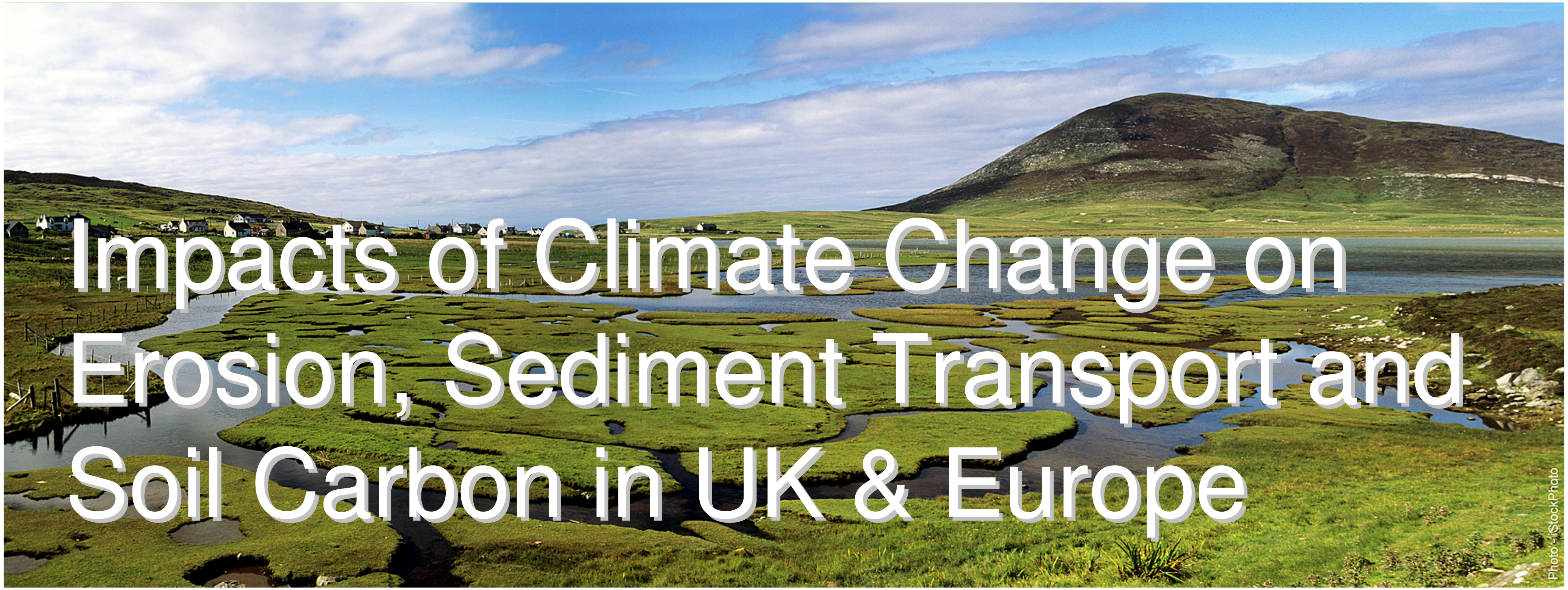
Impacts of Climate Change on Erosion, Sediment Transport and Soil Carbon in UK & Europe



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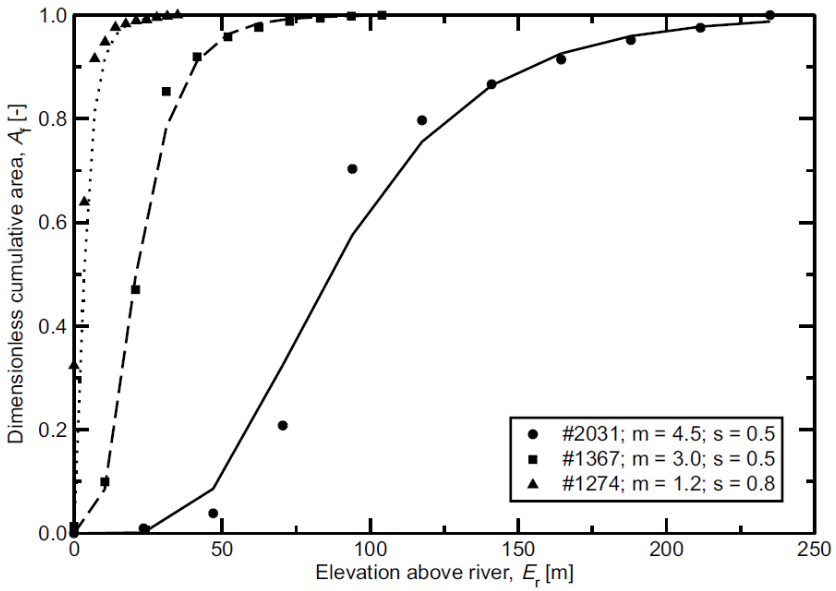
Key Project Objectives

