Characterizing forest species communities of Guiana shield using Sentinel-2 images

Jean-Baptiste Féret
UMR TETIS, INRAE — jb.feret@teledetection.fr

PROGYSAT, kick-off workshop
June 23, 2021

Characterizing forest species communities of Guiana shield using Sentinel-2 images

- ## Context & objectives
  - Satellite information to address ecological challenges
  - Towards an operational forest diversity monitoring system fueled with RS data

- **Sentinel-2 covering temporal – spatial – spectral dimensions**

- **Mapping forest diversity using the R package `biodivMapR`**

The erosion of biodiversity is accelerating. Tropical regions are particularly impacted.
→ Strong need for operational methods able to map and monitor biodiversity

Exploitation of natural resources

**Remote sensing provides useful information to :**

- **Monitor complex systems over large scales**
- **Link Earth observation with ecological knowledge & climate data**
- **Feed regional / national / international statistics on biodiversity and forest degradation**
- **Fuel higher level models and studies integrating ecology and socio-economical perspectives**

Important steps have been made in the past decade to develop and apply operational applications meeting current ambitions and emergency.
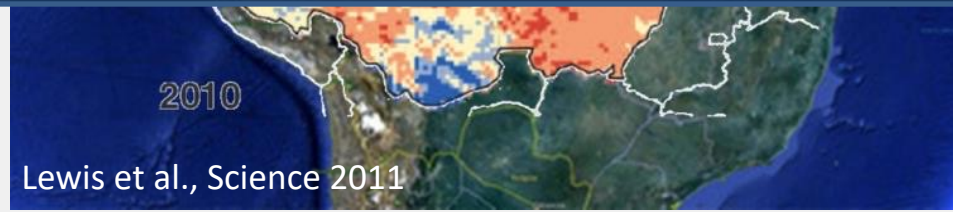
http://green.blogs.nytimes.com

Lewis et al., Science 2011

How to link remote sensing observation to biodiversity ?

Accessibility and maturity of techniques and technologies opens the way for original operational ecological applications / biodiversity monitoring
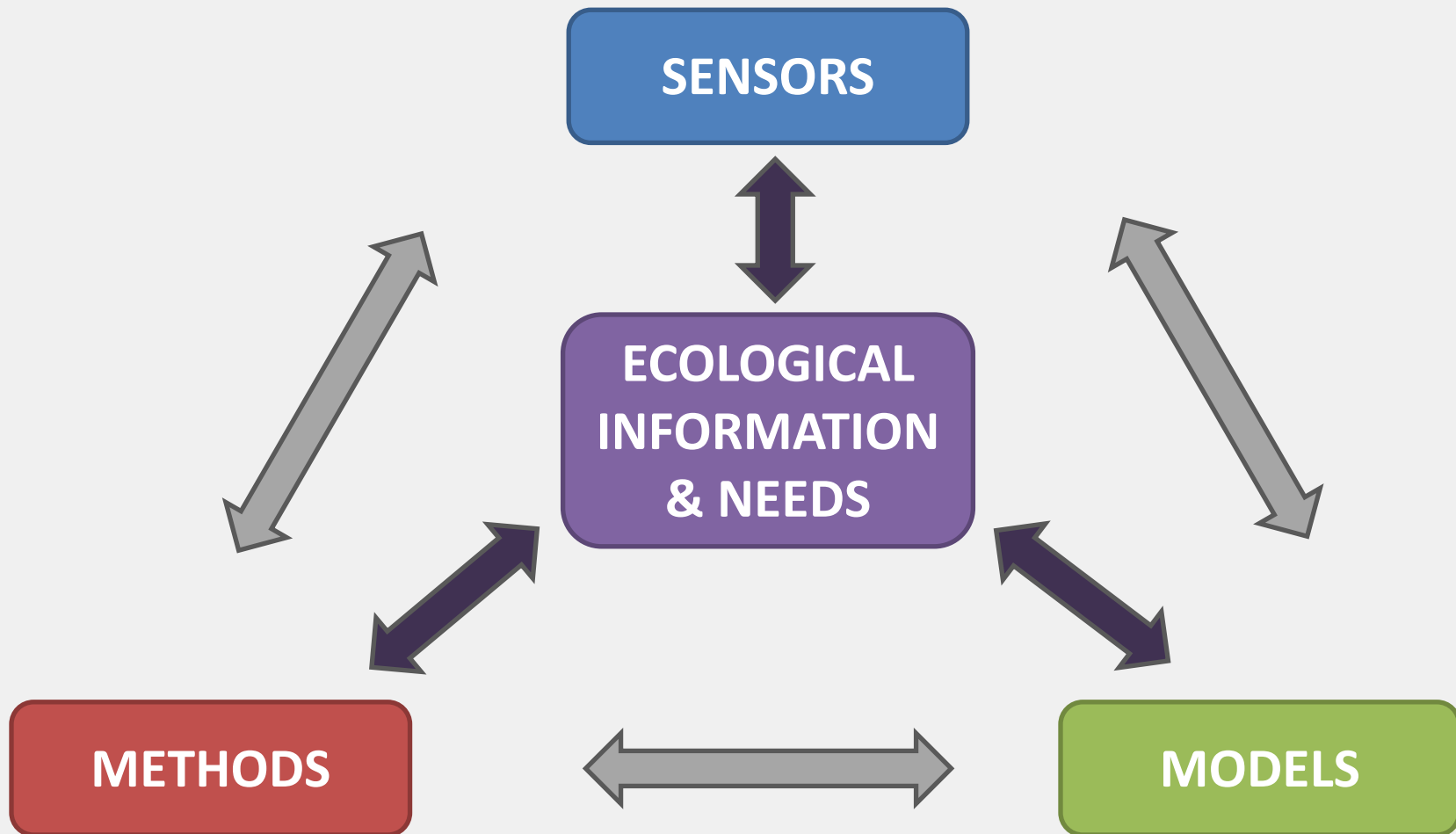
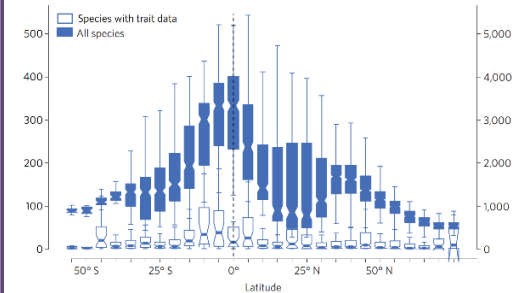# How to link remote sensing observation to biodiversity ?

