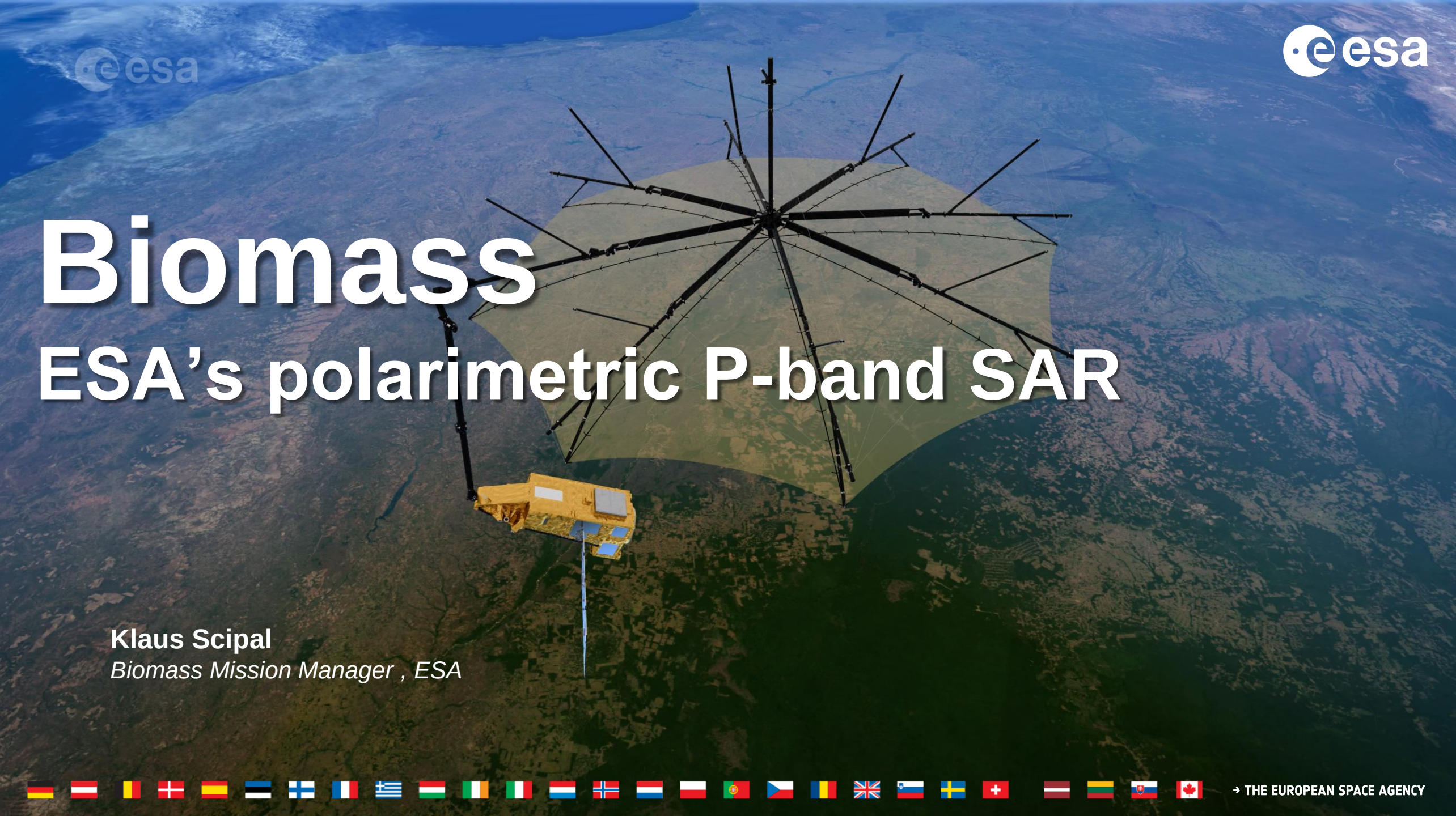


Biomass

ESA's polarimetric P-band SAR

Klaus Scipal
Biomass Mission Manager , ESA

Earth Explorer Missions

Fate of anthropogenic CO2 emissions (2015–2024)

Sources = **Sinks**

88%
9.8 ± 0.5
GtC/yr

12%
1.4 ± 0.7
GtC/yr

50%
5.6 ± 0.02
GtC/yr

21%
2.4 ± 0.8
GtC/yr

29%
3.2 ± 0.4
GtC/yr

- Land-use change (**source**) and land uptake (**sink**) have the largest uncertainties in the global carbon budget.
- Relative uncertainty:
  - Land-use change 50%
  - Land uptake 33%
- This reflects uncertainty in both loss and gain of **biomass**.

We don't properly understand the key change processes.

Source: Friedlingstein et al 2025; Global Carbon Budget 2025

GLOBAL CARBON project

How to weight a tree?

