Bridging global and basin scale water quality modeling towards enhancing global water quality modeling and management

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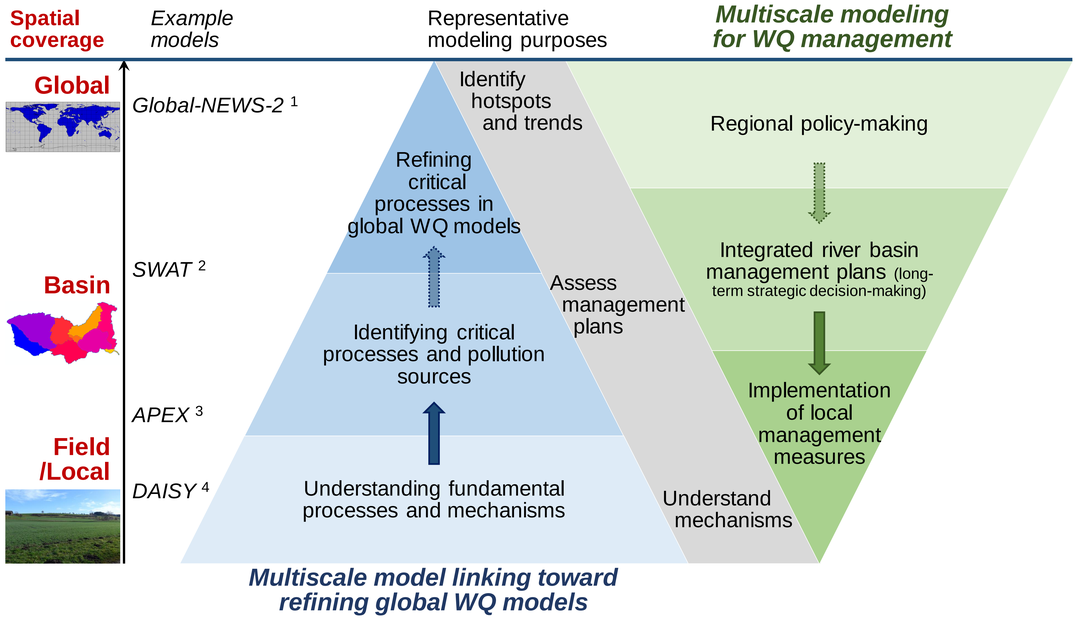
Motivation

- Basin/field scale water quality (WQ) models for a wide range of pollutants have been actively developed over the past few decades and widely used for a variety of purposes.
- Global water quality models (WQMs), such as Global-*NEWS*-2[1], are increasingly used to gain unique insight into the state and trend of WQ issues under global climate and socio-economic changes.
- A scale-independent WQM currently does not exist, but linking WQM of different spatial scales can help to address water quality issues across different scales.
- In this work, we argue that WQMs of different spatial scales should be better linked and support each other to ensure effective WQ management and further development of global WQMs.

Proposed framework to bridge WQMs of different spatial scales

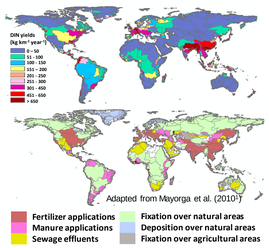
- Two directions are proposed to improve the linkages of WQ modeling across different spatial scales:
  - multiscale WQ modeling towards enhanced WQ and water resource management, and
  - refinement and enhancement of global WQ models using smaller-scale mechanistic understanding.



Multiscale WQ modeling towards enhanced WQ management

Example of dissolved inorganic nitrogen (DIN) transport into surface water

Global

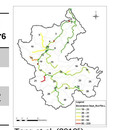


Identify global hotspots and source apportionment

Regional policy-making to address regions, basins & pollution sources of concern

Basin

NO_3^- fluxes (ton/year) to stream by SWAT[6]	
Surface runoff	17
Lateral flow	1
Tile flow	1302
base flow	575



Tang et al. (2012[5])

Assist in designing long-term basin management plans, considering climate and socio-economic changes:
- Identify **critical source area** and **critical transport pathways**
- Project **future changes** and evaluate potential **preventive strategies**

Local actions in response to basin management plans

Field/Local

Evaluate management measures:
- Buffer strips
- Application timing/rate control
- Alternative tillage practices
- Infrastructural development for grey/black water treatment
- Alternative manure management measures among others

- Context-specific basin-scale WQ management benefits from global WQMs to identify regions of concerns and requires local implementation of mitigation and/or prevention measures.
- Such an integrated manner of management strategy requires close collaborations among modelers of different spatial scales.

Challenges to current global WQ modeling call for enhancements of global WQMs.

- Strong spatiotemporal variability of biogeochemical processes v.s. coarse resolution of global WQMs
- Interdependence of pollutant processes & env. effects v.s. uncoupled modeling of different pollutants
- Risks of complex global WQMs with insufficient data to drive and/or validate the models

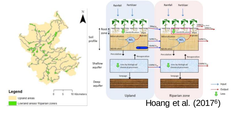
Enhancement of global WQMs

Field/Local

Riparian wetlands efficiently remove nutrients and pesticides primarily through **sediment trapping, plant uptake and denitrification**, but with strong temporal variabilities.

Mechanistic representation in basin-scale dynamic WQMs

Basin

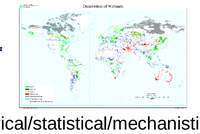


Hoang et al. (2017[6])

- **Dominant processes** in riparian wetlands at spatiotemporal scales relevant for global WQMs
- Critical geophysical **parameters** influencing the removal rates

Further simplified representation

Global



Empirical/statistical/mechanistic methods, e.g., $Load_{out} = R^F * Load_{in}$
- R^F = Constant
- $R^F = f(HRT, Q_{in}, OC_{sediment}, T, pH$, etc.)
- Direct inclusion of basin-scale methods for the **dominant processes**

Including processes gaining importance with increasing spatial coverage, e.g., atmospheric deposition of volatile pesticides

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