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Inland Routing Model Development for Compatibility with the Next Generation Water Resources Modeling Framework and Basic Model Interface Operability

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Why Improve Inland Routing?

Facilitate and encourage community engagement to enhance channel/reservoir routing models and data assimilation

- **Continental-scale framework Tree-Based Channel Routing (t-route)** for 1-D channel and reservoir routing solutions and data assimilation.
- **Parallel computing** using stream junction orders and independent networks.
- **Heterogenous application** of channel routing models.
- **BMI compatible**
- **Hydrofabric Agnostic**
- **Modular Design**

Framework for Channel and Reservoir Routing

- Continental-scale framework for 1-D channel and reservoir routing solutions with vector-based river network data.
- Parallel computing enabled by breaking into independent sub-networks using junctions orders.
- Reservoir routing based on a simple water balance.
- Streamflow nudging using observed data.
- Data Assimilation using various types of observed outflow data.

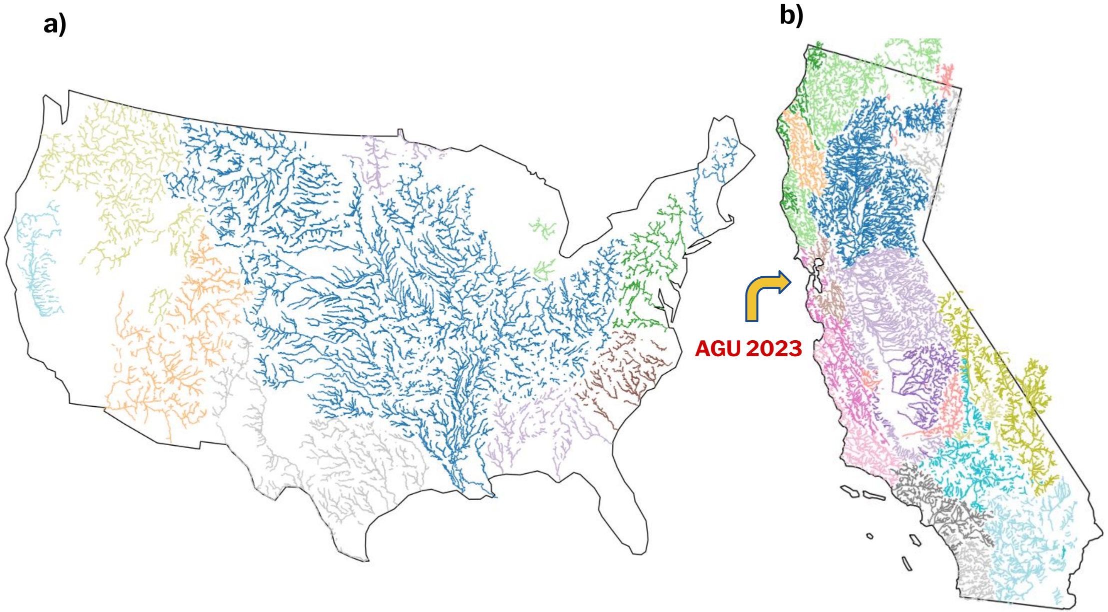


Figure 1. Independent sub-networks covering CONUS (a) and California (b) for computing diffusive wave as well as parallel computing of MC

Heterogeneous Channel Routing with t-route

	Muskingum-Cunge	Diffusive wave
Domain	Individual stream segment	Independent sub-network
Compute Process	Parallel on CONUS using junction order and short-time step	Serial on a sub-network using junction order
Routing Direction	Upstream to downstream	Both directions
Numerical Scheme	[One-dimensional explicit scheme]()	[Implicit Crank-Nicolson scheme]()