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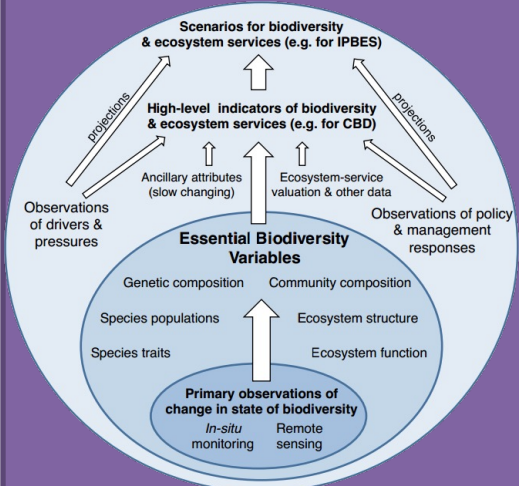
SENSORS

METHODS

MODELS

ECOLOGICAL INFORMATION & NEEDS

Jetz et al. (2016) "Monitoring plant functional diversity from space" Nature Plants

Pereira et al. (2013) "Essential Biodiversity Variables" Science

Roadmap :

- Define & implement EBVs to monitor multiple dimensions of biodiversity

- Reduce data & knowledge gaps (functional traits, distribution of species communities…)

- Integrate biodiversity considerations in international policies

- Preserve & restore ecosystems (functions, service) vital for human well-being in context of climate change

- Reduce rate of biodiversity loss

The erosion of biodiversity is accelerating. Tropical regions are particularly impacted.
→ Strong need for operational methods able to map and monitor biodiversity

Objectives of the WP :

- Implementation and operationalization of a processing chain dedicated to forest diversity mapping based on Sentinel-2 satellite images

- Collaboration with ecologists / forest agencies / local organizations to :
  - Produce a first set of maps in regions of interest identified by partners
  - Comparison with ground observations & knowledge for validation

- Upscaling process to produce validated diversity map over the Guiana shield

- Explore potential of satellite time series for forest degradation monitoring

Characterizing forest species communities of Guiana shield using Sentinel-2 images

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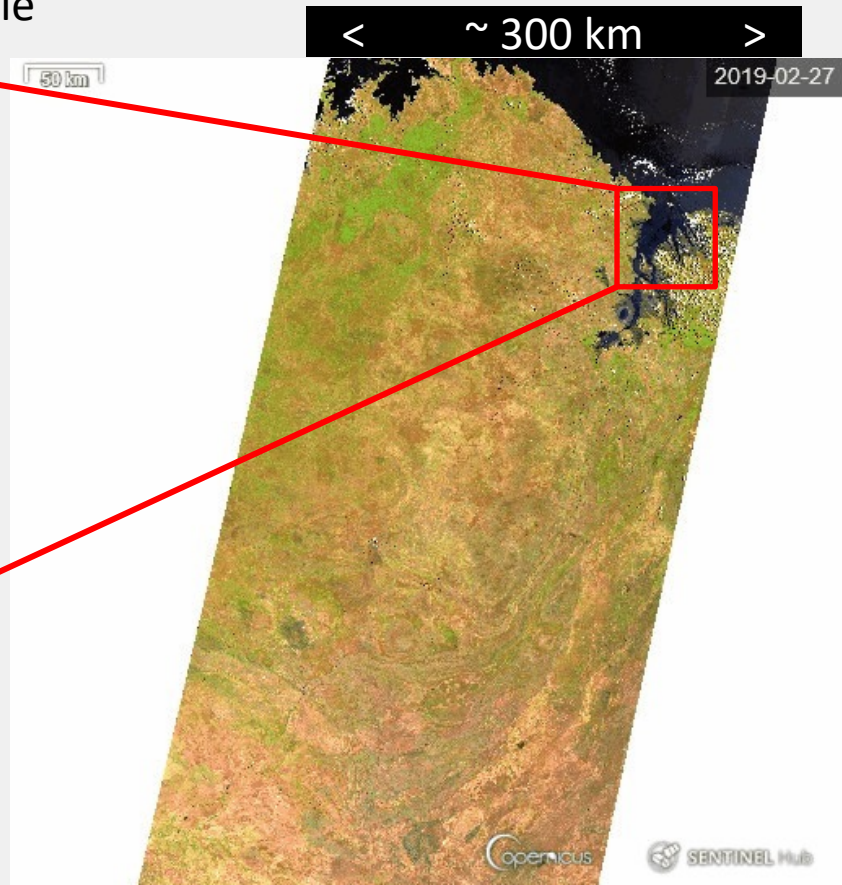- **Mapping forest diversity using the R package `biodivMapR`**

