Monthly rainfall erosivity factor as a soil erosion prevention tool

Joint EFIPLANT & IEFC Annual Meeting 2019

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Joint work

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Outline

- Soil erosivity and R-factor
- Predicting the R-factor in the Basque Country with GAMs
- Conclusions

Soil erosion

- Climate, soil characteristics, topography, and crop conservation and management practices affect soil erosion.
- It also has an impact on ecosystem services, such as water quality and quantity, biodiversity, agricultural productivity and recreation.
- The ability to predict these effects is key.
- Rainfall is one of the main causes of soil erosion.

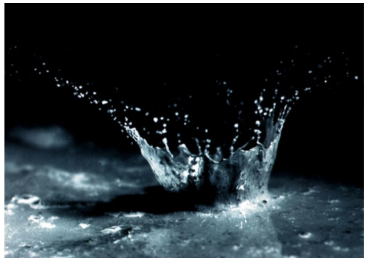
Soil loss Equations

- **USLE** (*Universal Soil Loss Equation*), developed by **US Department of Agriculture** (Wischmeier and Smith. 1960 and 1978).

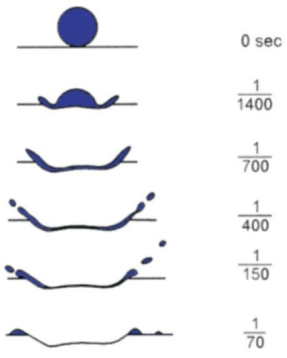
- **RUSLE** (*revised USLE*). Renard, et al. 1997

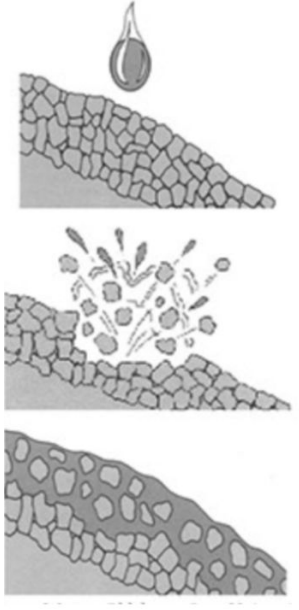
- It is a method to identify areas susceptible to erosion, as well as the rate of soil loss in the medium term.

Rainfall erosion factor



- The R factor is one of the most important aspects of the RUSLE model.
- It is the combined effect of the duration, magnitude and intensity of each rain event.





R-factor

- It is the product of kinetic energy (E) and the maximum intensity in 30 minutes (I_{30}). Weighted by the number of erosive events.
- **Formula:**

$$R = \frac{1}{n} \sum_{j=1}^{n} \sum_{k=1}^{m_j} (EI_{30})_k$$

- RIST (*Rainfall Intensity Summarisation Tool*) software (available at USDA)

REDES: Rainfall Erosivity Database on the European Scale

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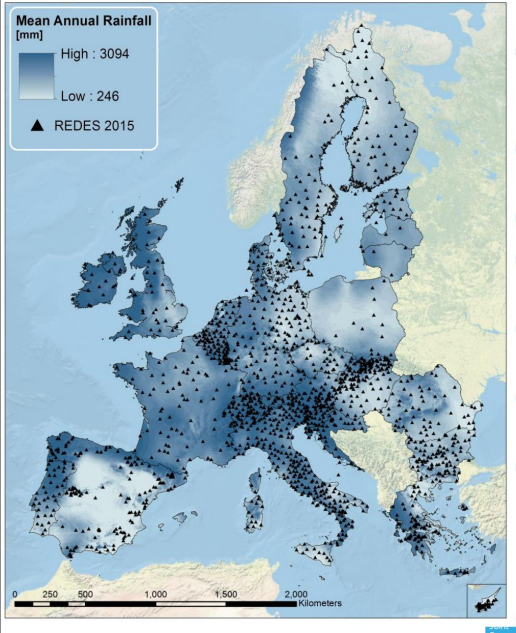
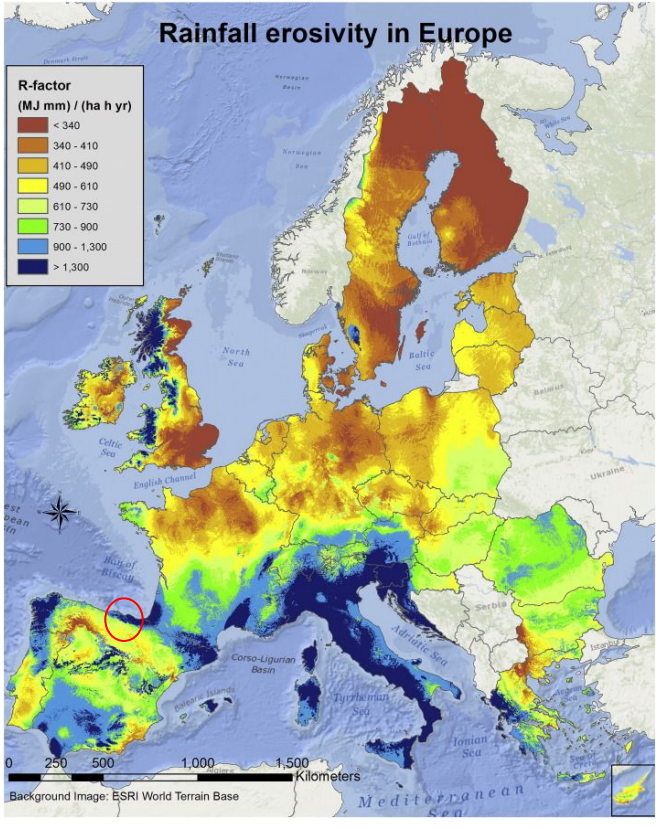


- **1,541** Precipitation stations with detailed rainfall intensity; **1675 Precipitation Stations** in 2015 update (all countries)
- **Calibration requested:** 5 min, 10-min, 15 min, 60 min.
- **Temporal Resolution**: 30-Minutes
- **Time series**: 7 – 56 Years (Mean: 17.1yr; 75% of time series in 2000-2010)
- **Data**: 29,000 years of High Temporal resolution rainfall records (GB of data)
- **Average density:** 1 station per 50km x 50km
- **Stations distribution**: 6.5% of the REDES stations in > 1,000m a.s.l

REDES: Rainfall Erosivity Database on the European Scale

Panagos, Ballabio, et al. 2015. *Science of the Total Environment.*

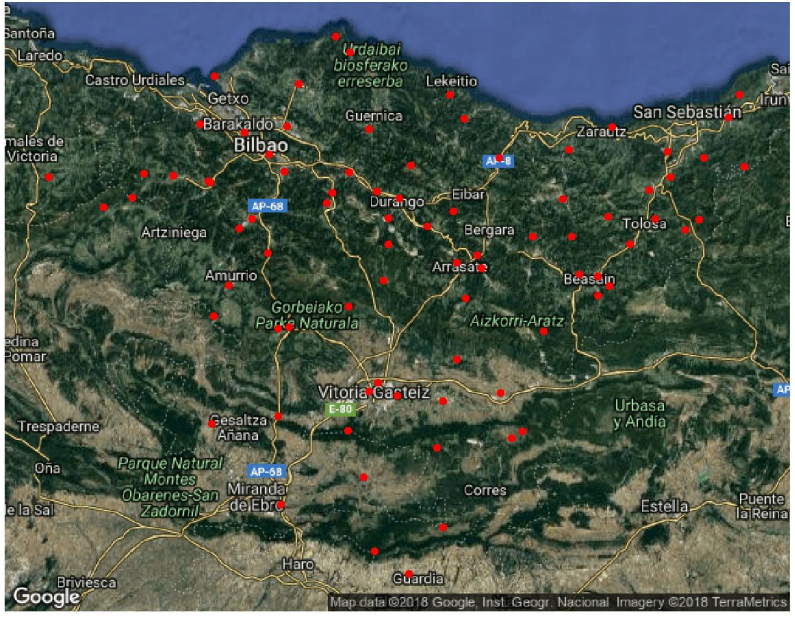
- Spatial resolution 1km x 1km
- There are also regional maps in Switzerland, Italy and Greece.
- **Our goal** is to make the first map of the R factor at Basque Country level in a higher resolution.



