

Remote Sensing based modelling of the terrestrial carbon cycle of Europe

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Abstract

Using simulation models on terrestrial carbon cycling is an important way to get sufficient insight into impacts of climate change. Remote Sensing (RS) techniques have been used to develop an operational method to derive Net Primary Production (NPP) data for European ecosystems. The method has been developed on the concept of finding so-called fingerprints of photosynthetic activity of different ecosystems. Normalized Difference Vegetation Index (NDVI) values from satellite images were used to calculate NPP values of these ecosystem per grid cell of 20x20 km². In a later phase, the methodology will be applied to a grid cell size of 1x1 km² and the results will be implemented in the terrestrial carbon submodel of IMAGE-2.

1. INTRODUCTION

The increase of CO₂ is the product of a series of interactions between terrestrial ecosystems, oceans, atmosphere, and human activities. As a result of changes in land use, e.g. by urbanization, the terrestrial carbon cycle will be disturbed, and as a consequence climate change will be influenced. Reversely, climate change will influence net primary production of ecosystems, and this might lead to changes in natural vegetation patterns [1].

A methodology has been developed on the application of RS-techniques to obtain data of biomass by NDVI-values [2]. It

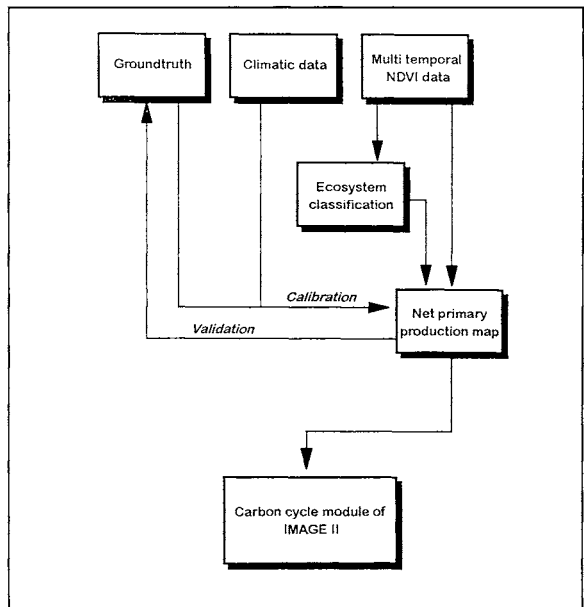


Figure 1. Overview of the method

has been shown that these NDVI-values could be used to determine stocks of carbon in ecosystems, which is important to calibrate carbon cycling models on terrestrial ecosystems.

Carbon cycling models are used to obtain better insight into impacts of climate change. However, these type of simulation models can only be calibrated with crude estimations for net primary production. Within the framework of the non fossil carbon cycle, these net primary production data determine the reliability to forecast effects of climate change to great extent. This problem occurs especially extrapolating small scale effects to regional areas. RS-techniques can be used to estimate photosynthetic activity *q_p* NPP.

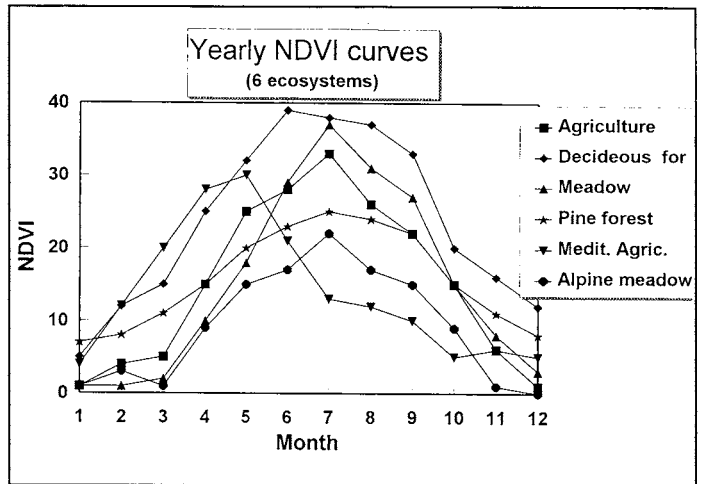


Figure 2. Yearly NDVI curves of 6 ecosystems.

The aim of this RS project is to develop an operational methodology to derive NPP estimates for European ecosystems using satellite images, preferably from NOAA, to calibrate carbon cycling models, such as in IMAGE-2. For this, the study has been focused on the classification of satellite images to determine the spatial distribution of different ecosystems and on the determination of a possible relationship between NDVI values and NPP.

2. CLASSIFICATION

The terrestrial carbon submodel of IMAGE-2 is based on a grid cell raster which covers the whole earth. One of the characterizations of each grid cell is its land cover type. In this submodel, 17 main ecosystems are defined. Remote sensing techniques can be used to determine NDVI values in relation to NPP rate, because these values are characteristic for the photosynthetic activity.

The analysis of the curves of the multi temporal NDVI values throughout the year per land cover type showed the typical characterization of the different land cover types. As an example, NDVI curves of different ecosystems in Germany are shown in Figure 2.

