Ensuring globally the TanDEM-X height accuracy: Analysis of the reference data sets ICESat, SRTM and KGPS-Tracks

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1. INTRODUCTION

The TanDEM-X mission will derive a global digital elevation model (DEM) with satellite SAR interferometry. Two radar satellites (TerraSAR-X and Tandem-X) will map the Earth in a resolution and accuracy, which was never possible in earlier missions: an absolute height error of 10m resp. a relative height error of 2m for 90% of the data are aimed at. Height references with respect to those accuracies are used at different stages of the processing (phase unwrapping, DEM calibration, DEM verification) to guarantee the final TanDEM-X DEM quality.
In this paper the main height reference data ICESat, SRTM, and kinematic GPS-Tracks (KGPS) are analyzed regarding to their accuracy. For ICESat it is especially important to compute a reliable quality measure. Comparisons with reference data are used to analyze relevant parameters and obtain a reliable quality measure. SRTM will be adjusted to ICESat to be consistent with the ICESat heights. Finally, a global set of kinematic GPS measurements is collected and evaluated with a new evaluation approach to ensure the best possible accuracy for validation.

2. USE OF HEIGHT REFERENCE DATA WITHIN THE DEM PROCESSING

Height references are used at different stages in the DEM processing. The interferometric SAR processing has to be supported by reference heights to fix phase ambiguities. For TanDEM-X it is foreseen to use a SRTM version that is adjusted towards the ICESat heights. The main references for calibration are ICESat data that are introduced in the DEM calibration as ground control points. They will ensure that the DEM calibration will reach the 10m absolute height error requirement. Further on, the calibration parameters have to be verified before applying them to generate the final DEM. This is done with the high accuracy of globally distributed KGPS data. All reference data are stored in a data base. An upgrade of the spatial database was necessary to hold and handle point-like data like ICESat and GPS points together with related attributes.

3. QUALITY ASSESSMENT OF ICESAT

The Ice, Cloud, and land Elevation Satellite (ICESat) measures land elevations since its launch in 2003. By November 2005 it had already collected over 1 billion data points. The footprint of the laser sensor has about 70m in diameter, spaced at 170m intervals along earth's surface. Several studies stated a height accuracy of 0.1m - 1m (depending on weather and terrain). To get a sense of the usefulness of this information for the DEM calibration in the TanDEM-X mission own investigations are made analysing the ICESat height measurements with regard to surface type and land cover. A digital surface model (DSM) and a digital terrain model (DTM) serve as reference, respectively. The heights are compared according to the size and characteristics of the ICESat footprint. This analysis will deliver a set of parameters from which a quality measure for each ICESat point can be deduced. Important parameters for example are the number of returned peaks, the signal width and its intensity. Once the quality measures are found the points are used for DEM calibration, i.e. to estimate height offsets and slopes in range and azimuth for each DEM acquisition.

4. FITTING SRTM TO ICESAT

SRTM is still assumed to have long-wavelength errors up to a level of 10m. To have the best available reference DEM for phase unwrapping SRTM will be adjusted with the help of ICESat data to reduce these long-wavelength errors locally.

For the correction of SRTM selected ICESat points with good quality measures will be chosen. The earth surface is divided into regional zones to which height offsets are calculated. As functional model it is foreseen to use spherical harmonics to model the regional zones of the earth. Then, for each zone the offset will be determined by a least-squares adjustment based on the differences between ICESat and SRTM. Finally, the correction function will be applied to each SRTM tile.

5. GPS-TRACKS FOR VERIFICATION

For ensuring the final TanDEM-X DEM accuracy after DEM production resp. DEM calibration a verification with higher accuracy reference data is mandatory. These reference data should be available world-wide for larger regions on each continent. For this purpose GPS tracks with high vertical precision will be used.

Kinematic GPS-Track measurements are a very fast and easy method to measure 3-D positions all over the world. The track points should have accuracy in height of about 0.5m to validate the required residual relative height error of 2m. PDGPS or configurations with reference stations or SAPOS service will deliver the quality, but these approaches are very time-consuming, cost intensive and not world-wide available.

Therefore, the new GPS processing approach PPP (Precise Point Positioning) is used. It is a post-processing approach that uses precise ephemeris information of the GPS satellites and an ionosphere model. In the Tandem-X project the GIPSY software of JPL and the online service at “National Resource Canada” will be used.

The GPS evaluation is in a close cooperation with the FIG (International Federation of Surveyors). Interested scientists and organizations are invited to participate in the DEM verification process with high-resolutions DEMs or KGPS-tracks. Here, an independent scientific group for final DEM Evaluation will be build up.

6. CONCLUSIONS

In this paper an analysis on the reference data sets used for TanDEM-X is made. The preparation of ICESat data, the adaptation of SRTM towards ICESat heights and the evaluation of kinematic GPS tracks is explained.