The application of Bayesian approaches in water quality modelling

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Presentations

Presentations

Key challenge	Key finding
Craig Stow: Process based or probabilistic models? https://doi.org/10.5194/egusphere-egu2020-9925	
• **Are complex models better?** • **The need for explicit uncertainty analysis of process-based models** • **Specification of prior distribution** • **Computational challenges**	• The benefits of Bayesian approaches
Song Qian: A normative definition of a Bayesian prior https://doi.org/10.5194/egusphere-egu2020-17978	

• **How to derive and formulate a prior distribution?**
• **Prescriptive definition of a Bayesian prior**
	• Two case studies presented:
	  • Modelling of cyanobacterial toxins
	  • Improvement of chemical calibration curve

Presentations

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George Arhonditsis: Castles built on sand or predictive limnology in action? The importance of Bayesian ensembles to support our ecological forecasts https://doi.org/10.5194/egusphere-egu2020-7836	
• **Many different model structures and many different parameter sets within a chosen model structure can acceptably reproduce the observed behavior of a complex environmental system**	• Need to adopt a multi-model strategy rather than the single "best-fit" model Present a methodological framework to develop multi-model ensembles • Implemented framework on 2 cases studies
Yong Liu and Sifeng Wu: Resilience indicator for ecosystems subject to high risk of irreversible degradation: a probabilistic method based on Bayesian inference https://doi.org/10.5194/egusphere-egu2020-6182	
• **Ecosystem degradation is usually abrupt with unexpected shifts** • **Some ecosystems might be subject to high risks of irreversible degradation because of strong undesirable resilience**	• A practical framework to identify sensitive regions for conservation as well as opportunities for mitigation • Method implemented on lake eutrophication

Presentations

Key challenge	Key finding
Daniel Obenour et al.: **Assessing within-lake nutrient cycling through multi-decadal Bayesian mechanistic modeling** https://doi.org/10.5194/egusphere-egu2020-4232	
• **Bayesian calibration of a mechanistic model to understand nutrient recycling from lake bottom sediments** • **Combine mass-balance model with Bayesian inference**	Nutrients stored in lacustrine sediment are an important source of internal loading to the reservoir for multiple decades, and will dampen the effects of external watershed loading reductions
Ibrahim Alameddine and Eliza Deutsch: **Understanding Harmful Algal Bloom Dynamics in a Mediterranean Hypereutrophic Reservoir insights from a Bayesian Network and a Structural Equation Model** https://doi.org/10.5194/egusphere-egu2020-6709	
• **Identifying pathways between the physical lake conditions and the nutrient loads on one hand and ecological endpoint on the other** • **Comparing BN and SEM model structures**	Prior model structure not supported by data Models largely concur in structure Both models capture temperature effects and direct nutrient pathways and highlight the importance of internal loading

Presentations

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Danlu Guo et al.: **A Bayesian hierarchical model to predict spatio-temporal variability in river water quality at 102 catchments** https://doi.org/10.5194/egusphere-egu2020-4725	
Challenges to explain temporal variability in water quality using statistical models **Linear statistical models are limited in representing water quality datasets with large proportions of below-detection-limit records**	Model improvements should focus on: • Alternative statistical model structures to improve fitting for truncated data • Better representation of non-conservative constituents by accounting for biogeochemical processes
Minkyu Jung et al.: **A Hierarchical Bayesian Model for Spatio-Temporal Water Quality Modeling in a Chainging Climate in South Korea** https://doi.org/10.5194/egusphere-egu2020-21271	
Difficult to obtain accurate predictions of water quality due to the large spatio-temporal variability in a changing climate	**Hierarchical Bayesian model** can capture the key aspects of the water quality parameters in terms of seasonality and their uncertainty

