第29回日本情報地質学会講演会 講演要旨集 039-040頁 2018年

SBAS-InSAR for detecting and characterizing topographic change in a geothermal plant area

Panggea G. Sabrian*, Katsuaki Koike*, Asep Saepuloh**, and M.N. Heriawan***

*Graduate School of Engineering, Kyoto University, Katsura C1-2-215, Kyoto 615-8540, Japan.
Email: sabrian.ghiyats.57n@st.kyoto-u.ac.jp
**Faculty of Earth Sciences and Technology, Bandung of Institute Technology, Bandung, Indonesia.
***Faculty of Mining and Petroleum Engineering, Bandung of Institute Technology, Bandung, Indonesia.

Key Words: Geothermal resource, SBAS, coherence, deformation, uplift, Wayang Windu

Introduction

Geothermal potential in Indonesia is estimated approximately as 28,100 MW with potential resources of 13,440 MW and reserves of 14,473 MW at the 265 locations throughout the country. Currently only about 1,189 MW (4%) is utilized to generate electricity. Geothermal energy has advantages of being renewable and environmentally friendly. Thus, intensive exploration and clarification of geothermal potential are indispensable to develop this huge renewable energy. One of the regions that has high potential of geothermal resource is the Wayang Windu field, West Java. The geothermal system in this area is known to be a transition between vapor domination and water dominance with four upwelling centers. The system becomes young and more dominated by water towards the south (Bogie *et al.*, 2008).

Surface deformation has been prevalent in many geothermal fields around the world, especially already-operated geothermal fields in Indonesia. This requires many sets of spatial technologies to precisely detect and monitor the deformation. One of the effective technologies for this is Interferometric Synthetic Aperture Radar (InSAR). Based on those background, this study focus on the use of InSAR technique for detecting and characterizing the surface deformation in the Wayang Windu field (Figure 1).

Methods

To analyze the surface deformation in the Wayang Windu field, seven scenes of ALOS PALSAR image (L-band) in the period of 2009-2011 and a method, Small Baseline Interferometric Synthetic Aperture Radar (SBAS-InSAR) were used. This method can provide accurate result and minimize the atmospheric effect.

The SBAS-lnSAR algorithm was firstly demonstrated by Berardino *et al.* (2002) as a method to reduce the atmospheric effect and topographic error. Then, this algorithm was improved to clarify the time-series deformation by using interferograms generated by image pairs of small baselines only, because such pairs can reduce the spatial decorrelation. The atmospheric effect can be removed through applying the temporal high-pass and low-pass spatial filters to the interferograms. Because there are temporal gaps in the image pairs (i.e., their acquisition dates are more or less different), SBAS-lnSAR uses the Singular Value Decomposition (SVD) approach based on the minimum deformation standard criteria to reduce "link" the separate small baseline subsets, clearly increasing the temporal sampling rate.

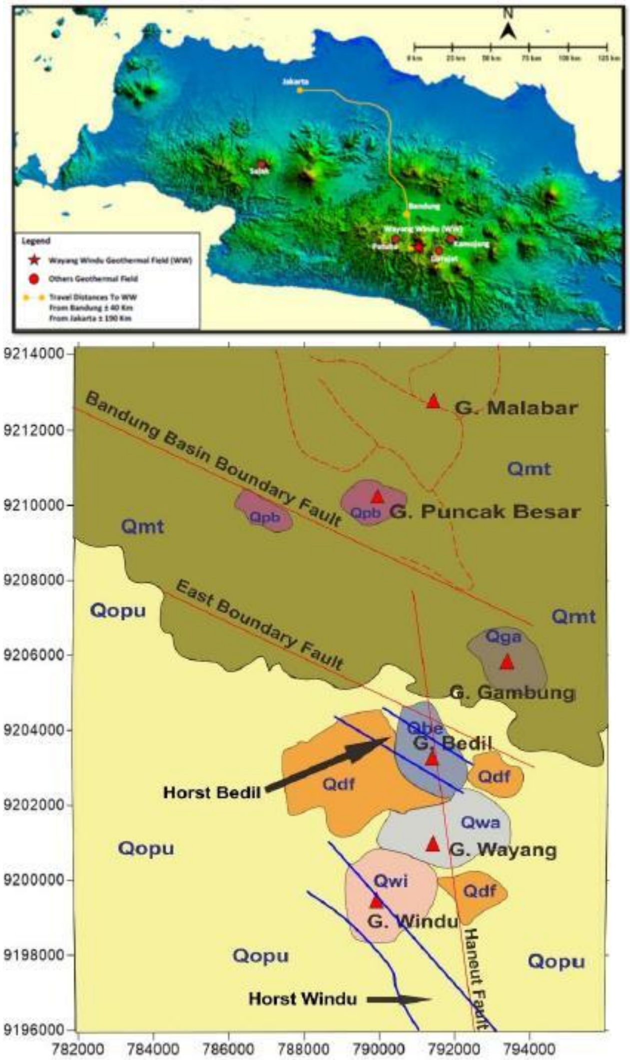

Figure 1. Location of the Wayang Windu geothermal field and a geological map around the field by Malik and Rustadi (2012) and Masri *et al.* (2015).

After that, the SBAS algorithm has been improved to (1) suppress errors caused by temporal decoration and other noise effects, (2) increase the estimate of linear deformation by reducing the phase unwrap error, (3) reduce furthermore the atmospheric effect and topographic errors, and (4) reduce the orbital errors by using specific reference points and interferogram phase values in the other pixels. For example, Lee *et al.* (2010) improved the SBAS algorithm to increase the estimation accuracy of the time-series deformation by the following four methods. First, the error of unwrap phase was corrected under an assumption that the atmospheric effect was generally correlated spatially and temporally. After the removal of atmospheric effect, the time series deformation was again calculated by applying the SVD approach and other methods (Schmidt and Biirgmann, 2003) to furthermore suppress the noise effect. Thirdly, the applied procedure eliminated the possibility of a phase bias at reference points caused by the orbital and atmospheric effects (Lee *et al.*, 2010). Finally, those reductions of the atmospheric effect and topographic errors and the accuracy time-series measurements of deformation were enhanced through the iteration procedures of the three steps.

