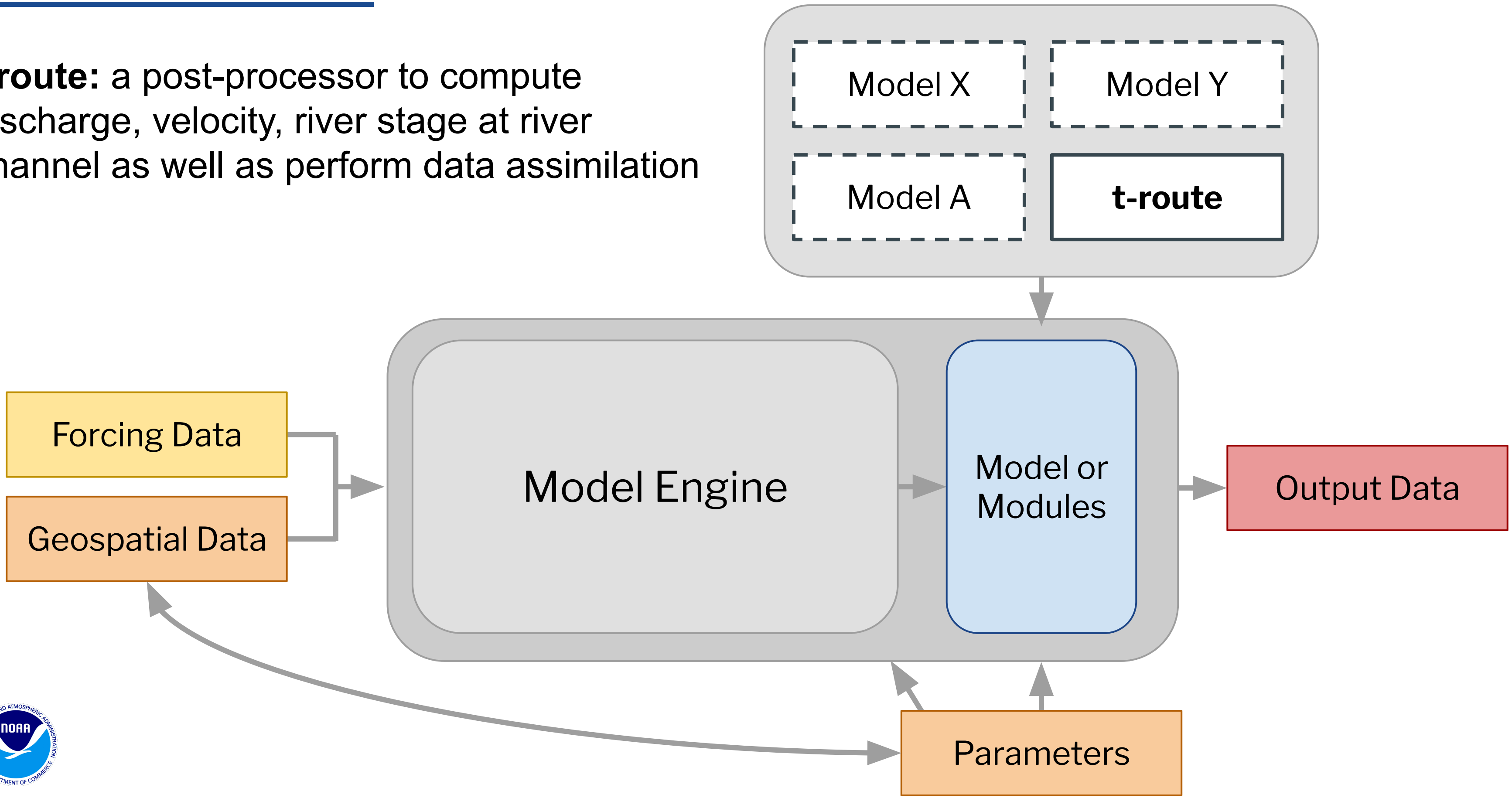
OWP | OFFICE OF WATER PREDICTION

River routing capability in the Next Generation Water Resources Model Framework

Naoki Mizukami, Adam Wlostowski, Andy W. Wood, Keith S. Jennings, Wanru Wu, Luciana Kindl da Cunha, Nels Frazier, Fred L. Ogden, Trey C. Flowers

Next Generation Water Resources Model Framework (Nextgen)

