CHAMBER OF SURVEY AND CADASTRE ENGINEERS OF TURKEY

Earth Remote Sensing Data Analysis Center
ERSDAC

Monitoring Mining Induced Subsidences Using GPS and InSAR

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CONTENTS OF STUDY

OBJECTIVES OF STUDY

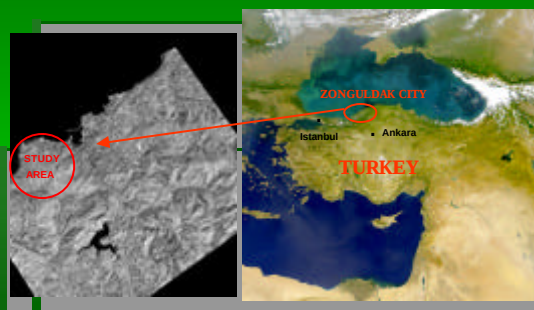
Underground mining causes subsidence effect on the earth surface. It is possible to monitor this effect by geodetic surveying methods.

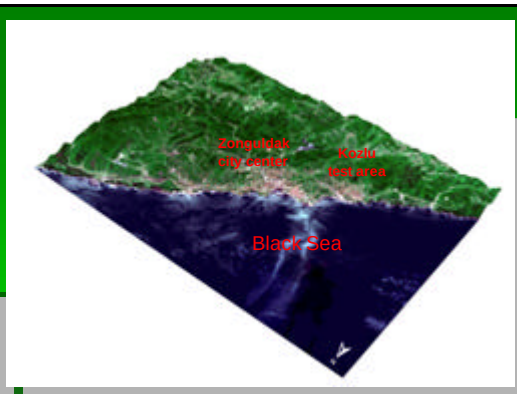
However, these methods have some difficulties to apply in places where topography is hilly or forestry or dense urbanization is available.

These difficulties can be overcome using InSAR technique to monitor subsidence effects. In order to study the performance of InSAR on determining subsidence effects, an investigation has been carried out in Kozlu region of Zonguldak Hardcoal Basin, Turkey.

Using JERS-1/SAR and RADARSAT images subsidence areas and amounts have been determined. These results obtained from InSAR have been compared those obtained from GPS observations of a geodetic control points established in the region.

TEST AREA FOR THIS STUDY





3-D model derived ASTER image for test area

In Zonguldak Hardcoal Basin (ZHB), production activities have been continued since the year of 1848.

Up to now the raw coal about 400 million ton has been extracted from the basin which has the area of 15000 km2 whose 3000 km2 is under the sea.

In this basin, the coal seams are limited to the upper carbonifer layers. These layers, whose total thickness changes between 600-800 m, have a very complex geological structure.

The coal production in the region has been carried out in the production panels with different geometrical pattern and different height, using different production techniques.

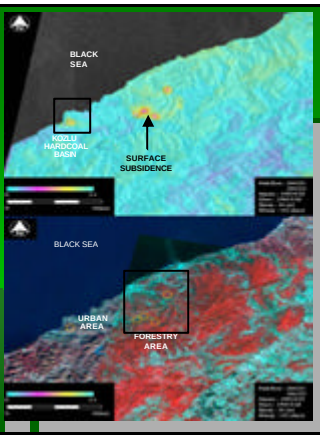
Kozlu region treated in this study is one of the oldest production areas of the basin.

MEASUREMENT OF GROUND DEFORMATION USING INSAR and GPS

At the beginning of this study, a deformation map is formed by differential application of two different images in 1995 taken from JERS-1/SAR satellite.

In this map five deformation zones have been detected. The four of these zones are in the forestry area which is not appropriate to apply GPS observation technique.

The only urban area which the subsidence is observed is related to the Kozlu region. In this area, a GPS network has been established to confirm the deformations detected by InSAR technique.

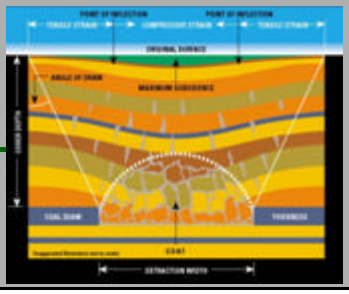


The image above shows deformation surface obtained from JERS-1 satellite.

