Integrating data and models for national SOC monitoring and reporting : implementation for French croplands

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The land use, land-use change and forestry (LULUCF) activities and crop management (CM) in Europe could be an important carbon sink As emphasized by the 4 per mille initiative, the land use, land-use change and forestry (LULUCF) activities and crop management (CM) could be an important carbon sink through soil organic carbon (SOC) sequestration. Recently, the EU decision (529/2013) required European Union's member states to define modalities in order include greenhouse gas (GHG) emissions and removals resulting from activities relating to CM in order to, "no later than 15 March 2022, submit their final annual estimates for accounting of cropland management and grazing land management". Tier 1 is still currently the most commonly used method used in national SOC inventories. Estimates currently published in national inventories are subject to various sources of uncertainty, because of the modeling approaches and because of uncertainty attached to the various dataset involved. Understanding and quantifying this uncertainty and providing unbiased estimates with accurate confidence interval is crucial for reliably reporting and support decision-making and policies that aims to mitigate greenhouse gases through soil C storage.

Here, we present a Tier 3 framework for croplands, consisting of process-based modelling combined with statistical models. It uses both Long Term Experiments (LTE) and soil monitoring networks (SMN) databases and has three main components. 1) Process-based models are run on LTE databases and models errors are statistically modelled. 2) Process-based models are run on SMN databases and model predictions are complemented by statistical models of errors. 3) SOC predictions on SMN sites are aggregated in ordered to yield regional or national estimates. We used a LTE database with 20 long-term croplands experiments in France and more than 100 treatments taking into account different agricultural practices such as tillage, organic amendment, inorganic fertilization, cover crops, etc. The SMN database was the French SMN (i.e. Réseau de Mesure de la Qualité des Sols, RMQS) based on a systematic 16kmx16km grid. On each site, SOC stocks are monitored and information about cropping systems is recorded. We evaluated the Century, RothC, AMG and ORCHIDEE models within this framework and benchmarked them against the Tier1 approach. We showed that i) the simplest process based models preformed better than more complex ones and that ii) forcing carbon inputs into soils using agricultural statistics is more efficient than simulating it explicitly in models. National level estimates yielded by the framework, had reasonable level of uncertainty and similar trends for each process-based model. Overall, we emphazise the need for integrating data from monitoring systems at different scales, both from long term experiments and from monitoring networks, with process-based and statistical models, in order to yield valid national estimates with quantified uncertainty.