GRASS GIS 7:
A theoretical and practical course

Session 1 – Temporal data analysis (TGRASS)

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Session Objectives

- Temporal GRASS framework
- Registration of maps
- Time series analysis

New Space-Time functionality in GRASS 7

Developer: Sören Gebbert

Temporal data processing in GRASS GIS

The temporal GIS framework in GRASS introduces three new datatypes that are designed to handle time series data:

- *Space time raster datasets* (strds) are designed to manage raster map time series. Modules that process strds have the naming prefix *t.rast*.
- *Space time 3D raster datasets* (str3ds) are designed to manage 3D raster map time series. Modules that process str3ds have the naming prefix *t.rast3d*.
- *Space time vector datasets* (stvds) are designed to manage vector map time series. Modules that process stvds have the naming prefix *t.vect*.

Temporal data management in general

List of general management modules:

- t.connect
- t.create
- t.remove
- t.register
- t.unregister
- t.info
- t.list
- t.rast3d.list
- t.vect.list
- t.vect.db.select
- t.sample
- t.support
- t.topology

Export/import conversion

- t.rast.export
- t.rast.import
- t.rast.out.vtk
- t.rast.to.rast3
- r3.out.netcdf
- t.vect.export

Statistics and gap filling

- t.rast.gapfill
- t.rast.univar

Querying and map calculation

- t.rast.list
- t.rast.extract
- t.rast.gapfill
- t.rast.mapcalc
- t.rast3d.extract
- t.rast3d.mapcalc
- t.rast3d.univar
- t.vect.extract
- t.vect.import
- t.vect.observe.strds
- t.vect.univar
- t.vect.what.strds

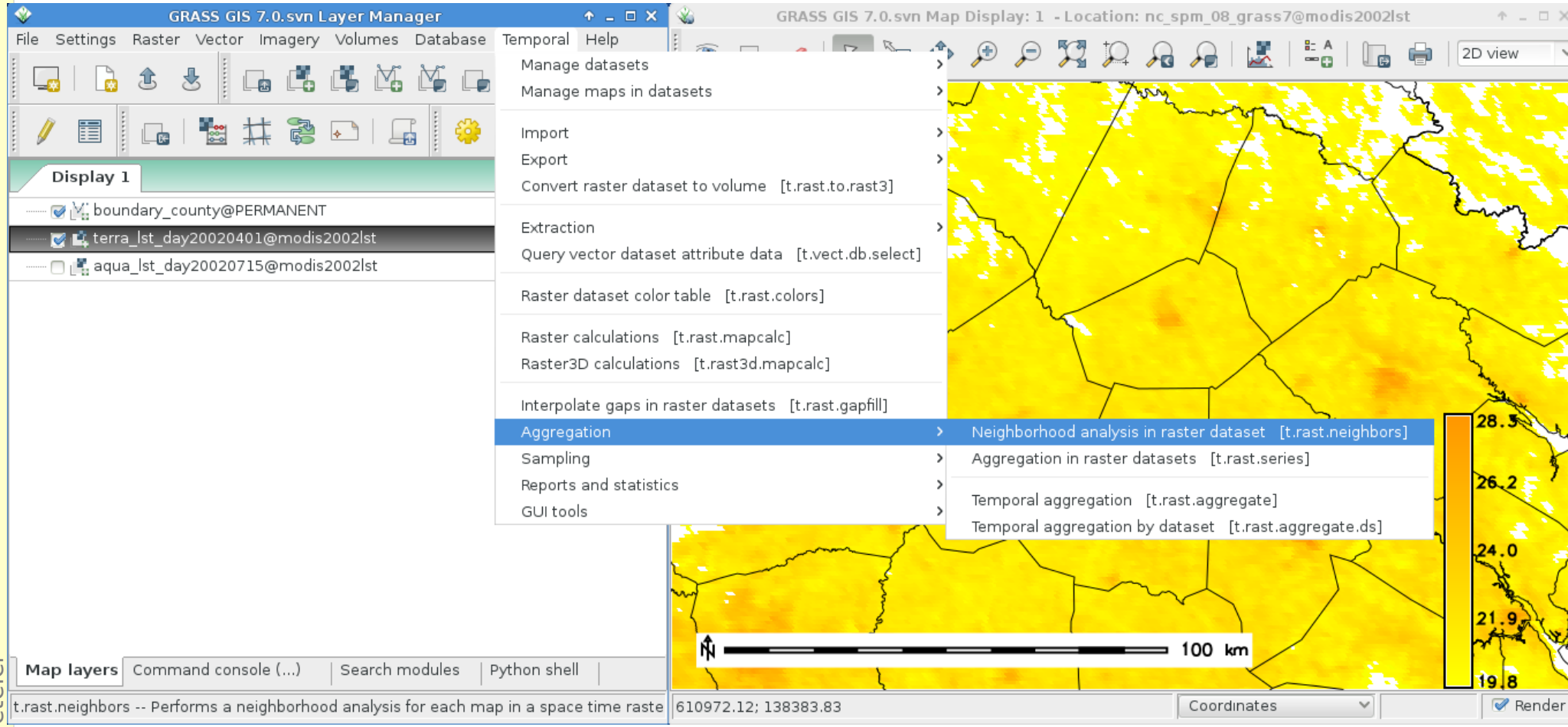
Aggregation

- t.rast.aggregate.ds
- t.rast.aggregate
- t.rast.series

Space time datasets are stored in a temporal database. SQLite3 or PostgreSQL are supported as SQL database back end. Connection settings are performed with t.connect. As default a sqlite3 database will be created in the PERMANENT mapset that stores all space time datasets and registered time series maps from all mapsets in the location.

