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The challenge of mapping forest cover changes: forest degradation detection by optical remote sensing time series analysis

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While deforestation is referred as the conversion of forests to non-forested areas, degradation implies subtle changes in forest structure with no change in land use. Degradation does not show a decrease in forest area, but a gradual reduction in biomass, changes in floristry and faunal composition or soil degradation. Our study site is located in Guinea forest, in the Unesco World Heritage classified forest of Ziama. Here, the different degrees of forest degradation make their detection more complex than that of deforestation: while the latter is very visible in tropical broadleaf forests, degradation is difficult to observe by remote sensing. In these tropical regions, the classic NDVI saturates at high vegetation density, its application is hampered in dense and structurally complex vegetation assemblages. We compare two methods to solve this issue in a 2-year Sentinel-2 time series.

(i) Multitemporal Spectral Mixing Analysis (SMA)

Spectral unmixing is the process of decomposing the spectral signature of a mixed pixel into a set of members and their corresponding abundance: green vegetation, non-photosynthetic vegetation, soil and water. Pure pixels are homogeneous in terms of land occupation, whereas mixed pixels represent mixtures of different materials. In this analysis, we assume that dense forests show higher abundance of green vegetation than degraded forests. We hypothesize degraded forest can be described as a mixture of vegetation and soil, showing higher abundance in soil than dense forests. Moreover, abundances of each of these members vary in time, reflecting processes operating on the ground (regeneration, seasonal changes). Multi-temporal SMA allows confirming classes by grouping pixels with common histories. While multitemporal NDVI failed, classification of multitemporal SMA maps accurately forest degradation. Above all, it appears that forest degradation is predominately located in forest-non-forest interfaces, indicating an edge effect.

(ii) Multitemporal biophysical parameters of forest cover

Drier vegetation is known to be one of the main edge effect consequences, due to stronger winds and hotter microclimate at the edge. Assuming degraded forests are under moisture stress, we suppose that lower Canopy water content CWC (amount of liquid water in canopy foliage) and lower Leaf area index LAI describe degraded forest systems with reduced and drier leaf cover. Based on several known positions of degraded and dense forests, classification of multitemporal CWC maps more accurately forest degradation in highly ambiguous areas. In particular, on steep slope, LAI overestimates forest degradation where CWC does not. Our results indicate that leaf area is not the only parameter describing forest degradation and moisture stress due to edge-effect enables forest degradation detection. Finally, Moisture Stress Index MSI, involving NIR and SWIR bands, confirms moisture stress in edge vegetation.