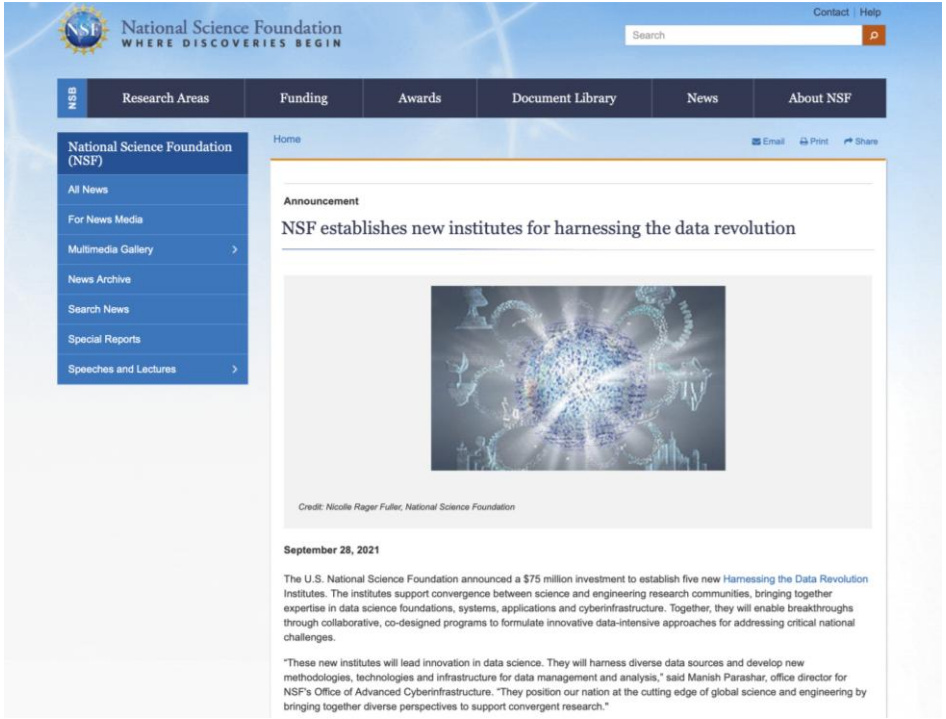
I-GUIDE
Institute for Geospatial Understanding through an Integrative Discovery Environment

Geospatial AI and Data Science for Sustainability

Shaowen Wang
University of Illinois Urbana-Champaign

Award #: 2118329

Harnessing the Data Revolution



https://www.nsf.gov/news/special_reports/announcements/092821.jsp

I-GUIDE

Vision: Enable digital discovery and innovation through harnessing the geospatial data revolution

Mission: Advance convergence and geospatial sciences for holistic sustainability solutions

