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Realizing the impacts of early vegetation on global biogeochemical cycles through a process-based model (LYCOm)

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Lycopsids are one of the earliest occurring groups of vascular plants, encompassing a long evolutionary history from its early bushy herbaceous structures during the late Silurian into forests of tree-like structures in the Middle Devonian. These early plants may have contributed to substantial changes in the composition of Earth's atmosphere, partly related to the biotic enhancement of weathering. To achieve a more quantitative assessment of the biogeochemical impacts of these organisms, it is necessary to quantify their physiological characteristics, spatial distribution, carbon balance, and their hydrological impacts during their span of evolution starting from the Silurian. Here, we present a process-based Lycopsid
Model (LYCOm), developed for the estimation of the influence of the Lycopsids on biogeochemical cycles, which has been applied at the global scale.
The model provides reasonable coverage of the lycopsids for today besides the estimation of weathering rates. The current model features ranges of
key physiological traits of lycopsids to predict the emerging characteristics of the Lycopsida community under any given climate by implicitly simulating the process of natural selection. In this way, extinct plant communities can also be represented. In addition to physiological properties, the model also simulates weathering rates using a simple limit-based approach and estimates the biotic enhancement of weathering by these plants. The model has been locally validated using net primary productivity from on-site observations. The model includes key features such as the distribution of biomass above and below ground, along with a plausible root distribution in the soil affecting water uptake by plants. LYCOm can simulate realistic properties of today's lycopsid communities with Net Primary Production (NPP) ranging from 100 g carbon m^{-2} $year^{-1}$ to 245 g carbon m^{-2} $year^{-1}$. Our limit-based weathering model predicts a mean chemical weathering rate ranging up to 45.1 cm ka^{-1} rock, thereby highlighting the potential importance of such vegetation for the enhancement of chemical weathering. This step brings us closer to predicting the abundance and weathering impacts of the lycophytes in the geological past when they were prevalent. Although our method is fraught with some constraints and uncertainties, it represents a novel, complementary approach towards estimating the impacts of lycopsids on biogeochemistry

and climate.