Parameterising MACRO for EU-wide predictions

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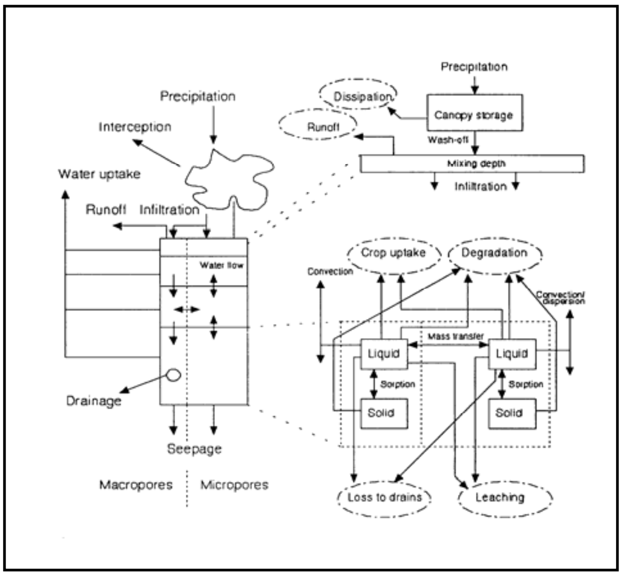
Task

- Develop a suite of pedotransfer functions (model parameter estimation routines) to parameterize the MACRO model from EU-wide data:
  - Soil Geographic database of Europe v.1.0
    - 250 benchmark soil types ('FOOTPRINT soil types')
  - SPADE 2 database for soil horizon properties
    - horizon designation; upper depth (cm); lower depth (cm); clay, silt and sand (%); pH; organic carbon content (%); bulk density (g cm^{-3}), stone content (%)
  - HOST ('Hydrology of Soil Types') system
    - Simplified to 14 hydrologic classes (8 unique classes for MACRO parameterisation)
    - Substrate geology, presence of impermeable or slowly permeable soil horizons ('mottling')

MACRO



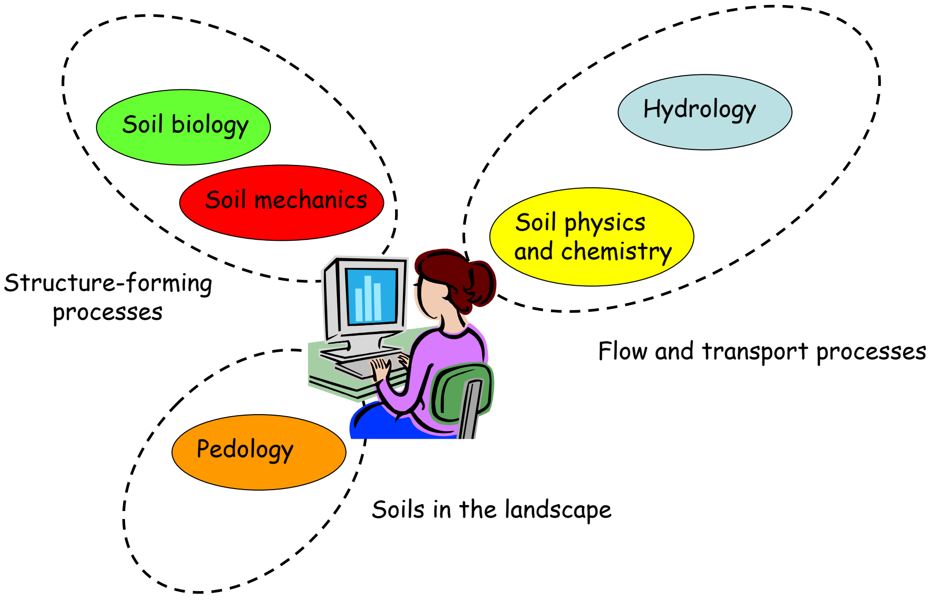
Matrix hydraulic properties

- Water retention (HYPRES functions)
- Saturated matrix hydraulic conductivity
  - predicted from saturated matrix water content and van Genuchten's *n*, based on a database (n=70) of tension infiltrometer data*
- Dispersivity set to the median value for a subset (n=116) of the database reported by Vanderborght & Vereecken** (= 3.4 cm)
  - Steady flow rates < 1 mm h^{-1}

