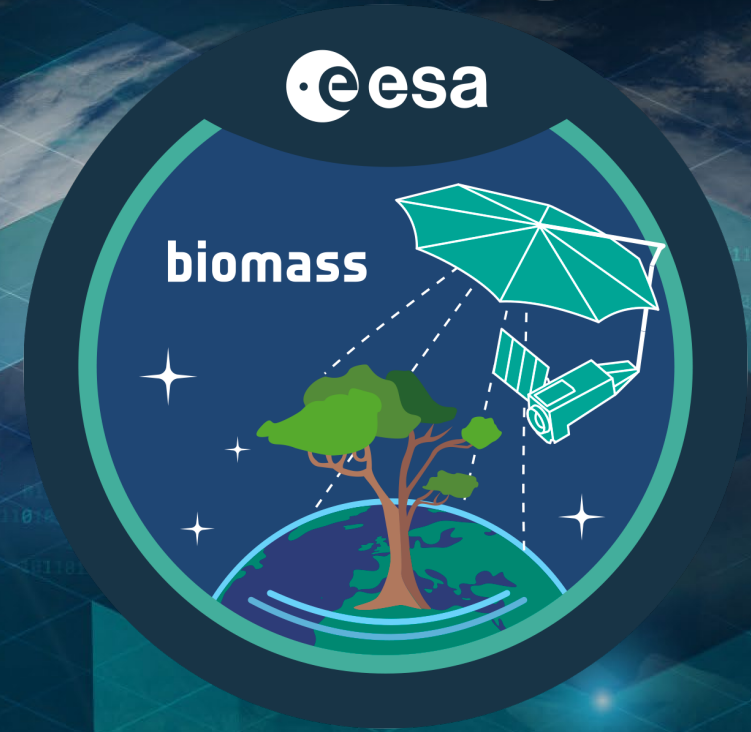


living planet symposium | BONN

23-27 May
2022

TAKING THE PULSE
OF OUR PLANET FROM SPACE



BIOMASS Ground Segment architecture, multi-Mission Algorithm And Analysis Platform (MAAP) and related Open-Source developments (BioPAL)

Clément Albinet¹, Nuno Miranda¹, Stefanie Lumnitz¹, Bjorn Frommknecht¹, Klaus Scipal¹, Gabriella Costa¹, Henri Laur¹, Michele Caccia², Valentina Faccin³.

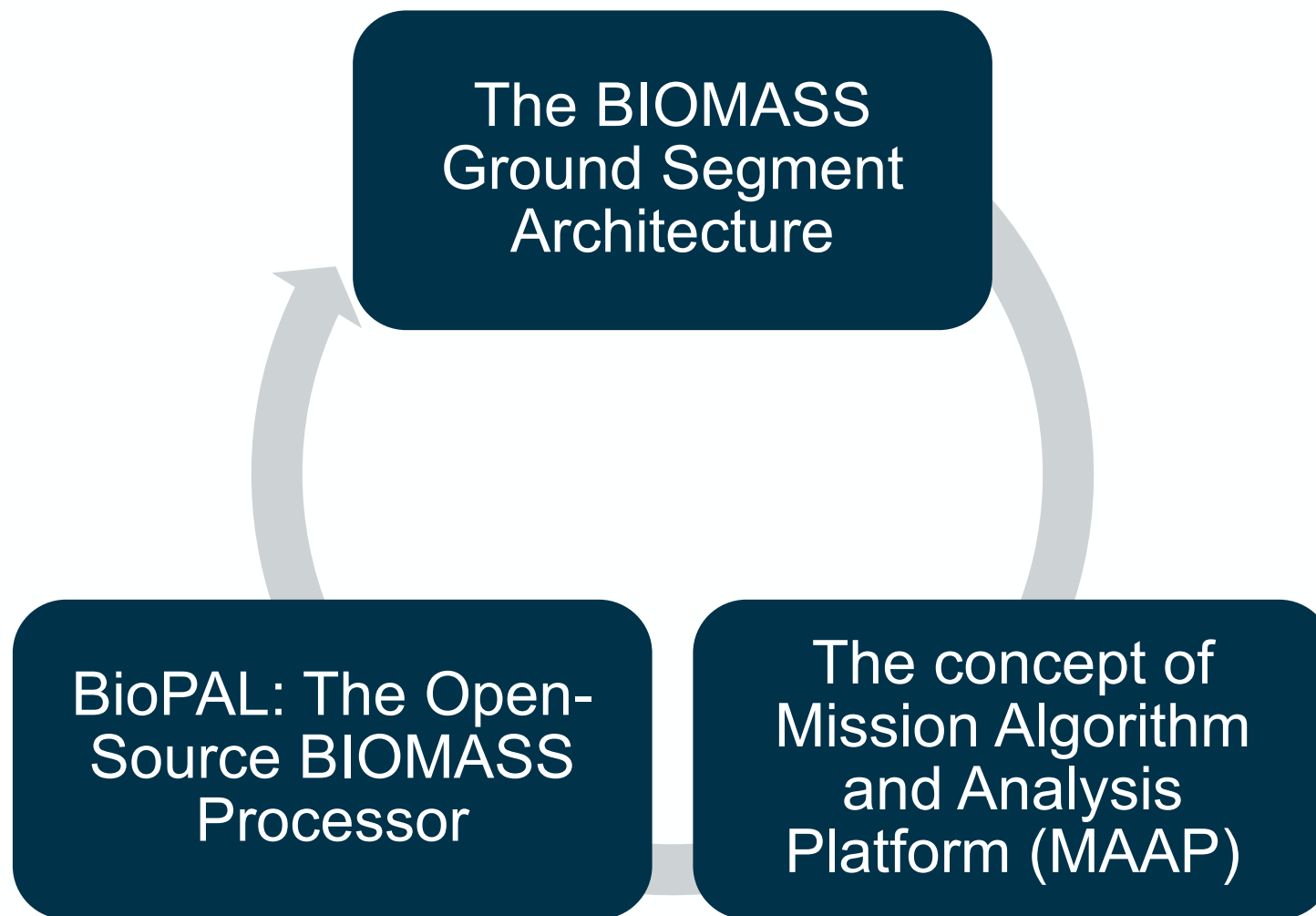
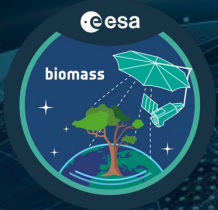
¹ ESA - European Space Research Institute, Italy

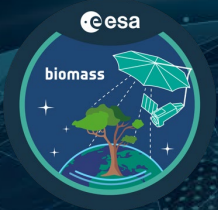
² RHEA, Italy

³ Serco, Italy

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Wednesday 25th May 2022





The BIOMASS Ground Segment

The **BIOMASS** Ground Segment is composed by several entities:

- **Flight Operations Segment (FOS)**

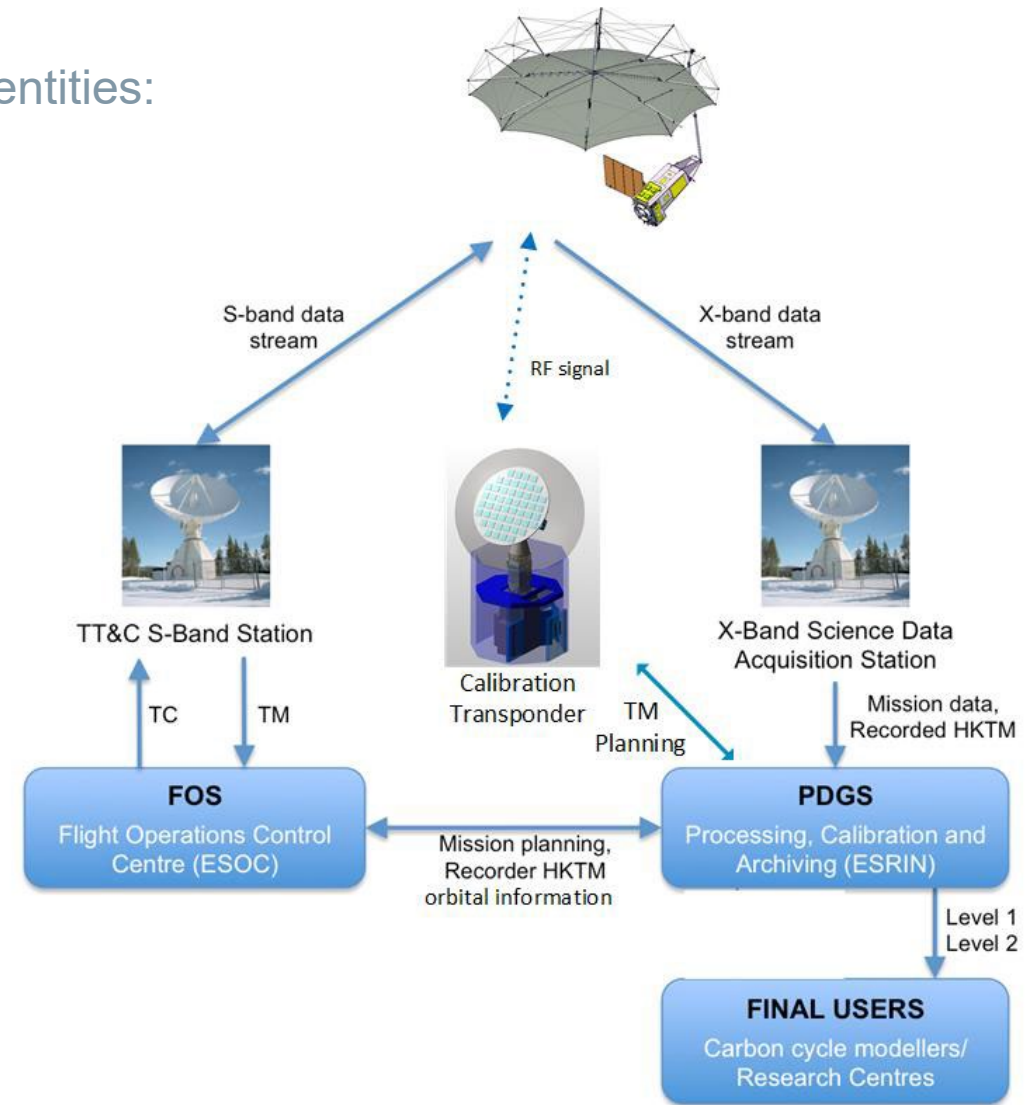
- **Calibration Transponder**

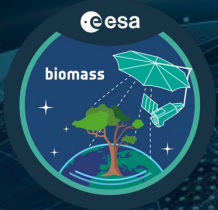
Biomass calibration concept towards mission operations

[Philip Willemsen | European Space Agency \(ESA\) | Germany](#)

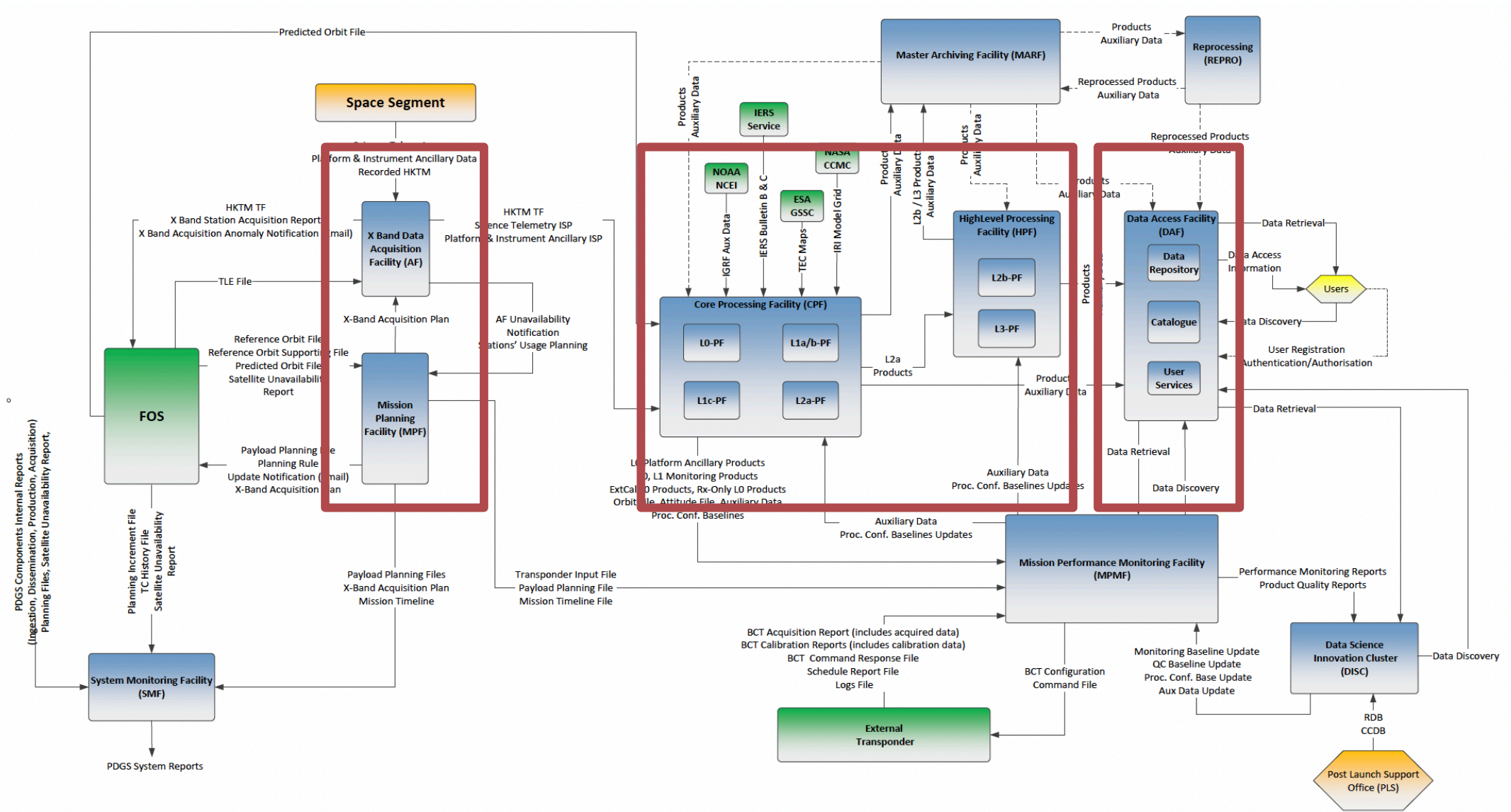
• **Payload Data Ground Segment (PDGS)**

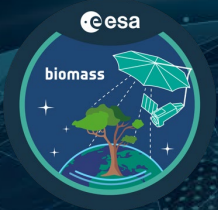
- Science Data Acquisition
- Mission Planning
- Data Handling (i.e. Processing)
- Data Access
- Archiving
- Performance Monitoring



