SWAT Conference 2013

July 17-19, 2013 Toulouse, France

SOILTREC

SEVENTH FRAMEWORK PROGRAMME

Development of the SWAT-Integrated Critical Zone Model

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The Critical Zone: Treetop to Bedrock

SOIL FUNCTIONS

- Food and fibre production
- Filtering water
- Transforming nutrients
- Carbon storage
- Biological habitat
- Gene pool

- EU Thematic Strategy for Soil Protection, EC (2006) outlines soil functions and soil threats.

Modeling Soil Functions and Soil Threats

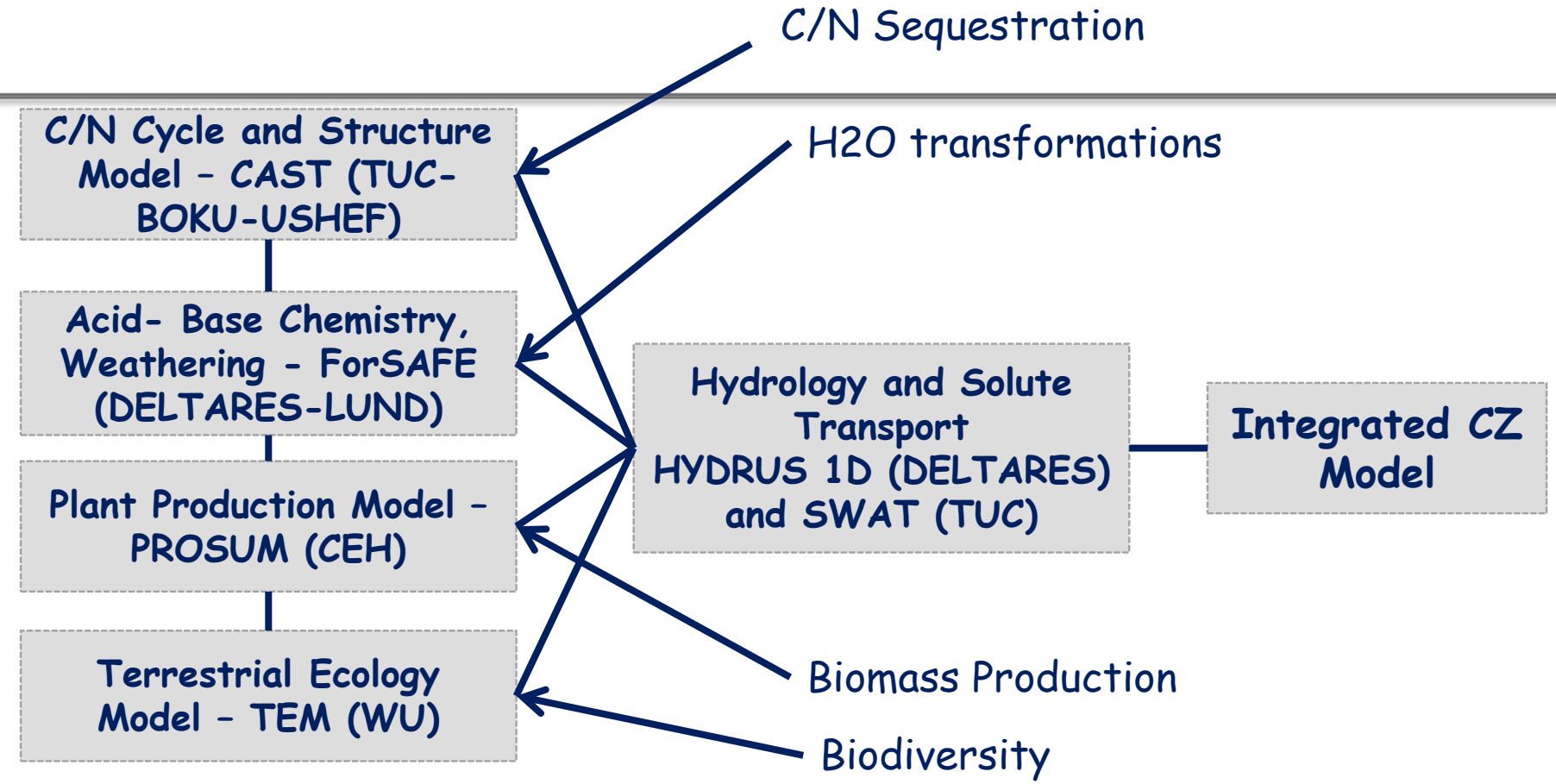
Soil Functions…

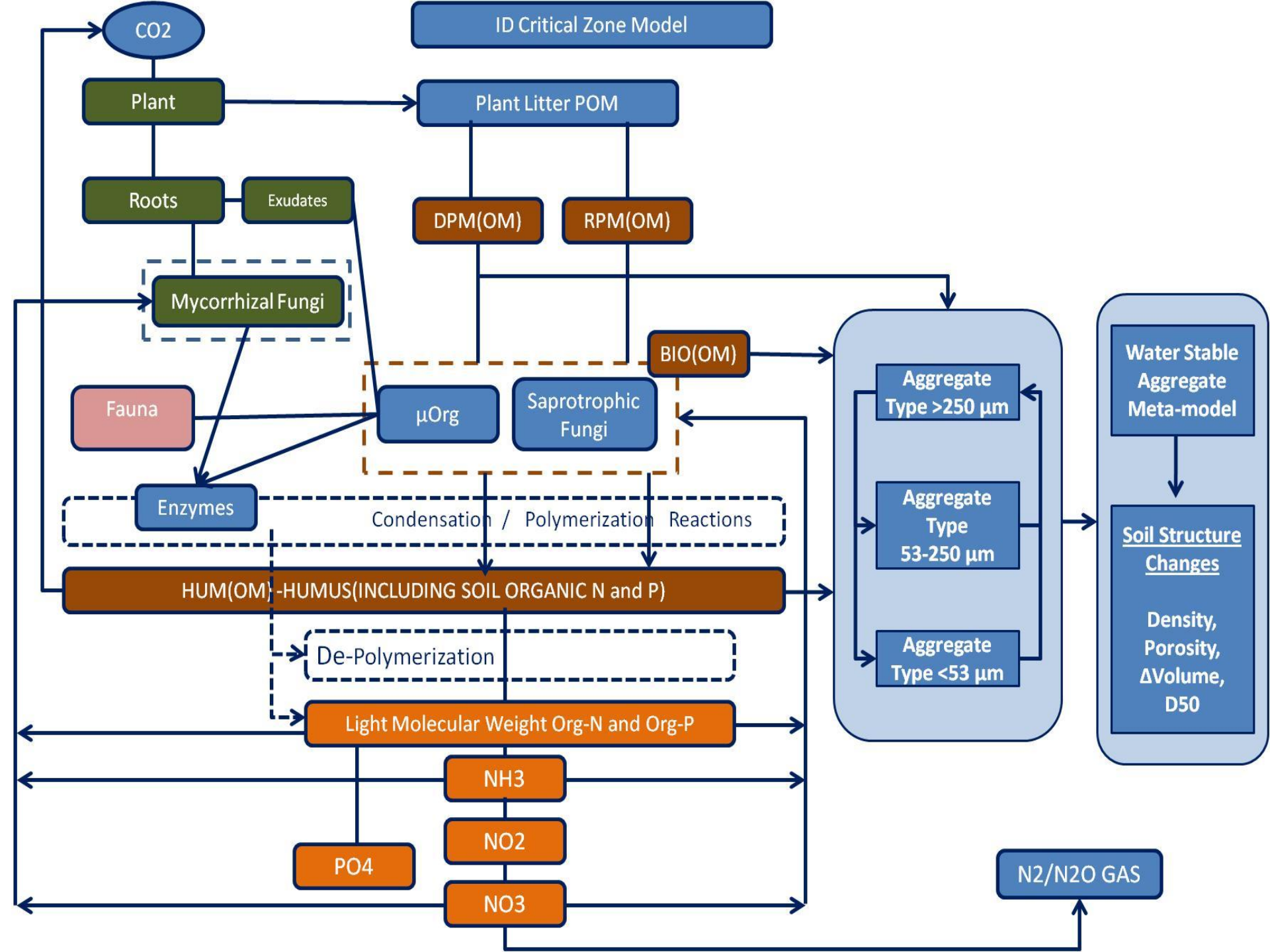
1. Food and biomass production
2. Carbon and nitrogen sequestration
3. Habitat and gene pool (biodiversity)
4. Filtering and transformations

