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PROFILER 3.1 XL, A FREE SOFTWARE FOR TOPOGRAPHICAL PROFILE CONSTRUCTION AND ANALYSIS IN MICROSOFT EXCEL ©

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Abstract – Profiler 3.1 XL is the latest version of a free software for beach profile construction and analysis. It is a Visual Basic for Application (VBA) program running in Microsoft Excel©. Profiler 3.1 XL was expressly designed to be easily used by scientists, technicians and students interested in coastal measurement and evolution. This software proposes several functions: e.g. profile calculation, graphical representation, computation of basic indicators (alignment, volume, slope), bars and berms identification, profile comparisons.

***Résumé** – Profiler 3.1 XL est la dernière version d'un logiciel gratuit de construction et d'analyse descriptive de profils topographiques, notamment de profils de plage ; il est cependant utilisable pour d'autres types de relief. C'est une extension de Microsoft Excel©. La programmation est réalisée en Visual Basic pour Applications. Ce programme a été spécialement conçu pour être manipulé facilement la communauté scientifique, les étudiants et les gestionnaires s'intéressant à la mesure et l'évolution du littoral. Il propose de nombreuses fonctions : calcul et représentation graphique des profils, calcul de paramètres descriptifs de base (orientation, volume, pente), identification de barres et bermes, comparaison des profils.*

Introduction

A beach profile is a cross section diagram showing elevation evolution versus distances along a transect perpendicular to the shoreline. On such a graph, dune, beach, intertidal and/or subtidal bars can be identified (Kraus, 2005). The shoreline position is sometimes quite difficult to determine on aerial photographs and moreover, has several definitions (BOAK & TURNER, 2005), but it can be more easily defined on a profile. Beach profiles are often used in spatial and temporal analysis. For example, it is possible to monitor shoreline movements, to measure beach level variations, to calculate volume evolutions and to compute sediment budgets. These profiles are also used as a basis for numerical simulations aiming to understand or predict beach evolution under hydrodynamic and aerodynamic forcing (KEIJESERS *et al.*, 2014).

Profiles can be measured in scientific and academic studies in the short-term. In the long-term, they are more and more surveyed in the framework of coastal or shoreline observatories (JEANSON *et al.*, 2010; SUANEZ *et al.*, 2012). After a few years, a great amount of data can be collected: the JARKUS database of the Rijkswaterstaat (a department of the Dutch Ministry of Infrastructures and Environment in charge of water

management) includes profiles measured several times a year, every 500 m alongshore, since 1965. Therefore computer tools are necessary for the analysis of such datasets.

Data can be collected in the field with various kinds of instruments, from very simple (graduated frames to estimate distances and differences in level, EMERY, 1961; PUELO *et al.*, 2008) to more sophisticated ones (height measurement sensors, theodolites) or using advanced technologies (total electronic stations, DGPS). Some data are extracted from Digital Elevation Models, for example processed with LiDAR measurements (KLEMAS, 2011). These topographic studies need geometric treatments to be converted into lengths, volumes and to compute evolutions (BRABANT *et al.*, 2012).

We carried out a bibliographic research in order to list computer programs able to treat topographical profiles. It seems that they are few. We organized them into two categories. In the first one, we classified a small number of software systems especially dedicated to topographical analysis that are often complicated to use. Some are quite ancient, have not been updated for a long time and do not run on the latest versions of Windows; e.g.: Beach Morphology Analysis Package (BMAP) is the free software developed by the Coastal and Hydraulics Laboratory of the US Army Corps of Engineers but has not been updated since the beginning of the 1990s (SOMMERFELD *et al.*, 1993). In the same category, some other programs are recent but not free; for example, Beach Profile Analysis Toolbox (BPAT) developed by the NIWA, National Institute of Water and Atmospheric Research in New-Zeeland. We also listed programs for general land surveying data treatment; e.g. COVADIS is a plugin in the CAD program AutoCAD.

