

Operational data provenance for anticipatory disaster planning

Pleány talk: 2019 ESIP Winter Meeting 'Increasing the use and value of Earth science data and information'

Dr. Christina Bandaragoda, University of Washington

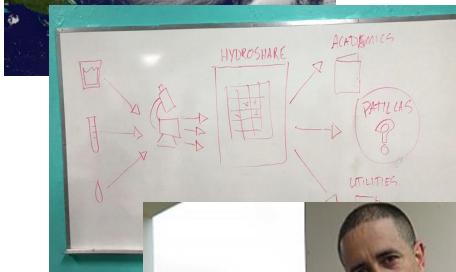
January 15, 2018 Bethesda MD

Proposed testable hypothesis

There are immediate short-term societal and public benefits when hurricane-impacted individuals and communities 'own' their drinking water data.



Increasing the value and usability of earth data



Case study: rural decentralized water quality data





Is this water safe to drink?

Leptospirosis and Superfund site water quality questions after Hurricane Maria in Puerto Rico (2017) highlighted the difficulties communication, availability and trustworthiness of data when a natural disaster hits and the power goes out.



Is this water safe to drink?

Do people have and use ***decentralized*** data?

Leptospirosis is expected to increase due to human encroachment into wildlife habitat, climate change and environmental shifts. Surveillance for leptospirosis is important for early detection of cases because early treatment is crucial to decrease morbidity and mortality (Guerra, 2013).

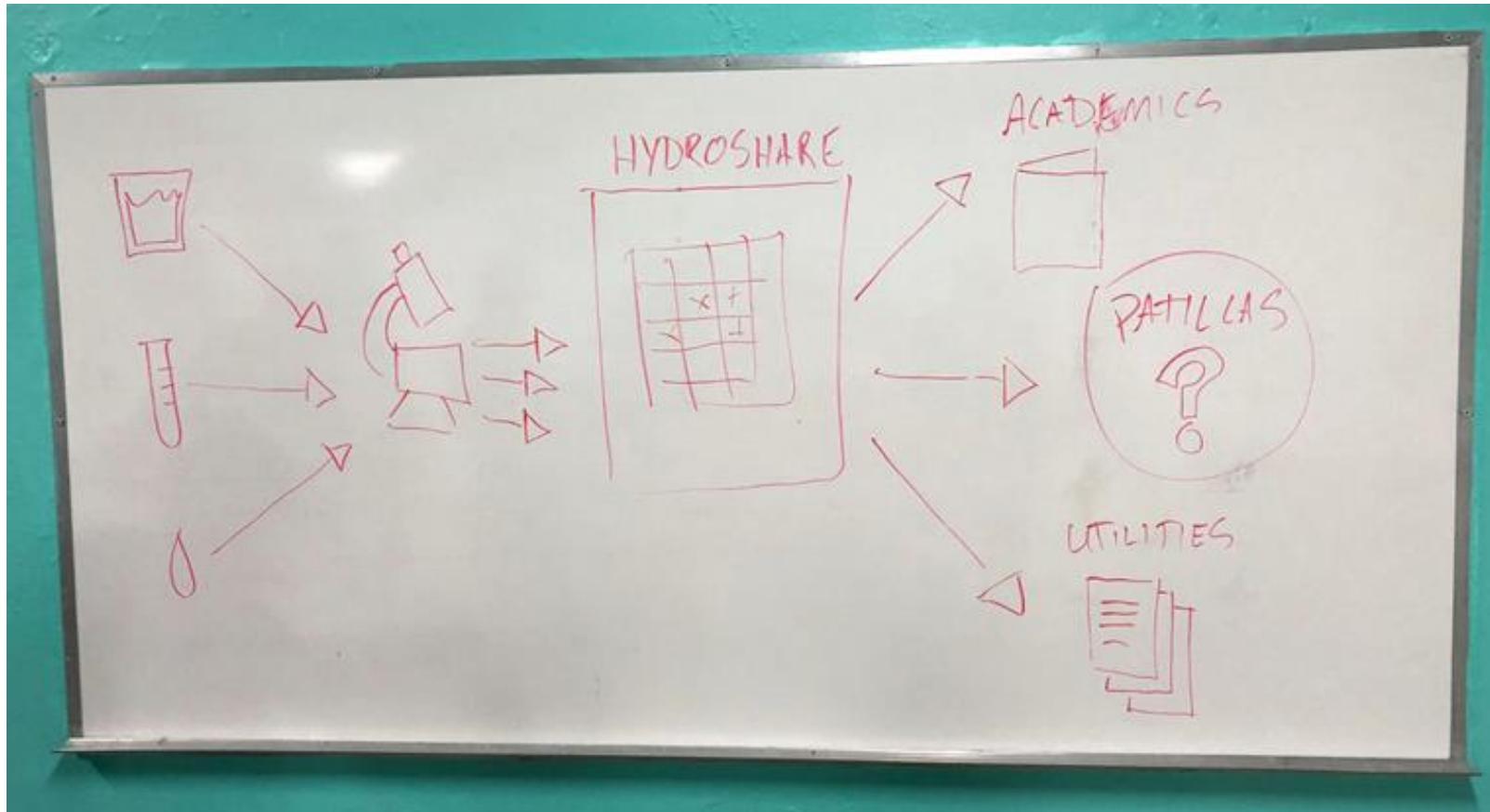


Is this water safe to drink?

Do people have and use **centralized** data?

Well water from a federally designated Superfund site in hurricane hit Puerto Rico meets federal drinking water standards and it fit for consumption [U.S. EPA & Virginia Tech; Sutter, 2017; Sutter and Lavandera, 2017].

Cyberinfrastructure to the Rescue?



Presentation Overview

1. Case study demonstrations: **Hydroshare + RAPID Almost like Maria**
2. Mesh network: informational systems to function with no central power grid: **ESIPlab project + Meshing with Data**
3. Awareness campaign: **Nuestra Agua & Waterhackweek**



Coming soon:

Cybertraining: **Waterhackweek & Custom products**
Organizational science and research: **water mesh**

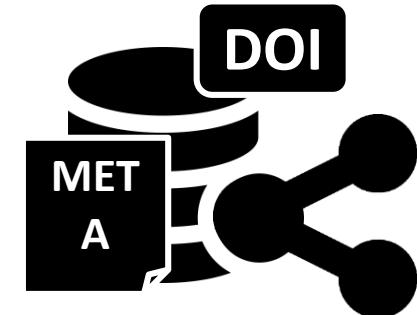




HYDROSHARE

Ideal Investigator Data Workflow

- Easily create a digital instance of a dataset or model
- Quickly share it with colleagues (perhaps privately at first)
- Add value through collaboration, annotation, and iteration
- Describe with metadata
- Efficiently...share publicly or formally Publish



This is still not as easy as it should be!

