River Model Inter-comparison for (and before) SWOT

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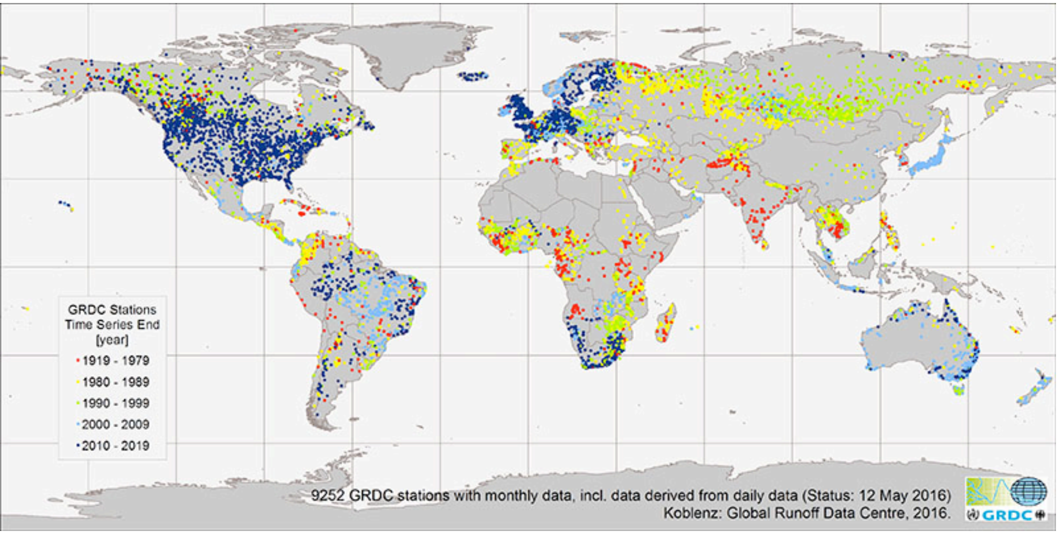
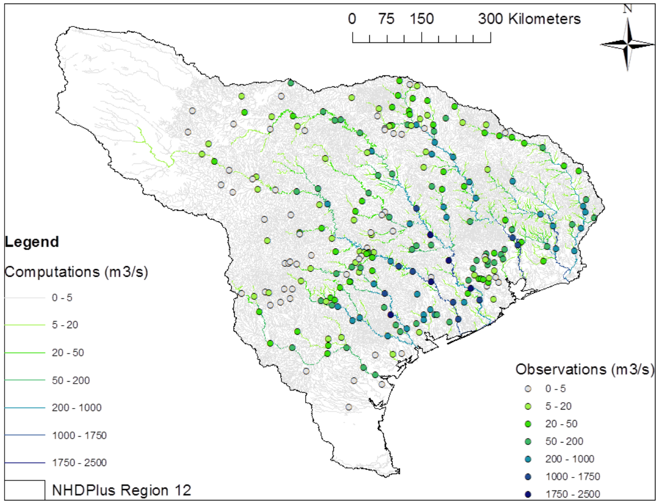
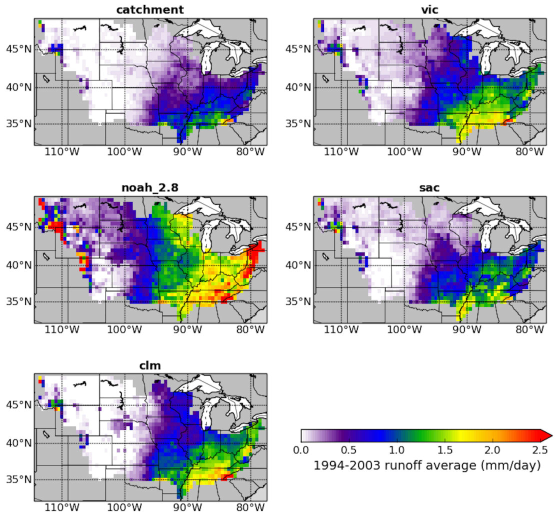
Motivation



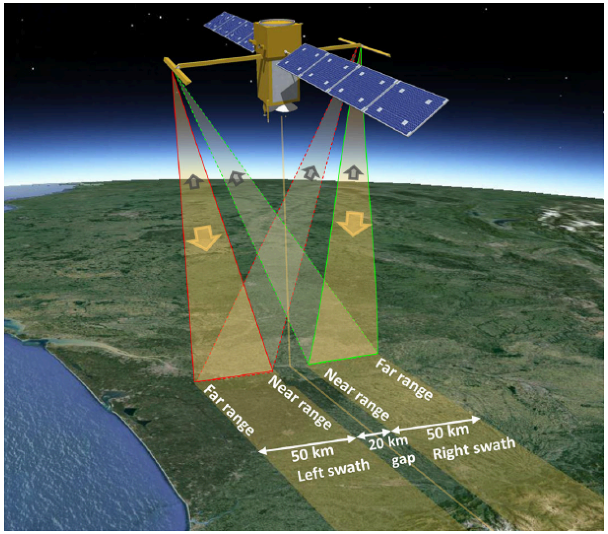
River gauges are disappearing (http://grdc.bafg.de)