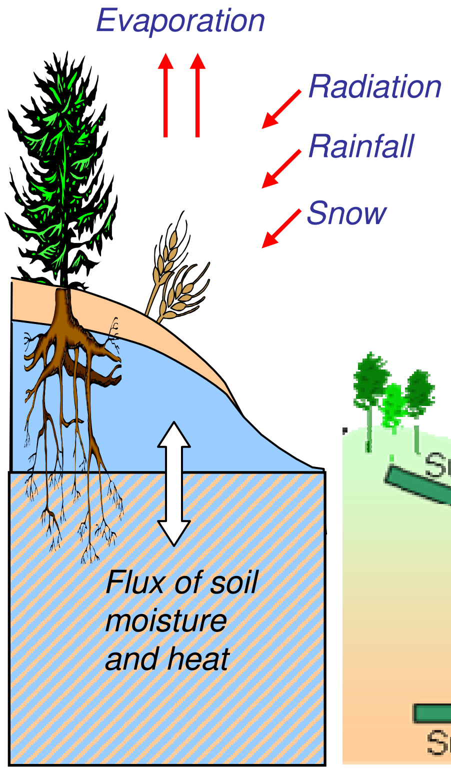
- Erosion by water is among the most severe threats to soil in Europe.
- Our modelling system combines the CEH Grid-2-Grid river flow model with Leeds PESERA soil erosion model;
- We predict the effects of climate and land-use change on soil erosion and sediment transport in the UK and Europe.

Hydrology in JULES/Grid-2-Grid

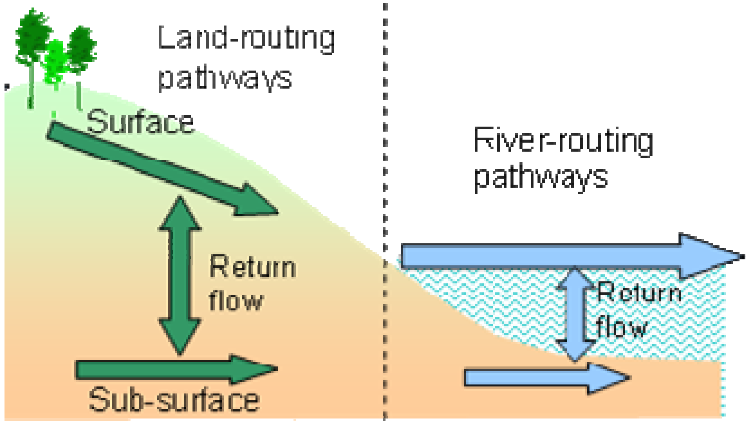


JULES takes **temperature**, **wind speed**, **humidity**, **LW** & **SW radiation** and **precipitation** from RCM;

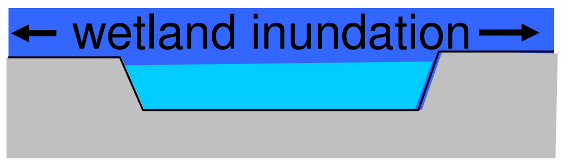
Diagnose state of **soil moisture** by using a Pareto distribution of soil moisture store sizes;



