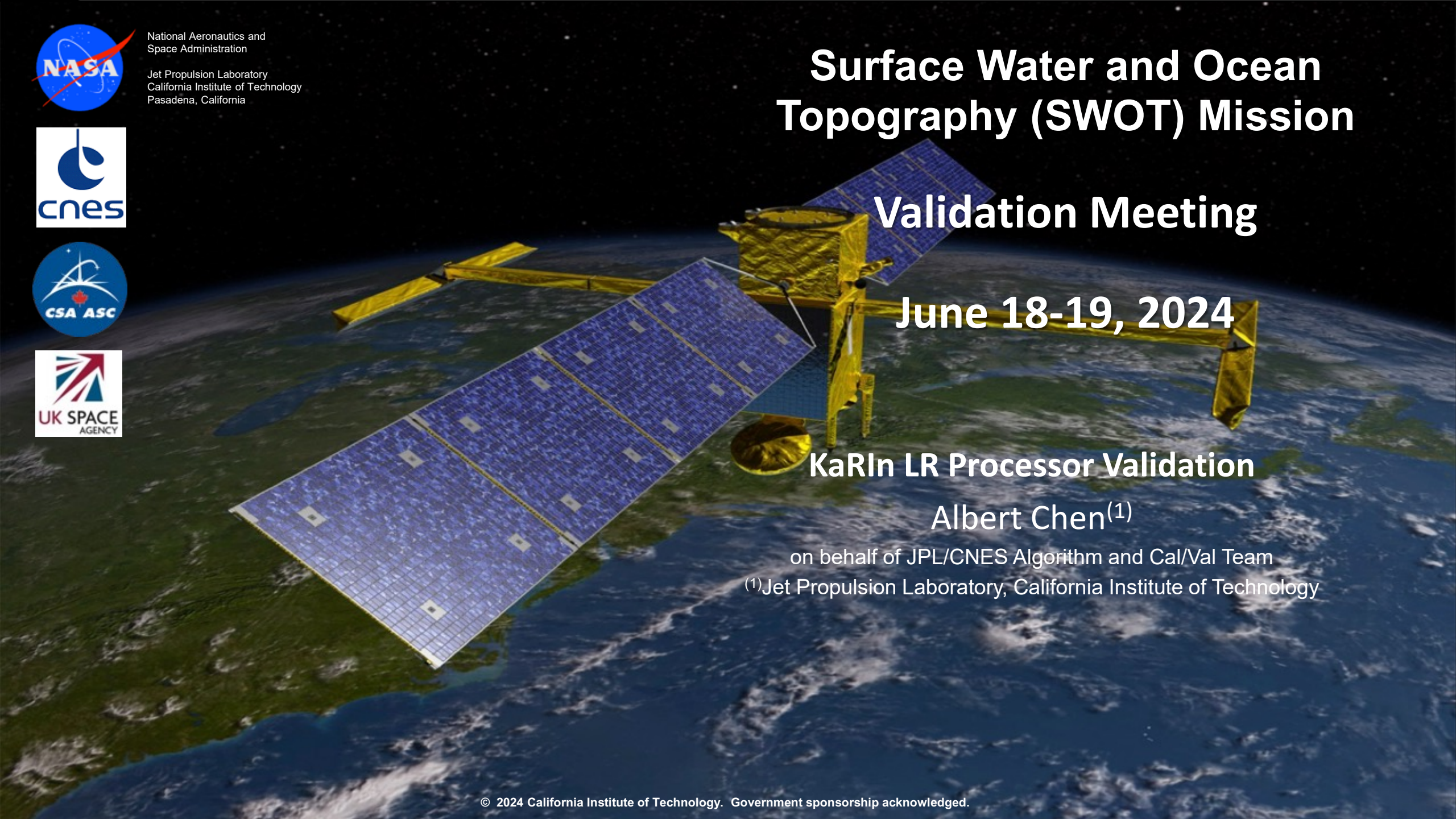

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Surface Water and Ocean Topography (SWOT) Mission

Validation Meeting

June 18-19, 2024

KaRIn LR Processor Validation

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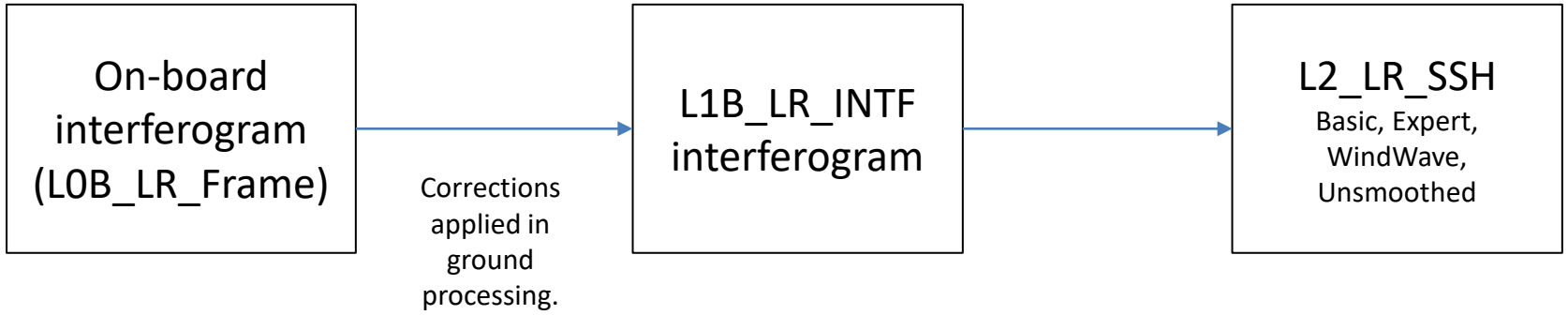
on behalf of JPL/CNES Algorithm and Cal/Val Team

[(1)]Jet Propulsion Laboratory, California Institute of Technology

Overview



- For LR data, an interferogram is computed on board the satellite, a novel method developed for SWOT.
  - Thus, the L1B_LR_INTF processor is novel for SWOT as well.
- Prior to launch, all LR processors were tested and validated using simulated data.
  - Some additional bug fixes were needed after launch.
- Here we show some examples and analyses with real flight data that illustrate that the processors have the expected behavior, further validating their implementation.

