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Extended Abstract

The feasibility of using InSAR technique to measure land subsidence caused by petroleum extraction

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Abstract

Groundwater withdrawal is a common cause of land subsidence, but extracting oil, gas, or minerals also contributes to subsidence. Land subsidence over oil and gas fields leads to natural and manufactured disasters such as the destruction of critical and strategic infrastructure. Due to the consequences and irrecoverable damage caused by this phenomenon, it is necessary to regularly monitor areas subject to subduction in oil and gas fields. Despite high accuracy, the use of geodetic techniques such as Global Navigation Satellite System (GNSS) to regularly monitor crustal deformation in a wide coverage is limited by some disadvantages like discontinuous data collection, the need for installation of the equipment on the ground or direct contact with the ground which is time- and cost-consuming. In contrast, InSAR technology has been widely used in recent decades to monitor crustal deformations with spatiotemporal resolution and lower cost and time. This study aims to present a new methodology based on the Persistent Scatterer-InSAR (PS-InSAR) method to investigate the correlation between land subsidence and petroleum extraction in the southwestern region of Iran with active oil and gas fields during two periods from 2017/04 to 2017/10 and from 2019/04 to 2019/10, respectively with the highest and lowest petroleum extraction. The results showed that subductions of 10 to 30 cm from 2017/04 to 2017/10 with an annual rate of 20 to 50 cm have occurred in southwestern Iran around the active oil fields which might be due to the significant petroleum extraction since 2016.

1. Introduction

Land subsidence, a globally studied phenomenon, occurs from natural processes and human activities [1, 2]. Geomatics engineering employs various methods, including geodetic and remote sensing technologies, to measure land subsidence. [3-5]. Despite high accuracy, the use of geodetic techniques such as GNSS to regularly monitor crustal deformation in a wide coverage is limited by some disadvantages like discontinuous data collection, the need for installation of the equipment on the ground or direct contact with the ground which is time- and cost-consuming. InSAR technology [6] has been widely used in recent decades to monitor crustal deformations with spatiotemporal resolution and lower cost and time. This study introduces a new methodology, utilizing the PS-InSAR method, to explore the correlation between land subsidence and petroleum extraction in Iran's southwestern region. The investigation spans two periods, from April 2017 to October 2017 and from April 2019 to October 2019, representing the highest and lowest petroleum extraction levels.

2. Methodology

Various techniques exist for crustal movement measurement using radar interferometry. Two main algorithms, Persistent Scatterer (PS-InSAR) and Small Baseline methods (SBAS), are widely

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employed. While PS-InSAR provides millimetric accuracy, it measures displacements only over PS points, not corresponding to target points. This limitation hinders its applicability for monitoring surface deformations over target areas. To address this, the study introduces an extended workflow using spatiotemporal interpolation methods to approximate a continuous surface of displacement based on the PS-InSAR algorithm. The innovations of the study include the development of this extended workflow and the utilization of data mining methods to explore the correlation between land subsidence and petroleum withdrawal.

3. Results and Conclusions

This study aims to develop a new algorithm based on the classic PS-InSAR method to investigate the correlation between land subsidence and petroleum extraction in Iran's southwestern region. The investigation spans two periods: from April 2017 to October 2017 and April 2019 to October 2019, representing the highest and lowest levels of petroleum extraction. After calculating the crustal deformation rate on PS points, efforts are made to determine a specific deformation rate around active oil fields. The results are depicted in Fig. 1 and Fig. 2.

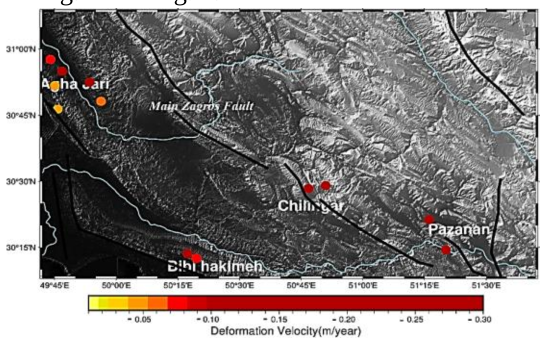

Fig. 1. Land subsidence around the active oil fields in the study region from 2017/04 to 2017/10

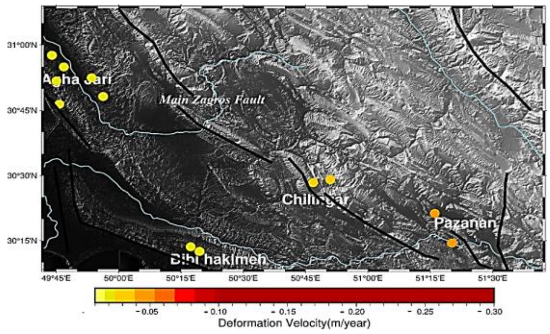

Fig. 2 Land subsidence around the active oil fields in the study region from 2019/04 to 2019/10

Results indicate the most substantial subsidence, approximately 30 cm annually at rates ranging from 20 to 50 cm, occurred in southwestern Iran around active oil fields, likely attributed to substantial petroleum extraction since 2016. Conversely, during the period from April 2019 to October 2019, the recorded subsidence notably decreased in the same regions. These findings suggest a direct correlation between petroleum extraction levels and land subsidence. The proposed methodology, utilizing high-resolution radar remote sensing data for regular monitoring of crustal deformation around active oil and gas fields, facilitates risk management and damage control due to land subsidence. However, it's important to note that factors beyond petroleum withdrawal, such as tectonic activities and extraction of underground water and minerals, significantly contribute to land subsidence. Establishing a direct correspondence between subsidence and oil extraction encounters limitations and challenges. To enhance reliability in monitoring subsidence linked to oil or gas extraction, simultaneous monitoring of deformations from tectonic activities or other resources is recommended.

4. References

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