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BRIX: The first Biomass Retrieval Inter-comparison eXercise

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What is BRIX?

- BRIX is an algorithm intercomparison experiment.

- The objective of BRIX is twofold:
  1. Provide an objective, standardized comparison and assessment of biomass retrieval algorithms developed for the Biomass mission.
  2. Establish a platform to involve scientists in the development of retrievals that have so far not been part of the Biomass community.

- These objectives shall be achieved by making available standardised test cases (based on campaign data), inviting the scientific community to develop and apply retrieval algorithms based on this test case, and finally compare and evaluate the performance of submitted results.

- For the purpose of an objective algorithm evaluation ESA has set up the Biomass Test Bed.
BIOMASS Level 2 Algorithm Test Bed

Goals:
- To refine the existing biomass retrieval algorithms
- To allow to benchmark the algorithms

Cloud computing platform for processing available P-band airborne campaign data

- Harmonized data (GeoTiff, ESRI)
  - SLC SAR images
  - Local incidence angle
  - Kz
  - DEM
  - ROI shapes

- Common tools
  - Projectors
  - Matchup tool

- Orchestrator
  - Data processing management

ESA Campaign data available today
- Indrex-2 (553 GB)
- BIOSAR-1 (42 GB)
- BIOSAR-2 (93 GB)
- TROPISAR (66 GB)
- BIOSAR-3 (49 GB)
- AfriSAR (1364 GB)

The BIOMASS L2 Algorithm Test Bed is the seed of the MAAP
What BRIX is not!

➢ BRIX should not be a competition where the best performing algorithm wins. The exercise should be a **scientific experiment** with a focus on the **intercomparison of algorithms**.
Retrieval Challenges

**BRIX has following challenges:**

1. How to optimally use the available PolSAR, PolInSAR and TomoSAR data in the retrieval?

2. The transferability of the retrieval developed over on site (Lopé) to three sites that are separated by several 100 km, which requires to account for different ecological characteristics and forest structure.

3. How to correct for topographic effects?
Retrieval Scenarios

- Develop a biomass retrieval based on the data that has been acquired during the AfriSAR campaign for the La Lopé super site.

- The retrieval will be evaluated over the three independent test sites Mondah, Rabi and Mabounie with existing forest plot data and lidar estimates of biomass.

- 2 Scenarios:
  - PolInSAR-Stack: 3 fully polarimetric interferometric images in two headings
  - TomoSAR-Stack: 8-11 fully polarimetric interferometric images
4 Participants

- Leicester/JPL (Maryam Pourshamsi, Mariano Garcia Alonso, Joao Carreiras / Marco Lavalle) ➔ Modeling

- CESBIO (Colette Gelas) ➔ Semi-Empirical/Likelihood

- IFAC (Simonetta Paloscia, Emanuele Santi) ➔ Machine Learning

- EURAC (Padovano Antonio, Notarnicola Claudia) ➔ Machine Learning
Milestones

1. Experiment call (22 May 2017)

2. Registration (Deadline: 30 June 2017)
   - Experts have 7 months to develop and apply their algorithms to the test scenarios.

3. Results Submission (Deadline: 16 February 2018)
   - Resulting biomass maps are submitted in the prescribed format to ESA including appropriate algorithm documentation (ideally in the form of a peer-reviewed publication, but at least in the form of an ATBD) and a brief experience report on the exercise set-up (limitations of their algorithm, suitability of data, what’s good/what’s bad etc.).

4. BRIX workshop (30 May 2018 at ESRIN)
   - Workshop between all participants to present and discuss the different retrievals and the results
Example of result

$\left( r^2 = 0.84 \mid \text{RMSD} = 62.7 \right)$

Trendline ($a=0.95 \mid b=19.78$)
Evaluation Metrics

- **Bias**
  \[ \mu = \frac{1}{n} \sum (B_x - B_y) \]

- **Covariance**
  \[ \sigma = \sqrt{\frac{1}{n-1} \sum (B_x - B_y - A)^2} \]

- **RSMD**
  \[ RMSD = \sqrt{\frac{1}{n} \sum (B_x - B_y)^2} \]

- **Pearson Correlation**
  \[ r = \frac{n \sum B_x B_y - \sum B_x \sum B_y}{\sqrt{n \sum B_x^2 - (\sum B_x)^2} \sqrt{n \sum B_y^2 - (\sum B_y)^2}} \]
Lopé – Metrics per team and scenarios

![Graph showing metrics per team and scenarios for PolInSAR-Stack and TomoSAR-Stack.]
Mabounie – Metrics per team and scenarios

![Graph showing metrics for PolInSAR-Stack and TomoSAR-Stack](image-url)

- **PolInSAR-Stack**
- **TomoSAR-Stack**
Mondah – Metrics per team and scenarios

![Graph showing Mondah metrics per team and scenarios](graph.png)
Rabi – Metrics per team and scenarios

PolInSAR-Stack
Analysis

• Similar behaviour for the 4 models, while they are based on different methods: semi-empirical/Likelihood model (CESBIO), modeling (Leicester) and machine learning (IFAC and EURAC).

• Very good results on Lopé (where the training ROIs were provided).
• Worse results on the other sites (where the training ROIs were not provided).

➢ A first conclusion is that using the same ROIs for training and validation will introduce strong bias in the estimation of the retrieval.

• Note that CESBIO trained their model on a subset of the ROIs (≥ 0.5 ha only).
General comment

• Variety of algorithms types (poly log, machine learning...)

• The standard file format and georeferencing helped a lot the analysis.

• The algorithms were well documented (paper, user manual for algorithm...)

• Effort to be compliant with the testbed.

• Great effort!

However, no team was fully compliant with the protocol...
Possible share of results & publication

- After the experiment has been closed, we try to make the evaluation scripts available on the testbed. This allows people to repeat the experiment and compare their results against the published ones.

- ESA commits not to distribute the outcome of the exercise without prior consent of the participants.

- It is however planned to publish the results in a joint journal paper that shall be co-authored by all participants and data providers.
BRIX-II

Recommendations:

• Better use of tomographic information
• Compare also visually the biomass maps
• Provide SAR simulator or simulated data
• Provide pieces of algorithms or data (Notching, POA, PolInSAR, TomoSAR...)

Planned:

• P-band + L-band + LIDAR (co-organised with NASA / CEOS)
• 2 Workshops (preparatory workshop and intercomparison workshop)
If you are interested, go to the website:

https://earth.esa.int/web/sppa/meetings-workshops/hosted-and-co-sponsored-meetings/brix