Save Our Earth

Bridging the Scales in Atmospheric Sciences : Local to Global

Monitoring the Temporal Variation of Formaldehyde Emissions over Islamabad, Pakistan Using MAX-DOAS and Satellite Observations

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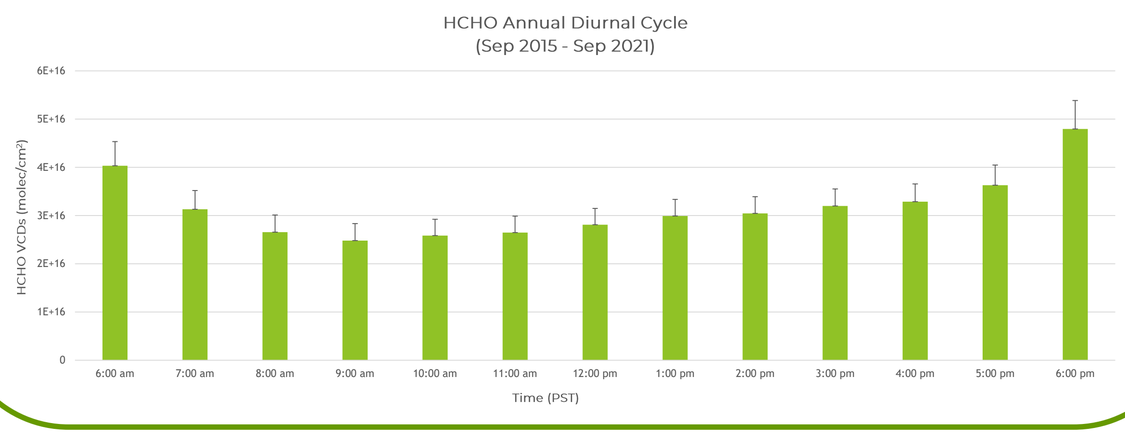
Introduction

Isoprene is the most abundant biogenic VOC and significantly impacts atmospheric chemistry through the production of ozone. Its residual lifetime is <1 hour, making it difficult to accurately measure emissions on a large scale. Formaldehyde (HCHO), which is a by-product of isoprene oxidation, can be used as a proxy for the analysis of isoprene emissions. Photolysis of HCHO causes a series of reactions which lead to the formation of hydroxyl radicals, consequently resulting in the formation of tropospheric ozone. In this study, MAX-DOAS, OMI, and TropOMI observations were utilized to assess the fluctuations in HCHO levels over NUST, Islamabad, Pakistan in order to gain insights into the sources, distribution, and potential impacts on the local atmosphere.

