Current status of the BIOMASS mission

1. Mission concept and objectives

2. Key steps since selection:
   - External calibration
   - Inversion algorithms

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National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Fate of anthropogenic CO_2 emissions (2007–2016)

Underpinning motivation for the BIOMASS mission

Sources = **Sinks**

34.4 ±1.8 $GtCO_2$/yr
88%

4.8 ± 2.6 $GtCO_2$/yr
12%

17.2 ±0.4 $GtCO_2$/yr
46%

11.0 ± 2.9 $GtCO_2$/yr
30%

8.8 ± 1.8 $GtCO_2$/yr
24%

Budget Imbalance = difference between estimated sources & sinks

2.2 ± 4.3 $GtCO_2$/yr
6%

BIOMASS mission objectives

BIOMASS is ESA's 7th Earth Explorer mission, selected in 2015 for launch in 2022.

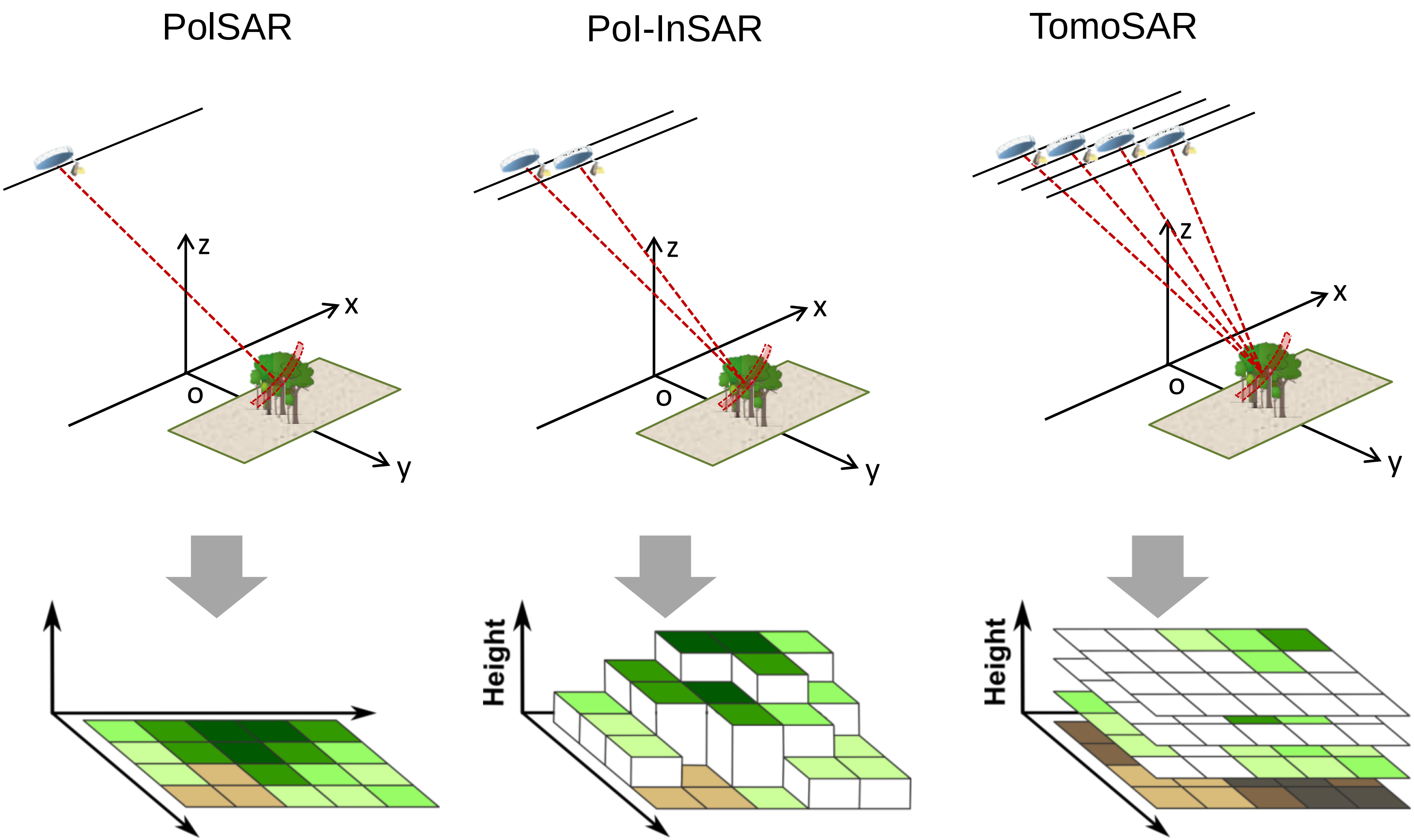
Primary objective: determine the worldwide distribution of forest above-ground biomass (AGB) in order to reduce the major uncertainties in carbon stocks and fluxes associated with the terrestrial biosphere, including carbon fluxes associated with Land Use Change, forest degradation and forest regrowth.

