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

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Interferometric TOPS Chain Description

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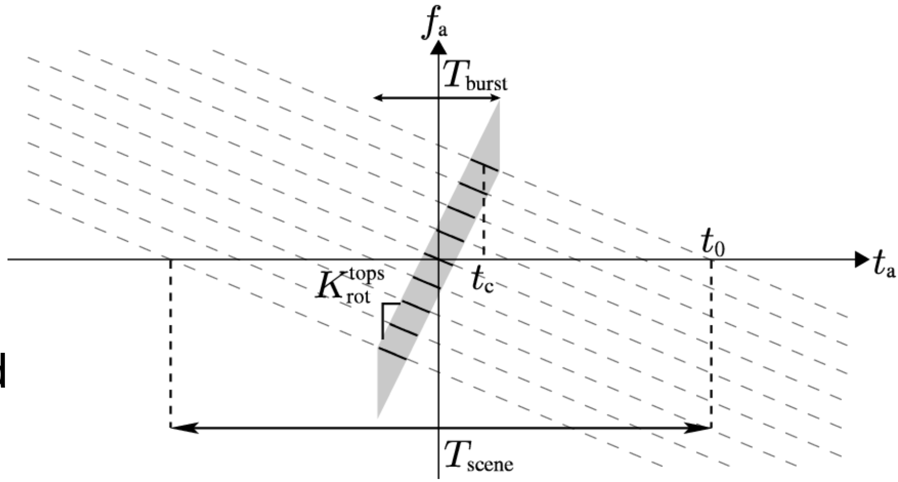
Knowledge for Tomorrow

scientific exploitation of operational missions

TOPS InSAR Chain



- **Particularities of the TOPS signal**
  - Azimuth-dependent Doppler centroid
  - Doppler variation larger than azimuth sampling frequency
  - Burst mode (synchronization required burst-wise processing)
- **Critical steps**
  - Offset computation for coregistration
  - Interpolation
  - Azimuth spectral filtering
- **Selected strategy**
  - Geometric coregistration + global offset estimation
  - Valid for stationary scenarios (or scenarios with slow deformation rates, e.g., PSI)

TOPS Coregistration

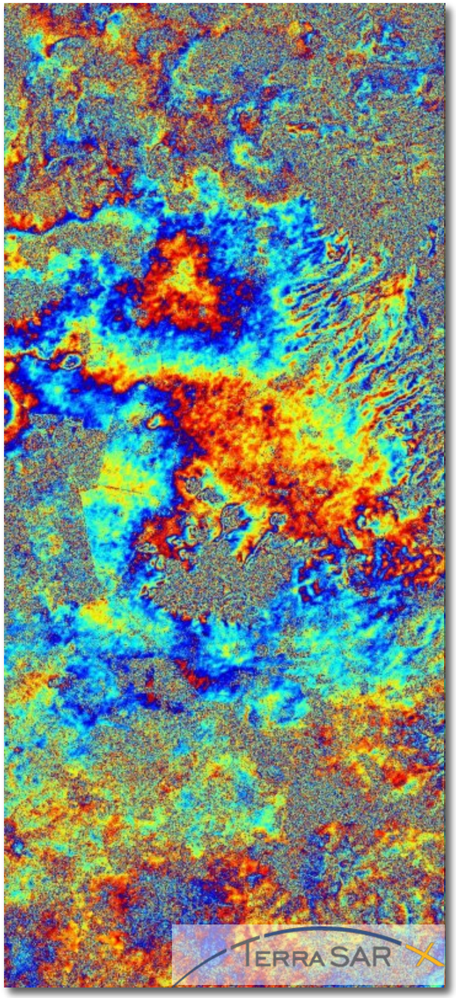
- Azimuth-variant Doppler centroid introduces strong requirements in terms of the required azimuth **coregistration** performance.

$$\phi_{err}(t_a) = 2\pi f_{DC}(t_a)\Delta t$$

- If not done accurately, azimuth phase ramps remain, hence introducing **phase jumps** between bursts.

- Coregistration requirement for Sentinel-1: ~1 cm (~0.001 pixels) for a jump smaller than $\pm$1.5º.

