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

# Deliverable 6.1: Validation framework and description of regional validation sites


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# 1. Introduction

Deliverable 6.1 is part of WP6 “Regional validation”, which aims to provide an independent regional assessment, validation and comparison of the BACI products. Deliverable 6.1 provides the description of the validation framework and the independent data sources that will be used for the validation exercise.

The BACI validation framework presented here aims to provide a characterisation and independent assessment of relevant regional events detected in the new downstream data products generated in WP4 and the generic BACI index developed in WP5. It will allow to assess the sensitivity and potential of the new BACI products to detect various climate (i.e. drought) and human-induced changes (i.e. forest conversions) in different regional contexts.

The objectives of the validation exercise are:

1. Characterization of detected events for further assessment
2. Independent assessment of characterized events against reference data in terms of spatial and temporal quality
3. Identify recommendations for further internal improvement of the BACI products
4. Stimulate feedback and engagement with regional experts and potential users

The validation exercise is a critical step in the communication of the BACI results to potential user communities. Ultimately, the validation exercise aims to create international awareness and confidence in the BACI results and their adoption by a number of potential user communities (e.g. modellers).

### 1.1 BACI products and first results

The validation framework aims to characterise and independently assess events detected in the two types of BACI products:

(i) Generic BACI index and the suite of methods for “novelty detection” (WP5). The most relevant events (hotspots) will be validated, whereby a selection will be made by the production team (WP5) considering the size, timing and magnitude of the events. A minimum size of the events will be defined. Assessing the BACI index will be the priority of the validation framework.

(ii) New downstream data products (WP4). Relevant downstream data products will be validated in a regional context for some key extreme events in terms of better characterizing these events.

The validation will focus on the six BACI focus regions in Europe and Africa (Fig. 1). The regions cover a large range of different environmental and socio-economic drivers and phenomena (e.g. climate extremes, political changes that result in land-use changes such as deforestation, increased land-use intensities, human-induced degradation) (MS5 “*Final selection and geo-referencing of regional study areas*”). The regional validation sites are located within these target areas. A large variety of reference data is available for the regional validation sites; e.g. land use change information, socio-economic data, biodiversity data, dendrology data.

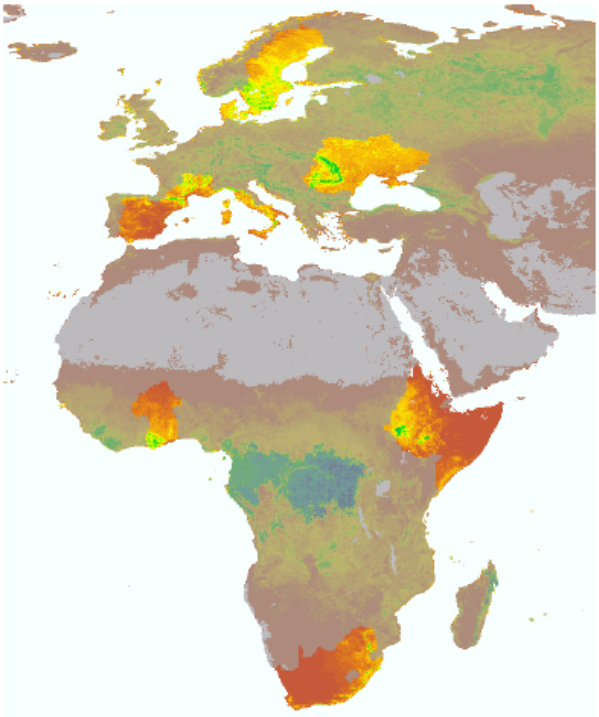
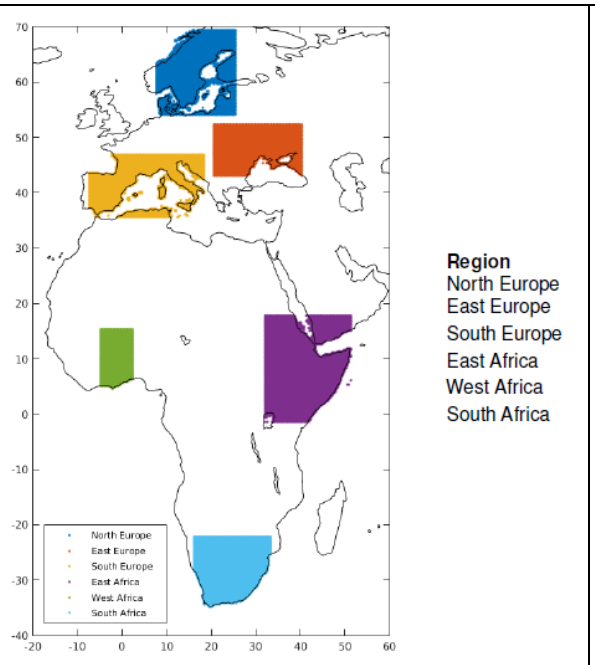


**Figure 1: Selected focus areas to be explored in BACI.** Highlighted areas show the focus areas where high-quality ground data are used to explore, train, and validate the BACI products. The background color of the map indicates maximum LAI (red = low, green/blue = high). The regional focus areas may be expanded or shifted at a later stage of the project, if the analytic framework identifies different or additional hotspots of change.

Figure 1: BACI focus areas across Europe and Africa.

In November 2016, the first initial BACI results were produced for the six BACI focus regions using data from the CABLAB data cube (Guanche 2016) (Fig. 2). The initial results included hotspot maps and identified events provided on a 0.25° resolution and included information on a) the intensity of the maximum event (abnormal amplitude of the patterns), b) the year of the maximum event and c) the amount of abnormal events per pixel annually from 2001 to 2011 (Guanche 2016).




| Hotspot | Coordinates | | | | Year |
|---|---|---|---|---|---|
| | min long | max long | min lat | max lat | |
| North Europe | | | | | |
| 1 | 16.75 | 24 | 66.5 | 69 | 2010 |
| East Europe | | | | | |
| 1 | 31.75 | 34.3 | 47.6 | 50.5 | 2006 |
| 2 | 20.6 | 27.5 | 49.5 | 52.375 | 2009 |
| 3 | 20.6 | 24 | 45.125 | 49 | 2011 |
| South Europe | | | | | |
| 1 | 3.175 | 8.9 | 44.75 | 46.75 | 2003 |
| 2 | -7.35 | -1 | 36 | 39.6 | 2009 |
| East Africa | | | | | |
| 1 | 43.375 | 51.7 | 6.125 | 12.5 | 2004 |
| 2 | 32 | 39.8 | 12.625 | 17.95 | 2007 |
| West Africa | | | | | |
| 1 | -5 | 2.25 | 4.75 | 8.2 | 2001 |
| 2 | 0.5 | 2.6 | 12.7 | 15.4 | 2003 |
| 3 | -2.4 | 0.35 | 14.4 | 15.4 | 2006 |
| 4 | -5 | -4 | 14.25 | 15.4 | 2010 |
| South Africa | | | | | |
| 1 | 16.5 | 20.75 | -25.75 | -23.5 | 2001 |
| 2 | 30.75 | 66.5 | -23.5 | -22.125 | 2003 |
| 3 | 16.15 | 20.75 | -29.5 | -25.3 | 2006 |
| 4 | 23.75 | 27.25 | -23.125 | -22.125 | 2009 |
| 5 | 19.85 | 23.5 | -31.75 | -29.25 | 2009 |

Figure 2: Location of the six BACI focus regions (left) and detected hotspots-year extreme (right) (Guanche 2016).

Based on the initial results, a first characterisation of detected BACI hotspot events in terms of co-occurring socio-economic and environmental changes was performed in MS12 ("*First identification of hotspots*"). MS12 provided key lessons learnt and defined a number of prerequisites that need to be addressed to allow a comprehensive characterisation and independent assessment of detected BACI events. For example, detailed information from the production team (WP5) on the driving BACI specific input variables for individual detected events are essential. Information should include the importance and direction of the different input variables for identified hotspot events.

The lessons learnt in MS12 provided the foundation for the two step validation framework presented here. A two-step process is essential since the BACI product as "index" cannot be directly validated but should rather be first characterized (in terms of the types and causes of events) before it can be quantitatively compared to appropriate reference data reflecting the types and causes of regional events, and assessed by independent experts.