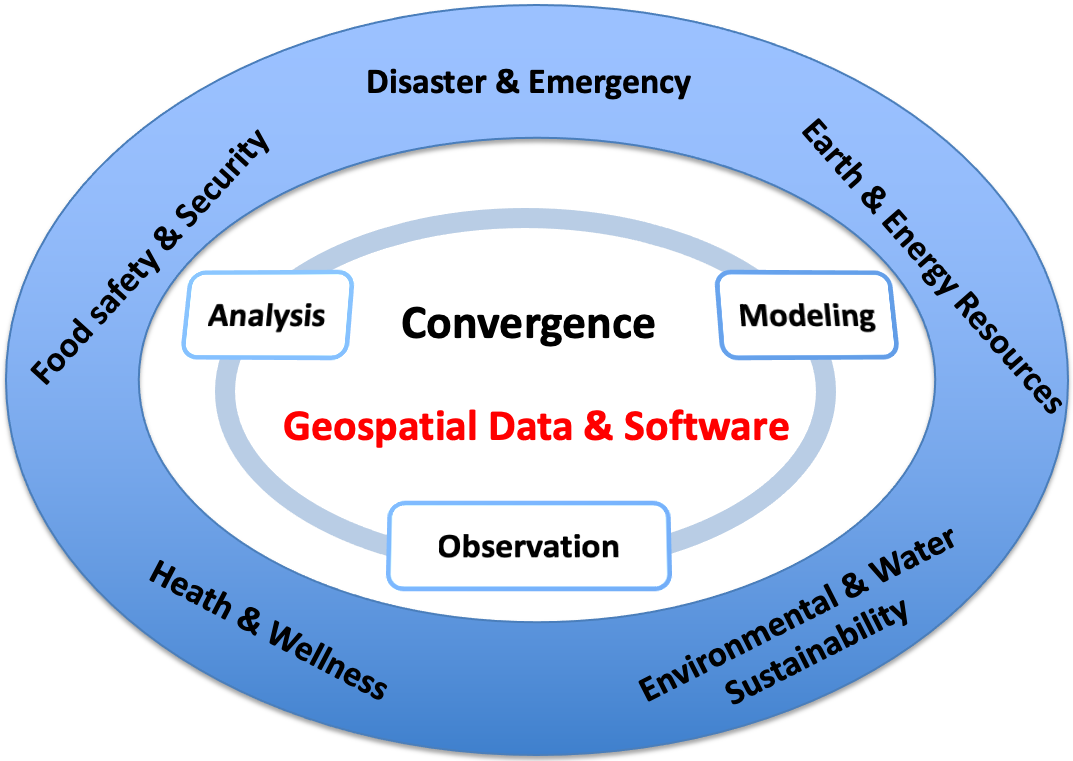
http://i-guide.io

I-GUIDE Collaborating Institutions

Partners


AAG
Association of American Geographers
AGU
Advancing Earth and Space Science
AGILE
DPI
Discovery Partners Institute
EarthCube
NASA
Google
NWC
National Water Center
MAXAR
Technologies
Microsoft
Midwest Big Data Hub
California Academy of Sciences
museum of science+industry chicago
Oak Ridge National Laboratory
outlier
Research & Evaluation
SGCI
Science Gateways Community Institute
The HDF Group
TLP
Thomas Lucas Productions Inc.
USGS
science for a changing world
WGIC
World Geospatial Industry Council

Motivation

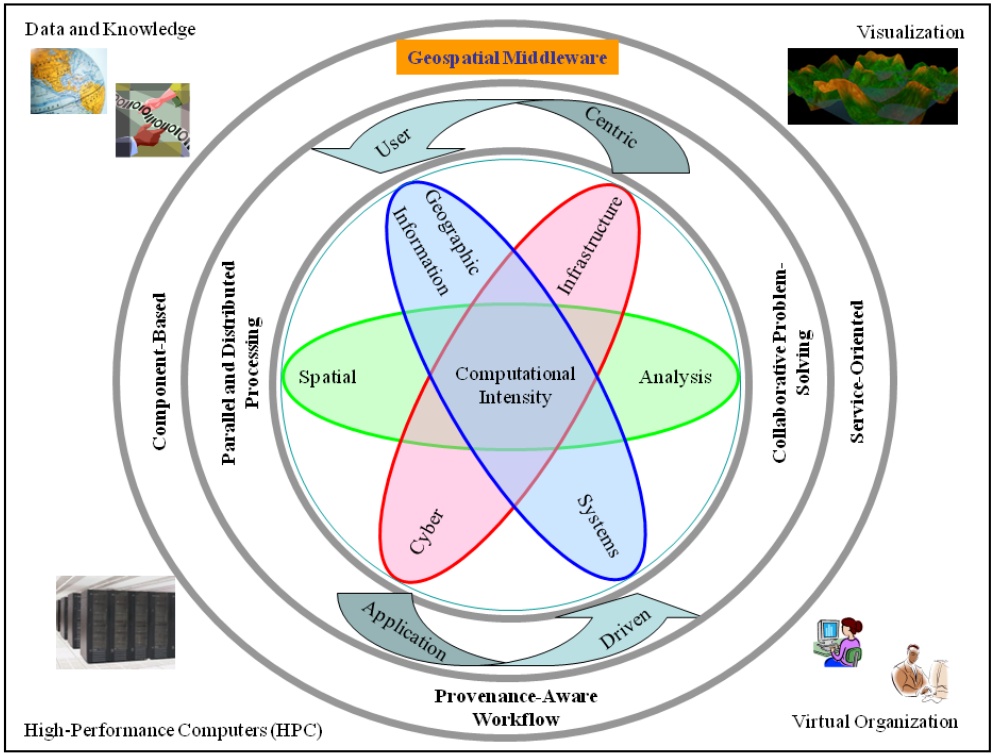

Disaster & Emergency
Earth & Energy Resources
Environmental & Water Sustainability
Heath & Wellness
Food safety & Security
Analysis
Convergence
Modeling
Geospatial Data & Software
Observation

Convergence

"*integrating knowledge, methods, and expertise from different disciplines and forming novel frameworks to catalyze scientific discovery and innovation*"

