Geodata and algorithms in R

Geographic raster data in R

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DAAD summer school

Find the slides and the code

https://github.com/giscience-fsu/daad_summerschool

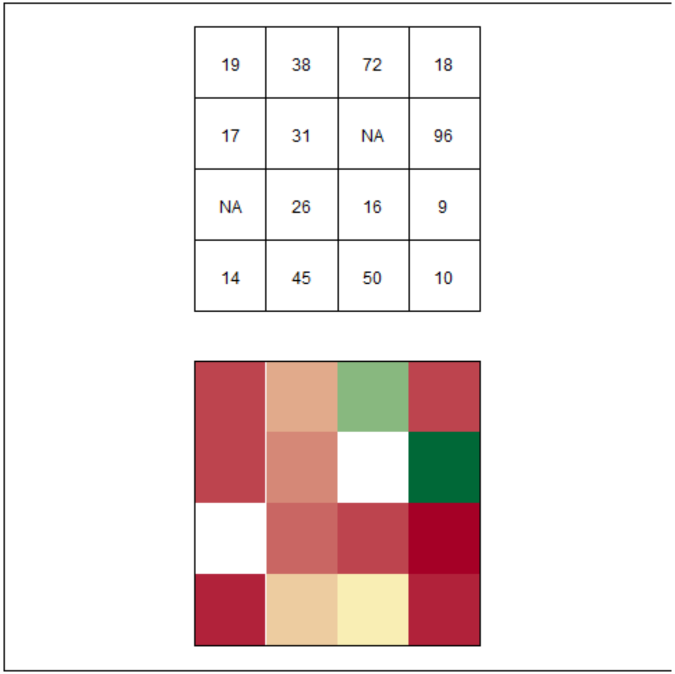
Please install following packages:

```
install.packages(c("sf", "raster", "spData", "dplyr", "RQGIS"))
```

Or use our geocompr docker image. See the geocompr landing page for instructions how to use it.

Raster data model

- Continous fields represented by pixels (cells)



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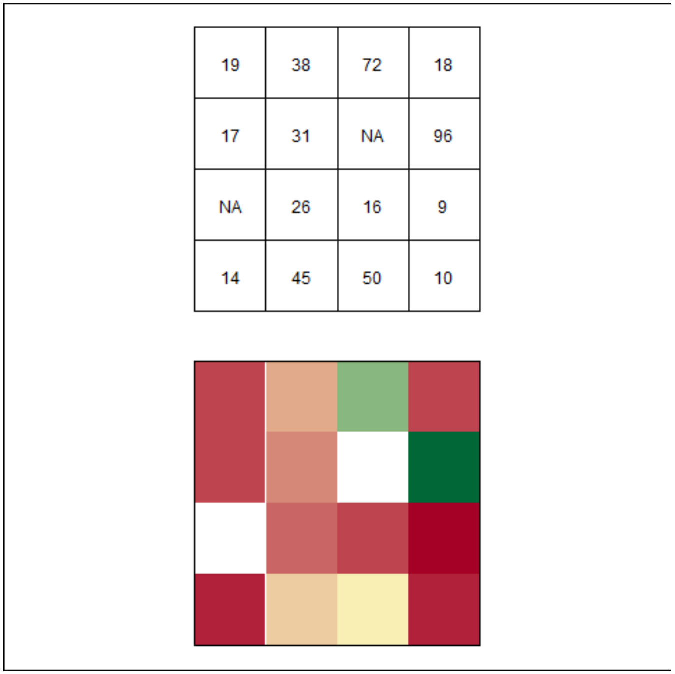

