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.
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
Driving Data: Regional Climate Models

- Climate change: Future warming of 1.8-4.0 °C 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.

Jones et al., 2002
• 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.

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

**Temperature change (degC)**

**Relief (m per 250 m)**

**Land cover**

- X: Natural, Dry Cereal
- C: Autumn-sown Arable
- A: Pasture
- P: Vineyard
- V: Forest
- F: Bare soil

Five figures showing main effects
Land-use, Climate, and Soil Erosion

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

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

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
Carbon sequestration

Over millennial timescales, 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.

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.
Thank you

Q&A