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Examination of InSAR tropospheric delay correction with JRA-55 reanalysis data

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Interferometric Synthetic Aperture Radar (InSAR) phase signal contains not only surface deformations but also propagation delays due to Earth's atmosphere, which is the principal limiting factor for InSAR application of small deformation with amplitude of a few centimeters or less. The atmospheric propagation delay is caused by the difference of refractive index between in atmosphere and in vacuum, and can be divided into the ionospheric delay and the tropospheric delay (Doin et al., 2009). Bevis et al. (1992) showed that the tropospheric delay consists of the hydrostatic delay due to dry gases and the wet delay due to water vapor. In the case of InSAR, the hydrostatic delay can be negligible and therefore the principal source of the tropospheric delay is due to the heterogeneity of water vapor in time and in space (Zebker et al., 1997). Previous studies proposed correction methods which used GNSS delay data or numerical weather model outputs. However, it is still insignificant for detecting small surface deformation.

Jolivet et al. (2014) showed that reanalysis data like ECMWF Interim Re-Analysis (ERA-Interim) data is useful to mitigate topography-correlated tropospheric delay from InSAR data. However, previous studies used only one of the model data as a case study and didn't apply the correction to other areas.

In this study we examined an effect of the tropospheric delay correction with Japanese 55-year reanalysis (JRA-55) data that is designed to produce a high-quality homogeneous climate dataset covering the last half century (Kobayashi et al., 2015). The horizontal resolution of JRA-55 is TL319 (approximately 60 km) and has 60 vertical layers. JRA-55 data are available every six hours. Pressure, temperature and specific humidity are interpolated to the SAR acquisition time and then used to calculate refractive index. We used the calculation method proposed by Jolivet et al. (2014) to estimate the tropospheric delay in the zenith direction and then converted to the line-of sight direction with a simple trigonometric function. In addition, we estimated the tropospheric delay with ERA-Interim data for comparison. SAR data used were derived from ALOS/PALSAR around Nagoya prefecture (Path-Frame: 411-690). We used the GAMMA software to generate interferograms and the 10 m-mesh digital ellipsoidal height model generated by the GeoSpatial Information Authority of Japan to remove the topographic fringe. To avoid the spatial decorrelation, interferometric pairs with the perpendicular baseline of less 3000 m were generated. As a result, 309 interferograms were generated from 28 SAR single-look complex images. Although some of interferograms have long-wavelength phase variations that may be caused by orbital estimation error or ionospheric disturbance, we didn't apply polynomial fitting to remove it because of the difficulty to determine whether that variation are due to the tropospheric delay or not.

In consequence of the tropospheric delay correction with JRA-55 and ERA-Interim data, the averaged standard deviation of all interferograms slightly reduced from 1.26716 cm to 1.25231 cm by JRA-55 and slightly increased to 1.26797 cm by ERA-Interim. We further examined the correction effect when dividing the estimated delay into the hydrostatic component and the wet component. In JRA-55, the averaged standard deviation slightly reduced to 1.26053 cm and 1.2659 cm by applying the hydrostatic and wet delay correction, respectively. On the other hand, in ERA-Interim, the averaged standard deviation slightly reduced to 1.26223 cm and 1.2659 cm by applying the hydrostatic delay correction and increased to 1.28106 cm by applying the wet delay correction. These results indicate that one of the factors of correction failure by ERA-Interim would be due to the low reproducibility of the actual wet delay.

In the presentation, we will report correction effects of JRA-55 and ERA-Interim, and discuss the difference of these effects.

Keywords: InSAR, tropospheric delay, reanalysis data, JRA-55, ERA-Interim