Detecting changes in essential ecosystem and biodiversity properties- towards a Biosphere Atmosphere Change Index: BACI

Deliverable 3.5: LAI, Biomass, Ecosystem structure

Project title:	Detecting changes in essential ecosystem and biodiversity properties- towards a Biosphere Atmosphere Change Index
Project Acronym:	BACI
Grant Agreement number:	640176
Main pillar:	Industrial Leadership
Topic:	EO- 1- 2014: New ideas for Earth-relevant space applications
Start date of the project:	1st April 2015
Duration of the project:	48 months
Dissemination level:	
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Date of submission:	30 March 2018

Deliverable 3.5 - LAI, Biomass and ecosystem structure

The aim of task was the collection and synthesis of airborne and terrestrial LiDAR - derived biomass and vegetation structure data; forest inventory data and hyperspectral data when available. For the Milestone 10 multi-temporal datasets were selected after receiving suggestions in this sense by project partners, also in view of the BACI WP6 and WP8 validation activities.
Thus, a number of datasets were collected including:
Field data, lidar and hyperspectral data for different Ghana forest reserves;
Field data, lidar and hyperspectral data for Sierra Leone Gola National Park;
Lidar-derived Digital Surface Model for the Roda area in Thuringia, Germany;
Lidar airborne and terrestrial, multispectral and hyperspectral data for the Harwood Forest, UK.
For project validation activities, these datasets have been only partially tested, due to different time frames and scales with respect to BACI indices and products under elaboration.
At present, the use of lidar or structure data for BACI validation is still under discussion. The available multitemporal datasets, providing information on forest structure, are limited in extent and number, and their use in BACI will be better evaluated during the last year of project activities, as additional validation set or surrogate ground truth set.

In the last months, the importance of integrated ground and remote sensing data, especially those able to characterize the vegetation structure (lidar, Synthetic Aperture Radar) for ecosystem attributes quantification has been highlighted in a number of research activities conducted in the BACI framework, namely:

a) *Vaglio Laurin, G., Balling, J., Corona, P., Mattioli, W., Papale, D., Puletti, N., ... & Urban, M. (2018). Above-ground biomass prediction by Sentinel-1 multitemporal data in central Italy with integration of ALOS2 and Sentinel-2 data. Journal of Applied Remote Sensing, 12(1), 016008.*

In this research, focused on the Viterbo province BACI area of interest, above ground biomass has been estimated at unprecedented spatial resolution for high biomass density using integrated ground data and structural/phenological information from SAR and optical data. Inventory data from the Italian National Forestry inventory have been used as additional validation set. The research illustrates a method to deliver temporal repeated information at a scale useful for management purposes, evidencing both limitations and opportunities derived by the use of different sensors.

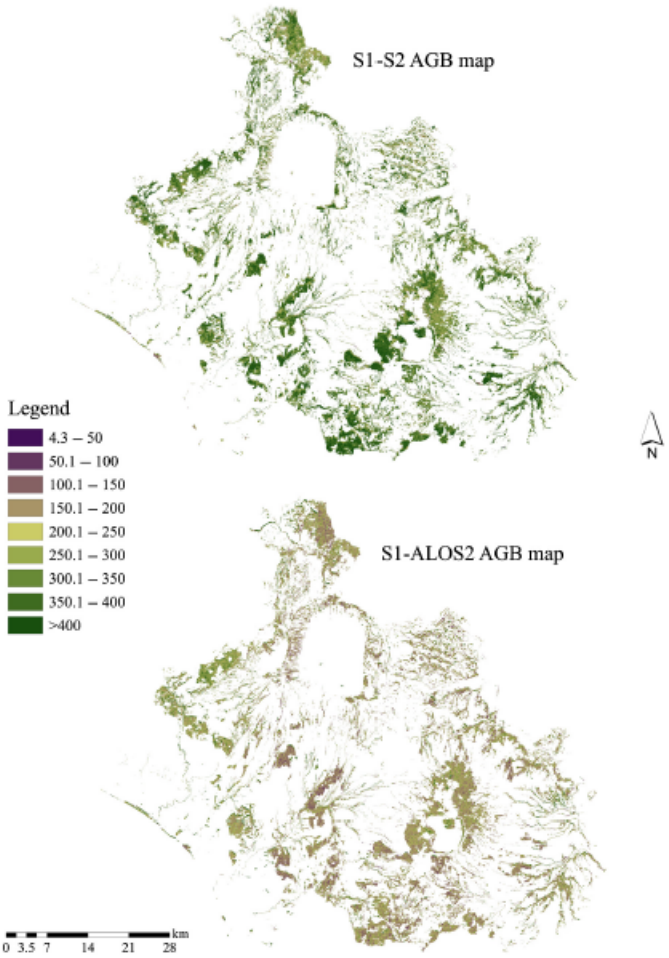

Fig. 6 AGB maps of Viterbo province.

