ALMA MATER STUDIORUM
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arpa
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# Errors In Water Retention Measurements: Consequences On The Soil Water Budget


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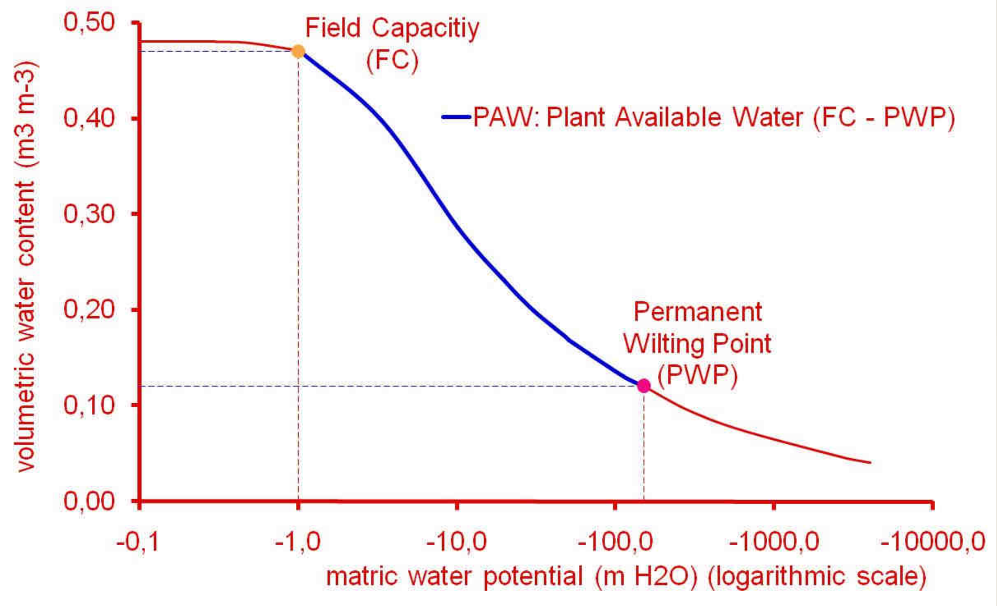
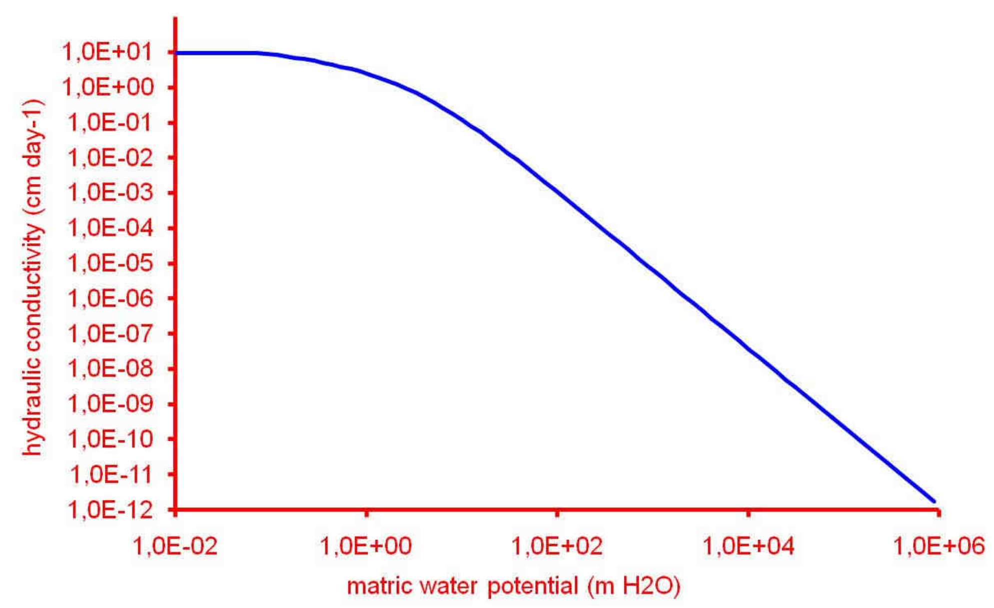
The Soil Water Retention Curve (SWR):

is an important soil property, and it is the relationship between:

- Soil water content ($m^3\ m^{-3}$);
- Matric water potential ($m\text{-}H_2O$);




When experimental data of hydraulic conductivity are not available, the SWR is used to derive the hydraulic conductivity curve, which is necessary for solving Richards equation.

