**Spatio-temporal trend analysis of spatial climate data (temperature and rainfall) using R programming**

**Tutors:** Bruno Montibeller1 and Holger Virro1

1University of Tartu, Department of Geography, Chair of Geoinformatics.

Under the climate change threat, we need to quantify the spatio-temporal trend of temperature and rainfall patterns to understand and evaluate the potential impacts of climate change on ecosystems services, energy fluxes and biogeochemical processes. There are wide range of global or regional scale climate data freely available in a gridded format that can be used in spatio-temporal analysis studies. These data can be derived directly from satellite remote sensing data or based on reanalysis of time series of weather stations data. Additionally, some gridded data are also developed by the combination of time series of remote sensing data and weather stations data.

Different methodologies have combined spatial data sets and nonparametric statistical methods, such as the Mann-Kendall (MK) test, to infer about the temporal trends of climatic variables. The MK test analyzes if there is, or not, a monotonic trend in the series by calculating difference between earlier and later data points in the time series. Very high positive differences are an indicator of increasing trend whereas very low negative differences indicate decreasing trends. A statistical significance is also calculated for each trend using the normalized test statistic Z. In addition to the trend calculation, it is also possible to quantify the magnitude of the trends. The magnitudes can be estimated by using the nonparametric Sen statistic, more specifically, the Sen’s slope estimator, which is given by the median of the slopes of each pair of points. To calculate the Sen’s slope, the times series data is ordered accordingly to the time (as function of time) and a confidence interval is provided for each slope value.

The objective of this workshop is to give an overview of where to obtain gridded climate data, provide a simple R based workflow for data wrangling and perform trend analysis on gridded climate data. R is a freely available open source program for data manipulation, calculation and graphical display. For the workshop, the participants do not need any prior knowledge in R. However, it is highly recommended that the participants have installed R programming (Preferable version 3.6.3 - <https://www.r-project.org/>) and RStudio (RStudio Desktop - <https://rstudio.com/products/rstudio/download/#download>) beforehand. More information of how to install R programming and RStudio in the following link < <https://www.youtube.com/watch?v=orjLGFmx6l4>>.

During the workshop, the participants will learn how to handle and apply different operation on raster data and vector data in R. Some of the operation are: i) crop multiple raster using vector data and save as new files; ii) raster values check (e.g. outliers and NA); iii) conversion of raster into vector polygon data; iv) conversion of spatial data in tabular data (data frames); v) modify and reorganize data frames; vi) create and apply functions; vii) use conditions statements; viii) join operations; ix) create bivariate map; and x) save the results. We will be using the *raster, wql, dplyr, sf, biscale* and *ggplot2* libraries.