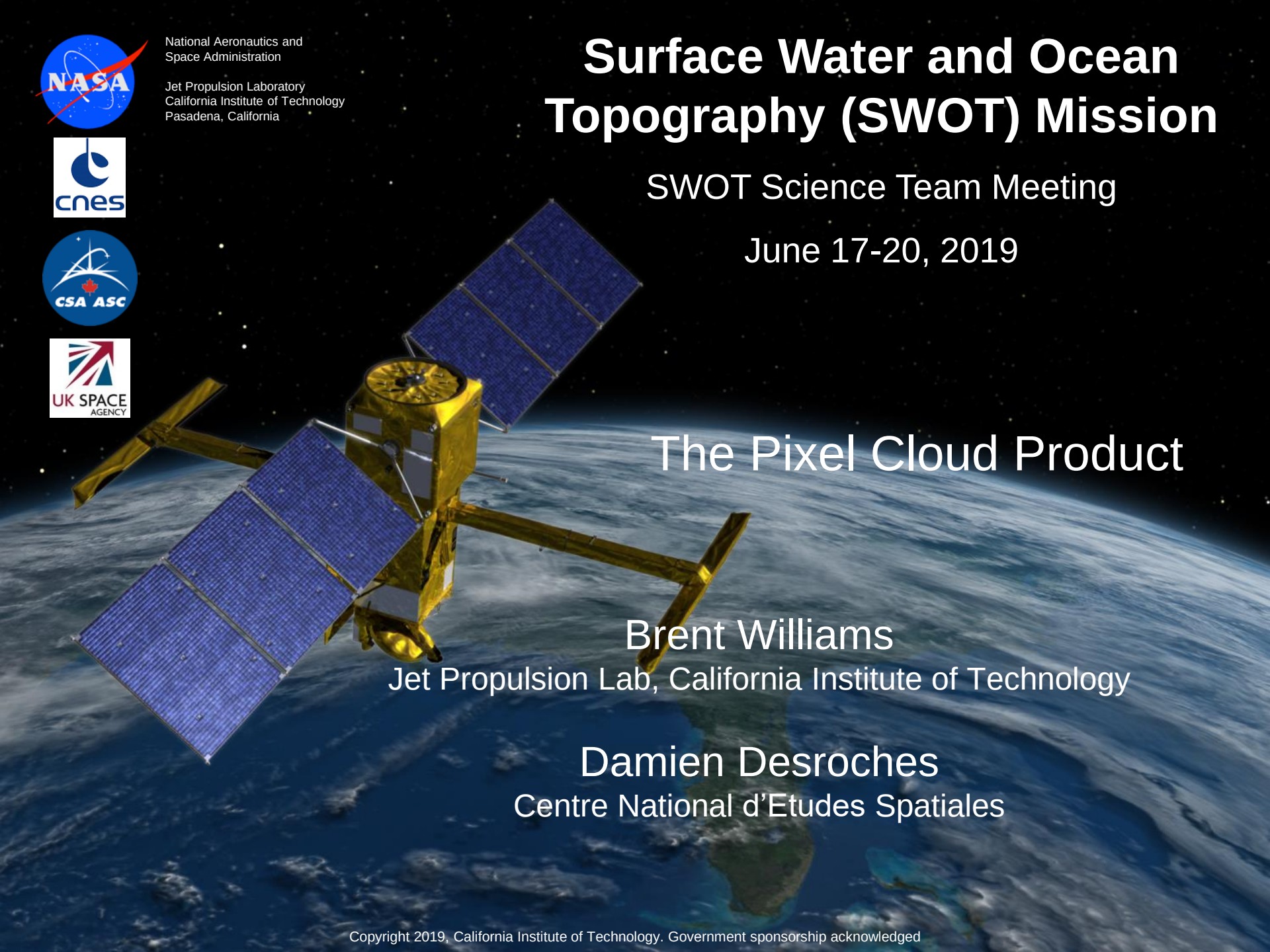

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Surface Water and Ocean Topography (SWOT) Mission

