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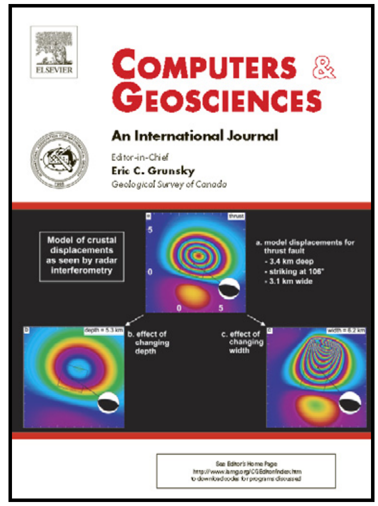

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Short note

Release of a 10-m resolution DEM for the Italian territory: Comparison with global-coverage DEMs and anaglyph-mode exploration via the web

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<h1>1. Introduction

Digital elevation models (DEMs) are fundamental in environmental and morphological studies. DEMs are obtained from a variety of sources and generated in several ways. Nowadays, several elevation datasets are available for free (e.g., Shuttle Radar Topographic Mission (SRTM), http://www.jpl.nasa.gov/srtm; ASTER, http://asterweb.jpl.nasa.gov/), and the choice of the DEM which better suits the target of the study is crucial (e.g., Hubbard et al., 2007). TINITALY/01 is currently the most accurate DEM covering the whole Italian territory (Tarquini et al., 2007). This DEM was created by using heterogeneous elevation datasets obtained from existing digital cartography.

Human vision provides a 3D perception of the world. Computers can recreate such a capability in a 2D monitor by using several techniques. Anaglyphs are a simple but effective method to convey the depth perception which allows a 3D vision of a DEM. A free webGIS to explore an anaglyph representation of TINTALY/01 is presented, and the whole DEM is now downloadable for scientific purposes.

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<h1>2. The TINITALY/01 DEM

TINITALY/01 is a DEM in triangular irregular network format (TIN) created for the whole Italian territory in the UTM 32 WGS 84 coordinate system (Tarquini et al., 2007). The DEM was obtained from heterogeneous vector datasets, mostly consisting in elevation contour lines and elevation points from several sources. The input vector database was carefully cleaned up to obtain a seamless TIN derived by using the DEST algorithm (Favalli and Pareschi, 2004).

The whole TINITALY/01 DEM was converted in grid format (10-m cell size) according to a tiled structure composed of 193, 50-km side square elements (Fig. 1). The grid database consists of more than 3 billions of cells and occupies ~12 Gb of disk memory.

<Fig. 1 here>

<H1>3. The TINITALY/01 DEM vs global-coverage DEMs

In recent years, an increasing number of elevation datasets covering entire countries are available to the public. Examples are the 10- or 30-m resolution National Elevation Dataset for the United States (NED; http://seamless.usgs.gov), the 10-m resolution DEM for Japan (Geographical Survey Institute of Japan; http://fgd.gsi.go.jp/), the 5- or 10-m resolution DEM for the UK (http://www.neodc.rl.ac.uk/), or else the 50-m resolution BD ALTI DEM for France. Here we briefly compare the TINITALY/01 DEM with the two spaceborne-based DEMs with an almost global coverage recently released via the web: the 90-m resolution SRTM and the 30-m resolution ASTER elevation datasets. These two DEMs cover also the whole Italian territory.

At the beginning of this century a quasi-global elevation dataset from the SRTM was released (Rabus et al., 2003). It consists of a 90-m cell size DEM which has been shown to be appropriate for morphometric analyses over large areas or to focus on the broad morphology of features.

The ASTER DEM with a 30-m cell size has been released more recently (Hayakawa et al., 2008). The ASTER has a higher resolution with respect to the SRTM dataset. Nevertheless, this fact does not necessarily imply a higher DEM quality, because, as an example, the ASTER DEM is affected by the limits of the ASTER sensor, which is locally disturbed by clouds (Hubbard et al., 2007).

