GRASS GIS an overview of the applications in 2005.

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Abstract

The world of GIS is always in development, and this fact is particularly true for Open Source GIS. Among the GIS software, in the last years GRASS GIS has known wide popularity as it is well documented by the recent GRASS Users conferences, both at national and international levels and the incoming ones. The creativity and fantasy of the researchers together with the freedom of the source code has leaded to the application of GRASS GIS in many different ways, sometimes involving fields like medicine and palaeonthology in which the potential of the software has been used in non conventional manners. This article is an organized overview of a wide amount of applications of this GIS to many different topics and problems, not only in the geographical field. The range of applications goes from environmental modeling to DTM validation, from atmosphere modeling to LIDAR data elaboration, from wildlife management to Avalanche risk assessment, from GPS planning to geomorphologic modeling, from study of human body to modeling the teeth of primates. Because of the Open Source and Free Software development model of GRASS, the development and the applications are entwined, giving each other new momentum. Moreover, because of the current intense development of GRASS it is possible to foresee exciting and entirely new fields of applicability especially for 3D modeling, time series elaboration and Data Base management.

1. Introduction

GRASS GIS is currently gaining wide popularity due to its high quality and its Open Source/Free Software nature. GRASS overall high quality is well acknowledged by its spreading within scientific and academic institutions, as well as by public administrations and professional users.

GRASS benefits from its Open Source/Free Software development model because of the effectiveness of this model and because of the good reputation Open Source/Free Software is gaining not only between IT technicians.

The number of GRASS applications is growing rapidly, with the typical advantage of Open Source/Free Software projects, where applications and development are tightly entwined. In fact, often an application leads to the development of new modules, which are then used for other applications and so on.

A collection of GRASS applications is important because it can make GRASS users aware of its many capabilities and it can attract new users, who can find here a reference to documentation of GRASS’ use in their application field of interest.

2. Applications overview

To collect the applications it is possible to use as reference books, articles and papers in electronic and traditional format. However, without any doubt Internet is the main source where it is possible to reach the applications of a software like GRASS, whose spreading all over the world is due to Internet itself. This collection has been organized following some classification criteria, and some papers surely are at the border between the different classification topics that

have been chosen. The goal of this classification is to help the reader who looks for a specific application without losing the possibility to consider the overall GRASS capability at the same time. The bibliography is as accurate as possible, we have tried to cite printed papers or official electronic papers, but it may happen that in some cases the references are only abstracts of conferences or internet sites.
GRASS applications are here classified simply by their scientific and/or application area, because this is probably the most direct way to present a list of works in the GIS field.

The applications are organized in the following categories and sub categories:

1. Modelling and analysis of topographic data;
2. Climate and atmospheric models;
3. Investigations about habitat and, more in general, animals population;
   Habitat and fauna
   Epidemiology
4. Forest studies and environmental monitoring ;
   Forest and images classification
   Forestry studies
5. Land use and landscape planning;
6. Geology, Geomorphology;
   3D modelling of geologic structures
   Planetary geology
   Landslides risk mapping
   Glaciers
   Geomorphology
7. Risk and hazard management;
   Erosion hazard
   Wildfires risk mapping
   Traffic and acoustic pollution
   Avalanche risk mapping
   Flooding and hydrological hazard forecasting
   Traffic management
8. Archeological investigations;
9. GPS planning;
10. Web GIS and portable technologies;
11. Investigations about the teeth structure of Primates;
12. Medical diagnostic.

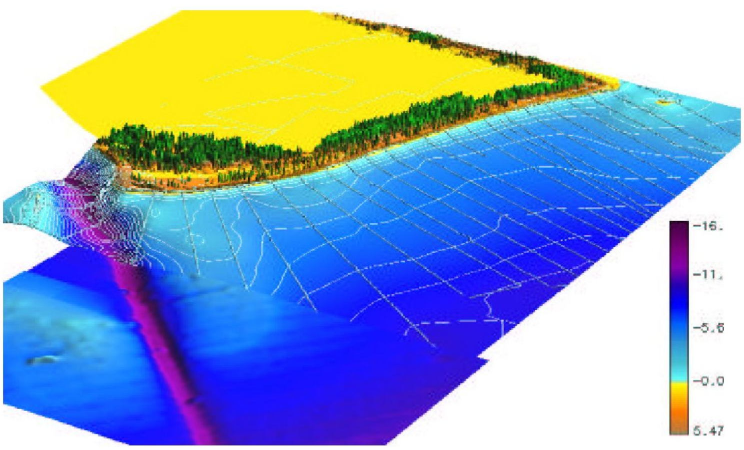


Figure 1 Lidar Data (Mitasova et al. 2002)

Modelling and analysis of topographic data

Spatio-temporal monitoring of evolving topography using LIDAR, Real Time Kinematic GPS and sonar data (Mitasova et al., 2002): presents the spatial interpolation and topographic analysis of different types of high resolution data, such as LIDAR, GPS and sonar data.

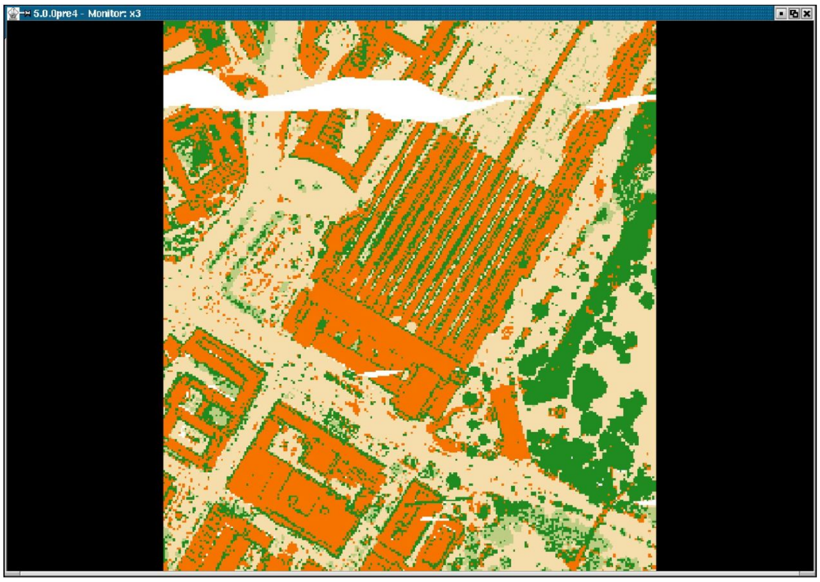


Figure 2: Managing and processing LIDAR data within GRASS, (Brovelli et al., 2002)

Managing and processing LIDAR data within GRASS (Brovelli et al., 2002): describes a procedure for the automatic detection and removal of features over a high resolution DSM from LIDAR.
Integrazione dei dati laser scan e iperspettrali per la stima di parametri strutturali e funzionali della vegetazione (Altobelli et al., 2004) in which the authors use laser scanned data and Mivis multispectral images to extract vegetation data.

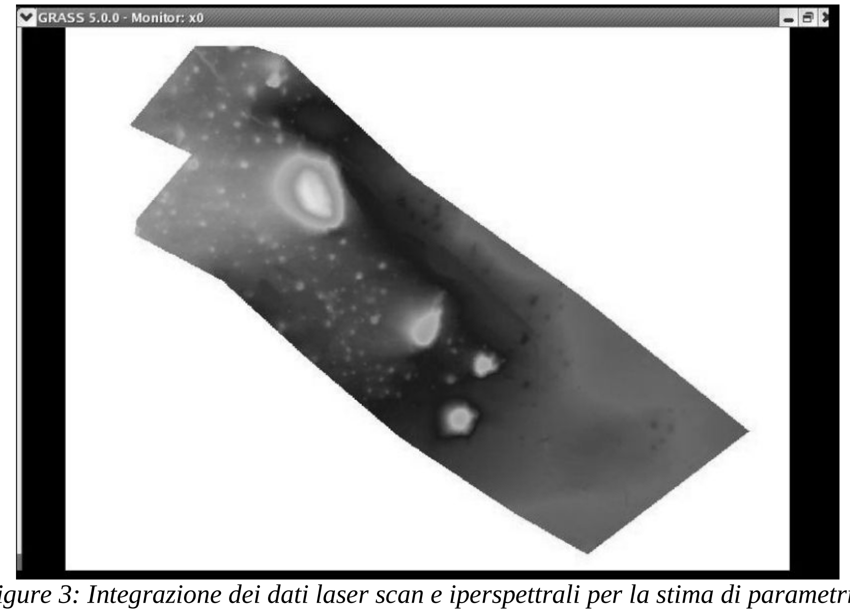


Figure 3: Integrazione dei dati laser scan e iperspettrali per la stima di parametri strutturali e funzionali della vegetazione (Altobelli et al., 2004)

Impiego di GRASS per l'analisi di modelli digitali del terreno (DTM) (Luna et al. 2004) analyses the application of different DTMs in GRASS.

I.FFT coregister un nuovo algoritmo per la registrazione automatica di immagini basato su FFT (Miori et al. 2004) presents a new FFT based algorithm to automatically register images.
Trasformazione tra datum e sistemi cartografici in ambito nazionale: implementazione di un software in ambiente GRASS e sue prestazioni (Baiocchi et al., 2004) accents datum transformations and cartographic systems, in particular in Italy.
New GRASS modules for Multiresolution Analysis with wavelets (Zatelli et al., 2002a): provides GRASS of an efficient (from both a mathematical and a computational point of view) way to represent the same phenomena at different resolutions and filter out signal features. Some applications to geomorphologic problems are presented.

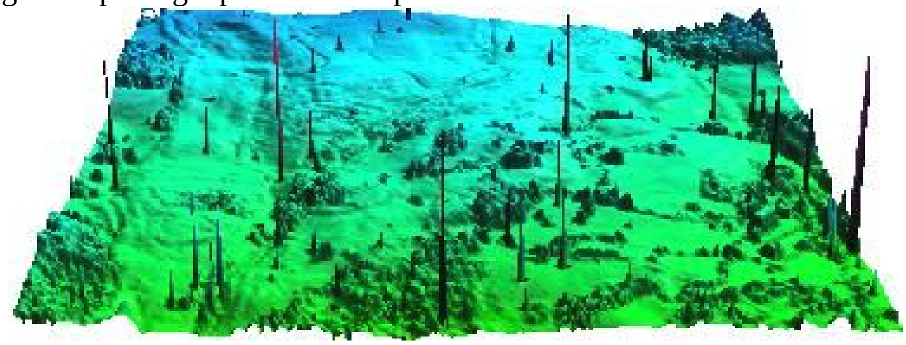


Figure 4: New GRASS modules for Multiresolution Analysis with wavelets (Zatelli et al., 2002a)

Multiresolution Analysis with GRASS (Zatelli, 2003) accents the application of multiresolution analysis method.

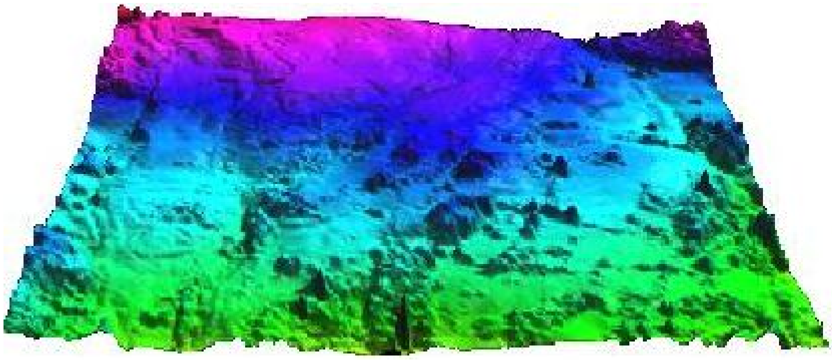


Figure 5: Multiresolution Analysis with GRASS (Zatelli, 2003)

A new approach to the polygons rasterization in GRASS (Biagi et al., 2001): new techniques for the vector to raster conversion are presented.

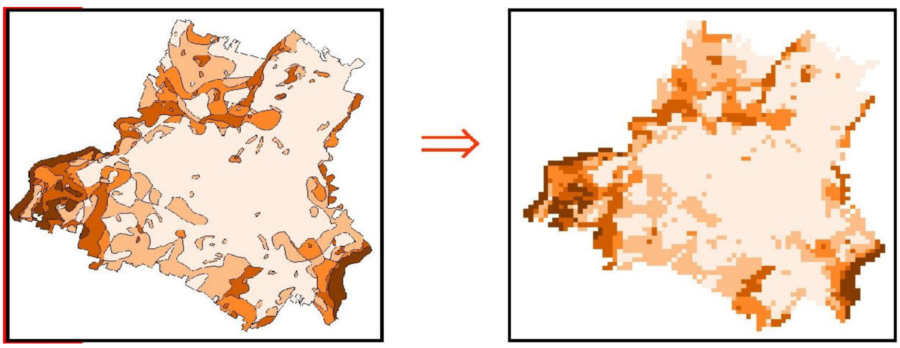


Figure 6: A new approach to the polygons rasterization in GRASS (Biagi et al., 2001)

Introducing the Linear Reference System in GRASS (Blazek, 2004). Radim Blazek, one of the programmers more involved into the GRASS development, introduces and explains the new linear reference system.

