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Verifying the distributed temperature sensing Bowen ratio method for measuring evaporation

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Evaporation is an important process in the hydrological cycle, therefore measuring evaporation accurately is essential for water resource management, hydrological management and climate change models. Current techniques to measure evaporation, like eddy covariance systems, scintillometers, or lysimeters, have their limitations and therefore cannot always be used to estimate evaporation correctly. Also the conventional Bowen ratio surface energy balance method has as drawback that two sensors are used, which results in large measuring errors. In Euser et al. (2014) a new method was introduced, the DTS-based Bowen ratio (BR-DTS), that overcomes this drawback. It uses a distributed temperature sensing technique (DTS) whereby a fibre optic cable is placed vertically, going up and down along a measurement tower. One stretch of the cable is dry, the other wrapped with cloth and kept wet, akin to a psychrometer. Using this, the wet and dry bulb temperatures are determined every 12.5 cm over the height, from which the Bowen ratio can be determined.

As radiation and wind have an effect on the cooling and heating of the cable's sheath as well, the DTS cables do not necessarily always measure dry and wet bulb temperature of the air accurately. In this study the accuracy in representing the dry and wet bulb temperatures of the cable are verified, and evaporation observations of the BR-DTS method are compared to Eddy Covariance (EC) measurements. Two ways to correct for errors due to wind and solar radiation warming up the DTS cables are presented: one for the dry cable and one for the wet cable. The measurements were carried out in a pine forest near Garderen (The Netherlands), along a 46-meter tall scaffold tower (15 meters above the canopy). Both the wet (T_{wet}) and dry (T_{dry}) temperature of the DTS cable were compared to temperature and humidity (from which T_{wet} is derived) observations from sensors placed along the height of the tower.

Underneath the canopy, where there was barely any direct sunlight, the non-corrected temperatures correlated well for both T_{dry} (R^2=0.998) and T_{wet} (R^2=0.995). Above the canopy the two temperature corrections worked well T_{dry} (R^2=0.978) and T_{wet} (R^2=0.979).

The comparison of the latent and sensible heat flux from the BR-DTS and the EC-system was often not possible, due to large energy balance residuals estimated during north-eastern winds (using an averaging interval of 30 minutes). For the limited days with other wind directions the BR-DTS overestimated the latent and sensible heat flux. Additionally, we even found that the applied temperature corrections resulted in a lower performance due to increased uncertainties in the applied corrections. Furthermore, we found that both the corrected and uncorrected DTS-temperatures resulted in rather similar latent and sensible heat fluxes, due to the fact that BR-DTS applies gradients of temperatures over the height, rather than absolute values. Hence, based on our limited data, the correction methods are not recommended if one is interested in the fluxes.