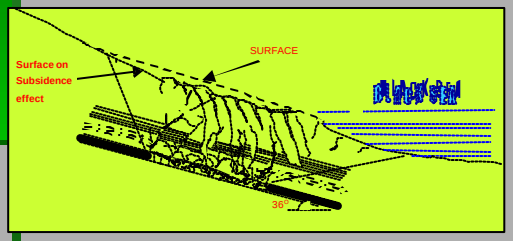
The image below is ASTER infra-red image of the region.

WHAT IS MINE SUBSIDENCE?

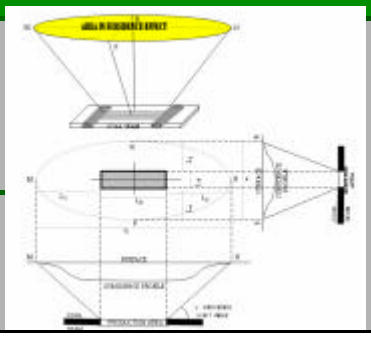
Subsidence can be described as the lowering or settling down of the land's surface. When mining takes place, the earth's forces are redistributed and there is a tendency for the void to close. Some of this effect may be transferred to the surface as mine subsidence. The extent to which subsidence occurs in a particular location depends upon the width and height of the coal extracted, its depth from the surface, and the rock types found in the overlying strata.

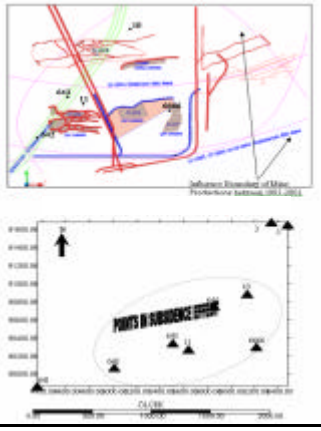


When the subsidence mechanism in the region is investigated it is observed two constitutions in the direction of and the perpendicular direction to the production. It is known that this mechanism is induced by the constant factors relating to geological structure and the variable factors relating to the geometry of production area



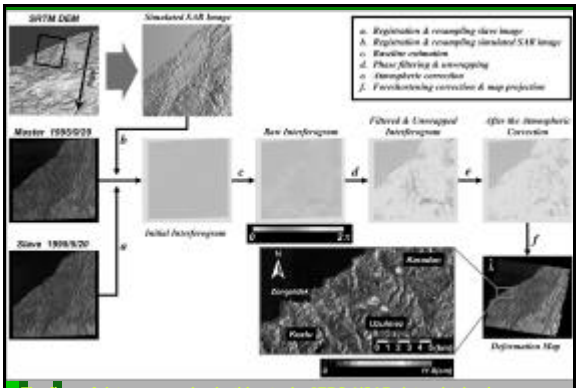
For GPS and InSAR observations, determining the area which subsidence affects on the earth surface is an important issue. The effect area on the earth surface can be determined when the dimensional parameters of the panel constituted in the gallery mined, i.e. width and length of the panel, thickness of the gallery, and lower and upper heights of the panel, are known





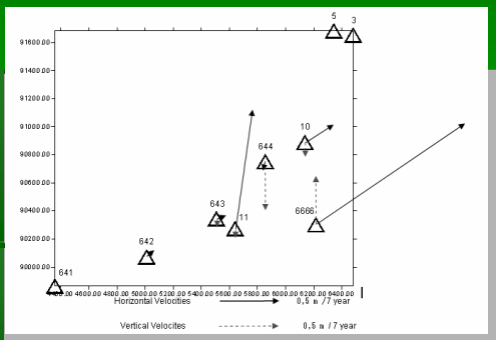
Effect areas of coal seams in the test region

