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California Institute of Technology
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Surface Water and Ocean Topography (SWOT) Mission

Validation Meeting

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KaRIn Data Self-Consistency

Albert Chen[(1)]

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

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

Overview

- Consistency between Calibration and Science orbit.
- Consistency between LR and HR measurements.
- Consistency among 9 LR beams.

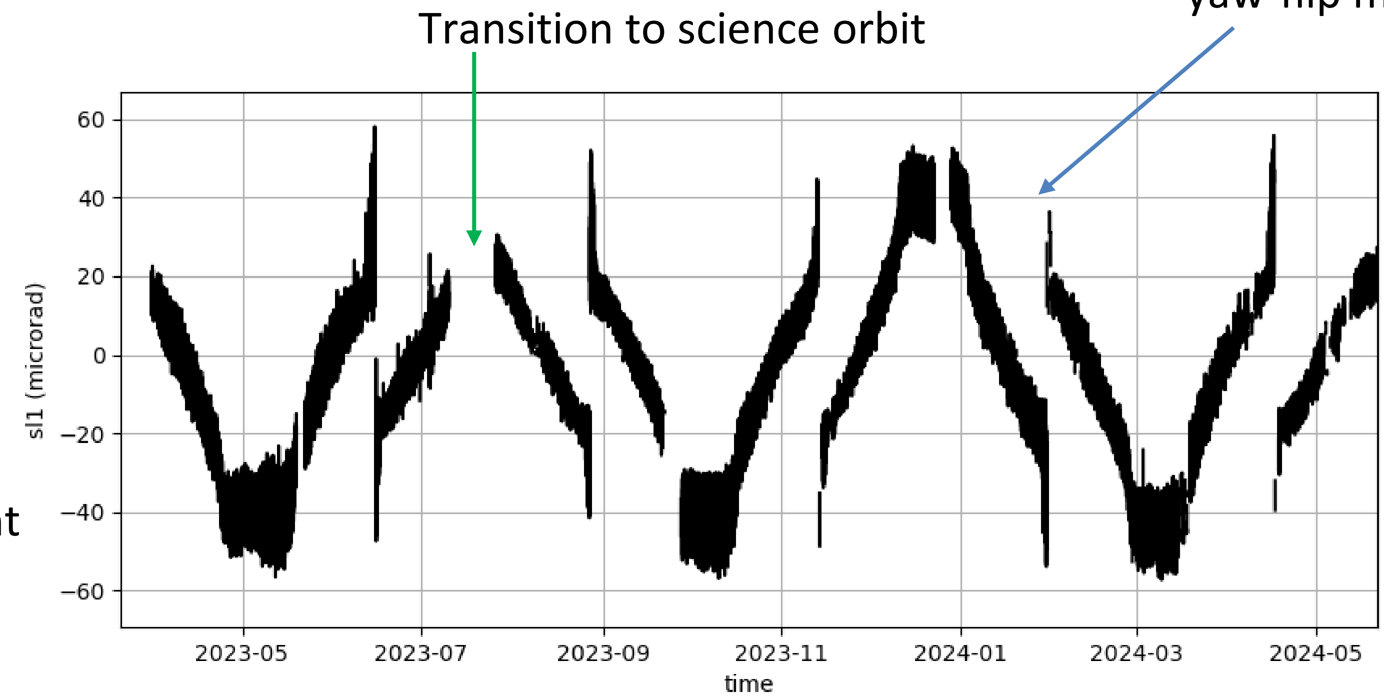
SWOT

Calibration vs. Science Orbit

- Results show that static calibration parameters estimated from Calibration data can be applied to Science orbit data with no changes.
- For example, the time series of SSH tilt estimated by XOverCal shows the same pattern before and after transition to the Science orbit, indicating that no change is needed in the antenna lever arms and static interferometric phase parameters.

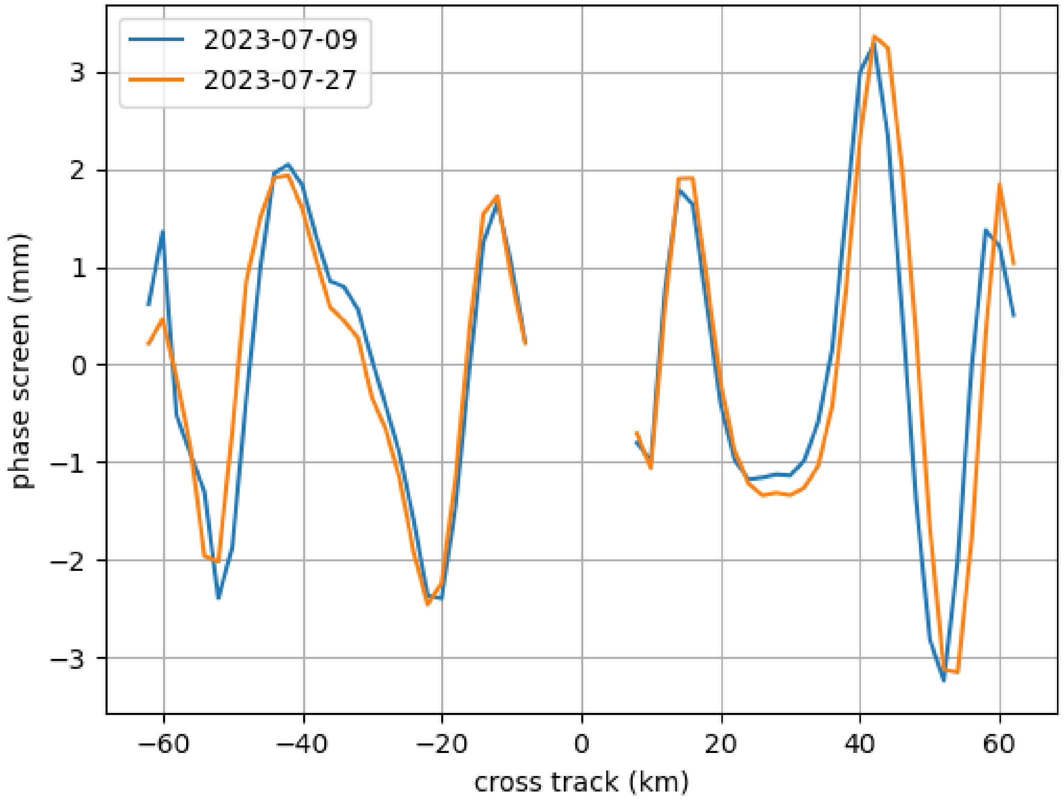
Version B and Version C both use a single set of static calibration parameters for both Cal/Val and Science data.

1 microrad of tilt causes 6 cm height error at far range.



Calibration vs. Science Orbit

- Residual phase screens estimated from last full day of Calibration orbit and from first full day of Science orbit agree to better than 1mm.
- Phase screen calibration estimated from Calibration data is valid for Science data as well.

