GRASS as Temporal GIS

Sören Gebbert

THÜNEN Institute of Climate-Smart Agriculture

November 23, 2013

THÜNEN

Topics

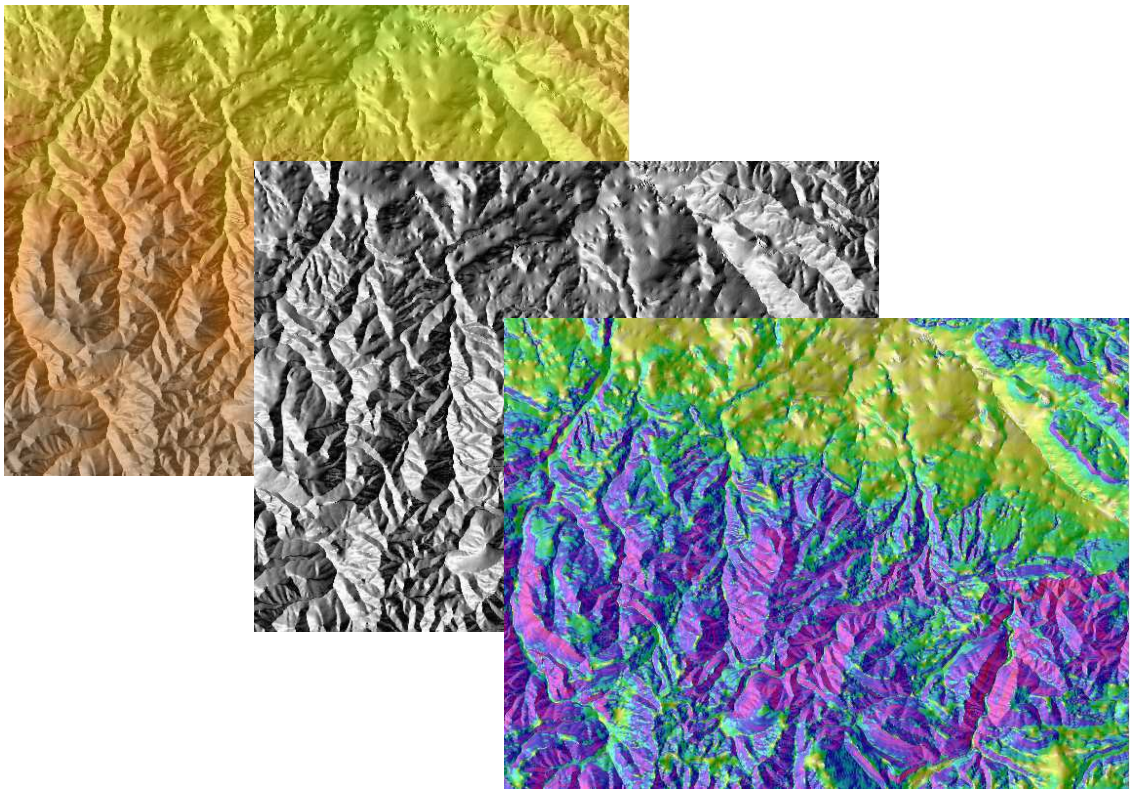
THÜNEN

GRASS GIS

- GRASS Geographic Resources Analysis Support System
- Multipurpose raster, 3D raster and vector based GIS
- Developed 1982 - 1995 at CERL in Illinois/USA
- Since 1999 open source under GPL license with active international development community
- Very modular, provides GUI, command line and batch processing support
- About 500 modules for management, processing, analysis and visualization of geographical data are available (GRASS version 7 2013 Aug.)

THÜNEN

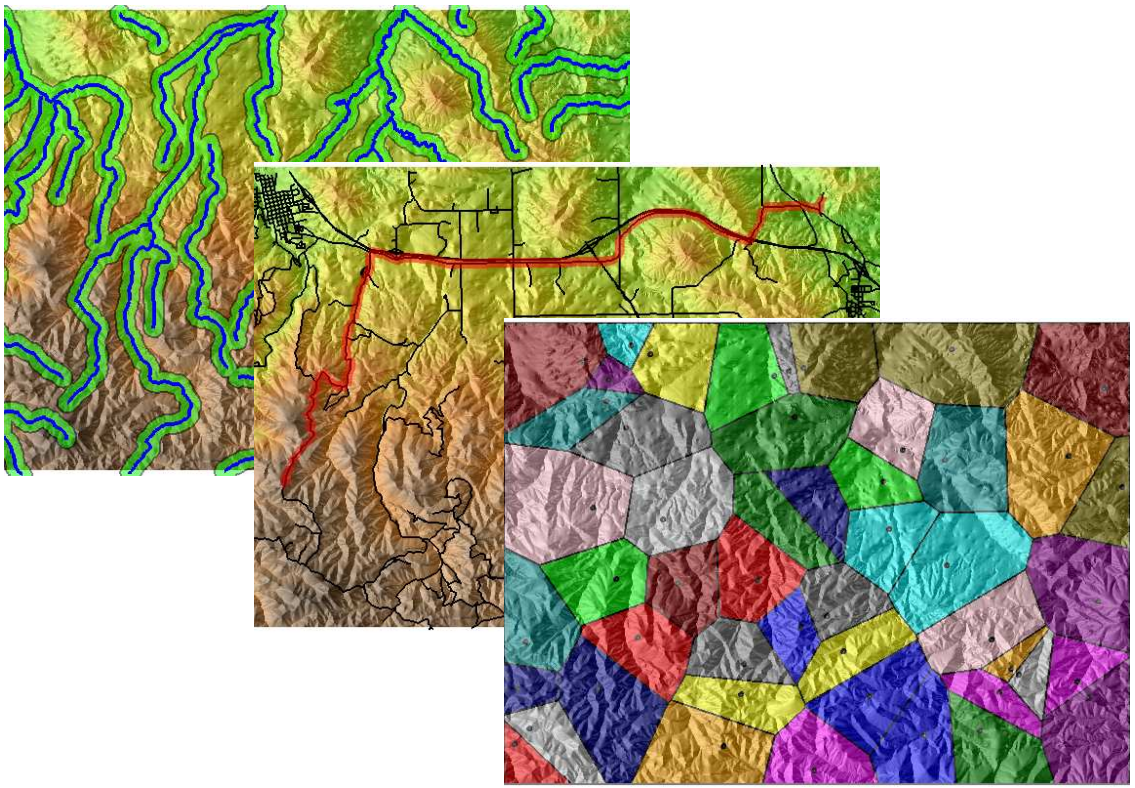
Raster processing



- Slope, Aspect
- Exposition
- spatial aggregation
- Map algebra
- Spline Interpolation
- Principal components
- ...

