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Pinpointing stack NO_x emissions from space

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Since two decades, satellite instruments like GOME(-2), SCIAMACHY, and OMI allow the retrieval of tropospheric NO_2 on global scale with increasing spatial coverage and resolution. By temporal averaging, spatial patterns of anthropogenic sources can be identified, but are limited by the satellite ground pixel size.

S5p/TROPOMI offers a high spatial resolution of up to 3.5×7 km^2, which is more than 10 times higher as compared to OMI. This allows to detect also weaker sources and to partly resolve the spatial distribution of NO_x sources within a megacity or urban areas. However, at these spatial scales, the impact of wind fluctuations becomes crucial when deducing NO_x emission patterns from NO_2 column measurements. For instance, plumes from power plants can often clearly be identified in daily TROPOMI NO_2 maps, but are smeared out in temporal mean maps due to changing wind directions.

Here we present high-resolution NO_x emission maps based on the continuity equation in differential form:

- the daily NO_2 flux is derived from TROPOMI NO_2 column measurements and ECMWF wind fields
- daily sources (emissions) and sinks (reaction with OH) are given by the divergence of the NO_2 flux
- temporal means are calculated for the resulting emissions instead of the NO_2 column densities.

By this procedure, the smearing caused by wind fluctuations is prevented.

The divergence, i.e. the spatial derivative, is very sensitive to strong gradients as occurring for strong localized emissions like from power plant stacks. Thus, this approach allows to pinpoint NO_x point sources.

This method clearly reveals stack emissions from power plants and industrial complexes, and also works over polluted background conditions, like the Saudi-Arabian capital Riyadh or the South African Highveld.