Trends in tropospheric NO_2 from SCIAMACHY over megacities in the Mediterranean and Middle East

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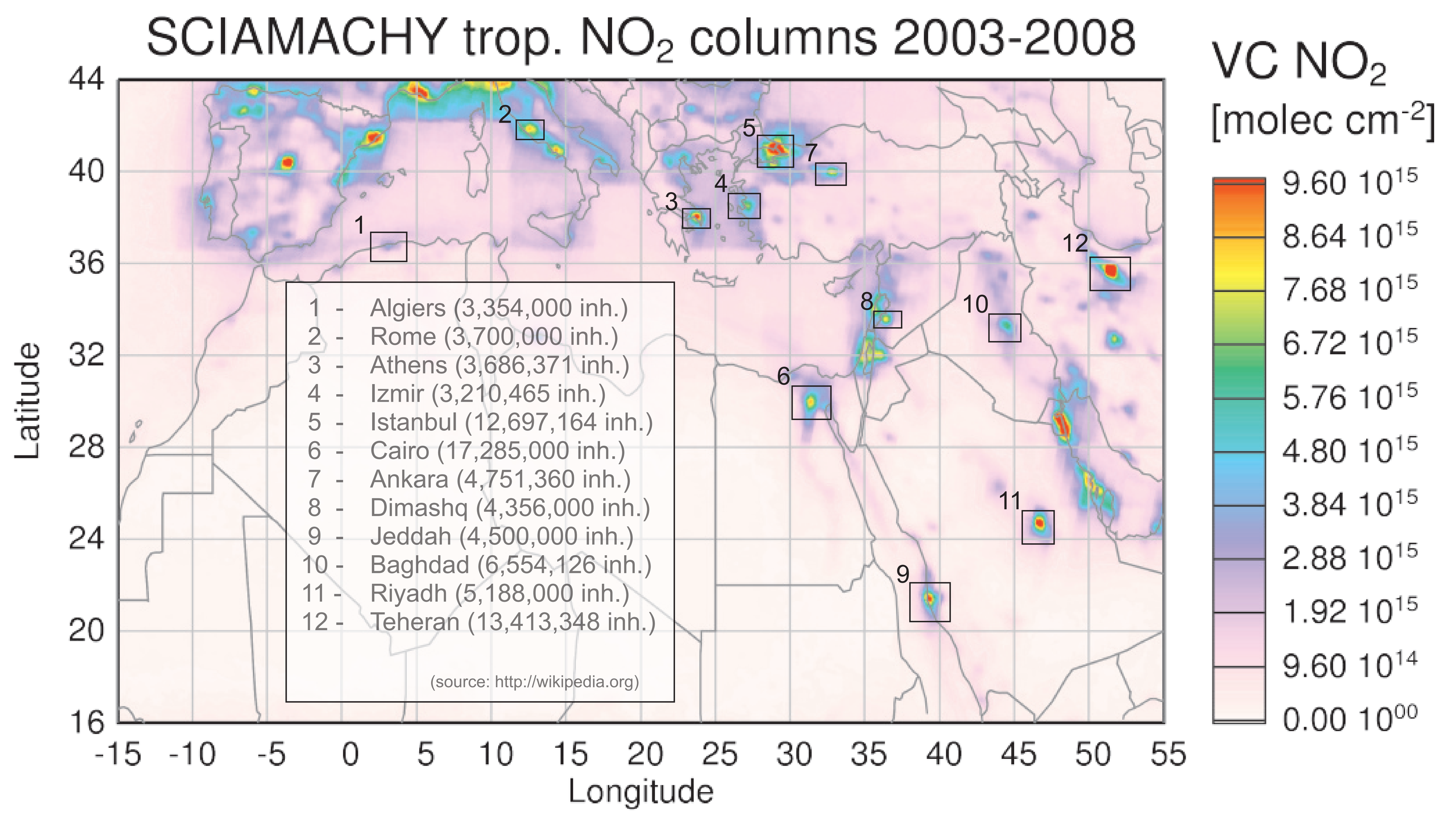
Description of the dataset

To evaluate the temporal evolution of tropospheric NO_2 columns over twelve selected megacities of the Mediterranean and Middle East regions, data derived from the Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY (SCIAMACHY) have been analysed. NO_2 column abundances have been calculated using the Differential Optical Absorption Spectroscopy (DOAS) method. The stratospheric contribution to total columns has been accounted for by subtracting a Pacific Ocean reference sector. Tropospheric air mass factors have been derived using NO_2 profiles from MOZART model results for the year 1997.
Satellite measurements were gridded on a 0.0625° x 0.0625° on which annual mean values have been calculated to derive trends.

Investigated Megacities

Based on population size, twelve megacities of the Mediterranean and Middle East regions have been selected for this study. This map shows their location as well as SCIAMACHY mean tropospheric NO_2 values for the years 2003-2008.



