Geophysical Research Abstracts
Vol. 19, EGU2017-8760, 2017
EGU General Assembly 2017

Evaluation of wind regimes and their impact on vertical mixing and coupling in a moderately dense forest

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In the last decades much attention has been devoted to improving our understanding of organized motions in plant canopies. Particularly the impact of coherent structures on turbulent flows and vertical mixing in near-neutral conditions has been the focus of many experimental and modeling studies. Despite this progress, the weak-wind subcanopy airflow in concert with stable or weak-wind above-canopy conditions remains poorly understood. In these conditions, evidence is mounting that larger-scale motions, so called sub-meso motions which occupy time scales from minutes to hours and spatial scales from tens of meters to kilometers, dominate transport and turbulent mixing particularly in the subcanopy, because of generally weaker background flow as a result of the enhanced friction due to the plant material.
We collected observations from a network of fast-response sensor across the vertical and horizontal dimensions during the INTRAMIX experiment at the Fluxnet site Waldstein/ Weidenbrunnen (DE-Bay) in a moderately dense Norway spruce (Picea Abies) forest over a period of ten weeks. Its main goal was to investigate the role of the submeso-structures on the turbulent wind field and the mixing mechanisms including coherent structures. In a first step, coupling regimes differentiating between weak and strong flows and day- and nighttime-conditions are determined. Subsequently, each of the regimes is analyzed for its dominant flow dynamics identified by wavelet analysis. It is hypothesized that strong vertical wind directional shear does not necessarily indicate a decoupling of vertical layers, but on the contrary may create situations of significant coupling of the sub-canopy with the canopy layers above. Moreover, rapid changes of wind direction or even reversals may generate substantial turbulence and induce intermittent coupling on a variety of time scales.
The overarching goal is to improve diagnostics for vertical mixing in plant canopies incorporating turbulence and submeso-motions and to develop a classification of flow modes capable of representing the main driving mechanisms of mixing in forest canopies.