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An open-source multi-sensor methodology for the mapping of mangrove structural types using remote-sensing in Madagascar

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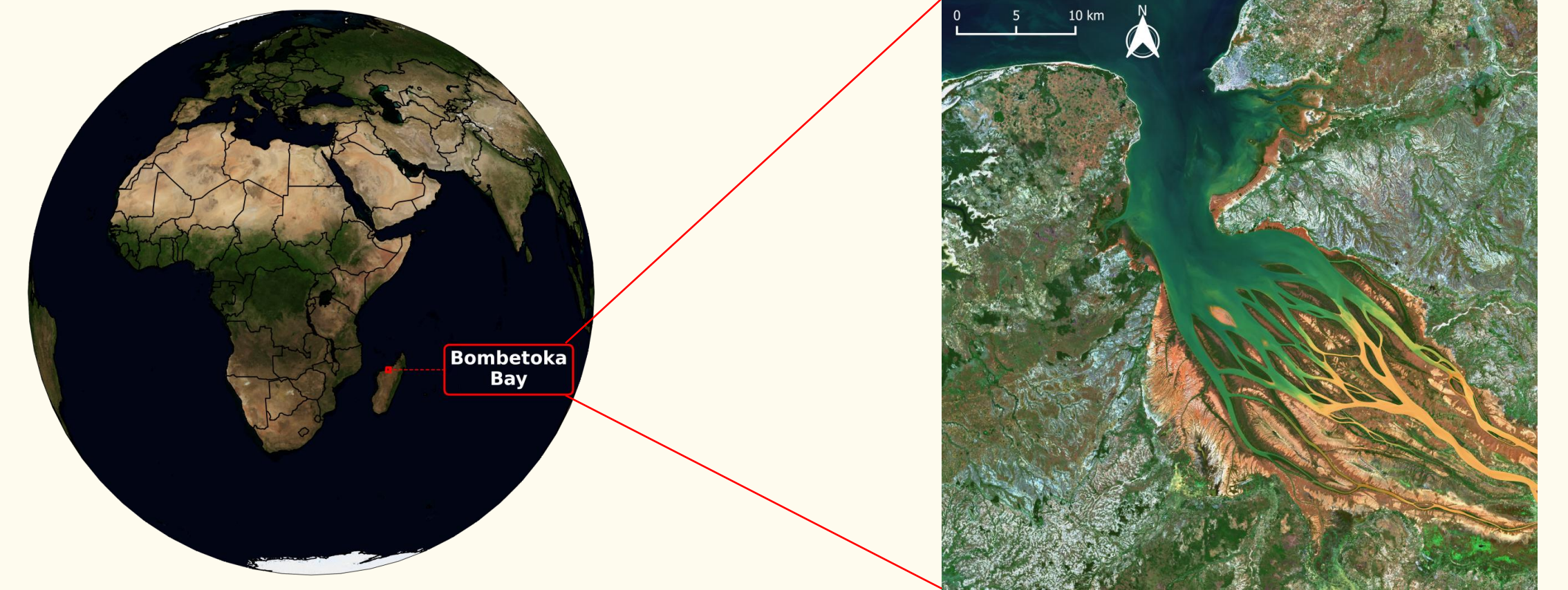
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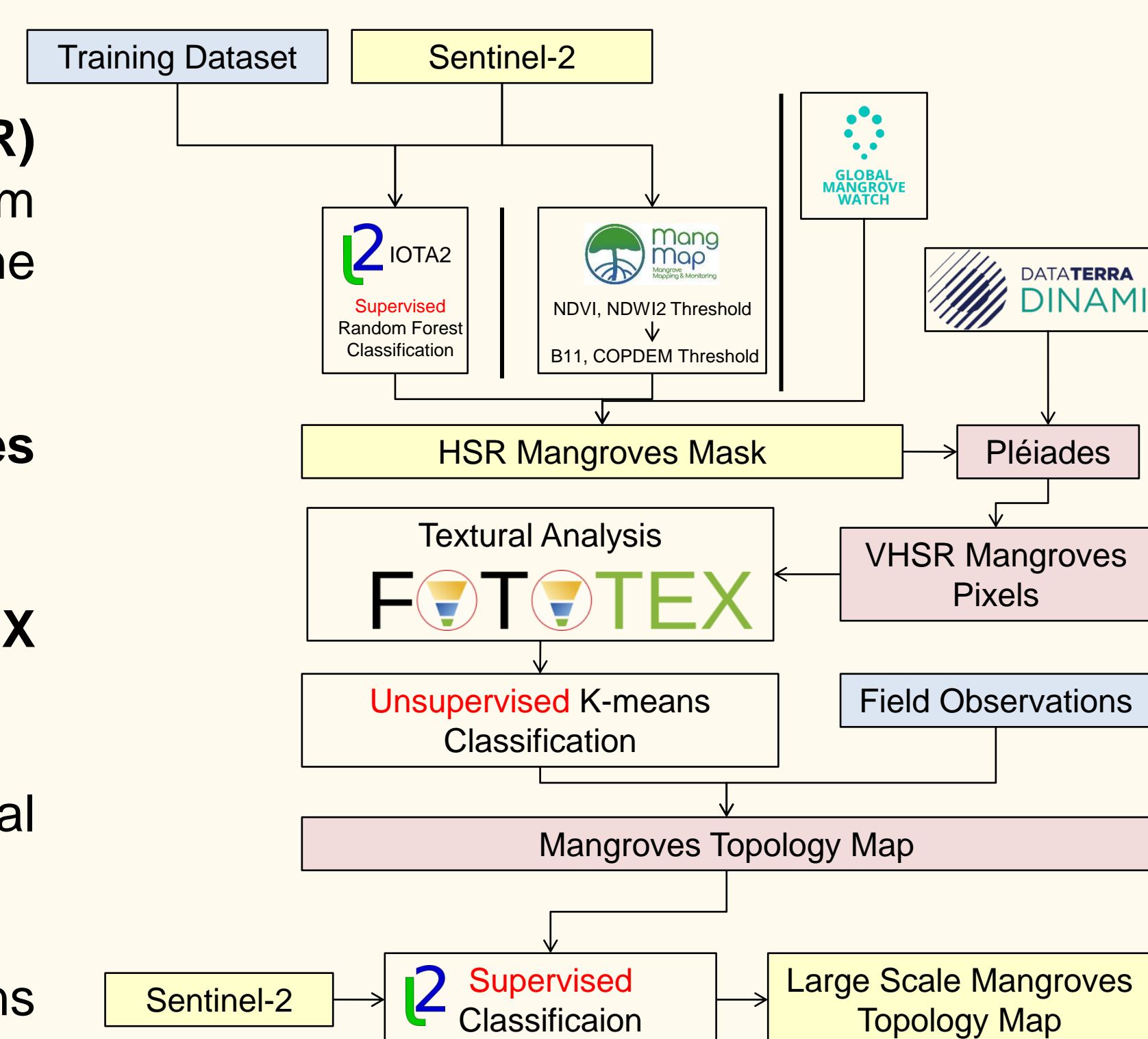
Introduction

