METEOMET
Metrology for Meteorology

Andrea Merlone

Interaction with the metrology community

Andrea Merlone

MeteoMet coordinator

METEOMET
Metrology for Meteorology

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

EURAMET
European Association of National Metrology Institutes

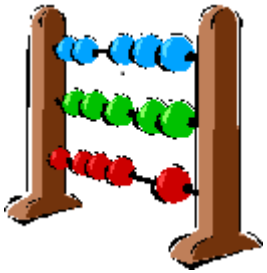
European Metrology Research Programme (EMRP) is a metrology-focused European programme of coordinated R&D

MeteoMet Management

Budget: **4 413 683** € (JRP) + **485 000** € (REGs)

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

Biggest EMRP Consortium ever!



- **6** Work packages
- **62** Tasks
- **170** Deliverables

A huge amount of work…

- **377** man/women-months
- **5** REGs -> 64 months
- Total **441** man-months

~37 years!

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

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Participants

Unfunded Partners:

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

REG Organisations

Comitato EV-K2-CNR
Karlsruher Institut für Technologie
Aarhus Universitet
IMAMOTER – CNR
Climate Change Center – C3 – Univ. Rovira I Virgili

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
ARPA Lombardia	Italy
Lobard & Marozzini	Italy
Società Meteorologica Italiana	Italy
CAE	Italy
Università degli studi di Cassino	Italy
Galileo ambiente	Italy
Meteo Duomo	Italy
Climate Consulting	Italy
CERIS - CNR	Italy
Università di Torino dip. Fisica	Italy
Università di Torino dip. Scienze della Terra	Italy
Michell Italia S.r.l.	Italy
Extreme Energy Events Project (Uni. Torino)	Italy
Environmental Agency of the republic of Slovenia	Slovenia
C3-Universidad Rovira i Virgili, Tarragona	Spain
Agencia Estatal de Meteorologia	Spain
Swedish Meteorological and Hydrological Institute	Sweden
Department of Meteorology, University of Reading	UK
University of Edinburgh	UK
National Centre for Atmospheric Science (NCAS) Univ. Leeds	UK
Rotronic	UK
Turkish State Meteorological Service	Turkey
EarthTemp Network	UK / INT
International Surface Temperatures Initiative	INT
GCOS-GRUAN	INT

By January 2013 21 Exchange of letters signed

Universities, research centers, hydro-meteo services, instruments manufacturers, international institution

International Surface Temperatures Initiative

GCOS Reference Upper Air Network (GRUAN)

International Events

- WMO CIMO Training Workshop on Metrology *November 21-25, 2011*
- *4th GRUAN Implementation Meeting (ICM-4), March 5– 9, 2012*
- *Meteo services workshop Satellite Euramet TC-T. Istanbul 22 April 2012*
- *MeteoMet presented at ITS 9, March 21 2012*
- *WMO-CIMO-TECO Conference Brussels 16-18 October 2012*

Local Events

- IV Krajowa i V Międzynarodowa Konferencja *12-14 September 2011*
- Italian Consortium meeting, *April 13 2011, Italy*
- *JMA Meeting March 13 2012*
- *NMIJ Meeting March 14 2012*
- *UME Seminar April 17 2012*

Aim

The project is focused on the **traceability** for surface and upper air measurements of temperature, pressure, humidity, wind speed and direction, and reciprocal influences between measurands

