Biomass Phase-E Cal/Val Activities

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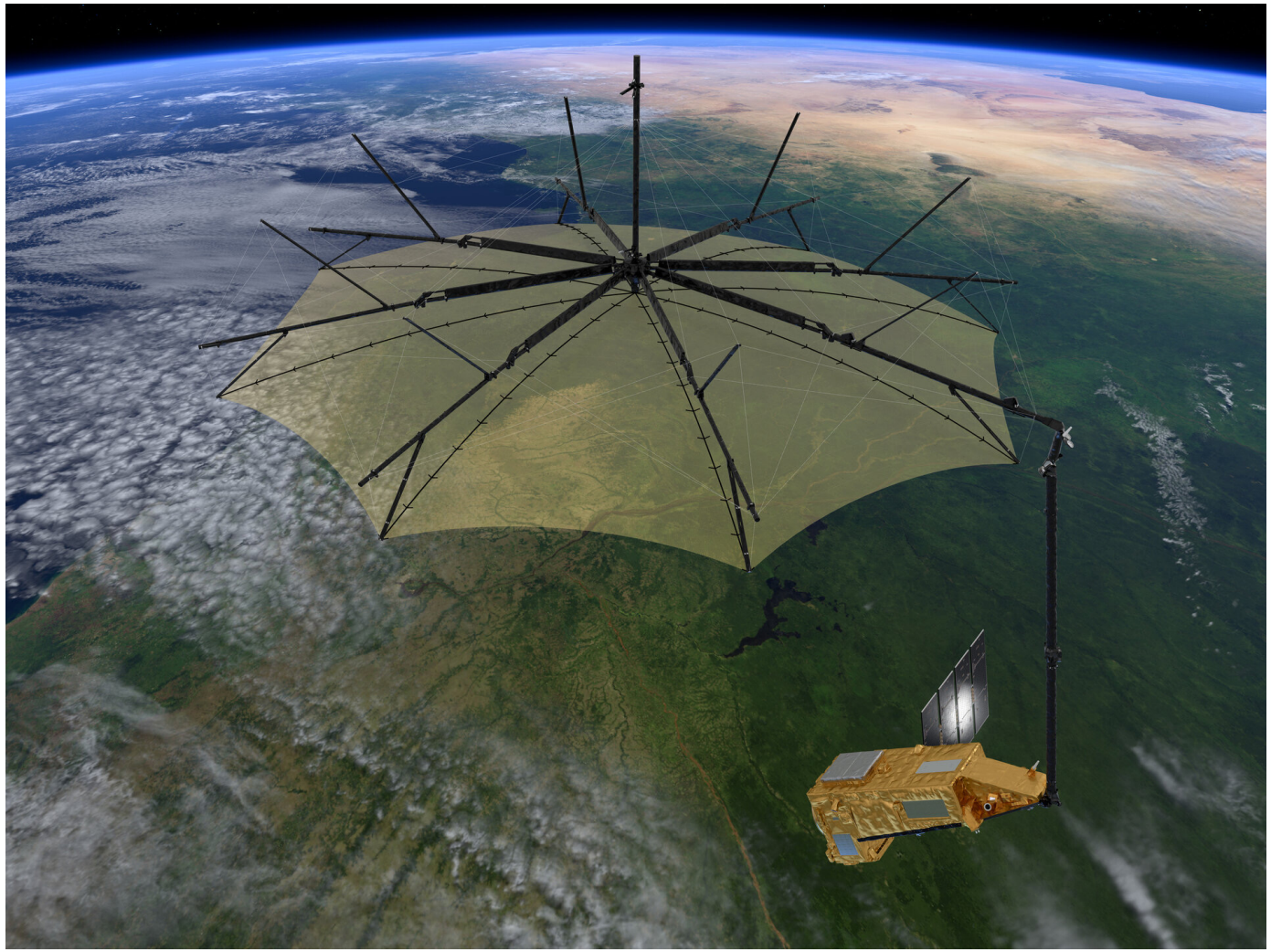
Overview

- Recall Phase E1 coverage
- Phase E1 Targets of Opportunity
- L1 calibration examples:
  - Targets of Opportunity
  - Antarctic calibration (Dome-C)
- L2 validation approach
- Cal/Val AO



