PhaenOPT – a regional satellite based phenological monitoring using web-based geo-processing and information services

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Abstract

Global satellite-based time series data has been available free of charge for many years and can be used for various environmental monitoring activities. The objective of this work is to develop, describe and monitor different climate impact indicators on a regular basis with satellite data linking in-situ measurements with satellite for vegetation phenology analyses. Therefore, a geo-processing and information service infrastructure has been developed to automate data download, processing, analysis, sharing and visualization.
Keywords: Phenology, Vegetation, Geoprocessing, OGC services, Webportal, Earth Observation

1 Motivation

The on-going climate change has multiple influences to the environment. Because of the rising annual mean temperatures, the first bloom of many plants is continuously shifted towards winter. Temporally changes of this climate impact indicator have negative effects, e.g. to the human health and to agriculture. To monitor the development of climate impact indicators the Thuringian parliament started a monitoring program in 2016.

The main objective of the joint research project "PhaenOPT" is to develop, describe and monitor different climate impact indicators on a regular basis with satellite data. Furthermore, we want to link in-situ measurements with satellite data, to implement remote sensing analyses in a federal state institute and to establish a web-based information service.

2 Data and methods

For our purposes, we use annual phenological in-situ observations of the German Weather Service (DWD) as well as satellite time series from the NASA MODIS sensor to study climate-induced changes of phenological parameters of plants. Therefore, we work with the MODIS long time series of the 250 m NDVI/EVI product (MOD/MYD13Q1) to develop a process chain, which extracts the annual cycle of these two vegetation indices. Towards the end of the project, we transfer the chain to Sentinel-3 (OLCI) data. We then apply the software TIMESAT (Jönsson and Eklundh, 2004) to the MODIS datasets to model the phenological parameters of the growing season (begin, end, duration) for each natural geographic unit of Thuringia and for each season since 2000.

To calibrate the parameters used in and verify the results of TIMESAT we apply the annual phenological point data of the DWD. This free available datasets are collected consistently with identical standards since the mid-20th century and are an indispensable basis for climate research. We interpolate the dataset to the extent of Thuringia by regression kriging using the package automap (Hiemstra et al., 2009) of the program language R. We also collect additional crowd sourced data from the smartphone application MySeasons to densify the existing phenological data basis.

The acquisition and processing of the data (in-situ observations as well as satellite data) have been automated and are provided in an operational processing chain leading to a web-based geospatial data infrastructure. Users are able to work with the resulting data in an interactive client and compare modelling outputs with in-situ observations without the need to process any data. Furthermore, this service for the Thuringian population will visualize direct impacts of the climate change to the environment.

3 Geoprocessing and information services

In order to simplify the access to the data archives of various satellite missions and to facilitate the subsequent processing, a regional and multi-source data and processing middleware has been developed. The aim of this system is to

provide standardized and web-based interfaces to multi-source time-series data for individual subsets (regions) on Earth. For further use and analysis, a uniform data structure and data format for the integrated datasets has been defined and implemented. Interfaces to the data archives of the sensors MODIS (NASA) as well as the satellites Landsat (USGS) and Sentinel (ESA) have been integrated the middleware system. Based on this, the middleware also offers the possibility to carry out various scientific algorithms on the pre-processed data, such as the calculation of trends and breakpoints of vegetation time-series data. Jupyter Notebooks are linked to the data and further processing and analyses can be conducted directly on the web server using Python and the statistical language R. Standard-based web services as specified by the OGC are provided for all functions of the middleware (data discovery, access, visualization, processing). The middleware system is developed as Python-based open source library, which can be installed on any server. Currently, the use of cloud services, such as Amazon Web Services, Google Earth Engine, is being researched and tested.

4 Conclusions

As a result of this project it is possible to process large-scale remote sensing data into information for specific phenological phases with an automated approach. Plant specific phenological phases are linked with NDVI/EVI thresholds of satellite data to directly obtain phenological information. We also derive long-term developments of climate impact indicators from the satellite time-series data.

References

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