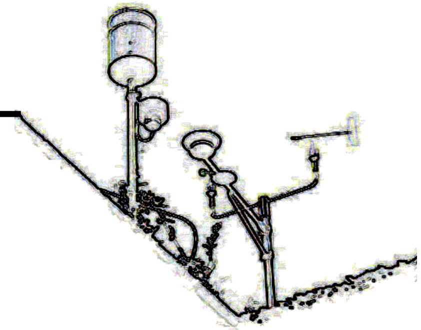
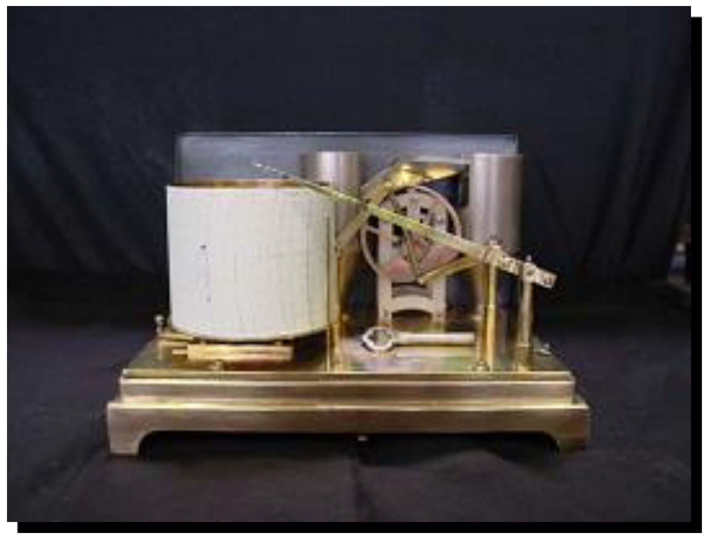
JMA/WMO Workshop on Quality Management of Surface Observations
RA II WIGOS Project
Tokyo, Japan, 19-23 March 2018



Accuracy of precipitation measurements, instrument calibration and techniques for data correction and interpretation

Tokyo, 22 March 2018



Luca G. Lanza
Mattia Stagnaro
Arianna Cauteruccio

University of Genova - DICCA
Dept of Civil, Chemical and Environmental Engineering

LC-PrIn B. Castelli
WMO/CIMO Lead Centre “B. Castelli” on Precipitation Intensity

WMO

INTRODUCTION

Applications of the "rain intensity" variable:

- Meteo-hydrological warnings
- "coupling" of meteorological and hydrological models
- Flood forecasting, protection and mitigation
- Urban hydrology, engineering design
- etc.

Measurement of Rainfall Intensity (RI)

(lack of knowledge, expertise, standardization, recommendations, instruments, etc.)

WMO Expert Meeting on Rainfall Intensity Measurements
Bratislava (Slovakia), April 2001

from 0.02 to 2000 mm·h^{-1}
from 0.02 to 0.2 mm·h^{-1} rep. as trace
Time resolution : 1 minute

Max acceptable error for RI :

- from 0.2 to 2 mm·h^{-1}: 0.1 mm·h^{-1}
- from 2 to 2000 mm·h^{-1}: 5 %

- Intercomparison of measurement instruments
- I° phase: Laboratory tests (counting errors in controlled conditions)
- II° phase: Field Intercomparison (catching errors in operational conditions)

Previous WMO Intercomparison Experiences

. 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 first time studied in meteorological evaluations)
. WMO Intercomparison of Present Weather Sensors/Systems (Leroy *et al.*, 1998).
only for qualitative information (light, moderate, intense)

- focused on cumulative (total) precipitation
- low precipitation intensity (snow)
- combined effect of counting and catching errors
- catching-type gauges only

Catching errors = Errors due to the atmospheric conditions at the collector, as well as to the wetting, splashing and evaporation issues. Indicate the capability of the instrument to collect the volume of water corresponding to the definition of precipitation at the ground, i.e. the amount of water falling through the horizontal projection of the collector area.

Counting errors = Related to the capacity of the instrument to correctly "sense" the amount of water actually collected by the instrument. These errors occur for both the catching and non catching types of gauges, even if in the latter case their quantification is really difficult, and can hardly be performed in laboratory conditions.

Correction of precipitation measurement errors

$$P_C = k[P_g + \sum_i \Delta P_{gi}]$$

[Sevruk, 1979]

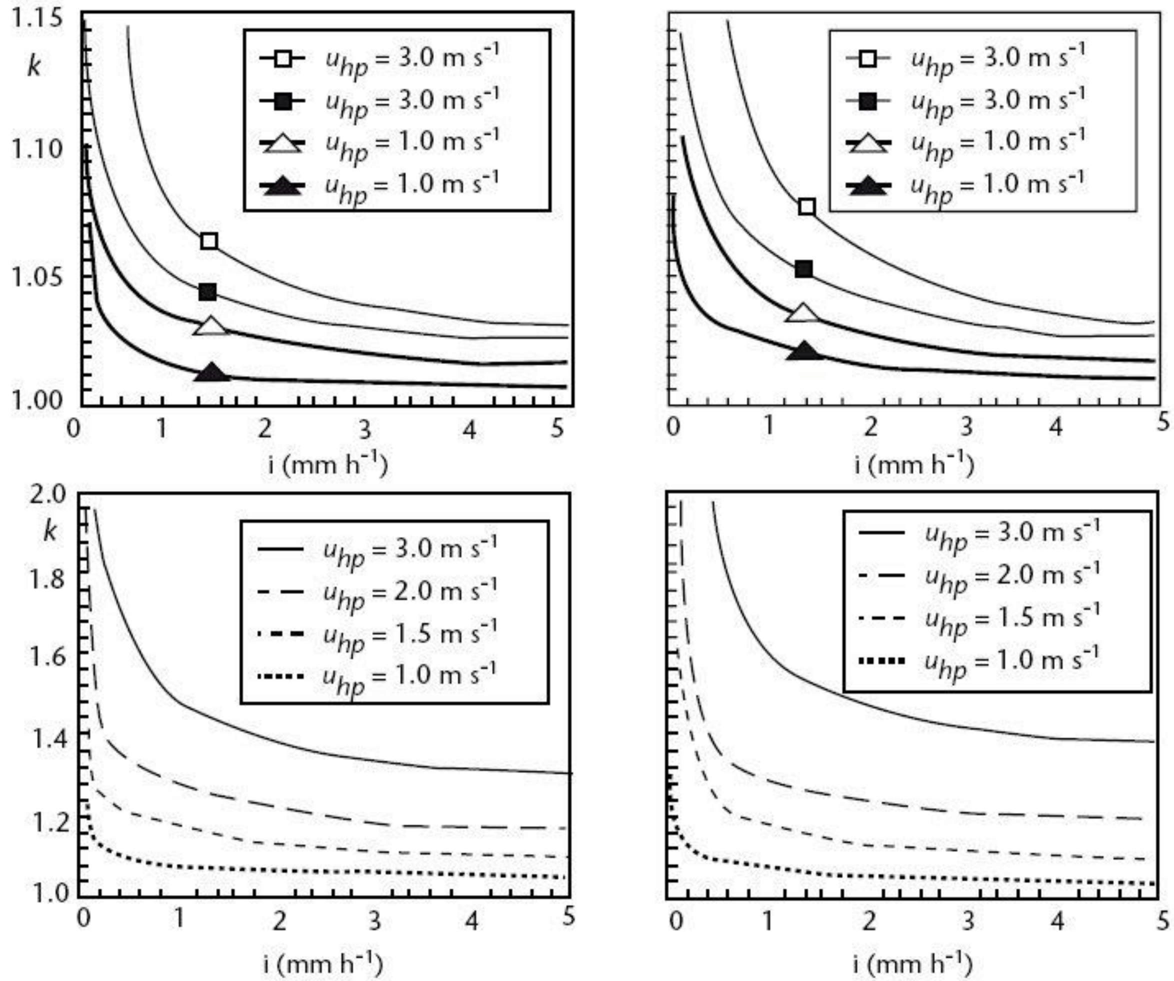
- P_C: corrected value;
- P_g: precipitation measured by the instrument;
- ΔP_{gi}: correction terns for various error sources;
- k: correction coefficient for wind effects.

Symbol	Type of error	Magnitude	Meteorological influencing factors	Instrumental influencing factors
k	Losses due to the deformation of the airflow above the instrument collector	2-10% (10-50% for snow)	Wind velocity and precipitation microstructure	Shape, area and height of the collector
ΔP_{g1} + ΔP_{g2}	Losses due to wetting of internal walls of the collector and the mechanics of the instrument	2-10%	Rainfall intensity, type of precipitation, tipping bucket movements	Shape, area and height of the collector, age and materials of both the collector and the measuring unit
ΔP_{g3}	Evaporation losses	0-4%	Type of precipitation, air temperature and wind velocity between the end of precipitation and its measurement	Surfaces of the collector and the measuring unit
ΔP_{g4}	Splashing of drops	1-2%	Rainfall intensity and wind velocity	Shape and height of the collector, type of installation

Totalizer TBR

Liquid precip.

orographic vs. convective



← Scale ?

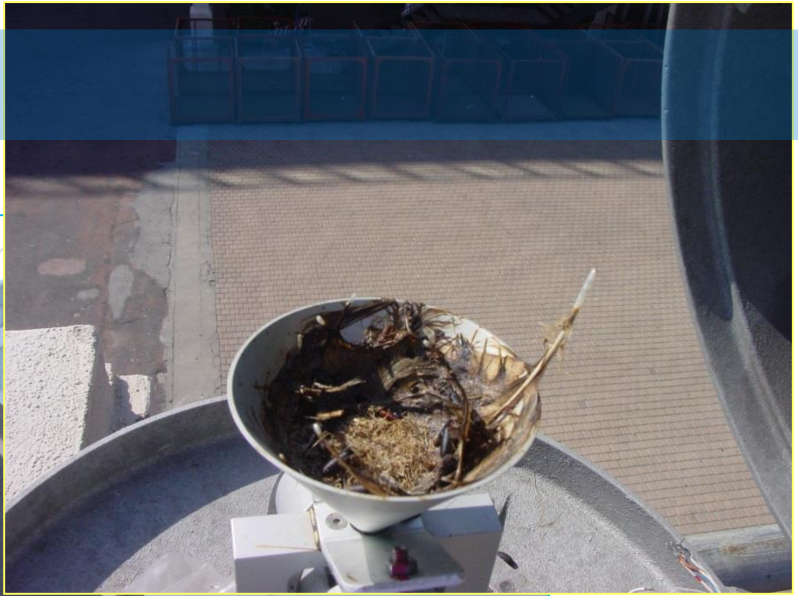
Solid precip.

always *k* > 1 (underestimation)

Figure 6.3. Conversion factor k defined as the ratio of "correct" to measured precipitation for rain (top) and snow (bottom) for two unshielded gauges in dependency of wind speed u_{hp}, intensity i and type of weather situation according to Nespor and Sevruk (1999). On the left is the German Hellmann manual standard gauge, and on the right the recording, tipping-bucket gauge by Lambrecht. Void symbols in the top diagrams refer to orographic rain, and black ones to showers. Note the different scales for rain and snow. For shielded gauges, k can be reduced to 50 and 70 per cent for snow and mixed precipitation, respectively (WMO, 1998). The heat losses are not considered in the diagrams (in Switzerland they vary with altitude between 10 and 50 per cent of the measured values of fresh snow).

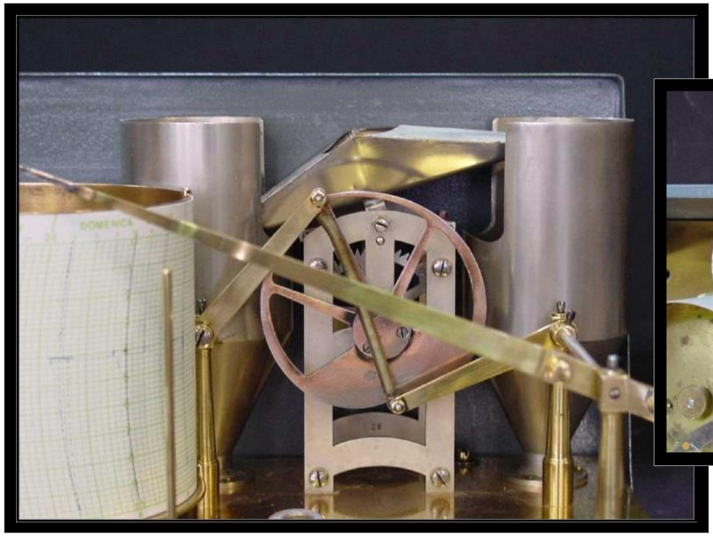
WMO

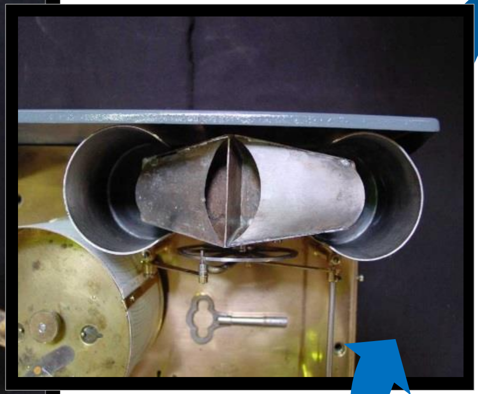
Further catching errors …



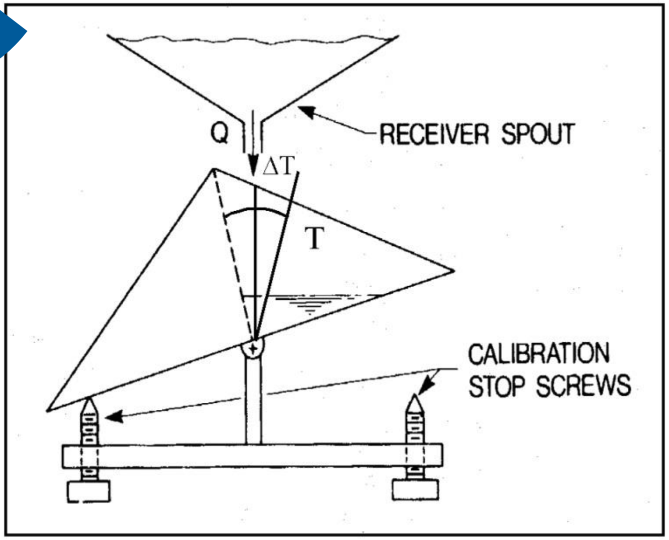
Counting errors

Tipping-Bucket Rain gauge (TBR)



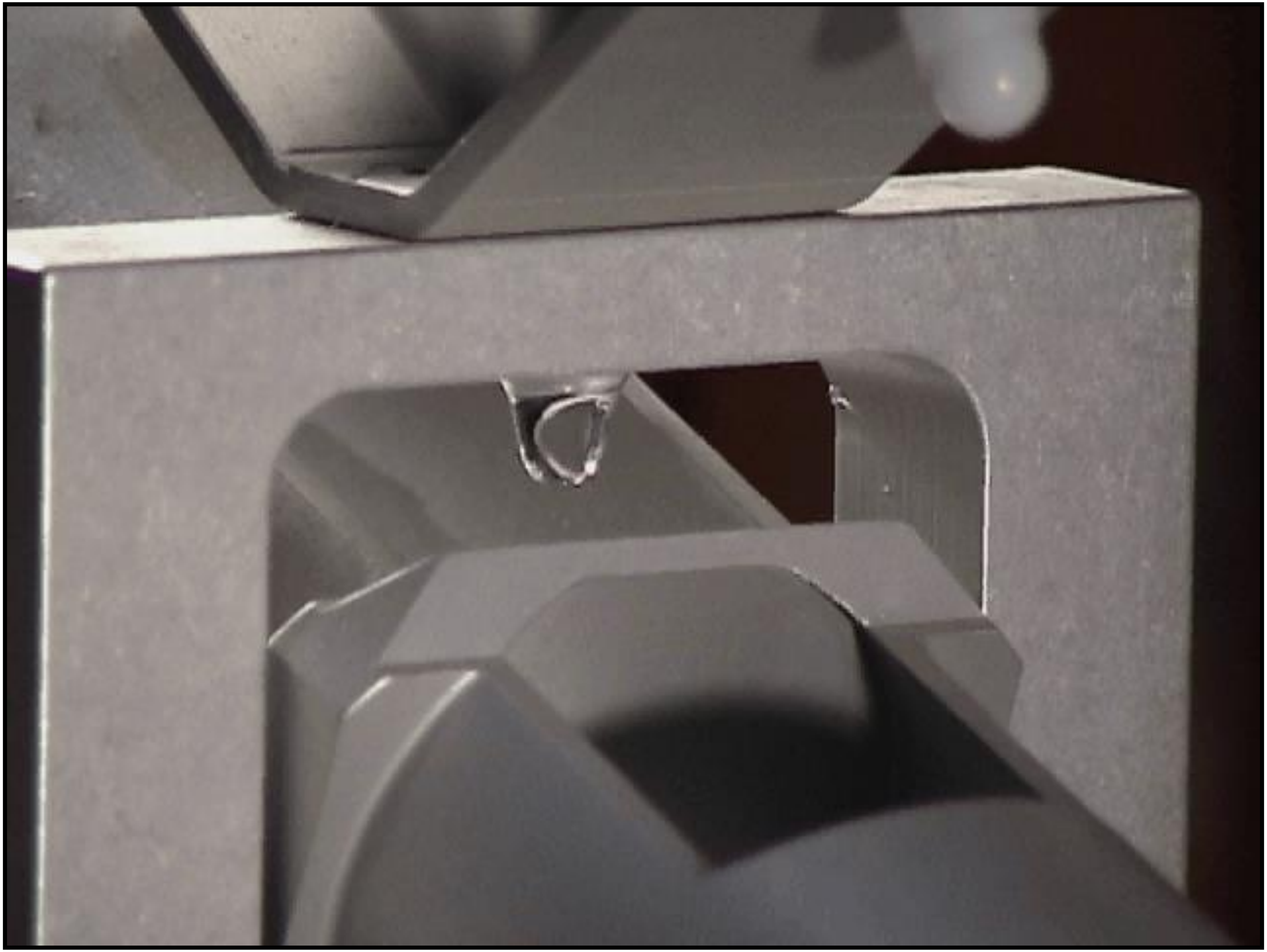


Precipitation measurements are affected by a number of error sources due to uncertainties in both the catching and counting phase.

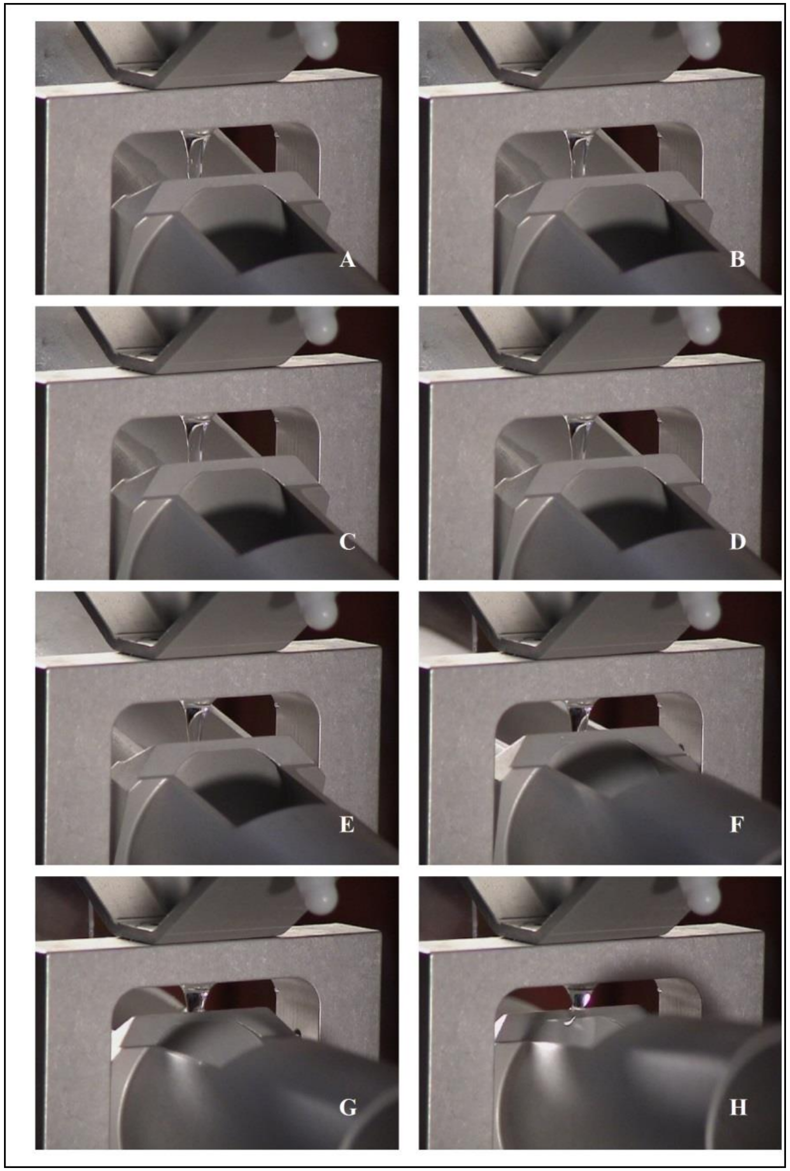


Most of the uncertainties due to catching problems have a limited impact on the measurement of heavy rainfall rates, while they may strongly affect the measurement of total (cumulated) daily, monthly or longer time scale rainfall.

On the contrary, **systematic mechanical errors** related to the characteristics of the counting of the tips, though scarcely relevant in terms of cumulated values, may have a large impact on the **measurement of rainfall intensity**, **with increasing impact upon increasing the rainfall rate**.



The tipping-bucket rain gauge

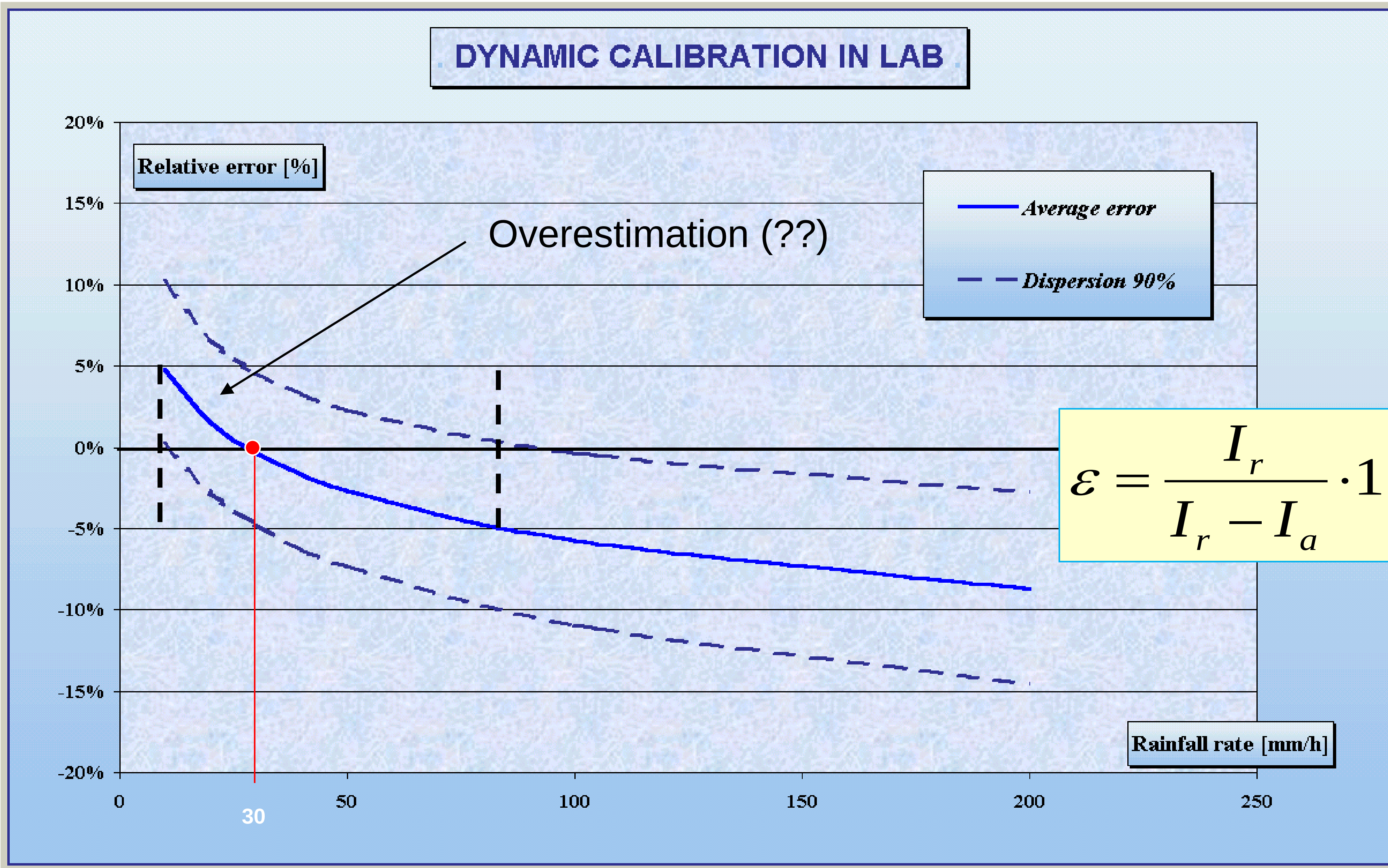


The **measurement of rainfall intensity**, traditionally performed by means of tipping bucket rain gauges is therefore **subject to a systematic underestimation of high rain rates** due to the amount of water lost during the tipping movement of the bucket.

