

GRASS a Free and Open Source raster and vector GIS software on GNU-Linux for generation of integrated Geoscience Datasets

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GRASS ORIGIN AND GROWTH

GRASS (Geographic Resources Analysis Support System) has been under continuous development involving a number of federal US agencies, universities and private companies since its launch in 1982. US Army Construction Engineering Research Laboratory (USA-CERL) completed it as version 4.1 in 1992 and provided five updates and patches to this release through 1995.

Baylor University, the first 'GRASS Research Group' adds numerous programs for 4.2 version (1997) and takes control of the GRASS development. Baylor University developed versions up to 5.0 with several new modules and fixes. The international GRASS Development Team at IT-irst (Trento, Italy) has been releasing the later versions: GRASS 5.0 stable – Sept 2002, GRASS 5.0.3 – Nov 2003, GRASS 5.3 – May 2004, GRASS 5.7 – June 2004, GRASS 6.0.0beta1 – Jan 2005.

UTILITY FOR GEOSCIENCES

Being a raster and vector GIS with 3-D capabilities GRASS can handle all the different data formats, i.e., satellite imagery, aerial photos, scanned raster, SRTM (Shuttle Radar Topography Mission), vector .dwg, .dxf, .shp, .e00, .arc, .GPS, available for earth scientists. With georeferencing and projection support all the unprojected data as well as the data with different projections can be brought to the same projection for viewing, overlaying and further analysis.

Different thematic maps like geology, geomorphology, landuse, soils, topography, structure, seismic, geophysical and geochemical data can be processed and generated.

GRASS data are stored in a directory referred to as DATABASE (also called "GISDBASE"). This directory must be created before working with GRASS. Within this DATABASE, the projects are organized by project areas stored in subdirectories called LOCATIONS.

RASTER GRASS

Traditionally GRASS has been very strong in raster data processing and analysis. It has both supervised and unsupervised radiometric image classification and supervised radio and geometric classification capabilities, image fusion with Brovey transform, morphological analysis like slope and aspect, flowlines, tracing a flow through a DEM, watershed analysis and cost surfaces, image geocoding and volume visualisation (isosurfaces and profiles) tools.

VECTOR GRASS

The versions later to 5.7 have improved vector processing capabilities especially in the attribute data management through a SQL-based DBMS and support to vector analysis. Digitization and topology building is on the fly with the closing of the digitization. Raster to vector conversion is automatic but may involve careful post-conversion drawing clean up operation.

Large number of vector data formats are supported and different formats can be freely imported into and also exported. All the popular formats like .dwg, .dxf, ESRI .shp, .arc coverages, .e00, SRTM, CSV ASCII text, GPS point, VMAP0 (National Geospatial Agency), Map Info tables are supported.

Point data can be imported with elevation /3-D attributes and contours can be generated after extrapolation of the raster surface by inverse distance weighted, bilinear and regularized splines with tension methods.

GRASS supports the projection of the files being imported on the fly either by creating new Location or importing into a Location with projection. It can override the projection of the file being imported if the user wishes so.

METHODOLOGY:

IMPORTING A RASTER IMAGE /MAP AND GEOREFERENCING

The command **r.in.gdal** attempts to preserve projection information when importing raster datasets if the source format includes projection information, and if the GDAL driver supports it. If the projection of the source dataset does not match the projection of the current location **r.in.gdal** will report an error message

If one wishes to ignore the difference between the apparent coordinate system of the source data and the current location, one may choose the -o flag to override the projection check.

If the user wishes to import the data with the full projection definition, it is possible to have **r.in.gdal** automatically create a new Location based on the projection and extents of the file being read. This is accomplished by passing the name to be used for the new Location via the Location parameter and the raster will be imported with the

entering the values when it prompts for confirmation. After giving as many points as desired (minimum is 4) click **Analyze** menu button. It will show the RMS error. You have the option to delete the points which are erroneous. The points can be saved to a file by clicking on the **file** menu and giving a name. When done click **Done**. And click exit.

