Save Our Earth

Bridging the Scales in Atmospheric Sciences : Local to Global

Exploring seasonal variation and temporal trend of Tropospheric Column Ozone and its precursors by exploiting satellite observations

Amara Aziz[1] , Muhammad Fahim Khokhar[1], Sofia Baig[1] and C-CARGO Team[1]

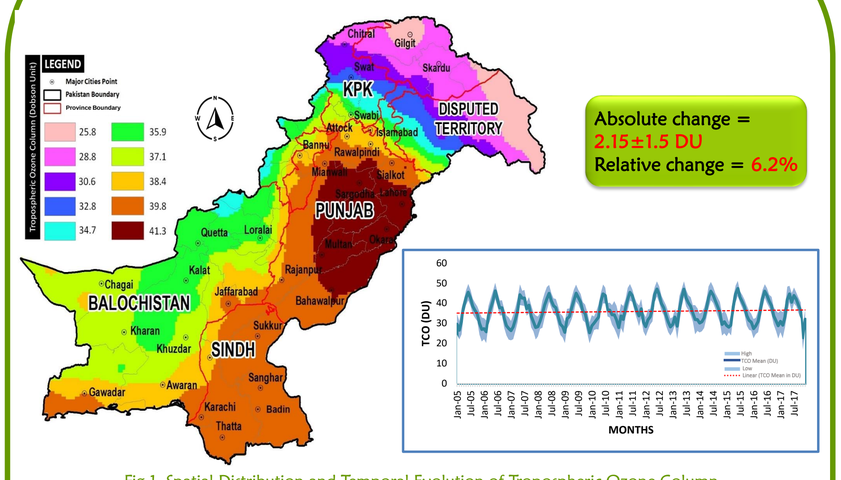
[1]Institute of Environmental Science and Engineering (IESE), NUST Islamabad, Pakistan

Climate Change & Atmospheric chemistry Research Group C-CARGO

INTRODUCTION

Air pollution has become a serious environmental problem in densely populated Asian countries, especially Pakistan, being the sixth largest populous country in the world. Dramatic growth in population along with the significant increases in industry and number of vehicles have contributed to high concentrations of air pollutants, including tropospheric column ozone (TCO) and its precursor gases. The study aimed to develop a database and analyse the spatio-temporal distribution of tropospheric column ozone and its precursors (NO2, HCHO) over Pakistan

Tropospheric Ozone



Absolute change = 2.15±1.5 DU
Relative change = 6.2%

Fig 1. Spatial Distribution and Temporal Evolution of Tropospheric Ozone Column

Temporal trend of TCO over Pakistan was prepared by plotting monthly averaged TCO retrieved from Aura OMI/MLS observations during 2005-2017. The mean map (2005-17) shows highest values observed in Punjab and Sindh due to large number of industries and urbanization

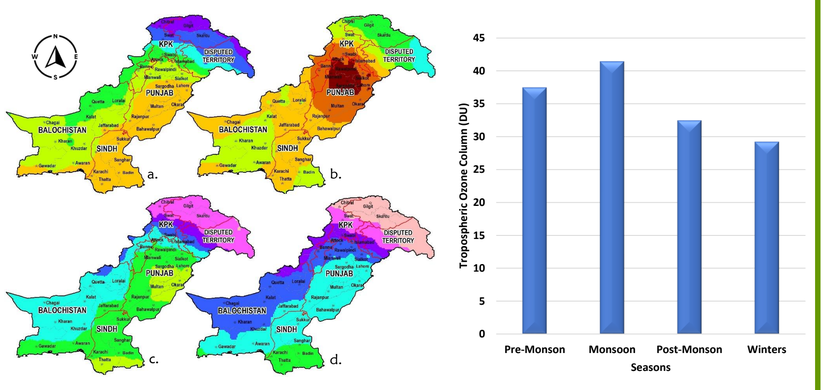
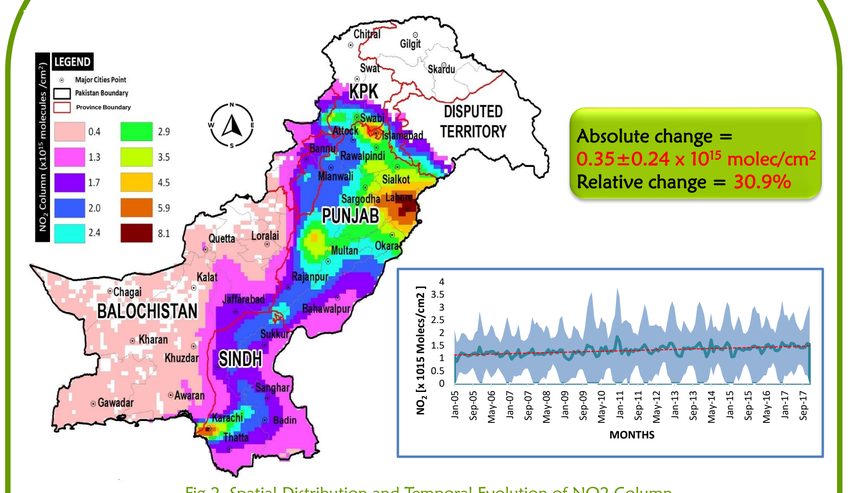


Fig 4. Seasonal-averaged OMI TCO for 2005–2017. (a) Pre Monsoon (MAM); (b) Monsoon (JJAS); (c) Post Monsoon (ON); (d) Winter (DJF).

