The Abdus Salam
International Centre
for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization

IAEA International Atomic Energy Agency

2444-1

College on Soil Physics - 30th Anniversary (1983-2013)

25 February - 1 March, 2013

Introduction to Soil Physics

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The Abdus Salam International Centre for Theoretical Physics

30 years

Introduction to SOIL PHYSICS

Donald Gabriels

Department of Soil Management

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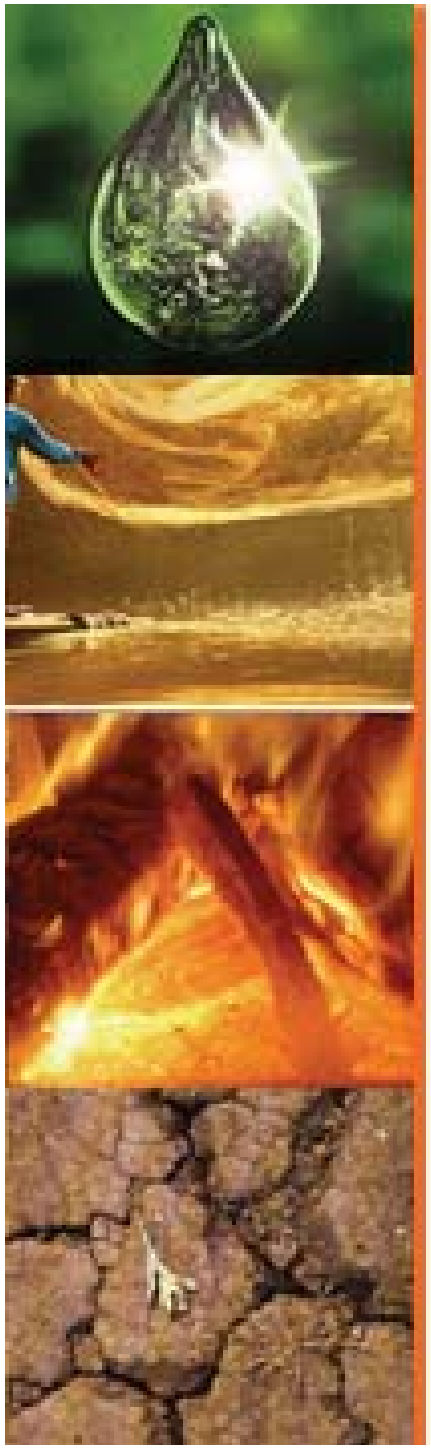
What is physics ?
(of the soil)



PHYSICS : study of 4 (5?) elements of nature

- Earth
- Water
- Air
- Fire
- 5?

Element 1: Earth

Earth ≠ soil

- Soil
- Vegetation
- Man
- Animals

Physics of the earth = physics of the soils with the physical processes affected by the impact of human activity and by the effect of climatic factors on the other elements

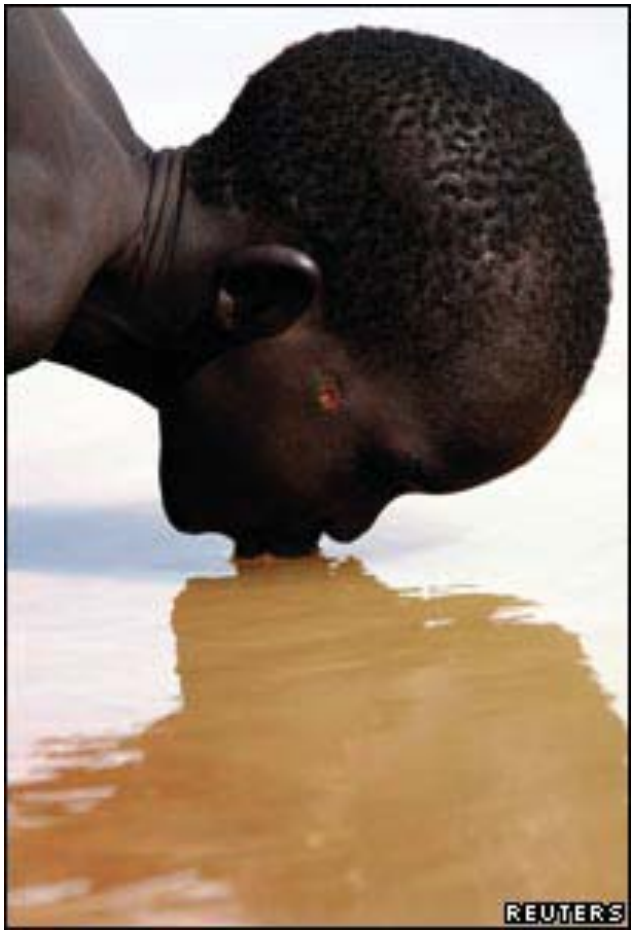
Element 2: Water

- Water is a problem?
- Is there sufficient water?

Normaly the volume of water in the soil (1 meter thick) is (can be) larger than the volume of water in all the rivers in the world

BUT!! Water has to enter into the soil

⇒ Soil Physics: physical processes of water in the soil



Element 3: Air

- Air:vapor, gass
- Air: vapor, gass in the soil
- Air: (vapor and gass) in the atmosphere

Movement of mass of air ⇒wind

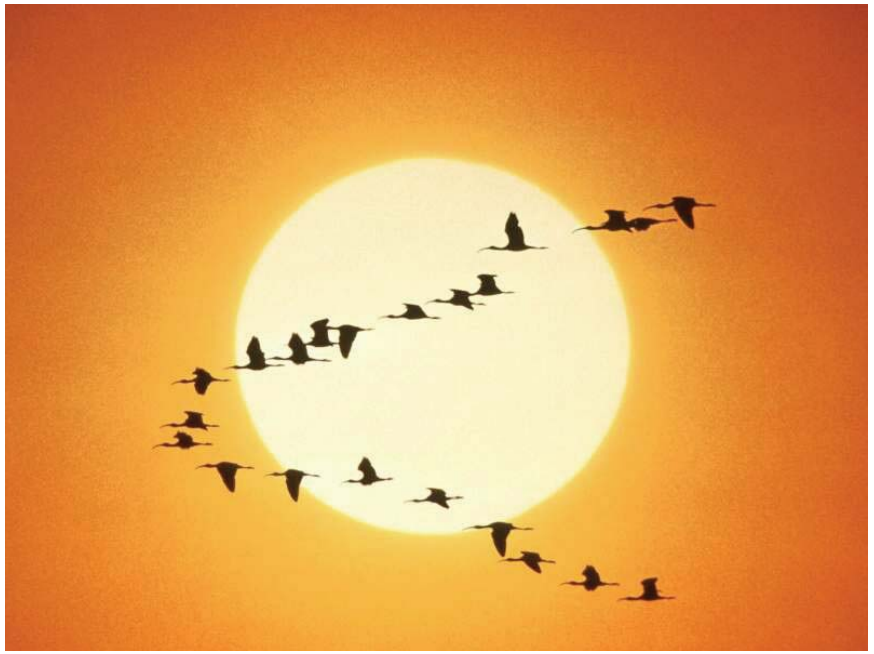
The most important cause of climate change is the emission of gass

