SEOM – INSARAP: Sentinel-1 InSAR Performance Study with TOPS Data

ESA-ESRIN Contract 4000110587/14/I-BG

Investigations with Sentinel-1 IW Data

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scientific exploitation
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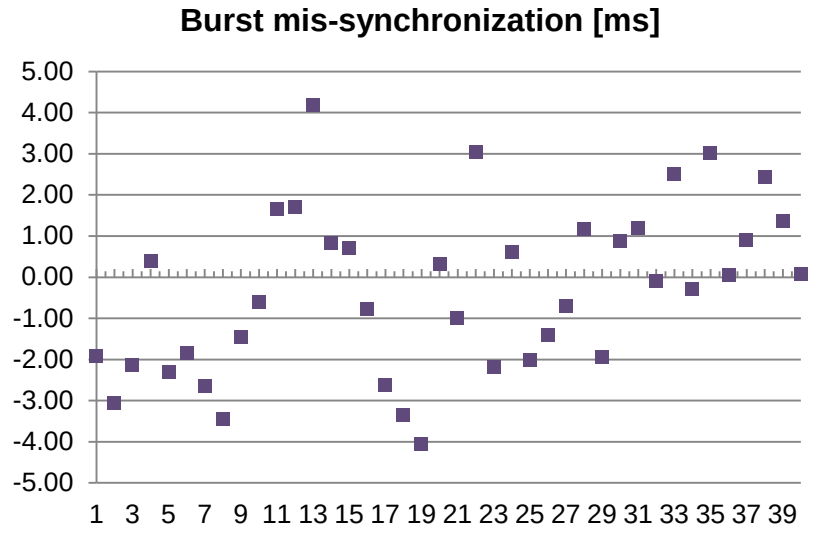
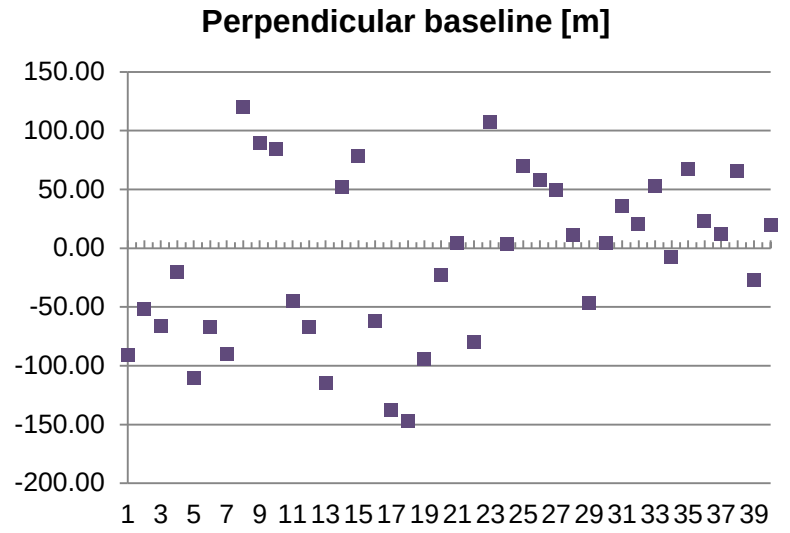
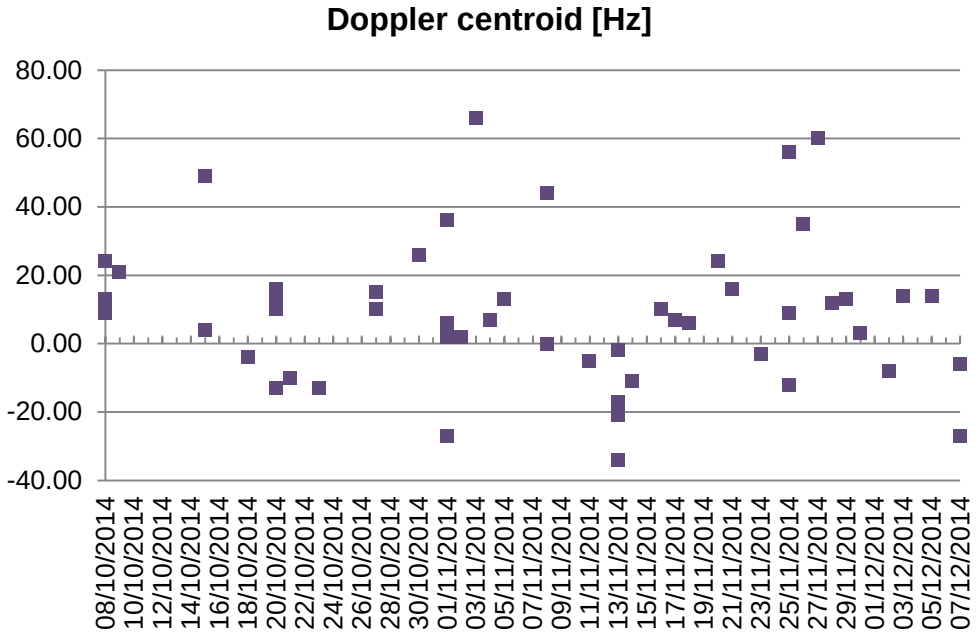
Statistical Analysis with Sentinel-1 Interferograms