Sentinel-2 covering temporal – spatial – spectral dimensions

- **Temporal dimension :**
  - Past: RS archives (**USGS National Satellite Land Remote Sensing Data Archive**)
  - Present: Monitoring Earth surface 'continuously' : MODIS, Landsat, Sentinel, Planet …

https://apps.sentinel-hub.com/eo-browser/
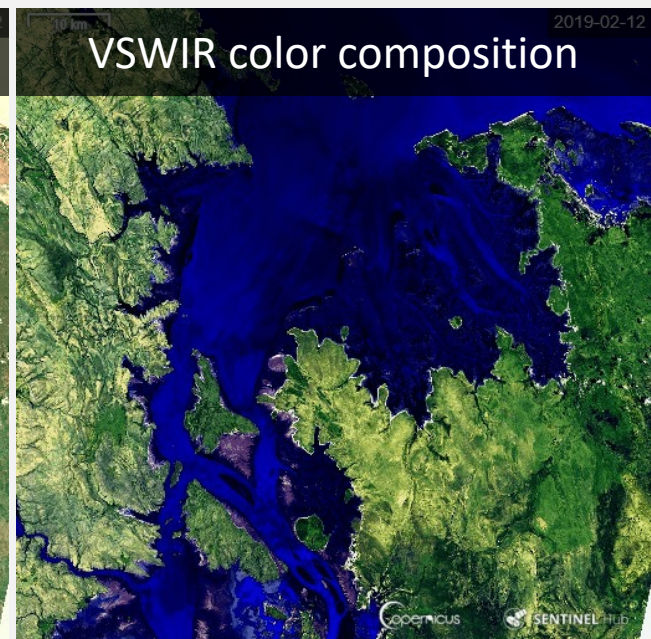
Sentinel-2 time series, Ord River (AUS), 2019

Sentinel-2 covering temporal – spatial – spectral dimensions

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- **Spatial dimension :**
 - From local to regional to global scale

VNIRSWIR color composition

< ~ 300 km >

Sentinel-2 covering temporal – spatial – spectral dimensions

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- **Spectral dimension :**
  - Sensitivity to vegetation properties of interest to discriminate among vegetation types and identify forest response to climate changes and degradation
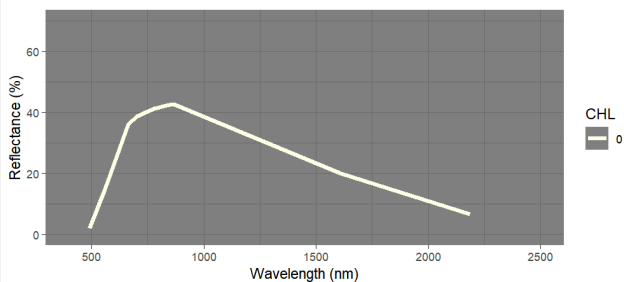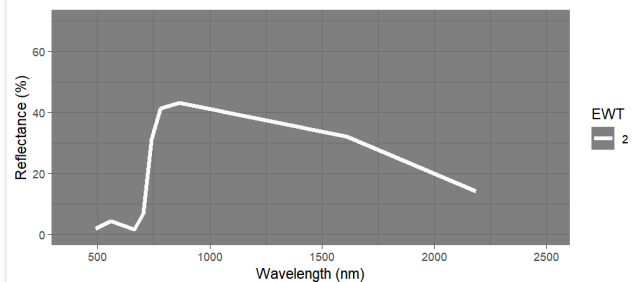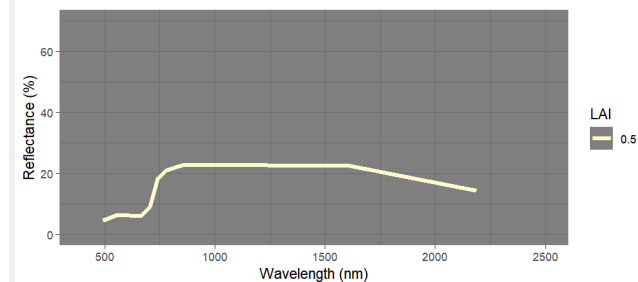
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- Use spectral information to explore multiple dimensions of biodiversity :

