



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 (Patchification!)

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 Mediterranean ecosystems
 - Increasing spatial and temporal uniformity (Depatchification!)

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



Hydrology Model

Processes Modelled:

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

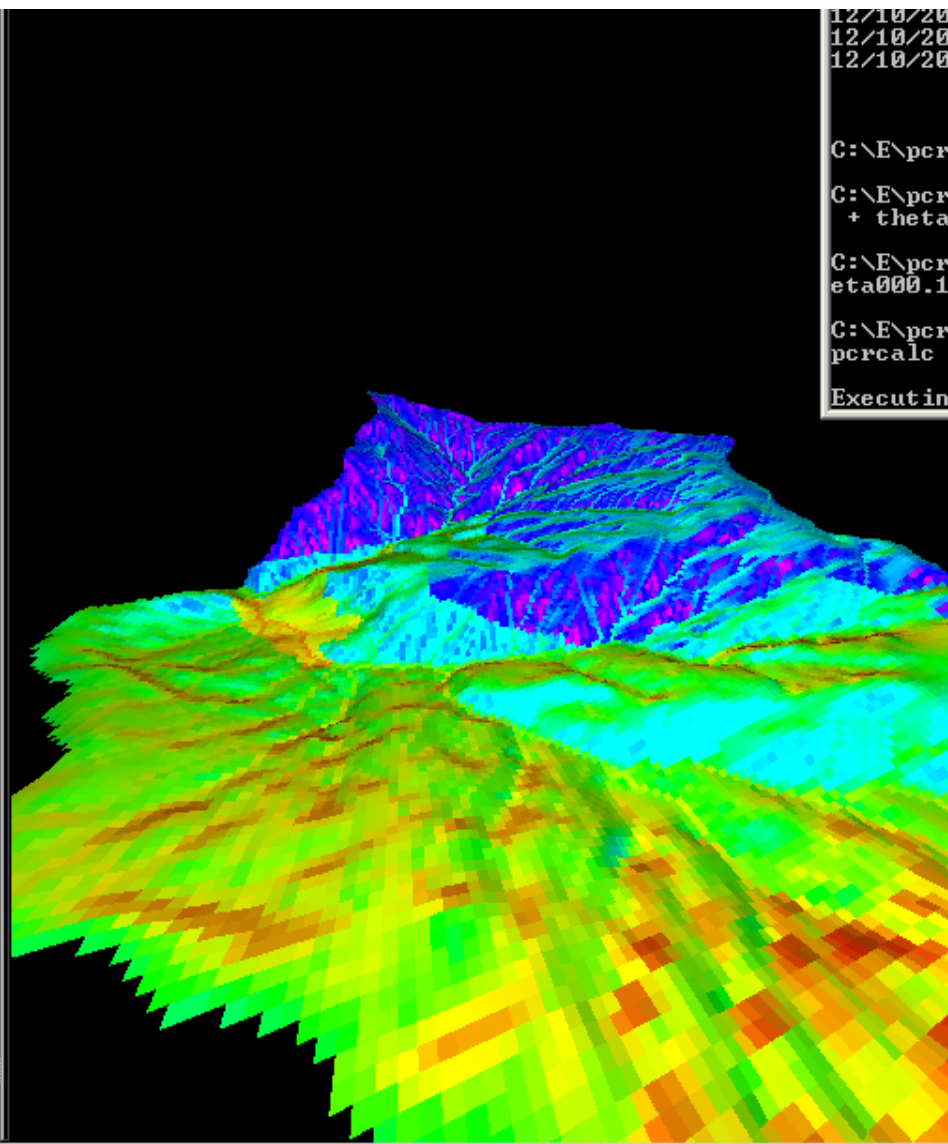
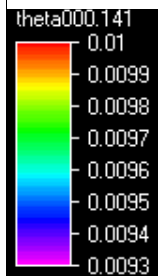
Plant Model

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



Cursor

time: 0
x: 0
y: 0
z: 0

```
12/10/2002 12:48 142,392 infil000.142
12/10/2002 12:48 142,392 recharge.142
12/10/2002 12:48 142,392 theta000.142
142,392 rootbion.142
142,392 LAI00000.142
142,392 erosion0.142
142,392 evap0000.143
142,392 ievap000.143
142,392 rainfa00.143
142,392 bdatwf00.143
1914 File(s) 262,416,066 bytes
2 Dir(s) 284,770,304 bytes free

C:\E\pcraster\colombia\tambito\hydromod\tpalonly\cellular>dis
C:\E\pcraster\colombia\tambito\hydromod\tpalonly\cellular>agu
+ theta000.141
C:\E\pcraster\colombia\tambito\hydromod\tpalonly\cellular>agu
eta000.141
C:\E\pcraster\colombia\tambito\hydromod\tpalonly\cellular>pcr
pcrcalc version: May 31 2001 (win32)
Executing timestep 40
```

```
#Throughflux=Theta*tan(slopeDeg);
#Throughflow=accuflux(1ddmap,Throughflux);

BDAhead=(BDSlope*((WF+(Infil-Evap-Recharge*RockD))/1
ahead #wrong?
BDAhead=if(BDAhead gt RockD then RockD else BDAhead)

PorAhead=1-((BdatWF+((BDAhead-BdatWF)/2))/RockD); #
WF=WF+((Infil-Evap-Recharge)/PorAhead); #mm
WF=if(WF lt 0 then 0 else WF);
report WF = if(WF/1000 gt soilDepth then soilDepth*1
report Theta=Theta+((Infil-Evap-Recharge)/(soilDepth

#-----growth-----

Growth=(RUE*Theta)*(0.95*(1-exp(-0.7*LeafAreaIndex))
Growth=Growth*0.8; #growth resp
Maintenance=(0.015*((AirTemp-15)/10)**1.5))/24; #g/
LeafBiomass=LeafBiomass+(Theta*Growth)-(Maintenance*
RootBiomass=RootBiomass+((1-Theta)*Growth)-(Maintena
LeafBiomass=if(LeafBiomass le 0 then 0.001 else Leaf
RootBiomass=if(RootBiomass le 0 then 0.001 else Leaf
report LeafAreaIndex=LeafBiomass/LeafDensity;
Cover=if(LeafAreaIndex gt 1.0 then 1.0 else LeafArea

#-----Erosion-----
```


THE MEDACTION PSS NOT JUST HYDROLOGY AND VEGETATION

Step Run Stop Reset 01 Jan 2000

System diagram

```
graph TD; subgraph "Climate & weather"; direction TB; S[Scenarios]; end; subgraph "Vegetation"; direction TB; NV[Natural vegetation]; PG[Plant growth]; end; subgraph "Hydrology & soil"; direction TB; H[Hydrology]; E[Erosion]; Sal[Salinisation]; end; subgraph "Water management"; direction TB; Dem[Demands]; Res[Resources]; end; subgraph "Farm"; direction TB; Prof[Profit]; Land[Land]; end; S --> NV; S --> PG; S --> H; S --> Dem; S --> Res; S --> Prof; S --> Land; NV --> H; PG --> H; PG --> Dem; PG --> Res; H --> Dem; H --> Res; Dem --> PG; Res --> PG; Prof --> Land; Land --> Res;
```

Climate & weather Parameters

Global climate change scenario: HADCM2

Change between 2000-2030 at Alhama de Murcia

	Precipitation [mm]	Temperature [°C]
Model prescribed change	7.010	0.630
Additional user defined change	0.000	0.000
Estimated total change	7.010	0.630

Climate & weather Parameters

Precalculation...
Climate change...
Weather generators...

Climate & Weather; Weather generators Parameters

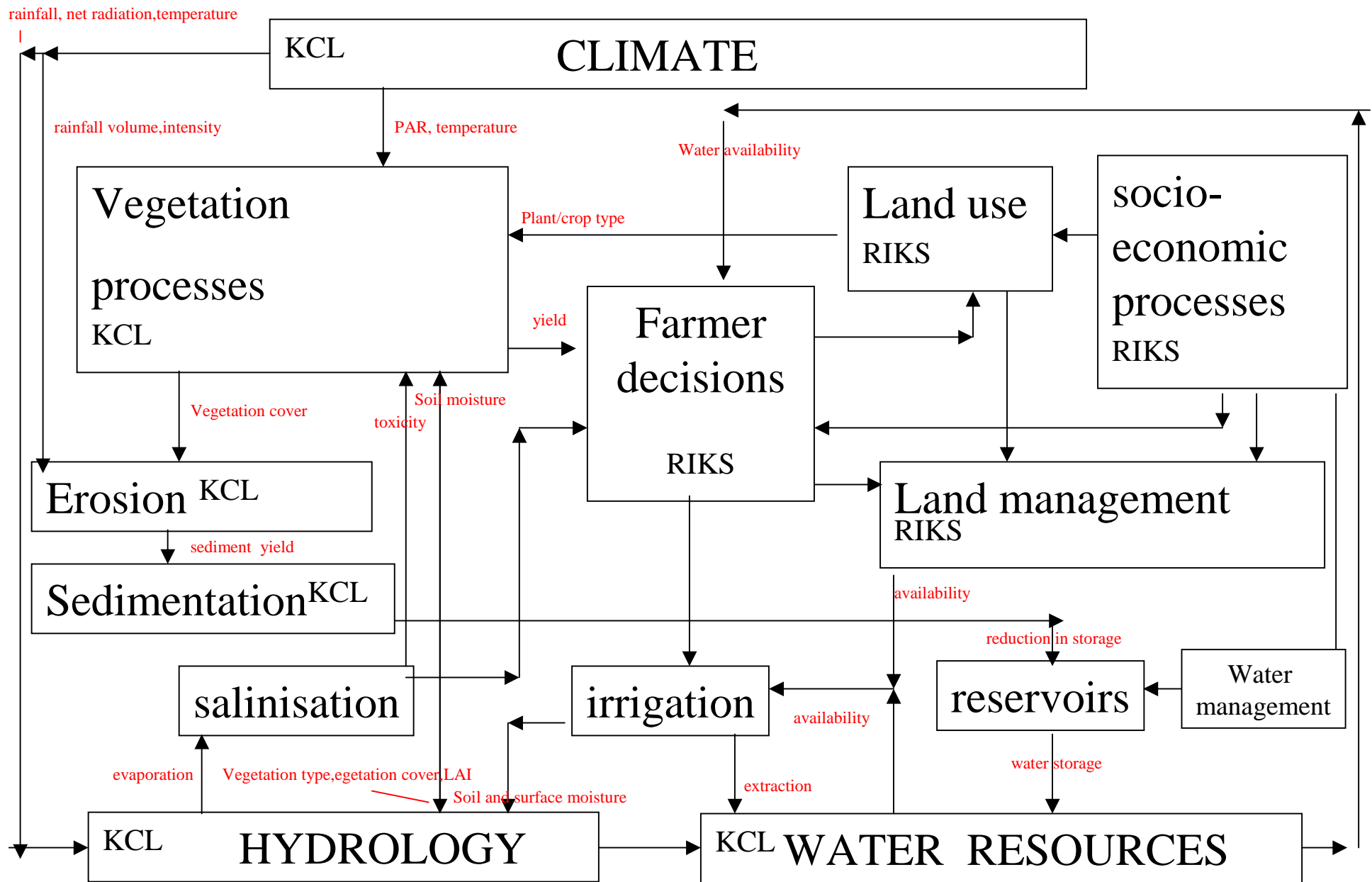
Precipitation offset...
Temperature offset...