The second category includes “homemade” and free programs created by research organizations according to their needs. The JARKUS database in the Netherlands is analyzed with scripts written in Matlab. The MADDOG project in French Brittany (SUANEZ *et al.*, 2012) is an Internet platform offering tools for diagram construction, data treatment, mapping and storing. “The Beach” (CHANDRASEKAR *et al.*, 2009) is programmed in Visual Basic. It was designed to be used by non-specialists and to transform distance and elevation measurements made with the Emery method (Emery, 1961). It is well adapted to structures with few technical and financial resources.

Profiler 3.1 XL could find its place in this category. It is the latest version of free software for construction and descriptive analysis of topographic profiles, mainly beach profiles, but it can be used with various reliefs. It is a plugin in Microsoft Excel©. Programming was done in Visual Basic for Applications. This toolkit has been designed to be easily manipulated by a non-specialist audience in land surveying and geometry within the scientific community, students and managers involved in coastal measurement and evolution. For now, the download address is: <https://www.dropbox.com/sh/h8exwy52cdmx8zd/V5rXC3Gzn0>.

In this paper, we present ergonomics of the program and three examples of functions.

Mains functions and ergonomics

Working in Microsoft Excel© offers several advantages: this is a commonly used program, offering a fairly simple framework and features that our software will operate. It is possible for example to import data to process and record the results in various formats (text, spreadsheets, databases) from and to different data sources: by exporting the XY coordinates of the profile in csv format it can then be spatialized in GIS software.

Profiler 3.1 XL provides functions that can be classified into five categories: 1) importing and formatting files from various measuring devices; 2) data preparation (e.g. conversion of XYZ coordinates into cumulative distances and elevation); 3) graphing (spatial distribution of measured points, profile); 4) simple analyses (e.g. computing profile orientation, slope, volume, altitude interpolation along the profile, profile cutting into sections of equal length for further analysis); 5) more sophisticated analyses (e.g. identification and description of berms, ripples or bars, comparison of profiles in pairs). Analysis functions allow working over the entire length or only a section of the profile.

After startup, a Profiler 3.1 XL menu appears in the Add-ins tab (figure 1). As for those of Excel, to activate a function, first select a range of data, regardless of its location on the active worksheet and then click on the function in the menu. For simple functions, the results are given in a dialog box. For more advanced features, they are displayed in a new worksheet. The user's spreadsheet is not changed.

