

Multi-year validation of atmospheric NO₂ measurements with the Ozone Monitoring Instrument onboard the EOS-Aura satellite using spectrometric ground-based NO₂ measurements at Zvenigorod, Russia

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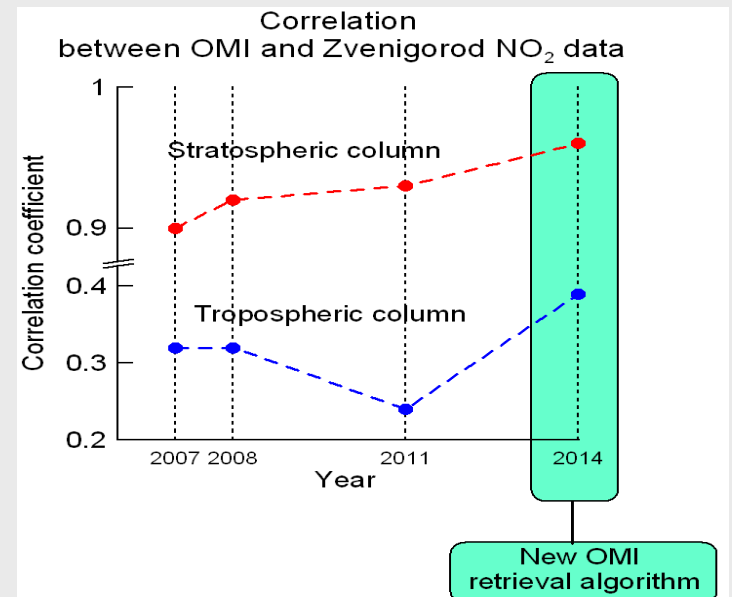
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Motivation

- **NO₂ measurements with the OMI instrument were validated by different scientific groups during the first three years of operation of the instrument (*Celarier et al., 2008; Ionov et al., 2008; Brinksma et al., 2008; Buscela et al., 2008; Gruzdev and Elokhov, 2009*).**
- **Good or satisfactory correlation between stratospheric NO₂ columns retrieved from OMI and ground-based measurements was obtained for entire-year data.**
- **Correspondence between tropospheric NO₂ columns is worse.**
- **We have recently shown (*Gruzdev and Elokhov, 2013*) that the good correlation between stratospheric NO₂ columns is largely due to the NO₂ annual cycle which is approximately the same for OMI and ground-based data,**
- **while the lack of correlation between tropospheric NO₂ columns at Zvenigorod was, in part, due to the wrong annual cycle in tropospheric NO₂ derived from OMI measurements.**

Motivation

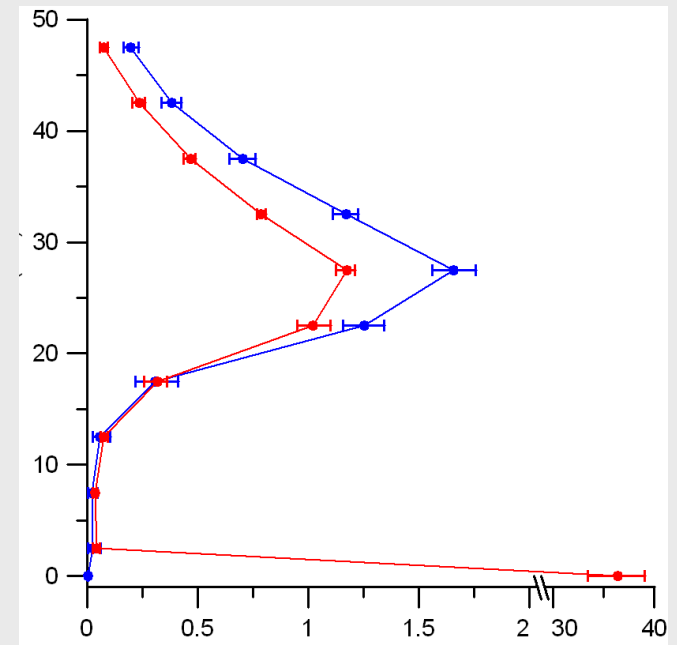
- Recently, a new algorithm for retrieval of NO₂ vertical columns from nadir-viewing satellite instruments was proposed, which was applied to OMI measurements (*Buscela et al.*, Atmos. Meas. Tech., 2013).
- It has resulted in an improvement of the entire-year correlation of OMI NO₂ data with results of ground-based measurements at Zvenigorod.
- A detail comparison of OMI NO₂ data with data of ground-based measurements are presented below.



