BioSpace25 - Biodiversity insight from Space
10 - 14 February 2025 | ESA-ESRIN | Frascati - Italy

Exploring tree functional diversity with remote sensing over the Congo Basin within the CoForFunc project

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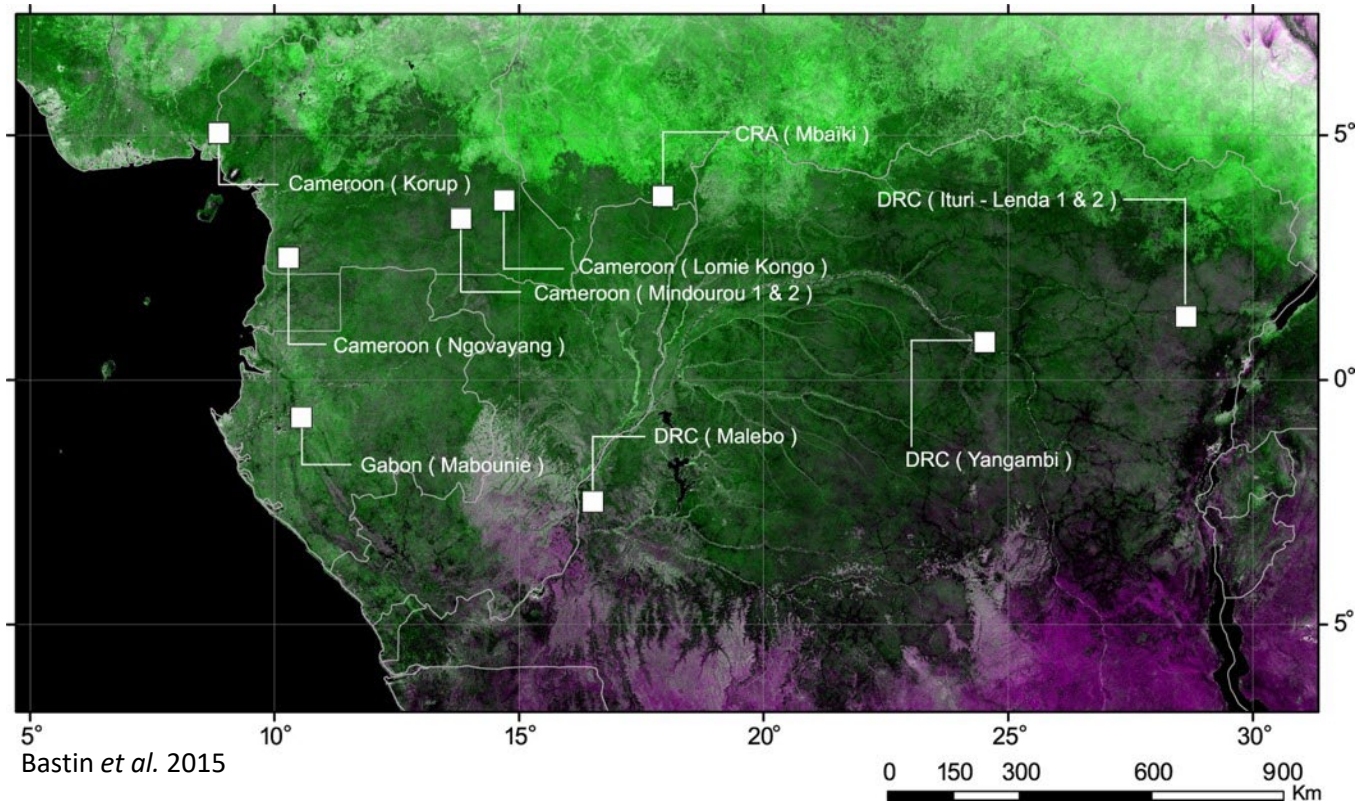
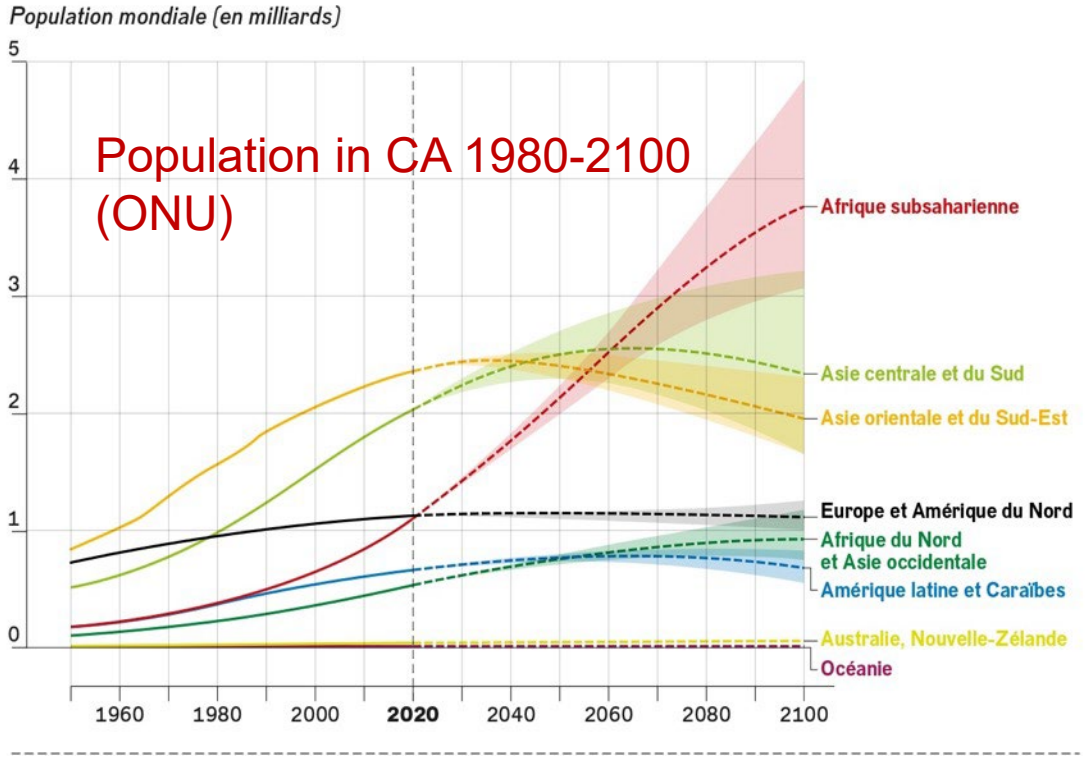
Context: central African forests

⇒ Second largest forest block in the world



Bastin *et al.* 2015

⇒ Accelerating climate, demographic and economic changes



⇒ Beyond deforestation, expected changes in forest species and functional composition with feedbacks on ecosystem services, including global carbon and water cycles