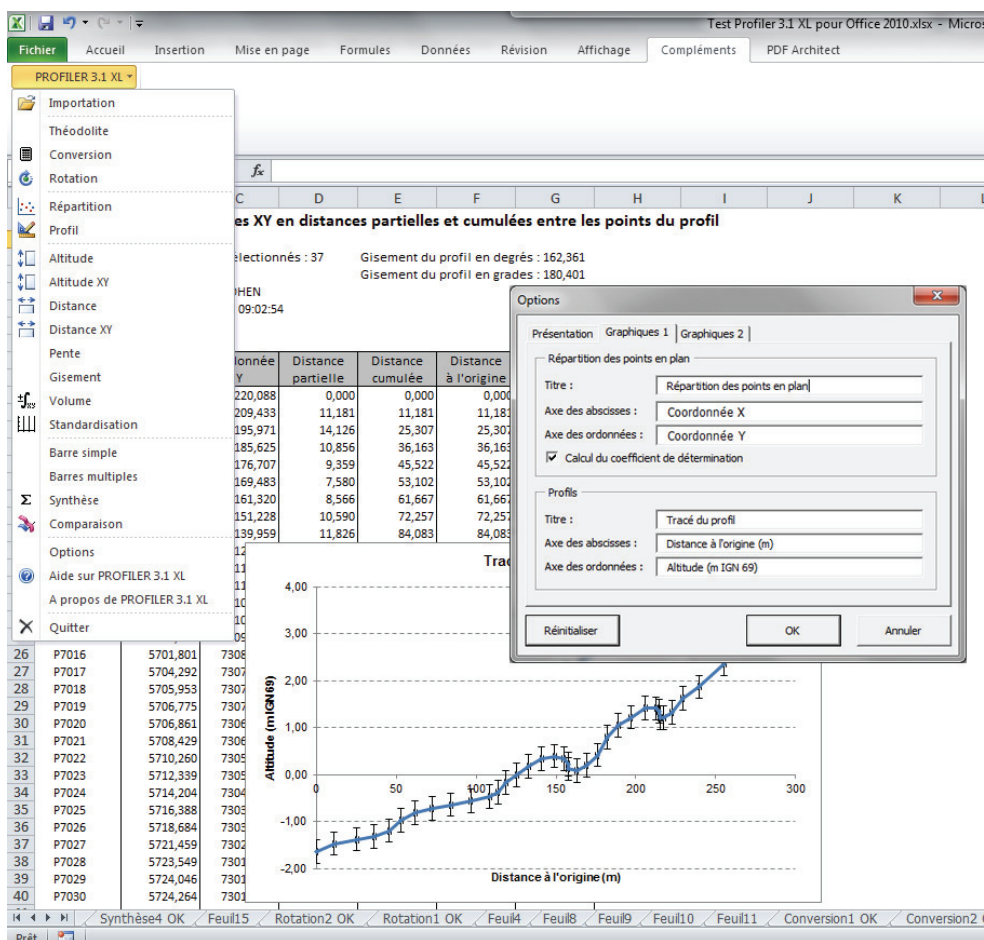


Figure 1 – The Profiler 3.1 XL menu;
Examples of a profile chart and of the “Options” window.

For repetitive tasks, some processes can be customized using the "Options" function. For example those of the "Charts 1" tab allow setting the titles and names of "Spatial distribution of points" and "Profiles" diagrams for further drawings. The "R-square coefficient" option (r^2) is useful to estimate the alignment quality of a profile along an axis: this coefficient varies between 0 and 1: when it tends to 1, the points are well aligned; when it tends to 0 and the points are distributed winding around the axis, it may be caused by a problem of leveling of a theodolite or a total electronic station.

Profiler 3.1 XL includes routines for detecting errors in the selected data (e.g. whether the data range does not have the number of columns needed to calculate or if it contains text or empty cells) and data entry errors in the dialog boxes (e.g. if a value out of range of the variable to be treated was entered). A specific message indicates the type of error at every occurrence. The software offers online help with summary, keywords indexed and search function. A 40-page manual in PDF format is also provided.

Figure 1 shows the main menu of the program with the different functions and the dialog "Options". In the background, the result of the "Conversion" function is shown. On the topographic profile error bars have been added to indicate an error margin in vertical measurements (here they are much exaggerated to be clearly obvious). This error margin may be related to an imperfect vertical position of the prism reflector with a tachometer or to approximations to compute coordinates by GPS.

Example of the “Conversion” function

This is probably one of the most used functions. It transforms the XYZ coordinates of points aligned along an axis (XY plane coordinates of points and Z elevations) through the Pythagorean theorem into distances (partial distances between points taken in pairs, cumulative distances summing the partial distances and distances from the origin between the point of departure and the point of the line in the table -Figure 2) and Z. The profile orientation is calculated. Distances from the origin and altitudes are used to automatically draw the topographic profile. Two conversion modes are available. In “Mode 1”, it is considered that the first point on the list to be processed is the beginning of the profile, often corresponding to a fixed feature (e.g. a geodetic milestone where a tachometer is installed). Figure 2 illustrates this mode and depicts the different types of calculated distances. An example of the use of the R-square coefficient for estimating the alignment quality of the profile points is presented. Here $r^2 = 0.99$ as some points are not (deliberately) not well aligned. “Mode 2” can be chosen when the total station is located in the profile, for example, on top of a dune and surveys are carried out on both sides; negative distances are obtained on one side of the measuring station and positive distances on the other side (figure 3a). “Mode 2” can also be used when the survey has been made with a GPS without a fixed reference point and when several profiles at successive time or neighbors in space are to be compared: a common data point is selected to be used as fixed point. Figure 3b shows an example of comparison of two adjacent profiles approximately 270 m apart, surveyed in April 2014 in Baie des Citrons in Noumea. The point selected in the drop down menu of “Mode 2” is considered as the reference point for overlaying and is the top of an upper beach wall. Thus, we see that the P1 profile, north of the bay is higher and wider than the P2 profile located in the south in an eroding area.

