Data-Driven Observations for Water Resource Management

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Project Objective

- 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

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New Observing Strategies (NOS)

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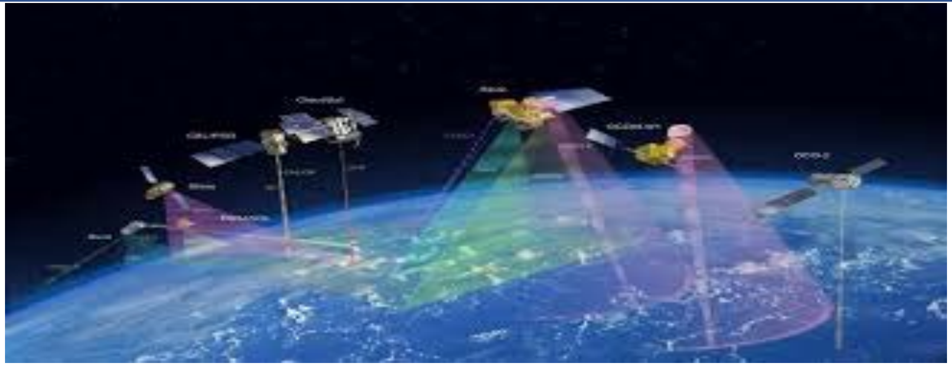
Constellations



Onboard Intelligence

Uplink/Downlink

Ground Station as a Service
On the Cloud

Processing

Planning

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

Reduce Latency *Provide Traceability* *Increase Efficiency*

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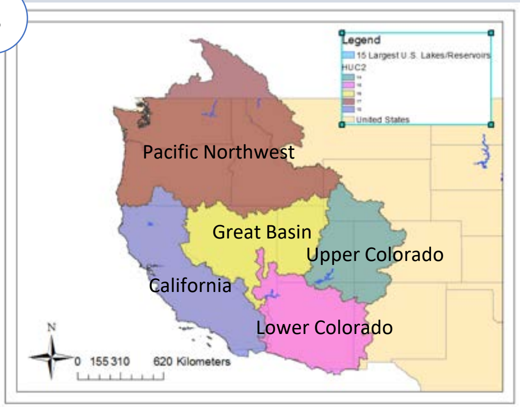
WSWM at JPL: Realizing a Long-Term Vision

1

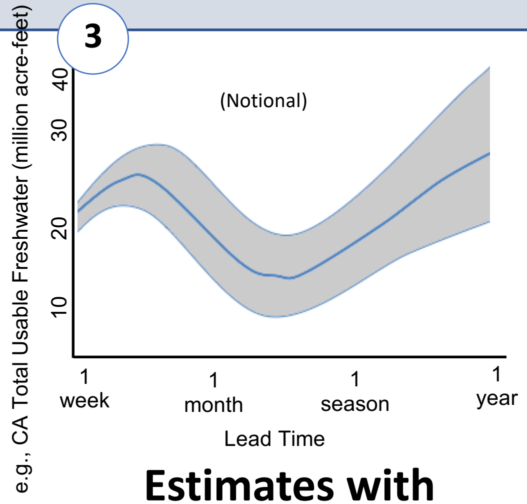
Observations

2

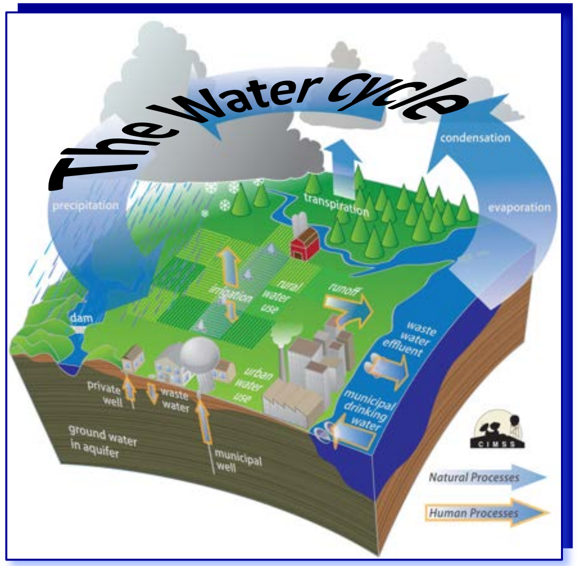


Coupled and Validated Computer Models

3



Estimates with Uncertainties



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DEPARTMENT OF WATER RESOURCES

