

CASE STUDY: Global Warming - the forest from the trees

APPENDIX 2: The Measurement of Air Temperature

The temperature of air is a measure of the average speed of the molecules that make up the gases of the atmosphere. The faster the molecules are moving (in response to absorbed energy from the environment) the higher will be the recorded temperature.

In meteorological stations throughout Australia temperatures are measured in degrees Celsius (C). By international scientific agreement, the temperature of water at its “freezing point” (i.e. the “triple point” at which solid, liquid and gaseous water are in equilibrium) is set as 0 °C and at its boiling point as 100 °C.

The recorded temperature of air is defined by the World Meteorological Organisation as “*the temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation.*”

*“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)**.” (WMO, 2008 p. 1.2-2).*

Metadata (to be distinguished from “Met. Data”, i.e. Meteorological Data) is recorded information about the particular circumstances under which raw scientific data (e.g. meteorological records) have been collected in any given situation. It is a vital form of data without which the raw observations might be of no use at all. For example, if for a particular period of time a maximum thermometer at a Meteorological Station is accidentally subject to the direct radiation of the Sun due to damage to the Stevenson Screen then it is likely that the temperatures recorded will be excessively high. Metadata in this case would be a record of the particular dates and manner in which the recordings were compromised by the damaged Screen.

“Radiation from the sun, clouds, the ground and other surrounding objects passes through the air without appreciably changing its temperature, but a thermometer exposed freely in the open can absorb considerable radiation. As a consequence, its temperature may differ from the true air temperature ... with the more usual operational thermometers the temperature difference may reach 25 °C under extremely unfavourable conditions. Therefore, in order to ensure that the thermometer is at true air temperature it is necessary to protect the thermometer from radiation by a screen or shield that also serves to support the thermometer. This screen also shelters it from precipitation while allowing the free circulation of air around it...” (WMO, 2008, p. 1.2-3).

Other kinds of **metadata** which must be recorded are such things as the type of instrumentation used in measurement (e.g. liquid-in glass thermometers rather than say electrical resistance thermometers used in many automatic weather stations), dates of calibration of the instruments, as well as any overall changes in location or environment of the Meteorological Station.

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"For routine observations of air temperature, including maximum, minimum and wet-bulb temperatures, liquid-in-glass thermometers are still commonly used. ... by calibration with respect to a standard thermometer, a scale of temperature can be marked on the stem, or on a separate scale tightly attached to the stem.

The liquid used depends on the required temperature range; mercury is generally used for temperatures above its freezing point (-38.3°C), while ethyl alcohol or other pure organic liquids are used for lower temperatures.

*The **ordinary station thermometer** is the most accurate instrument of all meteorological thermometers. Usually it is a mercury-in-glass-type thermometer. Its scale markings have an increment of 0.2°C or 0.5°C , and the scale is longer than that of the other meteorological thermometers. The ordinary thermometer is used in a thermometer screen to avoid radiation errors. A support keeps it in a vertical position with the bulb at the lower end....*

*The recommended type for **maximum thermometers** is a mercury-in-glass thermometer with a constriction in the bore between the bulb and the beginning of the scale. This constriction prevents the mercury column from receding with falling temperatures. However, observers can reset it by holding it firmly, bulb-end downwards, and swinging their arm until the mercury column is reunited. A maximum thermometer should be mounted at an angle of about 2° from the horizontal position, with the bulb at the lower end....*

*As regards **minimum thermometers**, the most common instrument is a spirit thermometer with a dark glass index, about 2 cm long, immersed in the spirit. ... Minimum thermometers should be supported in a similar manner to maximum thermometers, in a near-horizontal position. Various liquids can be used in minimum thermometers, such as ethyl alcohol, pentane and toluol." (WMO, 2008 p. 1.2-4&5).*

