

```
882 #' # the three output rasters are returned in a list of length 3
883 #' terrain
884 #' }
885
886 run_qgis <- function(alg = NULL, ..., params = NULL, load_output = FALSE,
887                     show_output_paths = TRUE, qgis_env = set_env()) {
888
889   # check if the QGIS application has already been started
890   tmp <- try(expr = open_app(qgis_env = qgis_env), silent = TRUE)
```

# Integrating R with GIS for Statistical Geocomputing

Jannes Muenchow



# Where to find the material



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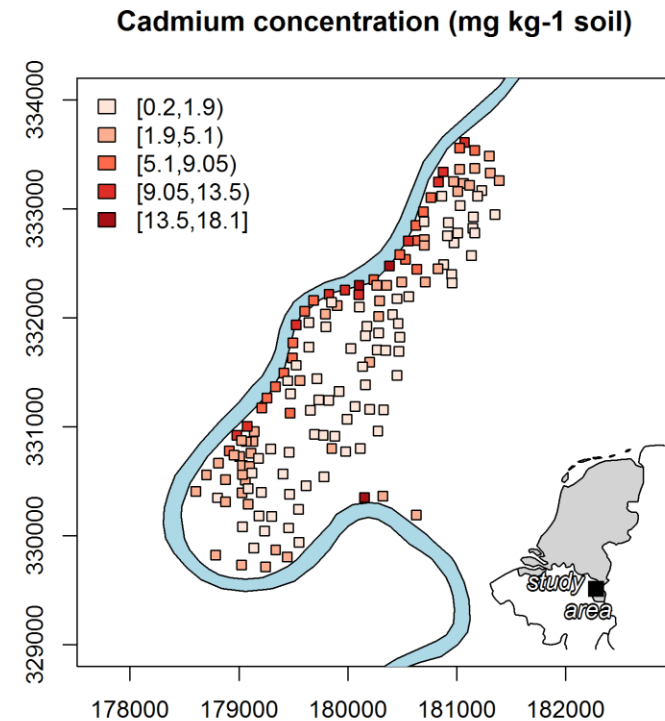
[https://github.com/jannes-m/geostats\\_rqgis](https://github.com/jannes-m/geostats_rqgis)

# Contents



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## 1. R as a GIS



Data: Rikken, M.G.J & Van Rijn, R.P.G. (1993).

# Contents



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1. R as a GIS
2. R-GIS bridges

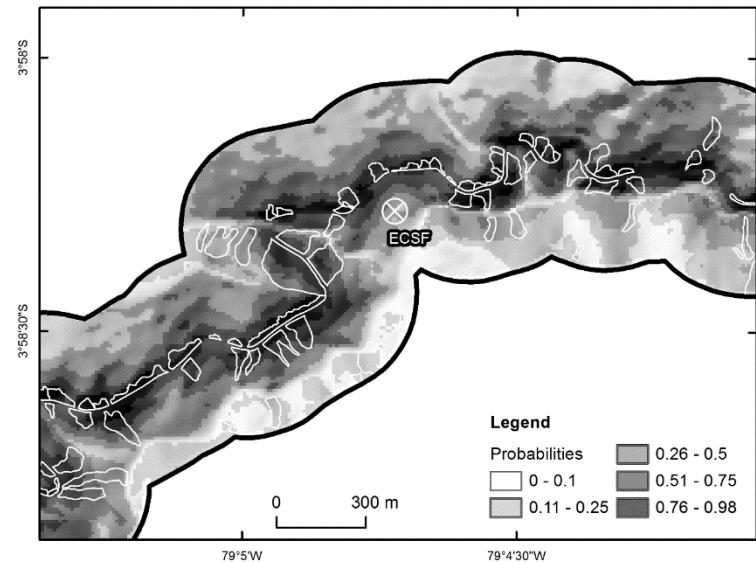


# Contents



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1. R as a GIS
2. R-GIS bridges
3. R/GIS examples



Brenning et al. (2015): Landslide susceptibility near highways.

# Contents



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1. R as a GIS
2. R-GIS bridges
3. R/GIS examples
4. RQGIS, RSAGA, rgrass7





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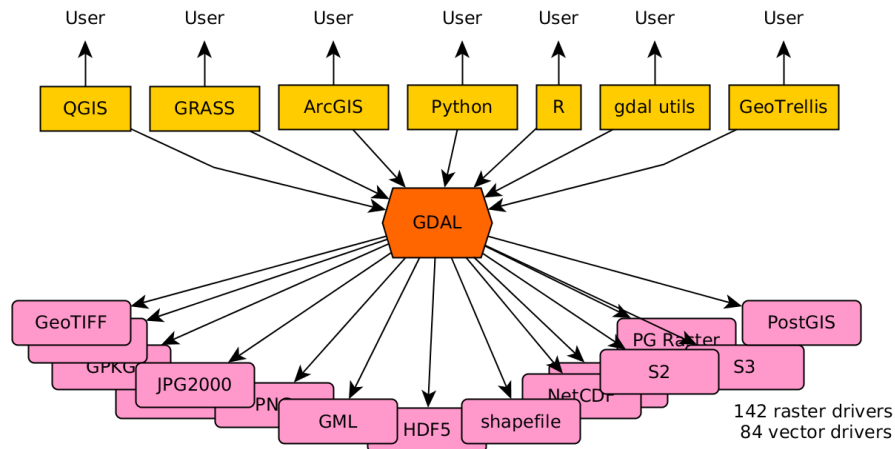
## R AS A GIS



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# R as a GIS

- More than 100 geo-related R packages (<https://cran.r-project.org/web/views/Spatial.html>)
- Package **rgdal** for importing and exporting geodata

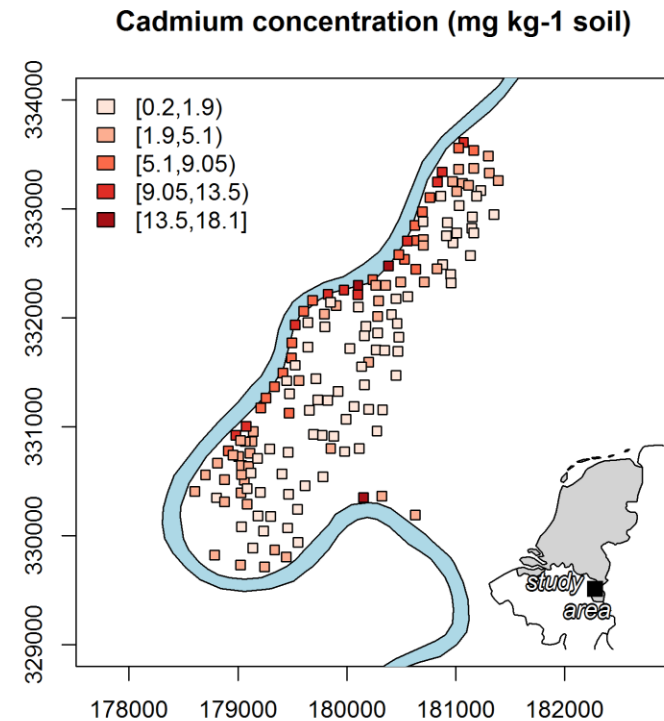


<http://r-spatial.org/2016/11/29/openeo.html>



# R as a GIS

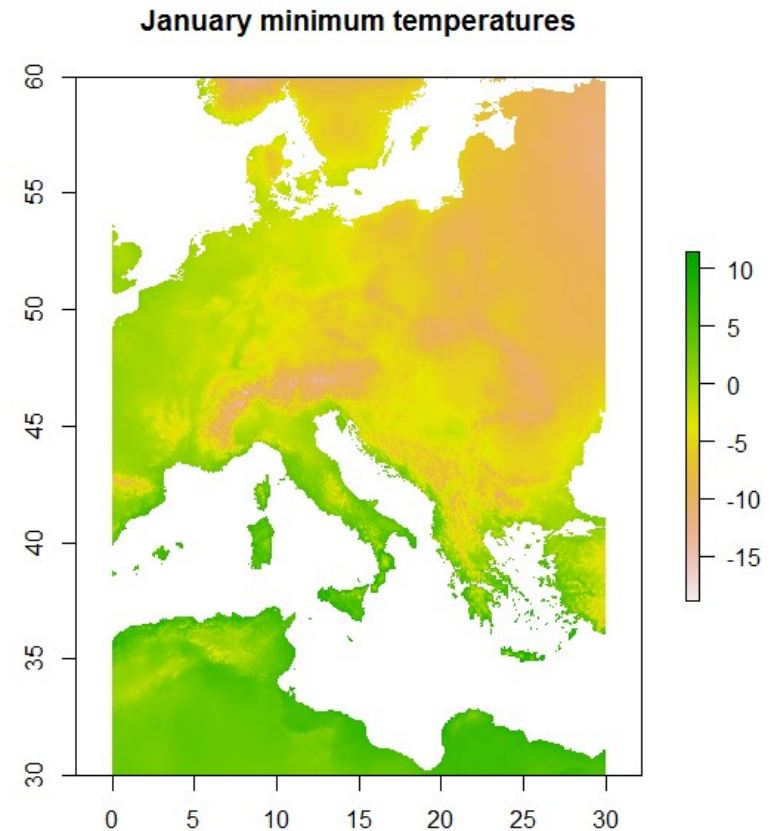
- More than 100 geo-related R packages (<https://cran.r-project.org/web/views/Spatial.html>)
- Package **rgdal** for importing and exporting geodata
- Packages **sp** and **sf** for vector geodata



Data: Rikken, M.G.J & Van Rijn, R.P.G. (1993).