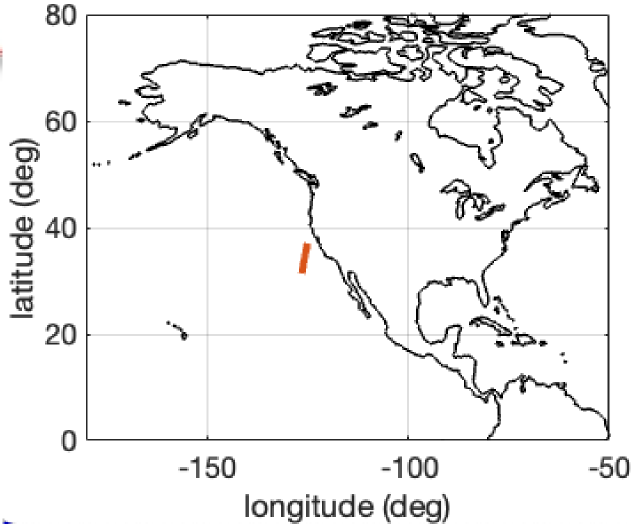


LR/HR comparison approach

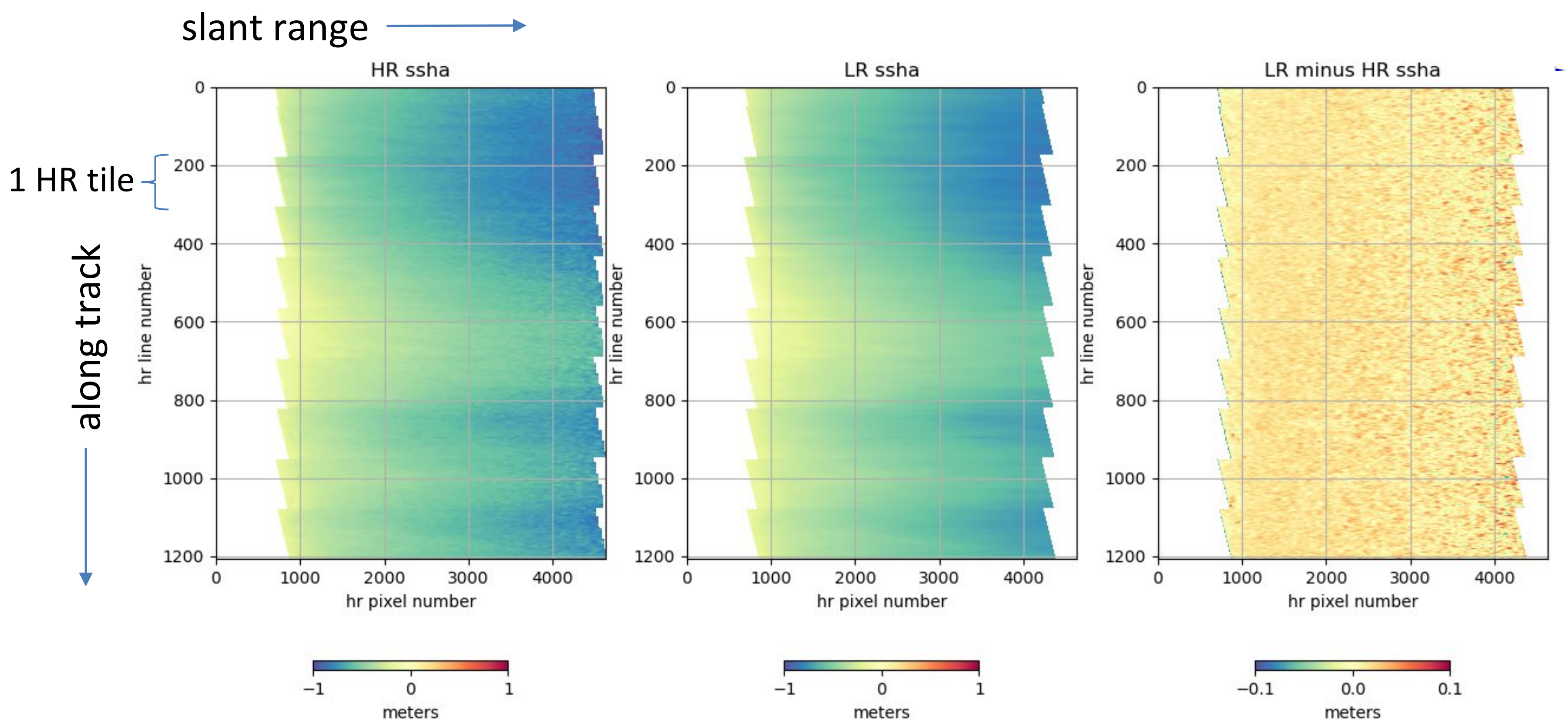
- KaRIn processing uses XOverCal computed from LR products to correct quadratic errors in HR products.
  - Quadratic height errors must be the same in both LR and HR processing chains for this to work.
  - To validate this approach, we compared LR and HR data at several locations in the ocean using data from the Cal/Val phase.
- The comparison was done using locally processed HR results (not the operational HR products)
  - Special offline processing was used to increase complex averaging (not available in public products) to avoid wave-bunching effects in HR data over ocean.
- The same sea-state bias correction was applied to both LR and HR, and the same tide and MSS were used to compute SSHA.
- No XOverCal correction is applied to either LR or HR data.
- The data are compared by resampling the LR SSH into the HR grid.

Example LR/HR comparison

- In this example, the quadratic height error is relatively small.
- Spatial variation of SSHA looks the same in both LR and HR images.
- Difference between LR and HR shows very little cross-track or along-track variation.