Tree allometry links biomass to

$$AGB = \rho \cdot \left(D/2\right)^2 \cdot H$$

Wood density

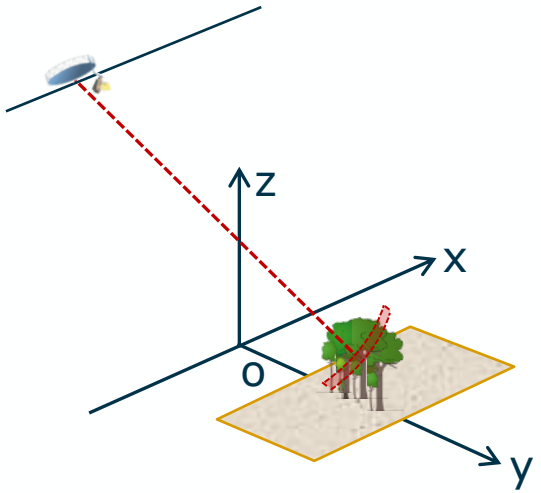
Diameter

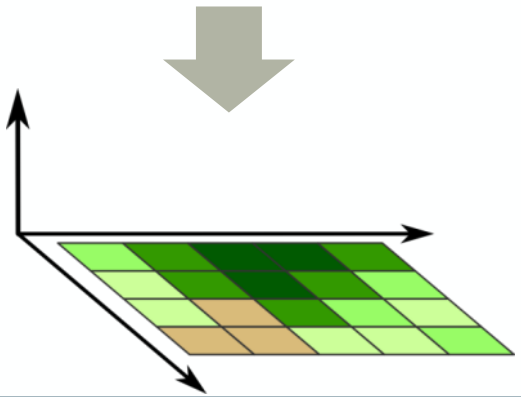
Height


esa

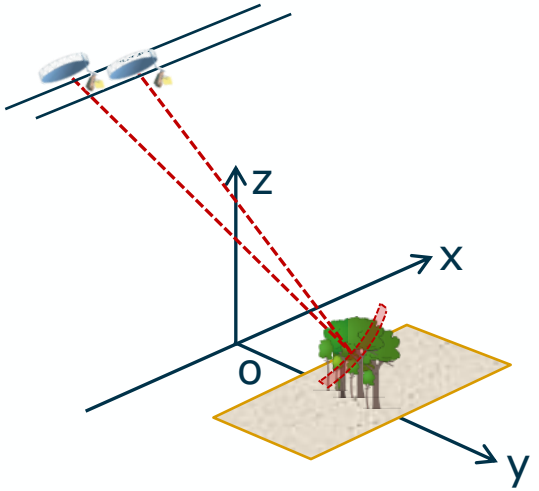
Synthetic Aperture Radar contains structure information

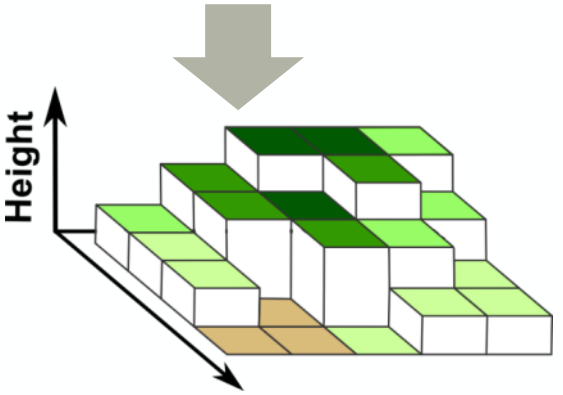
PolSAR
(SAR Polarimetry)



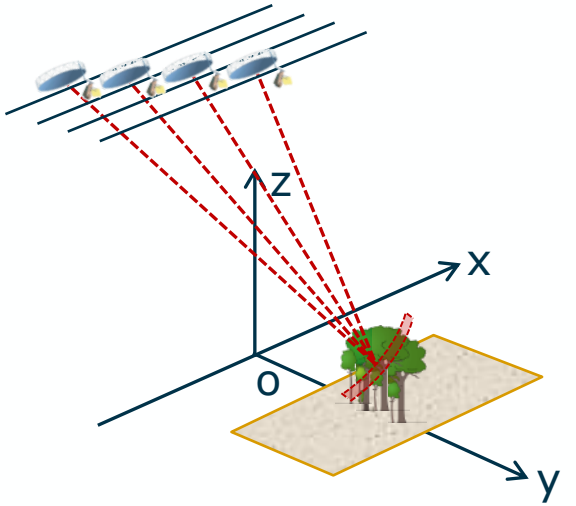


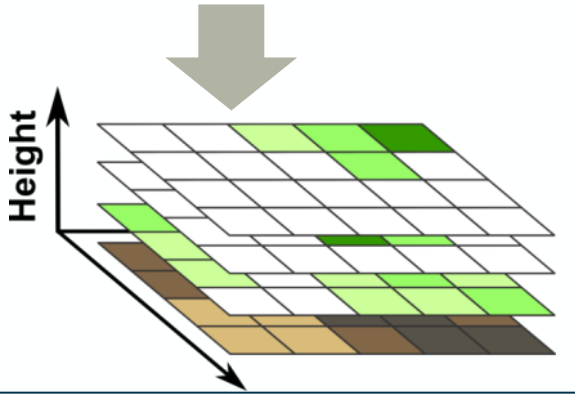
PolInSAR
(Polarimetric SAR Interferometry)