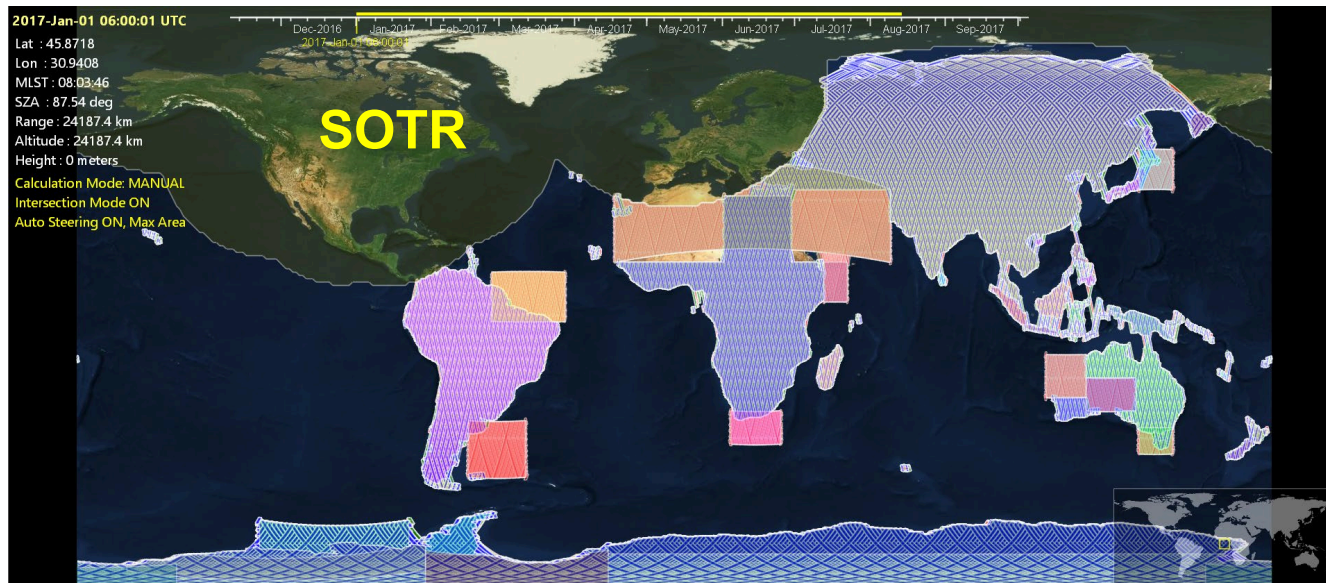


The BIOMASS PDGS



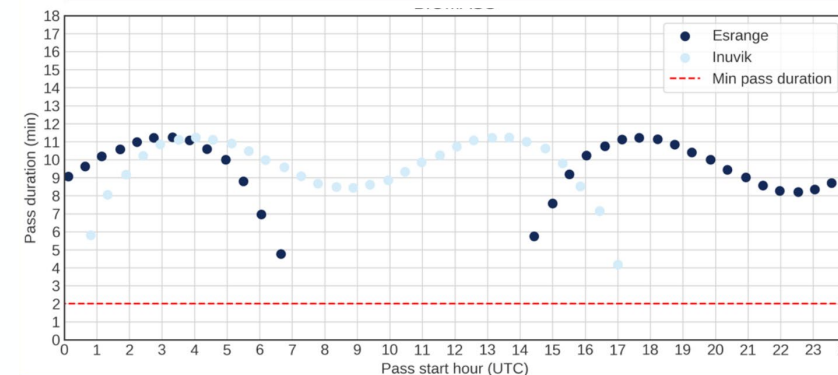
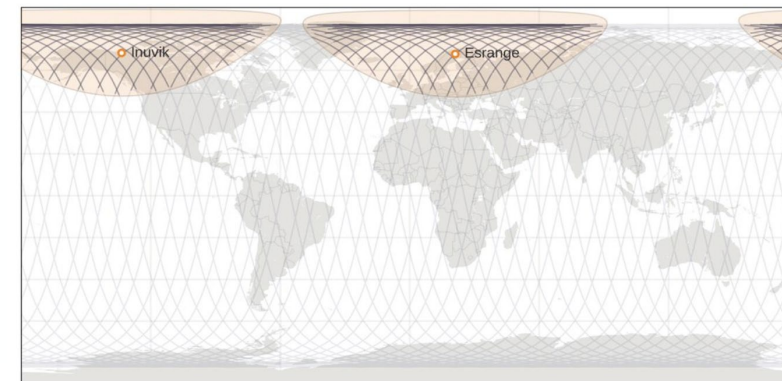


PDGS: Acquisition & Planning



BIOMASS First Global coverage (INT)

- **BIOMASS** observation scenario is implemented by the Mission Planning System for Primary objectives (Forests) and secondary objectives
- Observation mask is limited by primary P-band users (ITU regulation)
- Average Sensing 20min (40 min peak) of data per orbit is acquired and downlinked through two X-band stations allowing 10 min visibility at each pass.



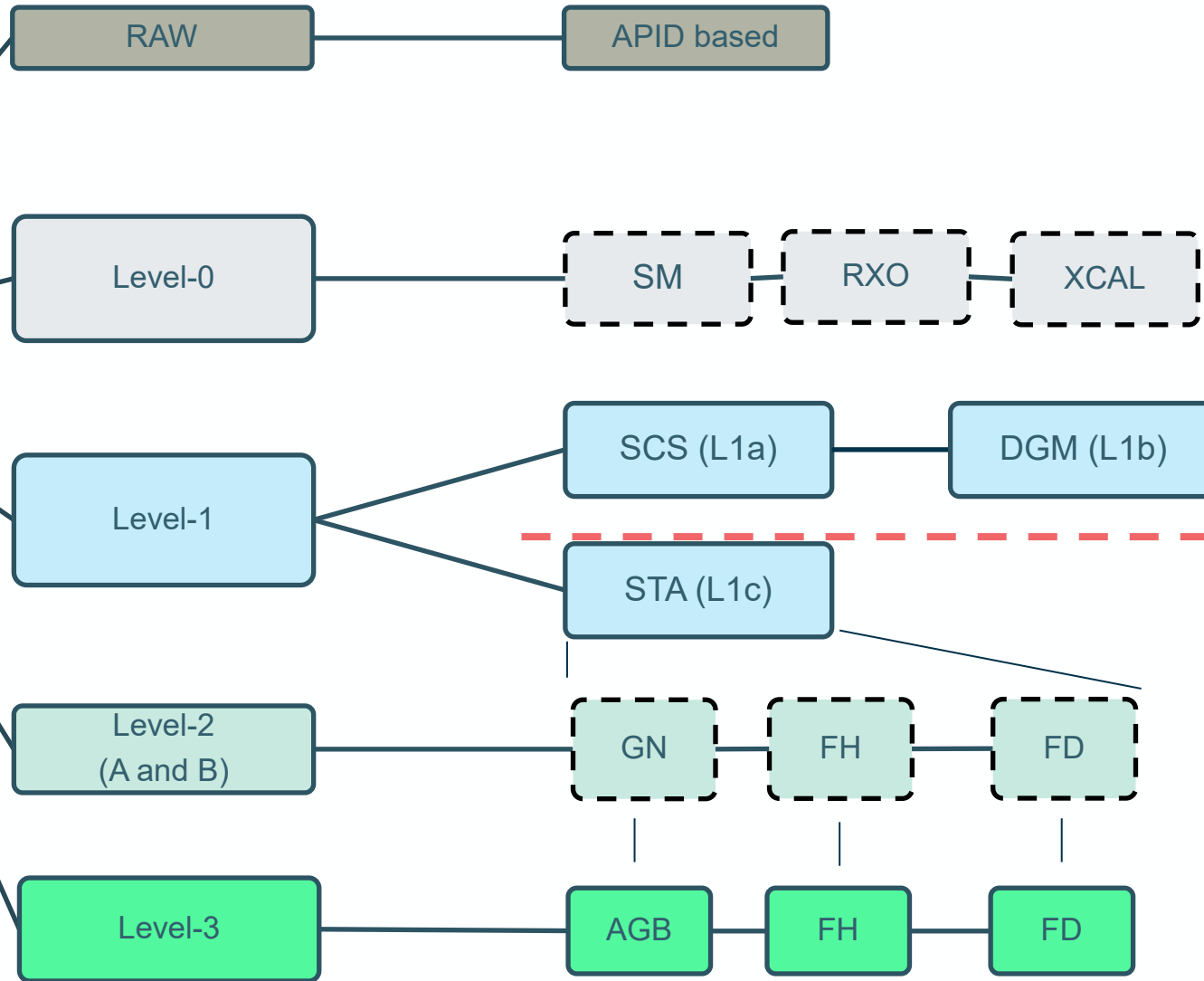
BIOMASS X-band stations network (Kiruna + Inuvik)