SWOT Science Team Meeting

June 17-20, 2019

The Pixel Cloud Product

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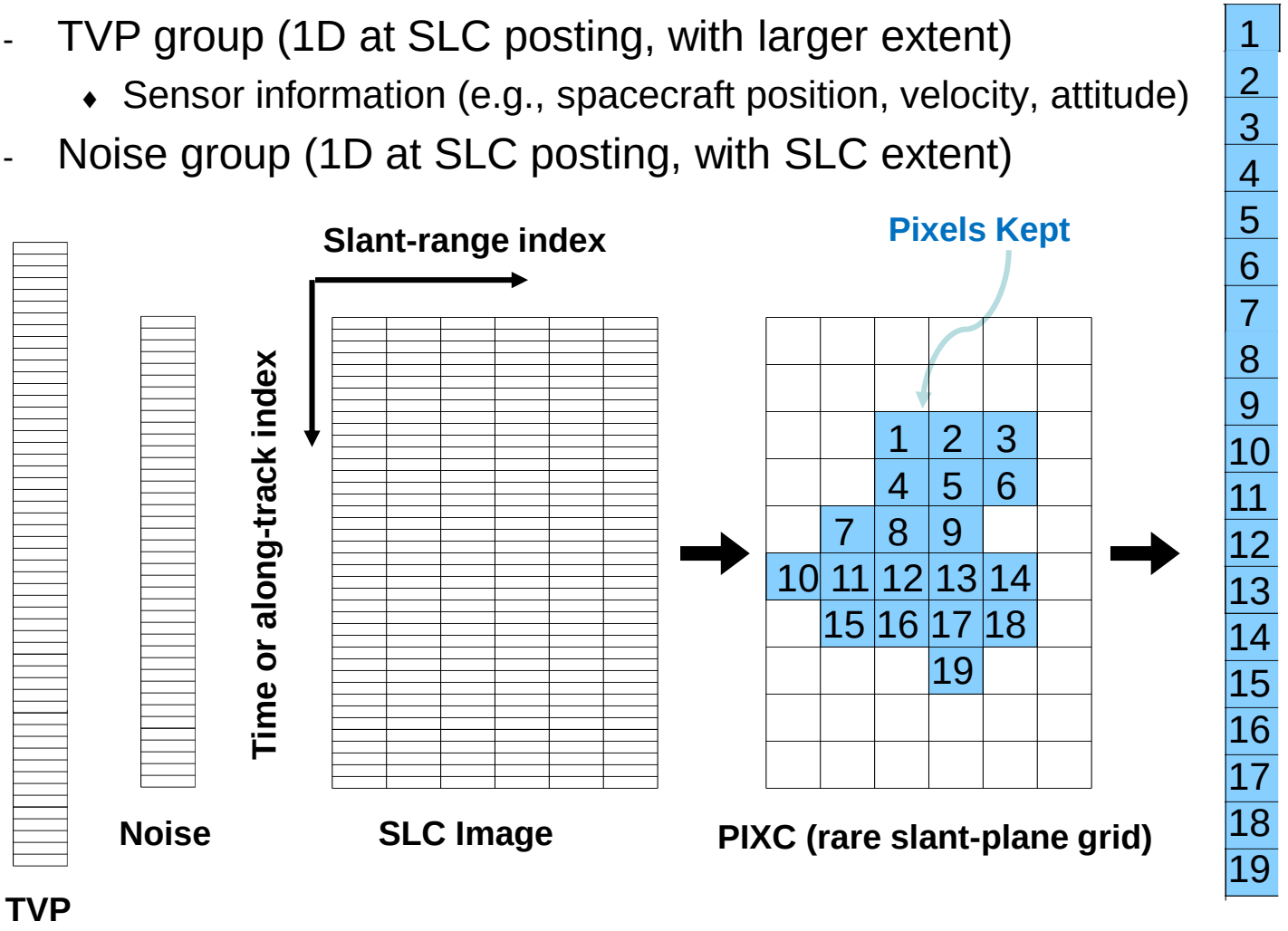
Intended Users

- PIXC and PIXCVec are expert products, intended users are:
  - Hydrologists interested in studying fine-scale details in a local region
    - Higher spatial resolution, but noisier than vector products
    - Users who want to use their own customized algorithms for height reconstruction and geolocation
  - Users interested in low level data for calibration/validation and downstream algorithm development
  - Possibly other applications around inland water
    - Lowest level of data available that is geolocated
    - Studies like Ka-band scattering, rain, ice/snow, soil moisture, urban sprawl, inland water body wind vector/wave height estimation etc…
- The “raster” product can also serve most/many hydrology users that need finer scale measurements than the vector product, but don’t need detail and additional complexity of the pixel cloud

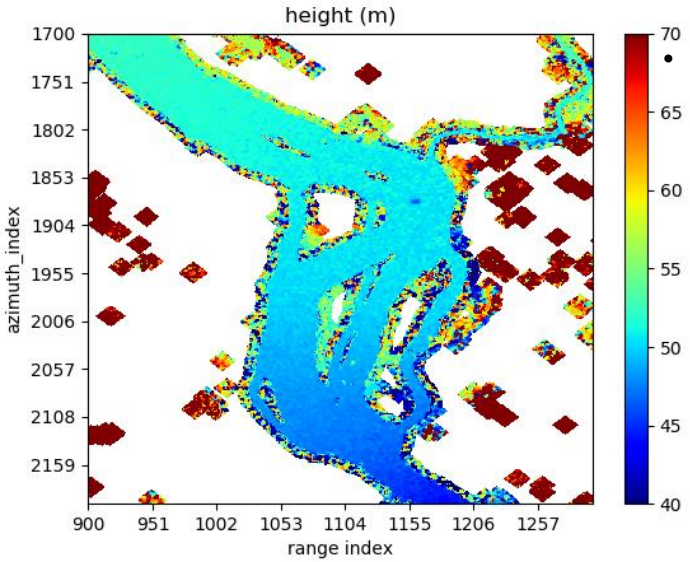
L2_HR_PIXC Format

- NetCDF format with global attributes and 3 groups
  - Pixel Cloud (PIXC) group (1D list of kept 2D rare radar-grid pixels)
  - TVP group (1D at SLC posting, with larger extent)
    - Sensor information (e.g., spacecraft position, velocity, attitude)
  - Noise group (1D at SLC posting, with SLC extent)