Soil physics: physical processes of air at the interphase between 'land' and atmosphere

Element 3: Fire

FIRE

SUN

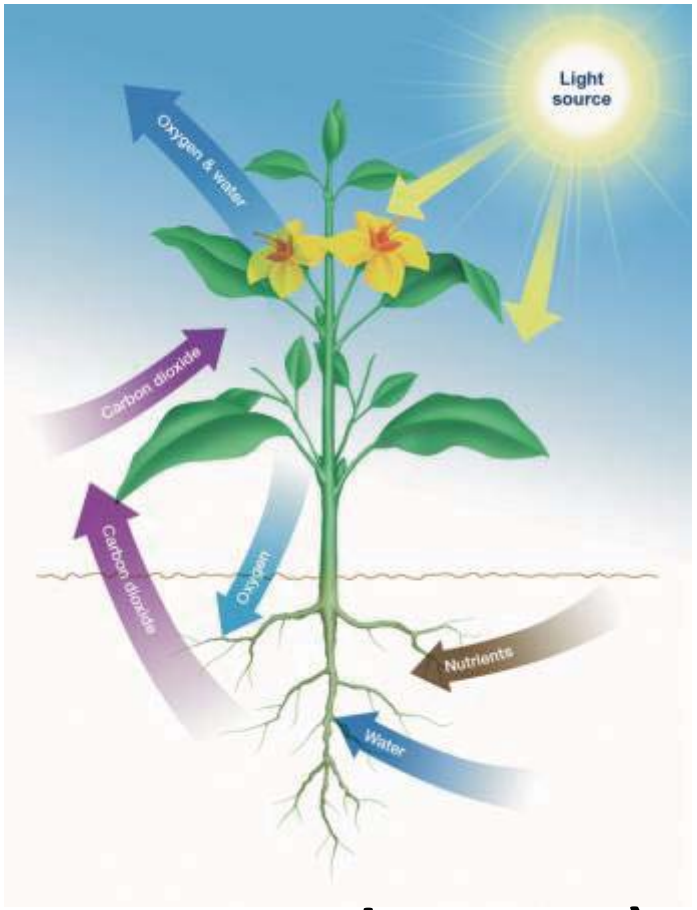


Element 4: Fire

Fire refers to light and energy
light⇒ solar energy ⇒photosynthesis

Spanish: el sol = sun
French: le soleil
Spanish: el suelo = soil
French: le sol = soil

Indonesian: air = water
French: eau = water



Soil physics: physical processes (transport and storage) of energy at the interphase between 'land' and amosphere.

Element 5??

Wood

Wood = organic matter

Organic matter = plant

Plant = photosynthesis

Photosynthesis = light

Light= energy= sun

Sun = fire = element 4

adama → **means in Hebrew: soil**

First man (hu-man): ha-adam (from soil)

→ **Adam & Hava**

"Mystic Lamb
John and Hubert Van Eyck
Gent, Belgium

Gaea → godness of earth

→ "geo" (soil-earth)

geo + ergon

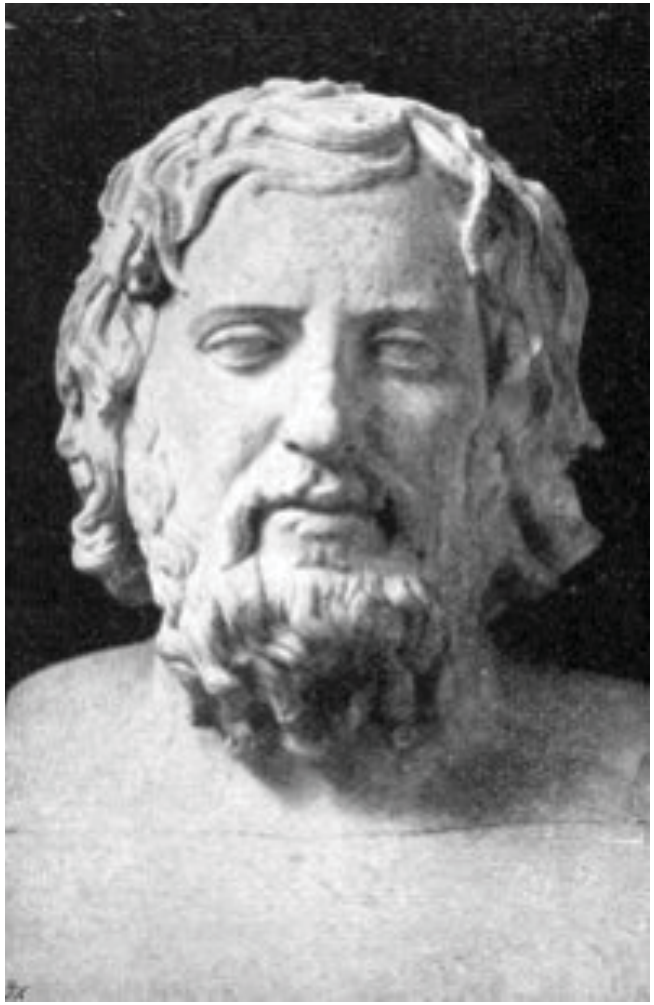
(Working the soil)

→ Georges (José)

homme-hombre-human
(homo….humus)

"Gaia"

Link soils and mankind?

