Derivation of channel network of an alpine region from high-resolution DTMs: the example of the Autonomous Province of Trento (Italy)

M. Cavalli[1], S. Trevisani[2], B. Goldin[1], E. Mion[1], L. Marchi[1]

[1] **National Research Council of Italy - Research Institute for Hydrogeological Protection, Padova, Italy** ***(marco.cavalli@irpi.cnr.it)***

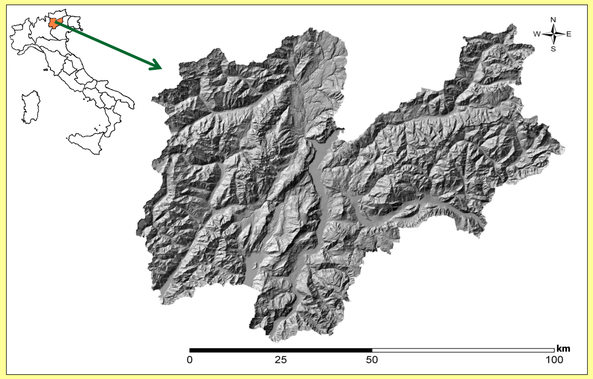
[2] **University IUAV of Venice, Faculty of Architecture, Venezia, Italy**

Introduction

The mapping of the channel network plays a fundamental role in different landscape management issues, such as technical cartography, water resources management, geo-hydrological risk analysis, and legal matters related to land use. LiDAR-derived, high-resolution digital terrain models (HR-DTMs) of regional coverage open interesting prospects for the analysis of landscape, including derivation and analysis of channel network.

We present our experience in the derivation of channel network from regional HR-DTM for an alpine region (Autonomous Province of Trento, Northern Italy).

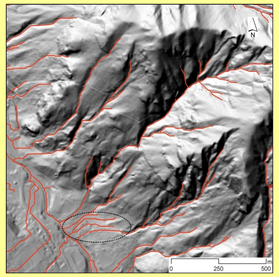
Study area



- The Autonomous Province of Trento covers an area of 6210 km^2 and has a total population of 507,030 (2006);
- landscape is orographically complex; about 70% of the area lies above 1000 m, with a mean elevation of 1400 m;
- geology is characterized by a high variety of lithotypes; Quaternary deposits are widespread;
- forests cover around 50% of the territory; valley floors are mostly occupied by agricultural areas; mountain grassland and bare land are present at the highest elevations;
- a LiDAR-derived DTM with a resolution of 2 m covers the whole territory .

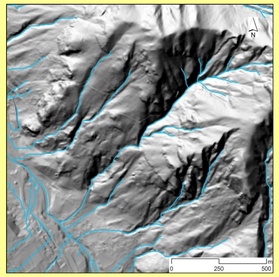
Channel network extraction

A preliminary analysis was conducted in order to test different algorithms for extracting a preliminary ('raw') channel network from the HR-DTM.



Slope-Area method

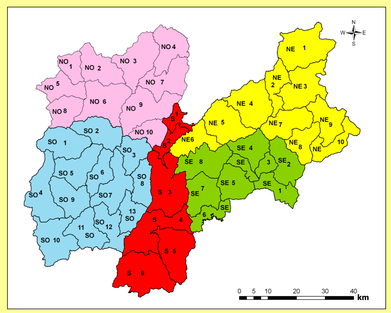
This approach identifies channel heads based on a combined threshold of upslope area and local slope. This method required some adjustments in slope calculation in order to achieve a reliable channel network when a HR-DTM is used.



Curvature-based method

The algorithm (Tarboton & Ames, 2001) first identifies upwards curved grid cells. A raster map of drainage area is then computed on upwards curved grid cells. A threshold is applied to this map to delineate channels.

Both approaches generate suitable results in terms of drainage density and channel heads location; the curvature-based algorithm was preferred for its better performance in low-slope areas (see the images above).



