Publishable Summary for 19SIP03 CRS
Climate Reference Station

Overview

To understand climate change, scientists need detailed data on many different environmental parameters. Data on temperature, humidity and pressure – currently captured by automatic weather stations for forecasting – could provide important additional data for climate monitoring. But to use this data reliably, climate scientists need to be able to compare data from different instrumentation with different measurement methods and operated by different network stations. A consistent approach to instrument calibration with robust links to SI units and a better understanding of the environmental factors that influence measurement accuracy are key for introducing a reference system that will underpin all climate measurements.

This project builds on the metrology for meteorology results and methods developed during the preceding EMRP projects ENV58 MeteoMet2 and ENV07 MeteoMet. This project will do this by providing definitions, guidelines and measurement methods in order to improve the comparability of climate data. The project's primary supporter is the World Meteorological Organisation (WMO) which needs to significantly increase data comparability between climate observing networks by introducing consistent technical specifications for the set-up of Climate Reference Stations.

Need

Continuous, high-quality, scientific observations of the global environment are critical for defining the state of the Earth's integrated environmental system and establishing climate trends. The Intergovernmental Panel on Climate Change (IPCC), the World Meteorological Organisation and the United Nations Environment Program and Framework Convention on Climate Change (UNFCC) have recognised the need for sustained and robust climate observations. It has also become increasingly evident that data gathered for routine weather predictions do not always meet the quality standards needed for climate science purposes. Small changes over a long time periods are characteristic of climate trends, but these occur during larger shorter-term variations associated with weather and other natural climate variations. Measurements also need to be comparable over large geographic areas and extended time frames through the traceability to a metrological reference. The introduction of climate reference instruments at existing meteorological network stations would provide high accuracy quality data and enable the identification of potential problems with network data homogeneity. A tiered station concept is included in the WMO observing network design principles and GCOS report 226, which promotes the transferral of information from high quality reference observations to other measurements to improve their quality and utility.

At present a lack of unique definitions of the key instrumental and technical features for a climate reference station, as well as reference measurement procedures has generated a multitude of approaches among different nations and National Meteorological and Hydrological Services (NMHS), reducing the comparability of results over geographic areas and across time periods. This is the main cause of the huge efforts needed to harmonise climate data and detect biases in local and global climate trends.

ENV58 MeteoMet2 and its predecessor project ENV07 MeteoMet analysed the performance of meteorological instruments, improved SI traceability and investigated how quantities of influence such as temperature, humidity and snow cover effect affect instrument responses. Key outputs from these projects were: (a) dedicated calibration procedures and specific system characterisations for the realistic calibration of sensors used for climate related measurements in the field and (b) an evaluation of the effects of weather conditions and siting of the CRS on measurement quality. The output generate a recognised contribution to the WMO "Guide to Instruments and Methods of Observation" (WMO-No. 8), which is the world reference document on implementing observing stations.

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This SIP directly builds on ENV58 MeteoMet2 outcomes and will characterise temperature sensor features and reference station set-ups both in the lab and during field trials. From the results this project will prepare and submit recommendations to the WMO and the GCOS Surface Reference Network for their implementation.

Objectives

The goal of this project is to create impact by supporting the WMO and the GCOS in defining the measurement parameters, and the requirements needed for a technical specification for reference stations in ground-based climate observation networks.

The specific objectives are:

1. To define and evaluate the characteristics of reference grade temperature instruments for climatology use, by the identification of uncertainty budget components, including time-series adjustment estimations to preserve their homogeneity, and setting target measurement uncertainties. This includes the commissioning of a reference grade observing station in the lab, for performance assessment.
2. To install the laboratory evaluated reference grade observing station (objective 1) in an appropriately identified field site and operate it for at least one year to enable instrument performance to be assessed and measurement uncertainties determined over a wide range of environmental seasonal conditions. Combined with the results of objective 1 this will form the basis of a paper to be submitted to an open access meteorological journal.
3. To draft and submit a report containing comprehensive recommendations for potential inclusion in documents of (a) the WMO Commission of Instruments and Methods of Observation task team on “Uncertainty” and task team “Classification (WMO guide No. 8), (b) the WMO Commission of Climatology requirements for the recognition of reference stations and c) the GCOS manual for the Global Surface Reference Network based on the results from objectives 1 and 2.