Soil Threats…

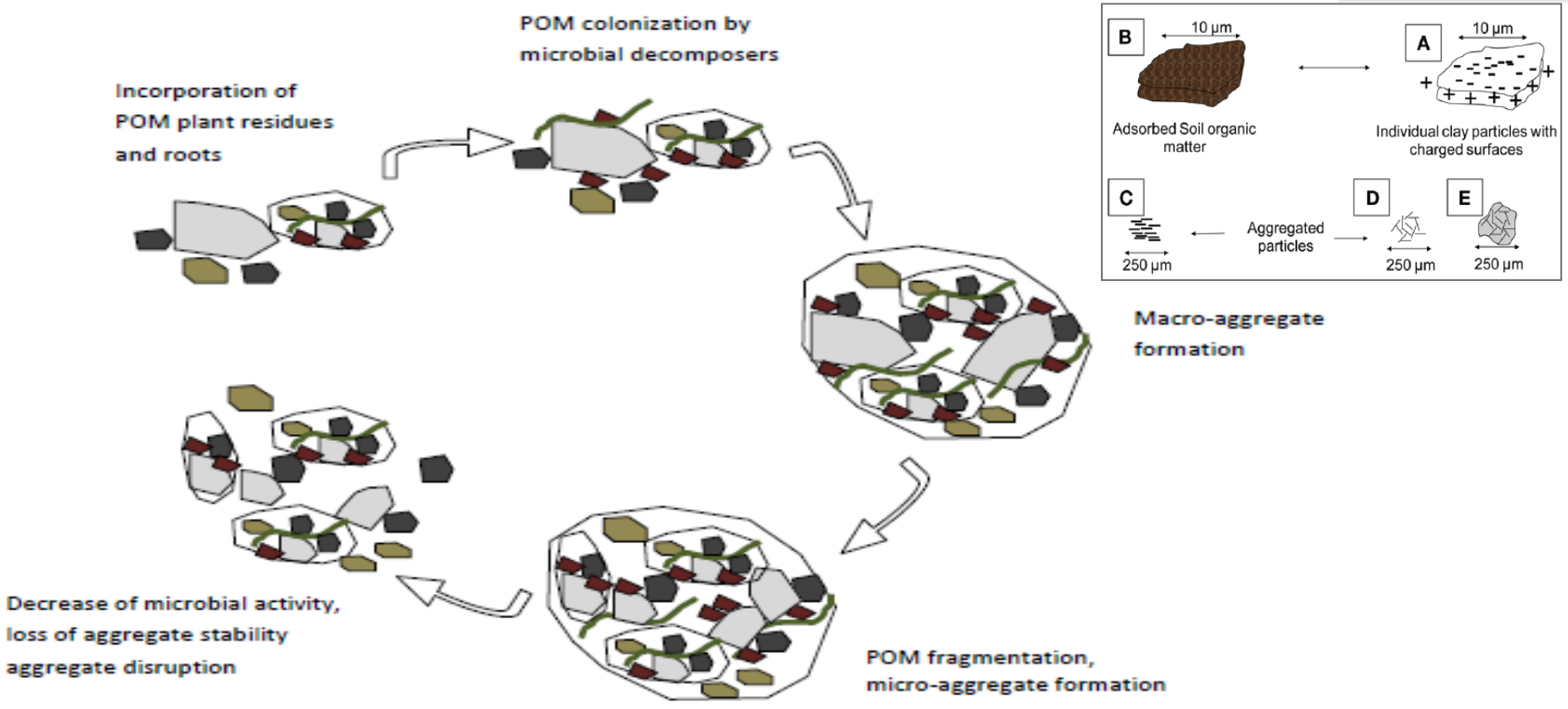
1. Loss of organic matter
2. Loss of biodiversity
3. Erosion
4. Compaction

Integrated CZ Model - Soil Functions




ID Critical Zone Model
CO2
Plant
Plant Litter POM
Roots
Exudates
DPM(OM)
RPM(OM)
Mycorrhizal Fungi
BIO(OM)
Fauna
µOrg
Saprotrophic Fungi
Enzymes
Condensation / Polymerization Reactions
HUM(OM)-HUMUS(INCLUDING SOIL ORGANIC N and P)
De-Polymerization
Light Molecular Weight Org-N and Org-P
NH3
NO2
NO3
PO4
N2/N2O GAS
Aggregate Type >250 µm
Aggregate Type 53-250 µm
Aggregate Type <53 µm
Water Stable Aggregate Meta-model
Soil Structure Changes
Density, Porosity, ΔVolume, D50

CAST Model – Conceptual Structure



ROTH-C MODEL

Initialize with cropland:

DPM+RPM=POC

BIO+HUM+IOM=silt-clay related carbon

BIO = 3% of SOC

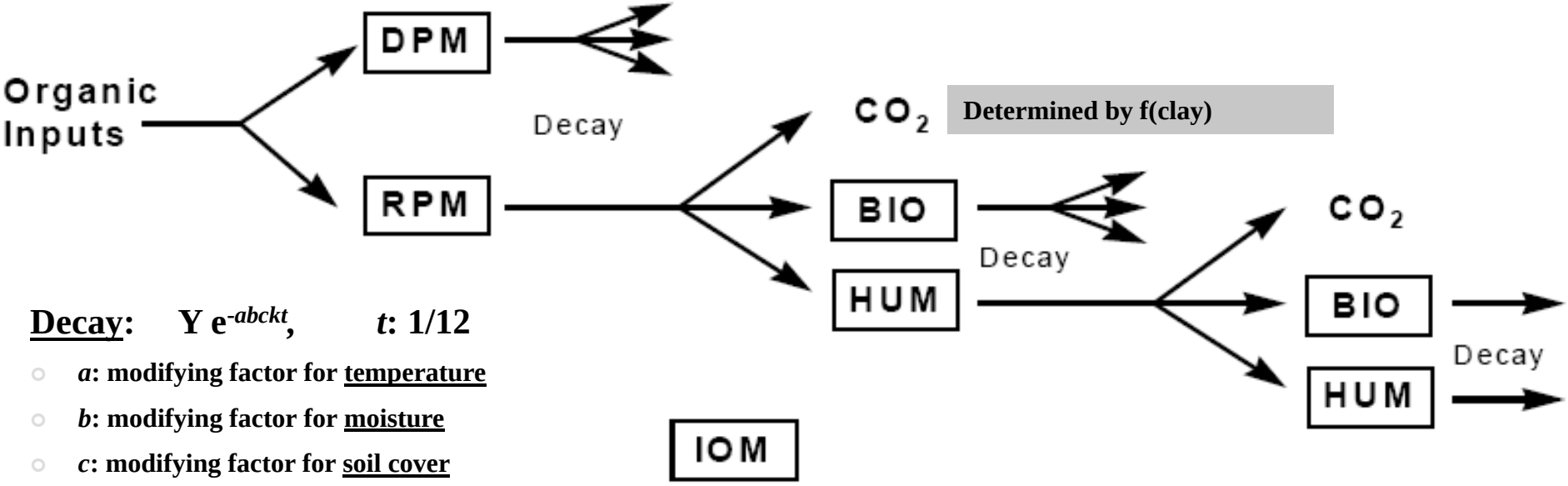
IOM = 0.049*SOC$^{1.139}$

DPM/RPM ratio

crops and improved grassland: 1.44

unimproved grassland and scrub: 0.67

Forest: 0.25



Decay: $Y\ e^{-abckt}$, ***t*: 1/12**

- ***a*: modifying factor for temperature**
- ***b*: modifying factor for moisture**
- ***c*: modifying factor for soil cover**
- ***k*: the decomposition rate constant, y^{-1}**