15. Image ---> Rectify and georeference image group--->Affine and polynomial rectification ---> i.rectify db

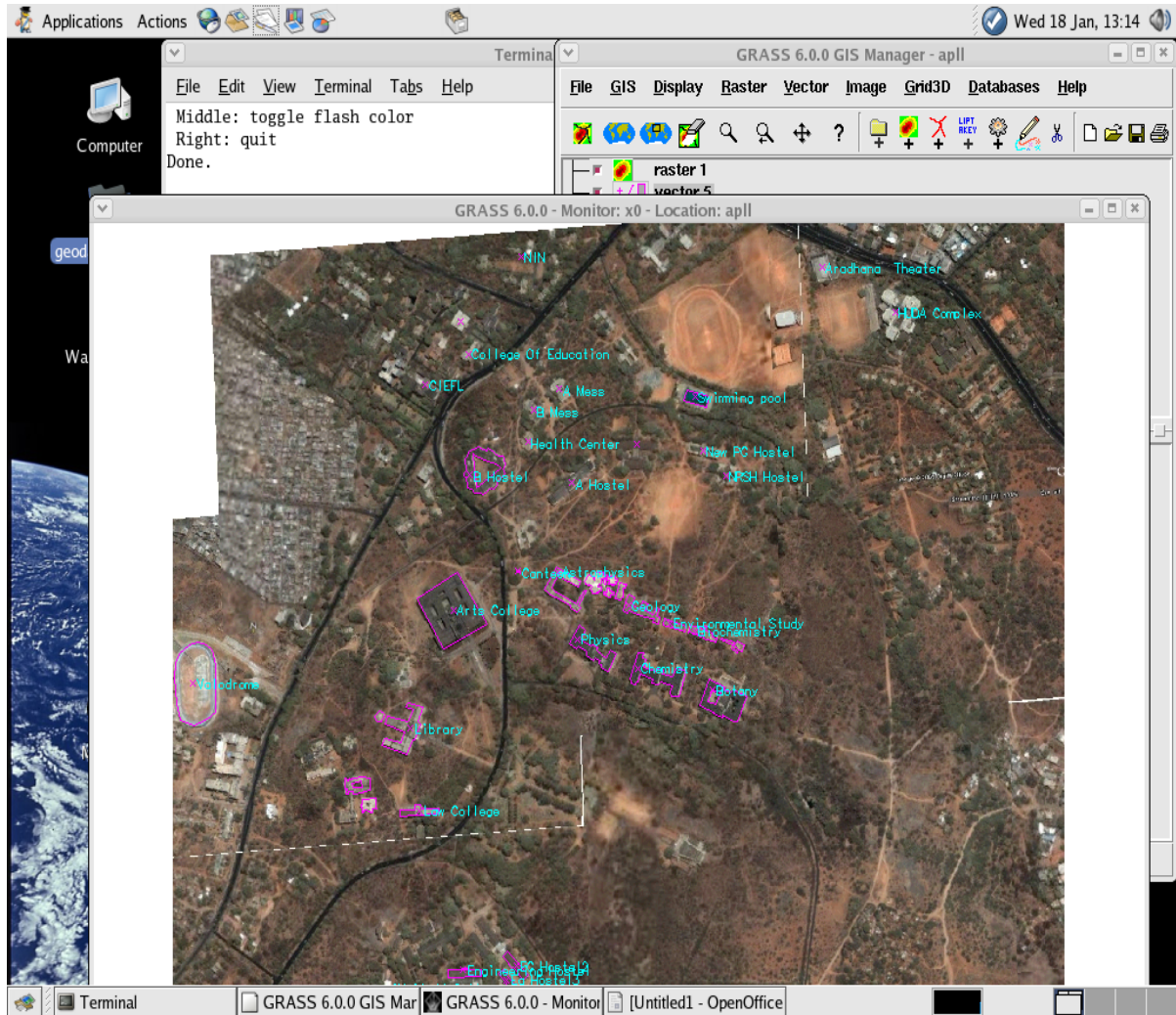


Fig. Osmania University image from 'Google earth georeferenced and digitised showing different departments

GEOREFERENCING AN IMAGE : 2. IMAGE TO REFERENCED-RASTER RECTIFICATION

16. For image rectification with reference to a georeferenced raster the difference is in choosing the **plot raster** option in the i.points dialog box. Click to the right side of the image in the monitor to plot the raster and choose the desired referenced-raster available in the projected location by double clicking on the name.