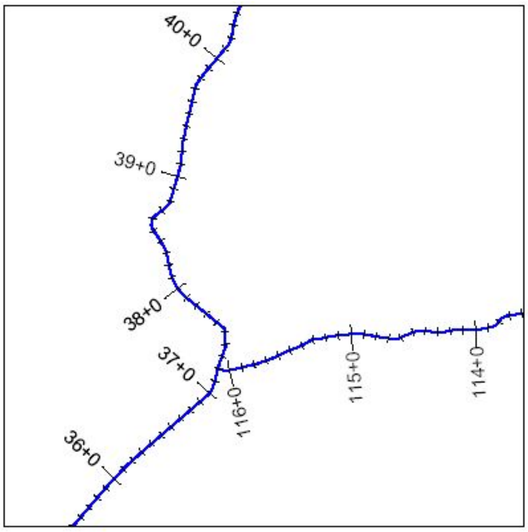


Figure 7: Introducing the Linear Reference System in GRASS (Blazek, 2004).

GRASS-based High Performance Spatial Interpolation Component for Spatial Decision Support Systems (Kun Lu et al., 2004). The development of a Spatial decision support system in which GRASS plays an important role is described.

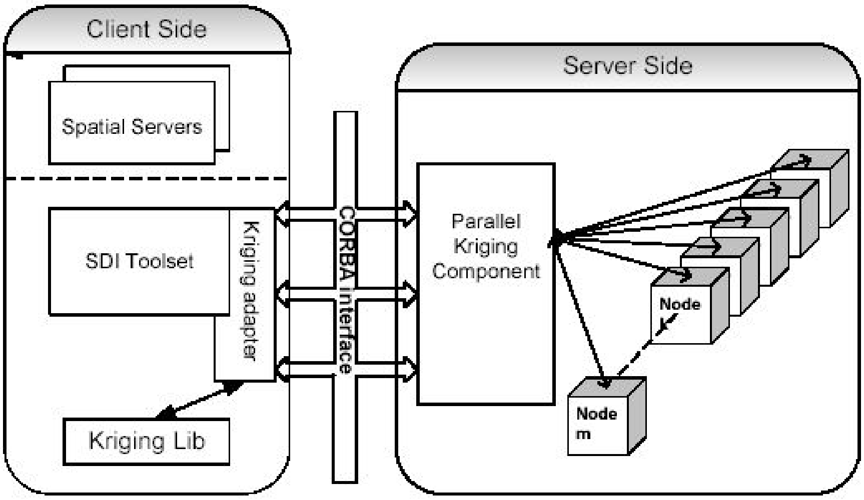
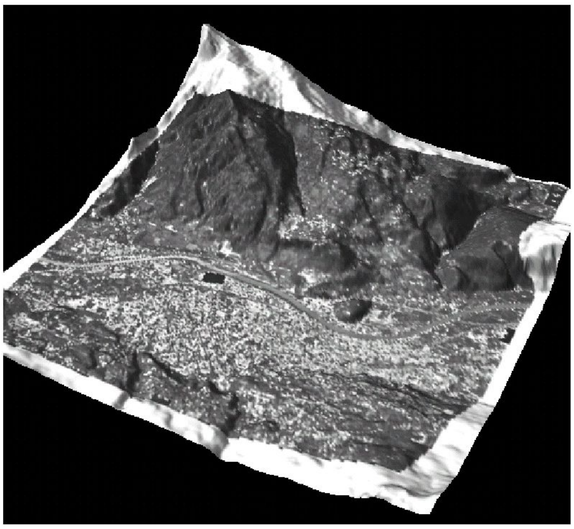


Figure 8: GRASS-based High Performance Spatial Interpolation Component for Spatial Decision Support Systems (Kun Lu et al., 2004)

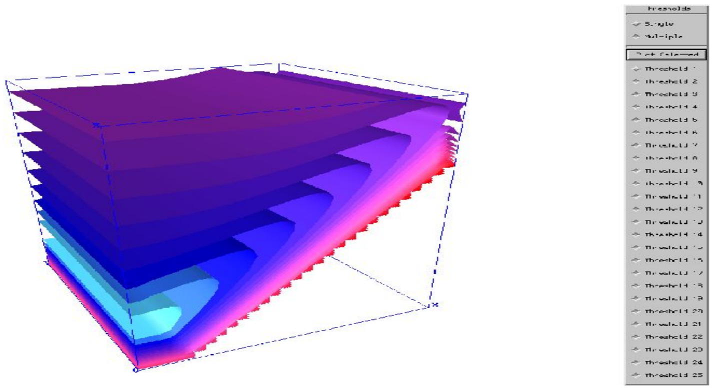
Simultaneous image orientation in GRASS (Bergamini et al., 2004), the authors investigate the technique to obtain simultaneous image orientation in the production of ortophotos with GRASS, posing the accent on the inconsistencies between different images.



Climate and atmospheric models

3D vector approach to local thermally driven slope winds modelling (Vitti et al., 2004), 2D/3D GRASS modules use and development for atmospheric modeling (Zatelli et al., 2002): reports the use and the development of GRASS 3D raster modules to develop local meteorological models.

Modelling of evaporation processes over tilted slopes by means of 3D GRASS raster (Ciolli et al., 2002): exploits the power of the 3D GRASS map algebra (r3.mapcalc) to implement a simplified model generalizing Prandtl model for sloping valleys winds taking into account humidity and evaporation processes on the soil.



Utilizzo di GRASS e R per la spazializzazione dei dati meteorologici in una valle alpina (Rea et al., 2004), the combined use of GRASS and R to obtain the distribution of meteorological data in Non valley, Trentino, is described.

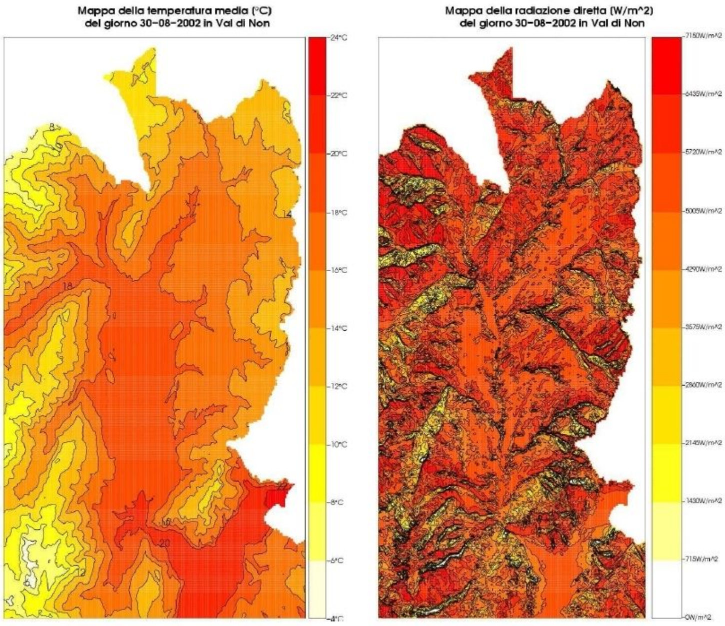


Figure 11: Utilizzo di GRASS e R per la spazializzazione dei dati meteorologici in una valle alpina (Rea et al., 2004):

Development of a complete climate database using a new GRASS module (Sboarina, 2002): presents the development of a gridded topographic and monthly mean climate database for the Trentino region. A specific GRASS module, r.clim, has been implemented.

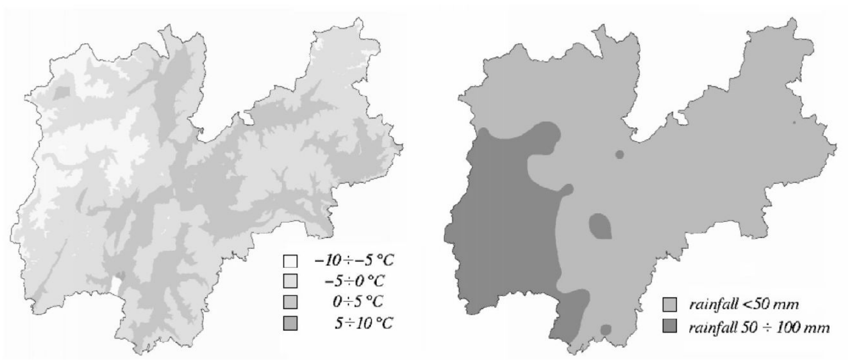


Figure 12: Development of a complete climate database using a new GRASS module (Sboarina, 2002):

Applications of Artificial Intelligence Methods in GRASS GIS for Radarmeteorology and Soil Erosion Research (Loewe 2004). The application of techniques to obtain data about erosion through radarmeteorology is described in an application for South Africa.

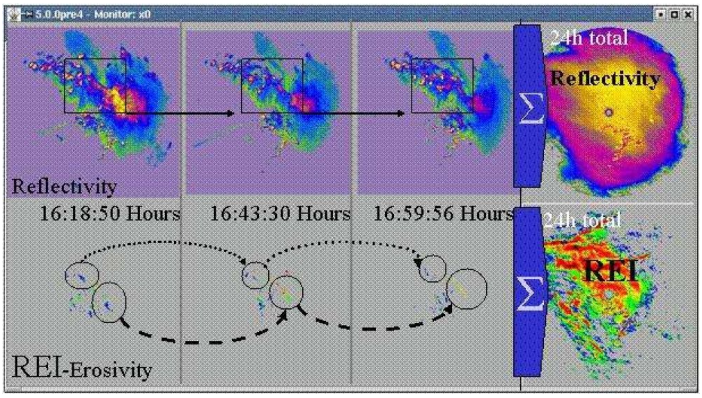


Figure 13: Applications of Artificial Intelligence Methods in GRASS GIS for Radarmeteorology and Soil Erosion Research (Loewe 2004)

Investigations about habitat and, more in general, animals population

Habitat and fauna

In search of Habitats ~ testing a GNU approach (Nieminem J., 2002): potential endangered habitats have been mapped by the use of ecological criteria.

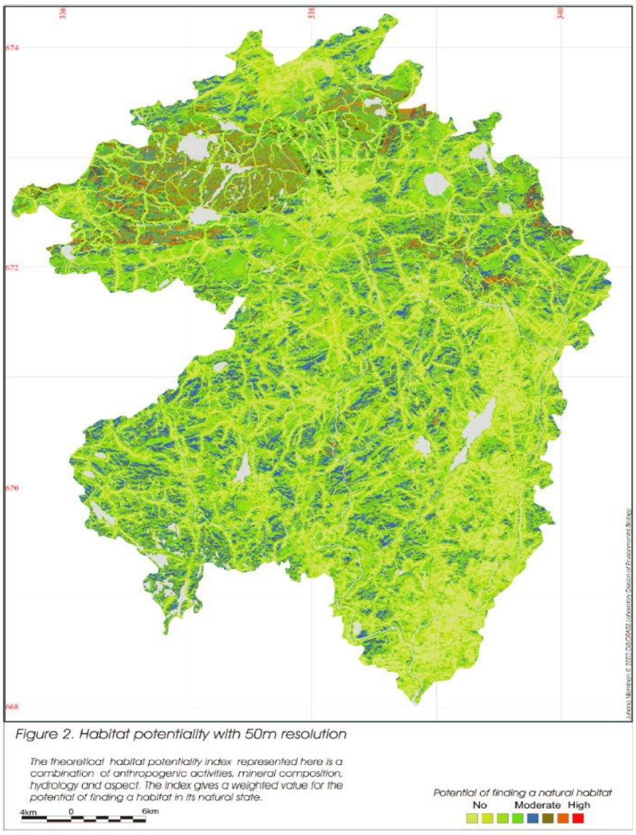


Figure 14: In search of Habitats ~ testing a GNU approach (Nieminem J., 2002)

Wildlife Management and Landscape Analysis in the GRASS GIS (Menegon et al., 2002) the study describes an application in Trentino.

Environmental Gis Database For The White Sea (Kaitala et al., 2002): a database for the White sea, including bathymetric, hydrological, hydrochemical and hydrobiological data, is used to validate numerical ecosystem modeling applications for the evaluation of possible effects of the climate change and growing human impact on the ecosystem and on the different aspects of the wildlife.

