Continental scale hydrologic-hydraulic model inter-comparison

MGB model
Mississipi basin
Preliminary results

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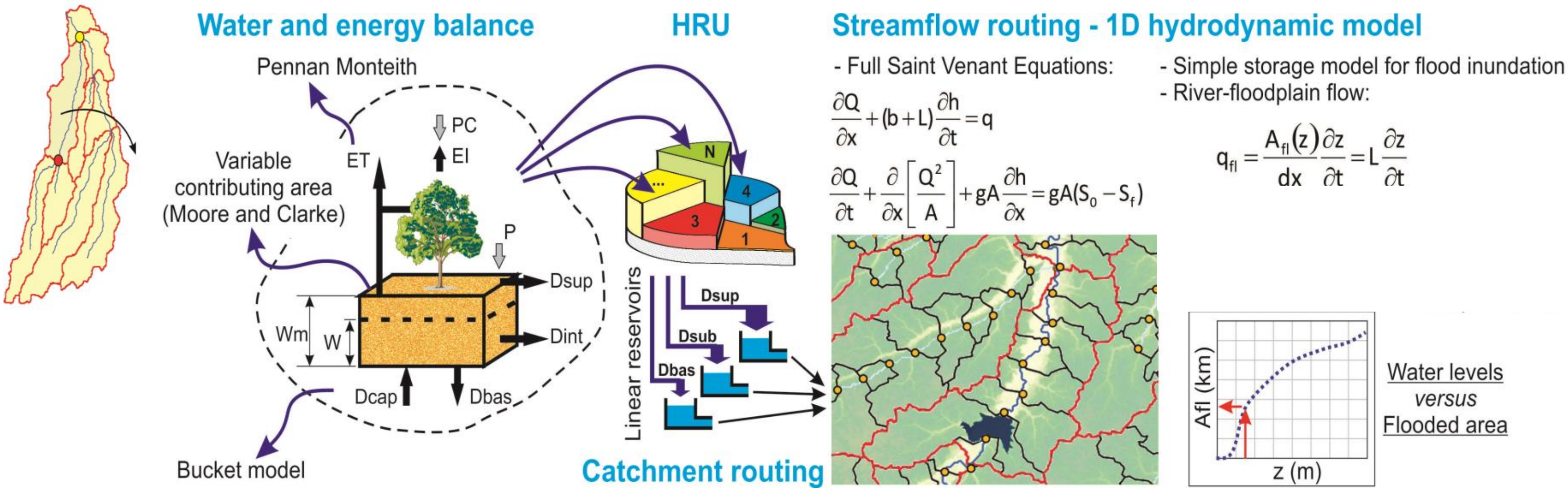
Modelo de Grandes Bacias (MGB-IPH) [*Collischonn et al.*, 2007; *Paiva et al.*,2011; Pontes et al., 2015]

Coupled Hydrology – Hydraulic model for large basins



Catchment Flow Routing

- Surface , subsurface and groundwater runoff are routed using linear reservoirs

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River network routing:

	Continuity equation	*Momentum equation*
Muskingum-Cunge	$\frac{\partial A}{\partial t}+\frac{\partial Q}{\partial x}=0$	$\cancel{\frac{\partial Q}{\partial t}}+\cancel{\frac{\partial(Q^2/A)}{\partial x}}+\cancel{gA\frac{\partial h}{\partial x}}=gAS_0-gAS_f$
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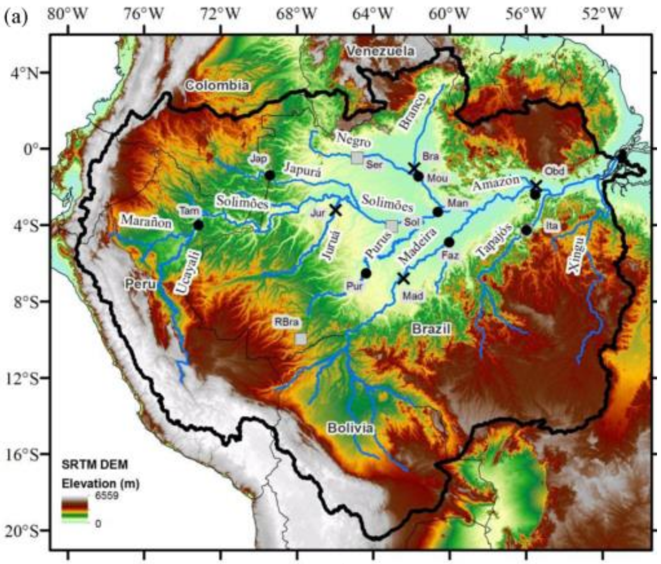
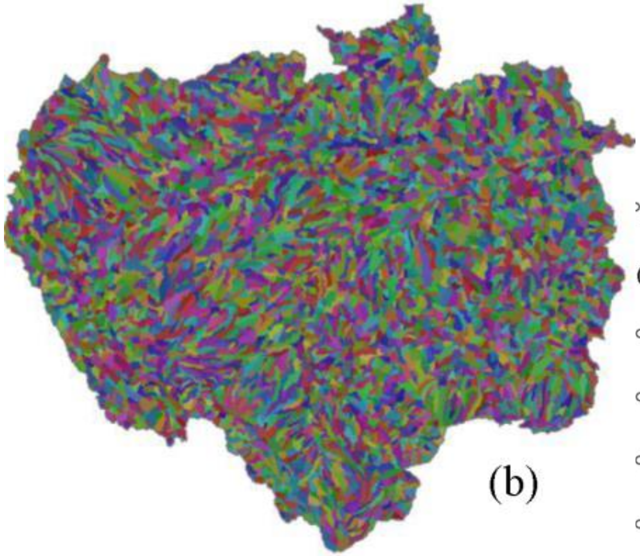
Several model applications in South American rivers:

- Flood forecasting and optimal reservoir operation
- Climate change studies
- Land use and land cover changes
- Coupling with SIAQUA-IPH water quality model
- Coupling with sediment transport model
- Use in water management studies
- Coupling with remote sensing data

Ex.: Amazon application (Paiva et al., 2013 WRR)