Precipitation change fraction with increasing altitude [1/m]: 0.00
Temperature change with increasing altitude [°C/m]: -0.00

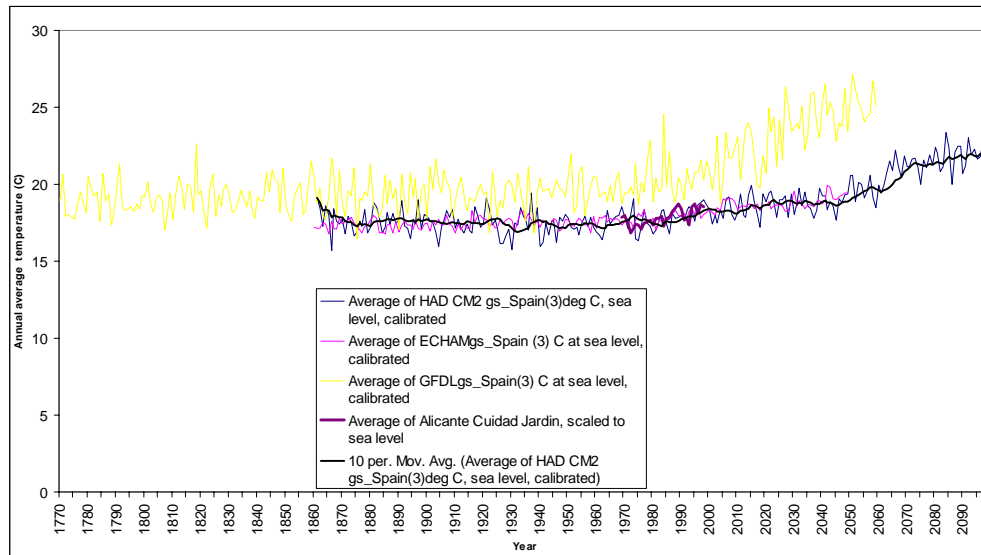
Outputs

Precipitation	Map
Sunlight	Map
Temperature	Map
Cloudiness [%]	70.0
Precipitation [mm]	5.3
Sunrise	07:56

Offset factors [-]



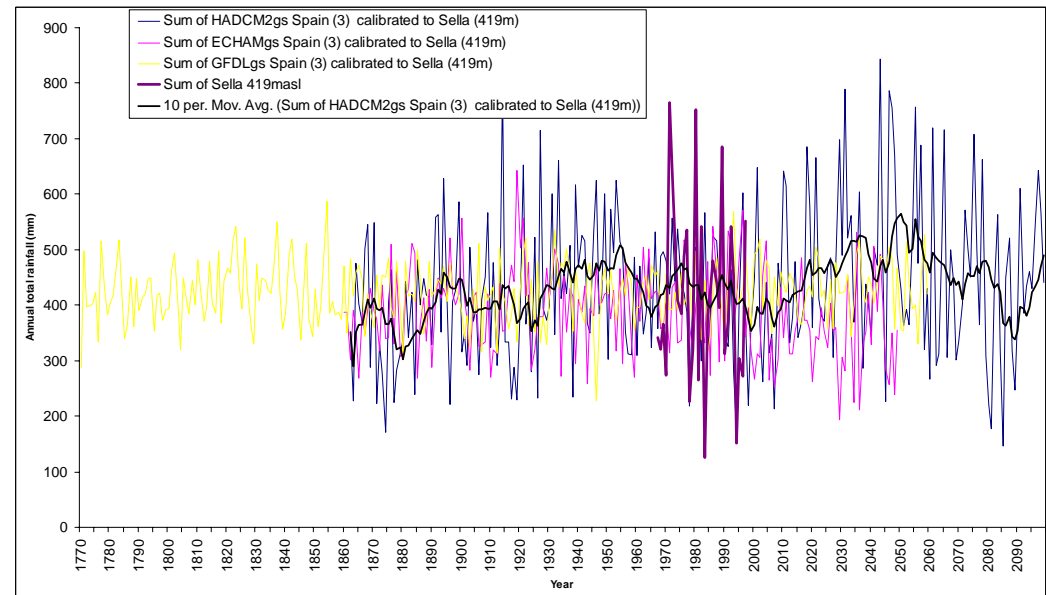
MEDACTION System diagram



...driven by climate change
scenarios
...with integrated CA land use
change model

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 Ciudad Jardin is shown in purple.

Marina Baixa

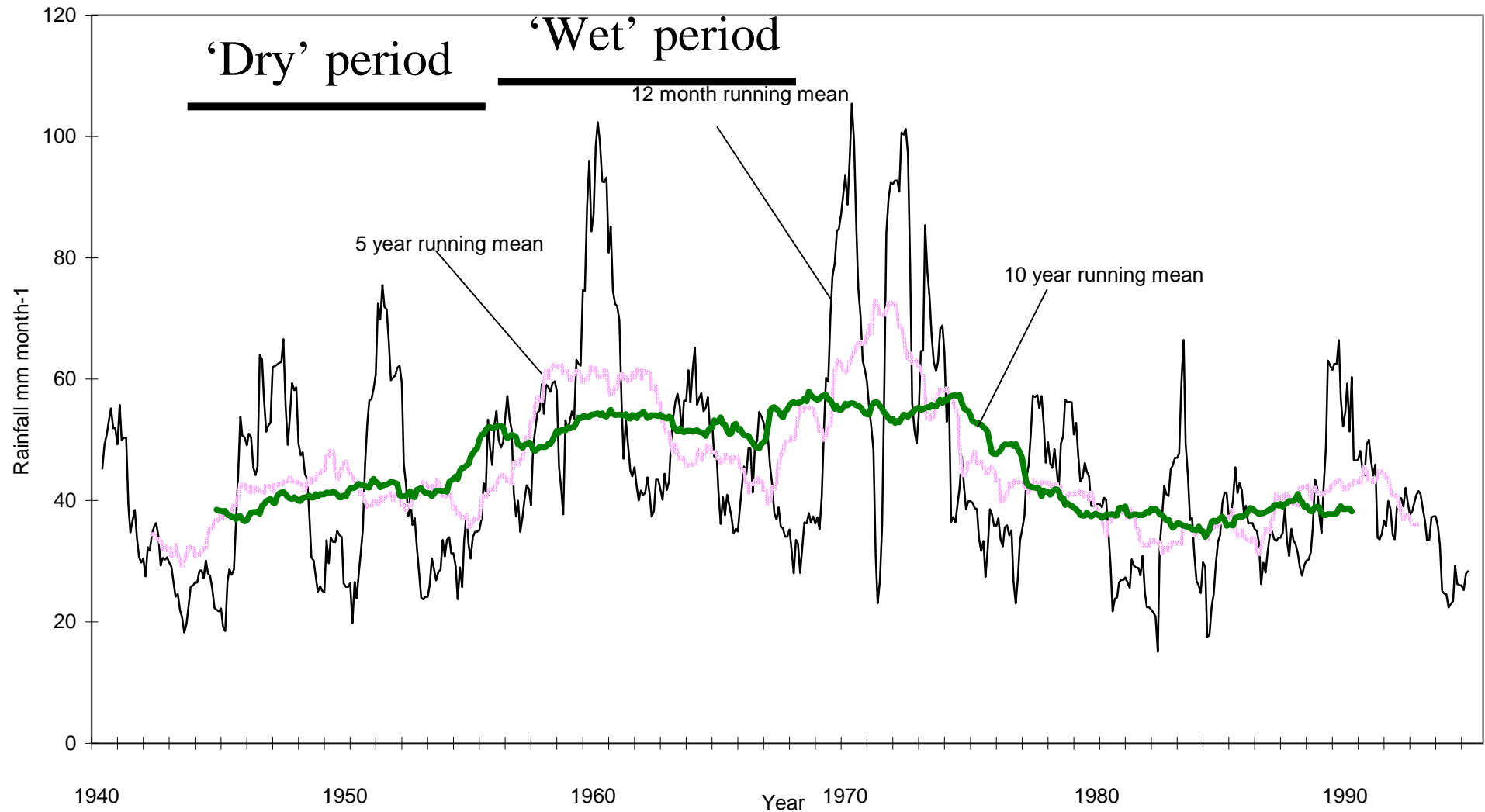


Change in annual total rainfall downscaled for Marina Baixa (419 m above sea level). HADCM2gs is represented in blue, GFDLgs in yellow and ECHAMgs in pink. The historic record for Sella is shown in purple.

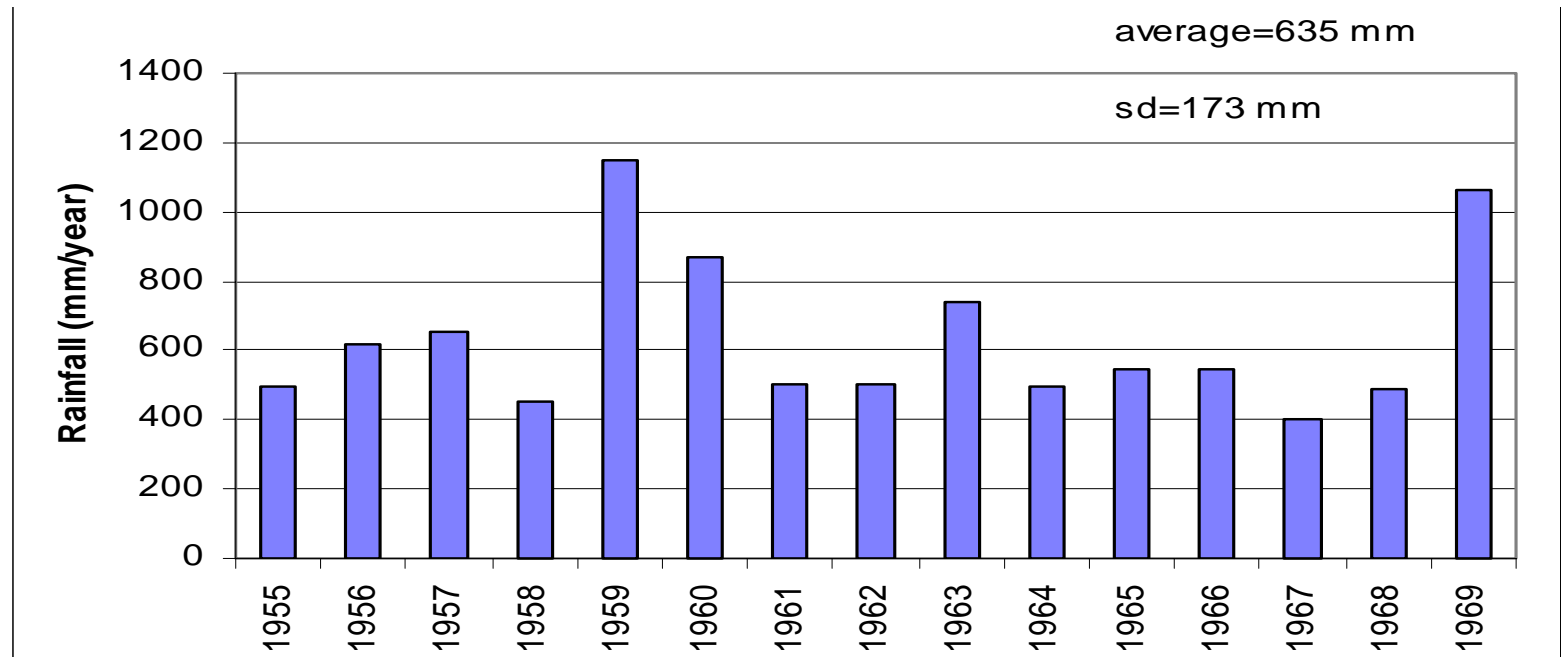
But...The context of climate variation

- 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

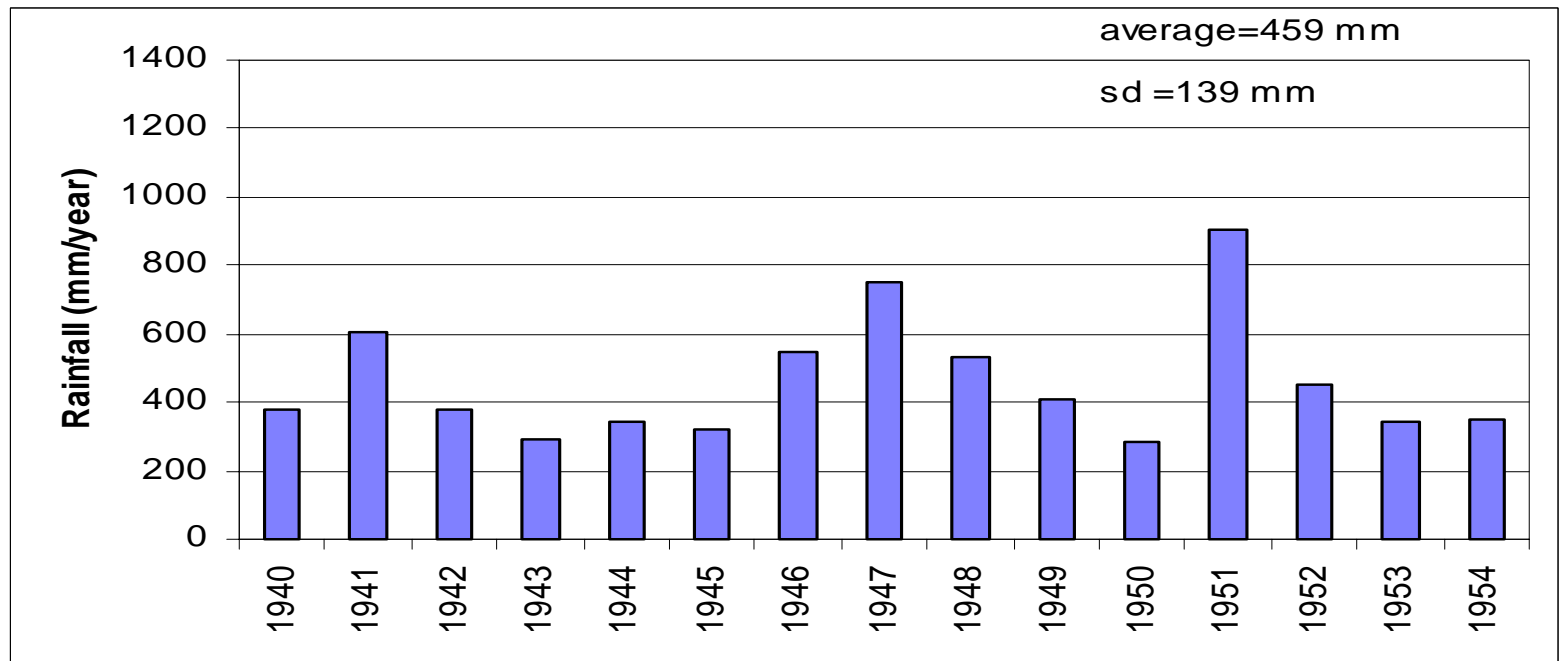
Rainfall variability : Castilla la Mancha, Spain