https://grass.osgeo.org/grass72/manuals/temporalintro.html

New Space-Time functionality in GRASS 7

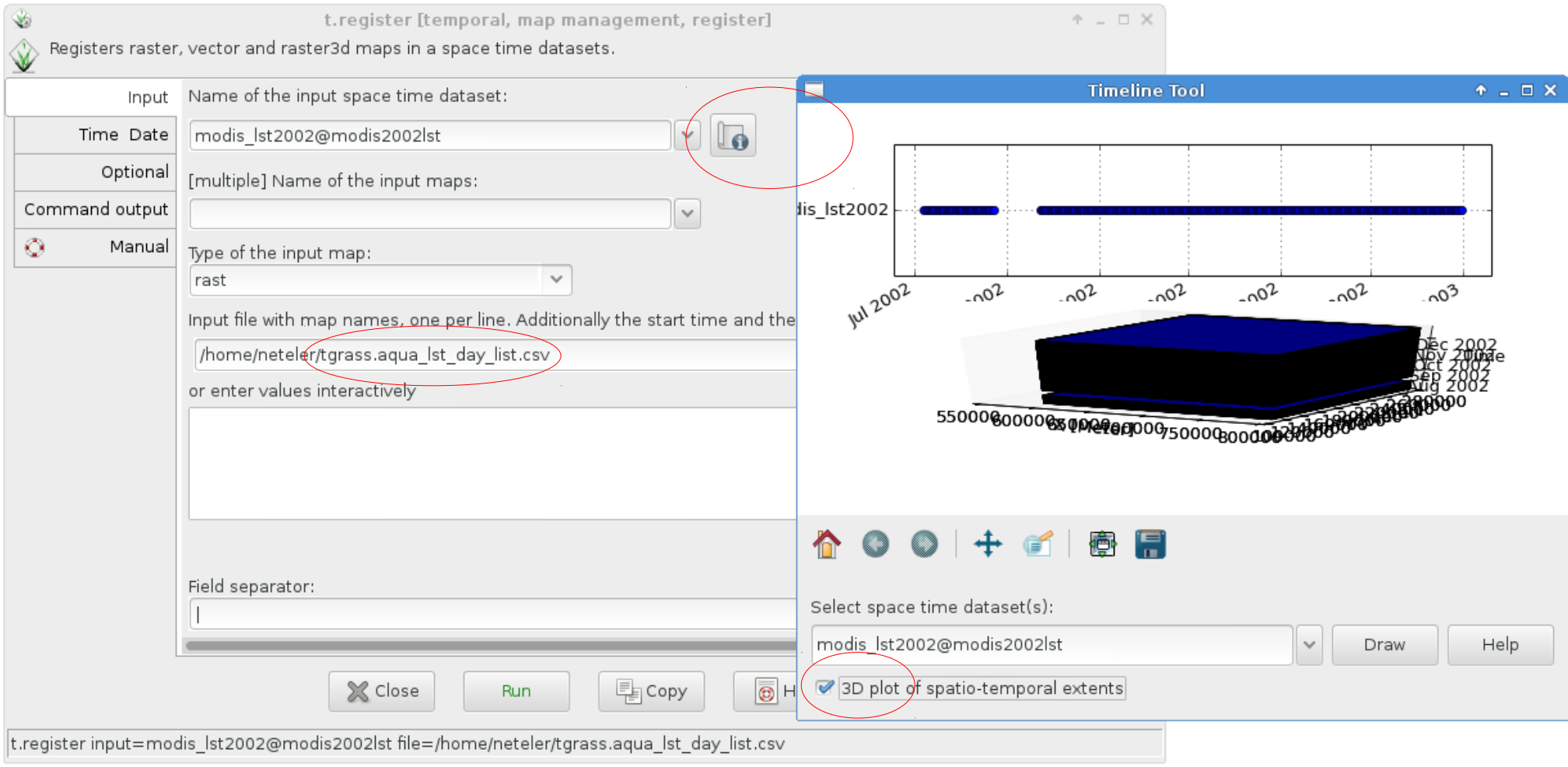


Temporal GRASS (TGRASS) menus

Gebbert, S., Pebesma, E., 2014. *TGRASS: A temporal GIS for field based environmental modeling*. Environmental Modelling & Software 53, 1-12. (DOI)

