Comparison of measurement accuracy of different soil moisture sensors in the field and implications for validation of remote sensing products

Heidi Mittelbach, Irene Lehner and Sonia I. Seneviratne - Institute for Atmospheric and Climate Science, ETH Zurich, SWITZERLAND - heidi.mittelbach@env.ethz.ch

Motivation

Soil moisture strongly affects surface fluxes with consequent impact on temperature, evapotranspiration, boundary layer stability and runoff generation (Seneviratne et al., 2010). Soil moisture measurements are essential to parameterize models and to calibrate and validate remote sensing-derived soil water products. Additionally, soil water fluxes, e.g. evapotranspiration, can be estimated using these measurements. In this study four soil moisture sensors are compared based on field measurements by applying the calibration function provided by the manufacturers.

Data basis

- SwissSMEX/-Veg (www.iac.ethz.ch/url/research/SwissSMEX) site Rietholzbach RHB (pre-alpine)
- Daily data for time period 7 May 2009 to 31 December 2010
- Precipitation and 2 m air temperature
- Actual evapotranspiration from weighing lysimeter
- Three precipitation free periods to estimate the evapotranspiration using the soil water balance approach
- Soil type: clay loam to loam (USDA soil taxonomy)
- Soil temperature and soil moisture measurement in 5, 15, 25, 35, 55, 80, and 110 cm depth
- Parallel installed soil moisture sensors: TRIME-IT/-EZ (IMKO GmbH, Germany), 10HS (Decagon Devices, United States), CS616 (Campbell Scientific, United States), SISOMOP (University of Karlsruhe, Germany; in 5 down to 55 cm)
- Calibration function provided by the manufacturer; CS616 with and without recommended temperature correction; TRIME-IT/-EZ is the reference sensor (Mittelbach et al., 2011)
- Temperature dependency following Verhoef et al., 2006

Results

Absolute VWC and its anomalies

- The sensor to be tested correlate well with the reference sensor. Indicated in grey are dry periods used for ET estimation.
- Absolute errors between reference sensor and sensor to be tested as well as the frequency distribution of VWC.
- Temperature dependency for different depths and different VWC. It is difficult to make a statement for 10HS and SISOMOP, because of their high absolute error in VWC.

Conclusion

For the RHB site and applying the manufacturer functions:

10HS
- limitation with measuring VWC above 40 Vol.%
- the drier the moisture conditions, the better is its performance
- anomalies in depths with VWC < 30 Vol.% are represented reasonable

CS616
- With the applied temperature correction:
  - strong negative dependency of VWC to soil temperature
  - leads to overestimation of absolute VWC and its anomalies especially in depths with small VWC variations.
- Without temperature correction performs better up to VWC of 60 Vol.%

SISOMOP
- underestimates the absolute VWC but represents anomalies reasonable.

TRIME-IT/EZ
- appropriate as reference sensor, good estimation of evapotranspiration

A site specific calibration is highly recommended for 10HS, CS616 and SISOMOP.

References:

