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DEM smoothing to avoid the staircase effect of coarse DEM

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Sébastien Lehmann, Hervé Squvidant, Nicolas Saby, Jean-Baptiste Paroissien, Rossano Ciampalini, et al.. DEM smoothing to avoid the staircase effect of coarse DEM. Global Soil Map, Oct 2013, Orléans, France. pp.1. hal-01209158

HAL Id: hal-01209158

<https://hal.science/hal-01209158v1>

Submitted on 6 Jun 2020

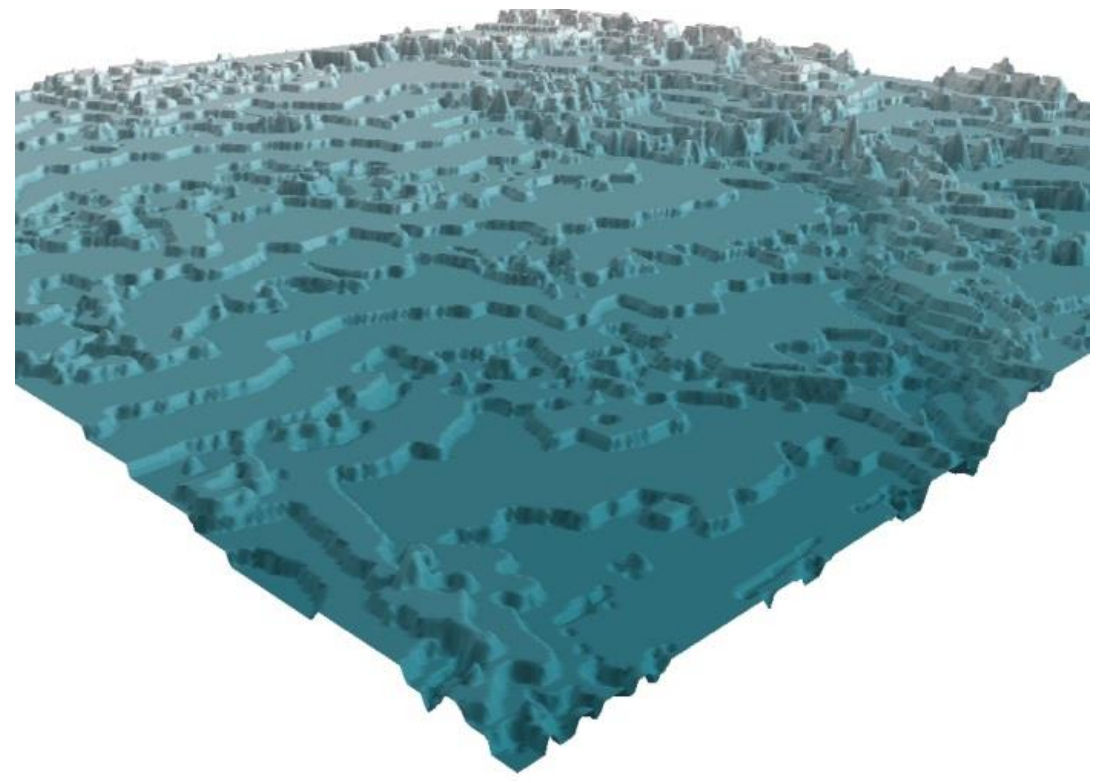
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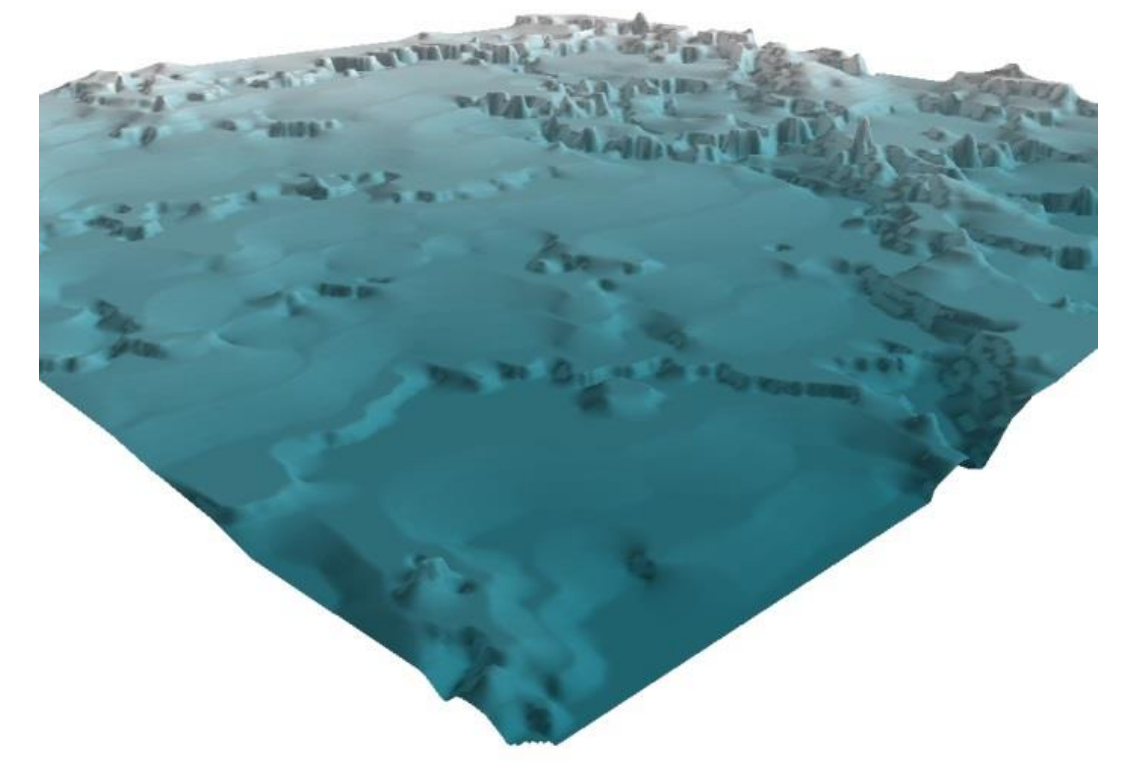
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INTRODUCTION