Mystery between gauges (David et al. 2013)

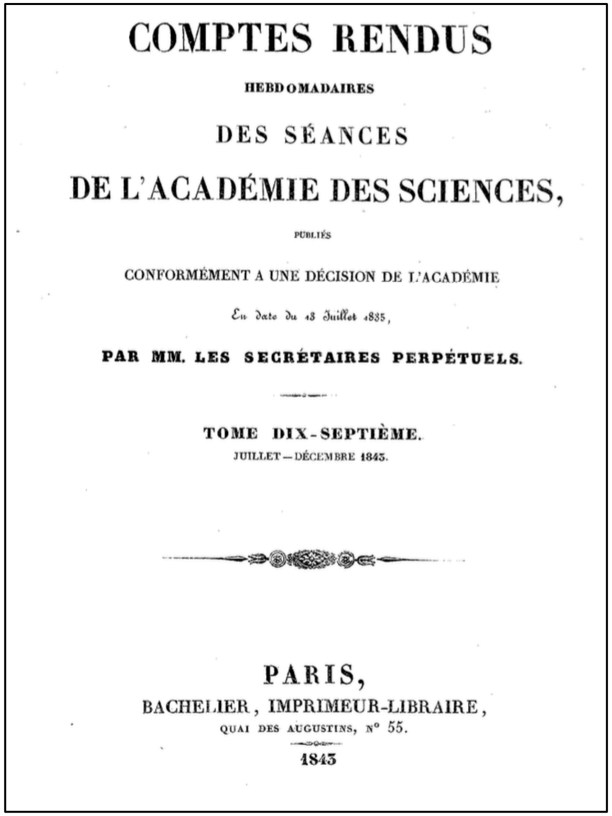


Runoff is uncertain (from D. Lettenmaier)



SWOT should help (Biancamaria et al. 2016)

Background (1/4)



COMPTES RENDUS

HEBDOMADAIRES

DES SÉANCES

DE L'ACADÉMIE DES SCIENCES,

PUBLIÉS

CONFORMÉMENT A UNE DÉCISION DE L'ACADÉMIE

En date du 13 Juillet 1835,

PAR MM. LES SECRÉTAIRES PERPÉTUELS.

TOME DIX-SEPTIÈME.

JUILLET — DÉCEMBRE 1843.

PARIS,

BACHELIER, IMPRIMEUR-LIBRAIRE,

QUAI DES AUGUSTINS, N° 55.