Definition of city boundaries

To define the boundaries of the areas to be investigated, the maxima of the six-year SCIAMACHY dataset were plotted in contour plots. For each city, a threshold value was determined to select the area inside a steep gradient in the maxima.
Compared to using mean values for the boundary selection, this method yields larger areas and thus lower NO_2 values. However, selecting a too small area leads to a larger scatter in observed columns because, depending on the meteorological conditions, the location of a city's NO_2 plume can vary considerably. Therefore, these quantities would be masked out when selecting the city area along a steep gradient in the mean measurements.

Selected References

• Konovalov, I. et al., **Satellite instrument based estimates of decadal changes in European nitrogen oxides emissions**, *Atmos. Chem. Phys.*, **8**, 2623-2641, 2008.
• Richter, A. et al., **Increase of tropospheric nitrogen dioxide over China observed from space**, *Nature*, **437**, 129-132, 2005.
• van der A, R. J. et al., **Trends, seasonal variability and dominant NO_x source derived from a ten year record of NO_2 measured from space**, *Journal of Geophysical Research*, **113**, D04302, 2008.

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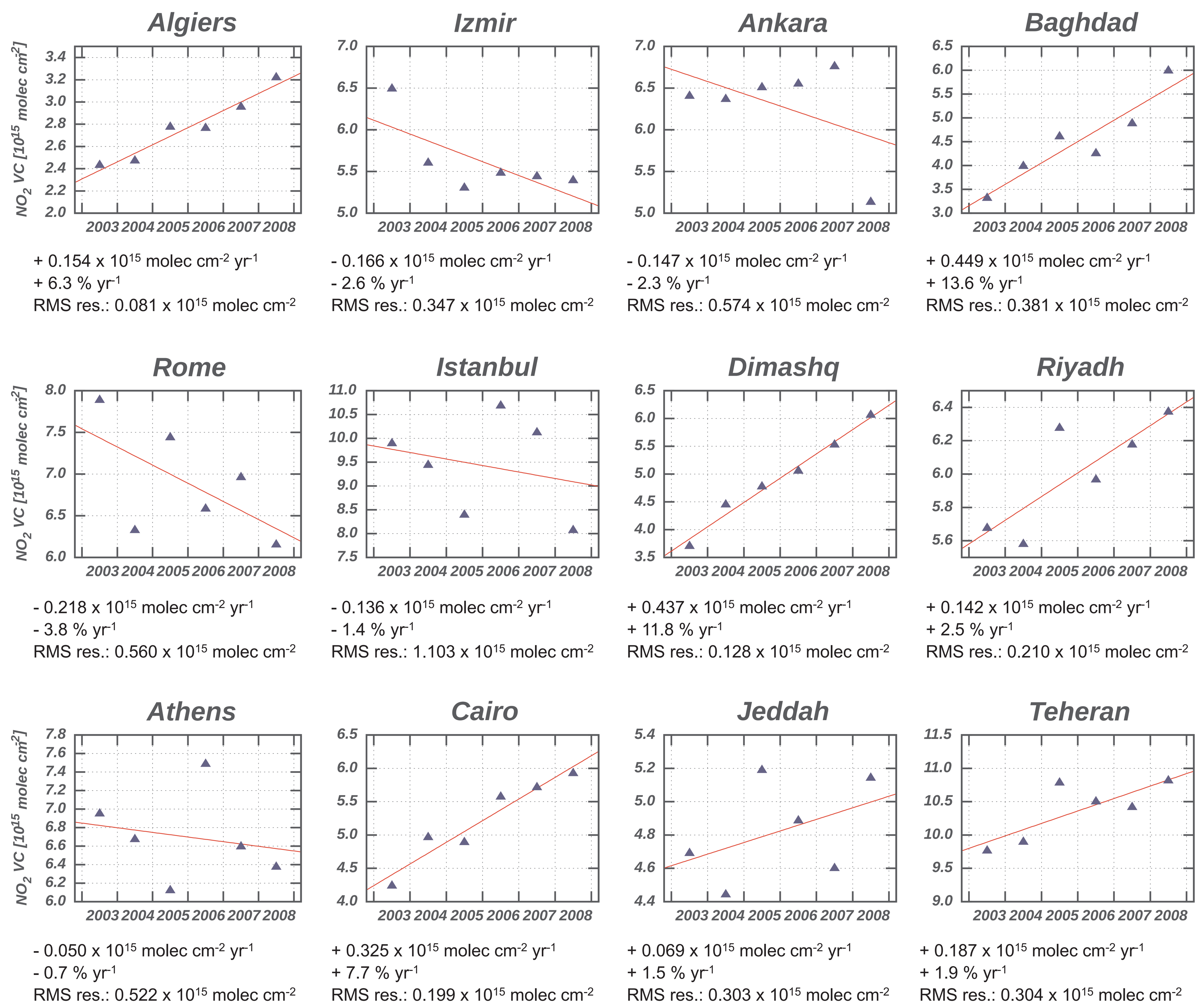
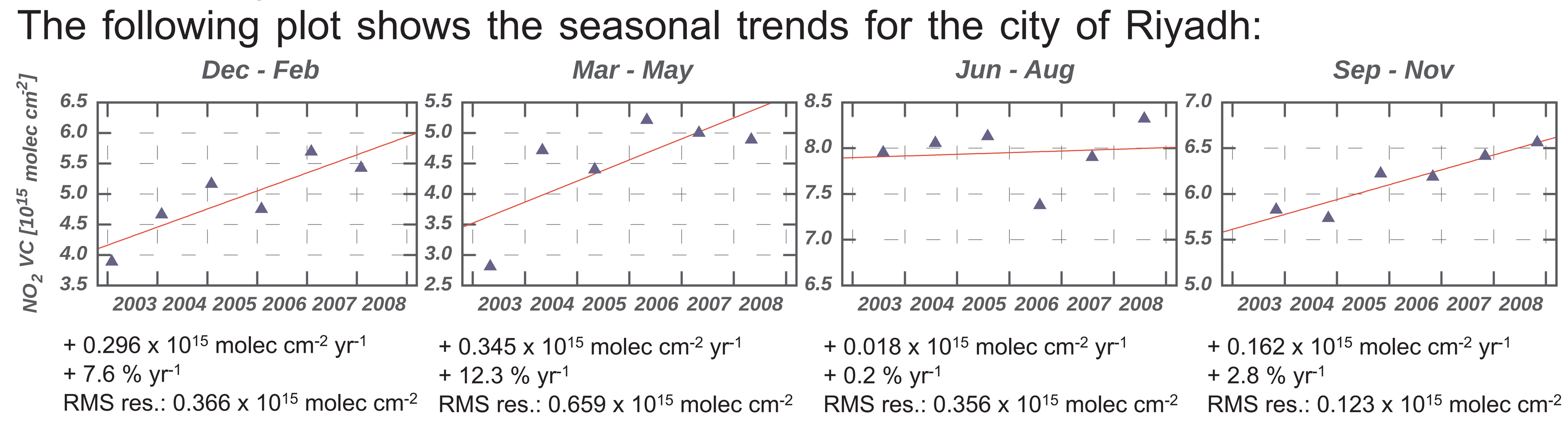
Observed annual trends