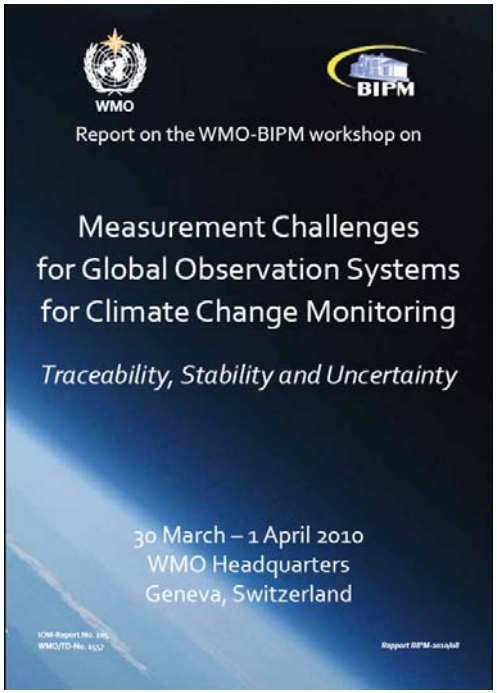
- ✓ achievement of robust climate data with measurement uncertainty budget
- ✓ accurate interpretation of historical temperature data series

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

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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**

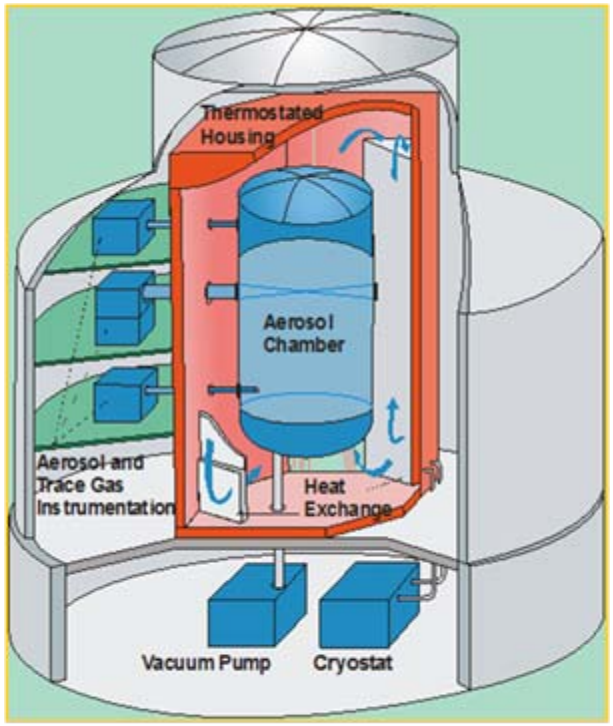
REG2

Researcher Excellence Grant

Denis Smorgon

Karlsruher Institut für Technologie (Germany)

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

AquaVIT 2 (2nd circular)

International Intercomparison of atmospheric water vapour instruments

- **New aspects compared to AquaVIT1:**

Conduct multiple test runs. For each run, an initial water vapour mixing ratio is added to the chamber in the range 1 - 1000 ppmv (1 atm), a constant chamber temperature is chosen from the range 183 - 253 K, and the chamber pressure is then stepwise reduced over the nominal range 1000 - 50 hPa. At each pressure step, instruments will record the chamber mixing ratio.

- **Timeframe :** April 2nd - 19th, 2013

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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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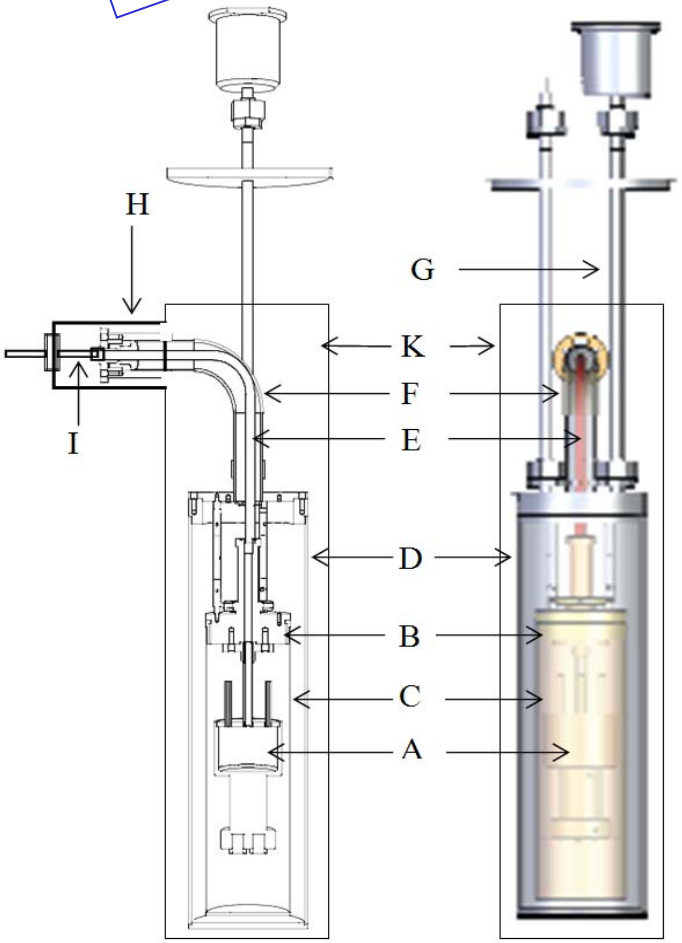
Starting activities