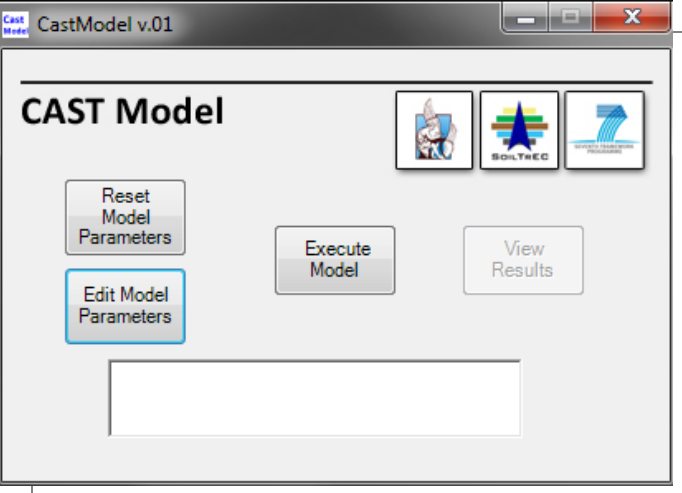
RPM : Resistant Plant Material

DPM : Decomposable Plant Material

BIO : Microbial Biomass

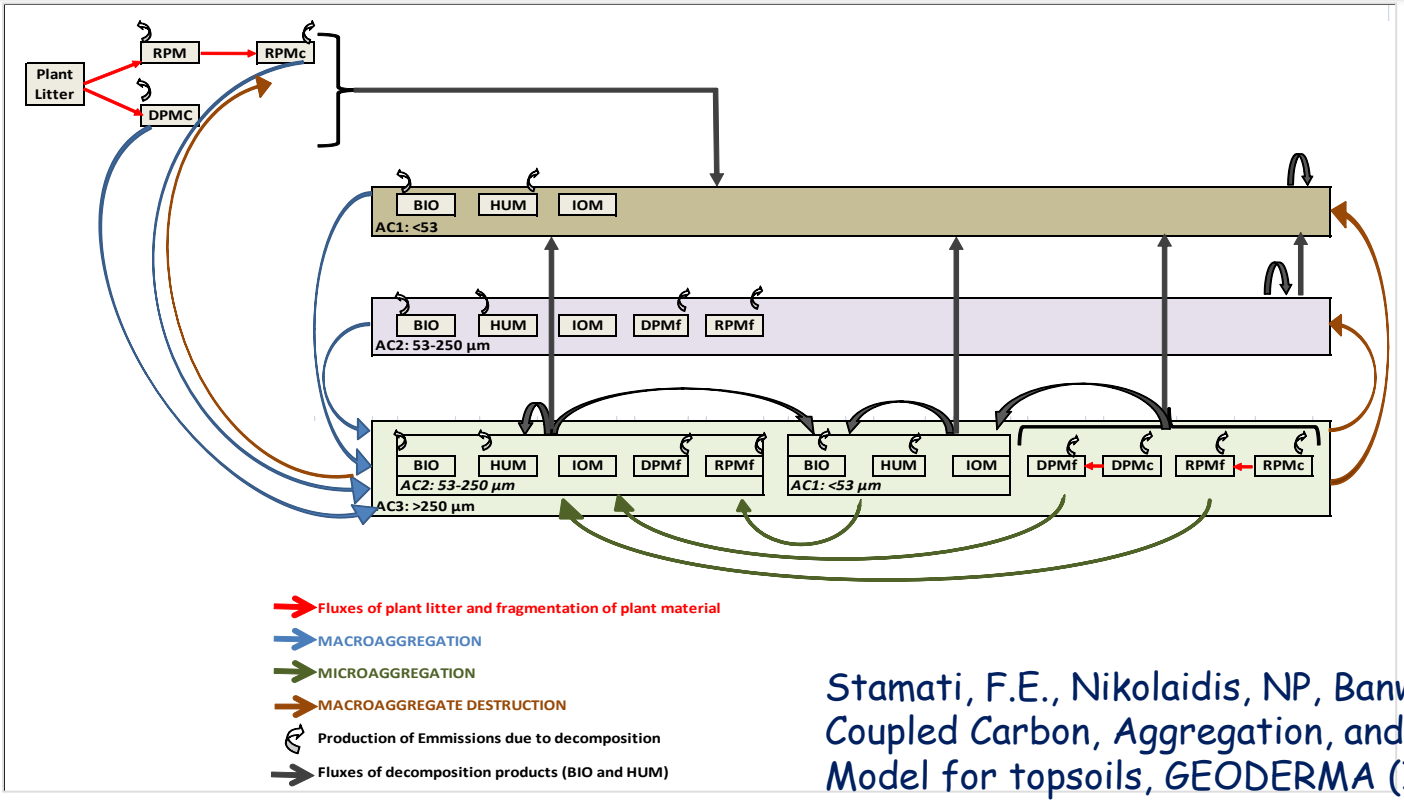
HUM : Humified OM

IOM : Inert Organic Matter



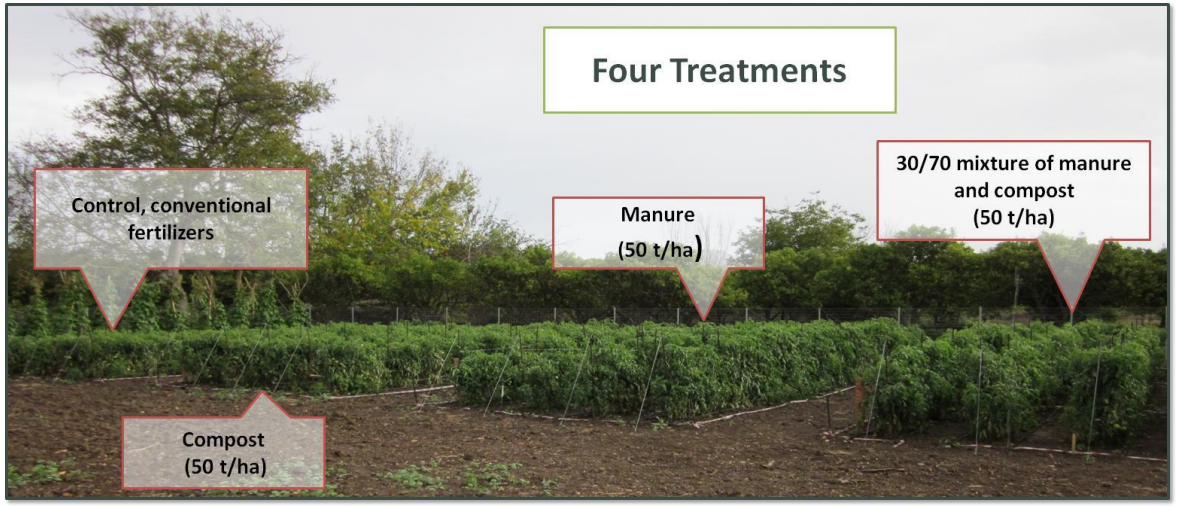
CAST Model – Conceptual Structure

SEVENTH FRAMEWORK PROGRAMME



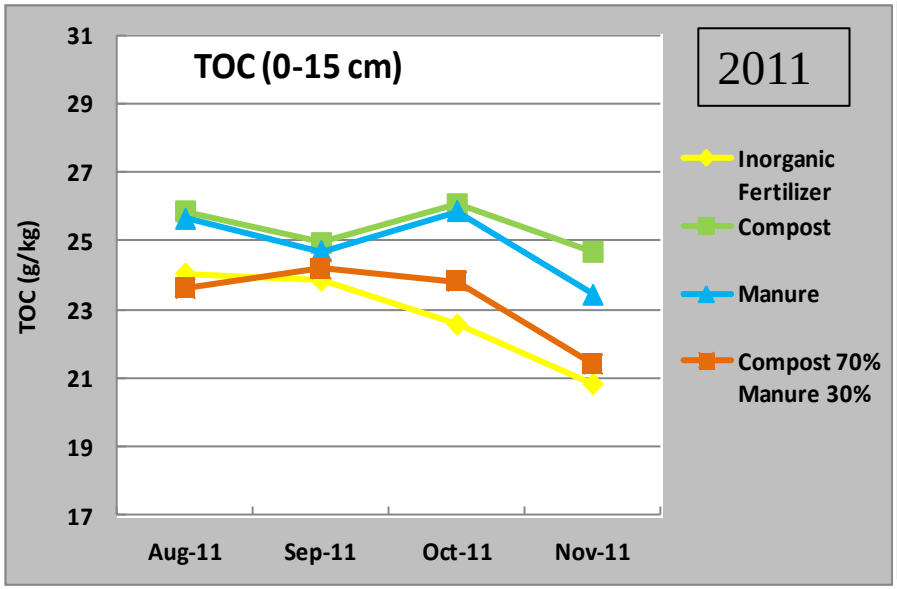
Stamati, F.E., Nikolaidis, NP, Banwart, S.W., Blum, A., Coupled Carbon, Aggregation, and Structure Turnover Model for topsoils, GEODERMA (In Press)

