

SPATIAL AND SEASONAL DISTRIBUTION OF NO₂ POLLUTION OVER BULGARIA, BASED ON TROPOMI MEASUREMENTS

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Keywords: atmospheric pollution, remote sensing, ecology

Abstract: In this paper we study the spatial and seasonal distribution of NO₂ pollution over Bulgaria. As a main data source we use monthly measurements of the Tropomi space instrument onboard Sentinel 5P satellite. The hot points of NO₂ over Bulgaria are two kinds - Sofia and Plovdiv cities and Stara Zagora region. First two are the biggest cities in the country, whether last one is typical industrial region and the place with biggest amount of summer fires. Results for both kinds of hot places are compared and discussed.

ПРОСТРАНСТВЕНО И СЕЗОННО РАЗПРЕДЕЛЕНИЕ НА ЗАМЪРСЯВАНИЯТА С NO₂ НАД БЪЛГАРИЯ ПО ДАННИ ОТ ТРОПОМИ

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Ключови думи: атмосферни замърсявания, дистанционни изследвания, екология

Резюме: В тази статия ние изследваме пространственото и сезонно разпределение на замърсяването с NO₂ над България. Като основен източник на данни използваме месечни измервания на космическия инструмент Тропоті на борда на сателита Sentinel 5P. Горещите точки на NO₂ над България са два вида - София и Пловдив и Стара Загора. Първите два са най-големите градове в страната, докато последният е типичен индустриален регион и, в добавка, област с най-много летни пожари. Резултатите за двата вида горещи точки се сравняват и обсъждат.

Introduction

One of the main air pollutants in urban environments is nitrogen dioxide NO₂ is a reddish-brown gas and one of the nitrogen oxides, highly toxic by inhalation. Like most toxic gases, the inhalation dose affects the degree of toxicity. Prolonged exposure to low concentrations of gas, as well as short-term exposure to high concentrations, may cause a variety of health problems. The dangerous level is above 560 µg/m³. This serves as a basis for determining the permissible norms for air pollution [1].

There are two methods for measuring and analyzing the air quality - through measurements with ground stations and with satellite data. Both approaches have their advantages and disadvantages. Ground stations provide a continuous flow (usually every hour), but are a point measurement. Satellite measurements are from 1 to several times a day, but they give a global picture. They measure the presence of a pollutant in the entire atmospheric column above an area of the earth's surface with a size corresponding to the spatial resolution of the measuring instrument.

Only from the end of 2018, with the launch of the European satellite Sentinel 5P, we have satellite data with enough high spatial resolution (in this case 3.5 x 7 km) [2], which allows us to study the detailed distribution of air pollutants even over large cities.

The aim of the present work is to study the territorial and seasonal distribution of NO₂ over Bulgaria. Results show that main NO₂ sources there are biggest Bulgarian cities of Sofia and Plovdiv

as well as Stara Zagora region – the biggest industrial place in our country. In this work we compare the results of ground and satellite measurements and discuss the possibility of using data from Sentinel 5P.

Data and regions of interest

For studying spatial and seasonal NO₂ distribution we choose to use both satellite and ground station measurements. We use monthly averaged values in both cases. We use satellite data from TEMES service [3] and ground station data from European Environment Agency [4].

On Fig. 1 we show examples for the typical daily and monthly distribution of NO₂ measured from the Tropomi instrument.

