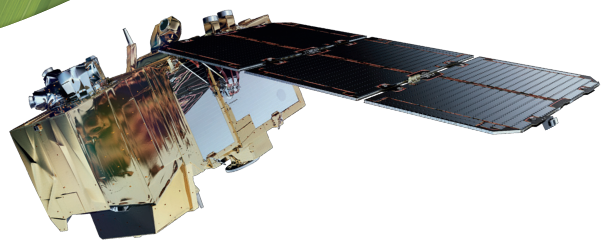
Towards fully automated Sentinel-2 type based continuous

LAND MONITORING



Introduction

With the successful launch of the first Sentinel-2 (S-2) satellite in 2015 a new chapter for European and global land monitoring was opened. The Sentinel-2 mission is a land monitoring constellation of two satellites that will provide high resolution optical imagery every 10 days with one satellite and 5 days with two satellites. The mission will provide a global coverage of the Earth's land surface allowing to identify, monitor and govern changes in landscapes caused by consumption patterns and economic production sectors. In order to be able to formulate and implement sustainable measures, a continuous, efficient land monitoring information service is of critical importance. Here, the LandMon project comes into play. It aims to pave the way for a full exploitation of the potential of Sentinel-2 observations to provide operational land monitoring information solutions by the preparation of supercomputer ready processing chains for land cover and land use monitoring.

Sentinel-2 Simulated Database

The operational land monitoring builds on a simulated database of S-2-like imagery, which is based on time series of cloud-free, "bottom-of-the-atmosphere" (BOA) multi-spectral Landsat images. Such time series of satellite observations are suitable to identify and monitor land cover and land use. In order to generate universal classification methods an extended study area was selected, which covers a total area of 86.550 km2 extending from North of Munich to the Adriatic Sea.

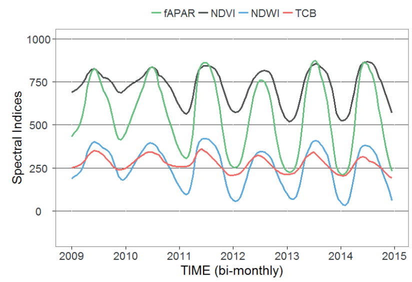
The study area was selected in order to get a non-homogenous area with a large extent. The large extent was necessary to ensure, that the developed algorithms can handle extreme data amounts. The heterogeneous study area guarantees that the methods developed for the LandMon project are not too specific for a certain ecosystem. The algorithms developed for the LandMon package are all based on the analysis of time series data.
To get a good representation of the full vegetation cycle, each year is covered by 24 images (two images per month). To create a "Sentinel-2-like database", Landsat (5, 7, and 8) observations were used together with an algorithm developed in this project. From the filtered reflectance in the six spectral channels of Landsat, the NDVI (Normalized Difference Vegetation Index), NDWI (Normalized Difference Water Index), fAPAR (fraction of absorbed photosynthetically active radiation) and Tasseled Cap Brightness (TCB) were calculated.

Phenological Parameters

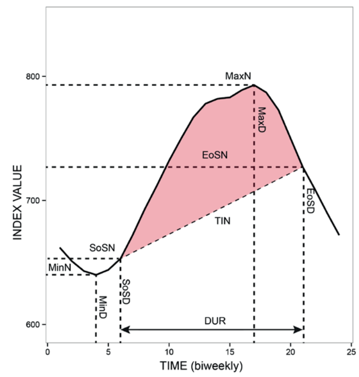
A key product of the LandMon project is the extraction of phenological parameters from time series data. The phenology describes the periodically recurrent growth and development of plants during a year. Therefore, phenological parameters describe the characteristic features of the phenology. In the LandMon project the vegetation index time series data is used to derive the most meaningful phenological parameters to describe their characteristics (Atzberger et al. 2014, Vuolo et al. 2011). These following parameters appear to have a high informative value for identification and monitoring of land cover and land use in the subsequent processing steps:

- **Start of season (SoSN/SoSD)**
- **End of season (EoSN/EoSD)**
- **Duration (Dur)**
- **Maximum and minimum value (MaxN/MinN)**
- **Time of maximum and minimum value (MaxD/MinD)**
- **Integral of the cyclic fraction (TIN)**

The phenological parameter abbreviation are appended by either the letter "N" for number or values or the letter "D" for date for the occurrence of the phenological parameter.



Example of a time series (15-day resolution) for four vegetation indices calculated from the smoothed/gap-filled reflectance data set. The four vegetation indices are NDVI, NDWI, fAPAR and TCB.



Schematic representation of the phenological parameters on a yearly index curve.

References:

Atzberger, C., Klisch, A., Mattiuzzi, M. & Vuolo, F. (2014): Phenological metrics derived over the European continent from NDVI3g data and MODIS time series. – Remote Sensing, 6, 257-284.

