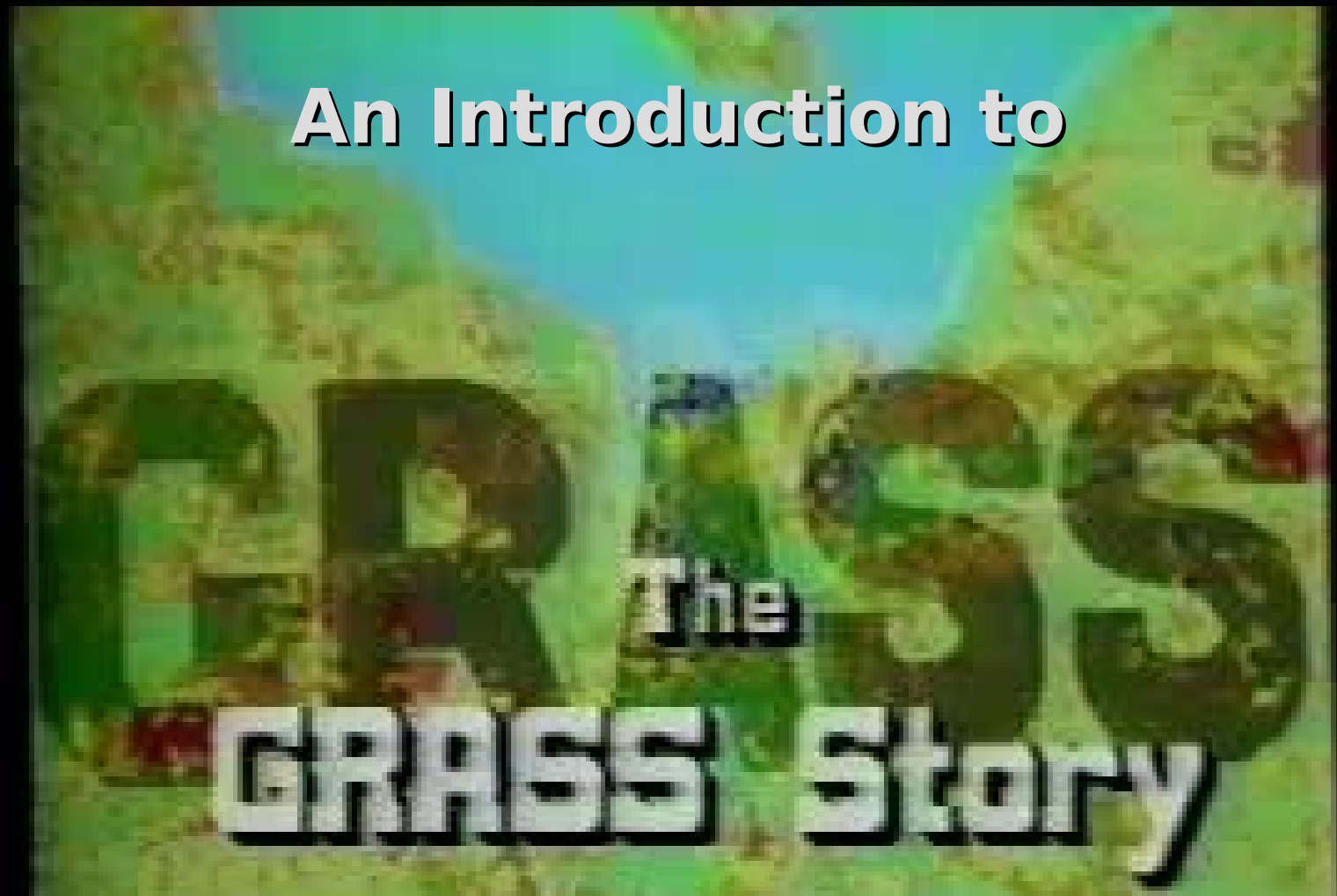
An Introduction to



http://grass.osgeo.org

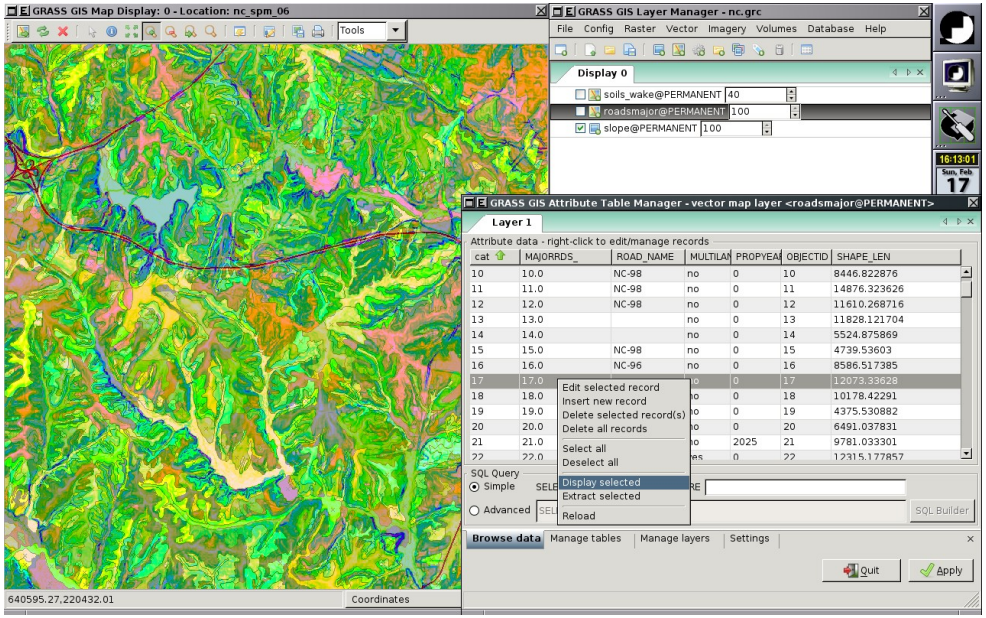
Markus Metz, Markus Neteler

Structure of this seminar

Introduction to GRASS GIS

Impart working knowledge of GRASS

Exercises on statistical procedures in GRASS



What is GRASS GIS ?

Geographic **R**esources **A**nalysis **S**upport **S**ystem

Free and Open Source since 1984

Member of OSGeo Your Open Source Compass

Linked to GDAL, QGIS and R

Portable: GNU/Linux, Mac OSX, MS-Windows, SUN, etc.

GRASS Features

Raster 2D/3D processing

Vector 2D/3D processing

Native raster and vector format

3D visualization system

Database Management System (DBMS)

- DBF, sqlite, PostgreSQL, MySQL

GRASS database concept

GRASS database

folder with Locations

Location

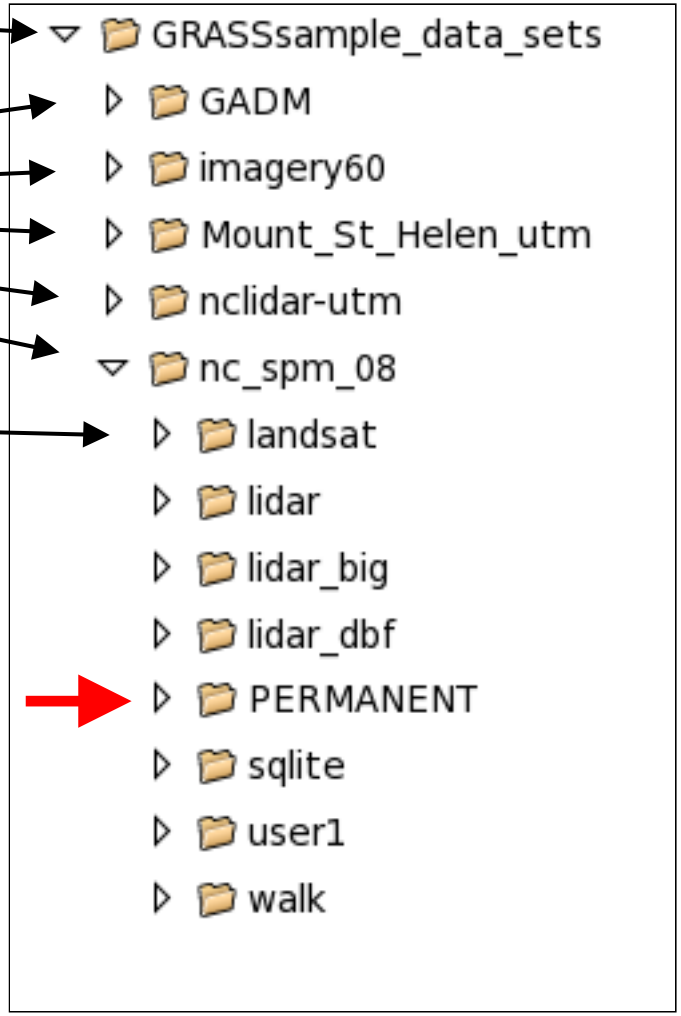
folder with Mapsets

Mapset

collection of maps and support data

Each Location

- is defined by a projection
- can hold several mapsets



GRASS database concept

Exercise

start GRASS

any way you like, but with a GUI please

GRASS database concept

Exercise

open the North Carolina dataset

```
> grass64 -wx /home/user/GRASS_sample_datasets/nc_spm_08/geostat2010/
```