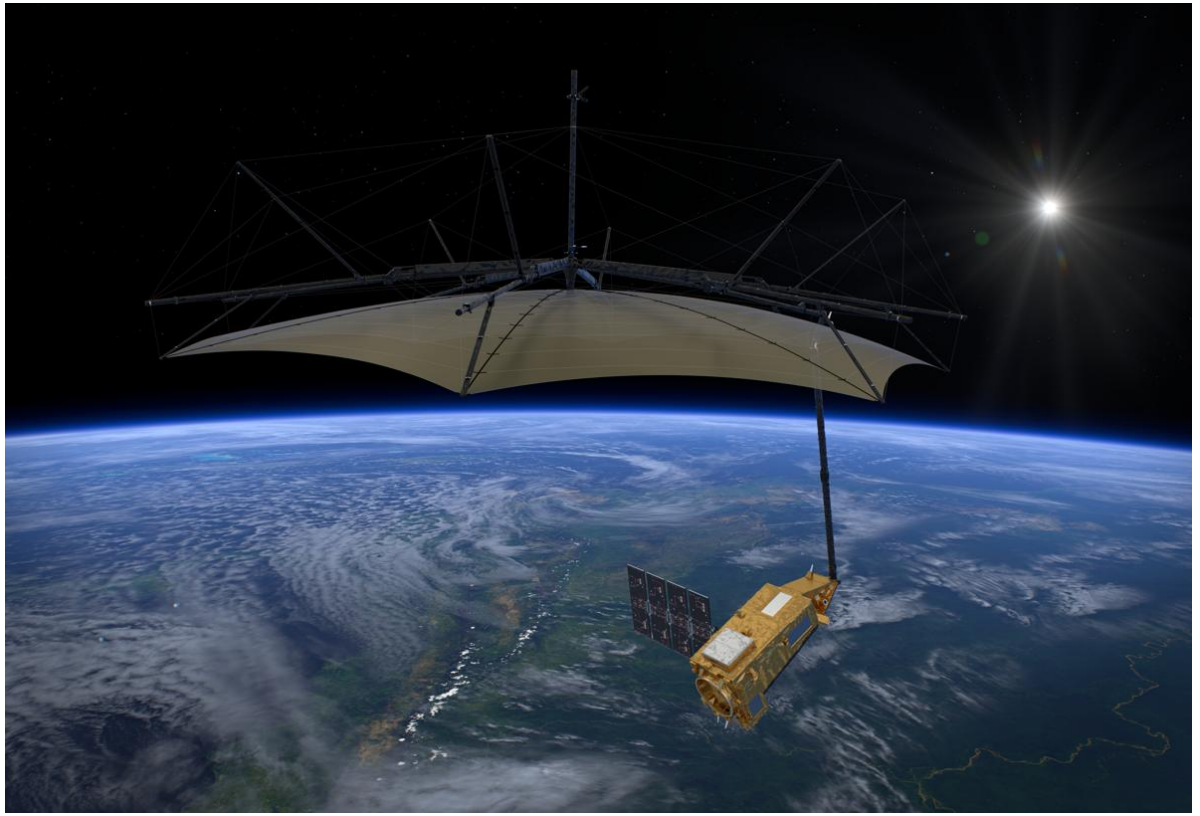


TomoSAR
(SAR Tomography)



