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# OBSERVATIONS OF ROTORS AND DOWNSLOPE WINDS IN THE FALKLAND ISLANDS


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## 1. INTRODUCTION

Mount Pleasant Airfield (MPA) is located to the south of the Wickham range (height 643 m), a long east–west orientated ridge on East Falkland, south Atlantic. When the wind has a northerly component aviation traffic at MPA is frequently hampered by low-level turbulence associated with lee waves. This is often termed 'rotor streaming' by forecasters. A field campaign has been conducted which is aimed at observing the near-surface flow across and downwind of the Wickham range. Numerical simulations by Vosper (2004) highlight the significant rôle that can be played by a low-level temperature inversion in determining the flow over a mountain of similar size to Wickham. Such inversions are common in flows over the Falkland Islands.

## 2. DESCRIPTION OF THE EXPERIMENT

An array of automatic weather stations (AWS) recording surface pressure (using sensitive microbarographs), wind speed and direction (at 2 m), temperature and relative humidity were used to record data on East Falkland from November 2000 until October 2001. The AWSs were arranged along a transect oriented roughly normal to the Wickham ridge, with a dense cluster located across MPA (see Fig. 1). Twice daily radiosonde measurements and web-cam time-lapse photography were also employed. Full details of the work presented here are given by Mobbs et al. (2004).

## 3. RESULTS

During the experiment periods of intense flow acceleration and wind variation frequently occurred to the

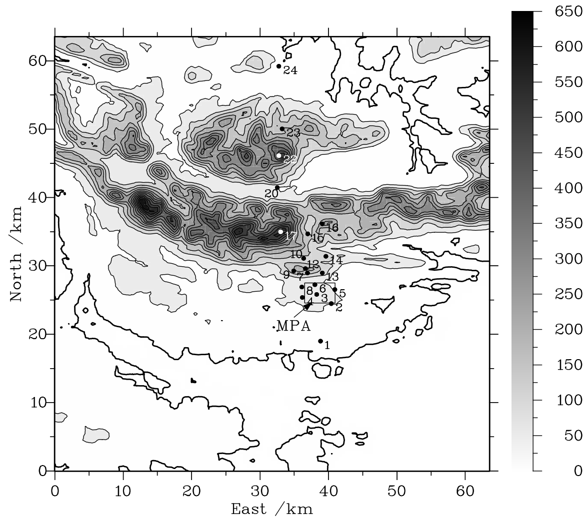


Figure 1: The terrain surrounding MPA on East Falkland (heights in meters). Also shown are the locations of the AWS sites (denoted by filled circles) and the approximate position of MPA.

lee of the Wickham ridge in northerly flow. An example of the wind vectors at the AWS sites during such a case, where both lee-side flow acceleration and wind variation were observed (9 February 2001), is shown in Fig. 2. The marked turning and convergence of the wind in the vicinity of MPA is a likely indicator of flow separation, which can be linked to the occurrence of lee-wave motion or a hydraulic jump aloft. Also shown in Fig. 2 are the 10 minute average values of the surface pressure perturbation, deduced from the pressure measurements made at the AWS sites. A clear north–south asymmetry is present in the pressure variation across the mountains, indicating a high drag state. Downwind of the mountains the rapid transition from negative to positive values implies an adverse pressure gradient which is consistent with the occurrence of flow separation.


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An example of the cloud formations which are sometimes observed during rotor events is presented in Fig. 3. The structure of the cloud over the Wickham range indicates overturning and a primary vorticity component which is parallel to the ridge.

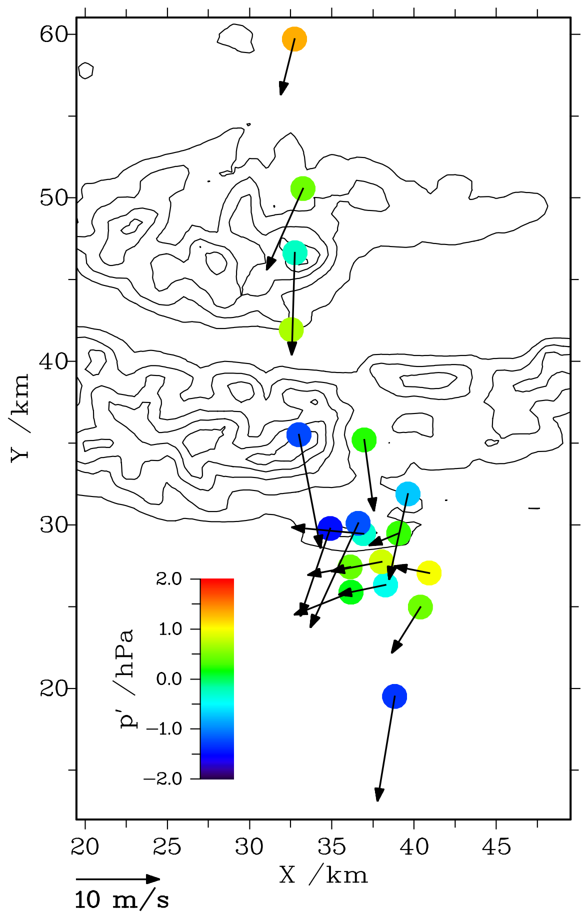


Figure 2: The 10 minute average wind vectors measured at the AWS sites at 1510 UTC on 9 February 2001. The lee-side flow is accelerated relative to that upwind, and exhibits a high degree of spatial variability. Also shown are the values of the 10 minute average surface pressure perturbation (denoted by the colored circles), deduced from the microbarograph measurements.

