# OPEN HOUSE

# Pedostructure Characterization Laboratory

# Benchmarks and Activities

# Soil-Water Modeling

# Characterizing Nonrigid Aggregated Soil–Water Medium Using its Shrinkage Curve

Erik Braudeau,* Jean-Pierre Frangi, and Rabi H. Mohtar

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- Introduce the Pedostructure concept.

- Bridge the gap: pedological and its hydro-functioning.
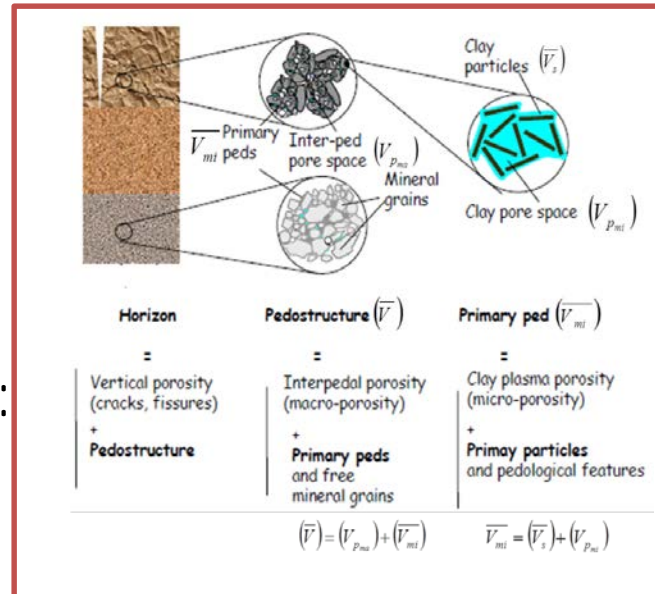


Pedostructure Concept
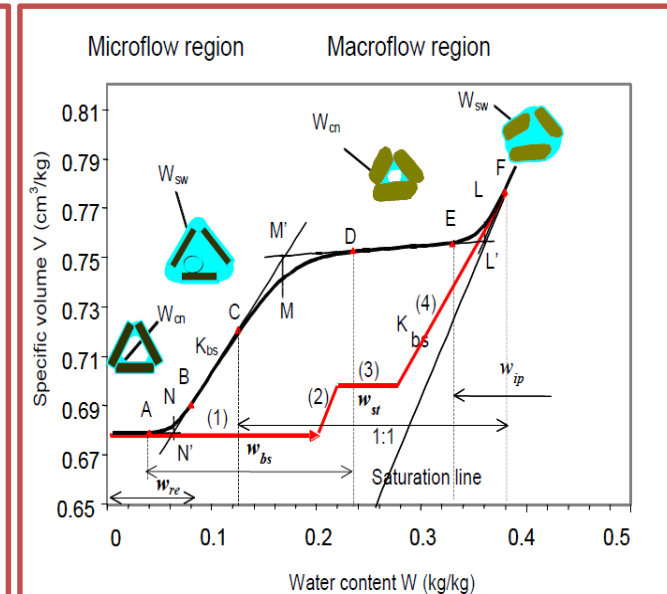


Soil Shrinkage Curve

# Water potential in nonrigid unsaturated soil-water medium

Erik Braudeau

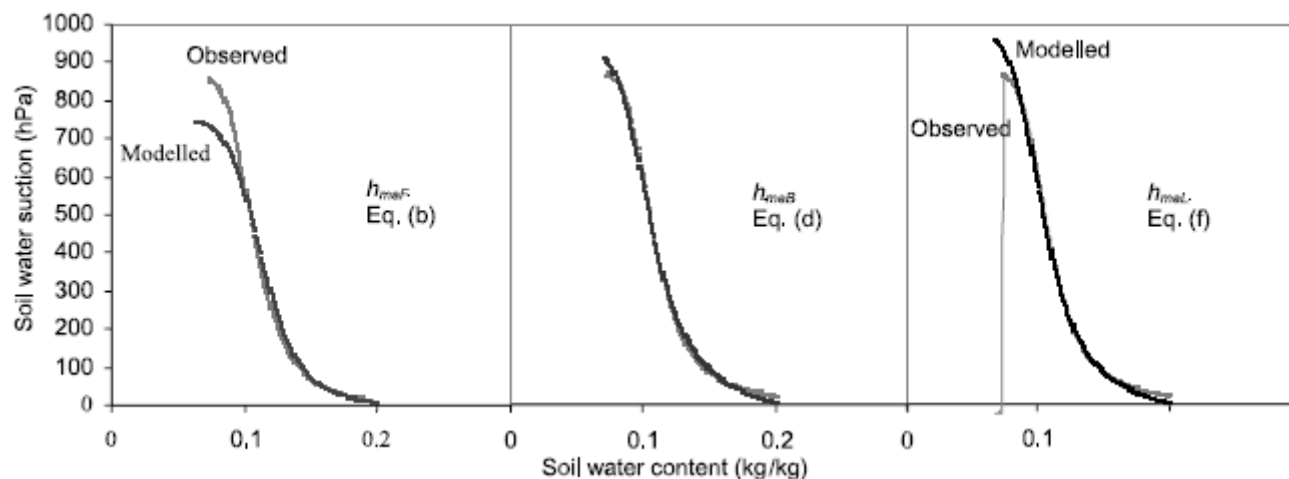Institut de Recherche pour le Développement (IRD), Montpellier, France

