

Measurement of relative humidity and barometric pressure in national surface-weather observation networks



gradients give us information on wind direction and wind speed respectively. This information is crucial not only for meteorologists interpreting synoptic (large-scale) weather charts, but also for any numerical weather prediction model.

Why measure relative humidity

Air humidity is another basic measurement in meteorology. It indicates the likelihood of dew or fog and reflects how comfortable we judge the air to be. There are several different humidity-critical processes, for example in aviation, that require accurate environmental humidity measurements to prevent problems caused by high or low humidity. Similarly, humidity measurements in a measurement network give us an understanding of dry and moist areas prone to the occurrence of fog or even a thunderstorm, depending on the season and synoptic situation.

Air pressure and relative humidity sensors are part of meteorological surface weather station. The measurements are used as initialization data for weather models. This application note describes the multi-stage process from observation to weather model, where every stage affects the end result. The more accurate the measurements, the more accurate the weather forecast.

Why measure air pressure

Monitoring air pressure changes is a time-honored method of forecasting the weather. Wall barometers in houses the world over have helped people foresee changes in the weather.

A rapid drop in air pressure indicates an approaching storm or rain front, while increasing pressure brings the promise of clearer skies and sunshine.

Air pressure measured across a network gives us much more information than a single point measurement. When pressure measurements are taken at the same time from a wide area, we can draw a pressure field map (black lines in the meteorological map, see last page). The pressure field tells us where the center of the low or high pressure is located. Isobars and pressure



Relative humidity is the ratio of the partial pressure of water vapor in the air to the saturated vapor pressure of water at a certain temperature.

Measurement sites

In modern meteorology, surface-weather sensors are installed at meteorological observation sites, forming a network which produces regional surface-weather information and monitor the synoptic meteorological situation on the ground. In order to improve the quality of meteorological measurements worldwide, the World Meteorological Organization (WMO) provides siting instructions for harmonizing measurement methods.

Meteorological observation sites are carefully chosen to represent the surrounding area. Ideally, the site should be flat land surrounded by open space. Observation sites should not be located close to buildings, walls, or water sources such as lakes or rivers.

Calibration maintains data quality

The measurement characteristics of relative humidity and air pressure sensors will vary over time. Sensor manufacturers may estimate this phenomenon, known as 'drift', by stating the sensor's average long-term stability. However, regular calibration checks should be made to quantify this potential problem. In calibration, the sensor reading is compared against a known standard to determine how closely the instrument's output matches the standard over the expected operational range.

The recommended calibration interval for Vaisala pressure sensors is two years, while relative humidity and temperature sensors should be calibrated every 12 months.



A Vaisala HMP45D relative humidity sensor with Vaisala DTR13 radiation shield installed at a Finnish Meteorological Institute site. Dew point calculations are carried out by the central data collection system.



The Finnish Meteorological Institute has about 200 meteorological and climatological weather stations around Finland. The stations send weather reports to the central data collection system in Helsinki at 10-minute intervals, using GPRS.



An air pressure sensor (Vaisala PTB pressure transmitter) installed inside a weather-station enclosure at a Finnish Meteorological Institute site. Temperature-compensated pressure and sea-level pressure measurements are calculated by the logger.

Data validations

Raw data from the sensors must be quality checked to ensure that it meets the quality requirements for uncertainty, resolution, continuity, homogeneity, and representativeness.

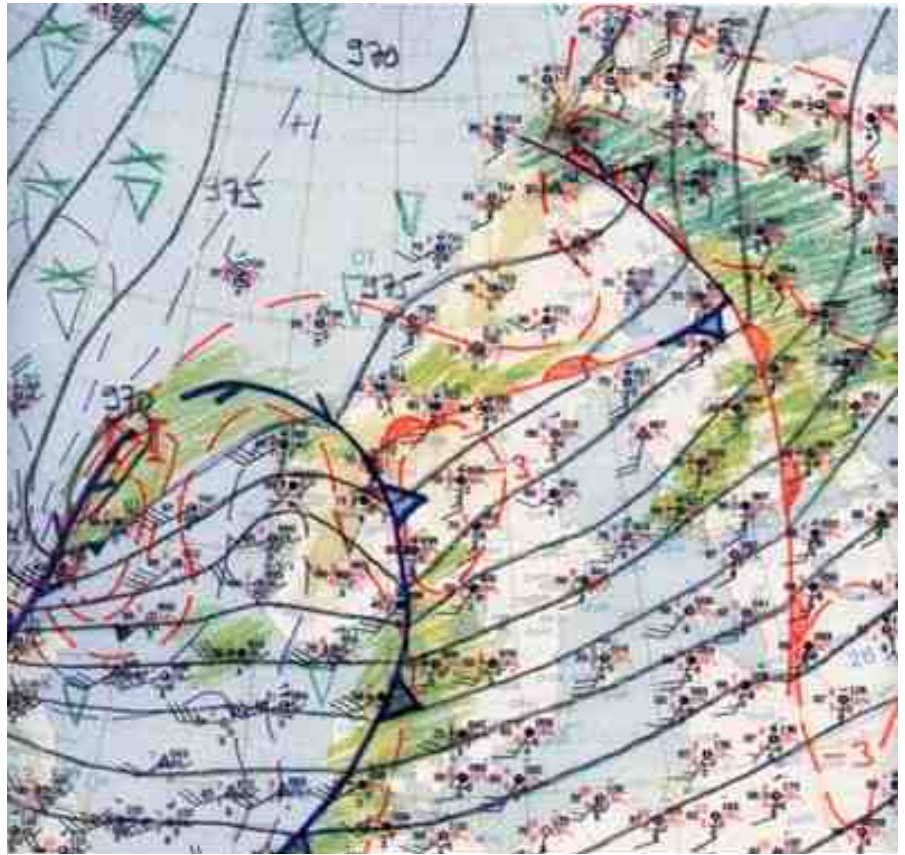
The first quality check is usually done on site by the logger, where the minimum/maximum values and maximum allowed difference between two measurements are validated. More advanced quality checking is done by the central data collection system. An example of this is a spatial data-quality check, in which data from different locations is compared to ensure validity.

Observations as the basis for weather models

Surface-weather observations such as air pressure and humidity measurements are necessary and important prerequisites for forecasting. An accurate picture of the current atmospheric conditions is required for the initialization of weather models and also for the meteorologist interpreting the synoptic charts. The source observations for weather forecasts can be obtained from international networks, ships, drifting buoys, satellites, upper-air sounding observations, and aircraft.

Finally the forecast

The results of weather models are post-processed to make them more usable by duty meteorologists. In its simplest form, this means plotting



A meteorological map with plotted surface-weather observations, including the meteorologist's hand-drawn analysis of the isobars, weather fronts, and precipitation areas.

graphs and maps to visualize the results. Typically, a meteorologist making a weather forecast has access to the results of several NWP models and observations from all around the world. Using their knowledge and experience, the forecaster uses this information to make the forecast that is supplied to the public and to various specific end-users or authorities responsible for general safety.

Challenge

Numerical weather prediction (NWP) is an integral part of modern weather forecasting and uses the mass of information obtained from an observation network. Since atmospheric movements are composed of complicated phenomena highly sensitive to initial conditions, the observation network is still too sparse and sends data too infrequently to deliver an accurate picture of the situation for NWP, i.e. weather models. This limits the useful duration of weather forecasting to approximately 10 days.

References

1. WMO CIMO GUIDE, WMO No. 8 (2014 edition)
2. www.fmi.fi

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