

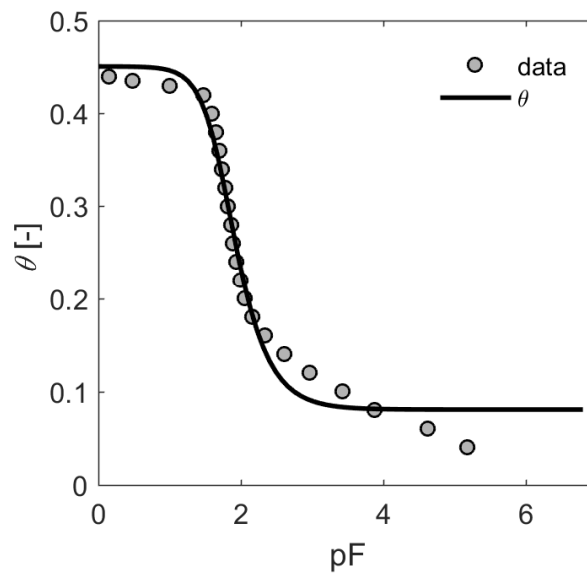
Improving the PDI model scheme to predict absolute non-capillary hydraulic conductivity from the water retention characteristics

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Retention Model:

$$\theta(h) = (\theta_s - \theta_r)S + \theta_r$$

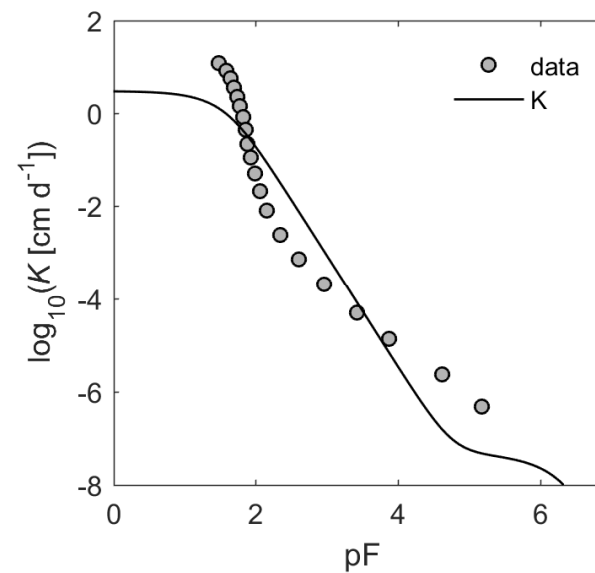


4 fitting parameters:

$$\alpha, n, \theta_s, \theta_r$$

Conductivity Model:

$$K = K_s K_{r,c} + K_{\text{vap}}$$



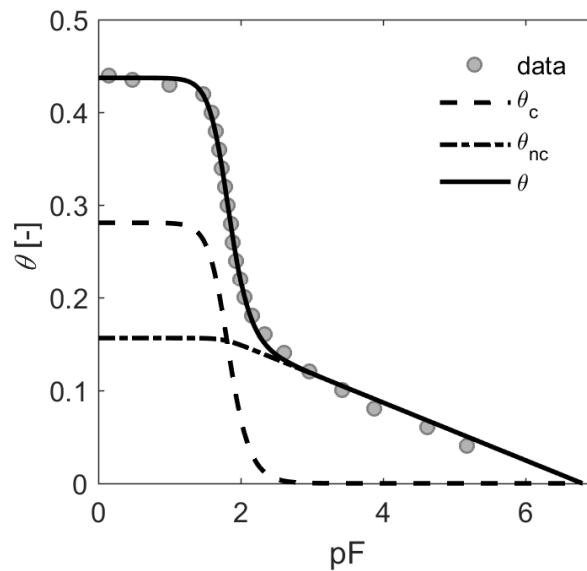
2 fitting parameters:

$$K_{s,c}, \tau$$

Established
models neglect
non-capillary
retention and
conductivity

Retention Model:

$$\theta(h) = (\theta_s - \theta_r)S_c + \theta_r S_{nc}$$

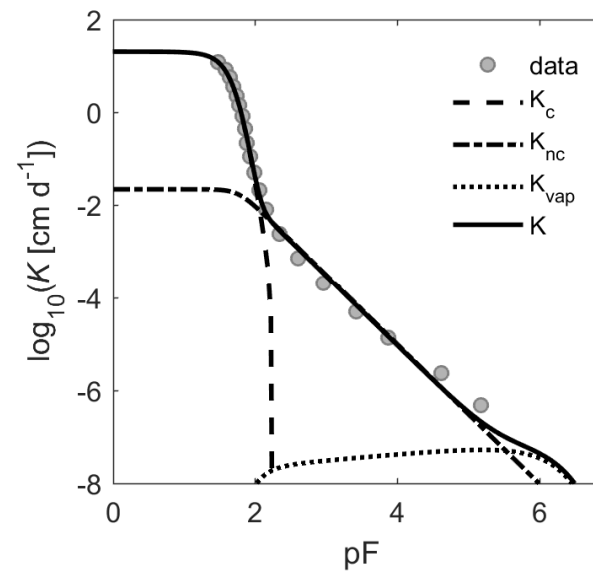


4 fitting parameters:

$$\alpha, n, \theta_s, \theta_r$$

Conductivity Model:

$$K = K_{s,c}K_{r,c} + K_{s,nc}K_{r,nc} + K_{vap}$$



3 fitting parameters:

$$K_{s,c}, K_{s,nc}, \tau$$

One additional
fitting
parameter: $K_{s,nc}$

Problem I with PDI

Neglecting physical processes, which are dominant under dry conditions:

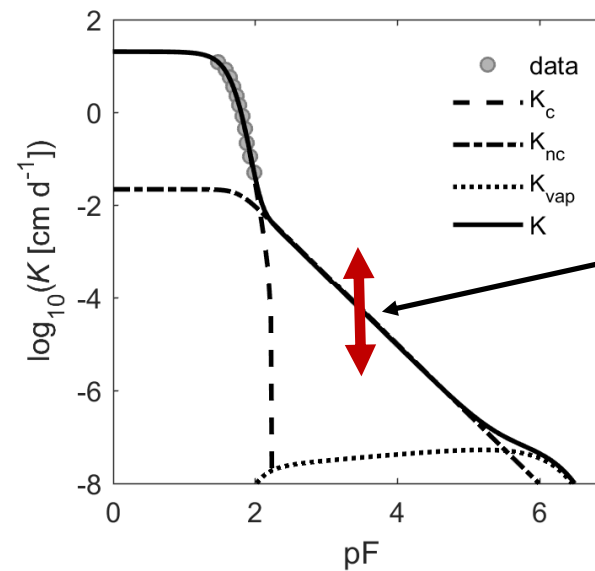
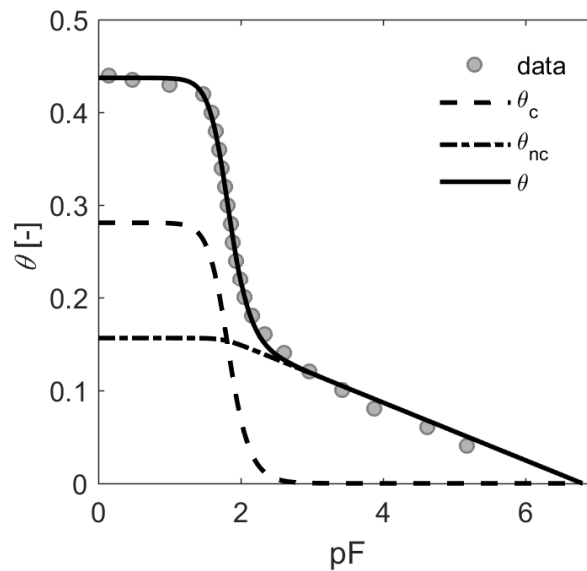
1. Not accounting for molecular component of disjoining pressure isotherm, which describes film thickness as function of matric potential.
2. Not accounting for increased viscosity near mineral surfaces.

Problem II with PDI

Needs one extra parameter ($K_{s,nc}$) to calculate absolute film conductivity.



