# ALOS PALSAR FOR TEMPORAL ANALYSIS OF SURFACE DEFORMATION ON MUD VOLCANO ERUPTION IN SIDOARJO USING DINSAR TECHNIQUE

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**ABSTRACT:** Since 29 May 2006 up to now, the hot mud volcano has erupted with enormous volume (the highest rate is $5x10^4$ $m^3$/day) in Sidoarjo, Western Java, Indonesia. It covers the area around 6 $km^2$ and destructs important infrastructures (road, railroad, electricity, school, etc) including residence houses. The actual cause of this eruption is still debatable among scientist. This incident has been declared as national disaster by the Indonesian government. The location of disaster, which is in between two big cities, not only give a great impact to the citizen who lives in mud eruption surrounding area, but also people in two cities in term of electricity and distribution, communication, transportation and economy. Several actions have failed to stop the eruption, in order to prevent mud spreading area, man-made dam was constructed and the height reaches more than 15 meters. The eruption of sub surface material to the surface also brought up surface deformation problem. In this study, we will monitor this disaster in term of surface deformation and locate the deformation affected area by implementing Differential Interferometry Synthetic Aperture Radar (DInSAR) technique using ALOS-PALSAR data taken between the years 2006 and 2008. The subsidence more than one meter detected in surrounding area outside the dam.

## 1. INTRODUCTION

Differential synthetic aperture radar interferometry (DInSAR) is a technique using direction using synthetic aperture radar (SAR) data taken at two separate acquisition times or two different observation positions. It detects accurately the ground displacement or land deformation in the antenna line-of-sight (slant-range). This technique has been applied in many applications such as earthquake, landslide and volcano hazard (Stramondo et al., 2006; Tralli et al., 2005). The advantages of this technique, but not limited, are giving wide coverage spatial perspective of deformation on study area, low cost compared to conventional methods and easy to apply even when the study area is inaccessible. Despite of its advantages, the DInSAR method currently still implement as complementary to ground-based methods such as leveling and global positioning system (GPS) measurements, because of its validity of the result (Raucoules et al., 2007).
The study area in this paper is Sidoarjo District, East Java, Indonesia. Since May 2006, hot volcanic mud erupted in enormous volume in this area, which turns into national disaster. The ALOS-PALSAR data will be used to investigate the land deformation characteristic based on temporal analysis by using DInSAR technique, due to the enormous hot volcanic mud eruption in this area. In this study, the ability of DInSAR technique will be investigated in such rare disaster.

## 2. STUDY AREA

The hot mud erupted in Porong district, Sidoarjo, East Java, Indonesia. Porong district is geographically located at 7° 30´19" - 7°33´46" S and 112° 41´ 0"- 112° 44´1" E, about 900 km east of Jakarta and 14 km south of Surabaya (see Figure 1). On 29 May 2006, the mud volcano erupted in this area because of drilling activities for gas exploration. The enormous volume of mud erupted and spread quickly and suddenly become a disaster. The mud covers surrounding area, including houses, factories, schools, paddy fields, highway and many important infrastructures. The embankment (man-made dam) with the height over 15 meters has been built within radius 2 kilometers in order to prevent larger affected area (Davies et al., 2006).

## 3. DATA AND METHODOLOGY

A series of SAR interferograms is computed from ALOS/PALSAR data taken on eight different acquisition days between 2006 and 2008. The data was processed in two sets. The first set has seven pair by using one data, taken before the eruption, as a master for each pair. The second set also has seven pair in total, but the pair are created based on minimum temporal interval. The detail parameters of each pair (interval time and perpendicular baseline) of first and second sets are summarized in Table 1 and Table 2, respectively.

The DInSAR technique will be applied to each data pair for extracting the land deformation information. It technique will exploit the phase information that stored in every data (Raucoules et al., 2007). We employed the ROI_PAC software to apply the DInSAR technique into each data pair (Rosen et al., 2000). The DInSAR result can be derived by using precise satellite orbital information, with the help of Digital Elevation Model (DEM) of Sidoarjo area, obtained from the ASTER Global Digital Elevation Model (GDEM) for topography phase removal.