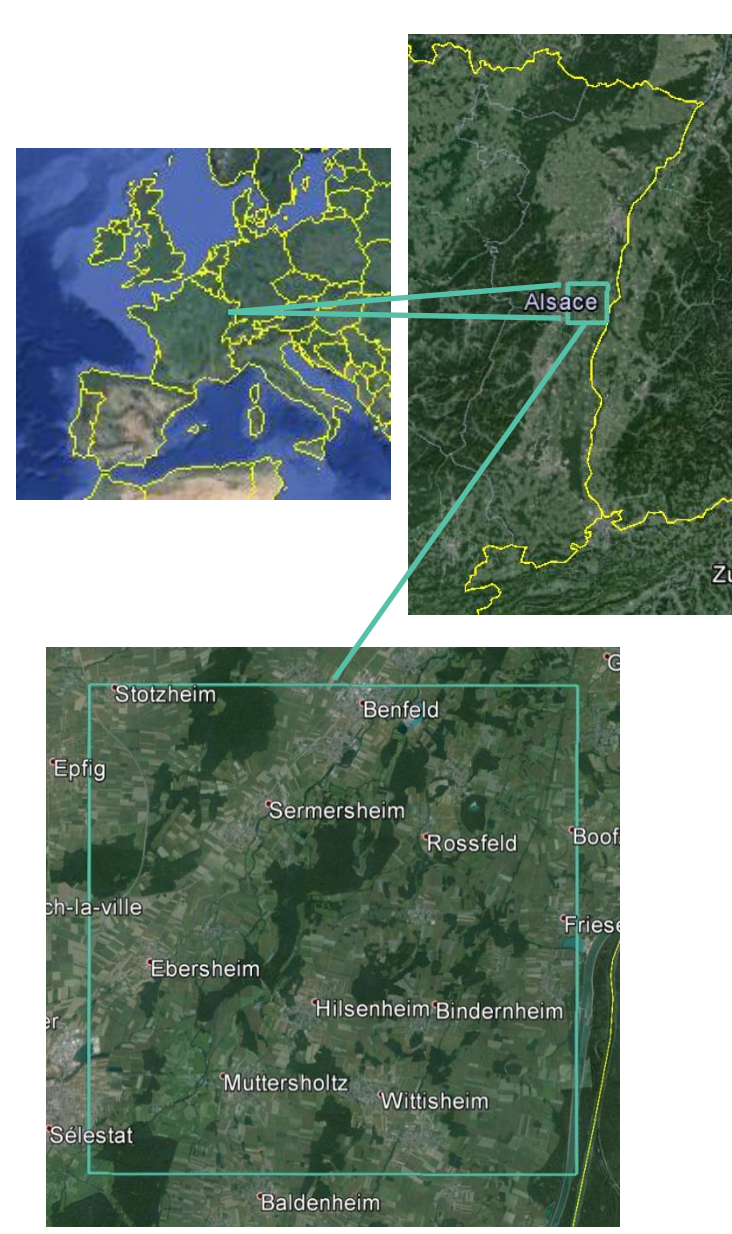


In the case of delineation of wetlands, the Terrain Wetness Index (Beven and Kirkby, 1979) is particularly relevant but also sensitive to flat areas. The altitudinal resolution also has a strong influence on variable because it affects directly slope calculation. A metrical resolution in elevation for a 25 m DEM (horizontal resolution), as provided by the IGN (French National Geographic Institute), leads inevitably