### 1.2 BACI validation framework

A two-step validation framework is used (Fig. 3). Detected events (WP4 and WP5) are characterise in a first step, before the characterised events are independently assessed in the second step. The key elements are briefly described in the following. A detailed description is provided in sections 2 - 5. The link and feedback mechanism of the validation framework with WP2-5 and BACI users is depicted in Fig. 4.

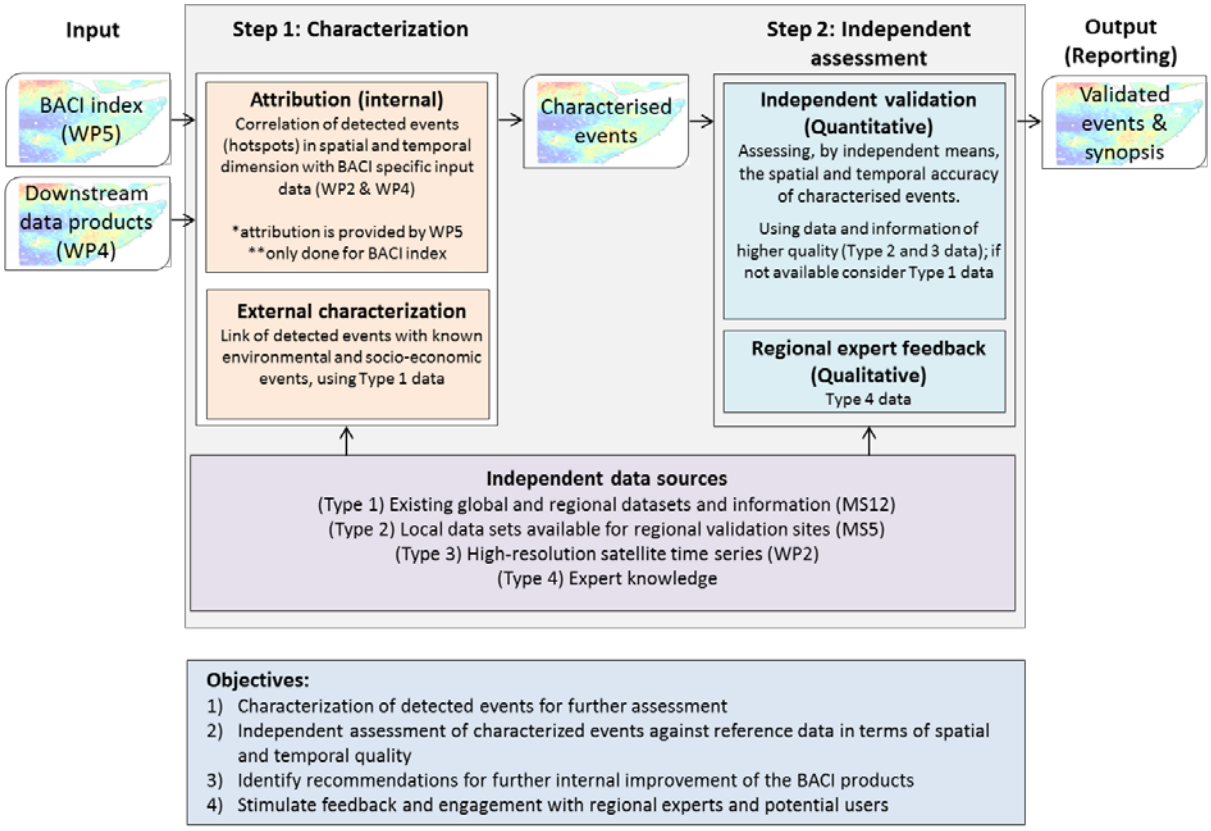



Figure 3. Validation framework for BACI products.

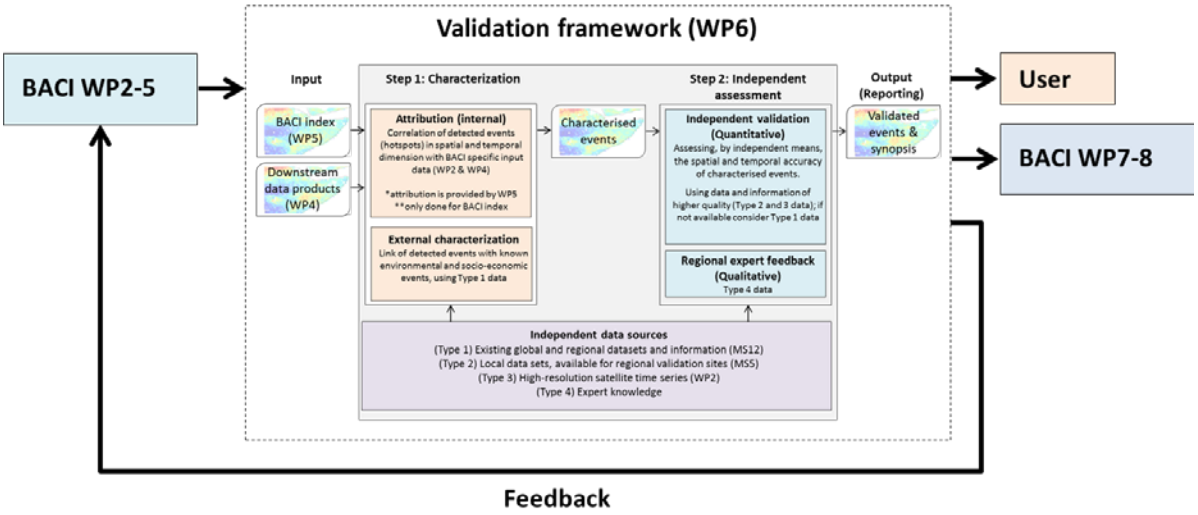



Figure 4: Linkage and feedback mechanism of validation framework with WP2-5 and Users.

Independent data sources: Independent data sources constitute the basis of the validation framework. Four types of independent data sources are available; a detailed description is provided in section 2.

- (Type 1) Existing global and regional datasets and information (MS12)
- (Type 2) Local datasets available for regional validation sites (MS5)
- (Type 3) High-resolution satellite time series (WP2)
- (Type 4) Expert knowledge

Step 1: Characterisation (Section 3)

- Attribution (internal): Correlation of detected events in spatial and temporal dimension with BACI specific input data (WP2 & WP4). For each detected event the location, size, timing and magnitude will be provided alongside with a detailed information on the importance (influence) of each input parameter on the detected event. Besides the level of importance, the direction (i.e. positive or negative correlation) of each input parameter is provided.

  The attribution is performed by WP5.

- External characterisation: Link of detected events with known environmental and socio-economic events, using existing global and regional datasets and information (Type 1 data). In combination with the attribution it will allow a characterisation of detected events (e.g. as a drought event) using data sources not used for generating the BACI products.

  The external characterisation is performed by WP6.

Step 2: Independent assessment (Section 4)

- Independent validation (Quantitative): Assessing, by independent means, the spatial and temporal accuracy of characterised events. Relevant regional and local datasets, available for regional validation sites (Type 2 data) and high-resolution satellite time series (Type 2 data) will be used as main reference data. If these are not available (e.g. for many socio-economic drivers), existing global and regional datasets and information (Type 1 data) will be considered in replacement.

  The independent validation is done by WP6 in combination with BACI partners, responsible for the regional validation sites. High-resolution satellite time series for the BACI focus areas are provided by WP2.

- Regional expert feedback (Qualitative): BACI project partners responsible for the different regional validation sites will identify regional experts knowledgeable in types of events detected by BACI, which can act as an independent source of information for the assessment. The information provided by the experts will be acquired systematically and will provide qualitative feedback on how the BACI-based results match their understanding of the regional processes. This process will be particularly important for confidence building with stakeholders outside the BACI project and underpin any efforts to eventually deliver BACI products to various user groups.

  The regional expert feedback is done by WP6 in combination with the regional validation site responsible BACI project partners.

  Note: The independent validation and the regional expert feedback do not depend on each other and can be performed individually. As both are strongly dependent on the availability of useful reference data and regional experts their feasibility may differ case by case. In terms of socio-economic changes regional expert knowledge might be more abundant than type 2 or 3 data in many cases. However, it is intended to perform both as jointly they will provide a more consolidated assessment of detected events.

