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This is the author's manuscript

Original Citation:

Availability:

This version is available http://hdl.handle.net/2318/1637358 since 2017-05-25T12:42:06Z

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(Article begins on next page)

13 December 2025

Living Planet Symposium 2016—Prague, Czech Republic from 9-13 May 2016

Application of CurvaTool, a Tool for Semi-Automatic Linear Feature Detection, to TanDEM-X Intermediate DEM, SRTM and ASTER Global DEMs – a Case Study from NW Italy

Sabrina Bonetto[1], Anna Facello [2,3], Gessica Umili[1]

[1]Department of Earth Sciences, University of Turin, Valperga Caluso 35, 10125 Turin, Italy (sabrina.bonetto@unito.it) (gessica.umili@unito.it) [2] CNR-IRPI, Strada delle Cacce,73 - 10135 Torino, Italy.; [3] TriM– Translate into Meaning srl, Torino Italy.

Corresponding author (anna.facello@irpi.cnr.it)

1. INTRODUCTION

In recent years, space-borne satellite and high altitude aircraft images and their products, such as Digital Terrain Models (DTM) and Digital Elevation Models (DEM), have been providing observations of geological lineaments and their relationships to nearby geomorphic and geological features.

In this work, a TanDEM-X IntermediateDEM (scientific proposal DAMAGE IDEM-DEM_GEOL0206) of a geologically well-known area (the Maritime and Ligurian Alps domain) has been processed by CurvaTool code (1). The obtained results have then been compared to those obtained from SRTM and ASTER GDEM. The purpose of this work was to compare the results obtained from DEMs in order to validate the quality and accuracy of TanDEM - X IntermediateDEM.

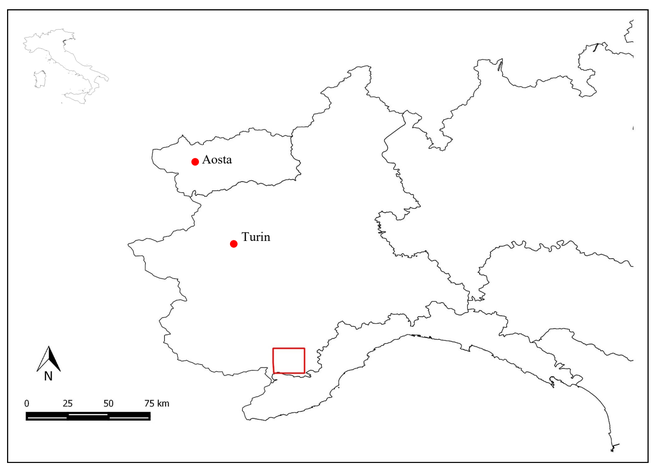


Figure 1 - The analysed areas, Maritime and Ligurian Alps domain (Italy).

2. METHODOLOGY AND DATA

21 Methodology

CurvaTool code (2) is based on the assumption that usually a surface geological lineament can be geometrically identified as a convex or concave edge of the surface of a DEM, particularly in presence of a structural control of the geomorphological evolution of the analyzed area. The code requires the user to fix a pair of thresholds (Tmax, Tmin) in order to identify and extract interesting linear features. The first one (Tmax) on maximum principal curvature, to detect points belonging to significant convex edges, and the second one (Tmin) on minimum principal curvature, to detect points belonging to significant concave edges (Table 1).

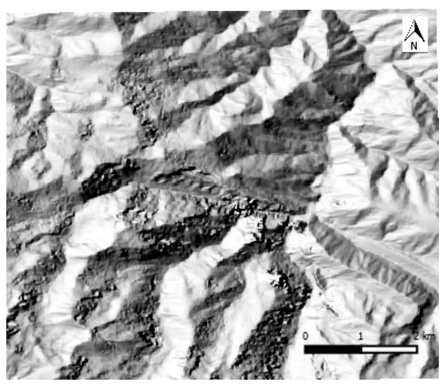


Figure 2—TanDEM-X IDEM 30m (hillshade)

Table 1

	Tmax	% accepted points	Tmin	%accepted points
Aste GDEM 30m	0.003	21.0	-0.003	18.8
Srtm 30m	0.003	20.2	-0.003	17.9
Tandem X 30m	0.003	24.7	-0.003	20.2
Tandem X 12m	0.008	20.0	-0.006	18.7

2.2 Dataset

(i) TanDEM-X IntermediateDEM, resolutions of 1 (30m) and 0.4 arc-second (12m);

(ii) Shuttle Radar Topography Mission (SRTM), resolution of 1 arc-second (30m);

(iii) ASTER Global Digital Elevation Model (ASTER GDEM), resolution of 1 arc-second (30m).

