ISIMIP Water Quality Sector

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6th May, 2025

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OptimESM Optimal high resolution Earth System Models for exploring future climate change

ISIMIP Inter-Sectoral Impact Model Intercomparison Project

PROCLIAS

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

WWQA World Water Quality Alliance

Large community

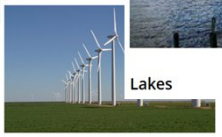
ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

WWQA
World Water Quality Alliance

Water (global)

Groundwater

Water Quality (in development)



Lakes

Energy (in development)

Deltares
Enabling Delta Life

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PBL Netherlands Environmental Assessment Agency

UFZ HELMHOLTZ
Centre for Environmental Research

VUB VRIJE UNIVERSITEIT BRUSSEL

National University of Life and Environmental Sciences of Ukraine

Université Yembila Abdoulaye Toguyeni UYAT

IIASA International Institute for Applied Systems Analysis

European Commission
JOINT RESEARCH CENTRE

Ministry of Water and Environment
REPUBLIC OF UGANDA

RUHR UNIVERSITÄT BOCHUM RUB

University of Nottingham
UK | CHINA | MALAYSIA

cmcc
Centro Euro-Mediterraneo sui Cambiamenti Climatici

IHE DELFT
Institute for Water Education
under the auspices of UNESCO

NIOO NEDERLANDS INSTITUUT VOOR ECOLOGIE (NIOO-KNAW)

Utrecht University

جامعة الملك عبدالله للعلوم والتقنية
King Abdullah University of Science and Technology

Acknowledgments

ISIMIP PROCLIAS cost WWQA WIMEK GRoW invent water NutriBudget PATHWAMED erc Starting Grants WAGENINGEN UNIVERSITY & RESEARCH

GROW-101041110

Community building and our highlights (selected)

Community building and our highlights (selected)

2020-2025

2019

2017

WWQA
World Water Quality Alliance

Community building and our highlights (selected)

2020-2025

○ **New** ISIMIP Water Quality Sector

Water Quality (in development)

Editorial overview: Water quality: A new challenge for global scale model development and application

Nynke Hofstra, Carolien Kroeze, Martina Flörke, Michelle T.H. van Vliet

2019

2017

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World Water Quality Alliance

ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

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- **10** workshops (hybrid)

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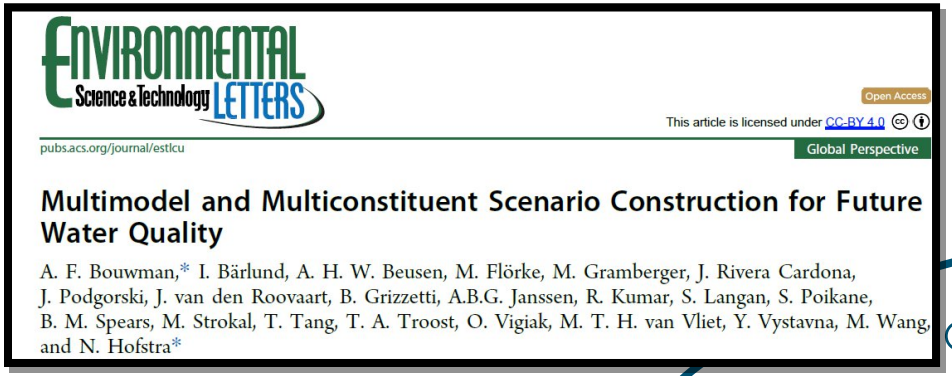