Results

The expected final outputs in relation to the objectives, are:

1. The results of the project’s survey of commercially available thermometers and shields, both new technologies and those normally adopted by ground based meteorological stations, will lead to the selection of devices for performance evaluation in a laboratory setting and the derivation of their associated measurement uncertainties under controlled conditions. Results from these evaluations will be included in recommendations for submission to the WMO, and GCOS for the commissioning and operation of climate reference stations (objective 3).
2. The performance validation and associated measurement uncertainties determined during field operation of selected instrumentation (objective 1) will drive the realisation of a reference station prototype set-up. The prototype will have its performance evaluated and the results will be reported in an open access paper published in a meteorological journal. In addition, these results will be included in recommendations for submission to the WMO, and GCOS for the commissioning and operation of climate reference stations (objective 3).
3. The results from the evaluation of selected instruments both under controlled laboratory conditions (objective 1) and also from the project’s field trial (objective 2) will be used to draft an advisory report on the required instrument technical features and reference station set-ups for use by surface-based climate observing networks. This will be submitted to both the WMO, and GCOS expert teams for consideration for inclusion in their guides and requirements for the setting up and operation of climate reference stations. In addition, these recommendations will also be submitted to the Copernicus Climate Change Service (C3S) as a basis for consideration for the formation of an EU reference climate network.

Impact

This project will promote the widest possible uptake of the outputs of ENV07 MeteoMet and ENV58 MeteoMet2 by the WMO by direct interactions between project partners who also sit on the WMO expert teams. This will facilitate project result dissemination directly to the relevant expert teams for inclusion in guidance material such as the WMO “Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8) - the reference document on instrument implementation for meteorological and climatological sites. In addition, the results of this project will support the creation of the Global Surface Reference Network (GSRN) by GCOS. The GSRN network requires the metrological qualification of a broad suite of instrumentation.

The project will also provide the first contributions for possible future initiatives towards the creation of an EU reference climate network. Project results will also be delivered to the C3S of the European Centre for Medium-Range Weather Forecast (ECMWF) by the project coordinator who is member of the advisory board of a C3S project on uncertainty in climate data.

This project's results on the technical specifications for reference stations and sites will be of interest to instrument manufacturers to test and validate new measurement systems that may be used more broadly. The process works both ways: technological advances, new measuring principles, new solutions to reduce the effects of the influencing quantities, evolving measurement and calibration procedures, should be immediately recognised and integrated to improve the climate reference stations and networks.

The adoption of this project's unique definition and requirements for the technical setup, measurement procedures and uncertainty evaluation for climate reference stations will substantially address the present lack of a common approach in detecting climate trends. This will improve data comparability across regions and time and allow a more robust understanding of climate evolution locally and globally. The key impact of the definition of Climate Reference Station features and implementation of the GSRN will be the capability to provide the highest quality data from meteorological and climatological observations. Apart from the obvious benefits to society of better understanding climate evolution and progress toward climate change mitigation, the availability of traceable and comparable data from a range of both critical and representative global environments will be invaluable in supporting high-quality research on climate processes and in the development and validation of new climate models.

List of publications:

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

<table>
<tr><td colspan="2">Project start date and duration:</td><td>1 November 2020, 36 months</td></tr>
<tr><td colspan="3">Coordinator: Andrea Merlone, INRIM Tel: +39 01 13 91 97 34 E-mail: a.merlone@inrim.it
Project website address: https://www.meteomet.org/crs/</td></tr>
<tr><td colspan="3">Primary Supporter: Manola Brunet, World Meteorological Organisation</td></tr>
<tr><td>Internal Funded Partners:
1. INRIM, Italy
2. DTI, Denmark
3. SMU, Slovakia</td><td>External Funded Partners:</td><td>Unfunded Partners:</td></tr>
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