Prediction of the R factor in the Basque Country

Source: OPEN DATA EUSKADI

- Precipitation meteorological data (2003-2016).
- 82 stations
- measurements > 10 years
- Precipitation data every 10 min



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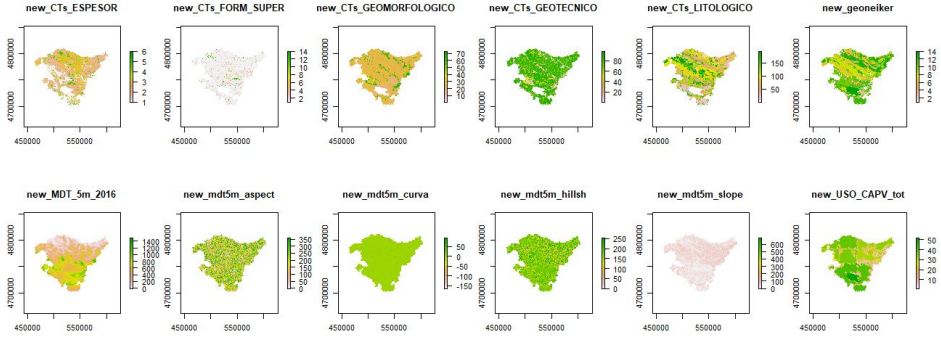
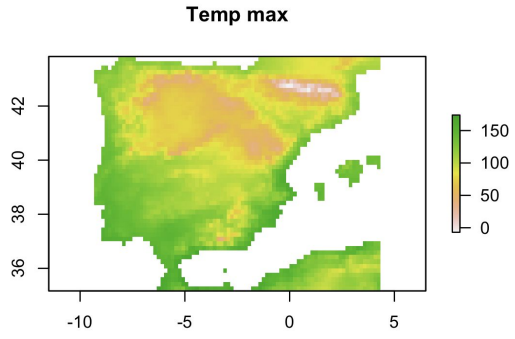
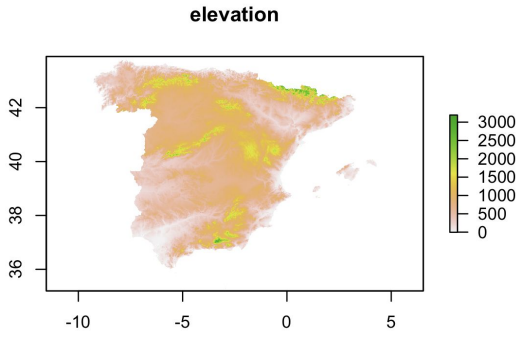
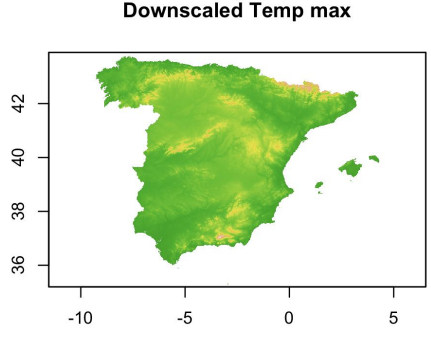


- **Covariates:**
  - Min/Max average precipitacion
  - Average temperature
  - Elevation and orientation (Digital Terrestrial Model)
  - Scales 25m x 25m ,100 m x 100m o 800m x 800m
  - Unifty all scales at spatial level (*spatial downscaling*) **!!!**
  - **Predict at 10m x 10m = 231,564,800 cells !!!**

Spatial downscaling (illustration)

