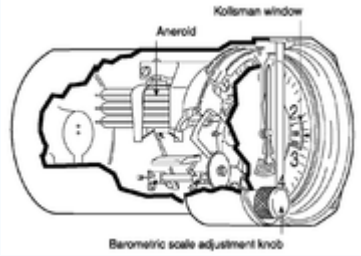
Altimeter

An altimeter is an instrument used to measure the altitude of an object above a fixed level. The measurement of altitude is called altimetry

Pressure altimeter

Pressure altimeter (also called barometric altimeter) is the altimeter found in most aircraft. In it, an aneroid barometer measures the atmospheric pressure from a static port outside the aircraft. Air pressure decreases with an increase of altitude—approximately 100 millibars per 800 meters or one inch of mercury per 1000 feet near sea level.

The altimeter is calibrated to show the pressure directly as an altitude above mean sea level, in accordance with a mathematical model defined by the International Standard Atmosphere (ISA). Older aircraft used a simple aneroid barometer where the needle made less than one revolution around the face from zero to full scale. Modern aircraft use a "sensitive altimeter" which has a primary needle that makes multiple revolutions, and one or more secondary needles that show the number of revolutions, similar to a clock face. In other words, each needle points to a different digit of the current altitude measurement.



On a sensitive altimeter, the sea level reference pressure can be adjusted by a setting knob. The reference pressure, in inches of mercury in Canada and the US and millibars (or hectopascals) elsewhere, is displayed in the *Kollsman Window*, visible at the right side of the aircraft altimeter shown here. This is necessary, since sea level reference atmospheric pressure varies with temperature and the movement of pressure systems in the atmosphere.

In aviation terminology, the regional or local air pressure at mean sea level (MSL) is called the QNH or "altimeter setting", and the pressure which will calibrate the altimeter to show the height above ground at a given airfield is called the QFE of the field. An altimeter cannot, however, be adjusted for variations in air temperature. Differences in temperature from the ISA model will, therefore, cause errors in indicated altitude.

Kollsman-type barometric aircraft altimeter as used in North America displaying an altitude of 80 feet.

The calibration formula for an altimeter, up to 36,090 feet (11,000 m), can be written as:

$$h = \frac{(1 - (P/P_{ref})^{0.19026}) \times 288.15}{0.00198122}$$

where *h* is the indicated altitude in feet, *P* is the static pressure and P_{ref} is the reference pressure (use same units for both). This is derived from the barometric formula using the scale height for the troposphere.

Radar altimeter

Main article: Radar altimeter

A radar altimeter measures altitude more directly, using the time taken for a radio signal to reflect from the surface back to the aircraft. The radar altimeter is used to measure height above ground level during landing in commercial and military aircraft. Radar altimeters are also a component of terrain avoidance warning systems, warning the pilot if the aircraft is flying too low, or if there is rising terrain ahead. Radar altimeter technology is also used in terrain-following radar allowing fighter aircraft to fly at very low altitude.

Global Positioning System

Global Positioning System (GPS) receivers can also determine altitude by trilateration with four or more satellites. However, altitude determined using autonomous GPS is not precise or accurate enough to supersede the pressure altimeter for aviation use without using some method of augmentation.

Other modes of transport

The altimeter is an instrument optional in off-road vehicles to aid in navigation. Some high-performance luxury cars which were never intended to leave paved roads, such as the Duesenberg in the 1930s, have also been equipped with altimeters.

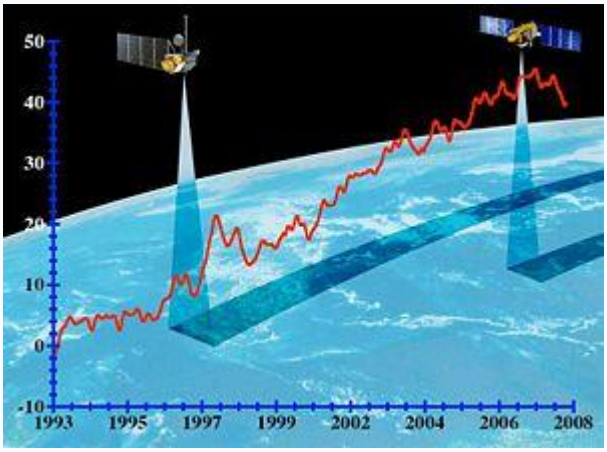
Mountaineers use wrist-mounted barometric altimeters when on high-altitude expeditions, as do skydivers.

Measuring air pressure

The local atmospheric pressure or *ambient pressure* is displayed in the Kollsman window of a sensitive altimeter, when it is adjusted to read zero altitude.[1]

Satellites

Main article: Satellite altimetry



This graph shows the rise in global sea level measured by the NASA/CNES ocean altimeter mission TOPEX/Poseidon (on the left) and its follow-on mission Jason-1. Image credit: University of Colorado

A number of satellites (see links) use advanced dual-band radar altimeters to measure height from a spacecraft. That measurement, coupled with orbital elements (possibly augmented by GPS), enables determination of the terrain. The two different wavelengths of radio waves used permit the altimeter to automatically correct for varying delays in the ionosphere.

Spaceborne radar altimeters have proven to be superb tools for mapping ocean-surface topography, the hills and valleys of the sea surface. These instruments send a microwave pulse to the ocean's surface and time how long it takes to return. A microwave radiometer corrects any delay that may be caused by water vapor in the atmosphere. Other corrections are also required to account for the influence of electrons in the ionosphere and the dry air mass of the atmosphere. Combining these data with the precise location of the spacecraft makes it possible to determine sea-surface height to within a few centimetres (about one inch). The strength and shape of the returning signal also provides information on wind speed and the height of ocean waves. These data are used in ocean models to calculate the speed and direction of ocean currents and the amount and location of heat stored in the ocean, which, in turn, reveals global climate variations.