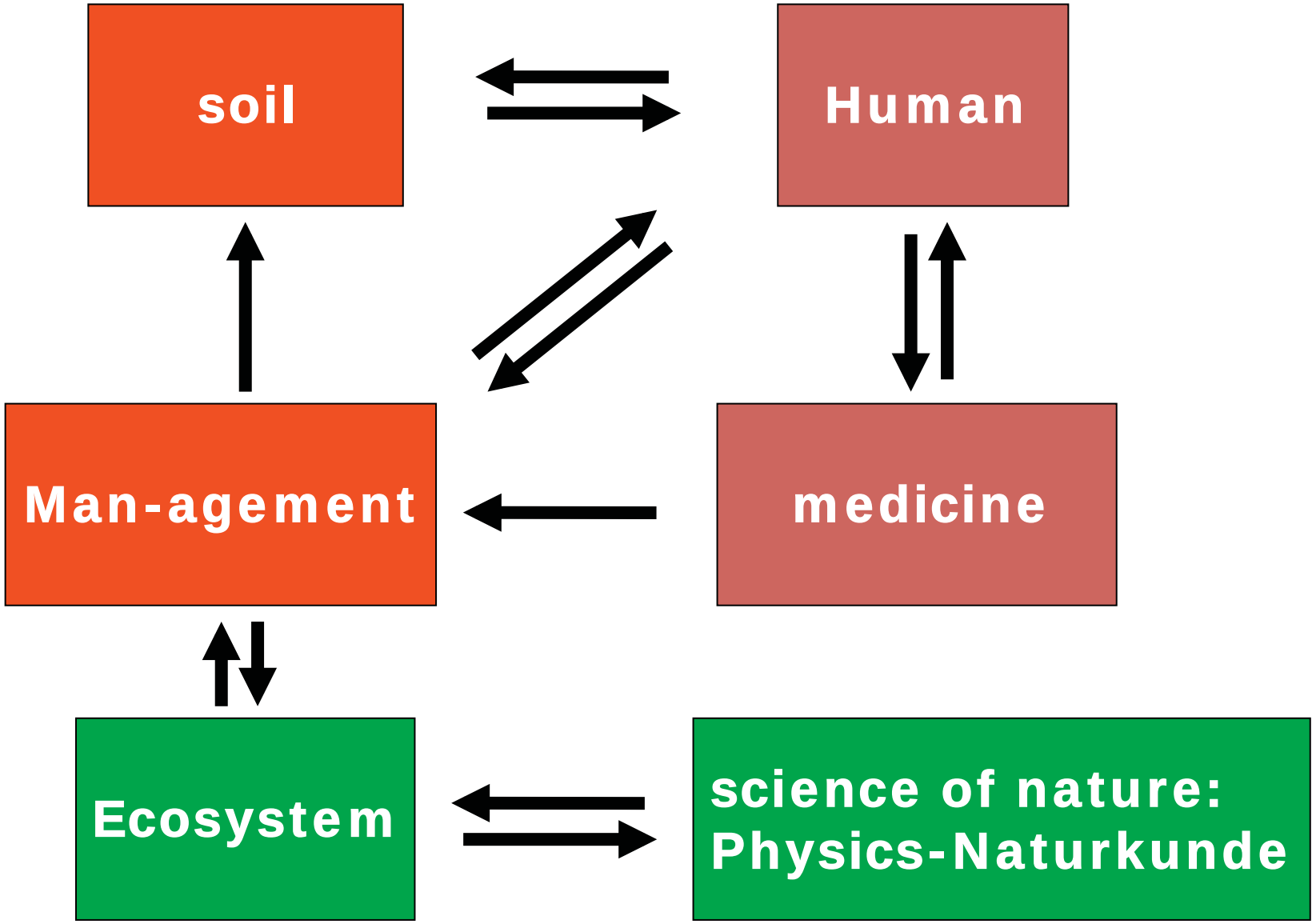


homo **→ derived from "humus", living material of the soil**

"… To be a successful farmer one must first know the nature of the soil…"

in *Oeconomicus* by Xenophon

(ca. 400 BC)

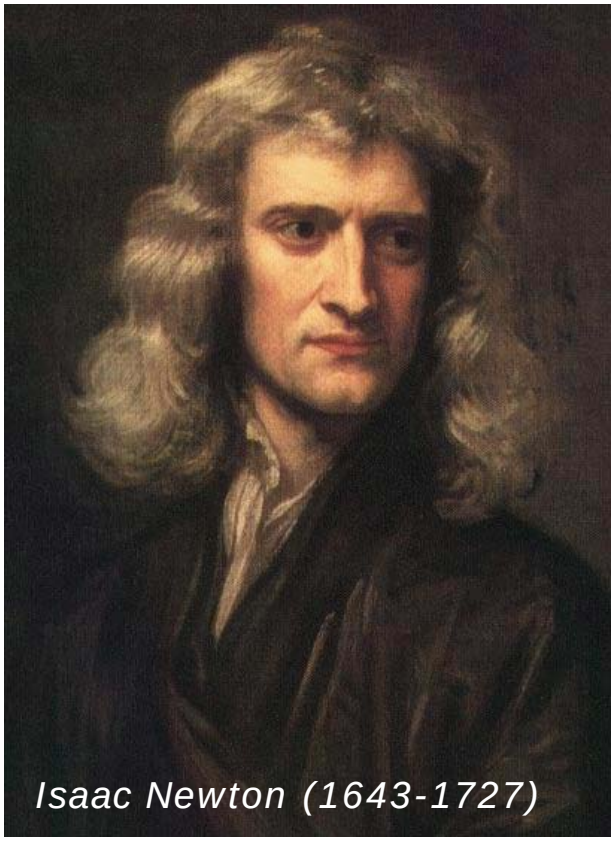

soil
Human
Man-agement
medicine
Ecosystem
science of nature:
Physics-Naturkunde

What is physics of soil?

- >6000 years ago:
- irrigation + plowing
- (water-soil-work)

What is soil physics?

- **>6000 years ago:**
- **irrigation and plowing**
- **water-soil-work**



Isaac Newton (1643-1727)

- **From mid 17th century: A science called Physics (time of Newton)**

- *What is soil physics?*

- **>6000 years ago:**
- **irrigation and plowing**
- **water-soil-work**

- **From mid 17th century: A science called Physics (time of Newton)**

- **First part of 19th century: science of agriculture → soil physics**

- *What is soil physics?*

- >6000 years ago:
- irrigation and plowing
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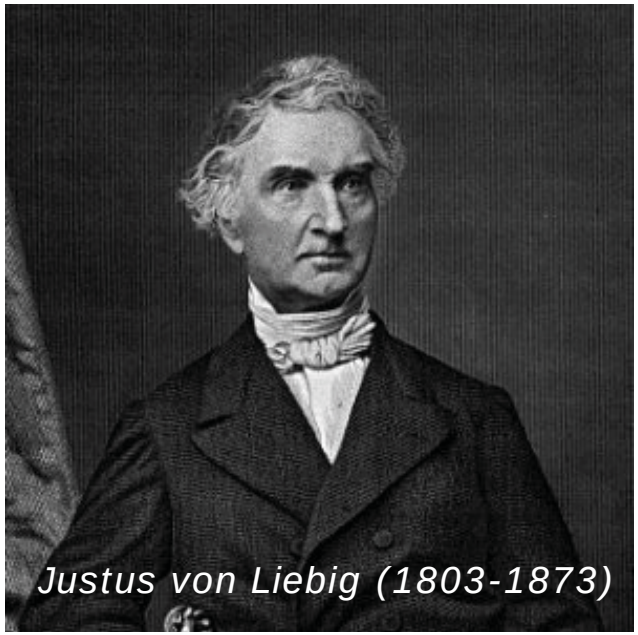
Justus von Liebig (1803-1873)

- From mid 17th century: A science called Physics (time of Newton)

- First part of 19th century: science of agriculture → soil physics

- New theories of chemistry: soil fertility' (chemicals-nutrients) time of Liebig

- *What is soil physics?*

- >6000 years ago:
- irrigation and plowing
- water-soil-work

- From mid 17th century: A science called Physics (time of Newton)

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- New theories of chemistry: soil fertility' (chemicals-nutirents) time of Liebig

- 20th century: new discipline

- **<u>During the first years</u>**: descriptive

  → distribution of particles, moisture content, potential, porosity, temperature

- **<u>Afterwards:</u>** : quantitative and lesss qualitative

  → more mathematics to describe the dynamica of the soil system

  Darcy, (1856): flow of water through a system: the conductivity of a system

What is soil physics?

