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ASSESSMENT AND COMPARISON OF OPEN SOURCE GIS SOLUTIONS

Arnaud RODIER

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Supervised by : Bruno Chatenoux

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ABSTRACT

In a vision of sustainable development, NGOs, international agencies as well as developing countries look for unexpensive GIS (Geographic Information System) solutions for the management of their goods and natural resources. Subsequent to the widespread use of GIS, many projects of GIS open sources have been developed in the last decade to reach high potentials. Thus, the community of interested users and developers is increasing, which should be a guarantee of quality and responsiveness.

This report proposes an overview of the actual options available in term of open source GIS. It tries to distinguish different kind of user to determinate which software are adapted to a particular profile of user.

The main goal of this document is to realize an assessment of open source GIS software, to list an inventory of the best GIS solutions available on the internet and to perform a set of tests for all the software selected, in order to evaluate their strength and weakness as well as their potentiality. A synthesis table gives a summary of all the tests that have been done, and functionalities that the software have with a small evaluation.

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1. INTRODUCTION

This report was written in the context of a 3 months internship performed in UNEP/GRID-Europe. This document is part of the validation for the certificate of specialization in Geomatics proposed by the University of Geneva.

The main goal of this document is to realize an assessment of open source GIS software. This assessment is done in regards of three profiles of users. User profiles are the following:

- The *basic* users who use GIS in a professional frame or in their leisure activities. This type of users needs a user friendly GIS to facilitate the handling of the simple functions used. In a way, basic users need to facilitate the display of different kind of data or make simple map.

- The *intermediate* users who already have basic knowledge of GIS. This type of users handles GIS software with the aim of an effective management of their environment. They need to be supervised and have protocols to progress with tools of geoprocessing within the framework of a project.

- The *expert* users in GIS, who have robust knowledge in the domain. They are totally independant and need powerful GIS application to develop complex operations.

Each type of user above can determine the best software according to his needs in the synthesis table. This table presenting the results of several tests is described on chapter 2.1.

Before beginning the assessment of open source GIS, it is useful to clarify a few definitions.

1.1 Open source

There are two types of "free" software. In fact, there is open source software and free software (freeware). Freeware are price free but are not free in their use most of the time. In other words, they are free of charge but there is no way to access the source code.

On the other side, the open source software give a source code that anyone can access. The Free Software Foundation provides a definition of the open source software based on four aspects:

- The freedom to run the program, for any purpose (freedom 1).
- The freedom to study how the program works, and change it to make it do what you wish (freedom 2). Access to the source code is a precondition for this.

- The freedom to redistribute copies so you can help your neighbour (freedom 3).
- The freedom to distribute copies of your modified versions to others (freedom 4). By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.

The quality of an open source software is often proportional to the number of its developers. The larger development communities and user stretch are, the more it becomes a guarantee of quality and responsiveness. Similarly, the community of users has the primary role to make up for shortcomings and suggestions, and has an influence commensurate with its size.

1.2 Licences

Several conditions and rules must be followed according to the licences. A software licence is more or less restrictive. There is two kinds of licences which are associated to the proprietary licence and to the free software, which are respectively " copyright " licences and for most " copyleft " licences. The following short descriptions apply to the licences of the software that have been tested.

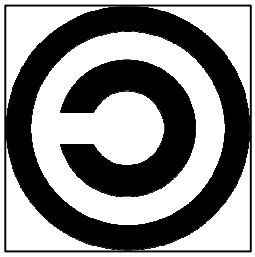


Figure 1 : Symbol of "Copyleft"

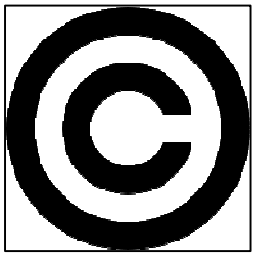


Figure 2 : Symbol of "Copyright"

Five types of licences can be distinguished for the open source software:

- A license belongs to the "public domain" when the software belongs to everyone. In juridical terms, a software that belongs to the public domain has no licence as there is no copyright. A developer can give his work to the public domain. Moreover, a software or a developer work also enters public domain and becomes free of copyright when its author died more than 70 years ago in the European Union and more than 50 years ago in Switzerland (see art 39, RS 231.1, Loi fédérale sur le droit d'auteur et les droits voisins).

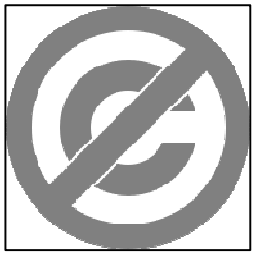


Figure 3 : Symbol of "Public domain"

- The BSD licences (Berkeley software distribution) have few restrictions on distribution and are relatively close to the public domain. These licenses allow distributing a free software in a proprietary one. These licenses thus make it possible to any player to change the license under which the software is distributed.

- The GPL (General public licence) is the first and foremost copyleft license, which means that derived works including any changes can only be distributed under the same license terms.

The "copyleft" software allows the integration of BSD license and redistributes it under the GPL. The opposite is not possible. The underlying principle is that one benefits freely from the work of others but any modifications one makes must be released under the same terms. For this reason copyleft licenses are also known as reciprocal licenses, they have also been described as "viral" due to their self-perpetuating terms. The risk of falling in competition with a modified version proprietary of his own work is non-existent.

- Licences LGPL (Lesser General public licence) are compatibles with GPL licences and allow linking some modules of any free software or proprietary. It has the ability to use tools with LGPL in proprietary software, if these tools remain LGPL.

The LGPL licenses have no copyleft clause. We have on the other hand the obligation to make available the source code of software and to indicate these changes.

- MPL licence (Mozilla public licence) is halfway between the license BSD and the GPL licence. It means that the modifications of a file under MPL must be made public, it is not necessarily the case of the other files added to the application. It can combine files under MPL license and under another (proprietary or not) in the same software, and only changes to files under MPL must be published under this license.

The studied software in this report contain the following licenses: GPL, LGPL, MPL 1.1 (see summary table on appendix 1).

1.3 Interoperability

The term interoperability is used to describe the capability of different programs to exchange data via a common set of exchange formats, to read and write the same file formats, without any restricted access or implementation.

The simplest idea is to define an explicit standard, a norm or a group of norms that each element will implant in its own system. The interoperability only concerns the external behaviour of each system, not their internal mechanisms.

For example, proprietary software are not interoperable most of the time. Indeed, proprietary software are accompanied by a proprietary file format ensuring his publisher to keep its market share. This requires all clients to buy periodically the next version contrary to open source software. Fortunately such tendency is decreasing as proprietary software are starting to offer import/export function in/to open source formats.

1.4 Common libraries

The use of libraries facilitates the development work and reduces duplication of efforts. It also increase the reliability of the software that use them as everyone use the same code and then bug detection and fixes are quickly done.

GDAL (Geospatial Data abstraction library) is an open source programming library and set of utilities that allow users to manipulate raster data. It is also a translator library for raster geospatial data formats.

OGR is the vector analogue, also comes with GDAL.

2. METHODOLOGY

This chapter presents the procedure of the open source GIS software assessment that is described in this report.

2.1 Selection of software

There are more than hundred of open source GIS software available on the internet. First of all, a large selection of potentially interesting software has been done. Two web sites (http://opensourcegis.org/, http://freegis.org/), which are gathering the most of GIS solutions, were used to make the selection.

All internet sites of the selected software were visited to be sure that they fitted with the definition of open source desktop GIS.

Many of the selected software were eliminated in a later step of exploration because they did not correspond to desktop SIG software.

The selected software are the following:

- Quantom GIS 1.4.0 (QGIS)
- Grass 6.4
- uDig 1.2

} OSGeo4W

- Diva 7.1.7
- gvSIG 1.1
- ILWIS 3.7
- MapWindows 4.8
- Natural Resources Database 2.5.2
- Open JUMP 1.3
- OrbisGIS 2.2
- OSSIM 1.8.4
- SAGA 2.0.4
- SPRING 5.1.5

After a long process of selection and searching, all software above were set up. I noted the time taken and the ease for each of them for the installation. Several information were also recorded, such as:

- Operating system
- Programming language
- License type
- Version
- User community, Web/help resources

Before the testing procedure of the software, the size and activity of the community has been evaluated. An active community ensures the development of

program functionality. On one hand, we have a large community of users to report bugs and software defects. On another hand, it is also the community of developers that receive those error messages and correct the bugs. The aim is thus to continuously improve the application and provide assistance on the internet which is the basis for development. The availability of tutorials and web resources on the website were also reviewed.

The simplicity of the software based on its ease of handling was evaluated and weighted, and a note was given.

SPRING and OSSIM are GIS open sources software which have lots of potential but they were finally not tested because of their complexity of handling.

