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Reviving the Bowen Ratio method for Actual Evaporation with Distributed Temperature Sensing

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We have used the technique of distributed temperature sensing (DTS) with a fiber optic cable to determine actual evaporation over land. The results were compared with measurements using a surface layer scintilometer, surface renewal and eddy covariance techniques. Dry and wetted sections of a fiber optic cable were suspended from a six meter high tower in a sugar beet trial in KwaZulu-Natal, South Africa. From the principle of a psychrometer, a near continuous observation of vapor pressure and temperature at 0.20 m intervals of a vertical column of air above the field could be derived. Subsequently it allowed accurate determination of the ratio of sensible and latent heat, i.e. the Bowen ratio over time and in the vertical. Using measurements of the net radiation, soil heat flux and the Bowen ratio sensible heat flux, the actual evaporation could be determined as the residual of the shortened energy balance equation.

The advantage of the DTS method over the traditional Bowen ratio method is that one and the same sensor (the fiber optic cable) is used, with sufficient accuracy to discriminate small differences in temperature and vapor pressure respectively, hence giving numerous gradient measurements over the vertical. The traditional Bowen ratio method relies on only a few sensors that require careful calibration to detect the real differences of temperature and vapor pressure. Comparing the improved method with the traditional Bowen Ratio method, shows that the improved method gives more stable and constant results than the standard method.

The DTS data were reliable, provided that water blown by strong wind from the wetted cable does not affect the temperature of air at the location of the dry cable. Under these conditions the vertical air temperature was not representative for the air temperature over the fetch of the crop. The experiments were carried out in South Africa, in November 2011 (summer) under varying radiation conditions. In this way it was demonstrated that direct exposure of the fiber optic cable to these high radiative conditions (max incoming short wave radiation = 900 w/m̂2) had no noticeable effect on the evaporation results.