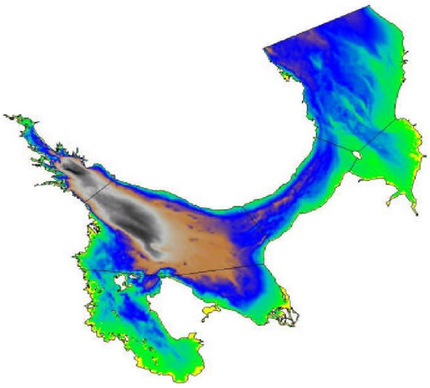


Figure 15: Environmental Gis Database For The White Sea (Kaitala et al., 2002)

Using GRASS and Spatial Explicit Population dynamics Modelling as a conservation tool to manage grey squirrel (Sciurus carolinensis) in northern Italy (Tattoni et al., 2004) and *Modelling the expansion of a grey squirrel population: implications for control. Biological Invasion* (In press Tattoni et al., 2004). The expansion of an invader species is investigated in this paper.

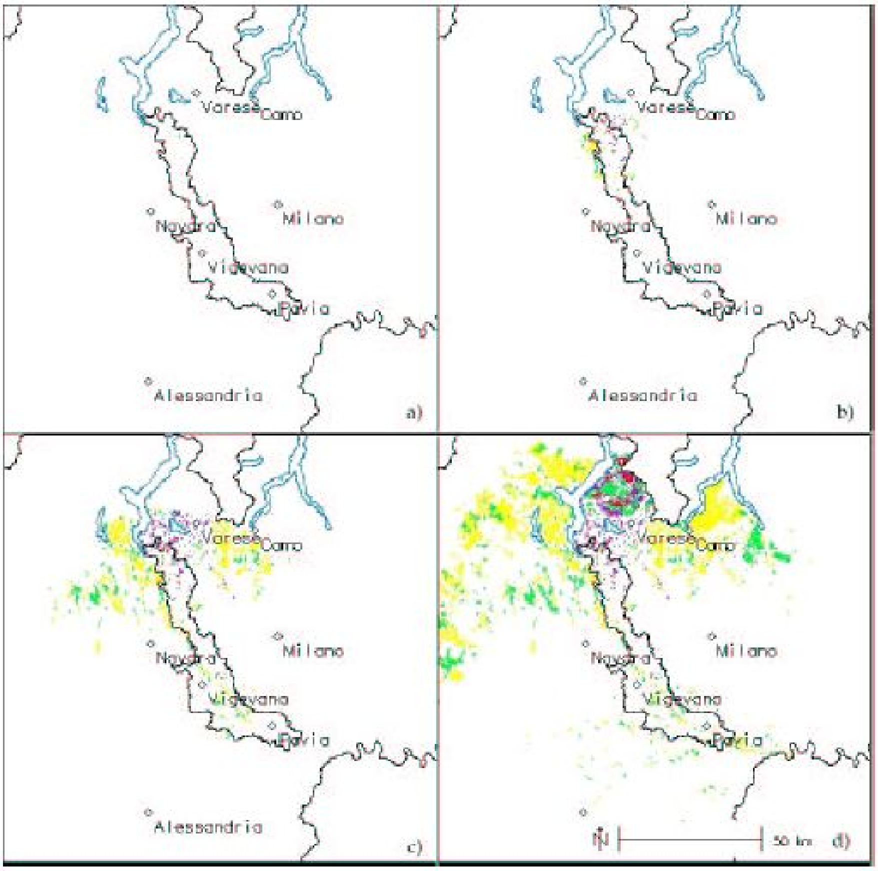


Figure 16: Using GRASS and Spatial Explicit Population dynamics Modelling as a conservation tool to manage grey squirrel (Sciurus carolinensis) in northern Italy (Tattoni et al., 2004)

GIS-based modeling of denning habitat of the timber rattlesnake (Crotalus horridus) in Northwest Arkansas with notes on model assessment. (Browning et al. 2000) In this case it seems that GRASS has been used to model the habitat of a rattlesnake, but the abstract of a conference is the only reference we have found about this work.

Dove mangiano i cinghiali: un modello spaziale predittivo (Cavallini et al., 2004). the authors have developed a predictive model to identify the probability that wild boars cause damages and they have applied the model in an area of Tuscany where the problem is particularly important.

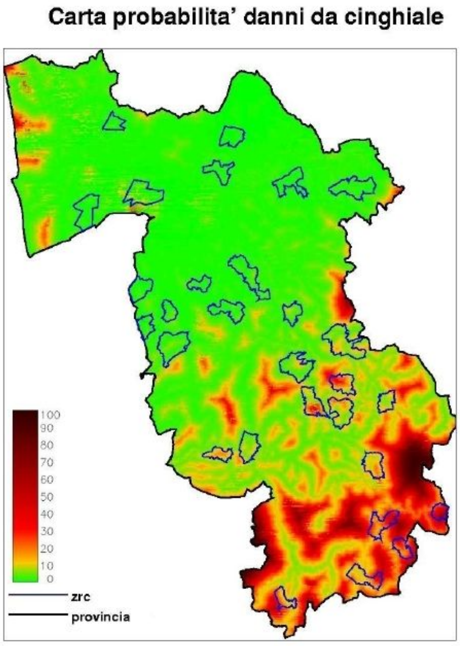


Figure 17: Dove mangiano i cinghiali: un modello spaziale predittivo (Cavallini et al., 2004).

A Geographic Information System Approach to Evaluate the Effects of the Endangered Species Protection Program on Mosquito Control. (Spradling et al. 1998). In this case GRASS has been applied to mosquito distribution.

Analysis of food habit of chamois using GIS (Guastella et al., 2003), the authors have developed an analysis of the different seasonal and spatial food preferences by means of GRASS.

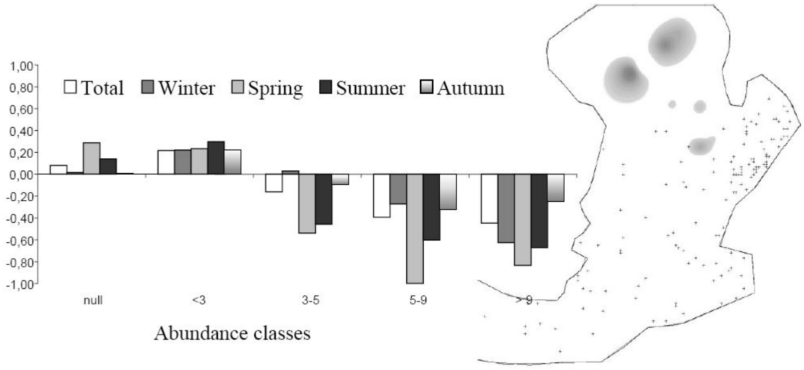


Figure 18: Analysis of food habit of chamois using GIS (Guastella et al., 2003)

Epidemiology

Remote Sensing/GIS techniques for risk assessment of Borrelia burgdorferi infection (Altobelli et al., 2001): the risk of Borrelia burgdorferi infection has been evaluated using remote sensing data processed in GRASS.

Figure 19: Remote Sensing/GIS techniques for risk assessment of Borrelia burgdorferi infection (Altobelli et al., 2001)

Geographical Information Systems and Bootstrap Aggregation (Bagging) of Tree-Based Classifiers for Lyme Disease risk prediction in Trentino, Italian Alps (Rizzoli et al. 2002). The information about ticks distribution and Lyme disease has been elaborated by means of GRASS.

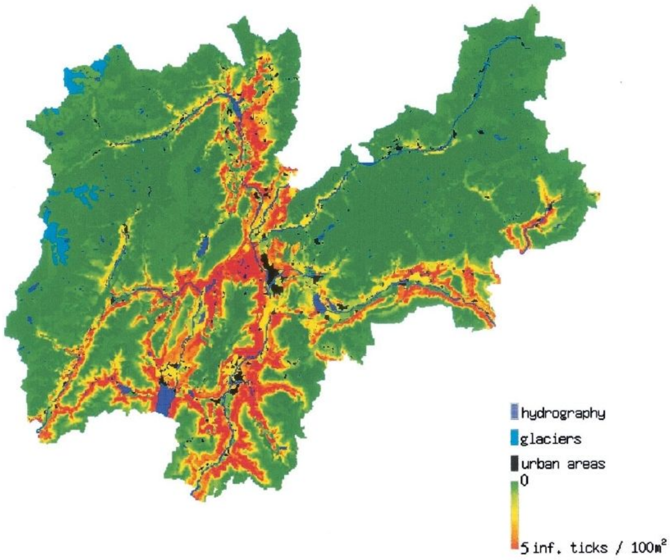


Figure 20: Geographical Information Systems and Bootstrap Aggregation (Bagging) of Tree-Based Classifiers for Lyme Disease risk prediction in Trentino, Italian Alps (Rizzoli et al. 2002)

Rapid epidemiological mapping L.donovani infection in eastern Sudan : preliminary report (Sharief and Khalil, 2004).

Forest studies and Environmental monitoring

Forestry and images classifications

Valutazione tramite fotogrammetria e GIS della dinamica della copertura forestale e della provvigione legnosa (Ciolli et al., 1999): reports how the joint use of GRASS and of analytical photogrammetry techniques has been used to assest the forest dynamics.

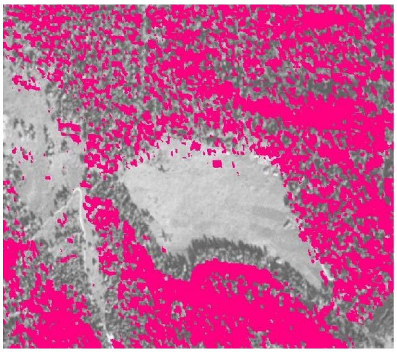


Figure 21: Valutazione tramite fotogrammetria e GIS della dinamica della copertura forestale e della provvigione legnosa (Ciolli et al., 1999b)

Digital analysis of multitemporal aerial images for forest and landscape change detection (Ciolli et al., 2001). A multitemporal analysis of very heterogenous aerial images to detect forest and lanscape changes has been carried out by the authors.

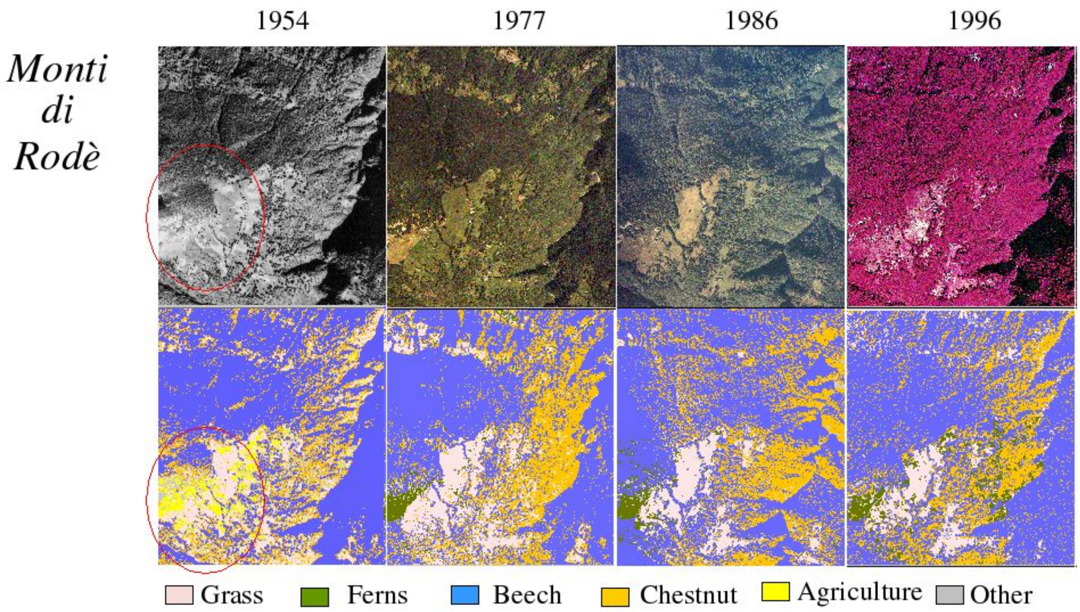


Figure 22: Digital analysis of multitemporal aerial images for forest and landscape change detection (Ciolli et al., 2001).

Classification Analysis of LANDSAT Images of Mixed Coniferous and Deciduous Riparian Forest in Nature Conservation Zone Using GRASS/PostGIS Link (Gromyko and Shevlakov, 2004). The image analysis capabilities of GRASS have been used to classify vegetation starting from LANDSAT images taken in different seasons.

