Assimilating remote sensing data with forest growth models

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As we are entering an era of increased supply of remote sensing data, we believe that data assimilation that combines growth forecasts of previous estimates with new observations of the current state has a large potential for keeping forest stand registers up to date (Ehlers et al. 2013). The data assimilation will update a forest model e in an optimal way based on the uncertainties in the forecast and the observations, each time new data becomes available. These forecasting and updating steps can be repeated with new available observations to get improved estimations. In this study we present the first practical results from data assimilation of mean tree height, basal area and growing stock. The remote sensing data used were canopy height models obtained from matching of digital aerial photos over the test site Remningstorp in Sweden. The photos were acquired 2003, 2005, 2007, 2009, 2010 and 2012 and normalized with a DEM from airborne laser scanning.

The procedure for the data assimilation was as follows: mean tree height, basal area and growing stock were predicted on 18 m × 18 m raster cells using the area based method. Ten meter radius sample plots were used as field calibration data. For each photo year, the field data were adjusted for growth to have the same state year as each acquisition year of the photos. Growth models were constructed from National Forest Inventory plot data. Data assimilation could then be performed on raster cell level by initially start with the estimates from 2003 year´s photos. This prediction was then forecasted to year 2005 by calculating the growth for the raster cell. This forecasted value is then blended with the new remote sensing estimation collected 2005. The process was then repeated for the following years where new measurements were available. In this study, extended Kalman filtering was used to blend the forecasted values with the new remote sensing measurements. Validation was done for 40 m radius field plots. Further, the results were also compared with two alternative approaches: the first was to forecast the first remote sensing estimate to the endpoint and the second was to use remote sensing data acquired at the endpoint only.

The preliminary results for the eight forest stands show that the variances were lower when using assimilation of new estimates and there were less fluctuation compared to only using remote sensing data from the endpoint. However, the mean deviation from the measured value 2011 was lower when only data from the endpoint were used. The assimilated values 2011 were consistently closer to the validation data compared to only forecasting the starting estimate from 2003 to 2011.

Reference

Ehlers, S., Grafström, A., Nyström, K., Olsson, H., and Ståhl, G. 2013. Data-assimilation in stand-level forest inventories. Canadian Journal of Forest research 43:1104-1113.