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Ground deformations associated with underground coal-mining observed by Sentinel-1 SAR images in vegetated area

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Coal is the largest energy source for China, and over 90% coal production in China is from underground mining. However, underground mining usually trigger large-scale ground deformations, which tend to develop as hazards. Therefore, the central government of China issued the "green mine" policy in 2017, which requires to strictly implement scientific and orderly exploitation and keeping the disturbance to the mining area and surrounding environment within the limits of sustainable development in the whole process of coal mining. This policy necessitates accurate monitoring of ground deformations induced by underground mining. Satellite Interferometric SAR (InSAR), especially the multi-temporal InSAR techniques have been successfully used to monitor deformations associated with underground mining. But temporal decorrelation still remains a big challenge because many underground mining takes place beneath farmland or forested region. Given the advantages of Sentinel-1 (S-1) in short revisit time, small baselines and free accessibility, underground mining deformations can be monitored somehow with S-1 InSAR in vegetated areas. In this research we report such an application in an underground coal-mine site located in Xuzhou, Jiangsu province of China. Four working panels are investigated

The working panels are all beneath farmland where winter wheat is sowed before the end of October and reaped around next late May, then corn or rice is planted during the coming summer season from June to September. Therefore the C-band S-1 interferograms can keep good coherence only when both images are acquired in the period of late October to next early April (this period is called coherent period thereafter) when the newly planted winter wheat is in its early growing stage. Three subsets of S-1 images acquired during three consecutive coherent periods are used to generate mining-induced ground deformations.

During each coherent period, all of the interferograms with 12-day separation and some of the interferograms with 24-day separation and good coherence are selected and phase-unwrapped. Then these two sets of unwrapped interferograms are stacked, and finally the temporal deformations along SAR line-of-sight (LOS) are calculated under the least square principle. The temporal and spatial characteristics of the LOS deformation time series (DTS) are analyzed by considering extraction stage and extraction parameters of the working panel. Based on the analysis, we can diagnose whether the underground exploitation overstepped its designed

boundary, or whether the working panel has been exploited for longer time than the designed extraction period.