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Competition and niche differentiation in LPJmL4: A trait-based approach towards functional diversity in modelling grassland ecosystems

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Grassland ecosystems cover about one-quarter of the earth's land area, exist in various environments and with different functional diversity (FD). Climate, soil, disturbances and management practices influence sequestration and storage of carbon. Functionally diverse grassland ecosystems may have increased productivity and carbon storage. State of the art dynamic global vegetation models (DGVMs) rarely consider flexible plant traits underpinning FD. We extend the Lund-Potsdam-Jena managed land version 4 (LPJmL4) DGVM implementing additional C3 and C4 grass plant functional types (PFTs). Trait values are selected randomly from prescribed ranges in a manner that added grass PFTs follow either an exploitative or conservative strategy for resource acquisition. Results are compared to observations and analyzed to evaluate the effect of different trait values. Further a fixed PFT combination assembled from the mean trait values of the prescribed ranges is used for global simulations. For these we analyze environmental gradients of net primary productivity (NPP) and discuss expected and simulated niche differentiation. All simulations are conducted under three precipitation regimes (potential irrigation, actual and reduced precipitation).

Our results reveal the potentials and limitations of the model's current implementation of competition. We derive essential changes necessary to improve the representation of niche differentiation and FD in grasslands in LPJmL4. The model is able to reproduce existing findings from empirical studies showing that leaf traits (specific leaf area and leaf turnover) and leaf to root ratio strongly influence productivity. Modeled productivity depends on light and water availability. We identified an overlap of factors determining the allocation of light and water between the different PFTs. Therefore, the model is currently unable to simulate niche differentiation and trade-offs between strategies.

We propose to adjust the model to independently determine resource allocation to include these trade-offs and assemble PFTs following the leaf economic spectrum. Achieving this our aim is to contribute to the understanding of facilitation and competition in differently managed grassland ecosystems with variable FD.