# BIPM, EURAMET AND METEOMET

Andrea Merlone

EURAMET TG Environment chair
BIPM – CCT TG Environment chair
MeteoMet coordinator

# *Metrology for Climate. Why?*

*Contribution in evaluating measurement uncertainties (Full documented traceability)*

*Dedicated calibration procedures*

*Reference grade data - Comparability*

# Reference grade climate data

Andrea Merlone

Measurement Uncertainty evaluation

User


Manufacturter
Instr. Provider
Accredited Lab.

In field measurement

# BIPM, EURAMET AND METEOMET

## Andrea Merlone

EURAMET TG Environment chair
BIPM – CCT TG Environment chair
MeteoMet coordinator

# BIPM is located in Sevres

Andrea Merlone

BIPM


Did you know?...

# *New* SI in 2018.

Now based on fundamental constants.

Last values submission to CODATA: **01 July 2017**

Adoption of new SI: CGPM **2018**

Practical change in the defined standards: **20 May 2020**

## The (new) SI will be the system of units in which:

- the ground state hyperfine splitting frequency of the caesium 133 atom $(^{133}Cs)_{hfs}$ is exactly 9 192 631 770 hertz,
- the speed of light in vacuum $c$ is exactly 299 792 458 metre per second,
- the Planck constant $h$ is exactly 6.626 06X x $10^{-34}$ joule second,
- the elementary charge $e$ is exactly 1.602 17X x $10^{-19}$ coulomb,
- the Boltzmann constant $k_B$ is exactly 1.380 6X x $10^{-23}$ joule per kelvin,
- the Avogadro constant $N_A$ is exactly 6.022 14X x $10^{23}$ reciprocal mole,
- the luminous efficacy $K_{cd}$ of monochromatic radiation of frequency 540 x $10^{12}$ Hz is exactly 683 lumen per watt,

***New definition of the kelvin.***

***The kelvin, symbol* K*, is the SI unit of thermodynamic temperature; its magnitude is set by fixing the numerical value of the Boltzmann constant to be equal to exactly* 1.380 65X × $10^{-23}$ *when it is expressed in the SI base unit* $s^{-2}$ $m^2$ kg $K^{-1}$*, which is equal to* J $K^{-1}$*.***

Thus one has the exact relation k = 1.380 65X × $10^{-23}$ J/K. The effect of this definition is that the kelvin is equal to the change of thermodynamic temperature T that results in a change of thermal energy kT by 1.380 65X × $10^{-23}$ J.

**But no worries…**

***ITS-90 will remain for years (decades…).***

**And temperature will still be measured and expressed in kelvin (K) or degrees Celsius (°C).**

25th Meeting of the
CCT • 51

RECOMMENDATION T 3 (2010)
On climate and meteorological observations measurements

The Consultative Committee for Thermometry (CCT),

*considering that*

- global average temperature records are essential in understanding how the climate is changing;
- the consequences of these changes have deep impacts on different aspects of social, political and economic life;
- the need exists to improve the quality of data collection by assuring worldwide traceability in measurements involved in climate studies and meteorological observations, as expressed by climate-data users and during the recent WMO-BIPM joint workshop on "Measurement Challenges for Global Observation Systems for Climate Change Monitoring: Traceability, Stability and Uncertainty" (Geneva March 2010);
- the signing of the MRA by WMO will lead to closer liaison and cooperation with the thermal metrology community;

*recommends*

- to encourage NMIs and the scientific community, especially temperature metrologists, to be prepared to face new perspectives, needs, projects and activities related to the traceability, quality assurance, calibration procedures and definitions for those quantities involved in the climate studies and meteorological observations;

to encourage NMIs and the scientific community, especially temperature metrologists, to be prepared to face new perspectives, needs, projects and activities related to the traceability, quality assurance, calibration procedures and definitions for those quantities involved in the

quality assurance needs of the climate change and monitoring communities.

- to support a strong cooperation between NMIs and Meteorological Institutions at local, national and international levels;
- to encourage NMIs to work with the relevant meteorological networks to support a monitoring framework for traceable climate data over long temporal terms and wide spatial scales based on best practice metrology;

# WMO Commission of Instruments and Methods of Observation

Andrea Merlone

**BIPM** → **WMO**


WMO-OMM
Dr W. Zhang
Director, Observing and Information Systems Department
7 bis, avenue de la Paix
Case Postale 2300
CH- 1211 Genève 2
Suisse

Sèvres, 14 November 2014

Dear Dr Zhang,

I have the pleasure to accept your kind invitation, for representatives of the Consultative Committee for Thermometry (CCT) of the CIPM, to participate in a number of WMO CIMO Expert Teams where collaboration would be pertinent, perfectly in line with the signature made by the WMO of the CIPM MRA in 2010. For this purpose, I have identified five expert teams where CCT participation could be of mutual benefit. These are listed in the enclosed annex, as well as the contact details of the persons that I have nominated, respectively.

The CCT, under the auspices of the CIPM, has recently formed a Task Group on Environment – particularly dedicated to issues related to thermometry and humidity – to notably identify where our particular expertise in metrology and associated technologies may best contribute to progress within climatology and environmental issues. The group has also the task to promote a coherent and comprehensive approach on thermal metrology for environment. It would be of great value if one representative of the WMO CIMO may participate in this group. For this reason I kindly invite you to nominate a member to take part.

I am looking forward to a constructive collaboration.

With my best regards,

Yuning Duan

Dr Yuning Duan
President of the Consultative Committee for Thermometry
Member of the International Committee for Weights and Measures (CIPM)

Andrea Merlone (**INRiM**) on A1 Expert Team on Operational In Situ Technologies

Michaeld de Podesta (NPL) on A.2 Expert Team on Developments in Situ Technologies

Carmen Garcia Izquierdo (CEM) on A.3 Expert Team on Instrument Intercomparisons

Michael de Podesta (NPL) on C.1 Expert Team on Operational Metrology

Christian Monte (PTB) on A.5 Task Team on Radiation References

**WMO RIC6**
Drago Grosely
ARSO

**GRUAN**
Peter Thorne

**BIPM**
CCT TG ENV ←

# WMO Commission for Climatology



On February 2015 Andrea Merlone (**INRiM**) is nominated member of the OPACE1 of WMO **Commission for Climatology**

WMO OMM
Weather • Climate • Water
Temps • Climat • Eau

**WORLD METEOROLOGICAL ORGANIZATION**

CLPA/CCl-16, ANNEX II

**SIXTEENTH SESSION OF**
**COMMISSION FOR CLIMATOLOGY (CCL-16)**

**NOMINATION FOR MEMBERS OF OPEN PANELS OF CCl EXPERTS (OPACEs)**

*Please complete the form in English and return by e-mail (cca@wmo.int) or fax (+41 22 730 80 42)*

Country: Italy

**1. Title:** Dr **2. Gender:** Male
**3. Surname:** Merlone **4. First name:** Andrea
**5. Nationality:** Italy **6. Date of Birth:** 04-01-1970
**7. Contact details:**
Address:
Str. delle Cacce 91,
10135
Torino
Tel: +39 011 3919 734
Telefax: +39 011 3919 747
E-mail: a.merlone@inrim.it

**8. Highest Degree:** Ph.D.
**9. Affiliation:** Istituto Nazionale di Ricerca Metrologica
**10. Position Held:** Senior Researcher
**11. Previous contributions to WMO activities:**
BIMP-CCT Member of WMO CIMO A1 Expert Team on Operational In Situ Technologies

**12. Level of knowledge of working languages:**
English Good French Fair Russian None Spanish Fair

**13. Nominated as member of the following OPACE** (see Annex I)
Please select one or more items within the related OPACE, that pertain to your area of competence.
*OPACE 1: Climate Data Management*

- ☐ Climate Data Management Systems
- ☑ Climate Observations Standards and Practices
- ☑ Climate Observational Needs
- ☐ Climate Data Rescue
- ☑ Climate Data Quality Control

*On 1st June 2017, BIPM launches the Working Group Environment of the CCT.*

**Most of the nations participating in the work of CCT Joined the new working group.**

# BIPM, EURAMET AND METEOMET INITIATIVES

## Andrea Merlone

EURAMET
European Association of National Metrology Institutes

BIPM
ΜΕΤΡΩ ΧΡΩ

METEOMET
Metrology for Meteorology

**EURAMET TG Environment chair**
**BIPM – CCT TG Environment chair**
**MeteoMet coordinator**

# Meteorology

European

**Meteorological Society**

# Metrology

European

**Association of National Institutes of Metrology**


Maximum impact can be achieved if the research agendas are used to target long-term objectives.

…to enable and stimulate related investments in facilities and equipment…

…and pooling of metrological resources across national boundaries to tackle key societal challenges.

## 2014

## EURAMET starts the new Task Group on Environment

# EURAMET TG ENV Members

## Convenor

Andrea Merlone
INRiM

Annarita Baldan
VSL

Carmen Garcia I.
CEM

Ryszard Broda
Polatom

Bernd Güttler
PTB

Volker Ebert
PTB

Richard Brown
NPL

Julian Groebner
PMOD - WRC

Eric Georgin
LNE - CETIAT

Ragne Emardson
SP

Bertrand Calpini
WMO – CIMO
(MeteoSwiss)

Roger Atkinson
WMO - CIMO

# EURAMET TG ENV

**Main task: contribution to the Strategic Research Agenda**

**In spring 2016 EURAMET publishes the first impact report about the joint research project and activities started with the EMRP call of 2010.**

EMRP projects':
www.euramet.org/emrp-industry-environment-2010

and
www.euramet.org/emrp-energy-environment-2013

Case studies
www.euramet.org/metrology-for-societys-challenges/metrology-for-environment/impact-casestudies-emrp-environment-theme/


European Metrology Research Programme

EURAMET

Environment impact report

A summary of the outputs and impact of the first EMRP joint research projects in Environment.