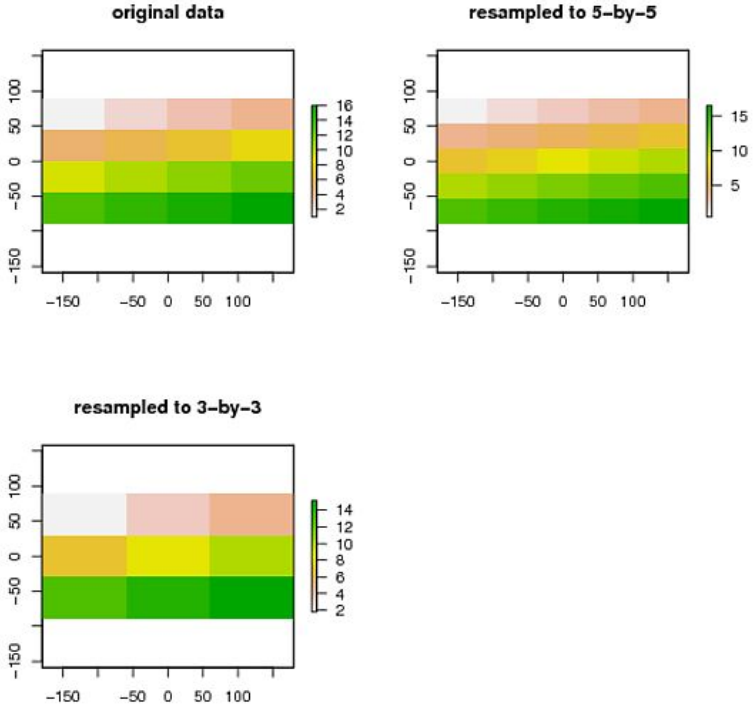


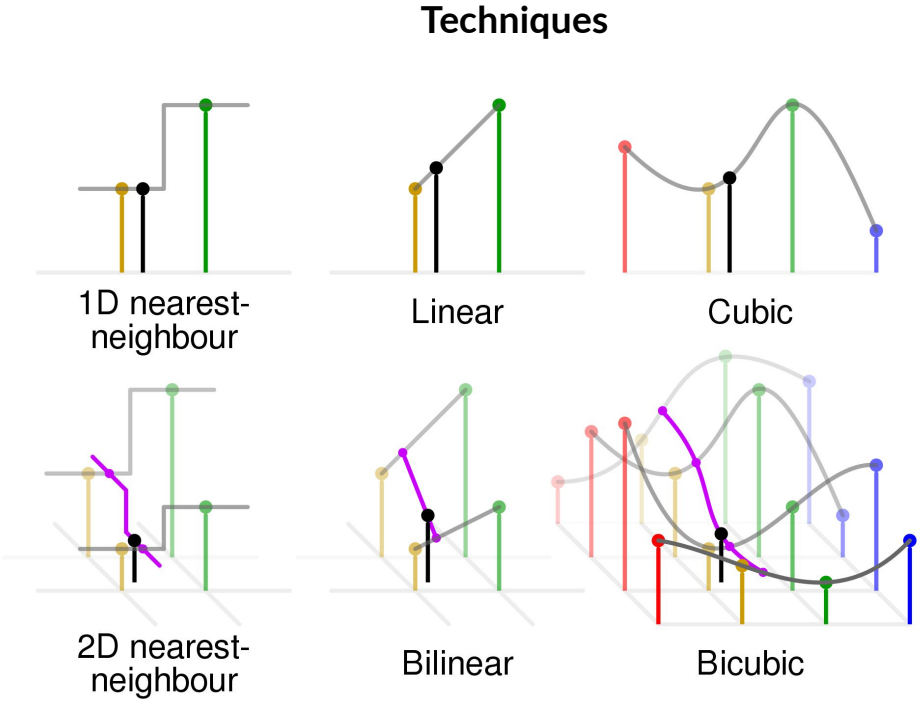




- Geostatistics.
- GIS (Geographic Information Systems).
- Geocomputation.
- Interpolation and resampling methods.