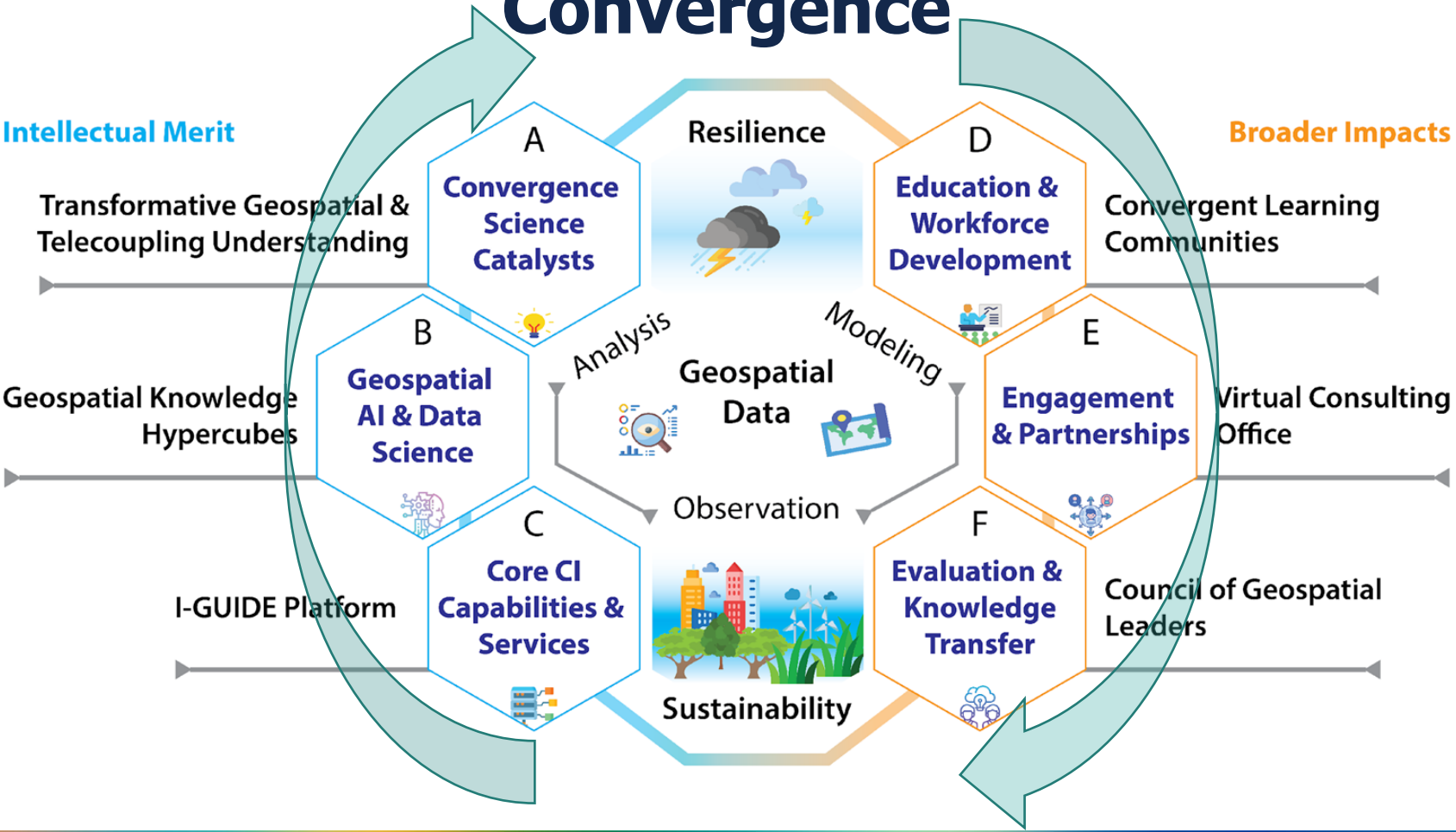
https://www.nsf.gov/crssprgm/nano/reports/MCR_2020-1020_PrinciplesOfConvergenceInNatureSociety_JNR_27p.pdf

CyberGIS



Wang, S. (2010) "A CyberGIS Framework for the Synthesis of Cyberinfrastructure, GIS, and Spatial Analysis." *Annals of the Association of American Geographers*, 100(3): 535-557

