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Johann FANK: Comparison of calculated ET_0 to measured lysimeter grass ET

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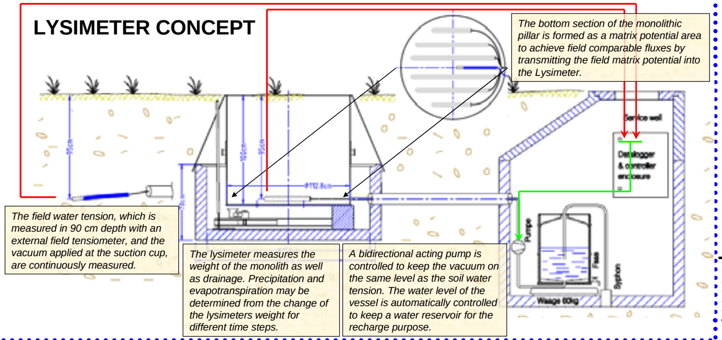
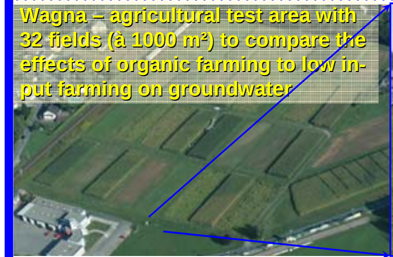
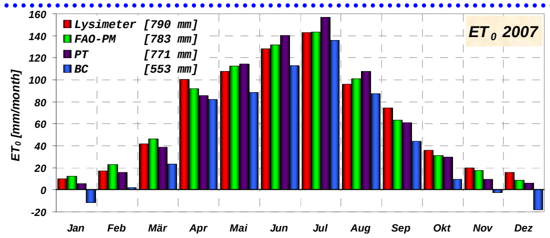
Data acquistion and lysimeter installation





In 2006 a monolithic lysimeter have been implemented in the Wagna agricultural test field in southern Austria to measure the water balance parameters precipitation and evapotranspiration as exact as possible.
The lysimeter has a surface of 1 m² and a depth of 1 m. The precision load cells on the concrete fundament measure the lysimeters weight with a resolution of 35 g (0.035 mm water equivalent).
The lysimeters surface is cultivated by grassland which is cut during the vegetation period once a week to a length of 12 cm – as the reference height of the FAO-Penman-Monteith equation.
The weight of the lysimeter and of the seepage water container is registered with a time interval of 1 minute.
Beside the lysimeter a standard weather station has been installed where the parameters to solve the Penman-Monteith equation (air temperature, relative humidity, radiation, wind velocity) for calculating grass-reference-evapotranspiration (ET_0) are measured in a standard height of 2 m in 10 minutes interval.

ET_0 – calculation 2007: comparison of results (3 equations)

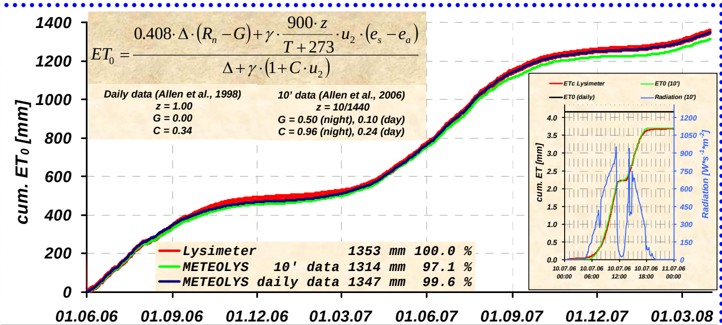


Deviation to lysimeter measurement		year 2007	apr-sep	okt-mar
FAO-PM	Penman-Monteith (Allen et al., 1998)	-1.0%	-0.9%	-1.3%
PT	Priestley-Taylor (Steiner et al., 1991)	-2.5%	2.5%	-25.3%
BC	Blaney-Criddle (Doorenbos & Pruitt, 1977)	-30.0%	-15.2%	-98.3%

Meteorological data of the METEOLYS – standard weather station at test field Wagna has been used to calculate grass reference evapotranspiration using 3 different equations (FAO-PM and PT on daily BC on monthly data basis). Results has been compared to measured grass evapo-transpiration (corrected to conditions not short of water during water stress periods) at HYDROLYS – Lysimeter. Monthly and yearly sum of ET_0 as well as the deviation to lysimeter are visualized. Results show best agree-ment to calculated values using FAO-PM equation.

Penman-Monteith ET_0 – calculation: comparison of various time steps

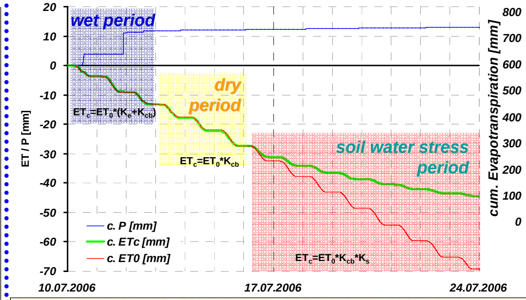
$$ET_0 = \frac{0.408 \cdot \Delta \cdot (R_n - G) + \gamma \cdot \frac{900 \cdot z}{T + 273} \cdot u_2 \cdot (e_s - e_a)}{\Delta + \gamma \cdot (1 + C \cdot u_2)}$$

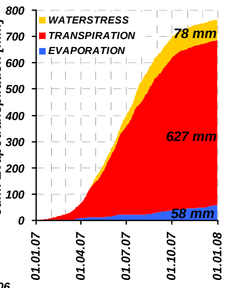


Results comparison over long time observation periods show a very good agreement between measured grass ETc at HYDROLYS – Lysimeter results and calculated METEOLYS ET_0 on a daily data base (deviation of the sum over 22 month = 0.4 %). 10' data calculation of daily sum of of ET_0 better reflects the influence of changing weather conditions during the day. This effect is shown for July, 10th 2007 where a thunderstorm about noon reduces evapotranspiration rates.