Resampling (illustration)





Geoadditive models

- Extension of Generalized Additive Models (Hastie and Tibshirani, 1990).
- Combines Kriging with additive (non-linear) smooth effects.

$$E(y) = f(\text{longitude, latitude}) + f(\text{temperature}) + \ldots +$$

- Open source Software in R
  - E.g. mgcv, gam, etc …
- Time variable can also be included (space-time modelling).

Geoadditive model - R factor map in the Basque Country

R factor, period 2003-2016 MJ mm ha^{-1} h^{-1} yr^{-1}

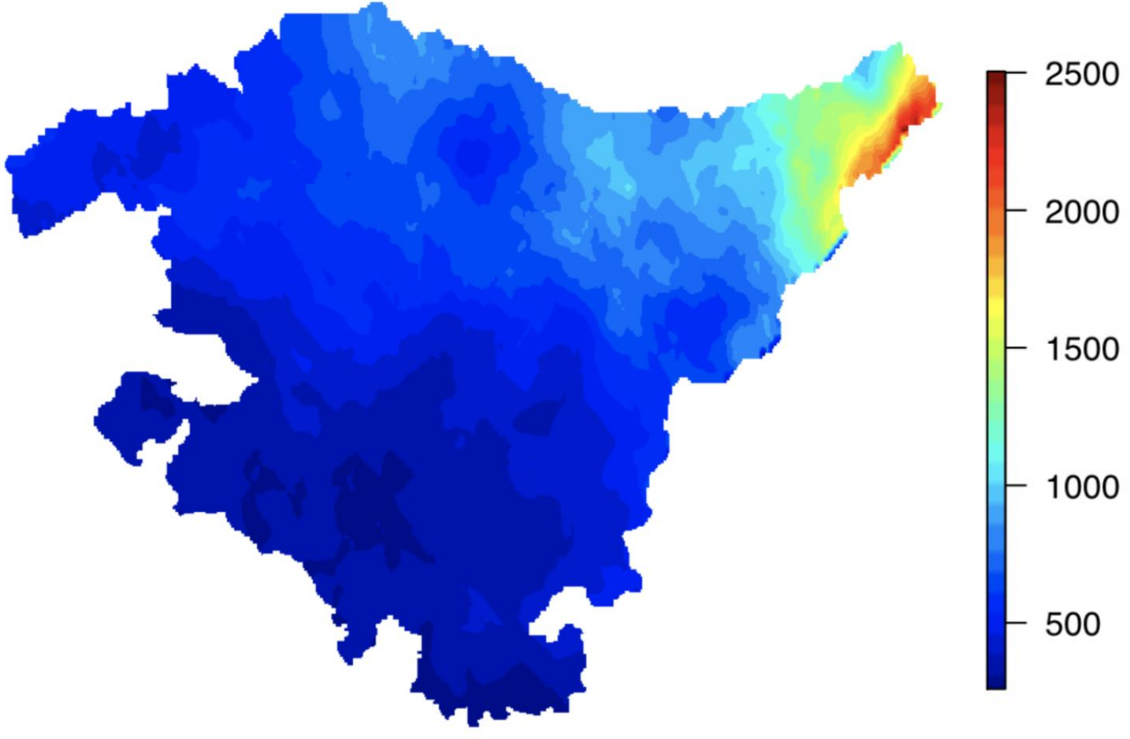
Grid of 10m x 10m

GAMs

- Spatial coordinates X,Y
- Climate covariates

Efficient computation:

- R library raster



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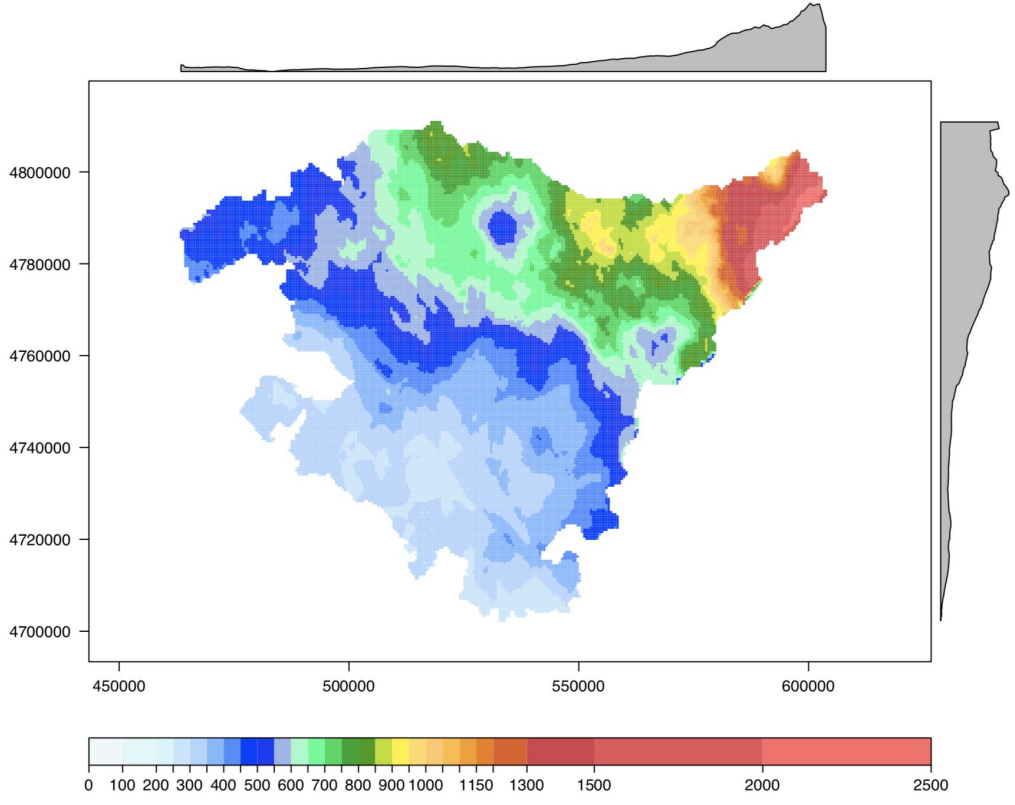

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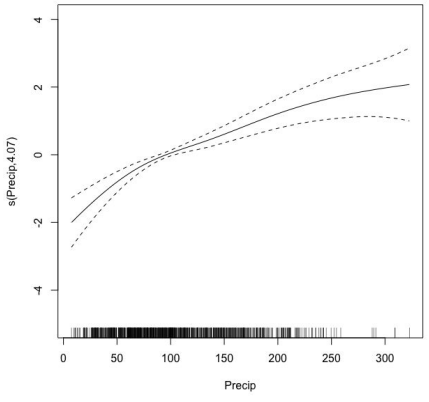
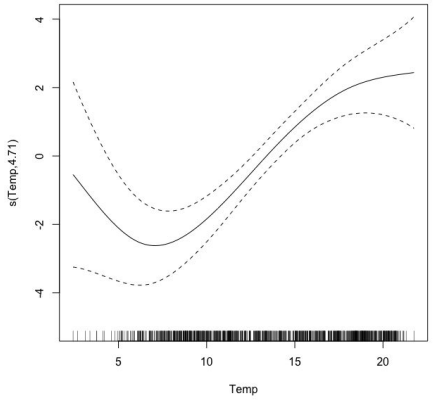
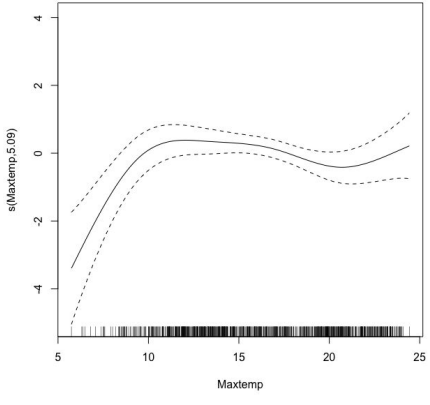
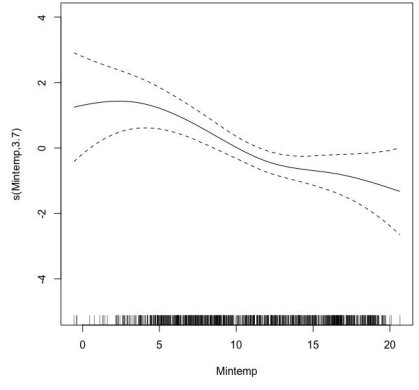