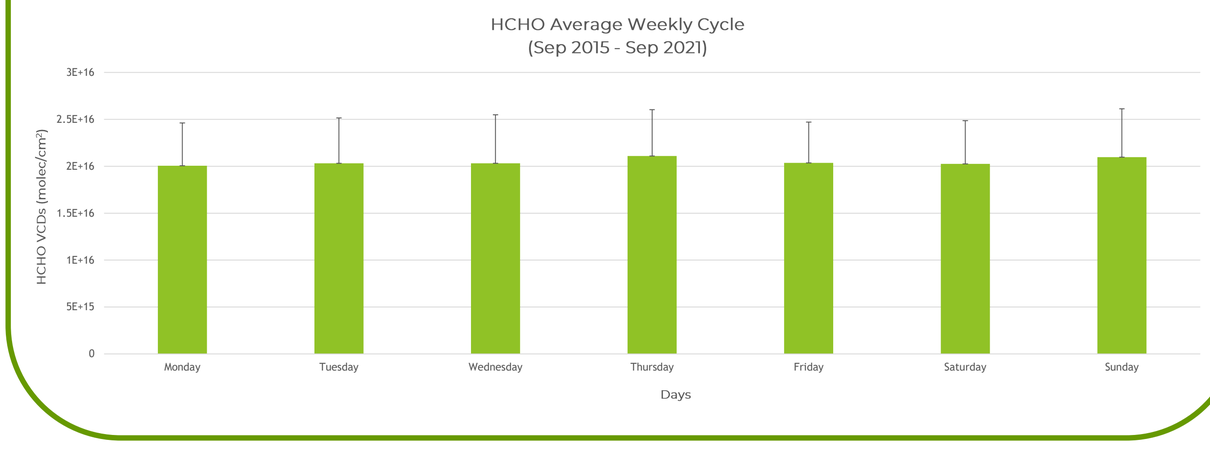
HCHO Diurnal Cycle

HCHO concentrations were maximum during the early morning and late evening. It is higher in the morning due to background concentrations and lower solar intensity. As solar intensity increases, HCHO concentrations begin to decline, reaching a minimum between 9-10 am mainly due to photolysis. HCHO concentrations start increasing in the afternoon due to increasing temperature, resulting in more biogenic emissions and consequent increase in the rate of VOC oxidation.



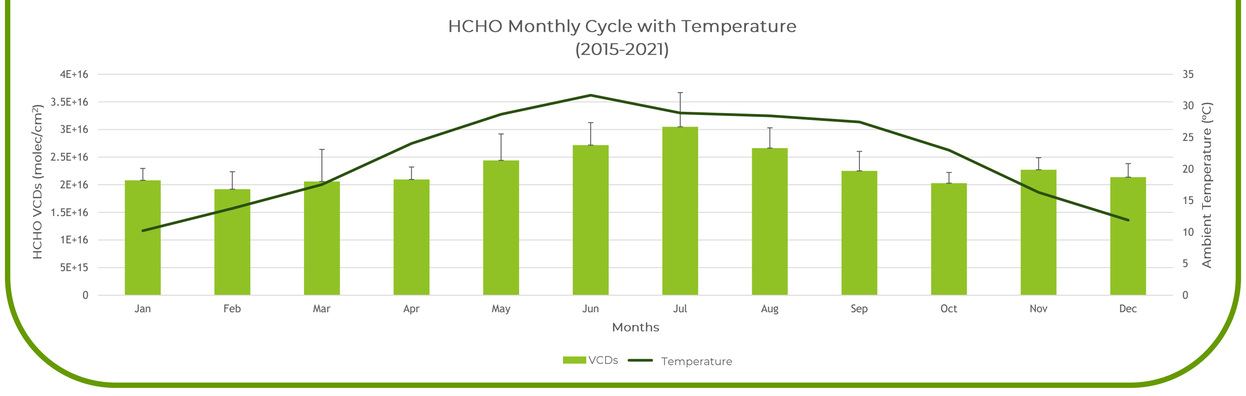
HCHO Weekly Cycle

The average weekly cycle of HCHO has an almost similar trend throughout the week. No weekend effect was observed as the study site is adjacent to a main highway. Additionally, there is significant vegetation cover surrounding the study site, which contributed to HCHO concentrations throughout the week.