The aim of the **SOS-MAMBO** project, funded by CNES (French Space Agency) in the frame of the TOSCA program, is to develop a new **methodological framework based on open-source multi-sensor and multi-resolution remote sensing combined to in-situ measurements to map mangroves types at fine scale**. The test site is the Bombetoka Bay, located in the North-West of **Madagascar**, at the Betsiboka River mouth in the Indian Ocean. In the Bombetoka Estuary, islets are continuously evolving as a result of erosion and accretion processes. On those islets, multiple mangroves species at different development stages can be found.

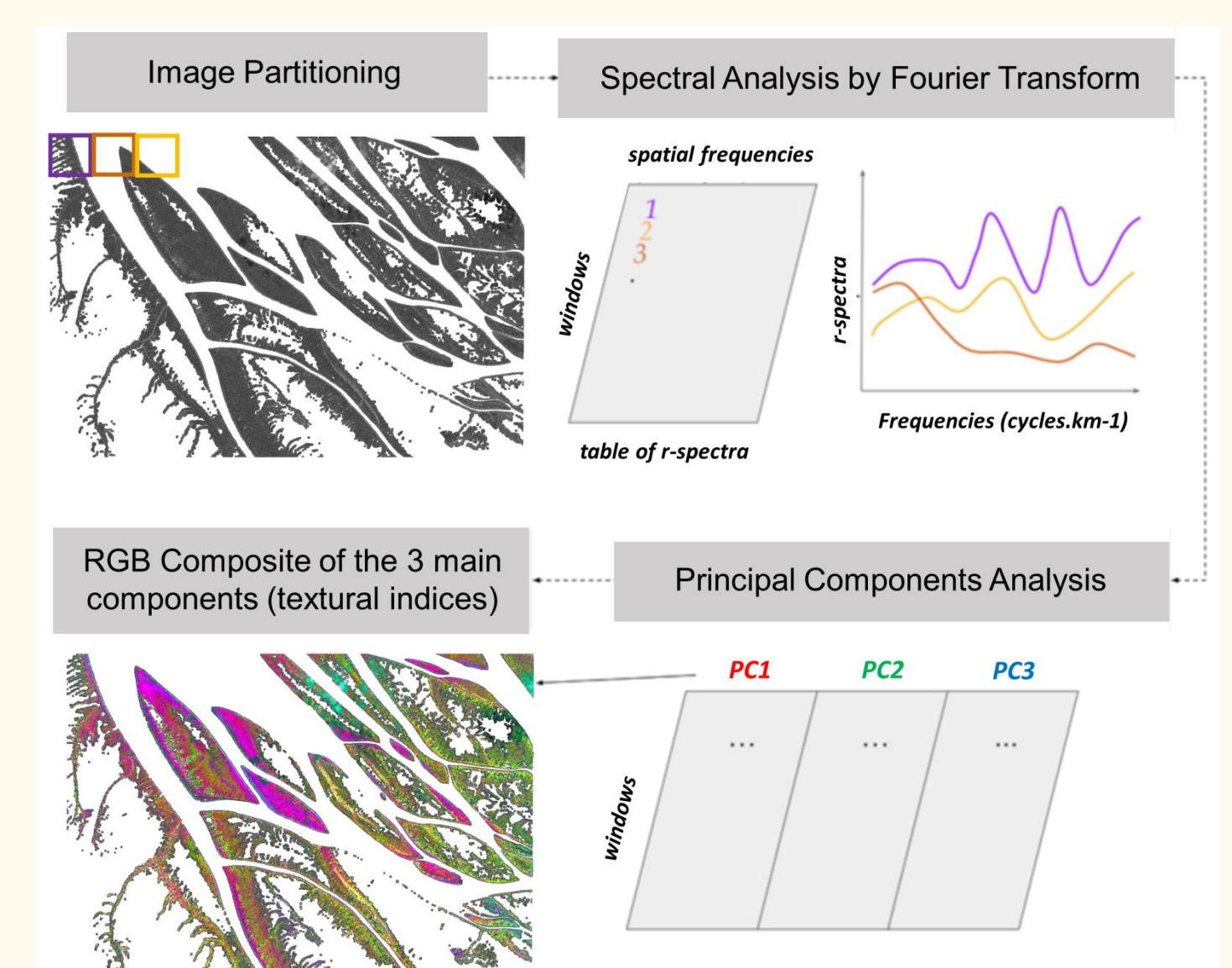


Data and Method

- 1) Mangroves areas are extracted from **High Spatial Resolution (HSR) Sentinel-2 images** (10 meters) using a mask from the MangMap platform [1], or from a supervised Random Forest classification calculated with the IOTA2 processing chain [2], or from Goba Mangrove Watch (GMW) [3].
- 2) Mangroves pixels of a **Very High Spatial Resolution (VHSR) Pléiades** image (0.5 m) are extracted with the HSR derived mask.
- 3) A textural analysis of the extracted pixels is applied with the **FOTOTEX** algorithm [4].
- 4) An **unsupervised k-means classification** is applied on the textural indices calculated with Fototex.
- 5) **Field observations** are used to **label** the results of the k-means classification.