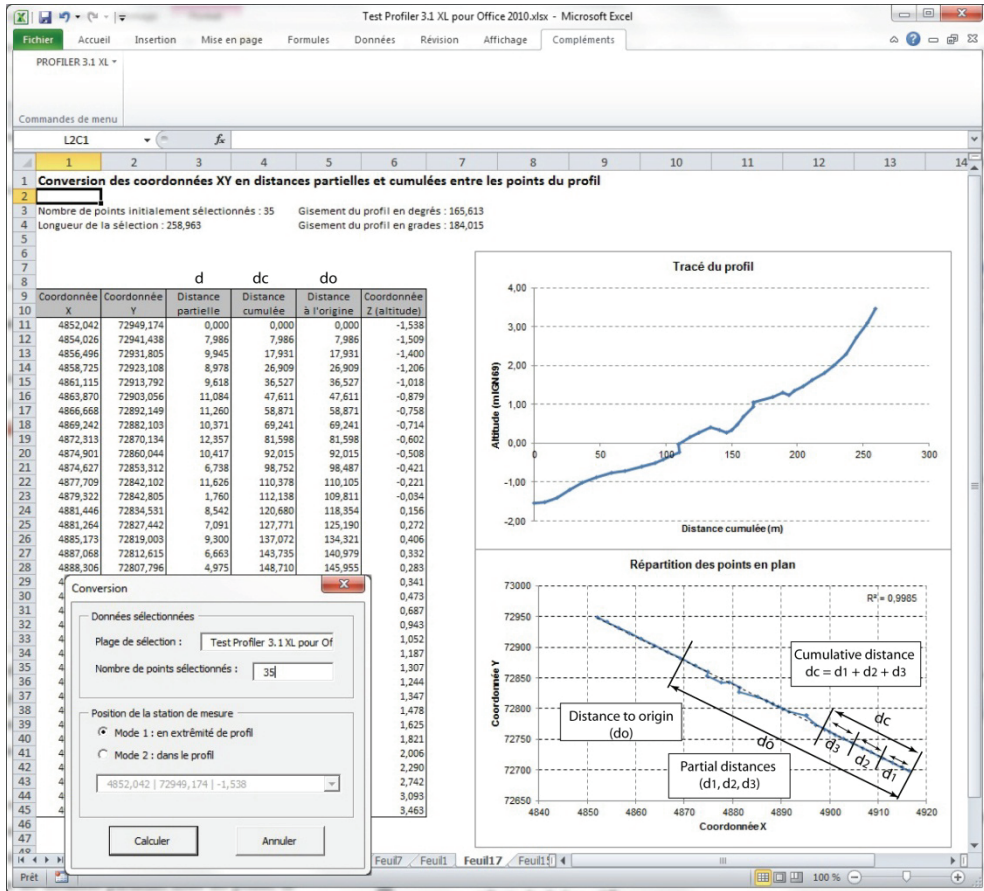


Figure 2 – Example of the dialog box and results of the “Conversion” function in mode 1.