1843

Saint Venant (1843)
→ the golden equations

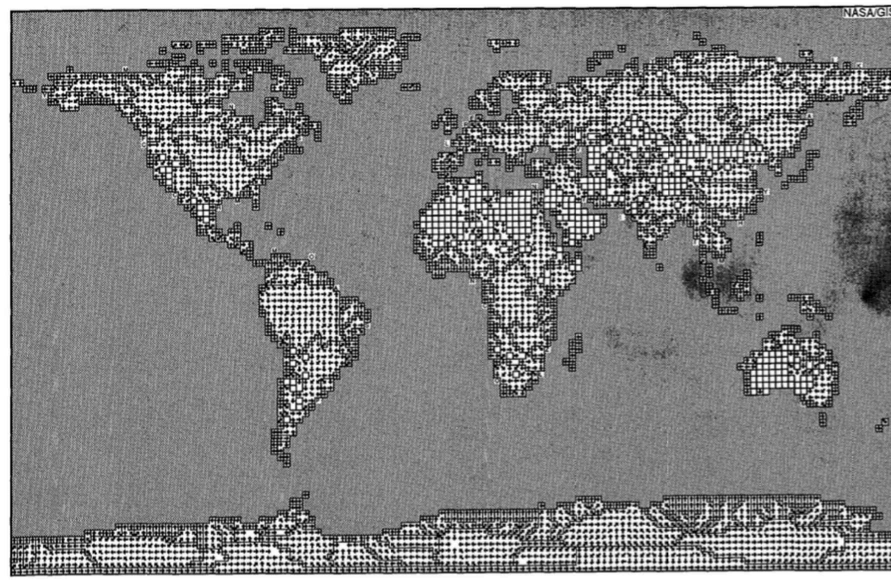


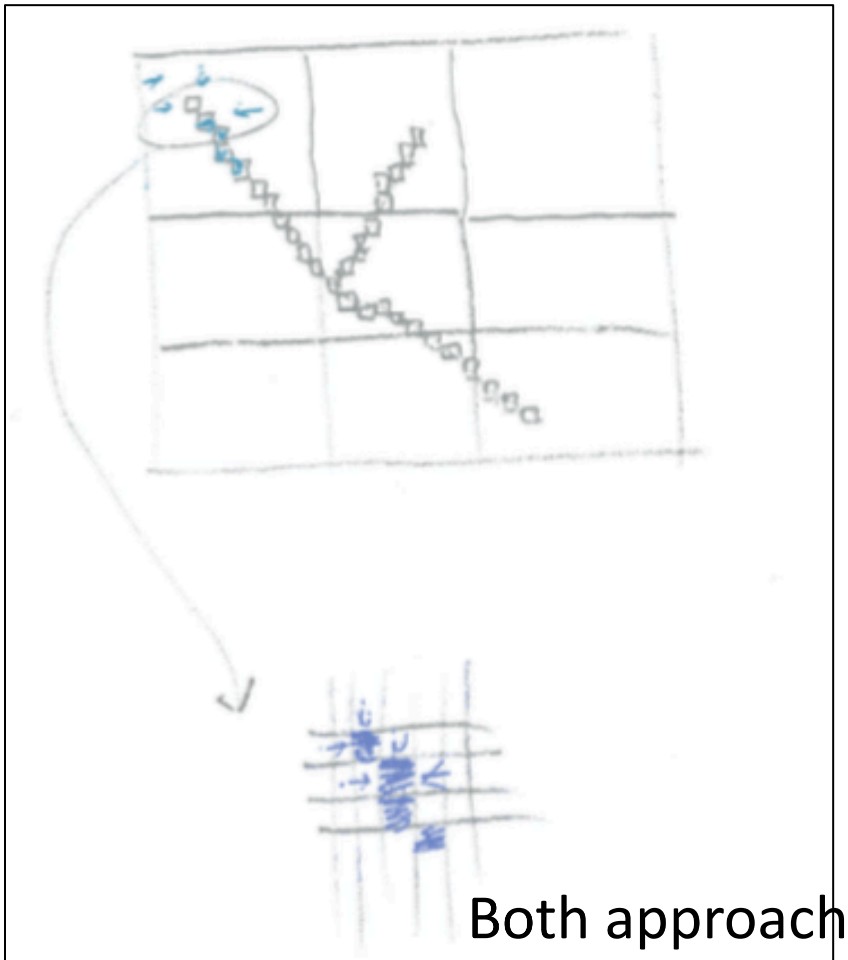
FIG. 1. Direction map for river flow for 2° × 2.5° horizontal grid resolution. Arrows indicate the direction of flow out of a grid box. Boxes without arrows drain internally. A letter corresponding to the first letter of each river's name is located at the river's mouth.

Miller et al. (1994)
→ the first global scale river model

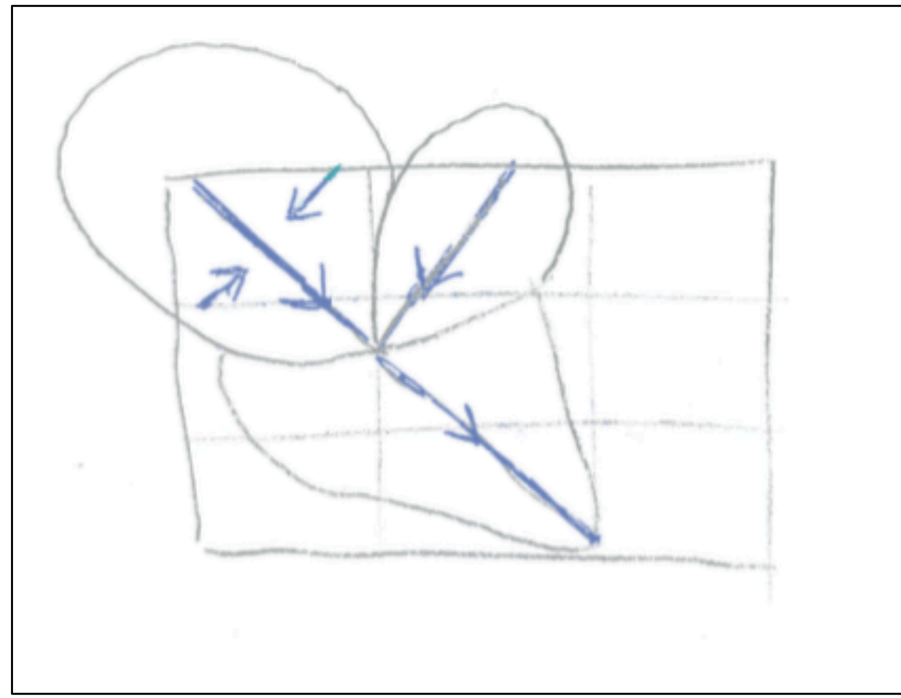
Modeling across scales involves a variety of simplifications

Background (2/4)

