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Deriving sensible heat flux from vertical integration of high resolution high frequency DTS measurements in a Douglas Fir forest

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Besides the ubiquitous eddy covariance (EC) method, other micrometeorological methods have been developed to measure sensible heat fluxes near the surface in the boundary layer. Here we address the surface renewal method, which utilises the fact that near-surface temperature has a strongly 'ramped' structure as a result of turbulent sweeps which 'renews' air within the canopy with ambient air. This allows the measurement of sensible heat flux with just a thermocouple (after local calibration of the method using EC).

In recent years the measurement method of Distributed Temperature Sensing (DTS) has seen further development allowing its widespread application in atmospheric sciences. With DTS the temperature along a fibre optic cable can be measured at high resolution (35 cm) and high frequency (1 Hz) for cable lengths up to hundreds of metres.

By placing a fibre optic cable vertically along a flux tower in a Douglas Fir forest in the Netherlands, we were able to measure the vertical temperature profile at high frequency, akin to having a string of dozens of thermocouples. We found that above the forest the time scale of the surface renewal ramps was in the order of 1 minute. As a continuous full vertical profile is available, we can improve on standard single point surface renewal by using the available vertical information.

The first results are promising, as the correspondence between our method and the EC during daytime gives an R^2 of 0.8, which is high in view of the complexity of the terrain and the fact that non-stationary turbulent transport is involved. Note that, in contrast to EC, the renewal method is less susceptible to rain and tilting of the instrument. In future research, a more detailed, long-term climatological assessment is foreseen in order to investigate the robustness and generality of the methodology.