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GWPs and GTPs for forest bioenergy and products with global coverage at 0.5° x 0.5° spatial resolution

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The effects on climate of various greenhouse gas (GHG) emissions can be aggregated in common units through a variety of emission metrics. The Global Warming Potential (GWP), introduced by the IPCC in 1990, is based on the integrated radiative forcing of a pulse emission divided by an equivalent integration for the reference gas, usually CO_2, at an arbitrary time horizon (TH). The Global Temperature change Potential (GTP) is the ratio between the temperature response to a GHG emission pulse at a certain point in time and the temperature response for a reference gas. Other metrics like the integrated GTP (iGTP), TEMP, and metrics embedding economic considerations or a dynamic, target-specific TH are used in the literature. Recent studies developed impulse response functions and emission metrics for CO_2 emissions from biomass combustion or oxidation for applications in bioenergy and harvested wood products (HWP) analyses. As the resulting metrics depend on the resource turnover time and hence on site specific characteristics like the type of biomass species, local climate, site productivity and other factors, these metrics are today available only for a limited number of cases and selected locations. In this work, we provide spatially-explicit GWPs and GTPs for bioenergy and HWP sourced from renewable forests with a global coverage of forest areas at a resolution of 0.5 degrees x 0.5 degrees. The Global Forest Model (G4M) developed at IIASA is used to provide the mean annual increments (MAI), rotation periods and above ground carbon of the forests of the globe. G4M uses a dynamic Net Primary Production (NPP) model to simulate how growth rates are affected by changes in temperature, precipitation, radiation, and CO_2 concentrations. NPP post harvest dynamics are then modeled using tree-specific functions combined with the grid-specific MAI. Heterotrophic respiration (Rh) is exogenously modeled with the YASSO model. NPP and Rh are then combined in a Net Ecosystem Productivity (NEP) profile to represent a post-harvest chronosequence, which is normalized to the original pulse so that the biomass resource is replenished across the rotation period. IRFs and emission metrics are then computed for each grid following the CMIP5 standard protocol. Data are also aggregated at a national level and country-specific emission metrics for the various HWPs (paper, board, housing materials, etc.) are computed using the decay rates of the products in the various nations. Results show some typical geographical patterns. For instance, GWPs values generally increase while moving towards northern (i.e. boreal) regions and mountainous areas, where lower soil productivity and economic considerations usually lengthen the rotation period (and decay rates of residues are also slower owing to a colder climate). GTPs are usually significantly different from GWP. They are generally smaller in magnitude and show negative values for TH = 100 when forests have a rotation period in the range of 80-120 years, because the respective temperature response function exhibit a cooling contribution around that time. The scientific and policy implications of such a spatial and metric-related variability of the results will be discussed, and possible tradeoffs identified.