BIOMASS Product Family tree



Acronyms:
 FD: Forest Disturbance
 FH: Forest Height
 AGB: Above Ground Biomass



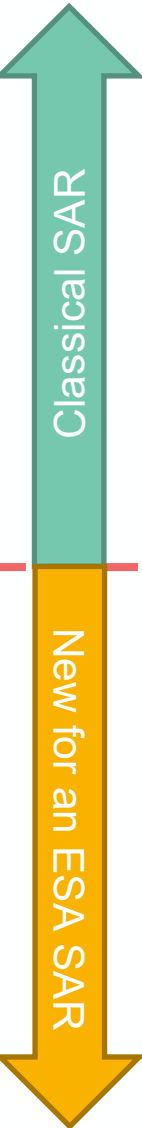
Demod +
Re-packaging

Re-packaging
+ chopping

SAR
processing

Co-
registration

"Forest"
retrieval



BIOMASS Mission Data Volume

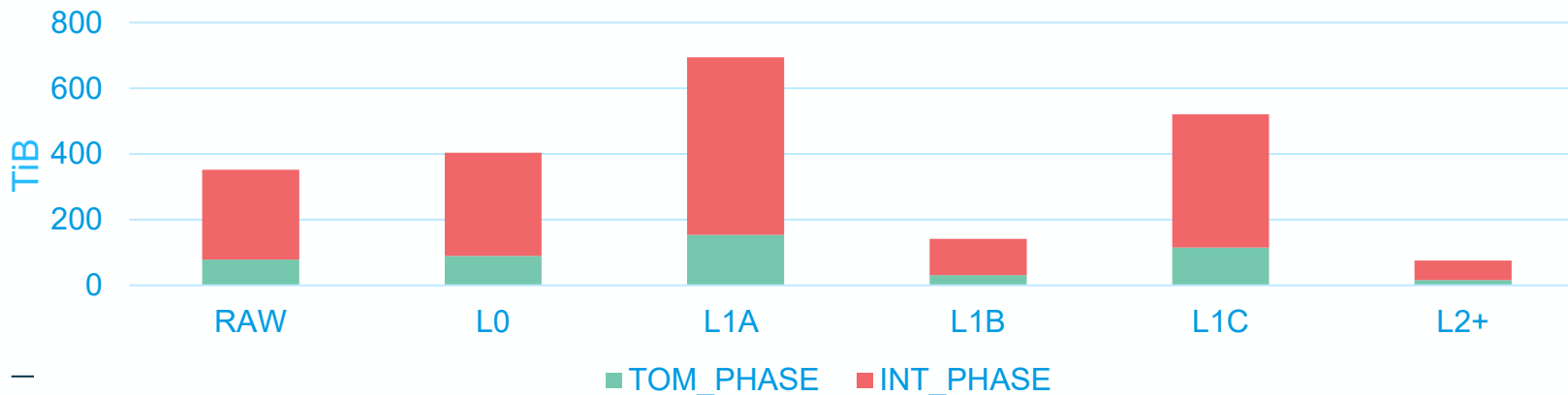


	REPEAT_CYCLE	MAJOR_CYCLE	MONTHLY	GLOBAL_COVERAGE	INT_PHASE (6 GC) [0% OVH]
CADU_VOLUME	0.70	7.47	6.54	52.28	313.68
RAW_VOLUME	0.61	6.52	5.70	45.63	273.77
PLATANC_VOLUME	0.00	0.00	0.00	0.00	0.01
SARANC_VOLUME	0.00	0.00	0.00	0.00	0.01
L0_VOLUME	0.70	7.48	6.55	52.38	314.28
LOM_VOLUME	0.00	0.03	0.02	0.20	1.19
ORBIT_VOLUME	0.00	0.00	0.00	0.00	0.01
ATTITUDE_VOLUME	0.00	0.00	0.00	0.00	0.01
L1A_VOLUME	1.20	12.86	11.25	90.02	540.10
L1C_VOLUME	0.90	9.64	8.44	67.51	405.08
L1B_VOLUME	0.25	2.63	2.30	18.43	110.56
TOTAL	4.35	46.64	40.81	326.45	1958.71

Overall the mission will generate 3-4PB over the 5 years

BIOMASS is a quarter of Sentinel-1 unit

BIOMASS Mission Volume (1 baseline)



BIOMASS Product layout

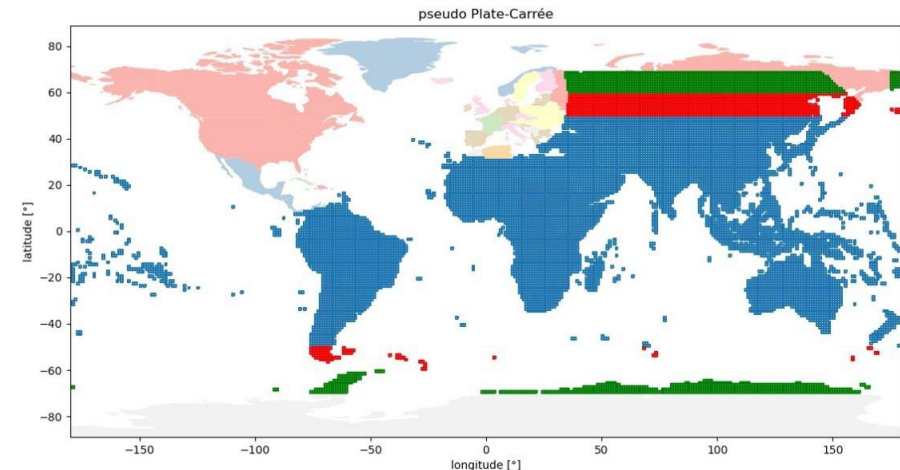
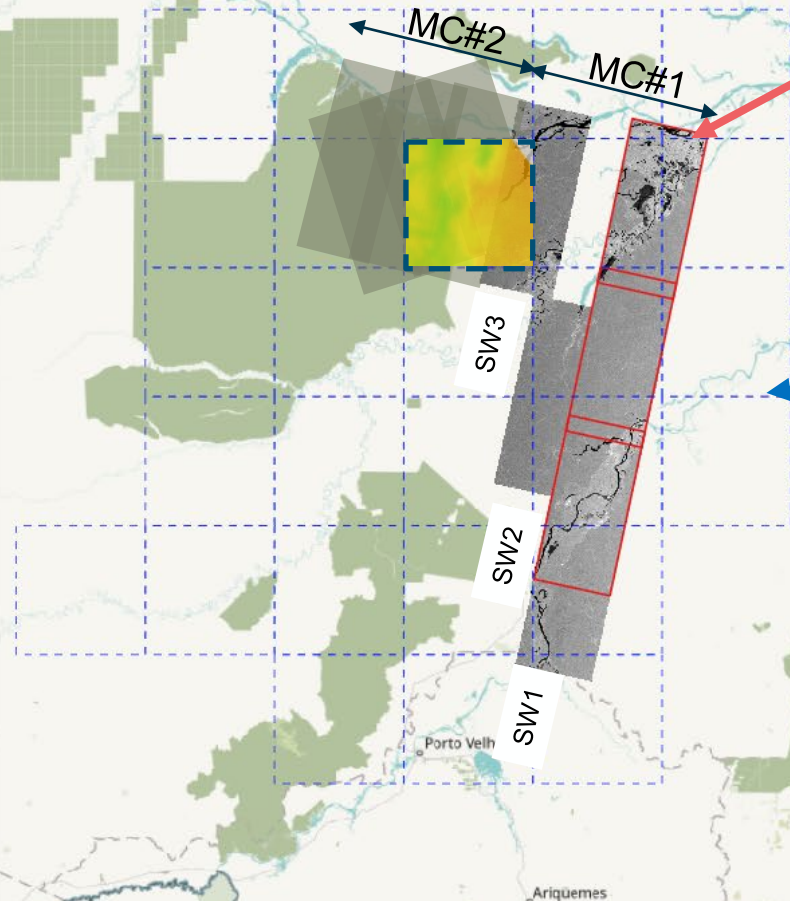
“Low-Level” products in instrument geometry:

L1A/B/C & L2A products will be provided as standard frames of ~20s each:

- L1C are **coregistered** frames on a single reference image
- L2A are intermediary step to the final products

“Higher Level ” products in “map” geometry

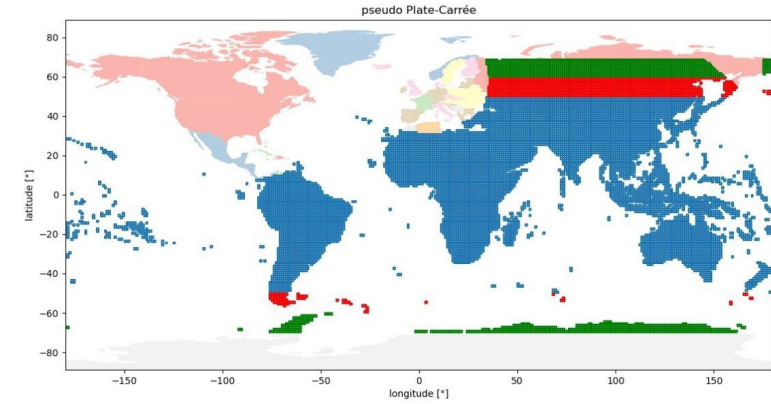
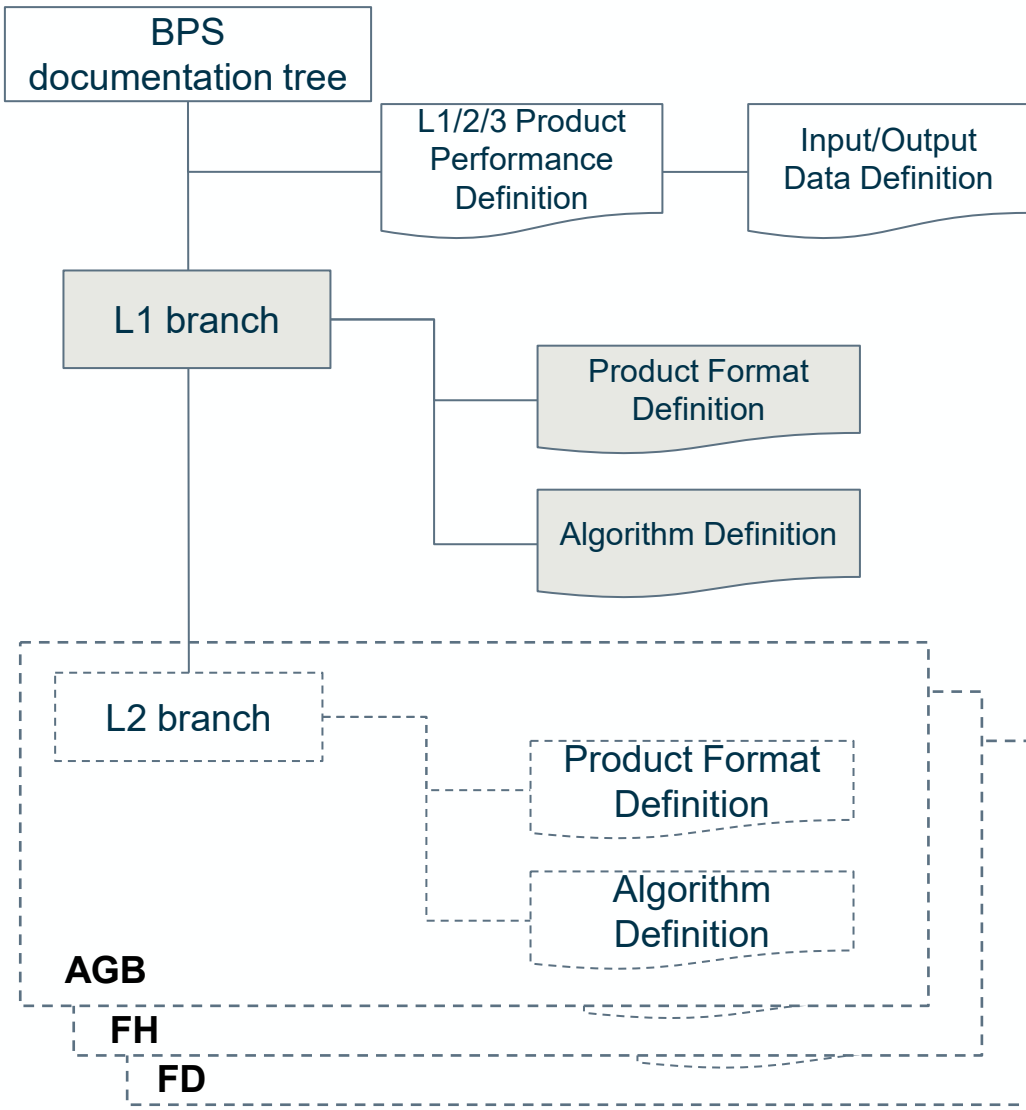
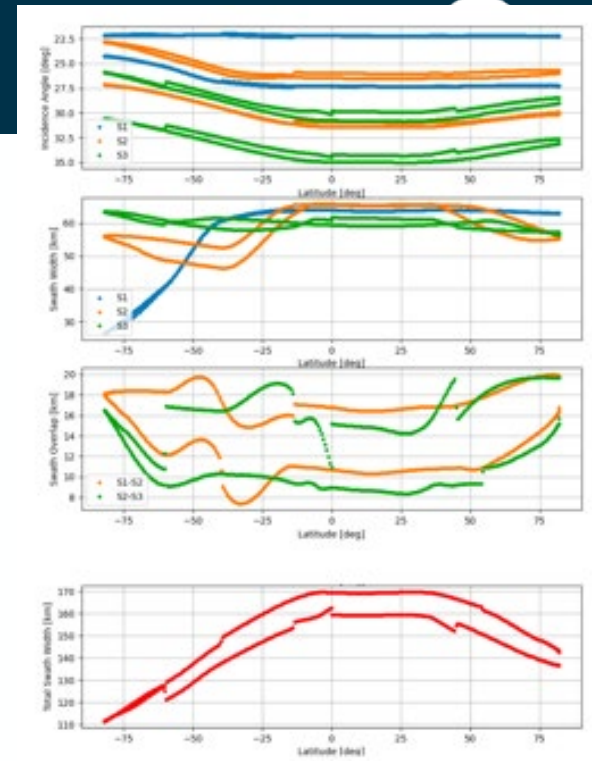
- Higher level products (L2B, L3) are combining L2A frames on a pre-defined tile grid (1°x1°)