THÜNEN

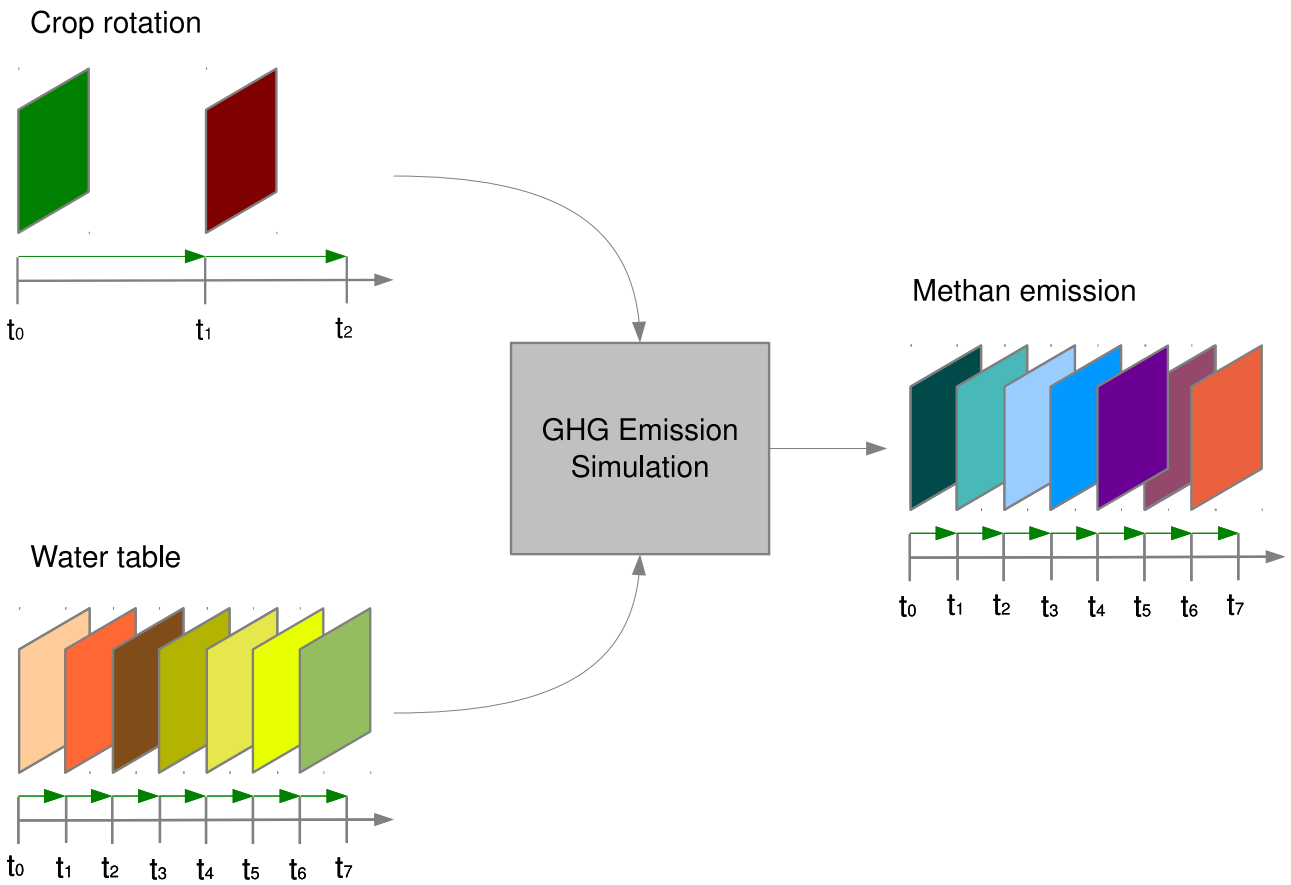
Vector processing



- Generalize, Buffer
- Patch,Overlay, Select,Extract
- Shortest Path
- Traveling salesman problem
- Delaunay, Voronoi triangulation
- ...

Why a temporal GIS?

We need to model and assess GHG emissions, Soil Organic Carbon (SOC) change and Land Use Change (LUC) at continental scale with different spatial and temporal resolutions



Why reinventing the wheel?

PCRaster

CDO

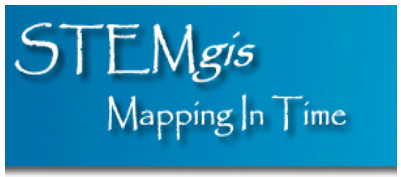
PENNSTATE

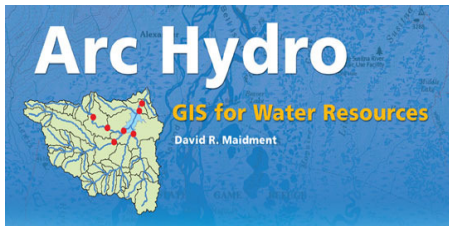
GeoVISTA

GeoViz Toolkit

STempo

Temporal Analyst
for ArcGIS





Available temporal GIS and related multi purpose environmental modeling solutions do not fit our needs

THÜNEN

Topics

Temporal GRASS GIS goal

- Development of the first comprehensive field based temporal GIS
- Efficient management, processing, analysis and visualization of large spatio-temporal fields and their interactions
- Providing interoperability between sophisticated spatio-temporal analyzing tools like CDO, R and ParaView
- Creating an intuitive object oriented spatio-temporal framework

THÜNEN

What is a field based temporal GIS?

Two important Temporal GIS classifications (Goodchild 1989, Heuvelink 1998)

a) Temporal GIS dealing with objects like points, lines, arcs, areas that represent geometrical or topological features in space and time
b) Temporal GIS dealing with fields, natural, social or epidemiological. Their attribute data representing the distribution of temperature, precipitation, hydrological or ecological patterns in space and time

We use the field based approach in GRASS GIS.

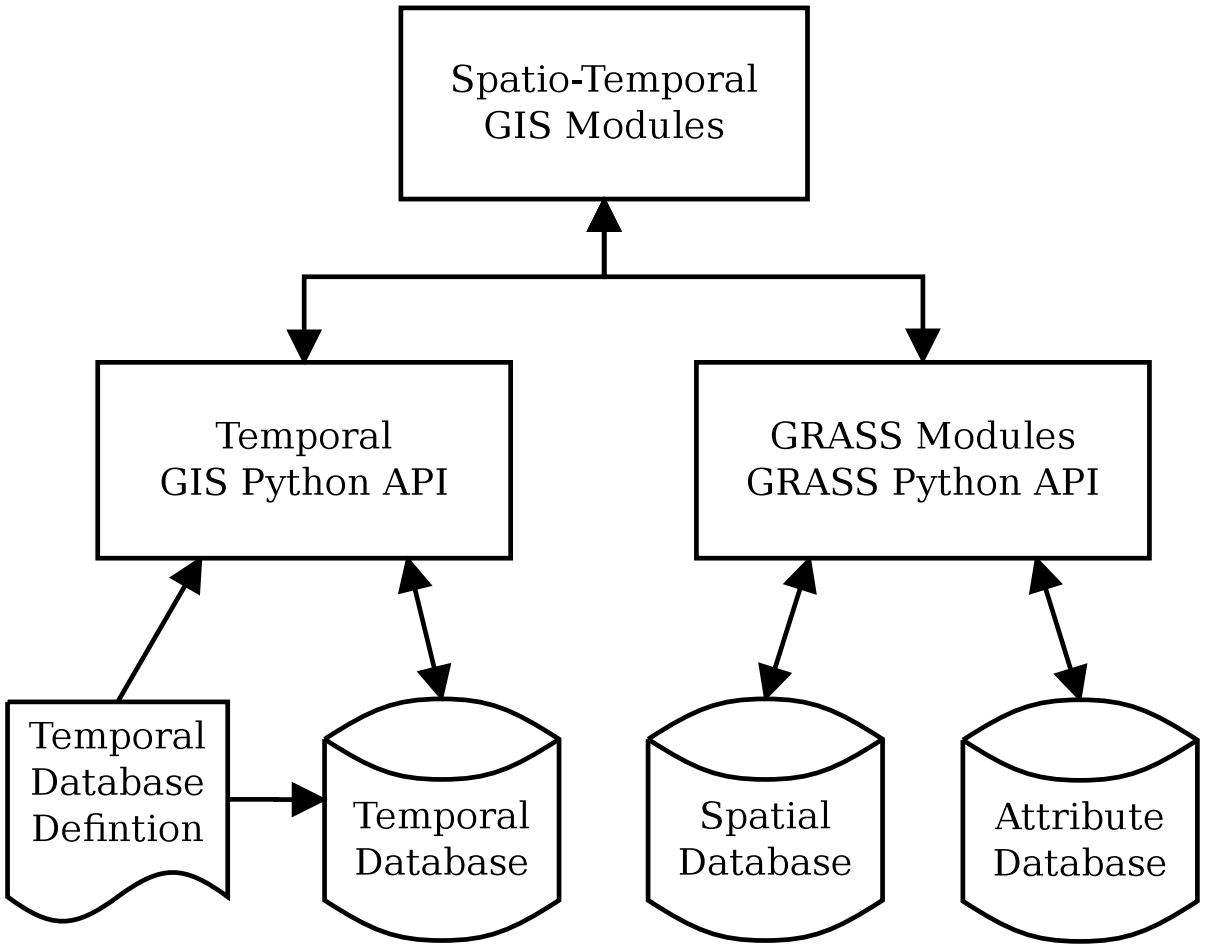
THÜNEN

Temporal GRASS GIS concept

- Do not break the existing GRASS GIS functionalities and assure backward compatibility
- Follow the UNIX paradigm, create small modules for a specific purpose and combine them to manage complex tasks
- Design time support for the existing datatypes: raster, 3D raster and vector map layers
- Design new spatio-temporal datatypes, space time datasets, that manage time series data
- Reuse existing raster, 3D raster and vector modules to process space time datasets