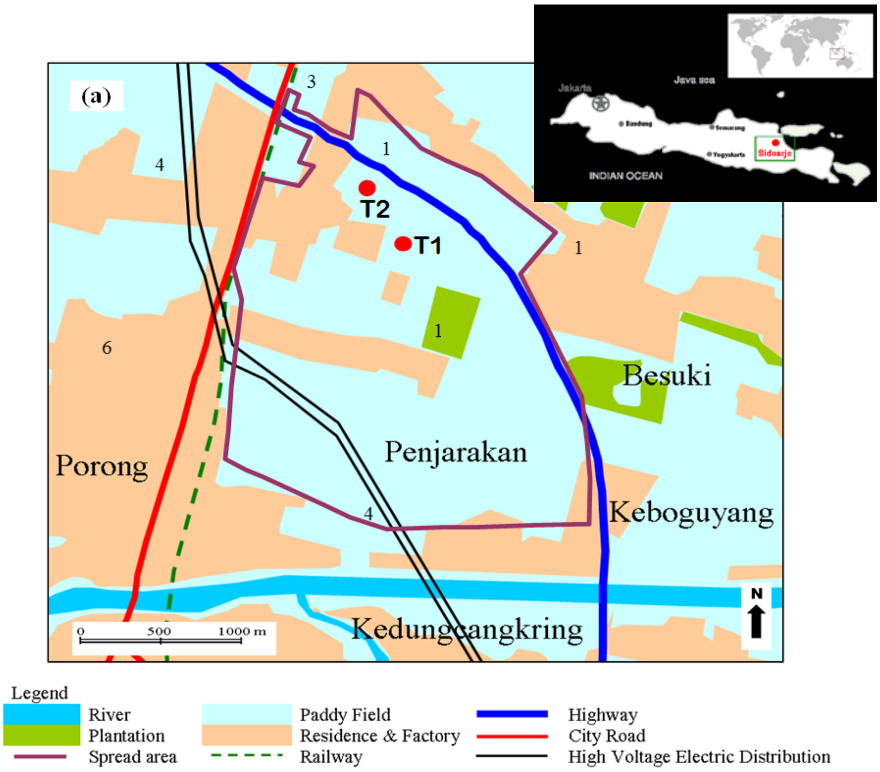


Figure 1. Study Area

Table 1. First set. Data taken on 20060519 as master

| Pair number | Acquisition Date | | Baseline Perpendicular (m) | Interval Time (Week) |
|---|---|---|---|---|
| | Master | Slave | | |
| 1 | 20060519 | 20061004 | 2165.59 | 19 |
| 2 | 20060519 | 20061119 | 2771.4 | 26 |
| 3 | 20060519 | 20070104 | 108.41 | 32 |
| 4 | 20060519 | 20070219 | 1598.54 | 39 |
| 5 | 20060519 | 20071122 | 1103.74 | 78 |
| 6 | 20060519 | 20080524 | 463.77 | 105 |
| 7 | 20060519 | 20081124 | 1995.26 | 131 |

## 4. RESULT AND DISCUSSION

Figure 2 shows the DInSAR interferogram from each data pair of first set. All DInSAR process results show three areas of land deformation (two subsidences and uplift) on mud volcano eruption surrounding area. The areas are the embankment surrounding (center, subsidence), the north west of embankment (left side, subsidence) and the north east of embankment (right side, uplift). These three areas are appears in all pairs. The result also shows the land deformations area are getting larger and the deformation changing are getting bigger along to longer interval time observation. The noise that appears in the center of embankment area may occur because of low coherence between two observation data. The cause of low coherence is possibly because the activity of embankment construction activity and continues changing of mud surface due to the still-active eruption during satellite observation time. The largest deformation estimation reach over 70 centimeter in some points based on DInSAR calculation during 131-week interval times.