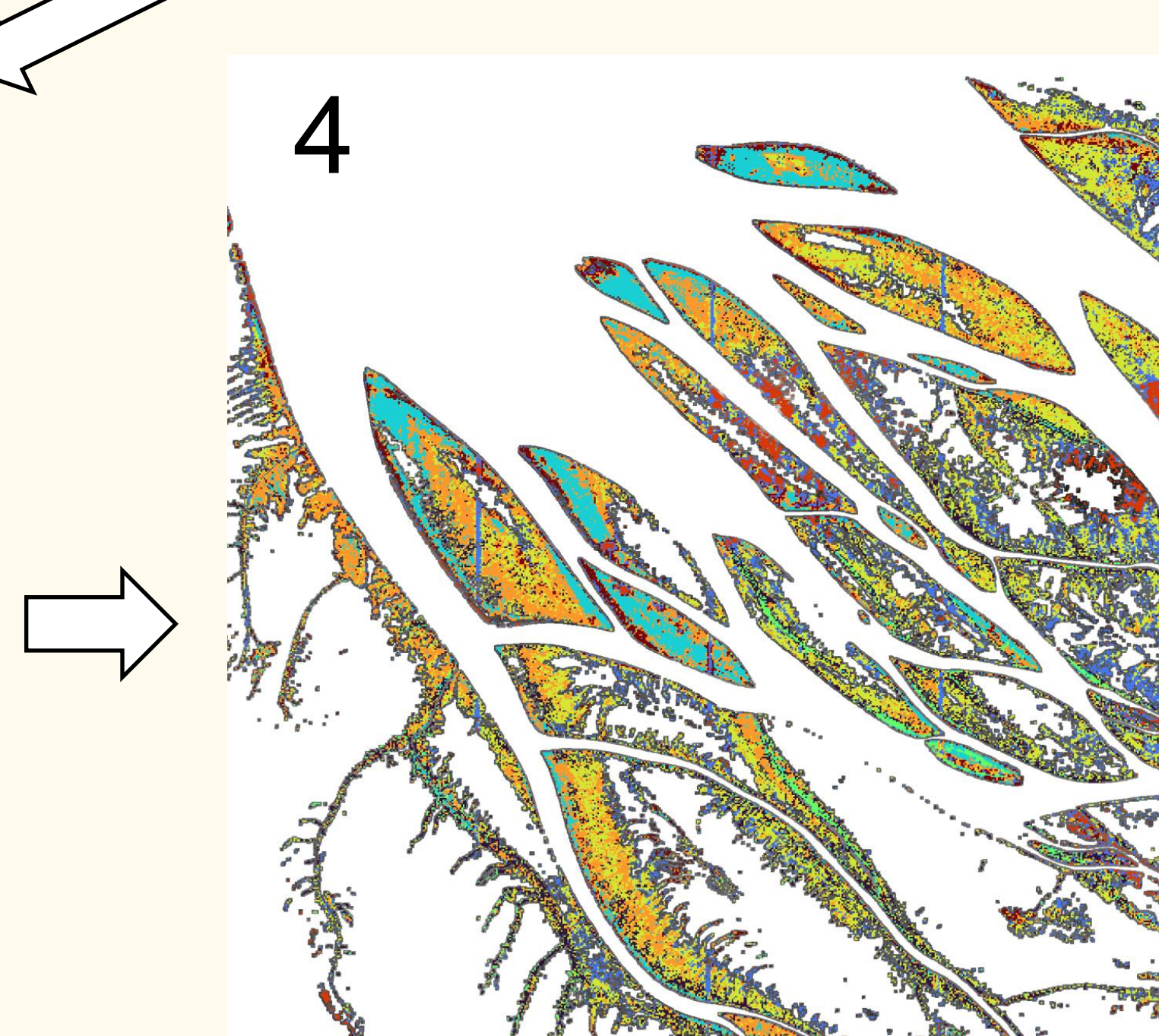