Environmental Science & Technology Letters

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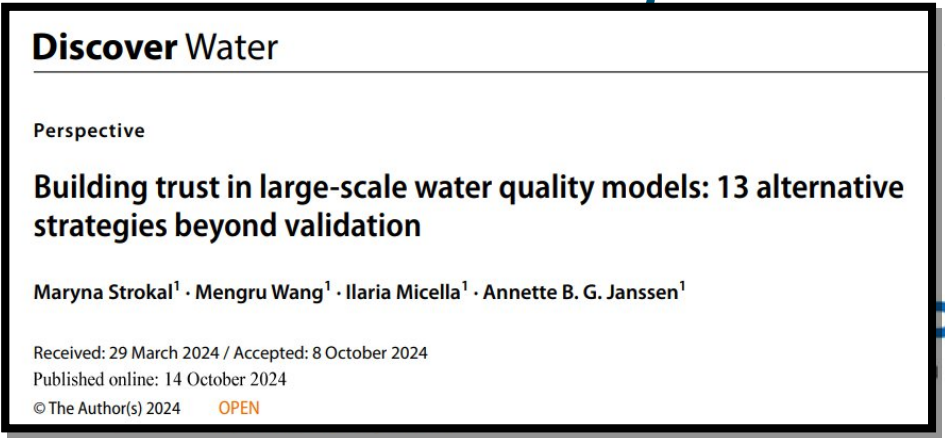
Global Perspective

Multimodel and Multiconstituent Scenario Construction for Future Water Quality

A. F. Bouwman,* I. Bärlund, A. H. W. Beusen, M. Flörke, M. Gramberger, J. Rivera Cardona, J. Podgorski, J. van den Roovaart, B. Grizzetti, A.B.G. Janssen, R. Kumar, S. Langan, S. Poikane, B. M. Spears, M. Strokal, T. Tang, T. A. Troost, O. Vigiak, M. T. H. van Vliet, Y. Vystavna, M. Wang, and N. Hofstra*



Discover Water

Perspective

Building trust in large-scale water quality models: 13 alternative strategies beyond validation

Maryna Strokal[1] · Mengru Wang[1] · Ilaria Micella[1] · Annette B. G. Janssen[1]

Received: 29 March 2024 / Accepted: 8 October 2024

Published online: 14 October 2024

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2020-2025

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- 10 workshops (hybrid)
- 4 webinars (online)
- At least 5 update meetings (online)
- **Two papers (published)**

Community building and our highlights (selected)


Environmental Science & Technology Letters

Multimodel and Multiconstituent Scenario Construction for Future Water Quality

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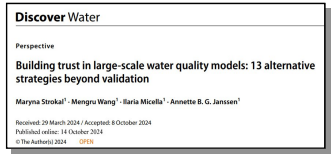
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- Two papers (published)
- **Special Issue**

WWQA
World Water Quality Alliance

ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

Special issue – Fast Track

- Environmental Research Letter (ERL) & Environmental Research Water (ERW)
- At least 10 large-scale models
- At least 10 papers (submitted or in prep)
- Largely ISIMIP 2

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Focus on Model Intercomparisons of Water Quality Under Global Change Impacts

Guest Editors

Martina Flörke, *Ruhr-Universität Bochum, Germany*
Nynke Hofstra, *Wageningen University, Netherlands*
Rohini Kumar, *Helmholtz Centre for Environmental Research (UFZ), Germany*
Maryna Strokal, *Wageningen University, Netherlands*
Michelle T. H. van Vliet, *Utrecht University, Netherlands*

Scope

Photo by Bernd Dittrich on Unsplash

Water quality is under threat in many places on Earth due to climate change and extremes (*e.g., droughts, floods*) that are integrated with socio-economic developments (*e.g., agriculture, urbanization*). Water quality models have been developed and combine our knowledge and data to estimate water pollution, its sources, and impacts of a wide range of pollutants such as salinity, nutrients, salinity, pathogens, plastics, and chemicals. These models are diverse in their temporal and spatial representation and their modelling approaches. Such diversity offers a great opportunity to compare model results to identify robust pollution hotspots, their sources and explore trends under global change across multiple pollutants, scales, scenarios, and sectors.

