COMPARISON OF SRTM ELEVATION DATA WITH OTHER TOPOGRAPHIC DATASET FOR ITALY

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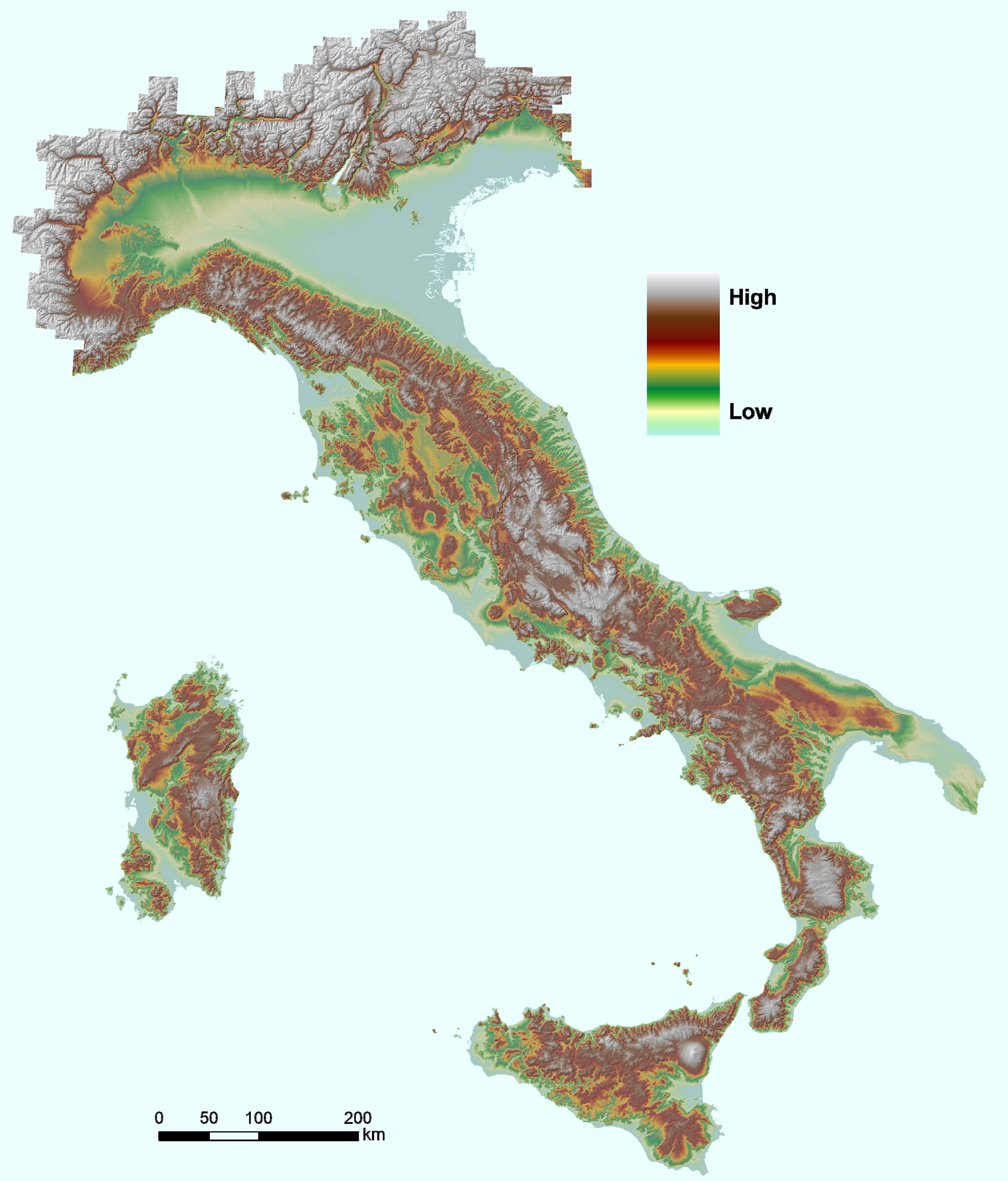
Topography is basic to many earth surface processes. It is used in analyses in hydrology and geomorphology, and many others, as a means both of explaining processes and of predicting them through modelling. Our capacity to understand and model these processes depends on the quality of the topographic data that are available.

