Conference Volume | **4th Symposium of the Hohe Tauern National Park for Research in Protected Areas** September 17th to 19th, 2009, Castle of Kaprun | pages 233-235

Detection and monitoring of vegetation patterns and borderlines in high mountain environments by using combined terrestrial and remote sensing methods in the Hohe Tauern National Park

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Summary

The GLORIA network collects ground-based, multi-site, long-term monitoring data since 1999 to document how changes in biodiversity and vegetation patterns correlate with climate change in the world's high mountain ecosystems (www.gloria.ac.at). To broaden GLORIA's basic multi-summit approach, this project will apply more terrestrial and remote sensing methods. All methods will be combined in order to use the synergetic effects of detailed information at a large scale as well as area-wide information at a smaller scale.

The proposed study site is located in the Hohe Tauern Range, Austria, which will serve as the first study site to realize this conception. A second study site is located in the Norwegian Scandes and is chosen to validate the innovative monitoring-concept.

Retrospective analyses of orthophotographs will reveal the previous development of the study regions. Current vegetation patterns and critical borderlines will be recorded by terrestrial vegetation mapping as well as by semi-automated classifications of very high resolution satellite data and aerial photographs. Furthermore transects with permanent plots perpendicular to the borderlines in question will be implemented. The results will be used for a sub-pixel classification of RapidEye data which provide very high temporal resolution. Phenological time series will be defined. Consequently, change detection will be accomplished to test the feasibility of the data for a monitoring system.

Thus, the concept should afford the monitoring of the changes in community distribution and altitudinal determined borderlines beyond the GLORIA summit areas and the processes involved.

Keywords

Remote sensing, very high resolution satellite data, QuickBird, RapidEye, subpixel classification, high mountain environment, vegetation monitoring, GLORIA network

Background and Objectives

High mountain environments are sensitive to climate change, because climate-related ecological factors become dominant with increasing altitude. Therefore, the effects of climate change may be more pronounced compared to ecosystems of lower altitude. A key aspect is the presence of narrow ecotones, where changes are significant over short distances. This may lead to rapid recognition of changes if boundaries shift – it also allows gradient studies within smaller areas. Reinvestigations of old "monitoring summits" in the Alps have shown that plants have migrated upwards during the 20th century. An increase of mean annual air temperature (MAAT) since the late 19th century is the most likely cause of this upwards shift (Pauli et al. 2005). Auer et al. (2002) report from a rising of the MAAT of 1.6°C since 1886 at the Hoher Sonnblick Meteorological station (3106 m a.s.l., 15km E of Hinteres Langtalkar) which is above the global average of 0.74°C (IPCC 2007).

The Global Observation Research Initiative in Alpine Environments (GLORIA) is a large-scale worldwide observation network for changes in mountain biodiversity and vegetations patterns. The initiative offers a long-term in-situ monitoring, based on network of standardized observation sites

in the world's high mountain environments (www.gloria.at). One GLORIA "Target Region" contains four summits of different elevation, which cover the major ecotones (subalpine / lower alpine, lower alpine / upper alpine, upper alpine / subnival, subnival / nival), or (in lower mountain ranges) at least a certain altitudinal gradient from the treeline ecotone upwards. The standardized sampling design consists of three different plot types arranged around each summit: Detailet vegetation recording, accurate cover estimations and frequency counts in $1m^2$ plots, a species list with coarse cover estimations for the whole summit area (upper 10m) and, since 2008, a modified frame pointing in $100m^2$ quadrats. Continuous measurements of the soil temperature are conducted to compare temperature and snow regimes (PAULI et al. 2005, PAULI et al. 2004).

In this project, GLORIA's basic multi-summit approach should be broadened: more terrestrial methods and remote sensing methods in addition will be applied combined in order to use the synergetic effects of detailed information at a large scale as well as area-wide information at a smaller scale. The new RapidEye data will be tested due to their feasibility in high mountain environments. By applying terrestrial and remote sensing methods parallel and in combination, new aspects regarding to content and methods are expected.

Study Area, Data and Methods

The proposed target region is located in the Hohe Tauern Range in the Alps, Austria, which will serve as the first study site to realize this conception. A second study site will be chosen in the Norwegian Scandes to validate the remote sensing part of the innovative monitoring-concept.

Satellite data (QuickBird, RapidEye), orthophotographs and digital elevation models (DEMs) will be used for investigations. Orthophotographs and QuickBird data provide very high geometric resolution, whereas the RapidEye system yields very high temporal resolution due to the constellation of five identical earth observation satellites which are capable of imaging any point on earth each day.

Table 1: Characteristics of the used satellite data

	QuickBird	**RapidEye**
Geometric resolution	0.6 m pan, 2.4 m multi-spectral	6.5 m
Bands	4 (vis & nir)	5 (vis & nir & red edge)
Dynamic range	16 bit	12 bit
Scene size	16.5 x 16.5 km	77-km-wide swaths extending at least 1,500 km in length
Revisit time	3 to 7 days	Off-nadir: daily; Nadir: 5,5 days

Retrospective analyses of orthophotographs and historical data will reveal the previous development of the target regions in order to estimate land use and climate impact. The current situation of vegetation patterns and borderlines will be recorded by terrestrial vegetation mapping (according to Braun-Blanquet) as well as by semi-automatic classifications of the QuickBird data. Subsequently, the terrestrial mapping will serve as validation for the semi-automatic classification. To investigate critical borderlines, transects with permanent plots perpendicular to the borderlines in question (treeline, upper vegetation limit, snow cover thresholds) will be implemented. The results will be used as basis for a sub-pixel classification of the RapidEye data. These data will be used to define phenological time series to find the best point in time to separate the classes of interest. Consequently, change detection will be used to test the feasibility of the data for this monitoring system.

Outlook

Thus, the concept should afford the monitoring of the changes in community distribution and altitudinal determined borderlines beyond the GLORIA summit areas. We expect to achieve very detailed information about vegetation patterns and the processes involved. Both, information and a tool set for including remote sensing in combination with and beyond GLORIA-methods will provide a basis for long-term vegetation monitoring. Summarized, in this project, a monitoring method will be developed by observing two target regions at three spatial and two temporal scales to provide information about changes in vegetation cover.

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