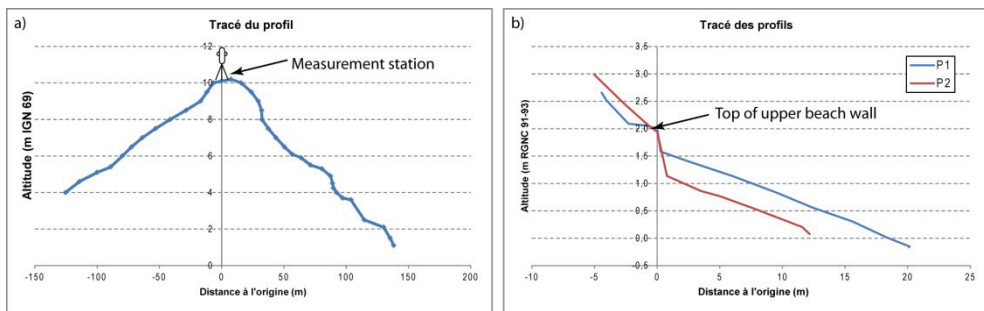


Figure 3 – Examples of profile charts using the “Conversion” function in mode 2.

Example of the «multiple bars» function

This function allows the automatic detection and description of the positive undulations throughout the length or a section of a topographic profile (e.g. intertidal or subtidal bars, submarine dunes, ripples). It is based on the writings of BRANDER (1999) and MASSELINK & ANTHONY (2001). These undulations are defined in relation to the beach slope and can be modeled in several ways (figure 4):

- 1) With a simple linear regression of elevations in function of distances that represent a uniform slope. The regression equation is $y = a x + b$ where a is the slope coefficient; this choice is well adapted to beaches with regular slopes.
- 2) With a polynomial regression to model a non-homogeneous slope with curves (one for a polynomial of order 2, two for a polynomial of rank 3, etc.); this option is adapted to convex or concave slopes.

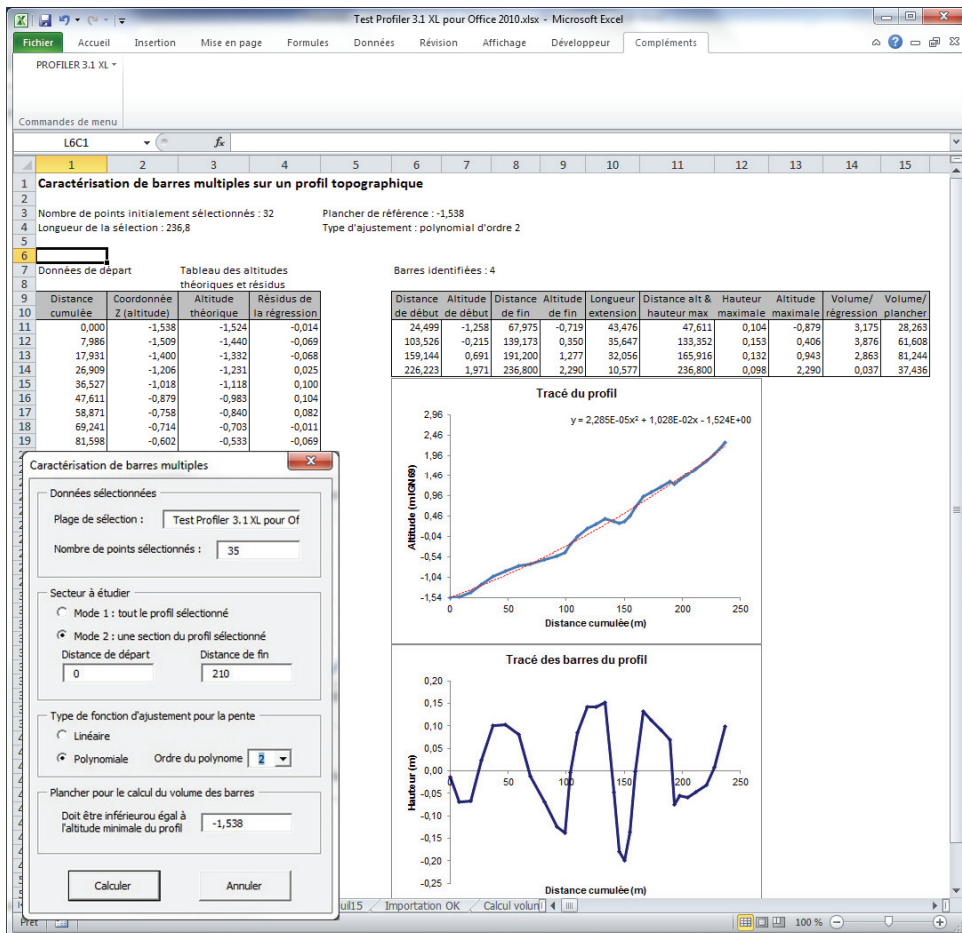


Figure 4 – Example of the dialog box and results of the “Multiple bars” function.