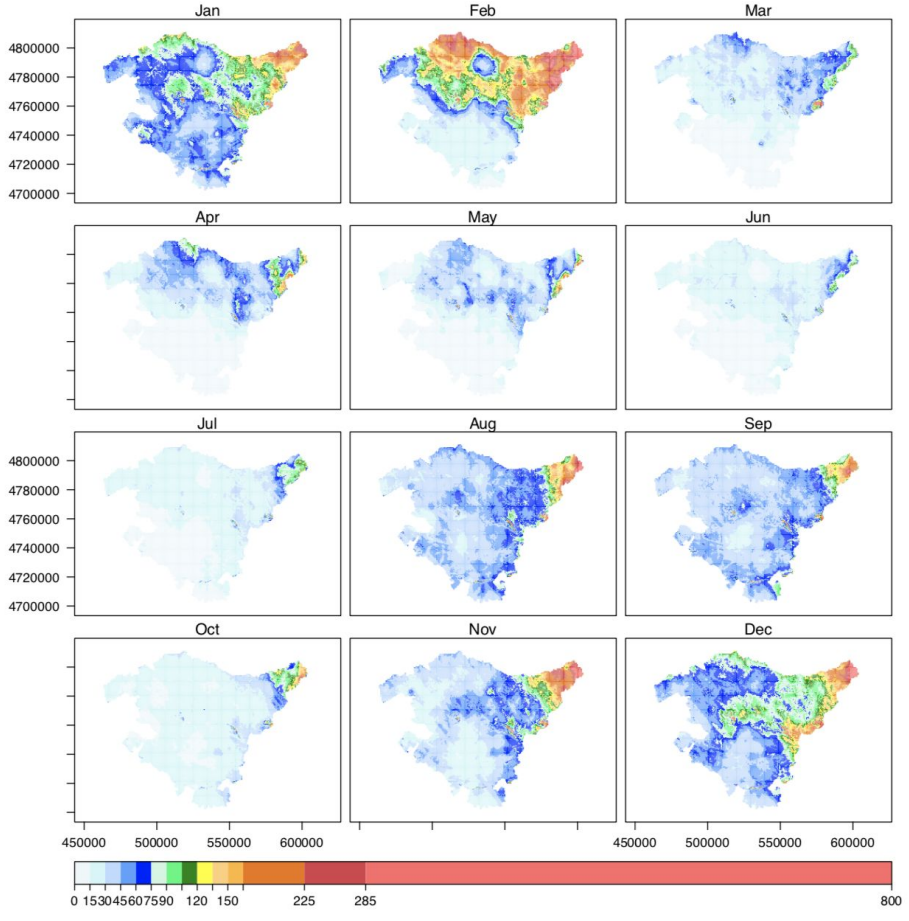
Geoadditive model - R factor map in the Basque Country

R factor, period 2003-2016 MJ mm ha^{-1} h^{-1} yr^{-1}

Grid of 10m x 10m

Space-time GAMs:

- Spatial coordinates X,Y
- Climate covariates
- Monthly R-factor (stationarity)



Conclusions

- GAMs are a flexible modelling tool for predicting R-factor at any spatial and temporal scales.
- Advance computation is required. raster library in R provides fast methods.
- Spatial *downscaling* based on resampling methods were performed (*).
- Monthly R-factor maps provides useful information for policy makers.
- Further work:
  - Forecasting/extrapolation with GAMs is possible (next 10, 20, 30 years).
  - Climate models information can be also integrated (Climate change scenarios).

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