

DTM edition in IGN France An operational process to generate contour lines

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ABSTRACT

IGN introduced a new semi automated tool for cartographic contour line generation at the beginning of year 1999. After six months experience in the three digital units involved in this evolution, new requirements appear concerning large data flow management, increased reliability for the existing functionalities and new interactive tools to improve manual editing.

1. INTRODUCTION

IGN France is a government agency commissioned to capture and manage the French national geographical databases. The Ecole Nationale des Sciences Géographiques, and four research laboratories improve and support these products, with fields of proficiency such as digital cameras, image processing, GIS and geodesy. IGN carries out research of common interest corresponding to its activity with the goal of mid and long term improvement of its own production tools. Considering digital photogrammetry, 3 work units equipped with four fully digital plotters each complete the 6 other analytical units designed for BD TOPO® data capture (under completion, with sub-metric positioning).

Although many subjects such as roads and building recognition are under development, the first new semi-automated tool, for contour lines generation, was put in the 3 digital units at the beginning of year 1999 and will now be presented. This needs to compute the DTM at first and requires automated post-processing. After manual editing, a raster to vector transformation is performed to achieve the cartographic purpose. Two kinds of software components are used:

Socet Set (LH Systems) with several specialised modules such as Automatic Terrain Extraction (ATE), Interactive Terrain Edit (ITE), FGIS (Feature GIS) and the Developer kit (DEVK).

Home made softwares written in C, Cshell.

Contour lines produced are imported the GIS GeoCity used for data capture. The images used are black and white, at 1 : 30 000, scanned at 14 µm on the film. The data capture is made in a model at 1 : 10 000. In addition to the database constitution itself, the basic product is cartography at 1 : 25 000. A possible use at a larger scale requires special attention. The steps of this new process will be illustrated from DTM's computed from the following pair of images.

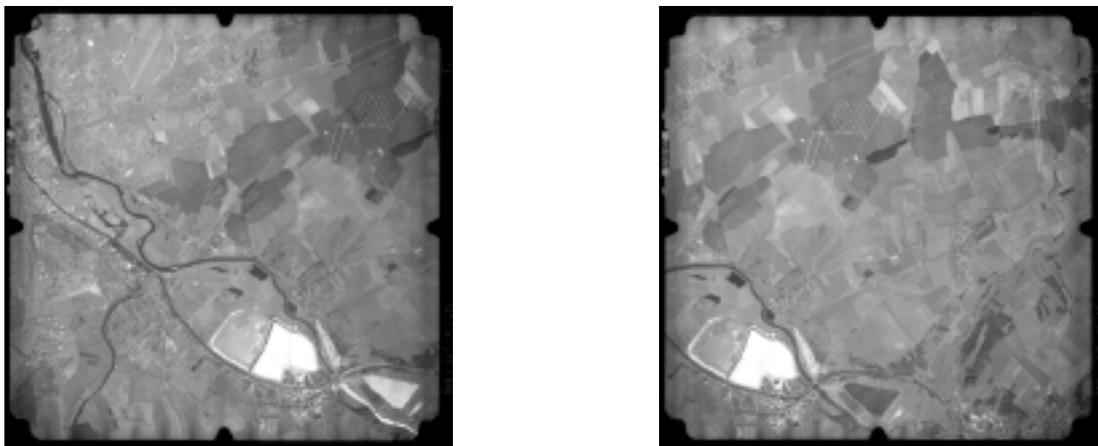


Figure 1: Nancy area (East France): scale 1 : 30 000, 14/04/96, images 77-79.

2. DESCRIPTION OF THE NEW PROCESS

2.1. Automatic DTM computation

Image correlation is now a standard technique to identify automatically homologue points within a large set of images. The Adaptive ATE (AATE) combines intensity-based and edge-based methods, the algorithm has a recursive approach to determine the parallax between two images. It works firstly on small scale images, under-sampled. At every step, the post density is doubled along both X and Y axis until the full resolution is reached. At the beginning, a sparse post spacing is used for the DTM completion; afterwards, it is progressively densified. A few years ago, the user had to use pre-defined strategy files containing a complete set of parameters for every step of the correlation algorithm; one could also edit it to tune some of these default values more precisely. Now, the software sets the parameters automatically according to several characteristics including terrain type, signal power, flying height, X and Y parallax and image noise level.

