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Exploring the uncertainty in the parameterisation of soil heterotrophic respiration processes in the CABLE land surface model

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Increasing temperature due to the human-induced rise in atmospheric concentrations of carbon dioxide is predicted to enhance the soil heterotrophic respiration (HR) and corresponding release of CO_2. Furthermore, recent projections agree that this positive climate-carbon feedback should reduce the ability of the land surface to act as a sink for human emissions throughout the 21st century in spite of the CO_2-fertilisation effect on primary production. However, large differences between simulations illustrate the lack of consensus in the parameterisation of soil carbon processes.
Land surface models usually calculate heterotrophic respiration rates with a soil moisture-respiration function (SMRF) and a soil temperature-respiration function (STRF). There exist a large variety of such functions and we propose here to explore the uncertainty linked to the sole differences between them. Therefore, we implemented 7 SMRFs and 8 STRFs obtained from published studies into the original CABLE source code without making any further modification in its structure. Then, all 56 single combinations of a SMRF and a STRF were used to model heterotrophic respiration, and hence net ecosystem exchange (NEE), at 12 flux tower sites representing various hydro-climatic and vegetation conditions.
After comparison with available NEE data, none of these models outperforms the other ones at all sites and different combination even provide NEE of opposite sign. Furthermore, it seems that a better STRF would have some aspects of a lower sensitivity function, to correctly simulate inter-seasonal variations, combined with the ability of a high sensitivity STRF, to also capture the highest values of HR and NEE. As an attempt to solve this problem, we propose a new STRF based on a sigmoid function shaped at each site according to local soil temperature conditions. Our study also underlines the need for an improvement in the LSM's ability to adequately simulate soil temperature and soil moisture before integrating SMRF and STRF that are based on large observational datasets, a crucial point if soils are to be used as carbon sinks to compensate for climate change.