# R as a GIS

- More than 100 geo-related R packages (<https://cran.r-project.org/web/views/Spatial.html>)
- Package **rgdal** for importing and exporting geodata
- Packages **sp** and **sf** for vector geodata
- Package **raster** for raster geodata



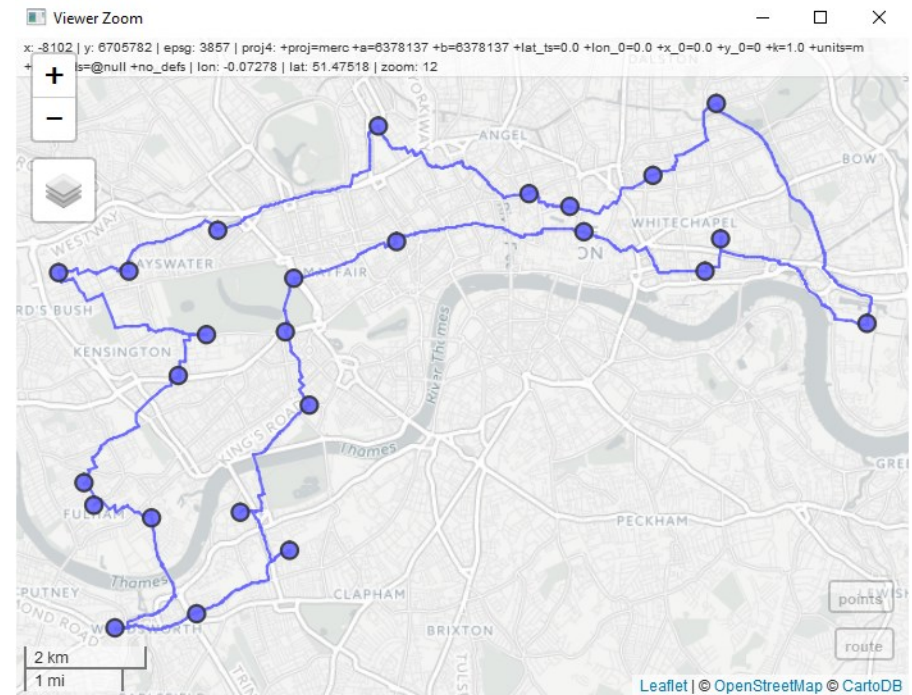
Data: <http://www.worldclim.org/>.

# Interactive map handling



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- Interactive visualization through **mapview** (based on **leaflet**)



# R as a GIS



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Defining a GIS as a system for the analysis, manipulation and visualization of geographical data (Longley, Goodchild, Maguire, and Rhind 2011), one could argue that R has become a GIS

# But what about...



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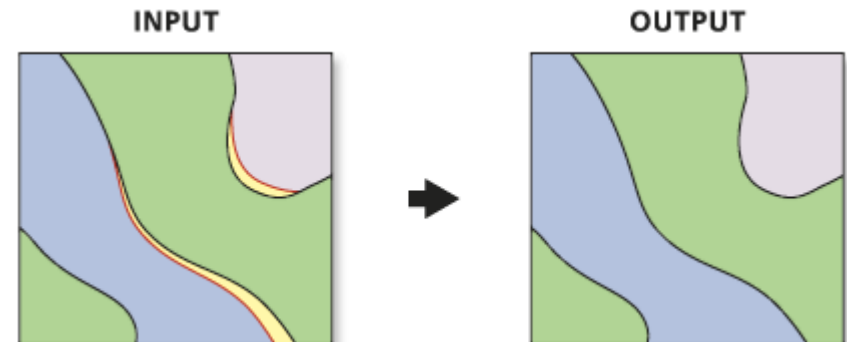


(digitizing)



(Geodatabase-functionality  
and topology rules)

<http://www.unioneag.org>

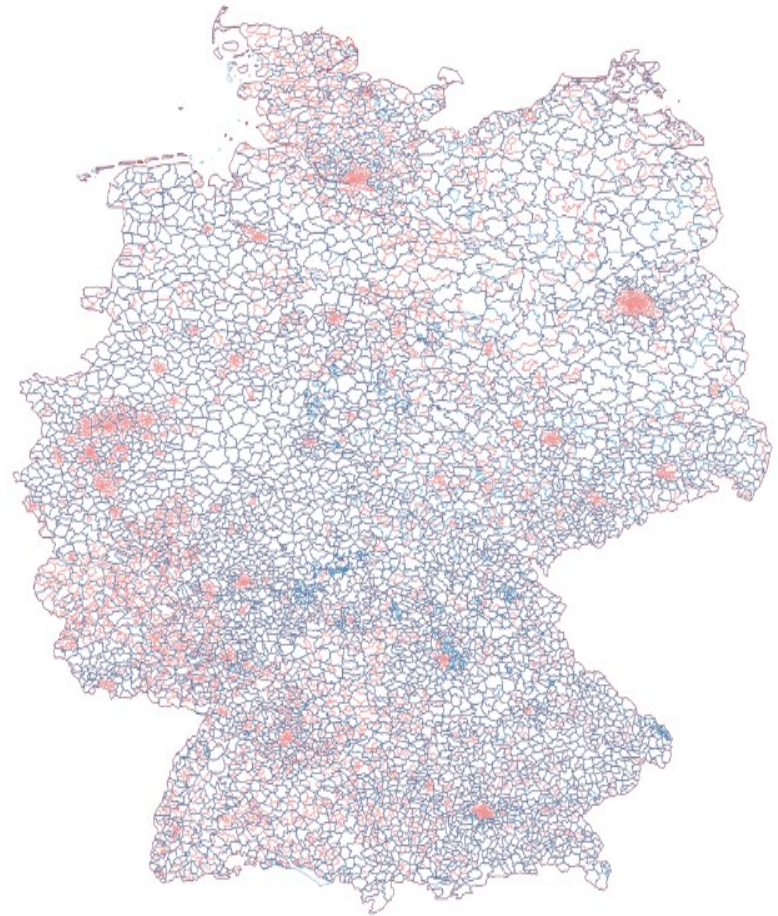




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# Computationally demanding operations

- Computationally demanding operations

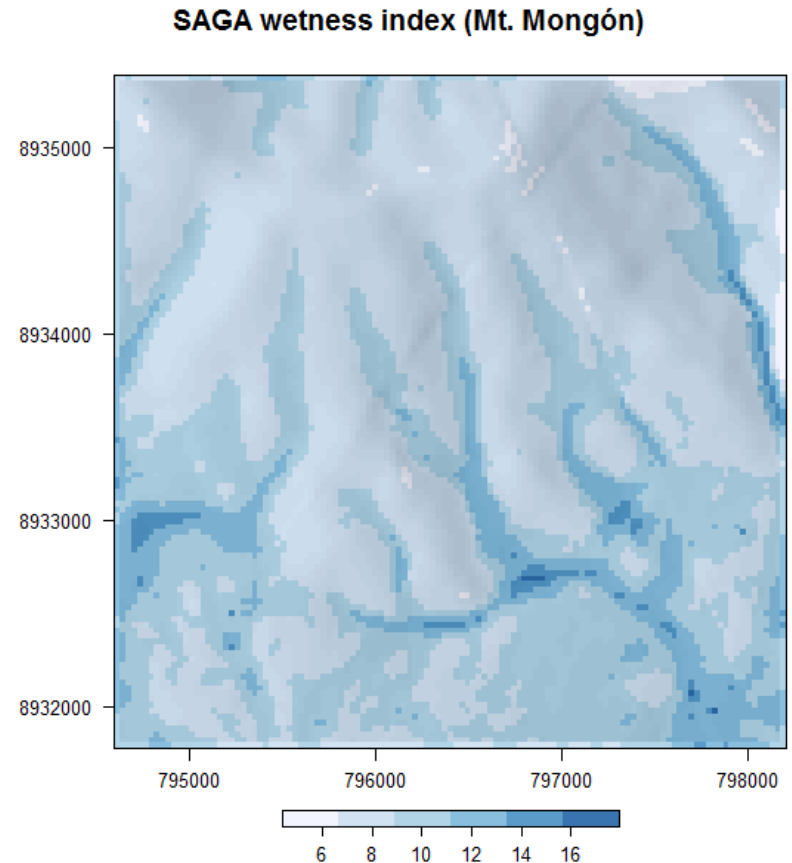




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# Missing geoalgorithms

- Catchment area
- Catchment slope
- Saga Wetness Index
- Lidar processing
- ...