‘Wet’
period

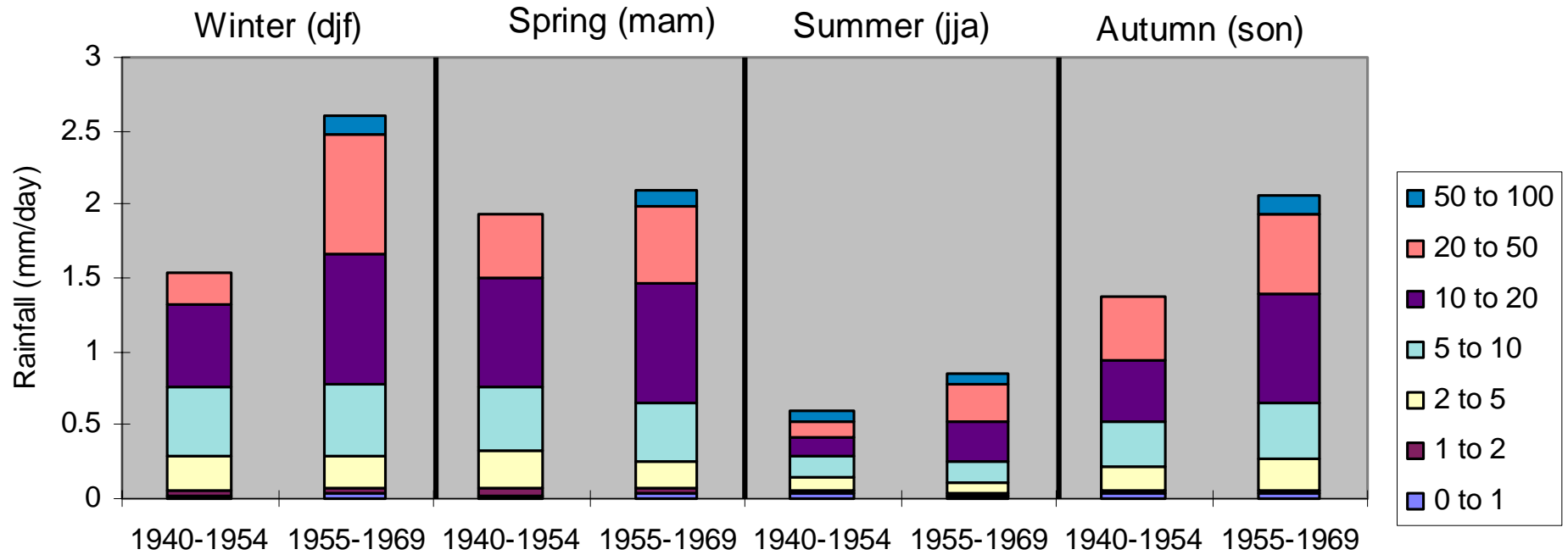


‘Dry’
period



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 ³ water/m ³ soil),	+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%

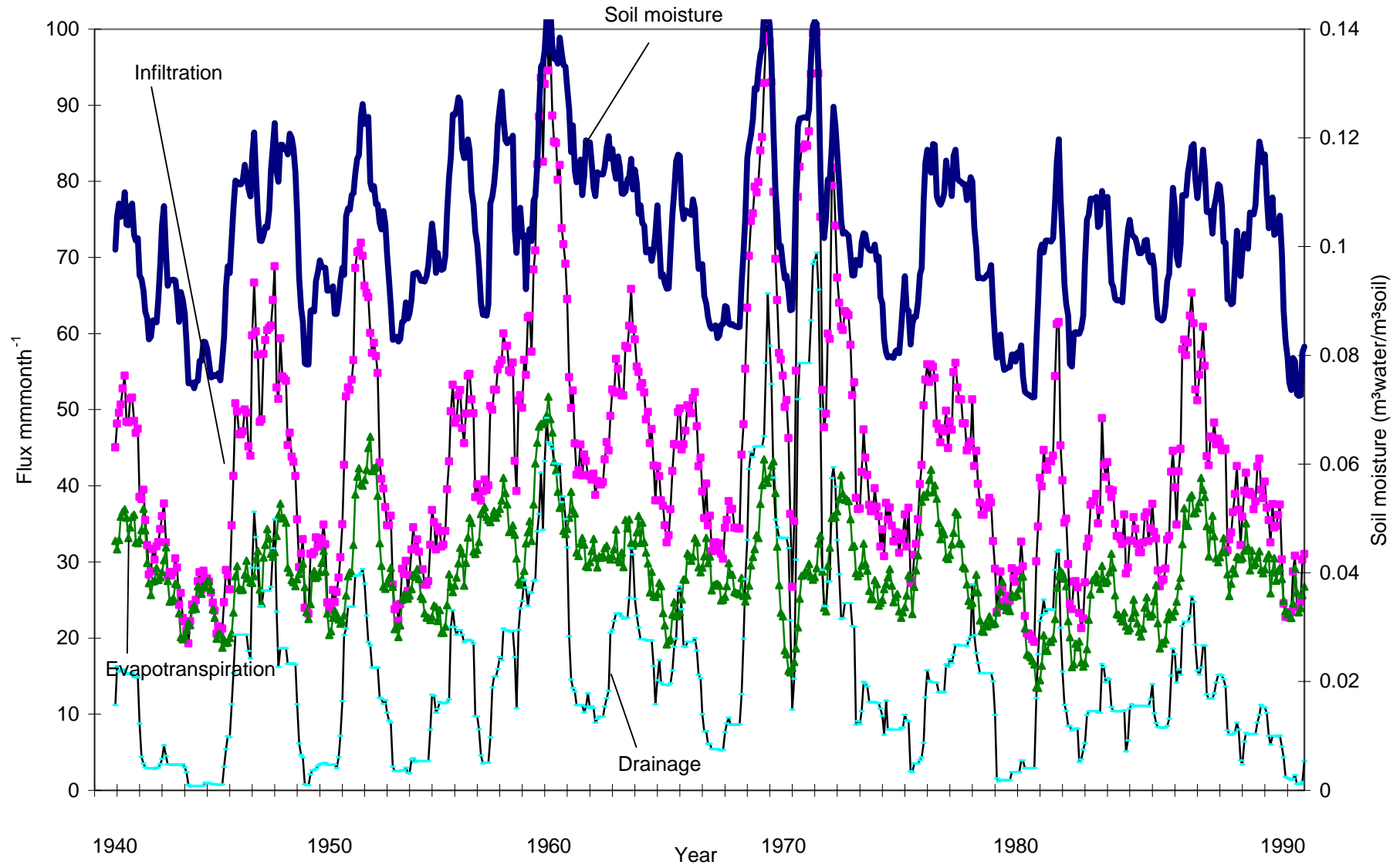
Table 3. Percentage change of inputs and hydrological fluxes between a dry period (1940-1954) and a corresponding wet period (1955-1969) for Mota del Cuervo. These are model results.

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					
<i>Inputs</i>	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%
<i>Vegetation</i>					
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 coccifera* at Mota del Cuervo. These are model results.

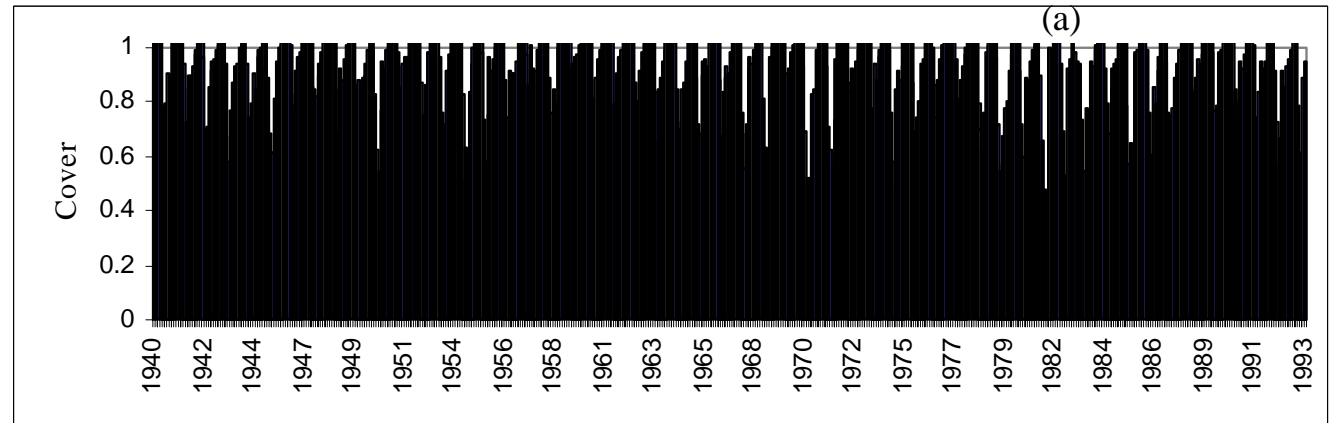
Rainfall increases 38%, radiation decreases 1%

All biomass significantly increases.

