# Identification of Inconsistent Areas between Interpolated GNSS and Actual Ground Deformation for Estimating 3-D Ground Deformation from SAR Images

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In recent years, disasters related to civil engineering structures, such as landslides caused by torrential rains, have become increasingly serious. Constant monitoring of civil engineering structures is essential to take measures in advance and minimize damage. However, conventional surveying methods such as leveling are costly and do not allow efficient management. Therefore, three-dimensional ground deformation estimation using Synthetic Aperture Radar (SAR) is attracting attention. By integrating satellite-mounted microwave radar images (SAR images) with Global Navigation Satellite System (GNSS) or leveling results, it is possible to estimate ground deformation over a wide area. Since GNSS or leveling provides point data as results , we need to interpolate them to integrate with SAR data (area data). The accuracy of the interpolation is very important because it greatly affects the accuracy of the three-dimensional ground deformation estimation. Especially in areas with insufficient GNSS or leveling data, the ground deformation estimated by interpolation may not match the actual ground deformation, and in such cases, it is confirmed that the accuracy of ground deformation estimation by combining SAR images with GNSS, or leveling data deteriorates. To prevent accuracy degradation, it is useful to remove the interpolated ground deformation components that are inconsistent with the actual ground deformation and reanalyze. However, there is no way to know the actual ground deformation, so the challenge here is how to ensure consistency between interpolated ground deformation and actual ground deformation when the exact actual ground deformation is not known. In this study, we propose a method to identify the points where the actual ground deformation and interpolated ground deformation may not match, based on SAR images and GNSS or leveling results that are available. We used a simulator that generates pseudo-SAR images under arbitrary conditions to study the method. The proposed method uses the ground deformation in the radar line-of-sight estimated from ascending and descending SAR images and the vertical, east-west, and north-south deformation observed by GNSS. By taking the difference of three-dimensional ground deformation obtained from the integration of ascending or descending orbits and GNSS, we can estimate the points where the interpolated ground deformation does not match the actual ground deformation. The difference between the two estimates is small at points where the interpolated ground deformation is consistent with the actual ground deformation, while the difference between the two estimates is large at points where the interpolation is incorrect. By using this method, we can identify the points where the interpolation results do not match the actual ground deformation. It will enable more effective SAR analysis in the estimation of three-dimensional ground deformation.

**Keywords:** synthetic aperture radar, 3-D ground deformation, global navigation satellite system, civil engineering infrastructure monitoring, inconsitent data integration