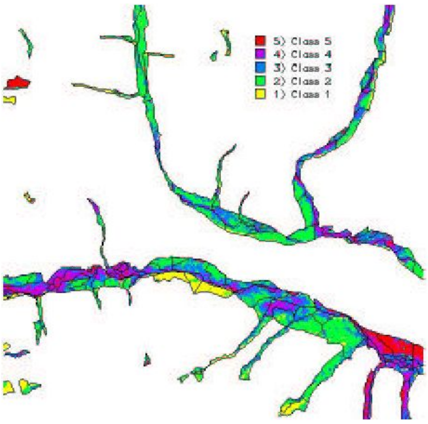


Figure 23: Classification Analysis of LANDSAT Images of Mixed Coniferous and Deciduous Riparian Forest in Nature Conservation Zone Using GRASS/PostGIS Link (Gromyko and Shevlakov, 2004)

Analysis of spatial and temporal changes of forest cover in the Mount Pulag National Park, Philippines (Turda et al., 2004) is an application of GRASS using different images to detect forest cover changes in Asia.

Forestry

Analisi delle relazioni tra variabili ecologiche e tipologie forestali in aree montane: un caso di studio (Turco et al., 2004): in this application the interactions between ecological conditions and forest types distribution have been studied.

Humus Forestali Manuale di Ecologia per il riconoscimento e l'interpretazione – applicazione alle faggete (Zanella et al 2001, elaborations carried out by Sboarina): in this case the maps which have supported the whole study have been developed by means of GRASS.

The Role of Goal-Oriented Autonomous Agents in Modeling People- Environment Interactions in Forest Recreation (Deadman et al. 1994) Forest recreation is a very interesting issue in forest management, the paper describes a theoretical framework and a model for simulating hiker behavior in a natural environment using intelligent agents, discrete event simulation (DEVS) and GIS data.

A GIS procedure to map forests with a particular protective function. (Zampa et al., 2004). The study faces the problem to individuate the forests with particular protective purposes in the Province of Trento.

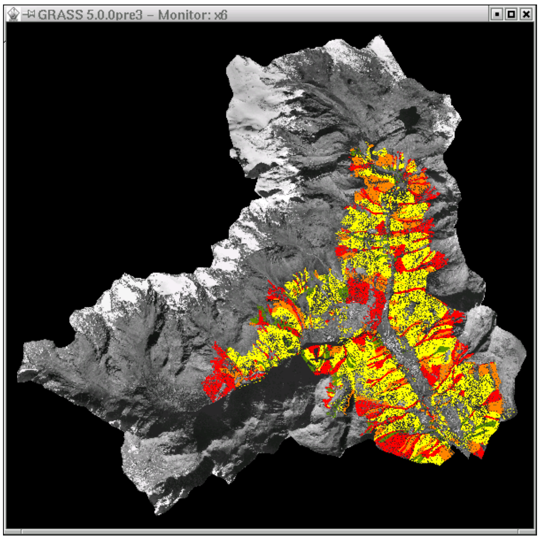


Figure 24: A GIS procedure to map forests with a particular protective function. (Zampa et al., 2004)

Land use and landscape planning

A GRASS-DataMining integrated procedure for land cover classification. (Bezzi and Vitti, 2004). Data Mining techniques have been applied in this work to perform land cover classification in an italian area.

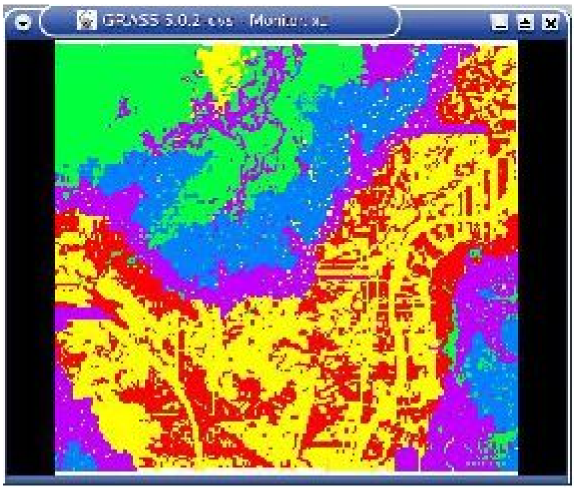


Figure 25: A GRASS-DataMining integrated procedure for land cover classification. (Bezzi and Vitti, 2004)

Geographic Resources Decision Support System for land use, land cover d*ynamics analysis* (Ramachandra e Kumar, 2004). The paper describes a freeware interface that uses GRASS to produce a decision support system for decision making and resource planning.

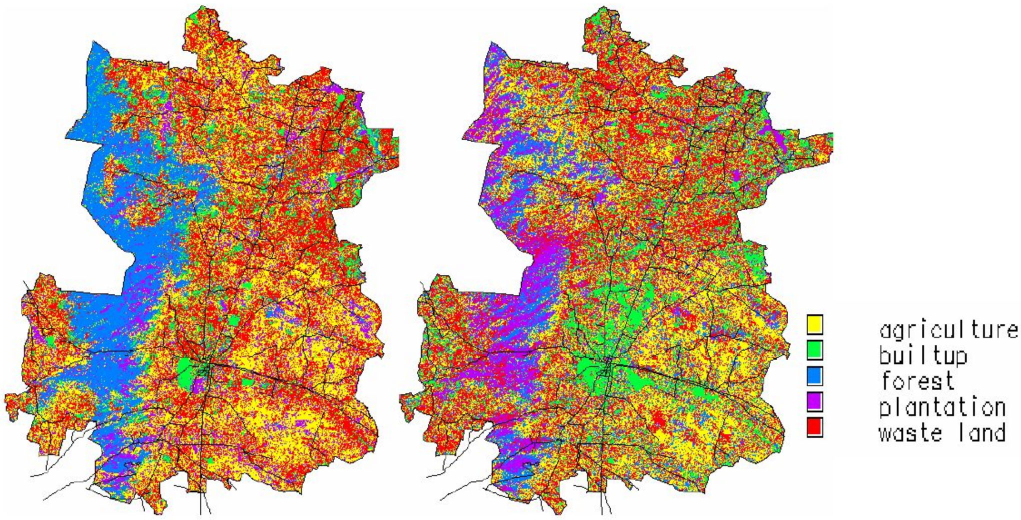


Figure 26: Geographic Resources Decision Support System for land use, land cover dynamics analysis (Ramachandra e Kumar, 2004)

Land use change maps in a developing country. Application of GRASS GIS in Caia district (Ciolli et al., 2002): the land use change of the Caia District (Mozambique) is investigated by means of series of satellite imagery.

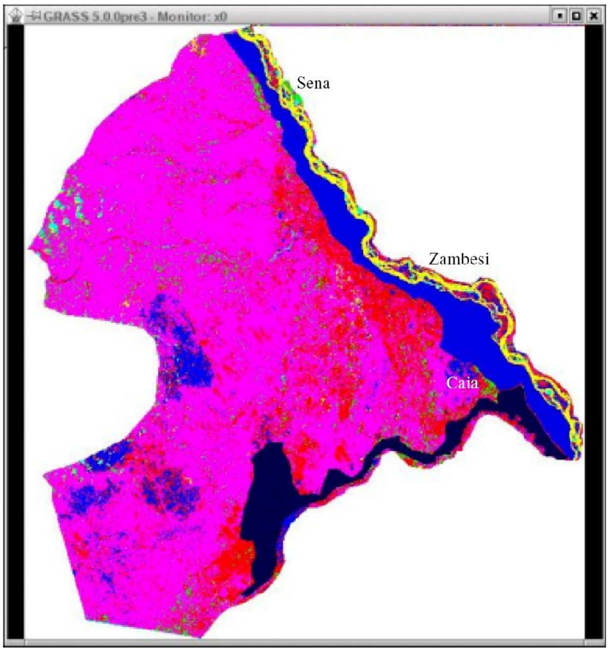


Figure 27: Land use change maps in a developing country. Application of GRASS GIS in Caia district (Ciolli et al., 2002a)

Amazonia Landscape mapping and Biodiversity estimation using remote sensing and local communities knowledge know-how (Fabbro, 2001).
ISOLA project environmental information system (Aime et al., 2001) and *Il sistema informativo ambientale del progetto ISOLA* (Aime et al., 2002) the ISOLA project, part of the European LIFE/Environment program, provides methods and tools to assist environmental control and planning for a medium-sized town.
Caratterizzazione delle relazioni tra dinamiche demografiche e fattori fisici: un'applicazione in ambiente montano (Miorelli et al. 2003) The interactions between demographic dynamics and physical, morphological characteristics of a mountain area are investigated in this paper.

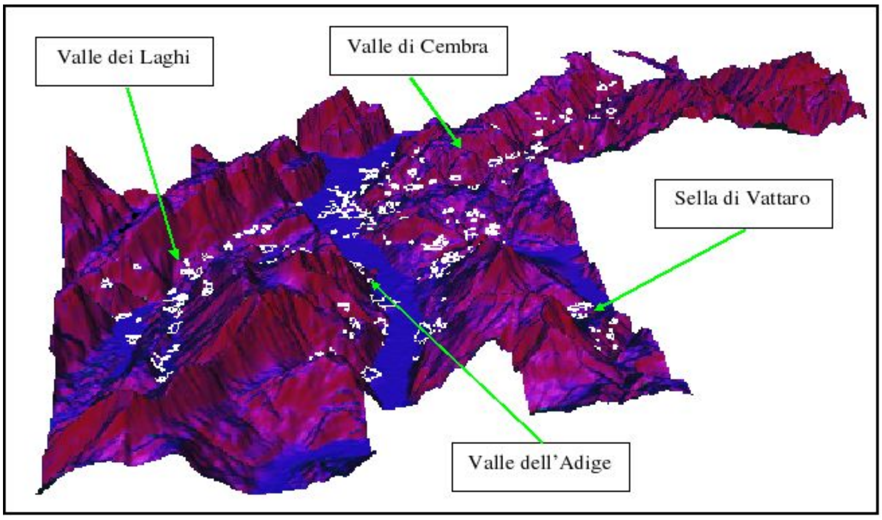


Figure 28: Caratterizzazione delle relazioni tra dinamiche demografiche e fattori fisici: un'applicazione in ambiente montano (Miorelli et al. 2003)

Wildlife Management and Landscape Analysis in the GRASS GIS (Menegon et al., 2002): describes how new GRASS GIS resources have been developed and integrated for centralized data archiving and predictive modeling in several wildlife management tasks in Trentino, Italian Alps.

Trasformazioni territoriali e map algebra (Achilli et al., 2004) in this work map algebra is applied to detect changes in the particular environment of the Barene.

The solar radiation model for Open source GIS: implementation and applications (Hofierka et al., 2002): presents a new, substantially improved solar radiation model r.sun implemented in GRASS GIS and two applications that can be useful in landscape planning studies.

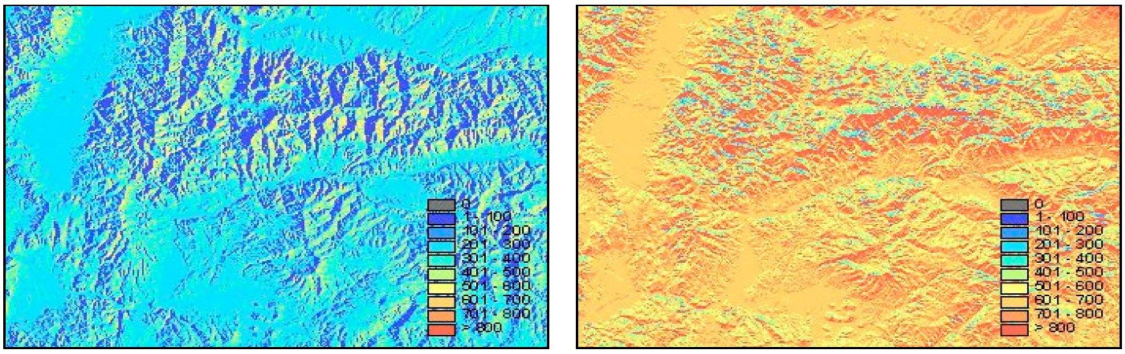


Figure 29: The solar radiation model for Open source GIS: implementation and applications (Hofierka et al., 2002)

GI (Geographic Information)-Based Estimation of solar radiation and PV (photo voltaic) generation in central and eastern europe on the web. (Huld et al. 2003) Solar radiation is calculated for a wide area of Europe to estimate the potential photovoltaic panels installation and to plan the installation.

Genetic algorithm for assimilating remotely sensed evapotranspiration data using a soil-water-atmosphere-plant model. Implementation issues (Chemin et al., 2004). Once more GRASS has been used in a complex model.

