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Actual Evaporation Measurement with a Glass Fiber Optic Cable

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Several measurement techniques exist to determine actual evaporation based on the instability of air near the ground surface due to solar heating. Scintillometers and eddy covariance towers are sophisticated equipment, but expensive and often have technical problems resulting in large data losses. The Bowen ratio method, using a humidity and temperature gradient in a vertical column of air, is still an elegant method, can be cheap, but relies on quality data.

We have investigated the Bowen ratio method applying the relatively new technique of distributed temperature sensing (Selker et al. 2006) with a glass fiber optic cable. For this purpose both a wetted and dry cable were installed hanging from a 10 meter (inflatable) tower to the ground surface. Cables were coiled to obtain a 20 cm resolution of temperature. By using the principle of the psychrometer, a near continuous distributed humidity profile is created of the 10 meter air column. Temporal resolution is in the order of a few minutes. The humidity profile and temperature profile allow determining a Bowen ratio. Additionally continuous measurements of net short and long wave radiation were performed with the Kipp & Zonen CNR1 radiometer. With estimates of the soil heat flux actual evaporation was determined.

For temperature measurement with a fiber optic cable a pulsing laser light is transmitted into a glass fiber optic cable. The reflected signal received is then analyzed for Raman backscatter, which can be related to temperature. From the travel time of the emitted laser light, it can be derived from which position along the cable a certain reflection originates. Accuracy is better than 0.1 ˚C and within minutes changes of temperature are observed (Selker et al. 2006a). Temperature observations can be monitored on the spot or can be stored on a data logger for further analysis.

The ongoing research focuses on making the method operational in the field, and comparing results with using electronic humidity and temperature sensors. Differences in temperature observations from the fiber optic cables and the sensors are analyzed in the research and its consequences for determining humidity and the Bowen ratio. One reason for differences in observations is the heating of the cables from solar radiation.

The advantage of the method applying a fiber optic cable is that, better than with point observations in a vertical column of air, the continuous measurements and high spatial resolution give valuable information of how humidity and temperature profiles develop over a day. In this way the method turns out to be a valuable tool to compare different equipment and methods to determine actual evaporation.