Secondary objectives

1. imaging of sub-surface geological structures in arid environments
2. generation of a true Digital Terrain Model that does not suffer biases over dense forests
3. measurement of glacier and icesheet velocities
4. estimation of ionospheric Total Electron Content and its changes along the dawn-dusk orbit of the mission.

BIOMASS measurement modes

BIOMASS will be the first P-band SAR (70 cm wavelength) in space



BIOMASS products

	Forest AGB	Forest height	Deforestation
Resolution	200 m	200 m	50 - 60 m
Accuracy	20%, or 10 t/ha for AGB < 50 t/ha	20 - 30%	Classification accuracy of 90%

- 1 near-global map of biomass and height from tomography in first 14 months
- Updated biomass and height maps from polarimetry and interferometry every 7 months for rest of 5-year mission
- Annual maps of deforestation

In the TomoSAR and Pol-InSAR phases the orbit repeats every 3 days (7 times for TomoSAR, 3 times for Pol-InSAR)

Major post-selection activities

Industry: All sub-contracts have been set up and ESA's risk assessments passed; instrument is being built

Science activities are crystallised in two main ESA contracts:

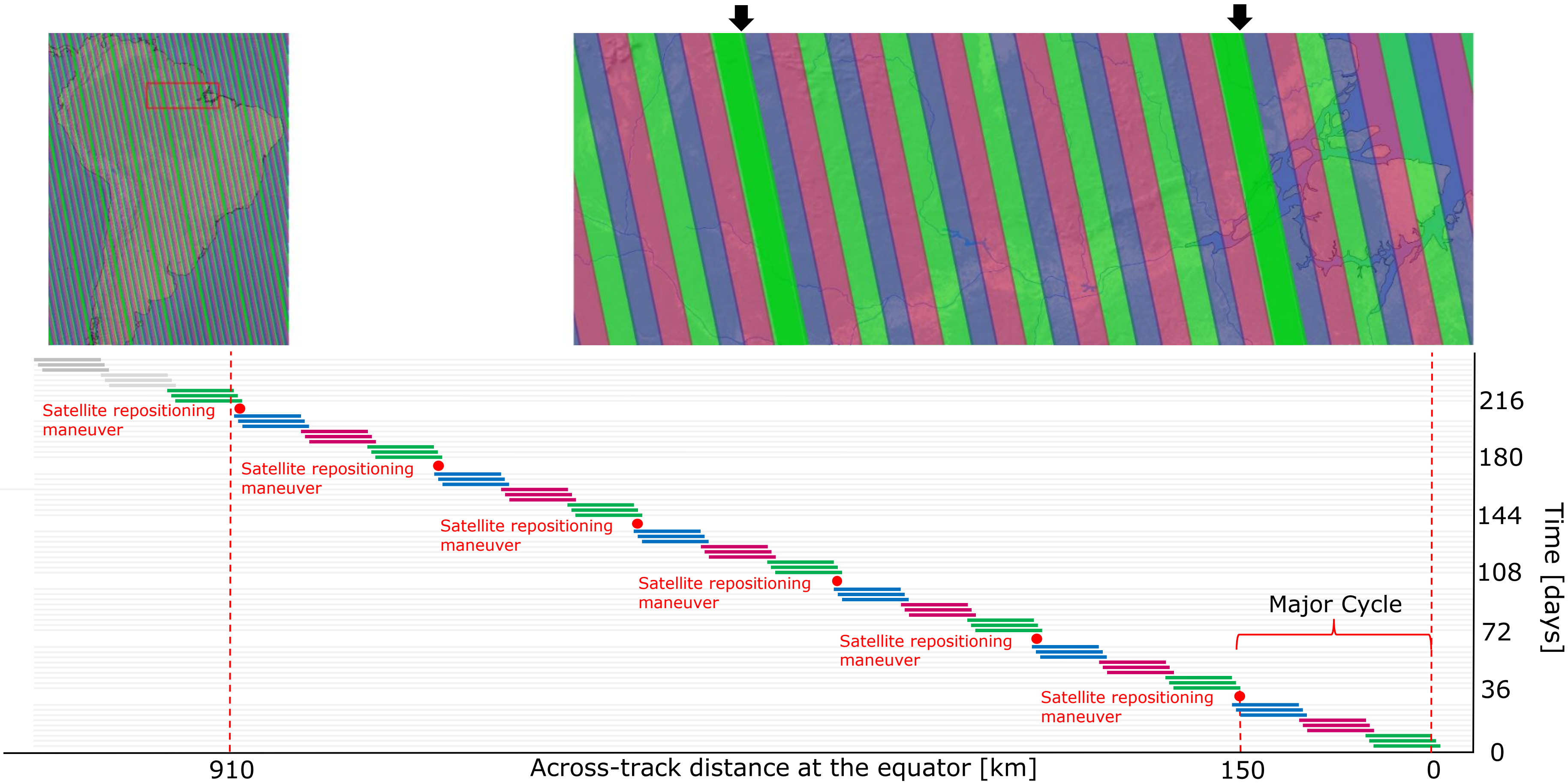
1. Define the external calibration strategy
2. Finalise the Level-2 algorithms to measure AGB, height and disturbance and provide them to ESRIN for implementation

Associated activities:

- Combining measurement modes
- Dealing with environmental changes: land and ionosphere
- Training and validation; augmenting the in situ networks
- CCI-Biomass

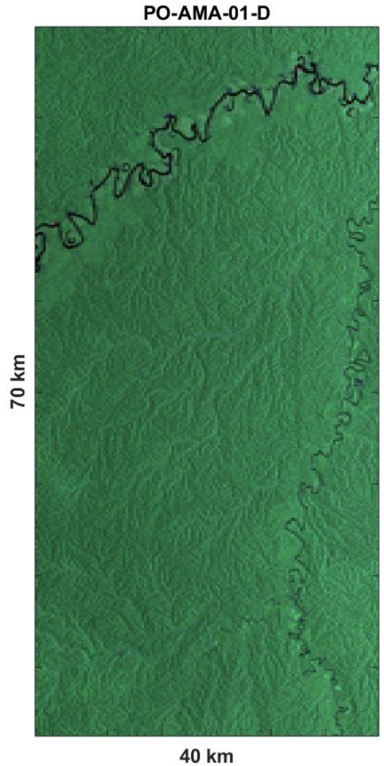
Global Coverage Strategy

Forced by the desire for global tomographic coverage



“Normal” Radar Calibration Procedures

Use repeated visits to a transponder.



Use the radiometric stability of the rainforests

These aren’t suitable for BIOMASS because:

- The orbit pattern limits the use of calibration devices
- BIOMASS is designed to measure space/time variation in forests

Implications: natural targets are essential for routine calibration

A calibration transponder would only be seen:

- once in 14 months in the Tomographic phase
- once every 7 months in the Interferometric phase.

Hence **natural targets of opportunity have to be used** for routine calibration between visits to the transponder.

