# Spatiotemporal Variability in Ozone Across Korean Peninsula

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## Abstract
Ground-level ozone (O3) has adverse effects on human health, vegetation, and the ecosystem. The goal of this study is to assess spatiotemporal variability in ozone on various sites across the Korean Peninsula. The Pandora ground-based spectrometer, and the OMI sensor from the Aura satellite, were used to quantify total column ozone in the urban and coastal regions of South Korea. Based on the data, there is an agreement in measuring the total column of ozone. Thus, both Pandora and OMI should be used to quantify ozone.

## Introduction
Ground-level ozone is a product of atmospheric photochemical processes. The substantial increase in anthropogenic activities caused the amount of tropospheric ozone to increase significantly as well (Zhao et al. 2015). This is due to the high ambient temperatures, intense reactions between nitrogen oxides and volatile organic compounds, and thin boundary layers. When O3 concentration at ground-level reaches 70ppb, human and ecosystem health can suffer – chest pain, coughing, shortness of breath, throat irritation, and toxic chemical reactions in plants.

South Korea has multiple urban and rural areas with approximately 51.25 million people as of 2016. Sites included in our study are Seoul-Yonsei, Gwangju, Busan, Olympic Park, Anmyeondo, Taehwa Mountain, Songchon, and Yeoju. Seoul is the most populated city, with approximately 10 million people as of 2016.

In this study, measurements of ozone were collected continuously from May 18, 2016 to June 2, 2016 in various sites across South Korea. This data were used to assess spatiotemporal variability in ozone and patterns in ozone concentrations.

## Methodology
Pandora instruments were installed across the Korean Peninsula, in order to continuously monitor O3 concentration. The OMI sensor was used to measure TCO3 across the entire peninsula and surrounding bodies of water. Matlab was used to map, quantify and analyze TCO3 variability.

## Results and Discussion

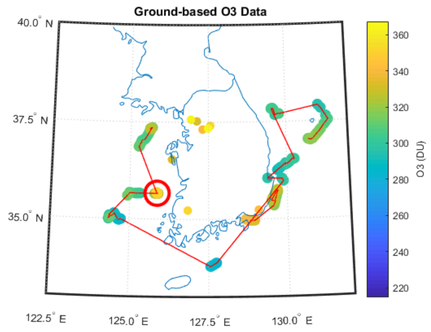


**Fig.1**

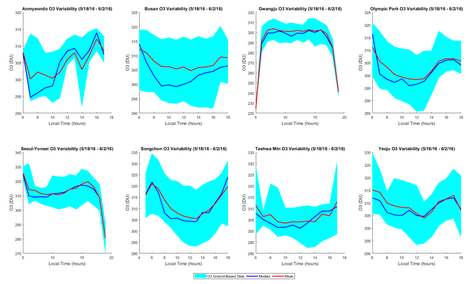


**Fig.2**

Figure 1 and 2 showed the measurements taken by Pandora from May 18, 2016 to June 2, 2016. Figure 2 displayed some spikes at around 5:00 to 6:00am and 3:00 to 4:00pm whereas figure 1 displayed the highest concentration in northern and southern parts of South Korea. In addition, it showed that there are some high amount of ozone away from the land.

**Fig.3**

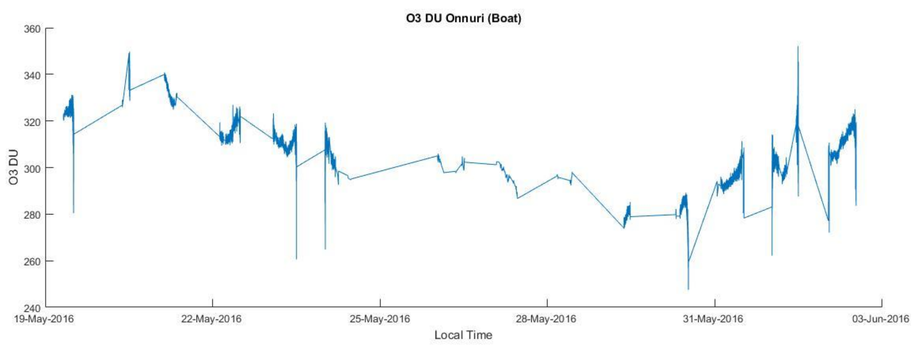


Figure 3 shows measurements taken by Pandora, mounted on the boat Onnuri. From May 18 to May 23, there was an incline, near the city of Busan. As the boat move towards the rural setting, the amount of ozone decreased. Around May 31 to June 3, there was a spike as the boat approached Seoul. This is due to the boat moving from rural areas to urban areas.

**Fig.4**

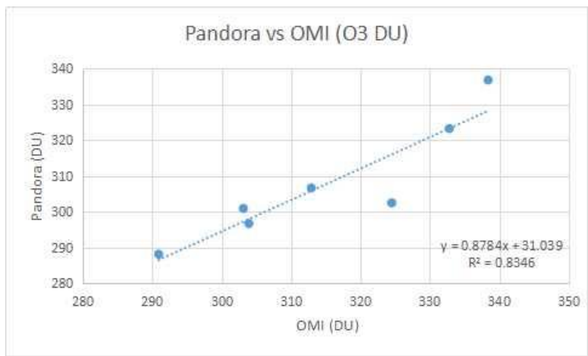


Figure 4 presented a comparison of Pandora and OMI. It displayed an agreement in measuring the total column of ozone.

## Conclusion
Pandora and OMI both have strengths and weaknesses in quantifying the TCO3. Pandora has a high temporal resolution but low spatial coverage. Conversely, OMI has a high spatial coverage, but low temporal resolution. In Fig 2, we organized TCO3 concentration by time of day, providing a diurnal variation. In Fig 1, site location and highest recorded O3 levels were plotted, showing spatial coverage provided by ground-based sensors, which illustrates the amount of ozone in different areas.. Fig 3 contains the TCO3 levels encountered by the Pandora instrument mounted on the Onnuri, with high O3 levels near urban areas and low O3 levels in rural areas, demonstrating the changes in the amount of ozone over time. Hence, both Pandora and OMI should be used because figure 4 showed that by using both Pandora and OMI, we can verify that the measurements are correct.

## References
Herman, J., A. Cede, E. Spinei, G. Mount, M. Tzortziou, and N.Abuhassan (2009), NO2 column amounts from ground-based Pandora and MFDOAS spectrometers using the direct-sun DOAS technique: Intercomparisons and application to OMI validation, J.Geophys. Res., 114, D13307, doi:10.1029/2009JD011848.

Zhao H, Wang S, Wang W, Liu R, Zhou B (2015) Investigation of Ground-Level Ozone and High-Pollution Episodes in a Megacity of Eastern China. PLoS ONE 10(6): e0131878. https://doi.org/10.1371/journal.pone.0131878.

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