TIME EVOLUTION OF SURFACE SOIL HYDRAULIC PROPERTIES

GENERAL OUTLINE

I Main objectives and general presentation

II Beer-kan method and field measurements

III Theoretical treatment

IV Results and conclusion

MAIN OBJECTIVES

(1) Characterize the hydraulic properties of 4 plots :

- **identical initial agricultural history,**
- **four different treatments repeated since 1994.**

(2) Emphasize the significant drift in soil properties in terms of temporal variability.

GENERAL CONTEXT

- Altitude : 1200 m
- Latitude : 19.1° N
- Mountain semi-arid tropical climate
- Rain : 400 to 650 mm

PLOTS DESCRIPTION

Plot 1 : Conventional Tillage (CT)

Plot 2 : Direct Sowing, no residue (DS0)

Plot 3 : Direct Sowing, 1.5 t/ha (DS1.5)

Plot 4 : Direct Sowing, 4.5 t/ha (DS4.5)

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SOIL HYDRAULIC PROPERTIES

- Soil retention curve : Van Genuchten with Burdine condition

$$\frac{\theta}{\theta_s} = \left(1 + \left(\frac{h}{h_g}\right)^n\right)^{-m} \quad \text{with} \quad m = 1 - \frac{2}{n}$$

- Soil conductivity curve : Brooks and Corey

$$\frac{K}{K_s} = \left(\frac{\theta}{\theta_s}\right)^{\eta}$$

CUMULATIVE INFILTRATION IN SOIL

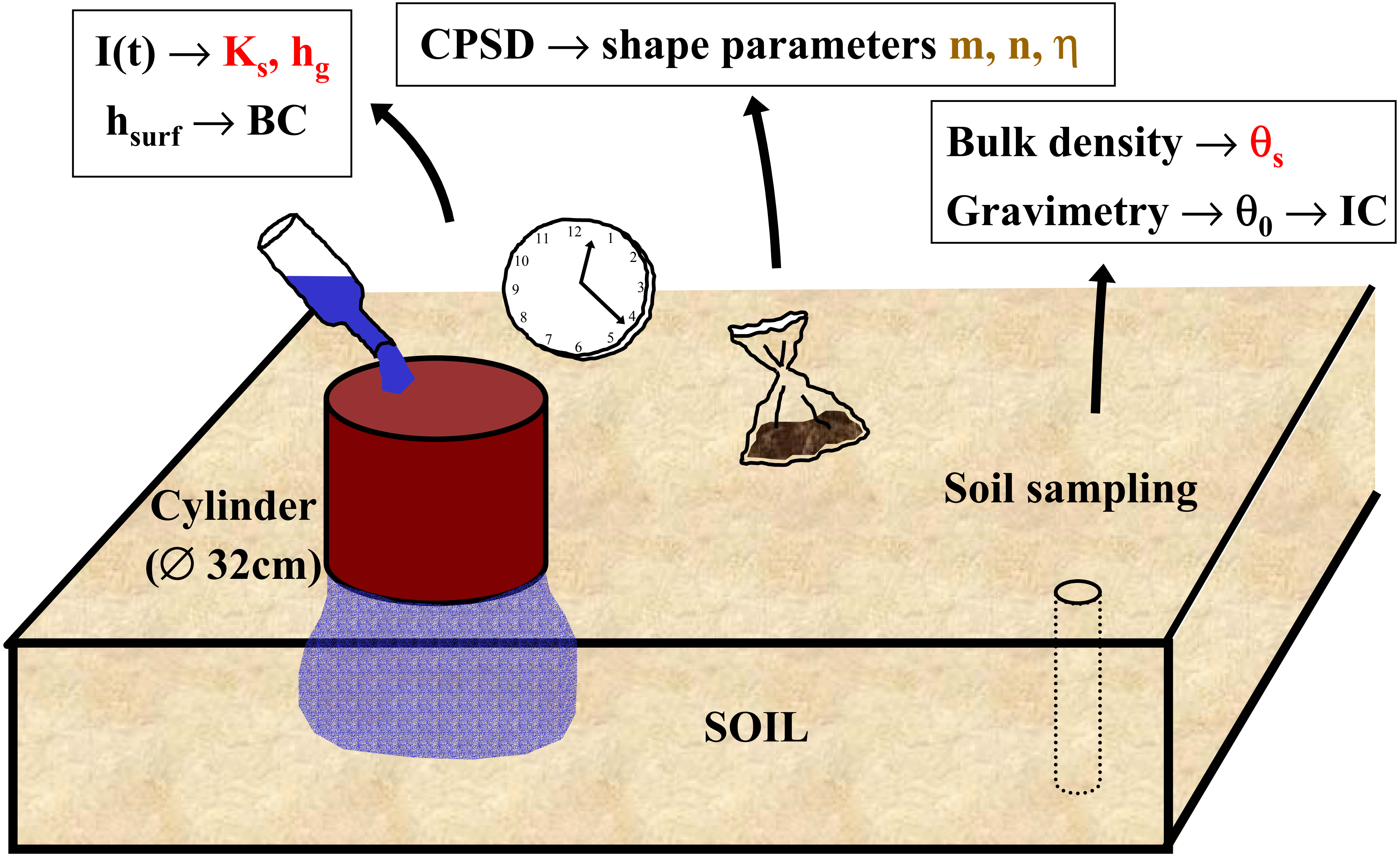
Cumulative infiltration in soil (I) is defined as :

