Characteristics of dissolved and atmospheric methane concentrations along a freshwater-seawater transect from the River Elbe into the North Sea

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Surface waters are known to be significant sources of greenhouse gases (CH4 and CO2), but our understanding of large scale patterns is still incomplete. The greenhouse gases in rivers originate both from in-stream processes and interactions with the catchment. For coastal seas, rivers are suspected to be one of the main source of greenhouse gases, while the role of the interjacent tidal flats is still ambiguous. Especially the reaction of the entire system on terrestrial hydrological extremes such as low flow situations are still under consideration. The functional understanding of such events and their impacts on the water chemistry along its transition pathway in the terrestrial and limnic compartment as well as in the coastal marine environment is crucially needed for the evaluation of its relevance in the Earth system. As part of a MOSES campaign (Modular Observation Solutions for Earth Systems) spanning disciplines as well as earth system compartments we investigated the aquatic as well as the atmospheric compartment in and above the Elbe River from inland waters through the tidal section of the river and the estuary to the North Sea with the goal to explore spatial heterogeneity of CO2 and CH4 concentrations in the water and in ambient air above the water during a low water period in summer 2020.

Overall, dissolved CH4 concentrations ranged over three orders of magnitude. Along the freshwater part of the transect, dissolved CH4 increased and weirs and harbors appeared to be hot spots of elevated CH4 concentrations both for the dissolved and atmospheric phase. We observed a longitudinal gradient of CO2 in the river which was closely linked to primary production. In the estuary and the marine part, dissolved CH4 concentrations of the transect were determined by the variability of temperature and salinity. Correlations with other water parameters revealed the complex regulation of dissolved CH4 concentrations along the freshwater-seawater continuum. For atmospheric CH4 above the North Sea, wind direction and wind speed proved to be crucial. Besides the typical diurnal fluctuations of atmospheric CO2 and CH4, an observed link between dissolved and atmospheric concentrations has to be further clarified.