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On the phase linking of distributed scatterers - improvement of measurement density in non-urban areas-

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Preface: Persistent scatterer interferometry (PSI) makes use of points with temporally coherent phase to achieve high accuracy measurements. However, in non-urban environments, the PS density is generally very low and distributed scatterers (DS) are dominant. Thus, it is difficult to monitor crustal deformation in a mountainous area where many active faults/volcanoes are located. To improve the spatial density of the measurement points, the use of DS, in which the phase quality should be comparable to PS, is indispensable.

Phase Linking: The small baselines subsets (SBAS) approach has been developed to extract high-quality phase information from DS. The SBAS, however, requires reliable phase unwrapping of each single interferogram. On the other hand, different approaches have been recently proposed (e.g., Monti-Guarnieri et al, 2008), in which the retrieval of phase time series is done ”before” unwrapping. In this method, the single-master phase time series is optimized on the basis of coherence information using all the multilooked ”wrapped” interferograms. The optimal phases are obtained as the maximum likelihood estimate of a complex circular Gaussian distribution for multilooked (statistically homogeneous) pixels. This approach is called phase linking as the phases stem from the results of linking all the interferogram phases.

Feasibility test by simulated data: To confirm the effectiveness and to test how well our algorithm works, we first applied it to simulated data. We generated a data set of 24 SLC images with 50 by 50 pixels, in which deformation with a constant speed is included and two kinds of (temporally-decreasing and seasonally changing) coherence matrices were used to simulate the decorrelation noise. A small fringe pattern can be recognized from standard master-slave interferograms with multilooking of 5 by 5, while the estimates by the phase linking could reproduce the true deformation for all interferograms. The standard deviation of the residual from the true phases is close to the theoretical lower limit, namely, Cramér-Rao bound, with a difference of about 0.1-0.2 rad at maximum for all interferometric pairs. On the other hand, there are large differences of about 1.5 rad at maximum for simple multilooked interferograms.

Application to actual data: We applied the method to ALOS/PALSAR data observing Japanese mountainous area, in and around Midagahara volcano where grass/trees cover the land. Only 12 SAR images are available due to the long-term snow-covered-land. We compared the results of a standard PSI analysis. In PSI analysis, the amplitude dispersion method to pick up PS candidates does not have a good performance for small data set, thus we used also the signal-to?clutter ratio method. For DS analysis, we first picked up statistically homogeneous pixels for multilooking by applying the 2-sample KS-test (Ferretti et al., 2011), and then conducted the phase linking. To get the same quality points for both analyses, we used the spatio-temporal consistency as a quality indicator (Hanssen et al., 2008) to select final measurement points. Resultantly, the PSs of 7094 pixels were obtained in full pixel size of 720000, while we could get the optimized DSs of 82138, leading that the observation density significantly improves. In this analysis, we found locally-distributed inflational ground deformation in the geothermal area. The increase of measurement point density contributes to grasp the spatial extent of inflational ground deformation. We can identify that the phase linking of DSs effectively works well for crustal deformation observation in mountainous area.

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Keywords: Phase linking, Distributed scatterers, InSAR time series analysis, Persistent scatterer interferometry (PSI)