GRASS

Exerc

open

```
> gra                                                    ets/nc_
spm_0
```

GRASS database concept

Exercise

get projection information for the North Carolina Location

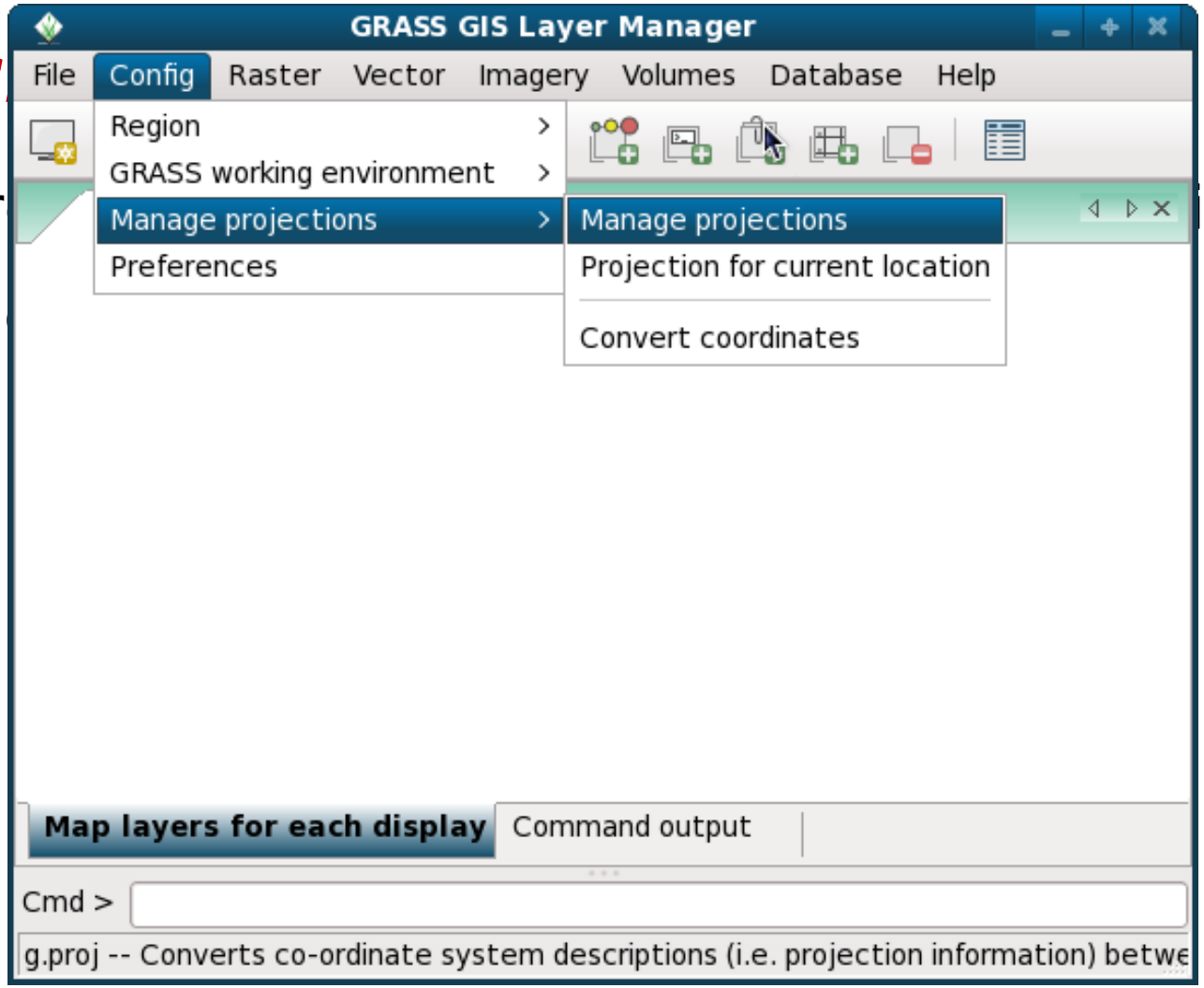
- command: g.proj
- wxGUI: Config -> Manage projections -> Manage projections

GRASS database concept

Exerc

get pr ina

Locati



GRASS database concept

Exercise

get projection information for the North Carolina Location

```
> g.proj –p
> g.proj –j
> g.proj –w
> g.proj -e
```

GRASS database concept

Exercise

```
> g.proj –p
> g.proj –j
> g.proj –w
> g.proj -e
```

```
name         : Lambert Conformal Conic
proj         : lcc
datum        : nad83
a            : 6378137.0
es           : 0.006694380022900787
lat_1        : 36.16666666666666
lat_2        : 34.33333333333334
lat_0        : 33.75
lon_0        : -79
x_0          : 609601.22
y_0          : 0
units        : meters
```

GRASS database concept

Exercise

```
> g.proj –p
> g.proj –j
> g.proj –w
> g.proj -e
```

```
name         : Lambert Conformal Conic
proj         : lcc
datum        : nad83
a            : 6378137.0
es           : 0.00669438002290078
lat_1        : 36.16666666666666
lat_2        : 34.33333333333334
lat_0        : 33.75
lon_0        : -79
x_0          : 609601.22
y_0          : 0
units        : meters
```

} ellipsoid GRS80

} standard parallels

reference latitude

reference longitude

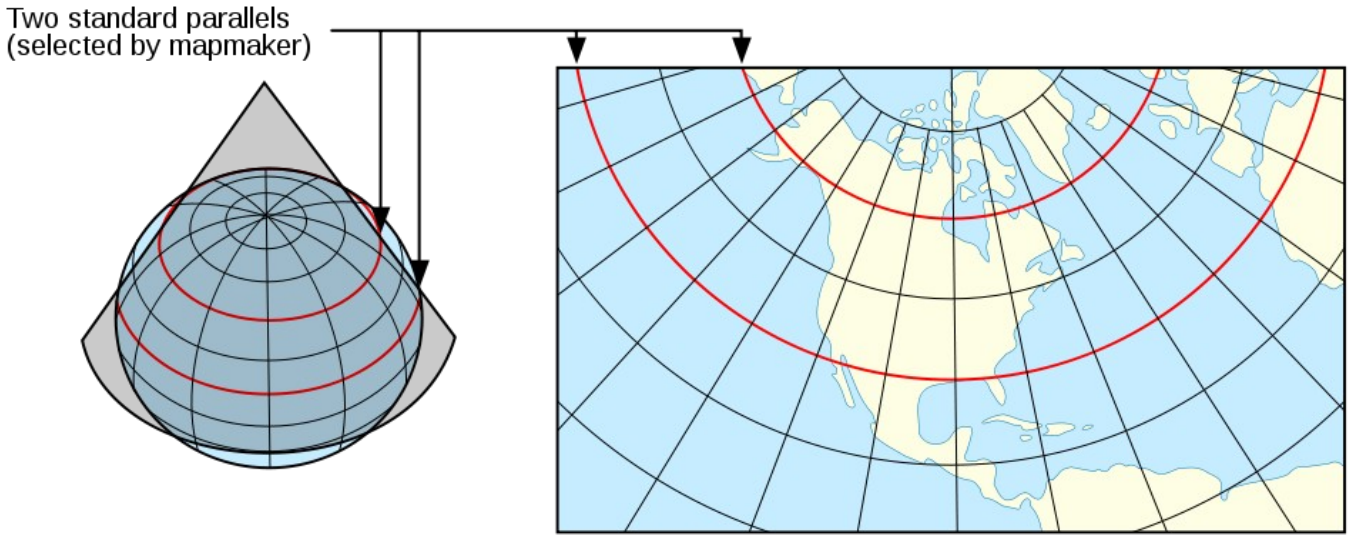
} lon and lat shifts

GRASS database concept

Exercise

projection of the North Carolina Location:

- Identical to NAD83(HARN) / North Carolina
- EPSG code: 3358



GRASS database concept

Locations are defined by projection

→ transfer maps between locations = map reprojection

Raster reprojection

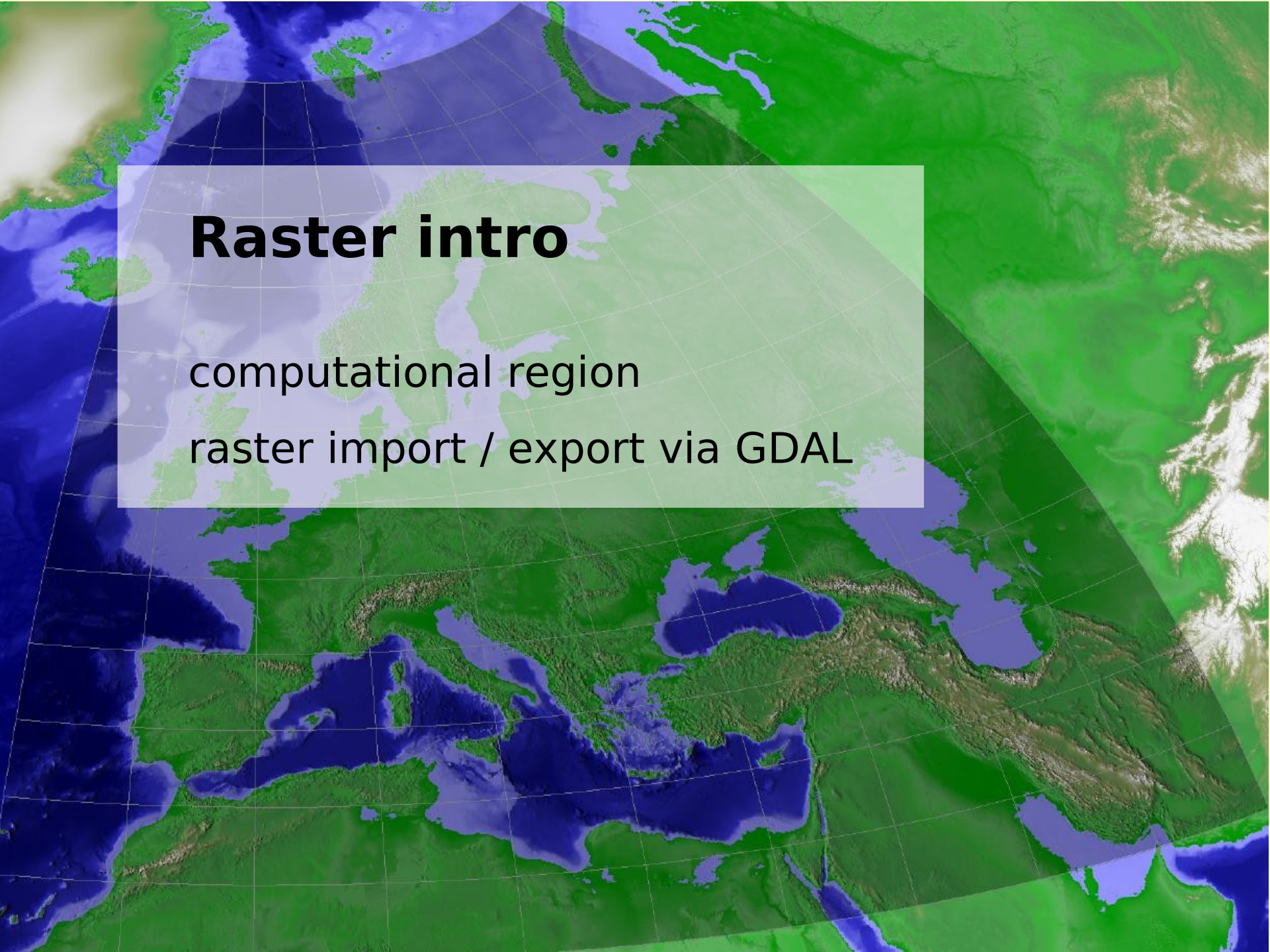
set desired extends and resolution prior to reprojection

Vector reprojection

the whole vector map is reprojected by coordinate conversion

GRASS command structure

prefix	***function class***	***type of command***	***example***
g.*	general	general data management	*g.rename: renames map*
d.*	display	graphical output	*d.rast: display raster map* *d.vect: display vector map*
r.*	raster	raster processing	*r.mapcalc: map algebra* *r.univar: univariate statistics*
v.*	vector	vector processing	*v.clean: topological cleaning*
i.*	imagery	imagery processing	*i.pca: Principal Components Analysis on imagery group*
r3.*	voxel	3D raster processing	*r3.stats: Voxel statistics*
db.*	database	database management	*db.select: select value(s) from table*
ps.*	postscript	map creation in PostScript format	*ps.map: PostScript map creation*

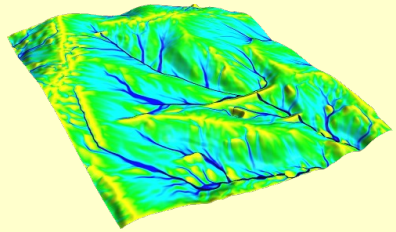


Raster intro

computational region

raster import / export via GDAL

Raster intro



Computational region

- defined by extends and resolution
- applies to raster operations

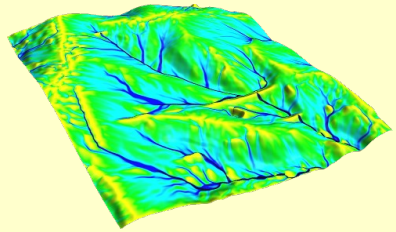
Raster region

- defined by extends and resolution
- each raster map has its own region
- computational region overrides raster region

Display region

- extends of the current map display
- independent of the current computational region and the raster region

Raster intro

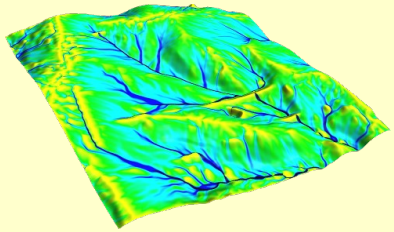


Computational region

command: g.region

wxGUI: Config -> Region -> Set region

Raster intro



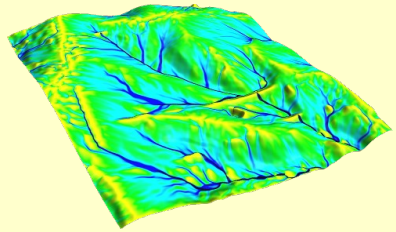
NULL values and MASK

- NULL values: e.g. gaps in DEM
- MASK: mask out areas outside region of interest / study area
  - MASK'ed cells are read as NULL cells -> usually skipped

Raster import/export via GDAL

- 105 supported formats in gdal version 1.7.1

Raster intro

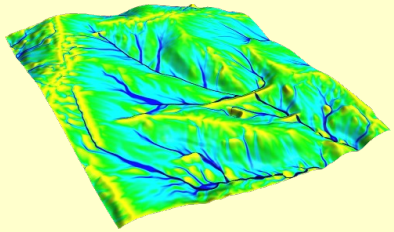


Exercise

load raster map to display

zoom into map

Raster intro



Exercise

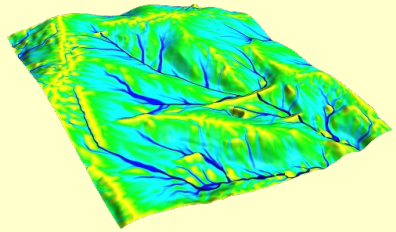
load raster map to display, check region

```
> g.region -p
```

