Spatial simulation of the impacts of Climate Change & Land Use change on soil C in ECOSSE in England & Wales?

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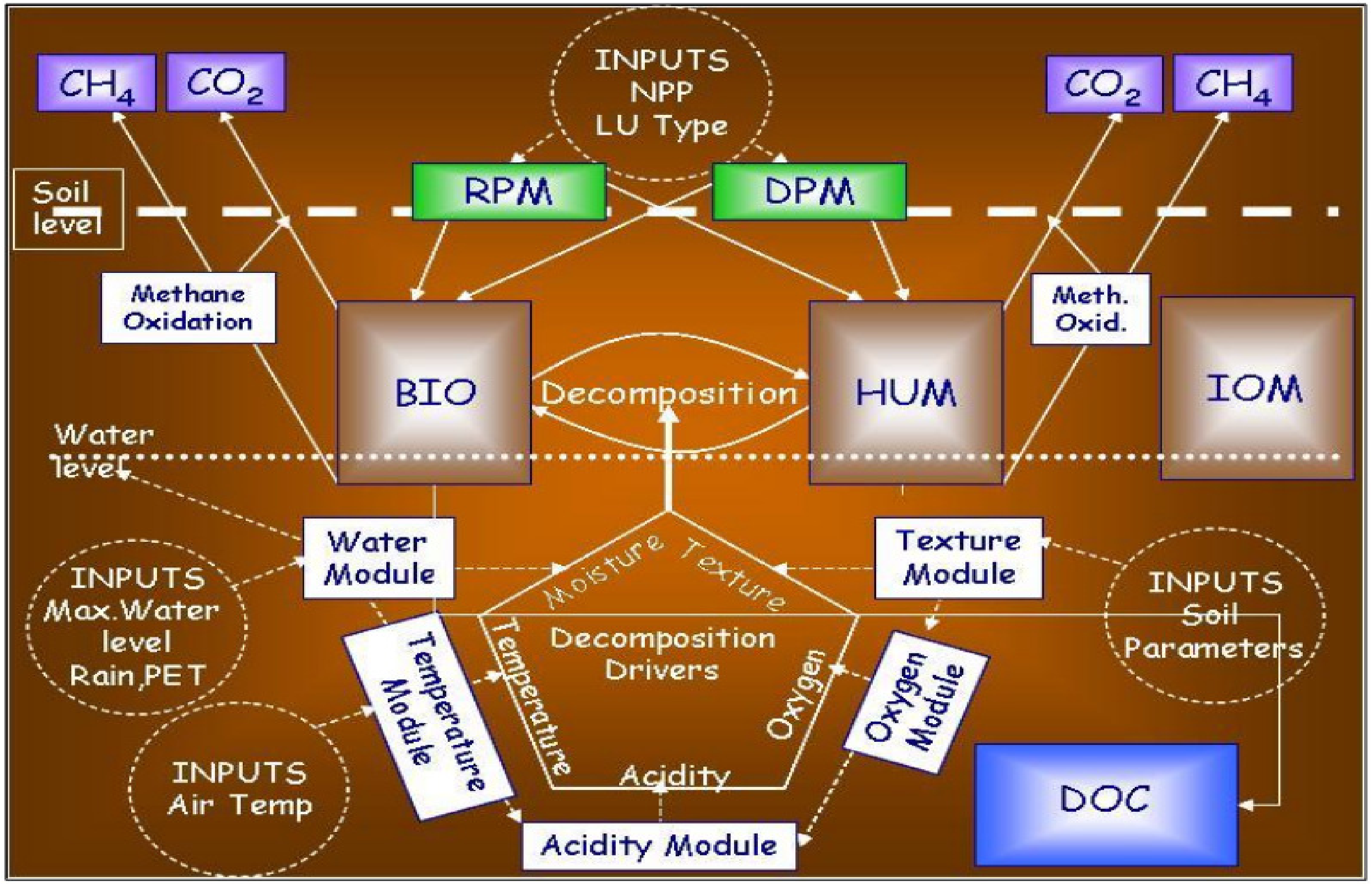
Background

- ECOSSE is the predecessor of the JULES CN Module
- The ECOSSE version used in this simulation is different from the CN module being in JULES in the following ways:
  - It has its own routines to initialize water
  - It takes air temp as soil temp, a small error expected at depth
  - pH routines not turned on, pH assumed at 7
  - DOC and CH_4 modules not turned on

Structure of the C components of ECOSSE



Reference: Smith, et al. (2010). Model to Estimate Carbon in Organic Soils – Sequestration & Emissions (ECOSSE). User-Manual

