“Tension-free” Lysimeters versus „Controlled tension“ Lysimeters - A Simulation Study

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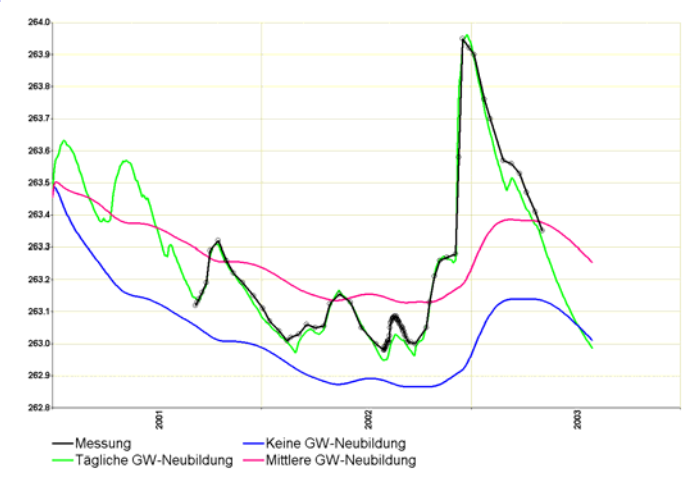
General problem:

We do need exact data on ground water recharge for:

- Definition of the maximum allowable ground water extraction in regions with limited ground water reserves
- Input data for transient ground water flow modelling

Groundwater Recharge and Model calibration



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Measurement of ground water recharge using lysimeters

- **Preconditions:**
  - **Prevent oasis effects**
  - **Measurements deeper than rooting depth**
  - **Soil water potential at lower end of the lysimeter must correspond with soil water potential of the surrounding soil**

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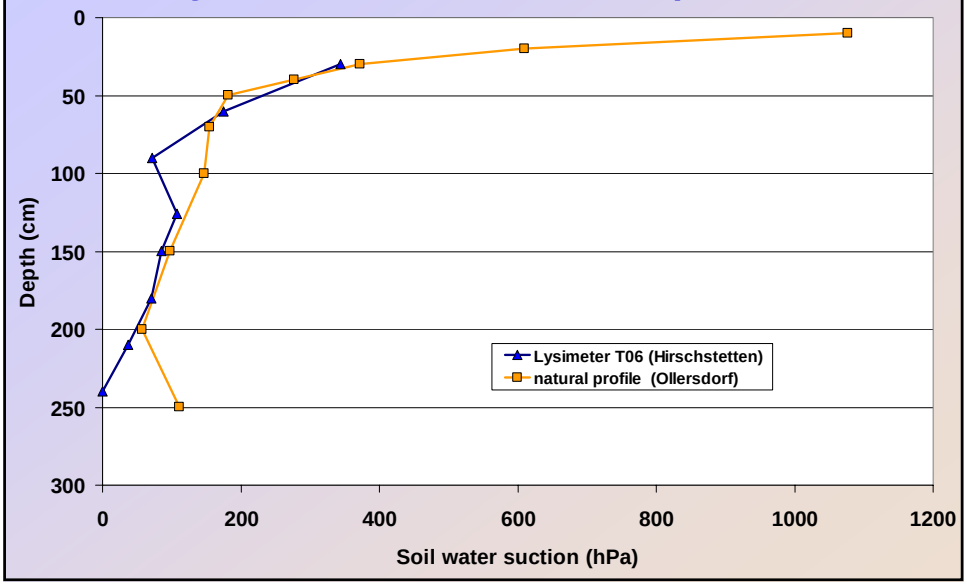
Comparison of soil suction within a „tension-free lysimeter and a natural soil profile



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Installation of the suction cup strip at the bottom of the lysimeter column

Implementation of controlled suction at the lysimeter bottom is rather expensive! Therefore we are starting with a simulation study to answer following questions:

- **are controlled suction lysimeters needed in every situation?**
- **should – on the other hand – existing tension free lysimeters be converted to suction lysimeters to yield realistic measurements of deep percolation?**

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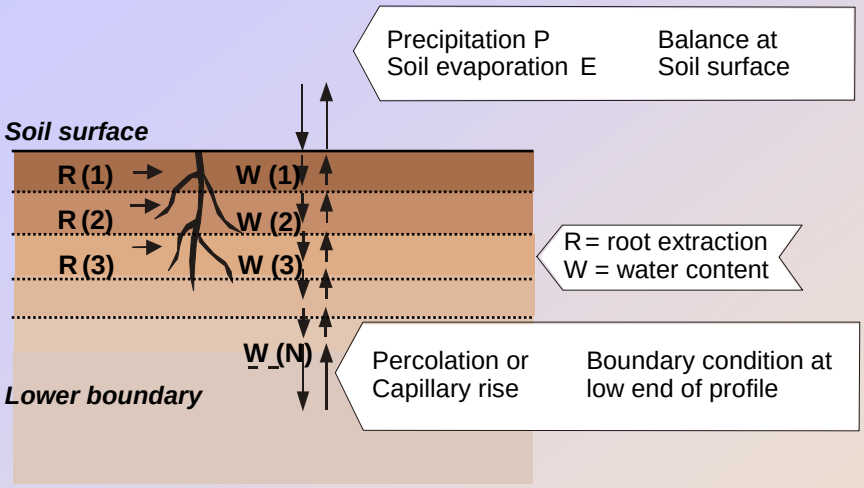
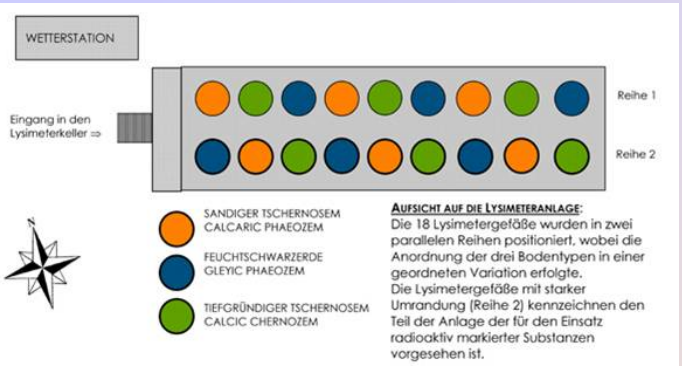
Material and methods

- **Simulation model SIMWASER**
  - **Simulation of natural soil profile: lower boundary = ground water surface**
  - **Simulation of „controlled tension lysimeter“: lower boundary = tension applied**
  - **Simulation of „tension free lysimeter“: lower boundary condition: psi=zero**
- **Case study**
  - **tension free lysimeter = HIRSCHSTETTEN**
  - **controlled tension lysimeter = WAGNA**

Simulation model SIMWASER



Lysimeter HIRSCHSTETTEN



Lysimeter Research Station near Vienna
18 lysimeters with each 6 of them containing typical soils from the Marchfeld (Lower Austria)

