Key findings from a field campaign measuring canopy flows over complex terrain

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Why study canopy air flows over complex terrain?

• Increase our understanding of flow dynamics: wind energy, tree damage.

• Improve our ability to predict the yield of wind turbines sited in complex terrain, improve the skill of numerical weather prediction models through incorporation of orographic drag.
1. Collect a dataset of flow measurements within and above a forest on a hill.

2. Identify the significant features of this flow that differentiate it from
   i) flow over an unforested hill.
   ii) flow over a flat, homogeneous forest.

3. Compare experimental case studies with model results to help validate and improve recent model developments.
Vertical Profiles

3 x 18m towers

Canopy heights: 8-12m

Purpose: to provide vertical velocity and temperature profiles within and above the canopy.

Instrumentation: four 3-D sonic anemometers, six temperature sensors, six cup-anemometers.

Logging frequency: Sonic 10Hz
Surface Measurements
12 automatic weather stations (AWS).

Purpose: to provide data showing the dynamics of surface flows within and outside the canopy over the ridge.

Measurements: wind speed and wind direction at 2m, temperature, pressure.

Logging frequency: 3 seconds.
$u_g = 33 \text{ms}^{-1}$

$\alpha_g = 253^\circ$

$u = 13 \text{ms}^{-1}$

$\alpha = 240^\circ$

$Fr = 18$
$u_g = 12 \text{ms}^{-1}$

$\alpha_g = 125^\circ$

$u = 4 \text{ms}^{-1}$

$\alpha = 101^\circ$

$\text{Fr} = 7$
On the windward slope of a forested hill the inflection point in the velocity profile is smoothed out by highly active turbulent mixing at the top of the canopy.

A separation bubble was found to form on the lee slope of the forested hill. Within the bubble there is very little variation in wind speed or vertical momentum flux with height.

Inhomogeneities in the canopy and the terrain on a length scale as small as h appear to have a significant impact on flow.
THANK YOU
Thoughts for future work

• Continue investigations into the appropriateness of turbulence closure scheme within canopy, but also with height above canopy in roughness sublayer. Investigate the robustness for varying hill dimensions.

• Investigate the effect a stable boundary layer on canopy flows over complex terrain. Particularly understanding the processes involved in night-time drainage flows.

• Gain a good understanding of the effect of clearings on flows, and incorporate into models. What are the length scales involved, both horizontal and vertical?