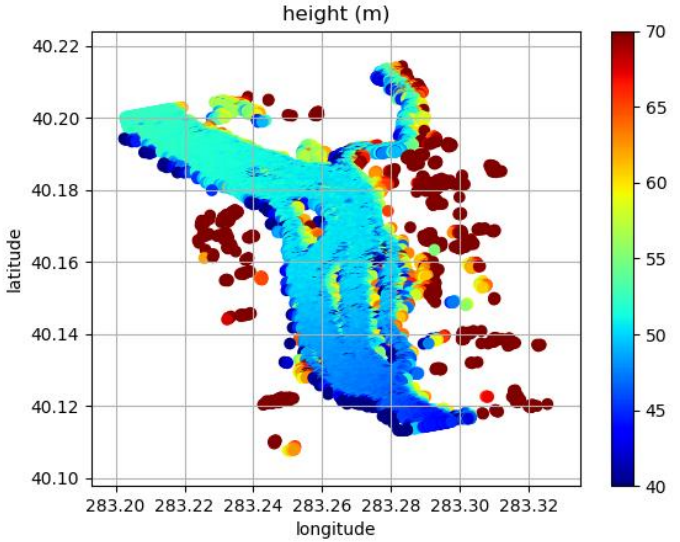
Pixel Cloud Example

Slant-plane

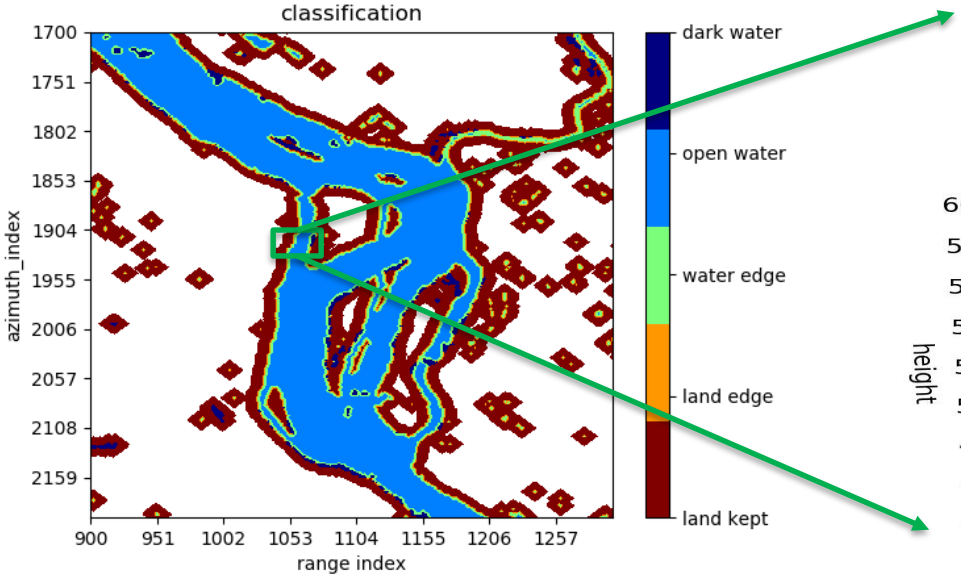


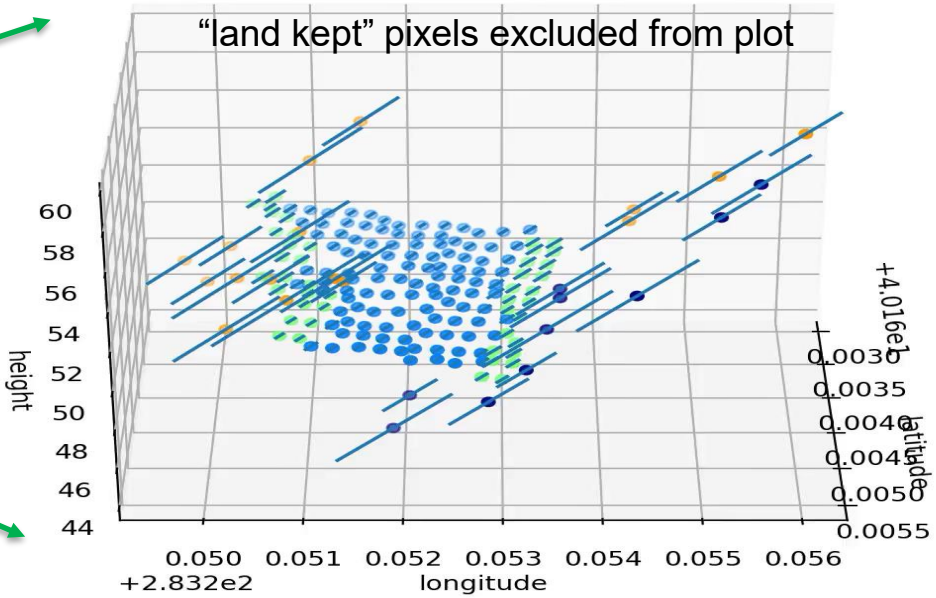
Can be viewed either as a sparse 2d slant-plane image or as 3-d geolocated point cloud for each pixel cloud variable.

Ground-plane



classification with 2-σ geoloc. uncert. bars





Pixel Cloud Group Variables

Rare

- Grid related items (azimuth and range index)
- Interferometric measurements
  - Interferogram, 2 channel powers, coherent power)
  - Number of rare looks
- Radiometric calibration terms
  - X-factor for 2 channels
- Water detection/flag items
  - Classification, water fraction (and uncertainty variables)
  - Dark/bright land flags, prior water probability, layover impact

Medium

- Geolocation related variables
  - Longitude, latitude, height, pixel area (on ground), incidence angle
- Quality flag
- Variables needed to compute geolocation/height uncertainty
- Illumination time for each pixel
- Phase unwrapping region mask
- Instrument and geophysical corrections (geoid, Earth tides, media delay corrections)

Status

- PIXC Product Description Document in revision based on Science Team reviewer feedback

- ATBD drafted, under internal review among ADT subgroup
  - Most algorithms baselined, but many are likely to be revised
    - Water detection fairly stable, with only minor revisions expected
    - Actively working on phase unwrapping, dark water flagging
    - Bright land flagging algorithm development is starting up
    - Geophysical corrections and phase screen corrections not yet implemented but not expected to be challenging
    - Layover mitigation work deferred based on layover results reported last year