TCO showed strong seasonality with monsoon (JJAS) maximum and winter (DJF) minimum levels

Nitrogen Dioxide



Absolute change = 0.35±0.24 x 10^{15} molec/cm^2
Relative change = 30.9%

Fig 2. Spatial Distribution and Temporal Evolution of NO2 Column

Temporal record of NO2 column densities over Pakistan was prepared by plotting monthly averaged NO2 retrieved from OMI observations during 2005-2017. Maximum NO2 amounts were observed over regions with extensive anthropogenic activities and population (Punjab and Sindh provinces) while regions (Baluchistan and KPK) with less population exhibited smaller amounts

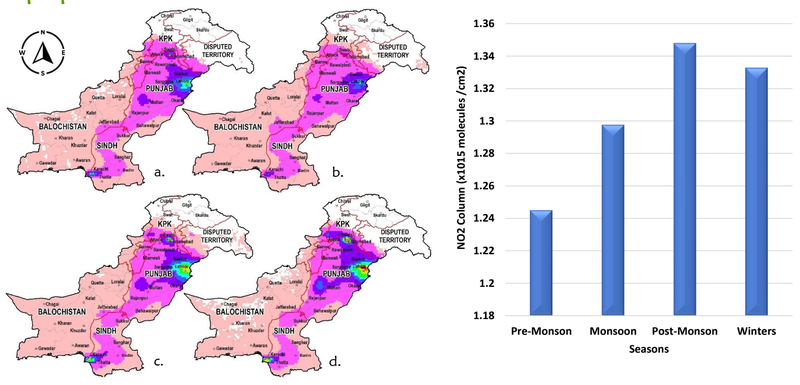
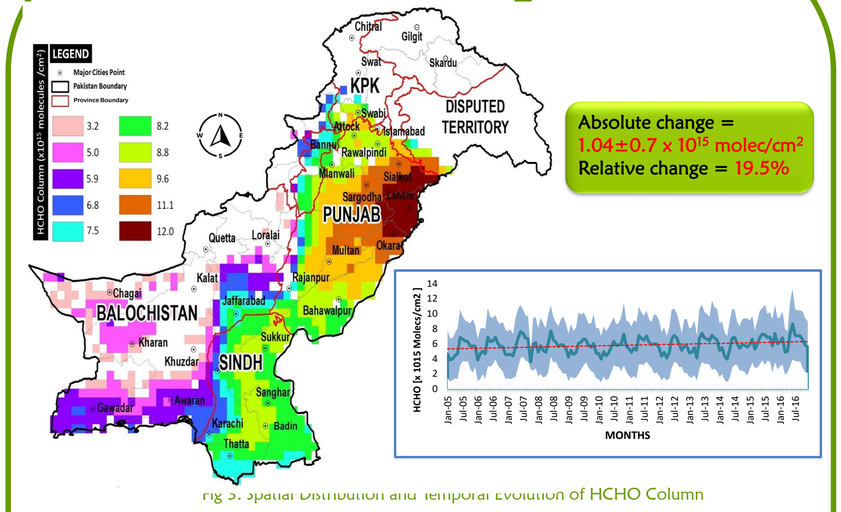


Fig 5. Seasonal-averaged OMI NO_2 VCDs for 2005–2017. (a) Pre Monsoon (MAM); (b) Monsoon (JJAS); (c) Post Monsoon (ON); (d) Winter (DJF).

Highest values in winter was consistent with areas with heavy industrial load (such as Lahore) and densely populated cities (such as Sialkot, Sargodha and Karachi)

Formaldehyde



Absolute change = 1.04±0.7 x 10^{15} molec/cm^2
Relative change = 19.5%

Fig 3. Spatial Distribution and Temporal Evolution of HCHO Column

Temporal trend of HCHO over Pakistan was prepared by plotting monthly averaged HCHO retrieved from OMI observations for the years 2005-2016. HCHO is mainly highest in urban and highly polluted areas because HCHO is produced as a by-product of oxidation of VOCs

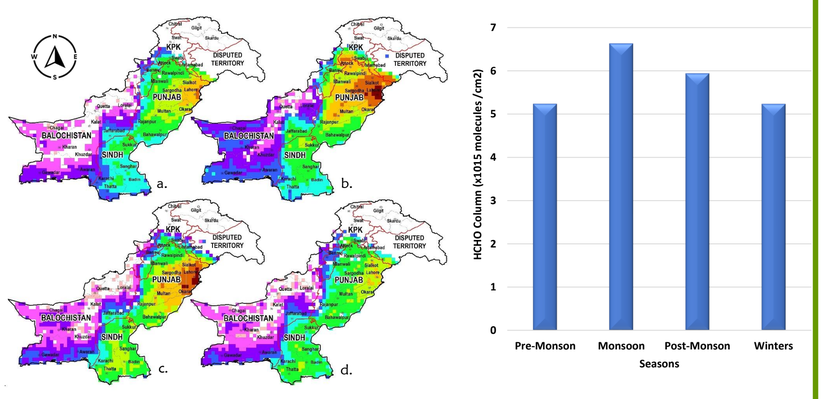


Fig 6. Seasonal-averaged OMI HCHO VCDs for 2005–2017. (a) Pre Monsoon (MAM); (b) Monsoon (JJAS); (c) Post Monsoon (ON); (d) Winter (DJF).

