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Unmixing the patterns within big data: Discriminating forests in French Guiana using the MODIS time-series

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I. Introduction

Despite the availability of 40+ years of remotely sensed satellite data, from multiple sources (e.g. Landsat, MODIS, SPOT), and multiple types of sensors (e.g. optical, radar, thermal), tropical forests are still poorly understood in terms of their composition and functioning. This is particularly true for French Guiana, the sparsely populated and highly forested French overseas Department which comprises the French segment of the biologically diverse Guiana Shield ecoregion (see Figure 1).

While French Guiana’s forests have been mapped under successive global land cover assessment initiatives such as the Global Land Cover Characterization (GLCC), Global Land Cover 2000 (GLC2000), and GlobCover 2000, among others, French Guiana’s forests are repeatedly depicted as one large ‘green carpet’, despite evidence from the ground that French Guiana possesses a range of diverse forest ecosystems. In 2011, the need to go beyond the ‘green carpet’ effect led researchers to publish a new map of French Guiana’s forest landscape types which was based on data from the Vegetation instrument onboard the SPOT-4 satellite, and differentiating the ‘green carpet’ into five main groups of forest [6].

Given the increasing availability of multitemporal remotely sensed data, the overall objective of this study was to examine the extent to which forest types in French Guiana could be discriminated via unmixing of multispectral, multispectral reflectance data.

II. Methods

This study utilizes data from the 15-year archive of MODIS, particularly data which has been adjusted for the bi-directional reflectance distribution function (BRDF), and normalized to nadir-viewing angle (i.e., the MOD43A4 product). In terms of the adjustment for BRDF, the MOD43A4 data utilized is derived from observations from MODIS Terra and MODIS Aqua, and models reflectance based on the local ‘solar noon’ (i.e. when the sun is at its highest point in the sky), with the solar azimuth being normalized. Use of reflectance data for the solar noon in theory should minimize intra-scene shadowing. Reflectance data at 463nm resolution were acquired for the MODIS reference site h12v08 (covering much of eastern Guyana, all of Suriname and French Guiana, and parts of Brazil), for the period 18 Feb. 2000 - 17 Feb. 2015, representing 188 months of data. Data (originally 16-day averages) were grouped into their respective months, and the quality flag data contained within the MOD43A4 dataset were utilized to extract only reflectance data which had undergone full BRDF inversion. Monthly composites were then generated from the 188 months of data, producing 12 monthly averages (Figure 2).

III. Results

Minimum-mean-maximum composites for reflectance of bare soil, NPV, and PV are displayed in Figures 4-5, which reveal French Guiana’s forests as being less than uniform in their reflectance of these endmembers. In the bare substrate composites, dark areas depict forests with consistently low exposure of bare soil and substrate over the 6 months compositing (e.g. the forests covering the northern 2/3 of the territory and a patch of forest in the south).

Beyond being able to utilize the composites as visual cues for forest composition and structure, assessing the trends at the 4 pilot sites is also illustrative. Figures 6, for instance, illustrate the intra-annual variation in the bare substrate fraction at those 4 sites. It can be observed that each site displays its own distinctive terms of bare substrate fractional cover, and this is largely also true for the NPV and PV fractions, as well (Figures 7).