Outstanding tree diversity

Photo credits: Pierre Ploton





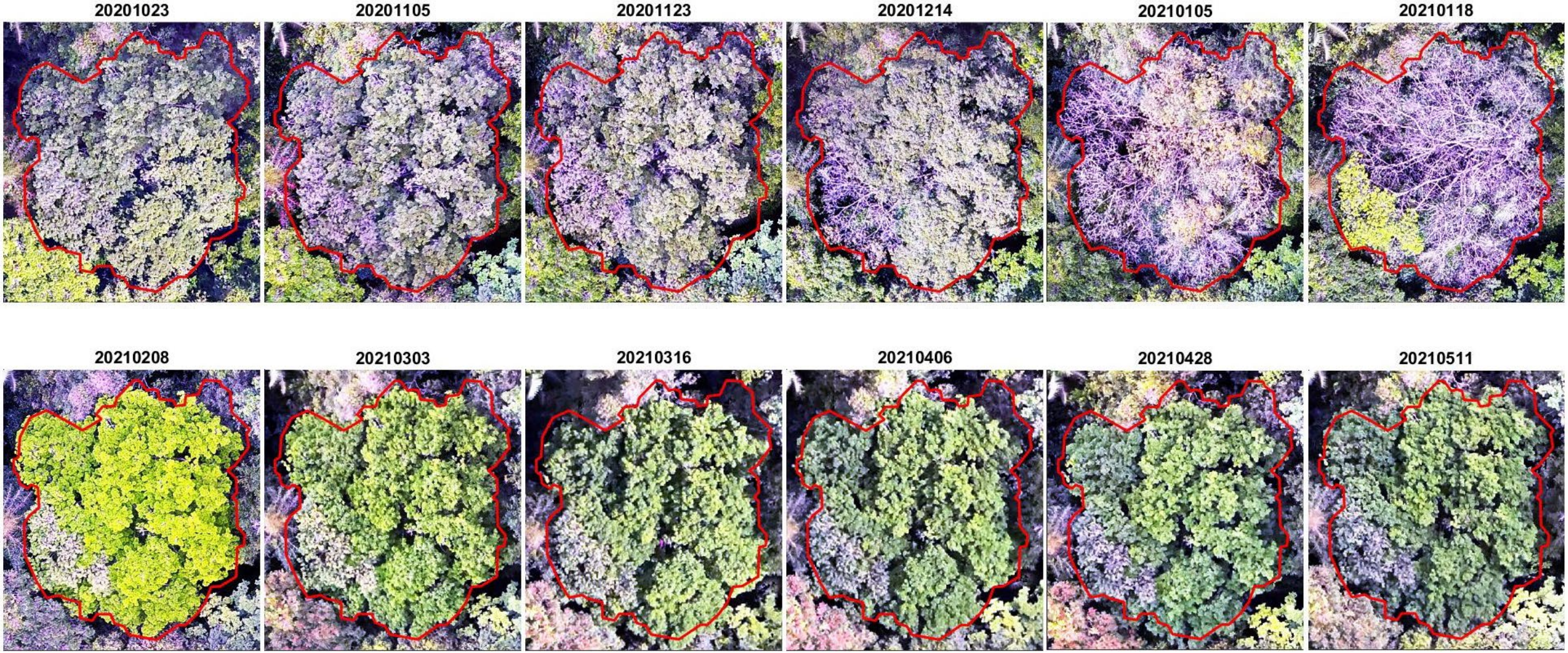

Outstanding leaf diversity

Photo credits: Pierre Ploton





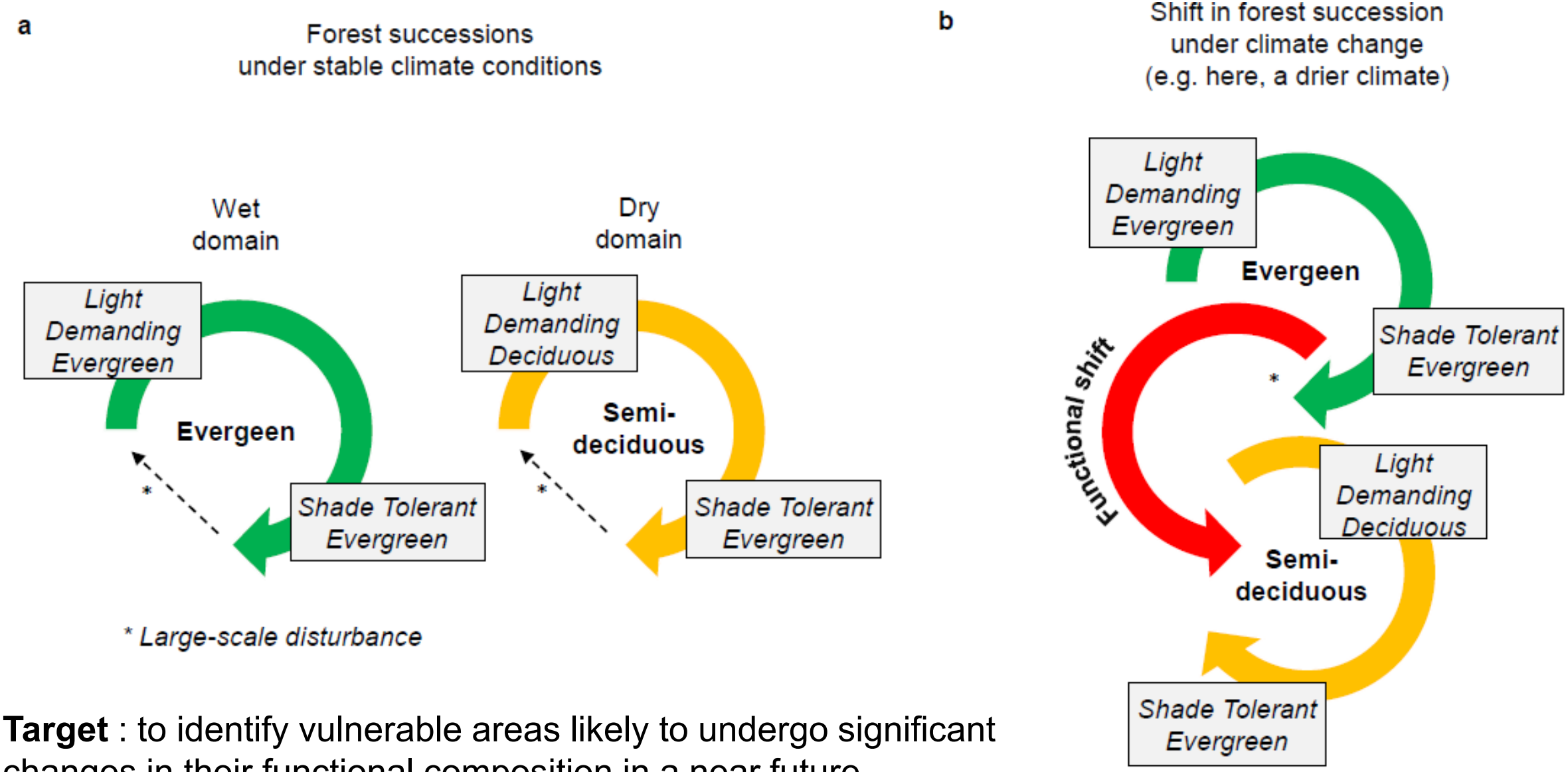

Outstanding phenological diversity



** Photos from French Guyana*

Photo credit: Nicolas Barbier & PhenObs project

Hypothesis: functional shifts



Target : to identify vulnerable areas likely to undergo significant changes in their functional composition in a near future

CoForFunc project

Toward a biome-scale monitoring of the **Co**ngo Basin **For**est **Func**tional composition

4 Funded
European partners

4 Non-Funded African partners

(Cameroon, Rep. Congo, Dem. Rep. Congo + collab Gabon)

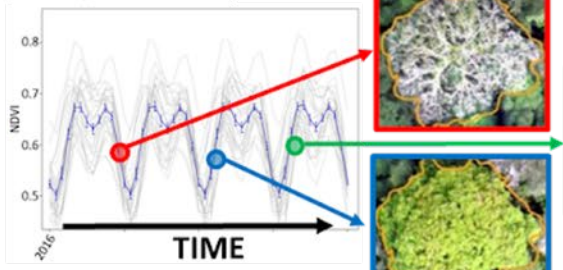
WP1. Sharing data → ground-truth estimates of tree (functional) diversity

Data harmonization | **Data acquisition - Citizen science** Pl@ntNet | **Essential Biodiversity Variables (EBV)**

Validation

Data

WP2. Characterizing tree phenology patterns from repeated drone surveys

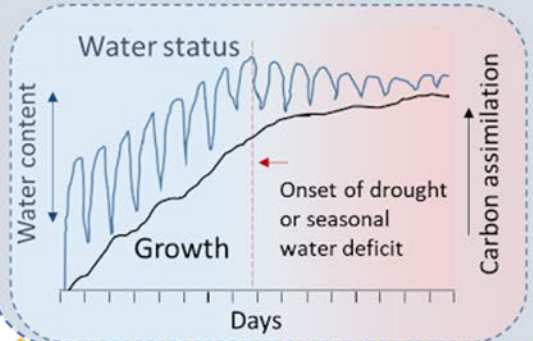


6 observatories (Fig 2)

Phenophase identification

Leaf cohort aging

WP3. Tree monitoring for a mechanistic interpretation of phenological behaviours



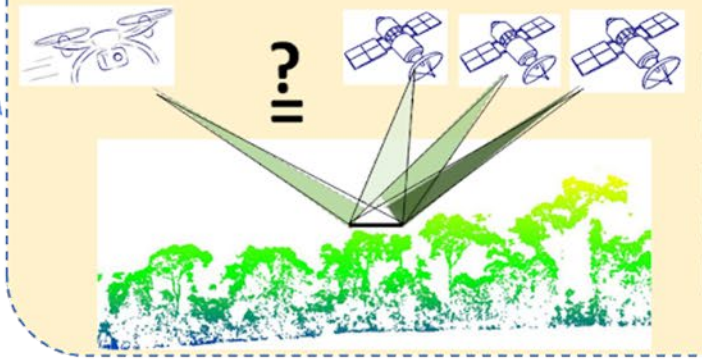
Soft traits

- Wood density
- Specific leaf area
- Leaf nutrients
- Stomatal density

Seasonal (leaf)

- Water potential
- Water content
- Turgor loss point
- Fluorescence

WP4. Towards a better understanding of Ecosystem Functional Properties from space



Novel ways to map functional properties from multi space-borne sensors

WP5. Phenology-related EBV and projection onto expected change scenarios to assess vulnerability