SPRING is a software which is very interesting for its diversity and capacity of tools like image segmentation, 3D, hydrologic process and digital terrain modelling. OSSIM is a software specialized in remote sensing, image processing and geographical analysis.

Natural Resources Database (NRDB) and OrbisGIS software were quickly eliminated from the initial selection for reasons of bad performances. NRDB is a software which deals with database and tabular data. It supports only vector files.

OrbisGIS has a simple GIS user interface. However, he does not offer great possibilities. Available formats are also limited.

2.2 Data

2.2.1 Preparation of the standard database

In order to test these software, it was necessary to gather a great amount of data. The data used has been provided by Mr. Bruno Chatenoux, coworker at the UNEP/GRID. This data come from a project on the erosion of the Jamaican littoral, realized with the Jamaican government. The files are the following :

Name	Description	Format	Projection
Census_2001	Sub-county of parishes in Jamaican west coast	.shp	jad2001
jam_salb_jan00-aug09	SALB subdivision of Jamaica in 13 administrative units, called parishes	.shp	WGS84
BATHY CONTOURS	Bathymetry of Negril beach, Jamaican west coast	.dxf	UTM17N
Hotels	Hotels from Negril area, Jamaican west coast	.txt	jad2001
imagery	Satellite image of Negril area, Jamaican west coast	.tif	No defined

map	Openstreetmap vector	.osm	WGS84
08jan17_1010010007954300_jamaica	Satellite image of a part of Jamaican west coast	.img	WGS84
srtm_21_08	Digital Elevation Model (DEM)	ESRI grid	WGS84
srtm_21_09	Digital Elevation Model (DEM)	.asc	WGS84
CNTRY92	Map of the world	.shp	WGS84
ibtracs_points	IBTrACS best tracks cyclone itinerary	.shp	WGS84
test_lines	Random worldwide line used as a test for true buffer creation	.shp	No defined
truebuffer500km	Buffer realised with real distance	.shp	No defined

Table 4 : Description of data

2.2.2 Test

In order to test the software interoperability, several files formats have been tested. The following file formats are concerned:

- shapefiles (.shp)
- openstreetmap (.osm)
- taged image file (.tif)
- drawing exchange format (.dxf)
- image disque (.img)
- ASCII (.asc)
- texte (.txt)
- ESRI grid

As in the real life, these files did not have similar projections. It was therefore possible to evaluate the software capacity to deal with projections. The aim is to see which projection library is used by the software, and to check if the software makes the projection change directly when another layer of projection (projection "on the fly") is added. If the projection is not transformed automatically, it is necessary to check if a manual reprojection is possible. The possibility to make a "homemade" projection with custom parameters has also been tested.

Then, it was checked whether the software had the capacity to:

- connect web-services (WMS, WCS, WFS)
- make digitalization with attached topology and snapping mode
- make basic geoprocessing (clip, buffer, intersect, merge)
- connect to database (tabular, relational, PostGIS)
- make spatial images analysis (histogram, filter, composition, segmentation)
- export various formats
- produce a layout

- deal with geographic coordinates greater than 180 degrees in WGS84 projection[1]
- deal with real distances

Some capacities could not be directly tested but were subjected to documentation research, among others 3D, web connexion services (WCS), Web feature services (WFS), PostGIS and georeferencement.

It is possible to add interesting functions in several programs thanks to additional plugins. Qgis offers the possibility to add the extension GRASS. With uDig, it is possible to add the Axios extension. And gvSIG offers the possibility to add the Sextante extension. A detailed description of the procedure to follow in order to install these extensions is given at the end of this document, within the appendixes. The software described here have been tested with their respective plugins.

3. RESULTS

This chapter synthesizes the results of the assessment. First of all, a recapitulation of the different software capacity is presented below to have a good overview. A table comporting full details is available at the end of this document on appendix 1.

	Software	*QGIS*	*gvSIG*	*SAGA*	*ILWIS*	*GRASS*	*uDig*	*MapWindow*	*Diva*	*OpenJUMP*
Usability	User friendliness	5	5	3	3	2	4	4	3	4
	Ease of installation	5	5	5	5	4	4	5	5	4
	Ease of handling	5	3	4	4	1	4	5	4	4
	Ease of use	5	4	4	4	2	4	2	3	2
	Summary	**5**	**4.25**	**4**	**4**	**2.25**	**4**	**4**	**3.75**	**3.5**
Interoperability	Georeferencement	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
	Projection	3	3	2	3	3	4	4	2	3
	Imported formats	3	3	3	3	2	2	3	2	2
	Exported formats	4	3	2	2	4	3	2	1	1
	Connection with external database	3	3	3	3	3	2	4	4	3
	Addition of web services	3	4	1	1	3	3	3	1	2
	Summary	**3.2**	**3.2**	**2.2**	**2.4**	**3**	**2.8**	**3.2**	**2**	**2.2**
Processing	Digitalization	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Geoprocessing	4	5	5	5	5	5	4	2	2
	Spatial images analysis	4	4	5	4	5	1	1	2	2
	Summary	**4**	**4.5**	**5**	**4.5**	**5**	**3**	**2.5**	**2**	**2**
	User community	A, G	A, G	A, S	A, S	A, G	A, G	A, G	A, S	A, G
	Web/help ressources	extensive	extensive	extensive	extensive	extensive	extensive	extensive	medium	extensive
	3D	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
	Cartography / Layout	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
	Scores	**4.1**	**4.0**	**3.7**	**3.6**	**3.4**	**3.3**	**3.2**	**2.6**	**2.6**

Table 5 : Synthesis table, maximum grades in yellow

[1] Observation of the software behaviour for latitude exceeding 180°with the "CNTRY92" file which is the map of the world.

The table above is a summary of assessment and tests that are part of this report. The evaluation has been split into sections which are usability, interoperability and processing.

The last section describes functionalities that are difficult to score. Finally a score is attributed by summing the averaged scores of the three sections in order to facilitate comparison. The terminology is explained in the table below.

Usability and **processing** functionalities	1=bad ,2=medium, 3=good, 4=very good, 5=excellent
Interoperability - formats tested	1=bad ,2= good, 3= excellent
- other	1=bad ,2=medium, 3=good, 4=excellent
User community	A=active community, NA=no active community
	G=growing, S=stable, D=decreasing
Web/help resources	extensive/medium/minimal

Table 6 : Legend of the synthesis table (table 5)

All usability and processing functionalities are scored from 1 to 5, as 1 is the worse and 5 is the best. Then for the interoperability lines, except for the formats tested which has 3 levels, the fourth other functionalities tested have 4 levels. The functionality that have binaries response, Yes or No, are not taken account in the score. For the community, two criterions are described: the activity of the community: A=active community and NA=no active community; and the development of the community: G=growing, S=stable, D=decreasing. The evaluation of the Web/help resources was given three levels which are extensive/medium/minimal, and they are not included in the score too.

There are many functionalities evaluated in the usability section which need some explanations to avoid confusions.

"User friendliness" describes the graphics and the modernity of the user interface. "Ease of handling" describes the facility to start with the new software and the time to understand the way it works. Once the handling is done the user want to use the software. "Ease of use" describes the facility to use functionalities of the software.

All software tested below run with Windows operating system, but several run with Linux or Mac as well. A short presentation of each software tested is done on the next chapters.

3.1 QGIS 1.4.0

Quantum GIS (QGIS) is an official project of the Open Source Geospatial Foundation (OSGeo). It supports numerous vector, raster, and database formats and functionalities on a user friendly interface.

QGIS provides a continuously growing number of capabilities provided by core functions and plugin. You can visualize, manage, edit, analyse, use GPS data and compose printable maps.

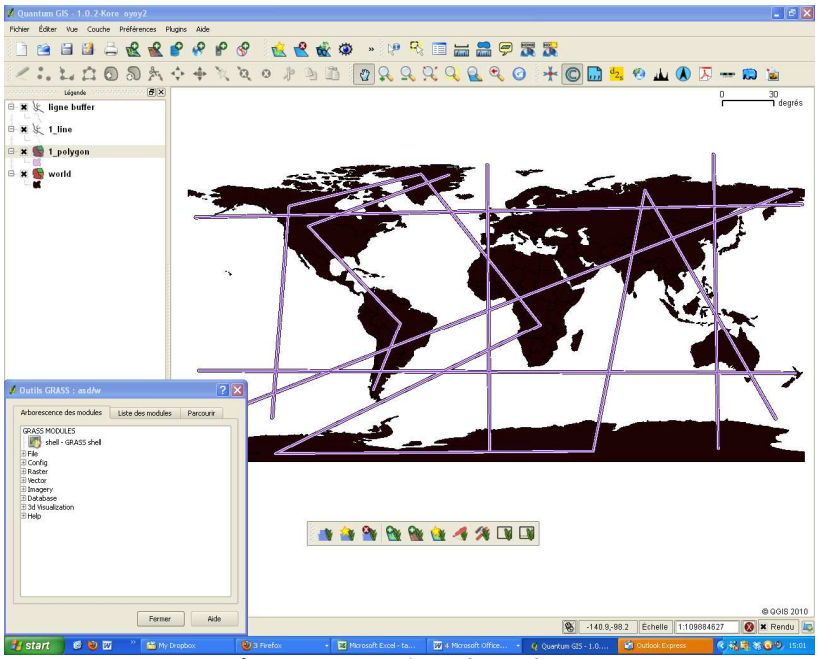


Figure 7: User interface of QGIS

Quantum GIS is maintained by an active group of volunteer developers who regularly release updates and bug fixes. Currently, developers have converted QGIS into 31 languages and the application is used internationally in academic and professional environments.