- Analysis based on IW acquisitions over pilot sites (54 images, 40 interferograms).
- All acquisitions after October 2nd (due to new synchronization strategy).
- Sentinel-1 burst synchronization requirement: 5 ms.
- Total zero Doppler steering (Doppler around 0 Hz from beginning of October).

Statistical Analysis with Sentinel-1 Interferograms



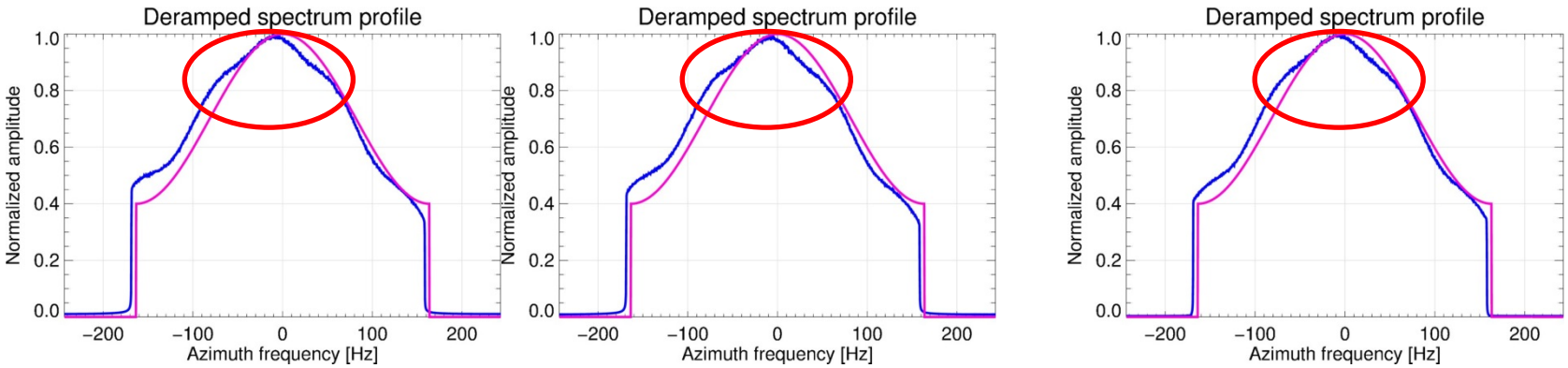




Std.Dev. Burst mis: 2 ms
Std.Dev. $B_\perp = 69$ m
Std.Dev. Doppler = 20 Hz (6.5% az. Bandwidth)

Azimuth Spectrum Shape in the IW Mode

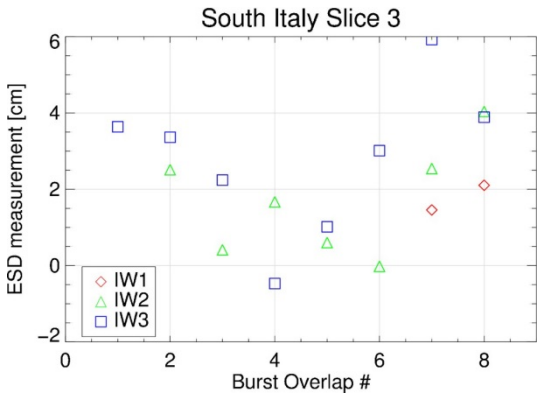
- Below are shown the (along range) averaged profiles of deramped and demodulated spectra for one single burst of several independent data takes (the blue line is the estimated; the purple one is the expected).
- Effect still observed in the latest products (December 2014).

