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Biogeosciences
Discussions

Interactive comment on "Cajander larch (*Larix cajanderi*) biomass distribution, fire regime and post-fire recovery in northeastern Siberia" *by* L. T. Berner et al.

L. T. Berner et al.

lberner@whrc.org

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General Comments:

1. "The article "Cajander larch (Larix cajanderi) biomass distribution, fire regime and postfire recovery in northeastern Siberia" is an excellent body of work showing how data from different spatial resolution satellite sensors can be used to scale up information on the relationship between tree shadows and above ground biomass to examine issues of climate change."

REPLY: We would like to thank AR2 for their valuable feedback on the manuscript and, in particular, to the attention paid to the biomass mapping component of our study.

2. "While I like the approach presented in this paper, I was curious as to how sun angle variation and snow depth may have influenced AGB estimates among the WorldView-1 models. If this potential source of model error was assumed negligible, some explanation as to why is warranted."

REPLY: This is a very good observation that warrants further clarification in the manuscript. We inserted the following text into the methods section starting on line 11 of page 7561:

"On the day that the WorldView-1 images were acquired, snow depth near Cherskii was approximately 56 cm (Davydov, unpublished data)."

We also inserted the following text into the methods section starting on line 9 of page 7564:

"The impact of variations in sun angle on TSFWV was assumed to be minimal since the WorldView-1 images were all acquired on the same day at local noon and since Leboeuf et al. (2007) showed that normalizing TSF based on sun and sensor geometry had a non-discernible impact on the relationship between TSF and field biomass measurements. The effect of variations in snow depth on TSFWV were also assumed to be negligible due to the minimal topographic relief in the area."

References: Leboeuf, A., Beaudoin, A., Fournier, R., Guindon, L., Luther, J., and Lambert, M.: A shadow fraction method for mapping biomass of northern boreal black spruce forests using QuickBird imagery, Remote Sensing of Environment, 110, 488-500, 10.1016/j.rse.2006.05.025, 2007.

3. "Also, I was curious as to why winter Landsat-5 data were not used to scale up WorldView-1 AGB estimates? Models presented here relate TSF-WV to AGB and then AGB to summer Landsat-5 data. Models making use if winter Landsat-5 data would have outperformed that of summer Landsat-5 models. The key is the benefit of snow cover, which hides potentially confounding spectral signatures related to

variable ground vegetation and moisture status. Adding a section about choice of summer Landsat-5 data over winter (with snow cover) data should be mentioned; with an acknowledgement that research has shown that winter Landsat-5 data has produced more accurate estimates of AGB compared to those calibrated with summer Landsat-5 data."

REPLY: We fully agree with the referee's comment that mapping AGB using Landsat-5 imagery acquired during winter would have been preferable to using imagery acquired during summer due to the snow-masking effect on non-tree vegetation. Unfortunately, we were unable to find winter imagery from Landsat-5 through either the USGS (http://glovis.usgs.gov/) or NASA (http://reverb.echo.nasa.gov/). We inserted the following text starting on page 7561 at line 17:

"Though mapping AGB using Landsat imagery acquired during periods with snow cover has yielded better results than using snow-free images (Wolter et al. 2012), we were unable to find winter imagery of our study area through either the USGS (http://glovis.usgs.gov/) or NASA (http://reverb.echo.nasa.gov/) and therefore used images acquired during summer."

Reference: Wolter, P. T., Berkley, E. A., Peckham, S. D., Singh, A., and Townsend, P. A.: Exploiting tree shadows on snow for estimating forest basal area using Landsat data, Remote Sensing of Environment, 121, 69-79, 10.1016/j.rse.2012.01.008, 2012.

4. "Also, references were made to non-tree vegetation (herbaceous and woody brush). Shadow contributions from woody brush can have substantial influences on total shadow fraction, which will vary according to snow depth. Again, what was the snow depth and what were the impacts on model calibration?"

REPLY: This is an important point of discussion that we did not adequately address in the current version of the manuscript. We insert the following text on page 7575 at line 14:

"Comparison of the WorldView-1 images with digital photographs taken across the study area revealed that when the WorldView-1 images were acquired snow tended to mask much of the low stature birch and willow shrub cover found in upland forests, while in some riparian areas tall willow and alder protruded above the snow. Though many of these tall riparian shrubs were excluded from the analysis as part of our liberal water mask, in some instances the shadows generated by these shrubs were included in the tree shadow maps. This likely lead to an over estimation of larch AGB in riparian areas. Additional work is needed to understand the contribution of shrubs to carbon pools in this region."

5. "Much of the work in the paper hinges on accurate estimation of fire age from the interpretation and or timing of satellite images. As the authors have stated, recent fires in boreal landscapes produce unique multi-spectral signatures in the visible, near infrared, and short-wave infrared regions of the electromagnetic spectrum and that such signatures become decreasingly detectable over the course of $\sim$six years. After six years, stand-replacing disturbance is not spectrally distinguishable as that of fire. I was curious as to why attempts were not made using the n=25 field plot data to link tree ring data of "surviving trees" to the fire origin of spectrally ambiguous disturbance patches that were beyond the stated 6-year mark in age? With such tree ring data, one could have developed empirical regression equations to relate disturbance age to multi-temporal vegetation progression signatures using Landsat-5 data to better estimate disturbance origin among older fire scars...even if the Landsat archive was spotty. This, of course, assumes that fire is the dominant stand-replacing disturbance agent in this region."

REPLY: This is a very interesting suggestion that warrants investigation, but is beyond the scope of the current manuscript. One possible issue with this approach is that at a given stand age, tree density and aboveground biomass can vary quite widely (Alexander et al. 2012). This variation might make it challenging to identify a unique spectral signature for a given stand age. In future research, we will consider how these

and additional tree ring data sets might be used to map the age of older fire scars.

Reference: Alexander, H., Mack, M., Goetz, S., Loranty, M., Beck, P., Earl, K., Zimov, S., Davydov, S., and Thompson, C.: Carbon Accumulation Patterns During Post-Fire Succession in Cajander Larch (Larix cajanderi) Forests of Siberia, Ecosystems, 1-18, 10.1007/s10021-012-9567-6, 2012.

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