Vuolo, F., Richter, K. & Atzberger, C. (2011): Evaluation of time-series and phenological indicators for land cover classification based on MODIS data. – Proceedings Vol. 8174 Remote Sensing for Agriculture, Ecosystems, and Hydrology XIII, DOI 10.1117/12.898389.

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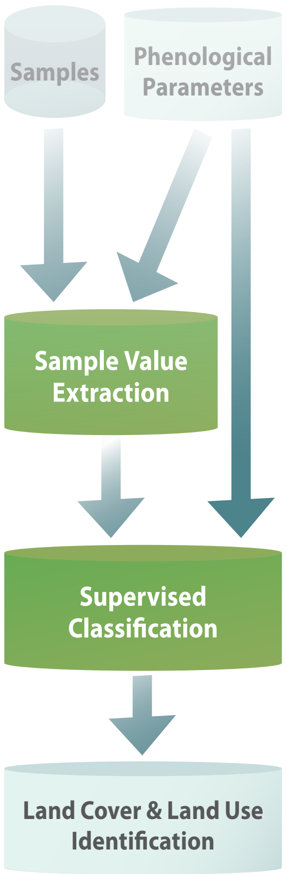


LandMon Python Package

All developed algorithms are structured within a LandMon Python package, which offers a tool set for the retrieval of phenological parameters, the extraction of training samples based on geospatial point data, and advanced machine learning algorithms for the classification of multidimensional raster data. Additionally, several validation functions are implemented into the Python package.

(1) Phenological parameter (Pheno-Para Module)

A key aspect of the LandMon project is the investigation of phenological parameters for the identification and monitoring of land cover and land use. Because the algorithms developed for the extraction are computational expensive, they passed through a range of benchmarking and performance improvements steps.

(2) Point statistics (Point-Stats Module)

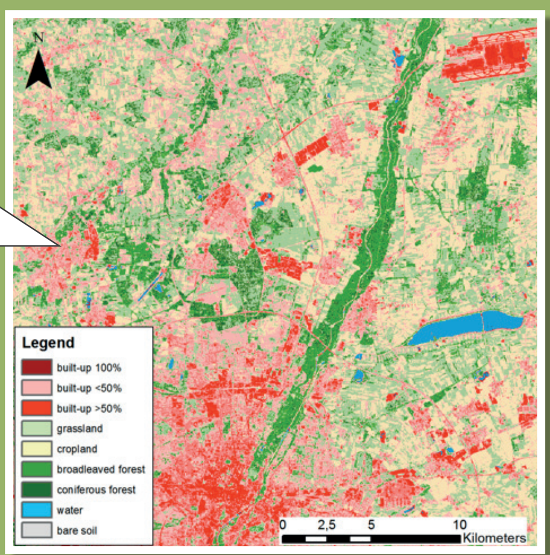
Because supervised classification algorithms are used for the identification of land cover and land use, the generation of labelled sample data is an indispensable step for the training of the machine learning algorithms. Thus, a module was developed, which is capable of extracting raster values based on the location of single labelled geospatial point data. These algorithms were optimized for the highest performance.

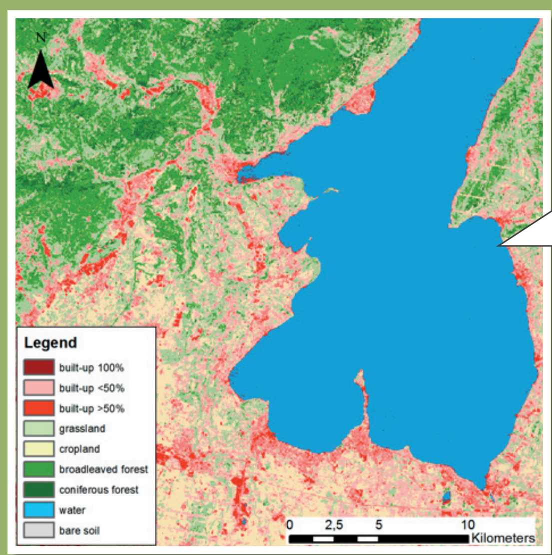
(3) Machine learning (Machine-learning Module)

The final step involves the identification of land cover and land use. This task is part of the machine learning module, which was developed for the classification of raster data. Additionally, several functions for the validation of the classification results are implemented in this module. As a classification strategy, supervised classification methods are utilized, which result in the implementation of the Random Forest classification module. For future developments also different classification algorithms (like support vector machines and artificial neural networks) are planned to be integrated into the module. Again, these algorithms were optimized for the highest performance.

Spectral composite covering the study area (true colour composite).

Land Cover Map (Munich Metropolitan Area 2013)





Land Cover Map (Lake Garda 2013)

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