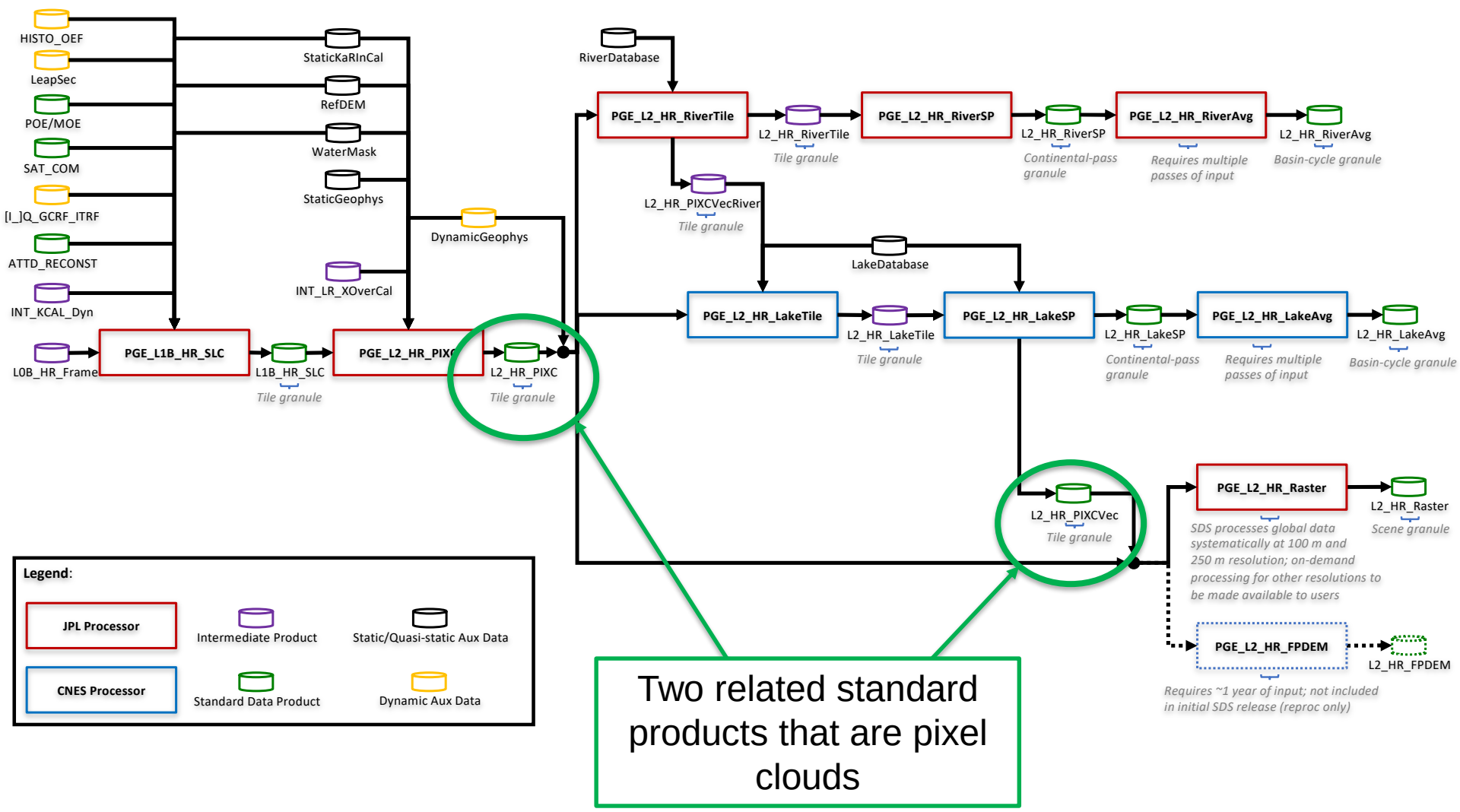
- Example data products will be made available
  - Plan to distribute a PIXC sample product consistent with the river sample products when they are ready

Recent Work

- Continuing to implement, upgrade, and validate algorithms
  - Especially phase unwrapping, water detection and dark water flagging
  - Algorithm-specific analyses as well as end-to-end validation w.r.t. science requirements
  - Using simulations as well as AirSWOT data for validation
- Implemented uncertainty-related algorithms
  - Uncertainties after aggregation do not simply fall off as 1/sqrt(N)
  - PIXC product has been defined to have all the information needed to
    - Optimally aggregate to nodes/lakes/raster bins
    - Estimate height and area uncertainties of the aggregates
  - Optimal height and water area aggregation and uncertainty estimation from quantities in the pixel cloud is currently being tested and validated in the context of the RiverTile processor

