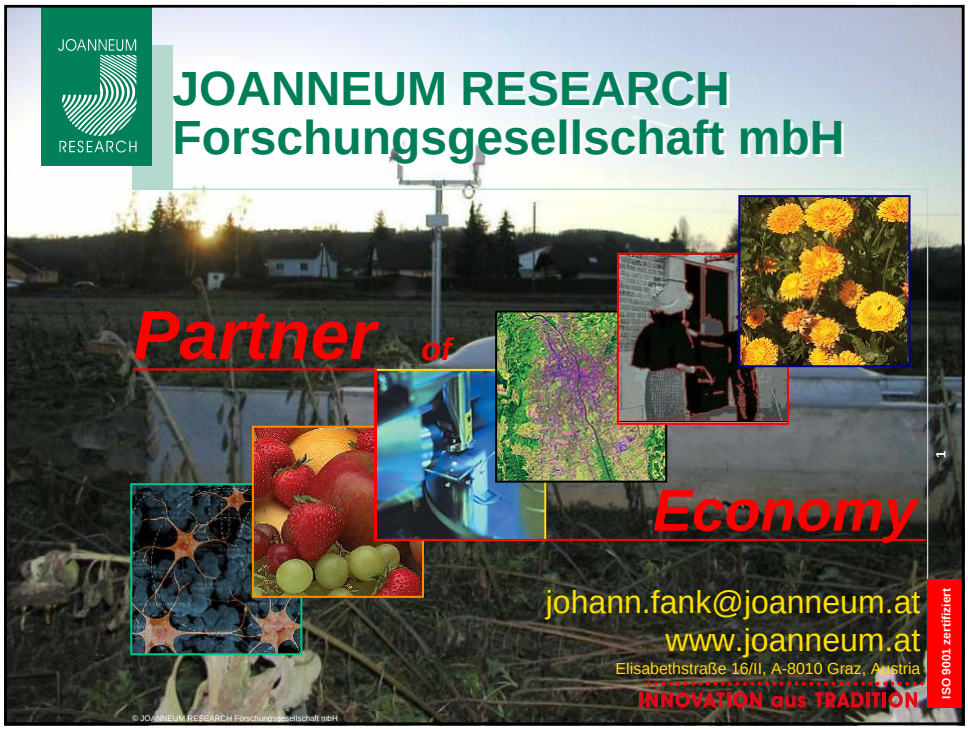
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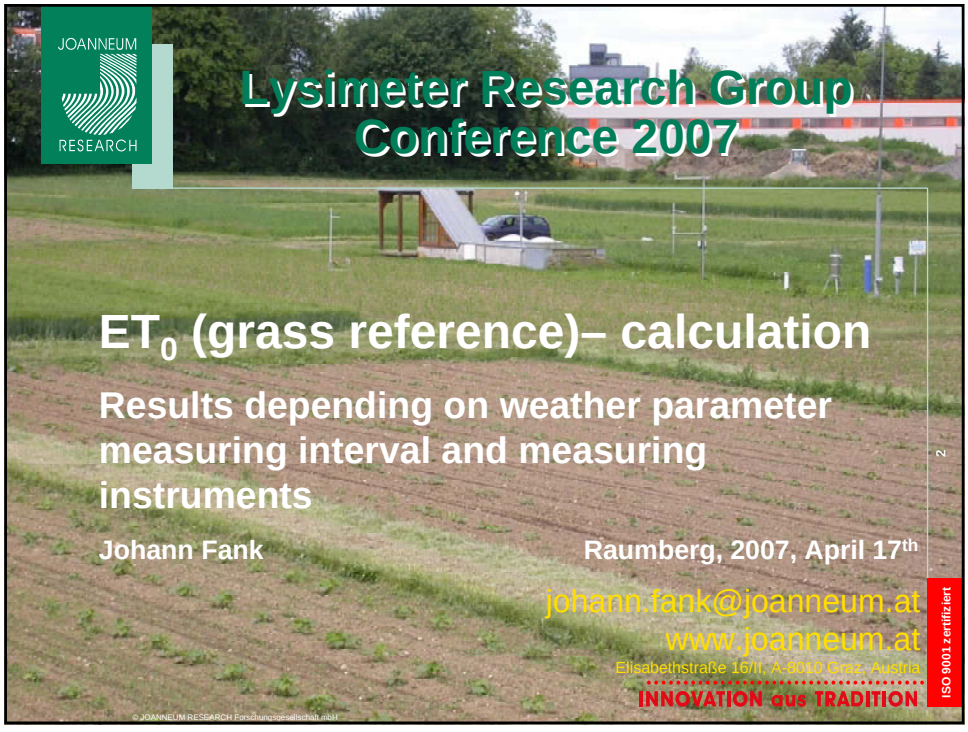
JOANNEUM
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Lysimeter Research Group
Conference 2007
ET0 (grass reference)– calculation
Results depending on weather parameter measuring interval and measuring instruments
Johann Fank
Raumberg, 2007, April 17th
johann.fank@joanneum.at
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Investigation Goals