What is soil physics?

measuring, modeling and evaluating the characteristics of a soil and managing the physical processes in the soil

- **Porosity and bulk density (apparent density)**
- **Water retention curve (pF) $\theta(h)$**
- **Hydraulic Conductivity Ks, $K(h)$**
- **Aggregate stability**
- **Mechanical Resistance**
- **Consistency**

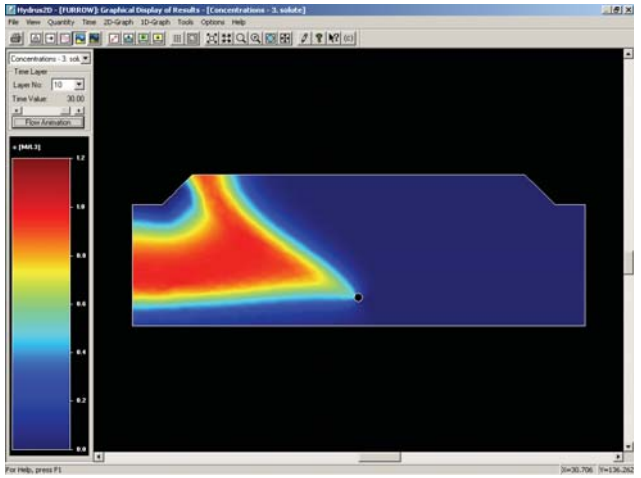
What is soil physics?

Why measure, model and manage the physical characteristics of a soil?

APPLICATIONS!!!

- 'inputs' in models for simulating transport of water, liquids, sediments on or in the soil

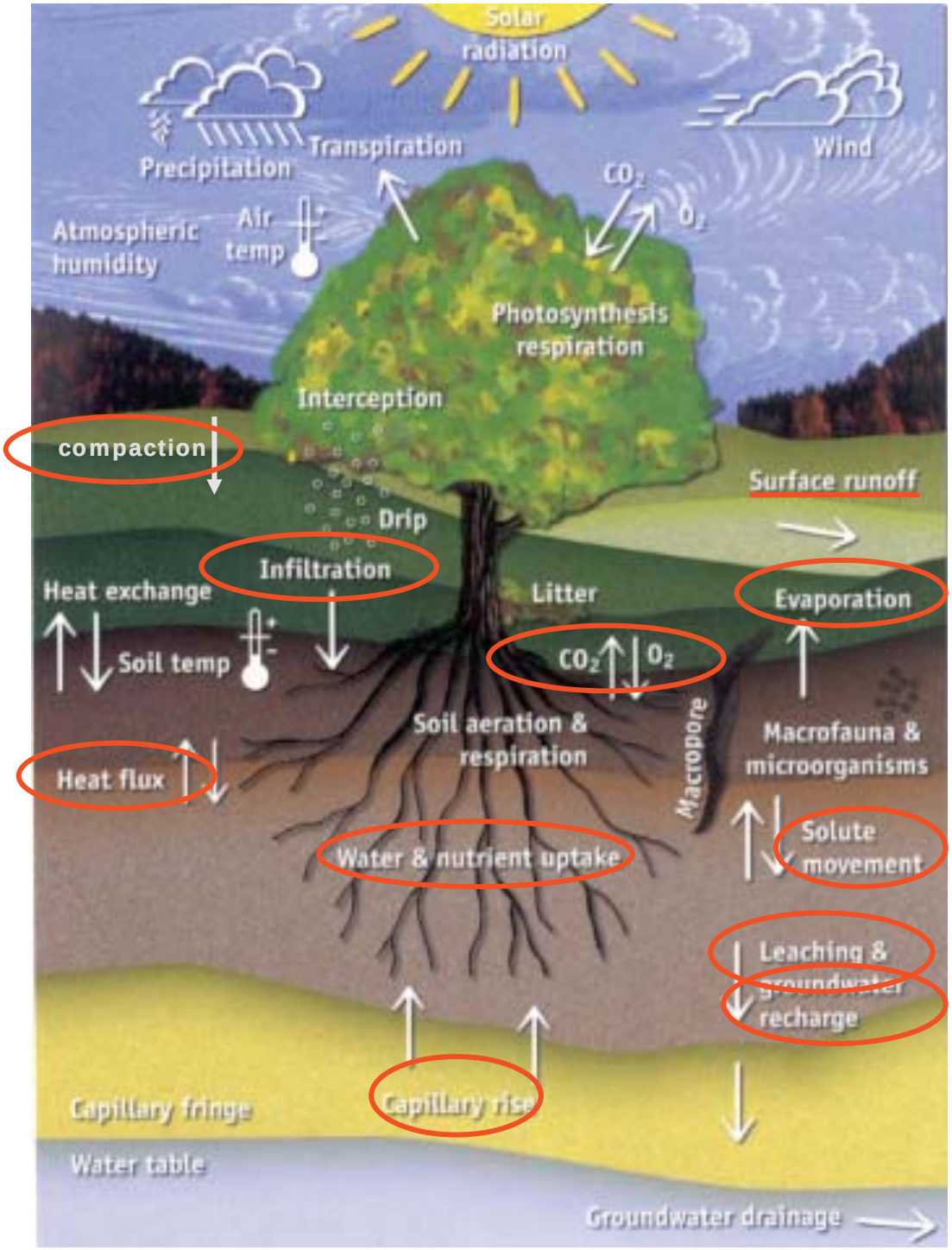
- Determination of indicators of soil physical quality



HYDRUS-2D

Why soil physics?