Tarquini et al. (2007) carried out a comprehensive assessment of the accuracy of the TINITALY/01 DEM, finding a root mean square error in elevation (RMSEz) between 0.8 and 6.0 m. Rabus et al. (2003), for the SRTM elevation dataset, found an absolute vertical accuracy of ± 16 m at 90% confidence, while Hirano et al. (2007) found an RMSEz for the ASTER DEM within the design specification of 7–50 m. For both ASTER and SRTM DEMs, the error increases as the topography become rougher. As an example, for the ASTER DEM, Kaab (2002) found an RMSEz of 60 m in rough high mountains and 18 m in moderately mountainous terrains.

<Fig. 2 here>

An in-depth comparison is beyond the scope of the present work; nevertheless, we selected an example to highlight the characteristics of the TINITALY/01 DEM with respect to the two global-coverage SRTM and ASTER DEMs. We selected Mount Etna (Sicily, Italy), where a very high resolution, LIDAR-derived topography was available for comparison (Favalli et al., 2009). In this area, the TINITALY/01 DEM showed an RMSEz of 1.98 m (Neri et al., 2008), while we calculated an RMSEz of 7.78 and 9.36 m for the SRTM and ASTER DEMs, respectively. Fig. 2 shows the elevation profiles obtained from the LIDAR-derived DEM, the 10-m cell size TINITALY/01 grid, and ASTER and SRTM DEMs. The two spaceborne-based DEMs are too coarse to precisely reveal fundamental features such as cone craters and cone outlines, while the TINITALY/01 DEM provides the necessary detail.

<H1>4. Anaglyph-mode navigation of the DEM and related webGIS

The human brain is equipped to produce a 3D perception of an observed scene by coupling two images acquired by the eyes from a slightly different point of view. This is the basic principle of the stereo vision, widely applied for the examination of couples of aerial stereoscopic photographs. The observation in stereo mode conveys a deeper understanding of landscape morphologies, and can fruitfully support the detection of subtle features. Add-on modules enabling 3D vision in anaglyph mode have been recently made available for both freeware and commercial programs (e.g., Google Earth and ESRI ArcGIS), suggesting the validity of this method. Here we use a custom software (Tarquini and Favalli, 2011) which produces full-resolution anaglyph images from arbitrarily large DEMs, to obtain a seamless anaglyph layer of the entire TINITALY/01 database at 10-m resolution.

The ESRI ArcGIS server is used to set up a webGIS (http://labtel2.rm.ingv.it/surfit/), where the described 10-m resolution anaglyph layer is freely accessible for navigation (Fig. 3). The viewpoints for anaglyph creation are set symmetrically to a nadiral axis pointing toward the center of Italy, at an almost infinite distance, obtaining a very low distortion. The anaglyph layer is geo-referenced in the UTM WGS84 zone 32 projection system. To view the anaglyphs, users must wear anaglyph glasses with a green (or blue) left lens and a red right lens, but we set up also a layer of shaded relief images with an elevation color ramp.

<Fig. 3 here>

<H1>5. Concluding remarks

The 10-m resolution TINITALY/01 DEM (Tarquini et al., 2007) is compared with the two, coarser resolution, global-coverage, spaceborne-based SRTM and ASTER DEMs and with a high resolution LIDAR-derived DEM. Afterward, we presented a webGIS which allows the exploration of a 10-m resolution anaglyph layer showing the landforms of the whole Italian territory in 3D. The webGIS (http://labtel2.rm.ingv.it/surfit/) is open to the public, and can be used to carry out a preliminary analysis of landforms. The TINITALY/01 DEM is now available for scientific purposes on the basis of a research agreement (write to tinitaly@pi.ingv.it).

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Figure captions:

Fig. 1. Shaded relief image with color table of the TINITALY/01 DEM with the tiles composing the elevation dataset. For the European countries we used the SRTM DEM, while the bathymetry is from the GEBCO dataset (http://www.gebco.net/). Ticks mark UTM WGS 84-km coordinates.

Fig. 2. Comparison of the elevation profiles obtained by using a LIDAR-derived topography, the TINITALY/01 grid, the ASTER, and the SRTM elevation datasets.