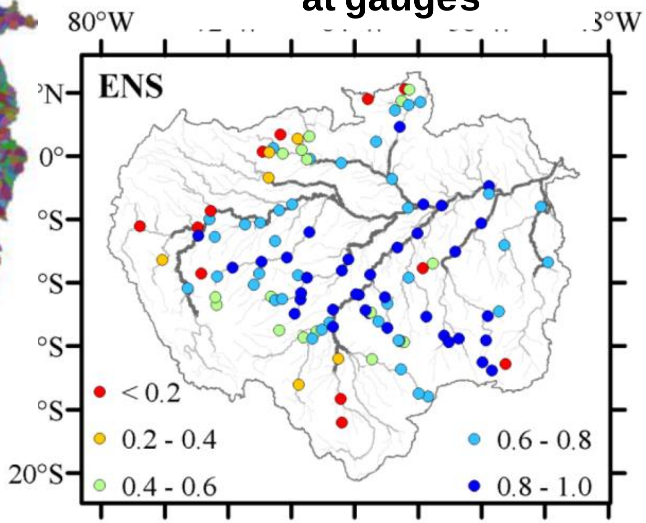


SRTM DEM

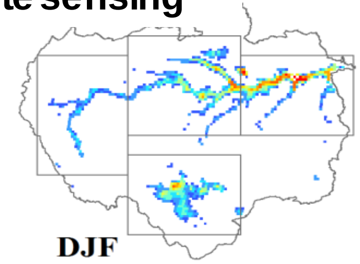


5763 catchments

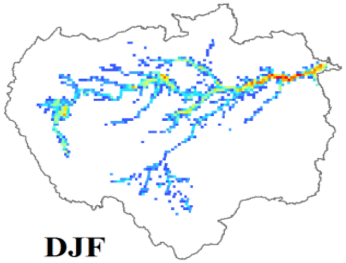
Nash and Suttcliffe at gauges



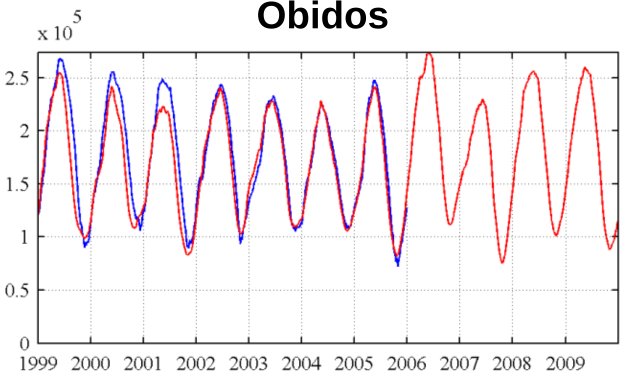
Remote sensing



Model



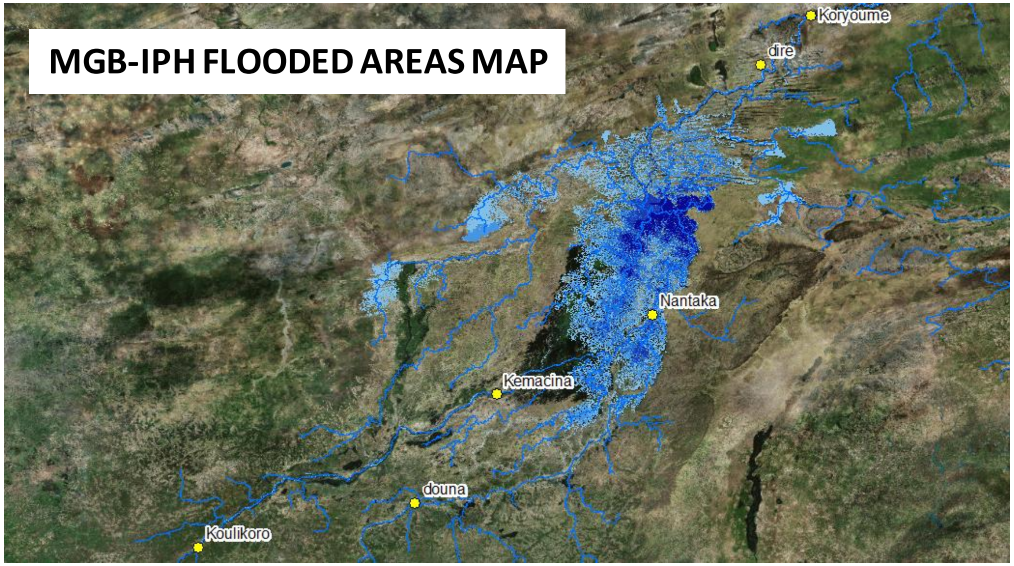
Óbidos



ENS = 0.89, ENSlog = 0.89, DI = -11 days, ΔV = -5 %

Niger River Basin

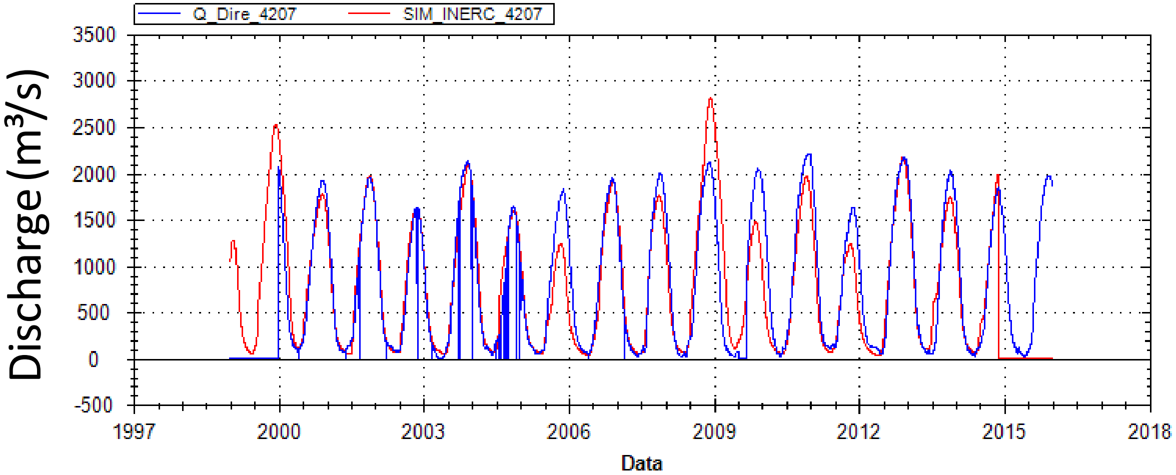
Inner Delta



Niger Inland Delta:

- ~30-50% of inflow waters (~Kemacina + Douna gauges) evaporate until Dire gauge
- Coupled hydrologic and hydrodynamic modeling

Diré gauge, downstream of Inland Delta



Fleischmann et al., in preparation

MGB coupling with river altimetry data

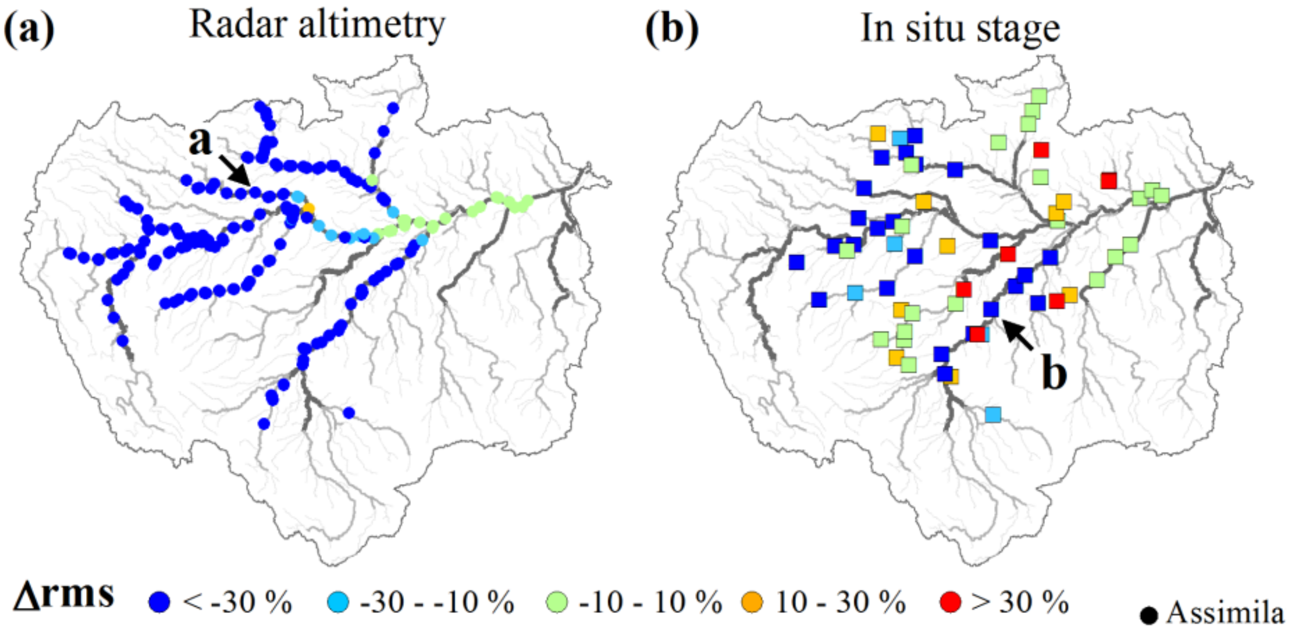
- Use altimetry for model validation (e.g. Paiva et al., 2013 WRR)
- Model calibration using altimetry (e.g. Getirana et al.,)
- Model / Altimetry based rating curves (Paris et al., 2016 WRR)
- Data assimilation (Paiva et al., 2013 HESS)

Ex.: Data Assimilation ENVISAT altimetry

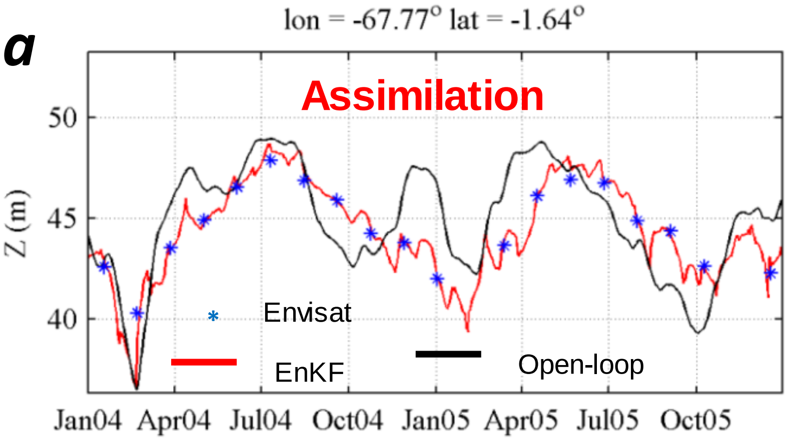
Paiva et al. 2013. HESS

- Ensemble Kalman filter improved water level estimates
- Improvement at daily basis, even though altimetry data has ~35-day temporal resolution

Amazon Basin



a



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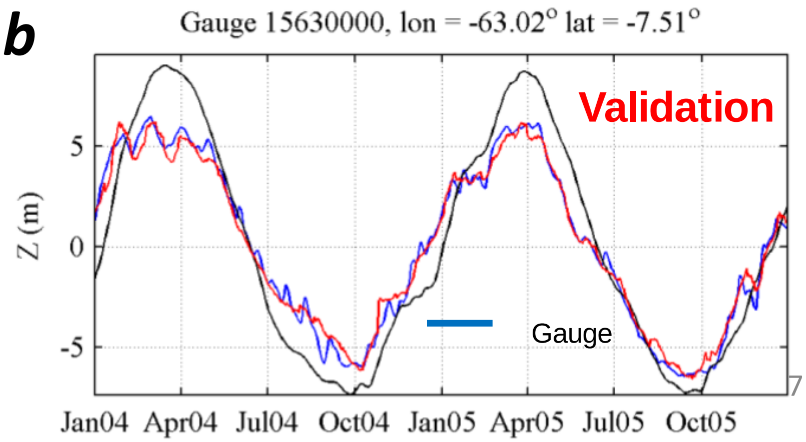

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Mississipi basin
Preliminary results

