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Vertical profiles of selected mean and turbulent characteristics of the boundary layer within and above a large banana screenhouse

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The area of agricultural crops covered by screens is constantly increasing worldwide. While irrigation requirements for open canopies are well documented, corresponding information for covered crops is scarce. Therefore much effort in recent years has focused on measuring and modeling evapotranspiration of screen-covered crops. One model that can be utilized for such estimations is the mixing length model. As a first step towards future application of this model, selected mean and turbulent properties of the boundary layer above and below a shading screen were measured and analyzed.

Experiments were carried out in a large banana plantation, covered by a light-weight horizontal shading screen deployed 5.5 m high. During the measurement period, plant height increased from 2.5 to 4.1 m. A 3D ultrasonic anemometer and temperature and humidity sensors were mounted on a lifting tower with a manual crank that could measure between 2.8 and 10.2 m height, i.e., both below and above the screen. In each profile, the sensors measured at different heights during consecutive time intervals of about 15 min each. Vertical profiles were measured around noon when external meteorological conditions were relatively stable. An additional stationary tower installed within the screenhouse about 20 m to the north of the lifting tower, continuously measured corresponding reference values at 4.5 m height.

Footprint analysis shows that out of the 62 measured time intervals, only in 4 cases the 90% flux contribution originated from outside the screenhouse. Both horizontal air velocity, Uh, and normalized horizontal air velocity increased with height. Air temperature generally decreased with height, indicating that the boundary layer was statically unstable. Specific humidity decreased with height, as is typical for a well irrigated crop. Friction velocity, u_*, was higher above than below the screen, illustrating the role of the screen as a momentum sink. The mean ratio between friction velocity below and above the screen was 0.55. Vertical profiles of the surface drag coefficient $Cd = (u_*/Uh)^2$ showed a consistent decease of $\sqrt{Cd}$ with height, mainly above the screen. This result is expected since, with a constant flux layer, the surface drag is bound to decrease with height. The energy spectrum of each velocity component, both below and above the screen, was calculated separately and their sum, the 3D spectrum (Tennekes and Lumely, 1972), was plotted as a function of frequency. Slopes of linear fits to the spectra ranged between -1.42 and -1.68, with a mean value of -1.59±0.04. These slopes are close to -5/3 (-1.67), the value typical of the inertial subrange in steady state turbulent boundary layers (Stull, 1988).