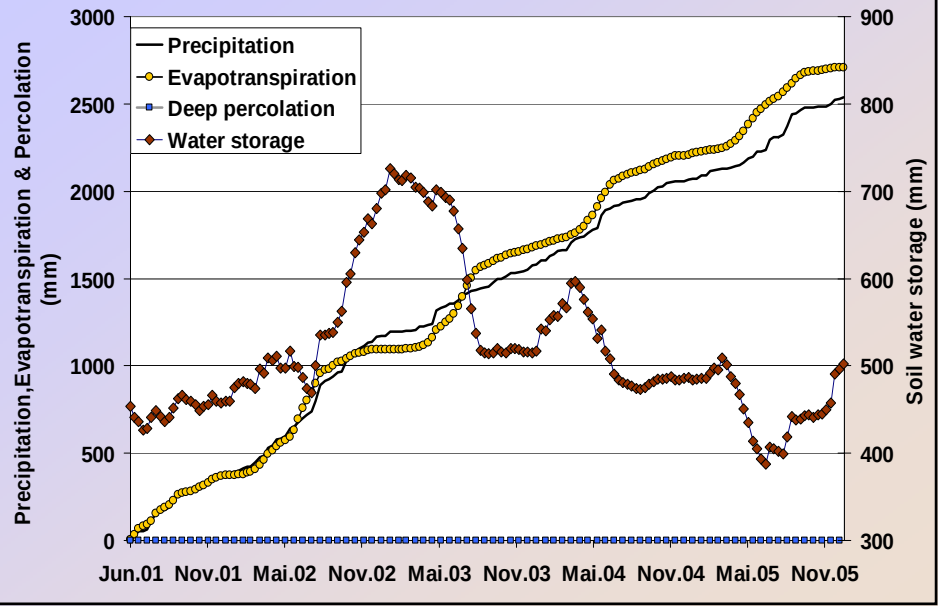
Precipitation: ~ 500 mm/a
Temperature: 10.5 °C

Lysimeter HIRSCHSTETTEN

- Backfilled
- Tension free (gravity)
- Non weighable

- In different depths the lysimeters are equipped with
  - Tensiometers
  - FDR water content sensors
  - Suction cups

Tension free lysimeter at Hirschstetten



Suction Controlled Lysimeter WAGNA

- **Mechanized Cultivated, Precise Weighing Monolithic Lysimeter**
- **Minimize Lysimeter Measurement Errors**
  - **Prevent Oasis/Island effects**
  - **Prevent lower boundary effects**

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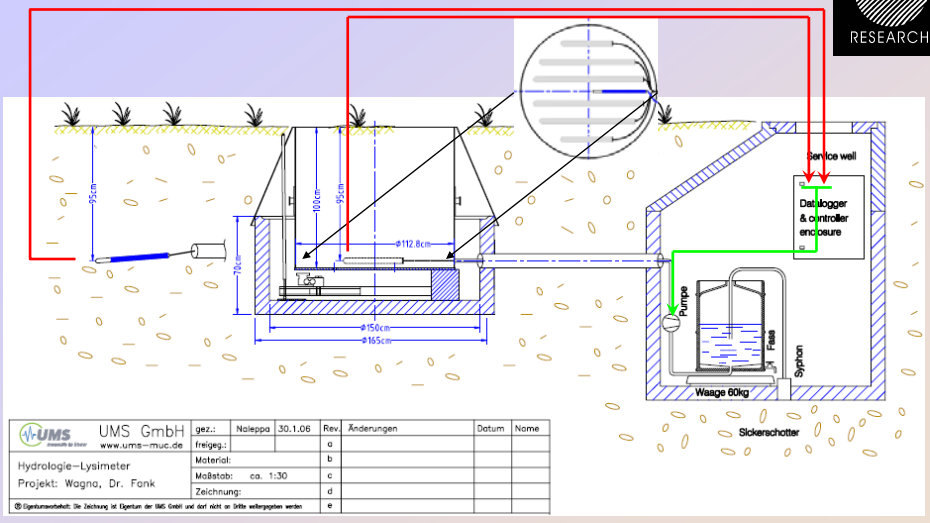
Contolled suction lysimeter WAGNA

