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Biogeosciences Discussions

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Interactive Comment

Interactive comment on "Changes in growth of pristine boreal North American forests from 1950 to 2005 driven by landscape demographics and species traits" *by* M. P. Girardin et al.

M. P. Girardin et al.

Martin.Girardin@rncan.gc.ca

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We thank the two referees for their helpful comments. Below are responses to their comments and changes made to the original manuscript.

Anonymous Referee #1

Referee #1: My only major comment is that, without a stronger indication that the standardization is working, the conclusion of significant changes in boreal tree growth and subsequent analysis of demographics-stress interaction needs to be accompanied by a more earnest description of the uncertainty. [...] If understood correctly from examples in Fig. 1, age-response functions were fit to relatively short individual core time series, which seems like it would have the flexibility necessary to remove a finite component of any low-frequency anthropogenic signals. What reasons do we have to believe the applied standardization was successful in differentiating multi-decadal environmental signals from age decline and all the additional gap dynamics present in densely occupied stands?

Response: The referee has a point: plot-level time series under study for mature forests range in length from about 80 years and over, and it can be expected that long-term signals in such series will not be recovered. This could cause an absence of a long-term trend in growth as seen in mature jack pine and black spruce forests. This point was addressed in a comment posted on 14 March 2012 that can be found at http://www.biogeosciences-discuss.net/9/C292/2012/bgd-9-C292-2012.pdf. Therein a sensitivity analysis consisted on the application of the regional curve standardization (RCS) technique to the jack pine tree-ring width measurement series, and comparing the final results to those presented in the original manuscript. The RCS approach has the potential to preserve the evidence of long-time scale forcing of tree growth. The two standardization methods yielded very similar changes in mean jack pine growth for the post-1920 period. The multi-decadal variability characterizing the period under study remains largely unaffected by the application of the detrending.

Additionally, some sensitivity tests were made on mature and overmature black spruce trees established between 1860 and 1905 on silty-sand, loamy-sand, and sand, with depth of the organic layer ranging from 5 to 25 cm. Overmature trees established prior to 1860 were excluded of this analysis as they did no satisfy the assumption of homogeneity in level and slope of growth curves. The 294 available black spruce measurement series were aligned by cambial age, scaled using the power-transformation method, and the arithmetic mean of ring width for each ring age was calculated. A regional curve (RC) was then created by applying a flexible smoothing (Hugershoff) to the age series of arithmetic means (Fig. 1 of this response letter). Next, each one of the original ring-width measurement series was divided by the RC value for the appropriate ring age to create standardized series. Finally, the standardized series were realigned by calendar year and averaged using a bi-weight robust mean to create the mature black spruce tree growth index (TGI). These analyses are related results are included in the Supplementary material, Appendix 7. As shown by Fig. 1 of this response letter, changes in growth of mature black spruce obtained through the application of the RCS technique were similar to those obtained using the exponential detrending approach. The multi-decadal environmental signal thus appears to be adequately recovered.

That said, the text that follows was added to page 1039: "The detrending procedure applied to individual ring-width measurement series can inevitably remove some of the long-term climate-driven variability and this effect is proportional to the length of individual ring-width measurement series being treated (Cook et al., 1995). This limitation can increase the proportion of false negative results when analyzing trends in short TGI time series, and perhaps lead to an apparent demographic-related trend in forest growth as observed in the current study. That said, application of a conservative detrending procedure in which ring-width measurements were scaled against an expectation of growth for the appropriate age of each ring (i.e. the Regional Curve Standardization technique; Esper et al., 2003) support the robustness of the results on mature forests for the period under study (Girardin, 2012; Supplemental material Fig. S6). Additionally, we found that demographic and species differences in direction and levels of trends persist after the application of a flexible detrending technique to the ring-width measurements (i.e. 80-year smoothing splines; Supplemental material Fig. S8). The higher frequency variability (interannual to multidecadal) that characterizes the period under study remains largely unaffected by the application of detrending."

Referee #1: It is interesting that model trends were more positive than the TGI trends. Is this an artefact from including simulations at younger ages? Ultimately, it would be valuable to evaluate tree growth in gravimetric or volumetric units. TGI is only one dimension of a three-dimensional problem and "SD units yr-1" is difficult to interpret. Is the relative magnitude of a trend in TGI directly comparable with that of model NPP?

Response: Yes, the distribution of model trends is slightly more positive because the full range of stand biomass was included in the simulation experiment. From simple observations of the distribution of confidence intervals on Fig. 2a and 5a, one can note that trends in TGI have higher significance than those of the NPP simulations (observation that is confirmed after computation of confidence intervals at the 95% level). Not all of the trends in TGI are being reproduced by the experimentation. But we advise that caution is needed with this data-model comparison for number of reasons, including autocorrelation structure in the TGI data that significantly differ from the simulated data, and the noisy nature of the climatic data used in the simulation experiment (see Material and methods and Discussion sections). At this stage, the comparison should remain qualitative.

Referee #1: Pg. 1031, line 18: Should BF3 be in the equation? It says below (line 28) that species presence also affects TGI.

Response: Species effects take place via the BF2 equation. Once the equation for BF2 is solved, its solution feeds into the BF4 equation for soil type interactions. Afterward, the solution from BF4 enters into the regression equation for the calculation of the TrendTGI. Slight modifications were made to the text by including BF2 and BF3 on line 28 of page 1031.

