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High-resolution global surface water quality modelling

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1. Introduction

- Good surface water quality is crucial for ecosystems and humans.
- Physically-based models can help overcome shortcomings associated with in-situ monitoring.
- To this end, we have developed a multi-pollutant dynamical water quality routing model (*DynQual*).
- Here, we provide a model description and demonstrate capabilities by assessing spatio-temporal trends in global water quality.

2. Model description

- Open source model code; Python & PCRaster; coupled to PCR-GLOBWB2.
- Global coverage at 5 arc-minute spatial resolution; daily temporal resolution.
- Validated against observations from monitoring stations worldwide.

Approach:
1. Quantify pollutant emissions
2. Routing through stream network
3. In-stream decay processes
4. Compute concentrations

- Water temperature (Tw)
- Total dissolved solids (TDS)
- Biological oxygen demand (BOD)
- Fecal coliform (FC)

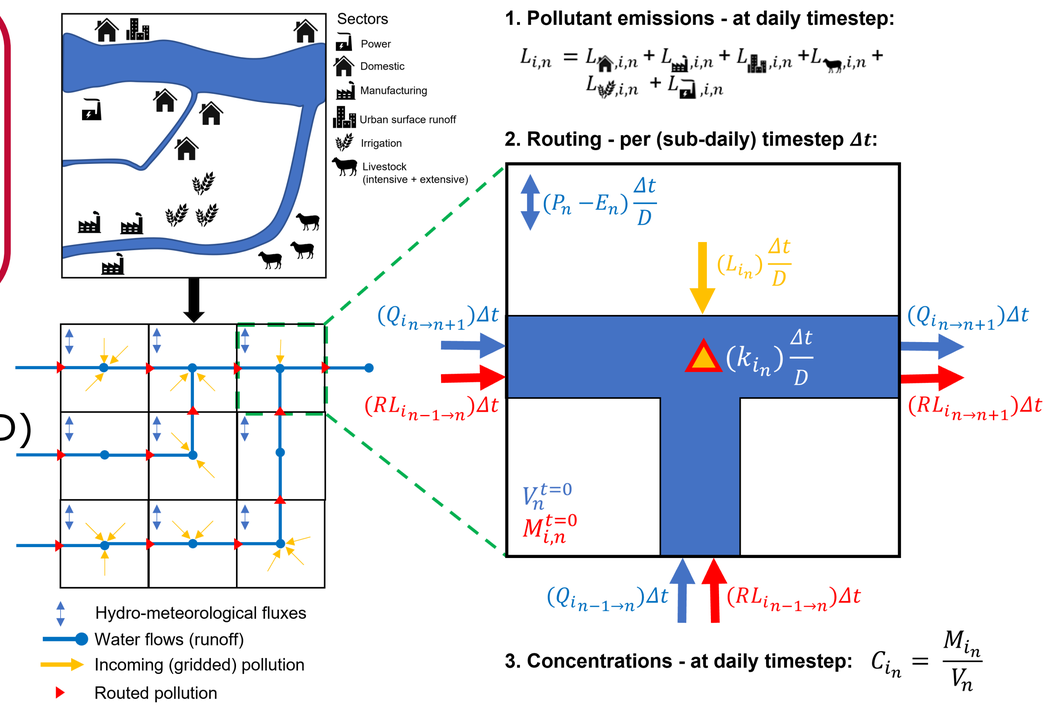

Fig 1. Schematic overview of DynQual, including a translation of local hydrological and socio-economic situation into a local drain direction (LDD) map that includes hydrological and pollutant fluxes, and a representation of the gridcell based processes (pollutant emission calculation, routing procedure and computation of pollutant concentrations) in an individual DynQual gridcell.