Automatic derivation of the raw channel network:

- A resolution of 4 m of the LiDAR DTM has been chosen to achieve the optimal trade-off between the high detail required and the large extent of the areas to be analysed;
- Due to the difficulties to manage a unique 4 m DTM of the Province, the study area has been divided into 5 macroareas (North-East, North-West, South, South-East, South-West) in which the basic layers (depitted DTMs, flow directions, upslope areas) have been derived;
- A further subdivision into 47 hydrologic drainage basins was necessary in order to define, for homogeneous areas, the appropriate thresholds for channel extraction.

Channel network supervised analysis

The raw channel network needs a supervised control aimed to check the spatial pattern of the channels and to classify every reach of the hydrographic network into one of the following three classes:

1. Real (existing channels);
2. Virtual (virtual connections in correspondence of lakes or linking isolated channel reaches to major streams);
3. Covered (in correspondence of culverts and bridges).

The supervised analysis was carried out by means of different informative layers that can be grouped into three main classes:

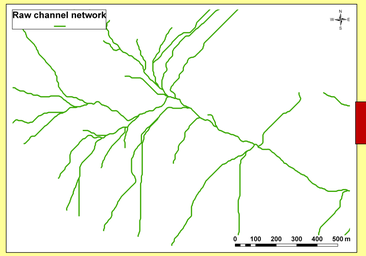
- geomorphometric indexes derived from HR-DTM: 2 m resolution shaded relief map, openness (Yokoyama et al., 2002), local anomalies (calculated as the difference between the original and a smoothed version of the DTM), plan curvature;
- high-resolution orthophoto imagery (panchromatic and near-infrared);
- technical cartography (1:10000, 1:25000).

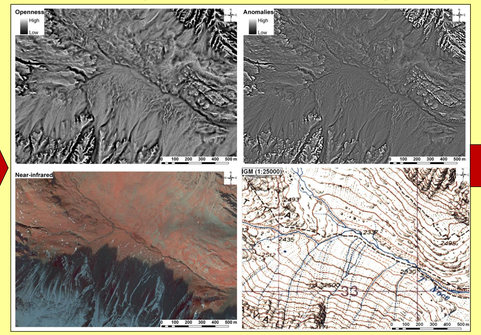
Covered channel reaches are easily classified in GIS environment by intersecting the layer of road network with the supervised channel network.

Field surveys are required to refine the channel network in urbanized areas, in which automatic channel network extraction often fails and supervised control is not able to detect the real location of the channels.

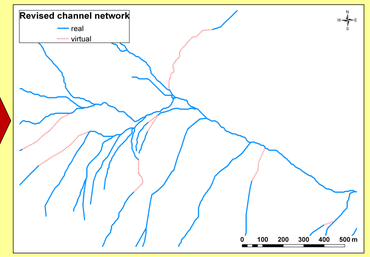
Geomorphometric and thematic layers

Raw channel network





Revised channel network



Conclusions

- A two-steps procedure (automatic extraction and supervised control) has been implemented for the derivation of the channel network from a high-resolution digital terrain model at regional scale.
- The procedure provides satisfactory results in areas less affected by human activities, also in presence of dense vegetation cover and complex morphology.
- In urban areas, and in other zones with a strong anthropic influence, the GIS-derived channel network has to be complemented and corrected by means of field surveys.
- This approach is a cost/time efficient methodology that fits well with the needs of a dynamic and constantly up-to-date cartography.

References

Yokoyama R., Shirasawa M., Pike R., 2002. Visualizing topography by openness: a new application of image processing to digital elevation models. Photogrammetric Engineering and Remote Sensing, 68, 257- 266.

Tarboton D. G., Ames D.P., 2001. Advances in the mapping of flow networks from digital elevation data, in World Water and Environmental Resources Congress, Orlando, Florida, May 20-24, 2001, ASCE.

Acknowledgements

This study has been funded by Provincia Autonoma di Trento – Servizio Bacini montani, in the context of the implementation of the map of natural hazards.