S-1 instrument and product performance status

CSCDA workshop, ESRIN, 2015
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S-1A : Events since IOCR

- **IPF 236**: Data released to the users, preliminary calibration
- **AOCS**: Update of the AOCS to correct for roll and pitch offset
- **Deramping TN**: Release of the TOPS deramping Tech. Note, [Sentinel online library](https://qc.sentinel1.eo.esa.int/) [Fringe recom.]
- **RxG**: Activation of the Rx Gain correction (Range varying gain)
- **WV K**: WV product calibrated
- **Orbit Av**: Availability of restituted and precise orbit files [https://qc.sentinel1.eo.esa.int/](https://qc.sentinel1.eo.esa.int/)
- **L2**: generation of L2 Ocean product for validation
- **RAW TDS**: Delivery of the RAW decoded TN and associated TDS, [Sentinel online library](https://qc.sentinel1.eo.esa.int/) [Fringe recom.]
- **IPF 243**: IPF processor update improving calibration, fixing GRD slicing issues, 1st L1 format change

Next To come:
- **RDB4**: Update of the RDB to introduce new quaternion reference frame
- **SM Ical**: Removal of the calibration pulses in SM to correct for scalloping effect
• **S-1 Doppler stability:**
  - S-1 is Total Zero Doppler Steered
  - Doppler measured from IW products $6.2 \pm 19.4\text{Hz}$ with no noticeable trends

• **Burst synchronisation is a pre-requisite for TOPS based interferometry:**
  - Burst overlap $> 96\%$ with no trend around the orbit

• **Orbital baseline well controlled:**
  - Normal baseline is of $3.17 \pm 75\text{m}$
  - Along track baseline is within $\pm 20\text{m}$
• NESZ is measured over area of low backscatter (e.g. ocean under low wind speed) and compared with theoretical profiles (---)

• Mission requirement is -22dB (---)

• NESZ is as expected

--- NESZ Theo.
--- Measurement

2.2dB
• TOPS products are radiometrically corrected for:
  – Elevation Antenna Pattern
  – Azimuth Antenna Element Pattern (TOPS descalloping)

• In presence of noise (no signal returned to the radar), these corrections are shaping the noise
  – Data acquired over ocean at low wind speed
  – Cross-polarisation

• It is visually not “nice” but it is an expected feature of the processing
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<tbody>
<tr>
<td>SM</td>
<td>SLC</td>
<td></td>
<td>[1.7 x 4.3] to [3.6 x 4.9]</td>
<td>1</td>
<td>0.94</td>
<td>-20.18±0.87</td>
<td>-12.56±0.81(1)</td>
<td>8.7x8.6</td>
<td>[3.5-3.7]</td>
<td>3.40</td>
<td>-20.61±0.68</td>
<td>-12.81±1.14(1)</td>
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<td>GRD</td>
<td>FR</td>
<td></td>
<td>9 x 9</td>
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<tr>
<td>IW</td>
<td>SLC</td>
<td></td>
<td>[2.7 x 22] to [3.5 x 22]</td>
<td>1</td>
<td>0.94</td>
<td>-19.10±4.56</td>
<td>-12.46±3.03(1)</td>
<td>19.85x21.43</td>
<td>4.4</td>
<td>4.80</td>
<td>-19.72±3.34</td>
<td>-12.17±3.07(1)</td>
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<tr>
<td>GRD</td>
<td>HR</td>
<td></td>
<td>20 x 22</td>
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<tr>
<td>EW</td>
<td>SLC</td>
<td></td>
<td>[7.9 x 42] to [14.4 x 44]</td>
<td>1</td>
<td>0.90</td>
<td>-20.54±3.12</td>
<td>-12.46±3.03(1)</td>
<td>50.56x50.46</td>
<td>2.7</td>
<td>2.60</td>
<td>-20.22±1.41</td>
<td>-11.73±4.57(1)</td>
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<tr>
<td>GRD</td>
<td>HR</td>
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<td>50 x 50</td>
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(1) Worse than the requirement due to the measurement approach being more stringent (2D-ISLR) than the requirement (1D-ISLR). Using an adapted approach ISLR is back within specification.
S-1 Absolute Radiometric Calibration

- Radiometric accuracy of products processed with the IPF V236, considering all beams and polarisation together
  - For SM: $-0.03 \pm 0.24\text{dB}$
  - For EW: $-0.16 \pm 0.35\text{dB}$
  - For IW: $0.016 \pm 0.3\text{dB}$

- Most of the measurement were made while all the radiometric correction were not yet applied
  - Roll correction $\rightarrow$ EAP
  - Gain variation over Rx time