Rabi H. Mohtar

Centre de Coopération International en Recherche Agronomique pour le Développement (CIRAD), Montpellier, France

Department of Agricultural and Biological Engineering, Purdue University, West Lafayette, Indiana, USA

- Apply the pedostructure concept to develop a water retention function (WRF).
- **Water flow** in soil medium.

# Modeling the Swelling Curve for Packed Soil Aggregates Using the Pedostructure Concept

Erik Braudeau* and Rabi H. Mohtar

E. Braudeau, Institut de Recherche pour le Développement (IRD), Pôle de Recherche Agronomique de la Martinique, BP 214, F-97283 Le Lamentin, Martinique, France; R.H. Mohtar, Agric. and Biological Engineering, Purdue Univ., West Lafayette, IN 47906, USA. Received 28 June 2004. *Corresponding author (erik.braudeau@ird.fr).

- Derive a pedostructure swelling curve equation (SwC).
- Micro-macro pore water exchange rate.
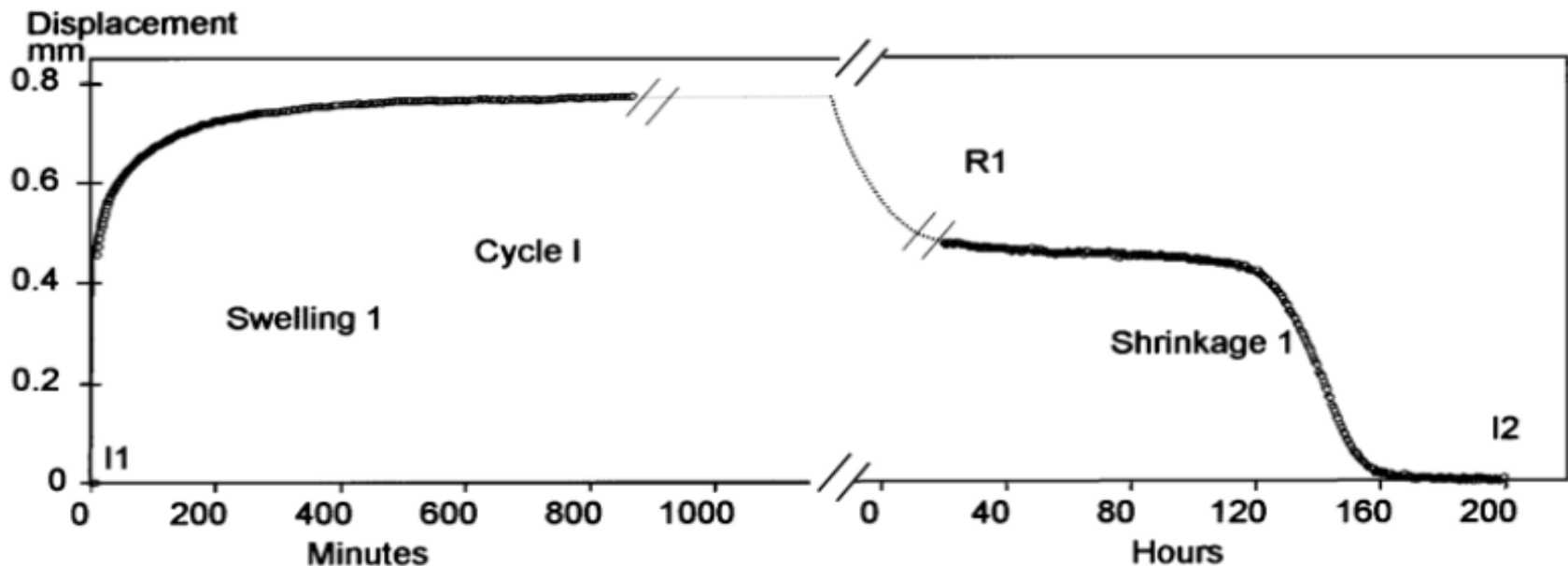
# Hydrostructural characteristics of two African tropical soils

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[a]*Institut de Recherche pour le Développement (IRD), BP 8006, 97259 Fort de France, Martinique*, [b]*Institut Sénégalais de Recherche Agronomique (ISRA), BP 27, Kaolak, Sénégal, and* [c]*Agricultural and Biological Engineering, Purdue University, West Lafayette, IN 47906, USA*