# Interface



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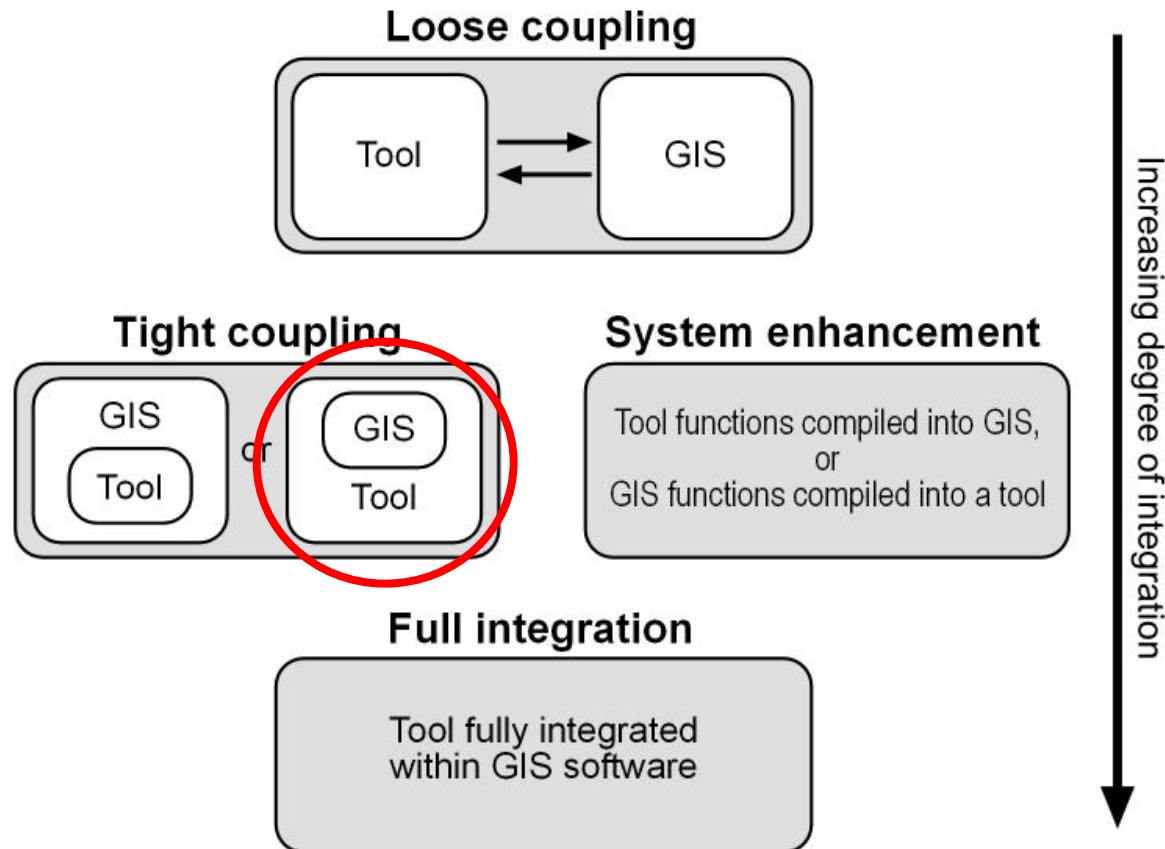
R has been designed from the beginning as an interactive interface to other software packages (Chambers, 2016).



# GIS interfaces



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<http://www.geocomputation.org/2000/GC009/Gc009.htm>

# R-GIS bridges



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RSAGA



RQGIS



GRASS GIS

rgrass7



RPyGeo

# GIS-R bridges



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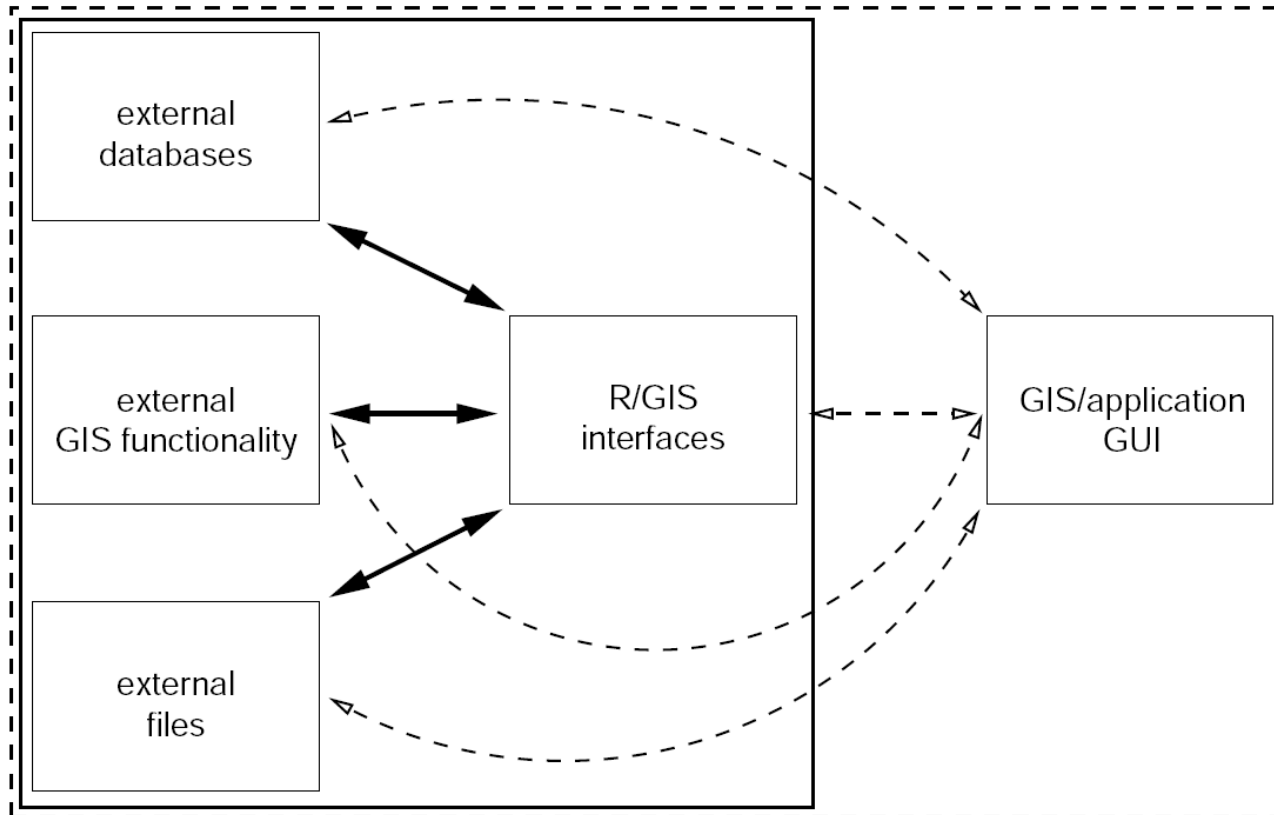
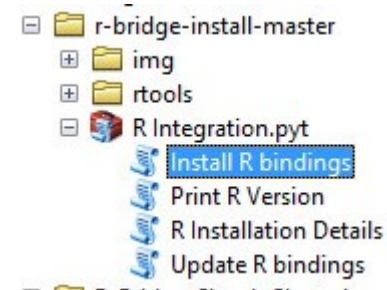
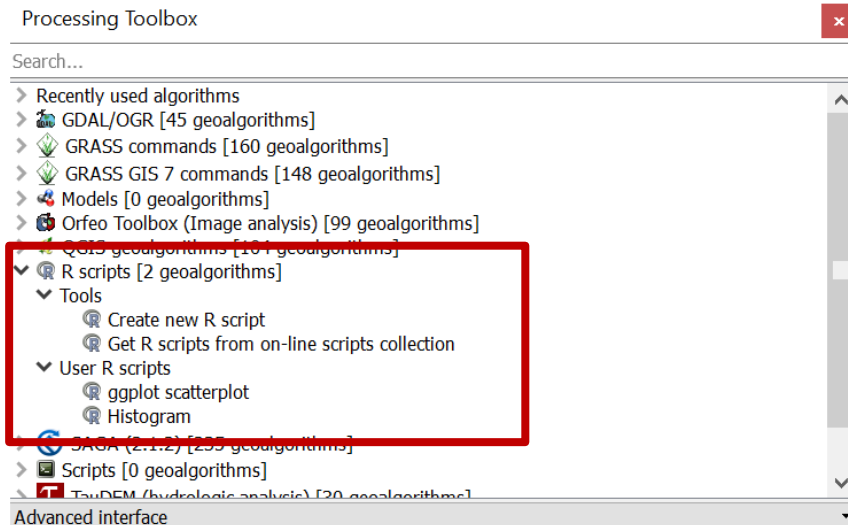


Figure taken from Bivand, 2014.