Shuttle Radar Topography Mission 90 meter gridded elevation data is available by free download from ftp://edcftp.cr.usgs.gov/pub/data/srtm. The near-global dataset is not correctly geoid-located and contains numerous regions with no data due to SAR shadowing or layover, an abundance of cells with erroneously high or low values (peaks and sinks), and it also includes pixels with radar returns from rough water. The data therefore requires several pre-processing steps including interpolation across data voids and clipping to mask out open water areas.

Assemblage and local interpolation of the DEM for Italy was performed importing the single tiles into ArcInfo using a simple Arc-Macro Language. From the assembled DEM we obtained morphometric variables that we used to evaluate the quality of SRTM data through direct comparison with cartographically derived DEMs at differing resolution.

The comparison between different DEMs can be performed at pixel base or at zonal base using homogeneous morphometric regions. These comparisons were completed on altitudinal differences, for first order topographic derivatives, with a Dem at 230m scale of the whole Italian country, with a DEM at 25m scale of the Umbria Region and with a DEM at 10m scale of the Cecina river basin in the Toscana Region.

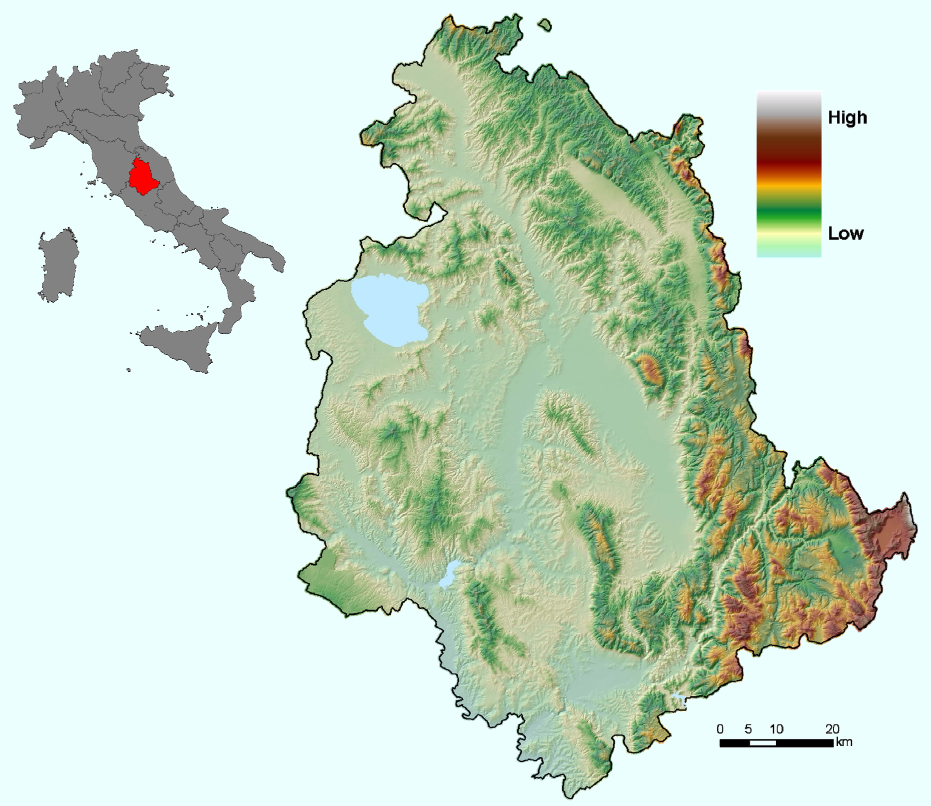
THE 230 METER RESOLUTION DTM



The 230 meter resolution DEM available for the whole Italian country, is based on the "Mean Height Values" compiled by estimating mean elevation values, by both manual and machine methods, on the 1:25.000 scale topographic maps (Carozzo et alii, 1985). The manual data, prepared for central and southern Italy, for Sicily and Sardinia, were read off contour maps using a square-grid template spaced at 7.7 arc-seconds of latitude and 10 arc-seconds longitude. Each point was assigned an altitude value, to the nearest meter, by averaging contour lines and spot heights within each grid square. Machine gathered-data were obtained for the rest of the country (northern Italy) by computer interpolation of digitized contours. The elevations gridded by both methods were organized into 280 separate matrices, each corresponding to an IGMI topographic sheet in the 1:100.000 scale series.

The matrices were assembled in a single DTM at a ground resolution of 230 meter by mosaicking and correcting all the 280 original files (Reichenbach et alii, 1993).