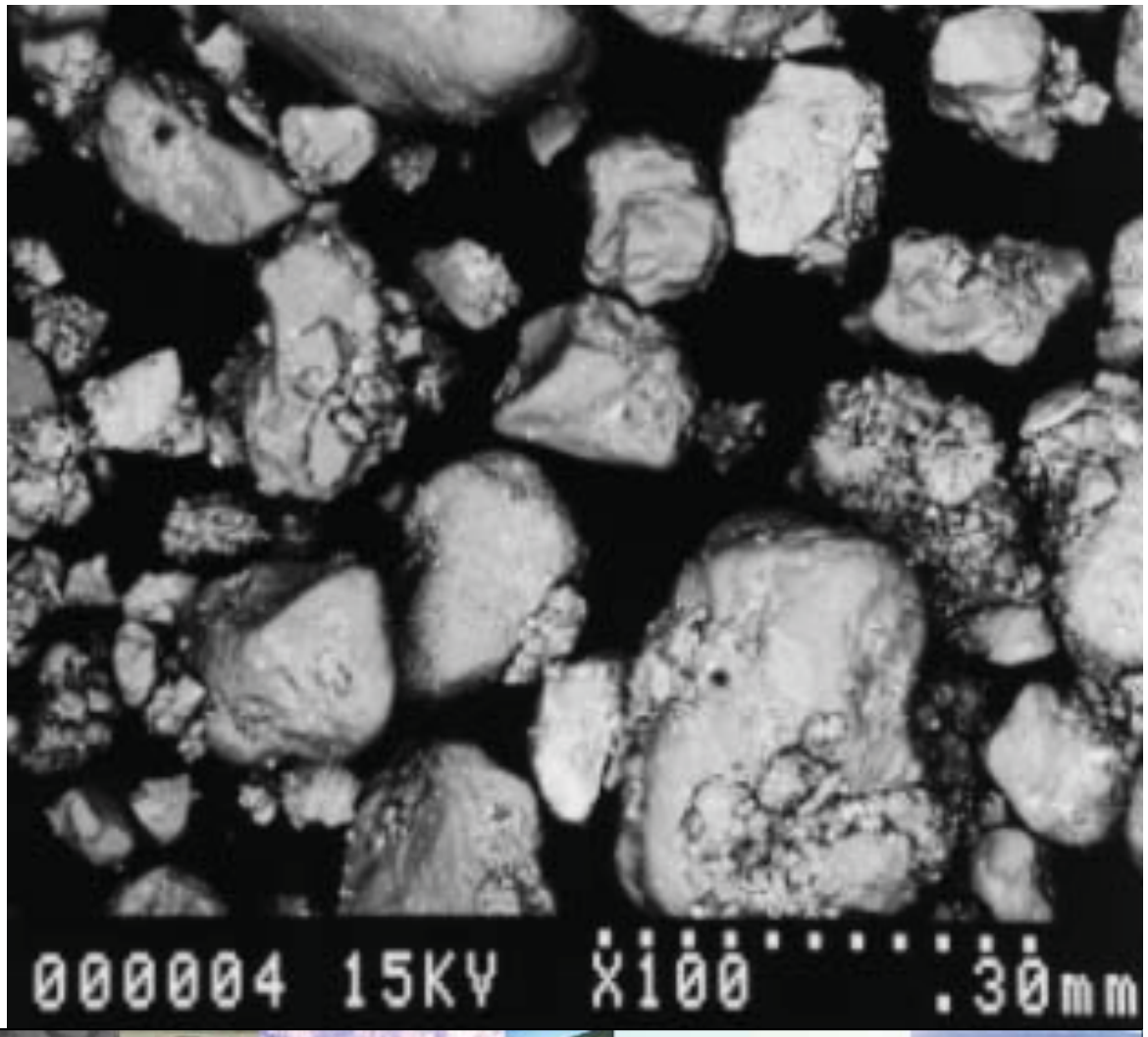
measuring, modeling and managing the physical characteristics and processes in the soil


Solar radiation
Precipitation
Transpiration
Wind
Atmospheric humidity
Air temp
CO_2
O_2
Photosynthesis respiration
Interception
compaction
Surface runoff
Drip
Infiltration
Heat exchange
Soil temp
Litter
Evaporation
CO_2
O_2
Soil aeration & respiration
Macropore
Macrofauna & microorganisms
Heat flux
Water & nutrient uptake
Solute movement
Leaching & groundwater recharge
Capillary fringe
Capillary rise
Water table
Groundwater drainage

Hillel (1998)

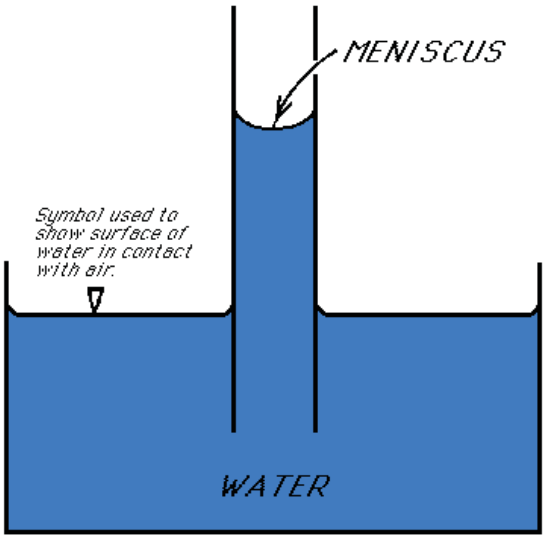
Microscopic scale

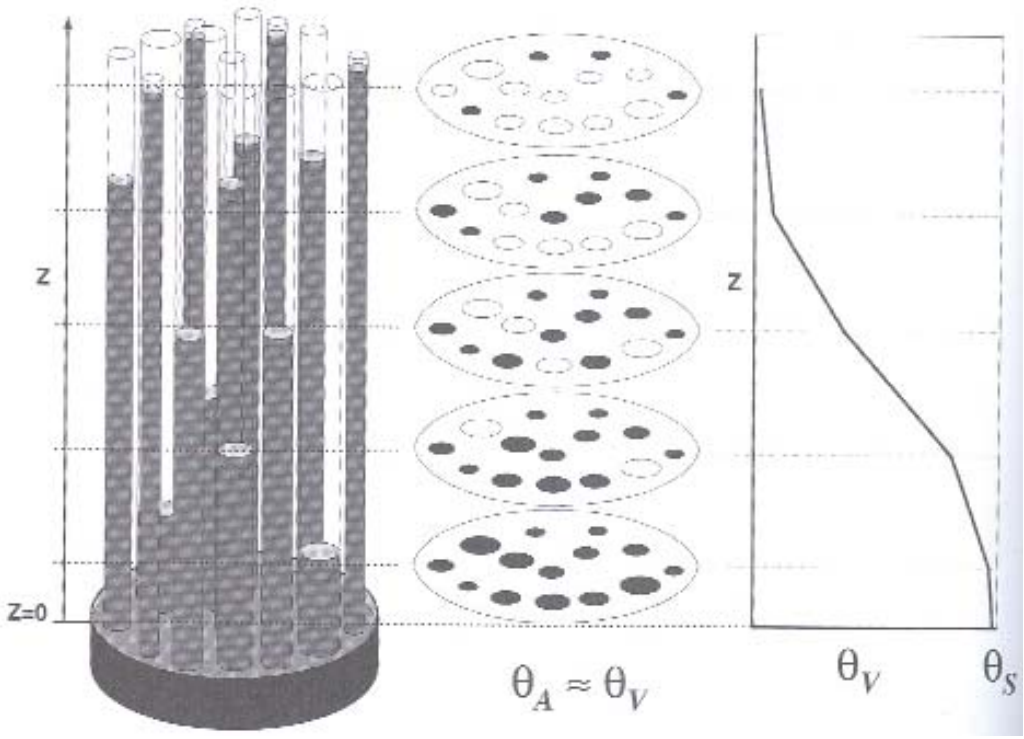
- Micro pores
- Meso pores
- Macro pores