Convert to **surface** and **subsurface flow.**

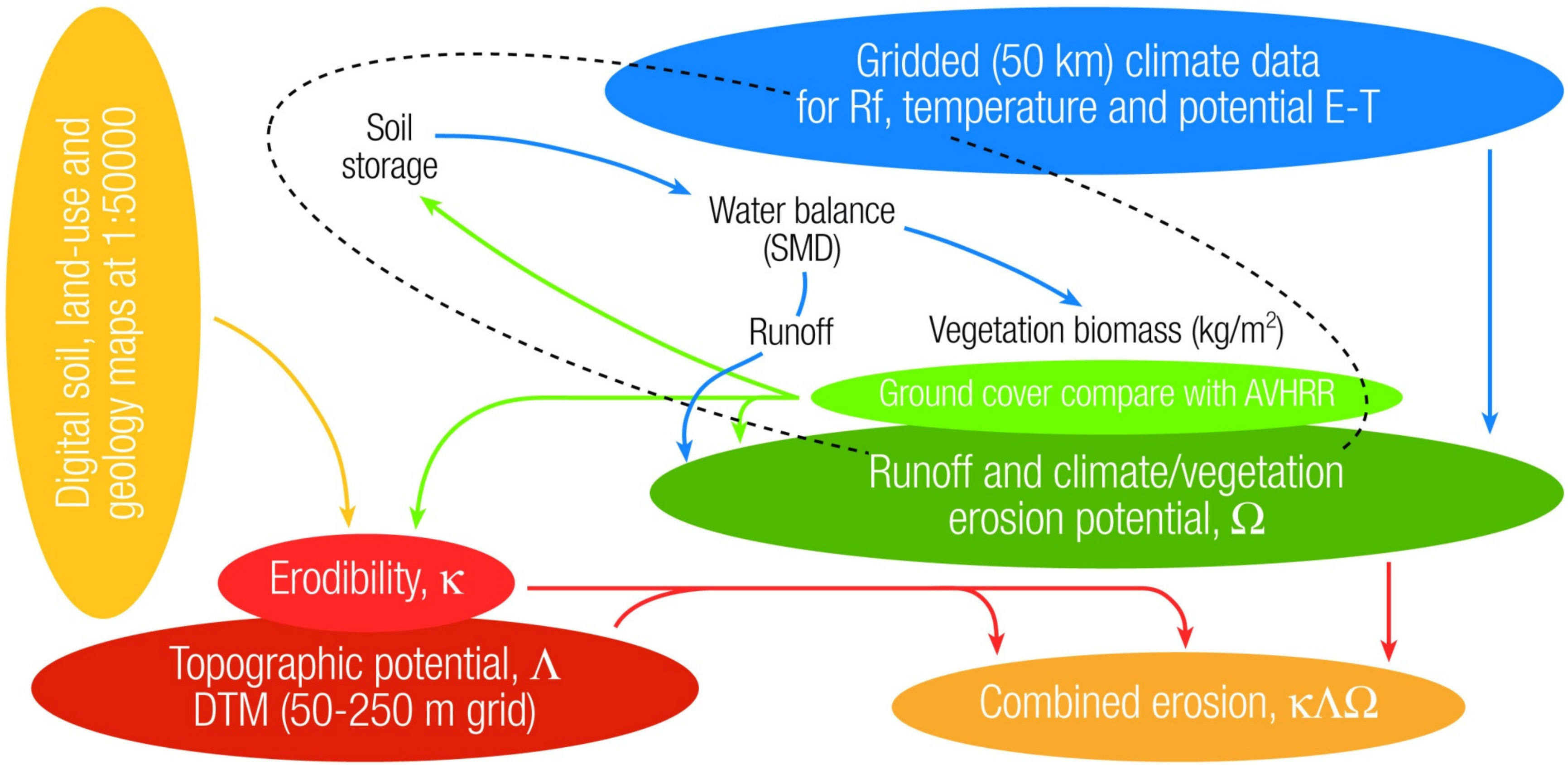


Inundated wetland area calculated using sub-grid elevation data



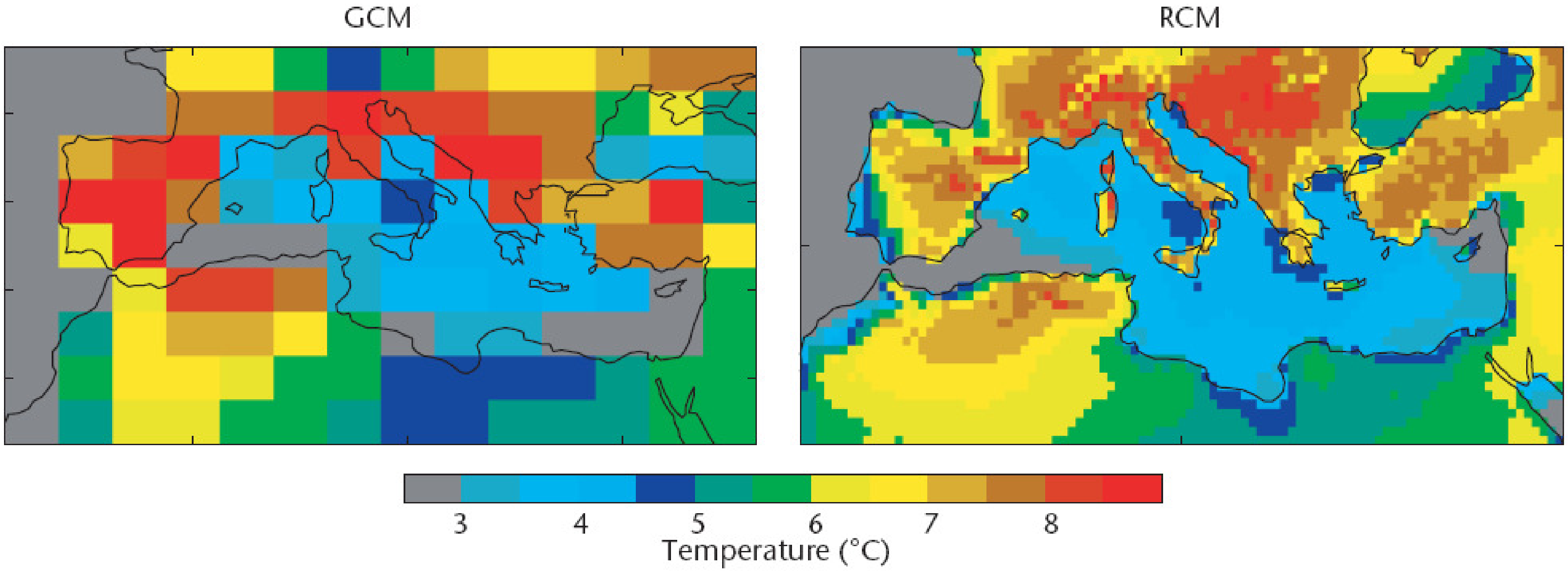
Bell *et al.*, 2007; Dadson *et al.*, 2006, 2007

PESERA Model



Mike Kirkby and Brian Irvine

Driving Data: Regional Climate Models



- Climate change: Future warming of 1.8-4.0 ℃ by 2100.
- Wetter winters & drier summers in NW Europe; more extremes.
- For Earth Systems Science applications, climate models need hydrology: driver of heat and water fluxes at land surface.
- 25 km RCM offers significant improvement over 2.5° (~300 km) GCMs; still too coarse for hydrology, need to parameterize.