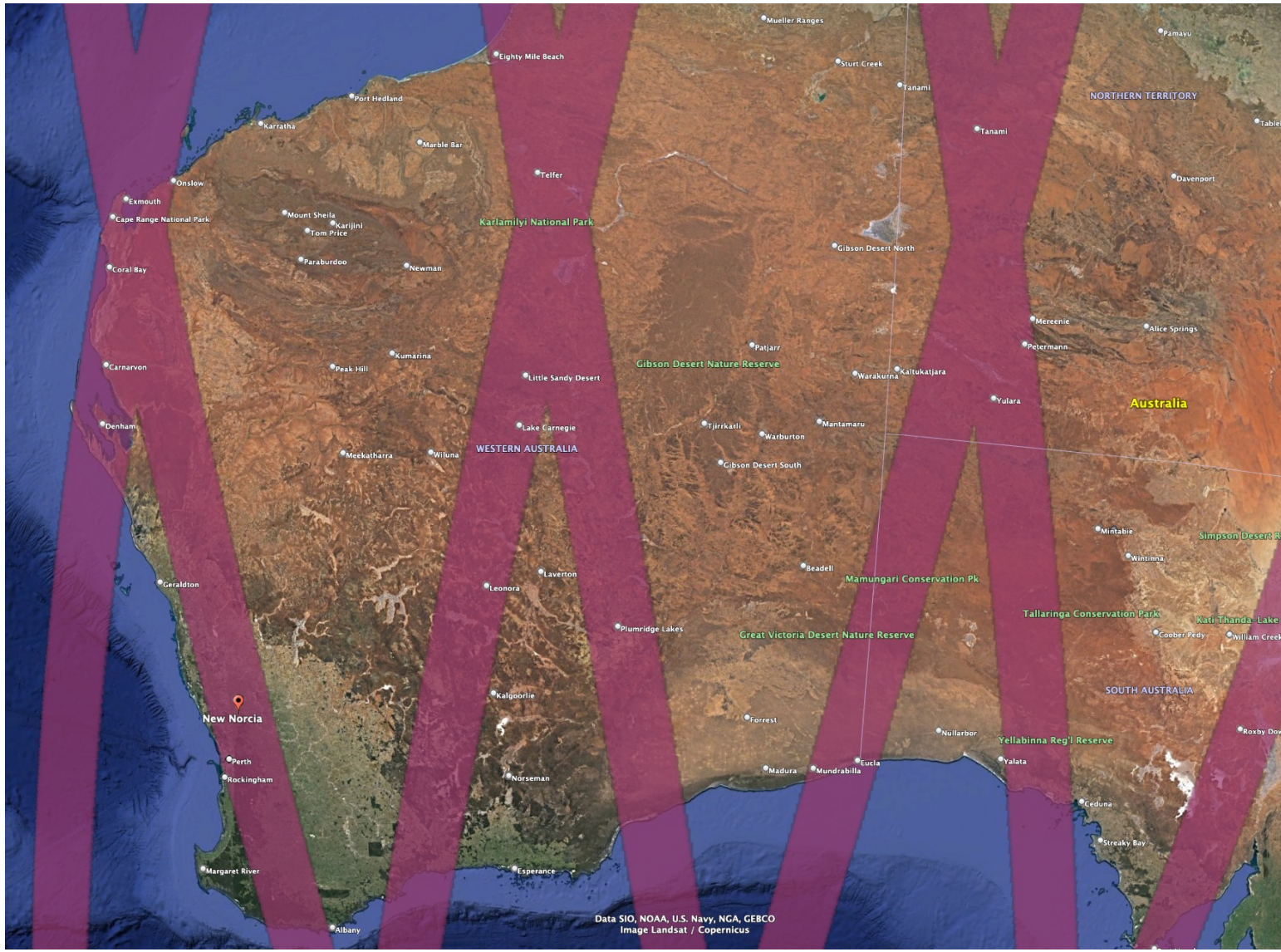
Phase E1 orbit(s)

Orbit :

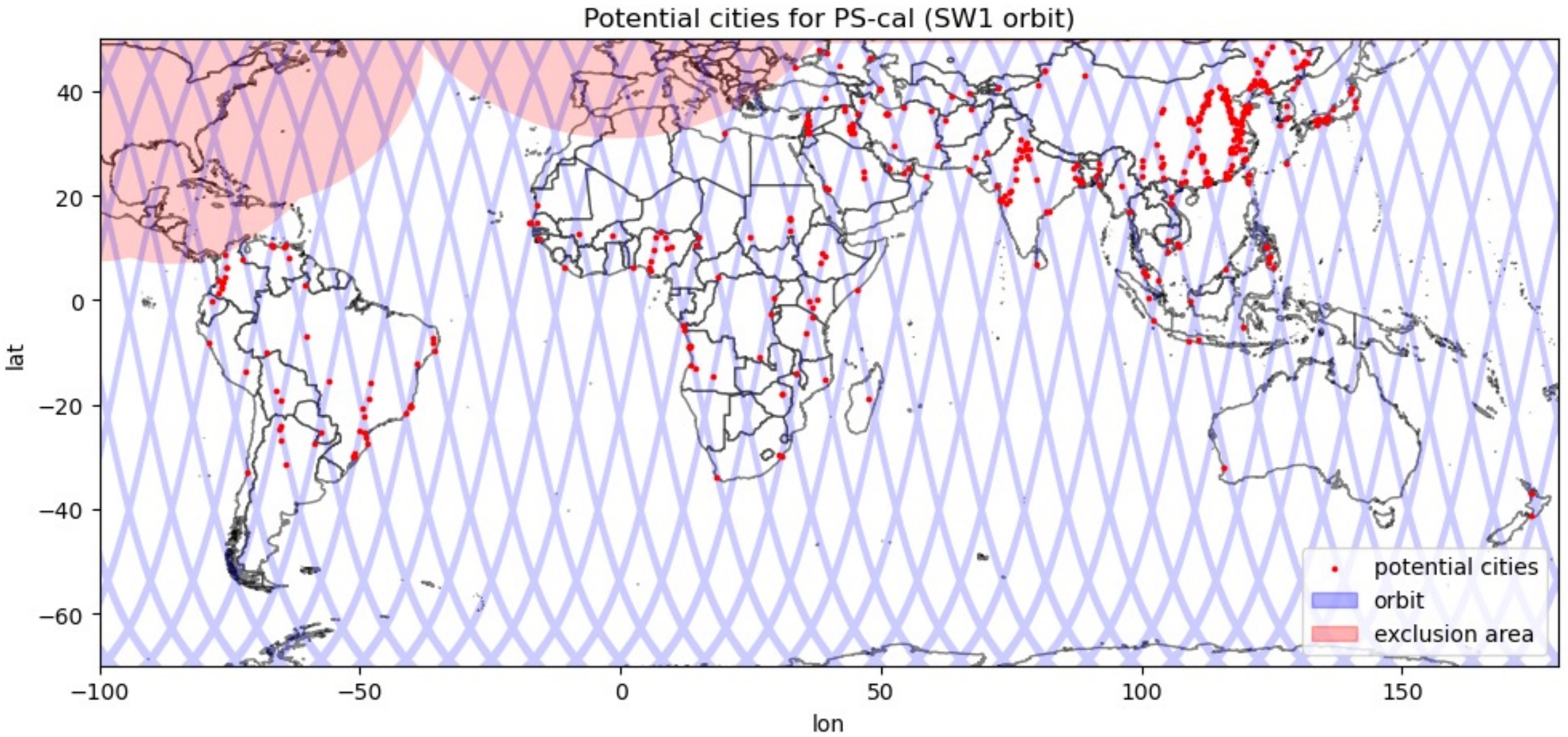
- Sun-synchronous, dawn-dusk
- Orbit height: 666 km
- (Near) repeat cycle: 44 orbits
- (Near) cycle length: 3 days

During the commissioning phase, the orbit has been chosen to maximise revisits over the Biomass Polarimetric Active Radar Calibrator (PARC) located at ESA's New Norcia Station.