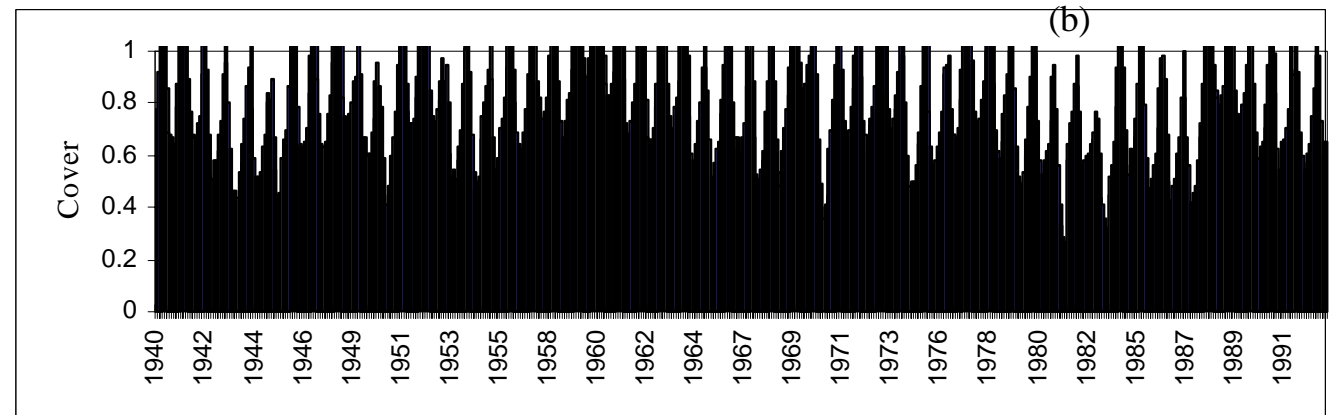
Change is seasonally variable

Significant long term vegetation variability

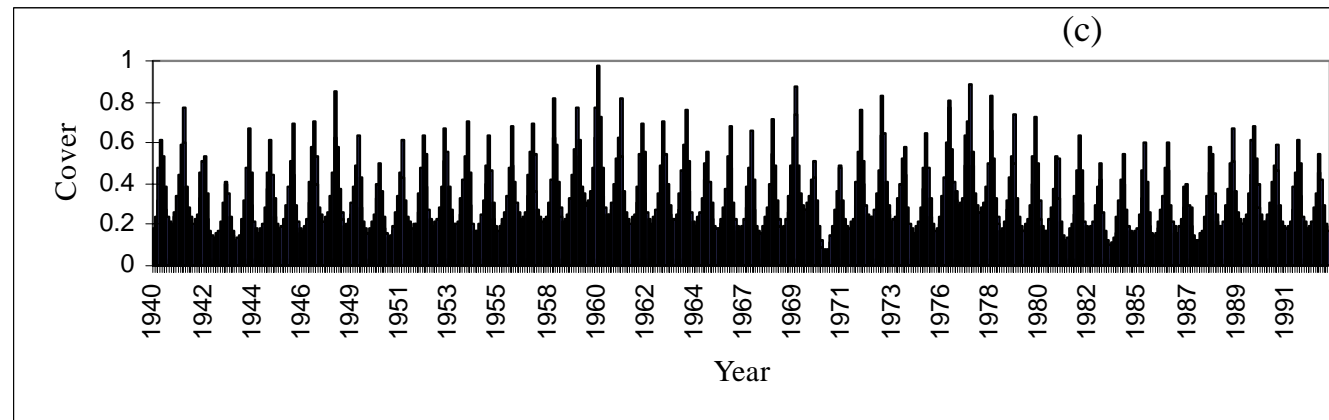
Shrub FT
Quercus cocciferra



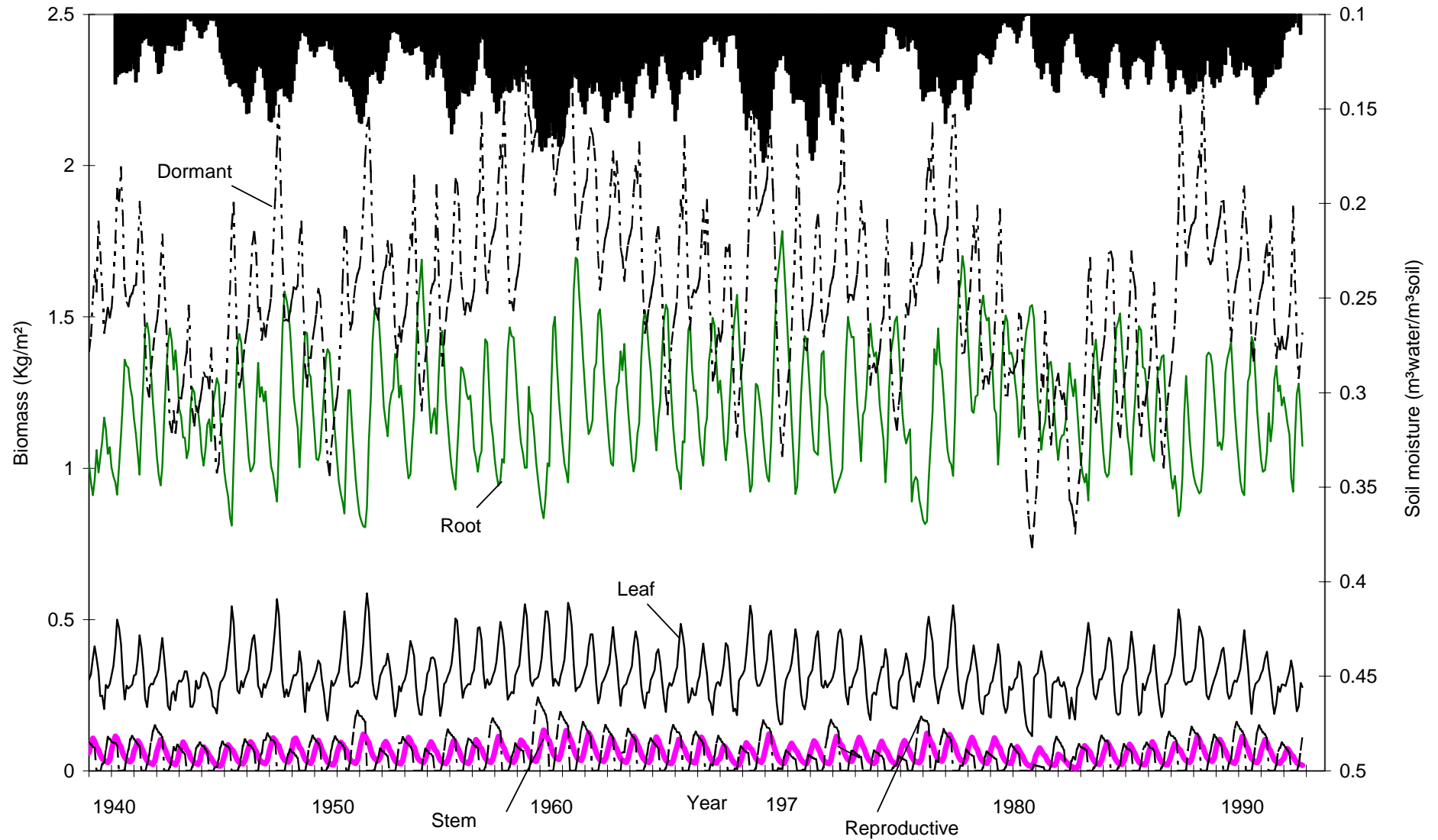
Dwarf shrub FT
Thymus vulgaris



Grass FT
Stipa tenecissima



Complex responses of plant resource partitioning



Climate sensitivity

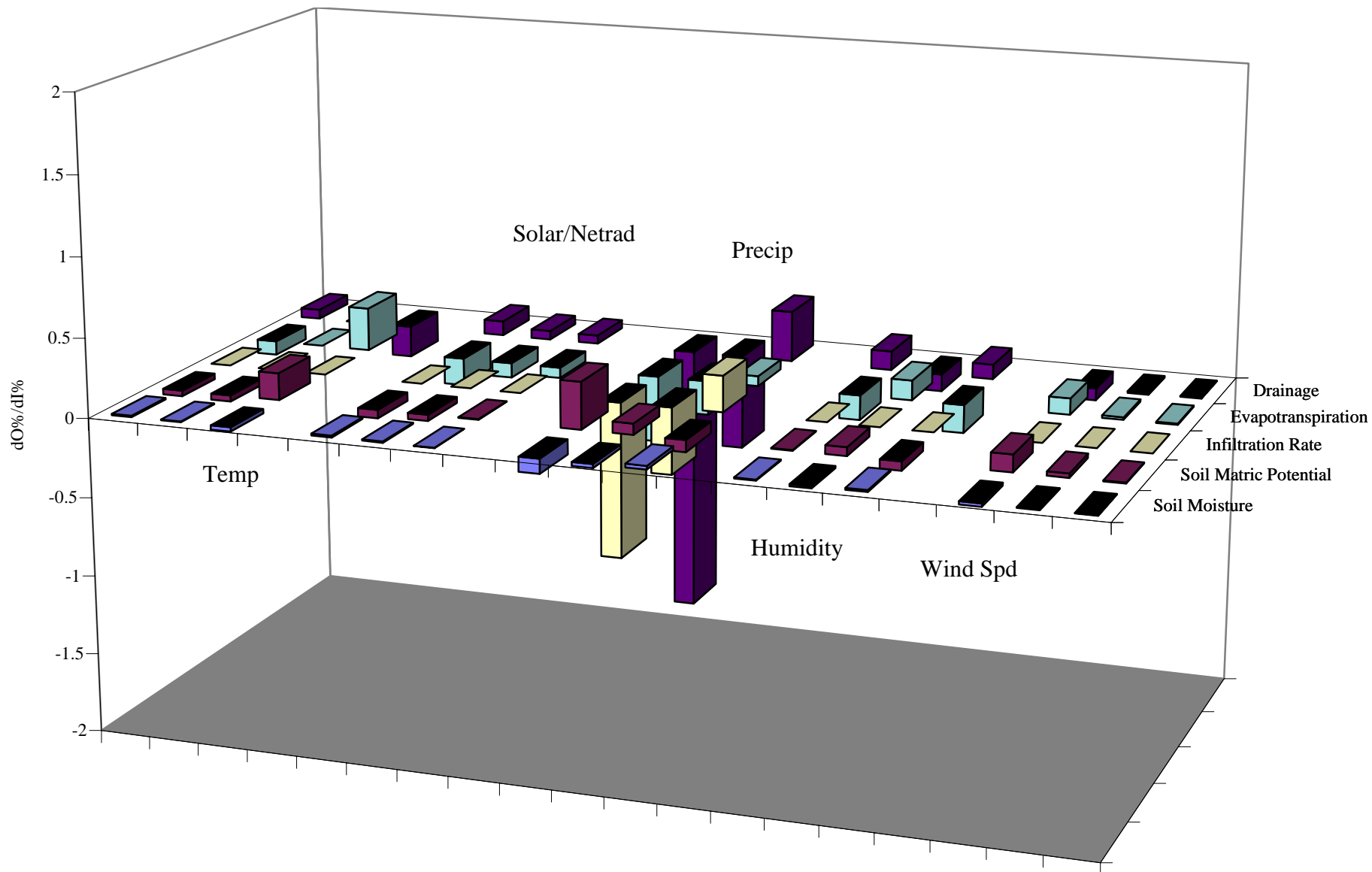
‘Usual’ approach to climate impacts modelling

- 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 scenarios for (1*CO₂, 2*CO₂)
- Draw implications of the change in process observed in terms of its likely impact