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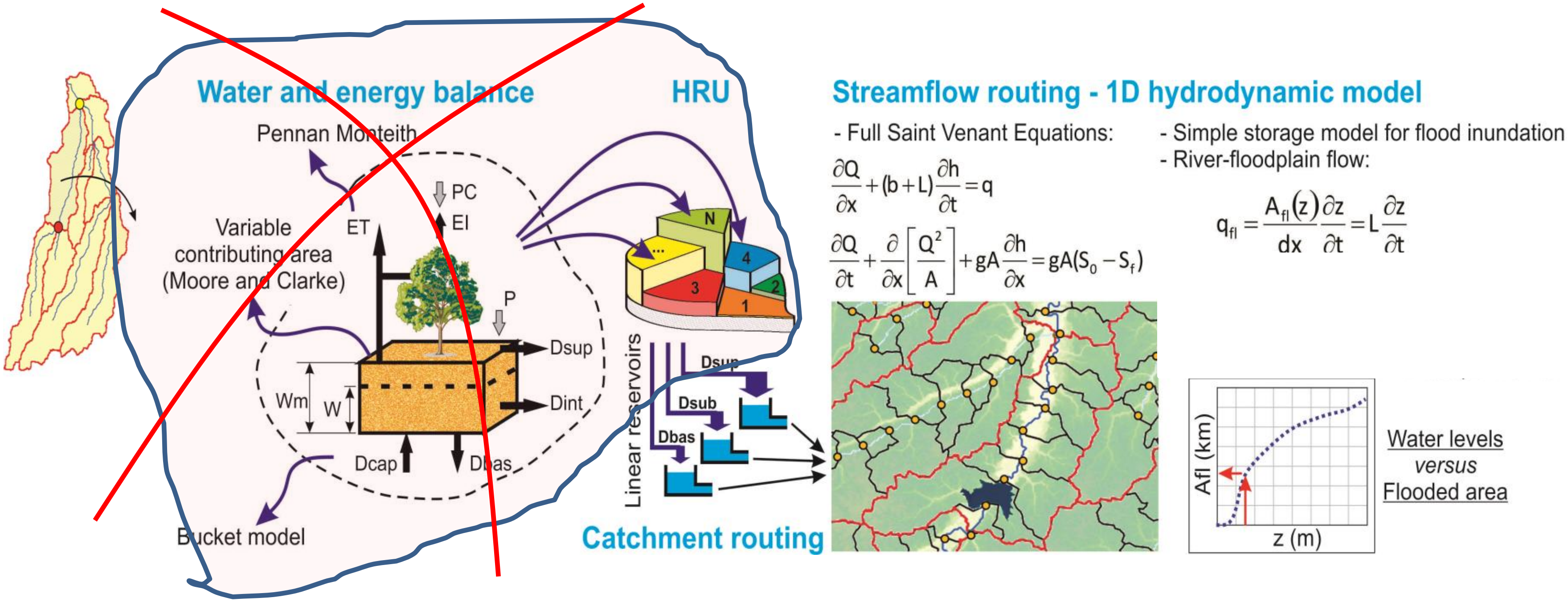

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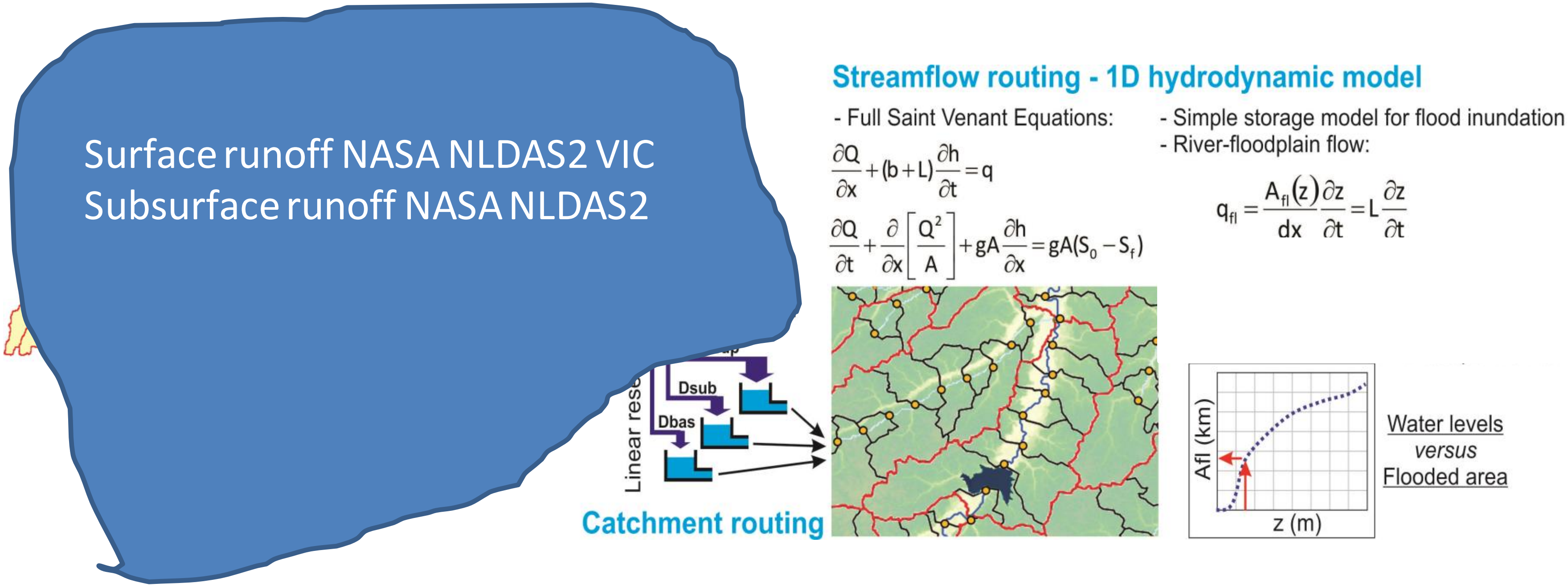

Surface runoff NASA NLDAS2 VIC
Subsurface runoff NASA NLDAS2

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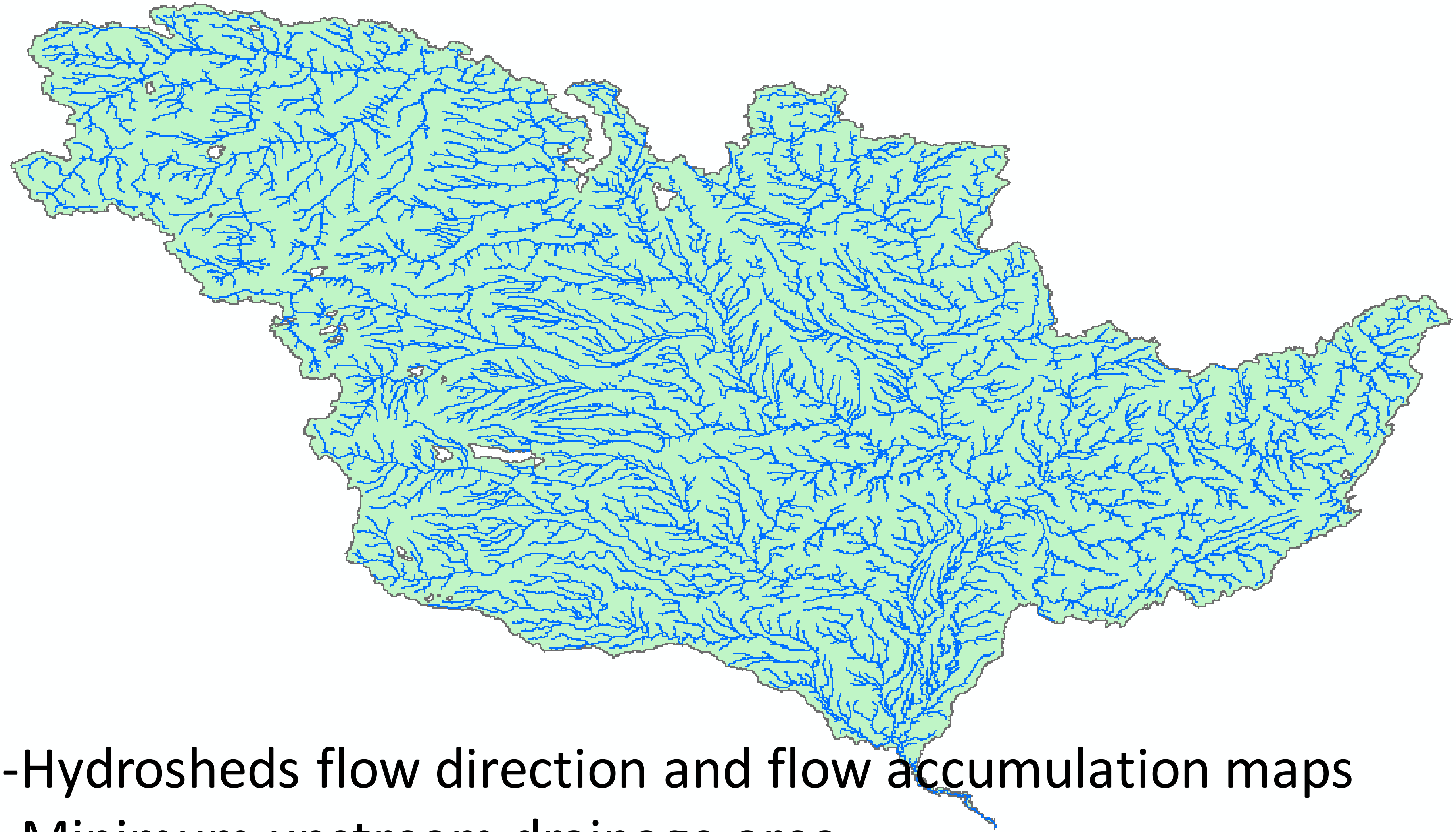
Model River network