THE 25 METER RESOLUTION DTM
THE UMBRIA REGION

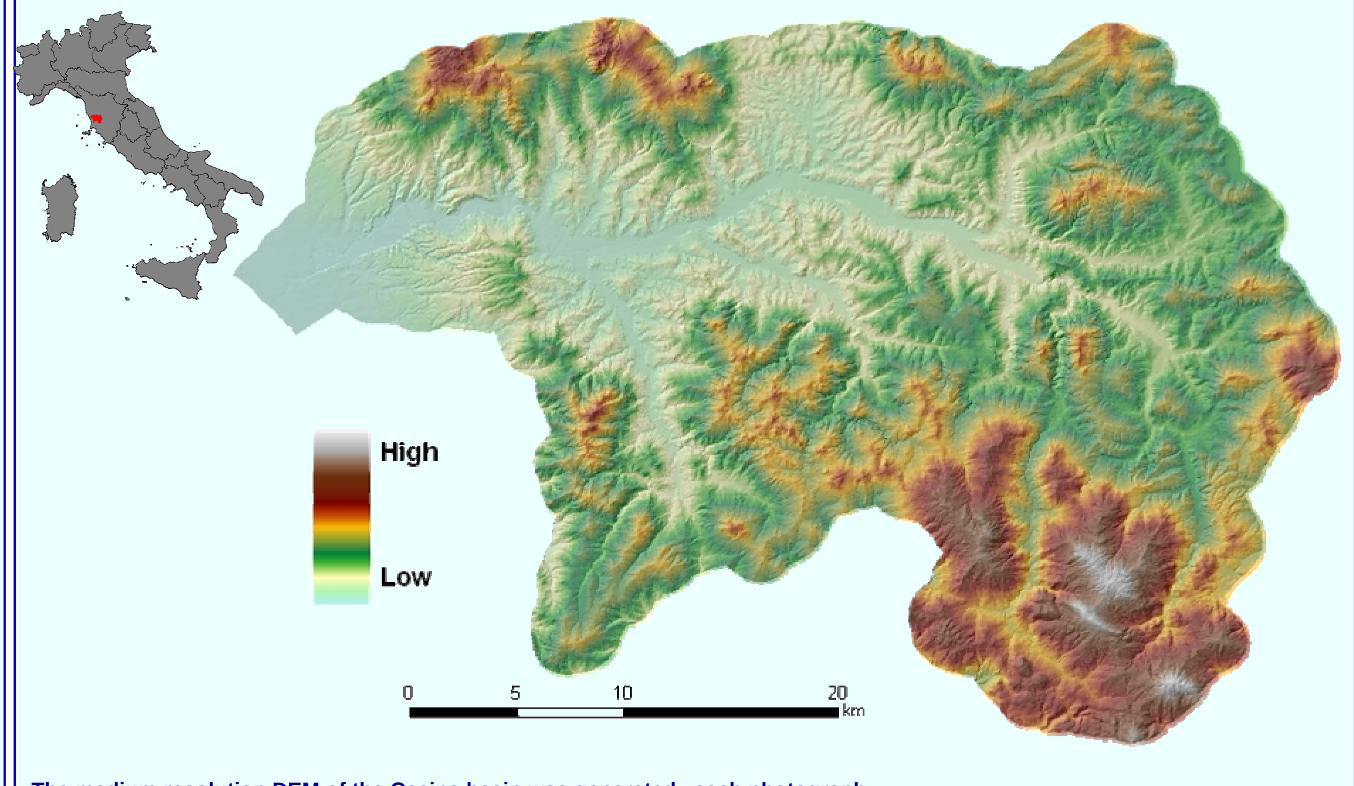


The DEM of the Umbria Region was generated interpolating the contour lines obtained from the IGMI (Istituto Geografico Militare Italiano) 1:25,000 scale topographic maps.

We completed the DEM through several working steps. The first step consisted in a check of the contour lines of the entire IGMI topographic data set to verify and correct the right attribution of the elevation to the lines. Then we checked the exact geometry of the lines and we re-drawn along the rivers or steep scarps all the missing section of the contours. In the second step we assembled 131 IGMI sheets at 1:25:000 scale to obtained 21 tiles which were interpolated to produce a preliminary TIN that was then transformed in a 25 meters ground resolution grid.