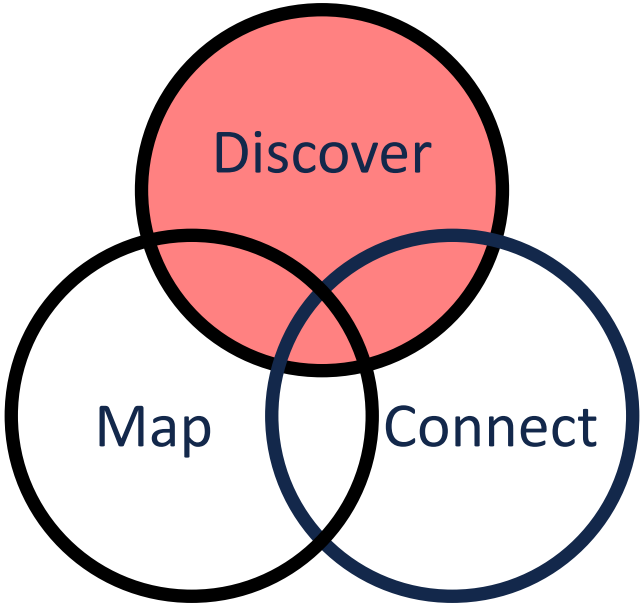
Convergence



Map, Connect, Discover

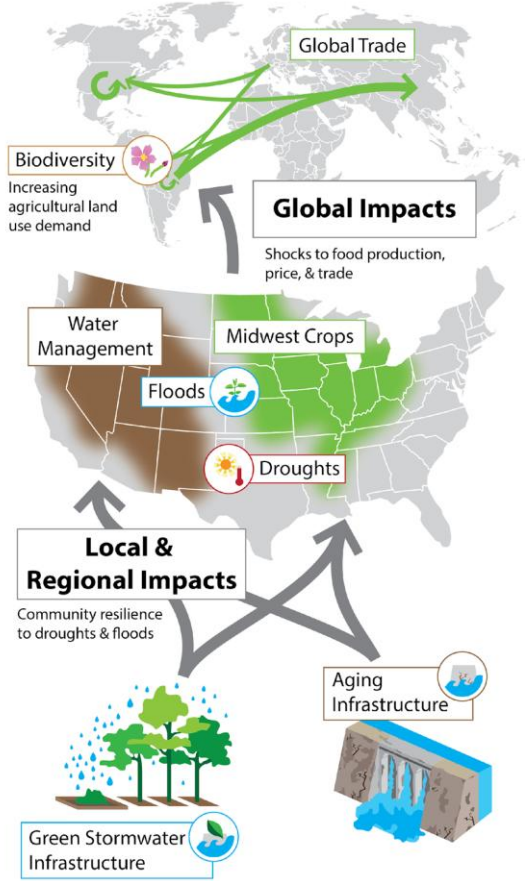
https://www.un.org/sustainabledevelopment/blog/2015/12/sustainable-development-goals-kick-off-with-start-of-new-year/#

Catalyzing Convergence Science



Convergence Science Catalysts

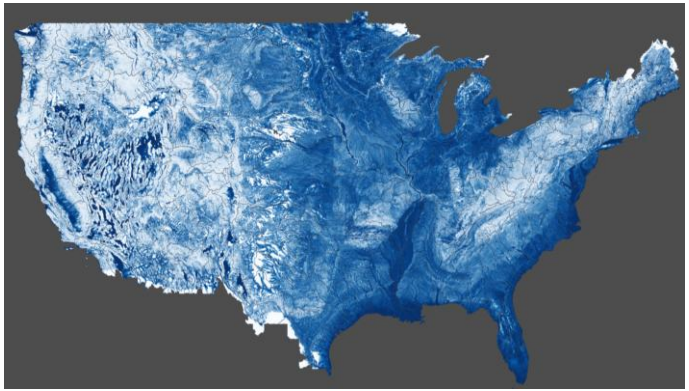
- Hydroclimatic extremes and associated vulnerability
- Socioeconomic impacts of potential climate induced disasters
- Global-local-global analysis of sustainability from the perspectives of biodiversity, fertilizer, and land use
- Telecoupling, food commodity (soybean/corn), production and trade, disasters, and land use/cover change in distant regions



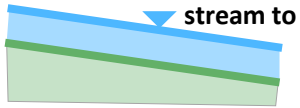
Map Flood Inundation at Continental Scale

Catchments and Flowlines

Digital Elevation Model



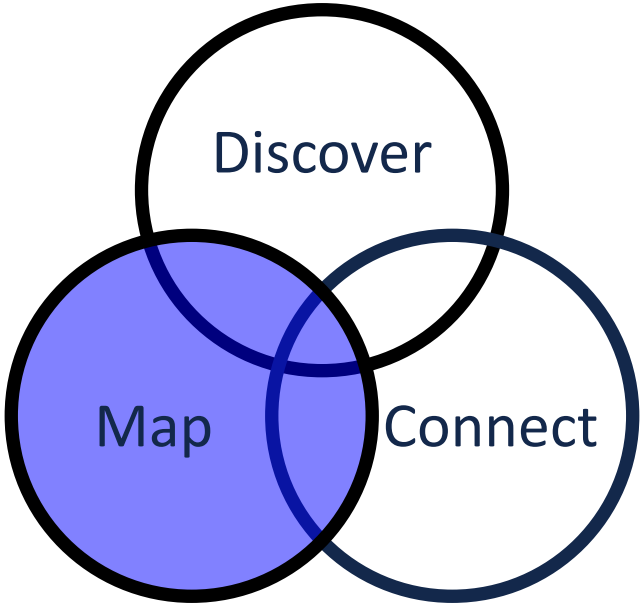
Height Above Nearest Drainage (HAND)
(relative elevation of land surface cell above cell in stream to which it flows)



