TanDEM-X Acquisition Planning and DEM Performance in the Third Year of Operation

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TanDEM-X Global DEM Acquisition Plan

**1st Global Coverage**
- Small baseline (~200 m)
- Height of Ambiguity ~ 50 m

**2nd Global Coverage**
- Increased baseline (~300 m)
- Height of Ambiguity ~ 35 m

Combination:
- Dual Baseline Phase Unwrapping
- Improved relative height accuracy

**3rd Year Acquisitions**
- Antarctica
- Difficult terrain to account for shadow & layover
  => Different viewing geometry
- Deserts

**Requirement for Relative Vertical Accuracy**
- < 2 m for flat terrain
- < 4 m for mountainous terrain
Formation Flying Configuration

Commissioning Phase

1st Global Coverage

2nd Global Coverage

Antarctica & Difficult Terrain

Height of Ambiguity $\leftrightarrow 2\pi$ Interferometric Phase

large baseline $\leftrightarrow$ small HoA $\leftrightarrow$ small rel. height error
Relative Height Error

Second Coverage

(Acquisition started: Mar 29, 2012)
Quicklook Mosaic: Coherence

Map resolution: 500m x 500m
Quicklook Mosaic: Relative Height Error from Coherence

Map resolution: 500m x 500m

Good performance after a single acquisition already

Height error estimated from \( f(\text{coherence, HoA, # Looks}) \)

Critical areas:
- Deserts
- Forests
- Topography
More than 300,000 bistatic scenes analyzed (until mid July)

3rd & 4th Coverage for Difficult Terrain necessary

<table>
<thead>
<tr>
<th>Coverage</th>
<th>p-to-p 90% RHE &lt; 2 m (slope &lt; 20%)</th>
<th>p-to-p 90% RHE &lt; 4 m (slope &gt; 20%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Global DEM</td>
<td>66.40%</td>
<td>79.40%</td>
</tr>
<tr>
<td>2nd Global DEM*</td>
<td>75.42%</td>
<td>84.91%</td>
</tr>
<tr>
<td>Combination of 1st and 2nd Global DEM*</td>
<td>90.30%</td>
<td>95.64%</td>
</tr>
</tbody>
</table>

* For second coverage more easier / good quality regions have been processed so far
Evaluation of first DEM Tiles (1° x 1°)

<table>
<thead>
<tr>
<th></th>
<th>Steep (&gt;20% slope)</th>
<th>Flat (&lt;20% slope)</th>
<th>void</th>
<th>water</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pixels</td>
<td>%</td>
<td>pixels</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>N44E010</td>
<td>34633176</td>
<td>42,75</td>
<td>43931092</td>
<td>54,22</td>
<td>420240</td>
</tr>
<tr>
<td>N44E011</td>
<td>21395660</td>
<td>26,41</td>
<td>58661668</td>
<td>72,41</td>
<td>0</td>
</tr>
</tbody>
</table>

Results Height Error PDF

<table>
<thead>
<tr>
<th></th>
<th>% below 4m</th>
<th>% below 2m</th>
</tr>
</thead>
<tbody>
<tr>
<td>N44E010</td>
<td>98,98</td>
<td>94,40</td>
</tr>
<tr>
<td>N44E011</td>
<td>99,59</td>
<td>98,71</td>
</tr>
</tbody>
</table>
Radargrammetry to Resolve Phase Ambiguity Band

Parallactic angles \( \rightarrow \) time delays in SAR = phases in InSAR

\( t_{sl} / 2 \)  \( t_{ma} / 2 \)

- becoming globally independent of SRTM DEM as reference
- especially important in regions > 60 deg latitude where no SRTM is available
Absolute Height Error of Scene-Based RawDEMs

90% within +/-10 m already before DEM Cal.
Antarctica Acquisitions

- Acquisition in local winter to avoid melted ice → improve quality

- Orbital inclination → Left-Looking acquisitions required

- Left-Looking acquisitions → lower energy provision by solar panels
Antarctica Acquisitions

Right-Looking

Left-Looking

Very flat incidence angles
Antarctica Acquisitions – flat incidence angles

- Very flat incidence angles required for center Antarctica (61°)
  → Thorough performance analysis performed
- Updated SAR instrument configuration for lower PRFs performed

2000 Hz

3350 Hz
Difficult Terrain: Shadow/Layover Acquisitions

Mountains & Steep terrain

Height of Ambiguity / m

Argument of Latitude / deg

0 90 180 270 360

20

60

100

140
Crossing Orbits over Andes

Overlapping region
Crossing Orbits over Andes

2 overlapping acquisitions available: ASCENDING + DESCENDING

ASCENDING

→ Shadow ASC
→ Layover ASC

DESCENDING

→ Shadow DESC
→ Layover DESC
Crossing Orbits over Andes

2 overlapping acquisitions available: ASCENDING + DESCENDING

Reduction of shadow & layover after the combination of ASC/DESC orbit acquisitions
Formation Change for 3\textsuperscript{rd} & 4\textsuperscript{th} Coverage

\begin{itemize}
  \item 1\textsuperscript{st} & 2\textsuperscript{nd} coverage
  \begin{itemize}
    \item Useful cross-track baselines on northern (southern) hemispere in ascending (descending) orbit
  \end{itemize}
  \item 3\textsuperscript{rd} & 4\textsuperscript{th} coverage
  \begin{itemize}
    \item Useful cross-track baselines on northern (southern) hemispere in descending (ascending) orbit
  \end{itemize}
\end{itemize}

August 2013 for 8 month
Identification of Difficult Terrain Areas via Slope Map

Salar de Uyuni

[Map with slope percentage indicators]

[Image of Salar de Uyuni]
Re-Acquisition of Deserts

- Sandy Deserts: low backscatter => low coherence => high relative height error
  → Smaller incidence angles: 15° - 28° (nominal 28° – 48°)

- Rocky deserts present difficult topography
  → acquisition with different viewing geometry as for mountainous regions
Coverage of 3rd & 4th Acquisition

- Shadow and Layover
- Desert
Conclusion

- **DEM performance statistics**
  - **Global relative height error:** < 2 m for > 90% of all scenes
  - **First DEM tile analysis (1° x 1°):** Relative height error fulfills requirement for > 90% of all pixels

- **Status of acquisition plan in the 3rd year**
  - **Antarctica:** Leftlooking & flat incidence angles
  - **Difficult terrain:** Shadow/Layover reduced by ascending + descending acquisitions
  - **Deserts:** Better performance with steeper incidence angles

- **TanDEM-X System is very flexible and performs remarkably well**