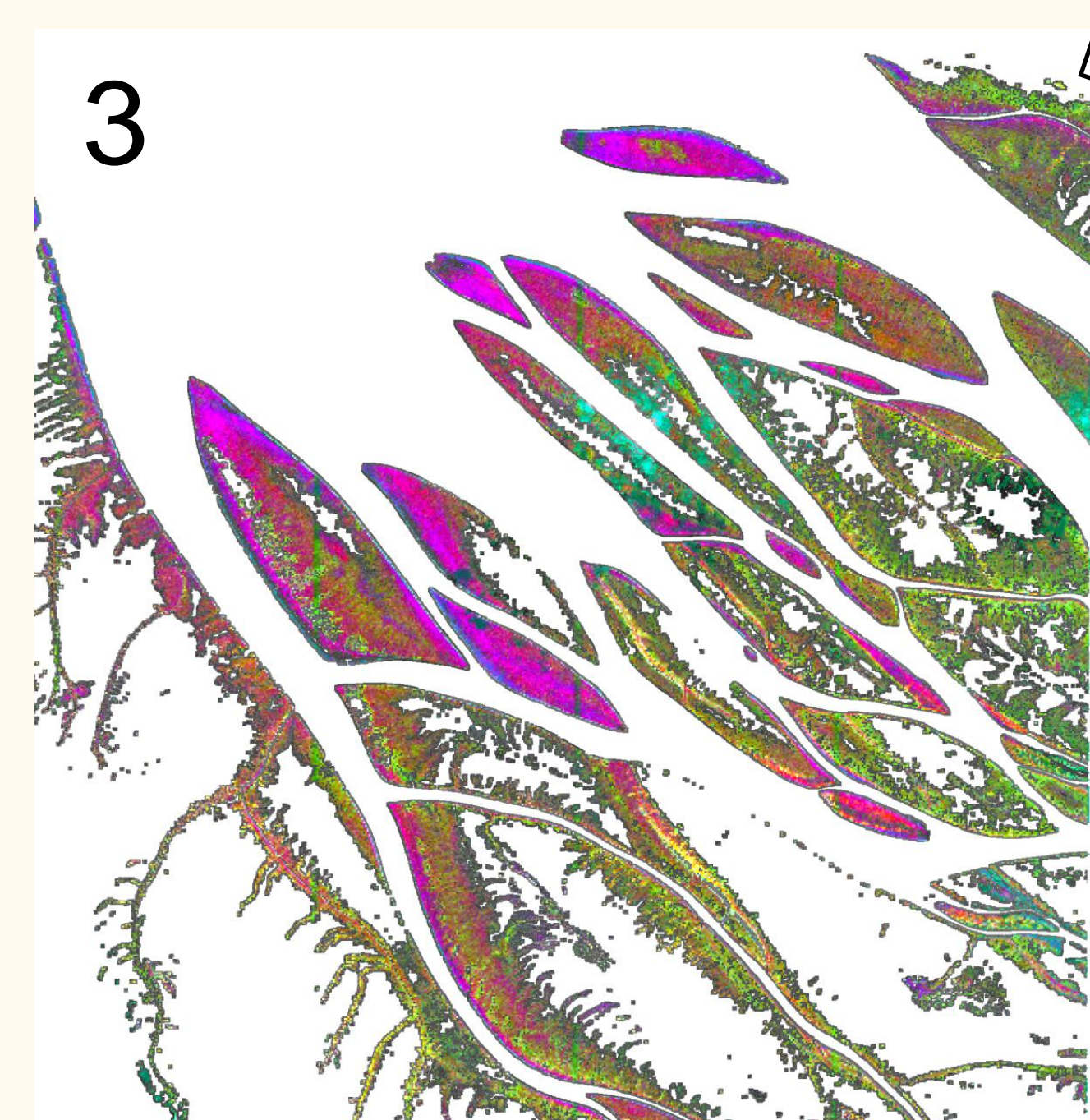
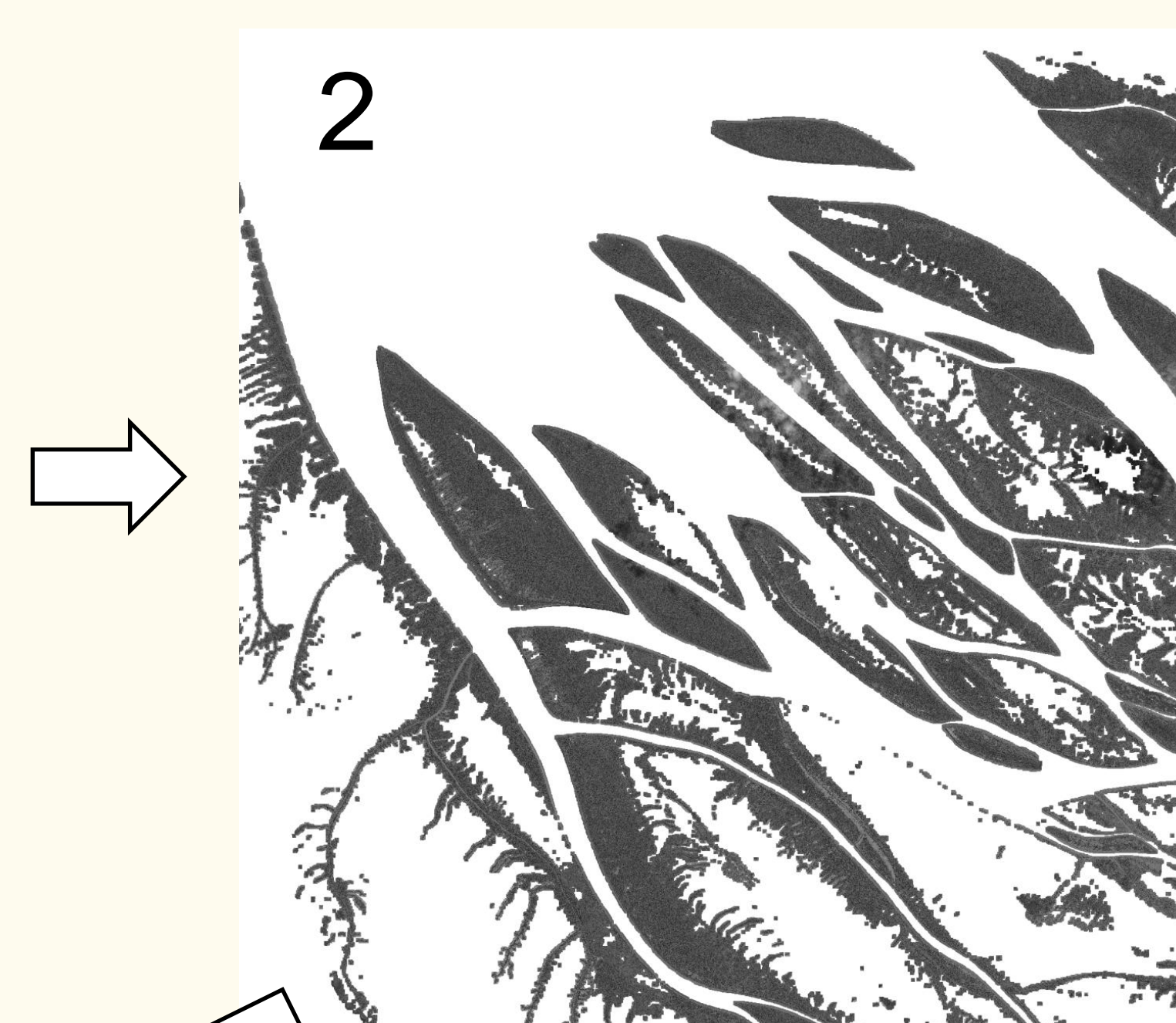