$$\mathbf{I = I_{h(\theta),K(\theta),IC,BC}}$$

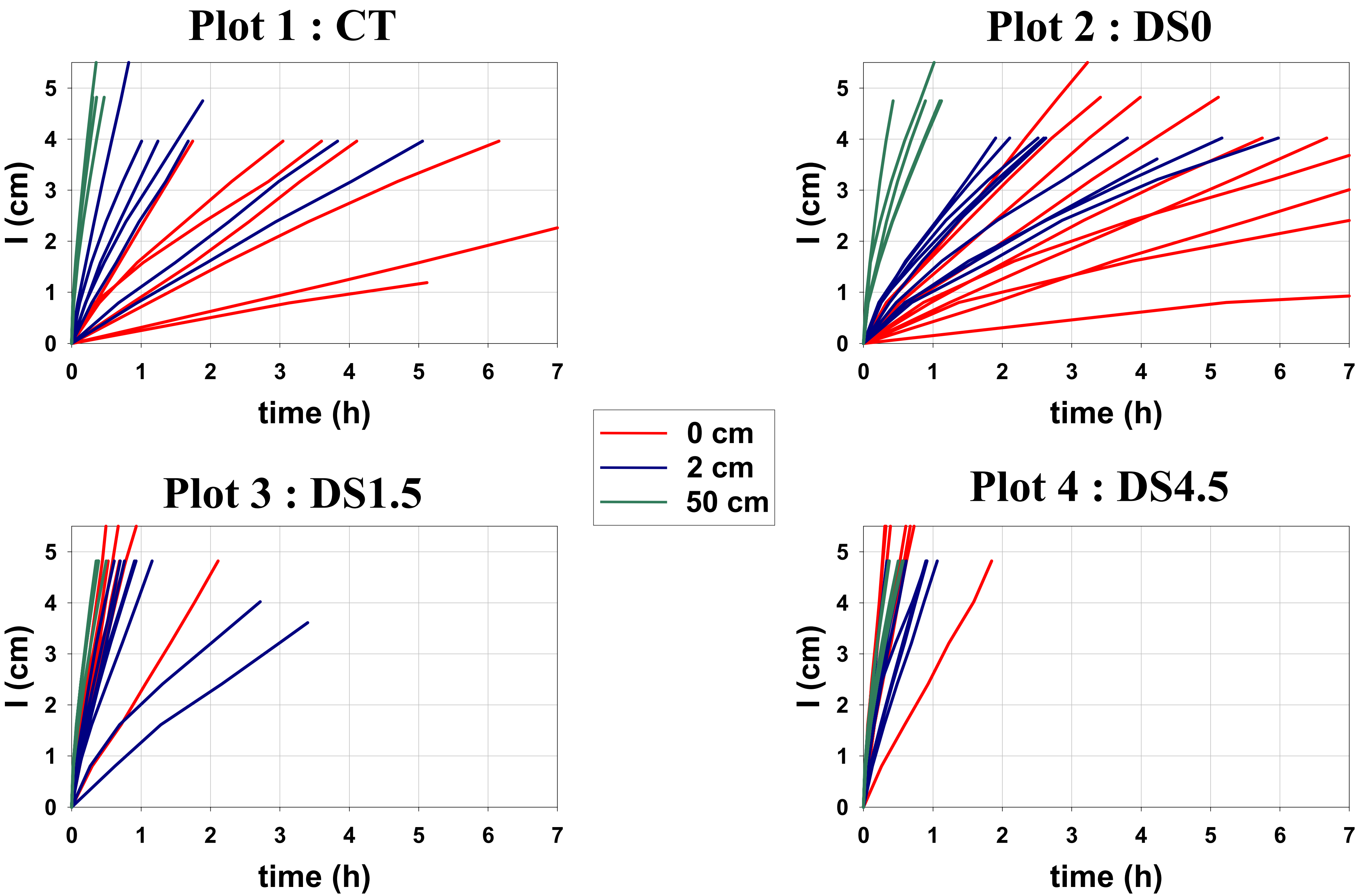
with :

- $h(\theta)$: soil retention curve,
- $K(\theta)$: soil conductivity curve,
- IC : initial conditions (such as θ_0),
- BC : boundary conditions (such as h_{surf}).