- Apply the pedostructure concept to calculate **soil water holding** characteristics (**agronomic properties**):

  - Permanent Wilting Point
  - Field Capacity
  - Readily available water
  - Coefficient of linear extensibility
  - Soil air capacity

- Characterizing and comparing the hydro-structural behavior of two African soils.
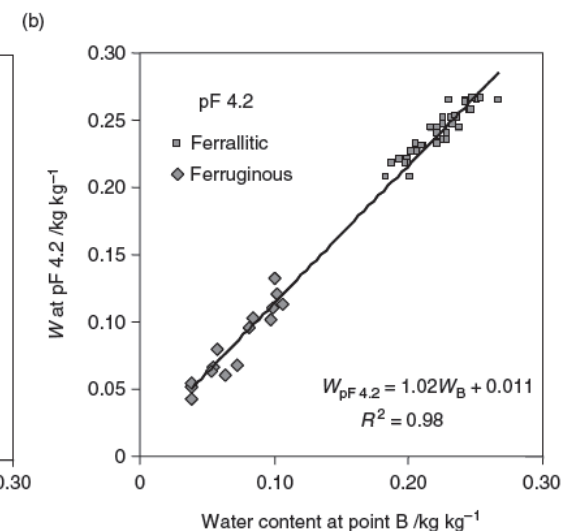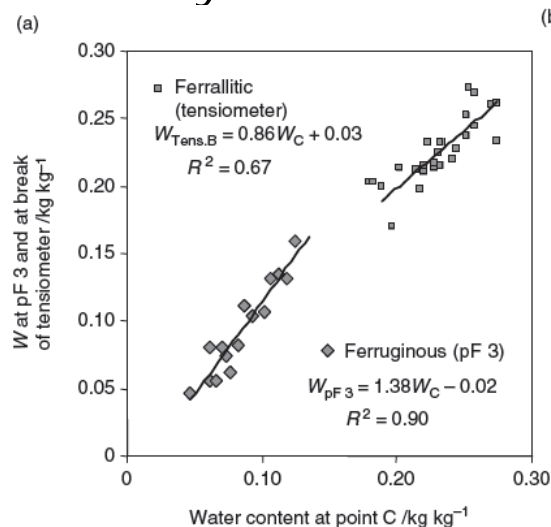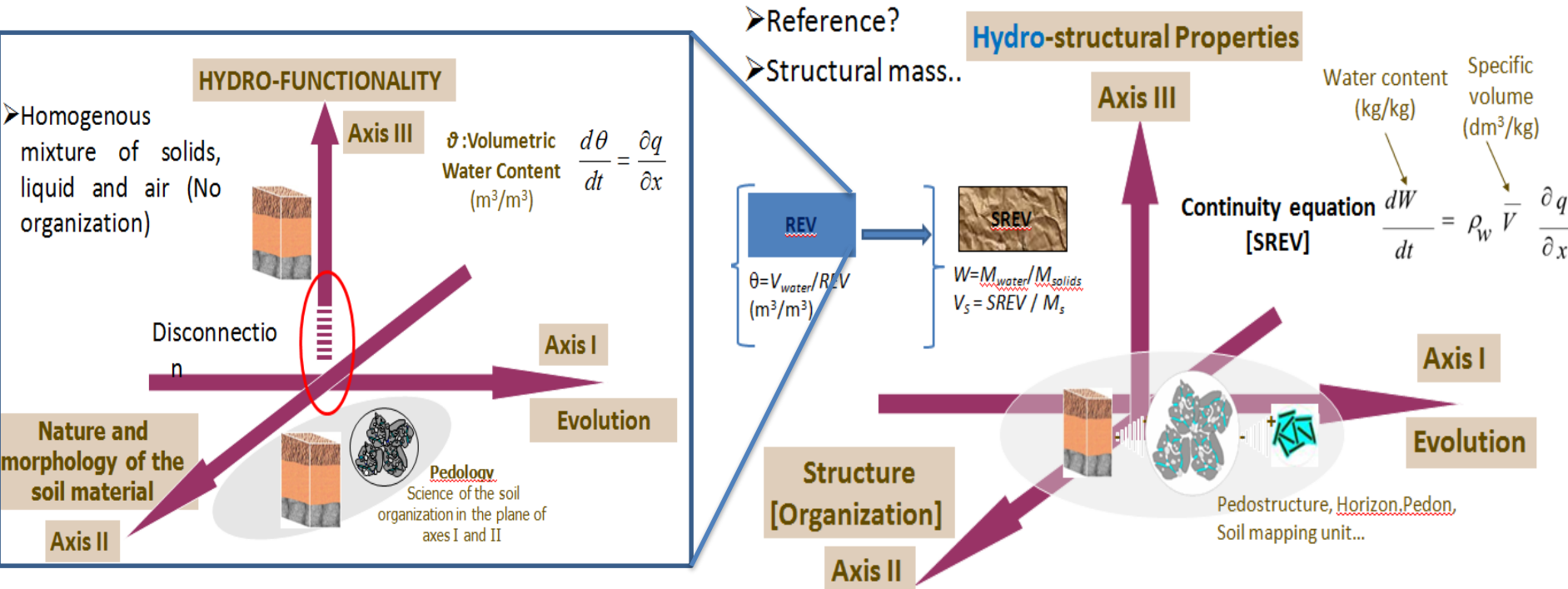
# Modeling the soil system: Bridging the gap between pedology and soil–water physics

