World Meteorological Organization
Commission for Instruments and Methods of Observation

Metrological Traceability for Meteorology

Q: Is it true that a temperature measurement of 20 °C from one place and from one point in time can be compared to an identical measurement from a different location and/or time?

A: Only if each temperature measurement is *metrologically traceable* to a common standard.

The same is the case for all other meteorological quantities.

What is metrological traceability?

Metrological traceability is defined as "the 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".

In simple terms, metrological traceability is a direct link between a result of a measurement made in the field and a result of the best possible measurement made in a calibration laboratory. It ensures that different measurement methods and instruments used in different countries at different times produce reliable, repeatable, reproducible, compatible and comparable measurement results. When a measurement result is metrologically traceable, it can be confidently linked to the internationally-accepted measurement references.

What is the key benefit of *metrological traceability*?

Ensuring metrological traceability enables full confidence to be held in the truth of measurement results. This leads to confidence in the implications of the measurements: in the forecasts and warnings derived from the measurements; in climate analyses and trends derived from the measurements. And this in turn leads to improvements in disaster risk reduction, climate change mitigation, advice for policy developers, human health and safety, and property protection.

What are the consequences of a lack of *metrological traceability*?

Lack of metrological traceability of measurement results sacrifices the above benefits and reduces confidence in the accuracy of our analyses and predictions. Ultimately this brings into question the usefulness to meteorological measurements for the global community. So the consequences of untraceable measurement results are severe. Measurement traceability is essential.

Figure 1: The result of a lack of metrological traceability: thermometers exposed to same environment give different readings.

How can *metrological traceability* be ensured?

Traceability of meteorological measurement results is assured by ensuring a documented, unbroken chain of instrument calibrations, from the working instruments used for field measurements, all the way up the metrological hierarchy pyramid to the primary standard.

At the top of the pyramid is an internationally defined and accepted reference, in most cases the ***International System of Units (SI),*** whose technical and organizational infrastructure has been developed by the ***Bureau International des Poids et Mesures – BIPM*** (www.bipm.org).

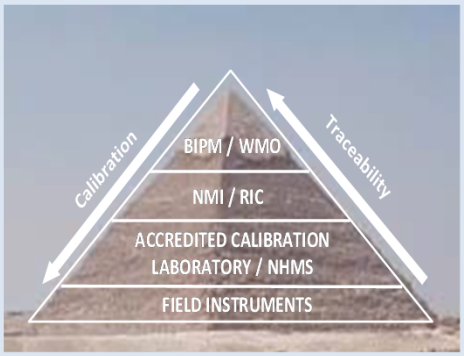

Figure 2: Metrological and meteorological heirarchy

At the national level, practical realization of the SI quantity definitions is the main task of the National Metrology Institutes (NMIs). They maintain national primary standards and inter-compare them periodically, issuing quantitative equivalence statements published in the key comparisons database of the BIPM.

The third link in the traceability assurance chain is the responsibility of calibration laboratories, accredited in accordance to the international standard ISO/IEC 17025. Accreditation ensures that the calibration methods they employ are appropriate, well executed and recognised worldwide. Importantly, it also ensures that the unbroken chain of calibrations is well documented, i.e. metrological traceability is assured.

The WMO, through its Regional Associations, has established Regional Instrument Centres (RICs) in each Region.

A RIC's responsibilities include:

- maintenance of a set of standard meteorological instruments,
- maintenance of the traceability of its measurement standards and measuring instruments to the SI, and
- provision of assistance to Members of the Region in calibrating their national meteorological standards and related environmental monitoring instruments.

In turn, the National Meteorological and Hydrological Services (NMHSs) ensure traceability of the measurement results under their responsibility by ensuring regular calibrations of all their instruments. The best way for each NMHS to achieve this is through establishment of its own calibration laboratory. This process requires the purchase of laboratory standards that must be calibrated at a RIC (or NMI) regularly, staffing by well-experienced laboratory personnel, and accreditation of the laboratory according to the ISO/IEC 17025 standard. These requirements involve significant investment and maintenance costs, but they ensure independence and reliability of the service.

A less advisable option is, for each and every field instrument, to purchase an initial calibration with appropriate traceability and accreditation. This calibration could be purchased from the manufacturer or from other accredited laboratories, but this needs to be followed up with regular recalibrations for all those instruments. Although this option seems to be cheaper, this is only a temporary saving. Regular calibrations generate cumulative costs which eventually exceed the cost of an NMHS's own calibration laboratory.

Who is responsible for metrological traceability assurance?

The responsibility for traceability assurance lies with a NMHS, which should provide for all the necessary steps in the traceability chain, i.e. enable the required calibrations of all their meteorological instruments.

It is up to each NMHS to choose the most suitable approach for its traceability assurance, but ensuring the metrological traceability of all measurement results is strongly recommended.

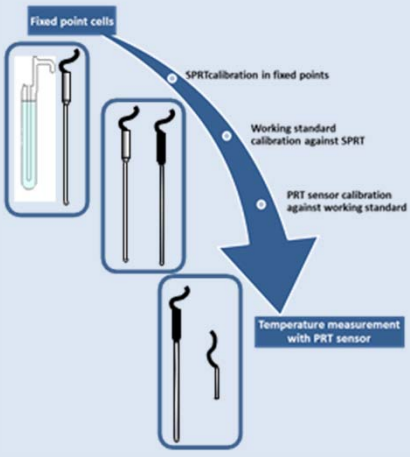

Figure 3: Example of measurement traceability chain for temperature measurements.

Further information is available at:

1) www.bipm.org/en/publications/guides/vim.html
2) ilac.org/publications-and-resources/ilac-documents/procedural-series/
3) www.wmo.int/pages/prog/www/IMOP/publications/CIMO-Guide/Provisional2014Edition.html
4) www.wmo.int/pages/prog/www/IMOP/publications/IOM-109_TECO-2012/Programme_TECO-2012.html