OMI-AO Progress Report

ID: **2926**

Title of the Proposal:
Validation of OMI ozone and NO_2 vertical column data with ground-based spectroscopic measurements in Russia and NIS

Type: 4th Progress Report

Date: 31. Aug. 2007

Status: We continued validation of AURA OMI nadir level 2 data by means of comparisons with correlative ground-based measurements over Russia/NIS in 2004-2007. Our studies were focused on the investigation of OMI ozone and NO_2 nadir products - OMTO3, OMDOAS and OMNO2.

Problems: We have experienced technical problems with some of our ground-based instruments. Thus, one of the M-124 ozonometer ("Petropavlovsk") have been removed due to the degradation of optic filters, which are not produced in Russia anymore. Besides, the UV-VIS installed at St.Petersburg was not operating for a number of days in spring 2007, due to the instrument upgrade. We had also to re-analyse the full time serie of UV-VIS NO_2 vertical column data acquired at St.Petersburg in 2004-2006. The instrument is now back to normal operation since July 2007.

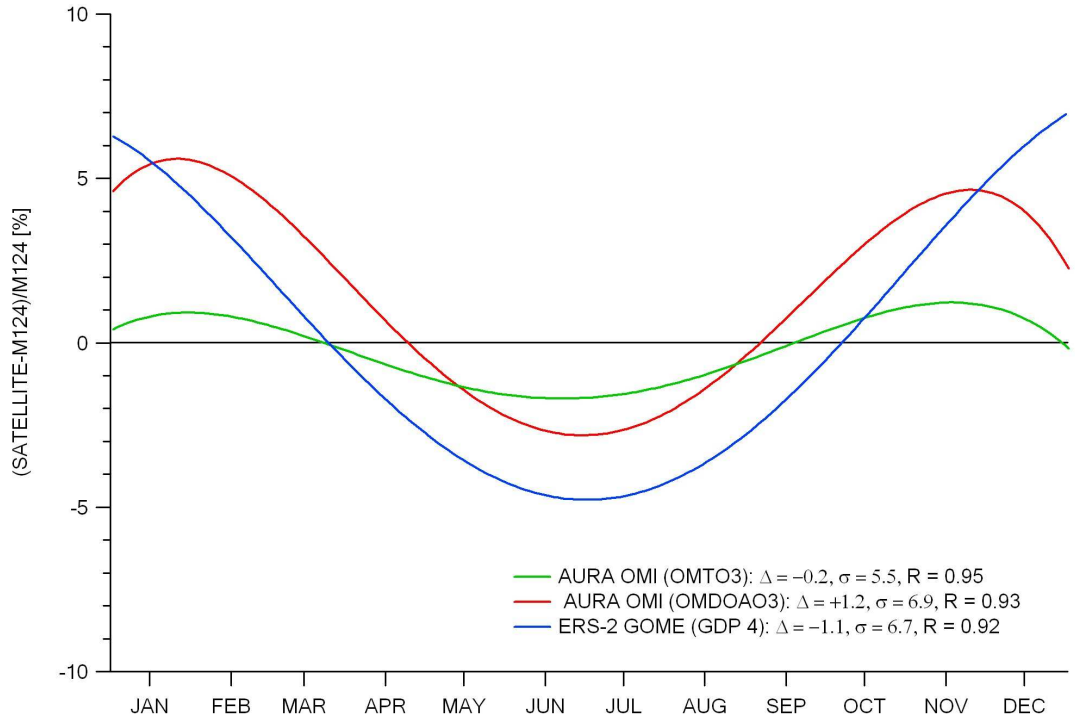
Achievements: Compared to the previous Progress Report, we have updated our results with an analysis of the new ground-based data, acquired in 2007:

Ozone (O_3)

According to the results of comparison with the measurements of 13 Russian UV filter ozonometers (M-124) in 2004-2007, TOMS-like OMI total ozone (OMTO3) agree with ground-based data within -0.2±5.5%, which is better than similar estimate for the comparisons of M-124 with GOME GDP4 (-1.1±6.7%). DOAS-type OMI total ozone (OMDOAO3) is systematically higher than OMTO3 in winter (up to 5%), and agree with correlative ground-based measurements within +1.2±6.9%. To compare with satellite total ozone data we use daily averaged M-124 measurements, both direct sun and zenith sky mode (either clear sky or cloudy). The processing of M-124 measurements utilizes empirical coefficients of cloud correction, which is determined by the visual estimation of cloud optical density through the color scale and homogeneity of clouds at the sky zenith. We have not found that the agreement between satellite and ground-based data depends much on the cloud fraction of correlative satellite pixel. However, selecting the OMI DOAS data with cloud fraction < 25% provides an agreement with ground-based M-124 measurements of about +1.0±5.8% (which is better than that for OMI DOAS data with cloud fraction > 25%, +1.4±7.5%).