Erik Braudeau [a], Rabi H. Mohtar [b,*]

[a] Institut de Recherche pour le Développement (IRD), UMR BIOEMCO, 32, av. H. Varagnat, 93143 Bondy, France
[b] Department of Agricultural and Biological Engineering, Purdue University, 225 S University Street West Lafayette, IN 47907-2093, USA



HYDRO-FUNCTIONALITY

Axis III

$\vartheta$ : Volumetric Water Content $(m^3/m^3)$

$$\frac{d\theta}{dt} = \frac{\partial q}{\partial x}$$

➤ Homogenous mixture of solids, liquid and air (No organization)

Disconnection

Axis I

Evolution

Nature and morphology of the soil material

Axis II

Pedology
Science of the soil organization in the plane of axes I and II

➤ Reference?
➤ Structural mass..

REV

$\theta = V_{water}/REV$ $(m^3/m^3)$

SREV

$W = M_{water}/M_{solids}$
$V_S = SREV / M_s$

Hydro-structural Properties

Axis III

Water content (kg/kg)   Specific volume $(dm^3/kg)$

Continuity equation [SREV]

$$\frac{dW}{dt} = \rho_w \, \overline{V} \, \frac{\partial q}{\partial x}$$

Axis I

Evolution

Structure [Organization]

Axis II

Pedostructure, Horizon,Pedon, Soil mapping unit…

# How to Scale?

Toward delineating hydro-functional soil mapping units using the pedostructure concept: A case study

Mohammed Salahat [a], Rabi H. Mohtar [b,c,*], Erik Braudeau [b,d], Darrell G. Schulze [e], Amjad Assi [b]

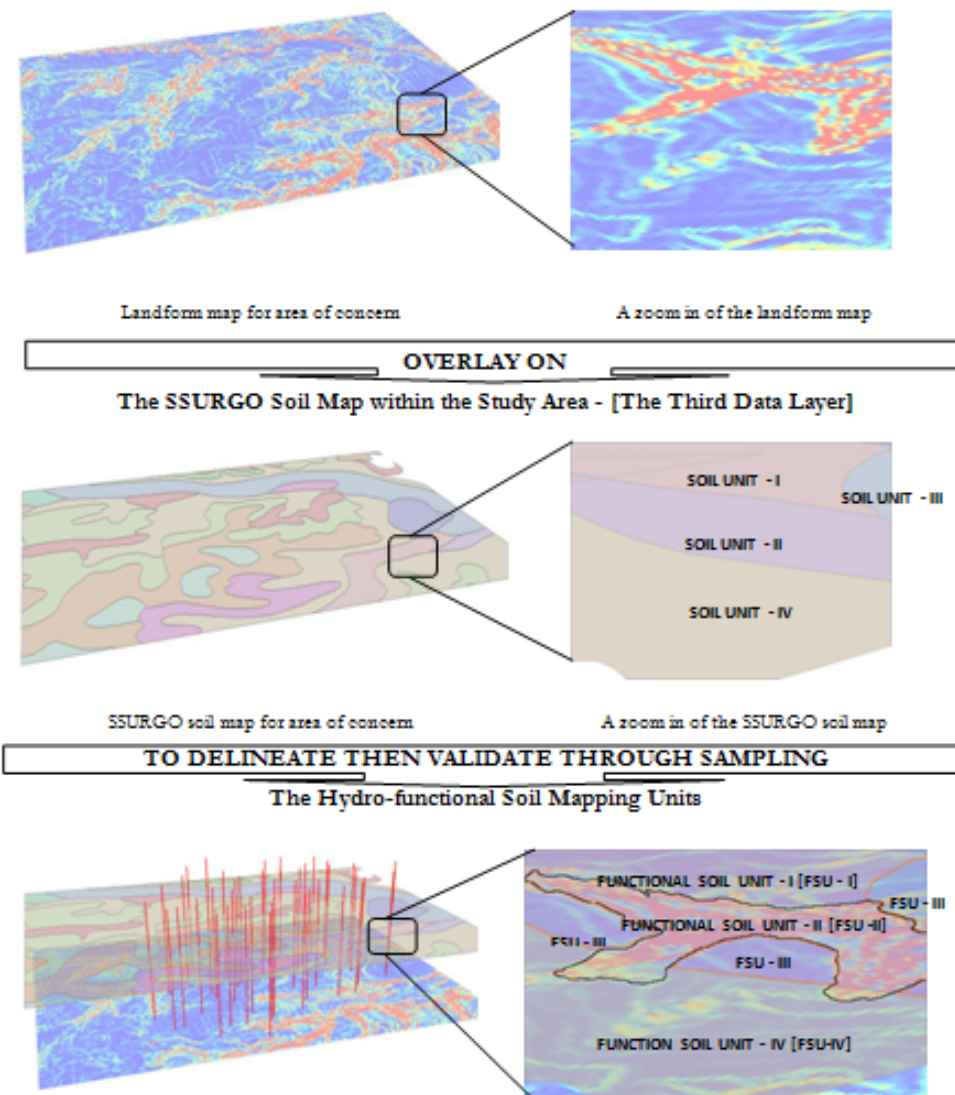[a] Natural Resources and Environment Department, The Hashemite University, Zarqa, Jordan
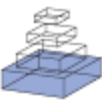[b] Qatar Environment and Energy Research Institute, Qatar Foundation, Doha, Qatar
[c] Agricultural Biological Engineering Department, Purdue University, West Lafayette, IN 47906, USA
[d] Institute for Research Development, IRD, Bondy, France
[e] Agronomy Department, Purdue University, West Lafayette, IN 47907, USA