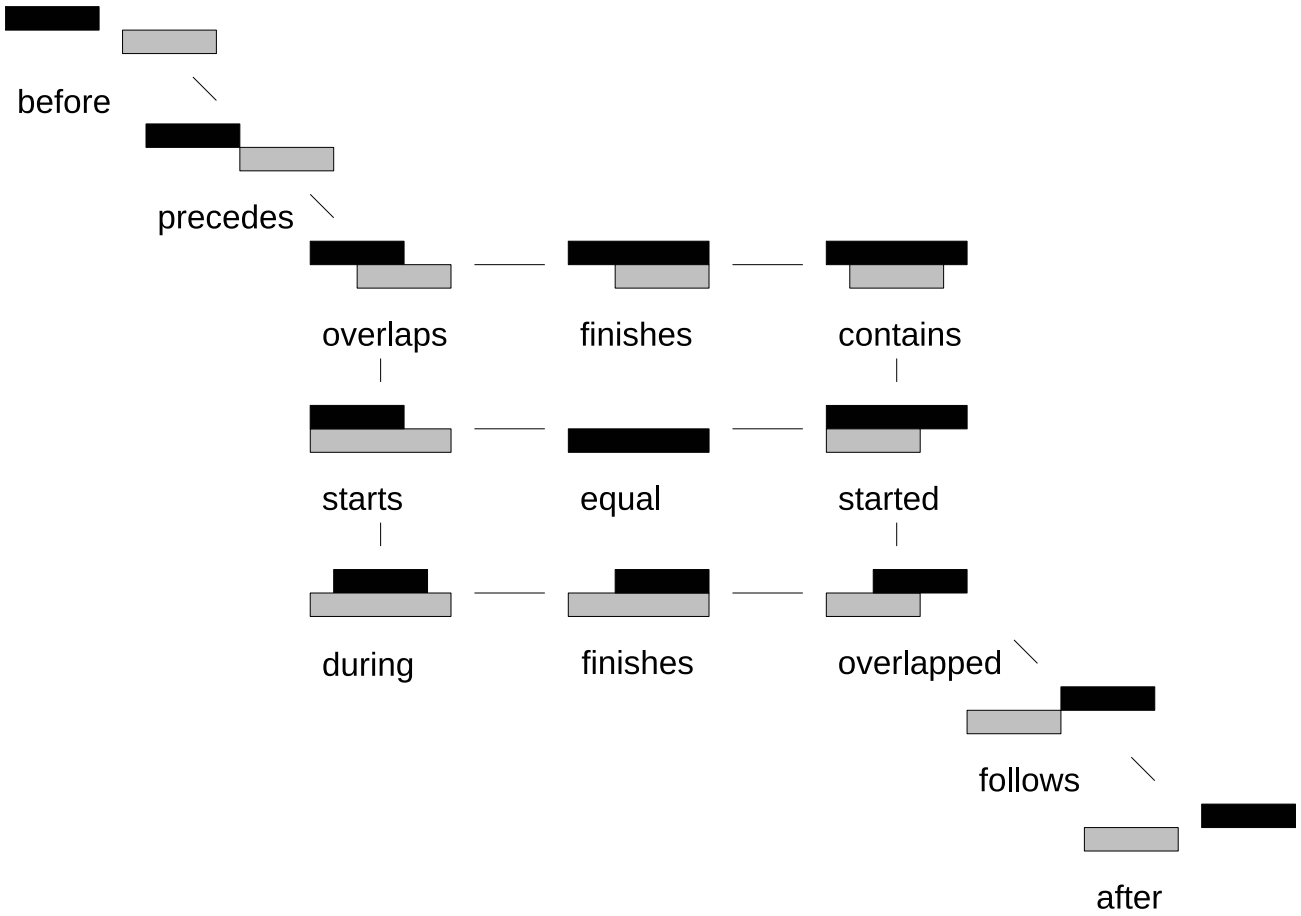
THÜNEN

Temporal GRASS GIS concept



Temporal relationships

Supported temporal relationships (Claramunt and Jiang 2001).

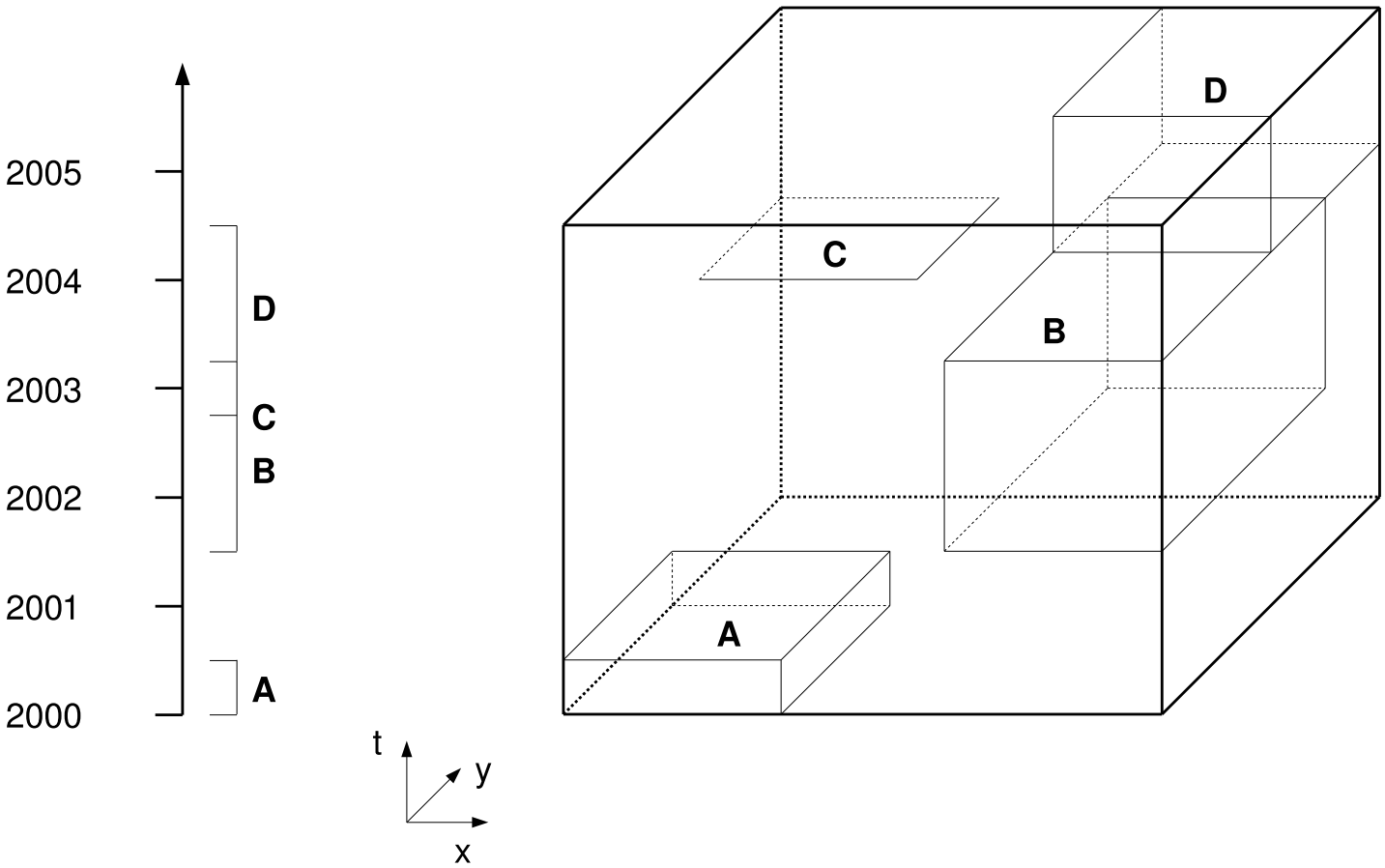


Temporal GRASS GIS concept

- Use interval time and time instances of absolute (Gregorian calendar) and relative time (years to seconds)
- Use a SQL database to store the temporal and spatial extent of space time datasets, map layers and their metadata
- Use the SQL database to store relations between maps and space time datasets
- Implement a comprehensive object oriented temporal framework
- Implement new GRASS modules based on the temporal framework for managing, processing and analyzing of space time datasets

THÜNEN

Space time datasets



Space time datasets

Base information

id	name	mapset
ds@test	ds	test
.		
.		
.		

