DEM smoothing to avoid the staircase effect of coarse DEM

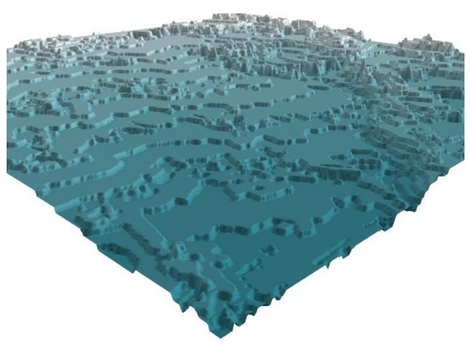
Sébastien Lehmann, Hervé Squividant, Nicolas Saby, Jean-Baptiste Paroissien, Rossano Ciampalini, Manuel Martin

DEM smoothing to avoid the staircase effect of coarse DEM

Lehmann S.[1], Squividant H.[2], Saby N.P.A[1], Paroissien J-B[1], Daroussin J.[3], Ciampalini R.[1], Martin, M.P.[1]

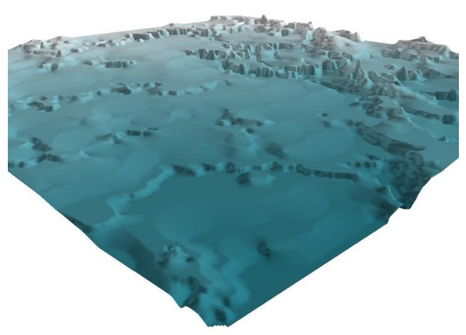
Contact : sebastien.lehmann@orleans.inra.fr

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.

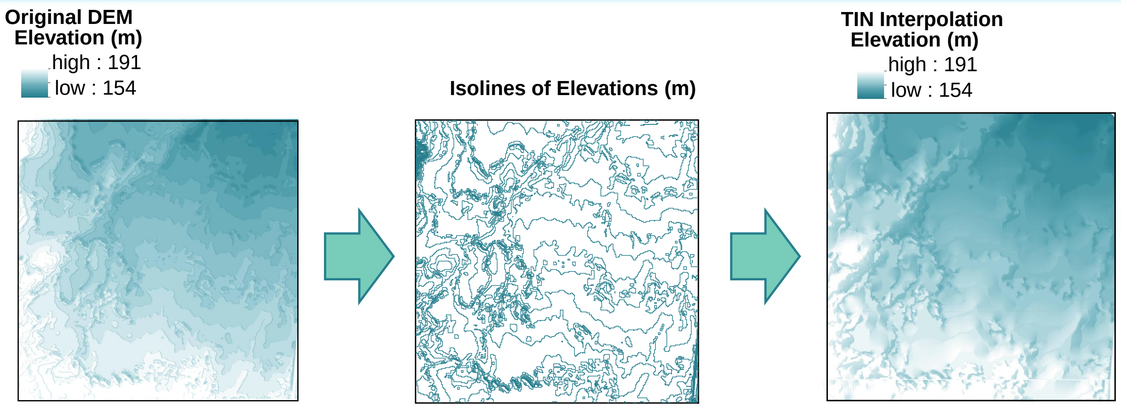
The study shown here compares different methods of DEM smoothing which can be used to mitigate the staircase effect and produce a more realistic model with a decimetric altitudinal resolution.



MATERIAL & METHOD

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

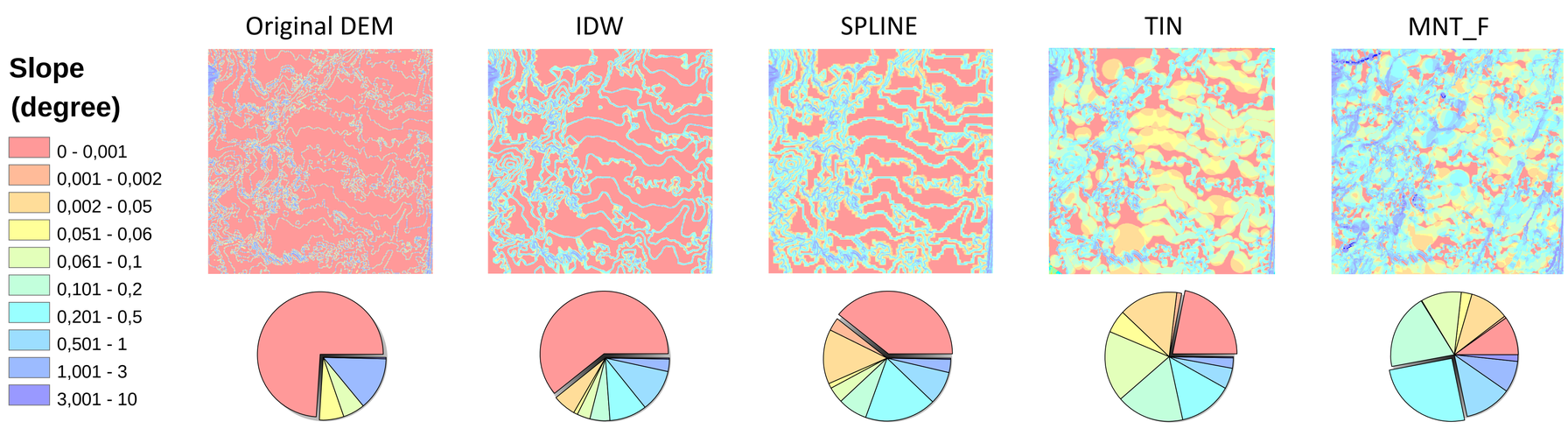
Area :
225 km²
Parent Material :
Recent alluvial deposit from the Rhine (Holocene)
Morphology :
Rhine valley with a very low slope oriented to the NE.
Land-use :
Intensive agri & forest
Climate :
Semi-continental
Mean annual T : 10° C
Total annual precipitation : 600mm

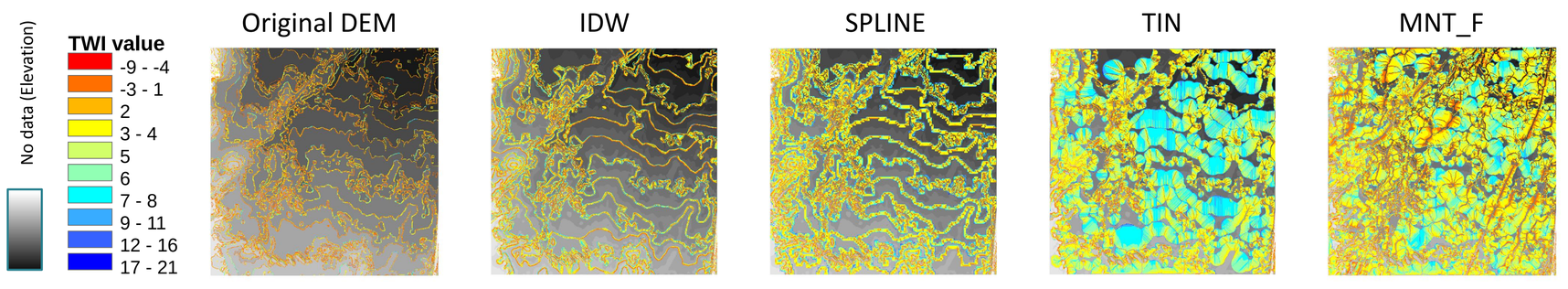


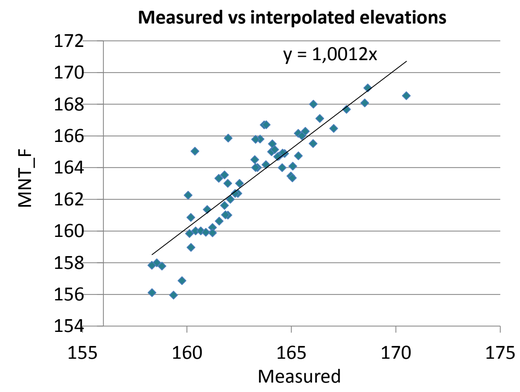
The original DEM is converted into isolines of Elevations or single points situated on those lines. The elevations data from the original DEM are then interpolated using several methods implemented in ArcGis (ESRI, 2011) : Inverse Distance Weighted interpolation (IDW), Spline function with tension (Franck, 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.







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 obvioulsly 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
Beven, K.J., Kirkby, M.J., 1979. A physically based, variable contributing area model of basin hydrology. *Hydrological Sciences Bulletin* 24 (1), p. 43–69.
Franke, R. 1982. Smooth Interpolation of Scattered Data by Local Thin Plate Splines. *Computer and Mathematics with Appllications*. Vol. 8. No. 4. p. 273–281.
Herbert Edelsbrunner, 1996. « Incremental Topological Flipping Works for Regular Triangulations », *Algorithmica*, vol. 15, p. 223–241.
Software
ESRI 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute

[1]INRA, US 1106, InfoSol Unit, CS 40001 Ardon, F-45075 Orleans 2, France
[2]INRA, UMR1069, Sol Agro et hydrosystème Spatialisation, F-35000 Rennes, France
[3]INRA, UR0272, UR Science du Sol, CS 40001 Ardon, F-45075 Orleans 2, France