Implementing a vector-based river routing scheme within the WRF-Hydro modeling system

Peirong Lin[1], Zong-Liang Yang[1], David Gochis[2], Wei Yu[2], Cédric H. David[3], David Maidment[4]

1. Jackson School of Geosciences, University of Texas at Austin
2. Research Application Laboratory, National Center for Atmospheric Research
3. Center for Hydrologic Modeling, University of California at Irvine
4. School of Civil and Environmental Engineering, University of Texas at Austin

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Outline

* 1. Introduction
* 2. WRF-Hydro/RAPID Coupling
* 3. Future Work/Discussions
* 4. Implications for Operational Hydrology/Data Assimilation

Introduction – Background

* Climate modeling is increasingly used by climate scientists to inform water management
  * Hyper-resolution modeling (***O***(1km) or less)
  * Human infrastructures (e.g. dams, reservoirs, etc.)

* **Novel data structures** and **modeling strategies** are needed to resolve the gap between climate modeling and water management

* Wood et al. (2011); Lehner et al. (2013);
  * **A shift from "grid/raster to vector" environment** could benefit hyper-resolution modeling, supporting spatially detailed applications

Introduction – Models

* **WRF-Hydro**
  * A model coupling framework between the Weather Research and Forecasting (WRF) model and terrestrial hydrological models
  * A comprehensive tool for hydroclimate research
  * http://www.ral.ucar.edu/projects/wrf_hydro/
* **RAPID model**
  * A vector-based river routing scheme
  * http://www.ucchm.org/david/rapid.htm

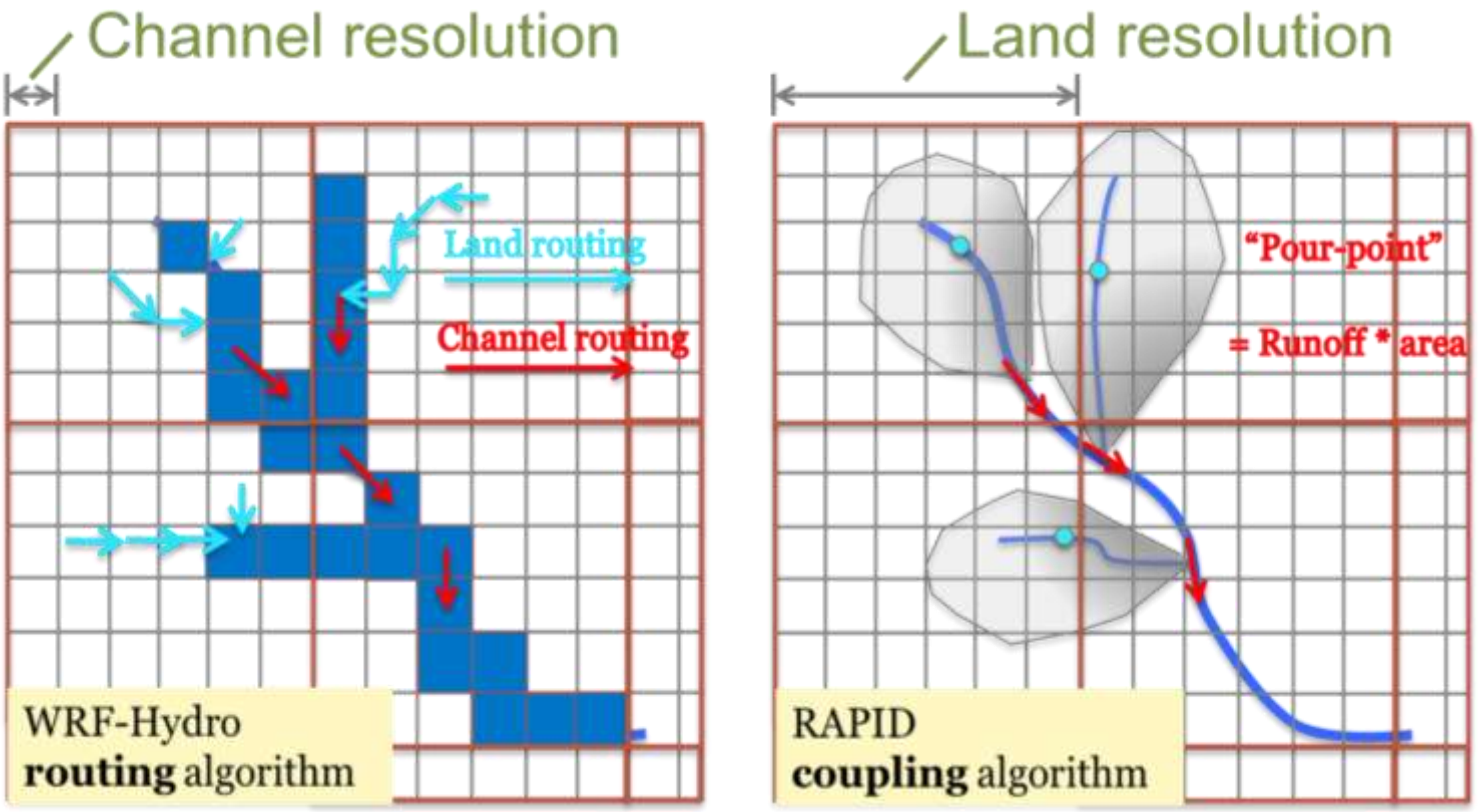
Introduction – Different Routing Concepts