Absolute average difference and standard deviation (Δ, σ), and correlation (*R*) between M-124 and satellite data in 2004-2007

STATION	GOME GDP4			OMI OMTO3			OMI OMDOAO3		
	Δ	σ	R	Δ	σ	R	Δ	σ	R
St.Petersburg	+1.66	7.27	0.92	+1.54	5.83	0.95	+4.28	7.42	0.93
Irkutsk	-	-	-	+0.74	6.02	0.92	+1.69	6.39	0.91
Y.-Sahalinsk	-	-	-	+0.28	5.72	0.93	+1.34	6.35	0.92
Samara	-3.49	6.29	0.89	-3.93	5.25	0.92	-1.97	5.94	0.91
Murmansk	+0.07	7.55	0.93	-0.22	6.75	0.96	+0.50	9.57	0.90
Magadan	-	-	-	+0.72	5.08	0.95	+2.15	6.29	0.94
Yakutsk	-	-	-	-0.25	4.94	0.96	+0.50	7.00	0.93
Pechora	-3.07	5.96	0.95	-2.74	4.33	0.98	-1.95	7.18	0.94
Krasnoyarsk	-	-	-	+1.94	6.15	0.92	+3.73	5.71	0.94
Vitim	-	-	-	+0.37	4.47	0.96	+1.42	7.10	0.93
Voronezh	-1.79	5.80	0.90	-0.92	4.41	0.95	+0.94	5.39	0.93
Arhangelsk	-0.01	5.27	0.95	+0.39	4.86	0.96	+1.95	6.84	0.91
Nikolaevsk	-	-	-	-0.01	3.44	0.98	+1.74	3.84	0.98
OVERALL:	-1.06	6.69	0.92	-0.21	5.49	0.95	+1.25	6.89	0.93

