

# **DIELMO 3D, S.L.**

**Digital Elevation Models**



## High quality Interpolation method:

For the production of Digital Elevation Models (DEM), we use a completely new interpolation method, developed by DIELMO 3D S.L.. This new method is not based on triangulation and does not have anything to see with the methods used until this moment. Its main features are:

- Low computational cost, so it has no limitation on the number of entry points and the final file size, so we can generate a DEM from millions of XYZ points with a very high spatial resolution. This is a great advantage over other interpolation methods whose computational cost is not linear, which causes the computer to run out of memory when we try to calculate a DEM from many points of entry.
- It uses all points of the contour lines. The algorithms based on triangulation make a selection of points in order to reduce the mistakes that appear in the interpolation (standard errors of triangulation) and to reduce the computational cost. The interpolation method used by DIELMO rasterize the contour lines, using all the information of the contour lines.
- It does not round the heights. Usually, all the interpolation algorithms round the height values to 1m. In fact some standard formats of DEM work with integer numbers. This produces steps, especially when we are working with high spatial resolution and in areas where the difference in heights is small. For this reason, we deliver our DEM in binary format float32 without rounding the values (with all the decimals).

Figure1 shows a horizontal profile of a DEM. On the right we have the original data with a smooth surface and the left have represented the same data but rounded to 1m.

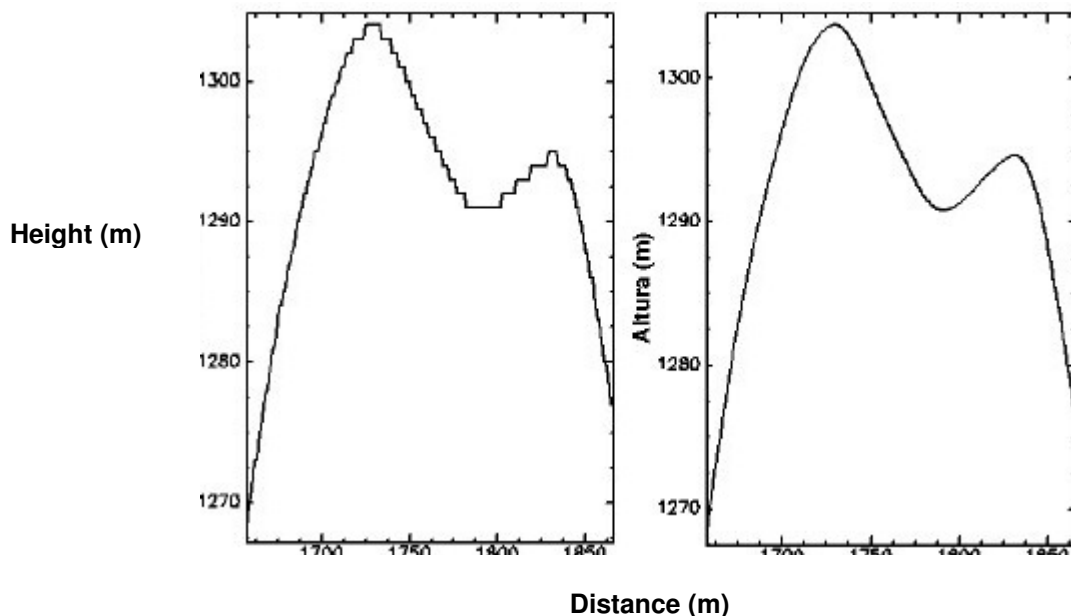


Figure 1.- Horizontal profile of a rounded and without a rounded DEM and a smooth DEM (product offered by DIELMO).

The rounding effect that we can see in the figure 1, makes for example that we cannot be able to have precision in the study of the water flow in areas where the variation of heights is small. In addition this effect also is appreciated in the calculation of the DEM shaded relief (figure 2).

