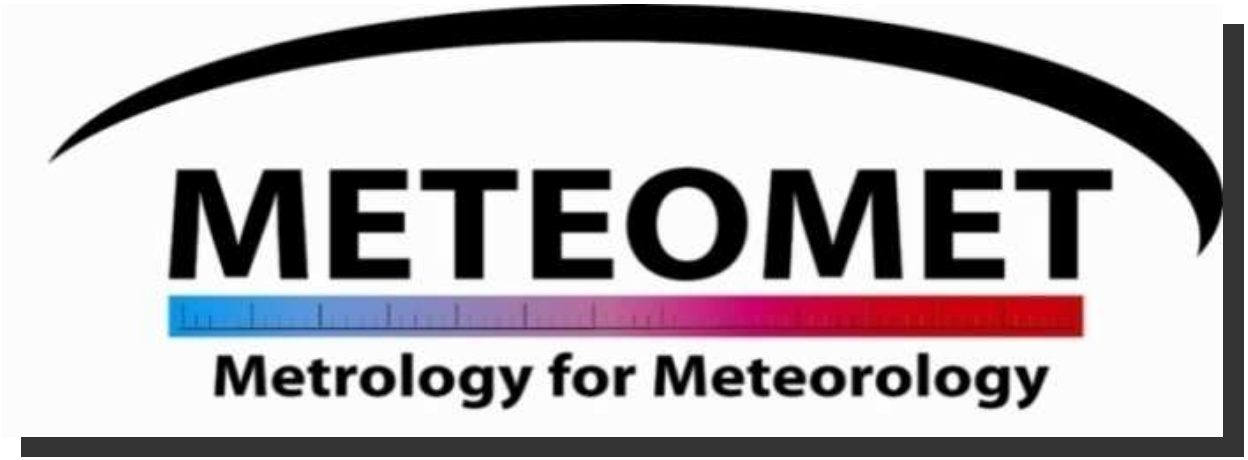
Andrea Merlone

A New Challenge for Meteorological Measurements:



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The Project

MeteoMet is an **EMRP** Project

Call 2010: **Metrology for Environment**

Start date: 1 October 2011

funded by **European Community** and **EURAMET**

European Association of National Metrology Institutes (EURAMET) is a European Regional Metrology Organisation. It coordinates the cooperation of National Metrology Institutes (NMI) of Europe in fields of research, traceability to the SI units, calibration and measurement capabilities, knowledge transfer

European Metrology Research Programme (EMRP) is a metrology-focused European programme of coordinated R&D

February 2010. PRT

EURAMET
European Association of National Metrology Institutes

Phase I. 117 *Proposed Research Topic*

EMRP selects, groups, excludes

Phse II. 18 *Selected Research Topic.*

July 2010 Partnering meeting.
JRP preparation

JRP Submitted for evaluation

November 2010. Review conference

Phse III. 9 *Joint Research Project* funded

METEOMET
Metrology for Meteorology

1 October 2011.
Project Sart

Partners

Coordinator :

Andrea Merlone - INRiM- Italy

Funded Partners:

Centro Español de Metrologia	Spain
Czech Metrology Institute	Czech Republic
Danish Technological Institute	Denmark
Główny Urząd Miar	Poland
Instytut Niskich Temperatur i Badan Strukturalnych	Poland
Instituto Nacional de Técnica Aeroespacial	Spain
Istituto Nazionale di Ricerca Metrologica	Italy
Justervesenet	Norway
Laboratoire Commun de Métrologie	France
Centre Tec. des Industries Aérauliques et Thermique	France
Metrology Institute of Slovenia - Univ Ljubiana	Slovenia
Mittatekniikan keskus'	Finland
National Physical Laboratory	United Kingdom
Physikalisch-Technische Bundesanstalt	Germany
Scientific Metrology	Belgium
Slovensky Metrologicky Ustav	Slovak Republic
Technical Research Institute of Sweden	Sweden
Ulusal Metroloji Enstitüsü	Turkey

METEOMET
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Partners

Collaborators:

Royal Meteorological Institute of Belgium	Belgium
Bulgarian National Insitute of Meteorology	Bulgaria
Czech Hydrometeorological Institute	Czech Republic
Danish Meteorological Institute	Denmark
Vaisala Oyj	Finland
Finnish Meteorological Institute	Finland
MétéoFrance	France
METEOMODEM	France
Istituto di Scienze dell'Atmosfera e del Clima	Italy
Università di Milano	Italy
Società Meteorologica Italiana	Italy
CAE	Italy
Università degli studi di Cassino	Italy
Galileo ambiente	Italy
Meteo Duomo	Italy
Climate Consulting	Italy
Università di Torino	Italy
Michell Italia S.r.l.	Italy
Extreme Energy Events Project (Uni. Torino)	Italy
National Metrology Institute	Japan
Japan Meteorological Agency	Japan
Environmental Agency of the republic of Slovenia	Slovenia
C3-Universidad Rovira i Virgili, Tarragona	Spain
Agencia Estatal de Meterorologia	Spain
Swedish Meteorological and Hydrological Institute	Sweden
Met. Office Research Unit	UK
Department of Meteorology, University of Reading	UK
University of Edinburgh	UK
Rotronic	UK
NOAA	USA
Turkish State Meteorological Service	Turkey
International Surface Temperatures Initiative	INT
GCOS-GRUAN	INT
WMO-CIMO	INT

Unfunded Partners:

Aarhus Universitet	Denmark
Chalmers University of Technology	Sweden
Uniwersytet Wrocławski, Zakład Klimatologii i Ochrony Atmosfery	Poland

REG

Comitato EV-K2-CNR
Karlsruher Institut für Technologie
Aarhus Universitet

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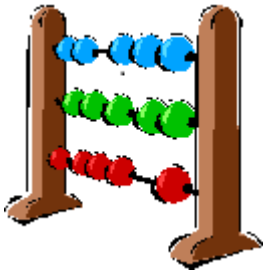
MeteoMet Numbers

Budget: 4 413 683 €

- 18 Funded Partner
- 3 Un-funded Partners
- 3 REG Home Org.
- 34 Collaborators

Biggest EMRP Consortium ever!



- 6 Work packages
- 30 Tasks
- 65 Deliverables

A huge amount of work…

- 377 man/women-months
- 3 REGs -> 42 months
- Total 419 man-months

35 years!