A world of grids

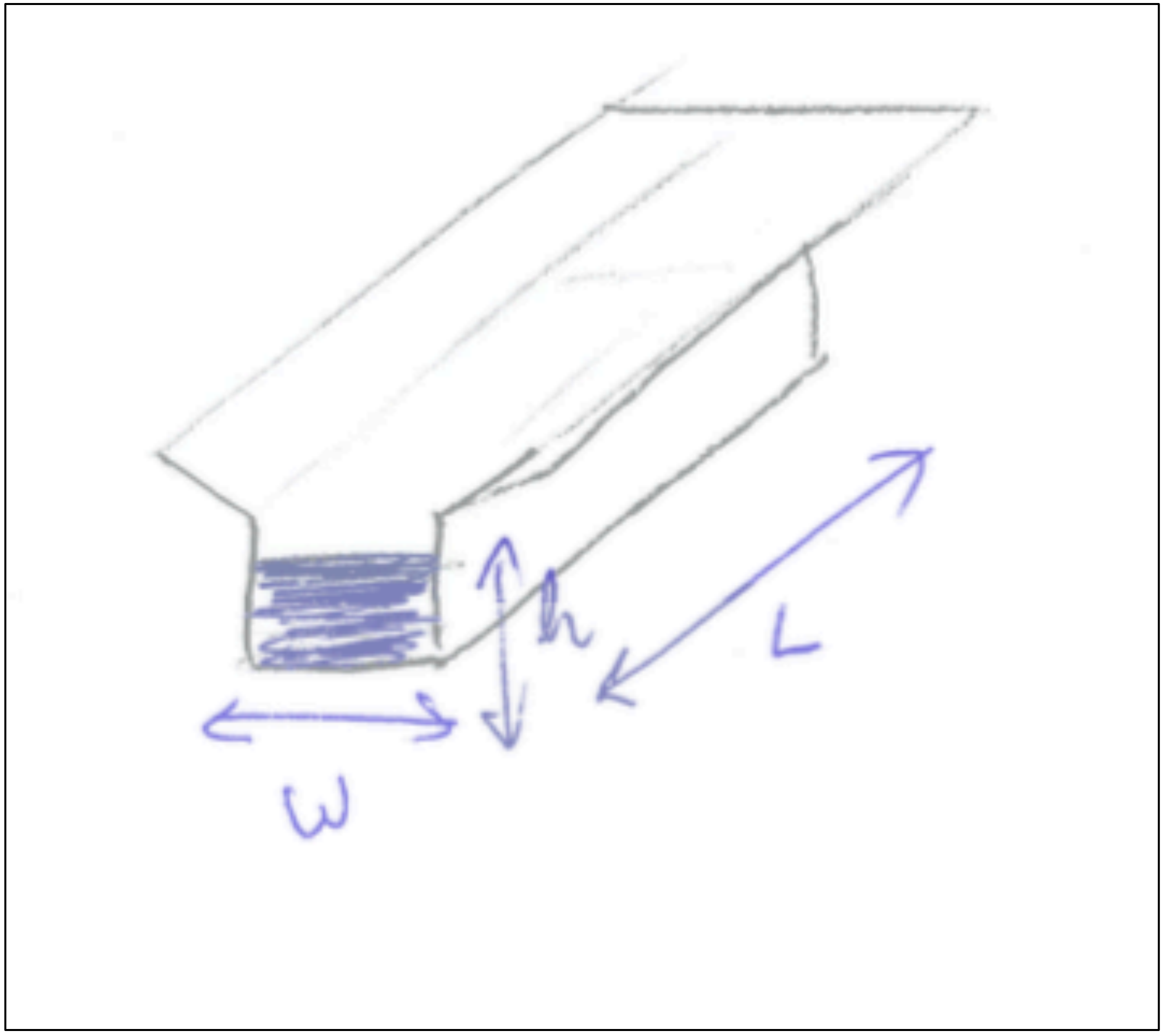


A world of features



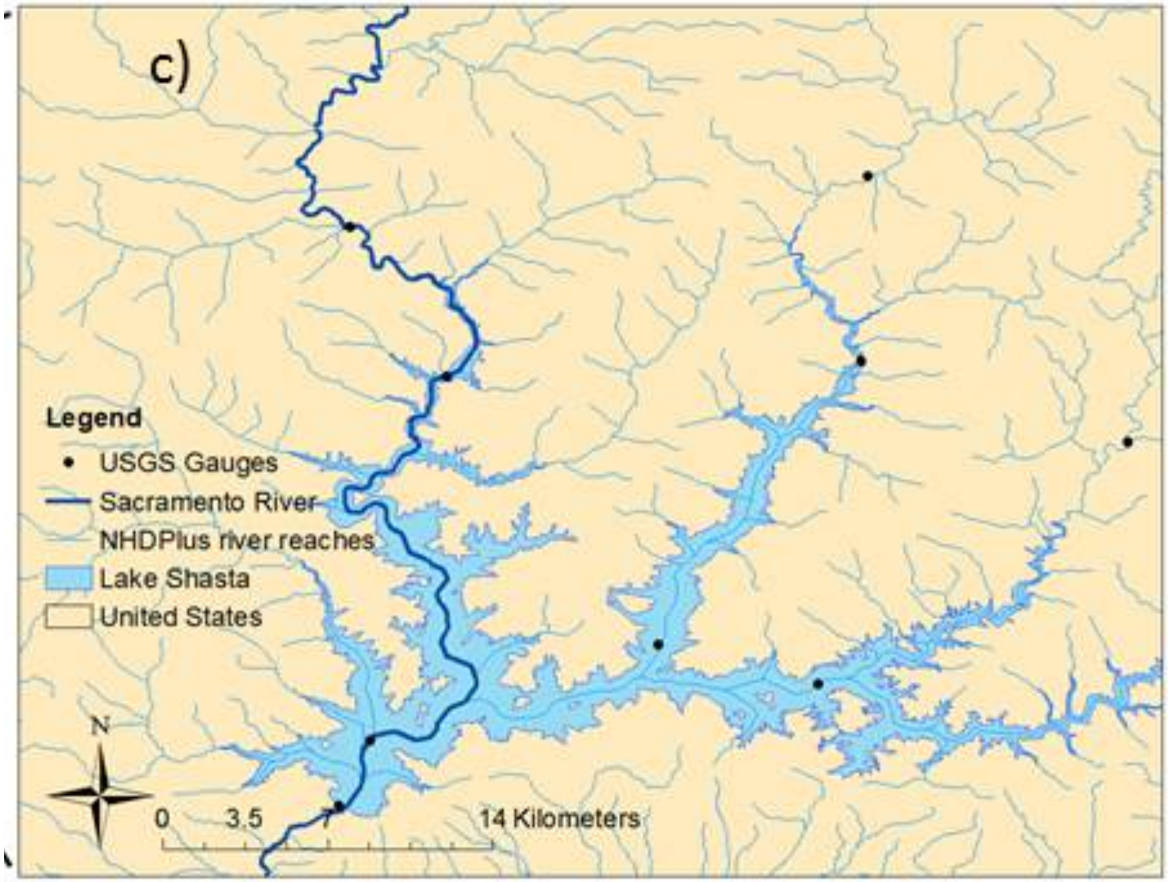
Both approaches are equally frequent

Background (3/4)



A variety of equations is used

Background (4/4)



Anthropogenic effects are often not represented

Objectives

Understanding the best integration methods between expected SWOT terrestrial retrievals and existing global hydrologic/hydrodynamic models

1. How can we best **prepare for the expected SWOT continental to global measurements before SWOT even flies**? That is, how can we understand the relationships between existing **surface water variations and expected SWOT capabilities**?