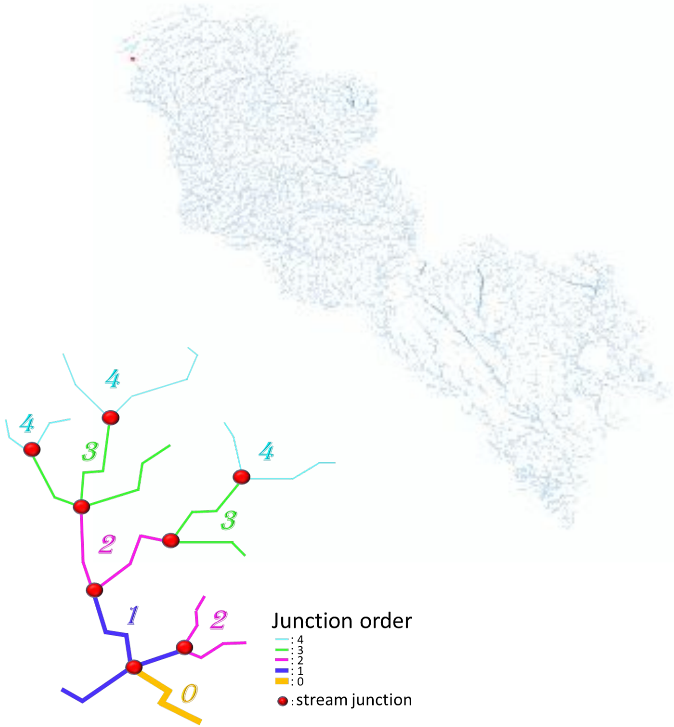
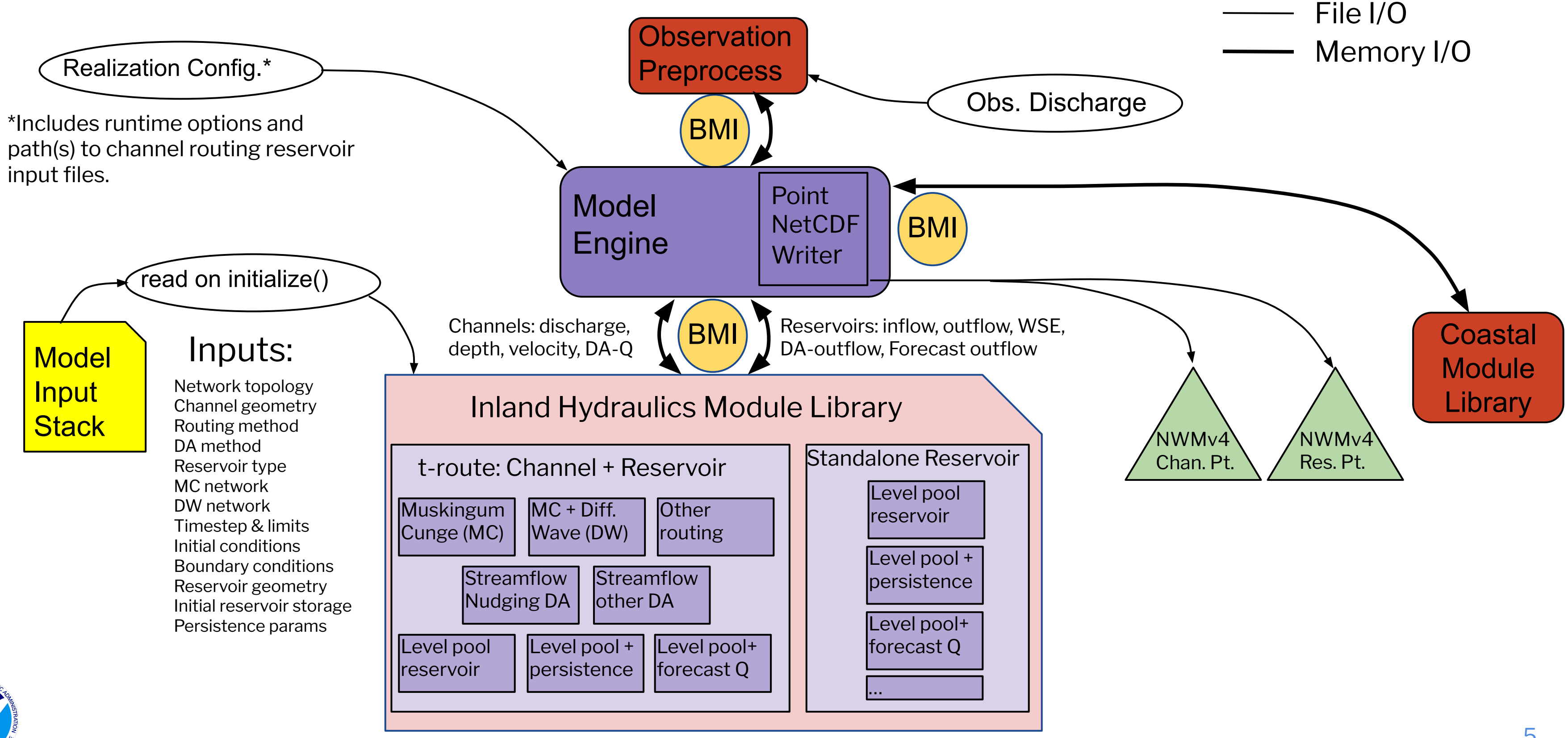