- **Determination of water balance parameters**

Water Balance Equation
(for a certain volume and time step)

$$P-ET-D-\Delta S = 0$$

P	=	*Precipitation*
ET	=	*Evapotranspiration*
D	=	*Drainage, groundwater Recharge*
ΔS	=	*change of stored water volume*

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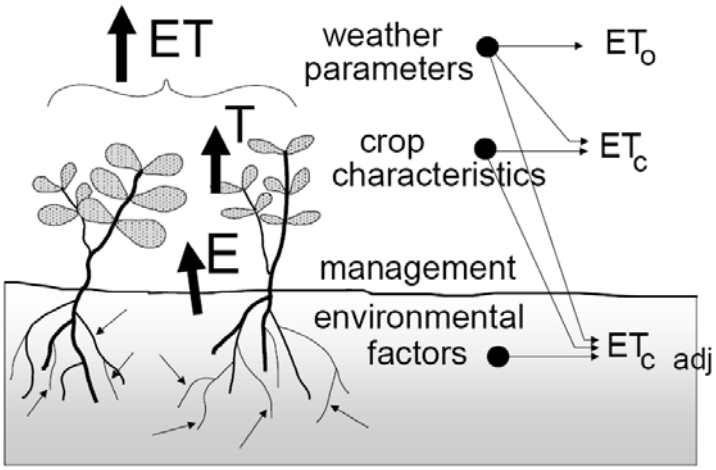
Factors affecting Evapotranspiration (Allen et al. 1998)



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Contents

- **Reference evapotranspiration (ET_0)**
  - FAO Penman-Monteith equation
  - Meteorological Data
  - Lysimeter for validation
- **Determination results**
  - Dependency on measurement intervals
  - Dependency on different measurement environment
  - Comparison to lysimeter measurements
    - On a daily basis
    - Long term evaluation
    - ET_0 during winter months
- **Conclusions**

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FAO Penman-Monteith equation

24-h calculation time step

$$ET_O = \frac{0.408\,\Delta\,(R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34\,u_2)}$$

ET_O	reference evapotranspiration [mm day^{-1}],
R_n	net radiation at the crop surface [MJ m^{-2} day^{-1}],
G	soil heat flux density [MJ m^{-2} day^{-1}],
T	air temperature at 2 m height [°C],
u_2	wind speed at 2 m height [m s^{-1}],
e_s	saturation vapour pressure [kPa],
e_a	actual vapour pressure [kPa],
e_s-e_a	saturation vapour pressure deficit [kPa],
Δ	slope vapour pressure curve [kPa °C^{-1}],
γ	psychrometric constant [kPa °C^{-1}].

- G = 0
- T = (Tmin+Tmax) / 2
- RH = (RHmin+RHmax) / 2

Short calculation time step

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

ET_0 = *Referenzverdunstung* [$mm \cdot d^{-1}$]
Δ = *Steigung der Sättigungsdampfdruckkurve* [$kPa \cdot °C^{-1}$]
Rn = *Strahlungsbilanz an der Referenzoberfläche* [$MJ \cdot m^{-2} \cdot d^{-1}$]
G = *Bodenwärmestrom* [$MJ \cdot m^{-2} \cdot z^{-1}$]
γ = *Psychrometerkonstante* [$kPa \cdot °C^{-1}$]
z = *Berechnungszeitschritt [d]*
T = *Lufttemperatur in 2 m Höhe über Boden* [°C]
u_2 = *Windgeschwindigkeit in 2 m Höhe über Boden* [$m \cdot s^{-1}$]
e_s = *Sättigungsdampfdruck [kPa]*
e_a = *aktueller Dampfdruck [kPa]*
C = *Aerodynamischer Widerstandsbeiwert* [$s \cdot m^{-1}$]

- G = 0.5 * Rn during night time
  0.1 * Rn during day time
- T, RH = mean value of time step
- C = 0.96 during night time
  0.24 during day time

