Automatic error-term estimation approach for improving the accuracy of InSAR time-series analysis - Example on the Arima-Takatsuki Fault Zone, Japan

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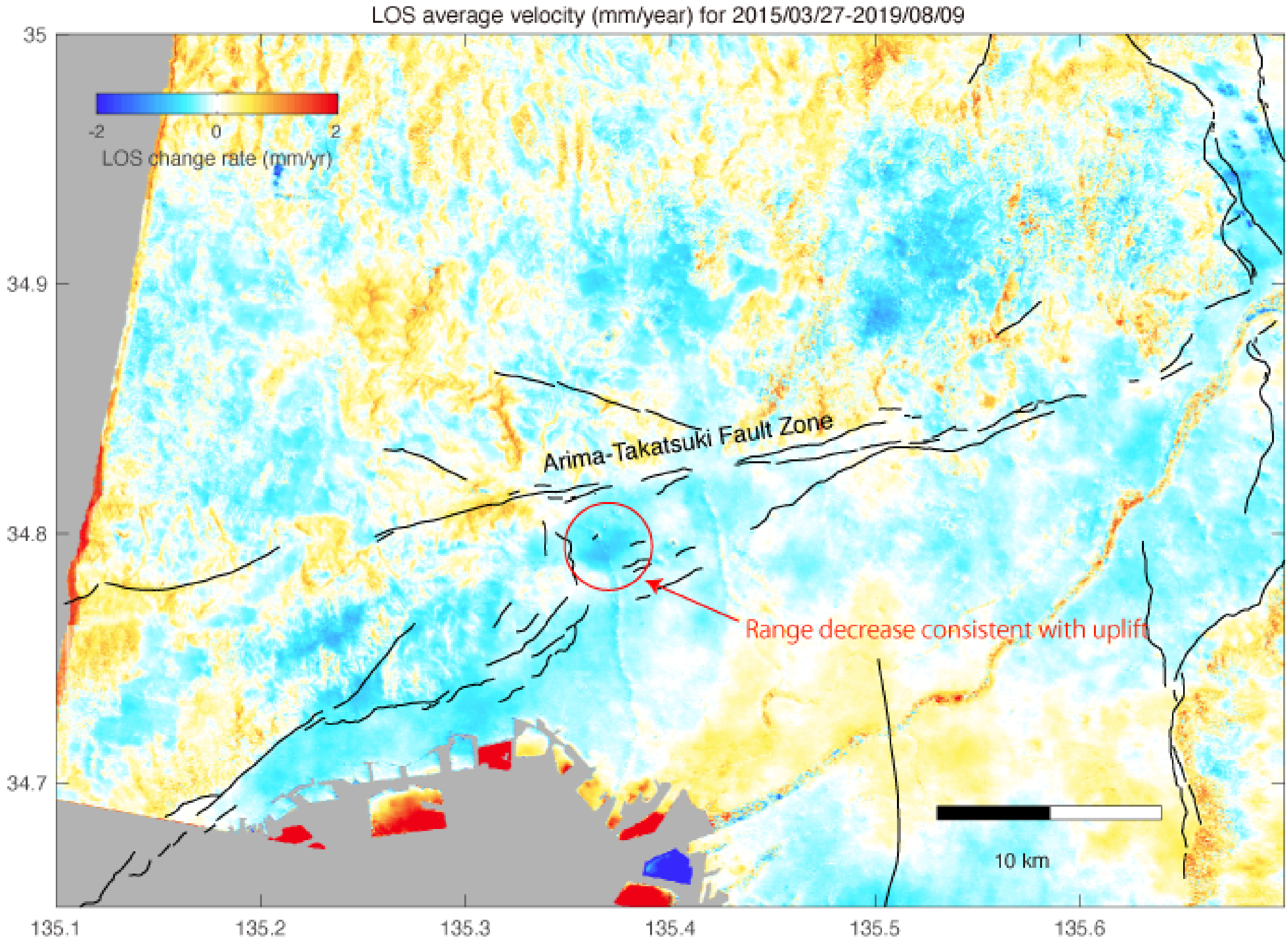
InSAR time-series (InSAR-TS) analysis enables us to obtain the time-series of line-of-sight (LOS) displacements over a wide area by using a number of SAR images repeatedly acquired on the area. Among the factors affecting the accuracy of the InSAR-TS analysis, I focus on three factors that may severely limit the detection of small signals. Firstly, it is often the case that the selection of the reference point (determining the offset in each interferogram) is problematic. Wrong selection largely deteriorates the accuracy of the displacement time-series, and there are cases where the whole scene cannot be assumed to be stable. Secondly, interferograms often contain ramp-type artifact that originate from inaccuracy in the orbit data or ionospheric disturbance. Correction for this type of noise is often difficult, especially when one attempts to obtain the displacements of long wavelengths. Thirdly, the altitude-correlated phase delay in the troposphere is often the most significant noise source in interferograms. Although many studies using weather models have been conducted to mitigate this kind of noise, simple regression of the phase change with respect to the altitude is often the most effective method. This kind of regression approach, however, can sometimes over-correct the true deformation signals.

Fukushima et al. (2019, Earth, Planets and Space) proposed an InSAR-TS analysis method to simultaneously solve for the displacement time-series and the error terms mentioned above (plus the error in the digital elevation model), and succeeded in obtaining clear signals caused by fault creep. In the proposed method, the unwrapped phase in interferograms is assumed to be composed of a linear combination of the LOS displacement, offset, planar ramp, altitude-correlated phase, and error in the used digital elevation model. A set of unwrapped small-baseline interferograms is then inverted to simultaneously obtain the displacement time-series and the parameters describing the error terms under the minimum norm condition on the displacement time-series.

In this study, the method was applied to the ALOS-2 data acquired around the Arima-Takatsuki Fault Zone located on the margin of the Osaka Plain in western Honshu, Japan. The data consisted of 26 images acquired between March 2015 and August 2019 from a descending orbit along Path 21 and Frame 2910. Some of the original interferograms contained severe noise such as a phase ramp equivalent to approximately 25 cm of LOS displacements. The average velocity field obtained by applying the method captured the relative range decrease (negative LOS change rate) of the southern side with respect to the northern side of the fault zone with a localized signal of up to approximately 1 mm/year around (latitude, longitude) = (34.79, 135.38), which are consistent with the results of an InSAR-TS analysis of Sentinel-1 data (Morishita, 2021, PEPS). Given the fact that the Sentinel-1 dataset had much favorable conditions (much larger number of data (133 images for the descending dataset) and much smaller ionospheric noise), the consistency in the average velocity field suggests the effectiveness of the noise correction method.

Keywords: InSAR, Arima-Takatsuki Fault Zone


LOS average velocity (mm/year) for 2015/03/27-2019/08/09
-2
0
2
LOS change rate (mm/yr)
Arima-Takatsuki Fault Zone
Range decrease consistent with uplift
10 km
35
34.9
34.8
34.7
135.1
135.2
135.3
135.4
135.5
135.6