Microscopic scale

→ 1. models to determine the pore distribution

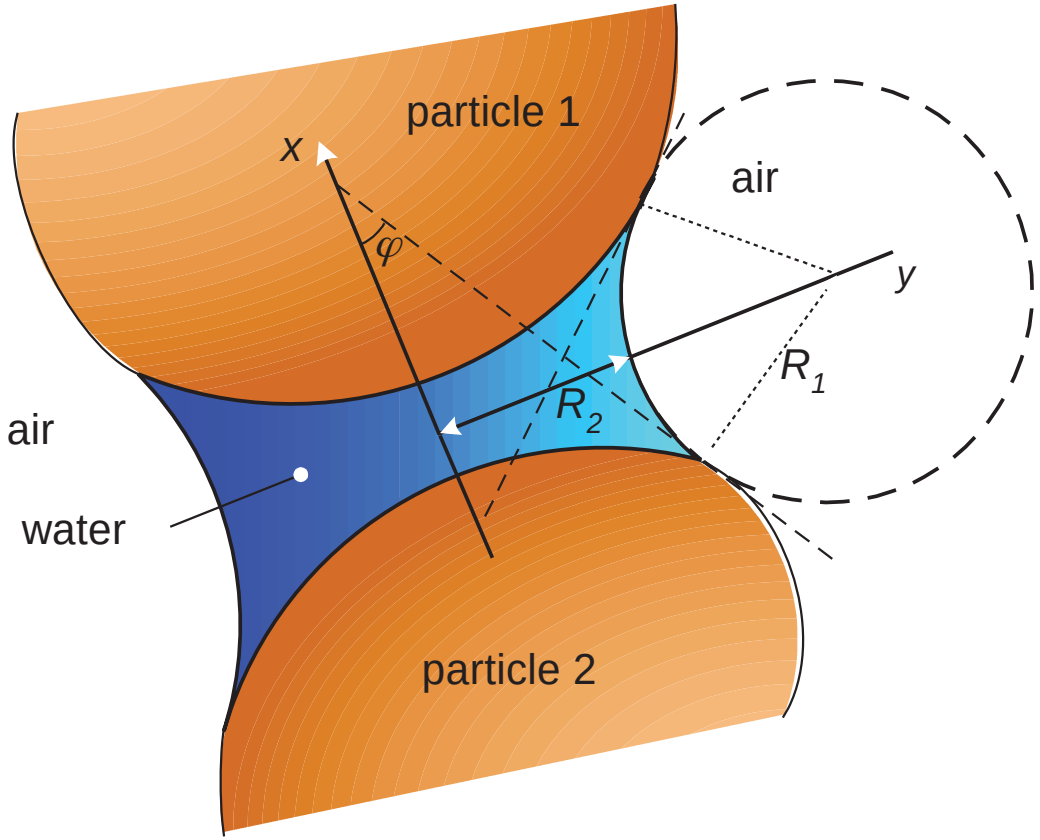


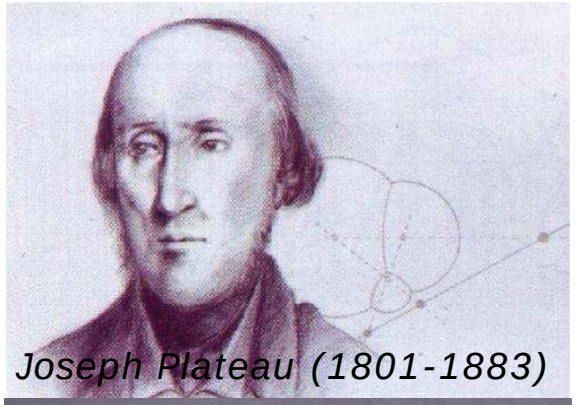


Law of capilarity of Hagen-Poisseuille

Microscopic scale

→ 2. models to determine the capillary and adhesive forces

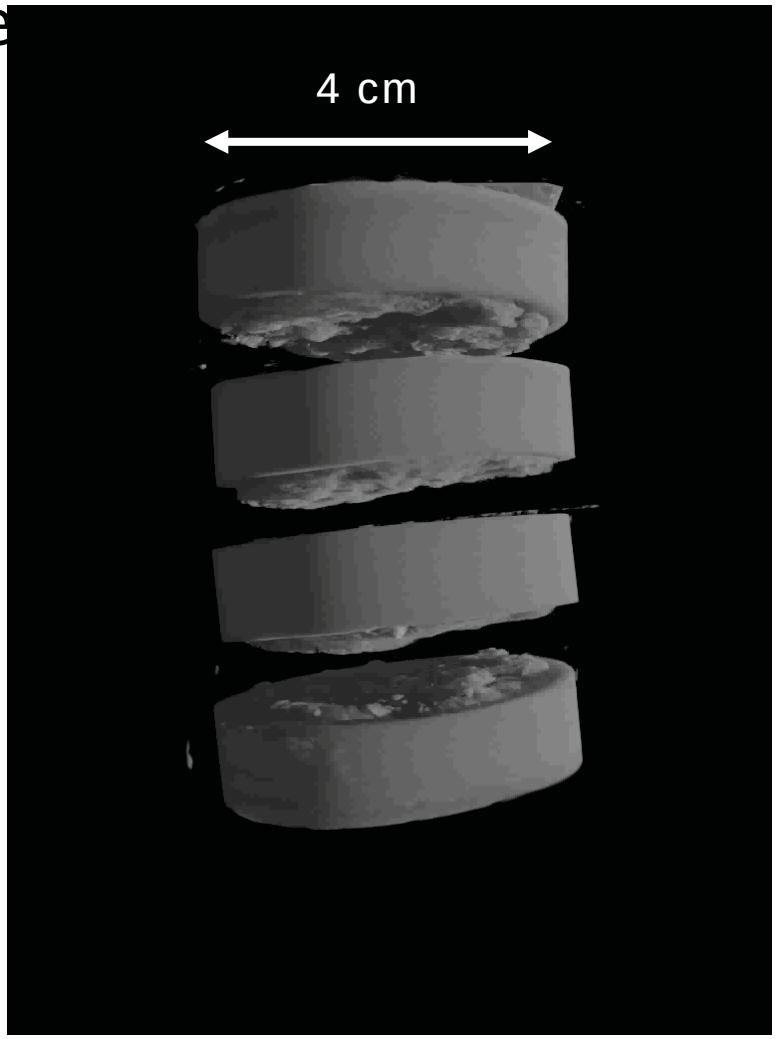



Joseph Plateau (1801-1883)


Phenakistoscoop

Microscopic scale

→ 3. X-ray , tomography, thin slide



Macroscopic scale

- **aggregate**

Macroscopic scale

- aggregates
- Undisturbed samples (Kopecky ring)

