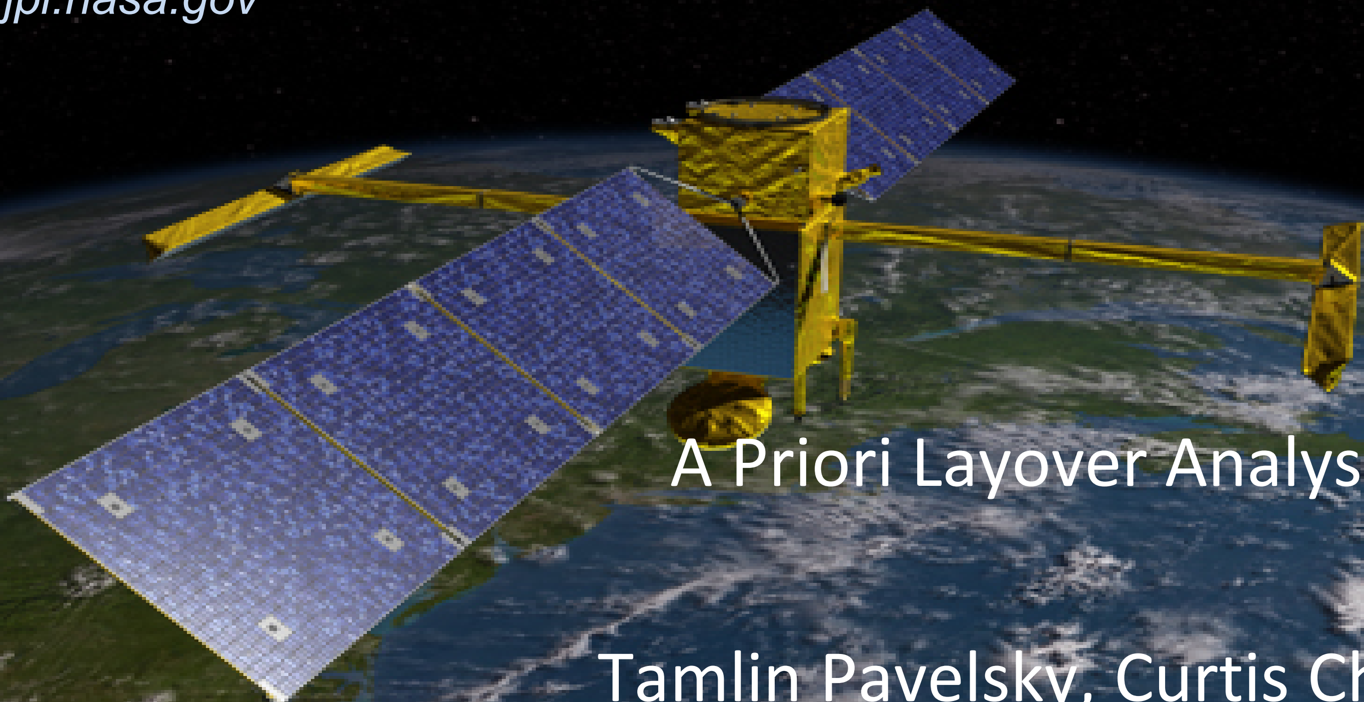
National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Surface Water and Ocean Topography (SWOT) Mission

http://swot.jpl.nasa.gov



A Priori Layover Analysis

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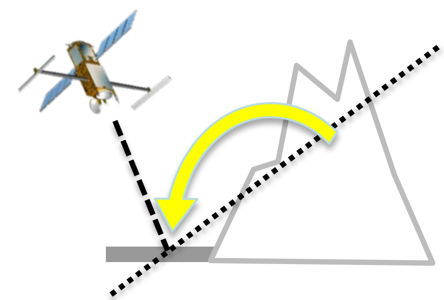
Layover Background

- Layover occurs when, due to topography, multiples returns from different points on the ground come back at the same time.

Layover: points within the lines produce a return in the same range bin



- When returns from the terrain “lay over” water pixels, the measured water heights will have a bias (and a geolocation error) that is proportional to the relative difference in heights, contrast, and illuminated areas.
- This effect is given purely by geometry, and there is no “knob” available in the Flight System to improve it. Mitigation is via algorithm flagging.

