Geophysical Research Abstracts
Vol. 18, EGU2016-10981-1, 2016
EGU General Assembly 2016
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An application of Data Assimilation to a dynamic global vegetation model: fusing CLM(ED) model results with streams of observed data

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We implement a data assimilation approach for a Dynamic Global Vegetation Model (DGVM), named the CLM(ED) for its combined strengths of a Community Land Model (CLM) and an implementation of the Ecosystem Demography (ED) concept. This unique model combination allows for scaling the behavior of forest ecosystems by aggregating individual trees into representative "cohorts", and thus allows for the prediction of plant distribution (including stem distribution, mortality, and growth) directly from their given physiological traits. The model is constantly improving as it evolves, as less simple empirical models are used and more physically based ones are included to represent the physiological and biogeochemical processes taking place on the land-air surface. For example, very recently a mechanistic model simulating the photosynthetic capacity was implemented for a better representation of a leaf's nitrogen allocation. Some possible outputs of CLM(ED) include GPP, NPP, LAI, and interestingly, predictions of biome boundaries. In this study, we first conduct a global sensitivity analysis by estimating the range of model parameters from literature. Then, an application of Data Assimilation (DA) is introduced, where we attempt to fuse the model simulations with observed data, such as GPP. The updated system properties achieved through DA allow for better parameterization and more accurate overall predictions of vegetation dynamics. More importantly, this study addresses structural uncertainties within the model, and by combining model estimates with observed measurements, we aim to improve the overall representation of the underlying processes by explicitly pinpointing deficiencies in the model structure. We advocate the use of DA in Earth System Models for many reasons, including the direct benefit linked to the recent availability of ecological data sets, the efficient implementation within models thanks to improvements in computational power, and the proven ability of DA to progress environmental modeling frameworks.