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Meteorological Data

- **Automatic Weather Station of the Austrian Meteorological Survey**
  - ➔ Parameter
    - Temperature (2 m)
    - Rel. Humidity (2 m upper value of 95%)
    - Wind speed (10 m)
    - Solar radiation
  - ➔ Interval: 2 sec. stored as
    - mean values of 1 Min.
    - mean values of 10 Min.
    - mean values of 1 hour
  - ➔ Direct imported from the meteodat - datalogger
- **Automatic Weather Station of UMS at Wagna Research Station (METEOLYS)**
  - ➔ Parameter
    - Temperature (2 m)
    - Rel. Humidity (2 m calibrated at 33 and 97 %)
    - Wind speed (2 m)
    - Solar radiation (2 m)
  - ➔ Interval: 1 Min. stored as mean values of 10 Min.
  - ➔ Stored on a DT80 - Datalogger

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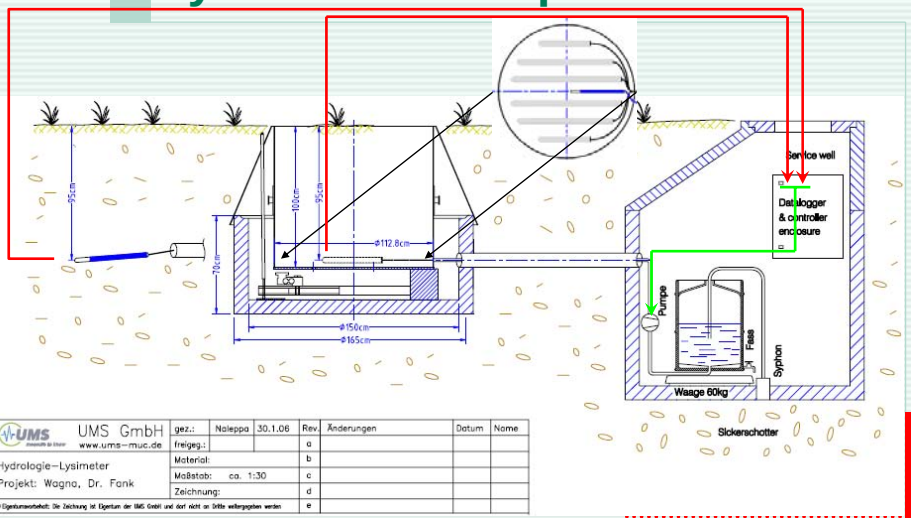
ET_0 – calculation validation Lysimeter concept



UMS GmbH www.ums-muc.de	gez.:	Naleppa	30.1.06	Rev.	Änderungen	Datum	Name
	freigeg.:			a			
Hydrologie–Lysimeter	Material:			b			
Projekt: Wagna, Dr. Fank	Maßstab:	ca. 1:30		c			
	Zeichnung:			d			
© Eigentumsvorbehalt: Die Zeichnung ist Eigentum der UMS GmbH und darf nicht an Dritte weitergegeben werden				e			

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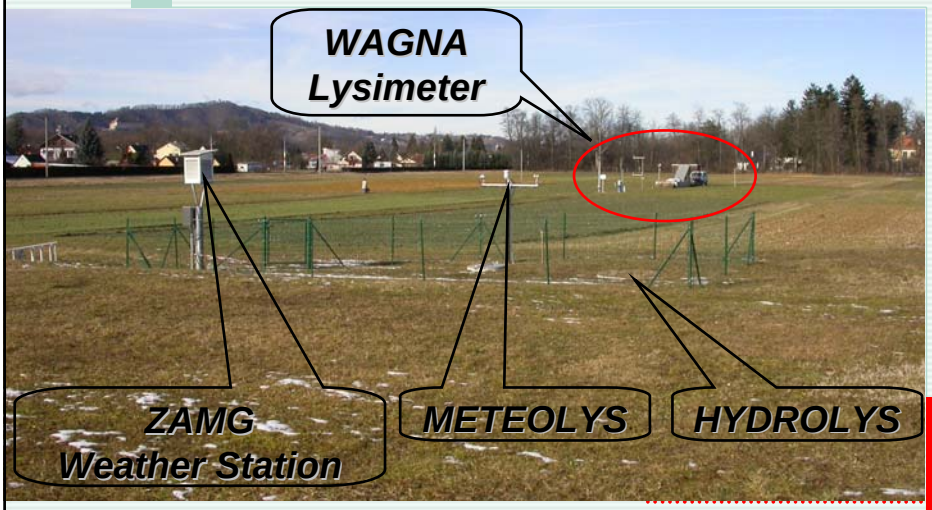
HYDROLYS
Implementation at Wagna



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Comparison of different calculation time steps and sensors