WP2 Task 2.1

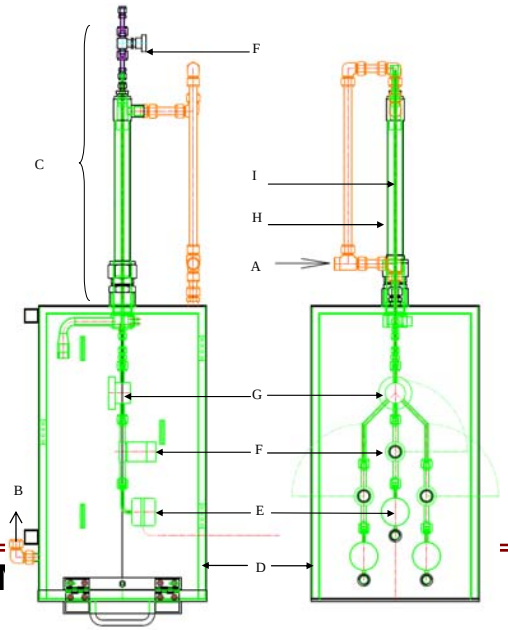
le cnam

CETIAT



• 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

CETIAT

• 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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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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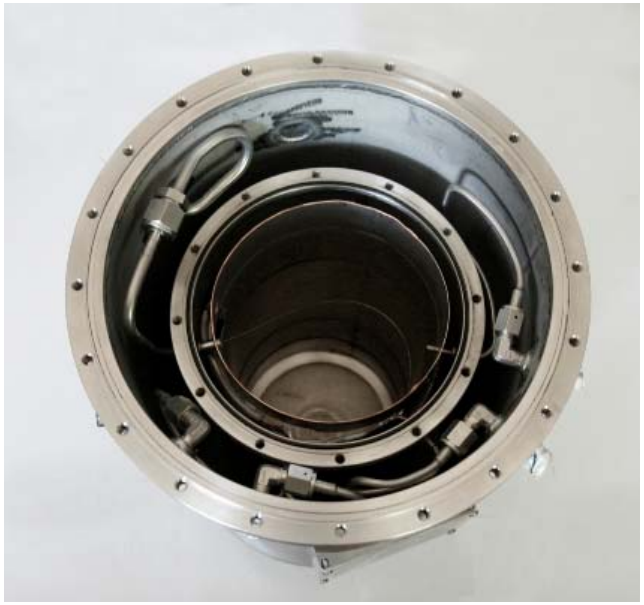
Transportable chamber for calibration of temperature, pressure and humidity sensors. Three quantities generated independently and controlled by means of standard instruments.



Calibration campaigns already “booked” for the Everest pyramid and Spitsbergen.

Anyone here (Ny Alesund - Potenza) interested in testing the device?

REG1

Researcher Excellence Grant (REG)

First example of high altitude weather stations traceable to national standards

- 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.

