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The lower urban boundary layer structure in unstable stability regime: insights from LIDAR measurements during the FluxSAP 2012 campaign in Nantes, France

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The objective of the proposed study is to investigate the structure of the lower unstable urban boundary layer and to test the validity of the Monin-Obukhov similarity theory from LIDAR measurements performed in the city of Nantes, France. Investigating the processes that govern the exchanges of momentum, heat and mass between the urban surface and the atmosphere indeed has proved to be very challenging both from an experimental and a theoretical point of view because of the strong heterogeneity of the urban terrain and the complexity of the flow over very-rough surfaces. In particular, the presence of the roughness sublayer that extends to 2-3 times the canopy height challenges the well-known Monin-Obukhov similarity theory (Foken, 2006) but also the experimentalist as it requires the use of tall measurement masts to reach an hypothetical constant-flux layer, which can turn out to be impractical to use in an urban environment.

To overcome this last obstacle, the proposed study is based on the use of a vertically-scanning, commercially available WindCube V2 LIDAR to measure the three components of the wind speed at 12 levels between 40m and 200m above ground, coupled to high-frequency measurements of wind speed and temperature via ultrasonic anemometers. The measurements were performed over a one-month period in June 2012, in the framework of the field campaign FluxSAP 2012 at the ONEVU site in the city of Nantes, France, where long-term flux measurements using a 30m high mast has been conducted since 2008. Based on both the long-term measurements and the one-month campaign, the micro-meteorological characteristics of the measurement site are first analysed and presented. The urban boundary layer structure in unstable stability regime is then investigated using the wind profiles obtained between 40 and 200m from the LIDAR. Given the 20m vertical spatial resolution of the WindCube LIDAR and the altitude (40m) of the lowest measured point where strong vertical velocity gradients can be expected, the influence of the already known volume-averaging effect of the LIDAR on wind speed and turbulence (Sathe, 2011) is first analysed using theoretical profiles obtained from the Monin-Obukhov similarity theory derived for homogeneous terrain (Högström, 1988). Comparison between measured wind profiles and theoretical profiles including a zero-plane correction to account for the presence of the urban canopy is then presented. Applicability of the similarity theory and the associated universal functions is further tested by studying the vertical evolution of the vertical gradient of the wind speed.