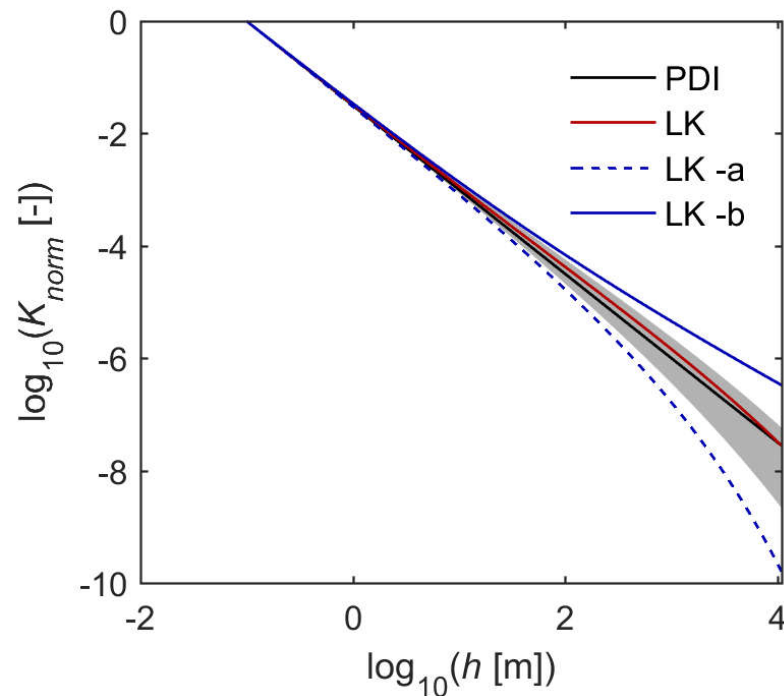
Problem if no information for film conductivity in data.



no information
for K_{nc}

Analyzing Problem I

Neglecting physical processes

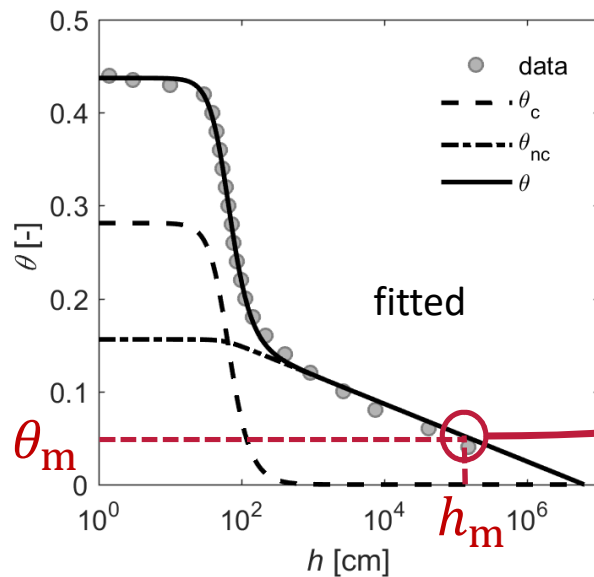


- LK: Lebeau and Konrad (2010): Physical based model, accounting for both **molecular component** of disjoining pressure (DP) and **increased viscosity** near mineral surfaces.
-  : Range for LK model for values of Hamaker constant between 10^{-20} to 10^{-19} J.
- LK -a: LK **without molecular component** of DP
- LK -b: LK **without viscosity effect**
- PDI: neither accounting for molecular component nor for viscosity effect.

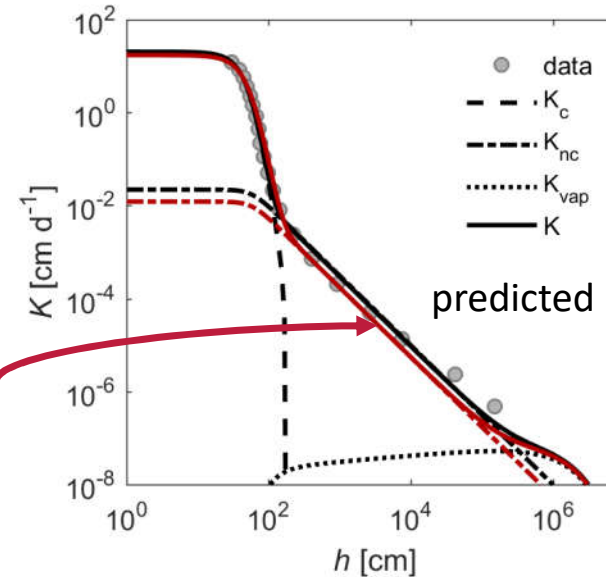


Effects of neglecting both processes cancel each other out. Simple PDI $K_{r,nc}$ is well in accordance with LK.