Necessary properties of radiometric calibrators

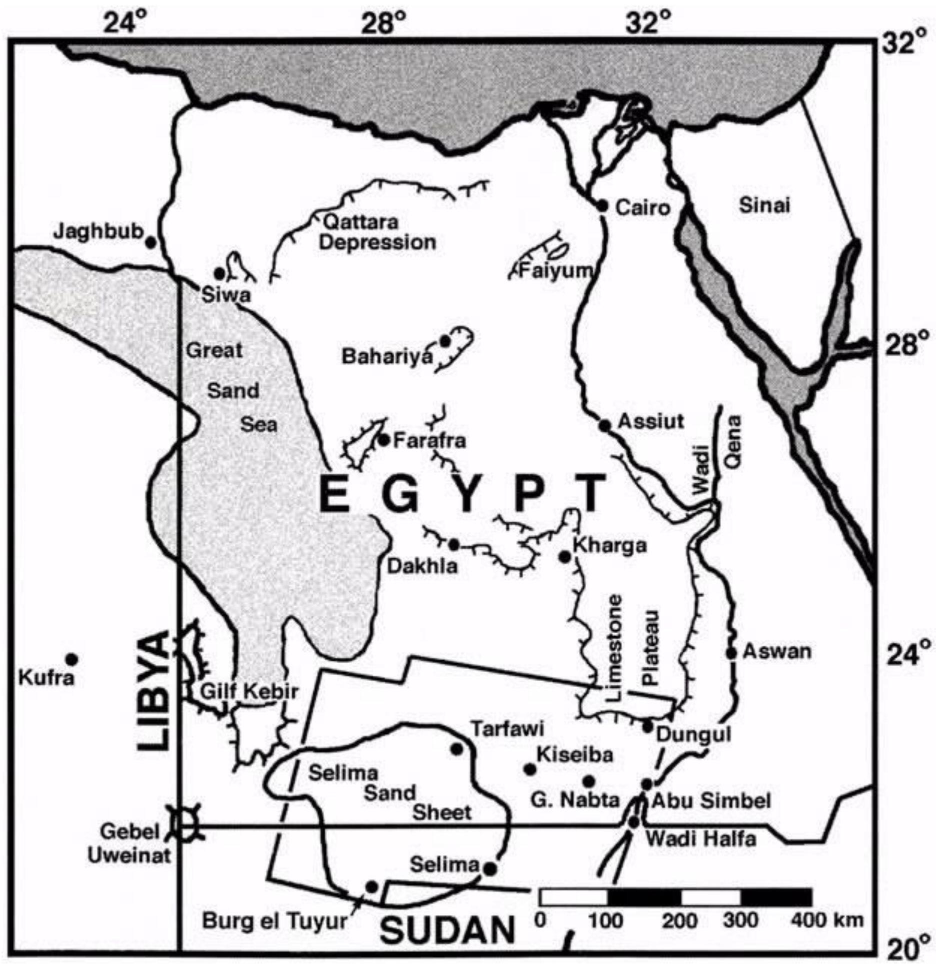
1. Temporal stability
2. Known Radar Cross-Section or σ^0
3. Large Signal to Clutter Ratio (SCR; point targets) or large Signal to Noise Ratio (SNR; distributed targets)
4. Distributed reference targets need to be spatially homogeneous & sufficiently large

