Guide to Meteorological Instruments and Methods of Observation

World Meteorological Organization

Weather • Climate • Water

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(c) The soil at various depths;
(d) The surface levels of the sea and lakes;
(e) The upper air.

These measurements are required, either jointly or independently and locally or globally, for input to numerical weather prediction models, for hydrological and agricultural purposes, and as indicators of climatic variability. Local temperature also has direct physiological significance for the day-to-day activities of the world's population. Measurements of temperature may be required as continuous records or may be sampled at different time intervals. This chapter deals with requirements relating to (a), (b) and (c).

2.1.3.2 Accuracy requirements

The range, reported resolution and required uncertainty for temperature measurements are detailed in Part I, Chapter 1, of this Guide. In practice, it may not be economical to provide thermometers that meet the required performance directly. Instead, cheaper thermometers, calibrated against a laboratory standard, are used with corrections being applied to their readings as necessary. It is necessary to limit the size of the corrections to keep residual errors within bounds. Also, the operational range of the thermometer will be chosen to reflect the local climatic range. As an example, the table below gives an acceptable range of calibration and errors for thermometers covering a typical measurement range.

Thermometer characteristic requirements

Thermometer type	*Ordinary*	*Maximum*	*Minimum*
Span of scale (°C)	–30 to 45	–30 to 50	– 40 to 40
Range of calibration (°C)	–30 to 40	–25 to 40	–30 to 30
Maximum error	<0.2 K	0.2 K	0.3 K
Maximum difference between maximum and minimum correction within the range	0.2 K	0.3 K	0.5 K
Maximum variation of correction within any interval of 10°C	0.1 K	0.1 K	0.1 K

All temperature-measuring instruments should be issued with a certificate confirming compliance with the appropriate uncertainty or performance specification, or a calibration certificate that gives the corrections that must be applied to meet the required uncertainty. This initial testing and calibration should be performed by a national testing institution or an accredited calibration laboratory. Temperature-measuring instruments should also be checked subsequently at regular intervals, the exact apparatus used for this calibration being dependent on the instrument or sensor to be calibrated.

2.1.3.3 Response times of thermometers

For routine meteorological observations there is no advantage in using thermometers with a very small time-constant or lag coefficient, since the temperature of the air continually fluctuates up to one or two degrees within a few seconds. Thus, obtaining a representative reading with such a thermometer would require taking the mean of a number of readings, whereas a thermometer with a larger time-constant tends to smooth out the rapid fluctuations. Too long a time-constant, however, may result in errors when long-period changes of temperature occur. It is recommended that the time-constant, defined as the time required by the thermometer to register 63.2 per cent of a step change in air temperature, should be 20 s. The time-constant depends on the air-flow over the sensor.

2.1.3.4 Recording the circumstances in which measurements are taken

Temperature is one of the meteorological quantities whose measurements are particularly sensitive to exposure. For climate studies in particular, temperature measurements are affected by the state of the surroundings, by vegetation, by the presence of buildings and other objects, by ground cover, by the condition of, and changes in, the design of the radiation shield or screen, and by other changes in equipment. It is important that records should be kept not only of the temperature data, but also of the circumstances in which the measurements are taken. Such information is known as metadata (data about data).

2.1.4 Measurement methods

In order to measure the temperature of an object, a thermometer can be brought to the same temperature as the object (namely, into thermodynamic equilibrium with it), and the temperature of the thermometer itself can then be measured.