PROJECT INFORMATION

Project title: Taking a remote look at canopy nitrogen to improve global climate models

Project ID: 84

Contact person: Yasmina Loozen (y.m.a.loozen@uu.nl)

PROJECT DESCRIPTION

Understanding the role of terrestrial ecosystems in removing carbon dioxide (CO_2) from the atmosphere is a fundamental challenge to predict future changes in earth climate. For example, forests are an important carbon sink taking up an estimated 30% of carbon emissions (Churkina *et al*., 2009; Schulze, 2006). The drivers behind this process are still debated but the nitrogen (N) cycle is likely to play an important role as N is a limiting resource for plant growth (Smith *et al*., 2002).

Including N cycle in modeling approaches is thus essential to accurately predict C storage. To achieve this, indicators of N cycling, such as foliar N content are necessary. Foliar N is widely used in ecosystems models (Ollinger and Smith, 2005; Smith *et al*., 2001; Zaehle and Friend, 2010) and plays a fundamental role in the processes of photosynthesis and NPP (Ollinger *et al*., 2008; Reich, 2012; Smith *et al*., 2002). However, data availability within the N cycle is limited and N cycle data is lacking at a global scale.

Optical remote sensing has the potential to provide these foliar N estimations globally. Foliar N has already been studied with remote sensing at local and regional scale (Huang *et al*., 2004; Huber *et al*., 2008; Kokaly *et al*., 2009; Ollinger *et al*., 2008; Schlerf *et al*., 2010). We propose a method to estimate foliar N globally with remote sensing products, calibrated with large global plant trait databases.

The remote sensing products used in our analyses are Meris-Envisat records, which provide high temporal global images with strategically placed spectral bands in the red-edge region, which allows the computation of the MERIS terrestrial chlorophyll index (MTCI) for the estimation of vegetation chlorophyll and N-content (Dash and Curran, 2007). The use of the red-edge region to estimate canopy N was highlighted by imaging spectroscopy studies (Huang *et al*., 2004; Huber *et al*., 2008; Schlerf *et al*., 2010). MTCI proved to be successful at estimation of physiological processes like GPP and carbon fluxes estimation (Boyd *et al*., 2012; Harris and Dash, 2010; Peng and Gitelson, 2011) as well as chlorophyll and leaf N concentration (Tian *et al*., 2011).

Analyzing the relationship between MTCI and field measured foliar N from the TRY database (Kattge *et al*., 2011) has already yielded promising preliminary results. Foliar N data from ICP Forests will provide us with the opportunity to increase the European coverage of our foliar N data analysis. Moreover, the homogeneity in measurements standards within ICP Forest foliar chemistry data assures us of the high quality of the data. In the try database, on the contrary, every contributor has its own sampling and measurement method, which increases the disparity among the data. Being able to carry out our analysis with ICP Forest foliar chemistry records will thus allow us to calibrate the relationship between foliar N and remote sensing products more accurately.

The analyses will be carried out at European scale and will consist of both a linear and a multiple regressions. The multiple regression analysis will include, apart from foliar nitrogen and MTCI, environmental variables, such as temperature, precipitation, soil types and elevation and LAI.

The obtained global foliar N maps could then be assimilated into LPJ-GUESS, a Dynamic vegetation model which includes the key biogeochemical and biophysical processes and feedbacks between the C and N cycles.

This study is funded by NWO the Netherlands Organization for Scientific Research as a four years PhD project: NWO ALW-GO-AO/14-12.

References

Boyd, D. S., Almond, S., Dash, J., Curran, P. J., Hill, R. A. & Foody, G. M. (2012). Evaluation of envisat MERIS terrestrial chlorophyll index based models for the estimation of terrestrial gross primary productivity. IEEE Geoscience and Remote Sensing Letters 9(3): 457-461.

Churkina, G., Brovkin, V., Von Bloh, W., Trusilova, K., Jung, M. & Dentener, F. (2009). Synergy of rising nitrogen depositions and atmospheric CO2 on land carbon uptake moderately offsets global warming. Global Biogeochemical Cycles 23(4).