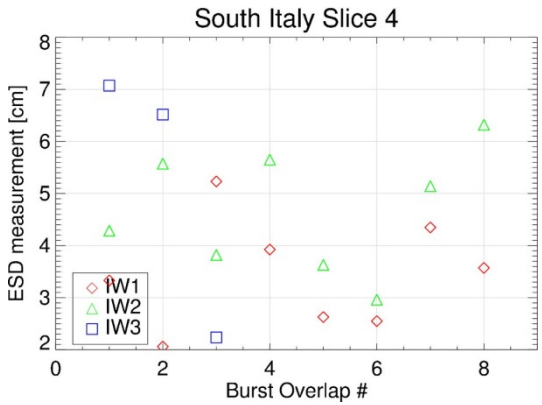


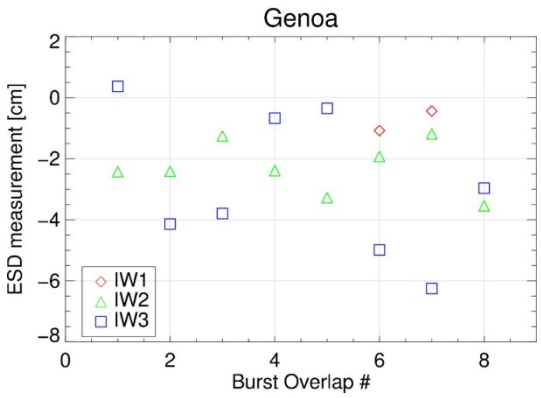
- If effect corrected at some point (assuming the processor is the cause), time series might have to be reprocessed due to impact in radiometric accuracy (amplitude dispersion index).

Inconsistency of Azimuth Shifts

- The shift between bursts (computed using GPS tag or time from ascending node, *azimuthAnxTime*) results in a **non-integer** number of azimuth samples.
- Both time tags are **truncated to microsends** ⇒ almost one centimetre in along-track.
- Residual azimuth coregistration error consistency: in **stationary scenes**, the estimated residual error should be almost constant for the whole image.
- However, the analysis reveals quite different estimations from burst to burst and from sub-swath to sub-swath.

