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Interactive comment on "Validation of modelled forest biomass in Germany using BETHY/DLR" *by* M. Tum et al.

Anonymous Referee #2

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GENERAL COMMENTS:

The authors propose a new approach to validate modeled net primary productivity (NPP) based on national forest inventory data. The approach is novel and the attempt to develop a new validation procedure that utilizes the readily available wide pool of forest inventory data is welcome. In order to guarantee the usefulness of dynamic biomass models, their outputs must be validated. Many countries in Europe, North America and Asia have active National Forest Inventory programs that produce data that could be used to validate such models. Hence, there is great potential for further research in this field.

The article is generally clear and well-written and proceeds in a logical order (apart from some minor lapses in clarity, see specific comment 1). The BETHY/DLR model

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Interactive Discussion

Discussion Paper

and the data sets are mostly described in sufficient detail (see specific comment 1). The text is easy to read.

In my specific comments (2 and 3), I express some concern regarding the validation methods used and suggest minor amendments. Although the proposed changes are small, they might affect the conclusions. I recommend that this article be accepted once these concerns have been addressed, given that the results still remain meaningful. Due to the importance of the topic and the wide array of potential applications, this paper deserves to be finalized.

SPECIFIC COMMENTS:

(1) MEAN ANNUAL INCREMENT

The authors validate their modeled forest NPP data, using empirical data on mean annual increment (MAI) of the above-ground biomass stock, obtained from the German NFI. To convince the readers, the authors need to be more clear about what is meant by MAI.

Firstly, the authors need to be more consistent in their use of terminology. In the manuscript MAI is referred to in many different ways. Some examples:

1689 (21-22): “mean annual increment (MAI) in above-ground biomass (including bark) 1695 (26-27): “the growth increment of timber growing stocks” 1697 (3): “the mean annual net increment” 1697 (8-9): “net increment of the total above-ground biomass stock”

Partially because of the inconsistent terminology and uncertainty of weather you are referring to annual increments or total biomass stocks (=net increment from all years) the explanation of the treatment of NFI data on pages 1697-1698 is slightly confusing.

Secondly, the author’s need to be more explicit about how MAI is measured/reported at the NUTS-1 level in the German NFI. At least two alternatives come to mind:

GMDD

4, C697–C704, 2011

(A) On the stand level, MAI is usually calculated by dividing the stock of biomass in standing trees (+removals in all past years) by the age of the stand. One way to estimate MAI on the regional scale is just to add up the MAI values for all forest stands in the region. This is the most logical alternative that first comes to mind.

(B) The other alternative is that the authors are actually using data on Current Annual Increment (CAI), which is the current annual growth of a forest stand. On the regional level current annual increment can be calculated by summing up CAI of all forest stands.

Whatever the definition is, the authors need to state it clearly. Moreover, if definition (A) is correct, the author's need to state why they chose to use MAI data (which is based on information on the past and present growth of the forests) instead of CAI data (which more accurately describes the growth of the forests in one year). Was CAI data not available, and MAI data was adopted as a proxy?

(2) VALIDATION METHOD:

The authors compare their NFI and BETHY/DLR based estimates of above-ground biomass increment (p. 1700, 19-29; p. 1720, Fig. 4.). NFI-based estimates (Mt/NUTS-1/a) are plotted against BETHY-based estimates (Mt/NUTS-1/a) and a line is fitted using linear regression. The authors argue that the increment less underestimated deciduous forests than coniferous ones (p. 1700, lines 23-26).

However, when the number of observations is small, the slope of the OLS-regression line is very sensitive to outliers. In the case of deciduous forests in 2000 and 2001 (the two upper panels in Fig. 4.) there are two outliers marked by red circles in the attached Fig. 1. These outliers have a strong impact on the slope of the regression line. Should they be omitted, the slope would not be as steep. Also the conclusion might change: the underestimation of annual biomass increment of deciduous forests could in fact be greater than of coniferous forests. The authors need to address this problem. (Also coniferous forests have two major outliers, but these do not appear to have a strong

GMDD
4, C697–C704, 2011

impact on the slope of the regression line).

One way to do this, could be to normalize the data for NUTS-1 regions by dividing the annual above-ground biomass by forest area (deciduous or coniferous) in each region. In this case the units for in Fig. 4. would not be Mt/NUTS-1/a, but Mt/ha/a or Mt/kmˆ2/a instead. If the annual biomass increment in the outlier regions is high because they have extensive forests, this normalization procedure could make these regions more comparable with the rest of the sample.

In addition to the practical need for normalizing the data ("the need to get rid of outliers"), there is also a theoretical reason for doing so. Forest age structure, species composition, weather conditions, etc. are all important variables that affect the annual biomass increment. Nevertheless, holding forest structure constant, the areal extent of forest functions as a scaling factor: NUTS-1 regions with extensive forests have a higher annual biomass increment than NUTS-1 regions with very little forest. Hence, forest area is an important variable influencing the annual biomass increment. If we compare the BETHY/DLR estimates with estimates derived from the NFI data, using (un-normalized) annual biomass increment values, we will be (for the large part) comparing how well GLC2000 forest cover data matches the German NFI data. However, if the data are normalized, we can assess how well BETHY-DLR performs in simulating the effect of the other variables (forest characteristics, weather conditions, etc.)

