AVEC Workshop.

Effects of land abandonment and global change on plant and animal communities.

Can we distinguish between climate and land abandonment effects?

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Outline

- Introduction : some thoughts on the issue
- Climate change within the context of climate variability
- Climate impacts mediated by land use/cover
- Climate impacts mediated by *land*
- A landscape *mosaic* of responses
- Conclusions?

Some thoughts :1

- Climate change (CC) impacts
  - Comparable with those of current climate variability
  - Complex, non uniform and **not** without feedback!
  - Long term, large area
  - Transient change of state (not usually rapid)
  - Ecological and hydrological degradation of marginal Mediterranean ecosystems
  - Increasing spatial and temporal complexity (Patch-ification!)

Some thoughts :2

- Land abandonment (LA) impacts
  - Also not without feedbacks
  - Shorter term, smaller area
  - Usually threshold change of state
  - Ecological and hydrological aggradation of Marginal Mediterreanean ecosystems
  - Increasing spatial and temporal uniformity (De-patchification!)

Some thoughts :3

- Combined impacts
  - LA and CC interact to determine impacts
  - Impacts occur at a range of scales
  - Impacts can be transient and threshold
  - Outcome dependent on land use/cover, *land*, and climate
  - ‘Green’ patches responding in a different way to ‘brown (grey)’ patches
  - A spatial and temporal mosaic of responses

Approach

- **(a) understand the individual processes separately**
- **(b) integrate them within the context of dynamic, process based spatial models**

- 1 dimensional SVAT – modelling : focus on plant-hydrology interactions across different land uses, land types, climate changes (EFEDA, MEDALUS)

- 2 dimensional eco-hydrological modelling at the landscape scale : focus on aggregate (catchment) responses to land use and climate change (MODULUS)

- Policy support systems (PSS) – focus on process interaction and connectivity (MEDACTION, DESURVEY)

PATTERN 1D/2D SVAT/Growth Model

Key Processes

Cellsize : 1m

Timestep : variable (seconds to day/night)

Improving the data :

Weather Generator

Processes Modelled/downscaled

- Rainfall
- Solar Radiation
- Net Radiation
- PAR Radiation
- Temperature
- Wind speed

interacting :

Hydrology Model

Processes Modelled:

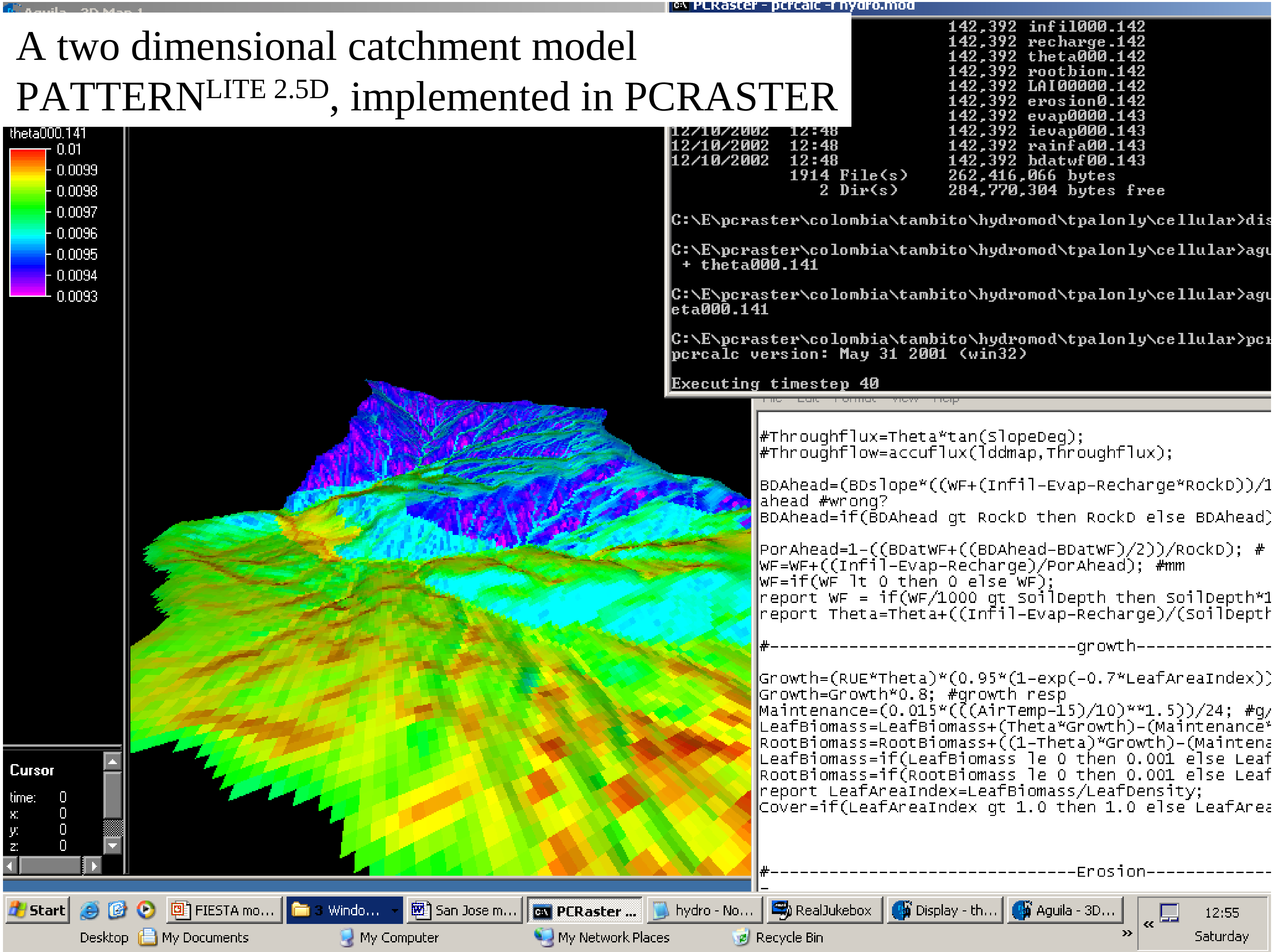
- Interception
- Infiltration
- Overland flow
- Routing
- Recharge
- Evapo-transpiration
- Erosion
- Soil moisture
- Surface water detention

Plant Model

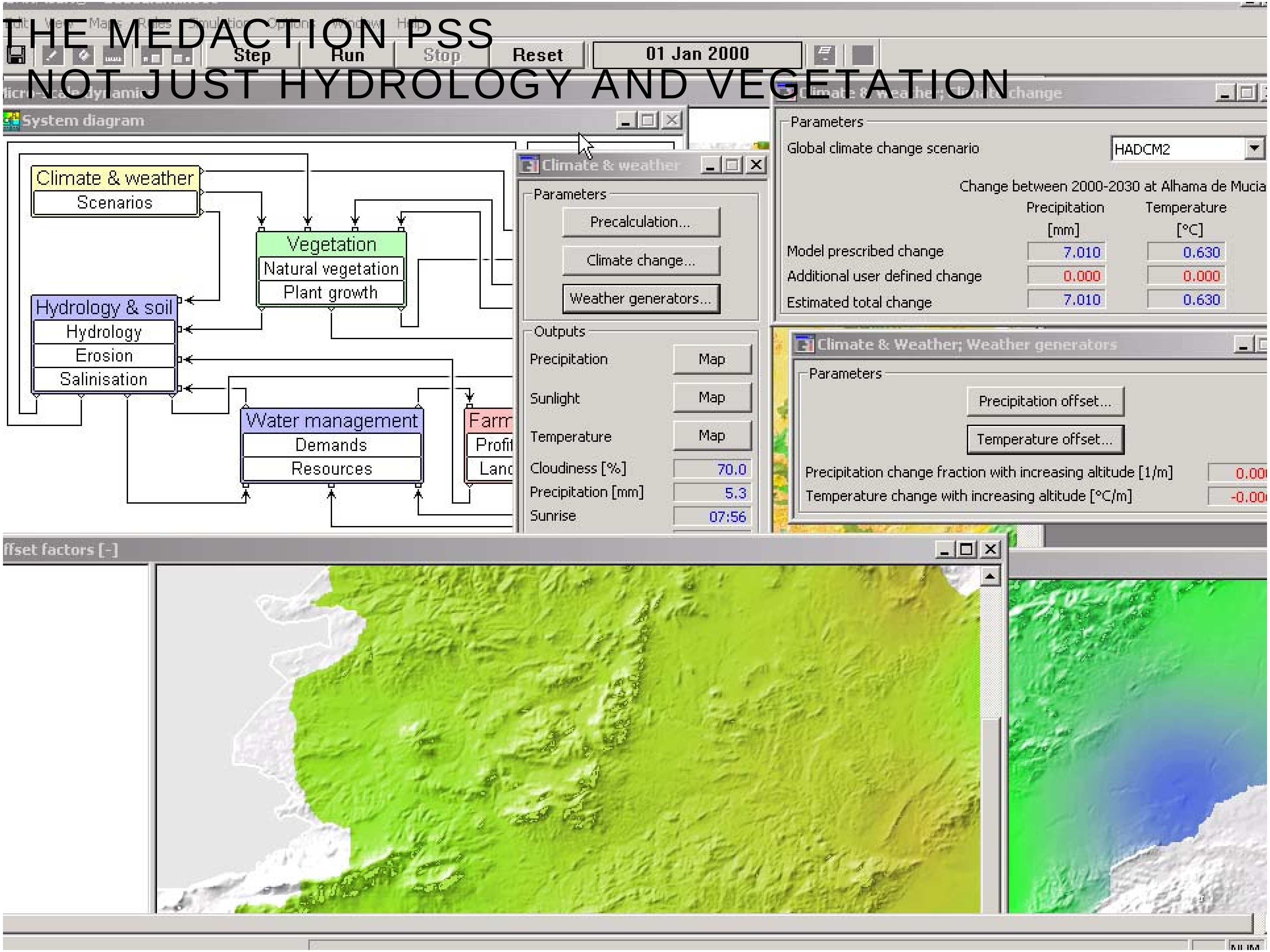
Processes Modelled:

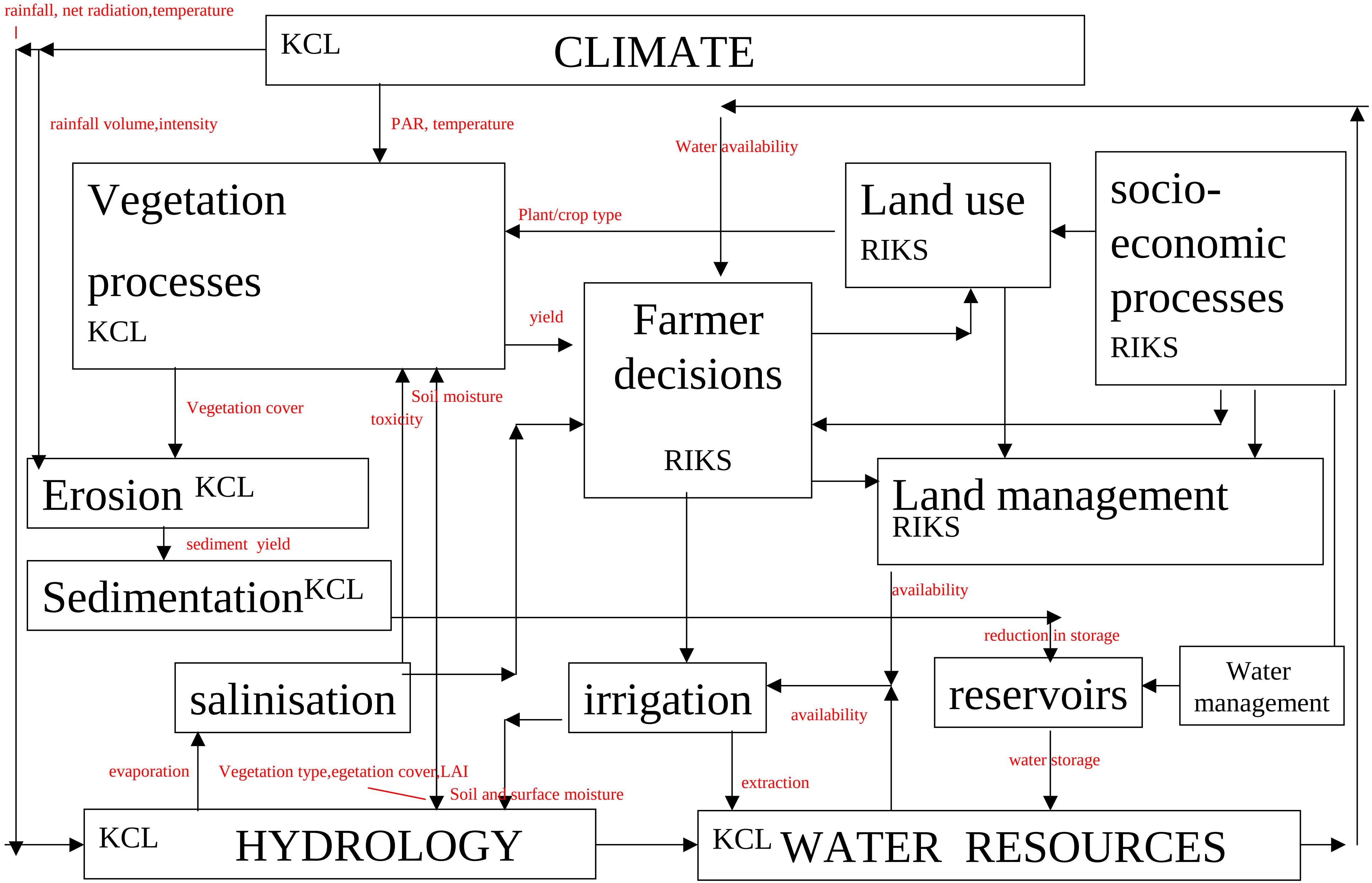
- Photosynthesis and respiration
- Biomass Allocation
- LAI and height increment
- Harvesting
- Sowing
- Germination

A two dimensional catchment model PATTERN$^{LITE\ 2.5D}$, implemented in PCRASTER