Figure 2. t-route configured junction orders for computing diffusive wave as well as parallel computing of MC

Inland Hydraulics Module Library in the NextGen Framework

Current/Future State



Basic Model Interface

- Simulate full CONUS routing via BMI functions
- Pass observations/forecasts between BMI models

```
DAforcing = bmi_DAforcing.bmi_DAforcing()
DAforcing.initialize(
  bmi_cfg_file='Standard_AnA.yaml'
)

troute = bmi_troute.bmi_troute()
troute.initialize(
  bmi_cfg_file='Standard_AnA.yaml'
)
…
troute.update_until(n)
```

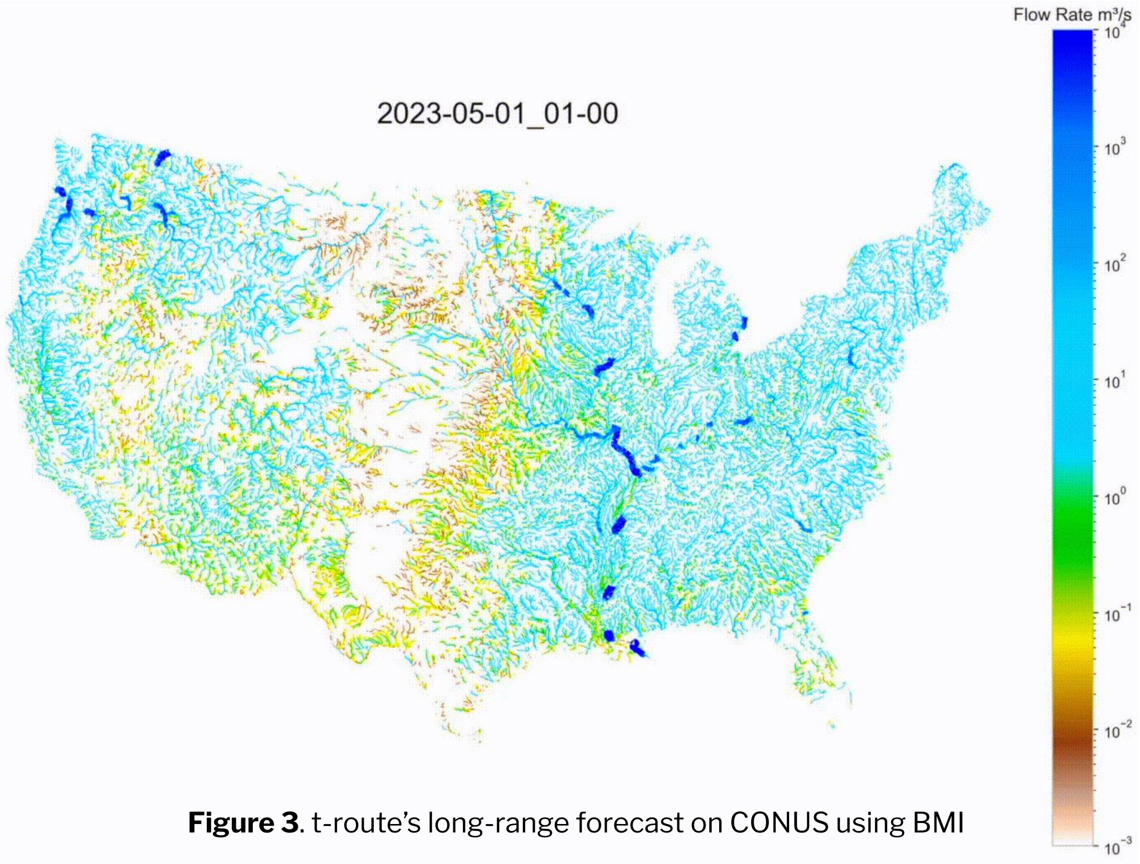
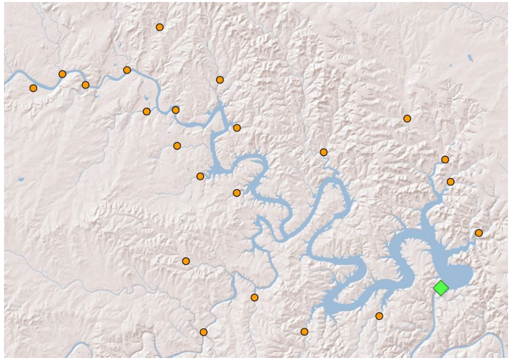