Aim

The project is focused on the traceability of measurements involved in the climate change evaluation: surface and upper air measurements of temperature, pressure, humidity, wind speed and direction, and reciprocal influences between measurands

- ✓ achievement of robust climate data with measurement uncertainty budget
- ✓ accurate interpretation of historical temperature data series

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Background

2010 April 1.

A piece of history in science is jointly written by WMO[1] and BIPM[2].

WMO signs the Mutual Recognition Arrangement (MRA)

1. World Meteorological Organization
   Official United Nations' authoritative voice on weather, climate and water, scientific organization.

2. Bureau International des Poids et Mesures

World Meteorological Organization
Working together in weather, climate and water

MRA

BIPM

Michel Jarraud, Secretary General of the WMO, signed the Arrangement on behalf of the WMO. The signing ceremony took place on *1 April 2010*

Left to right: Len Barrie (WMO), Andrew Wallard (Director BIPM),
Michel Jarraud (Secretary General WMO), Ernst Göbel (President CIPM), Wenjie Zhang (WMO)

2010 May 4-7. XXV Comité Consultatif de Thermométrie (CCT) meets and prepares a significant reccomendations for the CIPM[1].

•**CCT Recommendation to CIPM T3 (2010):** “encourage NMIs to face activities related to the traceability, quality assurance, calibration procedures for quantities involved in the climate studies; support a strong cooperation between NMIs and Meteorological Institutions”

1. Comité International des Poids et Mesures

Needs

Data users requirements:

Define measurements standard

Traceability to national standards

Define Calibration procedures

MeteoMet Key point:

The success of any climate investigation depends upon the availability of reliable data!

Data reliability

Uncertainty-evaluation methods

Improve data quality, continuity and homogeneity

Interpretation historical data series

European common approach

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Objectives

- Traceability to national standards for climate parmeters
- Definition of measurement protocols in line with WMO
- Uncertainty evaluation for climate measurements
- Calibration of weather stations and reference radiosondes
- Improved humidity sensors and calibration methods
- Development of novel instruments for ground based observations
- Assessment of historical temperature data series and data homogenization (type B uncertainty inclusion)
- Improve communication and co-operation between Meteo Institute and NMI

Metrological support to climate monitoring

A large Consortium

Why?

- ❖Realization of a wide scale European monitoring system.
- ❖NMIs operating in several areas for tests in different environmental conditions.
- ❖Support an uniform approach to the measurements traceability
- ❖Constitution of a wide forum for discussing and proposing common procedures.
- ❖Better addressing direct impact and dissemination of results and best practices through the numerous existing links between NMIs and “end users” at local level.

Reliable climate data is geographically equally relevant!

Structure

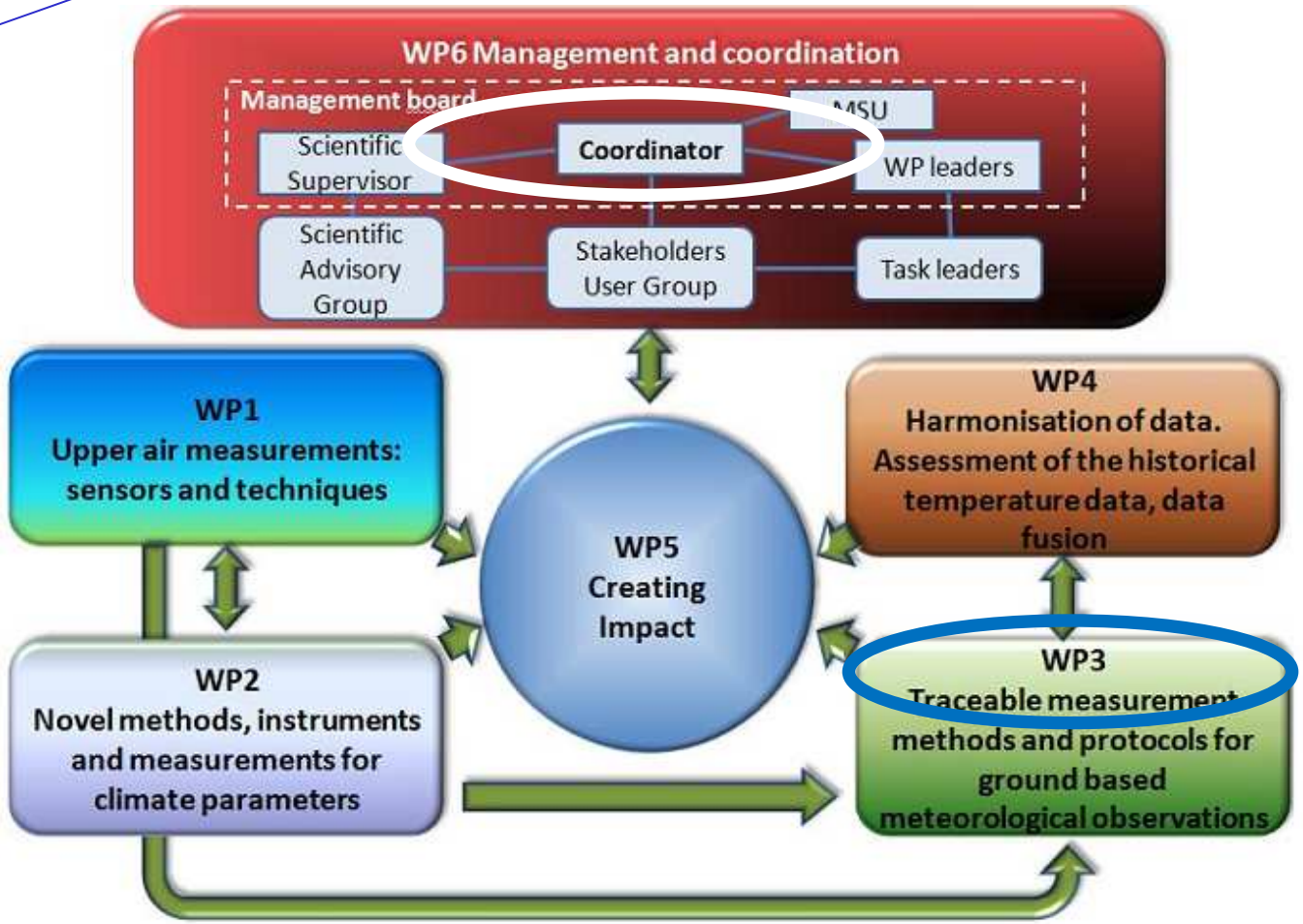
6 Work packages

3 addressed **topics**:

- *upper air measurements*
- *ground based measurements*
- *assessment of uncertainties in historical temperature measurement data*

Structure

6 Work packages



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WP1

Upper air measurements: sensors and techniques

PTB KIT Karlsruher Institut für Technologie MIKES

- Realisation of traceable, self calibrating TDLAS hygrometers
- Traceable evaluation of the line strength and line broadening of the spectral absorption lines of the water molecule including temperature and pressure dependence (P=1 Pa ÷ 1200 hPa T=-65 °C ÷ 20 °C)
- Study and construction of a traceable mobile humidity generator for calibration of mobile field hygrometers and definition of procedures.
- Intercomparison of airborne field humidity sensors of different types (AQUAVIT 2).
- Development of a reference system for calibrating humidity and temperature sensors of radiosondes

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WP2

Novel methods, instruments and measurements for climate parameters

le cnam CETIAT GUM iNRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA NPL National Physical Laboratory SP CHALMERS

- New measurements to improve the saturation water vapour pressure formula [-80 °C ÷ +100 °C]
- Development of hygrometers based on microwave quasi-spherical resonant cavities measurement (uncertainties level 10^{-5}).
- Ultrasonic anemometer for sonic temperature.
- Novel atmospheric free-space, non-contact, multi-sensors measuring T, P, airflow combined with water vapour.
- Traceability schemes for GPS and Galileo based measurements.
- Facility for accurate calibration, in air, of air temperature sensors.

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WP3

Traceable measurement methods and protocols for ground based meteorological observations

Danish Technological Institute

- ❖Weather stations database: use, sensors, design, calibration, traceability, uncertainties.
- ❖ Evaluation of the effect of solar radiance and aging on weather stations
- ❖ Uncertainty evaluation of ultrasonic anemometers data and new procedure for on-site calibration.
- ❖Construction of dedicated facilities for the combined calibration of T, RH and P sensors in weather stations. In-situ calibration of Alps, arctic and Everest stations.
- ❖Validation of weather stations data-logging software.

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WP4

Harmonisation of data. Assessment of the historical temperature data, data fusion

❖Assessment of the historical temperature measurement methods with respect to used techniques, procedures and instruments

❖ Development of the calculation model for uncertainty evaluation of the historical data with respect to ITS-90 introducing the data fusion method to support temperature uncertainty estimation

❖Creation of a novel computational software tool model for the historical and future temperature data series harmonisation, taking into account traceability

REG1

Researcher Excellence Grant (REG)

- Manufacture of a reduced dimension calibration chamber (with simultaneous generations of whole range of T and P values) for weather station operating under extreme environmental conditions (in collaboration with **INRiM**)

- Installation and test of device at the **Ev-K2-CNR Pyramid Laboratory** located at 5,050 meters a.s.l. in Nepal at the base of Mount Everest.

First example of high altitude weather stations traceable to national standards

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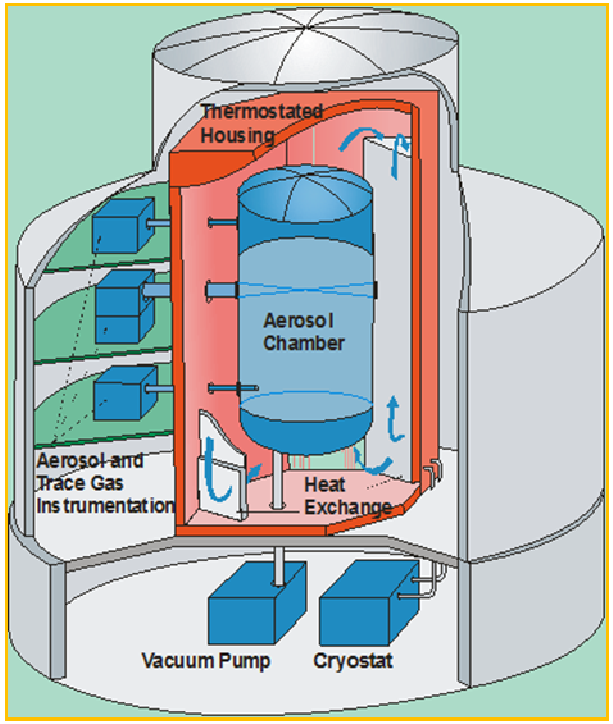
REG2

Researcher Excellence Grant

Denis Smorgon

Karlsruher Institut für Technologie (Germany)

KIT Karlsruher Institut für Technologie



AIDA chamber

Aim

Organisation and realisation of the 2nd international intercomparison campaign AQUAVIT 2 of airborne field humidity sensors in the AIDA chamber

Activity coordinated with:

- European COST Action ES0604: Atmospheric Water Vapour in the Climate System (WaVaCS),
- SPARC water vapour initiative (World Climate Research Program)
- GRUAN