Table 2. Second set. Minimum interval time between each data pair.

| Pair number | Acquisition Date | | Baseline Perpendicular (m) | Interval Time (Week) |
|---|---|---|---|---|
| | Master | Slave | | |
| 1 | 20060519 | 20061004 | 2165.59 | 19 |
| 2 | 20061004 | 20061119 | 605.86 | 6 |
| 3 | 20061119 | 20070104 | 2879.02 | 6 |
| 4 | 20070104 | 20070219 | 1707.07 | 6 |
| 5 | 20070219 | 20071122 | 494.98 | 39 |
| 6 | 20071122 | 20080524 | 639.87 | 26 |
| 7 | 20080524 | 20081124 | 1531.52 | 26 |

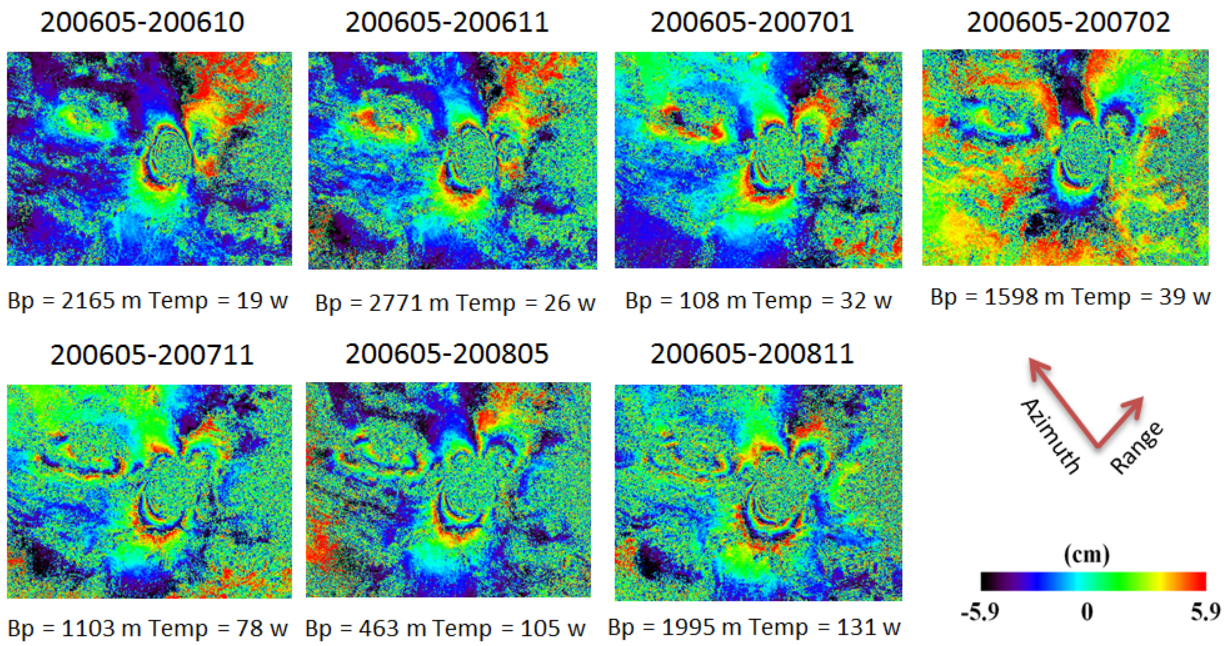


Figure 2. DInSAR result of first set of data pairs.

The noise gets worse and the accuracy was decrease along the increasing of interval time. In order to get the better analysis and accuracy, the pair with minimum interval time was processed. All the pair of minimum interval time was collected in second set.

Figure 3 shows the result of second sets and focused only for deformation in the surrounding of embankment, because of other two deformation areas do not always appear in every pairs. The results show better accuracy compared to first set. The area inside the embankment always has noise for the same reason as mentioned above. The longer the interval time, noise gets worse. The largest deformation estimation reach 150 centimeter in some points based on DInSAR calculation on pair 200610-200611 during 6-week interval times.