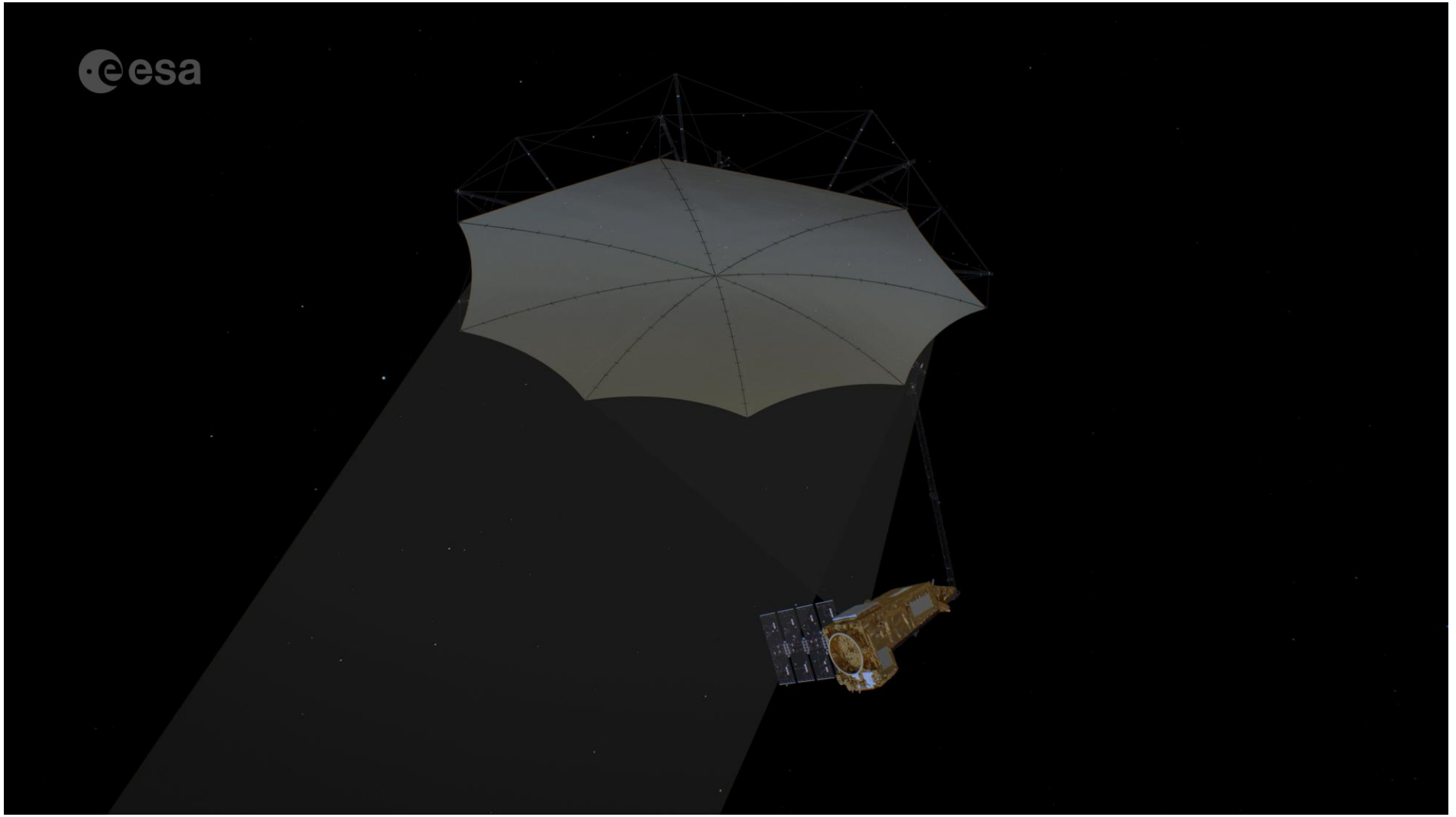


Biomass Mission in a nutshell



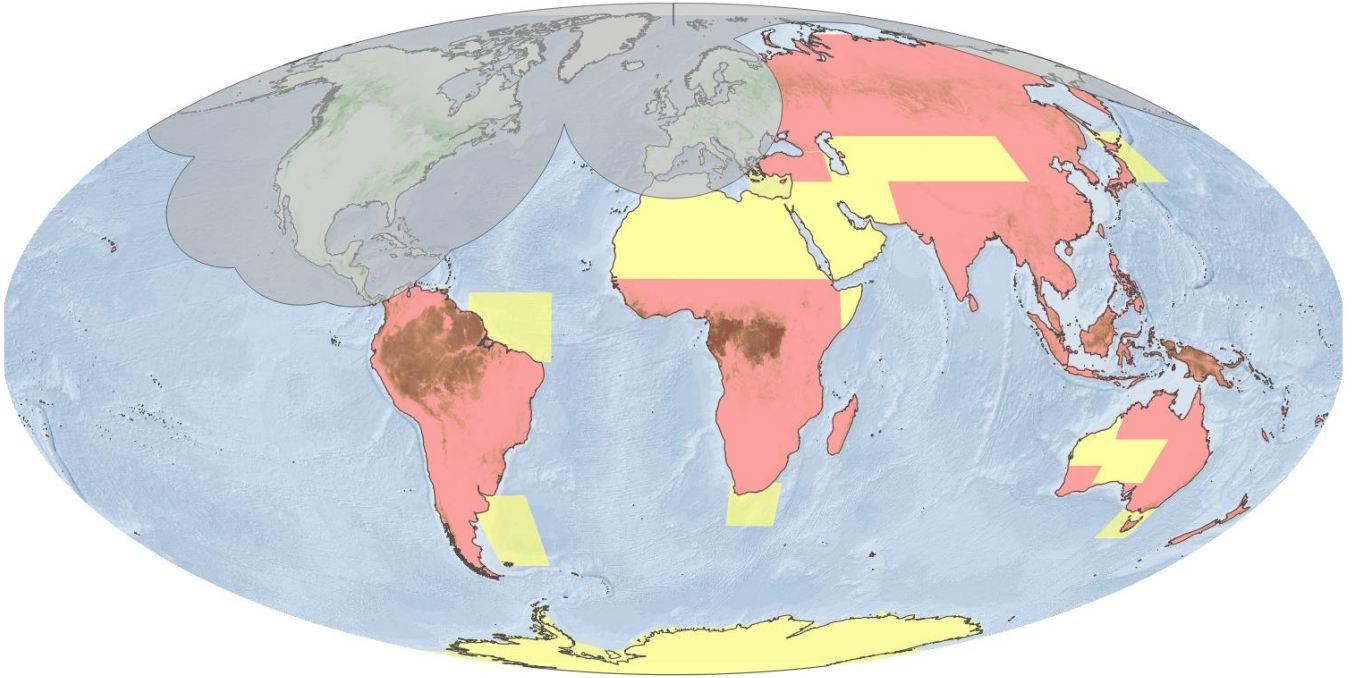
- ✓ Full polarimetric P-band (435 MHz) Synthetic Aperture Radar with 6 MHz bandwidth
- ✓ Single satellite, operated in a polar sun-synchronous orbit
- ✓ Multi-repeat pass interferometry (3 passes in nominal operations) with a 3 days repeat cycle
- ✓ Two mission phases: Tomography (first 18 months), Interferometry (rest of the mission lifetime, with a 9 months repeat)
- ✓ Global coverage both on asc. and des. passes
- ✓ 5 years lifetime

How Biomass builds up global coverage



Coverage

- Systematic Acquisitions for forested land (red area)
- Best effort acquisitions for non forested areas (yellow areas)
- Acquisition over Europe and N-America barred by US Space Objects Tracking Radar (SOTR)
- Repeat cycle is 9 months over equator during INT

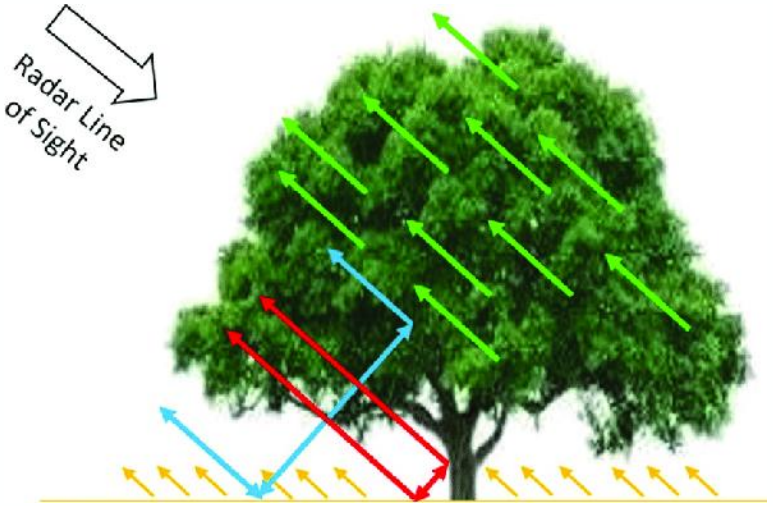


(Red = Primary objective coverage mask, Yellow = Secondary objective coverage mask)

How can we use Biomass to retrieve AGB

Retrieval algorithm

- Scattering can be described by three terms volume + double bounce + soil, such as in the Truong Loi Model below