If the authors wish to retain the current formulation (comparing the totals for NUTS-1 regions in Mt/NUTS-1/a, which I do not recommend) the usefulness of the BETHY/DLR model can be tested using another simple test (attached Fig. 2.). The idea is to run two regressions with the NFI-based estimate for the annual biomass increment as the dependent variable. In the first regression the NFI-based estimate explained by the corresponding BETHY-based estimate. In the second regression, the NFI-based estimate is explained by forest area data from GLC2000 alone.

If the fit of the second regression better (e.g. it has a higher R-squared value), our

GMDD
4, C697–C704, 2011

conclusions are not flattering for the BETHY-model. In this case, we are better at forecasting above-ground biomass increment on the NUTS-1 level if we use GLC2000-data and OLS-estimated fixed parameter values, than if we use estimates produced by the BETHY/DLR model (corrected by OLS-estimated parameters), and we can conclude that the BETHY/DLR model does little more than adds noise to GLC2000 data. On the other hand, if turns out that the first regression has better fit, we can conclude that the BETHY/DLR model improves our forecasts and, hence, is useful. [If you decide to normalize your data, it will not be necessary to incorporate this type of an analysis into your validation study. However, you might want to run it just out of curiosity to convince yourselves that you are on safe ground].

(3) JUSTIFICATION OF VALIDATION ON THE NUTS-1 LEVEL

"The output of BETHY/DLR is a time series of NPP in daily steps, at the resolution and projection of the land cover classification. Here 1 km2 resolution is used, in a latitude-longitude projection using the WGS84 (World Geodetic System 1984) datum." (p. 1691, 25-27). In my view, the modeling results should be (optimally) validated at the same resolution, but this may not be possible if NFI data is only available on the NUTS-1 level.

The authors need to either justify the choice of resolution at which the model is validated (in the introduction), or discuss the uncertainties that arise from validation at this resolution (in the discussion). Is there a possibility that important information is lost in aggregation of either NFI data or BETHY/DLR outputs? Is it possible that the validation results appear to be better because the validation is done using highly aggregated data and local variation is cancelled out?

TECHNICAL CORRECTIONS:

p. 1697, 23: "age-dependant" should be "age-dependent" p. 1700, 20: "estimated above-ground biomass" should be "estimated above-ground biomass increment" p. 1720, Fig. 4. caption: "Estimated above-ground biomass" should be "Estimated above-

GMDD

4, C697–C704, 2011

ground biomass increment”

Interactive comment on Geosci. Model Dev. Discuss., 4, 1685, 2011.

GMDD

4, C697–C704, 2011

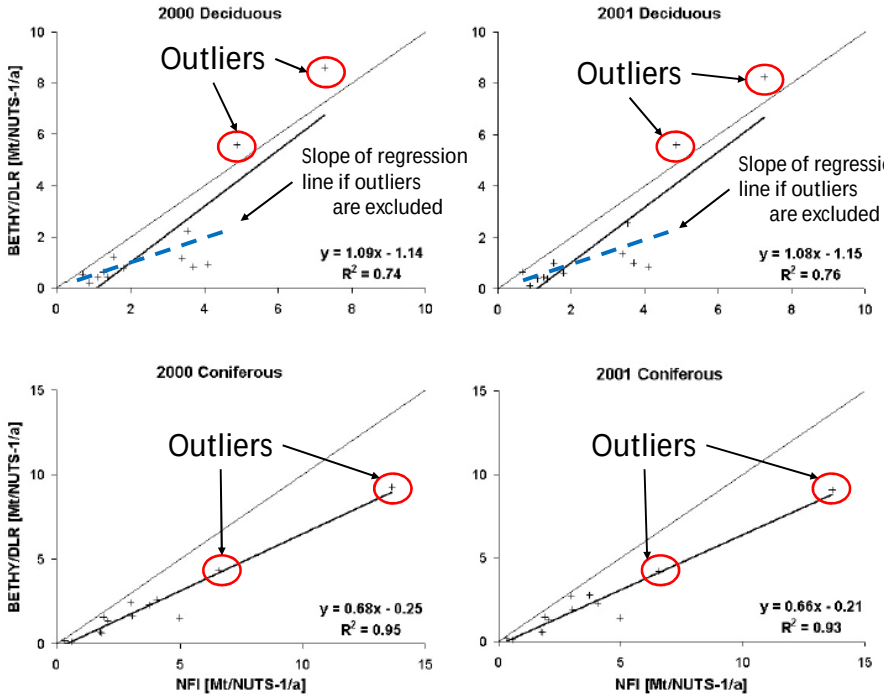

Fig. 1. Outliers in Fig. 4.

GMDD
4, C697–C704, 2011

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$$[1] \quad y_i = \alpha_0 + \alpha_1 x_i + \varepsilon$$

$$[2] \quad y_i = \beta_0 + \beta_1 z_i + \varepsilon$$

y_i is the NFI-based estimate for above-ground biomass increment (Mt/NUTS-1/a)

x_i is the BETHY-based estimate for above-ground biomass increment (Mt/NUTS-1/a)

z_i is the GLC2000-based estimate for forest area (km2) in each NUTS-1 region

$\alpha_0, \alpha_1, \beta_0, \beta_1$ are estimated parameters, and

i Is an indicator for NUTS-1 regions

Fig. 2. Formulae for alternative testing approach

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