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Study of land subsidence by INSAR time series of ALOS-2, Sentinel-1 and GNSS CORS stations in Chaopraya basin, samutprakan, Thailand

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Abstract

Samutprakan province is the most important industrial province and one of the main ports of Thailand, located in the north coast of Thailand near Bangkok. This area is receiving the impact of climate change from sea level rise and land subsidence, caused by many factors such as use of ground water from many industries in this province and surrounded area, the movement of earth surface and the numerous constructions in this area. This study will identify the movement ratio of land subsidence rate in last six years by using Interferometric Synthetic Aperture Radar (InSAR) time series technique from ALOS-2 satellite, Sentinel-1 and Precise Point Positioning (PPP) from GNSS CORS stations to identify the rate of land subsidence and compare the land subsidence with three difference methods above in last 6 years of Samutprakan province Thailand.

1. Introduction

Samutprakan province is one of the economically most important provinces in Thailand. The province is located in the northern gulf of Thailand near Bangkok. This province is facing flooding from sea level rise. This problem is getting closer to the capital city: Bangkok. Samutprakan and surrounding provinces are facing sea level rise, flooding, and land subsidence. The land subsidence is an important factor of flooding in Samutprakan, shown by case studies showing that the land subsidence in Samutprakan is caused by many factors such as the use of ground water, land reclaiming, and movements of the Earth surface. The Department of Groundwater Resources started to do research between 1978 - 1981 and they found land subsidence of more than 10 cm per year in Bangkok and Samutprakan. After that, the study of land subsidence has been widespread to many Universities in Thailand such as King Mongkut University of Technology vicinity (Bangmod), Chulalongkorn University, and Kasetsart University to work on monitoring land subsidence in the central part of Thailand.

2. Method

This study will identify the movement ratio of land subsidence rate in the last six years by using Interferometric Synthetic Aperture Radar; InSAR time series technique from ALOS-2 satellite, Sentinel-1 and Precise Point Positioning (PPP) from GNSS CORS stations to identify the rate of land subsidence and compare the land subsidence with three difference methods above in last 6 years of Samutprakan province Thailand. Both techniques are used to identify data from difference sources to find the subsidence rates of the study area in Samutprakan, in order to allocate the suitable area for industrial constructions and farming areas. The result from this thesis will benefit the residents in Samutprakan and the planning of industrial areas in the next 6 to 12 years and indicate the most accuracy methods from these three methods.

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2.1. Equations and analysis

The SAR system transmits the microwave pulse that consists of amplitudes and phases. The difference phases represent the Earth's surface movement by using the phase difference between two SAR acquisitions (Δϕ), as shown in Equation 1. Hence, Δϕ can calculate the ground surface movement in LOS of a satellite (Δr), but Δϕ is wrapped difference phase form. So, measuring the deformation, the interferometric phase needs to be unwrapped. Simultaneously, the fundamental InSAR principle is used differential SAR interferometry (DInSAR) by a spatial ground surface of a stable object. The phase difference (Δϕ) (A. Ferretti et al., 2001; Hanssen, 2001) as shown in Equation 2 is the summation of a phase of surface movement, or phase contribution of the pixel in the satellite LOS direction relate to ground deformation (ϕdef), phase of orbit error (ϕorbit), topographic effect phase (ϕtopo), phase of noise (ϕnoise), and atmospheric phase delay (ϕatm). The phase difference is calculated based on Equation 1 and Equation 2.

$$\Delta\phi = \phi 1 - \phi 2 = 4\pi \ \lambda \ \Delta r \qquad (1)$$

where

ϕ1, ϕ2: the phase of each acquisition
λ: wavelength of radar
Δr: the difference in range (LOS) between two SAR acquisitions

$$\Delta\phi = \phi atm + \phi def + \phi topo + \phi orbit + \phi noise \qquad (2)$$

where

Δϕ: interferometric phase (or phase difference)
ϕatm: Atmospheric Delay
ϕdef: phase contribution related to ground deformation
ϕtopo: Topographic Effect
ϕorbit: Orbit Error
ϕnoise: Noise

3. Results

The validation of results between Sentinel-1images ascending mode and BPLE CORS station from 2014-2020 can be interpreted in results of land subsidence velocity in mm/year. Both results retrieved from different sensors and programs. The results of Ps points from Sentinel-1 represented the velocity of BPLE CORS station leveled up 47.7 mm/year in blue points of map in figure 28. The results from GNSS CORS station by AUSPOS online processing is 27.5 mm/year. The difference land subsidence velocity of 2 sources indicated in 20.2 mm/year or 2 cm/year. The trend of 2 sources has relative in results and graph in figure 28. Thus, the result of 2 different sources presented in the same of land subsidence in trend that relate to results of DPT CORS station with level down in Sentinel-1 and DPT CORS station.