3. RESULTS AND DISCUSSION

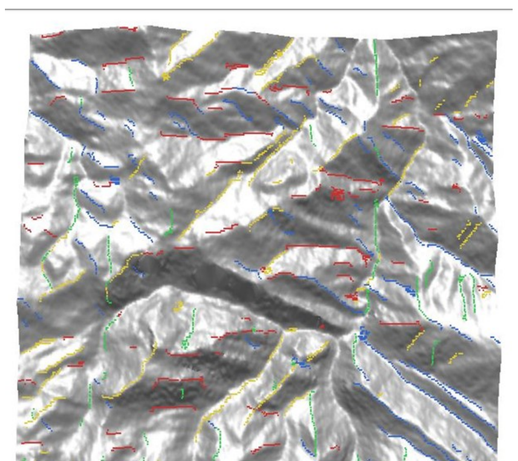
DEMs have been processed by means of CurvaTool software, obtaining respectively 469 linear features from SRTM 30m, 549 from ASTER GDEM 30m, 641 from TanDEM-X 30m and 4462 from TanDEM-X 12m (Figure 3).

Four set orientations were identified, according to geomorphological and structural literature data. In Filters have been applied to semi-automatically detect linear features in order to perform a cluster analysis and therefore to correctly assign them to the four different sets (Figure 4). Filter code operates the classification of the dataset attributing each edge to the correspondent input set (angle measured clockwise respect to the N and the relative variability range as the standard deviation). Non-classified edges are recorded as “others”.

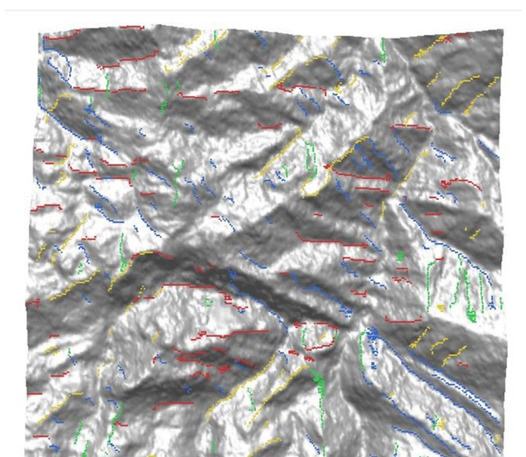
Filters are consistent with the sets direction identified by the literature:

EW: 90° (+-10 standard deviation)
NS: 181 (+-10 standard deviation)
NE-SW: 225°(+-10 standard deviation)
NW-SE: 315°(+-10 standard deviation)

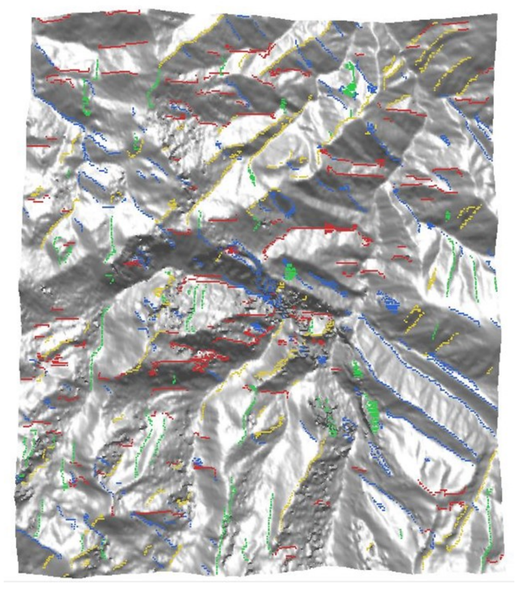
Figure 4—Image of shaded DEM with lineaments extracted by CurvaTool and processed with Filter. corresponding to: set1(EW, red), set2(NS, green), set3(NE–SW, yellow) and set4(NW–SE blue).