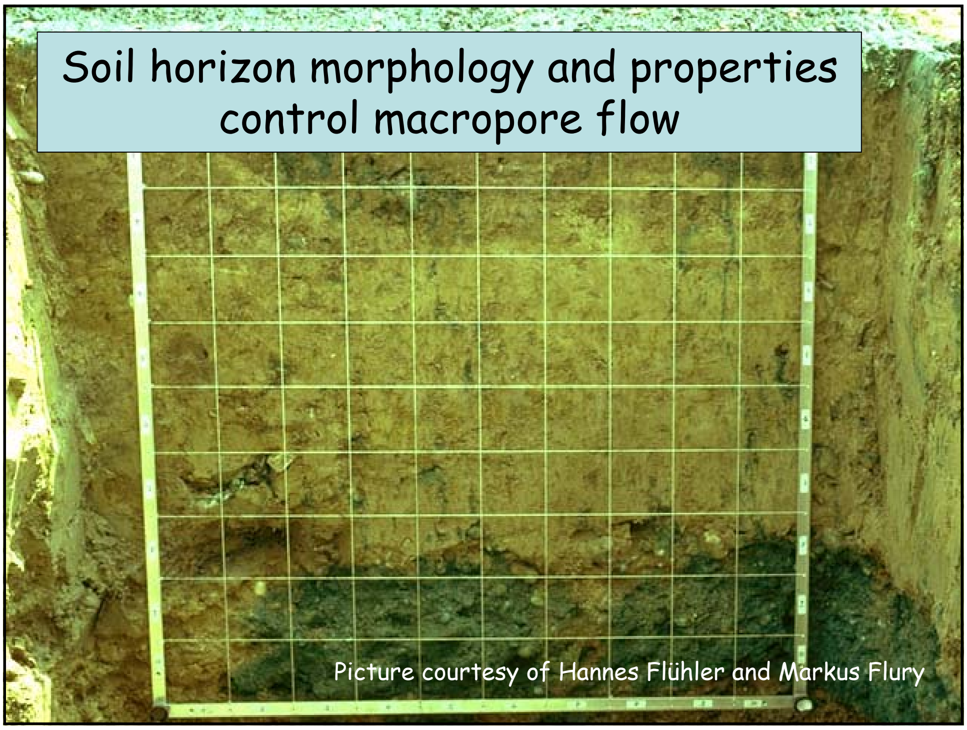
*Geoderma, 108, 1-17

**Vadose Zone J., 6, 29-52.

How can we predict macropore flow?



