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Modeling fire spatial non-stationary in Portugal using GWR and GAMLSS

Ana C. L. Sá (1), Maria A. Amaral Turkman (2), Ioannis Bistinas (1), and José M.C. Pereira (1)

(1) Centro de Estudos Florestais, Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal, (2) Departamento de Estatística e Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa, Lisboa, Portugal

Portuguese wildfires are responsible for large environmental, ecological and socio-economic impacts and, in the last decade, vegetation fires consumed on average 140.000ha/year. Portugal has a unique fires-atlas of burnt scar perimeters covering the 1975-2009 period, which allows the assessment of the fire most affected areas. It's crucial to understand the influence of the main drivers of forest fires and its spatial distribution in order to set new management strategies to reduce its impacts. Thus, this study aims at evaluating the spatial stationarity of the fire-environment relationship using two statistical approaches: Geographically Weighted Regression (GWR) and Generalized Additive Models for Location, Scale and Shape (GAMLSS). Analysis was performed using a regular 2kmx2km cell size grid, a total of 21293 observations overlaying the mainland of Portugal. Fire incidence was determined as the number of times each grid cell burned in the 35 years period. For the GWR analysis the group of environmental variables selected as predictors are: ignition source (population density (PD)); vegetation (proportion of forest and shrubland (FORSHR)); and weather (total precipitation of the coldest quarter (PCQ). Results showed that the fire-environment relationship is non-stationary, thus the coefficient estimates of all the predictors vary spatially, both in magnitude and sign. The most statistically significant predictor is FORSHR, followed by the PCQ. Despite the relationship between fire incidence and PD is non-stationary, only 9% of the observations are statistically significant at a 95% level of confidence. When compared with the Ordinary Least Squares (OLS) global model, 53% of the R2 statistic is above the 26% global estimated value, meaning a better explanation of the fire incidence variance with the local model approach.

Using the same environmental variables, fire incidence was also modeled using GAMLSS to characterize non-stationarities in fire incidence. It is shown that the magnitude and spatial distribution of fire are modeled with parameters which are a smooth function of space. The flexibility of this model makes it suitable for dealing with zero inflated datasets, allowing modeling the scale and shape parameters, related with the dispersion, positive skewness and leptokurtosis of the fire incidence data. Covariate analyses highlight the importance of vegetation and precipitation data for modeling the spatial distribution of fire data.