* Current WRF-Hydro utilizes **grid-based routing**
  * "Two-steps" routing
  * **Land routing:** routing before the water reaches the river channel (based on topography)
  * **Channel routing:** routing in the river channels (Muskingum, etc.)

* RAPID model is a **vector routing scheme**
  * "Pour-point" routing

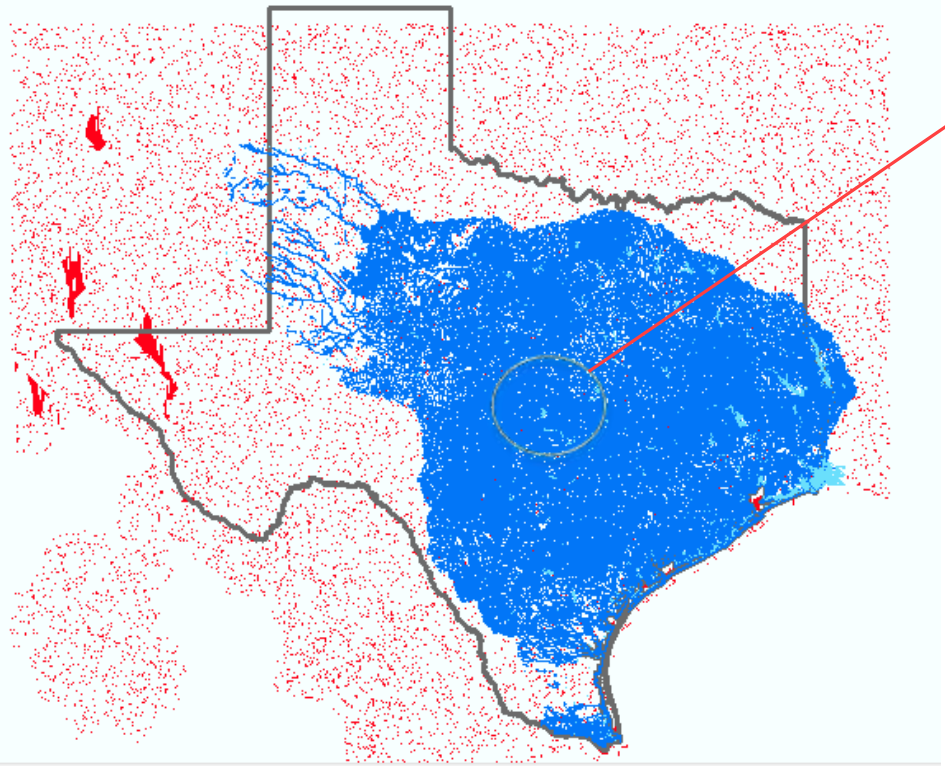
Introduction – Different Routing Concepts