Reporting (Section 5): The results will be presented in a validation report (Deliverable 6.2 "*Product comparison and validation report"*). We will identify recommendations for further internal improvement of the BACI products and stimulate feedback and engagement with regional experts and potential users (Fig. 4).

The reporting is done by WP6 supported by the BACI project partners responsible for the regional validation site.

# 2. Independent data sources

### 2.1 Existing global and regional datasets and information (Type 1)

Major global and regional datasets and information to support the characterisation of key environmental and socio-economic events is provided in Table 1 and Table 2.

Table 1 provides an overview on the key environmental indicators and supporting datasets, including their time class, available time steps and spatial resolution. Note that the list largely summarizes continental to global datasets. For a better external characterisation, additional regional datasets may be considered.

Table 2 provides an overview on the key socio-economic indicators and supporting datasets. For a better external characterisation, additional regional datasets may be considered. Socio-economic indicators are very heterogeneous, spanning demographic changes, changes in land cover, or changes related to land-management. Spatial and temporal resolution of the listed indicators and available datasets varies greatly, i.e. from national level data to the level of communities or the pixel level and annual data to several year intervals. Similar to environmental changes, socio-economic changes are characterized by time-spans in which they usually occur, where rapid changes in the case of extreme events (warfare, conflicts) can be distinguished from periodic changes that occur over several weeks to months (land occupation), or long-term changes, such as the gradual expansion of land use, land abandonment, or intensification. This distinction will be important background information for the characterisation and independent assessment of detected events. For a better external characterisation, additional regional datasets may be considered.

Table 1: Environmental indicators and supporting datasets. The “Time class” refers to the time period under which changes likely occur, i.e. rapid (within days), periodic (seasonal, i.e. weeks to a few month) and long term (one to several years to decades).

| Indicator | Time-class | Data sources | Available time steps | Spatial resolution |
|---|---|---|---|---|
| **Precipitation** | Periodic, long term | Local / National Weather data | Daily, Monthly | Local to sub-national |
| | | National statistics | Daily, Monthly | National |
| | | Literature recherché | | |
| **Temperature** | Periodic | Local / National Weather data | Daily, Monthly | Local to sub-national |
| | | National statistics | Daily, Monthly | National |
| | | Literature recherché | | |
| ***Climate extremes*** <br>*a) Droughts* <br>*b) Floorings* <br>*c) Fires* | Rapid, episodic, long-term | Global climate data archives | Daily, Monthly, Annual | |
| | | Global water bodie dynamics (Pekel et al., 2016) | Annual,1984 - 2015 | 30 m |
| | | Tree cover change (Hansen et. al., 2013) | Annual, 2000 – 2012 | 30 m |
| | | National statistics | Daily, Montyly | |
| | | Literature recherché | | |

Table 2: Socio-economic indicators and supporting datasets. The "Time class" refers to the time period under which changes likely occur, i.e. rapid (within days), periodic (seasonal, i.e. weeks to a few month) and long term (one to several years to decades).

| Indicator | Time-class | Data sources | Available time steps | Spatial resolution |
|---|---|---|---|---|
| **Population change** | Periodic, long term | FAOSTAT (FAO 2017b) | annual | National |
| | | National statistics | Annual | Sub(national) |
| | | Literature recherché | | |
| | | Gridded population data (Lloyd, Sorichetta, and Tatem 2017) | recent | 3 and 30 seconds |
| **Conflicts** | Periodic | Environmental conflict atlas (https://ejatlas.org/) | Various | Points of occurrence |
| | | Literature recherché | | |
| **Land cover changes**<br>*a) Forests (deforestation, logging, shifting cultivation)*<br>*b) Cropland*<br>*c) Grazing land*<br>*d) Infrastructure*<br>*e) Unproductive* | Rapid, episodic, long-term | CORINE land cover Europe (Copernicus Programme 2014) | 1990, 2000, 2006, 2012 | 100 m |
| | | CAPRI data (Leip et al. 2007; Britz and Leip 2009) | | NUTS 2/3 |
| | | Forest harvest intensity in Europe (Levers et al. 2014) | | |
| | | LUCAS land use/cover change project (Tóth 2013) | 2006, 2009, 2012 | 270 000 points |
| | | GLC 2000 (Bartholome et al. 2002) | 2000 | 1 km |
| | | globCORINE | 2005, 2009 | 300 m |
| | | globCover | 2005, 2009 | 300 m |
| | | Tree cover change (Hansen et. al., 2013) | 2000 – 2012 | 30 m |
| | | Changes in agricultural areas (Ramankutty et al. 2002) | | |
| | | HYDE project (Klein Goldewijk et al. 2011) | | |
| | | Literature recherche | | |
| | | ESA Climate Change Initiative: Land cover changes (ESA 2017) | 1992 - 2015 | 300 m |
| **Land management**<br>*a) Cropland harvest*<br>*b) Cropland abandonment Grazing amount*<br>*c) Forestry harvest*<br>*d) Green infrastructure*<br>*e) Livestock density*<br>*f) Livestock composition*<br>*g) Irrigation*<br>*h) Fertilizer use*<br>*i) Mechanization* | Episodic, long term | FAOSTAT (FAO 2017b) | Annual | National |
| | | CAPRI data for Europe (Leip et al. 2007; Britz and Leip 2009) | | NUTS 2/3 |
| | | HANPP Europe (Plutzar et al. 2015) | 2006, 2009, 2012 | 1 km |
| | | Cropland extent global (Monfreda et al. 2008) | Ca. 2000 | 10 km |
| | | HANPP 2000 (Haberl et al. 2007) | Ca 2000 | 10 km |
| | | National statistical records | Annual | (Sub)national |
| | | Expert interviews | | |
| | | Cropland abandonment (Estel et al. 2016) in Europe | 2000 - 2012 | 5 km |
| | | Forest harvest intensity (Levers et al. 2014) for Europe | 2000 - 2010 | Subnational |
| | | National statistical records | Annual | (Sub)national |
| | | Forest resource assessment FAO | | |
| | | CORINE land cover Europe | 1990, 2000, 2006, 2012 | 100 m |
| | | Livestock distribution Europe (Neumann et al. 2009) | Ca 2000 | |
| | | Siebert et al. (2015) areas equipped for irrigation | 1900 - 2005 | |
| | | AQUASTAT (FAO 2017a) | Annual | National |

| | | | | |
|---|---|---|---|---|
| | | International Fertilizer association (IFA 2017)<br>Crop areas and yields (Mueller et al. 2012)<br>Agricultural intensity changes in Europe (Temme and Verburg (2011) | Annual<br>Ca 2000<br>Ca 2000 | National<br>25 km<br>1 km |
| | | Crop yield changes ((Iizumi et al. 2014) | 1982 - 2006 | 1.125° |
| | | Intact forest changes (Potapov et al. 2008) | 2000 - 2013 | |
| **Extreme events**<br>*a) Windfalls*<br>*b) Pests* | Rapid, episodic | Tree cover change (Hansen et. al., 2013) | 2000 – 2012 | 30 m |
| | | Literature recherché | | |

## 2.2 Local datasets available for regional validation sites (Type 2)

A large variety of reference data is available for the regional validation sites; e.g. land use change information, socio-economic data, biodiversity data, dendrology data. The initial list of independent regional validation sites is presented in MS5 ("*Final selection and geo-referencing of regional study areas*"). New, not expected, hot spots are added in the course of the project. This document provides an updated overview of the available data for the regional validation sites in Annex 1.

Annex-1 provides for each site, a comprehensive overview of (i) project partner responsible, (ii) available reference datasets, (iii) comments and further description and (iv) main driver of change / preliminary assumption.