BEER-KAN METHOD



Cumulative infiltration (I) vs time



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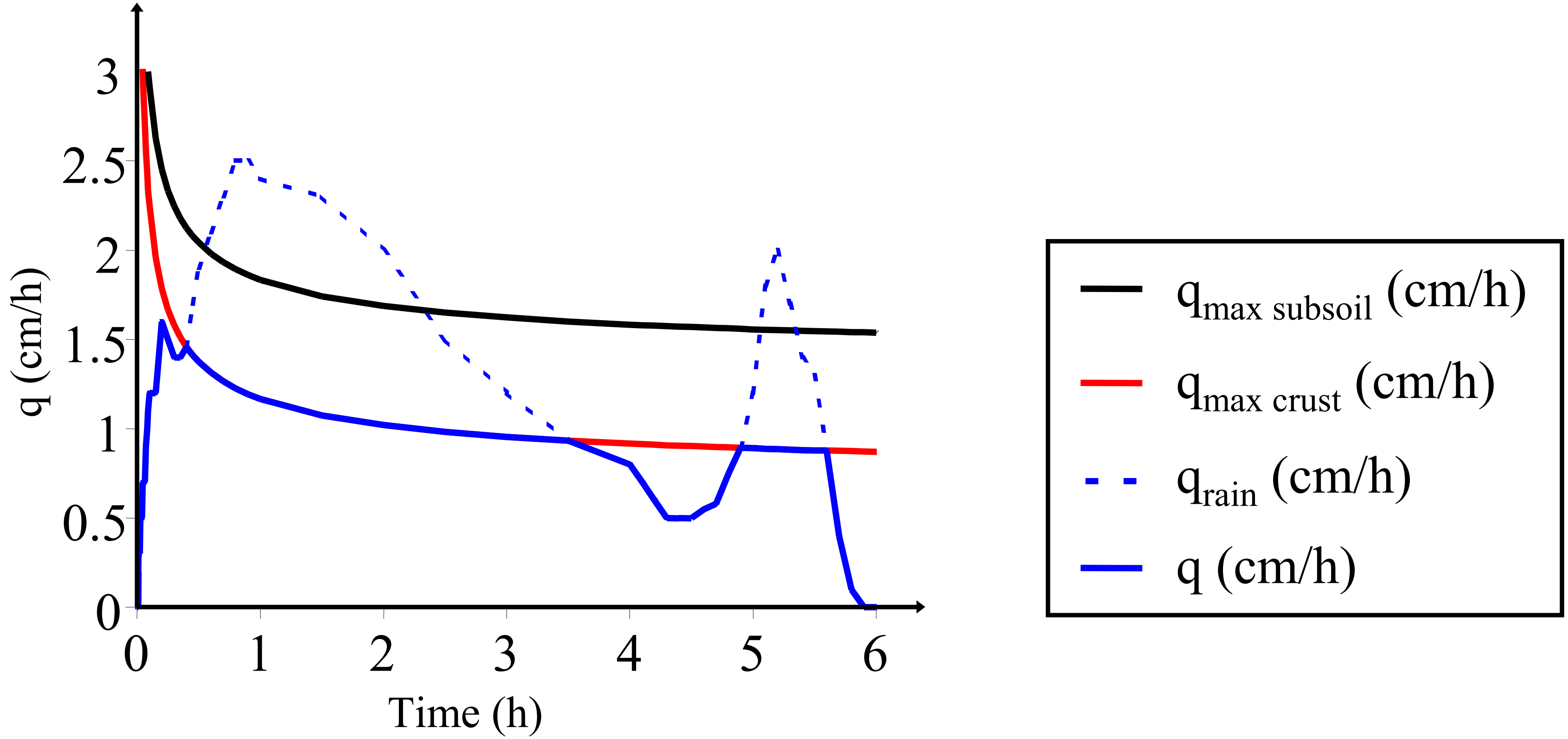
SPECIAL CASE OF CRUSTED SOIL

If $\begin{cases} K_{s\ crust} < K_{s\ subsoil} \\ S_{+\ crust} < S_{+\ subsoil}\ (*) \end{cases}$ then the crust controls entirely infiltration :

(*) S_+ is soil sorptivity ($m.s^{-0.5}$)



SCALING INFILTRATION : THEORY

SCALING

- **Dimensional log-shaped infiltration curve I(t) :**

$$\frac{2(K_s - K_0)}{S_+^2} I = \frac{2(K_s - K_0)^2}{S_+^2} t + \ln\left(1 + \frac{2(K_s - K_0)}{S_+^2} I\right)$$

with : S_+ soil sorptivity ($m.s^{-0.5}$) and $K_0 = K(\theta_0)$ initial conductivity ($m.s^{-1}$)