Soil horizon morphology and properties control macropore flow

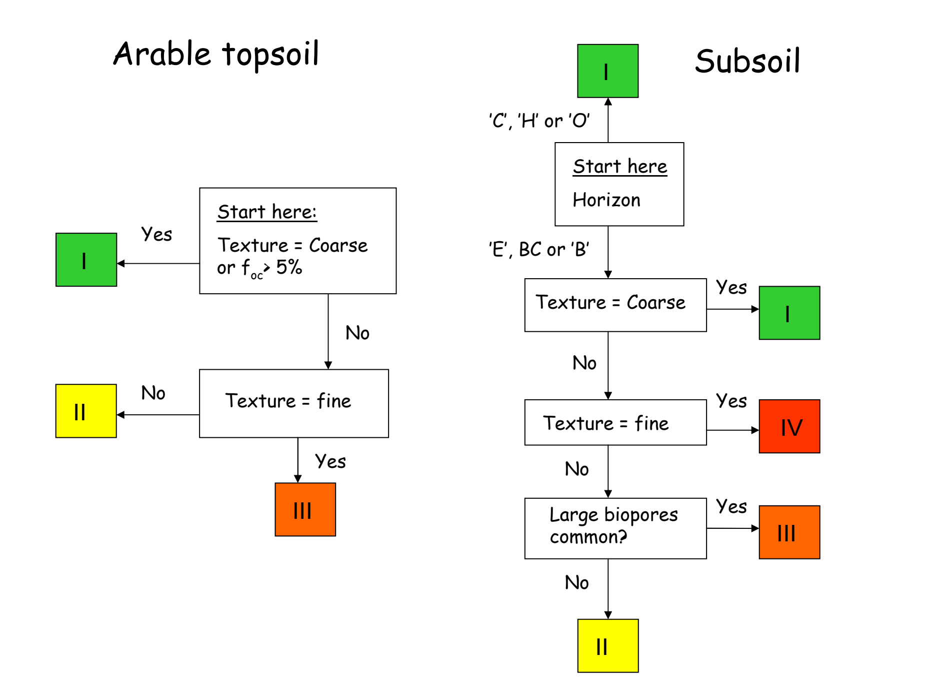


Picture courtesy of Hannes Flühler and Markus Flury

Methodology

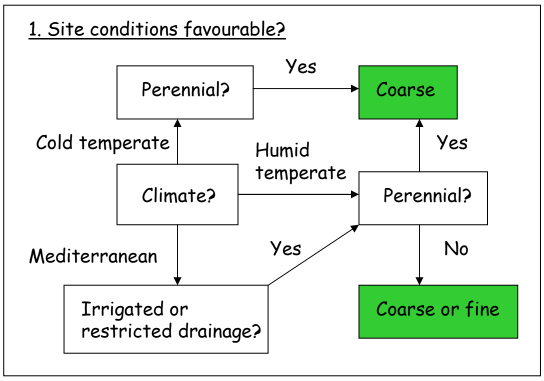
- Each horizon in each FOOTPRINT soil type allocated to one of four classes with respect to the potential for macropore flow:
  - I = none
  - II = low
  - III = moderate
  - IV = high
- Structure-forming and degrading processes:
  - Literature review* (e.g. tillage effects)
  - Classification trees
    - Aggregation (LANDIS and SEISMIC databases, U.K.)
    - Earthworm biopores (deep-burrowing anecic species)
      - meta-analysis of the abundance of *Lumbricus terrestris* L. (n = 87)

*Eur.J.Soil Sci., 58, 523-526.



*Large biopores common?

*>8 anecic earthworms/m^2



2. Zone of functional burrows

Upper limit = max(0, tillage depth)

Lower limit = upper boundary of first soil horizon with *limiting factor*

Limiting factors : rock ('R'); drainage depth; 'BC', 'C' or 'O' horizon; pH < 5; bulk density >1.8 g cm^{-3} ; limiting texture (see flow chart)

Class pedotransfer functions

Class	Parameter	
	Kinematic exponent, n*	[a]diffusion pathlength, d (mm)
I	6.0	1
II	4.0	15
III	3.0	50
IV	2.0	150

[a] set to 3 mm in the uppermost intensively tilled layer in arable soil independent of class. Intensive tillage (e.g. harrowing, rotovating) shatters and pulverizes the soil to create a fine 'crumb' or granular structure, with a spherical geometry that maximises mass exchange

$$K_{s(ma)} = \frac{6000\,\varepsilon_{ma}}{n^*}$$

Macroporosity

Soil	Horizon	[a]Texture		
		Fine	**Medium**	**Coarse**
Topsoil (mineral)	[b]Undisturbed	0.05		
	[c]'A_t'	0.05		
	[d]'A_p'	0.03	0.04	0.05
Subsoil (mineral)	[e]Upper 'B' or 'E'	0.016	0.016	0.05
	[f]Lower 'B' or 'E'	0.008	0.008	0.05
	'BC'	0.002	0.004	0.04
	'C'	0.002	0.004	0.03
Organic	'O'	0.05		

[a]fine=clay,silty clay,silty clay loam, coarse = sand, loamy sand, medium = all others

[b]perennial crops i.e. grassland, vines, orchards etc.

[c]intensively (secondary) tilled uppermost soil layer

[d]ploughed but not secondary tilled

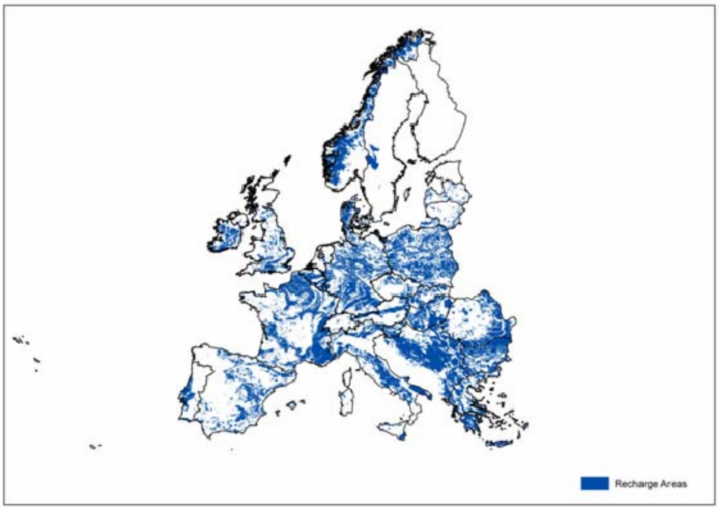
[e]mid-point depth of horizon <50 cm

[f]mid-point depth of horizon >50 cm

Site hydrology

- Simplified HOST system defines bottom boundary condition
  - Groundwater recharge only (unit hydraulic gradient)
  - Discharge to surface water only (zero flow)
  - Both recharge and discharge (percolation as function of water table height)
- Drainage system dimensions estimated using the Hooghoudt equation

European soils with only groundwater recharge



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