BIOMASS Product documentation

sa

Product ID	SW_SCS
Product Type	Strips, Start Range, Single Look, Complex
Main Product Characteristics	
Foot Value	Complex (Amplitude proportional to interfered look magnitude, and Phase)
Coordinate System	Start Range
Slits Per Frame	64 (32 Amplitude + 32 Phase)
Polarization Options	Full (HH, HV, VH, VV)
Beam ID	81 82 83
Ground Range Coverage [km]	28 km - 83 km (Latitude dependent)
	Equator 84.05 85.60 87.15
	South-Pole 26.54 58.02 83.48
Start Range Resolution [m]	23.40 23.46 23.48
Azimuth Resolution [m]	7.62 7.63 7.66
Start Range Pixel Spacing [m]	19.81
Azimuth Pixel Spacing [m]	Average 4.97
	Min 4.54 4.45 4.38
	Max 4.85 4.48 4.92
Incidence Angle @ Mid-swath [deg]	Equator 24.89 24.43 22.95
	South-Pole 23.19 24.98 28.23
Equivalent Number of Looks (ENL)	1
Radiometric Resolution [dB]	3
Product Performance Parameters (see Sec. 6.4)	
Range PRF [Hz]	-18 ± 2
Azimuth PRF [Hz]	-18 ± 2
3D PRF [Hz]	-8 ± 5.3
Total Ambiguity Ratio [dB]	-18
SNR [dB]	-28
Channel Co-registration Accuracy [meters]	better than 1/100 of a pixel
Radiometric Bias [dB] (1 sigma)	0.3
Radiometric Stability [dB] (1 sigma)	0.5
Absolute Location Accuracy [m]	±1 @ 1-sigma
Cross-talk accuracy [dB]	180
Channel imbalance accuracy [dB]	180
SAR Processing Parameters	
Number of Looks (range x azimuth)	1 x 1
Look Overlap (range x azimuth)	50%
Range Look Bandwidth [MHz]	6.2
Azimuth Look Bandwidth [Hz]	843.0
Range Hanning Weighting Coefficient	0.91 0.86 0.80
Azimuth Hanning Weighting Coefficient	0.77 0.76 0.80
Data Size & Volume for a Nominal Frame (21-second Long) @ Equator	
Approx. # of Lines	30807 32069 31326
Approx. # of Pixels per Line	1562 1676 1652
Max Data Volume (Single Polarization) [MB]	379 389 385
Max Data Volume (Full Polarization) [MB]	1276 1356 1380
Average Data Rate (Mbps)	87 74 75
Data Size & Volume for a Nominal Frame (21-second Long) @ South Pole	
Approx. # of Lines	32866 32467 31962
Approx. # of Pixels per Line	529 1167 1918
Max Data Volume (Single Polarization) [MB]	125 295 381
Max Data Volume (Full Polarization) [MB]	500 1182 1444
Average Data Rate (Mbps)	24 56 68



L1/2/3 Product Performance Definition



How to make the future of EO users better?

Innovative instrument



Innovatiation in the ground
segment?

“Mission Algorithm and Analysis Platform”

→ *It's a Virtual open and collaborative environment that...*



Enables researchers to easily discover, process, visualize, and analyze large volumes of data.



Provides tools and infrastructures to bring data into the same coordinate reference frame to enable comparison, analysis, data evaluation, and data generation.



Provides a version-controlled science algorithm development environment that supports tools, co-located data, and processing resources.

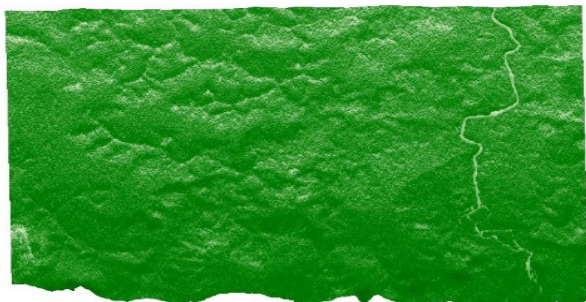


Addresses intellectual property and sharing issues related to collaborative algorithm development and sharing of data and algorithms.

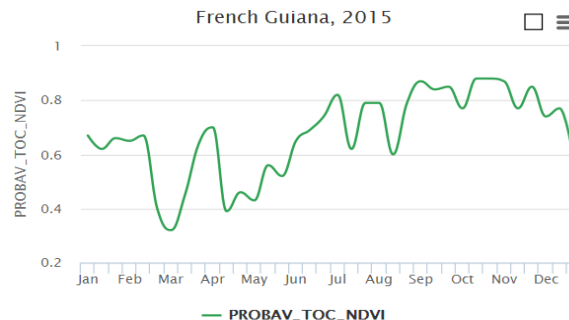
→ Data visualisation

2D data visualisation

- Search, discovery, overlay
- L1, L2, L3



Time series visualisation

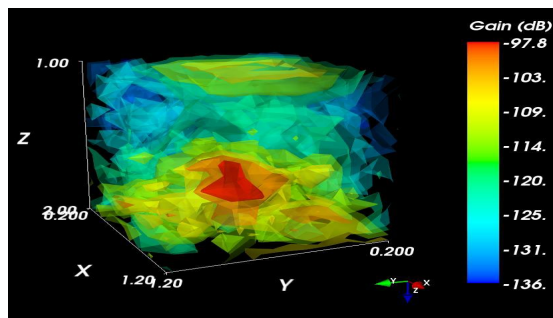


In-situ measurement (e.g. Forest Observation System)

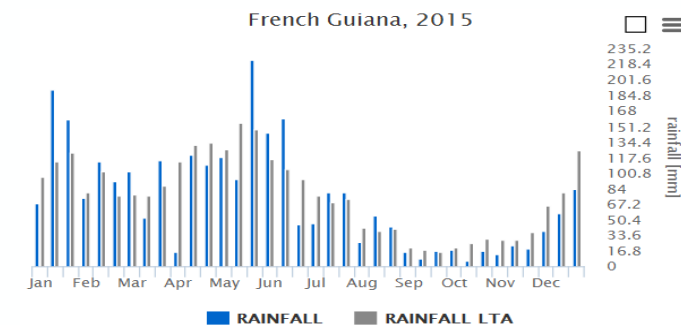


3D data visualisation

- PolinSAR, TomoSAR



Meteorological data



→ Data processing (product generation)

Select existing algorithms

Official L1, L2/3 algorithms

Research L1, L2/3 algorithms

Generate products

- Systematic generation (every 6 months)
- On demand



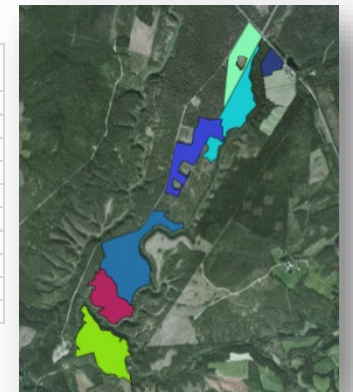
Download data



Upload data

- raster, vector, table

Stand id	Biomass [ton/ha]	Biomass error [ton/ha]
1	201.9	25
5	159.6	25
9	218.4	25
10	150.4	25
12	267.1	25
14	52.0	25
15	111.5	25
16	264.8	25
17	142.5	25
18	246.3	25



Share computed data

- Share link to give access to the data
- Export figure
- Embedded content in webpages, pdf...



