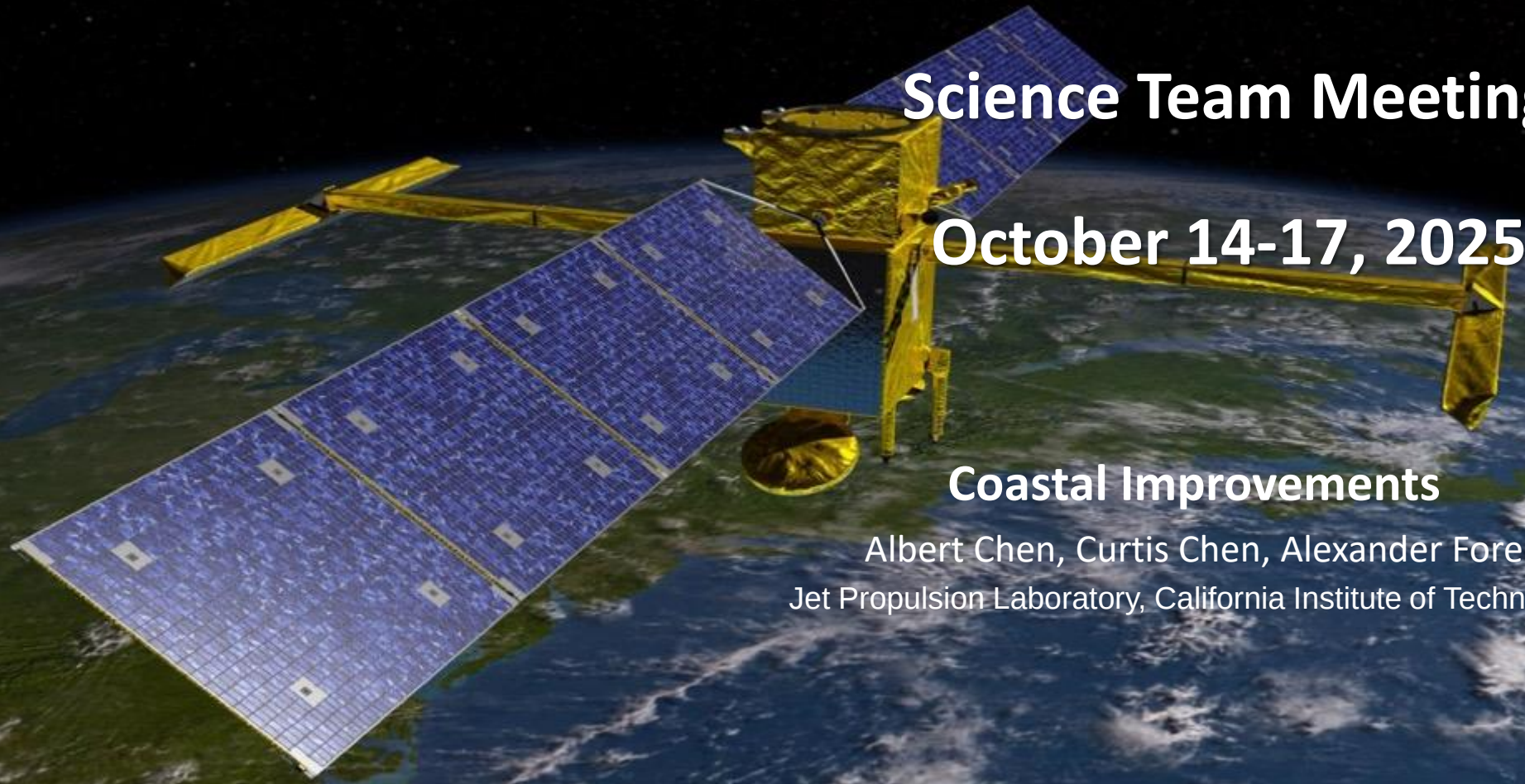
National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Surface Water and Ocean Topography (SWOT) Mission

