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GeoHazard description for the Varna region in the frame of the Pangeo project

Описание на геоложките опасности за района Варна като част от проекта Пангео

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Introduction

PanGeo was a 3-year EC FP7 R&D ‘Space’ project (1st Feb 2011–31st Jan 2014). The main objective of the project was to provide free, online information on geohazards for 52 of the largest towns in the EU (two in each country, except only one in Luxembourg and Cyprus). For Bulgaria, these two towns are Sofia and Varna (Ruskov et al., 2014). For each town were made a GIS Ground Stability Layer (GSL) and a ‘Geohazard Description document’ (Stoykov et al., 2013a, b). Users of the PanGeo service include local authorities, civil protection agencies, geological surveys, insurers and businesses providing environmental and land reporting services and of course the general public (Bateson, Glenfield, 2011; Jordan et al., 2011).

The area covered by the GSL of Varna includes the town of Varna and other surrounding boroughs, with a total population of about 304 000 inhabitants in 2011. Urban areas cover ~ 258 km^2 while the town of Varna covers ~ 153.6 km^2. Mountains and forest units cover approximately 28%, while agriculture and semi-natural cover around 60% of the area.

Methods

PanGeo offers a free and open access to geohazard information service in support of GMES (Global Monitoring for Environment and Security). PanGeo geohazard information is derived from integrations of (1) satellite radar Persistent Scatterer Interferometry (PSI) for ground instability measurement; (2) geological land use and other geospatial information available at the University of Mining and Geology, Sofia and (3) the land use and land-cover information provided by the EC’s Urban Atlas. PSI is the most advanced class of differential interferometric Synthetic Aperture Radar techniques (DInSAR) based on data acquired by spaceborne SAR sensors. One of the advantages of PSI is its sensitivity to small deformations, which in terms of deformation velocity are in the region of 1 mm/year. PSI also offers wide-area coverage (ERS standard imagery, for instance, cover 100 by 100 km) typically associated with a relatively high spatial resolution (Ferretti et al., 2001). PSI products are the raw output provided by the PSI Providers (PSIPs), i.e., PSI products include no interpretation as to the cause of any motion observed.

PSI processing for Varna area was carried out in the period between 16th June 1992 and 16th November 2009. It was used three satellite data type – ERS-1 and ASAR (Fig. 1) with the Interferometric Point Target Analysis (IPTA) algorithm and between 20 and 36 number of scenes. For this period more than 100 000 number of PS were identified. The Average PS density (PS/km^2) is in range 26–34 (Table 1).

Results and discussion

PanGeo project is objective focused on geohazards relating to ground instability and mapping phenomena in the urban environment where there effect is most damaging. Ground movements (upwards, sideways or downwards) can be induced by very wide range of natural and unnatural manmade geological processes with some processes being so slow as to be imperceptible to the naked eye while others may cause large scale obvious movement in the ground. Whatever the “geohazard” they have the potential to