to a staircase effect with leaps over large surfaces which wrongly appear as flat and straight.



The study shown here compares different methods of DEM smoothing which can be used to mitigate the staircase effect and produce a more realistic model with a decimetric altitudinal resolution.

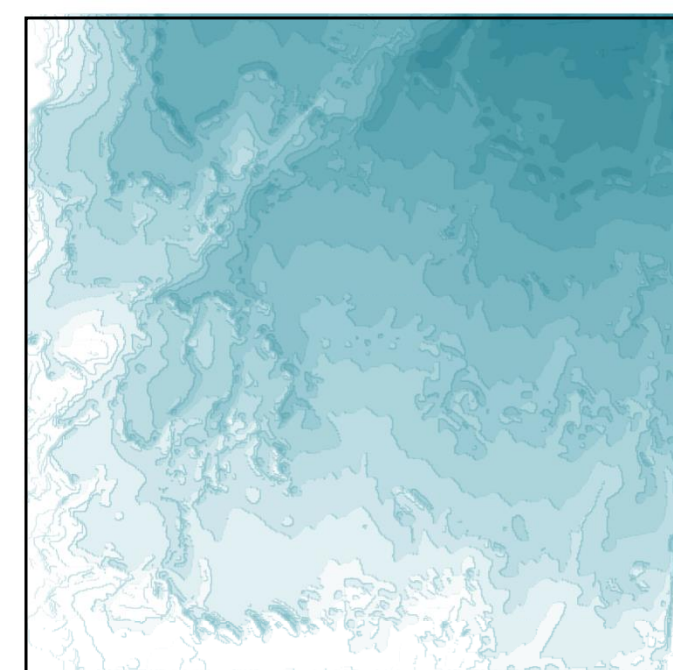
MATERIAL & METHOD



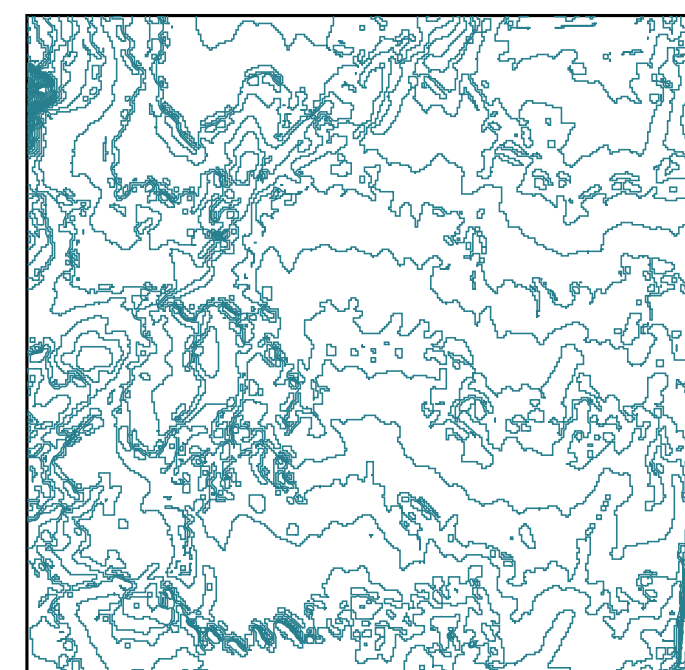
15km
Study area located in North-East France, In Alsace region