Gary Sherman began development of Quantum GIS in early 2002, and it became an incubator project of the Open Source Geospatial Foundation in 2004. Version 1.0 was released in January 2009.

+++ Positive aspects +++	--- Negative aspects ---
- User friendliness - GRASS plugin, that offers lots of tools (see appendix 2) - Capabilities and facility to digitalize.	- Some tools like reading relational data base or the segmentation could be improved.

3.2 gvSIG 1.1

gvSIG is a GIS desktop application designed for capturing, storing, handling, analyzing and deploying any kind of referenced geographic information in order to solve complex management and planning problems. It features a wide range of tools, which turns gvSIG into the ideal tool for users working in the field. gvSIG is known for having a user-friendly interface and being able to access the most common formats, both vector and raster ones.

Key features of gvSIG:
- Integrating in the same view both local (files, databases) and remote data
- Being available in several languages

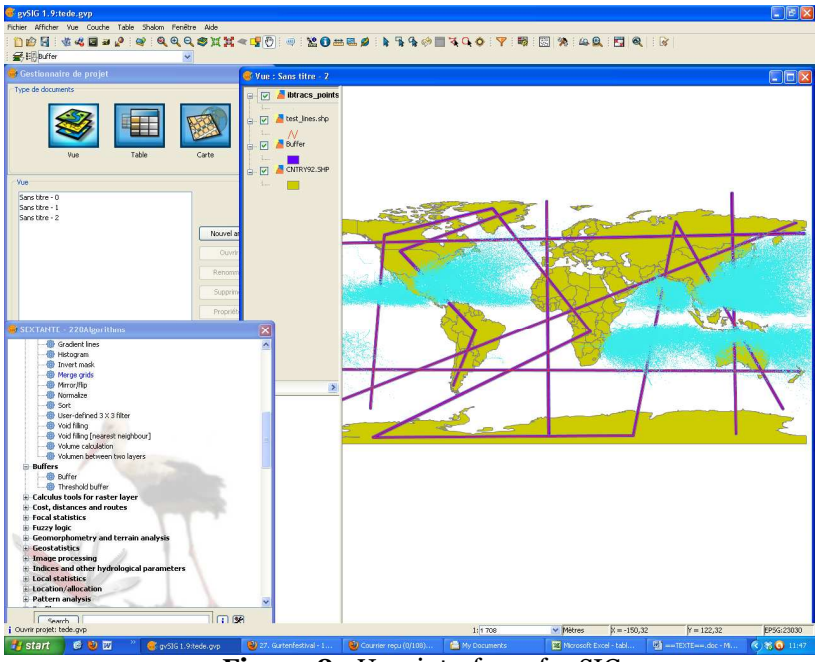


Figure 8 : User interface of gvSIG

The project gvSIG was started in the end of 2003 by the initiative of the Infrastructure and Transport council (CIT) of the Valencien government. gvSIG has the aim to provide to the professional or simple users a friendly display of geographical data.

Some menus appear only when the corresponding window is open and active, making possible to perform actions on the active windows in the foreground. For example, the menu "Map" has different button from the "View" menu which is confusing at first, but the user get used quite quickly.

+++ Positive aspects +++	--- Negative aspects ---
- Lots of available languages - Sextante plugin contains many tools (see appendix 3) - User friendliness	- Hard to handle at the beginning

3.3 SAGA 2.0.4

SAGA is the abbreviation for System for Automated Geoscientific Analyses. It has been designed for an easy and effective implementation of spatial algorithms. It provides many tools of geoprocessing, as DEM, geo-statistics and image processing. SAGA offers a comprehensive, growing set of geoscientific methods and provides an easily approachable user interface with many visualisation options.

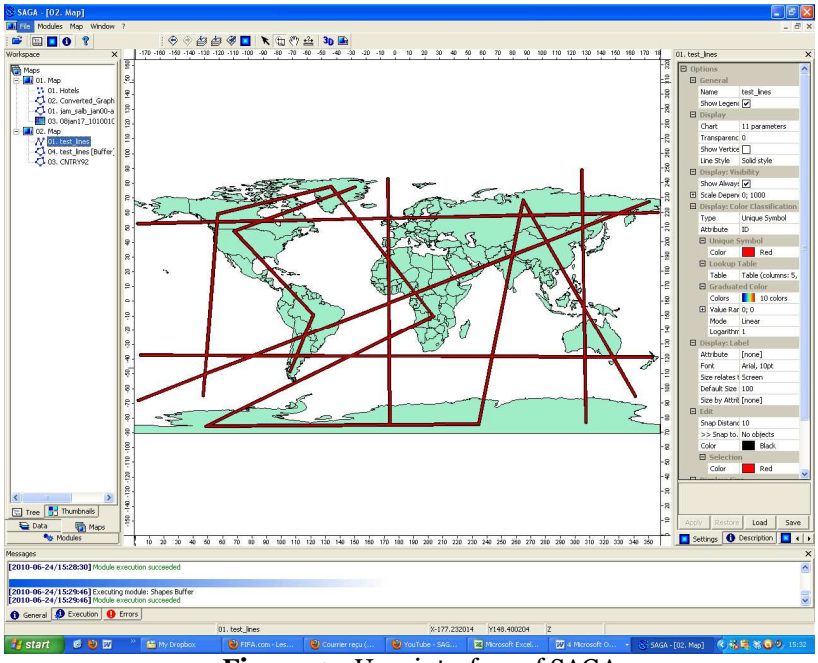


Figure 9 : User interface of SAGA

Most past and current SAGA developments come from the team around J. Böhner and O. Conrad, both are now working at the Institute of Geography, University of Hamburg, Germany.

The idea for the development of SAGA evolved in the late 1990s during the work on several research projects at the Dept. for Physical Geography, Göttingen. A research focus was the analysis of raster data, particularly of DEM, which have been used e.g. to predict soil properties, terrain controlled process dynamics as well as climate parameters. This required the development and implementation of many new methods for spatial analysis and modelling.

+++ Positive aspects +++	--- Negative aspects ---
- Many tools: Geostatistics, semi-variogram, cost analysis - Lots of possibilities in raster analysis, kriging - Very simple to handle and use	- No growing community - No web services available - Digitalization not so effective.

3.4 ILWIS open 3.7

The Integrated Land and Water Information System (ILWIS) is a PC-based GIS & Remote Sensing software. ILWIS comprises a complete package of image processing, spatial analysis and digital mapping.

Key features of ILWIS:

- Import and export of widely used data formats
- Comprehensive set of image processing tools
- Image georeferencing, transformation and mosaicing
- Advanced modeling and spatial data analysis
- Geo-statisitical analyses, with Kriging for improved interpolation
- Set of operations on DEM and DTM (Digital Terrain Model) and hydrological processing.

Raster or vector files have to be imported in ILWIS, before to be open as ILWIS files.

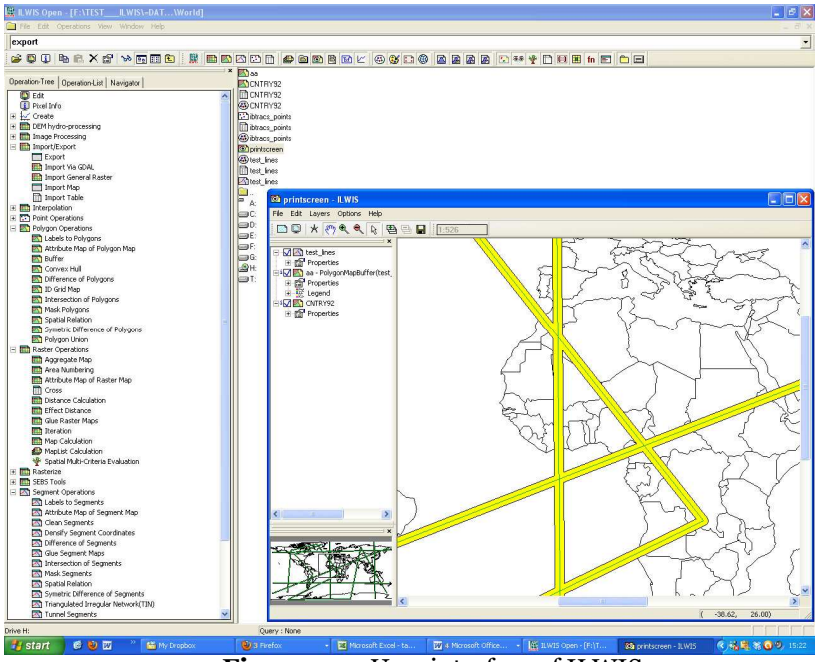


Figure 10 : User interface of ILWIS

As per 1 July 2007, ILWIS software is freely available as open source software. This software version is called ILWIS open. It was developed by ITC up to release 3.3 in 2005.