For the Biomass Antenna pattern characterisation (swath 1), a small westward drift is commanded ~ 2.8 km allowing the PARC to move from far to near-range in the swath over time



Potential use of PS in urban areas during IOC



Recalibration/monitoring using opportunistic targets

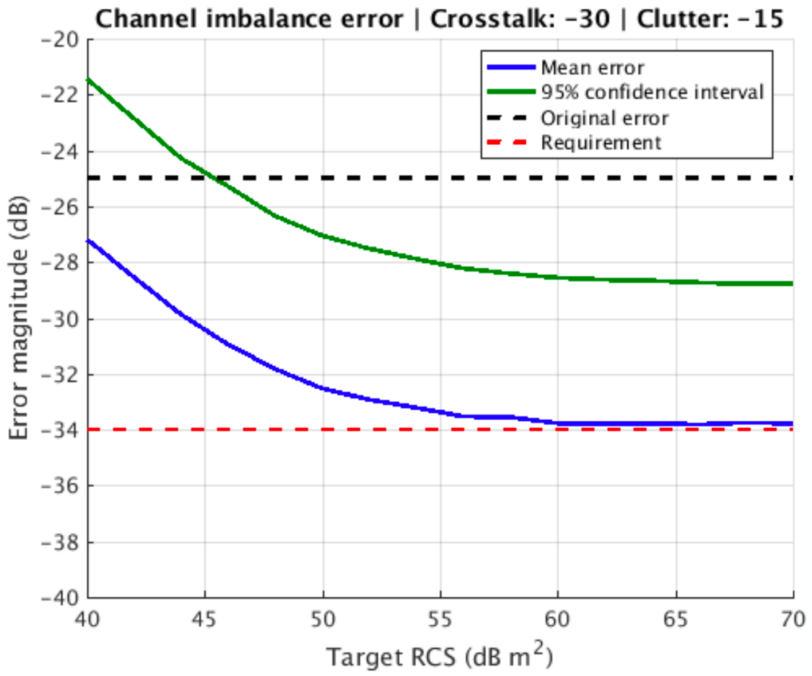
Can we solve the polarimetric system equations using alternative targets?

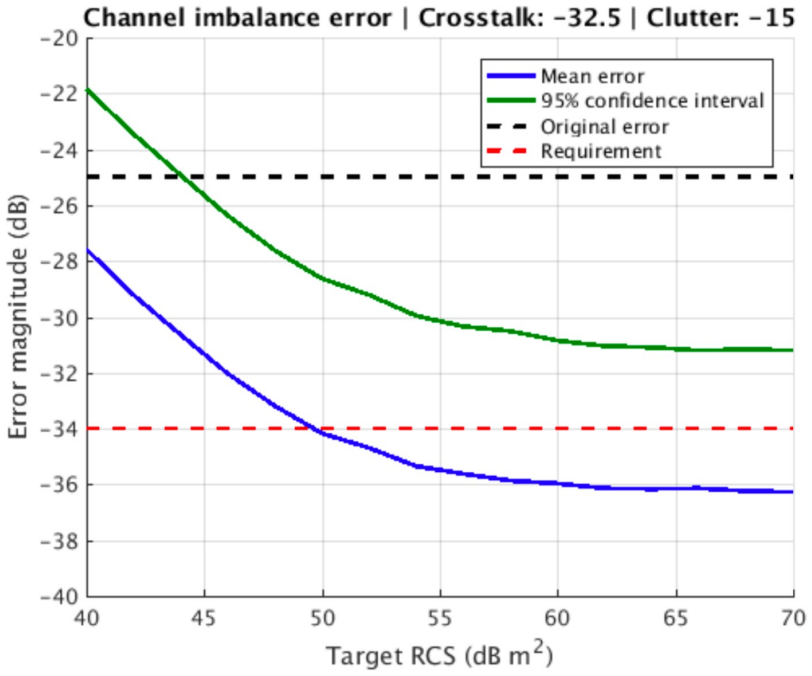
Assumption: cross-talk levels are sufficiently known and stable

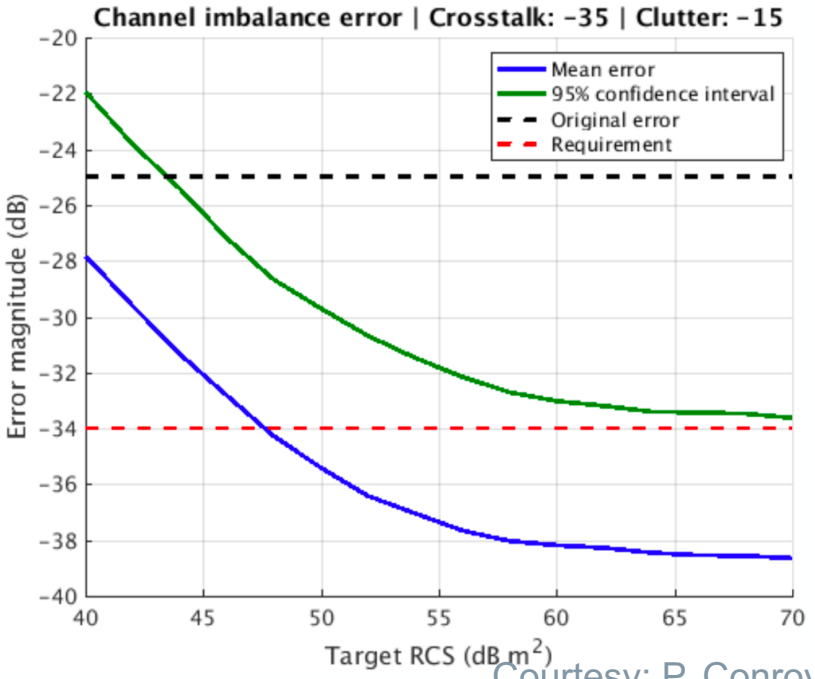
$$\mathbf{M} = \begin{bmatrix} 1 & 0 \\ 0 & f_1 \end{bmatrix} \begin{bmatrix} \cos\Omega & \sin\Omega \\ -\sin\Omega & \cos\Omega \end{bmatrix} \mathbf{S} \begin{bmatrix} \cos\Omega & \sin\Omega \\ -\sin\Omega & \cos\Omega \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 0 & f_2 \end{bmatrix}$$