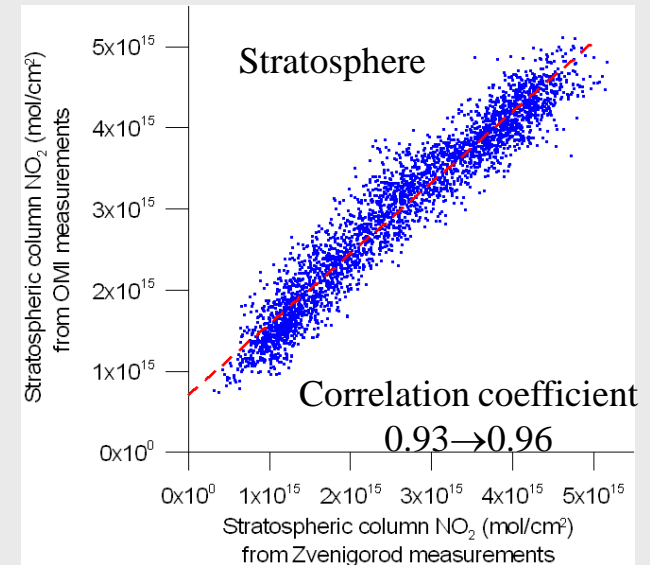
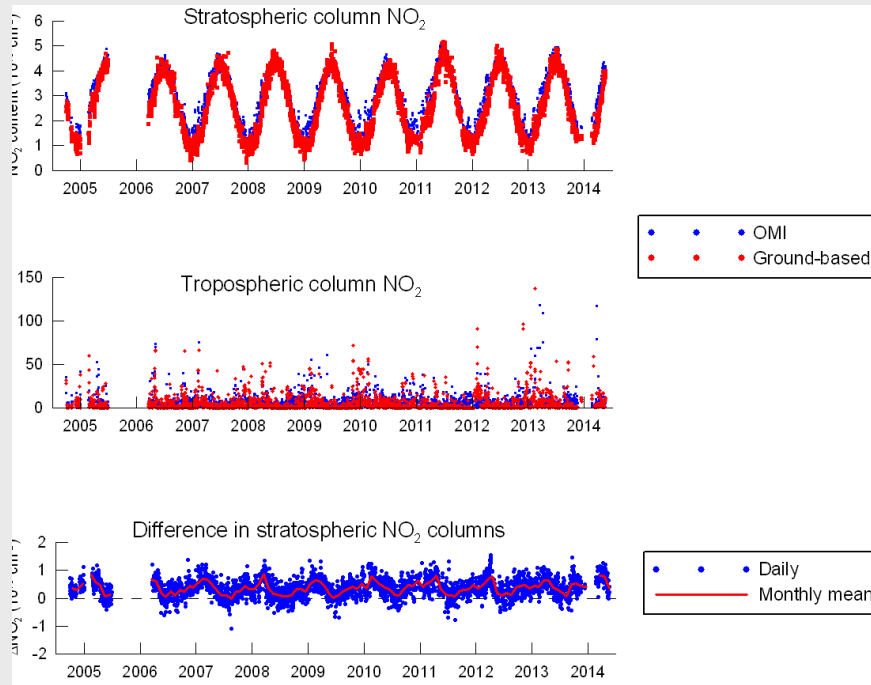
Method of NO₂ measurements at Zvenigorod

- The station is located in a rural area 50 km west to Moscow.
- Vertical NO₂ profiles are retrieved from results of twilight measurements of slant column abundances of NO₂ at Zvenigorod.
- Stratospheric and tropospheric NO₂ columns are obtained from the NO₂ profiles.
- The NO₂ content in the atmospheric boundary layer can significantly increase under conditions of anthropogenic pollution.
- Taking into account of the boundary-layer NO₂ is very important for correct estimates of stratospheric NO₂.

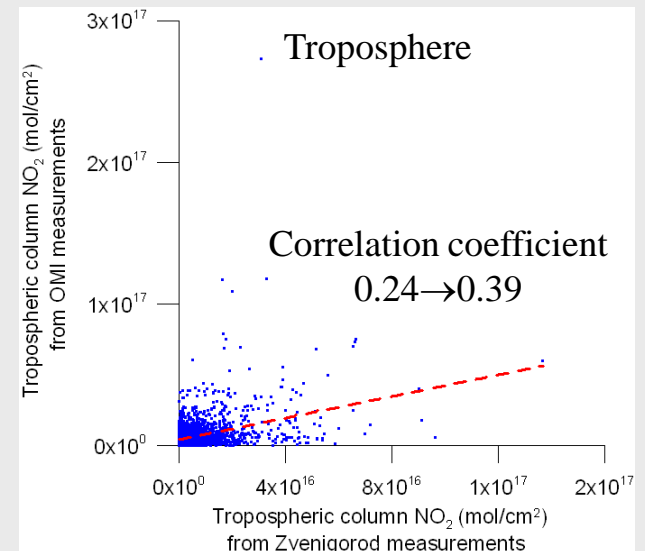
Examples of NO₂ profiles in conditions of polluted and unpolluted surface layer



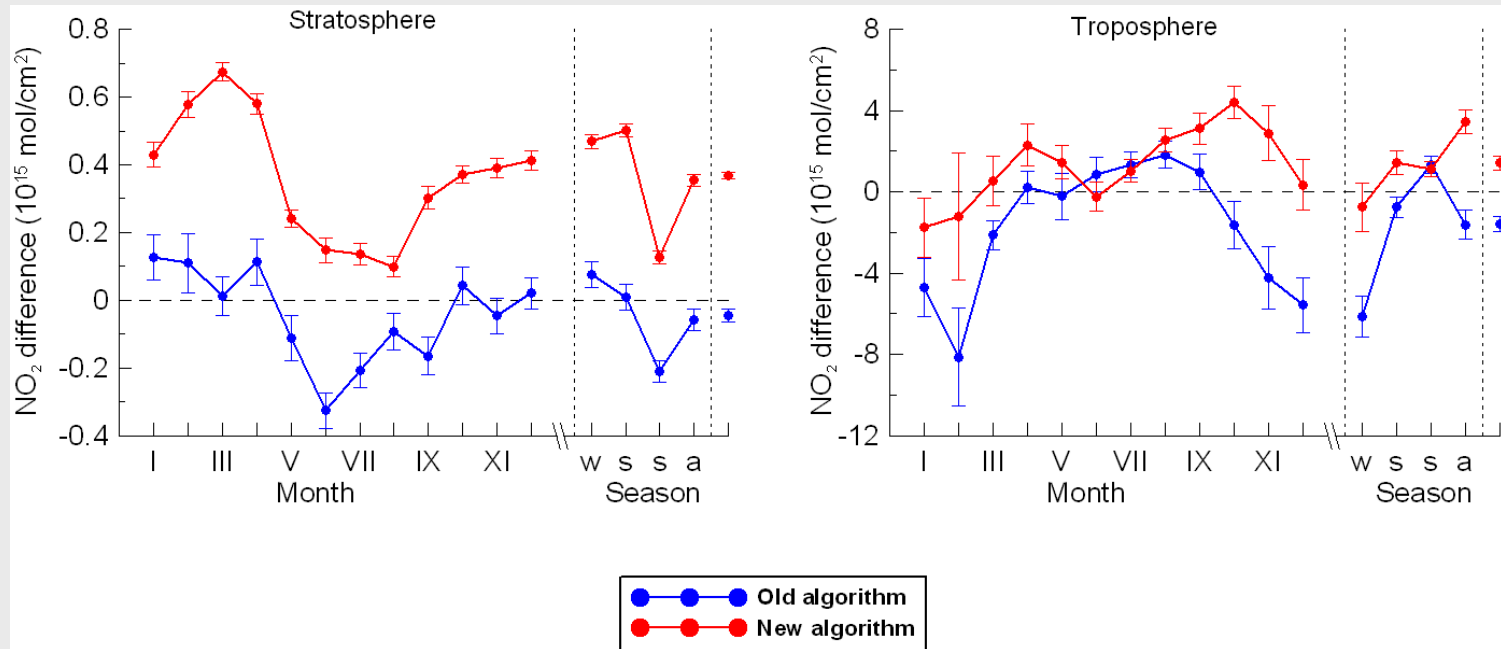
Comparison: General features



- The new algorithm of NO₂ retrieval from OMI measurements has resulted in an increase of correlation of satellite data with data of ground-based measurements.
- As before, the high correlation between stratospheric NO₂ columns is significantly due to the NO₂ annual cycle.

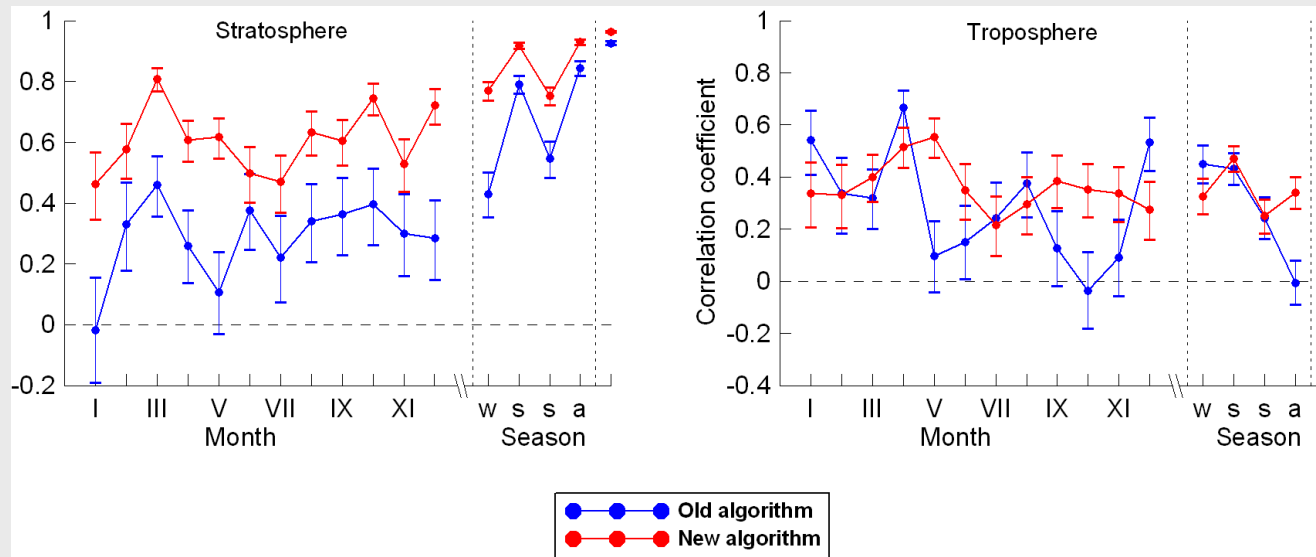


Comparison: Seasonally dependent difference in NO₂



- With the use of the new algorithm, stratospheric NO₂ columns derived from OMI measurements are generally overestimated compared to results of ground-based measurements. The overestimation approaches 40% in winter.
- Along with this, there is an improvement of correspondence between tropospheric NO₂ columns.