  - **Taxonomic / functional diversity based on <u>spectral heterogeneity</u>**
    - Spectral Variation Hypothesis applied to hyperspectral / multispectral data
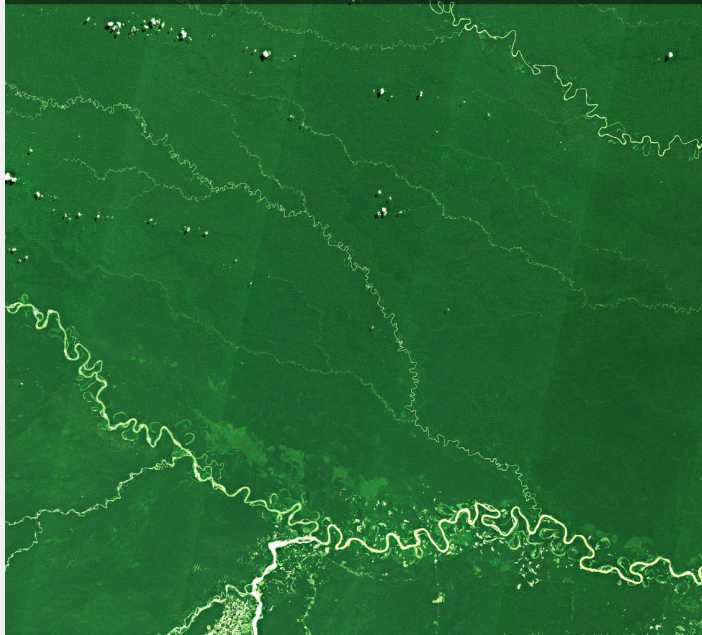   - α- and β-diversity mapping

APPLICATION

Methods in Ecology and Evolution | BRITISH ECOLOGICAL SOCIETY

`biodivMapR`: An R package for α- and β-diversity mapping using remotely sensed images

Jean-Baptiste Féret ⓘ | Florian de Boissieu ⓘ

https://jbferet.github.io/biodivMapR/index.html

Sentinel-2 image (Peru, T19LCG)

Sentinel-2 image (Brasil, T20MPA)

- Use spectral information to explore multiple dimensions of biodiversity :

  - **Taxonomic / functional diversity based on <u>spectral heterogeneity</u>**

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    - α- and β-diversity mapping

<u>usual metrics for</u>
<u>α-diversity :</u>

- Richness
- Shannon index
- Simpson index
- Fischer index

- ...

How to link remote sensing observation to biodiversity ?

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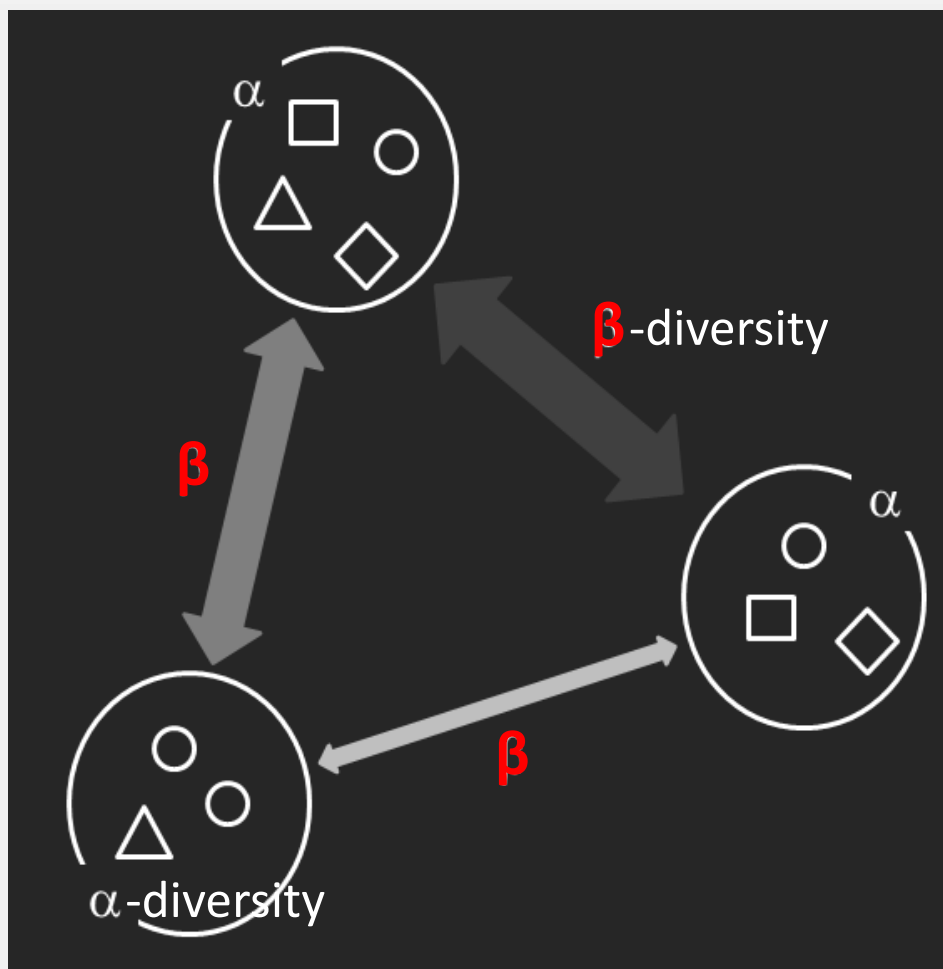
usual metrics for
β-diversity :

