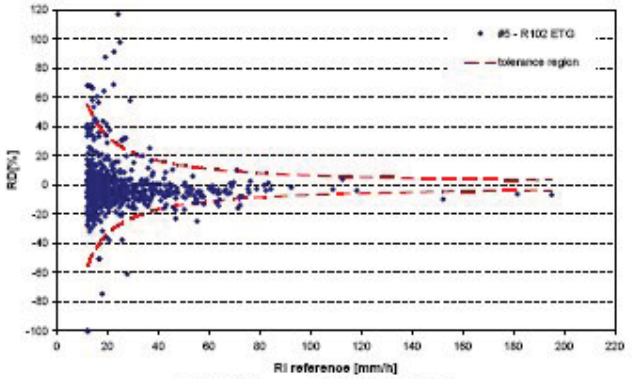
E. Vuerich (Italy)
C. Monesi (Italy)
L.G. Lanza (Italy)
L. Stagi (Italy)
E. Lanzinger (Germany)

WMO/TD-No. 1504
2009

Field Intercomparison Measurements

RI scatter plot (above) and **RD scatter plot** (below) display the results of the comparison of 1-min rainfall intensity measured by R 102-ETG and reference intensity. The uncertainty lines are calculated according to the procedure described in *Final Report, sec. 5.3.2-5-3-3.*





(Relative difference: RD=100(RI-RI$_{ref}$)/RI$_{ref}$).

WORLD METEOROLOGICAL ORGANIZATION

INSTRUMENTS AND OBSERVING METHODS
REPORT No. 99

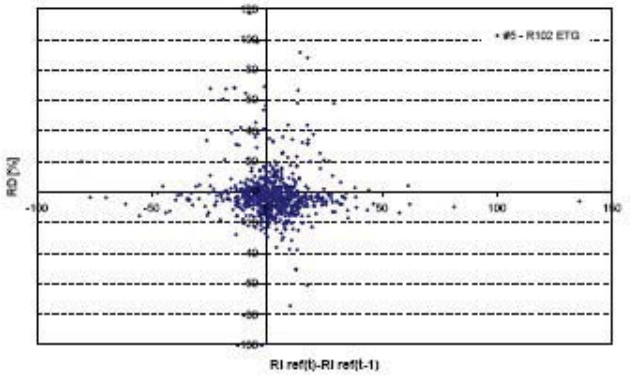
WMO FIELD INTERCOMPARISON OF RAINFALL INTENSITY GAUGES

(Vigna die Valle, Italy)
October 2007 - April 2009

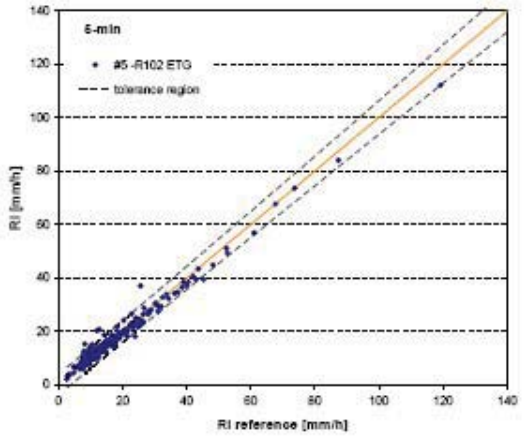
E. Vuerich (Italy)
C. Monesi (Italy)
L.G. Lanza (Italy)
L. Stagi (Italy)
E. Lanzinger (Germany)

