DETCTION AND CALUCULATION OF PEATLAND SUBSIDENCE IN INDONESIA BY USING INTERFEROMETRIC SYNTHETIC APERTURE RADAR

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ABSTRACT: Peatland is a kind of wetlands with a thick waterlogged organic soil layer storing large amount of carbon. Peatland plays important roles not only as a carbon sink but also as a habitat of many endangered species. In recent years, peatland in the world has been destroyed due to drainage or fire for agricultural use. When peatland is affected by such human activities, its organic carbon is decomposed into the air as greenhouse gases, and the ground level goes down. This phenomenon is called "peatland subsidence". In Indonesia, one of the largest peatland owners, peatland subsidence appears frequently. Because of this, people near the seashore suffer serious floods caused by tide or heavy rain during the rainy season. In addition, peatland emission has a great effect on global warming. Thus in Indonesia, under such circumstances, appropriate management of peatland is an urgent issue.

In this study, peatland subsidence in Jambi, Indonesia, was assessed with time-series of ALOS/PALSAR data based on InSAR technique. Firstly, PALSAR raw data was converted into SLC data. Secondly, interferometric processings were conducted to generate interferograms from SLC images. Thirdly, a group of time-series interferograms was created thorough PS-InSAR analysis. Finally, subsidence distribution, subsidence amount, and subsidence velocity were calculated spatially. As a result, significant land surface deformation originated from peatland subsidence was observed from 2007 to 2011.

1. INTRODUCTION

1.1 Background

Peat is composed of accumulated vegetation or organic matter that is partially decayed. Peatland, an area where peat can be found, is defined as a kind of wetlands with a thick waterlogged organic soil layer. Peatland plays an important part in the environment since it has a unique ecosystem and can effectively store large amount of carbon. Recently, peatland in the world has been rapidly decreasing mainly due to the land use change for agriculture. Human activities such as fire or drainage decompose peatland's organic soil layer into greenhouse gases (GHG) that accelerate global warming. Simultaneously, the ground level of peatland gets lower and the risk of floods increases. This phenomenon is called "peatland subsidence".

Indonesia is one of the largest peatland owners and peatland subsidence appears frequently. Farmers near the seashore suffer from serious floods caused by tidal effect and heavy rain during the rainy season. In 2005, peatland emission was estimated to be about 772 Mt CO_2eq that accounted for 38 % of total Indonesia's annual GHG (DNPI 2010). Thus, under such circumstances, appropriate management of peatland is an urgent issue. To mitigate peatland emission and peatland subsidence, many research works have been ongoing in Indonesia.

1.2 Objective

The objective of this study is to detect the distribution of peatland subsidence and to calculate the extent of subsidence by using InSAR (Interferometric Synthetic Aperture Radar) technique. In addition, with PS (persistent scatter) analysis, assessment of the subsidence velocity is also the purpose of this study.

2. METHODOLOGY

2.1 Site description

Figure 1 shows study site and footprint of dataset used in this study. The region of interest in this study is Jambi and its vicinity, Indonesia. Jambi is located on the east coast of central Sumatra. The Batang Hari River (Sungai Batanghari), the longest river in Sumatra, flows through Jambi and empties into the South China Sea. Because of its low elevation and considerable land subsidence, these areas are often damaged by floods. The general land surface of Jambi is relatively flat with the elevation about 10 meters above the mean sea level.