zoom into map, check region

```
> g.region -p
```

Raster intro



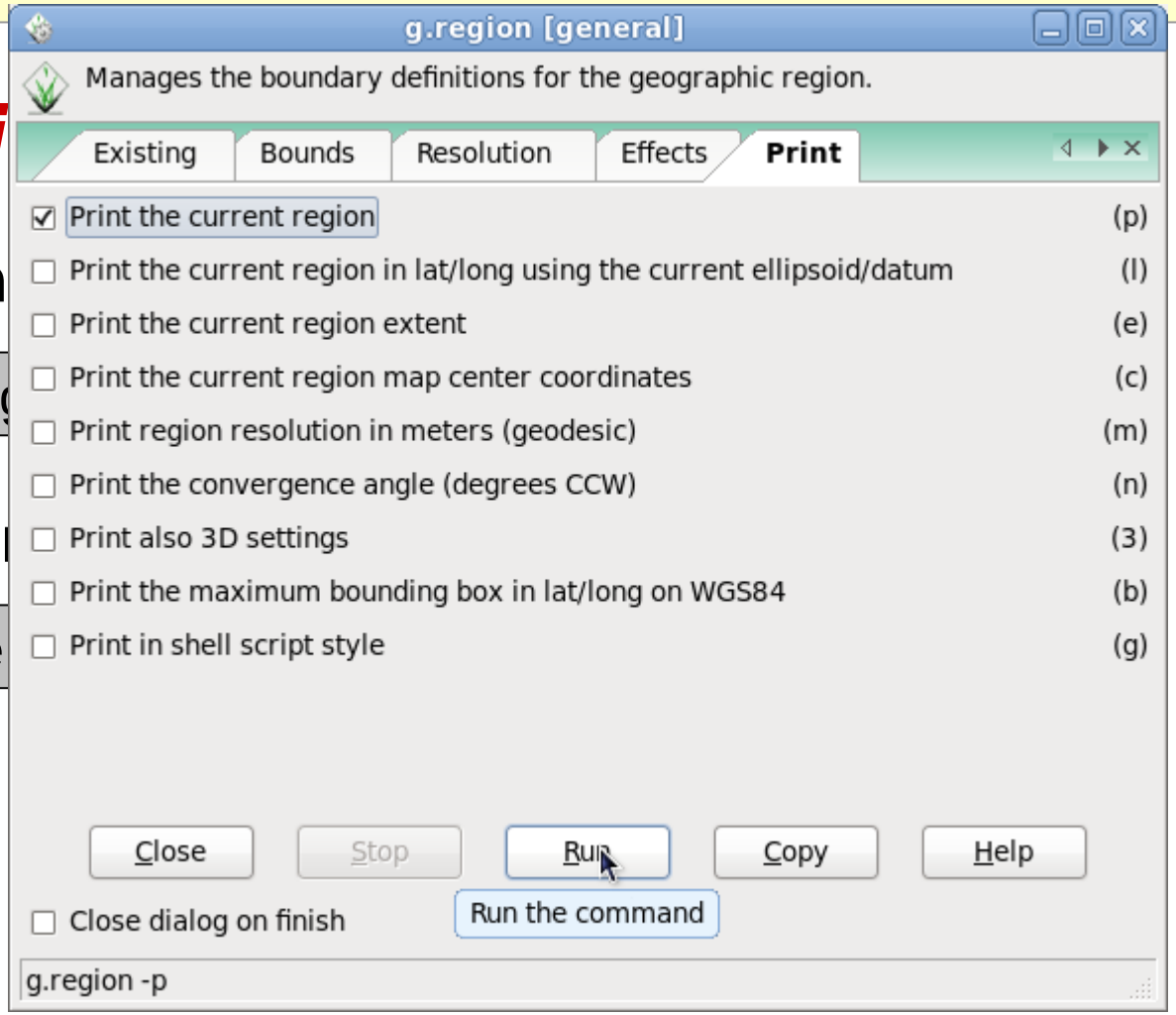
Exerci

load ra

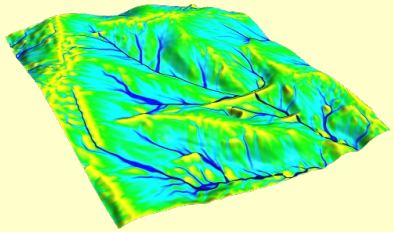
```
> g.reg
```

zoom i

```
> g.re
```



Raster processing

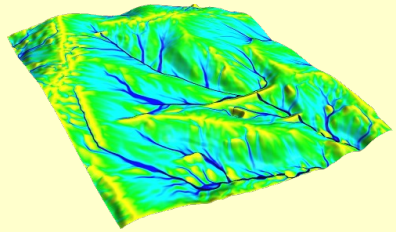


Import/export raster maps

- r.in.* and r.out.*
- r.in.gdal always imports the complete map

!! Raster export adheres to computational region !!

Raster processing

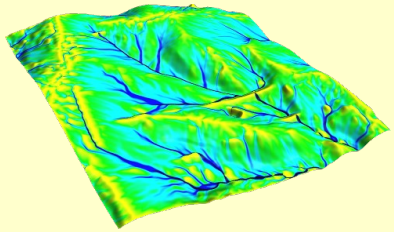


Exercise

Raster export via GDAL

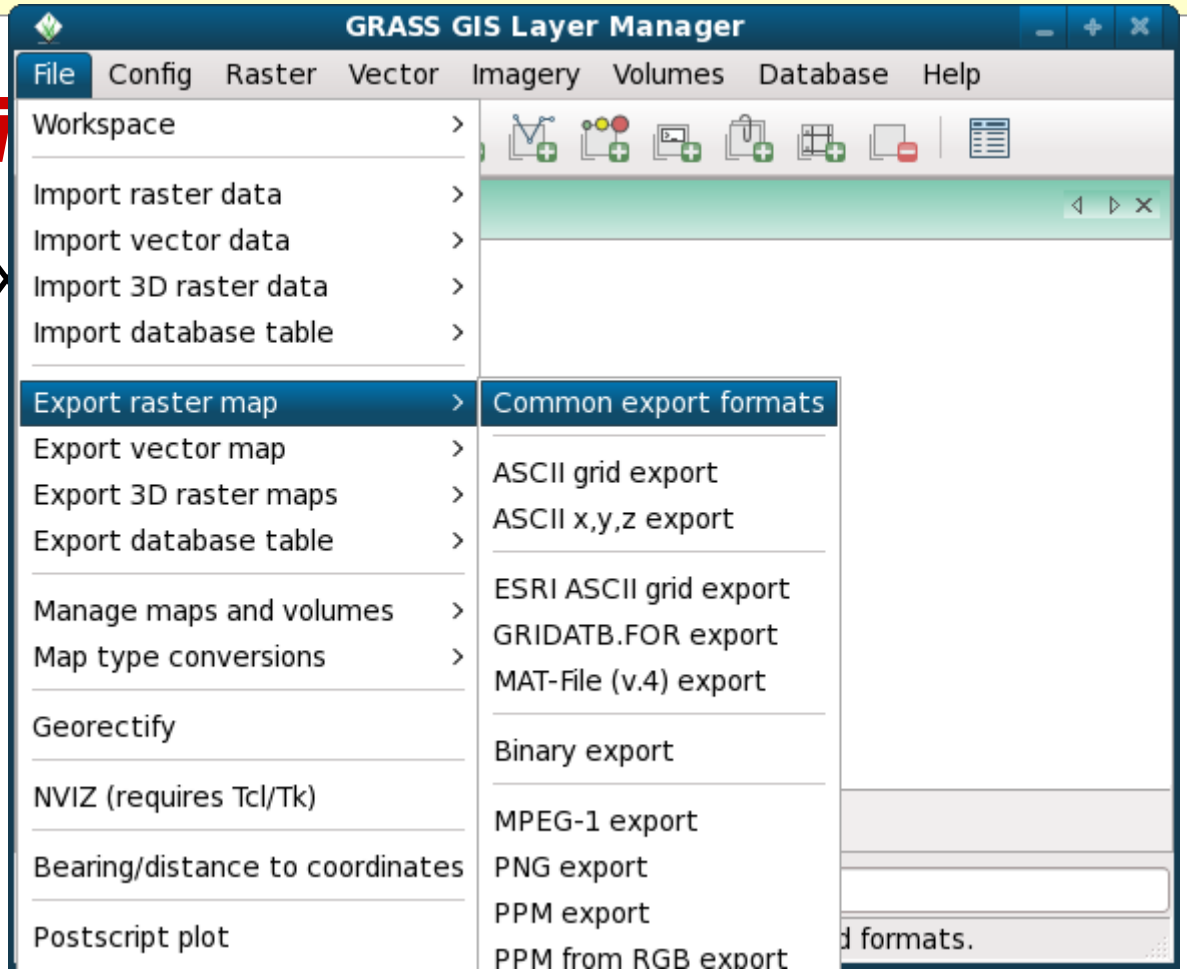
- command: r.out.gdal
- wxGUI: File -> Export raster map -> Common export formats

Raster processing

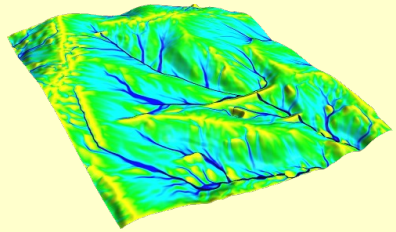


Exerci

Raster ex



Raster processing



Exercise

Raster export via GDAL

set region to some raster map

```
> g.region –p rast=<raster>
```

export this raster with r.out.gdal

```
> r.out.gdal input=<raster> output=<raster>.tif
```

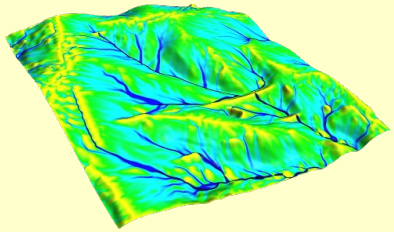
display this raster, zoom in, set region from display

export again with r.out.gdal

compare size of the two exported raster maps

compare output of gdalinfo

Raster processing



Example raster module groups

- resampling
- Reprojection/georectification
- map calculator
- Terrain analysis
- Hydrologic modeling
- Reports and statistics

Raster maps: DEMs, land cover, climatic maps ...

Imagery maps: Landsat, MODIS, SPOT, QuickBird ...

Vector intro

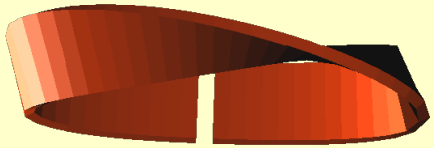
native vector format

vector import/export via OGR

vector topology

vector 2D/3D support

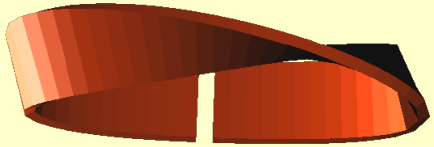
Vector intro



Native vector format

- Vector topology
- m:n mapping of geometry features to attributes
- Vector layers
- OGC Simple Features <-> Topological Vector Conversion
- Database Management system (DBMS)
- SQLite, PostgreSQL + PostGIS, MySQL(, DBF)