- In the frame of a project with ESA, a technique based on spectral diversity (named *enhanced* spectral diversity, **ESD**) was developed, implemented and tested with TSX TOPS data.

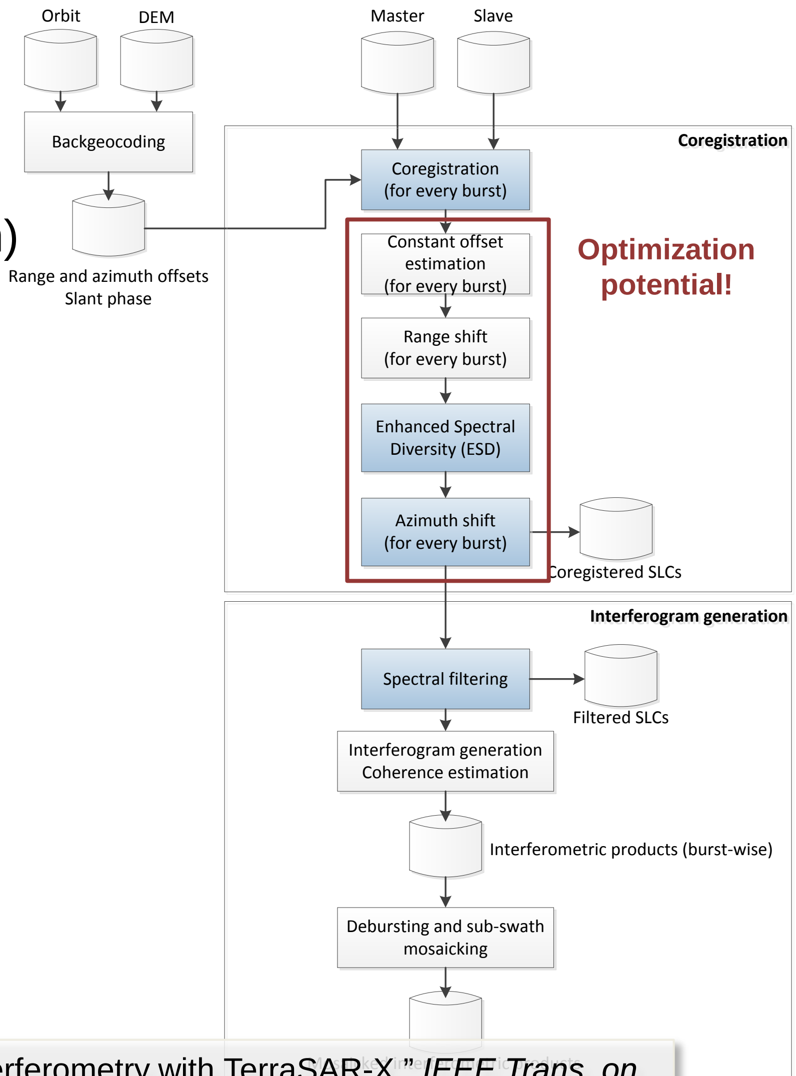


TOPS InSAR Chain [1]

- **Main Workflow**
  - Backgeocoding
  - Coregistration
    - Nominal from geometry [2] (interpolation)
    - Global offset (ESD in azimuth)
  - Interferogram generation
    - Spectral filtering (optional)