17. Pick a point, first in the source image and then the same point in the target referenced-raster. Use of zoom function for both the source and target raster maps is a must to achieve high accuracy. The color of the accepted pair of points changes to green. Continue the process till enough points distributed widely over the whole of the area are picked. For image rectification the order of polynomial transformation should preferably be greater than for scanned rasters. And as the order of transformation increases the minimum number of control points required also increases. (number of points $n = (p+1)(p+2)/2$) where **p** is the order of transformation required. Though according to the above calculation the third order transformation requires a minimum of 10 GCPs it is always recommended to define more control points than the bare minimum. Then analyse for RMS error as mentioned above. An acceptable RMS error should be less than half a pixel size in terms of ground distance or true distance.

Note: Georeferencing works even if the RGB files are removed and only the composite file (false color) is left in the image group. But regrouping is required.

POINTS created during georeferencing by default are stored in the respective **group** folder of a raster file.

NB:Latitudes longitudes can be obtained using GPS for well known land marks and points of intersection of roads,

railways and streams and used as keyboard input while georeferencing.

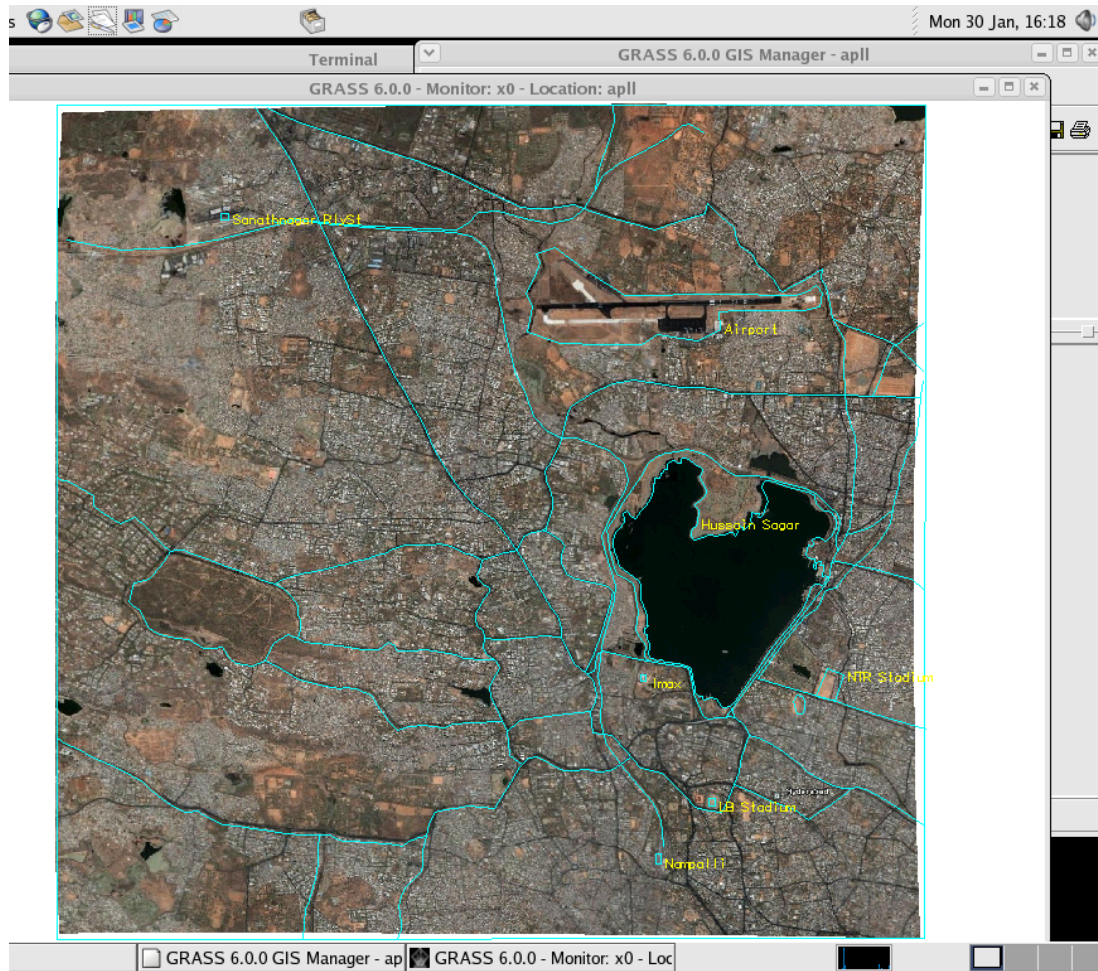


Fig. Georeferenced image of Hyderabad saved from 'Google earth' and vectorised showing roads and a few landmarks

IMPORT AND EXPORT

Import and export functions:

- Can retain projection of the source map.
- Can create new Location, having the same projection as that of the source map, automatically.
- Can override the projection of the map being imported in to a location without projection or having a different projection.

Vector import supported formats:

- ESRI Shapefile, UK.NTF, SDTS,TIGER, S57, MapInfo File, DGN, VRT, AVCBin, REC, Memory, CSV, GML, ODBC, OGD, PostgreSQL, SRTM (Shuttle Radar Topographic Mission), VMap0
- Further available drivers such as IHO S-57 (ENC), depend on the local installation (OGR library)
- ASCII points file or GRASS ASCII file
- Old GRASS vector format
- ESRI e00 format (requires avcimport program for versions later than 5.7)
- Garmin GPS waypoints/Routes/Tracks