Fig. 3. Example of anaglyph image of the Majella Mountain (Abruzzo region, Italy), obtained from the TINITALY/01 DEM. Ticks mark UTM 32 WGS 84-km coordinates.

Fig 1:

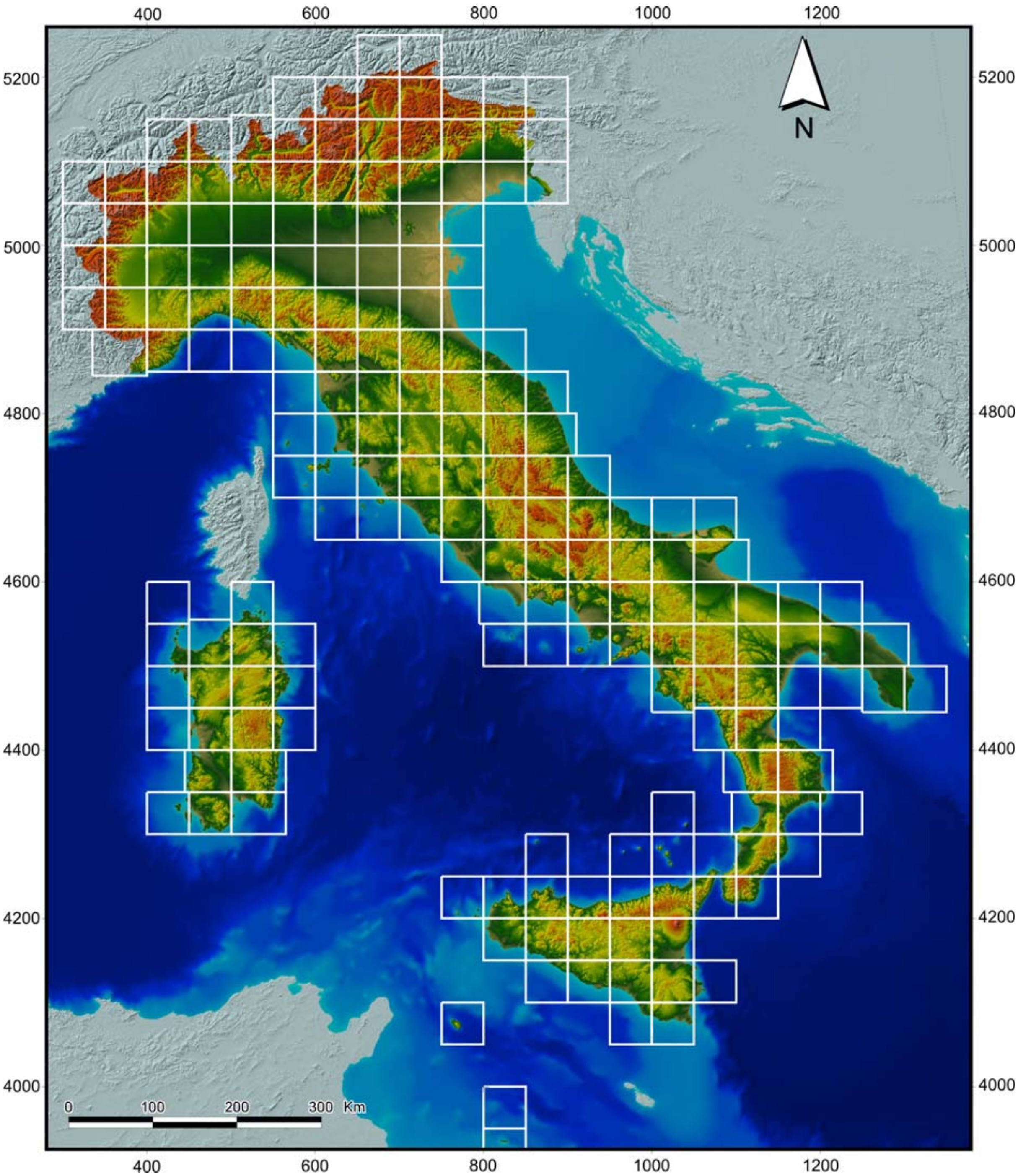
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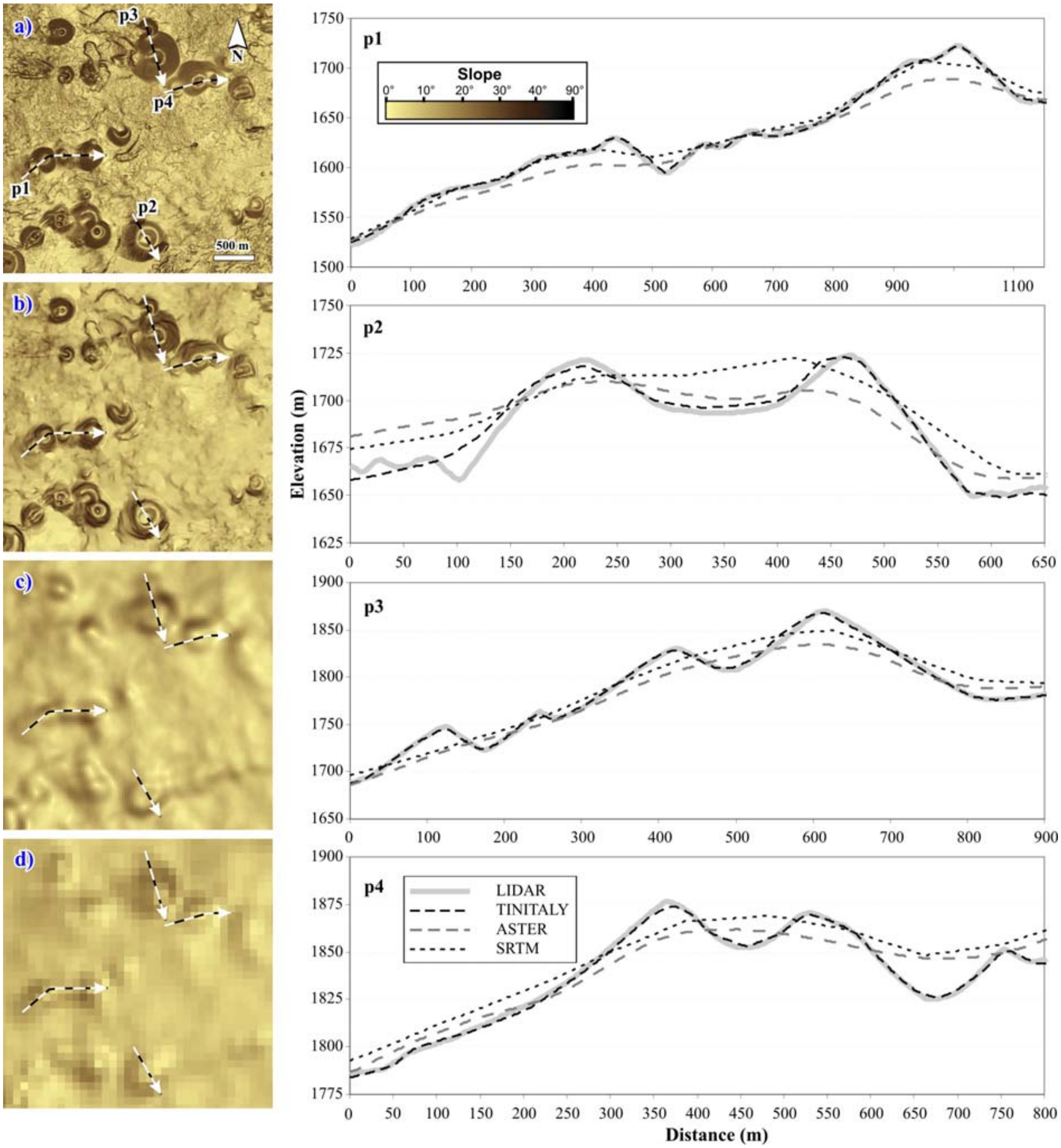
Fig 2: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p3
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b)
c)
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0°
10°
20°
30°
40°
90°
Elevation (m)
Distance (m)
LIDAR
TINITALY
ASTER
SRTM

Fig 3: