CCT member Activity Report

Period: January 2024 to April 2026

Institute: INRiM – Istituto Nazionale di Ricerca Metrologica (Italy)

State economy: Italy

Number of persons involved in thermometry of the institute: 25

Short summary of research and development:

Development of primary gas thermometry methods, including acoustic gas thermometry (AGT) and refractive index gas thermometry (RIGT) to realize the new definition of the kelvin and for determination of the differences (T-T_{90}) between the thermodynamic temperature and ITS-90 in the range 10 K and 700 K; Maintenance and development of the fixed points of the International temperature scale of 1990 (ITS-90); Research activities to extend the contribution of the thermal metrology community to climate science and meteorology, e.g. construction and metrological characterization of miniaturized Ga fixed-point cells for space applications. Design and realization of thermal apparatus in support of fundamental research (e.g. atomic and quantum physics);

Development of primary humid gas standards covering the trace water regime for amount fraction of water in N_2 and Ar down to 4 nmol/mol (frost point temperature to −105 °C); Development of a high-pressure moist hydrogen generator covering the frost point temperature range from -65 °C to -10 °C (amount fraction of water from 100 nmol/mol to 500 µmol/mol). Maintenance and development of measurement standards for air temperature in the range between -40 °C to 180 °C.

Determination of thermophysical properties, including speed of sound, heat capacity, vapour pressure of fluid substances (e.g. air, water, seawater, hydrogen, refrigerants, liquid natural gas, biofuels, ..).

Research activities of INRiM “Applied Thermodynamics” sector have been mainly oriented towards progressing and extending the contribution of the thermal metrology community to climate science and meteorology.

Participation and piloting of international Key Comparisons in Temperature and Humidity; Dissemination and services related to NMI role: calibrations – Inter-Laboratory Comparisons (ILC) – industrial testing and investigations – technical workshops – training; Development of new CMCs for thermometry and humidity.

Participation into the working groups and Committees of BIPM and Euramet including Chairmanship of the WG Environment (CCT-WG-Env) and of TG-Env-AirT; participation in working groups, including Non-Contact Thermometry (CCT-WG-NCTh); Thermophysical Quantities (CCT-TG-ThQ); Body Temperature Measurement (CCT TG-NCTH-BTM); Digitalization (CCT-WG-Dig).

Chairmanship of the Strategy working group of EURAMET TC-T.

Collaboration with the World Meteorological Organization (WMO) with INRiM staff member or chair of several WMO expert teams and committees.

Short summary of recent comparison activity:

- EURAMET.T-S7 (Euramet Project No 1457 – Coordinated by INRiM) Comparison of measurement parameters required in radiance temperature scale realisation from 156 °C to 1100 °C. Approved May 2026.
- CCT-K11 Comparison of blackbodies for infrared ear and forehead thermometers from 34.0 °C to 43.0 °C. Measurements in progress

- CCT-K8: Key comparison of realizations of local scales of dew-point temperature of humid gas; completed;
- EURAMET T.K8, Key Comparison of high dew-point temperatures: completed;
- CCT K9: Key Comparison of SPRT calibration between Ar and Zn fixed points; completed
- CCT K2.2: Bi-Lateral Key Comparison between INRiM and NIM on realizations of the ITS-90 from 24.5 K to 273.16 K: waiting for completion of NIM measurement activities;
- EURAMET.T-K9: Regional key comparison: follows corresponding CCT K9; completed
- coordination of the WMO ILC on temperature, pressure and humidity: the ILC is now being organized in the WMO South American and African Regional Instrument Centres.

Short summary of other activities:

Several **international** and **national research projects** are running, or have been completed in the reporting period, in the areas of thermometry or hygrometry, with the contribution of INRiM or coordinated by INRiM. These include:

- EPM 25RPT02 (2026-2029) Supporting emerging technology uptake for thermodynamic temperature dissemination "Setup-T"– INRiM coordination. The project aims at establishing the technology, methods and procedures for the calibration and comparison of sensors used to realise and maintain wire-scales over an extended strategic temperature range (4 K – 300 K).
- EPM 24GRD06 (2025-2028) Metrology for comparable and trustworthy greenhouse gas remote sensing datasets “MetCTG”. The project will improve the accuracy of spectral line parameters for satellite greenhouse gases retrievals and ground-based observations; gas matrices with SI-traceable amount of water vapour will be generated and investigated by the consortium.
- EPM 24GRD11 (2025-2028) Metrology for hydrogen vehicles 3 “MetroHyVe3”. The project aims to develop the metrology infrastructure for hydrogen refuelling stations and provide new measurement standards, methods, and best practices for measurement of both hydrogen quality and quantity, including trace water as a key hydrogen contaminant.
- HORIZON-CL4-2023-DIGITAL-EMERGING-01 CNECT (2024-2028) Quantum Enhanced Photonic Integrated Sensors For Metrology "Quantify" INRiM coordination. Among the project objectives: Development of a photonic/phononic integrated Quantum Enhanced Temperature sensor and its metrological characterization.
- EPM23FUN01 (2024-2027) Photonic and quantum sensors for practical integrated primary thermometry "PhoQuS-T". The project aims to take advantage of the kelvin redefinition by developing novel small-scale optical based primary thermometry approaches for the dissemination of thermodynamic temperature to industries such as semiconductor, micro- and nanotechnology, aerospace and naval, green energy and quantum technologies.
- EPM 22IEM02 (2023-2026) Dissemination of the Redefined kelvin "DireK-T" – INRiM coordination. The project aims at testing a comparison of realization of thermodynamic temperature in the range 4 K to 303 K with dissemination of the kelvin over the same range and T-T_{90} determinations between 4 K and 700 K.
- EPM 21GRD03 (2022-2025) Metrological framework for passive radiative cooling technologies "PaRaMetriC" – INRiM coordination.
- EPM 21GRD05 (2022-2025) Metrology for the hydrogen supply chain “Met4H2”. This project developed novel and improved standards for the safe application of hydrogen, flow measurement, and hydrogen quality assessment with a focus on trace water measurements as a key hydrogen contaminant.

