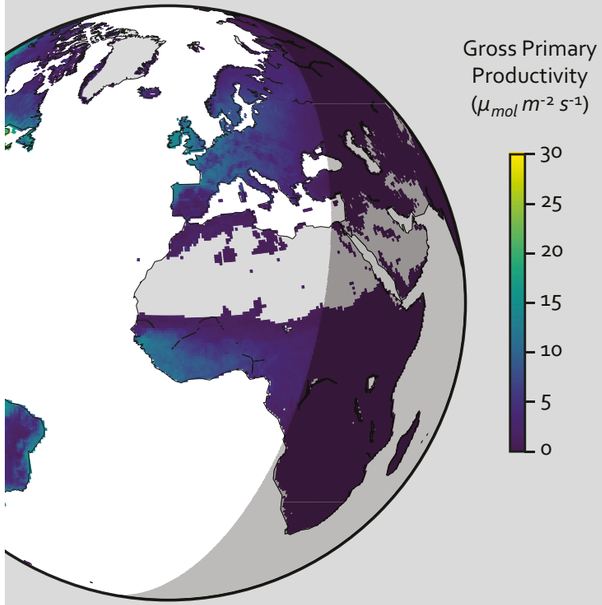
BACI

ecosystems. The BACI project aims to tap into the yet-to-be realized potential of existing and scheduled space-borne Earth observations. In conjunction with ground data it will allow us to derive new essential ecosystem variables and to detect changes in ecosystem functioning. Co-interpreting these data will lead to a general "index of change" and essential downstream data products.



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PROJECT INFO

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http://baci-h2020.eu

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DETECTING CHANGES IN ESSENTIAL ECOSYSTEM & BIODIVERSITY PROPERTIES

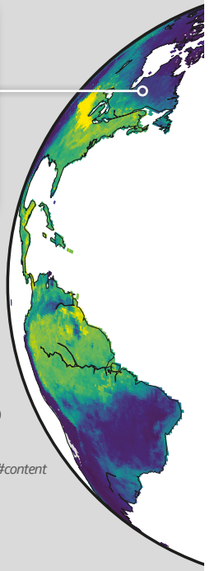
TOWARDS A

BIOSPHERE
ATMOSPHERE
CHANGE
INDEX

PROJECT

Space data archives and space-borne Earth observations play an essential role in monitoring ecosystems. Their transformations and responses to human interventions or climate extremes can now be studied in more detail than ever. This development is complemented by an increasing availability of a wide range of ground data. They cover many aspects of ecosystem functioning, structure, and other parameters relevant to fully describe the functional biogeography of

GPP globe map: The total uptake of CO_2 via photosynthesis ("Gross Primary Production, GPP") can only be observed from eddy covariance towers. However, using modern machine learning methods and high-resolution ancillary data (e.g. from satellites or meteorology), we were able to estimate GPP at half-hourly intervals at the global scale. In this figure, we see how the day-night transition in GPP occurs. [8]

