



Annex to the Air Temperature Metrology – ATM EURAMET project form

**Overview.**

This Euramet project includes two main activities:

1. Perform a pilot study (in the form of an interlaboratory comparison) to explore issues around calibration in air of temperature sensors ;
2. Feed into a guidance document the findings from the pilot study.

**Background and need for the project.**

Air temperature is measured for a multitude of purposes. Atmospheric air temperature is the key variable in indoor climatisation, in meteorological observations and climate studies. It is also critical to precision dimensional and mass measurements. Understanding and fully evaluating measurement uncertainty for air temperature measurements is an open scientific and technical issue now motivating research efforts and discussion both at the CIPM CCT and in WMO expert teams. In meteorology traceability of measurement is increasingly requested and strongly motivated by the need for comparability of data among different measuring stations, different networks including different methods, and in different times and places. Documented traceability of measurement results requires full understanding and evaluation of influencing quantities effects and associated components in the measurements uncertainty budget. As yet these are not fully understood. A number of experiments have already addressed and solved specific aspects of atmospheric air temperature measurements, quantities of influence and uncertainty components. During the MeteoMet projects (EMRP 2011-2017) some of these effects were investigated mainly in terms of single components in the overall measurement uncertainty budget: sensors dynamics, measuring site characteristics and presence of disturbing obstacles, direct and reflected radiation, wind and rain. Not only the in situ air temperature measurement uncertainty is presently a subject of study, but also the calibration of thermometers in air still requires definition of procedures and prescription including calibration uncertainty evaluations, being a significant component of the overall measurement uncertainty. While

calibration of temperature sensors in liquid is well characterised, the calibration of thermometers in air still requires definition of procedures and guidelines.

The problem on the lack of a guide for the calibration of thermometers in air was underlined at the EURAMET TC-T meeting of 2017 and work was started under the leadership of Andrea Merlone (INRiM) in promoting work and collaborative research for the production of such a guide. The guide will be prepared under the auspices of Euramet TCT WG on guides.

The analysis of the air temperature measurement procedures and uncertainty evaluation, including the aspects and contributions due to the calibration of sensors is also a task of the CCT Working Group on Environment and is included in the strategy roadmap of CCT.

## Objectives

### Task 1. Collection of thermometers for performing the ILC.. Task leader: project coordinator

To achieve complete understanding on issues and difficulties met in calibrating thermometers in air, different thermometers will be included in this study. They will be identified in order to cover a representative number of typologies i.e. those usually involved in air temperature measurements for different applications such as in industry, indoor ambient, meteorology and climate: metal sheathed prts, meteorological thermometers, indoor and industrial sensors. The ILC will only include PT100 or better quality sensors; radiation shields will not be included in the study. A number of thermometers will be collected in groups of at least three identical ones, to make one available for each intercomparison loop. Manufacturers will be requested to volunteer to provide sensors.

Responsible	Deliverable	Month
Project coordinator and volunteers	Collect groups of three identical thermometers	6

### Task 2 - Interlaboratory comparison of techniques for calibration of thermometers in air in the range of atmospheric temperature. Task leader: JV

An interlaboratory comparison will be performed as a pilot study for the evaluation of a best procedure to be adopted for the calibration of thermometers in air. The comparison will be performed within the limits of near surface atmospheric air temperature<sup>1</sup>, from -80 °C to + 60 °C with two different ranges:

Range A: -80 °C to 60 °C

Range B: -40 °C to 60 °C

Participants can choose one of the two ranges considering that a condition for joining the pilot comparison is for all participants to have the capability to cover the whole temperature range for the selected option.

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<sup>1</sup> The lowest natural temperature ever directly recorded at ground level on Earth is -89.2 °C (-128.6 °F; 184.0 K) at the Soviet Vostok Station in Antarctica on July 21, 1983 by ground measurements.

<https://wmo.asu.edu/content/world-meteorological-organization-global-weather-climate-extremes-archive>

The task leader, in cooperation with the pilot laboratories will draft the comparison protocol/s that will be agreed by all participants prior to the start of the comparison. All participants will have to describe the procedure they adopt for calibrating the sensors in air. A form will be prepared by the task leader the pilot laboratories and the jrp coordinator and discussed among all participants.