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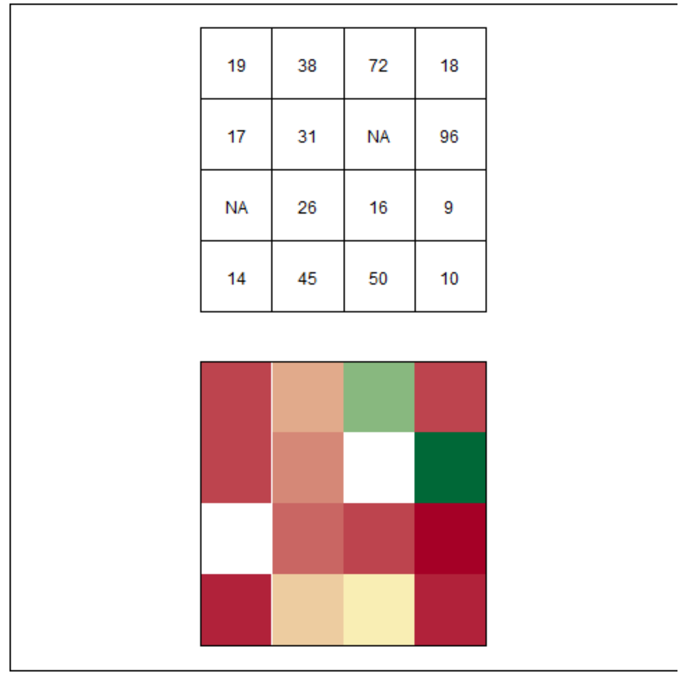

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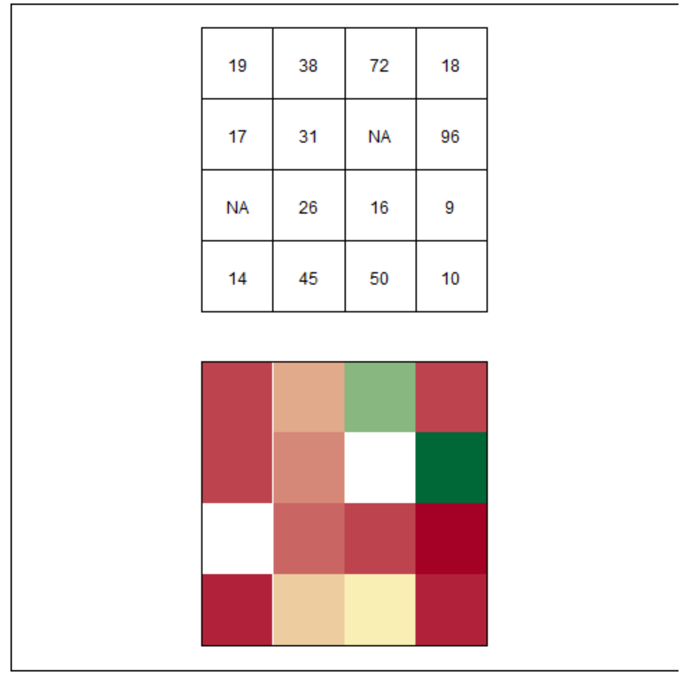

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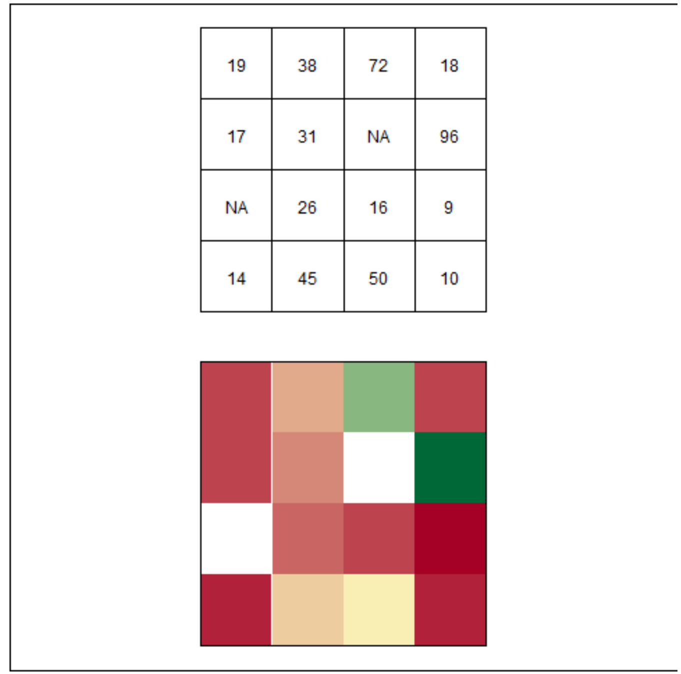