WMO/TD-No. 1504
2009

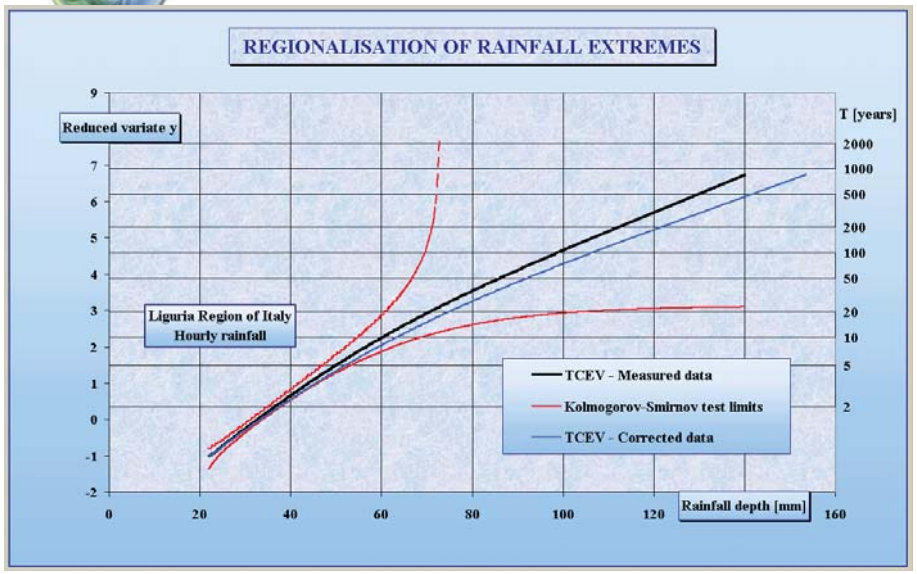
RI variation response plot: Comparison between relative difference (RD) and the time variation of RI reference ($RI_{ref}(t)$- $RI_{ref}(t-1)$)

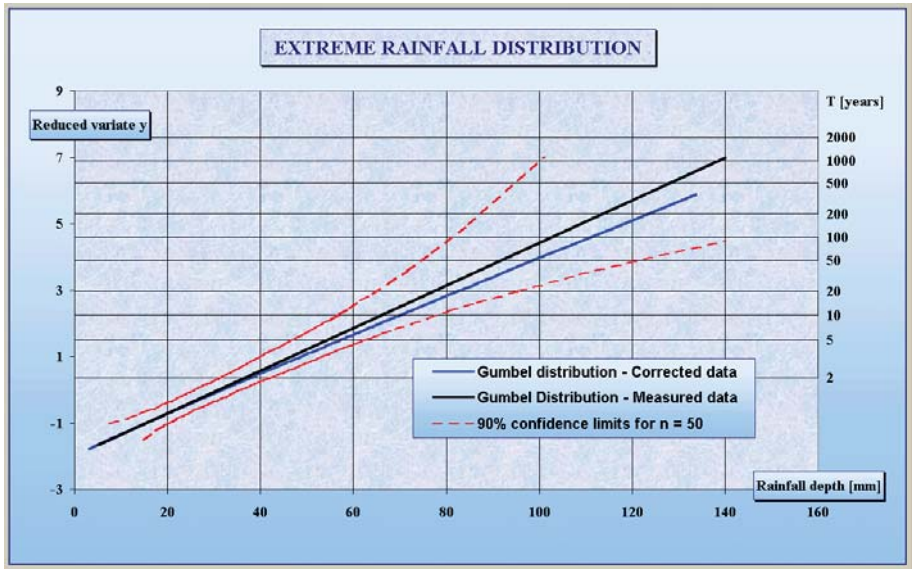


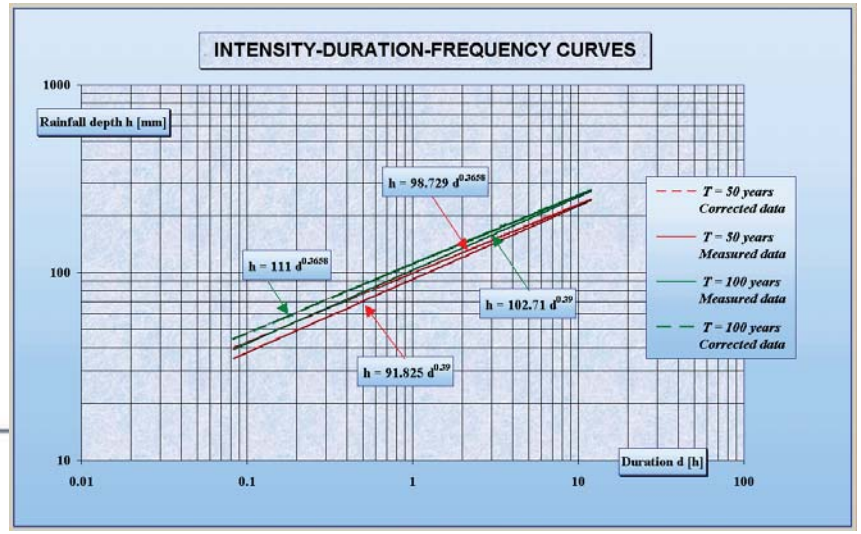
5min RI scatter plot: Comparison between 5-min averages of rainfall intensity measured by R 102-ETG and reference intensity. The uncertainty lines are calculated according to the procedure described in *Final Report*, sec. 5.3.2-5-3-3.