- After commissioning phase (dedicated cal orbit), transponder contact is limited
- Depending on the achieved cross-talk & local clutter levels, targets with RCS in the range 50 – 60 dBm^2

→ corresponding to trihedral between 10 and 18.5 m side edges… OR …







Courtesy: P. Conroy

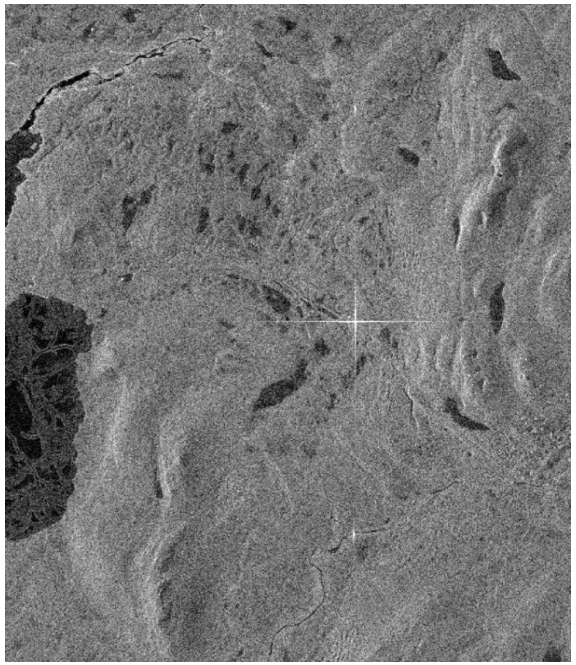
Use of radiotelescopes for Biomass calibration

Courtesy: K. van 't Klooster, F. Ceba Vega

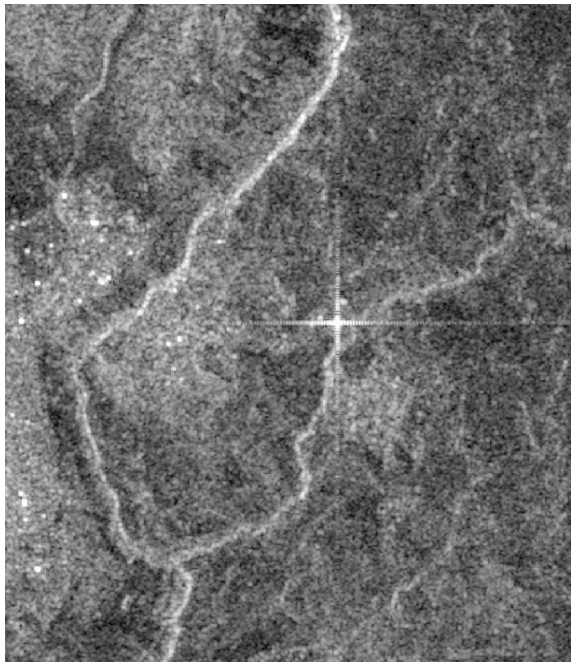
Investigated targets using Sentinel-1

- Radiotelescopes and data downlink stations (Spring 2011 with ERS-2 and Envisat)
- Matera and Kiruna response clipped in Sentinel-1 SLC data
  - S1 PDGS ensures DLR transponders (~61 dBm^2) within dynamical range
  - Solution: reprocessing of datasets
- Orgov ROT54 is not saturated in Sentinel-1