Data Input

- Soil
  - Top five dominant soil series in each grid
    - Based on revised national soil map in 2001
  - Soil parameters
    - Four land use types
    - Two main layers: 0-30cm, 30-100cm
    - Measured C content, C%, clay%, Silt%, Sand%, Bulk density

Reference: Falloon, P., Smith, P., Bradley, R.I., Milne, R., Tomlinson, R., Viner, D., Brown, T. 2006. RothCUK – a dynamic modelling system for estimating changes in soil C from mineral soils at 1-km resolution in the UK. Soil Use and Management, September , 22, 274–288. doi: 10.1111/j.1475-2743.2006.00028.x

Data Input

- Land use
  - The 1990 CORINE land cover database for the U.K.
    - Arable, Grassland, Semi-natural, Woodland
  - Broad types grouped by Falloon et al. (2006)

- Climate:
  - Baseline: HadRM3 output for 1980 – 2009
  - 2020 - 2080: the UKCIP02 predictions for 2020, 2050, 2080. All the four emission scenarios.
  - NPP derived from MIAMI model

Reference: Falloon, P., Smith, P., Bradley, R.I., Milne, R., Tomlinson, R., Viner, D., Brown, T. 2006. RothCUK – a dynamic modelling system for estimating changes in soil C from mineral soils at 1-km resolution in the UK. Soil Use and Management, September , 22, 274–288. doi: 10.1111/j.1475-2743.2006.00028.x

Water

- Simple piston flow as described by Bradbury et al. 1993
  - Field capacity / Saturated water content determined by soil composition
  - Potential evapotranspiration calculated by Thornthwaite Method
  - Assumed restricted drainage, excess drainage re-adjust the water content of the layers from bottom of the profile upward and establish the water table

Reference: Bradbury, NJ, Whitmore AP, Hart PBS, Jenkinson DS (1993). Modelling the fate of nitrogen in crop and soil in the years following application of 15N-labelled fertilizer to winter wheat. J Agr. Sci. 121: 363-379

