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Application of PS-InSAR Technique for Measuring the Coastal Subsidence in the East Coast of South Korea

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Abstract

Subsidence is a widespread phenomenon caused by both natural and anthropogenic activities, particularly in the coastal areas. Eventually, the impact of coastal subsidence can affect the monitoring of sea level rise by in-situ tidal gauge stations. The Korean peninsula is one of such areas that reported considerably rapid sea level rise than the global average in the recent years. Therefore, there is a need for assessing the land subsidence component of relative sea level rise for better future prediction models. Space borne Interferometric SAR technique provides millimeter level of accuracy in displacement measurements. The objective of this study is to estimate the earth's surface movements along the coastal areas of Pohang, South Korea. To achieve that, we acquired C-band Sentinel-1 data during 2016 – 2017. Time-series Stanford Method of Persistent Scatter (StaMPS) InSAR analysis proved technique to measure displacements at high-resolution with reduced decorrelation noise from interferograms. The results showed about 1.83 cm/year subsidence in the Pohang coastal area, whereas significant sea level rise is observed in this region. The results will provide further insight into the localized subsidence rates in the study sites and its impact on the sea level monitoring.

1. Introduction

Sea level rise (SLR) is a serious issue in this century around the world as it is directly coincided with the Earth's temperature. Several countries has equipped with permanent Tidal gauge stations for continuous monitoring of SLR in the recent decades. Tide gauge measurements indicates that the rate global sea level rise has increased from ~1.7 mm/year in the late 20th century to ~3.1 mm/year in the 21st century [1]. Some of the tidal gauges in Korean peninsula has showed rapid SLR than the global mean sea level rise [2].

Despite its importance, the observed sea level data from tidal gauges are subject to the contribution of various factors. Particularly, local land subsidence in the coastal areas where tidal gauges are located will contribute as error factor in sea level monitoring. Land subsidence is the vertical displacement of Earth's surface is caused by both natural and anthropogenic activities [3]. Thus, estimation of contribution of land subsidence is very important in the precise sea level measurements.

Although, permanent global positioning system (GPS) stations provides precise horizontal and vertical displacement measurements, is still not available at every tidal gauge stations and only sparse observation fails to present local variability of land around tidal gauges. In order to achieve better estimates of subsidence, space borne Synthetic Aperture Radar (SAR) interferometry (InSAR) is well known technique to determine subsidence at high spatial resolution [4]. Furthermore, time series of InSAR analysis observes the surface displacements over time at the level of millimeter level of accuracy [5-7].

The main objective of this study is to measure the surface displacement on the coastal areas of east Korea and to assess the impact of local land subsidence in the sea level rise estimation by time-series InSAR analysis using space borne SAR data.

2. Study Area

South Korea is primarily surrounded by three seas, itself have importance of sea level acceleration related studies. According to Korea Hydrographic and Oceanographic Agency, there are about 46 tidal gauge station in total along the coasts of Korean peninsula continuously monitors the sea level and tidal heights. Among these stations, Jeju Island, pohang and mokpo has reported considerably rapid sea level rise than other stations [2]. Therefore, we chose Pohang region as our study area. Figure 1 shows the location of tidal gauge stations available in the Korean peninsula.

Figure 1. Study area map showing tidal gauge stations located in the South Korea and inset shows location of Pohang tidal guage station.

3. Materials and Method

In this study, we used C-band Sentinel-1 SAR data, which is freely provided by European Space Agency (ESA). Table 1 shows the information about the image acquisitions for the Pohang region used in this study.

Table 1. Sentinel-1 SAR data description

Description	Pohang
No. of Scenes	49
Period	2015/11–2017/01
Orbit	Ascending
Inc. angle	~41.3º
Spatial resolution	5 m x 20 m
Master	2016/10/16

The interferograms stacks were generated with respect to the single master scene. The selection of master scene is important in achieving better coherent interferogram stacks. Based on the baseline decorrelation (Equation 1) and temporal decorrelation (Equation 2), the master scene is selected. 2 x 1 looks were applied in range and azimuth, respectively [4]. Therefore, the pixel spacing is about 4 m x 13 m.

SRTM DEM having 30 m spatial resolution is used to remove the topographic phase in the interferogram to generate differential interferograms. For time series analysis, StaMPS identifies the refined stable scatterers (PS) in space and time [7]. The initial selection of PS is performed by amplitude dispersion index and iteratively refines the PS based on coherence of nearby pixels. Following that 3-D phase unwrapping method is applied in time and space achieved by SNAPHU.

4. Results and Discussions

Figure 2 shows the mean subsidence velocity map (cm/year) for the Pohang and region, respectively. The estimated mean subsidence velocity shows that the location of the Pohang tidal gauge station is severely affected by the local land subsidence (Figure 2). In case of time series displacements, shows gradual subsidence in the tidal gauge stations, which is measured about 1.83 cm/year in the LOS direction.

It is worth noting that the Pohang tidal gauge station measured significant sea level rise in the recent years (KHOA). Therefore, it may be believed that the sea level measurements in this station has affected by the local land subsidence.

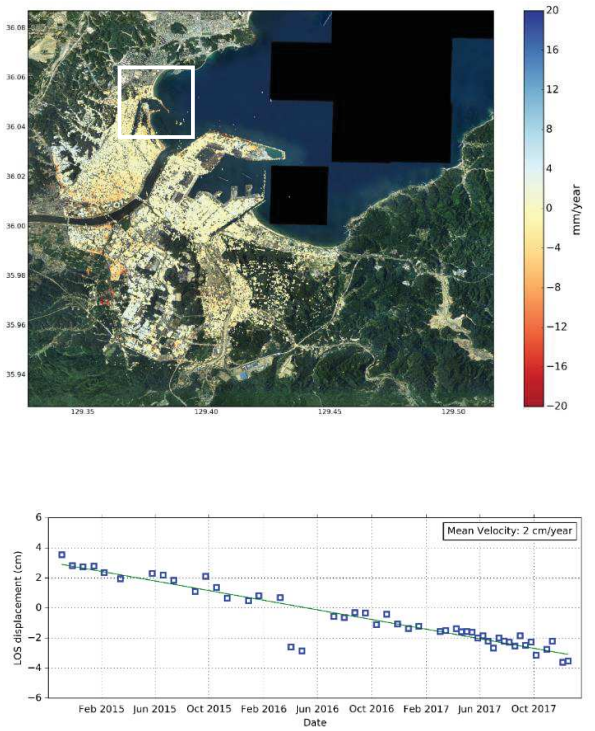

Figure 2. (a) Mean Subsidence velocity map (cm/year) for the pohang region (b) Time-series displacements at Point A.

5. Conclusions

In this study, we presented the initial results in measuring the mean subsidence velocity and time series displacements for the Pohang. We observed strong subsidence in the Pohang region during 2016 at the rate of 1.87 cm/year. Thus, it is expected that the measured sea level rise is exaggerated as the station locations undergoes subsidence. Further study includes time series analysis by utilizing ascending orbit and GPS data for precise subsidence measurements.

6. Acknowledgements

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