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Community paper

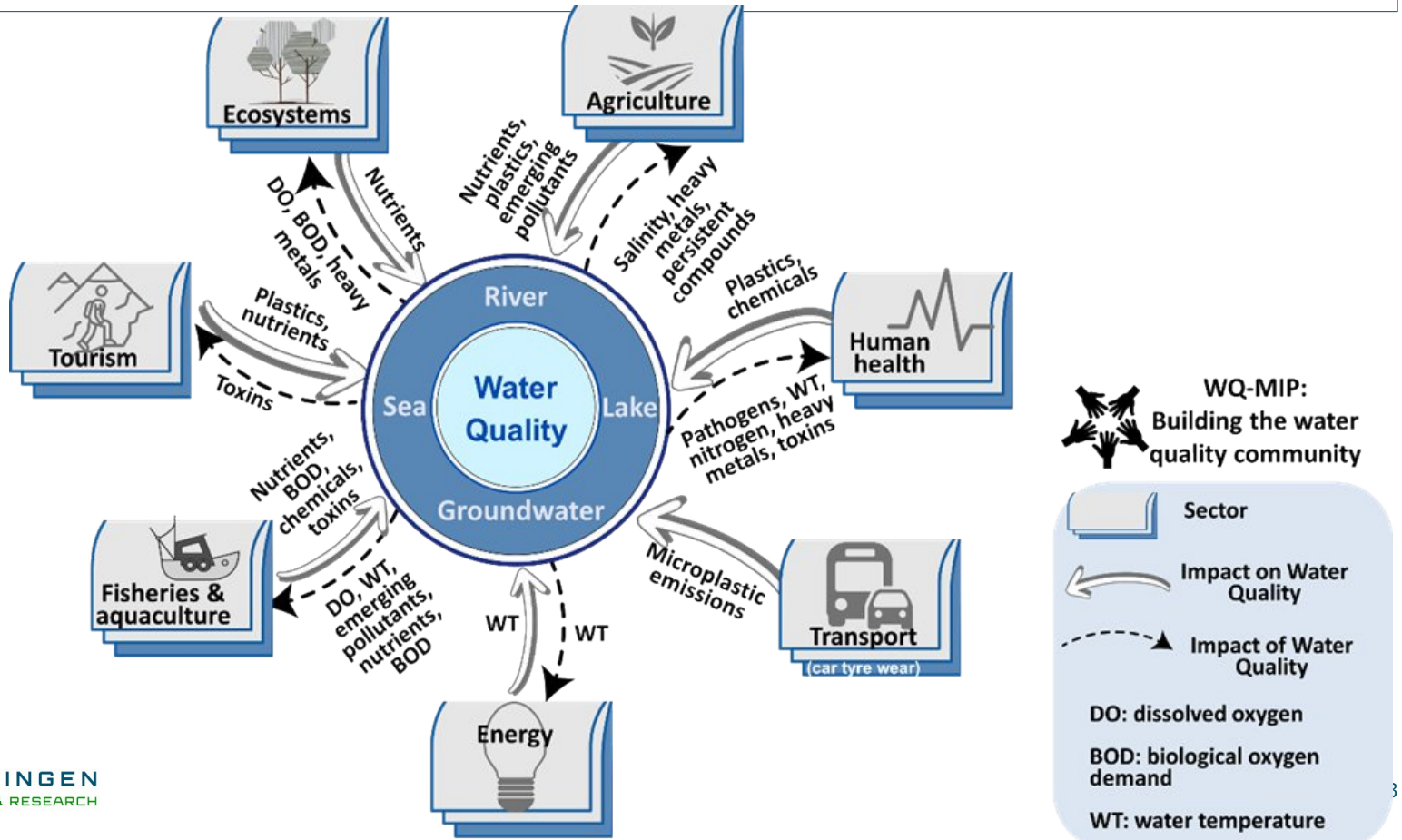
Advancing water quality model intercomparisons under global change:

Perspectives from the new ISIMIP water quality sector

Maryna Strokal, Rohini Kumar, Mirjam P. Bak, Edward R. Jones, Arthur H.W. Beusen, Martina Flörke, Bruna Grizzetti, Albert Nkwasa, Katrin Schweden, Aslihan Ural-Janssen, Ann van Griensven, Olga Vigiak, Michelle T.H. van Vliet, Mengru Wang, Inge de Graaf, Hans H. Dürr, Simon N. Gosling, Nynke Hofstra, Maria Theresa Nakkazi, Issoufou Ouedraogo, Robert Reinecke, Vita Strokal, Keerthana Suresh, Ting Tang, Floris S.R. Teuling, Ammanuel B. Tilahun, Tineke A. Troost, Dianneke van Wijk, Ilaria Micella

From left to right

Water quality and cross-sectoral linkages



7 Large-scale water quality models
9 Water quality constituents

DynQual
(temperature, BOD, TDS,

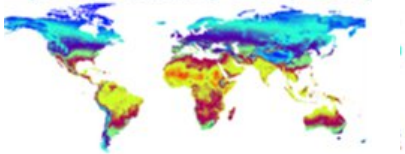
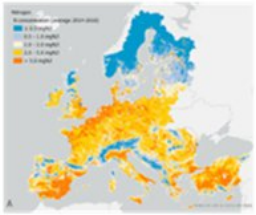


IMAGE-GNM
(phosphorus, nitrogen)

mQM
(nitrogen)

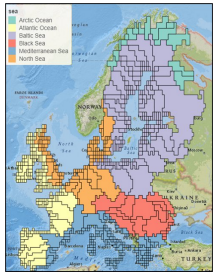
GREEN
(nitrogen, phosphorus)



SWAT+
(nitrogen, phosphorus)

MARINA-Multi
(nitrogen, phosphorus, plastics, triclosan, diclofenac)

MARINA-Nutrients



Models differ

- Annual, monthly
- Gridded, basin, and sub-basin
- Water quality constituents
- Model input data

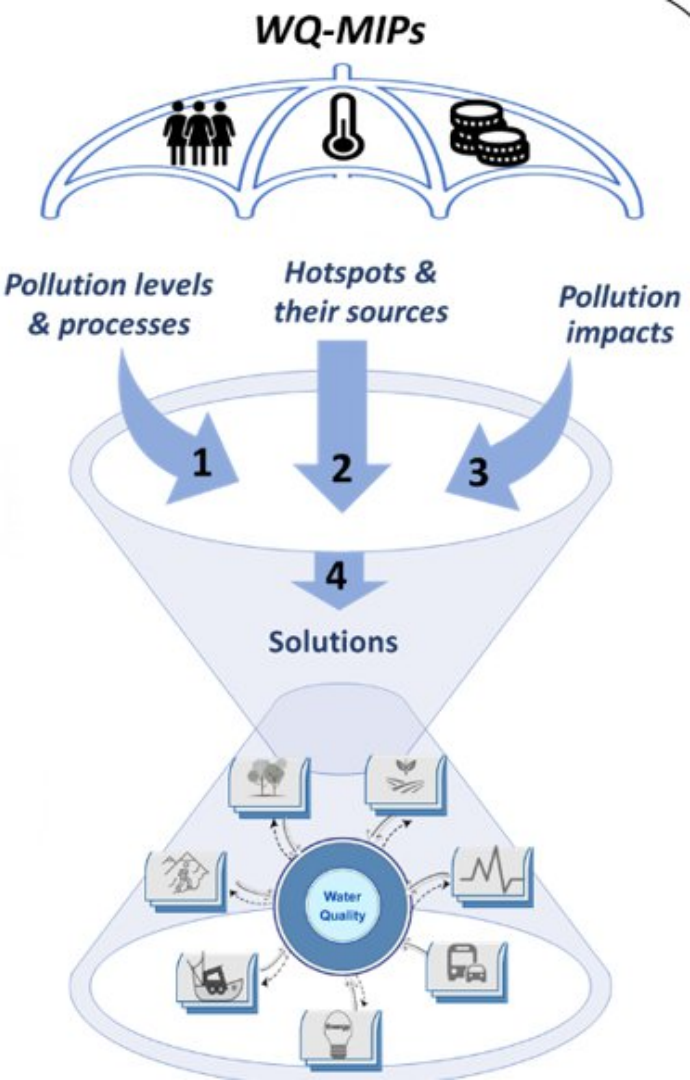
Four objectives for model intercomparisons of water quality (WQ-MIPs)

