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Effect of socioeconomic variables in predicting global wildfire ignition occurrence

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Wildfires are a pervasive feature of the terrestrial biosphere and contribute large carbon emissions within the Earth system. Humans are responsible for the majority of wildfire ignitions. Physical and empirical models are used to estimate the effects of fires on vegetation dynamics and the Earth system. However, there is no consensus on how human-caused fire ignitions should be represented in such models.

We aim to identify which globally available predictors of human activity explain global fire ignitions as observed by satellites. We apply a random forest machine learning framework to state-of-the-art global climate, vegetation, and land cover datasets to predict global fire ignition density remote sensing data. We establish a baseline against which influences of socioeconomic data (cropland fraction, gross domestic product (GDP), road density, livestock density, and grazed lands) are evaluated to determine their effects on fire ignition occurrence predictions. Our results show that a baseline random forest without human predictors captures the spatial patterns of fire ignitions globally but overestimates ignition occurrence, with the highest predictions over Sub-Saharan Africa and South East Asia. Adding human predictors one by one to the baseline model reveals that human variables vary in their effects on fire ignitions, and GDP is the most vital driver of fire ignitions. We also find that high road density leads to decreased ignitions globally despite improved environmental access, mainly because these regions are primarily human settlements and will have fewer fires. A combined model with all human predictors shows that the human variables improve the ignition predictions in most areas of the world; still, some regions, e.g., East Africa, have worse predictions than the baseline model.

We conclude that an ensemble of human predictors can add value to physical and empirical models. There are complex relationships between the variables, as evidenced by the improvement in bias in the combined model compared to the individual models.

Furthermore, the variables tested have complex relationships that random forests may struggle to disentangle. Further work is needed to reach concrete conclusions at a global scale, but rather introduce the need for additional work to detangle the complex regional relationships between these variables, particularly across Central and Eastern Africa, where the full model performs poorly despite the high availability of fire ignition data.