GPS Control points used between1995 and 2003 in the test region



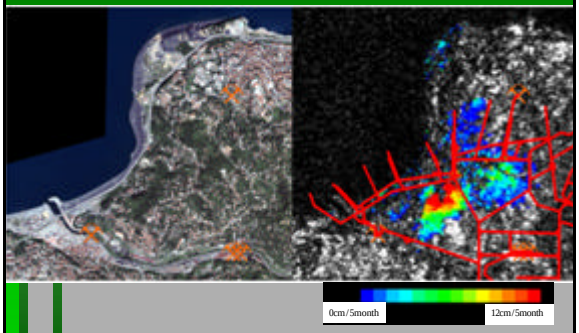
The flow of data processing in this study JERS-1/SAR data obtained on September 29th, 1995 and May 20th, 1995 were used for Master and Slave image respectively

DEFORMATIONS OBTAINED FROM GPS AND InSAR BETWEEN 1996-2003

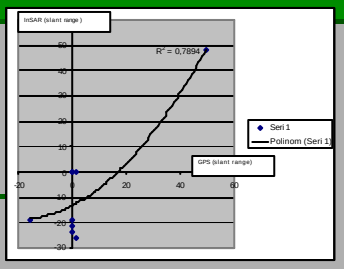


Deformation vectors obtained from GPS

DEFORMATIONS OBTAINED FROM GPS AND InSAR BETWEEN 1996-2003



Deformations obtained from InSAR with an interval of 132 days in 1996



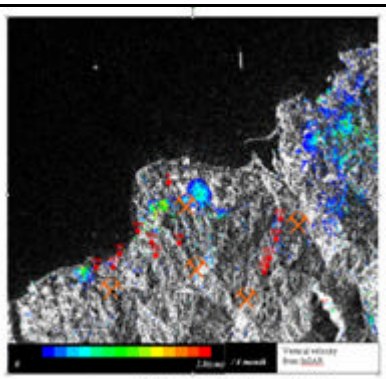
Regression graphics of deformation slant ranges obtained from GPS and InSAR with an interval of 132 days in 1996

DEFORMATIONS OBTAINED FROM GPS AND InSAR AFTER 2005

(a) ZK-01 (b) ZK-02

In October and November 2005, GPS measurement was conducted in the surrounding of Kozlu coal mine by ZKU. The interval between two measurements was as shortas 1 month, but a displacement with more than 45 millimeter should be measured if the extracted deformation has been active at the present. Comparison was made between InSAR and GPS measurement results in the areas of ZK-01and ZK-02 in Fig.5 where deformations were clearlydetected byInSAR.

The amounts of displacement measured by InSAR in the area of ZK-01and ZK-02 were 42.724 millimeter and 61.180 millimeter respectively, while that obtained by GPS measurement were 50.895 millimeter and 60.602 millimeter respectively. This leads an evaluation that InSAR and GPS measurement is highlyconsistent having close agreement with variance less than 9 millimeter.



CONCLUSIONS AND FURTHER WORKS

In this study, the subsidence effects on Kozlu region in ZHB which happen between 1996-2003 and between 2005 -2006 have been investigated using GPS and InSAR techniques. In conclusion, the followings have been obtained:

1. JERS-1/SAT and RADARSAT have been provided consistent results with GPS. In this way, spatial and temporal details have been possible to produce in Kozlu region.
2. In the same parallel with GPS, diferential InSAR analyses have been provided to monitor the deformation in short periods such as 0-5 month
3. Subsidence effects in places where GPS method can not be applied have been successfullydetermined by InSAR
4. Subsidence effects in places where GPS method can not be applied have been successfully determined by InSAR As for the accuracyof measurement, InSAR results correspond to the GPS measurement data within 9 millimeter variance. This proved that InSAR provides highly accurate variation measurement with less than 8% of phase (1cm). From the results described above, ground deformation has been taking place in Kozlu coalfield even after 1995.

5. In the future, real-time ground deformation measurement will take over this study by using PLASAR (Phased Array type L-band Synthetic Aperture Radar) loaded on ALOS (Advanced Land Observing Satellite), which was launched in January 2006. In addition, this study will develop to 3D deformation measurement, which integrates complementarily GPS measurement, leveling and multiple spaceborne SAR data.

ON THE BEHALF OF MY GROUP, I WOULD LIKE TO EXPRESS MY SPECIAL THANKS TO ALL AUDIENCE FOR YOUR ATTENTION.