Cycle 479, pass 013, tiles 210-219, Right swath

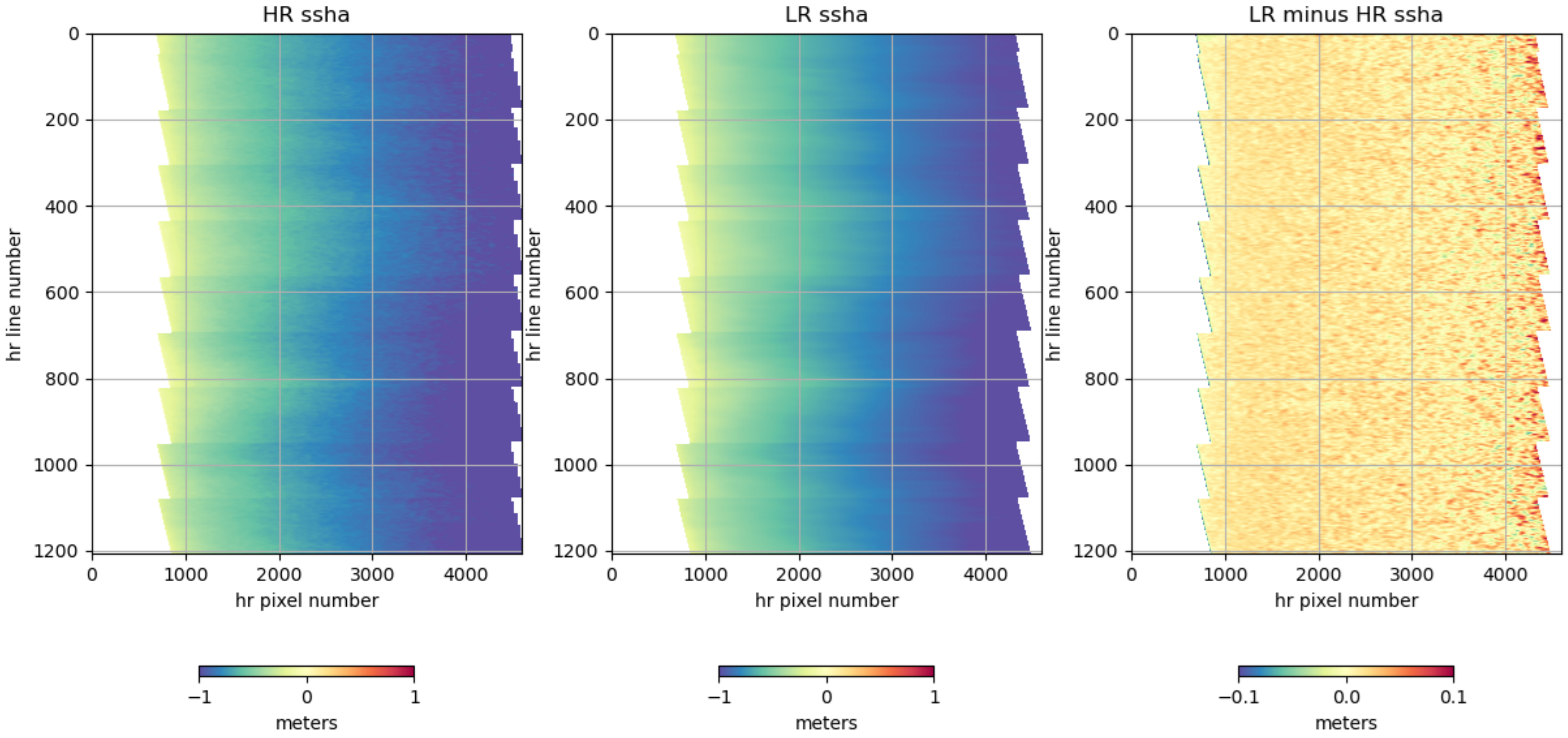


~ 600 km

Example LR/HR comparison

- This example has ~ -1 m quadratic height error, which is common to LR and HR.
- Thus, XOverCal estimated from LR data would be applicable to HR data as well.

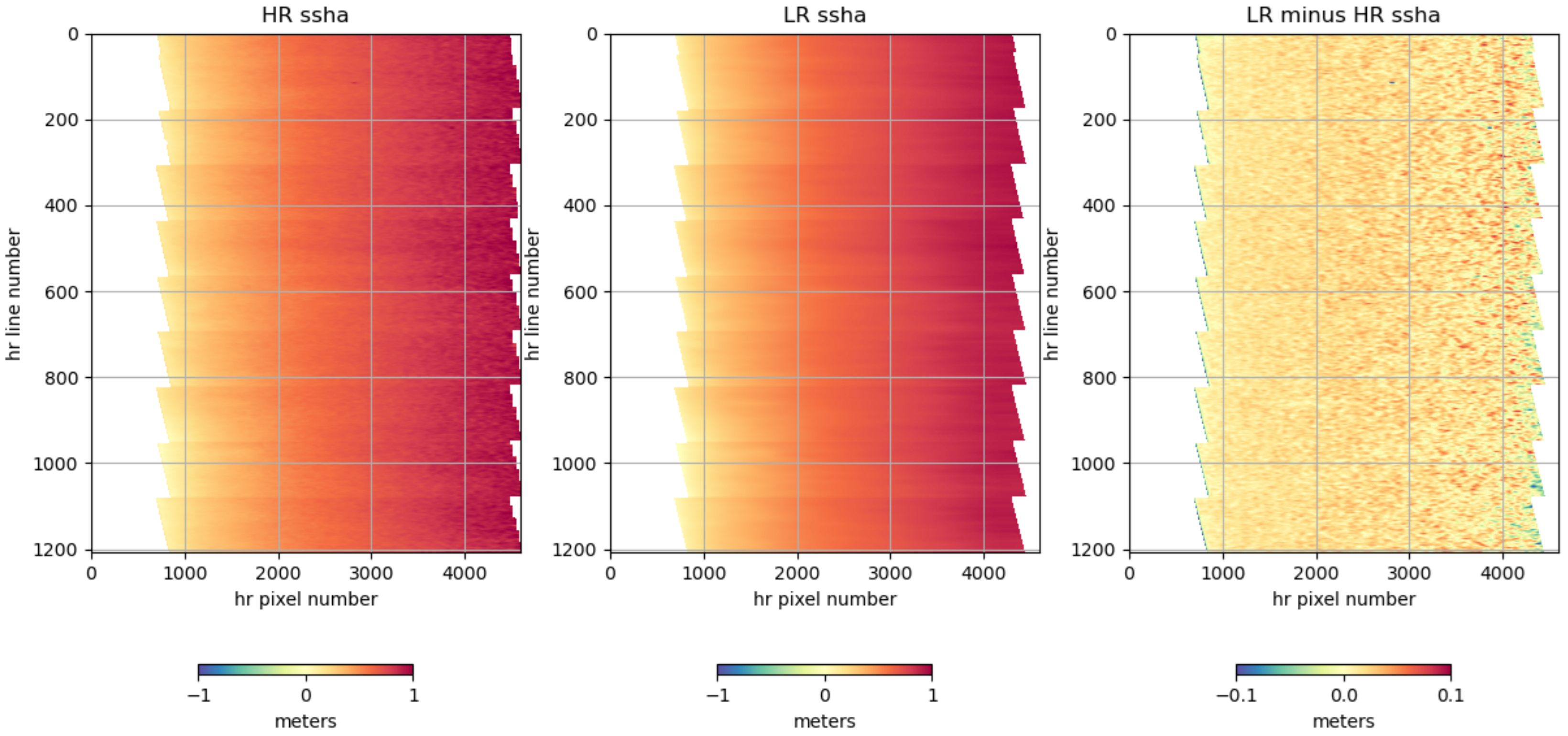
Cycle 541, pass 013, tiles 210-219, Right swath