Science Team Meeting

October 14-17, 2025



Coastal Improvements

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URS335866 / CL#25-4108

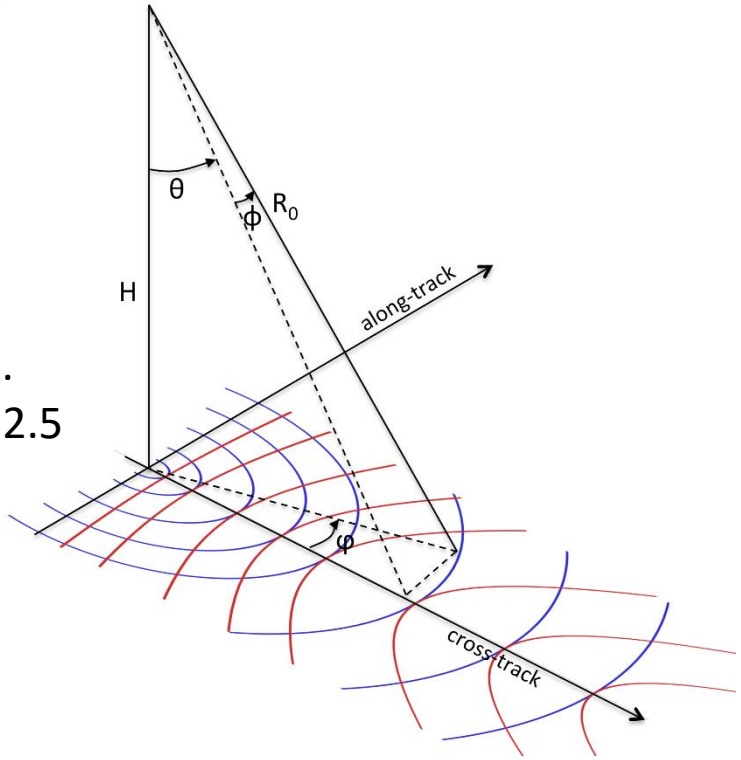
Introduction and Background

Coastal artifacts due to interpolation of phase bias correction:

- The L1B_LR_INTF computes a “phase bias correction” to the L0B interferometric phase that accounts for (among other things):
  - Doppler centroid used by OBP.
  - Ground-reconstructed spacecraft attitude and orbit.
  - KaRIn antenna patterns and pointing.
- The phase bias correction is generally smooth and slowly varying over the ocean.
- Due to its computational cost, the phase bias correction is only computed every 2.5 km in along-track. It is then interpolated to the LR native grid using a sinc interpolator.
  - This doesn’t work well when there are sudden “jumps” in the phase bias correction, which tends to happen in coastal areas because the contrast between land and ocean causes jumps in the on-board Doppler centroid estimates.

Proposed Solution:

- We have developed some updates to the L1B_LR_INTF processor to improve performance in coastal areas in two ways:
  - Spline interpolator has less ringing near coasts than sinc interpolator.
  - Better account for jumps in OBP Doppler centroid.
- Disclaimer: there can be other issues near coasts that we are not addressing here (tide models less accurate, SSB less accurate, etc.)

