CR-ADVEX: An ADVection EXperiment at a moderately-sloped Douglas-fir site

Christian Brümmer[1], Adrian Leitch[1], T. Andy Black[1], Rachhpal Jassal[1], Zoran Nesic[1], Nicholas Grant[1], Andreas Christen[2], Andrew Hum[1], Dominic Lessard[1], Rick Ketler[1], Andrew Sauter[1] and Dave Spittlehouse[3]
[1]Biometeorology and Soil Physics Group, UBC Faculty of Land and Food Systems, [2]Land-Atmosphere Interactions Group, UBC Department of Geography, [3]BC Ministry of Forests and Range

Introduction

In this poster, we describe results from an advection experiment using a thermocouple array and sonic anemometers operated at a moderately-sloped, 35-m tall Douglas-fir site (DF49) near Campbell River on Vancouver Island. The objectives of the experiment were to:

1) Characterize the prevailing daytime and nighttime microclimate above and below the forest canopy,
2) Detect vertical and horizontal temperature differences along a 60-m long sloping transect in the vicinity of the main tower, and
3) Quantify sensible heat advection and its influence on the energy balance closure (*C*) of the site.

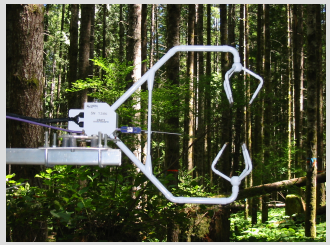

Figure 1: CSAT-3 sonic anemometer and fine-wire thermocouple at the 2-metre height, Pole IV

Hypothesis

Annual *C*, i.e. $(LE + H)/(R_n - G)$, at DF49 in 2007 was ca. 75% with high diurnal and seasonal variability. We hypothesize an improved *C* by including the horizontal and vertical advective *H* fluxes (D_H and D_V) in a two-dimensional control volume that includes the eddy-covariance tower. For a typical heat capacity of air, a control volume height of 4 m and a horizontal velocity of 1 m s^{-1}, D_H in W m^{-2} is given by $(5 \times 10^3)\partial T/\partial x$, where $\partial T/\partial x$ is in °C m^{-1}. D_H ranges from a negligible 1.0 W m^{-2} for $\partial T/\partial x$ = 0.2 °C per km, to a highly significant 100 W m^{-2} for $\partial T/\partial x$ = 2 °C per 100 m.

1

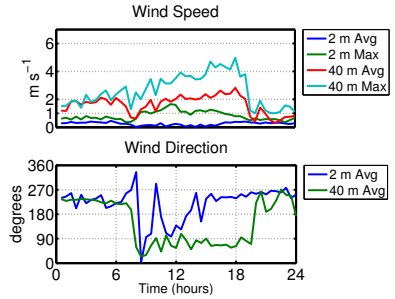

Figure 2

Wind speed and direction at the DF49 tower at 2 and 40 metres on August 11, 2008. The diurnal cycle shows the local land and sea breeze circulation. Note the lower wind speeds and the greater persistence of downslope (240°) flow at the 2-metre height.

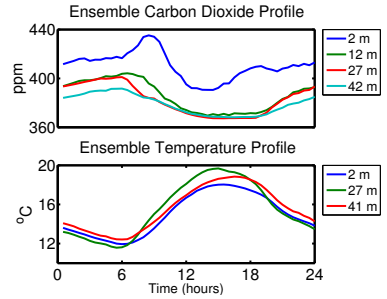

Figure 3

Ensemble averages of carbon dioxide and temperature profiles for the 63 days of the midsummer experiment. The crown space is represented by the 27-m height measurements. On average, trunk space air is stable in daytime and unstable at night.

2

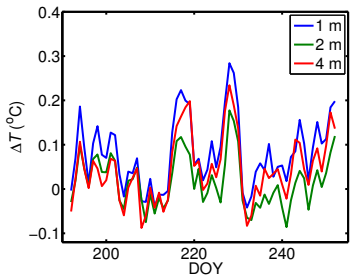

Figure 4

Daily (24 h) mean difference of T_a between Pole IV (upslope) and Pole I (tower) (i.e., IV – I). Low-frequency waves affecting all levels were due to differences in net radiation over the summer. Positive ΔT values were consistently observed at DF49 over the 60-m long transect.

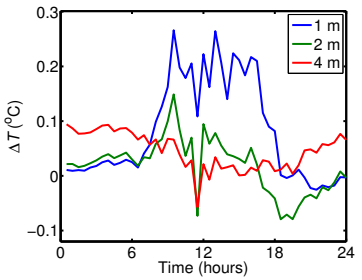

Figure 5

Ensemble average of T_a differences between Pole IV (upslope) and Pole I (tower) (i.e., IV – I). Positive nocturnal T_a gradients were observed at the 4-m height, while the upslope location was also warmer at 1 and 2 m during daytime.

3

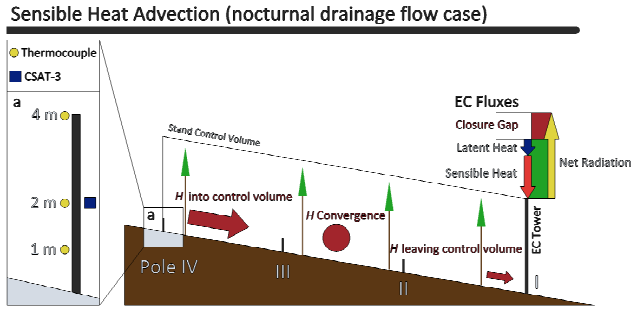

Figure 6

The effect of nighttime ΔT between positions IV and I at the 4-m height (Fig. 4) on *C* at DF49, assuming downslope drainage flow is established. Both day and night observed ΔT will improve *C* at DF49, under anabatic and katabatic flow.

Future Work

It will be important to establish the existence of a consistent gradient in T_a with all four (I-IV) thermocouple arrays. Advective fluxes of *H* could then be calculated with confidence, and their impact on *C* at DF49 could be evaluated. This summer, the experiment will also be extended to include the horizontal advection of CO_2.

References

Aubinet, M. (2008) Eddy covariance CO_2 flux measurements in nocturnal conditions: an analysis of the problem. Ecological Applications. 18: 1368–1378.

Foken, T., Wimmer, F., Mauder, M., Thomas, C., and Liebethal, C. (2006) Some aspects of the energy balance closure problem. Atmospheric Chemistry and Physics. 6: 4395–4402.

Heinesch, B., Yernaux, M. and Aubinet, M. (2007) Some methodological questions concerning advection measurements: a case study. Boundary-Layer Meteorology. 122: 457–478.

Humphreys, E. R., Black, T. A., Ethier, G. J., Drewitt, G. B., Spittlehouse, D. L., Jork, E.-M., Nesic, Z., and Livingston, N. J. (2003) Annual and seasonal variability of sensible and latent heat fluxes above a coastal Douglas-fir forest, British Columbia, Canada. Agricultural and Forest Meteorology. 115: 109–125.

Thom, A. S. (1975) Momentum, mass and heat exchange, In: Monteith, J. L. (ed) Vegetation and the Atmosphere, Vol. 1, Principles, Academic Press, London, 278 pp.