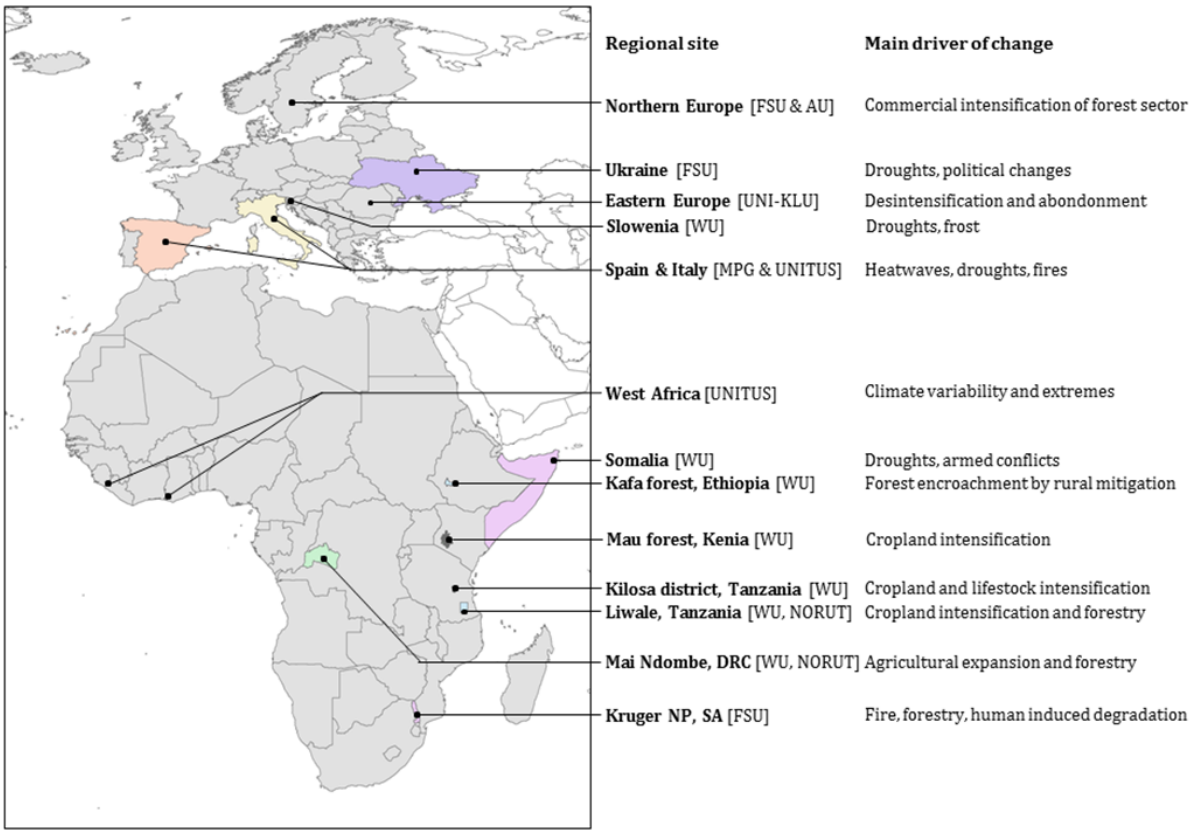



Figure 3: Overview of the current selection of regional validations areas.

### 2.3 High-resolution satellite time series (Type 3)

Both, high resolution optical and Radar satellite time series will be considered.

Optical time series: Optical time series information from Landsat and Sentinel-2 will be considered. Both are publicly available. In particular the long term and continuous Landsat time series (since 1970, Woodcock et al. 2008) will be a valuable source to validate the detected events. Fully processed Landsat data can be downloaded directly via the United State of America's Geological Survey (USGS) Landsat Surface Reflectance (SR) Climate Data Records (CDR) (http://landsat.usgs.gov/CDR_LSR.php). Google Earth Engine allows analysing Landsat and Sentinel-2 time series data for the BACI target regions without downloading the data locally.

Radar time series: Radar satellite time series from Sentinel-1, ERS-1/2, ENVISAT ASAR, will be available fully processed for all six BACI focus areas through WP2. As Radar penetrates through clouds and can operate day and night, it has particular value in regions with frequent could cover (e.g. parts of Africa) where cloud-free optical data is limited (Reiche et al. 2016). In particular, Sentinel-1 (since 2015) has significant potential as, for the first time, dense SAR time-series data are provided over tropical forest areas free and openly. Sentinel-1 will potentially support validating events detected for recent years. For validating changes before the Sentinel-1 era, Radar has limited capacity as only a few observations per year are available for many; in particular tropical regions (Rosenqvist et al. 2007). Google Earth Engine allows analysing Sentinel-1 time series data for the BACI target regions without downloading the data locally.

### 2.4 Expert knowledge (Type 4)

Regional experts knowledgeable in types of events detected by BACI will be nominated by the BACI partners responsible for the various regions. This selection will have to consider the results of the characterization of the BACI products since the choice of experts might vary based on the types and causes of changes identified, i.e. atmospheric versus biosphere events, forest changes versus changes in water parameters. It has to be assured that experts can act as independent sources of information for the assessment.

The BACI product information has to be provided for expert feedback in an easy-to-understand way including the size, timing and location of the event and including the results of the characterization in terms of driving variables and overlaps with events detected in the external datasets. Then the expert feedback will be acquired in terms of expert interviews and will provide qualitative feedback on how the BACI-based results match their understanding of the regional processes. This process will be particularly important for confidence building with stakeholders outside the BACI project and underpin efforts to eventually deliver BACI products to various user groups.

# 3. Characterisation

### 3.1 Attribution

Definition: Correlation of detected events in spatial and temporal dimension with BACI specific input data.

Responsibilities: The attribution is done by WP5.

For each detected hotspot event a comprehensive attribution will be provided, including the following information. The attribution is only done for events detected by the BACI index and not for required for the new downstream products produced in WP4.

- Size and location
- Timing
- Magnitude of change
- Decomposition of the BACI input parameter in terms of key driving variables, indicating their individual importance and direction of change

### 3.2 External characterisation

Definition: Link of detected events with known environmental and socio-economic events, using existing global and regional datasets and information.

Reference data: Global and regional datasets and information (Type 1 data; Section 2.1)

Responsibilities: The characterization is done by WP6.

A wide range of environmental and socio-economic indicators will be used to explain the interrelation between environmental and socio-economic changes with detected events. Appropriate global and regional datasets and information (Type 1 data; Section 2.1) will be used.

This will also allow putting socio-economic changes in perspective with environmental changes, in terms of their influence on biosphere-atmosphere variables. To characterise an individual hotspot event, the list of environmental and socio-economic indicators and supporting datasets will be cross-checked and possible links will be established. This may require the spatial and/or temporal harmonisation of the datasets to match the spatial and/or temporal resolution of the BACI products.

We expect detected hotspot events in which both, socio-economic as well as environmental indicators show significant changes. For instance, if temperature and precipitation changes (environmental parameters) as well as declining crop yields (a socio-economic parameter) point to a drought event in in the horn of Africa, the BACI hotspot events will be primarily characterized as a hotspot of environmental change, which had, however, repercussions on the socio-economic system.

For an efficient external characterization, the events should cover a significant proportion of the respective territory; this allows to make use of the more robust socioeconomic data which usually are available at the national level (for Europe: Nuts; see MS12).

The characterised hotspot events will also allow for scrutinizing key socio-economic and environmental processes that co-occur with biosphere-atmosphere changes on a regular basis, while we might find others to be of minor importance.

# 4. Independent assessment

The independent assessment includes two parts, independent validation and regional expert feedback. To ensure the independence of the process, the independent assessment must fulfill the following requirements:

- In-situ and other suitable reference datasets will be used for validation that have not been used for the production of the BACI products
- Independent validation should be performed by staff not involved in the final BACI algorithm development/selection.
- Regional experts should be consulted that were not included in the production and/or characterisation process.

Note that the independent validation and the regional expert feedback do not depend on each other and can be performed individually. As both are strongly dependent on the availability of useful reference data and regional experts their feasibility may differ case by case. In terms of socio-economic changes regional expert knowledge might be more abundant than type 2 or 3 data in many cases. However, it is intended to perform both, because jointly they will provide a more consolidated assessment of detected events.

### 4.1 Independent validation

Definition: Assessing, by independent means, the spatial and temporal accuracy of characterised events.

Reference data: Local datasets available for regional validation sites (Type 2, Section 2.2); High-resolution satellite time series (Type 3, Section 2.3); (existing global and regional datasets and information (Type 1, Section 2.1))

Responsibilities: The independent validation is done by WP6 together with the regional validation site responsible BACI project partners. High-resolution optical and Radar time series for the BACI focus areas are provided by WP2.

Relevant regional and local datasets, available for regional validation sites (Type 2) and high-resolution satellite time series (Type 3) will be used as main reference data. A dataset is considered as relevant if it allows to independently validate the characterised type of change (e.g. drought). If such are not available (e.g. for many socio-economic drivers), existing global and regional datasets and information (Type 1) may be considered.

