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Modelling global surface water quality under uncertain climate and socio-economic change

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Human activities greatly impact surface water quality due to the emission of various pollutants associated with different water use sectors (e.g. irrigation, livestock, domestic, energy and manufacturing)[1,2]. In-stream concentrations are also strongly dependent on the dilution capacity of receiving waters, which is related to both the hydrological regime and surface water abstractions. Pollutant emissions, hydrological regimes and surface water abstractions are all projected to change into the future as a result of both (uncertain) climate change and socio-economic developments. Yet, quantitative projections of future surface water quality are sparse, particularly at the global scale.

In this work, we apply a new high-resolution global surface water quality model (*DynQual*)[3] to project water temperature (Tw) and total dissolved solids (TDS), biological oxygen demand (BOD) and fecal coliform (FC) concentrations for the time period 2005-2100, considering multiple scenarios that combine Representative Concentration Pathways (RCPs) with Shared-Socioeconomic Pathways (SSPs). Input from five general circulation models (GCMs) is used to force *PCR-GLOBWB2*, the hydrological model coupled to *DynQual*, to account for the large range of uncertainties inherent in the climatological projections.

The mechanisms that drive patterns in future surface water quality are a complex balance between changes in pollutant emissions, the dilution capacity of streams and in-stream decay processes, which are strongly driven by water temperature, under global change. Patterns of both water quality improvement and deterioration exist, which vary greatly across world regions. Reductions in pollutant emissions across most of Western Europe, North America and East Asia drive trends towards surface water quality improvements, irrespective of climate and socio-economic scenario. Conversely, developing countries are more sensitive to (uncertain) climate and socio-economic changes, with surface water quality typically improving under SSP1-RCP2.6, a mixed response under SSP5-RCP8.5 and strong degradation under SSP3-RCP7.0. Changes to the hydrological cycle are particularly important for surface water quality in the Amazon basin, with substantial reductions in discharge projected under SSP3-RCP7.0 and SSP5-RCP8.5. These changes result in reduced dilution capacities of rivers and thus higher in-stream concentrations, for

instance of TDS.

Surface water quality deterioration occurs across Sub-Saharan Africa under all scenarios, albeit to different magnitudes, which substantially increases the number of people that are exposed to poor water quality. Under SSP3-RCP7.0, the “worst-case” scenario for all constituents considered in our study, 4.2 billion people will be exposed to surface water with unsafe levels of organic (BOD) pollution by 2100. With 1.5 billion (36%) of these people located in Sub-Saharan Africa, compared to 290 million (11%) in the historical reference period, we conclude that Sub-Saharan Africa will become the new hotspot of water quality issues.

References

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