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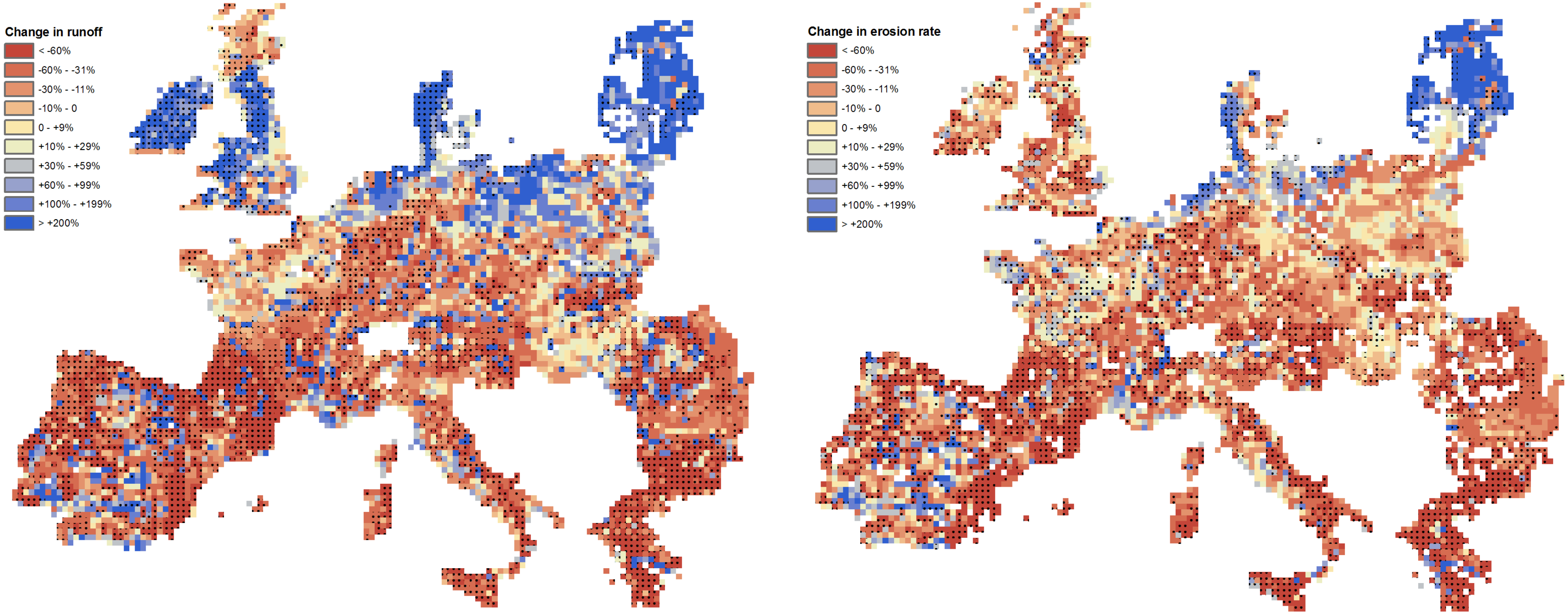
Jones *et al.*, 2002

Climate Impacts on Soil Erosion



- By 2080s: Reduced runoff and erosion in S. Europe; increases in Netherlands, Denmark, Baltic;
- No consistent picture for the UK; mostly a reduction;
- Land-use change is sufficient to outweigh climate forcing.

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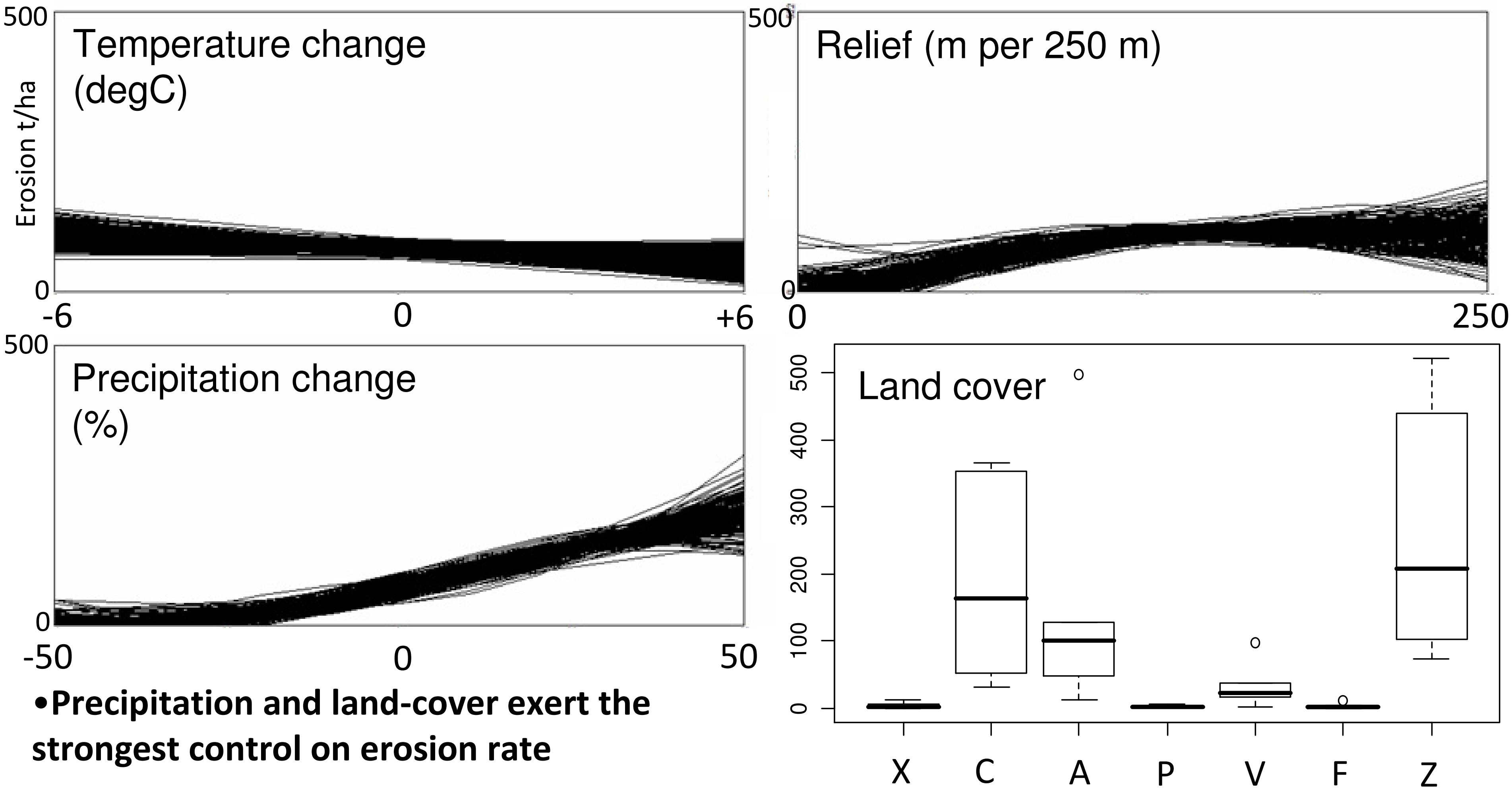
Dadson *et al.*, 2010 *Geophysical Research Abstracts*, *12*, EGU2010-7047
Dadson *et al.*, in prep.