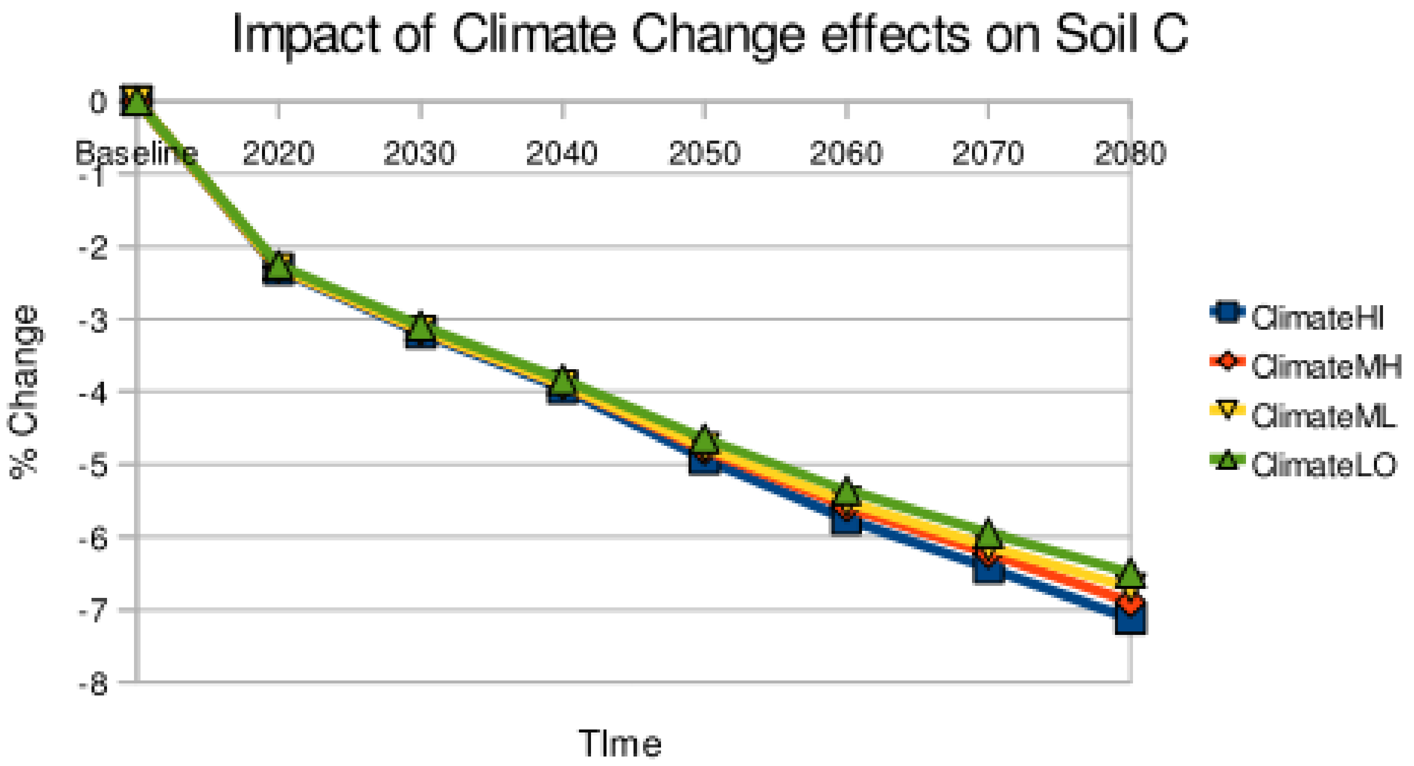
Initial sizes of SOM pools

- Depend on NPP and land use types
- Using Plant Input to spin-up SOM pools for 10,000 years
- Simulated total C value compared with measured C value
- Plant Input adjusted and spin-up again till the difference is 0.0001 kgC ha^{-1}

$$C_{in} = C_{in,def} \times \frac{C_{tot,meas}}{C_{tot,sim}}$$

Reference: Coleman K, Jenkison DS (1996). RothC-26.3 – A model the turnover of carbon in soil. In Powlson DS, Smith

Results – Impact of Climate Change effects

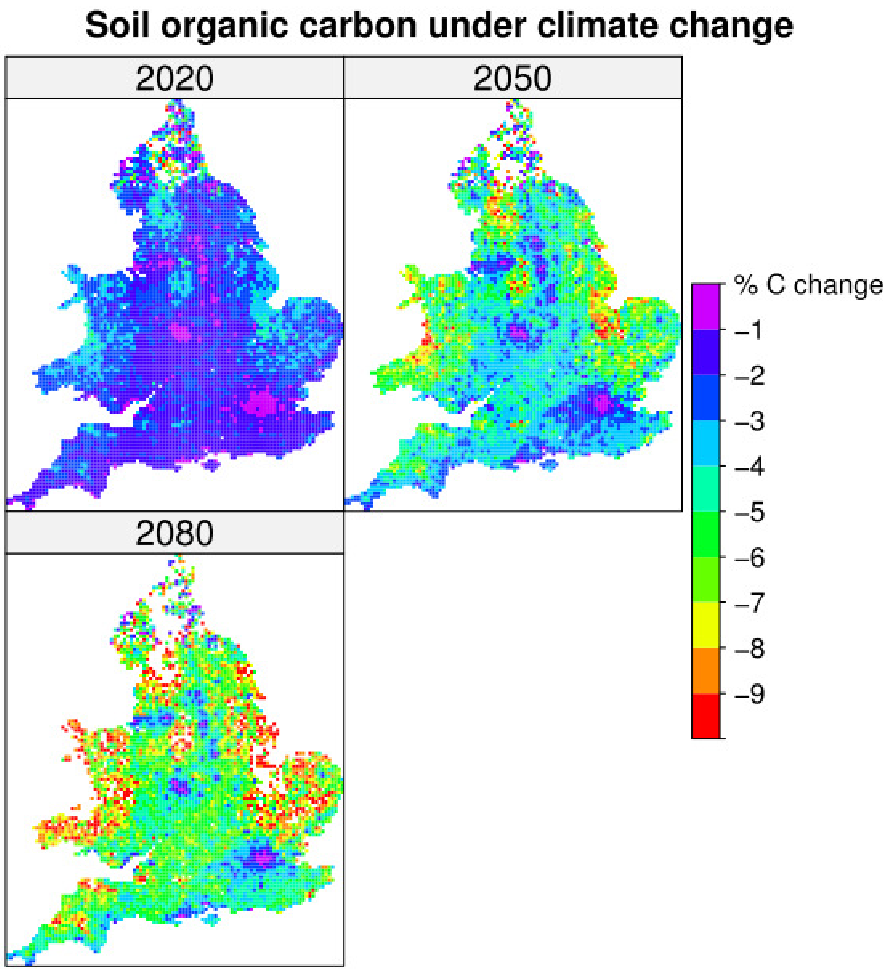


Results – Impact of Climate Change effects

Emission Scenario	Baseline	2020	2050	2080
High	0	-2.32	-4.92	-7.13
Medium-High	0	-2.29	-4.81	-6.90
Medium-Low	0	-2.29	-4.77	-6.70
Low	0	-2.25	-4.65	-6.49

k value: 0.08 – 0.09% per year loss for the period from 2010 – 2080.