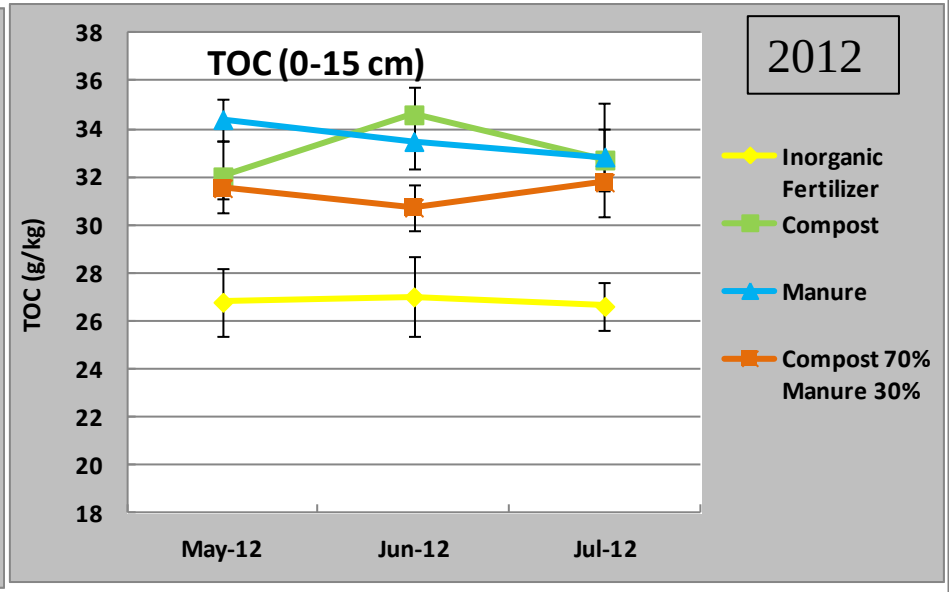
Carbon Amendments – Soil Fertility and Structure



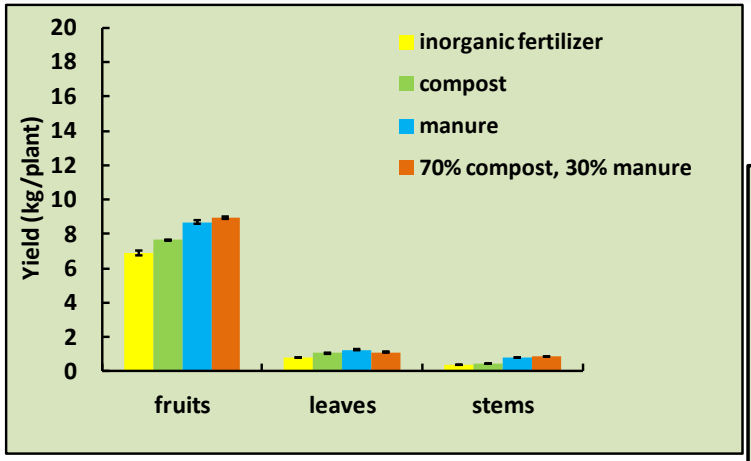
Properties
Water content profiles
Field capacity
Bulk density
Soil texture
WSA determination
Soil pH and electrical conductivity
Organic C and total N
Extractable P
PMN (Potential Mineralizable Nitrogen)
EMN (Exchangeable Mineral Nitrogen)
Net N mineralization rate
Net nitrification rate
Bulk chemical analysis

Carbon Sequestration (2011-2012)