The entire Umbria DEM is organized in a matrix of 6542 rows and 4947 columns. Elevations ranges from a maximum of 2400 m a. s. l to a minimum of 40 m a. s. l.

THE 10 METER RESOLUTION DTM
THE CECINA RIVER BASIN



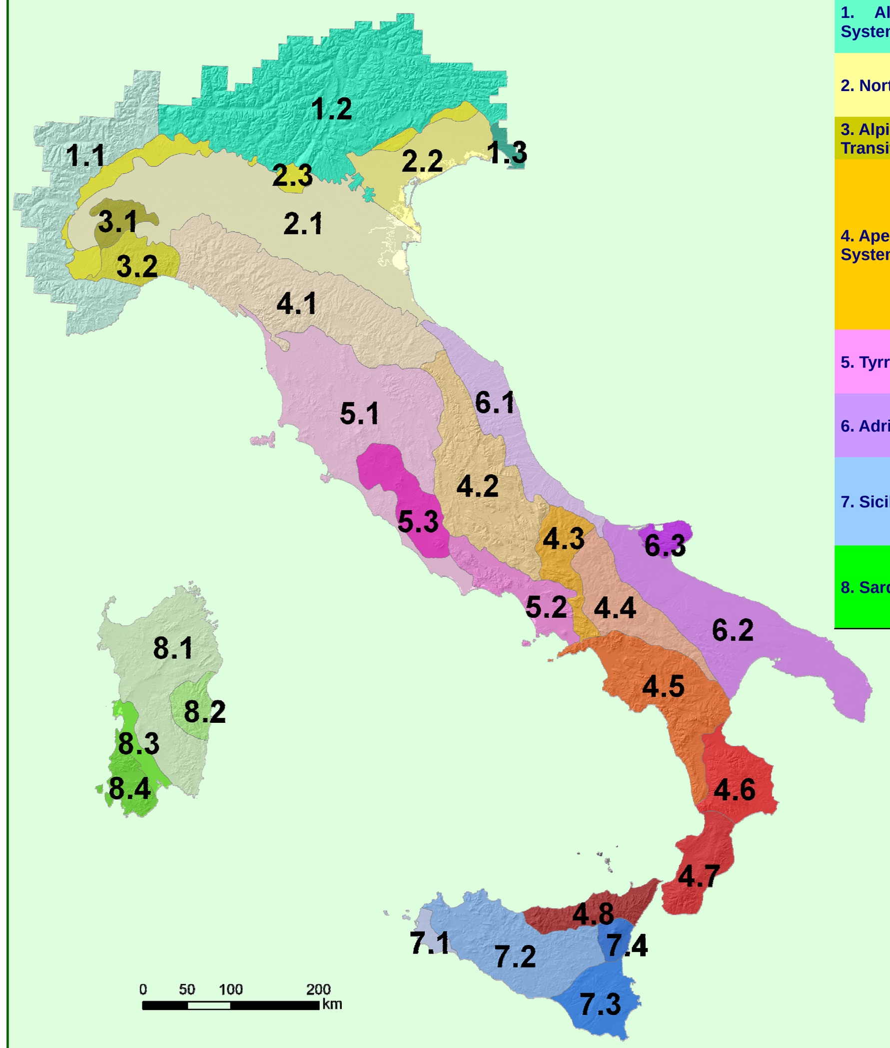
The medium resolution DEM of the Cecina basin was generated from aerial stereo-photographs. The DEM has an horizontal resolution of 10 m and a vertical resolution of 0.1 m with an estimated maximum vertical error of less than 0.5 m where the basin is not covered by closed vegetation. In areas where the basin presents closed vegetation canopies, about 56% of the catchment, the vertical error is larger.