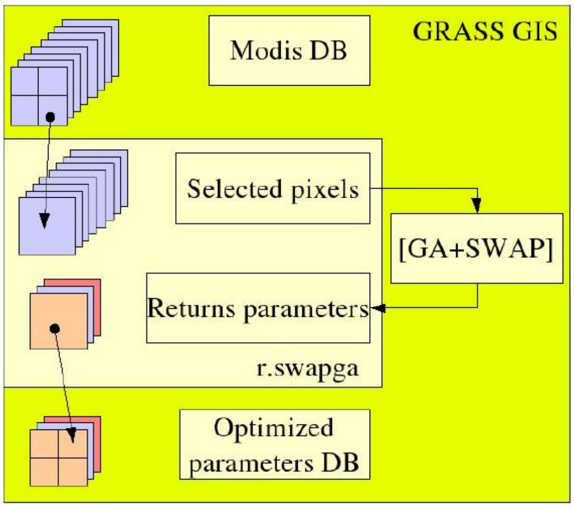


Figure 30: Genetic algorithm for assimilating remotely sensed evapotranspiration data using a soil-water-atmosphere-plant model. Implementation issues (Chemin et al., 2004)

Geology, geomorphology

3D modelling of geologic structures

Construction and Visualization of Three Dimensional Geologic Model Using GRASS GIS (Masumoto et al., 2002) and *Three Dimensional Geological Model by FOSS GRASS GIS* (Kajiyama et al., 2004) describe the implementation of methodologies and algorithms for 3D modeling and visualization of geologic models using the Open Source GRASS GIS environment.

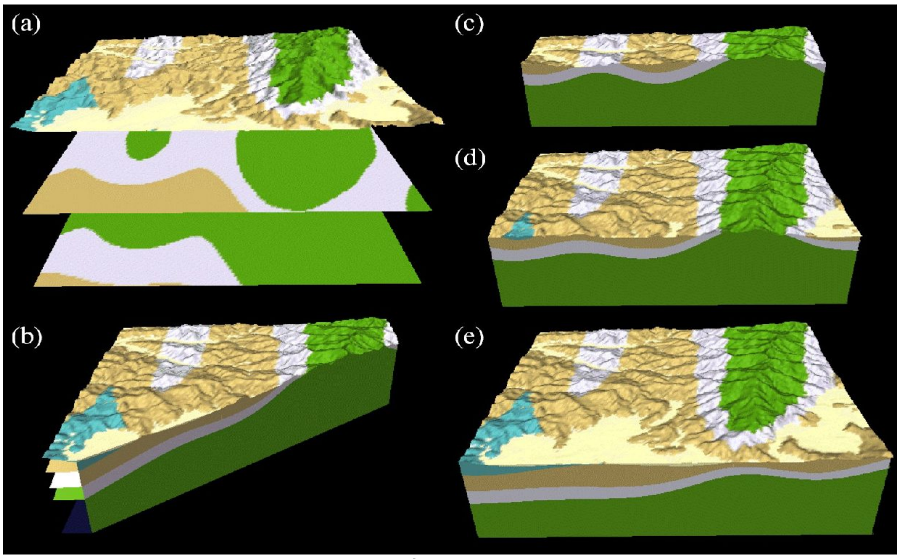


Figure 31: Construction and Visualization of Three Dimensional Geologic Model Using GRASS GIS (Masumoto et al., 2002).

3-D Geologic Modeling and Visualization of Faulted Structures (Yonezawa et al., 2002): the estimation of surfaces and the visualization of 3-D geologic structure has been carried out using GRASS and NVIZ.

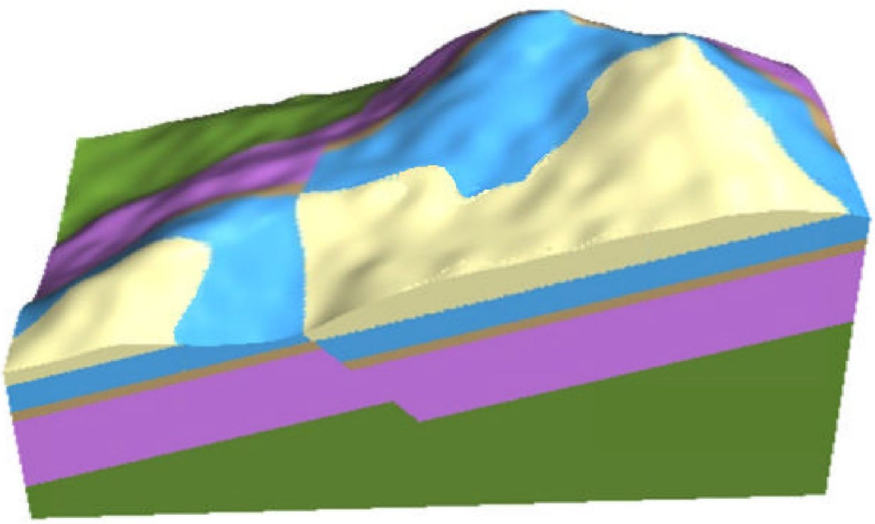


Figure 32: 3-D Geologic Modeling and Visualization of Faulted Structures (Yonezawa et al., 2002).

Planetary Geology

Identifying wrinkle ridges structures from Mars MGS and Viking mission data: using Grass in planetary geology (Frigeri et al., 2002b): wrinkle structures have been identified by GRASS raster based analysis at different resolutions on the Mars surface.

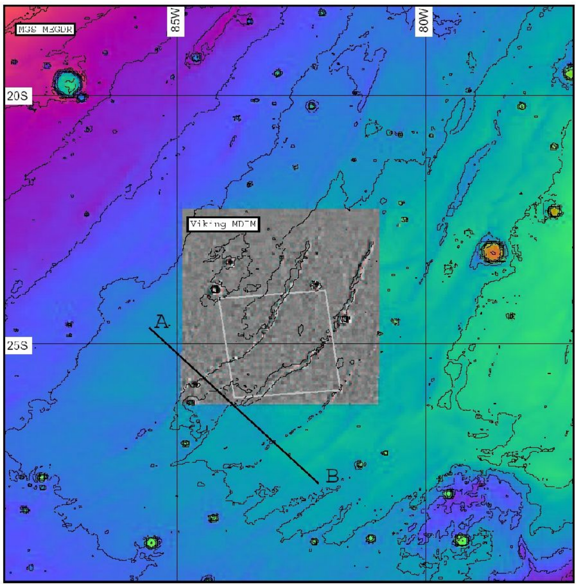


Figure 33: Identifying wrinkle ridges structures from Mars MGS and Viking mission data: using Grass in planetary geology (Frigeri et al., 2002b)

Landslides risk mapping

A GRASS GIS based Shell script for Landslide Susceptibility zonation (Clerici et al., 2002): describes a script that, starting from a Landslide Inventory map and a number of factor maps, automatically carries out the whole procedure resulting in the construction of a Landslide Susceptibility map.

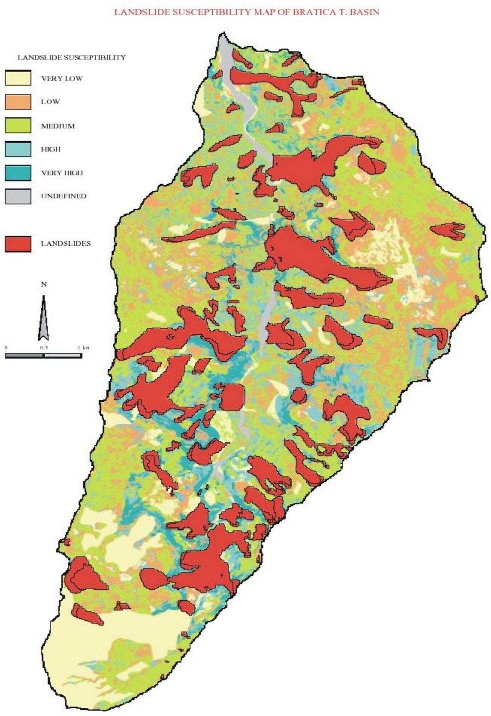


Figure 34: A GRASS GIS based Shell script for Landslide Susceptibility zonation (Clerici et al., 2002)

Using GRASS in evaluation of landslide susceptibility in Handlovská Kotlina basin (Paudits et al., 2002): reports the procedure to develop a map representing the degree of potential hazard for the Handlovská Kotlina basin.

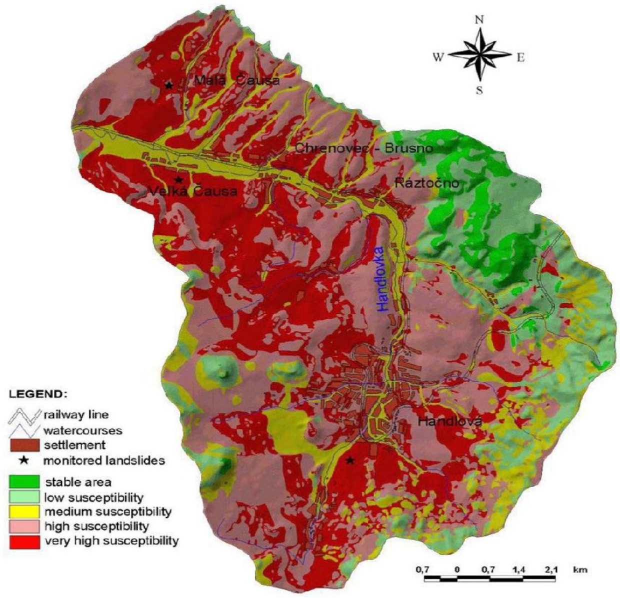


Figure 35: Using GRASS in evaluation of landslide susceptibility in Handlovská Kotlina basin (Paudits et al., 2002)

Development of Landslides Susceptibilty Maps using Artificial Neural Networks and Weigth of Evidence Method in Quebrada Lo Canas, Chile using GRASS GIS (Fock, 2004)

Glaciers

Scale-dependent geomorphometric analysis for glacier mapping at Nanga Parbat (Bonk, 2002): reports the use of hierarchically modeling to delineate alpine glaciers on the landscape.

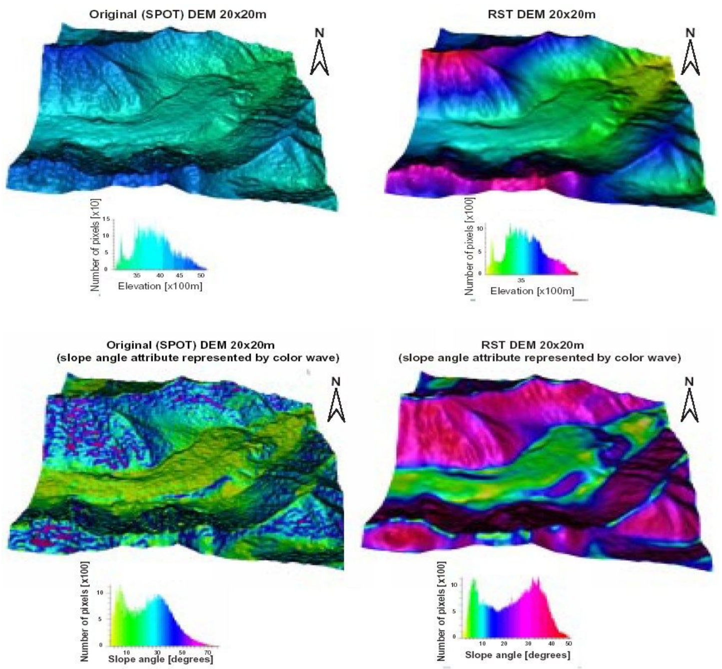


Figure 36: Scale-dependent geomorphometric analysis for glacier mapping at Nanga Parbat (Bonk, 2002)

Geomorphology

Horton: a new set of tools for geomorphological analysis ported into GRASS (Rigon et al., 2002): describes many new GRASS routines for the analysis of DEMs and the geomorphologic analysis.

