Inter-agency comparison of TerraSAR-X/ TanDEM-X baseline solutions

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Introduction

TanDEM-X (TerraSAR-X add-on for Digital Elevation Measurement) is the first Synthetic Aperture Radar (SAR) mission using close formation flying for bistatic SAR interferometry. The primary goal of the mission is to generate a global digital elevation model from the configurable SAR interferometer with space baselines of a few hundred meters. As a key mission requirement for the interferometric SAR processing, the relative position, or baseline, of the two satellites must be determined with an accuracy of 1mm (1D RMS) from GPS measurements collected by the onboard receivers.

Operational baseline products for the TanDEM-X mission are routinely generated by the German Research Center for Geosciences (GFZ) and the German Space Operations Center (DLR/GSOC) using different software packages (EPOS/BERNESE, GHOST) and analysis strategies. For an independent performance assessment, TanDEM-X baseline solutions are, furthermore, generated at the Astronomical Institute of the University of Bern (AIUB) on a best effort basis using the BERNESE software. Note that GFZ solutions presented on this poster are also based on BERNESE.

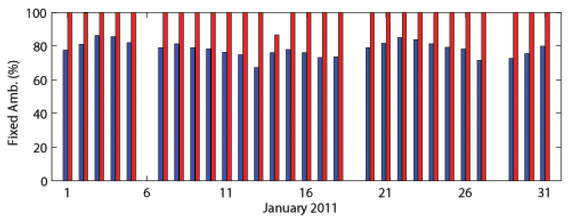
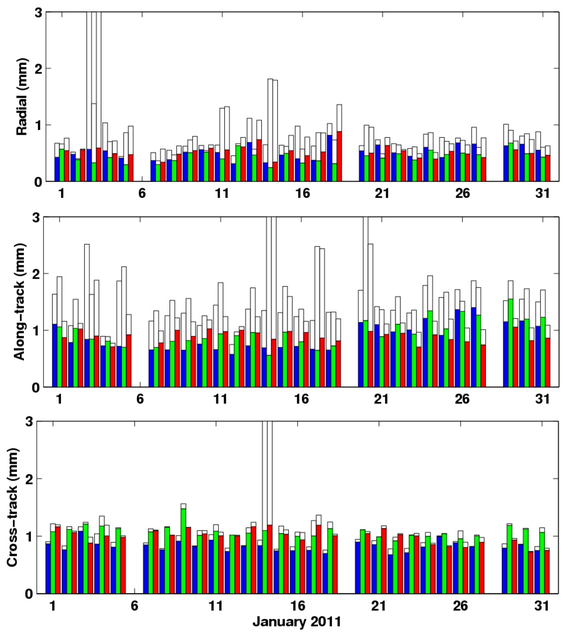


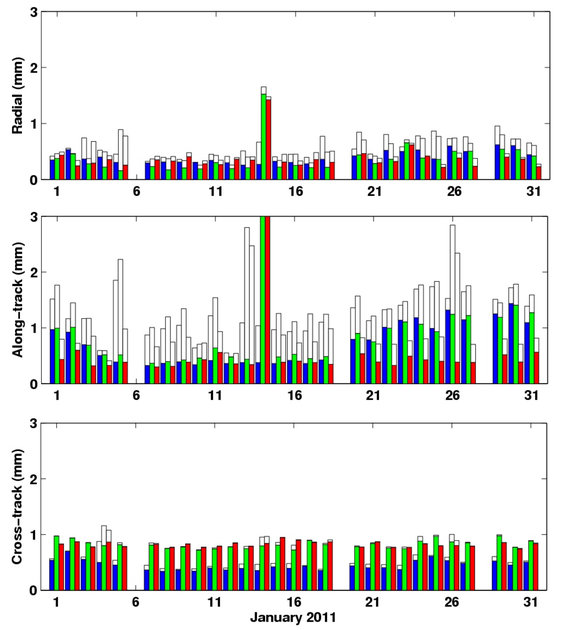
Figure 1: Daily percentage of resolved narrow-lane ambiguities for dual-frequency solutions and resolved L1 ambiguities for single-frequency solutions using BERNESE. Ambiguity resolution is crucial for generating high-quality baseline solutions.