- **Invariant nondimensional log-shaped infiltration curve I*(t*) :**

$$I^* = t^* + \ln\left(1 + I^*\right)$$

with : $I^* = \alpha_I . I$ *and* $\alpha_I = \frac{2(K_s - K_0)}{S_+^2}$

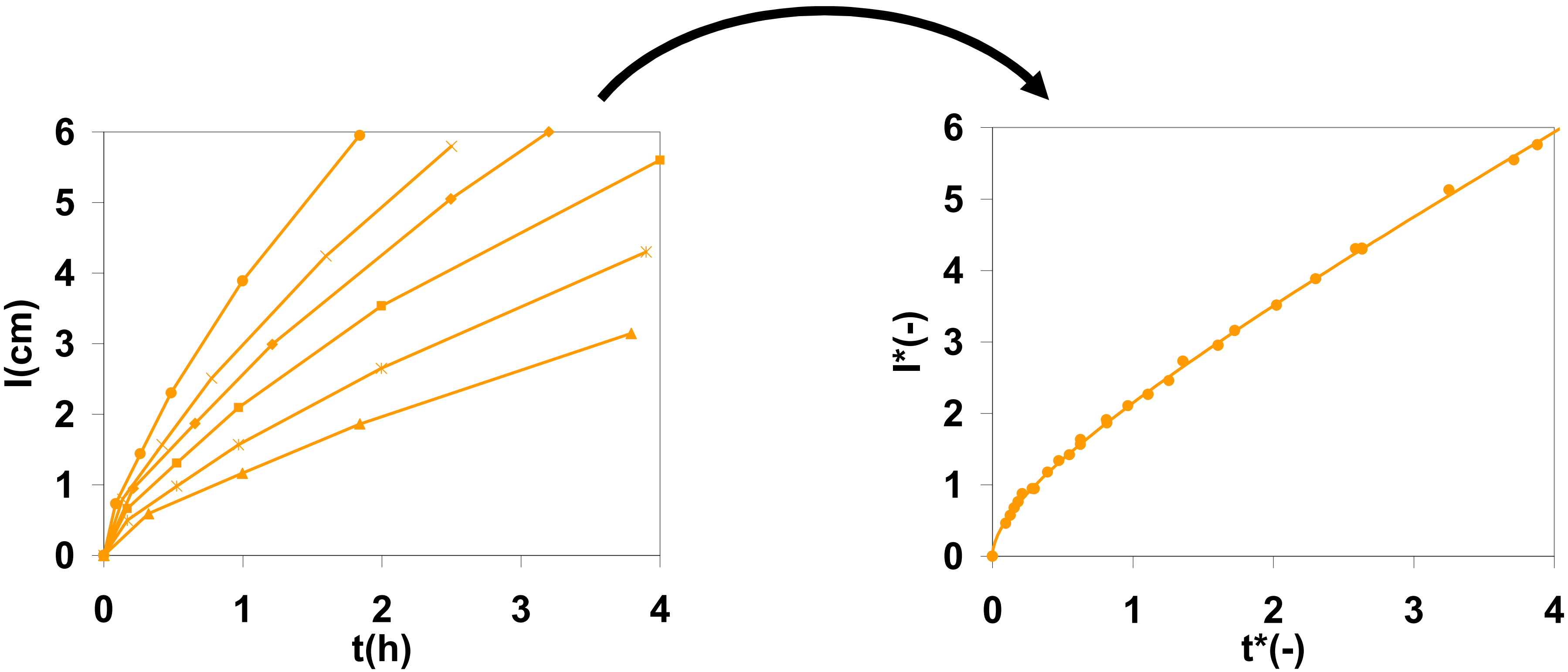
$t^* = \alpha_t . t$ *and* $\alpha_t = \frac{2(K_s - K_0)^2}{S_+^2}$

SCALING INFILTRATION : EXAMPLE

SCALING

$$I^{*} = \alpha_{I} . I$$

$$t^{*} = \alpha_{t} . t$$



- **A set of dimensional infiltration curves**
- **1 nondimensional infiltration curve**
- **A set of fitted scaling parameters α_I, α_t**

FROM SCALING FACTORS TO SOIL PARAMETERS

- **Soil texture parameters :**

(1) $m.n$ = function of cumulative particle size distribution

(2) $$\eta = 3 + \frac{2}{m.n}$$

- **Soil structure parameters :**

(3) $$\frac{\alpha_t}{\alpha_I} = K_s - K_0$$

(4) $$\begin{cases} S_+ = f(h_g) \\ S_+ = g(\alpha_I) \end{cases} \Rightarrow h_g = f^{-1}(g(\alpha_I))$$

(5) $$\theta_s = \varepsilon \cdot 2^{m-M}$$

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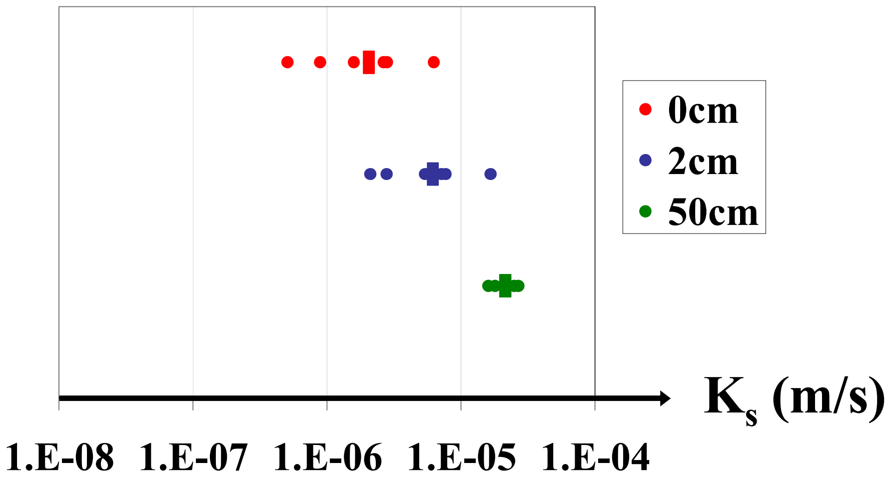
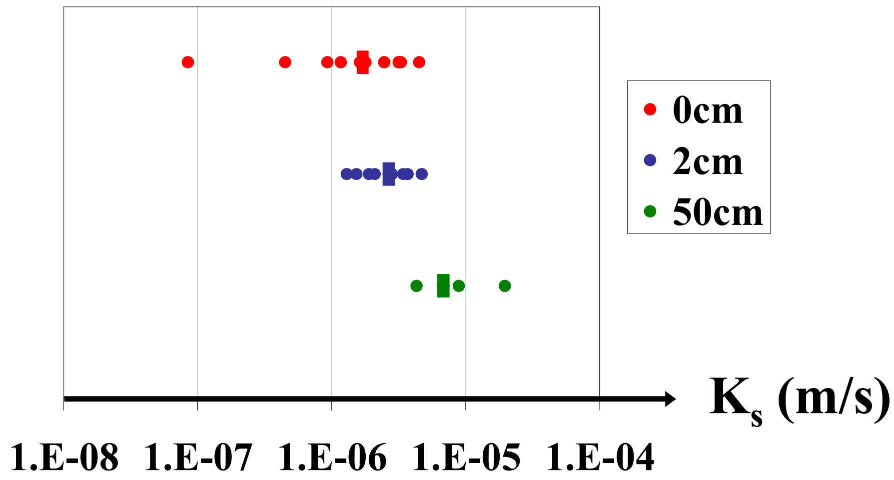
COMPARISON OF K_s VALUES