The aerial photographs were acquired on April 2001 from an airplane at an elevation of 3600 feet above the ground surface at a map scale of 1:4000. Kinematics GPS was used to collect high accuracy horizontal coordinates for the centre point of each photograph.

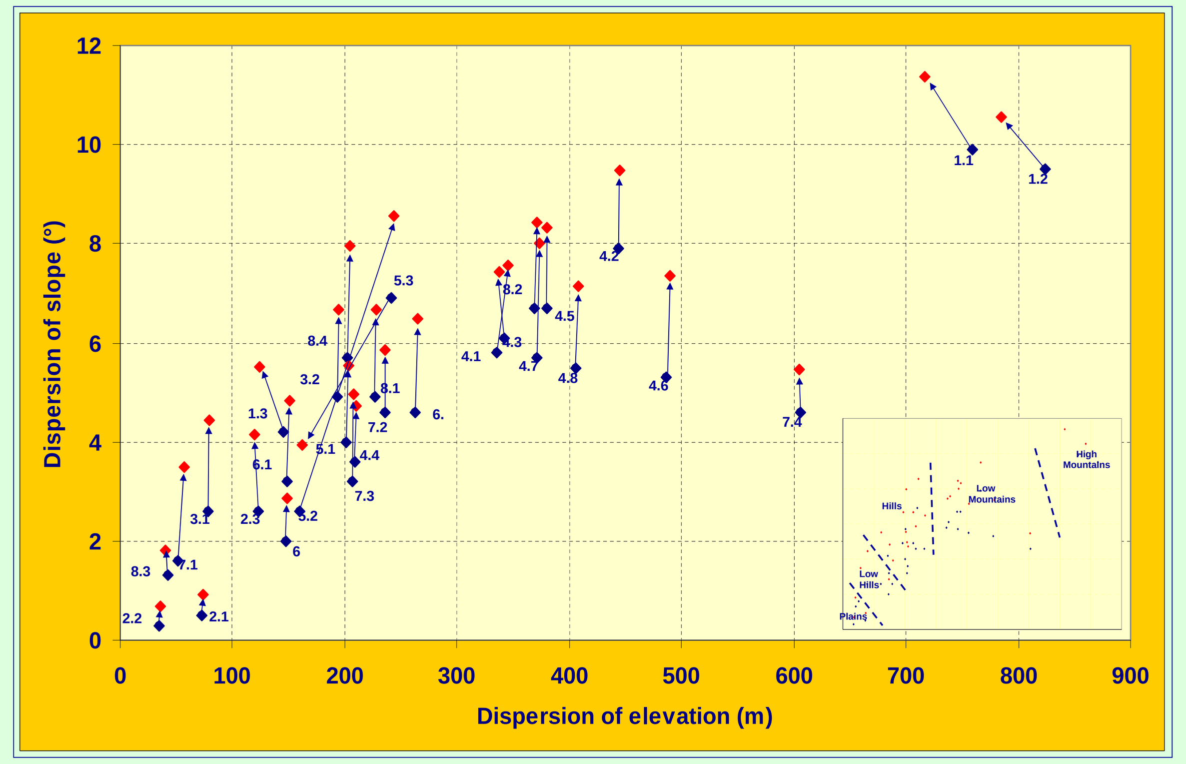
The photos were used as input to a Zeiss P3 analytical stereo data capture system, which scanned the data in sections, creating separate models for each photo pair. Models were projected in UTM coordinates. Elevation values were recorded every 15 m along east-west scan line using automated stereo-plotters. Scan lines for adjacent models were offset by 15 m relative to each other. The data were densified to a 10 m horizontal resolution to generate a grid, using linear interpolation along each scan line and at right angles of the scan lines. Each data point represents the average grid cell elevation.