The aim of this theme is to improve data quality for environmental policy making, underpin environmental research activities and stimulate technological innovation. The research is focused at both the local environmental level for air, water and soil quality and at the global level for challenges relating to climate change.

EURAMET e.V. - the European Association of National Metrology Institutes

# BIPM, EURAMET AND METEOMET INITIATIVES


## Andrea Merlone

EURAMET TG Environment chair
BIPM – CCT TG Environment chair
MeteoMet coordinator

# 2011 October 1.

MeteoMet Joint Research Project official start date!

# METEOMET

Metrology for Meteorology

Meteomet is a EURAMET joint research project


11 M€ Budget

300 Deliverables

960 Man months

(80 years!)

**MeteoMet is the**

**larger EURAMET consortium**

21 National Institutes of Metrology

12 Universities

13 Research centers

9 Instrument Companies

10 Meteo agencies

Andrea Merlone

SECONDA UNIVERSITÀ DEGLI STUDI DI NAPOLI
SCUOLA POLITECNICA E DELLE SCIENZE DI BASE
DIPARTIMENTO DI MATEMATICA E FISICA

CENTRO FERMI
Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi

METEO FRANCE

University of Reading

Società Meteorologica Italiana Onlus

ENVIRONMENTAL AGENCY OF THE REPUBLIC OF SLOVENIA

I U A V

IMAMOTER
Istituto per le Macchine Agricole e Movimento Terra
Consiglio Nazionale delle Ricerche

Centre for Climate Change

UNIVERSITAT ROVIRA I VIRGILI

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

UNIVERSITÀ DEGLI STUDI DI GENOVA

LMD

Hochschule Bonn-Rhein-Sieg
University of Applied Sciences

Fribourg
Alpine Cryosphere and Geomorphology

Uniwersytet Wrocławski

AARHUS UNIVERSITY

ARPA Valle d'Aosta

PRINCETON UNIVERSITY

VAISALA

Rodeker Scientific

rotronic
MEASUREMENT SOLUTIONS

Thies CLIMA

GRUAN

nke INSTRUMENTATION

Arpa Piemonte

Lufft
a passion for precision

WORLD METEOROLOGICAL ORGANIZATION

AEMet

setra SENSING SOLUTIONS

SHOM
L'océan à la carte

International Surface Temperature Initiative

seac

FHMZ

CAE
monitoring your world.

Cal Power

MODEM
Meteomodem.com

OMD

Climate Consulting

3a

Lombard&Marozzini

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

GeoClimAlp

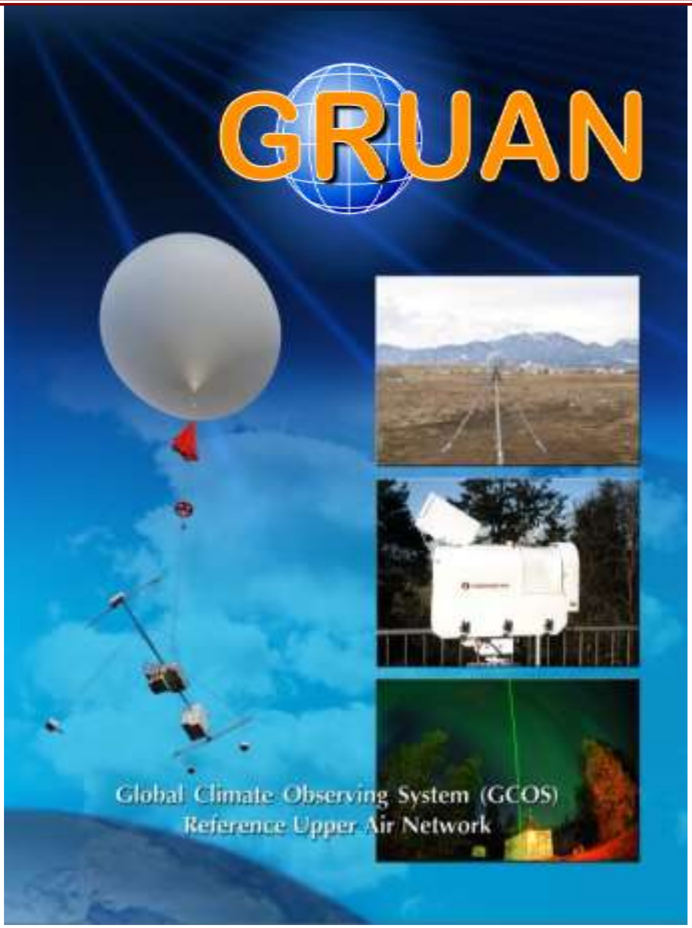
IZNE

ISAC

FMI

| Domain | GCOS Essential Climate Variables |
|---|---|
| **Atmospheric** (over land, sea and ice) | **Surface:** Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget<br><br>**Upper-air:** Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance).<br><br>**Composition:** Carbon dioxide, Methane, and other long-lived greenhouse gases[3], Ozone and Aerosol, supported by their precursors[4]. |
| **Oceanic** | **Surface:** Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton.<br><br>**Sub-surface:** Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers. |
| **Terrestrial** | River discharge, Water use, Groundwater, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture. |

The Working Group on the GCOS Reference Upper Air Network (GRUAN) was established in recognition of the importance of initiating reference-quality observations of atmospheric column properties, in particular temperature and water vapor pressure, from the surface into the stratosphere to enhance the monitoring and understanding of climate variability and change.

