3D GEOLOCATION CAPABILITY OF MEDIUM RESOLUTION SAR SENSORS

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1. ABSTRACT

Persistent Scatterer Interferometry (PSI) [1,2] can estimate height and Line of Sight (LOS) deformation of Persistent Scatterers (PS) relative to a reference point. But the main limitation comes in understanding where these reflections stem from, what is exactly deforming, and with respect to what [3,4,5]. One of the vital parameters in identifying and associating radar scatterers to real world objects comes from scatterer's 3D geolocation and its quality.

In previous studies, after compensating atmosphere and tidal effects, absolute geolocation accuracy of trihedral corner reflectors (CR) in case of TerraSAR-X was reported in [6,7,8] to be in the order of a few centimeters in azimuth and range directions. Later, in [9] time-series Interferometric SAR (InSAR) acquisitions were exploited to enhance the geolocation capability in three dimensions viz. azimuth, range, and cross-range. First the 3D geolocation and its precision are modelled as a variance-covariance matrix for each pixel in radar geometry with azimuth (a), range (r), and cross-range (c) coordinates. Then the error ellipsoids in radar geometry for these pixels are propagated during geocoding into local geodetic datum geometry, with Northing (N), Easting (E) and Height (H) coordinates as shown below.

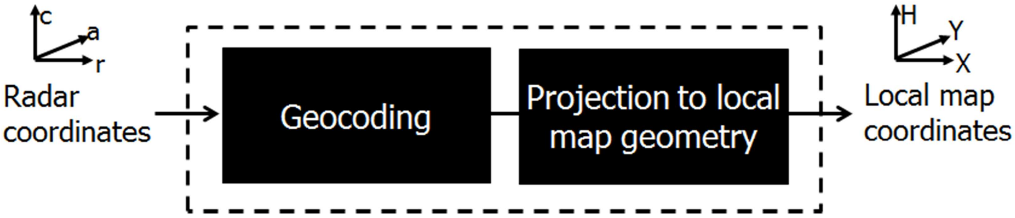

Fig. 1: Propagation of error: radar to map geometry

Towards this goal, corner reflectors installed in Delft, the Netherlands for a period of 1 year were used. The permanent GPS network of the Netherlands was used to correct for the atmospheric path delay component. The geocoded error ellipsoid in the map geometry improves our ability to associate radar reflections to real world objects as shown below for CR (Fig.2) and non-CR pixels (Fig.3). In addition this ellipsoidal confidence interval provides 3D geolocation quality of the sensor used. This methodology has been demonstrated for TerraSAR-X sensor [9].

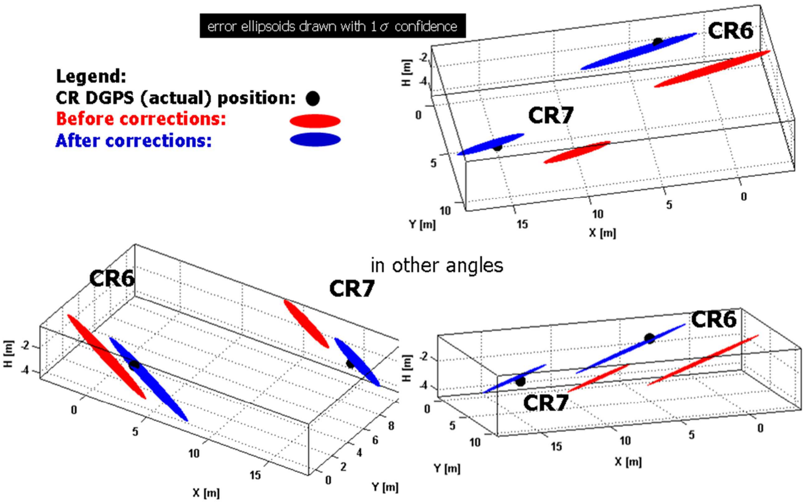

Fig. 2: Demonstration of 3D geolocation capability for TerraSAR-X. Geolocation of corner reflectors with its uncertainty shown using error ellipsoid with 1σ confidence interval. Results of both before (in red) and after (in blue) geodynamic and atmospheric corrections are given with respect to its true position (in black).