b) *Vaglio Laurin G., Pirotti F., Callegari M., Chen Q., Cuozzo G., Lingua E., Notarnicola C., Papale D. Potential of ALOS 2 and NDVI to estimate forest above ground biomass, and comparison with lidar-derived estimates . Remote Sens. 2017, 9(1), 18; doi:10.3390/rs9010018*

This study tested joined SAR and multispectral data in two sites, namely northern Italy and California, for above ground biomass estimation. Minor differences in results were related to the different characteristics of the considered ecosystems. The comparison with estimates derived from lidar data evidenced the advantage of using such data type when fine scale information is requested. At the same time, given the similarity in

accuracy obtained by lidar and SAR, the study highlighted the value of SAR-derived structure information for forest parameters characterization, especially when area-based data are sufficient. The research can help in the selection of proper instruments for monitoring baseline and changes in forest biomass.

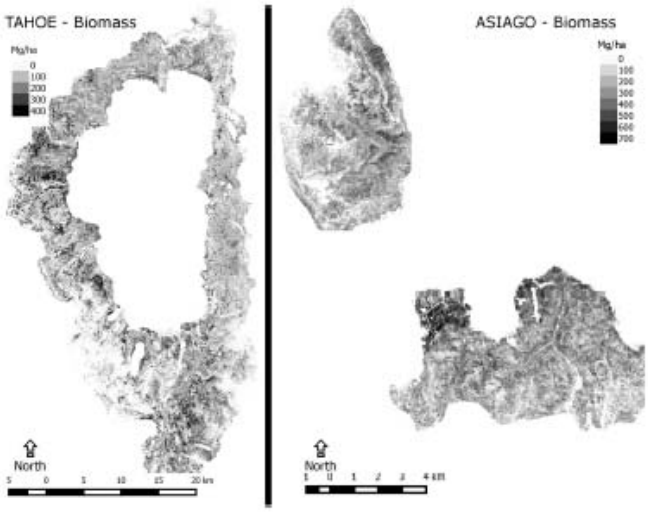

Figure 2. Lidar-derived AGB map for Tahoe area (**left**) and Asiago area (**right**).

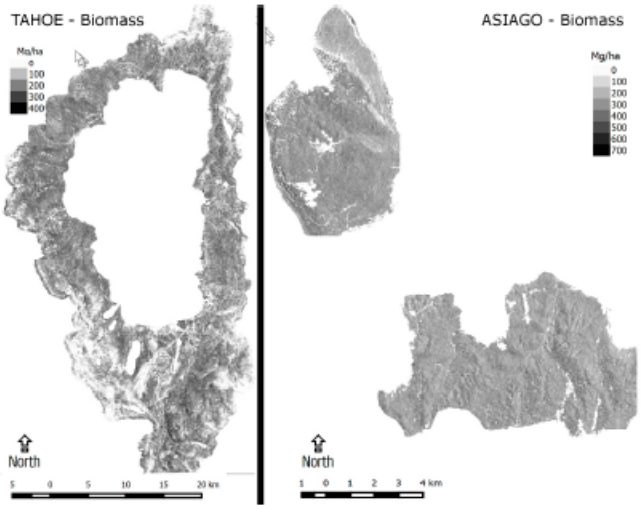

Figure 5. SAR + NDVI based map for Tahoe area (**left**) and Asiago area (**right**).

c) *Vaglio Laurin G., Puletti N., Chen Q., Corona P., Valentini R., 2016. Above ground biomass and tree species richness estimation with airborne lidar in tropical Ghana forests.* ***International*** *Journal of Applied Earth Observation and Geoinformation 52 (2016) 371–379.*

The monitoring of tropical forests, such as the West African ones target of BACI project, is not a trivial task due to very high biomass density and high variety in tree species. The research illustrated the usefulness of lidar to characterize not only the above ground biomass in this complex ecosystem, but also the species richness, also confirming the previously observed link between these two variables.