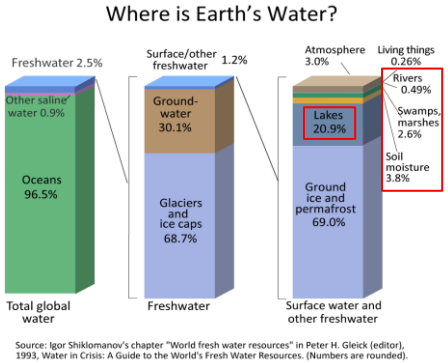
Liu, Y. Y., Maidment, D. R., Tarboton, D. G., Zheng, X., and Wang, S. (2018) “A CyberGIS Integration and Computation Framework for High-Resolution Continental-Scale Flood Inundation Mapping”. *Journal of the American Water Resources Association*, DOI:10.1111/1752-1688.12660

"*Combination of detailed GIS representation of stream network and supercomputing to determine the flow is transformative – CyberGIS has delivered a major success for the nation!*" – Dr. David Maidment @ 2015 CyberGIS All Hands Meeting

Geospatial Science at Scale



Streamline Delineation

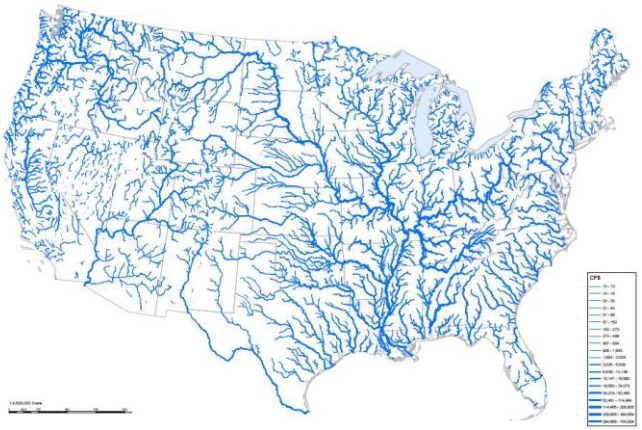


rivers

swamps

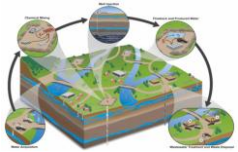
lakes

creeks



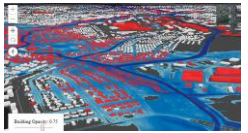
National Hydrography Dataset

Manage riverine and coastal navigation and safety



Assess water availability and water rights

Agriculture suitability

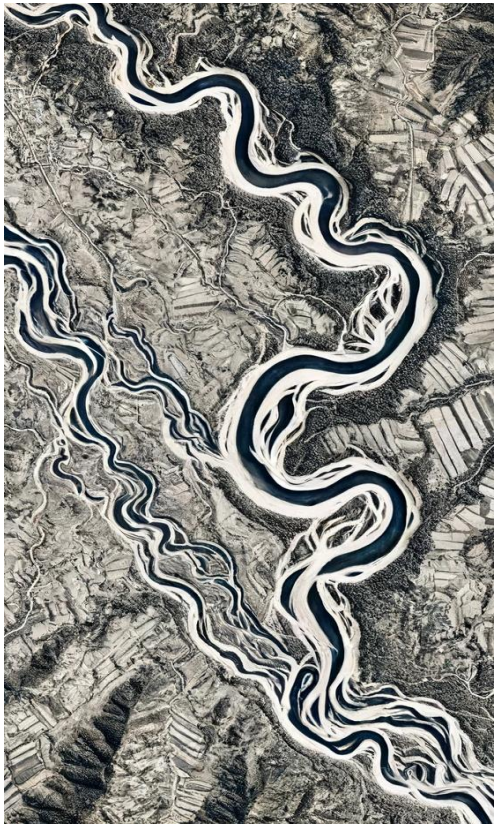


Model and map flood risk

Reference:
Moore, R.B., McKay, L.D., Rea, A.H., Bondelid, T.R., Price, C.V., Dewald, T.G., and Johnston, C.M., 2019, User's guide for the national hydrography dataset plus (NHDPlus) high resolution: U.S. Geological Survey Open-File Report 2019–1096, 66 p., https://doi.org/10.3133/ofr20191096.

Challenges of Streamline Delineation

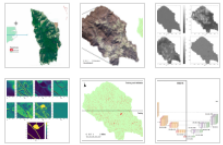
- Spatial heterogeneity
- Complex connectivity
- Uncertain flow paths
- Seasonal variability
- Computational intensity



Outline

Show full outline

Figures (9)



Show 3 more figures

Tables (10)

Table 1
Table 2
Table 3

ELSEVIER

Environmental Modelling & Software
Available online 24 July 2024, 106165
In Press, Journal Pre-proof What's this?