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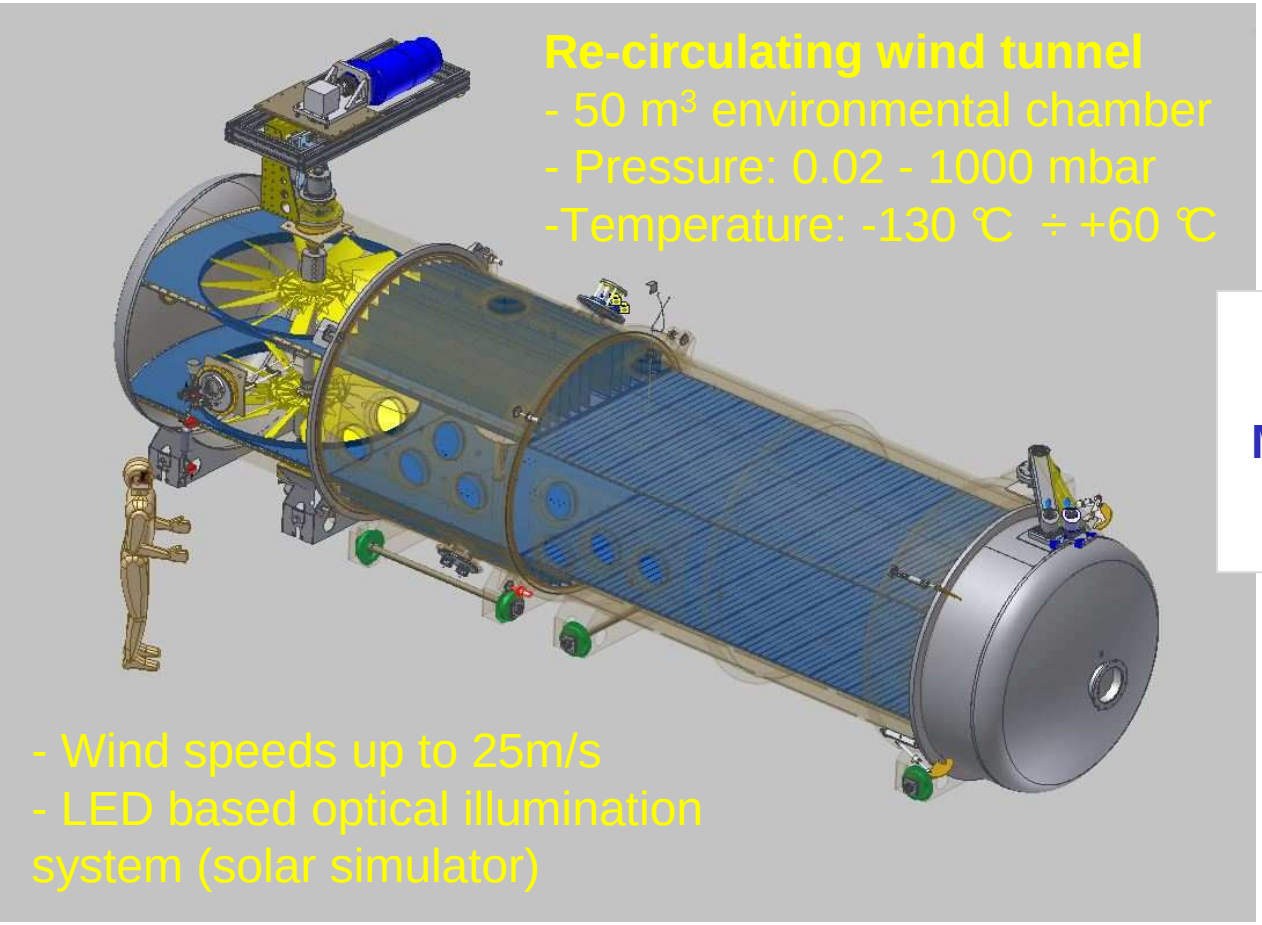
REG3

Researcher Excellence Grant



Re-circulating wind tunnel
- 50 m^3 environmental chamber
- Pressure: 0.02 - 1000 mbar
-Temperature: -130 ℃ ÷ +60 ℃

- Wind speeds up to 25m/s
- LED based optical illumination system (solar simulator)

Christina Holstein-Rathlou

Mars Simulation Laboratory

Aarhus University

Adaptation of facility for testing, calibration and comparison of meteorological sensors

Starting activities

Kick-off Meeting
12 - 13 October 2011

Historical Meteo observatory in Moncalieri (Italy) where an unbroken temperature data series is recorded since 1753.

Andrea Merlone (Coordinator) and Roger Atkinson (WMO-CIMO) at the meeting

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Starting activities

June 23, 2011
Signed collaboration with **International Surface Temperatures Initiative**

December 13, 2011
Signed collaboration with **WMO GCOS Reference Upper Air Network** (**GRUAN**)

International Events

- WMO CIMO Training Workshop on Metrology for the English-speaking countries of Region V (South-West Pacific), *November 21-25, 2011*
- *4th GRUAN Implementation-Coordination Meeting (ICM-4), March 5t– 9, 2012*

Local Events

- IV Krajowa i V Międzynarodowa Konferencja Naukowo-Techniczna "Metrologia w Technikach Wytwarzania", *12-14 September 2011, Warszawa*
- Italian Consortium meeting, *April 13rd, 2011, Italy*

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Starting activities

- **Task 3.3 activity 2: The ultrasonic anemometer investigation**

- Physical model for the seeding deposition effect on the ultrasonic anemometer probes created. The model predicts that a seeding deposit of e.g. 1 mm and a distance between the ultrasonic probes of e.g. 100 mm will result in up to 10 % deviation on the wind speed measurements.

- Currently considering the uncertainty components of an experiment and how to prepare and perform the experiments to validate the model.

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Starting activities

WP1 Task 1.3

PTB

- **Task 1.3: Development of a mobile humidity generator for calibration of mobile field hygrometers and an improved calibration procedure for field sensors.**

(PTB)

Start month March 2012, End month May 2014

The aim of this task is to develop a portable humidity generator traceable to national standards for use for on-site calibration of field sensors. The target range of the generator depends on the results of the investigation of suitable polymeric materials (deliverable 1.3.1) and should cover the most important range from 50 ppmv to several hundred ppmv. The uncertainty achieved depends on the temperature control and will be in the range of 7 % or better. This task includes the calibration and validation of the new developed humidity generator against national humidity standards and the development of calibration procedures for the on-site calibration of humidity sensors.

Description of work:

A portable permeation or diffusion type humidity generator will be developed. The experimental setup for this generator consists of a temperature controlled diaphragm cell with a membrane with known permeation or diffusion rate for water vapour. One part of the cell will be filled with water whilst a stream of pure and dry air or nitrogen flows through the other part. The resulting water vapour concentration of the gas stream depends on the permeation rate of the membrane material, the dimension of the surface area of the membrane, the temperature of the cell and on the flow rate of the air.