- MATLAB mapGen files
- AutoCAD dwg/ dxf (requires OpenDwgToolkit for versions later than 5.7)

STEPS FOR IMPORTING VECTOR FILES:

1. File--> Import --> Vector map --> Various formats using OGR (v.in.ogr dialog opens, which can import several formats like ESRI Shapefile, UK .NTF, SDTS, TIGER, S57, MapInfo File, DGN, VRT, AVCBin, REC, Memory, CSV, GML, ODBC, OGD, PostgreSQL).

for importing **ESRI shape** files the *mapName.shp* file should be given as input.

for **Mapinfo** files the *mapName.tab* file should be given as input.

for ESRI coverages the **arc.adf / tic.adf** should be given as input.

For importing point data

File--> Import --> Vector map --> ASCII points file or GRASS ascii file (v.in.ascii dialog opens)

- The file should be stored as Text CSV file.

- **No** header row information should be there.

- The number of the column having X, Y coordinates has to be given in respective input parameters

- 3-D maps can be generated using Z value and the Z values can be in more than one column; then the input for that column is the number of columns having z values. For example geochemical data having values of several elements can have many columns of Z value data.

- Full path of the ASCII file has to be given.

3. For **importing .dxf / .dwg files** the v.in.dwg dialog can be invoked by typing **v.in.dwg** at the command prompt in the terminal. This can import both .dwg and .dxf files. At command prompt > **v.in.dwg**

'TRANSFORMATION' AND 'PROJECTION' OF VECTORS

Transforming vector map either digitised from a scanned image or imported in to GRASS is performed by the v.transform command which requires either the transform coordinates stored in a simple text file or the X, Y shift values in degree decimal form (not in degree /minute/seconds). Transform-coordinates-file is a **text** file with the coordinates required for transformation, stored in four columns separated by spaces or tab as file delimiters. The first line of the file should be a comment, that is, it should start with '#' character. These coordinates can be copied to this file from the (last four columns) points file generated during georeferencing of the image using the i.points (Grass.run.sh), 'Set ground control points from raster map' command (GCPs). Or they can be generated by clicking on the points of interest in the vector map by using the **d.where** command.