The independent validation will assess accuracy and precision of detected events by comparing with reference datasets in different regions. The following dimensions will be targeted:

- Space: spatial extent and co-location of events assessed through error matrix and related accuracy measures. Consolidated methods consistent with Stehman (2012) and Olofsson et al. (2014) will be used. We will report standard accuracy measures such as the area adjusted overall accuracy (OA), producer's accuracy (PA; 1-omission error) and user's accuracy (UA; 1 – commission error).
- Time: temporal correlation (for trends), time-lags (for events) and related correlations, and stability (sensitivity versus noise and variability in accuracy over time) from time series comparison. The approach is consistent with approaches recommended in (Cohen et al. 2010; DeVries et al. 2015; Hansen et al. 2016; Zhu & Woodcock 2014, Reiche et al., 2015). We will report temporal measures, such as the mean time lag.

Note that for socio-economic data, spatial and temporal accuracy assessment might not be possible, due to e.g. the (usually) coarse spatio-temporal resolution of the underlying data sets (e.g. time slices every 5-10 years, resolution of regions or nations). There will likely be cases for which only national data in several-year intervals are available. However, the coarse-resolution socio-economic data sets can provide added value in terms of relevance of detected BACI-events, in particular if larger events are selected. It is hypothesized that if the occurrence of BACI hotspots is "visible" in changes reported in national or sub-national socio-economic statistics, the BACI event can be considered exceptionally relevant.

### 4.2 Regional expert feedback

Definition: Independent feedback from regional experts.

Reference data: Regional experts (Type 4, Section 2.4).

Responsibilities: The regional expert feedback is done by WP6 in combination with the regional validation site responsible BACI project partners.

Facilitating the independent expert feedback requires:

- The identification and selections of regional experts. They will be nominated by the project partners as people knowledgeable in a certain region on climate and land dynamics. Final selection of the experts can only be done once BACI results are characterized (step 1). The choice of experts might vary based on the types and causes of changes identified and it has to be assured that the experts can act as independent source of information for the assessment.

- The BACI information has to be provided for the expert interaction in an easy-to-understand way in order to warrant time-efficiency and a high impact of BACI results amongst the user community. This includes the size, timing and location of the event, as well as the results of the characterization in terms of driving variables and overlaps with events detected in the external datasets. Such a presentation of the BACI events has to be developed and tested before being used for the expert interaction. Experts should be able to assess the added value of BACI results for their own work, as they also represent the potential user community. This will allow to build incentives for an efficient collaboration with experts, as well as to warrant a high impact of BACI outside the project consortium.

- A standardized questionnaire form (initially offline but once consolidated as online form) should be developed to gather systematic feedback, including:

    - Expert awareness and understanding of the BACI results (and characterization) including feedback on how the expert conceived the BACI information
    - Does the expert recognize the event in terms spatial and temporal dimension and its type and causes. We will develop some metrics to what extend BACI results match the experts perceptions
    - Any additional information on the event, its causes and impacts that can be provided from the regional expertise and whether other experts should be consulted. Recommendations on the importance and relevance of the

information provided by BACI, how this information could be used by whom on a regular basis

- A synthesis for compilation and analysis of the expert feedback including information on the quality and usefulness of the BACI products for different regional contexts. This will include recommendations on how this expert interaction and feedback framework could be expanded to involve people that can be seen as "users" of the BACI outputs. A central aim will be to raise awareness, as well as to build engagement and confidence on the usefulness of BACI for event detection in a longer perspective amongst potential users. .

# 5. Reporting

Responsibilities: The reporting is done by WP6 supported by the regional validation site responsible BACI project partners.

The results will be presented in a validation report (Deliverable 6.2 "*Product comparison and validation report"*). The report will describe in detail the validation procedures (characterisation and independent assessment), how validation was implemented and how it varies for the different BACI results. The results for the individual validated BACI hotspot events will be synthesised.

We will identify recommendations for further internal improvement of the BACI products and stimulate feedback and engagement with regional experts and potential users (see Fig. 4).

# 6. Summary

This report (Deliverable 6.1) provides the validation framework for the BACI products. Based on lessons learnt from MS5 and MS12 a two-step validation framework was developed to characterise and independently assess relevant regional events detected in the new downstream data products generated in WP4 and the generic BACI index developed in WP5. A two-step approach is essential since the BACI product as "index" cannot be directly validated but should rather be first characterized (in terms of the types and causes of events) before it can be quantitatively compared to appropriate reference data reflecting the types and causes of regional events, and before it can be assessed by independent experts.

The objectives of the validation exercise are:

1. Characterization of detected events for further assessment
2. Independent assessment of characterized events against reference data in terms of spatial and temporal quality
3. Identify recommendations for further internal improvement of the BACI products
4. Stimulate feedback and engagement with regional experts and potential users

The validation exercise is a critical step in the acceptance and uptake of the BACI results by a wide range of the potential user community and stakeholders.

# 7. References


Bartholome, E., A. S. Belward, F. Achard, S. Bartalev, C. Carmona-Moreno, H. Eva, S. Fritz, J. M. Gregoire, P. Mayaux & Stibig, H.J. (2002). GLC 2000: Global Land Cover Mapping for the Year 2000. *Project Status, November*.
https://www.researchgate.net/profile/Sergey_Bartalev2/publication/235707577_GLC_2000_Global_Land_Cover_Mapping_for_the_Year_2000_Project_Status_November_2002/links/55c0e2c608aed621de1505cb.pdf.

Britz, W. & A. Leip (2009). Development of Marginal Emission Factors for N Losses from Agricultural Soils with the DNDC–CAPRI Meta-Model. *Agriculture, Ecosystems & Environment* 133 (3): 267–279.

Cohen,W.B., Yang,Z., & Kennedy,R. (2010). Detecting trends in forest disturbance and recovery using yearly Landsat time series: 2. TimeSync - Tools for calibration and validation. *Remote Sensing of Environment*, 114, 2911–2924.

Copernicus Programme (2014). Copernicus Land Monitoring Services. http://land.copernicus.eu/pan-european/corine-land-cover.

DeVries,B., Verbesselt,J., Kooistra,L., & Herold,M. (2015). Robust monitoring of small-scale forest disturbances in a tropical montane forest using Landsat time series. *Remote Sensing of Environment*, 161, 107–121.

ESA (2017). ESA Climate Change Initiative - Land Cover Project 2014-2017. European Space Agency. http://maps.elie.ucl.ac.be/CCI/viewer/download.php.

Estel, S., Kuemmerle, T., Levers, C. Baumann, M. & P. Hostert (2016). Mapping Cropland-Use Intensity across Europe Using MODIS NDVI Time Series. *Environmental Research Letters* 11 (2): 24015. doi:10.1088/1748-9326/11/2/024015.

FAO (2017a). AQUASTAT. *Http://www.fao.org/nr/water/aquastat/main/index.stm*.

FAO (2017b). FAOSTAT: Statistical Database of the United Nations Food and Agricultural Organization. *Http://faostat.fao.org/*.

Guanche, Y. G. (2016). BACI Fast Tracks - Extremes Detection. FSU Jena.

Haberl, H., K.H. Erb, F. Krausmann, V. Gaube, A. Bondeau, C. Plutzar, S. Gingrich, W. Lucht, and M. Fischer-Kowalski (2007).“Quantifying and Mapping the Human Appropriation of Net Primary Production in Earth’s Terrestrial Ecosystems. *Proceedings of the National Academy of Sciences* 104 (31): 12942.

Hansen,M.C., Potapov,P. V, Moore,R., Hancher,M., Turubanova,S.A., Tyukavina,A., Thau,D., Stehman,S. V, Goetz,S.J., Loveland,T.R., Kommareddy,A., Egorov,A., Chini,L., Justice,C.O., & Townshend,J.R.G. (2013). High-resolution global maps of 21st-century forest cover change. Science, 342, 850–853.IFA. 2017. “International Fertilizer Association.” *Http://www.fertilizer.org/statistics*.

Hansen,M.C., Krylov,A., Tyukavina,A., Potapov,P. V, Turubanova,S., Zutta,B., Ifo,S., Margono,B., Stolle,F., & Moore,R. (2016). Humid tropical forest disturbance alerts using Landsat data. *Environmental Research Letters*, 11, 34008.