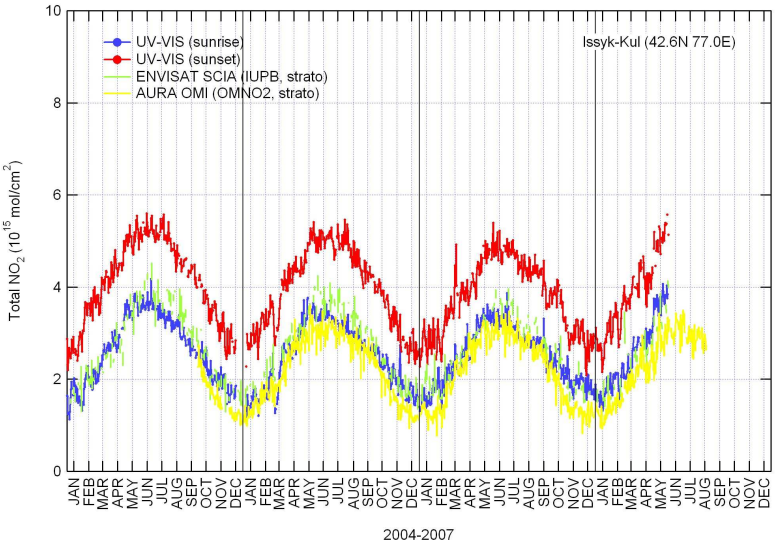


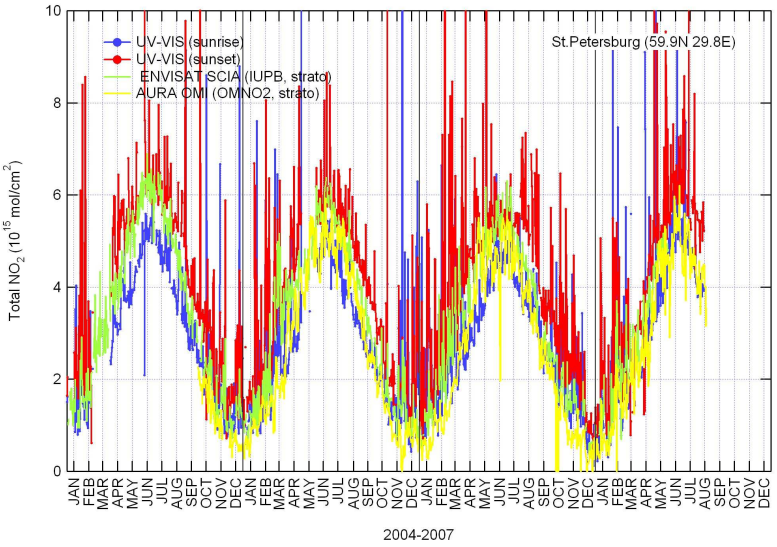
Relative difference between satellite data (OMI, GOME) and correlatve ground-based measurements of M-124 in 2004-2007, as a function of season

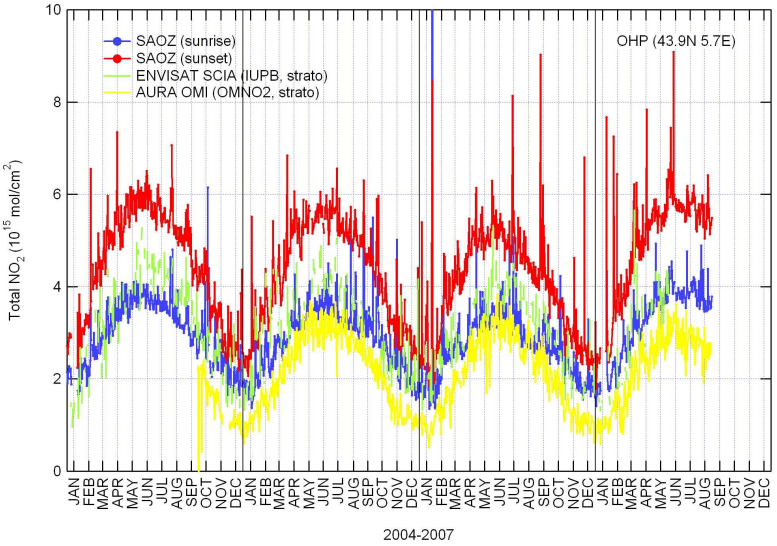
Nitrogen dioxide (NO_2)

OMI NO_2 column data (OMNO2) was compared to ground-based UV-visible twilight observations at Issyk-Kul (Kyrgyzstan, 43N/77E) and St.Petersburg (Russia, 60N/30E) in 2004-2007. Overall, adjusted to the time of sunrise, OMI NO_2 data agree with UV-VIS ground-based data within -14.0±13.2% ($-0.3\pm0.3\times10^{15}$ molec/cm^2) over remote station at Issyk-Kul, and worse – over polluted area of St.Petersburg, -15.3±40.7% ($-0.4\pm1.5\times10^{15}$ molec/cm^2).

