1. Nitrogen oxides (NOx) emissions from biomass burning

Nitrogen oxides (NOx = NO + NO2) originate from a large number of anthropogenic and natural sources with the latter including the burning of biomass (dead and living vegetation). During the combustion process, nitrogen (N) present in the biomass and in amino acids is converted to NOx and mainly to NO, respectively. Further NOx may also result from the reaction of dissociated oxygen (O) with nitrogen (N2) in the air at very high temperatures. These released chemical compounds play a role in many chemical reactions including the production of ozone (O3).

The exposure to biomass burning related air pollution has impacts on the public health. However, there still exist large uncertainties about the exact amount of biomass burning emissions arising especially from the various approaches (‘bottom-up’ versus ‘top-down’).

It is expected that with the ongoing trend of global warming and its feedback mechanisms, the frequency and intensity of fires will increase in many parts of the world, especially at higher latitudes inside of continents.

2. SCIAMACHY and MODIS

SCIAMACHY on-board ENVISAT was launched in a sun-synchronous polar orbit in March 2002. It was designed for a wavelength region between 240-2380 nm at a moderate resolution of 0.2-1.5 nm with spatial resolution being 60 x 30 km². Local equatorial overpass times: ~10:00 a.m. The retrieval of atmospheric NO2 is based on the Differential Optical Absorption Spectroscopy (DOAS) using the fitting window 425-450 nm. The stratospheric slant columns are removed by subtracting total NO2 columns from a ‘clean’ region (180-220° longitude). Here, only pixels with cloud fraction < 0.2 are considered (FRESOC algorithm). Finally, tropospheric slant columns are converted into vertical columns by applying monthly airmass factors (MOZART model).

MODIS on-board Terra was launched in a sun-synchronous near-polar orbit in December 1999. It was designed for collecting land surface products (e.g. fire) and provided with 36 spectral bands ranging in wavelength from 0.4-14 μm. Local equatorial overpass time: ~10:30 a.m.

The differences in a- and 11-μm blackbody radiation emitted at combustion temperatures are used to derive active fires at 1 km².

3. Temporal correlation of fires and NO2 columns

Fig. 2: Temporal variability of tropospheric NO2, monthly mean tropospheric NO2 over Africa north of the equator (left), Africa south of the equator (middle) and South America (right) (Setzer et al. 2008). Here, the NO2 tropospheric columns are 1 x 1° best fitting NO2 columns from a ‘clean’ region (180-220° longitude).

The uncertainties between observed and estimated NO2 columns are up to ±50% for Africa north and south of the equator and up to ±100% in South America due to negative concentrations observed by the SCIAMACHY instrument occasionally (Fig. 7).

4. Simple linear model for NO2 prediction

Monthly means of MODIS and SCIAMACHY data are used to create a linear relationship between fire counts and emission intensity (reflected in NO2 columns)

NO2 = a * fire_counts + b

Lower (higher) y-intercepts are attributed to lower (higher) wet season NO2 levels originating from anthropogenic sources, lightning and soil (Fig. 6).

Least-squares coefficients on the basis of 1 x 1° pixels (Fig. 3 and 6) are used to predict the NO2 columns.

Variable slope values attributed to differing types and composition of vegetation? (e.g. agricultural lands, dry and wet savanna, forest) Smoldering vs. flaming?

5. Conclusions

• Although NOx emissions from biomass burning are relatively small in magnitude when compared to anthropogenic sources, they influence atmospheric chemistry in large parts of the world.

• In some regions, the annual cycle of fire activity is reflected by the seasonal variability of tropospheric NO2 at a high degree (r > 0.8).

• Increased wet season NO2 levels over African regions may be attributed to higher emission rates of savanna soils and agricultural lands.

• Least-squares slopes and y-intercepts between fire counts and NO2 columns show a heterogeneous distribution and could reflect spatial changes in vegetation and wet season NO2 sources, respectively.

• The prediction of NO2 columns was tested by using fire counts and coefficients of the 1 x 1° best fitting least-squares regression line. It was shown that uncertainties decrease when spatially mean coefficients are applied.

Acknowledgements

• MODIS fire counts have been retrieved from: ftp://neespi.gsfc.nasa.gov/data/s4pa/Fire/MOD14CM1.005/

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Selected references