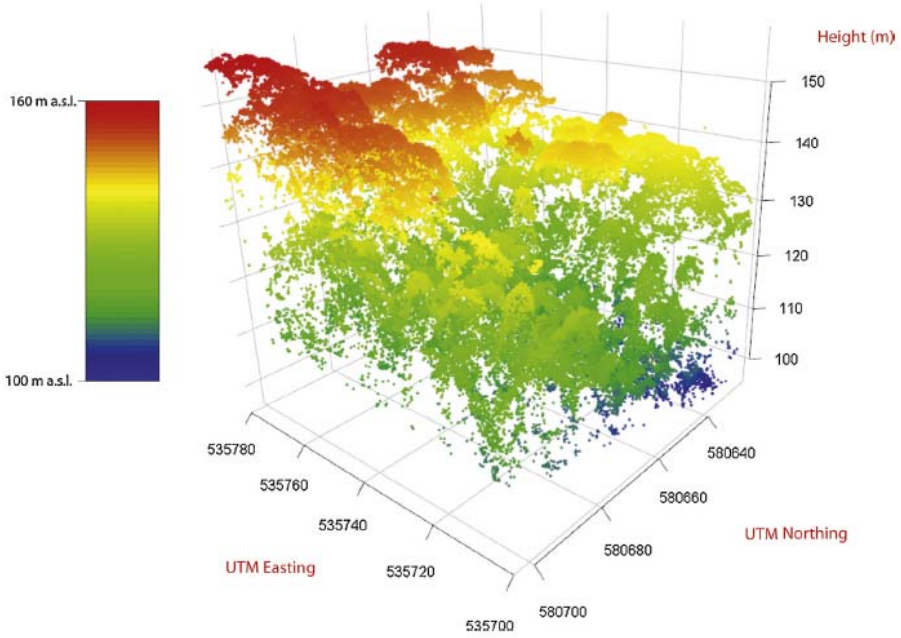

Fig. 2. Lidar data collected over a 40 × 40 m plot, with height in meters above sea level (a.s.l.).

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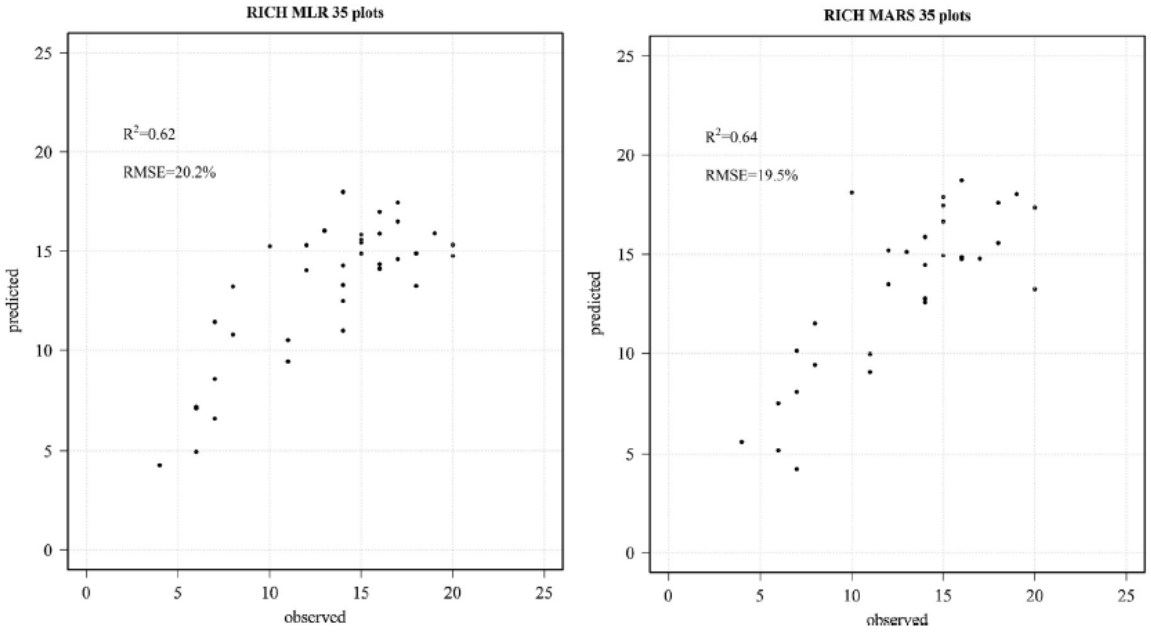


