Using of satellite data for evaluation and monitoring of forest ecosystems response on climate change in Slovakia

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Using of MODIS data for phenological observations with relation to climate change

Introduction
The main objective is a suggestion of system for continuous evaluation of forest ecosystems response on environment changes. The response is evaluated by biophysical and productive characteristics of forest ecosystems derived from satellite data from spectroradiometer MODIS. Times series of data from 2000 on, acquired in 1-day or in 8-day intervals, are analyzed for biophysical and productive characteristics. The forest compartment is the lowest forest management unit, to which information obtained from MODIS can be related. Forest compartment’s area (from 5 to 30 ha) approximately corresponds to area of MODIS pixel (6.25 ha in the most important red and infrared bands).

Forest phenology
Under the modelling of phenology of forest tree species is understood a prediction of main phenological events. The bases of the modelling is Normalised difference vegetation index (NDVI) modified by atmospheric correction.

Phenological curve is used for determination of beginning and end of cambial growth events. They are determined by derivations (from 1st to the 3rd order) and curvatures of the modelled curve. Phenological observations on monitoring plots serve for verification of hypothesis.

The example of modelling of NDVI curve during one year is shown. NDVI values were calculated from MODIS product for pure beech stand (Fagus sylvatica L.). The 6 parameter sigmoid curve is suitable for modelling of curve from beginning to the end of growing season and also autumn phenological phase.

Inter-annual variability during summer is not possible to investigate. Phenological curve is used as a basis for analysis of relation between NDVI curve and terrestrially observed phenophases. The aim of analysis is to define of phenophase events. NDVI database was the basis for analyses was prepared from period 2000-2005. A wider program of PP allows computer derivation of 1st and 2nd order from sigmoid function and then calculates extremes. These extremes are calculated for spring phase and autumn phase too. All outputs are calculated for all image points. Each output is produced in two forms. One is vigenus of sigmoid curve and the day corresponding to extreme values.

Data processing
Huge amount of input data required software automation. The process of Modis data acquisition was labour consuming, but later on it was automated by scripts in ArcGIS environment. Now download, preprocessing and clipping is done in one step.

The downloaded scenes need quality assessment. Scenes of poor quality were not downloaded. Scenes with radii taking out of the region were excluded, because their true spatial resolution is not guaranteed. Almost 40% scenes from 2000-2005 were downloaded from NASA server. Besides the visual quality assessment, the subpixels of quality were analyzed to allow quality assessment of measured radiation at pixel level.

A new software product “Phenological profile” was designed for estimation of parameters of phenological curve, its derivations and curvatures. All parameters are derived from NDVI values.

Another functionality of the software is that it allows to interpolate the value for the pixels that did not pass through the quality criteria, using NDVI values derived before and after the day with unobservable value.

Results
The project still continues. The solved problems are aimed at derivation of annual dynamics of Normalised difference vegetation index (NDVI) by using sigmoid curve and analysis of the curve course in relation to the observed phenophases. New software product “Phenological profile” was developed for modelling and interpretation of course of phenological curves.

The original MOD17 algorithm is parameterized for conditions of forest ecosystems in Slovakia as follows:
- Meteorological data from permanent land meteorological stations are used.
- PRI is calculated from real data obtained at the 15-minutes interval from AMRR (NDAA meteorological satellite). After the down-scaling and conversion into 8-day MODIS product is used for GPP computations.
- LAI and AER patterns is up-scalsed to 250 m resolution by NDVI maps. Data needed for derivation of LAI and vegetation parameters were acquired from long-term terrestrial measurements on monitoring plots.

Monitoring heath state of forest stands in Slovakia using Landsat and SPOT data

Introduction
The project is aimed at evaluation of health state of forest stands in Slovakia and the effects of disturbances. Web map application offers to users three levels of information on the spatial resolution from 10 to 30 m, namely:
- Actual satellite images distributed from USGS server and pre-processed for visualization of forest ecosystems in order to detect annually after events occurred.
- Combination of satellite images for two periods for simplification of visualization of changes of health state.
- LiDAR data can be combined with satellite images and expressed by the parameter of defoliation.

Web map application is widely used by government forestry administration and other users.

Visual comparison of two Landsat scenes
It is easy to prepare scenes, but identification of changes may be problematic for unmanned and users and spatial resolution is lower. It is technically possible to add a new scene to the web map application within tens of minutes after it was published by USGS agency. Low costs and full region coverage are further advantages of Landsat scenes.

Scenes contain channels in combination 4/5/3 – near infra-red, infra-red and red bands on satellite images.

Direct change identification
by composition of satellite scenes from two different periods. Creating the composition of SPOT and Aster scenes is usually finance, time and labour consuming, but enables easier identification of changes resulting from spuce decline and windbreaks. Composition will show the areas with change of state in red colours. Intensity of red colour depends on amplitude of change. Forest stands without changes are shown in green, blue or blue colours.

The evaluation of forest health condition
It is based on two-phase regression sampling (Bucha, 2003). This approach uses more precise ground assessment of trees defoliation for improvement of classification of forest condition from satellite images. It is based on Landsat ETM+ (with resolution 30 and 15 m res.) and SPOT (10 m) and Aster images (with resolution 15 m).

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