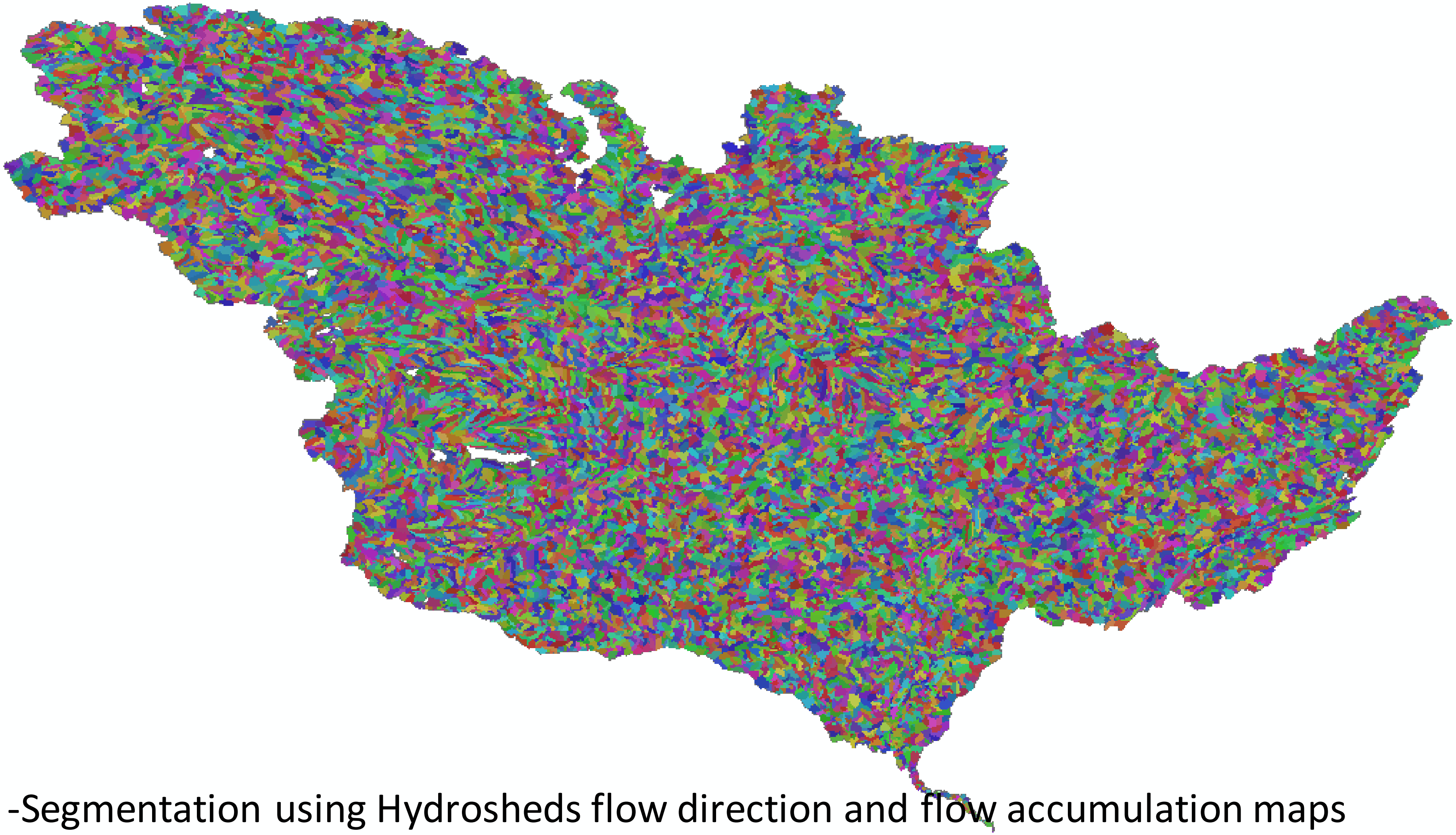


-Hydrosheds flow direction and flow accumulation maps

-Minimum upstream drainage area

- Geoprocessing using IPH Hydro Tools

Model Catchments

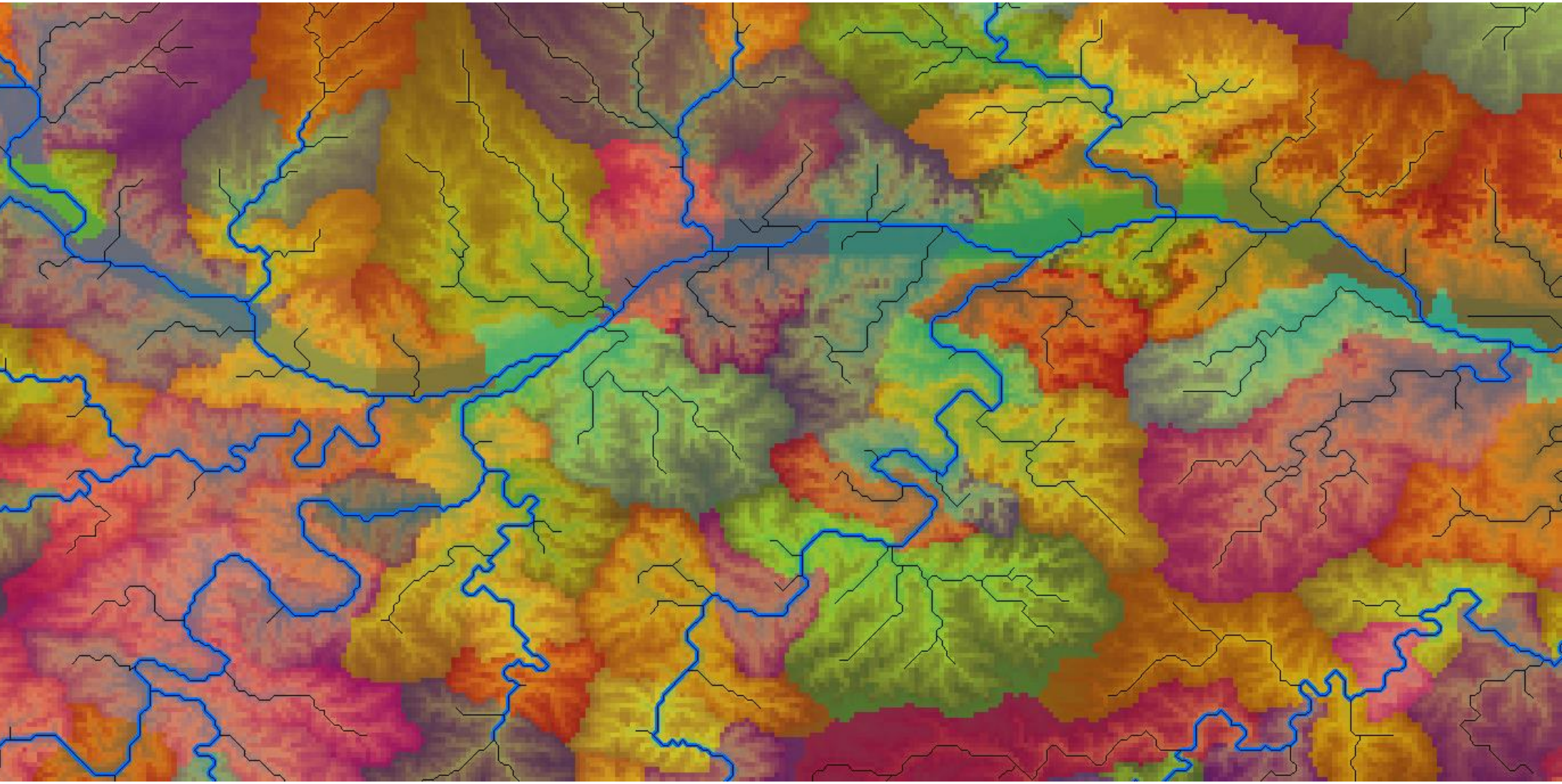


-Segmentation using Hydrosheds flow direction and flow accumulation maps

- ~16,000 Catchments with river reaches of 10 km.

- Geoprocessing using IPH Hydro Tools

Model River network

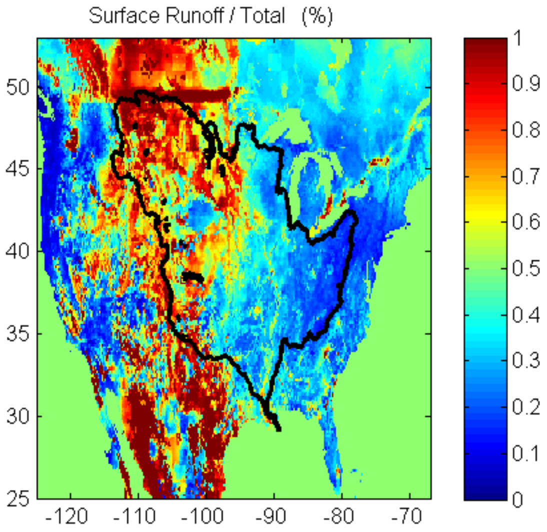


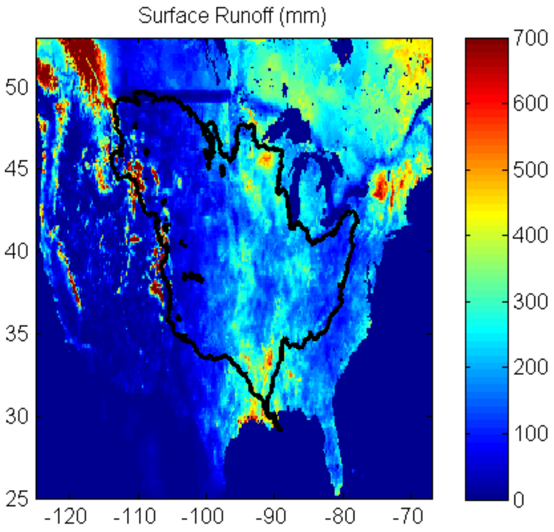
-Hydrosheds DEM

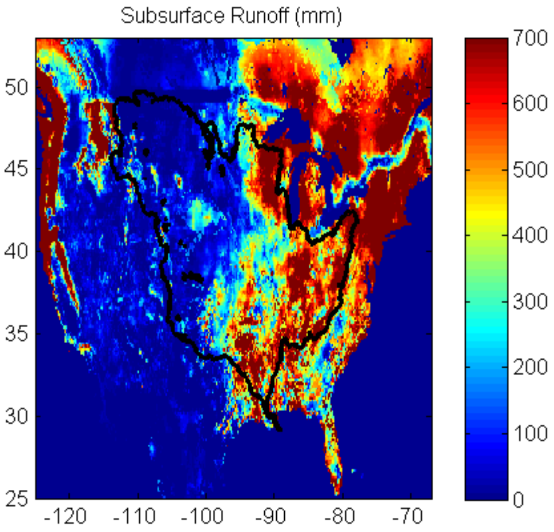
-Catchments with river reaches of 10 km.