Temporal extent

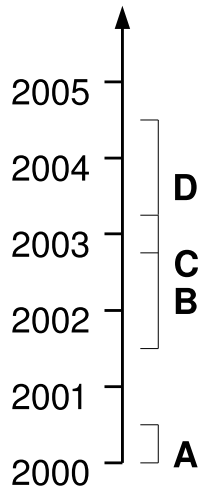
id	start	end
ds@test	2001	2004.06
.		
.		
.		

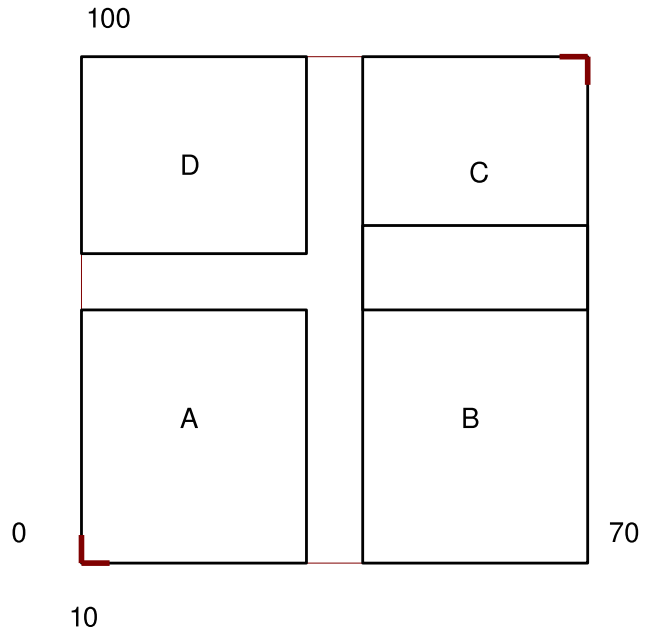
Spatial extent

id	north	south	east	west
ds@test	100	10	70	0
.				
.				
.				

Map register

id
A@test
B@test
C@test
D@test





Topics

THÜNEN

Modules to manage space time datasets

t.create

Create a space time dataset

t.register

Assign time stamps and register raster, vector or voxel map layers in a space time dataset

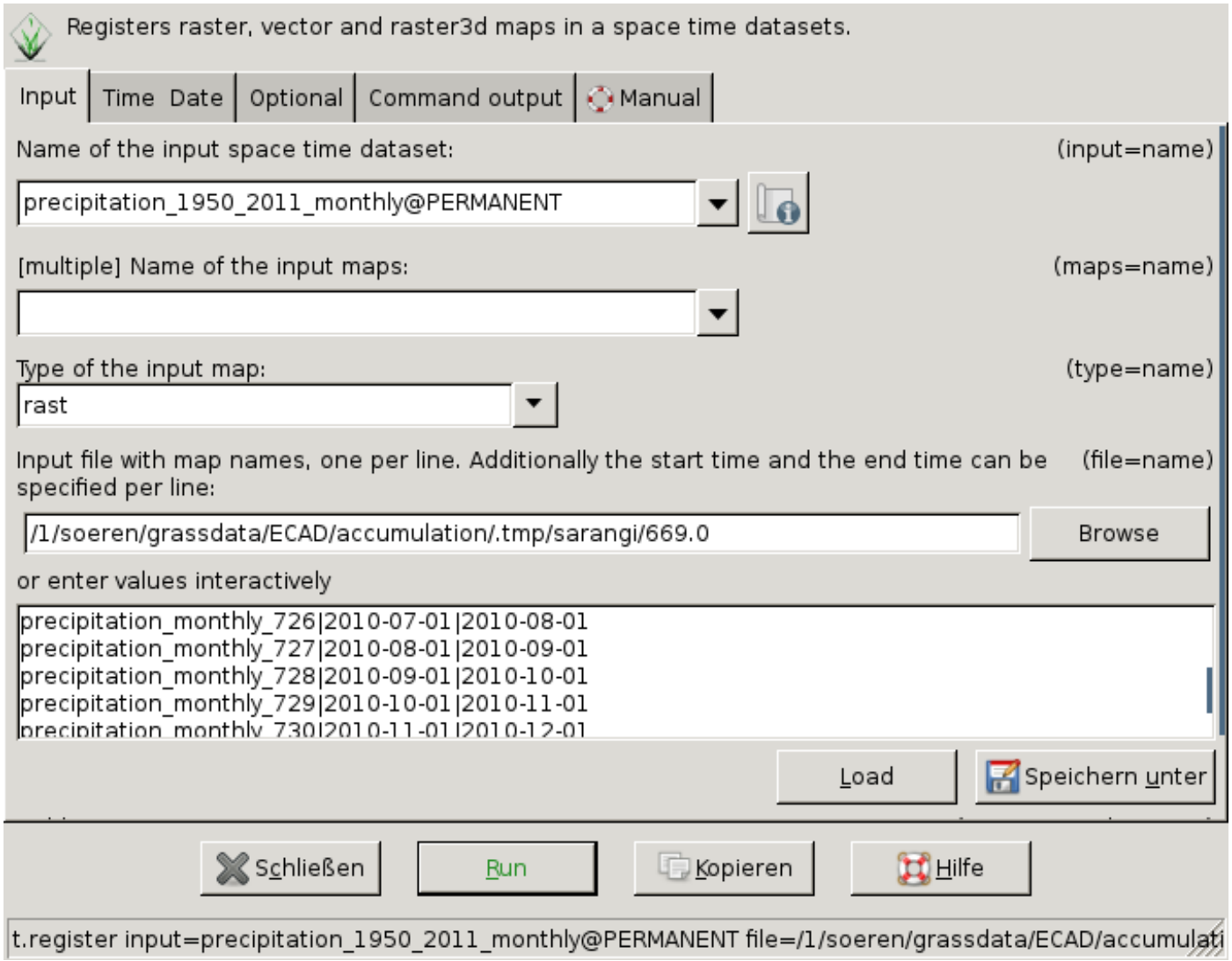
t.unregister

Unregister map layers from space time datasets

t.remove

Remove space time datasets

t.register


Registers raster, vector and raster3d maps in a space time datasets.
Input
Time Date
Optional
Command output
Manual
Name of the input space time dataset:
(input=name)
precipitation_1950_2011_monthly@PERMANENT
[multiple] Name of the input maps:
(maps=name)
Type of the input map:
(type=name)
rast
Input file with map names, one per line. Additionally the start time and the end time can be specified per line:
(file=name)
/1/soeren/grassdata/ECAD/accumulation/.tmp/sarangi/669.0
Browse
or enter values interactively
precipitation_monthly_726|2010-07-01|2010-08-01
precipitation_monthly_727|2010-08-01|2010-09-01
precipitation_monthly_728|2010-09-01|2010-10-01
precipitation_monthly_729|2010-10-01|2010-11-01
precipitation_monthly_730|2010-11-01|2010-12-01
Load
Speichern unter
Schließen
Run
Kopieren
Hilfe
t.register input=precipitation_1950_2011_monthly@PERMANENT file=/1/soeren/grassdata/ECAD/accumulati

Modules to manage space time datasets

t.support

Modify the metadata of a space time dataset

t.topology

Shows and checks the temporal topology of a space time dataset

t.shift

Temporally shift a space time dataset

t.snap

Create a valid temporal topology of a space time dataset

Modules to process space time raster datasets

t.rast.list

List registered raster map layers. Support *SQL WHERE* statements as well as methods like: *list by time order* or *list by granularity*

t.rast.series

Performs different aggregation algorithms on all or a subset of raster map layers in a space time raster dataset

t.rast.extract

Extract space time raster datasets from an existing STRDS using *SQL WHERE* statements and *map-calculation* expressions.

