Evaluating the Surface Water Ocean Topography Mission Hydrologic Observations

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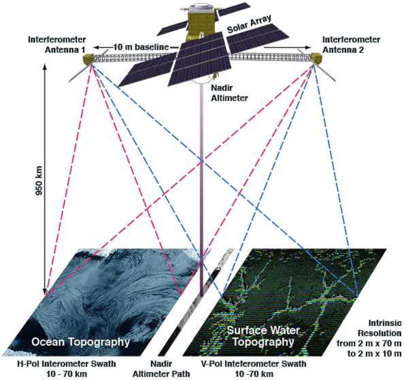
The SWOT satellite

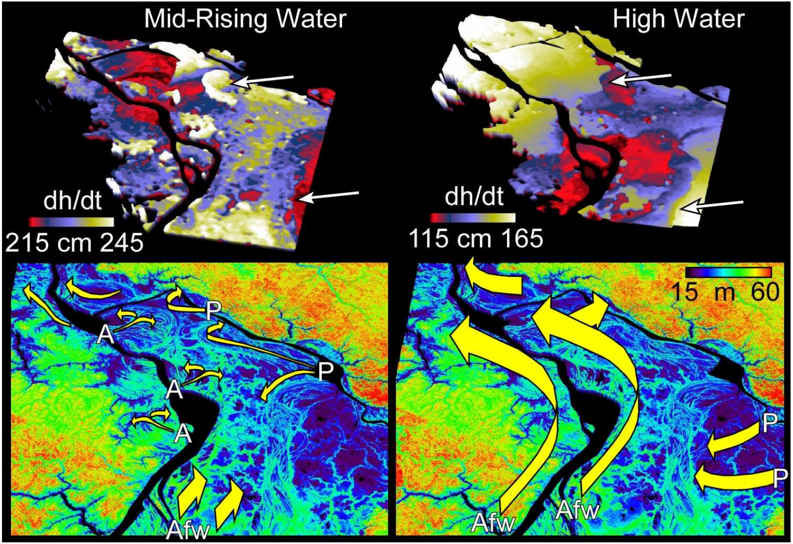


- Surface Water Ocean Topography (SWOT) satellite mission
- Ka-band SAR interferometric system
- Two swaths, 10 and 60 km on each side of the nadir track
- WSOA and SRTM heritage
- Produces heights and co-registered all weather imagery

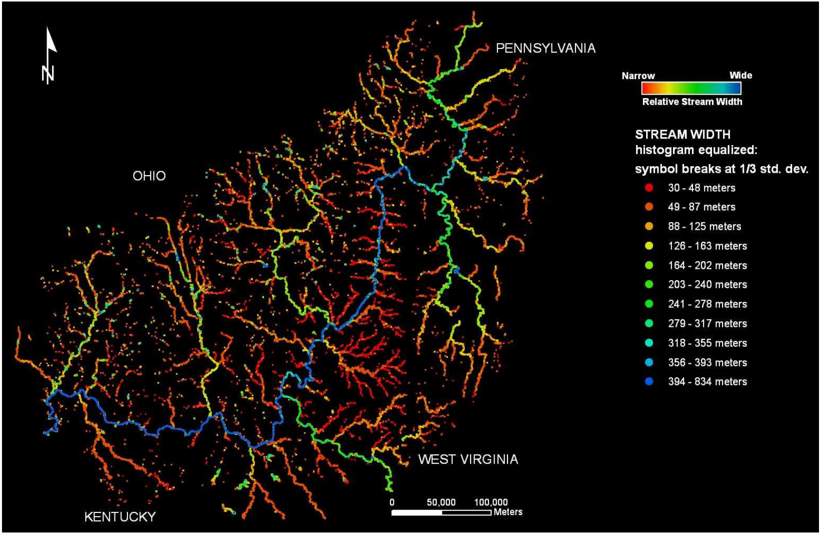
What type of measurements?