western states water council

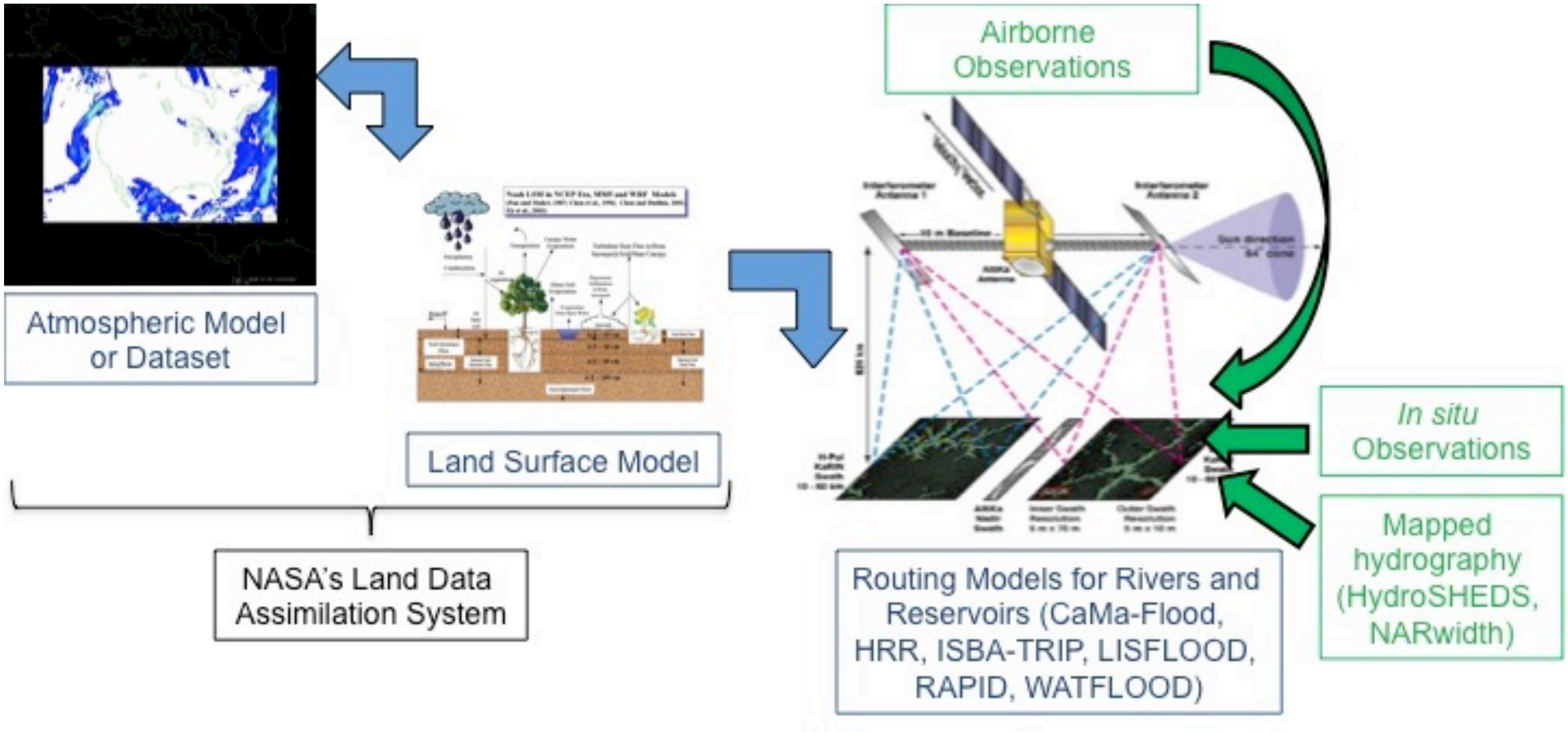
U.S. DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

(Prospective customers)

Colorado River Basin

Stakeholders and Customers

Classic river modeling paradigm

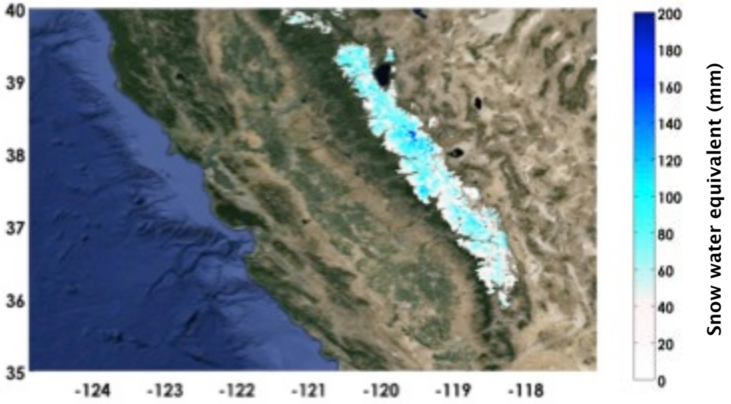


River Routing Models conserve mass.

