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Modelling temporal change in biomass at the national extent with stereo aerial imagery

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Accurate quantification of above ground biomass (AGB), and it's pools and fluxes, over large heterogeneous regions is important for national carbon accounting and mitigation of rising CO_2 levels. There is an increasing need for consistency in the methodology of nation-wide accounting and the monitoring of changes over time. While repeat airborne laser scanning (ALS) data has been used successfully for monitoring AGB over time, repeat capture of ALS over large regions is rare and costly and often with considerable variation in data specifications. Here we consider canopy height models derived from stereo aerial imagery as an alternative to ALS. We take advantage of repeat acquisitions of nation-wide stereo aerial imagery to model and map AGB at two time steps and use these maps to determine AGB changes over time. In Switzerland, stereo imagery is captured to a standard specification on an ongoing cycle with repeat coverage every 6 years. This work uses observation data from the Swiss NFI 3 (2004-2006) and NFI 4 (2009-2017), a logistic regression modelling approach and explanatory variables of canopy height, elevation and remote sensing based tree type maps. The R2 values from cross-validated models ranged from 0.48 to 0.57 (mean 0.54) suggesting a comparable model performance to published ALS-based AGB predictions for Switzerland. We find that the relationship between the canopy height model and AGB remains stable over time (between two different National Forest Inventories) allowing for AGB change monitoring. Our results showed that the time difference between AGB measurements in the field and image capture is particularly important, with model performance dropping considerably at time differences greater than 2 years. Stratification by elevation or aspect improves the ability to predict changes in AGB over time. On the whole, we show that cost-effective repeat stereo aerial imagery can provide reliable estimates of AGB across space and time in a large and topographically heterogeneous area. We conclude that stereo-imagery is a valuable alternative to ALS for AGB monitoring.