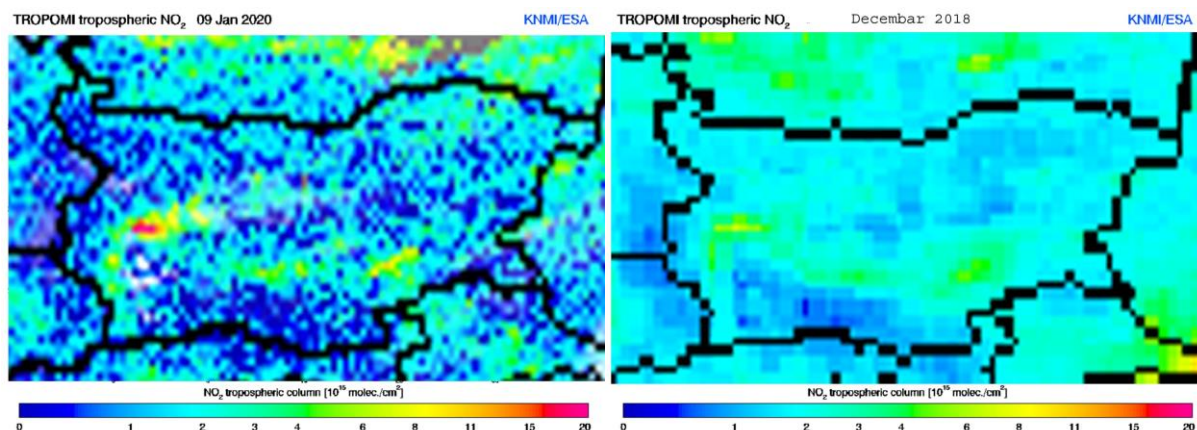


Fig. 1. Examples for typical daily and monthly NO₂ distribution over Bulgaria

As we see from the picture above, there are three regions with higher NO₂. They are the regions over Sofia and Plovdiv cities and the region south of Stara Zagora.

Tropomi data covers the full Bulgarian region almost every day. Ground stations, used in this work are as follows:

- Sofia: Nadezda, Hipodruma, Pavlovo, Mladost, Drugba and Orlov most
- Plovdiv: Kamenitca, Trakia and Banya
- Stara Zagora region: Stara Zagora – zelen klin, Galabovo and Dimitrovgrad.

Results

On Fig. 2 we show seasonal distribution of NO₂ over Sofia measured by Tropomi for the region February 2018 – September 2020. On Fig. 3 we show seasonal NO₂ distribution, measured by all ground stations in Sofia as well as an averaged NO₂ distribution and comparison between averaged measurements from different ground stations.

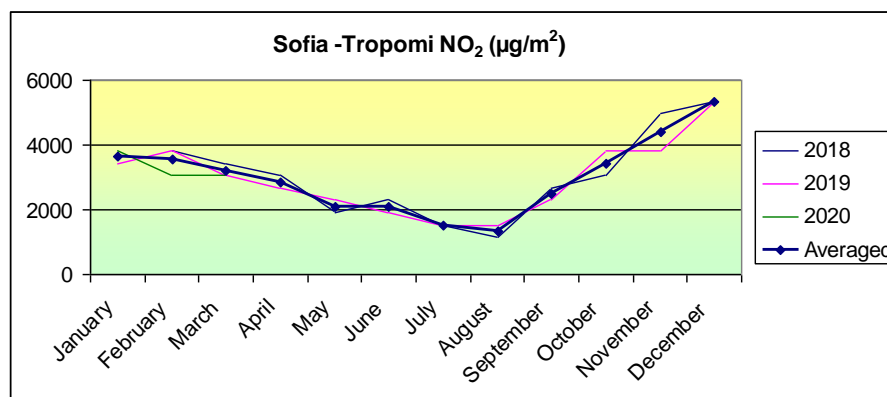


Fig. 2. Seasonal distribution of NO₂ over Sofia, measured by Tropomi for the period February 2018 – September 2020

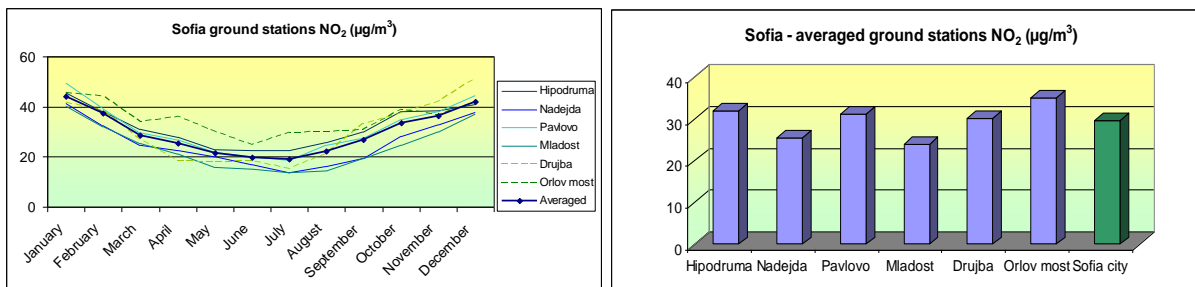


Fig. 3. Seasonal NO₂ distribution, measured by all ground stations in Sofia, averaged NO₂ distribution and comparison between averaged measurements from different ground stations.