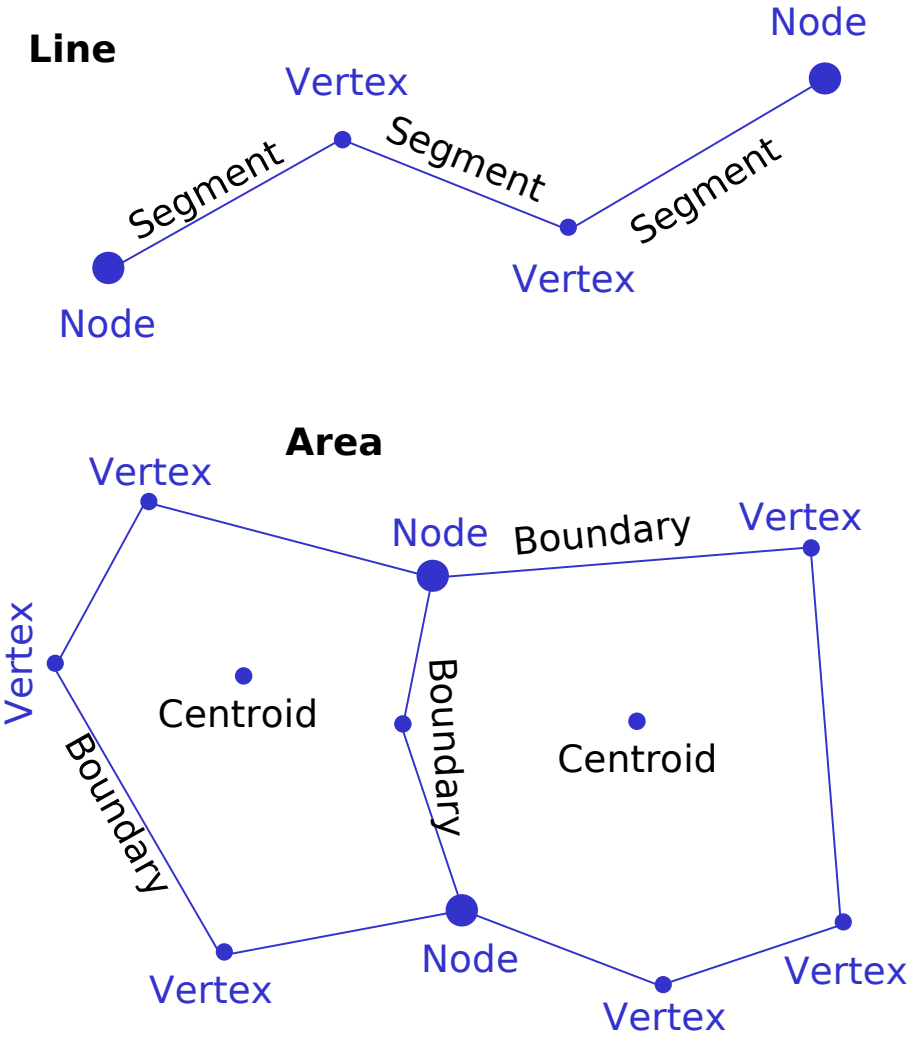
GRASS Vector model



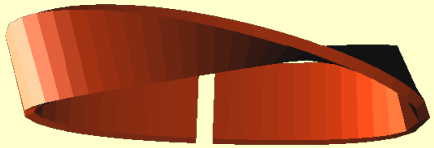
Vector geometry types

- Point
- Centroid
- Line
- Boundary
- Area (Boundaries + Centroid)
- Face (3D Area)
- [Kernel (3D Centroid)]
- [Volumes (Faces + Kernel)]

All types are **true 3D**: x,y,z



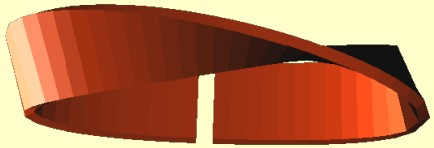
Vector processing



Import/export vector maps

- v.in.* and v.out.*
- v.out.ogr always exports the whole map
- OGR supported formats: 40

Vector processing



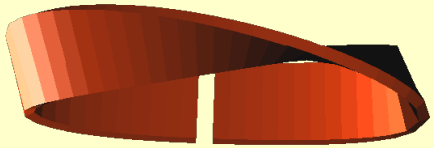
Exercise

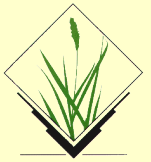
Vector import via OGR

command: v.in.ogr

wxGUI: File -> Import vector data -> Import vector data

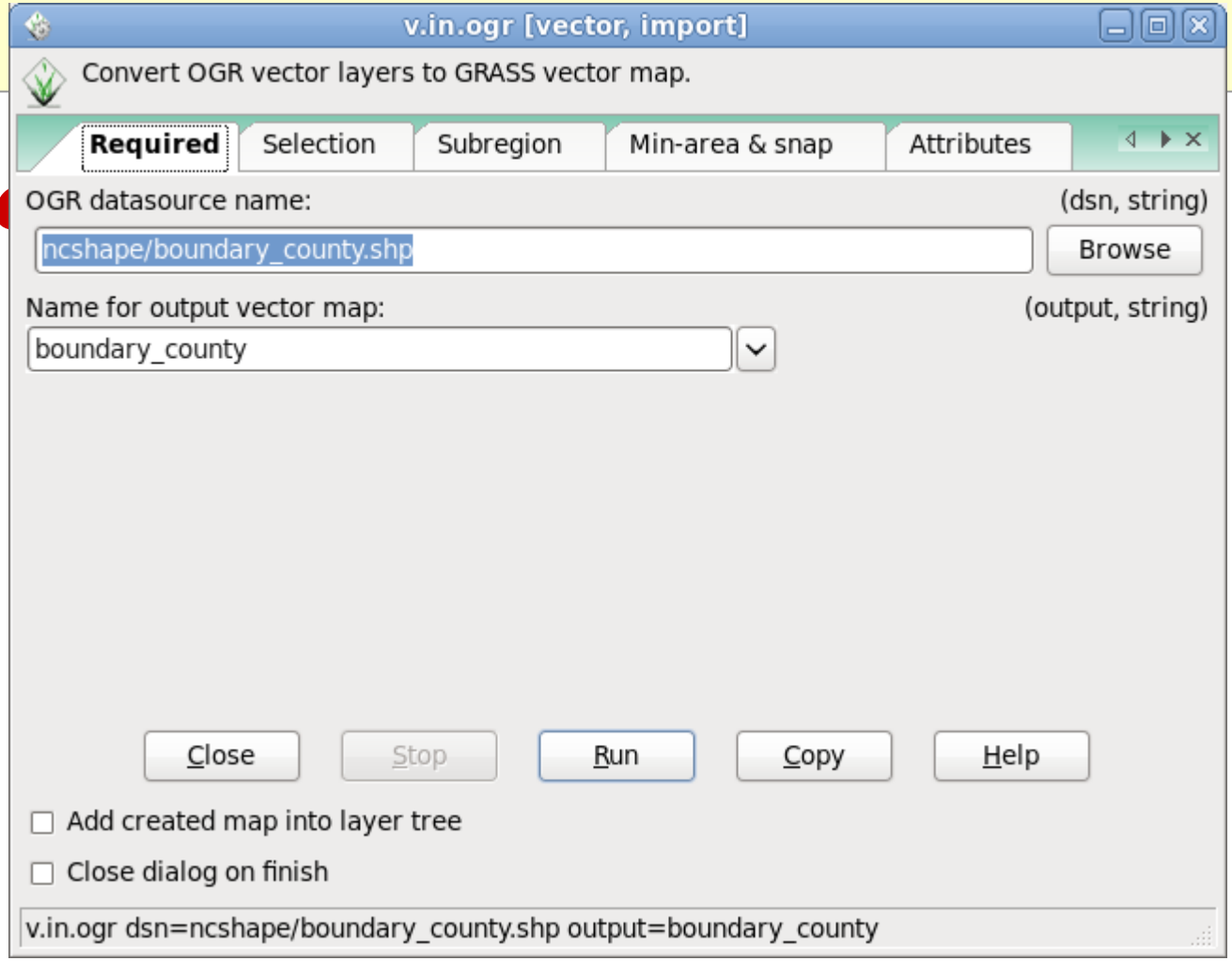
Vector processing



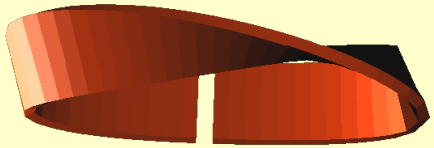


Exer

Vector



Vector processing

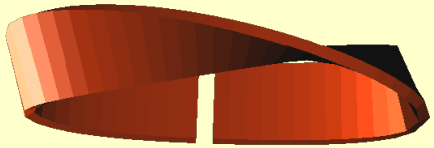


Exercise

Vector import via OGR

- Read output:
  - Cleaning procedures
  - Summary of topology building

Vector processing

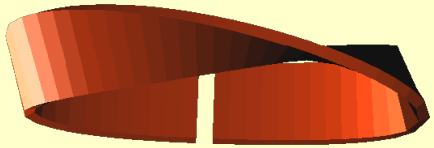


Exercise

Vector import via OGR

- Cleaning procedures for area import
  - break polygons
  - remove duplicates
  - break boundaries
  - remove duplicates
  - clean boundaries at nodes
  - change dangles to lines
  - remove bridges

Vector processing



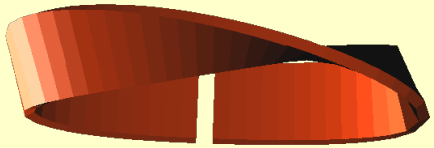
Exercise

Vector import via OGR

Summary of topology building

Number of nodes: 2040
Number of primitives: 2836
Number of points: 0
Number of lines: 0
Number of boundaries: 1910
Number of centroids: 926
Number of areas: 926
Number of isles: 130

Vector processing



Summary of topology building

No need to worry about

Number of areas without centroid:

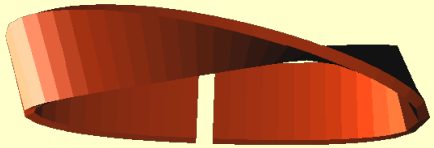
... but watch out for

Number of incorrect boundaries:

Number of centroids outside area:

Number of duplicate centroids:

Vector processing



Example vector module groups

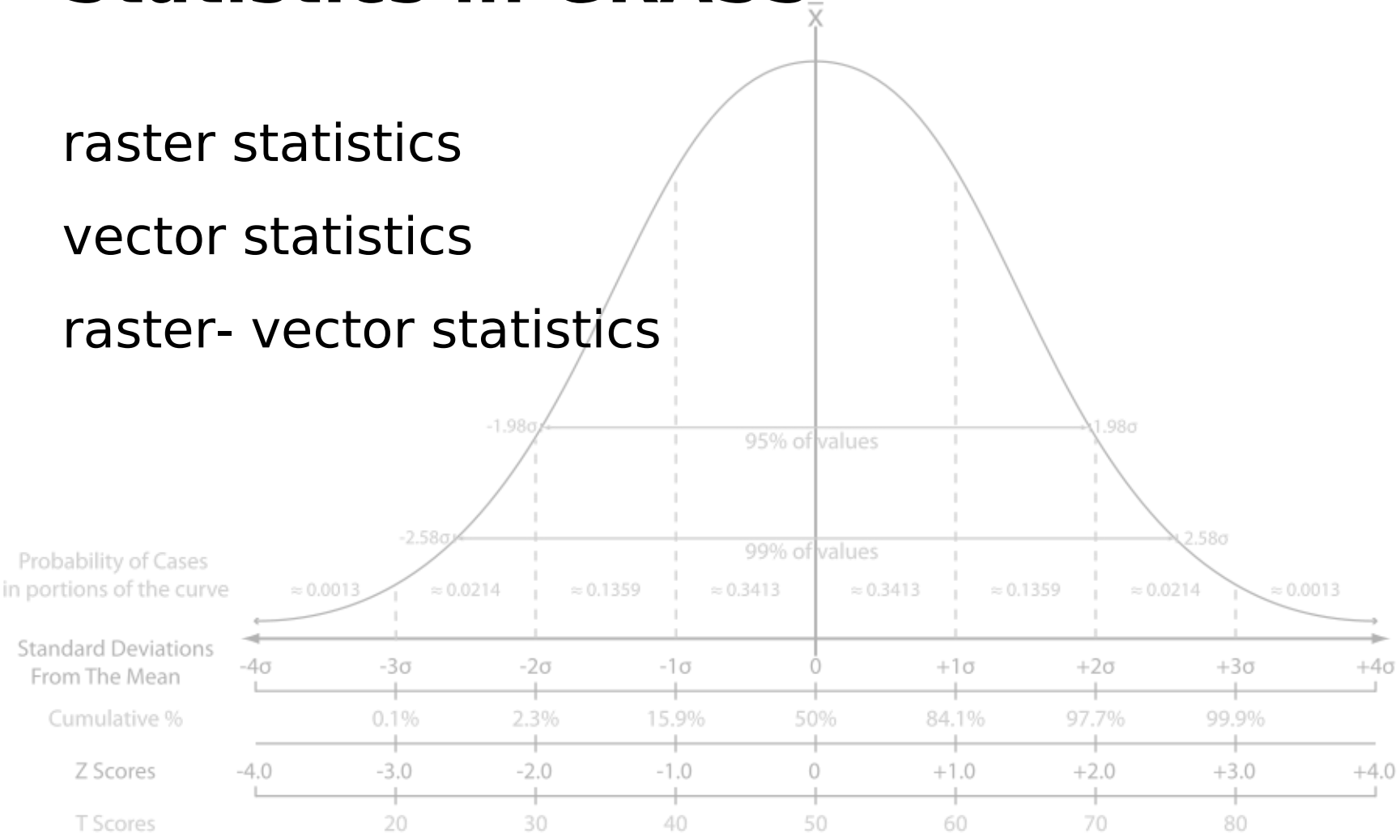
- Topological geometry feature editing
- LiDAR analysis
- Linear referencing
- Network analysis

Statistics in GRASS

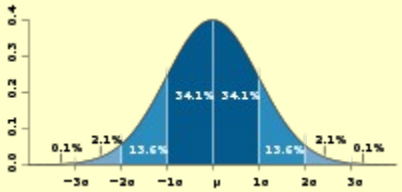
raster statistics

vector statistics

raster- vector statistics



Statistical modules



Statistics on one raster

- General statistics
  - General area statistics
  - Range
  - Quantiles
  - Sum per category
  - Univariate statistics
  - Sample transects
- Neighbourhood analysis
- Resampling using aggregate statistics

Statistical modules

General statistics

GUI: Raster -> Reports and statistics

Statistical modules

General area statistics

command: r.stats

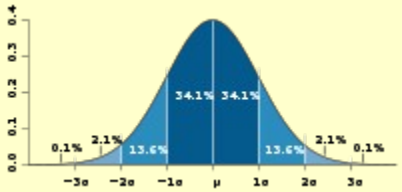
wxGUI: Raster -> Reports and statistics -> General statistics

Statistical modules

General area statistics

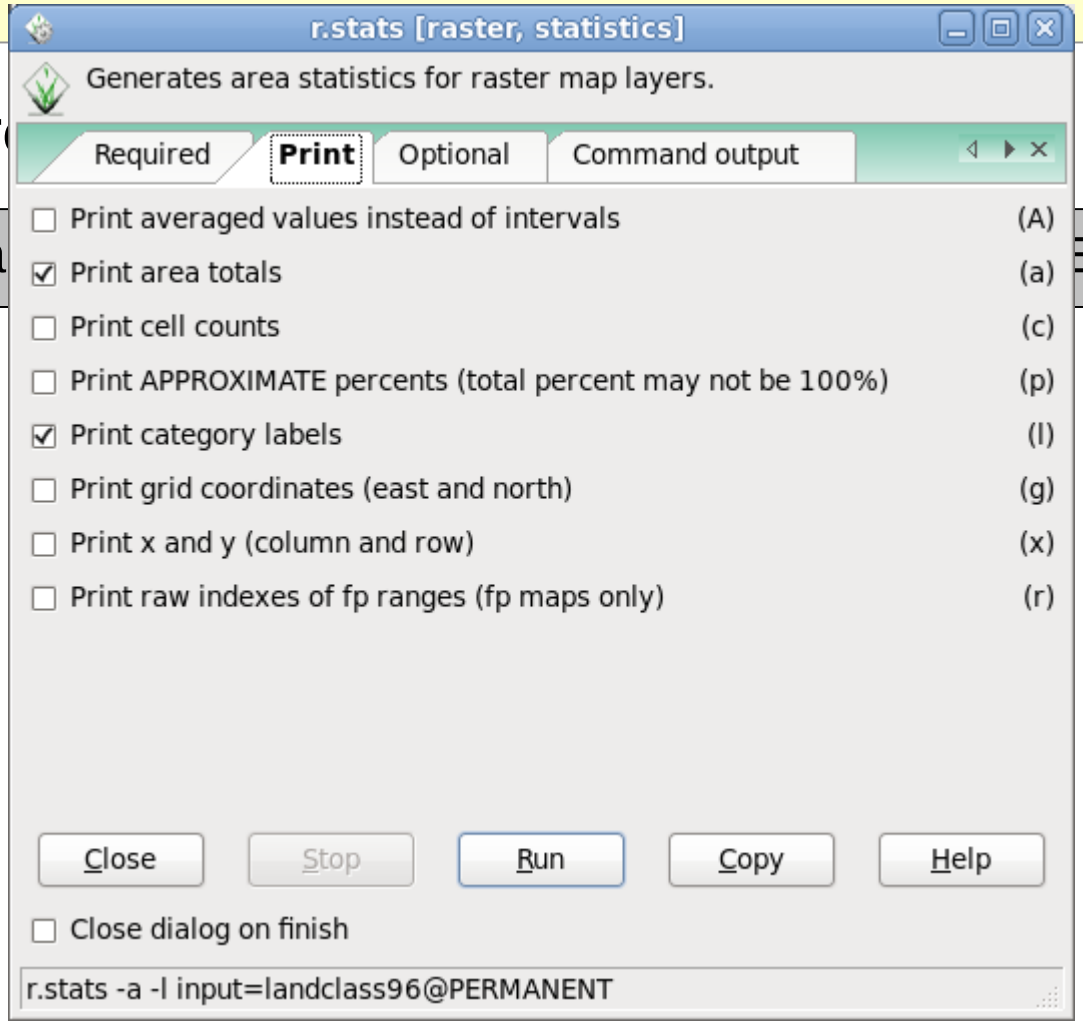
```
> r.stats -al input=landclass96@PERMANENT
```

Statistical modules



General ar

```
> r.sta                                                    ENT
```