Matera



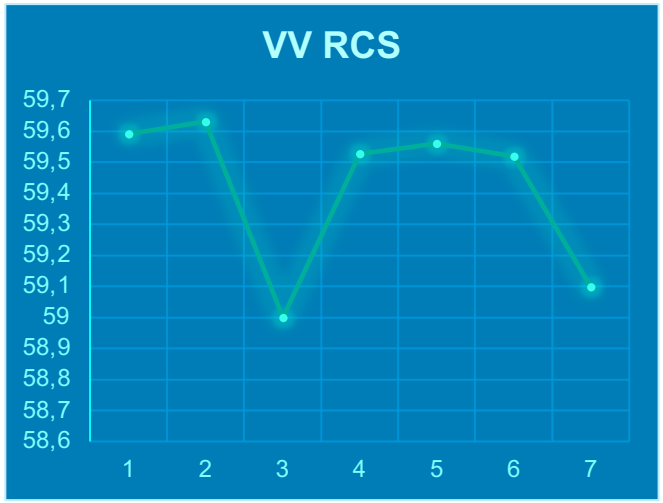
Kiruna

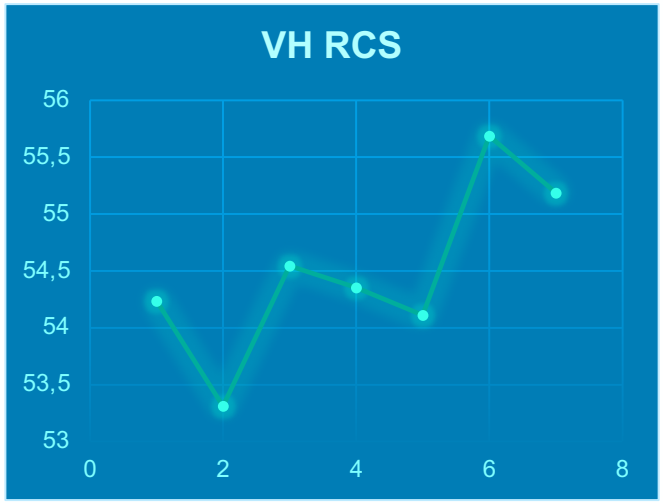


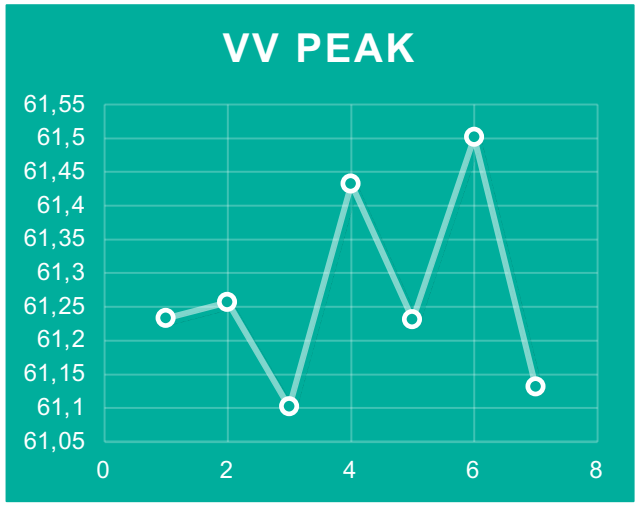
Orgov

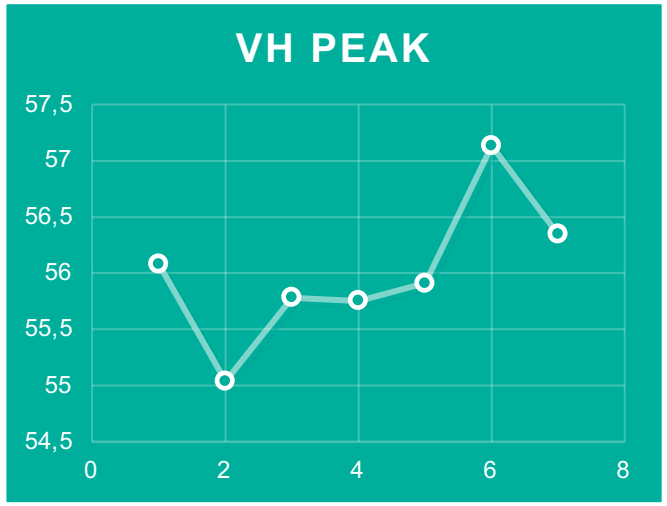
Courtesy: K. van 't Klooster, F. Ceba Vega

Orgov @ C-band









- 7 products equi-spaced 12 days and with the same observing geometry
- Orgov RCS stability 0.6 dB for VV and 2.3 dB for VH (peak-to-peak values)
- For peak method → within 0.4 dB for VV and 2.1 dB for VH
- Orgov is a complex target to precisely model (feed structure), but very stable in VV and consistent target during Sentinel-1 observations
- Due to low RCS and polarimetric properties not recommended for Biomass monitoring

S1B_IW_SLC__1SDV_20190902T030820_20190902T030847
S1B_IW_SLC__1SDV_20190914T030821_20190914T030848
S1B_IW_SLC__1SDV_20190926T030821_20190926T030848
S1B_IW_SLC__1SDV_20191008T030822_20191008T030848
S1B_IW_SLC__1SDV_20191020T030822_20191020T030849
S1B_IW_SLC__1SDV_20191101T030821_20191101T030848
S1B_IW_SLC__1SDV_20191113T030822_20191113T030849

Courtesy: K. van 't Klooster, F. Ceba Vega

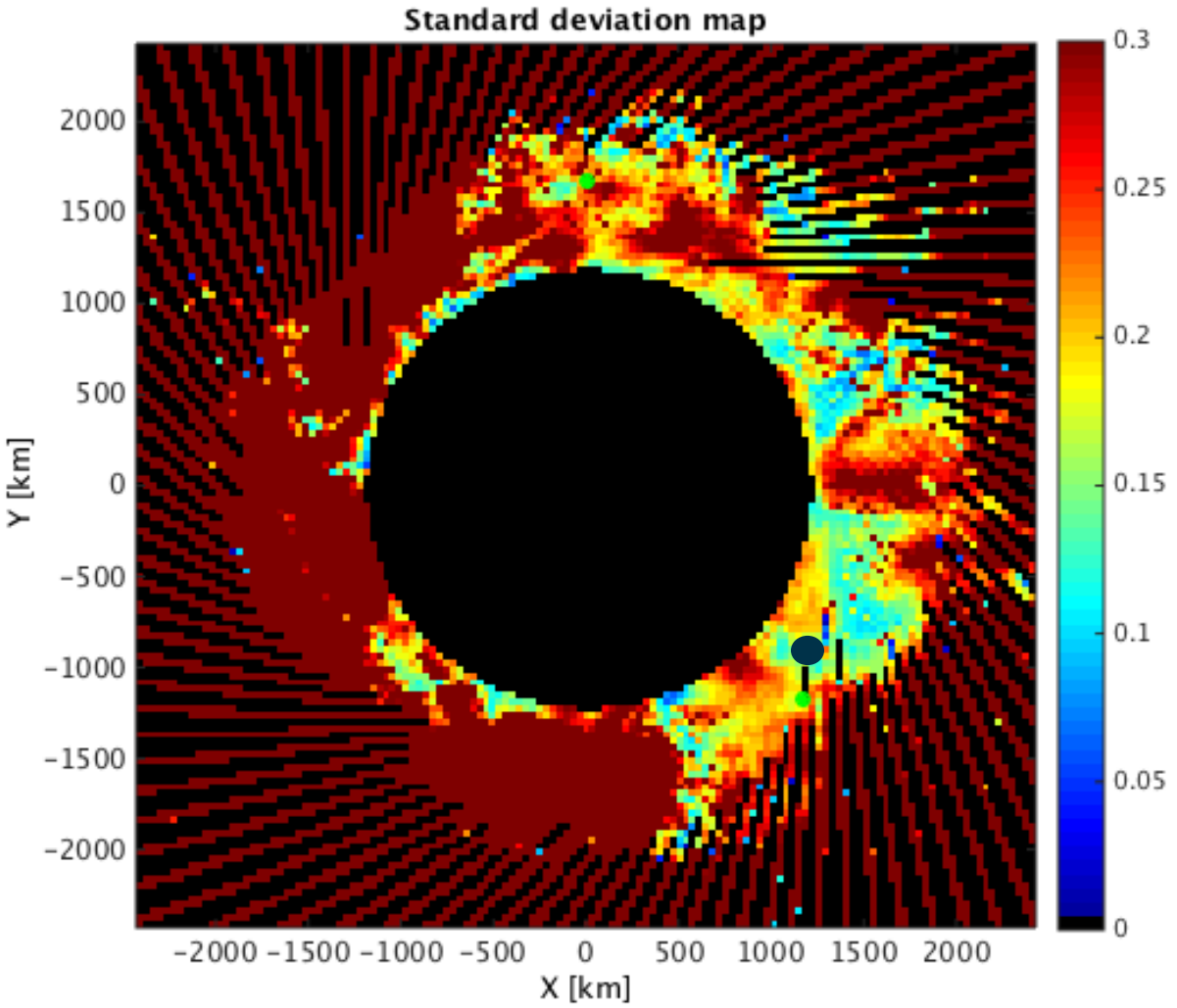
Calibration in the Dome C region

Dome-C merits:

- Relatively strong backscatter at Dome-C (–12 dB @ L-band).
- High temporal stability (0.2 dB @ L-band).
- Large region seen from many orbits.
- Flat and relatively homogenous region.

Additional justification:

- Dome-C is already used for calibration purposes, and it is well characterised.
- British Antarctic Survey, Copenhagen University and others plan additional in situ measurements.
- The Concordia Station in the Dome-C region can offer logistical support for in situ and airborne measurements (accommodation, fuel etc.).



L-band sigma0 standard deviation [dB]

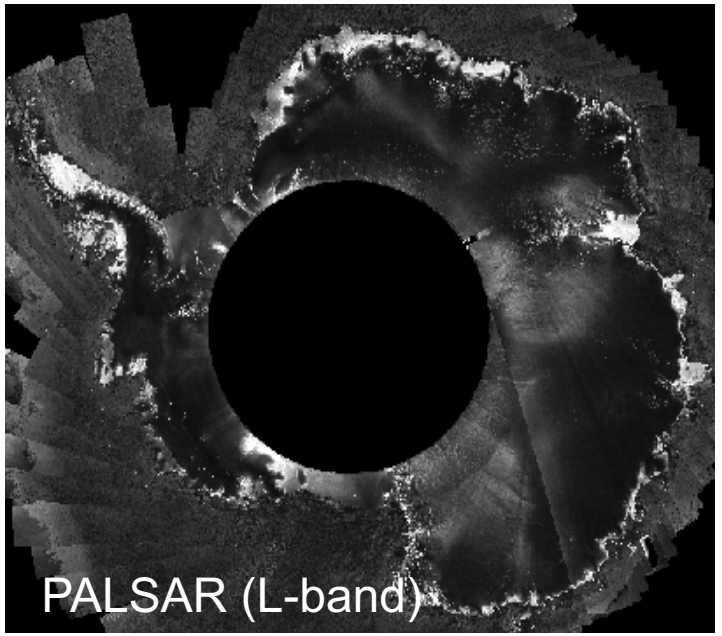
Biomass Antarctic campaign objectives

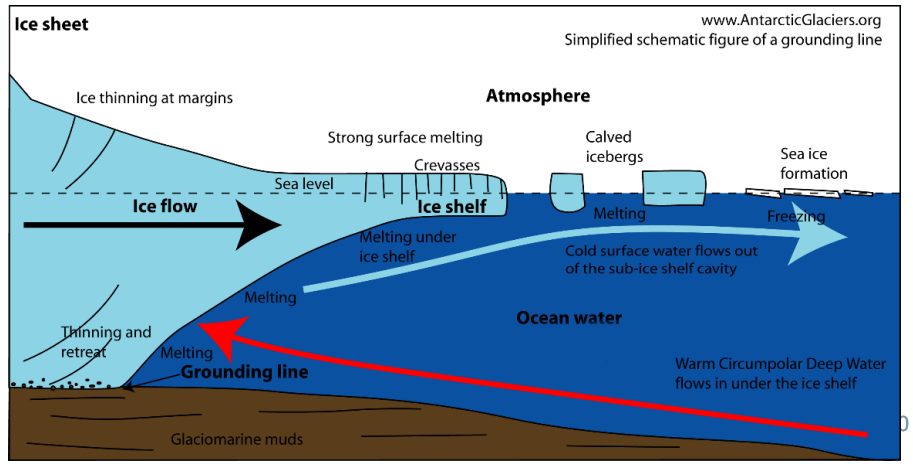
- **Characterize P-band backscattering in the Dome C region**
  - sigma-0 and its spatial variation
  - dependency on incidence angle
  - dependency on the aspect angle (anisotropy due to aeolian processes)
  - ice structure, e.g. penetration depth, surface-to-volume ratio, layering.

- **Ice shelf mapping**
  - feasibility of mapping the basal tomography with tomography
  - characterize the backscattering from surface, volume, base
  - extinction, firn depth, coherence etc.

- **Objectives not directly linked to the Biomass SAR**
  - Radar ice sounding, complement in situ measurements etc.

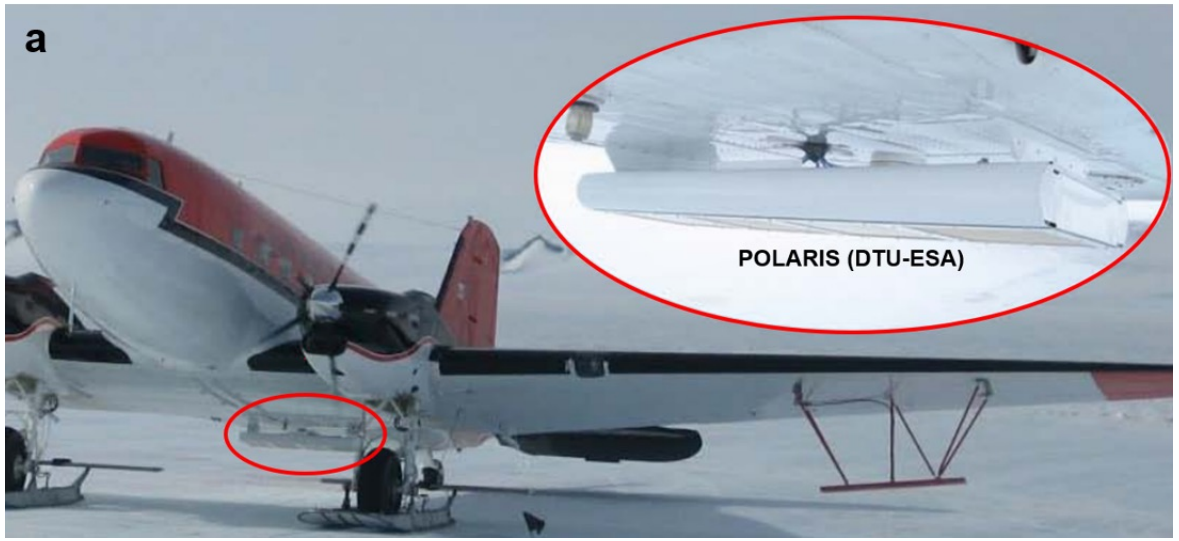
→ Flight opportunity: November/December 2023