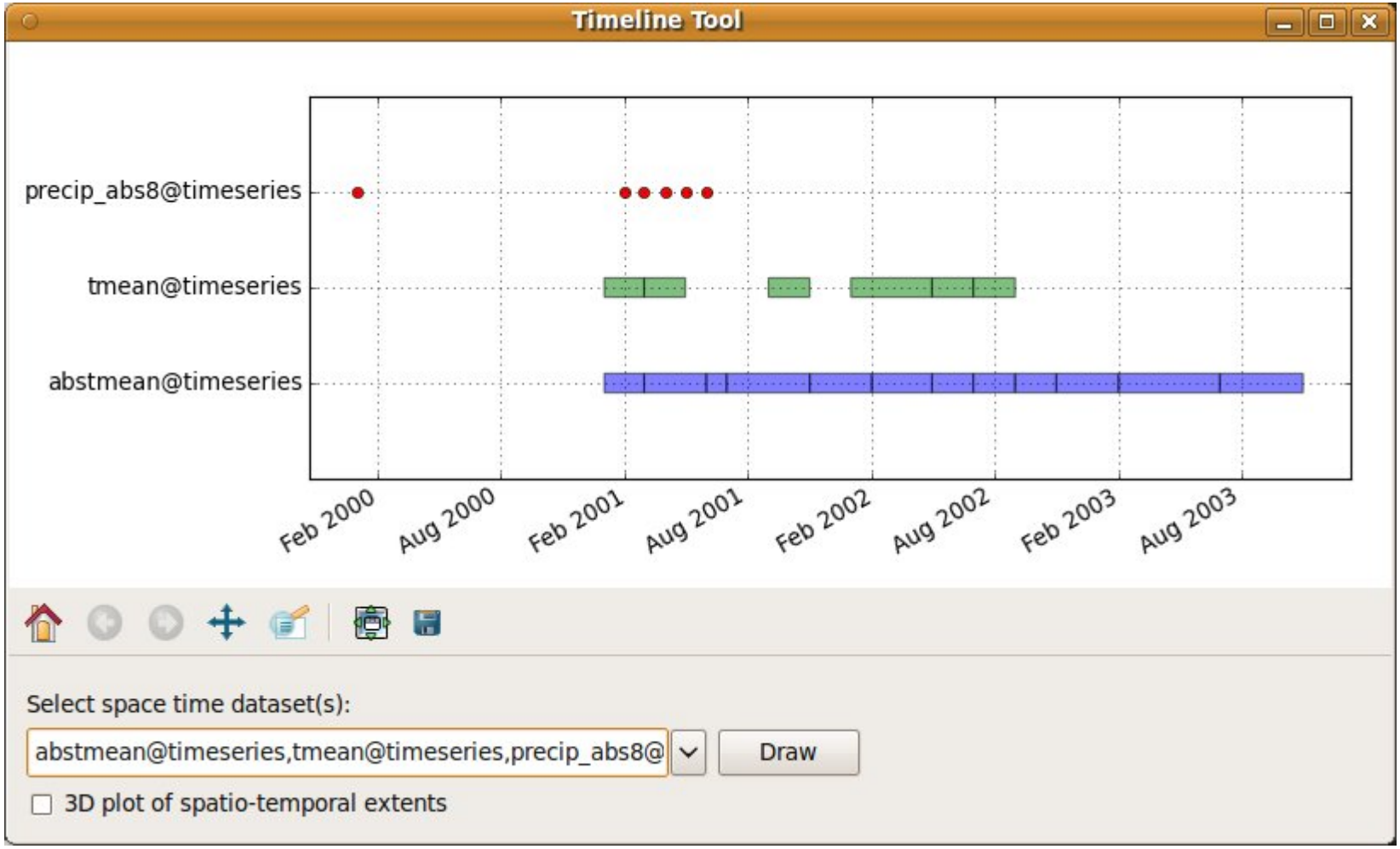
New Space-Time functionality in GRASS 7

Example: daily MODIS Land Surface Temperature time series



t.register: Registers raster, vector and raster3d maps in a space time dataset

New Space-Time functionality in GRASS 7



Screenshot: S Gebbert/A. Petrasova

g.gui.timeline: show raster, vector and raster3D maps in a space time dataset

Gebbert, S., Pebesma, E., 2014. *TGRASS: A temporal GIS for field based environmental modeling*. Environmental Modelling & Software 53, 1-12. (DOI)

Data: time series

Course data download address:

http://courses.ncsu.edu/mea592/common/media/02/nc_climate_spm_2000_2012.zip

Get the package and save it on your computer.
Unpack the GRASS GIS location into your HOME/grassdata/