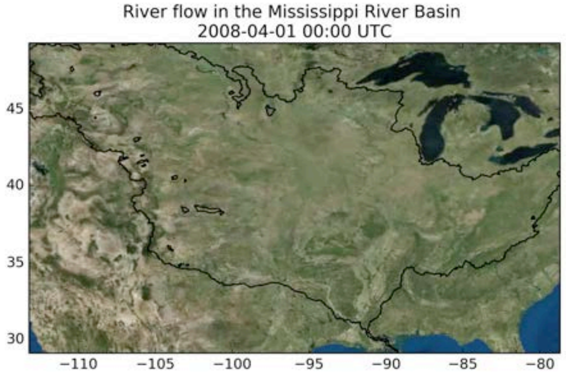
Credit: Cedric David

Value of Assimilation

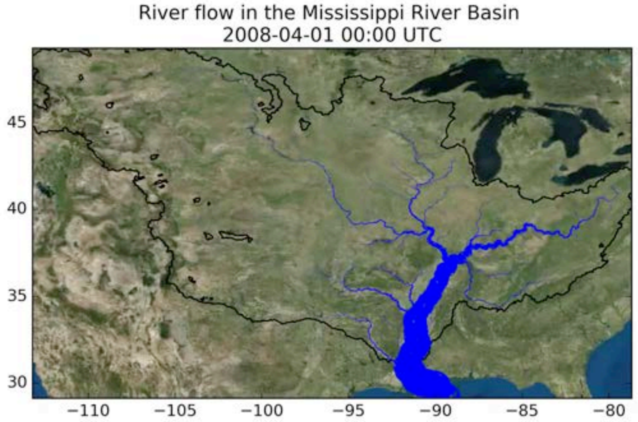
Model



Observation (e.g., SWOT)



https://github.com/c-h-david/rrr



Assimilated data

https://github.com/c-h-david/rrr

Observations add <u>accuracy</u> to model, but model also adds <u>information</u> to observations

THIS DRIVES DATA SCIENCE CHALLENGES: SCALABILITY, FUSION, UNCERTAINTY, ETC

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A NOS Scenario: Observe Peak River Flow Events

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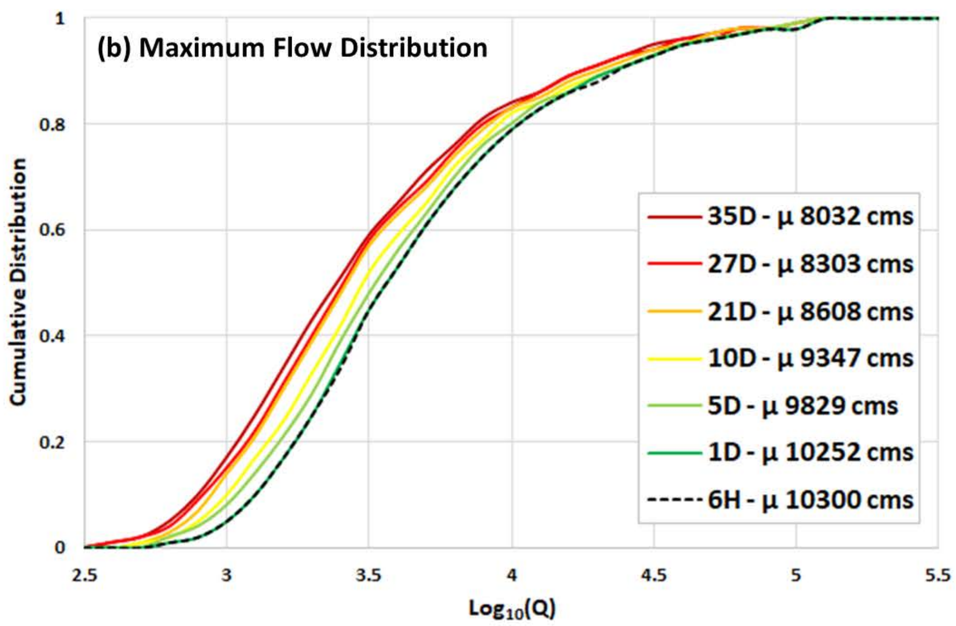
Science Goal: Observe river Peak Flow events.

- 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.