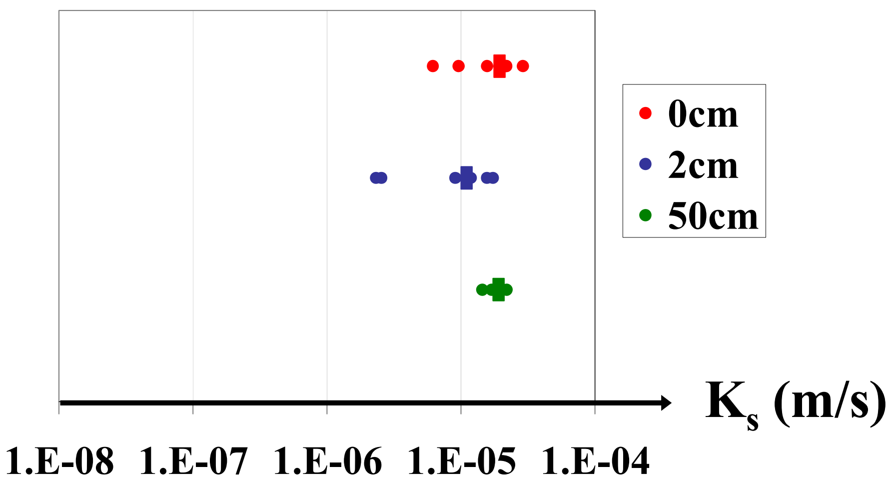
Plot 1 (CT)



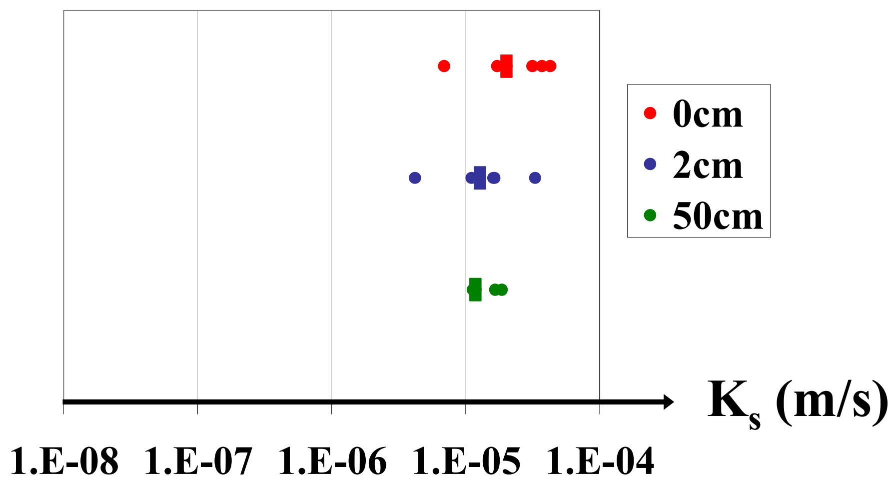
Plot 2 (DS0)



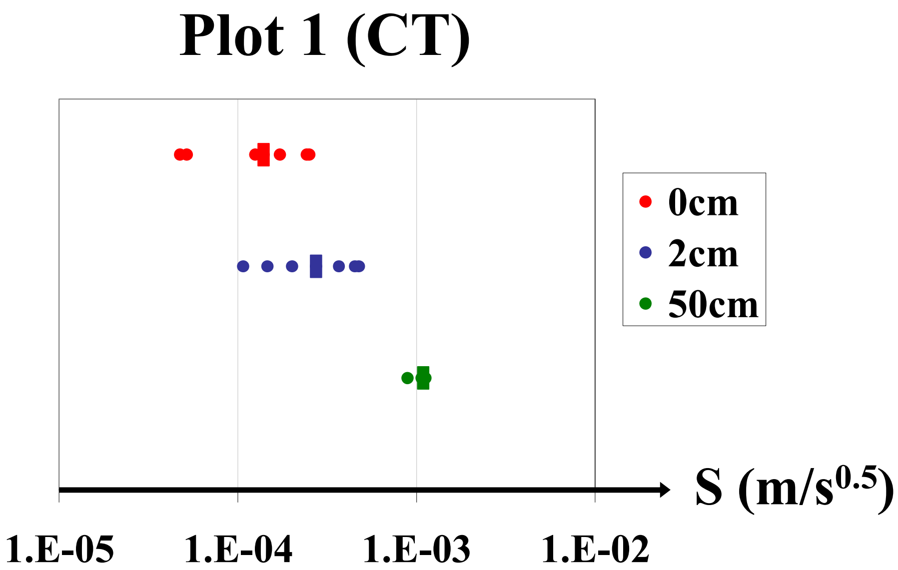
Plot 3 (DS1.5)