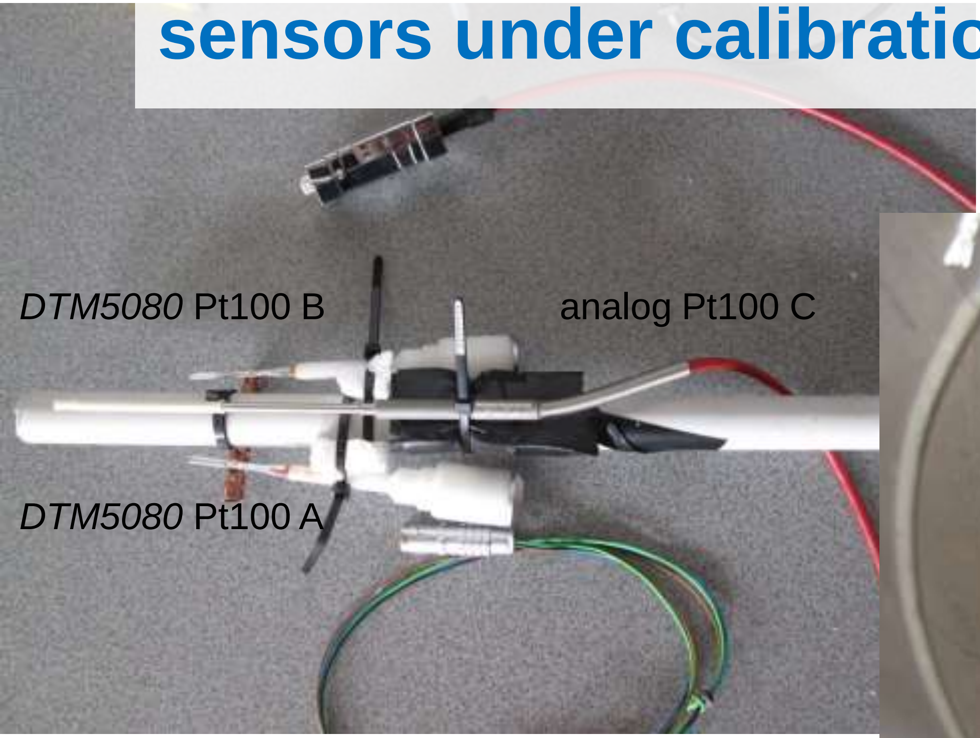


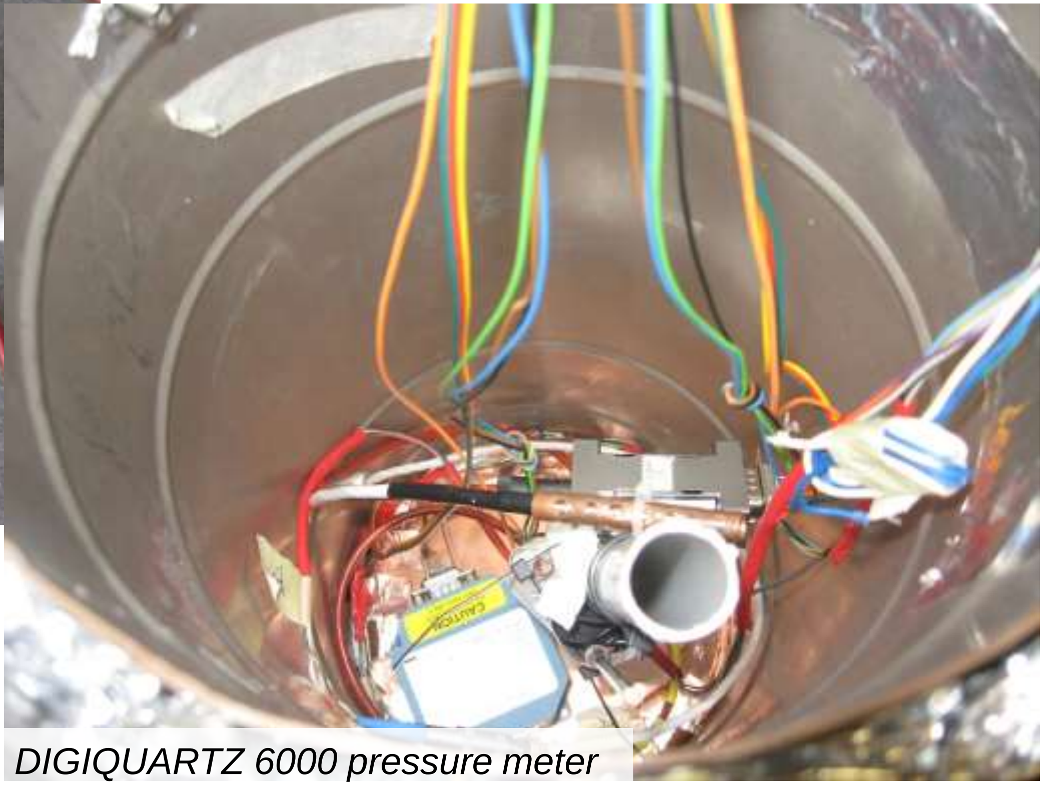

A long lasting cooperation is being established aiming at fully define uncertainty components and calibration procedures.

# Mission “Arctic Metrology” 2014 and 2017

Andrea Merlone

# Inside of EDIE 1
## sensors under calibration and reference standard

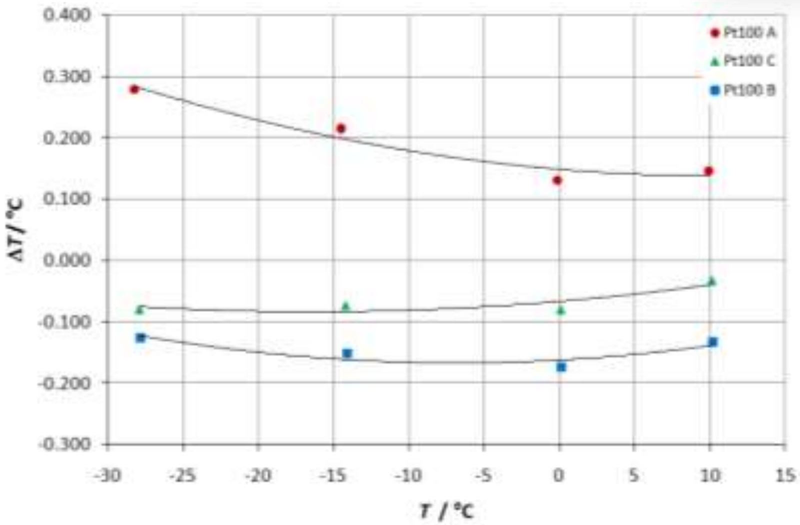


*DIGIQUARTZ 6000 pressure meter*

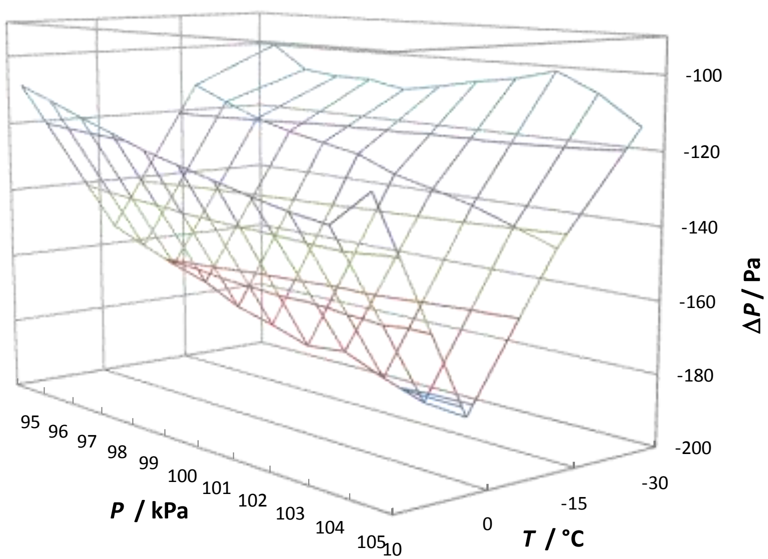
| Calibration Range | |
|---|---|
| Temperature | -30 °C to 10 °C |
| Pressure | 95 kPa to 105 kPa |

# Calibration curves




$$T_c(T) = T - \Delta T(T) = T + a + bT + cT^2$$

| Uncertainty contribution | PT100 A | PT100 B | PT100 C |
|---|---|---|---|
| *Temperature reference* | 0.011 °C | 0.011 °C | 0.011 °C |
| *Chamber uniformity* | 0.006 °C | 0.009 °C | 0.019 °C |
| *Sensor under calibration* | 0.007 °C | 0.008 °C | 0.014 °C |
| *Calibration curve* | 0.026 °C | 0.017 °C | 0.018 °C |
| **Standard Uncertainty** | **0.029 °C** | **0.022 °C** | **0.026 °C** |
| **Expanded Uncertainty (*k*=2)** | **0.058 °C** | **0.044 °C** | **0.052 °C** |




$$P_c(P,T) = P + a + bP + cT + dPT + eT^2$$

| Uncertainty contribution | |
|---|---|
| *Pressure reference* | 0.3 Pa |
| *Chamber uniformity* | 2.5 Pa |
| *Sensor under calibration* | 0.3 Pa |
| *Calibration curve* | 26 Pa |
| **Standard Uncertainty** | **26 Pa** |
| **Expanded Uncertainty (*k*=2)** | **52 Pa** |

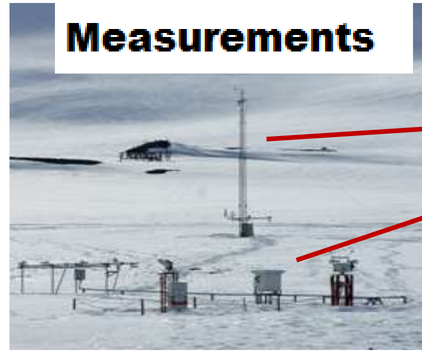
# Metrology lab

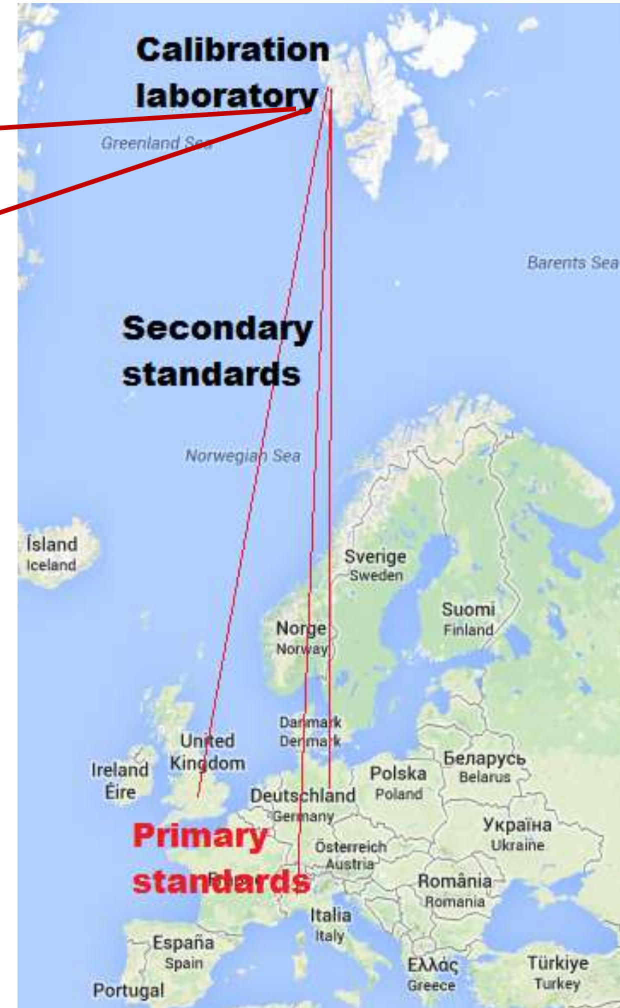
Andrea Merlone

METEOMET

METEOMET
Metrology for Meteorology

EURAMET




le cnam

PTB Physikalisch Technische Bundesanstalt

CEM CENTRO ESPAÑOL DE METROLOGÍA

MIKES Centre for metrology and accreditation

pmod wrc

SP

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

Seconda Università degli Studi di Napoli SUN

DANISH TECHNOLOGICAL INSTITUTE

Andrea Merlone

# May 2017 metrology campaign

4 temperature sensors and one barometer of the CCT were dismantled together with the logger. The instruments were calibrated between -25 °C and + 15 °C and from 90 kPa to 110 kPa.

