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Global fires representation in climate models

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Fires are a global-scale environmental phenomenon, affected by and affecting the global climate. Fire is a process of enormous complexity, depending on myriad parameters. It is neither practical, nor possible to account for all details when modeling global fires at coarse resolutions. In this case, it is reasonable to concentrate on the most important factors that define fire occurrence, while keeping in mind the availability of reliable global information on these factors. We suggest a simple algorithm that allows determining worldwide flammability conditions from vegetation density and a set of meteorological parameters: precipitation, relative humidity, and temperature. These parameters are readily available, and are well verified on a global scale. Given distribution of ignition sources, this method provides the distribution of fire counts, which is easily verified against actual near-global satellite records (unlike burned areas, existing global data on which is less certain).

There are two main sources of fire ignition: lightning discharges and human activities. Information on global lightning distribution is available from the OTD satellite sensor. Global characteristics of anthropogenic ignitions are, largely, unknown. Humans influence fire patterns not only by adding ignition sources, but also by suppressing both anthropogenic and natural fires. Both effects increase with increasing population, to some extent canceling each other. Both success of ignition and effectiveness of fire suppression depend on flammability, making it the primary parameter defining fire activity patterns on a global scale. We test two ignition source models. One incorporates anthropogenic and lightning ignitions, and anthropogenic fire suppression. The other assumes ubiquitous ignition source. We evaluate the model using GPCP precipitation, NCEP/NCAR temperature and relative humidity, and MODIS Leaf Area Index as a proxy for global vegetation density. Both ignition models provide similar results, except for heavily populated areas, where anthropogenic effects dominate. The algorithm reproduces the spatial distribution of global fires fairly well, and recreates the seasonal variations of global fire activity, observed with MODIS and VIRS satellite instruments. We compare model results with 20 years of burned areas records derived from AVHRR data, using a common approach for estimating burned area from fire counts, and past climate simulations from the GISS climate model. The model reproduces the interannual variations reasonably well, recreating the large deviations following the eruptions of El Chichon and Pinatubo volcanoes. Further examination of past fires shows that fire activity have been slowly increasing over the last century, with significant regional variability of fire trends.