A comparison of NDVI curves of the same type of ecosystems in other regions of

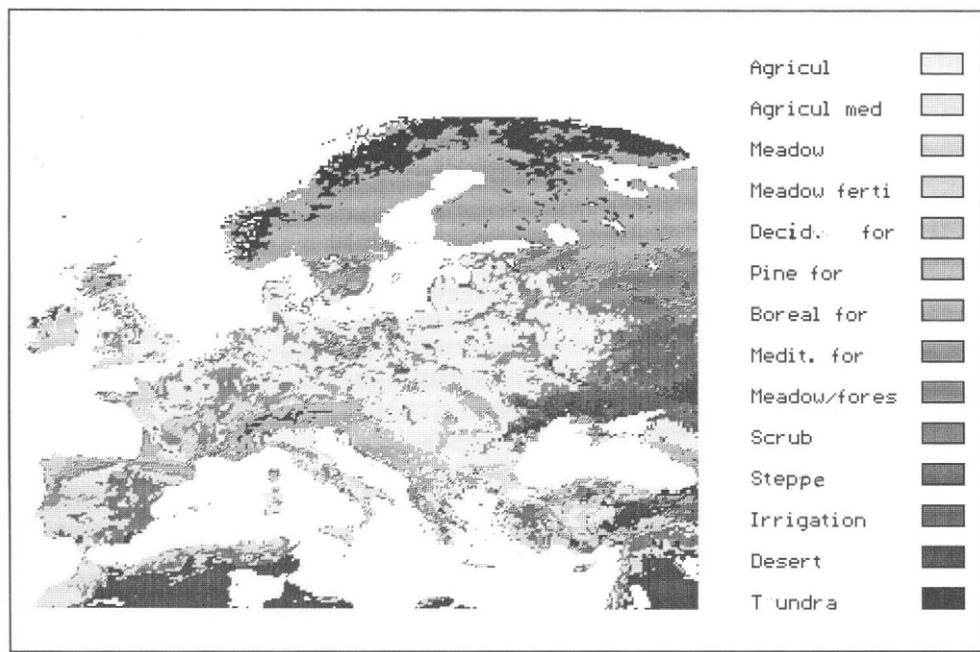


Figure 3. Classification of 14 defined ecosystems in Europe.

western Europe show similar results. In combination with so-called training sites, the different ecosystems are classified using bi-weekly NDVI values [3]. The preliminary results of the 20x20 km² ecosystem map of western Europe are shown in Figure 3.

3. NET PRIMARY PRODUCTION

An analysis on the relationship between annual cumulative NDVI and annual production was performed for different sites in Europe. From these results, a significant relationship was shown between NDVI and NPP. However, it was also shown that this relation differs for different regions. For this climatic data were used to adjust the NPP values. The results are shown in Figure 4.

The results of the annual NDVI values for various ecosystems in different regions in Europe are in agreement with the expectations. For example fertilized meadows always have a relatively high NPP, as a result of an elongated growing season due to a high nutrient availability.

4. CONCLUSIONS

The results of this study show the applicability of Remotely Sensed data to determine the spatial distribution of NPP of the defined ecosystems in Europe. Different methods have

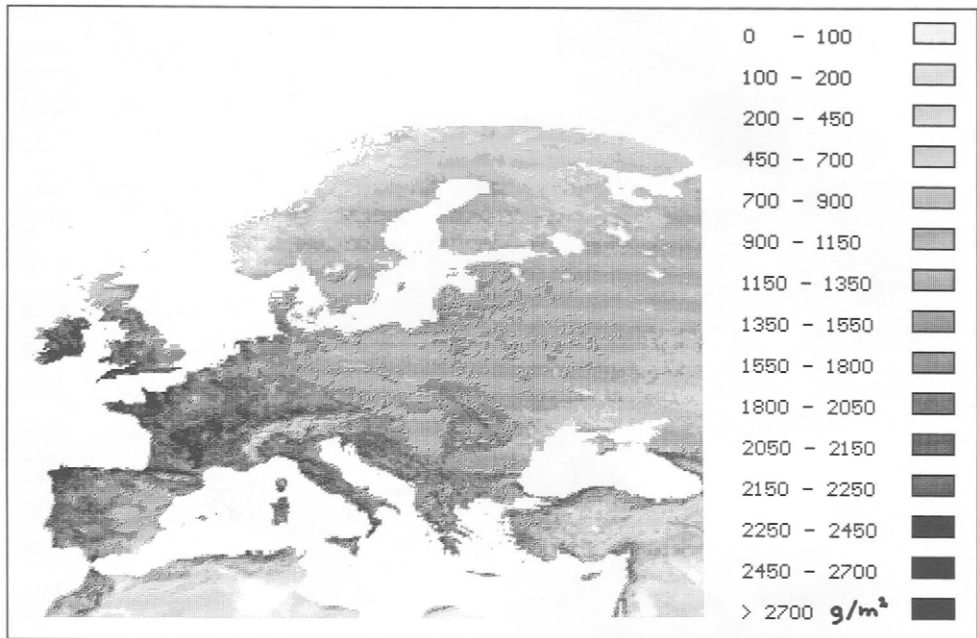


Figure 4. Map of net primary production of different ecosystems.

been tested to obtain good results within certain reliability limits. The most reliable method turned out to be a combination of a supervised classification with training sites and an unsupervised classification. The results will be validated and implemented in the terrestrial carbon submodel of IMAGE-2 in a further phase of this project.

5. ACKNOWLEDGEMENTS

This study has been commissioned by the Dutch Remote Sensing Board (BCRS), project no. NRSP-2 4.2/TO-08.

6. REFERENCES

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