Example LR/HR comparison

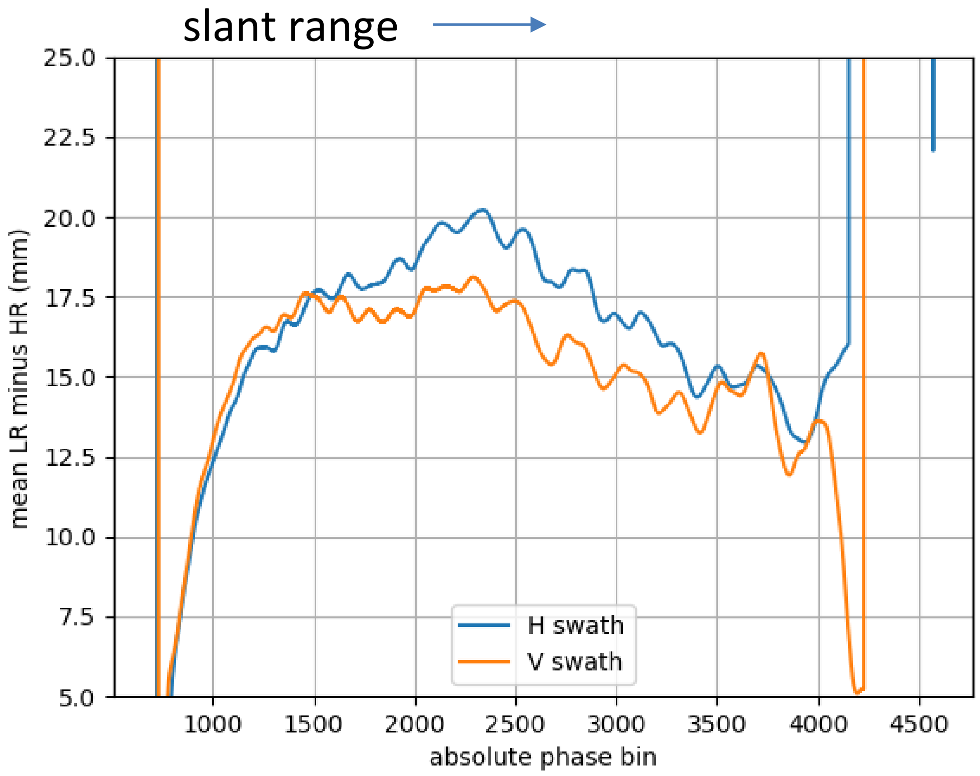
- Another example, this time with ~ +1 m quadratic height error, which is common to LR and HR.
- This example is in the yaw-flip configuration, whereas previous examples were nominal yaw.

Cycle 558, pass 013, tiles 210-219 , Right swath



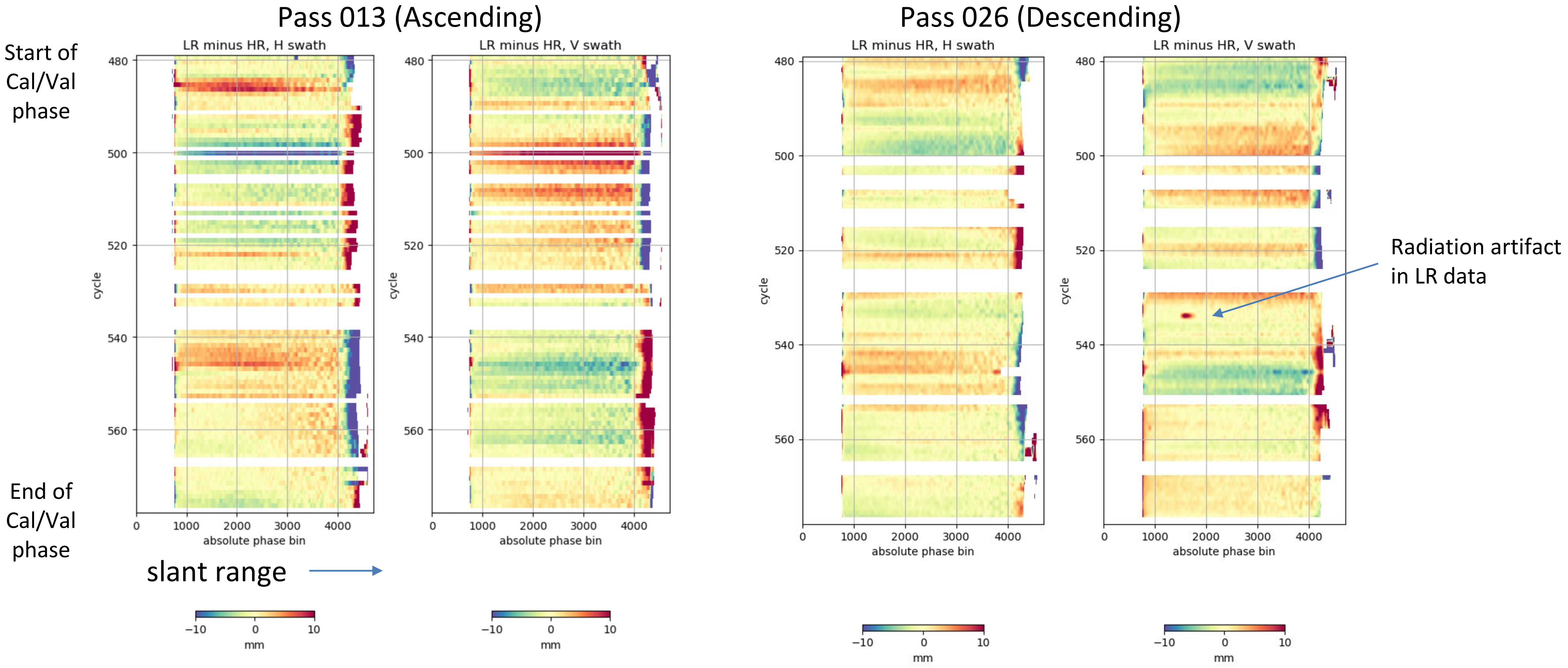
LR/HR mean difference

- We performed the comparison between LR and HR data using ~600 km of ascending and descending data each day, for 100 days of data from the Cal/Val phase.
- This plot shows the mean difference between LR and HR SSHA.
- Mean bias between LR and HR is ~15 mm (can be adjusted using static calibration) and stable (see next slide). Additional analysis ongoing.