Area : 225 km²
Parent Material : Recent alluvial deposit from the Rhine (Holocene)
Morphology : Rhine valley with a very low slope oriented to the NE.
Land-use : Intensive agri & forest
Climate : Semi-continental
Mean annual T : 10° C
Total annual precipitation : 600mm

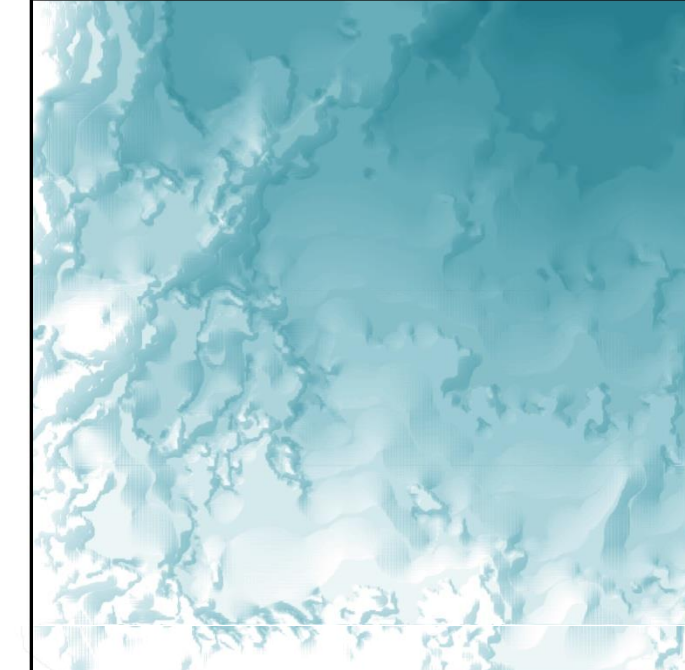
Original DEM Elevation (m)
high : 191
low : 154



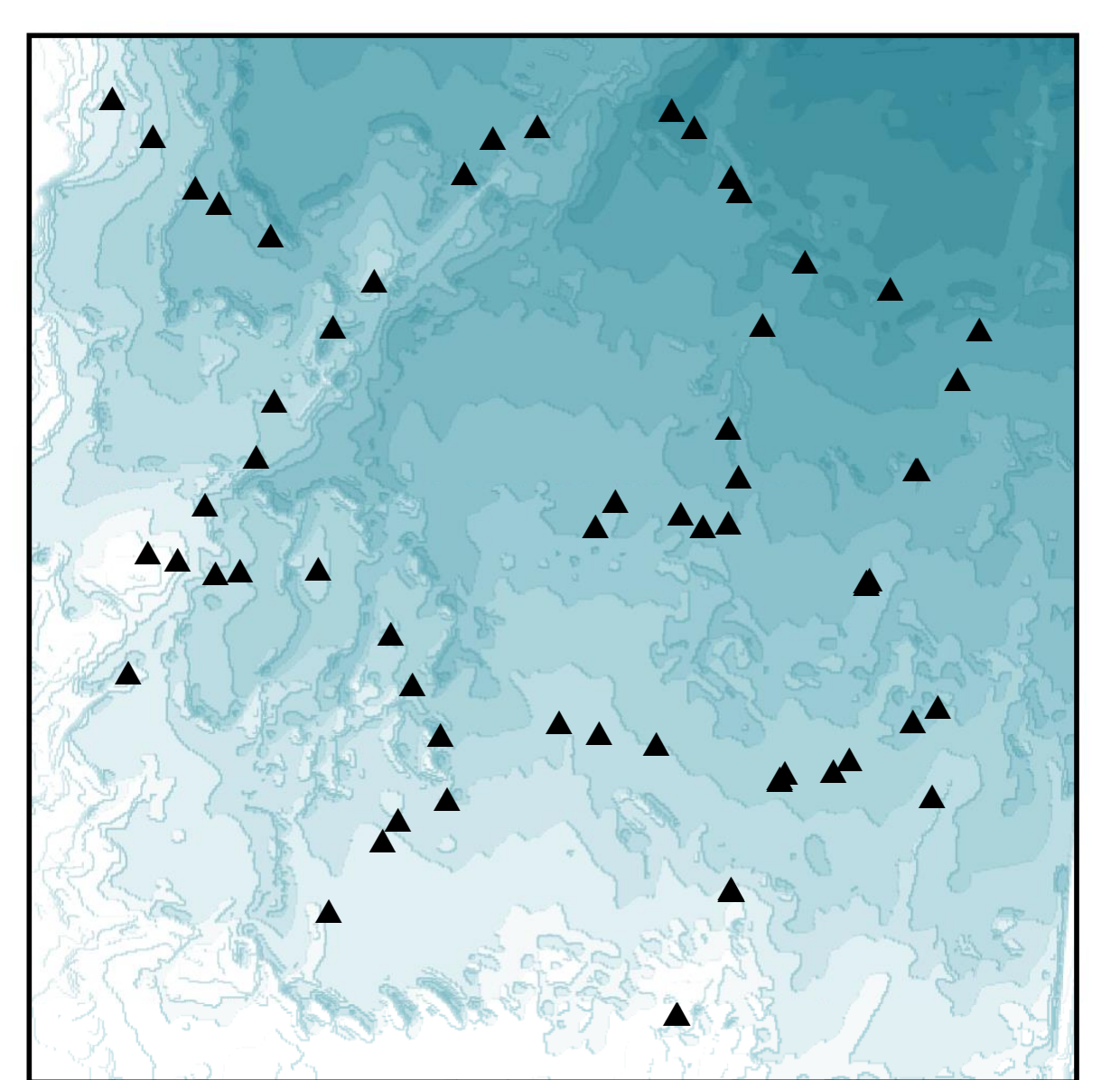
Isolines of Elevations (m)