- Delineate a hydro-functional Soil Mapping Units.

- These units contains not only qualitative data but also quantitative data (hydro-structural parameters).

- These units can be used in Larger scale models.



Landform map for area of concern — A zoom in of the landform map

**OVERLAY ON**

The SSURGO Soil Map within the Study Area - [The Third Data Layer]

SOIL UNIT - I
SOIL UNIT - III
SOIL UNIT - II
SOIL UNIT - IV

SSURGO soil map for area of concern — A zoom in of the SSURGO soil map

**TO DELINEATE THEN VALIDATE THROUGH SAMPLING**

The Hydro-functional Soil Mapping Units

FUNCTIONAL SOIL UNIT - I [FSU - I]
FSU - III
FUNCTIONAL SOIL UNIT - II [FSU -II]
FSU - III
FSU - III
FUNCTION SOIL UNIT - IV [FSU-IV]

# Physics of the soil medium organization part 1: thermodynamic formulation of the pedostructure water retention and shrinkage curves

Erik Braudeau[1,2]*, Amjad T. Assi[1,3], Hassan Boukcim[4] and Rabi H. Mohtar[5]

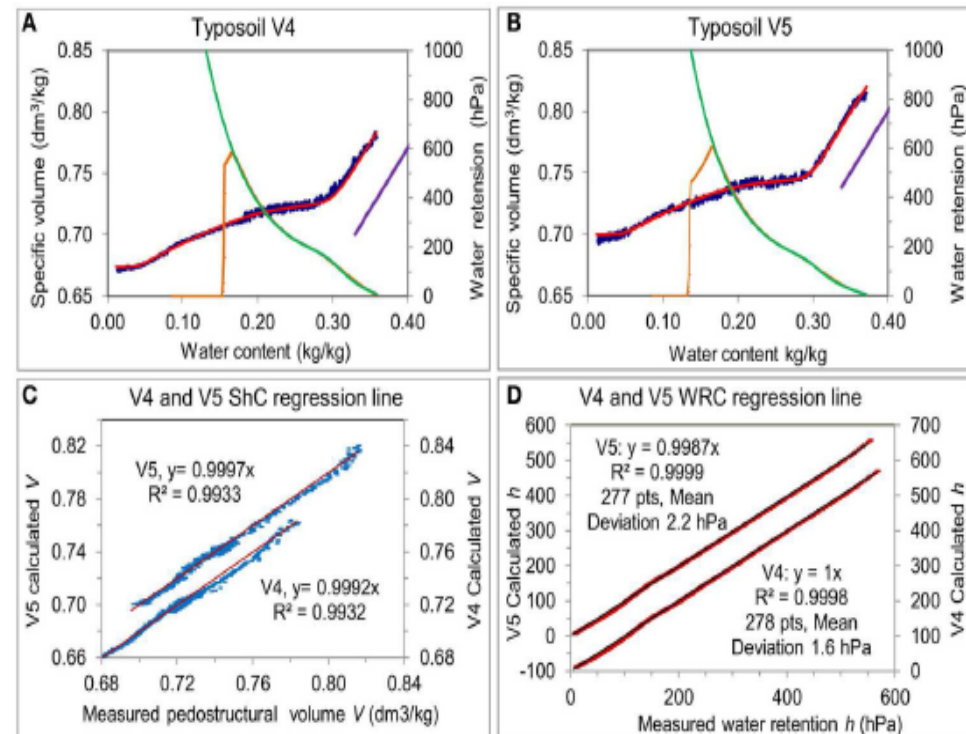[1] Qatar Foundation, Qatar Environment and Energy Research Institute, Doha, Qatar
[2] Institut de Recherche pour le Développement, Bondy, France
[3] Department of Agricultural and Biological Engineering, Purdue University, West Lafayette, IN, USA
[4] Valorhiz SAS, Parc Scientifique Agropolis II Bat 6, Montferrier-sur-Lez, France
[5] Biological and Agricultural Engineering Department, and Zachry Department of Civil Engineering, Texas A&M University, College Station, TX, USA