- SWOT will measure
  - Water surface elevation (**h**)
  - Temporal and spatial variability in heights (**dh**/**dt** and **dh**/**dx**)
  - Water inundation (water/no water)
  - Lake and reservoir storage (changes)
- Examples of similar measurements from other sensors
- SWOT will improve their heritage

Amazon repeat-pass interferometric SAR



Ohio River widths (LandSat-derived)



Courtesy: Jon Partsch

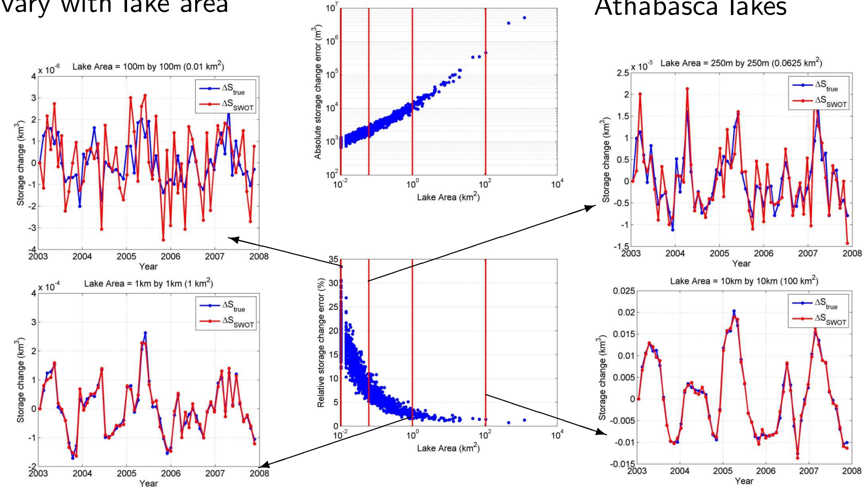
Virtual mission motivation

- What will SWOT "see"?
  - Height and width accuracy of rivers, lakes, wetlands and reservoirs
  - How many times will rivers be observed per orbit cycle?
  - How far upstream the river network will SWOT observe?
- How will SWOT estimate discharge?
  - What are the expected errors and what is the contribution of different sources?
  - "Direct" retrieval and Data assimilation
  - Estimating other parameters (e.g. bathymetry, roughness)