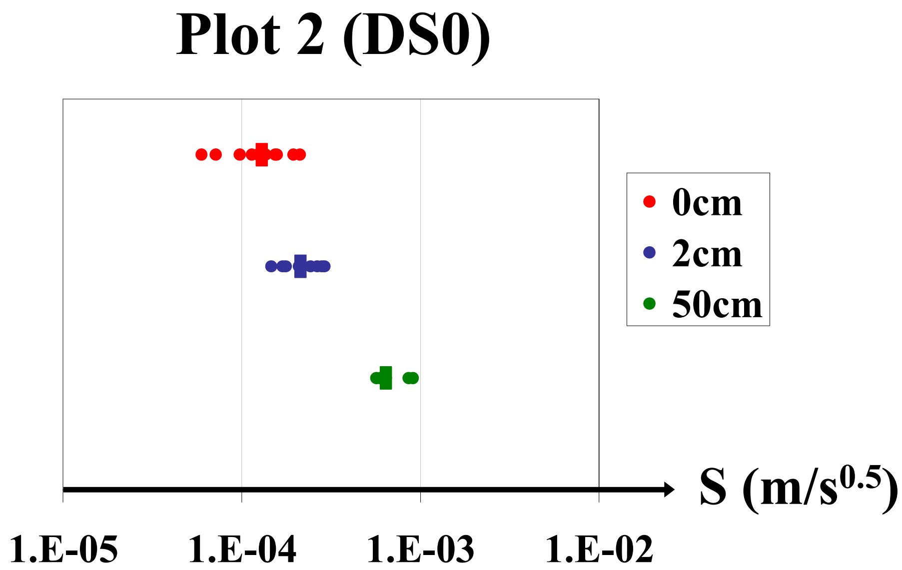


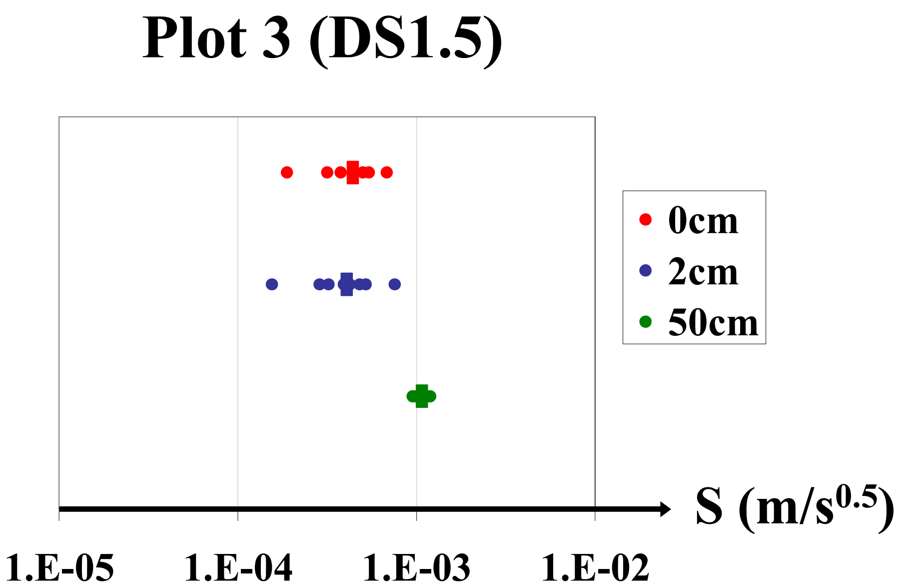
Plot 4 (DS4.5)