L1B_LR_INTF processor

- The on-board processor interferogram contains signals from the instrument (e.g. spacecraft roll, etc.) as well as geophysical signals.
- L1B processor applies corrections as accurately as possible, ideally creating an interferogram whose phase only contains the geophysical SSH signal.

Key differences between on-board and L1B interferograms

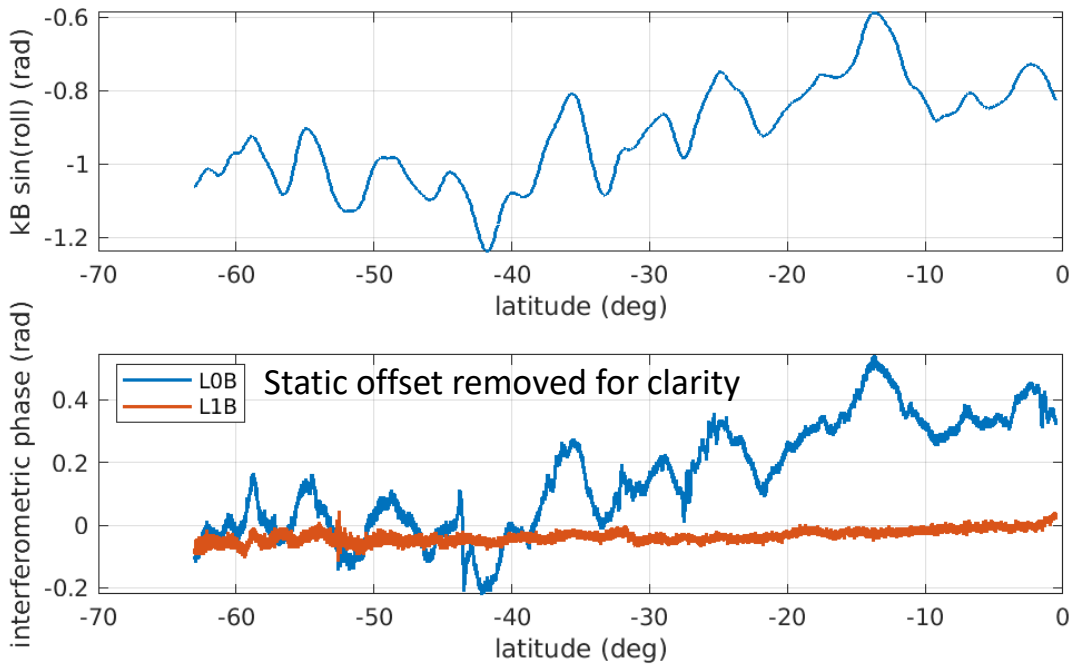
Interferogram computed by On-Board Processor	L1B_LR_INTF product
Assumes ideal attitude.	Uses ground-processed attitude (ATTD_RECONST).
Uses on-board orbit (DORIS).	Uses ground-processed orbit (MOE/POE).
Assumes ideal antenna pointing.	Uses antenna pointing from static KaRIn calibration.
Assumes constant global mean atmospheric delay.	Uses ECMWF model dry and wet troposphere, and NASA/JPL global ionosphere map.
No dynamic calibration.	Performs dynamic calibration using KaRIn internal calibration data.
Pixels have no associated latitude/longitude locations.	Computes reference locations for each pixel using orbit and reference DEM.

Example on-board and L1B interferograms

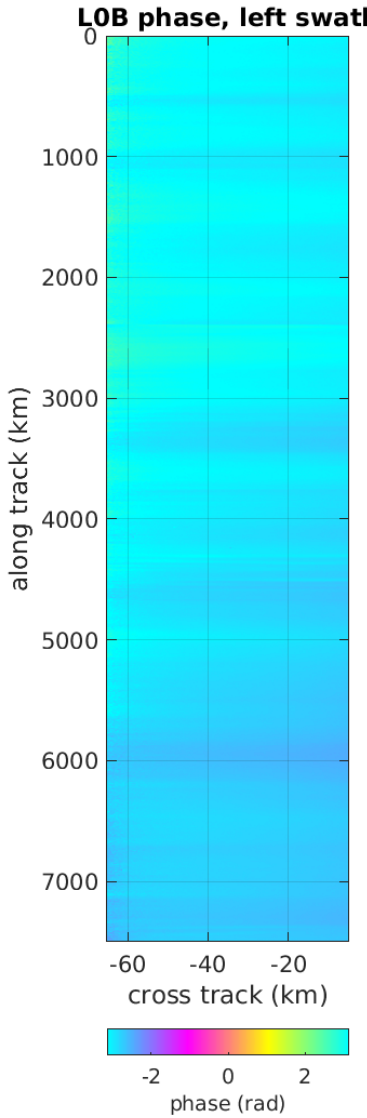
- Much of the spatial variation in on-board interferogram phase is due to non-geophysical signals, most notably spacecraft roll.
- Analysis of real data indicates that the L1B processor correctly handles time-varying attitude observed in flight.
- Plots show beam 5 only. Other beams behave similarly.

Plot shows simple approximate formula for interferogram phase caused by spacecraft roll. (L1B processor uses full 3-D geometry.)

