Turbulence observations in separation eddies

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Turbulence measurements

Wind and turbulence measurements from Baring Head on the south coast of Wellington have been obtained recently. A 12 m tower at the site which has been used for monitoring carbon dioxide as part of an atmospheric chemistry programme has also been used for one set of wind measurements. The anemometer used has been a Vector 101M instrument. The tower is just at the top of a steep cliff so that southerlies approaching the site are deflected upwards by the slope and anemometers at the top of the tower are likely to be in an regime in which the airflow is curving over from a flow up the cliff to a quasi-horizontal one. A second taller tower is approximately 75 m further back from the cliff edge and almost in line with the first in southerly winds.

For the turbulence measurements, instruments have been placed at two levels on the second tower. At the top (23 m above ground), a Vector anemometer and vane were fixed. At a lower position (about 15 m above ground), a further Vector anemometer and vane were placed together with a vertical pointing propeller anemometer. The data have been logged at 2 Hz over about 6 weeks before the vertical propeller anemometer was broken. The data includes a number of southerly wind events, on the whole unexceptional for the site but showing a variety of interesting turbulence behaviours.

One small part of a single southerly event is shown in Fig. 1. This was the most common regime with large vertical wind speeds approaching 10 m/s in this case and horizontal speed fluctuations of over 10 m/s. The wind direction at the 15 m anemometer was showing a reverse flow for a significant portion of the time but the eddy was not stationary but apparently shedding at quite a high frequency. A reversed flow is apparent for a short time at the 23 m level. The turbulent motions are clearly coherent with a periodicity of 10 - 20 seconds. High friction velocities were measured averaging about 3 m/s in events like that in Fig. 1.

The range of turbulence regimes will be discussed and reasons for the different degrees of separation will be presented. The implications for wind damage in steep terrain will be commented on.

Fig. 1: A time series of two minutes of 2 Hz wind data from Baring Head. The top graph represents the vertical speed at the 15 m level (tower 2). The middle panel shows the horizontal wind speed on the 12 m tower (thin continous line), at the top of the 23 m (second) tower (thick continuous line), and at 15 m on the second tower broken line. The panel at the bottom shows the wind direction for the three anemometers using the same plotting convention.