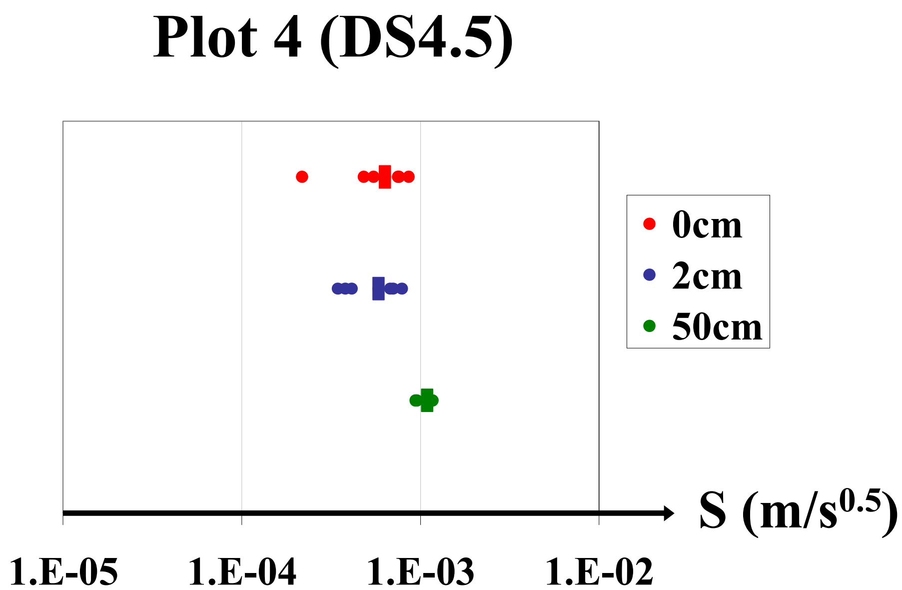


COMPARISON OF SORPTIVITY VALUES (S)



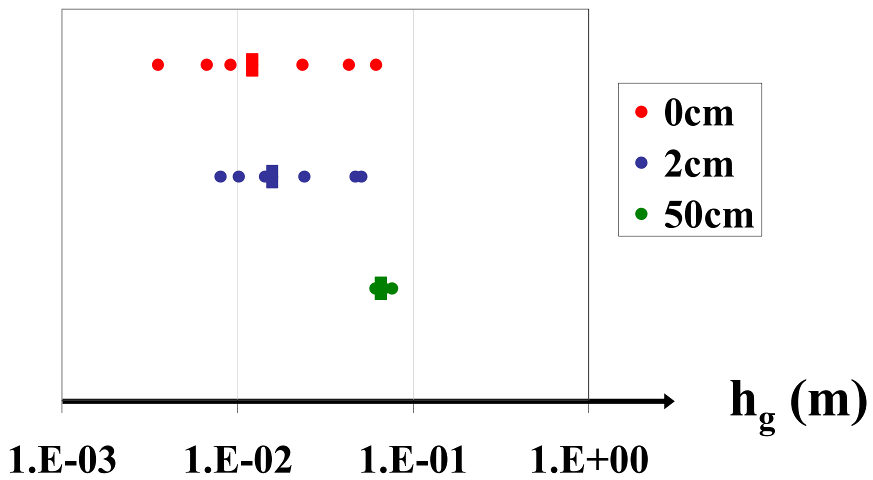




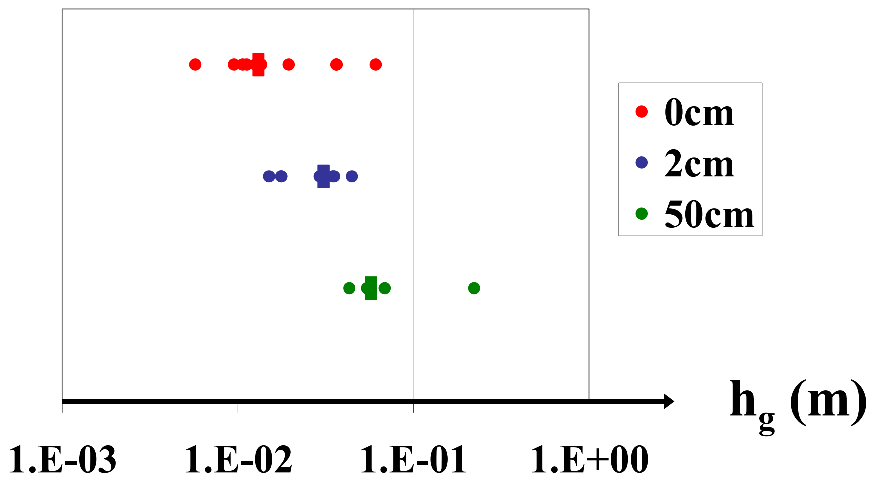


COMPARISON OF h_g VALUES

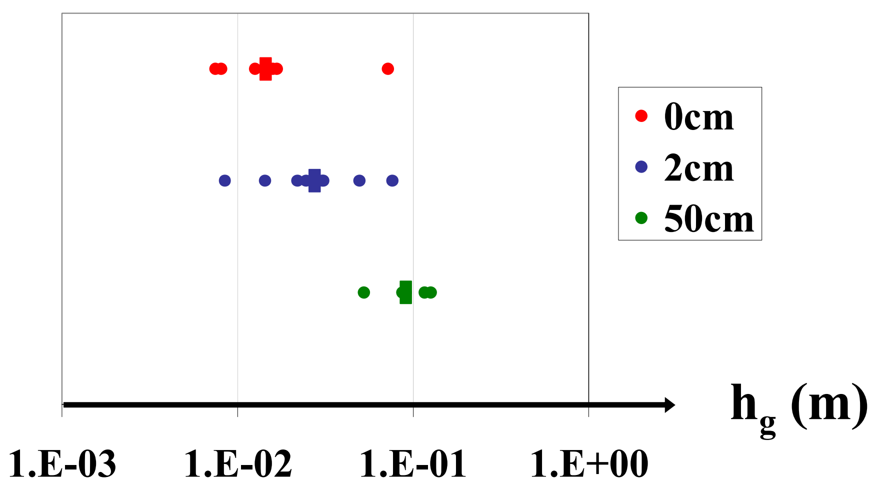
Plot 1 (CT)



