Data-Driven Observations for Water Resource Management

Dan Crichton, Steve Chien, Cedric David, James Mason, Safat Sikder, Ben Smith

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The study will identify driving science and applied science (natural hazard) use cases that illustrate NOS concepts, focusing in particular on Hydrology science challenge use cases from the Western States Water Mission (WSWM). The study will identify relevant observing assets, models, and datasets that could be included in the testbed to support these use cases.
Integrated Data-Driven Vision

- Onboard Intelligence
- Uplink/Downlink Planning
- Processing on the Cloud
- Ground Station as a Service

Science Data Archives → Science Modeling → Analytics and Visualization → Understanding and Decision Support

Reduce Latency  Provide Traceability  Increase Efficiency
WSWM at JPL: Realizing a Long-Term Vision

1. Observations

2. Coupled and Validated Computer Models

3. Estimates with Uncertainties

4. Stakeholders and Customers

- Colorado River Basin
- [Prospective customers]

(Colorado River Basin)

- e.g., CA Total Usable Freshwater (million acre-feet)
- 1 year
- 1 month
- 1 season
- (Notional)

Lead Time

- 1 week
- 20
- 30
- 40

Water Cycle

- Precipitation
- Evaporation
- Runoff
- Groundwater
- Human Use

- [Environmental, Natural, Human, Water Resources]

- U.S. Department of the Interior
- Bureau of Reclamation
River Routing Models conserve mass.
**Value of Assimilation**

**Observations add accuracy to model, but model also adds information to observations**

This drives data science challenges: scalability, fusion, uncertainty, etc.
A NOS Scenario: Observe Peak River Flow Events

**Science Goal:** Observe river Peak Flow events.
- Radar for surface water height and extent
- Visual for surface water extent
- In situ for stream flow
- UAVs, airborne, etc. if available

**Challenge:** Peak events are short, and often occur between repeat passes.

**Approach:** Retask based on model predicts.
- Use existing models to predict peak flow
- Retask one or more assets to observe.
- Select from assets that will be in position during event.
- Predict allows pre-positioning UAVs, airborne.

Max flow under-observed; higher uncertainty.
NOS Observations of Peak River Flow

Assimilate:
New observations improve model

Flood Forecast

Task available assets to observe predicted event

Radar Altimetry
Surface water height

Visual
Surface water extent

Altimeter Interfrometer Radiometer

Sentinel-3

Dove Cubesats

SWOT

CYGNSS cubesats

NWW forecast from RFC
Reservoir release
Forcing File

Atmospheric Forcing
MM5/ARW

WRF-Hydro Runoff
Noah-MP LSM

Surface/subsurface Runoff per catchment
Runoff File

Connectivity, Muskingum parameters
Static Files

NFIE-Hydro NFIDPlus catchments and flowlines

Simulated streamflow for each NFIDPlus river reach

AIST & ESIP
New Observing Strategies (NOS)
Computer forecasts of river flow increasingly being produced at continental/global scales using NASA’s RAPID

Purple points show current NWS FF locations
Blue lines show the potential extent of FF using this framework, which includes the flow routing using RAPID

Global-Scale Flood Forecasting

- Accuracies indicate the ERA-RAPID produced similar forecast as operational GloFAS
- Resolution of ERA-RAPID in much higher than GloFAS, allows the regional FF

Nationwide Flood Forecasting

- Previously Snow et al. (2016) used the ECMWF reanalysis and forecast ensembles to forecast flood using the RAPID model.
- Available through Tethys of BYU

Comparison of Global-Scale FF using ECMWF/ERA-RAPID and Operational GloFAS (Qiao et al., 2019)
A Preliminary Global-Scale Flood Alert methodology was developed using the same modeling approach

Global-Scale 10-Years (2000-2009) Retrospective Flow for Large River Systems:
- Flow at 2.94 million river reaches (MERIT River Network; Lin et al., 2019) were simulated using RAPID model
- GLDASv2.1 LSM runoff data were used as the input (publicly available)
- The largest 123,583 river reaches were selected (in red) based on long term mean discharge (i.e., where \(Q_{\text{mean}} \geq 100 \text{ m}^3/\text{sec}\))

Flow Exceeding 90th Percentile:
- Number of days when flow exceeds the 90th percentile at any one 6-hourly time step: shows some characteristics of flooding patterns globally
- Near tropic and arctic, 90th percentile exceedance of flow is spread over numerous days indicating “flashier” flood events, while mid latitudes floods are of longer duration
- This 90th percentile flow approach can be used to generate “triggers” for flood alerts globally using existing forecasting systems
References


Thank You!
future goal: assimilation of SWOT data when SWOT launches to fill in space/time blanks

Challenge: data assimilation methods need a way to relate errors in observed variables to errors in the corrected variables
RAPID Model

• Generated various datasets in Western United States and worldwide
  • 700K rivers (20 years, 3 hours daily)
  • 3M rivers (~3 years e hours daily)

• Developed by Cedric David

• We are using this data to support some proposed development with Steve Chien’s task.
Sources of errors in river discharge

- Input error (runoff)
- Model structural error (flow wave equation)
- Parameter error (e.g. propagation time)

Considerations Involved in Evaluating Mathematical Modeling of Urban Hydrologic Systems

By DAVID R. DAWDY

HYDROLOGIC EFFECTS OF URBAN GROWTH

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1591-D

Dawdy (1969)

A healthy literature exist on river discharge error, surprisingly relatively little exists on the impact of runoff error on discharge error, such knowledge is needed to assimilate discharge into runoff.

Runoff is uncertain (from D. Lettenmaier)

Geophysical Research Letters

Analytical Propagation of Runoff Uncertainty Into Discharge Uncertainty Through a Large River Network

Credit: Cedric David