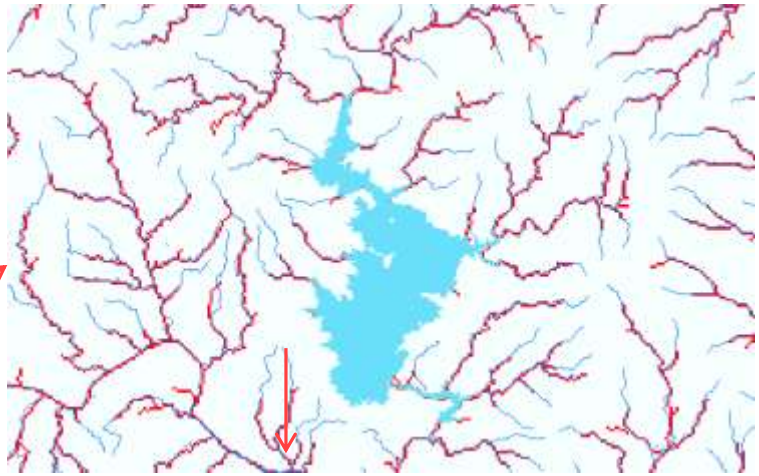
WRF-Hydro **grid-based** routing **VS** RAPID **vector-based** routing



Introduction – Different River Network/Data Structure

* Red: WRF-Hydro river network
  * (extract from DEM, other topographic input)
* Blue: RAPID river network
  * NHDPlus (or HydroSHEDS)





Quite similar but:

WRF-Hydro:

1 million+ nodes (grids)

RAPID:

60 k+ links (river reach)

Introduction – Vector- VS grid-based Routing

* Each has its own advantages/disadvantages

	Grid-based	Vector-based
River network accuracy	**Depends** (input terrain resolution, and river generation algorithm)	**Usually better** (GIS datasets from survey, aerial photo, etc.)
Computational efficiency	**Low**	**High**
Routing performances	Depend on the **routing algorithm** **upstream regions** (detailed descriptions, better performances)	Depend on the **coupling algorithm**

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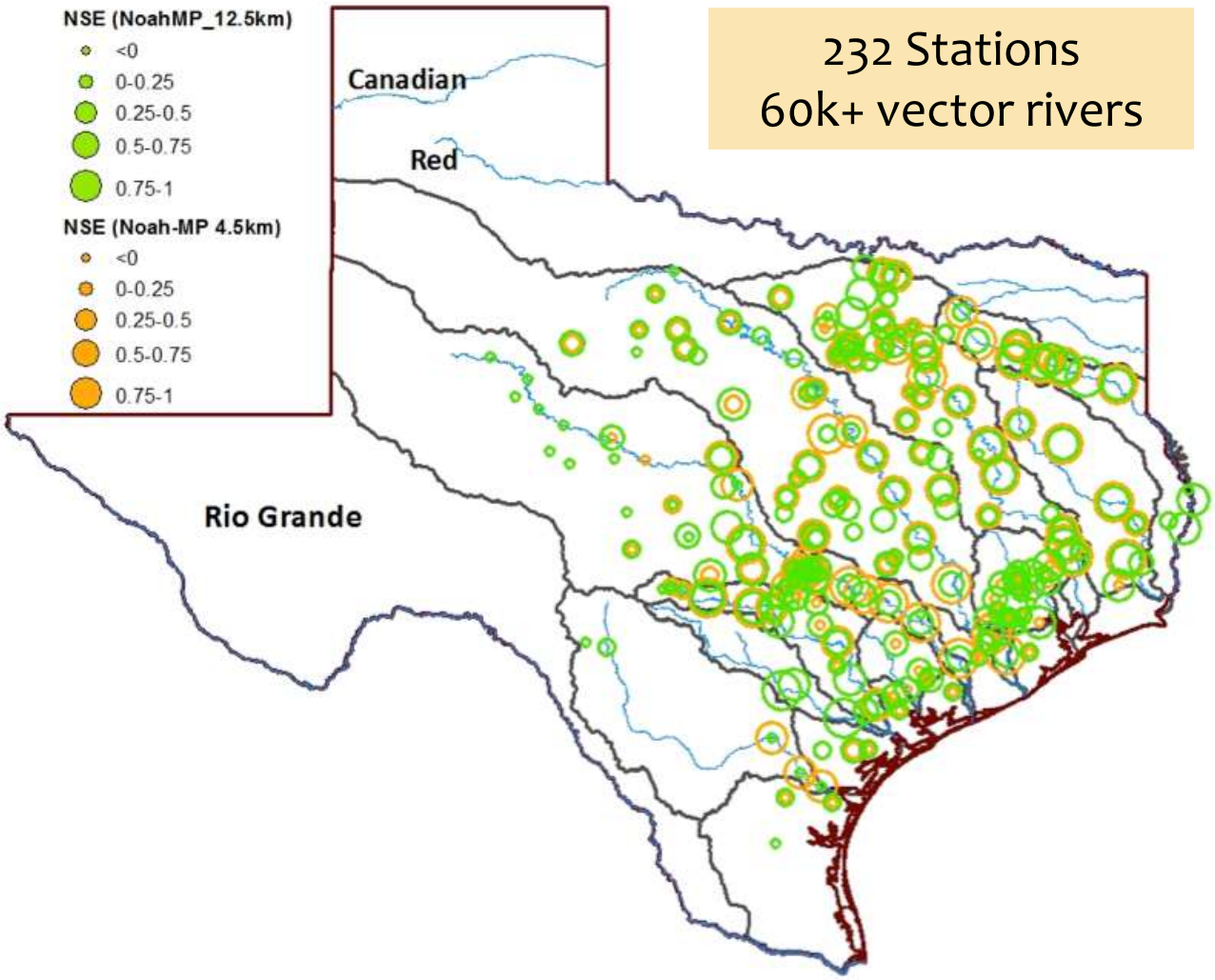
* **RAPID model**
  * A vector-based river routing scheme