Two graphs are displayed on the results worksheet: one shows the “classical” topographic profile, the statistical regression or slope and its equation; the second exhibits the undulations with a vertical component expressed not in elevation but in height.

The residuals (difference between real profile and theoretical elevations on the mean slope/regression) are computed: the positive ones are considered as ridges and the negative ones as runnels. The limits between a ridge and a runnel are the intersections of the profile and the regression (figure 4). Thus, it is possible to calculate the position of these points and determine the horizontal extension of the bars. The bars’ crest is the maximum positive residual; its height is the difference between the elevation on the profile and that on the regression. Two types of bar "volume" are calculated, one corresponding to the area between the profile and an elevation datum defined by the user (figure 5a), the other to that between the profile and the regression (Figure 5b).

The following examples were computed using surveys carried out in Dunkirk (France) on the southern North Sea shore where beaches are characterized by ridges and runnels. On figure 4, the program identified four bars. But only the first three are complete; the fourth on the right corresponds to the dune toe. Using this function over several successive profiles in time is interesting to study the evolution of the position and shape of the bars, for example under changing hydrodynamic conditions (Sedrati, 2006).

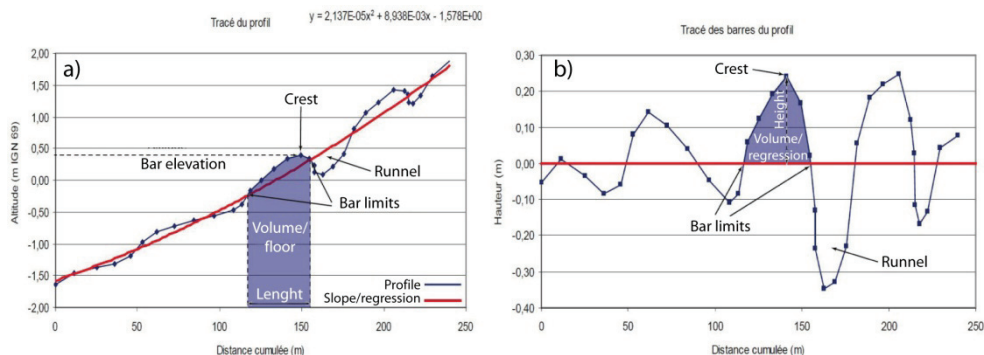


Figure 5 – Principles of bars limits, crest and volume calculation.

Example of the «comparison» function

This function allows making comparisons between two topographic profiles. To be comparable, the profiles are first divided into sections of equal length. The results worksheet comprises (figure 6):

- 1) In the header, the cutting value (length of sections), the floor elevation, the extension of each profile and the common length, the volumes and the difference in volume of the two profiles.
- 2) In the left table, the original data; in the right table, for both profiles, the standardized cumulative distances, the corresponding theoretical elevations (interpolated with a simple linear regression) and their differences, the volumes of each section and their differences.

3) Two diagrams are displayed: one shows the superposition of the two profiles (colored curves) and their difference (vertical bars), the other only presents the difference between the profiles (it is a zoom on the first chart). Positive values express accumulation and negative ones erosion.

The "comparison" function can be used for conventional profiles (with distance and elevation data), but also for bars data (distances and the regression residuals) for example, to estimate the temporal evolution. On figure 7a, we notice that the bars have shifted to the right (upper beach) and increased in height. The eroding zones correspond to bar departure and accumulative ones to bar arrival (figure 7b).

