Flexible Integration of Lakes in Global River Systems

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Abstract

Streamflow, biogeochemical cycling, and flux transport models rely on digital representations of river networks. At local to regional extents, such representations can be very detailed and account for individual hydrologic features such as dams and river diversions. However, at continental to global extents, these hydrologic features are often far less resolved. This lack of detail can lead to a mismatch between the resolution of hydrologic features relative to the resolution of the network itself. One solution to such mismatches is to impose a "global" standard hydrologic feature resolution. However, this approach may fail to provide critical information that is essential for accurate modeling because it removes hydrologic feature data (such as lakes) that could otherwise be passed to calibration and fitting routines. In this research, we test how variations in river network resolution may introduce such resolution mismatches. Using Viti Levu, Fiji as a case study, we show that even small "coarsening" of network resolution has a significant effect on lake representation and has carry-on effects on overall network transport. Because these effects were less pronounced for networks with larger lakes, this indicates that including lakes even in coarse models may be very informative given the extent to which available chemical and hydrologic data is skewed towards larger lakes.

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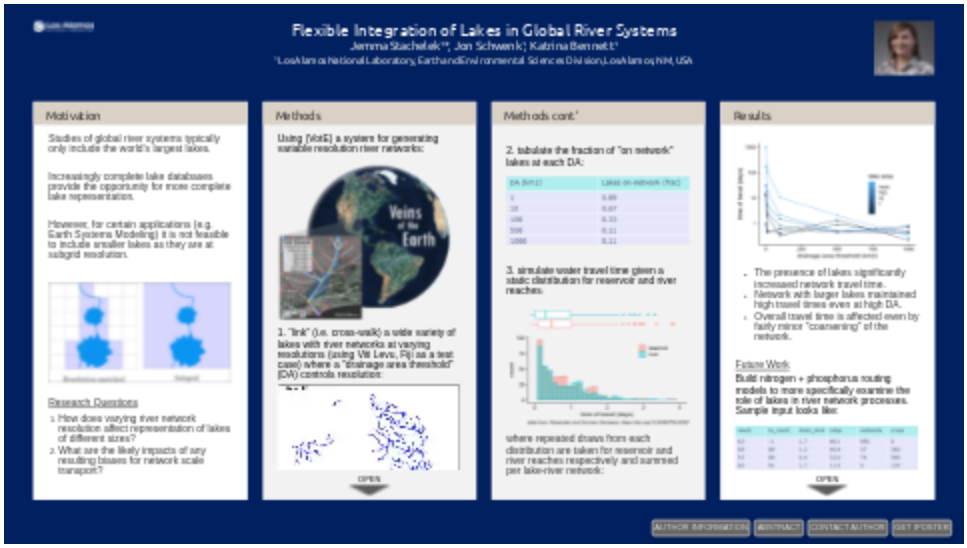
`threshold.gif` available at https://authorea.com/users/540684/articles/600299-flexible-integration-of-lakes-in-global-river-systems

Flexible Integration of Lakes in Global River Systems



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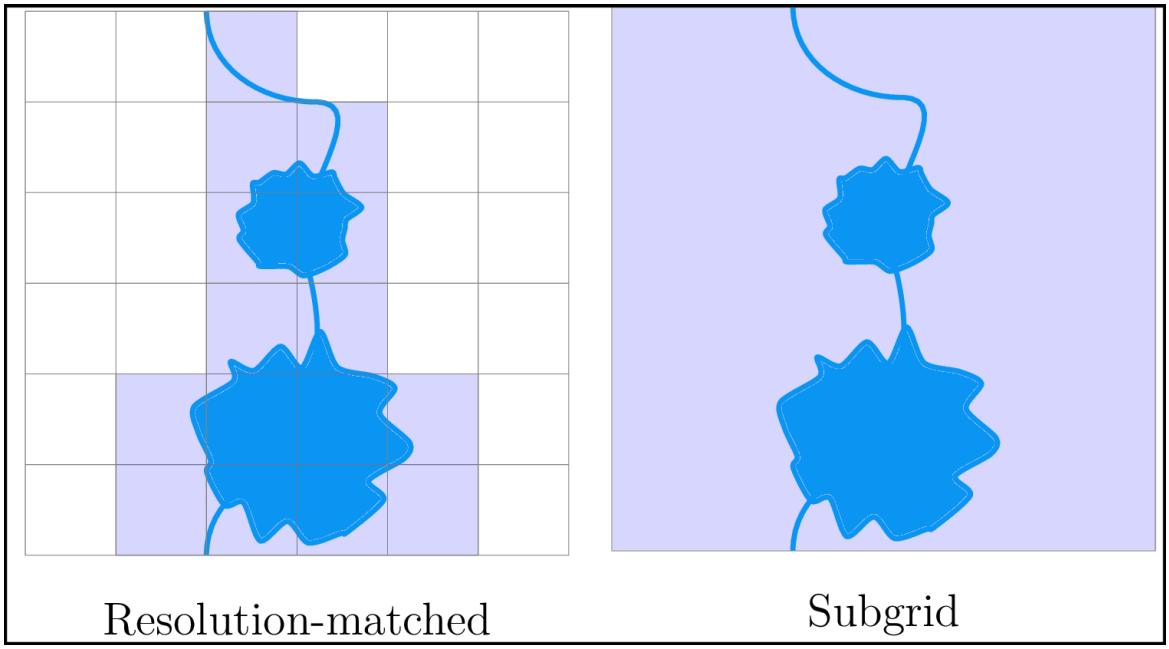
PRESENTED AT:

MOTIVATION

Studies of global river systems typically only include the world's largest lakes.