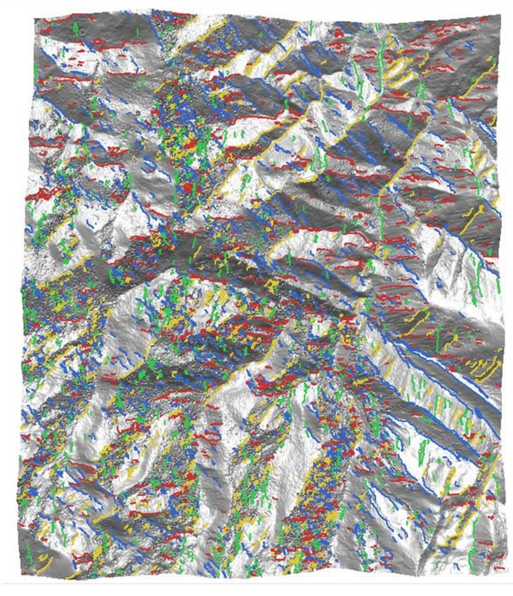
SRTM_30m



ASTER GDEM_30m

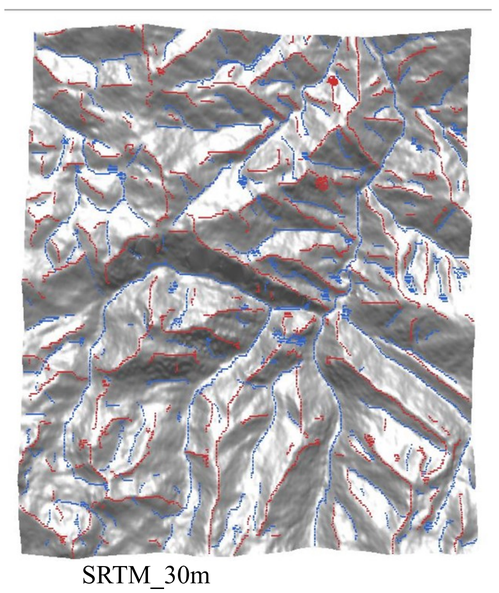


TanDEM-X 30m



TanDEM-X 12m

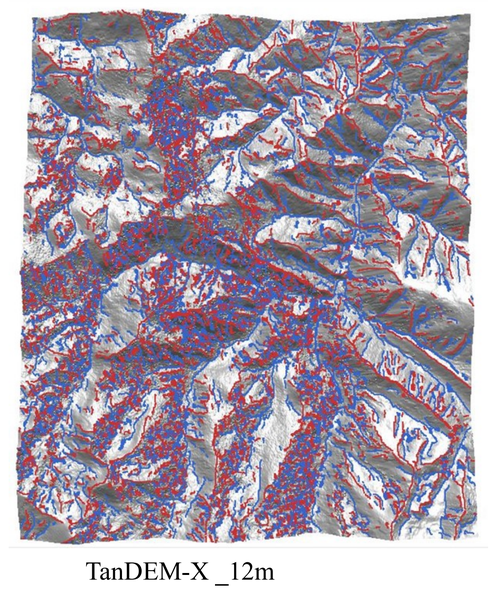
Figure 3 - Map of linear features extracted by CurvaTool, distinguished into ridges (red) and valleys (blue). A ridge is an edge formed by vertices which correspond to positive values of maximum principal curvature. Similarly,a valley is an edge formed by vertices which correspond to negative values of minimum principal curvature .



SRTM_30m

ASTER GDEM_30m

TanDEM-X _30m



TanDEM-X _12m

Table 3 shows the number of linear features (%) assigned to each set, while Table 4 indicates the number of unclassified features (%) according to the assigned filter.

It is possible to observe that for all the 30 m resolution DEMs the percentage of assigned linear features is more than 50%, in particular TanDEM-X (30 m) presents he greater value, slightly higher than that of SRTM.

Table 3—Number of linear features (%) assigned to each set

% tot	Srtm 30m	Aste GDEM30m	Tandem X 30m	Tandem X 12m
Set 1	16.0%	14.0%	17.9%	14.1%
Set 2	9.8%	10.0%	9.8%	12.1%
Set 3	12.8%	11.3%	11.9%	12.0%
Set 4	20.5%	20.2%	20.1%	19.3%
TOTAL	59.1%	55.5%	59,7%	57.5%

Table 4—Number of linear features (%) that were not assigned to one of the four sets.

Not classified	Srtm_30m	Aster-GDEM_30m	Tan-dem_X_30m	Tan-dem_X_12m
N° lineamenti	192	244	258	1896
% tot	40.9%	44.4%	40.2%	42.5%

Generally, TanDEM X IDEM (in particular the 12 m resolution one) gives a slightly higher percentage of extracted lineaments with respect to ASTER and SRTM global DEMs. However, 12 m resolution TanDEM X IDEM suffers from a high level of noise on the surface, therefore it could need a pre-processing step in order to be ready for the linear features extraction.

Also, the results of this application are intersting in terms of effectiveness of the assessment of potential geological lineaments. The semi-automatic process for linear feature detection shows two great advantages in respect to the manual process: first of all it allows for the identification of the most interesting portions of territory, which require to be furtherly investigated in detail; moreover, it allows the user to analyze zones that are not directly accessible.

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(2) Umili G., Ferrero A.M., Einstein H.H. (2013). A new method for automatic discontinuity traces sampling on rock mass 3D model. Computers & Geosciences 51: 182–192

ACKNOWLEDGEMENTS

The TanDEM-X IDEM data is provided by the German Space Agency. The authors are grateful for the provision of the data (methoDs bAsed on digital elevation models to Monitor and Analyse GEostructural hazard (DAMAGE) Proposal: IDEM_GEOL0206).