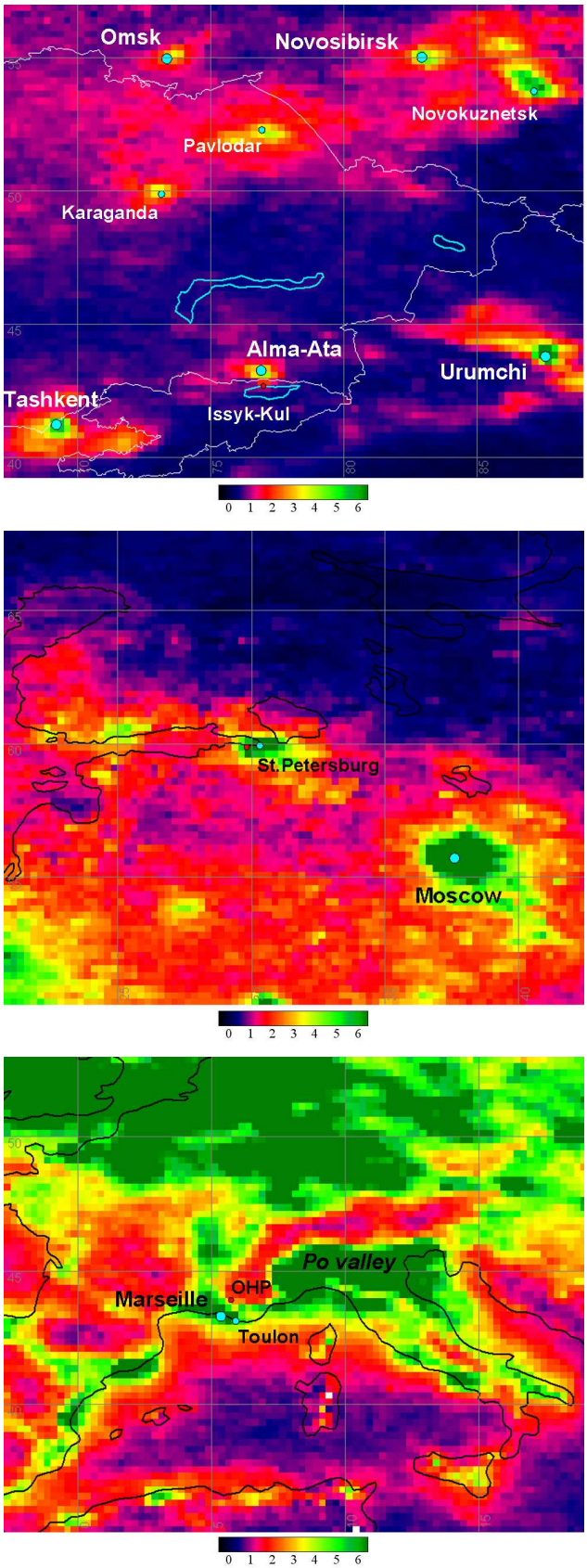
Comparative validation study have been carried out, including correlative UV-visible ground-based observations in mid-latitudes – at Issyk-Kul station in Kyrgyzstan and Observatoire de Haute-Provence in France (SAOZ), for the period of 2004-2006. Although being a remote mountainous sites, both stations were found to be exposed to local pollution sources. Considerable tropospheric pollution in the region of Issyk-Kul and OHP was detected by OMI, and also observed in the results of ENVISAT SCIAMACHY NO_2 mapping. The annual tropospheric NO_2 column over Issyk-Kul is estimated to be 0.72×10^{15} molec/cm^2 and 1.19×10^{15} molec/cm^2, as measured by OMI and SCIAMACHY, respectively. At OHP, the annual tropospheric NO_2 column is estimated to be even much higher: 2.56×10^{15} molec/cm^2 and 3.14×10^{15} molec/cm^2, as measured by OMI and SCIAMACHY. Therefore, direct comparison between OMI and ground-based measurements of NO_2 total column is impossible, as the ground-based twilight measurements are much less sensitive to tropospheric NO_2, than satellite nadir measurements. Consequently, stratospheric NO_2 column was calculated as a difference between OMI total and tropospheric column, and compared with correlative ground-based measurements at Issyk-Kul and OHP. All OMI data have been compensated for NO_2 diurnal photochemical change and normalized to sunrise values using a photochemical box model. According to comparison results, midlatitude OMI stratospheric NO_2 column data underestimate correlative ground-based measurements by $(0.29\pm0.28)\times10^{15}$ molec/cm^2 and $(0.82\pm0.62)\times10^{15}$ molec/cm^2 at Issyk-Kul and OHP, respectively. However, these differences are at the limit of error bars of compared measurements, as it comes from the estimates of their absolute accuracy: $\sim0.6\times10^{15}$ molec/cm^2 and $\sim0.2\times10^{15}$ molec/cm^2, for ground-based UV-visible and satellite OMI instrument, respectively. Besides, the present study shows better agreement, compared to similar validation of ERS-2 GOME data over Issyk-Kul in 1996-2003, but worser agreement, compared to validation of ERS-2 GOME data over OHP in 2004-2006 and SCIAMACHY in 2004-2005. The latter may be attributed to the difficulties of stratosphere-troposphere separation within the OMI processing algorithm in the presence of heavy NO_x pollution at OHP. For the accurate validation of satellite OMI NO_2 data, the effects of tropospheric pollution should be further studied in detail. The smoothing errors, arising from the difference in spatial sensitivity (both vertical and horizontal) of compared remote sensing measurements, can be evaluated by means of the careful investigation of corresponding averaging kernels. Comparison of UV-visible ground-based measurements with the initial OMI NO_2 data (assuming stratospheric AMF, before the spatial smoothing and stratosphere-troposphere separation is applied in the OMI algorithm) may be useful as well, as it will probably be more consistent with the similar validation studies of ERS-2 GOME and ENVISAT SCIAMACHY satellite instruments.





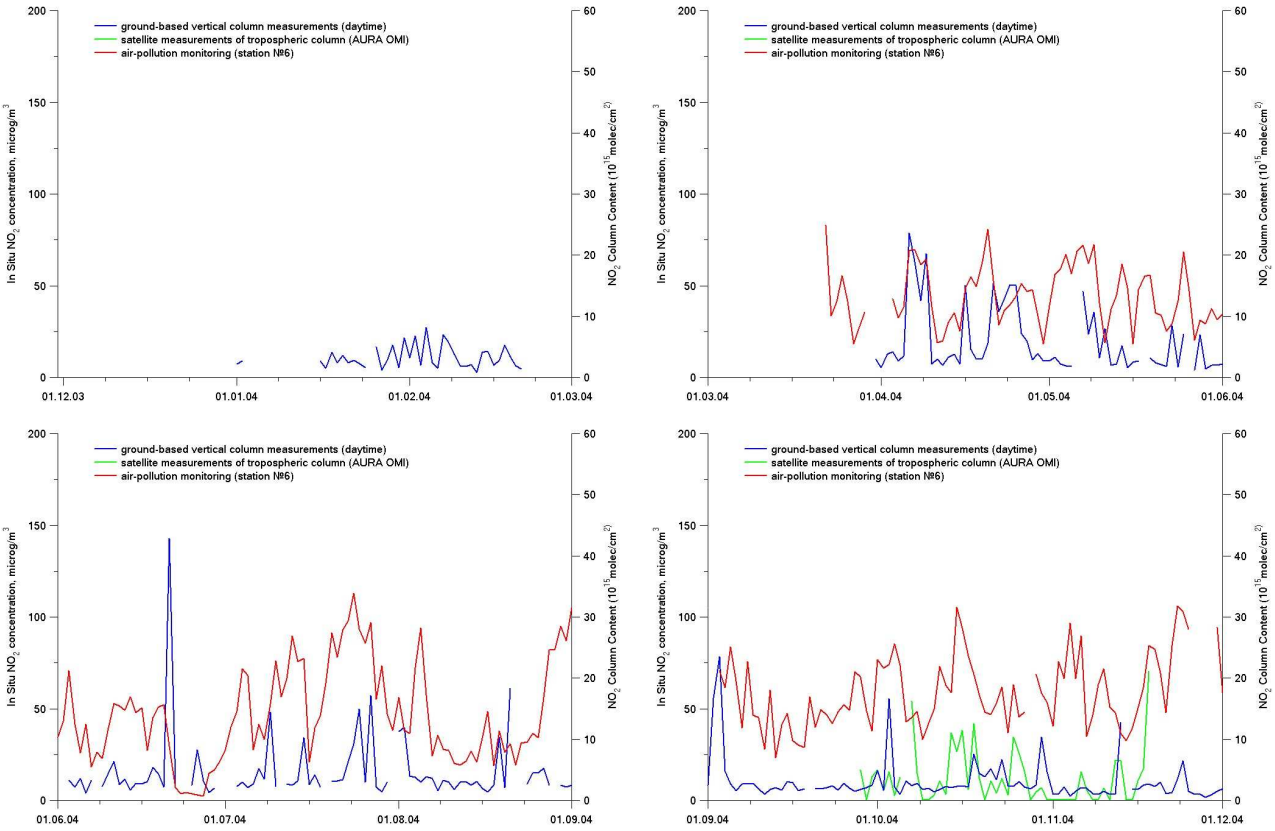


Comparison of ground-based total NO_2 measurements at Issyk-Kul, St.Petersburg and OHP with operational ERS-2 GOME, scientific ENVISAT SCIAMACHY and AURA OMI data in 2004-2007

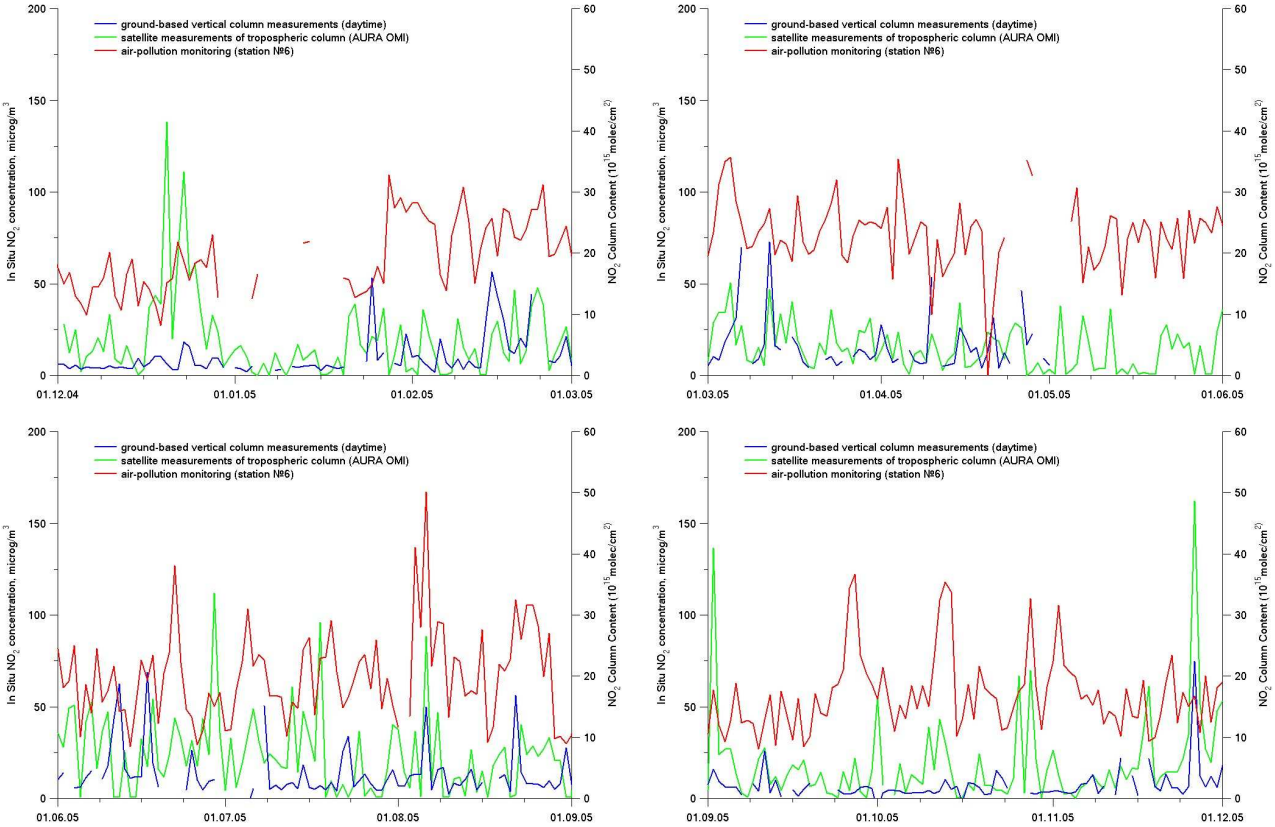


Annual map of tropospheric NO_2 vertical column over Issyk-Kul, St.Petersburg and OHP, produced from the global data of ENVISAT SCIAMACHY monthly mean tropospheric NO_2 in 2003-2006, 10^{15} molec/cm^2 (available at http://www.temis.nl).