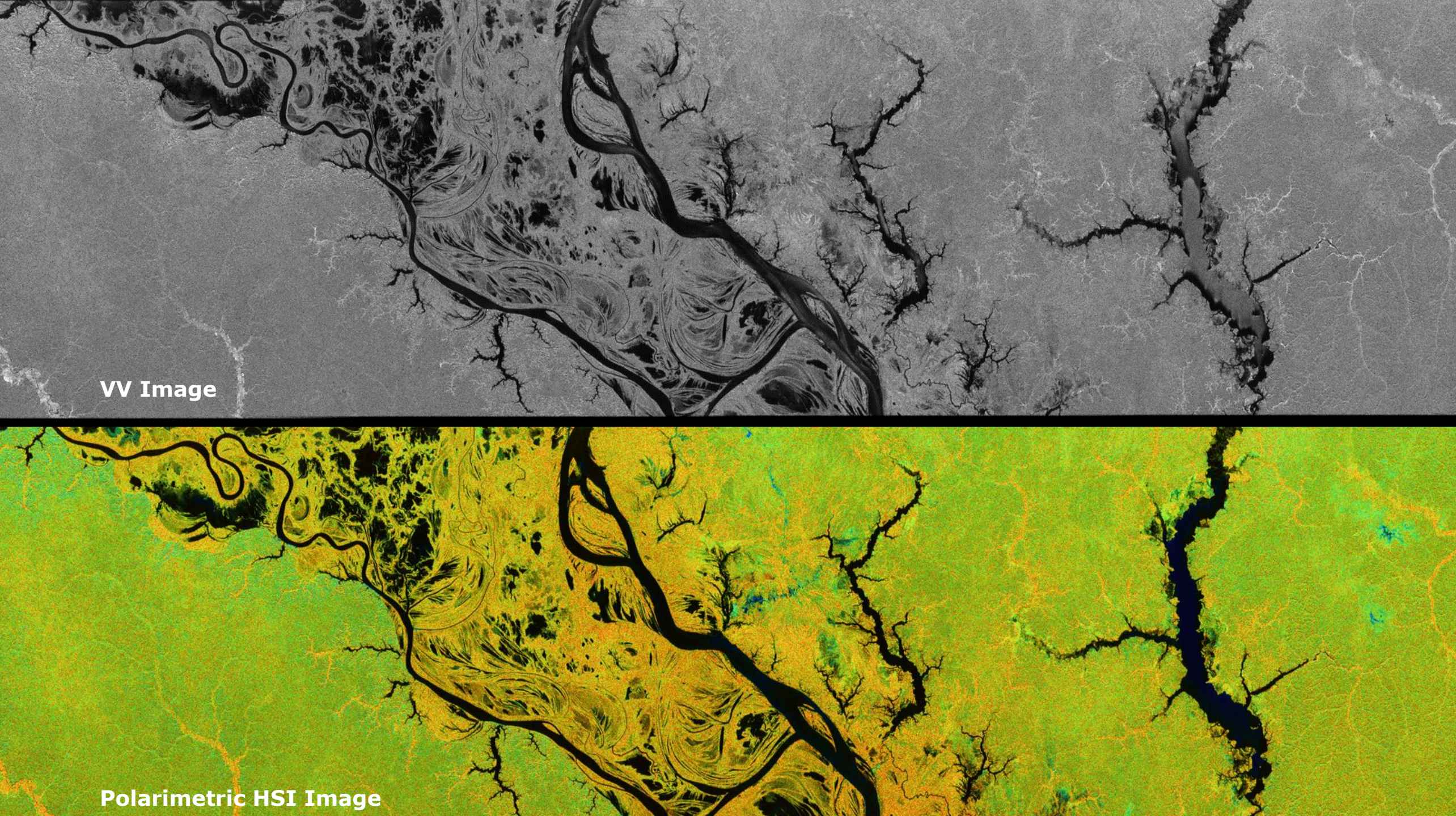


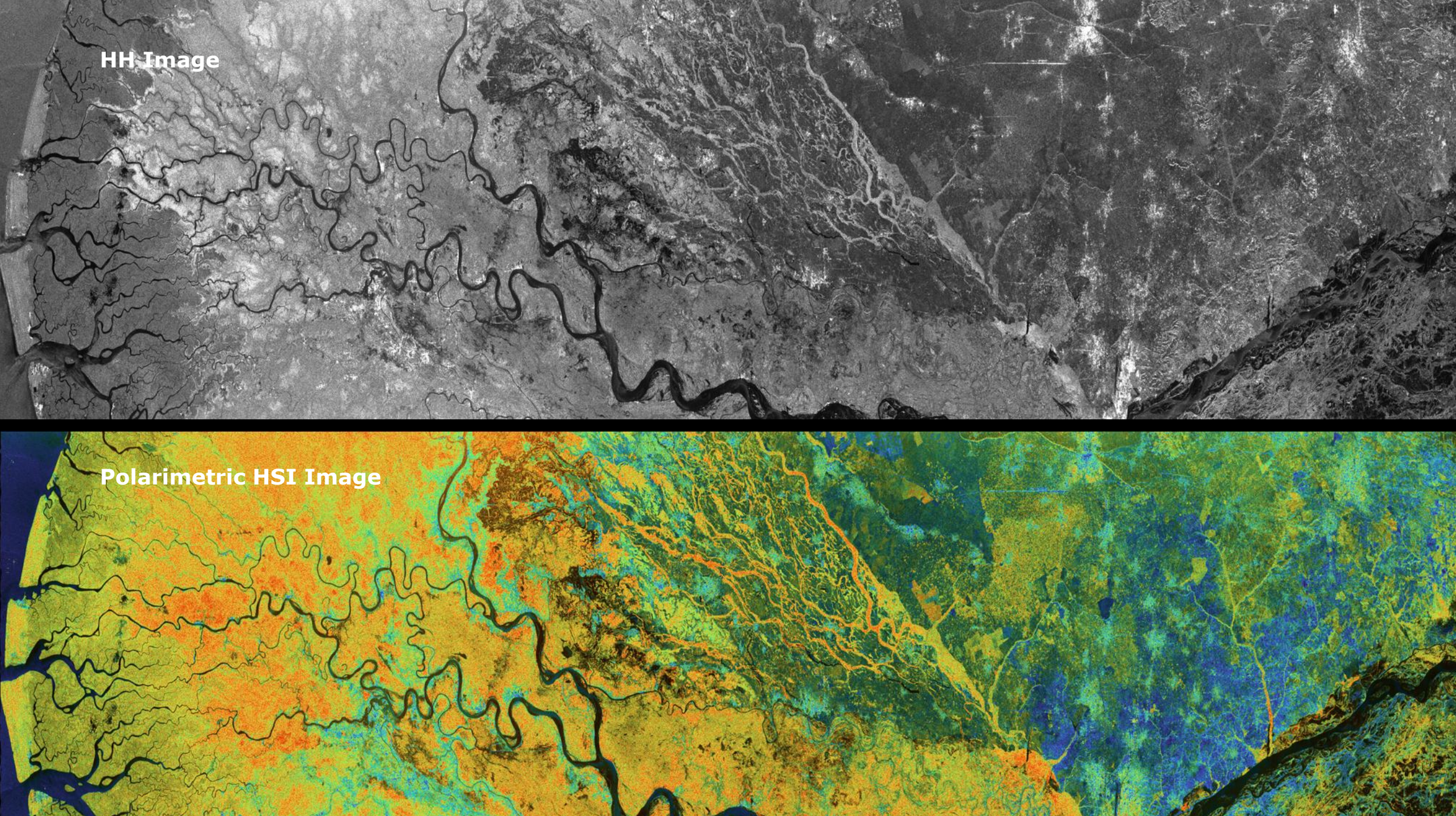
$$\sigma_{pq} = \text{volume} + \text{double} - \text{bounce} + \text{soil}$$

$$= A_{pq} W^{\alpha_{pq}} \cos\theta \left(1 - \exp\left(-\frac{B_{pq} W^{\beta_{pq}}}