Transfer Learning with Convolutional Neural Networks for Hydrological Streamline Delineation

Nattapon Jaroenchai [a b], Shaowen Wang [a b], Lawrence V. Stanislawski [c], Ethan Shavers [c], Zhe Jiang [d], Vasit Sagan [e], E. Lynn Usery [c]

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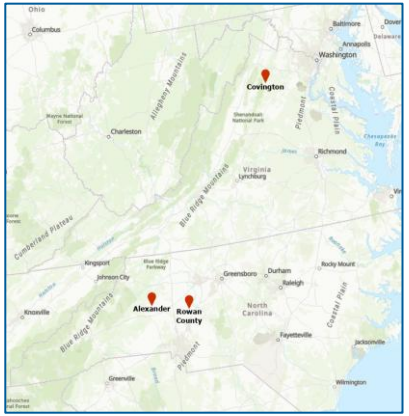
https://doi.org/10.1016/j.envsoft.2024.106165 Get rights and content

Highlights

- Transfer learning approach for hydrographic streamline delineation is proposed.
- U-Net models with ImageNet pre-trained backbones outperform the model trained from scratch.
- Transfer learning improves transferability of streamline delineation across geographic locations.

Abstract

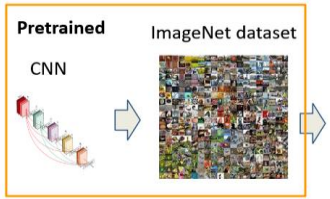
Hydrological streamline delineation is critical for effective environmental management, influencing agriculture sustainability, river dynamics, and watershed planning. This study develops a novel approach to combining transfer learning with convolutional neural networks that capitalize on ImageNet pre-trained models to improve the accuracy and transferability of streamline delineation. We evaluate the performance of eleven ImageNet pre-trained models and a baseline model using datasets from Rowan County, NC, and Covington River, VA in the USA. Our results demonstrate that when models are adapted to a new area, the fine-tuned ImageNet pre-trained model exhibits superior predictive accuracy, markedly higher than the models trained from scratch or those only fine-tuned on the same area. Moreover, the ImageNet model achieves better smoothness and connectivity between classified streamline channels. These findings underline the effectiveness of transfer learning in enhancing the delineation of hydrological streamlines across varied geographies, offering a scalable solution for accurate and efficient environmental modelling.

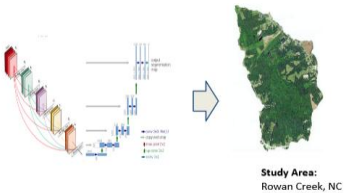


Study Area:
Rowan Creek, NC

Study Area:
Covington River, VA

Other U-net models
(ImageNet)

