

Snow and Vegetation Monitoring in the Scandinavian Mountains

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Abstract

The monitoring of snow and vegetation in mountainous areas in Scandinavia are motivated from needs within climatic monitoring, hydrology, nature protection / management and resource management. We present our long time activities within satellite image based snow monitoring in Scandinavia, as well as more recent work in the field of vegetation mapping and monitoring of mountainous vegetation in Norway.

A set of daily products that are related to the metamorphosis and the melting of the snow cover has been developed. It comprises SCA (Snow Covered Area), SGS: Snow Grain Size, STS: (Snow Temperature at Surface) SSW (Snow Surface Wetness) and SDP (Snow distribution pattern) The SCA product are improved by combining cloud free parts of several acquisitions

Vegetation mapping and monitoring involves requires multi-temporal sets of imagery to cope with and take advantage of the phenological variations during the growth season.. This requires methods for time-alignment between scenes from different years. A contextual classification method that considers the phenological stages is presented. The application of the methods are the mapping of domestic animal feeding capacity of mountainous vegetation and the monitoring long-term vegetation changes in the mountains.

One significant and common problem for efficient monitoring and mapping from space is the cloud cover issue. The strategies we have developed to overcome this problem involves combination of several dataset. The approaches for the snow distribution pattern, as well as phenology alignment involves combinations of different spatial resolutions.

KEY WORDS: Scandinavia, snow and vegetation mapping, monitoring

1. Snow monitoring

The SCA product presents the Snow Covered Area from MODIS data. The snow cover area is represented as the snow cover fraction for each 250m MODIS cell, using a method originally developed from AVHRR (Solberg and Andersen 1994). The SCA product has been operational and is currently being delivered as a daily service to selected users by KSAT in Tromsø. The cloud cover problem can be reduced significantly by combining results from more than one acquisition or by combining results from optical and radar satellites (Solberg et al., 2004, 2006).

The Snow Grain Size (SGA) and Snow Temperature at Surface (STS) products are both related to the metamorphosis of the snow cover and may be used to predict the onset of snow-melting. The two products are estimated from MODIS 1km data. Several algorithms were tested for STS (Amlien and Solberg, 2003), and we selected Key's split-window algorithm (Key, 1997). SGS is represented by an index retrieved from MODIS bands 2 and 7: $SGS = (M7 - M2) / (M7 + M2)$ (Koren et al. 2004). One important restriction is that the two products can only be estimated when the snow cover is complete.

Snow surface wetness (SSW) is being estimated by analyzing the recent development of SGS and the current STS. Increasing SGS and STS near 0 °C is a clear indicator of wet or moist snow. It is also possible to identify where SCA have fallen below 100% and correct our SCA estimates (Koren et al 2006).

The snow distribution product differs from the SCA service in the way that it yields the snow cover as a binary mask, but with a much better geometric resolution. The product addresses the snow distribution pattern, and it was intended to utilize high-resolution scenes like Landsat to yield weekly or fortnightly snow distribution maps. Due to the cloud cover issue, such maps can only rarely be retrieved directly. We therefore estimate the current snow distribution pattern in an area by combining the SCA product from MODIS with an empirical snow distribution model based on snow masks retrieved from Landsat data.

2. Vegetation mapping and monitoring

In the classification and monitoring of vegetation it is essential to utilize the phenology of the vegetation to increase the separation between classes. However, this is also hampered by the lack of sufficient cloud-free acquisitions. Our solution is to use cloud-free data from several years in order to compose a multi-temporal dataset that represents the phenological variation during a season. Since these years may have phenological development schemes that varies in time, we developed a method that converts the actual acquisition time to a time that corresponds better to the actual phenological development

(Huseby et al. 1995). The method models the phenological development for the actual season by means of medium resolution data, like MODIS data.

In order to utilize the multi-temporal datasets for the classification we have developed a Hidden Markov Chain approach, which addresses the vegetation classes and a series of phenological stages through the season (Aurdal et al. 1985). The phenological stage for a given acquisition is not predefined, but is given as a prior probability to the Bayesian classifier. In training phase the spectral signature of each stage for each class must be estimated. In a pilot study we found that this approach had similar classification accuracies as a standard multi-layer approach, but it was much more robust in the sense that the training parameters could be applied for wider areas.

Vegetation resource mapping has been addressed in an ongoing work where we studied vegetation classes related to the feeding capacity for domestic animals, which are grazing in the lower mountainous areas. The work has confirmed the need to consider datasets that represents various phenological stages, in order to make more class separations. One particular problem related to the use of remote sensing data is that the grazing quality depends mostly on the understory vegetation, often hidden under trees and bushes. In general, some manual interpretation seems to be necessary, and thus data with high resolution. The grazing quality classes seem to be related to the more detailed subclasses in the vegetation nomenclature, which are not easily seen in the spectral signal alone. Terrain parameters like elevation aspect, curvature etc. have a potential, but remain to be examined.

The Norwegian landscape has changes significantly the last decades due to reduced use of the mountains and other marginal areas. Formerly open areas are now gradually closing up due to the establishment of bushes and trees. Monitoring these long-term changes are therefore an important issue. The basic idea behind the vegetation monitoring service is to consider the 'phenological time' of an incoming satellite image and then compare it with corresponding data from former acquisitions. Spectral changes in an area indicate possible changes in the vegetation there. Several uncertain indications during the service may confirm each other if they give similar results.

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