Although this intrinsic inaccuracy can be suitably corrected through **dynamic calibration** of the gauge, the usual operational practice in many weather services and manufacturers relies upon a **single point calibration**, based on the assumption that dynamic calibration is not much significant when the total rainfall depth is to be recorded.

Such a single point calibration also results in some **overestimation** of **low intensity rainfall** due to the artificial displacement of the zero error condition.

Single point calibration vs. Dynamic calibration

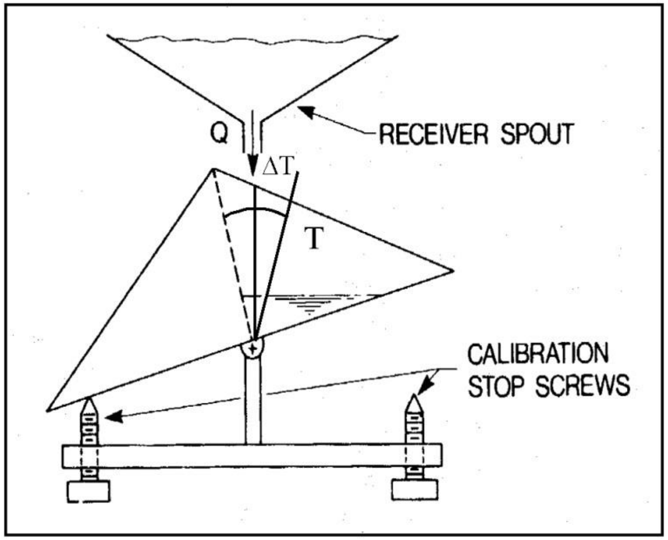


$$\varepsilon = \frac{I_r}{I_r - I_a} \cdot 100$$

(about 60 instruments, various models, used at the former Hydrographic Service of Genoa - Italy)

Single point calibration vs. Dynamic calibration

Calculation of h_n based on the V_n of each bucket and the collector diameter D
20 g = 20000 mm3 (ρ = 1g/cm3)
1000 cm2 = 100000 mm2 → 20 g / 1000 cm2 = 0,2 mm
(sensitivity of the instrument)



h_n = nominal rain depth per tip
(e.g. 0,2 mm – settings of the data logger)

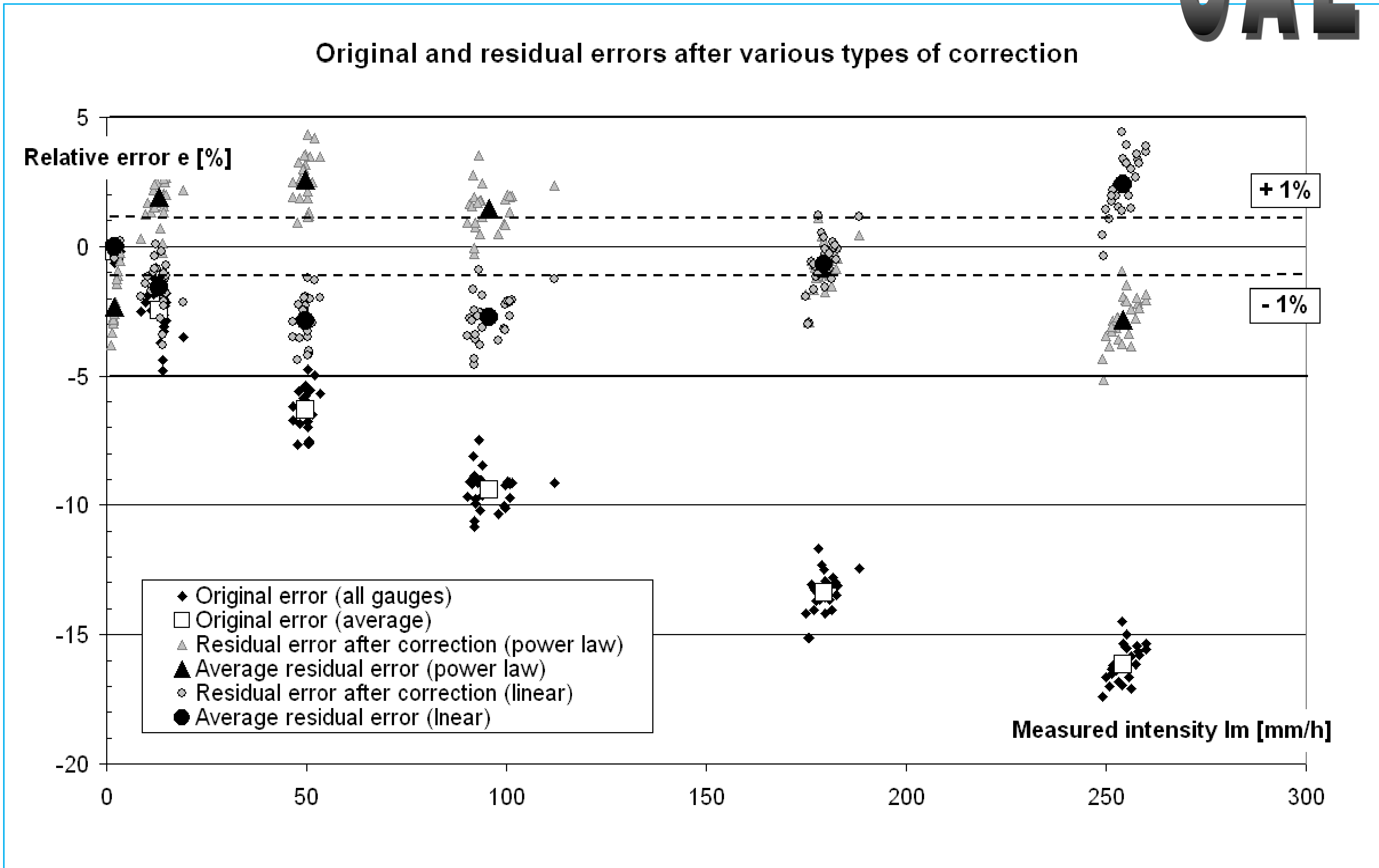
h_v = actual rain depth per tip

$h_n = h_v$ → always underestimation
$h_n > h_v$ → overestimation (move the error curve upward)
$h_n < h_v$ → underestimation (move the error curve downward)

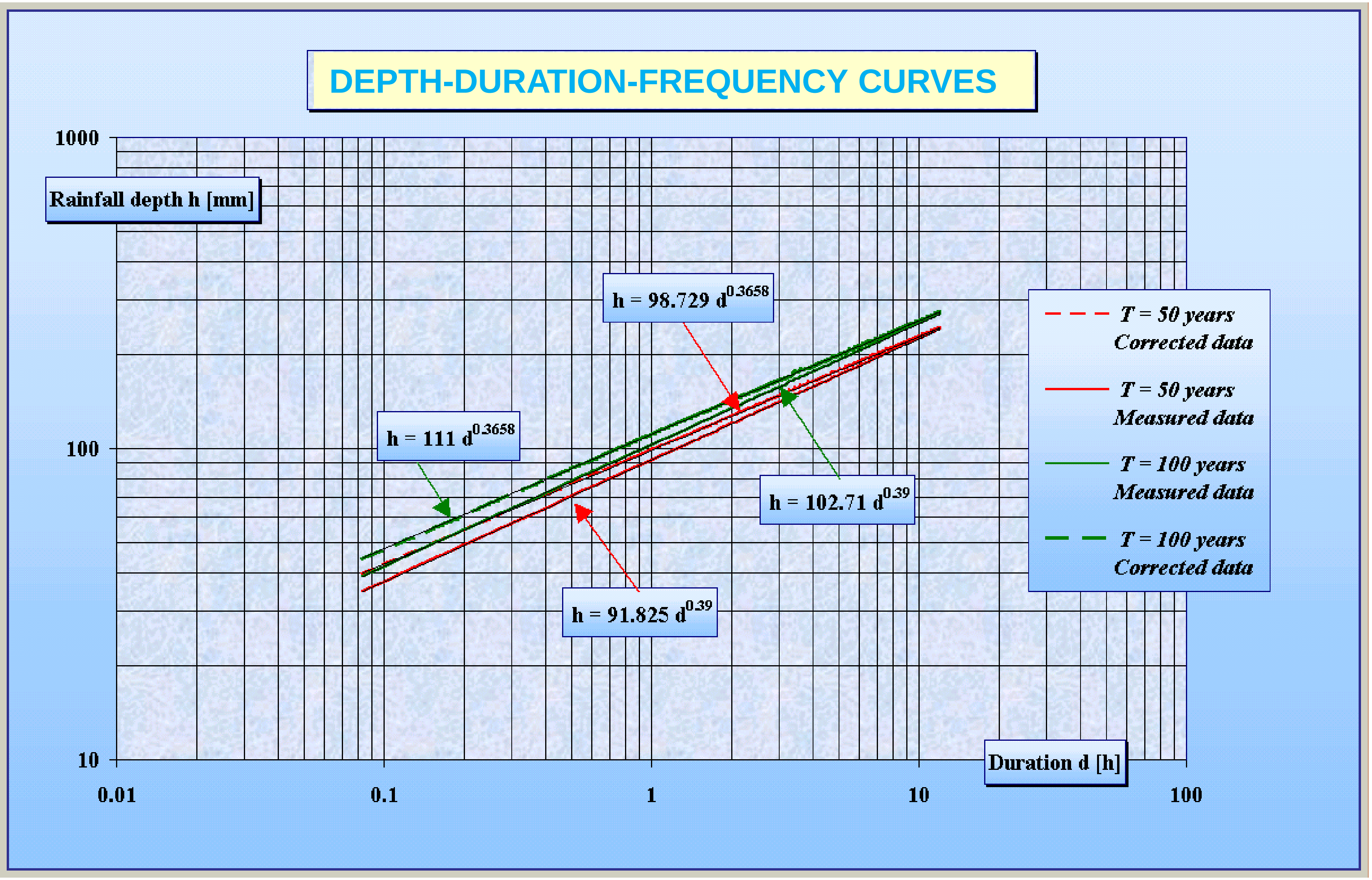
ADJUSTMENT OF THE STOP SCREWS
$h_v = f(h_n)$: e% = 0 at $I = I_{rif}$ → single point calibration

$h_{vd} = h_{vs}$? → balancing of the two buckets

Dynamic calibration – correction curve

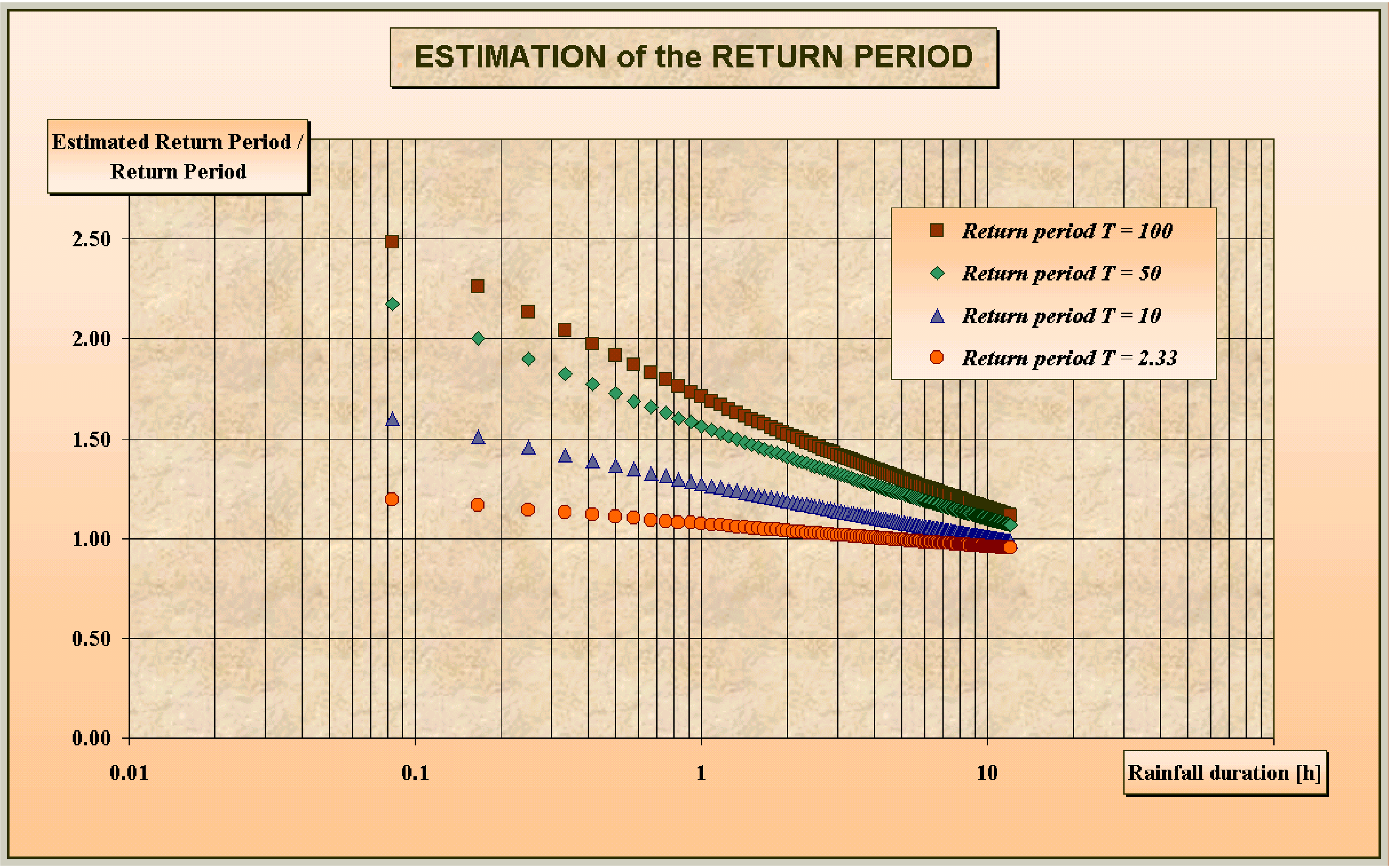


Propagation of the errors - extreme event statistics



(La Barbera et al., 2002)

Propagation of the errors - extreme event statistics



(La Barbera et al., 2002)

Underestimation of design rainfall: historical records

Typically short records (recent) → T = 30 – 60 years

Recorded historical series
Δt = ?

≈ 1 min

Direct correction using a calibration curve

Single series of corrected data

≈ 1 hour

Stochastic downscaling (disaggregation scheme ?) with MonteCarlo generation

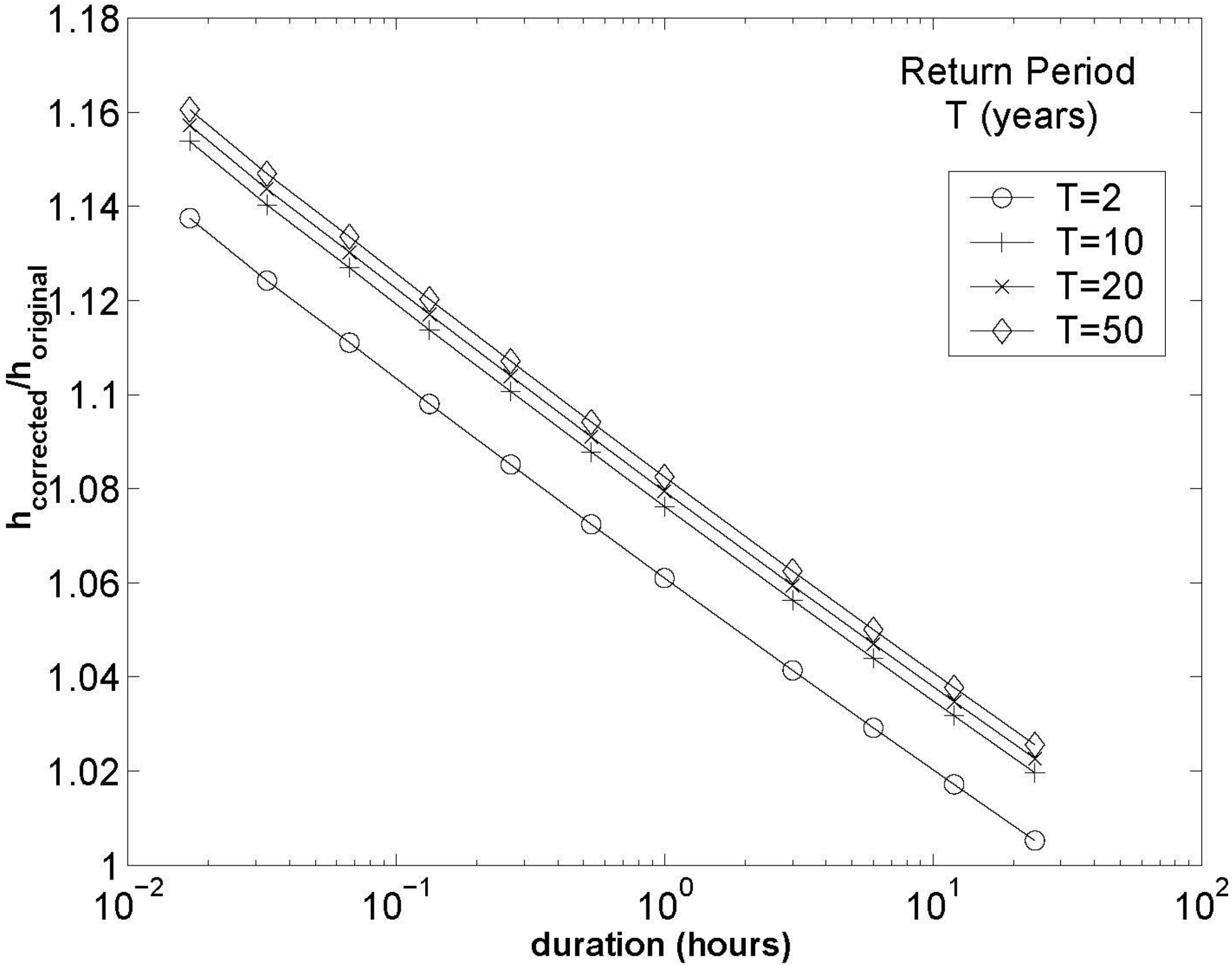
Correction using a calibration curve

Ensemble of corrected series
→ Most probable values

Statistics of extreme values

Typically long records (historical) → T = 100-200 years

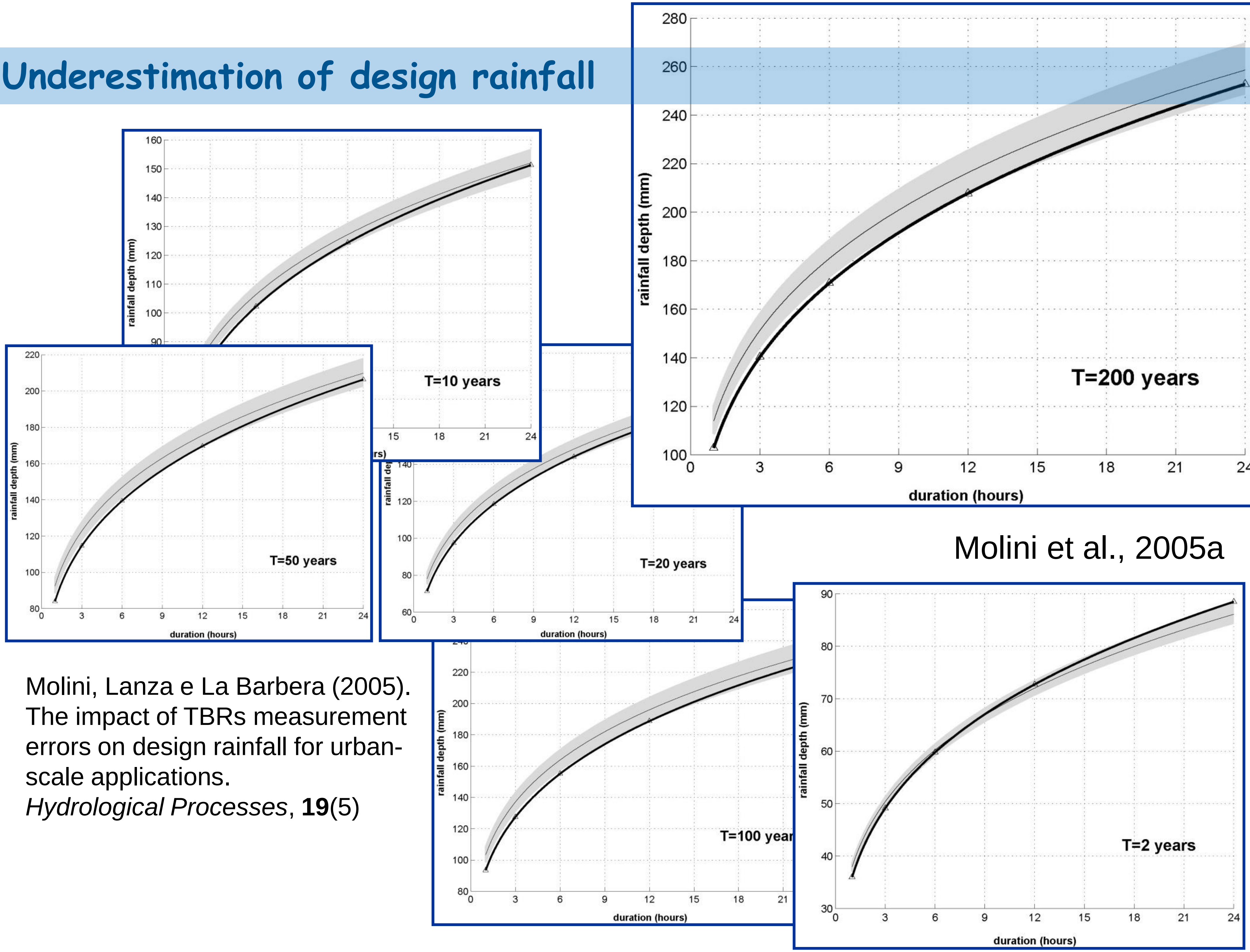
Underestimation of design rainfall: historical records



(Molini et al., 2005)

Obtained «gain» from direct correction of the series recorded at a high resolution (1 min) in Genoa – Villa Cambiaso

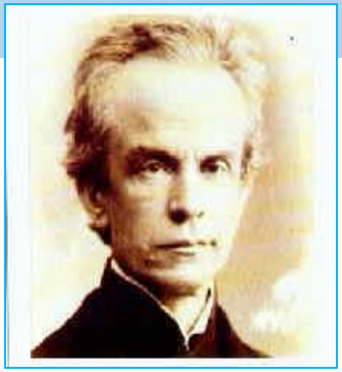
Underestimation of design rainfall



Molini et al., 2005a

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

The WMO/CIMO "intercomparisons"



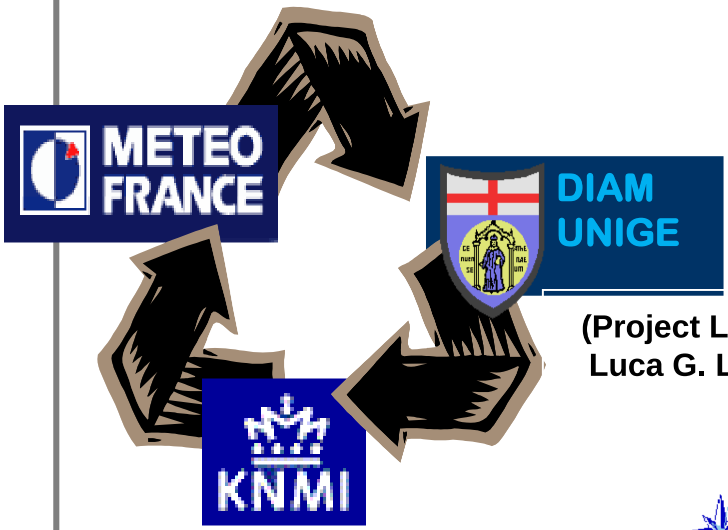
Father Francesco Denza (1872) – Italian Meteorological Society

"… in order for meteorological investigations to deliver progresses for the human beings … it is necessary not only to have numerous observers and observations/measurements that are taken with intelligence and accuracy, but also that meteorological investigations are performed with the **same methodology and carefully intercompared instruments**".