Referee #1: Pg. 1033, line 15: These trends are valuable information. To facilitate comparisons, it might be helpful to also report the trend in relative terms (i.e., relative to long-term mean NPP).

Response: Percent changes in NPP were added to the text (computed by multiplying the linear trend by the number of years in the simulation period, then dividing by the long-term mean NPP).

Anonymous Referee #3

Referee #3: The authors discuss various potential biases influencing their results.

These seem minor apart from the relatively uncertain climate (i.e. moisture) data, which derives from a rather coarse-spatial resolution reanalysis dataset. Efforts have been made to validate temperature and precipitation data using CRU 2.1 (0.5res.) grids. Not surprisingly, the authors found a poor match between the precipitation variability of the climate model (NCEP) and station based (CRU) data. I agree with the choice of the 20CR dataset since in absence of reliable long-term measurements from climate stations, CRU precipitation data might not be robust for the study area. Yet, the interpretation of the climatic drivers of forest growth (i.e. fig. 3) should be made cautiously in light of the suboptimal moisture data.

Response: Indeed. We added the following text to page 1039: "Simulation experiments conducted using Climate Research Unit TS2.1 gridded data as climate input yielded results that were very similar to those reported in this study with respect to the distribution of regression slopes. Nevertheless, uncertainties in climate data have an effect on the empirical models of forest growth and climate relationships: interpretation of the climate drivers of forest growth (i.e. Fig. 3) should be done cautiously in light of the suboptimal moisture data."

Referee #3: - 2.2, lines 14ff: Some more details on the biomass calculation would be useful, especially on how the upscaling from single trees to the stand level was done. To me it was also not fully clear, how these total aboveground biomass data were included in the study since later, only the TGI were used.

Response: The text was revised as follow: "Aboveground biomass was estimated for each stem within a plot using measured diameter at breast height and the species-specific tree biomass equations of Lambert et al. (2005). Values were summed to obtain estimates of plot-level total aboveground biomass. We assumed a 50% biomass to carbon conversion factor. Stand attributes were used later on as input to the stand-level process-based model."

Referee #3: - 2.3, line 21: This should probably be "NCEP", not NECP

Response: Corrected

Figure 1. Mature black spruce tree growth index (TGI) and 95% confidence interval obtained after the application of two different standardization techniques. A) TGI record obtained after the application of an exponential fitting (TGI EXP) to measurement series as described in the manuscript. B) TGI record obtained through the application of the Regional Curve Standardization technique (TGI RCS). C) Mean growth curves for trees established between 1860 and 1905. Gray shaded area shows 95% confidence intervals associated with the mean growth of trees for each ring age. The red line is the regional curve obtained after application of a smoothing to the mean growth of trees. (D) Scatter-plot of TGI EXP and TGI RCS, 1950-2005.

Interactive comment on Biogeosciences Discuss., 9, 1021, 2012.

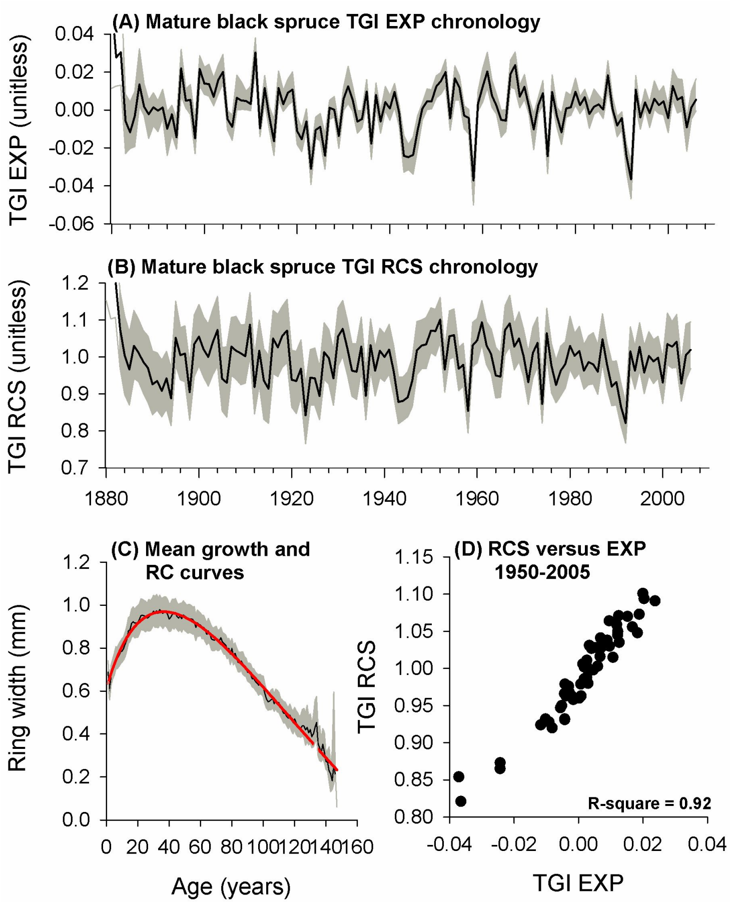

Fig. 1. Mature black spruce TGI obtained after the application of two different standardization

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