STEPS FOR TRANSFORMATION:

Display --> show geographical position--> invokes the **d.where** command.

vector---> Rectify and georeference vector map---> opens v.transform dialog

An example of transformation coordinate file for v.transform command:

```
# transformation coordinates ; this line is a comment only
542.0      247.5   76.0   14.8
446.5      247.6   76.2   14.8
540.7      443.4   76.0   14.2
445.6      443.5   76.2   14.2
```

NB: If the i.points file is stored in a different path than the vector file give the full path to that file or move the points file to the same folder where the vector file resides.

PROJECTION CONVERSIONS

v.proj: To project from one projection system to another. Maps from other Locations/ Mapsets having a different projection other than the current Location/ Mapset can be re-projected to the current Location and Mapset. If both the Locations are in the same DATABASE folder it is sufficient to give the map name, Location name, Mapset name and the DATABASE parameter can be left blank.

STEPS FOR CHANGING PROJECTION:

Vector ---> Develop map ---> Reproject vector from other location (for vector maps)

Raster ---> Develop map ---> Reproject raster from other location (for raster maps)

****NB:** As with all transformations to raster, *we have to define the Grid resolution for the new raster map with*

g.region , before applying the interpolation method; may end up with a raster map of only one or a few pixels, if the resolution is too coarse (high value) or the map generation may be inordinately delayed if the resolution is set too fine/ high (low value). *g.region res = 5* (5 meters if units are meters or in degree decimal for degrees at command prompt or in *g.region* dialog)

CONTOURING AND 3-D SURFACE INTERPOLATION

From point data: A one-time creation of point *data file for any number of variables helps in quickly creating several raster surface & contour (variable distribution) maps. The point vector file depicts the location of sample sites and the values for different variables are available as attributes in the .dbf (database table) file. By selecting one column at a time from this info file as 'Z' value **Raster Surface maps** can be prepared using 'Regularised Spline Tension (RST) interpolation from vector points' function from Raster menu. Vector contour maps are prepared from these raster surface maps by selecting 'Generate vector contour lines' function from Raster menu. The Min, Max and Contour Interval can be set for any particular contour map.

Since same Region (which depicts map limits, projection and grid specifications) is set for all the maps, element distribution maps can be overlaid one above the other for visual comparison.

- The name of a database table is same as that of a vector map name.
- The column names can be changed in the *mapName.dbf* file under *dbf* folder within a *Mapset*.
- The column names can be found by going to Database menu in the GIS manager window:
- Database--->Database information--->Describe table ('-c' option that is 'print columns names only' gives only column names) or Database--->Database information--->List columns

■ While giving the **column names with spaces** (when viewed in Edit attribute form mode) use **underscore** wherever there is a space in the column names in *v.surf.rst* dialog or GIS manager.

STEPS FOR CREATION OF 3-D SURFACE & CONTOURS:

2. Import ASCII point data from .csv file (File-->Import-->Vector-->ASCII point file)
3. Set Region to the generated point Vector file : GIS-->Region-->Manage Region-->*g.region* dialog box—>Set region to match this Vector Map
4. To view the Point Vector File:
'Add Vector' icon in the GIS Manager. b) Enter vector file name by clicking on the 'vector name' tab. c) Select the file name from the dialog box. d) Click on the 'Display Selected Layers Icon' on the GIS Manger
5. Creating Raster surface: ** set the resolution with *g.region res = 5* (5 meters if units are meters or in degree decimal for degrees at command prompt or in *g.region* dialog)
Raster-->interpolate surfaces-->Regularised spline tension interpolation from vector points or contours **or** from the terminal using **v.surf.rst** command.