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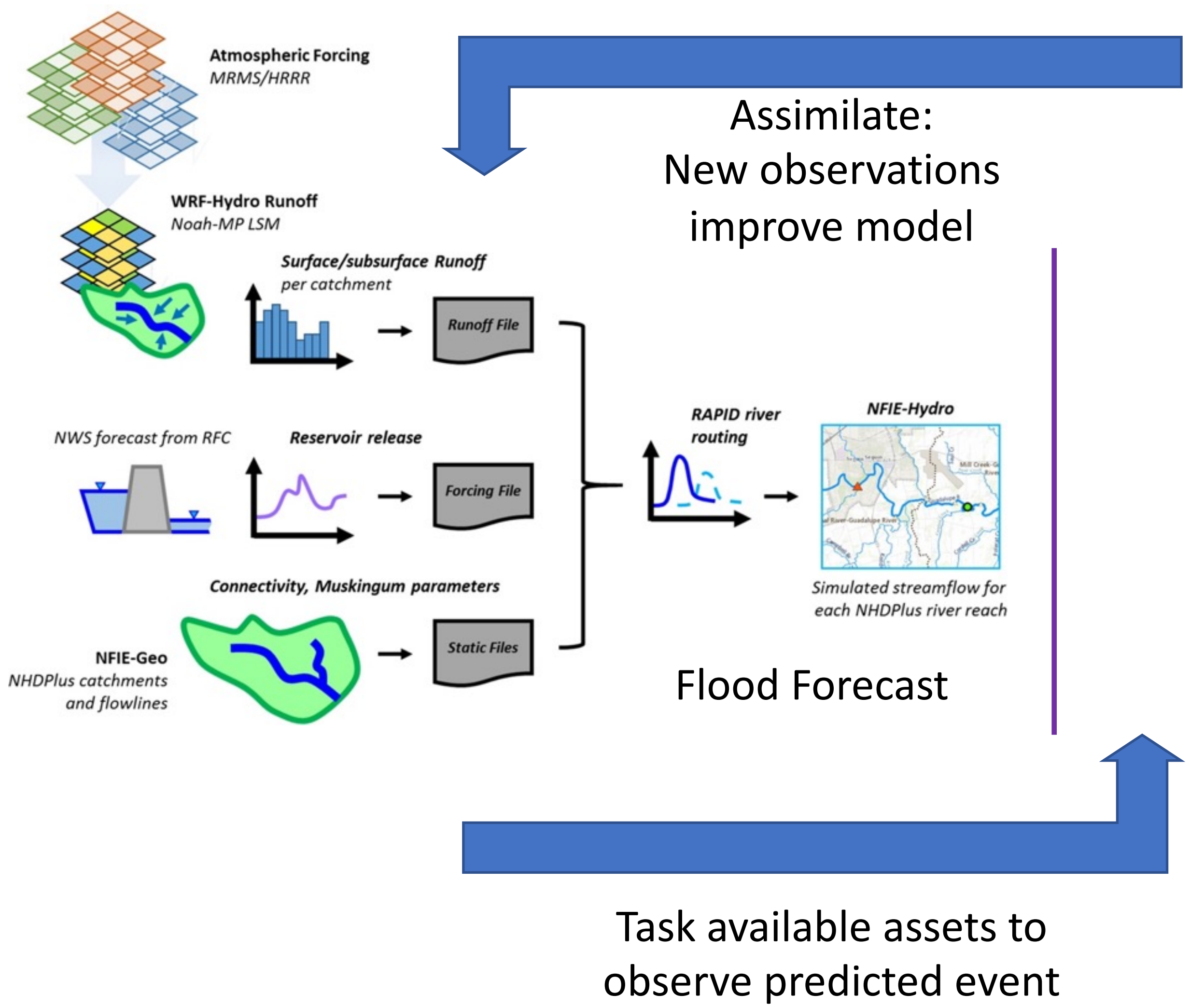
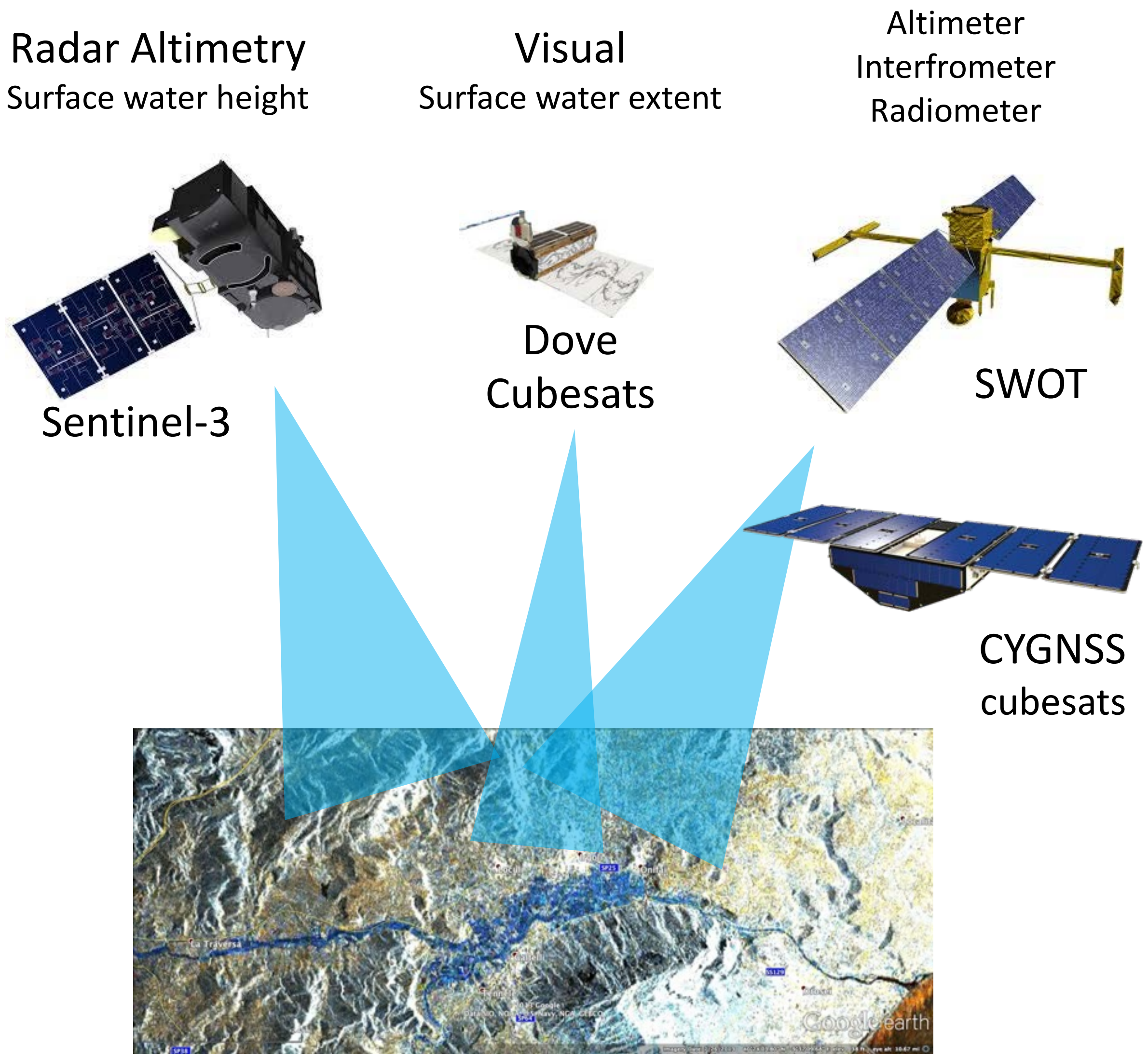
NOS Observations of Peak River Flow





