INTRODUCTION TO GRASS

Markus NETELER

Institute of Physical Geography and Landscape Ecology University of Hannover, Germany
neteler@geog.uni-hannover.de

1. GRASS GIS - Open Source GIS

The market of Geographical Information Systems (GIS) is highly dominated by commercial systems. Considering related publications (GIS-Report 2000), hundreds of systems are available. These GIS systems address different target groups comparably to the heterogenous GIS world. The history of Computer software demonstrates that many people (only) rely on commercial systems. But since 1991, when Linux operating system was born, a new era of software philosophy became to reach the masses. The "open-source" movement was not born that time, but received impressive input and motivation. The other very important push factor for the still growing open-source movement is the internet, as being used for communication and data/software exchange. GRASS is the worldwide largest open-source GIS project currently ongoing. The package can be downloaded in source code and selected binaries from http://www.geog.uni-hannover.de/grass/ and worldwide mirrors.
The history of the open-source Geographical Information System GRASS ("Geographic Resources Analysis Support System") could be continued for a long time. Due to the lack of GIS systems meeting the requirements for military land planning and management purposes the Environmental Division of U.S. Army Construction Engineering Research Laboratories (USACERL) decided to develop their own system in 1982. The first version of GRASS was released 1985. It was made available to the public (especially to other governmental organizations and universities) but has been spread worldwide with evolving internet communication. The GRASS 4.1 release in 1993 was the last major revision undergone by CERL and again published in public domain. Until 1995 CERL internally developed a new GRASS 5 version with completely rewritten raster and sites formats. However, due to the withdrawal of CERL from GRASS in 1995 it was not officially published. Until 1997, when Baylor University started to take over the GRASS development, the system was used and modified with individual interest without official support. From 1998 onwards University of Hannover and University of Champaign-Illinois joint the GRASS Development Team with further support by worldwide programmers. GRASS 5 development is currently lead by University of Hannover to coordinate programming efforts within the growing worldwide GRASS Development Team.
The release of GRASS 5 under GNU General Public License (GPL) in October 1999 protects the various authors from misuse of their developments, especially in other commercial systems. For the general user the open source model offers full insights into the system. Users can analyse the methods internally used, understand their functionality, modify methods to their purpose, error check and, in case required, correct or update methods. The speed to fix problems is usually much higher than in commercial systems. GRASS 5 is quite stable now and offers many new features comparing to GRASS 4.x (Neteler 2000b). Another general purpose of the open-source release under GPL is the opportunity for users to implement their own ideas or to suggest modifications which could be implemented by

everyone familar with programming. Currently GRASS 5 is in the top-ten list of biggest open-source programs available (http://www.codecatalog.com/topten).
GRASS (Geographical Resources Analysis Support System) is a comprehensive GIS with raster, topological vector, image processing, and graphics production functionality. Since it has been an open-source system for a decade, many researchers developed their own functionality. Many new capabilities have been included into the GRASS release. By this means GRASS offers capabilities of interest to totally different user groups. In addition to environmental research groups at universities the system is used by local and national governmental organizations, as well as by private companies. The option to use GRASS as an internet server GIS offers opportunities to establish online environmental and civic information systems and touristic map servers. Several different GRASS internet servers have been developed, they are based either on JAVA or script-based (CGI, PERL). So far GRASS has mainly been used by the scientific community. This offers competitive advantages as new methods have been implemented and verified. Especially innovative concepts have been introduced into the GRASS 5 release.
The policy of open-source-movement to publish problems rather than hiding them allows to speed up the system's maturing process. Error identification and removal have high priority within the project beside adding new functionality. Whilst users of commercial systems are dependent of the annual release cycles (or less frequently), open source products undergo several releases each year. Even if there is no help at all available users still have the chance to correct existing problems themselves.

2. GRASS Community

GRASS is a comprehensive GIS with raster, topological vector, image processing, and graphics production functionality. As it is an open-source system for a decade, many researchers developed their own functionality. Partly they have been included in later GRASS releases. By this means GRASS offers capabilities being interesting for totally different user groups. Beside environmental research groups at universities the system is used by governmental organizations, but also by communities and companies. The option to use GRASS as an internet server GIS offers opportunities to establish online environmental and civic information systems and touristic map servers.