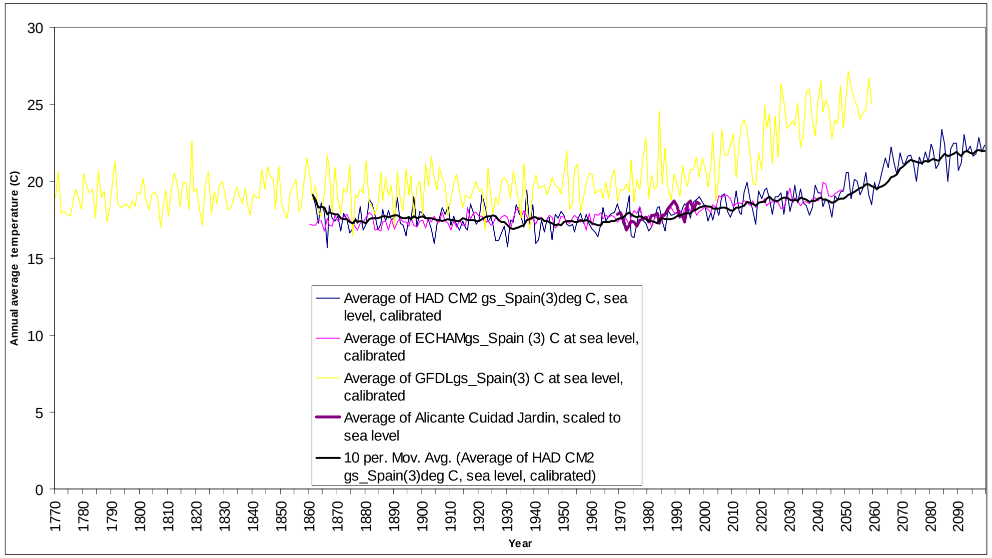


THE MEDACTION PSS
NOT JUST HYDROLOGY AND VEGETATION





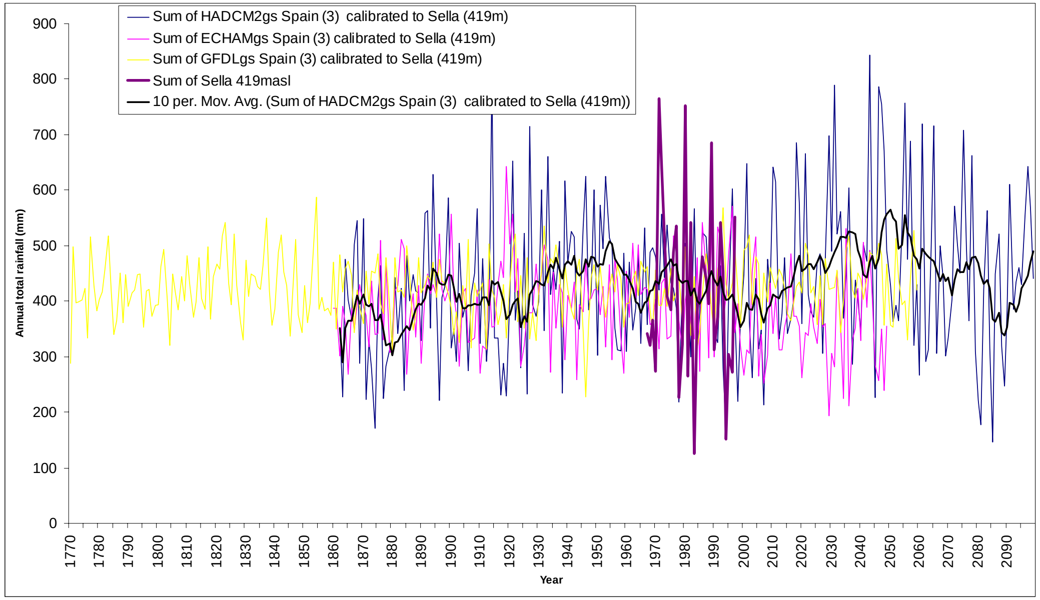
MEDACTION System diagram



Change in annual average temperature downscaled for Marina Baixa (sea level). HADCM2gs is represented in blue, GFDLgs in yellow and ECHAMgs in pink. The historic record for Alicante Cuidad Jardin is shown in purple.

...driven by climate change scenaria
…with integrated CA land use change model

Marina Baixa

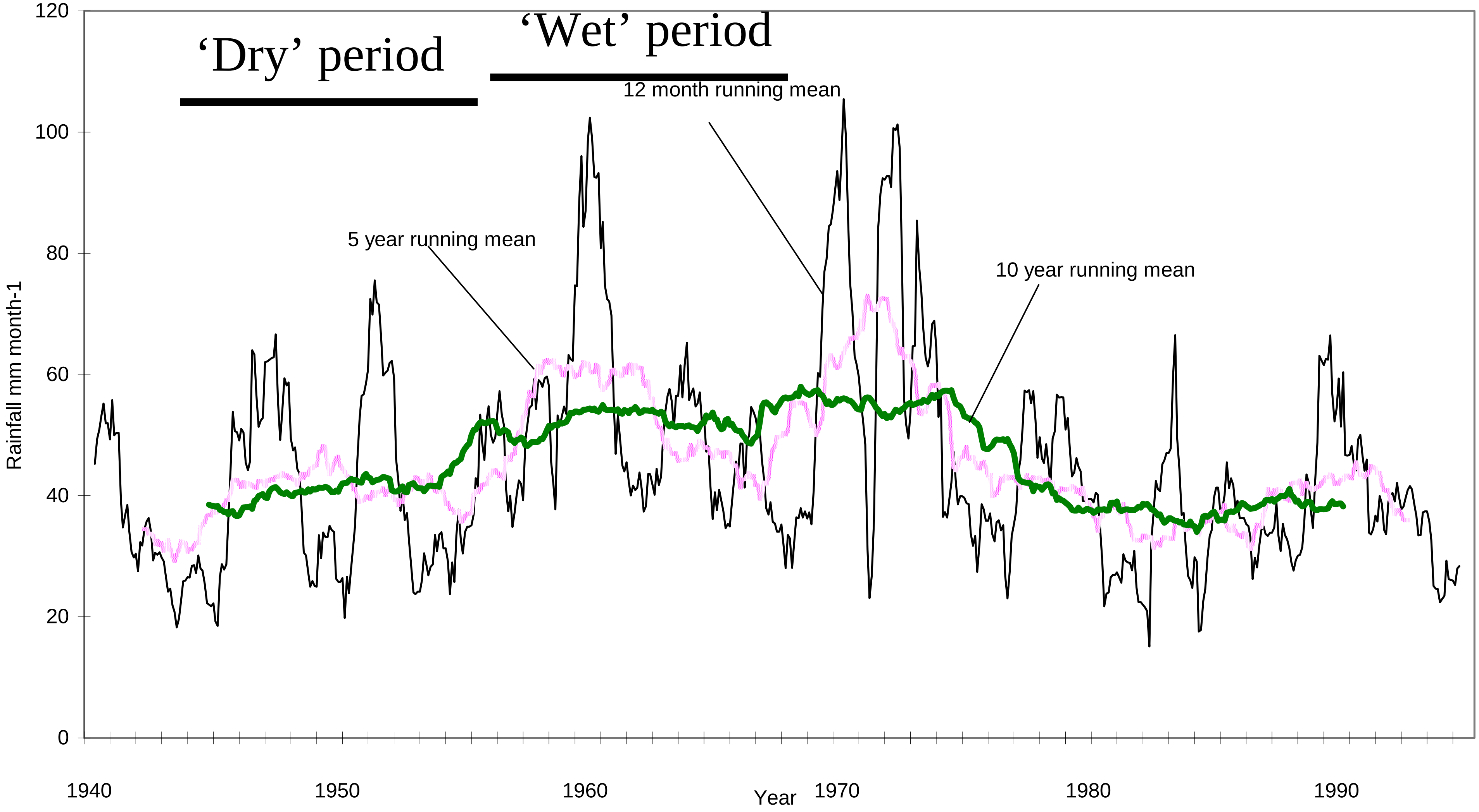


Change in annual total rainfall downscaled for Marina Baixa (419 m above sea level). HADCM2gs is represented in blue, GFDLgs in yellow and ECHAMgs in pink. The historic record for Sella is shown in purple

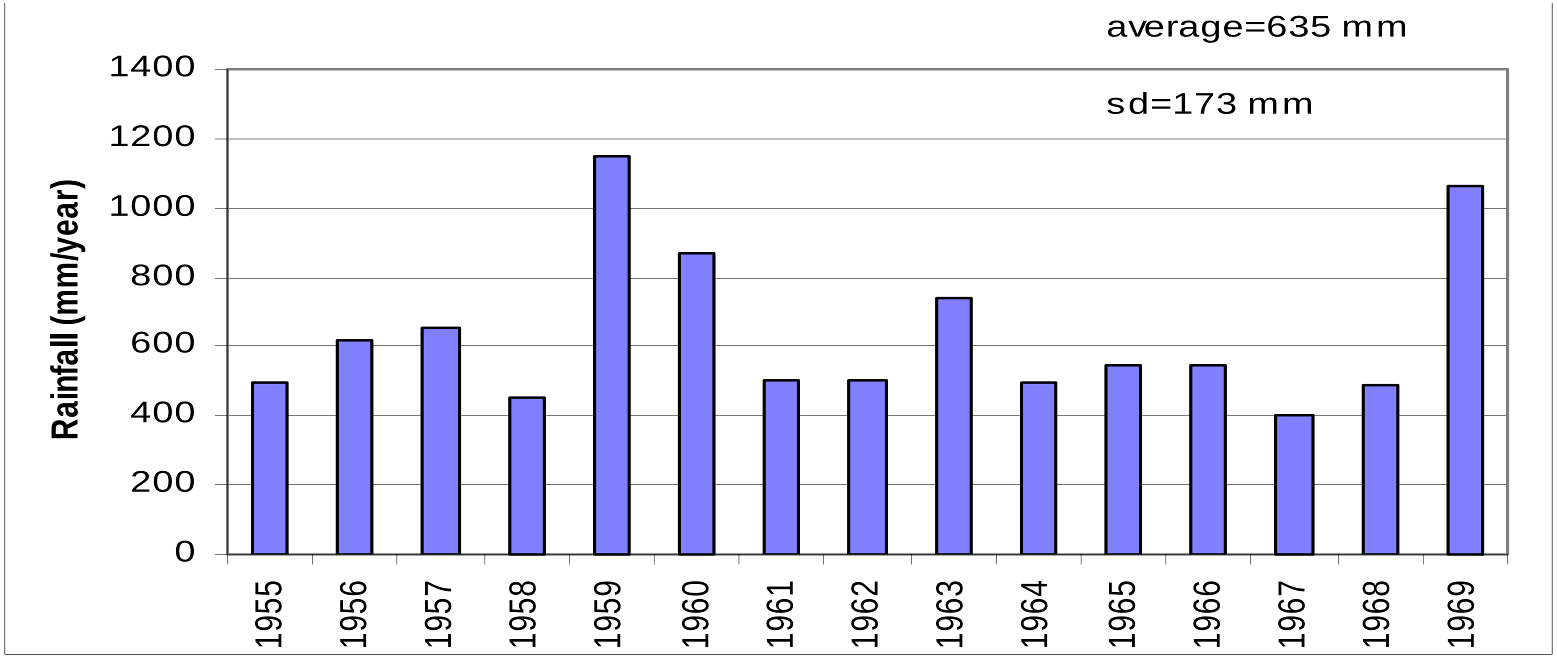
But…The context of climate variation

- Med. Climates extremely variable at all scales (especially for rainfall)
- Absolute rates of temporal climate variation much greater than those of climate change (especially for rainfall)
- Since rainfall is already biologically marginal in many areas, impacts of climate variation are significant
- Med. ecosystems highly adapted to climate variation (plant-soil feedbacks very tight)
- Thus transient climate change would have to be sustained and significant to have an important effect since plant system is already limited by climate variation

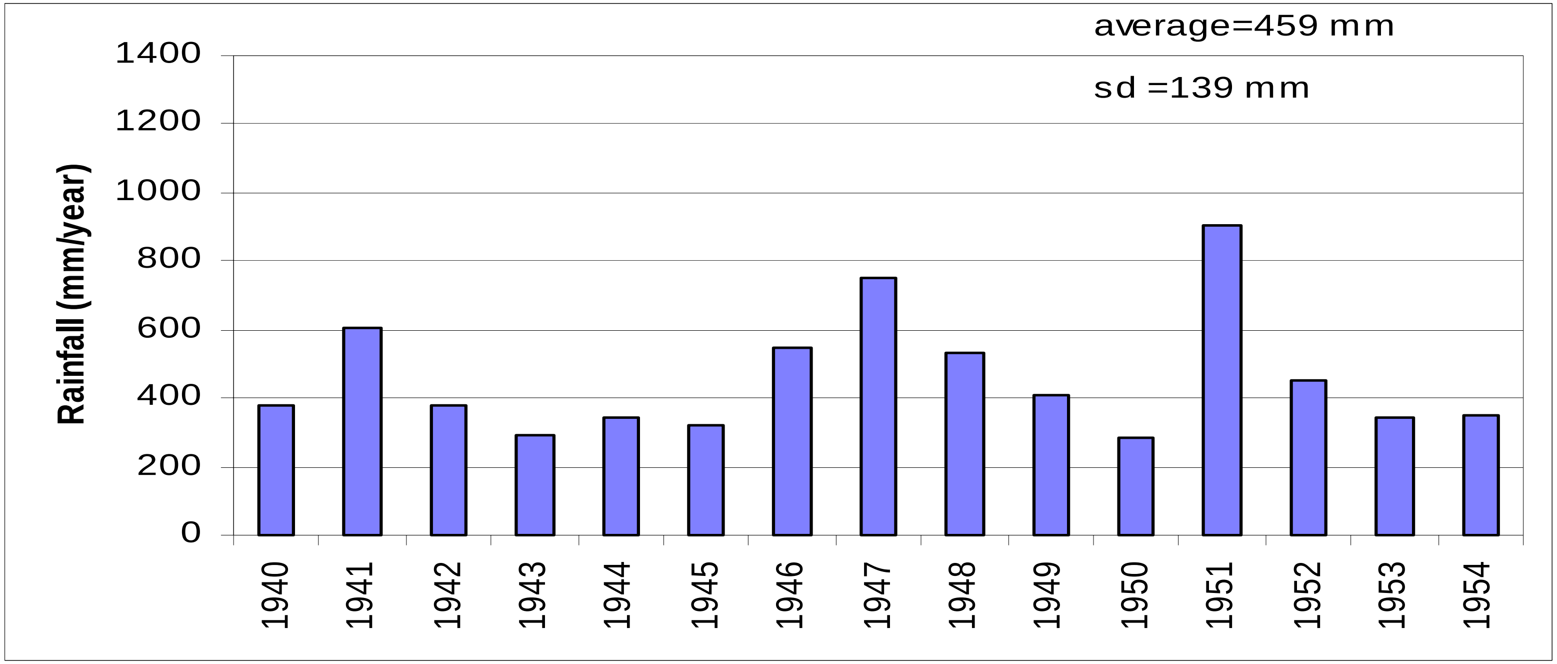
Rainfall variability : Castilla la Mancha, Spain