+++ Positive aspects +++	--- Negative aspects ---
- Ease of handling - Easy to learn, it has full on-line help - Extensive tutorials for direct use - Effectiveness in geoprocessing.	- No possibility of connection with WMS/WCS/WFS - Exported formats are limited - User interface

3.5 GRASS 6.4

GRASS (Geographic Resources Analysis Support System) is a raster/vector GIS, image processing, a data management and graphics production system. GRASS contains over 350 programs and tools to render maps and images on screen and paper. This software can manipulate raster, vector, can process multi spectral image data and create, manage, and store spatial data. GRASS is an official project of the Open Source Geospatial Foundation.

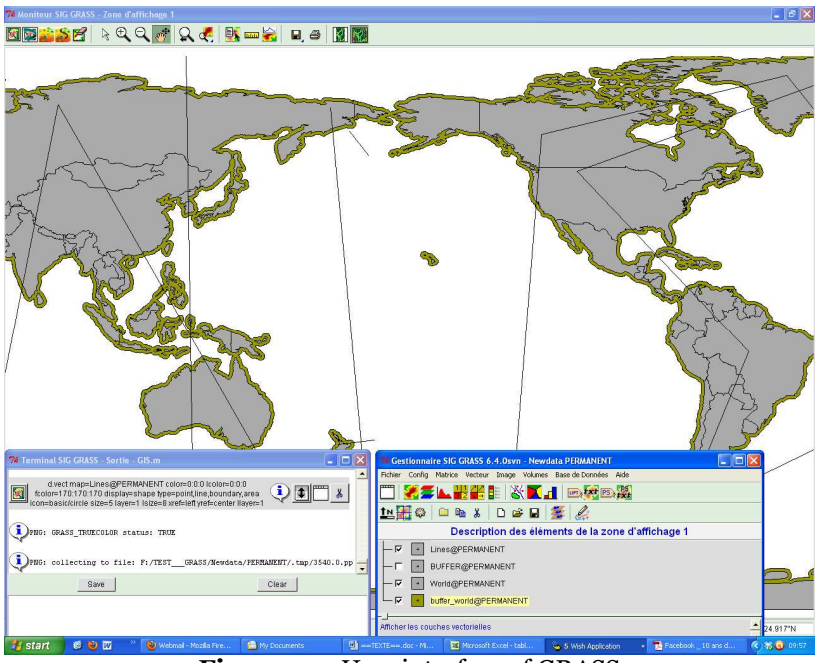


Figure 11 : User interface of GRASS

Originally developed by the U.S. Army Construction Engineering Research Laboratories (USA-CERL, 1982-1995), as a tool for land management and environmental planning by the military, GRASS has evolved into a powerful utility with a wide range of applications in many different areas of scientific research. GRASS is currently used in academic and commercial settings around the world, as well as many governmental agencies including NASA, NOAA, USDA, DLR, CSIRO, the National Park Service, the U.S. Census Bureau, USGS, and many environmental consulting companies.

+++ Positive aspects +++	--- Negative aspects ---
- High potential software - 3D - Test "world tour"	- Hard of handling - Hard of using - User interface different from other

Even though this software does not have the best marks, it is the one that has the biggest potential in term of processing capacities. An initiation is described on appendix 4 to start a session in GRASS.

3.6 uDig 1.2

The goal of uDig is to provide a complete Java solution for desktop GIS data access, editing, and viewing. uDig aims to be:

- User friendly, providing a familiar graphical environment for GIS users
- Internet oriented, geospatial web services (WMS, WFS, WCS)
- GIS ready, providing the framework on which complex analytical capabilities can be built, and gradually subsuming those capabilities into the main application.

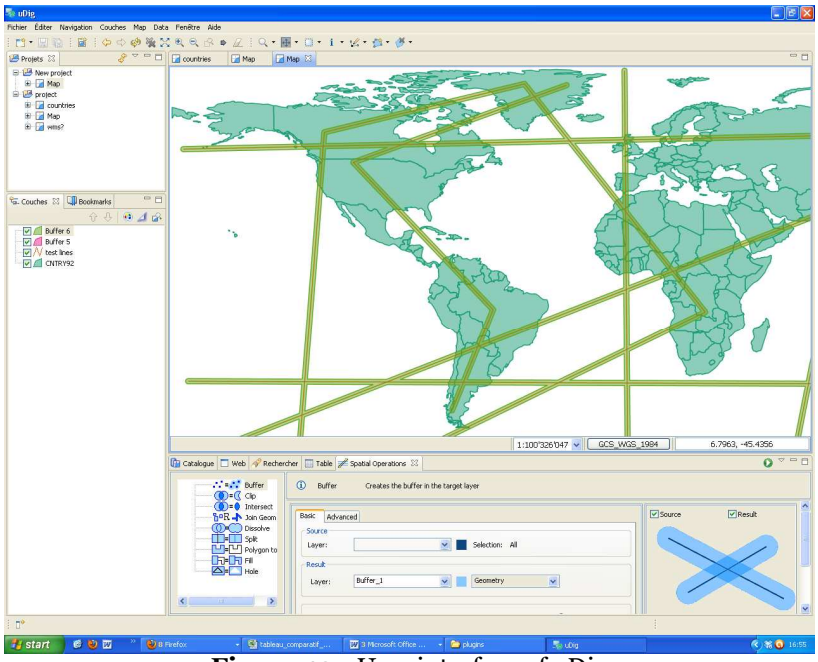


Figure 12 : User interface of uDig

uDig is a produced by a community led by Canadian-based consulting company Refractions Research.
uDig can use GRASS for complex vector operations and also embeds JGRASS and Sextante plugin which is opening the door to the processing of complex operation. It supports shapefiles, PostGIS, WMS, and many other data sources natively. uDig provides tools to create plugins or contribute to the main build.

Help is very useful, with good explanations on use of functions and plugin. It is possible to add some geoprocessing tools (buffer, clip, intersect, join, dissolve, split, polygon to line, fill, hole) with a special plug-in called Axios. The process to install this plugin is described on the appendix 5.

+++ Positive aspects +++	--- Negative aspects ---
- Possibility to add lots of plugin notably Axios and Sextante - Easy integration of WMS, WCS	- Hard to install plugins - Problems with data source/path - Can be very slow

- Excellent help documentation - Simple of handling and using.	- No spatial images analysis - Bad handling of external database

3.7 MapWindow 4.8

MapWindow is an extensible geographic information system for simple viewing and processing spatial data. It includes a complete scripting editor. This means that you can write plugins to add additional functionality.

The MapWindow application is a free, extensible, GIS that can be used:

- As an alternative desktop GIS
- To distribute data to others
- To develop and distribute custom spatial data analyses

The MapWindow GIS open source project includes a desktop application capable of viewing shapefile, and raster data in many formats. It can reproject data, clip, merge, and perform other geoprocessing through a "GIS Tools" plugin. Developer-users can extend the application by writing plugins.

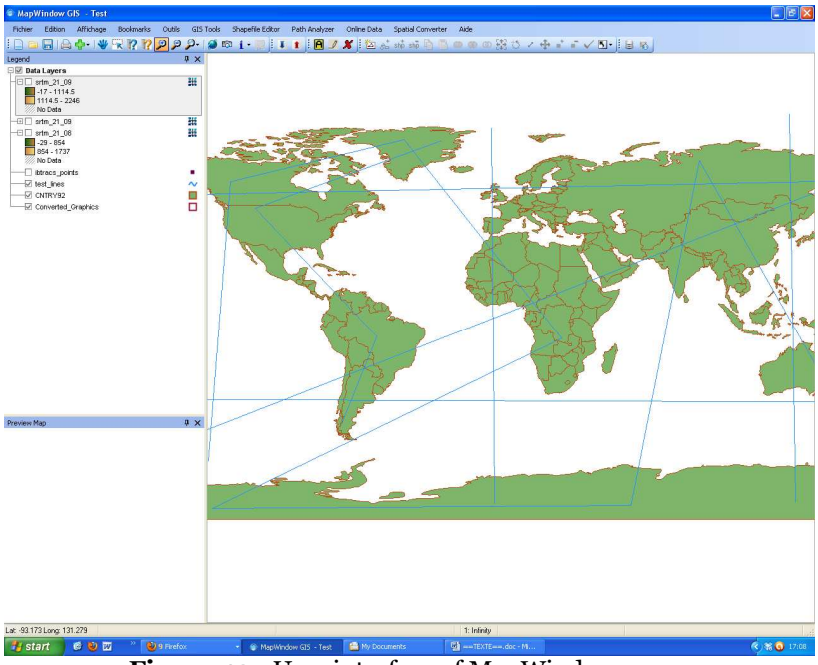


Figure 13 : User interface of MapWindow

+++ Positive aspects +++	--- Negative aspects ---
- Possibility of using plugin Sextante - Lots of languages available	- Not very stable - Buggy during our test - Very slow processing - Can be very slow as your open it.

