GEOLOCATION ACCURACY OF TERRASAR-X HIGH-RESOLUTION PRODUCTS

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TerraSAR-X (TSX) is the first civilian spaceborne radar satellite with the ability to observe the Earth with a resolution on the order of ~1 m. At this resolution, the effect of the atmosphere - especially the troposphere - needs to be considered [1]. The largest path delays at X-band occur in the troposphere; they are caused by hydrostatic (air pressure), wet (water vapour) and liquid (water droplet) variations. Switzerland's diversity of flat, rolling and Alpine terrain makes it ideal territory for geometric validation studies. By situating trihedral corner reflectors (CRs) within sites at different altitudes and imaging these sites using TSX's stripmap (SM) and high-resolution spotlight (HS) modes, the geometric accuracy of the delivered products was measured; suitably-placed high- and low-altitude reflectors provided further indications of the effect of the path delay on the image product geolocation accuracy.

The products were first terrain-geocoded using the best available digital height model (DHM) for each scene. For the area of Zürich, Switzerland, a 2 m digital surface model (DSM) obtained from LIDAR was available from the Swiss Federal Office of Topography (swisstopo). Terrain-geocoded products were overlaid on a digital 1:25'000 topographic map from swisstopo. Initial visual inspections confirmed very good edge to edge correspondence for all available products.

To support precise quantitative measurements, a total of nine trihedral CRs were placed within five sites in the Swiss midlands and one Alpine site (Zurich, Malters, Rohrdorf, Meiringen, Interlaken, and Jungfraujoch, respectively). The CR positions were estimated with ~cm accuracy with differential GPS (DGPS) surveys. The CRs served as reference points for both estimating the acquisition system's absolute geolocation accuracy and measuring the path delay effects of the atmosphere on the radar signal.

For the investigation into atmospheric path delays, six TSX stripmap scenes (30 km x 20 km) were acquired, each containing two pairs of identical CRs, two at high altitude and two at low altitude. CR pairs were used at both the mountain and valley locations for redundancy and error-checking purposes. The altitude difference between CRs of a given pair was ~3 km; each pair was positioned to have nearly identical range distances to the sensor. This arrangement effectively isolated the effect of the atmosphere: Any observed range differences between two CRs of a given pair should be due mainly to the differences in the atmospheric path length. Given the range and azimuth timing annotations delivered with the level 1b products, it was possible to predict the slant range and azimuth image coordinates of a given CR under ideal conditions (i.e. no path delay). Furthermore, the TSX annotated nominal total atmosphere and azimuth delays provided an indication of the adequacy of the TSX processor's built-in atmospheric model. Range differences between the high- and low-altitude reflectors helped quantify small variations in the path delay, while azimuth differences were due to a combination of smaller effects. Initial investigations showed that the TSX high-resolution products received already meet the specified tolerances [2] once the annotated nominal atmospheric corrections are taken into account during the predictions.

Biases dependent on the orbital configuration were observed in the imaged CR azimuth positions relative to the predicted times; ascending orbits exhibited shifts of ~ +0.5 m, descending orbits ~ -0.5 m. We provide possible explanations for residual biases together with models for their correction, listing approaches for improving upon the already excellent geometric accuracy of TSX image products.

REFERENCES

[1] M. Jehle, D. Perler, D. Small, A. Schubert and E. Meier, "Estimation of Atmospheric Path Delays in TerraSAR-X Data using Models vs. Measurements," *Sensors*, Vol. 8, doi 10.3390/s8128479, pp. 8479-8491, 2008.

[2] T. Fritz and M. Eineder, "TerraSAR-X Ground Segment Basic Product Specification Document", DLR Document TX-GS-DD-3302, Issue 1.5, Section 3.4, February 24, 2008