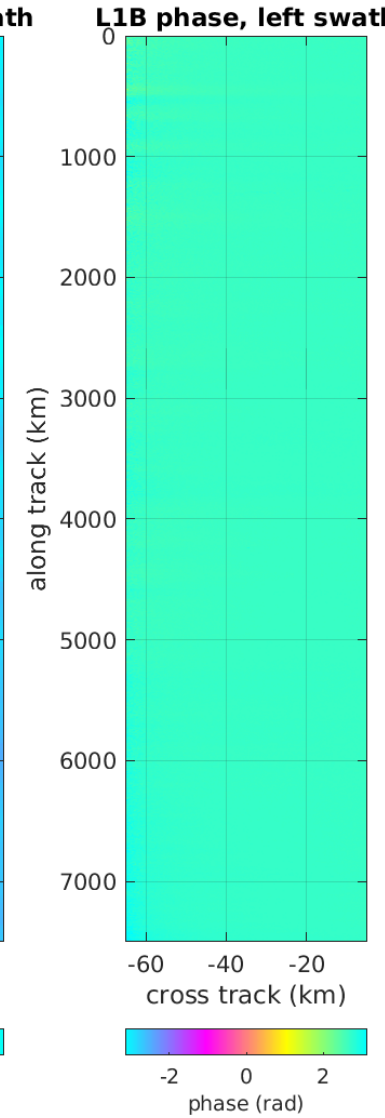
Cycle 013 pass 425



Computed on-board



Fully-corrected

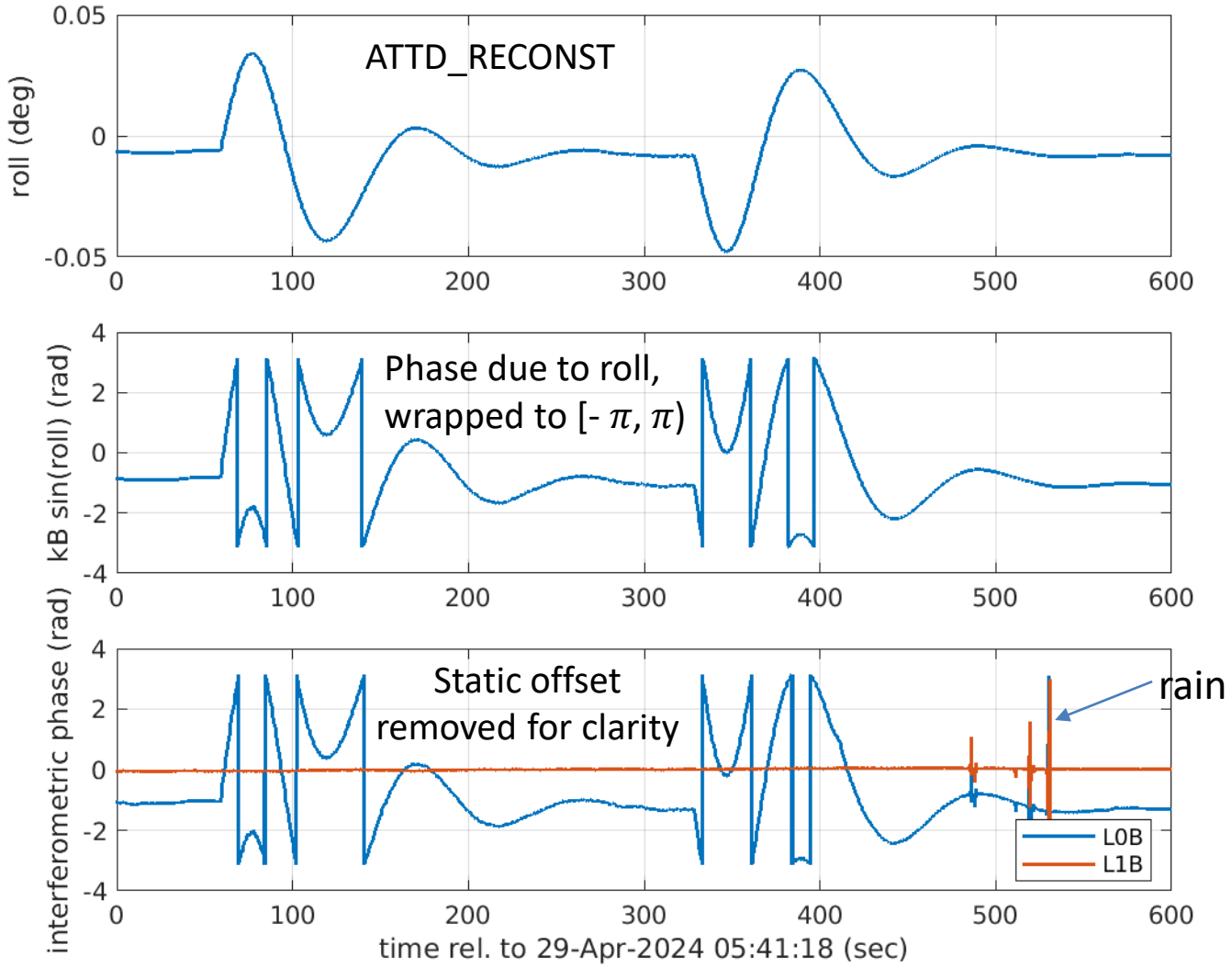


Interesting L1B interferogram test cases

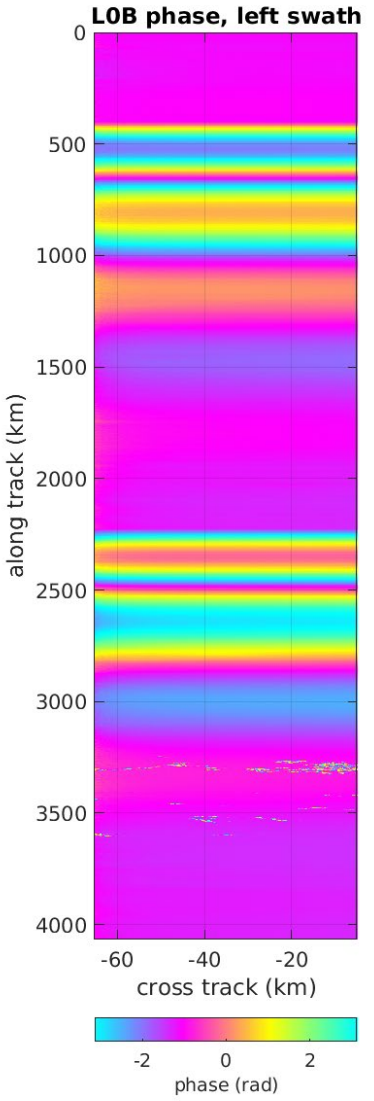
- The next two slides show examples of L1B interferograms produced from off-nominal cases:
  - During a spacecraft solar-array rotation.
  - After an inadvertent incorrect KaRIn command.
- These data are typically flagged as bad, but they can serve as “stress tests” for L1B processor.