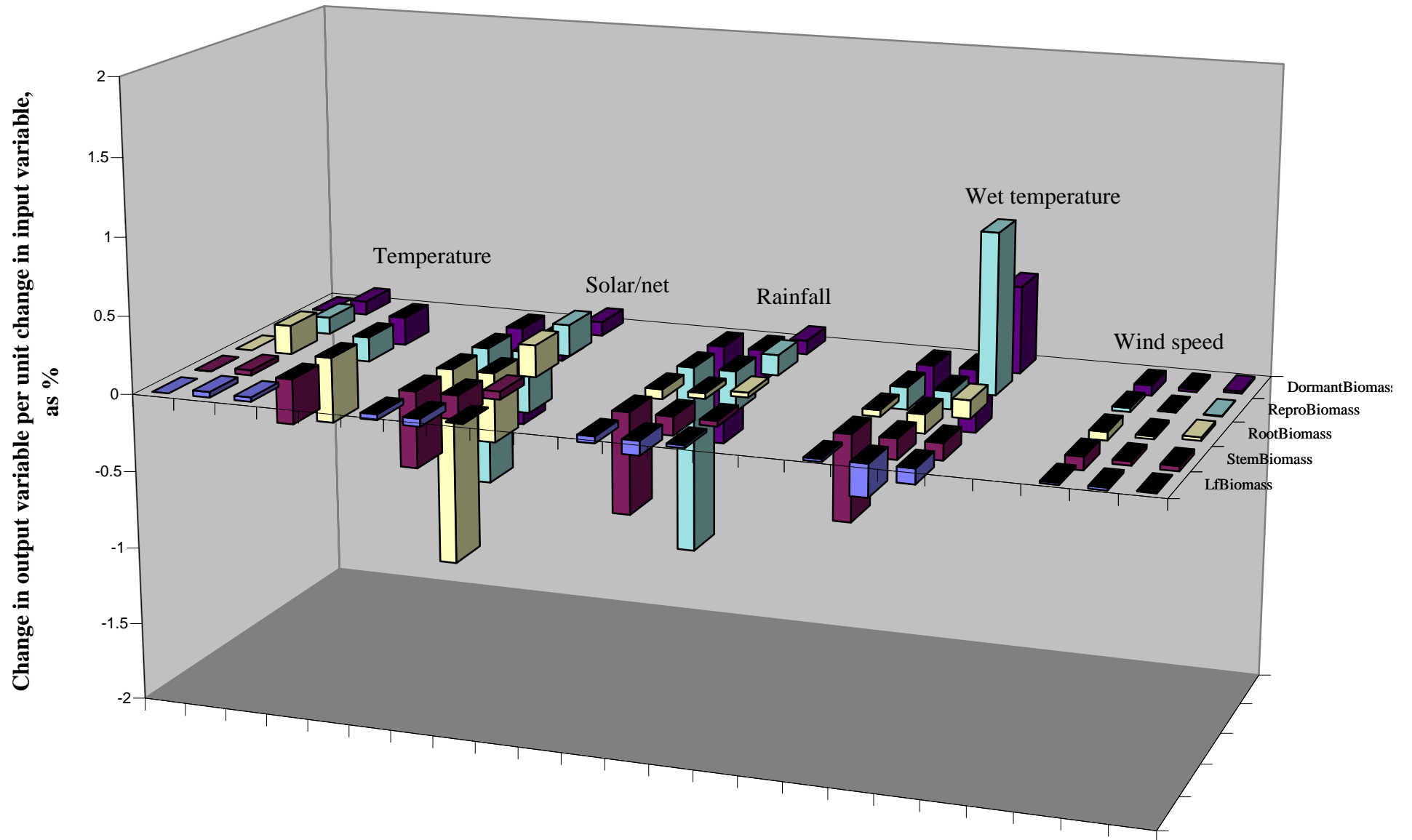
Sensitivity approach

- 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



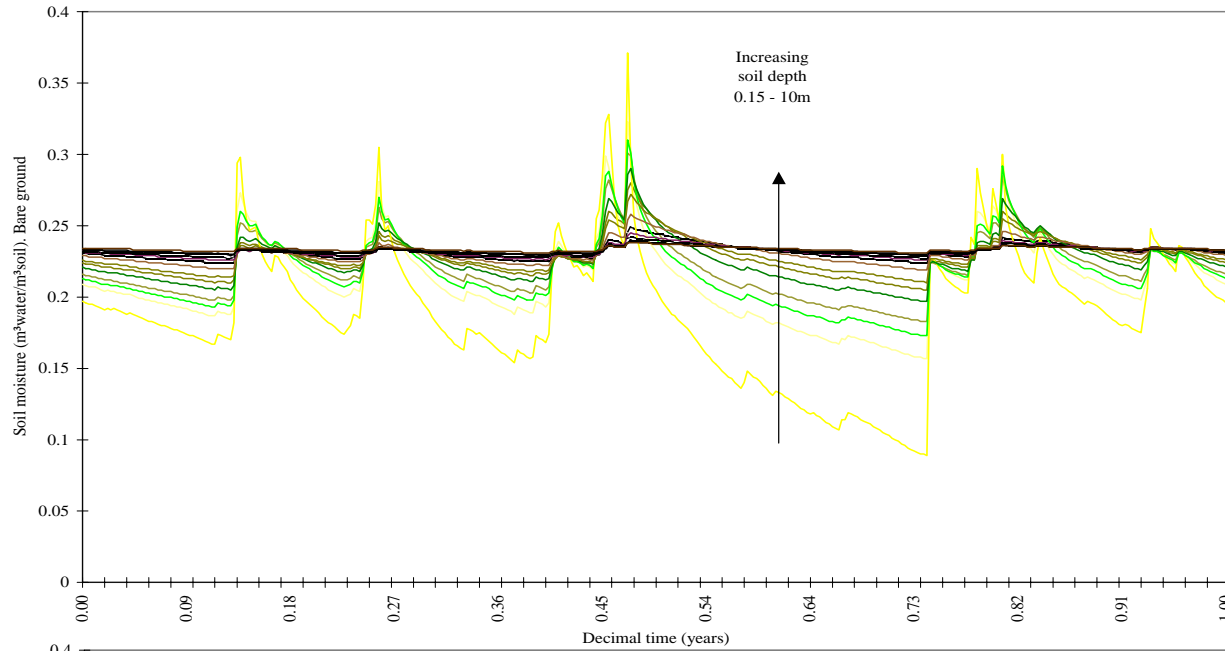
PATTERN : Plant sensitivity to climate



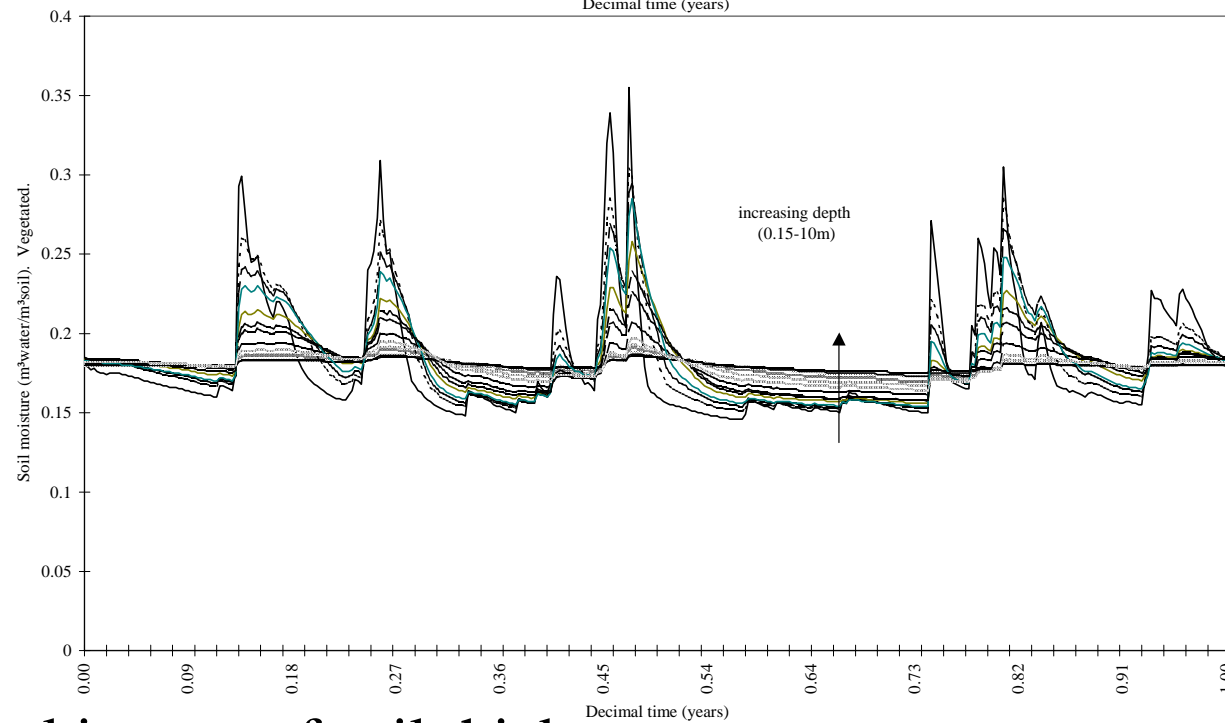
Climate impacts by land cover :1

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

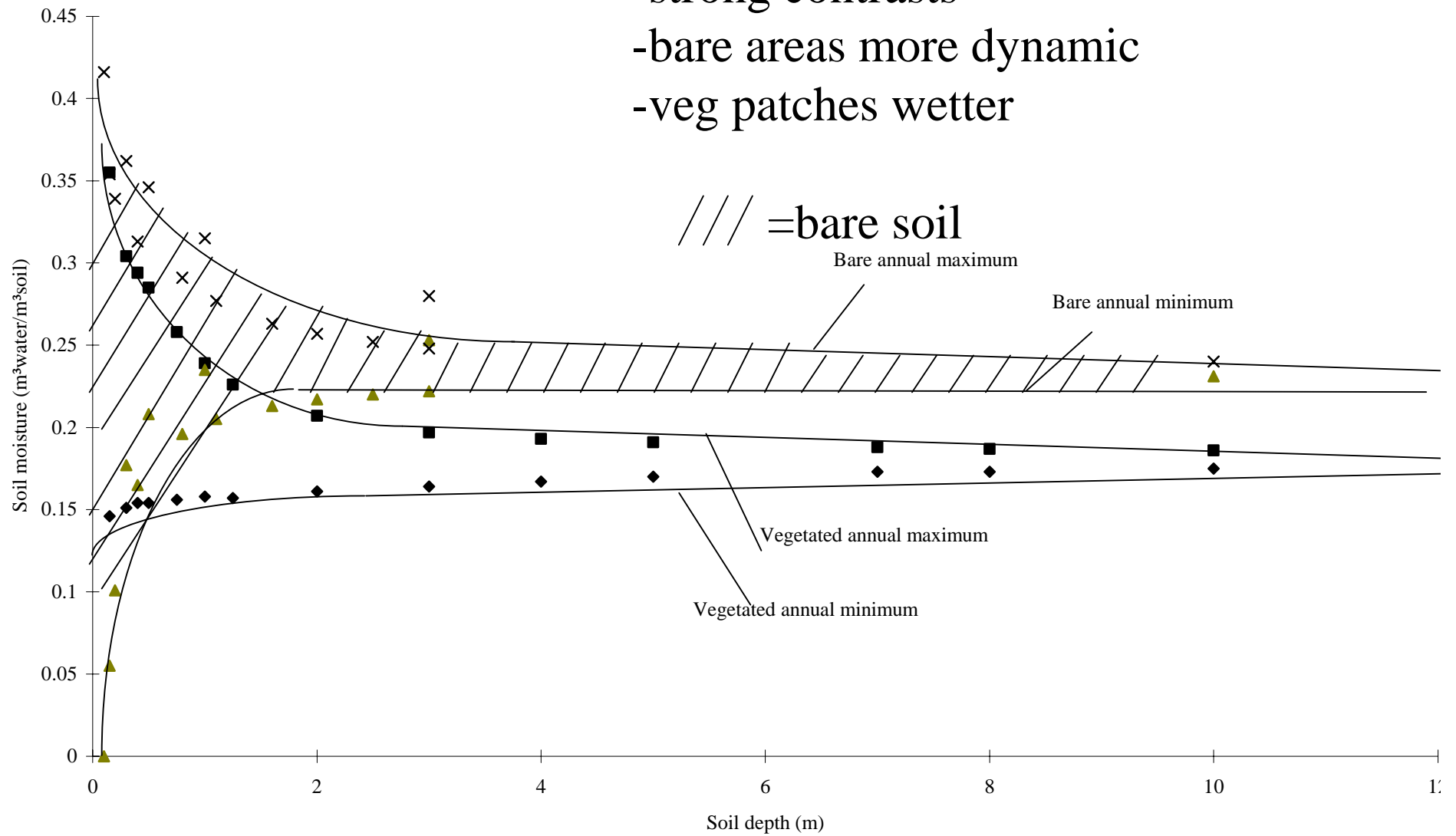


