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River Model Inter-comparison Project for SWOT¹

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1. NASA's decision to proceed with the SWOT mission will not occur until completion of the National Environmental Policy Act (NEPA) compliance process. SWOT is a proposed NASA mission at this time and the information in this paper is pre-decisional, to be used for planning and discussion purposes only

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Motivation



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



Runoff is uncertain (from D. Lettenmaier)



Mystery between gauges (David et al. 2013)



SWOT should help (Biancamaria et al. 2016)

Background (1/4)





Fig. 1. Direction map for river flow for $2^{\circ} \times 2.5^{\circ}$ 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

Saint Venant (1843) → the golden equations

Modeling across scales involves a variety of simplifications

Background (2/4)

A world of grids



A world of features



Background (3/4)



A variety of equations is used

Background (4/4)



Lake Shasta, CA

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, related hydraulic parameters
- Global availability of data products or modeling methods
- Start with river basins with existing team publications
- Increasing complexity

Modeling paradigm



Such a system could be used to generate SWOT-like data before SWOT launches



River model

SWOT-like data

-80

Such a system could be used to assimilate SWOT data when SWOT launches



SWOT data



River model

-80

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)
- MGB-IPH (R. Paiva)
- Lohman et al. (C. Fisher)
- TRIP (H. Kim)
- ISBA-TRIP (A. Boone)
- WATFLOOD (J. M. Fiset)
- Others?

Experimental design

		2016			2017			2018			2019				Legend			
]	Tasks	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Mississippi
Feasibility for	High resolution			1														Niger
applying the	Low resolution			1														Saint-Lawrence
simulator at	Vector products			1														Amazon
continental scale	Method selected				1													7 mild20m
and alternatives	Simulated truths				1			1				1				1		
	Design/prep.	1				1				1				1				
T	Simulations	1		_		1				1				1				
of hydro models	Multi-forcing variab.		1				1				1				1			
	Intra-model variab.		1				1				1				1			
	Inter-model variab.		1				1				1				1			
Investigating the	Flow				1				1				1				1	
integration of	Height				1				1				1				1	
SWOT data into	Slope]				1	1		1				1				1	
all hydro models	Width]					1			1			1				1	
Write scientific papers								1				1				1	1	
Total number	of tasks per year		1	2			1	2			1	2			1	12		

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].

RivMIP website

RAPID Hub - Interco	omparison × +							
→ i rapid-hub.org/inter	comparison.html	C	C Q Search		☆自◀		◙	=
JPL -								
Home Download Help Publications Documents Animations Training Intercomparison Contact	INTERCOMPARISON General information Welcome to the home of the "Continental-scale hydrologi NASA under Research Oppo Water and Ocean Topography Membership Here is the current list of mei But the more the merrier! If Experimental design is well as the sources from whit Teleconferences We hold monthly teleconfere 2016-07-29 Presentation C.1 2016-07-29 Presentation C.1 2016-08-31 Presentation C.1 2016-08-31 Presentation C.1 2016-08-31 Presentation R.1 2016-08-31 Presentation R.1 2016-08-31 Presentation R.1 2016-10-3 Agenda 2016-10-3 Agenda 2016-10-3 Summary 2016-11-07 Agenda 2016-1205 Summary 2016-11-07 Agenda 2016-1205 Jummary 2016-11-07 Agenda 2017-02-17 Presentation E.1 2016-202 Summary 2017-01-12 Presentation K.1 2017-02-07 Agenda 2017-02-28 Presentation G.1 2017-02-28 Presentation G.2 2017-02-28 Presentation G.3 2017-02-28 Presentation G.3 2017-02-28 Presentation G.3 2017-02-17 Agenda 2017-04-17 Presentation D.2 2017-04-17 Agenda 2017-04-17 Agenda	Surface Water and Ocei c/hydraulic ('hydro') mu truinties in Space and F y Science Team, althoup mbers. y Science Team, althoup mbers. y Science Team, althoup mbers. y Science Team, althoup mores, some of the mater David (fixed typo) David Andreadis Seighley Yamazaki Kim Andreadis David Schumann keshima	an Topography (SWOT) odel inter-comparison". T atm Sciences (ROSES) gh most members are vol ing the team, please dont : Mississippi River Basin ed. ial used in the past are p	Science Team (ST The core of this eff solicitation NPH lunteer participant t hesitate to get in a and includes info rovided below.	r) Working Gro fort is currently ISZDA001N-S s. touch.	up (WG) funded H WOT: St	on yy urface used as	