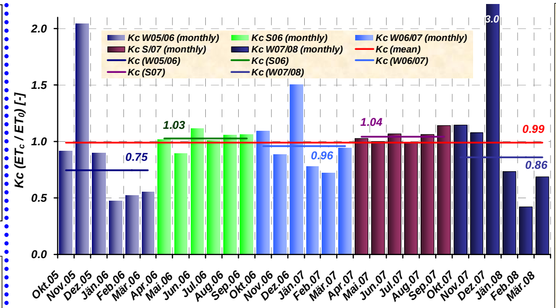
Allen, R. G., Pereira, L. S., Raes, D. & Smith, M (1998): Crop Evapotranspiration. FAO Irrigation and Drainage Paper No. 56, 300 p.
Allen, R.G., Pruitt, W.O., Wright, J.L., Howell, T.A., Ventura, F., Syder, R., Itenfisu, D., Steduto, P., Berengena, J., Yrisarry, J.B., Smith, M., Pereira, L.S., Raes, D., Perrier, A., Alves, I., Walter, I. & Elliott, R. (2006): A recommendation on standardized surface resistance for hourly calculation of reference ETo by the FAO56 Penman-Monteith method. Agricultural Water Management 81, 1–22
Doorenbos, J. & Pruitt, W.O. (1977): Crop water requeriments. FAO Irrigation and Drainage Paper, 24, 179 p.
Steiner, J.L., Howell, T.A. & Schneider, A.D. (1991): Lysimetric evaluation of daily potential evapotranspiration models for grain sorghum. Agron. J., 83:240-247

Crop Coefficient (K_e, K_c, K_s) validation for grass in humic climate region





Measurement of grass evapotranspiration (ETc adj.) using a precise weighing monolithic lysimeter show the effect of plant water availability depending on specific soil conditions.
During dry periods where soil water availability solve plant water demand the agreement to calculated grass reference evapotranspiration (ET_0; Allen et al., 2006) is nearly perfect (ETc adj. = ETc). The transpiration coefficient (K_{cb}=ETc/ET_0) is validated to equal 1. During wet periods the evaporation coefficient (K_e = ETc/ET_0-K_{cb}) is calibrated. During soil water stress periods ETc adj. decreases in comparison to calculated values. The water stress coefficient (K_s = ETc/ET_0/K_{cb}) is calculated.
Calculation results are used (a) to correct measured ETc adj. to conditions non short of water (ETc) and (b) to split ETc into the evapotranspiration components evaporation, transpiration and waterstress. Calculation results for the year 2007 are shown in the right part of the graph above.



The calculated plant coeffi-cient for cutted grass (12 cm length; K_c=K_{cb}+K_e) over a long term observation period (Oct. 2005 to March 2008) results to 0.99 and meets the excpected value (1.00) near-ly perfect. Due to the influ-ence of K_e the calculated K_c-value is a little higher (1.03 to 1.04) during the vegetation periods (April to Sept.). During winter months the monthly variability of K_c is much higher, mean K_c is lower than 1. The main influences for a decrease of the K_c-value are snow cover and foggy periods. The high values in December show an active vegetation period.

Additional information about modular lysimeter systems you will find at:

Lysimeter construction techniques:	www.ums-muc.de/systems_solutions/lysimeter
Lysimeter Research Group:	www.lysimeter.at
Lysimeter Test Area Wagna (Austria):	www.lysimeter.com

Comparison of calculated ET_0 to measured lysimeter grass ET

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In 2006 a monolithic lysimeter have been implemented in the Wagna agricultural test field in southern Austria to measure the water balance parameters precipitation and evapotranspiration as exact as possible. The lysimeter has a surface of 1 m² and a depth of 1 m. The precision load cells on the concrete fundament measure the lysimeters weight with a resolution of 35 g (0.035 mm water equivalent). The lower boundary condition of the lysimeter is realized as a suction cup rake. The soil water tension measured in 0.9 m below surface in the undisturbed soil profile is transferred via an automatic controlled vacuum pump to the suction cups.

The lysimeters surface is cultivated by grassland which is cut during the vegetation period once a week to a length of 12 cm – as the reference height of the FAO-Penman-Monteith equation.

The weight of the lysimeter and of the seepage water container is registered with a time interval of 1 minute. Precipitation amount and evapotranspiration may be determined with a very high resolution in time.

Beside the lysimeter a standard weather station has been installed where the parameters to solve the Penman-Monteith equation (temperature, relative humidity, radiation, wind velocity) for calculating grass-reference-evapotranspiration (ET_0) are measured in a standard height of 2 m.

In this paper the measured grass evapotranspiration during the year 2007 is compared to calculated reference evapotranspiration using different formulas (FAO-Penman-Monteith, Tayler-Priestly, Blaney-Criddle) on a daily basis. In a second part measured date are compared to calculated values resulting from Penman-Monteith calculation using different time steps. The crop coefficient of grass in a humid climatic region using the double coefficient method is validated.