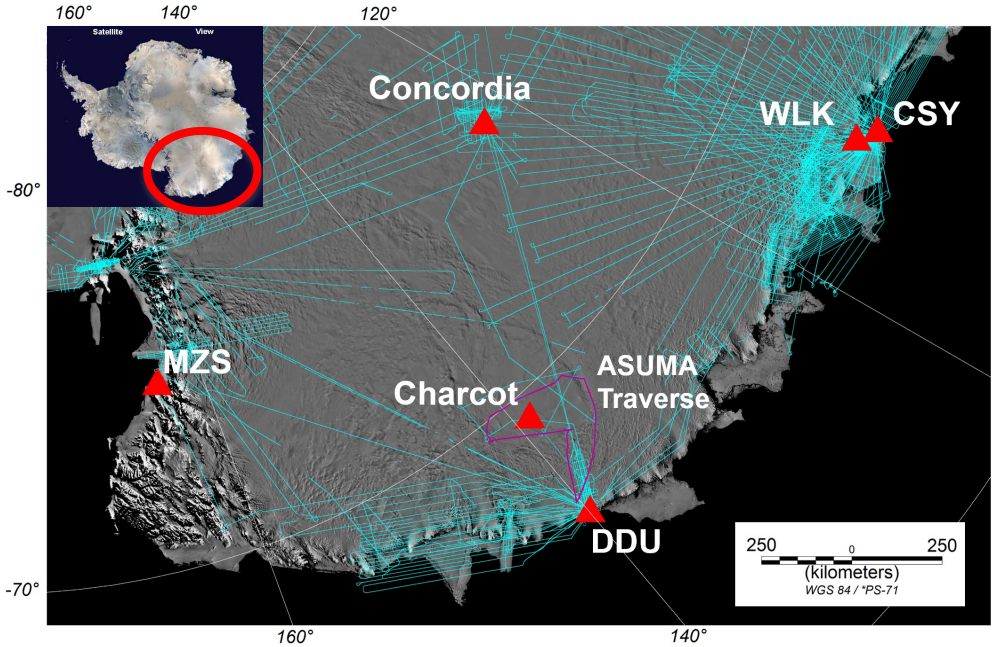




Biomass Antarctic campaign / Test sites

- Dome C/Concordia in support of Biomass calibration and secondary objectives.
- Ice shelf, e.g. the Cook ice shelf in George V Land.
- ASUMA traverse at Dumont d'Urville Station (DDU).
- The old French Charcot Station (retrieval – buried under 25 m firn).
- Sites of opportunity, e.g. fast flowing ice or in situ measurement sites on transits to/from Concordia and to/from Cook.





L2 product validation: overview

Above-ground biomass (tons / hectare)

- 200 m resolution
- 1 map every ~9 months during INT phase
- global coverage of forested areas outside SOTR areas
- accuracy of 20%, or 10 t ha^{-1} for biomass < 50 t ha^{-1}

Upper canopy height (meter)

- 200 m resolution
- 1 map every ~9 months during INT phase
- global coverage of forested areas outside SOTR areas
- accuracy of 20-30%

Areas of forest clearing (hectare)

- 50 m resolution
- 1 map every 6 months for 4 years
- global coverage of forested areas outside SOTR areas
- 90% classification accuracy

BIOMASS can operate with a resolution of ~55m in range

L2 product validation

From CEOS biomass validation strategy document (2018):

"We propose the creation of a **CEOS Forest Biomass Reference System** as an equitable and sustainably-funded system of recurrent site-based measurements that will serve as a lasting interface between the Earth Observation agencies and ground-based tree-by-tree measurement initiatives.

No single EO mission or agency would alone support the costs of this implementation; this infrastructure is designed to become **a common good for the entire EO community**. With this project, CEOS has the opportunity to coordinate this effort, and liaise with the ground research and forestry community."

For the Biomass mission, the product validation approach builds upon CCI Biomass as well as CEOS activities in close collaboration with partner agencies.

L2 product validation: in situ plot measurements

Field Measurements and derived estimates are not truth – there can be large errors.

- Need transparent handling and reporting of errors, consistent definitions
- Recommendations for measurements
- Summary of uncertainties in allometric models, recommendations for improving allometries
- Terrestrial Laser Scanning (TLS) where possible

Jerome Chave, Kim Calders, Keryn Paul et al.