2. What is the **added value of including SWOT terrestrial measurements into global hydro models** for enhancing our understanding of the terrestrial water cycle and the climate system? Are current global hydrologic models ready to ingest expected SWOT data? What SWOT variable(s) or SWOT-derived product(s) offer the best promise for integration and for data assimilation?

Approach

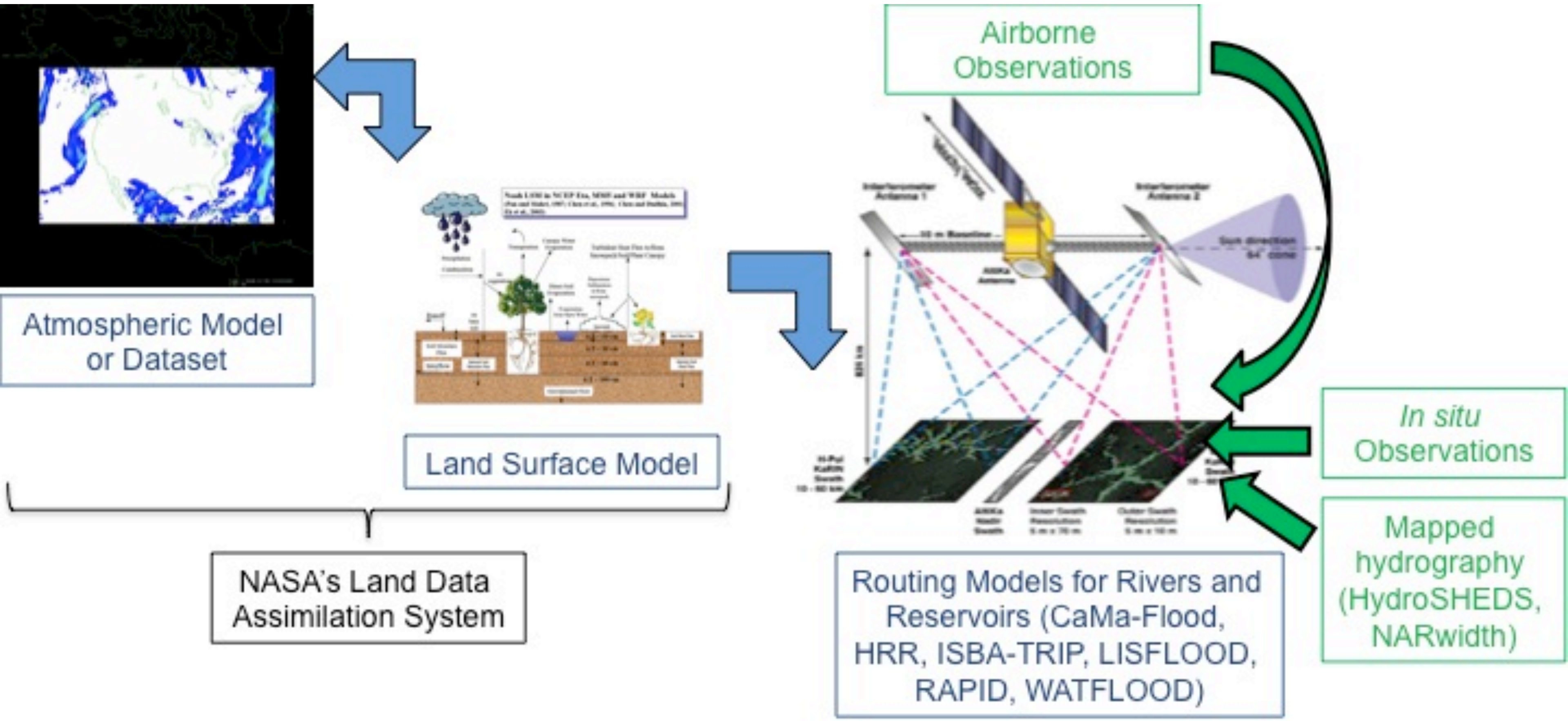
Justification

- Low barrier of entry to engage many
- Consistency among simulations despite model differences (apples/apples)
- Consistency among simulations despite basin differences
- Some expertise of the core team in study areas
- Walking before running