L1B interferogram during solar array rotation

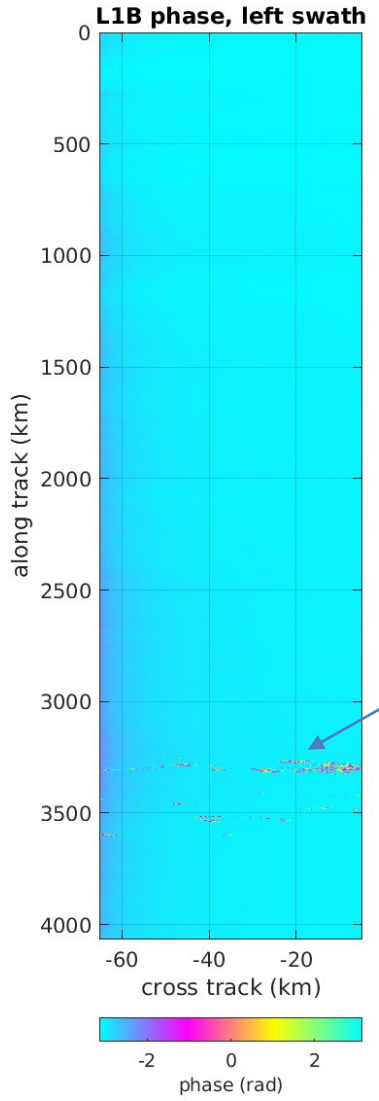
Cycle 014 pass 330, around 37.3° N



Computed on-board



Fully-corrected

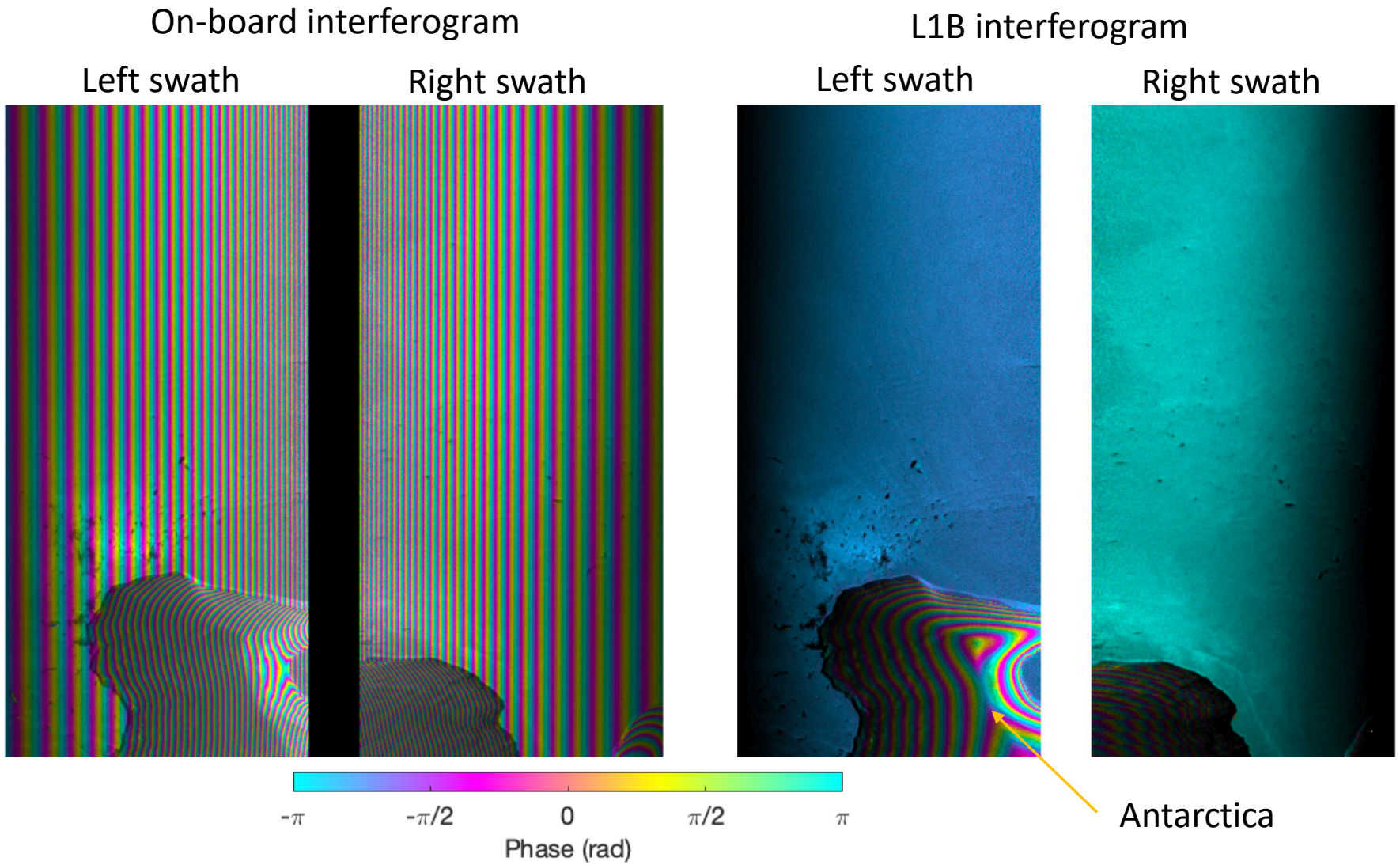


On-board orbit unavailable

Cycle 457 pass 026 (prior to end of commissioning)

Fringes due to inaccurate real-time knowledge of spacecraft altitude are corrected by L1B processor.

(This is due to DORIS disable, which does not happen during nominal KaRIn operation.)