Ability of SWOT to observe storage change

Height and areal errors vary with lake area

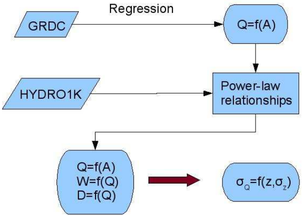
Results from Peace Athabasca lakes

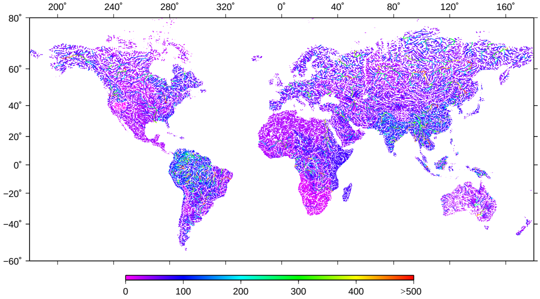


Courtesy: Hyongki Lee

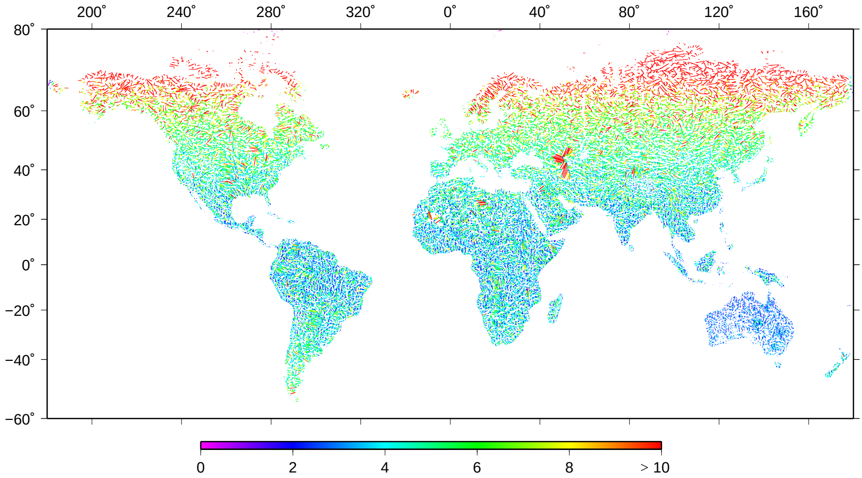
A river characteristics global database

- In-situ measurements of river characteristics are sparse and inadequate
- Need to create a realistic global river network to evaluate SWOT observations
- Power law regressions to relate drainage area to discharge, width, depth



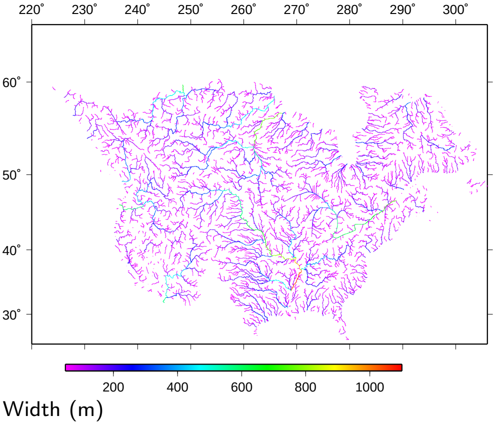


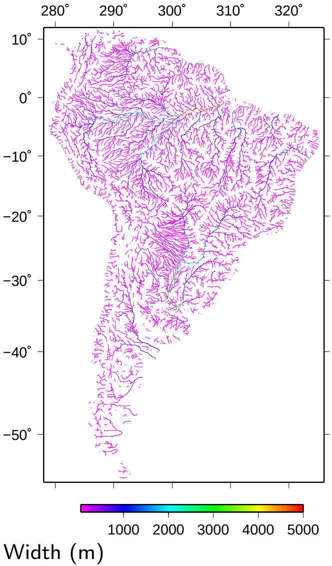
Global map of number of observations per orbit cycle



What rivers will SWOT see?

- Rivers with withs $>$ 50 m will be observed
- We can evaluate the characteristics of rivers observed





Estimating river discharge

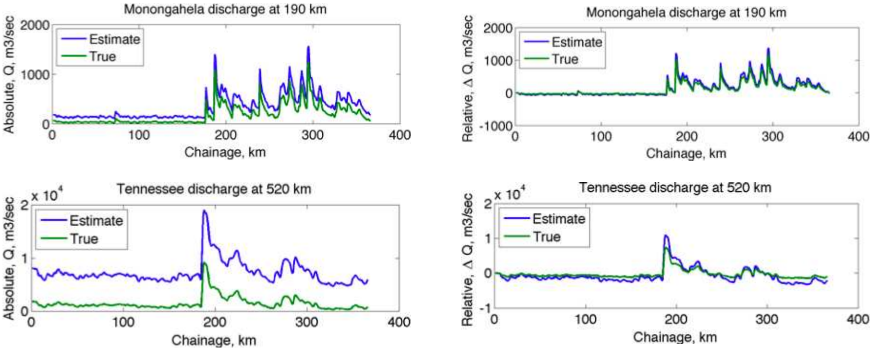
- **"Direct" retrieval**

$$Q = \frac{1}{n} w S^{\frac{1}{2}} z^{\frac{5}{3}}$$

  - Fast method based on Manning's equation
  - Similar to SRTM-based discharge estimation over Amazon

- **Data assimilation**
  - Coupling of hydrodynamics and hydrologic models
  - Channel and floodplain discharge: states
  - Water surface elevations: observations
  - Computationally more expensive