Hypothesis: 1. The vector-based scheme could largely increase the computational efficiency in terms of river routing
2. The novel data structure and modeling strategy would benefit a variety of water resource research and applications

Model Coupling – RAPID Model Performances

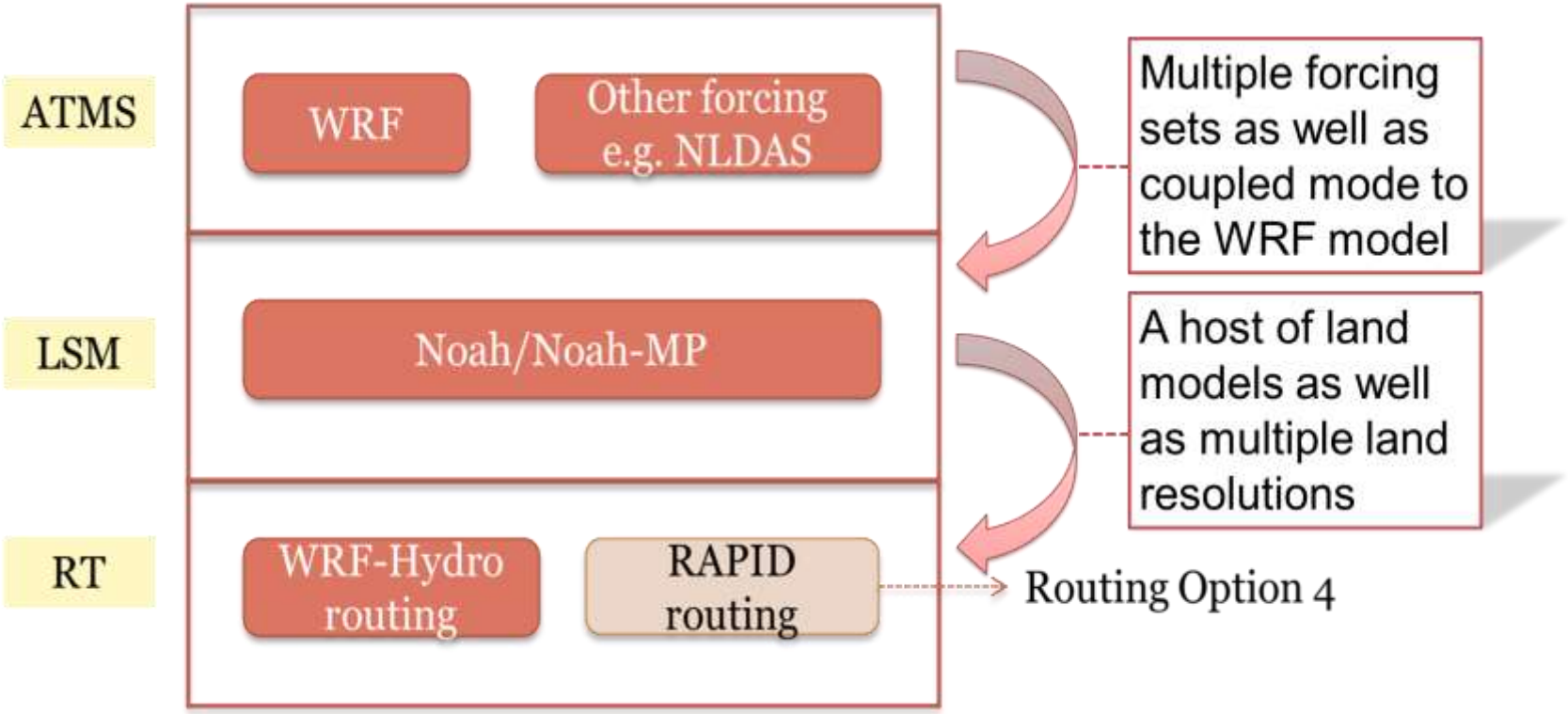
* Nash-Sutcliff Efficiency (NSE)
* 2000 – 2007 offline simulation (with different resolution Noah-MP LSM runoff output)
* Good performances; Downstream better than upstream