Fig. 4. Scatterplots of the estimations for tree species richness (RICH), with multilinear regression (MLR) and MARS *earth* model.

d) *Vaglio Laurin G., Vittucci C., Tramontana G., Bodeshein P., Ferrazzoli P., Guerriero L., Jung M., Mahecha M., Papale D. SMOS Vegetation Optical Depth and Ecosystem Functional Properties: exploring their relationship in tropical forests. IGARSS 2018, Valencia (accepted as oral presentation).*

Data from the Soil Moisture and Ocean Salinity (SMOS) mission were recently exploited to derive ecosystem information. Here the strength of an innovative relationship, between SMOS V620 algorithm outputs and BACI Ecosystem Functional Properties (EFPs) derived from flux towers data, was preliminary investigated for Africa and South America forests. High correlation values were found between SMOS vegetation optical depth (VOD) and EFPs, for the year under analysis (2014). The differences found at continental level and among different EFPs were commented, and related to the VOD sensitivity to above ground biomass. The results suggest that SMOS VOD data represent a tool able to provide repeated information on forest ecosystem processes and features at global scale.

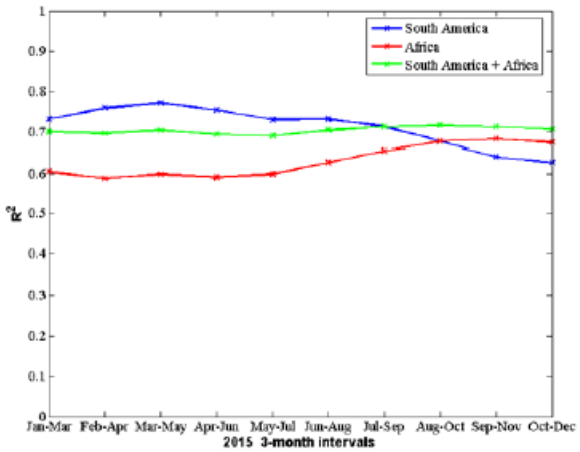


Figure 1. R^2 trend for the VOD-AGB map relationship, in different 3-month intervals.

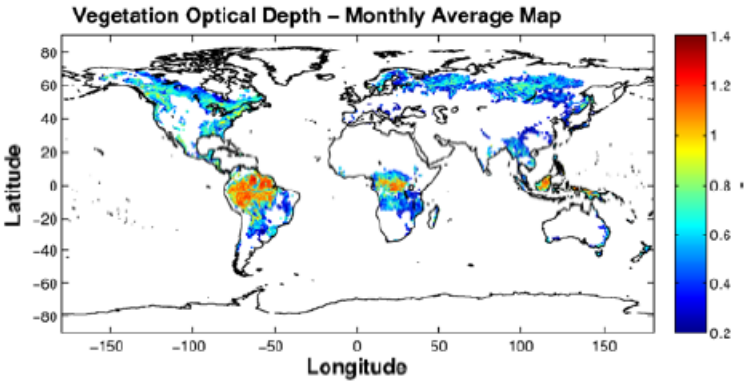


Figure 6. VOD averaged for the July month.

For the present Task 3.5 deliverable, to avoid useless storage of data, not of immediate use in project activities, we focused in:

- *Country level search of datasets, with multi-temporal characteristics*. The following information was collected, for facilitating direct data access:
  1) Denmark realized lidar surveys for two dates, 2008 and 2014. Certain lidar – information are accessible through a website (in Danish) after registration, but for selected locations only https://download.kortforsyningen.dk/content/dhmpunktsky.
  2) Northern Spain lidar data from two dates (2008 and 2012) are accessible at ftp://ftp.geo.euskadi.net/lidar/
  3) UK maintain at http://catalogue.ceda.ac.uk free access to selected lidar-derived datasets
  4) Netherland single data lidar data can be accessed at http://geodata.nationaalgeoregister.nl/ahn1/atom/ahn1_uitgefilterd.xml but a second survey has been already realized.