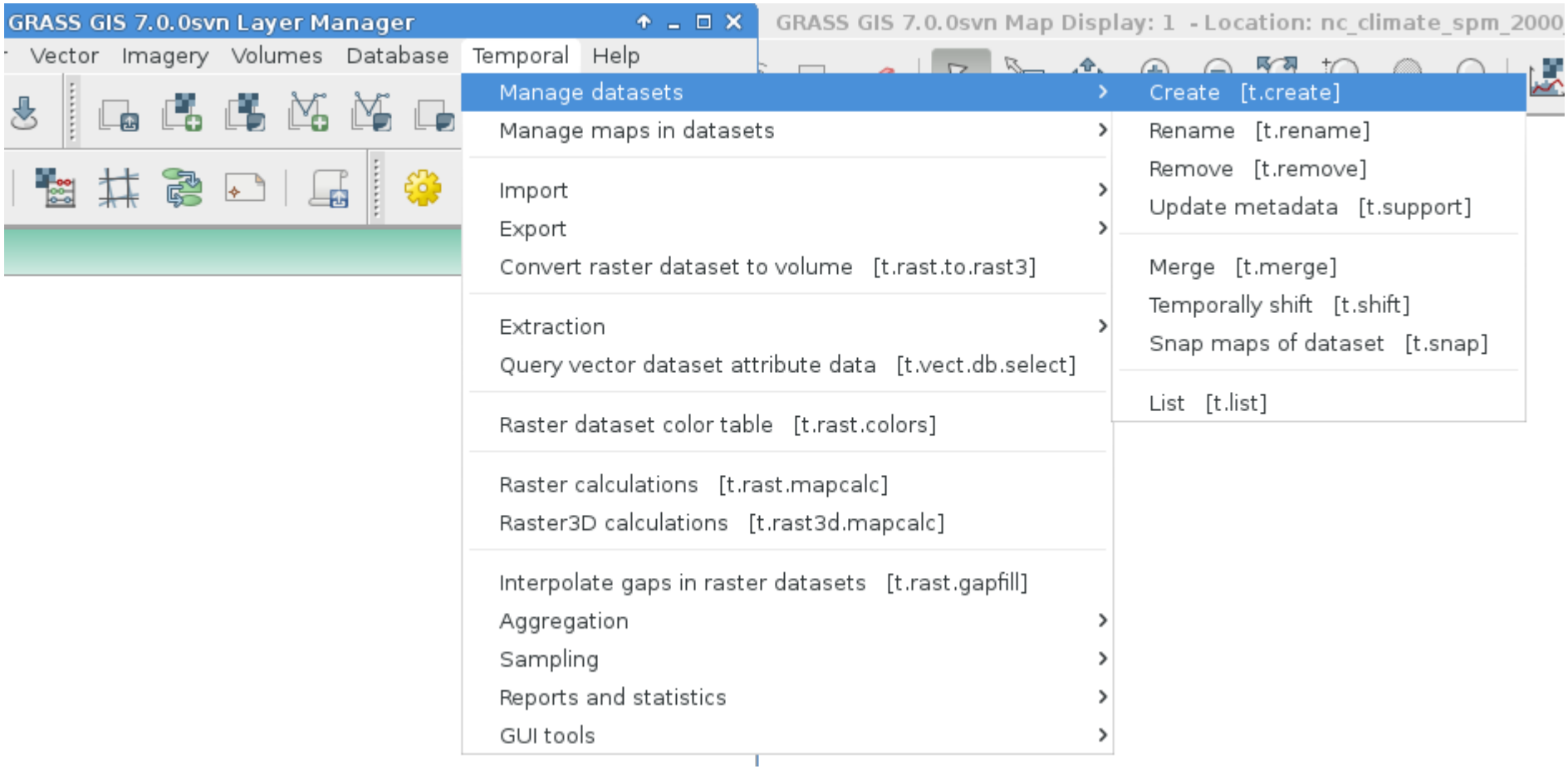
Content for exercises:

- Aggregated gridded data for NC (PRISM)
- Elevation model at 500m

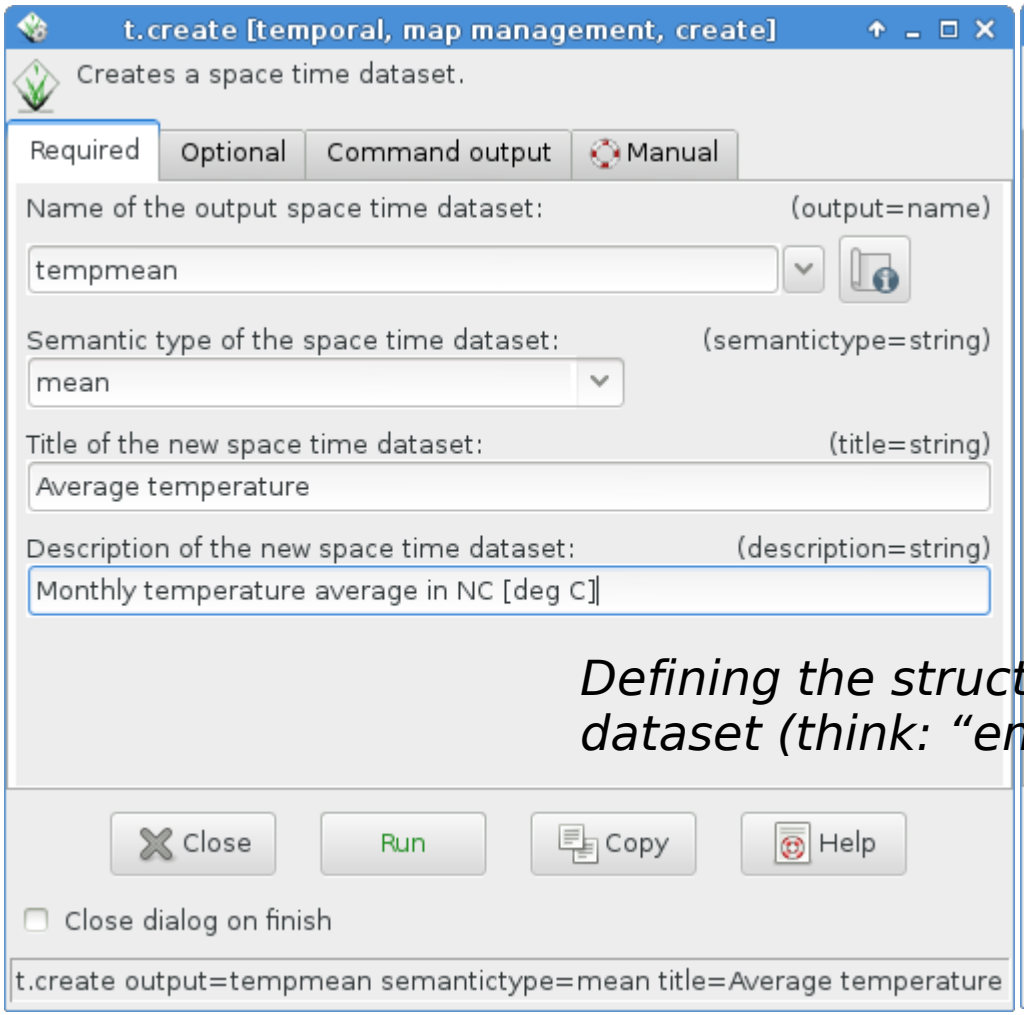
Exercise – GRASS GIS 7 startup with NC climate data