TIN Interpolation Elevation (m)
high : 191
low : 154



▲ Measured altitude

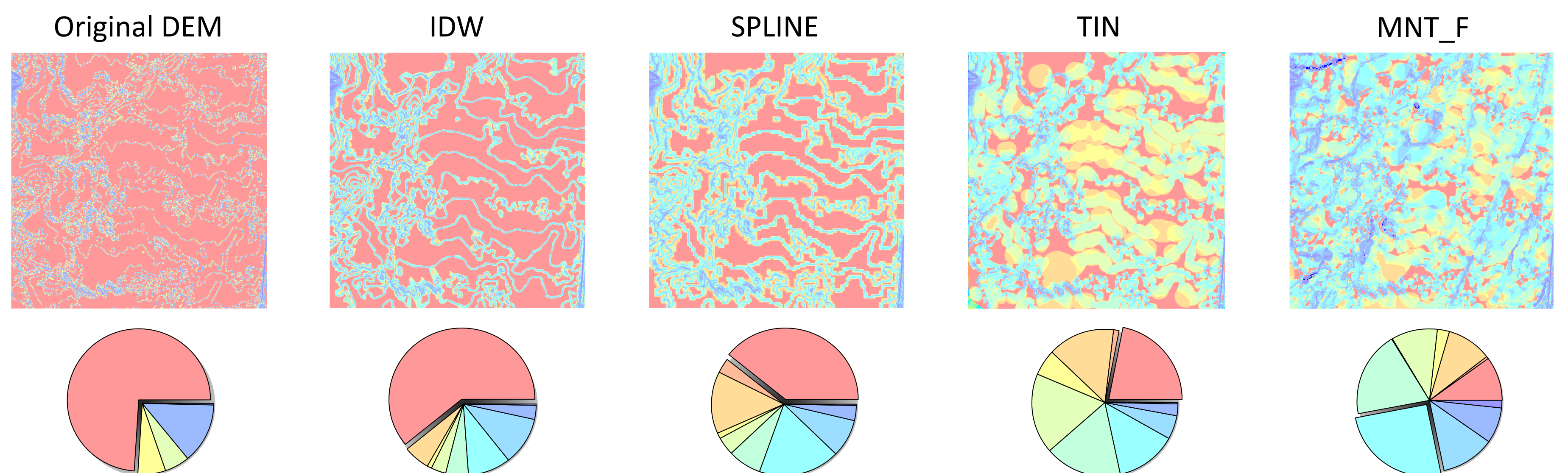
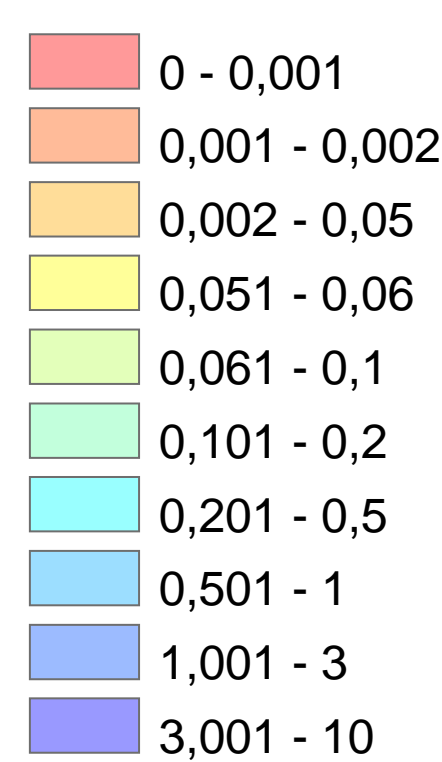