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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**

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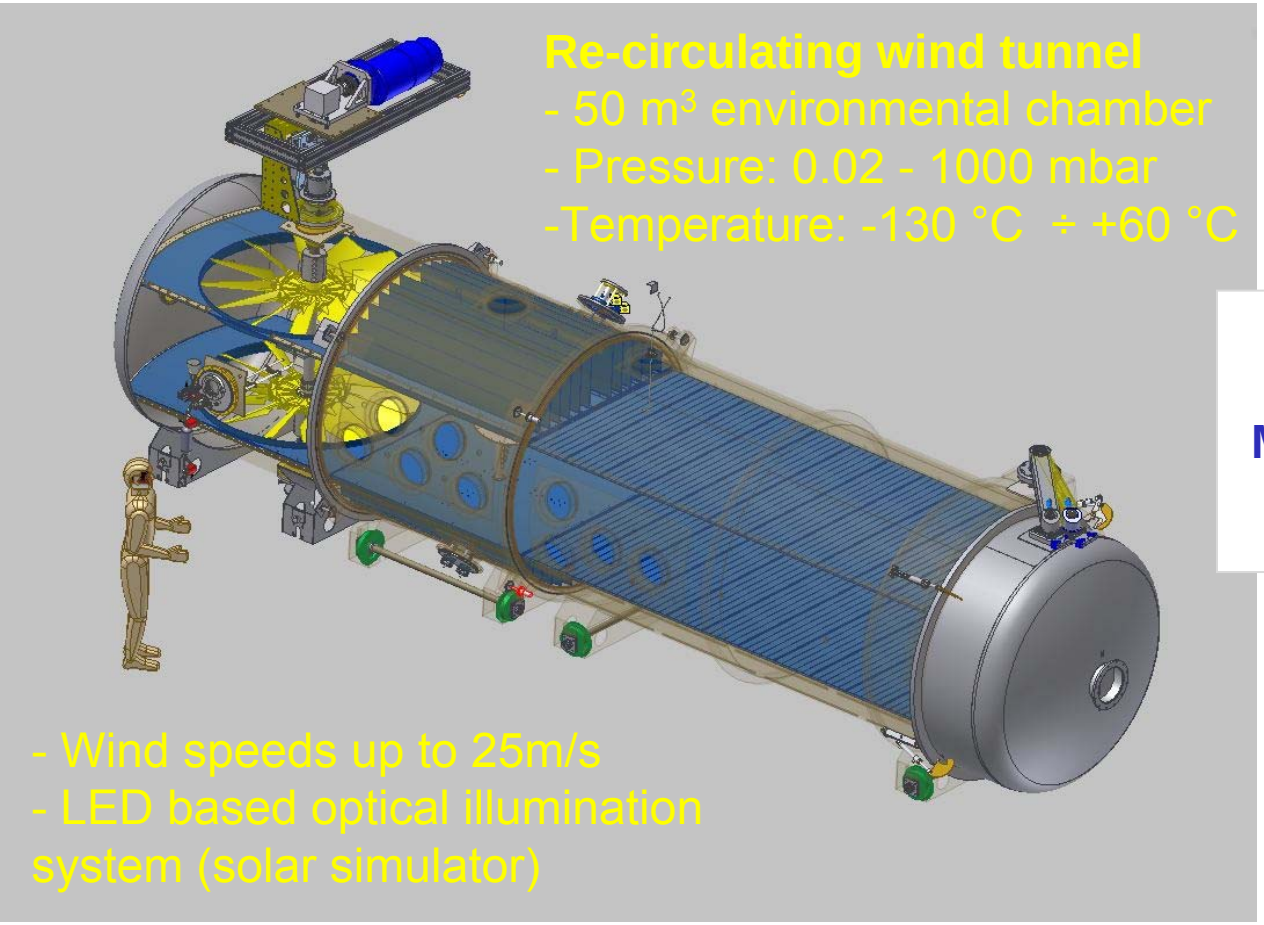
REG3

Researcher Excellence Grant



Christina Holstein-Rathlou

Mars Simulation Laboratory

Aarhus University

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

REG5

Organisation Research Excellence Grant

the use of calibrated instrumentation will reduce the parallel period of installation, ideally to zero, if both old and new instruments are calibrated with a traceable procedure.