- The radiometric accuracy is for the time being limited by two main issues:
  - Unexpected polarimetric gain imbalance
  - Residual of range radiometric corrections (under assessment)

- Radiometric calibration activity is on-going:
  - Geoscience Australia site
  - DLR site will restart soon

IW calibration measures over DLR target

Geoscience Australia site
Mean relative RCS IW1 = $0.01 \pm 0.23\text{dB}$
Mean relative RCS IW2 = $0.04 \pm 0.32\text{dB}$
• Analysis of gamma profiles over the rainforest shows unexpected variation of the backscatter with range

• This is confirmed comparing ocean backscatter with expected sigma 0 from wind model

• The IPF is correcting for a Rx Gain variation that is $T^\circ$ dependent. The coefficient currently used are probably not adapted to the current antenna $T^\circ$
  → re-Characterisation will happen in the coming months

• Empirical corrections are also under investigation
Geolocation accuracy

- Product geolocation accuracy depends on the source of orbit used for processing:
  - GNSS embedded in the source packets: IPF issue leading to degraded geometric performance (error > 100m) \(ightarrow\) fix under testing (error <1m)
  - Restituted orbit files (available few hours after downlink)
  - Precise orbit files (available 21d after sensing)

- The PDGS is configured to use the restituted orbit files. However, in some cases GNSS could be used leading to degradation of the geolocation accuracy

<table>
<thead>
<tr>
<th>SM SLC</th>
<th>Slant range offset [m]</th>
<th>Azimuth offset [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNSS(SSP)</td>
<td>5.45±24.33</td>
<td>2.19±58.2</td>
</tr>
<tr>
<td>Restituted</td>
<td>1.30±0.06</td>
<td>2.03±0.58</td>
</tr>
<tr>
<td>Precise</td>
<td>1.24±0.06</td>
<td>1.84±0.34</td>
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<table>
<thead>
<tr>
<th>SM GRDF</th>
<th>Slant range offset [m]</th>
<th>Azimuth offset [m]</th>
</tr>
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<tbody>
<tr>
<td>GNSS(SSP)</td>
<td>5.37±2.59</td>
<td>0.49±59</td>
</tr>
<tr>
<td>Restituted</td>
<td>1.30±0.19</td>
<td>1.95±0.51</td>
</tr>
<tr>
<td>Precise</td>
<td>1.27±0.19</td>
<td>1.89±0.40</td>
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User product
Fix under testing
Product geolocation accuracy

• “Out of the box” accuracy
  – Measured over an uncontrolled calibration site (GSA 40 CRs)
  – Geocoding using orbit/timing and classical range-Doppler approach
  – Making no specific correction

• S-1 system geolocation accuracy
  – Measured over controlled calibration site (UZH)
  – Correcting for atmosphere, geodesy (plate tectonic, earth tide)

• Enhanced S-1 system geolocation accuracy
  – All previous corrections
  – Full bi-static correction

IW GRD ALE using restituted OSVs
Mean ± standard deviation:
Δrg: -2.00 ± 1.07 m
Δaz: 3.15 ± 1.36 m
→ Within the pixel

SM SLC ALE using precise OSVs
Mean ± standard deviation:
Δrg: 1.24 ± 0.06 m
Δaz: 1.84 ± 0.34 m

System accuracy
System bias
Anthology of slicing issue 2014/11/16
Greenland
EW GRDM

20150320 to 22
Greenland
EW GRDM

FIXED WITH IPF 243
Other known issues

- L1 products are ready to support any application

- There are still non-blocking known issues:
  - Jitter in the TOPS SLC burst timing \(\rightarrow\) fixed but not yet deployed
  - Jitter in the product orbit annotation creating phase jumps if used \(\rightarrow\) mitigated by the usage of external orbits
  - Geolocation error if no orbit files are used for processing \(\rightarrow\) mitigated by the usage of RESORB orbits during processing
  - Denoise vector not verified yet \(\rightarrow\) doesn’t prevent any application
  - Scalloping in SM \(\rightarrow\) will be fixed by removing the internal calibration pulse sequence from the timeline
  - Geometric Doppler not reliable \(\rightarrow\) will be fixed by changing the frame of the quaternions on-board
Conclusion

• Instrument is performing as expected with no major degradation impacting the product quality since IOCR

• S-1A Level-1 product qualification is completed. S-1A products are suitable for supporting all applications including INSAR

• Instrument and product performance are routinely monitored by a dedicated team of experts (S-1 Mission Performance Center)

• Product improvement loop is on-going:
  – Know issues are being addressed
  – Further improvement in the radiometric calibration will come in short term

• We need your feedback to improve

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