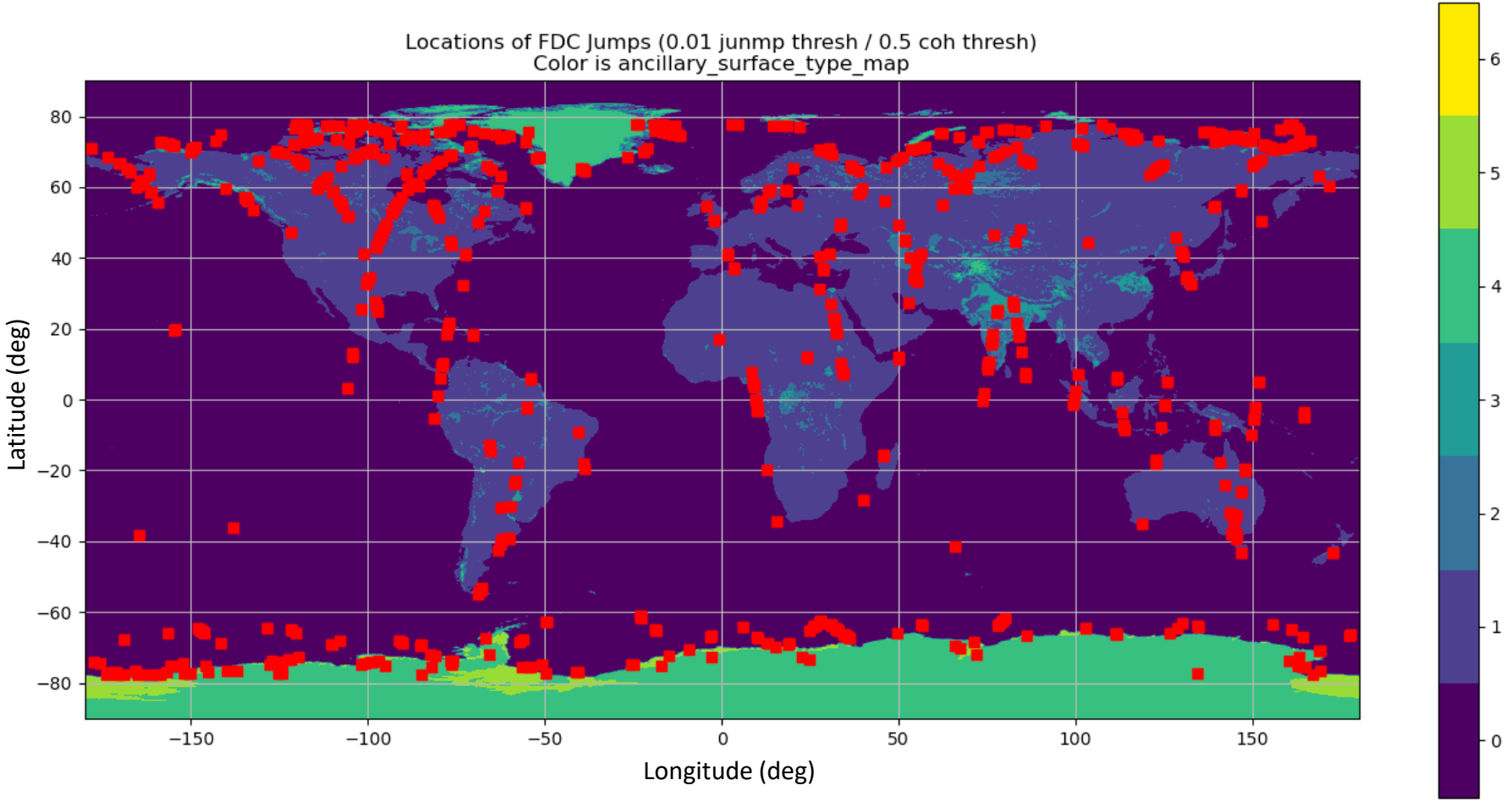


Observed phase is biased because contours of constant phase (red) on Earth surface do not align with contours of constant range (blue).

- *Bias depends on beam pointing because echo is weighted by beam footprint on ground.*
- *Beam pointing depends on OBP estimate Doppler centroid.*
- *Phase bias is removed during ground processing using knowledge of Doppler centroid estimate*