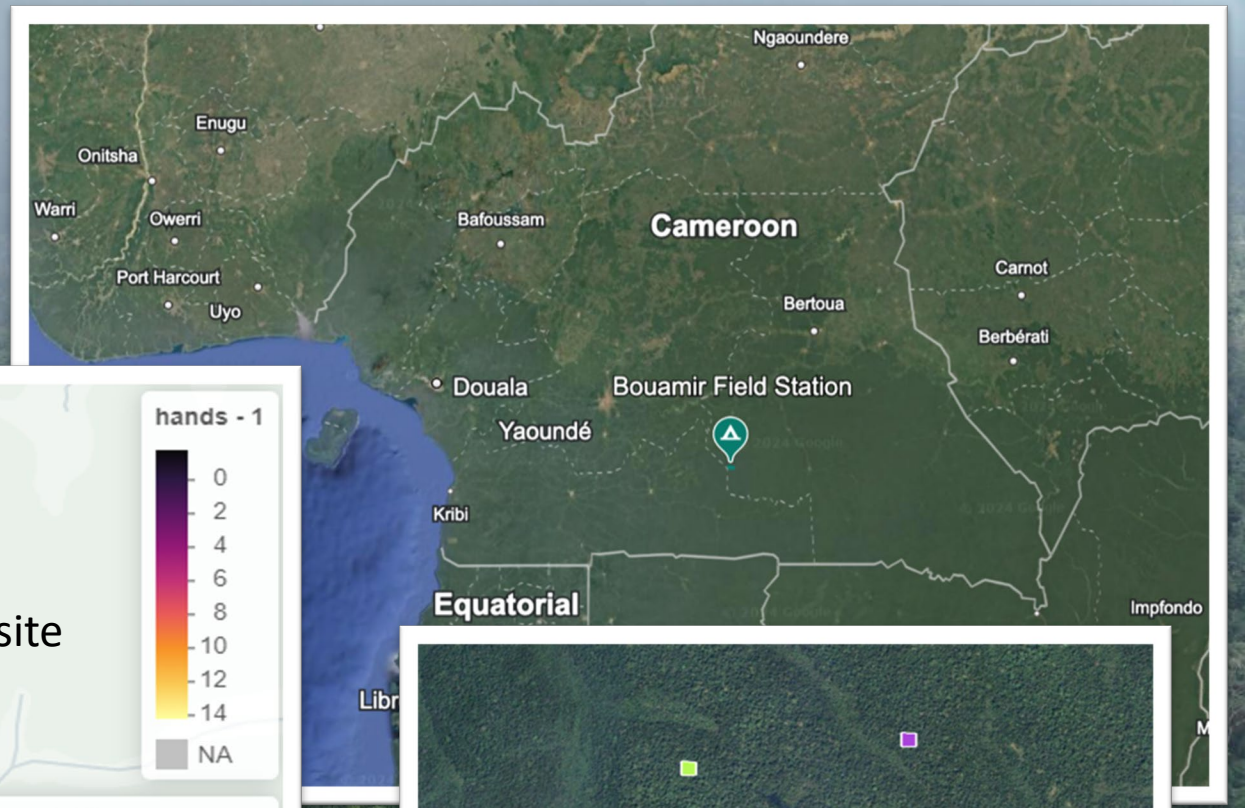
Wall-to-wall functional biome-scale EBV crossing ground inventory data and spatial RS-data

Space-for-time substitution and trend analysis approaches

Multi-assessment and land planning recommendations

WP6. Project management, communication and dissemination

Bouamir site (Dja reserve)



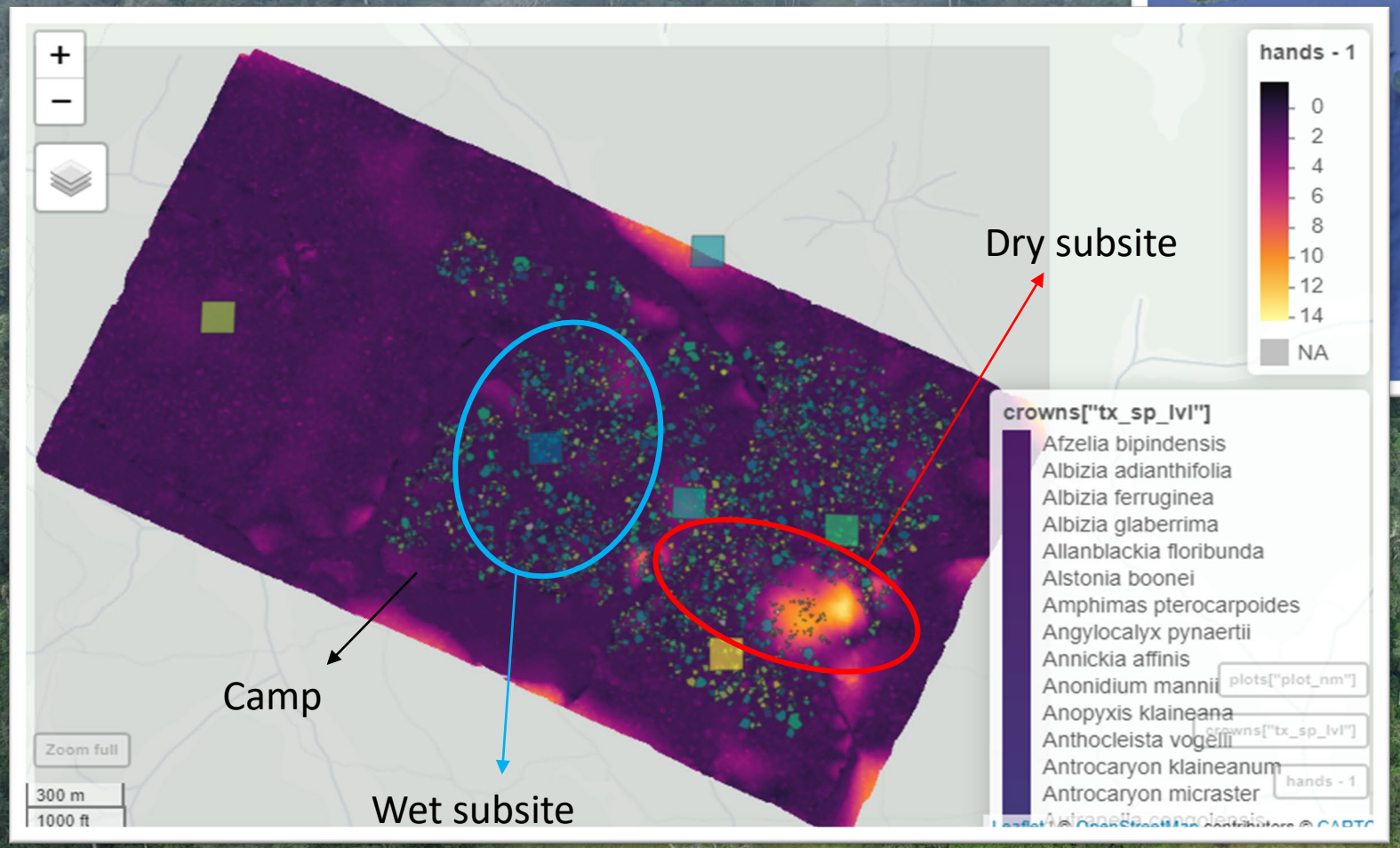


Photo credits: Pierre Ploton

CoForFunc

Photo credits: CoForFunc


NASA/Photo from the ISS

EFPs from space in a challenging environment: 3 approaches

TASK 1

Phenology assisted by Geostationary

TASK 2

Hydraulic and structural traits from microwave

TASK 3

Photosynthetic traits from SIF + Geostationary

Going Diel : Going closer to sub-daily temporal resolution …

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Phenology from geostationary orbit

nature COMMUNICATIONS

ARTICLE

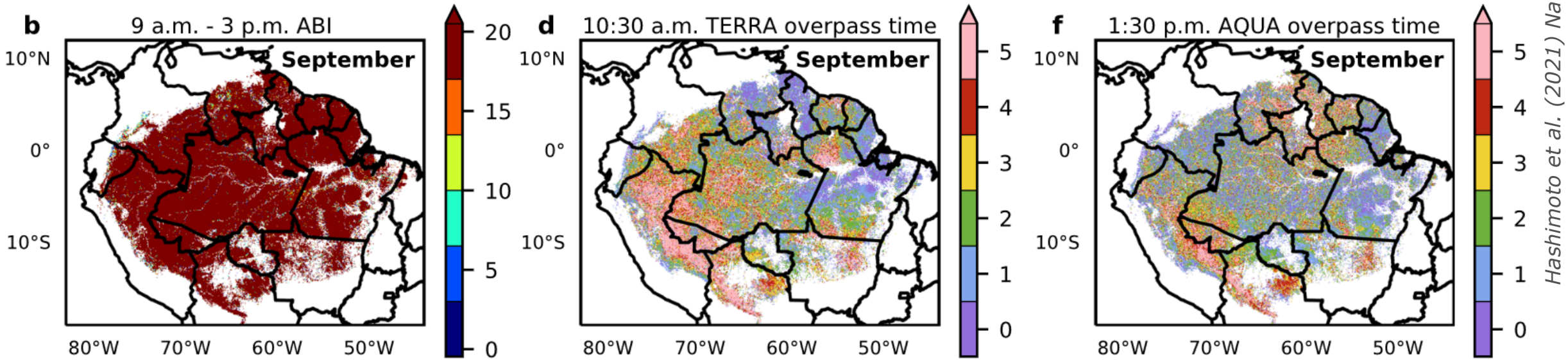
https://doi.org/10.1038/s41467-021-20994-y OPEN

Check for updates

New generation geostationary satellite observations support seasonality in greenness of the Amazon evergreen forests