3. GRASS Capabilities

GRASS is a "common" GIS which supports common vector and raster applications. It's functionality is comparing to high-end GIS systems with an emphasis on raster applications. Despite this, growing vector capabilities are currently implemented. The vector format is fully topological in opposite to desktop GIS systems.This is a major advantage in data management as implicit errors can be avoided.
The modular concept is a main advantage of this system. After starting it only the environment is customized to find the GRASS modules. By this means the memory overhead is very small, leaving much space for further map computations. Each GIS function is stored in its own small program and can be started within the GRASS environment, either by graphical user interface, command line or script based.
Data are commonly stored in the built-in database. This limits the number of attributes per geo-object to a singular object. To vercome this problem, GRASS 5 comes along with a set of SQL tools for attribute management (vector, raster and site data attributes). A direct interface to the open-source DBMS PostgreSQL (http://www.postgresql.org), an interface to ODBC drivers (to link GRASS to mySQL and others) and a preliminary direct Oracle interface are provided.

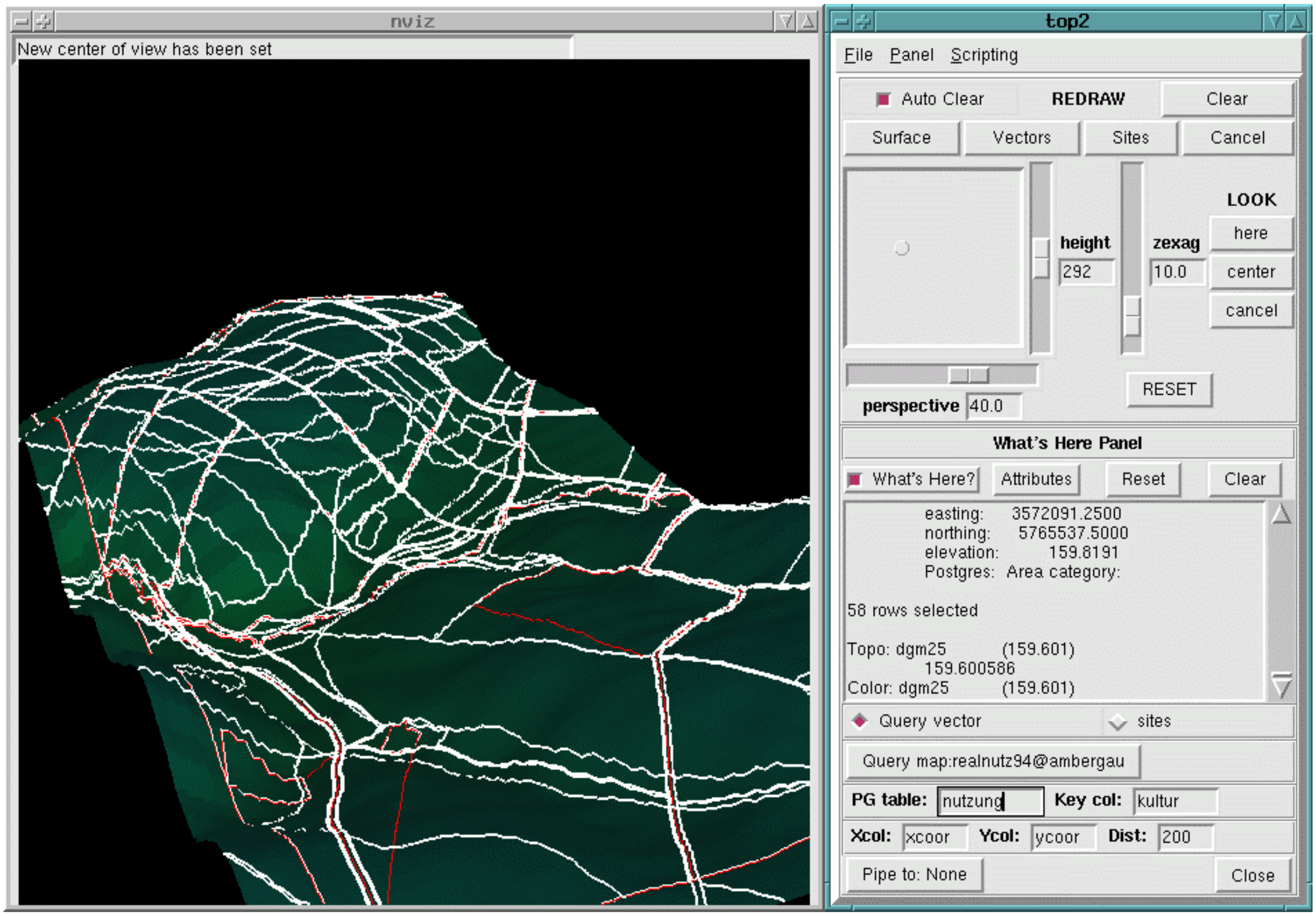

Fig.1 - The NVIZ screen displaying raster and vector data (3D query mode with link to SQL database)

Beside the standard 2D raster format a volume raster format (3D tiles) has been implemented to run full volume applications. Such format is for particular interest in geology, soil science, meterology and other fields. By now volumes can be fully described in raster format. First modules to perform easy data exchange, 3D map algebra, 3D interpolations and prototype 3D visualization have been integrated. The interface to the external Vis5D visualization tool allows to use different volume view methods like isosurfaces, semi-transparent clouds and movable isoline profiles.

GRASS 5 provides a DateTime management library and first modules to "timestamp" raster, vector and site maps. The library provides much more functionality which can be used in own modules. DateTime management is required for automated mapping systems e.g. to run a network of climatic measurement instruments with integrated data analysis.

To support multidimensional data integration, the sites format has been improved to accept multidimensions and multiple attributes. Field data can be easily imported into the system through data tables. Common commercial vector and raster GIS formats are supported as well. Data visualization can be performed by "NVIZ" visualization tool (Brown et al. 1997, ported to Tcl/Tk by Hofierka 1999/GeoModel s.r.o.) which offers an intuitive way to generate perspective views of own datasets. Optionally "NVIZ" can be linked to PostgreSQL to allow data queries in perspective views.