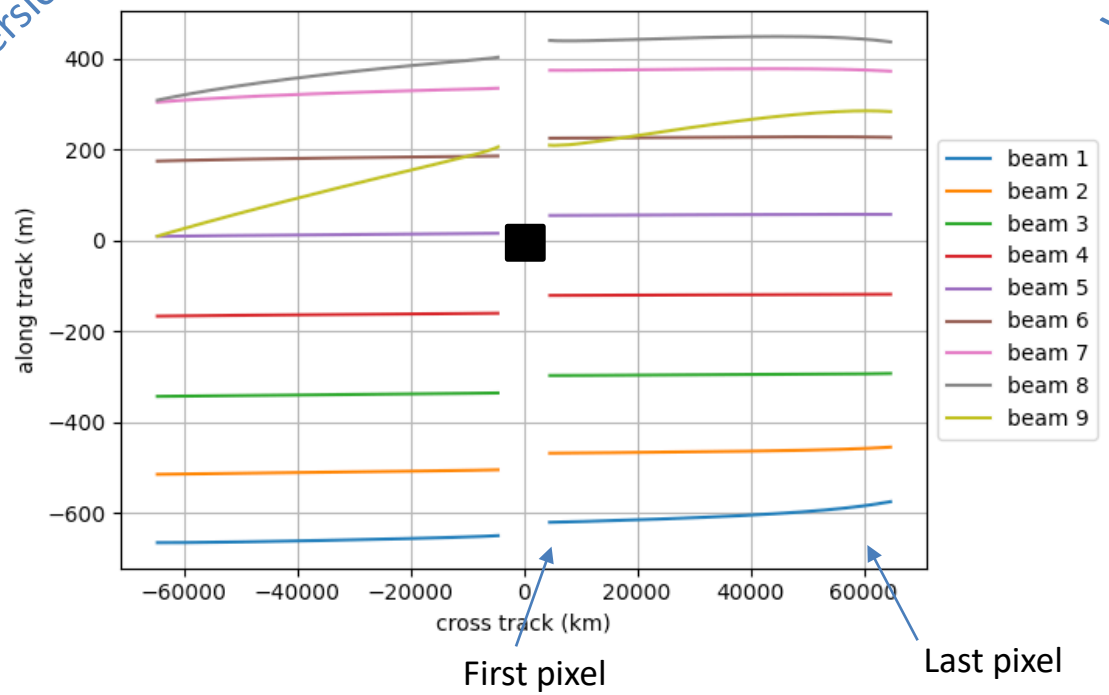


L1B reference locations

- In addition to computing phase corrections, the L1B processor computes the reference locations for each pixel.
- After completion of antenna pointing calibration, the reference locations for the 9 beams have the expected relationship to each other.
- The plots show the reference locations for one line of L1B data, relative to the spacecraft nadir point.

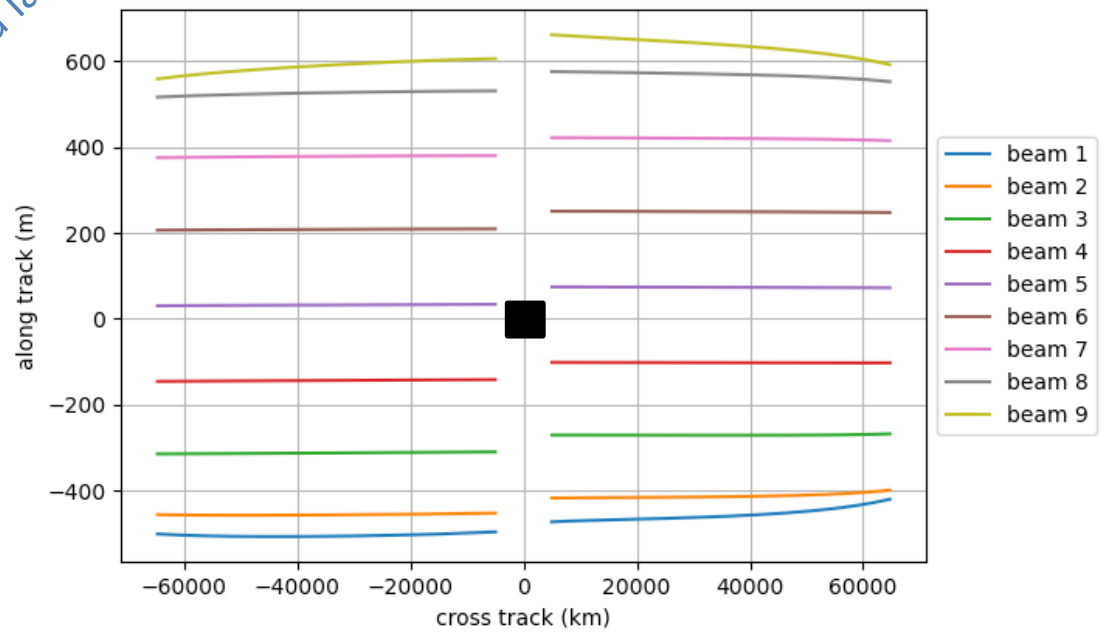
Version A

Prior to antenna pointing calibration
(cycle 483 pass 026)



Version B and later

After antenna pointing calibration
(cycle 013 pass 425)

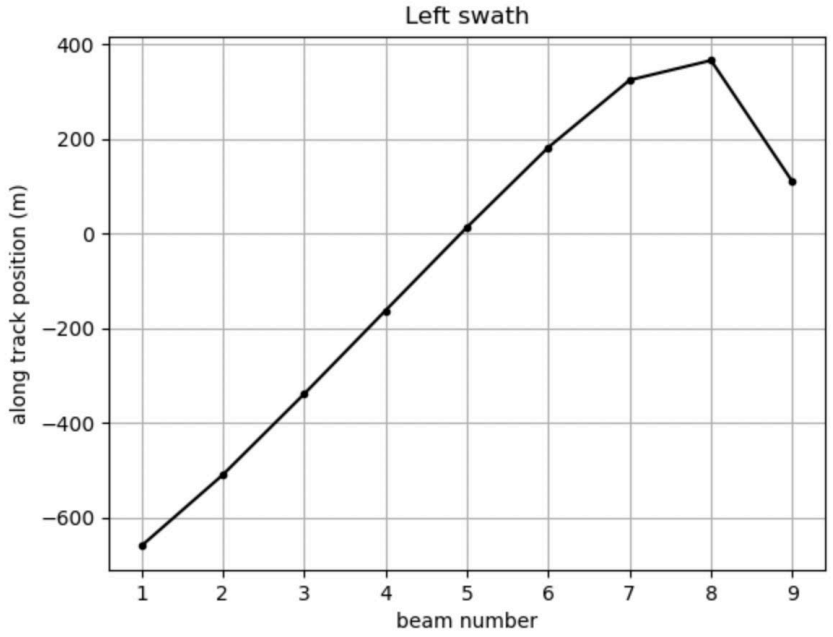


L1B reference locations

- These plots show the along-track position of reference locations at the middle of left swath for one line of L1B data, relative to the spacecraft nadir point.
- Note outermost beams slightly closer to their neighbors due to grating lobes in azimuth point-target response.
- Right swath (not shown) is similar.