3.8 Diva 7.1.7

DIVA-GIS is a free computer program for mapping and geographic data analysis. It can be used to analyze data, for example by making grid (raster) maps of the distribution of biological diversity, to find areas that have high, low, or complementary levels of diversity. DIVA-GIS is particularly useful for mapping and analyzing biodiversity data, such as the distribution of species. With specific functionalities to predict species distributions using the BIOCLIM or DOMAIN models.

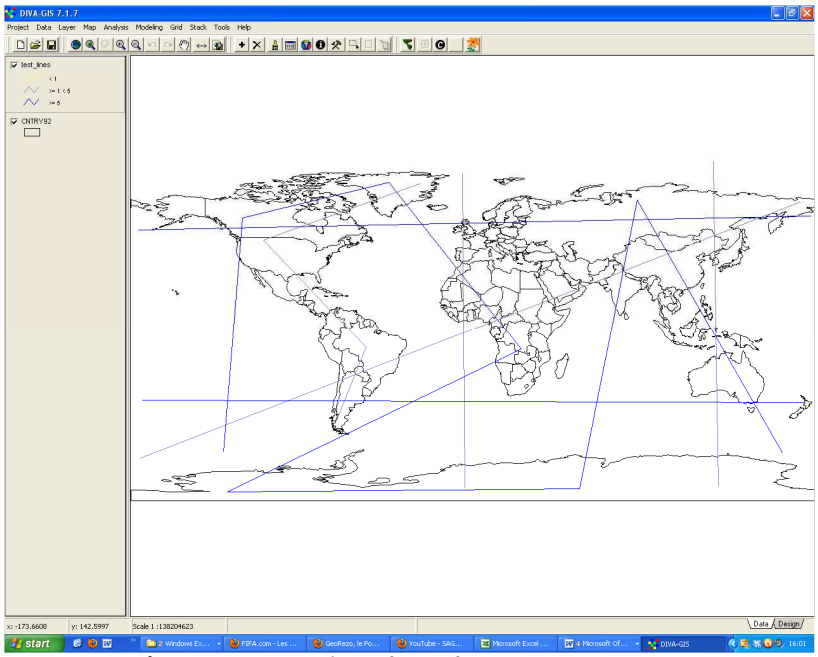


Figure 14: User interface of DIVA

DIVA-GIS started out as data storage tool to transfer descriptive location data into geo-coded decimal data sets, and acquired additional functionality for biodiversity analysis and crop prediction based on climate data.

+++ Positive aspects +++	--- Negative aspects ---
- Geostatistic - Distribution of biodiversity - Predicted species distribution - Regression - Terrain modelling	- Geoprocessing

3.9 OpenJUMP 1.3

OpenJUMP project started as JUMP GIS. After the initial creation and deployment of JUMP, regular development of the program by Vivid Solutions stopped. However, the company was gracious enough to continue offering support to the user community that had grown around JUMP, and answering the questions of developers that had begun to improve JUMP in small ways, or who had customized it to fit their needs. Today the open source application OpenJUMP is developed and maintained by a group of volunteers from around the globe.

The current version can read and write shape files and simple GML files. It has limited support for the display of images and good support for showing data retrieved from WFS and WMS web-services. So OpenJUMP can be use as GIS Data Viewer.

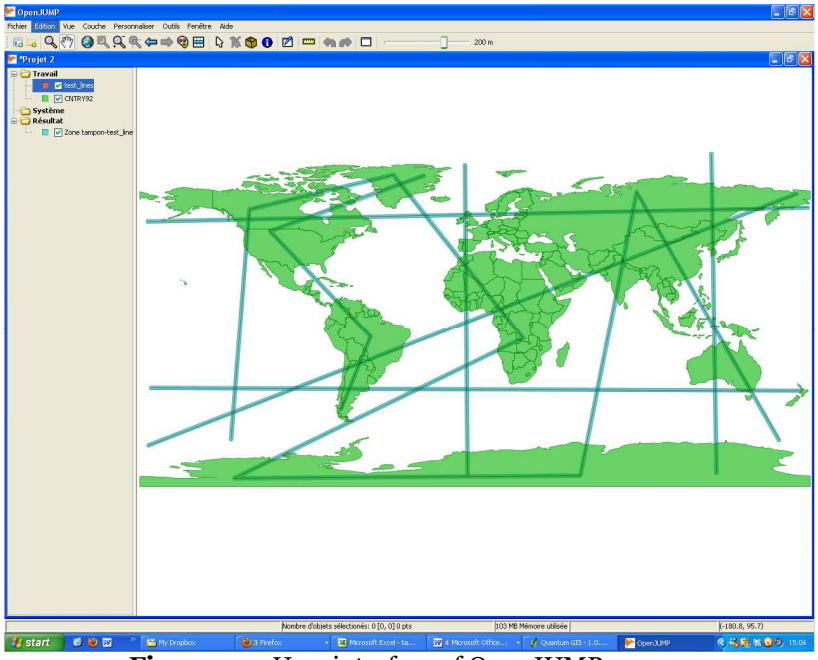


Figure 15 : User interface of OpenJUMP

+++ Positive aspects +++	--- Negative aspects ---
- Sextante GIS plugin available	- Limits in reading very large data files limited support for cartographic projections - OpenJUMP has several bugs in many conditions, when downloading heavy files, during a projection, when adding an plugin among other - Sextante extension is very difficult to install - No layout possibilities

3.10 Osgeo4w

Osgeo4w is a set up package gathering several software, like GRASS, QGIS, uDig, OpenEV and some libraries like GDAL. In our case, we are interested only in GRASS, QGIS, uDig and in the libraries. This package is easy to download and to set up.

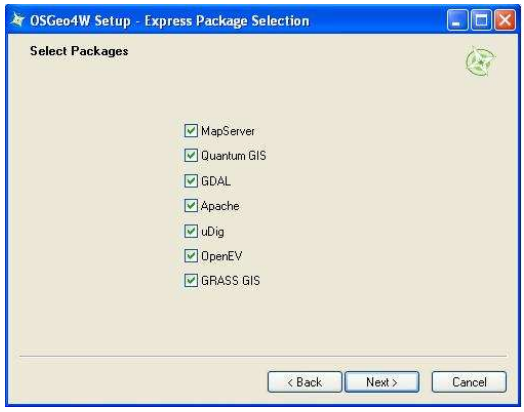


Figure 16 : Packages selection with Osgeo4w

With the set up package OSGeo4w, the aim was to make it possible to set up several included software without using any web connexion (see appendix 6).
This has been done in order to give a CD with all the necessary software to the countries with webconnexion that is not performant enough.

Several tests have been done on freshly installed windows XP virtual machine in order to find the correct procedure, including the right package. In fact the set up is not easy as it has to be done manually and the packages have to be chosen manually too.

+++ Positive aspects +++	--- Negative aspects ---
- Possibility to set up several chosen programs - Quick and easy set up with a good web connexion	- Set up without connexion is more difficult but easy when following the appendix 2.

All the tests that have been done are summarized in a table with further information about each software tested (see appendix 1).

4. SYNTHESIS

The following table summarizes which software is adapted for which user. Some GIS software can be adapted to different kind of user.

		SOFTWARE								
		QGIS	gvSIG	SAGA	ILWIS	GRASS	uDig	MapWindow	Diva	OpenJUMP
USER	Basic	×	×				×	×	×	×
	Intermediate	×	×	×	×		×	×		
	Expert	×	×	×	×	×				

Figure 17 : User profiles linked to software

This table shows that QGIS and gvSIG can be used by any kind of user. These software are the best noted software of the table 5. The five best noted (QGIS, gvSIG, SAGA, ILWIS and GRASS) can be used by experts and the four others (uDig, MapWindow, Diva, OpenJUMP) are more for basic users. Intermediate users have quite a large choice among six software. The most important criteria of this table are the 3 sections of table 5 which are usability, interoperability and processing.