Even if the algorithm behaves properly on black and white images, one can never assume how ground surface and above ground objects will be measured according to the date and the hour of flight, the vegetation development, the digitised conditions, local reflectance... A visual control is still required to make an appropriate diagnostic of the result accuracy. This helps tuning the automated post processing strategy to make this data fit the user's requirement.

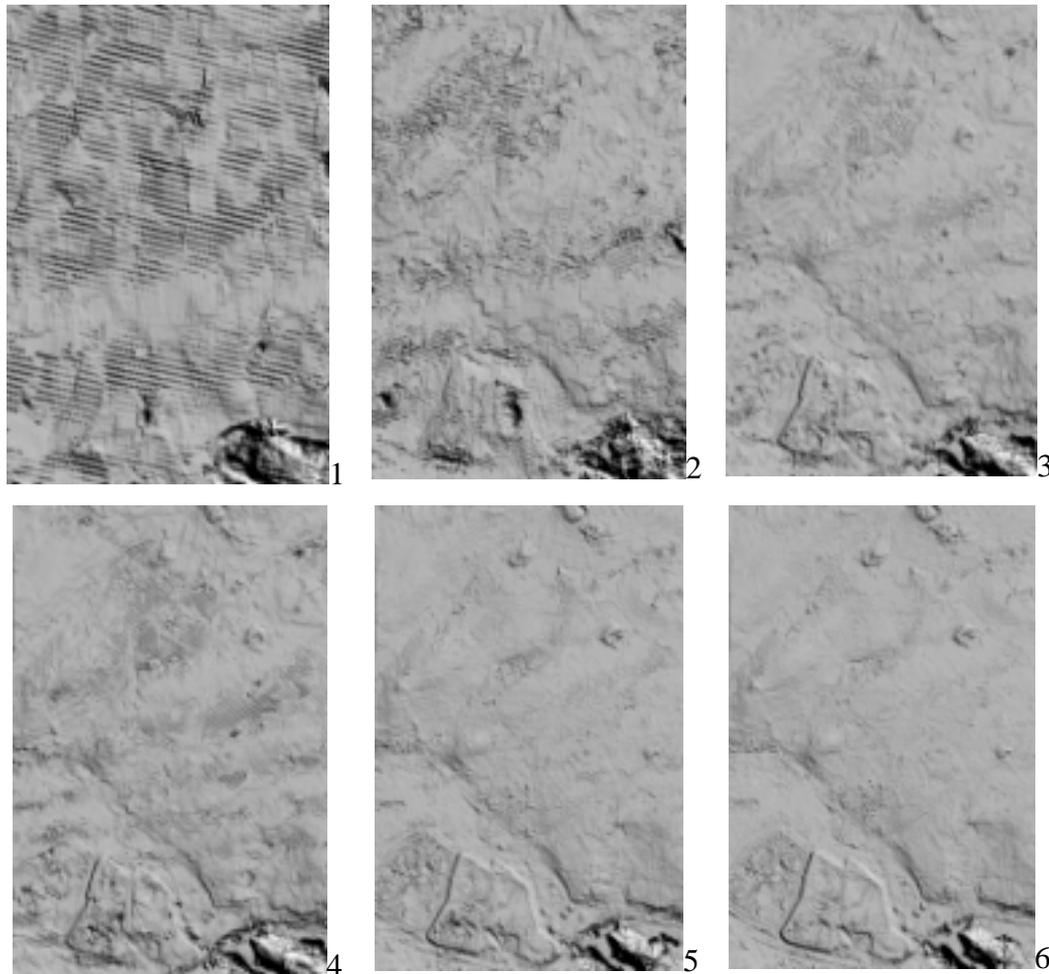


Figure 2: Nancy area: terrain shading provides powerful control to visualise surface evolution after each step; here, the first one is on the upper left and the last on the lower right. No additional filtering should be performed before the end of the correlation to allow a quick visual control of the rough DTM.