HCHO showed seasonal maxima during summer and minimal during winter

SOURCES AND SINKS OF TROPOSPHERIC OZONE AND PRECURSOR GASES

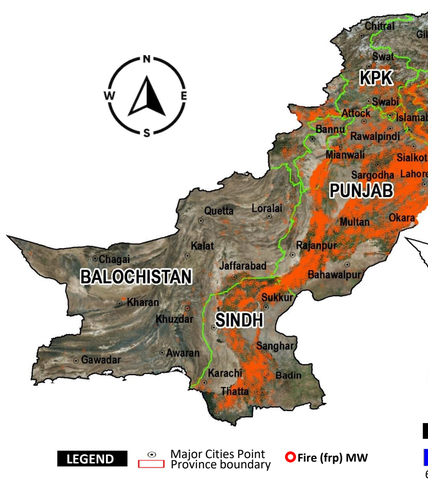


Fig. 7(a) Distribution of Active Fire (MODIS) 2005-17

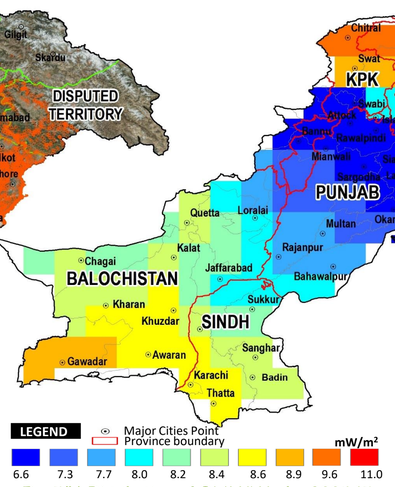


Fig. 7(b) Distribution of OMI UV-Index 2005-17

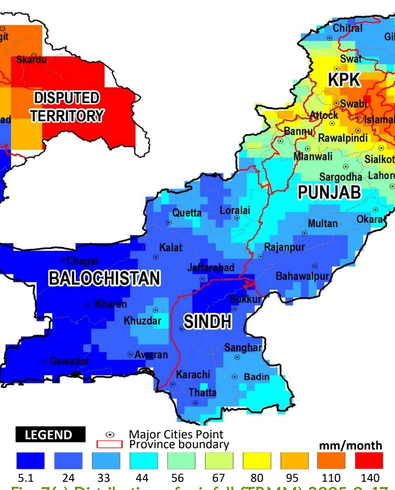


Fig. 7(c) Distribution of rainfall (TRMM) 2005-0..17

Fig. 7(a) shows the total fire counts over Pakistan due to biomass burning and agricultural activities. It is observed that the locations of fire events (red dots) coincide with the areas of high concentration supported by positive correlation of all observed gases. Sufficient light is required for photochemical processes, the observed pattern of the UV index from OMI is illustrated in Fig. 7(b) It can be inferred that the sunlight condition can be a partial contributor of the high values of TCO and HCHO. Rainfall trend (TRMM) over Pakistan is shown in Fig. 7(c). It can affect the spatiotemporal characteristics of TCO and precursors to some extent. The spatio–temporal distribution of precipitation over Pakistan is observed to be uneven.

Table 1. Correlation (r) analysis among Ozone and its precursors

	TCO	NO_2	HCHO	Fire	UV-I	TRMM
TCO	-	-0.47	0.55	0.97	0.91	0.25
NO_2	-0.47	-	0.03	0.93	-0.13	-0.25
HCHO	0.55	0.03	-	0.96	0.43	0.08

The above table shows that O_3 exhibits significant negative correlation (0.47) with NO_2. In addition, the correlation between O_3 and HCHO is strong (0.55) but positive. For HCHO and NO_2, the correlation was (0.03). From significant correlations, it can be observed that ozone and precursor gases are originating from the same sources over Pakistan. Although, they might differ temporally as in the case of a different seasonal cycle due to various diverse processes involved in tropospheric chemistry. For further validation, Fire, UV Index and Rainfall data products are used for the correlation analysis among TCO and it's precursors.

CONCLUSION

Significant spatio-temporal variability of HCHO, NO2 and O3 is observed over the region; Punjab showed the highest values for all the observed gases

Increased industrialization, transportation, urbanization, fossil fuel/biomass burning and agricultural activities are identified as main anthropogenic sources in the region.

Meteorological conditions including fire emissions also play a role in spatio-temporal variability of precursor gases. Fire emissions are observed to be the main contributor of increased ozone and precursor gases supported by significantly positive correlation.

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For details: Amara Aziz

e-mail: amara.azizz@hotmail.com

Phone: +923315993639