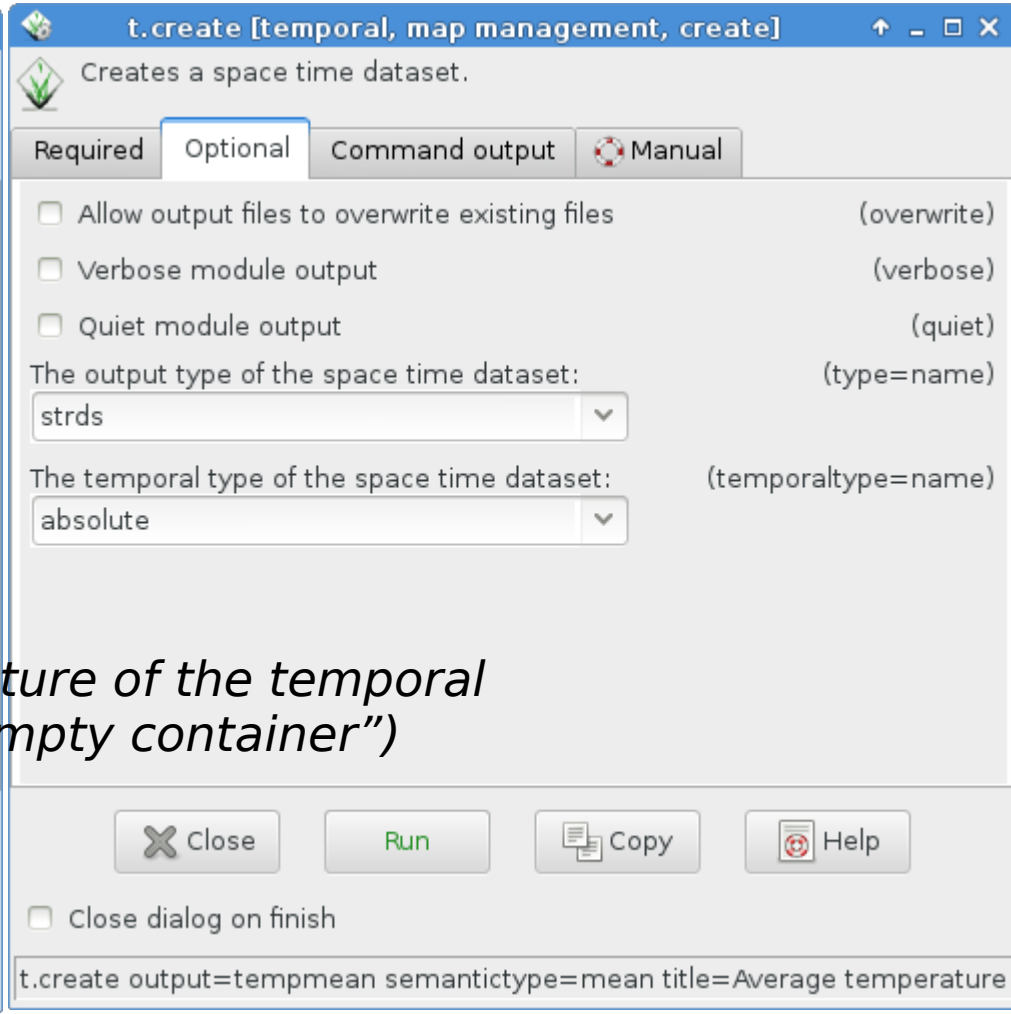
Exercise based on material developed by Anna Petrášová, NCSU (group led by Dr. Helena Mitasova)

Exercise – Temporal support in GRASS GIS 7



Exercise – Temporal data creation: Temp+Precip





Defining the structure of the temporal dataset (think: "empty container")

```
t.create output=tempmean type=strds semantictype=mean temporaltype=absolute \
  title="Average temperature" description="Monthly temp. avg in NC [deg C]"

t.create output=precipsum type=strds semantictype=mean temporaltype=absolute \
  title="Precipitation" description="Monthly precip. sum in NC [mm]"
```