QGIS and gvSIG have the best scores. QGIS has a better score than gvSIG in table 5. But gvSIG has better notes if we only see the technical specificity, especially in processing.

ILWIS, uDig or MapWindow can be a good choice depending on the needs of the user. uDig and MapWindow have good note in interoperability and ILWIS has really good notes in processing.

GRASS and SAGA have the higher note for the processing section. GRASS is for expert users only because of his difficulty of handling and use. In contrary, OpenJUMP is more adapted to basic users, his usability is quite good, despite of its weakness in interoperability and processing.

Some software, such as SAGA, ILWIS and Diva, could have much better results if the statistical analysis capacity had been taken into account.

5. PERSPECTIVES

Some capacities have not been tested in the context and during the production of this work. It would have been interesting to examine the different software for further information. An extended research could have been done in the following subjects:
- Selection mode
- Layout
- Parallelization
- Topology

Firstly, the type of selection method the software has (selection by attribute, selection by location) could have been tested. For instance, gvSIG has several methods of selection including standard selection method, a request selection tool as well as a different buttons for the following selection options: buffer zone, circle, polyline, from a rectangle or from a polygone.

Other elements that would have been interesting to consider are a detailed research about the layout and the management of metadata. The customization of the layout is important for the people who wish to produce detailed and well presented maps, inserting a personalized legend, a scale bar, a north arrow and text.

Then, parallelization is not a well-known instrument that consists of a cluster of several software which run complex and heavy applications. This tool is expected to be progressively improved in the following years.

Finally, the topology has several rules with different functions that can be listed.

In this report, the processing functionalities were listed but were not timed (Windows operating system). It would have been interesting to compare these times with the time taken by the same functionalities in a Linux operating system. A comparison between the bugs in the two different operating systems could have also been performed.

A test project with several processes could be established to be tested by each software, to evaluate the difference in their performance for each step. In this way, the software can be easily compared and assessed.

6. CONCLUSION

The philosophy of open source software is based on collaboration, mutual support and sharing of knowledge. Open source software are a great option in comparison with those qualified as proprietary. Open source software occupy a relatively small market in terms of individual users, but their reputation is in constant progression.

More than an ethical choice, the choice of a GIS open source software can bring you lots of benefits. Benefits are the following:
- Availability of its source code, that means no problems to continue to use it even if the project would be given up by its original developers
- Transparency thanks the source code, the examination of the software security is possible
- Standard formats, that provides the security to read personal data free of charge for a very long time
- Less bugs, because they are corrected progressively by the developers community
- Problems of virus almost non-existent
- Last but not least, it's free!

The difficulty of this work lies in the fact that I had to become familiar and used to every working environment.

Before beginning this assessment of the selected software, doubts were already present. All functionalities tested indicate that open source GIS software are now performing alternative to proprietary packages. They have also several interesting specificities. As their equivalent in the propretary family, open source GIS have basic functionnalities that can be increased with the installation of plugins. Such process varies from one software to another and can (like in proprietary) be quite complex. The protocol of installation of key plugins on the main software can be found in appendices, as well as the protocol of installation offline of OSGEO4W.

7. REFERENCES

1. Open source gis in general:

http://opensourcegis.org/

http://freegis.org/

Library GDAL
http://www.gdal.org/formats_list.html

Library OGR
http://www.gdal.org/ogr/ogr_formats.html

2. Software:

Diva
http://www.diva-gis.org

GRASS
http://grass.itc.it/

gvSIG
http://www.gvsig.gva.es

Ilwis
http://www.ilwis.org

Mapwindow
http://www.mapwindow.org

Natural resources database
http://www.nrdb.co.uk/

OpenJUMP
http://www.openjump.org

OrbisGIS
http://brehat.ec-nantes.fr/orbisgis/doku.php

OSGeo4w
http://trac.osgeo.org/osgeo4w

OSSIM
http://www.ossim.org/OSSIM/OSSIM_Home.html

QGIS
http://qgis.org/

SAGA
http://www.saga-gis.org/en/index.html

Spring
http://www.dpi.inpe.br/spring/english/index.html

uDig
http://udig.refractions.net

8. APPENDICES

1. SUMMARY TABLE

2. USE OF THE PLUG-IN GRASS IN QGIS

3. SETTING UP OF THE PLUG-IN SEXTANTE IN GVSIG

4. GRASS INITIATION

5. SETTING UP OF THE PLUG-IN AXIOS IN UDIG

6. SETTING UP OSGEO4W WITHOUT WEB CONNEXION

1. SUMMARY TABLE

Software	*QGIS*	*gvSIG*	*SAGA*	*ILWIS*	*GRASS*	*uDig*	*MapWindow*	*Diva*	*OpenJUMP*
Operating System	Mac, Windows, Linux	Windows, Linux	Windows, Linux	Mac, Windows, Linux	Mac, Windows, Linux	Mac, Windows, Linux	Windows	Mac, Windows	Windows, Linux
Programming Language	Python, C++,C	Java	Python, C++,C	MS, Visual C	Python, Tcl/TK,C	Java	C# & VB.NET	Java	Java
License	GPL (v2)	GPL(v2)	GPL, LGPL	GPL	GPL	LGPL	MPL 1.1 (Mozilla public licence)	LGPL	GPL
User friendliness [1]	5	5	3	3	2	4	4	3	4
Ease of installation [1]	5	5	5	5	4	4	5	5	4
Ease of handling [1]	5	3	4	4	1	4	5	4	4
Ease of use [1]	5	4	4	4	2	4	2	3	2
User community [1]	A, G	A, G	A, S	A, S	A, G	A, G	A, G	A, S	A, G
Web/help resources	Extensive, good web site in 4 languages (english, german, french, portugese), forum, workbook	Extensive, installation guide, Many language available	Extensive, user guide, forum	Extensive, 25 case studies of various disciplines	Extensive	Extensive, very good explication how to install. Lots of language available	Extensive	Medium	Extensive, user guide, forum (installation, function, plugin questions)
Documentation	User guide, coding and compilation guide, gentle introduction, API documentation	Everything in internet, user manual,extension, remote sensing and graphic manuals (english and spanish)	User guide (pdf, 400 p.) and manual (pdf, 216 p.)	Quick introduction, user guide (13 chapters)	First step manual, module list, programmer's manual	First step manual, concepts, references	Introduction (pdf)	Manual (spanish and english)& tutorial (pdf)	Tutorial, OJ plugin description (pdf), lots of languages available
Vector formats	.shp, .mif, .tab, .gml	.shp, .shp, .dxf, .gml, .dwg, .dgn, .kml	OGR	.shp, .dxf	OGR, .dxf	.shp	.shp	.shp	.shp,
Raster formats	.tiff, .img, .asc, .ecw, .dem, .bmp, .rst	.tif, .rst, .img, .asc, .jpg, .bmp, .gif, .jpeg2000, .raw	GDAL	GDAL	GDAL	.asc, .tif, .sid, .ecw, .img, .dt0, .dt1, .dt2, .on1 ,.on2, .on5, .gif, .jpg, .png	.bmp, .gif, .png, .jpg, .dbf	.tif, .jpg, mrSID,.rst, .flt, .bil, .bip, .bsq, .kmz, .grs(grass)	.tif, .tiff, .gif, .jpg, .png,

Files tested	Census_2001.shp (jad2001)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
	jam_salb_jan00-aug09.shp (WGS84)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	BATHY CONTOURS.dxf (UTM17N)	No (Yes with plugin in version 1.5.0)	Yes, but doesn't work with this data	Yes	Yes	Yes but how, No	No	No, Yes with plugin	No	No, Yes with plugin
	Hotels.txt (jad2001)	No	Yes, but how	Yes	Yes	No	No	Yes (.dbf, .xls, .csv)	Yes	No
	imagery.tif	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
	map.osm (WGS84)	Yes with special plugin	No	No	No	No	No	No	No	No
	08jan17_1010010007954300_jamaica.img (WGS84)	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No
	srtm_21_08 (Esri GRID, WGS84)	Yes but not well	Yes but not well	Yes but not well	No	No	No	Yes	No	No, Yes with plugin
	srtm_21_09.asc (WGS84)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Connection with external database	tabular (.xls, .csv)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No, Yes with plugin
	relational (.mdb)	No	No	No	Yes	No	No	Yes	Yes	No
	PostGIS	Yes (with the "SPIT" plugin:shp to postgis)	Yes	Yes	No	Yes	Yes	Yes, with special plugin	Yes	Yes
Exported possible file formats		.png, .jpg, .bmp, .xpm, .xbm, .tif, .tiff, .ico, .jpeg, ESRI ArcGrid, .vrml, .PPM image, GRASS ASCII, gml OGR, PostGIS,	.png, .jpg, .bmp, …possibilities to export .tif in .gml or .kml and .shp in .kml or .gml or .dxf or PostGIS	.bmp, .png, jpg, .tif, .gif, .pcx, .pdf, .svg	.e00, .shp, .dxf, .seq, .gis, .lan, .tif, .bmp, .img, .asc, .smt, bna	OGR,GDAL mpeg-1, .png, .ppm, .pov-ray, .tiff, .vrml, .vtk, .ascII, .dxf, .svg, .ascII 3D	.pdf,.bmp,.wbmp ,.pnm,.gif,jpeg 2000,.png,.jpeg,.tif, geotiff, raw, .ascII, shp	.bmp, .gif, .png, .jpg, .dbf, .xls, .csv	.txt, .tif, .bmp,	.png, .jpg, .svg
Cartography / Layout		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Addition of web services	WMS	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes
	WFS	Yes	Yes	No	No	Yes	Yes	Yes	No	there is a plugin
	WCS	No	Yes	No	No	No	No	No	No	No