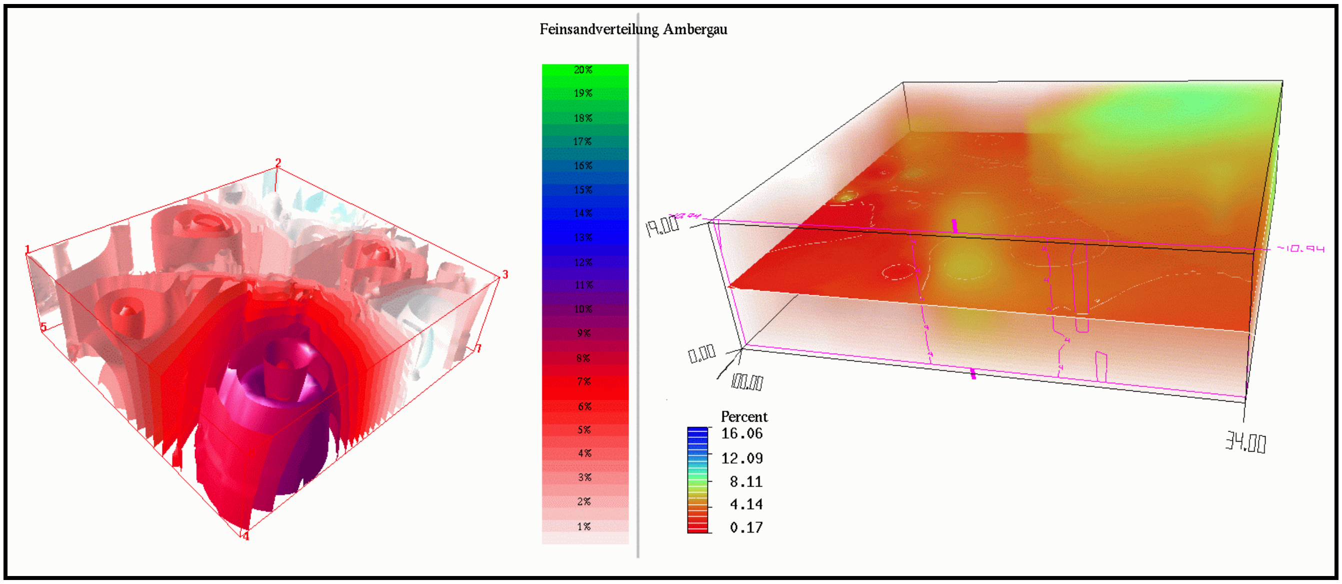

Fig.2 - 3D raster volume representations: The left figure displays isosurfaces representing soil texture distribution (fine sand share) generated by r3.showdspf, the right figure was created by Vis5D (fine sand share, view rotated by 90 degree). The project volume is: 2 km x 2 km x 2 m depth.

New efforts were made to link external open-source software packages to overcome existing limitations of GRASS. Important is support for geostatistics and spatial data analysis by interfacing GRASS to "R". As GRASS does not offer sophisticated geostatistical tools, an interface project to "R" statistical data language has been started (Bivand & Neteler 2000). It already allows to exchange raster, vector and sites data to and from "R". "R" is a very comprehensive open-source package and sometimes called "GNU-SPlus". It is available at http://cran.at.r-project.org. It allows cluster analysis, using classifier and interpolation techniques, exploratory data and time-series analysis and much more.

GRASS is fully scriptable and therefore eligible to create internet GIS servers. Internet coupling can be done by "GRASSLinks" (originally developed by Susan Huse, REGIS, UC Berkeley) or other script based servers. Thereby GRASS can be controlled by web users to query datasets and perform calculations. New developments are using PHP3 and online DBMS-server as well as JAVA.

Beside common GIS functionality GRASS provides several simulation models for environmental modelling (loose and tight coupling). Several erosion models have been integrated into (AGNPS 5.0, ANSWERS, TOPMODEL), infiltration and runoff models and cellular automata for wildfire simulation are shipped with the software package.

4. Support of own developments

As GRASS is in open source and released under GPL license, users can modify the system for their own purposes. Usually new functionality will be integrated by implementing one or several new modules. The system comes along with a sophisticated GIS library which can be accessed by C-language API. This library is fully documented in "GRASS 5.0 Programmer's Manual" (Neteler 2000a). Because all modules are in open source, existing tools and routines can be easily modified.