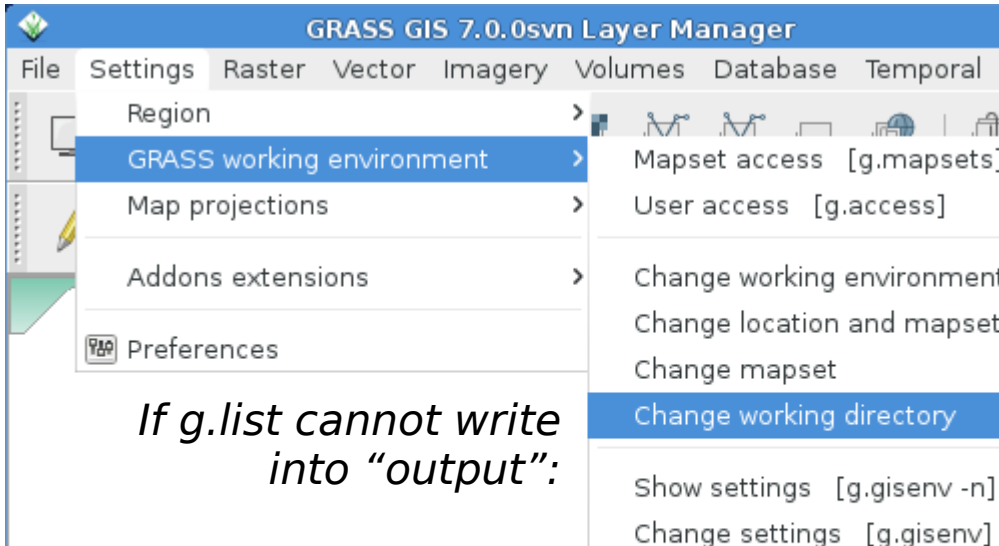
Exercise – Temporal data registration: Temp

Registering the existing raster maps into yet empty STRDS datasets:

1) Temperature data

List TEMP raster maps with g.list
(note: maps must be in search path, manage with `g.mapsets -s`)

```
g.list type=raster pattern="*tempmean*"

# … if ok, then save to file for t.register
g.list type=raster pattern="*tempmean*" output=maps_tempmean.txt
t.register -i input=tempmean type=rast start=2000-01-01 increment="1 months" \
           file=maps_tempmean.txt

# get some info
t.rast.list input=tempmean

# more possibilities how to list maps
t.rast.list input=tempmean \
 columns=name,start_time,end_time \
 method=gran granule="1 years"
```



If g.list cannot write into "output":

Exercise – Temporal data registration: Precip

Registering the existing raster maps into yet empty STRDS datasets:

2) Precipitation data

List PRECIP raster maps with g.list

```
g.list type=raster pattern="*precip*"

# … if ok, then save to file for t.register
g.list type=raster pattern="*precip*" output=maps_precipsum.txt
t.register -i input=precipsum type=rast start=2000-01-01 increment="1 months" \
          file=maps_precipsum.txt

# get some info
t.rast.list input=precipsum

# more possibilities how to list maps
t.rast.list input=precipsum columns=name,start_time,end_time \
  method=gran granule="1 years"
```

Exercise – Time series analysis

Univariate statistics

... can be combined with “where” conditions

```
# univariate statistics (use where to limit output)
t.rast.univar tempmean where="start_time > '2010-01-01'" -h

# aggregate time series by seasons
t.rast.aggregate input=tempmean output=tempmean_seasonal \
  base=tempmean_seasonal \
  granularity="3 months" method=average \
  where="start_time >= '2000-03-01' and start_time < '2012-11-01'"

# get information about the new aggregate:
t.info tempmean_seasonal
```

Exercise – Time series analysis

Extract summer periods and convert to degrees Fahrenheit

- we do extraction with conversion on the fly
- the strftime() function is also used in R and SQL/SQLite, used for timestamp parsing

```
# strftime('%m', start_time) returns the month of the map start timestamp
# It is not a GRASS GIS function but SQL (here: SQLite)
# … our job uses multiple cores, here: 4

t.rast.extract input=tempmean_seasonal \
  where="strftime('%m', start_time)='06'" \
  expression="(tempmean_seasonal  * 9.0/5.0) + 32" \
  output=tempmean_F_summer base=tempmean_F_summer nprocs=4
```

Exercise – Time series analysis

Show plot of min and max values

```
# first run t.rast.list and copy output to a file (you should set working
# directory from menu beforehand)
t.rast.list -h input=tempmean_F_summer columns=start_time,min,max
separator=comma

t.rast.list -h input=tempmean_F_summer columns=start_time,min,max \
  separator=comma output=output.txt


# now go to Python shell tab in the wxGUI and enter:
import matplotlib.pyplot as plt
plt.plotfile("output.txt", cols=(0,1,2), delimiter=',', subplots=False)
plt.show()
```

Exercise – Time series analysis

A similar exercise with precipitation dataset using a different conversion

```
# aggregate data using time intervals of tempmean_F_summer
# convert millimeters to inch
t.rast.aggregate.ds input=precipsum sample=tempmean_F_summer \
  output=precip_summer \
  base=precip_summer method=average

t.rast.mapcalc inputs=precip_summer expression="precip_summer / 25.4" \
  output=precip_inch_summer base=precip_inch_summer nprocs=4
```