Modules to process space time raster datasets

t.rast.mapcalc

Spatio-temporal raster algebra

t.rast.aggregate

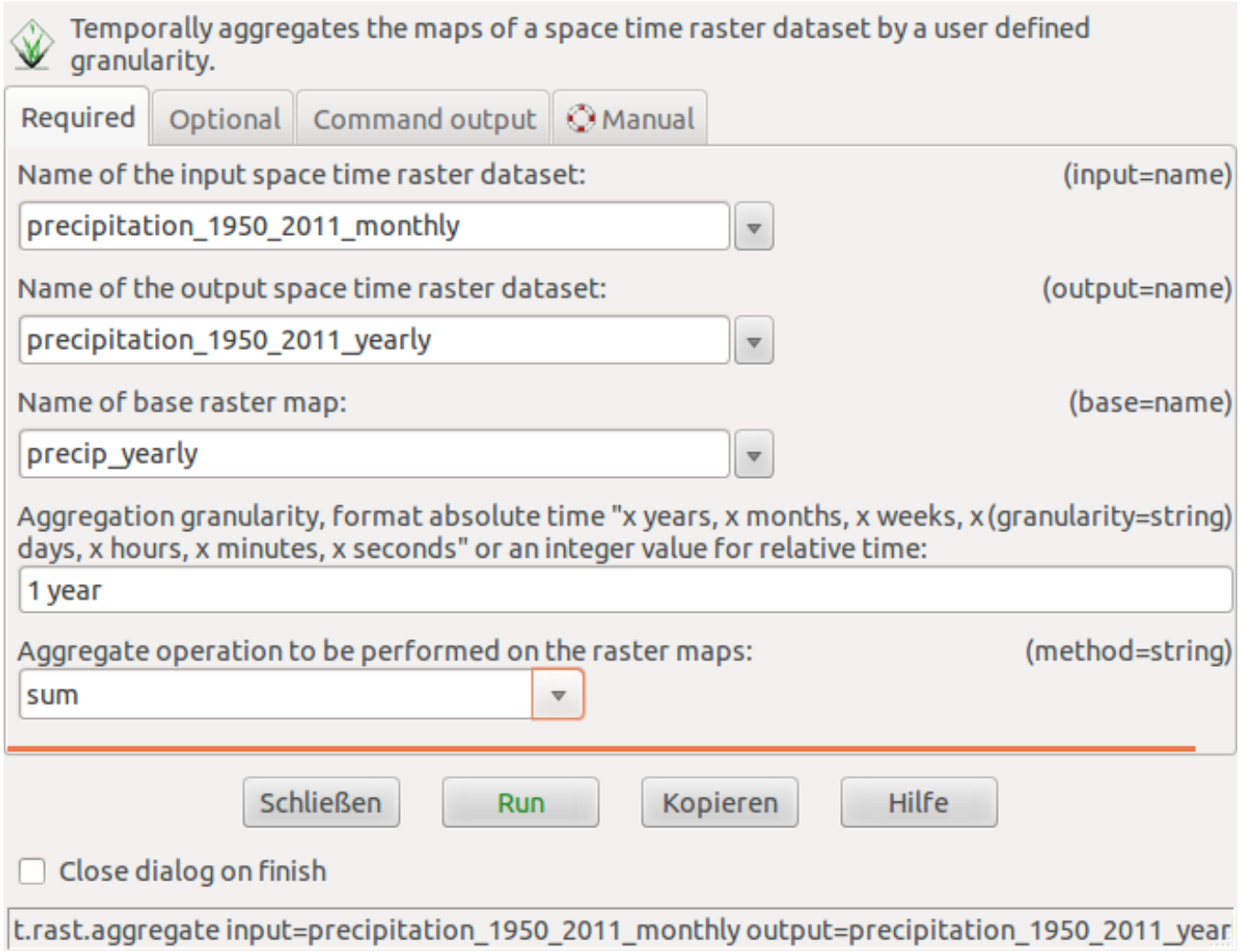
Temporally aggregate a space time raster dataset using different statistical aggregation methods

t.rast.univar

Calculates univariate statistics for each registered raster map layer of a space time raster dataset

THÜNEN

t.rast.aggregate



t.info precipitation_1950_2011_yearly

```
+-------------------- Space Time Raster Dataset -----------------------------+
|                                                                            |
+-------------------- Basic information -------------------------------------+
| Id: ........................ precipitation_1950_2011_yearly@PERMANENT
| Name: ...................... precipitation_1950_2011_yearly
| Mapset: .................... PERMANENT
| Creator: ................... soeren
| Creation time: ............. 2013-09-18 13:35:16.243647
| Temporal type: ............. absolute
| Semantic type:.............. mean
+-------------------- Absolute time -----------------------------------------+
| Start time:................. 1950-01-01 00:00:00
| End time:................... 2012-01-01 00:00:00
| Granularity:................ 1 year
| Temporal type of maps:...... interval
+-------------------- Spatial extent ----------------------------------------+
| North:...................... 75.5
| South:...................... -0.5
| East:.. .................... 75.5
| West:....................... -40.5
| Top:........................ 0.0
| Bottom:..................... 0.0
+-------------------- Metadata information ----------------------------------+
```