The original DEM is converted into isolines of Elevations or single points situated on those lines. The elevations data from the original DEM are then interpolated using several methods implemented in ArcGis (ESRI, 2011) : Inverse Distance Weighted interpolation (IDW), Spline function with tension (Franck, 1982) (SPLINE), Triangular Irregular Networks (Edelsbrunner, 1996) (TIN), Terrain function integrating topographic breaklines (MNT_F). The interpolations are validated by a dataset of 60 geodetic points measured by the IGN with centimetric precision.

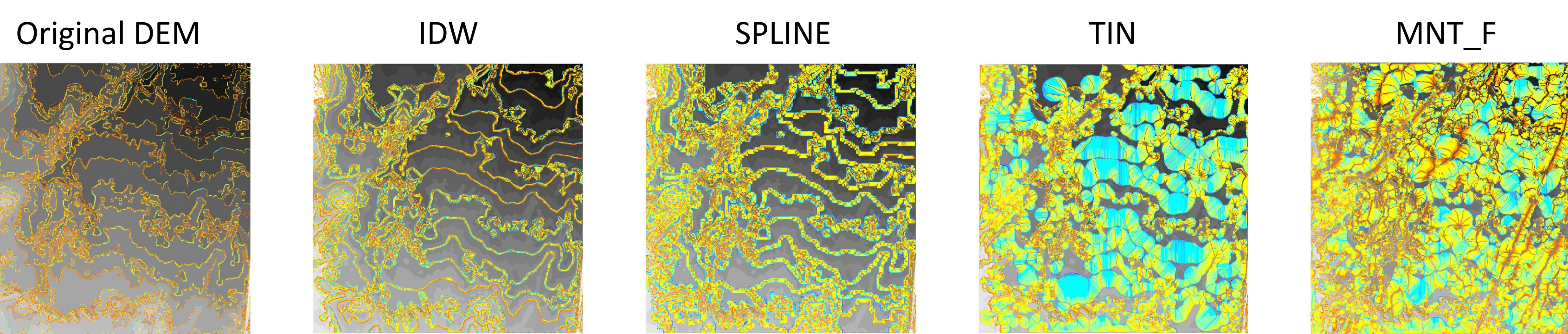
RESULTS

The original DEM shows a majority of its surface (75%) covered with slopes equal to 0. The proportion of null slopes decreases with the following interpolations : IDW (66%), Spline (34%), TIN (23%), MNT_F (12%). The MNT_F interpolation gives a majority of slopes (25%) between 0,2 and 0,5 degree.