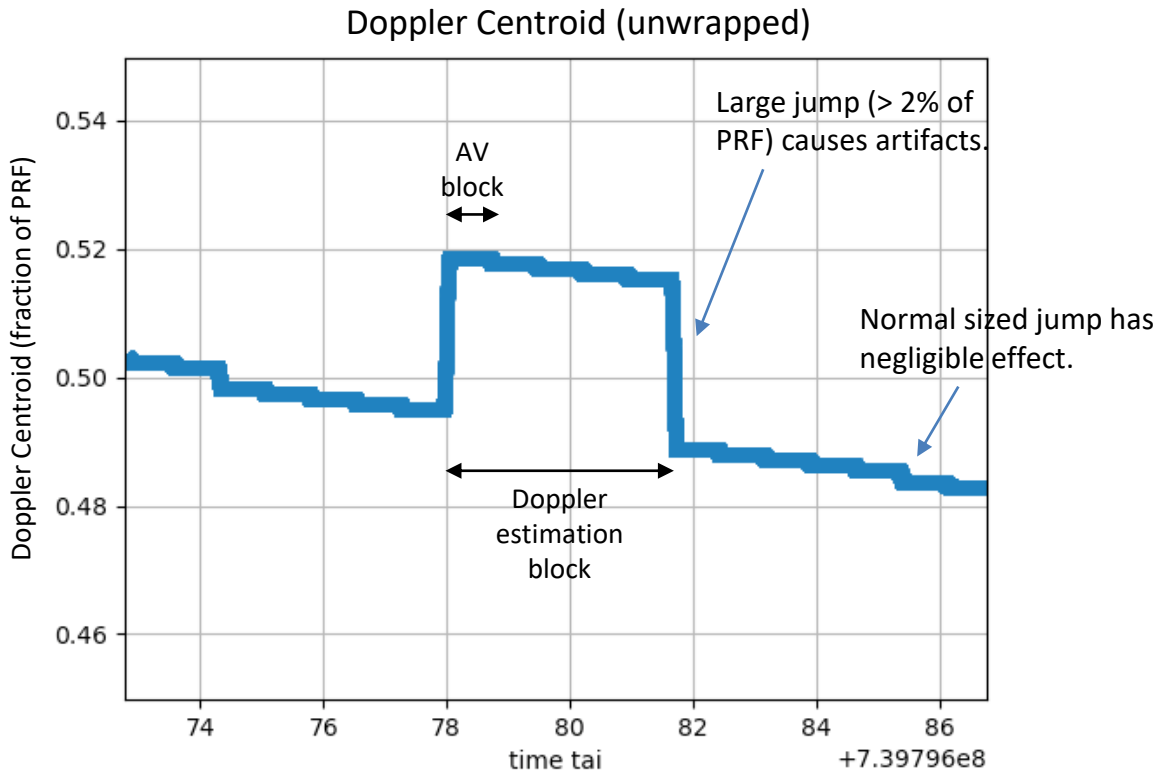
Doppler centroid jumps

- Doppler centroid jumps cause artifacts in Version D data.
- The large Doppler centroid jumps mainly occur around coasts and over land.
- Sea ice may make jumps more likely in polar regions.
- Large storms or small islands may sometimes cause jumps in areas that are otherwise open ocean.



Doppler centroid jumps

Example from cycle 549 pass 001.



- The small jumps at AV block boundaries are controlled by OBP Doppler Centroid Correction Table, using *a priori* knowledge.
  - Current configuration: 5 AV blocks per Doppler estimation block for LR.
- The large jumps are due to how the on-board pulse-pair Doppler estimator (same estimator as used for mitigation Doppler product) responds to areas with large, sudden changes in reflectivity in along track.

- LR Doppler centroid is updated every 100 unsmoothed lines (~ 25 km, but not exactly).
- Empirical data from a 100-line block is used in the OBP to estimate the Doppler for the **next** 100-line block in real time. This tends to be problematic when a block containing lots of land is used to estimate the Doppler for the next block containing purely ocean, i.e. at coasts.
- The difference between estimated and true Doppler centroid is generally too small to have a noticeable effect on performance (it gets accounted for during phase bias correction in L1B_LR_INTF).
- The edges between Doppler blocks do cause a problem, because phase bias correction is done once every 2.5 km and interpolated (interpolator assumes smooth function). Thus when **one** Doppler block is poorly estimated, we get **two** edges (and two artifacts).

Proposed Improvement and Example Results

To improve performance at Doppler jumps and coasts, we have updated the code to:

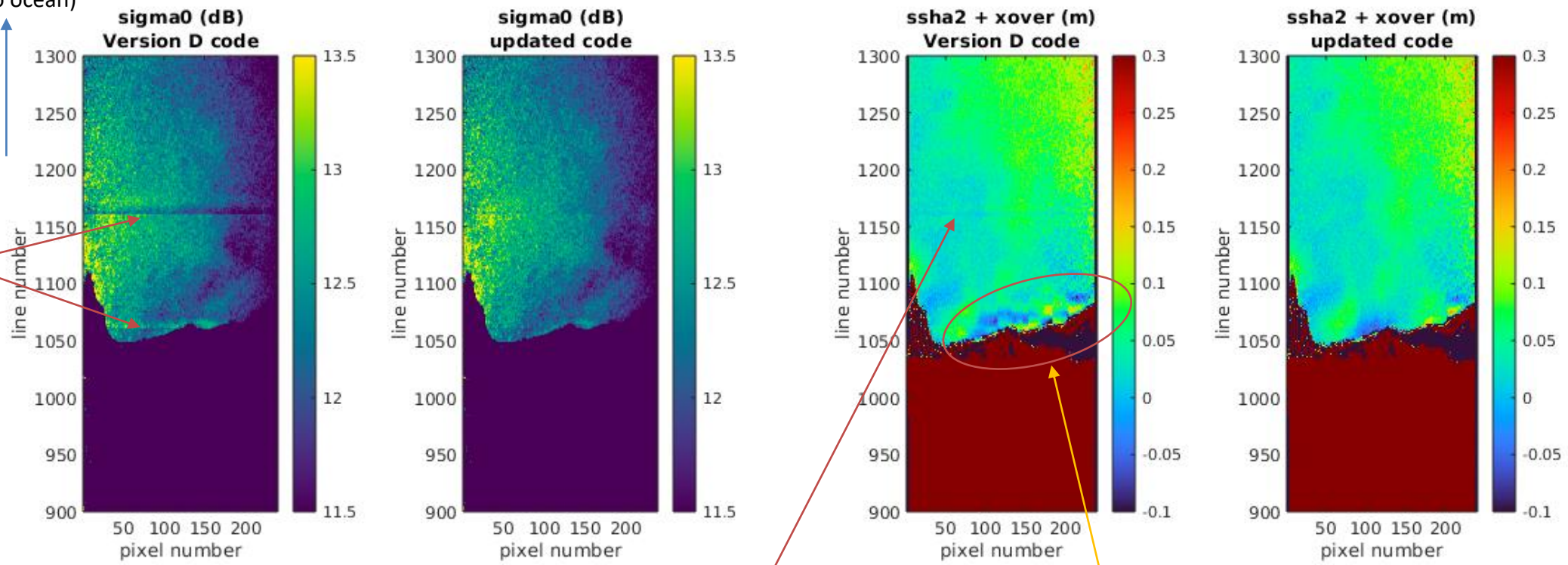
- Interpolate the phase bias correction using a cubic spline interpolator instead of a sinc interpolator.
- Compute the phase bias correction at 4 extra points at 250-meter spacing surrounding Doppler centroid jumps.

Example from cycle 549 pass 001, right swath, at Egypt/Mediterranean Sea.

Along-track (flying from land to ocean)

L1B beam 1 sigma0

L2 Unsmoothed Beam-combined SSHA



Two edges due to one Doppler block poorly estimated.

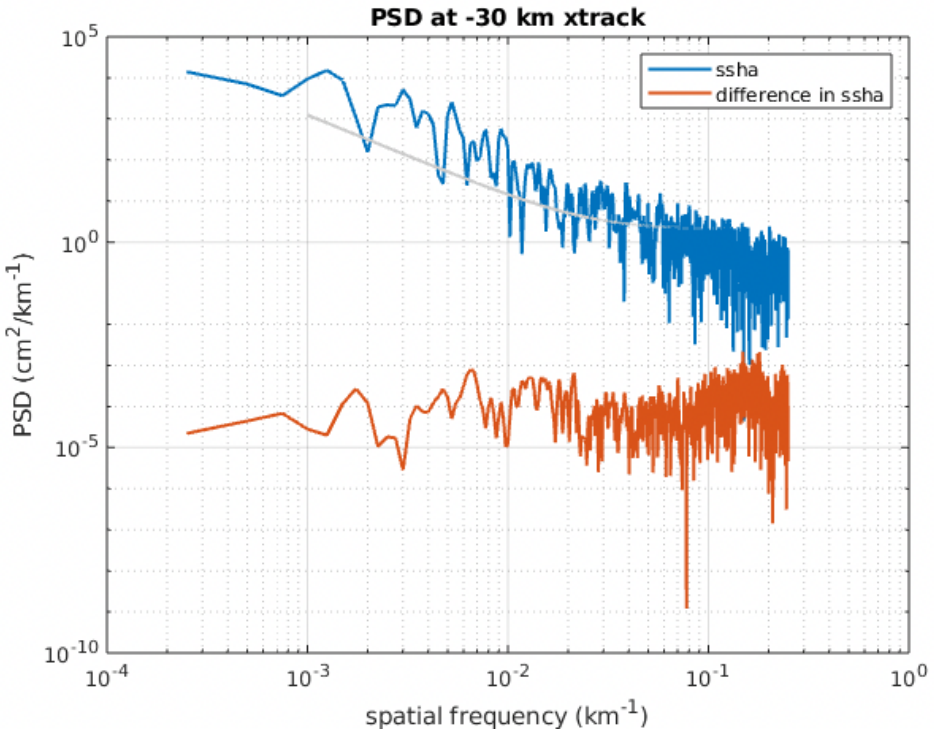
Doppler jump artifact.

