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Spatial analytics of self-organized vegetation pattern in semi-arid regions: an example on tiger-bush patterns in Sudan

Christoph Hinz, **Konlavach Nengsuwan**, and Daniel Cavieds-Voullieme
Brandenburg Technische Universität Cottbus-Senftenberg, Hydrology, Umweltwissenschaften, Cottbus, Germany (christoph.hinz@b-tu.de)

The concept of local-scale interactions of spatially periodic vegetation patterns are well known in arid and semi-arid regions. The vegetation patterns are easily observable from aerial and satellite photography. Additionally, various mathematical models have been developed to reproduce the patterns observed in nature, aimed towards understanding the driving factors leading to pattern properties. Several studies exist attempting to analyse spatial properties of these patterns, their spatial distribution and their relationship to topography and climate. However, there are limitations in how these studies provide spatially-distributed statistics, and on the specifics of vegetation patch and band geometries, making it difficult to compare to model predictions.

This study proposes a new workflow (implemented in R) to measure geometric characteristics of vegetation bands and patches. We use high-resolution satellite imagery as the base dataset. Color filters are used to binarise and identify individual patches/bands of arbitrary irregular shapes. We then compute different geometrical properties, such as patch-size, separation between them, orientation, among others. Additionally, the principal axes of each patch/band are identified, and used to measure characteristic lengths and widths, for which statistics are then computed, and can be represented in spatial subdomains to allow for spatial analysis at different scales. The strategy can also be easily applied to modelling results, thus facilitating comparison, and the algorithm is flexible enough to yield different forms of patterns and spatial extent.

As a test case, we apply this workflow to a study site (11.05 N, 28.35 E) in Kordofan, south Sudan (a region previously reported and documented in the literature), using Google Earth Imagery as input. For this domain (3500 x 1400 m), the results show that the length of the patches has a strong positive correlation with their width. Additionally, the length and the average nearest neighbor distance displayed a small positive correlation to the elevation. Using the available ALOS topography, the results also confirm that that 92% of the bands in our study area are oriented perpendicularly to the slope direction, as is expected from these systems.

This test is a first step into applying this workflow to a larger extend within Kordofan and other regions known to exhibit vegetation bands (tiger bush in wester Africa, Australia, Nevada) and perform extensive geometric and spatial analysis of the bands, as well as simulated banded systems obtained from numerical models.

Keywords: Vegetation patterns, Self-organization, Tiger-bush, Geometric analysis, Oriented direction