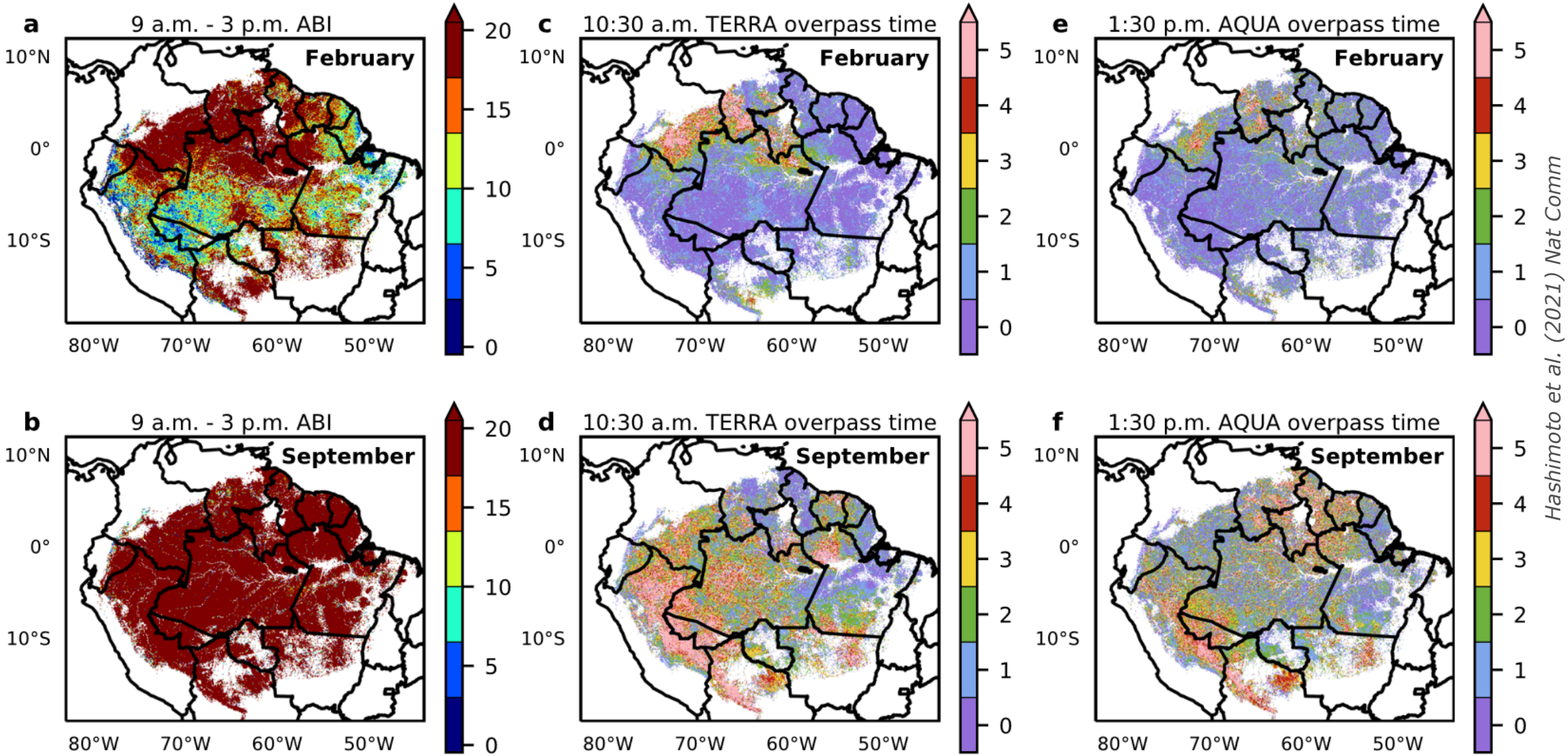
Hirofumi Hashimoto [1,2]✉, Weile Wang [1,2], Jennifer L. Dungan [2], Shuang Li [3], Andrew R. Michaelis[2,4], Hideaki Takenaka [5,6], Atsushi Higuchi [6], Ranga B. Myneni [7] & Ramakrishna R. Nemani [2]

Differences in clear sky observations



Hashimoto et al. (2021) Nat Comm

Fig. 3 Number of clear-sky observations per month by Advanced Baseline Imager (ABI) in wet and dry seasons in 2018. Top row is February, 2018 (the wet season) and bottom row is September, 2018 (the dry season). In particular, **a** and **b** show the numbers for the time window from 9 a.m. to 3 p.m. (local time). **c**, **d** The numbers for the time window at 10:30 a.m. **e**, **f** The corresponding numbers for a time window at 1:30 p.m.



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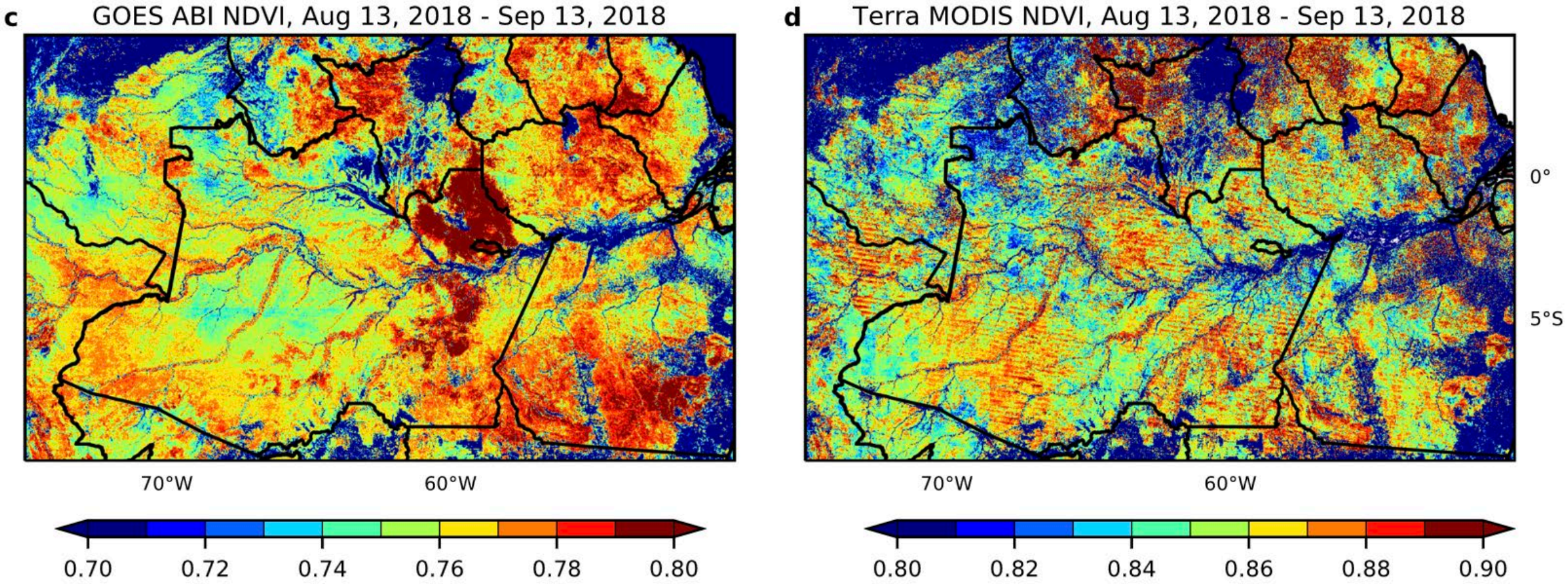
Differences in the mapping of phenology

