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Variation in plant traits explains much of the global biogeographic patterns of distribution of major forest functional types

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Contrasting foliage types (needle and broad leaf) and phenological habits (deciduous and evergreen) represent different adaptive strategies of trees, which can be quantified by the differences in a number of key plant traits. Previous studies have used vegetation models to explain adaptive advantage of different strategies as represented by the mean values of those key plant traits for each plant functional types, and are unable to explain the co-existence of multiple plant functional types in the absence of disturbance. However significant variations and co-variations among those key plant traits that have been observed within a plant functional type may have significant implication on the simulated competition among different plant functional types. Here we use the Australian Community Atmosphere-Biosphere-Land Exchange model (CABLE) to explore whether the observed key plant traits (leaf life span, leaf carbon allocation fraction, basal respiration rate of plant tissue, and leaf C:N ratio) can explain the observed co-existence of four forest types (evergreen or deciduous, needle leaf or broad leaf forests) globally. To incorporate the intra-specific variation of plant traits into the model, we run four groups of ensemble simulations, with each group including only one PFT prescribed in all forested land cells. Then we calculate the annual NPP at each one-degree forested land cell for each of 200 parameter sets that are randomly generated from the observed mean and variances of those key plant traits. Using NPP as a proxy for fitness, we calculate the probability of a forest PFT with higher NPP than all other three forest PFTs for each forested land cell by comparing each of 200 NPP estimates of a forest PFT with the NPP estimates of all other three forest PFTs. Assuming that probability is proportional to area abundance, we then compare the estimated abundance of all four forest types with the estimates from remote sensing. Overall our results captured the global biogeographic pattern that evergreen needle leaf forests dominate in boreal region, evergreen broad leaf forests in tropical region, and that deciduous forests are distributed quite widely across a broad range of environmental conditions, which agrees broadly with the estimated global pattern from remote sensing. Variations and co-variations of four key plant traits can explain significant fractions of global variations of relative abundance of different forest functional types, and should be taken into account in simulating global vegetation dynamics.