Exercise – Time series analysis

Are precipitation and temperature correlated?

```
# download extension r.regression.series
g.extension extension=r.regression.series

# run g.list and save output into a file
g.list type=raster pattern="tempmean_F_summer*" separator=comma
g.list type=raster pattern="tempmean_F_summer*" separator=comma \
   output=tempmean_F_summer.txt

g.list type=raster pattern="precip_inch_summer*" separator=comma \
   output=precip_IN_summer.txt

# commands between backticks `...` are executed first (here: print list):
r.regression.series xseries=`cat tempmean_F_summer.txt` \
  yseries=`cat precip_IN_summer.txt` output=corr method=corcoef

r.colors map=corr color=differences
```

Exercise – Time series analysis

Display temperatures in Raleigh, NC

```
# add this line to a file point.txt or add it 'interactively' in the
v.in.ascii dialog

echo "638863,225446" > point.txt

v.in.ascii -t input=point.txt output=raleigh separator=comma


# create a vector map and space-time vector dataset with values of summer
temperature in Raleigh

t.vect.observe.strds input=raleigh strds=tempmean_F_summer \
  output=raleigh_tempmean_summer \
  vector_output=raleigh_summer column=tempmean


# list temperature values

t.vect.db.select input=raleigh_tempmean_summer columns=tempmean \
  separator=comma where="cat = 1"
```

Exercise – Time series analysis: plotting

Plot the values using matplotlib commands as before

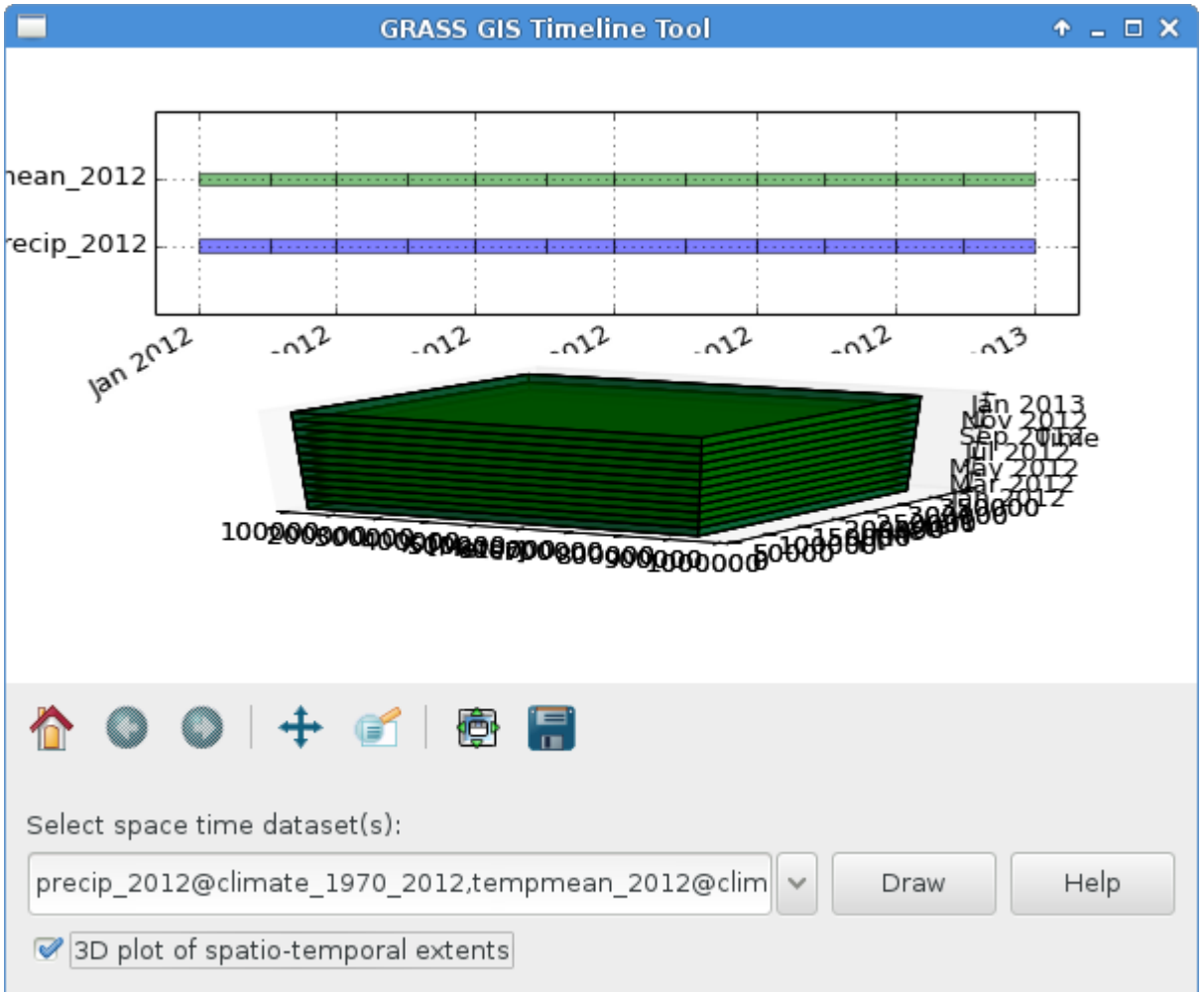
Extract one year and animate it (a few slides later)

```
t.rast.extract input=tempmean output=tempmean_2012 \
  base=tempmean_2012 where="start_time >= '2012-01-01'"

t.rast.extract input=precipsum output=precip_2012 \
  base=precip_2012 where="start_time >= '2012-01-01'"

# change color table if desired (to precipitation_monthly or create your own)
t.rast.colors input=precip_2012 rules=precipitation_monthly
```

