Higher-order statistics of the turbulent flow in a sparse Lodgepole Pine canopy

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An accurate modeling of plant-atmosphere interactions relies on an appropriate implementation of canopy turbulence. In the roughness sublayer of forests we encounter conditions that result in non-zero 3rd order moments and hence strongly skewed probability density distributions.

Describing relationships and simplifications is complicated by the extreme range of canopy morphologies. Interestingly, most studies done so far (field, wind-tunnel, and flume experiments, but also numerical simulations) focussed on dense canopies. Less information has been published on sparse canopies even though they form a significant part of the global land surfaces - in particular in the boreal zone. Are any previously reported findings for high order turbulence applicable in sparse canopies?

Experimental set-up.

This question has been addressed in a recent field experiment in a sparse Lodgepole Pine stand in Central British Columbia, Canada. Data was sampled using a vertical array of ultrasonic anemometers at the ‘Kennedy Siding’ tower (55° 06' 43''N, 122° 50' 23''W). Eight Campbell Scientific CSAT-3 ultrasonic anemometers were simultaneously operated at 10 Hz at different heights (z/h = 0.16, 0.44, 0.68, 0.87, 1.06, 1.25, 1.56, and 1.96) over one month in August / September 2007. The stand surrounding the tower has a mean canopy height of h = 16 m, a low canopy cover of only 24.3%, and a leaf area index of 1.38. The site is located in flat terrain and the fetch in all wind directions extends to at least 1 km.

The role of 3rd order moments in the TKE budget.

In the roughness sublayer, 3rd order moments play a crucial role in the budget of turbulent kinetic energy (TKE). The turbulent transport term - described by the vertical divergence of Duj = -w'w''w''' - is a significant transport process controlling local turbulence in the canopy.

The importance of the turbulent transport term - The following figure illustrates the importance of the various terms in the TKE budget that create, relocate and destroy TKE. Turbulent transport of TKE (green bars) forms the biggest source in the lower trunk space and is a significant sink above.

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