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Displacement Monitoring over Dagushan Open-pit Iron Mine by Means of Small Baseline Subsets Analysis

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Abstract

Dagushan Iron Mine is the deepest open-pit iron mine in Asia, with abundant iron ore resources. With continuous open-pit mining activities, the stairs extend to underground step by step, and engineering geological conditions are gradually revealed. The factors affecting slope stability are also changing gradually, e.g., exposure of surface water and groundwater. The lithological structure and composition of the slope body are also changing, as well as the effect of blasting on the ore body during mining process, along with the change of the slope safety and stability. Therefore, in order to ensure the safe operation of the mine, it is necessary to conduct slope stability monitoring with non-contact strategy. This kind of non-contact monitoring doesn’t need to install measurement points on the dangerous slope, and thus no need to worry about sliding problems of the measurement points.

As an effective non-contact deformation monitoring tool, SAR interferometry has good potential in displacement monitoring of mines. With a stack of SAR images, time series InSAR is able to overcome spatial and temporal decorrelation problems, as well as the atmospheric phase artifacts, resulting in high precision deformation estimates[1][2]. Small baseline subsets analysis (SBAS) is able to estimate deformation using all the high quality interferograms, which improves the utilization of SAR data and is suitable for analysis on long time series[3]. Therefore, the SBAS method is used to monitor the displacements in Dagushan open-pit iron mine. In this paper, 117 sentinel-1 images acquired from 2017 to 2019 are used, as well as the 3-arc-second DEM generated by the German TanDEM-X mission[4][5]. With height accuracy of approximately 1m, TanDEM-X DEM can be used to remove the topographic phase from the interferograms.

The estimated displacements map in line-of sight direction show that the northern slope, western part and the northern part of the dump suffer from severe displacements. In order to assess the precision of the displacement estimates, a comparison with on-site date collected by measurement robots is carried out. There is a very good consistency between the two results. The outcome of this study can help with mine disaster prevention and mitigation, and provide technical support for ensuring safe mining activities.

Data processing and results

Study area

Dagushan Iron Mine is one of the five major open pit iron mines in Anshan. It is also the earliest open pit mine to start deep pit mining.

Fig.1 Study Area – Dagushan Iron Mine

Methodology

We applied the SBAS analysis to 17 Sentinel-1B images. During data processing, a super master is first selected according to the spatial and temporal baselines. All the slave images are coregistered to the super master image during coarse coregistration and fine coregistration. In order to improve the quality of interferograms, Goldstein filter is applied on all interferograms. Then, phase unwrapping based on minimum cost flow is conducted for each interferogram. The residual topographic artifacts, as well as the atmospheric phase screen (APS) signals, are also estimated and filtered out. Based on the unwrapped interferograms, the average displacement rate and displacement time series are estimated using singular value decomposition method.

