Predicting evaporation from an oak forest

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Summary

This thesis presents results of an an investigation into predicting evaporation from an oak forest. Forest evaporation consists of evaporation of intercepted rainfall (interception) and evaporation through the stomata in the leaves (transpiration). Central in this study is the Penman-Monteith equation which is used to predict evaporation loss. The measurements that were required in the present study were carried out in an oak forest on one of the Castricum lysimeters.

In chapter 2 it is described how aerodynamic parameters, which are of paramount importance to interception, change when trees lose their leaves. It appears that roughness length does not change, the zero plane displacement heighth is lowered only a few meter. This results in almost equal aerodynamic resistances in summer and winter. High evaporation rates and interception losses in winter may be the consequences of this.

In chapter 3 two interception models are compared and tested on observations of interception. The models, the analytical Gash-model, and the computer model of Mulder, are used to predict interception loss in summer and winter. Both models give good predictions of interception loss. Small discrepancies with observed values occurred in summer periods and were probably due to changing structural characteristics of the canopy as a result of attaques of caterpillars in previous years.

Chapter 4 describes the modelling of transpiration of a pine forest in England. Important in this chapter is a model of surface conductance developed by Stewart. This model is used in the Penman-Monteith equation to predict transpiration. Meteorological input consists of simulated values of radiation, vapour pressure and temperature. These input data are calculated from standard meteorological data obtained at a grassland station. Hourly transpiration values compare well with observed values. The model was also used to predict transpiration for a whole year. Because transpiration is strongly dependent on the amount of soil moisture, an estimate of soil

moisture deficit was required. This was produced by calculating a running water balance for every simulated day. The predicted transpiration and soil moisture deficits agreed well with observed values.

In chapter 5 measurements of stomatal conductance on oak leaves are described. The relation between stomatal conductance and solar radiation and vapour pressure deficit is described. The measured values of conductance were used to estimate total canopy conductance. Estimated transpiration rates were found to be high. The Omega factor, which can be used to show whether transpiration is regulated by incoming net radiation or by the atmospheric humidity deficit, was low, indicating a substantial coupling between transpiration rates and vapour pressure deficit.

Chapter 6 is concerned with the modelling of transpiration of the Castricum oak forest. Analogous to the conductance model used in chapter 4, a model of stomatal conductance is developed, which describes stomatal conductance in dependence of solar radiation and vapour pressure deficit. This model is based on measurements of stomatal conductance (chapter 5). From this model total canopy conductance is derived and used in the Penman-Monteith equation to predict transpiration. Transpiration could be predicted rather well when a limit was introduced in the model, which regulated transpiration above a certain value. The basis of this limit is at present unclear although there are some indications which point in a physiological direction. Measurement of soil water content by neutron probe and observations of groundwater depth in the lysimeter indicated that the trees first used water from the unsaturated zone and only when this reservoir was emptied, started to use water from the saturated zone.