Plots show SCIAMACHY annual mean tropospheric NO_2 columns (blue) and their linear least squares fit (red). For each city, the annual trend (absolute and relative) as well as the RMS of the fit residuals are given.

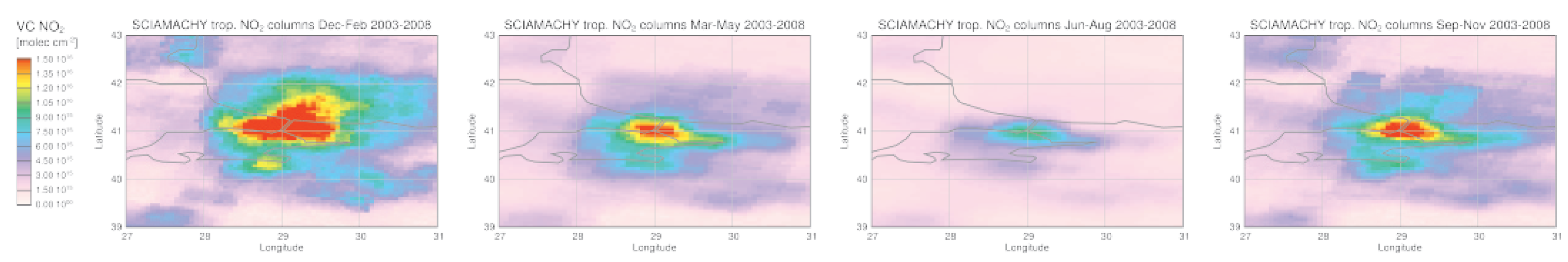


Investigating seasonal trends

The four seasons contribute with differing weights to the annual trends, due to the different absolute values in observed column abundances. Therefore, it is interesting to study the trends of the different seasons individually.
Naturally, the fit quality is poorer for seasonal than for annual trends, due to the reduced sample size.
The following plot shows the seasonal trends for the city of Riyadh:



Due to variations in the predominant meteorological conditions, the location of the NO_2 plume varies with season. For calculating exact seasonal trends, one would need to account for this in the selection of the city boundaries (see above).
The following plots show mean tropospheric NO_2 columns for the different seasons for Istanbul:



Results

• Clear positive trends can be observed in the annual mean tropospheric NO_2 columns over the cities of Algiers, Cairo, Dimashq, Baghdad, Riyadh and Teheran. Jeddah also shows increasing values, but with a larger scatter.
• The city of Ankara shows a clear positive trend for the years 2003-2007, with an unusually low value following in 2008.
• The patterns of Athens and Istanbul resemble each other, with very high NO_2 in 2006 following a very low value for 2005, but generally no trend can be identified.
• Of all observed cities, Rome and Izmir are the only ones showing a clear decrease in mean tropospheric NO_2 values.

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