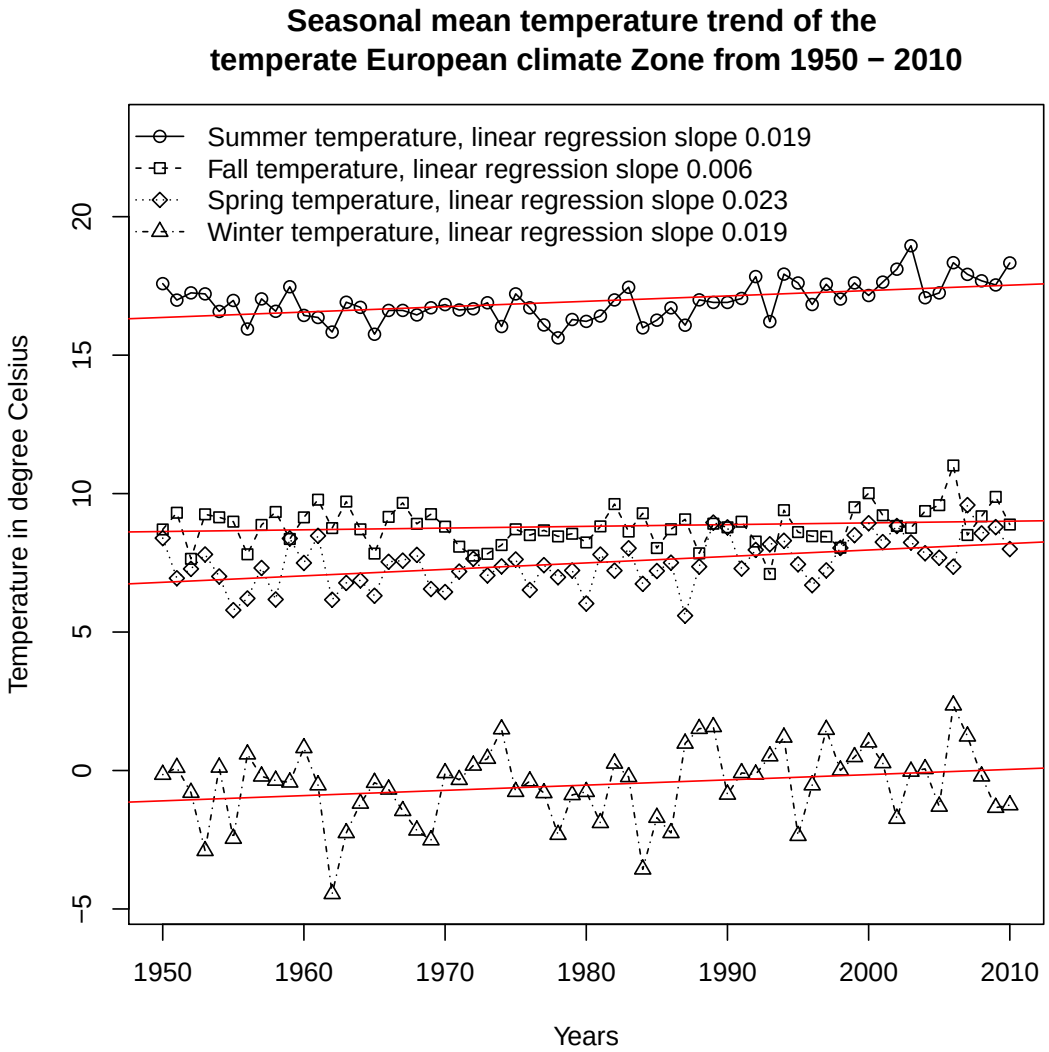
THÜNEN

t.info precipitation_1950_2011_yearly

```
+-------------------- Metadata information ---------------------------------+
| Raster register table:..... precipitation_1950_2011_yearly_PERMANENT_raster_register
| North-South resolution min:. 1.0
| North-South resolution max:. 1.0
| East-west resolution min:... 1.0
| East-west resolution max:... 1.0
| Minimum value min:......... 0.0
| Minimum value max:......... 2059.0
| Maximum value min:......... 16881.0
| Maximum value max:......... 35116.0
| Number of registered maps:.. 62
|
| Title:
| Yearly precipitation 1950 - 2011
| Description:
| Yearly precipitation 1950 - 2011 in [0.1 mm]
| Command history:
| # 2013-09-18 13:35:16
| t.rast.aggregate
|     input="precipitation_1950_2011_monthly"
|     output="precipitation_1950_2011_yearly" base="precip_yearly"
|     granularity="1 year" method="sum"
| # 2013-09-18 14:28:35
| t.support in="precipitation_1950_2011_yearly"
|     title="Yearly precipitation 1950 - 2011"
|     descr="Yearly precipitation 1950 - 2011 in [0.1 mm]"
|
+-----------------------------------------------------------------------------+
```

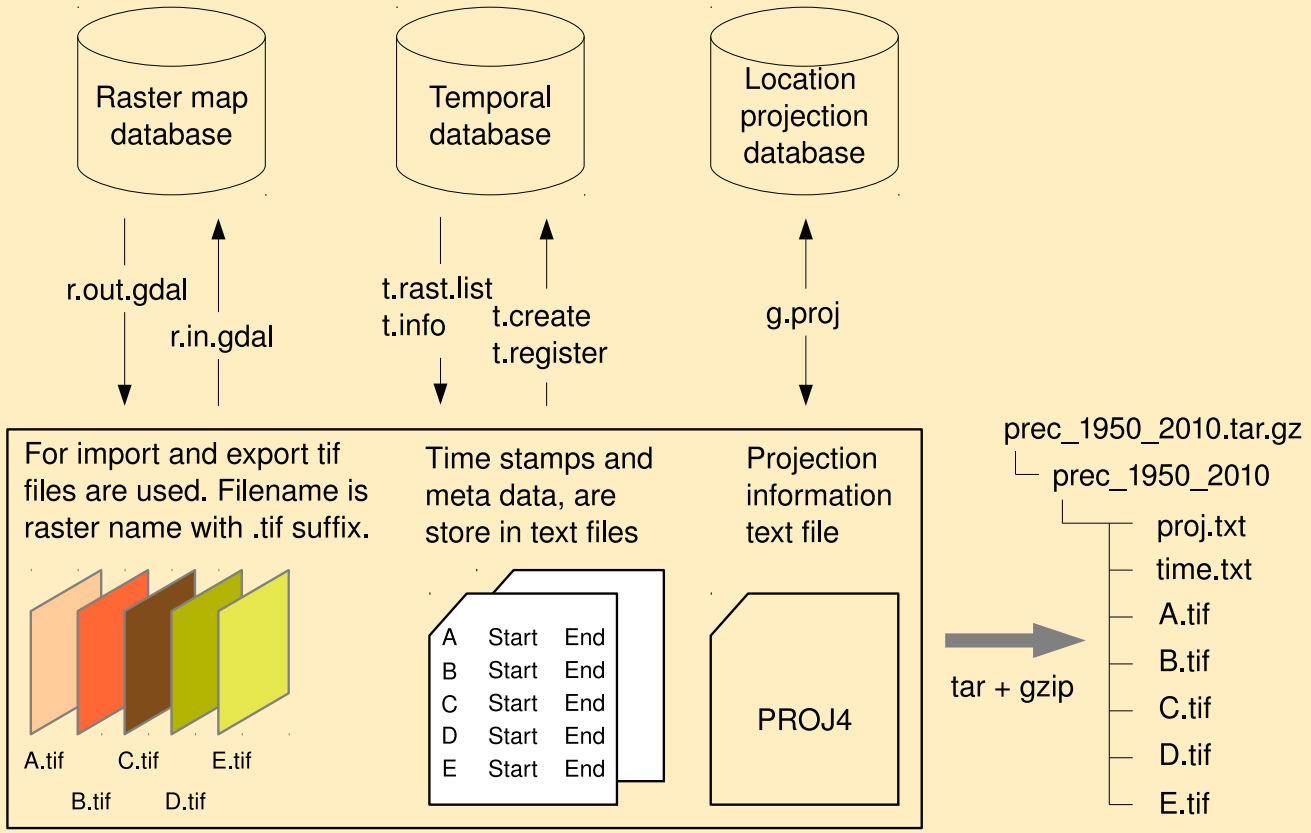
THÜNEN

t.rast.aggregate + t.rast.extract + t.rast.univar + R



Import and Export of space time raster datasets

t.rast.export and t.rast.import



Modules to process space time vector datasets

t.vect.list

Lists registered vector map layers of a space time vector dataset

t.vect.extract

Extracts a subset of a space time vector dataset. Supports *SQL WHERE* queries for metadata and attributes.

t.vect.univar

Calculates univariate statistics of attributes for each registered vector map layer of a space time vector dataset

THÜNEN

Modules to process space time vector datasets

t.vect.db.select

Prints attribute data of vector map layers of a specific space time vector dataset

t.vect.observe.strds

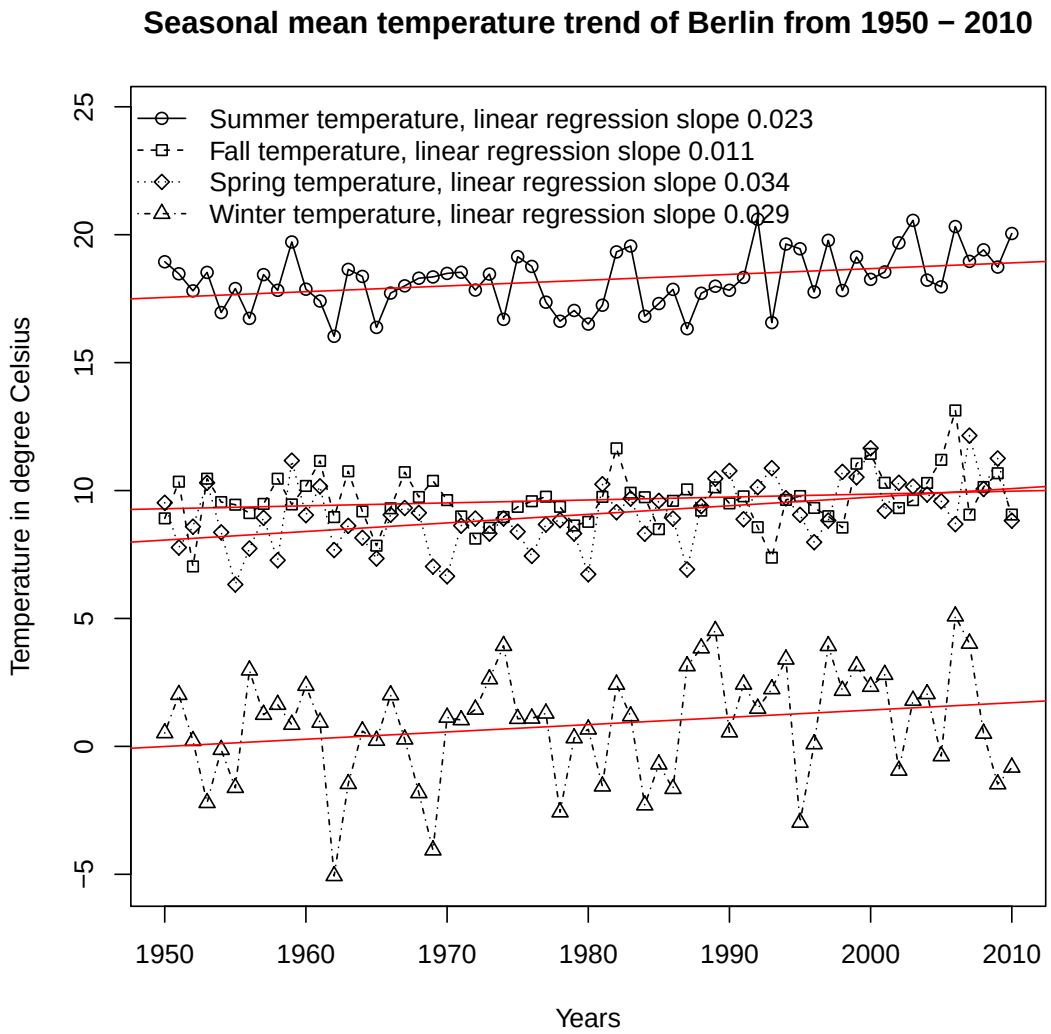
Observe specific locations in a space time raster dataset over a period of time using vector points

t.vect.what.strds

Store values of raster map layers at spatial and temporal positions of vector points as vector attributes