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Computer forecasts of river flow increasingly being produced at continental/global scales using NASA's RAPID

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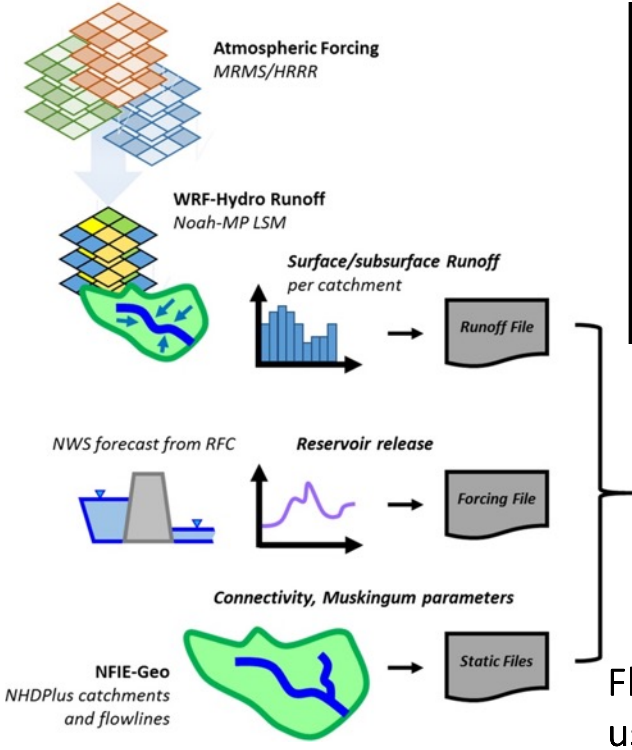
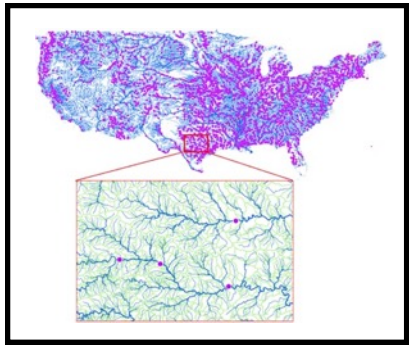




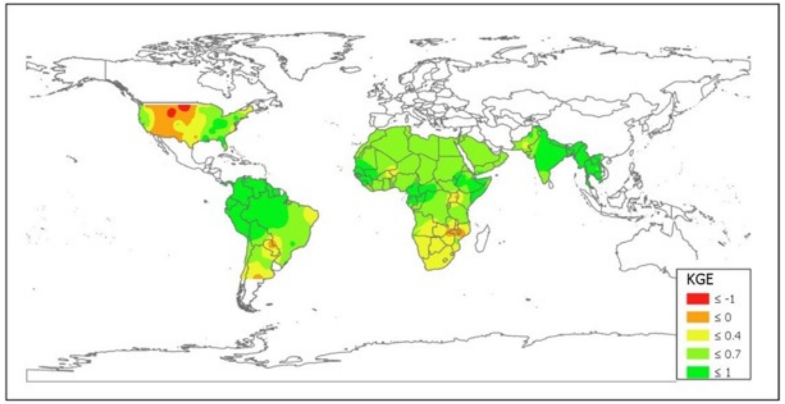
- Purple points show current NWS FF locations
- Blue lines show the potential extent of FF using this framework, which includes the flow routing using RAPID