Deserts as calibrators

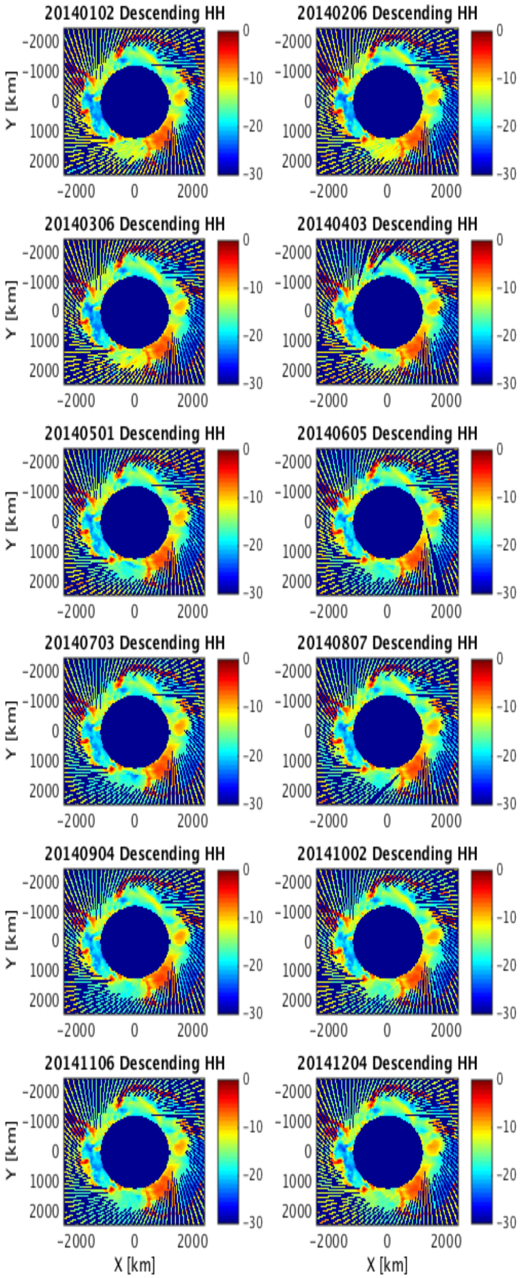
Ksar Ghilane oasis, Tunisia (top Landsat), imaged at L-band by ALOS-2 (middle) and P-band by SETHI (bottom), with three regions of interest in yellow boxes

	band	θ °	HH(dB)	VV(dB)	HV(dB)
Reg. 1	L	36.5°	-21.3	-20.3	-34.9
	P	33-36°	-21.0	-21.2	-39.5
Reg. 2	L	36.5°	-22.9	-21.9	-37.1
	P	40-43°	-26.7	-25.6	-38.8
Reg. 3	L	36.5°	-19.1	-17.9	-32.4
	P	53-57°	-19.0	-18.3	-27.6

Deserts as calibrators



Selima Sand Sheet in Eastern Sahara



Icesheets as calibrators

Space Object Tracking Radar restrictions mean that we cannot use the Arctic, and must use the Antarctic.

Aquarius L-band scatterometer measurements were used to assess radar brightness, stability and homogeneity.

Dome C is bright and stable at L-band, and expected also to be at P-band.

Ionospheric scintillation may affect radiometry but current calculations indicate this is not a significant problem

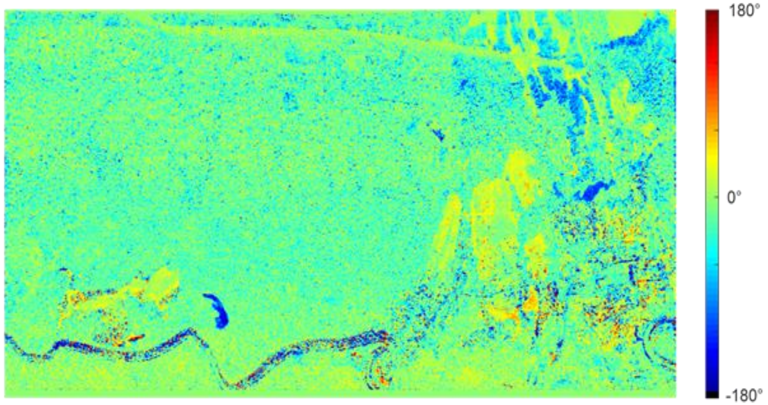
Biomass estimation: Three major steps forward

1. Development of methods for ground cancellation using **tomography or Pol-InSAR** to isolate volume scattering.
2. Development of an approach to solve the volume scattering equation that minimizes the need for reference data.
3. Strong evidence that the volume layer 25-35 m above the ground in tropical forest is strongly correlated with the total AGB.