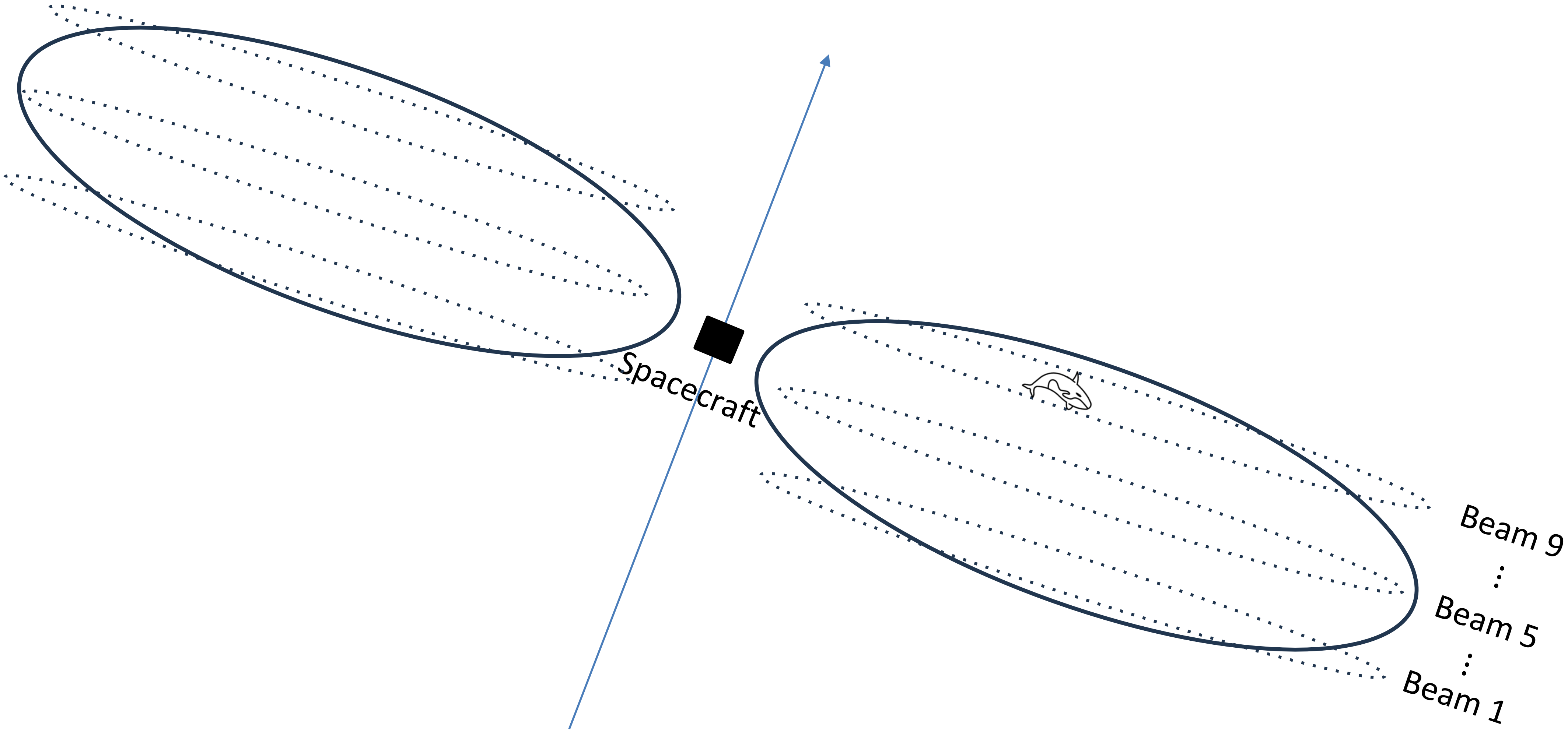


Stability of LR/HR difference

- These images show variation of the difference between LR and HR around the mean.
- The standard deviation over 100 days is about 3 mm.

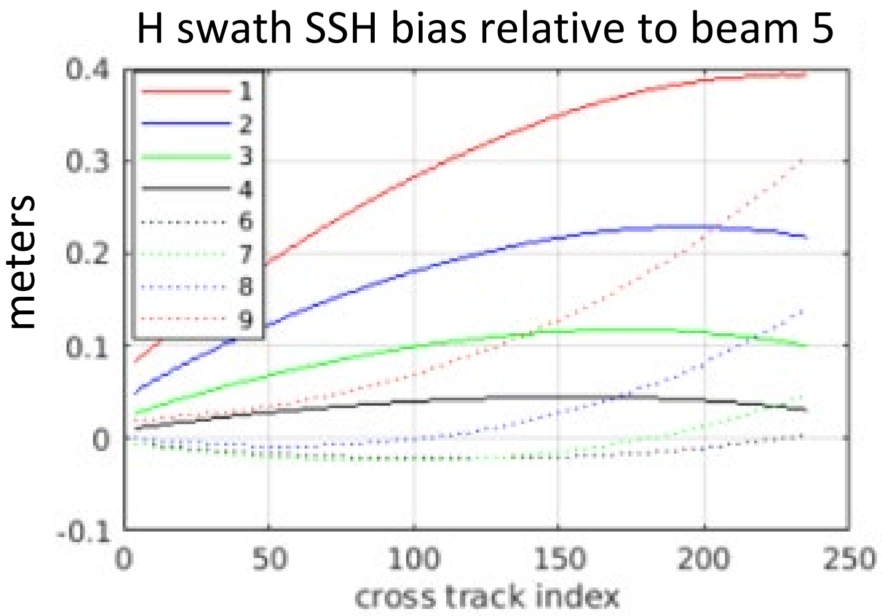


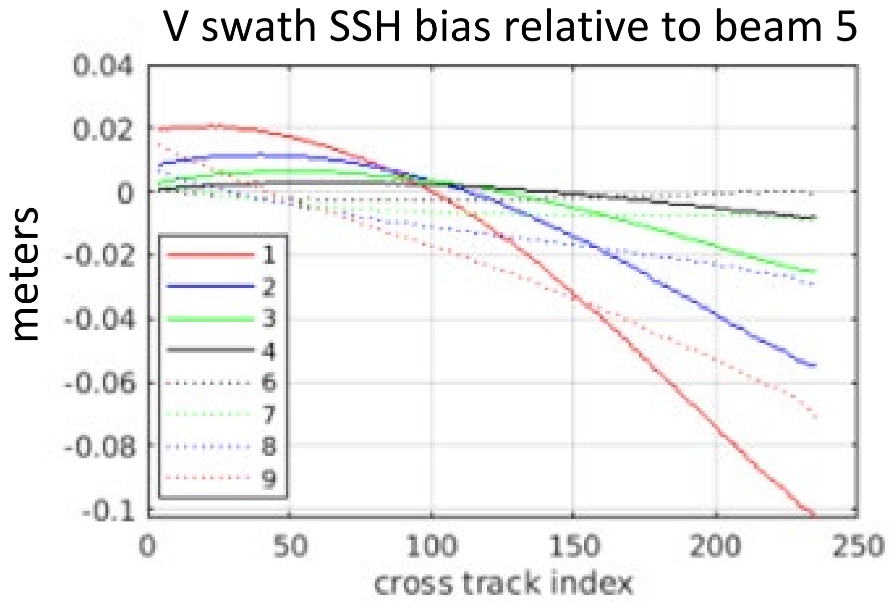
9 LR Beams: Conceptual Illustration



SSH of 9 LR Beams

- The 9 LR beams have cross-track dependent SSH biases of up to 0.4 meters relative to the central beam (beam 5). Users who derive heights from L1B_LR_INTF products will notice these biases.
- These biases are most likely due to imperfect antenna pattern knowledge.
- Due to change in sequence of beams (fore/aft), beam 1 for yaw-flip data has the same bias as beam 9 for non yaw-flip data, etc.
- These beam-dependent biases do not affect accuracy of final beam-combined, calibrated SSH/SSHA. (See next slides.)