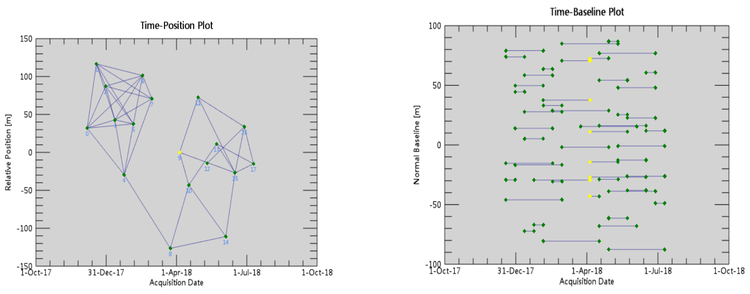
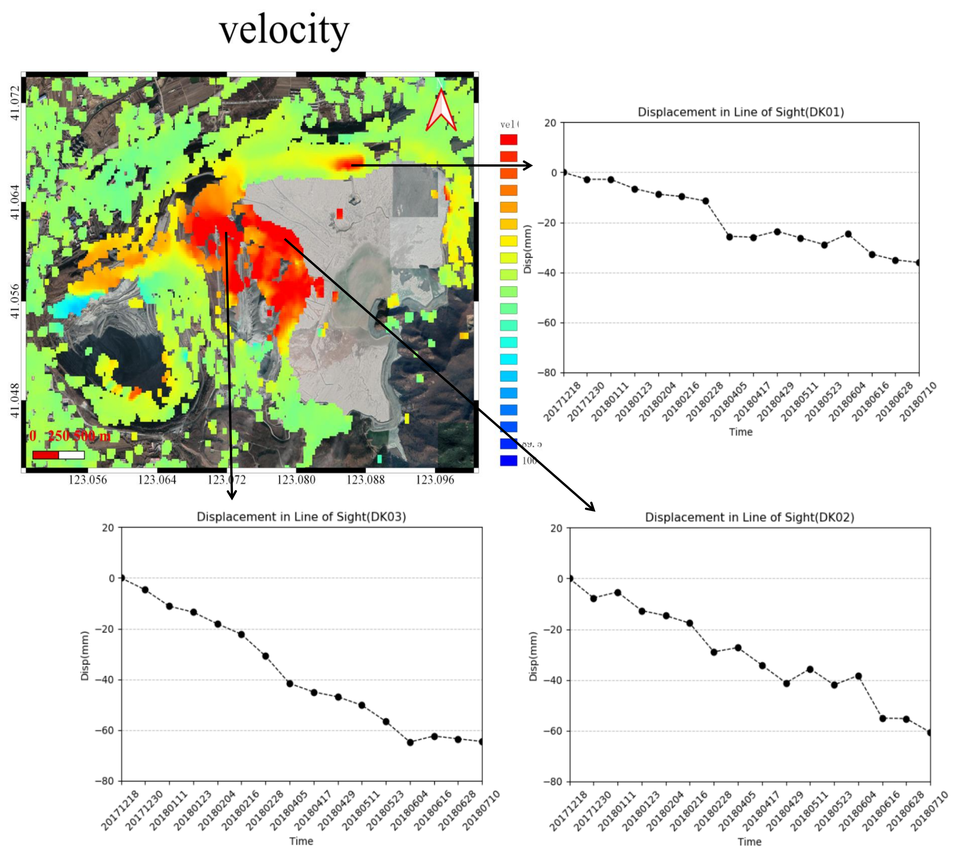


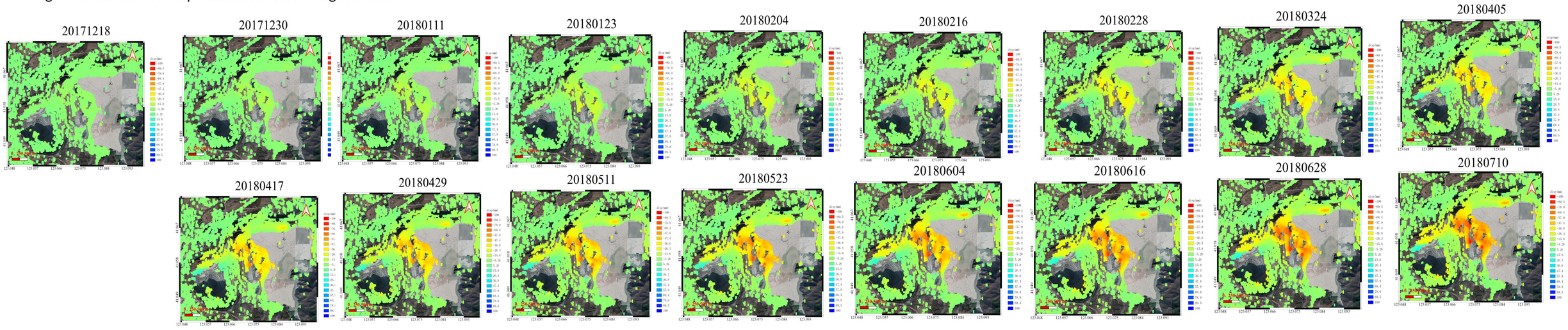
Fig.2 The spatio-temproal Baselines of the Dataset

Fig.3 Displacement Rate in Line of Sight [mm/yr] and Time Series Plots of three points



According to the velocity figure, we can see the areas with obvious subsidence.
Displacement values of three points are obtained to show their cumulative displacements in LOS.

Fig.4 The cumulative Displacement in Line of Sight in mm.



Conclusions

In this paper, 17 Sentinel-1B images is used to monitor displacement in Dagushan Iron Mine by SBAS_InSAR technology. The average ground deformation rate, time series of land subsidence and cumulative displacements in Dagushan from 2017 to 2018 were obtained. The estimated displacements map in line-of sight direction show that the northern slope, western part and the northern part of the dump suffer from severe displacements. And this study shows that it is feasible to use SBAS technology to monitor land subsidence in non-urban areas, the outcome of this study can help with mine disaster prevention and mitigation.

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