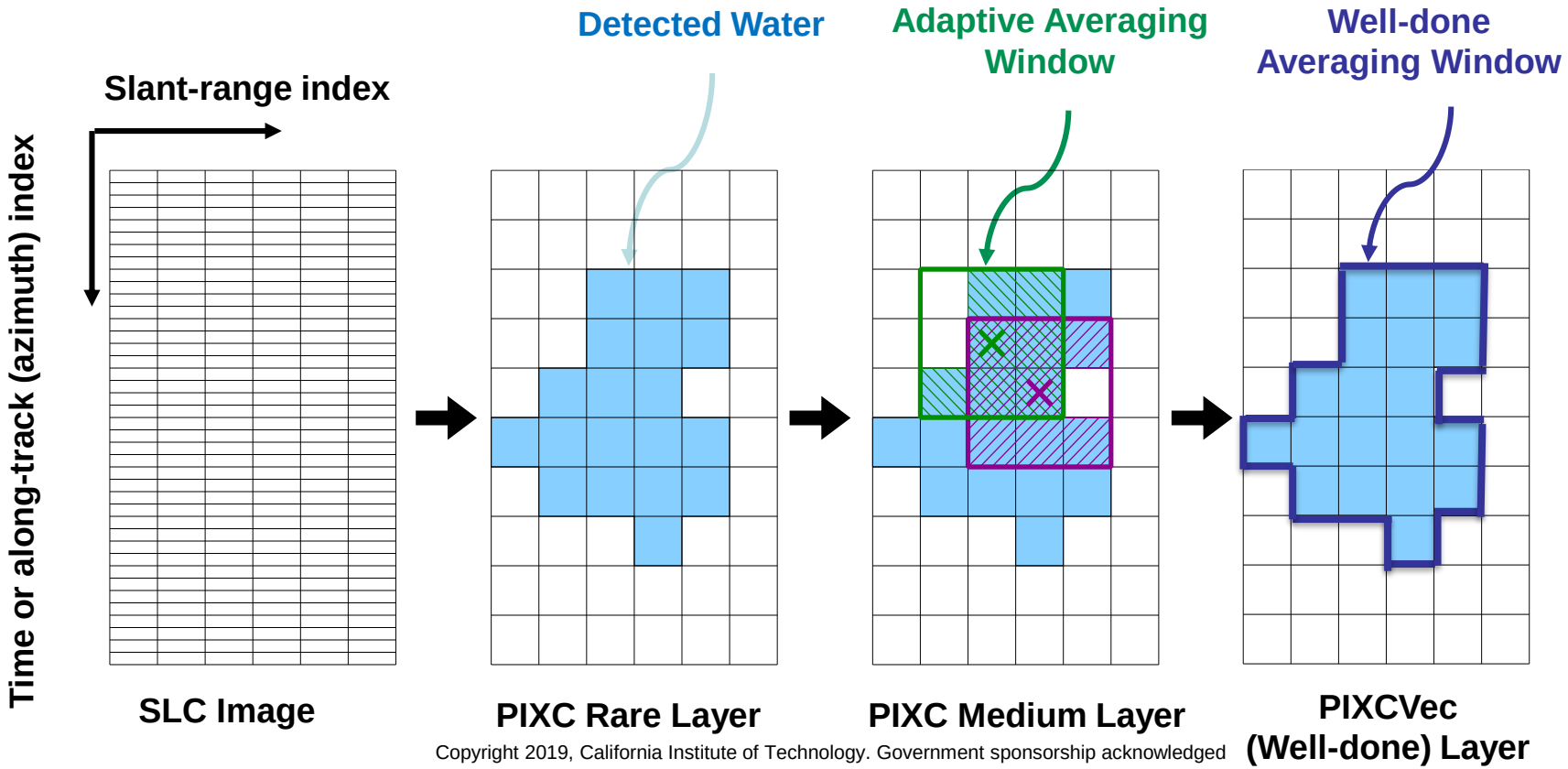
Backup

High Rate Algorithm Flow



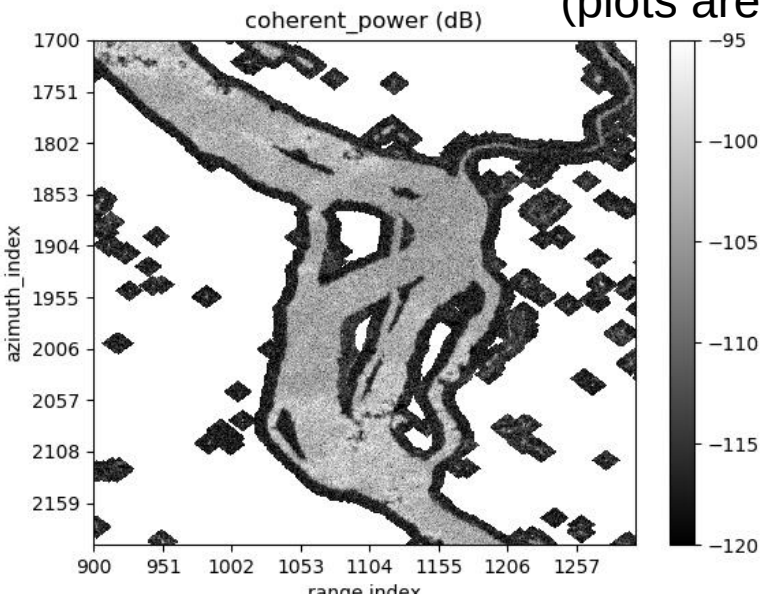
Pixel Cloud Group

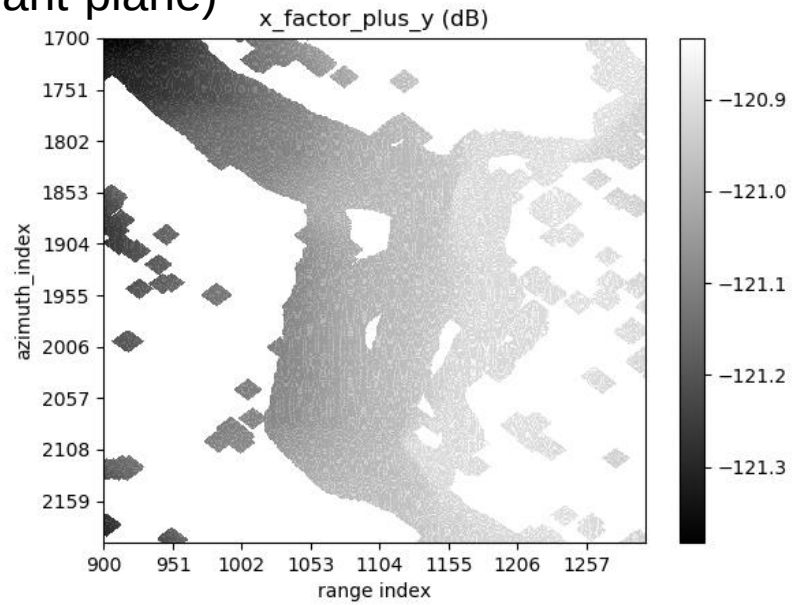
- Multiple levels of smoothing
  - Rare and Medium layers on same ‘rare’ slant-plane grid
  - Well-done layer in PIXCVec product (not PIXC), but on same grid
  - Rare and medium variables are in same group with no explicit tags indicating rare or medium