System	*ZAMG*				*UMS*		*HYDROLYS*
Method	ET_0 - ASCE			ET_0 - FAO	ET_0 - ASCE	ET_0 - FAO	ETr
Intervall	1 Minute	10 Minutes	60 Minutes	Daily values	10 Minutes	Daily values	10 Minutes
OCT 2005	29.5	29.6	37.3	34.5	29.4	30.5	26.9
NOV 2005	6.5	6.5	13.2	14.2	6.2	12.1	12.7
DEC 2005	8.1	8.0	12.7	10.9	7.9	8.7	7.1
JAN 2006	6.4	6.3	10.6	8.4	6.6	7.2	3.1
FEB 2006	17.6	17.5	22.1	18.9	17.7	16.9	9.2
MAR 2006	43.4	43.3	50.6	46.4	44.2	45.9	24.4
APR 2006	59.9	60.4	71.1	70.0	60.7	67.1	61.7
MAY 2006	87.3	87.9	99.4	98.4	87.3	94.1	78.5
JUN 2006	112.1	112.2	124.0	122.9	110.1	116.7	120.3
JUL 2006	132.6	132.0	142.4	141.7	131.3	134.9	135.7
AUG 2006	75.8	76.2	86.0	88.3	75.5	84.3	83.4
SEP 2006	67.8	67.7	75.4	71.4	67.7	65.6	77.7
OCT 2006	43.0	43.0	49.1	44.6	42.0	37.0	48.6
NOV 2006	17.2	17.2	22.8	21.4	16.7	14.8	17.3
DEC 2006	7.1	7.3	12.2	10.8	6.7	6.8	10.2
JAN 2007	14.1	14.9	16.3	12.9	13.5	9.0	9.9
FEB 2007	23.1	23.5	28.6	25.4	22.1	20.0	17.0
MAR 2007	44.4	44.4	52.6	48.6	43.6	42.6	41.7
SUM	**795.9**	**798.1**	**926.6**	**889.8**	**789.4**	**814.3**	**785.6**
%-Deviation	1.3%	1.6%	18.0%	13.3%	0.5%	3.7%	0.0%

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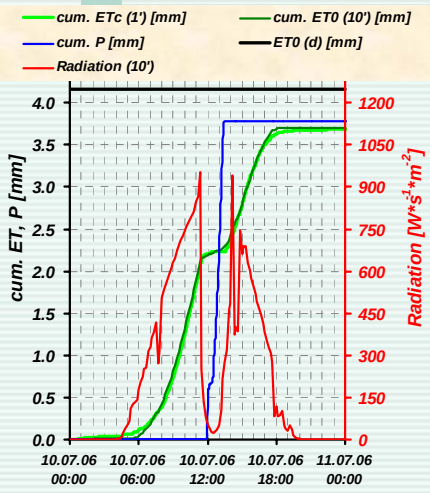
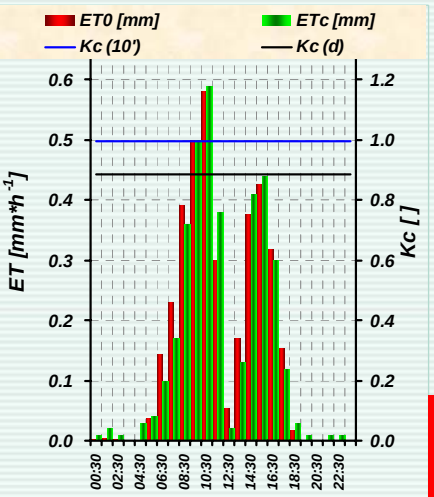
Evaluation

comparison of calculated ET_0 and measured ETc





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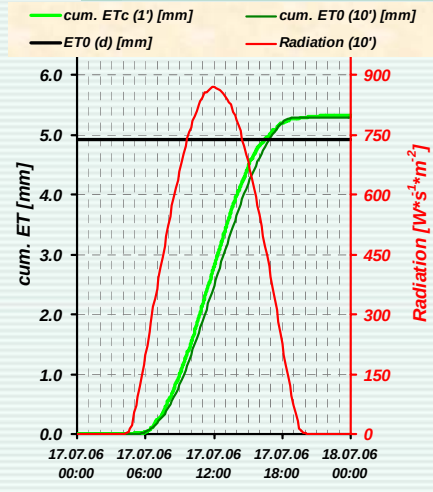