Centre for Climate Change (C3) at University Rovira I Virgili
Manola Brunet

- estimating the impact of the introduction of AWS in historical temperature series resulting from conventional observation systems, calculate the systematic bias (size and shape) that the gradual changeover to AWS are introducing in long temperature series, estimate both an instrumental calibration strategy

GRUAN manual and guide

- A revision of the GRUAN manual and guide was delivered in 2012. The revsion has been made by Andrea Merlone, on behalf of the MeteoMet consortium and by Walter Bich, chairman of the WG1 of JCGM.

- The revision suggested changes for the internal consistency of the terminology and for its general agreement with the GUM and VIM.

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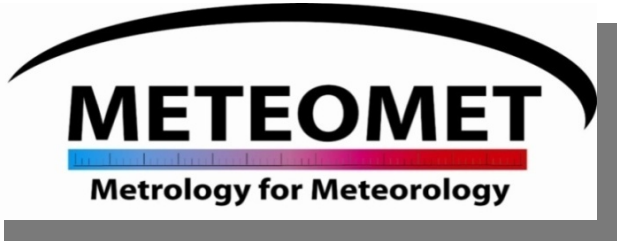

Charter
Joint Committee for Guides in Metrology (JCGM)

The Joint Committee has the responsibility for maintaining and up-dating the *International vocabulary of basic and general terms in metrology (VIM)* and the *Guide to the expression of uncertainty in measurement (GUM)*

http://www.bipm.org/en/committees/jc/jcgm/wg1.html
http://www.iso.org/sites/JCGM/JCGM-introduction.htm

The ideal method for evaluating and expressing the uncertainty of the result of a measurement should be:

- *universal*: the method should be applicable to all kinds of measurements and to all types of input data used in measurements.

- *internally consistent*: it should be directly derivable from the components that contribute to it, as well as independent of how these components are grouped and of the decomposition of the components into subcomponents;
- *transferable*: it should be possible to use directly the uncertainty evaluated for one result as a component in evaluating the uncertainty of another measurement in which the first result is used.

Care must be taken to the use of the correct terminology.

Uncertainty. Parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

Accuracy. It is not a quantitative value.

Error. Is always unknown. Not to be used in place of uncertainty. Don't say "error bars"!

Precision. Sometimes misleading. (Resolution, sensibility, suggested)

Such a common use is fundamental within and among communities.

Near-Future plans (2014-2017)

European metrolgy calls plan

3 years

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

Only for the Environment calls the follow up continuity can be applied.

The follow up JRP can start the same day the first project ends.

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

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

- "WMO greatly appreciates the strategic research currently being carried out under the environmental projects of EMRP, in particular ENV-03, ENV-04, ENV-06 and ENV-07 (MeteoMet) are making positive inroads in their respective key problem areas in **calibration and traceability** of meteorological measurements. Given the evident progress being made under these current projects, **WMO welcomes and supports the intention of EURAMET to pursue additional and/or follow-on environmental** projects in its 2013 call.
- The most critical area for metrology research is the calibration of instruments and traceability of measurements (both surface and space-based) of the Essential Climate Variables (ECVs) defined by the Global Climate Observing System (GCOS). „

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METEOMET 2

Metrology for air, water and soil
Essential Climate Variables

- **Water vapour formula defined with reduced uncertainties** (followup to deliv. 2.1.3)

- **Study on uncertainty and definition of a standard radiation shield for radiosondes thermometers?** (followup to deliv. 3.2.5)

- **Temperature, pressure and humidity generation for radiosondes sensors.**

  In the ENV07 MeteoMet project, a temperature-humidity calibration system for radiosondes has being developed to cover the needed humidity and temperature range. Adding the pressure control in a temperature-humidity radiosonde calibration system (1 kPa to 100 kPa abs. at -80 °C to +20 °C) is needed to improve the correspondence between calibration and measurement conditions.