3. Spatial patterns

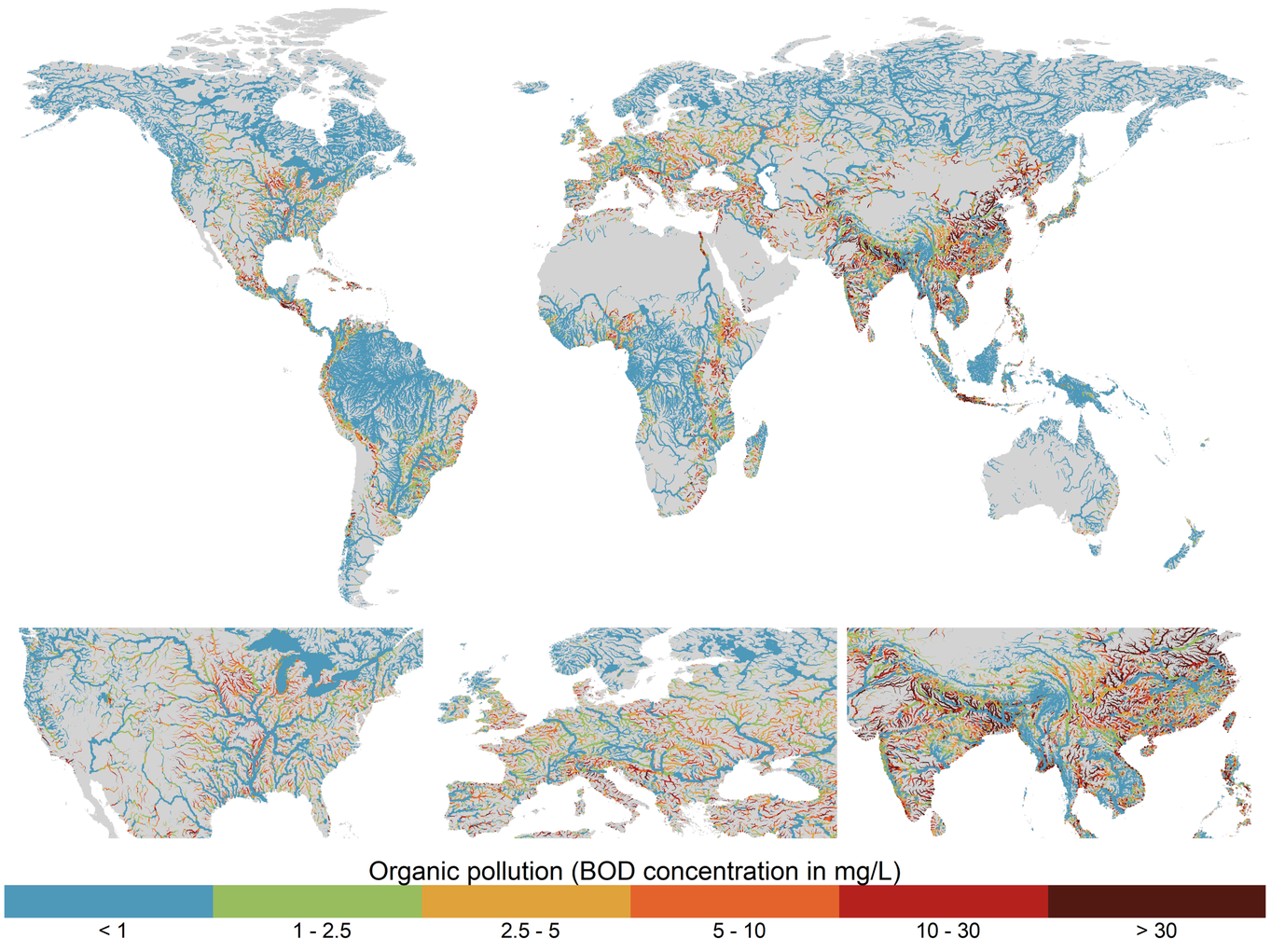

Fig 2. Annual average biological oxygen demand (BOD) concentrations for the period 2010 – 2019.