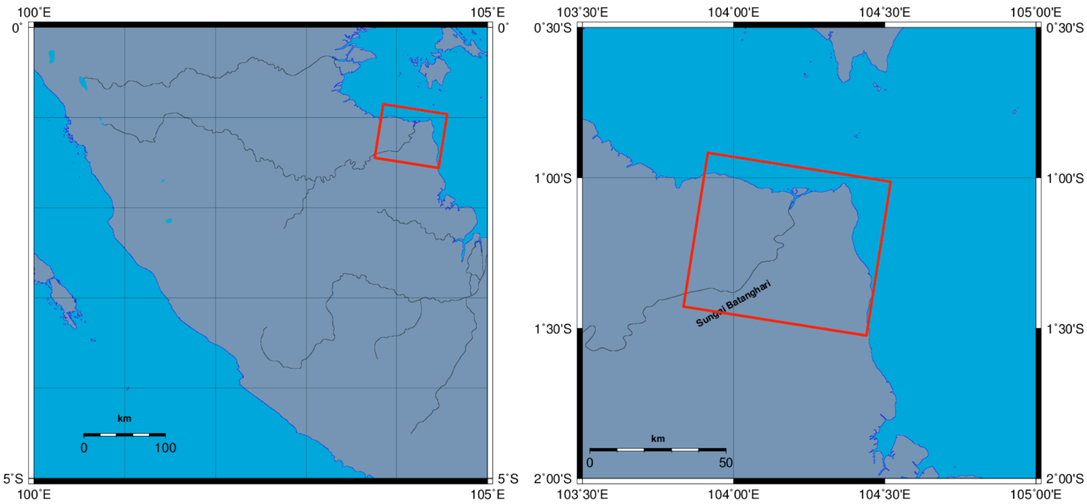

Figure 1. Study site (Jambi, Indonesia) and footprint of dataset.

2.2 Data set

6 scenes of level 1.0 raw Phased Array type L-band Synthetic Aperture Radar (PALSAR) images in Fine Beam Single (FBS) mode with spatial resolution approximately 10 m of the study area were used. Table 1 shows the detailed information of those data. They were observed by Advanced Land Observing Satellite (ALOS) during the period between December 2007 and January 2011 in descending orbit (Path-Row: 110-3640). In order to minimize temporal resolutions, the image acquired in 2009 was selected as a master image.

Shuttle Radar Topography Mission (SRTM) data with a 3-arcsecond geographical resolution (90 m) was used as the external Digital Elevation Model (DEM) in the interferometric processing.

Table 1. ALOS/PALSAR data used in this study.

PALSAR HH Level 1.0 FBS 110-3640 (Descending)					
Scene-ID	Date	Master/Slave	Bpara (m)	Bperp (m)	Day
ALPSRP102263640	2007/12/26	Slave	-269.79	-384.04	-460
ALPSRP142523640	2008/9/27	Slave	101.87	-60.07	-184
ALPSRP155943640	2008/12/28	Slave	-75.65	-289.69	-92
ALPSRP169363640	2009/3/30	Master	0	0	0
ALPSRP223043640	2010/4/2	Slave	-192.66	-199.56	368
ALPSRP263303640	2011/1/3	Slave	-52.13	-4.88	644

2.3 Flowchart of this research

To measure the location and amplitude of surface deformation caused by peatland subsidence over the past 3 years, PS-InSAR analysis, one of the InSAR time-series analyses, was conducted. In this method, pixels whose reflections are dominated by a single scatterer (e.g., buildings, bridges, dams) are extracted as PS points. Since those PS points are assumed to have the stable backscatter characteristics, time-series surface deformation can be detected by tracking the change of their pixel values (Fukushima, 2011).

Figure 2 shows the flowchart of data processing. In this study, Stanford Method for Persistent Scatterers (StaMPS) was used to process data. StaMPS (Hooper *et al*., 2012) is a software package for PS-InSAR analysis. In this package, ROI_PAC (Rosen *et al*., 2004) is used for creating Single Look Complex (SLC) backscatter intensity images, and Doris (Kampes *et al*., 2003) for interferometric processing.

In SAR recovery process, 6 scenes of PALSAR raw data were converted into SLC with ROI_PAC respectively. SLC image retains the phase and amplitude information that is necessary for interferometric process. Then, pairs of master SLC image (2009/3/30) and each slave SLC image were processed with Doris supplemental by SRTM data to generate interferograms from SLC images. Finally, PS-InSAR analysis was performed with those interferograms.

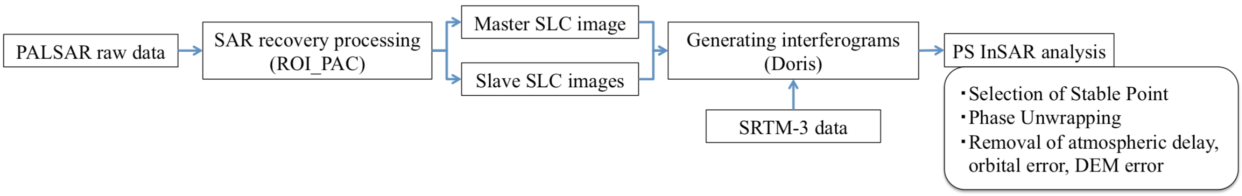

Figure 2. Data processing flowchart with StaMPS software.