Comparison: Seasonally dependent correlation



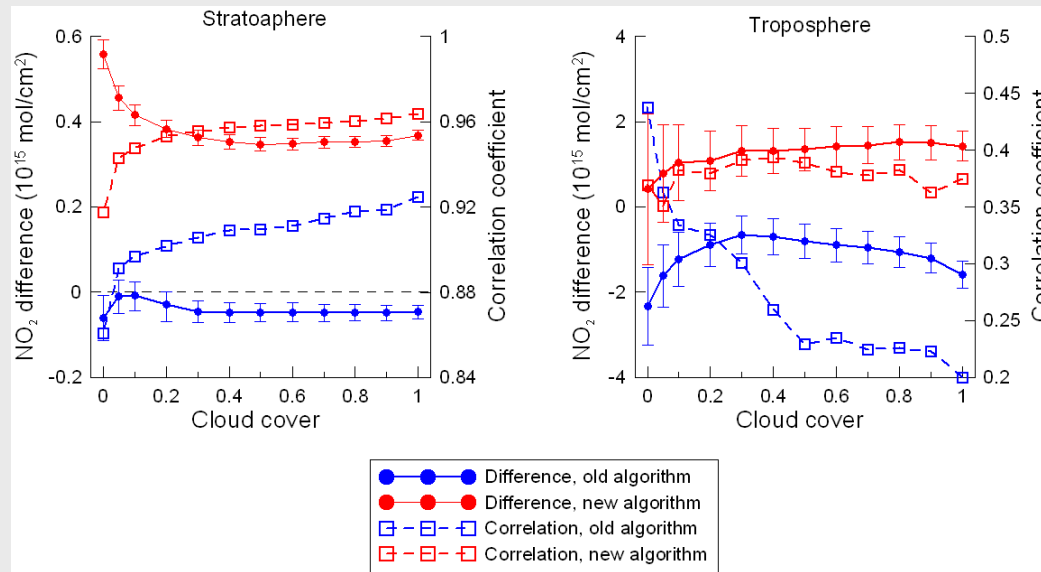
Old algorithm

- Monthly correlation coefficients for stratospheric NO₂ are low (~0 in January). On the whole, they are even less than those for tropospheric NO₂. Thus, the high entire-year correlation between stratospheric NO₂ columns (~0.9) is due to the annual cycle.

New algorithm

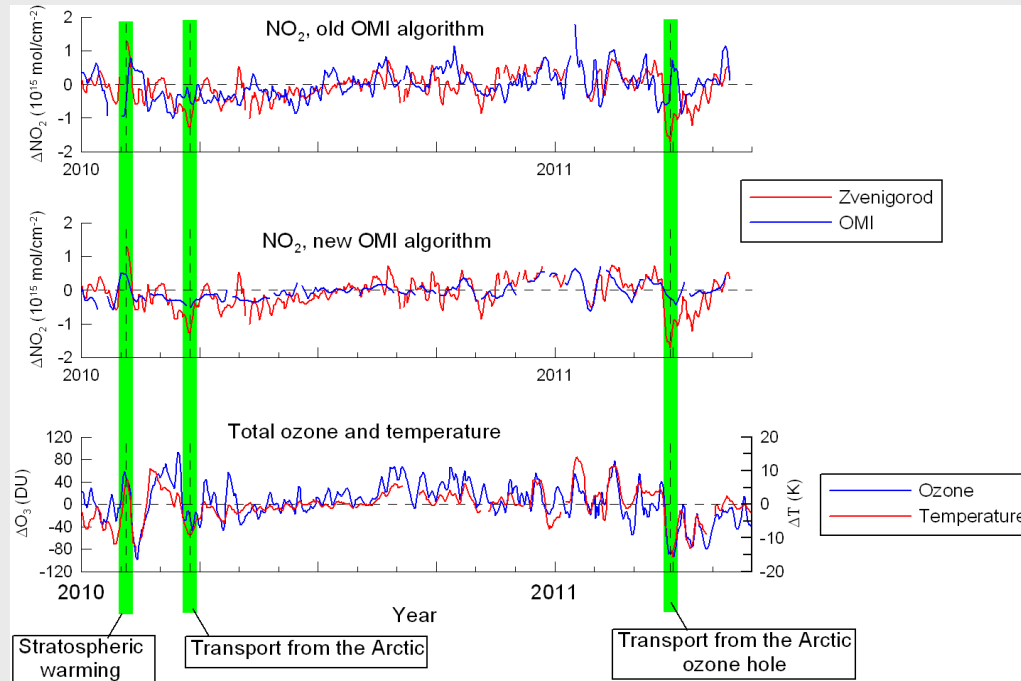
- The correlation between stratospheric NO₂ columns has been significantly improved. However it is still not so high (~0.6) as would be desirable.
- A general improvement of the correlation between tropospheric NO₂ columns can be also noted. The correlation coefficients are somewhat lower (~0.4) compared to those for stratospheric NO₂ columns.