Figure 3. t-route's long-range forecast on CONUS using BMI

Standalone Reservoir Modules with BMI

- Simulate a single RFC reservoir via BMI functions
- Aggregate inflow from multiple incoming flowpaths
- Assimilate gage observations/forecasts



```
model = bmi_reservoirs.bmi_reservoir()
model.initialize('/bmi_reservoir_example.yaml')
…
for hr in range(240):
   temp_inflows = inflows_array[hr,:]
   model.set_value('lake_water~incoming__volume_flow_rate',
         np.array(temp_inflows))
   model.update_until(3600)
```

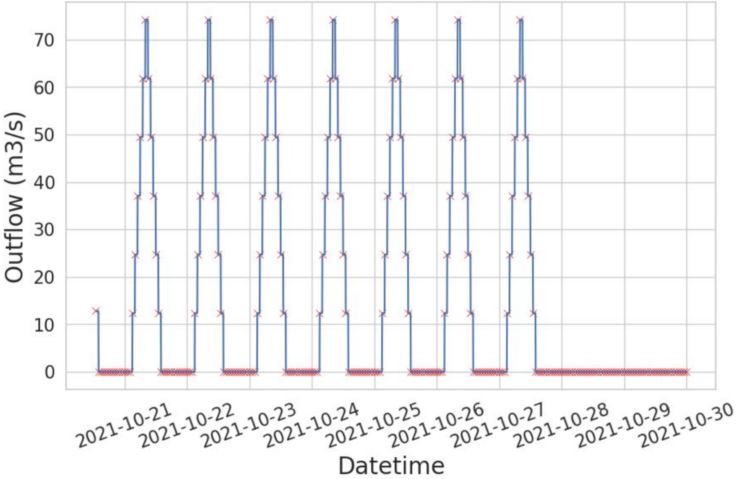
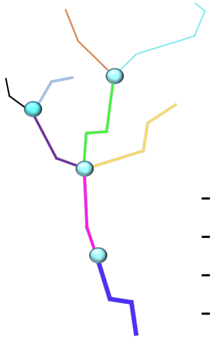


Figure 4. RFC reservoir DA for mid-range forecast using BMI

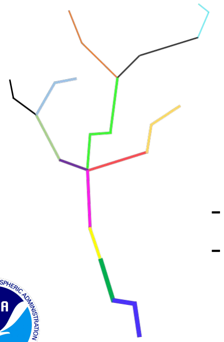
t-route in the Next Generation National Water Model

Next Generation Water Resources Modeling Framework Hydrofabric



- flowpath to nexus
- nexus to flowpath (same numeric IDs)
- Single flowpath between nexuses
- Github

NHDPlusV2 Hydrofabric



- link to link
- Single or multiple links between junctions

Common Network Features:

- Vector-based river network
- Directed acyclic graph (upstream to downstream)
- Flowpaths can merge downstream, but cannot split downstream