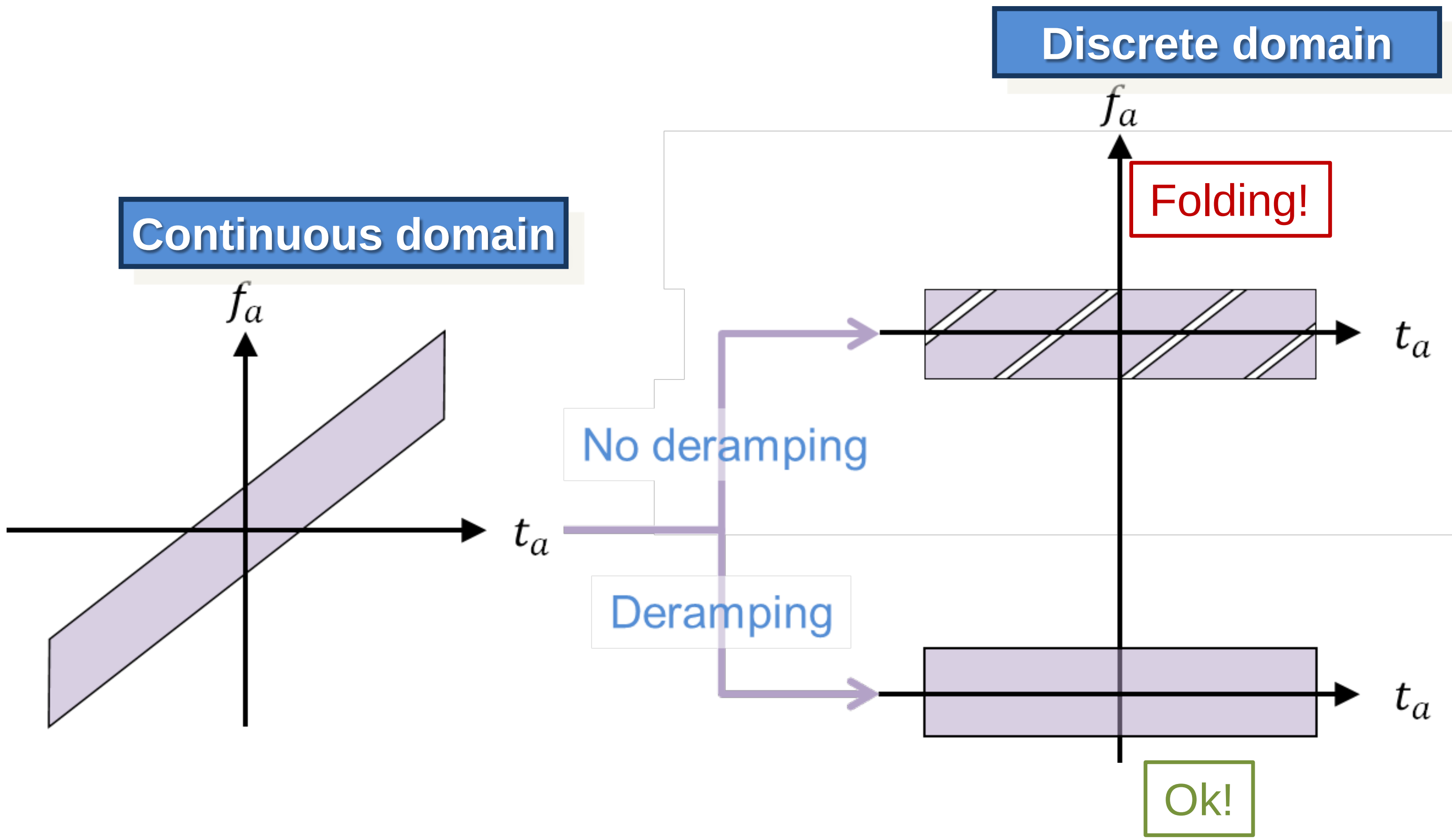
- **TOPS specific processing**
  - Blue-coloured blocks are TOPS-specific
  - Burst-wise processing
  - Debursting and mosaicking performed at the end (for interferogram generation)

- **Approach validated with more than 100 TOPS pairs of different sensors (TSX/RADARSAT-2/Sentinel-1), including time series.**



[1] P. Prats, R. Scheiber, L. Marotti, S. Wollstadt, A. Reigber, "TOPS Interferometry with TerraSAR-X," *IEEE Trans. on Geosci. and Remote Sens., vol. 50, no. 8, Aug. 2012.*
[2] E. Sansosti, P. Berardino, M. Manunta, F. Serafino, G. Fornaro, "Geometrical SAR Image Registration," *IEEE Trans. on Geosci. and Remote Sens., vol. 44, no. 10, Oct. 2006.*

