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Changes in Aerosol Optical Depth in Three Heavily Populated Cities in Indo Gangatic Plains–Delhi, Dhaka and Karachi

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Abstract—*The study presents decadal changes (2005-2014) in aerosol optical depth (AOD) over three heavily populated and polluted cities lying in Indo-Gangetic Plains (IGP). The cities chosen are namely, Delhi (28.6° N, 77.2° E), Dhaka (23.7° N, 90.4° E) and Karachi (24.9° N, 67.0° E) located in India, Bangladesh and Pakistan respectively. IGP is one of the most populous and polluted regions in Asia. The three locations chosen are representatives of the varied aerosol concentrations and type within IGP. The paper focuses on analyzing decadal satellite data obtained from Multiangle Imaging Spectroradiometer (MISR) sensor onboard NASA'S Terra Platform. The quantified seasonal variations have been presented for the three cities. The average annual AOD values are found to be >0.4 in the three cities. Using MISR Level 3 data, it is observed that the annual average AOD has been increased by 4%, 12% and 6% for Delhi, Dhaka and Karachi respectively.*
Keywords*: Delhi, Dhaka, Karachi, MISR, decadal*

1. INTRODUCTION

Aerosols play important role in altering Earth's radiation budget and cloud properties. The aerosol loading is not only important for observing their climatic impacts but also for human health related studies. This paper discusses the variation of aerosol optical depth, an indicator of aerosol columnar loading over three heavily populated cities of Asia i.e. Delhi, Dhaka and Karachi lying in Indo-Gangetic Plains whereas, Karachi lies in West IGP; Delhi in Central IGP and Bangladesh in East IGP. Thought IGP as a whole, is one of the most polluted and populated regions of world, but due to the varied locations of the three cities within the IGP (also in different countries), the type of aerosols and the amount of aerosol loadings are expected to be different. Previous works in this direction have been attempted at zonal level and for individual locations too. Many works related to spatio-temporal AOD characteristics have been reported over Indian region (Babu et al.,2013; Dey & Di Girolamo,2011; Mehta, 2015). Over Delhi, in particular, similar works have been attempted too. For details, pl. refer to works by Lodhi et al., 2013, Srivastava et al., 2014. Alam et al. 2011 have monitored aerosol patterns over Pakistan using MODIS, TOMS and MISR datasets. Bibi et al. 2015 have compared MODIS, OMI, MISR and CALIPSO AOD for four locations of IGP region and validated the results against AERONET datasets. Begum et al., 2010 identified sources of aerosols (fine and coarse particulate matter) over Dhaka. In this paper, the average AOD at annual and seasonal levels have been presented for the past ten years. Using MISR data, it is observed that the aerosol loading has increased in these cities during the last decade.

2. MISR LEVEL 3 DATA

MISR sensor is onboard NASA's Terra satellite. There are nine cameras at nine look angles in four wavelength regions. The AOD Level 3 data MISR_AM1_CGAS is available at a spatial resolution of 0.5^{o}X0.5^{o}. The data can be downloaded from ftp://l5eil01.larc.nasa.gov/pub/misrl2l3 MISR. The AOD retrieval method utilizes Look up Table approach for different surface targets types. For more details regarding the AOD retrieval techniques employed to generate the data product, pl. refer to Kahn et al., 2009.The location of the three cities have been depicted in Fig. 1.

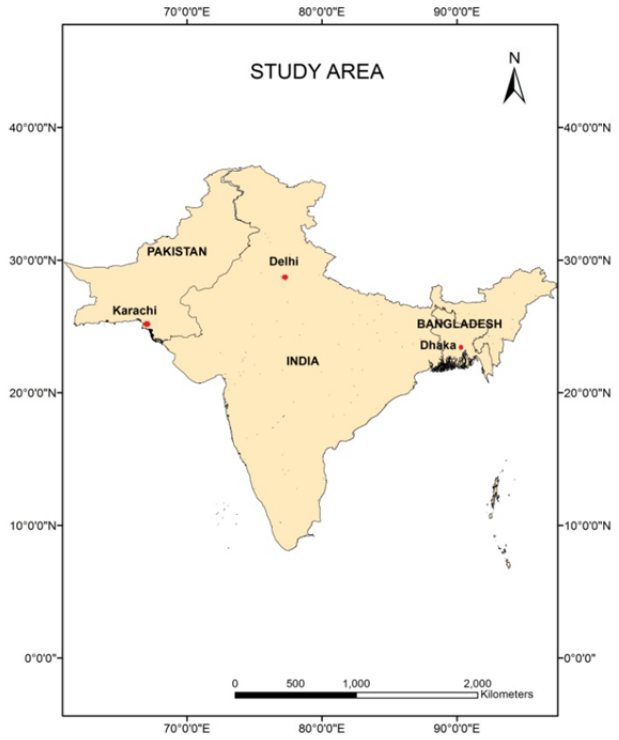

Fig. 1: Study area

3. RESULTS

The mean AOD at annual and seasonal levels have been depicted in Fig. 2. It is evident that the three cities have high levels of pollution in terms of aerosol loadings. The average annual AOD is >0.4 for the three cities. For Delhi and Karachi, the maximum AOD values are encountered during the monsoon season owing to the prevalent meteorology. In Dhaka, however, the aerosol load is mostly concentrated during winter and pre-monsoon seasons. During the past decade, the aerosol loadings show an overall increase over the three cities under consideration indicating that there could have been increase in anthropogenic emissions, especially during winter season in Delhi and Karachi. Whereas, there is a strikingly high record of AOD values during the monsoon season over Bangladesh. The results however, should be used with caution because of the uncertainties in aerosol retrieval algorithm. The future work should be directed in comparing the obtained results using other satellite datasets for the considered time domain.

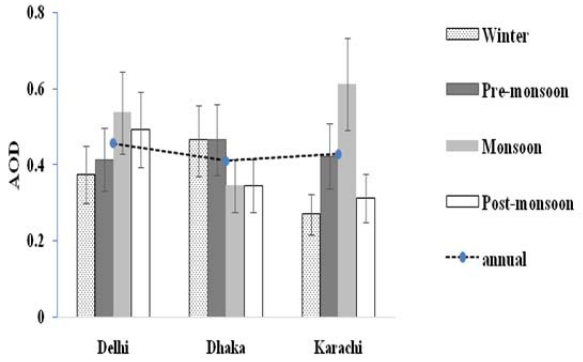

Fig. 2: Annual and seasonal average AOD from MISR for Delhi, Dhaka and Karachi

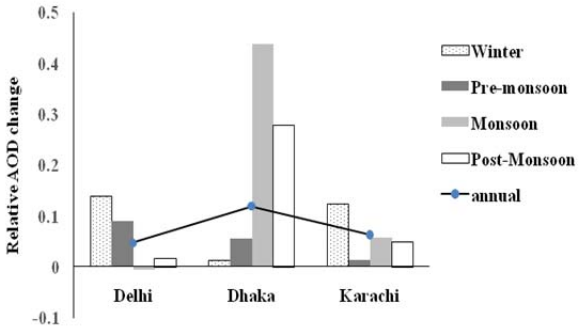

Fig. 3: Annual and seasonal relative AOD changes from MISR for Delhi, Dhaka and Karachi

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