- EMPIR 20IND02 (2021-2024) Metrology for trace water in ultra-pure process gases “PROMETH2O” - INRiM coordination. The project will develop a range of optical methods to measure amount fractions of water down to 5 ppb for gases other than nitrogen, and a primary method down to 50 ppb to validate chilled-mirror hygrometers down to –105 ° C.
- EMPIR 20IND06 (2021-2024) Metrology for trace water in ultra-pure process gases “PROMETH2O” - INRiM coordination. The project developed a range of primary standard generators covering the frost point temperature down to -105 °C and amount fraction of water down to 4 nmol/mol in N2 and Ar matrices, and improved primary spectroscopic methods down to 50 ppb.
- EMPIR 20IND27 (2021-2024) Metrology for decarbonisation of the gas grid “Decarb”. INRiM contributed by thermodynamic property measurements of natural gas and biogas fluid mixtures
- H2020 MIDAS (2021-2024) – Modular and Integrated Digital Probe for SAT Aircraft Air Data System. Partnership of INRiM with Politecnico di Torino for the characterization of prototype sensor systems for small aircraft. Sensors are being tested under a wide range of variability of the quantities of interest: temperature, pressure (altitude), airspeed and angles.
- EMPIR 19SIP03 (2020-2023) Climate Reference Station “CRS” – INRiM coordination – study of best instrumentation for completing a Climate Reference Station for the future GCOS Surface Reference Network. A test site field installation, together with the INRiM laboratories will provide a research infrastructure for the project and initiative.
- EPM 24RPT03 “A^2TM” – WP leading. The project aims at the characterization of a prototype sub-chamber, to be put inside commercial climatic chambers, for the calibration of temperature sensors in air. G. Coppa leads WP4, coordinating impact and outreach activities.
- EURAMET P1459 “Air Temperature Metrology” - INRiM coordination . At the TC-T meeting in 2026 it was decided to end the project and postpone the production of guidelines for calibration of temperature sensors in air until the completion of project A^2TM.
- Italian PRIN project “Rockfall” – coordination. The project aimed at the definition of a model of heat transfer in high-mountain rock faces, to have a better understanding of the phenomena that trigger rockfalls in mountain areas. Merlone and Coppa led the unit in charge of calibrating, characterizing, installing and analysing data from the instruments in the designated mountain area.
- Italian PRIN project “Mirable” – participation. MIRABLE project developed a low-cost multisensor platform for Indoor Environmental Quality monitoring underpinned by a rigorous metrological framework. Characterization of the multisensor performances were conducted under controlled conditions in the thermal domain (temperature).
- COST Action “CRIM” – coordination. The Action addresses the critical needs for traceable measurements to the International System of Units (SI) and robust uncertainty quantification in atmospheric and climate research. The primary objective of CRIM is to foster collaboration and harmonization among researchers, institutions, and stakeholders across Europe, and beyond, to enhance the quality, reliability, and credibility of observational data in climate science. The final aim is to ultimately improve confidence in detecting climate trends and predicting severe events.
- Forum Balloon (2021-2025) Partnership of INRiM with CNR-INO and Italian Space Agency for the development of a prototype stratospheric balloon

From 2025, the group on thermal metrology for climate of INRiM started the planning and organization of new research activities and services in the new Institute's headquarters in Matera. Preliminary work regarded surveying needs of traceability and uncertainty evaluation in environmental measurements for climate stations and in agro-meteorology.

In 2026 the start of a WMO-sanctioned intercomparison of air thermometers, solar shields and dataloggers of climate stations belonging to GSRN network is expected. The intercomparison will be hosted and performed by INRiM and will feature both laboratory and field activities

In 2024, WMO has awarded INRiM the status of “Measurement Lead Centre (MLC) on Traceability and Field Metrology”. This marks the first time that an NMI has been recognized as MLC, and strengthens the commitment of INRiM in the topic of climate monitoring from the metrology community.

Collaboration with the WMO. INRiM Staff is extending the membership and chairmanship of the WMO expert teams: WMO ET “Measurement Uncertainty” – A. Merlone chairperson – Evaluation of measurement uncertainties in meteorological observations, terminology; WMO Standing Committee on Measurement Instrumentation and Traceability – A. Merlone Member; WMO ET Quality, Traceability and Calibration – A. Merlone Member. Activities on training, siting validation-verification GCOS Surface Reference Network – GSRN; INRiM is member of the Task Team for the creation of the GSRN with A. Merlone serving as chair of the subgroup 5 on Science and Research and member of the SG3 on Uncertainty; GCOS Reference Upper Air Network – GRUAN. G. Coppa member; Global Cryosphere Watch (GCW) Best Practices team for permafrost observations: Merlone (co-chair) and Coppa (member). Work finalized in 2024 with the publication of a chapter in WMO’s “Guide to the Instruments and Methods of Observation (WMO #8) Volume 2 – Measurement of Cryospheric Variables” dedicated to permafrost; EMN COO: Coppa contact person for section “Earth Observation”; Merlone cross-sectional and Strategy expert.

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