http://rapid-hub.org/intercomparison.html Current membership Experimental design

Agenda for monthly telecons Presentations Meeting minutes

Design table

Data sources

Туре	Variable	Source	Spatial res.	Temp. res.	Download link
	Surface runoff	NASA NLDAS2 VIC	1/8°	1h	ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/NLDAS/NLDAS_VIC0125_H.002/
	Subsurface runoff	NASA NLDAS2 VIC	1/8°	1h	ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/NLDAS/NLDAS_VIC0125_H.002/
	Surface and subsurface only (grad files)	NASA NLDAS2 VIC	1/8°	1h	http://hydro.iis.u-tokyo.ac.jp/~yamadai/tmp/SWOT-MIP/grads.tar.gz
Runoff	Surface and subsurface only (geotiff files)	NASA NLDAS2 VIC	1/8°	1h	http://hydro.iis.u-tokyo.ac.jp/~yamadai/tmp/SWOT-MIP/gtiff.tar.gz
	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
	Gridded DEM (changed format)	Computed	15 arcsec	-	http://hydro.iis.u-tokyo.ac.jp/~yamadai/tmp/SWOT-MIP/mi1.condem.tif
Topography	Gridded DEM (adjusted for no negative ele	Computed	15 arcsec	-	http://hydro.iis.u-tokyo.ac.jp/~yamadai/tmp/SWOT-MIP/mi1.elevtn.tif
	Vector River Network	HydroSHEDS	15 arcsec	-	http://hydrosheds.cr.usgs.gov/datadownload.php?reqdata=15rivs
Hydrography	Vector River Basin	HydroSHEDS	15 arcsec	-	http://hydrosheds.cr.usgs.gov/datadownload.php?reqdata=15bass
	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 cells, and a spherical Earth of radius a-f/3 for WGS84 spheroid)
	Bankful Discharge	Computed	15 arcsec (HydroSHEDS river network)		http://doi.org/10.5281/zenodo.61758
	Bankful Width	Computed	15 arcsec (HydroSHEDS river network)	-	http://doi.org/10.5281/zenodo.61758
Hydrographic	Bankful Height	Computed	15 arcsec (HydroSHEDS river network)	-	http://doi.org/10.5281/zenodo.61758
geometry	Floodplain width	???	???	-	???
	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 equation)
River hydraulics	Muskingum x	Constant	15 arcsec (HydroSHEDS river network)	-	0.3
Land hydraulics	Manning's n	Constant	15 arcsec (HydroSHEDS river network)	-	0.1
Observations	River discharge	USGS NWIS DV	Irregularly spaced points	24h	http://waterdata.usgs.gov/nwis/dv & http://rapid-hub.org/docs/SWOT_ST_WG_Example_Outputs.csv & http://rapid-hub.org/docs/SWOT_ST_WG_C
Model outputs	River discharge	All of us	Irregularly spaced points	24h	See example given above

Simulation

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

Last update 12/6/16

Analysis

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

File formats



14 locations throughout the Mississippi River Basin

As specified in experimental design table:

http://rapid-hub.org/docs/SWOT_ST_WG_Mississippi_Experimental_Design.pdf

Processing toolbox



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

Currently being updated with the Python scripts for analysis

E README.md



build passing

The Reproducible Routing Rituals (RRR) is a Python and bash shell toolbox that combines many repetitive pre and post-processing tasks that are common to studying the movements of water on and underneath the land surface. Such tasks include the preparation of files corresponding to:

Preliminary results





Outlet of Missouri River





Outlet of Upper Mississippi River





Outlet of Ohio River





Parallel: the variety of Land Surface Models





We have a similar variety in the river modeling world

Mosaic



Noah MP



CLM

NASA's Land Information System (GSFC)



... is a crucial component of GRACE studies





🛅 JPL 👻						
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A similar system can be built with multiple river/lake models for SWOT...



Thanks! Questions?