‘Wet’ period

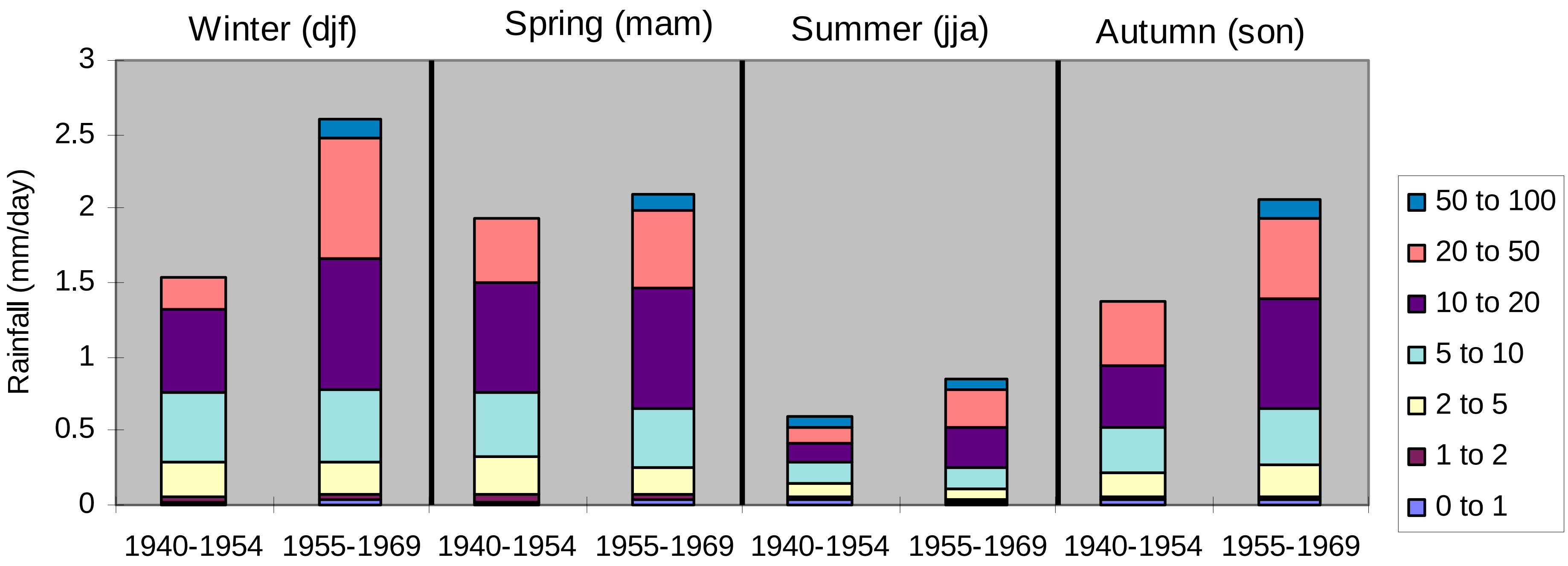


‘Dry’ period



Rainfall, Mota del Cuervo

Variation in rainfall intensity and seasonality



Comparison of rainfall between periods 1940-1954 (dry) and 1955-1969 (wet), Mota del Cuervo

Climate variation : equilibrium effects on hydrological fluxes

% change from (1940-54, dry) to (1955-1969, wet) : Mota del Cuervo					
	Winter	**Spring**	**Summer**	**Autumn**	**TOTAL**
Inputs					
Rainfall (mm/month)	+65%	+8%	+44%	+50%	**+38%**
Solar radiation (W/m^2)	-4.63%	+2.02%	+0.35%	-2.32%	**-0.85%**
Fluxes					
Infiltration (mm/month)	+63%	+7.71%	+42%	+49%	**+37%**
Evapotranspiration (mm/month)	+4.48%	+1.06%	+34%	+25%	**+13%**
Sum of Recharge (mm/month)	+130%	+20.55%	+160%	+156%	**+93%**
Soil Moisture (m^3water/m^3soil),	+7.60%	+0.62%	+2.27%	+6.66%	**+4.63%**
Soil Matric Potential (m water),	-30%	+3.24%	+1.08%	-28%	**-8.93%**
Surface runoff (mm/month)	+136%	+21%	+193%	+110%	**+87%**

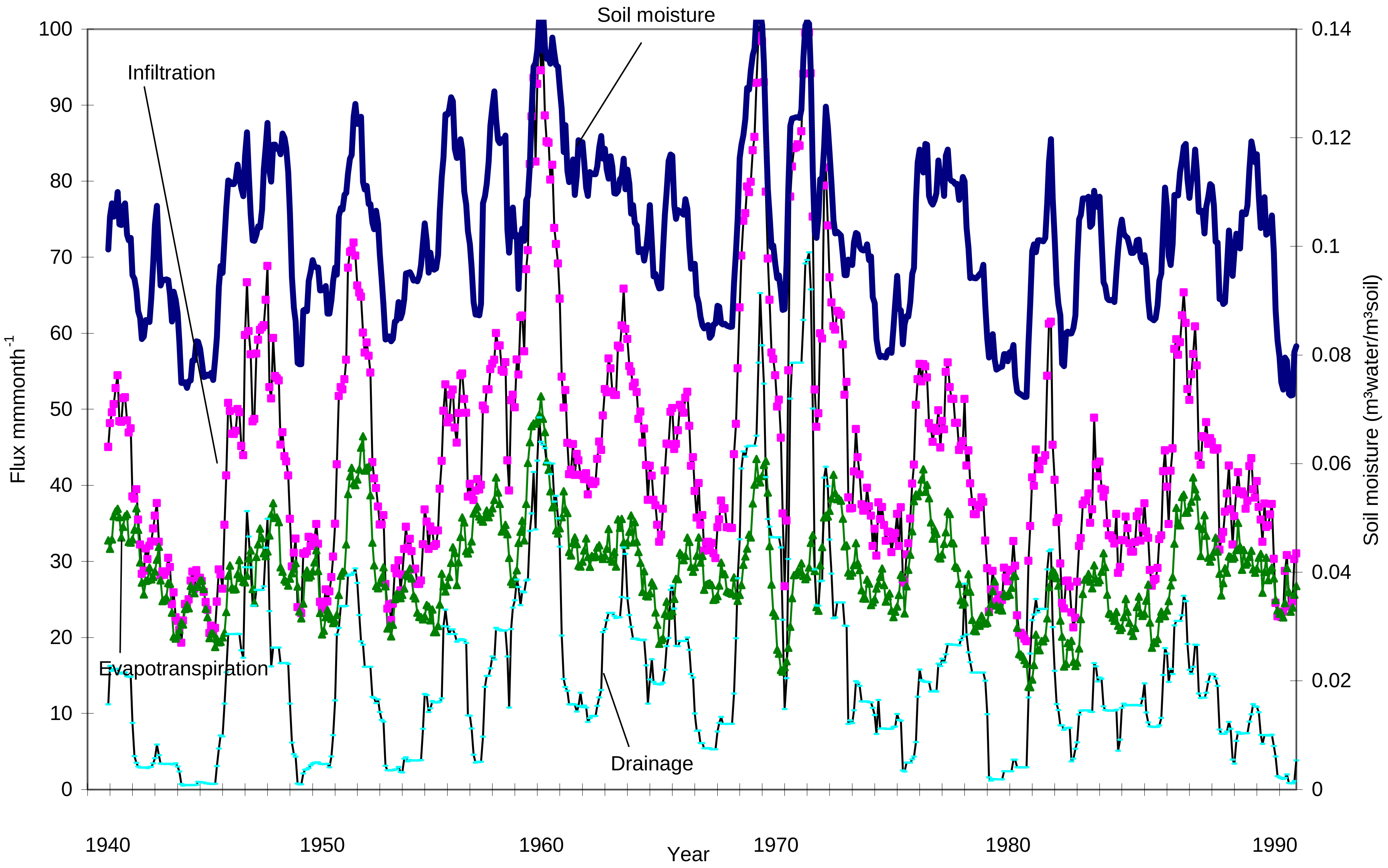
Table 3. Percentage change of inputs and hydrological fluxes between a dry period (1940-1954) and a corresponding wet period (1955-1969) for Mota del Cuervo. These are model results.

Rainfall increases 38%, radiation decreases 1%

Infiltration, recharge and runoff and soil moisture significantly increase

Change is seasonally variable

Significant long term hydrological variability



Climate variation : equilibrium effects on vegetation properties

% change from (1940-54, dry) to (1955-1969, wet) : Mota del Cuervo					
Inputs	**Winter**	**Spring**	**Summer**	**Autumn**	**TOTAL**
Rainfall (mm/month)	+65%	+8%	+44%	+50%	**+38%**
Solar radiation (W/m^2)	-4.63%	+2.02%	+0.35%	-2.32%	**-0.85%**
Vegetation					
Leaf dry biomass (Kg)	+200%	+426%	+338%	+199%	+300%
Stem dry biomass (Kg)	+299%	+948%	+1299%	+1515%	+925%
Root dry biomass (Kg)	+228%	+268%	+100%	+12%	+135%
Dormant dry biomass (Kg) (woody stems)	+1469%	+1325%	+1820%	+1965%	+1626%

Table 4. Percentage change of inputs and biomass components between a dry period (1940-1954) and a corresponding wet period (1955-1969) for *Quercus cocciferra* at Mota del Cuervo. These are model results.

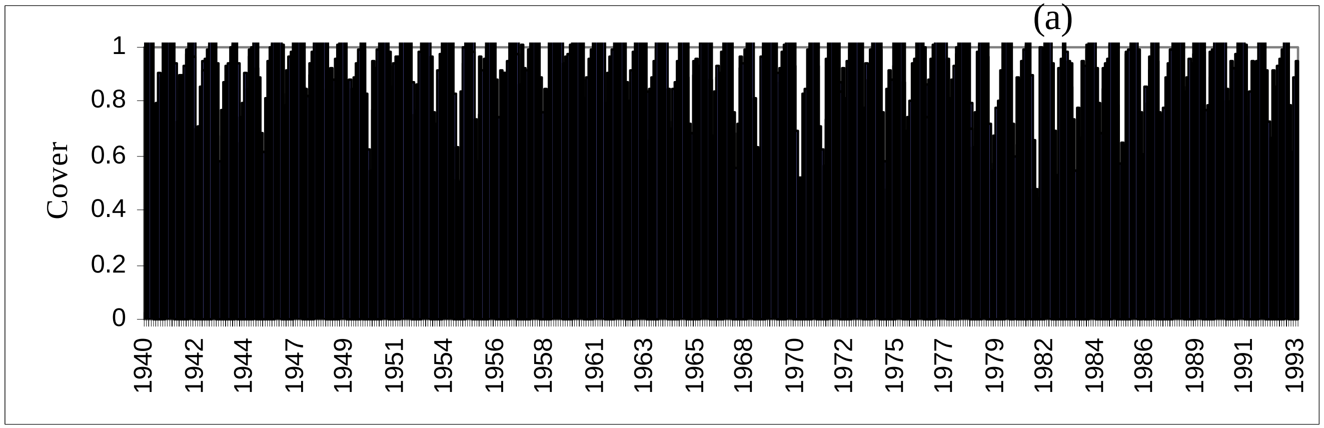
Rainfall increases 38%, radiation decreases 1%

All biomass significantly increases.

