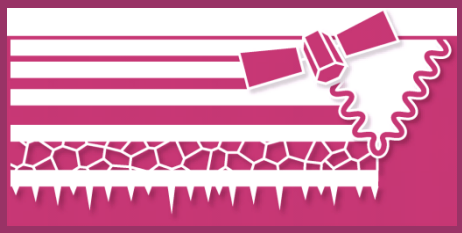
ESA DUE Permafrost



Pan- Arctic Land Cover Product

incl. GlobCarbon LAI and Fire Affected Area Information

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Contents

1 Product overview

Analyzing the vegetation structure and dynamics on pan boreal scale, global land cover, fire and phenological products will be utilized. The aim is to use existing global products to regionalize patterns and processes through integrating and synthesizing earth observation information from multiple information sources. This process will include the following points by building on the usefulness of moderate-resolution satellite data that provide information and indicators for permafrost conditions and change monitoring. (1) The detection of large and cumulative land change, spatial indicators and hot spot areas. (2) The analysis of inter-annual versus intra-annual dynamics to analyze long-term term trends for large areas. (3) The support to more detailed analysis in finer-scale remote sensing approaches and field surveys. (4) The exploration of the relationships on different observation variables, as well as spatial temporal analysis of patterns and detected changes over large regions. The following table gives an overview of the data sources which will be integrated (Tab. 1).

Tab. 1: Data products overview.

	data products	spatial resolution	temporal resolution	time series
land cover	MODIS Land Cover	500 m	yearly	2001 – 2007
	GLOBCOVER	300 m	-	2005/2006
	SYNMAP	1 km	-	1991 and 2000
	MODIS VCF	500 m	yearly	2000 – 2005
vegetation dynamics	GLOBCARBON (LAI)	1 km	monthly	1998 – 2007
fire affected area	MODIS BA	500m	monthly	since 2000
	GlobCarbon BA	1 km	monthly	1998 - 2007
	Terra Norte BA	1 km	monthly	2000 - 2006
	ATSR World Fire Atlas	1 km	monthly	since 1995

The yearly MODIS land cover product (17 classes - IGBP) with a spatial resolution of 500 m uses the MLCCA (MODIS Land Cover Classification Algorithm) to extract land cover information from multi-temporal satellite data (Friedl et al. 2002).

GlobCover (22 classes – LCCS) is produced by MERIS (Medium Resolution Imaging Spectrometer) satellite data of the years 2005 and 2006 with a spatial resolution of 300 m (Arino et. al 2007a). The product generation is performed by supervised and unsupervised classification approaches for each of the so called equal-reasoning areas.

The SYNMAP product is a best estimate classification which was developed by synergetic combination of the land cover products GLCC (Global Land Cover Characterization), GLC2000 (Global Land Cover 2000) and MODIS (48 classes). In the algorithm the land cover information from each dataset is used to convey an affinity score, which describes the similarities and discrepancies between the products (Jung et al. 2006).

MODIS VCF provides information about the cover percentage of trees, herbaceous and barren within a 500 m pixel. The principles of the algorithm is based on DeFries et al. (2000) but was improved in recent years. A regression tree uses MODIS reflectance as well as training data and NDVI values to extract the cover percentage for each pixel (Hansen et al. 2002).

The GlobCarbon LAI (leaf area index) product with a spatial resolution of 1 km is available for the years 1998 to 2007. The product is extracted out of MERIS reflectance satellite data by using the red, near infrared and shortwave infrared spectral information. The algorithm uses model-based look-up table described in Deng et al. 2006 (Plummer et al. 2007).

The harmonized fire affected area product is based on two global (MODIS and GlobCarbon), one regional (Russian burned area from Terra Norte) burned area and one active fire (ATSR World Fire Atlas (WFA)) product. The burn scar information from MODIS (500 m) and GlobCarbon (1 km) products are showing regions of burn scars over the pan-arctic area since 1998. The MODIS product identifies burned area by using information of the reflectance changes in different spectral channels (Roy et al. 2002, Roy et al. 2005). GlobCarbon is using different algorithms to extract burned areas out of ATSR-2, AATSR and SPOT-VEGETATION satellite data (Roy & Boschetti 2008, Simon et al. 2004). The regional burned area product is based on SPOT-VEGETATION data and provides information for the years 2000 – 2005 (Bartalev et al. 2007). The World Fire Atlas (WFA) provides information about fire hotspots on global scale since 1995. The active fire product is based on satellite data from ATSR-2, AATSR (Arino et al. 2007b).