Solving Problem II: K_{nc} - prediction



4 fitting parameters
($\alpha, n, \theta_s, \theta_r$)



2 fitting parameters
($K_{S,c}, \tau$)

New: PDlc
(PDI constrained)

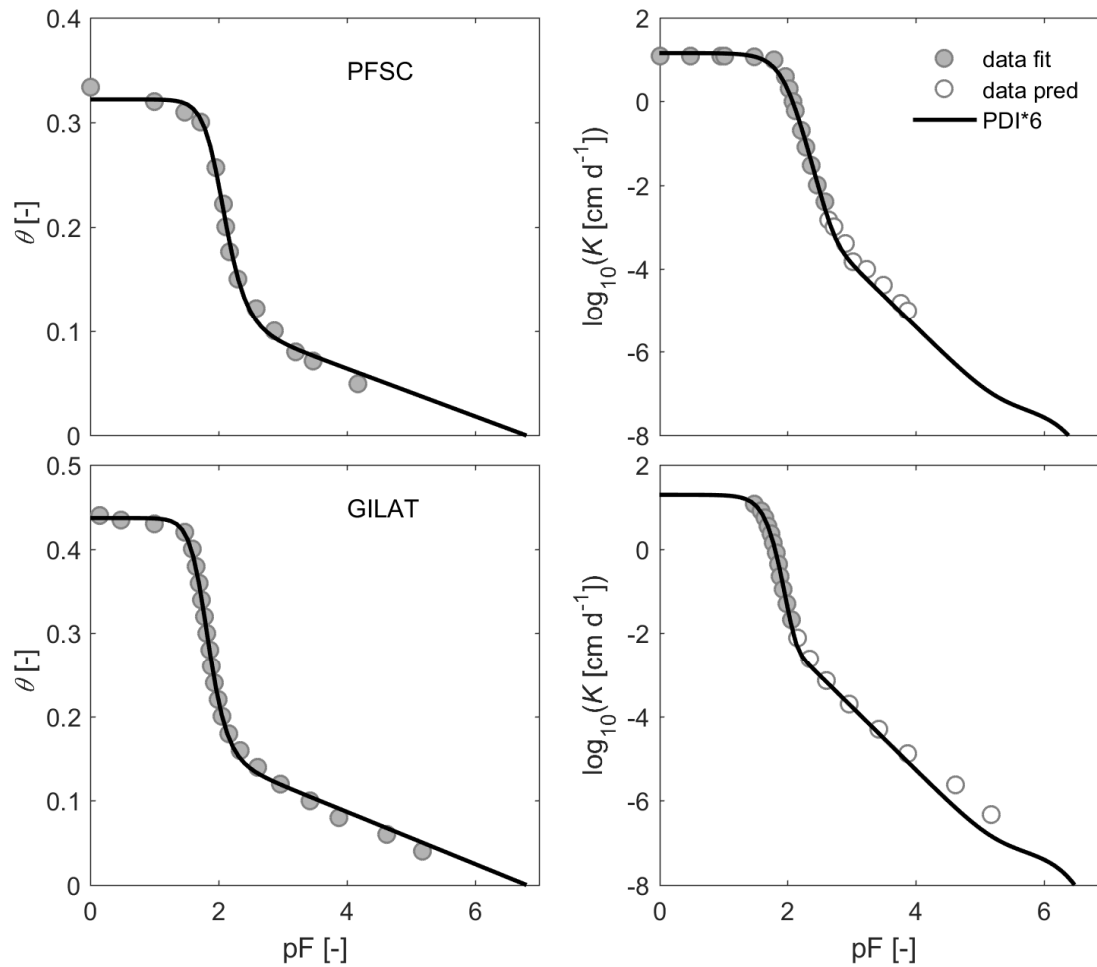
Theory of
Tuller and Or (2005),
Tokunaga (2009) and
Lebeau and Konrad (2010)



