Modeling of Climate Change Effect on Soil Organic Carbon Storage in Louisiana's Watersheds

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Introduction

The Earth's climate is changing as a result of increasing greenhouse gases (GHGs). Soil organic carbon (SOC) is sensitive to changes in climate conditions. Future changes of SOC are of great importance to global carbon cycle and climate variation.

Research Objectives

This study aimed to determine potential climate change effects on SOC storage in Louisiana's watersheds and analyze spatial distribution of the change with respect to land cover.

Methodology

Data sources:

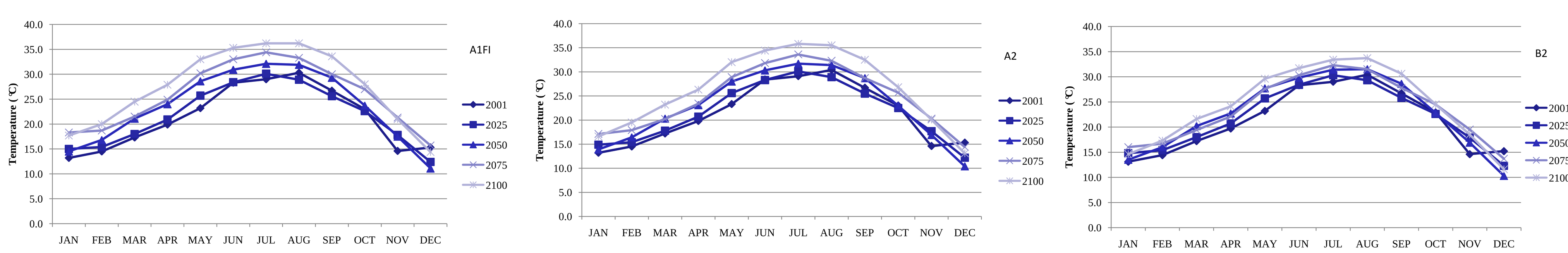
- USDA NRCS Soil Geographic Database (STATSGO)
- USGS National Land Cover Data (NLCD)
- High resolution grid 0.5°x0.5° monthly temperature and precipitation between 1901-2000 and 2001-2100, from Climate Research Unit , University of East Anglia, UK (Figure 1)
- LDEQ Sub-watersheds

Climate change scenarios based on UK Hadley Centre climate model (HadCM3):

- A1FI - fossil intensive, very rapid economic growth, global population, no alternative energy technology developments
- A2 - heterogeneous world, slow economic development and technological change, medium emissions
- B2 - economic, social and environmental sustainability, low emissions scenario

Modeling:

- Modeling - RothC model, a soil organic carbon turnover model (Figure 2); GIS
- Major data input - current SOC, soil clay content, Louisiana land cover at the sub-watershed scale (Figures 3, 4 and 5)
- Model parameterization - inert organic matter (IOM), decomposable plant material (DPM) and resistant plant material (RPM)
- Model run – for the top 30-cm soil on forest and crop lands across Louisiana



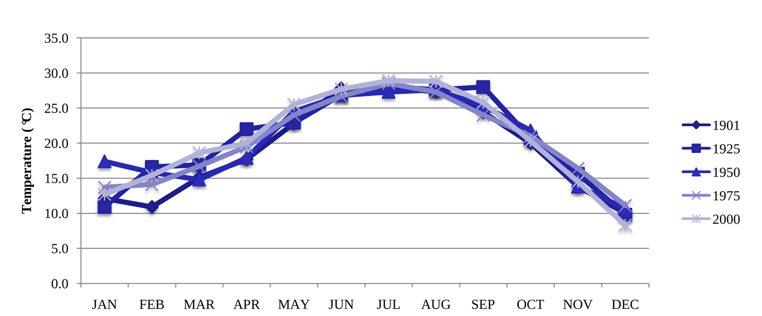


Figure 1: Temperature in 1901, 1925, 1950, 1975, and 2000 vs. 2001, 2025, 2050, 2075, and 2100 at A1FI, A2, and B2 scenarios in Baton Rouge.