Objective 1: pollution levels & their processes (uncertainties)

Objective 2: hotspots & their sources (priority areas)

Objective 3: pollution impacts (priority sectors)

Objective 4: strategy effects (uncertainties)



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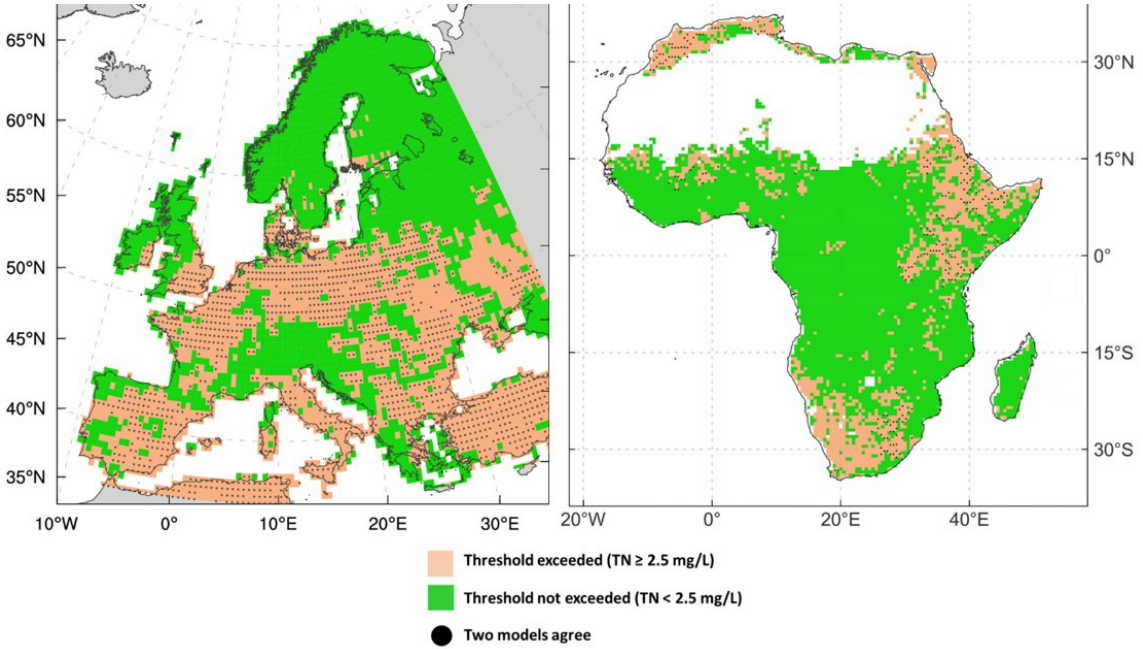
Three examples

(1) Agreement on pollution levels among models

IMAGE-GNM vs mQM

IMAGE-GNM vs SWAT+



- Europe: **>2/3** of the critical areas will exceed the 2.5 mg/L threshold in 2050
- Africa: **27%** of rivers will exceed the critical threshold of 2.5 mg/L in 2050

IMAGE-GNM: Beusen et al., (2022)

MQM: Kumar et al., (2020); Nguyen et al., (2022)

SWAT+: Nkwasa et al., (2024)