# GIS-R bridges – QGIS & ArcGIS



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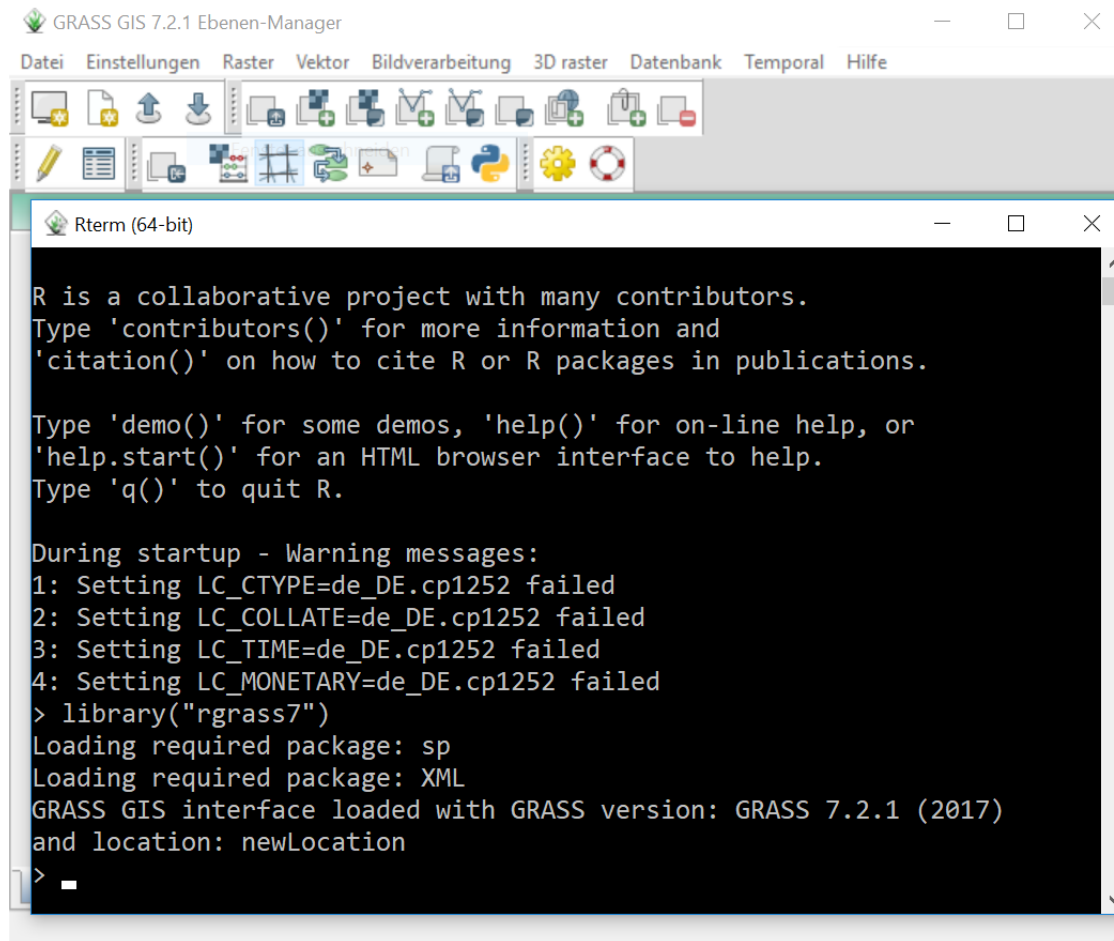


<https://www.r-bloggers.com/combining-arcgis-and-r-clustering-toolbox/>

# GIS-R bridges - GRASS



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The image shows two overlapping windows from a Linux desktop. The top window is titled 'GRASS GIS 7.2.1 Ebenen-Manager' and has a menu bar with 'Datei', 'Einstellungen', 'Raster', 'Vektor', 'Bildverarbeitung', '3D raster', 'Datenbank', 'Temporal', and 'Hilfe'. Below the menu is a toolbar with various icons for file operations and GIS processing. The bottom window is titled 'Rterm (64-bit)' and contains a terminal window with a black background and white text. The text in the terminal is as follows:

```
R is a collaborative project with many contributors.  
Type 'contributors()' for more information and  
'citation()' on how to cite R or R packages in publications.  
  
Type 'demo()' for some demos, 'help()' for on-line help, or  
'help.start()' for an HTML browser interface to help.  
Type 'q()' to quit R.  
  
During startup - Warning messages:  
1: Setting LC_CTYPE=de_DE.cp1252 failed  
2: Setting LC_COLLATE=de_DE.cp1252 failed  
3: Setting LC_TIME=de_DE.cp1252 failed  
4: Setting LC_MONETARY=de_DE.cp1252 failed  
> library("rgrass7")  
Loading required package: sp  
Loading required package: XML  
GRASS GIS interface loaded with GRASS version: GRASS 7.2.1 (2017)  
and location: newLocation  
> █
```



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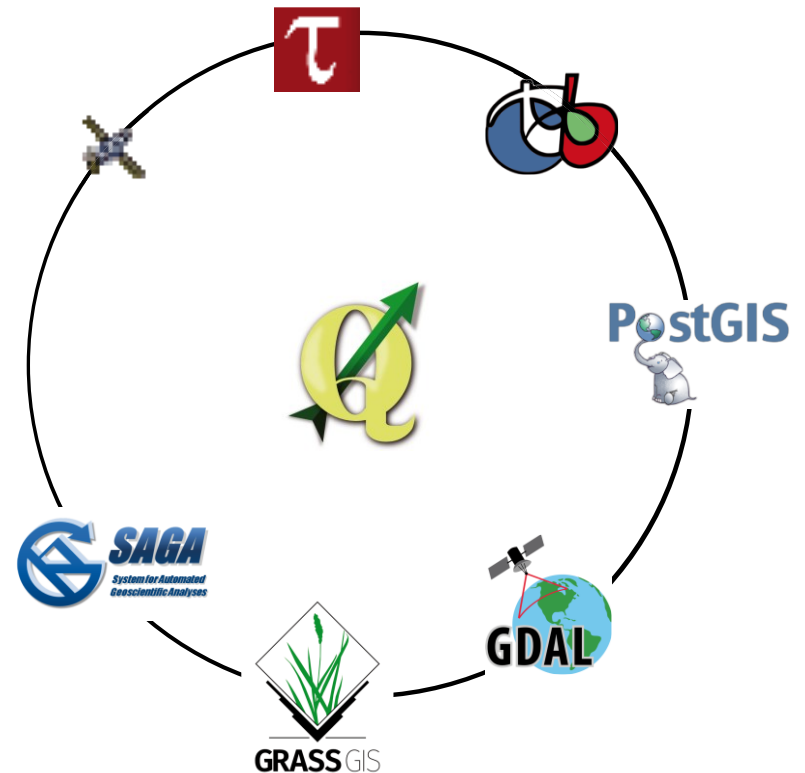
**R-GIS BRIDGES**