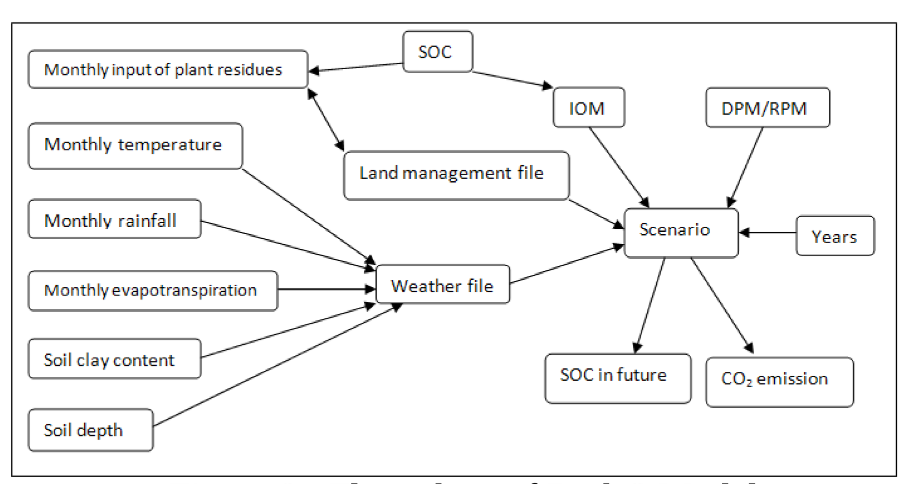


Figure 2: Flow chart of RothC Model.

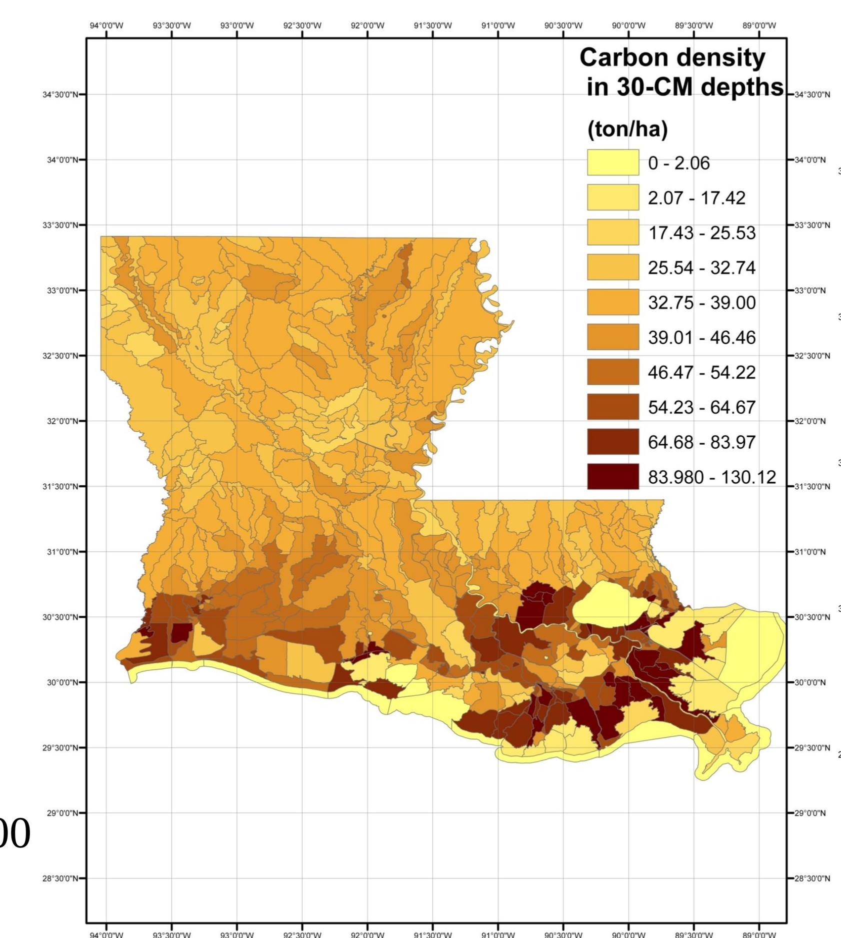


Figure 3: Spatial distribution of SOC in the top 30-cm depth of Louisiana's watersheds.