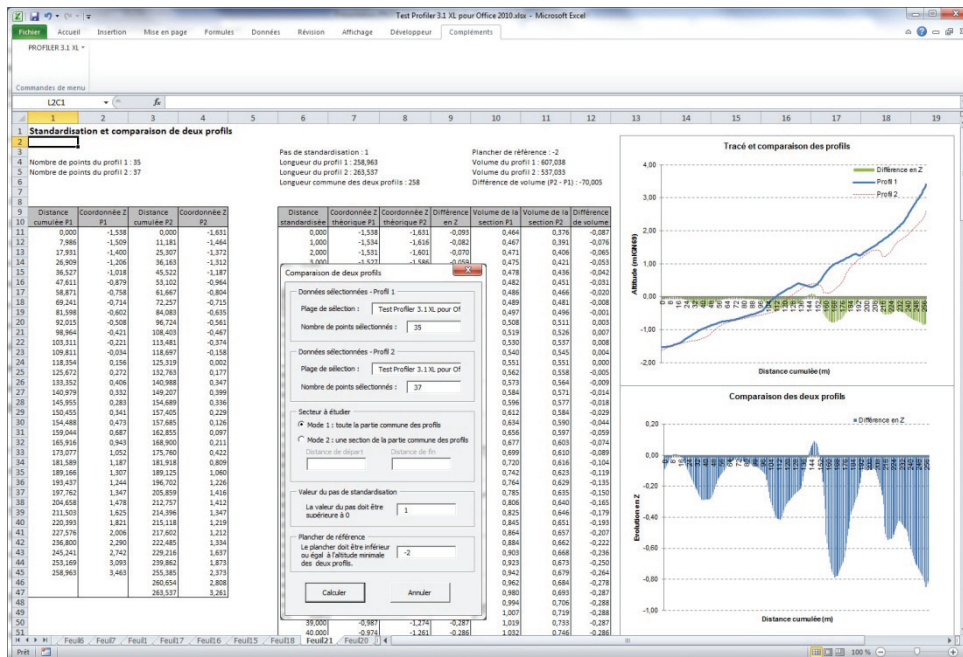


Figure 6 – Example of the dialog box and results of the “Comparison” function.

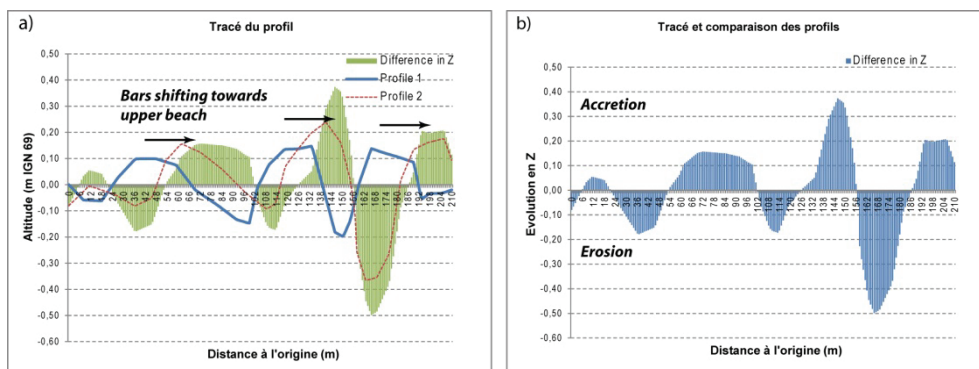


Figure 7 – Comparison of data treated with the “Multiples bars” function

Conclusion and perspectives

Profiler 3.1 XL is a free and, we hope, user-friendly software. We already plan to develop new functions, e.g. to check profiles alignment, to take into account error margins, to compare more than two profiles. We also would like to organize a collaborative development of the next versions and try to program them into OpenOffice to enable a broader and totally free software distribution. For now, Profiler 3.1 XL is only available in French but an English version should be ready in the months to come.

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