Enter Vector Point file name, Name of column for using as Z values, and output raster file name for elevation (Z) b. View the Raster surface map

6. Creating Vector Contours from the Elevation Raster surface (raster-->generate vector contour lines)
7. Use **r.null** to modify the raster to generate threshold maps after nullifying values below the total of Mean + Standard Deviation. To get the statistics for a raster use **r.univar** :

Raster-->Develop map --> manage null values(**r.null**). Give the range e.g. -50-70 (minus 50 to 70)

Raster--> Reports and statistics--> univariate statistics --> **r.univar** dialog opens

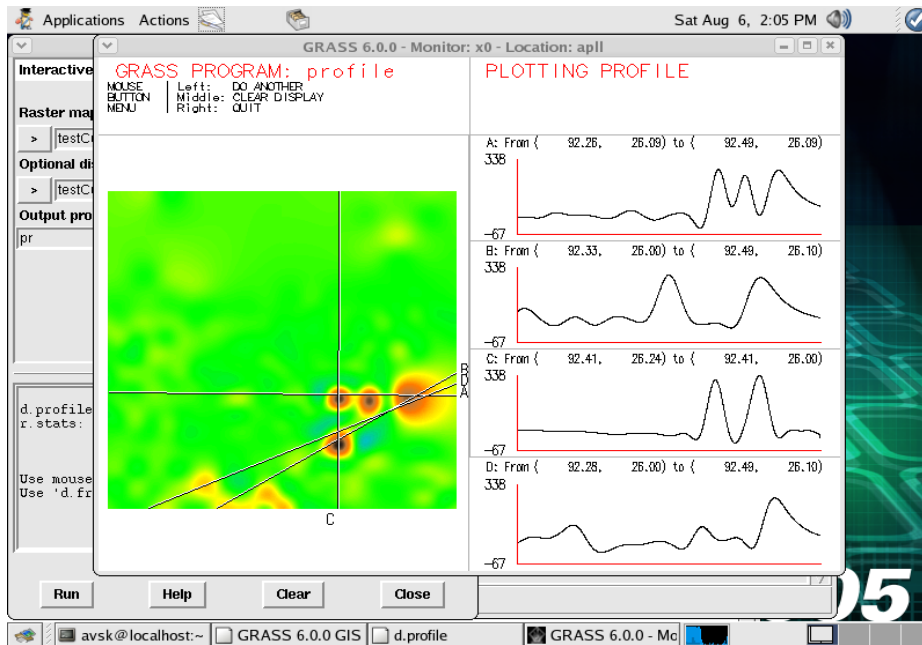
*See steps for import of point data, under import & export topic, for file format.

NB: As with all transformations to raster, **we have to define the Gird resolution for the new raster map with *g.region* , before applying the interpolation method

10. Create profiles with *d.profile* command.

Raster--> Terrain analysis-->Profile Analysis-->**d.profile** dialog appears

Fig. Geochemical profiles generated from surface elevation map showing anomalies



HARDWARE AND OS REQUIREMENTS:

Operating Systems: GRASS can be installed on any of the OS viz., GNU/Linux, Sun Solaris, Mac OS, MSWindows with Cygwin, HP-UX, DEC-Alpha, AIX, BSD, iPAQ/Linux and other UNIX compliant platforms (32/ 64 bit). The authors have worked on PCQ Linux2005 (Fedora), Mandrake10, Debian flavours of Linux all of which are free versions. It is also found that the MS Windows versions of GRASS are not as fast as their GNU-Linux variants.

Hardware: The bare minimum is a 586 processor and 64 MB RAM, however for efficient processing especially for large raster files 1GB can vastly improve the performance. For geospatial data more RAM is generally more effective than a faster CPU. For 3-D visualisation high-end graphics card with open GL hardware acceleration will boost the speeds significantly. The GRASS, compiled on Linux system require about 100MB disk space, 90 MB on Windows and up to 180 on other Unix systems.

INTERNATIONAL SUPPORT: S/W can be downloaded from <http://grass.ibiblio.org>

GRASS-project: <http://grass.itc.it> and its mirrors grass5_AT_grass.itc.it

Newsletter online: <http://grass.itc.it/newsletter/>

CONCLUSION: GRASS, a free and open source GIS is eminently suitable for handling many geospatial data formats/types and will drastically reduce the software costs for GIS and makes it affordable not only in public and private organisations but all educational institutions at graduate and undergraduate levels. With increasing availability of quality data both high resolution 3-D raster and vector, hitherto restricted or prohibitively costly, over the Internet, that too free of cost, it is right time for all to utilise the same for learning GIS, processing and analysis.