

Reply

Reply to Ayek, A.A.E.; Al-Saleh, A.H. Comment on “Kazemi Garajeh et al. Monitoring Trends of CO, NO₂, SO₂, and O₃ Pollutants Using Time-Series Sentinel-5 Images Based on Google Earth Engine. *Pollutants* 2023, 3, 255–279”

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For Sentinel-5P products, the European Space Agency (ESA) validates the data collected by the TROPOMI instrument onboard the Sentinel-5P satellite using a network of ground stations and various techniques such as ZSL-DOAS, Pandora, and MAXDOAS. These are advanced tools used for atmospheric measurements from ground stations:

1. ZSL-DOAS: A technique of Differential Optical Absorption Spectroscopy (DOAS) that measures atmospheric gases by analyzing scattered sunlight at the zenith.

2. Pandora: A compact instrument for measuring total column gas concentrations like NO₂ by directly observing sunlight. It is part of the global Pandonia network.

3. MAXDOAS: Measures scattered sunlight at multiple angles to retrieve vertical distributions of gases in the lower atmosphere.

These tools are essential for validating and improving the comparison of satellite observations by providing reliable ground-based measurements.

Thank you for highlighting the use of ESA-standard validation instruments such as ZSL-DOAS, Pandora, and MAXDOAS. We fully acknowledge the robustness of these tools. However, in the context of our study [1], such instruments were not available in Arak, Iran. As a result, we used ground control points derived from regional environmental monitoring stations to assess the accuracy of Sentinel-5P data (See below).

While the European Space Agency (ESA) validates Sentinel-5P/TROPOMI data using a network of standardized ground-based instruments such as ZSL-DOAS, Pandora, and MAXDOAS, which offer high-accuracy atmospheric gas measurements [Sentinel-5P product types—S5P Validation Service], these tools are not always available in all geographic regions. In our study area (Arak, Iran), such specialized validation networks are not established. Therefore, we employed ground control points obtained from local environmental monitoring stations as a practical alternative for accuracy assessment. While these stations may lack the spectral precision of ESA’s instruments, they provide region-specific and temporally synchronized data, enabling a meaningful evaluation of satellite-derived pollutant concentrations.

4. The authors of the paper did not mention anything about the conversion methodology used or whether they utilized auxiliary data (such as air temperature). This raises

doubts about all the results presented by the authors, who claim to have converted gas density concentrations to ppm.

Finally, we provided further details regarding the process of conversion.

Conversion of Satellite Column Densities Using Laboratory-Based Calibration.

To address the challenge of converting total column gas densities derived from Sentinel-5P products (e.g., CO, NO₂, SO₂, O₃) into surface-level concentrations expressed in parts per million (ppm), a ground-based calibration methodology was employed, utilizing chemical laboratory analysis. Air samples were collected during field campaigns conducted at representative monitoring locations and were subsequently analyzed in the laboratory using standardized procedures to determine the concentrations of target gases in ppm. These high-accuracy, in situ measurements were then used to empirically calibrate the satellite-retrieved columnar data. In contrast to theoretical conversion methods, which rely solely on assumptions about atmospheric column height or uniform gas distribution, our approach establishes a localized empirical relationship between total column density (expressed in mol/m² or molecules/m²) and corresponding surface-level concentrations. This methodology inherently accounts for regional meteorological conditions, boundary layer dynamics, and the vertical distribution of pollutants, thereby improving the accuracy and applicability of the converted satellite data for assessing surface-level air quality.

Finally, we appreciate that you read this paper and provided valuable comments [2] which helped us to improve the quality of the manuscript further. We hope that you find the new version suitable for publishing.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Kazemi Garajeh, M.; Laneve, G.; Rezaei, H.; Sadeghnejad, M.; Mohamadzadeh, N.; Salmani, B. Monitoring Trends of CO, NO₂, SO₂, and O₃ Pollutants Using Time-Series Sentinel-5 Images Based on Google Earth Engine. *Pollutants* **2023**, *3*, 255–279. [[CrossRef](#)]
2. Ayek, A.A.E.; Al-Saleh, A.H. Comment on Kazemi Garajeh et al. Monitoring Trends of CO, NO₂, SO₂, and O₃ Pollutants Using Time-Series Sentinel-5 Images Based on Google Earth Engine. *Pollutants* **2023**, *3*, 255–279. *Pollutants* **2025**, *5*, 40. [[CrossRef](#)]

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