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Biogeosciences
Discussions

Interactive comment on "Thermal-based modeling of coupled carbon, water and energy fluxes using nominal light use efficiencies constrained by leaf chlorophyll observations" *by* M. A. Schull et al.

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This study offers two important advances on the traditional LUE model. One is the integration of carbon and water vapor fluxes in a single model, and this combined approach could be very useful. The second is the parameterization of a variable LUE based on chlorophyll content. The paper demonstrates the benefit of a variable LUE over that of an assumed fixed LUE. The study is well-grounded in a history of similar modeling with the TSEB approach, and takes advantage of a good dataset from the Mead site. The work appears sound and the paper is generally well-written.

Specific comments

One topic possibly worth discussing would be the functional role of [chl] in influencing LUE. As is, chlorophyll appears as a model "black box" with little explanation of mechanism (even if the mechanism seems obvious). How does this finding relate to a growing body of literature relating seasonally changing pigment ratios (chl:carotenoid ratios) and LUE? A brief explanation of the functional role of pigments seems warranted. For example, are pigments drivers of the LUE response, or are they the end result (e.g. via low N and subsequent senescence)? A bit more discussion of potential mechanism, even if minimal and speculative, could be useful in linking to other LUE model approaches. Since there is lots of recent literature on pigment ratios in the context of LUE, some linkage to that literature might be a useful starting point.

Author response:

We thank the reviewer for his/her valuable input and we agree that the manuscript would benefit by a description of the role of chlorophyll in the photosynthetic process and how it relates to LUE. We have added additional text to physically motivate the choice of chlorophyll as a link between optically based canopy inversion model output and the nominal LUE inputs required by the carbon/energy balance model. Please see the additions below.

Manuscript changes: We have added

Chlorophyll pigments absorb photosynthetically active radiation (PAR) and constitute a vital element in the photosynthetic machinery. Leaf chlorophyll is mechanistically linked to photosynthetic capacity (Houborg et al., 2013) through functional relationships with leaf nitrogen (e.g. Evans 1989; Schlemmer et al., 2013) and Rubisco (e.g. Theobald et al., 1998; Sage et al., 1987) that acts as a catalyst for carbon fixation within the leaf chloroplasts. These strong correlations make leaf chlorophyll an important control on vegetation productivity by serving as a proxy for the nominal efficiency of leaves in using the absorbed light for photosynthesis. The effective LUE will fluctuate in response to short-term changes in environmental conditions (e.g. temperature, humidity, wind speed), whereas the impact of variations in leaf chlorophyll will be more gradual as vegetation stresses are not immediately manifested in observations of leaf chlorophyll content (Houborg et al., 2011).

Evans, J., 1989. Photosynthesis and nitrogen relationships in leaves of C3 plants. Oecologia 78, 9–19.

Houborg, R., Cescatti, A., Migliavacca, M., Kustas, W.P., 2013. Agricultural and Forest Meteorology Satellite retrievals of leaf chlorophyll and photosynthetic capacity for improved modeling of GPP Meteorol. 177, 10–23. doi:10.1016/j.agrformet.2013.04.006

Sage, R.F., Pearcy, R.W., Seeman, J.R., 1987. The Nitrogen Use Efficiency of C3 and C4 Plants. Plant Physiol. 85, 355–359.

Schlemmer, M., Gitelson, A., Schepers, J., Ferguson, R., Peng, Y., Shanahan, J., Rundquist, D., 2013. Remote estimation of nitrogen and chlorophyll contents in maize at leaf and canopy levels. Int. J. Appl. Earth Obs. Geoinf. 25, 47–54. doi:10.1016/j.jag.2013.04.003

Theobald, J.C., Mitchell, R.A.C., Parry, M.A.J., Lawlor, D.W., 1998. Estimating the excess investment in ribulose-1, 5-bisphosphate carboxylase/oxygenase in leaves of spring wheat grown under elevated CO2. Plant Physiol. 118, 945–955.

Technical Corrections:

A couple difficult sentences needing attention on p. 14136: The sentence starting on line 15 seems to be missing something. For example, ", and seasonally..." would be clearer if it were revised slightly ("and that works seasonally. . .")

Author Response:

We agree with this observation and have changed this sentence to: The challenge for regional-scale carbon flux mapping using a LUE-based modeling system is to find a parsimonious yet robust means for specifying LUE spatially across the modeling do-

main for different landcover types, and seasonally in response to changing phenology and plant stress conditions.

Reviewer comment:

In the sentence starting on line 20: insert "and" before "therefore"

Author Response:

We agree. This sentence has been changed to: Changes in canopy chlorophyll are recognized to be sensitive to vegetation stress, crop phenology and photosynthetic functioning of the vegetation, (Gitelson, Viña, Ciganda, Rundquist, & Arkebauer, 2005; Ustin, Smith, Jacquemoud, Verstraete, & Govaerts, 1999; Zarco-Tejada, Miller, Mohammed, Noland, & Sampson, 2002) and therefore can be related to GPP.

Reviewer comment:

On p. 14147, the term "canopy assimilation of NEE" seems redundant. NEE (or canopy assimilation) alone tells the story here.

Author Response:

We agree that there is an apparent redundancy here and have changed the sentence to: At these times, the canopy assimilation is small and optimization of β_n using measured Ac is not as reliable.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/11/C8243/2015/bgd-11-C8243-2015-supplement.pdf

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