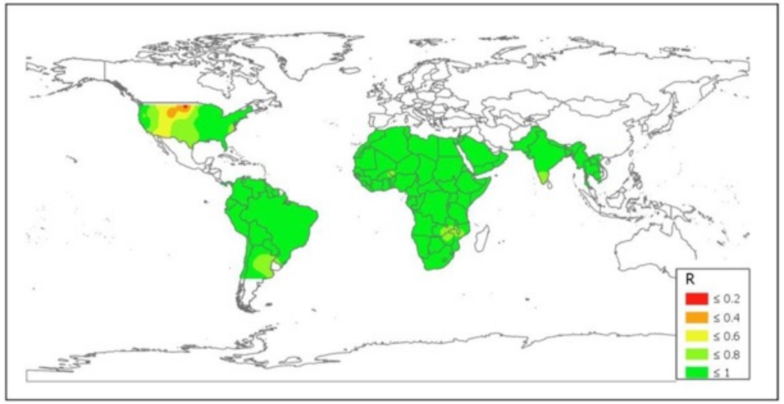
Nationwide Flood Forecasting

Flood Forecasting (FF) Framework using RAPID (*Salas et al., 2018*)

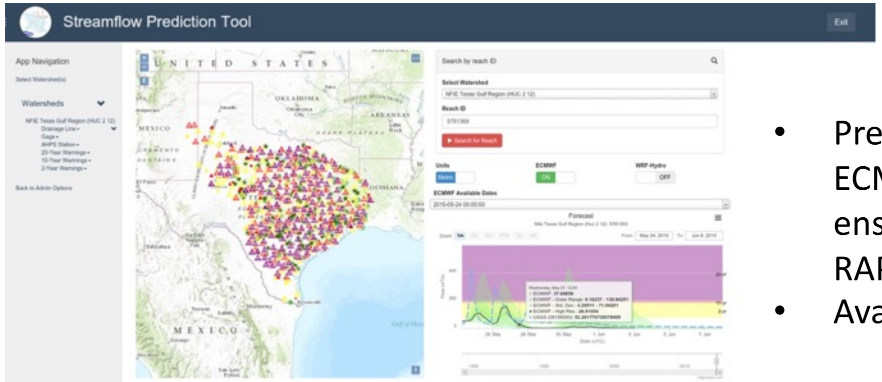
Global-Scale Flood Forecasting

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





Comparison of Global-Scale FF using ECMWF/ERA-RAPID and Operational GloFAS (*Qiao et al., 2019*)

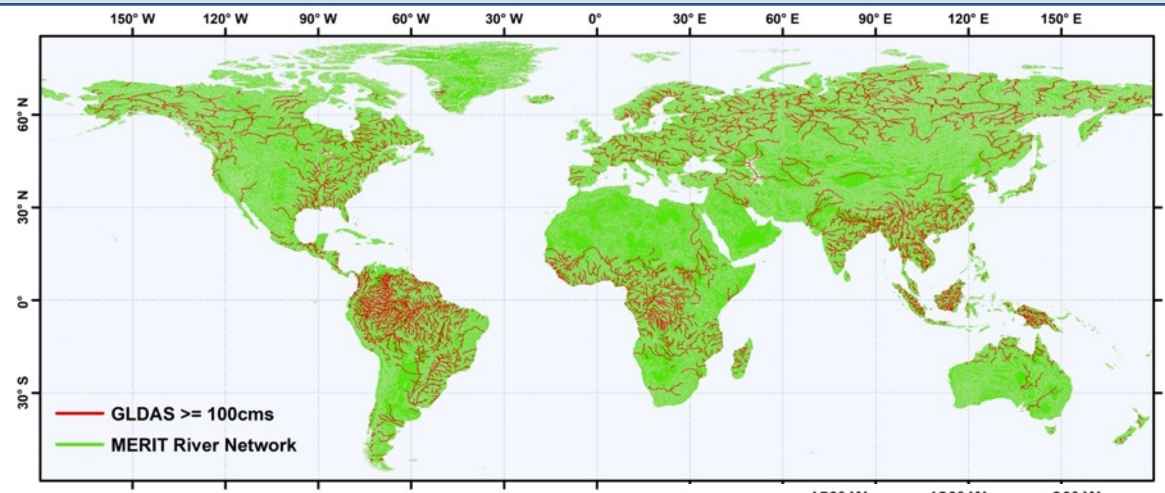


Nationwide Flood Forecasting

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

Generated Flood Alert using RAPID Simulated Flow (*Snow et al., 2016*)

A Preliminary Global-Scale Flood Alert methodology was developed using the same modeling approach