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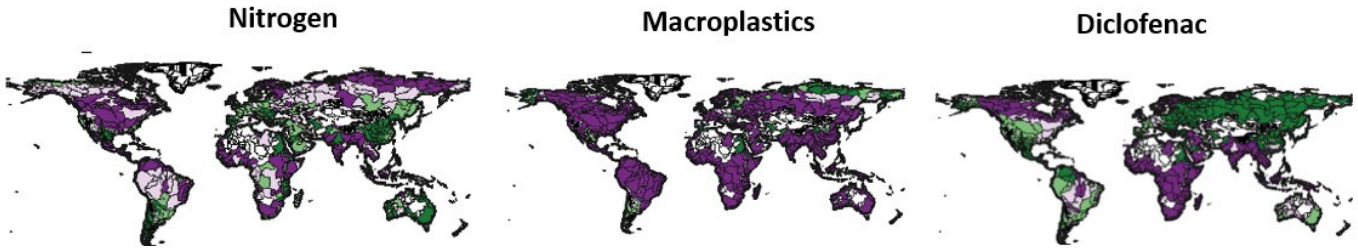
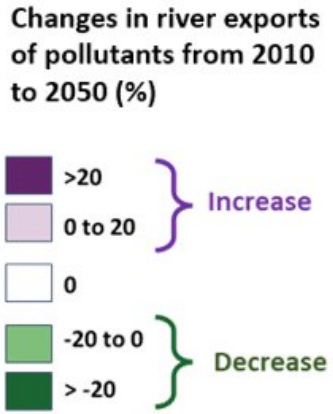
(2) Agreement on trends among pollutants & GCMs

3 pollutants from MARINA-Multi model



5 GCMS

1. GFDL
2. HADGEM
3. IPSL
4. MIROC
5. NORESM



Agreement on changes among 5 GCMs:

- Around **40%** agreement on decreases in **nitrogen** and **diclofenac**
- Around **80%** agreement on increases in **macroplastics**

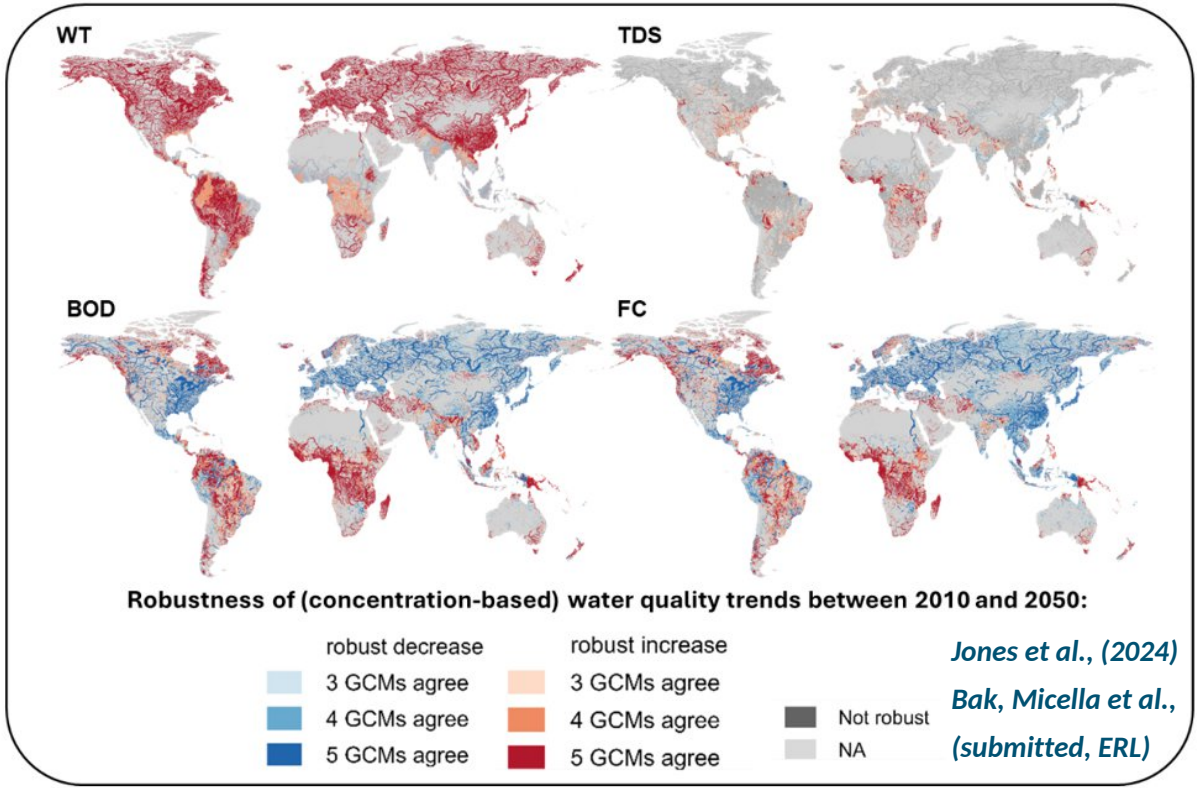
Micella et al., (2024)

