3D remote sensing of air pollution in China

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Abstract

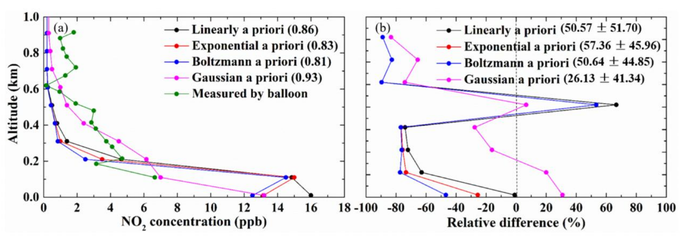
Atmospheric pollution has become a serious menace to public health in China, especially for the Beijing-Tianjin-Hebei region, the Yangtze River Delta and the Pearl River Delta. Recently, remote sensing observations from various platforms (e.g., ground-based MAX-DOAS, lidar, balloon, and satellite) have been extensively used for trace gas and aerosol measurements, which are frequently used to evaluate the air quality and study the formation mechanism of air pollution in China.

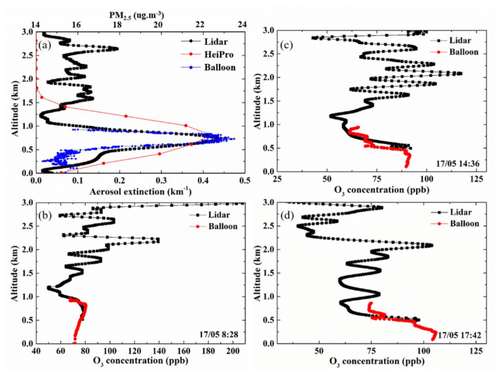
In this study, the column densities, vertical profiles and near-surface concentrations of the trace gases and aerosols can be derived from MAX-DOAS and provide additional information compared to in situ monitoring or satellite observations.

For a further explanation of the trace gases and aerosol properties, and to examine the variety of pollutant sources affecting the air pollution in China, three cases with different study objectives are discussed here, combining ground-based MAX-DOAS observation, lidar measurement, and satellite data, to build a comprehensive analysis.

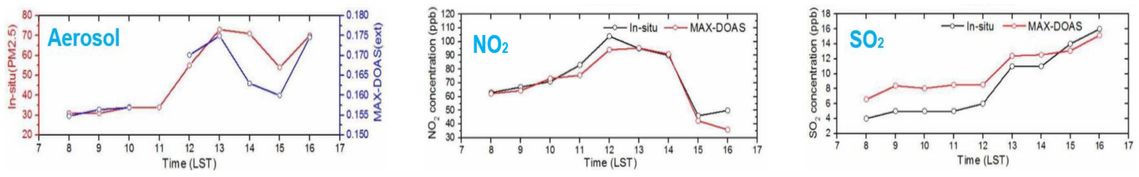
MAX-DOAS retrieval verification

Comparison of the vertical profiles of aerosol and NO_2 with balloon-based measurements



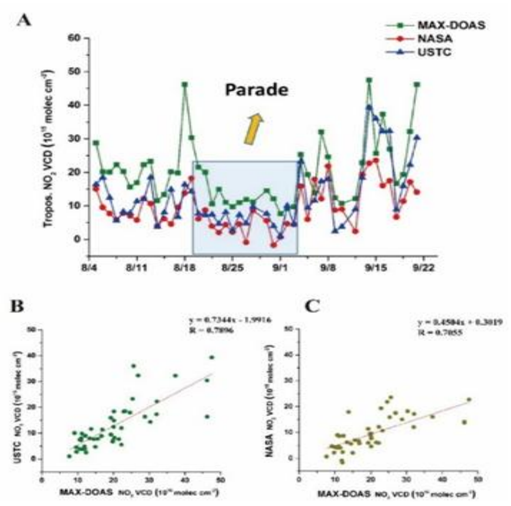


- Using balloon-based measurements as a reference, the NO_2 profile retrieved with the Gaussian aerosol a priori profile shows the best agreement.
- The aerosol profile retrieved using Gaussian a priori profile shows the best agreement with the balloon-based $PM_{2.5}$ measurements; both measurements show a peak value at about 0.75km above ground level.