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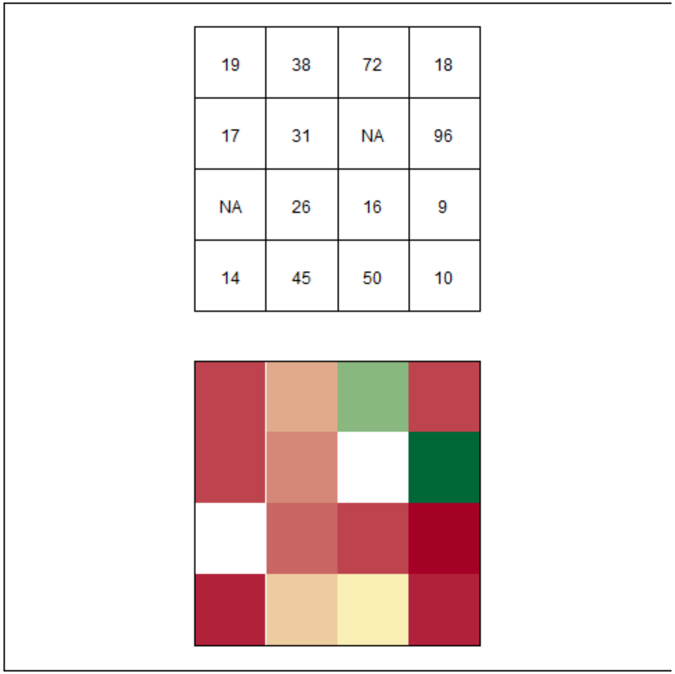

Further reading: https://geocompr.robinlovelace.net/spatial-class.html#raster-data

Raster data in R

Remember: the geographic raster data model is used to represent continuous surfaces. Rasters consist of a **header** and a **matrix** containing the actual values. Let's create a raster from scratch. In R we use the popular **raster** package written by Robert J. Hijmans (Hijmans, 2019).

Raster data in R

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```
library(raster)
elev = raster(nrow = 6, ncol = 6, res = 0.5,
              xmn = -1.5, xmx = 1.5,
              ymn = -1.5, ymx = 1.5,
              vals = 1:36)
```

Raster data in R

```
elev
```

```
## class       : RasterLayer
## dimensions  : 6, 6, 36  (nrow, ncol, ncell)
## resolution  : 0.5, 0.5  (x, y)
## extent      : -1.5, 1.5, -1.5, 1.5  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +ellps=WGS84 +towgs84=0,0,0
## source      : memory
## names       : layer
## values      : 1, 36  (min, max)
```

Raster data in R

```
plot(elev)
```

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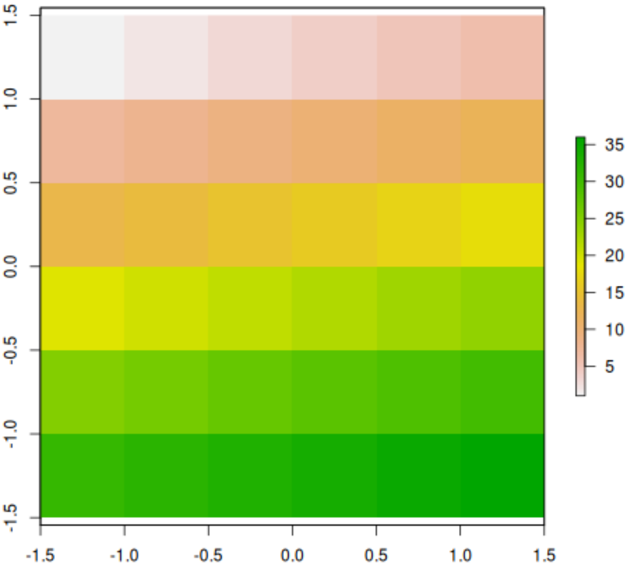

Raster attribute subsetting

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Further reading: https://geocompr.robinlovelace.net/attr.html#raster-subsetting

Spatial raster operations

Raster spatial operations - subsetting

using coordinates:

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extract(elev, data.frame(x = 0.75, y = 0.75))
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```
## [1] 11
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using a SpatialObject (`SpatialPointsDataFrame`):

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```