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Traceability and testing of humidity sensors for upper air observations

WMO Intercomparisons showed the need to further investigate the performance of humidity sensors, when possible, in conditions similar to those found by the sensors in the field, e.g. at low temperature and at low pressure.

Primary standards available at NMIs cover a wide range of dew/frost point temperatures, down to -100 °C, **but** are designed to operate at pressure above the ambient atmospheric pressure.

Proposal

- **To develop a thermodynamic-based humidity generator able to work at sub-atmospheric pressure (1000 hPa to 100 hPa), in the range -20 °C to -95 °C fp.**
- **The generated water vapor mole fraction would range from 0.03 mol/mol to 1.5 10^{-6} mol/mol.**
- **The calc. water vapor mixing ratio would range from 1 g/kg to 0.001 g/kg.**

Traceability and testing of humidity sensors for upper air observations

Benefits

- **Frost-point temperature and pressure would be controlled independently**, to simulate true atmospheric profile.
- The **simulated ascent rate** can be of the order of several m/s (or, equivalently, tens of Pa/s in pressure rate).
- **Frost-point and associated water vapor content can be slowly ramped**, while keeping the pressure and temperature constant to check/calibrate the sensors in different conditions.

All sensors are calibrated in terms of RH, but they are much more likely to be partial pressure dependent, with a strong temperature sensitivity, which means there is most likely a lower bound in partial pressure, not in RH. This has not been established at all (H.V.)

4.2 Reference surface ground based station

- Proposal for the definition of a reference surface ground based station for the record of main ECVs (temperature, pressure, humidity).

a) Definition of standard/reference ground based observations requirements for ground check of upper air data validation

a) Propose a European network of gound based reference-grade stations

4.3 Procedure for instruments intercomparisons

- A Protocol and procedure for the intercomparisons of weather stations will be formulized to WMO CIMO, following the activities of task 3.1. The procedure will include complete laboratory characterization of the sensors, evaluation of the effect of quantities of influence such as wind and sun, definition of intercomparison target uncertainties, on site measurements duration required, traceability achieved through a cycle of calibration (previous and successive to the comparison). This proposal will then include definition of site activities, laboratory activities, calibration activities and uncertainty evaluations.

- A similar procedure could be studied for GRUAN purposes.

- Intercomparison campaigns can then be the subject of future metrology funded activity under the possible EMPIR program

Sensors dynamics. Experimental and theoretical investigations

- At INRiM, under the ENV07 MeteoMet project, dedicated facilities have been and are being manufactured for the accurate calibration of atmospheric sensors. Those devices will allow the extension of the calibration uncertainty goal of ENV07 to a wider measurement uncertainty achieved to a more complete characterization of sensors capabilities. Sensors dynamics can be investigated through the generation of quick and controlled changes of the temperature, wind and pressure.

- **General overview of uncertainty definition (for temperature, humidity and pressure)**

2013. New opportunities for partners.

Research Excellence Grants increased.

New Organisation REG

Research Mobility Grants

EU validated Institutions can receive funds for REGs associated to JRP

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

EURAMET
European Association of National Metrology Institutes

Sept. – Oct. 2012. Collection of ideas

December 2012. PRT preparation. Support from collaborators

15 March 2013. PRT submission

EMRP selects, groups, excludes. SRT generated

May – June 2013. Partnering meeting

Sept 2013. JRP Submitted

EURAMET Evaluates JRPs

Andrea Merlone

Start thinking NOW!

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

Deadline: 15 march 2013

Just one sentence for each of the…

- 1) the activity proposed
- 2) the need motivating it (i.e. lack of calibration methods or accepted procedures or standards)
- 3) the state of the art (how things are done now)
- 4) the expected objectives
- 5) and the impact in innovation and improvement.

