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Future freshwater inflows to the Baltic Sea under changing climate and socioeconomics: learning from uncertainty

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The Baltic Sea is suffering from eutrophication caused by nutrient discharges from land to sea. These freshwater inflows vary in magnitude from year to year as well as within each year due to e.g. natural variability, weather patterns, and seasonal human activities. Changing climate and socio-economics contribute additional uncertainty to estimation of the freshwater inflows to the Baltic Sea that needs to be taken into account when planning management practices and mitigation measures.

Continental to global scale hydrological models have emerged in recent years as tools e.g. for flood forecasting, large-scale climate impact analyses, and estimation of time-dynamic water fluxes into sea basins. E-HYPE is a pan-European application of the HYPE model developed as a multi-purpose tool for large-scale hydrological analyses. HYPE is a process-based combined rainfall-runoff and water quality model.

We compared current freshwater inflows from land with those from dynamic modelling with E-HYPE using projections of climate change (RCP8.5) and scenarios of shared socioeconomic pathways (SSPs) for 2050s. We selected a range of climate models and socioeconomic assumptions to evaluate possible effects and to estimate the uncertainty and then evaluated impacts of selected nutrient mitigation measures under this range of conditions. We show that while climate change affects nutrient loads to the Baltic Sea, these impacts can be overshadowed by the impacts of changing socioeconomic factors such as land use, agricultural practices, population changes, dietary changes, atmospheric deposition, and waste-water collection and treatment by mid-century.

Here, we discuss our analyses and experiences with flows and nutrient generation, transport, and transformation in the Baltic Sea Drainage Basin under changing climate and socio-economic conditions. Our findings indicate that average nutrient loads are expected to increase by 8% and 14% for nitrogen and phosphorus, respectively, as a response to climate change on average. However, changes in the socioeconomic drivers can lead to significant changes in the loads, ranging from a decrease by 13% and 6% to an increase by 11% and 9% in nitrogen and phosphorus loads, respectively, depending on the socioeconomic pathway to be followed. This means that policy decisions still play a major role in climate adaptation and in managing eutrophication in the Baltic Sea region.