Current Field Retrievals and SAR Signal Coherence Analysis Using TerraSAR-X and TanDEM-X

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All existing examples of current measurements by spaceborne synthetic aperture radar (SAR) along-track interferometry (ATI) have suffered from short baselines and corresponding low sensitivities. Theoretically, the best data quality at X band is expected at effective baselines on the order of 30 m, i.e. 30 times as long as the baselines of the divided-antenna modes of TerraSAR-X. In early 2012, we had a first opportunity to obtain data at near-optimum baselines from the TanDEM-X satellite formation. In this paper we analyze two TanDEM-X interferograms acquired over the Pentland Firth (Scotland) with effective along-track baselines of 25 m and 40 m. For comparison we consider a TerraSAR-X Dual Receive Antenna mode interferogram with an effective baseline of 1.15 m, as well as velocity fields obtained from Doppler centroid analysis (DCA) of single-antenna data from the same scenes. We show that currents derived from the TanDEM-X interferograms have a residual noise level of 0.1 m/s at an effective resolution of about 33 m x 33 m, while DRA-mode data must be averaged over 1000 m x 1000 m to reach the same level of accuracy. A comparison with reference currents from a 1 km-resolution tide computation system shows good agreement in all three cases. The DCA-based currents are found to be less accurate than the ATI-based ones, but close to short-baseline ATI results in quality. We conclude that DCA is a considerable alternative to divided-antenna mode ATI, while our TanDEM-X results demonstrate the true potential of the ATI technique at near-optimum baselines. In a separate study, we analyze a series of interferograms from TanDEM-X that were acquired over the open ocean with slowly changing along-track baselines. This dataset permits the first satellite-based measurement of the signal autocorrelation (or coherence) as function of time, covering time lags from approx. 1.8 to 5.5 ms, and a comparison with the theoretical predictions on which all of our baseline recommendations for future along-track InSAR systems have been based so far.