- Bray Curtis dissimilarity
- Jaccard distance

- …

Mapping biodiversity using spectral diversity

APPLICATION

biodivMapR: An R package for α- and β-diversity mapping using remotely sensed images

Methods in Ecology and Evolution — BRITISH ECOLOGICAL SOCIETY

Jean-Baptiste Féret | Florian de Boissieu

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Imaging spectroscopy

Multispectral Data

Multisource information

biodivMapR

Diversity maps based on spectral diversity:

- ***Functional diversity (Villéger et al., 2008):***
  - FRic: Functional richness
  - FEve: Functional evenness
  - FDiv: Functional divergence

- ***Taxonomic diversity:***
  - α-diversity: Shannon's *H'*, Simpson
  - β-diversity : dissimilarity maps based on Bray Curtis

Mapping biodiversity using `biodivMapR` on imaging spectroscopy

Ecological Applications, 24(6), 2014, pp. 1289–1296
© 2014 by the Ecological Society of America

ECOLOGICAL APPLICATIONS
ECOLOGICAL SOCIETY OF AMERICA

Mapping tropical forest canopy diversity using high-fidelity imaging spectroscopy

JEAN-BAPTISTE FÉRET[1] AND GREGORY P. ASNER
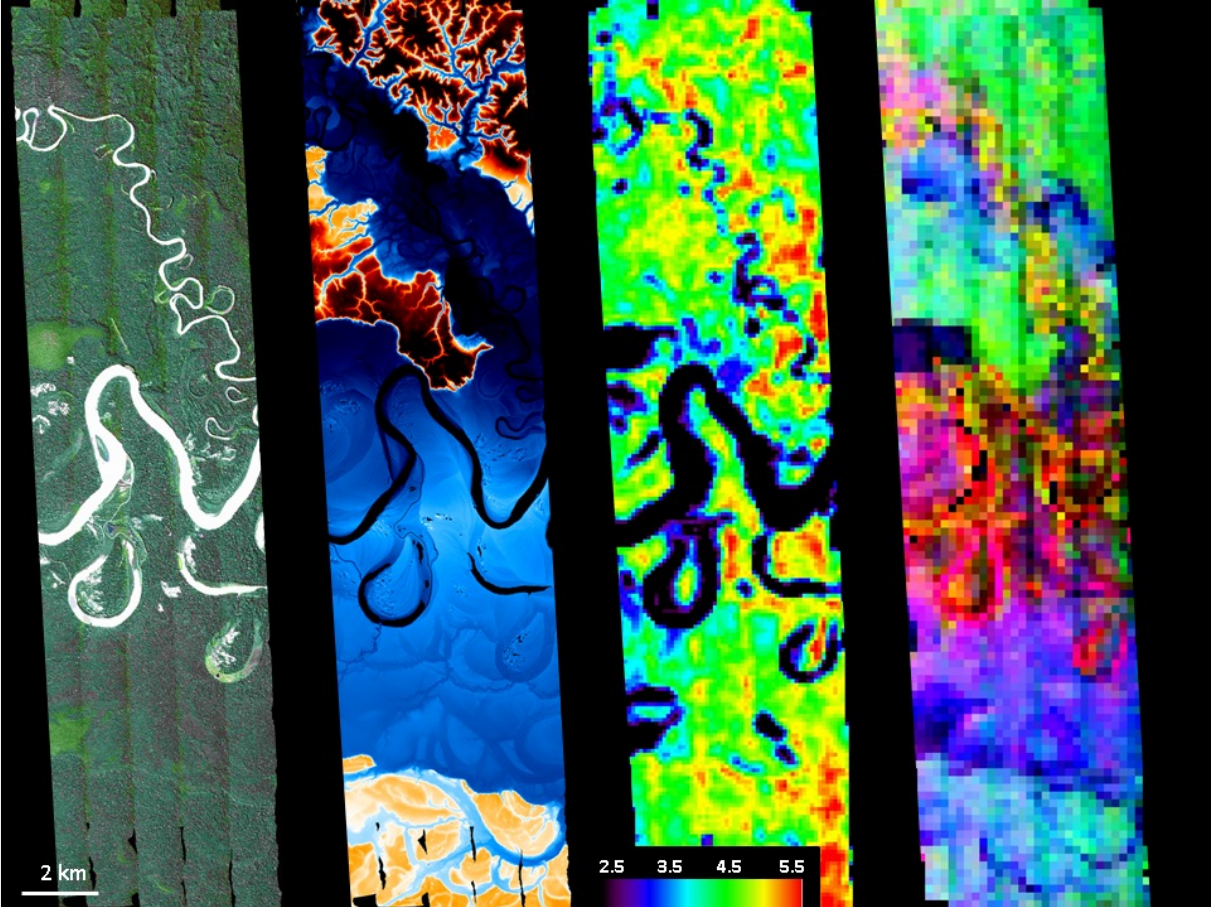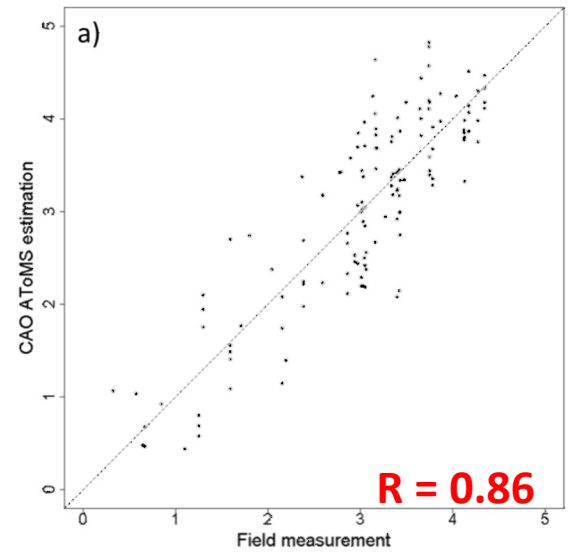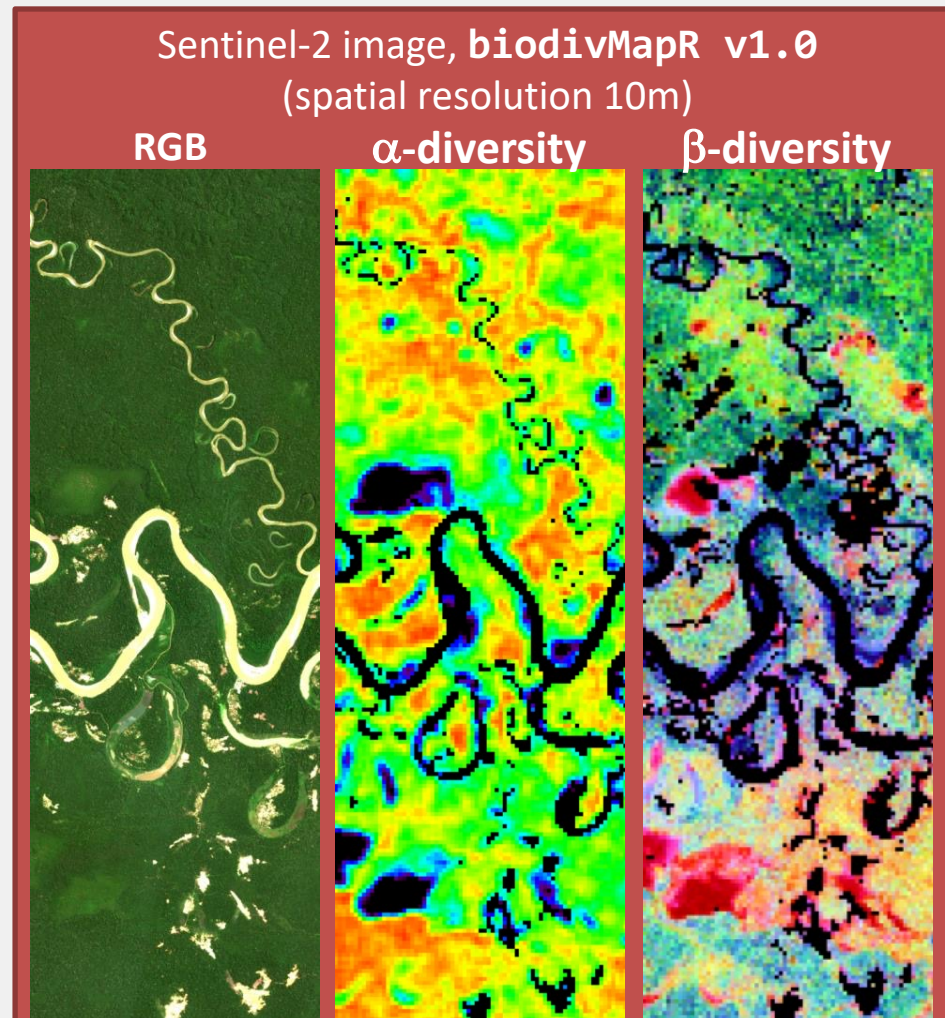
RGB   **DEM**   **α-diversity**   **β-diversity**