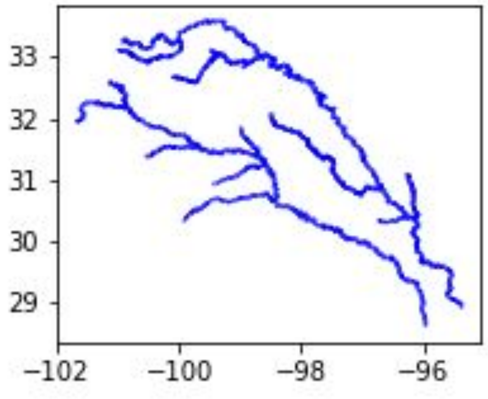
t-route: a post-processor to compute discharge, velocity, river stage at river channel as well as perform data assimilation



t-route

- Open source, community wide development
- Python-Fortran based codes.
- River network topological-based routing model.
- Shared memory parallel computing.
- Muskingum-Cunge (MC) and Diffusive wave routing.
- Level-pool lake routing.
- Heterogeneous routing domain (work in progress).

Parallel routing



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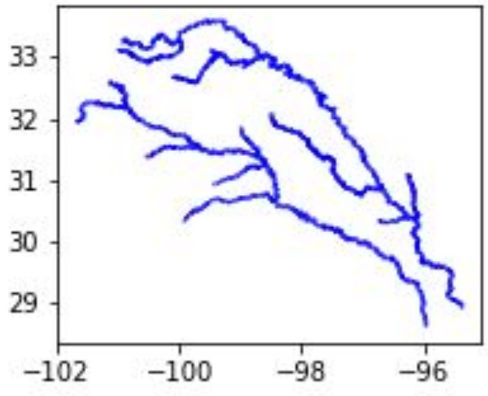