- Full hydrosheds river network (thin black lines)

Runoff fields


Surface Runoff / Total (%)


Surface Runoff (mm)


Subsurface Runoff (mm)

Surface runoff NASA NLDAS2 VIC 1/8° 1h
Subsurface runoff NASA NLDAS2 VIC 1/8° 1h

Spatial variability of Surface and Subsurface Runoff

Model parameters

Computational Reach lenght = ~ 10 km

Bankful Width (Andreadis et al. dataset)
Bankful Depth (Andreadis et al. dataset)
Manning’s coeficient: 0.03

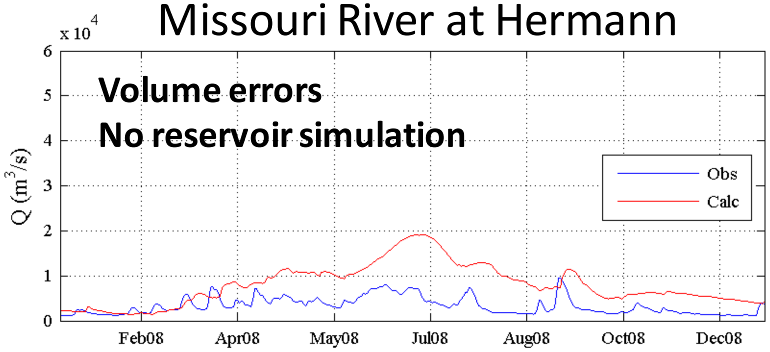
Bed elevation = SRTM Elevation – Bankful Depth

Floodplain topography – Extracted from SRTM HydroSHEDS 15 arcsec

Surface and baseflow routing parameters:
Time of concentration (Kirpich formula using slope and lenght of major tributary)
CS = 10
CB = 10 days

First results: HD model, default W and H

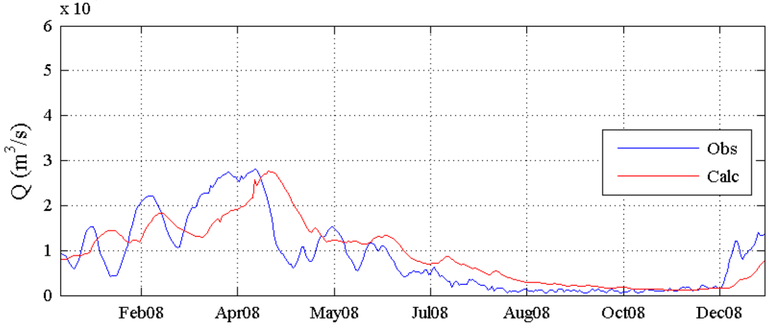
Missouri River at Hermann



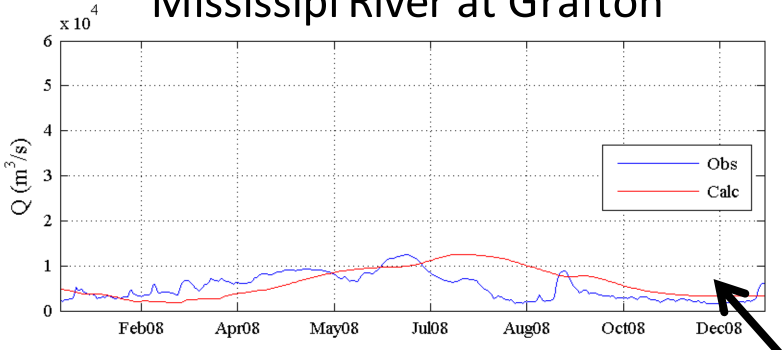
Volume errors

No reservoir simulation

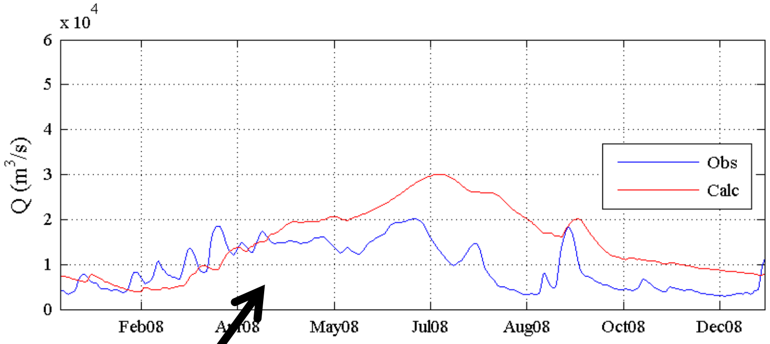
Ohio River at Metropolis



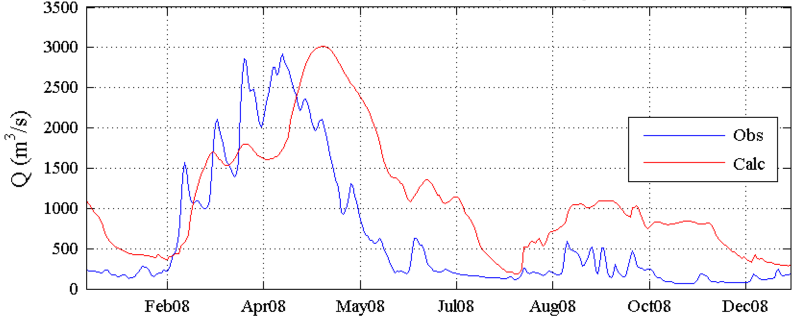
Mississipi River at Grafton



Mississipi River at Thebes

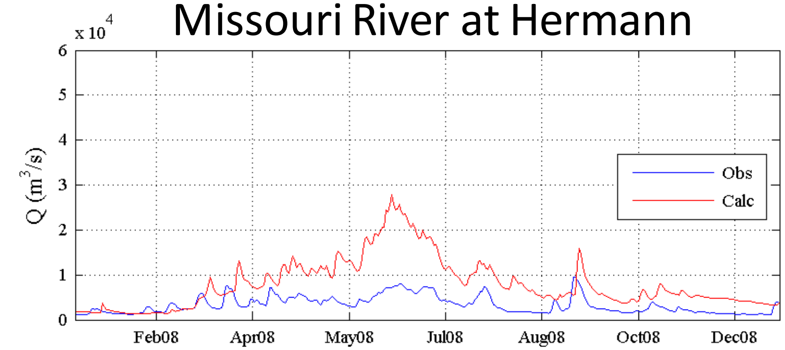


Red River at Spring Bank



Attenuated and delayed hydrograph

Simulations using larger Bankful Depth (H95)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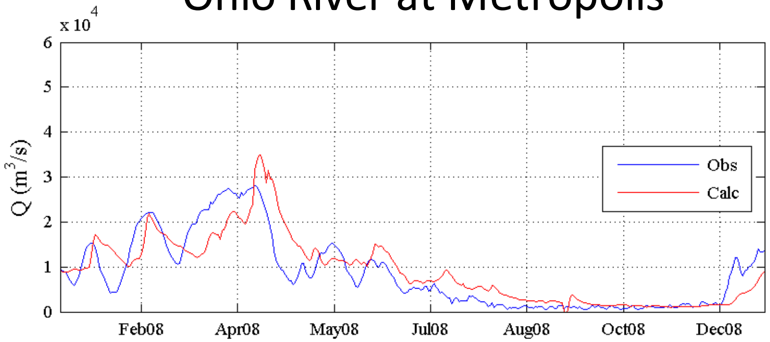
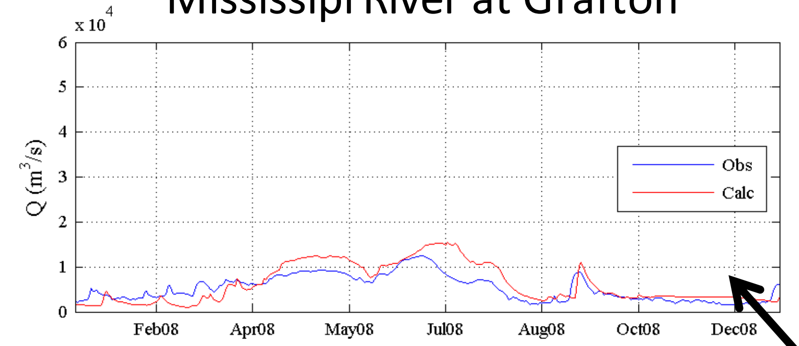

