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Land subsidence monitoring by D-InSAR technique

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ABSTRACT

Nowadays, the researches of using Differential Interferometric Synthetic Aperture Radar (D-InSAR) technique to monitor the land subsidence are mainly on how to qualitatively analyze the subsidence areas and values, but the analysis of subsidence process and mechanism are insufficient. In order to resolve these problems, 6 scenes of ERS1/2 images captured during 1995 and 2000 in a certain place of Jiangsu province were selected to obtain the subsidence and velocities in three time segments by "two-pass" D-InSAR method. Then the relationships among distributions of pumping wells, exploitation quantity of groundwater, and confined water levels were studied and the subsidence mechanism was systematically analyzed. The results show that using D-InSAR technique to monitor the deformation of large area can obtain high accuracies, the disadvantages of classical observation methods can be remedied and there is a linear relationship among the velocities of land subsidence, the water level and the exploitation quantity.

1. Introduction

As a new method for obtaining regional subsidence, compared with the conventional monitoring methods, D-InSAR technique has some advantages in some research fields, such as earthquake deformation, land subsidence, volcanic activity, landslide of mountains and so on [1–16]. Therefore, using D-InSAR technique to monitor the land deformation has become a research focus at home and abroad nowadays. Since Gabriel and his colleagues firstly proved that D-InSAR technique could detect the land deformation of centimeter level, a lot of researches on land subsidence have been developed by many scientists of different countries and some achievements were obtained [3]. Using ERS1/2 Tandem and JERS-1 L band images captured between 1993 and 1995, combined with GIS, some quantitative analysis was made on land subsidence in Appin area caused by long wall coal mining [4]. Hoffmann studied the land subsidence of Antelope valley in California caused by pumping the geothermal water to generate power [5]. Bernhard used the interferometric point targets analysis technique to obtain the land subsidence of Lost Hills oil area in California [6]. Using D-InSAR technique, Gong studied the land subsidence caused by groundwater over-exploitation of Cangzhou in Hebei province [7].

However, the present researches of using D-InSAR to monitor the subsidence are mainly in how to analyze the subsidence areas and values qualitatively, but the analysis of process and mechanism of the subsidence are obviously insufficient. In addition, the area studied in this paper, the recorded maximum level of subsidence had been over 881 mm during the past 30 years, and some serous damages are continuing. Although the leveling observation with a high precise was used to monitor the subsidence all the time, lots of control points were damaged every year, and a lot of manpower and material resource have been consumed for the observation and supplementation of control points. Therefore, in order to remedy the disadvantages of D-InSAR and classical observation methods, the subsidence and velocities in three time segments were obtained by "two-pass" D-InSAR method, and then according to the distribution of pumping wells, the exploitation quantity of the groundwater, the confined water level and the regression equations were established and the subsidence mechanism was systematically analyzed.

2. D-InSAR technique

D-InSAR technique is a method where phase information of radar carrier is used to obtain the land deformation. In the repeat pass mode, if the land deformation happened during the capture of the two images, the interferometric fringes generated by these two images mainly include some phase information as follows [17]:

$$\phi = \phi_{topo} + \phi_{disp} + \phi_{atmo} + \phi_{flat} + \phi_{noise} \quad (1)$$

where ϕ_{topo} is the topographic phase; ϕ_{disp} is the phase change due to movement of the pixel in the satellite line-of-sight direction; ϕ_{atmo} is the phase equivalent of the difference in atmospheric retardation between passes; ϕ_{flat} is the phase caused by reference plane;

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