- Hydraulic conductivity(cm $day^{-1}$);
- Matric water potential ($m\ H_2O$);

## Soil Water Retention (SWR) Curve

important for many agricultural and hydrological applications:

- computation of crop water requirements;
- irrigation scheduling;
- fertilization;
- computation of water fluxes;
- quantification of solute transport;

## If erroneous measurements of the SWR curve are obtained:

- erroneous computation of crop water requirements (irrigation scheduling and volumes);
- erroneous computation of the movement of the pollutants in soils and groundwater;

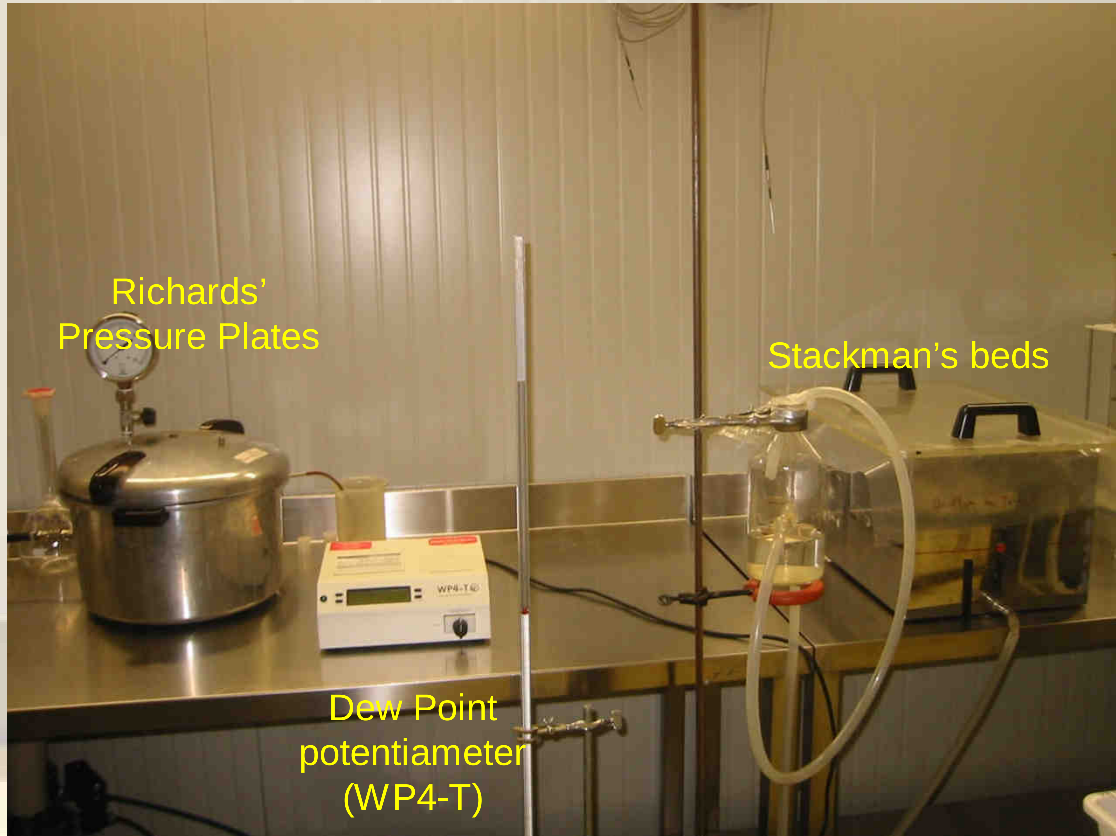
# SWR curve measurements

Traditional methods:
- Stackman's beds;
- Richards' Pressure Plates;

But......

Many studies have demonstrated the unreliability of Pressure Plates apparatus at more negative water potentials

(Peck and Rabbidge, 1969;
Madsen et al., 1986;
Gee et al., 2002;
Bittelli et al., 2009;
Bittelli and Flury, 2009)




Soil Physics Lab, University of Bologna

Alternative method at low potentials, used in this study:
- Dew Point Potentiameter (WP4-T Decagon devices Inc.)