Ohio River at Metropolis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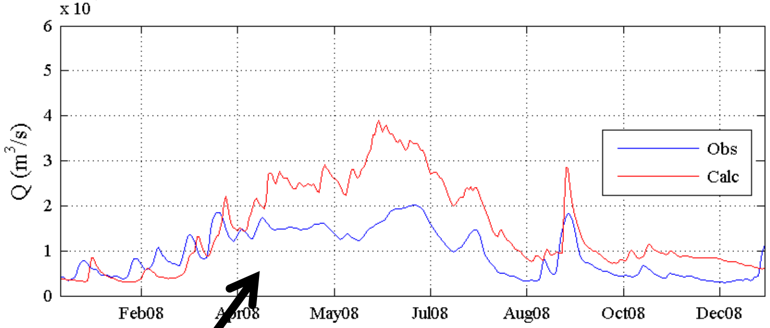
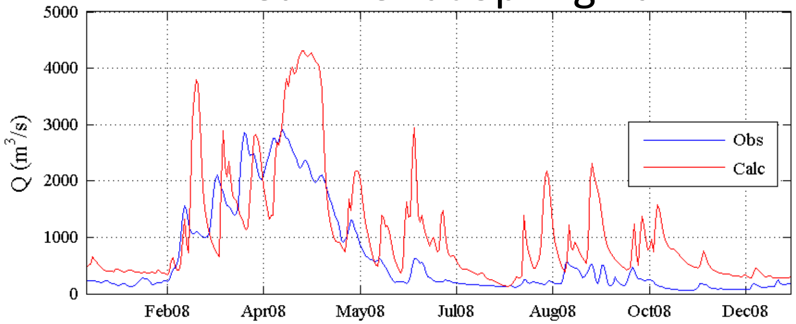
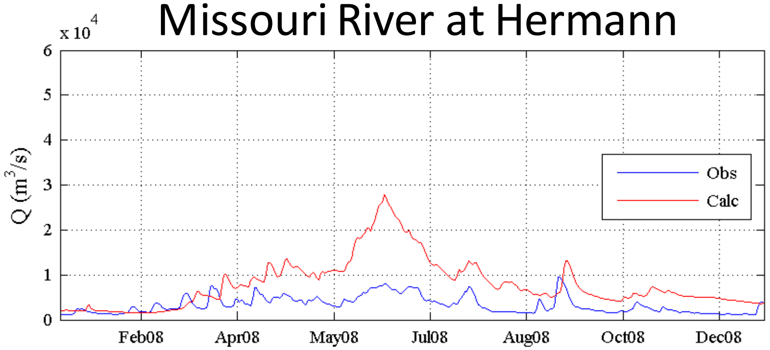

Mississipi River at Thebes


Red River at Spring Bank

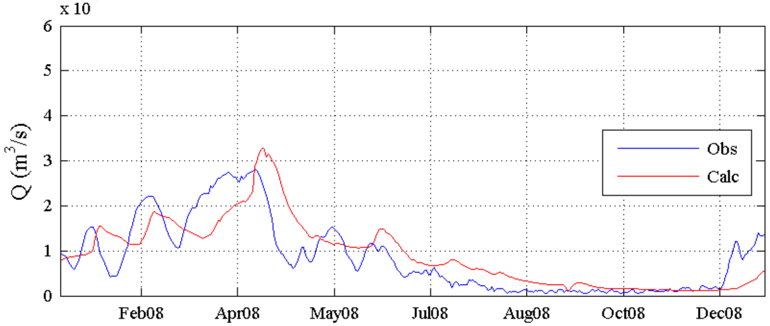
Improved timing

Simulations using larger Bankful Width (W95)