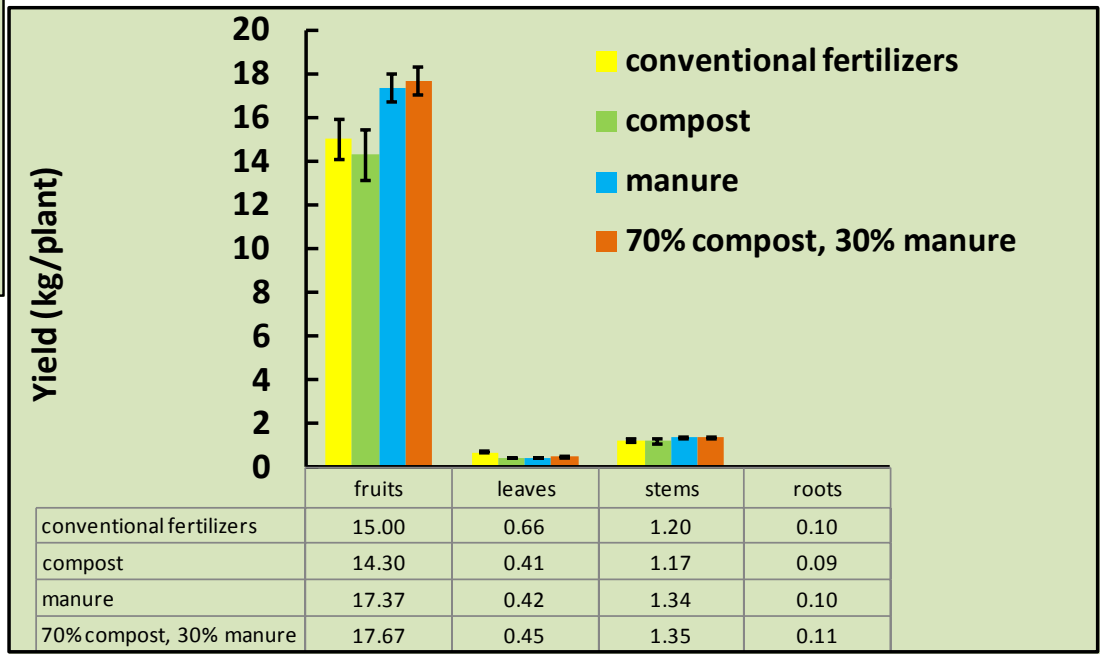


Carbon Amendments – Primary Productivity



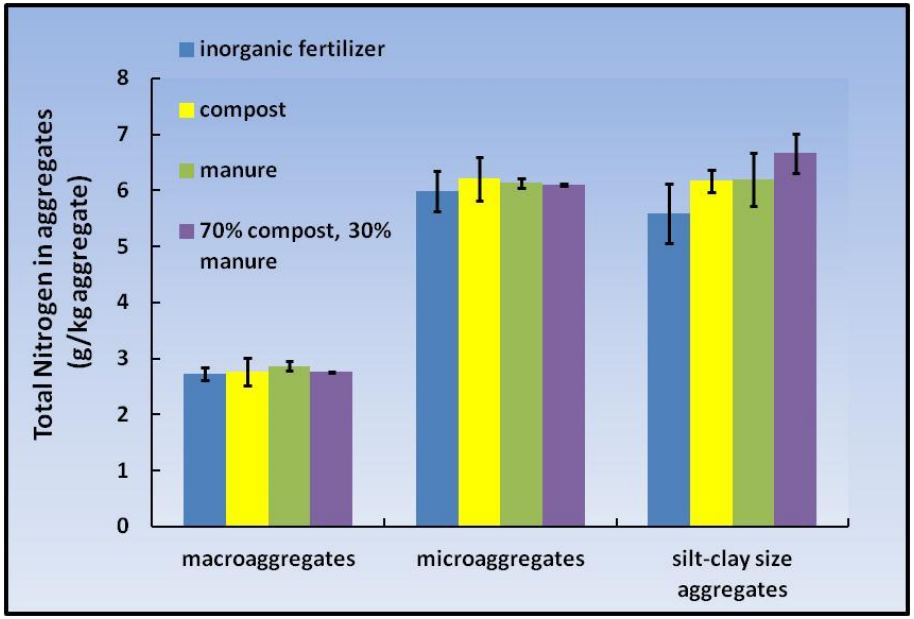
2011

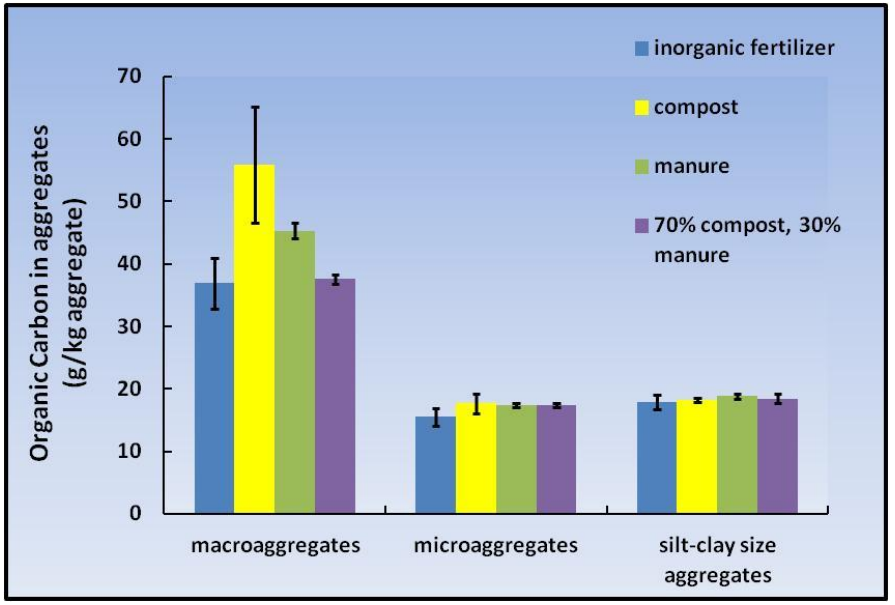
2012



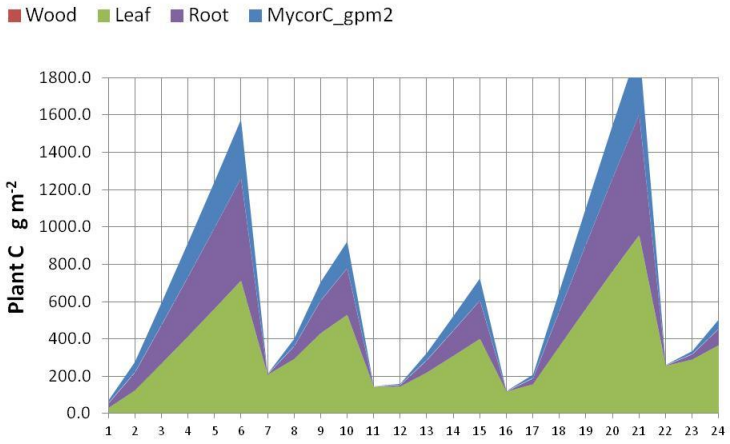
	fruits	leaves	stems	roots
conventional fertilizers	15.00	0.66	1.20	0.10
compost	14.30	0.41	1.17	0.09
manure	17.37	0.42	1.34	0.10
70% compost, 30% manure	17.67	0.45	1.35	0.11

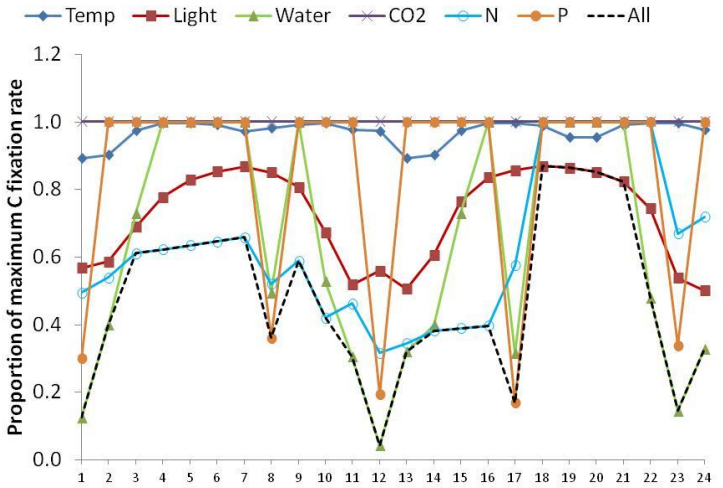
Carbon Amendments – Soil Fertility and Structure