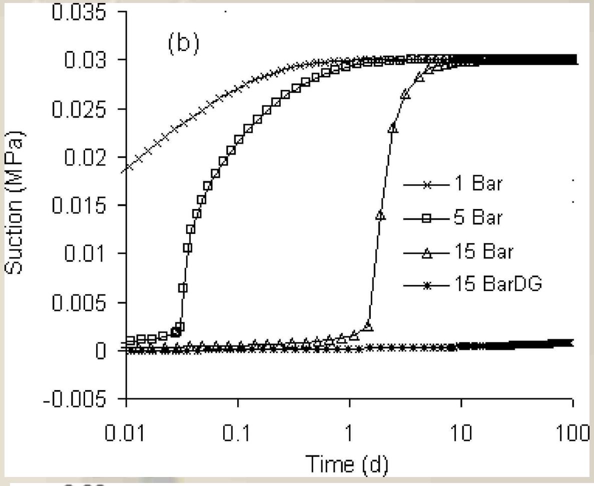
Goal of this study:

To investigate the effects of SWR curve measurements on the computation of the soil water balance

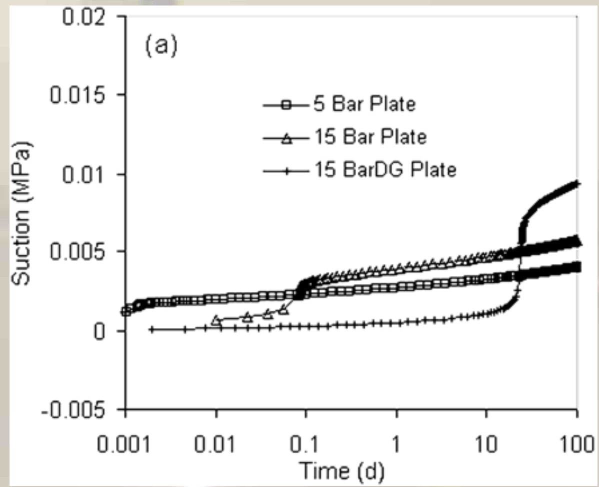
# Hydraulic non-equilibrium

1. back flow of the water from the membrane of the pressure plates into the samples, before the applied pressure was released (Richards and Ogata, 1961);
2. failure to achieve thermodynamic equilibrium between the soil samples and the pressure plates (Campbell, 1988);
3. loss of hydraulic contact between sample and plate after the desaturation of the sample and soil dispersion (Cresswell et al., 2008);
4. failure to achieve equilibrium between the soil samples and the pressure plates at the potential of -150 m-$H_2O$ (Gee et al., 2002);

