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Three dimensional water vapor distribution based on InSAR data during Seinoh heavy rain on 2 September 2008

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Interferometric Synthetic Aperture Radar (InSAR) phase signals allow us to map the Earth's surface deformation, but are also affected by earth's atmosphere. In particular, the spatiotemporal heterogeneity of water vapor near the surface causes unpredictable phase changes in InSAR data and prevents us from detecting few centimeters of crustal deformation. However, InSAR can provide us with a spatial distribution of precipitable water vapor with unprecedented spatial resolution in the absence of deformation signals and other errors (Fujiwara et al., 1998, Hanssen et al., 1999).

We generated the InSAR image from ALOS/PALSAR level 1.0 data acquired during the heavy rain on 2 September 2008 in Central Japan, so-called Seinoh heavy rain, and then we detected the localized signal which changed 120 mm in radar line-of-sight over a spatial scale on the order of 8 km. So far we have reported that; 1) the localized signal is likely to be an artifact of tropospheric propagation delay rather than that of either ground deformation or ionosphere, 2) comparing it with the 1 km weather radar rainfall intensity echo distribution, the small area with rainfall intensity greater than 80 mm/hr exists at the location of the signal in InSAR (Kinoshita et al., GSJ 2010, 2011 meeting, Kinoshita et al., 2011, JpGU). Here we report the estimated result of three dimensional water vapor distribution during the heavy rain based on the heavy rain-derived tropospheric delay signal in InSAR data with the ray tracing method (Hobiger et al., 2008). We used the GAMMA software for the InSAR analysis and the 10 m digital elevation model by GSI for the correction of topographic fringes.

The refractivity of earth's atmosphere is the function of pressure, temperature, and water vapor (Thayer, 1974). Therefore we estimated the three dimensional water vapor distribution to explain the localized signal in InSAR by at first setting the three dimensional field of pressure, temperature and water vapor around the localized signal at the SAR acquisition time, then modeling the tropospheric delay in InSAR with ray tracing. Here, since it is impossible to determine these three parameters uniquely from one refractivity without any constraint, and since the ray path of each pixel is parallel in InSAR, it is difficult to estimate these parameters by the inversion like GPS tomography (e.g. Seko et al., 2000). For these reasons, we assumed as a constraint that the values of pressure and temperature are same as the MSM data, and we only estimated the water vapor distribution, which is spatiotemporally variable and has large effect on the propagation delay, by trial and error. In this study we focus only on the localized signal in InSAR, and the region we estimate is 30 km square centered on the localized signal in the horizontal and 15000 m in the vertical.

As a result, we estimated that there is the dry region lower than 50 % in relative humidity above 5000 m altitude, and the large amount of water vapor higher than 90 % in relative humidity within 10 km square in the horizontal and from the surface to 9000 m in the vertical at the localized signal in InSAR. Calculating the zenith precipitable water vapor (PWV) from the estimated water vapor field, we found that the amount of PWV at the signal in InSAR is 12 mm higher than that around the signal, and the location of it is 3 km apart from the local maximum area of weather radar echo. Additionally, it seems that AMeDAS surface wind observation data shows the existence of the convergence zone at the signal in InSAR. This indicates that water vapor near the surface converges at the signal. For these reasons, the location of the dense water vapor area is markedly different from that of the maximum precipitation radar echo. This observation would represent that in the precipitation system for the heavy rain the actually precipitating area was 3 km distant from the area where the water vapor was flowing into.

Keywords: InSAR, Heavy rain, Ray tracing, Water vapor