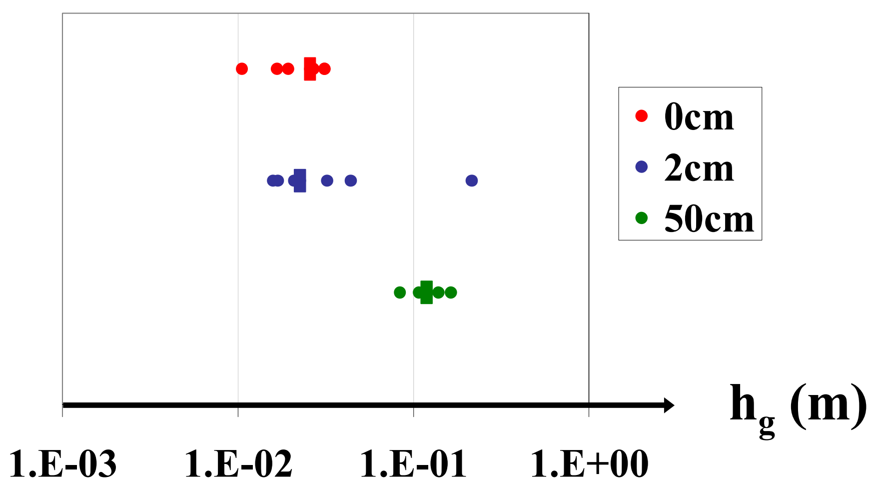
Plot 2 (DS0)



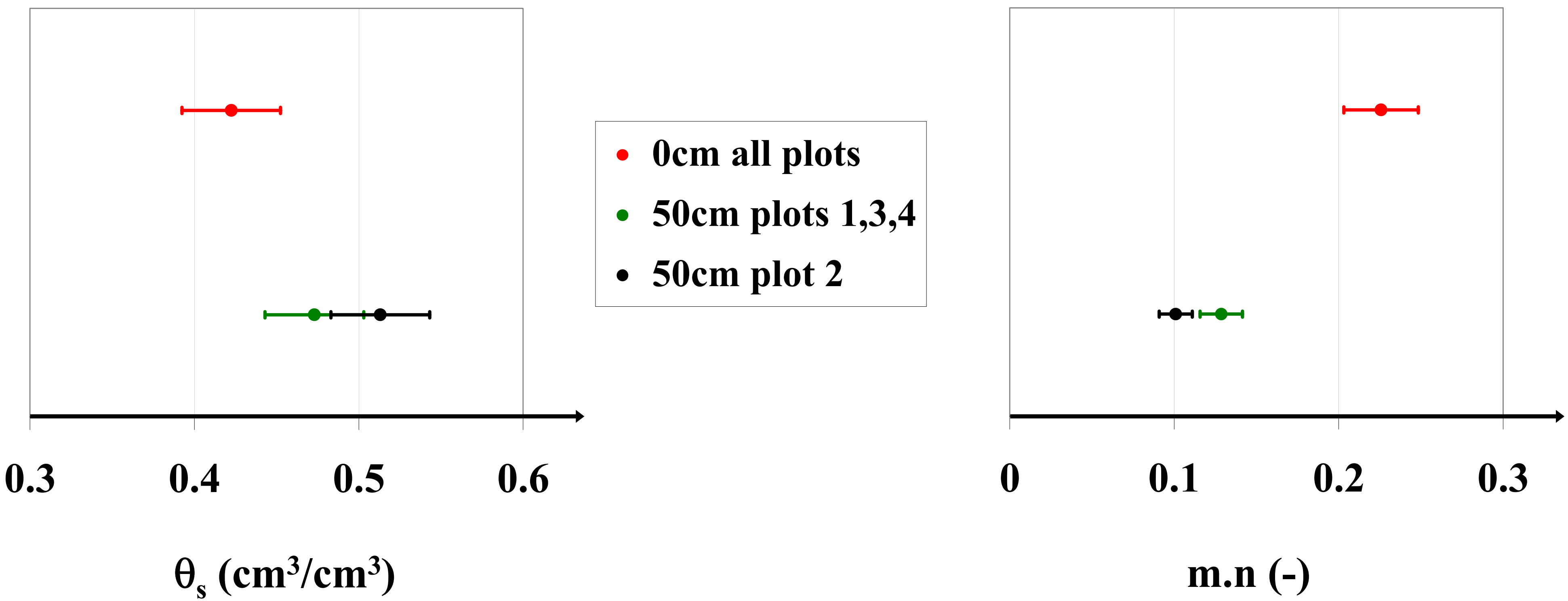
Plot 3 (DS1.5)



Plot 4 (DS4.5)



COMPARISON OF θ_s AND m.n VALUES



CONCLUSIONS

- **The physically based Beer-Kan method is suitable to estimate properly soil hydraulic properties h(θ) and K(θ).**

- **Different treatments can induce a significant temporal variability of surface soil layer conductivity in the long run (5 years).**

- **A small quantity of residue (DS1.5) provides with good soil protection and ensures high infiltration rate, whereas CT and DS0 leads to quick crusting.**