232 Stations
60k+ vector rivers

Model Coupling

* WRF-Hydro Architecture and RAPID implementation



Model Coupling – Details

WRF-Hydro

1

Shift from "grid/raster environment to vector environment"

ATMS

WRF

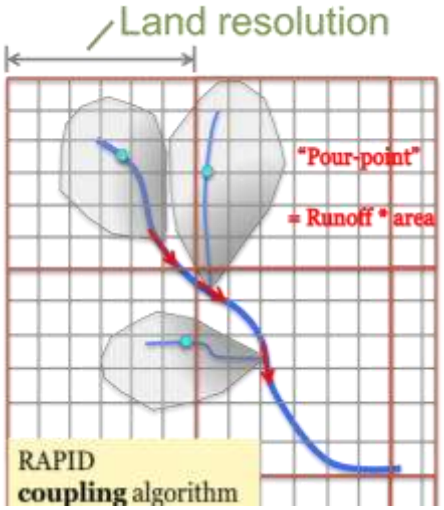
Other forcing e.g. NLDAS

LSM

Noah/Noah-MP

RAPID Coupler

2



RAPID routing on vector channels

Need geographic correspondence between grid-based LSM and vector-based river network – **"coupling" file**

Coupled WRF-Hydro/RAPID run

---- A case with idealized forcing

* Model set up: 4.5-km land resolution

48-hrs case: **3min on a single node**

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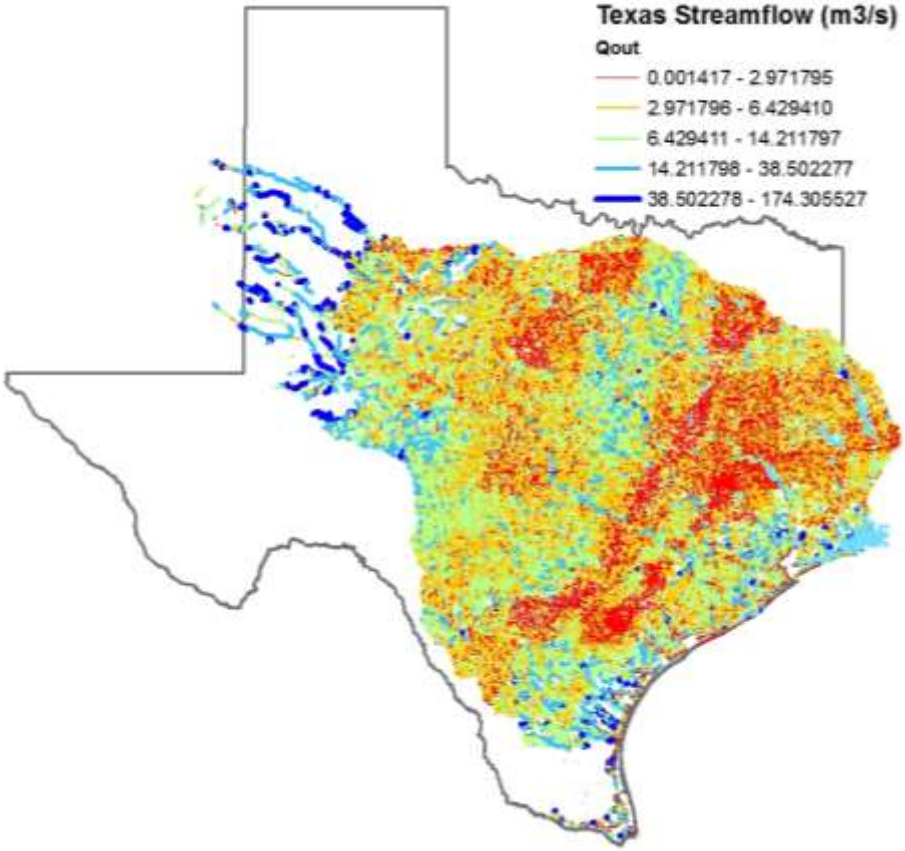

