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Landscape-scale modelling of soil carbon dynamics under land use and climate change

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Soil organic carbon (SOC) sequestration is highly linked to soil use and farming practices, but also to soil redistributions, soil properties, and climate. In a global change context, landscape, farming practice and climate changes are expected; and they will most probably impact SOC dynamics. To assess their respective impacts, we modelled the SOC contents and stocks evolution at the scale of an agricultural landscape, by taking into account the soil redistribution by tillage and water processes. The simulations were conducted from 2010 to 2100 under different scenarios of landscape and climate. These scenarios combined different land uses associated to specific farming practices (mixed dairy with rotations of crops and grasslands, intensive cropping with only crops rotations or permanent grasslands), landscape managements (hedges planting or removal), and climates (business-as-usual climate and climate change, with temperature and precipitations increase). We used a spatially SOC dynamic model (adapted from RothC), coupled to a soil redistribution model (LandSoil). SOC dynamics were spatially modelled with a lateral resolution of 2-m and for soil organic layers up to 105 cm. Initial SOC stocks were described with a 2-m resolution map based on field data and produced with digital soil mapping methods. The major factor of change in SOC stocks was land use change, the second factor of importance was climate change, and finally landscape management: for the total SOC stocks (0-to-105 cm soil layer) the change of land use, climate and landscape management induced a respective mean absolute variation of 10 to 20 tC ha-1, 9 tC ha-1 and 0.4 tC ha-1. When considering the 0-to-105 cm soil layer, the different modelled landscapes showed the same sensitivity to climate change, with induced a mean decrease of 10 tC ha-1. However, the impact of climate change was found different according to the different modelled landscape when considering the 0-to-7.5 and 0-to-30 cm soil layers: the more sensitive landscapes were those of intensive cropping. This shows the importance of considering not only the plough layer, but also the vertical distribution of SOC stocks to assess the variation in SOC dynamics under land use, landscape management or climate change. Finally, rural hedgerow landscapes were proved to be quite well adapted for soil protection in a context of climate change, focusing on both carbon storage and soil erosion.