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Assessment of global scale impacts on soil organic carbon stocks under different climate change scenarios

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Predictions of future climate encompass uncertainties, either due to the specific model implementation or due to the use of different models. In this study we assess the response at the global scale of soil organic carbon (SOC) stocks to the variability of climate inputs derived from global circulation models (GCM). A consistent global data set at 0.5 degree resolution of climate, soil and land use data has been compiled. This allows a consistent approach to be used to assess geographic variability in the impacts of climate change on SOC. For this study, two SRES climate scenarios (A1B, B2) and two climate forcing scenarios (+2° C and +4°C in 2050) were chosen using a pattern-scaling approach. Each climate scenario is obtained from seven different GCMs. Monthly temperature and precipitation were obtained from the GCMs, and yearly net primary production (NPP) and 5 yearly land-use information were obtained from the IMAGE model. These data were used to drive the SOC model RothC from 1970 up to 2100. The RothC model is one of the most widely used SOC models and has been evaluated in a wide variety of ecosystems including croplands, grasslands and forests and in various climate regions.

The IMAGE model only provides NPP and land use surfaces per SRES. To provide consistency between the driving climate variables and NPP data, the latter were scaled using the MIAMI NPP model. The MIAMI NPP model is a simple conceptual model that links NPP to long-term annual mean air temperature and total annual precipitation. NPP is limited by either one. The MIAMI model assumes that NPP increases with increasing temperature and precipitation. For each simulation of the climate scenario, a corresponding NPP surface was constructed, which in turn was used to scale the plant input values generated by the model. Land use change is assumed to be independent of climate change within the seven GCM simulations of each SRES. For the climate forcing scenarios, the NPP and land use surfaces of SRES A1B of the IMAGE model was used. RothC simulations were carried out in two ways: a) no land use change and b) including land use change. This allows the impact due only to climate change and land use to be distinguished. Initial results of the simulations of arable land use (no land use change) show a general increase in the global average SOC concentrations under A1B from 56 t ha-1 up to 59-63 t ha-1 in 2100. However, different trends can be observed at regional scale. Average arable SOC concentrations of Western Europe start off at 75.6 t ha-1 in 1970 and vary between 75 and 79 t ha-1 in 2100. A relatively high increase in SOC is observed in the Caribbean, with a rise from 43 up to 69 – 72 t ha-1. In warmer climates, SOC decomposition increases where soil moisture is not limiting. NPP also increases under higher temperatures. These two processes tend to cancel each other out in Western Europe, as suggested by other studies. However, in the example region of the Caribbean, an increase in NPP overrides increased decomposition and results in higher SOC concentrations.