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Desertification Indicators derived from Earth Observation Data: Application to Portugal and Brazil

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Almost half of the terrestrial land surface is occupied by dryland systems, where desertification processes may occur. These areas were inhabited by a third of the human population in the year 2000 and at least 90% of whom live in developing countries, on average lag far behind the rest of the world in human-well being and development indicators (Millennium Ecosystem Assessment, 2005). Prevention is the more effective way to combat desertification, hence observation and control of main factors of desertification became of paramount importance to manage and prevent critical situations. But in developing countries, the lack of reliable data and local resources to monitor biophysical parameters makes it a very hard task, almost impossible to achieve. Therefore, the objective of this work is twofold: to establish a set of desertification indicators which are able to quantify the dynamic of the phenomenon and, on the other hand, these indicators must be monitored and processed with very low costs for the end users. The proposed methodology consists of extracting the desertification indicators from free Earth Observation data (Landsat satellite images, NASA) and from Global Atmospheric Reanalysis data (ERA-interim, ECMWF) based on climate and biophysical factors dynamics. These factors should be able to characterize and discriminate the high and low susceptibility areas to the desertification processes over the dryland areas in Portugal and Brazil. The following assumptions were made:
1. Precipitation extreme events (floods and droughts) is the primary key variable;
2. Vegetation and soil are the most relevant biophysical factors;
3. Factor dynamics were extracted from time series data.

The analyses of climatic series allowed to categorize the areas with high and low susceptibility to desertification based on the trend (slope) of the variance of climatic extremes. Areas with high susceptibility to desertification show on average a trend towards greater homogeneity of the temporal parameter RL1 (Number of days with precipitation below 1 mm). On the other hand areas with low susceptibility to desertification, have a greater variability which means that in those areas, these extreme events are more frequent in recent times, thus increasing the temporal variance. The values of this variable are known on a grid of about 1.5ºx1.5º. Let's call the climate variable as C (x), where x are the spatial coordinates.

The spatial characterization of the dynamics of vegetation and soil were evaluated through radiometric indexes calculated from a time series of Landsat satellite images: NDVI (Normalized Difference Vegetation Index) and Brightness (tasseled cap transformation), respectively. Data analysis revealed that biophysical factors behavior over time is strongly related with the land cover class in both countries. For those land cover classes related with the vegetation cover these indexes show discriminating values in terms of susceptibility to desertification, i.e. in average radiometric indexes show different levels in areas more susceptible to desertification and areas less susceptible to desertification. High susceptibility areas to desertification show a low mean NDVI and high mean Brightness, and vice versa within a certain land cover class (e.g. forest or shrublands). Let's call these variables, vegetation and soil, as V (x) and S (x) respectively. From V(x) and S(x) a new variable B(x) was derived, considering for each land cover which variable was more discriminant of the desertification state. Finally, let us consider I(x0) [0, 1] ,a variable that takes the maximum value of susceptibility to desertification I(x0) = 1 to the lowest susceptibility to desertification I(x0) = 0, at each location x0. This variable was estimated by the linear combination of climatic data, C(xi), and the values B(x0) (function of LULC class) co-located at x0 using co-located cokriging,

The application of the proposed methodology to case studies in Portugal and Brazil validates the methodology for these semi-arid regions.