DONE

- Investigation of at least three materials (PTFE, PFA, PE) in order to identify a suitable membrane or tube material with a high permeation rate in the desired range. (PTB)
- Development and realisation of a portable permeation type humidity generator with a temperature controlled diaphragm cell and a membrane with known permeation rate for water vapour. However, if the results from the investigation of the permeable membranes do not satisfy the required short-term and long-term stability (typical annual drift shall be < 5 %), the portable generator may be developed as a diffusion type humidity generator. (PTB)
- New portable humidity generator realized and calibrated against national standards and its uncertainty assessed. (PTB)
- Development of a calibration procedure for field sensors using the portable humidity generator. (PTB)

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Starting activities

WP2 Task 2.1

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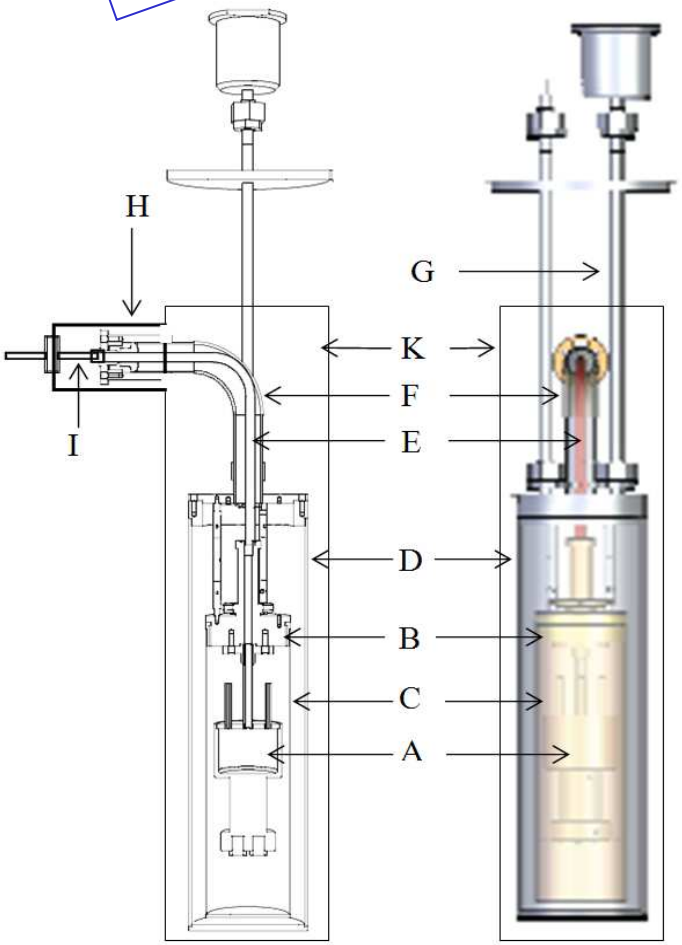
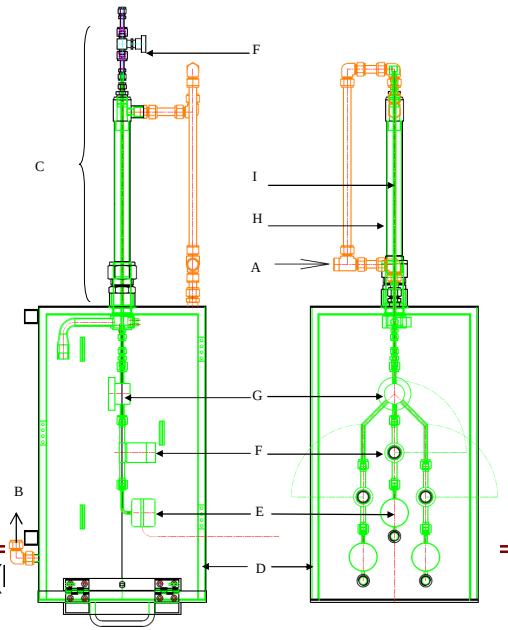


• Building of a facility dedicated to the measurement of the saturation vapor pressure and temperature of pure water. The apparatus allows performing a static measurement of *P* and *T* in a closed, temperature-controlled thermostat, conceived like a quasi-adiabatic calorimeter.

Water vapour pressure cell and associated adiabatic calorimeter



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Starting activities

WP2 Task 2.1

le cnam

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• characterization of the system (T=271.63 K, water vapour pressure 538.439 Pa) and evaluation of measurement uncertainties

TABLE 1. Uncertainty components on temperature measurements

Uncertainty source	Temperature measurement uncertainty u_{temp}/mK (K=1)
SPRT Calibration	0.30 to 0.84
SPRT Drift	0.2
Linearity	0.10
Resolution	0.09
Meas. Repeatability	0.37
Temperature Stability	0.08
Total	0.54 to 0.95

TABLE 2. Uncertainty components on pressure measurements.

Uncertainty source	Pressure measurement uncertainty u_{press}/mPa (K=1)
Zero	4
Pressure Calibration	50 (Equation7)
Resolution	10^{-6}×FS =0.13 (negligible)
Hydrostatic Correction	0.4 (negligible)
Thermal transpiration correction	0.03 (negligible)
Extrapolation to time zero	2
Total	50.20

•developing of a new calorimeter for the measurement of the triple point of water realized in copper cells.

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Starting activities

WP3 Task 3.5

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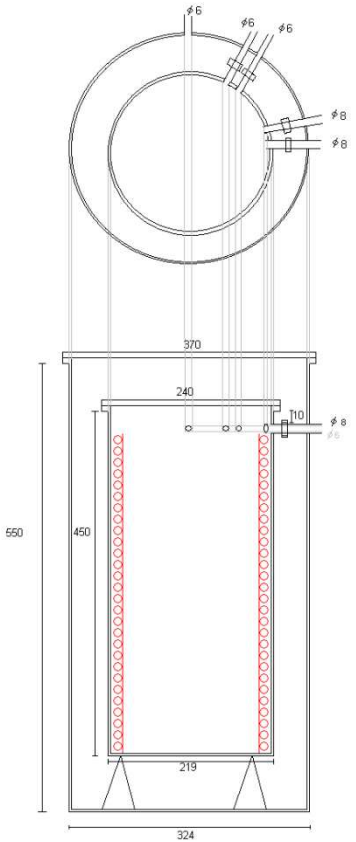
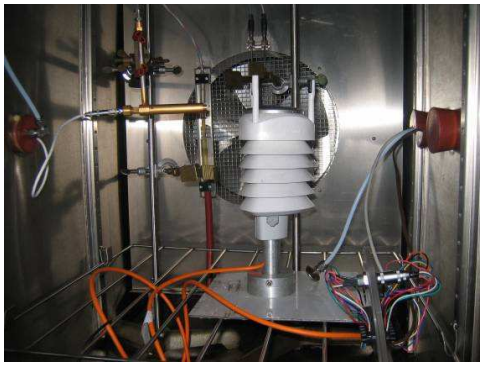
- Project of the portable dedicated facility for in situ calibration of weather station. Simultaneous generation of *T*, *P*, R*H*
- Chamber construction committed
- definition of mobile humidity generator