→ Product Algorithm Laboratory

**New concept
at ESA!**



Modify/write processing algorithms

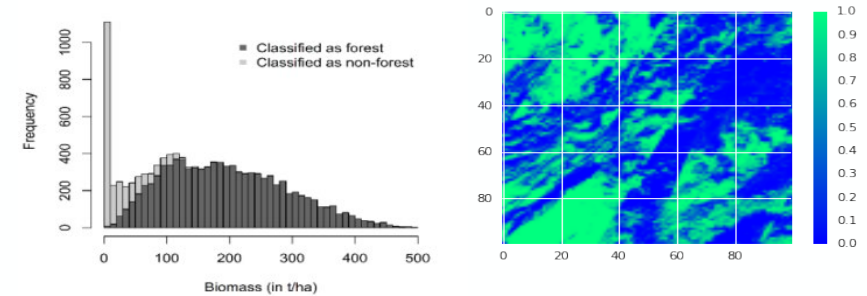
- Modify official L1, L2/3
- Compute own L1, L2/3
- Generate new products

```
Scripts Docs Assets S1* GetLink Save Run Reset
Filter scripts...
Private
  S1
  + New folder
  + New file
Shared
  + New repository
Examples
  Image
1 var p = function(image) { return image.log10().multiply(10)};
2
3 var pol = ['HH'];
4
5 var imgHH = ee.ImageCollection('COPERNICUS/S1').
6 filter(ee.Filter.eq('transmitterReceiverPolarisation', pol)).
7 filterMetadata('instrumentMode', 'equals', 'IW');
8
9 Map.addLayer(imgHH);
10 Map.setCenter(4.36, 50.86, 11);
```

Tools for self validation



Create figures



Share algorithms

- Share link to give access to the algorithm and/or environment



“Free access to all the functionalities”

- With a limit of processing time and data storage
- Additional resources can be ordered or allowed for specific users



→ Information sharing

Forum



- FAQ
- Conversations between users, with the agency...



Link to social networks

- Blogs
- Facebook, Twitter, Research gate...

Wiki



- All the information related to the mission, instrument, data acquisition...



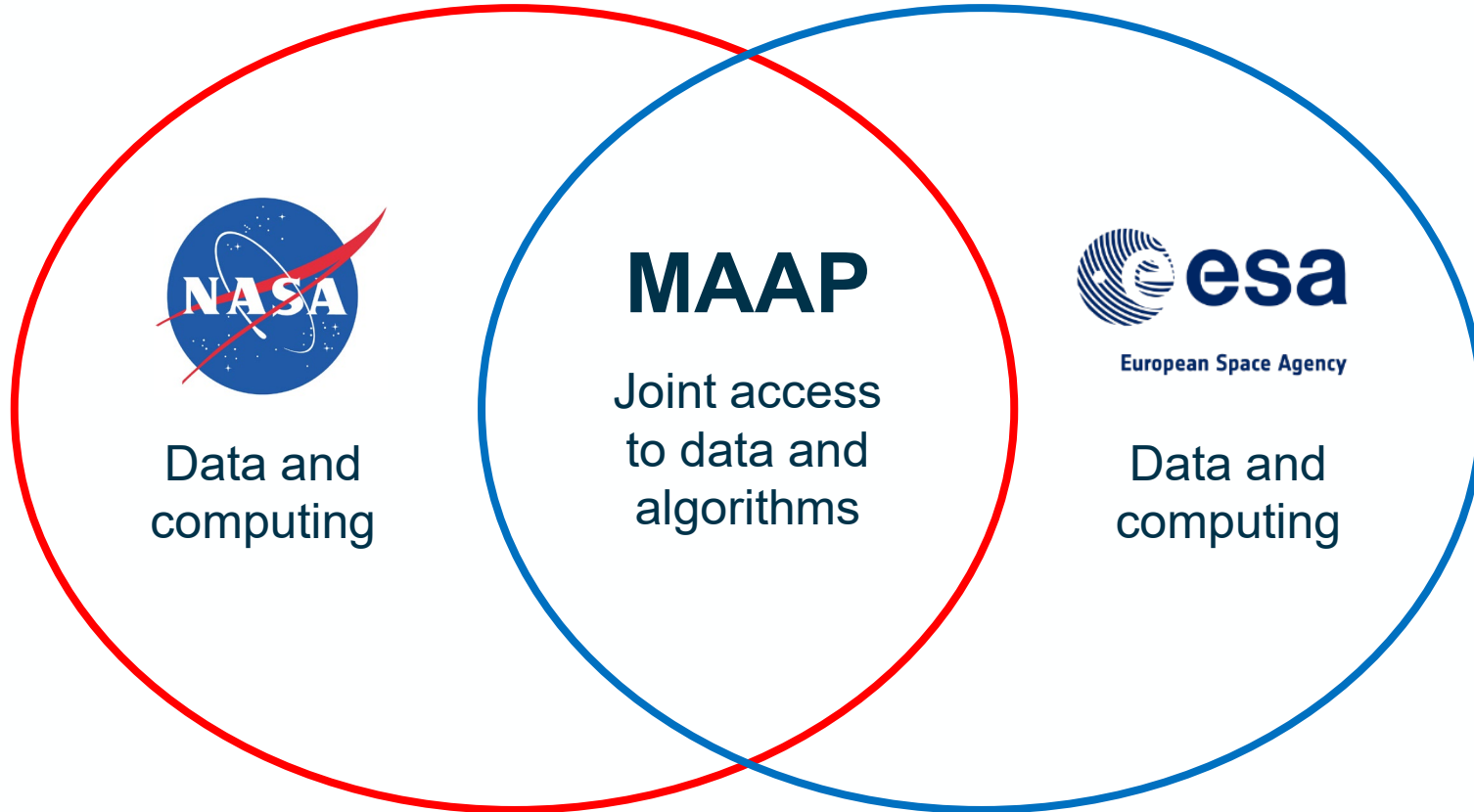
Link to online notebooks

- Write and execute live code (e.g. Jupyter)

```
In [11]: plt.figure(figsize=(8,6))
# Display the countries color-coded with their population.
ax = plt.subplot(121)
m.drawcoastlines()
patches = get_patches(africa, fc=get_colors('POP_EST', plt.cm.Reds), ec='k')
for p in patches:
    ax.add_collection(p)
plt.title('Population')
# Display the countries color-coded with their population.
ax = plt.subplot(122)
m.drawcoastlines()
patches = get_patches(africa, fc=get_colors('GDP_MD_EST', plt.cm.Blues), ec='k')
for p in patches:
    ax.add_collection(p)
plt.title('GDP')
```

NASA-ESA Multi-Mission Algorithm and Analysis Platform

Unified user access to the functions of joint NASA-ESA MAAP

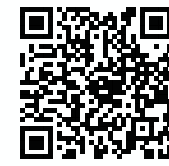


Up to date data and algorithms + Collaborative community



BIOMASS Product Algorithm Laboratory

**New concept
at ESA!**



Open source

Today:
Level-2 prototype algorithms

Tomorrow:
Level-1 (as much as possible),
Level-2 and Level-3 operational algorithms