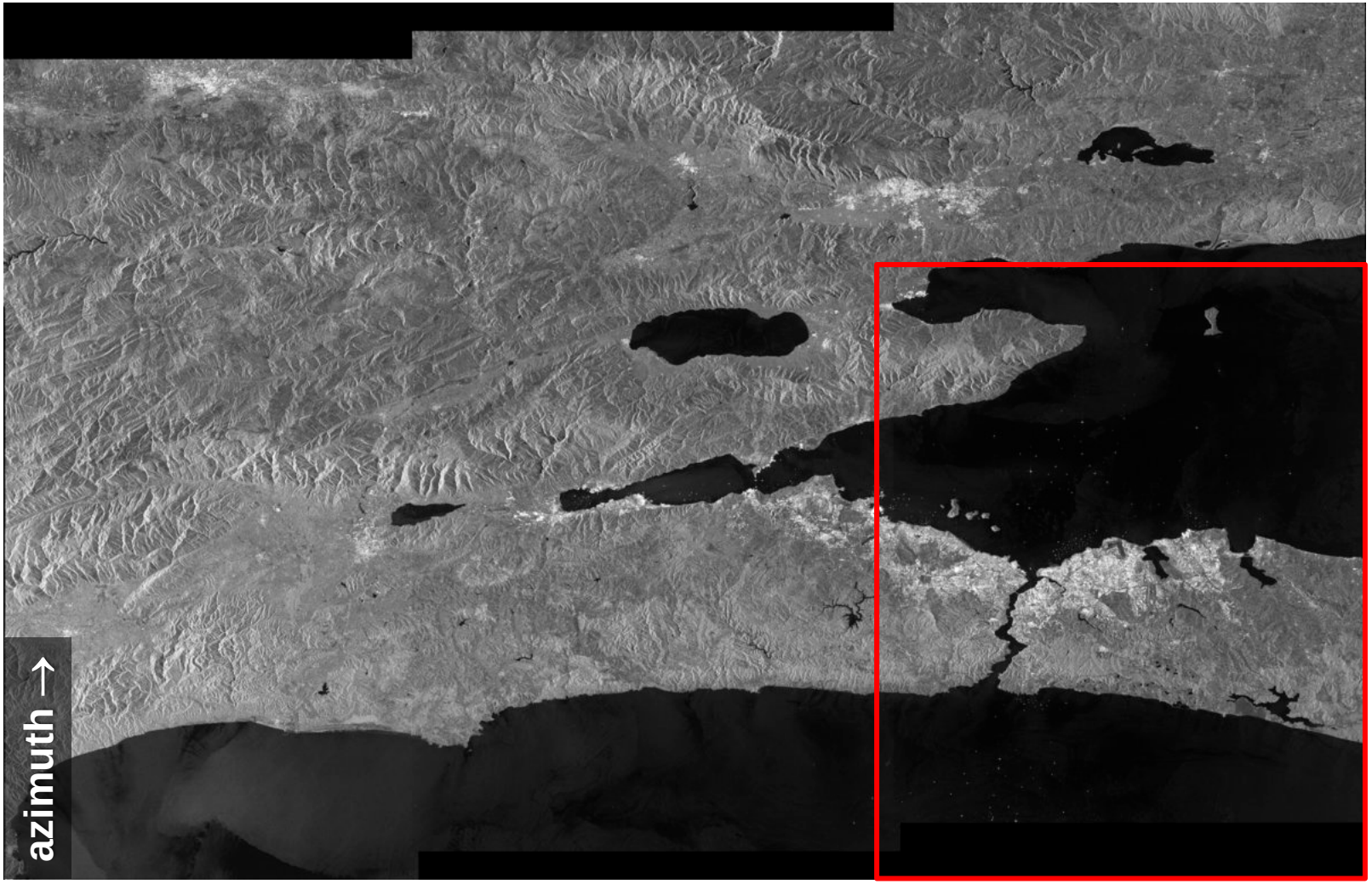




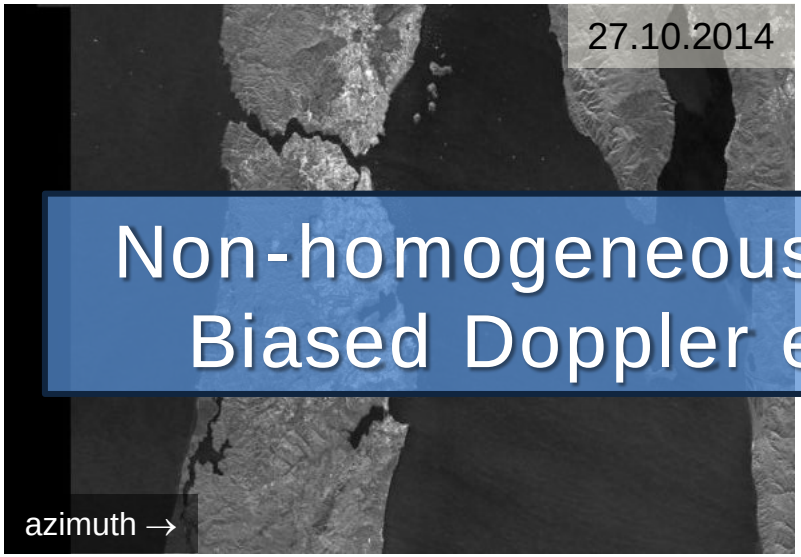


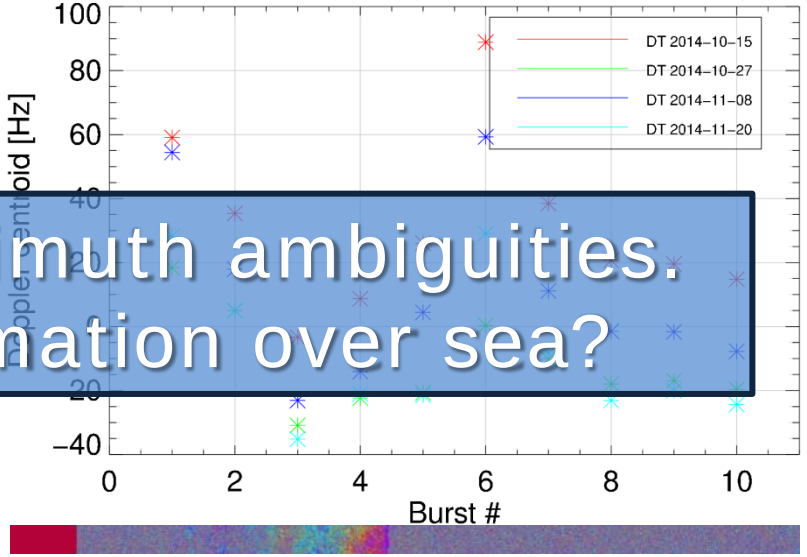
- The above analysis might indicate an improper alignment of azimuth bursts during L1 processing.