To control the GRASS 5 development, the source code is maintained in an electronic versioning system (CVS) which allows centralized code management and quality control. The CVS-server is accessible worldwide for reading and additionally by developers for writing. Since December 1999 GRASS source code is maintained in this centralized manner: The GRASS-CVS repository is fed by developers worldwide, new releases are extracted from it. Due to the "bazaar-type" development structures (comp.

Raymond 1997) everybody can access the repository and receive the latest versions. The GRASS Development Team encourages contributors to share their code with GRASS community and to integrate it into the main package. Information concerning the CVS-server is available at the GRASS site.

5. Future Plans in general GRASS Development

The increasing number of GRASS developers is an encouraging sign for GRASS' future. Current plans enfold improvements in the graphical user interface and related tools. Ongoing and planned projects are:

A new project has been started in Summer 2000 to "marry" GRASS modules and the OSSIM graphical studio (www.remotesensing.org/ossim/). As GRASS modules are already ported to Windows/NT, the OSSIM might become the general platform independent graphical user interface. Another visualization issue is the need to incorporate the new 3D raster volume format representation into NVIZ visualization tool.

At HPCC/NECTEC, Thailand, a project to rewrite the digitizing module with a new graphical user interface has been started. The results will be used to improve the current general user interface "tcltkgrass" or other GUIs. Additionally the GRASS initialization system is currently being rewritten at HPCC to a graphical system.

In planning stage is the upgrade of the existing vector format to full 3D vectors. As GRASS still lacks object-oriented structures, this might become part of the new vector format in conjunction with SQL databases. Multiple attribute support, which is already feasible by DBMS-linkage will be inherent part of the new format.

The source code will be restructured in near future to allow the splitting of GRASS into topic-oriented packages. By then users do not need to download the entire system but will be able to customize their local installation.

Future is looking bright for the open-source movement and in particular for GRASS GIS.

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