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Deriving required model structures to predict global wildfire burned area from multiple satellite and climate observations

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Vegetation fires have important effects on human infrastructures and ecosystems, and affect atmospheric composition and the climate system. Consequently, it is necessary to accurately represent fire dynamics in global vegetation models to realistically represent the role of fires in the Earth system. However, it is unclear which model structures are required in global vegetation/fire models to represent fire activity at regional to global scales. Here we aim to identify required structural components and necessary complexities of global vegetation/fire models to predict spatial-temporal dynamics of burned area. For this purpose, we developed the SOFIA (satellite observations for fire activity) modelling approach to predict burned area from several satellite and climate datasets. A large ensemble of SOFIA models was generated and each model was optimized against observed burned area data.

Models that account for a suppression of fire activity at wet conditions result in the highest performances in predicting burned area. Models that include vegetation optical depth data from microwave satellite observations reach higher performances in predicting burned area than models that do not include this dataset. Vegetation optical depth is a proxy for vegetation biomass, density and water content and thus indicates a strong control of vegetation states and dynamics on fire activity. We further compared the best performing SOFIA models with the global process-oriented vegetation/fire model JSBACH-SPITFIRE, and with the GFED and Fire_CCI burned area datasets. SOFIA models outperform JSBACH-SPITFIRE in predicting regional variabilities of burned area. We further applied the best SOFIA model to identify controlling factors for burned area. The results indicate that fire activity is controlled by regionally diverse and complex interactions of human, vegetation and climate factors.

Our results demonstrate that the use of multiple observational datasets on climate, hydrological, vegetation, and socioeconomic variables together with model-data integration approaches can guide the future development of global process-oriented vegetation/fire models and consequently can provide a better understanding of the interactions between fire and the Earth system.