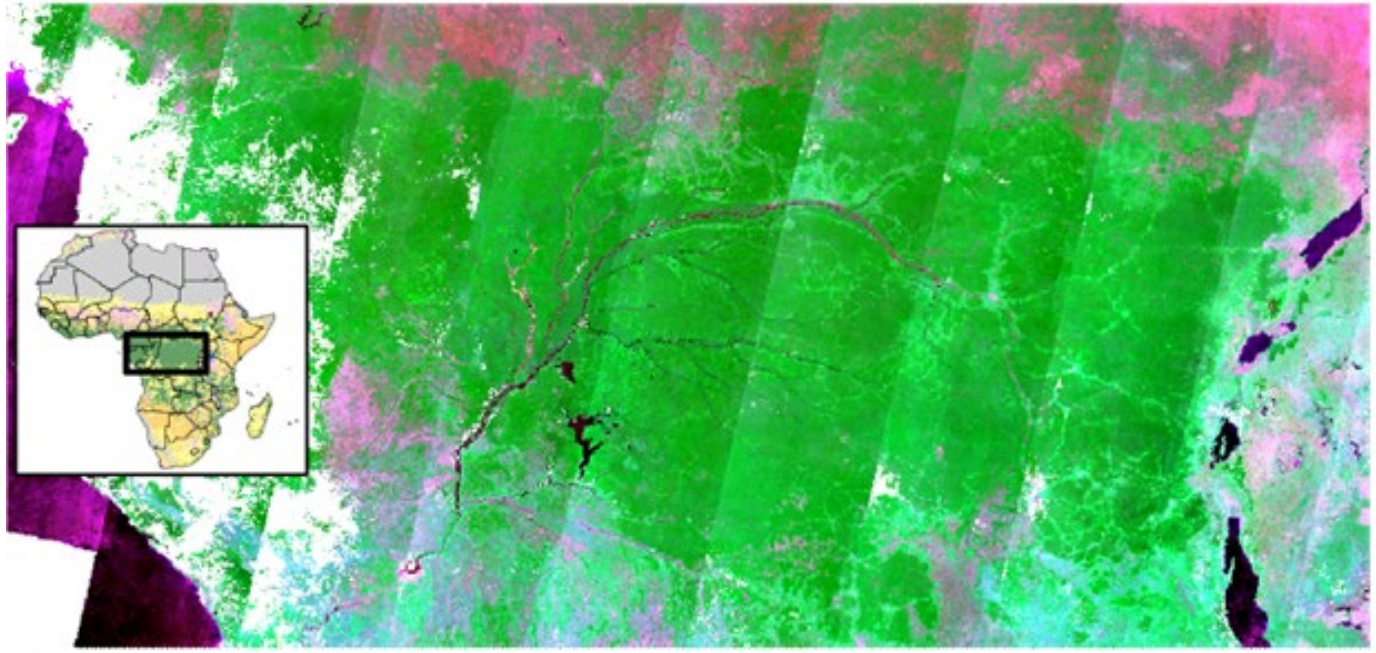


Hashimoto et al. (2021) Nat Comm

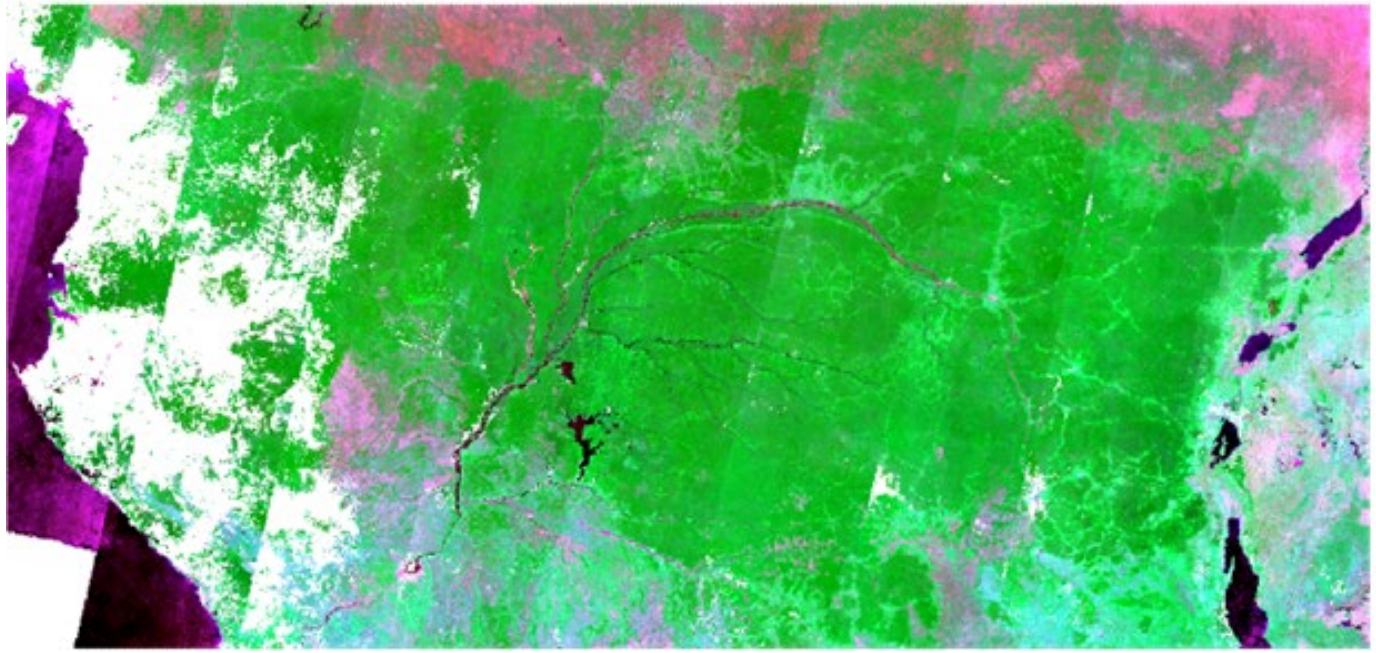
Fig. 4 Comparison between 2018 Advanced Baseline Imager (ABI) and Moderate Resolution Imaging Spectroradiometer (MODIS) monthly Maximum Value Composite (MVC) Normalized Difference Vegetation Index (NDVI). a and **b** are NDVI composites from February 2nd to March 5th (wet month). **c** and **d** are NDVI composites from August 13th to September 13th (dry month). **a** and **c** are GOES-16 ABI composites; **b** and **d** are Terra MODIS composites.

BRDF correction is an issue

Un-corrected S2 images

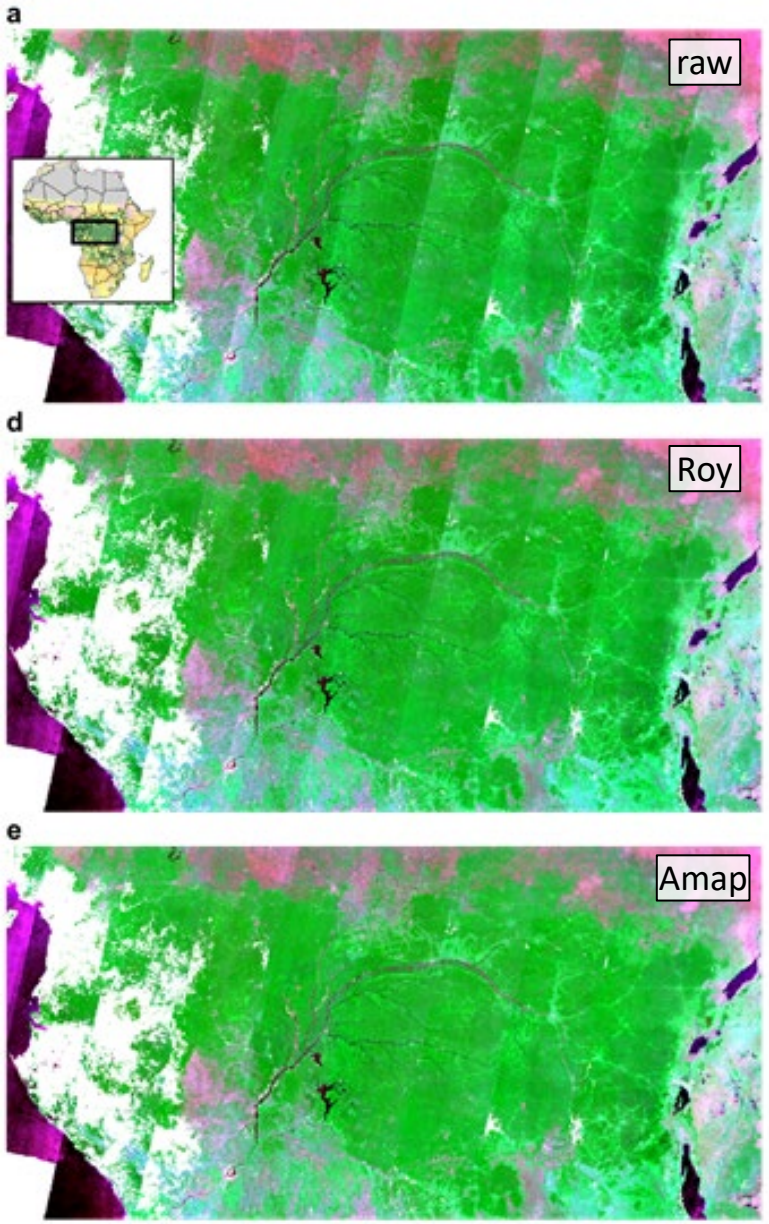


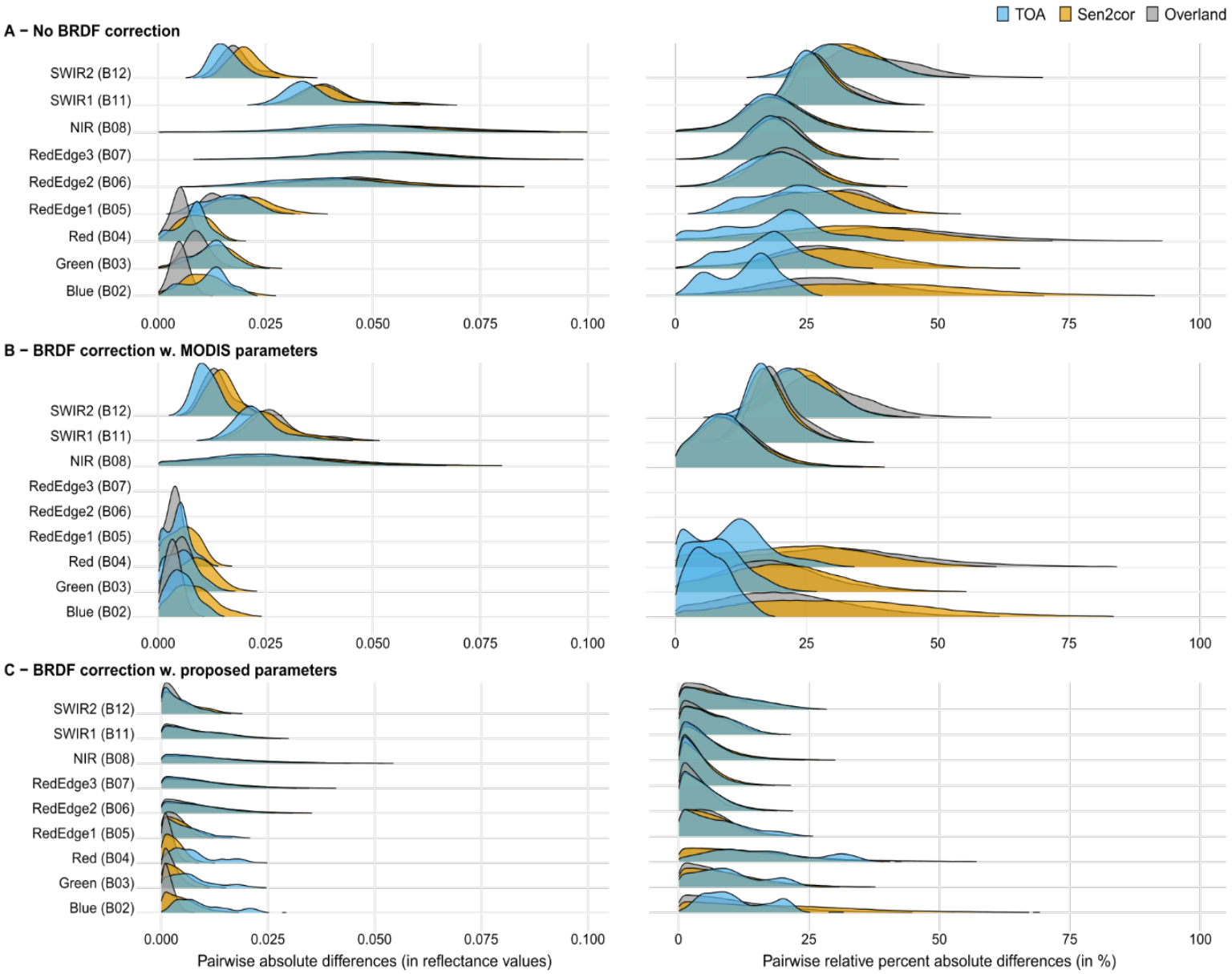
S2 images images after Roy. et al. correction