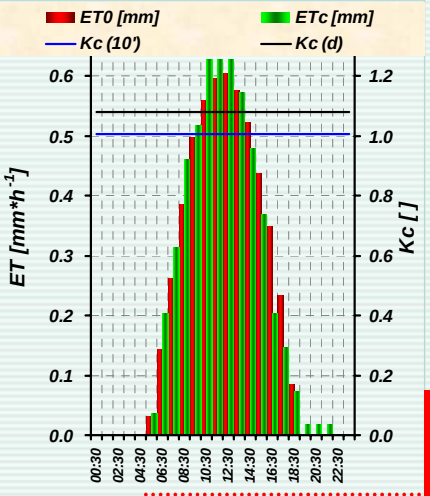

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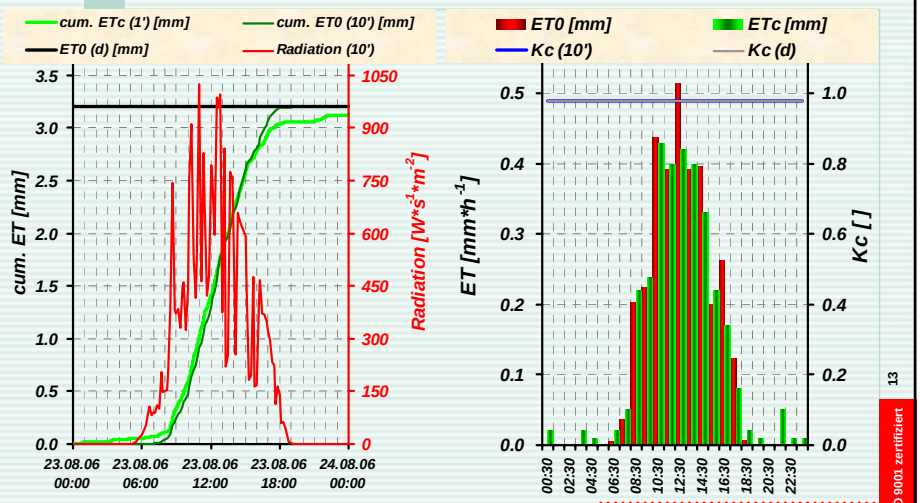
comparison of calculated ET_0 and measured ETc



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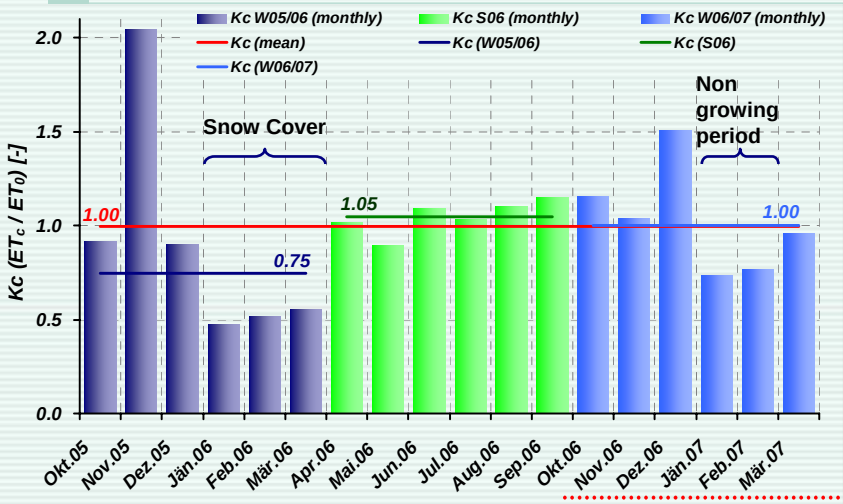
Seasonal Variation of Kc



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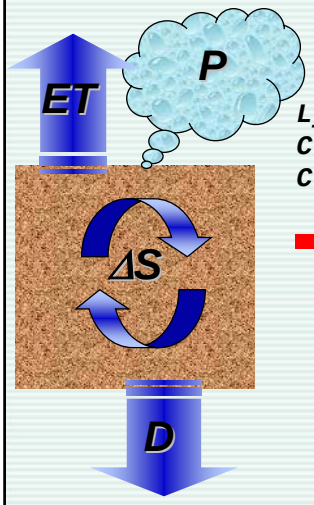
Conclusions



Water Balance 2006

	P	- ET	= D+ΔS
Lysimeter:	866.3	– 686.3	= 180.0
Clim.WB (10'):	832.8	– 681.5	= 151.3
Clim.WB (daily):	832.8	– 743.3	= 89.5

- **To minimize errors in parameter estimation we recommend the use of all available input data for**
  - ➔ Detailed water balance studies
  - ➔ Evaluation of lysimeter investigations
  - ➔ Validation and calibration of soil water and solute transport models