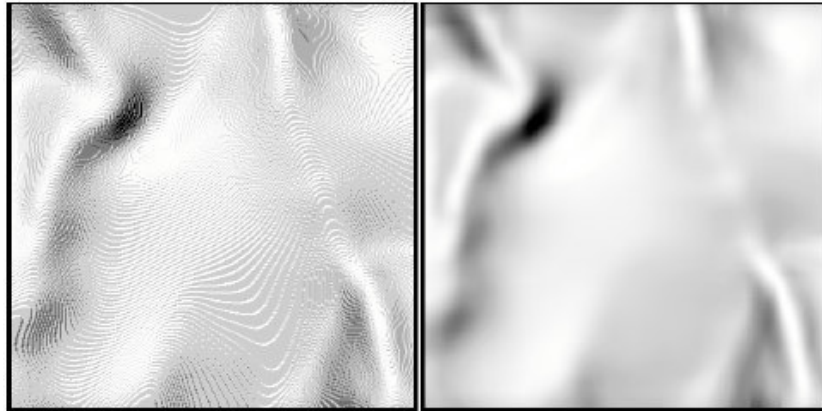


Figure 2.- DEM shaded relief obtained rounding the model and with all the decimals.

- Reconstruct the terrain surface in a smooth way, without the emergence of platforms, oscillations, unwanted abrupt changes in the slope and other artefacts produced by other Interpolation methods.

Here we can see an example of the emergence of oscillations and platforms in different Interpolation methods based on triangulation. To see this effect we have generated several models from the contour lines shown in figure 3, and we have extracted a vertical profiles of the line marked in red. The results of these vertical profiles are shown in figure 4.

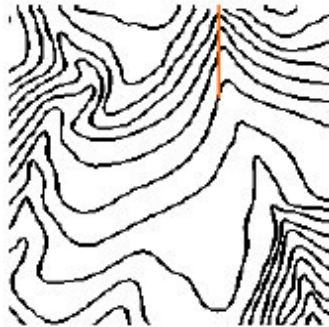


Figura 3.- Contour lines used for this example

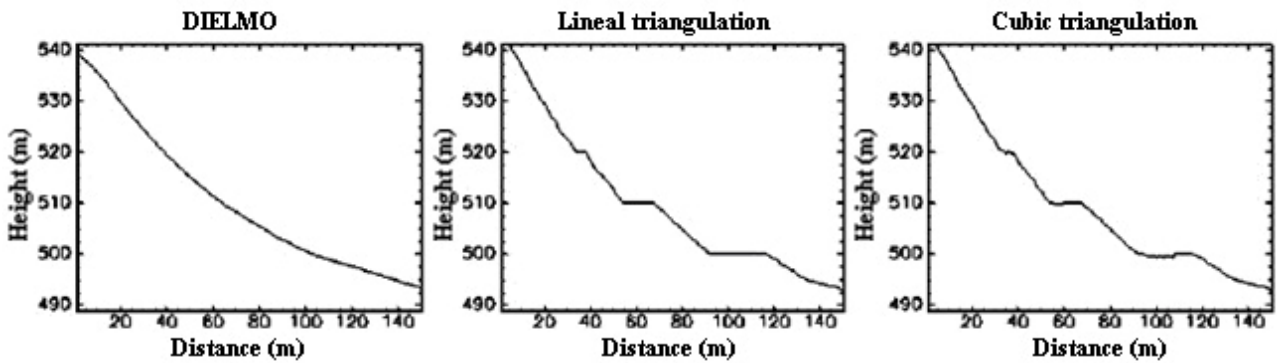


Figura 4.- Vertical profile created with the DIELMO's interpolation Method compared with those obtained with a linear and cubic triangulation.

As we see in the figure 4, in the linear triangulation, platforms appear in the areas where the contour lines close. In the cubic interpolation we observe the same problem, but in addition to the platforms there appear a series of oscillations produced by Gibbs's effect. All these devices also appear in the DEM shaded relief (Figure 5).

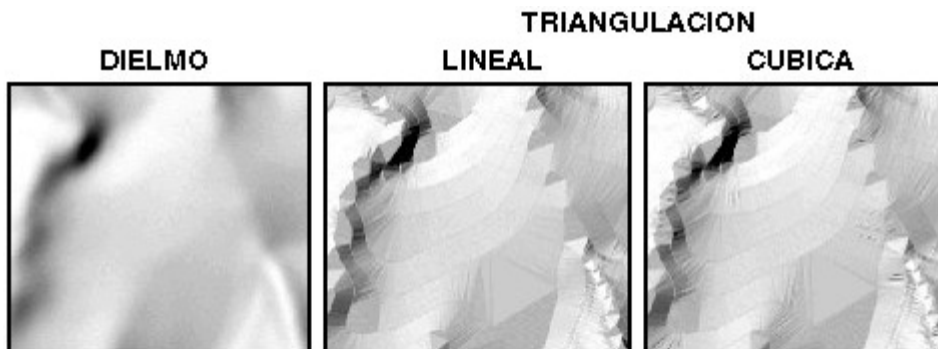


Figure 5.- DEM shaded relief generated by the method of DIELMO and those obtained by triangulation.