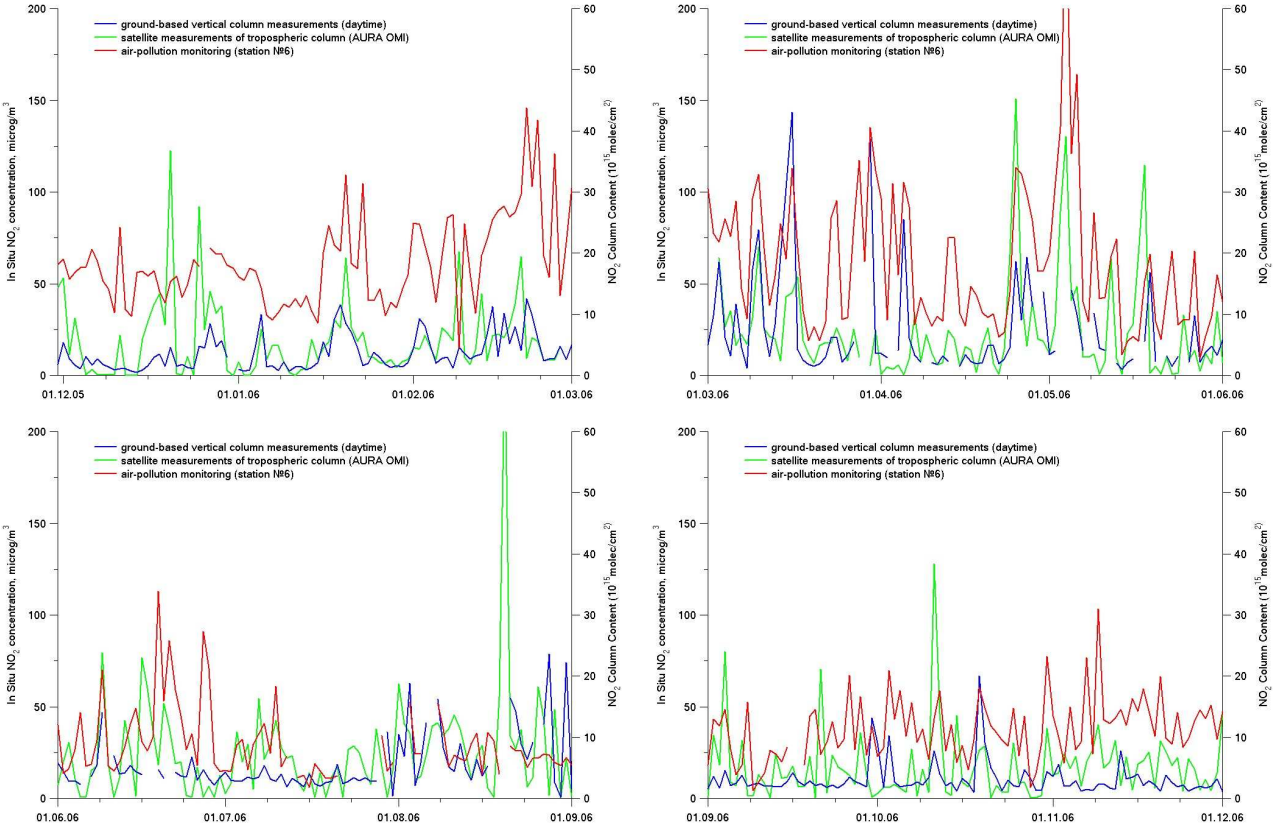
In addition to total column, we have executed a preliminary comparison of OMI tropospheric NO_2 ("NO2Trop" product) over St.Petersburg with correlative ground-based UV-VIS measurements, and *in situ* surface NO_2 observations in 2004-2006. Thus, reasonable temporal correlation between high NO_2 values in the data of *in situ*, ground-based and satellite measurements was observed in winter-spring of 2006. However, there are many other periods with a poor agreement. This will be studied later more in detail. Currently, the data of only one station of air-pollution monitoring system is available for comparison. We expect to get the data of few more *in situ* stations for our future investigation.



Comparison of ground-based column NO_2 observations at St.Petersburg with *in situ* NO_2 measurements and AURA OMI tropospheric NO_2 in 2004



Comparison of ground-based column NO_2 observations at St.Petersburg with *in situ* NO_2 measurements and AURA OMI tropospheric NO_2 in 2005



Comparison of ground-based column NO_2 observations at St.Petersburg with *in situ* NO_2 measurements and AURA OMI tropospheric NO_2 in 2006