Azimuth Ambiguities Analysis

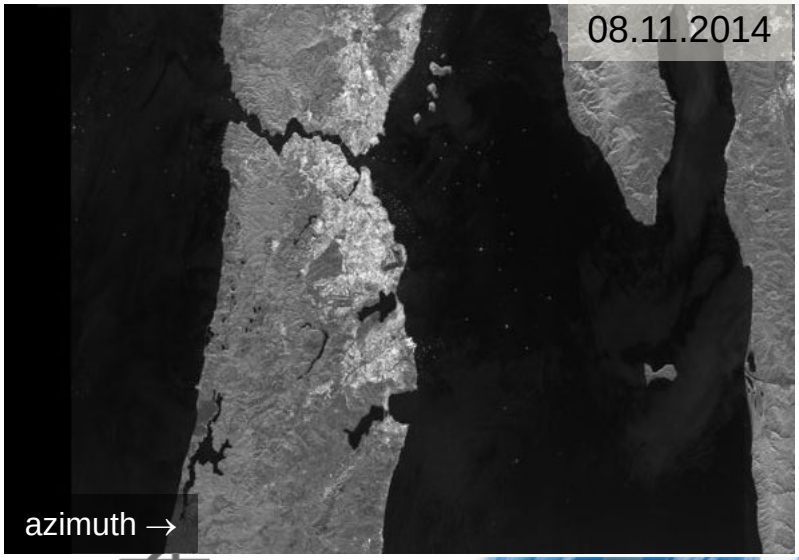


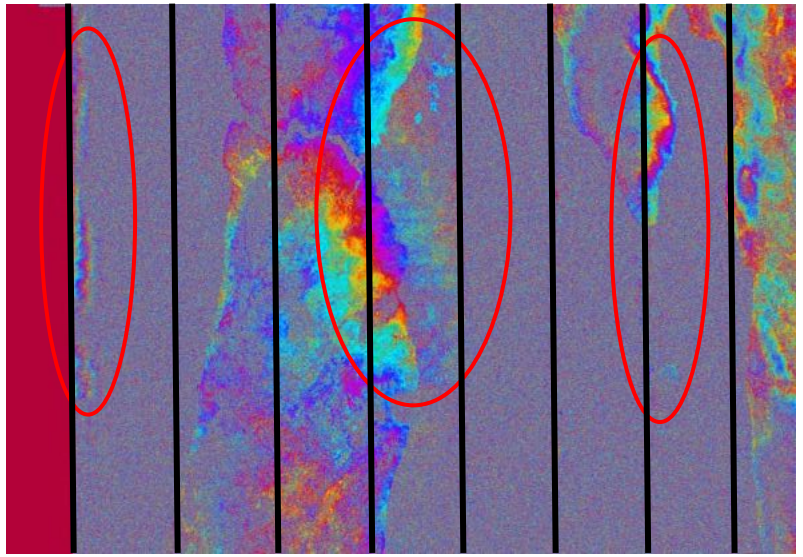
Azimuth Ambiguities Analysis (Master 15.10.2014)





Non-homogeneous azimuth ambiguities.
Biased Doppler estimation over sea?





The Stop-and-Go Effet in the TOPS Mode*

*M. Rodriguez-Cassola, P. Prats-Iraola, F. De Zan, R. Scheiber, A. Reigber, D. Geudtner, A. Moreira, "**Doppler-related Distortions in TOPS SAR Images**," *IEEE Trans. Geosci. and Remote Sensing*, vol. 53, no. 1, Jan. 2015.

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Distortions in the TOPS mode due to the Stop-and-Go approximation

- We differentiate two *stop-and-go* effects:
  - ***Slow-time*** stop-and-go: between transmission and reception of the chirp signal. **Corrected in Sentinel-1** (*bistatic* correction).