Whatever the sophistication of a interpolation method, if it is based on triangulation will always have these problems.

- Accuracy at contour lines. The resultant model reconstructs a smooth surface at the same time that it is adjusted to all the contour lines. The measures of this mistake are performed by means of two calibrators: the Mean Error (ME) and the Mean Square Error (MSE), defined in the equation 1, and measured in all the points of the contour lines.

$$MSE = \sqrt{\frac{1}{n} \sum e_i^2} \quad ; \quad ME = \frac{1}{n} \sum e_i \quad ; \quad e_i = z_{MDE} - z_{Mcpa}$$

Equation 1.-Equations of the Mean Error (ME) and the Mean Square Error (MSE)

For example in the DEM selected for this demonstration, the following errors have been measured: ME = -0,159m y MSE = 0,725 m for a total of 5286483 points. In Figure 6 we see how it reconstructs a smooth surface at the same time as it adjusts to all the contour lines.

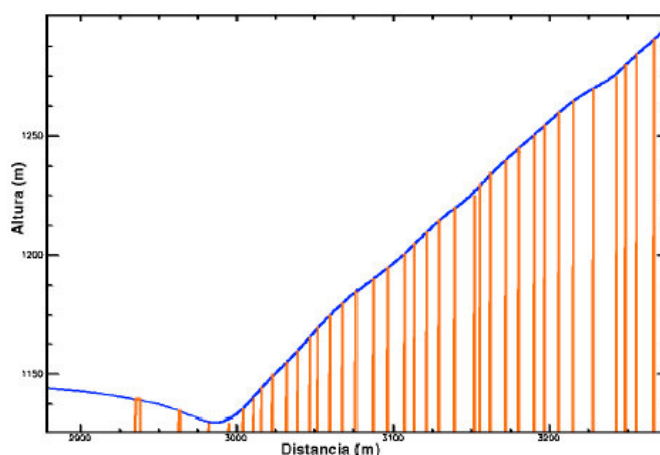


Figure 6.- Horizontal profile of a part of the DEM (blue line) along the points of the contour lines (red lines).

- Mistakes are independent of the shape of the contour lines. Any interpolation method based on triangulation or methods based on the generation of profiles on the contours matrix (such as the used by the software IDRISI), make mistakes depending on the shape of contour lines.

Suppose that we want to interpolate the contour lines of figure 7. At first glance we can appreciate that we will have problems in the surface's reconstruction between curves of 60 and 70 m if we are using an interpolation method based on triangulation. The problems will come due to the shape of the contour line at 70m, where there will appear a series of platforms corresponding to triangles with exactly the same value of height than the contour line.

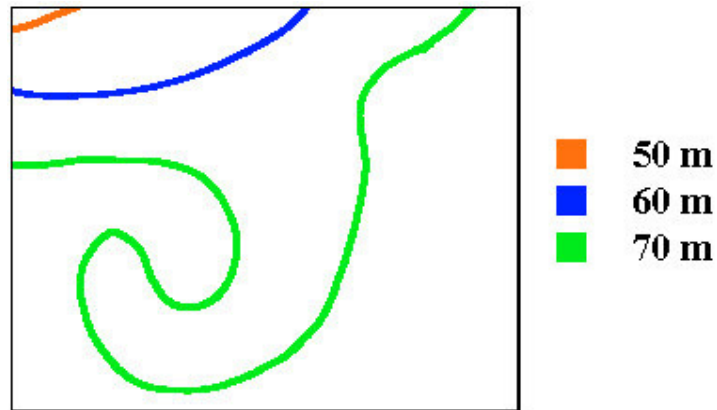


Figura 7.- Contour lines used for this example.