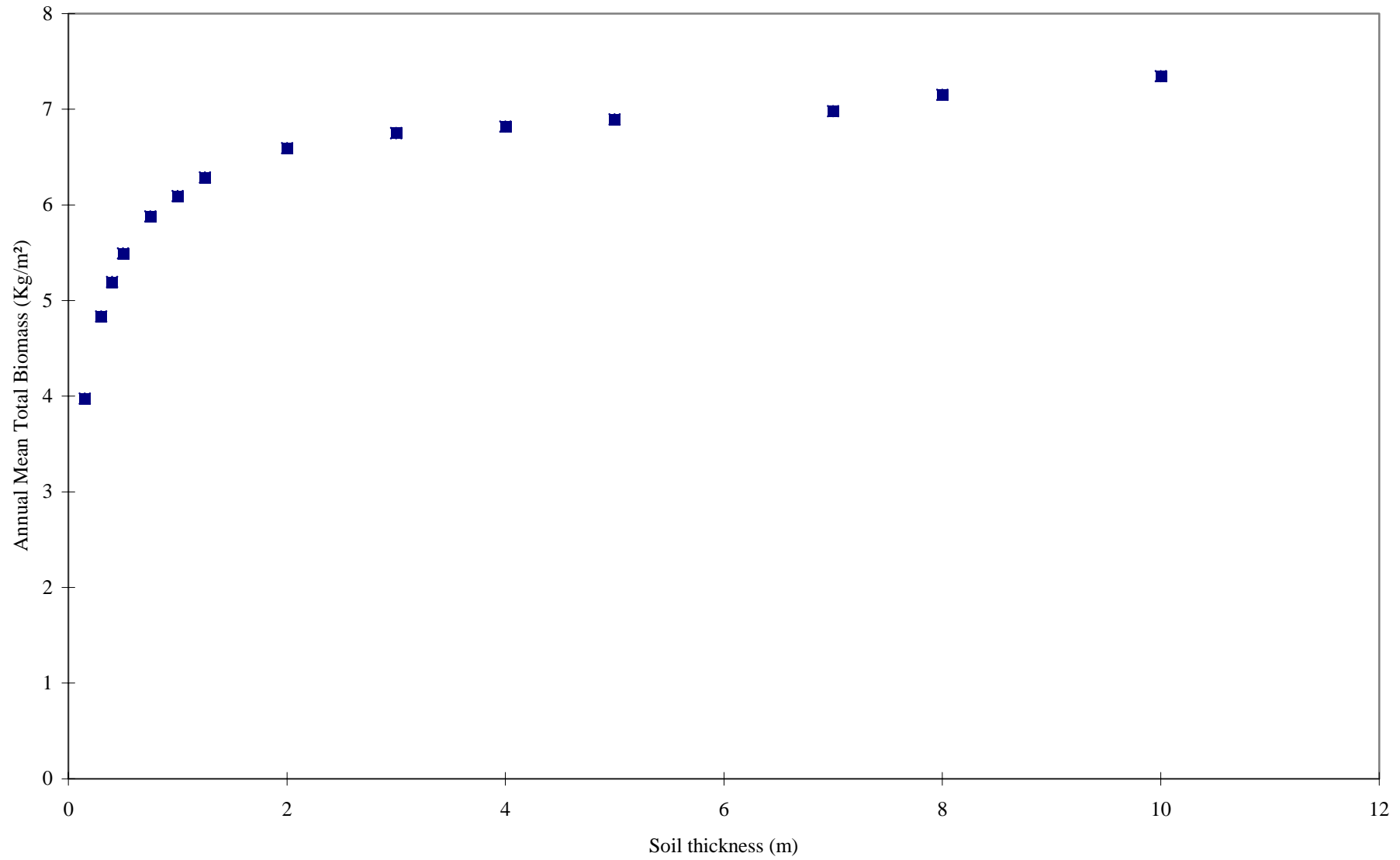
Vegetated

Hydrological impact of soil thickness

Moisture dynamics and soil thickness

- strong contrasts
- bare areas more dynamic
- veg patches wetter

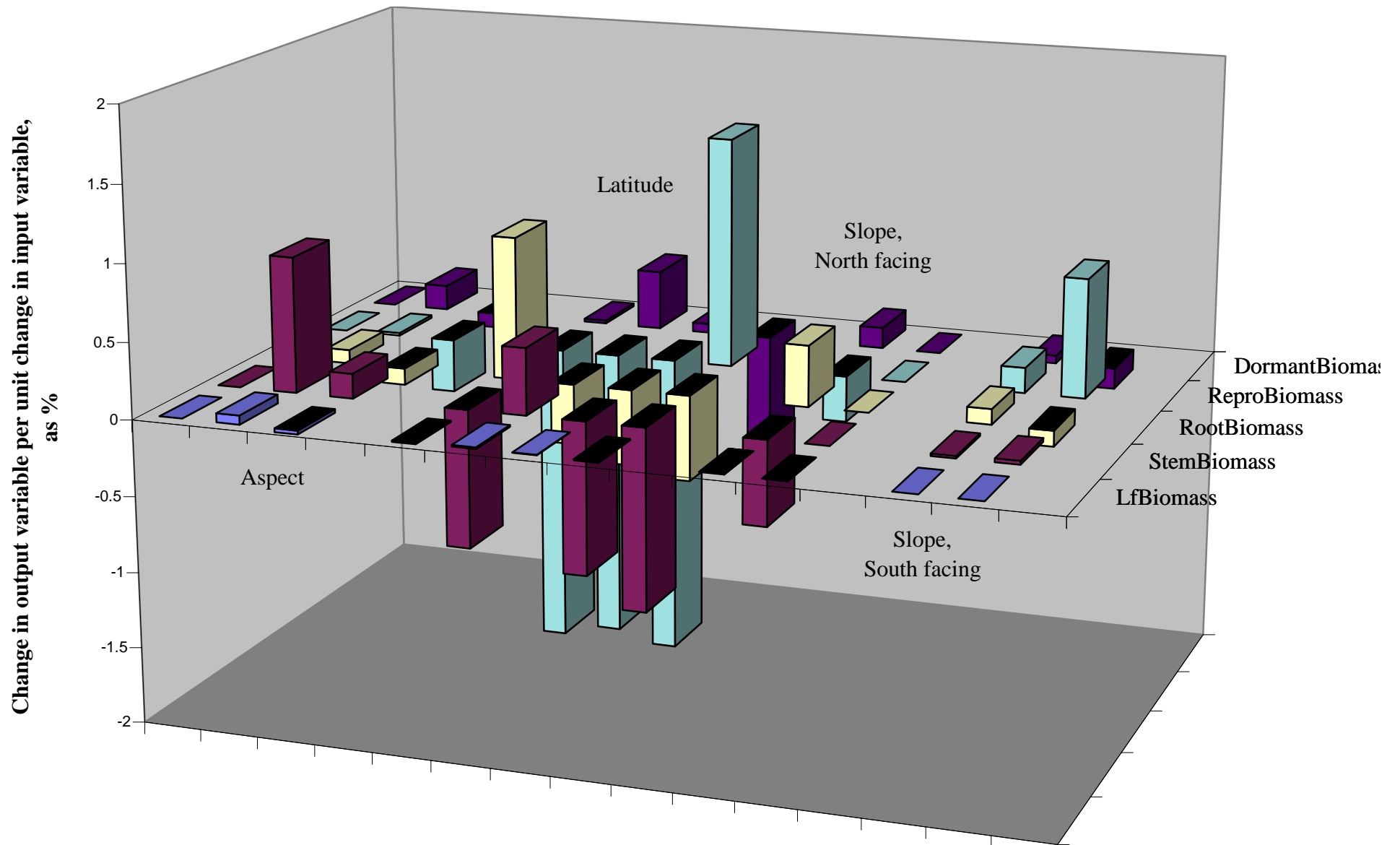




Total biomass impact of soil thickness

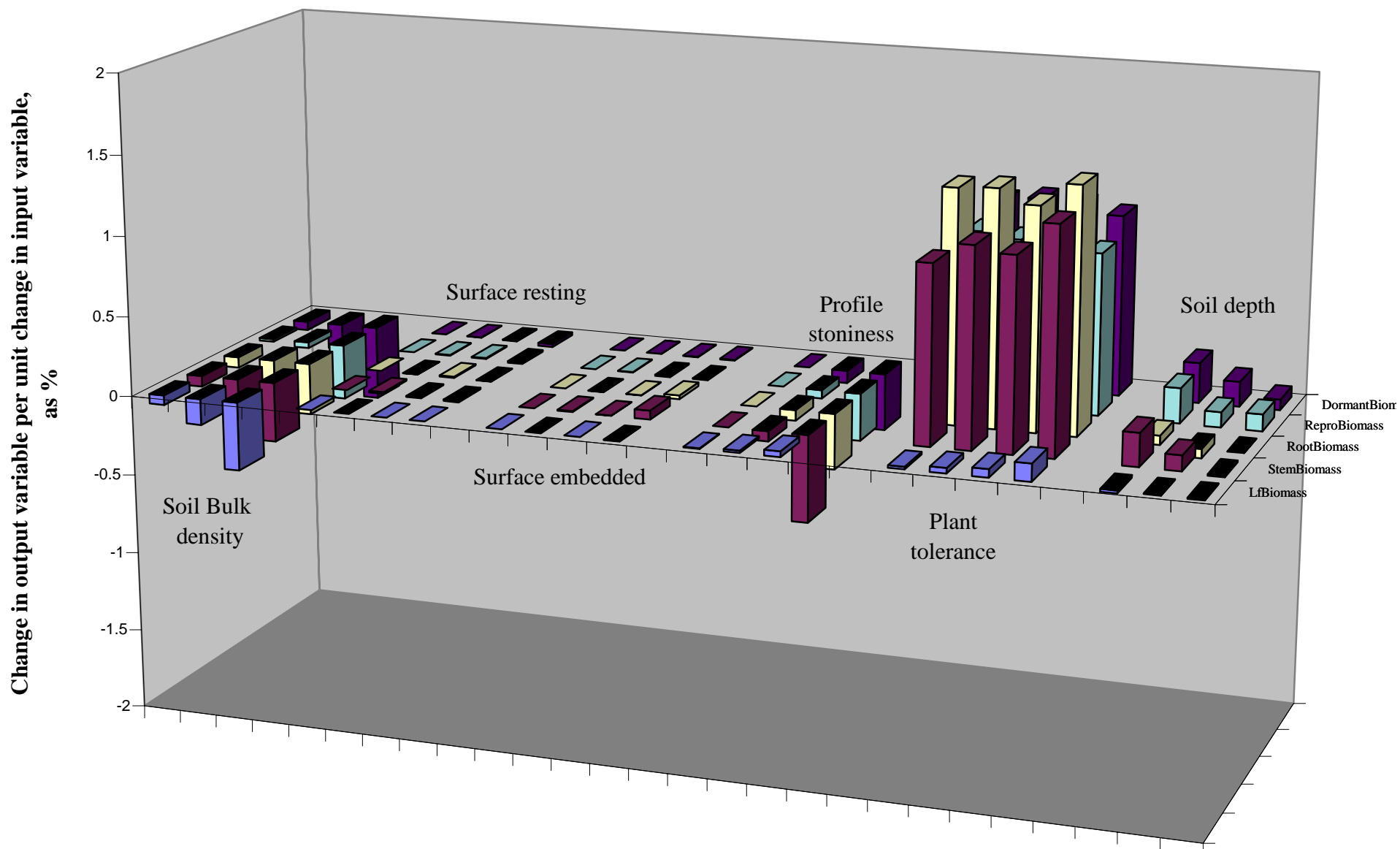
Climate impacts by land :3
Landscape properties