Due to the number of participants, three loops will be organized: one loop in the -80 °C to + 60 °C range A and 2 loops in the -40 °C to + 60 °C range B1 and B2.

Range A: NSAI NML

Range B1: CEM

Range B2: INRiM

The study will take into account the findings of the previous EURAMET P1061 intercomparison, carried out to investigate the reliability and equivalence of calibration methods used by NMIs in calibrating air thermometers. The effect of self-heating depending on the air velocity and a study on radiative heating will be included in the investigation.

The task responsible, JV, will take part in the three loops, to establish linked comparability among the three separate loops. Alternatively, a “miniloop” will be organized by the three pilots. The decision will be taken during the project.

At the end of the comparison, the ILC report will be drafted by the Task leader. A major part of the report will have to demonstrate achieved understanding and evaluation of the pros and cons of the different procedures used by the participating partners and used for defining the best practice. This will be based on the capabilities to make measurements with low uncertainty, by reducing the effect of quantities of influence and on the possibility to include a wide range of sensors so the procedure would have quite general applicability.

<b>Responsible</b>	<b>Deliverable</b>	<b>Month</b>
Task leader + Pilot labs	<b>ILC Protocol</b>	<b>6M</b>
Task leader + Pilot labs + project coordinator	<b>Form for procedure declaration</b>	<b>5M</b>
Pilot labs	<b>Loop report</b>	<b>24M</b>
Task leader + Pilot labs	<b>ILC Report</b>	<b>30M</b>

#### **Note on CMC support**

This project and ILC comparison are addressed to research purposes and for the preparation of the guide (Task 3). In order to compare and evaluate the best techniques adopted by different participants, the ILC will not be a blind one and will not be registered in BIPM KCDB. During the lifetime of the project participant can decide to take an appropriate action, to have a CMC ILC following this project, after the submission of the guide, thus in line with the guidelines possibly published.

**Task 2 Subtask 1 Liquid – air comparison. Subtask leader: BEV E+E.**

Participation in this task is on volunteer basis.

A comparison analysis of calibration results obtained in liquid (thermostatic bath) with respect to air (climatic chamber) will be made in terms of achievable uncertainties, representativeness of calibration with respect to measurement condition, possible errors.

Basically the calibration of thermal probes in liquid bath and in air should result in comparable values within related uncertainties. But usually the thermal behavior of the probes (e.g. self-heating) is significantly different. For achieving comparable results some correction for the calibration in air have to be taken into account which leads to an increase of measurement uncertainties. For the evaluation of these contributions the following investigations will be undertaken:

- Calibration in liquid bath in the range from -80 °C to 60 °C including direct contact with liquid for those sensors allowing to be immersed
- Investigation of self-heating in air at different air velocities.
- Investigation of response-time in air at different air velocities
- Calibration in air (temperature chamber) at different radiation conditions

A protocol on this activity will be prepared by the sub task leader and agreed by the participants. A final report will be prepared by the task leader, summarizing the results.

<b>Responsible</b>	<b>Deliverable</b>	<b>Month</b>
Sub Task leader + project coordinator and volunteers	Report on identified and possibly quantified difference/s between air and liquid calibration of a sub group of thermometers	M34

**Task 2 Subtask 2 INRiM – IMBiH bilateral comparison**

Sub task leader: INRiM

Based on the protocol developed for the inter-laboratory comparison carried out in the EURAMET project n. P1061, and in line with the protocol of this project, INRiM will organize a bilateral comparison with IMBiH as participant, in order to demonstrate the degree of equivalence of IMBiH with respect to INRiM which already held published CMC in the air temperature range between -20 °C and 80 °C.

<b>Responsible</b>	<b>Deliverable</b>	<b>Month</b>
INRiM	Report on INRiM – IMBiH bilateral comparison	M30

## Task 2 EURAMET Guidelines for calibration of thermometers in air

Task co-leaders: INRiM - SMD

Based on the best practice defined and reported in task 1, the participants will draft a proposal for a EURAMET guide on calibration of thermometers in air. The document will contain a full documented procedure for performing the calibration, together with definition of uncertainty budget components and methods for their evaluation.