Based on the requirements for the measurement of liquid precipitation intensity at the ground established by the Expert Meeting on Rainfall Intensity Measurements, Bratislava (Slovak Rep.), April 2001, the WMO initiated in September 2004 the first

LABORATORY INTERCOMPARISON OF RAINFALL INTENSITY (RI) GAUGES.

The intercomparison was held at the accredited laboratories of the Royal Netherlands Meteorological Institute (KNMI), Météo France, and the University of Genova – DIAm, in Italy.



(Project Leader: Luca G. Lanza)

WMO

WMO

WMO Laboratory Intercomparison of Rainfall Intensity Gauges

WORLD METEOROLOGICAL ORGANIZATION
COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION

EXPERT TEAM ON SURFACE-BASED INSTRUMENT INTERCOMPARISONS AND CALIBRATION METHODS

INTERNATIONAL ORGANIZING COMMITTEE (IOC) ON SURFACE-BASED INSTRUMENTS INTERSOMPARISONS

WMO Laboratory Intercomparison

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

Further objectives can be summarized as follows:

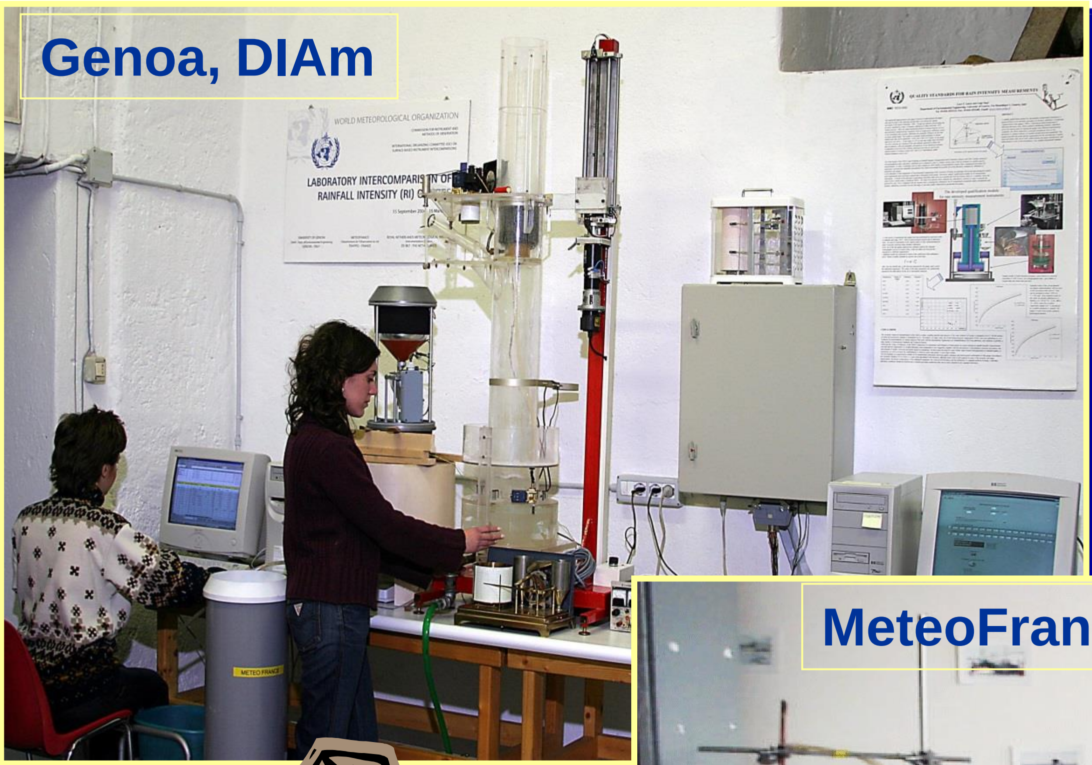
- To define a **standardized procedure** for laboratory calibration of catchment type rain gauges, including uncertainty of laboratory testing devices within the range from 2 to 2000 mm/h;
- To performances of the instruments under test;
- To comment on the need to proceed with a field intercomparison of catchment type of rainfall intensity gauges;
- To identify and recommend the most suitable method and equipment for reference purposes within the field intercomparison of catching and non-catching types of gauges;
- To provide information on different measurement systems relevant to improving the homogeneity of rainfall time series with special consideration given to high rainfall intensities

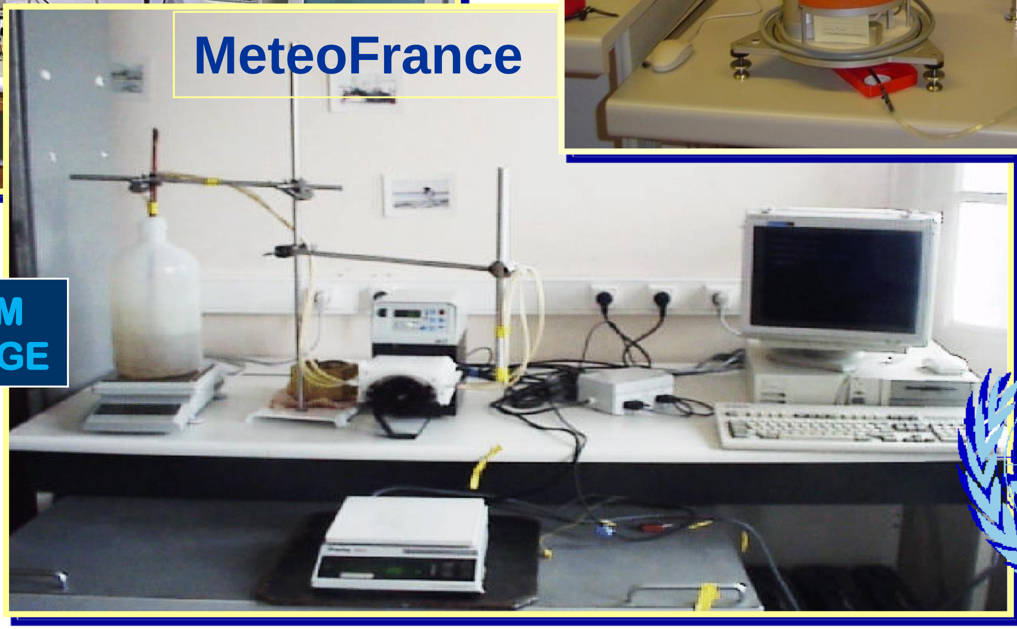
WMO

List of instruments involved in the Laboratory Intercomparison

COUNTRY & MANUFACTURER	MODEL TYPE	MEAS. PRINCIPLE	Number of instruments
ITALY - SIAP	UM7525	TIPPING BUCKET	2
ITALY – CAE	PMB2	TIPPING BUCKET	2
ITALY – ETG	R102	TIPPING BUCKET	2
CZECH REPUBLIC – METEOSERVIS	MR3H	TIPPING BUCKET	2
SWITZERLAND – LAMBRECHT	1518 H3	TIPPING BUCKET	2
UNITED KINGDOM – CASELLA	100000E	TIPPING BUCKET	2
INDIA – INDIA MET DEPT	TBRG	TIPPING BUCKET	2
AUSTRIA – PAAR	AP23	TIPPING BUCKET	1
USA – DESIGN ANALYSIS ASSOC	H340 – SDI	TIPPING BUCKET	1
JAPAN – YOKOGAWA DENSHI KIKI	WMB01	TIPPING BUCKET	2
AUSTRALIA – MC VAN Instr.	RIMCO 7499	TIPPING BUCKET	2
AUSTRALIA – Hydrol. Serv.	TB-3	TIPPING BUCKET	2
CZECH REPUBLIC – METEOSERVIS	MRW500	WEIGHING	2
SLOVAKIA – MPS SYSTEM	TRWS	WEIGHING	2
GERMANY – OTT HYDROMETRY	OTT	WEIGHING	2
FINLAND - VAISALA	VRG101	WEIGHING	1
NORWAY - GEONOR	T-200B	WEIGHING	2
FRANCE – SEROSI	SEROSI	CONDUCTIVITY	2
CANADA – AXYS Env. Syst	ALLUVION 100	WATER LEVEL	2

WMO Laboratory Intercomparison





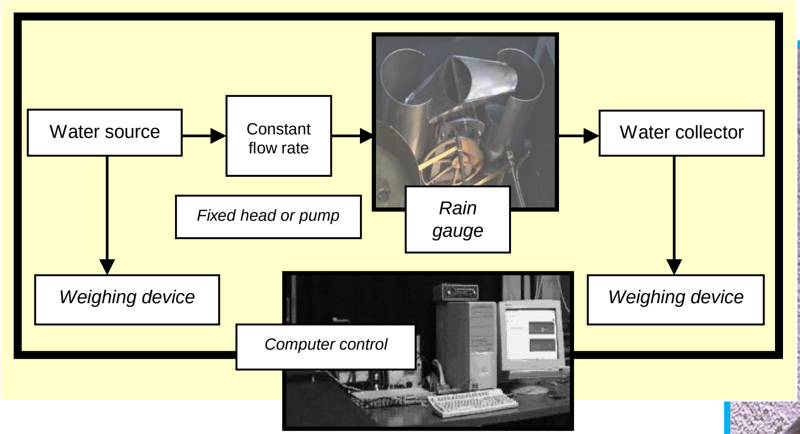
METEO FRANCE

DIAM UNIGE

KNMI

WMO

WMO Laboratory Intercomparison



Tipping-bucket rain gauges – Dynamic calibration

Each test was performed at least at **seven reference flow rates** with the following rules :

• At least at 2, 20, 50, 90, 130, 170, 200 mm/h;

• If the maximum declared intensity is less or equal to 500 mm·h^{-1}, further reference intensities are determined at 300 and 500 mm·h^{-1}.

• Beyond that, three further reference intensities are determined logarithmically between 200 mm·h^{-1} up to the maximum declared intensity.

The reference intensity is within the following limits:

1.5 – 4 mm·h^{-1} at 2 mm·h^{-1}

15 – 25 mm·h^{-1} at 20 mm·h^{-1}

and within a limit of ± 10% at higher intensities

WMO Laboratory Intercomparison

Weighing gauges

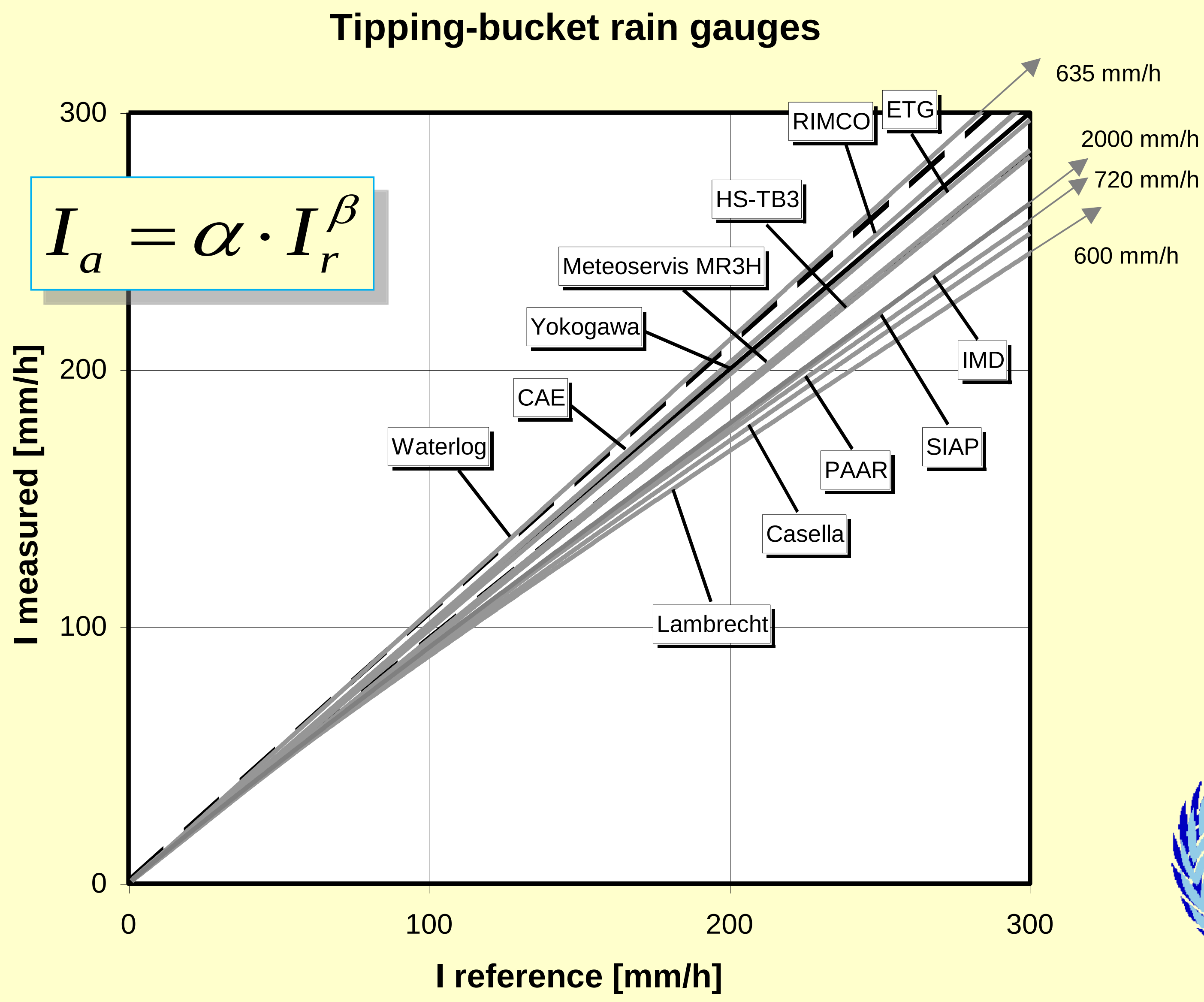
In addition to measurements based on constant flow rates, **the step response** of each instrument was checked based on the devices developed by each laboratory.

The step response of the weighing gauges was measured by switching between two different constant flows, namely from 0 mm·h^{-1} to 200 mm·h^{-1} and back to 0 mm·h^{-1}.

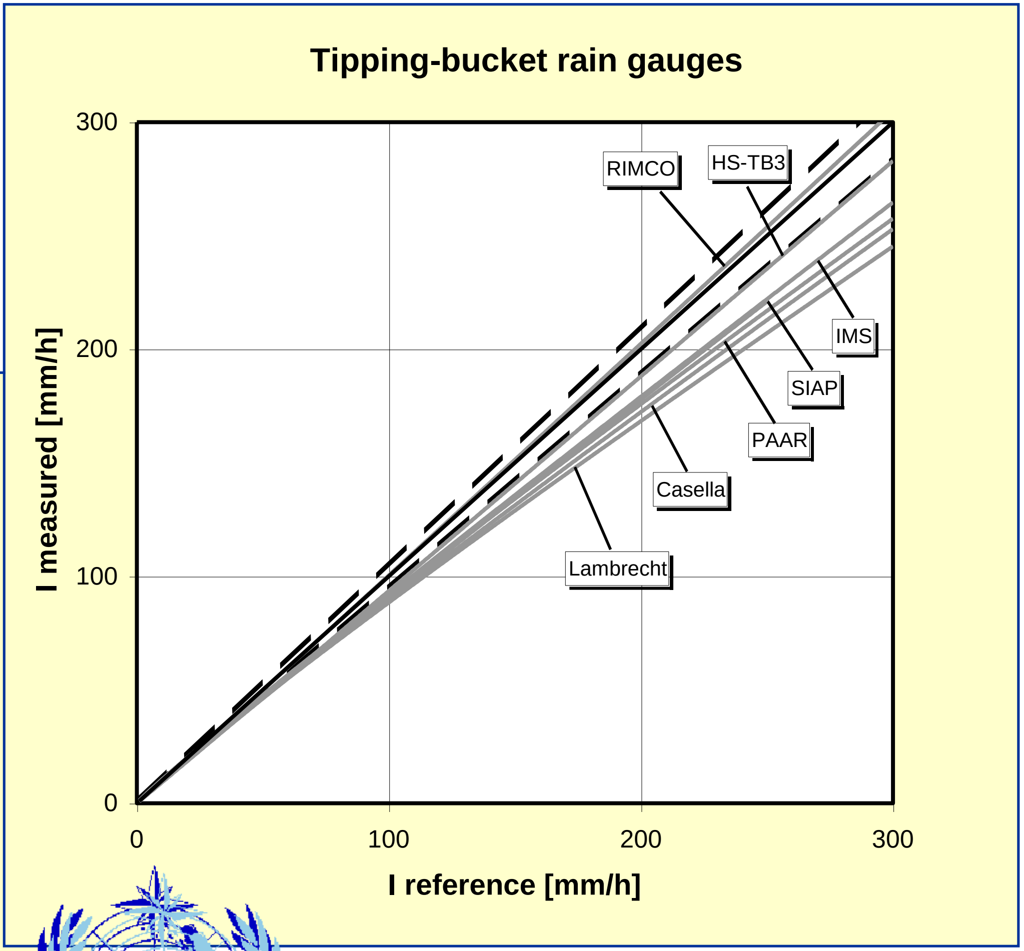
The constant flow was applied until the output signal of the weighing rain gauge was stabilized. The time resolution of the measurement was higher than 1 minute, e.g. 10 seconds, and the possible delay was evaluated by determining the first time interval when the measure is stabilized, within a maximum period of 10 minutes..

