Geophysical Research Abstracts
Vol. 14, EGU2012-3621, 2012
EGU General Assembly 2012

Tropospheric NO_2 column densities over oases of the Taklamakan desert (NW-China): satellite DOAS observations and ground based Multi Axis DOAS measurements

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We report about a study on the potential role of biogenic nitric oxide (NO) emissions from soil for the tropospheric nitrogen dioxide (NO_2) column density over typical, intensively used agro-ecosystems of NW-China. For that, we used (a) tropospheric NO_2 column data measured from both, satellite (SCIAMACHY) and ground based (MAX-DOAS) platforms, and (b) statistical data of agricultural management as well as observed meteorological data to estimate biogenic NO soil emissions, fast near-surface conversion of NO to NO_2, and the vertical dispersion of NO_2.

We have chosen three very remote oases (Milan, Ruoqiang, Waxxari) on the southern fringe of the Taklamakan desert in the extremely arid region of northwest China (Xinjiang Uyghur Autonomous Region). These target oases are isolated from each other as well as from other potential NO_2 sources (100-150 km). Therefore, the oases can be considered as typical areal sources of predominantly soil biogenic NO. Moreover, their areal extension is pretty comparable to the typical pixel size of satellite retrievals.

For the period 2003 [U+F02D] 2010, we used monthly mean tropospheric NO_2 vertical column densities (VCDs, in molecules cm$-$2) based on data of the SCIAMACHY satellite. With regard to the satellite observations, the three selected oases can truly be considered as tropospheric NO_2 hotspots in the "middle of nothing" (desert). VCDs of NO_2 were always higher during growing seasons. In the growing seasons of the last 5 years, tropospheric VCDs of NO_2 increased with the annual enlargement of sown and irrigated areas and obligatory strong application of fertilizers.

Furthermore, we performed ground-based MAXDOAS measurements in and around Milan oasis (39.26°N, 88.91°E) in May and June 2011. On a few occasions, we measured VCDs of NO_2 simultaneously upwind and downwind of Milan oasis applying two MAXDOAS instruments. VCDs of NO_2 were generally observed to be significantly higher at the downwind site. This again proved that the oasis itself is an areal source of NO_2 (which originates from NO, biogenically emitted from agricultural soils, and fastly converted .to NO_2 by reaction with atmospheric ozone). The attempt is made to quantify the oasis' NO_2 source strength (i.e. its NO soil emission strength) by application of the simplified form of the so-called Integrated Horizontal Flux Technique.

Observations from both, satellite and ground based platforms confirmed the effect of oasis agriculture on spatial distribution of vertical tropospheric NO_2 column densities. Strong biogenic NO emissions of NO from Milan soils are supported by laboratory results. Considering the ongoing and continuing development of agriculture in the 3000 km long chain of oases around the Taklamakan desert, soil biogenic NO emission may exceed anthropogenic NO_x sources in NW China and might consequently affect local and regional atmospheric chemistry.