Roy et al. have shown that taking the spatiotemporal average of MODIS coefficients (i.e. one set of coefficients per band) somewhat worked

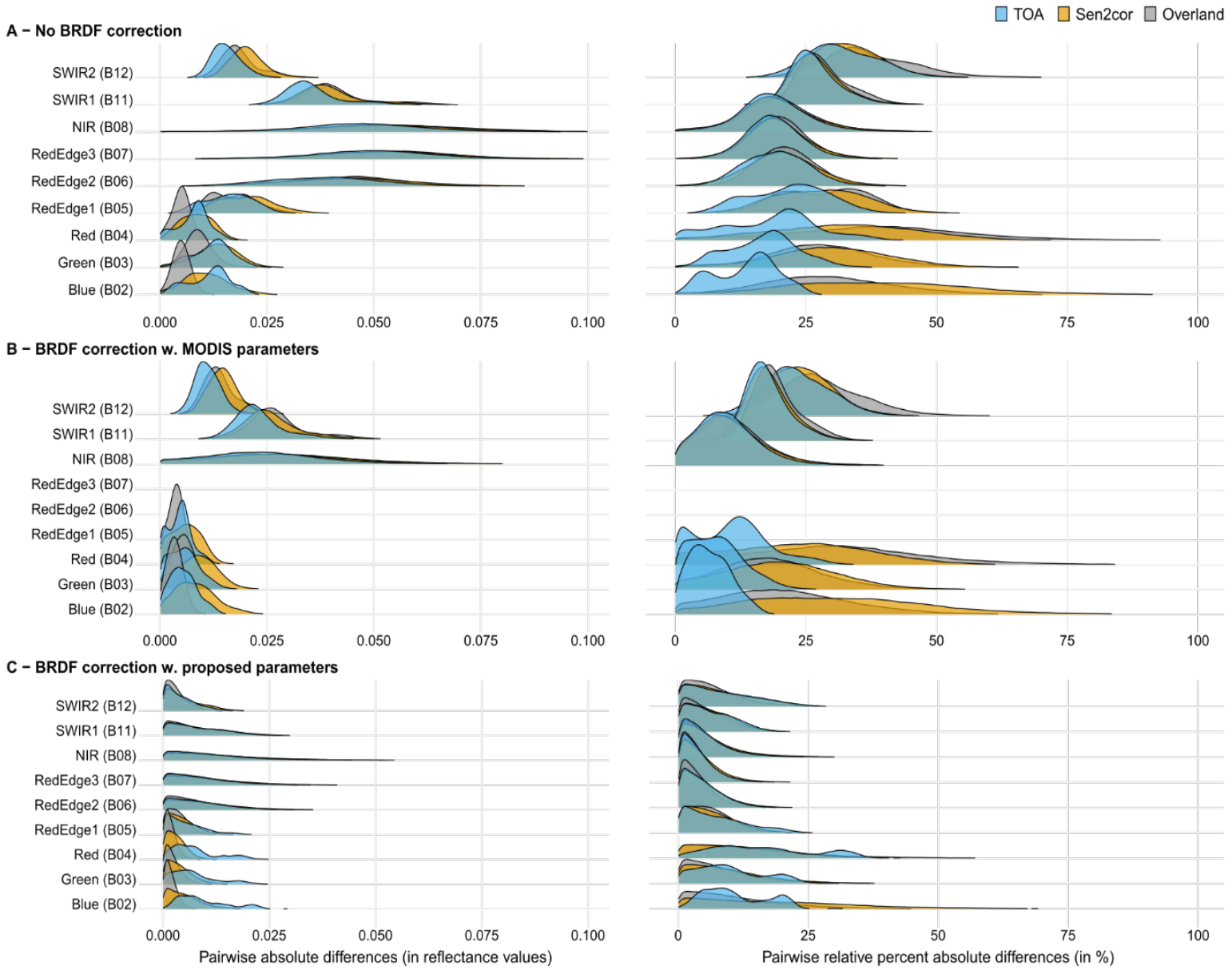
BRDF correction is an issue





BRDF correction is an issue

- BRDF effect are large on uncorrected data!
- BRDF effect remain large after Roy's correction
- Using S2-specific coefficients drastically reduce them…
  (but they remain substantial on the firsts bands!)
- Maybe geostationary data can help here!



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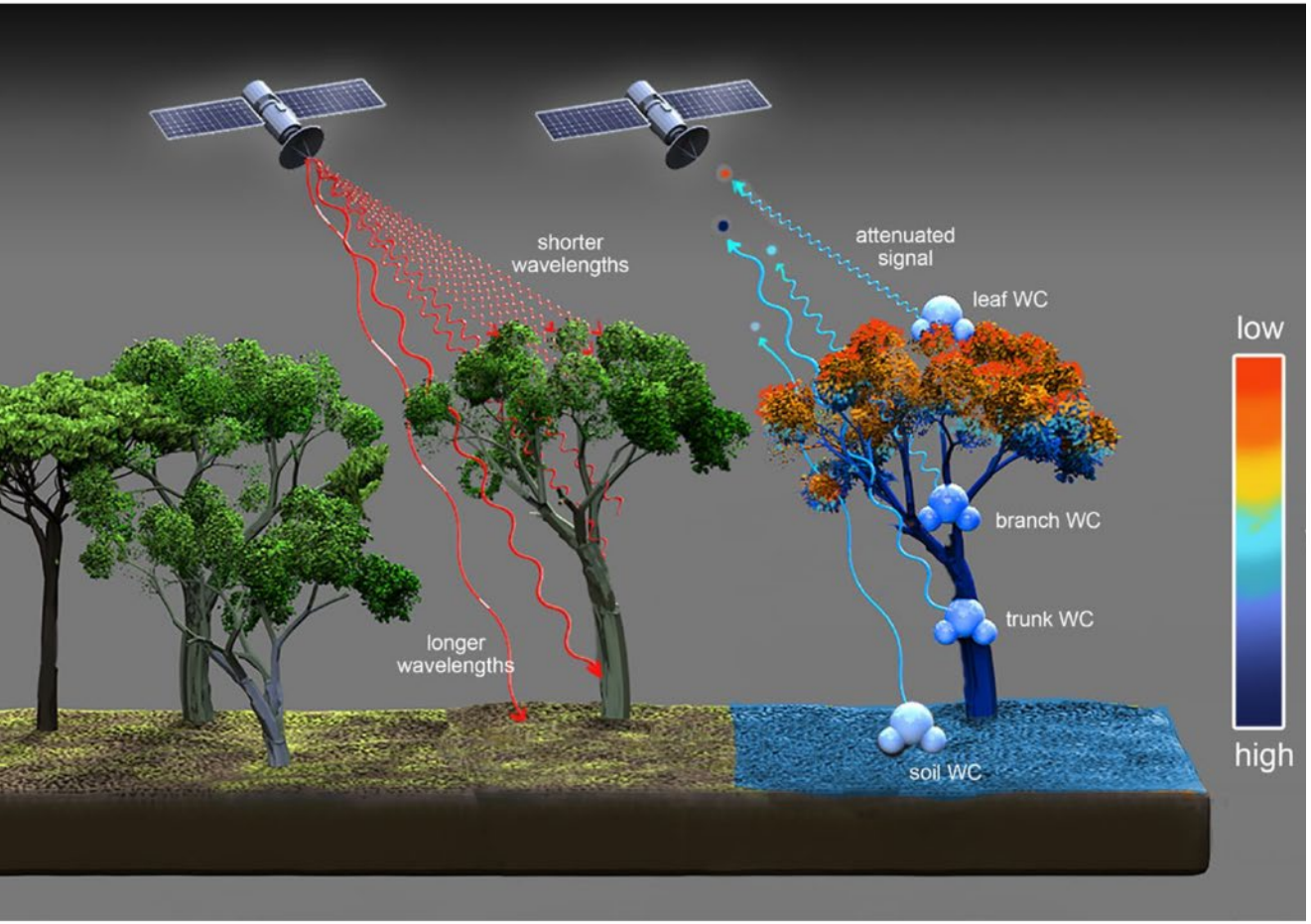
Going Diel : Going closer to sub-daily temporal resolution …

