PROGRAM B6.3

HighFire Risk: Analysis of lee-slope eddies

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Introduction

Understanding directional changes in surface winds, caused by their interaction with complex topography, is an important problem in fire spread modelling and bushfire risk management. Rugged parts of the terrain can produce micro- and meso-scale turbulent effects such as lee-slope eddies, which form when the wind separates from the surface in the lee of a ridge and turns back on itself producing a horizontal vortex that blows up the lee-slope. Lee-slope eddies can therefore result in directional changes of 180^{o} over those parts of the landscape prone to their formation. Lee-slope eddies are turbulent structures that can be exacerbated by the presence of fire, leading to increased production and advection of embers. Associated fire behaviour can pose serious threats to fire crews.

Observational studies

To investigate the prevalence and characteristics of lee-slope eddies we deployed eleven portable automatic weather stations (PAWS) in three transects in the Brindabella and Tidbinbilla Ranges to the west and southwest of the A.C.T. region. Half-hourly or hourly data was recorded for nine months between Dec 06 and Oct 07. Figure 1 shows the PAWS deployment. Each transect contained a ridge-top (reference) station, which was paired with each of the other stations in the transect. The wind speed and wind direction at station X will be denoted U_X and θ_X, respectively.

Results

Figure 2 shows joint wind direction distributions for the ridge-top station B1 and station B2 located about 150m downhill to the east. Figure 2a shows the results for all data, figure 2b is only for data satisfying $U_{B1} \geq 8$ m/s. The joint distributions display a definite modal structure that indicates a high likelihood of a lee-slope eddy at B2 when it is in the lee of the ridge, i.e. when $\theta_{B1} \approx$ WNW. Increasing the wind speed increases the probability of a lee eddy occurring to near certainty.

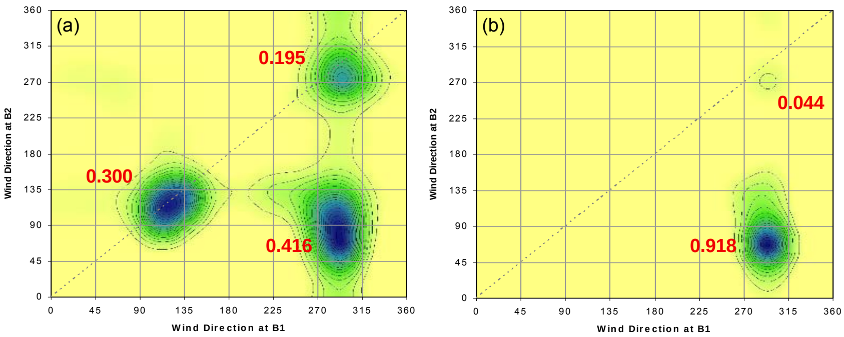

***Figure 2**. Joint wind direction distributions for B1 and B2. (a) All data, (b) data satisfying $U_{B1} \geq 8$ m/s. Approximate modal probabilities are given in red.*

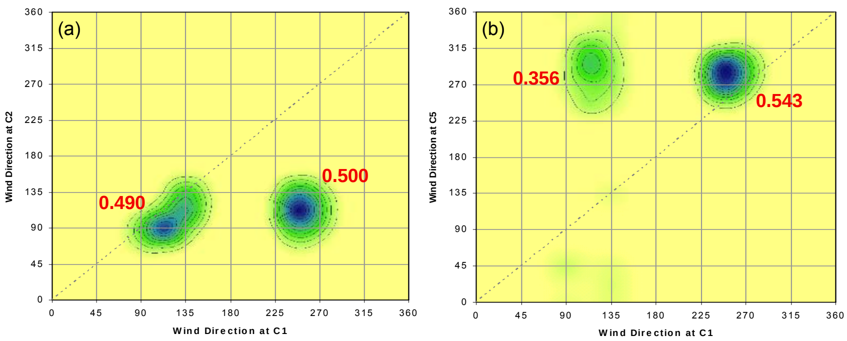

***Figure 3**. Joint wind direction distributions for (a) C1 and C2, (b) C1 and C5. Only data satisfying $U_{C1} \geq 4$ m/s are considered. Approximate modal probabilities are given in red.*

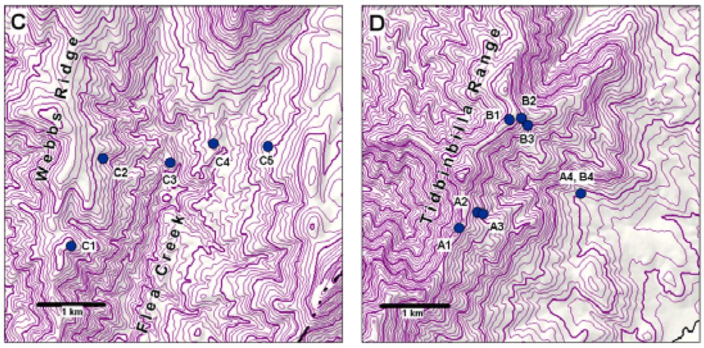

***Figure 1.** Maps showing terrain and location of PAWS deployments*

Figure 3 shows joint wind direction distributions for the ridge-top station C1 and stations C2 and C5. C2 is located on an east facing slope about 100 meters below C1 and C5 is located on a west facing slope on the other side of the valley from C1. A definite modal structure is again apparent. Figure 3a indicates a 50% chance of a lee eddy being present at C2 when $U_{C1} \geq 4$ m/s. Furthermore, if SSW $\leq \theta_{C1} \leq$ WNW then ENE $\leq \theta_{C2} \leq$ SSE with certainty. Figure 3b indicates the presence of a lee-slope eddy at C5 on the west-facing side of the valley when the bulk winds are from the east. The probability of eddy occurrence is less at C5 than it was at C2 due to the milder slopes and easterly winds. However, if ENE $\leq \theta_{C1} \leq$ SSE then SW $\leq \theta_{C5} \leq$ NNW with near certainty.

Conclusions

Our analysis has demonstrated the prevalence of lee-slope eddies in rugged terrain to the west of the A.C.T and has provided quantitative estimates of the likelihood of their occurrence on certain landform elements. These results are being extended to provide maps to assist fire mangers in assessing which parts of the landscape are likely to experience a lee-slope eddy.

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