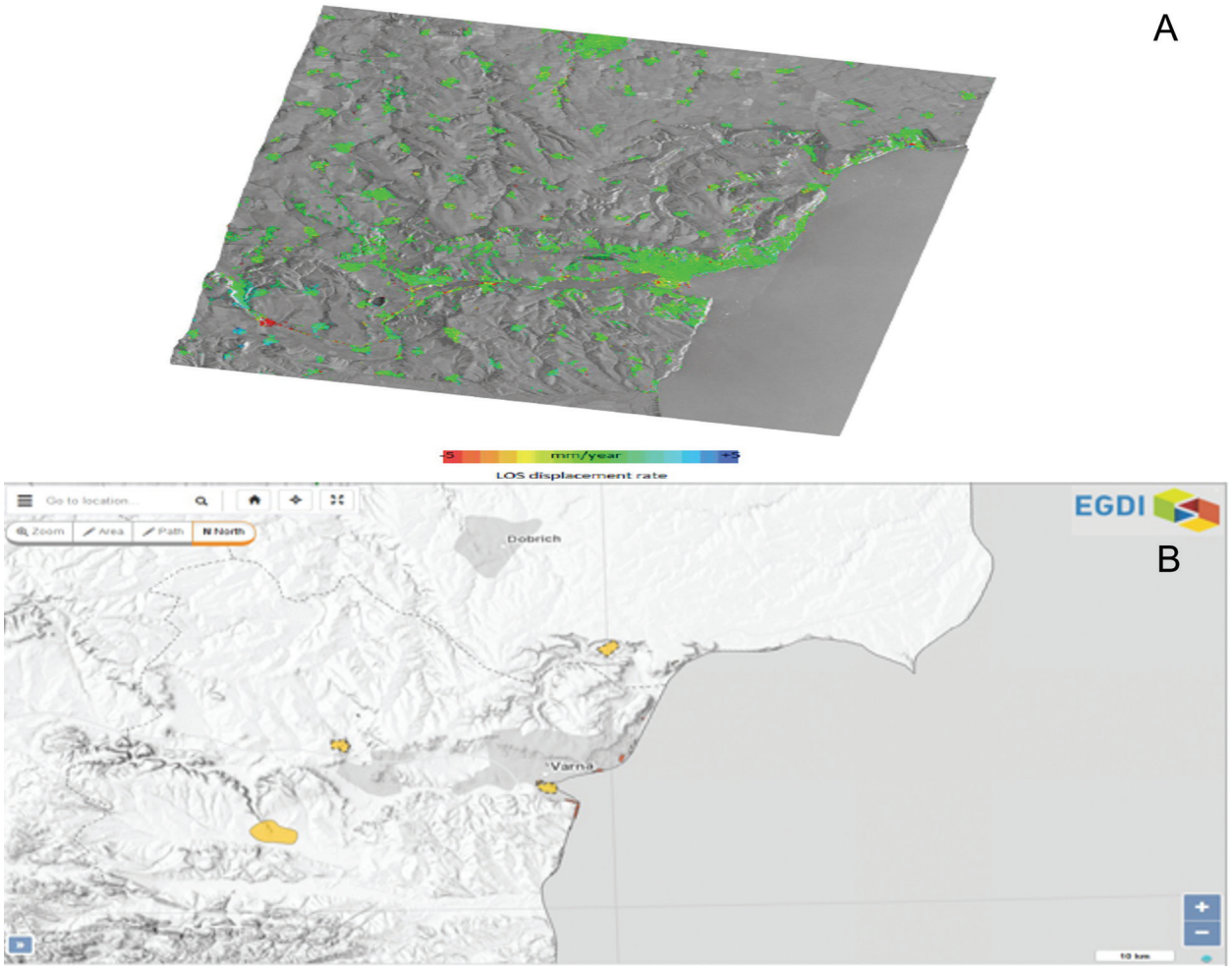

Fig. 1. GeoHazard Description for the Varna region. *A*, Varna average line-of-sight displacement map derived using PSI on ASAR data 2003–2009; *B*, Pangeo results for the Varna Region – published on EGDI (European Geological Data Infrastructure) website. Color polygons display types of geological hazards, grey polygons – signal reflection areas.

severely damage urban infrastructure and buildings (Bateson, Glenfield, 2011).

Geohazards can be descripted as either 'potential' or 'observed'. A potential geohazard is possible in the case that the local geology makes is more probable for ground movement to occur even if movement has not been measured. At the other hand, observed geohazards are where ground movement has been measured (by whatever method). The PanGeo ground stability layers captures both potential and observed geohazards.

Within PanGeo project ground stability geohazards are grouped into common classification themes describing the wide range processes at work (Cigna et al., 2012): 1) Deep ground motions (earthquake seismic hazard; tectonic movements; salt tectonics; volcanic inflation/deflation); 2) Natural ground instability (landslide; soil creep; ground dissolution; collapsible ground; running sand/liquefaction); 3) Natural ground movement (shrink-swell clays; compressible ground); 4) Man-made ground instability (ground water management – shallow compaction; ground water management – peat oxidation; groundwater abstraction; mining; underground construction; made ground; oil and gas production); 5) Other.

The area covered by the GSL corresponds to the administrative area of Varna, Avren, Suvorovo, Balchik, Dobrich, Provadiya amd Devnya Municipalities (~1110 km^2) and includes the city of Varna and other surrounding boroughs. The area falls in area of Varna and Dobrich regions.

It was identified 16 geohazard polygons over investigated area in 3 different categories (geological hazard, industrial area, mining sites), consisting of ~31 km^2 of observed and potential geohazards. Potential for natural ground movements is observed for the majority of the area. Geohazards observed

Table 1. ENVISAT ascending processing information

Point motion statistics (mm/year classes)	Points in each mm/year class count	%
–100.0 to –3.5	3409	3.3
–3.5 to –1.5	7617	7.4
–1.5 to 1.5	87 585	84.8
1.5 to 3.5	4555	4.4
3.5 to 100.0	163	0.2
Analysis type	IPTA single reference stack	
Master scene date	2005/07/25	
Number of PS identified	103 329	
Average annual motion rate of the entire processed area	–0.15 mm/year	
Standard deviation of average annual motion rate	1.77 mm/year	

through the PS data include both natural processes (compaction of the marine shore sediments) and anthropogenic instability due to water abstraction and recent engineering works.

Conclusions

PanGeo represent an online service that provides to all users open access to geohazard information across European towns down to a mapping scale of 1:10 000. Geohazards are natural and man-made phenomena that make the ground unstable and in a built environment can be both costly and dangerous. PanGeo's geohazard products have been created to improve decision-making and reduce risk. PanGeo data can be viewed in Google Earth or via the integrated "portal".

In the study are there is one larger area to the west of Varna with subsidence rates >10 mm/year. Apart from this mainly local motion is observed, especially along the river and the coast. More than 3% of the identified data point falls in the range between –100 and –3.5 mm/year class. The data are available on http://www.europe-geology.eu/pangeo/.

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