- For verification purposes, our retrieved aerosol, NO_2 and SO_2 surface concentrations from MAX-DOAS vertical profiles have been compared to results from ground chemical in-situ instruments.
- A very good agreement is found between MAX-DOAS and in situ data, indicating the good overall reliability and the robustness of our MAX-DOAS retrievals.

Satellite validation



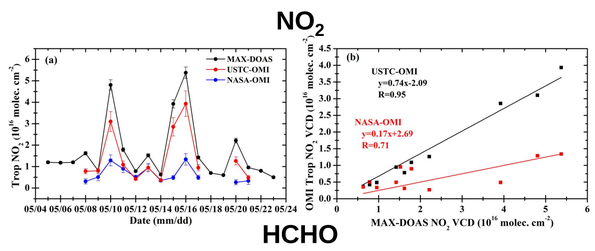
The USTC products compared with NASA results and ground-based remote sensing results

- Correlation：Relevance of the results of USTC satellite remote sensing and ground (~0.80) than NASA satellite results (~0.70), increase by ~ 13%.
- Absolute value ： The difference between USTC products and Groud-base results are systematically 17% smaller than that of NASA's (Liu et al., 2016).

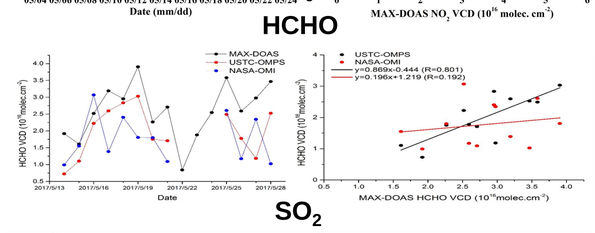
The MAX-DOAS measurements are used to validate the satellite products (e.g. OMI, OMPS).

- Tropospheric NO_2 VCDs measured with MAX-DOAS show a good agreement with USTC OMI product with a Pearson correlation coefficient (R) of 0.95. (Xing et al., 2017).
- Tropospheric HCHO and SO_2 VCDs measured with MAX-DOAS show a good agreement with USTC OMPS products with a Pearson correlation coefficient (R) of 0.80 and 0.76, respectively.