Comparison: Effect of cloudiness



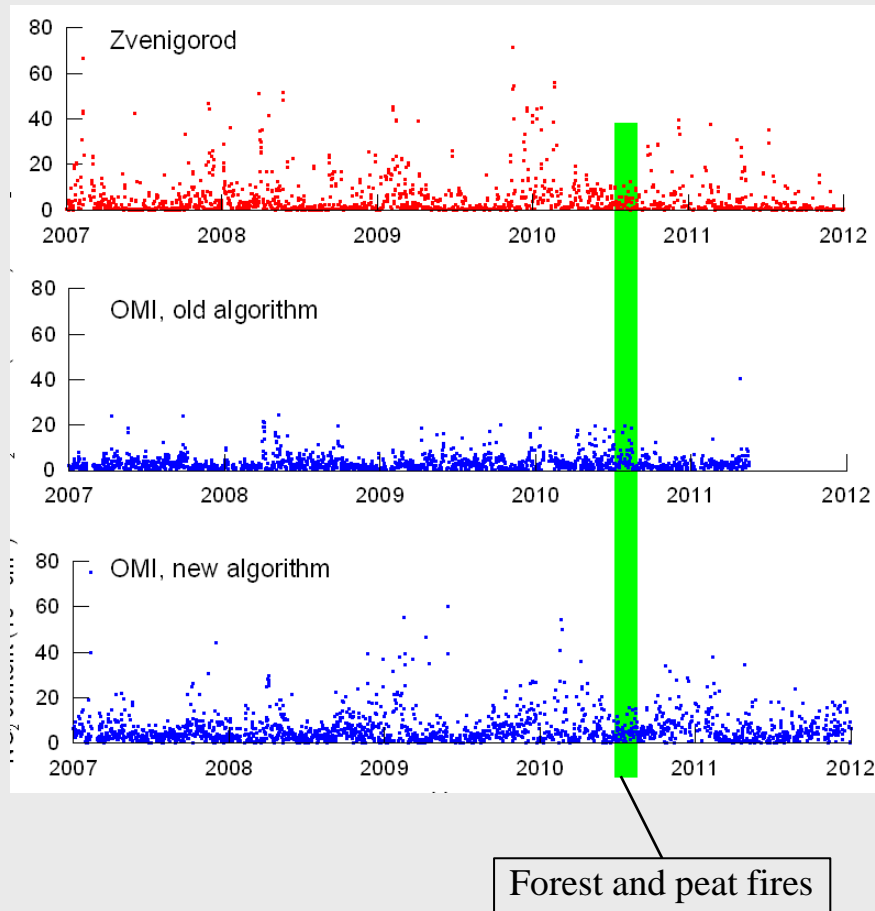
- Irrespective to the OMI retrieval algorithm, the correlation between stratospheric NO₂ columns derived from OMI and ground-based measurements decreases under clear-sky conditions.
- Besides, in the case of application of the new algorithm, the discrepancy between stratospheric NO₂ columns increases significantly, up to a factor of 1.5 under cloudless conditions.
- The correlation and the difference between tropospheric NO₂ columns is only weakly dependent on cloud cover if the new algorithm is used. Generally, the correspondence between tropospheric NO₂ columns has improved considerably.
- It should be noted that the correlation between tropospheric NO₂ columns under clear-sky conditions was better when the old algorithm was used (~0.45 versus ~0.25).

Specific events: Anomalies in stratospheric NO₂



- The OMI data retrieved with the old algorithm do not reproduce even most important and strong anomalies in stratospheric NO₂ over Zvenigorod such as negative anomalies related to transport from the Arctic and positive anomalies due to sudden winter stratospheric warmings.
- Application of the new algorithm have resulted in better correspondence to results of ground-based measurements. However the amplitudes of NO₂ deviations in OMI data are much less than the amplitudes of the anomalies derived from Zvenigorod data.

Specific events: Forest and peat fires in summer 2010



- According to OMI data retrieved with the old algorithm, the NO₂ contents in the low troposphere near Zvenigorod during the period of summer 2010 fires were larger than usually.
- According to data retrieved with the new algorithm, these contents were typical for this period of year,
- which corresponds to the results of ground-based measurements supported also by data of measurements of surface NO₂ concentration.

Conclusions

- OMI NO₂ measurements continue for 10 years.
- Application of the new algorithm to OMI measurements has resulted in a significant improvement of the correspondence of OMI data to data of ground-based measurements at Zvenigorod station according to some quantitative characteristics.
- In particular, intra-seasonal correlation between OMI and ground-based data has been improved.
- However there is a systematic discrepancy between OMI and Zvenigorod data on stratospheric NO₂, which is larger when measurements are done under cloudless conditions.
- Despite the completion of the official validation campaign, further validation OMI NO₂ measurements is needed.
- OMI NO₂ data for regions exposed to pollution should be used with caution for such problems as long term trends and short period variability.

**Thank you for your
attention**