Land-use, Climate, and Soil Erosion

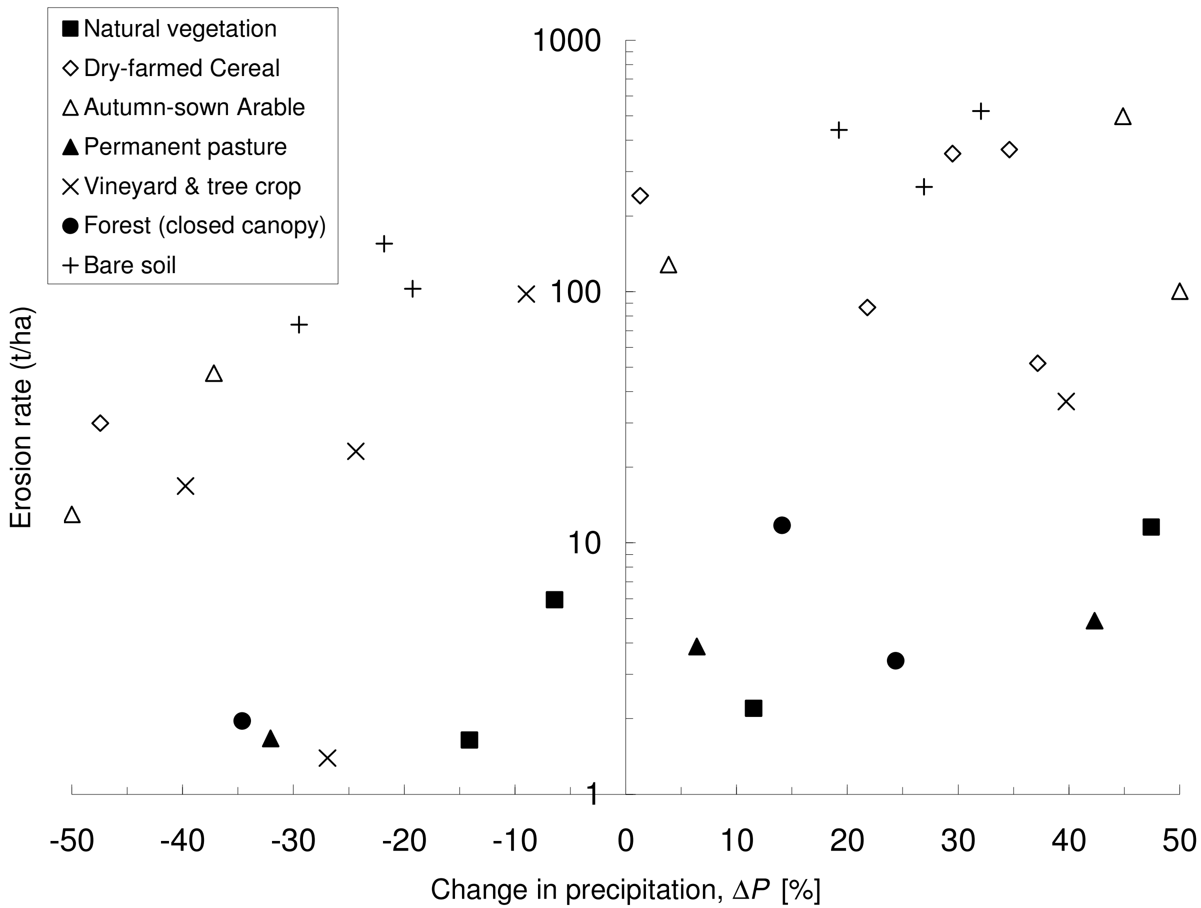


- **Precipitation and land-cover exert the strongest control on erosion rate**

- **Significant interaction term: erosional response to climate change is different for different land types)**

Natural, Dry Cereal, Autumn-sown Arable, Pasture, Vineyard, Forest, Bare soil

Land-use, Climate, and Soil Erosion



Effect	*Variance*
Temp	1.4
Precip	**22.4**
Relief	7.5
Cover	**30.8**
Temp.Precip	0.0
Temp.Relief	0.0
Temp.Cover	0.2
Precip.Relief	1.4
Precip.Cover	**17.3**
Relief.Cover	11.7

- **Range of land-use responses to climate change may be greater than climate change signal**

