TECHNIQUES AND EXAMPLES FOR THE 3D RECONSTRUCTION OF COMPLEX SCATTERING SITUATIONS USING TERRASAR-X

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ABSTRACT

The German radar satellite TerraSAR-X was launched in June 2007. Since then, it is continuously providing high resolution space-borne radar data which are perfectly suitable for sophisticated interferometric applications. I.e. the mission concept and the SAR sensor support the coherent stacking of radar scenes which is the basis for advanced processing techniques e.g. Persistent Scatterer Interferometry (PSI) and SAR tomography. In particular, the short repeat cycle of eleven days and the highly reproducible scene repetition of the spotlight acquisitions support the stacking and consequently the time series analysis of the radar data. Furthermore, the sensor's orbital tube is precisely controlled to be in the order of 200 m which basically allows to utilize the baseline spread of the stacked acquisitions. However, this small spread is actually limiting the resolution in the SAR tomography.

Interferometric applications could be demonstrated already in a very early stage of the TerraSAR-X mission. Because the resolution is 0.6 m in slant range and 1.1 m in azimuth in the high resolution spotlight mode the PSI and the SAR tomography processing results were impressive. Urban areas and single buildings could be mapped from space in three dimensions. Even the structural stress of single buildings caused by thermal dilation could be demonstrated. The reported results are based on an unexpected high density of long time stable point scatterers and extended spatially coherent distributed scatterer areas. The significant resolution improvement compared to previously used space-borne SAR sensors and the short radar wavelength of about 3.1 cm result in a significant change of the radar image characteristic. For the first time, distributed scatterers covering man made features can be utilized in a long time series analysis. In contrast to this particular advantage, extended layover areas are caused by typical buildings and as a consequence complicated scattering situations need to be resolved. DLR's operational InSAR processing system GENESIS had already been adapted to cope with the new sensor modes of TerraSAR-X and their new specific spectral characteristics. However, the new image characteristics e.g. the extended layover areas and the long time coherent distributed scatterer need better to be supported. Subject is to optimally exploit the available information e.g. the radar reflectivity. Several algorithms of the processing system can be adapted. An example is the estimation of the signal to clutter ratio (SCR) which is a very good indicator for the phase stability over time. With the high spatial resolution, the SCR needs to be retrieved together with the identification of the scatterer configuration. As a matter of fact, the scatterer configuration has now become a very important characteristic for each resolution cell. It influences e.g. the estimation data extraction, finally the estimation of the 3D location and basically the estimation precision. A typical resolution cell can be composed of a single dominant point scatterer surrounded by clutter, two or more dominant point scatterers in clutter and of distributed scatterers with a specific phase stability over time. The paper provides technical details on the updated algorithms and processing examples are reported.