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Master function for the solid:solution equilibrium of DOC in taiga and tundra soils of N. Russia: experimental and modeling results

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The formation and degradation of Dissolved Organic Carbon (DOC) in arctic environments is intensively investigated, in the context of DOC loading of arctic rivers and seas as well as climate change. However, chemical interaction studies are more scarce, in particular those involving modeling. We investigated DOC interactions in N. Russian taiga and tundra soils, and found that water extractable organic carbon (WEOC) comprises only a small fraction of total organic carbon, whereas DOC is again a small fraction of WEOC. The chemical composition of DOC in terms of humic, fulvic, and hydrophilic acids, the concentrations of dominant cations such as Ca and Al, and the solid iron oxide contents appear to differ profoundly for different soil horizons, as well as between taiga and tundra soils. To reconcile these differences, we processed the data with a simple Freundlich model and with advanced LCD (Ligand and Charge Distribution) modeling of DOC interactions. In the LCD modeling, a combination is made of advances such as CD-MUSIC, and Nica-Donnan approaches, that are implemented in the software ORCHESTRA (though adjusted for computational stability by us). To avoid fitting without good foundation, use is made of the generic parameterization of LCD in combination with measured, site-specific chemical data such as concentrations. We observe that the soil samples from both regions, soil types and horizons can be described with a single DOC sorption Freundlich isotherm. More interestingly, for the same set of samples, the LCD modeling enables us to cast DOC sorption into a single Master Function, that takes iron oxide content and Al and Ca concentrations of soil samples into account in a purely predictive way. Based on this Master Function, it is feasible to assess how DOC is sorbed onto the solid surface. In combination with DOC production and degradation models, our results provide a more balanced instrument to address changes in DOC loading to surface waters due to climate change.