Boreal-wide biomass estimation with ICESat-2

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1. Introduction

Aboveground biomass is a critical element of the global carbon cycle, both in terms of the large magnitudes of carbon stored in aboveground woody material, and the ecological carbon-climate feedbacks related to disturbances from pests and fire which are particularly important for carbon cycling in the boreal system. To date, high resolution biomass maps have been largely unavailable across the boreal system due to a dearth of active remote sensing data sensitive to forest structure at the spatial scales of boreal forest processes (~30m – 1 ha). ICESat-2 has produced forest height products at a 100-m segment resolution through the ATL08 product (Fig 1, Neuenschwander & Pitts, 2019), but the mission does not have an official biomass requirement or product. This research presents early results from two recently funded NASA projects (one through NASA's ABoVE program, and one through the ICESat-2 Science Team). These projects focus on using height data from ICESat-2 to estimate and map woody aboveground biomass for the boreal domain.

We explore the transference of models developed for NASA's Global Ecosystem Dynamics Investigation (GEDI) mission (Dubayah et al., 2020, Duncanson et al., 2020) that translate height measurements into estimates of biomass based on a global field and airborne lidar campaign, and compare these with models using simulated ICESat-2 over field plots. ATL08 has been reprocessed to the 30-m segment length and Relative Height (RH) metrics have been recomputed including ground photons to be more comparable to GEDI's RH metrics. We fit exhaustive suites of OLS models with different height predictors, and apply the best performing model per PFT to 30-m ATL08 for the globe north of 50 degrees latitude,

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producing estimates of AGBD and associated standard error for each 30-m ATL08 segment for the growing season. We then link AGBD from ATL08 to a wall-to-wall covariate stack at a 30 m resolution from Landsat and the Copernicus DEM. We fit a random forest model to predict AGBD from the covariate stack for each 40 km tile across the study domain. We propagate uncertainties from the field to ATL08 models through to the ATL08 to Landsat model through bootstrapping both sets of models fits to produce pixel-level estimates of uncertainty. The resulting 30-m AGBD and uncertainty products are representative of growing season conditions between 2019-2020.

2. Figures and Tables

2.2 Figures

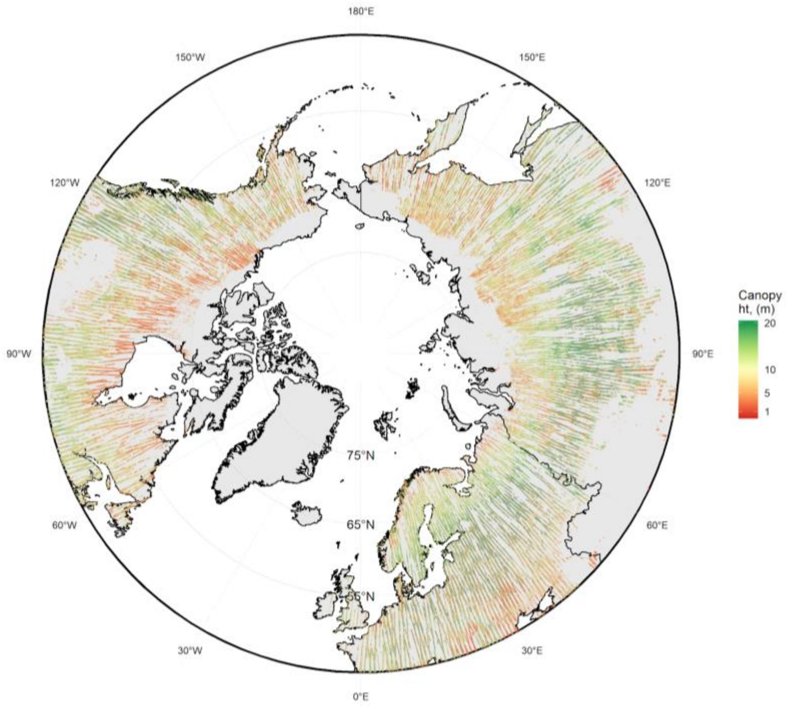

Fig 1. Relative Height (RH98) from ICESat-2's ATL08 product between 45 and 75 N captures height gradients by latitude.

2.3 Tables

Table 1 The top model for each MODIS Plant Functional Type and region stratum in the scenario where RH98 was forced into models and no RH metric lower than RH50 was considered. R squared (Rsq), %RMSE, mean residual error (MRE) and Slope were all calculated from geographic cross validation. MRE was the absolute mean binned residual error, expressed in Mg/ha.

Strata	R^2	%Rmse	MRE	Transform	Predictors
DBT North America	0.77	38.47	7.6	sqrt-sqrt	RH60, RH98
ENT North America	0.77	69.27	13.89	sqrt-sqrt	RH60, RH98
ENT Europe	0.69	52.55	2.04	sqrt-sqrt	RH98
Deciduous Broadleaf Trees	0.73	40.3	9.88	sqrt-sqrt	RH60, RH98
Evergreen Needleleaf Trees	0.69	63.35	5.73	sqrt-sqrt	RH98
Europe	0.67	53.33	4.1	sqrt-sqrt	RH98
North America	0.77	62.47	9.79	sqrt-sqrt	RH70, RH98

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