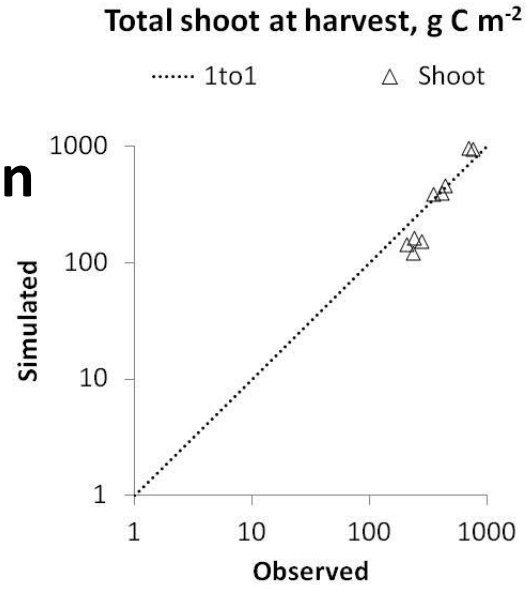


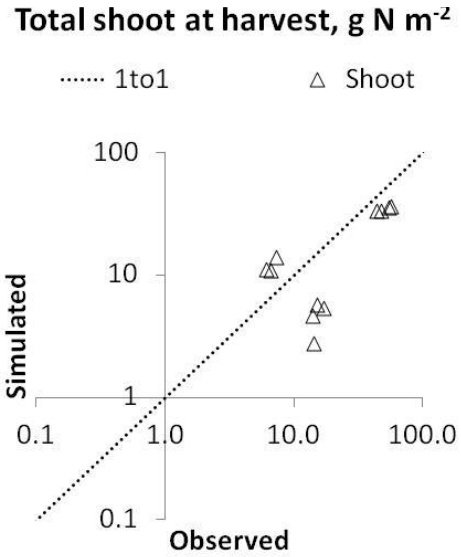
1D-ICZ Model – Plant Module Results



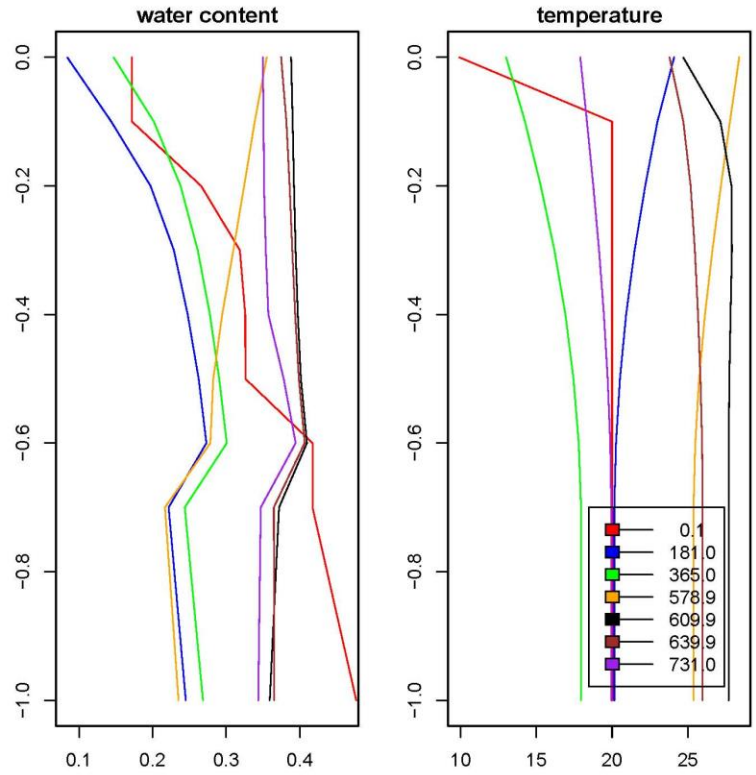


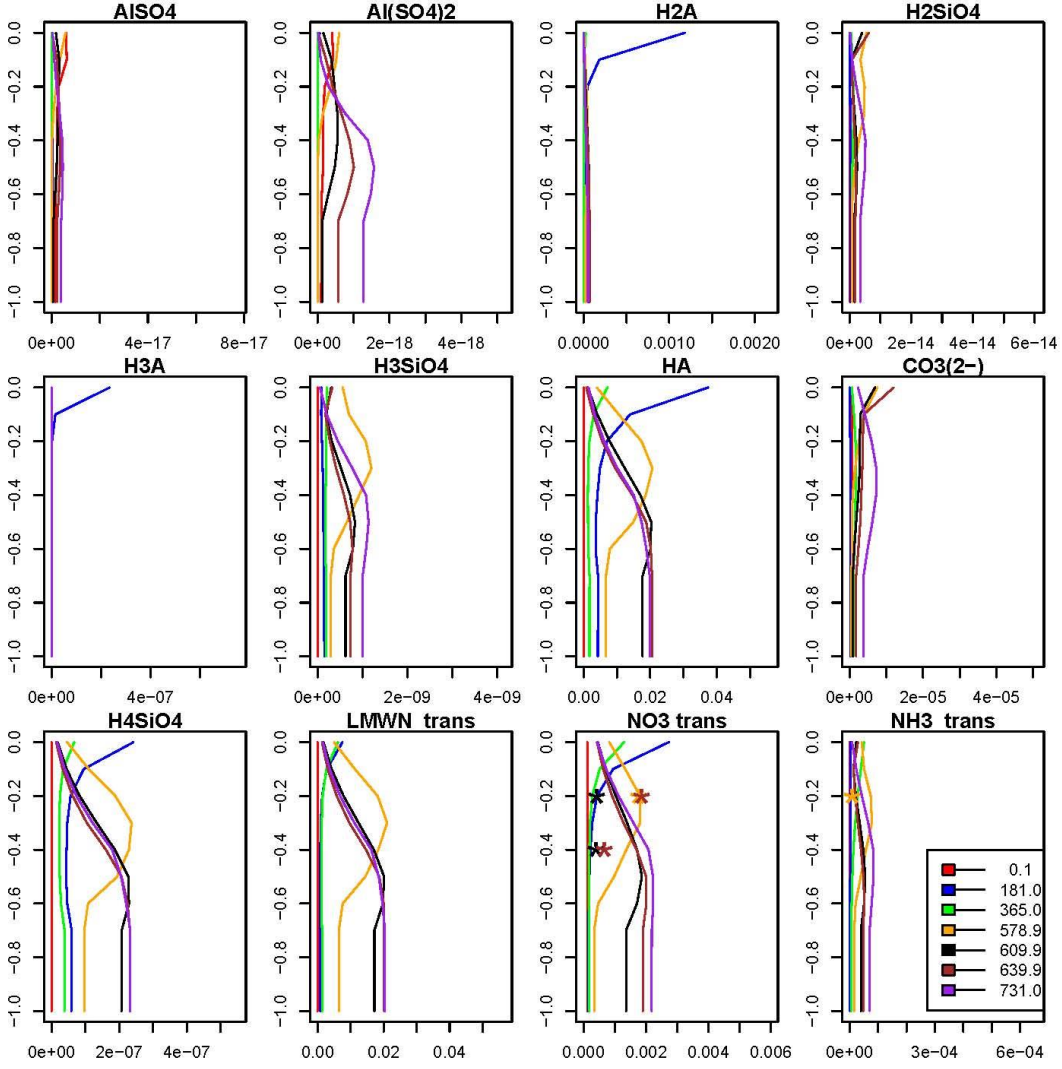
Biomass Production





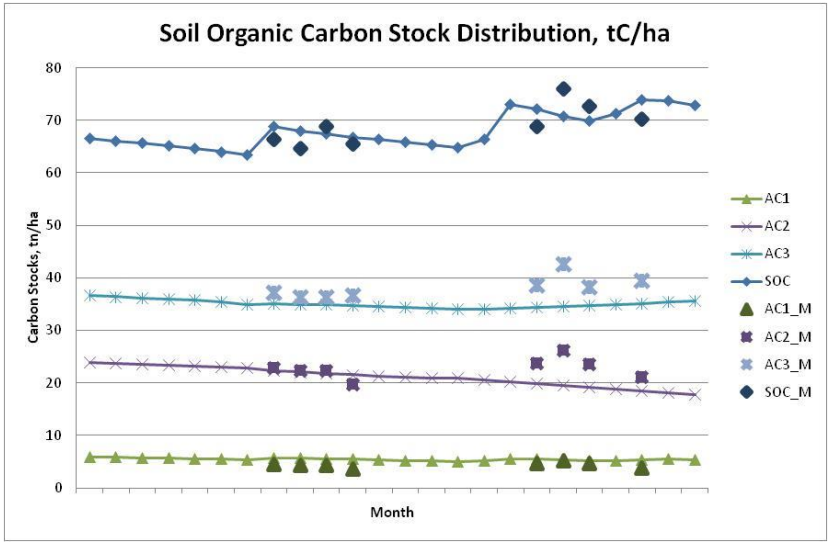
1D-ICZ Model – Solute Transport Module Results

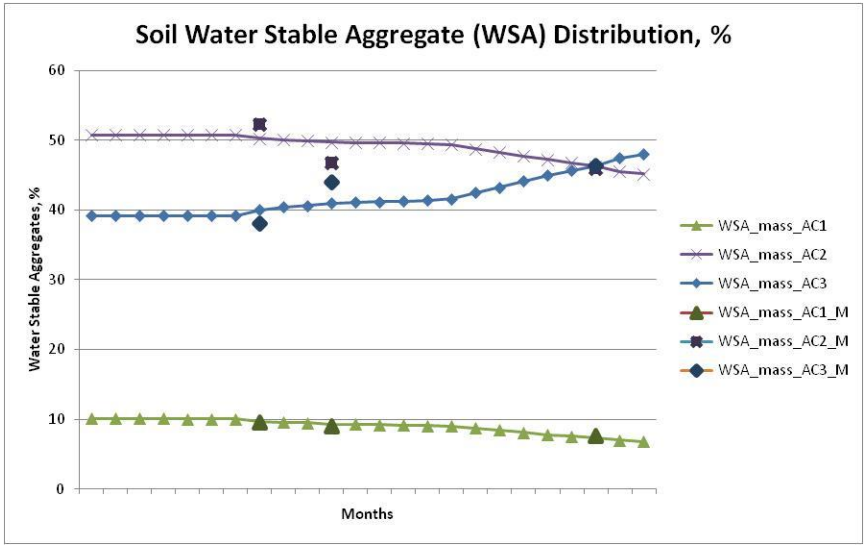




Water Filtration and Transformation

1D-ICZ Model – C/N/P and Soil Structure Module
Simulation of 2 year of Compost Addition