Plant sensitivity to landscape position

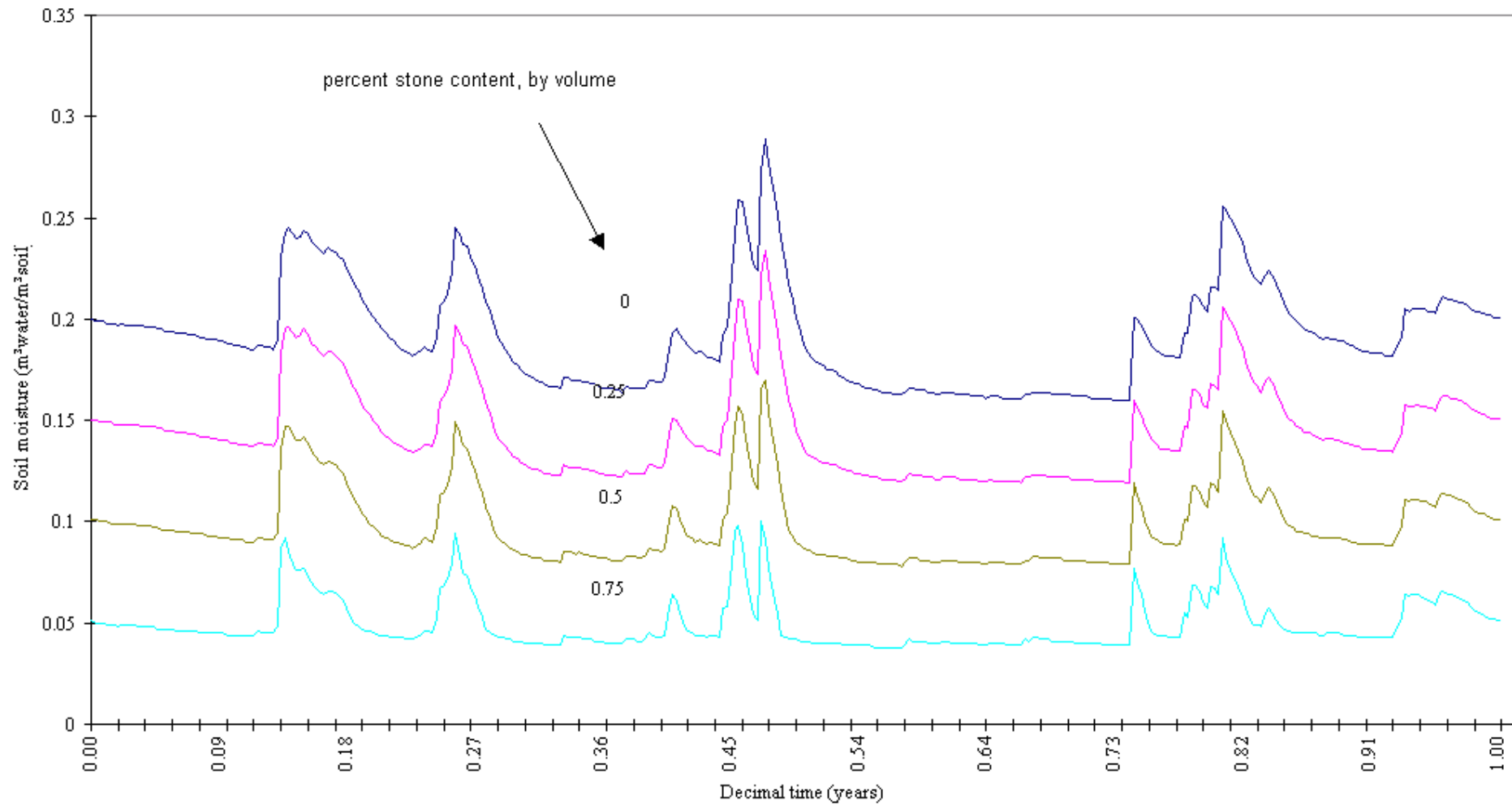


Climate impacts by land :4
Soil properties : hydrological impacts

Plant sensitivity to soil conditions

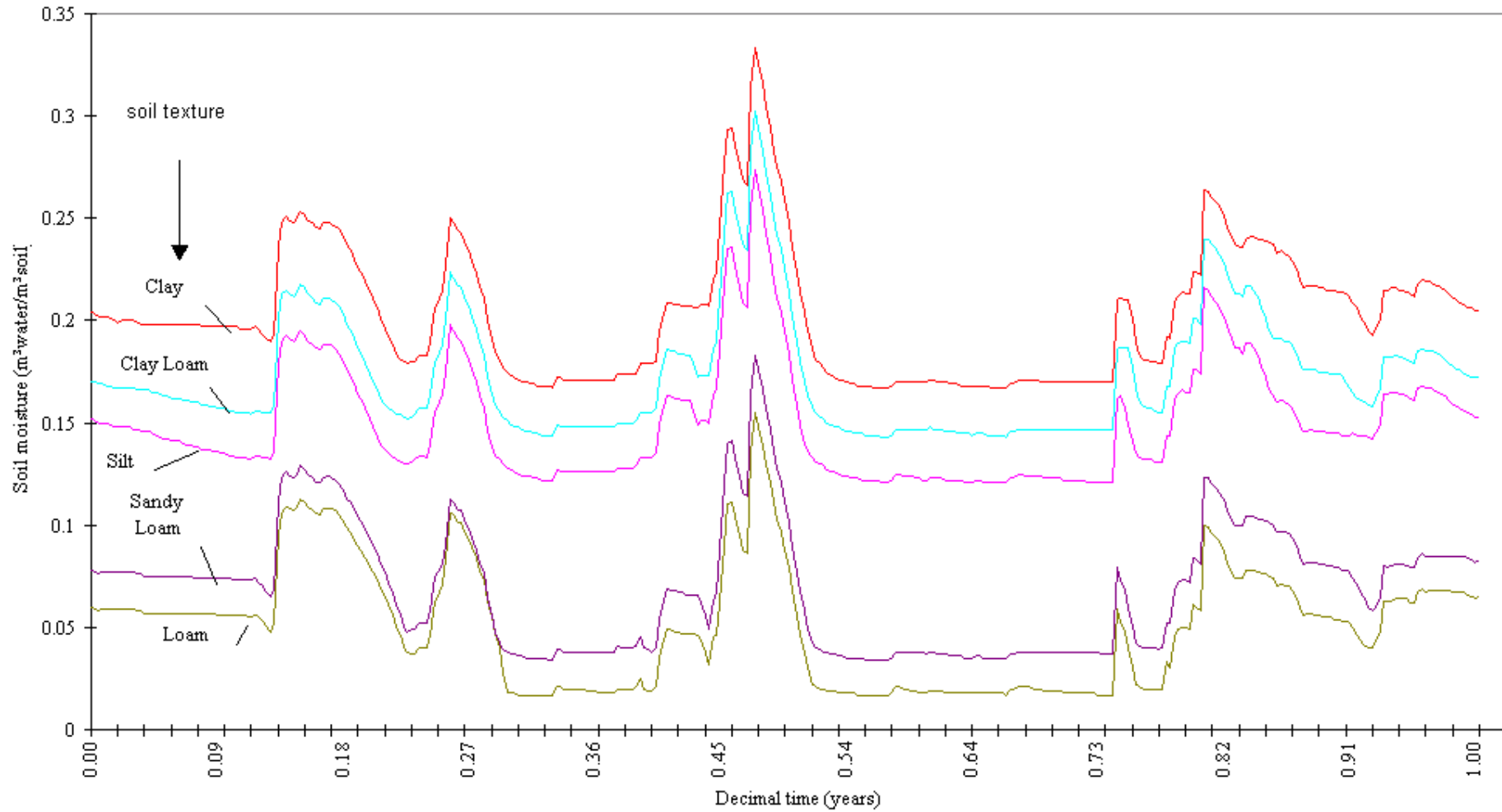


Impact of soil rock fragment content on soil moisture



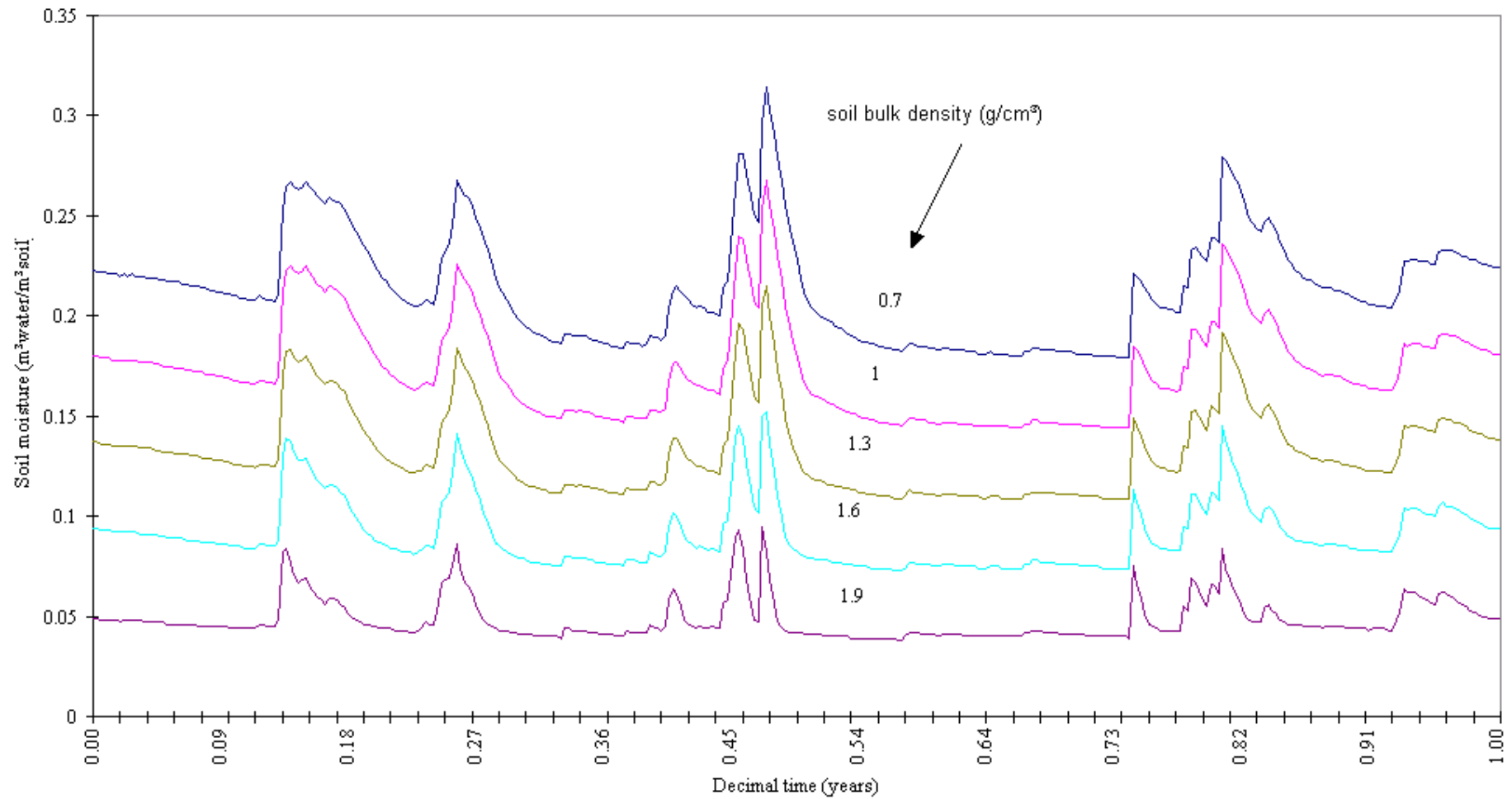
Reduces overall moisture and the temporal variation in soil moisture
Also difficult to measure/model at the landscape scale

Impact of texture on soil moisture



Affects mean soil moisture more than its variability

Impact of soil bulk density on soil moisture



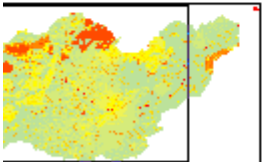
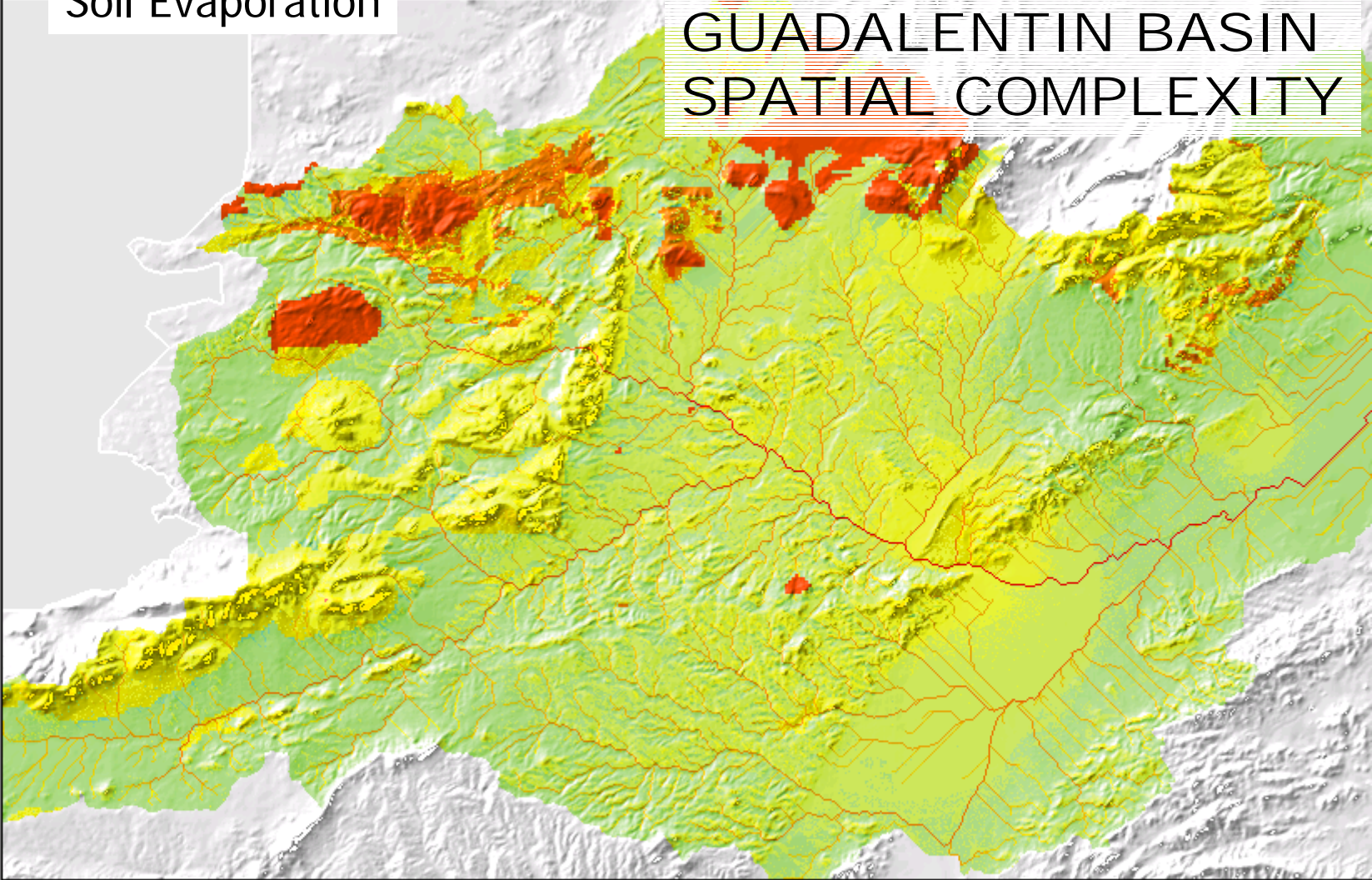
Acts in a similar way to rock fragment content, affecting both mean soil moisture and its variability

The mosaic of climate change impacts

- not modelled
- 1
- 1.1
- 1.2
- 1.3
- 1.4
- 1.5
- 1.6
- 1.7
- 1.8
- 1.9

Soil Evaporation

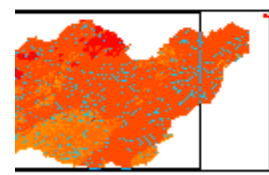
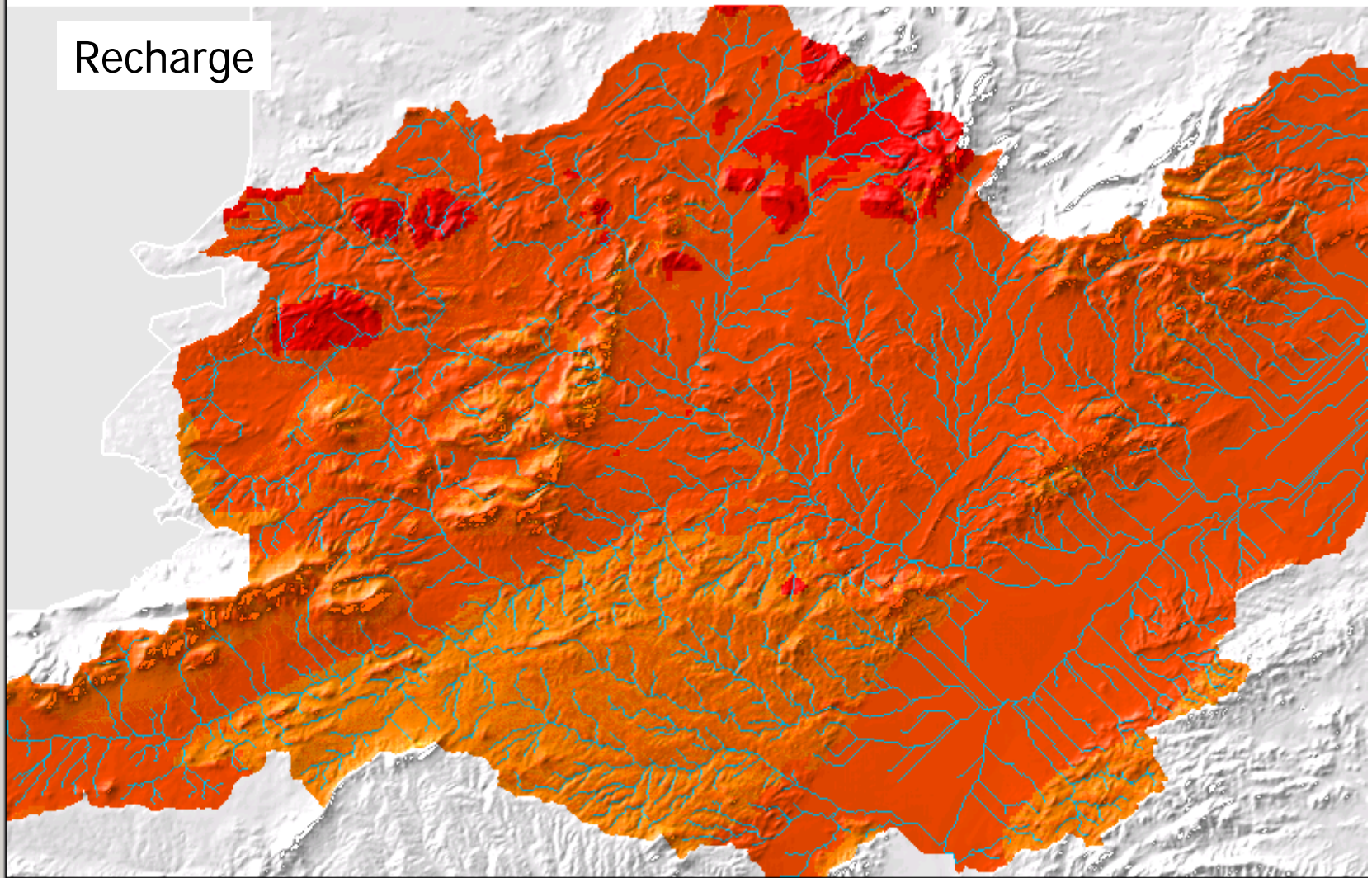
GUADALENTIN BASIN SPATIAL COMPLEXITY



not modelled

- 1
- 1.00001
- 1.0001
- 1.001
- 1.004
- 1.007
- 1.01
- 1.015
- 1.02
- 1.025
- 1.03
- 1.035
- 1.04

