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Vegetation fire emission coefficients derived from MODIS fire radiative power and GOME-2 tropospheric NO_2 measurements

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In this study, we use satellite measurements of fire radiative power (FRP) from the MODerate resolution Imaging Spectroradiometer (MODIS) and nitrogen dioxide (NO_2) from the Global Ozone Monitoring Experiment-2 (GOME-2) to derive fire emission coefficients for different types of vegetation. In a first step, monthly means of FRP have been analyzed for temporal correlation with monthly means of tropospheric NO_2 for five consecutive years from 2007 to 2011 on a 1° x 1° grid. The strongest correlation is largely confined to tropical and subtropical regions which account for more than 80% of yearly burned area on average globally. In these regions, the seasonal variation of fire intensity explained by the FRP data is reflected by the tropospheric NO_2 columns to a high degree. In a next step, spatially averaged regression coefficients were determined for four characteristic biomass burning regions. The obtained regression coefficients are used for the prediction of tropospheric NO_2 columns by simply applying a linear regression model. The best agreement between estimated and observed tropospheric NO_2 columns is found for the African regions north and south of equator with large fraction of the NO_2 signal being explained by the seasonal variability of FRP. Indeed, the determination of regression coefficients on a 1° x 1° grid highlights a spatial heterogeneity of slope values (here referred to as fire emission coefficients) indicating changes of emission intensity over different biomes. Therefore, a global land cover map was included in the analysis for deriving fire emission coefficients for different types of vegetation. Retrieved fire emission coefficients for the dominating types of vegetation burned are 0.022, 0.02, 0.019, 0.0185, 0.0131, and 0.0101 10^{15} molecules $10^{-4}\ mW^{-1}\ cm^{-2}$ NO_2 for wooded grassland, broadleaf evergreen forest, cultivated crops, broadleaf deciduous forest and woodland, grassland, and shrubs, respectively. However, the precedence of these values differs amongst the four selected regions for certain vegetation types by a factor of up to two which call into question the use of universal emission factors in recent bottom-up emission inventories. We conclude that our calculated fire emission coefficients may have possible implications for future efforts towards a minimization of uncertainties in global estimates of vegetation fire NO_x emissions.