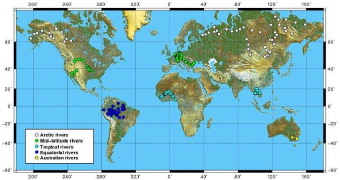
Discharge “direct” retrieval



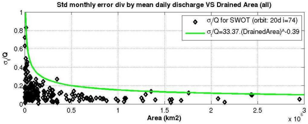
- Synthetic test over tributaries of the Ohio River basin
- Depth error propagates into discharge estimates
- However, discharge variations are accurate despite those errors

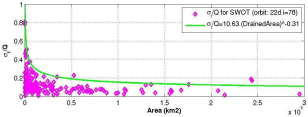
Assessing errors in discharge estimation from SWOT

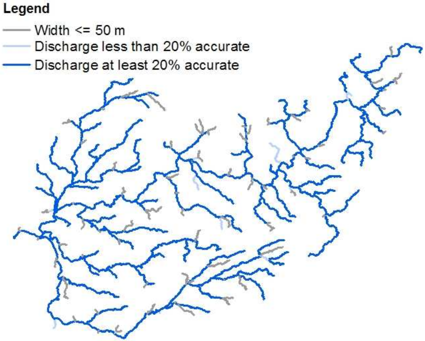
Used in-situ discharge measurements to examine errors due to (i) temporal sampling and (ii) height errors



$$\frac{\sigma_m^2}{Q^2} = \frac{\sigma_t^2}{Q^2} + \frac{\sigma_s^2}{Q^2}$$

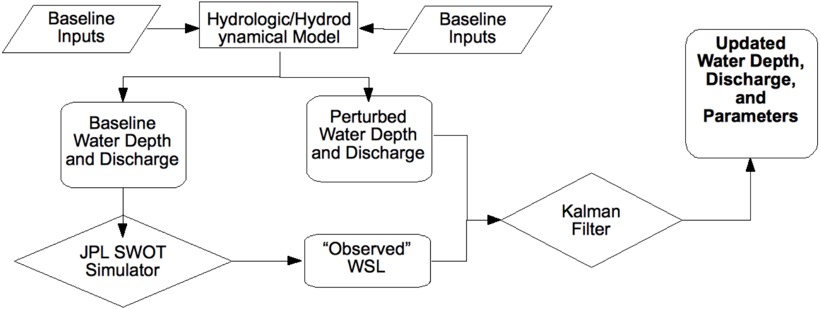






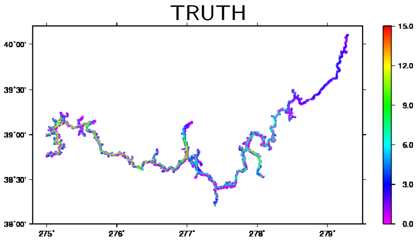
Assimilation schematic

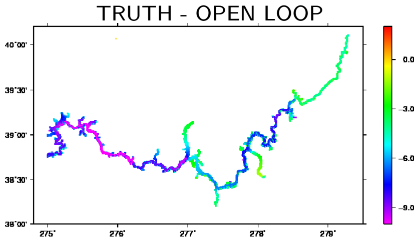
- Synthetic experiment where true WSE and discharge are simulated
- Expected height errors added to “true” WSE to generate SWOT observations
- Open-loop and Filter simulations use corrupted model inputs

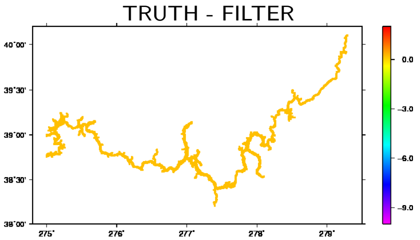


Data assimilation - Water depth

Water depth (in meters) maps for different simulations on 13 March 1995 (06:00)