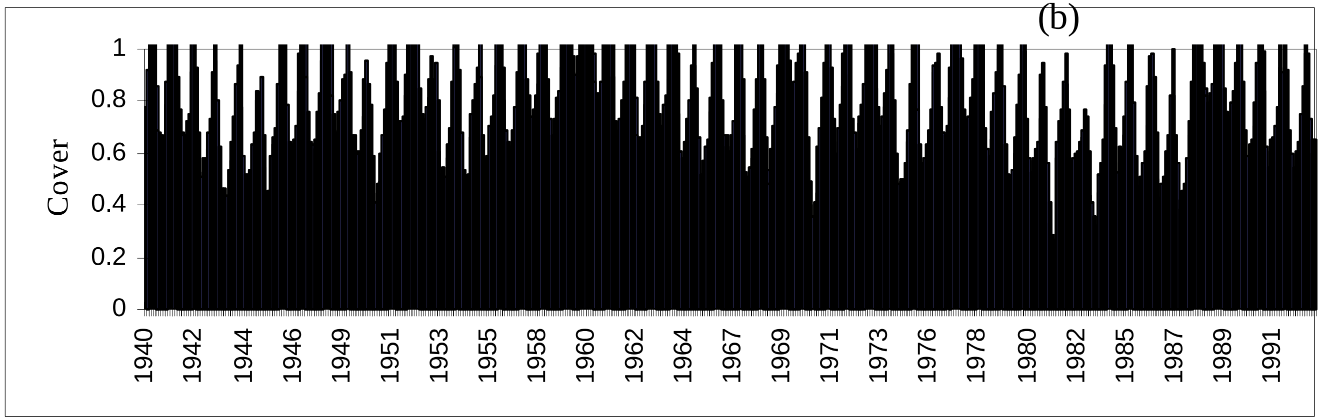
Change is seasonally variable

Significant long term vegetation variability

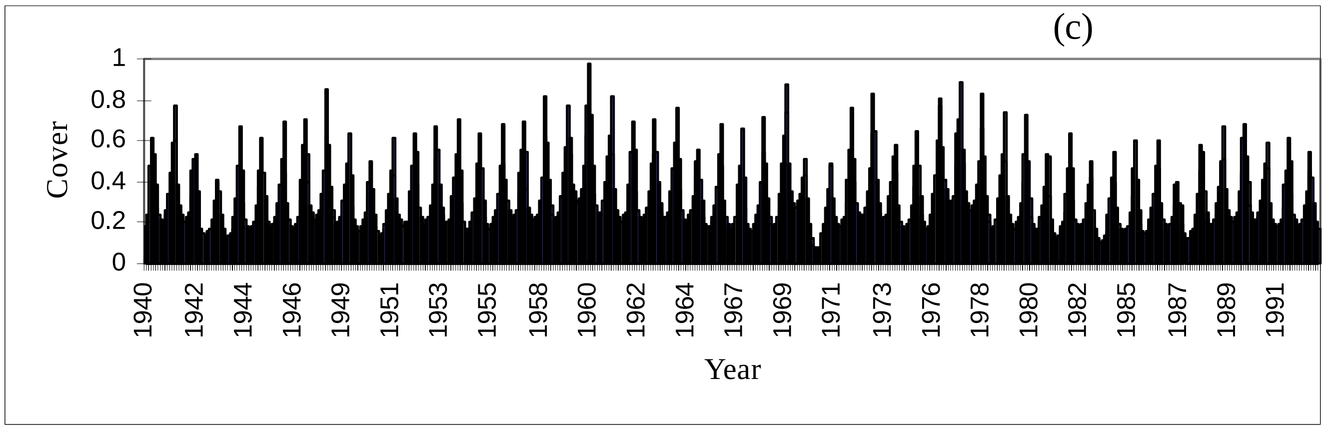
Shrub FT
Quercus cocciferra



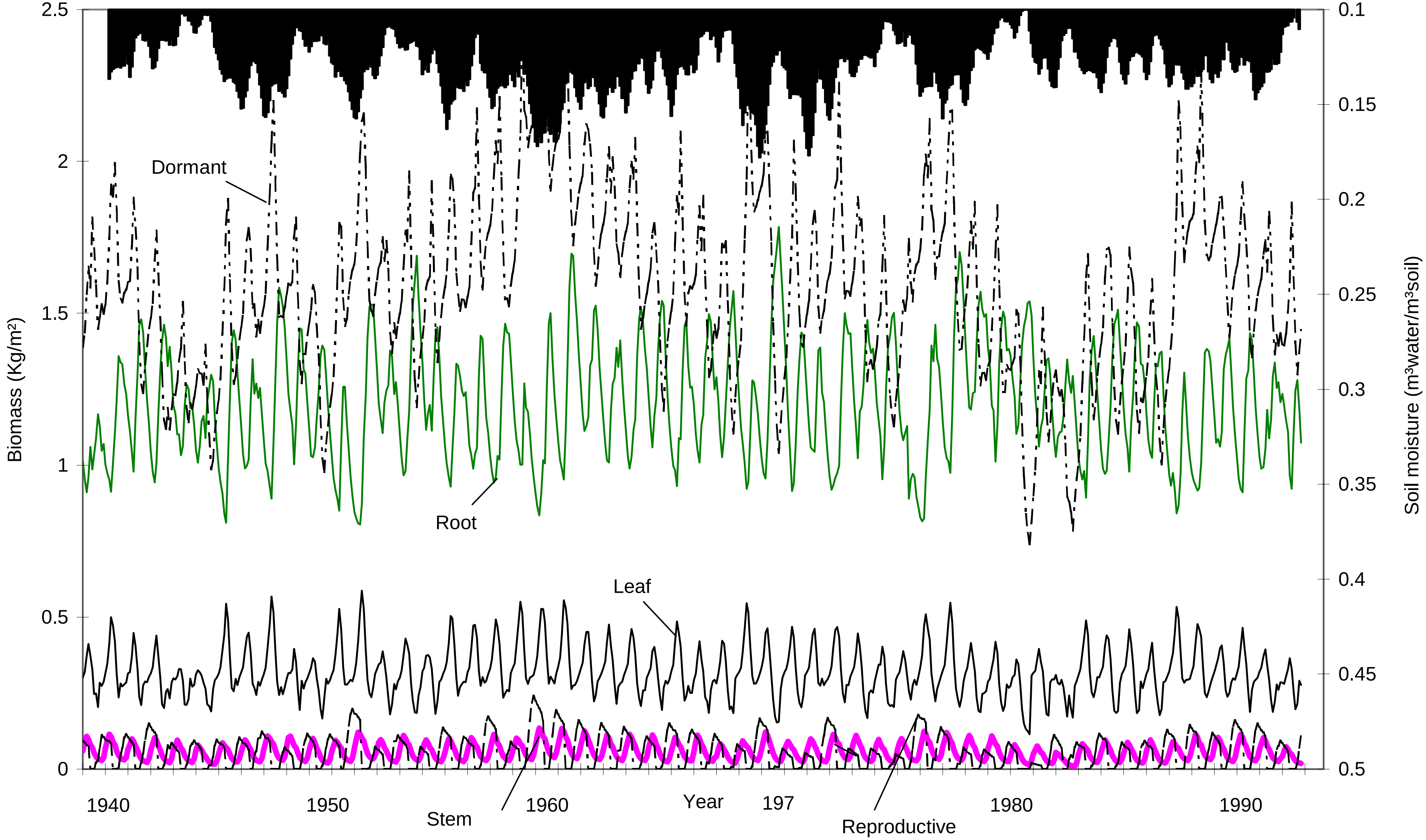
Dwarf shrub FT
Thymus vulgaris



Grass FT
Stipa teneccissima



Complex responses of plant resource partitioning



Climate sensitivity

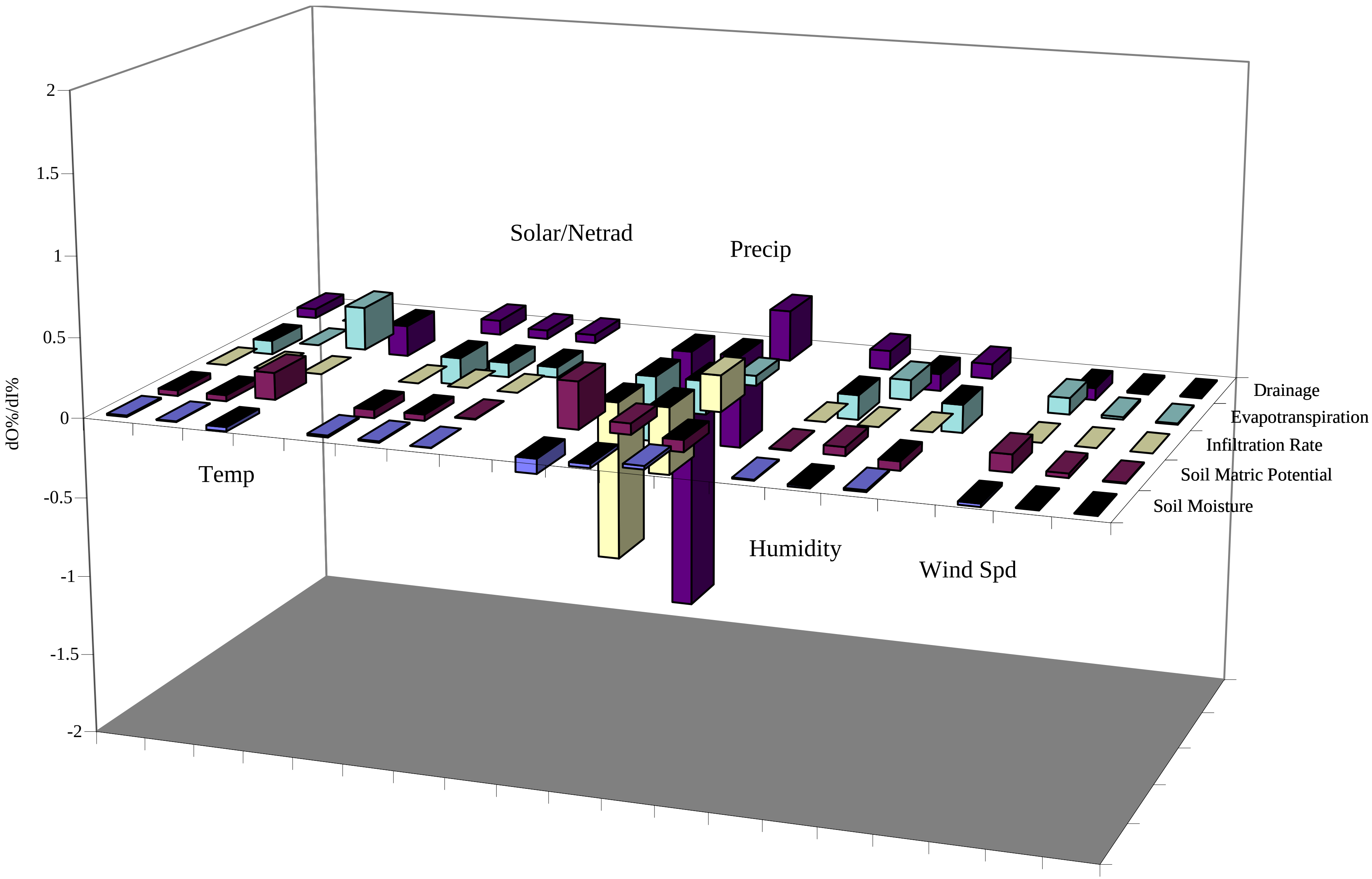
‘Usual’ approach to climate impacts modelling

•Look up climate results of latest GCM scenario
•Downscale the results to the area of interest
•Run simulation model of processes for equilibrium or transient climate scenaria for (1*CO_2, 2*CO_2)
•Draw implications of the change in process observed in terms of its likely impact

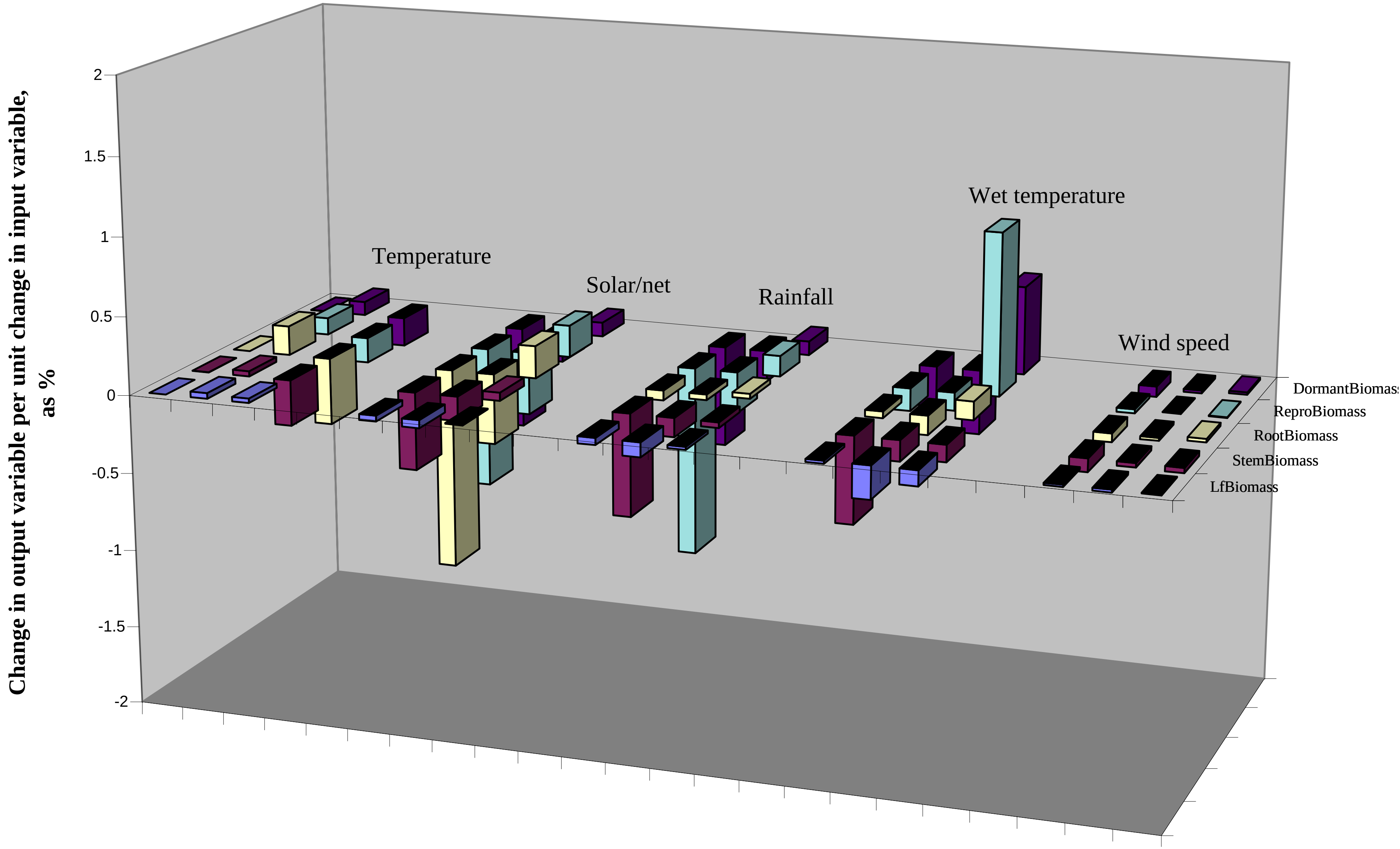
Sensitivity approach

•Understand the non equilibrium and transient nature of climates and thus the process systems which they effect.
•Develop tools to understand the **sensitivity** of systems to climate within the context of other drivers (such as LUCC)
•Identify sensitive systems and insensitive systems.