Bak, Micella et al (submitted) ERL

(3) Agreement on trends and potential impact

DynQual model

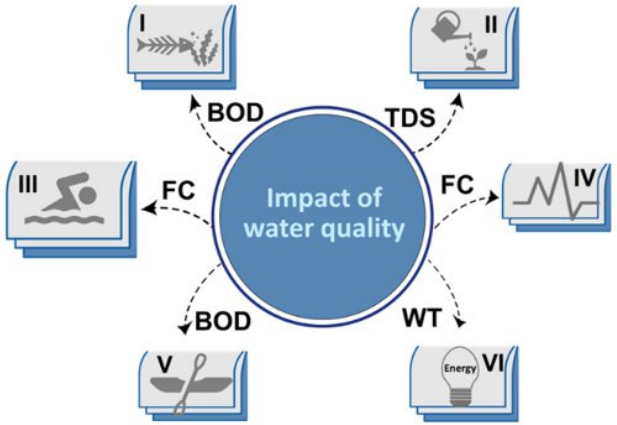
(a) Future water quality trends



Jones et al., (2024)

Bak, Micella et al., (submitted, ERL)

(b) Potential impacts on sectors



I: ↑ Organic pollution -> ↓ oxygen -> ↑ fish kills
II: ↑ Salinity -> crop damage
III: ↑ Pathogens -> diarrhea via swimming in polluted water
IV: ↑ Pathogens -> diarrhea via drinking of polluted water
V: ↑ Organic pollution -> ↓ oxygen -> ↓fish stock for aquaculture
VI: Warmer temperature -> not suitable for cooling purposes

Reflection

- ISIMIP2 (many models) vs ISIMIP3 (few models) climate forcing
- Internal consistency in scenario constructions (SSP5-RCP8.5...)
- Internal consistency in hydrological forcings

Next WQ-MIPs: support IPCC assessments

- **Special issue:** a lot to learn and support IPCC
- **Wish list using ISIMIP3 forcings:**
  - **Climate change attributions**: low effort
    - existing runs
    - e.g., water temperature
  - **Water scarcity & risk assessments**: moderate effort
    - Existing & new runs
    - non-agricultural pollutants such as emerging pollutants, plastics, and pathogens, driven by socioeconomic and urbanization drivers
  - **Cross-sectoral assessments**: high efforts
    - New runs (including small-scale models)
    - agricultural pollutants such as N and P
    - Data is not yet fully available (the largest challenge)

Thank you

Maryna.strokal@wur.nl, rohini.kumar@ufz.de, Ilaria.micella@wur.nl, mirjam.bak@wur.nl

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