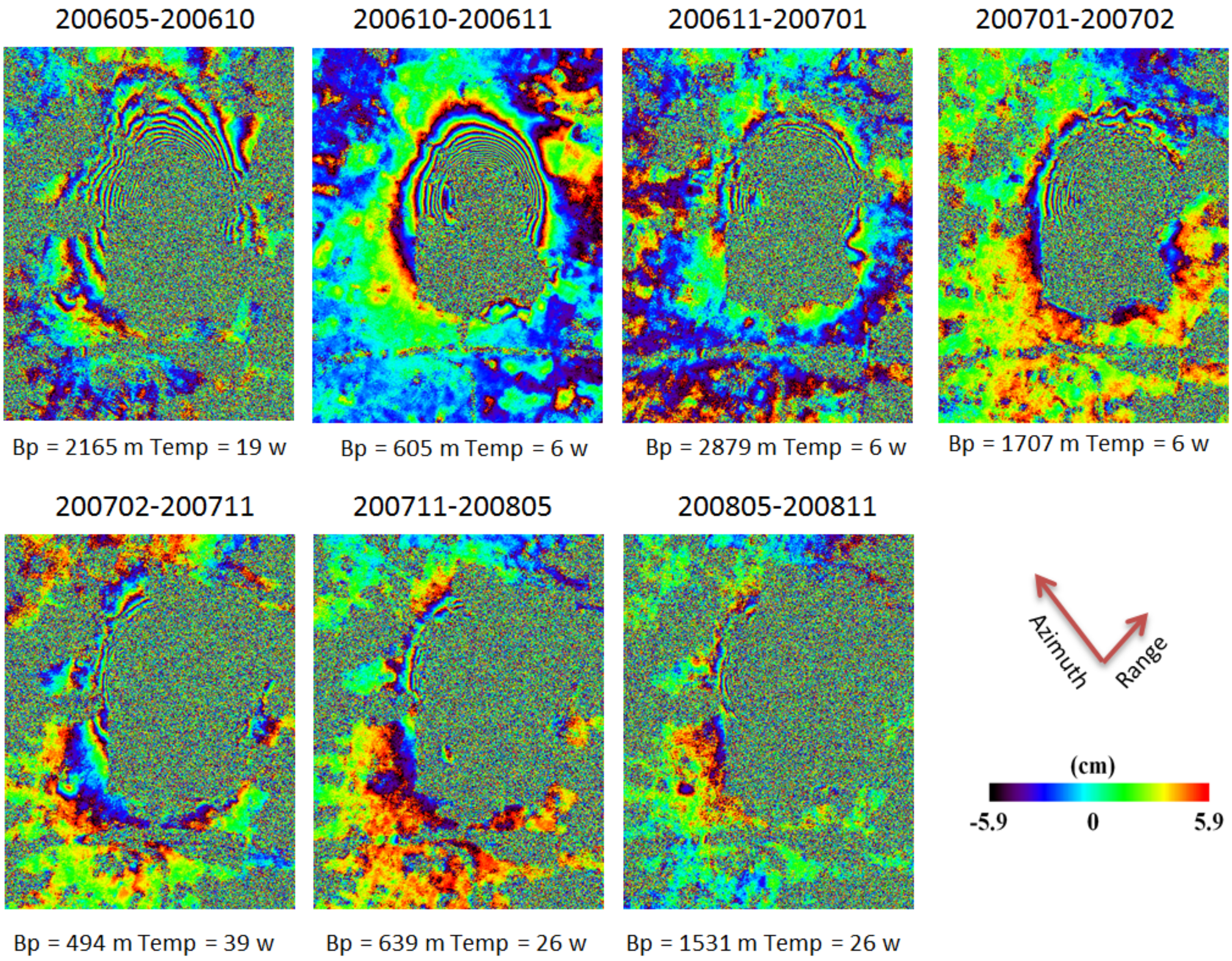


Figure 3. DInSAR result of second set of data pairs.

## 5. CONCLUSION

This study shows that DInSAR methods able to detect the ground deformation which occurred because of underground material eruption, not only in nearby the center of eruption but also in the area far from the center of eruption (more than 4 kilometers apart). The DInSAR analysis can be considered as potential tool to monitor the mud volcano eruption disaster with low cost, especially to detect ground deformation as an impact of such phenomenon which may occurred in remote area or dangerous area in such wide spreading area. The observation continuation becomes important to monitor the ground deformation and to prevent further human severe. In the future, several methods will be used to improve the analysis such as multiple aperture technique, get the two dimensional land deformations, Persistent Scattering InSAR, to reduce the noise because of temporal and atmospheric efeect. The GPS measurement will be applied to get validity result.

## 6. REFERENCES


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