# Arctic Metrology Workshops series

**1**$^{st}$ Torino April 2015

2$^{nd}$ Oslo May 2016

3$^{rd}$ Ny-Ålesund 2017

• Break out session @ Arctic Circle 2015



REYKJAVÍK • ICELAND
ARCTIC 2015 CIRCLE
OCTOBER 16 - 18

JOIN OUR MAILING LIST | ARCTIC NEWSWIRE | + SHARE

REGISTER FOR THE 2015 ASSEMBLY 16 -18 OCTOBER

2015 PROGRAM

ABOUT | BOARD | PARTNERS | SECRETARIAT | PRESS & MEDIA | 2014 | IMAGES | VIDEO

HÁSKÓLINN Í REYKJAVÍK
REYKJAVIK UNIVERSITY

## THE FUTURE OF ENERGY SECURITY IN THE ARCTIC

The Iceland School of Energy will organize a session on Thursday, October 15th, about the future of Arctic energy, with considerations of environmental and human security. The session will be organized in cooperation with the Harvard Kennedy School of Government and the Fletcher School of Law and Diplomacy at Tufts University.

## THE FOREIGN MINISTER OF CHINA

The Opening Session of the 2015 Arctic Circle Assembly will include an address by the Foreign Minister of the People's Republic China, Wang Yi.

EURAMET

## METROLOGY FOR ENVIRONMENT IN THE ARCTIC

High-accuracy measurements are needed to understand the evolution of the Arctic environment in its many extremes. EURAMET, the European Association of National Metrology Institutes, is hosting a breakout session promoting common activities between metrology and Arctic scientific research to improve data quality.


REYKJAVIK, ICELAND
FRIDAY, OCTOBER 16, 2015
REYKJAVÍK • ICELAND
ARCTIC 2015 CIRCLE
OCTOBER 16 - 18
PARIS2015
COP21-CMP11
ARCTIC CIRCLE
ArcticCircle.org


EURAMET
Arctic Circle 2015
2015 ASSEMBLY
Reykjavík, Iceland
October 15-18

# MMC Spain 2016

METROLOGY FOR METEOROLOGY AND CLIMATE

# & CIMO-TECO

World Meteorological Organization

**26-30 September 2016**
**Spain (Madrid)**

***ENVRIPlus Meeting***
***Soil Moisture Workshop***
***MeteoMet2 plenary meeting***

International Surface Temperature Initiative

BIPM

World Meteorological Organization

TC-T Thermometry EURAMET Technical Committee

IMEKO TC12

GRUAN

APMP

Andrea Merlone

World Meteorological Organization

**Conference Announcement**

MMC Beijing – China 2019

METROLOGY FOR METEOROLOGY AND CLIMATE

## October 2019 in Beijing – China

Hosted by Tempmeko&Tempbeijing

Organised by MeteoMet

and the National Institute of Metrology (NIM), Beijing – China

The conference will bring together world leading experts in measurement for meteorology and climate, in a joint event with the thermal metrology community attending Tempmeko, the International Symposium on Temperature and Thermal Measurements in Industry and Science and Tempbeijing, the International Conference on Temperature and Thermal Measurement.

For preliminary information on the event, venue, exhibition, please contact
Andrea Merlone – a.merlone@inrim.it

METEOMET
Metrology for Meteorology

# Full traceability to SI

Andrea Merlone

Laboratory and transportable calibration kits for temperature, pressure, humidity.

# Atmospheric air temperature measurements:

# can we evaluate a complete uncertainty budget?

# A thermometer measures the temperature of the air.

A thermometer measures the temperature of the air. ?

A thermometer measures the temperature of the air.

A (contact) thermometer gives an indication of its heat equilibrium at that time in that place under those conditions.

# This equilibrium is influenced by:



- **Convection heat exchange**
  - Gas (wind) speed
  - Turbulent, laminar or mixed flow
  - Heat transfer coefficient
  - Convection surface area
  - Temperature gradients
- **Conduction heat exchange**
  - Coefficient of conductivity
  - Thickness of the conduction/insulation layers
  - Temperature gradients
- **Radiation heat exchange**
  - Emissivity coefficients
  - Reflectivity coefficients
  - Diathermy
  - Sub-surface conductivity (surface temperature)
  - Temperature difference
- **Phase change and heat sources**
  - Condensation/evaporation
  - Sublimation/melting
  - Heat sources in the thermometer body
- **Transient heat transfer**
  - Specific heat capacity of the thermometer
  - Mass of the thermometer
  - Initial temperature of the thermometer
  - Gas temperature dynamics (lag)

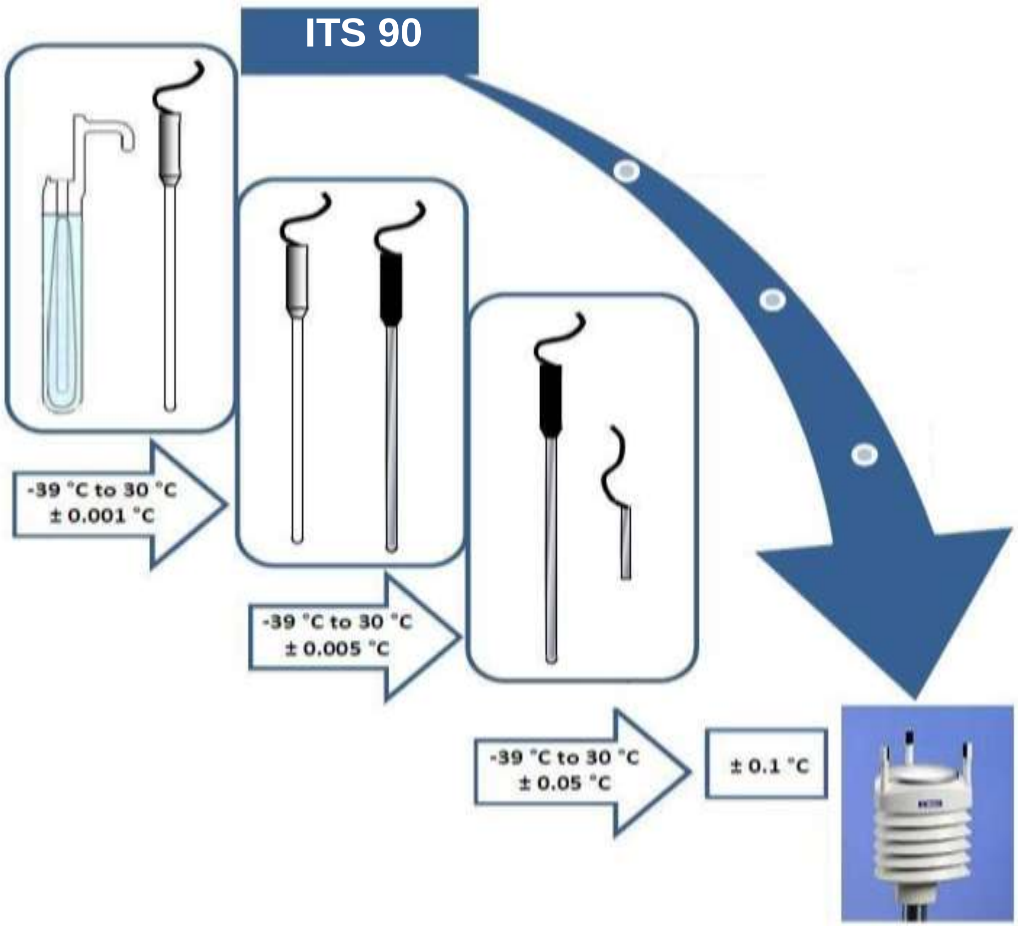
- Probe is not adiabatic
  - Radiation exchange with surrounding
  - Convection between the probe and air
  - Conduction along probe stem
- Probe has imperfect geometry:
  - Partial stagnation
  - Stagnation different in laminar, turbulent or developing flow
- Flow is compressible at stagnation locations even at mainstream velocities less then 1/3 Mach
- Probe has finite mass – therefore time lag
- Probe has relatively large heat capacity vs. air
- Probe faces enclosures/surroundings with temperature:
  - different from gas
  - different from probe
- Probe indicates mean temperature (gas, probe body), not gas temperature.
- Difference of self-heating in air to that at calibration should be considered
- Real gas does not have one single total temperature