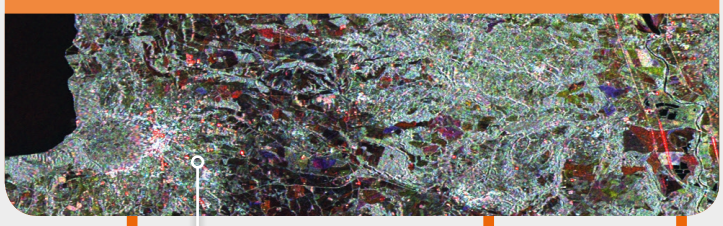


Sources:
[1] Copernicus Sentinel data (2015)
[2] Gaia Vaglio, UNITUS (Tuscia, Italy)
[3] Paul Bodesheim, MPI-BGC (Jena, Germany)
[4] Data: Yanira Guanche, FSU (Jena, Germany); Visualization: Paul Bodesheim, MPI-BGC (Jena, Germany)
[5] Visualization: Ulrich Weber, MPI-BGC (Jena, Germany)
[6] Top - *http://photozou.jp/photo/photo_only/237979/20328193?size=1024#content*
[6] Middle - Peter Leiter *https://commons.wikimedia.org/wiki/File:Außervillgraten.jpg*
[6] Bottom - *https://pixabay.com/de/ernte-feld-landwirtschaft-stroh-866122/*
[7] Angela Günther, MPI-BGC (Jena, Germany)
[8] Data: Paul Bodesheim; Visualization: Sujan Koirala, MPI-BGC (Jena, Germany)

ORIGINAL DATA

HARMONIZED EUROPEAN SPACE DATA AND EXISTING PRODUCTS

Novel space borne Earth observation (EOs) have tremendous potential for monitoring the state and transformation of land ecosystems and anthropogenic impacts. Today, these data are available at unprecedented spatial, spectral, and temporal resolutions. The aim of BACI is to provide a robust framework for optimally combining optical and radar EO data from multiple sources. BACI is using these new satellite data to detect and track critical changes in ecosystem function and services.



The new ESA Sentinel 1 satellites measure the state and change of surface properties, such as the moisture content, surface roughness, without any restrictions due to cloud cover or daytime. This picture shows the amount of received backscatter (echo reflected from the object) for different land cover types east of Lago di Bolsena, Italy. Water and unmanaged agricultural areas (dark areas) have very low backscatter intensities, whereas cities, settlements and forests (bright areas) result in higher backscatter of the radar signal. [1]

GROUND DATA

Using novel EO data critically depends on *in situ* measurements (e.g. land-atmosphere flux data, or ecosystem inventories describing ecosystem structure or their biodiversity). Today impressive archives of ground data are accessible. BACI is setting up a ground database with harmonized and standardized data from different sources including plant traits and phenology, ecosystem parameters derived at FLUXNET sites, synthesis datasets of biodiversity in plants, tree ring records, and LiDAR derived vegetation structure and biomass data. BACI wants to incorporate these data directly into new downstream data products. The grand challenge is propagating uncertainties across domains and spatial scales.

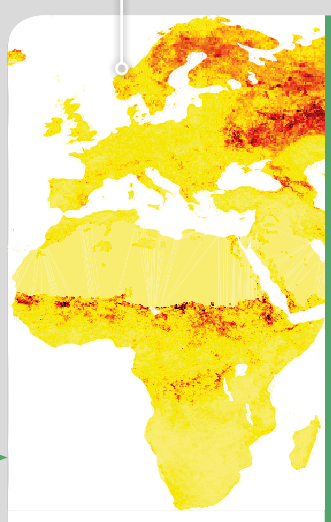
The tower in Ankasa Conservation Area (Ghana) (65 m high) with its meteorological and eddy covariance (flux) sensors allows us to understand daily and seasonal climate variations (e.g. rainfall, T°) on the forest backscattering from mature semi-deciduous and evergreen forest species (mean height 26 m) recorded by the satellite. [2]

PRODUCTS

NEW DOWNSTREAM DATA PRODUCTS – Essential Ecosystem variables

BACI focusses on deriving "Essential Ecosystem Variables" (EEVs). These are variables essential to the monitoring of the fundamental feedbacks in the Earth System. Of particular interest to BACI are interactions between the biosphere and atmosphere. Specific objectives include integrating Earth observations and in-situ data with machine learning methods to resolve the diurnal patterns of gross primary production, latent heat fluxes, or the spatial prediction of tree ring variability.

Hotspots of Anomalies: We combine different machine learning methods to detect extreme events in historical data and define those areas with abnormal records. Here the average anomalies in the year 2010, during the 2010 Russian heat wave. [4]



THE BIOSPHERE-ATMOSPHERE CHANGE INDEX (BACIndex)

The most exploratory part of the BACI project is developing a novelty index of change to detect (in near real-time) abrupt changes relevant to EEVs. We want to find transitions relevant to the functioning of terrestrial ecosystems, biosphere-atmosphere exchanges of matter and energy, and biodiversity related properties. The index is based on modern machine learning tools and will also detect major extreme events in our data streams.