2.2. Automated post-processing

2.2.1. Standard filtering

The Visual control gives a good idea of height and width of objects above ground such as buildings. For trees, it depends on the date of the flight; in early spring, the ground can be seen in woods, with shadows that help correlation to lay on the ground and obstructions are smaller, except for tree with persistent leaves. To tune these two parameters properly should preserve characteristic terrain elements (talwegs, crests, summits, depressions...). After this step, obstructions are removed and the DTM is also slightly smoothed.

For the purpose of the mean scale cartography considered here, a post spacing of 5 meters is chosen for lack of a smaller one. A larger value would produce smaller files but with a worse description of the ground surface. This generates approximately a DTM of 1 000 lines x 600 columns for one single pair of images. Larger DTMs are often processed on strips of 4 to 12 images, assuming that this is a homogenous correction, whatever the images are.

2.2.2. External data merge

If available, a database can bring external information to optimise the result given by the post processing exposed above. Elevations in DTM can be changed within an area delineated by the polygon surrounding the features. The most common uses are:

- inside polygons such as lakes or large rivers, all the elevations are valued with a constant that can be the average, the minimum or the maximum of all the posts inside the delineation.
- the possible addition of a constant to all the elevations inside a given polygon to remove over-ground obstructions such as canopies or buildings.

Elevations from networks of different classes of objects can also be used. According to the nature of these objects, a ground profile can be imposed. The available tools reset the elevations closer than an interpolation distance D from the axis of objects. If the elevations further than the interpolation distance are not affected, the others are interpolated from the axis to the frontier of the area given by the interpolation distance, according to a kind of profile given by the operator. The most common options are to interpolate with Uniform, U shape, V shape or Bulldozer option. This can be used for rivers, roads, hedges...

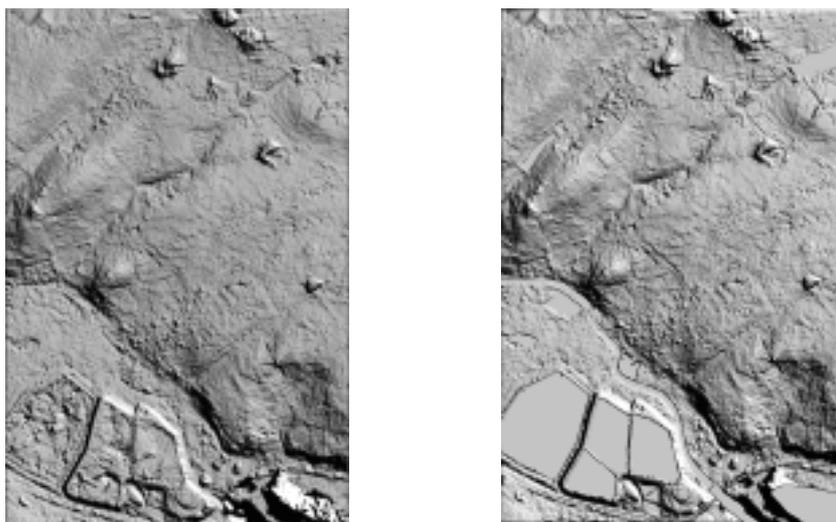


Figure 3: Nancy area: on the left, terrain shading after filtering trees and houses; woods and large buildings remain but the small characteristic lines are also preserved; on the right, elevations corresponding to lakes, rivers are set to a constant, and a bias has been removed for those corresponding to woods and houses.