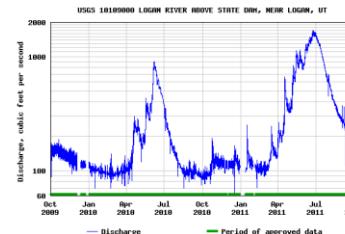
From Jeff Horsburgh



Motivation: Collaborative research

Advancing Hydrologic Understanding

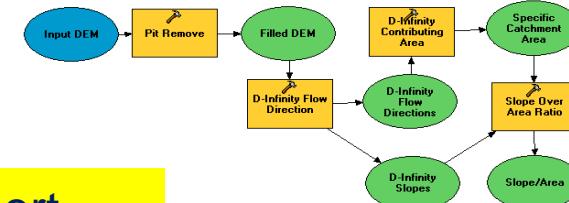
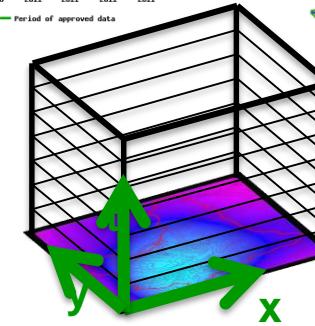
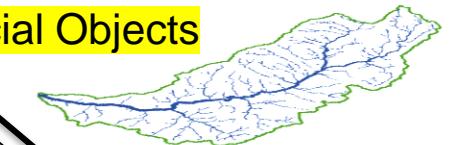
- requires integration of information from multiple sources
- using diverse types of data and models
- may be data and computationally intensive
- requires collaboration and working as a team/community



Resources

Data and models

Social Objects



Hydrologic Research is a team sport



HYDROSHARE

<http://www.hydroshare.org>

- Web-based Hydrologic Information System operated by the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI)
- Links to computational resources on JupyterHub server.
- Provides permanent publication of data and models with citable digital object identifiers that can link to literature
- Gateway for sharing research and models.

Findable Accessible Interoperable Reusable



The screenshot shows the HydroShare website interface. The top navigation bar includes links for MY RESOURCES, DISCOVER, COLLABORATE, APPS, HELP, and ABOUT. A user profile icon is in the top right. The main content area features a large image of a rainbow over a forested landscape. Below the image, the word "Discover" is centered, followed by the sub-instruction "Discover content shared by your colleagues and other users. Access a broad range of resource types used in hydrology." On the left, a sidebar titled "How it works" shows a step-by-step process: "Create data" (with a "1" icon), followed by a descriptive text about using the same methods as now, and a note that HydroShare supports a broad set of hydrologic data types. An icon of three overlapping circles with a plus sign is shown. To the right, a detailed resource page for "TW Daniels Experimental Forest (TWDEF) Lidar" is displayed. It includes sections for "Authors" (Michaela Teich, David G. Tarboton), "Resource type" (Generic), "Created" (Nov 17, 2016 at 9:11 p.m.), and "Last updated" (Dec 09, 2016 at midnight by Michaela Teich). The "Abstract" section describes the data collection, processing, and spatial distribution of snow depth. The "Subject" section lists categories like "TW Daniels Experimental Forest", "TWDEF", "Lidar", "DEM", and "Snow Depth". The "How to cite" section provides the citation information: "Teich, M., D. G. Tarboton (2016). TW Daniels Experimental Forest (TWDEF) Lidar, HydroShare, <http://dx.doi.org/10.4211/hs.36d3314971a547b8bc72dc60dd6b03c>". The bottom of the page indicates the data is shared under Creative Commons Attribution CC BY, with a link to <https://creativecommons.org/licenses/by/4.0/>.