2 Product specification

2.1 Pan-Arctic Land Cover Product

The harmonization of the land cover products is a key issue. In context of land cover characterization a harmonization can be understood as a process whereby the similarities between existing datasets are emphasized and inconsistencies are reduced (Herold et al. 2006). The user requirements show the need of percentage area information of vegetation physiognomy and barren. A first step is the aggregation of land cover products to pre-defined LCCS classifier (trees, shrubs, herbaceous, barren). The aim is to extract minimal and maximal values for the percentage cover of each classifier from the legend description of the land cover products. Based on this, the thematic precision (T_{pre}) of each land cover class is calculated:

$$T_{pre} = 1 - \frac{\left(lc_{p}_{max} - lc_{p}_{min} \right)}{100}$$

where lc is the land cover class of the product p.

The thematic precision is defined by the relation of the minimum and maximum percentage cover of vegetation types (min, max). In example, MODIS (IGBP) defines a tree cover from 60 % to 100 %. This results in a factor of the thematic precision of 0.6, which is higher than the definition

of forest classes in LCCS with a tree canopy > 15 % (T_{pre} = 0.15). The narrower the class description, the higher will be the weight of that land cover class in the product combination. The calculation will be done for each LCCS classifier (trees, shrubs, herbaceous, barren) (Fig. 1).

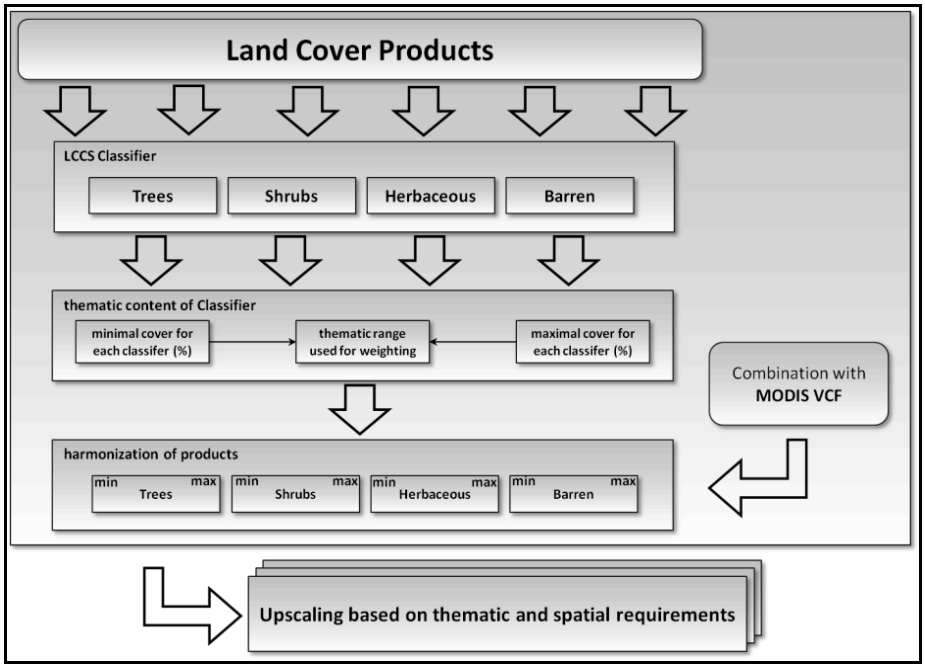

Fig. 1: Harmonization approach of different land cover products.

The percentage area of vegetation types and barren is linked to MODIS VCF to build a synergy product for each classifier. The resampling of the pan-Arctic land cover product Version 1 (Urban et al. 2010) (Fig. 2 – on top) to the required spatial resolution can be done without any restrictions.