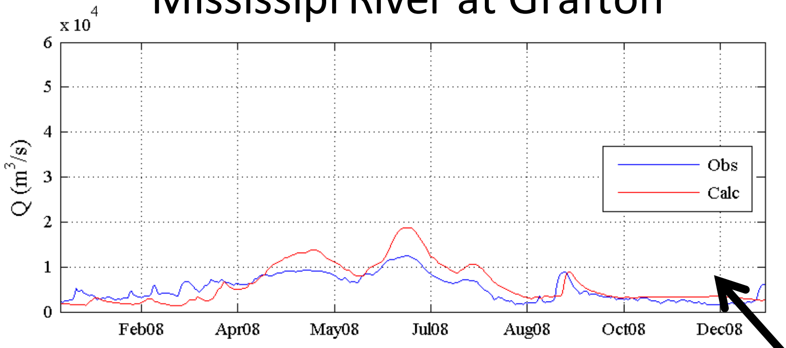
Missouri River at Hermann



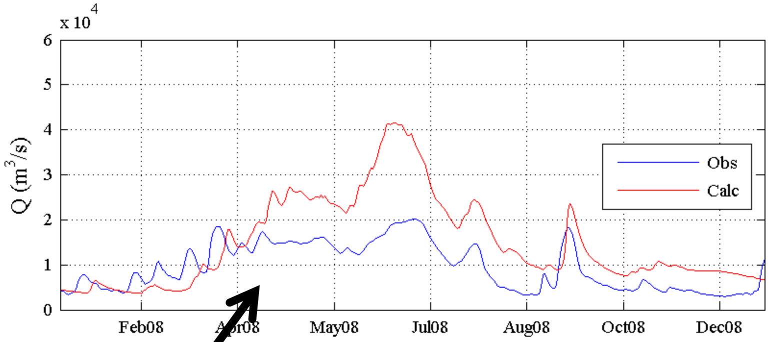
Ohio River at Metropolis



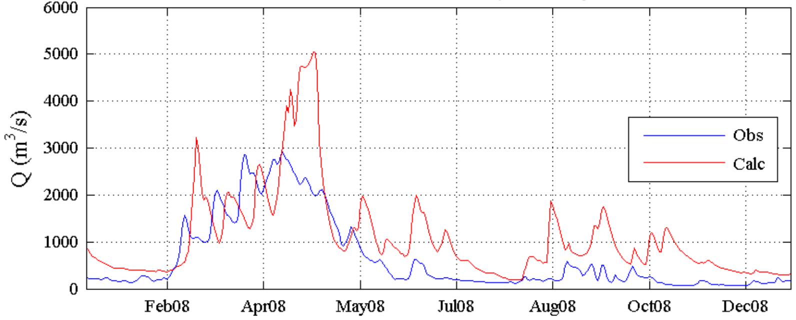
Missisipi River at Grafton



Missisipi River at Thebes

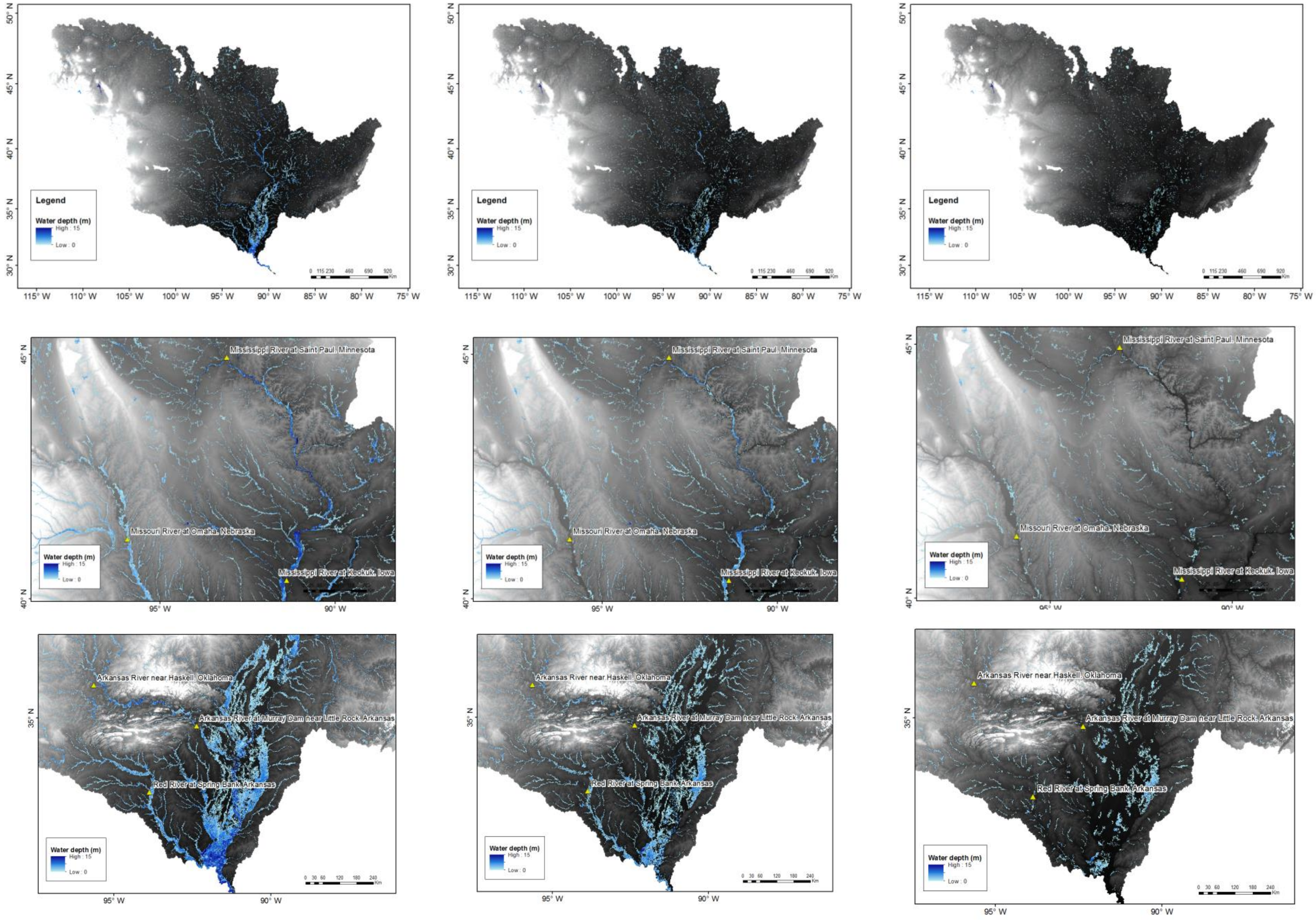


Red River at Spring Bank



Improved timing

Maximum flooded areas



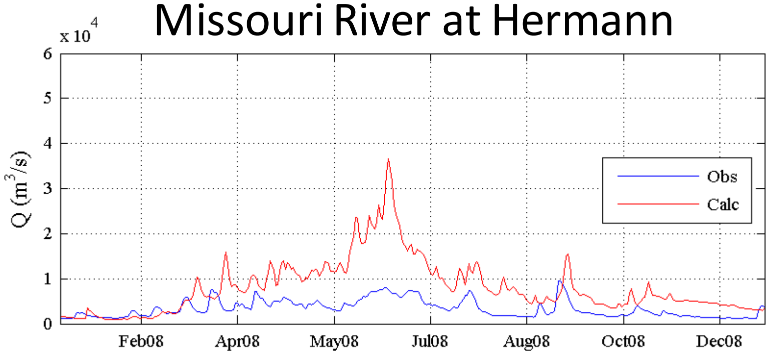
H, W default

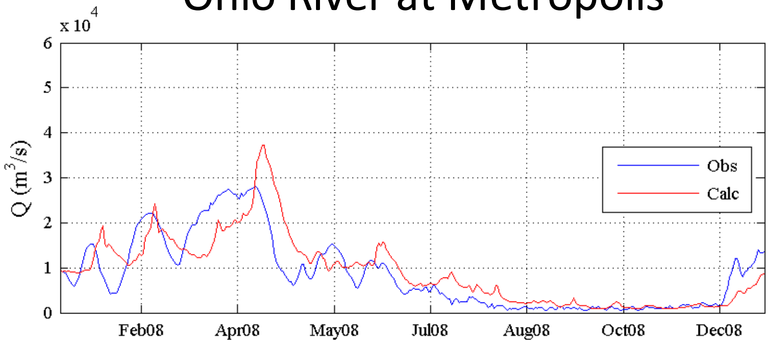
H95, W default

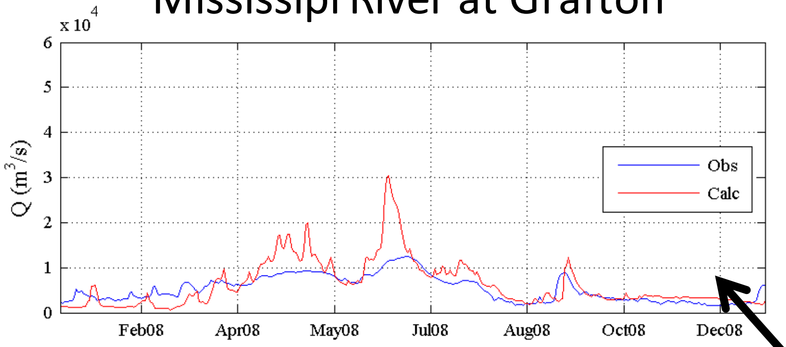
H95, W95

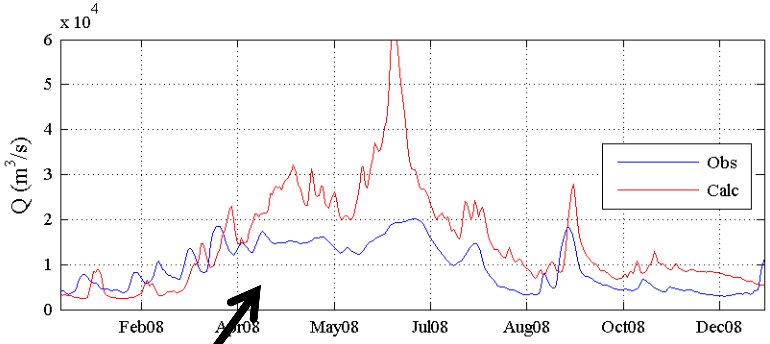
Different parameters change flooding and hydrograph timing

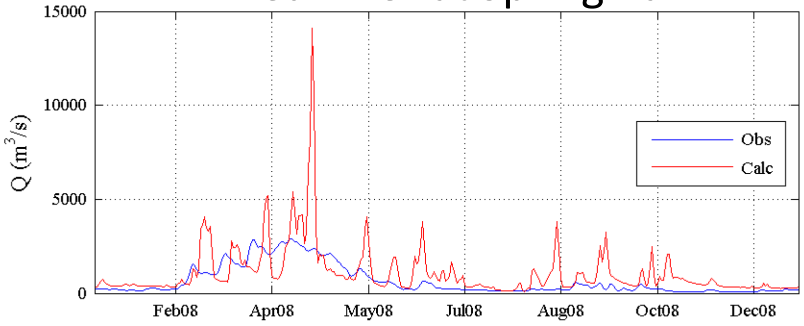
Simulations using Muskingum Cunge Routing (No floodplain or backwater)


Missouri River at Hermann


Ohio River at Metropolis


Mississipi River at Grafton

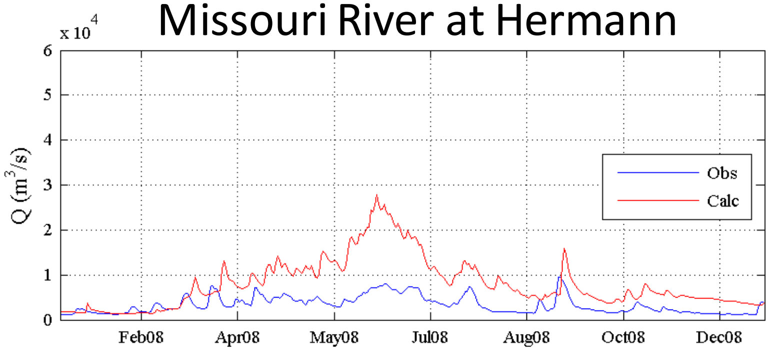

Mississipi River at Thebes


Red River at Spring Bank

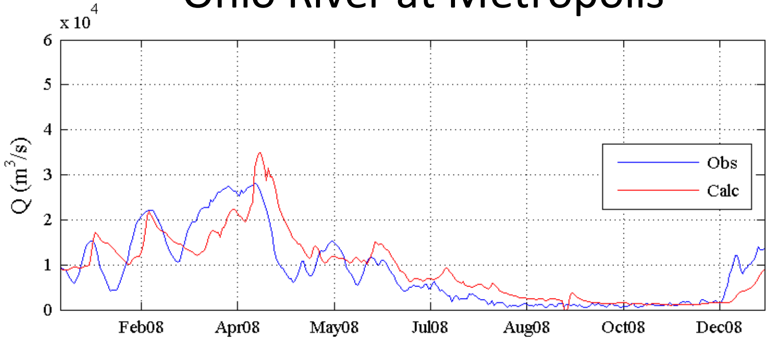
Needs backwater effect and/or inundation?

Simulations using larger Bankful Depth (H95)