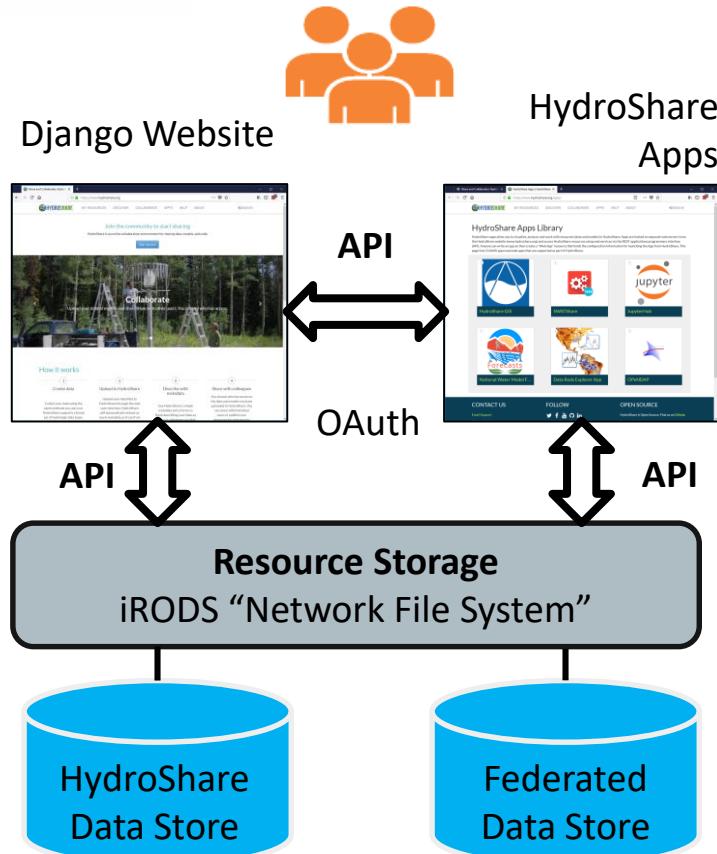
HYDROSHARE

Resource exploration

- Organize and annotate your content
- Manage access

Moving towards fully web based hydrologic innovation environment

Distributed file storage



Conceptual Architecture

Actions on Resources

- Web software to operate on content you have access to (Apps)
- Extensibility

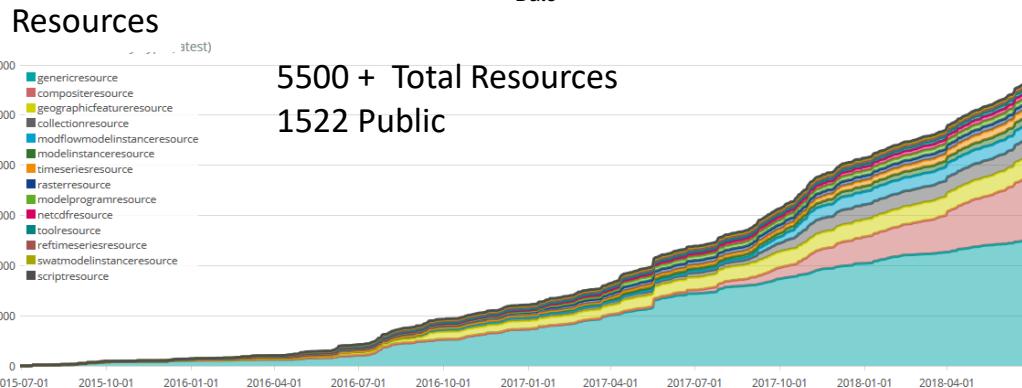
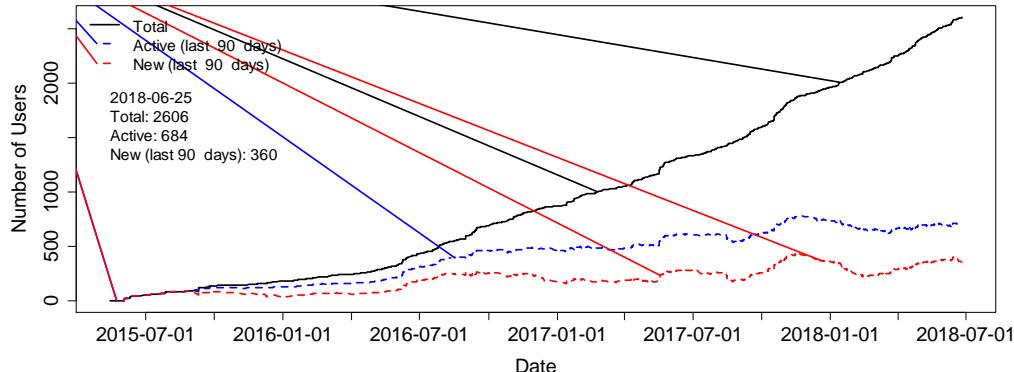
Anyone can set up a server/app platform (software service) to operate on HydroShare resources through iRODS and API

- SWATShare (Hubzero)
- JupyterHub
- Unidata – THREDDS
- NWM Viewer
- Tethys Apps



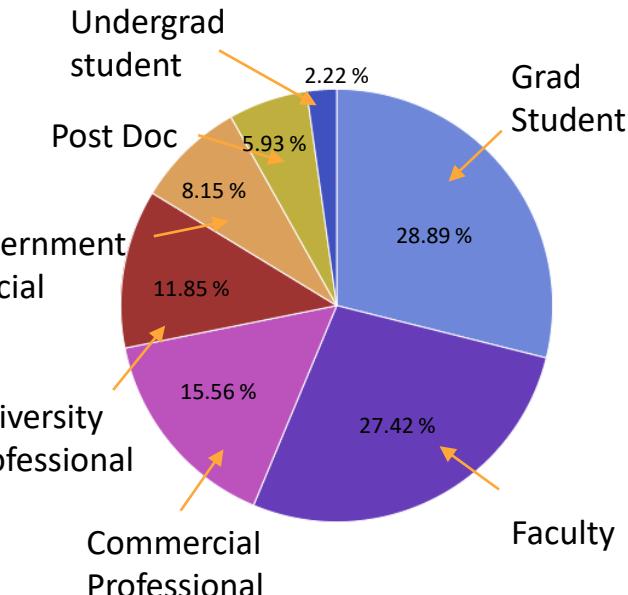
HYDROSHARE

Hydroshare Users as of 2018-06-25



Audience and User base

Primary audience is US Hydrologic Research community (NSF funding) but open to international use and use by water resource professionals, educators and citizen scientists



For users who have indicated type in their profile



HYDROSHARE

You invited Sara Lucero to join Puerto Rico Water Studies: Confidential
Oct. 25, 2018, 3:51 p.m.

[Cancel Request](#)

 Simón Mostafa invites you to join Operadores Acueductos Patillas
Nov. 1, 2018, 1:14 p.m.

[Accept](#)

[Decline](#)



Puerto Rico Water Studies: Confidential

 9 Members



Puerto Rico Water Studies

 20 Members



NUESTRA AGUA

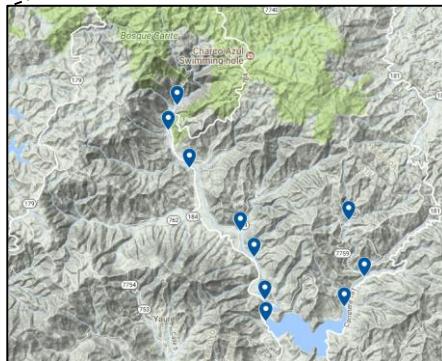
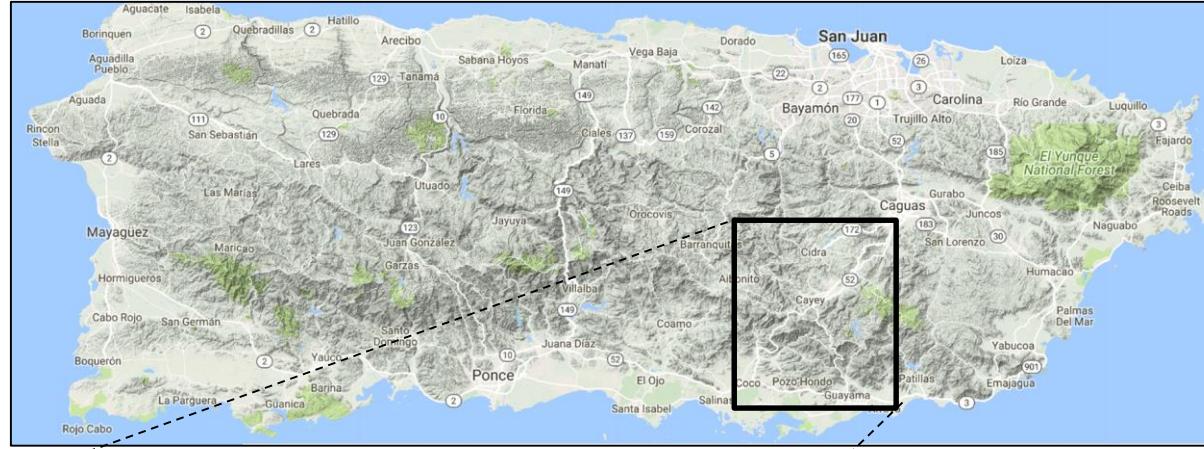
Vision