{\cos\theta}\right)\right) + C_{pq}\Gamma_{pq} W^{\delta_{pq}} \sin\theta \exp\left(-\frac{B_{pq} W^{\beta_{pq}}}{\cos\theta}\right)$$

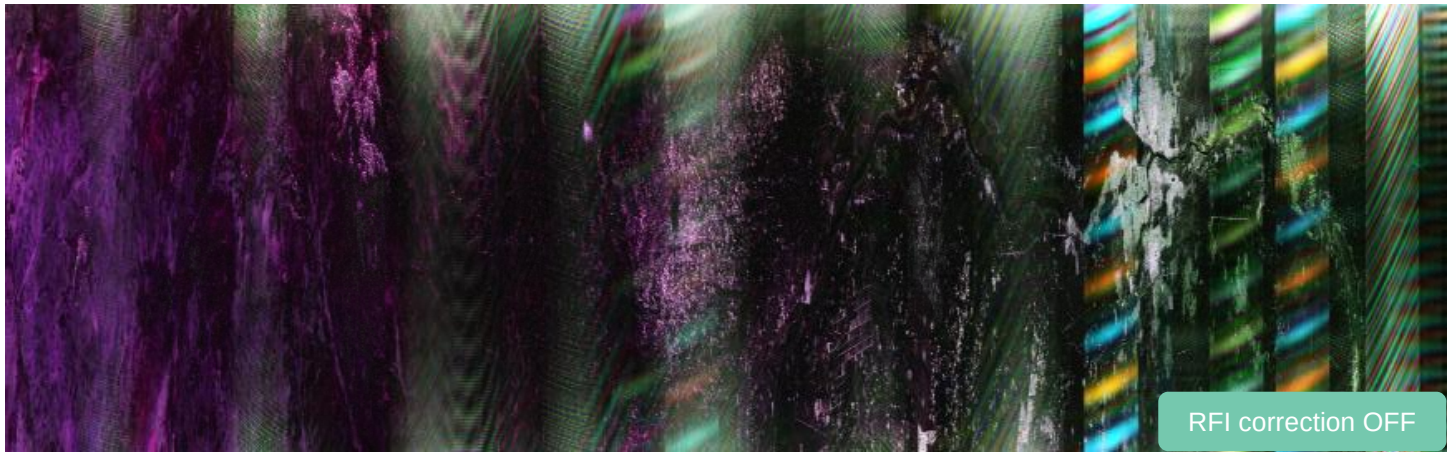
$$+ S_{pq} \exp\left(-\frac{B_{pq} W^{\beta_{pq}}}{\cos\theta}\right)$$