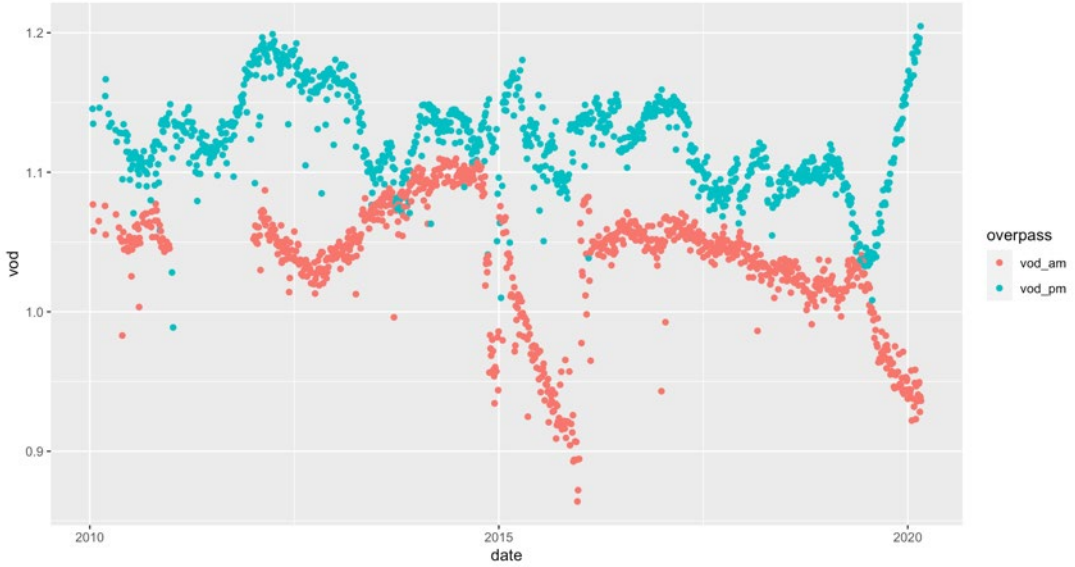
Vegetation water content from space



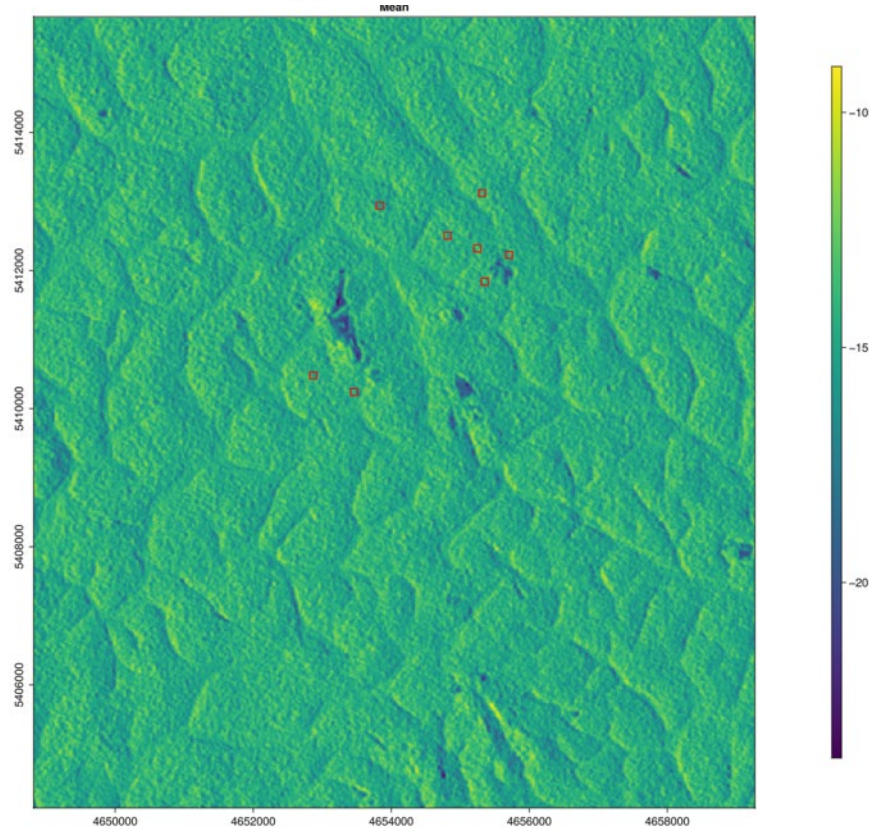
Konings et al. (2021) GCB

Remote sensing data collection

- SMOS-IC Passive L-band VOD (+ SM):
  - --- *Bouamir site (1 pixel) + all Congo Basin*
  - --- *currently 2000 to 2020, more to come…*
  - --- *ascending (06:00) and descending (18:00)*



- Sentinel 1 SAR C-band backscatter :
  - --- *Bouamir site (+ all Congo Basin)*
  - --- *start with 2020 to 2024, see if we extend…*
  - --- *Various polarizations…*



- *Maybe C-band passive VOD at 12:00 and 0:00*
- *BIOMASS P-band when available…*

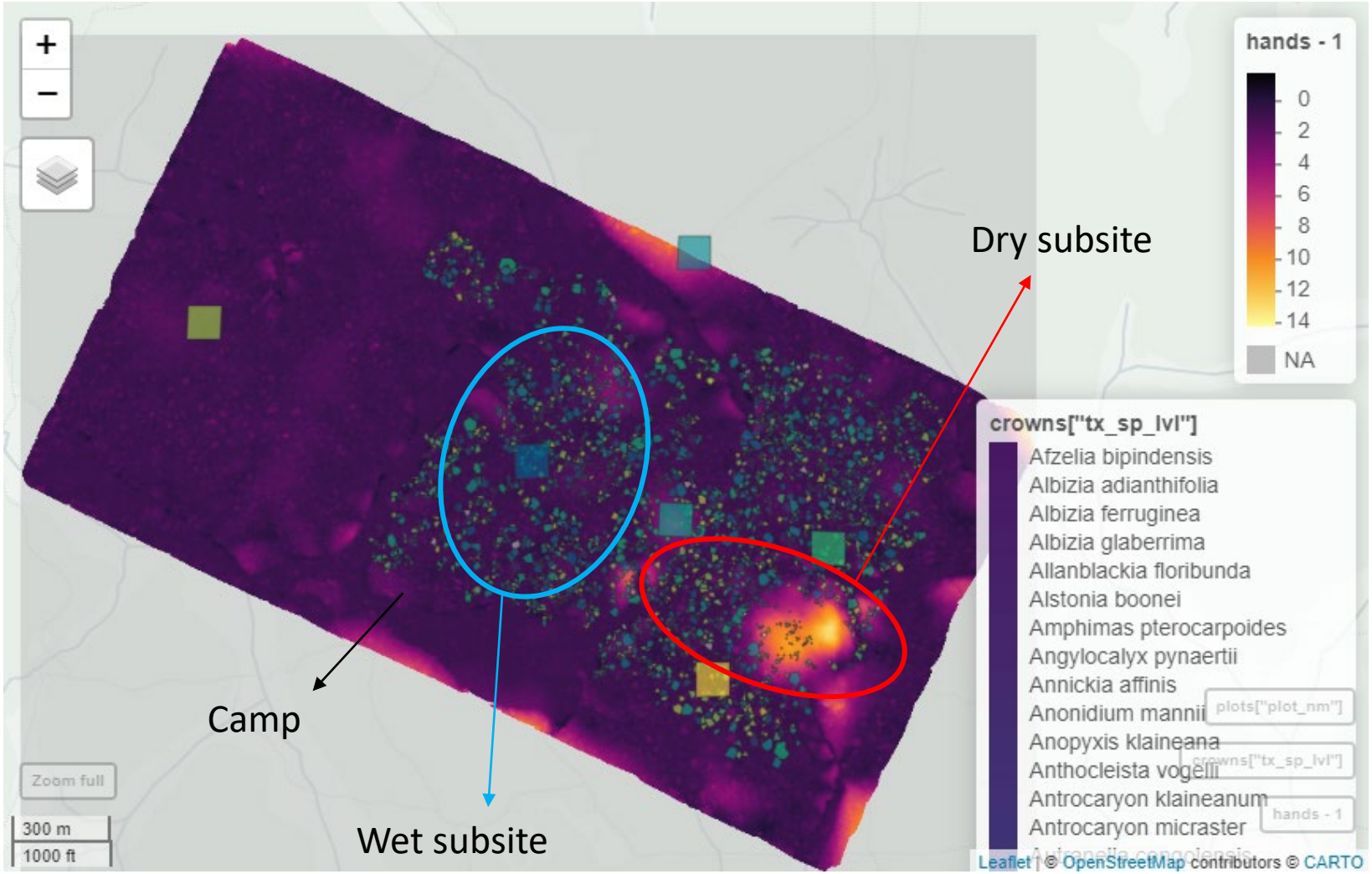
General experimental design

Two contrasting environmental situations (subsites):