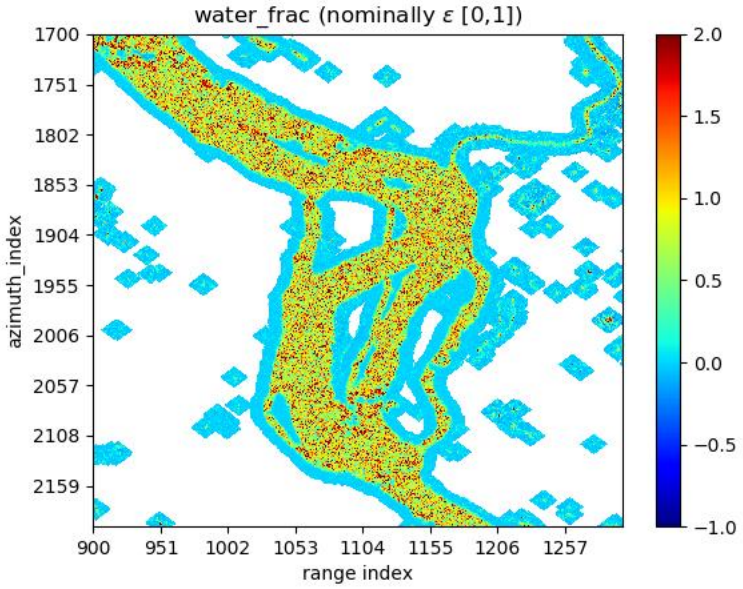


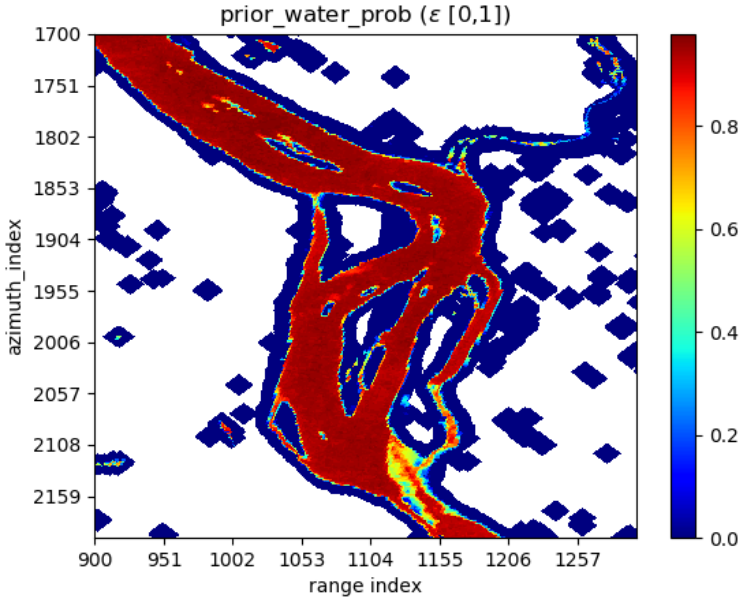
Examples (Rare)

(plots are in slant-plane)