COMPARING THE SRTM DTM WITH A LOW RESOLUTION DTM
USING THE TOPOGRAPHIC DIVISIONS FOR ITALY

Using the 230m resolution DTM and adopting a semi-quantitative approach that combined an unsupervised three-class cluster-analysis of four derivatives of altitude (elevation, curvature, frequency of slope reversal and elevation relief ratio), visual interpretation of morphometric maps, and comparative inspection of small-scale geological and structural maps, we partitioned Italy into topographic provinces and sections (**map below**) (Guzzetti and Reichenbach, 1994). Provinces are first- order divisions with distinct or unique geomorphologic characteristics that distinguish them from neighbouring areas. Section boundaries are less distinct and generally more open to interpretation.



Major division (Province)	Minor division (Section)
1. Alpine Mountain System	1.1 Western Alps 1.2 Central-Eastern Alps 1.3 Carso
2. North Italian Plain	2.1 Po Plain 2.2 Veneto Plain 2.3 Alpine Foothills
3. Alpine-Apennine Transition Zone	3.1 Monferrato Hills 3.2 Ligurian Upland
4. Apennine Mountain System	4.1 Northern Apennines 4.2 Central Apennines 4.3 Molise Apennines 4.4 Molise-Lucanian Apennines 4.5 Lucanian Apennines 4.6 Sila 4.7 Aspromonte 4.8 Sicilian Apennine
5. Tyrrhenian Borderland	5.1 Central Italian Hills 5.2 Tosco-Laziale Section 5.3 Lazio-Campanian Section
6. Adriatic Borderland	6.1 Central Apennine Slope 6.2 Murge-Apulia Lowland 6.3 Gargano Upland
7. Sicily	7.1 Marsala Lowland 7.2 Sicilian Hills 7.3 Iblei Plateau 7.4 Etna
8. Sardinia	8.1 Sardinia Hills 8.2 Gennargentu Highland 8.3 Campidano Plain 8.4 Iglesiente Hills

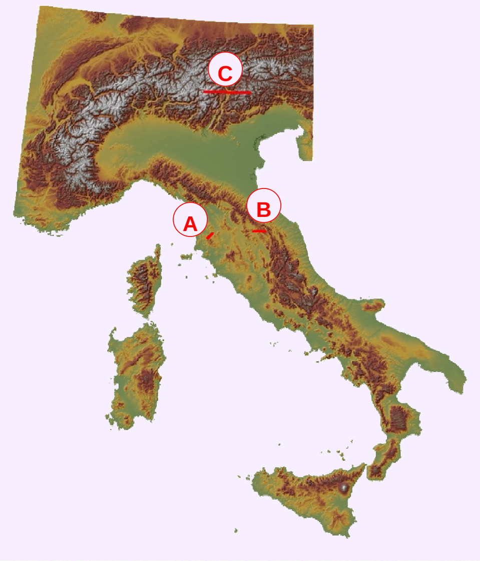


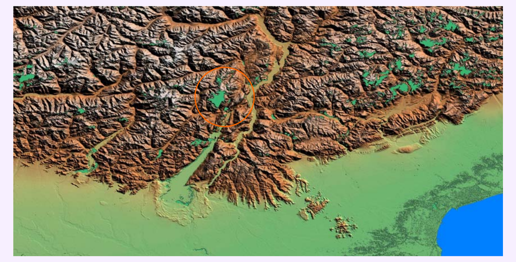
To compare the two national DTMS we analysed the difference of the dispersion of the elevation and of the slope within each topographic subdivision.