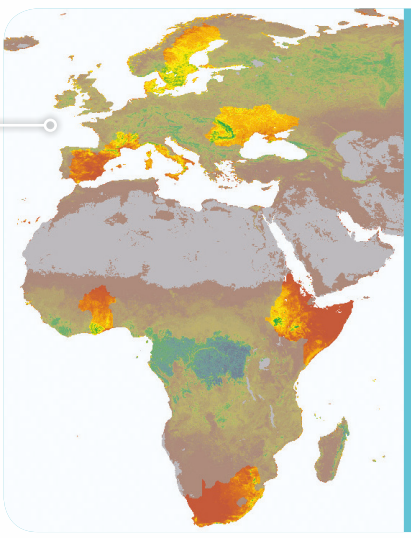
Eddy covariance towers can monitor carbon, water, and energy fluxes on the long-term and provide one measurement each half hour. Using modern machine learning methods and a wide array of additional data, we can now estimate these fluxes quite accurately across large areas. Here, we show a flux estimate over Europe at 17:30 on 19th July 2001. [3]

Development & user feedback

IMPACT ASSESSMENT & VALIDATIONS

USER

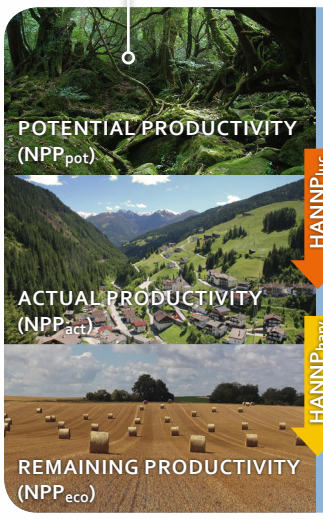
Selected focus areas to be explored in BACI. Highlighted areas show where high-quality ground data are used to explore, train, and validate the BACI products. New, unexpected hot spots are constantly added during the lifetime of the project. For instance, as a response to the recent drought event in Ethiopia 2015/2016, the district of South Wollo, Ethiopia was added to our regional efforts. [5]



REGIONAL VALIDATION

Both our novel data products as well as the "Biosphere-Atmosphere Change Index" will be evaluated against independent data. These evaluations take place at selected key study areas in Europe and Africa. We will quantify if detected patterns of variability or transformations correspond to human or climate induced environmental changes. We scrutinize in particular land-use drivers, and quantify impacts on ecosystem function and services related to food security and biodiversity targets.

Human Appropriation of Net Primary Production (HANPP) is a socio-ecological indicator framework that allows for integrated analyses of land use dynamics. It quantifies the amount of net primary production appropriated though land use. HANPP assesses two central land-use impacts on ecological energy and carbon flows: NPP withdrawals through agriculture and forestry harvest, as well as NPP changes induced by land conversions. In the BACI-context HANPP will be used as a tool for linking biosphere-atmosphere changes with socio-economic activities. [6]



SOCIOECONOMIC DRIVERS AND CONSEQUENCES

The specific analysis and quantification of socioeconomic drivers of change will be used to attribute observed changes directly to socioeconomic activities such as land-use. We aim to integrate the produced data in a common framework with socio-ecological analyses.

CONSEQUENCES FOR BIODIVERSITY ASSESSMENTS

BACI explores novel avenues to enable the exploitation of space data for biodiversity studies focusing on two major groups: birds and plants. Both groups are well-studied with a long history of monitoring. They are expected to show distinct dynamics in the face of ecosystem change, with birds responding relatively quickly and plants slowly. Our question is if and how the novel high-resolution EO's can effectively be used to advance e.g. species distribution modelling.