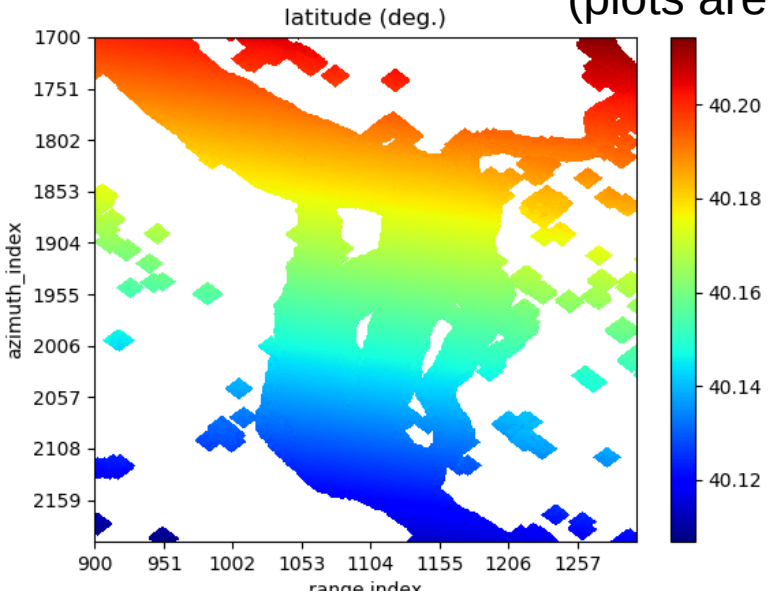


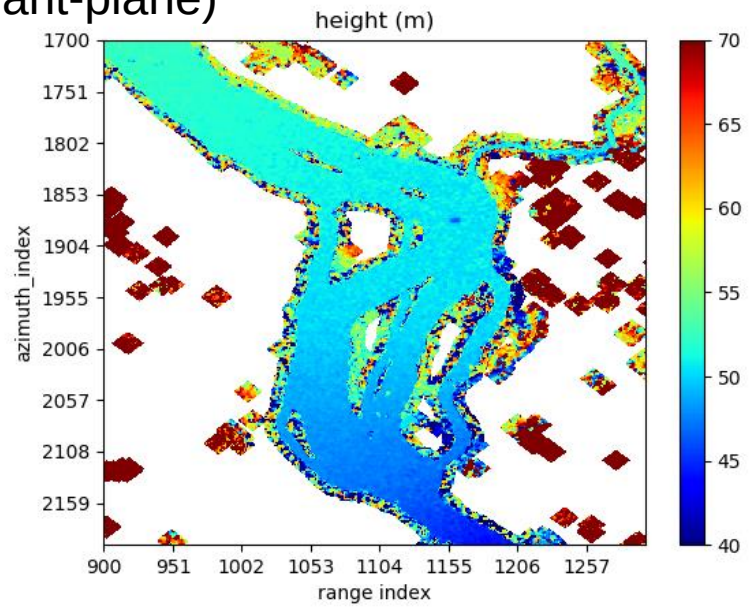


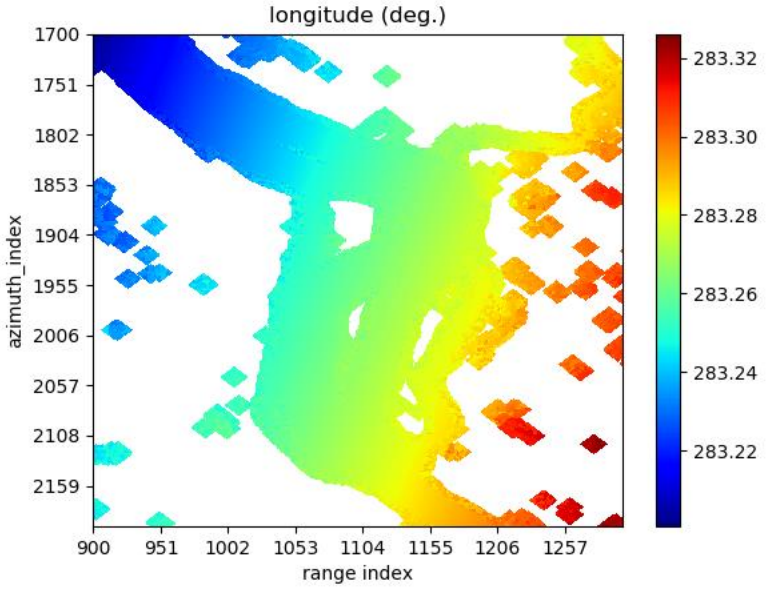


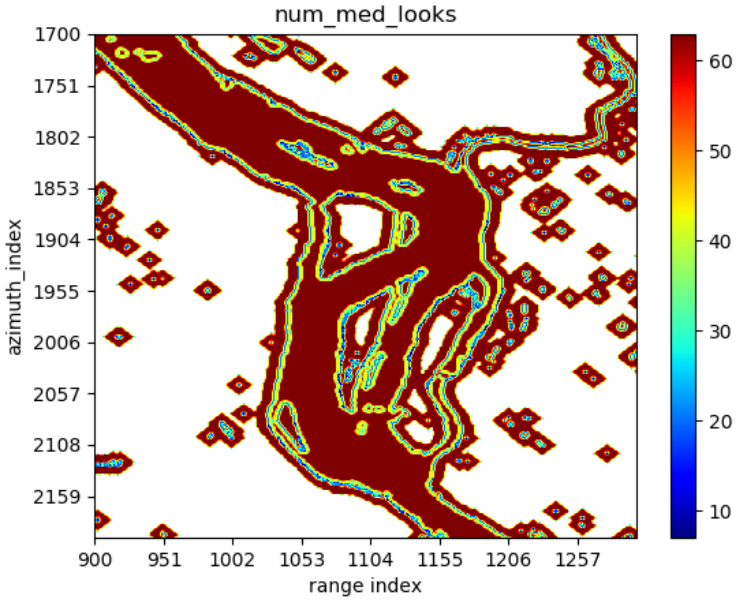
Examples (Medium)

(plots are in slant-plane)





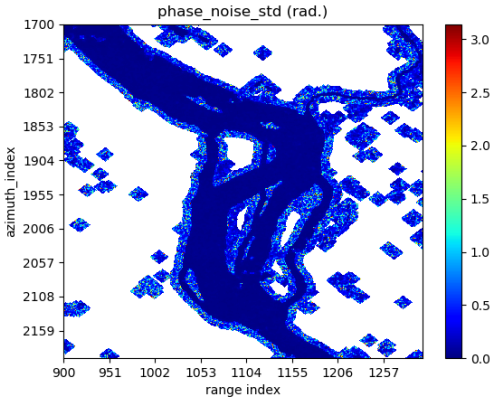




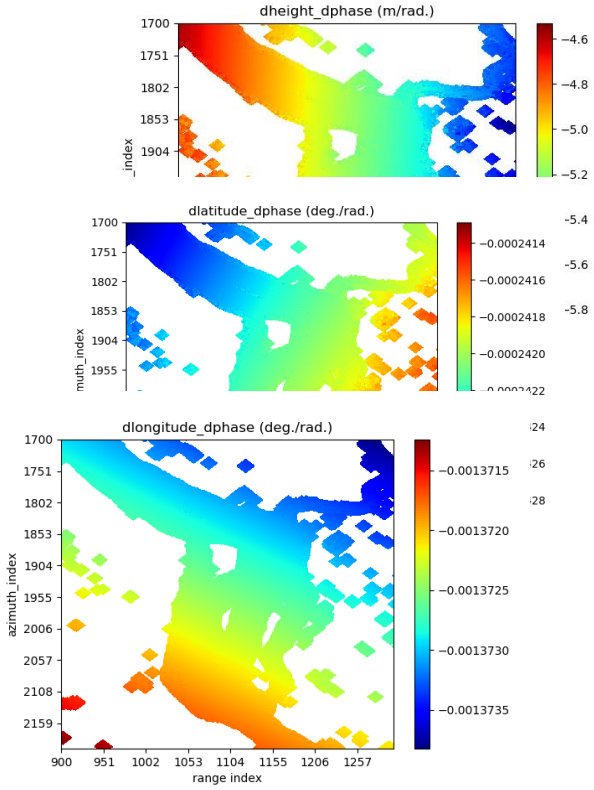
Pixel-wise Height Uncertainties (Random Component)

- Height/lat/lon uncertainties coupled
  - 1-sigma error bars are slanted lines in the 3D plots
  - Computed by phase noise std x |sensitivities|
  - Optimal height aggregation is inverse variance weighting using the height uncertainty