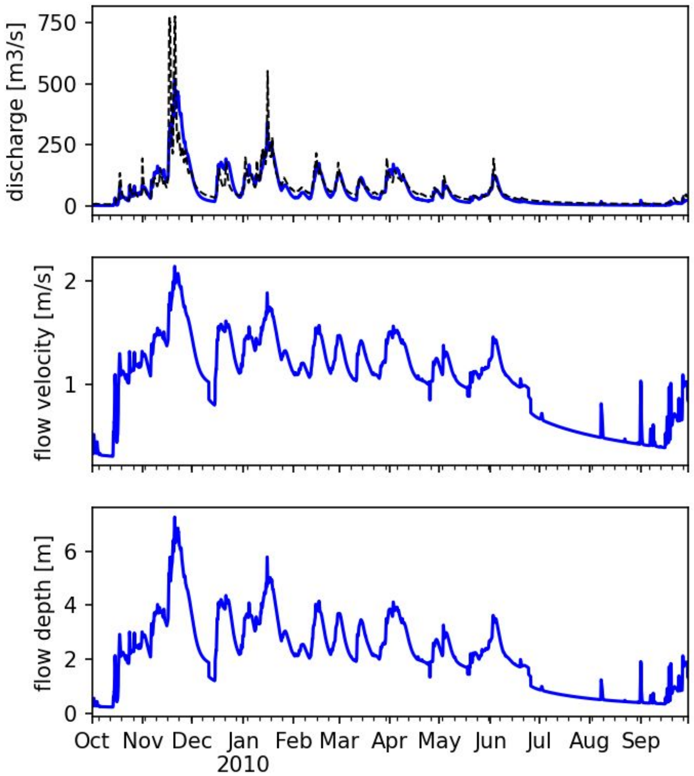
Current simulation example

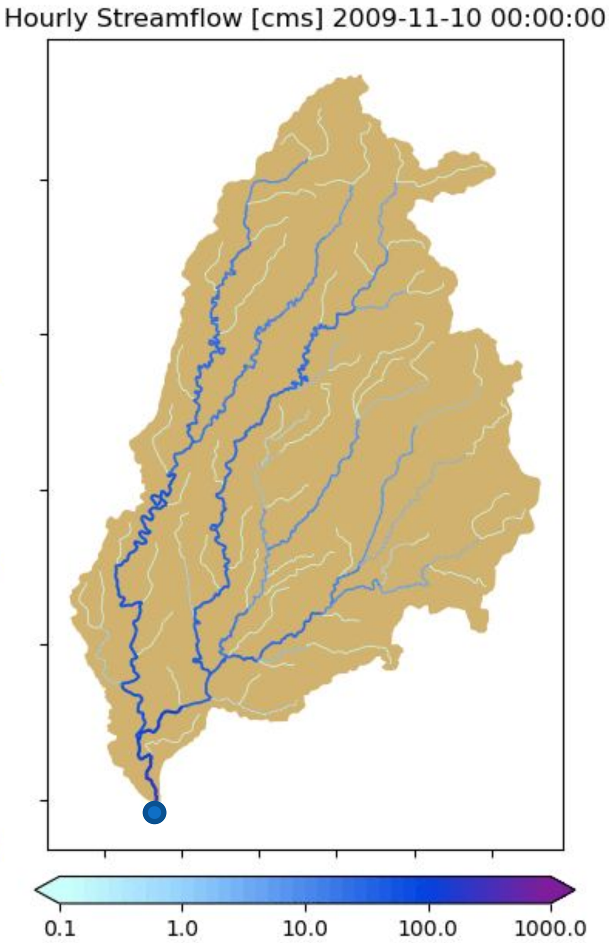
Nextgen model chain

1. *Noah-OWP Modular (hydrology above ground)*
2. *CFE (soil hydrology)*
3. *t-route (river routing)*

uniform routing: use a single routing method everywhere

12035000- SATSOP RIVER NEAR SATSOP, WA





Wave approximation

St. Venant equation (1-D shallow wave equation)

- Continuity equation

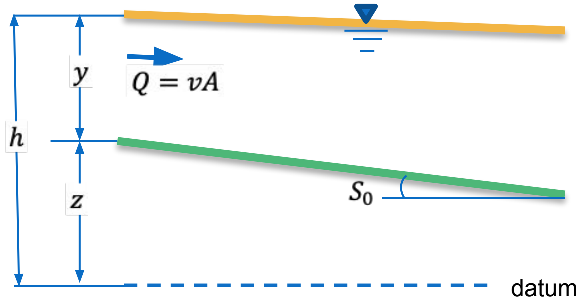
$$\frac{\partial A}{\partial t} = -\frac{\partial Q}{\partial x}$$

- Momentum equation

$$\frac{1}{A}\frac{\partial Q}{\partial t} + \frac{1}{A}\frac{\partial}{\partial x}\left(\frac{Q^2}{A}\right) + g\frac{\partial y}{\partial x} - g\left(S_0 - S_f\right) = 0$$

Local acceleration | Advective acceleration | Pressure | Gravity | Friction

Inertia term



A: Cross-sectional flow area

Friction slope $S_f = \frac{v^2}{f(n, A, y)}$

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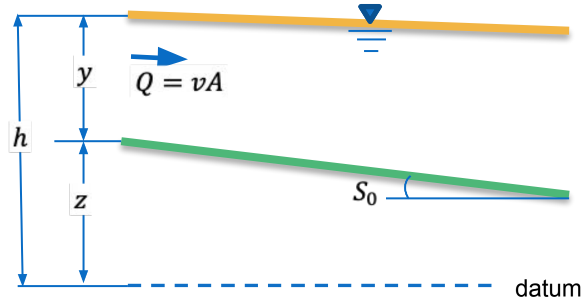

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Dynamic Wave
(inertia, pressure, & bed friction)

Computationally expensive

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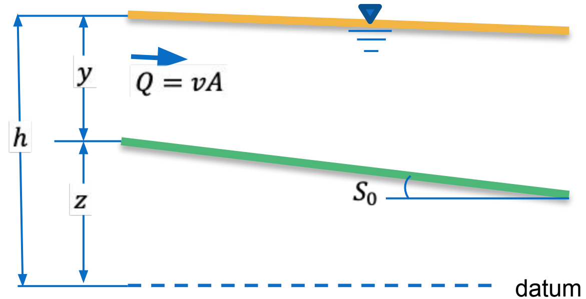
Pressure Gravity Friction



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Diffusive Wave
(pressure and bed friction)

Faster than Dynamic wave routing

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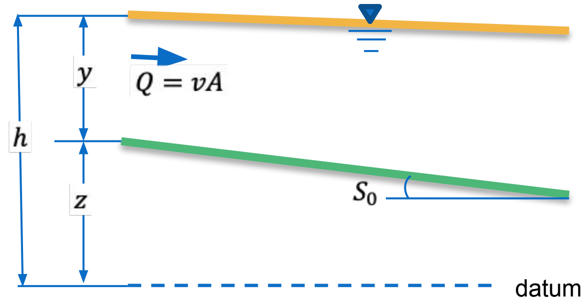
Gravity Friction