Iizumi, T., Yokozawa, M., Sakurai, G., Travasso, M. I., Romanenkov, V., Oettli, P., Newby, T., Ishigooka, Y. & J. Furuya (2014). Historical Changes in Global Yields: Major Cereal and Legume Crops from 1982 to 2006. *Global Ecology and Biogeography*, 23 (3): 346–357.

Klein G., K., Beusen, A., Drecht, G. & M. De Vos (2011).The HYDE 3.1 Spatially Explicit Database of Human-Induced Global Land-Use Change over the Past 12,000 Years. *Global Ecology and Biogeography* 20 (1): 73–86.

Leip, A., G. Marchi, R. Koeble, M. Kempen, W. Britz, & C. Li. (2007). Linking an Economic Model for European Agriculture with a Mechanistic Model to Estimate Nitrogen Losses from Cropland Soil in Europe. *Biogeosciences Discussions* 4 (4): 2215–2278.

Levers, C., Verkerk, P.J., Müller, D., Verburg, P.H., Leitão, P.J., Lindner, M. & T. Kuemmerle (2014). Drivers of Forest Harvesting Intensity Patterns in Europe. *Forest Ecology and Management* 315: 160–172.

Lloyd, C. T., Sorichetta, A. & A. J. Tatem (2017). High Resolution Global Gridded Data for Use in Population Studies. *Scientific Data 4* (January): 170001. doi:10.1038/sdata.2017.1.

Monfreda, C., N. Ramankutty, & Foley, J.A. (2008). Farming the Planet: 2. Geographic Distribution of Crop Areas, Yields, Physiological Types, and Net Primary Production in the Year 2000. *Global Biogeochemical Cycles* 22 (1): 1–19.

Mueller, N. D., Gerber, J. S., Johnston, M., Ray, D.K., Ramankutty, N. & Foley, J.A. (2012). Closing Yield Gaps through Nutrient and Water Management. *Nature* 490 (7419): 254–57. doi:10.1038/nature11420.

Neumann, K., Elbersen, B.S., Verburg, P.H, Staritsky, I., Pérez-Soba, M., de Vries, W., & W. A. Rienks (2009). Modelling the Spatial Distribution of Livestock in Europe. *Landscape Ecology* 24 (9): 1207–1222.

Olofsson,P., Foody,G.M., Herold,M., Stehman,S. V., Woodcock,C.E., & Wulder,M.A. (2014). Good practices for estimating area and assessing accuracy of land change. *Remote Sensing of Environment*, 148, 42–57.

Pekel, J-F., Cottam, A., Gorelick, N. & Belward, A.S. (2017). High-resolution mapping of global surface water and its long-term changes. *Nature*, 540. 418-422. doi:10.1038/nature20584

Plutzar, C., Kroisleitner, C., Haberl, H., Fetzel, T., Bulgheroni, C., Beringer, T., Hostert, P. et al. (2015). Changes in the Spatial Patterns of Human Appropriation of Net Primary Production (HANPP) in Europe 1990–2006. *Regional Environmental Change*, June, 1–14. doi:10.1007/s10113-015-0820-3.

Potapov, P. Yaroshenko, A., Turubanova, S., Dubinin, M., Laestadius, L., Thies, C., Aksenov, D., et al. (2008) Mapping the World's Intact Forest Landscapes by Remote Sensing. *Ecology and Society* 13 (2): 51.

Ramankutty, N., Foley J.A., & N. J. Olejniczak (2002). People and Land: Changes in Global Population and Croplands during the 20th Century. *Ambio* 31 (3): 251–57.

Reiche,J., Lucas,R., Mitchell,A.L., Verbesselt,J., Hoekman,D.H., Haarpaintner,J., Kellndorfer,J.M., Rosenqvist,A., Lehmann,E.A., Woodcock,C.E., Seifert,F.M., & Herold,M. (2016). Combining satellite data for better tropical forest monitoring. *Nature Climate Change*, 6, 120–122.

Reiche,J., Verbesselt,J., Hoekman,D., & Herold,M. (2015). Fusing Landsat and SAR time series to detect deforestation in the tropics. *Remote Sensing of Environment*, 156, 276–293.

Stehman,S. V. (2012). Impact of sample size allocation when using stratified random sampling to estimate accuracy and area of land-cover change. *Remote Sensing Letters*, 3, 111–120.

Siebert, S., Kummu, M., Porkka, M., Döll, P., Ramankutty, N. & B. R. Scanlon (2015). A Global Data Set of the Extent of Irrigated Land from 1900 to 2005. *Hydrology and Earth System Sciences* 19 (3): 1521–1545.

Temme, A.J.A.M., & P.H. Verburg (2011). Mapping and Modelling of Changes in Agricultural Intensity in Europe. *Agriculture, Ecosystems & Environment* 140 (1–2): 46–56.

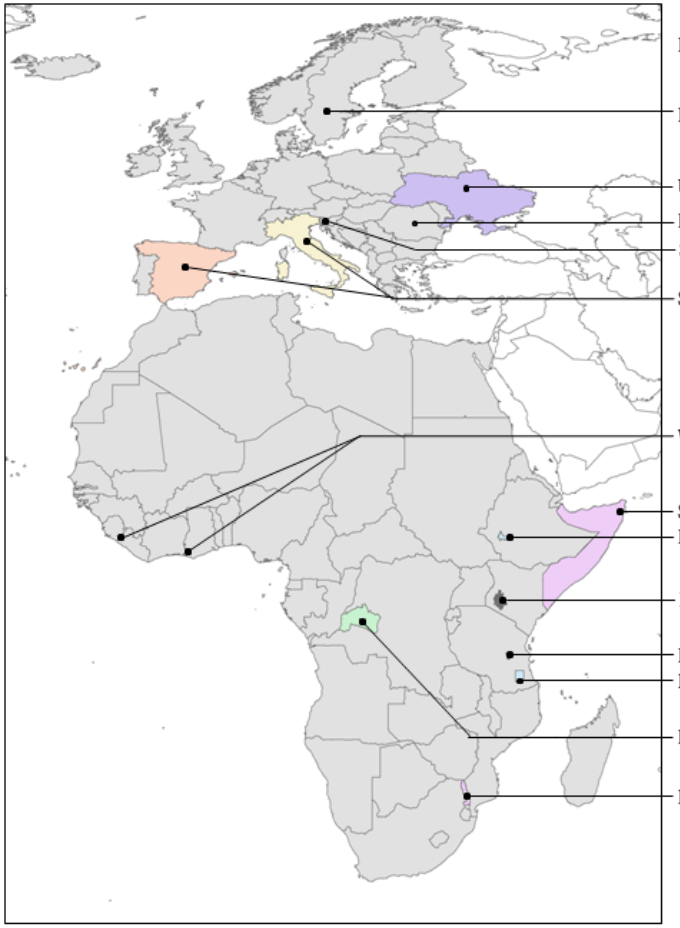
Tóth, G. (2013). 3. The LUCAS Topsoil Database Version 1.0. LUCAS Topsoil Survey Methodology, Data and Results, 9.

Woodcock,C., Allen,R., Anderson,M., Belward,A.,Bindschadler,R., Cohen,W., Gao,F., Goward,S.N.,Helder,D., Helmer,E.H., Nemani,R.,Oreopoulos,L., Schott,J., Thenkabail,P.S.,Vermote,E.F., Vogelmann,J., Wulder,M.A., & Wynne,R. (2008). Free access to Landsat imagery. *Science*, 320(5879), 1011.

Zhu,Z. & Woodcock,C.E. (2014). Automated cloud, cloud shadow, and snow detection in multitemporal Landsat data: An algorithm designed specifically for monitoring land cover change. *Remote Sensing of Environment*, 152, 217–234.

# 8. Annex 1

## 2.1 Overview



| Regional site | Main driver of change |
|---|---|
| **Northern Europe** [FSU & AU] | Commercial intensification of forest sector |
| **Ukraine** [FSU] | Droughts, political changes |
| **Eastern Europe** [UNI-KLU] | Desintensification and abondonment |
| **Slowenia** [WU] | Droughts, frost |
| **Spain & Italy** [MPG & UNITUS] | Heatwaves, droughts, fires |
| **West Africa** [UNITUS] | Climate variability and extremes |
| **Somalia** [WU] | Droughts, armed conflicts |
| **Kafa forest, Ethiopia** [WU] | Forest encroachment by rural mitigation |
| **Mau forest, Kenia** [WU] | Cropland intensification |
| **Kilosa district, Tanzania** [WU] | Cropland and lifestock intensification |
| **Liwale, Tanzania** [WU, NORUT] | Cropland intensification and forestry |
| **Mai Ndombe, DRC** [WU, NORUT] | Agricultural expansion and forestry |
| **Kruger NP, SA** [FSU] | Fire, forestry, human induced degradation |

Fig.1 Overview of the current selection of regional validations areas.