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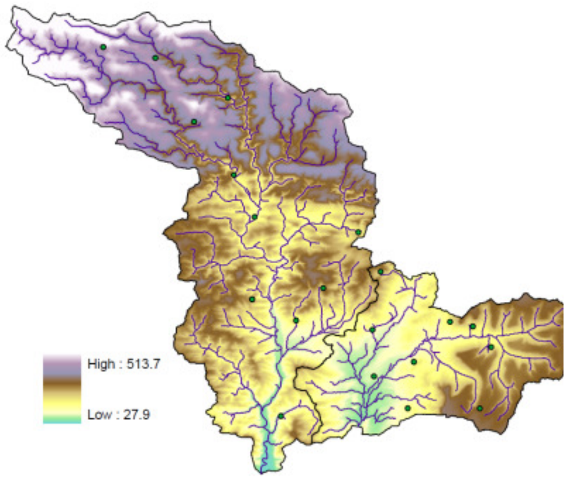
Dadson *et al.*, 2010 *Geophysical Research Abstracts*, *12*, EGU2010-7047
Dadson *et al.*, in prep.

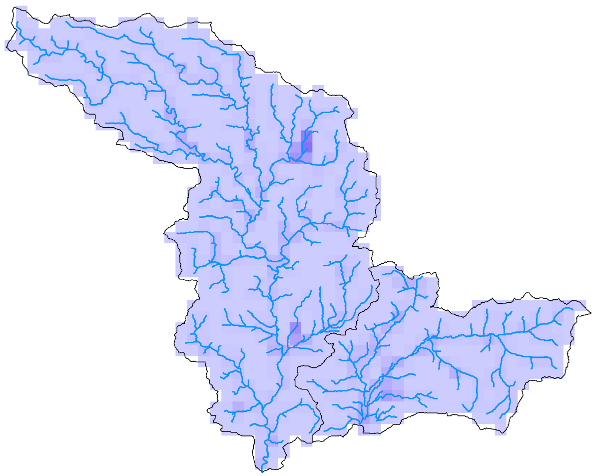
Implications for land management

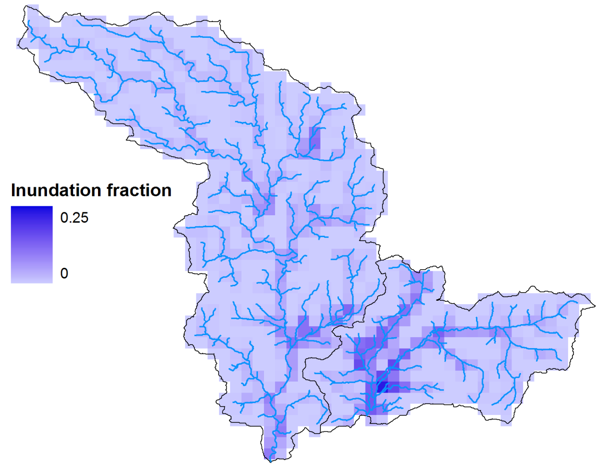
- **Under natural vegetation**: **Warmer** → higher evaporation, more vegetation, less runoff, less erosion;
- **Wetter** → more rapid vegetation growth, less runoff, and less erosion (unless plant growth is constrained by lower temperatures)
- Managed landscapes may be more susceptible to climate change, **but**: effective management at local scales may mitigate the local effects of changing regional and global climatic drivers

Large-scale inundation modelling

Where does the sediment go?
Need to simulate overbank inundation processes…







Representation of flooding using sub-grid-scale topography

Finer-scale digital elevation model are used to construct the probability density of height above the grid-box minimum