Result and Discussion

The coherence values among the seven scenes were low in general (Figure 2), which may originate from the thick vegetation in the study area. Coherence is an indicator for the level of noise in phase and describes all properties of the correlation between physical quantities of several SAR images by a value between 0 (high phase noise) and 1 (low phase noise). Because of the low coherence, the resultant SBAS-InSAR deformation map (Figure 3) shows that the detected deformation areas were limited in flat topography with sparse vegetation.

The most noteworthy feature of the deformation pattern is that the deformation is different between the northern and southern regions: the northern region is generally subside, while the southern region is uplift. This different pattern may be caused by the movement of the Bandung Basin boundary fault (Figure 1). The deformations at the production wells of geothermal plant were estimated to subside between 2 mm to 17 mm except for one well, WWT well at which the 16 mm uplift was estimated. This is likely due to the large uplift in the south region.

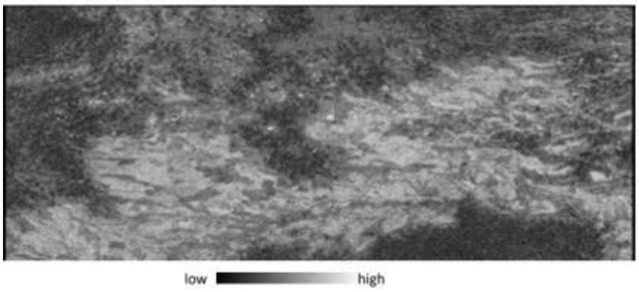

Figure 2. Coherent value over the Wayang Windu field in the single looking.

Conclusion

The results of SBAS-InSAR analysis suggested the deformation pattern was different between the northern and southern regions of the Wayang Windu geothermal field, subsidence or uplift pattern, respectively, due to the movement of the Bandung Basin boundary fault. In addition, geothermal reservoirs are known to be different between the two regions, vapour or liquid dominated reservoir. This physical different may also be a cause of the difference in deformation pattern. More detailed InSAR analyses are in progress to enhance the deformation accuracy using more SAR data pairs.

Acknowledgement: We sincerely thank Star Energy Geothermal (Wayang Windu) Ltd. for the collaboration of the Science and Technology Research Partnership for Sustainable Development (SATREPS) Program with JST, JICA, and Institute Technology of Bandung.

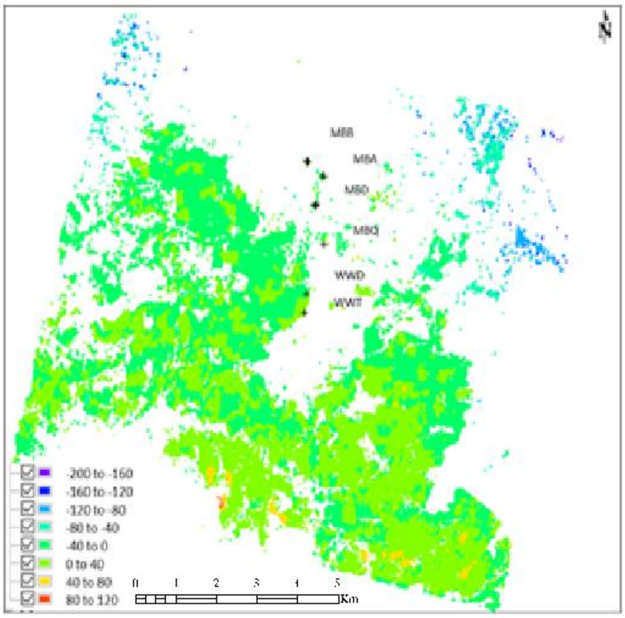

Figure 3. Deformation velocity estimated over the study field.

References

Berardino, P., Fornaro. G., Lanari, R., Sansosti, E. (2002) A new algorithm for surface deformation monitoring based on small baseline differential SAR interferograms. *IEEE Transactions on Geoscience and Remote sensing*, 40, 2375-2383.

Bogie, I., Kusumah, Y. I., dan Wisnandary, M. C. (2008) Overview of the Wayang Windu geothermal field, West Java, Indonesia. *Geothermics*, 37, 347-365.

Lee, C. W., Lu, Z., Jung, H. S., Won, J. S., Dzurisin, D (2010) Surface deformation of Agustine Volcano, 1992-2005, from multiple-interferogram processing using a refined small baseline subset (SBAS) interferometric synthetic aperture radar (InSAR) approach. Ch 18, p. 453-465.

Schimidt, D., Burgmann, R. (2003) Time-dependent land uplift and subsidence in the Santa Clara valley, California, from a large interferometric synthetic aperture radar data set. *Journal of Geophysical Research*, 108, 2416.

Malik, D., dan Rustadi, A. A. (2012) Surface thermal manifestation evolution under exploration stage In Wayang Windu field. *The 12th Annual Indonesian Geothermal Association Meeting & Conference*, Bandung.

Masri, A., Barton, C., Hartley, L., dan Ramadhan, Y. (2015) Structural permeability assessment using geological structural model integrated with 3D geomechanical study and discrete fracture network model in Wayang Windu geothermal field, West Java, Indonesia. *Proceeding Fortieth Workshop on Geothermal Reservoir Engineering*, California, California University, 1-12.