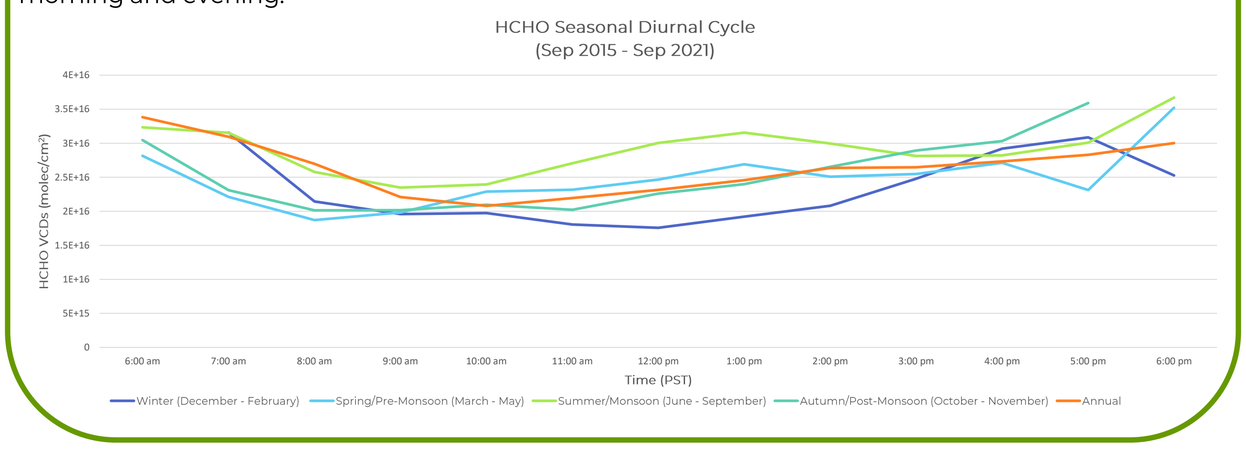
HCHO Monthly Cycle

HCHO concentrations are comparatively lower in winter months than in summer months. This can be attributed to higher temperatures and increased biogenic emissions of non-methane VOCs, such as isoprene. Plants emit isoprene as a response to heat stress, and the oxidation of isoprene produces HCHO as a by-product. Additionally, methane emissions and consequent oxidation by hydroxyl radicals are highest during the summer, resulting in greater HCHO concentrations.