3. RESULTS AND DISCUSSION

The interferograms made from interferometric processing are shown in Figure 3. The interference patterns (fringes) can be seen in all interferograms, particularly in the image taken in December 2008 due to the short time difference of two observations. Initial interferograms do not show surface deformation directly because they contain orbital errors, topographic errors, and the influence of the ionosphere. In Figure 3, although topographic errors were successfully removed with SRTM data, orbital errors and the influence of ionosphere still exist besides surface deformation. Those errors were removed in the further PS-InSAR analysis as shown in Figure 4. These pixels represent PS points extracted by StaMPS. 87347 points were analyzed in this study area. As time goes by, the whole ground seems to move down (from green to blue) gradually. A large expansion deformation (or shifting to the east) was also observed in the southwest part of the images. Figure 5 shows a mean velocity in the line-of-sight (LOS) direction projected on Google Earth. In the southeast part of study area (colored blue), the subsidence had developed rapidly from 2007 to 2001 with the maximum velocity of 142.8 mm/year. In the southwest part of study area (colored red), the tendency of moving up was detected which corresponding to the result of Figure.4.

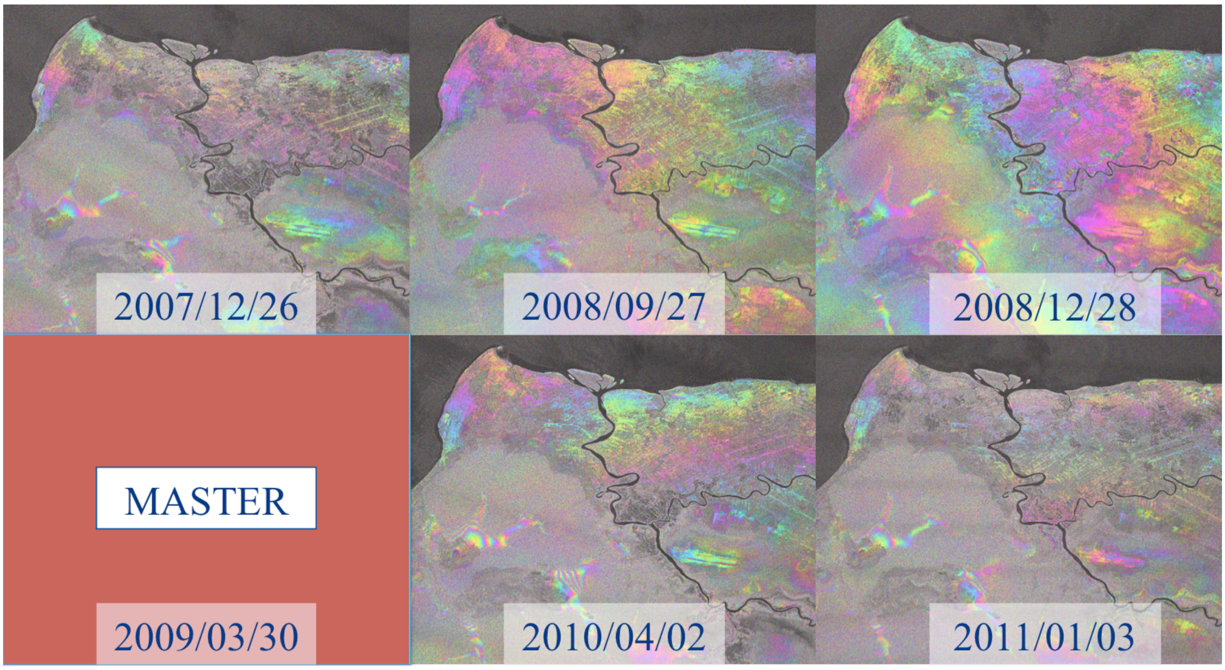

Figure 3. Interferograms made from interferometric processing.

(Note: mirrored due to the radar coordinate system)