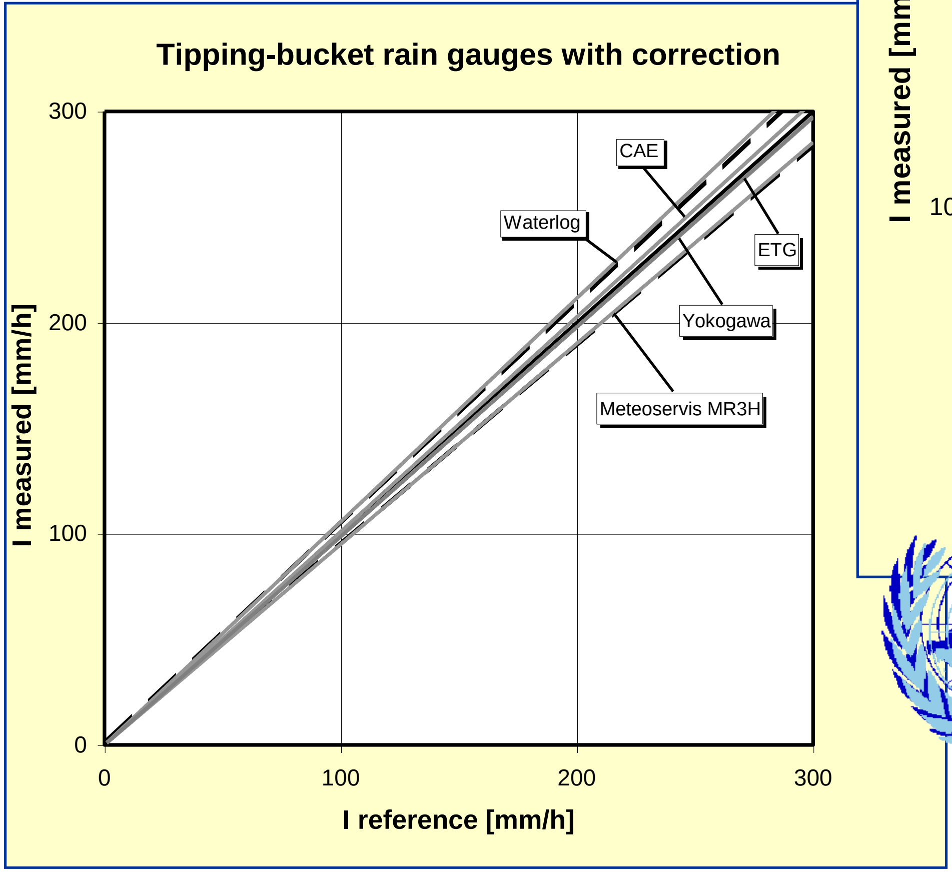
WMO Laboratory Intercomparison

$$I_a = \alpha \cdot I_r^{\beta}$$



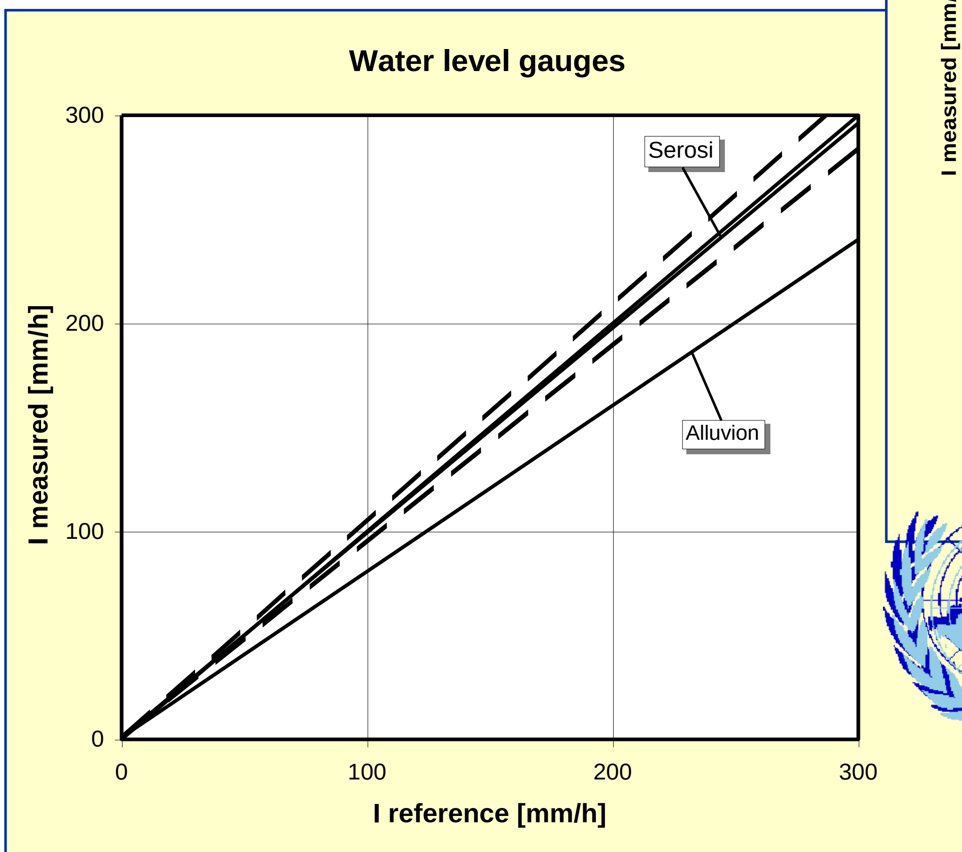
WMO Laboratory Intercomparison

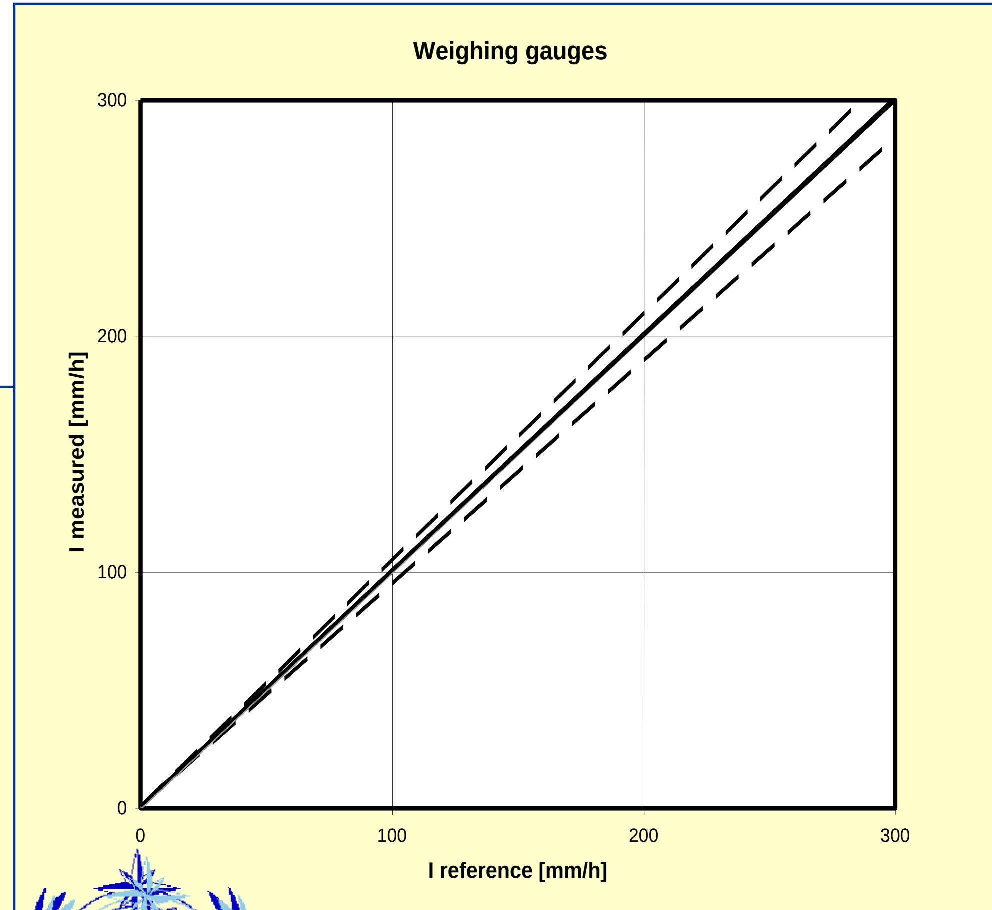




WMO

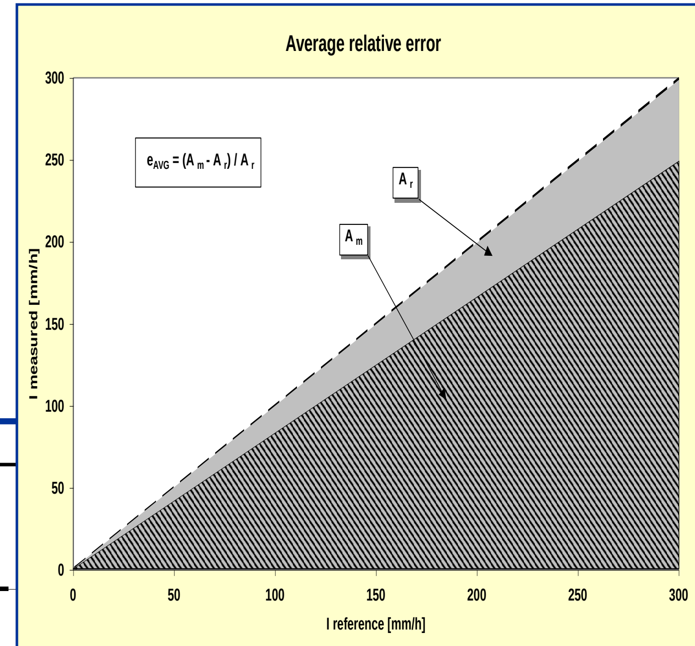
WMO Laboratory Intercomparison



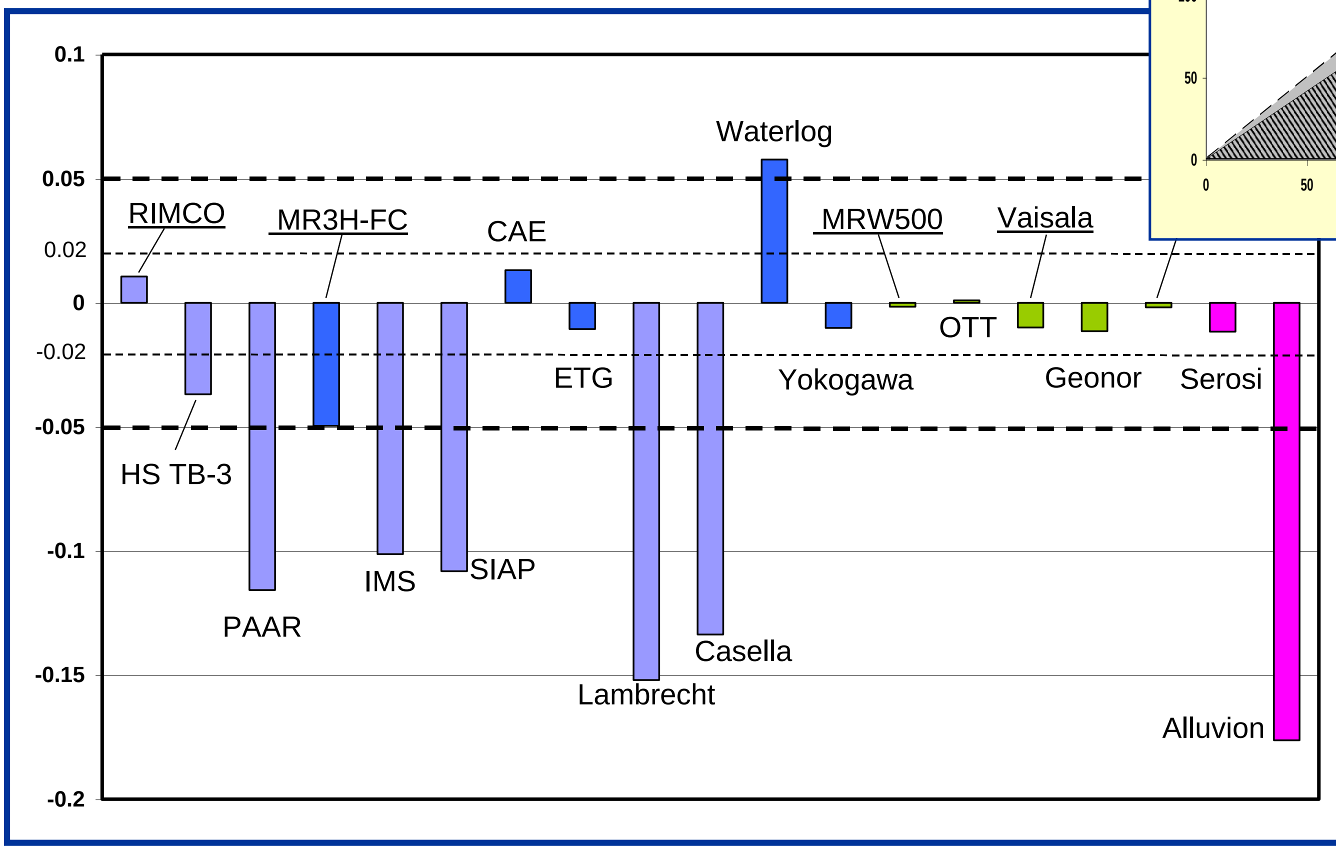


WMO

WMO Laboratory Intercomparison



Synthetic results of the Intercomparison



WMO

WMO

WHAT HAVE WE LEARNED from the INTERCOMPARISON ?

All the investigated instruments are subject to errors in the measurements of rainfall intensity.

Those tipping-bucket rain gauges that are equipped with a suitable software correction did provide good results.
Those with no correction show significant errors.

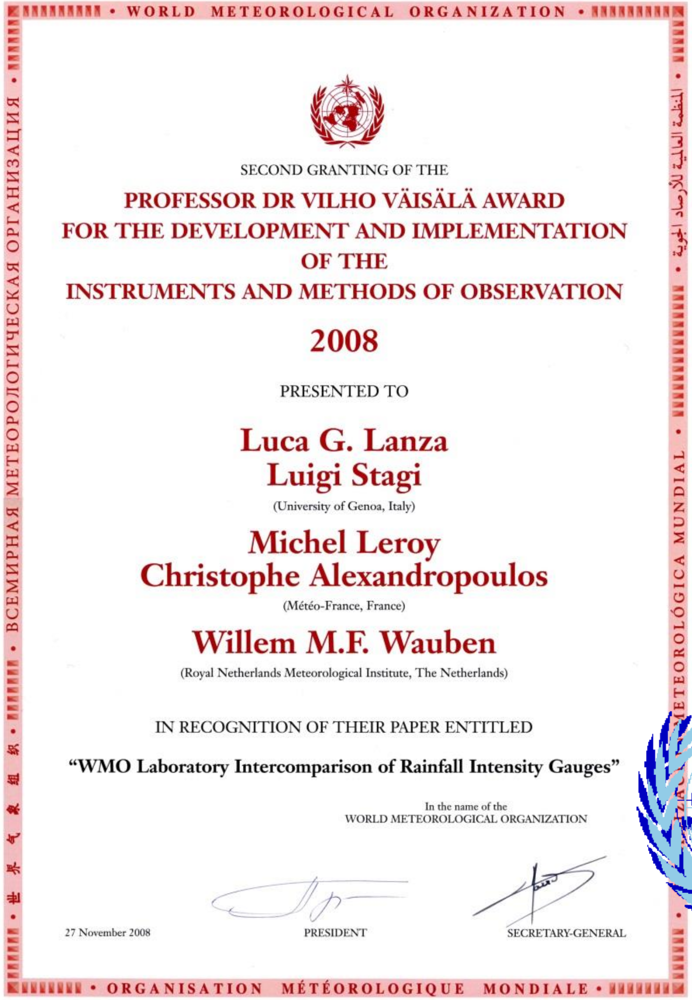
The error of weighing gauges is lower than for tipping-bucket gauges under constant flow rate conditions, provided the instrument is stabilizzed, which may take a considerable time (minutes).

However, those instruments show significant delays in detecting variations in time of the rain intensity.

In many cases significant differences have been noted in the behaviour of two individuals of the same model. Tests are necessary ona higher number of individuals (at least 30) to better evaluate the associated uncertainty.

Prof. V.Vaisala Award 2008

Lanza et al. (2005).
Final Report WMO Laboratory Intercomparison of Rainfall Intensity Gauges; De Bilt (The Netherlands), Genoa (Italy), Trappes (France); September 2004 – September 2005
(available at http://www.wmo.int/pages/prog/www/IMOP/reports.html)



WORLD METEOROLOGICAL ORGANIZATION

SECOND GRANTING OF THE
PROFESSOR DR VILHO VÄISÄLÄ AWARD
FOR THE DEVELOPMENT AND IMPLEMENTATION
OF THE
INSTRUMENTS AND METHODS OF OBSERVATION

2008

PRESENTED TO

Luca G. Lanza
Luigi Stagi
(University of Genoa, Italy)

Michel Leroy
Christophe Alexandropoulos
(Météo-France, France)

Willem M.F. Wauben
(Royal Netherlands Meteorological Institute, The Netherlands)

IN RECOGNITION OF THEIR PAPER ENTITLED

"WMO Laboratory Intercomparison of Rainfall Intensity Gauges"

In the name of the
WORLD METEOROLOGICAL ORGANIZATION

27 November 2008 | PRESIDENT | SECRETARY-GENERAL

ВСЕМИРНАЯ МЕТЕОРОЛОГИЧЕСКАЯ ОРГАНИЗАЦИЯ • 世界气象组织

ORGANISATION MÉTÉOROLOGIQUE MONDIALE

WMO

From the laboratory to field tests …

The main objective of the Laboratory Intercomparison was to **test the performance** of rainfall intensity catching type gauges from various manufacturers **under documented conditions.**

Laboratory →

- controlled conditions
- constant flow rates
- known reference intensity
- counting errors

Drawbacks:

- Rainfall is not real (variability, intermittency, …)
- No catching errors involved
- Working conditions are not real

→ Follow-up in the field
WMO Field Intercomparison of Rainfall Intensity Gauges
Vigna di Valle (Rome) – OTT07

WMO

WMO FIELD INTERCOMPARISON of RAINFALL INTENSITY (RI) GAUGES

WMO

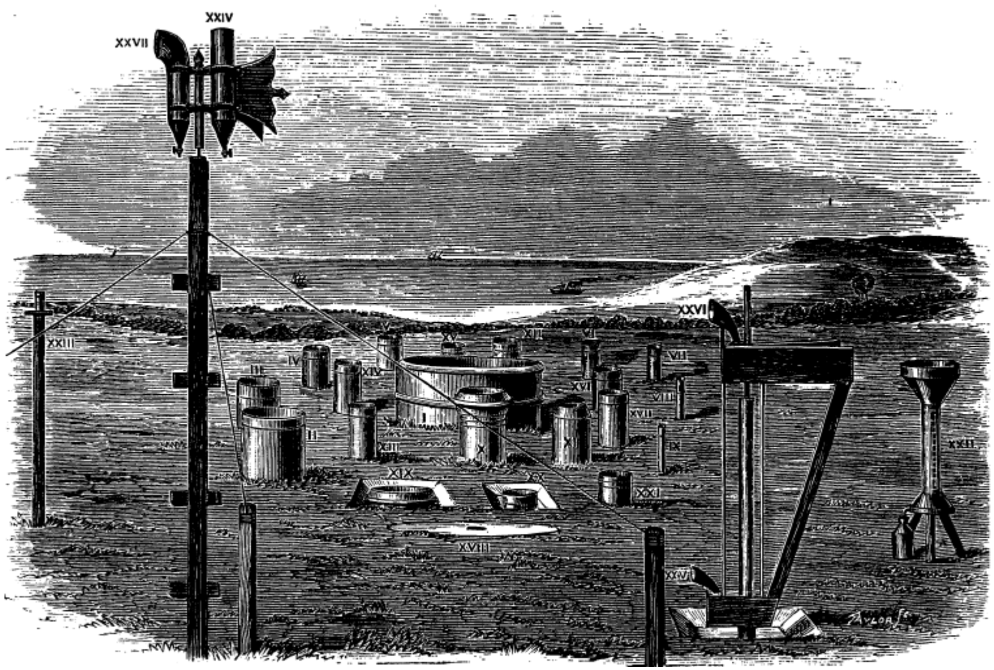
http://www.dicat.unige.it/wmo

2007-2009

Servizio Meteorologico dell'Aeronautica, ReSMA, Vigna di Valle, Roma

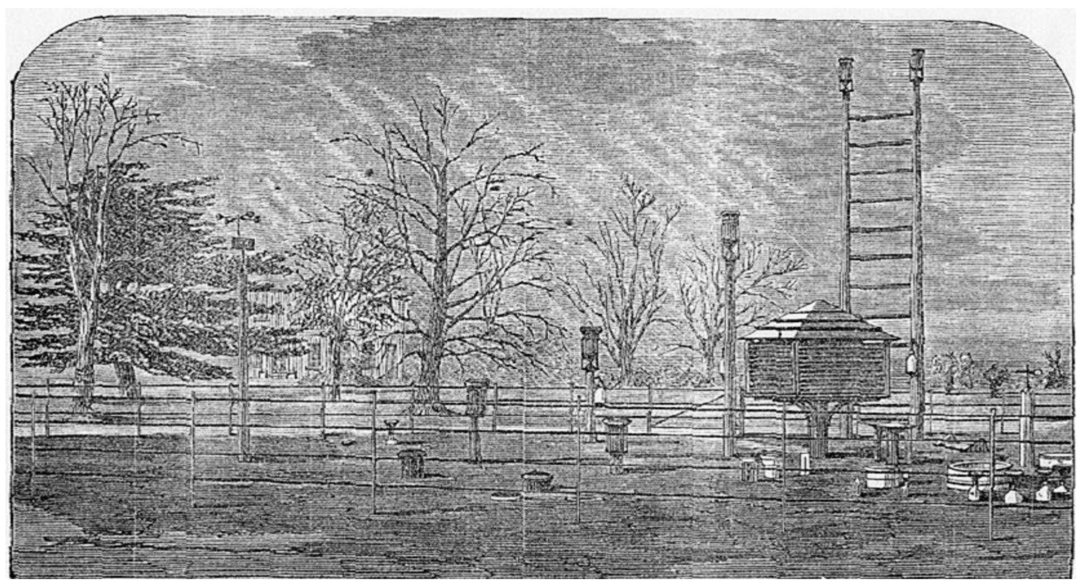
Università di Genova (DICAT)

A long tradition of Field Intercomparisons existed …



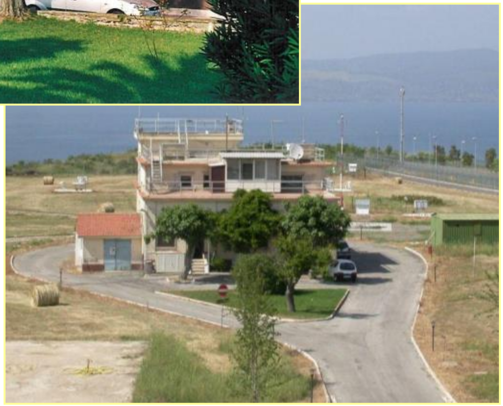
1871 – Symons performs the first intercomparison of rain gauges at Hawskers (Yokshire)

Experiment for studying the effect of installation hight of the instrument (Symons 1862)



The Field Test site in Vigna di Valle

RESMA – Experimentation Centre for Meteorological Instruments and historic observatory



ACTIVITIES:

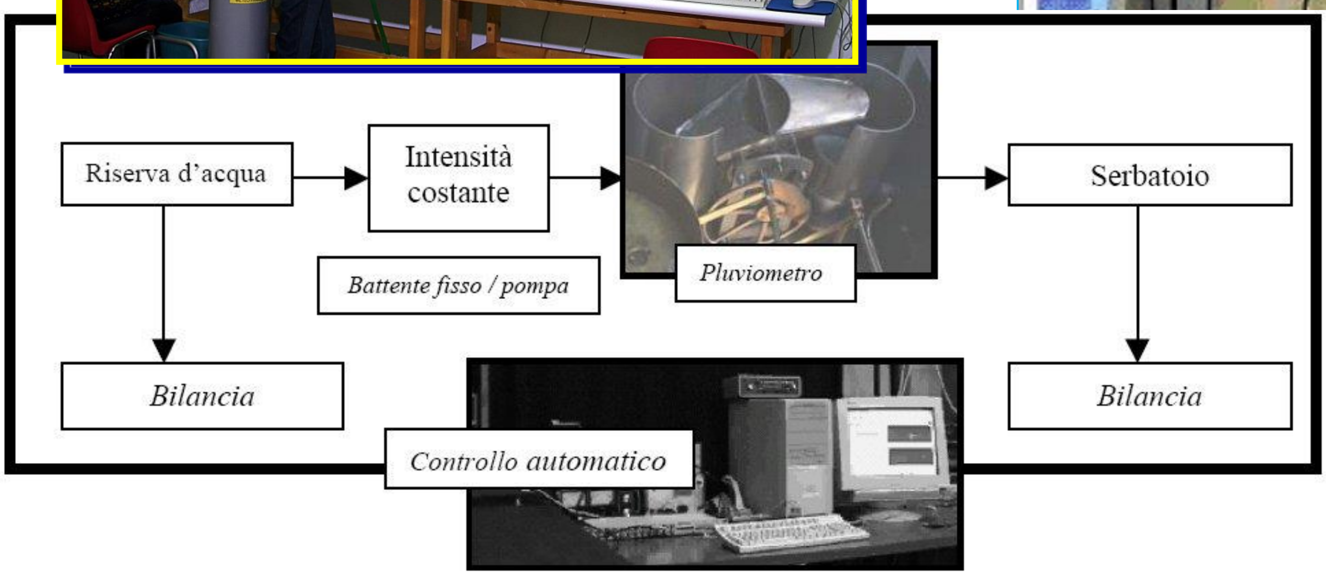
- Intercomparisons of meteorological instruments
- Performance tests and monitoring for WMO-GAW
- Metrological aspects of the measurement: reference standards and uncertainty