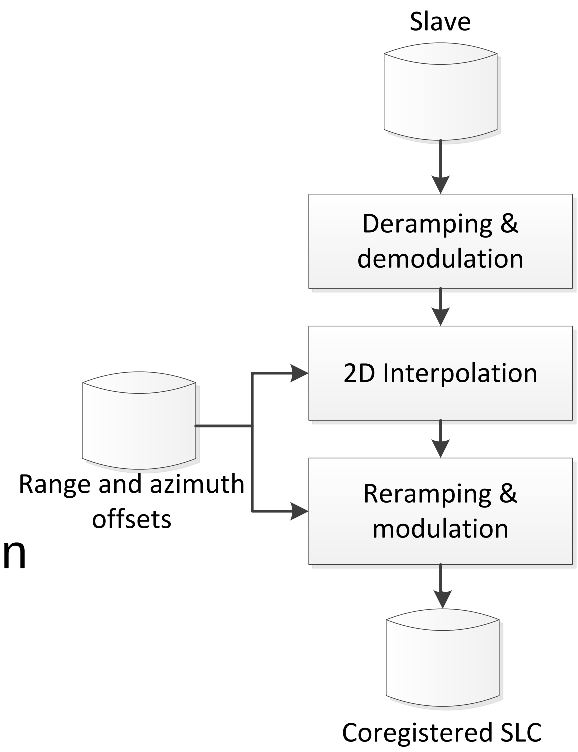
TOPS Azimuth Spectrum

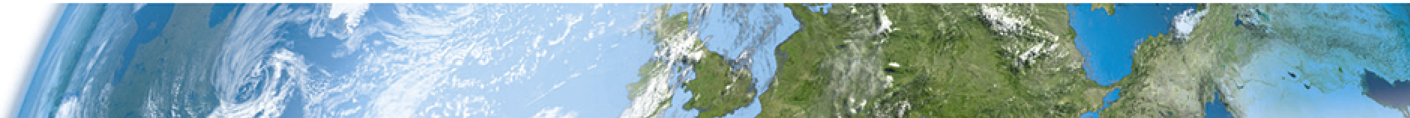


ESA document to compute the deramping function:
Definition of the TOPS SLC deramping function for products generated by the S-1 IPF
Reference: COPE-GSEG-EOPG-TN-14-0025

TOPS Coregistration

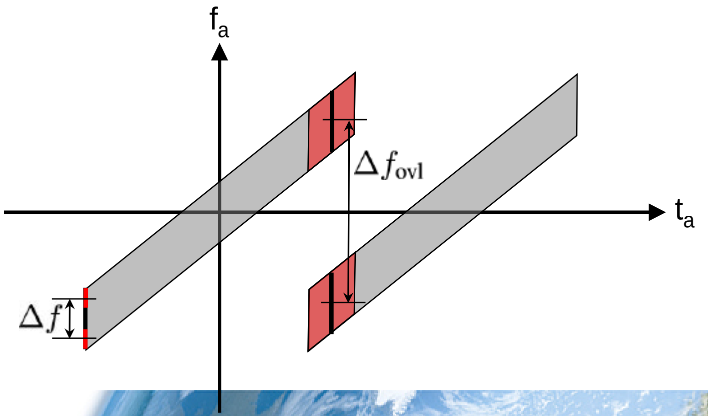
- **Deramping and demodulation**
  - Phase multiplication
- **2D Interpolation**
  - Offsets derived from geometry
- **Re-ramping and modulation**
  - Interpolation of deramping and demodulation phases using the offsets
  - Complex phase multiplication