## A (contact) thermometer is calibrated in (as close as possible) adiabatic conditions.

**A (contact) thermometer is calibrated in (as close as possible) adiabatic conditions.**

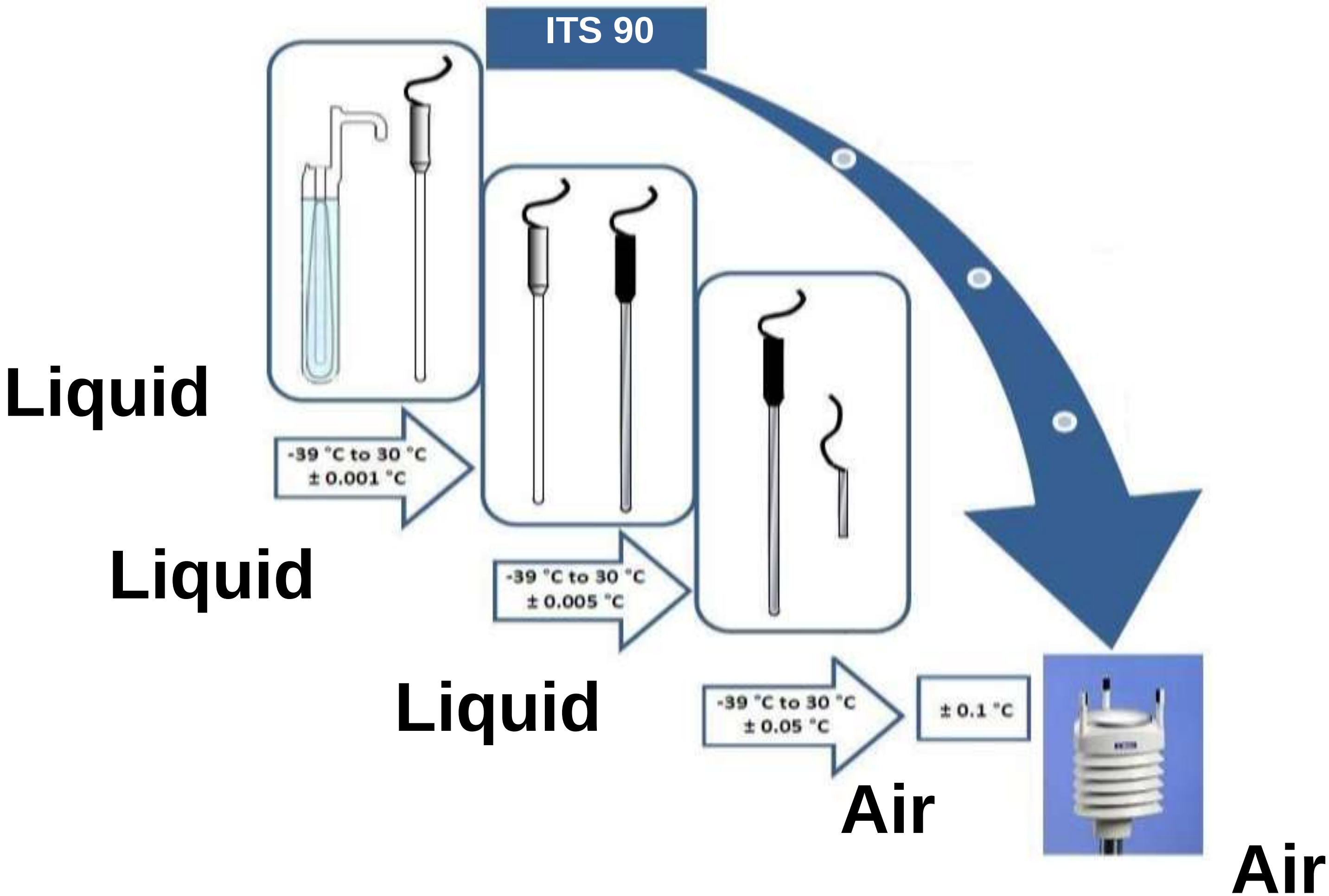
**But then a thermometer for atmospheric air temperature measurement is used in non-adiabatic conditions**

**Traceability**


ITS 90
-39 °C to 30 °C
± 0.001 °C
-39 °C to 30 °C
± 0.005 °C
-39 °C to 30 °C
± 0.05 °C
± 0.1 °C

METEOMET
Metrology for Meteorology

ITS 90



ITS 90
Liquid
-39 °C to 30 °C
± 0.001 °C
Liquid
-39 °C to 30 °C
± 0.005 °C
Liquid
-39 °C to 30 °C
± 0.05 °C
± 0.1 °C
Air
Air

**The calibration uncertinty**

**is NOT**

**the measurement uncertainty.**

A (contact) thermometer is calibrated in (as close as possible) adiabatic conditions.

But then a thermometer for atmospheric air temperature measurement is used in non-adiabatic conditions