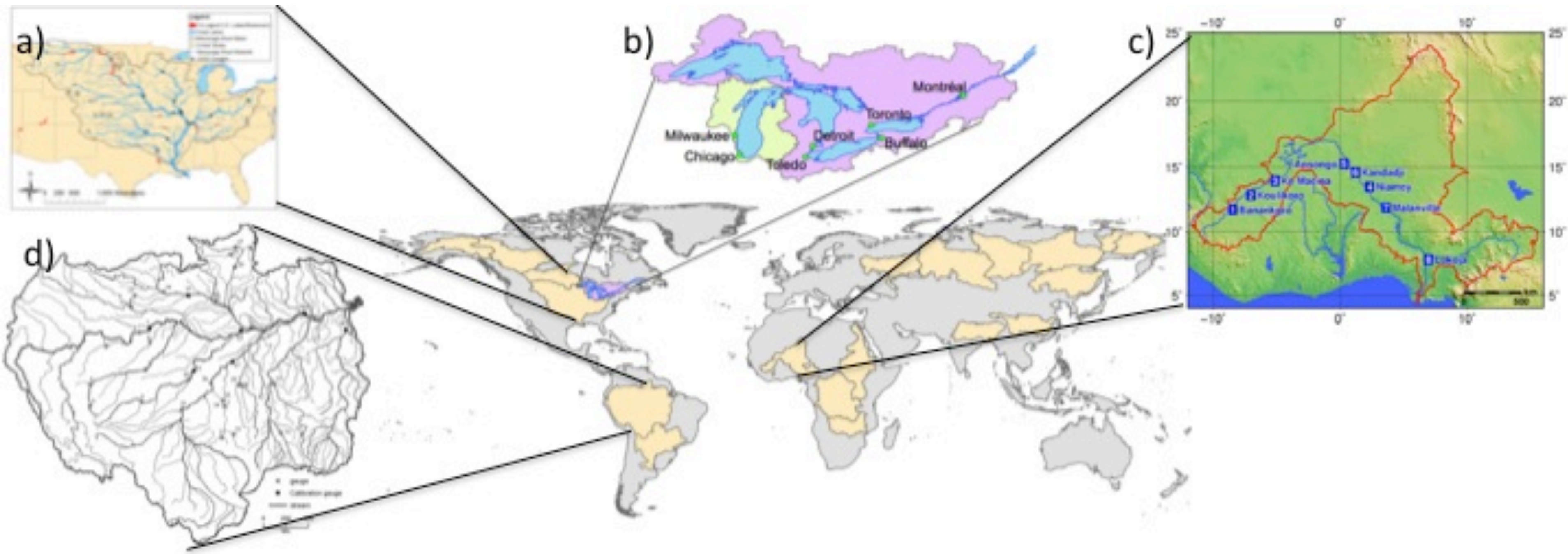
Consequence

- Datasets readily available online
- Same runoff forcing, related topography & river network
- Global availability of data products or modeling methods
- Start with river basins with existing team publications
- Increasing complexity

Modeling paradigm



Four basins in four years



The basins studied in this project benefit from existing studies:

a) the Mississippi [David et al., 2015],
b) Saint-Lawrence [Fry et al., 2014],
c) Niger [Pedinotti et al., 2014],
d) Amazon [Beighley et al., 2009].

Many models

- CaMaFLOOD (D. Yamazaki)
- HRR (E. Beighley)
- LISFLOOD (K. Andreadis)
- RAPID (C. David)
- ISBA-TRIP (A. Boone)
- WATFLOOD (J. M. Fiset)
- MGB-IPH (R. Paiva)
- TRIP (H. Kim)
- Others?