  - ***Fast-time*** stop-and-go: during transmission of chirp signal [2] (*real* Doppler). **Not corrected within the processing of Sentinel-1 TOPS data**.
    Chirp duration: 50 μs ⇒ the satellite moved about 40cm!
    Effect well-known in airborne FMCW SAR

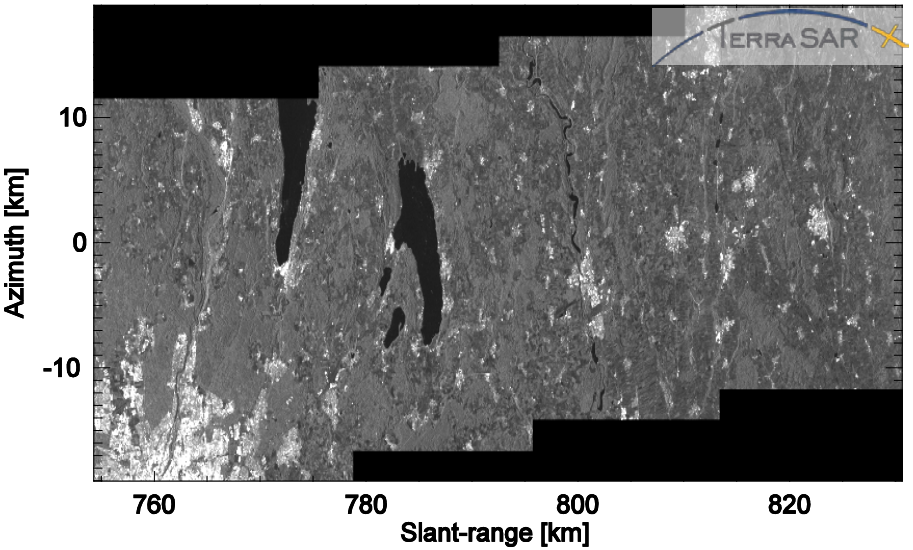
- If fast-time stop-and-go not corrected in the TOPS mode, **undesired systematic shifts in range** occur (azimuth-variant!):

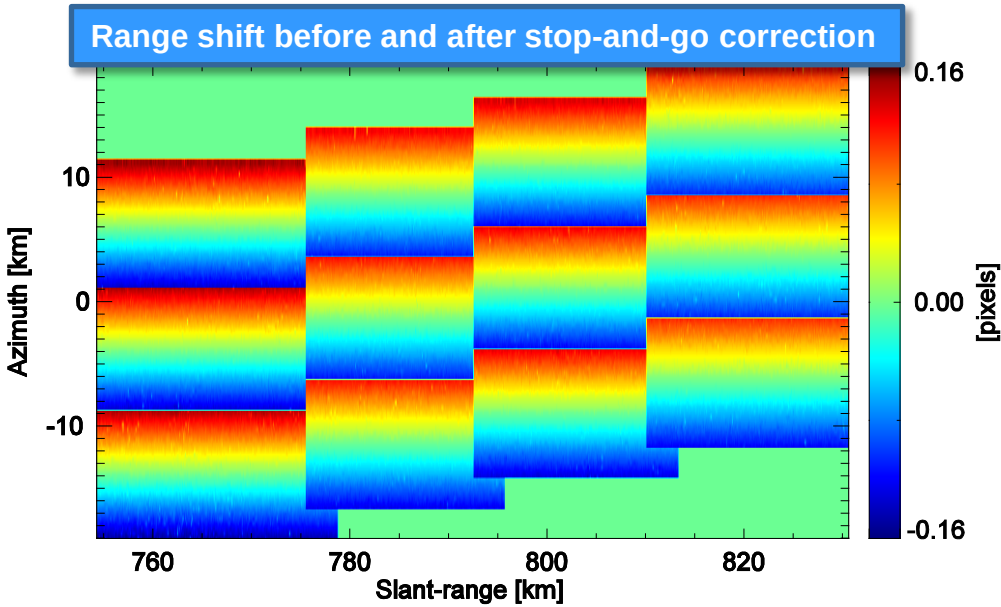
$$\Delta\tau = \frac{f_{DC}(t)}{\mathrm{K_r}}\ [s]$$

- **Easy correction** in the wavenumber domain.

Stop-and-Go in the TOPS Mode (cont.)