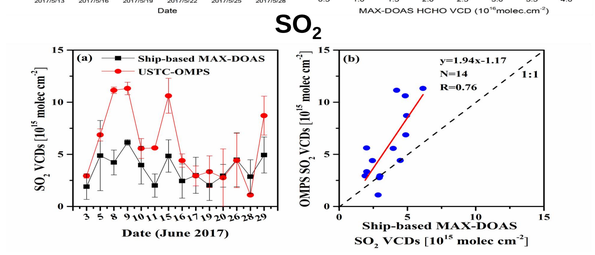
NO_2



HCHO



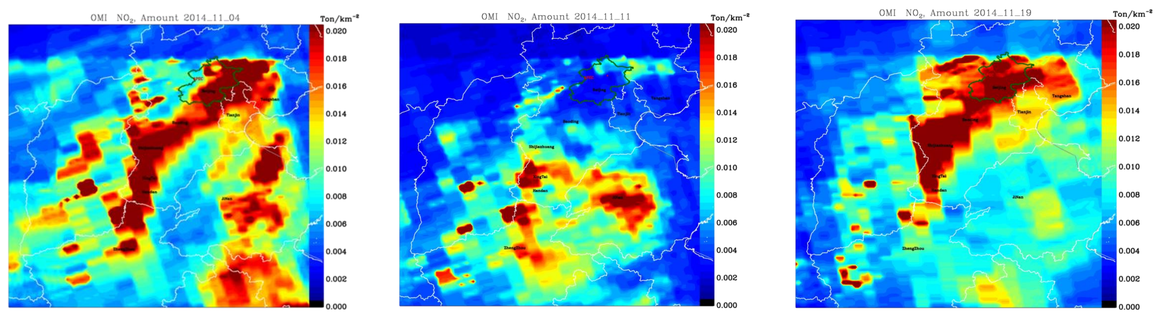
SO_2



Case study of 3D remote sensing of air pollution in China

Case 1 - Application of Atmospheric Satellite Remote Sensing

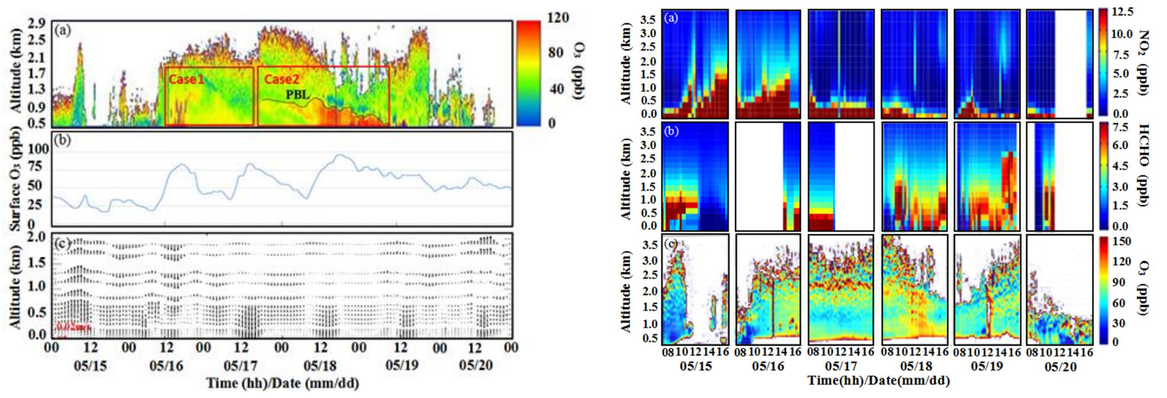
The NO_2 Distribution during 2014 APEC



- 4th November, before the APEC, there is a last larger-scale pollution in the Beijing-Tianjin-Hebei region.
- 11th November, during the APEC, the Beijing area is very clean.
- 19th November, after the APEC, the main urban agglomeration and had an obvious atmospheric pollution transmission effect.

Case 2 - Collaborative observations between ground-based and satellite

It is important to analyze the source of ozone using obtained NO_2 and HCHO vertical profiles.

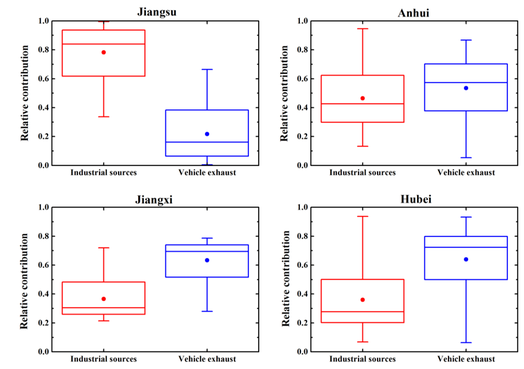


- Combined with NO_2-HCHO-O_3 vertical profiles for analysing the source of ozone, we found the ozone vertical concentrations was strongly correlated with HCHO, but weakly with NO_2.
- High abundance of VOCs and relatively strong radiance contribute to higher formation rates of O_3 at higher altitudes in Shanghai.

Case 3 - ship-based MAX-DOAS Campaign

Ship-based MAX-DOAS measurement campaign was carried out along the eastern part of Yangtze River between Shanghai and Wuhan during winter 2015.

Objectives of this study are to (i) obtain spatial distributions of tropospheric NO2, SO2, and HCHO along the Yangtze River and (ii) formulate the strategy of air pollution control and identification the effectiveness of air pollution control policies.



- Analysis of NO2/SO2 ratios shows higher contribution of industrial NO2 emissions in Jiangsu province, while NO2 levels in Jiangxi and Hubei provinces are mainly related to vehicle exhausts. The results indicate that different pollution control strategies shall be applied in different provinces.

References

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