JOANNEUM RESEARCH



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			
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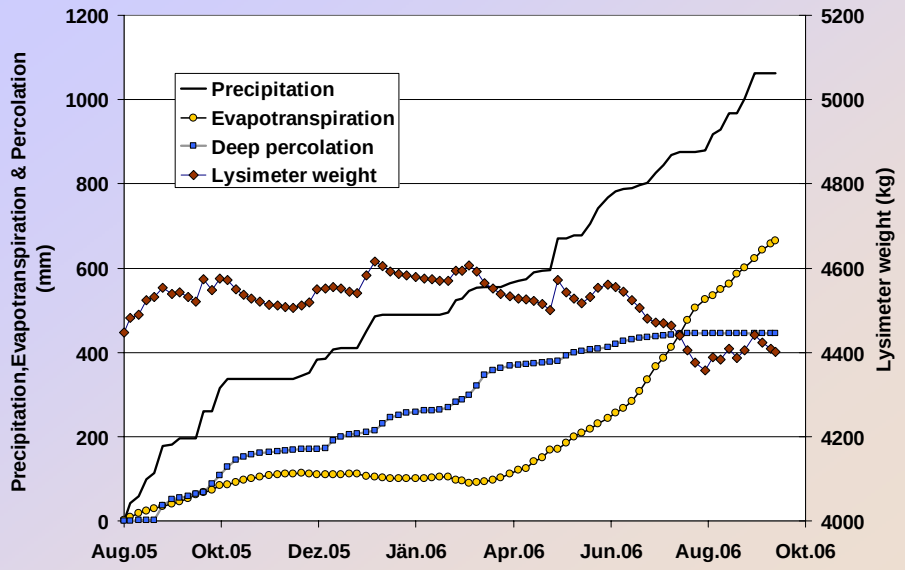
Controlled tension lysimeter WAGNA



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RESULTS

- **At the HIRSCHSTETTEN station simulated percolation for the “tension free” lysimeter was zero as the measurements, but was 120 mm for the simulated “natural” soil profile at this site.**
- **At the WAGNA station simulated ground water recharge of the natural soil profile properly fits with the deep percolation measured by the “controlled tension” lysimeter while simulated percolation of a simple tension free lysimeter is about 10% lower than the simulated “natural” recharge.**

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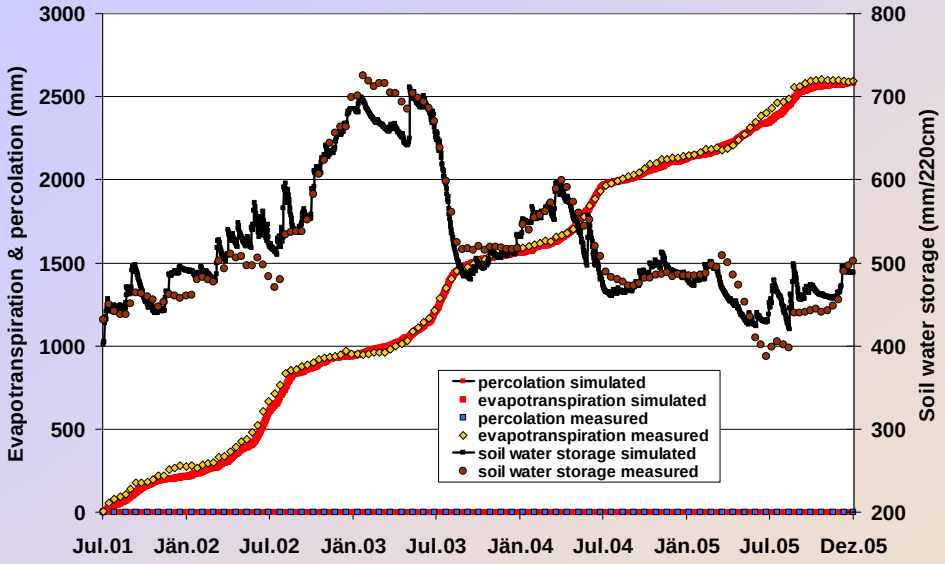
Simulated tension free lysimeter HIRSCHSTETTEN