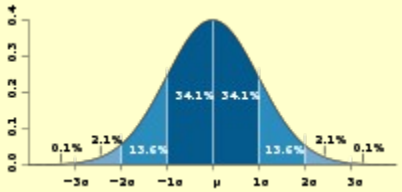
Statistical modules

Range

command: r.describe

wxGUI: Raster -> Reports and statistics -> Range of category values

Statistical modules

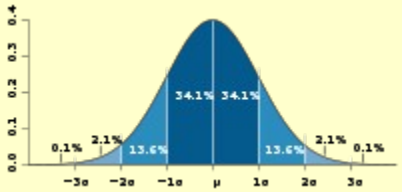


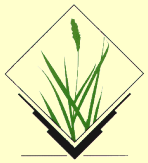
Range

r.describe

```
> g.region -p rast=elev_lid972_1m@PERMANENT
> r.describe map=landclass96@PERMANENT
> r.describe -d map=landclass96@PERMANENT
> g.region -p rast=landclass96@PERMANENT
> r.describe -d map=landclass96@PERMANENT
```

Statistical modules

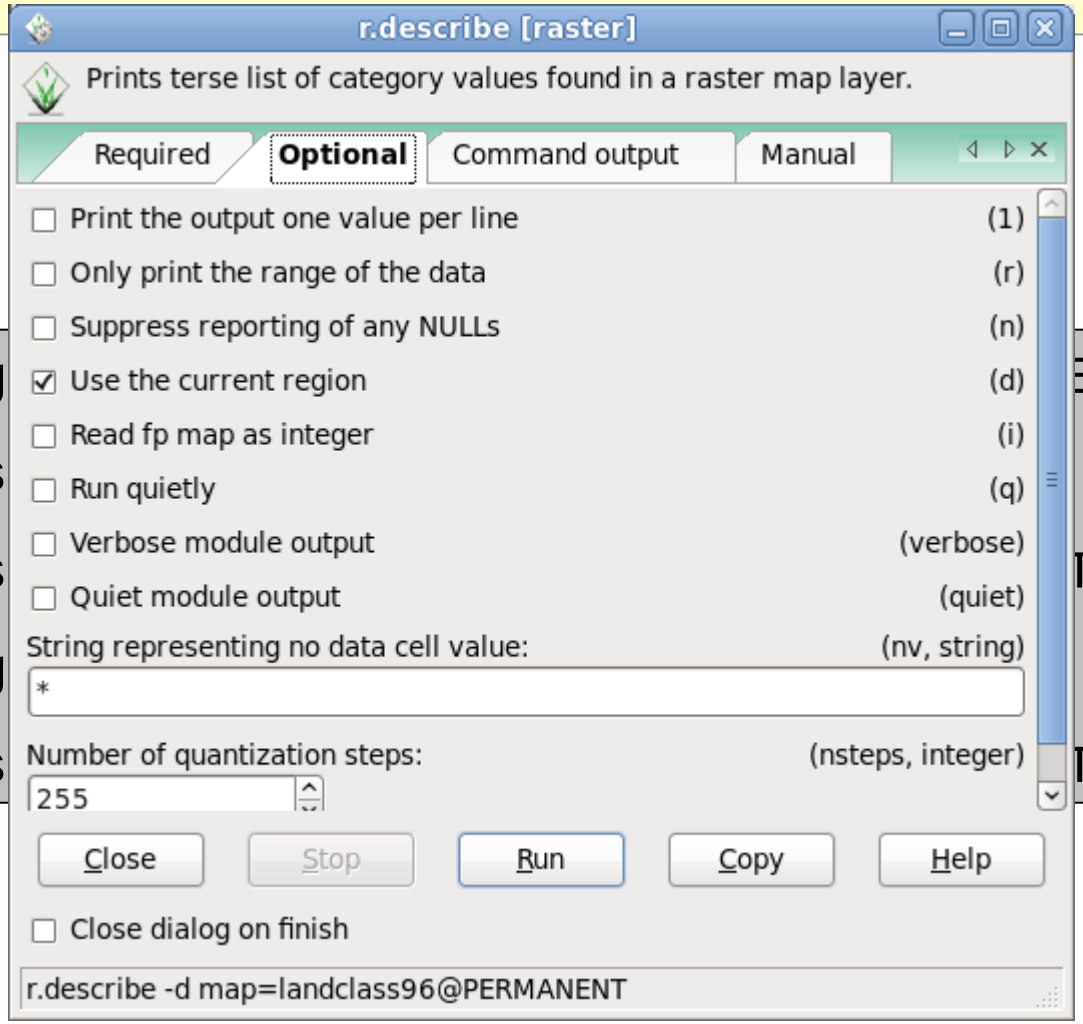




Range

r.describe

```
> g.reg                                          ENT
> r.des
> r.des                                           T
> g.reg
> r.des                                           T
```

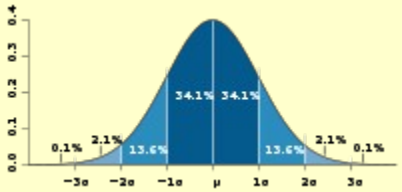


Statistical modules

Quantiles

- command: r.quantile
- wxGUI: Raster -> Reports and statistics -> Quantiles for large datasets

Statistical modules



Quantiles

r.quantile

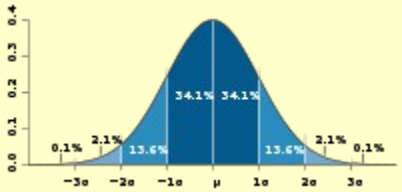
```
> g.region -p rast=elev_lid972_1m@PERMANENT
> r.quantile input=elev_lid972_1m@PERMANENT
```

Statistical modules

Sum per category

- command: r.report (also r.stats)
- wxGUI: Raster -> Reports and statistics -> Sum area by raster map and category

Statistical modules

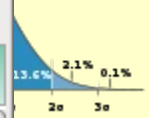


Sum per category

r.report

```
> g.region -p rast=landclass96@PERMANENT
> r.report map=landclass96@PERMANENT units=h,c,p
```

Statistic



Sum per ca

r.report

```
> g.reg
> r.rep                                                    ts=h,c,p
```

r.report [raster, statistics]

Reports statistics for raster map layers.

Required | Formatting | **Optional**

- [ ] Quiet (q)
- [x] Filter out all no data cells (n)
- [ ] Filter out cells where all maps have no data (N)
- [ ] Report for cats fp ranges (fp maps only) (C)
- [ ] Read fp map as integer (use map's quant rules) (i)
- [ ] Verbose module output (verbose)
- [ ] Quiet module output (quiet)

Units:

- [ ] miles
- [ ] meters
- [ ] kilometers
- [ ] acres
- [x] hectares
- [x] cell counts
- [x] percent cover

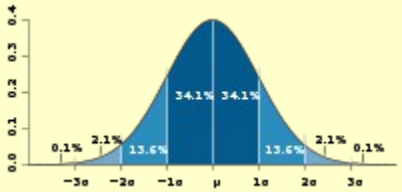
Name of an output file to hold the report: (output, string)

Close | Stop | Run | Copy | Help

- [ ] Close dialog on finish

r.report -n map=landclass96@PERMANENT units=h,c,p

Statistical modules



Category Information		cell	%
# description	hectares	count	cover
1 developed	5935.679	73077	29.31
2 agriculture	173.578	2137	0.86
3 herbaceous	2072.700	25518	10.23
4 shrubland	1366.936	16829	6.75
5 forest	10,255.875	126265	50.64
6 water	430.736	5303	2.13
7 sediment	15.758	194	0.08
TOTAL	20,251.261	249323	100.00

Statistical modules

Statistics on several rasters

- Correlation
- Regression
- Mutual occurrence
- Zonal statistics
- Raster map series

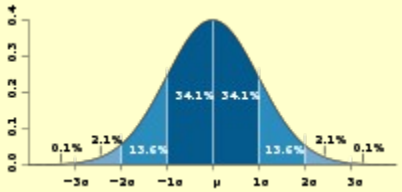
Statistical modules

Correlation/Covariance

command: r.covar

wxGUI: Raster -> Reports and statistics -> Covariance/correlation

Statistical modules



Correlation/Covariance

r.covar

```
> g.region -p rast=elev_lid972_1m@PERMANENT

> r.covar -r
map=elevation@PERMANENT,elev_lid792_1m@PERMANENT
```

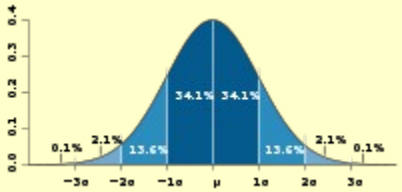
Statistical modules

Regression

command: r.regression.line

wxGUI: Raster -> Reports and statistics -> Linear regression

Statistical modules



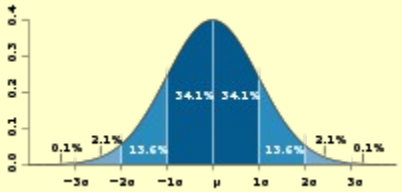
Regression

r.regression.line

```
> g.region -p rast=elevation@PERMANENT

> r.regression.line -g -s map1=elevation@PERMANENT
map2=elev_ned_30m@PERMANENT
```

