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Comparison of weak-wind characteristics across different Surface Types in stable stratification

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Atmospheric transport in weak winds and very stable conditions is often characterized by phenomena collectively referred to as submeso motions since their time and spatial scales exceed those of turbulence, but are smaller than synoptic motions. Evidence is mounting that submeso motions invalidate models for turbulent dispersion and diffusion since their physics are not captured by current similarity theories. Typical phenomena in the weak-wind stable boundary layer include meandering motions, quasi two-dimensional pancake-vortices or wavelike motions. These motions may be subject to non-local forcing and sensitive to small topographic undulations. The invalidity of Taylor's hypothesis of frozen turbulence for submeso motions requires the use of sensor networks to provide observations in both time and space domains simultaneously.

We present the results from the series of Advanced Resolution Canopy Flow Observations (ARCFLO) experiments using a sensor network consisting of 12 sonic anemometers and 12 thermohygrometers. The objective of ARCFLO was to observe the flow and the turbulent and submeso transport at a high spatial and temporal resolution at 4 different sites in the Pacific Northwest, USA. These sites represented a variable degree of terrain complexity (flat to mountainous) and vegetation architecture (grass to forest, open to dense).

In our study, a distinct weak-wind regime was identified for each site using the threshold velocity at which the friction velocity becomes dependent upon the mean horizontal wind speed. Here we used the scalar mean of the wind speed because the friction velocity showed a clearer dependence on the scalar mean compared to the vector mean of the wind velocity. It was found that the critical speed for the weak wind regime is higher in denser vegetation. For an open agricultural area (Botany and Plant Pathology Farm) we found a critical wind speed of $v_{crit} = (0.24 \pm 0.05)\ ms^{-1}$ while for a very dense forest (Mary's River Douglas Fir site) with a Leaf Area Index of LAI=9.4 m^2m^{-2}, the critical wind speed measures $v_{crit} = (1.0 \pm 0.1)\ ms^{-1}$.

Further analyses include developing an identification scheme to sample submeso motions using their quasi two-dimensional nature. Once separated from turbulence the properties of submeso motions and the impact of different canopy densities on those motions can be explored. We hypothesize that submeso motions are the main generating mechanism for the locally confined and intermittent turbulence in the weak-wind and stable boundary layers.