2 km

**Validation
(153 plots, several sites)**

Shannon's *H'*

CAO AToMS estimation
Field measurement
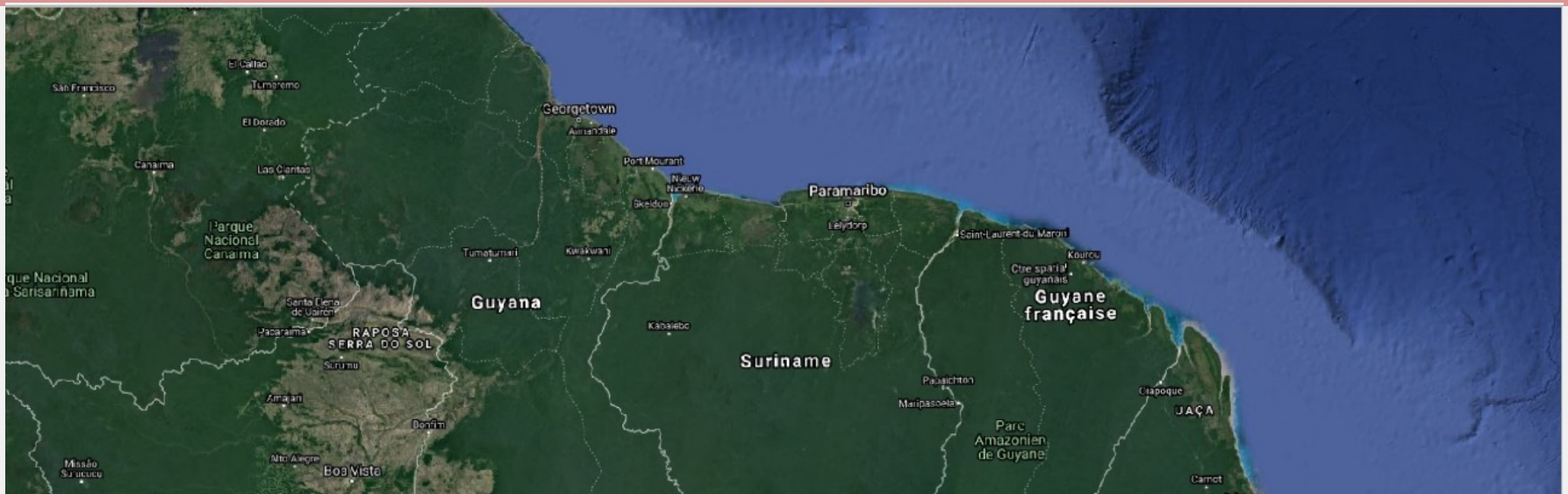
R = 0.86

Mapping biodiversity using `biodivMapR` on Sentinel-2 images

- Comparison between airborne imaging spectroscopy and Sentinel-2 satellite images



Airborne imaging spectroscopy, **`biodivMapR v0.x`**
(CAO AToMS: spatial resolution 2m)
RGB   α-diversity   β-diversity

Sentinel-2 image, **`biodivMapR v1.0`**
(spatial resolution 10m)
RGB   α-diversity   β-diversity
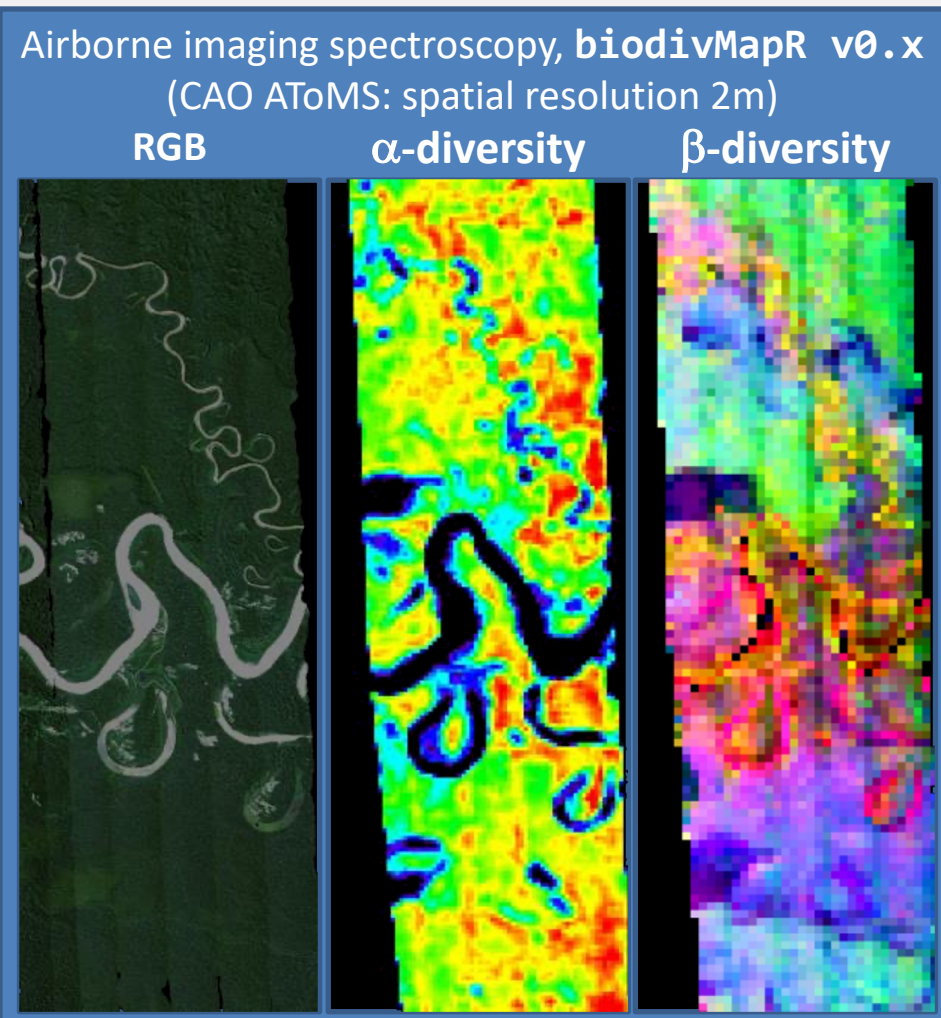
Mapping biodiversity using `biodivMapR` on Sentinel-2 images