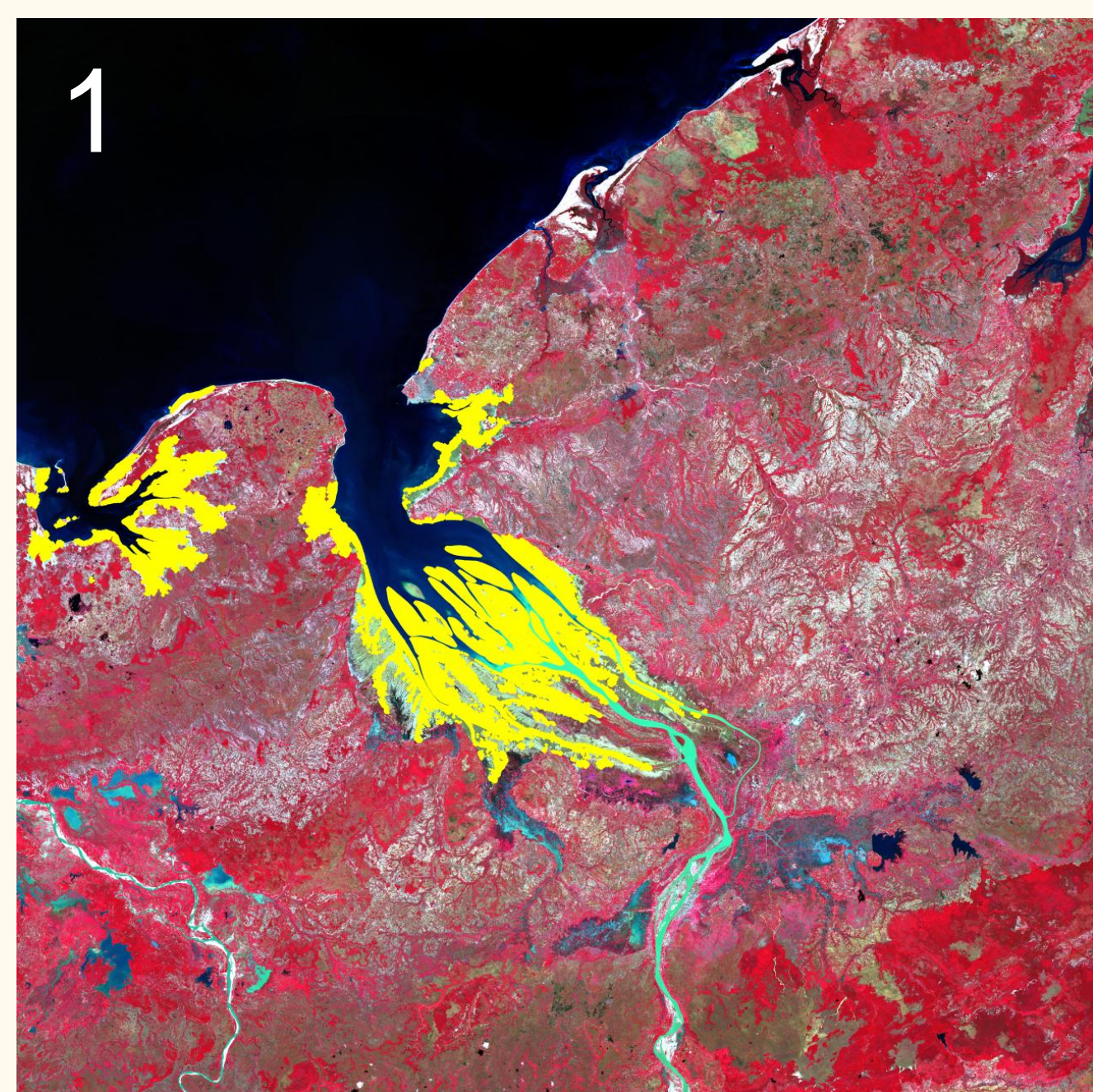