WMO Intercomparison in the Field

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

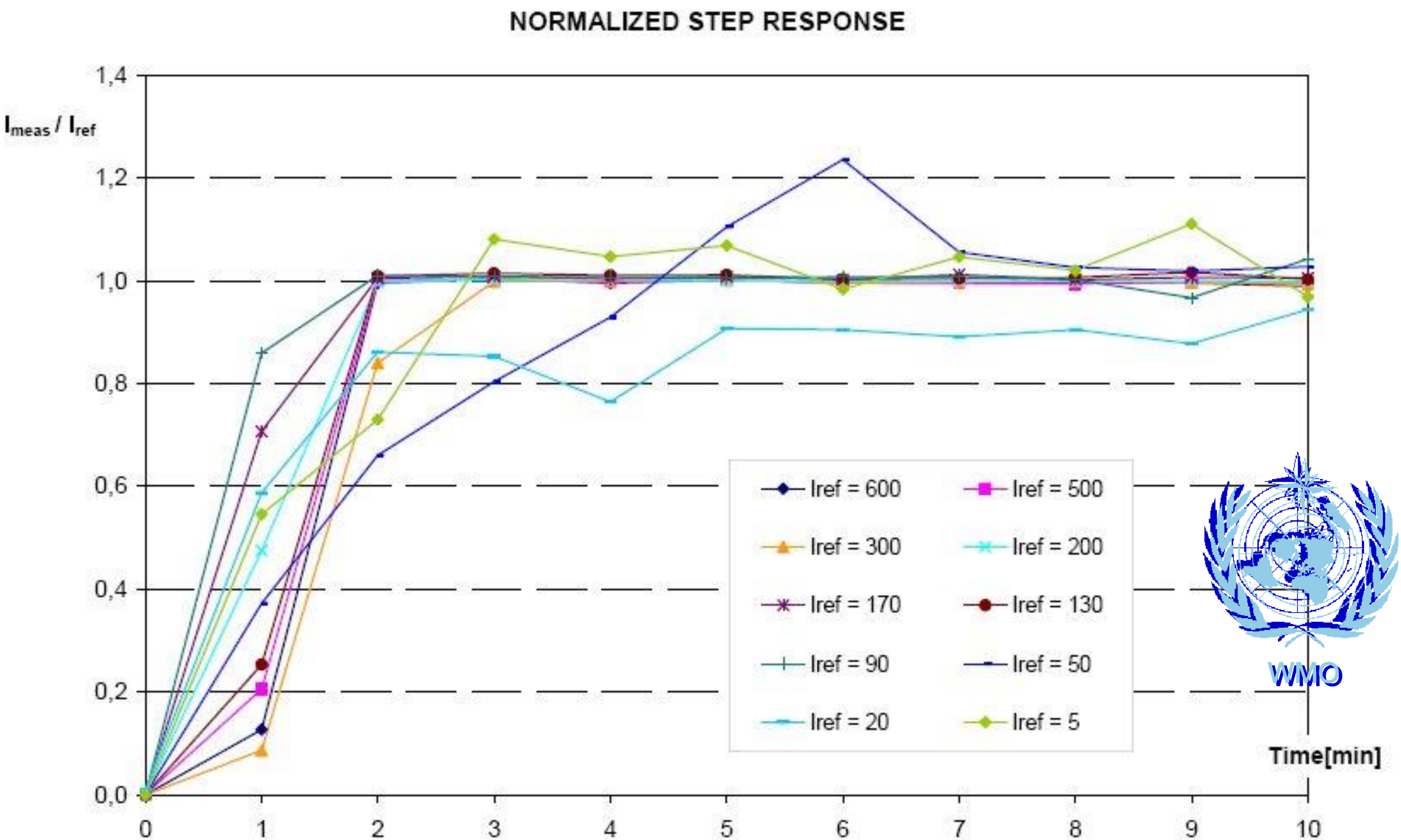
WMO Intercomparison in the Field

Preliminary laboratory tests

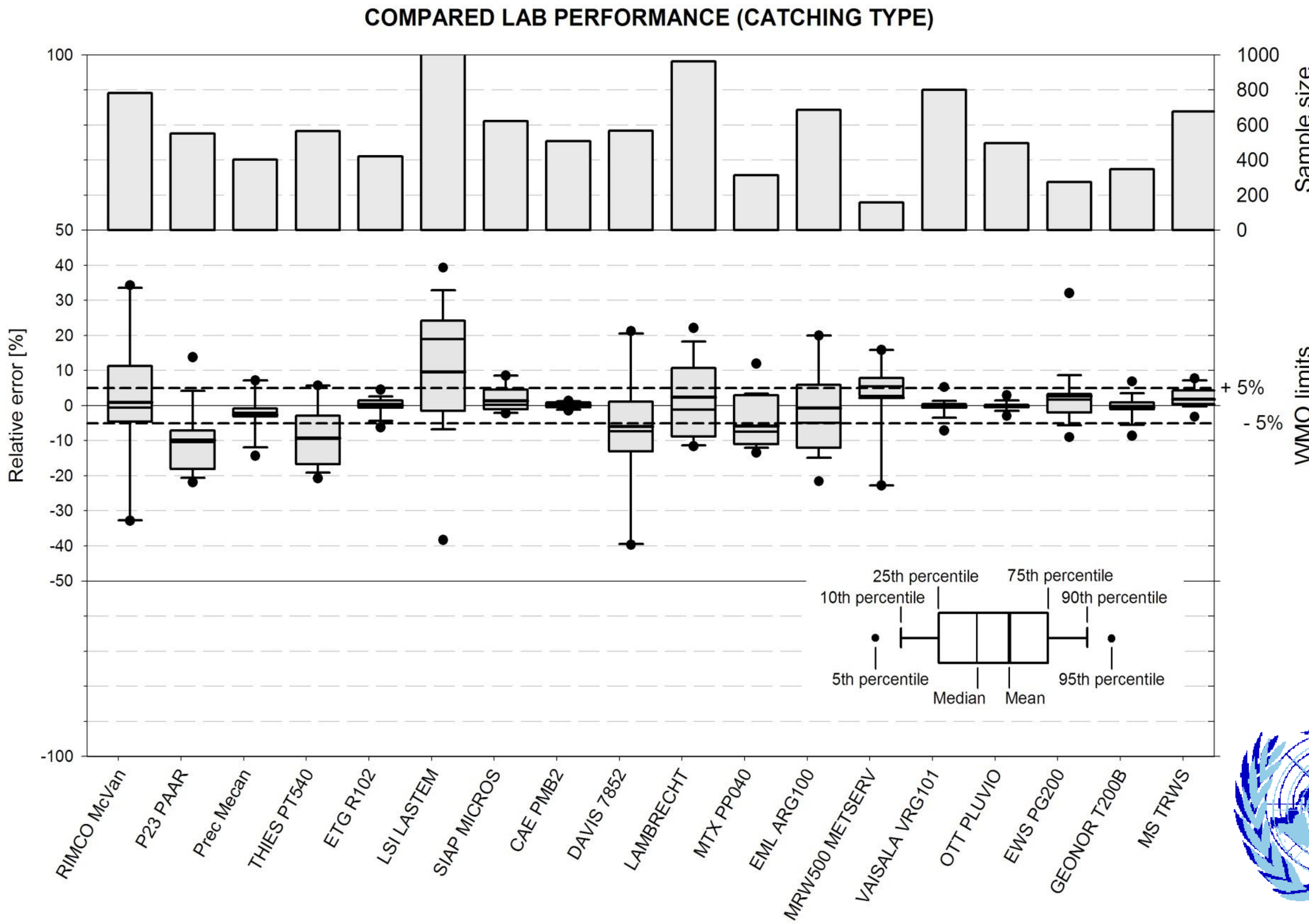


WMO

WMO Intercomparison in the Field



WMO Intercomparison in the Field

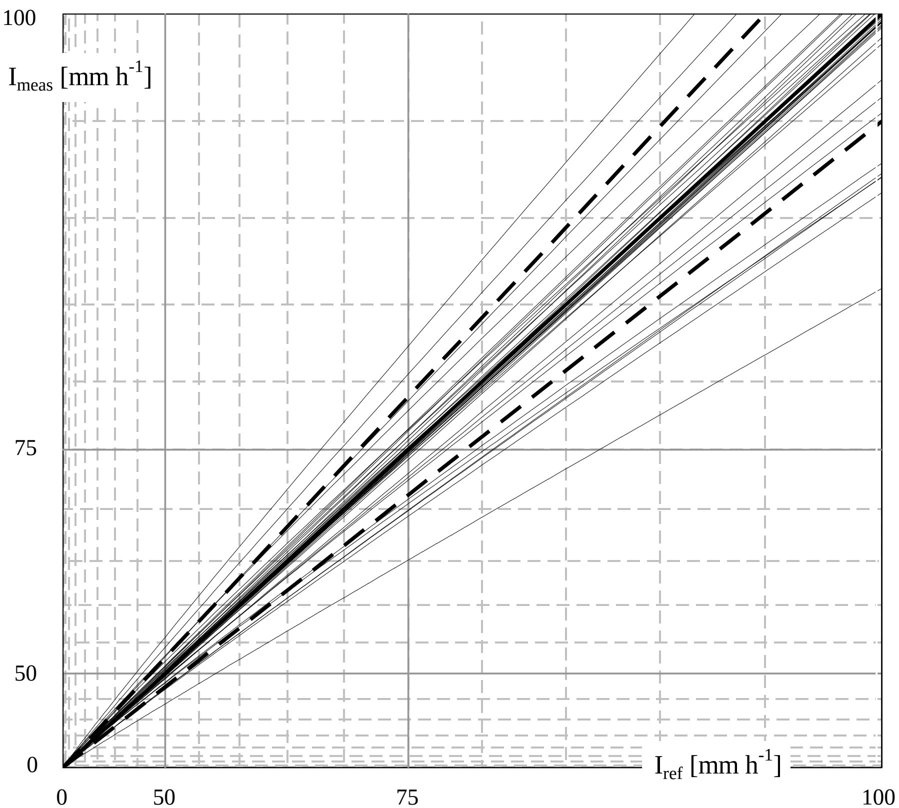


WMO

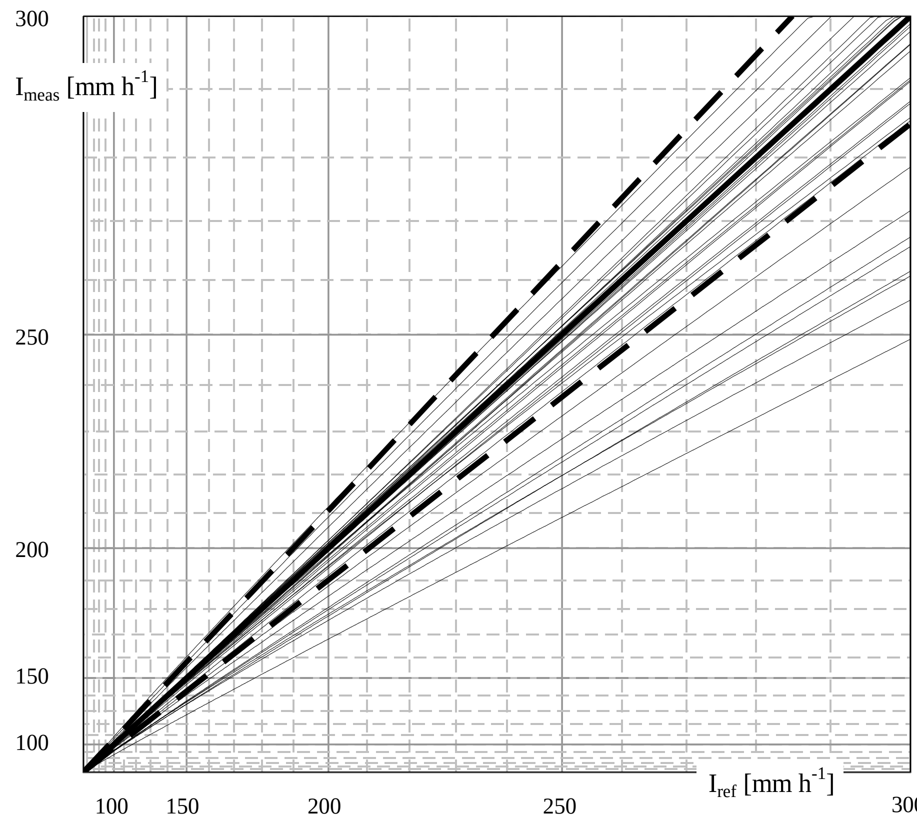
WMO Intercomparison in the Field

ALL CATCHING TYPE GAUGES

Range: 0-100 mm·h^{-1}



Range: 100-300 mm·h^{-1}

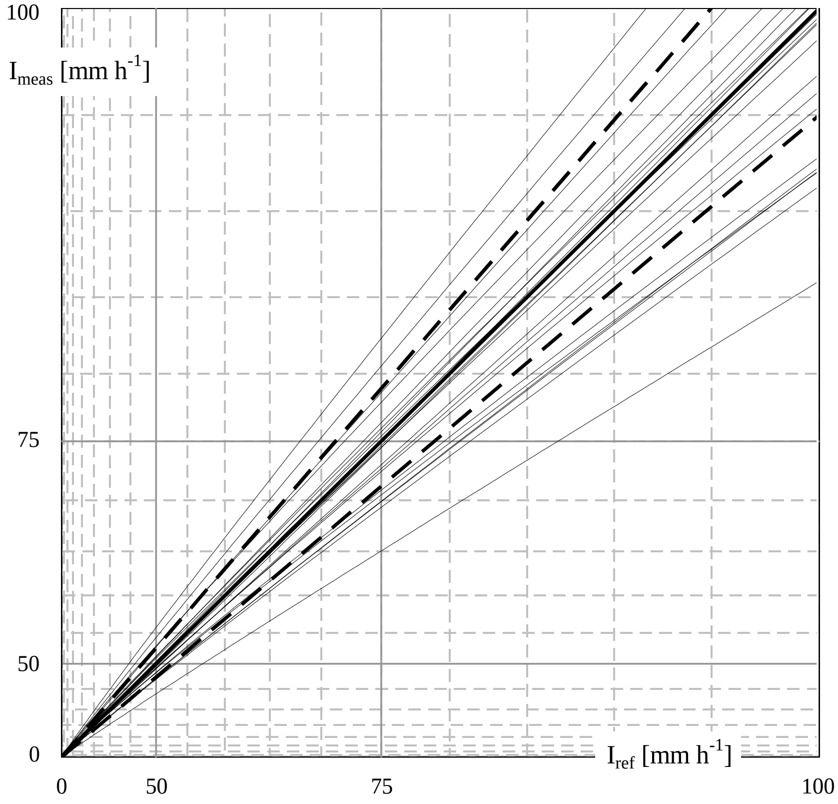


Note: both axes of the graphs are rescaled using a third order power law

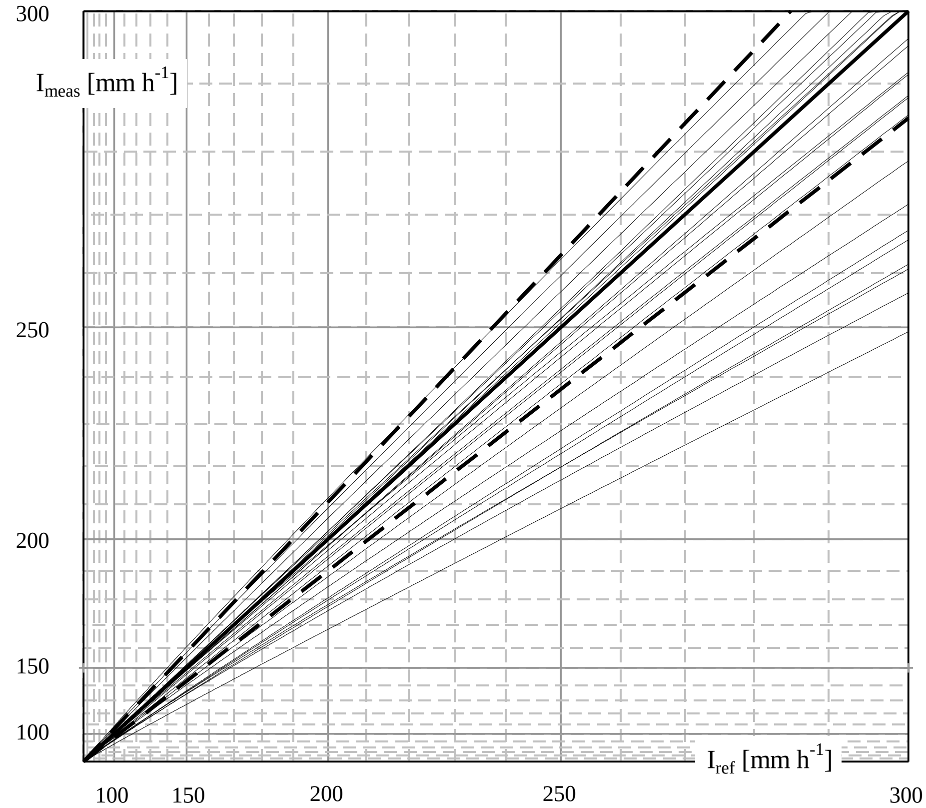
WMO Intercomparison in the Field

ALL THE TIPPING-BUCKET RAIN GAUGES

Range: 0-100 mm·h-1



Range: 100-300 mm·h-1

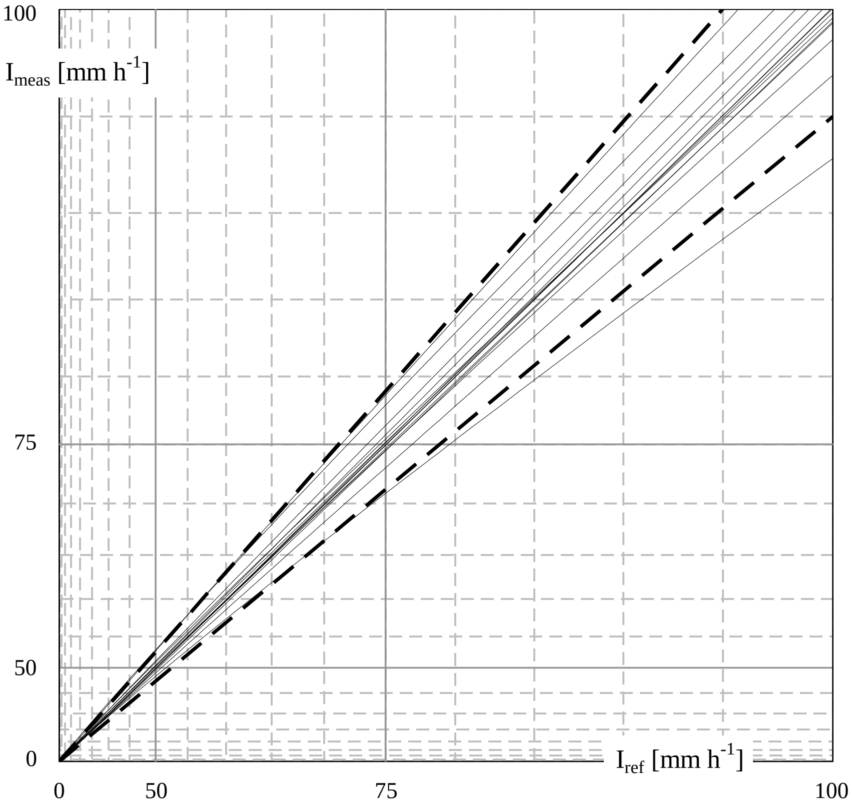


Note: both axes of the graphs are rescaled using a third order power law

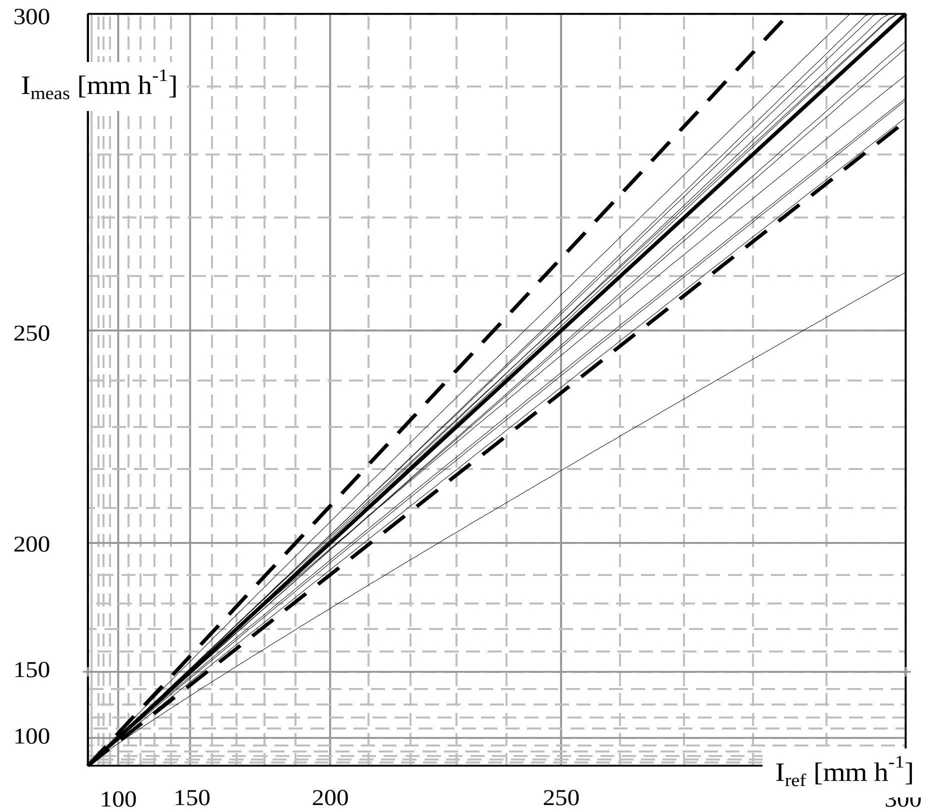
WMO Intercomparison in the Field

TIPPING-BUCKET RAIN GAUGES WITH CORRECTION APPLIED

Range: 0-100 mm·h-1



Range: 100-300 mm·h-1

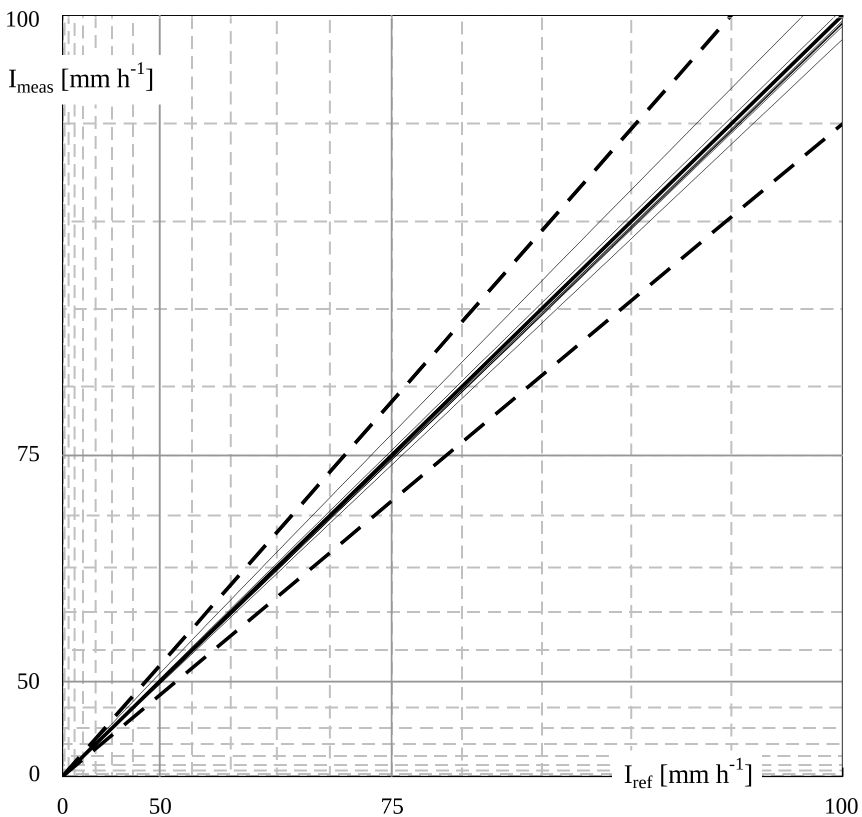


Note: both axes of the graphs are rescaled using a third order power law

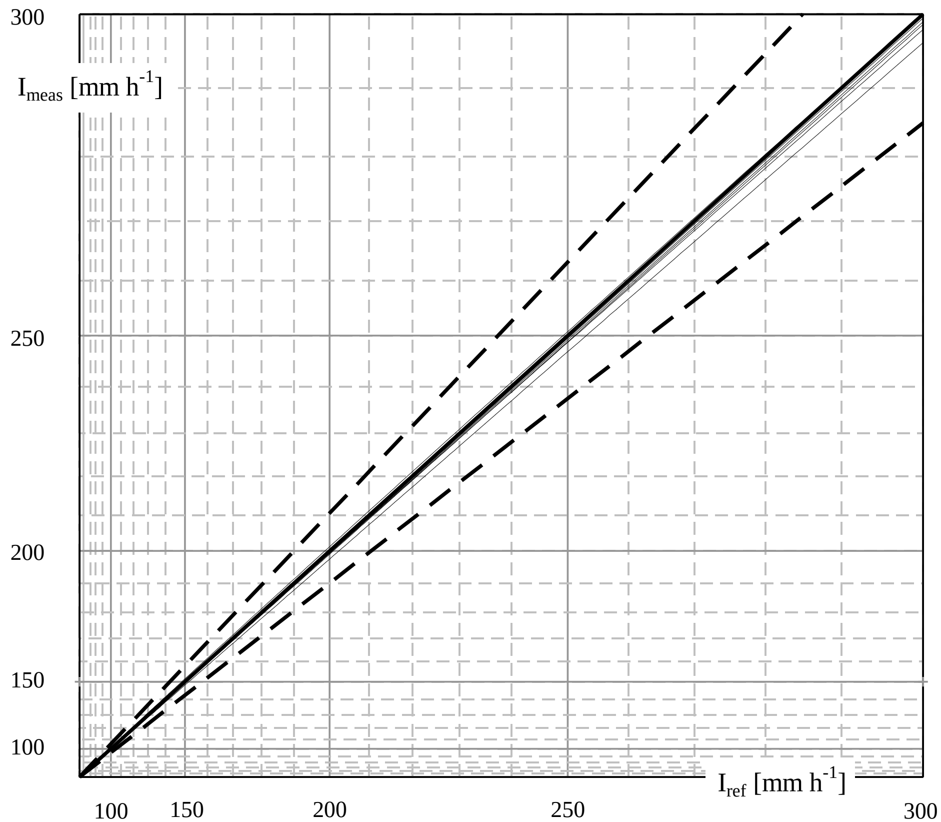
WMO Intercomparison in the Field

WEIGHING GAUGES

Range: 0-100 mm·h-1



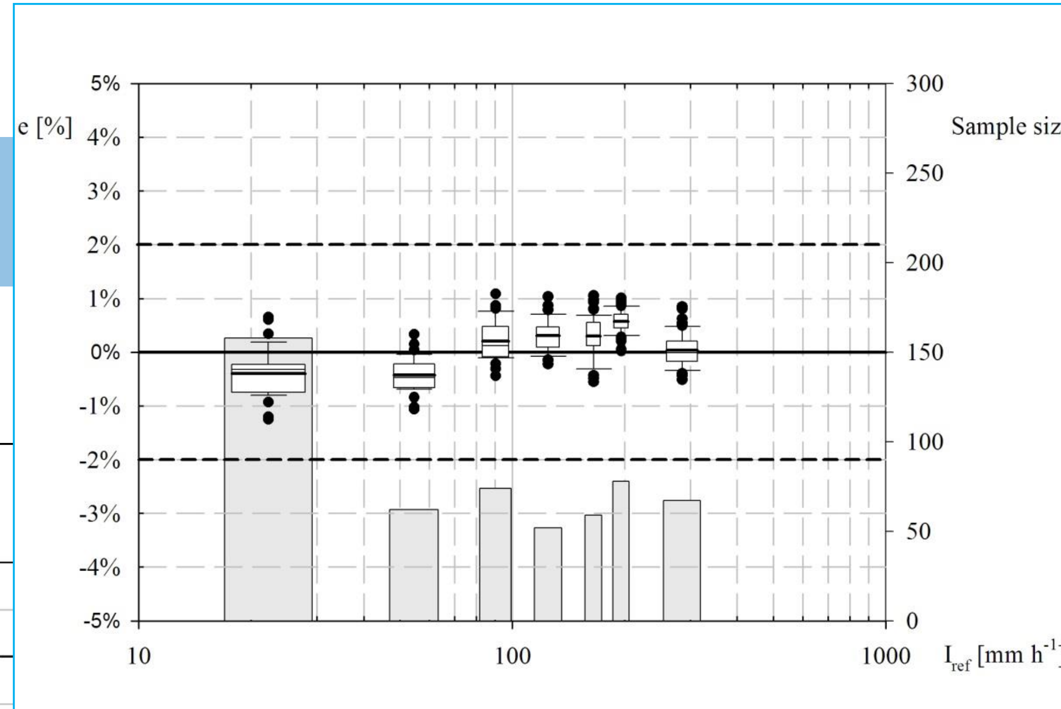
Range: 100-300 mm·h-1

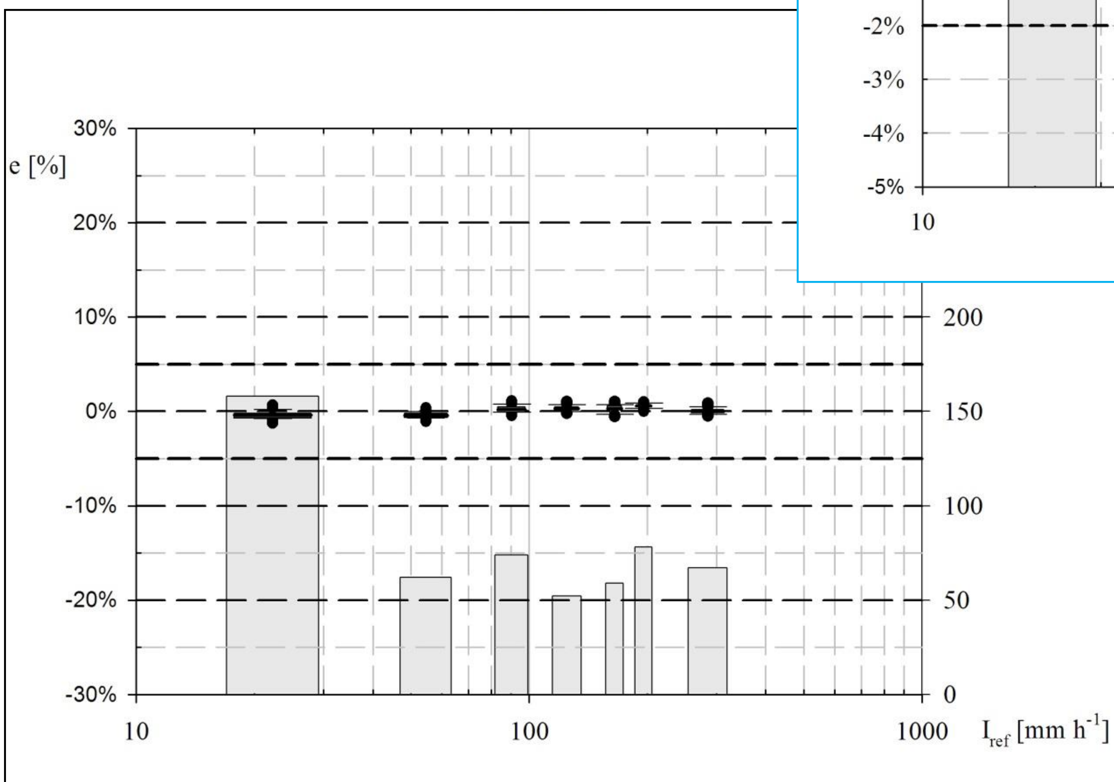