Presentations

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Lorenz Ammann et al.: **Patterns in time-dependent parameters reveal deficits of a catchment-scale herbicide transport model** https://doi.org/10.5194/egusphere-egu2020-9081	
Deterministic dynamic water quality models are too rigid: they do not allow for the stochastic nature of the system and are susceptible to structural errors	Introducing stochasticity through time-dependent parameters can reveal deficits in model structure and can allow for a better description of the intrinsic uncertainty of dynamic water quality models
Sakari Kuikka: **Experiences in applying Bayesian network models in interdisciplinary water quality decision analysis** https://doi.org/10.5194/egusphere-egu2020-7270	
Developing integrative Bayesian models in interdisciplinary analysis **Different traditions and quality criteria of different scientific fields create both technical and human challenges to the modelling tasks**	Applications are based mainly on the use of expert knowledge, especially for decision options that have not been applied before **Bayesian decision analysis for management provides scientifically justified uncertainty estimates**

Presentations

Key challenge	Key finding
Camilla Negri et al.: Modelling phosphorus pollution risk in agricultural catchments using a spatially distributed Bayesian Belief Network https://doi.org/10.5194/egusphere-egu2020-555	
Diffuse pollution of phosphorus (P) from agriculture is a major pressure on water quality Need to develop Decision Support Tools that can account for the uncertainty in both data and models	Model captures the difference in P loss risk between catchments, probably caused by contrasting hydrological characteristics and soil P sources. Climate change and land use change scenarios crucial to inform targeting of mitigation measures
Magnus Norling: Rapid development and evaluation of fast process-based models in Mobius https://doi.org/10.5194/egusphere-egu2020-7326	
Build and explore many model structures and evaluate model uncertainty	**Modelling frameworks are a good alternative to one-size-fits-all models,** and we hope Mobius will be a useful tool for promoting more robust modelling

Discussion

Discussion Points

Challenge	Question	Examples
Model complexity and uncertainty assessment	**Do we need simpler models, faster models, or both?** Developments in computational capacity have led to more complex models, not necessarily to better predictive performance	Craig Stow Magnus Norling
Prior distributions	**What is a good prior?** Expert elicitation, informative, and non-informative priors	Song Qian Daniel Obenour
Model structural uncertainty	**Is our model structure adequate?** Model ensembles, flexible and fast frameworks for controlled model comparison, flexibility in model structure through time-dependent parameters	George Arhonditsis Ibrahim Alameddine Magnus Norling Lorenz Ammann
Representing spatio-temporal variability in models	**Is our input data adequate?** **How do you decide on your spatio-temporal scale?** Data resolution – spatial & temporal, uncertainty in model predictions	Minkyu Jung Danlu Guo

Discussion Points

Challenge	Question	Examples
Need for decision support tools with explicit uncertainty quantification	**What is the way forward in using models for decision support?** **Are we effectively integrating uncertainties in our decision making process?** • Different traditions and quality criteria from different scientific fields (biology, sociology and environmental economics) create both technical and human challenges to the modelling tasks • Bayesian decision analysis for management provides scientifically justified uncertainty estimates	Sakari Kuikka Camilla Negri Craig Stow
Ecological system complexity and resilience – impacting effectiveness of mitigation interventions	**How best to simulate complex biophysical systems?** • Accounting for unexpected shifts in ecosystem states • Modelling nutrient recycling from sediments • Identifying pathways and feedbacks between drivers and response variables	Yong Liu Daniel Obenour Ibrahim Alameddine

Important announcements

- Thank you for supporting this session in this **EXCEPTIONAL** year – we look forward to meeting you in person in Vienna at EGU 2021!

- **SPECIAL ISSUE ALERT**
  - We are proposing a ***Special Issue*** on '**Frontiers in the application of Bayesian approaches in water quality modelling**' in the EGU Hydrology and Earth Systems Science Journal
  - Open both to presenters at this session over the past two years and to the wider community
  - Interested to contribute to the Special Issue? Please get in touch with miriam.glendell@hutton.ac.uk