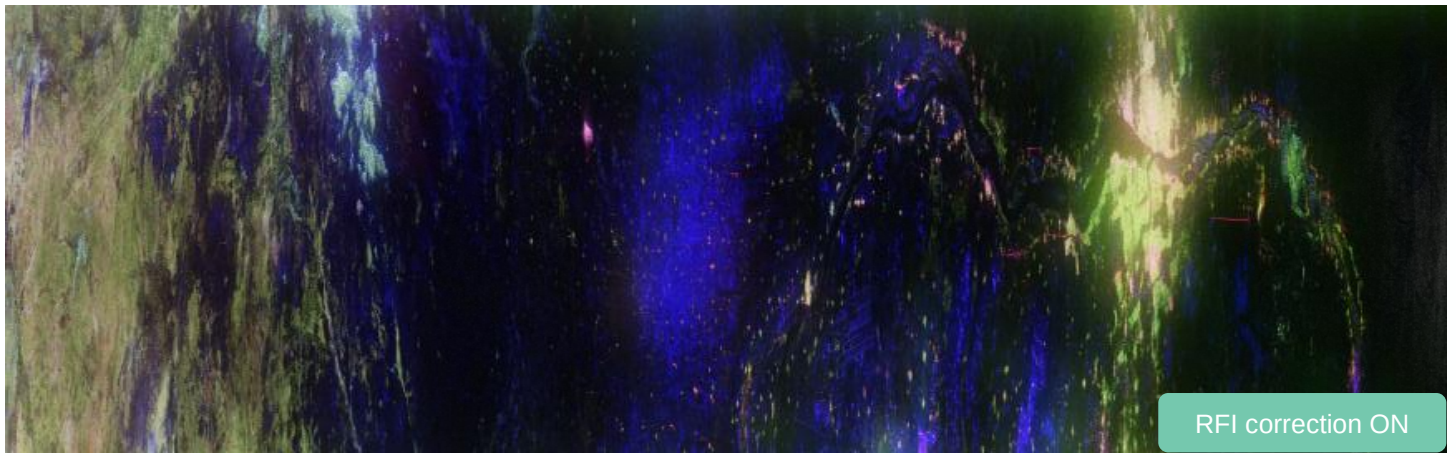
W = AGB
θ = incidence angle
pq = polarization