Results – Impact of Climate Change effects



Acknowledgement: thanks for Mark Richards on his map-plotting R script.

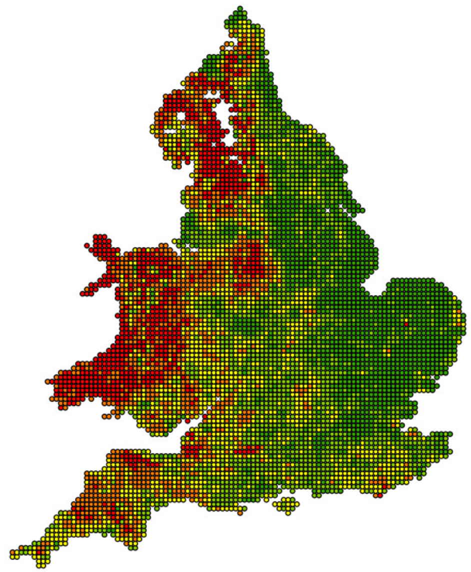
Results – Impact of land-use change effects

- The plan is to get two scenarios
  - Improved scenario: 20% Arable land to Grassland
  - Worse scenario: 20% Grassland to Arable land

- Unfortunately, the codes for the improved scenario may be fighting and generate unstable results

Results – Impact of land-use change effects

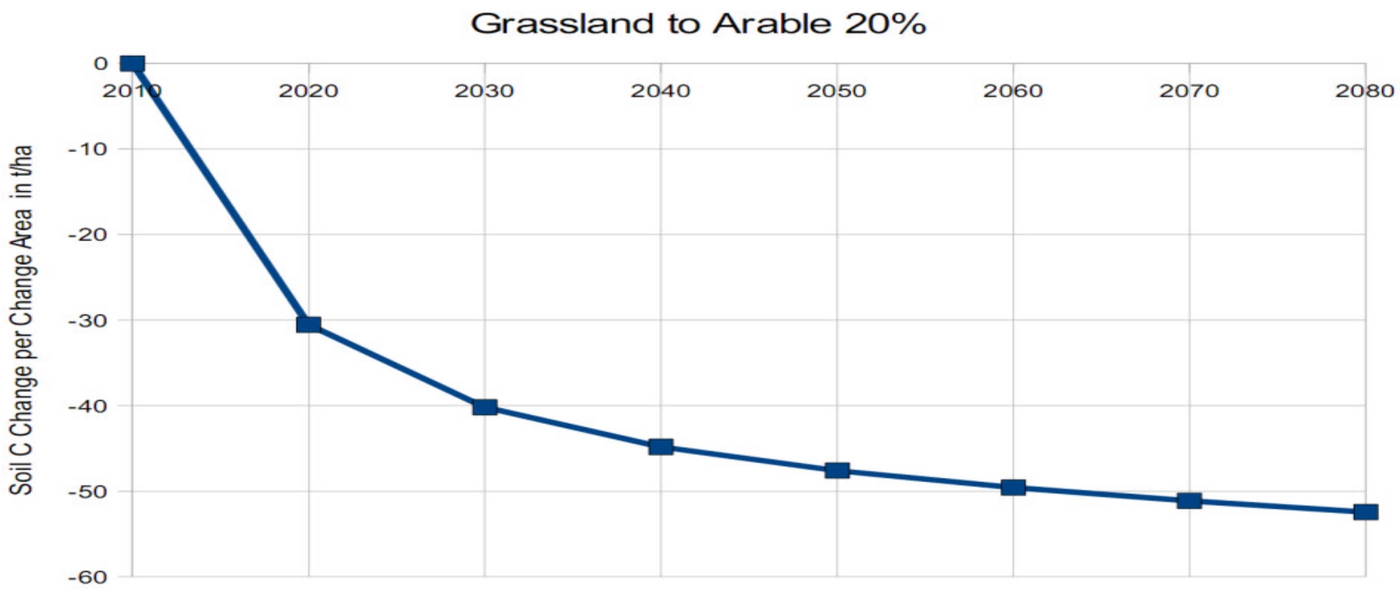
- 20% grassland to arable is simulated as of:
  - Predicted increase in food demand
  - Suitability of land for agricultural purposes
- Total Change Area:
  - 1,217,660 ha grassland



Smith, P., Bhogal, A., Edgington, P., Black, H., Lilly, A., Barraclough, D., Worrall, F., Hillier, J., Merrington, G. (2010). Consequences of feasible future agriculture land use

Results – Land Use Change effects

- Average C Change per LUC area:



- This sequence would give you -912 ktC yr^{-1}. In 70 years, 63 TgC

Thank you