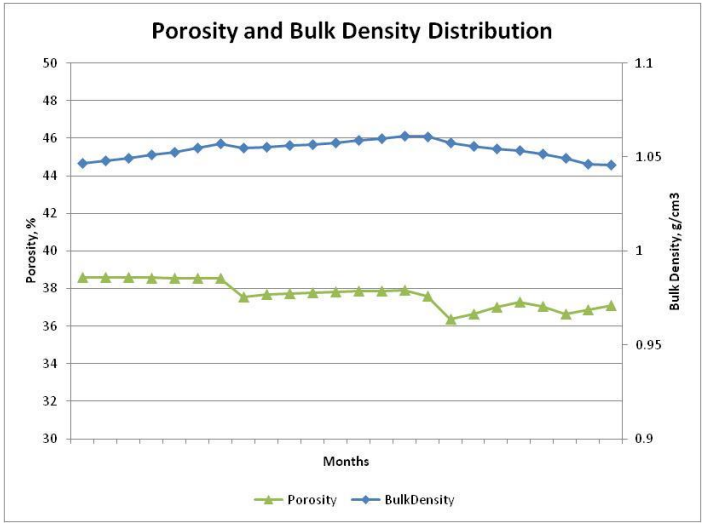




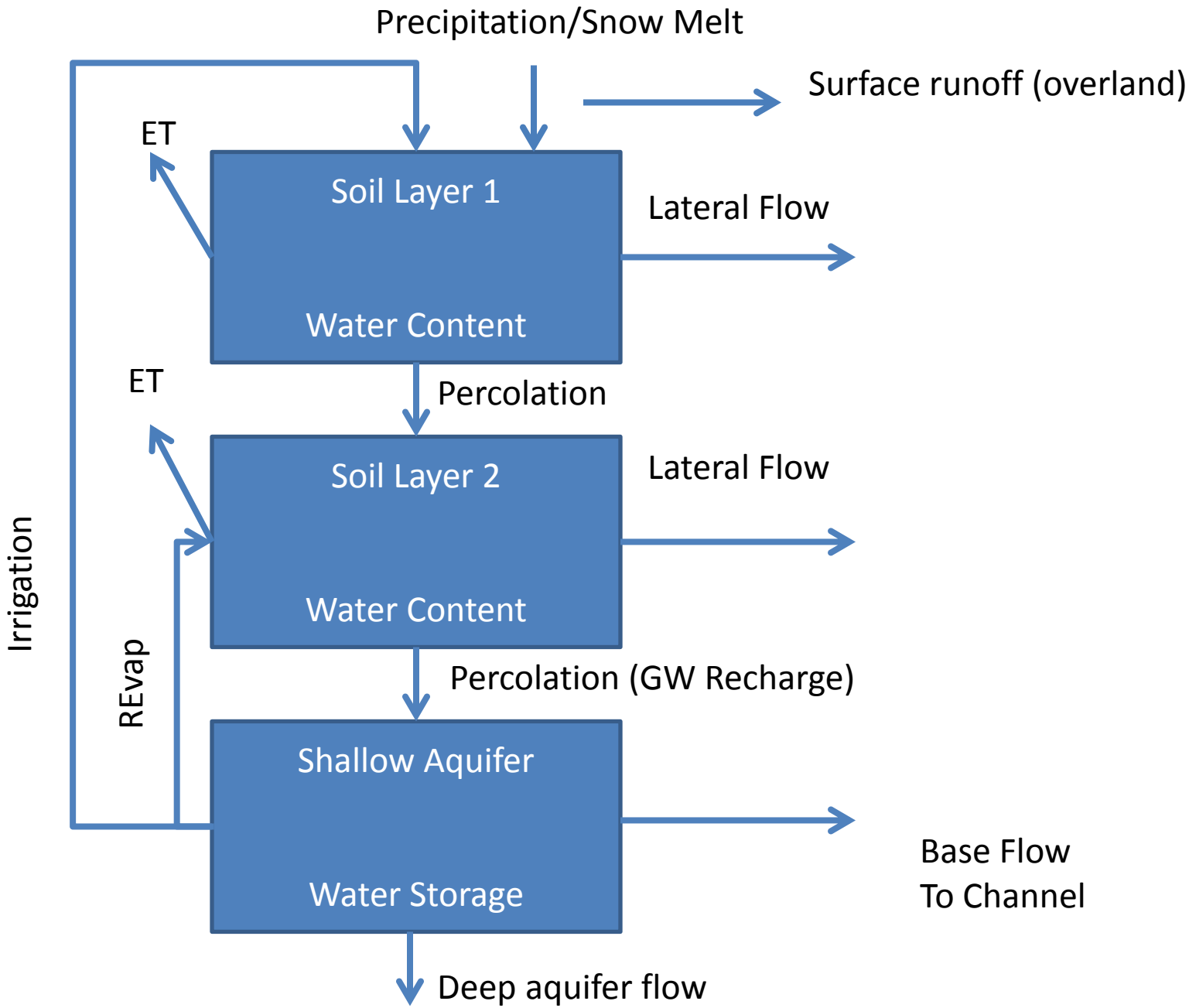
Carbon sequestration

Water Stable Aggregates – soil fertility

Porosity & Bulk Density – soil structure

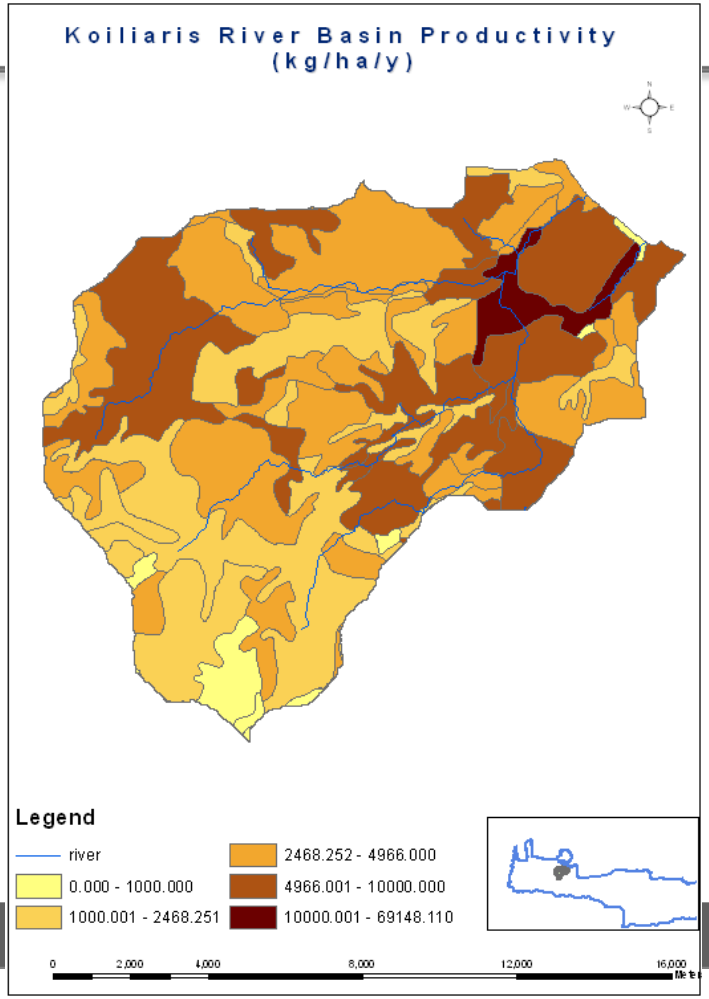


Hydrologic Representation of SWAT

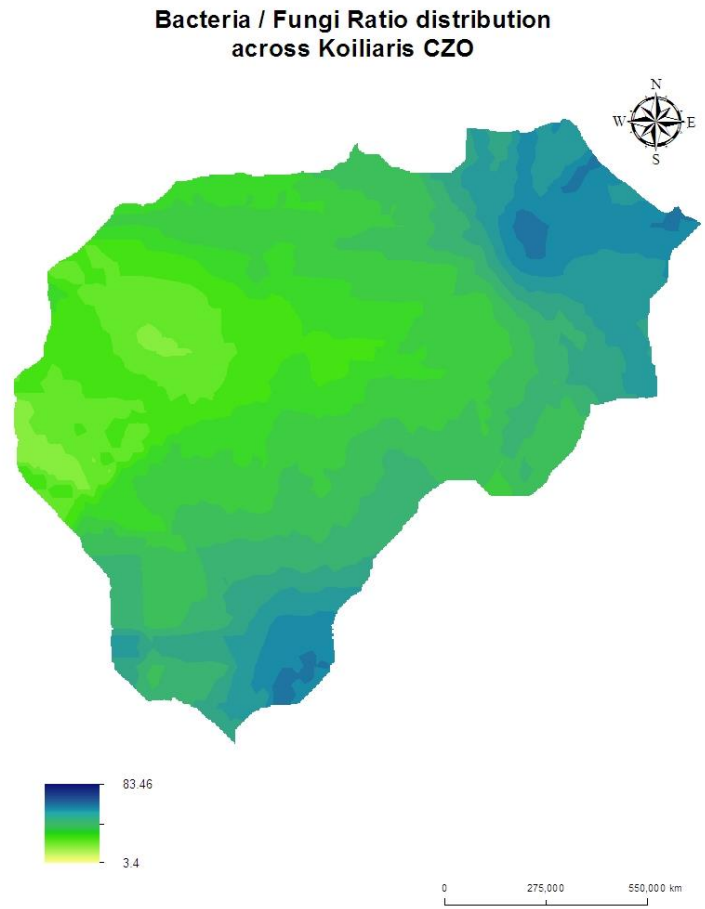


Soil Function Status of Koiliaris CZO

Biomass Production

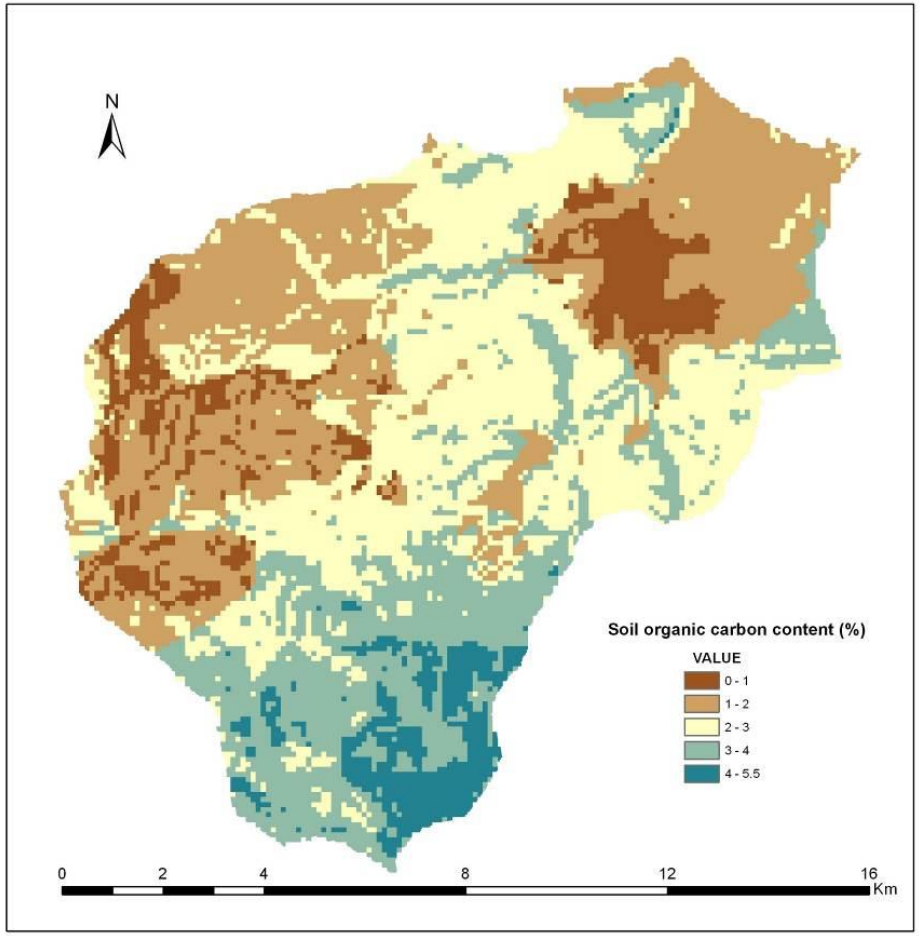


Biodiversity



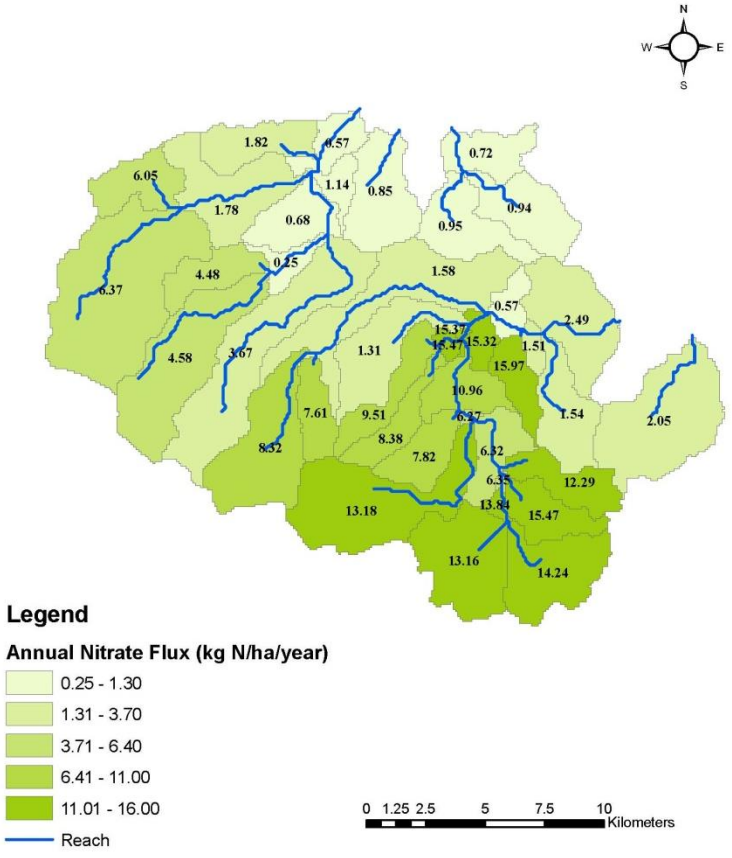
Soil Function Status of Koiliaris CZO

Carbon Sequestration

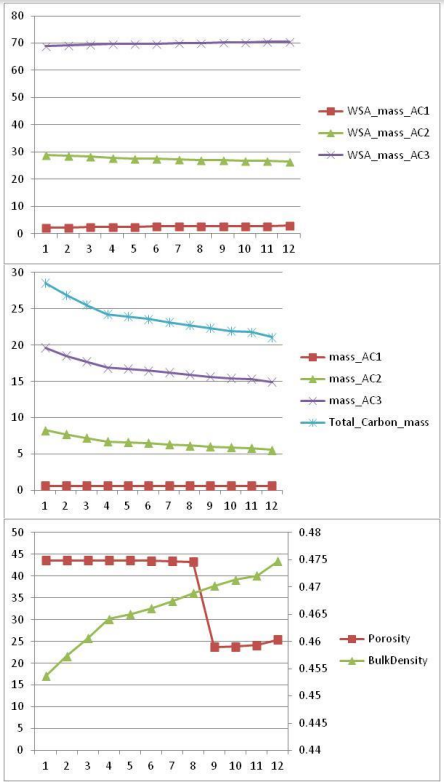


Water Filtration and Transformation

Annual Nitrate Flux to the Reach - Wet Year



ICZ Model – Dynamic Linking to Soil Structure



WSA

SOC

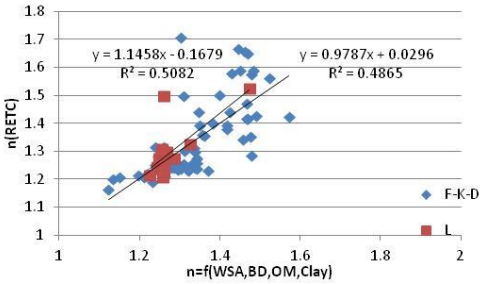
BD

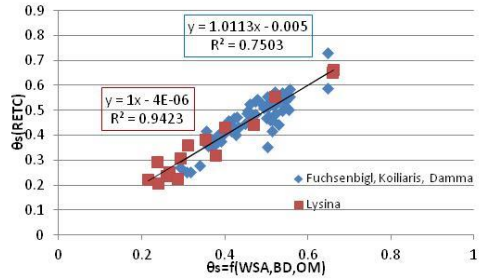
Pedotransfer Functions

Θs

α

n





As a function of WSA, SOC and BD

1D-ICZ

SWAT-ICZ

Conclusions and Scientific Advancement

Rigorous simulation and quantification of critical soil functions and ecosystem services:

- C, N and P storage in soils, a fundamental soil function which is simulated dynamically, including relationships between soil structure and organic matter protection;
- Biomass production including effects of mycorrhizae and exudates on nutrient acquisition;
- Quantification of C in microorganisms, fungi and consumers, as an index of soil biodiversity; and
- Water transformations and filtration and simulation of the weathering of base cations / nutrient elements.


Thank You