- Don't need your own software and platform to use
- Reduce installation, library and platform dependencies
- Data access and size, faster computation
- Re-use
- Reproducibility
- Transparency
- Trust
- Collaboration



NSF RAPID
RESEARCH

Case Study: Maria Archive



Public Data: Energy, Communications, Water operational, but with infrastructure challenges

Collaborative RAPID

BUILDING INFRASTRUCTURE TO PREVENT DISASTERS LIKE HURRICANE MARIA

PUBLIC ACCESS INFORMATION	OBJECTIVE 01 Water Quality Sampling Campaign	OBJECTIVE 02 Data Archive	OBJECTIVE 03 Cyberinfrastructure Advances	Expected Science Outcomes
	Drinking water samples from public streams	Baseline assessment: Population Health Data, Healthcare Providers and supporting organizations, natural system environmental variables, Public Water System location and Infrastructure status.	LANDLAB raster model grid and diverse data formats	
	Spatially aggregated anonymized information of the impact zone	Hurricane Maria health and environmental data from public data repositories and Luquillo CZO instruments in El Yunque National Park	Observation Data Model (ODM2)	DISASTER: Contamination, drought, landslides, bio-diversity DRINKING WATER: Geographic location and use data

Private Sensitive Data: Energy, Communications, Water operational, but with infrastructure challenges

Collaborative RAPID

BUILDING INFRASTRUCTURE TO PREVENT DISASTERS LIKE HURRICANE MARIA

OBJECTIVE 01 Water Quality Sampling Campaign	OBJECTIVE 02 Data Archive	OBJECTIVE 03 Cyberinfrastructure Advances	Expected Science Outcomes
PRASA Utility, community operated tank system, household data	Water samples with personal information	Population health researcher user-testing	HUMAN IMPACT: Spatial distribution of contamination or drought
Teacher collection of student health data (IRB)	De-identified water samples that can be geo-located	Water quality professionals and researchers user testing	
		Individual data owners user testing	

PRIVACY PROTECTED INFORMATION



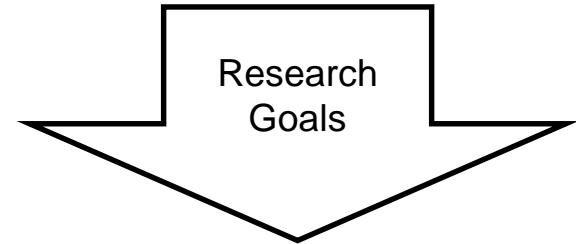
NSF RAPID
RESEARCH

Case Study: Maria Archive

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PRIVACY PROTECTED INFORMATION	PRASA Utility, community operated tank system, household data Teacher collection of student health data (IRB)	Water samples with personal information De-identified water samples that can be geo-located	Population health researcher user-testing Water quality professionals and researchers user testing Individual data owners user testing	DISASTER: Contamination, drought, landslides, bio-diversity DRINKING WATER: Geographic location and use data HUMAN IMPACT: Spatial distribution of contamination or drought.



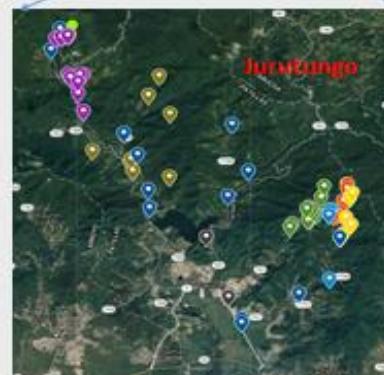
1. Archive Hurricane Maria data
2. Extend hydro-data model (ODM2) for genomic data
3. Design system to quantify disaster impacts to health with a spatial distribution of contamination



NSF RAPID
RESEARCH

Virginia Tech + InterAmerican University of Puerto Rico dataset: Experts on RAPID drinking water campaigns, post-disaster sampling and laboratory analysis

Water Quality
Sampling in
Patillas Region
of Puerto Rico



6 Small Drinking Water Systems
1 Drinking WTP + Distribution System

3 Surface Water Branches
1 Wastewater Treatment Plant

Sample data and map labels replaced by Jurutungo (slang for 'a far away place') to protect privacy.



NSF RAPID
RESEARCH

Virginia Tech + InterAmerican University of Puerto Rico Data Collection



Example System data: AP1TK2 (yellow points)

- Same source as AP1TK1
- Were using a solar powered bio-sand filter, but Maria took it offline and they had to repair some of the PVC lines themselves
- Dammed the stream with concrete upstream and then gravity fed via PVC to a chlorination tank and distributed
- There's still a question as to which watershed this falls into.



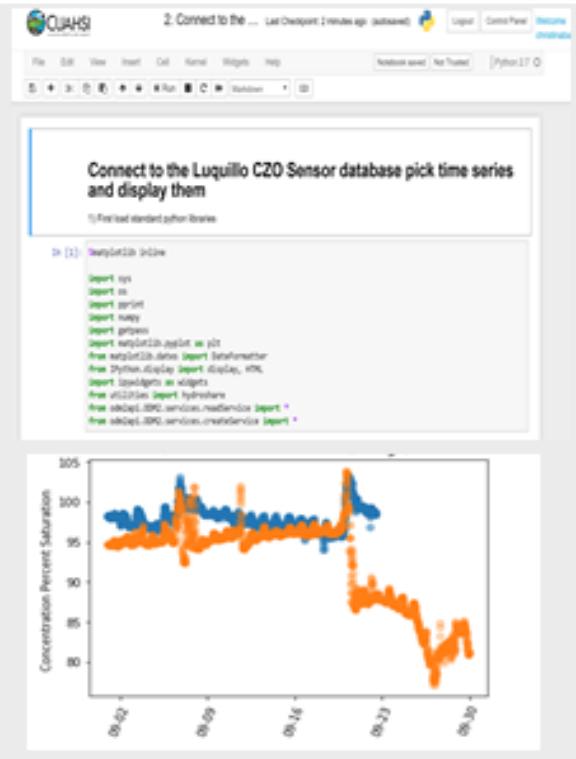


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Luquillo Critical Zone Observatory