2.2.3. Cartographic smoothing

Assuming that the cartographic constraints for the contour lines are to look smooth but also to give a good caricature of the terrain, IGN developed an algorithm called cartographic smoothing independently from Socet Set. The first step consists in computing a DCM (Digital horizontal Curvature Model). From this information, and by identifying appropriate thresholds, the topography is structured as connected areas labelled from the bottom line of valleys to ridges. That classification of the topography, usually in 4-6 classes, is enough to perform the second step that consists in an adaptative smoothing, with customised parameters for each one of the areas identified from the DCM. This DCM needs to be performed on a very smoothed DTM, temporary data issued from the rough data by using very large average smoothing windows (this prevents a complex set of small characteristic lines).

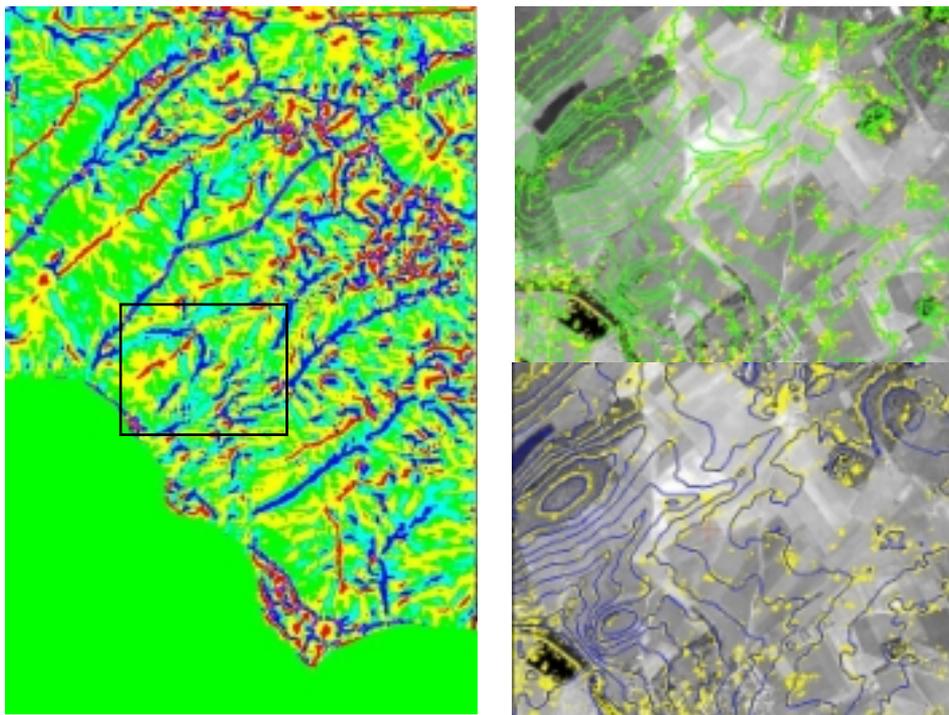


Figure 4: Nancy area: on the left, landform categories from the DCM; crest (in red), low convex areas in yellow, low concave area in green, and talwegs in blue and violet; on the upper right, comparison of contour lines (interval 5 meters) directly from correlation in yellow and after standard smoothing in green; on lower right, same in yellow, and cartographic smoothing in blue (this last result could probably be accurate enough for smaller scales).

In the near future, the choice of the parameters and thresholds has to be reduced according to the operator's recommendation. This will allow more automation at this stage.

2.2.4. Manual editing

Manual editing is the last step. After all the previous processes, the DTM obtained has still to be manually corrected. The module ITE offers three DTM editors for interactive manual editing:

- post editor: adjust the point height by manual measurement with the moving floating mark. The only use found valuable is to create spikes or small summits but is almost never used.

- linear editor: recalculate the elevation in a given bandwidth when characteristic lines do not caricature the terrain enough (because of trees or other “annoying objects”). For sub-urban areas, its use is also appreciated to figure small relief due to human activity which usually presents sharp slope changes: bridges, motorways, talus, which are always smoothed too much.
- area editor: change all elevations within an area delineated by a polygon given interactively, either to remove artefacts, or to modify the surface texture. The most useful tools are smoothing convolution (unfortunately pre-defined), interpolation in a 2D or 3D polygon, interpolation under constraints, plane fill, constant fill bias and filtering obstructions by giving the height and the width of objects to be removed.

