

Environmental flows: models

Modeling related to environmental flows





STAC meeting Dec 7, 2022

AI models

OpenAI.com <https://beta.openai.com/playground/>

ChatGPT

The screenshot shows a Google search for 'chatgpt'. The search results are displayed as 'top stories' with four articles:

- The Guardian:** AI bot ChatGPT stuns academics with essay-writing skills and usability. 19 hours ago. 
- Bleeping Computer:** OpenAI's new ChatGPT bot: 10 coolest things you can do with it. 6 hours ago. 
- Axios:** New AI chatbot is scary good. 4 hours ago. 
- The Verge:** AI-generated answers temporarily banned on coding Q&A site Stack... 2 hours ago. 

Example:

how can environmental flow modeling be improved by using machine learning?

Machine learning can help to improve environmental flow modeling by allowing for more accurate predictions of river flows and other environmental conditions based on more detailed data. Machine learning algorithms can be used to identify patterns in data sets related to environmental flows and can be used to create more accurate predictions of future environmental flows. Additionally, machine learning can be used to identify correlations between different environmental variables and river flows and can also be used to develop better models for predicting the effects of climate change on river flows.

Mean vs variance/Descriptive vs predictive

- Machine learning models – more focus on predictive
 - The usuals: genetic algorithms, boosted trees, ensembles, etc
 - The mixes: combining process based models with deep learning models
 - The newbies: contrastive learning
- Agent based models
- Variance/uncertainty modeling
 - hierarchical Bayesian models
 - surrogate models
 - spatial correlation models: (spatial stream network models or SSNs)

SSN references

https://www.fs.usda.gov/rm/boise/AWAE/projects/NationalStreamInternet/SSN_Bibliography.html

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- Larsen, S., B. Majone, P. Zulian, E. Stella, A. Bellin, M.C. Bruno, and G. Zolezzi. 2021. Combining Hydrologic Simulations and Stream-network Models to Reveal Flow-ecology Relationships in a Large Alpine Catchment. *Water Resources Research* 10.1029/2020WR028496.
 - French, D.W., D.E. Schindler, S.R. Brennan, and D. Whited. 2020. Headwater Catchments Govern Biogeochemistry in America's Largest Free-Flowing River Network. *Journal of Geophysical Research*
 - Rhea, A.E., T.P. Covino, C.C. Rhoades, and A.C. Brooks. 2022. Use of geostatistical models to evaluate landscape and stream network controls on post-fire stream nitrate concentrations. *Hydrological Processes* DOI: 10.1002/hyp.14689eosciences 10.1029/2020JG005851.
 - **Bayesian model:** Shenton, Will, Nicholas R. Bond, Jian DL Yen, and Ralph Mac Nally. "Putting the "ecology" into environmental flows: ecological dynamics and demographic modelling." *Environmental management* 50, no. 1 (2012): 1-10.
 - Bradford, Michael J., Paul S. Higgins, Josh Korman, and Jeff Sneep. "Test of an environmental flow release in a British Columbia river: does more water mean more fish?." *Freshwater Biology* 56, no. 10 (2011): 2119-2134.
 - **ML:** Theodoropoulos, Christos, Aikaterini Vourka, Nikolaos Skoulikidis, Peter Rutschmann, and Anastasios Stamou. "Evaluating the performance of habitat models for predicting the environmental flow requirements of benthic macroinvertebrates." *Journal of Ecohydraulics* (2018).
 - **Linking models:** Hipsey, M. R., Bruce, L. C., Boon, C., Busch, B., Carey, C. C., Hamilton, D. P., Hanson, P. C., Read, J. S., de Sousa, E., Weber, M., and Winslow, L. A.: A General Lake Model (GLM 3.0) for linking with high-frequency sensor data from the Global Lake Ecological Observatory Network (GLEON), *Geosci. Model Dev.*, 12, 473–523, <https://doi.org/10.5194/gmd-12-473-2019>, 2019.
 - Subratie, Kensworth C., Saumitra Aditya, Srinivas Mahesula, Renato Figueiredo, Cayelan C. Carey, and Paul C. Hanson. "GRAPLEr: A distributed collaborative environment for lake ecosystem modeling that integrates overlay networks, high-throughput computing, and WEB services." *Concurrency and Computation: Practice and Experience* 29, no. 13 (2017): e4139.