# Why (R)QGIS?



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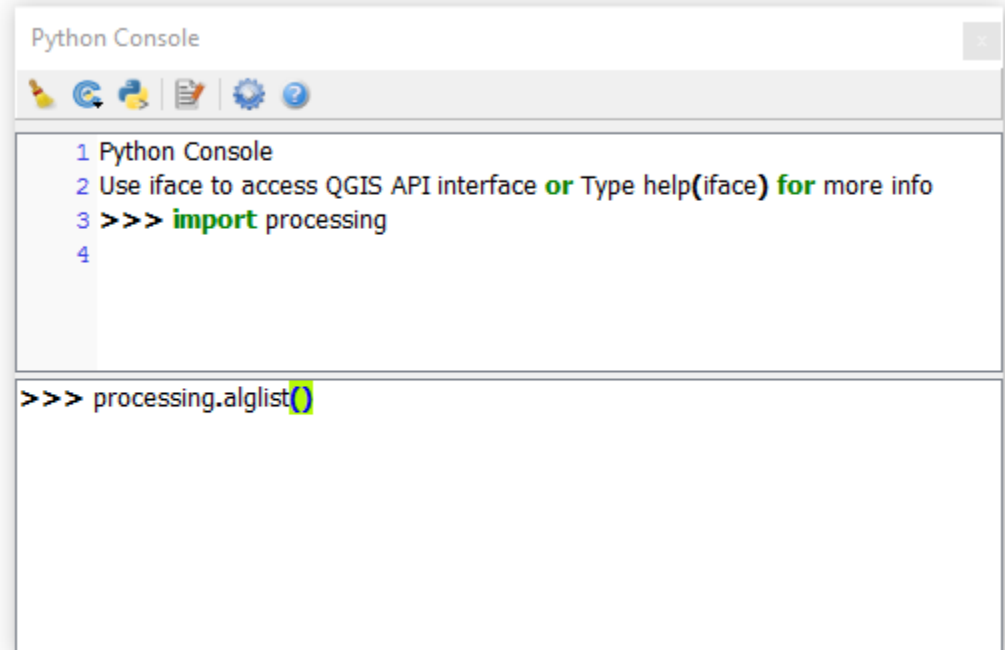
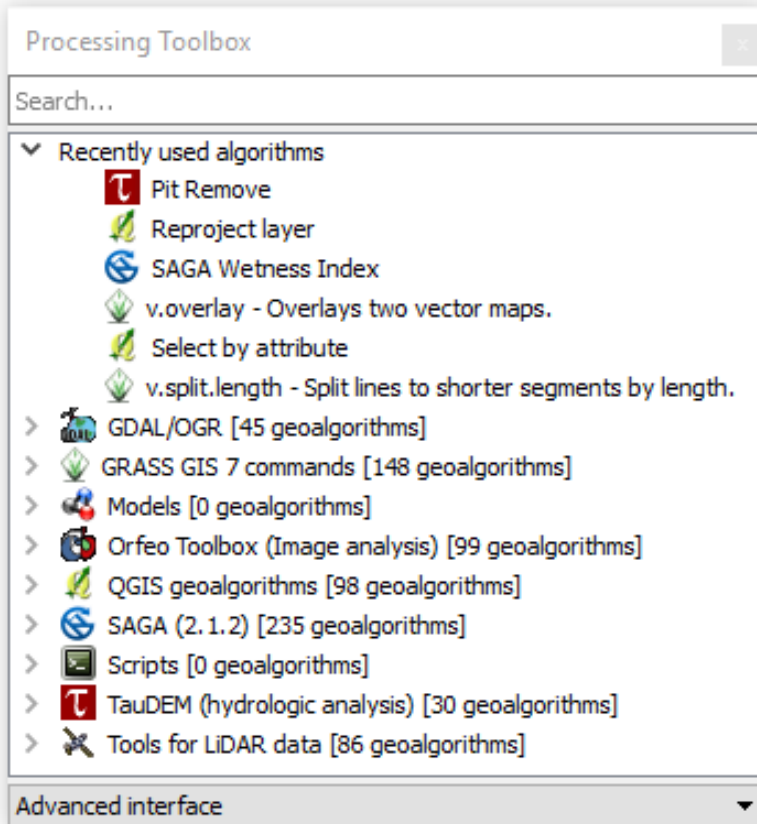
- One of the most-widely used Desktop GIS
- Unified interface
- Quite user-friendly



# QGIS – Python API



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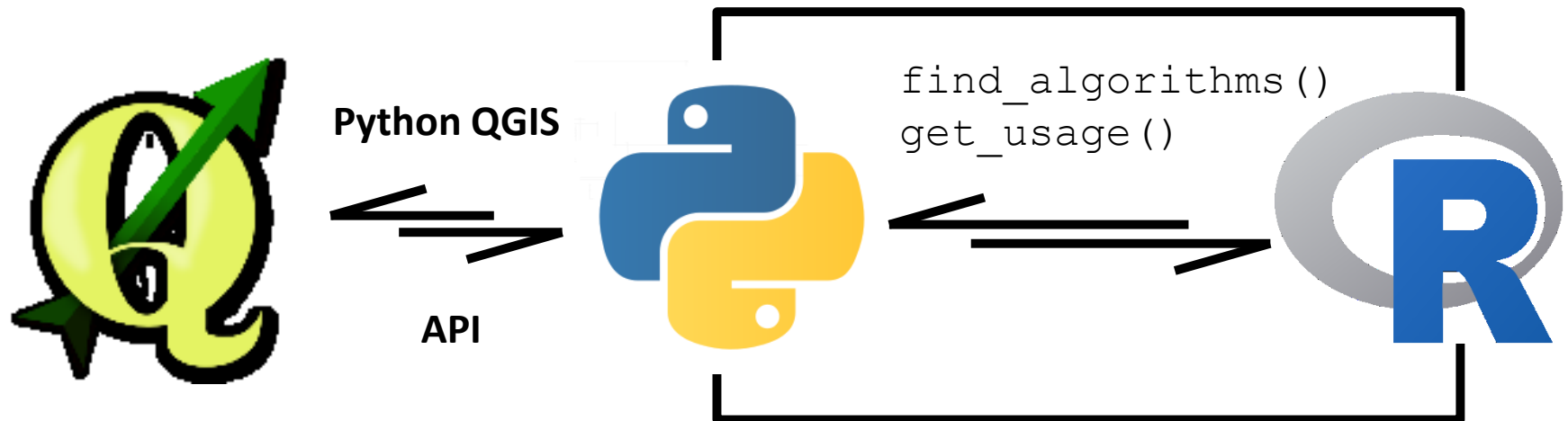


# Python tunnel via reticulate



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Python tunnel via **reticulate** (`open_app()`)





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## Example

```
library("RQGIS")  
get_usage("saga:sagawetnessindex")
```

```
ALGORITHM: Saga wetness index  
  DEM <ParameterRaster>  
  SUCTION <ParameterNumber>  
  AREA_TYPE <ParameterSelection>  
  SLOPE_TYPE <ParameterSelection>  
  SLOPE_MIN <ParameterNumber>  
  SLOPE_OFF <ParameterNumber>  
  SLOPE_WEIGHT <ParameterNumber>  
  AREA <OutputRaster>  
  SLOPE <OutputRaster>  
  AREA_MOD <OutputRaster>  
  TWI <OutputRaster>
```

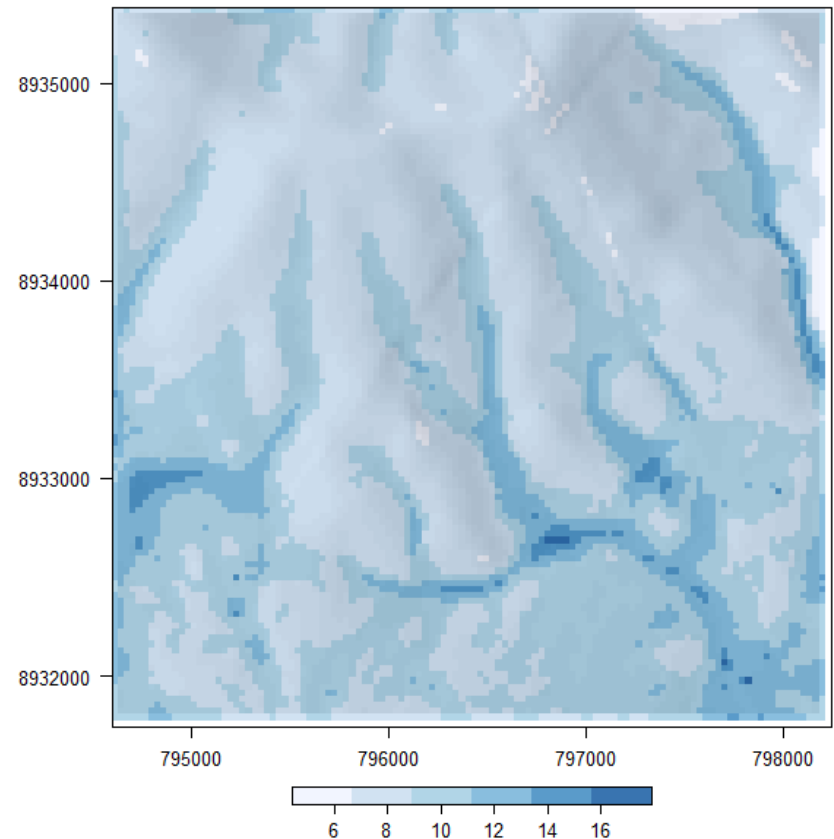
```
open_help("saga:sagawetnessindex")
```

# Let's run\_qgis



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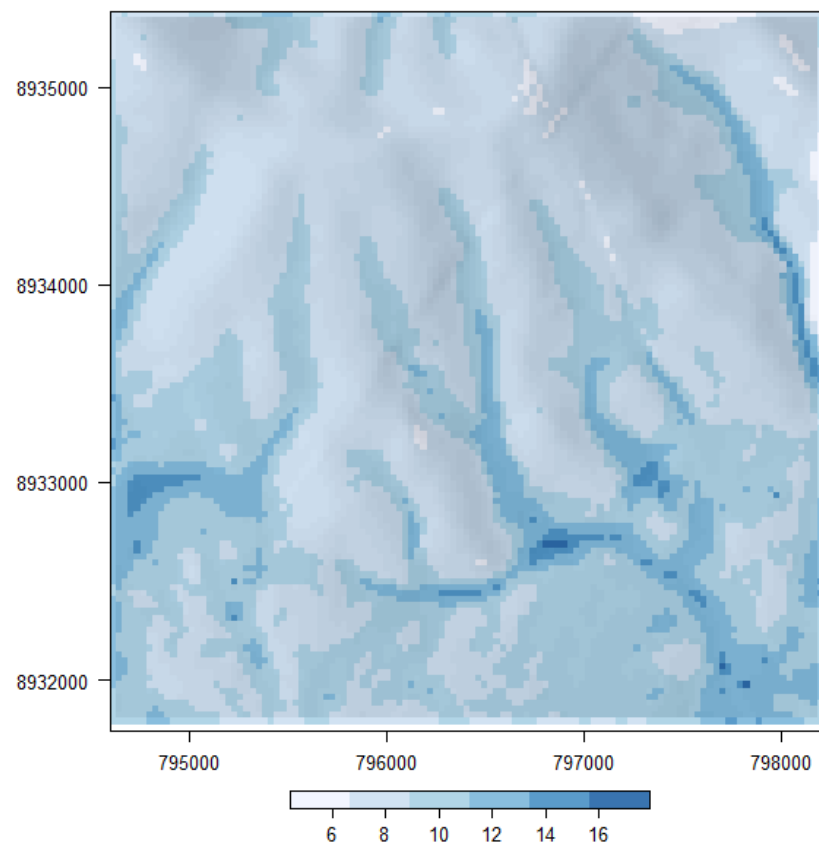
```
data("dem")
twi <- run_qgis(
  "saga:sagawetnessindex",
  DEM = dem,
  TWI = "twi.tif",
  load_output = TRUE)
```