**Traceability**

Andrea Merlone

An example: the albedo effect on air *T* values

# •Albedo

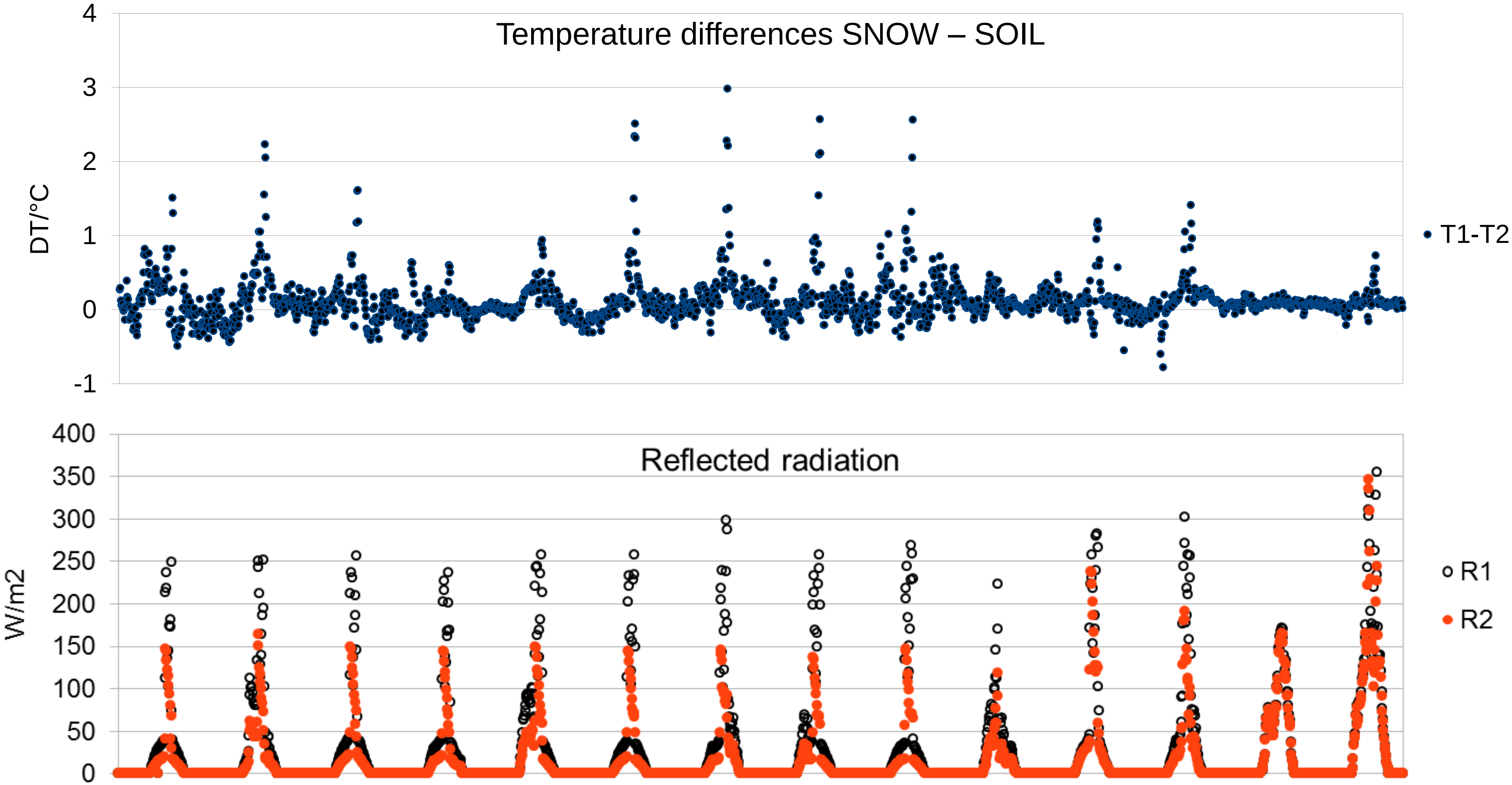
Andrea
Merlone

Measurement campaign and site maintenance

# •Albedo

Andrea Merlone

## Preliminary results

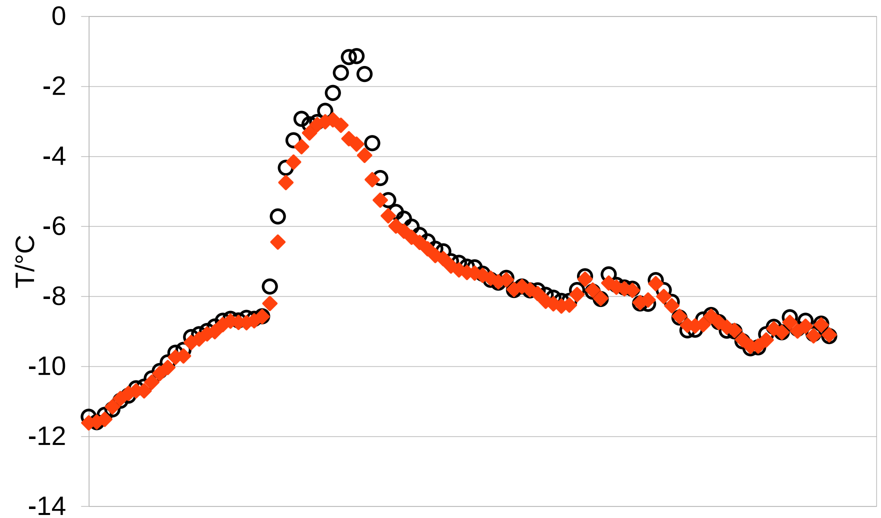


# •Albedo

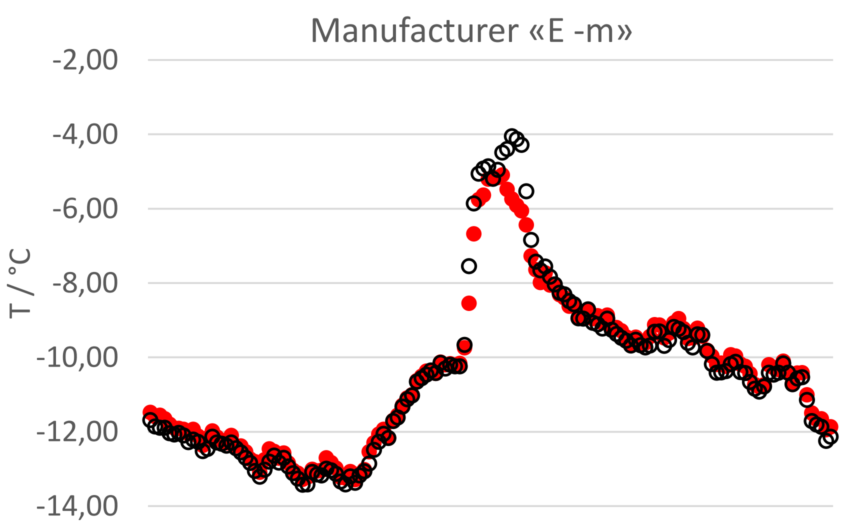
Andrea Merlone

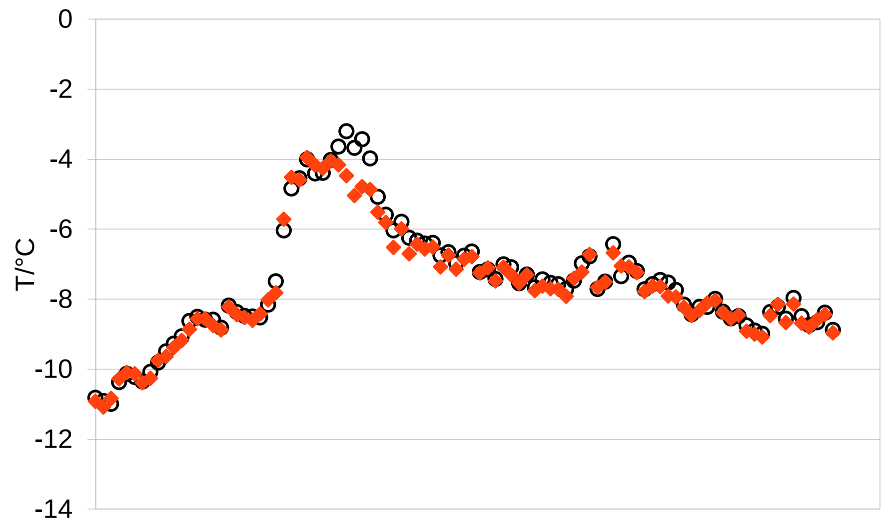
## Preliminary results

- SNOW
- NO SNOW




Manufacturer «C - c»
(Same sensor – different shield)



# Influence of rain on thermometers (DTI)

DANISH
TECHNOLOGICAL
INSTITUTE

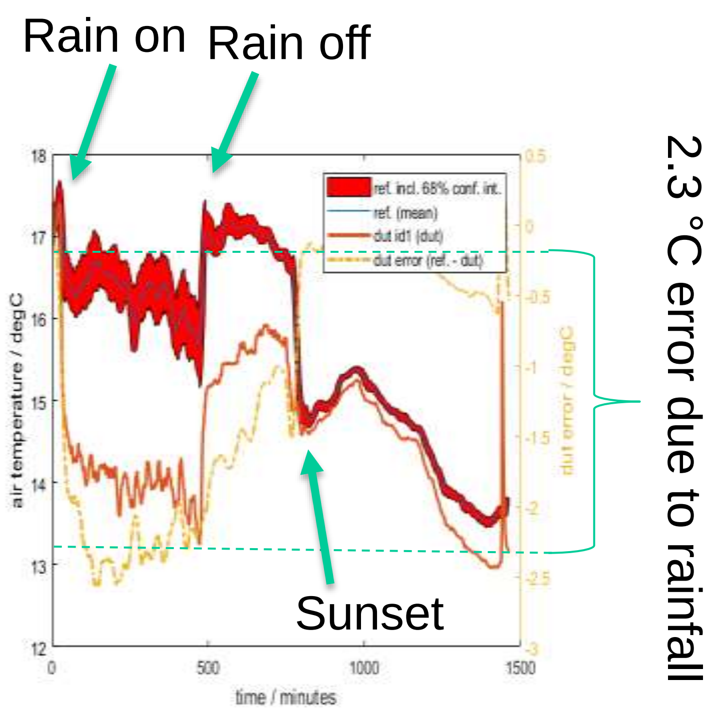
When rain starts, air temperature decreases.

Drops of rain are colder than the air.

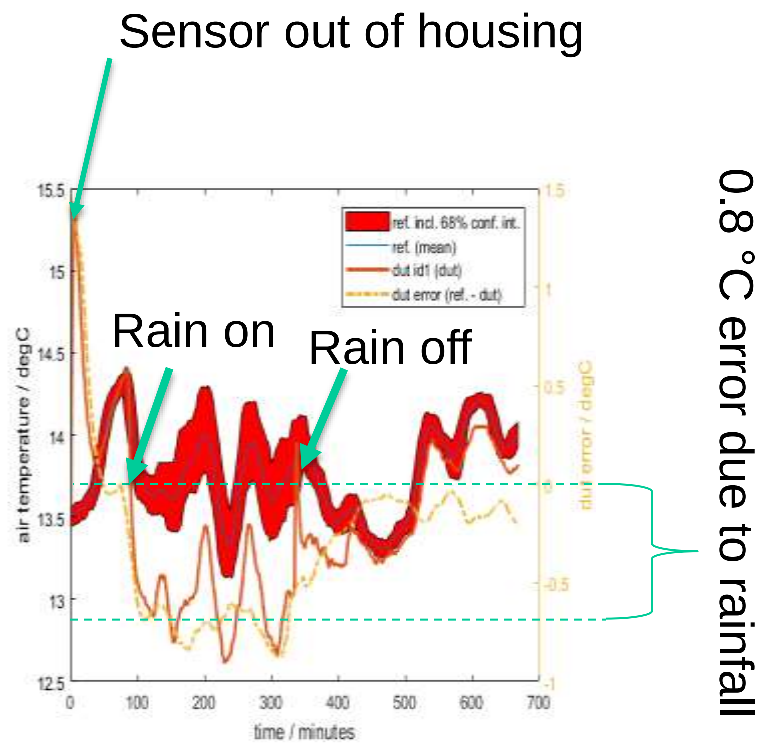
Convection, then conduction cause extra cooling (errors) in temperature measurements.

Andrea Merlone

# Weather station without active ventilation




Rain temperature ≈ 6.5 °C




Rain temperature ≈ 12 °C

- Cooling effect is highly dependent on temperature difference between air and water

- Takes hours for the cooling effect to wear off, after the end of the rainfall

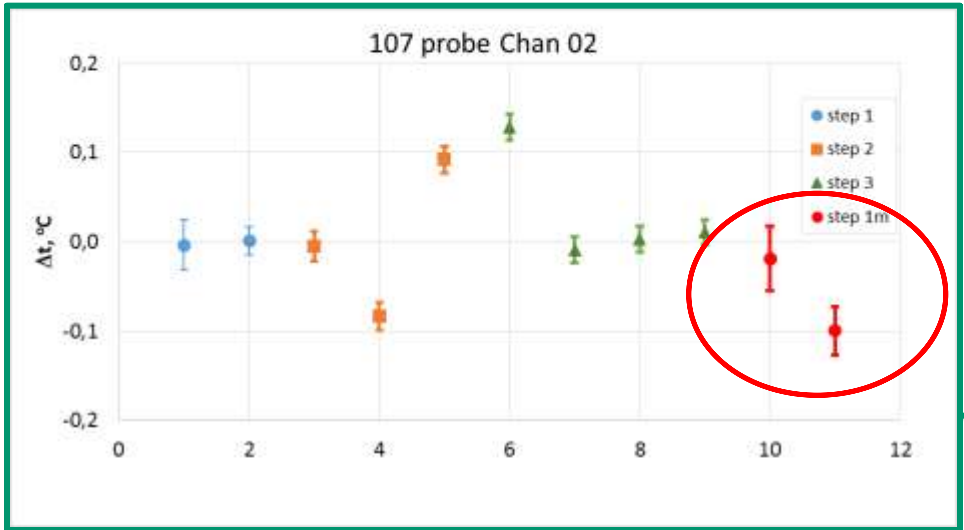
- Latency in the sensors can be significant