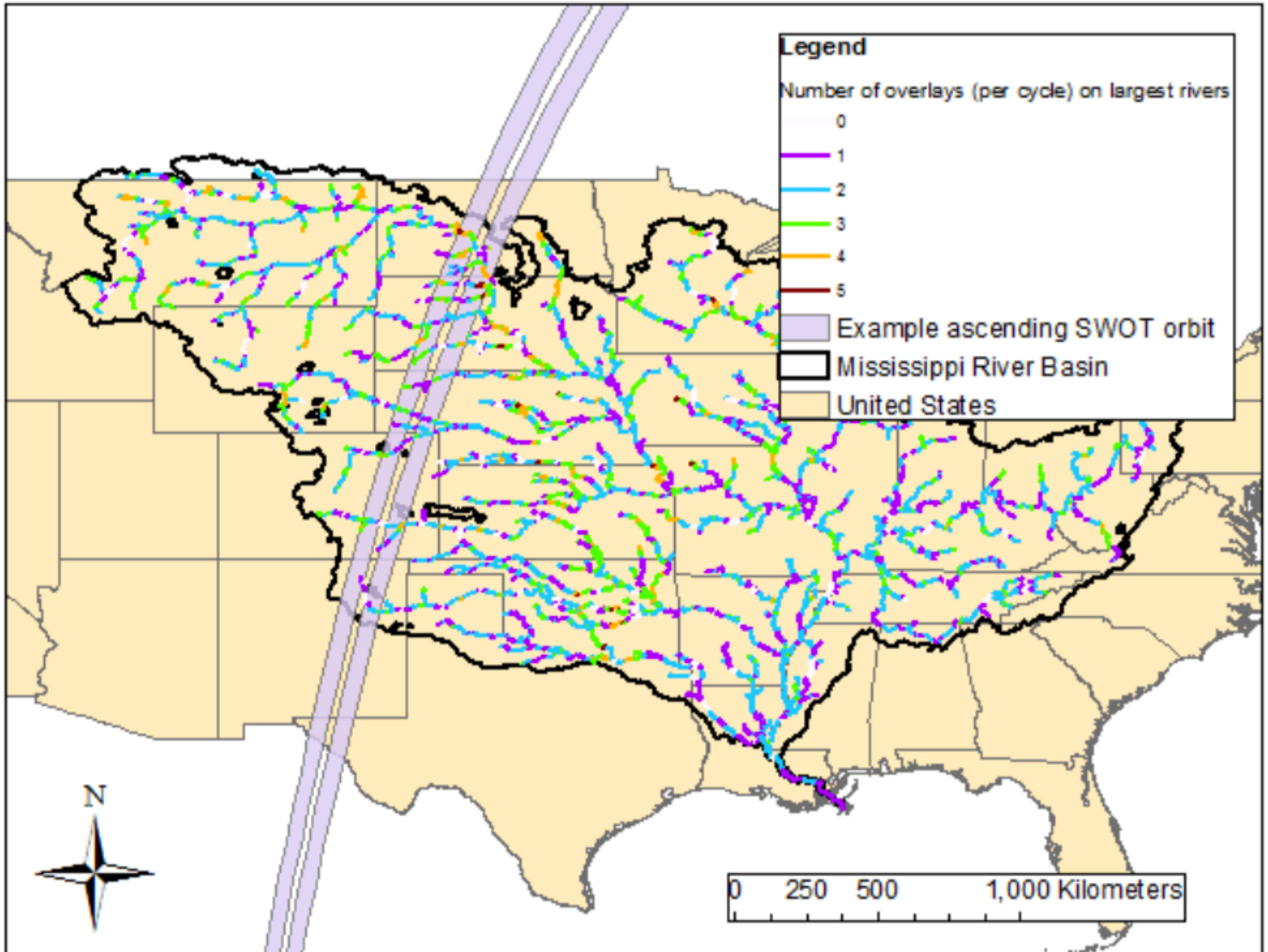
Experimental design

Tasks		2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4	2018 Q1	2018 Q2	2018 Q3	2018 Q4	2019 Q1	2019 Q2	2019 Q3	2019 Q4
Feasibility for applying the SWOT hydrology simulator at continental scale and alternatives	High resolution			1													
	Low resolution			1													
	Vector products			1													
	Method selected				1												
	Simulated truths				1			1				1				1	
Inter-comparison of hydro models	Design/prep.	1				1				1				1			
	Simulations	1				1				1				1			
	Multi-forcing variab.		1				1				1				1		
	Intra-model variab.		1				1				1				1		
	Inter-model variab.		1				1				1				1		
Investigating the integration of SWOT data into all hydro models	Flow				1				1				1				1
	Height				1				1				1				1
	Slope						1		1				1				1
	Width						1			1			1				1
Write scientific papers								1				1				1	1
Total number of tasks per year		12				12				12				12			

Legend
Mississippi
Niger
Saint-Lawrence
Amazon

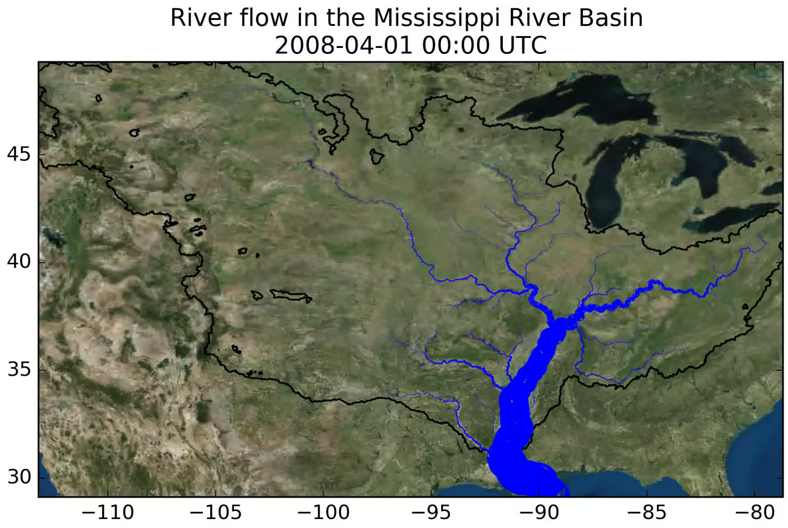
We will combine an inter-comparison framework consisting of a series of six horizontal water transfer schemes: **CaMa-Flood** [Yamazaki et al., 2011], HRR [Beighley et al., 2009], **ISBA-TRIP** [Decharme et al., 2012], **LISFLOOD-FP** [Bates and de Roo, 2000], **RAPID** [David et al., 2011], and **WATFLOOD** [Kouwen et al., 1993]. These models will be fed by runoff produced by the four land surface models of NASA's **GLDAS** [Rodell et al., 2004].