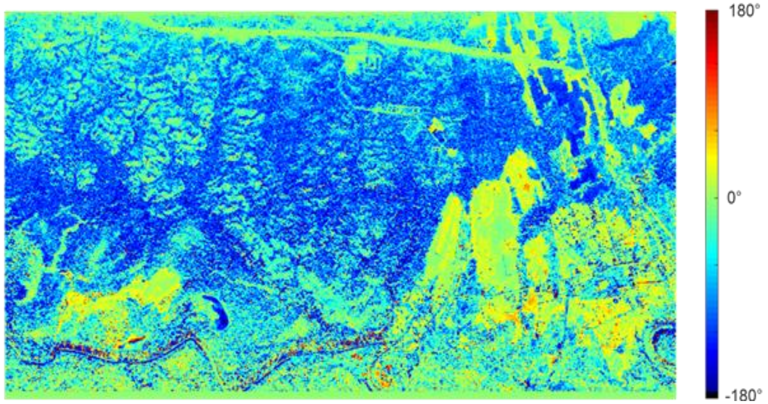
Isolating the volume by ground cancellation

HH-VV phase difference:

1. At 30 m height

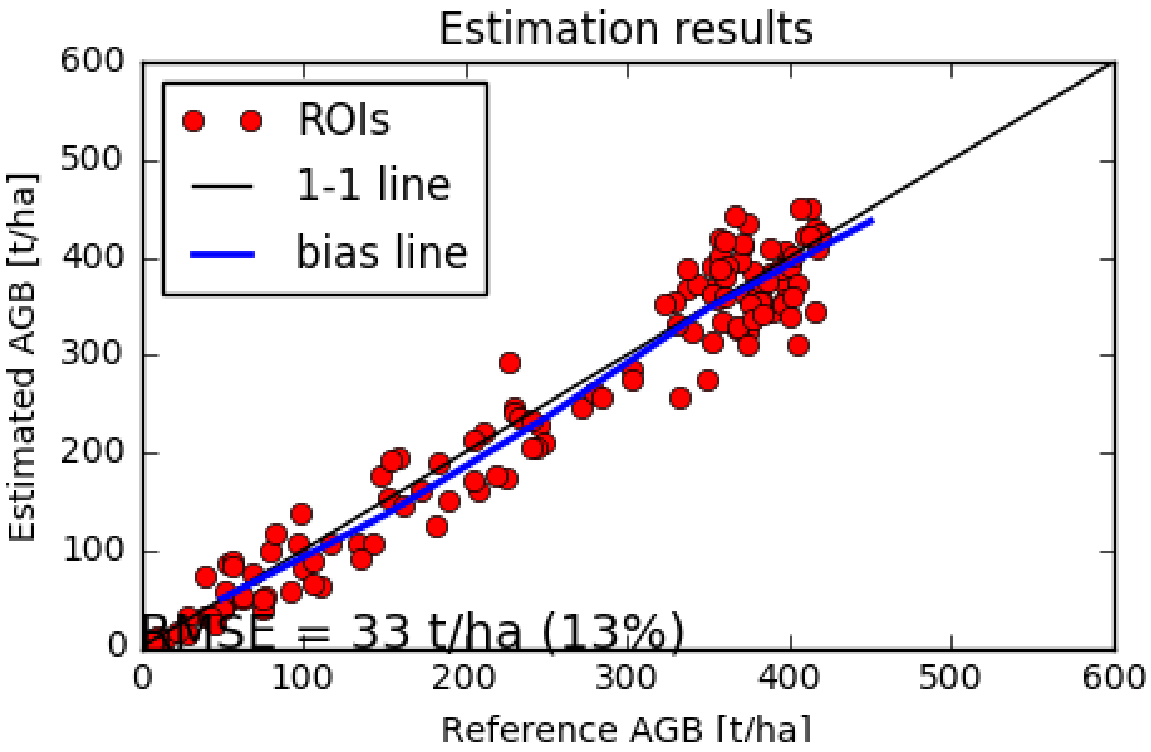


Tomographic section at terrain height



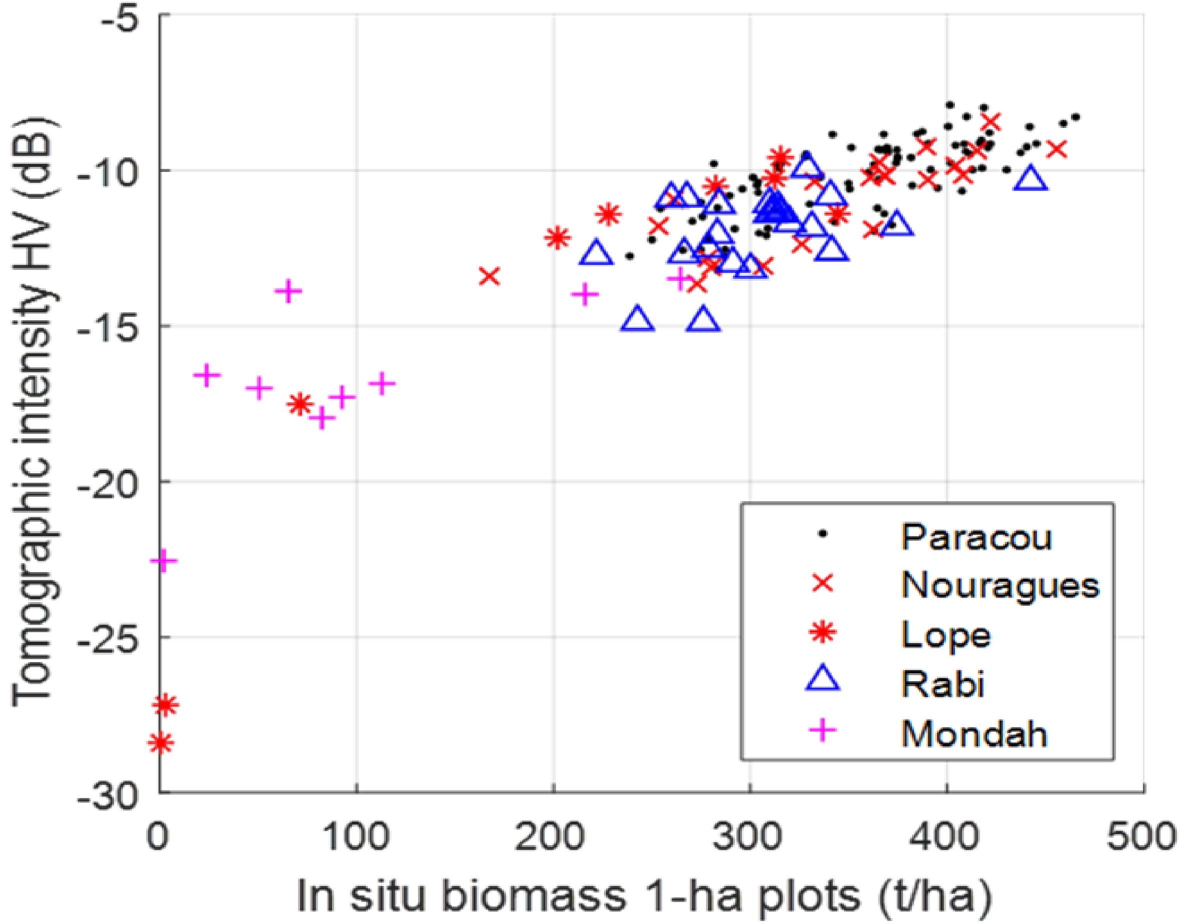
2. At ground level

Inversion of volume scattering gives accurate estimates of tropical biomass



Estimated against reference biomass at La Lopé, Gabon

AGB is strongly correlated with backscatter from 30 m above the ground as measured by tomography



Summary

1. BIOMASS is on track for launch in 2022.
2. The external calibration process is essentially defined, and involved answering many scientific and algorithmic questions, some of which we are still working on. There will be new campaigns to address some of these issues.
3. The core algorithms to produce the BIOMASS products are in place, though numerous issues still remain, e.g. combination of ascending and descending orbit data. These continue to be studied in the L2 contract.
4. There have been significant enhancements in resources for in situ data.
5. The launch of GEDI and a serious effort to combine the capabilities of NASA and ESA to get the best AGB product have major benefits for BIOMASS.