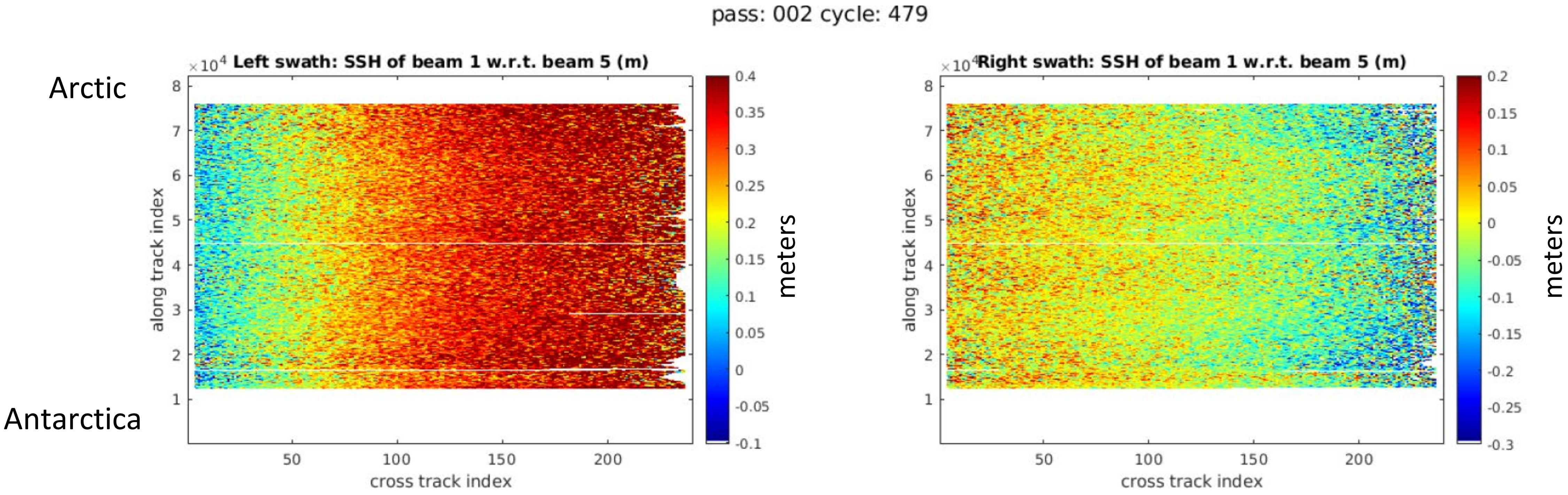




Plots show bias averaged over 40 granules.

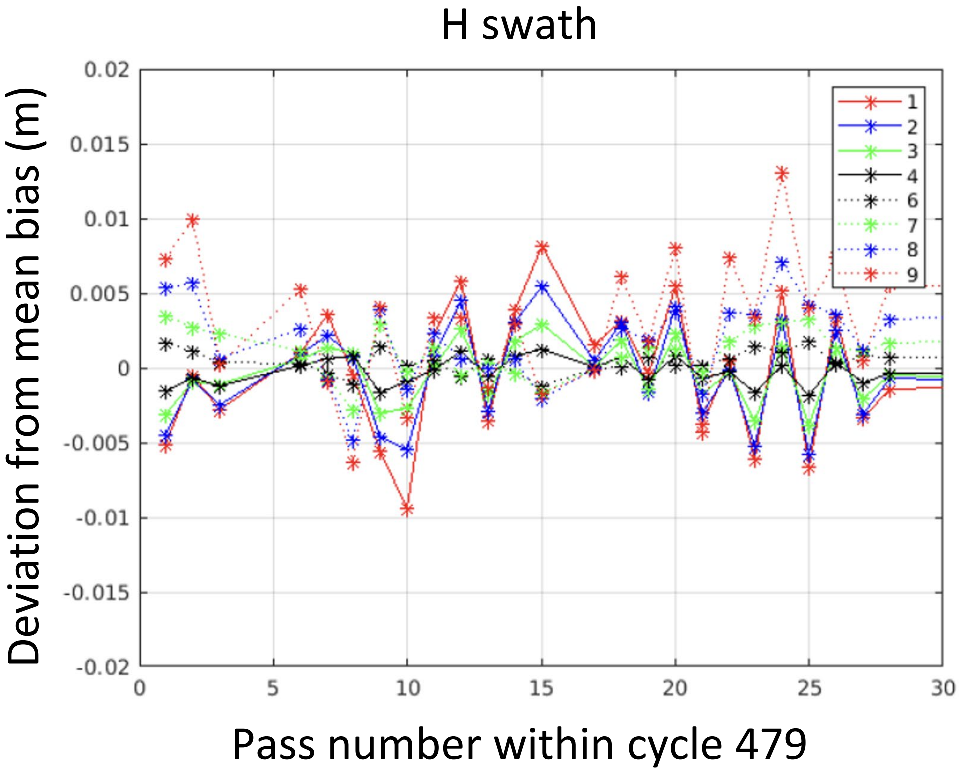
Example of bias relative to central beam

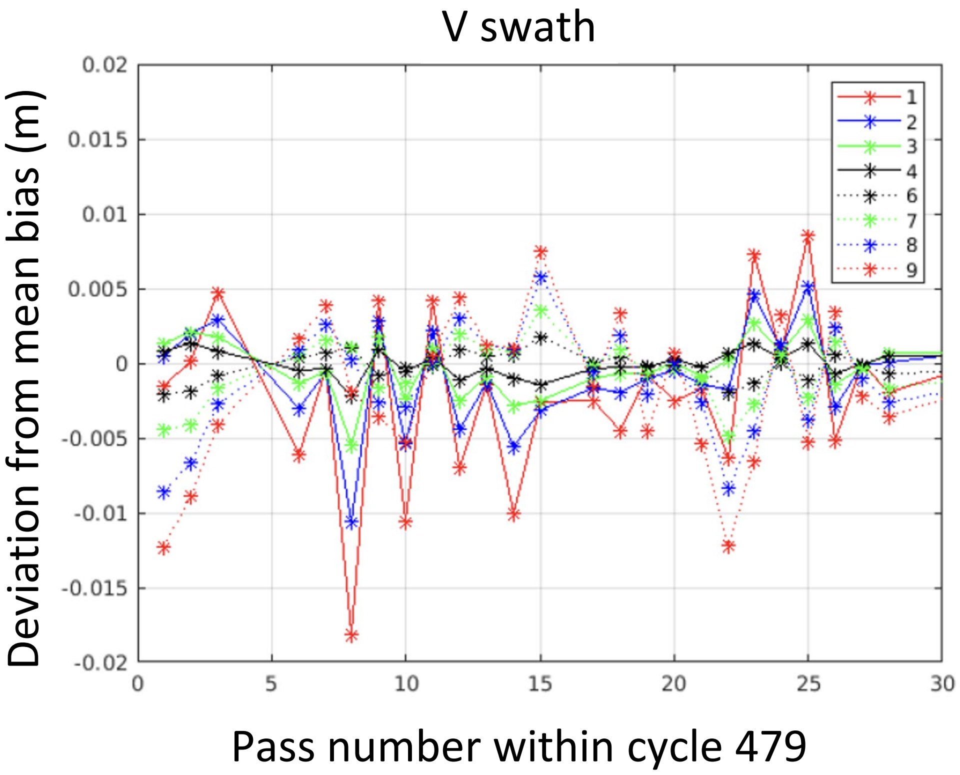
- These plots show an example of the difference between beam 1 and beam 5 SSH for a full granule.
- The difference is almost constant in along-track, consistent with what we expect from imperfect antenna pattern knowledge.
- **These beam-dependent biases are stable, so they result in a constant bias in the beam-combined SSH/SSHA, which is corrected by static calibration. Thus, they have minimal impact on accuracy of the fully-calibrated beam-combined SSH/SSHA in the L2 product.**



