Detecting Illegal Mining Activities Using DInSAR

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Study Area

The capital city of Zonguldak is located at Western Black Sea coast of Turkey, 330 km east from Istanbul and 270 km north from Ankara.

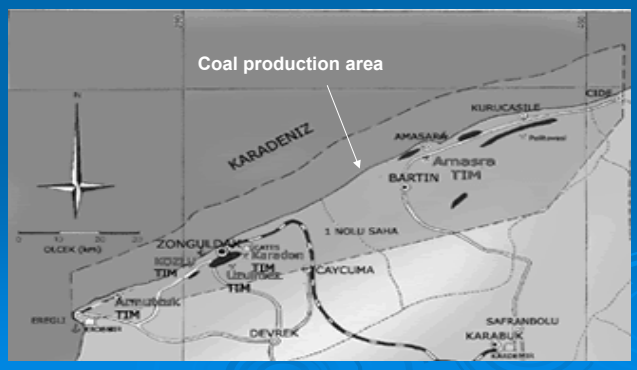
Figure 1. Location of study area.

Study Area

Its population is about 200.000. The city has a rolling and steep topography; altitudes range from 0 to 1000 meters from the coastal plains to inland. The terrain is heavily forested in the immediate vicinity of the city center.

Coal Production in Zonguldak

This city is the major center of coal production in Turkey. In this basin, hard coal production started in 1848, and has been officially carrying out by Turkish Hard Coal Enterprise (TTK) and some private companies authorized by TTK.



Coal production in Zonguldak

According to official records, coal productions are driven between the heights of +155 m and -550m and the yearly production is about 3 million ton; total production has been reached 400 million ton since 1848. However, there are also numerous illegal coal productions in different places of the basin. These illegal activities not only shortchange TTK economically and threaten life and property safety. To determine and prevent the illegal activities, routine field controls on the field are carried out by the TTK officers, but satisfactory results can not be achieved due to rough and heavily forested terrain.

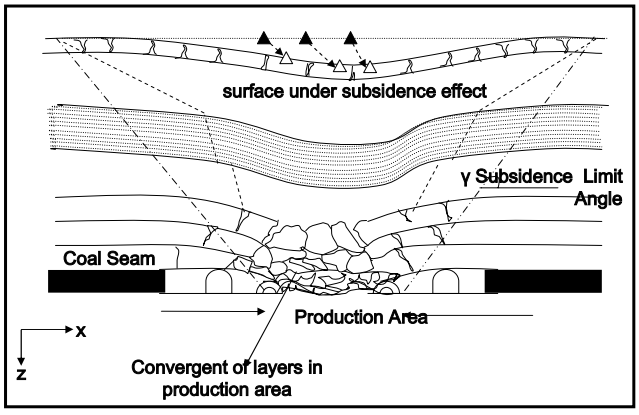
Study Aim

In this study, we suggest supporting the routine controls with the Space-Based Differential InSAR (D-InSAR) technique to detect illegal activities. For this purpose a pilot study has been performed in the Zonguldak hard coal basin. Considering the study area environed with forests, the proper choice for detecting illegal mines is to use SAR sensors providing L-band data which can penetrate vegetation and go through the ground surface. For that reason, JERS-1 data archive has been applied.

Mining Induced Subsidence Effect

Underground coal mining is performed in the uppermost brittle part of the Earth's crust. This part has a very susceptible stability formed over millions of years. During the mining activities, a large amount of mass is extracted from driven mine seams and large spaces are constituted below ground. Hence, the susceptible stability of the uppermost crust is damaged and a slow motion so-called subsidence is triggered from the depth of coal seam to the earth surface.

Mining Induced Subsidence Effect



Mining-induced subsidence constitution

Mining Induced Subsidence Effect

The subsidence induced at the depth of mine seam affects on a wider area on the surface. The width of the surface area under the subsidence effect and the amount of displacements in this area depend on the geological structure of the ground and the geometry of the production panel such as depth, width, length, thickness and inclination. In most cases, the subsidence progress on the ground can not be realized with visual sense, but detected by the geodetic methods such as GPS, Differential InSAR etc.

Data Used

As stated above the Zonguldak basin is environed with heavily forests. In such a case, L-Band InSAR data becomes the most proper choice to detect the surface changes because microwaves in L-Band can penetrate vegetation and go through the ground surface. For that reason, data archives of JERS-1 SAR sensor were decided to use for the pilot study.

JERS-1 satellite mission was ended in 1998; therefore, two data acquired on September 29th and May 20th, 2005 were used for Master and Slave image, respectively. The time gap between both images is 132 days.