$$K_{S,nc} = c h_a^{-3/2} \theta_m$$

$$c = \frac{2}{3} \frac{\pi^{7/3}}{\eta(\rho g)^{1/6}} \left(\frac{6}{A_{svl}} \right)^{1/3} \left(\frac{\epsilon_r \epsilon_0}{2} \right)^{3/2} \left(\frac{k_b T}{e Z} \right)^3 h_m^{1/3} \approx 98 \text{ cm}^{5/2} \text{ d}^{-1}$$

model test – missing data



● : data used to fit the model

○ : data not used in objective function

data source: Mualem, Y. (1976), *A catalogue of the hydraulic properties of unsaturated soils*, Tech. Rep., Technion, Israel Inst. of Technol.

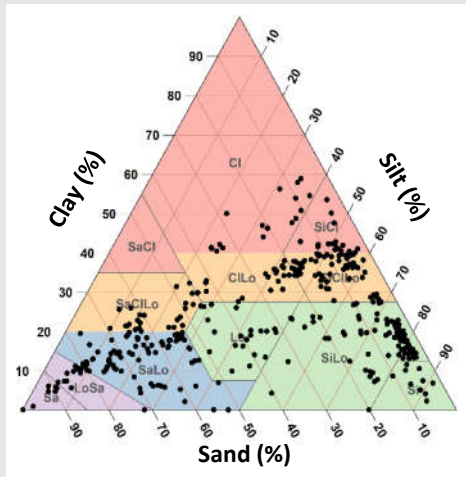
- Simple PDI $K_{r,nc}$ is well in accordance with physically based Lebeau and Konrad (2010) model.
- New simple but physical based scheme (PDIc) allows prediction of non-capillary conductivity.
- Number of free adjustable parameters is now the same as for the established models, which do not account for non-capillary processes.
- Next step: Test with comprehensive data set:
 - Hohenbrink, T. L., Peters, A., Iden, S. C., and Durner, W.: Extending established soil hydraulic property models by non-capillary water: A comprehensive model performance test, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-8929, (next slide).

Extending established soil hydraulic property models by non-capillary water: A comprehensive model performance test

Tobias L. Hohenbrink, Andre Peters, Sascha C. Iden and Wolfgang Durner

1 Objective: Comparing the performances of the **PDI model** with its **new PDlc version**

2 Data set:
484 **retention and conductivity** curves



Measured with:

- Evaporation method
- Dew point method

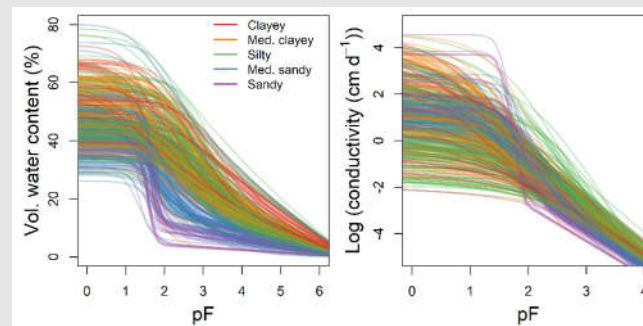
3 Different model combinations fitted:

Basic function:

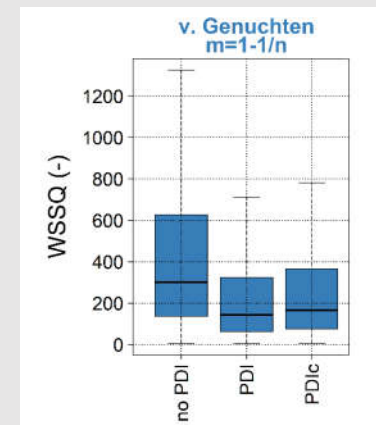
- Van Genuchten/Mualem

Consideration of non-capillary water:

- No PDI
- Original PDI
- New PDlc version



4 Overall model performance



Model performance for **texture classes**

