PROGYSAT
Projet de coopération Régionale d'Observation des GuYanes par SATellite

Mapping forest diversity using spectral diversity indices in the context of the Guiana Shield

Alexandre Defossez (IRD), Jean-Baptiste Féret (INRAE), Caroline Bedeau (ONF)

To prevent biodiversity loss, it is essential to be able to **monitor it on a wide scale** in time and space. Remote sensing can provide significant help in achieving this objective. **Forests of the Guiana Shield** are one of the **most diverse** worldwide but little is known about the spatial distribution of their diversity. Here, we proposed an application of the ***biodivMapR*** method (Féret & de Boissieu, 2020) in the context of the Guiana Shield which allow **to map spectral diversity** as a proxy for tree diversity. To produce such diversity maps, we used **Sentinel-2 time series**, which provide high spatial, temporal and spectral resolution.

Aerial photography of a canopy in French Guiana (IRD)

Spatial characterization of biodiversity

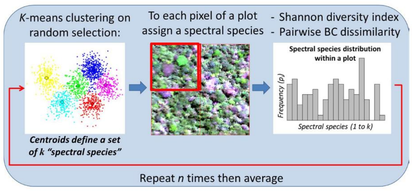
α-diversity: *Species richness or abundance of species for a given site.*
ß-diversity*: Change in species composition between different sites in space or time.*

How to estimate tree species diversity using optical satellite imagery?

Spectral Variation Hypothesis:

Spectral variability can be linked to habitat heterogeneity, ecological conditions or variations in biodiversity, depending on the scale and resolution of the data used.

(Palmer et al., 2000, 2002)



Computation of Spectral Diversity
(Figure from *Rocchini et al., 2018*)

Main methodological steps:

1. Production of Spectral Indices Composite Image
2. Spectral Diversity mapping
3. Validation using forest inventories

α-diversity indicator:

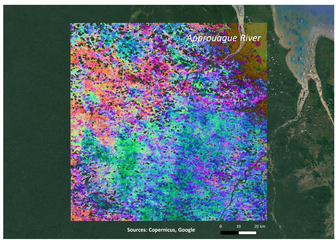
$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$$

S : Species Richness, the total number of species in a given environment.
p (i) : Proportion of species ***i*** in the environment.
n_i : Number of individuals of species ***i***.
N : Total number of individuals including all species.

β-diversity indicator:

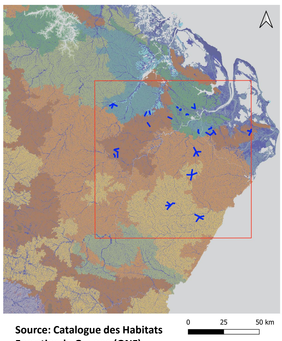
$$BC_{jk} = 1 - \frac{2\sum_{i=1}^{p} min(N_{ij}, N_{ik})}{\sum_{i=1}^{p} (N_{ij} + N_{ik})}$$

N_{ik} : Abundance of species ***i*** in sample ***k***.
N_{ij} : Abundance of species ***i*** in sample ***j***.
Min (…,…) : for species ***i*** present in ***j*** and ***k***, the minimum count of individuals between ***j*** and ***k***.



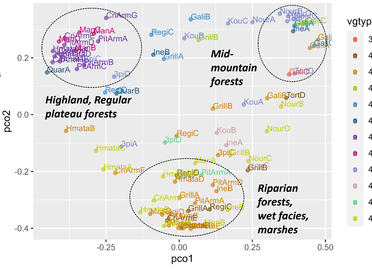
β-diversity

Validation of diversity maps was investigated in French Guiana using a **network of forest inventories** set up by the **French National Forest Office (ONF)**. Here, we looked for correspondences between different forest habitat types and β-diversity maps.



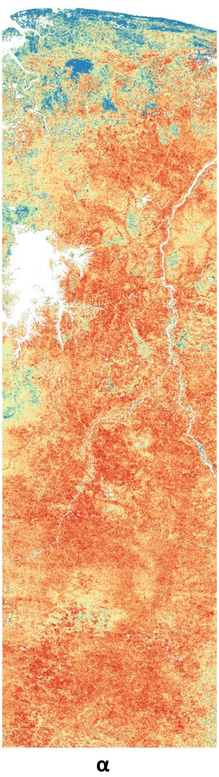
Map of Forest Habitat types in French Guiana centred on Sentinel-2 tile 22NCK

Source: Catalogue des Habitats Forestier de Guyane (ONF)

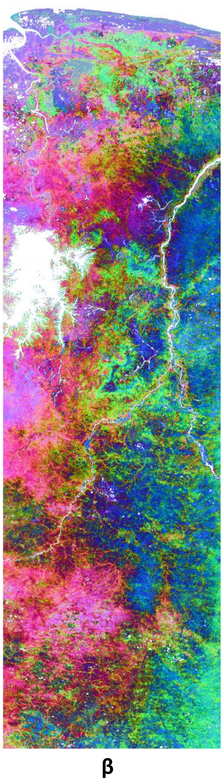


Distribution of forest inventory plots according to their BC dissimilarity values (β-diversity)

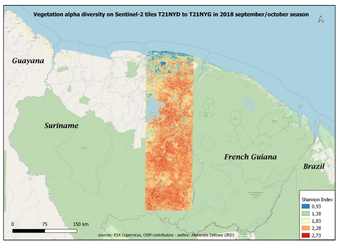
RGB



α



β



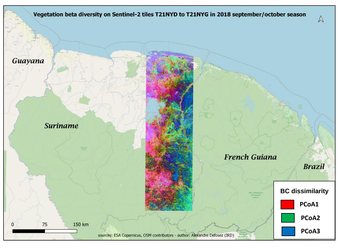


Illustration of vegetation spectral diversity along a N-S geographical gradient bordered by the Brokopondo reservoir to the west (Suriname) and the Maroni River to the east. In this example, spectral diversity maps (α,β) are derived of a composite image (Sentinel-2 time series in September-October 2018) of radiometric indices (EVI, NDVI, CRI1, CR_SWIR).