# Let's run\_qgis

Spatial object residing  
in R

```
data("dem")  
twi <- run_qgis(  
  "saga:sagawetnessindex",  
  DEM = dem,  
  TWI = "twi.tif",  
  load_output = TRUE)
```

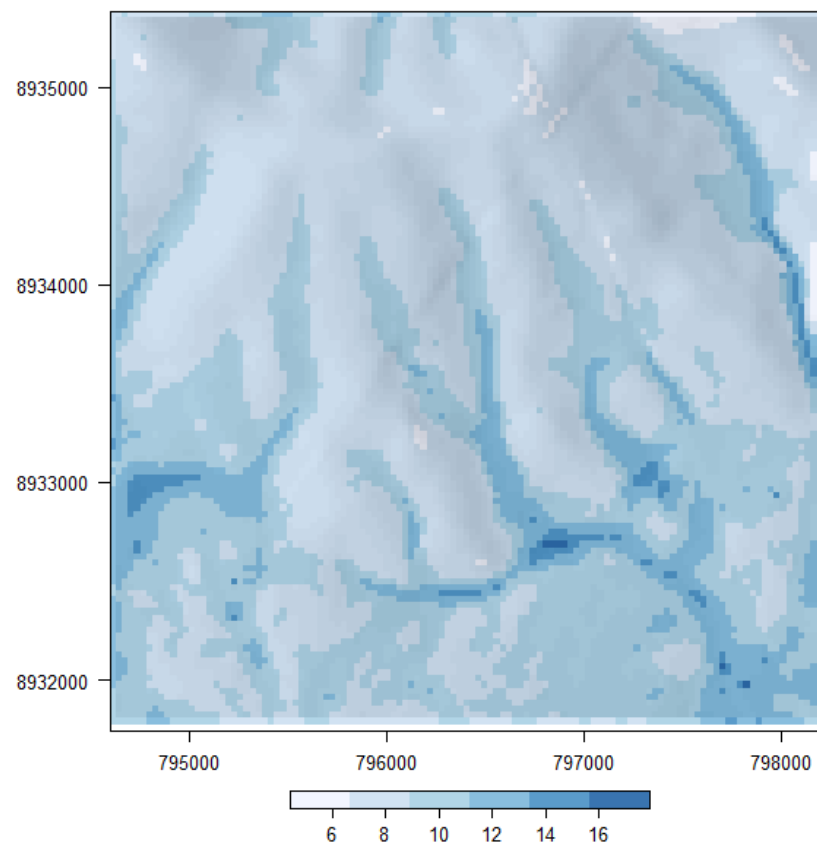


# Let's run\_qgis

Spatial object residing  
in R

```
data("dem")  
twi <- run_qgis(  
  "saga:sagawetnessindex",  
  DEM = dem,  
  TWI = "twi.tif",  
  load_output = TRUE)
```

Loads automatically the QGIS output  
back into R



# (R)SAGA



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- First SAGA release in 2004
- Also open-source
- Started out with a focus on raster processing
- >600 geoalgorithms
- Documentation improvable



**RSAGA**



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# RSAGA interface

- The RSAGA package provides R geocomputing functions that make use of the command line interface of SAGA GIS, `saga_cmd.exe`, to execute SAGA GIS modules.

```
#####  ##  #####  ##  
###    ##  ##      ###  
###   #  ##  ##  #####  #  ##  
      ### #####  ##    # #####  
##### #    ##  ##### #    ##
```

SAGA Version: 2.1.2 (64 bit)

under GNU General Public License (GPL)

Usage:

```
saga_cmd [-h, --help]  
saga_cmd [-v, --version]
```



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# RSAGA structure

## Geoprocessing environment

- List data structure with information on working directory, location of SAGA GIS binaries, etc.

## Geoprocessor (using SAGA GIS)

- Workhorse that calls SAGA GIS and provides low-level access to all SAGA GIS modules

## User-level interface functions (using SAGA GIS):

- e.g., `rsaga.local.morphometry`, `rsaga.hillshade`

## Local and focal functions (written in R):

- e.g., `multi.focal.function`, `grid.predict`

## Utility functions (written in R):

- e.g., `pick.from.ascii.grid`





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# The R-GRASS interface

- First released in 1984
- In the beginning developed by the US Army (1982 – 1995), also with a focus on raster processing
- Since 1997 developed by scientists/user community
- >500 geospatial algorithms
- Great documentation
- Uses SQLite as a geodatabase in the background



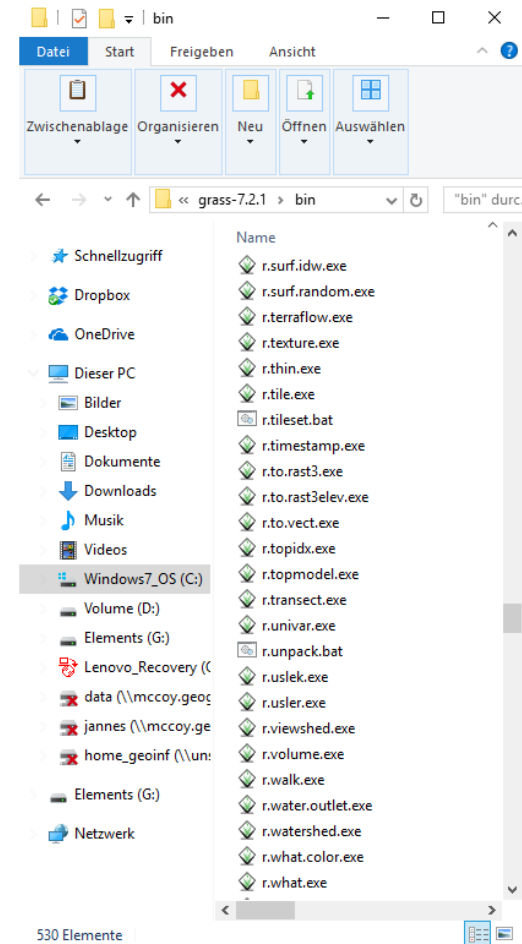
**rgrass7**



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# The R-Grass interface

“GRASS is a very large but very simple system – it is run as a collection of separate programs built using shared libraries of core functions. There is then no GRASS ‘program’, just a script setting environment variables needed by the component programs” (Bivand et al. 2008: 99).



# If you want to know more...

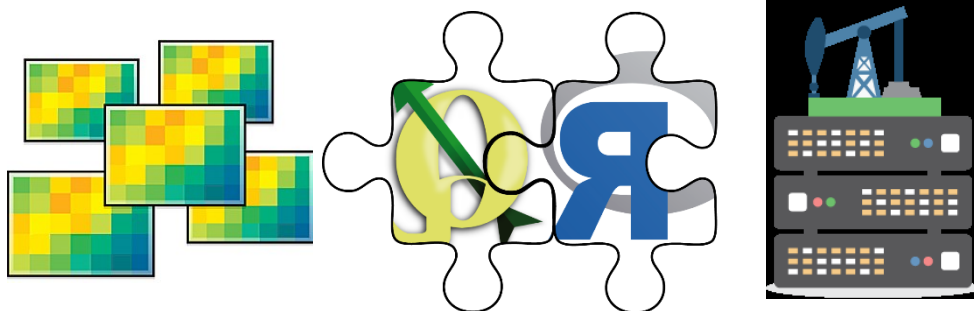


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- <http://robinlovelace.net/geocompr/>
- <https://github.com/jannes-m/geocompr/blob/master/13-gis.Rmd>