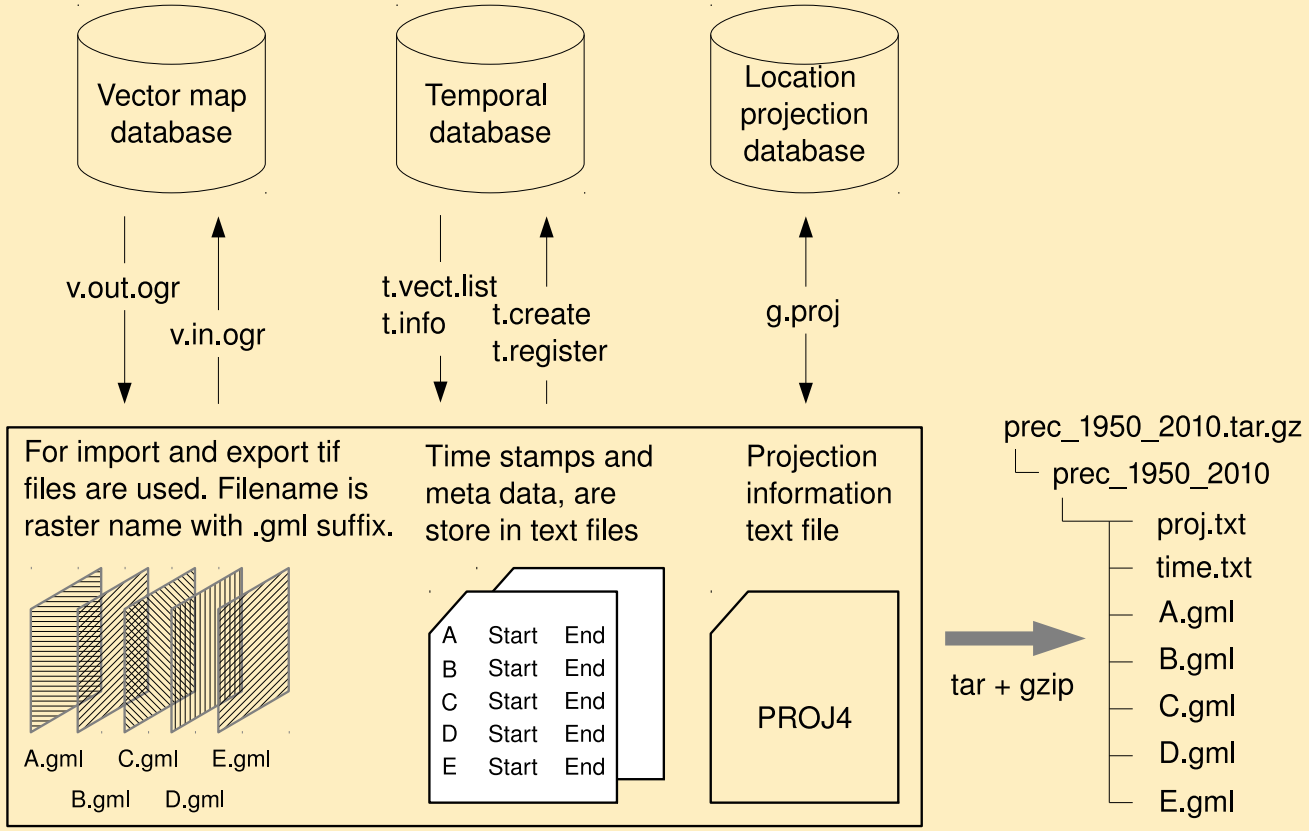
THÜNEN

t.vect.observe.strds + t.vect.db.select + R



Import and Export of space time vector datasets

t.vect.export and t.vect.import



Modules to process space time raster 3D datasets

t.rast3d.list

List registered 3D raster map layers.

t.rast3d.univar

Calculates univariate statistics from the non-null cells for each registered 3D raster map layer of a space time raster 3D dataset

