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Global lateral transfer and evasion of C in freshwater systems – a revised high-resolution budget analysis

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The net CO_2 evasion from rivers (FCO_2) is an important component when quantifying the lateral displacement of biologically fixed carbon from terrestrial systems and wetlands through the river network. Here, we present global maps of FCO_2 from stream orders 3 and higher at 0.5° resolution (Lauerwald et al., 2015 – GBC). This resolution is comparable to that of Earth System Model simulations of vegetation and soil C dynamics and is also compatible with GlobalNEWS simulations of fluvial DOC and POC exports to the sea (Mayorga et al., 2010 – Environmental Modeling and Software).

A GIS based approach was used to derive an empirical pCO_2 model trained on data from 1182 sampling locations. While only few sampling data are available for Asia and Africa, the sampling locations cover the full spectrum from high to low latitudes. The empirical model predicts pCO_2 from terrestrial net primary production, population density, and slope gradient within the river catchment and mean air temperature at the sampling location ($r^2 = 0.47$). The predicted pCO_2 map was combined with spatially explicit estimates of stream surface area and gas exchange velocity calculated from published empirical equations and data sets to derive the FCO_2 map. We used Monte Carlo simulations to assess the uncertainties of our estimates. At the global scale, we estimate an average river pCO_2 of 2400 (2019–2826) μatm and a FCO_2 of 650 (483–846) Tg C yr-1 (5th and 95th percentiles of confidence interval). Our maps reveal strong latitudinal gradients in pCO_2, stream surface area, and FCO_2. The zone between 10°N and 10°S contributes about half of the global CO_2 evasion.

Combining riverine FCO_2 with the estimated fluvial DOC and POC exports from GlobalNEWS and FCO_2 from lakes (downscaled from Raymond et al. 2013 – Nature), the total lateral transfer of biologically fixed C on land and in wetlands adds up to 1.3 Pg C yr-1. This estimate is likely conservative because CO_2 evasion from smaller streams is not included in our analysis. With the exception of dry and mountainous areas, the riverine CO_2 evasion from large river basins exceeds the export to the ocean. In tropical Africa and South America, the proportion exceeds even 75%. In SE-Asia, FCO_2 rates are similar to those in tropical Africa and S-America, but the POC exports are important as well in this region. To further investigate the C dynamics through the terrestrial-aquatic interface, fluvial C transport is now integrated into the land-surface scheme ORCHIDEE of the IPSL-Earth System Model. Preliminary results of the DOC and CO_2 dynamics in the largest world river (the Amazon) will also be presented.