The land cover product version 2 (Fig. 2 – below) was improved by using the Circumpolar Arctic Vegetation Map from Walker et al. (2005). The aim was to exclude cover percentage misclassification from trees in the arctic tundra regions to improve the representation of cover information within the taiga tundra transition zone. This is mandatory since the modeling group needs an exact definition of land cover types by distinguishing between forest and non-forest information in the high latitudes regions.

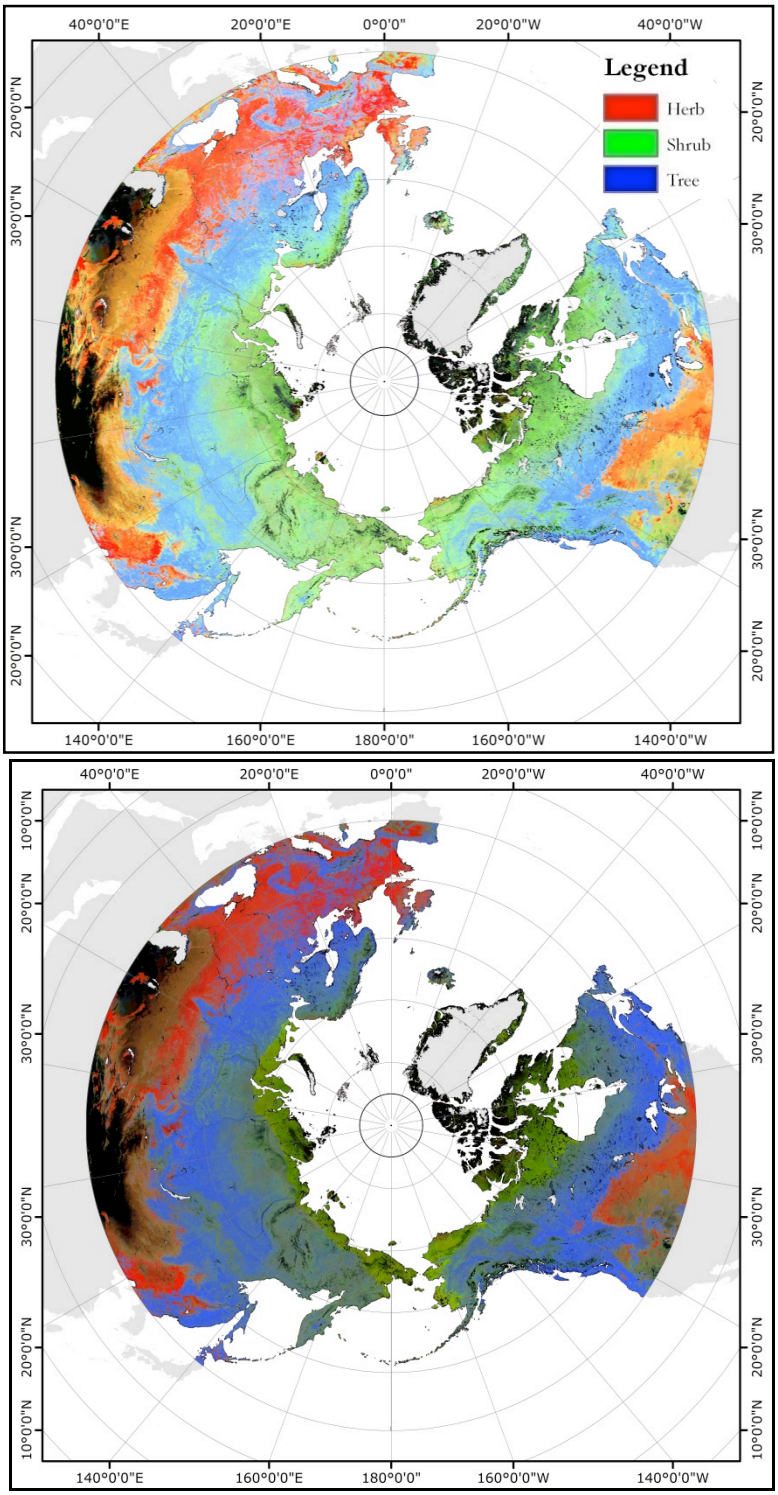

Fig. 2: Pan-Arctic land cover product (Version 1 – on top and Version 2 - below) providing percent-age cover information for vegetation physiognomy and barren areas (Legend: R (%-herb); G (%-shrub); B (%-tree), barren areas are displayed in black).