Example of floodplain inundation extent for the Exe in SW England

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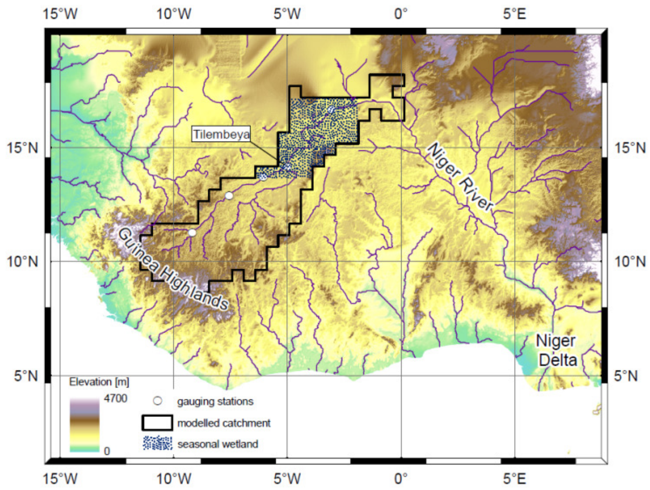
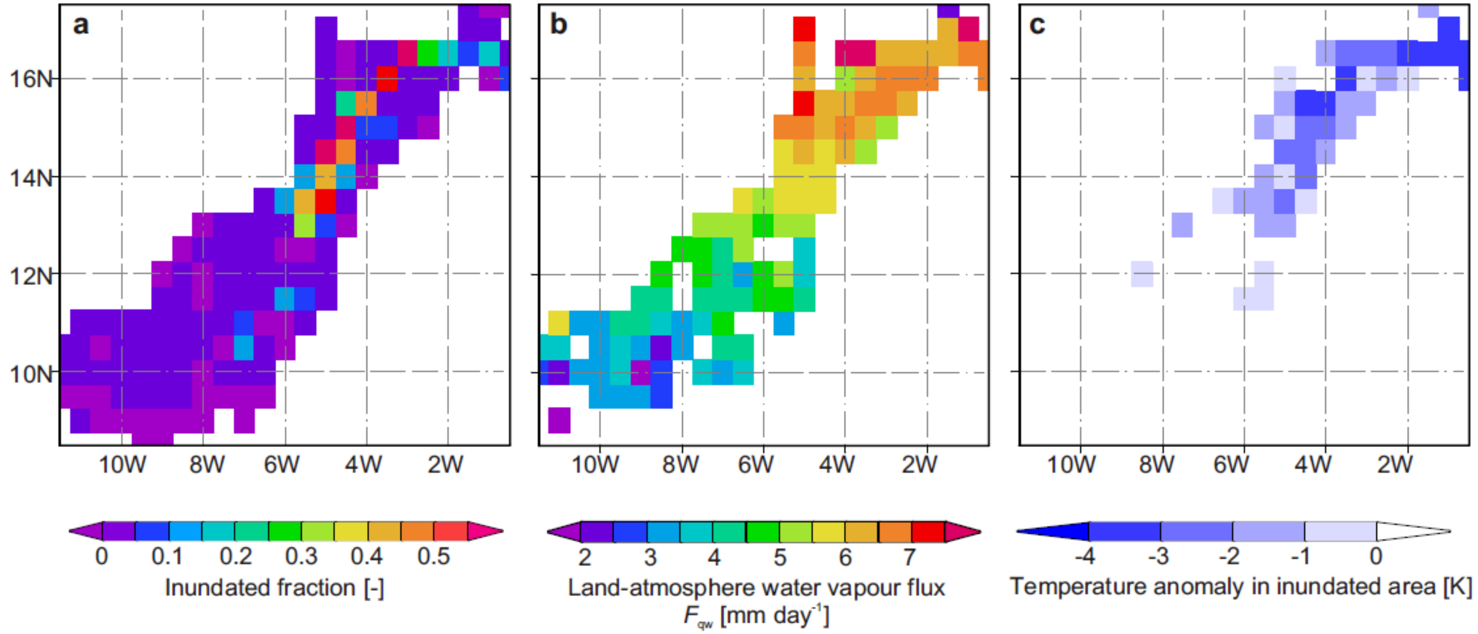
Global applications: Niger Inland Delta



- Spinoff to enable global inundation modelling in data-sparse areas
- Ability to simulate flooding in global environmental models like JULES
- Links with climate system; Met Office



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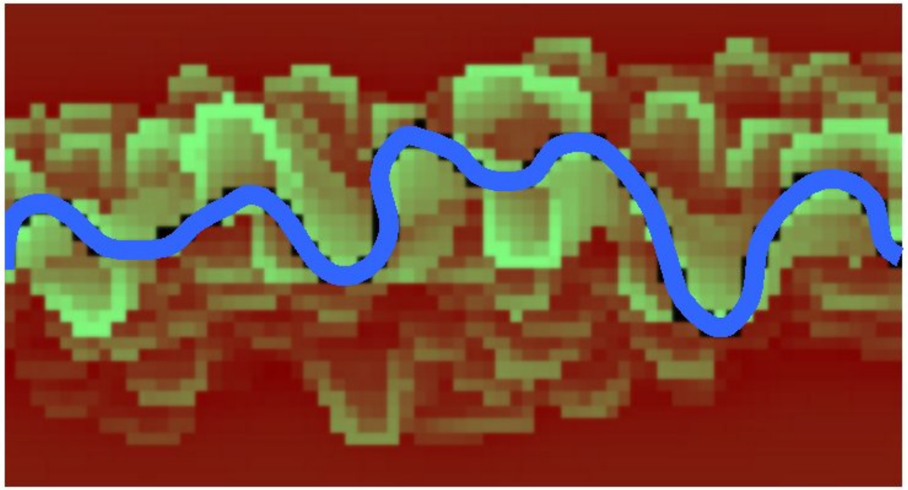
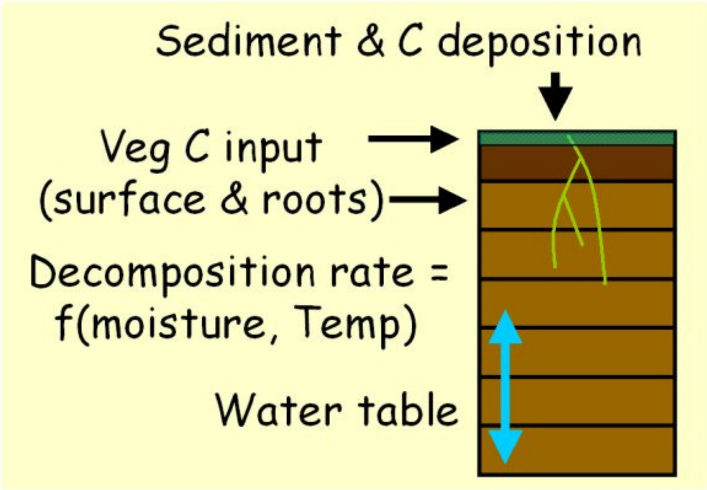
Dadson *et al.*, 2010, *Journal of Geophysical Research, 115, D23114.*

Floodplain sedimentation





- Floodplain Geomorphology and Biogeochemistry (FGB model) has been developed at Exeter
- Represents floodplain overbank sedimentation (Nicholas *et al.*, 2006), river channel migration (Ikeda *et al.*, 1981), and carbon accumulation and remobilization (RothC, Coleman and Jenkinson, 1996)
- Used to explore the effect of changes in discharge and water table on total carbon storage

