TanDEM-X DEM Calibration:
Correction of systematic DEM errors by block adjustment

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1. INTRODUCTION

The TanDEM-X mission will derive a global digital elevation model (DEM) with satellite SAR interferometry. The aimed accuracies are an absolute, resp. relative height error of 10m resp. 2m for 90% of the data. This paper gives an overview of the DEM calibration processor within the TanDEM-X mission. The DEM calibration of the *DEM Mosaicking and Calibration Processor* estimates residual, systematic height offsets and deformations of the interferometric DEMs. This paper focus on the new, continent wise block adjustment that is introduced for the calibration of thousands of interferometric DEMs. Ground control points are needed for calibration as well as for verification tasks.

2. ESTIMATION OF SYSTEMATIC DEM ERRORS

A couple of error sources contribute to remaining height errors in interferometric DEMs after the phase unwrapping process. For TanDEM-X the main systematic errors are described by a function of a third order polynom for one TanDEM-X DEM acquisition:

$$g_I(rg,az) = a_I + b_I rg + c_I az + d_I rg\ az + e_I az^2 + f_I az^3, \quad (1)$$

where I is the index of the DEM acquisition and a - f are the unkown error parameters. The main influence is the height offset a_I due to baseline inaccuracies followed by slopes in range and azimuth. The goal of the DEM calibration is to estimate systematic height errors to fulfil the required height accuracies.

2.1. Least squares adjustment approach

The formulation of DEM errors in a functional description for each DEM acquisition allows the estimation of the errors by a least-squares adjustment of adjacent DEM acquisitions. Prerequisite for the adjustment is the availability of suitable ground control points to assess the absolute height error offset with respect to WGS84. Also, reliable tie-points, i.e. identical points in overlapping DEM areas, are needed, to fulfil the strong relative vertical requirement of a 2m trend error in an area of 100km.

The core idea of the adjustment is that (tie-point) heights in overlapping areas should be nearly identical, apart from the random noise, after the error function is applied.

$$H_{i,J} + g_J + v_{i,J} = H_{i,K} + g_K + v_{i,K}, \quad (2)$$

where H are the heights of DEM J resp. DEM K and v the residuals.

2.1.1 Calibration reference data

The height offset to WGS84 is estimated by introducing absolute height reference data like ICESat data. Tie points in overlapping areas are determined from height and coherence data.

Studies on different configuration regarding tie-point and GCPs have been performed. In our study we vary the tie-point grid, the width of the ICESat ground track depending on the latitude and the distance between two ICESat points in flight direction. The more ground control points are used the more coefficients of the polynomial function can be estimated. The standard deviation and the significance of the estimated unknowns act as an indicator for the quality of the results.

2.1.2 Verification

For the verification of the DEM calibration a final quality control is foreseen that includes significant tests and the verification of the vertical accuracy against reference data. For this purpose GPS tracks with high vertical precision will be used. These GPS tracks have to be measured world-wide to verify the accuracies of the TanDEM-X DEM to meet the absolute height accuracy of 10m, respectively relative height accuracy of 2m.

After the calibration is performed the estimated corrections for each interferometric DEM are applied and a mosaic from all calibrated DEMs is composed. So finally, a mosaicked DEM is archived that is possible to order as a TanDEM-X DEM product.

3. RESULTS ON SIMULATED DEM DATA

The estimation of the coefficients is an iterative process, starting with the estimation of a polynomial function of third order and reducing the number of coefficients when the resulting significances are not high enough. For the simulations we consider two coverages (first and second year) of one region and verify the adjustment comparing both results. Some results about the design of the adjustment, parameter determinability, and distribution of tie-points will be described.

4. CONCLUSIONS

In this paper the approach for estimating residual, systematic DEM errors within the *DEM Mosaicking and Calibration processor* is described. It outlines the main features of the calibration approach to ensure the required accuracies and shows some results on simulated DEM data.