- Calibration of WXT510 and WXT520 Vaisala Weather stations (*P*, *T* only)



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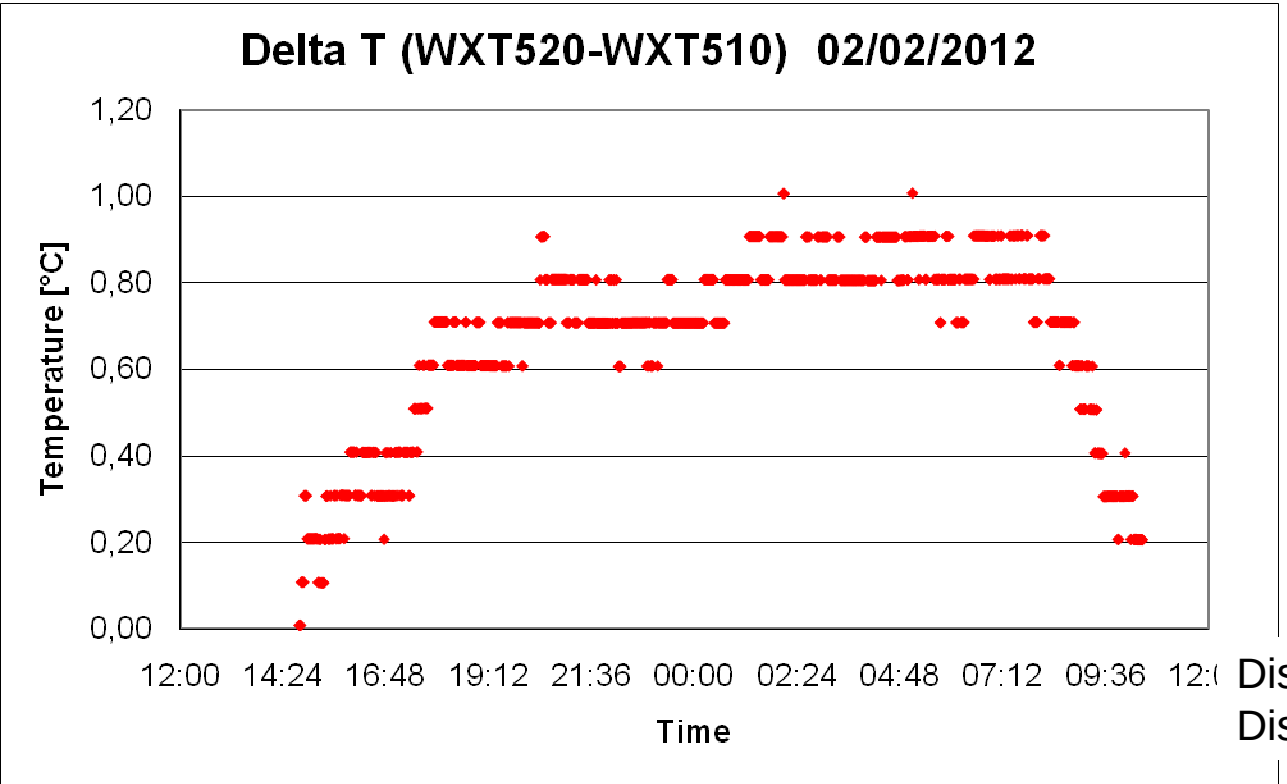
Starting activities

WP3

iNRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

- Estimation of uncertainty due to weather station siting -building closeness



Distance WXT520-building: 1.5m
Distance WXT520-WXT510: 5m

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Starting activities

WP3

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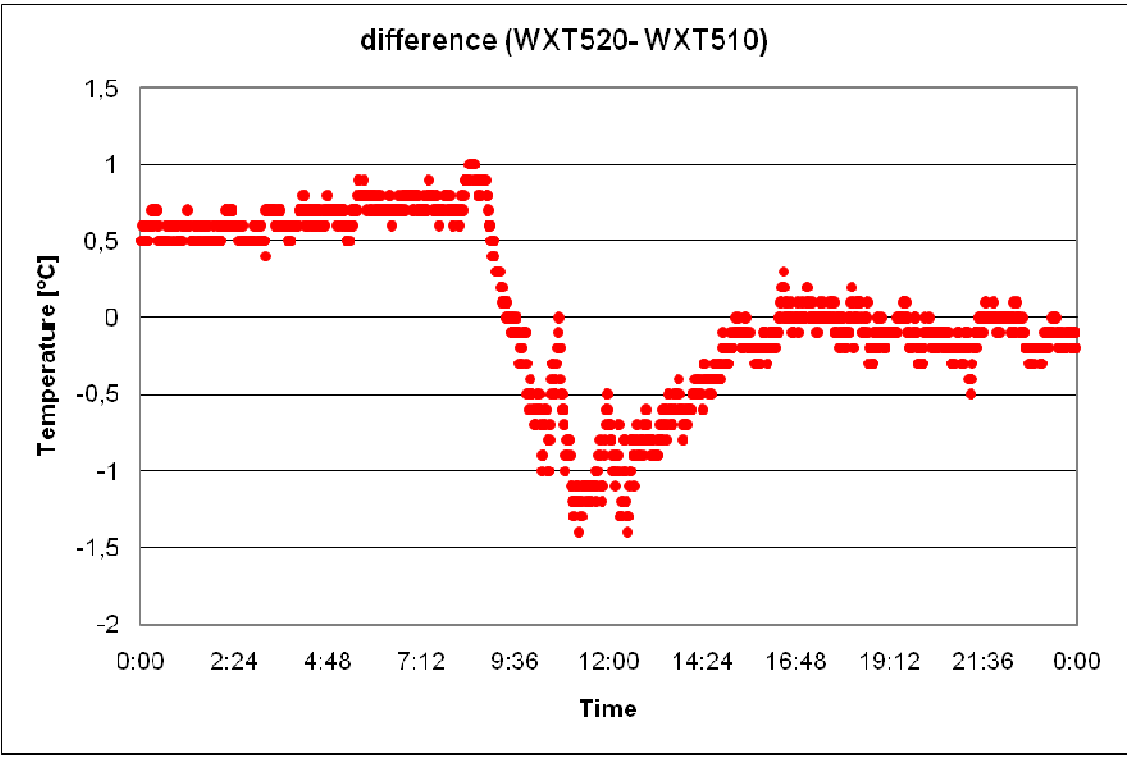
- Evaluation of ageing of weather stations



WXT520: year 2012
WXT510: year 2006

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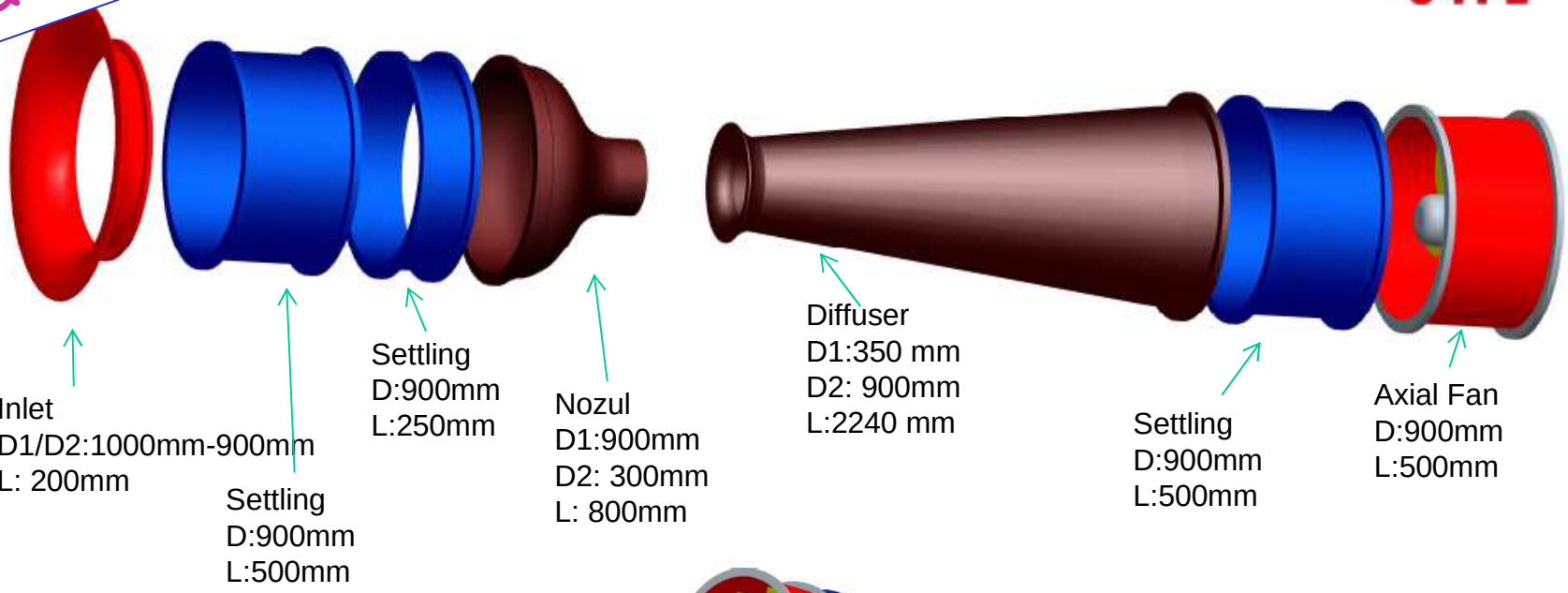
WP3
Task 3.3.1-3.3.3

Starting activities

TÜBİTAK UME

UME NEW WIND TUNNEL DESIGN FOR METEOMET PROJECT – 03/02/2012



Contraction ratio:	9:1
Diffuser angle:	7^0
Measurement section length:	800 mm
Nozul Diameter:	300 mm
Honeycomb L/D ratio:	120/20 mm
Screens porosity	<0,57
Velocity range:	0,2-40 m/s

METEOMET
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EMRP Plans

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EMRP ERAnet-plus

Metrology for ...

- SI units
- Health
- Length
- Electromagnetism

EMRP Article 169/185

Metrology for ...

2009	Energy	projects running
2010	**Environment**	projects running
	Metrology for Industry	
2011	Health	contracting
	SI broader scope	
	New Technologies	
2012	Metrology for Industry	preparation
	SI broader scope	
	Open excellence call	
2013	Energy	
	Environment	

2013. New opportunities for partners.

Research Excellence Grants increased.

New Organisation REG

Research Mobility Grants

Some preliminary ideas for a follow up project proposed.

Let's talk about…

EMRP Researcher Mobility Grants (RMGs)

EURAMET

RMGs aim to develop the capacity of individuals in Metrology

RMGs support employed researchers travelling to a JRP-Partner in a different country to undertake research additional to an EMRP Joint Research Project (JRP). The European Metrology Research Project (EMRP) funds joint research projects to advance metrology and its applications. In order to support countries building and furthering their capacity in metrology, RMG applications are encouraged from EURAMET member countries not currently participating in the EMRP. This currently includes: Albania, Bosnia & Herzegovina, Bulgaria, Croatia, Cyprus, FYR Macedonia, Greece, Iceland, Ireland, Latvia, Lithuania, Luxembourg, Malta, and Serbia. In addition NMIs and DIs from all EU member states and all countries associated with FP7 are also eligible (this currently includes the Faroe Islands, Montenegro and Israel).