FOTOTEX for canopy texture analysis (modified from *Teillet et al. 2021* <https://doi.org/10.3390/rs13122398>)



Results

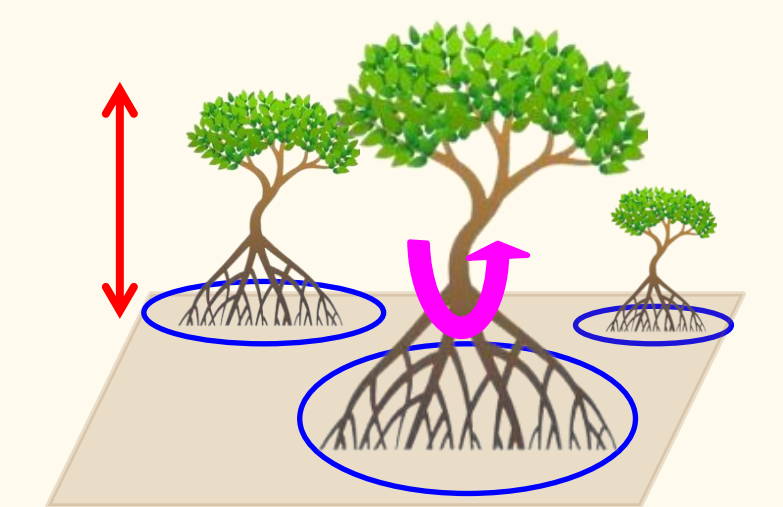
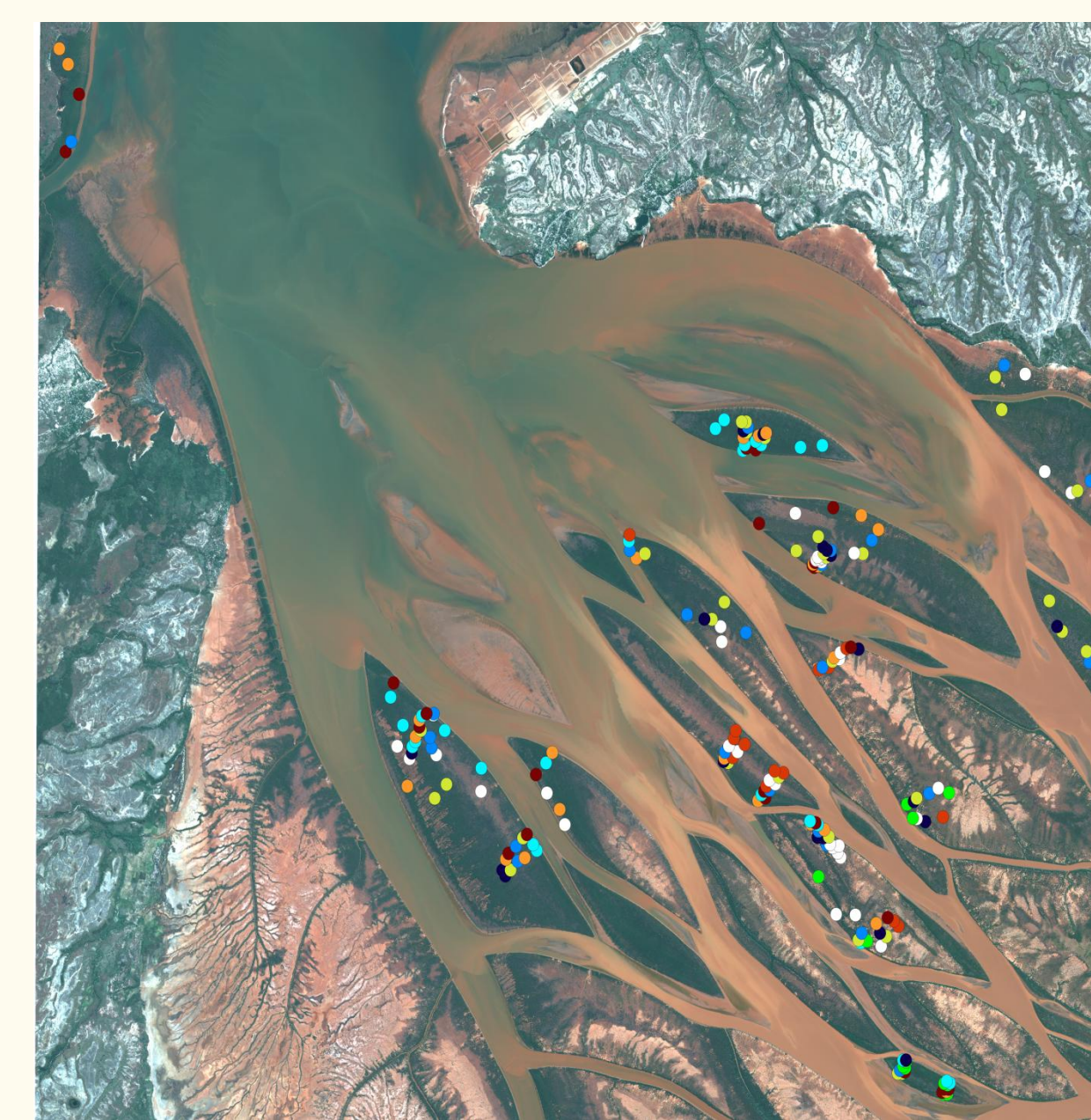
HSR Mangroves Mask (from Sentinel) VHSR Masked Pléiades (Panchromatic band)



