InSAR time-series analysis using Envisat images: Application on the region of two earthquakes in Niigata, central Japan

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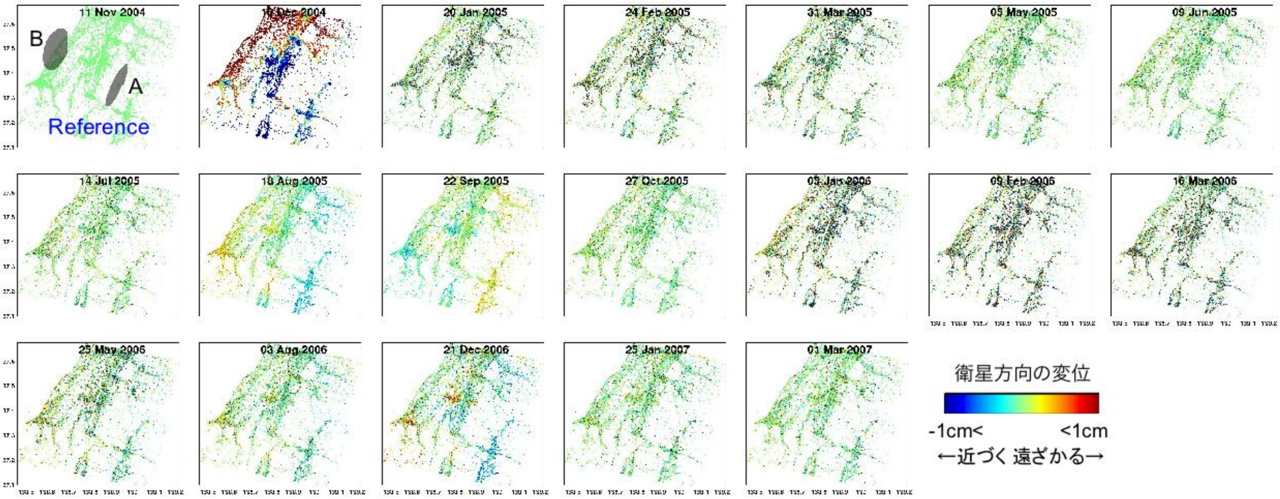
One of the recent major advances in SAR interferometry is the development of time-series analysis techniques of permanent/persistent scatterer (PS) and small baseline (SB) approaches. This study applies these two different kinds of InSAR time-series analysis methods on the region of two earthquakes, Mw 6.5 in October 2004 and Mw 6.6 in July 2007, which occurred in Niigata Prefecture, Japan. Since the source faults of the two earthquakes are only 30 km apart, it is likely that the first event in 2004 influenced the occurrence of the second one. In this research we attempt to precisely map the deformation occurred between the two earthquakes.

We use StaMPS/MTI (Stanford Method of PS/Multi-Temporal InSAR) to perform both PS and SB analyses. StaMPS/MTI is a package that uses, in addition to its own codes, other public-domain tools of InSAR processing. It can start processing from either raw or SLC data, where ROI_PAC software is used for SLC generation for the former case. Interferogram computations are done using Doris software. The PS analysis of StaMPS uses primarily spatial correlation of the phase to identify phase-stable pixels, as opposed to temporal correlation, as is the case for the most PS algorithms. Another significant difference against other PS algorithms is that StaMPS does not assume any approximate model of displacements (such as linear or periodic). A requirement is that the displacement gradients in space and time should not be steep for proper unwrapping. Therefore, StaMPS is well suited for measuring slow (time scale of months or more) and regional movements. The SB analysis of StaMPS/MTI uses amplitude difference dispersion values and then performs phase analysis in space and time to identify coherent pixels, which is not done in other SB methods. StaMPS/MTI uses a 3D unwrapping algorithm, which is advantageous over 2D algorithms because insufficient spatial density of persistent or coherent pixels can be compensated by unwrapping in time.

In this study, we used 29 Envisat ASAR raw images acquired between March 2003 and July 2007. All of these images were used to identify persistent and coherent pixels, but the phase modeling, or estimation of the temporal evolution of line-of-sight (LOS) displacements, was carried out using interferograms formed from 19 images acquired between the two earthquakes (18 and 35 interferograms for PS and SB analyses, respectively).

Preliminary applications of PS and SB methods identified sufficient coherent pixels (77,521 for PS and 249,871 for SB) to enable further processing. The PS results indicate a few cm of postseismic displacements of the 2004 earthquake in the first 8 weeks after the occurrence, but no detectable displacements later. Estimation in winter seasons is noisier, probably due to snow. Estimated displacements in summer to autumn of both 2005 and 2006 show a few mm of fluctuations, which might indicate some seasonal movements of the ground. The obtained LOS displacements were compared with GEONET GPS displacements (F2 solution) projected to the LOS direction. Results are generally comparable, though atmospheric variation makes the PS results noisier. At three stations the correlation is low, which requires further investigation.

(Figure caption)
Time-evolution of crustal deformation after the Niigataken-chuetsu earthquake (October 2004) and before the Niigataken-chuetsuoki earthquake (July 2007). The acquisition dates define the time steps, and the LOS displacements from the previous time step are shown in every plots. A and B: source regions of Niigataken-chuetsu and chuetsuoki earthquakes, respectively. The second plot (11 Nov. - 16 Dec. 2004) indicates postseismic deformation of a few centimeters. Random incoherent noise is commonly observed in winter seasons (January to March), which probably results from snow. Displacements of large wavelengths in July - Sept. 2005 and May - Dec. 2006 may indicate some seasonal deformation.


11 Nov 2004
B
A
Reference
20 Jan 2005
24 Feb 2005
31 Mar 2005
05 May 2005
09 Jun 2005
14 Jul 2005
22 Sep 2005
27 Oct 2005
16 Mar 2006
25 May 2006
03 Aug 2006
21 Dec 2006
25 Jan 2007
01 Mar 2007
衛星方向の変位
-1cm<
<1cm
←近づく 遠ざかる→