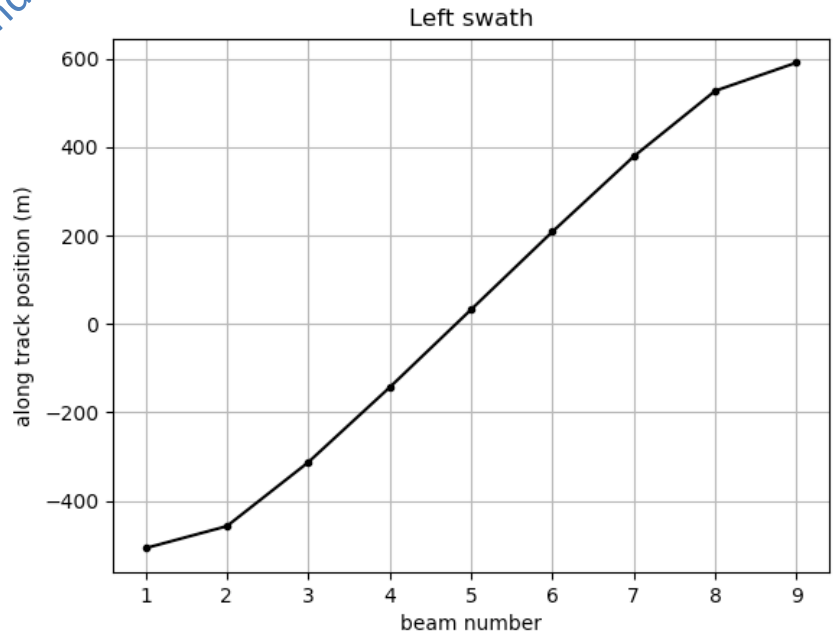
Version A

Prior to antenna pointing calibration
(cycle 483 pass 026)



Version B and later

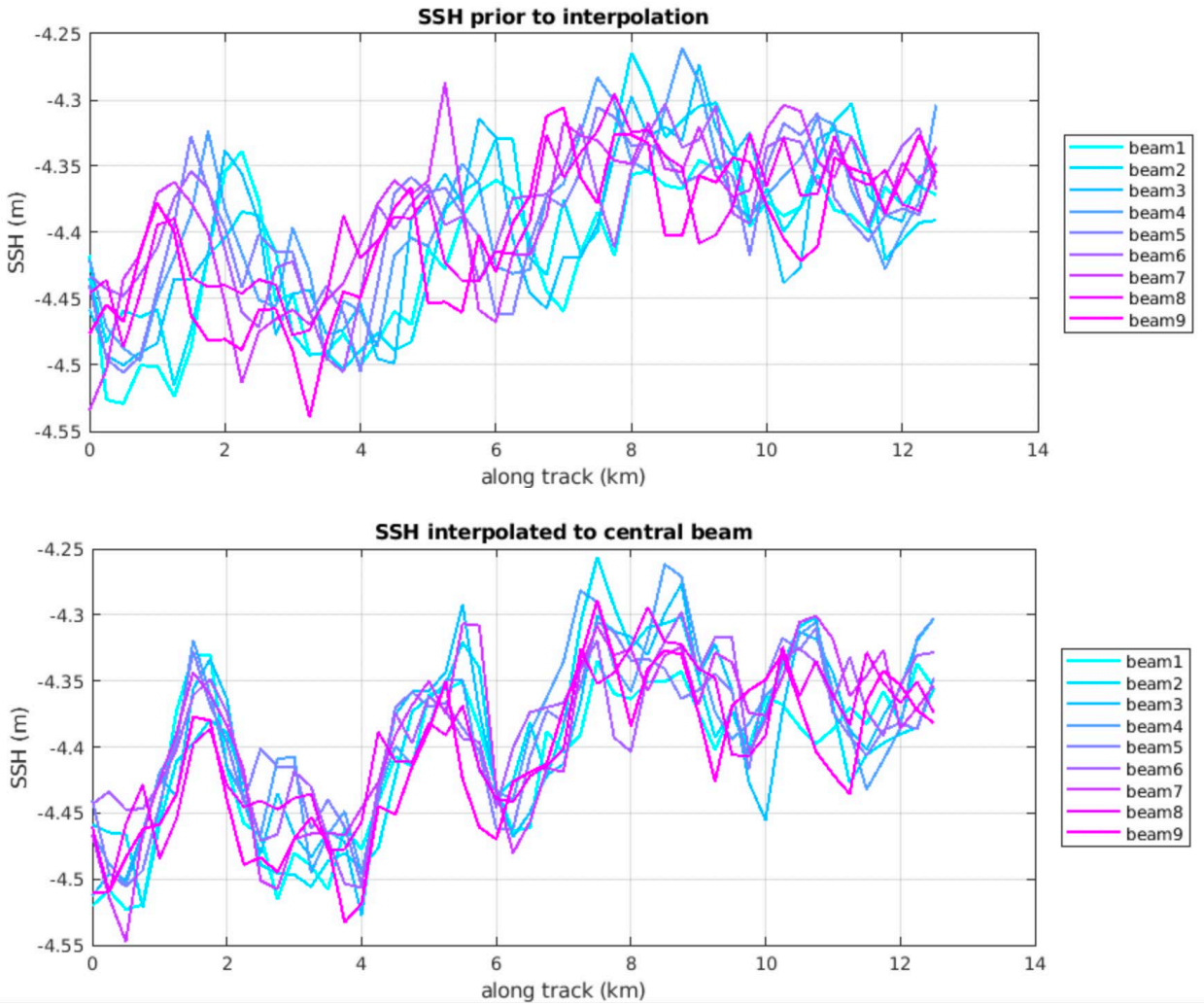
After antenna pointing calibration
(cycle 013 pass 425)



L2 processor

- The L2 processor interpolates all the beams into the same grid as the central beam.
- Examining the individual beam heights after this interpolation shows that the resampling aligns the measurements of the 9 beams.
- Beam-combining is done after this interpolation.
- Example shows SSH vs. along-track at center of right swath.