Fototex Textural Analysis

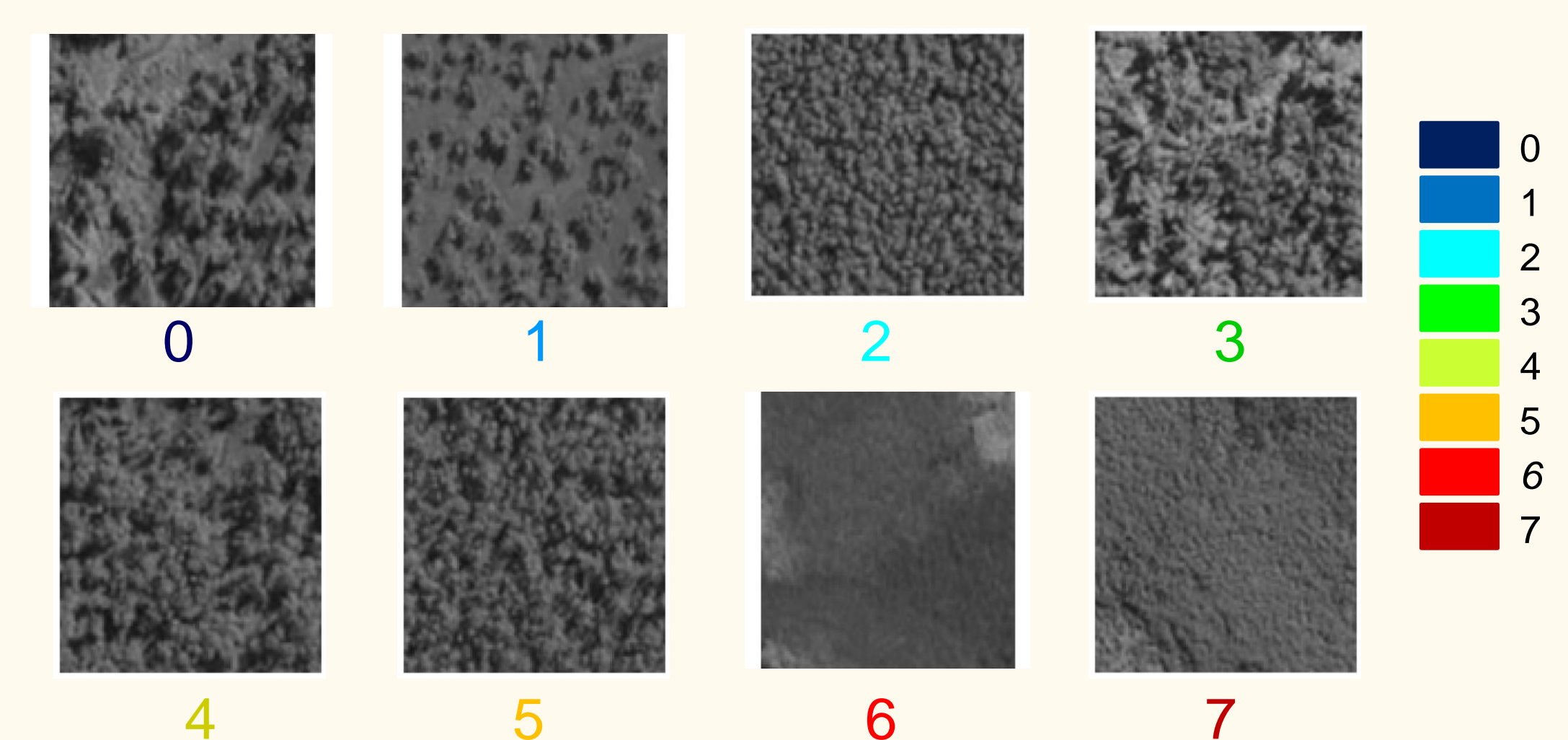
Unsupervised K-means classification

Field observations



- 5
- Tree density (○)
- Tree DBH (△)
- Tree height (□)
- Tree crown
- Tree health
- Phenological state
- Mangroves species

Fototex Pléiades windows for each k-means classes



The field observations are used to label the unsupervised k-means classification, giving a map of the structural typology of the mangroves of the Bombetoka Estuary.

Conclusion

We developed a framework to monitor the **mangroves typology at fine scale** with **open access remote sensing** data. Two field campaigns have been realized in 2023 and 2024, during which more than **200 field observations** of the Bombetoka mangroves phenological and geometrical data were collected. Correlations between the field observations and the **textural indices** are currently analysed, with the next step being the large scale classification mapping. Those results should be able to help mangroves **monitoring actors, stakeholders and policy makers** to improve **mangroves conservation decisions**. An early version of the processing chain is available at https://framagit.org/quentinmarsal/sos_mambo, allowing for textural analysis and unsupervised k-means classification of mangroves area.



References :

- [1] MangMap : <https://mangmap.org/en/>
- [2] IOTA2 : <https://framagit.org/iota2-project/iota2>
- [3] GMW : <https://www.globalmangrovetwatch.org>
- [4] Fototex : <https://framagit.org/espace-dev/fototex>