Mapping Land Subsidence With Multi-Frequency Time Series SAR Images

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Ground subsidence at relatively large amplitude has started in several coastal cities in China in 1980s, such as Shanghai and Tianjing. Following fast economy developments across the country thereafter, ground subsidence has expanded into inland areas. The main causes of ground subsidence in China are over-exploitation of groundwater and other underground resources. The subsidence has not only affected individual metropolis but it has also evolved into regional disasters. Currently, four major subsidence zones exist across the country: the Beijing-Tianjing- Tangshan area, the Yangtze River delta region centred at Shanghai, Suzhou and Wuxi, the Pearl river delta region centred at Guangzhou and Zhuhai, and the Weihe-Fenhe basin centred at Xi'an and Taiyuan. The total area affected by ground subsidence up to 2003 was approximately 930,000 km2, causing annual direct economic loss of over 1.2 billion US Dollar. Land subsidence has been recognized as the No.1 natural disaster in China. Therefore developing reliable and effective techniques to monitor land subsidence over large area is very important.

Traditionally, land subsidence is measured by ground-based techniques, such as spirit level, borehole extensometer and GPS. These methods cannot achieve a sufficiently high spatial density over large areas. In contrast, Interferometric SAR (INSAR) can achieve an accuracy comparable to GPS, but at a higher spatial density and a larger coverage when applied to ground subsidence mapping. Moreover, the newly developed time series INSAR techniques, e.g. permanent scatterers (PS) INSAR and small baseline subset INSAR, have substantially improved the reliability of deformation mapping because the temporal and spatial decorrelation associated with repeat pass differential INSAR can be effectively overcome with these techniques. This project aims to develop a methodology to map land subsidence by integrating multi-wavelength time series SAR images, e.g. ENVISAT C-band ASAR images and TerraSAR-X images. Time series C-band images are used to estimate large spatial scale deformation patterns and topographic errors. These information are then input into the processing of time series of high resolution TerraSAR-X images to detect localized displacements and heights of buildings and other man-made structures in more detail. The objective of this project is to develop the methodology of integrating time series C- and X-band INSAR processing to retrieve both large spatial scale and localized land subsidence information over a large area.

Two study areas will be chosen with one in Beijing and another one in Zhejiang province. These two areas are of different character. The Beijing test site is at the east of Beijing city, and is highly urbanized. It is in the north of China and the weather is usually very dry. The Zhejiang test site is located at the Taizhou region with very humid weather. This region is a small plain scattered with many towns. It is famous for its highly developed medium and small private enterprises and represents one of the most prosperous areas in China. For both test sites, time series ENVISAT ASAR and TerraSAR-X images acquired between 2008 Jan and 2010 Dec. will be collected. The National Administration of Surveying, Mapping and Geoinformation (NASG) of China, in collaboration with other related agencies, are going to launch a nationwide monitoring program. Land subsidence monitoring across the country will be an important component of the program. As the largest research institution affiliated to NASG, Chinese Academy of Surveying and mapping (CASM) has been funded by NASG to conduct a pilot research on operational monitoring of large area land subsidence by integrating satellite SAR remote sensing and ground measurement. The pilot research could provide some financial support for this DRAGON project.

利用多频时间序列SAR影像监测地面沉降

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自20世纪80年代以来，中国部分沿海城市发生了较严重的地面沉降，如上海、天津。随着经济的快速发展，地面沉降已从沿海地区发展至内陆地区。中国地面沉降的主要原因是对地下水和其它地下资源的过度开采。它不仅影响到少数大城市的发展，而且已经发展成为区域性地质灾害。目前，中国有4个主要的地面沉降区域，分别为京津唐地区、长三角地区（沉降中心有上海、苏州和无锡）、珠三角地区（沉降中心为广州和珠海）、汾渭盆地（沉降中心为西安和太原）。截至2003年，受地面沉降影响地区的总面积约为930,000 km2，每年造成的经济损失超过12亿美元。地面沉降已被公认为中国的首要自然灾害。因此，对于大范围的地面沉降而言，发展可靠、有效的沉降监测技术显得尤为必要。

地面沉降的传统监测方法为实地测量，如水准测量、地下凿洞的形变测量以及GPS测量等，但是它们不能获取大面积、高空间密度的测量结果。相反，利用合成孔径雷达干涉测量（InSAR）技术监测地面沉降，不但可以获得与GPS相当的测量精度，而且具有大范围、高空间密度监测优势。此外，近年来发展起来的时间序列InSAR技术，如永久散射体（PS）InSAR技术、小基线集InSAR技术，极大提高了形变监测的可靠性，因为它们可以有效克服重轨InSAR技术中存在的时间去相关和空间去相关问题。本项目研究目标为发展一种融合多波段时间序列SAR影像的地面沉降监测方法，如融合C-波段的ENVISAT ASAR影像和X-波段的TerraSAR-X影像。其中，C-波段的时间序列影像用于估计大范围的地表形变和地形误差，然后将这些信息用于高分辨率TerraSAR-X影像的时间序列InSAR处理，以监测局部地表形变，获得房屋和其他人工建筑物的详细高度信息。本项目发展的形变监测方法，通过融合时间序列C波段和X波段InSAR处理，能够有效监测大范围的地面沉降，不但可以获取大尺度的形变信息，而且可以获得局部微小的形变特征。

本项目选取了两个代表不同的地域特征的试验区，分别位于北京市和浙江省。北京试验区地处北京市东部。该地高度城市化，属于华北地区，气候干旱。浙江试验区为气候潮湿的台州平原，分布着众多城镇；该地是中国经济最繁荣的区域之一，尤其以高度发达的中小私营企业著称。对于两试验区的地面沉降监测，我们将采用2008年1月至2010年12月的时间序列ENVISAT ASAR和TerraSAR-X影像。近期国家测绘地理信息局将联合其他相关部门启动地理国情监测项目，其中全国性地面沉降监测将成为该项目的重要组成部分。中国测绘科学研究院作为国家测绘地理信息局直属的最大研究机构，在国家测绘地理信息局的大力支持下，正在开展卫星SAR遥感和地面测量相结合的大范围地面沉降监测预研项目。该项目可为本"龙"计划项目提供部分经费支持。