3 m-$H_2O$

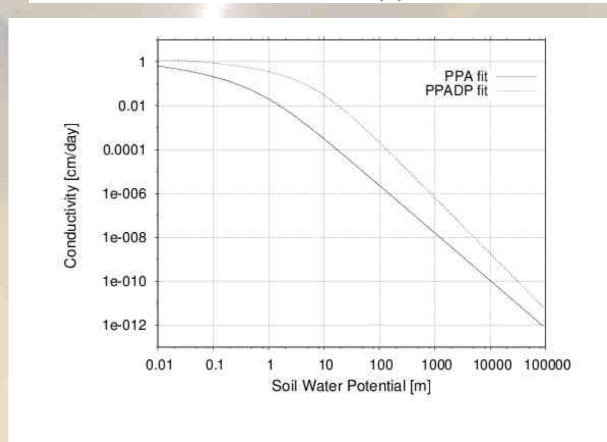



50 m-$H_2O$




## How much time to get equilibrium at 150 m-$H_2O$? Years....(Gee et al., 2002)

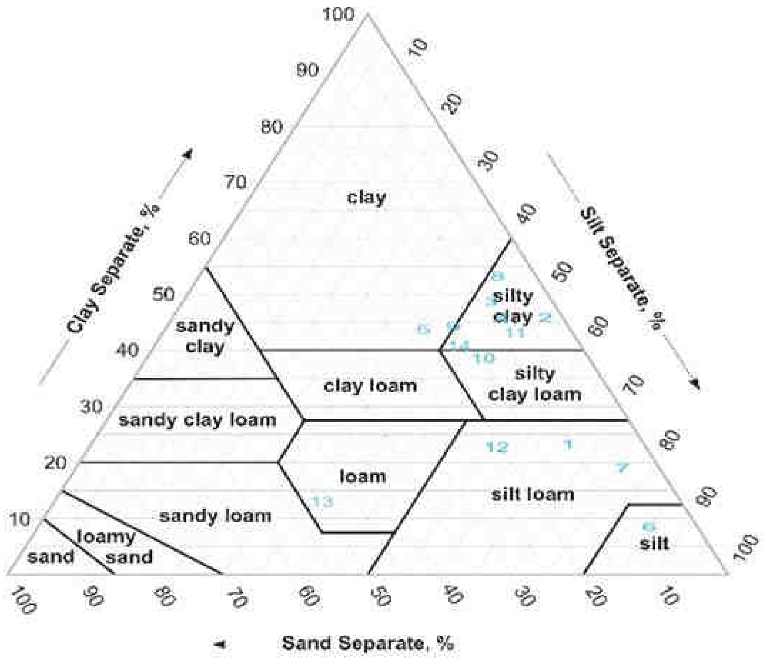
E9001P0001_0-10cm_silty clay



## Soil samples:

- Fourteen benchmark soil samples from the Emilia Romagna Region;

- different textural properties:
  - 50% of the samples are classified as silty clay;
  - other samples are classified as silt loam, loam, silt, clay and silty clay loam;




## Two sets of data:

- (Richards') Pressure Plates Apparatus (PPA) only;

- Combination of Pressure Plates Apparatus and Dew Point potentiameter (PPADP);

- Fitting of the two sets of retention data applying modified van Genuchten - Mualem hydraulic model (Ippisch et al., 2006);

$$S_e(h) = \begin{cases} 1 & if\ |h| \le |h_e| \\ \frac{1}{S_c}\left[1 + (\alpha|h|)^n\right]^{-m} & if\ |h| \ge |h_e| \end{cases}$$

- hydraulic conductivity (K) estimated applying the modified Mualem model (Ippisch et al., 2006);

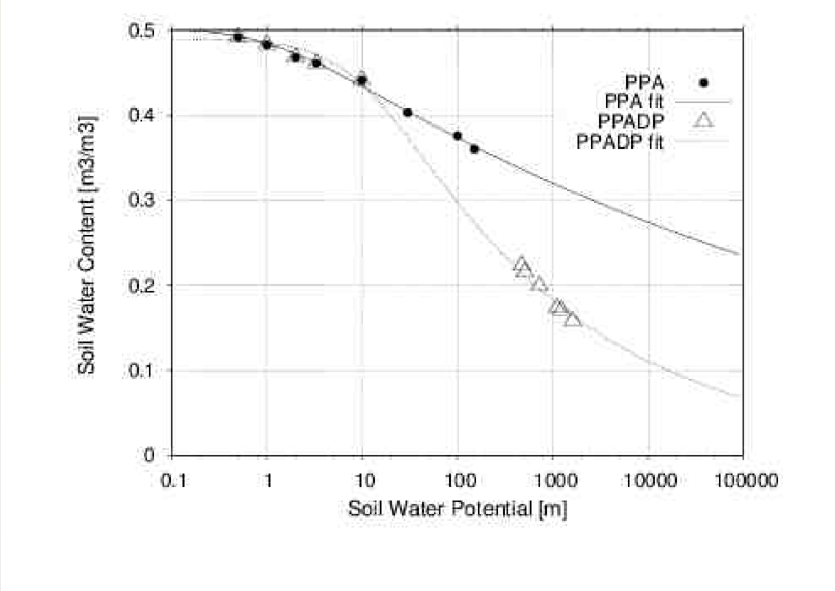
$$K = \begin{cases} K_s S_e^{\tau} \left\{ \frac{1 - \left[1 - (S_e S_c)^{\frac{1}{m}}\right]^m}{1 - \left(1 - S_c^{\frac{1}{m}}\right)^m} \right\}^2 & \text{if } S_e < 1 \\ K_s & \text{if } S_e \ge 1 \end{cases}$$

