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Ignoring fluvial C transfers leads to significant biases in the simulated land-C sink – A critical evaluation for the Amazon basin as case study

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While empirical work has highlighted the role of rivers as land-ocean link in the global C cycle and as important net-CO_2 source to the atmosphere for over more than a decade, state-of-the-art land surface models used to project the evolution of continental C cycling in response to climate variability, climate change, increasing atmospheric CO_2 levels and land use change still ignore the role of rivers.

The new land surface model ORCHILEAK simulates terrestrial C cycling between atmosphere, vegetation and soils as well as lateral transfers of dissolved organic C (DOC) and CO_2 along the river-floodplain network, incl. decomposition of DOC in transit, CO_2 exchange between water column and atmosphere, as well as the exchange of DOC and dissolved CO_2 between the water column and soils in riparian wetlands. This model has been validated against observations for the Amazon basin.

For this presentation, we have used ORCHILEAK to investigate the role of C cycling along the river-floodplain network for the C budget of the Amazon basin and to project the evolution of fluvial C exports in reponse to land use change, atmospheric CO_2 increase and climate change over the 21st century. Moreover, we ran alternative simulations with the C cycling along the river-floodplain network deactivated (‘land only’ model) while all other processes and forcings were kept as before in order to highlight the bias of land surface models ignoring the river-floodplain network as part of the C cycle.

We can show that for present-day, the ‘land only’ model simulates a net-uptake of atmopseric CO_2 which is about 9% lower than the standard ORCHILEAK results, because the C which should be exported to the coast is respired within the Amazon basin. However, at the same time we simulate a net-C sink in the Amazon basin with the ‘land only’ model which is 6% higher than the standard ORCHILEAK results, highlighting that the use of ‘land only’ models leads to significant errors in regional C budgets. Moreover, the representation of the inland water C loop changes substantially the simulated spatial patterns of C exchanges between the atmosphere and the continental surface, putting the use of ‘land only’ models into question when simulation results are to be compared to atmospheric inversions.

Our simulation results show further that the inland water C loop has an attenuating effect on the simulated interannual variability in the C budget of the Amazon basin. During wet years, when net-uptake of atmospheric CO_2 is high due to increased net primary production (NPP) and reduced soil heterotrophic respiration, fluvial exports of terrestrial C are higher as well - the opposite being true for dry years.

Our projections over the 21st century (following RCP 6.0) indicate that fluvial C exports may increase by about 25%, following the projected increase in NPP - with climate and land use change modifying the fraction of NPP being exported through the river-floodplain network. These results show that land-ocean transfers should not be considered to be constant, as done in existing regional C budget analyses.