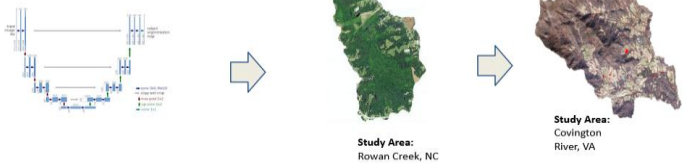




Study Area:
Rowan Creek, NC

Study Area:
Covington
River, VA

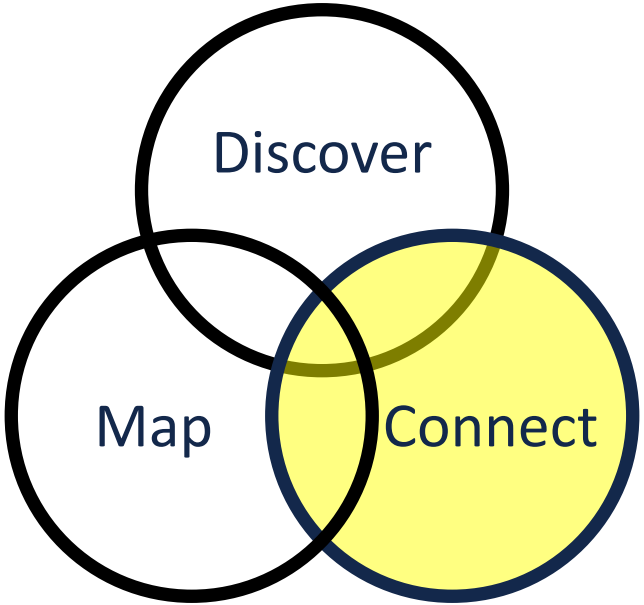
Attention U-net model



Study Area:
Rowan Creek, NC

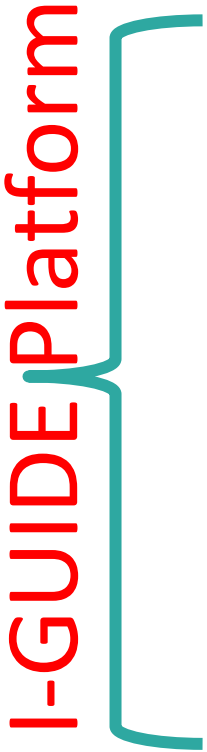
Study Area:
Covington
River, VA

I-GUIDE Platform



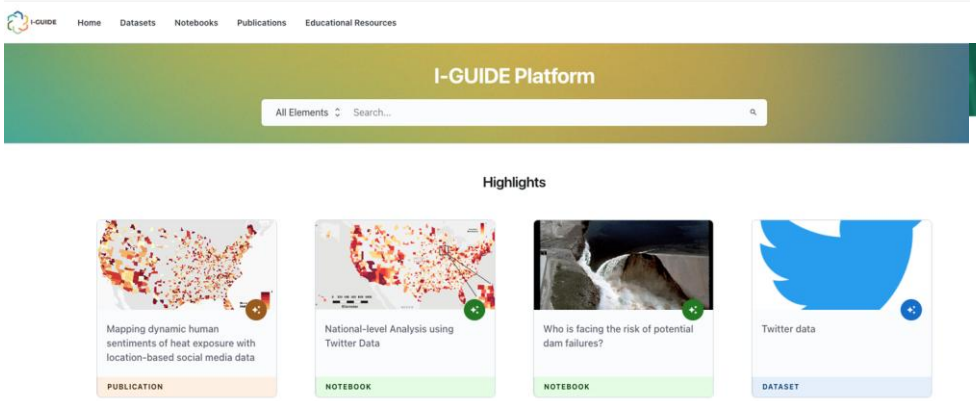
Connect

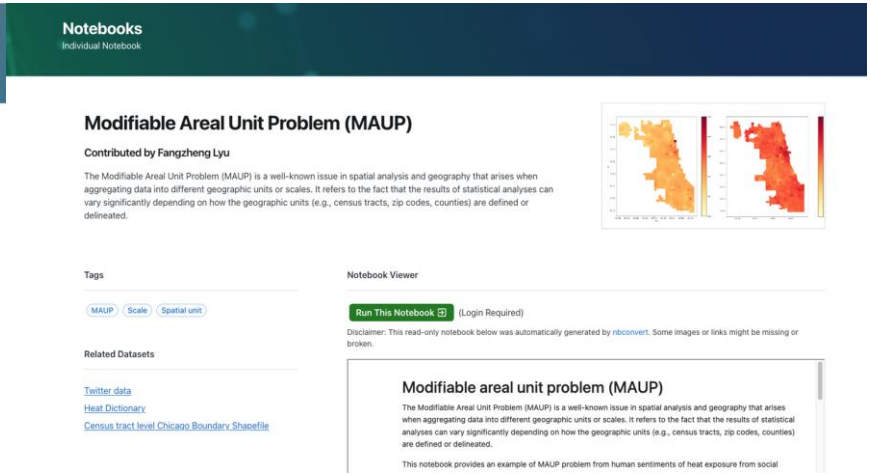
- Data
- Communities
- Domain knowledge
- Educational resources
- Partners



- Atmospheric science
- Computer science
- Data science
- Ecology
- Economics
- Environmental science and engineering
- Geographic information science
- Human-environment and geographical sciences
- Hydrology and water sciences
- Industrial engineering
- Information science
- Political science
- Sociology
- Statistics
- Etc.

Convergence Knowledge Sharing and Discovery





- Search and discovery across all knowledge elements
- Make connections and discover relationships between knowledge elements to enable convergence research and education
- Actionable knowledge elements
  - Launch Jupyter notebooks for data processing & analysis
  - Learn with linked educational materials