Typically, these rotor events were accompanied by a temperature inversion located close to the mountain-top height. In the radiosonde profiles, the frequency of such inversions and strong low-level stability in northerly flow is relatively high compared to other wind directions on East Falkland, indicating a climatological bias toward strong stability in northerly flow. The connection between stability and lee-side wind effects was investigated in a number of ways. For instance, the lee-side fractional speed-up at MPA, $\Delta s$, is defined,

Figure 3: A digital photograph of rotor cloud formation during 4 November 2000, taken looking north from MPA towards the Wickham range. Strong surface lee-side flow acceleration was observed around the time that this photograph was taken.

$$\Delta s = \frac{\overline{U} - U_{ref}}{U_{ref}},$$

where $\overline{U}$ is the average wind speed across the MPA AWS sites, $U_{ref}$ is the 2 m wind speed at the most northern (i.e. upwind in northerly flow) AWS site. It may be shown using linear theory that $\Delta s$ is expected to scale with the non-dimensional mountain height, $NH/U_{ref}$, where $N$ is a depth averaged Brunt-Väisälä frequency calculated over the lowest 500 m of the radiosonde ascents and $H$ is the mountain height. All radiosonde ascents obtained during northerly flow have been used to investigate the relationship between $\Delta s$ and $NH/U_{ref}$ and, as shown in Fig. 4, a clear correlation exists (correlation coefficient 0.75).

A recent numerical study by Vosper (2004) involving two-dimensional simulations of flow over an infinite ridge suggests that the behaviour of flows containing a strong temperature inversion is largely determined by two key non-dimensional parameters. The first of these is the Froude number, $F_i$, as defined for two-layer shallow water flow:

$$F_i = \frac{U}{\sqrt{g' z_i}},$$

where $g' = g\Delta\theta/\theta_0$, $\Delta\theta$ is the change in potential temperature across the inversion, $\theta_0$ is a reference potential temperature, $z_i$ is the inversion height and $U$ is the upstream wind speed. The second non-dimensional parameter is the ratio $H/z_i$. As shown in an accompanying paper by Vosper and Sheridan (P1.4) the occurrence of lee-waves on the inversion,

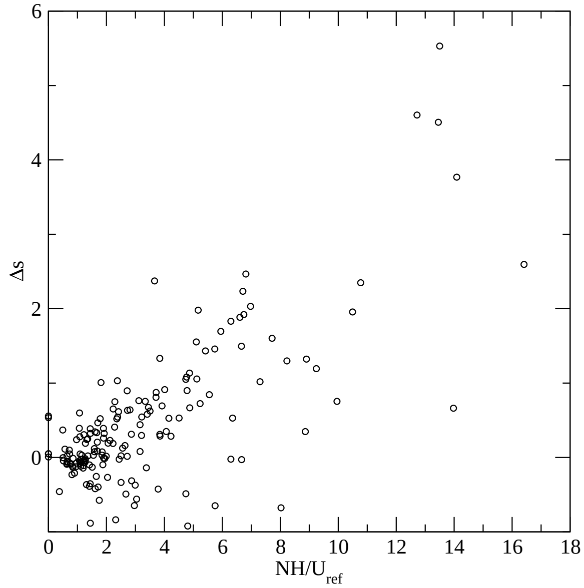


Figure 4: The variation of $\Delta s$ with $NH/U_{ref}$ as calculated from the MPA radiosonde ascents.

lee-wave rotors and hydraulic jumps is largely dependent on $F_i$ and $H/z_i$. In this study we have examined the dependence of the observed flow on the same parameters, determined from the radiosonde and AWS measurements. The surface winds on East Falkland can be classified into three (non-exclusive) types during northerly flow, according to the fractional speed-up, $\Delta s$, and the spatial variability of the flow downwind of the mountains. The latter is measured by the standard deviation, $\sigma$, of the flow at the downwind AWS sites. These flow types are:

1. Strong downwind acceleration.
2. Strong downwind acceleration and spatially variable flow.
3. Downwind deceleration.

By classifying the flow in this manner, a regime diagram analogous to that for the numerical simulations (see P1.4) can be constructed. This is shown in Fig. 5. Given the well-known difficulties of providing numerical forecasts of strong downslope winds and rotors on a local scale, the results obtained could prove useful in the development of alternative forecasting techniques.

## 4. REFERENCES


Mobbs. S.D., Vosper, S.B., Sheridan, P.F., Cardoso, R., Burton, R.R., Arnold, S.J., Hill, M.K.,


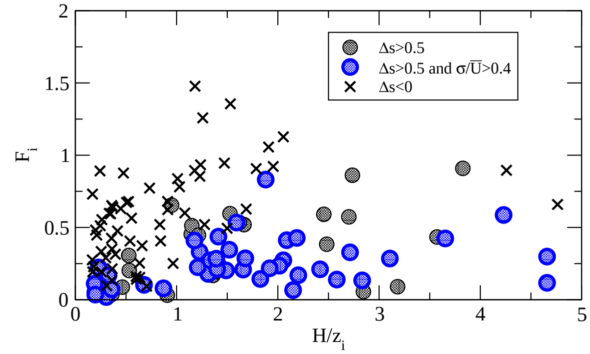


Figure 5: Flow regime diagram constructed from AWS measurements of fractional speed-up, $\Delta s$, and the maximum value of $\sigma/\overline{U}$ which occurred in northerly flow over 2 hour intervals.


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