- *Local level search, with multi-temporal characteristics*:
  We established a closed collaboration with the LIFE+ ForBioSense project in Bielowieza National Park, that collected multitemporal lidar and hyperspectral data for 2015, and 2017. A collaboration agreement between the LIFE+ ForBioSense and BACI project has been realized, to facilitate data exchange and joined research activities.

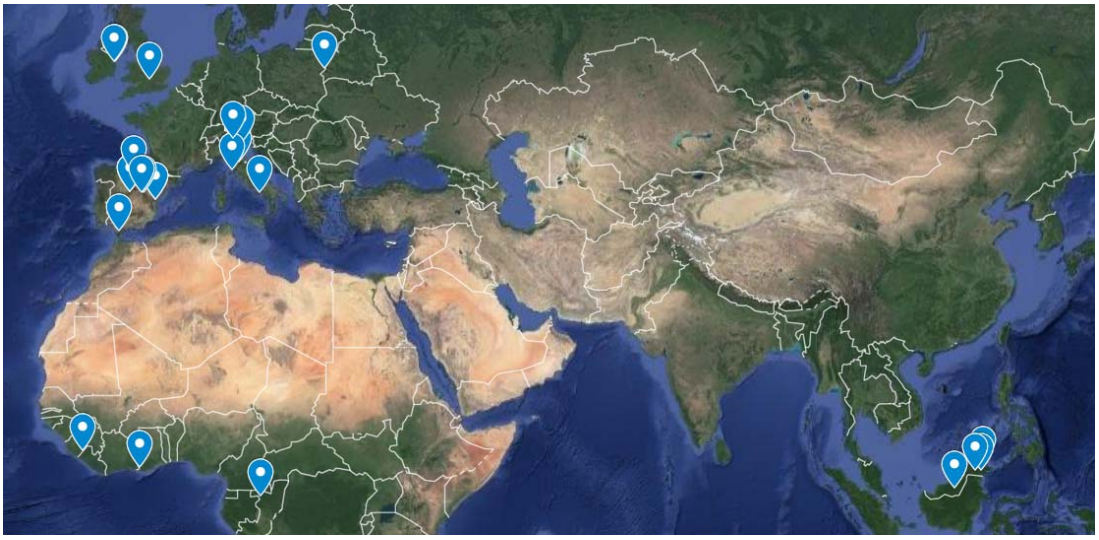
  Thanks to this LIFE + BioForeSense – BACI collaboration, a new initiative strictly related to the objective of this 3.5 Task originated. The initiative was called:

GlobALS - Global ALS Data Providers Database, and is coordinated by Dr. Vaglio Laurin (Tuscia University) and Dr. Sterenzac from LIFE+ project. The main idea, also developed to face the reluctance of data owner in sharing datasets, is to create a database which collects metadata on areas where joined field - ALS information has been acquired. The purpose is networking with academic world and scientific institutions: instead of heavy data storage, metadata and contact information are provided. A Scientific Board, already set up, manages the specific scientific questions that can be posed and answered by means of ALS –ground data information content. Different forms of collaboration (with or without data exchange) can be proposed and agreed. For example, data providers can chose to process their own data to avoid data diffusion, or ask support to others participants, fostering the establishment of collaborative research. Ancillary and additional data (e.g., terrestrial laser scanning data or other RS data) are also welcomed and can contribute to answer more specific and complex questions.

The initiative is presently supported by means of a Facebook page, and includes already > 40 locations/data providers worldwide. Documents to submit datasets and acquired standardized information are available. GlobALS has been informally presented to a number of web-based remote sensing/ecology research groups of interest.

https://www.facebook.com/GlobALSData/

GlobALS network, which is continuous expansion, will be presented at a special session on Ecosystem monitoring (organized by Dr. Vaglio Laurin) at the Italian Remote Sensing conference to be held in Florence 4-6 July 2018 (AIT 2018). Together with GlobALS, the BACI and LIFE+ projects will also be introduced, as examples of usefulness of remote sensing and ground structure data for monitoring ecosystem status and changes. A short communication on the GlobALS initiative in a journal is under preparation, and application for funding sources able to further support GlobALS development has been considered.



Current distribution of GlobALS datasets