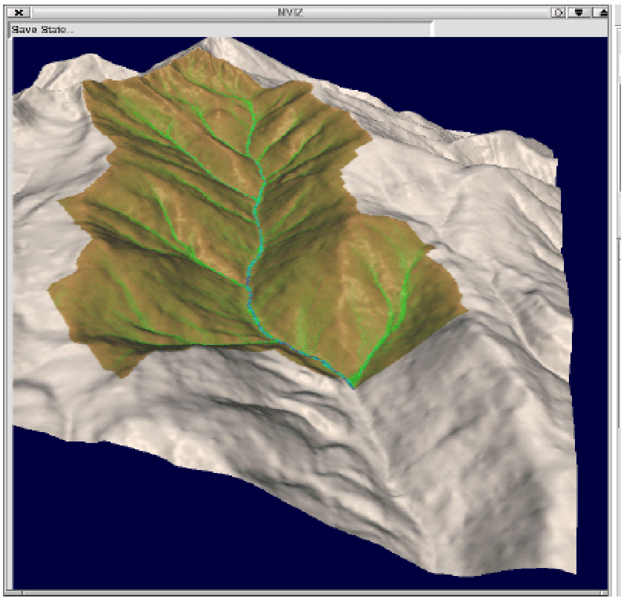


Figure 37: Horton: a new set of tools for geomorphological analysis ported into GRASS (Rigon et al., 2002)

Potential erosion map for Bagmati basin using GRASS (Raghunath, 2002): reports how the LS factor of the Revised Universal Soil Loss Equation (RUSLE) equation is evaluated by the watershed function of GRASS for the Bagmati basin (Nepal).

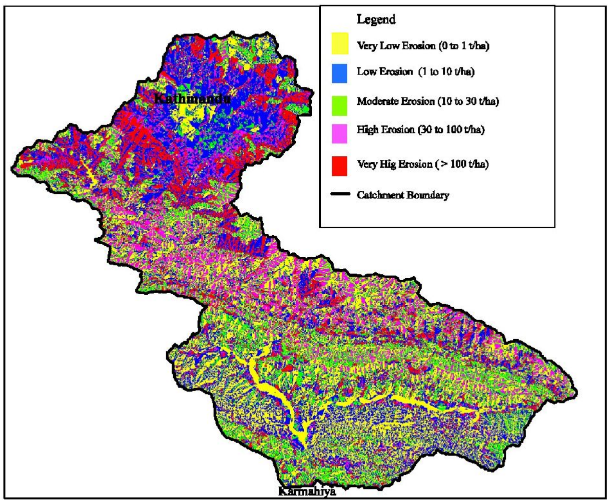


Figure 38: Potential erosion map for Bagmati basin using GRASS (Raghunath, 2002)

SIMPA, a GRASS based tool for Hydrological Studies (Alvarez et al 2004) A tool that a Spanish and Argentinian team of researchers have developed to study hydrological problems and risks.

Preliminary results of a study of the morphologic - planimetric variation of a central Italy creek (Marchesini et al. 2003)

Simulation of the Parma river blockage by the Corniglio landslide (Northern Italy), (Clerici A., et al. 2000).

DTM of a braided river: how to reproduce it? (Federici et al. 2004). The representation of braided river by means of GIS has been studied in this paper.

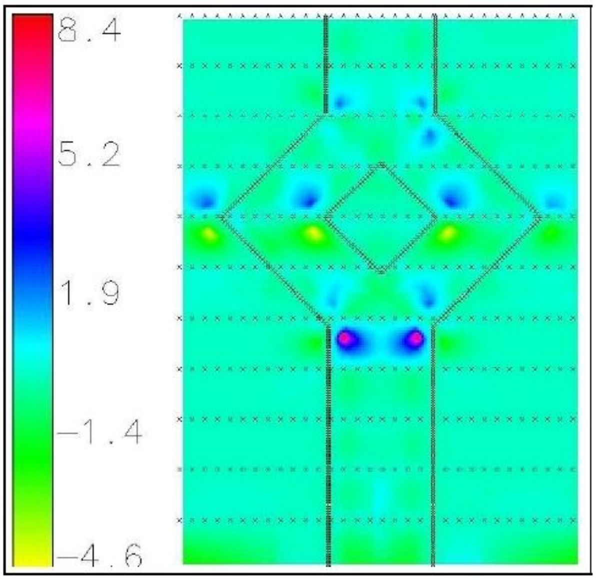


Figure 39: DTM of a braided river: how to reproduce it? (Federici et al. 2004).

Comparison of morphometric algorithms in GRASS (Ciampalini and Carnicelli 2004). In this paper different morphometric algorithms are compared using GRASS both for the construction of the models and for the comparison of the results.

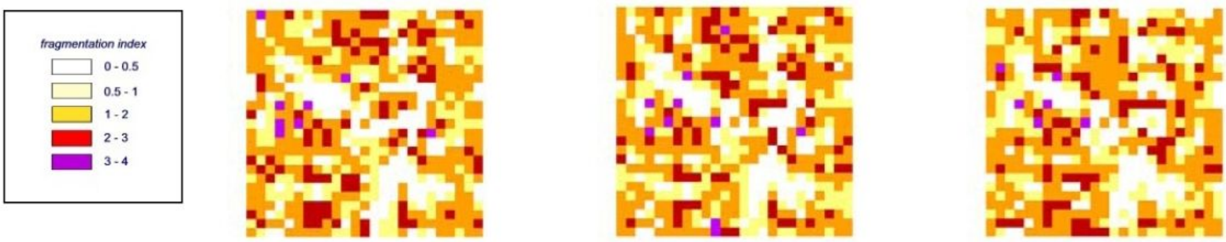


Figure 40: Comparison of morphometric algorithms in GRASS (Ciampalini and Carnicelli 2004).

Risk and hazard management

Erosion hazard

Assessment of Erosion Hazard using Open Source Resources Analysis Support System (GRASS) for Langkawi Island (Firuz Ramli M., et al. 2004). GRASS and RUSLE (Revised Universal Soil Loss Equation) were used to predict the soil erosion hazards in Malaysia.

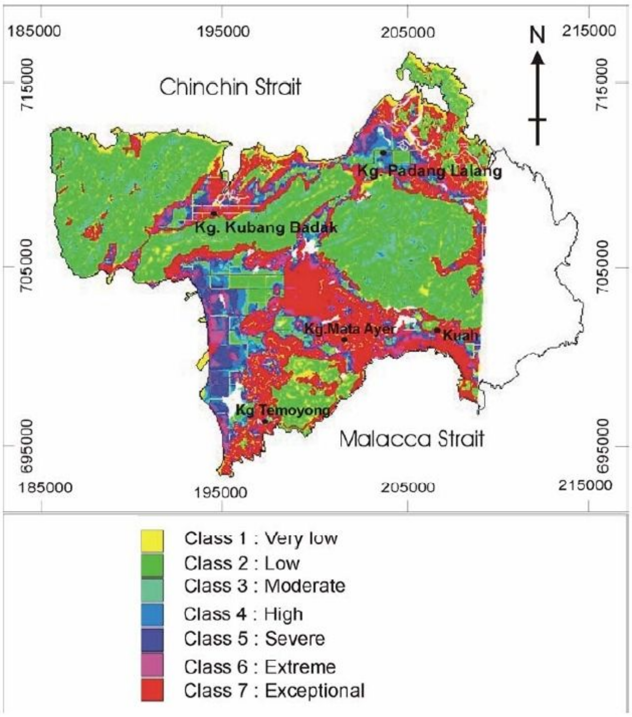
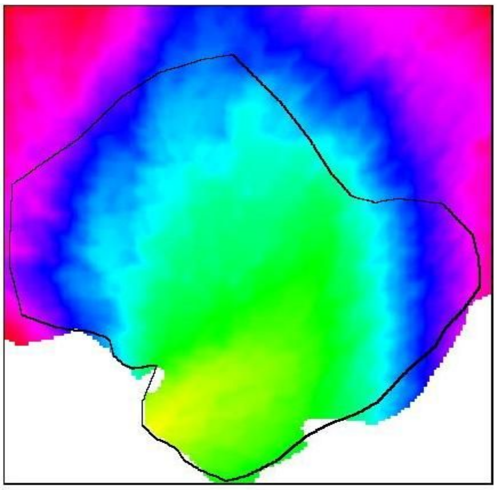


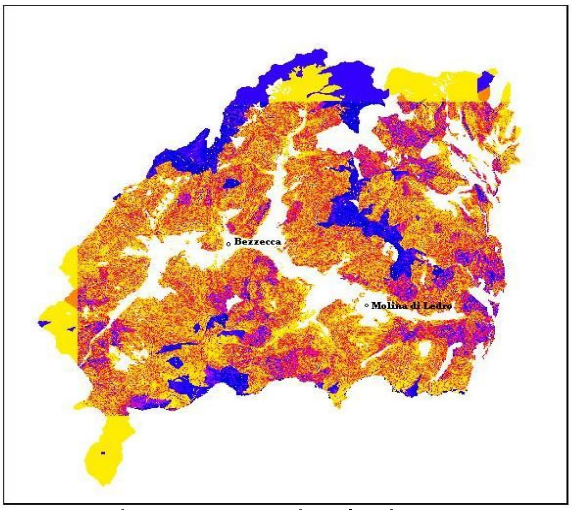
Figure 41: Assessment of Erosion Hazard using Open Source Resources Analysis Support System (GRASS) for Langkawi Island (Firuz Ramli M., et al. 2004).

Wildfires risk mapping

Valutazione del rischio da incendio utilizzando le capacità di analisi dei GIS (Ciolli et al., 1999a): describes the use of GRASS map algebra to implement wildfires hazard models, as well as some wildfires spreading simulations by the r.ros module.



Wildfire simulation



maximum spread velocity

Figure 42: Valutazione del rischio da incendio utilizzando le capacità di analisi dei GIS (Ciolli et al., 1999a)

Traffic and acoustic pollution

Modelling emission and dispersion of road traffic pollutant for the town of Trento (Cemin et al., 2002): reports how both 2D and 3D GRASS capabilities have been used to implement a traffic pollution model and to represent spatial data distribution.

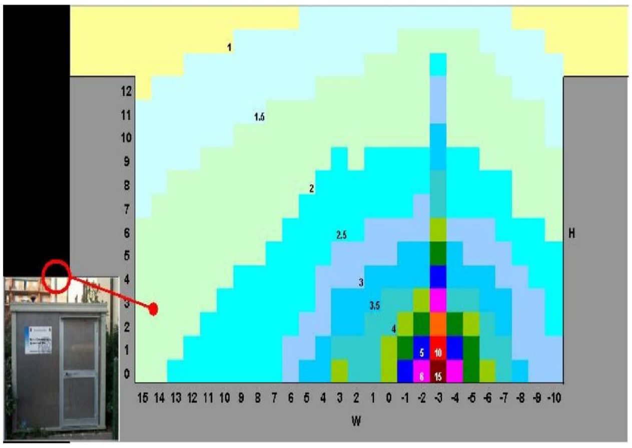


Figure 43: Modelling emission and dispersion of road traffic pollutant for the town of Trento (Cemin et al., 2002)

Uno strumento GIS per l'analisi della sofferenza acustica in territorio urbano (Brovelli et al., 2001): describes how GRASS has provided support to the acoustic suffering analysis, defined as the comparison between measured noise values and largest values allowed by the laws in force, with the use of existing modules and the development of new ones.

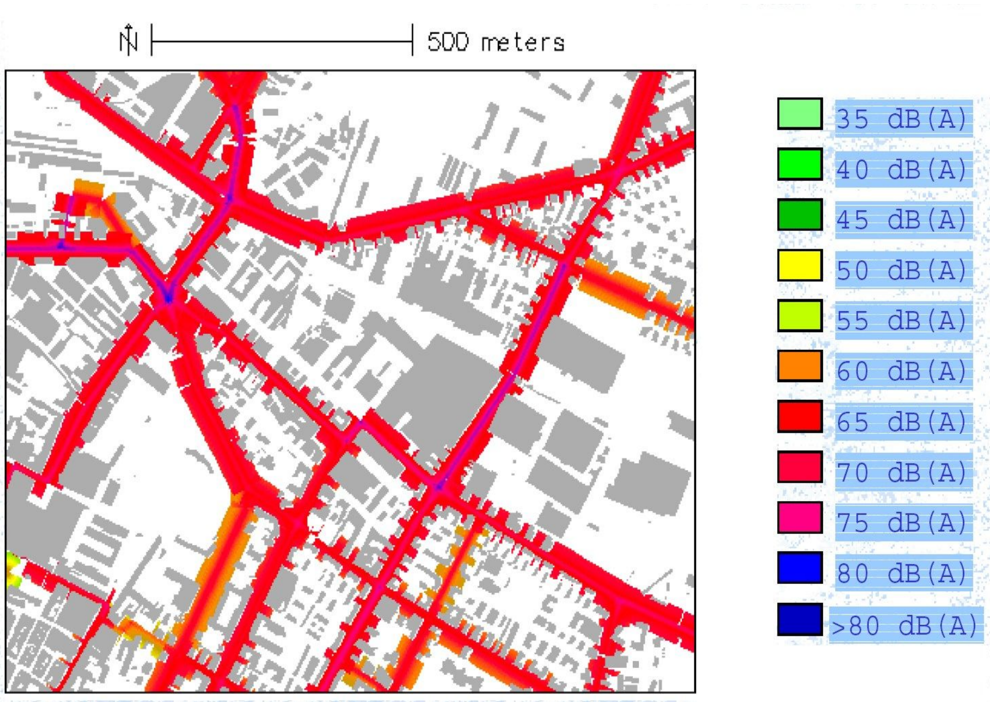


Figure 44: Uno strumento GIS per l'analisi della sofferenza acustica in territorio urbano (Brovelli et al., 2001)

Avalanches risk mapping

GIS and dendrochronological techniques for avalanche hazard mapping with GRASS (Bezzi et al., 2002): GRASS-GIS has been used to obtain an avalanche risk map based on morphological and vegetation features and to create maps of different avalanche paths through the years, recognized by the use of dendrochronological techniques.