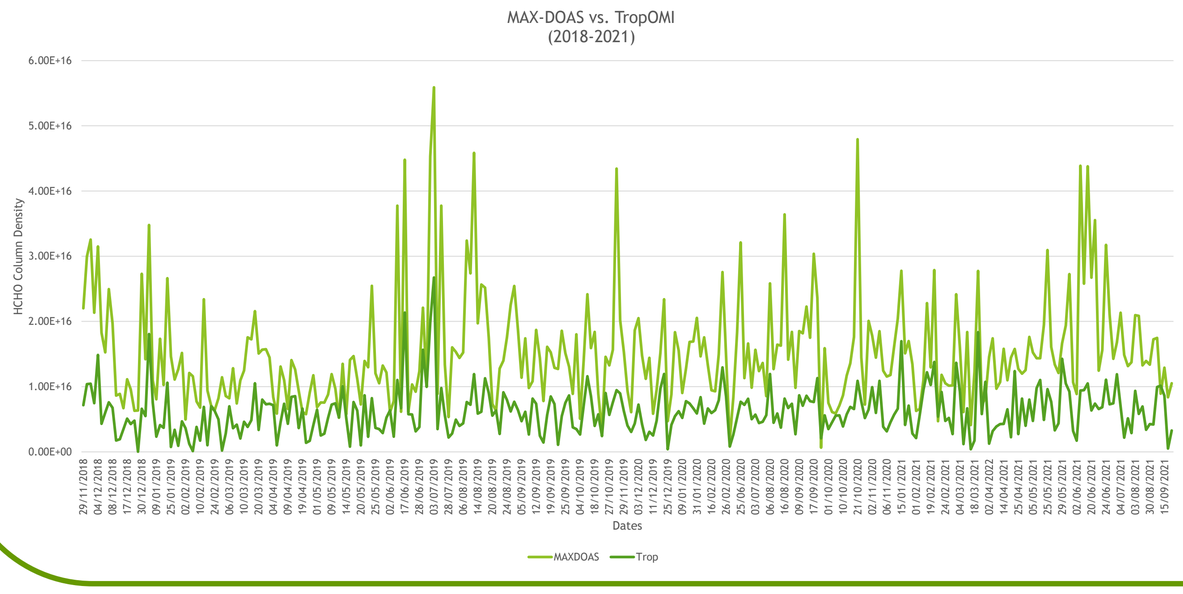
HCHO Seasonal Cycle

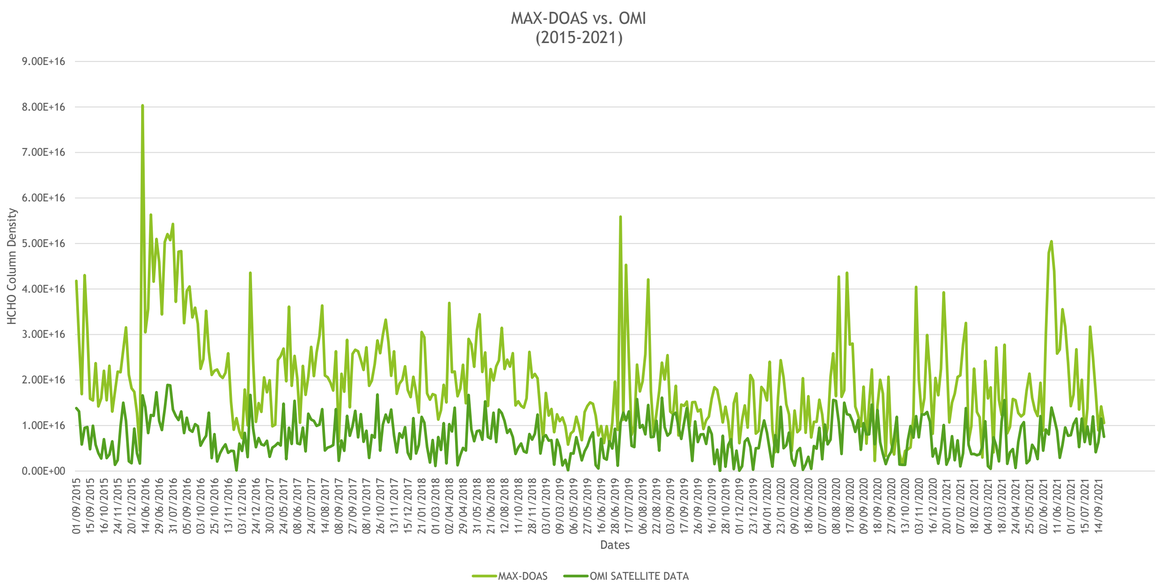
HCHO concentrations are highest during monsoon season and lowest in the winter, mainly due to increased biogenic VOC emissions in the summer. During winter months, solar intensity is much lower, resulting in slower photolysis, and higher background HCHO concentrations during the morning and evening.



Satellite Validation of MAX-DOAS Data

Tropospheric column daily averages from TropOMI and OMI were compared with ground-based HCHO MAX-DOAS observations, between 1-2pm PST. Satellite data severely underestimated ground-based HCHO observations. A correlation with Pearson values of 0.68 and 0.56 were observed for comparison of TropOMI (Sep 2018 – Sep 2021) and OMI (Sep 2015 – Sep 2021) with ground-based results, respectively.





Conclusion

HCHO mixing ratios measured during the study period of September 2015 to September 2021 over IESE, NUST, Islamabad, Pakistan was found to be higher during the summer months. This was due to higher temperatures, OH production, increased photolysis, and higher biogenic emission of VOCs. A positive correlation of 0.64 was found between HCHO VCDs and temperature data. Satellite observations greatly underestimated ground-based HCHO values. In order to improve air quality in Pakistan, is recommended to develop National Environmental Quality Standards for HCHO concentrations in ambient air, as well as to install continuous air quality monitoring stations throughout the country.

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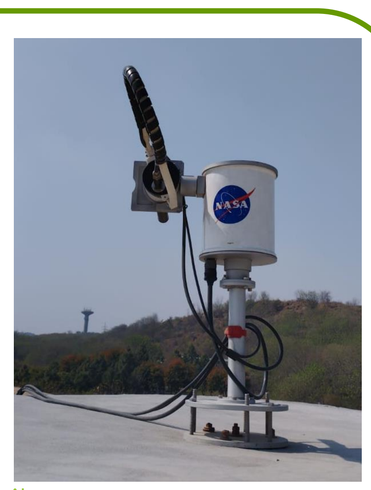

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