Note: both axes of the graphs are rescaled using a third order power law

WMO Intercomparison in the Field

Variability of the results at 1 minute resolution



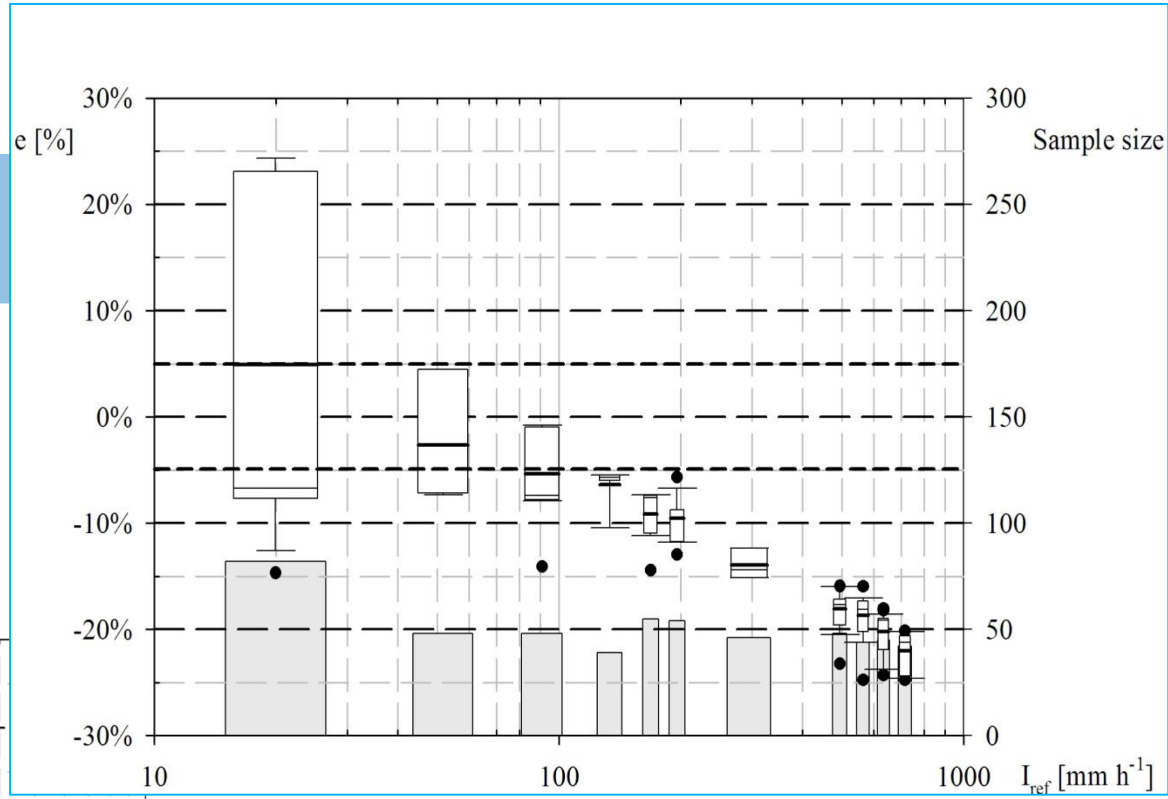


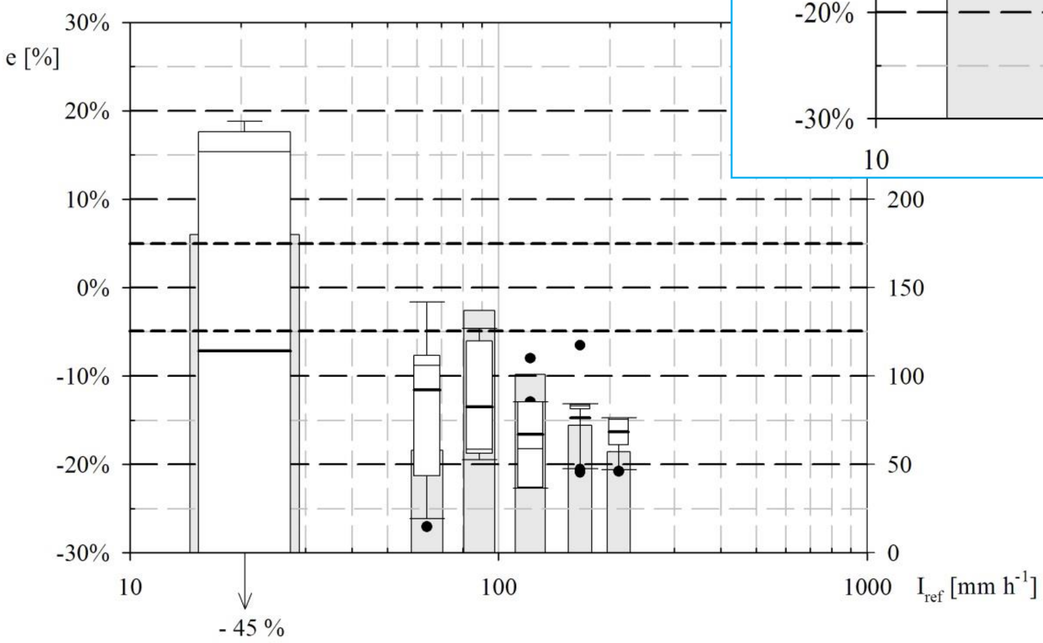
TBR with correction

WMO

WMO Intercomparison in the Field

Variability of the results at 1 minute resolution

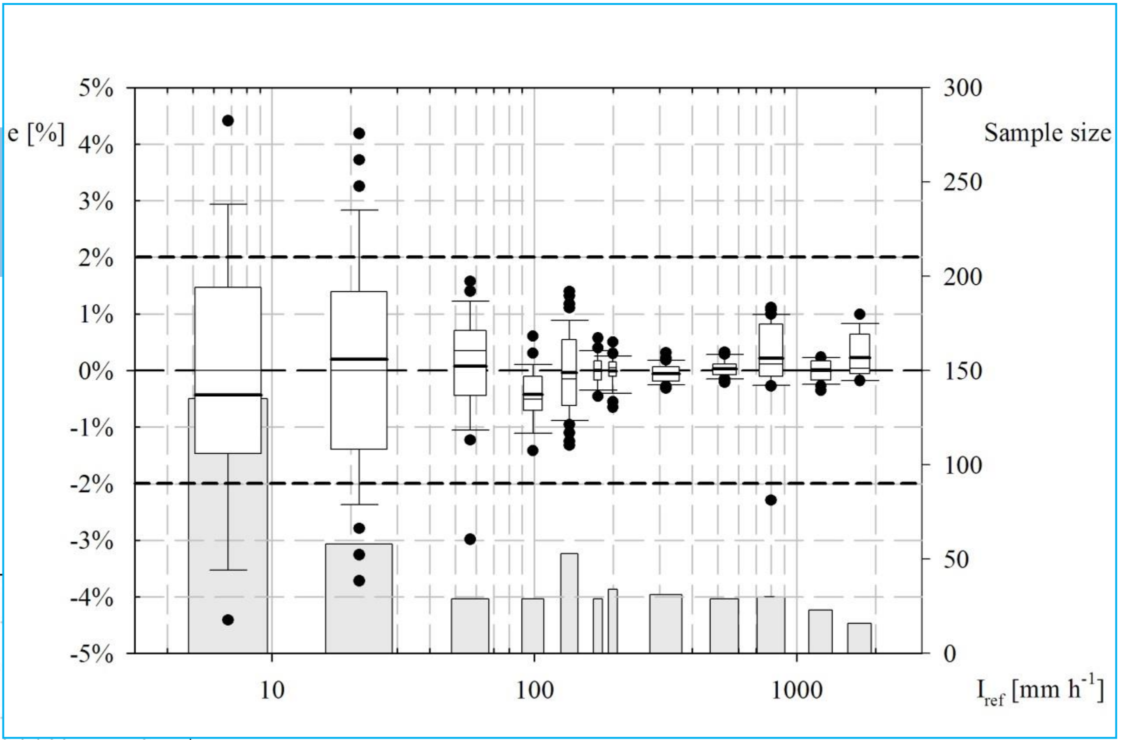


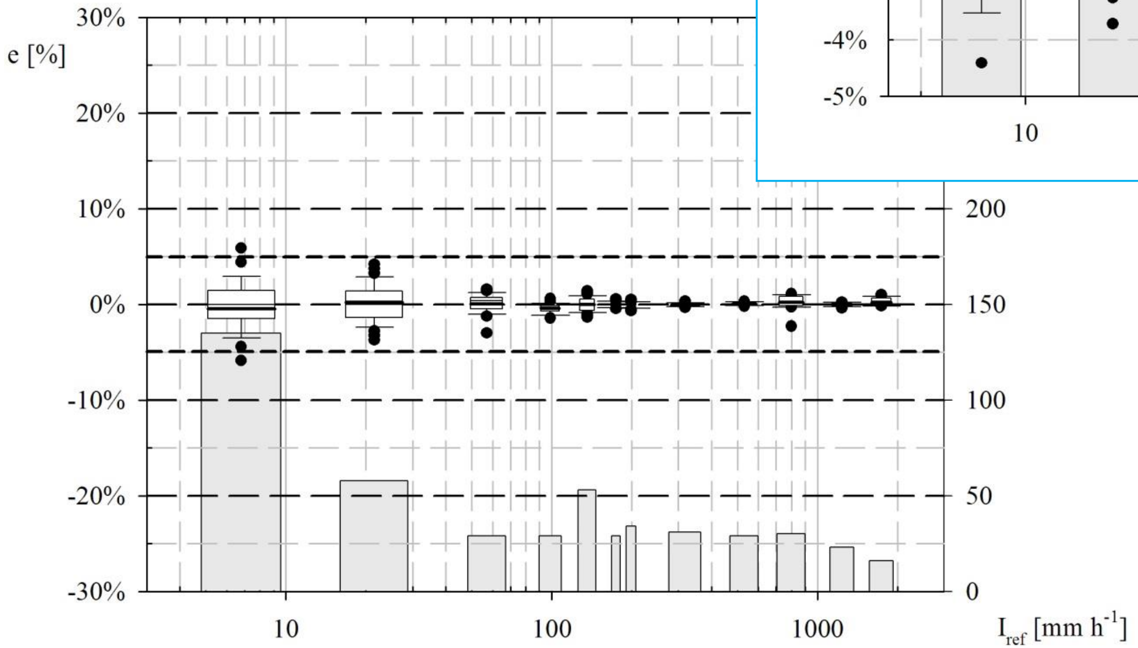


TBR with no correction

WMO Intercomparison in the Field

Variability of the results at 1 minute resolution



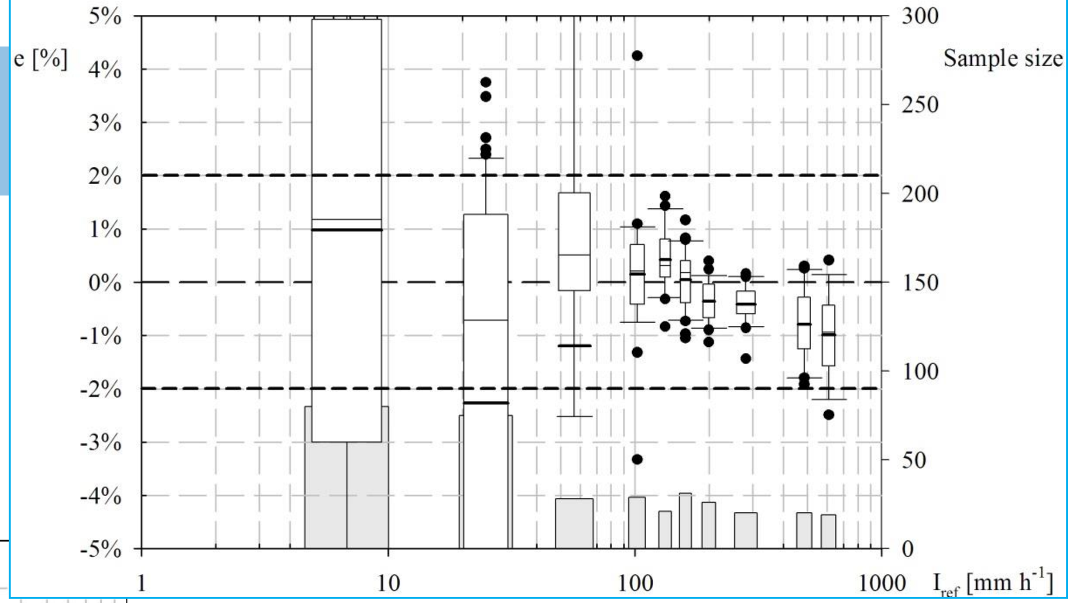


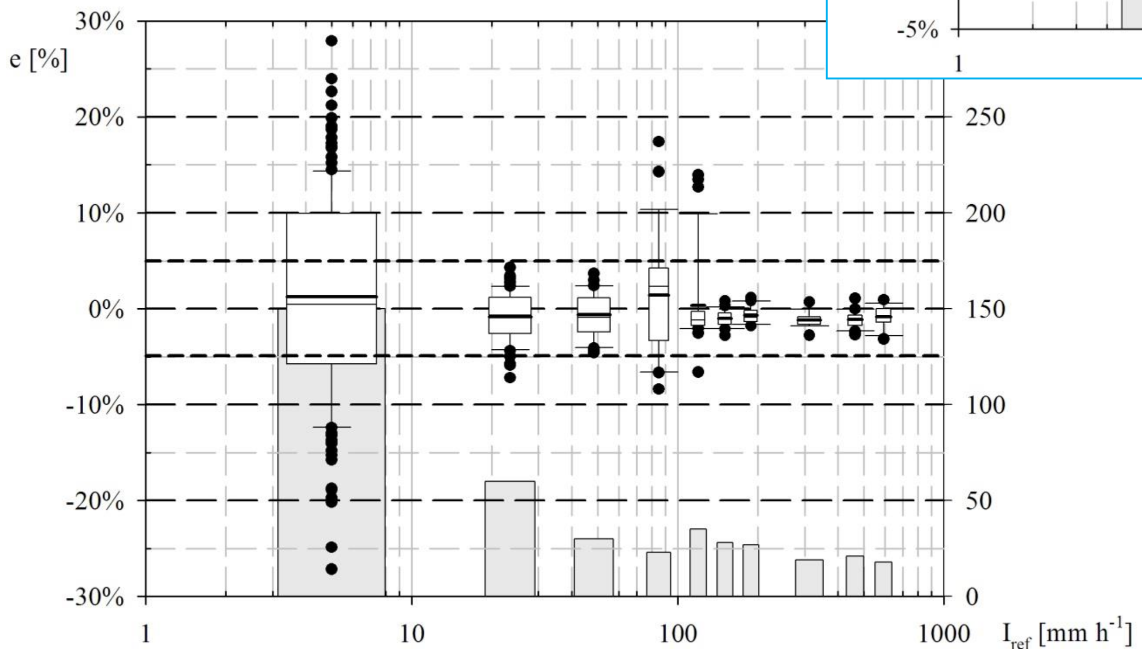
WG good dynamic response

WMO

WMO Intercomparison in the Field

Variability of the results at 1 minute resolution





WG scarce dynamic response

WMO

WMO Intercomparison in the Field

The reference (standard) “pit gauge"

WMO

According to EN13798:2002

- Avoids perturbation of the air flow at the instrument’s collector – wind effects (**JEVONS**, **1861**)

- Eliminates the influence of the shape of the gauge on the air flow

- The influence of the necessary collector on the surrounding air flow is riduced to a minimum because the surface of the collector is placed in the air layer with the minimum air movement.

- Also the influence of the turbulent vertical movements is reduced to a minimum, because these vanish in the vicinity of the ground.

