Sentinel-1 TOPS Processing in GMTSAR

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Outline

+ Introduction to TOPS
+ Issues Associated with TOPS
+ Geometric Alignment and Co-registration
+ Enhanced Spectral Diversity and Elevation Antenna Pattern Correction
+ Pre-Processing Chain of TOPS in GMT5SAR
+ Example for Patch-to-Patch processing.
A Few Types of SAR

StripMap

SpotLight

ScanSAR

What if we reverse SpotLight?
Introduction to TOPS

- Terrain Observation with Progressive Scans

Mittermayer et al., 2010
Introduction to TOPS

- TOPS v.s. ScanSAR Amplitude Images

Meta et al., 2010
Introduction to TOPS

Scattering issue with ScanSAR
Issues Associated with TOPS

- Spectrogram of TOPS data (interpolation issue)
Issues Associated with TOPS

+ Spectral Separation at Burst Overlap (co-registration issue)

\[ \Delta a = \text{PRF} \frac{\phi}{2\pi(f_u - f_l)} \]

Prats-Iraola et al., 2010

0.28mm requires 0.001 pixel co-registration accuracy
Issues Associated with TOPS

- Cross-Correlation (~0.1 pixel co-registration accuracy)
The Sentinel-1 SAR data are provided with a high-accuracy orbit product

- ~2-3 cm radial / cross track, ~5cm along-track

\[
\begin{align*}
    dr &= c_0 + c_1 r_m + c_2 a_m \\
    da &= c_3 + c_4 r_m + c_5 a_m
\end{align*}
\]

<table>
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<tr>
<th>(r_m)</th>
<th>(dr)</th>
<th>(a_m)</th>
<th>(da)</th>
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Geometric Alignment and Co-registration

After pure geometric alignment and co-registration
Geometric Alignment and Co-registration

- $x \times 10^{-4}$
Enhanced Spectral Diversity (ESD)

Remaining Discontinuity in Interferograms after Geometric alignment

$$\Delta \alpha = PRF \frac{\phi}{2\pi (f_u - f_i)}$$
Elevation Antenna Pattern (EAP) Correction

+ IPF 2.36 → IPF2.43 started to correct for the phase term (Mar 2015)

Any interferograms generated across this version change need to do EAP correction
Pre-Processing Chain in GMT5SAR

- Construct a low-resolution DEM
- Use the Precise Orbit to get the Azimuth and range shift LUT

Decision: EAP?
- Y: Add EAP info to the xml
- N: Deburst the SLC and apply the alignment and co-registration (using the LUT)

Decision: ESD?
- Y: Write PRM, LED and SLC
- N: Estimate the residual shift and update the LUT

- Deramp and Demodulate the SLC
- Apply the azimuth and range shift (LUT)
- Update the deramp demodulate function with the LUT
- Reramp and Remodulate the SLC
Example

Data that needs EAP correction and ESD

1) create the raw folder with all the data, copy s1a-aux
Example

+ Create a new xml that contains the AUX and manifest info

```bash
awk 'NR>1 {print $0}' < ../raw_orig/20150121_manifest.safe > tmp_file
cat s1a-iw1-slc-vv-20150121t134413-20150121t134424-004270-005317-001.xml tmp_file s1a-aux-cal.xml > tmp2_file
mv tmp2_file s1a-iw1-slc-vv-20150121t134413-20150121t134424-004270-005317-001.xml

awk 'NR>1 {print $0}' < ../raw_orig/20150403_manifest.safe > tmp_file
cat s1a-iw1-slc-vv-20150403t134413-20150403t134424-005320-006bc4-001.xml tmp_file s1a-aux-cal.xml > tmp2_file
mv tmp2_file s1a-iw1-slc-vv-20150403t134413-20150403t134424-005320-006bc4-001.xml
```

[Image of code execution output]

```xml
<?xml version="1.0" encoding="UTF-8"?>
<xml
```
Example

Run `align_tops[_esd].csh`

Generate LUT

EAP correction

Spectral Diversity

16
Example

+ Run p2p_S1A_TOPS.csh
Questions?