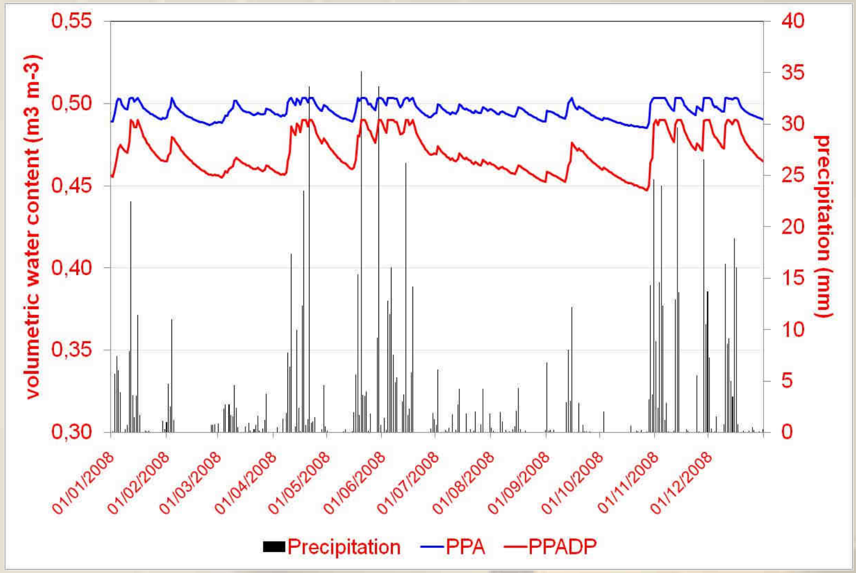
## Modeling:

- Soil water balance was computed using CRITERIA model (Marletto et al., 2007);
- simulations performed for bare soils with 1 meter of depth;
- climatological data:
  - cell 1410 - Carpaneto Piacentino (PC) from the Agricultural Research Council (CRA-CMA);
  - year 2008;
- 1D numerical solution of Richards equation (Bittelli et al., 2010);
- meteorological upper boundary condition and free drainage lower boundary condition;
- no groundwater;