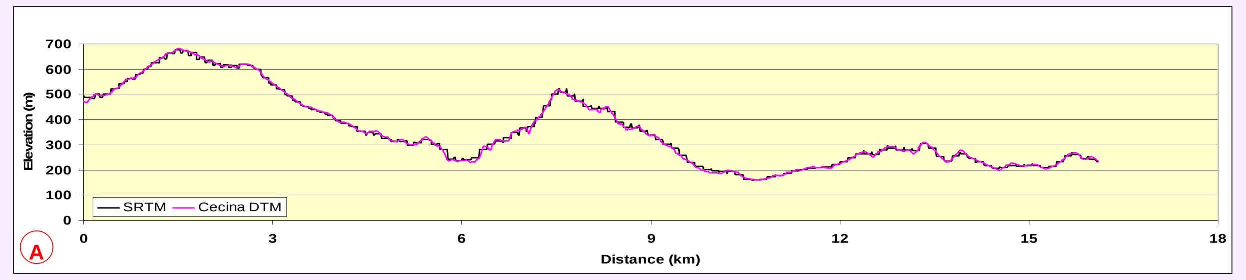
The graph shows the value of the dispersion of elevation and slope for the 230 m DTM (in blue) and the SRTM DTM (in red). The arrows put in evidence the difference between the two dataset. The majority of the subdivision show higher values of slope dispersion taking into account the grid resolution that describe better the roughness of the terrain. Two sections (1.1 and 1.2) show a smaller value of dispersion of elevation that can be explained by the presence of several missing data in the alpine chain. Another major difference is associated with the Tyrrhenian Borderland region where section 5.2 and 5.3 show very different values both in dispersion of elevation and slope. This is mainly due to the fact that the 230m DTM present within the lakes (very abundant in this section) the elevation of the water table level.

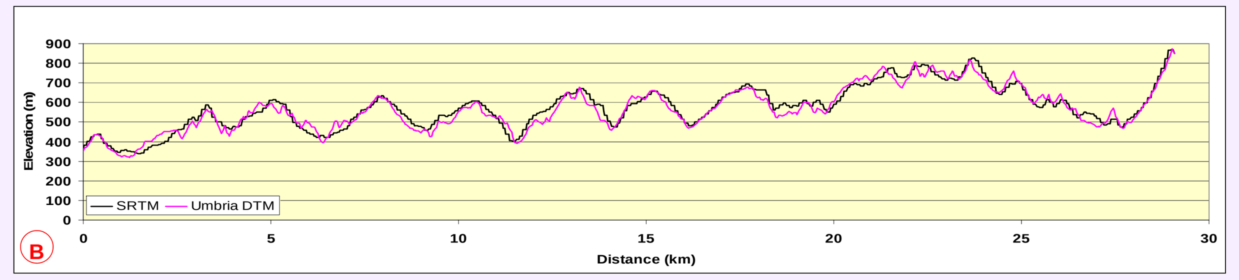
Based on the distribution of morphometric parameters and in particular on the dispersion of elevation and computed gradient (see graph) the 30 topographic divisions were grouped into four main classes or terrain types: plains, low hills, hills, low mountains, and high mountains. The two extremes - plains and high mountains - show very distinct morphometric attributes representing low and gentle versus high and steep terrain types. Between these two extremes low mountains and hills constitute two separate groups.