PATTERN : Hydrological sensitivity to climate

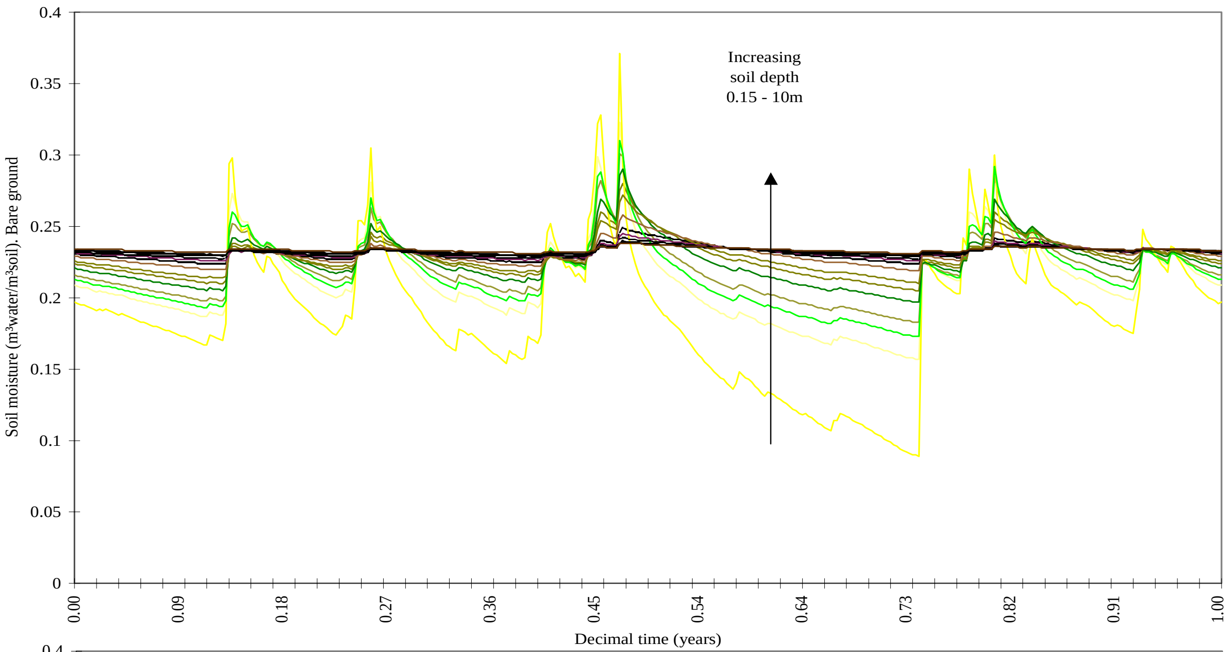


PATTERN : Plant sensitivity to climate

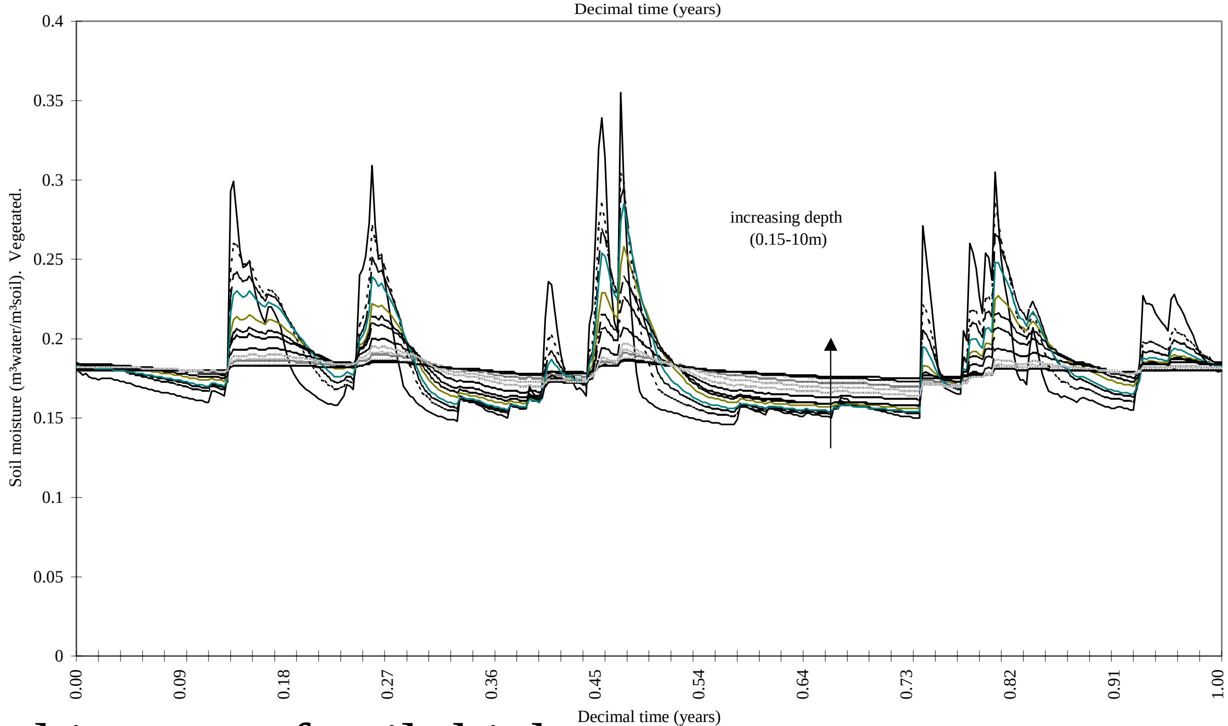


Climate impacts by land cover :1
Plants *vs*. no plants

- Plant growth and soil hydrology are mutually dependent
- Plant responses mitigate soil against climate impacts
- Highly spatially variable soil properties (such as soil thickness) control basic plant responses to climate
- Planted areas less hydrologically dynamic (and generally wetter) than bare patches



Bare soil



Vegetated

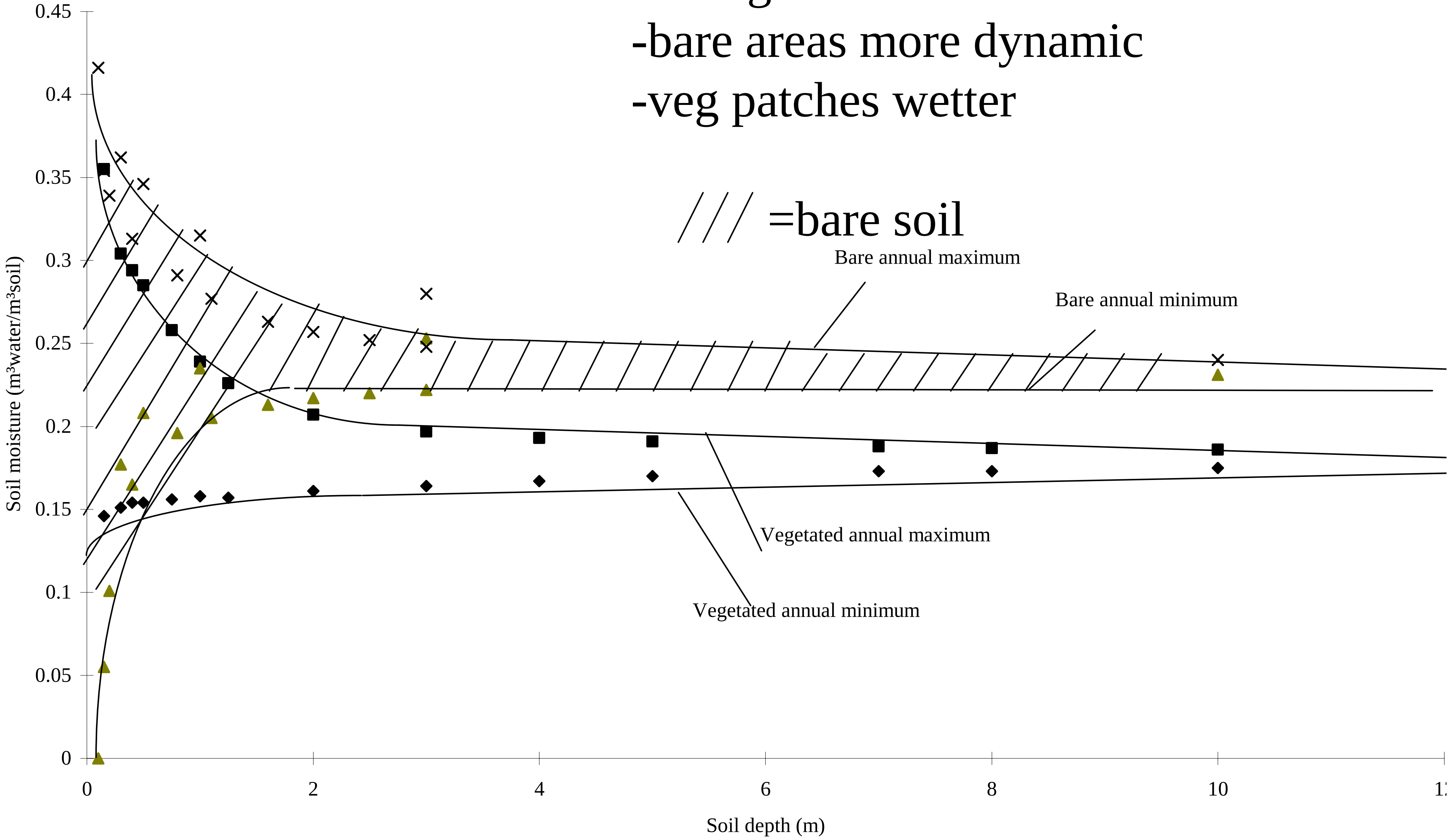
Hydrological impact of soil thickness

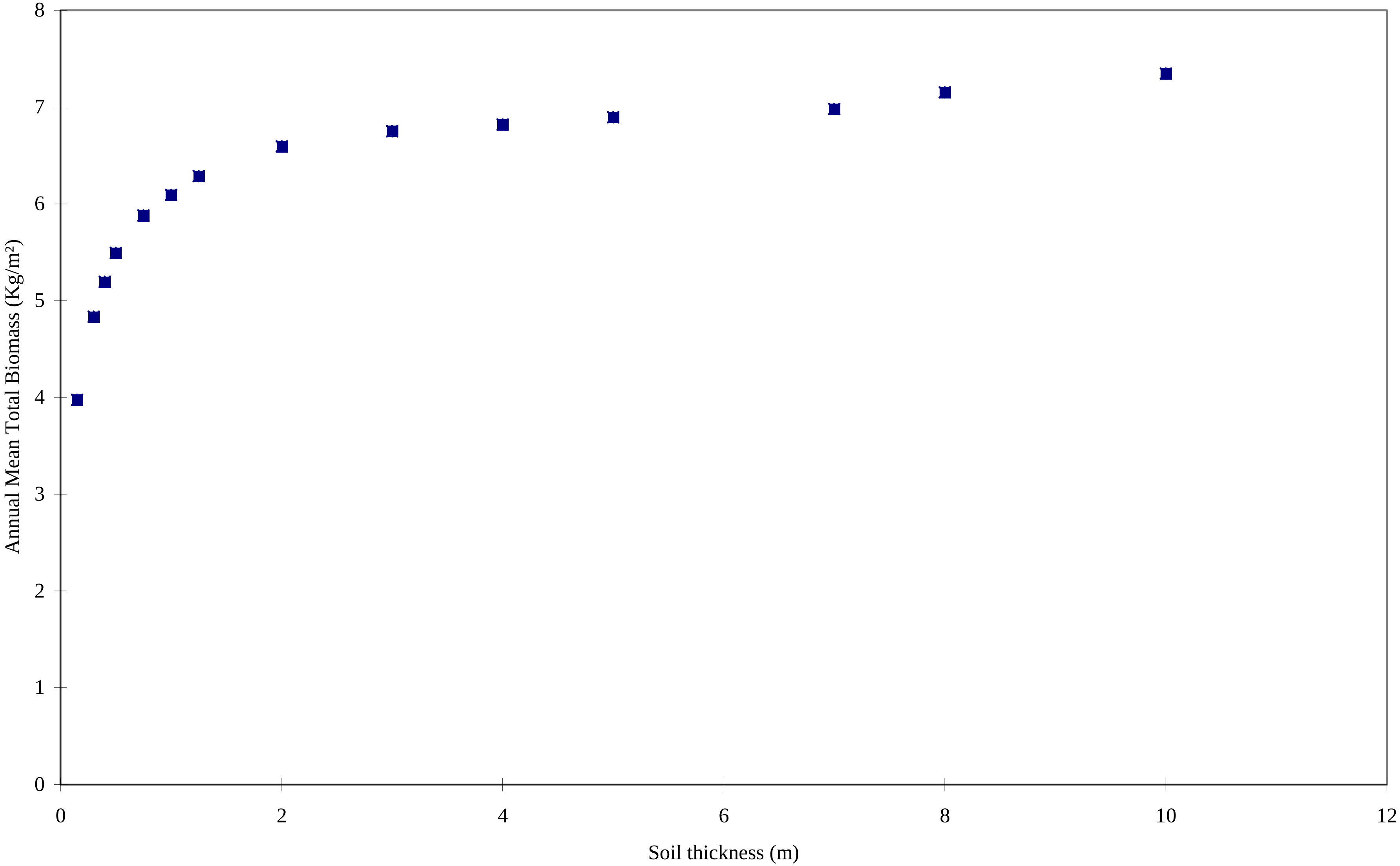
Moisture dynamics and soil thickness

-strong contrasts

-bare areas more dynamic

-veg patches wetter

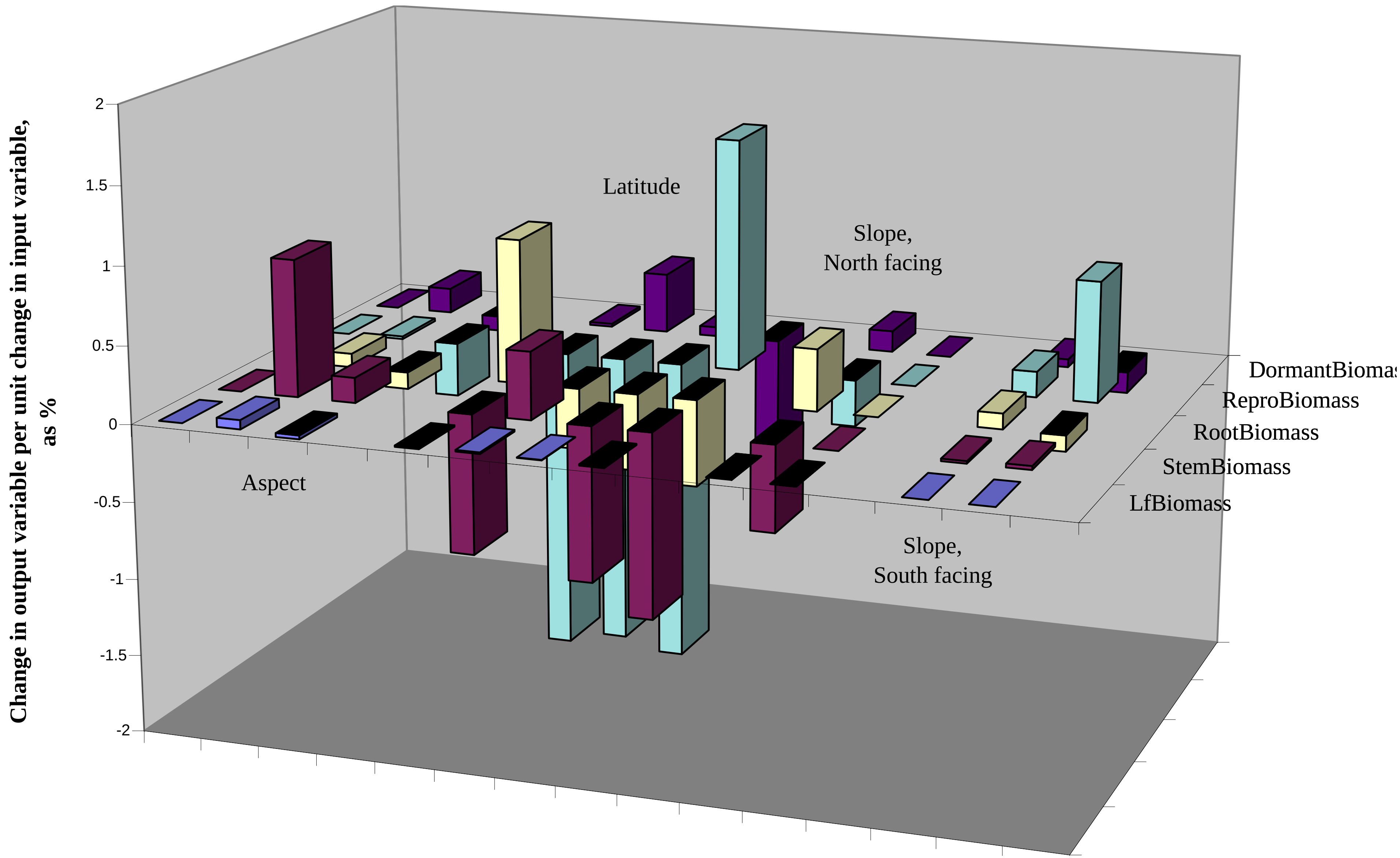




Total biomass impact of soil thickness

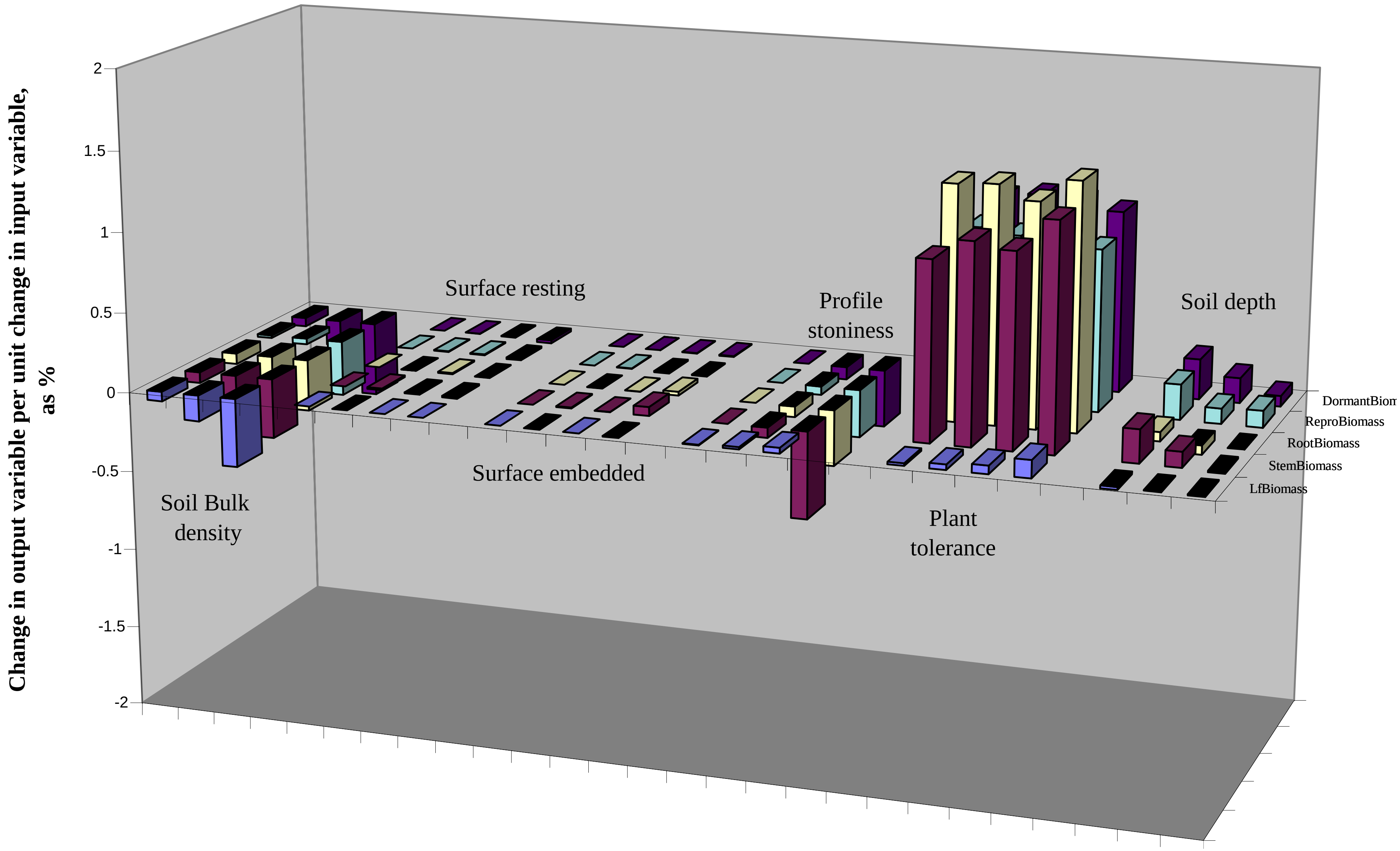
Climate impacts by land :3
Landscape properties

Plant sensitivity to landscape position

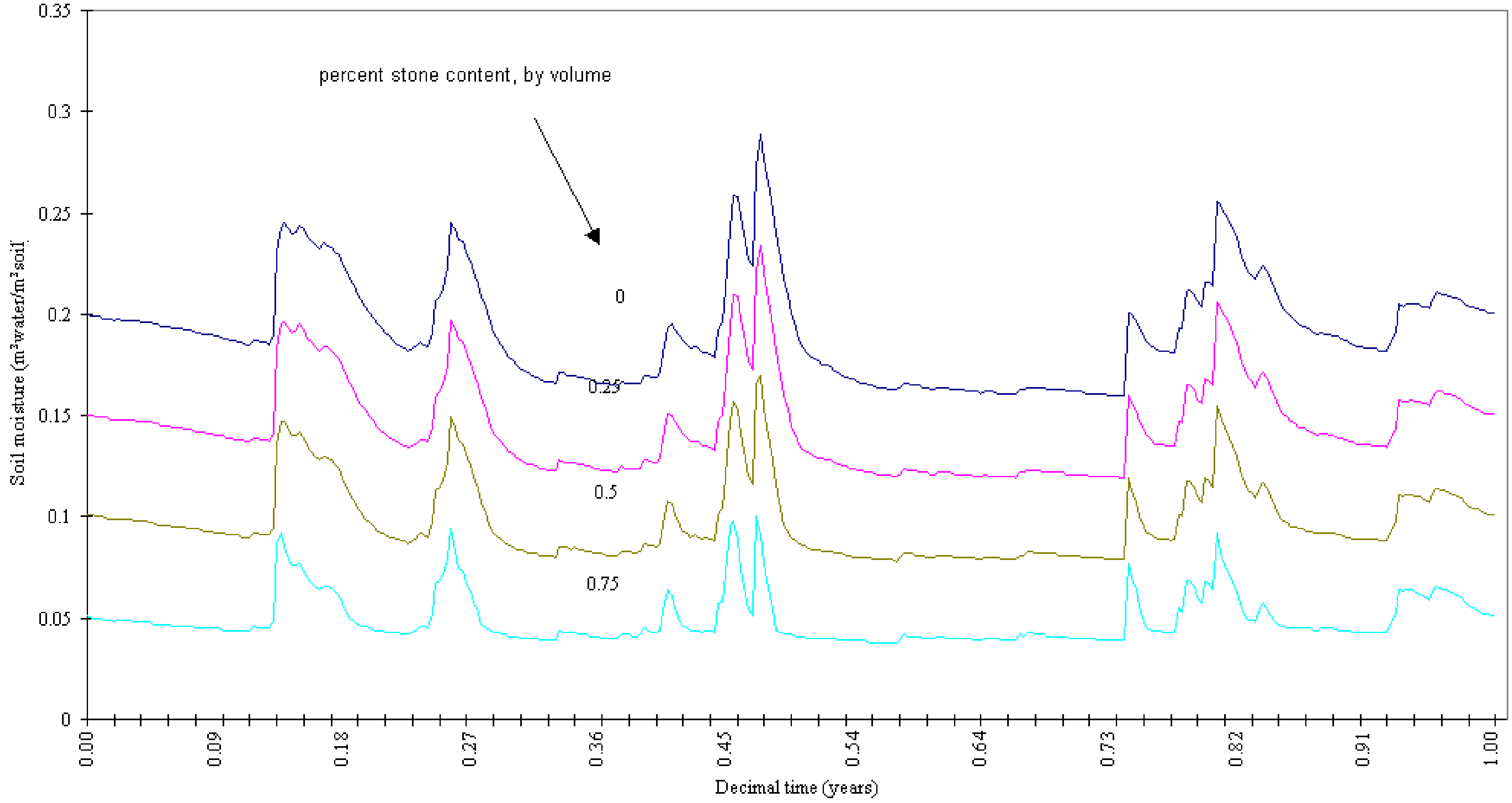


Climate impacts by land :4
Soil properties : hydrological impacts

Plant sensitivity to soil conditions

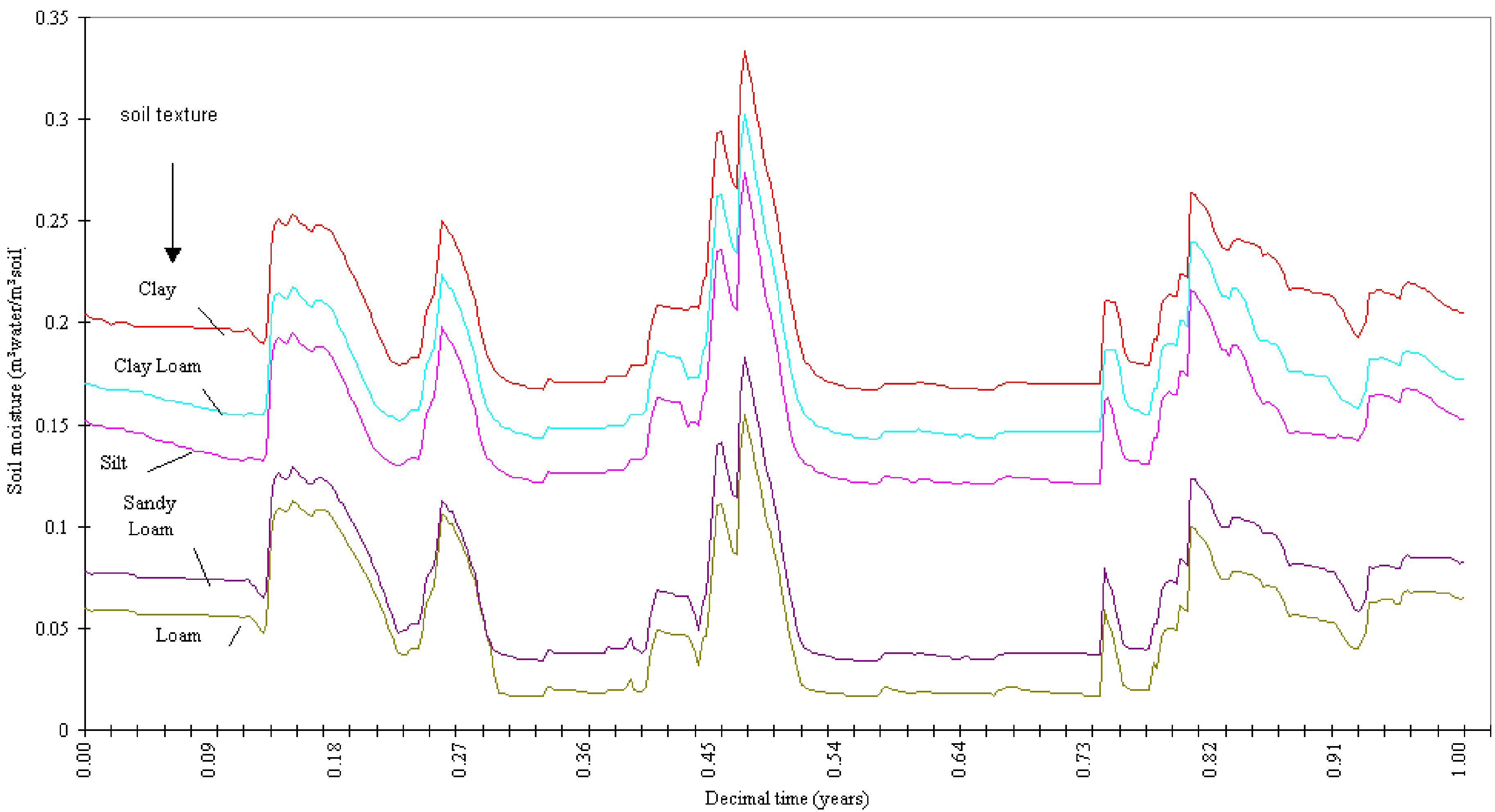


Impact of soil rock fragment content on soil moisture



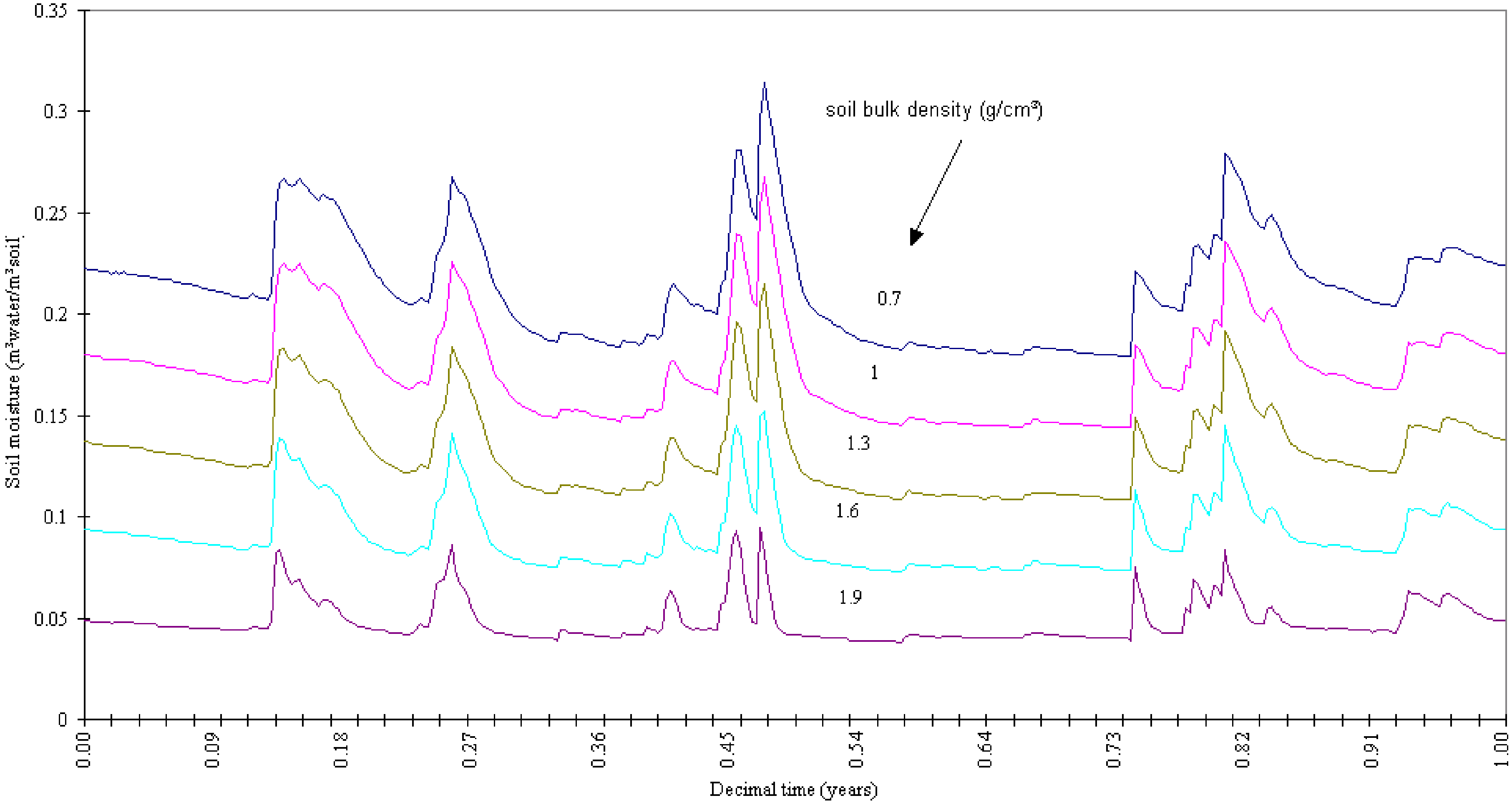
Reduces overall moisture and the temporal variation in soil moisture
Also difficult to measure/model at the landscape scale

Impact of texture on soil moisture



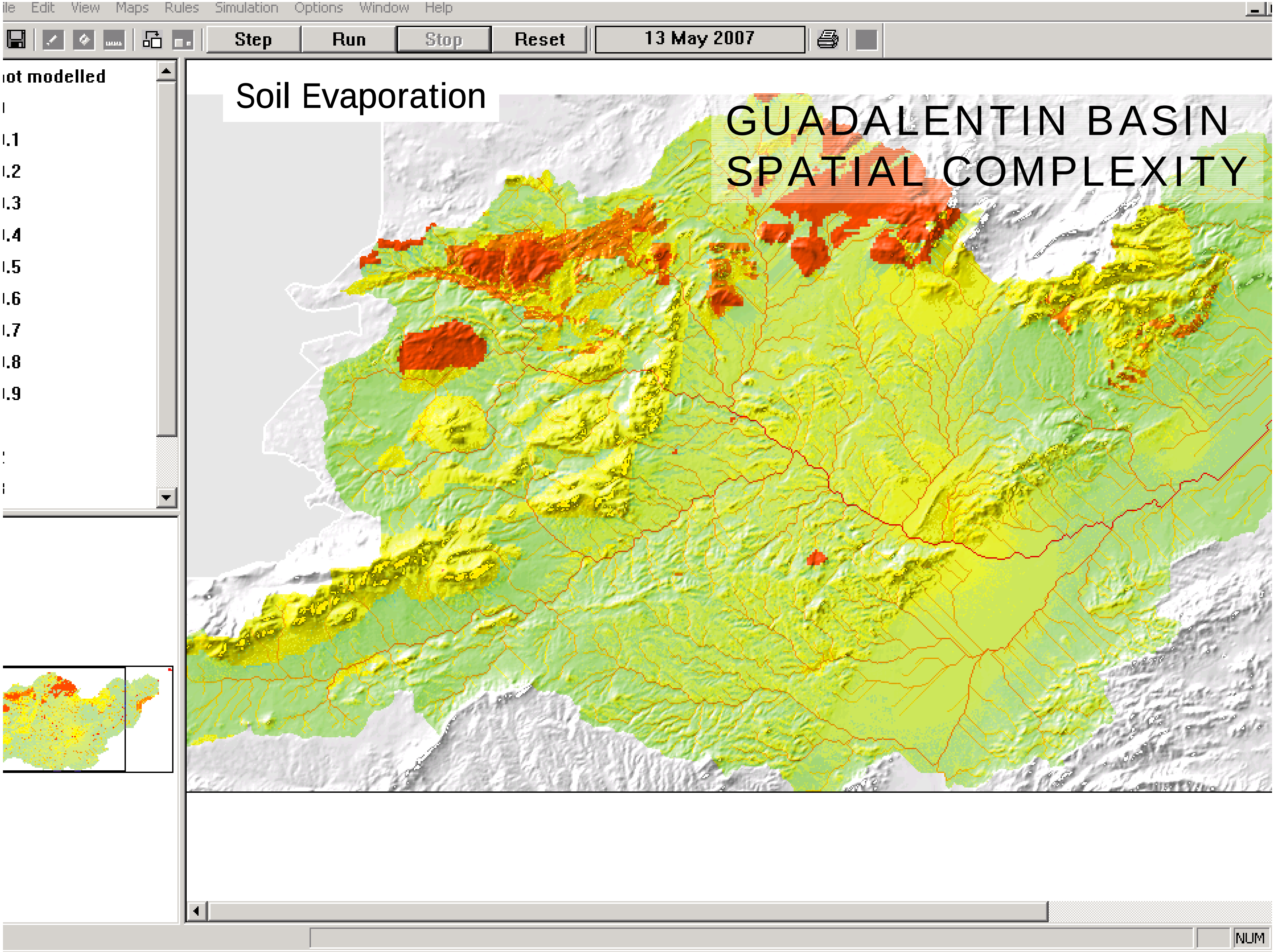
Affects mean soil moisture more than its variability

Impact of soil bulk density on soil moisture



Acts in a similar way to rock fragment content, affecting both mean soil moisture and its variability