The algorithms for the last two editors are available for an interactive use and for the automatic merge with features coming from a database. The time spent for editing seems to vary from 5 to 15 hours for a pair of images sized DTM (this range depends on the operator's experience and/or the difficulty of the area). On a project such as Ile de la Réunion, 40-50 hours were planned to do the job with the standard process. For huge relief such as mountains, a single correction applied by the operator with the tools mentioned above modifies large areas very quickly even if large shadows and trees slow down the work.

This remains true that for a flat landscape, the manual process would go faster and it is up to the work unit to choose the correct way of plotting contour lines: manual or semi-automated. The technique of DTM edition and tuning the parameters for the cartographic smoothing requires motivated operator, with an accurate 3D vision and a good aptitude to analyse the relief with its characteristics elements.

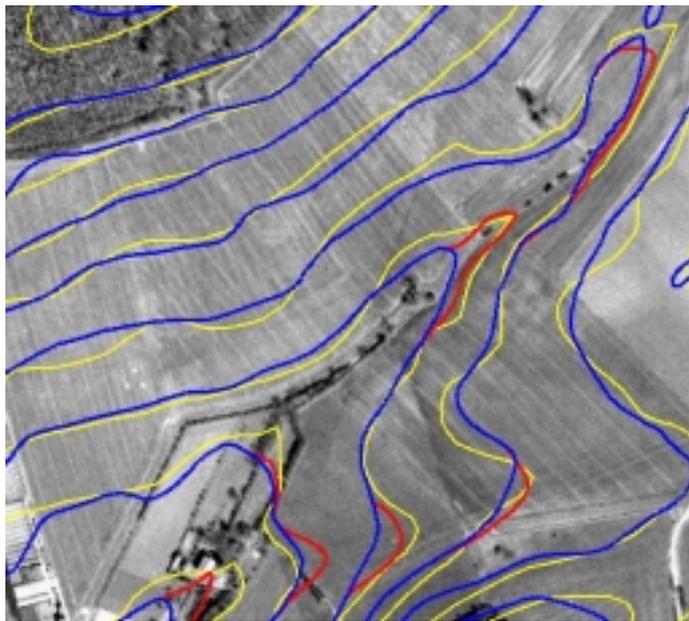


Figure 5: Nancy area: contour line comparison; in yellow, the manual plotting, in blue, after cartographic smoothing and in red, example of local edition on the cartographic smoothing.

2.2.5. Data project management

After the previous step, the DTM is converted into contour lines with an export format that can be imported in GeoCity.

Two kinds of operators use the process: the data manager prepares the data, by using ATE on the strip block. Afterwards, he performs post processings and cartographic smoothing.

Then, the edition operator can use ITE (DTM interactive tools). Prior to that, he extracts from the block a DTM corresponding to a pair of images, by taking also into account elevations which comes from overlapping strips already edited. Afterwards, he merges the edited data back with the strip from which they were extracted and with all the overlapping strips. All these steps have to be done very carefully to ensure that all the data used are correct and updated. An additional functionality was added to capture spot heights.

The global process guiding the operator is written in shell programs with menus that inform on the available data, activate home made softwares or open the required SOCET SET window to accomplish a task.

3. TECHNICAL REQUIREMENTS FOR THE NEAR FUTURE

3.1. Unlimited sized DTM

With the IGN France way of working, a BD TOPO® project is a block of 4 strips of 12 images each. Non interactive tools can be performed with difficulty for batch processing but their use becomes impossible when manual editing is required, performance being slowed down. This needs to extract from the DTM block, smaller areas to work on and to replace them after manual editing. This requires a heavy and day-to-day management of the overlap areas.