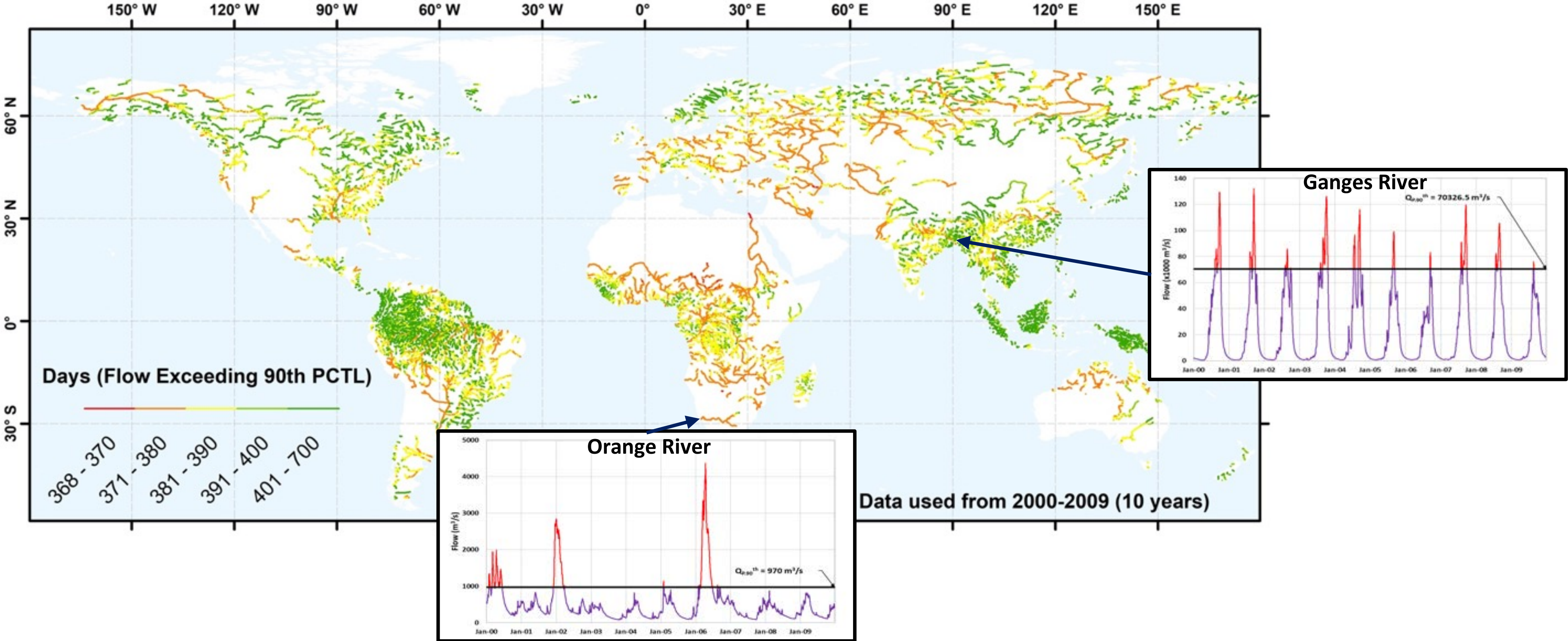


Global-Scale 10-Years (2000-2009) Retrospective Flow for Large River Systems:

- 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_{mean} >= 100 m^3/sec)

Flow Exceeding 90th Percentile:

- Number of days when flow exceeds the 90th percentile at any one 6-hourly time step: shows come 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

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- David, C. H., D. R. Maidment, G. –Y. Niu, Z. –L. Yang, F. Habets and V. Eijkhout (2011), River network routing on the NHDPlus dataset, Journal of Hydrometeorology, 12(5), 913-934. DOI: 10.1175/2011JHM1345.1

Thank You!

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

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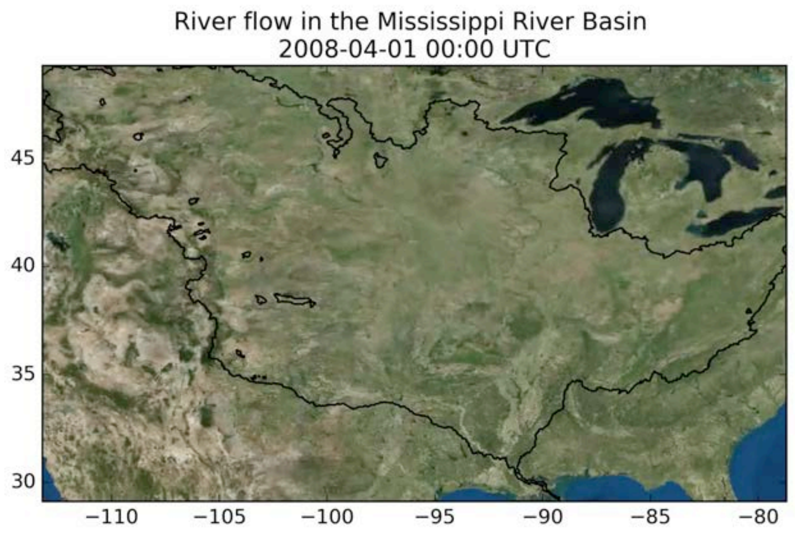
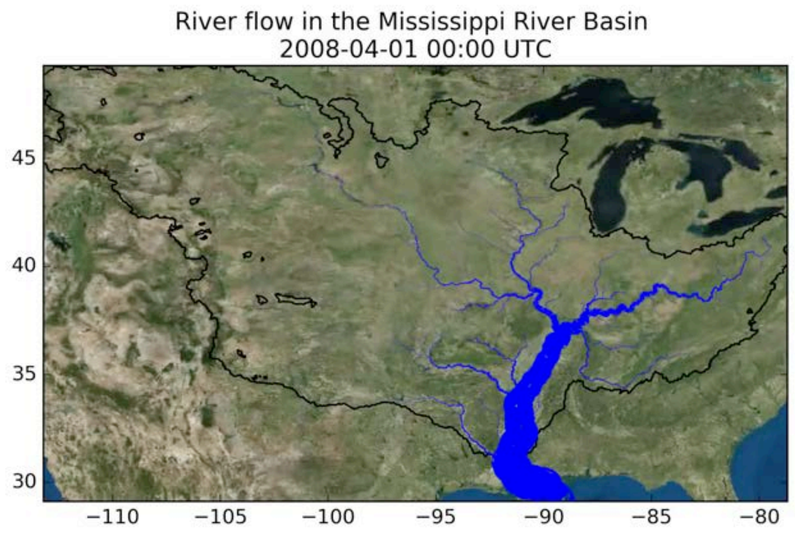