The mosaic of climate change impacts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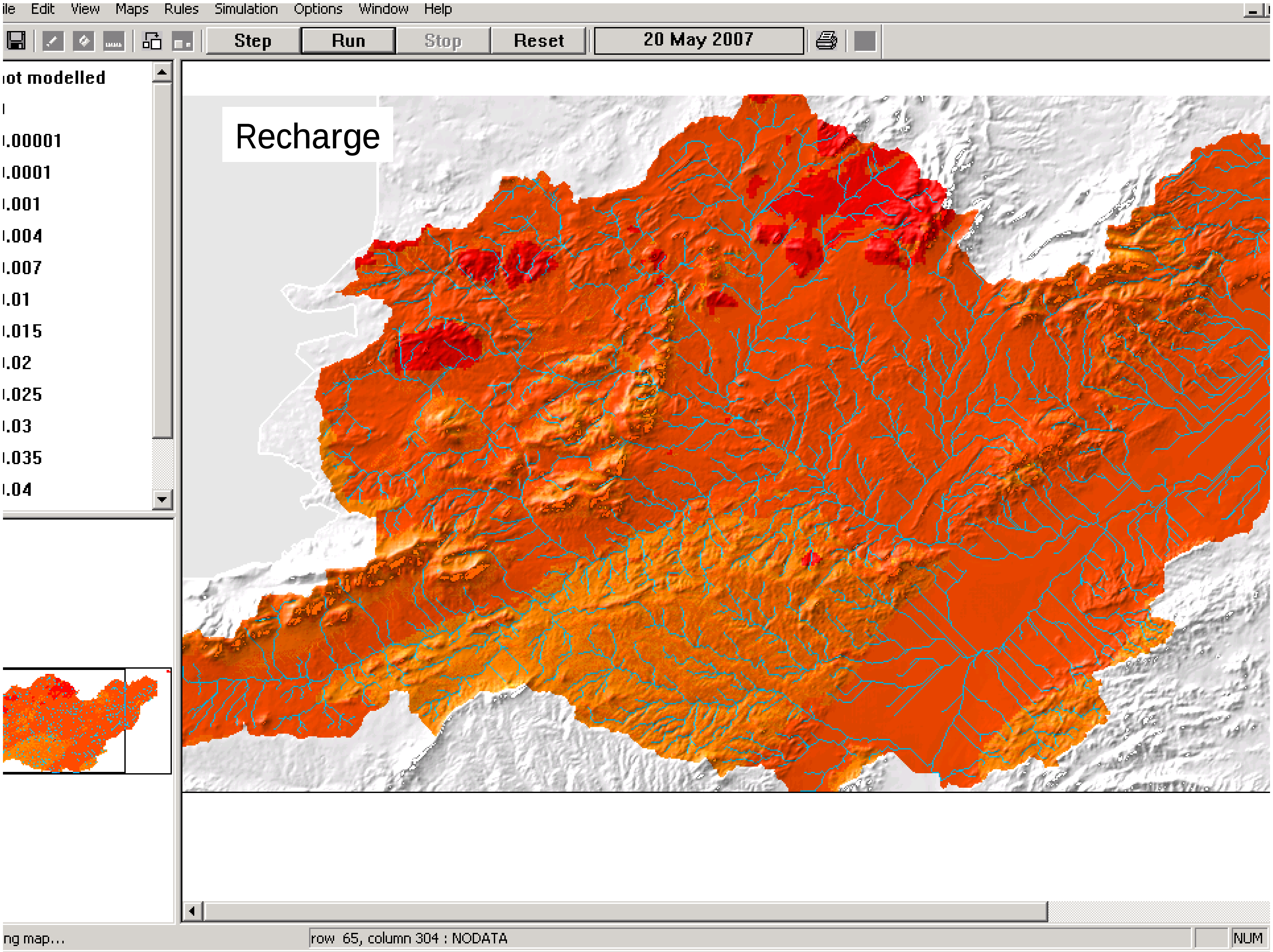
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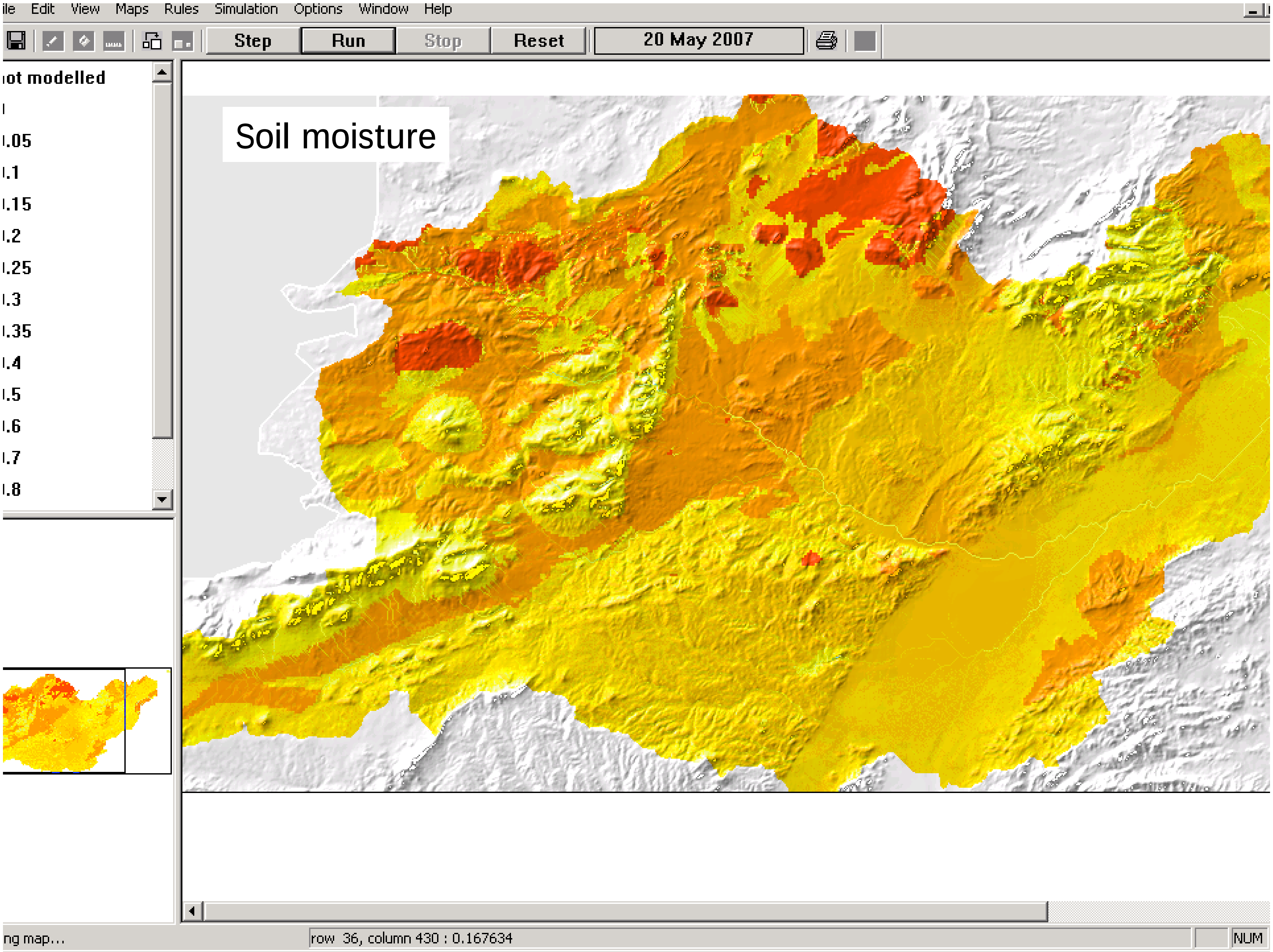
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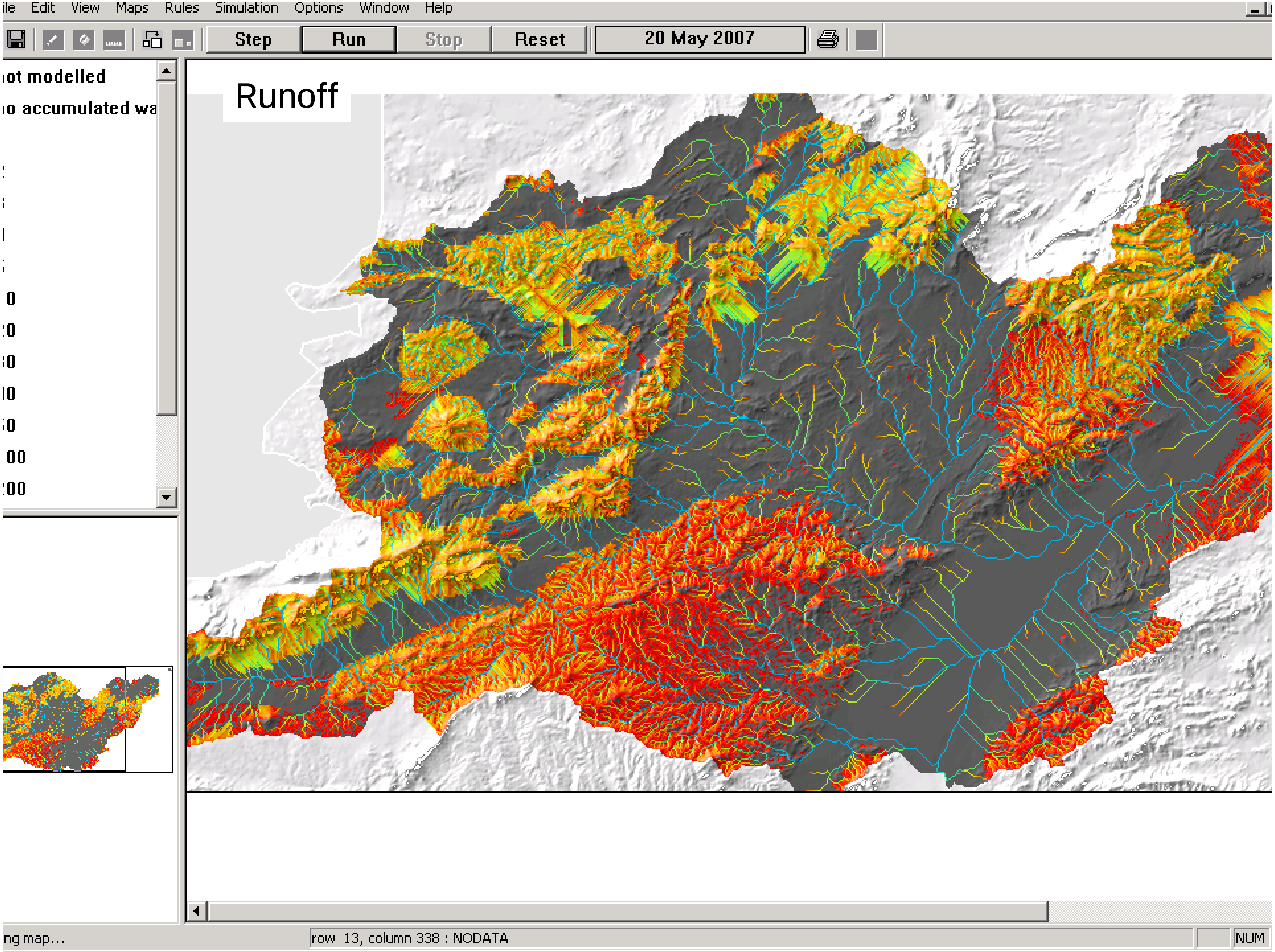
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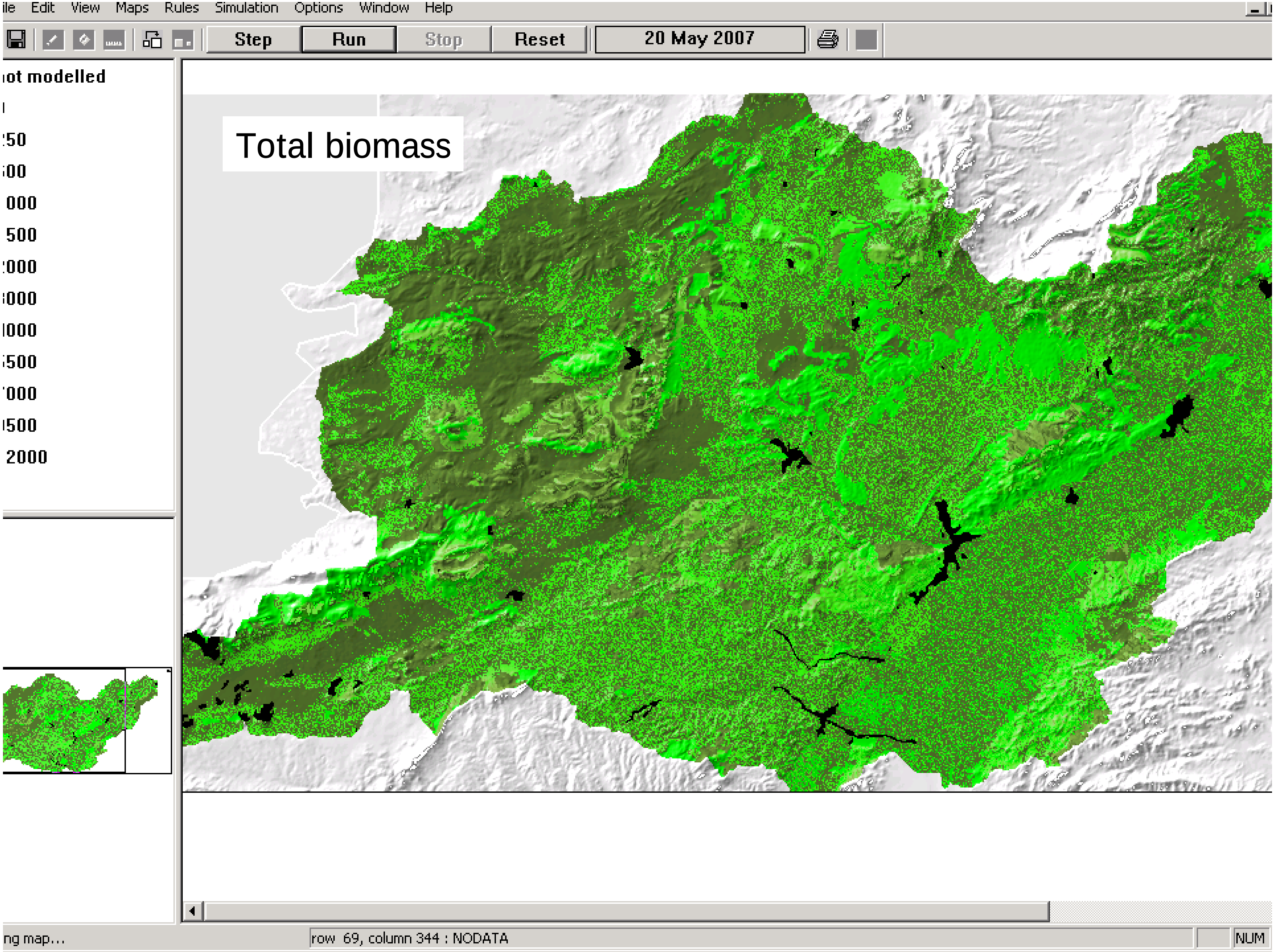
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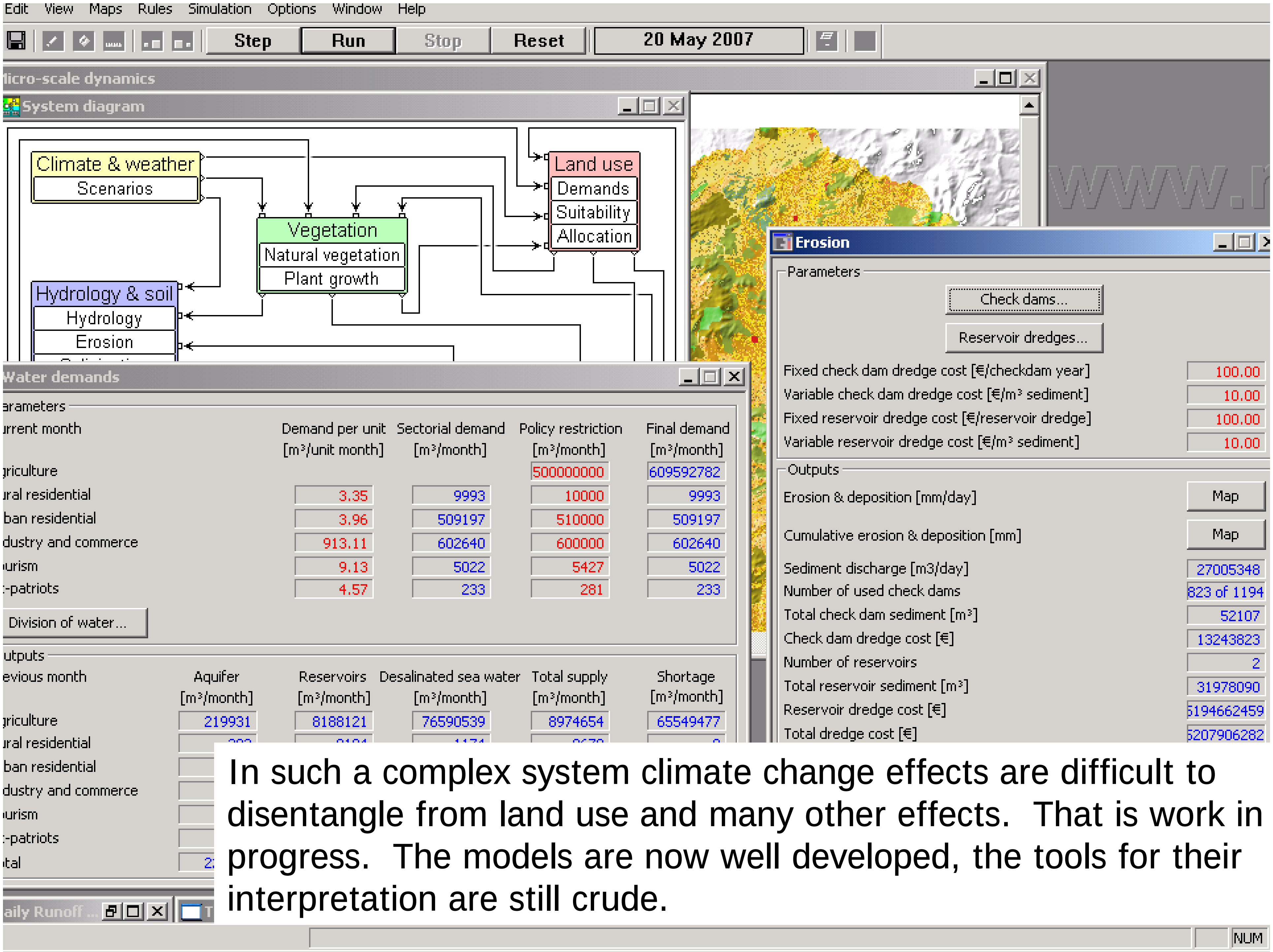

In such a complex system climate change effects are difficult to disentangle from land use and many other effects. That is work in progress. The models are now well developed, the tools for their interpretation are still crude.

Conclusions : separation of climate and land abandonment effects

- **Some of the most important controls are some of the most difficult to measure spatially (e.g soil thickness, rock fragment content, vegetation type).**

- **Vegetation-hydrology feedbacks are critical to understanding climate-land surface responses**

- **Landscape response to *climate variation* is already significant**

- **Landscape response to climate change may not be very different to the response to climate variation and will certainly be highly spatially variable**

- **Thus broad-brush approaches will not work – *the devil is in the (spatial) detail. Generalisations may not be possible – one needs to scale through a mosaic of patchy responses.***