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Kinematic Wave (Muskingum-Cunge)
(Bed friction)

Similar computational cost to diffusive wave routing

Heterogeneous river routing

High-resolution, large-domain routing for short-term flood forecasting:

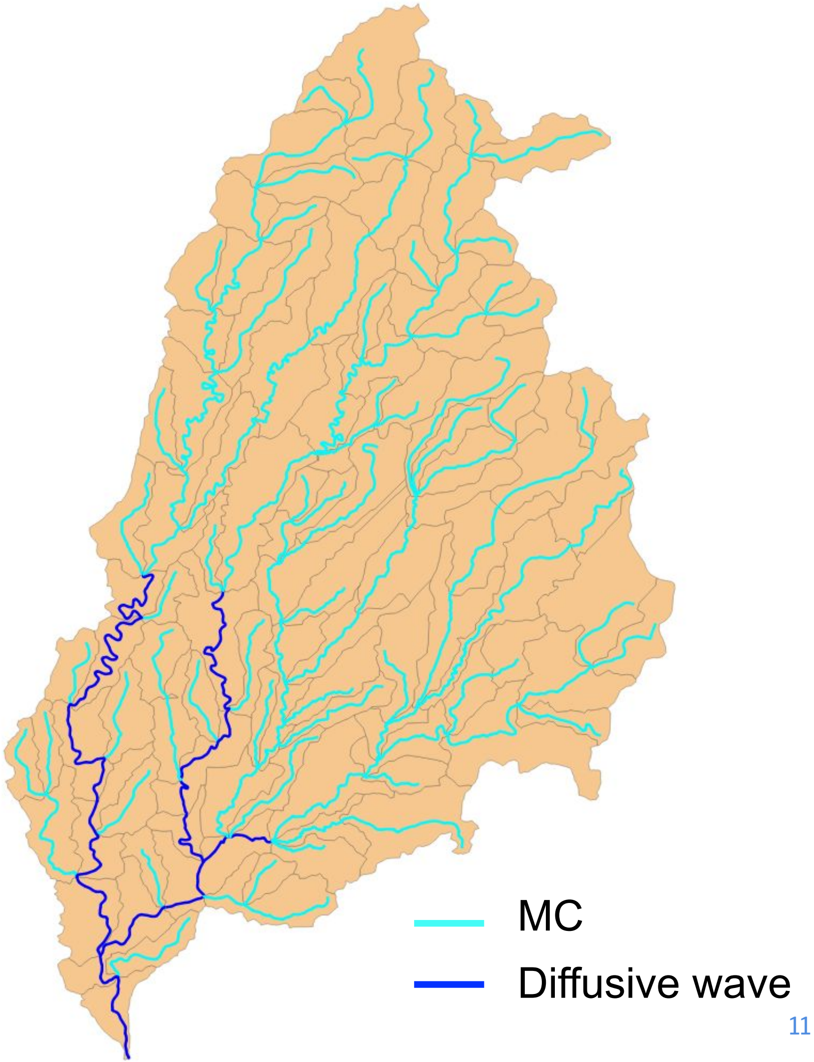
Meselhe et al., JAWRA (2021)

- Computational efficiency: Time-space dependent wave approximation to avoid expensive routing method (dynamic wave routing) everywhere.
- ~25 % of spatial-temporal hydraulic conditions may require dynamic wave routing.
- ~97 % of spatial-temporal hydraulic conditions may require diffusive wave routing.
- Appropriate wave approximations may be detected using "*dimensionless hydraulic parameters*" computed at each river reach and time.

Heterogeneous river routing

Routing methods depend on reaches and time.

(See illustration (this is not real setup)



On-going and Future work

- User-input wave domain.
- Run-time, automated wave domain identification at given time and reach.
- Dynamic wave routing
- DA capability (beyond nudging).

Thank You!

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naoki.mizukami@noaa.gov

https://water.noaa.gov

Back up slides

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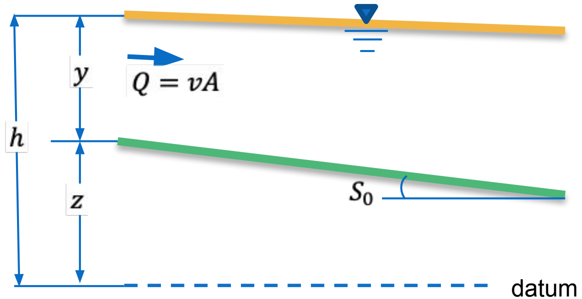

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