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# A spatial filter adaptive to slope size applied to differential SAR interferograms for landslide detection

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Differential interferometric SAR (DInSAR) is the technique to measure small surface deformation induced between acquisition times by measuring ground surface several times from satellite. Since it employs microwave, it can observe ground surface of dozens of kilometers square under cloud or volcanic smoke. Thus, DInSAR has been used for the ground subsidence and volcano monitoring.

In the DInSAR image, surface deformation is appeared as an interferometric fringe. On the other hand, the fringe caused by the change of atomospheric water vapor distribution between SAR acquisitions also appears frequently in the image. The fringe caused by the atomospheric effect not only hinders image interpretation but also makes an error in the estimation of surface displacement. In order to make a proper interpretation of local fringes caused by landslide and analyze them quantitatively, it is necessary to remove the fringe caused by the atomospheric effect.

We propose a spatial filter for DinSAR image which suppresses the fringes caused by the atomospheric effect while preserving those caused by landslide as clear as possible. The proposed filter is based on high-pass filter in the spatial frequency domain. The scale of the fringe caused by the atomospheric effect ranges, in general, from several hundred meters to several kilometers, while those caused by landslide is restricted by landslide itself whose size ranges, in general, from dozens meters to several hundred meters in Japan. Using this difference of the scale between the two fringes, one can suppresses the fringes caused by the atomospheric effect efficiently while preserving those caused by landslide.

However, in general, the scale of landslides differs depending on locations. In addition, the shape of landslides is also various and anisotropic. Thus, when detecting a fringe caused by an unknown landslide from DInSAR images, it is difficult to set the appropriate maximal size to be filtered. One needs to adjust the frequency through try and error. To avoid this, the proposed filter is adapted to the size of ground slopes by assuming that the size of landslides is restricted by its underlying ground slope. When filtering, the maximal size is decided based on the size of the slope. Thus, the fringes caused by landslide are preserved adaptively while suppressing those caused by the atomospheric effect.

The procedure of the proposed method is as follows. The slope is defined by the slope orientation angle in this research. In the image of the orientation angle calculated from DEM, pixels with similar values are merged and regarded as the identical slope. The merging is performed by the region growing method. By applying the two-dimensional Fourier transform to the binary image of the detected slope area, the power spectrum is generated. The spectrum is normalized to be a window function and applied to the spectrum generated from DInSAR image of the corresponding area. In this way, the filter is adaptively applied to each slope area. The filtered spectrum of the DInSAR image is transformed to the spatial domain, generating the filtered DInSAR image of the corresponding slope area. By applying the procedure to neighboring slopes, the filter is applied to whole the DInSAR image. In this research, the maximal size of the slope is defined so that the maximal size to be filtered is restricted.

The proposed method was evaluated applying to the DInSAR image of landslide area in Nagano and Yamagata prefecture, Japan. We compared two filters; high-pass filter and proposed filter. By the high-pass filter, the fringes caused by the atomospheric effect are better suppressed, as the maximal spatial frequency to be filtered is high, while the fringes caused by landslide become small and weak. The best spatial frequency is difficult to decide. On the other hand, the proposed method also suppresses the fringes caused by the atomospheric effect while preserving those caused by landslide.

Keywords: Differential SAR interferometry, landslide, spatial filter