- Introduce the SREV concept to enable the thermodynamic formulation of the pedostructure water retention and shrinkage curve.

- These two characteristic curves describe the hydrostructural equilibrium state of the soil medium at each value of the water content.

# Physics of the soil medium organization part 2: pedostructure characterization through measurement and modeling of the soil moisture characteristic curves

*Amjad T. Assi[1,2], Joshua Accola[1,3], Gaghik Hovhannissian[4], Rabi H. Mohtar[2,5]\* and Erik Braudeau[1,4]\**

[1] Qatar Foundation, Qatar Environment and Energy Research Institute, Doha, Qatar
[2] Department of Agricultural and Biological Engineering, Purdue University, West Lafayette, IN, USA
[3] Department of Biological Systems Engineering, University of Wisconsin-Madison, Madison, WI, USA
[4] Institut de Recherche pour le Développement (IRD), Pédologie Hydrostructurale, Bondy, France
[5] Biological and Agricultural Engineering Department and Zachry Department of Civil Engineering, Texas A&M University, College Station, TX, USA
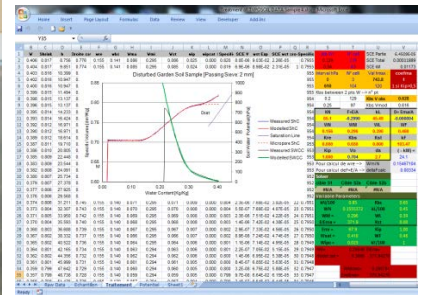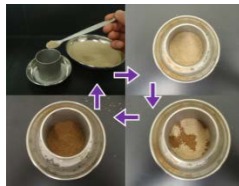
Sampling Site ➡ Sample Preparation ➡ Preparing the samples and Running the TYPOSOIL ➡ Extracting the Parameters

# Soil water thermodynamic to unify water retention curve by pressure plates and tensiometer

Erik Braudeau[1,2]*, Gaghik Hovhannissian[3], Amjad T. Assi[14] and Rabi H. Mohtar[5]*

[1] Qatar Environment and Energy Research Institute, Qatar Foundation, Doha, Qatar
[2] Pédologie Hydrostructurale, Institut de Recherche pour le Développement France Nord, Institut de Recherche Pour le Développement, Bondy, France
[3] Unité Mixte de Recherche 242, Institut d'Ecologie et des Sciences de l'Environnement de Paris, Institut de Recherche pour le Développement France Nord, Institut de Recherche Pour le Développement, Bondy, France
[4] Biological and Agricultural Engineering Department, Texas A&M University, College Station, TX, USA
[5] Biological and Agricultural Engineering and Zachry Departments of Civil Engineering, Texas A&M University, College Station, TX, USA

- All existing pF-curves in soil database can be re-taken and be fitted by the thermodynamic equations of the water retention curve.

- The 4 parameters of this curve are characteristics of hydro-structural behavior of the soil medium.