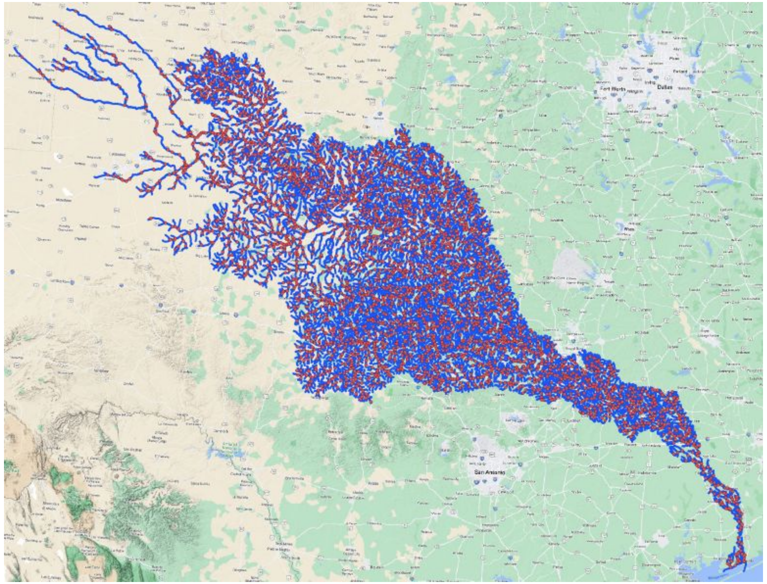
Acceptable file types:

- NetCDF
- Geopackage
- Json
- Geojson
- More are possible...

t-route in the Next Generation National Water Model

Network Agnostic

- LowerColorado_TX run on NHDNetwork and HYFeatures for comparison



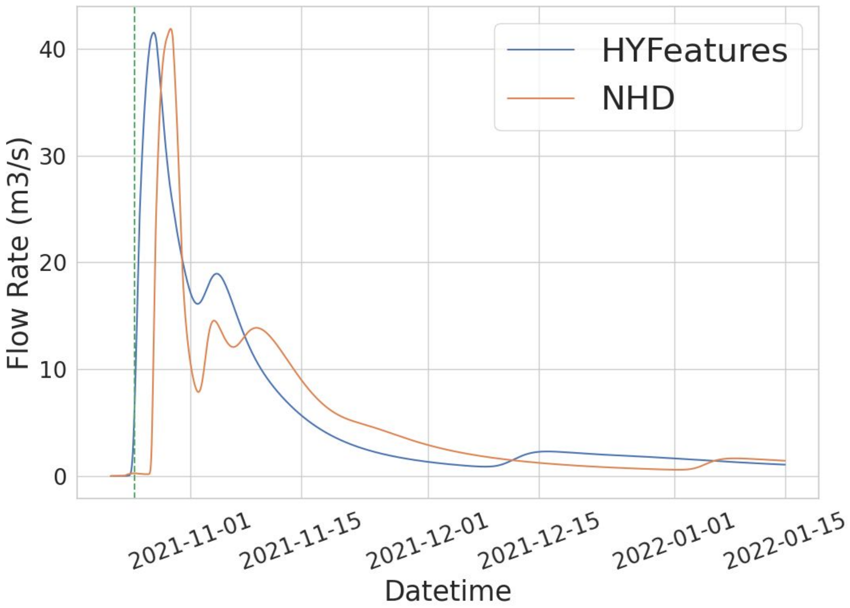


Figure 5. Lower Colorado River, TX test domain and t-route computed hydrographs for both hydrofabrics

Summary

Facilitate community engagement to enhance channel/reservoir models and data assimilation

- Continental scale, parallel computing of inland routing
  - Channel and reservoir routing
  - Data assimilation
- Basic Model Interface integration to conform to the Next Generation Water Resources Modeling Framework
  - Maintains functionality to call from command line
  - Separate reservoir module (can still operate internally in t-route)
- Internal modularity for fluid (pardon the pun!) configurations
  - Heterogeneous application of channel routing schemes
  - Network agnostic

Questions?

Thank You!

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https://water.noaa.gov

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