Georeferencement		Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Projection	on the fly	Yes	Yes, but doesn't work well	No	No	Yes, but it doesn't work so good	Yes	Yes	No	No
	manual	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No, Yes with plugin for vector layer
	custom	Yes	Yes	No …?	Yes	Yes	Yes	Yes	under development	No
Digitalization		Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	topology	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes
	snapping	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Geoprocessing	clip	No	Yes	Yes	Yes	Yes	Yes with axios plugin	Yes	No	No
	buffer	Yes	Yes	Yes	Yes	Yes	Yes with axios plugin	Yes	No	Yes
	intersection	Yes	Yes	Yes	Yes	Yes	Yes with axios plugin	No	No	No
	merge	Yes, the function exists but doesn't work well	Yes, the function exists but doesn't work well	Yes, the function exists but doesn't work well	Yes, the function exists but doesn't work well	Yes, the function exists but doesn't work well	Yes with axios plugin	Yes, automatically	Yes (yes with .grd)	No
Spatial images analysis	histogram	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes with plugin
	filter	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
	composition	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
	segmentation	No	No	Yes	No	Yes	No	No	Yes	No
3D		Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Real distance/buffer		No	No	No	No	No	No	No	No	No
Test "world tour"[2]		No	No	No	No	Yes	No	No	No	No

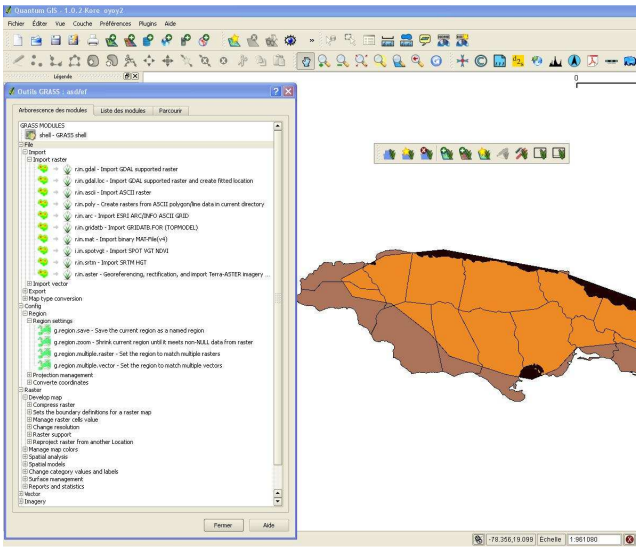
[1] See legend on table 6

[2] Observation of the software behaviour for latitude exceeding 180˚ with the "CNTRY92" file which is the map of the world.

2. USE OF THE PLUG-IN GRASS IN QGIS

The plug-in GRASS makes it possible to use lots of GRASS tools. It's a very good compromise between the user friendliness of QGIS and the efficiency of Grass. It works like GRASS software. That means that a database, a location and a mapset have to be created before beginning a session (see appendix 4). But it is a bit less restrictive, because a project can start without establishing a strict location. We can see in the screen image how it is organised and diversified.

The plug-in GRASS in QGIS software doesn't need any kind of installation. It only needs to select the good version as you download it.



3. SETTING UP OF THE PLUG-IN SEXTANTE IN GVSIG

Sextante is a set of free geospatial analysis tools. The installation of Sextante provides lots of very efficient functions. The following text describes the way to integrate the plug-in Sextante in gvSIG software.

The Open Source Observatory and Repository for European public administrations (OSOR) is a platform for exchanging information, experiences and FLOSS-based code for use in public administrations (http://forge.osor.eu/plugins/wiki/index.php?Downloads&id=13&type=g). In this web Url is located the official Sextante website. Sextante plug-in is on this web site available.

1. Install first gvSIG

2. Download Sextante.zip

3. Then locate the plug-in folder (C:\ProgramFiles\gvSIG_1.9\bin\gvSIG\extensiones) where you have installed gvSIG.

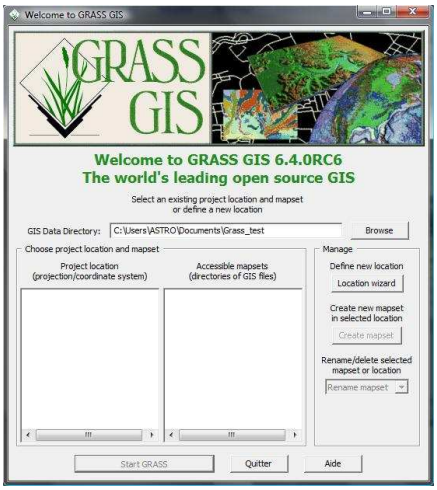
4. Create there a folder called "es.unex.sextante". Copy files from this folder "C:\Sextante\bindings\gvsig_1_9" to the "es.unex.sextante" folder. Erase "es.unex.sextante-0.5.jar" file. Then copy files from "core" folder into "es.unex.sextante" folder.

5. Open gvSIG and Sextante plug-in will be available.

N.B.: If you go directly to this Url (http://www.gvsig.org/web/projects/gvsig-desktop/devel/sextante/product/?searchterm=sextante), you can get sextante plug-in in the official website of gvSIG. Then there is an .exe file which can ease a lot the process of installing the sextante library.

4. GRASS INITIATION

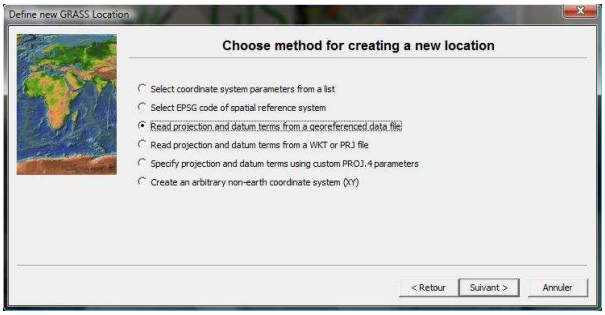
Before using GRASS, it is necessary to create a central directory in order to be able to work with GRASS. This central directory is comparable in a geodatabase.



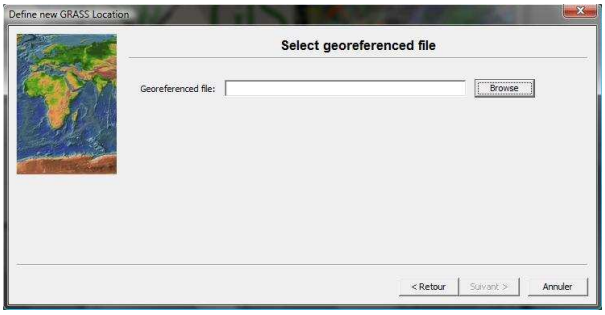
1. Set the GIS Data Directory :

Browse to an empty folder you have created before

2. After this step, the *project location* has to be set. Therefore select the radio button « location wizard ». The *project location* is based on the coordinate reference system and the geographic extent of the study area.

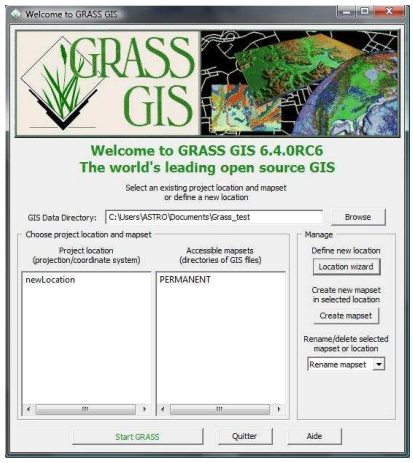


3. Then a window offers to choose a location that is a system of projection. You can choose it by different ways. The most usuable and simple way is to read a projection from a georeferrenciel data file you will use in the grass project.



4. After this step, you can begin a grass session. Therefore you just have to select Start GRASS.

You can create several *Mapsets* with the same location and also several location with the same central directory. Each time a location is created, a new *PERMANENT Mapset* is created automatically. The *PERMANENT Mapset* is made to store raw data from where multiple users can use it for processing.