Interpolator ringing at coastline.

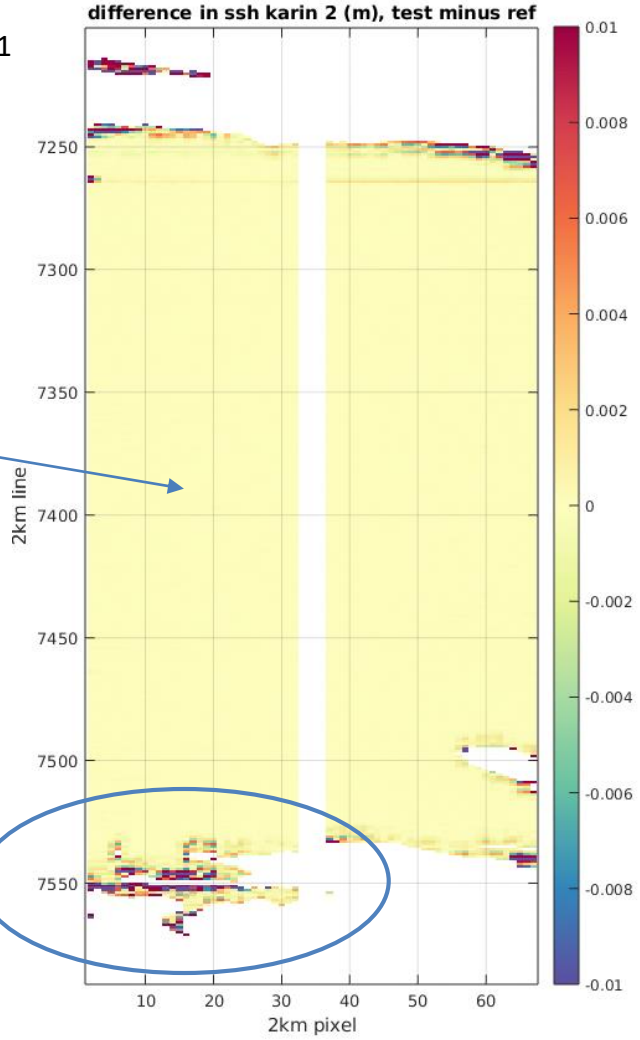
Sinc vs Spline interpolator

- The spline interpolator improves coastal performance without degrading open ocean performance.
- PSD of difference between sinc and spline is white and negligible over the open ocean.

Example: Cycle 549, Pass 001
PSD of ssha difference computed over South Atlantic Ocean.



Example: Cycle 549, Pass 001
at Black Sea.