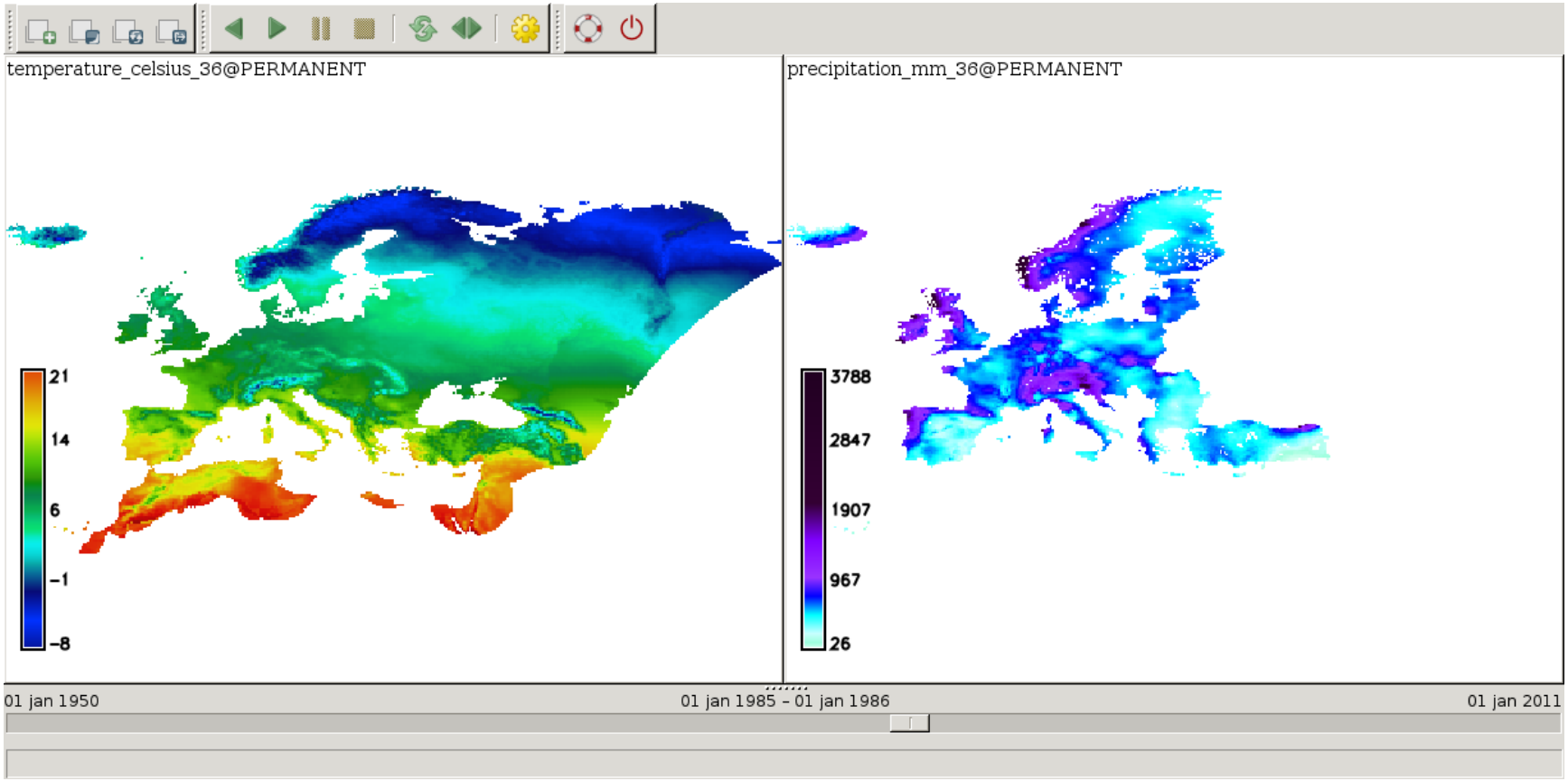
t.rasedt.mapcalc

Spatio-temporal raster 3D algebra

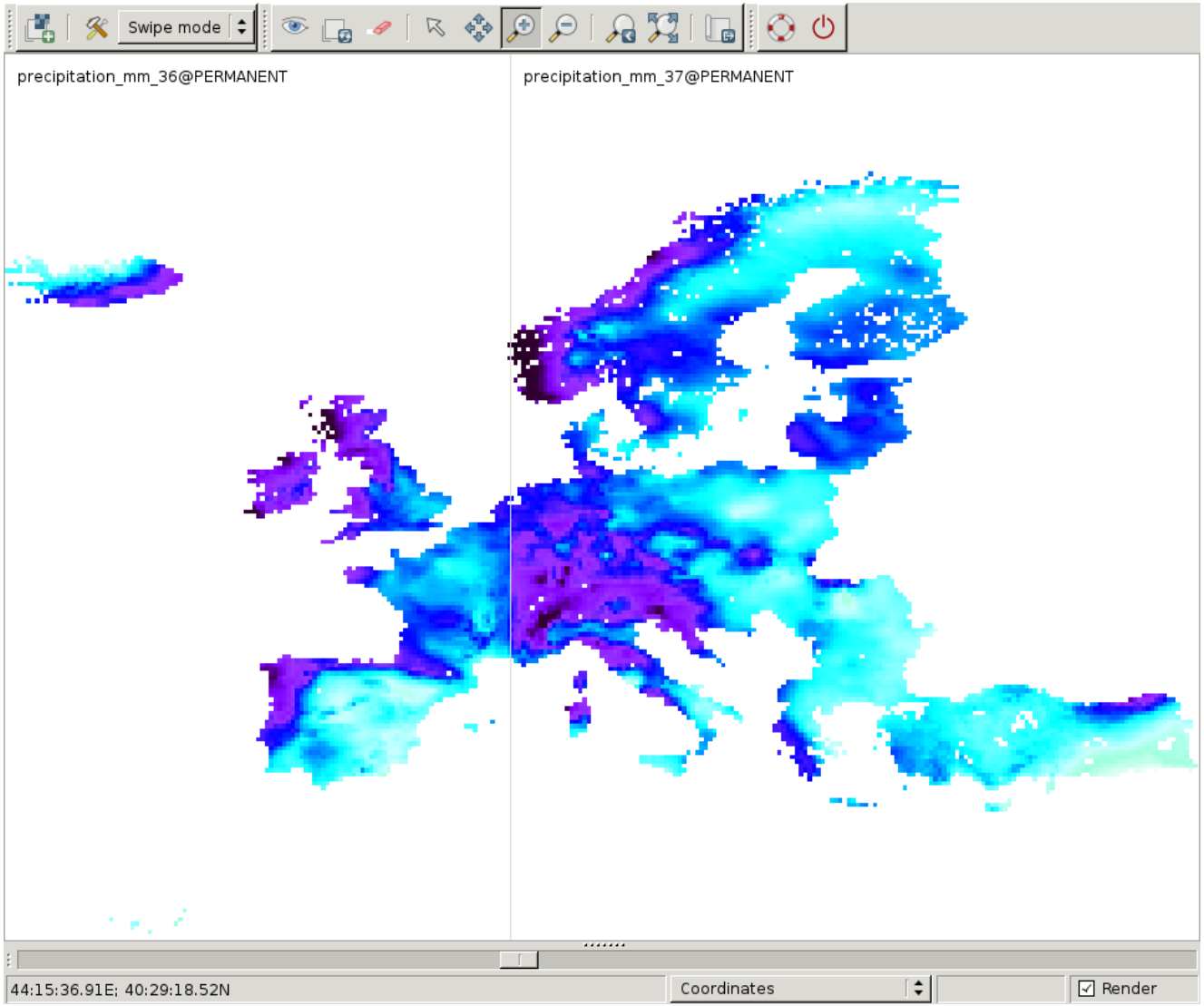
t.rast3d.extract

Extract space time raster 3D datasets from an existing STR3DS using *SQL where* and *r.mapcalc* queries.

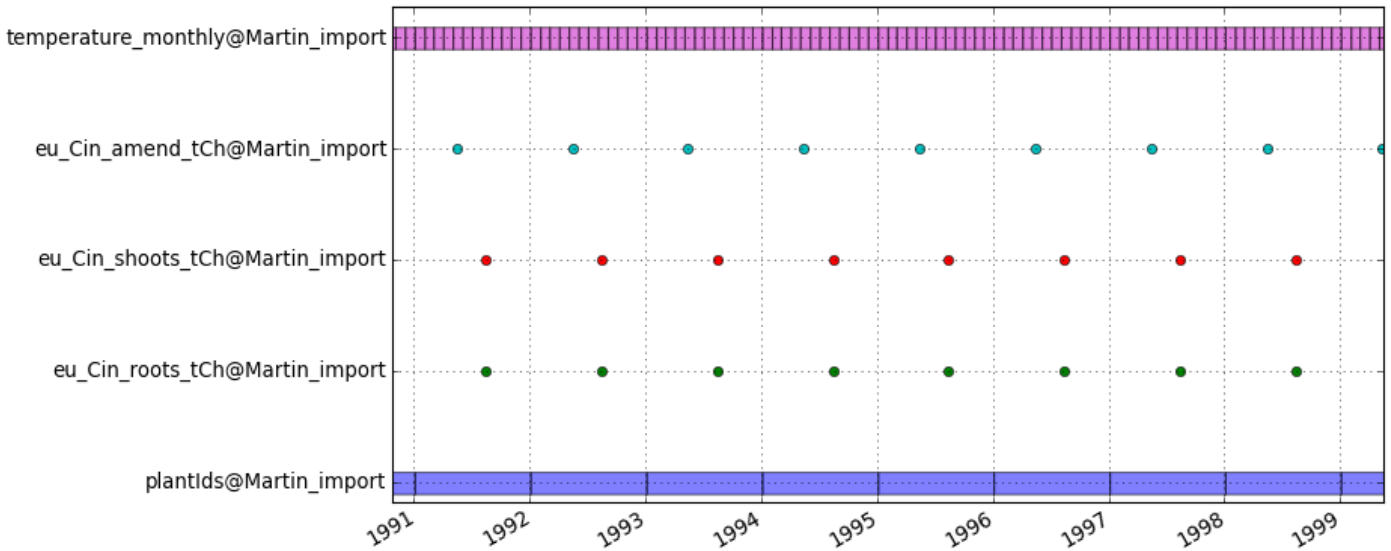
Animation with g.gui.animate

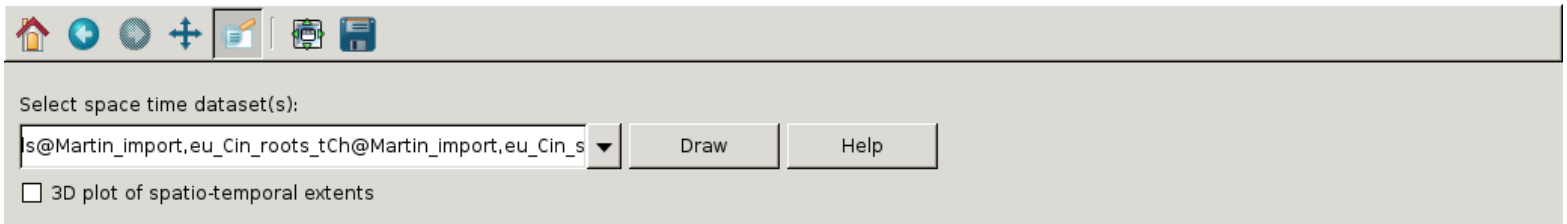


Comparison of two maps with g.gui.mapswipe



Time-line visualization with g.gui.timeline





The End

Thank you