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GPP and NEE estimation for global forests based on a deep convolutional neural network

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To generate FluxNet-consistent annual forest GPP and NEE, we have developed a deep neural network that can retrieve estimations globally. Seven parameters considering different aspects of forest ecological and climatic features which include the Normalized Difference Vegetation Index (NDVI), the Enhanced Vegetation Index (EVI), Evapotranspiration (ET), Land Surface Temperature during Daytime (LSTD), Land Surface Temperature at Night (LSTN), precipitation, and forest type were selected as the input. All these datasets can be acquired from the Google earth engine platform to ensure rapid large-scale analysis. The model has three favorable traits: (1) Based on a multidimensional convolutional block, this model arranges all temporal variables into a two-dimensional feature map to consider phenology and inter-parameter relationships. The model can thus obtain the estimation with encoded meaningful patterns instead of raw input variables. (2) In contrast to filling data gaps with historical values or smoothing methods, the new model is developed and trained to catch signals with certain levels of occlusions; therefore, it can tolerate a relativly large portion of missing data. (3) The model is data-driven and interpretable. Therefore, it can potentially discover unknown mechanisms of forest carbon absorption by showing us how these mechanisms work to make correct estimations. The model was compared to three traditional machine learning models and presented superior performances. With this new model, global forest GPP and NEE in 2003 and 2018 were obtained. Variations of the carbon flux during the 16 years in between were analyzed.