```
## [1] 11
```

using a SpatialObject (`SpatialPointsDataFrame`):

```
library(sf)
library(dplyr)
pt = st_point(c(0.75, 0.75)) %>%
  st_sfc %>%
  st_sf %>%
  as(., "Spatial")
# use the SpatialObject for subsetting
elev[pt]
```

```
## [1] 11
```

using another raster object:

```
clip =
  raster(nrow = 3, ncol = 3,
         res = 0.3, xmn = 0.6,
         xmx = 1.5, ymn = -0.45,
         ymx = 0.45,
         vals = rep(1, 9))
elev[clip]
```

```
## [1] 17 18 23 24
```

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elev[clip]
```

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## [1] 17 18 23 24
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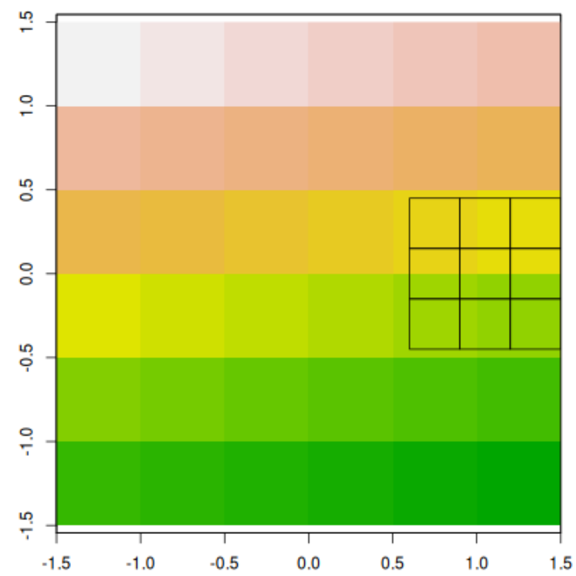

Map algebra - local operations

You may use with raster datasets:

- algebraic operators such as `+`, `-`, `*`, `/`
- logical operators such as `>`, `>=`, `<`, `==`, `!`
- functions such as `abs`, `round`, `ceiling`, `floor`, `trunc`, `sqrt`, `log`, `log10`, `exp`, `cos`, `sin`, `max`, `min`, `range`, `prod`, `sum`, `any`, `all`.

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```
elev + 1
elev^2
elev / 4
```

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Cell-by-cell operations are also called local operations. The calculation of the NDVI is one of the most popular examples.

Map algebra - focal operations

While local functions operate on one cell, though possibly from multiple layers, **focal** operations take into account a central cell and its neighbors. The neighborhood (also named kernel, filter or moving window) under consideration is typically of size 3-by-3 cells (that is the central cell and its eight surrounding neighbors) but can take on any other (not necessarily rectangular) shape as defined by the user.

Map algebra - focal operations