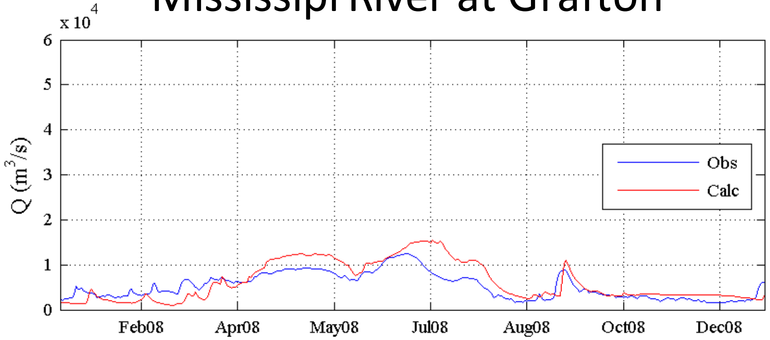
Missouri River at Hermann



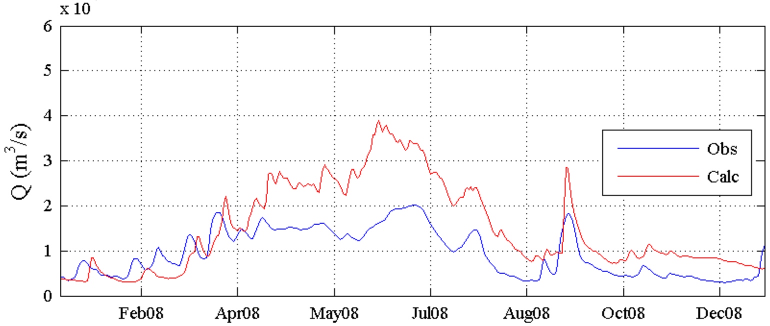
Ohio River at Metropolis



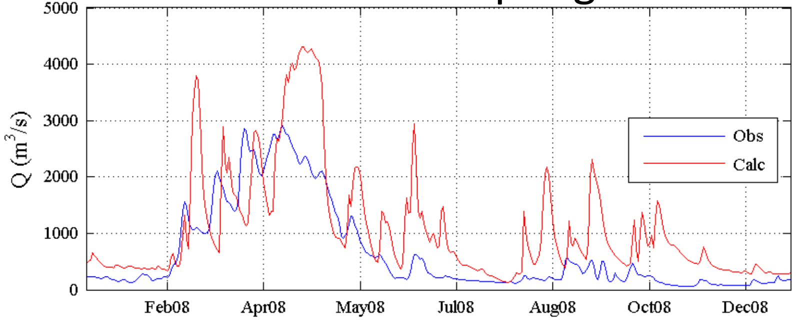
Missisipi River at Grafton



Missisipi River at Thebes

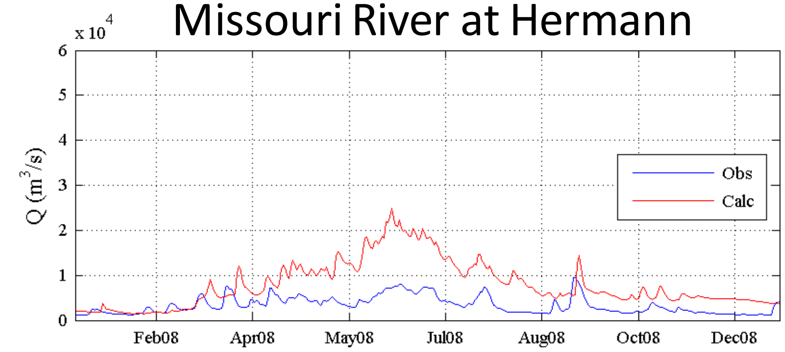


Red River at Spring Bank

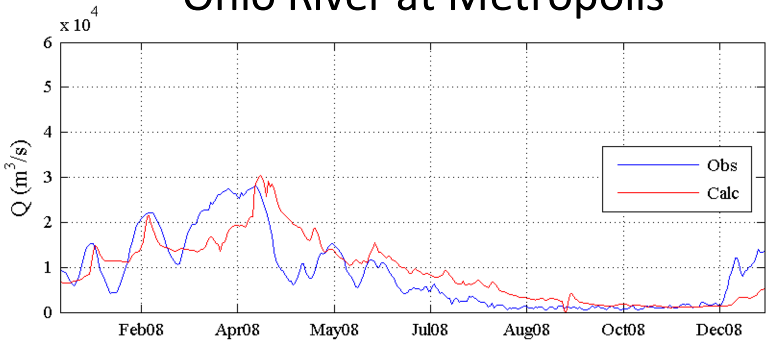


Simulations using Baseflow Routing(Linear reservoir)
CB = 10 days

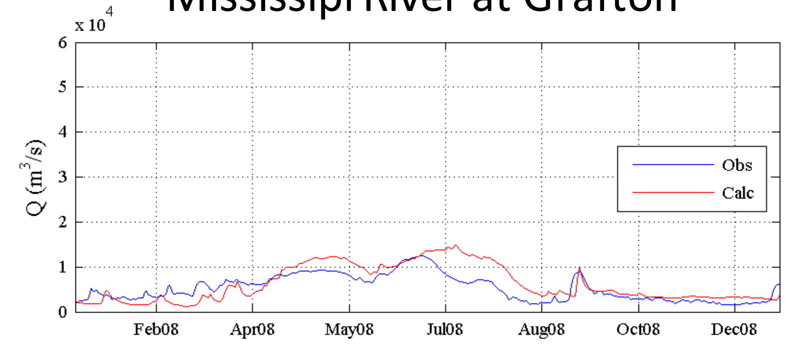
Missouri River at Hermann



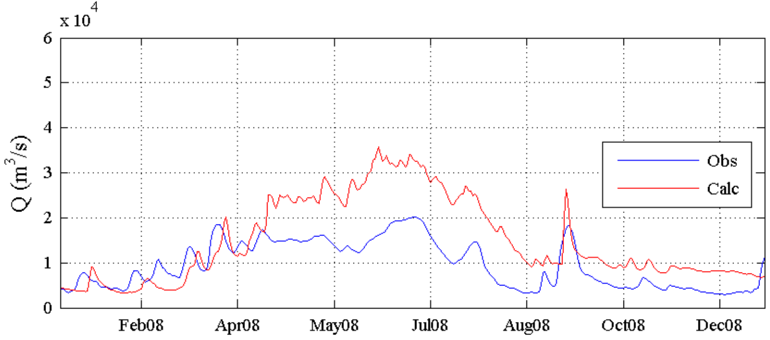
Ohio River at Metropolis



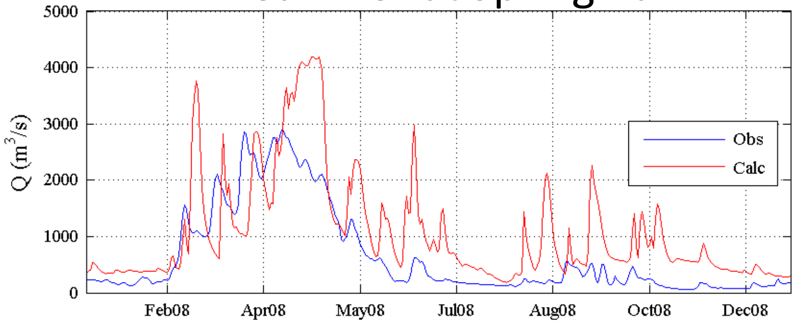
Missisipi River at Grafton



Missisipi River at Thebes



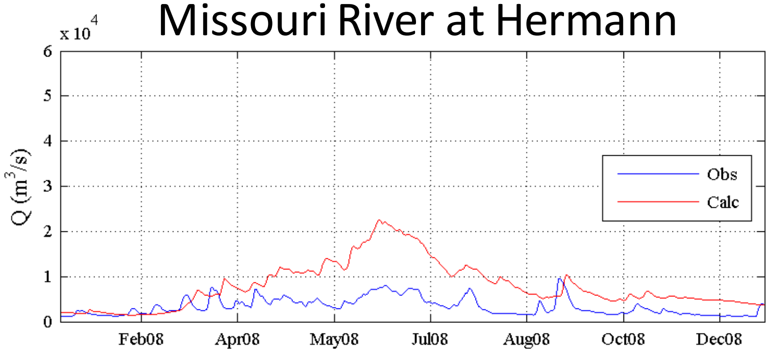
Red River at Spring Bank



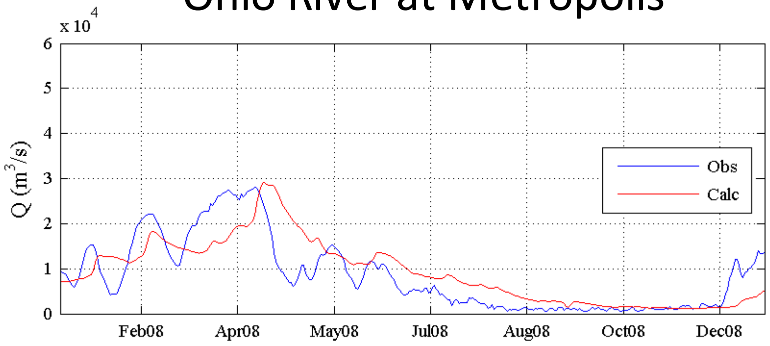
Baseflow routing smooth hydrograph

Simulations using Surface (CS=10) and Baseflow Routing (CB =10days)

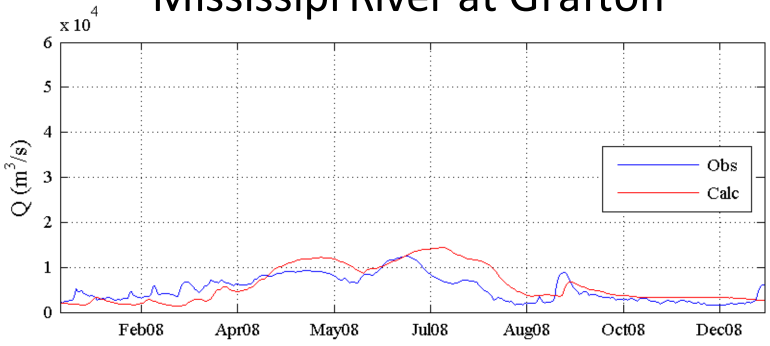
Missouri River at Hermann



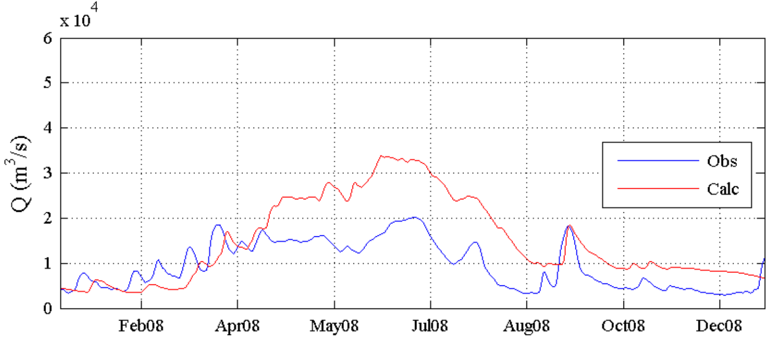
Ohio River at Metropolis



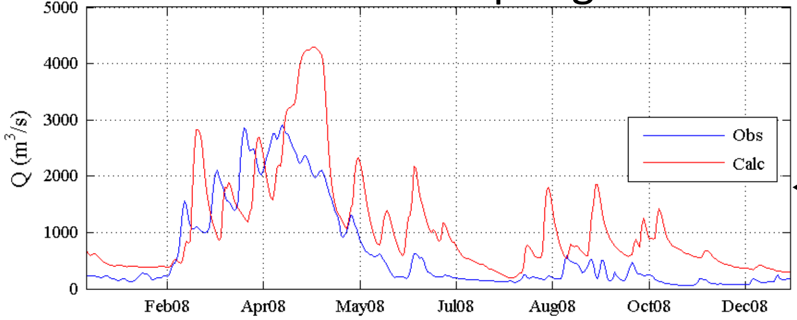
Missisipi River at Grafton



Missisipi River at Thebes



Red River at Spring Bank



← Surface runoff routing attenuates spiky hydrographs

Summary

- Large volume errors
  - Cause may be input runoff or reservoirs

- River geometry input parameters play important role on flooding timing of hydrographs

- Catchment routing smoothes spiky hydrographs

- Backwater and flooding may be important in some rivers

Some MGB References:

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