On the Predictability of PS occurrence and location based on 3D Ray-tracing models

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Publication date
2017

Document Version
Final published version

Citation (APA)
Yang, M., Dheenathayalan, P., Biljecki, F., & Hanssen, R. (2017). *On the Predictability of PS occurrence and location based on 3D Ray-tracing models*. 71. Abstract from Fringe 10th International Workshop on , Helsinki, Finland.

However, in practice, adjacent InSAR measurement points may exhibit a homogeneous or smooth behavior, in either space or time. This implies that the parameters of interest may be correlated and considered to be stochastic variates. Without considering this parameter signal correlation information, parameter estimation would be biased and therefore unreliable. Yet, simply applying global smoothing/multi-looking in space or time to filter the signal, is too harsh and will invoke more biases. Therefore, in the current study we propose to apply regularization in the parameter estimation, per cluster of points, based on available a priori signal information. As the signal information cannot be derived directly from the InSAR measurements, we obtain this information from other external sources (expert elicitation) and use them as constraints. This approach improves the accuracy, precision and reliability of the InSAR results. We demonstrate this approach both via simulations and on real data.

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Using persistent scatterer (PS) time-series InSAR, deformation of objects can be measured in order of millimeters. However, the exact physical nature and location of each scatterer is poorly known. Unlike conventional geodesic methods, PS scatterers are generally not pre-defined receivers or benchmarks. The occurrence of PS is strongly dependent on the specific orientation, geometry, and other characteristics of objects on the earth's surface, in relation to the parameters of the transmitted radar signals (e.g. direction, wavelength, polarization). Thus, though high-precision deformation estimates can be achieved, these uncertainties are a limitation to the use of this technique.

One solution to solve this problem is to estimate the 3D coordinates of scatterers by multi-baseline datasets, like persistent scatterer Interferometry[1, 2], Stereo-SAR[3], or SAR tomography[4]. However, the estimated positions, which are in order of several meters in cross-range direction for PS-InSAR, are still insufficient to detailed interpretation. Stereo-SAR requires the identification of (physically) identical scatterers, visible in both imaging geometries, which is not always possible for data stacks from different orbital tracks. SAR tomography only distinguish scatterers if the distance between scatterers is longer than the Rayleigh resolution in elevation[5]. Another way is to extract physical information of scatterers (size, material and temperature etc.) by building the time series amplitude function [6, 7], which also requires to solve the phase ambiguities of the scatterers. Consequently, the most important problem still is the understanding the origin and nature of PS, and the accurate estimation of its position.

Here, we attempt to improve our understanding of scattering mechanisms in an urban context in a new way, by simulating urban landscapes with varying level-of-detail (LOD),see Fig.1. We use a 3D SAR simulator based on Ray-tracing[8] to predict the radar scattering by illuminating a 3D scene by a known SAR sensor. The 'rays' can follow multiple reflections within the object scene, yielding some 'points' to behave as PS point scatterers. These potential scatterers will be predicted and localized. As the detected scatterers change with various level of detail (LOD) 3D models[9], we will explore the LOD effect on the identified scatterers. This yields useful information to improve the interpretation of actual PSI results, since it can be assessed whether specific elements of, e.g., a building will behave as PS or not. We report on the differences observed by illumination from various direction, as well as the differences due to different radar sensors. The simulated signals with their 3D coordinates may further support the connection between radar scatterers and real objects.

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