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Implications of a dynamic vertical root distribution for modelled water and carbon fluxes across selected ecosystems

Incorporating a novel rooting scheme into LPJ-GUESS

Roots play a key role in terrestrial carbon and water cycles, and therefore for the global climate system. They mediate plant evapotranspiration, influence photosynthetic processes and are responsible for atmospheric carbon transport into the pedosphere. Fine roots in particular are chiefly regulating water and nutrient uptake. Recent research has suggested that the representation of fine roots in ecosystem models may be too simplistic to accurately represent vegetation responses to predicted environmental changes. Hence, this thesis explores the implications of incorporating a dynamic vertical root distribution into a global dynamic vegetation model (LPJ-GUESS) for the modelled water and carbon fluxes.

In contrast to the current static root representation in LPJ-GUESS, root fractions per soil layers dynamically adapt to permafrost, and to soil water conditions if plants are under water stress. The different scheme outputs are contrasted and compared to observational data for gross primary production (GPP) and actual evapotranspiration (AET) from 15 FLUXNET sites representing a selected set of (Sub-)Arctic, water limited, and non-water limited ecosystems. Furthermore, the sensitivity of the new scheme to precipitation input and root reallocation rate is examined.

Model performance differs among sites

It was found that the new rooting scheme leads to differences in both modelled fluxes and can locally improve model accuracy with regards to the observational data. The total root-mean-square error (RMSE) for mean annual fluxes is reduced using the new scheme (GPP: 0.62 vs. 0.58 kg C m^{-2} $year^{-1}$ and AET: 144 vs. 138 mm $year^{-1}$). However, other sites and biomes were better represented by the static scheme. It is therefore crucial to analyse local results carefully as many input factors not directly determined by the root representation influence the accuracy of modelled fluxes (*e.g.* dominating plant functional types). It must also be distinguished between monthly and annual flux model accuracy. In Arctic sites with low plant productivity, the new initial root distribution and dynamic adaptation to permafrost do not considerably change modelled fluxes. Moreover, a dynamic adaptation due to water stress and availability alone may be too simplistic. Further development of the novel rooting scheme is therefore needed which is aggravated by limited data availability.

Keywords: Physical Geography and Ecosystem analysis, Ecosystem modelling, LPJ-GUESS, Vertical Root Distribution, Dynamic Root Distribution, Carbon and Water Flux Modelling

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