- ❖ lower (and wetter) slopes
- ❖ higher (and drier) slopes close to the rocky outcrops

Meaurements (100 trees):

- Seasonal radial growth
- Stem water deficit (diurnal change + growth)
- Soil Temperature
- Soil Moisture
- Air temperature
- RH



We may want to try GNSS instruments to measure ground VOD

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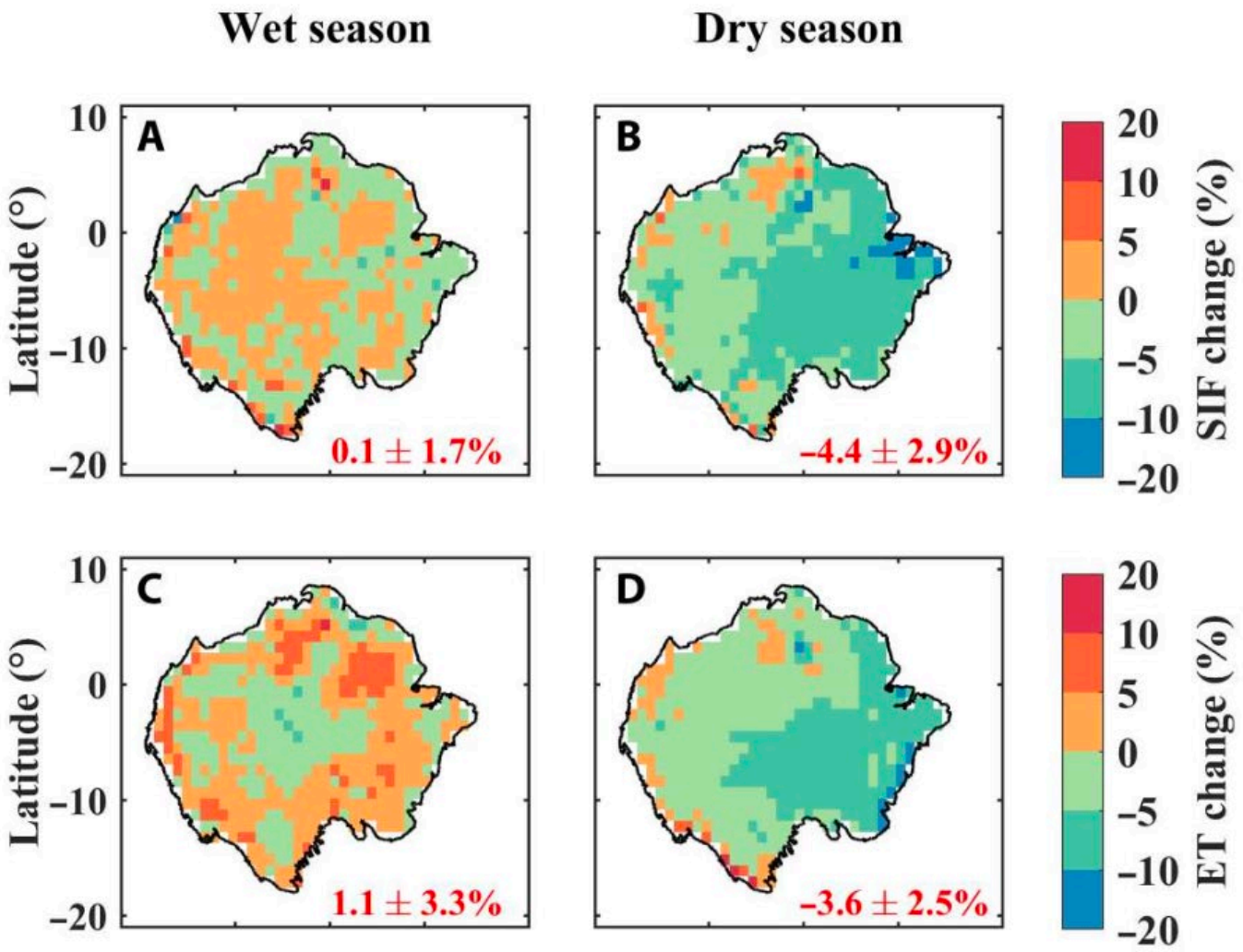
Stress from SIF: quantifying the mid-afternoon depression

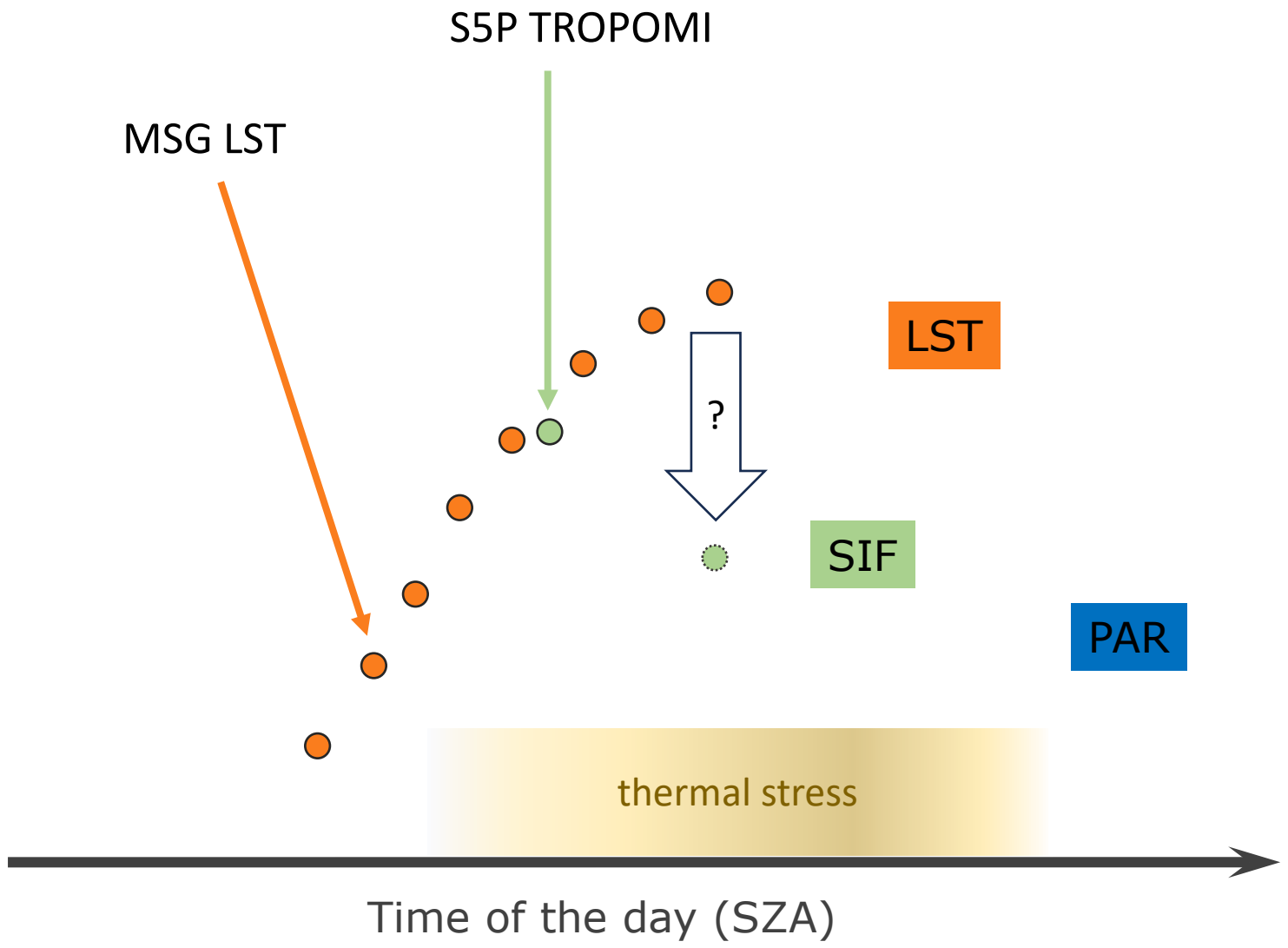
SCIENCE ADVANCES | RESEARCH ARTICLE



Zhang et al. 2023 SciAdv

- *Can we apply it in CBF?*
- *How far can we go with TROPOMI S5P SIF?*
- *Can we calibrate with OCO3 from ISS?*
- *Scale down with FLEX on Bouamir site?*

Can we get this midday/afternoon depression?



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Summary and 3 key recommendations

CoForFunc project:

Exploring what we can see in terms of functional diversity from multiple RS streams over the Congo Basin Forests

3 key recommendations for space agencies/community…

- *Facilitate access RS data in the diel (hyper-temporal) scale*
- *Facilitate the integration of multiple sources, across agencies*
- *Facilitate open access to imagery, workflows and computing power*

THANK YOU FOR YOUR ATTENTION

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CoForFunc

anr

belspo

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biodiversa+
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