Luquillo Critical Zone Observatory Data Archive & Visualization

Download data
Run Python code
Use Jupyter Notebooks
To analyze data –
e.g. dissolved oxygen drop in Luquillo CZO stream after Hurricane Maria



From Miguel Leon



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University of Washington + InterAmerican
University of Puerto Rico + UC Boulder +
Virginia Tech + Stakeholder Meetings

Participatory Design Workshops [Activity User Groups]

Card
sorting
data
priorities



Utility (PRASA)

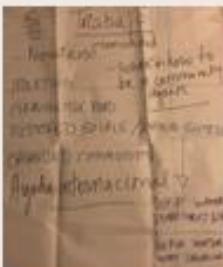


Government



Academic – health
researchers

Working/
Not
working



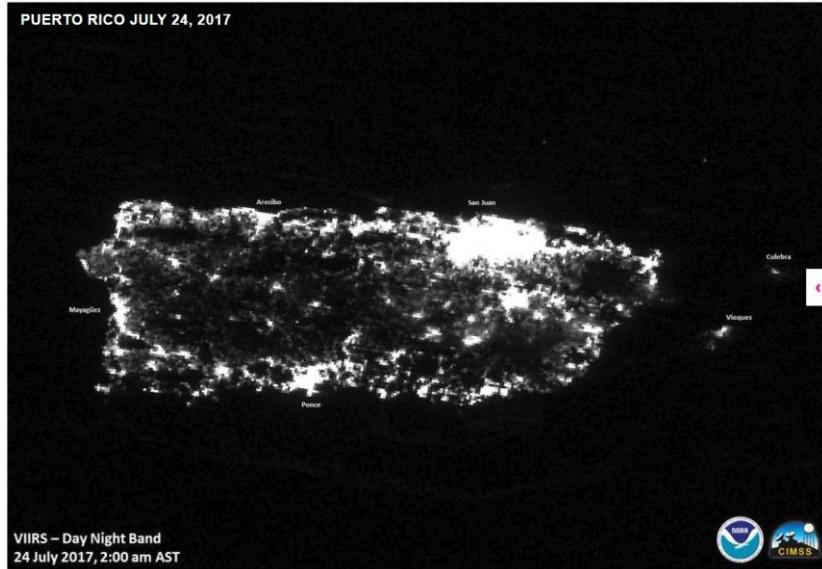
Community (non-PRASA water system)





NSF RAPID
RESEARCH

Nightlights in Puerto Rico July 2017



five days after Hurricane Maria





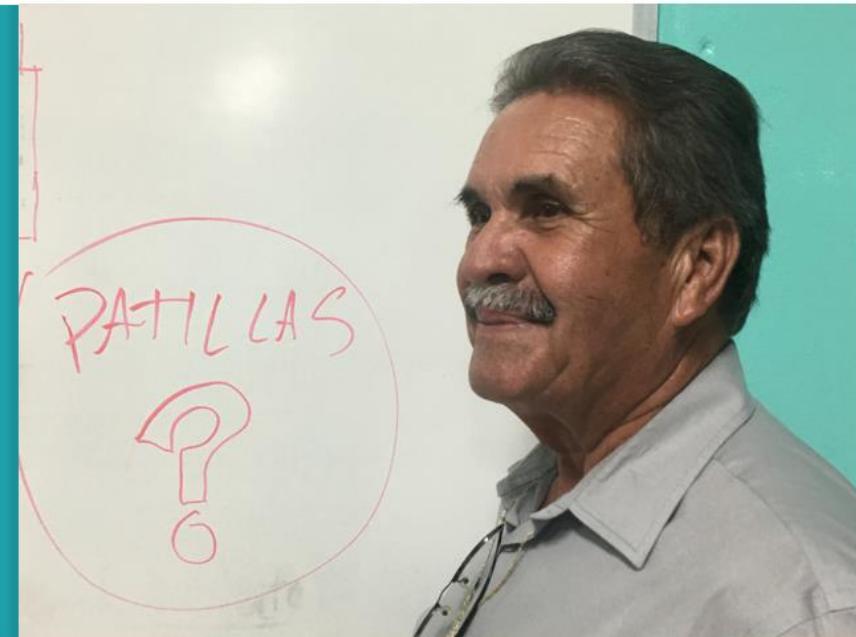
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RESEARCH

Power OFF: No Energy, No Communication, No Water.

“What works after a hurricane? ? ?

Our community.
Teach us
how to use our data.”

– Porfirio Fraticelli. Patillas Community Water System Operator.
NEW HYDROSHARE USER





NSF RAPID
RESEARCH

How can everyone “own” the data?





NSF RAPID
RESEARCH

Four (unexpected) Requirements:

1. Private risk reduction products for individuals
2. Anonymized public decision-making products
3. Trusted data quality control process and communication
4. Trusted organizational management



water mesh
clean water for everyone

Operational data provenance and cybersecurity for anticipatory disaster communication built on mesh networks

Project lead and contact details: Christina Bandaragoda, University of Washington; cband@uw.edu

Project partners and contact details: Graciela Ramirez-Toro, Interamerican University of Puerto Rico; Patricia Ordóñez, University of Puerto Rico Rio Piedras; Tim Sauder, Olin College

Partners on related projects: Fernando Rosario-Ortiz, University of Colorado Boulder; Amy Pruden, Virginia Tech

Student lead: Jimmy Phuong



Social network software disaster preparedness	Online earth data repository drinking water quality data
Decentralized communication hardware mesh network	Organizational institutions water utilities and households (formal and informal)

Four components, one case study

Social Network Platform



The image shows the Ushahidi logo at the top left, featuring a yellow globe icon and the word "Ushahidi" in white. Below the logo is a screenshot of a mobile application interface. The app displays a list of event reports, such as "Overrunning between 5th St. & Taylor Ave", "March begins at Tower Square, 1000 people in attendance", and "Overrunning reported; police requested more officers". Arrows from the text "Collect meaningful data" point to the icons for email, mobile phone, Twitter, and computer, which are positioned next to the app's interface.

Collect meaningful data

Gather data from any device with custom surveys and crowdsourcing tools

social enterprise that provides software and services to numerous sectors and civil society to help improve the bottom up flow of information.

Available	Requirements
YES	Private data information for individuals
YES	Anonymized public products
YES	Trusted communication & quality control process
YES	Trusted organizational management

Online Data Repository Platform



online, collaborative system for sharing and publishing a broad set of hydrologic data types, models, and code. It enables people to collaborate seamlessly in a high performance computing environment, thereby enhancing research, education, and application of hydrologic knowledge.