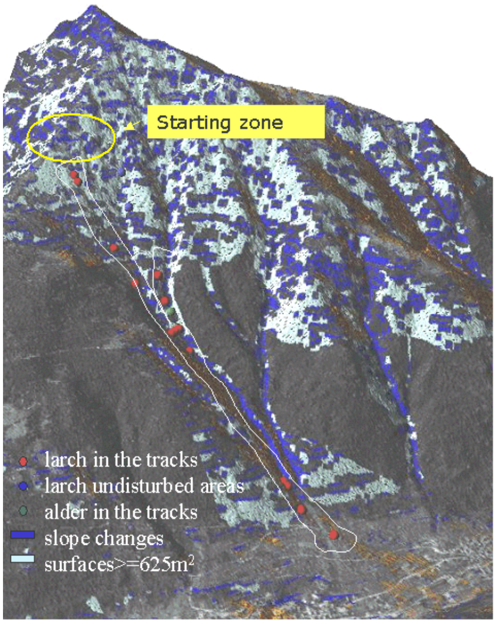


Figure 45: GIS and dendrochronological techniques for avalanche hazard mapping with GRASS (Bezzi et al., 2002).

GIS and dendrochronological techniques for avalanche hazard mapping with GRASS (Bezzi et al., 2002) and *Integration of dendrochronology and GIS techniques to study avalanche phenomena* (Bezzi et al., 2004). In this papers the integration of different techniques is improved and GRASS is used both as a tool to predict possible avalanche paths and as a tool to verify the results of field observations.

Figure 46: Integration of dendrochronology and GIS techniques to study avalanche phenomena (Bezzi et al., 2004)

Flooding and hydrological hazard forecasting

Weather Radar Enhanced Flash Flood Forecasting (O'Donnell, 2002): the forecasting of flood using weather radars is studied in an area particularly interested by the phenomenon.

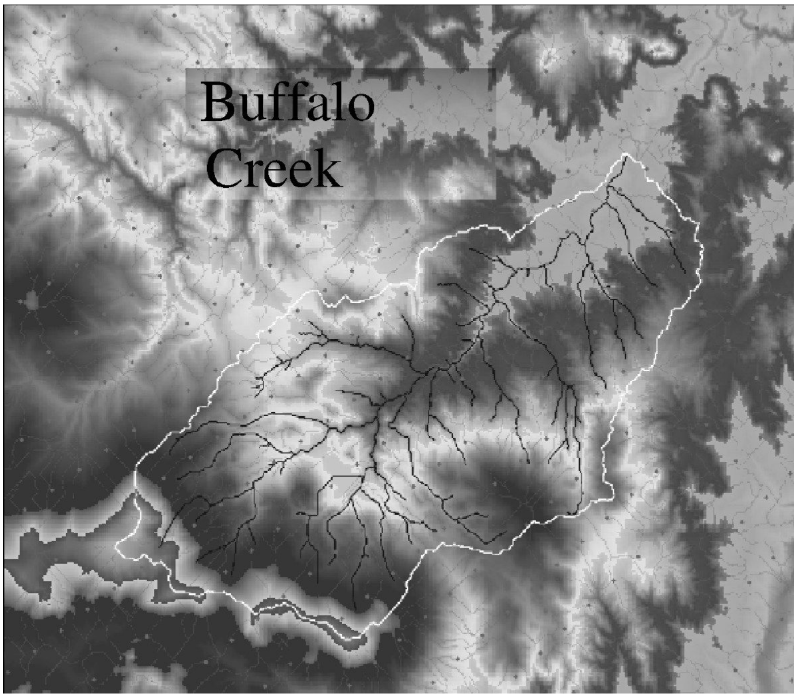


Figure 47: Weather Radar Enhanced Flash Flood Forecasting (O'Donnell, 2002).

A spatial decision support system for radar meteorologic data in South Africa (Lowe, 2002): weather radar can be useful to forecast problems or to assess a better use of water resorurces in African countries.

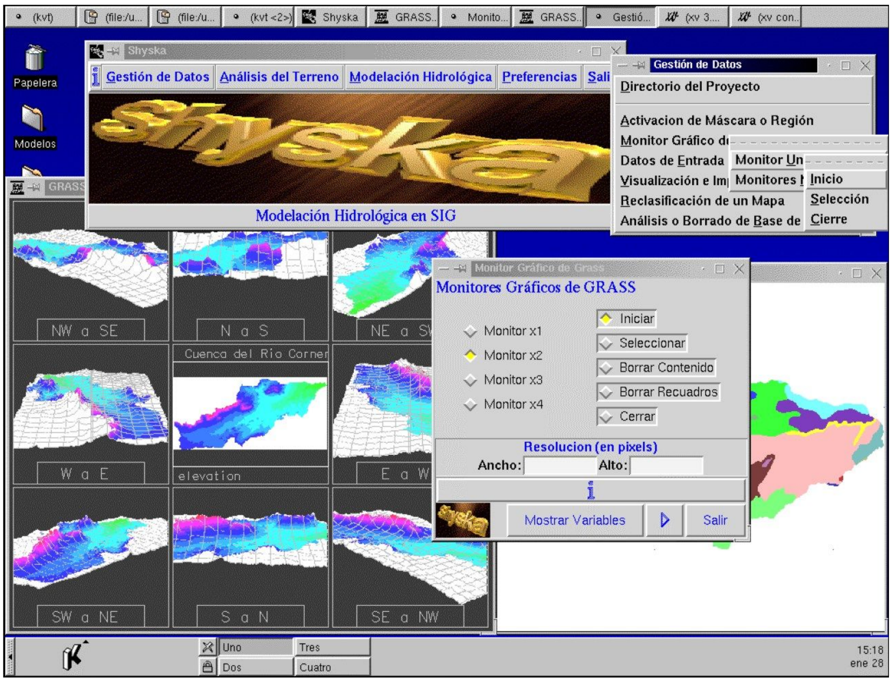


Figure 48: A GIS GRASS-embedded decision support framework for flood forecasting (Garcia Galliano, 2002).

A GIS GRASS-embedded decision support framework for flood forecasting (Garcia Galliano, 2002) Shyska system is presented in this paper.

An hydrological hazard prevention model for the alpine region: the case of Lago Maggiore (Brovelli et al. 2004) A study about hydrological hazard in an area at the border between Italy and Switzerland is presented.

Traffic management

Traffic database management with GRASS and PostgreSQL (Ciolli et al., 2003): GRASS and PostgreSQL have been used to manage and map a traffic database of the city of Trento (Italy).

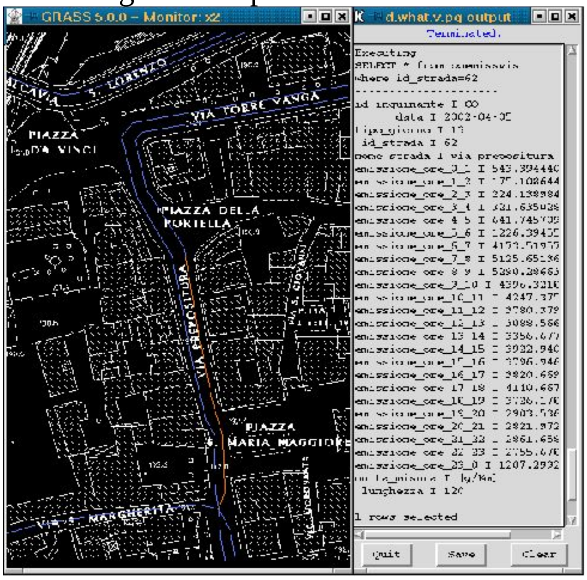


Figure 49: Traffic database management with GRASS and PostgreSQL (Ciolli et al., 2003).

Gestione e distribuzione via Web di dati di traffico integrati con modelli di emissione e dispersione dei principali inquinanti: applicazione alla città di Trento (Cemin et al., 2003) in this work an investigation about the possibility to distribute via web the data about the principal pollutants in Trento is carried out and in *Sistema integrato GIS-database per la gestione dei dati di traffico e produzione di mappe delle emissioni. Applicazione alla città di Trento.* (Cemin et al., 2004) a complete system to manage traffic and emission data is described.
Metodi geoinformatici open source per la mitigazione degli incidenti stradali. (Furlanello et al. 2004) in this work many different geoinformatics methods have been combined to individuate the principal sources of car accidents in Trentino.

Archaeology

An archaeological web GIS application based on Mapserver and PostGIS (Brovelli et al., 2002b): shows how a web-GIS of a natural and archaeological park in the Como area (Italy) has been set up by using Open Source Mapserver system.

GPS planning

New modules for satellite surveying planning in GRASS (D'Incà et al. 2002) describes new modules developed to improve the capacity of GRASS in the planning of GPS surveying.

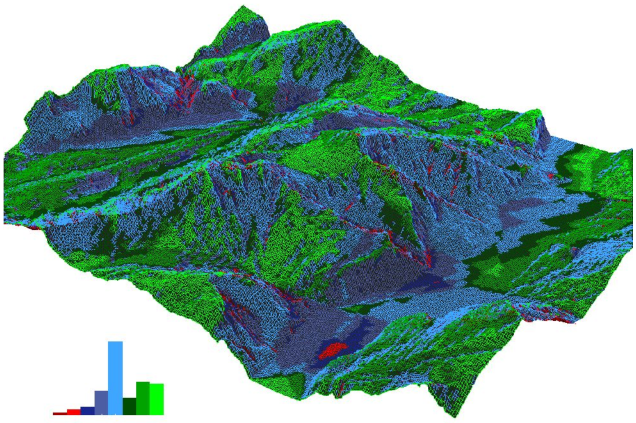


Figure 50: New modules for satellite surveying planning in GRASS (D'Incà et al. 2002).

Planning GPS automatico con ostruzioni realistiche (Fruet et al., 1999): reports how GRASS has been used to automatically perform GPS and GLONASS planning in urban and non urban areas.

WEB GIS and portable technologies

The GRASS server (Blazek et al., 2004) describes the architecture of a WebGIS server developed with GRASS.

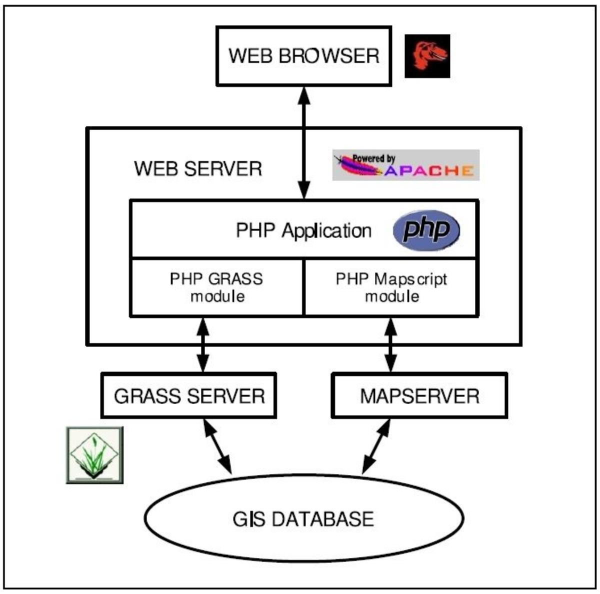


Figure 51: The GRASS server (Blazek et al., 2004) describes the architecture of a WebGIS server developed with GRASS.

GRASS on the WEB (Hess, 2002): proposes a design based on a combination of PHP, GRASS scripts and other Linux standard tools for the access to geocoded data through a standard web browser.

