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EDITORIAL

GUSTS, TURBULENCE AND MEAN SPEED

In reports from meteorological observing stations, wind is usually given as a mean speed. The gusts (the high values) and the lulls (the low values) are averaged over 10 minutes (or other suitable interval) so that a quantity which reflects the overall motion of the air is achieved. This is of more general significance than say gusts, which are a very local phenomena. In order to be truly 'representative', the observation needs to be made in open, flat land or over a sea surface.

Anemometers are used to assist in the routine observations at New Zealand stations and record the wind speed on a paper chart which advances a few cm in an hour. The recorder pen follows the variations of the wind speed on all time scales over a few seconds, leaving a trace but in which the successive gusts and lulls cannot be resolved because the ink lines merge into each other. However, the mean speed, and its trends and variations, are readily apparent on this chart and may be read off for meteorological reports. Squalls and other high gusts are well defined on the charts.

For some purposes the detailed (turbulent) structure of the wind field is important. For example, it needs to be considered in order to understand how anemometers respond to real winds, in theories of the vertical structure of the atmosphere, and for the design of structures which sway. The pen trace from an anemometer provides a time sequence showing the range of the speed excursions caused by the turbulence at an observing site. One simple parameter which describes it is called the *gust factor*. It is the ratio of the highest gust speed in a period of time to the mean speed. Another is the *turbulence intensity*. This is the ratio of the standard deviation of all the instantaneous speeds to the mean speed. It cannot be obtained directly from the trace, fortunately however, in many cases the latter parameter may be obtained from the former. There are, however, situations such as squalls, in which the magnitudes of the parameters may not be used to estimate each other because the mean speed is itself increased in the squall.

The *turbulence intensity* is now known from theory to be related to the degree of roughness of the land surface upwind of the observing site. A flat surface with grass 10 cm high on it will produce a *turbulence intensity* of 0.16 at 10m above ground and the highest gust in an hour will be about 50% above the mean speed. In this way boundary-layer turbulence can be seen to be a consequence of an airflow over a rough surface. It is in fact the mechanism by which the ground extracts momentum from the airflow. The kinetic energy of the wind which is converted into turbulent fluctuations is destroyed by being broken into smaller and smaller eddies ending up as a small amount of heat. The turbulence is, to stretch the point, wind being destroyed. Gusts are the high velocity parts of the turbulence and are a short-lifetime phenomenon.

It is apparent from the above that the mean speed is a more important parameter than the gust speed. Most anemometers, in proper calibration, measure the average fairly accurately. For gusts, however, the time of response to the anemometer is important and varies from instrument to instrument. Wind damage is also probably more dependent on mean speed than gust speed — a high, reasonably steady, wind will wrench off an insecure sheet of corrugated iron by working it back and forth with eddies formed by flow around its edges. There is, however, some evidence that pre-existing turbulence too may amplify an oscillatory tendency. This is probably especially important in New Zealand where hills and mountains generate wakes with some intense, comparatively long-living turbulence.

Present trends towards automatic weather stations mean that anemometers are no longer an aid to the human observer, but all that there is to tell us what the wind is or has been. Many continue to produce charts which are archived. However, future wind sensors should ideally capture, for direct computer archiving, the important details of the turbulent flow as well as the basic parameters of the mean speed. Present proposals are that the standard deviations of the speed and direction should be retained together with the means over the same periods, and also the maximum gust. These details are a basis for obtaining information about the stability of the atmosphere, land use around the anemometer and changing exposure conditions, and the nature of the passing weather features.

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