- BOD concentrations show considerable diversity across major world regions, with hotspots in Eastern China and Northern India (Fig 2.).
- Moderate BOD concentrations across North America and Europe, although typically below a commonly used threshold of 8mg l^{-1}.
- Pollution is still relatively low across much of Africa (Fig 2.), but water quality in the region is deteriorating (Fig 3.).
- Spatial patterns mask intra-annual variability, which is substantial, and thus should also be considered.

4. Temporal patterns

- Clear seasonal pattern in BOD concentrations in the Karnaphuli River, with average concentrations overall increasing from the 1980s until present (Fig 3.).
- Fig 3. also demonstrative of the dynamic capabilities of DynQual.

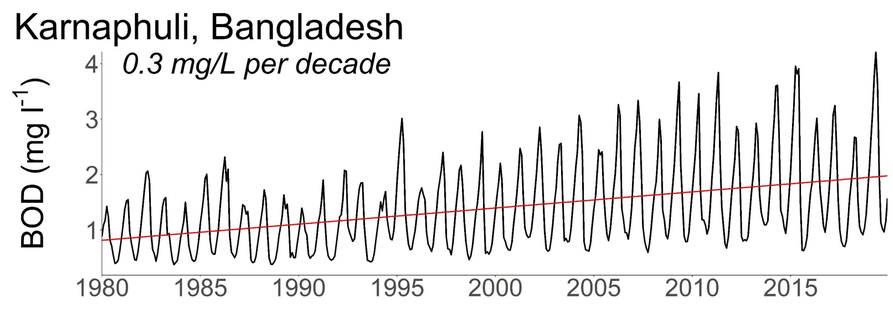

Fig 3. Simulated in-stream monthly average biological oxygen demand (BOD) concentrations, for an example location (Karnaphuli River).

5. Trends

- Strong regional patterns for BOD (Fig 4.), typically with water quality improvements in developed regions and degradation in developing countries.

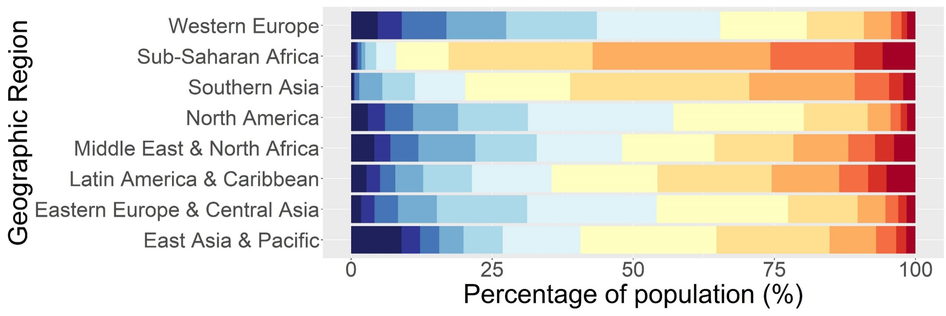

Fig 4. Average annual percentage changes in biological oxygen demand (BOD) concentrations for the period 1980 – 2019. Results are displayed for the proportion of population (%) inhabiting gridcells exhibiting different trends in pollutant concentrations, aggregated by geographic region.

6. Conclusions & Outlook

- DynQual output data has potential to inform assessment across broad range of fields.
- Model strengths include ability to simulate water quality with a consistent spatial and temporal resolution, particularly in ungauged catchments, and for future projections of surface water quality.

Code availability & literature

GitHub repository: https://github.com/UU-Hydro/DYNQUAL

Jones, E. R., Bierkens, M. F. P., Wanders, N., Sutanudjaja, E. H., van Beek, L. P. H., van Vliet, M. T. H. (under review) *DynQual*: a high-resolution global surface water quality model.
Jones, E. R., Bierkens, M. F. P., Wanders, N., Sutanudjaja, E. H., van Beek, L. P. H., van Vliet, M. T. H. (2022) Current wastewater treatment targets are insufficient to protect surface water quality. *Communications Earth & Environment,* 3, 221, doi:10.1038/s43247-022-00554-y.