Challenge for regional/national upscaling

- Need for storage and computational capacity

- Need to work on multi-tile processing (mosaic of images, products...)

Mapping biodiversity using `biodivMapR` on Sentinel-2 images
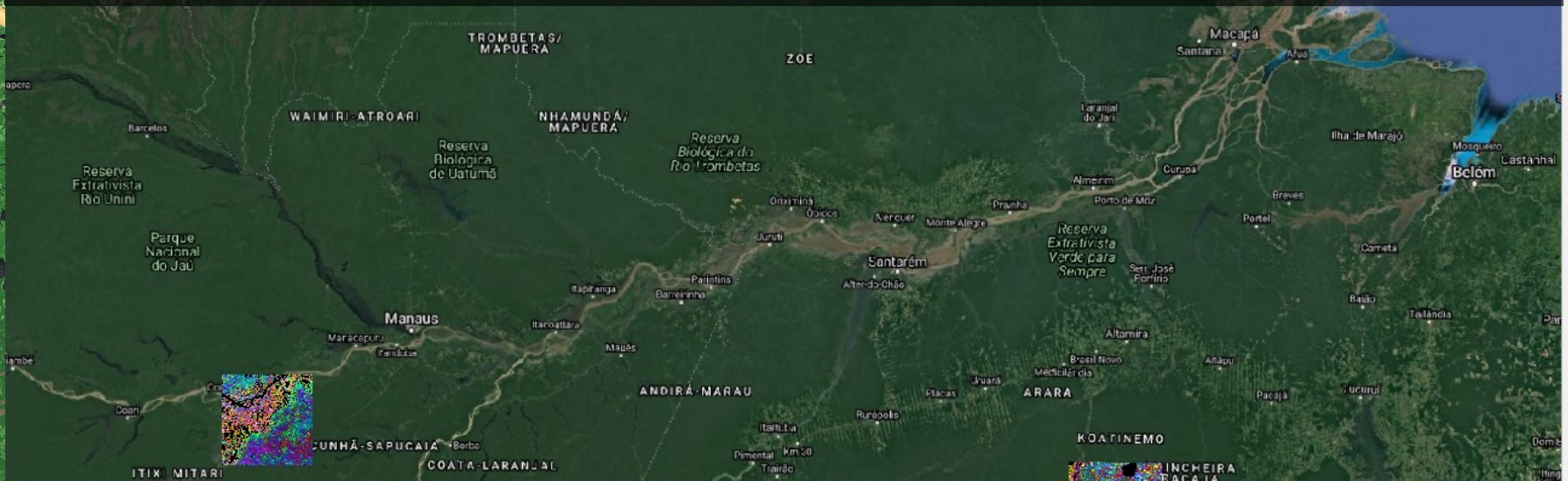
Roadmap & challenges :

- Step #1: implementation of the processing chain

  - **Produce high quality atmospherically corrected S2 images**

  - **Produce diversity maps over regions characterized by high cloud cover**

- Step #2: validation of the processing chain for regions of interest

  - **Exchange with partners to identify relevant study areas (diversity hotspots, high risks of degradation...)**

  - **Perform validation based on collaboration with ecologists**

- Step #3: upscale diversity mapping to regional/national scale

  - **Produce diversity maps beyond S2 tile dimensions (110x100 km)**

  - **Provide validated diversity map products to the community**

  - **Explore potential for forest degradation monitoring**

Thank you !

Questions?