5. SETTING UP OF THE PLUG-IN AXIOS IN UDIG

(http://www.ntclick.com/web/axios/frmManuales.aspx)

This section gives a procedure to install the Axios plug-in in order to use geoprocessing tools (buffer, clip, intersect, join, dissolve, split, polygon to line, fill, hole).

1. Open up *Help* > *Find and Install* from the menu bar

2. Select the *Search for New Features to Install* radio button and press *Next*

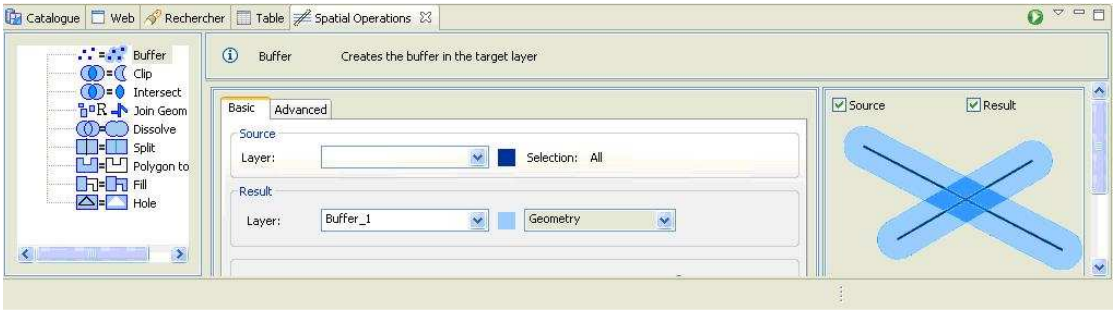
3. Select *New local site* > go to the place where you downloaded the plug-in

4. Agree to the license (which is LGPL)

5. Confirm the installation location

6. When prompted press *Yes* to restart uDig

Here is the Axios interface:

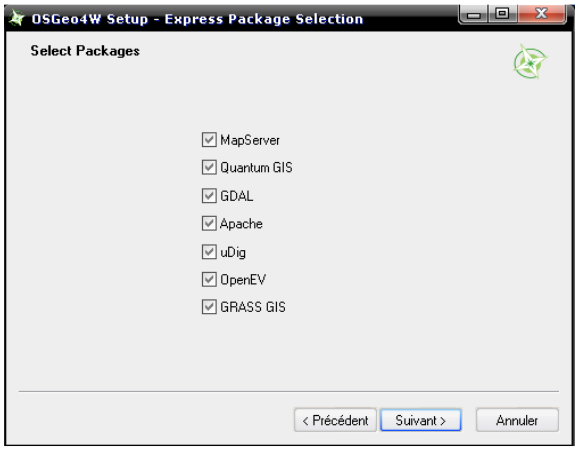


6. SETTING UP OSGEO4W WITHOUT WEB CONNEXION

Here is the procedure to install OSGeo4W without any web connexion:

1. Run osgeo4w-setup.exe. Choose Express Install > Next

2. Select Packages : click on packages needed



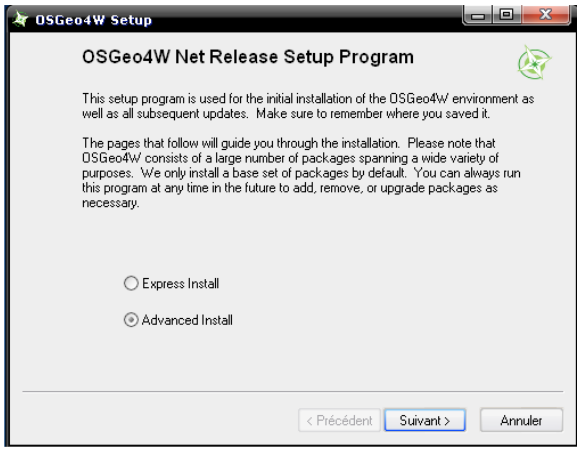
3. Start the set up.

4. Recover the data of the folder " http%3a%2f%2fdownload.osgeo.org%2fosgeo4w " and put it in a place known while adding the file " osgeo4w-setup.exe ".

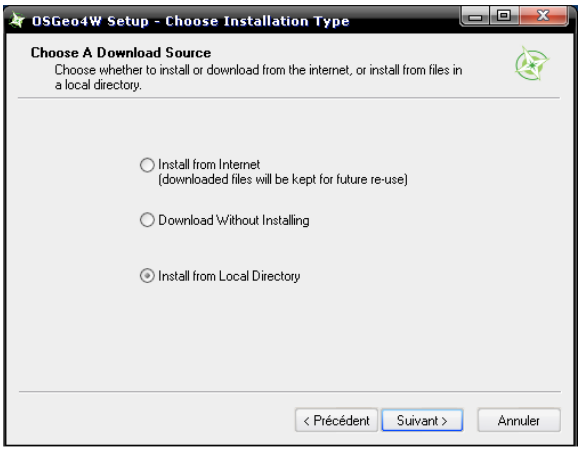
On the computer without any web connexion:

5. Run the file osgeo4w-setup.exe

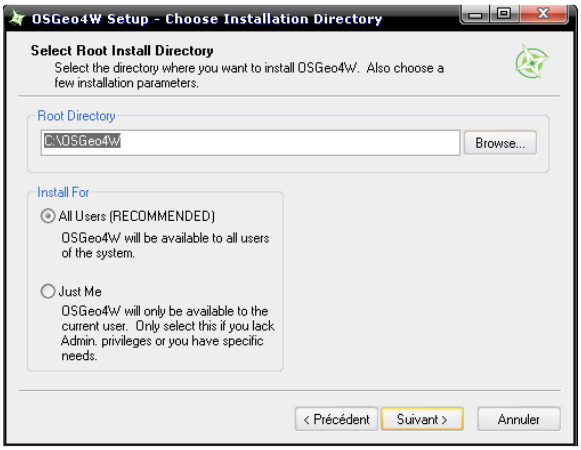
6. Choose > Advanced Install



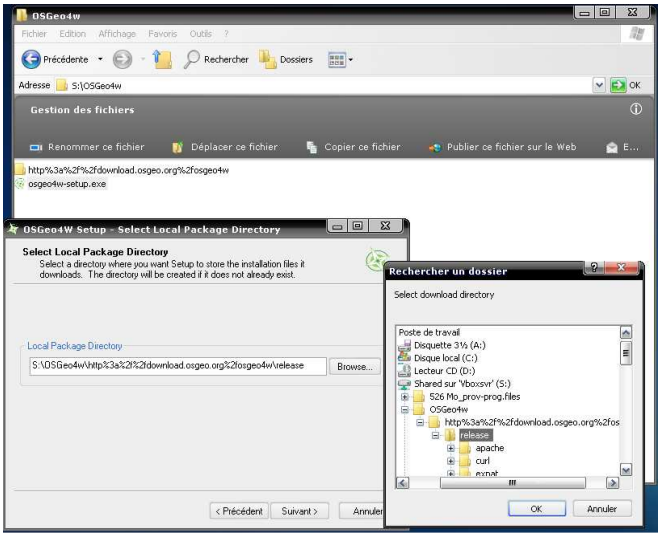
7. Choose > Install from Local Directory



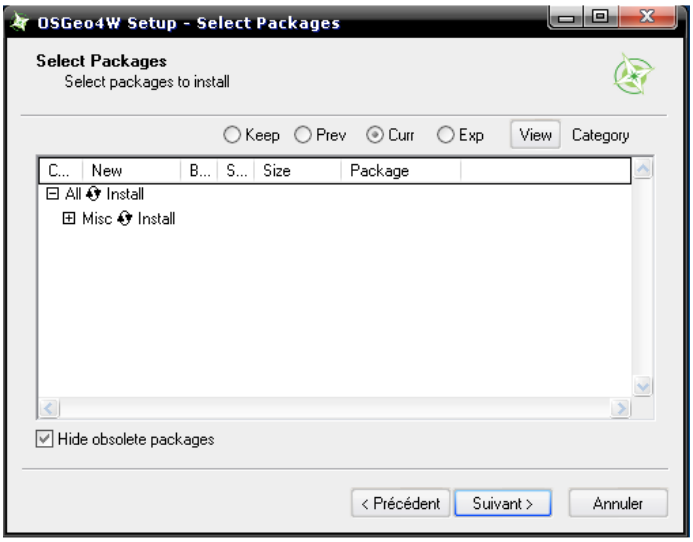
8. Choose a location for storing the installation files of the software



9. After this step, get the folder " http%3a%2f%2fdownload.osgeo.org%2fosgeo4w ", and be careful, choose the folder " release ".



10. Now select the packages that you wish to install. Keep "curr ", because is the more stable version. Click to change Default into Install.



11. Enjoy!