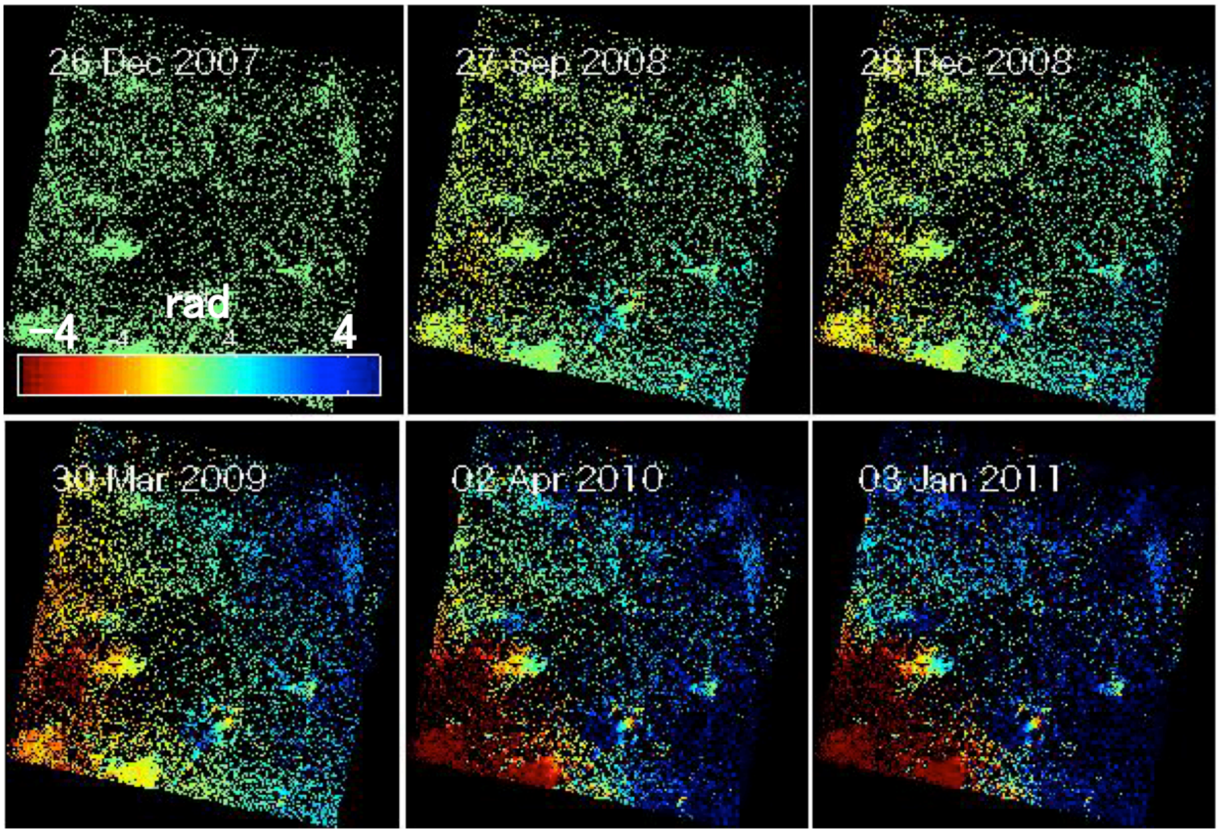

Figure 4. Result of PS-InSAR analysis.

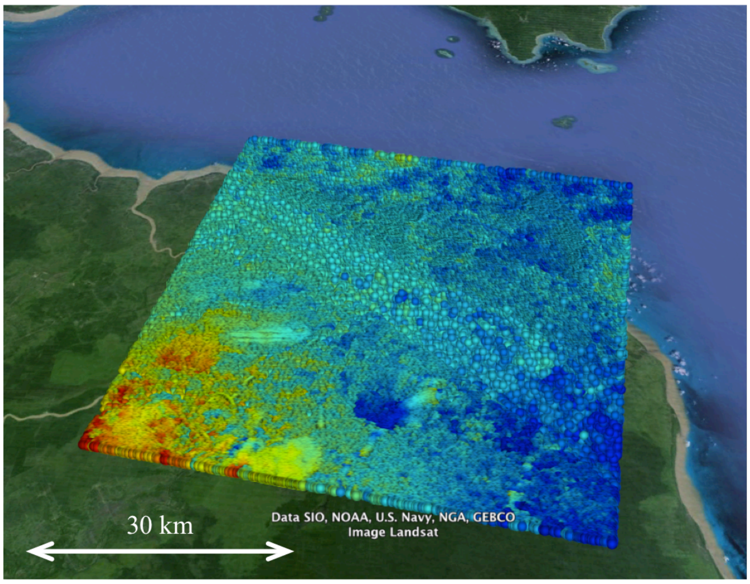

Figure 5. The mean velocity in the direction of LOS on Google Earth.

4. CONCLUSIONS AND FUTURE WORK

In this study, PS-InSAR analysis was conducted to monitor pattern of subsidence phenomenon in Jambi, Indonesia, with StaMPS software. As a result of PS-InSAR analysis, subsidence distribution and subsidence amount were calculated spatially, and a significant land subsidence was observed in the study area. In addition, the subsidence velocity was visualized.

Application of Small Baseline (SB) analysis, comparison between the results of SB analysis and PS analysis, and quantitative validation of the surface deformation based on the ground truth will be investigated as future works.

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