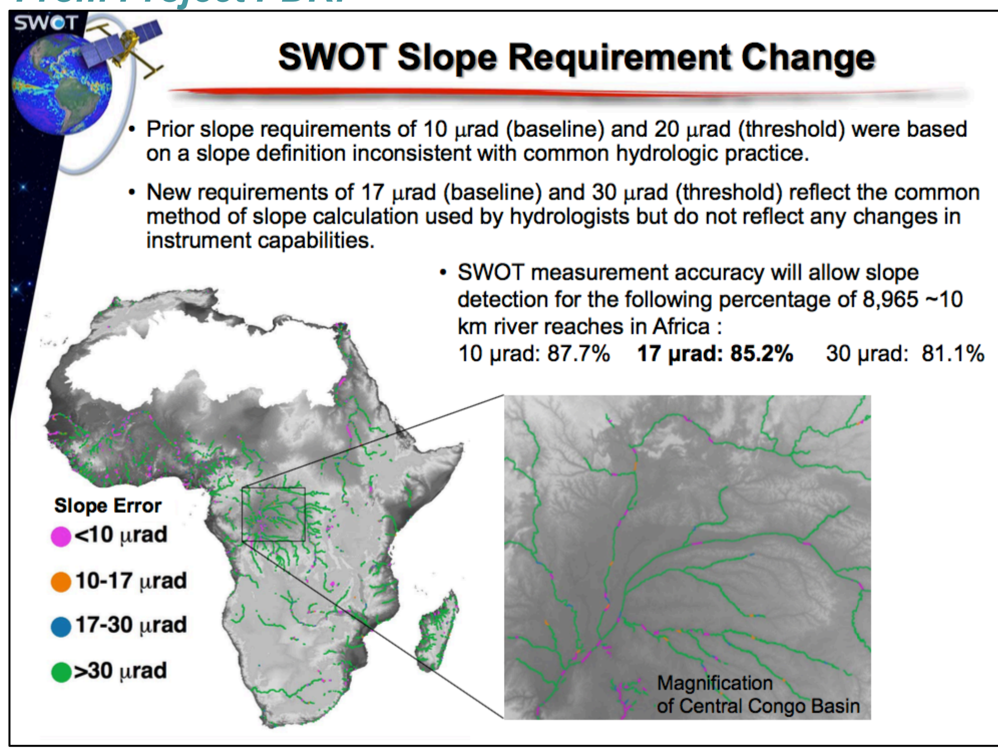
- Accurate knowledge of land topography is needed to flag water pixels affected by layover
  - SWOT height measurements are optimized for water, which is bright at near-nadir incidence angles
  - Land is too dark at near-nadir incidence angles for SWOT to make its own land DEM reliably for layover flagging

Needed Science Assessment

- Project PDR RFA on layover from M. Dettinger (RFA #14, AITS 769) requested more detailed science assessment of layover impact
  - RFA originator requested science analysis similar to what was done for slope requirement change
  - Assess how many reaches over continent would be unusable because of layover and show spatial distribution, not just statistics on height error vs. river width

- Approaches:
  - Parameterized model using DEM-derived roughness, viewing geometry, and estimates of water-land contrast.
  - Simple geometric simulations using existing DEMs and viewing geometry

From Project PDR:

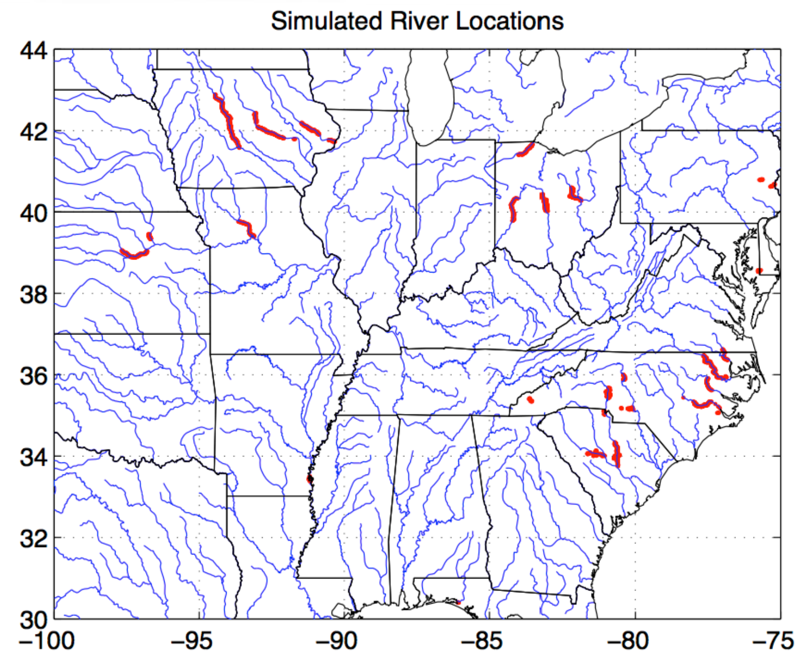


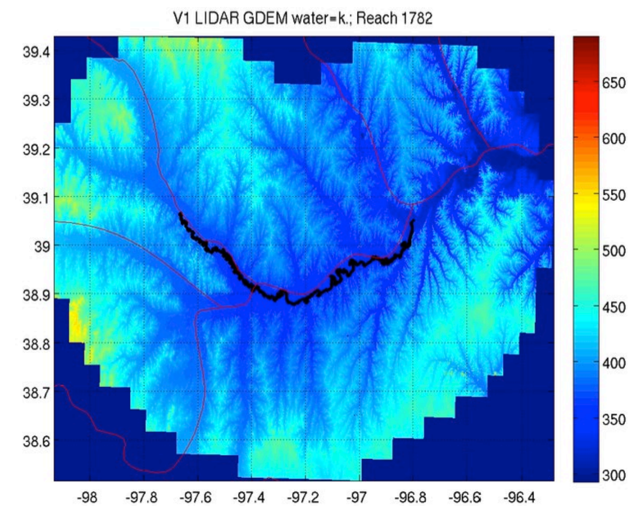
Parametrized Model Development Approach

- Develop theoretical model to describe expected statistical characterization of layover errors *after algorithm flagging*
  - Theoretical formulation is independent of simulations
  - Theoretical formulation provides more sound basis for extrapolating from limited set of simulations to wider scale
- Run high-fidelity simulations using lidar DEMs as truth and SRTM as reference DEM used for layover flagging
  - Simulations capture layover errors as well as ability of algorithms to flag layover and discard layover
  - Cannot use this direct simulation approach at basin scales because high-quality truth DEMs are not available everywhere

Lidar Data Sets for Simulation

- KaRIn SE team prepared lidar data set for initial layover assessment reported at Feb. 2016 Measurement Review
  - Got all US lidar DEMs from EROS data center
  - Found lidar DEMs that cover known rivers with enough surrounding land area that would lay over into rivers
    - Focused on rivers because of greater sensitivity to layover than lakes
    - Around 100 lidar scenes with rivers
  - Converted lidar point-cloud data into raster DEMs
    - Kept last return for bare-Earth DEM
    - Recently reran to keep first return for canopy-top scattering
  - Manually adjusted water heights to prevent water from being higher than land (conservative)
- Algorithm team running new simulations based on these DEMs
- DEMs and simulated data can be shared





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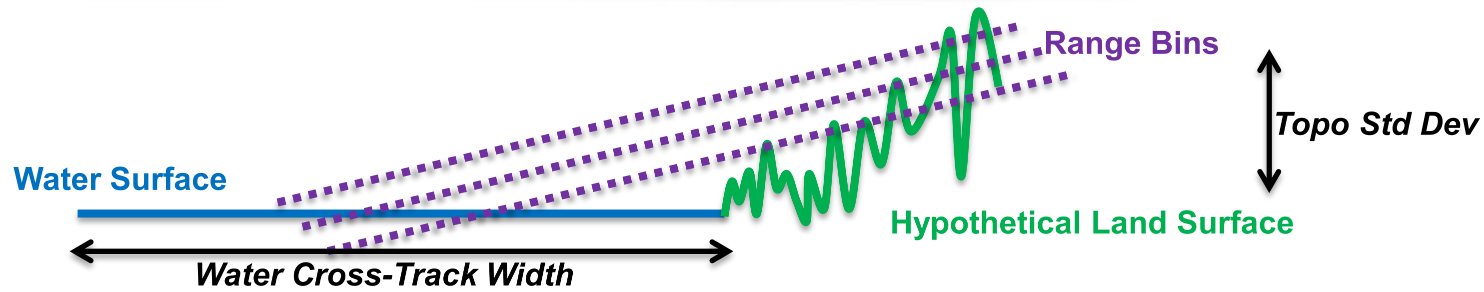
  - Cannot use this direct simulation approach at basin scales because high-quality truth DEMs are not available everywhere
- Use results from simulation to tune model parameters, especially related to error reduction from layover flagging algorithm
- Approach gives not only *what* areas may be affected geometrically by layover, but *how* those areas will be affected in terms of height errors (including effects of processing mitigations)
- Current status: Iterating simulations and model tuning

Key Model Parameters



- Roughness metric as parameter for describing topography (SRTM):
  - We do not need to model layover error exactly for each precise location on ground (ie, each pixel) because hydro processing averages over wide areas anyway
  - Parameterized model is intended to give statistical characterization of layover error, not prediction of error for specific pixels
  - Standard deviation of topographic heights over local window (e.g., 1x1 km box) is relatively robust parameter over quality of different DEMs
- Cross-track width of water body (GRWL):
  - Mapping of topography into slant plane gives cross-track projection
  - For rivers, first-order quantity of interest is river width divided by sinϕ, where ϕ is river flow direction relative to cross-track direction
- Imaging geometry and measurement parameters (various sources):
  - Incidence angle (important for layover geometric mapping)
  - Water/land contrast (to determine relative contribution of land contamination)
  - Resolution (to determine number of looks available for averaging)
- Algorithm flagging performance parameters (false alarm/missed layover detection) to be empirically tuned based on simulations

Timeline

July: JPL finishes provisional model development

August/September: model run and evaluated by science team representatives at continental scale (Pavelsky, Durand, & Sheng)

September 26-28: ADT Meeting where preliminary results will be presented and decisions on any additional work will be made.

1st Week of December: Results presented at Measurement Review