Available	Requirements
YES	Private data information for individuals
YES	Anonymized public products
TBD	Trusted communication & quality control process
TBD	Trusted organizational management

Decentralized Communications Network



A **mesh network** is infrastructure nodes (i.e. bridges, switches and other infrastructure devices) connect directly, dynamically and non-hierarchically to as many other nodes as possible and cooperate with one another to efficiently route data from/to clients.

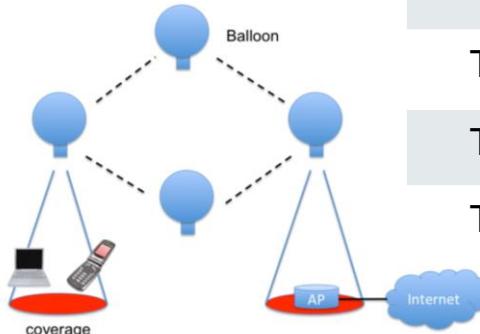


Figure 1. Shibata et al. balloon networking for disasters

Available	Requirements
TBD	Private data information for individuals
TBD	Anonymized public products
TBD	Trusted communication & quality control process
TBD	Trusted organizational management

Organizational Network

Institutions and Individual Consumers



NUESTRA AGUA



Available	Requirements
YES	Private data information for individuals
NO	Anonymized public products
TBD	Trusted communication & quality control process
TBD	Trusted organizational management

Community water systems in Puerto Rico (~240) are volunteers or part-time employees, as with public water utility districts, are committed to comply with Safe Drinking Water Act water quality and public communications standards.



 SIP Lab Project

43-hour hackathon June, 2018

worked to develop a minimum viable product that might serve as a solution to communications problems following natural disasters

user becomes a data purchaser or provider

Anybody Out There?

Worse case
disaster:
Utuado Bridge



→ “I need an ambulance. I am pregnant, my water broke. The road has collapsed. I can't move my car! Please help!” - 109 characters



ESIP Lab Project

Social network software



Ad-hoc wireless mesh networking for the zombie apocalypse.

Online earth data repository

text chat + emoji design

Decentralized communication hardware

Raspberry pi + cell phone
bluetooth

Organizational institutions

Utuado Bridge Scenario

Adept Relay: **Mesh Network App for Communications During Natural Disasters**
Team: Nicole Villa Juan Ramos Jimmy Phuong Julio Valdez

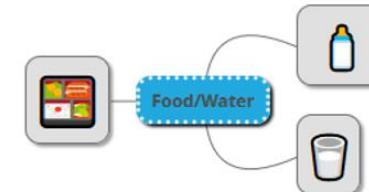
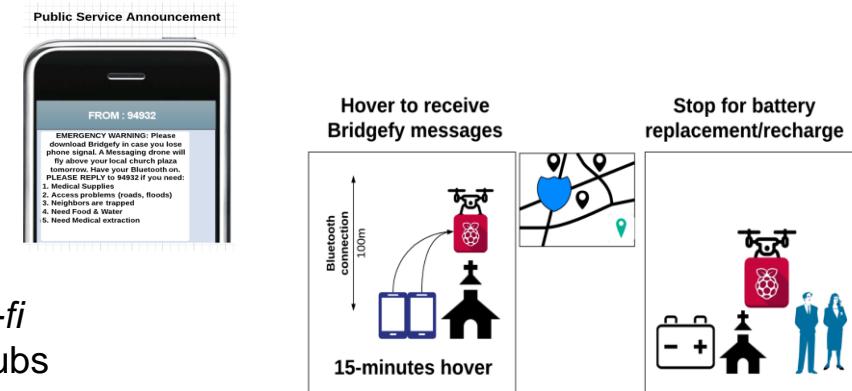


How to Couple Communication & Data Collection: During & After Disasters?

- use drones to establish a mesh communication network over a large region.
- use emojis as visual codes to simplify messages and reduce bandwidth
- unfinished end product used a open-source mesh network software called Byzantium.

The AdeptRelay Way (*One Proposed Solution*)

- Government sends out PSA to download the app
- PSA Alerts are targeted for high e.g: weather, resources, medical, etc.
- Drones equipped with raspberry pi (*bluetooth / wi-fi connection*) fly over pre-determined community hubs (churches)
- Emojis (8bits) ease burden on memory constraints





Communication Drives Data Collections → Which Directly Affects Rapid Action

Real time data-collection serves three purposes.

1. Community members immediately know other members' high priority needs
2. Archive time-sensitive data that can fuel machine learning
3. World community knows how to strategically assist vulnerable households