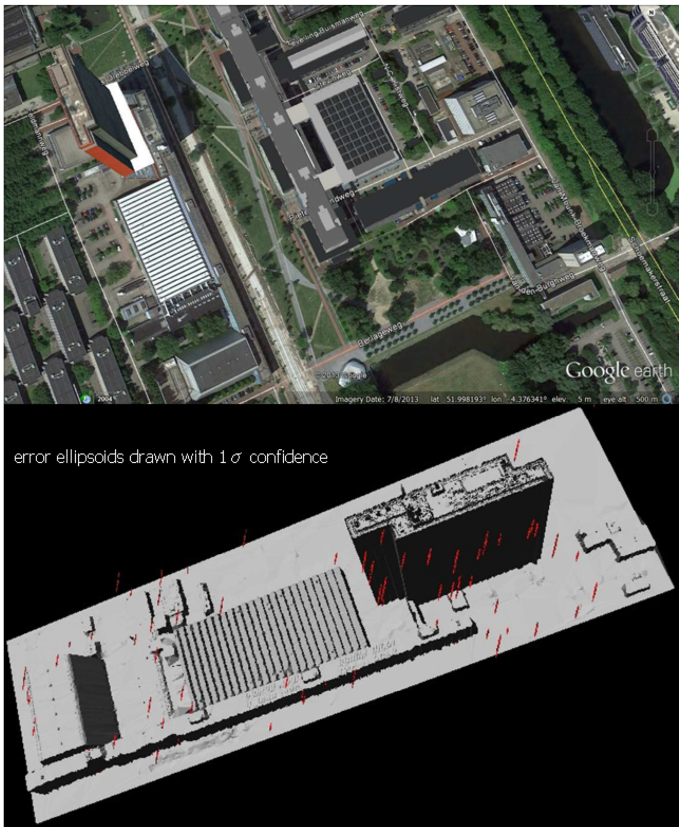

Fig. 3: 3D pixel positioning and its uncertainty for (non CR) coherent pixels. Error ellipsoids (in red) represent the geolocation error of coherent pixels in 3D with respect to its real world target.

In this paper we further extend the modeling, propagation and mitigation of 3D geolocation error of radar pixels for medium resolution satellites such as ERS-1/2 and Envisat. This analysis for medium resolution sensors – ERS, and Envisat will serve as a forecast on the geolocalization accuracy for Sentinel.

For this purpose five trihedral corner reflectors installed in Delft during the period 2003 to 2007 and images acquired with ERS and Envisat are used. CR phase centers are measured with differential GPS instruments to centimeter accuracy and their location in the respective radar images are predicted by range-Doppler geolocation. The predicted locations are then compared with their measured image positions. The measured positions are obtained by complex FFT oversampling to locate the CR intensity maximum [10,11,12]. Geolocation accuracy in case of Envisat for three CRs over a period of 5 years without any geodynamic and atmosphere corrections is shown in Fig.4. The geolocation error is found to be approximately 2m (0.5 pixels) in azimuth and 3m (0.4 pixels) in range. In addition the geolocation capability of Envisat is found to be drifting over time (from 2003 to 2007) as can be seen in Fig.4.

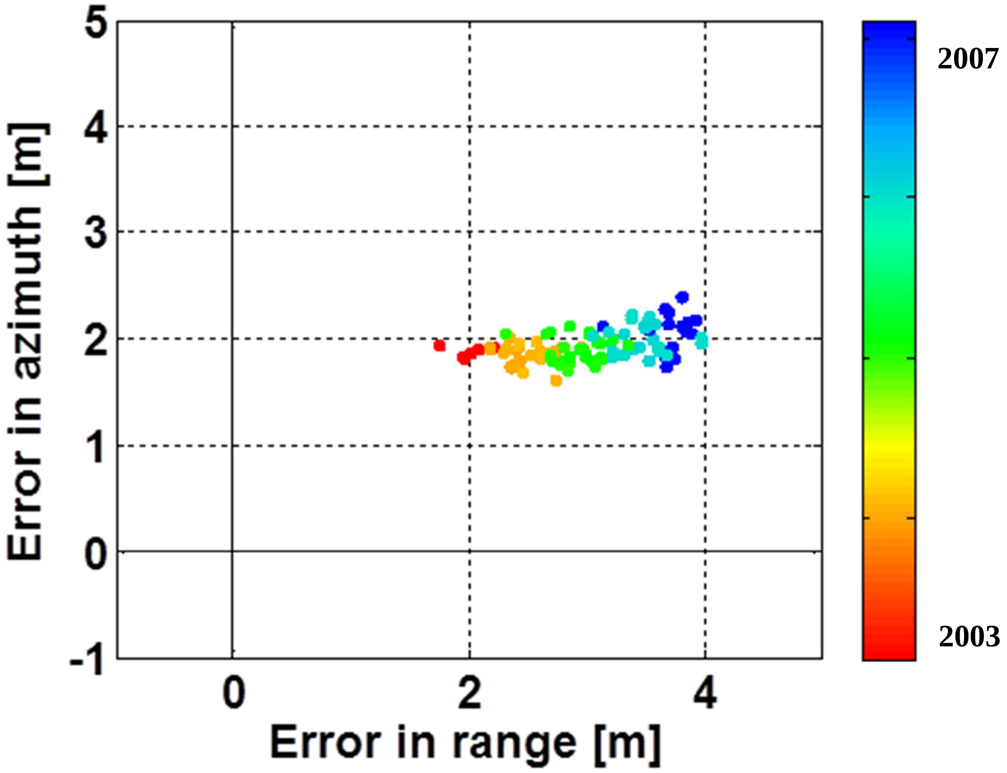

Fig. 4: Demonstration of geolocation accuracy for Envisat using 3 corner reflectors and 43 descending mode acquisitions, without any geodynamic and atmospheric corrections. Absolute geolocation error is found to be approximately 2m (0.5 pixels) in azimuth and 3m (0.4 pixels) in range. In addition the geolocation accuracy is drifting over time (from 2003 to 2007) as can be seen from the color change (error increase) over the years.

Further, the atmospheric path delay and geodynamic effects (such as Solid Earth Tide (SET), and Tectonics) are then computed for this test site and mitigated for coherent targets such as both CR and non-CR scatterers. For mitigation of the atmospheric path delay component, the permanent GPS network of the Netherlands is exploited. The results after the above mentioned corrections demonstrate the absolute geolocation capability of medium resolution sensors and will serve as an estimate for Sentinel.

2. REFERENCES

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