Preliminary results

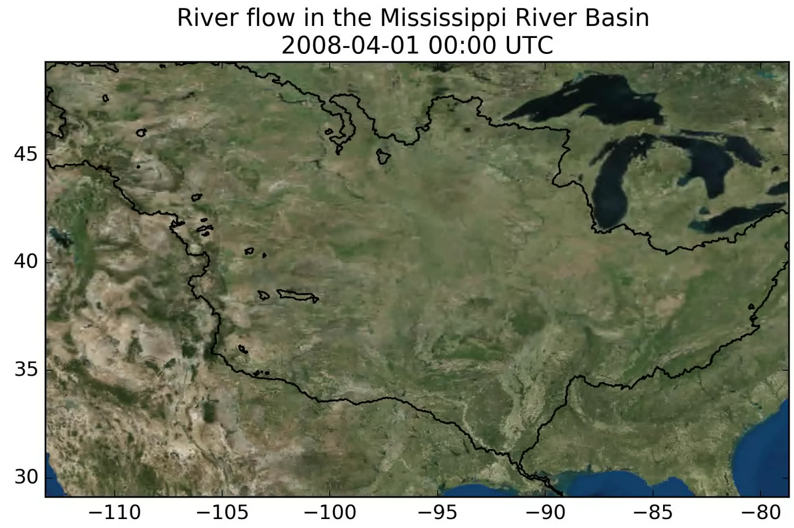


Preliminary work has started to sub-sample continental-scale model outputs based on a tentative SWOT trajectory. This endeavor was performed as community effort and is openly accessible to members of the SWOT Science Team.

SWOT data look alike



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



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

Thickness of blue lines is function of simulated *discharge*
10-year simulation using RAPID (2000-2009), 15-min time step, output every 3-hr
Sub-sampling based on orbit at 890 km altitude, 77.6° inclination, 20.86 days repeat
No observational error accounted for here

Preliminary Mississippi parameters

Edit (2017-06-19), the URL provided was a typo:
ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/NLDAS/NLDAS_VIC0125_H.002/
It's indeed the VIC data that we're using as specified in the "Source"

Data sources

Type	Variable	Source	Spatial res.	Temp. res.	Download link
Runoff	Surface runoff	NASA NLDAS2 VIC	1/8°	1h	~~ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/NLDAS/NLDAS_NOAH0125_H.002/~~
	Subsurface runoff	NASA NLDAS2 VIC	1/8°	1h	~~ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/NLDAS/NLDAS_NOAH0125_H.002/~~
Topography	Gridded DEM	HydroSHEDS	15 arcsec	-	http://hydrosheds.cr.usgs.gov/datadownload.php?reqdata=15demg
	Gridded Flow Accumulation	HydroSHEDS	15 arcsec	-	http://hydrosheds.cr.usgs.gov/datadownload.php?reqdata=15accg
	Gridded Flow Direction	HydroSHEDS	15 arcsec	-	http://hydrosheds.cr.usgs.gov/datadownload.php?reqdata=15dirg
Hydrography	Vector River Network	HydroSHEDS	15 arcsec	-	http://hydrosheds.cr.usgs.gov/datadownload.php?reqdata=15rivs
	Vector River Basin	HydroSHEDS	15 arcsec	-	http://hydrosheds.cr.usgs.gov/datadownload.php?reqdata=15bass
Hydrographic geometry	River reach length	Computed	15 arcsec (HydroSHEDS river network)	-	??? (to be computed after projection to North America Albers Equal Area Conic)
	Catchment area	Computed	15 arcsec (HydroSHEDS river network)	-	??? (to be computed from river reach centroid lon/lat the number of upstream c
	Bankful Width	Computed	15 arcsec (HydroSHEDS river network)	-	??? (to be computed based on equations from Andreadis et al. [2013])
	Bankful Height	Computed	15 arcsec (HydroSHEDS river network)	-	??? (to be computed based on equations from Andreadis et al. [2013])
	Floodplain width	???	???	-	???
River hydraulics	Manning's n	Constant	15 arcsec (HydroSHEDS river network)	-	0.03
	Muskingum k	Computed	15 arcsec (HydroSHEDS river network)	-	??? (to be computed from river length, bankful width, bankful height using TBD e
	Muskingum x	Constant	15 arcsec (HydroSHEDS river network)	-	0.3
Land hydraulic	Manning's n	Constant	15 arcsec (HydroSHEDS river network)	-	0.1

Simulation

Domain	Start time	End time	Output temp res.	Variable
Mississippi	1/1/00	12/31/09	hourly to daily	Q (m^3/s)

Analysis

Locations	Start time (CST)	End time (CST)	Resolution
14 gauges of D	1/1/00	12/31/09	daily

Time line

- 08/31/16
- 08/31/16 – 12/31/16 Analysis
- 12/31/16 Mississippi study completed

Thanks!