(plots are in slant-plane)



x



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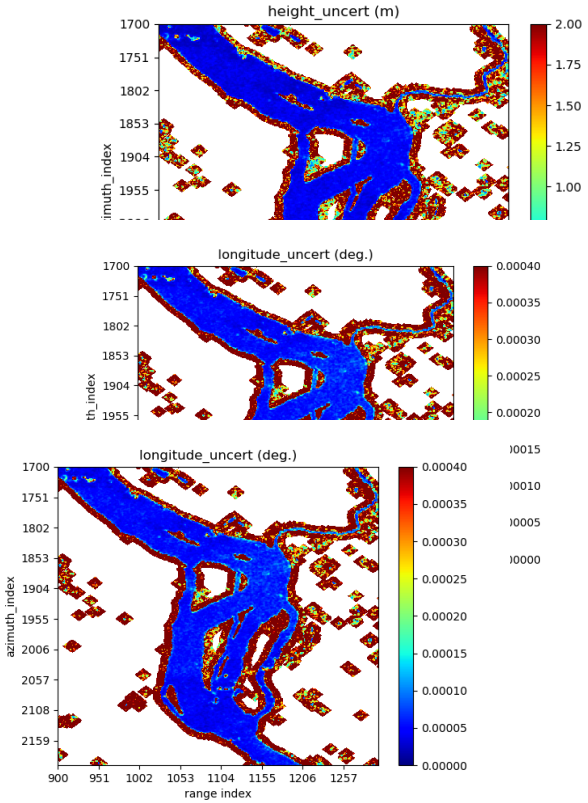
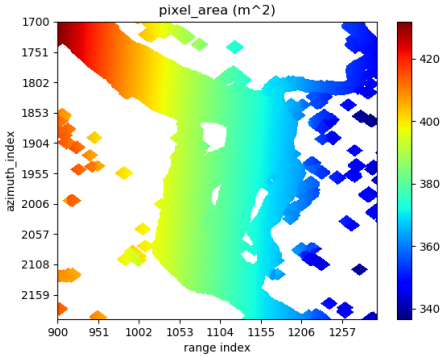
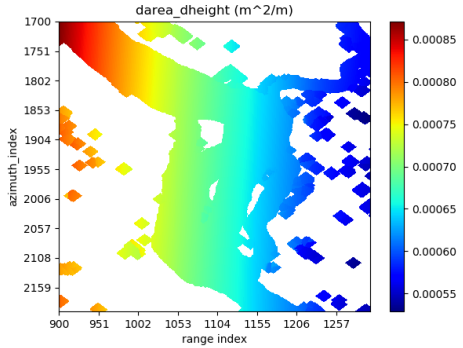


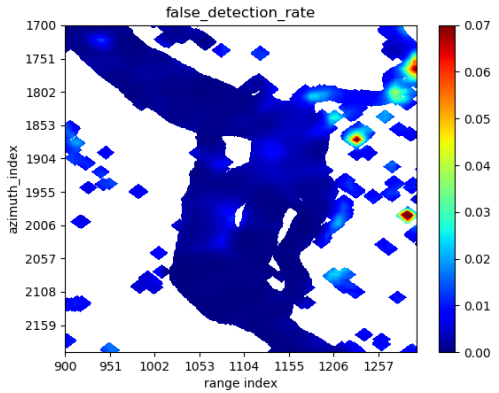
Pixel-wise Area Uncertainties

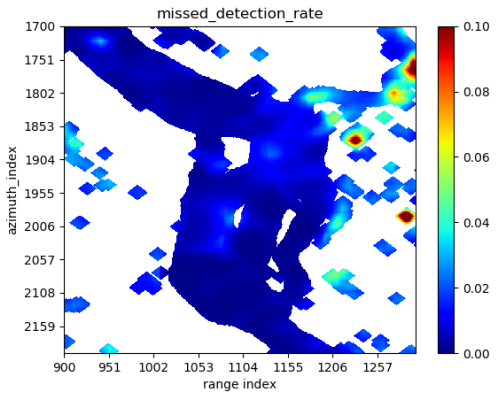
- Estimate of pixel area uncertainty given by sensitivity to height and an estimate of DEM height uncertainty (~10m)
  - This effect is generally negligible
    (plots are in slant-plane)

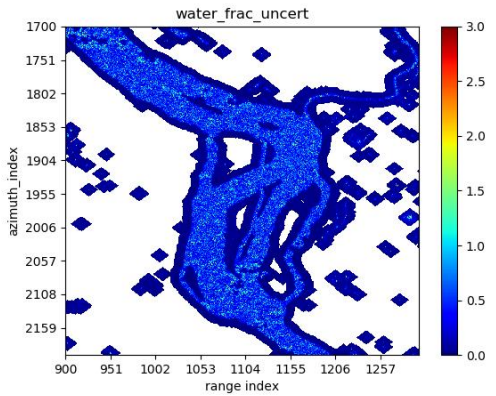




- Estimate of water area of a given pixel needs to incorporate detection errors and/or water fraction uncertainty etc…
  - Majority of error in water area estimates is due to these







PIXC and PIXCVec: 2 Standard Products

L2_HR_PIXC

- Main PIXC product with1-D list of geolocated radar image grid pixels around water (detected and prior)
- Rare-level interferogram information (4 effective looks)
- Medium-level (~50 looks) geolocated lat/lon/heights and uncertainty estimates
- Water detection and flagging results
- Calibration and sensor info.
- Height references and corrections (included but not applied)

L2_HR_PIXCVec

- Ancillary/overlay product contains info. not available until after river and lake vector level processing
- IDs for each pixel that was attributed to any feature (node, reach, lake, unknown …)
- Height constrained geolocation using aggregated heights at the water feature level (i.e., lat/lon/height for “well-done” level of smoothing)
- Available only after river and lake processors are run (e.g., smooth whole lake to single height)