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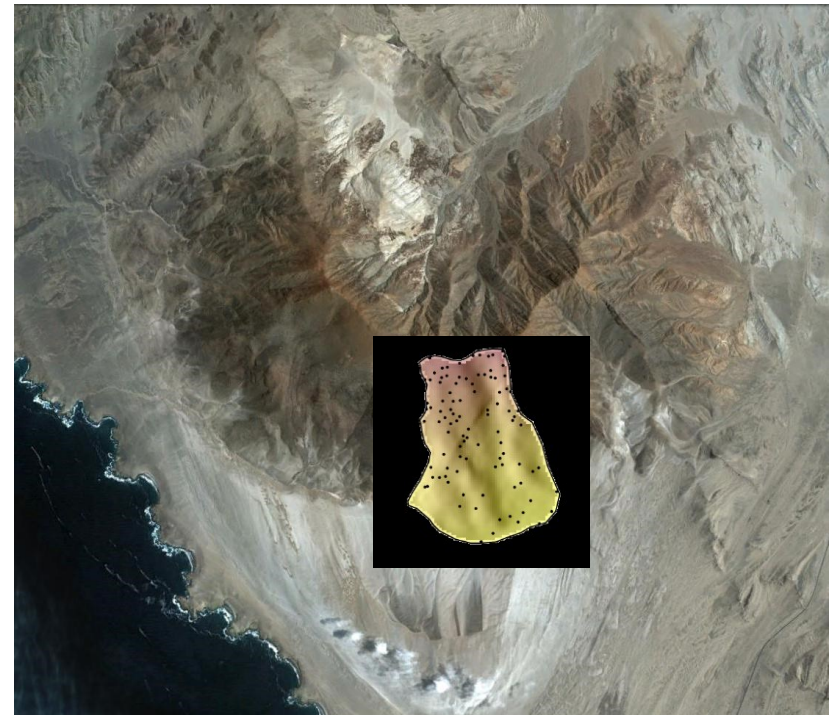


## R-GIS EXAMPLES

# Study area – Mount Mongón



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Source: Google Earth.

## Lomas – scientific context

- Highly endemic and strongly endangered vegetation formation just living of fog
- Altitudinal gradient
- Influence of ENSO
- Spatial prediction map of species richness to delineate conservation areas





# Austral summer



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# Austral winter



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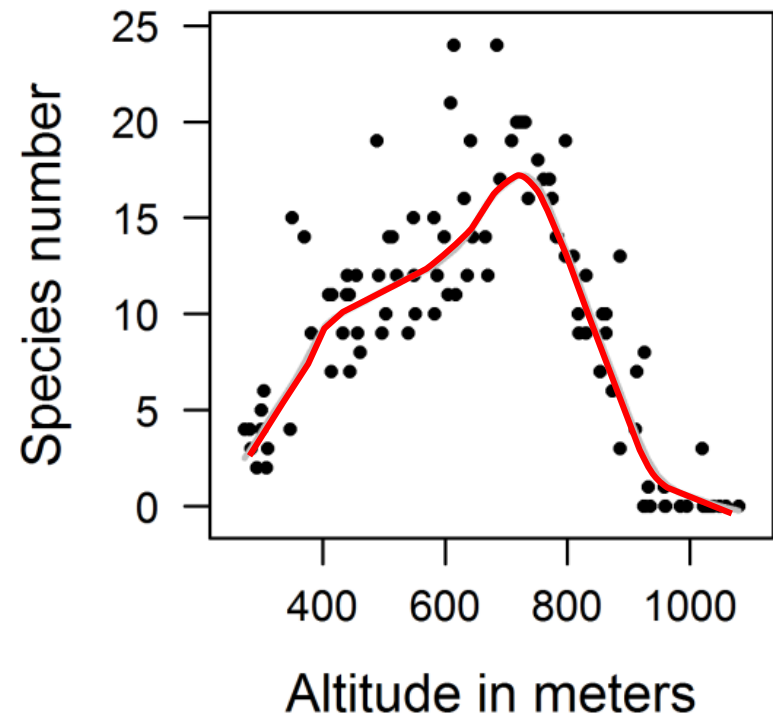




# Non-linear Poisson model

Predictors:

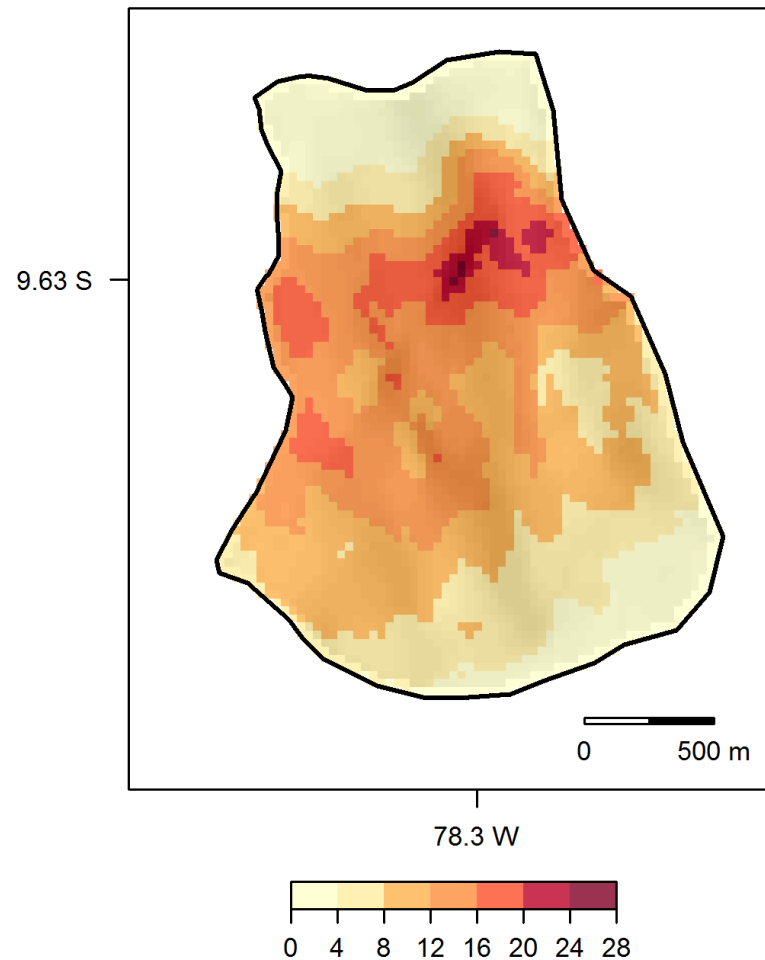
- Altitude
- catchment slope
- catchment area
- SAGA wetness index
- Curvatures
- solar radiation
- etc.



# Spatial prediction of plant species diversity



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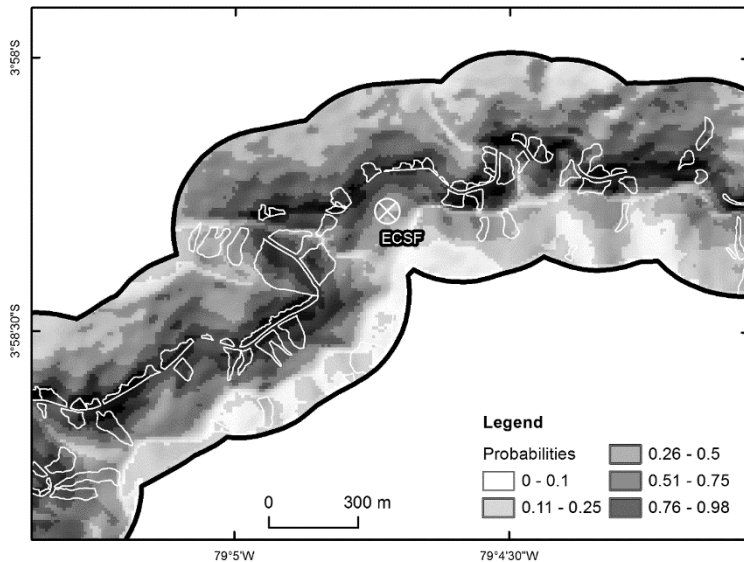


Muenchow et al. (2013): Predictive mapping of species richness and plant species' distributions.

# Landslide susceptibility



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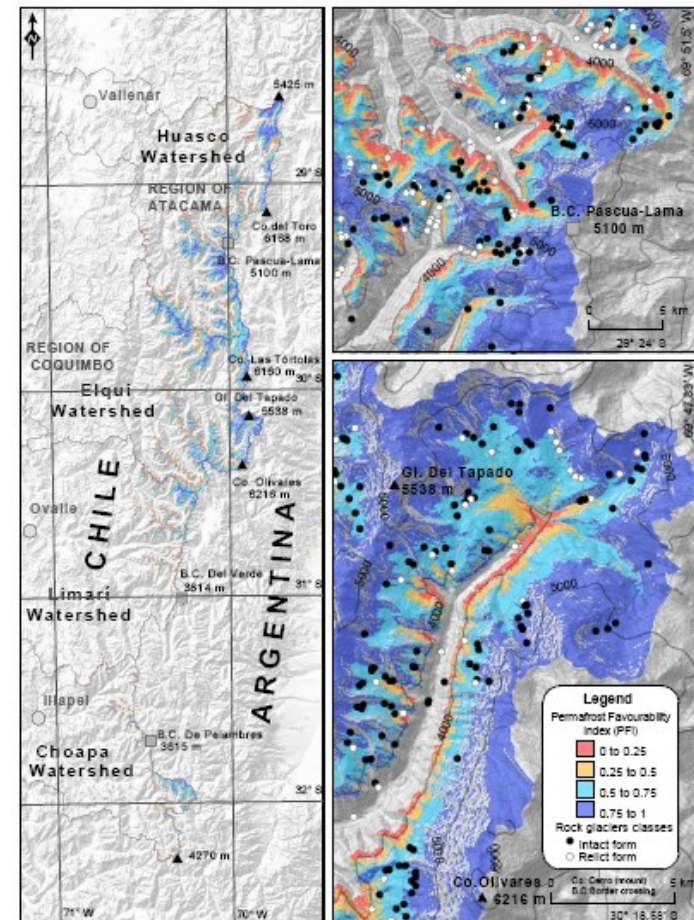
Brenning et al. (2015): Landslide susceptibility near highways.