Exercise – Timeline of the time series

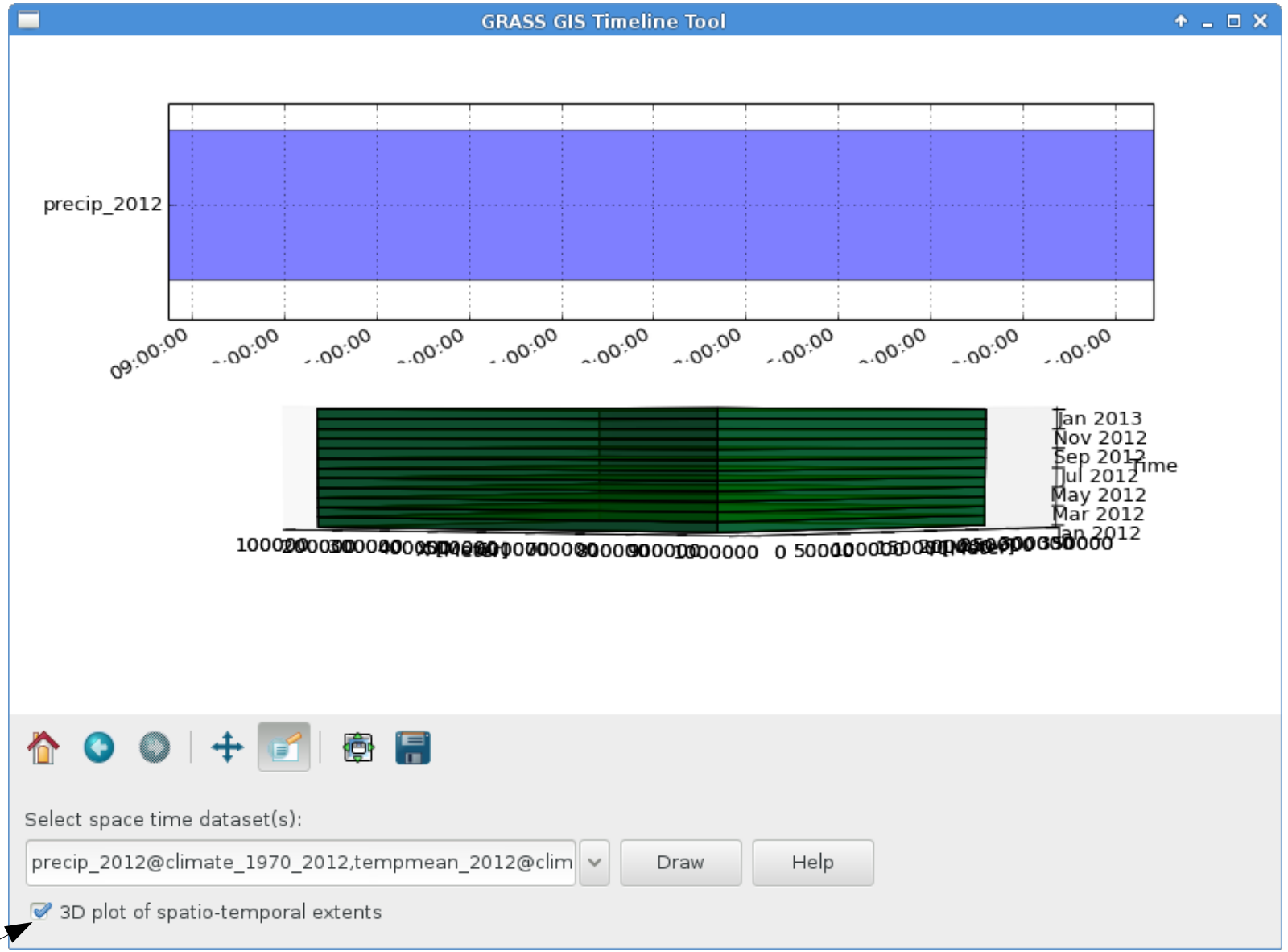
Display timeline of precipitation and temperatures observations or aggregates

```
t.info tempmean_2012
t.info precip_2012
g.gui.timeline input=tempmean_2012,precip_2012
```



Exercise – Timeline of the time series

Note: the 2D and 3D plot are zoomable (lense and right mouse button, respectively)



Exercise – Visualizing the time series: Animation

Display animation of precipitation and temperatures

```
# display legend, set min, max values in legend from t.info
t.info tempmean_2012
g.gui.animation strds=tempmean_2012

t.info precip_2012
g.gui.animation strds=precip_2012
```