



Publishable Summary for 19SIP06 COAT

Increasing the comparability of extreme air temperature measurements for meteorology and climate studies

Overview

Reliably formulating Climate Change policies and mitigation strategies relies on accurate early trend detection based on robust monitoring of Essential Climate Variables (ECVs) such as air temperature. In the Arctic, a region very sensitive to climate change, rigorous monitoring of ECVs provides early indications of climate change trends. Improved accuracy and standardisation in measuring air temperatures based on using reference instrumentation with robust traceability to SI units and reliable uncertainty evaluation is needed to generate higher quality data for trend analysis.

Building on the results of the EMRP project ENV58 MeteoMet2, this project will develop a validated intercomparison protocol of thermometers and radiation shields in the field and a best practice guide covering the use of thermometers and radiation shields in extreme cold environments. These documents will be submitted to WMO INFCOM/SC-MINT (WMO Infrastructure Commission/Standing Committee on Measurements, Instrumentation and Traceability formerly WMO-CIMO) for their consideration as potential reference documents for the meteorological and climate communities, manufacturers and end users.

Need

Currently, air temperature measurements, are performed by thermometers protected from the sun's radiation by a shield. Combinations of different models of thermometers and radiation shields are used around the world since neither, a specific thermometer nor a radiation shield, have been defined as a 'reference system' so far. The response of each system (thermometer + radiation shield) to fast temperature changes, residual sun radiation, wind, humidity, etc. depends on the system itself. In addition, each radiation shield has a specific influence on air temperature measurements, which is dependent upon the model of both, shield and thermometer. This makes the comparability of air temperature measurements, taken around the world, limited, creates inconsistencies in climate data series and reduces the accuracy and reliability of long-term air temperature data.

The project's Primary Supporter, WMO, recognises the reduction of these inhomogeneities in data as essential and in its 16th Session, the WMO-CIMO (Commission for Instruments and Methods of Observation) highlighted field intercomparison of instruments as the most powerful tool for increasing the comparability of measurements taken at different times and in different places.

Being aware of the WMO need for protocols for performing intercomparisons, ENV58 MeteoMet2 developed a feasibility study for an intercomparison of thermometers and radiation shields that was submitted to the WMO CIMO Expert team on Instrument Intercomparison for their consideration. However, this intercomparison has yet to take place. ENV58 MeteoMet2 also developed procedures for the determination of the inherent performance of thermometers and the evaluation of the influence of external factors (e.g. rain, buildings, roads) on air temperature measurements. However, the uptake and the application of these procedures needs further promotion in the form of a best practice guide for use by the user community.

Objectives

The overall aim of this project is to create impact from the results of ENV58 MeteoMet2 results by developing guidance to improve the comparability of air temperature measurements and to identify the performance limits of thermometers and radiation shields in Arctic. These results will be disseminated via a validated protocol and a best practice guide to WMO for their potential adoption as reference documentation.

The project addresses the following objectives:

1. To develop a validated protocol for planning and conducting in field intercomparisons for determining the performance of thermometers and radiation shields used for meteorological and climate purposes. This



will be based on the JRP ENV58 MeteoMet2 comparison feasibility study, the procedures for the evaluation of the inherent performance of thermometers and the results on the influence of external parameters on air temperature measurements. The intercomparison protocol will also include the conclusions and recommendations from previous field intercomparisons of radiation shields, including those organised by WMO. The intercomparison protocol will implement metrological concepts and it will be validated by the field measurements in the Arctic (Objective 2) and then reviewed and submitted to WMO-INF/COM/SC-MINT for potential consideration as reference document to support the harmonisation in the organization of future intercomparisons of thermometers and radiation shields.

2. To perform and make publicly available the results and conclusions of a field intercomparison of thermometers and radiation shields in the Arctic. This intercomparison will follow the protocol initially developed in objective 1 and will provide feedback for the validation of the final intercomparison protocol. From the results of the intercomparison a reference thermometer and radiation shield for air temperature measurements in Arctic environments will be identified, and the transfer functions between the different instruments involved in the intercomparison will be determined. These outputs will be disseminated to the Primary Supporter and submitted to an open access meteorological journal.
3. To produce a best practice guide for air temperature measurements in Arctic conditions. This guide will encompass the findings from this project as well as from JRP ENV58 MeteoMet2 outputs. The best practice guide will include standardised testing methods, preventive maintenance protocols and recommendations to manufacturers of thermometers and radiation shield on how to improve the performance of their products for Arctic environments. It will be submitted to the WMO-INF/COM/SC-MINT Expert team on surface and sub-surface measurements and to other Commissions and Expert teams of WMO for its potential consideration and inclusion in the Guide to Meteorological Instruments and Methods of Observation (WMO n° 8), and in the Guide to Climatological Practices.