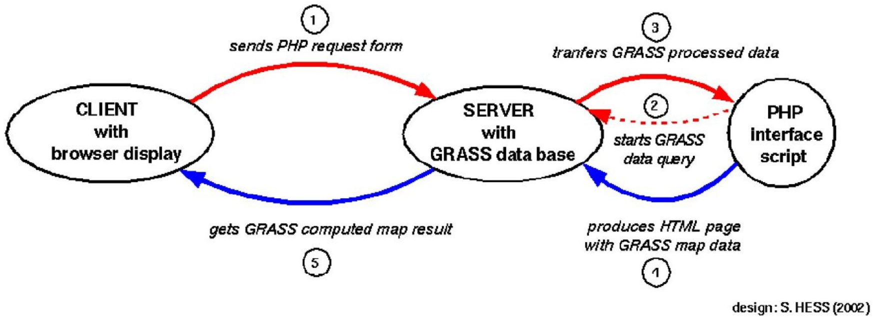


Figure 52: The GRASS on the WEB (Hess, 2002)

Using Mapserver to Integrate Local Government Spatial Data (Greenwood, 2002): describes the use of Mapserver to integrate spatial data from several county and municipal governmental departments.

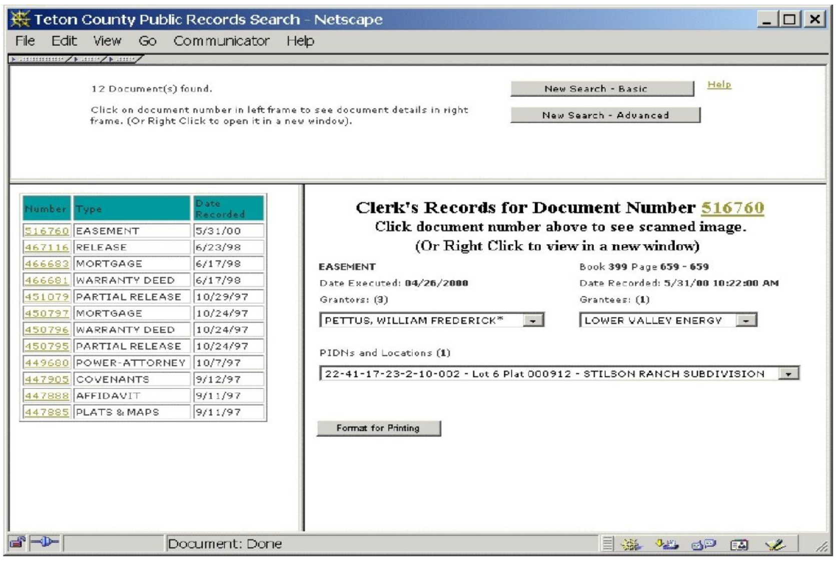


Figure 53: Using Mapserver to Integrate Local Government Spatial Data (Greenwood, 2002).

An archaeological web GIS application based on Mapserver and PostGIS (Brovelli et al., 2002) and *New WEBGIS technologies for geolocation of epidemiological data: an application for the surveillance of the risk of Lyme borrelliosis disease*. (Furlanello et al. 2002) are two other examples of webGIS developed by means of GRASS..

Implementing an online spatial database using the GRASS GIS environment (Raghavan et al., 2002): describes a prototype Spatial Information System for Geological Modeling (SISGeM) where the spatial data management is carried out using GRASS.

Figure 54: Implementing an online spatial database using the GRASS GIS environment (Raghavan et al., 2002)

GI-Based Estimation of solar radiation and PV generation in central and eastern europe on the web. (Huld et al. 2003): an interactive site to estimate solar radiation to evaluate the possibility to install photovoltaic panels has been built using GRASS. Maps are available via the internet.

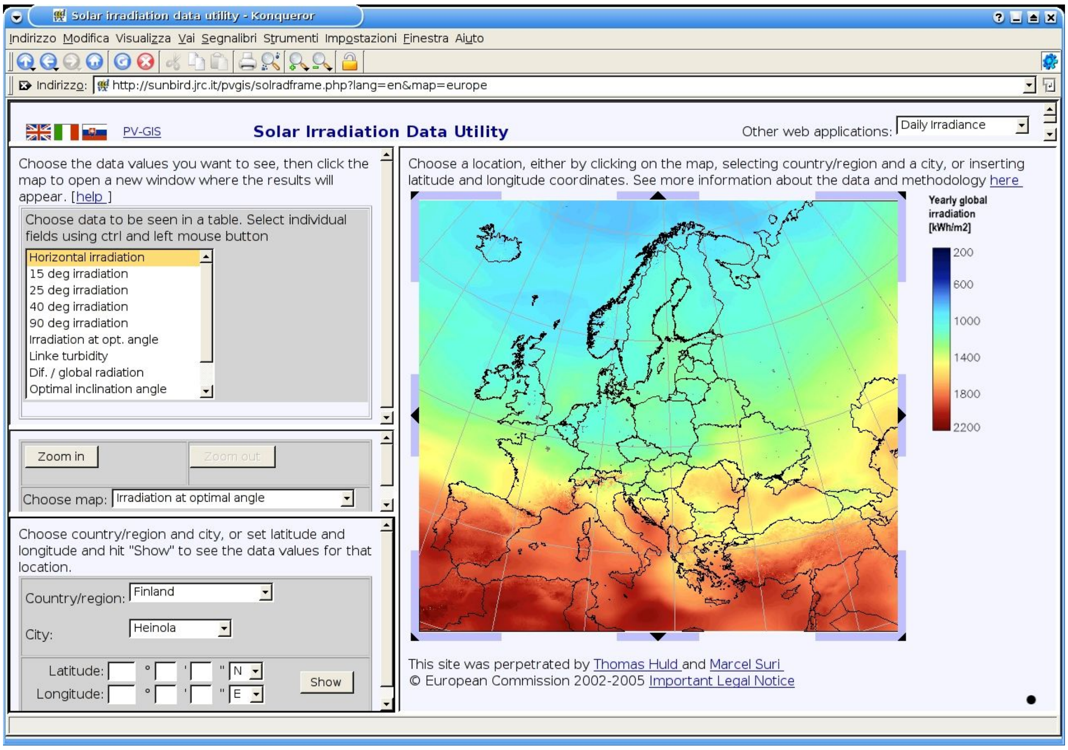


Figure 55: GI-Based Estimation of solar radiation and PV generation in central and eastern europe on the web. (Huld et al. 2003):

GRASS and PDA

Low cost PDA/Gps based field logging solution for GRASS data (Frigeri et al., 2002c): reports the set up of a simple Personal Digital Assistant (PDA) based field log system to store point data to be imported directly in GRASS as a site-file.

Figure 56: Low cost PDA/Gps based field logging solution for GRASS data (Frigeri et al., 2002c).

Experimental Mobile Wireless GRASS based GIS for Handheld computers running GNU/Linux (Stankovic et al., 2002): describes a stripped down GRASS version (baby GRASS) for the use on a Linux handheld computer.

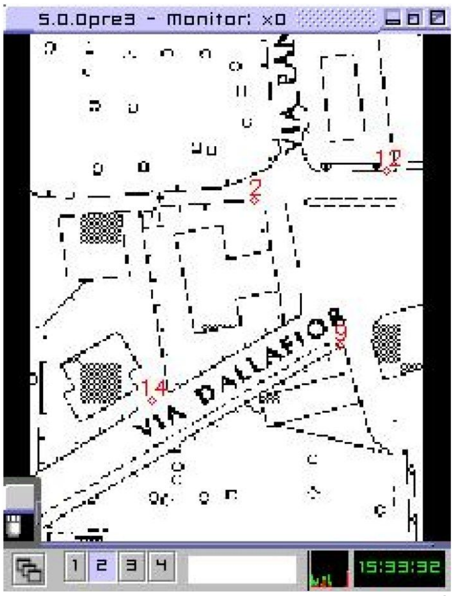


Figure 57: Experimental Mobile Wireless GRASS based GIS for Handheld computers running GNU/Linux (Stankovic et al., 2002)

Investigations about the teeth structure of primates

Modeling Primate Occlusal Morphology in Three Dimensions Using GRASS Software. (Zuccotti et al 1998): this is another very original and unusual application of GRASS. GRASS has been used as a tool to analyse both in two and in three dimension the teeth and the mouth morphology in primates.

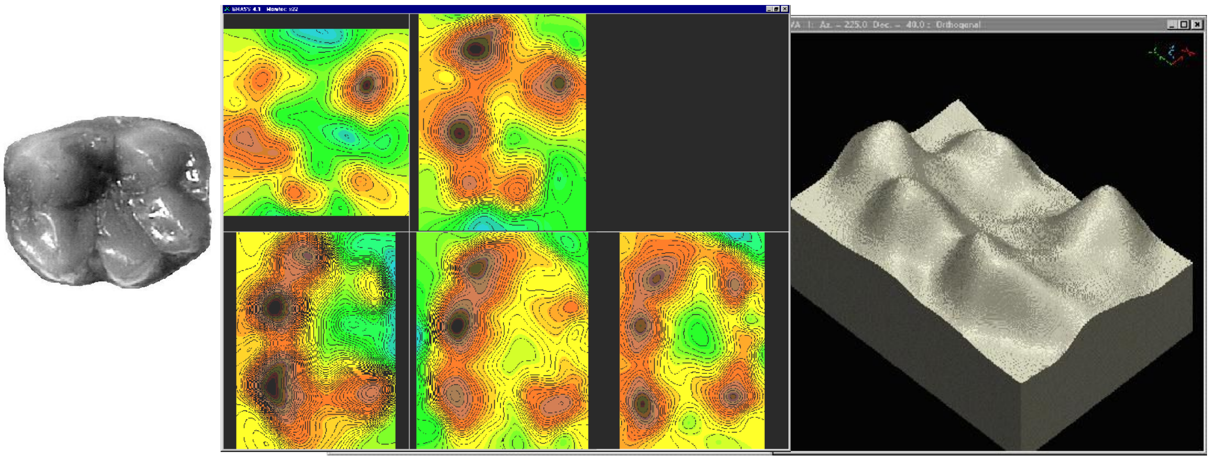


Figure 58: Primate teeth and mouth morphology analysis in two and three dimension with GRASS, (Zuccotti et al. 1998)

Medicine and diagnostics

GRASSlicer: A Medical Image Analysis and Visualization Tool (Isorna et al. 2004). One of the most original and unusual application of GRASS is certainly this one. A new interface called GRASSlicer has been created to use GRASS to analyse medical images to detect problems or pathologies.

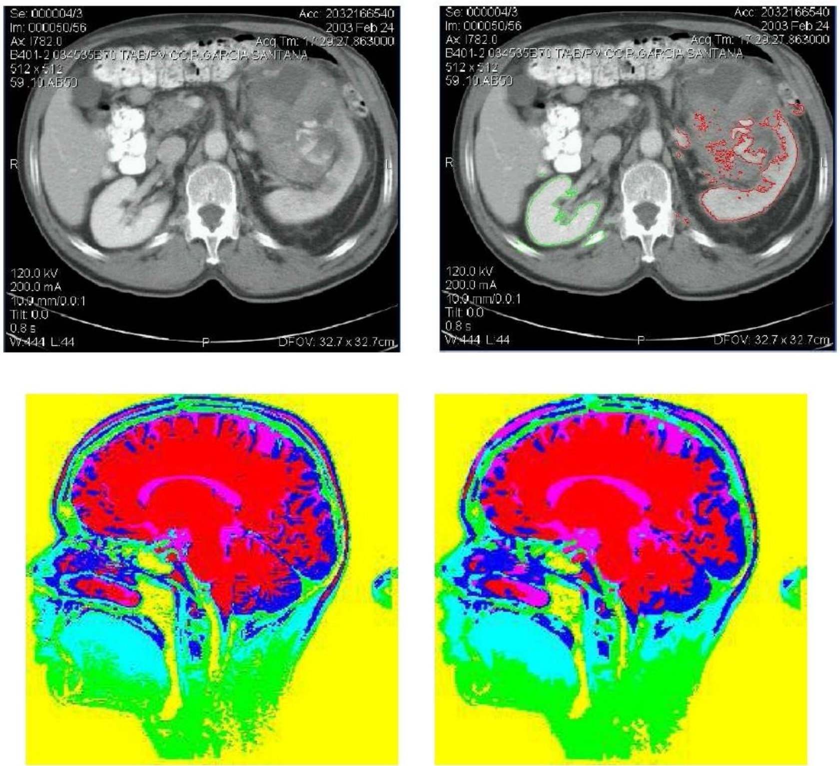


Figure 59: GRASSlicer: A Medical Image Analysis and Visualization Tool (Isorna et al. 2004).

6. Conclusions

This paper collects recent (as of april 2005) GRASS applications with bibliographic indications. This work is not meant to be definitive but an overview of the GRASS applications is provided, and it can represent a starting point for people inquiring about GRASS and related software capabilities. Moreover this witnesses the vitality and wide range of application of the GRASS project.

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