Future plans >2017

EU-cofunded joint metrology research

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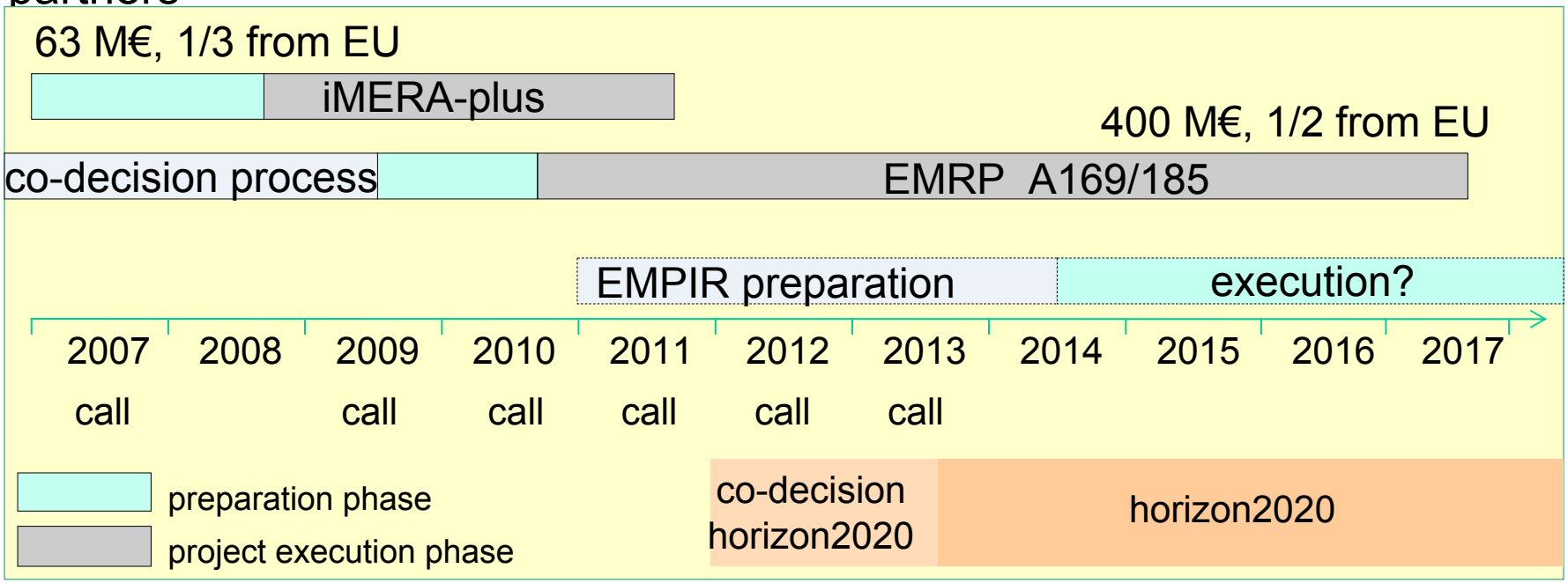
The **EMRP**

- coordinates national metrology research programmes of 22 European states
- has a jointly agreed strategic research agenda
- central EURAMET e.V. financial management contracts directly with partners



Preparation for the next phase „EMPIR“

Andrea Merlone

European Metrology Programme for Innovation and Research ("EMPIR")

Thematic pillars:

- Advanced Metrology meeting the **Grand Challenges Energy, Environment and Health**
- **Innovation:** Industrial implementation of advanced metrology for increased competitiveness
- Exploiting and serving **Basic Science** related to metrology

- **Article 185;** period of **seven years** with a total tentative budget of **500 M€, starting from 2015.**
- **Wider eligibility for project funds;** explore options for intl. partners
  - Open the programme (eligibility)
  - Innovation

A session on Environment will be hosted.

Shall we prepare an abstract? (Deadline 25 March)

Andrea
Merlone

METEOMET 2

Metrology for air, water and soil
Essential Climate Variables