On Fig. 4 and Fig. 5 we show the same for Plovdiv.

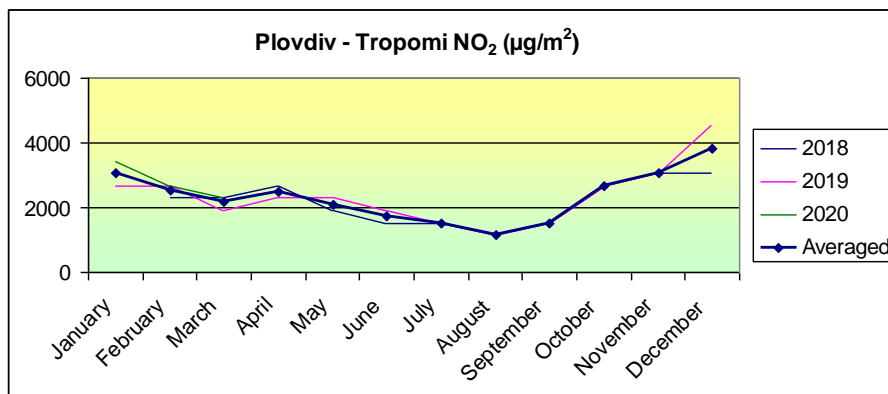


Fig. 4. Seasonal distribution of NO₂ over Plovdiv, measured by Tropomi for the period February 2018 – September 2020

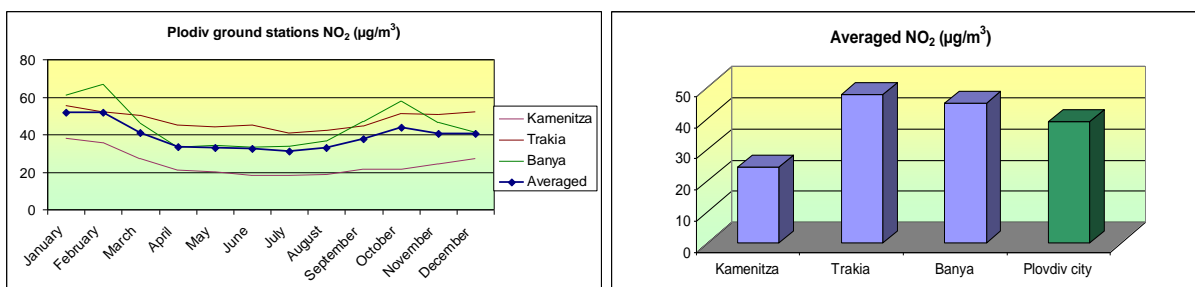


Fig. 5. The seasonal NO₂ distribution, measured by the ground stations in Plovdiv, the averaged NO₂ distribution and the comparison between averaged measurements from different ground stations.

On Fig. 6 we show the seasonal distribution of NO₂ over the Stara Zagora region, measured by Tropomi for the region February 2018 – September 2020.