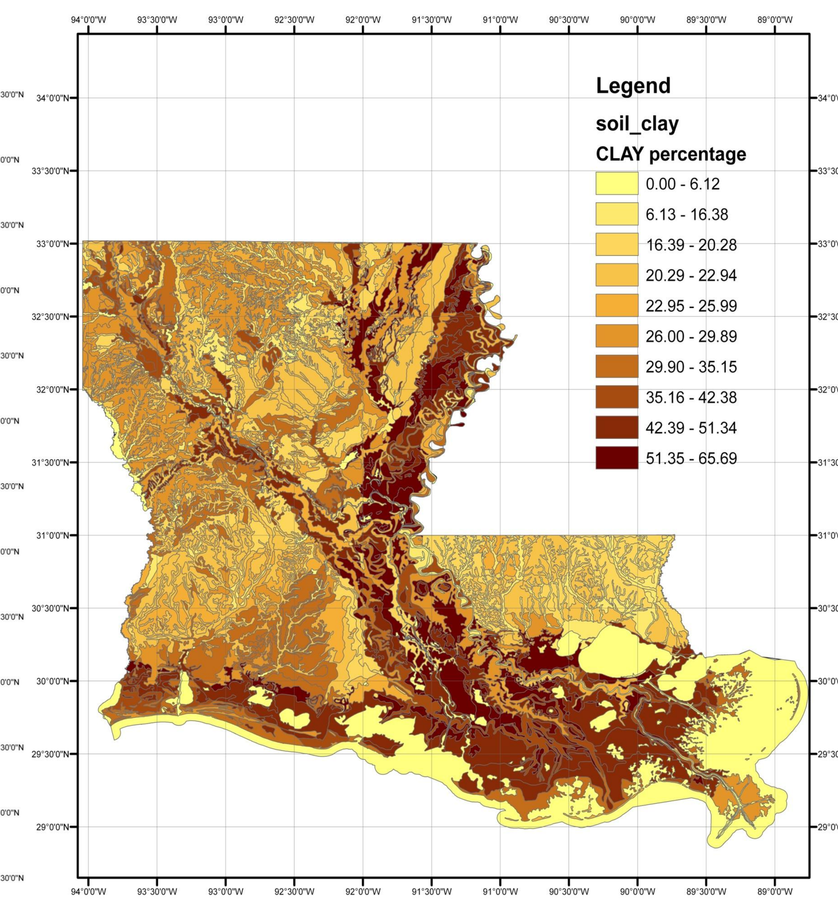


Figure 4: Spatial distribution of soil clay content in Louisiana.