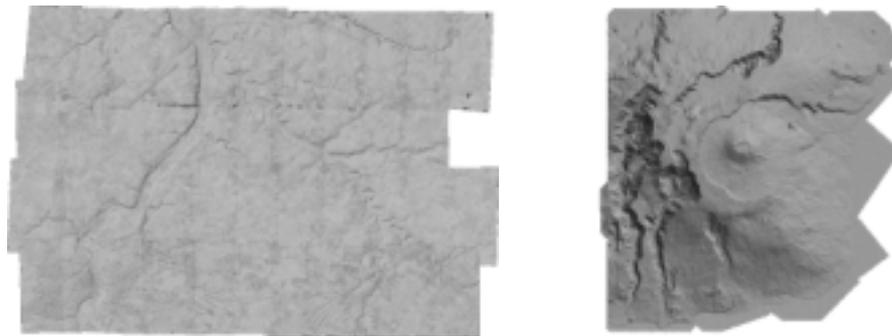


Figure 6: Large data set: on the left, Chartres project composed of 4 strips of 12 images corresponding to a DTM of 4300 lines x 6300 columns and on the right, extract of Ile de la Réunion block: 23 strips for a total of 70 DTM, corresponding to a pair of images each; this leads approximately to a DTM of 7000 x 6500 posts.

Bigger the data are, slower the softwares go. Here, the new process deals with large blocks and the software does not enable the operator to work interactively on them. As was done with the images, a tiled DTM format could be helpful. This is a major requirement because without it, processes have to cut frequently into the large data set, to allow edition on small areas, and then merge back the result with the first data set. This needs some temporary data, complicates the storage problem, slows down the process... More than half of the time spent on non edition tasks is lost in data management in the overlap areas.

3.2. Higher reliability; “What you see is what you get”

When editing a DTM, the operator usually uses images with a pixel twice bigger in both dimensions than the full image resolution. At that scale and after edition, the result appears correct and is exported nearly directly as contour lines. Unfortunately, the integration in a GIS shows unacceptable jagged segments when a display is asked to a much larger scale, as often done.

This probably happens during the resampling from raster to vector. The smoothness of contour lines should be preserved for all the scale bigger than the one used with primary data. Even if an additional filtering can be performed on the raster data, the only satisfactory solution is a reliable algorithm to convert the DTM to contour lines.

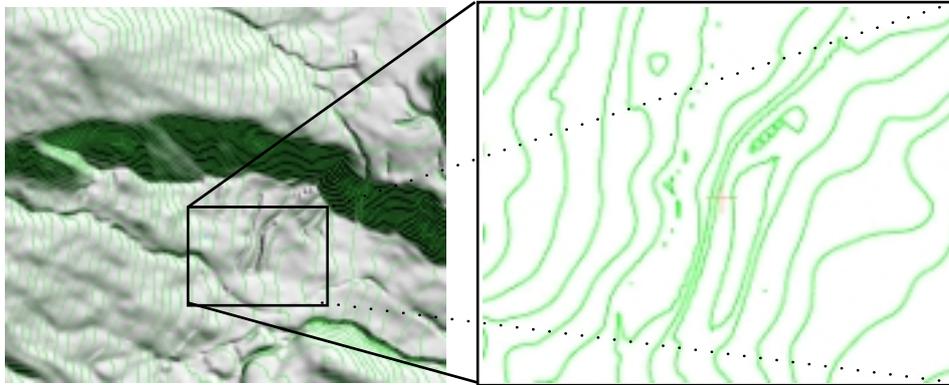


Figure 7: Jagged contour line: the size of these little breaks is in the same order as the DTM post spacing. These artefacts are localised along narrow characteristic lines edited by the linear editor; their size is close to the post spacing value.

3.3. More fonctionnalités

3.3.1. Powerful batch-processing

To merge external data to improve elevation reliability means to be able to choose the order of use the different classes and the different smoothing used. The same features are often used several time, at different steps. As it is not possible with to be done with Socet Set, all the main batch functionalities are at present done by home made procedures very basic tools from the Socet Set developer's kit.

3.3.2. An hybrid linear/area editor

The use of an area tool often generates bord effects, comparable to stair steps along the polygon perimeter. These undesirable effects could vanish if a reliable resampling method was used. Another approach would involve a feathering algorithm such as making a uniform slope resampling in a bandwidth following the poly gon contour given by the operator.