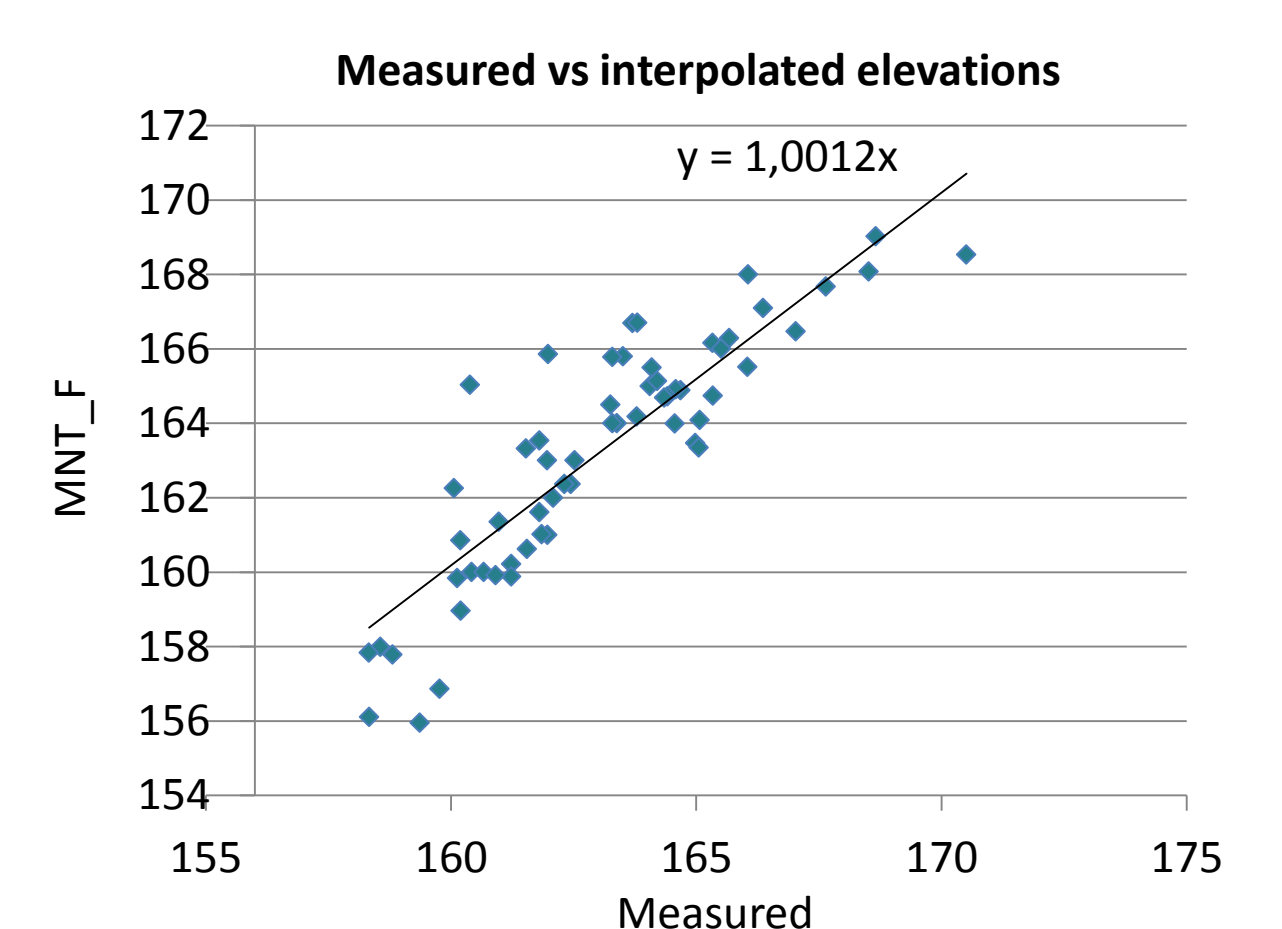
Slope (degree)



TWI value
No data (Elevation)
-9 - -4
-3 - 1
2
3 - 4
5
6
7 - 8
9 - 11
12 - 16
17 - 21



The Terrain Wetness Index (TWI) is directly correlated with the slope gradient. It appears that the TIN and MNT_F interpolations improve consequently the quality of this index. The MNT_F which takes into account the orographic and streams lines with their real elevations (given by the IGN BD_TOPO) is obviously the more realistic. The accuracy of the index calculation is validated with the Pearson coefficient comparing interpolated elevations and the elevations measured on the geodetic points.



Pearson product-moment correlation coefficient for all interpolations compared with the measured elevations

Elevation	original DEM	IDW	SPLINE	TIN	MNT_F
measured	0,904	0,919	0,917	0,911	0,935

CONCLUSION - PERSPECTIVES

We show that using a triangular irregular network interpolation, plus hard lines (streams and orographic lines) as calculated by the Terrain function in ArcGis, significantly improves the suitability of resulting DEM to calculate the TWI. To finish the demonstration, this results should be compared with observations of wet soils in the same region and with a more accurate DEM (e.g. LiDAR DEM).

References

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