2.2 GlobCarbon LAI

The GlobCarbon LAI product is generated by using 1 km ATSR-2, AATSR and MERIS on board of ENVISAT as well as SPOT VEGETATION data. The raw data is pre-processed by removing clouds, snow and shadows as well as doing an atmospheric correction utilizing the SMAC-Method. After this step preliminary leaf area information is derived for different vegetation classes using the Global Land Cover 2000 Classification (GLC2000), called ELAI. Within this LAI extraction, a BRDF correction (bi-directional reflectance distribution function) is applied to the data. By using the spectral information from the SWIR (short wave infrared) and spectral vegetation indices (SVI), the LAI values can be extracted independently from the sun angle by the following equation:

$$L_E = \int_{LE_{RSR}} [\![\left(SR * \int_{BRDF} (\theta v, \theta s, \phi]\!] \right) * \Psi \right)$$

where $\int_{LE_{RSR}}$ describes the relationship between the ELAI and SVI and ϕ, Ψ and θ describing the BRDF effects. Finally the LAI values are calculated by the division of ELAI (L_E) and a clumping index (Ω) (Plummer et al. 2007a-c).

Within the Data User Element Permafrost a pan-arctic LAI dataset for the years 1998 – 2007 was processed from the GlobCarbon database. It is available as yearly product representing the monthly LAI mean values. Due to storage efficiency the values in the product need to be recalculated by the following equation:

$$LAI = (0.1 * DN) - 0.1$$

where DN are the values in the pan-Arctic LAI product.

2.3 Harmonized pan-arctic fire affected area information

The fire products are integrated by the identification of fire affected areas based on the information of burn scars and active fires. Due to different temporal and spatial resolutions it is useful to combine these products to build a fire affected area database for the pan-arctic scale (Figure 3). Therefore it is mandatory to take similarities and disagreements of the products into account which can be extracted by cross comparison of the products. For each fire affected area a quality flag dataset is available which is based on the agreement between the products. In detail, a pixel with a value of 1 indicates that only one of the four fire datasets has detected a burn scar or fire hotspot. However, a pixel value of 4 indicates that three of the used datasets had detected a burn scar and the active fire product also classified this pixel as fire hot spot.