GEO-TREES

Large forest networks already exist. They have built standards, database management structures, verification systems. Even more importantly, they have built a trusted community within scientific research and have managed reputational risks

GEO-TREES builds upon three of these networks: **ForestPlots, ForestGEO, TmFO**

https://geo-trees.org

GEO-TREES is purpose-driven, so it is no substitute for established networks. It addresses a single very important science question (forest carbon)

GEO-TREES is more than the sum of the parts: it brings visibility to the EO community and credibility to a range of potential funders

GEO-TREES is a win-win: sites partners benefit from funding and increased visibility; existing networks benefit from continuity in funding streams, the EO community benefits from free-access biomass data

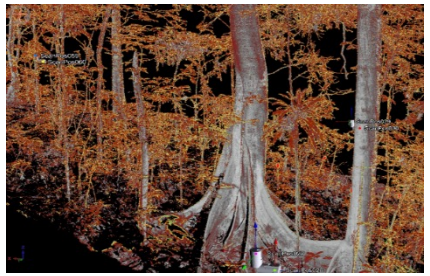
L2 product validation: Requirements for BRM sites

Field Plot Specs
- Preferably square (⇒ easier to link to gridded products)
- **Min plot size of 1 ha in tropics (⇒ minimizes edge effects)**
- **Permanent, well geopositioned, tagged, and identified**
- Stem-mapped where possible
- Smaller than 0.25 ha in temperate and boreal OK provided airborne lidar

Spatial Distribution of Field Plots
- Covering gradients sampled by airborne lidar (e.g. topography, biomass range, etc.)
- Sufficient number to train a lidar model (10-30 plots)

Airborne Lidar Specs
- Minimum 4 shots /m²
- **Preferably acquired in same season as field plots**
- **Acquired within ~2 years of field acquisition**
- Area min ~3x3 km (but less OK if using drone)
- Covers plots + local environmental, land history, and forest and structure gradients

Terrestrial Lidar Specs
- Sample in existing long-term plots
- **1 ha plots preferable**
- Grid pattern
- Spacing 10 m in dense areas, 20 m in open areas, or whatever yields consistent sampling and minimizes occlusion
- Instrument must have ability to range to tallest trees (e.g. Riegl vz400 or greater)



Committee on Earth Observation Satellites

Working Group on Calibration and Validation
Land Product Validation Subgroup

Global Aboveground Biomass Product Validation
Best Practice Protocol

Version 1.0 – 2020

Editors: Laura Duncanson, Mat Disney, John Armston, David Minor, Jaime Nickeson

CEOS LPV Cal/Val Best Practice Protocol for Above Ground Biomass

Recommendations for all data collections
- Data should be **fair**, to engage and support contributors based on mutual respect and deliver mutual benefits,
- Data should be **open**, to allow for transparent and reproducible remote sensing product validation
- Data should be acquired in **collaboration with long-term field plot networks and local partners** wherever possible to increase data consistency, longevity and capacity building
- **Repeated every ~5 years** or when disturbance detected

L2 product validation: plot2map

- **plot2map** (Araza et al. 2022): automated processing chain of AGB plot and map comparison in the context of map validation of AGB map products. The workflow includes preprocessing of forest inventory data and estimating plot-level uncertainties (measurement and allometric model errors, sampling/within-pixel errors, and temporal mismatch with the map year).
- Preprocessing of plot data is conducted with the BIOMASS package (Réjou-Méchain et al., Methods Ecology Evolution 2017), including estimation of SD. SD due to temporal mismatch is added.
- **plot2map** can also be run in the Multi-Mission Algorithm Platform (MAAP)

Araza, A., De Bruin, S., Herold, M., Quegan, S., … & Lucas, R. (2022). A comprehensive framework for assessing the accuracy and uncertainty of global above-ground biomass maps. *Remote Sensing of Environment*, *272*, 112917.

Réjou-Méchain, M., Tanguy, A., Piponiot, C., Chave, J., & Hérault, B. (2017). biomass: an r package for estimating above-ground biomass and its uncertainty in tropical forests. *Methods in Ecology and Evolution*, *8*(9), 1163-1167.

Biomass Announcement of Opportunity on Cal/Val

AO objectives:

1. to solicit **worldwide** proposals on calibration and validation (CAL/VAL)
2. to invite new research groups to participate in Biomass CAL/VAL

- As a CAL/VAL PI or co-PI, access to Biomass products and related quality information will become available to you first-hand
- Opportunity to quickly learn & cooperate directly with other Biomass CAL/VAL PIs and to perform joint activities
- PI's whose proposals are accepted will be invited to become members of the Biomass Cal/Val Team for which the Agency will organise dedicated meetings and workshops
- An important validation element is the collection and provision of independent measurements for both primary and secondary mission objectives for the Biomass mission

Note: funding of activities solicited through CAL/VAL AOs shall be covered by national/institutional resources

Announcement to be published through ESA public website after summer break

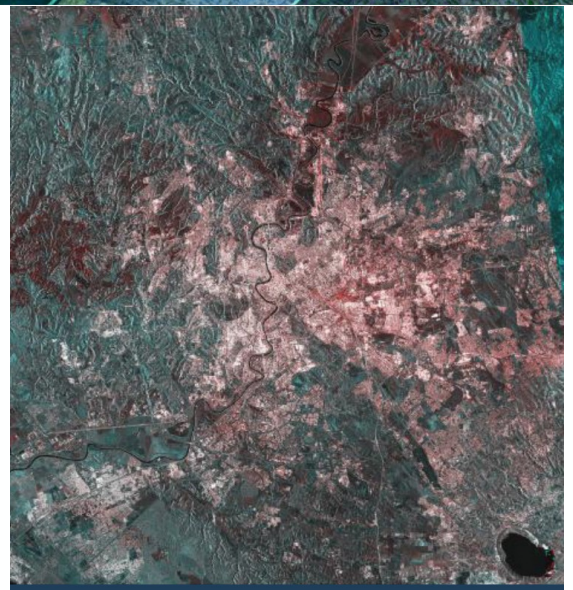
Announcement BioGeoSAR-2023

8th International Workshop on
Retrieval of Bio- & Geo-physical Parameters from SAR Data for Land Applications
Rome, Italy 15-17 November 2023

Organised around the following main themes:

- *Land-use and classification*
- *Agriculture*
- *Soil and hydrology*
- *Forestry*
- *Ice and snow*

SAPIENZA
UNIVERSITÀ DI ROMA



ANNOUNCEMENTS AND CALL FOR ABSTRACTS

Abstract submission opening	July 2023
Abstract submission closure	18 September 2023
Notification of acceptance	October 2023
Registration opening	July 2023
Issue of preliminary programme	October 2023
Issue of final programme	at the workshop
Workshop dates	15–17 November 2023

REGISTRATION AND ABSTRACT SUBMISSION

Further information and guidelines regarding the registration and abstract submission can be found on the workshop website at :

http://biogeosar.esa.int

Abstract submission opening early July 2023 (open until 18 September)

http://biogeosar.esa.int