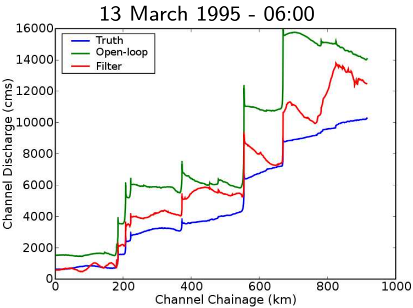


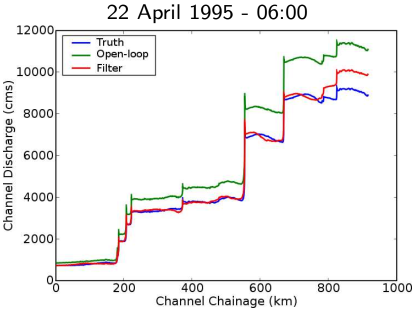




Data assimilation - Channel discharge

- Channel discharge profiles for the different simulations during two update times
- Calculated using uncertain width, roughness and depth

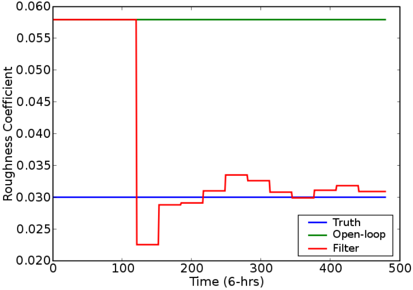




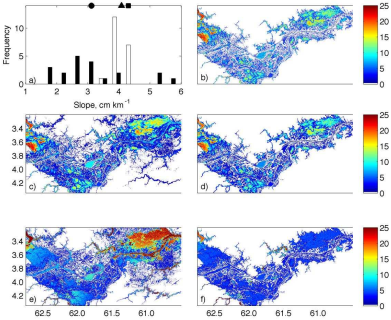
Estimating other river characteristics

- Exploit SWOT information content for indirect estimation of river characteristics

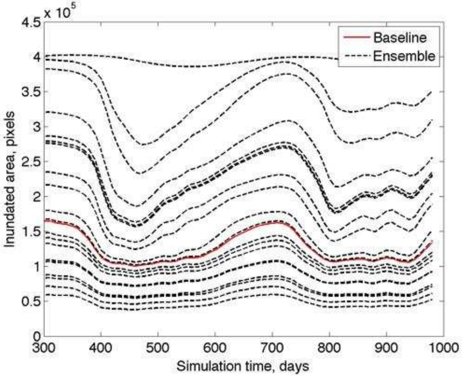
Estimation of channel roughness coefficient (Ohio River study domain)

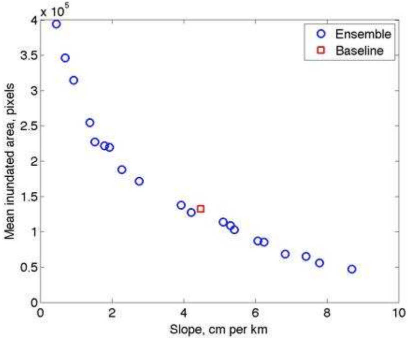


Estimation of river bathymetry (Amazon River study domain)



Bathymetric slope estimation





- SWOT can measure inundated area and total storage on floodplains
- Knowing these through time, allows selection of correct channel bathymetric slope

Ongoing work

- Expand data assimilation studies on different river basins (e.g. Mississippi, Ob)
- SWOT instrument simulation over entire continent
- Methods for retrieval of bathymetry (e.g. slope/width to depth stochastic models)
- Use of detailed in-situ measurements to evaluate the discharge estimation error budget
- Understand the role of long-wavelength errors (e.g. slope, geoid) affect Amazon hydrologic characterization
- Quantifying the impact of errors in the context of data assimilation (precipitation, lateral inflows)
- Optimization of hydrodynamics model for faster simulations
- Product delivery considerations (computational scalability etc)