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Biogeosciences Discussions

Interactive comment on "Remote sensing of ecosystem light use efficiency with MODIS-based PRI – the DOs and DON'Ts" *by* A. Goerner et al.

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This paper explores the potential for a universal PRI and LUE model formulation using MODIS. The study compares various LUE models formulations by varying the PRI reference band, sensor look angle, FAPAR calculation, and several derivations of LUE for a range of contrasting ecosystems. A novel and particularly revealing aspect of the work is the comparison of the conventional MODIS LUE (MOD17) against LUE optimized for local meteorology ("optimized MOD17) and LUE derived from MODIS PRI. MODIS PRI is further explored by varying the PRI reference wavelength and the sensor look angle (binning into MODIS view angle categories). The study represents an outstanding application of an experimental approach to remote sensing, which is sorely needed.

Many of the findings appear novel. A few findings appear to contradict other published studies, for example, publications showing the 550 nm region to be a good reference band at the whole-stand scale (Gamon 1992, Middleton et al. 2010), and other studies showing the value of off-nadir view angles for optimal PRI retrieval (many studies, including those by Hall, Hilker, Drolet cited in the manuscript). Since there is no clear consensus on these issues yet, this study adds valuable insights to these topics, and a bit further discussion of these topics may be warranted. Other findings are consistent with previous publications that show a strong confounding effect of seasonally changing greenness, canopy or stand structure on PRI, indicating that the component of PRI related to PSII LUE (the xanthophylls cycle) is often heavily confounded by seasonal shifts in pigments pool sizes (see Stylinski et al. 2002). When sampling complex landscapes, PRI can be heavily confounded by spatial or temporal variation in green vegetation cover or structure as shown in figure 5. All of these effects appear may well be present to varying degrees for the ecosystems sampled in this study, and further discussion of these confounding effects seems in order, given the strong link with FAPAR found for several sites (figure 5). Not surprisingly, these effects appear particularly strong for MODIS band 1 (the red band); previous studies (e.g. Gamon et al. 1992) indicate the green reference band (550 nm, close to MODIS Bands 4 & 12) best corrects for these confounding effects, and that other reference bands are often more confounded by varying green canopy structure. Clearly, this is a complex issue, but one that deserves further discussion and links to previous work on the topic of the “best” MODIS band. Regarding the link between PRI and FAPAR for seasonally greening ecosystems (ZA-Kru and US-MMS), the recent review paper by Garbulsky et al. 2010 may be instructive.

Note that the original PRI formulation in the paper cited (Gamon et al. 1992) used 550 nm as the primary reference band for these reasons. Later studies noted that for leaf-level reflectance, 570 nm appeared to be the best reference band. For this reason, 570 nm has been picked up as the “standard” reference band, but there is little compelling evidence that this is a suitable band for MODIS PRI. In fact other more recent studies

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(Middleton et al . 2009 cited in this manuscript) also noted that 550 nm appeared to be a good reference band, as found at some of the sites in this study. This manuscript adds additional insight into the topic of "best" PRI formulations, and further discussion is warranted.

The manuscript provides a nice summary of the challenges and promises of a LUE based on remote sensing, and it is clearly a valuable addition to the literature, particularly because of its exhaustive exploration of bands, angles, ecosystems, and LUE formulations. Few remote sensing studies ever attempt such a comparative approach, and the authors should be applauded for such an ambitious and comprehensive piece of work!

Minor issues & technical corrections:

Beyond the comments above, there are several minor issues that deserve attention:

The last part of the title ("-the DOs and DON'Ts") doesn't clearly fit the contents or presentation, and could probably be dropped.

Abstract, line 7 (and p. 6939 – the use of the term "efficiency" is confusing. Perhaps "effectiveness" would be a clearer term here.

Abstract, line 10 - "dependance" (with an a) should be spelled "dependence" (with an e).

Introduction, p6937 - From remote sensing, several other LUE formulation options exist, including those based on indices of surface temperature or moisture. A brief mention of these other possibilities seems in order.

Introduction, p. 6938 – "aircrafts" should be replaced by "aircraft sensors" since it is really the sensors doing the sensing (not the plane).

Introduction , p. 6938 – "hesitation" to evaluate a LUE model based on MODIS PRI is probably more an issue of "difficulty" (getting the data and doing the work). Many

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people have considered this kind of study, but have fallen short due to difficulties with data access.

Introduction , p. 6938 – in addition to being "widely apart," coverage of multiple sites represent varying structure and view angle, all of which add considerable complexity to the problem.

Introduction (last sentence) – The statement ". . .we try to comprehensively evaluate the aspects of a PRI-based LUE estimation" is vague – which aspects exactly? - Please list or explain.

Page 6939 – isn't Kruger a subtropical (not a tropical) location?

Page 6940 – "Ready-made faPAR products are known to differ" – from what? From each other? (Please clarify).

Page 6941 & 6944 (and elsewhere)- The issue of sensor angle remains unclear because it is not defined relative to sun position. Without this information, it is difficult to judge the significance of the angle binning results.

Page 6945 – The explanation for why ZA-Kru has the strongest deviation from the 1:1 (LUE-LUE) LUE line is not entirely clear.

Page 6946 – the fact that different sites have different optimal PRI reference bands probably reflects the different canopy structures (see above).

Page 6948 – A similar comment can be applied to the discussion of structure on PRI (the review of Garbulsky et al. 2010 might be helpful here).

Page 6950 – indices of surface temperature or vegetation water content, available from certain sensors, might provide useful alternatives to PRI for LUE.

Page 6951 – The statement that "It is unclear whether a satellite-derived PRI with a reference band at 570 nm , as favored for hand-held and air-borne sensors, ..." neglects the history of the evolution of the PRI formulation summarized above, which

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actually began with a green reference band close to MODIS band 12. 570 nm was subsequently derived with leaf-level measurements in mind. Consequently, the choice of "best" reference band for MODIS remains an open issue, and this study clearly adds to the story!

Page 6952 – "Dependant" (with an "a") should be dependent (with an "e").

Page 6952 – The ending of the paper might benefit from some suggestions on next directions.

Reference cited:

Garbulsky MF, Peñuelas J, Gamon JA, Inoue Y, Filella I. (2010) The Photochemical Reflectance Index (PRI) and the remote sensing of leaf, canopy and ecosystem radiation use efficiencies; a review and meta-analysis. Remote Sensing of Environment. doi:10.1016/j.rse.2010.08.023

Stylinski et al. (2002)Seasonal patterns of reflectance indices, carotenoid pigments, and photosynthesis of evergreen chaparral species. Oecologia, 131(3):366-374 doi:10.1007/s00442-002-0905-9.

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