Interactive comment on "Estimating spatial variation in Alberta forest biomass from a combination of forest inventory and remote sensing data" by J. Zhang et al.

J. Zhang et al.

zjian@ualberta.ca

Reply to anonymous Referee #1

RESPONSE: We are grateful for your comments. We carefully considered every comment from both reviewers in our revision, and we believe that the manuscript is now much improved. See below for our point-to-point responses (text in blue type).

This paper "Estimating spatial variation in Alberta forest Biomass from a combination of forest inventory and remote sensing data" makes a very good contribution to the task of quantification biomass over a huge territory. The manuscript is a well-written paper focused on spatial estimation of biomass. The use of four approaches to measuring and modeling biomass is a very interesting work. The use of almost 2000 plots and available LIDAR data for quantify biomass is very impressive. The strengths of the study are that it (1) makes use of a huge available data base from PSP and ABMI plots in Alberta, (2) quantification of biomass is evaluated comprehensively across a diversity of ecosystem-level, and (3) the impact of climatic variables were correlated with the biomass estimation.

RESPONSE: Thanks for the positive response.

I have several comments listed below, which some are not rather easy to deal with in a course of a minor revision. 1) Estimating biomass is difficult due to the use of many plots (where localization and representativeness of all different conditions and species have a major role) and LIDAR on quite large scale, which must deal with uncertainty (quantifiable). The essence of the problems is quantify bias and errors when changes in canopy height distribution could be affected by other environmental (eg. slope, aspect, hydrology) and ecological (eg. species) properties. The authors could read the work of Næsset and Gobakken, 2008; Naesset et al 2009 - 2011 and Disney et al., 2010 to take into account effects of canopy height estimation derived from LIDAR.

RESPONSE: We agree that one important part of biomass estimation is to deal with uncertainty. We used three error statistics (MAE, RMSE, and NRMSE) and R^2 on assessing model accuracy for our current study (see Section 2.3.5 Model accuracy assessment and Table 2). RMSE was used in the recommended paper (Næsseta et al. 2011) by the reviewer, and R^2 was used in another recommended paper (Næsseta & Gobakken 2008) by the reviewer.

Reference:

Næsset, E., Gobakken, T., Solberg, S., Gregoire, T. G., Nelson, R., Ståhl, G., & Weydahl, D. 2011. Model-assisted regional forest biomass estimation using LiDAR and InSAR as auxiliary data: A case study from a boreal forest area.Remote Sensing of Environment, 115(12), 3599-3614.

Næsset, E., & Gobakken, T. 2008. Estimation of above-and below-ground biomass across regions of the boreal forest zone using airborne laser. Remote Sensing of Environment, 112(6), 3079-3090.

2) Error is my principal concern in this manuscript. I have several questions that need more details; a) what is the error on localization of dataset? And what is the quantitative impact of this in the biomass calculation? b) Which is the margin of error for different data sources (eg. ground plots + LIDAR + cover map).

RESPONSE:

For permanent sampling plots (PSPs), we used recorded GPS locations of each plot, and deleted the plots without accurate geographic locations. For the plots from ABMI (Alberta Biodiversity Monitoring Institute), the public geographic coordinates of all the plots were used because the ABMI hides their sampling locations to ensure future access and representativeness of monitoring sites. ABMI applies a relatively modest random offset to geographic coordinates released to the public. Recent paper by Sólymos et al. (2013) has discussed this issue using ABMI data as an example.

For LiDAR data, we added one recent work by Bolton et al. (2013) on investigating the agreement between spaceborne LiDAR canopy height data (1-km resolution) we used and airborne LiDAR data (25-m resolution) in Canada's boreal forests. They found that airborne LiDAR derived canopy heights were in a good agreement with spaceborne LiDAR canopy height data as we used in the current study. In the Boreal Plains ecozone where our study area is located, the RMSE (root mean square error) between spaceborne and airborne heights was 4.39 m (Figure 4 in Bolton et al., 2013). We added one paragraph to discuss the possible influences on biomass estimations in our Discussion.

For Alberta land cover map, the resolution is 30 meters (ABMI 2012, ABMI Remote Sensing Group 2012). The map is derived by applying a semantic and spatial generalization algorithm to combine two pre-existing land-cover products: the Canadian Forest Service's Earth Observation for Sustainable Development (EOSD) map of the forested region, and Agriculture Agri-Food Canada's map of the agricultural zone. The overall accuracy of the map, as estimated by an extensive validation dataset, was 75% with 11 land cover classes (ABMI Remote Sensing Group, 2012). We added one sentence about accuracy assessment in Section 2.2.5 “Alberta land cover map”.

Reference:

Sólymos, P., Burton, C., Herbers, J., Boutin, S., & Schieck, J. 2013. Is accurate location information necessary for repeatability in field-based ecology? Frontiers in Ecology and the Environment, 11, 178-178.

Bolton, D. K., Coops, N. C., and Wulder, M. A. 2013. Investigating the agreement between global canopy height maps and airborne Lidar derived height estimates over Canada. Canadian Journal of Remote Sensing 39, S139-S151.

ABMI (Alberta Biodiversity Monitoring Institute). 2012. ABMI wall-to-wall Land Cover Map circa 2000, Version 2.1: Metadata. Alberta Biodiversity Monitoring Institute, Edmonton, Canada. Available at: www.ABMI.ca.

ABMI Remote Sensing Group. 2012. Accuracy Assessment of the Alberta wall to wall landcover polygon vector layer circa 2000, beta version (ABw2wLCV2000beta). 1st Draft. Alberta Biodiversity Monitoring Institute, Edmonton, Canada. Available at: www.ABMI.ca.

3) The authors speak about "accuracy" in the abstract, how a reader could know if this estimation is accurate? There is a lack of confidence interval in the analyses; the only one presented is for ground forest inventory plots - density of total tree biomass (see section 3.1).

RESPONSE: Thanks for this suggestion. We have added one column (“mean AGB density ± SD”) for each Natural regions and subregions in Table 3. Also, our analysis about model accuracy is related to this issue.

4) The numbers of data used for validation are not clearly detailed in the methodology (section 2.3.6).

RESPONSE: We have added a detailed description about validation method. We randomly divided the inventory plots into training data (60%) and testing data (60%).

These four approaches of AGB estimation were fitted with training data and evaluated with testing data. MAE, RMSE and NRMSE were calculated to assess model accuracy. This procedure was repeated 100 times, and the average values of these three model accuracy indicators were reported in Table 2.

5) Please complete the names of species in the study area such black spruce (eg. picea mariana Mill., Briton).

RESPONSE: We have added the missing species names (*Section 2.1 Study Area*).

6) Please clarify what means "sufficiently deep" in section 2.1.

RESPONSE: We have changed this sentence to "open jack pine, aspen and birch stands occur where the soil is sufficiently deep for retaining moisture and nutrients to sustain these species".

7) The validation seems perform very well for the entire average area. What happens with the performance of the models for each natural region? (see Table 2).

RESPONSE: Although we did the validation for each Alberta natural region, we didn't include the results in our manuscript. The reason is that the validation results of major natural regions are very similar with the result of the entire area.