Increasingly complete lake databases provide the opportunity for more complete lake integration and representation.

However, for certain applications (e.g. Earth Systems Modeling) it is not always feasible to include smaller lakes as they are at subgrid resolution.

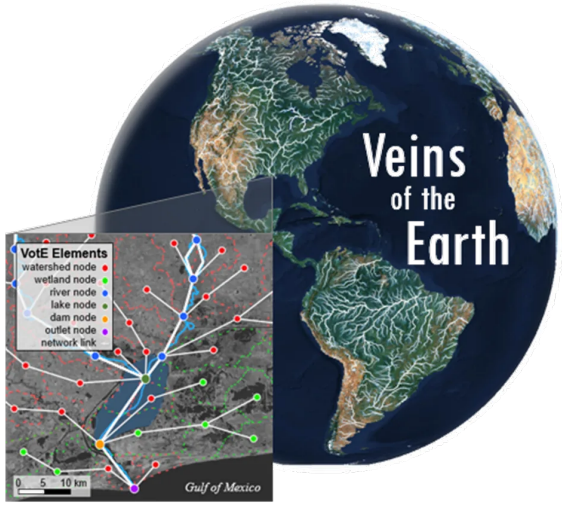


Research Questions

1. How does varying river network resolution affect representation of lakes of different sizes?
2. What are the likely impacts of any resulting biases for network scale transport?

METHODS

Using (VotE), a system for generating variable resolution river networks:



1. “link” (i.e. cross-walk) a wide variety of lakes with river networks at varying resolutions (using Viti Levu, Fiji as a test case) where a "drainage area threshold" (DA) controls resolution:

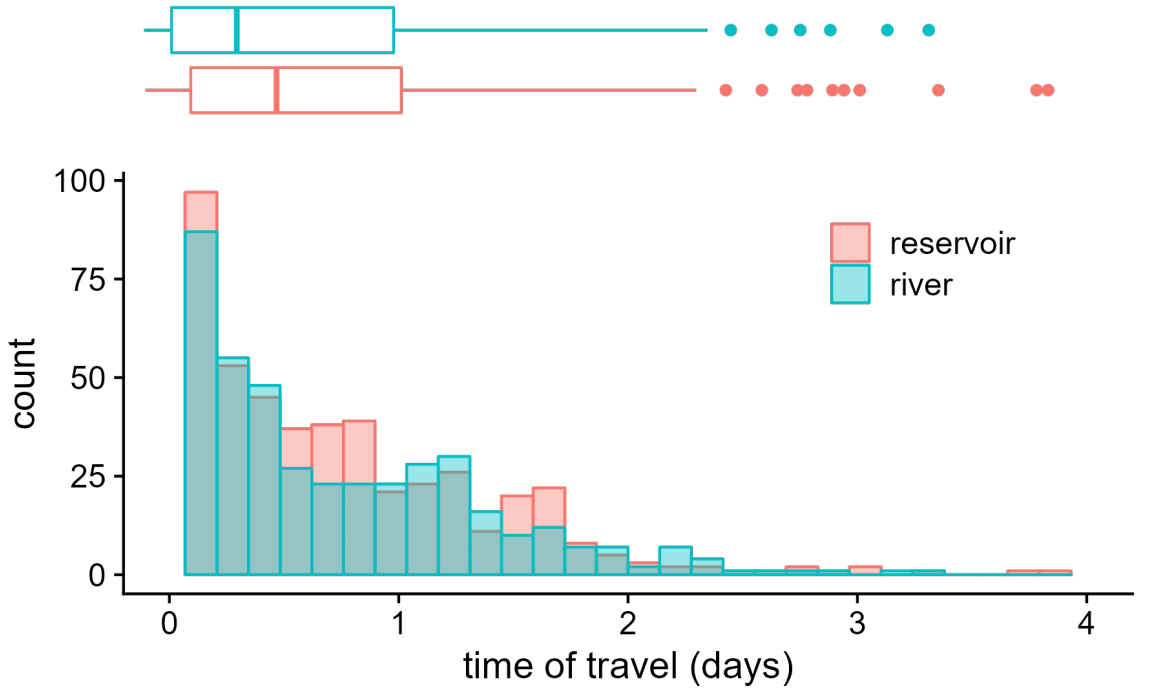
[VIDEO] https://res.cloudinary.com/amuze-interactive/image/upload/f_auto,q_auto/v1638566908/agu-fm2021/61-76-d1-53-fe-5c-27-ce-ee-58-de-63-7a-d1-86-46/image/test_m0wg0k.mp4

METHODS CONT'

2. tabulate the fraction of "on network" lakes at each DA:

DA (km2)	Lakes on-network (frac)
1	0.89
10	0.67
100	0.33
500	0.11
1000	0.11

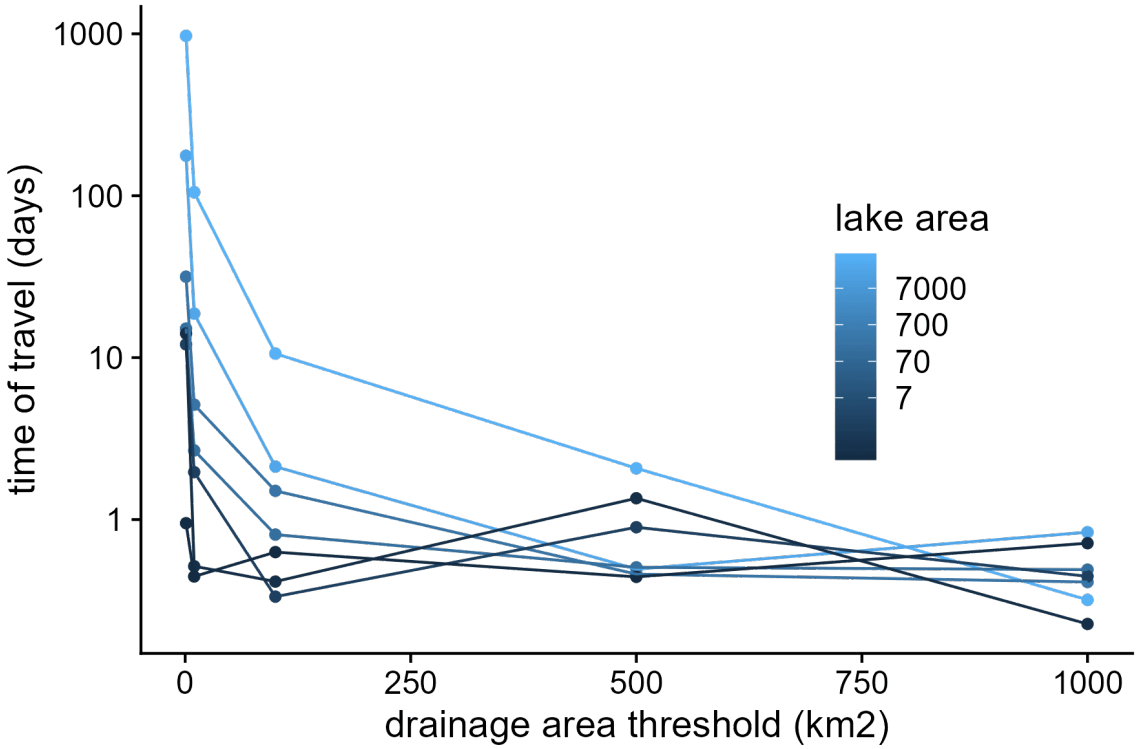
3. simulate water travel time given a static distribution for reservoir and river reaches:



data from: Alexander and Gorman Sanisaca, https://doi.org/10.5066/P9UAZ6F

where repeated draws from each distribution are taken for reservoir and river reaches respectively and summed per lake-river network:

RESULTS



- The presence of on-network lakes significantly increases network travel time.
- Network with larger lakes maintain high travel times even at high DA.
- Overall travel time is affected even by fairly minor "coarsening" of the network.

Future Work

Build nitrogen + phosphorus routing models to more specifically examine the role of lakes in river network processes. Sample input from the rapbro software package (https://github.com/jonschwenk/rabpro) looks like:

reach	to_reach	drain_dnst	ndep	wetlands	crops
63	-1	1.7	40.1	956	0
68	89	1.2	40.4	37	260
55	89	0.4	32.0	74	590
60	91	1.7	11.5	0	135
49	91	0.7	42.5	0	12
72	1	0.9	104.0	0	2145
69	1	0.7	35.2	0	20
41	90	1.5	17.9	0	1
56	90	1.3	44.0	0	0

AUTHOR INFORMATION

See https://jsta.rbind.io (https://jsta.rbind.io)

ABSTRACT

Streamflow, biogeochemical cycling, and flux transport models rely on digital representations of river networks. At local to regional extents, such representations can be very detailed and account for individual hydrologic features such as dams and river diversions. However, at continental to global extents, these hydrologic features are often far less resolved. This lack of detail can lead to a mismatch between the resolution of hydrologic features relative to the resolution of the network itself. One solution to such mismatches is to impose a “global” standard hydrologic feature resolution. However, this approach may fail to provide critical information that is essential for accurate modeling because it removes hydrologic feature data (such as lakes) that could otherwise be passed to calibration and fitting routines. In this research, we test how variations in river network resolution may introduce such resolution mismatches. Using Viti Levu, Fiji as a case study, we show that even small "coarsening" of network resolution has a significant effect on lake representation and has carry-on effects on overall network transport. Because these effects were less pronounced for networks with larger lakes, this indicates that including lakes even in coarse models may be very informative given the extent to which available chemical and hydrologic data is skewed towards larger lakes.

REFERENCES

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