https://platform.i-guide.io

Community Engagement

I-GUIDE Virtual Poster Competition

Data-Intensive Convergence Science

FAIR Geospatial Data for Sustainability Research

I-GUIDE

Navigating Geospatial Data Science

Workshop for Mid-Career Geospatial Researchers and Instructors

April 4-5, 2024 · University of Minnesota · Minneapolis, MN

Save the Date

I-GUIDE FORUM 2024

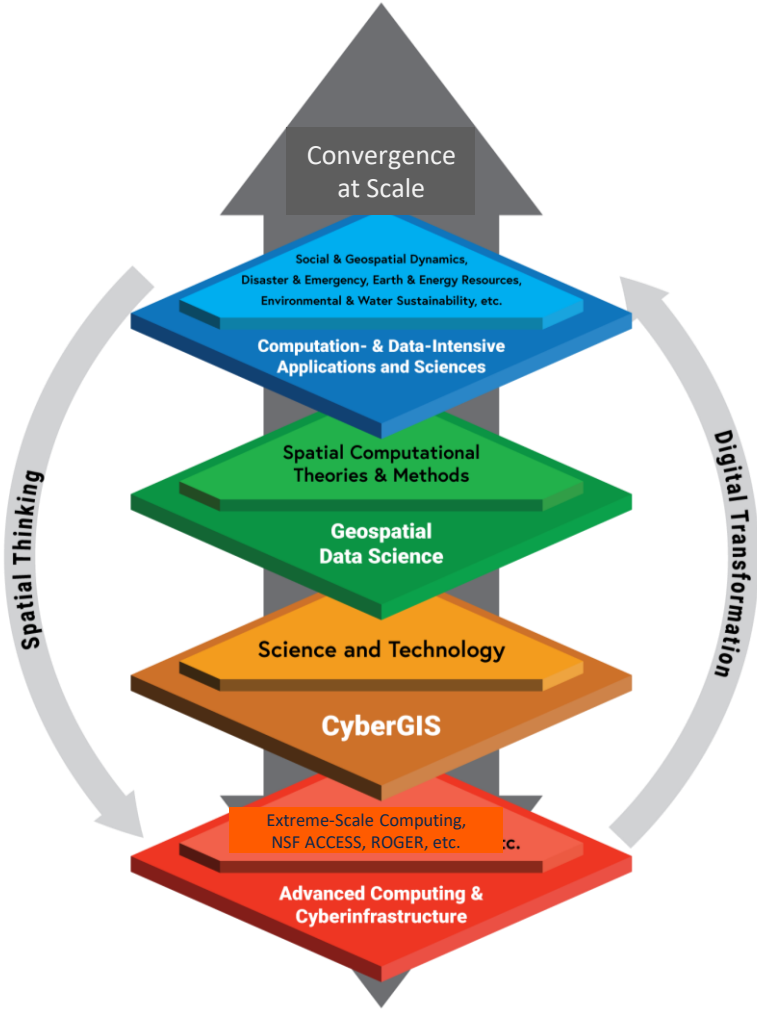
Convergence Science and Geospatial AI for Environmental Sustainability

October 14-16, 2024

Jackson, Wyoming

MAP | CONNECT | DISCOVER

AI for Sustainability



dm insights on location

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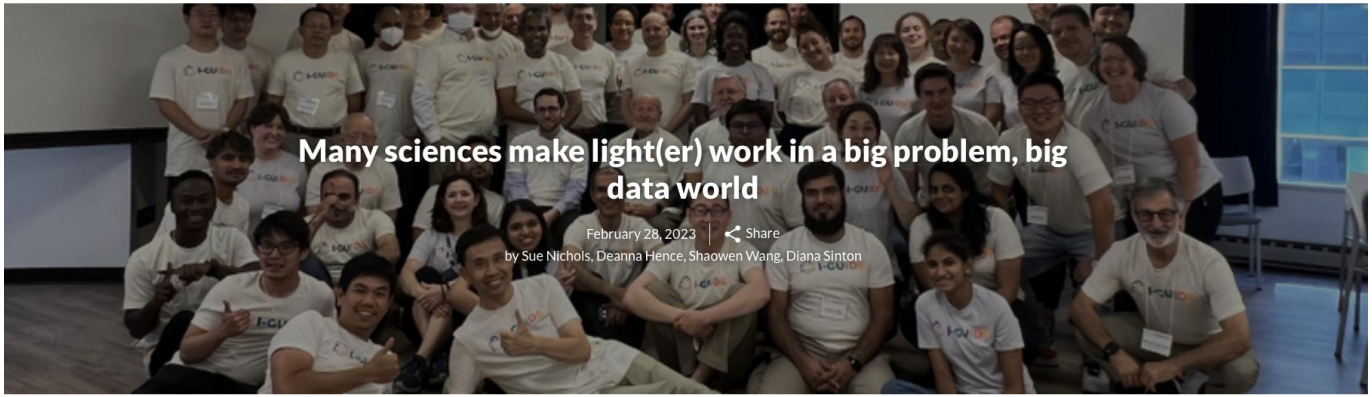

Many sciences make light(er) work in a big problem, big data world

February 28, 2023 | Share

by Sue Nichols, Deanna Hence, Shaowen Wang, Diana Sinton

It's raining cats and dogs when a hydrologist, a climatologist, a statistician, an economist, and a geospatial scientist walk into a bar. The bar is just down the road from a big old dam and they'd each glanced toward it when they'd pulled into the parking lot.

After a few weeks of steady rain, the whole dam area has been on everyone's mind. The hydrologist is thinking about the last time this dam overtopped. The climatologist and the statistician are debating how extreme this amount of precipitation would be considered and what may come in the future. The economist is remembering how disruptive flooding in this area is to the local businesses that export their goods to distant places, and the geospatial scientist is estimating the extensive numbers of vulnerable neighborhoods downriver.

https://www.directionsmag.com/article/12127

Thanks !

- **Comments / Questions?**
- **Contact: shaowen@illinois.edu**