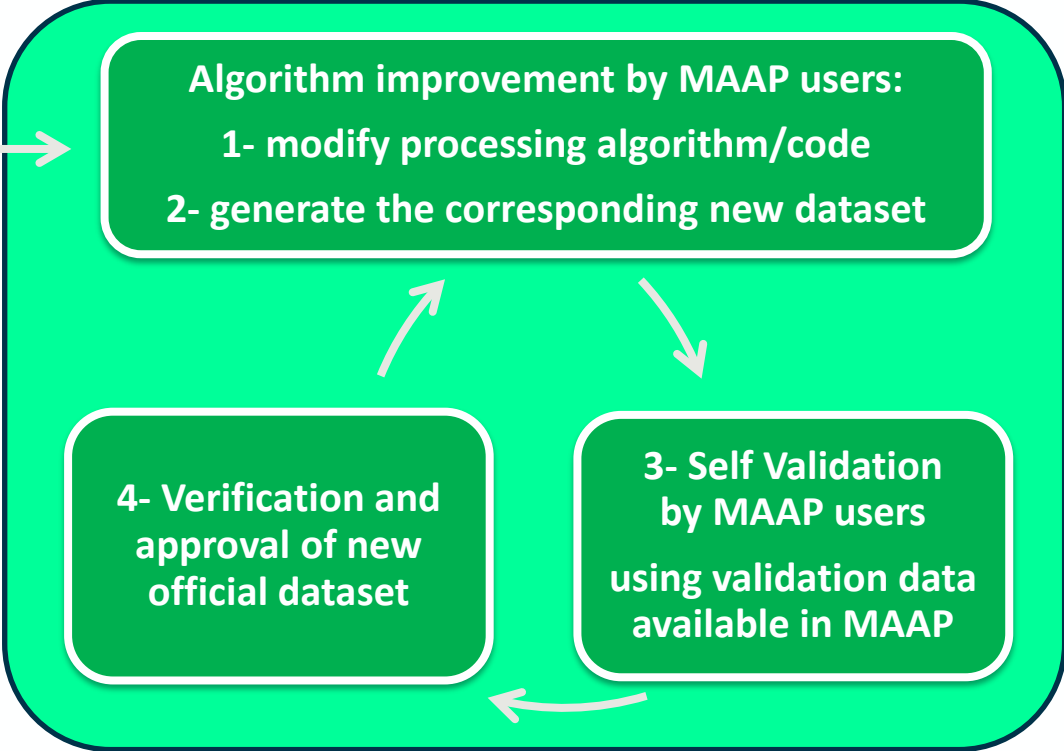
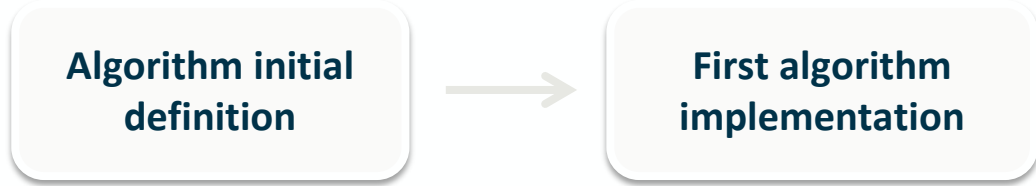


biopal@esa.int 
biopal.org 
github.com/BioPAL 



→ Product Algorithm Laboratory

New approach!



Mission Algorithm and Analysis Platform (MAAP)

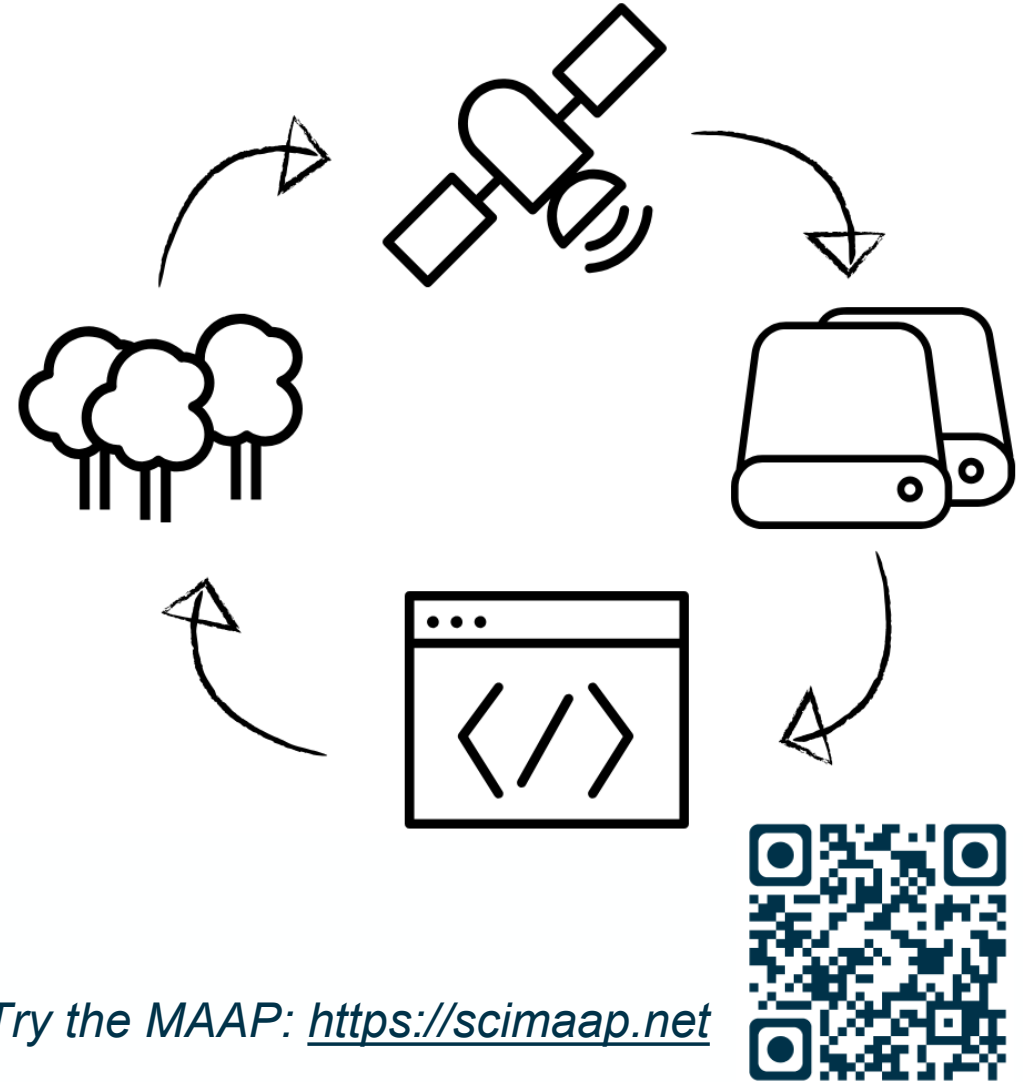
- Processing algorithms evolution is easier as the development and implementation are made within the same environment
- Allow to arrive faster to stable algorithms for R&D missions on a user cooperative approach
- People outside the core science team can contribute to the product improvement cycle

Concepts of “Open Science” → Well adapted to R&D EO missions



Conclusion

- The MAAP will make connections between data, algorithms, software and results.
- The MAAP brings together data from various spaceborne missions from various organizations to support development of global biomass maps.
- BioPAL and the Concept of the Product Algorithm Laboratory make it easier to reproduce results and build from existing work.
- They encourage collaboration between data scientists.



Try the MAAP: <https://scimaap.net>