VV Image
Polarimetric HSI Image


HH Image
Polarimetric HSI Image

BPS: L1AB overview – RFI mitigation





BIOMASS acquisition on North Africa, 23rd of May

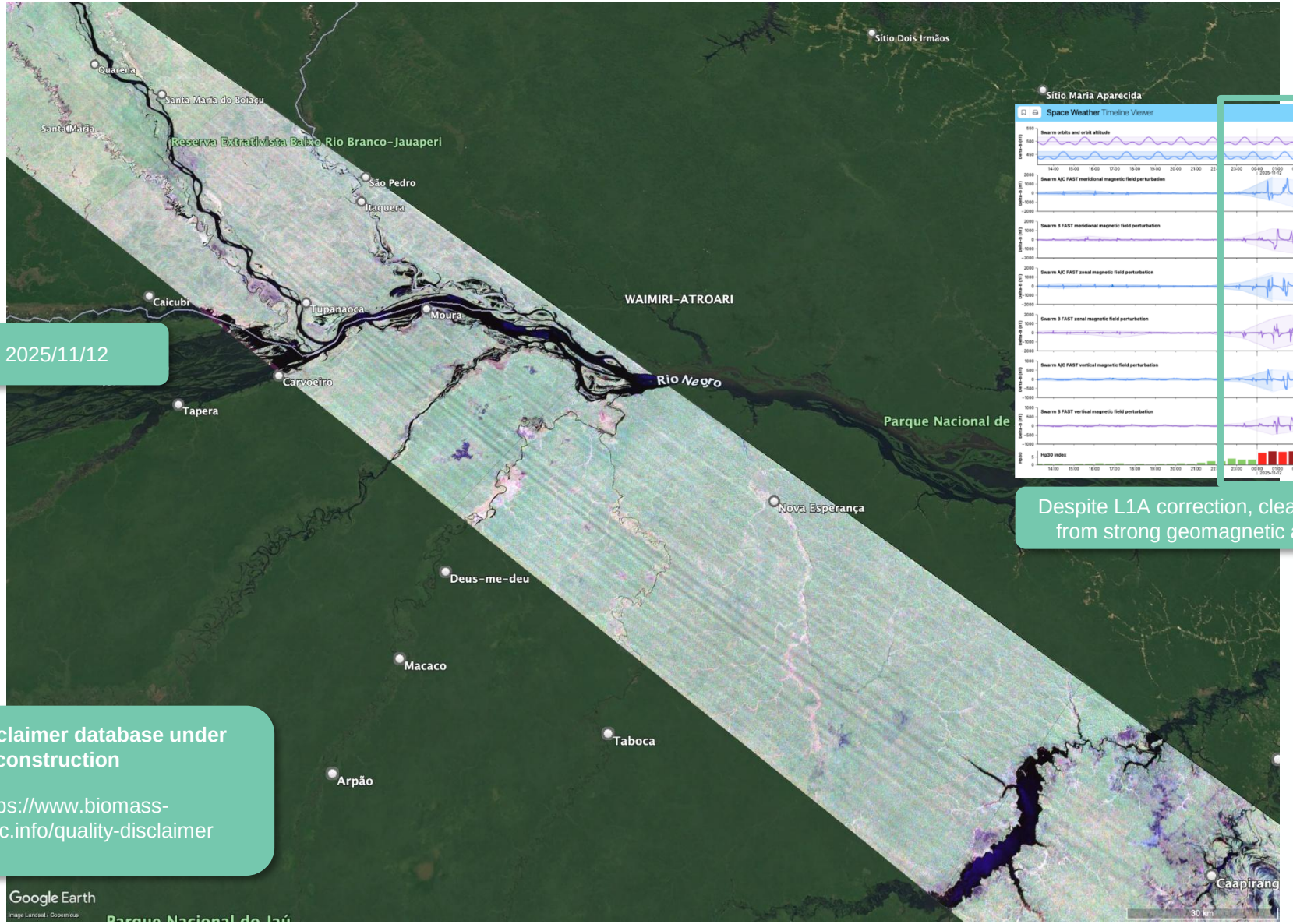
RFI Challenges

Results from IOC confirm RFI as one of the challenges for BIOMASS Processing

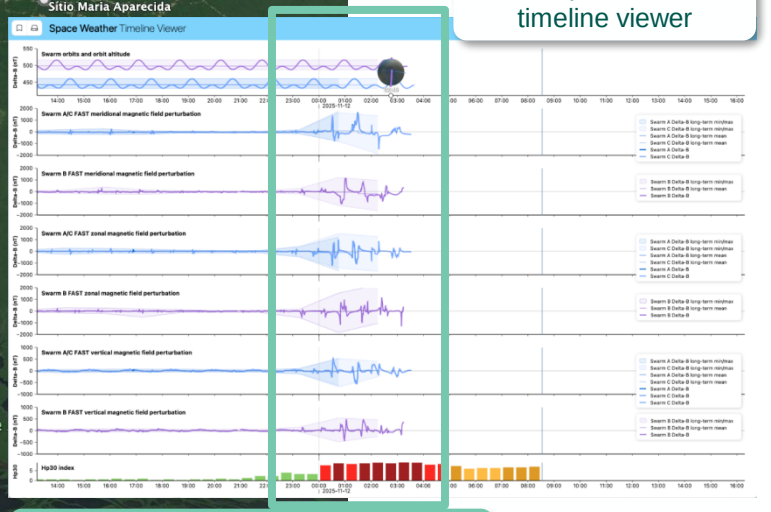
Correction at L1 is in place, but might impact:

- Radiometric consistence in time
- Polarimetric consistence of the frame
- InSAR consistence of the stack
- ***Baseline algorithm mitigates issue, but doesn't solve it and has potential impact on L2 products***

BPS: L1AB overview – Ionosphere Correction



2025/11/12



KNMI space weather timeline viewer

Despite L1A correction, clear impact from strong geomagnetic activity

Quality Disclaimer database under construction

https://www.biomass-disc.info/quality-disclaimer

ESA's first Open Science Explorer

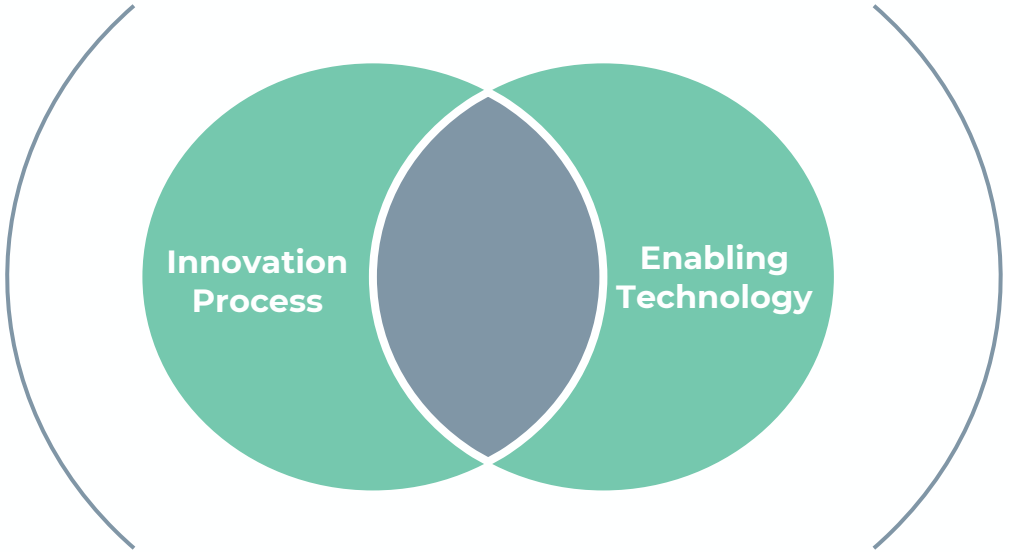
Facilitate advanced research and services in EO and beyond, through enabling an open, digital ecosystem based on the principles of openness, inclusiveness, and innovation.

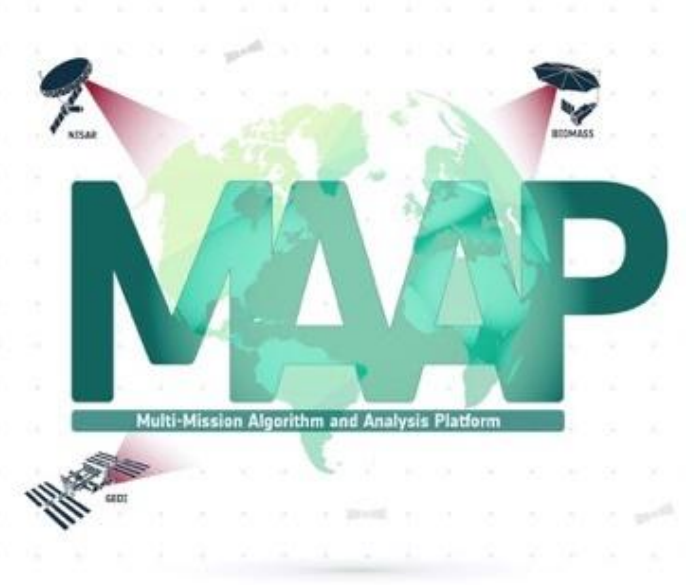
BioPAL

biopal@esa.int

biopal.org

github.com/BioPAL





Summary – BIOMASS a true Earth Explorer

1. BIOMASS successfully launched on 29th April 2025. Since 21st November Biomass is in full Operations.

2. BIOMASS is the first P-band SAR the and first mission to systematically acquire interferometric data. It is a true Earth Explorer, we have to face a lot of unknowns but also a lot of exciting science opportunities.

3. It is the first Earth Explorer not only sharing its data open and free but also following Open Source best practices for its higher level processors.

4. The new unique vision of Earth from Biomass will extend beyond forests and into measurements of ice, sub-surface geomorphology in deserts, topography, the ionosphere, ocean ...