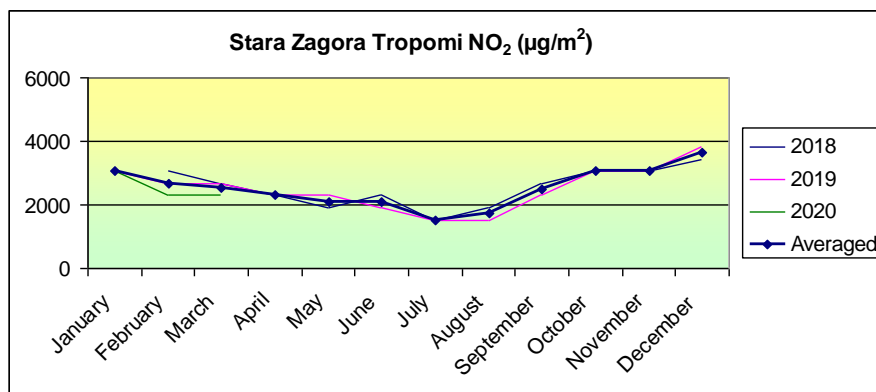


Fig. 6. Seasonal distribution of NO₂ over Stara Zagora region measured by Tropomi for the period February 2018 – September 2020

All three ground stations in Stara Zagora region show much lower measurement values for NO₂. Not even one monthly value is exceeding 30 µg/m², which is much lower than the measurements in Sofia and Plovdiv.

Result comparison and discussion

For comparison of the seasonal behavior in different chosen regions, on Fig. 7 we show together averaged Tropomi measurements.

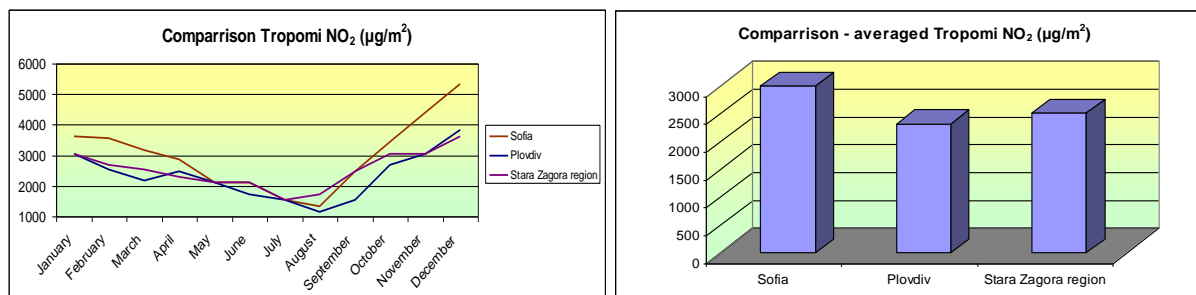


Fig. 7. Averaged Tropomi measurements over Sofia, Plovdiv and Stara Zagora region

As we see, the most polluted with NO₂ place is Sofia, then Stara Zagora region and then Plovdiv.

Seasonal behavior is similar over Plovdiv and Stara Zagora region, and a little different over Sofia. Above Sofia we see significant increase in autumn and winter months. This is probably caused by the typical Sofia inverse property. This difference we see mainly in satellite measurements. In ground station measurements the difference occurs again, but is smaller.

For spatial distribution of NO₂ in both cities we can say that there is much bigger difference between measurements from ground station in Plovdiv, while in Sofia NO₂ distribution is almost uniform.

Ground station seasonal NO₂ behavior in Stara Zagora and Dimitrovgrad is typical for the city, while in Galabovo monthly values are uniformly distributed. We think that this is because the main source of NO₂ in big cities is traffic and it is placed close to the ground stations, while in the Stara Zagora region the main NO₂ source is the industry and thus pollution is prolonged in the vicinity of the atmosphere.

We can say that Bulgaria definitely is not a NO₂ hot place. There is no place with averaged NO₂ value close to danger values.

Conclusions

The NO₂ hot regions in Bulgaria are Sofia, Plovdiv and Stara Zagora region.

While satellite NO₂ measurements are comparable in all tree regions, ground station measurements are much higher for big cities compared to values from stations in Stara Zagora region.

Surprising we don't see any decrease in NO₂ in 2020, with means that COVID-19 doesn't decrease NO₂ sources in Bulgaria.

Acknowledgments

The study was financed by ESA Contract Number No. 4000124150/18/NL/SC: "Satellite information downscaled to urban air quality in Bulgaria" (SIDUAQ).

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4. European Environment Agency - <http://discomap.eea.europa.eu/map/fme/AirQualityExport.htm>