Variability of bias relative to central beam

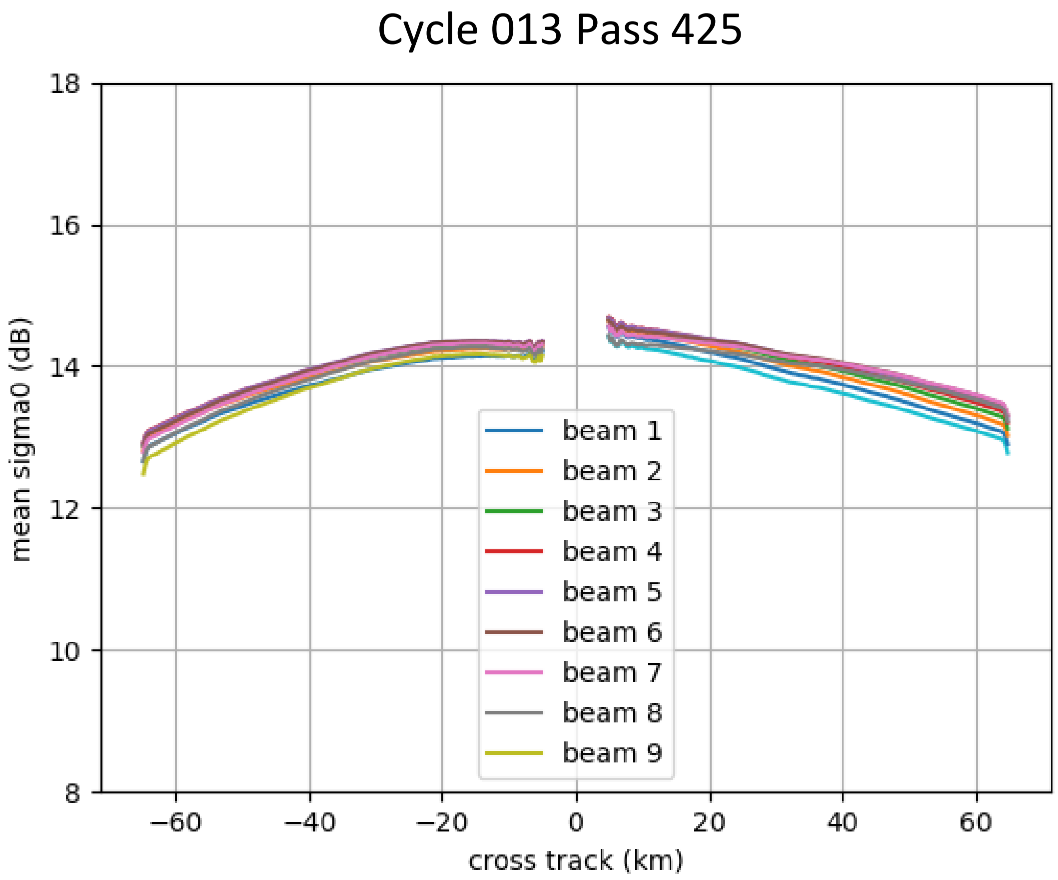
- The plots below show how much the beam biases vary over one day of data.
- The outer beams show the most variability, with beams 1 and 9 having biases that sometimes vary by ~ 1 cm.
- Variability over the 100-day Cal phase is similar.
- The 9 LR beams measure the same spatial variations in SSHA. **The biases of the 9 beams are typically stable to within a few mm, so their effect is removed by static calibration.**





Sigma0 of 9 LR beams

- L1B_LR_INTF product gives sigma0 for each beam.
- The plot shows mean sigma0 over open ocean for an example granule.
- The 9 beams agree with each other to better than 1 dB.
- Cross-track dependence of sigma0 is similar for H and V swath, indicating good antenna pointing calibration.



Summary

- Consistency between Calibration and Science orbit data indicates that static calibration estimated from Calibration data can be applied to Science data.
- Consistency between LR and HR measurements indicates that XOverCal calibration estimated from LR data can be applied to HR data.
- The 9 LR beams measure the same spatial variations, but with different biases.

Backup

SWOT

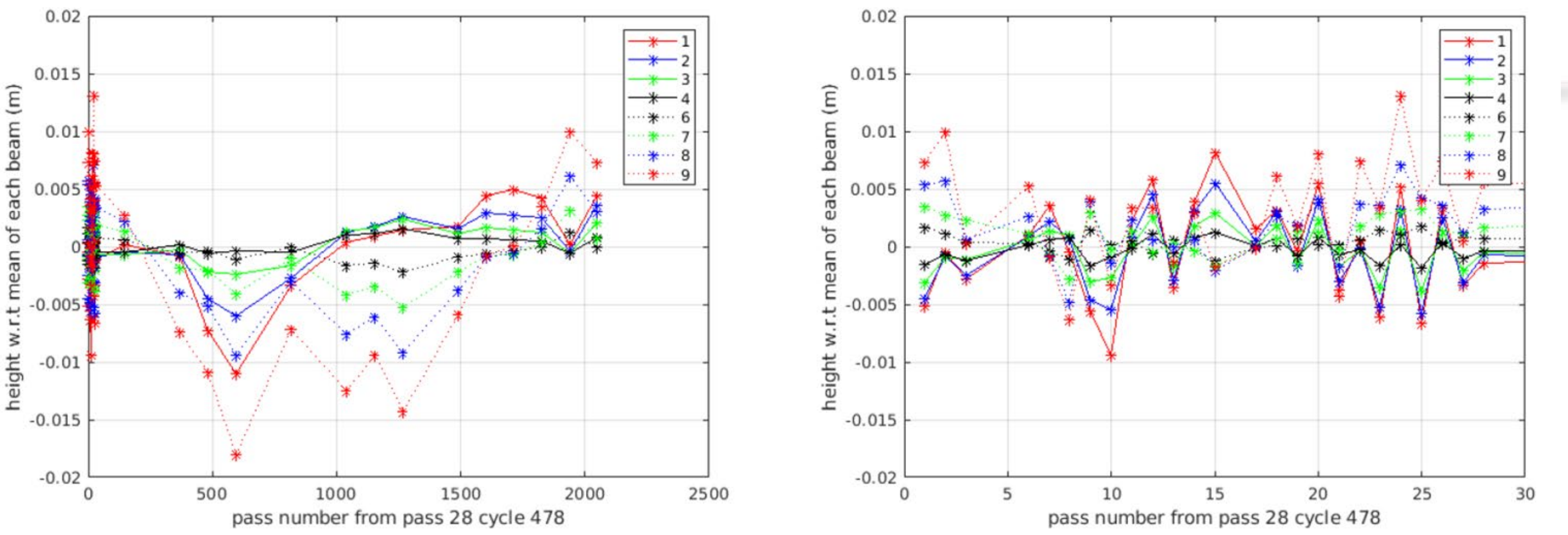
Yaw-flip

- The SWOT spacecraft flips between the non-yaw-flip and the yaw-flip configuration about once every 78 days.
- This is needed because one side of the spacecraft was designed to face the sun.