RMG benefits

- Contribute to a world leading metrology project
- Build links to key metrology organisations and researchers
- Opportunity to publish papers with world leading scientists
- Develop key skills to apply to your own research
- Financial support to attend conferences

RMG allowances*

For the RMG-Researcher:

- Mobility allowance 1800 € per month (contribution to accommodation, food, local travel, etc)
- Travel allowance 500 € each 3-months
- Family mobility allowance 300 € per month, if your family also move
- Conference / training allowance 1500 € on application, limited to once every 6-months
- NOTE: The RMG does not pay the researcher's salary. This must be paid as usual by the researcher's employer

For the Guestworking Organisation

- Contribution to overhead 200 € per month

*Some allowances are adjusted to reflect the cost of living in the country of the Guestworking Organisation, therefore the actual figure of the Grant will change

Summarised Eligibility Criteria

(Full criteria are given at www.emrponline.eu/edocs/eligibility.pdf)

The RMG-Researcher must:

1. Have the right to work in the country of the Guestworking Organisation for the entire duration of the RMG, and
2. Have a good knowledge of English (It is advantageous to know the language of the Guestworking Organisation)

The proposed research must:

1. Be relevant and additional to a current JRP. A list of JRPs can be found at www.euramet.org, and
2. Have a duration of 1-18 months (typically 6 months), and end before the JRP

The RMG-Researcher must be employed by:

1. An organisation located in a EURAMET member country not participating in the EMRP, or
2. An NMI or DI from any EU Member State, or FP7 associated country, or
3. A REG Home Organisation

The Guestworking Organisation (where the RMG-Researcher undertakes research) must be:

1. An NMI or DI participating in a JRP within the EMRP, and located in a different country to the Researcher's employer, or
2. A REG Home Organisation located in a different country to the Researcher's employer

Further information

- Call dates can be found on the website: www.emrponline.eu
- When a call is open www.emrponline.eu will contain details of:
  - Specific adverts for RMG vacancies
  - The RMG application process and allowances
  - Other EMRP Researcher Grants
- Details of the JRPs can be found at: www.euramet.org

Contact us (EMRP Helpline)

Tel: +44 20 8943 6666
e-mail: emrpA169@npl.co.uk

Glossary

DI - Designated Institute
EMRP - European Metrology Research Programme
EU - European Union
FP7 - The European Commission's Seventh Framework Programme
JRP - Joint Research Project
NMI - National Metrology Institute
REG - Researcher Excellence Grant
RMG - Researcher Mobility Grant

EMRP

European Metrology Research Programme
A Programme of EURAMET

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

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WMO – BIPM Joint liaiason meeting.
Geneva 14 February 2012.

Follow up project expected from MeteoMet for the 2013 EMRP Environment Call

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Follow up project expected preliminary ideas for a Proposed Research Topic (PRT)

Instruments and series.

From traditional instruments to automatic weather stations. How to smooth the change.

Agricoltural Meteorology

Electronic leaf mist control metrological assessment

Temperature, humidity and solar radiation.

Sustainable agricolture.

Plasmopara viticola. Target uncertainty for forecasting models.

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Follow up project expected preliminary ideas for a Proposed Research Topic (PRT)

Preliminary ideas for a proposed research topic

Indirect Climate Change indicators.

Phenology

Historical climate series and production

Biosystems adaptation. Statistical

Human behaviour. Alps as a wide scale open lab with historical traceability.

Water contact thermometry

High mountains lakes temperature

Water surface contact thermometry. A possible reference for satellites.

Follow up project expected preliminary ideas for a Proposed Research Topic (PRT)

Preliminary ideas for a proposed research topic

Link between upper air and ground based temperature, humidity and pressure measurements.

Pre – launch calibration and comparison (AWS – Radiosondes)

or Pre launch calibration in specific chamber (*P*, *T*, r*H*) (Practice-Procedures?)

Calibration of at least one GRUAN site ground based instruments

Definition of site *primary* standard and *work* standards.

Instruments change – Metrological assessment and *general* procedure proposal.

REG in MeteoMet will be adverted in 3 weeks

A possible scenario *(for a road to standardisation)*

Class A1 Weather stations. Calibrated in laboratory by means of dedicated chambers. Assessed traceability to national standards, control and procedures at the level of calibration services. No “In situ” calibration allowed. Mutual influence analysys of ALL the quantities measured and/or of influence.

Class A2 Weather stations. Calibrated by means of dedicated chambers; both in laboratory and in-situ. Assessed raceability to national standards. “In situ” calibration allowed by means of transportable “mini labs” devices. Influence of different quantities evaluated at lower accuracy than for Class A1.

Class B Weather stations. Calibrated by means of dedicated chambers; both in laboratory and in-situ. Assessed raceabuility to national standards. “In situ” calibration allowed through transportable devices. Single quantities measurement calibrations.

A possible scenario *(for a road to standardisation)*

Class B Weather stations. Calibrated by means of dedicated chambers; both in laboratory and in-situ. Assessed raceabuility to national standards. “In situ” calibration allowed through transportable devices. Single quantities measurement calibrations.

Class C Weather stations. Non-calibrated stations. Periodical substituitions (as it frequently happens today). To be slowly dismissed.

Class “X” Weather stations. Weatehr stations working in unders special conditions (upper or lower ends of the usual temperature and pressure ranges) or in “hardly reacheble” places (i.e. top of high mountains). Specific procedures for calibrations and substitutions to be studied, with care to the stability of the sensors.

EURAMET
European Association of National Metrology Institutes

Sept. – Oct. 2012. End of collection of ideas

December 2012. PRT preparation. Support from collaborators

February 2013. PRT submission

EMRP selects, groups, excludes. SRT generated

May – June 2013. Partnering meeting

Sept 2013. JRP Submitted

EURAMET Evaluates JRPs

Awarded projects start in June 2014

Start thinking NOW!

And help us better address the proposal to **your needs.**

Thank you

Andrea Merlone

Results

- Achievement of **validated climate indicators**: relevant challenge for metrology
- Stimulation to innovation through the realization of **new instruments**
- Robustness of climate **observations in high mountains**: early indicators of climate change
- Definition of criteria for the **validation of spatial and temporal series**: safe assessment of climate change
- Building of an **European center of excellence** for climate monitoring

NMIs contribution to climate and environmental policy

Andrea Merlone

Impact

- Scientific: More accurate climate models; more reliable databases and best defined historical analysis
- *Social and Environmetal* : more reliable prediction of short and long term consequences of climate change; tools for building effective trans-national adaptation programs and warning systems
- *Financial*: reduction of vulnerability of food system; risks mitigation planning; accurate energy delivery previsions and saving.

Robustness to social and political actions arising from meteorological observations and climate considerations