Dash, J. & Curran, P. J. (2007). Evaluation of the MERIS terrestrial chlorophyll index (MTCI). Advances in Space Research 39(1): 100-104.

Harris, A. & Dash, J. (2010). The potential of the MERIS Terrestrial Chlorophyll Index for carbon flux estimation. Remote Sensing of Environment 114(8): 1856-1862.

Huang, Z., Turner, B. J., Dury, S. J., Wallis, I. R. & Foley, W. J. (2004). Estimating foliage nitrogen concentration from HYMAP data using continuum removal analysis. Remote Sensing of Environment 93(1-2): 18-29.

Huber, S., Kneubühler, M., Psomas, A., Itten, K. & Zimmermann, N. E. (2008). Estimating foliar biochemistry from hyperspectral data in mixed forest canopy. Forest Ecology and Management 256(3): 491-501.

Kattge, J., et al., (2011). TRY - a global database of plant traits. Global Change Biology 17(9): 2905-2935.

Kokaly, R. F., Asner, G. P., Ollinger, S. V., Martin, M. E. & Wessman, C. A. (2009). Characterizing canopy biochemistry from imaging spectroscopy and its application to ecosystem studies. Remote Sensing of Environment 113(SUPPL. 1): S78-S91.

Ollinger, S. V., Richardson, A. D., Martin, M. E., Hollinger, D. Y., Frolking, S. E., Sc, P. B., Plourde, L. C., Katul, G. G., Munger, J. W., Oren, R., Smith, M. L., Paw U, K. T., Bolsta, P. V., Cook, B. D., Day, M. C., Martin, T. A., Monson, R. K. & Schmid, H. P. (2008). Canopy nitrogen, carbon assimilation, and albedo in temperate and boreal forests: Functional relations and potential climate feedbacks. Proceedings of the National Academy of Sciences of the United States of America 105(49): 19336-19341.

Ollinger, S. V. & Smith, M. L. (2005). Net primary production and canopy nitrogen in a temperate forest landscape: An analysis using imaging spectroscopy, modeling and field data. Ecosystems 8(7): 760-778.

Peng, Y. & Gitelson, A. A. (2011). Application of chlorophyll-related vegetation indices for remote estimation of maize productivity. Agricultural and Forest Meteorology 151(9): 1267-1276.

Reich, P. B. (2012). Key canopy traits drive forest productivity. Proceedings of the Royal Society B: Biological Sciences 279(1736): 2128-2134.

Schlerf, M., Atzberger, C., Hill, J., Buddenbaum, H., Werner, W. & Schüler, G. (2010). Retrieval of chlorophyll and nitrogen in Norway spruce (Picea abies L. Karst.) using imaging spectroscopy. International Journal of Applied Earth Observation and Geoinformation 12(1): 17-26.

Schulze, E. D. (2006). Biological control of the terrestrial carbon sink. Biogeosciences 3(2): 147-166.

Smith, B., Prentice, I. C. & Sykes, M. T. (2001). Representation of vegetation dynamics in the modelling of terrestrial ecosystems: Comparing two contrasting approaches within European climate space. Global Ecology and Biogeography 10(6): 621-637.

Smith, M. L., Ollinger, S. V., Martin, M. E., Aber, J. D., Hallett, R. A. & Goodale, C. L. (2002). Direct estimation of aboveground forest productivity through hyperspectral remote sensing of canopy nitrogen. Ecological Applications 12(5): 1286-1302.

Tian, Y. C., Yao, X., Yang, J., Cao, W. X., Hannaway, D. B. & Zhu, Y. (2011). Assessing newly developed and published vegetation indices for estimating rice leaf nitrogen concentration with ground- and space-based hyperspectral reflectance. Field Crops Research 120(2): 299-310.

Zaehle, S. & Friend, A. D. (2010). Carbon and nitrogen cycle dynamics in the O-CN land surface model: 1. Model description, site-scale evaluation, and sensitivity to parameter estimates. Global Biogeochemical Cycles 24(1): GB1005.