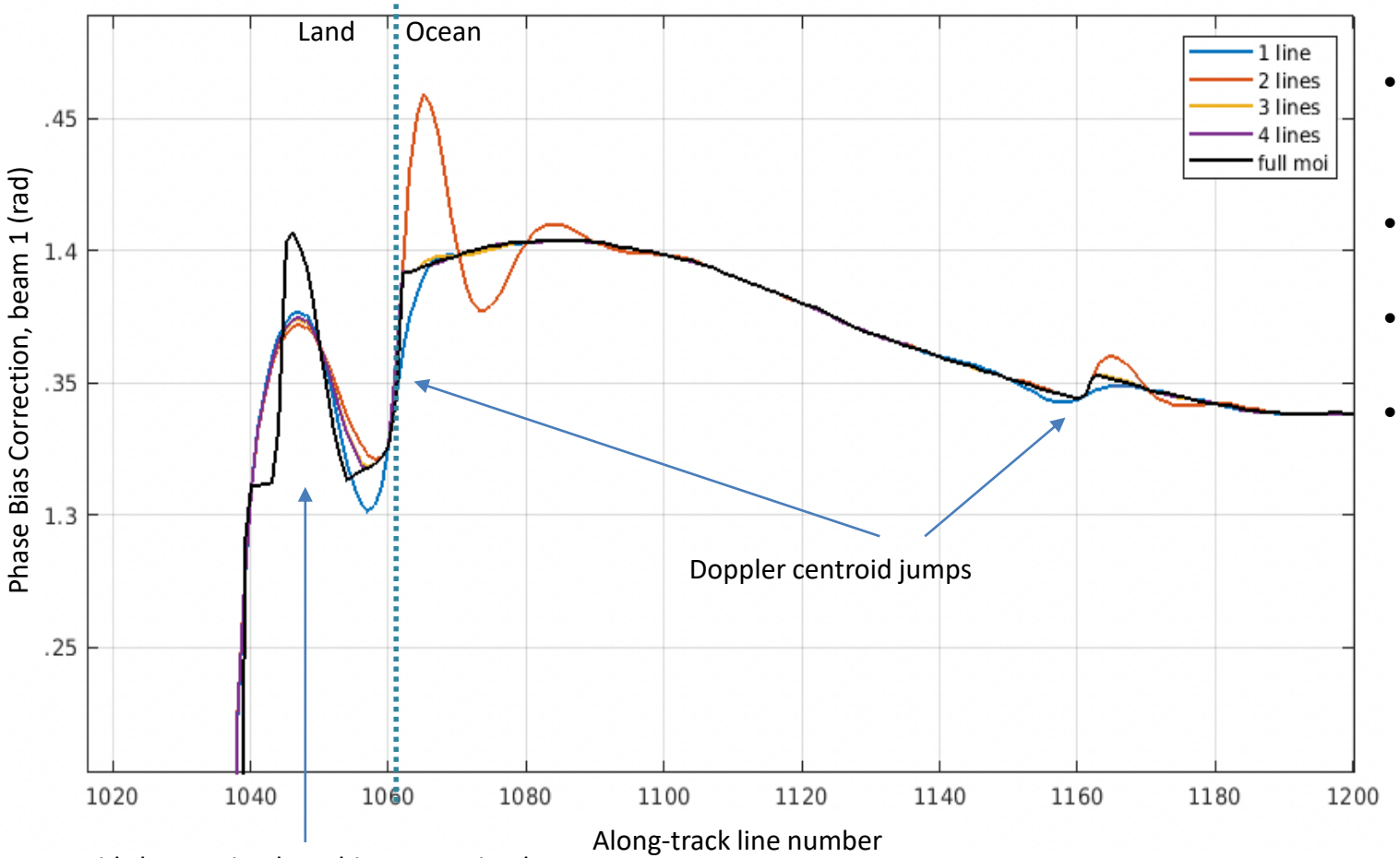


Difference in open ocean is zero mean and about 0.1 mm RMS.

Largest differences between sinc and spline interpolator are in coastal areas.

Computational Efficiency

Example from cycle 549 pass 001, middle of right swath



- Plot shows spline interpolator results, with 1 to 4 extra phase bias computations around each Doppler centroid jump.
- Black curve is ideal but too computationally expensive.
- The ringing in the blue/red curves is undesirable (causes artifact in final product).
- Purple curve is selected as a very good approximation (almost exactly on top of the black curve in the ocean region). → This can be implemented in operational processing with very small additional cost.

Summary

- Known artifacts exist in coastal areas in Version D.
- Proposed improvements to L1B_LR_INTF processor addresses sinc interpolator ringing and Doppler centroid jumps.
  - Improvements will likely be incorporated into future product version
- Other issues might remain. (User research results could inform further improvements.)

Backup

Example of Artifact