# Frontiers in ENVIRONMENTAL SCIENCE
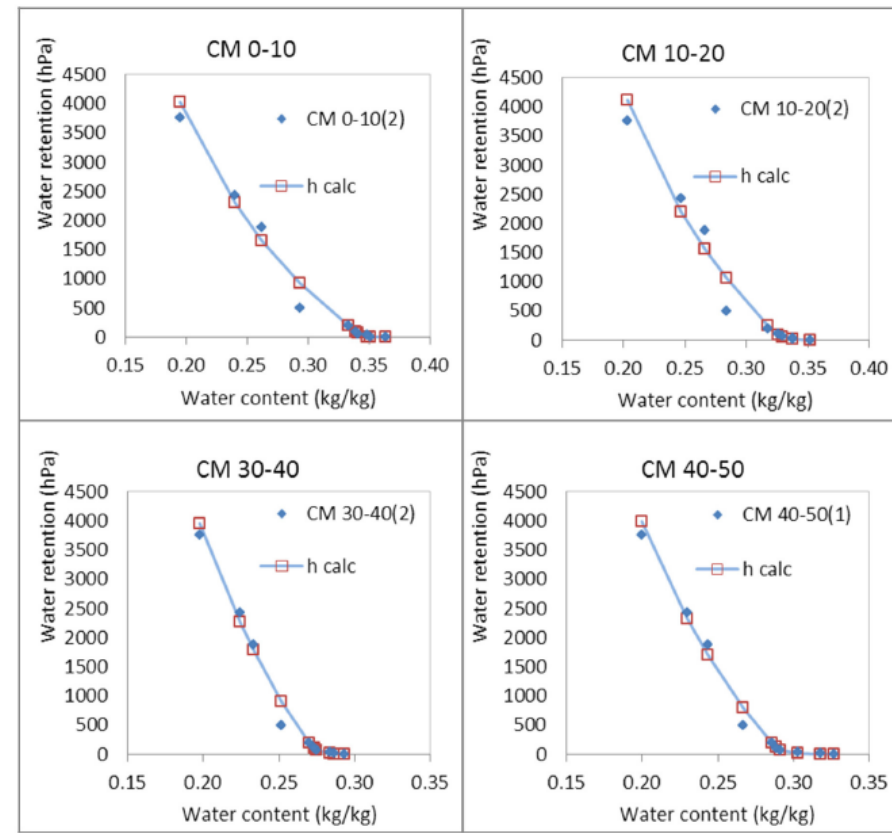
# A framework for soil-water modeling using the pedostructure and Structural Representative Elementary Volume (SREV) concepts

## Erik F. Braudeau[1]* and Rabi H. Mohtar[2]

[1] Hydrostructural Pedology, Centre de Recherche Ile de France, IRD France Nord, Institut de Recherche pour le Développement, Bondy, France
[2] Department of Biological and Agricultural Engineering, Zachry Department of Civil Engineering, Texas A&M University, College Station, TX, USA
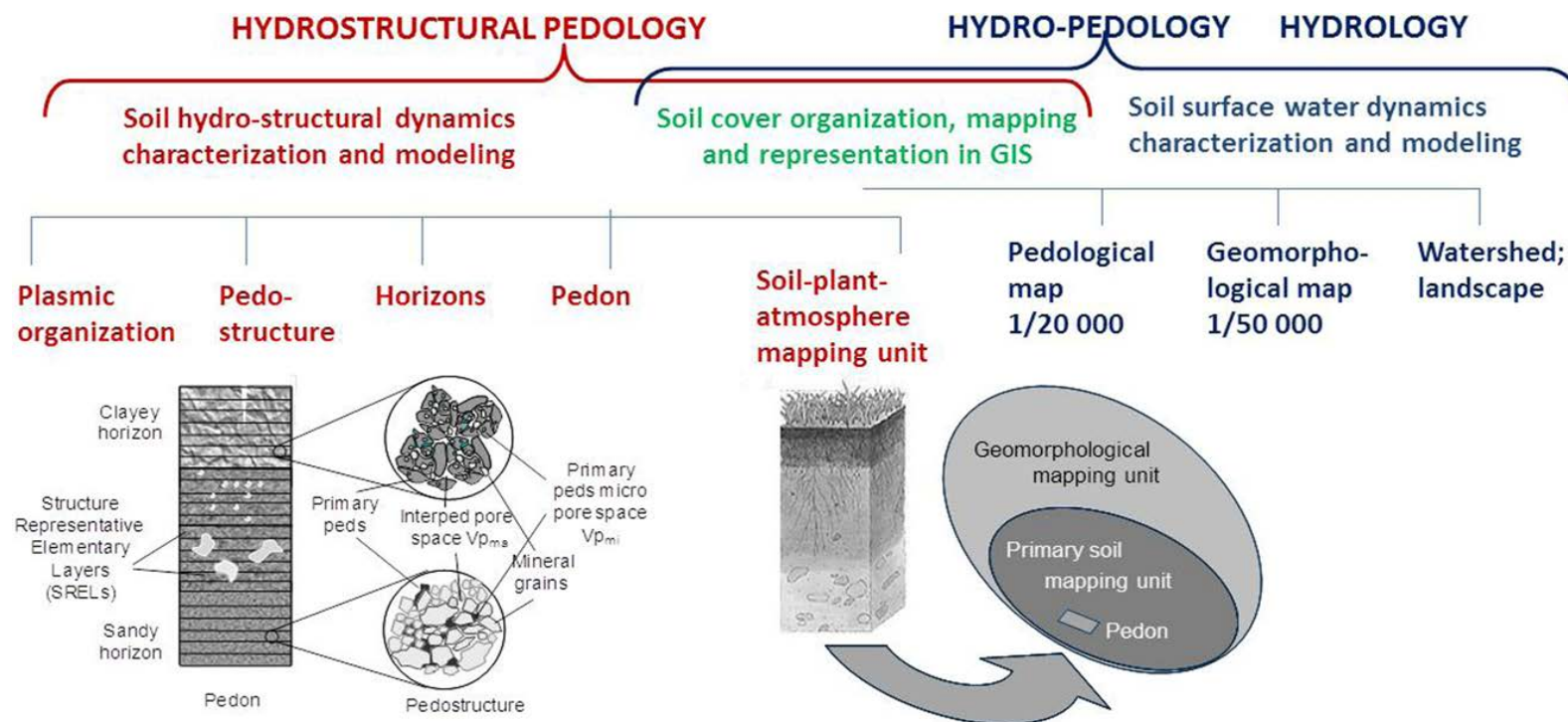
Kamel® is a multi-scale « soil water» model based on pedostructure and SREV concepts