Results

The progress towards objectives to date, are:

1. The initial comparison protocol covering the planning, initiating and conducting of field intercomparisons of thermometers and radiations shields for meteorological purposes has been written, and reviewed by the Primary Supporter and stakeholders. This intercomparison protocol includes the implementation of metrological concepts and procedures. Once finalised, it will be validated by field measurements in the Arctic (Objective 2) and the analysis of results from previous intercomparisons of radiation shields with the support of the Primary Supporter.
2. The collection of the instrumentation to be included in the comparison was completed and all the systems were characterized at CEM prior to their transportation to the arctic area in Ny-Ålesund. The deployment of all instrumentation was performed in July 2022 and air temperature data has been collected since then from the different sensors and radiation shields involved in the comparison. The data from the intercomparison will be subsequently used for the validation of the intercomparison protocol (Objective 1) and the derivation of the measurement best practice guide in Objective 3.

Impact

To date, five presentations on the project have been given to stakeholders, user communities and manufacturers:

- Presentation of the project to WMO. INF/COM/SC-MINT-ET on Surface and Subsurface Measurements
- Presentation of the project to the National meteorological Agency in The Netherlands
- Presentation of the project to International Association of Manufacturers of Meteorological Instrumentation (HMEI).
- Presentation at 54° Ny-Ålesund Scientific management Committee (NYSMAC) meeting
- Presentation of the project to Vaisala, Manufacturer of Metrological Instrumentation

The project was presented at seven conferences:

- CIM 2021, where a poster about the project was presented
- Waiting for MMC with an oral presentation
- Metrology for Green Deal (Spain) with an oral presentation.
- Congreso Español de Metrología (Spain) with an oral presentation
- BIPM-WMO workshop "Metrology for Climate Action 2022" with a poster.
<https://www.bipmwmo22.org/submissions/submission/16>



- The WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO-2022), with an oral presentation and extended abstract submission: <https://community.wmo.int/en/activity-areas/imop/publications-and-iom-reports/teco-2022-presentations#topic2>
- American Meteorological Society Meeting 2023, with an oral presentation

The outcomes of this Project will be shared with end-users via conferences, publications and with the support the Primary Supporter WMO. More specifically, the Project will submit the written validated intercomparison protocol for consideration to WMO INFCOM/SC-MINT as a reference document and promote its inclusion in the Guide to Meteorological Instruments and Methods of Observation (WMO n° 8). This intercomparison protocol will provide guidance on carrying out future intercomparisons of thermometers and radiation shields in field and it will support end users in the harmonisation of criteria and the implementation of metrological concepts in the development of future intercomparisons.

The conclusions on the performance of thermometers and radiation shields in Arctic conditions will contribute to of the development of guidelines and good practices and to show some typical behavior of sensors under the Arctic specific conditions with description of their limits, behaviour, response to external factors and measurement uncertainties. The transfer functions between the different thermometers and radiation shields involved in the intercomparison will also be determined. These outputs will be given to the Primary Supporter for their examination and will be submitted for publication to a meteorological open access journal. The results will help end-users to take decisions regarding measurement uncertainty when selecting their thermometers and radiation shields.

The project will also create impact by enabling the sharing of knowledge among metrologists, meteorologists and experts on environmental and climatological measurements by the dissemination of the best practice guide for air temperature measurements in arctic conditions, to the WMO for its potential consideration and inclusion in the CIMO Guide n° 8, and in the Guide to Climatological Practices (WMO n° 100). The promotion of this best practice guide by the Primary Supporter, will allow manufacturers of thermometers and radiation shields to be able to improve the performance of their products for arctic environments based on the information included in the best practice guide.

List of publications

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This list is also available here: <https://www.euramet.org/repository/research-publications-repository-link/>

Project start date and duration:		1 October 2020, 36 months + 6 months = 42 months
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