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Influence of Atmospheric Stability on the flow dynamics within and above a dense Amazonian forest

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This study provides a detailed analysis of the influence of atmospheric stratification on the flow dynamics above and within a dense forest for a 19-days campaign at the Amazon Tall Tower Observatory (ATTO) site. Observations taken at seven levels within and above the forest along an 81-meter and a 325-meter towers allow a unique investigation of the vertical evolution of the turbulent field in the roughness sublayer and in the surface layer above it.

Five different stability classes were defined on the basis of the behavior of turbulent heat, momentum and CO_2 fluxes and variance ratio as a function of h/L stability parameter (where h is the canopy height and L is the Obukhov length). The novelty is the identification of a ‘super-stable’ (SS) regime (h/L>3) characterized by extremely low wind speeds, the almost completely suppression of turbulence and a clear dominance of submeso motions both above and within the forest.

The obtained data classification was used to study the influence of atmospheric stratification on the vertical profiles of turbulent statistics. The spectral characteristics of coherent structures and of submeso motions (that may influence the energy and mass exchange above the Amazon forest) have been analyzed by wavelet analyses. The role of the main structures in momentum, heat and CO_2 transport at the different levels inside and above the forest and in different diabatic conditions was thoroughly investigated through multiresolution and quadrant analyses.

In unstable and neutral stability, the flow above the canopy appears modulated by ejections, whereas downward and intermittent sweeps dominate the transport inside the canopy. In the roughness sublayer (z £ 2h) the coherent structures dominating the transport within and above

the canopy have a characteristic temporal scale of about 100 sec, whereas above this layer the transport is mainly driven by larger scale convection (temporal scale of about 15 min).

In stable conditions the height of roughness sublayer progressively decreases with increasing stability reaching the minimum value ($z<1.35h$) in the SS regime. Above the canopy the flow is clearly dominated by ejections but characterized by a higher intermittency mainly in SS conditions. On the other hand, the rapid shear stress absorption in the highest part of the vegetation produces a less clear dominance of sweeps and a less defined role of odd and even quadrants inside the canopy in the transport of momentum, heat and CO_2. In the weakly stable regime ($0.15<h/L<1$) transport is dominated in the roughness sublayer by canopy coherent structures with a characteristic temporal scale of about 60 sec. As stability increases the influence of low-frequency (submeso) processes, with a temporal scale of 20-30 min, on flow dynamics progressively increases and becomes dominant in the SS regime where the buoyancy strongly dampens or completely inhibits turbulent structures whereas the large-scale oscillations propagate in the interior of the canopy modulating the heat and CO_2 transport.