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

ESA-ESRIN Contract 4000110587/14/I-BG

Options for PSI Times Series Processing

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Sentinel-1 TOPS Characteristics Relevant for PSI Processing (1)

- Frequent revisit (12 days)
- Large swath (250 km for IW mode)
- Burst-mode / sub-swaths
- Availability of overlap areas (azimuth and range)
- LOS varying both in elevation and azimuth
- LOS diversity in overlap areas
- Sensitivity to along-track motion at burst edges

Sentinel-1 TOPS Characteristics Relevant for PSI Processing (2)

- Lower azimuth resolution w.r.t. Envisat $\Rightarrow$ more ambigous surface deformation (gradient) in the azimuth direction
- Higher range resolution w.r.t. Envisat $\Rightarrow$ less ambigous surface deformation (gradient) in the range direction
- Expected less decorrelation noise w.r.t. Envisat:
  - Low thermal noise: reduction of the NES0 figure of 3 db
  - Low temporal decorrelation: reduction of a factor 3 of the time necessary to collect an interferometric stack useful for PSI processing
  - Low baseline decorrelation: ground range resolution 5 times better and max baseline (orbital tube) 10 times smaller
- Low sensitivity to topography due to the small baseline

Questions…

- How accurate should the azimuth coregistration be?
- Local azimuth coregistration considering motion necessary before PSI processing?
- Burst-wise PSI processing or first mosaicking and then PSI processing as conventional stripmap?
- What to do with overlap areas?
- Combination with other modes/sensors at SLC level?
- How to deal with the large data volume?

Azimuth Motion & Coregistration

- No need to coregister motion locally (pixel-wise) with high accuracy ⇒ Only precise global coregistration required.
- Depending on DEM and orbit accuracy even the precise global coregistration could be skipped (geometric coregistration only). Note: S1 Precise orbit product better than 5 cm. In any case, it is safer to perform the global coregistration.
- What happens with azimuthal motions?
  - The phase introduced by such motion close to burst edges is not a bias, but the projection in line of sight of the azimuthal motion ⇒ This information is within the interferometric phase.
  - The PSI processing will retrieve this LOS measurement.
  - Use of LOS vector and different geometries to obtain 3D displacement vector (Only for scientific experiments because overlaps cover 1 km every 20 km...)

Mosaicked vs burst-wise Sentinel PSI processing strategy

- Advantages:
  - Global and large scale artifacts (orbital, APS) can be better estimated and removed
  - Higher probability of valid integration/phase unwrapping paths
  - No need for mosaicking PSI results
  - Detection of larger scale deformations
- Drawbacks
  - Along track displacements (“false problem”):
    - Along track displacements introduce phase differences, due to the different LOS, in correspondence of the burst overlap areas:
      - $\pm\pi = \pm 75$ cm along track displacement in Sentinel-1
    - PSI deals with deformation in the scale of millimeters/ centimeters
      => very small phase jumps between burst - no problems for phase unwrapping
  - Exploitation of the overlapping areas (only 1 km every about 20 km):
    - Quality checks (Operational)
    - Scientific experiments (2D along/across track displacement decomposition, more PSs)

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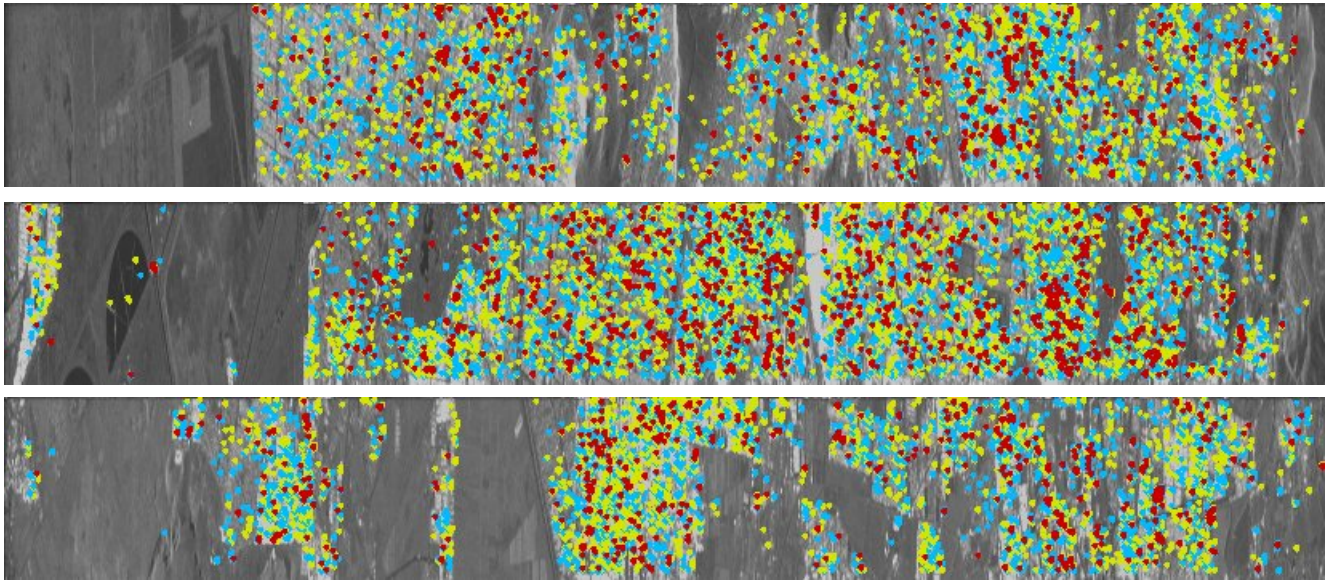
Overlap Areas

- One straightforward solution is to discard half of the overlap area per burst (sub-swath).
- However, overlap areas might contain slightly different PSs due to the different observation geometries (scientific experiments possible).
- Operationally, overlap areas can be used mainly for quality check purposes.
- Such PSs can be also exploited ⇒ larger PS density at overlap areas!