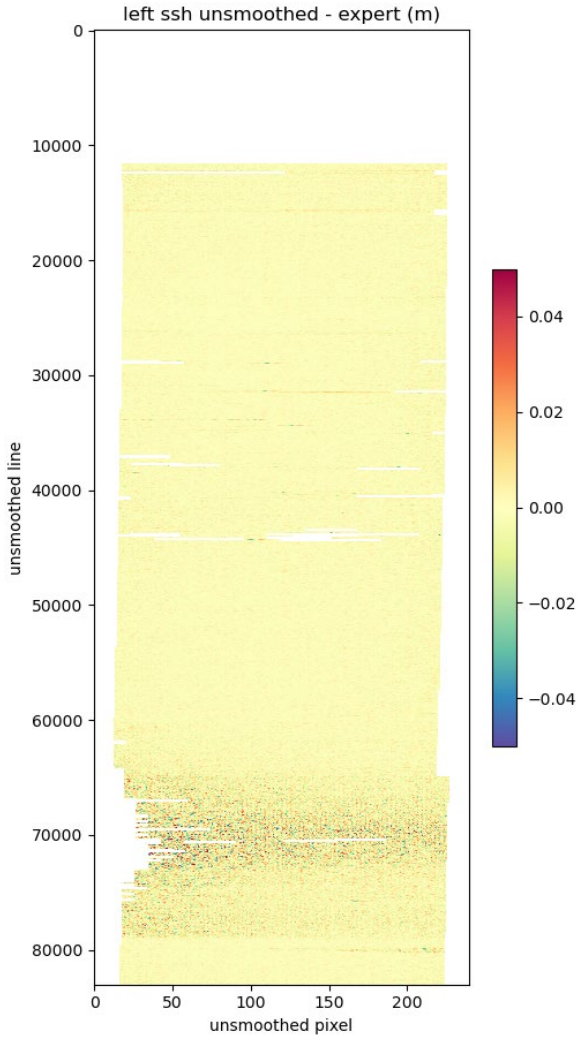
Cycle 010 Pass 037, near 24.7° S

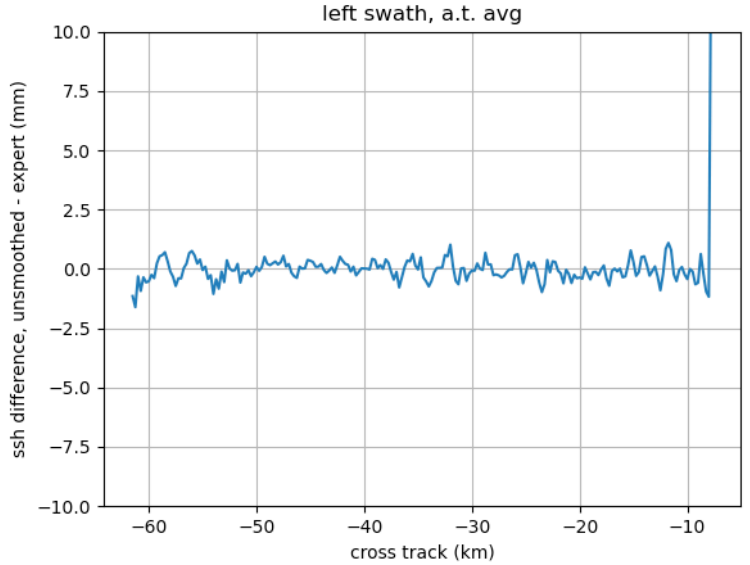


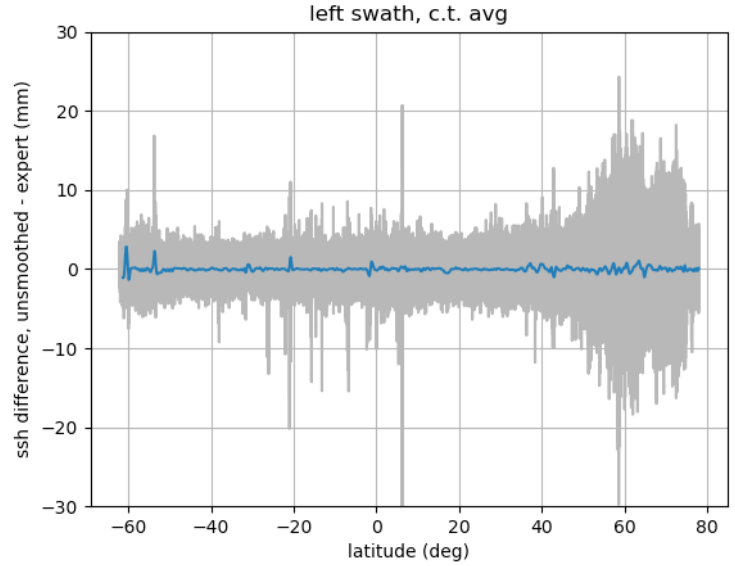
Unsmoothed vs. Basic/Expert

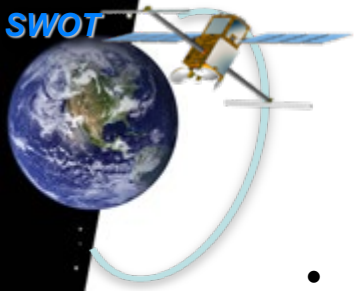
- The L2 processor produces results on both the native grid (Unsmoothed file) and the 2-km fixed grid (Basic/WindWave/Expert files).
- We have verified that the difference between Unsmoothed and Basic/Expert SSH is zero mean and has no dependence on cross-track or latitude.