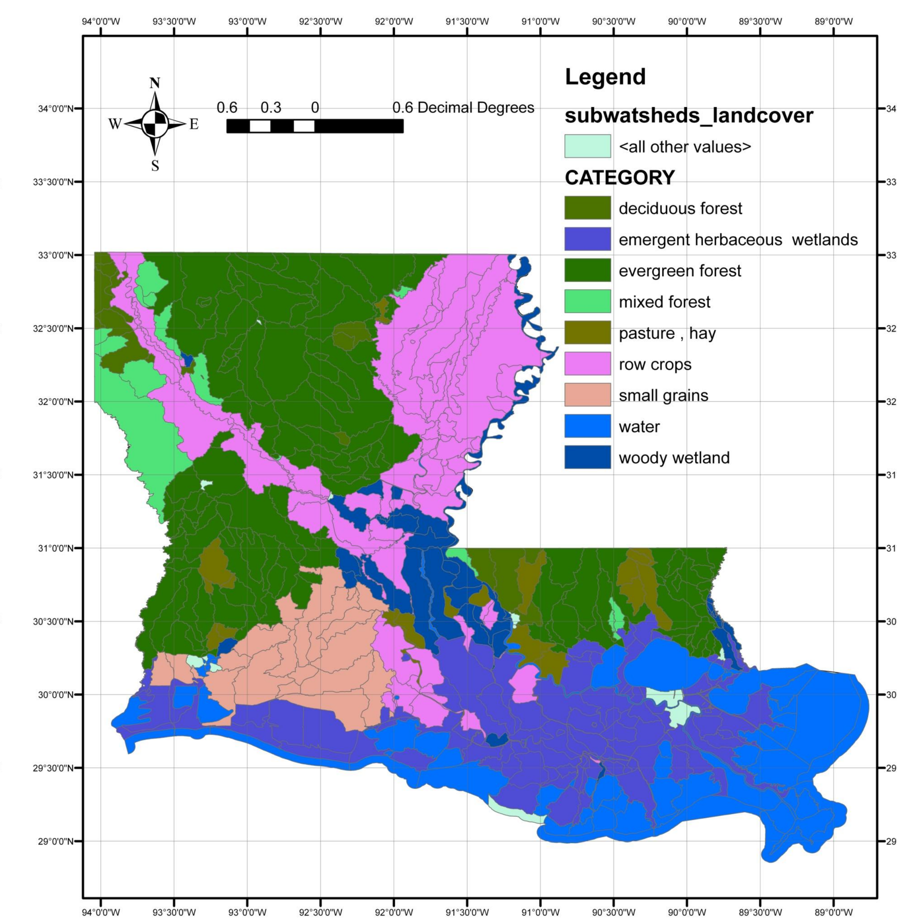


Figure 5: Land cover in Louisiana at the watershed scale.

Results

Considering only the climate impacts to Louisiana SOC, from 2001 to 2100, the mean SOC in both forest and crop lands in Louisiana will decrease in the HadCM3 scenarios A1FI, A2, and B2 (Figures 6 and 7). This assumes other factors are stable.

The mean forest SOC densities in the upper 30-cm depths were projected to decline from 32.3 tons per hectare in 2001 to 26.3, 27.8, and 28.6 tons per hectare in 2100 at scenarios A1FI, A2, and B2, respectively. The mean crop SOC densities in the upper 30-cm depths were projected to reduce from 41.8 tons per hectare in 2001 to 34.2, 36.3, and 37.3 in 2100 tons per hectare at scenarios A1FI, A2, and B2, respectively. Forest and crop lands were estimated to lose 18% of SOC at scenario A1FI and only 11% of SOC at scenarios B2 in this case (Figure 8).

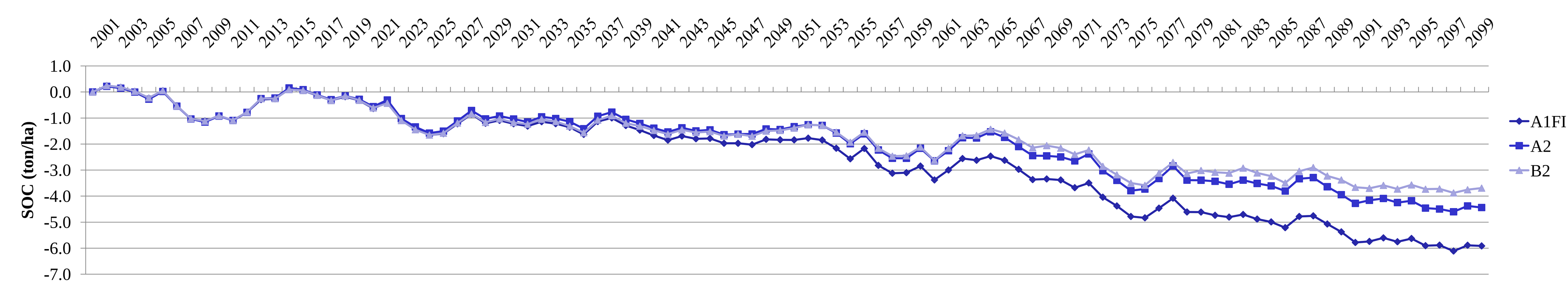


Figure 6: SOC changes from 2001 to 2100 in Louisiana's forest soils in reference to initial SOC content under three climate change scenarios.

