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Derivation of a northern-hemispheric biomass map for use in global carbon cycle models

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Quantifying the state and the change of the World's forests is crucial because of their ecological, social and economic value. Concerning their ecological importance, forests provide important feedbacks on the global carbon, energy and water cycles. In addition to their influence on albedo and evapotranspiration, they have the potential to sequester atmospheric carbon dioxide and thus to mitigate global warming. The current state and inter-annual variability of forest carbon stocks remain relatively unexplored, but remote sensing can serve to overcome this shortcoming. While for the tropics wall-to-wall estimates of above-ground biomass have been recently published, up to now there was a lack of similar products covering boreal and temperate forests.

Recently, estimates of forest growing stock volume (GSV) were derived from ENVISAT ASAR C-band data for latitudes above 30°N. Utilizing a wood density and a biomass compartment database, a forest carbon density map covering North-America, Europe and Asia with 0.01° resolution could be derived out of this dataset. Allometric functions between stem, branches, root and foliage biomass were fitted and applied for different leaf types (broadleaf, needleleaf deciduous, needleleaf evergreen forest). Additionally, this method enabled uncertainty estimation of the resulting carbon density map. Intercomparisons with inventory-based biomass products in Russia, Europe and the USA proved the high accuracy of this approach at a regional scale (r^2 = 0.70 – 0.90).

Based on the final biomass map, the forest carbon stocks and densities (excluding understorey vegetation) for three biomes were estimated across three continents. While 40.7 ± 15.7 Gt of carbon were found to be stored in boreal forests, temperate broadleaf/mixed forests and temperate conifer forests contain 24.5 ± 9.4 Gt(C) and 14.5 ± 4.8 Gt(C), respectively. In terms of carbon density, most of the carbon per area is stored in temperate conifer (62.1 ± 20.7 Mg(C)/ha(Forest)) and broadleaf/mixed forests (58.0 ± 22.1 Mg(C)/ha(Forest)), whereas boreal forests have a carbon density of only 40.0 ± 15.4 Mg(C)/ha(Forest). While European forest carbon stocks are relatively small, the carbon density is higher compared to the other continents.

The derived biomass map substantially improves the knowledge on the current carbon stocks of the northern-hemispheric boreal and temperate forests, serving as a new benchmark for spatially explicit and consistent biomass mapping with moderate spatial resolution. This product can be of great value for global carbon cycle models as well as national carbon monitoring systems. Further investigations concentrate on improving biomass parameterizations and representations in such kind of models. The presented map will help to improve the simulation of biomass spatial patterns and variability and enables identifying the dominant influential factors like climatic conditions and disturbances.