Cycle 008 Pass 031



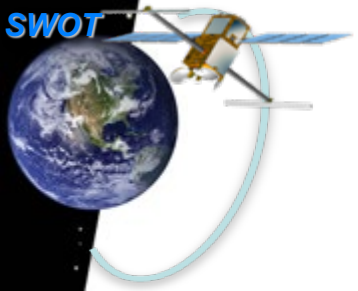






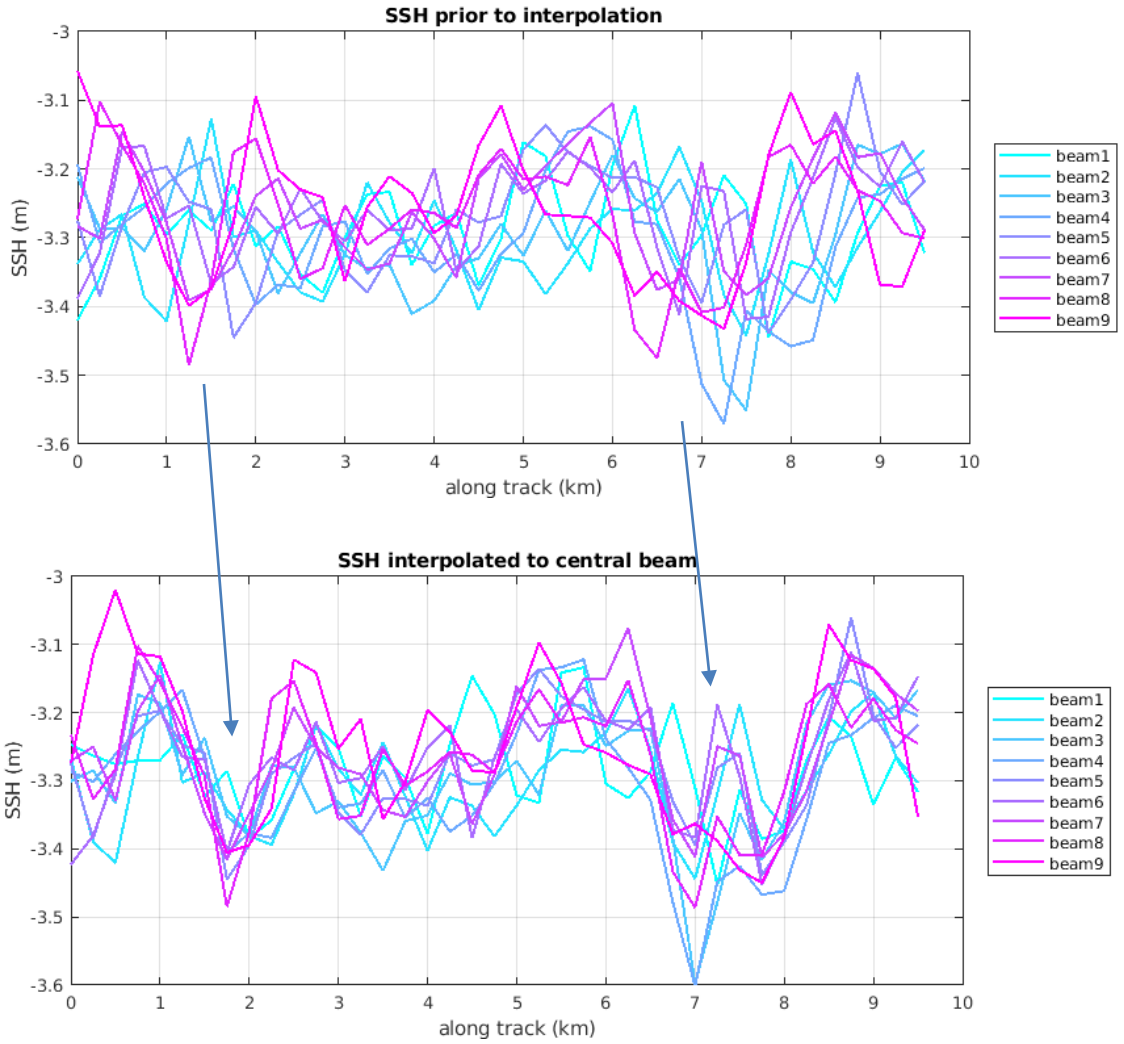
Summary

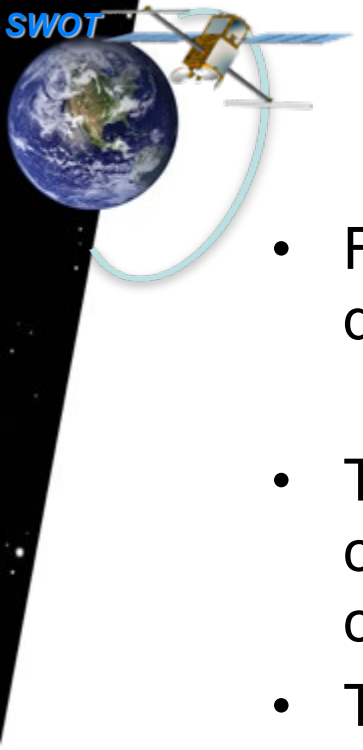
- In addition to testing/validation of LR processor software before launch, we have examined the results from processing real data, paying particular attention to intermediate results, difficult cases, etc.
- Results indicate that the primary functions of the LR processors work as expected on real data.



Backup

Cycle 484 Pass 005, around 38.9° S





Background

- For LR data, an interferogram is computed on board the satellite, a novel method developed for SWOT.
  - Thus, the L1B_LR_INTF processor is novel for SWOT as well.
- The L1B_LR_INTF processor applies corrections to the interferometric phase that cannot be computed on board due to insufficient real-time knowledge, computational complexity, etc.
- The L2_LR_PreCalSSH processor estimates SSH and produces output in both the native grid (~250 meter posting) and fixed grid (2 km posting).
- The L2_LR_SSH processor interpolates the cross-over correction to the fixed grid.
- Prior to launch, all LR processors were tested and validated using simulated data.
  - Some additional bug fixes were needed after launch.
- Here we show some examples and analyses with real flight data that illustrate that the processors have the expected behavior, further validating their implementation.