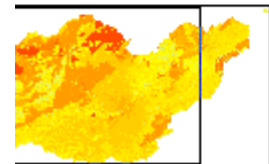
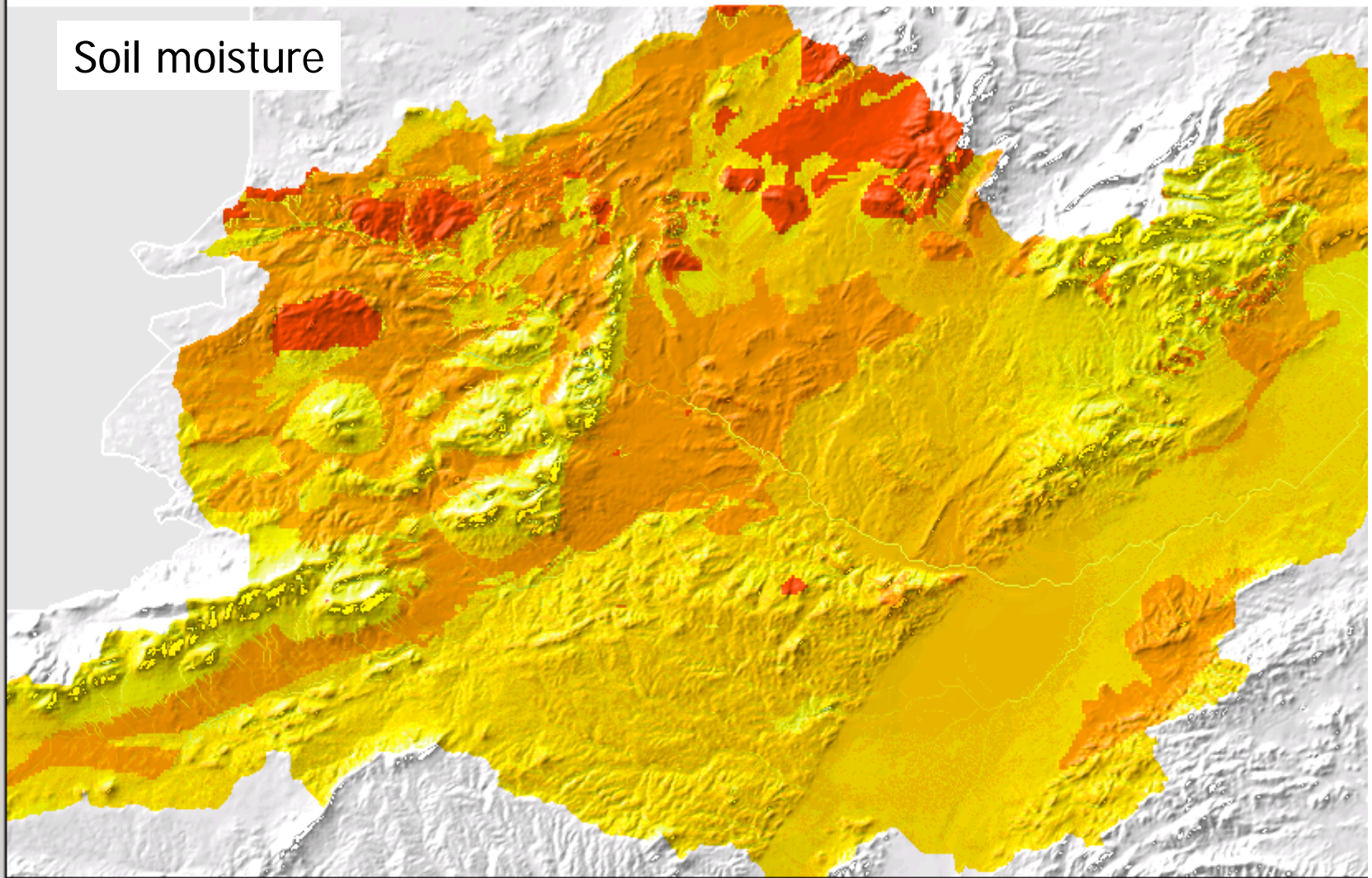
Recharge



not modelled

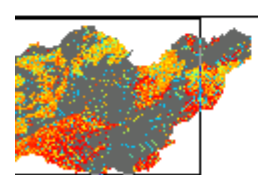
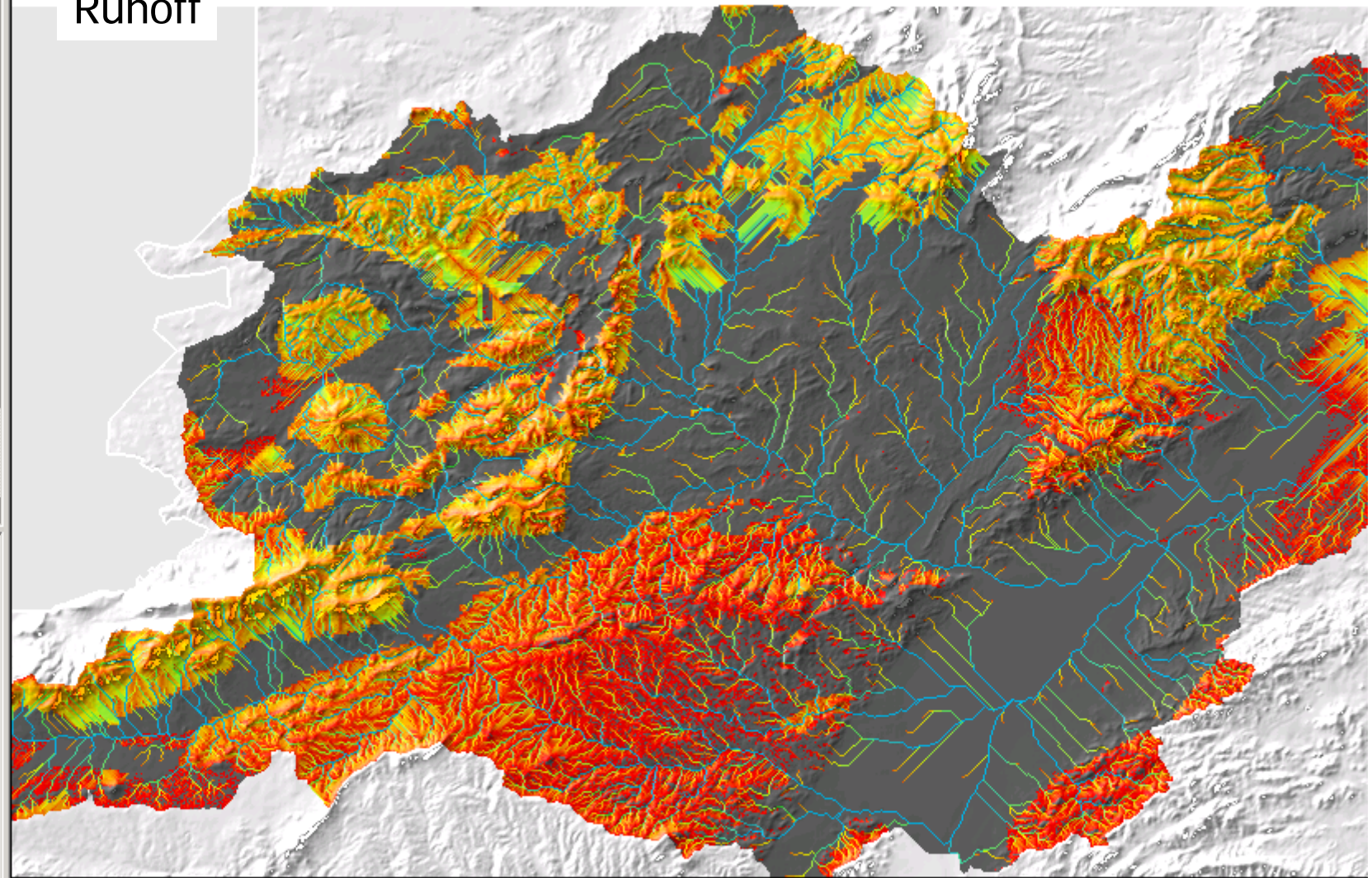
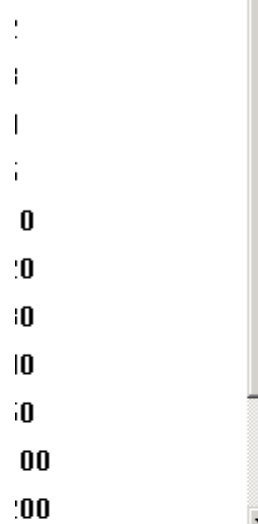
- 1
- 1.05
- 1.1
- 1.15
- 1.2
- 1.25
- 1.3
- 1.35
- 1.4
- 1.5
- 1.6
- 1.7
- 1.8

Soil moisture



not modelled
no accumulated wa

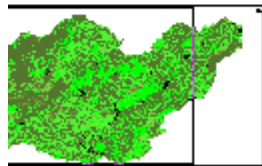
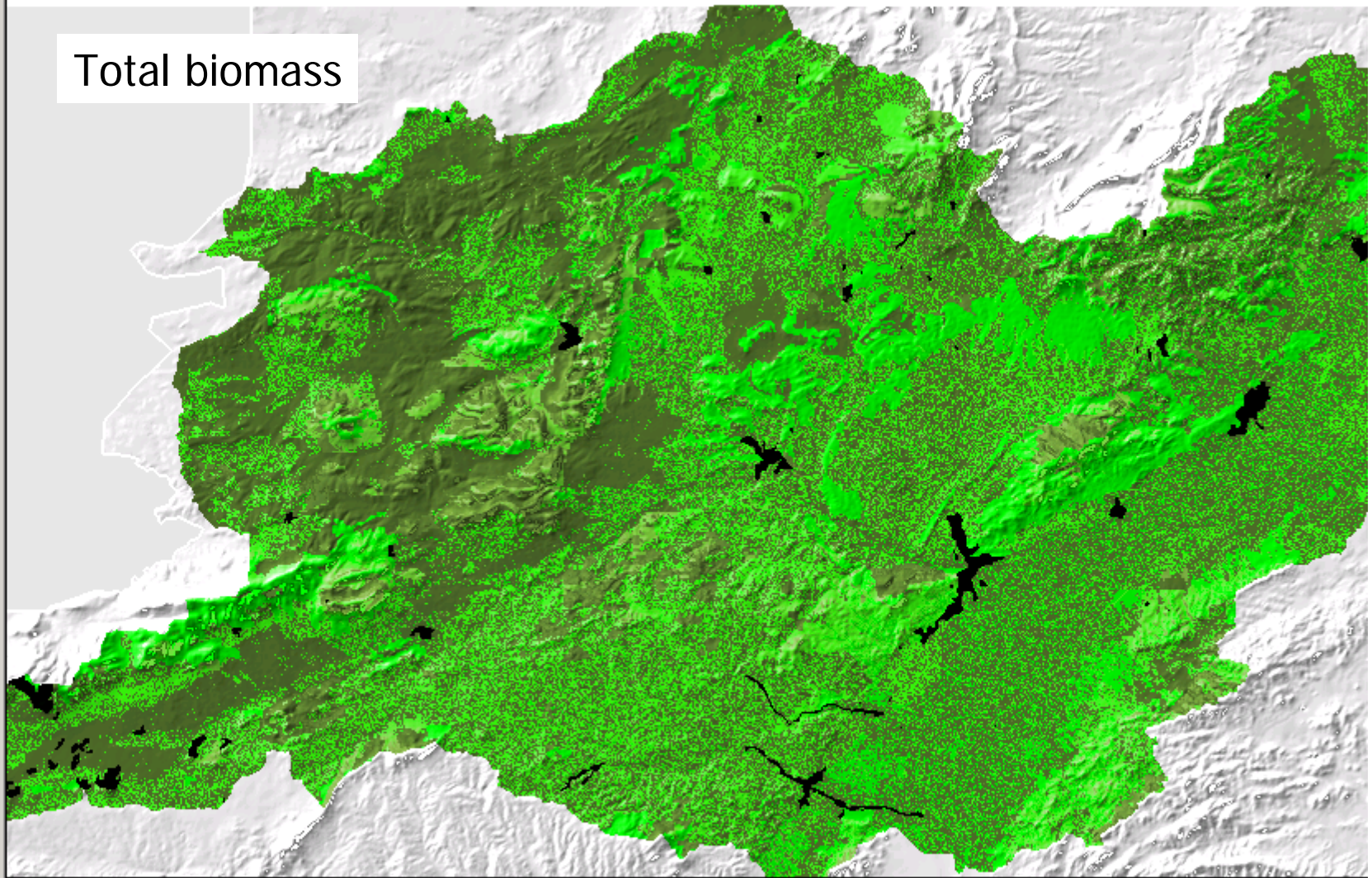
Runoff



not modelled

1
:50
:00
000
500
:000
:000
1000
:500
:000
1500
2000

Total biomass



Edit View Maps Rules Simulation Options Window Help

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micro-scale dynamics

System diagram

Climate & weather
Scenarios

Hydrology & soil
Hydrology
Erosion

Vegetation
Natural vegetation
Plant growth

Land use
Demands
Suitability
Allocation

Water demands

Parameters

Current month	Demand per unit [m ³ /unit month]	Sectorial demand [m ³ /month]	Policy restriction [m ³ /month]	Final demand [m ³ /month]
Agriculture			500000000	609592782
Rural residential	3.35	9993	10000	9993
Urban residential	3.96	509197	510000	509197
Industry and commerce	913.11	602640	600000	602640
Tourism	9.13	5022	5427	5022
Expatriots	4.57	233	281	233

Division of water...

Outputs

Previous month	Aquifer [m ³ /month]	Reservoirs [m ³ /month]	Desalinated sea water [m ³ /month]	Total supply [m ³ /month]	Shortage [m ³ /month]
Agriculture	219931	8188121	76590539	8974654	65549477
Rural residential					
Urban residential					
Industry and commerce					
Tourism					
Expatriots					
Total	2				

Erosion

Parameters

Check dams...
Reservoir dredges...

Fixed check dam dredge cost [€/checkdam year]	100.00
Variable check dam dredge cost [€/m ³ sediment]	10.00
Fixed reservoir dredge cost [€/reservoir dredge]	100.00
Variable reservoir dredge cost [€/m ³ sediment]	10.00

Outputs

Erosion & deposition [mm/day] Map

Cumulative erosion & deposition [mm] Map

Sediment discharge [m³/day] 27005348

Number of used check dams 823 of 1194

Total check dam sediment [m³] 52107

Check dam dredge cost [€] 13243823

Number of reservoirs 2

Total reservoir sediment [m³] 31978090

Reservoir dredge cost [€] 5194662459

Total dredge cost [€] 5207906282

NUM

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.***