```
r_focal = focal(elev, w = matrix(1, nrow = 3, ncol = 3), fun = min)
```

Map algebra - zonal operations

Zonal operations are similar to focal operations. The difference is that zonal filters can take on any shape instead of just a predefined window. Let's compute the mean elevation for different soil grain size classes.

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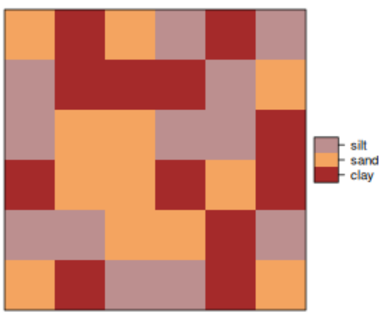

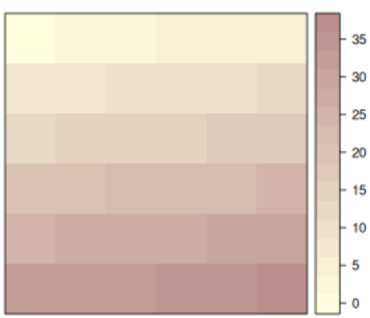

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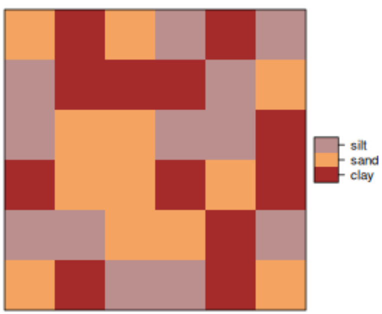

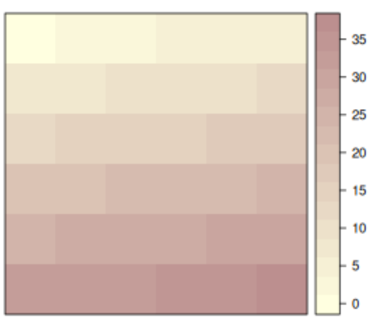


```r
library(spData)
zonal(elev, grain, fun = "mean")
```

```
##      zone  mean
## [1,]    1 17.75
## [2,]    2 18.50
## [3,]    3 19.25
```

Map algebra - global operations

Global operations are a special case of zonal operations with the entire raster dataset representing a single zone. The most common global operations are descriptive statistics for the entire raster dataset such as the minimum or maximum.

```
cellStats(elev, min)
```

```
## [1] 1
```

```
cellStats(elev, max)
```

```
## [1] 36
```

```
cellStats(elev, sd)
```

```
## [1] 10.53565
```

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```

Further reading: https://geocompr.robinlovelace.net/spatial-operations.html#spatial-ras

Your turn

- Attach `data("dem", package = "RQGIS")`. Retrieve the altitudinal values of the 10th row.
- Sample randomly 10 coordinates of `dem` with the help of the `sp::coordinates()`-command, and extract the corresponding altitudinal values.
- Attach `data("random_points", package = "RQGIS")` and find the corresponding altitudinal values. Plot altitude against `spri`.
- Compute the hillshade of `dem` (hint: `?hillShade`). Overlay the hillshade with `dem` while using an appropriate level of transparency.

Geometric operations on raster data

Intersecting geometry

If you want the intersecting geometry of two rasters, use the spatial subsetting syntax and set the `drop`-parameter to `FALSE`.

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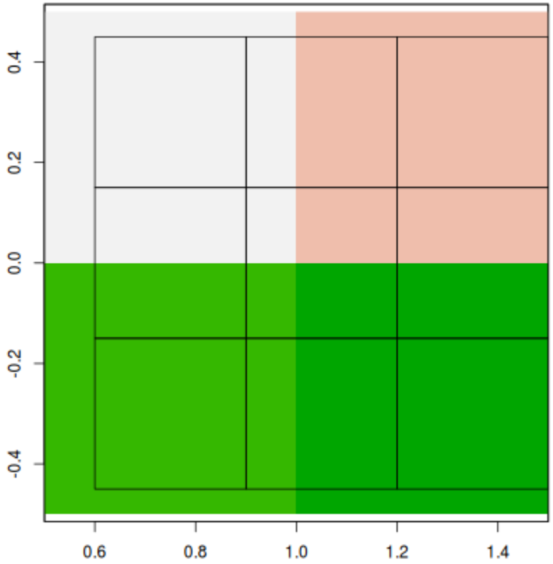
```
elev[clip, drop = FALSE]
```



Intersecting geometry

which in fact is the same as using `intersect()`:

```
raster::intersect(elev, clip)
```

```
## class       : RasterLayer
## dimensions  : 2, 2, 4  (nrow, ncol, ncell)
## resolution  : 0.5, 0.5  (x, y)
## extent      : 0.5, 1.5, -0.5, 0.5  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +ellps=WGS84 +towgs84=0,0,0
## source      : memory
## names       : layer
## values      : 17, 24  (min, max)
```

Aggregation and disaggregation

Change the resolution of a raster:

```
elev_agg =
  aggregate(elev, fact = 2,
            fun = mean)
```

Use `dissaggregate()` for increasing the spatial resolution of a raster

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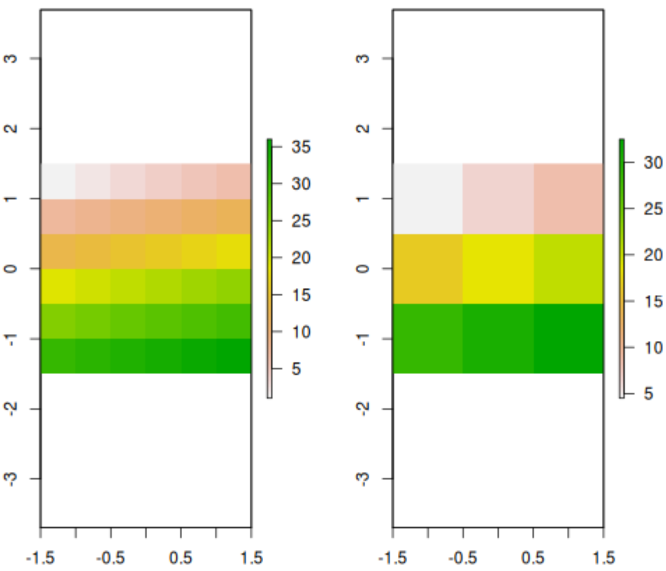

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library(spDataLarge)
proj4string(nz_elev)
```

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## [1] "+proj=tmerc +lat_0=0 +lon_0=173 +k=0.9996 +x_0=1600000 +y_0=10000000
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```
projectRaster(nz_elev, crs = st_crs(4326)$proj4string)
```

```
## class       : RasterLayer
## dimensions  : 1483, 1248, 1850784  (nrow, ncol, ncell)
## resolution  : 0.0119, 0.00901  (x, y)
## extent      : 164.9573, 179.8085, -47.53651, -34.17468  (xmin, xmax, ymin,
## crs         : +proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0
## source      : memory
## names       : elevation
## values      : 0, 3195.91  (min, max)
```

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## source      : memory
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```

Further reading on geometric raster operations:
https://geocompr.robinlovelace.net/geometric-operations.html#geo-ras

Your turn

- Decrease the resolution of `dem` (`data("dem", package = "RQGIS")`) by a factor of 10. Plot the result.
- Reproject `dem` into WGS84. Plot the output next to the original object.
- Randomly select three points of `random_points` (`data("random_points", package = "RQGIS")`). Convert these into a polygon (hint: `st_cast`). Extract all altitudinal values falling inside the created polygon Use the polygon to clip `dem`. What is the difference between `intersect` and `mask`. Hint: `sf` objects might not work as well with **raster** commands as `SpatialObjects`. Assuming your polygon of class `sf` is named `poly`, convert it into a `SpatialObject` with `as(sf_object, "Spatial)``.

Recap

We learned about:

- raster attribute operations
- spatial raster operations
- geometric raster operations

References

Hijmans, Robert J. (2019). *Raster: Geographic Data Analysis and Modeling*. R package version 2.8-19. URL: https://CRAN.R-project.org/package=raster.