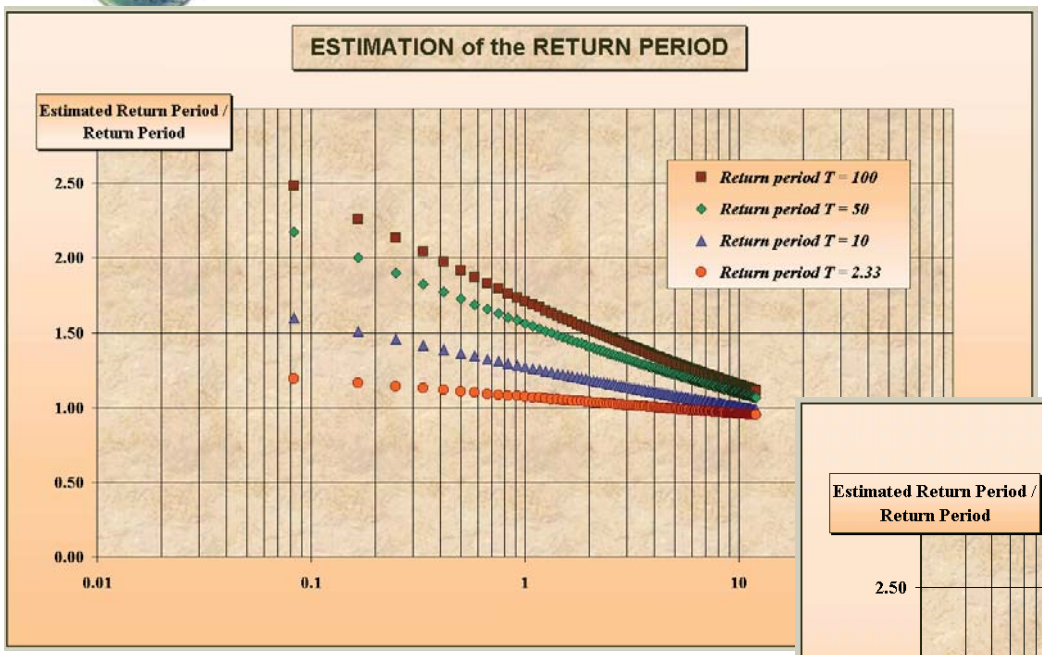
FLASH FLOODS AND PLUVIAL FLOODING

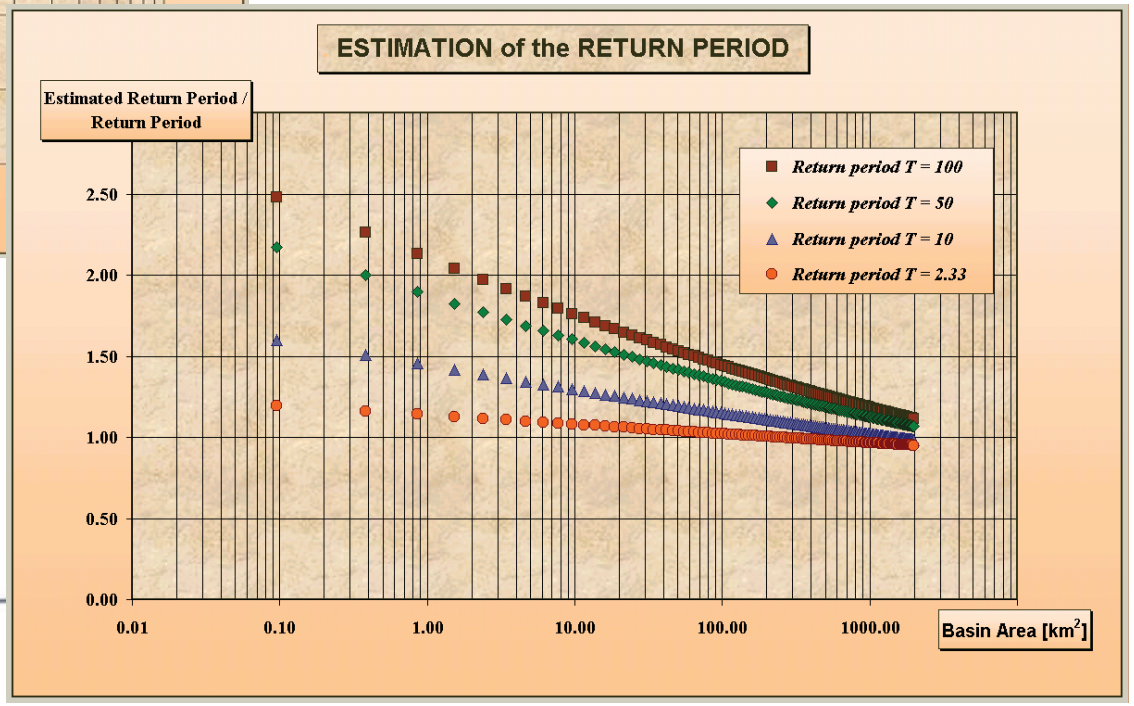




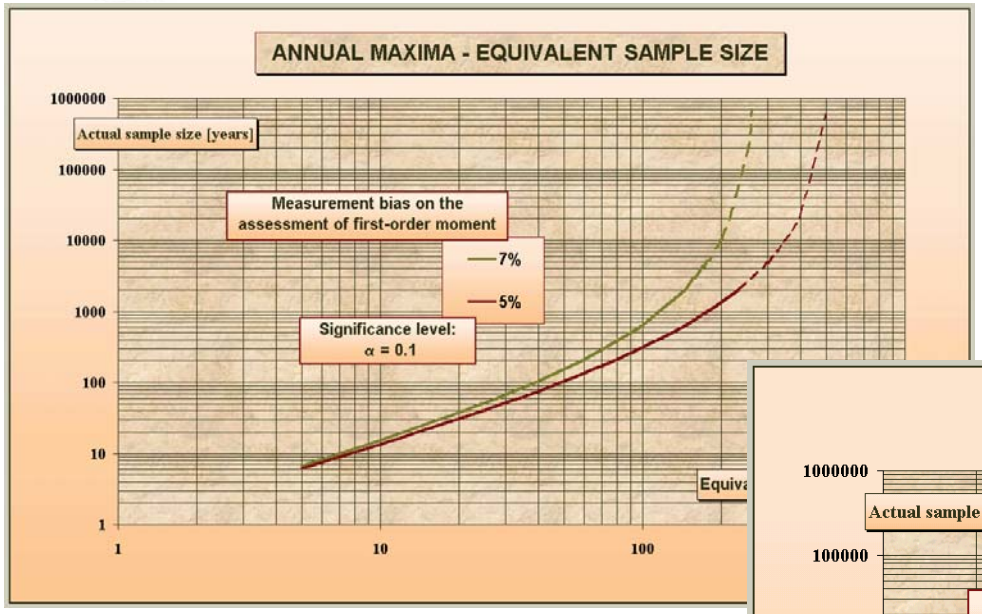


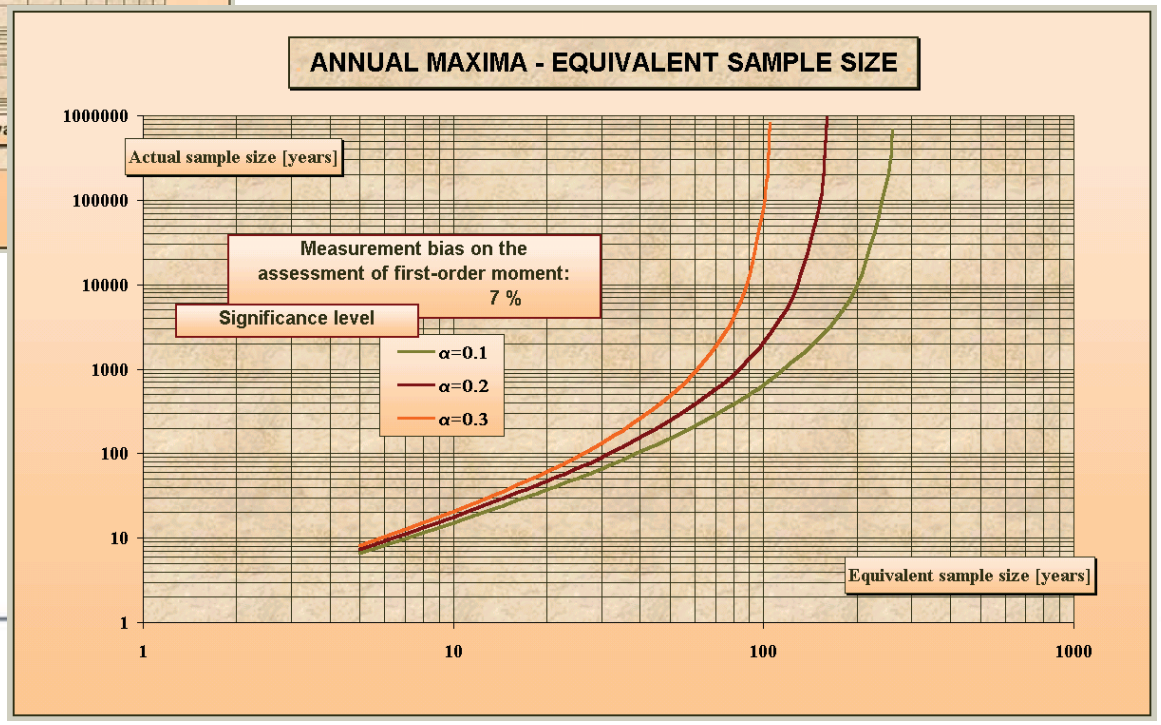
FLASH FLOODS AND PLUVIAL FLOODING

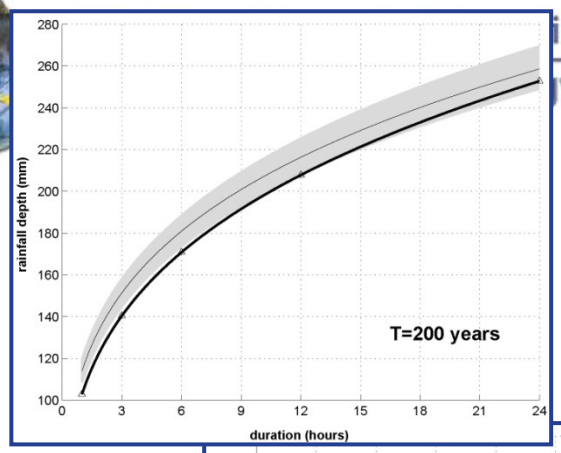


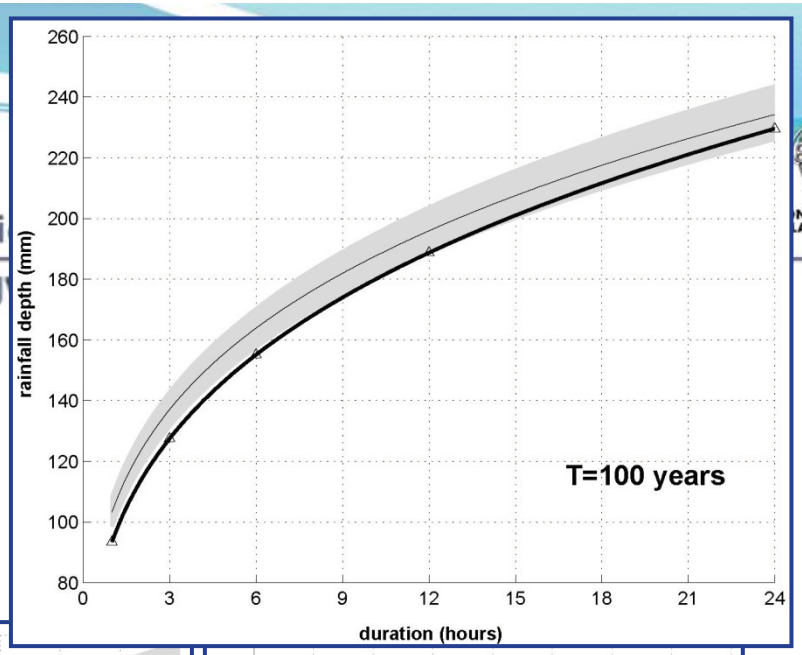


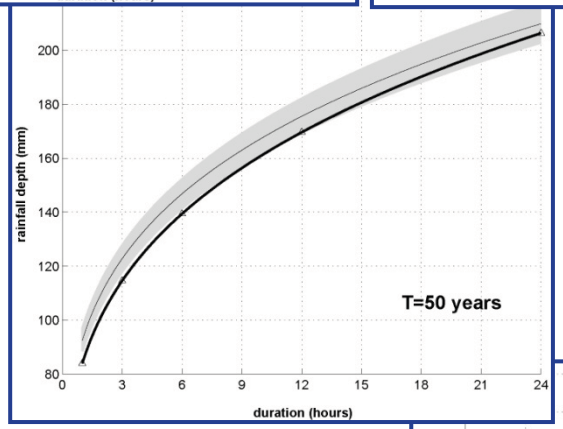
FLASH FLOODS AND PLUVIAL FLOODING

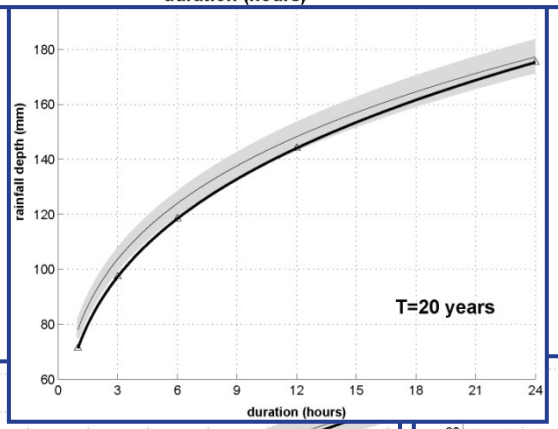


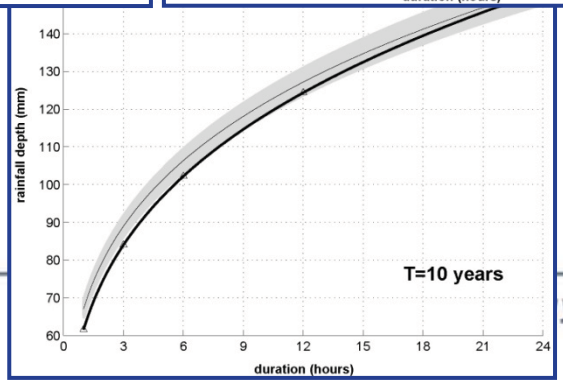


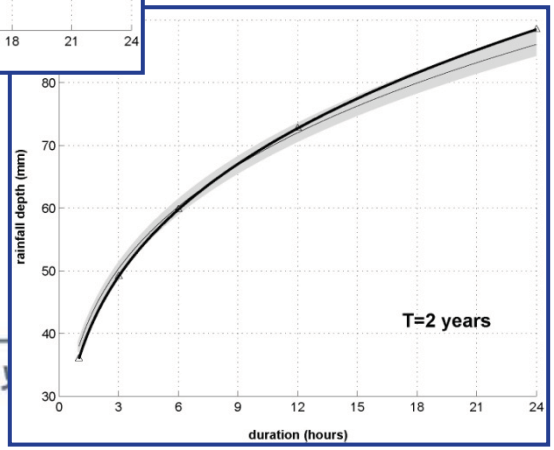












Molini, Lanza e La Barbera (2005).
The impact of TBRs measurement errors on design rainfall for urban-scale applications.
Hydrological Processes, 19(5)