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Uncertainties of Nitrogen Fixation in a Dynamic Global Vegetation Model

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Nitrogen is an essential nutrient for life on earth. However, most of it is in the form of dinitrogen (N2) unutilizable to life and only few organisms are able to break the triple bond, fix the nitrogen and thus make it available for cycling in the biosphere through “fixation”. In most state-of-the-art dynamic global vegetation models (DGVMs) including a nitrogen cycle, N fixation is simulated by the Cleveland et al. (1999) algorithm (O-CN, LPJ-GUESS, CLM), that correlates annual N fixation to evapotranspiration rates or net primary production. Nevertheless, this algorithm has two major uncertainties, which are investigated by us:
1. The algorithm is based on annual fixation rates that are then applied uniformly throughout the year. However, in nature nitrogen fixation is an expensive process, which occurs only under favorable conditions. Here we compare the annual fixation values evenly distributed over the year with daily-derived fixation values based on a modified version of the Cleveland algorithm. We postulate that in higher latitudinal regions with seasonal climate as well as in regions with a distinct dry/wet season, modeled growth is enhanced by daily derived values compared to evenly distributed values, whereas in tropical regions hardly any difference will be visible.
2. One distinguishes between symbiotic and unsymbiotic nitrogen fixation, where the first one is associated with higher plants as symbionts supplying the fixers with carbohydrates, whereas the second, unsymbiotic is performed by so-called cryptogamic covers (CC). We found that the fixation by CC is underrepresented by the Cleveland algorithm, and a correction thus leads to enhanced growth in forested regions of higher latitudes that feature substantial CC fractions.
Overall, the improvements of the algorithm proposed by us are expected to better reflect the reality of nitrogen fixation and cause an increased growth of vegetation, especially in higher northern latitudes.