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Stability and decoupling in a Douglas fir forest

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Complex ecosystems such as forests make accurately measuring atmospheric energy and matter fluxes difficult. One of the issues that can arise is decoupling between parts of the canopy and overlying atmosphere. This means that the vertical exchange of energy and matter is reduced or hampered. In this study we analyse high resolution (0.3 m) vertical temperature profiles measured in a Douglas Fir forest in the Netherlands using Distributed Temperature Sensing. The forest has a very open understory (0 - 20 m) and a dense overstory (20 - 34 m). Vertical profile data was collected for 250 days between 2015 and 2018, in all seasons.

We found that the understory was very often decoupled from the atmosphere (>90% of the time, both during day and night), and interestingly, did not correlate with either the above canopy or understory radiation, nor with the ambient wind speeds. Convection above the forest floor however, was common ($\sim$30% of the time). Some effect of the diurnal cycle was visible in the forest floor gradient, but the gradient seemed to be largely locally determined and independent of conditions above the canopy. This points towards the understory layer acting as a kind of mechanically 'blocking layer' between the forest floor and overstory. On clear nights two stable layers formed; both at the top of the canopy and above the forest floor, as the crown was open enough to allow radiative cooling of the forest floor. Within the overstory, convection was common on clear nights, as heat being released by leaves and branches in the lower part of the overstory warmed up the air, while the top of the overstory was radiatively cooled.

From the results, we conclude that the measured decoupling is a systematic feature, which is not dominated by a single factor, but rather by a more complex interplay between various factors. Local gradients and fluxes may be influenced by effects of field heterogeneity and advection, but these were not included in the present study. Therefore, an accurate description of the thermodynamics of the canopy-atmosphere system remains a challenge for future studies.