## 2.2 East Africa

Covering Ethiopia and Somalia with important climate events (droughts) and human migration (Ethiopia), armed conflicts (Somalia), effects of population growth (Kenia), and small-holder activities (Tanzania), fires and small holder activities (Mosambique).

| **Site** | **Project partners responsible** | **Available datasets for comparison and validation incl. high-resolution satellite data** | **Comments and further description** | **Type of change / preliminary assumption** |
|---|---|---|---|---|
| **Kafa mountain forest region, Ethiopia**<br><br>Forest encroachment around protected areas driven by rural migration | WU | Ground data:<br>• Land use change history data (2000-2015; ongoing)<br>• 150 forest inventory plots for emission factors<br>• Local ranger near-real time monitoring system (> 1000 ground observations related to forest change 2012–2015; ongoing)<br><br>High-resolution satellite (time series) data:<br>• SPOT5 annual coverage (2006 – 2011)<br>• RapidEye time series 2012-2015/16<br>• (PALSAR-1 and PALSAR-2 time series)<br><br>Data availability/restrictions within BACI:<br>• Full use for BACI project. Available at WU. | 1. Site and reference data are suitable to validate the following type of change:<br>• Land use/land cover<br>• Socio-economic<br><br>2. Central location (lat/long): 7°3 N, 35°9 E<br><br>3. Size (km²): 7.400<br><br>4. Suitable to assess the “fast-track BACI” products : YES<br><br>6. Key references:<br>• DeVries et al. 2015<br>• Pratihast et al. 2014<br>• Hailemariam, A., PhD Thesis | Intermediate events, Transient changes |
| **SW-Ethiopia** (Gambela, SNNPR) and **NW-Kenya** (N-Turkana) | - | - | - | Hot Spot |
| **Somalia**:<br><br>Drought and armed conflict and decline in agriculture production in 2010/2011 | WU | Ground data:<br>• Climate data analysis and reference data for armed conflict area<br><br>Data availability/restrictions within BACI:<br>• Full use for BACI project. Available at WU. | 1. Site and reference data are suitable to validate the following type of change:<br>• Climate extreme<br><br>2. Central location (lat/long): 6° N, 47°3 E<br><br>3. Size (km²): 640.000<br><br>4. Suitable to assess the “fast-track BACI” products: YES<br><br>6. Key references:<br>• Verbesselt et al., 2012 | Transient change, Hot spot in the South; Cold Spot in the North of Somalia |

| | | | | |
|---|---|---|---|---|
| **Mau Forests, Kenia**<br><br>Cropland intensification / deforestation for cropland and lifestock around | WU, UNI-KLU | Ground data:<br>• Historical land use change maps and analysis (from 1973 onwards)<br><br>Data availability/restrictions within BACI:<br>• Full use for BACI project. Available at WU. | 1. Site and reference data are suitable to validate the following type of change:<br>• Land use/land cover<br><br>2. Central location (lat/long): 0°3 S, 35°5 E<br><br>3. Size (km²): 23.000<br><br>4. Suitable to assess the "fast-track BACI" products: NO | Hot Spot |
| **Kilosa District, Tanzania**<br><br>Community / Small-holder driven deforestation for cropland and lifestock. (REDD+ project site with interventions) | WU | Ground data:<br>• Land use change history data (2000-2015; ongoing)<br><br>High-resolution satellite (time series) data:<br>• RapidEye time series 2012-2015/16<br><br>Data availability/restrictions within BACI:<br>• Full use for BACI project. Available at WU. | 1. Site and reference data are suitable to validate the following type of change:<br>• Land use/land cover<br>• Socio-economic<br><br>2. Central location (lat/long): 6° N, 47°3 E<br><br>4. Suitable to assess the "fast-track BACI" products: NO<br><br>3. Size (km²): 3.000<br><br>6. Key references:<br>• Sills et al., 2014;<br>• Local study with focus on livestock, transhumance, HANPP. Location Ololosokwan, Tanzania close to Serengheti. Does it match with S.R.?Source: http://www.uni-klu.ac.at/socec/downloads/WP149_webversion.pdf | We only find a very local Hot Spot (?) |
| **Mozambique**<br><br>Fires and small holder activities | WU | Ground data:<br>• National land cover maps<br>• Land cover change information?<br><br>Data availability/restrictions within BACI:<br>• Full use for BACI project. Available at WU. | 1. Site and reference data are suitable to validate the following type of change:<br>• Land use/land cover<br><br>2. Central location (lat/long): 6° N, 47°3 E<br><br>4. Suitable to assess the "fast-track BACI" products: NO | Large Hot Spot, especially in the South |
| **Liwale, Tanzania**<br><br>Agricultural expansion, charcoal, forestry | WU (NORUT) | Ground data:<br>• Airborne LiDAR<br>• forest inventory?<br><br>High-resolution satellite (time series) data:<br>• VHR (2008 – 2012, WorldView, Ikonos, RapidEye, Digital | 1. Site and reference data are suitable to validate the following type of change: A,B,C:<br>• Land use/land cover<br><br>4. Suitable to assess the "fast-track BACI" products: NO | Intermediate Events |

| | | | | |
|---|---|---|---|---|
| | | Globe)<br><br>Data availability/restrictions within BACI:<br>• Full use for BACI project. Available at WU. | | |

## 2.3 West and central Africa

Covering Sahel zone and forest/savannah transitions with large climate variability and human induced land change Wet evergreen, moist evergreen, and moist semi deciduous tropical forests; DRC: Tropical forest, Savanna, Wetlands.

| **Site** | **Project partners responsible** | **Available datasets for comparison and validation incl. high-resolution satellite data** | **Comments and further description** | **Type of change / preliminary assumption** |
|---|---|---|---|---|
| **Ghana, Sierra Leone**<br><br>Climate variability and extremes | UNI-KLU, UNITUS | Ground data:<br>A) Flux tower data from Ankasa-Ghana wet tropical forest, from 2009 to 2014 with gaps<br>B) Field plots data on forest species, biomass, biodiversity, with disturbance information for four southwest Ghana forest areas (parks and reserves). Field data collected in 2013<br>C) Land cover map for southeast Sierra Leone (surrounding Gola Rainforest NP) realized in 2012 with field/remote sensing data.<br>• Carbon Stock maps adapted from Saatchi Bacchini. Static for 2000, 5min resoluiton<br>• Source: Erb et al., in preparation | 1. Site and reference data are suitable to validate the following type of change: A,B,C:<br>• climate extremes/anomalies<br><br>6. Key references:<br>• Vaglio Laurin et al. 2013 | A) intermediate events<br><br>B) intermediate events<br><br>C) Cold Spot |
| **Mai Ndombe, DRC**<br><br>Expansion of agricultural and forest from local communities, forestry, | WU (NORUT) | Ground data:<br>A) Inventory?, Land cover data, OSFAC inventory data , ReCover data<br><br>High-resolution satellite (time series) data:<br>B) Rapideye (2011-2013), Kompsat (2011-2012) | 1. Site and reference data are suitable to validate the following type of change: A,B,C:<br>• Land use/land cover | Cold Spot |

## 2.4 Southern Africa

Impacts of fires and herbivores, and human induced woodland degradation, industrial forestry.

