MONITORING COAL-FIELD SUBSIDENCE

Integrating GPS and SAR

Subsidence of the earth's surface caused by underground mining can be monitored using terrestrial land-survey methods. However, applying these is difficult in hilly terrain and densely forested or urbanised areas. Such difficulties can be overcome with a combination of spaceborne SAR and GPS. InSAR accuracy corresponds to GPS and lies, with 9mm variance, in less than 8% of SAR signal phase.<P>

When a point on the earth's surface is subject to deformation such as subsidence, the distance, or slant range, between an orbiting SAR sensor and the point gradually changes over time. Slant range can be determined by measuring the phase of the SAR signal. With point subsidence, the slant-range and thus phase changes over time. Comparing SAR signal phases hitting the same point on the earth's surface at different times enables computation of whether the point is stable or undergoing deformation. The calculation process is rather complex and is documented in textbooks and scientific articles.

Zonguldak Coal-field
Zonguldak coal-field was selected as case-study to examine the possibilities of integrated complementary GPS measurements and InSAR data. The coal-field is located on the Black Sea coast, approximately 240 kilometres east of Istanbul. The terrain is ubiquitously steep, varying from nought to a thousand metres above sea level, and is covered by vegetation. Underground coal mining has been carried out here since 1848; three million tons of hard coal per year is produced, today resulting in subsidence causing damage to roads and buildings. Three coal-mines, Kozlu, Uzulmez and Karadon, are exploited by Turkish Coal Enterprises and several private companies. The thickness of the coal layers, which are of very complex geological structure, varies from 600m to 800m.

Results
A deformation map was created by comparing two images from the JERS-1/SAR satellite, showing five deformation zones (see Figure 1, central picture). The procedure used in creating the map is graphically illustrated in Figure 2. In the five zones a GPS network was established to confirm deformations detected by InSAR technique. Examination of both techniques reveals that InSAR and GPS provide highly consistent and closely correlated results, variance being less than 9 millimetres, that is better than 8% of SAR signal phase. The GPS and InSAR measurements also show correlation as high as 82%. As an upshot of this study real-time monitoring and 3D ground deformation measurements will be carried out over the areas using integrated complementary GPS measurement, levelling and multiple spaceborne SAR data.?

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