THE TWO FIGURES COMBINED TO CREATE LOGO
ARE REPRESENTATIVE OF THE NEED FOR COMMUNITY
INVOLVEMENT IN THE WATER SYSTEM

ABSTRACT DEPICTION
OF PEOPLE ALLOWS FOR
BOTH MALE AND FEMALE
VIEWERS TO SEE THEMSELVES
AS Viable VOLUNTEERS



GLASS SHAPE REINFORCES
THE WATER SYSTEM'S DELIVERY
OF SAFE POTABLE WATER
TO THE COMMUNITY

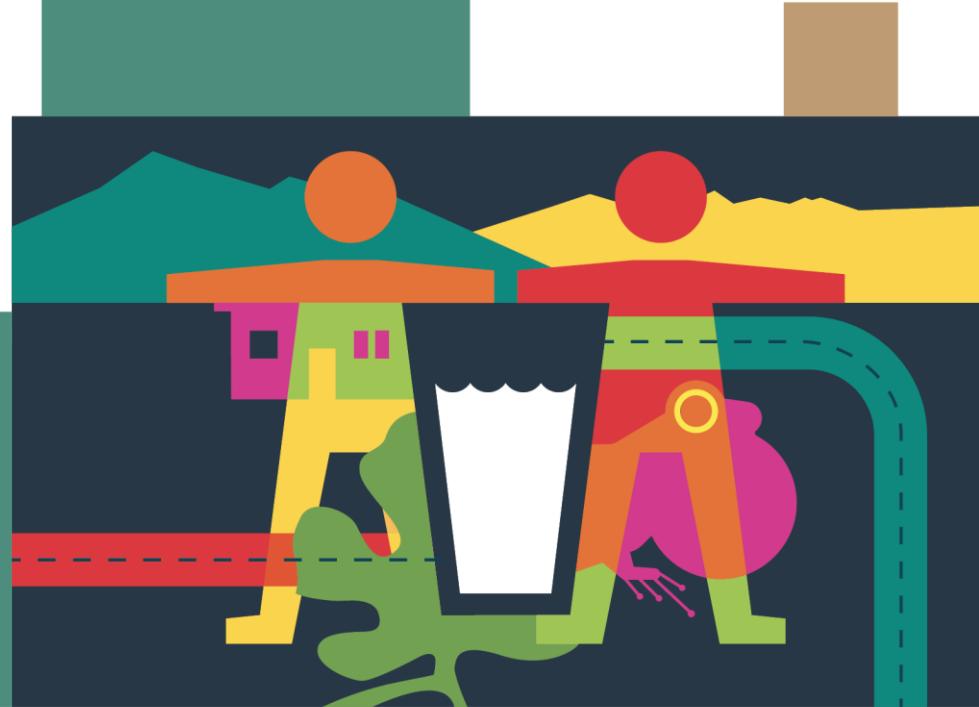
NUESTRA AGUA JURUNTUNGO

“OUR WATER” NAME
REITERATES THE COMMUNITIES
OWNERSHIP OF THEIR OWN
WATER SOURCE

SUBTITLE ALLOWS FOR SPECIFICATION
OF SPECIFIC NEIGHBORHOOD/TOWN



Data provenance on
cyberinfrastructure is hard to
visualize –
unless you paint a mural!





NUESTRA AGUA

SIP Lab Project

Lessons learned and outcomes from initial Awareness Campaign



We own the data.





Lessons learned from Cybertraining

Training the trainers works – first Hydroshare user instruction in Spanish was generated by users after receiving two one-hour demo sessions.





NUESTRA AGUA

Lessons learned from Cybertraining

Needs:
Customizable
reporting

From: Commanding Officer, Joint Base Anacostia-Bolling
To: Commanders/Directors of Tenant Organizations

Subj: 2017 ANNUAL DRINKING WATER QUALITY REPORT

Encl: (1) 2017 Annual Drinking Water Quality Report for Joint Base Anacostia-Bolling (JBAB)

1. In accordance with federal drinking water regulations, JBAB is providing you with the 2017 Annual Drinking Water Quality Report for Public Water System ID DC0000004, enclosure (1).
2. This routine report is required by law, and is being provided to ensure that you have all of the information regarding the quality of your drinking water. This is not being sent in response to a health threat.
3. The 2017 Annual Drinking Water Quality Report for JBAB, enclosure (1), provides information regarding drinking water monitoring conducted throughout calendar year (CY) 2017.
4. If you have any questions regarding the quality of your drinking water, contact the JBAB Drinking Water Program Manager at 202-404-1273.

Water quality vulnerabilities after hurricane & flooding natural disasters

Microbial Indicators							
	Units	EPA Limits		JBAB-Anacostia Drinking Water		Violations	Description/Typical Sources of Contaminants
		MCLG	MCL or TT	Highest	Range		
Total Coliform Bacteria	# of positive samples	0	1 positive sample/month	2*	0-2	No	Naturally present in the environment
E. coli Bacteria	Number Positive	0	0	0	0-0	No	Human and animal fecal waste

*The positive hit was resampled at the original location, upstream, and downstream. Some resample results came back positive for TC. For a system that collects fewer than 40 samples/month, if two or more samples during the month are positive, the system has a MCL violation for total coliform.

Water quality vulnerabilities after ‘cumulative economic disaster’

Lead and Copper							
	Units	EPA Limits		JBAB-Anacostia Drinking Water		Violations	Description/Typical Sources of Contaminants
		MCLG	Action Level (AL)	Samples Above AL	Range and 90th Percentile		
Lead-Monitoring Period June to Sept 2015	ppb	0	15	0	ND to 6.6 90th percentile is 1.4	No	Corrosion of household plumbing systems; erosion of natural deposits
Copper-Monitoring period June to Sept 2015	ppm	1.3	1.3	0	0.0088 to 0.46 90th percentile is 0.34	No	Corrosion of household plumbing systems; erosion of natural deposits

Lead and Copper results are from June to September 2015 monitoring period, which is the most recent sampling completed in accordance with Federal regulations. The next required sampling will occur in 2018.

Next steps: Waterhackweek

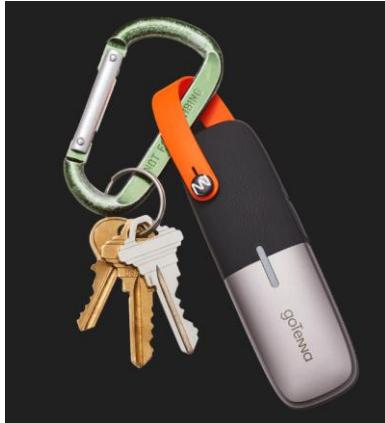
WATERHACKWEEK 2019

WORKSHOP ON WATER DATA SCIENCE
UNIVERSITY OF WASHINGTON ESCIENCE INSTITUTE
MARCH 25-29, 2019

mesh options: goTenna & txtTenna

Strengths

Without relying on cell service or an internet connection, goTenna Mesh generates a signal that connects with other units within range, effectively creating a people-powered, decentralized mesh network.



Possible Limitations (2019)

Cost of 8 goTenna: \$579
Water bill for one month: \$8

Android App
Broadcasts signed Bitcoin transactions
From Samourai Wallet

WATERHACKWEEK

 **SIP** Lab Project

imeshyou gotenna Map for Puerto Rico

January 15, 2019



WATERHACKWEEK

 SIP Lab Project



Social network software



Online earth data repository



Decentralized communication
hardware



TBD – white
space router?