3.3.3. Integration of cartographic smoothing in interactive tools

At the moment, our experience in production is only 6 months old. The relative complex tuning of the algorithm presses a more automated procedure to be used in the near future. With no more than two or three parameters accessible, this should give the opportunity of allowing its use, not only globally on an entire DTM, but also as a new area tool, inside a polygon given by the operator. To make this possible, a bigger experience is necessary. The operator's feedback will enact what can be done in terms of development.

3.3.4. More fonctionnalités

All IGN home-made tools are interesting, in reference to the cartographic mean scale purpose given in the introduction. Time spent on their development should not be lost again for similar application. In addition to the topics listed above, the other programs perform:

- large window smoothing : to prepare the terrain caricature,
- a slope calculator,
- a viewer of DTM, DCM or similar raster files to display their content on a grey level,
- a procedure to adapt the operator's personal bias by averaging measures of the image pair on the check/control points available.

3.3.5. Higher ergonomoy

Many of the programs involved in the new process are recent tools. Their ergonomoy was made at first from the developer's point of view, even for some Socet Set modules. The most important items are to:

- share properly the cursor between the different Socet Set modules such as ITE, SKECTH or FGIS,
- give standard references for naming,
- set the different default parameters to useful values,
- reduce the number of mouse clicks.

4. CONCLUSION

Introducing this new tool in production at IGN unit is now achieved but a lot has to be done to improve its performance. The present state of the art is a process that gives good results on areas with high relief but a larger use is still a goal. The use on sub-urban area is more problematic because of the numerous and various obstructions, with human-built shapes (non natural) such as bridges, talus along the roads... This will be possible with more automated programs and more reliable tools. The result given is enough for mean scale cartographic purpose but will improve with higher quality images, such as those given by IGN's digital camera; tests have already been performed and prove that the result is better, especially for flat and poor textured images.

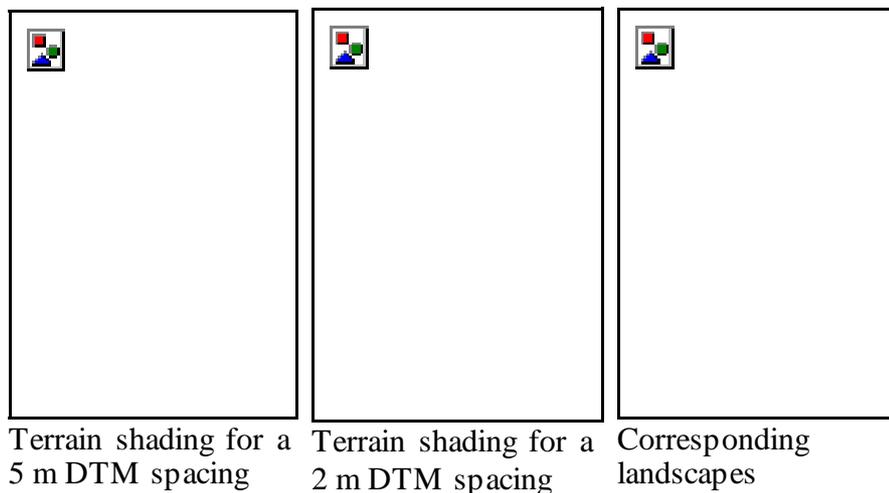


Figure 8: The surface obtained without any kind of filtering shows that images matching works better for flat and poor textured parts of the images that for the standard images.

The major change for operators is to work on raster data; the contour lines displayed must be recognised just as a very sparse representation of ground surface. This justifies the visual controls given by terrain shading, always proposed during the editing process. The boring part of the operator's work is here reduced, replaced by redundant information (as shown by the low value post spacing of 5 meters presented here). The manual part focuses now on a more specialised task that is to enhance the characteristic lines in the DTM, correlation algorithm still giving a surface which is not caricatured enough. The near future is now fully open to semi-automatic tools. This period will require a lot of effort on the interactivity between Man and Machine.

5. REFERENCES

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