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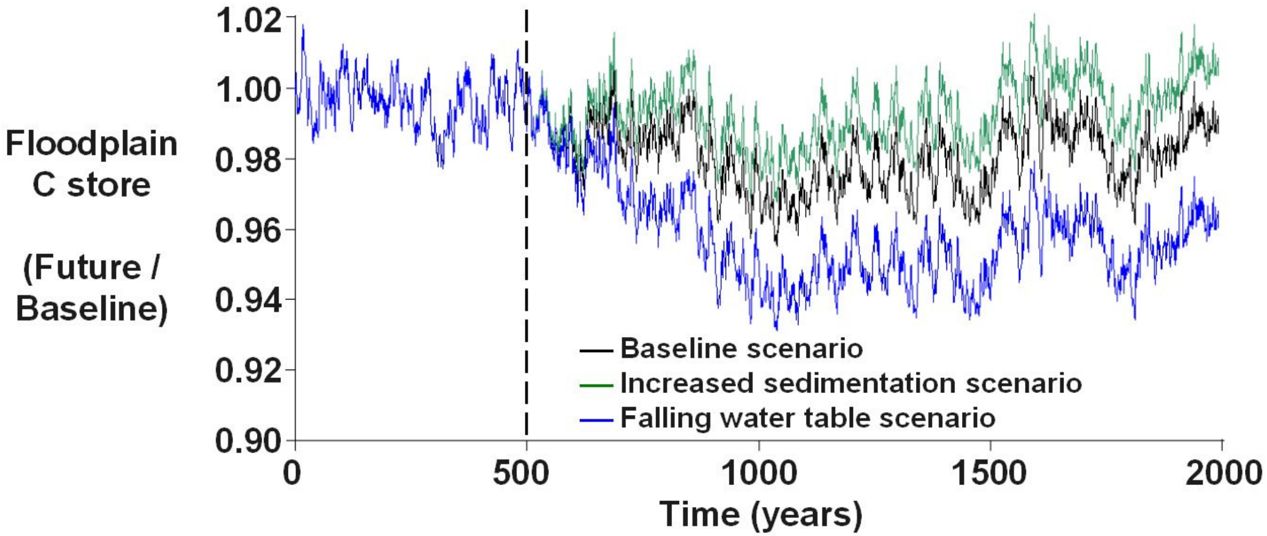
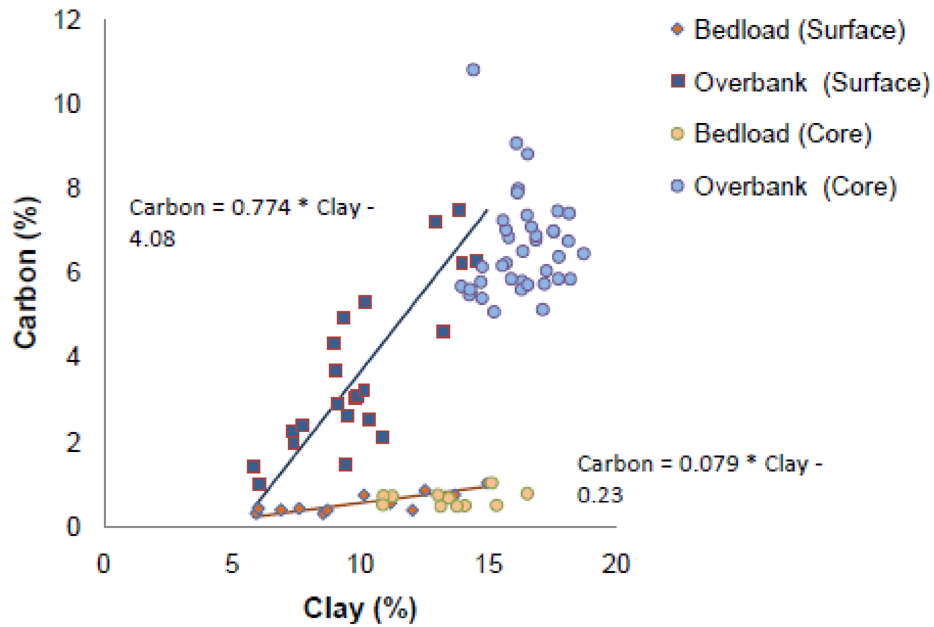
Carbon sequestration



Over millennial time-scales, increases in storage from deposition on floodplains may be outpaced by faster oxidation of floodplain carbon when water tables are lowered

In the River Culm, results show that although the floodplain receives a large amount of carbon from upstream, and is a significant carbon store, it may be a net source of carbon to the atmosphere.



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Quine, T.A. et al. (2010), *Geophysical Research Abstracts*, 12, EGU2010-8584

Conclusions

- N. Europe is likely to experience an increase in soil erosion under all scenarios; whereas S. Europe will probably see a decrease in erosion;
- The effects of changing land-use may be equivalent in magnitude to the effects of changing climate;
- Representation of sub-grid-scale floodplain processes leads to improved representation of energy and mass fluxes in geomorphic and land surface climate applications;
- Although floodplains are a large store of carbon, they may be net sources to the atmosphere when carbon produced by vegetation and carbon from the river catchment are taken into account;
- Over millennial time-scales, increases in carbon storage from deposition on floodplains may be outpaced by faster oxidation of floodplain carbon when water tables are lowered.

Q&A

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