Natural Environmental Organization Systemic representation using GIS
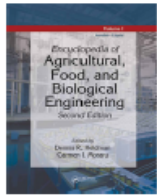
# Encyclopedia of Agricultural, Food, and Biological Engineering, Second Edition

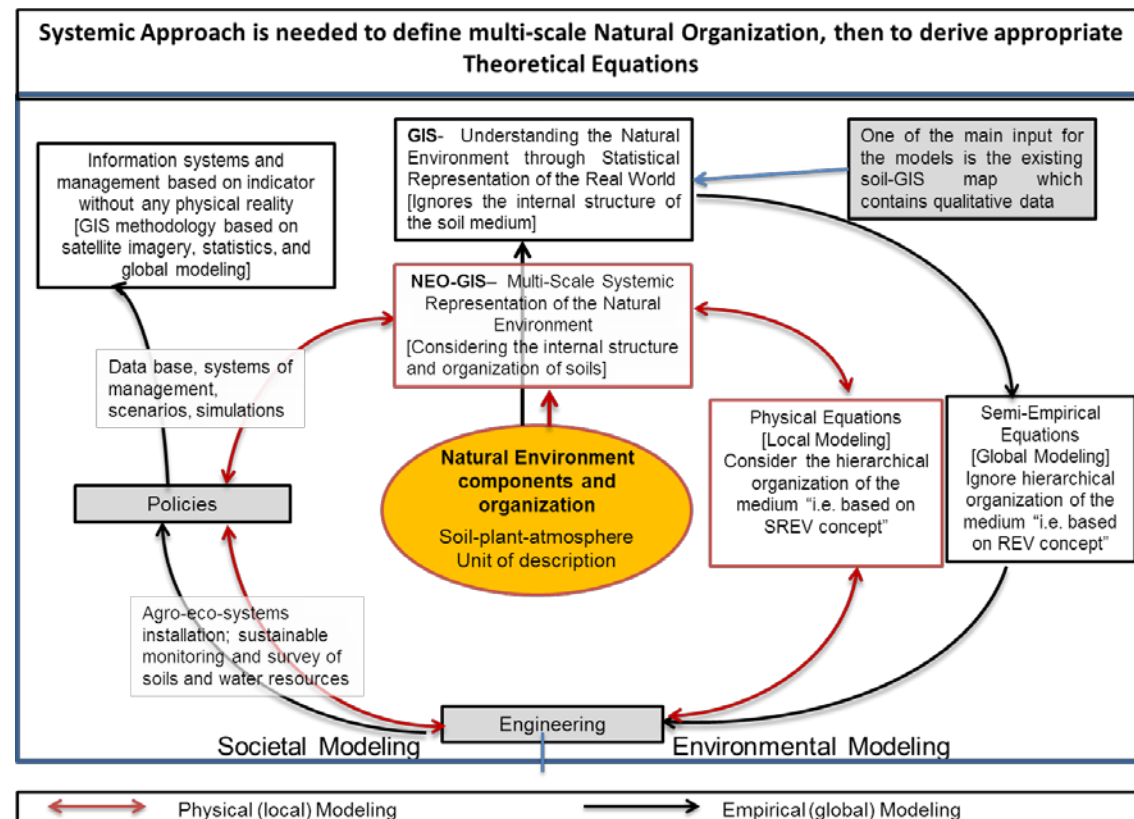# Integrative Environmental Modeling

Erik Braudeau [a] Rabi Mohtar [b]

[a] Qatar Environment and Energy Research Institute , Qatar Foundation, Doha, Qatar, and Institute for Development Research (IRD) , Bondy , France

[b] Biological and Agricultural Engineering Department, and Zachry Department of Civil Engineering , Texas A&M University , College Station , Texas , U.S.A.

Distinguishing two kinds of environmental modeling cycles:

- **Local** modeling cycle (a physical and multi-scale cycle) according to the soil medium organization.

- **Global** modeling cycle, out of scale of processes, which is necessarily statistically based.



Systemic Approach is needed to define multi-scale Natural Organization, then to derive appropriate Theoretical Equations