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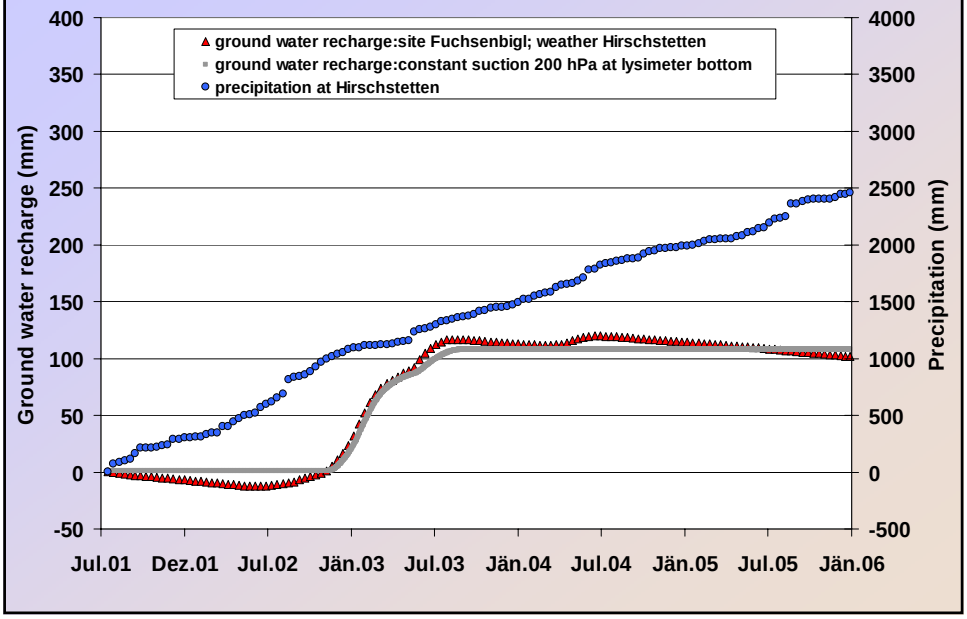
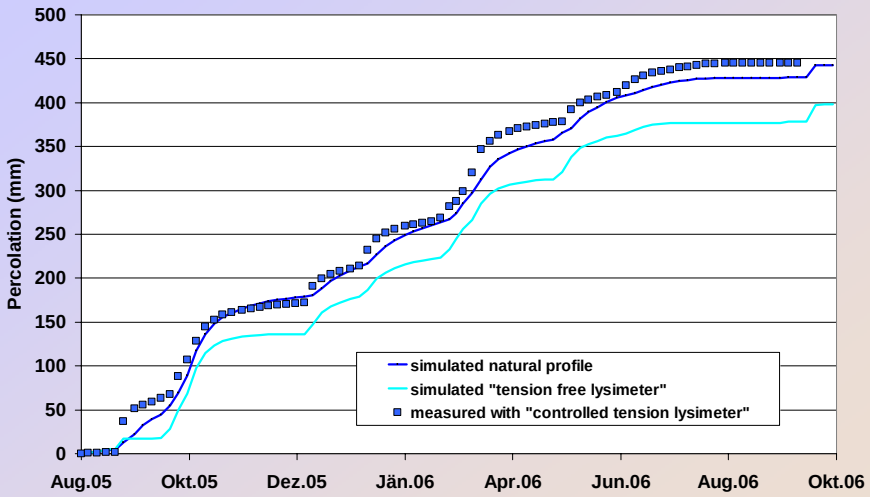
Simulated percolation at HIRSCHSTETTEN



Percolation at lysimeter WAGNA



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Summary and Discussion

- **Using simple tension free lysimeters, deep percolation (and thus ground water recharge) is underestimated at all.**
- **At sites with high precipitation or groundwater recharge this error may be tolerable (at the WAGNA station it is 10% of the supposed real percolation)**
- **In dry areas as in the MARCHFELD "controlled suction" lysimeters should be used at least for deep soil types that have high water holding capacity.**
- **If we use lysimeter data for calibrating soil water models we should use tension lysimeters, otherwise we transfer measurement errors into modelling**
- **Further investigations are needed to recommend the right lysimeter type for the respective site and soil profile.**

Thank you very much for your attention