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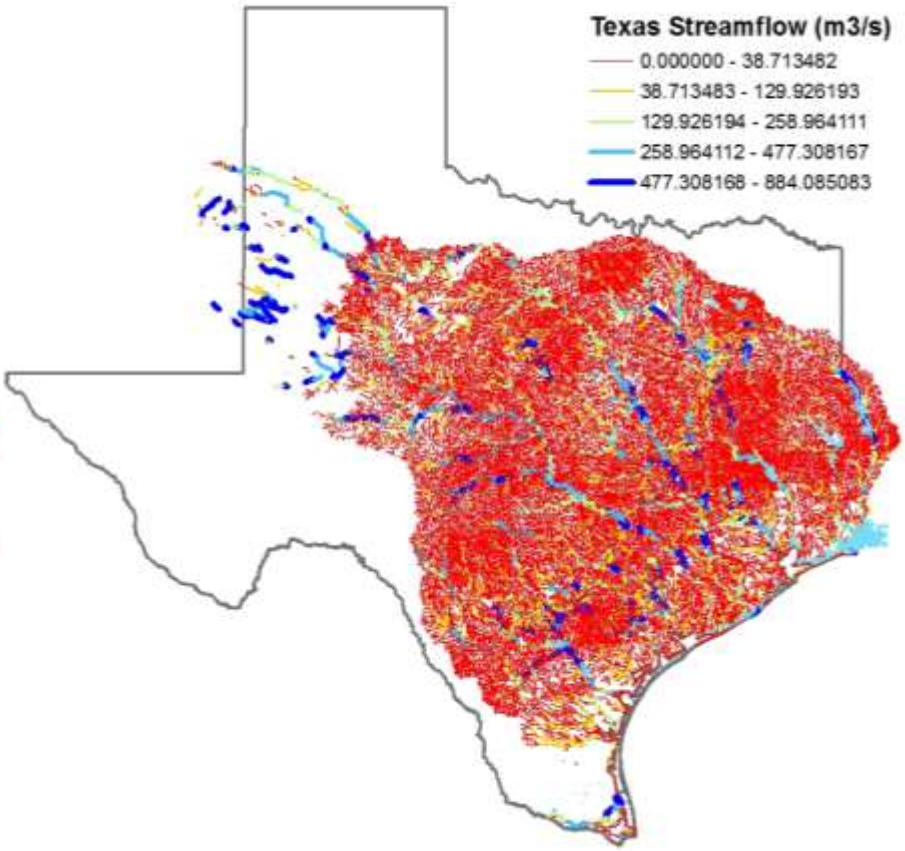

Data Store Format

* Two dimensions: Time & River IDs
* For example:
  * Texas has 68143 rivers, this run has 500-hrs
  * **Each link (river reach) & each time step has one discharge value**

Easier access/process to the **output data** format

```
netcdf RAPID.wrfhydro.200706 {
dimensions:
        Time = 500 ;
        COMID = 68143 ;
variables:
        float Qout(Time, COMID) ;
        int COMID(COMID) ;
}
```

Summary on the model coupling

* RAPID vector-based river routing scheme is successfully coupled to the WRF-Hydro system (as routing Option 4, new code package will be available soon)

* Computational efficiency: largely increased

On-going work

* Evaluating the newly coupled model's capability in terms of simulating floods (Hurricane Ike, Sep. 2008)

* Comparisons on the pros and cons in using vector- and grid-based routing scheme

Discussions

* WRF-Hydro/RAPID Framework
  * Multiple forcing sets
  * A host of hydrological models
  * Multiple land resolution

* Implications
  * **Ensemble forecasts**
  * **New data assimilation capability** based on vector-based channels (different from gridded discharge)

Thanks for attention!