Interferometric analysis of ALOS/PALSAR data for land subsidence monitoring and crustal deformation detection

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Abstract
We analyzed ALOS PALSAR interferometric data pairs from Sendai Plain, Japan, along the Pacific Ocean. Continuous fringe patterns were extracted from the data pair of which perpendicular baseline distance is more than 2000 m. Most of the interferograms generated in this study show fringe features that are independent from actual surface deformation. Some features are common to different interferograms produced by combining related data. We compared these fringe patterns with the simultaneously observed AVNIR-2 images. The cloud distribution patterns on the AVNIR-2 images are possible to explain interferometric fringe pattern as the atmospheric effect.

Keywords: AVNIR-2, atmospheric turbulence, phase delay

1. INTRODUCTION

Synthetic Aperture Radar interferometry (InSAR) is possible to detect land surface deformation. One of the technical problems in the detection of surface deformation by InSAR is the radar phase delays in the datasets used to generate an interferogram. The atmospheric signals should be separated from the actual surface deformation signals. It is pointed out that there are two types of signals due to atmospheric water vapors, topography-correlated delay and the turbulent mixing in the atmosphere [1]. The correction methods for topography-correlated phase delay has been discussed (e.g., [2][3][4]). The turbulent mixing signal in the atmosphere have been observed in many studies (e.g., [5][6][7]). Our previous study showed the similarity of fringe features in ERS SAR interferogram with the cloud distribution pattern observed by SPOT HRV image acquired 18 min after the SAR data [8]. This near-simultaneous observation SAR and optical sensor was a fortuitous case.
One of the advantages of ALOS is the capability to obtain concurrent data by AVNIR-2 and PALSAR. In this study, we compared the PALSAR interferograms with the AVNIR-2 images that were acquired simultaneously with the PALSAR data, and investigated the usefulness of synchronized observation by optical sensor for the interferometric analysis.

2. DATASETS AND STUDY AREA

We analyzed PALSAR data pairs covering Sendai Plains, located approximately 300 kilometers north of Tokyo, on the Pacific coast of Honshu, Japan. This area is downwind side of Oou mountain Range. The atmospheric gravity waves are commonly observed over this area.
PALSAR observes the same area with different off-nadir angle. There are datasets acquired from descending orbit with off-nadir angle 21.5°, 34.3°, 41.5°, and 50.8°on the study area. AVNIR-2 simultaneously observed the study area for several times on each off-nadir angle, respectively (Tab.1).
Differential interferograms were extracted from the same off-nadir angle data pairs using JAXA/SIGMA-SAR [9].

Table 1. ALOS PALSAR descending data sets used in this study.

Off-nadir Angle	Path	Center Frame	Date of the Image
21.5°	61	2840	02AUG06*,17SEP06
34.3°	57	2850	26AUG06,11OCT06*,26NOV06* 11JAN07*,14JUL07,29AUG07
34.3°	56	2850	24SEP06,25DEC06*, 12MAY07*,12AUG07,27SEP07*
41.5°	53	2850	19JUN06*,04AUG06*, 19SEP06*,04NOV06*, 07NOV07*
50.8°	47	2860	09JUN06, 25JUL06, 09SEP06

*Synchronized observation with AVNIR-2.

3. RESULTS

Continuous fringe patterns were extracted from the urban and agricultural area on the data pairs of which perpendicular baseline distance are more than 2000 m.
Most of the interferograms generated in this study show fringe features that are independent from actual surface movement. These patterns are not corresponded with geographical features. Some fringe features are common to different interferograms produced by combining related data. Fig.1 is one of the interferograms contains these

fringe pattern. We compared these fringe patterns with the simultaneously observed AVNIR-2 images. Fig.2 is an AVNIR-2 image acquired on the simultaneous timing with one of the PALSAR data for the interferogram on Fig.1.

4. DISCUSSION AND CONCLUSIONS

The rippled fringe pattern shown in Fig.1 corresponds with the thin cloud distribution pattern in Fig.2. This pattern comes from atmospheric turbulent. The cloud distribution pattern appeared on the optical sensor image show tropospheric turbulence as gravity waves. And it is related to distribution of atmospheric water vapor.

Thick cloud patterns are appeared on some AVNIR-2 images. Some of them directory appear on the interferograms, but the other cannot be found on the interferograms.

We examined the interferograms by the data pairs with different off-nadir angles. Generally, large off-nadir angle data pair shows the large phase difference patterns. Slant range increase with the off-nadir angle. Atmospheric phase delay increase is consistent with the slant range increase.

The distinction between atmospheric phase delay effects with surface deformation is necessary for monitoring of crustal deformation by natural disasters and land subsidence using the PALSAR interferogram. Simultaneously observed AVNIR-2 image is helpful to interpret the interferometric fringe pattern.

Acknowledgement

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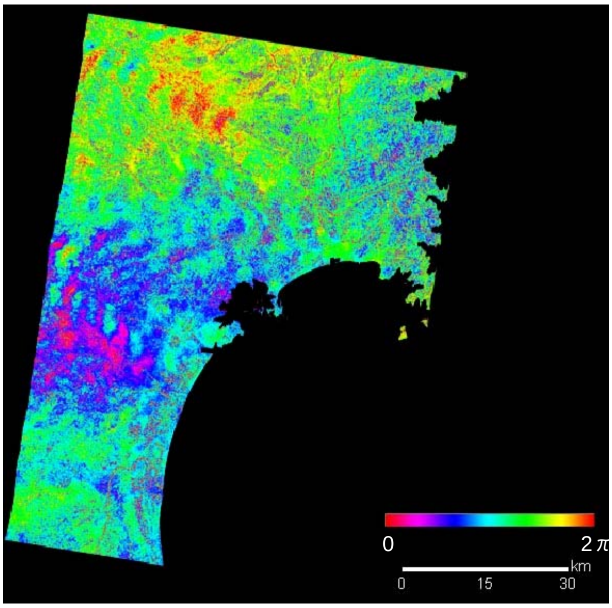

Figure 1. ALOS PALSAR interferogram from images acquired on 4 August 2006 and 4 November 2006 (Path:53, Center Frame:2850).

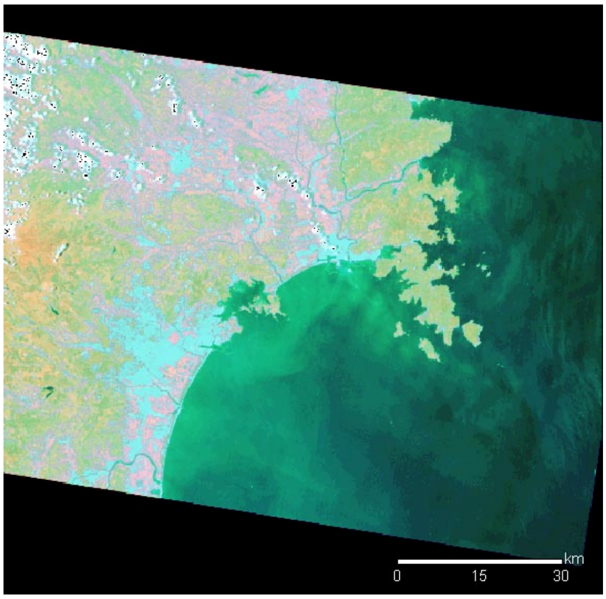

Figure 2. ALOS AVNIR-2 image acquired on 4 August 2006.