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Assessment of climate-carbon feedbacks from terrestrial biosphere and identification of an emerging constraint using remote-sensing data of soil moisture.

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The carbon sequestration by the ocean and the land biosphere reduces significantly (up to two thirds) the anthropogenic carbon dioxide emitted into the atmosphere, contributing to mitigate global warming and climate change. However, the efficiency of these sinks is likely to decrease with increasing temperature following a complex ensemble of processes that is referred as the climate-carbon feedback. Earth System Models (ESMs) are necessary to predict the evolution of these sinks with climate change and thus to calculate this feedback. CMIP5 models agree on the positive sign of the feedback, meaning a reduction of carbon uptake by the sinks under higher temperatures, but the uncertainty regarding the magnitude of the feedback remains large, especially for the land components of the models.

The climate-carbon feedback is not directly measurable but the recent availability of global observations of Essential Climate Variables (ECV) using remote-sensing data allows for the modelling community to better constrain the ESMs. In this study, as part of the ESA-CMUG project, we investigate the use of soil moisture, which integrates information about climate (temperature and precipitation) and soil properties as an emerging constraint to correctly simulate climate-carbon feedback due to the terrestrial biosphere. The original idea of this study is to link the soil moisture simulation performances of ESMs to a novel index of soil moisture-carbon feedback.

To do so, two groups of simulations have been analyzed. The first group consists in historical simulations of CMIP5 models running from 1850 to 2005. Results of these simulations can be directly compared with remote-sensing data of soil moisture from the Climate Change Initiative (CCI) of the ESA. These data are avalaible at the daily scale from 1978 to 2013 at 25-km resolution.
The other group of simulations consists of two simulations for each model, that are said « idealized », as to isolate the impact of climate change on the land carbon cycle, and thus to calculate the land carbon-climate feedback. This feedback is analysed in terms of sensitivity of the biospheric carbon sink to soil moisture change.

The comparison of sensitivities between models shows large contrasts regionally. These contrasts can be explained by many differences in the models. For instance, according to all models, allocation of carbon is globally higher in soils than in vegetation but these allocations strongly vary in terms of proportions and spatial distribution between the ESMs. Differences of sensitivities also reflect different parameterisations of biogeochemical processes (photosynthesis and respirations). As investigating all differences of the different models is a huge task that requires time and scientific developments, the relationship between the model soil moisture simulation performances and the sensitivity of the biogeochemical processes to this same variable can help, by reducing the dispersion between models, to assess more accurately the land carbon-climate feedback.