SWOT data → Assimilated in a river model

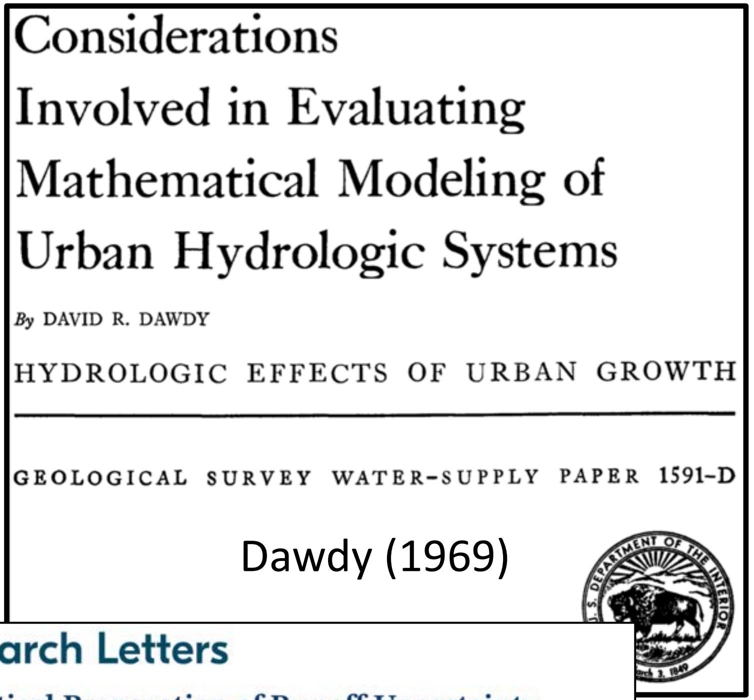
Challenge: data assimilation methods need a way to relate errors in observed variables to errors in the corrected variables

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)

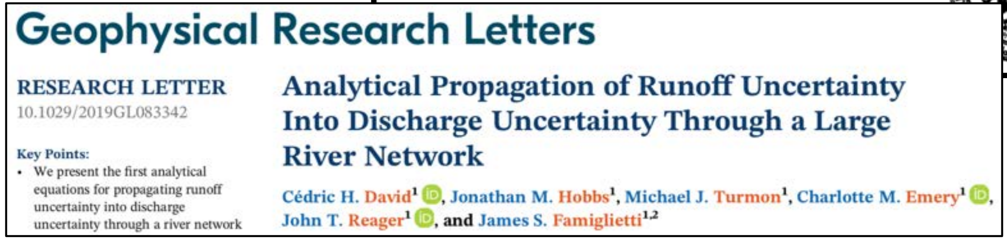

Considerations Involved in Evaluating Mathematical Modeling of Urban Hydrologic Systems

By DAVID R. DAWDY

HYDROLOGIC EFFECTS OF URBAN GROWTH

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1591-D

Dawdy (1969)


Geophysical Research Letters

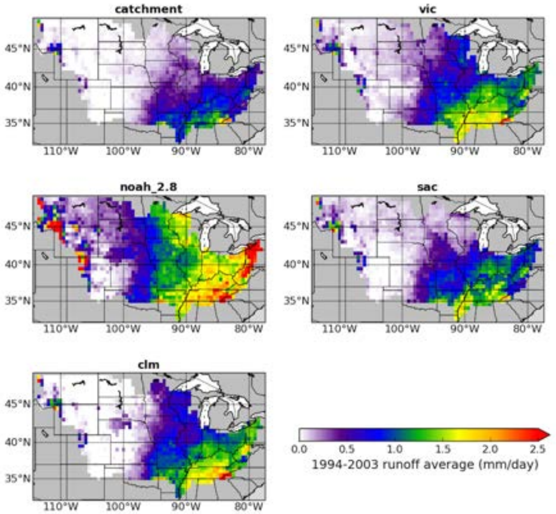
RESEARCH LETTER
10.1029/2019GL083342

Key Points:
- We present the first analytical equations for propagating runoff uncertainty into discharge uncertainty through a river network

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

Cédric H. David[1], Jonathan M. Hobbs[1], Michael J. Turmon[1], Charlotte M. Emery[1], John T. Reager[1], and James S. Famiglietti[1,2]

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



Runoff is uncertain (from D. Lettenmaier)

Credit: Cedric David