  → Darcian scale

5 cm

Macroscopic scale

- aggregates
- Undisturbed sample
- Pedon scale


Lublin, Polen

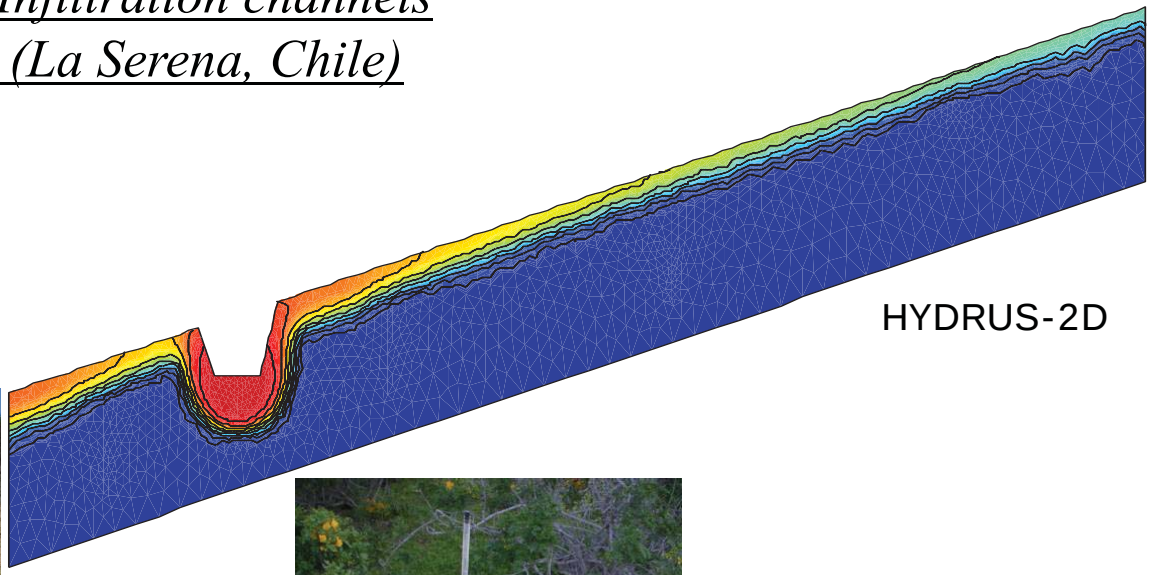

Ljubljana, Slovenië

Macroscopic scale

→ 1. input models (empirical→ deterministic)

zanjas, La Serena, Chile

Infiltration channels (La Serena, Chile)



HYDRUS-2D

Macroscopic scale

→2. Effect of soil management (tillage)

→ soil water content, drainage (physical quality of soil)

Macroscopic scale

- aggregates
- Ring samples (undisturbed)
- pedon scale
- column scale/ lysimeter

Macroscopic scale

- aggregates
- ring samples (undisturbed)
- pedon scale
- column scale/ lysimeter
- plot scale (homogeneous entity)

Macroscopic scale

→ 2. water balance in the field

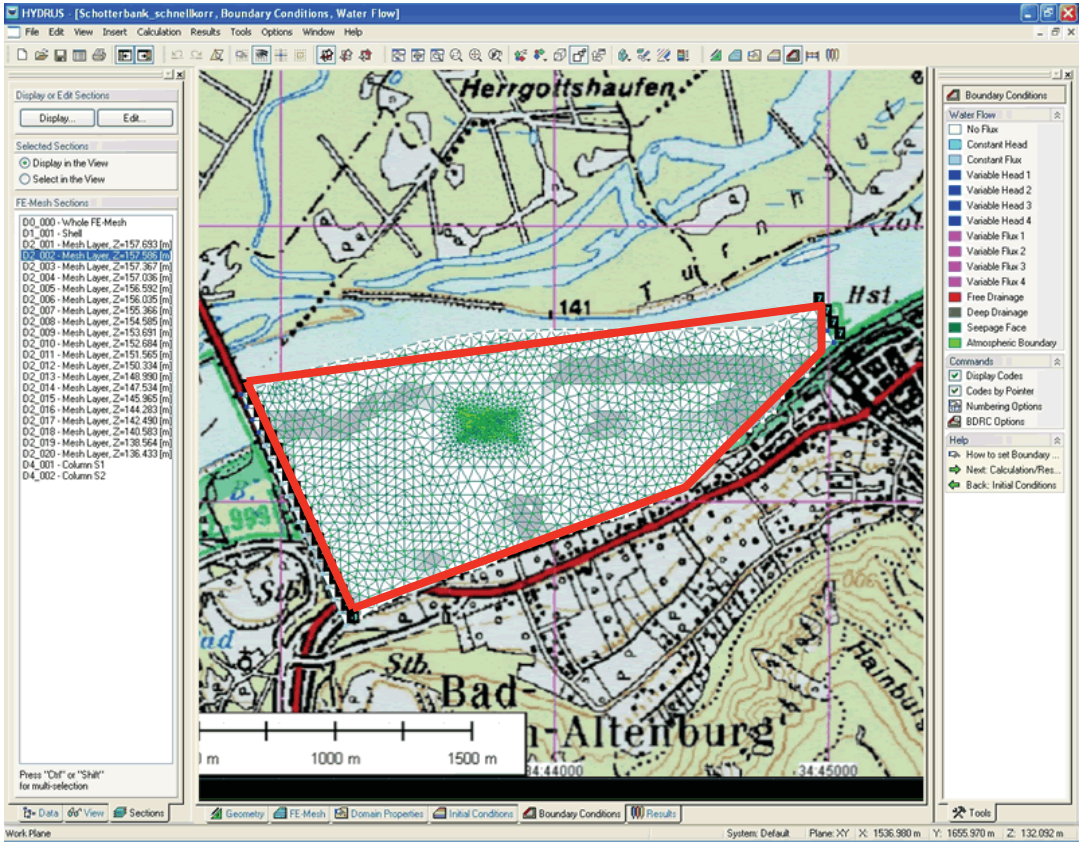
effect of tillage (China)

Conventional tillage	Subsoiling	Two crops System	Zero tillage	Minimum tillage

Megascopic scale

- Field scale (heterogeneous – spatial variability)

→ larger scale: upscaling???



Hydrus-2D

Megascopic scale

- Field scale (heterogeneous – spatial variability)
- watershed/community/region
- country -continent

