Fringe 2015 Workshop

Sentinel-1 IW mode time-series analysis

When / How / Whether to stitch?

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Objective

Sentinel-1 InSAR for routine and operational monitoring of __________?

• General assumption:
  Coregistration of TOPS data (tricky but) resolved

• Many issues resolved on a single interferogram level
  Slicing and Dicing

• Stack processing is still a potential uncertainty
Objective: Expectations from S-1
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500km (longitude)
Data Availability Considerations:

- Abstract submitted on a premise that we will have enough data for the workshop
- The longest stack we have is 14 images in 5 months
- Just enough perhaps, but not sufficient for reliable analysis

*We will discuss potential problems and opportunities based on the limited experience with small stacks.*
Transition to S-1 TOPS stacks

DInSAR

• Coregistration, coregistration, coregistration...

Time Series Analysis

• No big difference wrt existing modes, in principle “business as usual”
• The 'new' thing is availability of multiple overlapping bursts/swaths
  • Similar to ScanSAR, which hasn't been utilized to its full potential for InSAR yet
  • Implementation reliability of existing strategies is an issue, rather than new algorithmic problems

Operational considerations

• Data volumes – storage, distribution, bandwidth, etc.
Transition to S-1 TOPS stacks

DInSAR

- Coregistration, coregistration, coregistration...

Time Series Analysis

Note: Driver for change and algorithmic evolution of stacking methods will mainly be the new opportunities offered by the spatial and temporal coverage, as well as the redundancy due to the bursted nature of S-1 TOPS data.

S-1 TOPS is an opportunity to do more and better...

Operational considerations

- Data volumes – storage, distribution, bandwidth, etc.
S-1 Time Series Processing Considerations

- Spatial considerations
- Temporal considerations
  - how to integrate through S-1 data graph in 3-4 years time?
- Interpretation and mitigation of error sources
- Data volume challenges:
  - Interconnects both spatial and temporal considerations
  - How to make “Big (Sentinel-1) Data” small?

We try to treat the problem:
Agnostic in terms of the processing method
Spatial Considerations: Full Scene

- **Standard input – single IW slice:** 3 swaths x 9 bursts
- **General recommendation for coregistration is to:**
  
  “use a sufficient numbers of burst overlaps to reliable estimate the residual azimuth coregistration error”

- **From our experience so far:**
  - Couple of coherent overlap zones is sufficient
  - Exact number of coh pixels depends on ML factor
  - Usually couple of thousands

- **It is very unlikely that processing IW slices will result in coregistration issues**
Spatial Considerations: SMALL AOI

- **Small AOI**: 1 swath x 3 bursts

![Diagram showing a forest and a water body within a small area of interest.](image-url)
Spatial Considerations: SMALL AOI

- **Small AOI:** 1 swath x 3 bursts

**Question:**
- How to treat bursts?
- Individually?
- Or to process together?
- When to stitch?
The burst overlaps: definition

- Seeing the same area on the ground from slightly different view angles

Sketch of a geometry of two-looks on a target in the burst overlap zone
The burst overlaps: definition

- How big is the overlap zone?
  - 24 x 1500 ML pixels @50m resolution ~ (1.2 x 75 km)

- Where can we expect burst to cause troubles?
  - APS: likely minor, <250m separation at top of troposphere
  - Non-Isotropic targets (angle dependent phase = “flashing fields”)
  - Seeing different targets on the ground?

- Where can burst overlap help us?
  - Coregistration ← covered
  - Different target
Burst overlaps vs Deformation monitoring

• From limited experience in multi-look case we can preliminary conclude that issues with overlaps:

  “Very likely, while none of these potential problems cannot be completely ignored, in most of the cases their influence will be within the noise level or average out in temporal data stacking”
**Burst overlaps vs Deformation monitoring**

- From our limited experience with burst overlaps we can preliminary conclude that **potential opportunities** are:
  - Redundancy (as a result of angle diversity):
    - Anisotropic targets – eg dihedral – visible in one overlap but not in the other one
    - Completely different scatterers
      - cross pol $\rightarrow$ we have to see how HH/HV will work in C-band in urban setting.
Spatial Stacking of S-1: recap
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- **In Range**
  - Issues only in case of:
    1) large coregistration errors,
    2) crossing orbits, and
    3) presence of strong topography
    
    **Note:** All 3 factors need to be present at the same time to cause a problem.

- **In Azimuth:**
  - Potential coregistration errors propagation
  - Boils down to mitigation of unwrapping errors and APS
S-1 burst stitching: Open Questions

It's all about burst management/stacking in a context of mitigation of APS and minimizing error propagation of inevitable unwrapping errors:

1) **When?**

2) **How?**

3) **Why?**
When?

Phase space?

- Merge bursts interferograms before deformation estimation

Deformation space?

- **Single track:**
  - merge deformation results from burst stacks (or even sub-bursts stacks) from a single TOPS track
- **Multiple tracks (aka WAP):**
  - merge deformation results from sub-bursts / bursts / swaths / tracks
How?

Phase space?

- Use overlap phase metric for correction

Deformation space?

- Exploit existing WAP like processing algorithms
How?

Phase space?
• Use overlap phase metric for correction

Deformation space?
• Exploit existing WAP like processing algorithms

Special case: Non-stationary scenes
• How to 'merge' signal that observes different phenomena
Subquestion:

“How to exploit spectacular coherence of 12 days (soon 6 days) revisit?”

- Single-Master approach will work, but likely not not optimal
- (Small-Network Redundant) approach, but only short time (eg. 12+24+36). Maximizes coherence, but more complicated inversion.
- Combination of SBAS/PSI is the way to go: Something already adopted by most of the groups.
What is the 'final' answer?

**DEPENDS!!!**

- On the application, and processing framework
- Extent of signal of interest
- How much computing power you have?

**In our opinion the biggest challenges are:**

- Long wavelength APS
- Optimally 'navigating' in extensive networks in long stacks
- Unwrapping, always a problem

...we do not have definite answers yet
Discussion: Final Example
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