# Rock glaciers/permafrost



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- Computation of direct and diffuse incoming solar radiation



Azócar et al. (2017): Permafrost distribution modeling.

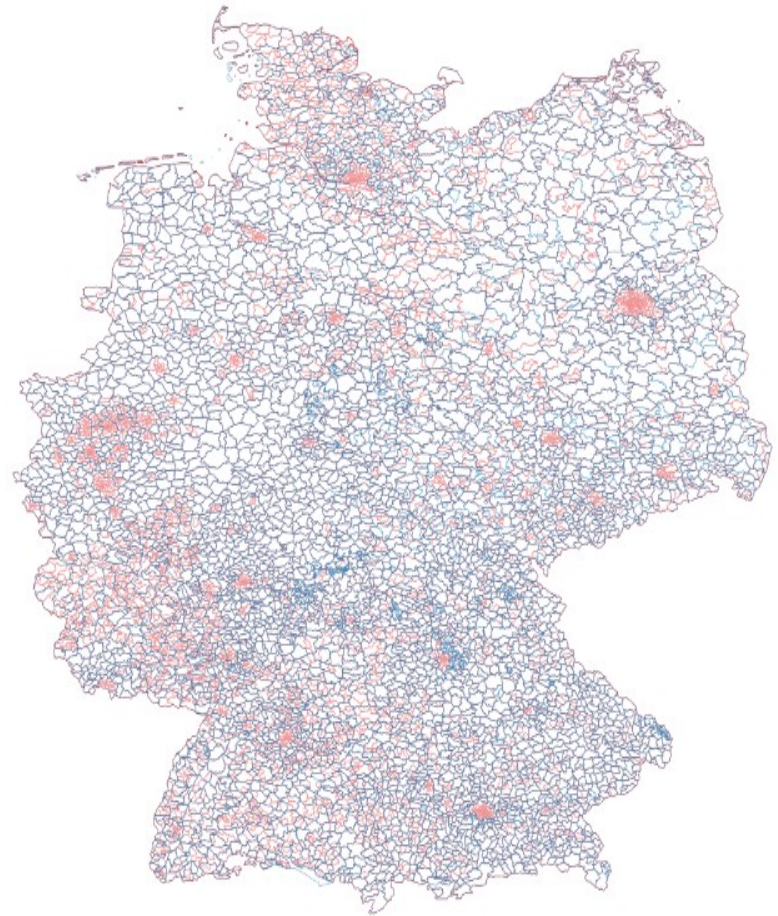


# Geomarketing



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- Unioning postal code with municipality layers





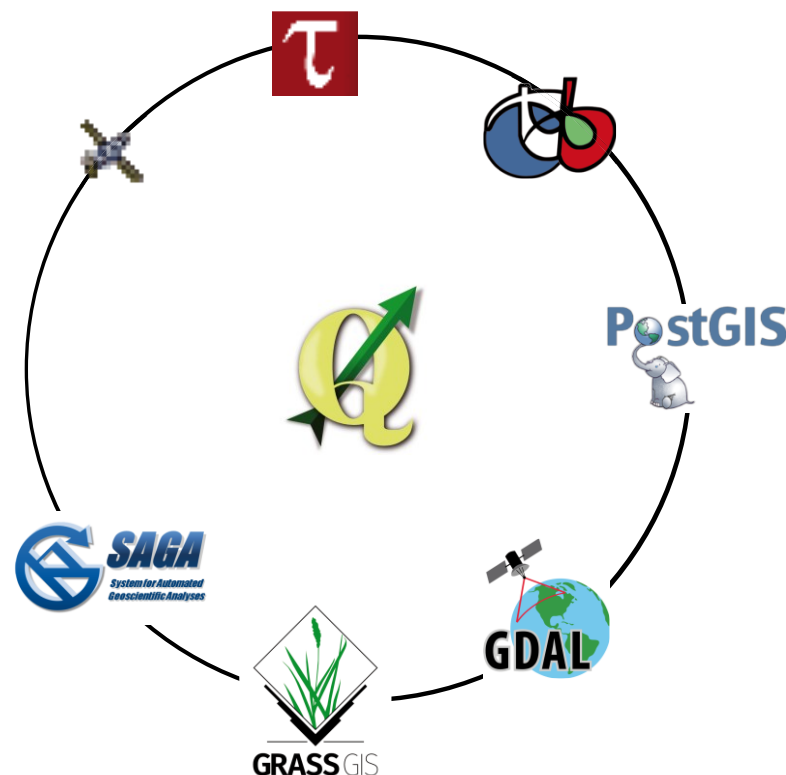
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## COMPARING R/GIS BRIDGES

# RQGIS vs. RSAGA/rgrass7

- Unified interface to SAGA, GRASS and further 3rd-party providers
- User-friendly
  - `open_help()`
  - R named arguments
  - Automatic retrieval of default values
  - On-the-fly import/export of spatial objects (`run_qgis`)
  - Automatic data conversions (e.g., asc, tif, etc.)



# But:



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- QGIS does not provide access to all SAGA and GRASS functionalities
- RSAGA has special geocomputing functions (written in R)
- QGIS establishes a new GRASS session for each call and barely supports the GRASS geodatabase



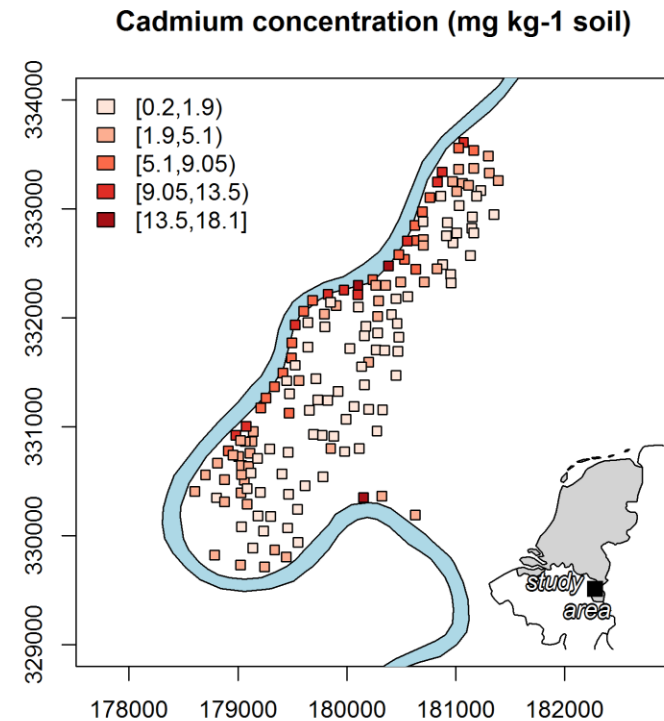


# Wrap-up



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- We can use R as a GIS



Data: Rikken, M.G.J & Van Rijn, R.P.G. (1993).

# Wrap-up



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- We can use R as a GIS
- Geoprocessing is (often) better done with the help of a GIS

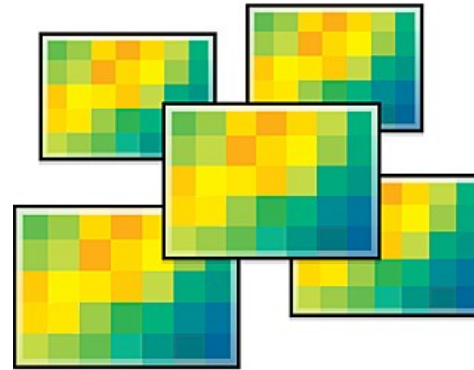


# Wrap-up



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- We can use R as a GIS
- Geoprocessing is (often) better done with the help of a GIS
- R-GIS integration combines the best of two worlds
- RQGIS, RSAGA, rgrass7 are all great





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# (R)QGIS installation instructions

Please follow the installation guide:

[http://jannes-m.github.io/RQGIS/articles/install\\_guide.html](http://jannes-m.github.io/RQGIS/articles/install_guide.html)

## **Windows Users:**

Use the OSGeo4W-installer (<http://trac.osgeo.org/osgeo4w/>)

## **Mac Users:**

Due to some strange issues, you need to install the QGIS Kynchaos version (otherwise GRASS might not work)



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# Literature

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