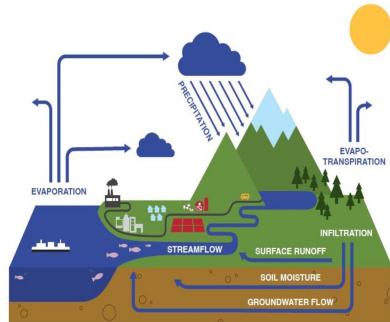
Organizational institutions



Four components, one case study

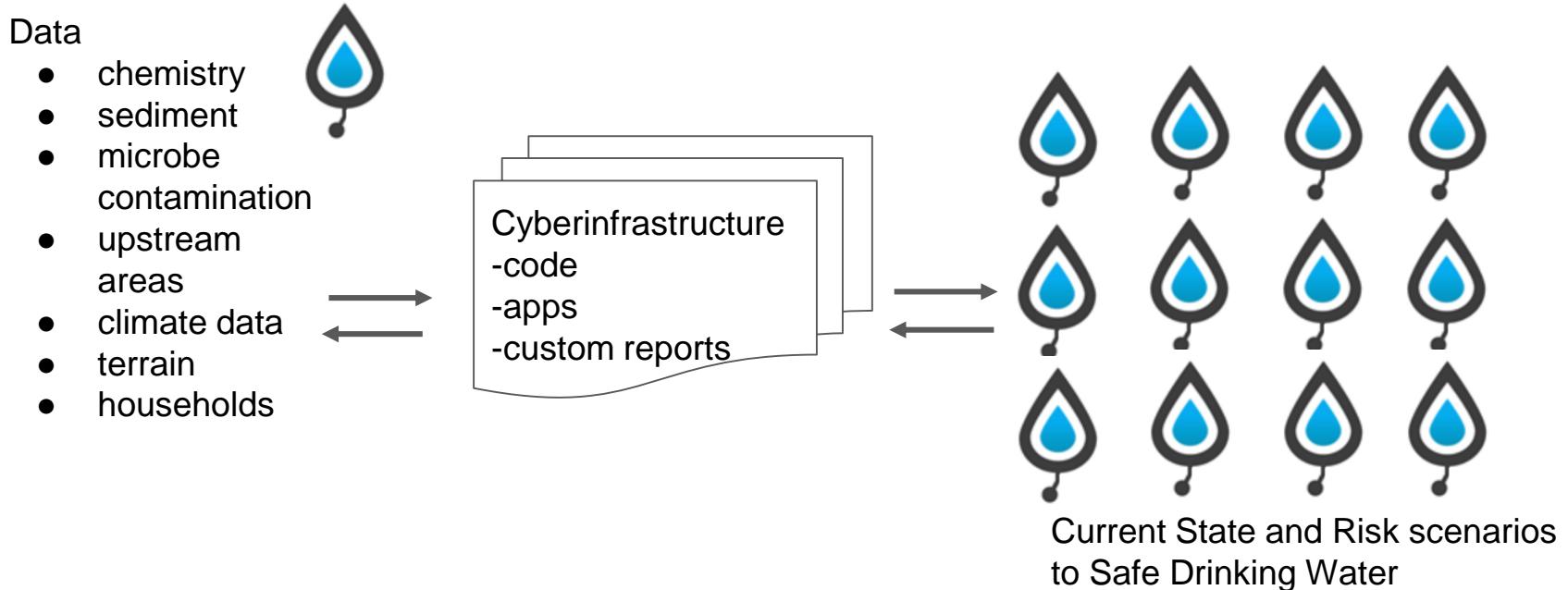


Steps for operationalizing data provenance from the household to public scales



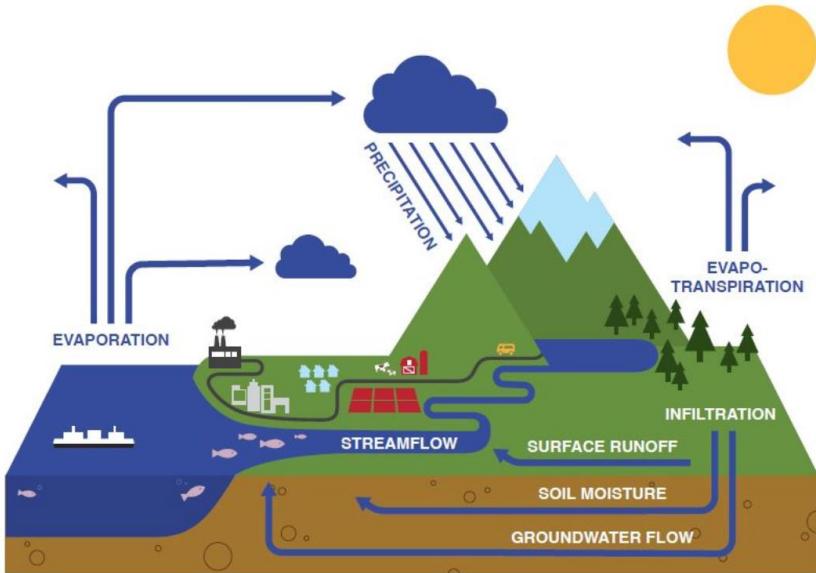
water mesh

online infrastructure for real-world health impacts



water mesh

online infrastructure model



1. private data asset
2. community repository
3. software tools
4. compute resources
5. risk management product
6. public benefit

water mesh

Case Study 1

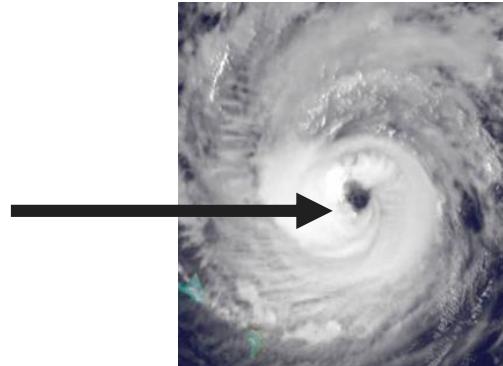
vulnerable drinking water



1. Drinking water samples ‘owned’ by stakeholders & shared with advocates (QC, legal, health).
2. HydroShare Groups
3. Landlab Toolkit
4. CUAHSI JupyterHub
5. Drinking water report with source area geo-risk and hurricane risk synthesis.
6. Rural water systems and public utilities enabled to anticipate hurricane risk and comply with Safe Drinking Water Act.

Hypothesis: There are long-term societal and public benefits when individuals and communities ‘own’ their earth data.

Data provenance is the eye of the storm in a hurricane of data.



Collaborators



Christina Bandaragoda, University of Washington
Graciela Ramirez-Toro, Inter American University of Puerto Rico
Tim Ferguson-Sauder, Olin College
Miguel Leon, University of Pennsylvania
Jim Phuong, University of Washington
Kelsey Pieper, Virginia Tech
William Rhoads, Virginia Tech
Jeffery Horsburgh, Utah State University
Jerad Bales, Consortium of Universities for the Advancement of Hydrological Science
Sean Mooney, University of Washington
Martin Seul, Consortium of Universities for the Advancement of Hydrological Science
Kari Stephens, University of Washington
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HydroShare is operated by CUAHSI with ongoing development through a collaborative project among Utah State University, Brigham Young University, CyberGIS Center University of Illinois, Tufts, University of Virginia, and RENCI University of North Carolina.



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<http://www.hydroshare.org>



Converging Projects

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