SATELLITE MONITORING OF DISTURBANCES IN ARCTIC ECOSYSTEMS

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1. ABSTRACT

This study explores the capability of satellite remote sensing to detect temporal changes in northern Fennoscandian regions through the application of a temporal model of surface bidirectional reflectance. Remote sensing offers the potential to monitor changes over large areas and at locations of difficult access. Specifically in remote Arctic locations, where ground surveys and aircraft observations are constrained by weather conditions and logistics, remote sensing provides a unique capability for repetitive and frequent sampling.

One of the main disturbances in mountain birch forests typical of northern Sweden and Finland is caused by outbreaks of defoliating insects such as the autumn moth (Epirrita autumnata) and the winter moth (Operophtera brumata). These outbreaks occur more or less cyclically every 9-10 years and attack mainly birch (Betula spp.) leaving a mosaic of open woodland within the forest [1]. It is expected that global warming will affect the incidence and the intensity of this outbreaks. The ecological and economical consequences can be severe hence the importance of a close monitoring of any shifts in the distribution of events. Defoliated areas of up to 6000 to 7000 ha of birch forest have been reported [2]. Severely affected areas could potentially be detected by satellite providing valuable data to understand the behavior, estimate the damage and predict the development of forest pests. Quantification of the impact of such outbreaks will also permit far more accurate estimation of the terrestrial carbon budget of such regions.

Other disturbance detected in Arctic regions are extreme and sudden winter warming events in which temperatures increase rapidly to above freezing, often causing snow melt across whole landscapes and exposure of ecosystems to warm temperatures [3]. These extreme and sudden winter warming events are among the most profound of climatic changes facing the Arctic and they might have severe consequences on the exposed vegetation. An analysis of snow cover could

The aim of this study is to analyse to capability of remote sensing to detect these disturbances and to develop an operational change detection algorithm. We use both long term coarse resolution NDVI series and shorter term higher spatial resolution (500m) surface reflectance data over the Fennoscandian area.

The algorithm must detect sudden changes in the surface bidirectional reflectance distribution function (BRDF) which are indicative of a loss of vegetation, in our case the loss of foliar biomass caused by the moth caterpillar activity. In the case of the warming extreme events we look for winter snowmelt events followed by a decrease in vegetation index values during the growing season.

Ideally, to successfully apply these algorithms, the surface state should remain static prior to any disturbance which is being sought. Dealing with deciduous forest this condition can only be accomplished working over a sliding window of a couple of weeks (unless some concept of phenology is included in the model). A further complication is the potential scarcity and sparseness of data available due to cloud cover. To tackle these problems we use data of both Terra and Aqua satellites in order to have as many samples as possible. The incorporation of BRDF effects in the algorithm [4] allows us to use reflectance data obtained on different days and under different geometries. Data can be unavailable for several days due to cloud cover, and natural phenological changes occurring during these periods would be detected as disturbances by the algorithm. To prevent this the algorithm must be able to account for underlying changes that can be due to vegetation phenology, as done in [5] by adding a kernel to the BRDF model.

The methodology here proposed represents a new approach to monitor forest damage by pest insects, which is valuable in climate change, ecology and economic studies. This work also exemplifies a new insight in the optimal use of satellite data at northern latitudes where atmospheric conditions limit the availability of useful data.

2. REFERENCES

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