- Shift depends on Doppler centroid ⇒ The bursts are skewed in range.





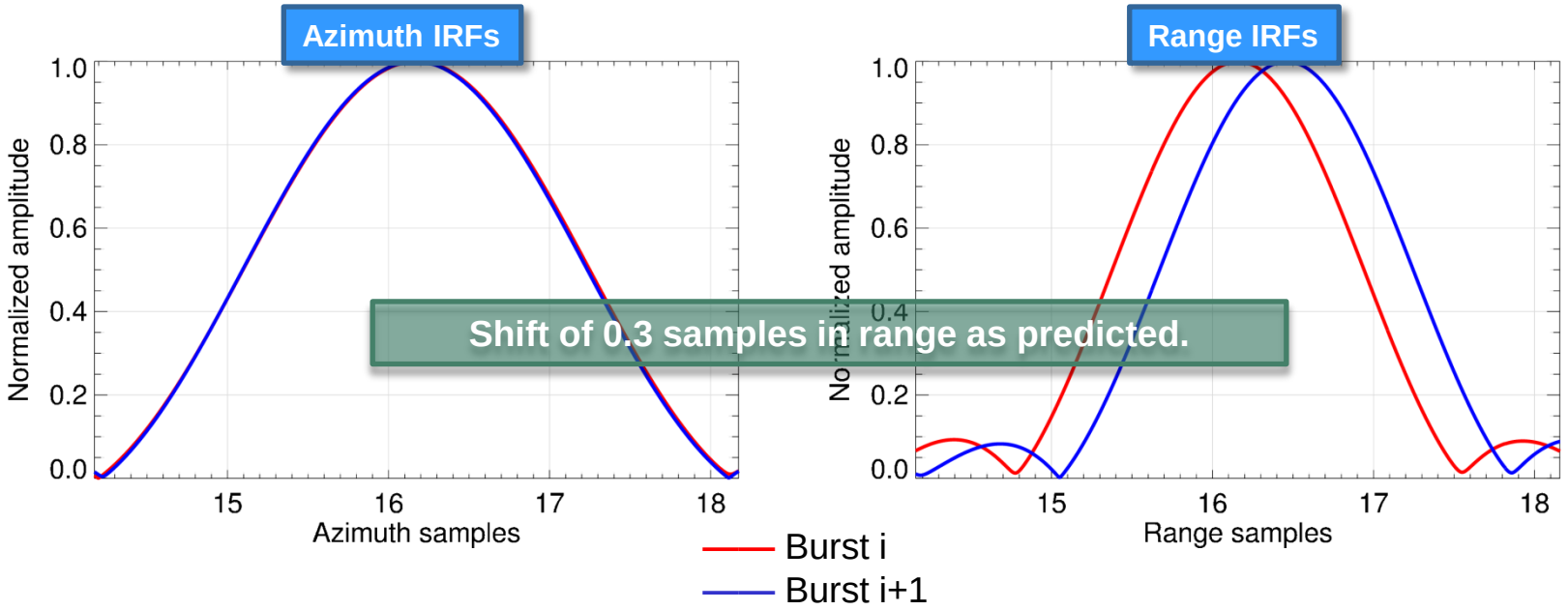
Maximum shift of ~35 cm for Sentinel-1 (70 cm among bursts)

Correlated for master and slave acquisitions but critical for accurate geolocation!

Results with Sentinel-1 TOPS Data

- Analysis of CR located at the overlap region

Data take: S1A_IW_SLC__1SDH_20140604T170819_20140604T170849_000903_000DFA_4472.SAFE



Summary

- TOPS InSAR processing: Geometric approach + (optional!) global offset.
- TOPS special considerations:
  - Phase interpretation: phase jumps will appear in scenes with azimuthal motion
    $\Rightarrow$ more sensitivity to along-track motion, but only at overlap areas.
  - Ionospheric scintillations might produce phase discontinuities between bursts.
  - Role of orbital tube.
  - Azimuth spectral filtering for speckle tracking.
- Investigations with Sentinel-1 IW interferograms:
  - Very good burst synchronization at data take start (2 ms std.dev.).
  - Total zero Doppler steering (20 Hz std.dev. $\approx 6.5\%$ az. bandwidth).
  - Minor issues found: shape of azimuth spectrum, inconsistency of azimuth shifts, fast stop-and-go correction not applied, non-homogeneity of azimuth ambiguities.

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