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Werner Rammer

Institute of Silviculture, Department of Forest- and Soil Sciences , University of Natural Resources and Life Sciences (BOKU), werner.rammer@boku.ac.at

Rupert Seidl

Institute of Silviculture, Department of Forest- and Soil Sciences , University of Natural Resources and Life Sciences (BOKU)

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Scaling Vegetation Dynamics: a metamodeling approach based on Deep Learning

Werner Rammer[1], **Rupert Seidl**[1]
[1]*Institute of Silviculture, Department of Forest- and Soil Sciences , University of Natural Resources and Life Sciences (BOKU)), werner.rammer@boku.ac.at, rupert.seidl@boku.ac.at*

Abstract: Terrestrial vegetation is of crucial importance for human well-being and provides a wide variety of ecosystem services to society. To tackle global issues such as climate change or biodiversity loss, managers increasingly demand tools that allow the prediction of vegetation dynamics at large spatial scales. While dynamic vegetation models with a faithful representation of demographic processes exist for local to landscape scale, addressing larger scales with the fine spatial grain required to answer management questions remains a challenge. We here introduce a new framework for Scaling Vegetation Dynamics (SVD) that at its core utilizes deep neural networks (DNNs). Deep Learning is an emerging branch of machine learning, currently revolutionizing computer vision, natural language processing and many other fields. In the context of SVD, a DNN learns vegetation dynamics from a high resolution process based vegetation model (PBM). Specifically, the DNN is trained to predict the probability of transitions between discrete vegetation states contingent on the current state, the residence time, environmental drivers (climate and soil conditions), and the spatial context (i.e., the state of neighboring cells). In addition, the density distributions of relevant ecosystem attributes (e.g., total ecosystem carbon or biodiversity) are derived from PBM output for each vegetation state, which allows assessing the impact of vegetation transitions on those attributes. In this contribution we introduce the conceptual approach of SVD and show results for an example application in the Austrian Alps. More generally, we discuss aspects of applying deep learning in the context of ecological modeling.

Keywords: *deep learning; metamodeling; vegetation transitions; SVD*