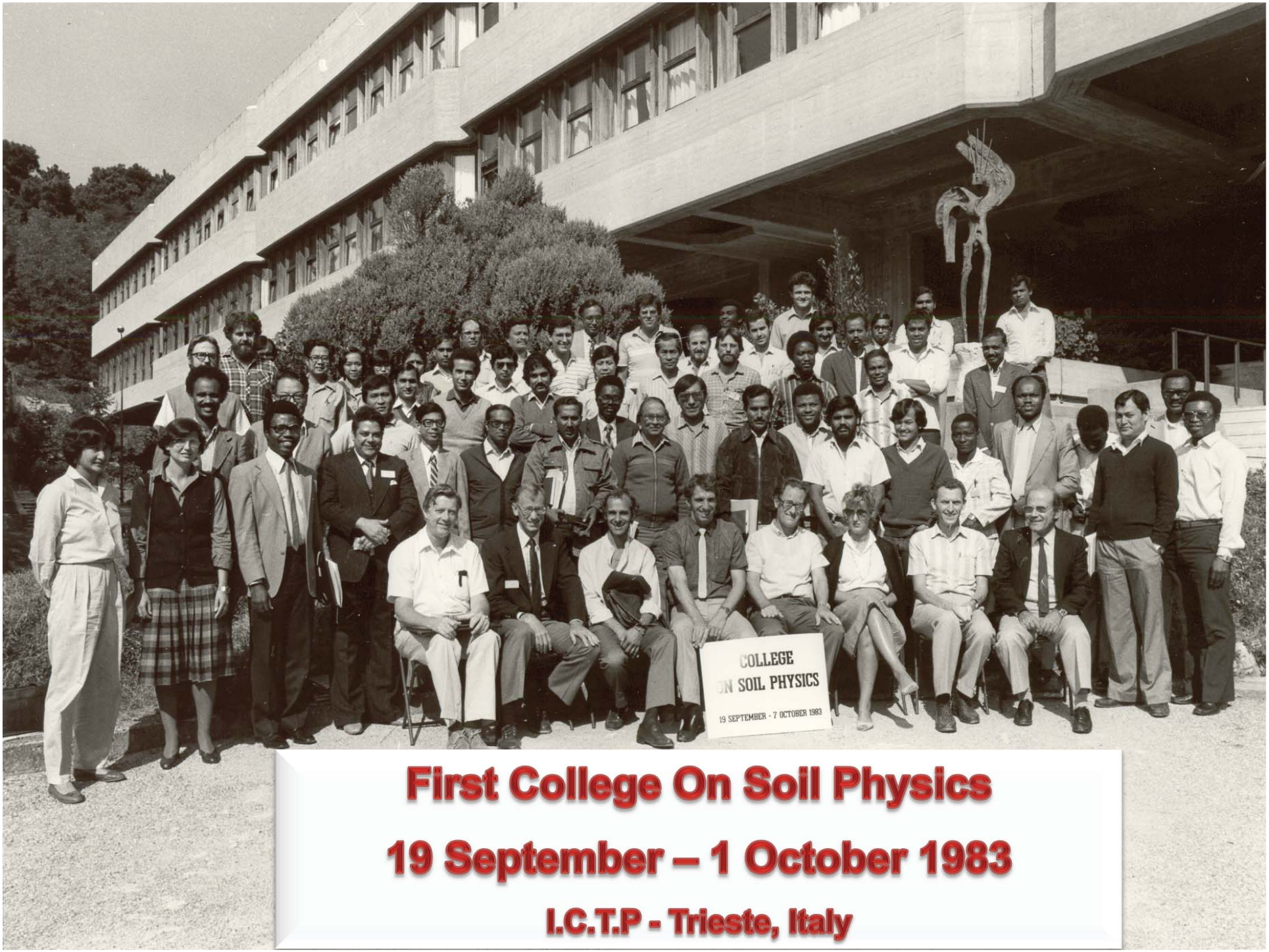
Map of Arid Zones of South America

Conclusions on role and objectives of soil physics

- **to measure, to model and to manage the characteristics and physical processes of soils**
- **from scanning thin slides to regional GIS applications**
- **It is necessary to combine basic research on soil physics with soil management applications**

"… the nation that destroys its soil, destroys itself…"

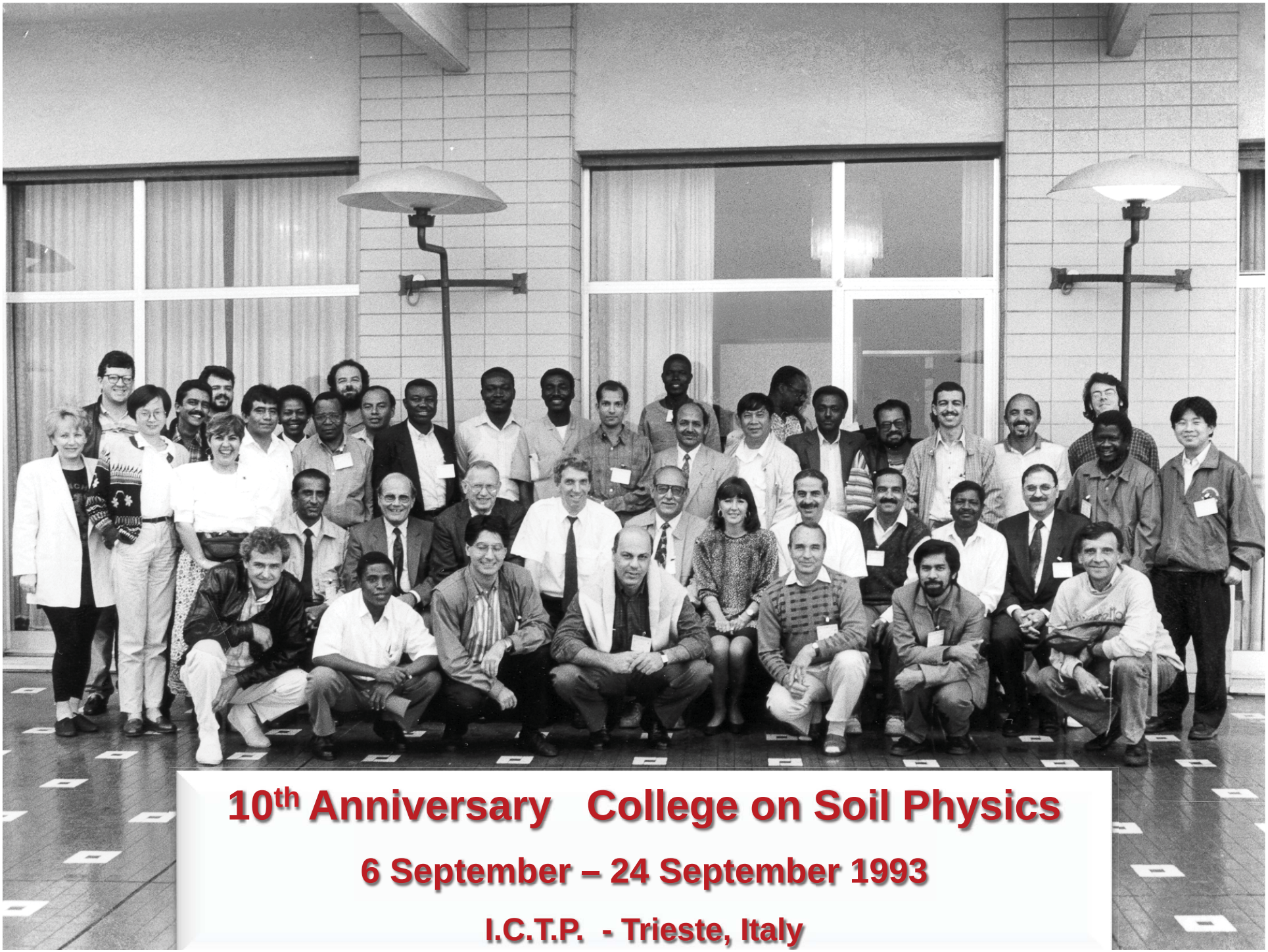
Franklin Delano Roosevelt



First College On Soil Physics

19 September – 1 October 1983

I.C.T.P - Trieste, Italy



10th Anniversary College on Soil Physics

6 September – 24 September 1993

I.C.T.P. - Trieste, Italy

20th Anniversary College on Soil Physics

ICTP **March 2003** **Trieste, Italy**

30th Anniversary

College on

Soil Physics

ICTP **2013** **Trieste, Italy**

Photo will follow!!!!!!!!!