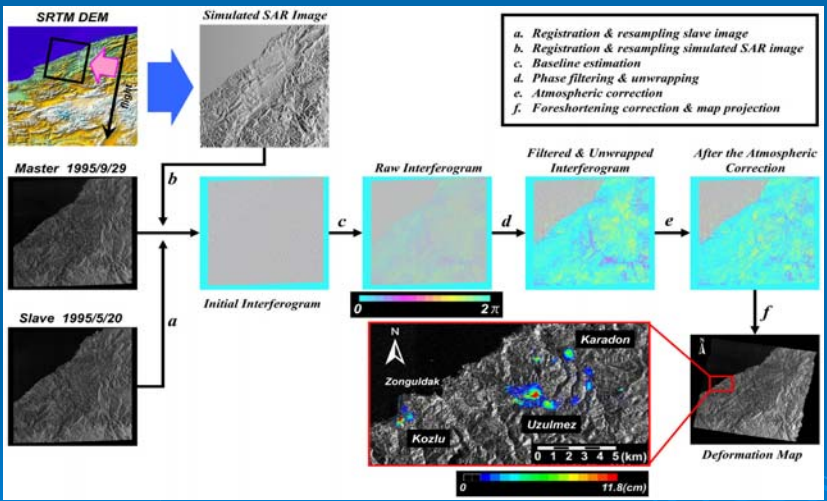
Differential InSAR Processing

Phase anomalies obtained by comparing both SAR images are composed of orbit, topoghraphic, atmospheric, deformation and noise components:

$$\phi = \phi_{orbit} + \phi_{topo} + \phi_{atm} + \phi_{def} + \phi_{noise}$$

Orbit, topographic, atmospheric and noise phase components are eliminated or reduced during the InSAR processing, and the deformation phase anomalies are obtained.

InSAR Processing Scheme

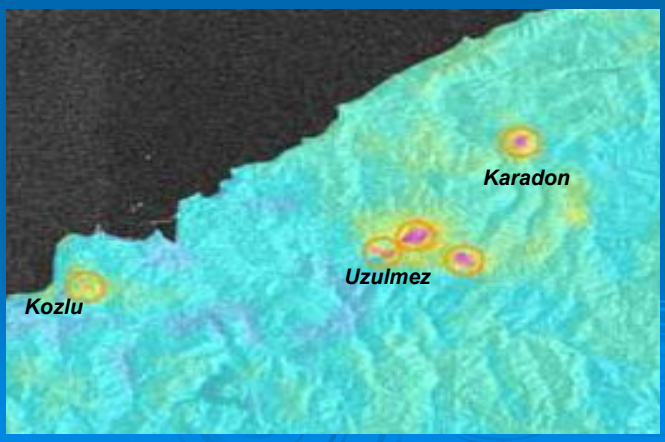


Sensor : JERS-1/SAR B_{temp} *: 132 (days)*
Master : 1995/9/29 B_{perp} *: 54.3 (m)*
Slave : 1995/5/20 *External DEM : SRTM*

SRTM (ftp://e0srp01u.ecs.nasa.gov/srtm/version2/)

Result

Processing JERS-1 SAR data is resulted in deformation phase anomalies in the five location of the Zonguldak basin, one in the Kozlu region, one in the Karadon and three in the Uzulmez region. The largest surface deformation has been detected in the Kozlu region with 2.4 cm. As for the Uzulmez and Karadon, surface deformations over 1.3 cm have been observed.



Result

These deformation anomalies can not be considered, in advance, to be mining-induced because landslides are common events in Zonguldak due to the steep topography. For that reason, the map archives of coal production of TTK was investigated, and the deformation zones in Kozlu and Uzulmez were confirmed as the localities that the legal mining activities. However, according to the production maps, the zone in Karadon is outside of the legal production areas. In order to determine the source of the deformation, we explored the zone, and were confronted with the scene below.

Result

Result

As this mining activity are not documented in the TTK production maps it is condidered to be an illegal activity, but for the exact decision the production of the private companies must be investigated.

Conclusion

- It is fact that Diferential InSAR is a quite effective tool to monitor surface deformations. As the underground mining activities cause subsidence effects on the ground they can be detected by DInSAR. This means it is possible to guess the localities in which illegal activities are conducted. Using this method, illegal activities can be contended more successfully and economically. This pilot study has been fulfilled to show the effectiveness of the technique on this issue. For future works, cooperation with TTK will be looked for. If it can be constructed, monitoring will be continued by L-Band Palsar data because JERS-1 mission was ended in 1998.

Thank you very much for your interest!