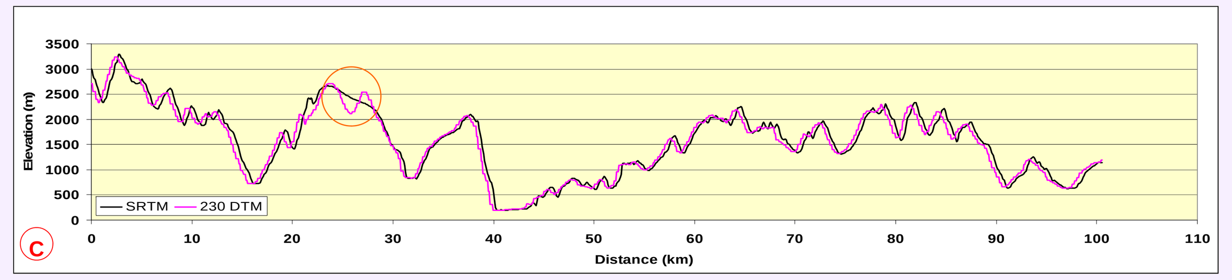
COMPARING THE SRTM DEM ALONG TOPOGRAPHIC PROFILES

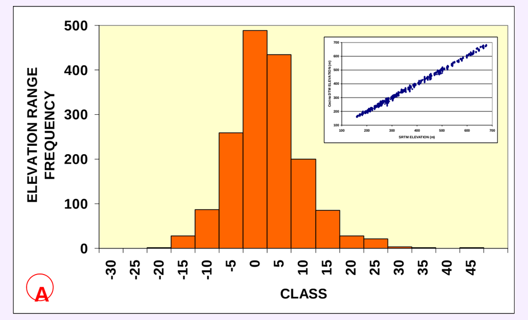


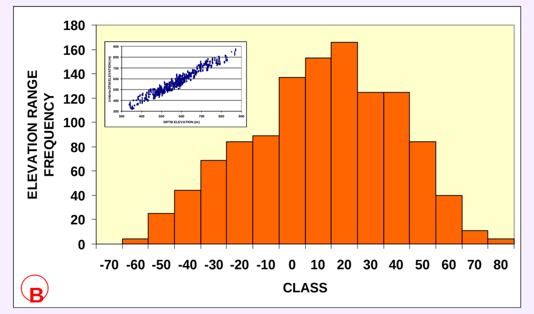


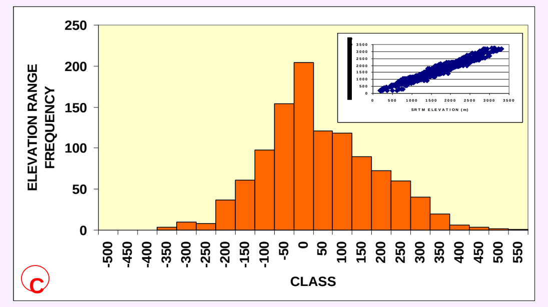












To evaluate the quality of the SRTM DEM, we compared the elevation values with one low resolution DEM (230m resolution) and two medium resolution data sets (25m and 10m resolution). The comparison was performed on pixel base along three different topographic profiles. The first profile was traced in the Cecina DEM along the River Pavone Valley, the second profile in the Umbria region along the Città di Castello area and the third profile in Northern Italy along the northern part of the Garda Lake trough a big missing pixel hole.

The SRTM/DTM 230m profile above show that the SRTM elevation values are not consistent in the interpolated area (red circle). The relative difference between the two values for each single point in the Histogram underlined the problems of shadowing effects in steep areas. The dispersion of the difference have an high frequency in this comparison.

In the SRTM/DTM 25m profile comparing the two different data sources, we see that vast contiguous areas of SRTM elevation cells are either significantly below or above the range of values found in the DEM 25m data source.

On the comparison of the Cecina DTM and the SRTM data, the SRTM elevation values were closer to the DTM 10m elevation values. The biggest difference between SRTM and DTM 10 m elevations was 20m. SRTM data underestimated the elevation on less occasions compared to the other two profiles. In lowland area the estimation error of the elevation is low than the steep areas.

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MORE INFORMATION???
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