WMO Intercomparison in the Field

WMO

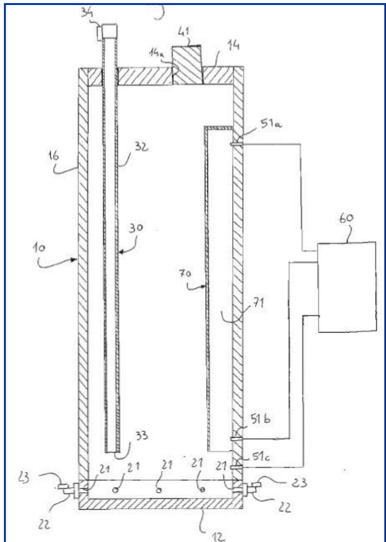
The field test site

WMO Intercomparison in the Field

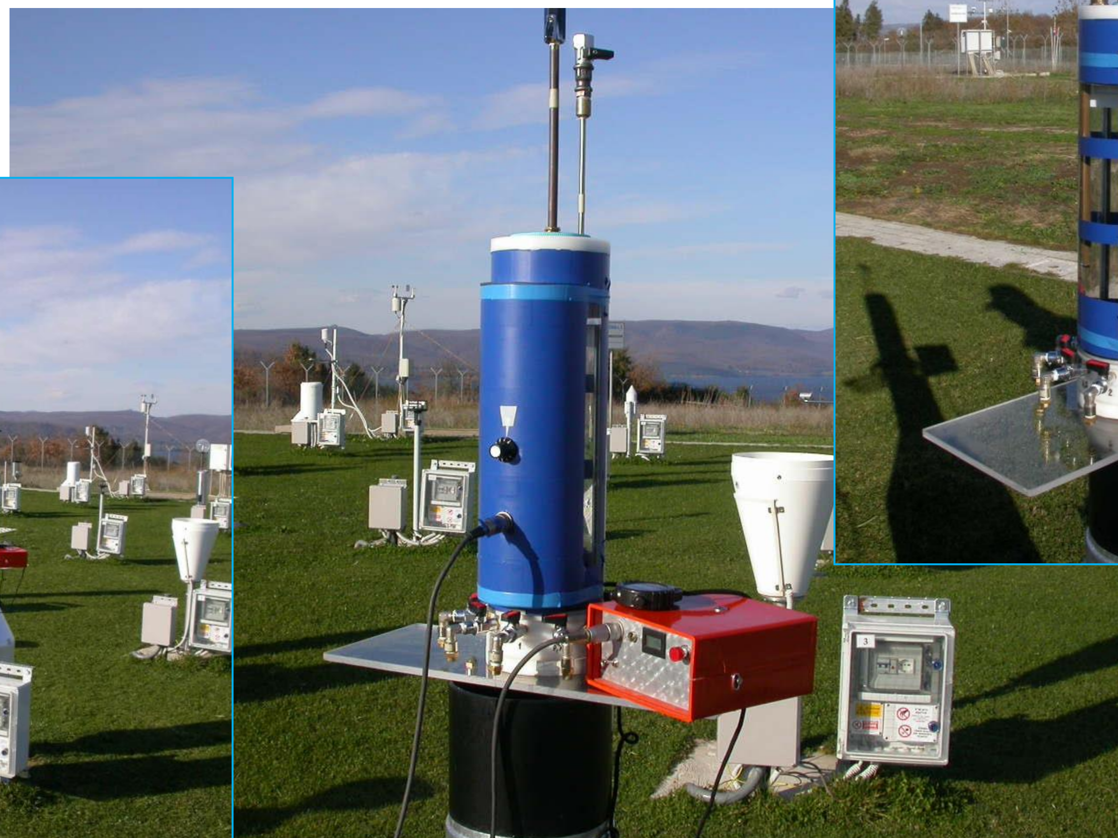
WMO

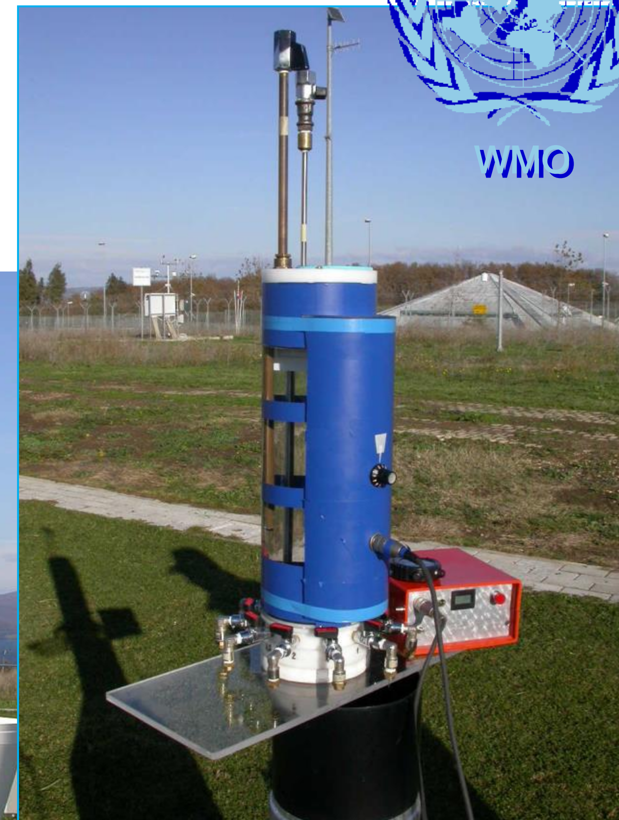
At the University of Genova a portable device was developed with the aim of performing **<u>in situ</u>** the same kind of tests that have been preliminary performed for the calibration of all catching type instruments in controlled laboratory conditions.

WMO Intercomparison in the Field



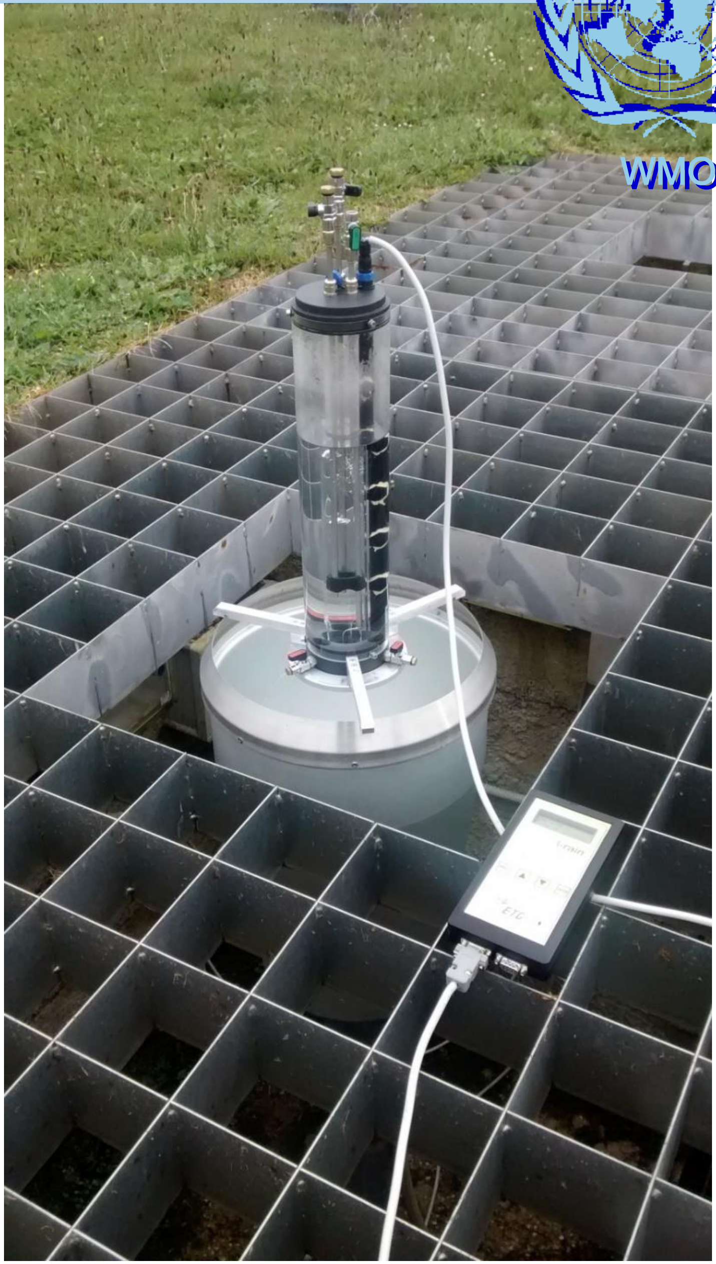
Stagi L. and Lanza, L.G. (2006). *Device for the generation of various known and constant liquid flow rates*. Patent University of Genoa n. 102006A000868, 7 December 2006



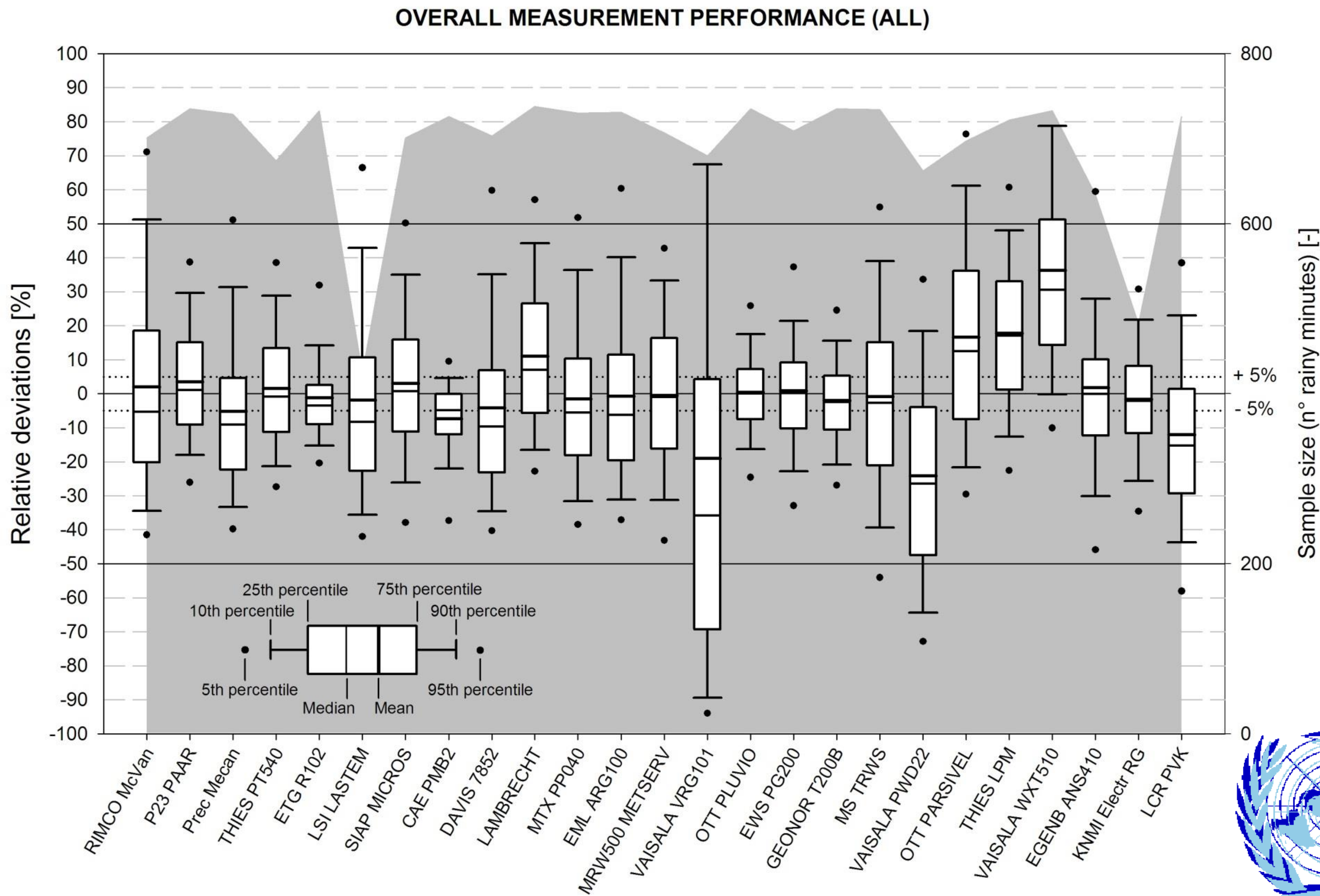


a WMO procedure was defined for performing tests in the field about the instrument calibration …

WMO Intercomparison in the Field

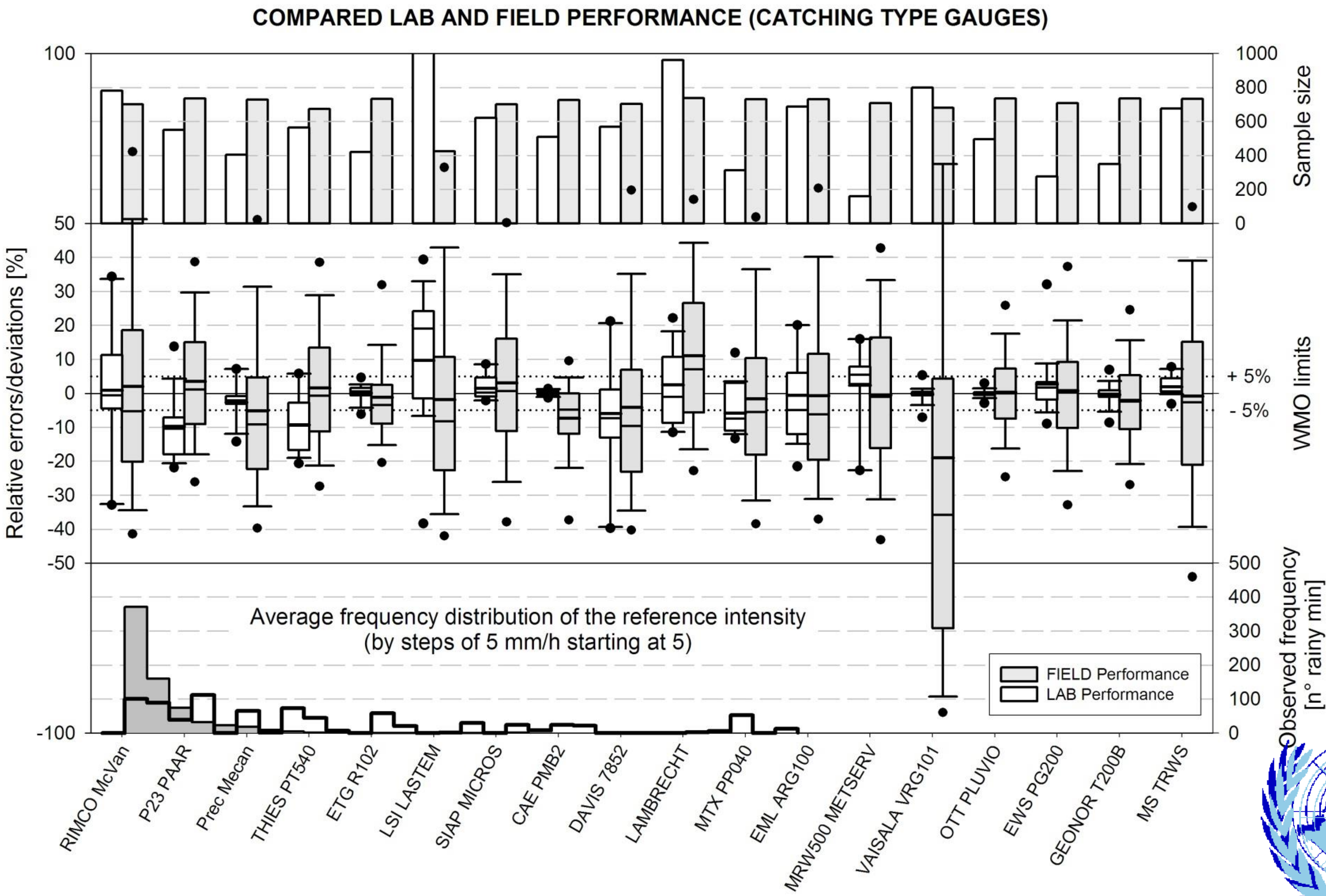


WMO Intercomparison in the Field



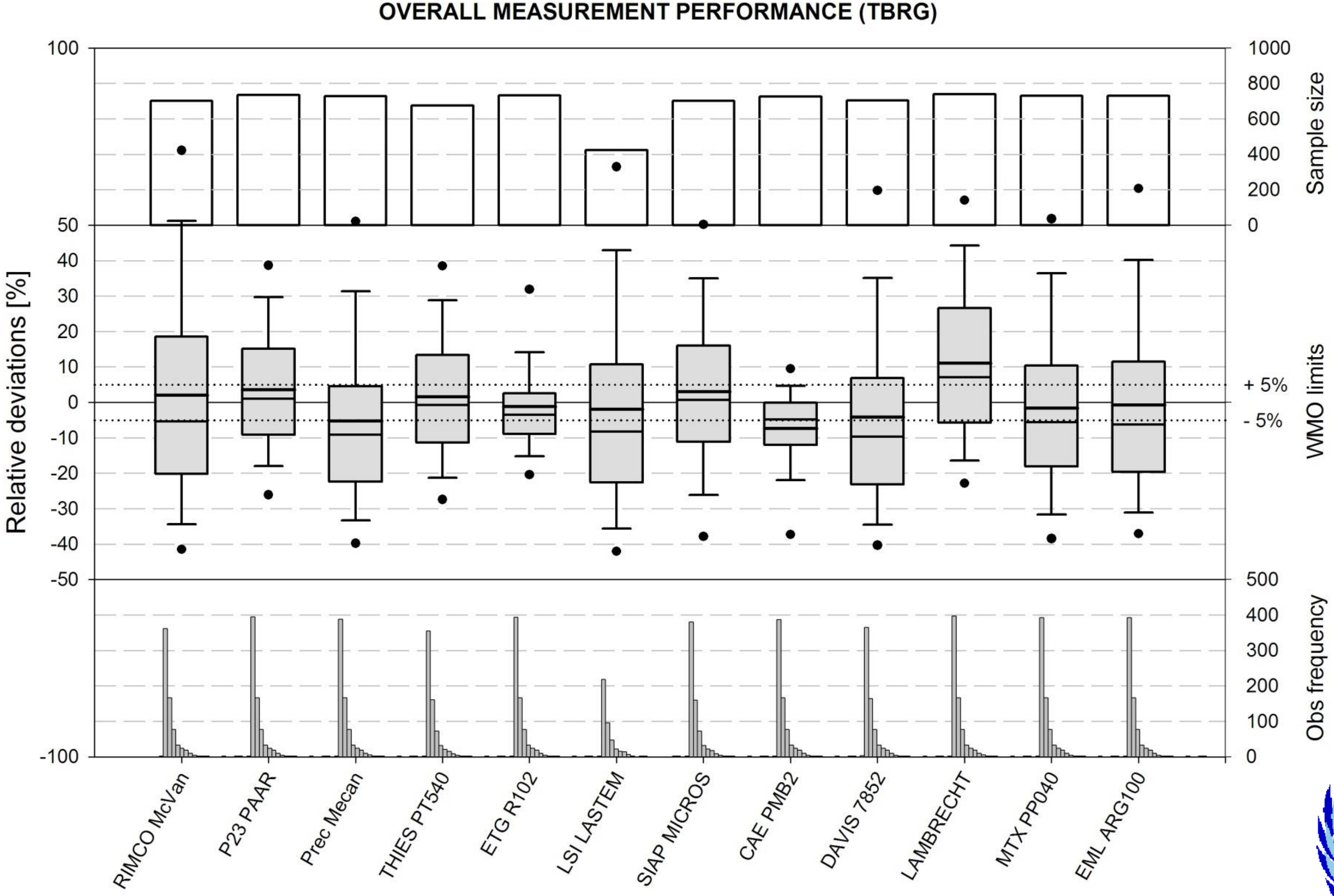
WMO

WMO Intercomparison in the Field



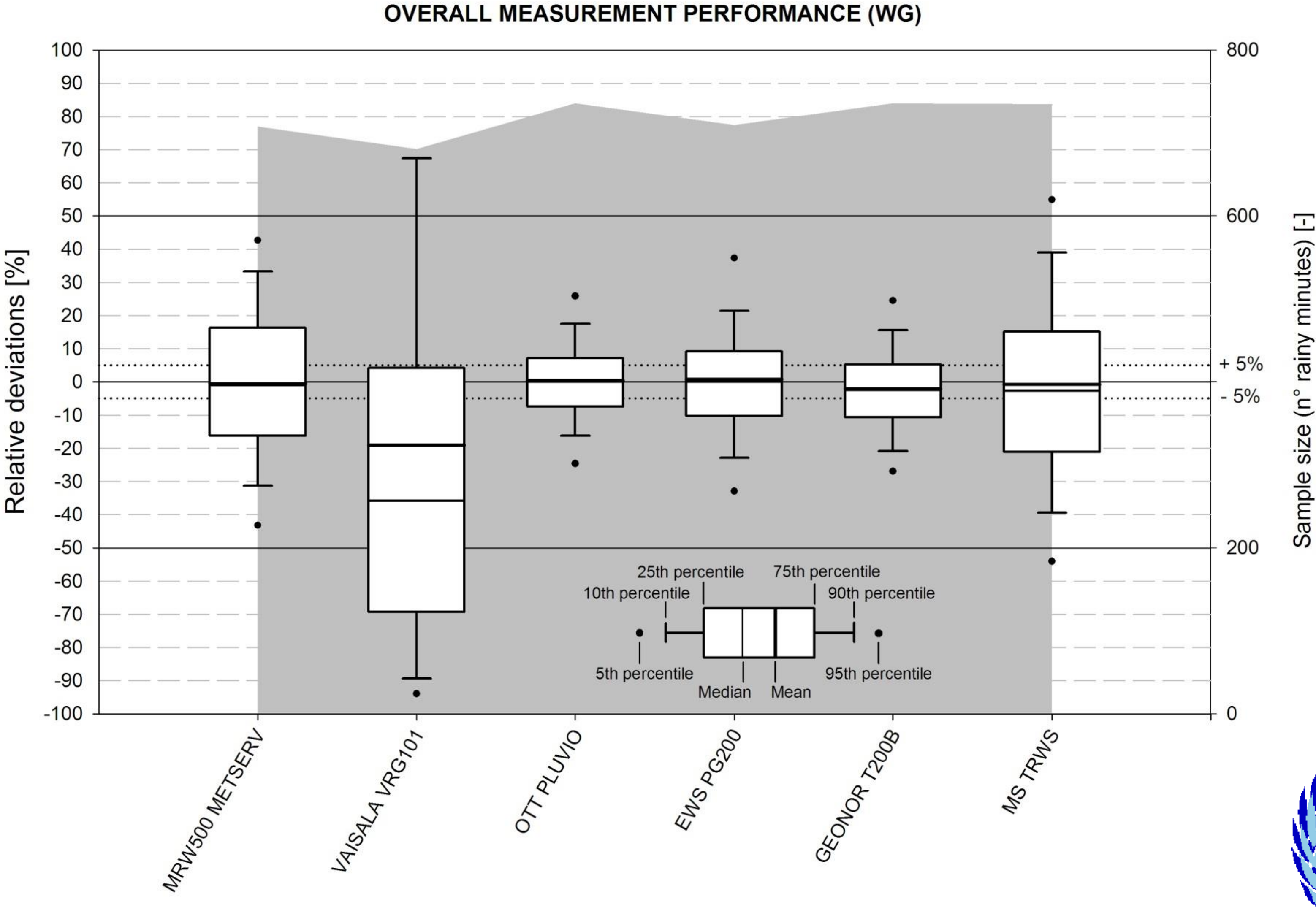
WMO

WMO Intercomparison in the Field



WMO

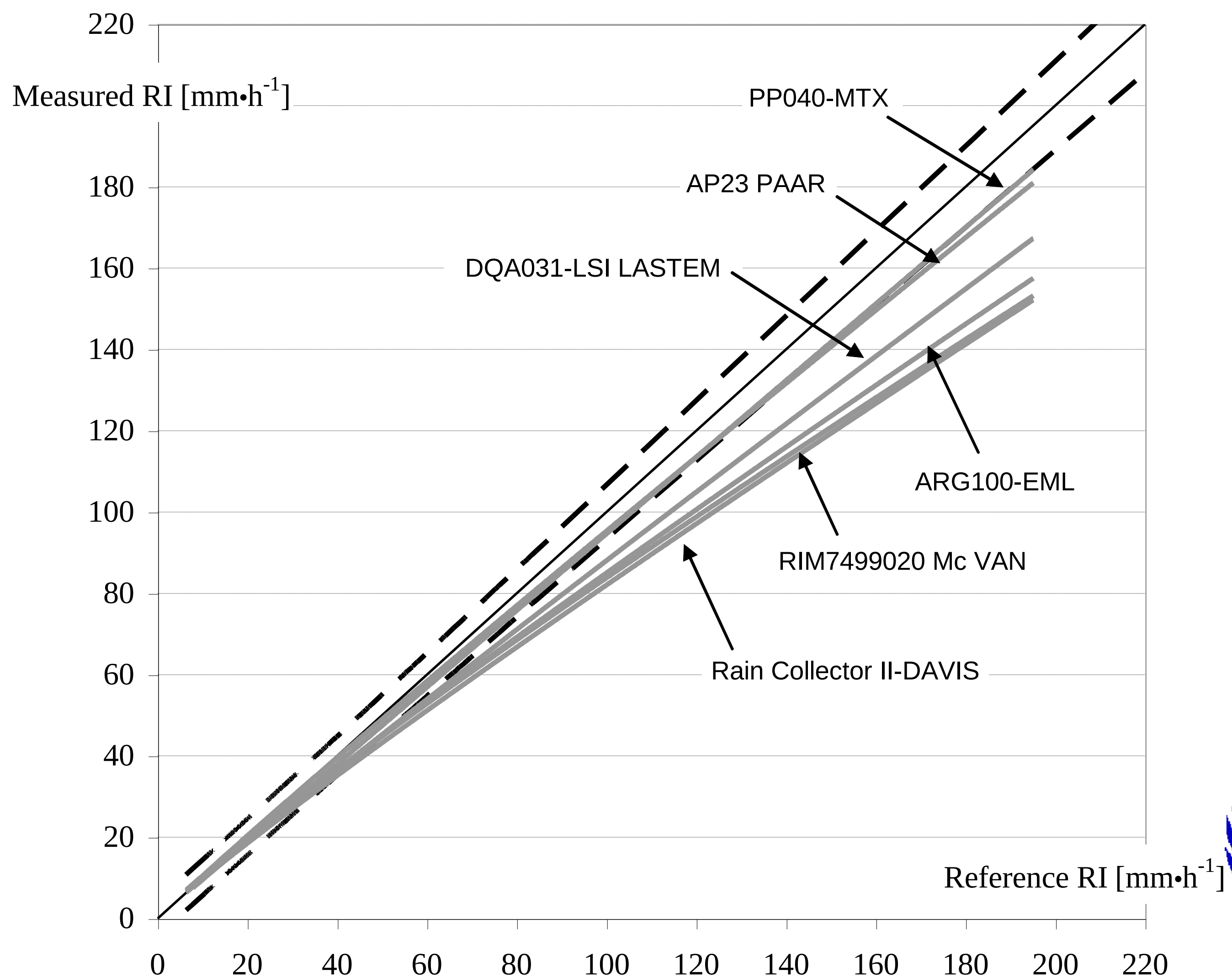
WMO Intercomparison in the Field



WMO

WMO Intercomparison in the Field

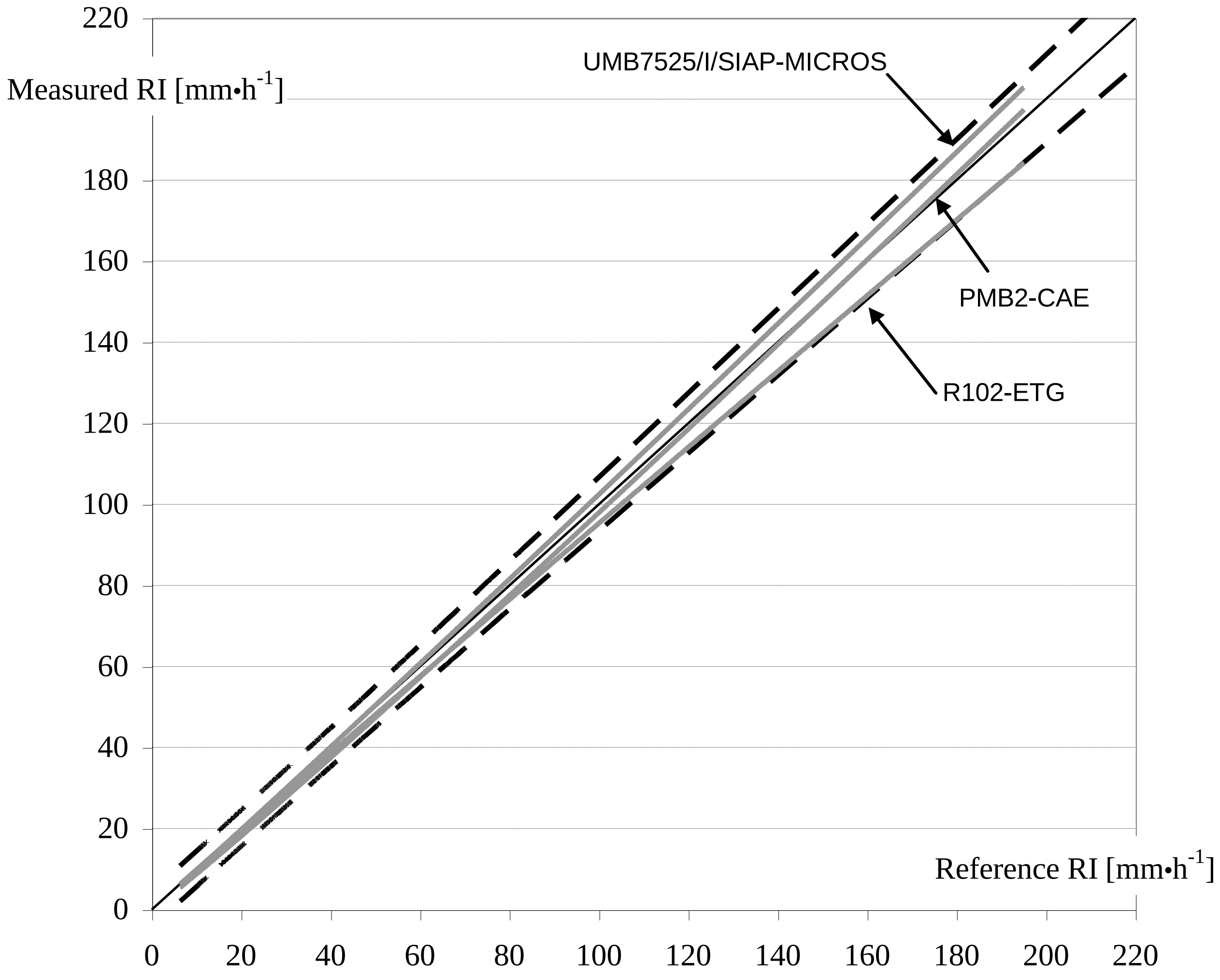
TIPPING-BUCKET (with no correction)



WMO

WMO Intercomparison in the Field

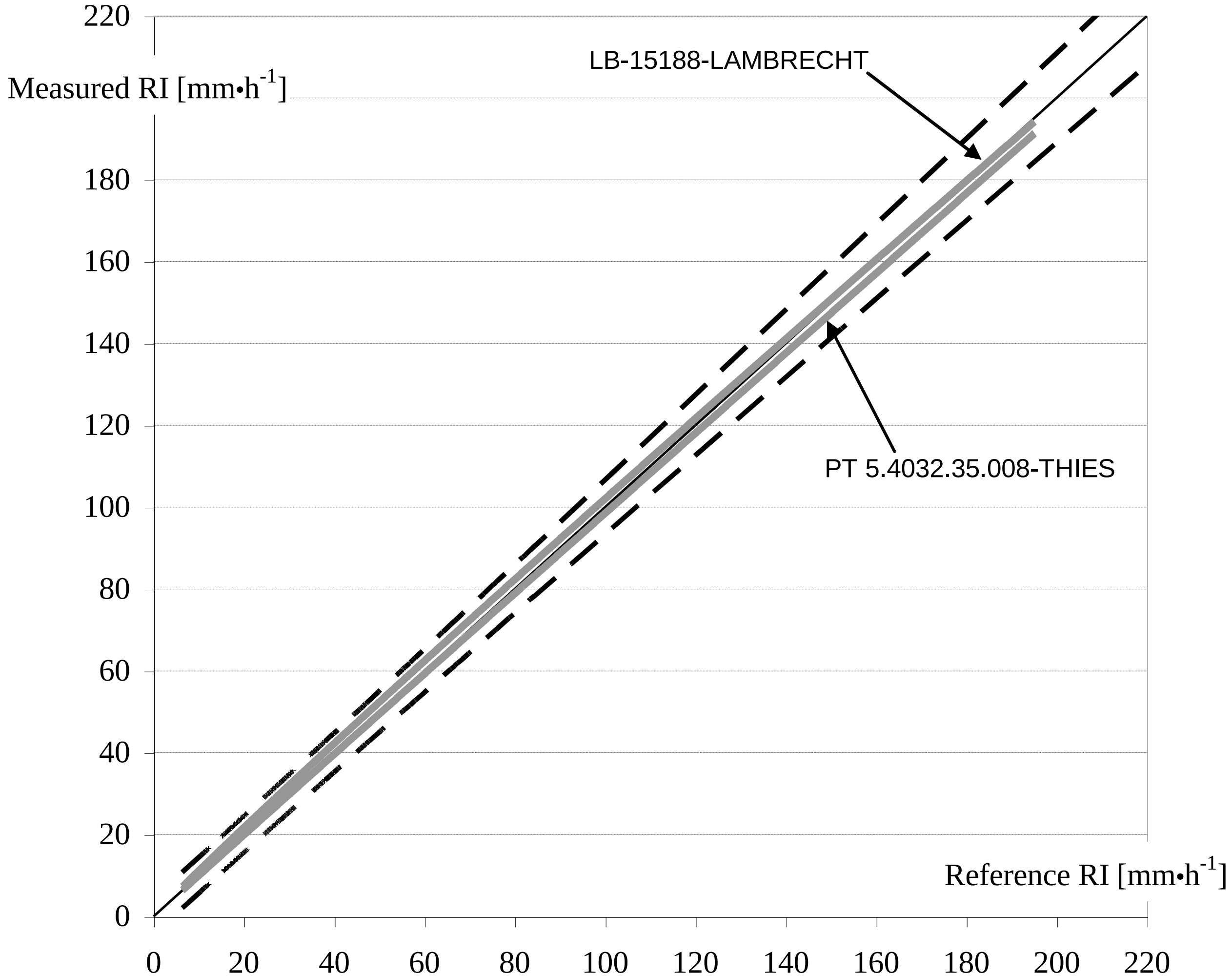
TIPPING-BUCKET (with software correction)



WMO

WMO Intercomparison in the Field

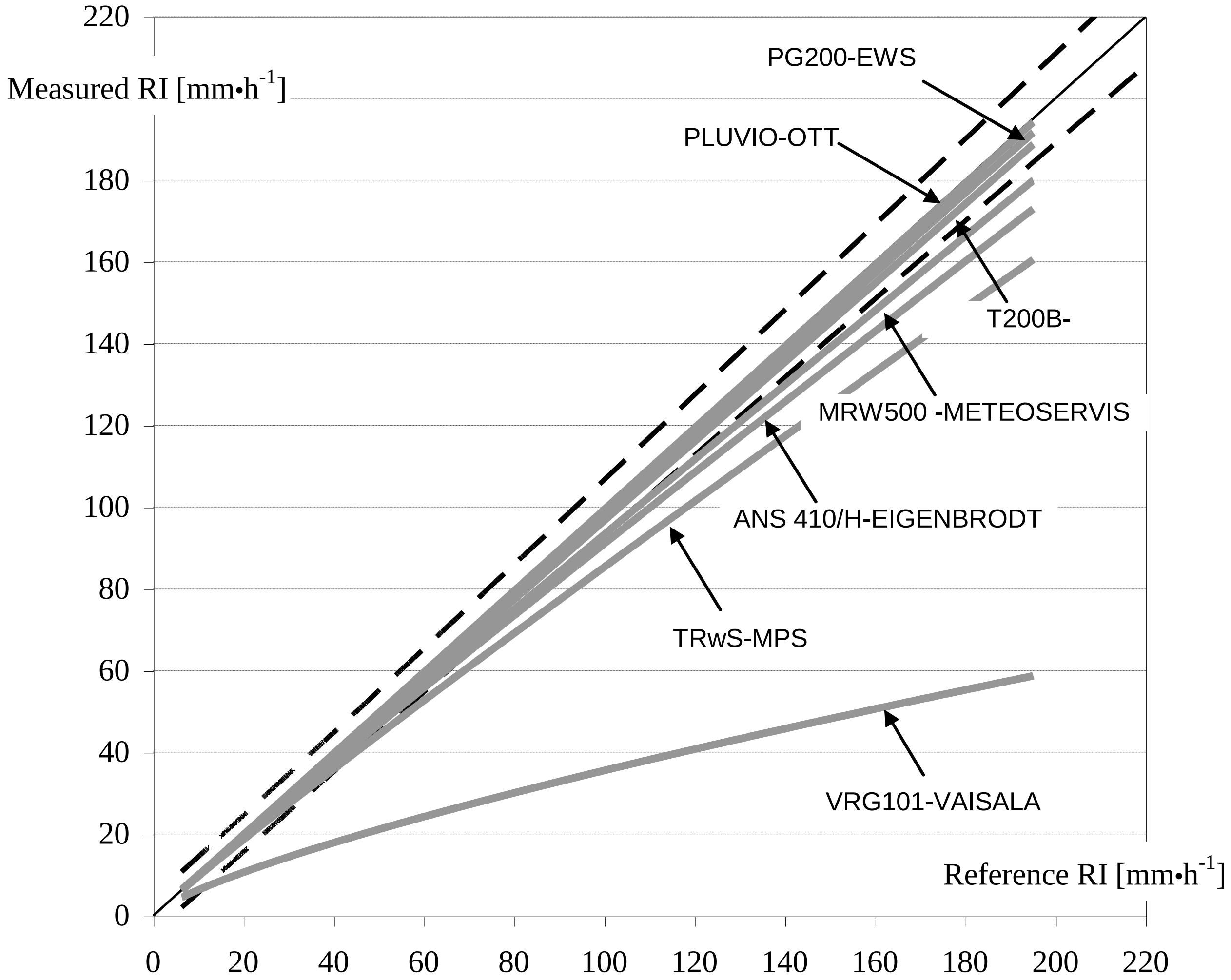
TIPPING-BUCKET (with pulse correction)



WMO

WMO Intercomparison in the Field

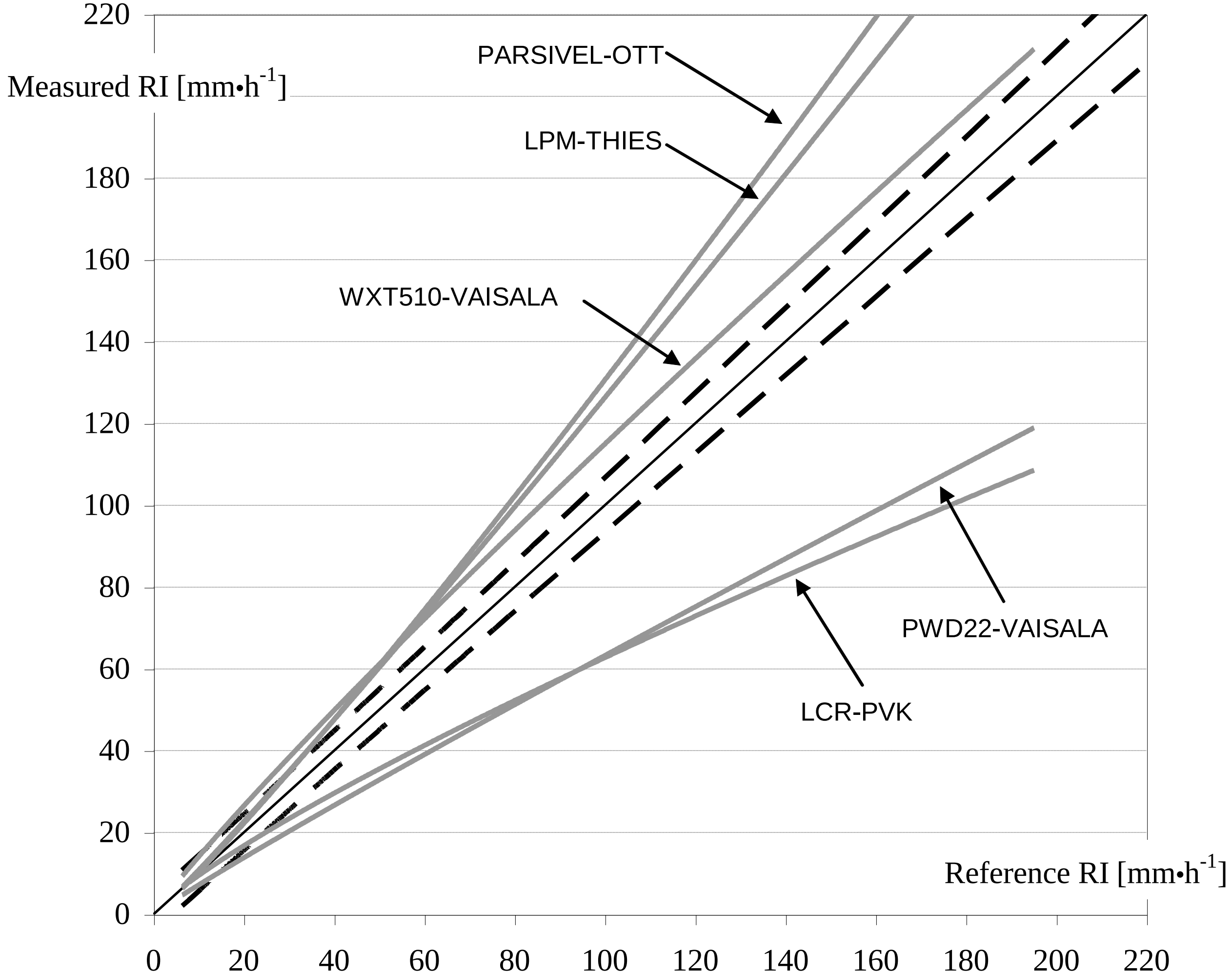
WEGHING GAUGES



WMO

WMO Intercomparison in the Field

NON CATCHING TYPE GAUGES



WMO

Prof. V.Vaisala Award 2010

Vuerich, E., Monesi, C., Lanza, L.G., Stagi, L. and E. Lanzinger (2009). *WMO Field Intercomparison of Rainfall Intensity Gauges.* World Meteorological Organisation – Instruments and Observing Methods Rep No. 99, WMO/TD No. 1504, pp. 286
(available at http://www.wmo.int/pages/prog/www/IMOP/reports.html)


WORLD METEOROLOGICAL ORGANIZATION

THIRD GRANTING OF THE

PROFESSOR DR VILHO VÄISÄLÄ AWARD

FOR THE DEVELOPMENT AND IMPLEMENTATION OF INSTRUMENTS AND METHODS OF OBSERVATION

2010

PRESENTED TO

Emanuele Vuerich
(Italian Meteorological Service, Italy)

Claudia Monesi
(University of Roma Tre, Italy)

Luca G. Lanza
(University of Genoa, Italy)

Luigi Stagi
(University of Genoa, Italy)

Eckhard Lanzinger
(German Weather Service, Germany)

IN RECOGNITION OF THEIR PAPER ENTITLED

"WMO Field Intercomparison of Rainfall Intensity Gauges"

In the name of the WORLD METEOROLOGICAL ORGANIZATION

1 September 2010 | PRESIDENT | SECRETARY-GENERAL

ORGANISATION MÉTÉOROLOGIQUE MONDIALE

WMO

References

- La Barbera, P., L.G. Lanza and L. Stagi (2002). Influence of systematic mechanical errors of tipping-bucket rain gauges on the statistics of rainfall extremes. *Water Sci. Techn.*, **45**(2), 1-9.
- Molini, A., Lanza, L.G. e P. La Barbera (2005). The impact of tipping bucket measurement errors on design rainfall for urban-scale applications. *Hydrological Processes*, **19**(5), 1073-1088.
- Molini, A., Lanza, L.G. e P. La Barbera (2005). Improving the accuracy of rain intensity records by disaggregation techniques. *Atmos. Res.,* **77**, 203-217.
- Lanza, L., Leroy, M., Alexandropoulos, C., Stagi, L. and Wauben, W. (2005). *Laboratory Intercomparison of Rainfall Intensity Gauges*. World Meteorological Organisation – Instruments and Observing Methods Rep. No. 84, WMO/TD No. 1304.
- Lanza, L.G. and L. Stagi (2008). Certified accuracy of rainfall data as a standard requirement in scientific investigations. *Advances in Geosciences*, **16**, 43-48.
- Lanza, L.G. and E. Vuerich (2009). The WMO Field Intercomparison of Rain Intensity Gauges. *Amos. Res.*, **94**, 534-543.
- Lanza, L.G. and L. Stagi (2009). High resolution performances of catching type rain gauges from the laboratory phase of the WMO Field Intercomparison of Rain Intensity Gauges. *Atmos. Res.*, **94**, 555-563.
- Lanza, L.G., Vuerich, E. and I. Gnecco (2010). Analysis of highly accurate rain intensity measurements from a field test site. *Advances in Geosciences*, **25**, 37-44.
- Lanza, L.G. e Vuerich, E. (2012). Non-parametric analysis of deviations of one-minute rain intensity measurements from the WMO field intercomparison. *Atmos. Res.*, **103**, 52-59.
- Lanza, L.G. e Stagi, L. (2012). Non-parametric error distribution analysis from the laboratory calibration of various rainfall intensity gauges. *Water Sci. Tecn.*, **65**(10), 1745-1752.

References

- Colli, M., Lanza, L.G. and P.W. Chan (2013). Co-located tipping-bucket and optical drop counter RI measurements and a simulated correction algorithm. Atmos. Res., 119, 3-12.
- Colli, M., Lanza, L.G. and P. La Barbera (2013). Performance of a weighing rain gauge under laboratory simulated time-varying reference rainfall rates, Atmos. Res., 131, 3-12
- Colli, M., Lanza, L.G., La Barbera, P. and P.W. Chan (2014). Measurement accuracy of weighing and tipping-bucket rainfall intensity gauges under dynamic laboratory testing. Atmos. Res., 144, 186-194.
- Santana, M.A.A., Guimarães, P.L.O., Lanza, L.G. and E. Vuerich (2015). Metrological analysis of a gravimetric calibration system for tipping-bucket rain gauges. Meteorol. Appl., 22, 879-885.
- Stagnaro, M., Colli, M., Lanza, L.G. and P.W. Chan (2016). Performance of post-processing algorithms for rainfall intensity measurements of tipping-bucket rain gauges. J. Atmos. Meas. Techn., 9, 5699–5706.

for further information:

http://www.precipitation-intensity.it

luca.lanza@unige.it

Wrap-up and perspectives

Generally, ***precipitation gauges*** (all types) ***are not satisfactorily calibrated***.

Rainfall and snowfall are still widely measured today with ***much lower accuracy*** than the present knowledge and technology would actually permit.

Common measurement procedures :

- do not correct/adjust for **SYSTEMATIC BIASES**
- do not report the measurement **UNCERTAINTY**

⇓

TRACEABILITY of the measurement
to the international standards can not be guaranteed

Wrap-up and perspectives

Before TRACEABILITY can be correctly addressed we need:

1) **BIAS assessment and correction/adjustment** *for catching type instruments:*

a) dynamic calibration in the laboratory

b) Interpretation and correction algorithms

TBRs	→	time-of-tip algorithms and correction for SME
WGs	→	time constant assessment & step response correction
Drop counters	→	drop volume calibration and correction
(…)		

c) correction for wind-induced undercatch

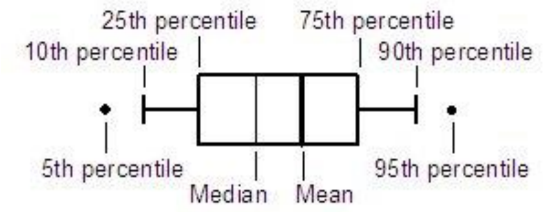
d) compliance with WMO, CEN, … ISO ?

NO replacement of the existing instruments is generally required to achieve all of the above

Wrap-up and perspectives

2) UNCERTAINTY assessment
for catching type instruments:

a) Calibration uncertainty → from dynamic calibration



b) Uncertainty sources in the field → from intercomparison campaigns (WMO FI/RI, SPICE, …) against a suitable reference

e,g, a future regional intercomparison of Rainfall Intensity gauges in Region II & V
(in collaboration with the WMO/CIMO Lead Centre on Precipitation Intensity)

---

*For the **CALIBRATION***
of non-catching type instruments →

(stay tuned …)