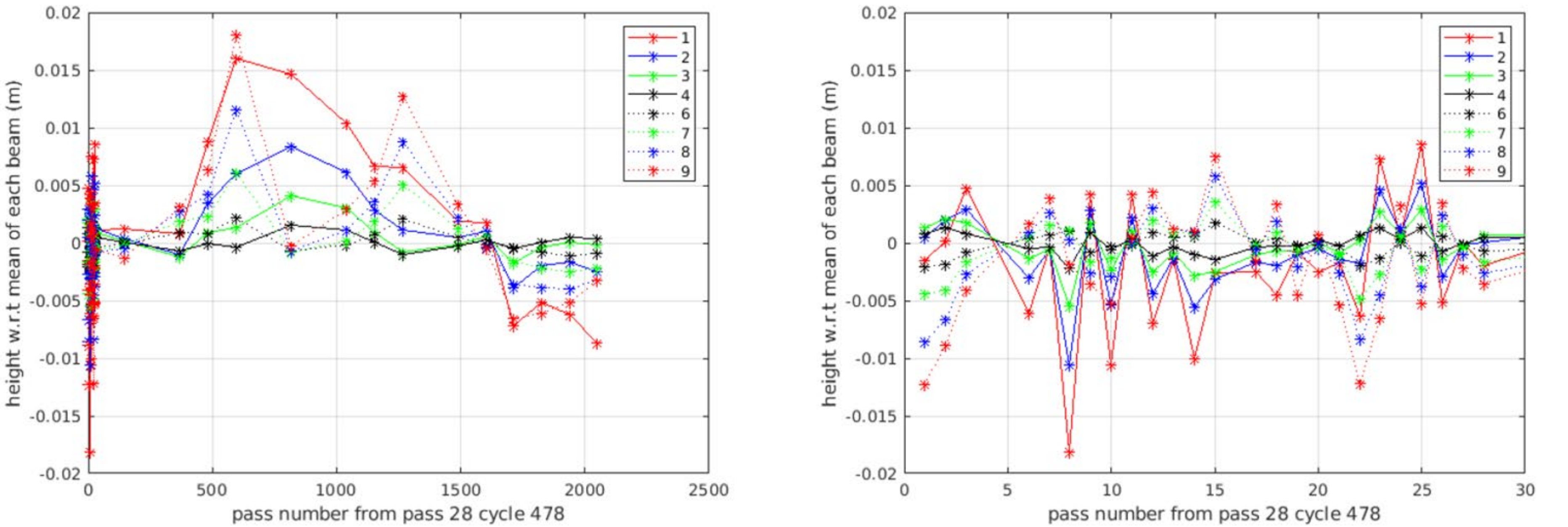
Non-yaw-flip (nominal yaw)	**Yaw-flip**
Spacecraft flying forward	Spacecraft flying backward
yaw variables (in TVP groups) is around 0°	*yaw* variables (in TVP groups) is around ±180°
Left swath H polarization, Right swath V polarization	Left swath V polarization, Right swath H polarization

See *polarization* attributes (HR products) or *polarization_karin* variables (LR products)

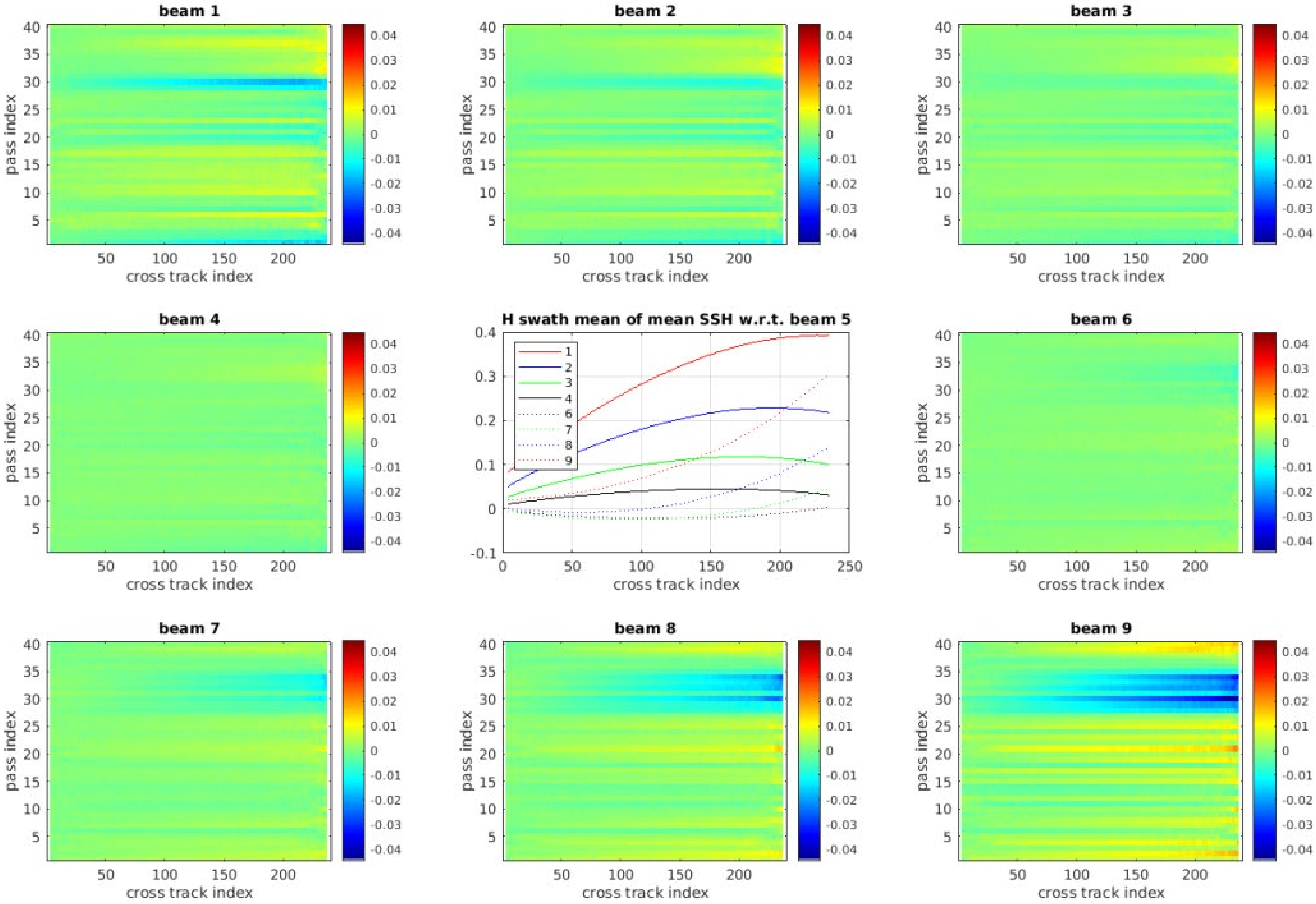
H swath deviation from mean as a function of pass number



V swath deviation from mean as a function of pass number



H swath mean of ssh w.r.t. beam 5 subtract mean of each beam



V swath mean of ssh w.r.t. beam 5 subtract mean of each beam