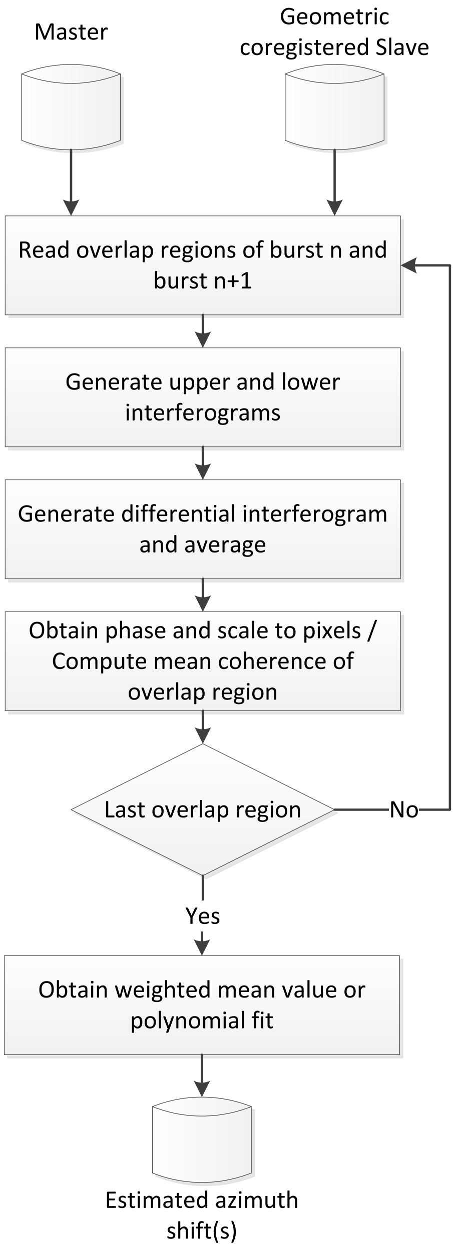




Enhanced Spectral Diversity (ESD)

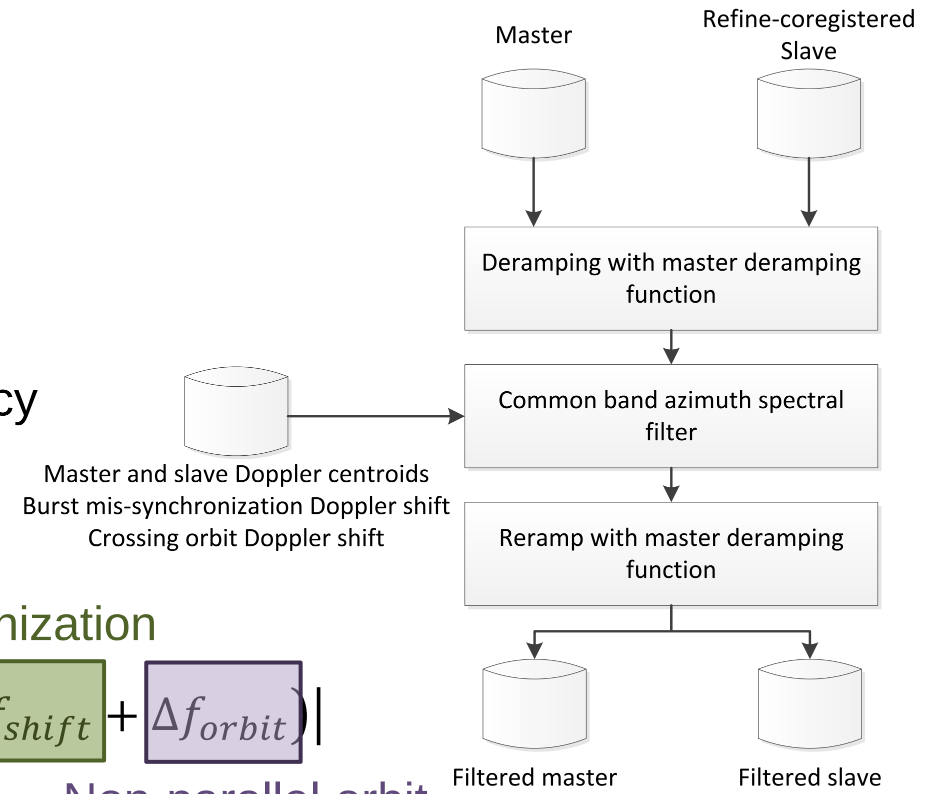
- **Exploitation of overlap eareas**
  - Very efficient, since input data already available
  - Very robust (even for low coherence values)
- **Averaging of all overlap areas or polynomial fit**
  - For a single slice (frame), averaging should suffice
  - For a combination of two or more slices, a polynomial fit might be better suited.
- **After estimation, shift each burst the given amount** ("Azimuth Shift" step)
- **Phase model** at overlap areas might be extended to include baseline errors (similar as done in airborne).





Azimuth Spectral Filtering

- **Needed in case of:**
  - Limited burst synchronization accuracy
  - High Doppler centroid differences



Burst mis-synchronization

$$B_{common} = B_a - \left| f_{DC}^{master} - \left(f_{DC}^{slave} + \Delta f_{shift} + \Delta f_{orbit} \right) \right|$$

Non-parallel orbit