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In-situ comparison of evapotranspiration estimates at the Rietholzbach catchment

Irene Lehner and Sonia I. Seneviratne
ETH Zürich, Institute for Atmospheric and Climate Science, Zürich, Switzerland (irene.lehner@env.ethz.ch)

The eddy covariance (EC) method is widely used to measure water, energy, and carbon fluxes and has been established as a reference for global networks (e.g. Baldocchi *et al.* 2001). However, uncertainties in the energy flux estimates resulting in a non-closure of the energy balance are known (e.g. Franssen *et al.* 2010) particularly in non-homogeneous and/or complex terrain. Evapotranspiration (ET) which is a significant term both for the water and the energy balance can be estimated with several methods (Seneviratne *et al.* 2010). In this study we compare ET estimates derived with the micrometeorological EC method, the hydrological lysimeter approach, and the catchment water balance.

The examined data set originates from the Rietholzbach catchment which is a small, pre-alpine research basin in the north-eastern part of Switzerland (http://www.iac.ethz.ch/url/rietholzbach). The area of 3.31 km^2 is only sparsely populated and primarily used as pasture land (73 %), steeper slopes are forested (24 %). In 1975 measurements were initiated to determine and understand the water balance and related processes. Amongst others a weighing lysimeter was built and catchment runoff as well as precipitation measurements were introduced. Recently, in May 2009 a flux tower in a grassland next to the valley bottom was established.

Every mentioned technique to estimate ET has its general and site-specific advantages and limitations:

(i) Applying the EC method half hourly statistics based on 10 Hz data from a ultrasonic anemometer (CSAT3, Campbell Scientific, Logan, USA) and an open-path CO_2/H_2O infrared gas analyser (Li7500, Li-Cor, Lincoln, USA) are calculated. The flux footprint is a few hundred m^2 under convective conditions. Given the tower location, the ET estimates represent grassland evapotranspiration only. In addition to the mentioned ET underestimation, the gas analyser measurements fail when water is on the sensor surface which is mainly a problem during precipitation events when ET can be assumed to be negligible.

(ii) Lysimeters are an accurate but costly technique to determine ET. The change in weight of the grass-covered lysimeter with a surface area of 3.14 m^2 and the outflow at the lysimeter bottom are measured on an hourly time step (balance resolution 100 g). A general limitation is given by the lack of connection of the soil column to lateral flow and to ground water. In addition, snow bridges in winter distort the measurements and precipitation events result always in an increase in weight but evapotranspiration rates are very small under these conditions.

(iii) The water balance approach integrates over the hydrological year and the whole catchment and determines ET as the difference of catchment precipitation and runoff. Thus, it is a basic long-term constraint for the consistency of ET on the catchment level. It is assumed that the change in catchment storage is negligible. This is often the case but year-to-year carry-over effects are observed in extreme years and limits the applicability of this constraint. Moreover precipitation is a point measurement while runoff is a catchment wide integrator.

These various approaches are evaluated over the time period May 2009 to October 2010, with a special focus on two drought events in autumn 2009 and summer 2010, respectively.

References:
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Franssen *et al.*, Agricultural and Forest Meteorology **150**: 1553-1567, 2010
Seneviratne *et al.*, Earth-Science Reviews **99**: 125-161, 2010