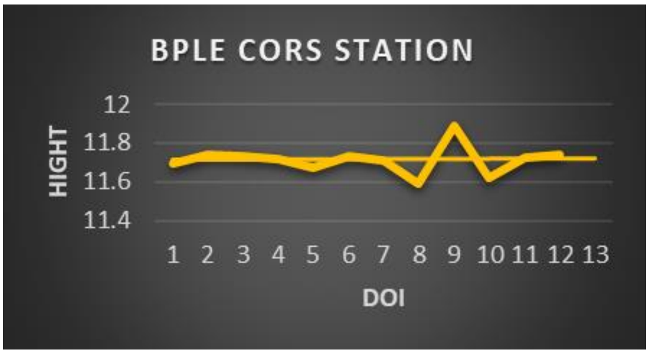

Figure 1. Height and trend of BPLE CORS station in Samutprakan

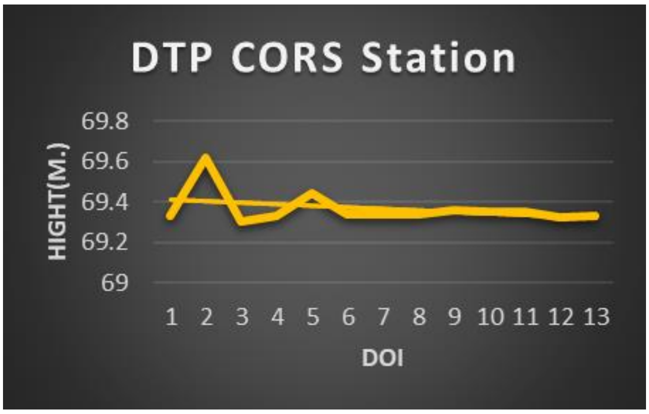

Figure 2 Height and trend of DPT CORS station in Samutprakan

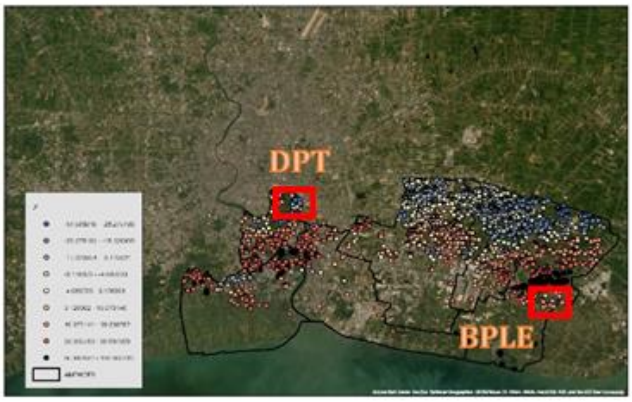

Figure 3. The land deformation spots in Samutprakan

4. Discussion

This research has studied the land subsidence in the most high-risk area in Thailand, Samutprakan by trying to use different of methodology and different sources such as satellite data from ALOS-2 and Sentinel-1 with SAR images that can detect the different of phases of radar energy on the earth surface. There are many studies of land subsidence in many places throughout the world that used InSAR time series of land deformation to study the trend of land deformation in the future for their interest and the change of disasters such as earthquake, volcano eruption, and ground water. In Samutprakan is also the area that is facing land subsidence and sea level raise every year. This research has provided the value, numbers, and trend of land subsidence in Samutprakan in order to know the change of earth surface movement in specific area to concern in some high-risk area of land subsidence. This study also used many different sources to present the numbers of land subsidence in Samutprakan to be various of options and find the most suitable methods and sources for further study.

5. Conclusion

All results have answered of this thesis that want to know the influence of land subsidence in Samutprakan. The influent of land subsidence came from the use of ground water, the city grows up with more populations. These reasons cause the land subsidence in Samutprakan. For the rate of land subsidence in Samutprakan have different rate in different area. In this study we focused on two CORS stations to be the ground base reference for land subsidence by two satellites. The land subsidence rate in the middle of Samutprakan; the location of DPT is going down because constructions, use of ground water, and higher populations. The land subsidence rate in BPLE CORS station is going up because the city from Samutprakan has been expanding to the urban area, so the leveling of BPLE CORS station is having the level up. The different of three sources in results are not highly different. The results from all sources presented in the same trend of land subsidence velocity. The different in numbers of millimeters that reliable accurate.

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