Seminar 10 April 2018

Evapotranspiration: how to parameterize it? How to measure it?

a critical review and a call for novel research

Water vapor is the most important greenhouse gas and the hydrological cycle plays a dominant role in our climate system. Surface evaporation is an important chain in this cycle. Evaporation affects highly the surface temperature also and is an important term in the surface energy budget. It also determines atmospheric stability. This seminar is confined to land surfaces, which usually are vegetated and, therefore, it is about evapotranspiration (ET), evaporation through the stomata of plants. In this way ET is coupled to CO2 fluxes through photosynthesis. In current GCM's ET is parameterized, i.e. it is described in terms of forecasted state variables. In nowadays parameterization schemes ET is coupled to simplified model for photosynthesis. All this is implemented in so-called SVAT's, soil-vegetation-atmosphere-transfer models. The problem arises how to validate ET in GCM's, which concerns spatial averaging over 10 km2 or more. At this scale, land surfaces are heterogeneous. It will be shown that long-path scintillometry are useful for this purpose. In the future, scintillometer networks can be implemented in the data assimilation procedures used in nowadays forecasting models.

In most SVAT's the starting point are the governing equations from which the Penman-Monteith equation for ET (PM) is derived. In this way, the model parameters such as surface resistance (r_s) are introduced. The objective of the seminar is to review critically concepts such these parameters. It will be stressed that e.g. r_s is not a physical quantity. This hampers experimental verification. To illustrate the points I want to make, I analyze a unique set of hourly micrometeorological gathered over well-watered grass surrounded by dry fields. I will discuss the governing equations for the PM. It will be shown that model parameters in PM can be tuned such that ET-PM compares well with independent lysimter data. But tests of sensible heat and surface temperature shows systematic errors. I conclude that PM must be regarded an empirical formula. If this is true, PM can be applied only for conditions under which the model parameters are tuned. But FAO adopted a version of PM as the 'ET-truth' by which it is applied in hundreds of studies for all kind of conditions without further ado. Because the grass field is surrounded by dry terrain actual ET is affected by so-called local advection. This topic will be discussed in detail. Under conditions of local advection basic assumptions made in micrometeorology, such as the existence of a constant flux layer, horizontal homogeneity, etc. are violated. The theoretical basis for most SVAT's are then violated.

Local advection makes also that the eddy-covariance method to measure ET cannot be used, because it requires installations well above the ground. Lysimetry is a good alternative, but not suitable for field campaigns. So, there is a need for a novel measuring technique. Evidence will be presented that laser scintillometry is a solution.

The seminar will end with wake-up call for young scientists. There is a strong need for novel fundamental (theoretical and instrumental) research on ET.

Short C.V. of Henk A.R. de Bruin

Henk de Bruin (1943-) studied experimental physics at the University of Amsterdam where graduated in 1969. From 1970-1985 he was Senior Scientist at Royal Netherlands. Meteorological Institute (KNMI), working on hydro- agro- and boundary layer meteorology topics. In 1982 he did his PhD at the Wageningen University. In 1981 he spent two months as Visiting Scientist at INRA, France and from 1982-1983 he was on sabbatical leave at the Institute of Hydrology (now CEH), Wallingford (UK). From 1978-1999 he was Guest Lecturer of Meteorology at IHE, Delft. By the end of 1985 he moved to the Wageningen University as associate professor. After his retirement in May 2007, he was, among other activities, parttime Scientific staff member Scintec, Rottenburg (untill 2013), Germany and he was 2 years Visiting Professor King's College, London, UK. He was advisor of many MSc- and Ph-D students. He is (co-)author of about 250 peer reviewed papers and numerous conference papers. Two papers were considered as benchmark papers on evaporation (Gash and Shuttleworth). According to ResearchGate his H-index is 49 excluding self-citations. He also wrote a number of popular scientific articles and columns in Dutch for the monthly journal Zenit and for the quarterly journal Meteorologica. He was involved in many international field campaigns all over the world. He contributed to improving the applicability of different measuring techniques for turbulent fluxes, such as eddy-covariance, the variance-flux method and scintillometry. His latest paper is on thermodynamics of evaporation of well-watered grass and on validation of his simple radiation-based formula, which lead to an operation EUMETSAT product on crop reference ET (ETo) derived from the European satellite MSG, by which for free daily ETo values are dissimilated operationally for each MSG pixel.