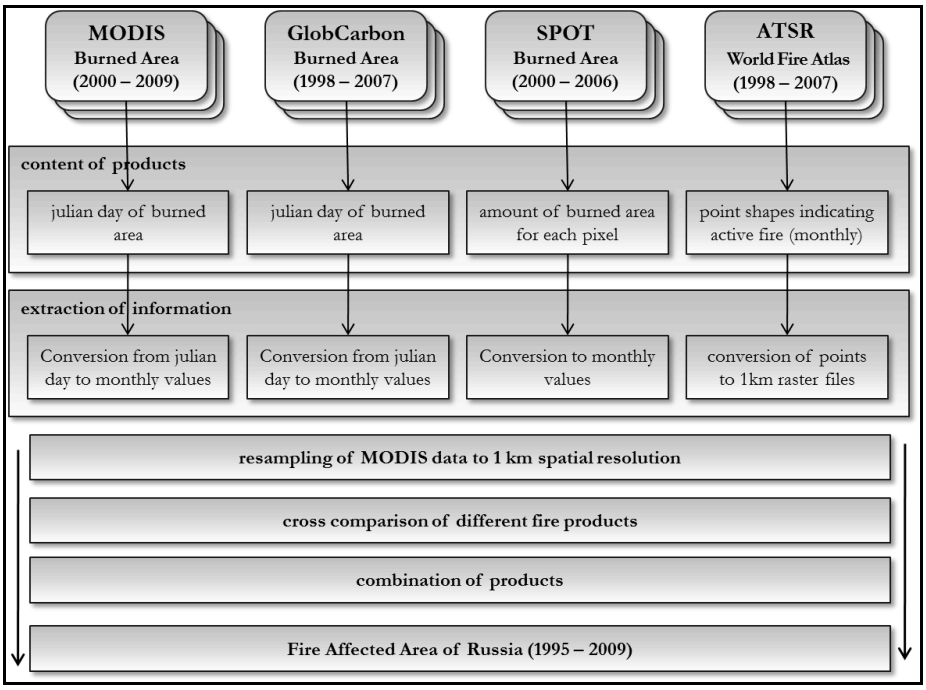

Fig. 3: Building a fire affected area database on pan-arctic scale using global and regional fire products.

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2.3 Nomenclature Names

Land Cover products

Version 1:
fsu_00000_lc_001_000_20000101_000000-20091231_235959_100_float.tif
Version 2:
fsu_00000_lc_002_000_20000101_000000-20091231_235959_100_float.tif

Bands:

Layer 1: %- tree cover
Layer 2: %- shrub cover (including low to tall-shrubs)
Layer 3: %- herbaceous cover (including the erect-dwarf and prostrate-shrub tundra)
Layer 4: %- barren and graminoid tundra (including surface water)

Burned Area product

FSU_00000_fire_v01_1996_08_int.tif
…
FSU_00000_fire_v01_YYYY_MM_int.tif
…
FSU_00000_fire_v01_2009_05_int.tif

Bands:

Layer 1: fire detection by one product
Layer 2: fire detection by two products
Layer 3: fire detection by three products
Layer 4: fire detection by four products

GlobCarbon LAI product

FSU_GlobCarbon_LAI_v01_1998_01_1998_12_pan_arctic_int.tif
…
FSU_GlobCarbon_LAI_v01_YYYY_MM_YYYY_MM_pan_arctic_int.tif
…
FSU_GlobCarbon_LAI_v01_2007_01_2007_12_pan_arctic_int.tif

Bands:

Layer 1 – Layer 12: each layer contains the monthly averaged GlobCarbon LAI

3 Data access and contact information

The global harmonized land cover product version 2 can be accessed via PANGAEA (http://doi.pangaea.de/10.1594/PANGAEA.780111) and should be cited as:

Urban, Marcel; Hese, Sören; Herold, Martin; Pöcking, Stefan; Schmullius, Christiane (2012): A fractional vegetation cover remote sensing product on pan-arctic scale, version 2, with links to geotiff image, Friedrich Schiller University of Jena, DE, doi:10.1594/PANGAEA.780464
In: DUE Permafrost Project Consortium (2012): ESA Data User Element (DUE) Permafrost: Circumpolar Remote Sensing Service for Permafrost (Full Product Set) with links to datasets. doi:10.1594/PANGAEA.780111

The global harmonized land cover product version 1 can be accessed via PANGAEA in Urban, M et al. (2012): A fractional vegetation cover remote sensing product on pan-arctic scale. doi:10.1594/PANGAEA.779575
As supplement to: Urban, Marcel; Hese, Sören; Herold, Martin; Pöcking, Stefan; Schmullius, Christiane (2010): Pan-Arctic land cover mapping and fire assessment for the ESA Data User Element Permafrost. Photogrammetrie Fernerkundung Geoinformation, 4, 283-293, doi:10.1127/1432-8364/2010/0056

All DUE Permafrost land cover, LAI and fire affected area products are stored on the Institute of Photogrammetry and Remote Sensing (TU Wien) FTP server which can be accessed via the DUE Permafrost data portal (www.ipf.tuwien.ac.at/permafrost). The dataportal includes a WebGIS for visualization. Login information is available on request.

For login access to the dataportal, contact Annett.Bartsch@tuwien.ac.at.
For questions about the product, contact Marcel.Urban@uni-jena.de or Christiane.Schmullius@uni-jena.de.
For ESA's technical officer, contact Frank.Martin.Seifert@esa.int.

Additional information on the ESA DUE Permafrost project can be found at the web - site: http://www.ipf.tuwien.ac.at/permafrost

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