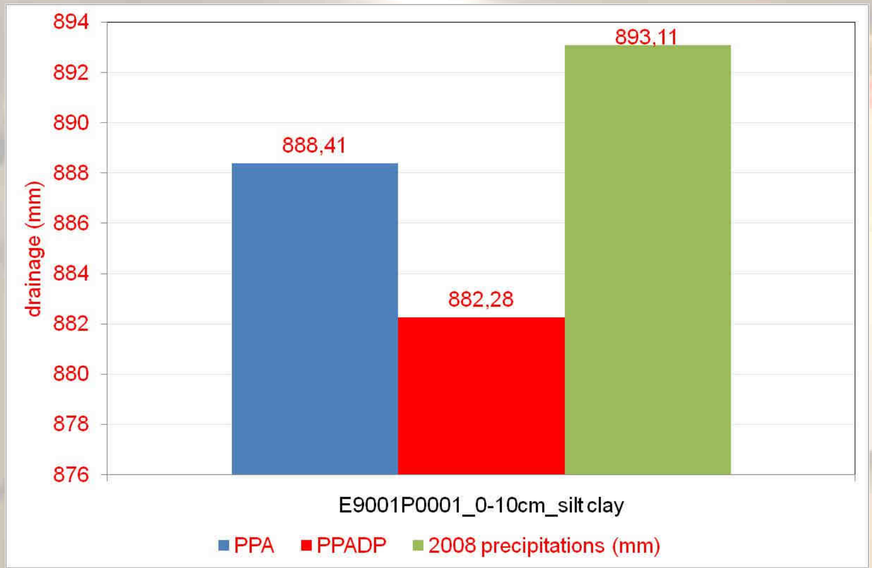
# Water budget: drainage only

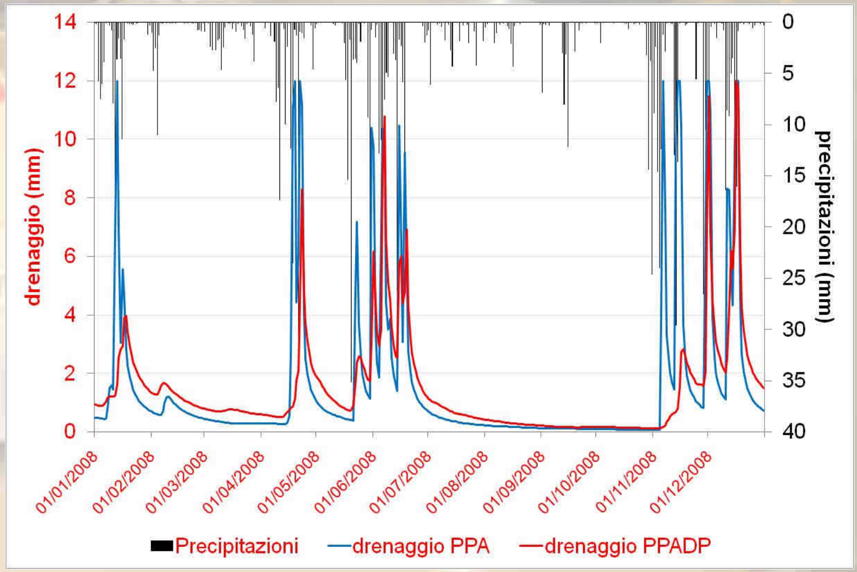
E9001P0001_0-10cm_silty clay



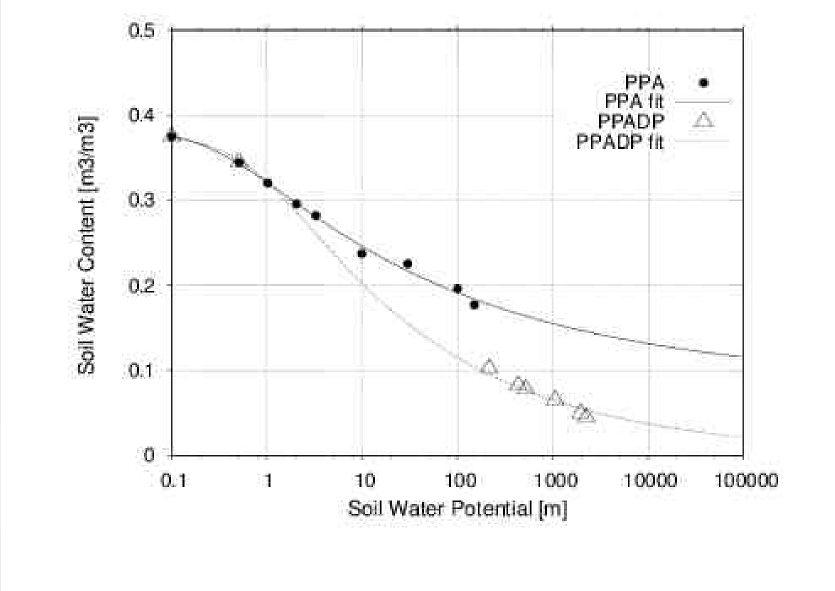

## Total annual rainfall (2008): 893,1 mm

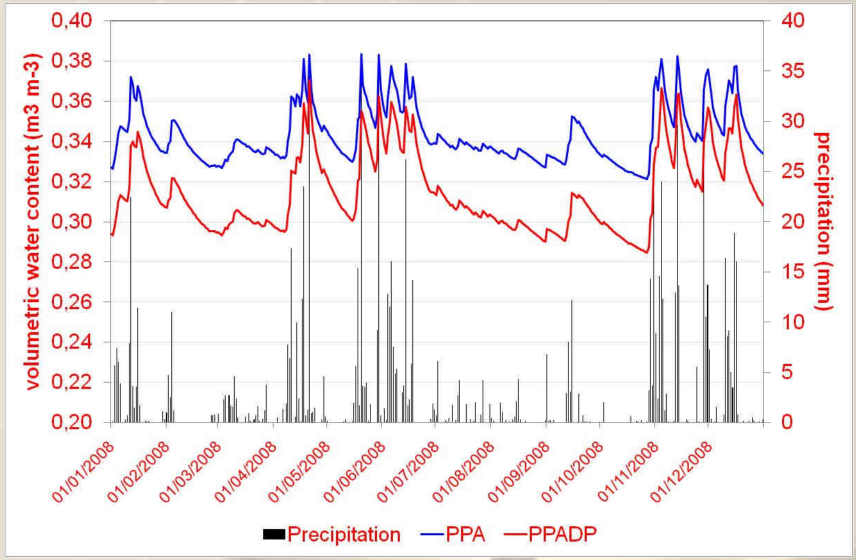


# Water budget: drainage only

E9001P0013_0-60cm_loam

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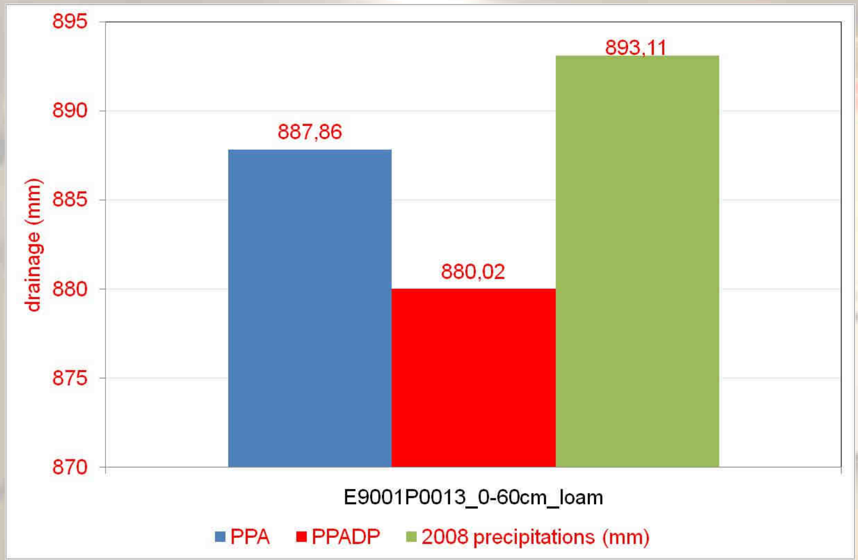


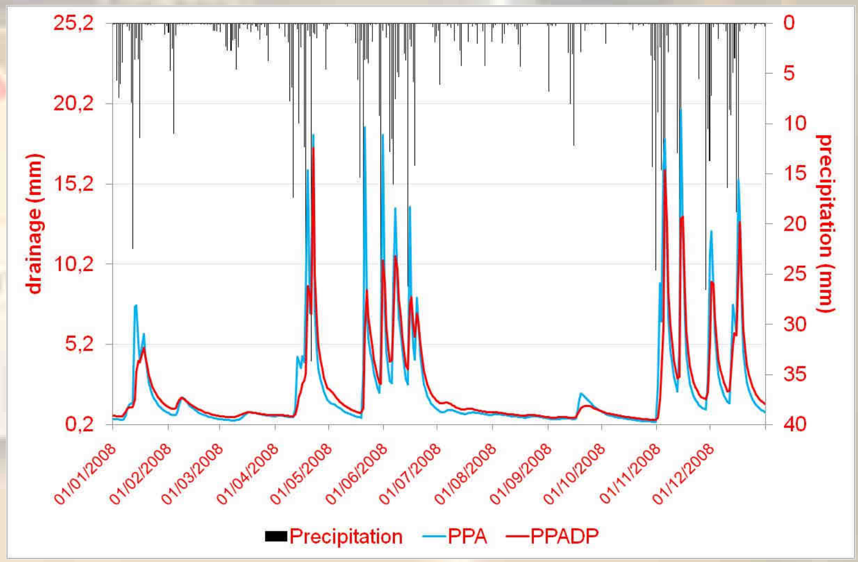

# Conclusions

Retention measurements made applying a combination of classic methods (Richards' Plates) with the Dew Point method, leads to:

1. A more correct estimation of soil water retention is needed: classic method underestimates Plant Available Water (35% - 45% less);

2. The soil obtained with the PPADP has a higher retention. Where, under the same water potential gradient, the soil measured with PPA determines a larger losses of soil water.

3. There results may have important implications when these properties are used to estimate solute transport into the groundwater or computation of irrigation volumes and schedules.

4. Unfortunately most of the current Pedotransfer functions were derived on erroneous measurement of SWR, making its application questionable.

# Thank you!