Dual-frequency reduced-dynamic solutions



	radial	along-track	cross-track
GFZ - DLR	0.5 (0.7)	0.8 (1.4)	0.8 (0.9)
GFZ - AIUB	0.4 (0.7)	0.9 (1.7)	1.0 (1.1)
AIUB - DLR	0.5 (0.8)	0.9 (1.2)	1.0 (1.1)

Single-frequency reduced-dynamic solutions



	radial	along-track	cross-track
GFZ - DLR	0.4 (0.5)	0.6 (1.2)	0.4 (0.5)
GFZ - AIUB	0.3 (0.5)	0.7 (1.4)	0.8 (0.9)
AIUB - DLR	0.3 (0.4)	0.4 (0.8)	0.8 (0.8)

Figures 2, Tables 1: Standard deviations of **dual-frequency** (left) and **single-frequency** (right) inter-agency comparisons for January 2011. Empty bars in the figures (corresponding median values (mm) are provided in the tables in parantheses) indicate the daily statistics for entire 24h arcs including maneuver periods. Filled bars in the figures (corresponding median values (mm) are provided in the tables w/o parantheses) exclude time intervals for each day starting 20 min before the first and ending 20 min after the second formation-keeping maneuvers performed daily on TanDEM-X. Days with orbit-keeping maneuvers performed simultaneously on TerraSAR-X and TanDEM-X are excluded from the comparison (Jan. 6, 19, 28). Single-frequency solutions benefit from the more robust ambiguity fixing (see Fig. 1).

	radial	along-track	cross-track
GFZ - DLR	-0.2	-0.4	-0.4
GFZ - AIUB	-0.1	-1.2	-1.1
AIUB - DLR	-0.1	0.7	0.7

	radial	along-track	cross-track
GFZ - DLR	-0.1	-0.8	-0.1
GFZ - AIUB	-0.2	-1.2	0
AIUB - DLR	0.2	0.3	0.8

Tables 2: Median values (mm) of the daily mean biases of the inter-agency comparisons when excluding maneuver periods. Biases of about 1mm at maximum are encountered between all agencies. Smallest biases occur for the radial direction due to tight relative constraints imposed in this direction between the empirical accelerations of TerraSAR-X and TanDEM-X. The same median values would result when maneuver periods are included in the statistics.

Conclusions

The achieved baseline performance is close to the mission specification, but independent bias calibration data takes will be required to fully meet the 1mm 1-D RMS target. Single-frequency solutions benefit from a more robust ambiguity fixing, but are potentially affected by errors caused by an incomplete compensation of differential ionospheric path delays.

Dual-/single-frequency kinematic solutions

	radial	along-track	cross-track
AIUB	**8.2**	**3.4**	**2.4**
DLR	**9.2**	**3.6**	**2.8**

Table 3: Median values (mm) of the daily standard deviations of baseline comparisons between kinematic and AIUB reduced-dynamic **dual-frequency** solutions (maneuver periods excluded).

	radial	along-track	cross-track
AIUB	**5.5**	**2.6**	**1.6**
DLR	**3.9**	**1.6**	**1.4**

Table 4: Median values (mm) of the daily standard deviations of baseline comparisons between kinematic and AIUB reduced-dynamic **single-frequency** solutions (maneuver periods excluded). Despite the short baseline of a few hundred meters, remaining differential ionospheric path delays disturb the kinematic baseline estimation if not properly modeled (as it is the case for the AIUB solution, note the occasional outliers in Fig. 3 below).

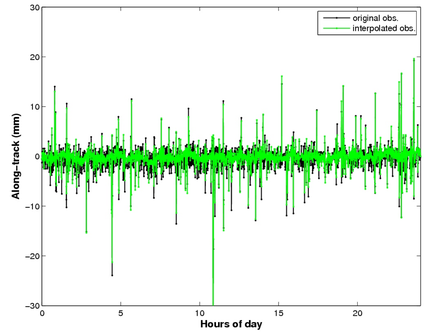


Figure 3: Along-track baseline differences between AIUB kinematic and AIUB reduced-dynamic baselines for January 1 using original or interpolated (for asynchronicities of up to a few microseconds in the measurement epochs of the TanDEM-X and TerraSAR-X GPS observations) single-frequency carrier phase observations. Only kinematic baseline estimates in the along-track direction are affected. Reduced-dynamic solutions are more robust due to the additional dynamical constraints.

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