| Site | Project partners responsible | Available datasets for comparison and validation incl. high-resolution satellite data | Comments and further description | Type of change / preliminary assumption |
|---|---|---|---|---|
| **Kruger National Park, SA** and its neighbouring communal woodlands<br><br>Extensification and intensification of forest plantations | FSU | Ground data:<br>• Field inventory data (Tree height, DBH and AGB)<br>• Very high resolution air photos and satellite data (KeyHole Corona Mission 60s/70s)<br>• Woody cover maps<br>• LiDAR flights (2010/2012/2014)<br>• Flux towers<br>• Local data on vegetation, soil moisture etc.<br><br>Data availability/restrictions within BACI:<br>• the data are only available within other projects and not open access; the validation will be done internally by the project partner of the Department for Earth Observation (FSU Jena)) -> further investigations needs to be done with respect to data quality, format, temporal coverage etc.<br>• Land use, HANPP, biomass dataset 1961-2006; national level.<br>• Source: Niedertscheider et al. 2012 | 1. Site and reference data are suitable to validate the following type of change:<br>• Land use/land cover<br>2. Central location (lat/long): 23° 54' S, 31° 28' E<br>3. Size (km²): approx: 21.000 km²<br>4. Suitable to assess the "fast-track BACI" products: YES<br>6. References<br>• Niedertscheider et al. 2012 | Hot Spot, more pronounced in the north and in direction to Limpopo / Mozambique |
| **Cape of Good Hope, SA** | - | - | - | Cold Spot |
| **Botswana** | - | - | - | Hot Spot |

## 2.5 Eastern Europe

Climate variability (drought), Land use change after system transformation and impact of socio-economic and demographic developments, e.g. natural re-forestation due to land abandonment.

| Site | Project partners responsible | Available datasets for comparison and validation incl. high-resolution satellite data | Comments and further description | Type of change / preliminary assumption |
|---|---|---|---|---|
| **Ukraine**<br><br>Impact of 2010 Ukraine drought event along with demographic and political changes | UNI-KLU | Ground data:<br>• National level analysis with focus on the increasing bioengery production in the Ukraine. Source: Schaffartzik et al. 2014 | 1. Site and reference data are suitable to validate the following type of change:<br>2. Central location (lat/long): 49° 00' N, 31° 00' E<br>3. Size (km²): approx: 603.000 km²<br>4. Suitable to assess the "fast-track BACI" products: NO | Hot Spot in Ukraine only for 2 of 6 methods (but sophisticate ones). More pronounced Hot Spot around the black sea in Romania, and in direction to the Russian border |
| **Eastern Europe**<br><br>Collapse of livestock systems in Eastern Europe, along with the disintensification and abandonment. | UNI-KLU | Ground data:<br>• Local data available from a EU projects done by UNI-KLU<br>• 1km land use and biomass flow maps, 1990, 2000, 2006 (covers the EU27 wall to wall). Source: Plutzar et al. 2015<br>• National level time series on Land use, HANPP, biomass dataset from +- 1900 for Albania and Romania. Source: Gingrich, Simone, et al. 2015 | 6. Key references:<br>• Gingrich, Simone et al. 2015<br>• Plutzar et al. 2015 | Transient |
| **Slovenia**<br><br>Extreme climatic events<br><br>Important climate events (droughts & frost) and their effect on wood production | WU | Please provide a further description of the reference data and if it can be shared within the BACI-project<br>• MODIS – NDVI and EVI data<br>• Ground-based phenological observation reaching up to 50 years for 54 locations (for *Fagus sylvatica* L.)<br>• Local climate data<br>• Dendrochronological data (database currently compiled or data gathered); Detailed beech cover map<br><br>Data availability/restrictions within BACI: Approval of the Slovenian partners is needed | 1. Site and reference data are suitable to validate the following type of change:<br>• Extreme climate effects on wood production<br>2. Central location (lat/long): 46.0500° N, 14.5000° E<br>3. Size (km²): 20,273<br>4. Suitable to assess the "fast-track BACI" products: NO<br>6. Key references:<br>• Decuyper et al. (in prep) | Hot spot |

## 2.6 Northern Europe

Climate and human induced changes to forest cover

| Site | Project partners responsible | Available datasets for comparison and validation incl. high-resolution satellite data | Comments and further description | Type of change / preliminary assumption |
|---|---|---|---|---|
| **Norway, Sweden, Finland, Denmark**<br><br>Commercial intensification of forest sector | FSU, AU | Ground data:<br>• Plot-wise measurements of GSV from National Forest Inventory (NFI): plots of 7 or 10 m radius, located on a pre-defined grid throughout the country (Axelsson et al., 2010).<br>• 1km land use and biomass flow maps, 1990, 2000, 2006 (covers the EU27 wall to wall). Source: Plutzar et al, 2015<br>• National level time series on Land use, HANPP, biomass dataset from +- 1900 for Sweden and Denmark. Source: Gingrich et al. 2015<br><br>Data availability/restrictions within BACI:<br>(the validation of Sweden is available without any restrictions (open access)) | 1. Site and reference data are suitable to validate the following type of change:<br>• Land use/land cover<br><br>Biodiversity (distribution of forest species)<br>2. Central location (lat/long): 63° 35' S, 16° 20' E<br>3. Size (km²): approx: 450000 km²<br>4. Suitable to assess the "fast-track BACI" products:YES<br>• Validation database of the NFI includes covers various forest parameter, e.g. forest area (different species), DBH,<br><br>5. Further comments:<br>• The reference information for Sweden is available without any restrictions.(http://www.slu.se/en/webbtjanster-miljoanalys/forest-statistics/)<br><br>6. Key references:<br>• Axelsson et al., 2010<br>• Plutzar et al., 2015<br>• Gingrich et al., 2015 | Hot Spots especially along the border Norway / Sweden and in South Finland |
| **Denmark, Sjællands** | - | - | - | Cold Spot |

## 2.7 Southern Europe

Central/Sourthern Spain, Italian forests and marquis. Italian coastal wetlands and dunes.

| Site | Project partners responsible | Available datasets for comparison and validation incl. high-resolution satellite data | Comments and further description | Type of change / preliminary assumption |
|---|---|---|---|---|
| **Spain, Italy**<br><br>Recent and intense regional heatwaves and droughts episode (e.g. 2005). Most relevant region in Europe for biomass burning and fires related emission, water scarcity with implications for crop production. | MPG, UNITUS | Ground data:<br><br>A) Eddy covariance towers multitemporal data in different Mediterranean ecosystems<br>B) Land cover change maps from aerial photos of the Viterbo province (Italy, 1954-90-99-09)<br>C) Remote sensing data for a protected site (200 ha) burnt in 2013 in Sardinia: pre and post burnt imagery (SAR, optical)<br><br>Spain:<br><br>D) Many sites with field spectroscopy measurements.<br><br>Italy:<br><br>• The national geoportal offers many different multitemporal data and change maps over the Italian territory. http://www.pcn.minambiente.it/GN/progetto_pcn.php?lan=en<br>• Analyses can be done online but usually data cannot be downloaded. A request for data download can be attempted if there is the interest for a specific dataset.<br>• 1km land use and biomass flow maps, 1990, 2000, 2006 (covers the EU27 wall to wall). Source: Plutzar et al. 2015<br>• National level time series on Land use, HANPP, biomass dataset from +- 1900 for Italy. as well as for Spain (from +- 1955). Subnational dataset for Italy. Sources: Gingrich et al. 2015; Niedertscheider et al. 2014<br><br>High-resolution satellite (time series) data:<br><br>C) CosmoSkyMed SAR data from 2013, Ikonos 2006, orthophotos 2006 | 1. Site and reference data are suitable to validate the following type of change<br><br>A) Suited to validate climate extreme/anomaly. Time series are different according to site. Tower footprint is variable but usually in the order of few hundreds of sq mt Additional data (field plots) maybe be available under request<br>B) Suited to validate land cover change<br>C) Suited to validate land cover change.<br><br>6. Key references:<br><br>• Schwarzlmüller & Elmar, 2009<br>• Vaglio Laurin G., Virelli M., Bacciu V., Avezzano R.G., Del Frate F., Schiavon G. and R. Valentini. Monitoring fire effects on the mediterranean vegetation with cosmo-skymed remote sensing data. ICBFR 2015, Alghero,Italy.<br>• Avezzano R., Vaglio Laurin G., Bacciu V., Covello F., Virelli M., Del Frate F., Schiavon G., Valentini R.. Use of Cosmo-SkyMed constellation for monitoring the post-fire vegetation regrowth: the Capo Figari case study. IGARSS 2014 proceedings.<br>• R. G. Avezzano, Vaglio Laurin G, Bacciu V., Covello F., Caltagirone F., Virelli M., Del Frate F., Schiavon G., and Riccardo Valentini. Post fire monitoring in a Mediterranean area with Cosmo SkyMed products. Forestsat 2014 proceedings, Riva del Garda, Italy, 4-7 November. | Intermediate events |