Different typologies of temperature sensors will be included with, if needed, different prescriptions and specific procedures. The guide will cover a range of sensor types; i.e. those usually involved in air temperature measurements for different applications such as in industry, indoor ambient, meteorology and climate. Thermometers equipped with ventilated radiation shields will also be considered as well as temperature sensors incorporated in relative humidity probes.

The proposed guide will include prescriptions on how to evaluate and minimize where possible, the effect of heat biases in the calibration accuracy, due to radiative and convective effects. The document will be submitted to TC-T Working Group on best practices (guides) for discussion and approval.

### Impact.

The main benefit of this project will be the preparation of a EURAMET guide for the calibration of thermometers in air. This will provide important best practice which is currently lacking. The work will also be presented at the CCT for possible adoption by other RMOs and as input to the WG ENV. This activity is aligned with the CCT strategy document<sup>2</sup> chapter “Guides on thermometry”.

Responsible	Deliverable	Month
Project coordinator	Report to CCT	36 M +
Project coordinator	Report to WMO	36 M +
Project coordinator - all	Publication and conference presentations	36 M +

36M + = not limited to M36

This proposal is also expected to bring valuable input to the following:

WMO CIMO Expert team on operational in situ technologies - for the definition of best practice and sustained performance classification

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<sup>2</sup> CCT Strategy document for rolling programme development for 2018 to 2027  
<https://www.bipm.org/utis/en/pdf/CCT-strategy-document.pdf>

GCOS task team on Global Surface Reference Network - for inclusion in the requirements of reference grade air temperature measurements

GRUAN - for the general aim at documented traceability for radiosondes temperature profiles.

### **Project advisory board.**

An advisory board is established to supervise the project progresses, avoid delays where possible, and revise all documents (protocols, reports). Advisory board members can be added during the lifetime of the project and can include representatives of the stakeholders community.

### **Meetings**

Project meetings are planned as satellite events of TC-T. The first meeting is scheduled on 9 April 2019 in Torino

#### List of acronyms

CCT = Consultative Committee for Thermometry

CIPM = the International Committee for weights and measures Comité International des Poids et Mesures

GCOS = Global Climate Observing System

GRUAN = GCOS Reference Upper Air Network

NMI = National Institute of Metrology

RMO Regional Metrology Organizations

WMO = World Meteorological Organisation

**Actions plan**

<b>What</b>	<b>When</b>
Identify Task 1 (IL) leader	Mid May - Done
Identify/confirm loop A leader Volunteer: NSAI NML	Mid May - Done
Identify Loop B1 and B2 leaders Volunteers: CEM, JV, INRiM, MIRS/UL-FE/LMK, UME	Mid May - Done
Identify Sub task 1.1 leader (liquid – air comparison) and task go-no go	Mid May - Done
Confirm Sub task 1.2 (INRiM – IMBiH bilateral sub comparison)	Mid May - Done
Identify Task2 leader	Mid May - Done
Declare participation in range A or B All participants	End May
Contact manufacturers and laboratories to make thermometers available for the ILC.	End June: confirm availability Mid September: sensors available at project coordinator or at task 1 leader sites.
ILC Protocol draft	End September
Procedure description form	End September
ILC loops start	October
Project meeting	9 April 2019 at TC-T in Torino
ILC end	April 2021
ILC loops report	June 2021
ILC complete report	July 2021
Guide preliminary draft	July 2021
Guide final draft	October 2021

**Participants and involved staff in the project. CONFIRMED**

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**Advisory board:**

Andrea (project coordinator)

Dolores (TC-T Chair person + pilot lab)

Stephanie (coordinator of PRT on air T and chair WG Hu CCT)

Miruna (Chair Best practice TC-T + co-resp. task 2)

Åge (Responsible Task 1),

Vito, (Pilot lab)

Dubhaltach (Pilot lab)