-burst 1

-burst 2

-common

-ca. 20% of points are detected in both bursts

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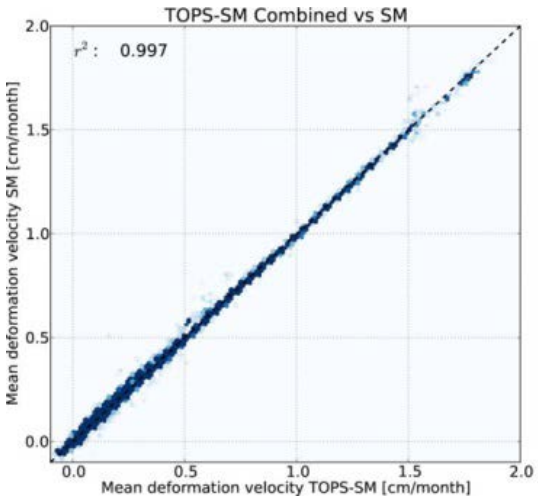
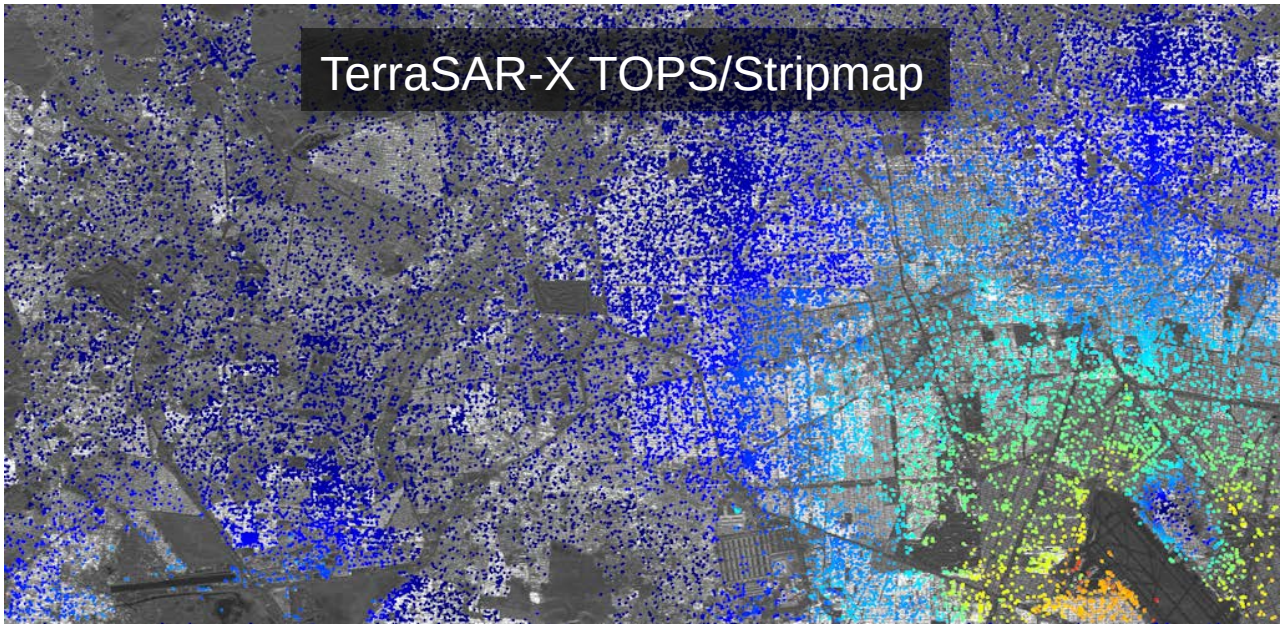
PSI Processing Strategy

	Burst-wise	Mosaic-wise
Scientific users	X	
Small area analysis	X	
Operative chains		X

Combination with Other Modes/Sensors

- Combination already proved with TerraSAR-X TOPS/stripmap, by exploiting point-like scatterers.
- Not possible with distributed scatterers due to the lack of azimuth spectral correlation at burst edges.
- Operationally preferable systematic IW acquisitions, without switching between modes
- Combination with other sensors (more than) challenging if flying in other orbits.





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Handling of Large Data Volume

- A single Sentinel-1 IW product is equivalent to about 9 ENVISAT IM products
- Increment of the observation frequency of a factor 3
- A significant increment of PS density is expected

- Possible to perform nationwide and worldwide analyses:
  - Parallel HPC systems / cloud solutions
  - Robust algorithms to guarantee automatic processing minimizing operator intervention

- Concern/questions:
  - Sentinel-1 L1 data available on a rolling archive.
  - How to access historical data for PSI time series processing?
  - Raw data process on demand possible?