# REPRODUCIBILITY AFTER MECHANICAL SHOCK

Andrea Merlone

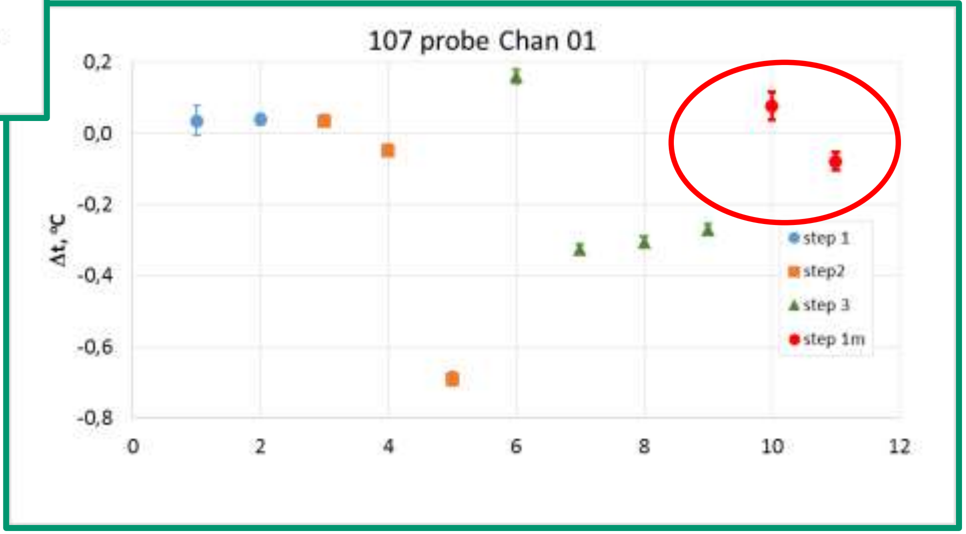


## Thermistors probe 107




**Δt = 0,35 °C**

**Δt = 0,11 °C**




**EURAMET TC THERM 2017**

**WG Best Practice Meeting** **Minutes**

**Tres Cantos, 25 April 2017, 17:15 to 18:30**

**Participants:**

| **Name, Institute** |
|---|
| Miruna Dobre, SMD (WG chair) |
| Murat Kalemci, UME |
| Radek Strnad, CMI |
| Søren Lindholt Andersen, DTI |
| Graham Machin, NPL (TC-T chair) |
| Mohamed Sadli, LNE-CNAM (standing for Y. Hermier) |
| Jean-Remy Filtz LNE-CNAM (invitee) |
| Eric Georgin, CETIAT |
| Andrea Merlone, |
| Aleksandra Kow |
| Ossi Hahtela, VT |

**Agenda:**

- Welcome and revi
  a. Søren Lin
- Task 1 Guidelines
  a. Euramet g
  b. New versi
  pending: photos needed for cg13.
  c. Progress on new guide on **surface temperature calibrations** within EMPIR EMPRESS project: Writing not started yet. Guide delivered by the project is higher level than Euramet calibration guides Eric send the Cetiat guides to

asking for revision. Murat, Mohamed and Radek are willing to contribute to the revision, Graham will ask Jon if he wishes to coordinate the work.

- **Air temperature** sensors calibration guide: a task group is being formed for the preparation of a guide on calibration of thermometers in air.
- Other topics for further consideration: radiative properties, in-situ calibration of thermocouples

# 2017 - CCT TG ENV starts the preparation of a review paper on the uncertainties in air *T* measurements.

## Open issue on VIM definition of traceability


The VIM defines metrological traceability as

*property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.*

Perfect for laboratory calibration,

but you meteorologists, are you happy with this definition?

# 2017 - CCT TG ENV discussion on a proposal to improve the VIM definition of "traceability"

Position document on the VIM definition of traceability[1]

Andrea Merlone[1], Walter Bich[2]

1. INRiM – CCT Task Group Environment Chair
2. INRiM – JCGM Working Group 1 Convener

*[other authors have already supervised the text and will be mentioned at the final draft]...*

Draft 3.3 – 2017_05_17

*Introduction*

In recent years, society has demanded higher quality products, processes and knowledge. This demand is directly reflected also in the strategies and priorities of National Metrology Institutes (NMIs) and Regional Metrology Organizations (RMOs). Several NMIs have assigned staff to new activities for directly disseminating best practice, defining dedicated calibration procedures and assisting evaluation of

Hence, **the definition could be revised** as follows:

*property of a measurement result whereby the result is related to a reference through a documented unbroken chain of* ***calibrations****, and the* ***measurement uncertainty*** *is composed of each of the calibration uncertainties and contributions due to the measurement conditions.*

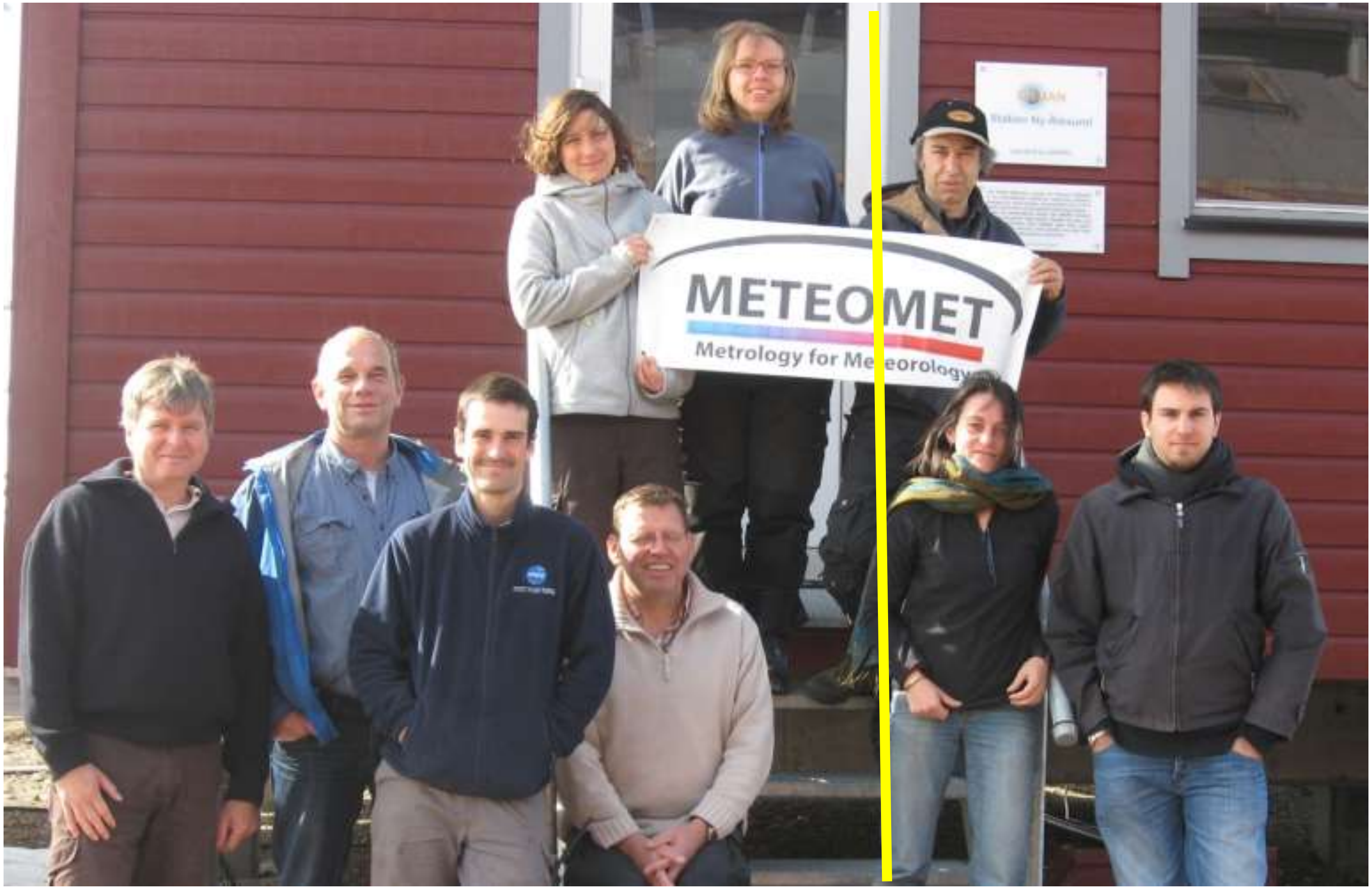
# Atmospheric air temperature measurements: can we evaluate a complete uncertainty budget?

**If yes, it will take 10…15 years of applied metrology.**

Keep on working together!