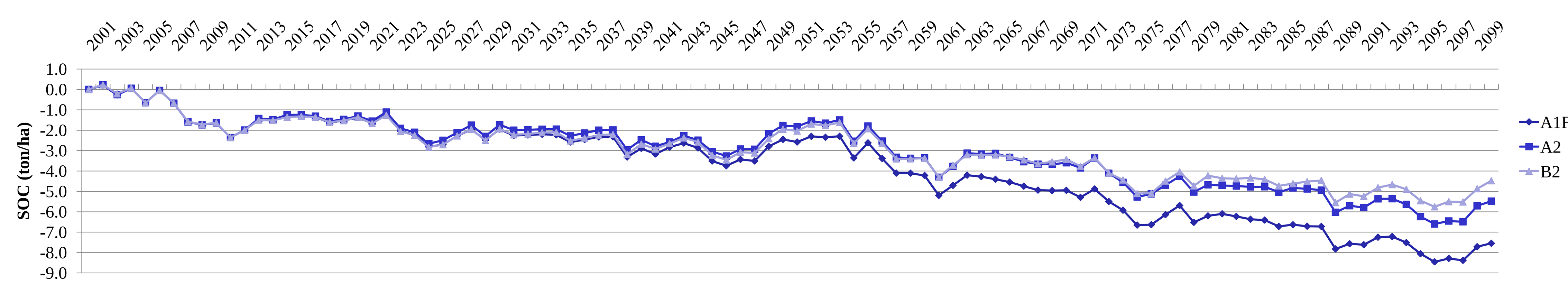


Figure 7: SOC changes from 2001 to 2100 in Louisiana's cropland soils in reference to initial SOC content under three climate change scenarios.

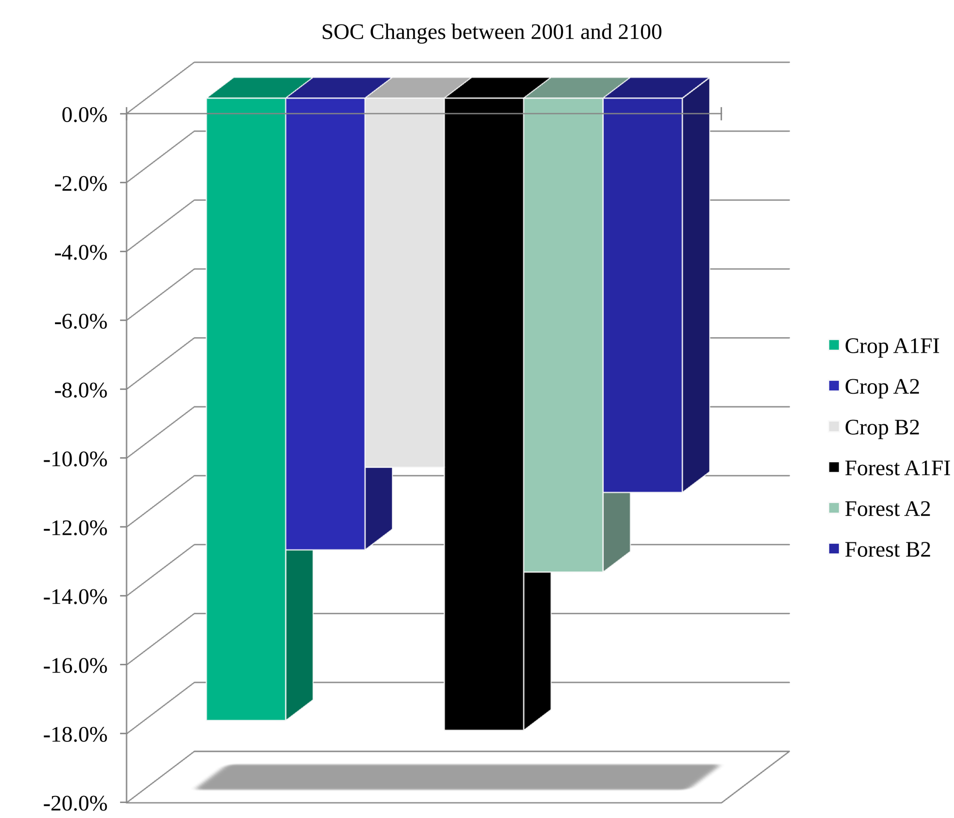


Figure 8: SOC changes in Louisiana forest and crop lands under three climate change scenarios between 2001 and 2100.

Summary

The emission scenario A1FI will have the greatest effect on SOC change in both forest and crop lands since the temperature will have the largest increase at that emission scenario. Increasing temperatures will speed decomposition of soil and will tend to lose SOC in the future. Scenarios B2 and A2 were projected to have less effect on SOC changes. The B2 scenario showed the least decline of SOC and the best scenario for carbon storage.

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