Statistical modules

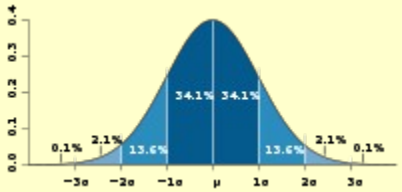


Mutual occurrence

command: r.coin

wxGUI: Raster -> Reports and statistics -> Mutual category occurences

Statistical modules



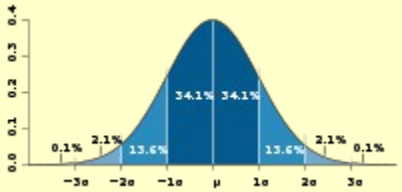
Mutual occurrence

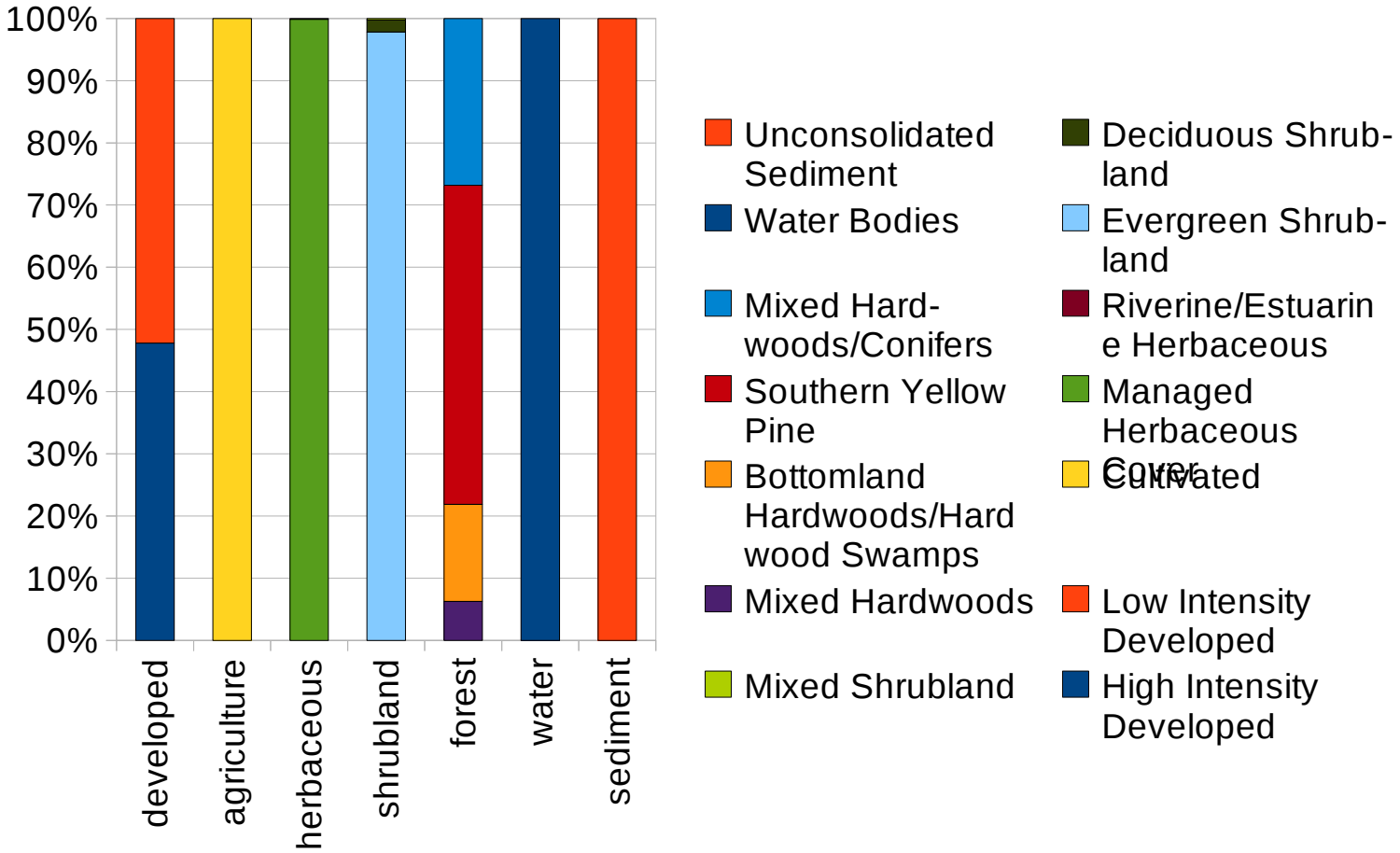
r.coin

```
> g.region -p rast=landclass96@PERMANENT

> r.coin map1=landclass96@PERMANENT
map2=landuse96_28m@PERMANENT units=c
```

Statistical modules





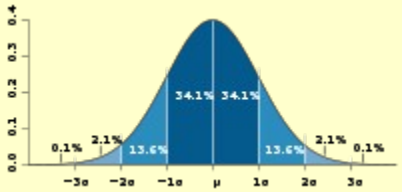
Statistical modules

Zonal statistics

command: r.statistics, r.univar.zonal (addons)

wxGUI: Raster -> Overlay rasters –> Statistical overlay

Statistical modules



Zonal statistics

r.statistics in 6.4 works with integer maps only (floating point ok in 6.5 and 7.0)

```
> g.region -p rast=elev_ned_30m@PERMANENT

> r.mapcalc ”elev_ned_30m.int =
int(round(elev_ned_30m@PERMANENT))”

> g.region -p rast=landclass96@PERMANENT

> r.statistics base=landclass96@PERMANENT
cover=elev_ned_30m.int method=average
output=elevation_by_landclass96
```

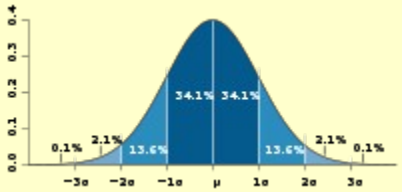
Statistical modules

Raster map series

command: r.series

wxGUI: Raster -> Overlay rasters -> Raster series

Statistical modules



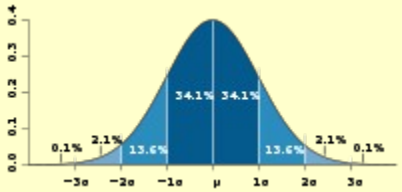
Raster map series

r.series

```
> g.region -p rast=precip_jan

> r.series input=`g.mlist pattern=prec*
separator=comma`
output=precip_mean,precip_median,precip_stddev
method=average,median,stddev
```

Statistical modules



Raster map series

r.series

With wxGUI:

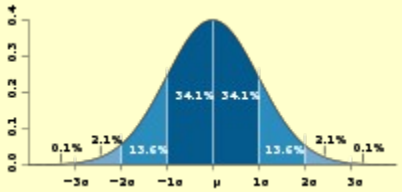
1. File -> Manage maps and volumes -> List filtered (g.mlist)
2. Raster -> Overlay rasters -> Raster series (r.series)
3. Copy output of g.mlist to input of r.series
4. Define output map names and aggregate operation options

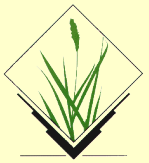
Statistical modules

Statistics combining raster and vector maps

- command: v.rast.stats
- wxGUI: Vector -> Update area attributes from raster

Statistical modules





Statistics combining raster and vector maps

v.rast.stats

First make a copy of vector boundary_county@PERMANENT

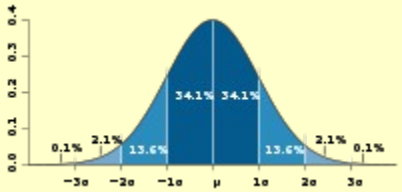
set region to elev_state_500m@PERMANENT

```
> g.copy
vect=boundary_county@PERMANENT,my_boundary_county

> g.region -p rast=elev_state_500m@PERMANENT

> v.rast.stats vector=my_boundary_county
raster=elev_state_500m@PERMANENT colprefix=elev
```

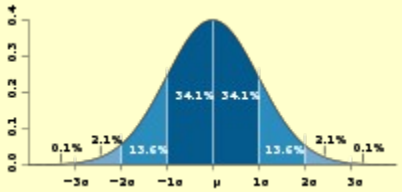
Statistical modules



Statistics on one vector

- command: v.univar, v.db.univar for attribute columns only
- wxGUI: Vector –> Reports and statistics –> Univariate attribute statistics for points

Statistical modules



Statistics on one vector

v.univar

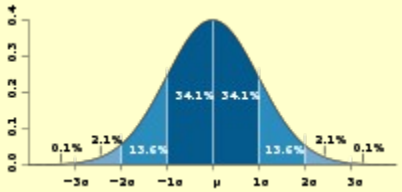
compare

```
> v.univar map=boundary_county@PERMANENT
type=centroid column=PERIMETER
```

with

```
> v.univar map=boundary_county@PERMANENT
type=boundary column=PERIMETER
```

GRASS + R



several possibilities

- Direct GRASS – R interface with R package spgrass6
- R package rgdal
- Calculate test statistics with GRASS,

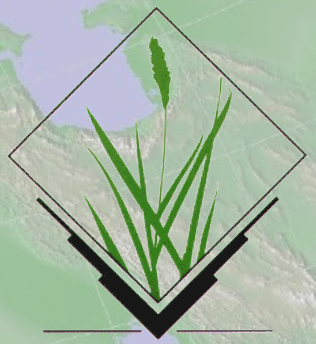
  test for significance with R

End of the seminar

Thank you for your interest and your attention!

Markus Metz and Markus Neteler

http://grass.osgeo.org



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