Andrea Merlone

# Keep on working together!




# WWW.METEOMET.ORG

Meteorological Applications

METEOROLOGICAL APPLICATIONS RMetS

## Compensation of solar radiation and ventilation effects on the temperature measurement of radiosondes using dual thermistors



| | |
|---|---|
| Journal: | *Meteorological Applications* |
| Manuscript ID | MET-17-0015.R1 |
| Wiley - Manuscript type: | Research Article |
| Date Submitted by the Author: | 13-Apr-2017 |
| Complete List of Authors: | Lee, Sang-Wook; Korea Research Institute of Standards and Science, Center for thermometry<br>Park, Eun Uk; Korea Research Institute of Standards and Science, Division of Physical Metrology<br>Choi, Byung Il; Korea Research Institute of Standards and Science, Center for Thermometry<br>Kim, Jong Chul; Korea Research Institute of Standards and Science, Center for Thermometry<br>Woo, Sang-Bong; Korea Research Institute of Standards and Science, Center for Thermometry<br>Kang, Woong; Korea Research Institute of Standards and Science, Division of Physical Metrology<br>Park, Seongchong; Korea Research Institute of Standards and Science, Center for Photometry and Radiometry<br>Yang, Seung Gu; Jinyang Industrial, Meteorological Environment Research Center<br>Kim, Yong-Gyoo; Korea Research Institute of Standards and Science, Division of Physical Metrology |
| Keywords: | Extreme Temperature < Topo-climate, Uncertainty Analysis < Verification, Techniques < Verification, Calibration < Forecasting, Sensor Networks < Climate change impacts |
| Manuscript keywords: | dual thermistors, solar radiation, ventilation, radiosonde, air temperature metrology, Metrology for Meteorology |

SCHOLARONE™ Manuscripts



Table 1. Uncertainty of wind speed, irradiance, and temperature

| Uncertainty of wind speed | Standard uncertainty ($m \cdot s^{-1}$) |
|---|---|
| - Calibration of anemometer | 0.06 |
| - Stability | 0.02 |
| **Combined uncertainty, $u_c(v)$** | 0.063 |
| **Uncertainty of irradiance** | (%) |
| **Uncertainty of the measured irradiance, $u_{c,r}(S_m)$** | 1.9 |
| - Calibration of pyranometer | 0.2 |
| - Stability | 0.5 |
| - Solar simulator reproducibility | 0.1 |
| - Spatial gradient in test section | 1.8 |
| **Uncertainty of calculated irradiance, $u_{c,r}(S_{cal})$** | 12.2 |
| - Compensation of wind speed, $\frac{\partial S_{cal}}{\partial v} \times u_c(v)$ | 0.1 |
| - Uncertainty of $(T_{Bl} - T_{Al})$, $\frac{\partial S_{cal}}{\partial (T_{Bl} - T_{Al})} \times u_c(T_{Bl} - T_{Al})$ | 12.1 |
| - Uncertainty of data scattering, (Max error in Fig. 4(b))/3 | 1.1 |
| **Uncertainty of temperature** | (mK) |
| **Uncertainty of $T_{Bl}$, $u(T_{Bl})$** | 43 |
| - Stability of thermistor | 40 |
| - Uncertainty due to measured irradiance, $\frac{\partial T_{Bl}}{\partial S_m} \times u_c(S_m)$ | 14 |
| **Uncertainty of $T_{Al}$, $u(T_{Al})$** | 41 |
| - Stability of thermistor | 40 |
| - Uncertainty due to measured irradiance, $\frac{\partial T_{Al}}{\partial S_m} \times u_c(S_m)$ | 6 |
| **Uncertainty of $(T_{Bl} - T_{Al})$, $u(T_{Bl} - T_{Al})^2 = u(T_{Bl})^2 + u(T_{Al})^2$** | 60 |
| **Uncertainty in temperature correction, $u_{c,cor}(T_{sensor})$** | 95 |
| **Uncertainty of $T_{Shade}$, $u_c(T_{Shade})$** | 27 |
| - Calibration of IPRT | 25 |
| - Stability of IPRT | 10 |
| **Compensation of wind speed, $\frac{\partial T_{sensor}}{\partial v} \times u_c(v)$** | 10 |
| **Compensation of irradiance, $\frac{\partial T_{sensor}}{\partial S_{cal}} \times u_c(S_{cal})$** | 90 |
| **Uncertainty of data scattering, (Max error in Fig. 6(a))/3** | 10 |

METEOROLOGICAL APPLICATIONS RMetS

**Dual temperature sensors having different emissivity in radiosondes for the compensation of solar irradiation effects with varying air pressure**

| | |
|---|---|
| Journal: | *Meteorological Applications* |
| Manuscript ID | MET-16-0161 |
| Wiley - Manuscript type: | Research Article |
| Date Submitted by the Author: | 13-Dec-2016 |
| Complete List of Authors: | Lee, Sang-Wook; Korea Research Institute of Standards and Science, Center for thermometry<br>Park, Eun Uk; Korea Research Institute of Standards and Science, Division of Physical Metrology<br>Choi, Byung Il; Korea Research Institute of Standards and Science, Center for Thermometry<br>Kim, Jong Chul; Korea Research Institute of Standards and Science, Center for Thermometry<br>Woo, Sang-Bong; Korea Research Institute of Standards and Science, Center for Thermometry<br>Park, Seongchong; Korea Research Institute of Standards and Science, Center for Photometry and Radiometry<br>Yang, Seung Gu; Jinyang Industrial, Meteorological Environment Research Center<br>Kim, Yong-Gyoo; Korea Research Institute of Standards and Science, Center for Thermometry |
| Keywords: | Temperature < Forecasting, Uncertainty Analysis < Verification, Extreme Temperature < Topo-climate |
| Manuscript keywords: | temperature sensor, solar radiation, radiosonde, air temperature metrology, thermal metrology for climate |



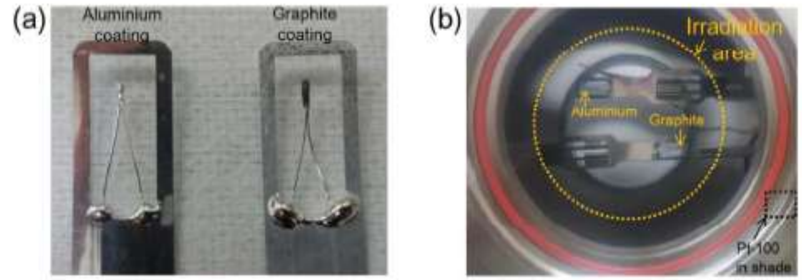
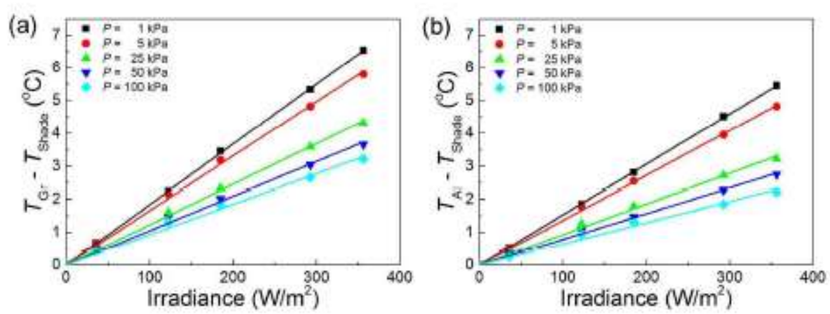



**Figure 1**: (a) Photograph of radiosonde temperature sensors (thermistors) coated with aluminium (left) and graphite (right). (b) Photograph of radiosonde temperature sensors coated with aluminium and graphite installed on the same incident plane inside the chamber which allows the control of air-pressure and irradiation from solar simulator. An extra Pt-100 temperature sensor is installed in the shaded area unexposed to the irradiation inside the chamber.



**PRIMARY STANDARD,**
standard that is designated or widely acknowledged as having the highest metrological qualities and
whose value is accepted without reference to other standards of the same quantity.
6.6. **REFERENCE STANDARD,**
standard, generally having the highest metrological quality available at a given location or in a given
organization, from which measurements made there are derived.
6.7. **WORKING STANDARD,**
standard that is used routinely to calibrate or check material measures, measuring instruments or
reference materials.
NOTES:
1 A working standard is usually calibrated against a reference standard.
2 A working standard used routinely to ensure that measurements are being carried out correctly is
called a **check standard.**

Procedure and protocol for interlaboratory comparison in the field of temperature, humidity and pressure

The intercomparison is now running as a WMO-CIMO action. Start date April 2016. First loop (of 3) ended August 2016.

World Meteorological Organisation
Working Group on Technology Development and Implementation (WG TDI)
in RAVI
Task Team on Regional Instrument Centre

in cooperation with

University of Ljubljana
Faculty of electrical engineering

# Final ILC protocol

INSTRUCTION FOR THE PARTICIPANTS IN THE INTERLABORATORY COMAPRISON

## Title: Intercomparison in the field of temperature, humidity and pressure

## MM-ILC-2015-THP

# 2 Description of the equipment

## 2.1 General

| Measuring quantity | Temperature | | Relative humidity | Air Pressure |
|---|---|---|---|---|
| Measuring instrument | Keysight/Agilent Hewlett Packard 34420A digital readout, 2 x Pt100 | | Capacitive hygrometer | Barometer |
| Manufacturer | HP, ELPRO | | Vaisala | Vaisala |
| Type | 34420A,<br>2210 4700/X | | HMP155<br>A2GB11A0A1A1A0A | PTB220<br>ACA2A3A1AB |
| Serial number | Loop 1<br>34420A:<br>US34000601<br>Thermometers:<br>395050316<br>395060316 | Loop 2<br>34420A:<br>MY42002060<br>Thermometers:<br>395090316<br>395100316 | Loop 1: K2250039<br>Loop 2: K2250040 | Loop 1: A4610018<br>Loop 2: W4230005 |
| Measuring range | (-200 ÷ 450)°C | | (0.8 ÷ 100) %RH | (50 ÷ 110) kPa |
| Output | Temperature;<br>Digital display,<br>GPIB | | Voltage (0..1V);<br>Analog output | Pressure;<br>Digital display,<br>GPIB |
| Accuracy | 0.05 °C at 20°C | | 1 %RH | 15 Pa |
| Uncertainty | 0.03 °C | | - | - |
| Minimum immersion depth | 150 mm | | - | - |
| |  | |  |  |

The instrument's owner: UL/FE-LMK.
For transportation purposes the measuring instruments will be placed in a protecting case.
In a case any of the above-mentioned equipment is missing at the receipt, the coordinator must be contacted.