But the models are constrained by data and design

- Many existing environmental flow monitoring programs have poorly defined objectives, non-justified indicator choices, weak experimental designs, poor statistical strength, and often focus on outcomes from a single event.

King et al. *Environmental Management* (2015) 55:991–1005

Data, data management and quality

- Environmental flows monitoring
 - Long term funding is needed
 - Data management plan – consistency across studies
 - Meta data is important and needs to be processed better
 - Avoid MS degree research – the three year interest
 - Avoid low cost bid – consider long term cost
 - Consulting firms have multiple interests
 - Cheap implies interns over researchers, lab shortcuts
 - quality of the researcher with a long-term investment
 - avoid: My data set is ~~clean~~ **NOT**, my code is available **NOT**
 - Data management checks are often for standards not quality

recommendations

- environmental flow monitoring programs should be implemented within an adaptive management framework;
- objectives of environmental flow programs should be well defined, attainable, and based on an agreed conceptual understanding of the system;
- program and intervention targets should be attainable, measurable, and inform program objectives
- intervention monitoring programs should improve our understanding of flow-ecological responses and related conceptual models;
- indicator selection should be based on conceptual models, objectives, and prioritization approaches;
- appropriate monitoring designs and statistical tools should be used to measure and determine ecological response;
- responses should be measured within timeframes that are relevant to the indicator(s)
- watering events should be treated as replicates of a larger experiment;
- environmental flow outcomes should be reported using a standard suite of metadata.
 - Incorporating these attributes into future monitoring programs should ensure their outcomes are transferable and measured with high scientific credibility.

King et al. Environmental Management (2015) 55:991–1005

What are some issues in environmental flow modeling? (OpenAI)

1. Complexity of hydrologic and hydraulic processes: Environmental flow modeling involves many complex hydrologic and hydraulic processes which can be difficult to accurately simulate and measure.
2. Uncertainty of data: Data used for environmental flow modeling can be uncertain and difficult to obtain.
3. Model calibration and validation: Model calibration and validation are important for obtaining accurate results but can be a time-consuming process.
4. Computational resources: Environmental flow modeling requires a high level of computational resources which can be costly and difficult to access.
5. Scale: Environmental flow models often have to be applied to different spatial and temporal scales, which can lead to inaccuracies due to the lack of data and the complexity of the processes.

What are some future directions in environmental flow sensor modeling research?

1. Developing more accurate models for predicting the effects of climate change on water flow.
2. Investigating the use of machine learning and artificial intelligence to improve the accuracy of environmental flow sensor models.
3. Developing methods to better integrate environmental flow sensor models with other environmental models.
4. Exploring the use of satellite imagery and remote sensing data to improve environmental flow sensor models.
5. Investigating the use of real-time data to improve the accuracy of environmental flow sensor models.
6. Developing methods to better integrate environmental flow sensor models with other water management systems.
7. Investigating the use of big data and cloud computing to improve the accuracy of environmental flow sensor models.
8. Exploring the use of digital twins to improve accuracy of environmental flow sensor models

<https://beta.openai.com/playground/p/U7Gn0ADbIS6o2fhVdcVoBGqR>

What are digital twins?

Digital twins are digital replicas of physical objects or systems. They are created by combining data from multiple sources, such as sensors, to create a digital representation of the physical object or system. Digital twins can be used to monitor the performance of physical objects or systems, predict their future behavior, and provide insights into how to optimize their performance.

Can contrastive learning be used to improve simulation models?

Yes, contrastive learning can be used to improve simulation models. Contrastive learning is a type of unsupervised machine learning that trains a model to distinguish between two different inputs. By teaching the model to distinguish between different inputs, it can develop a better understanding of how different inputs interact, which can be used to improve the accuracy of simulation models.

other refs

- Hipsey, Matthew R., Gideon Gal, George B. Arhonditsis, Cayelan C. Carey, J. Alex Elliott, Marieke A. Frassl, Jan H. Janse, Lee de Mora, and Barbara J. Robson. "A system of metrics for the assessment and improvement of aquatic ecosystem models." *Environmental Modelling & Software* 128 (2020): 104697.