In case of the IDRISI it is interpolated in horizontal direction, vertical direction and diagonally. These algorithms also produce mistakes depending on the shape of the contour lines. In the figure 8 we see a simple example that clearly shows this mistake in the event of a horizontal and vertical interpolation, after the average (bilinear interpolation).

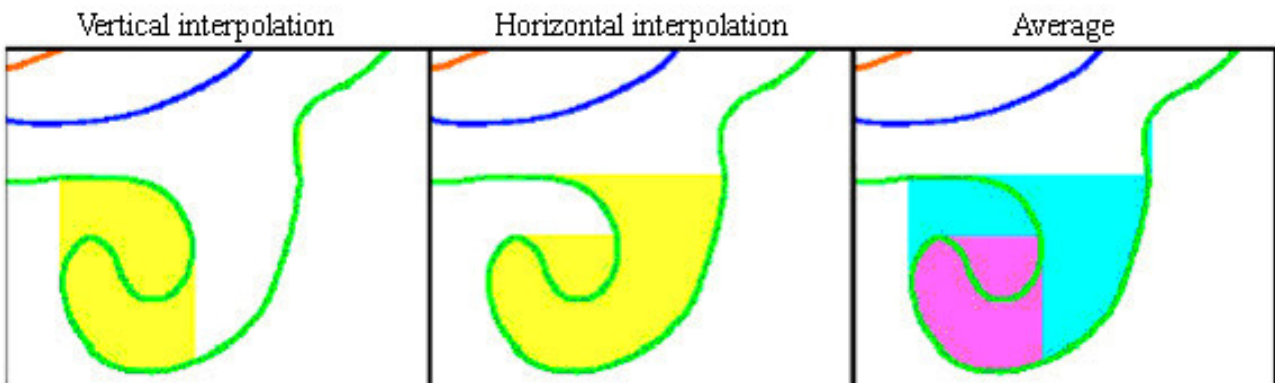


Figura 8.- Errors produced by the bilinear interpolation.

In the Figure 8 we represented in yellow the areas where due to the shape of contour line, horizontal or vertical interpolation produces a platform with exactly the same height value than the contour line. In pink colour we have represented the areas where after performing the average, the above mentioned platform continues appearing. This provokes sudden changes in slope that are not representative of the terrain in this area.

The interpolation method developed by DIELMO uses the spatial information of the shape of the contour lines. It does not have a definite structure, but it identifies the shape of the contour lines and interpolates from them. In this way we always avoid these mistakes and we produce a DEM hidrologically correct. In addition, the calculation can be made for high spatial resolution, because the interpolation method works well

regardless of the increase in the distance between the contour lines. In figure 9 we can see the result of the interpolation of the contour lines shown in figure 7 with the DIELMO's interpolation method.

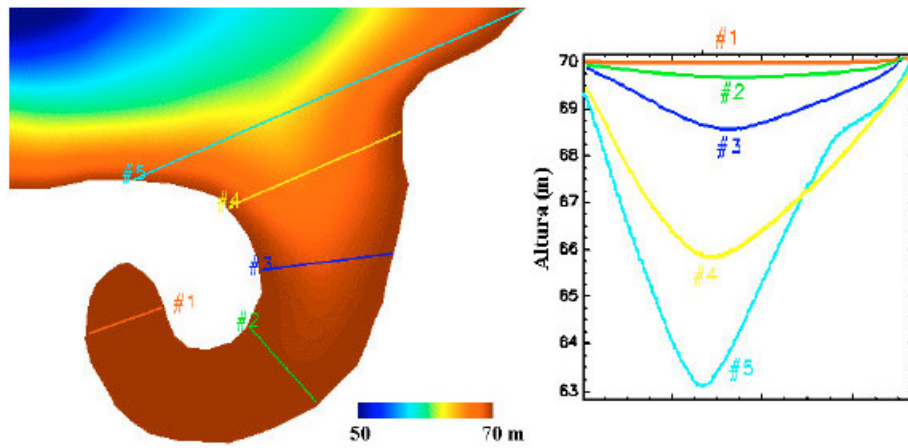


Figure 9.- Interpolation obtained with DIELMO's method.

As we see, in this case the reconstructed surface is a smooth DEM and hydrologically correct.