Association of Cloud Vertical Structure and Aerosols studied over Delhi Megacity.

Saloni Sharma[1] and Amit Mishra[1]

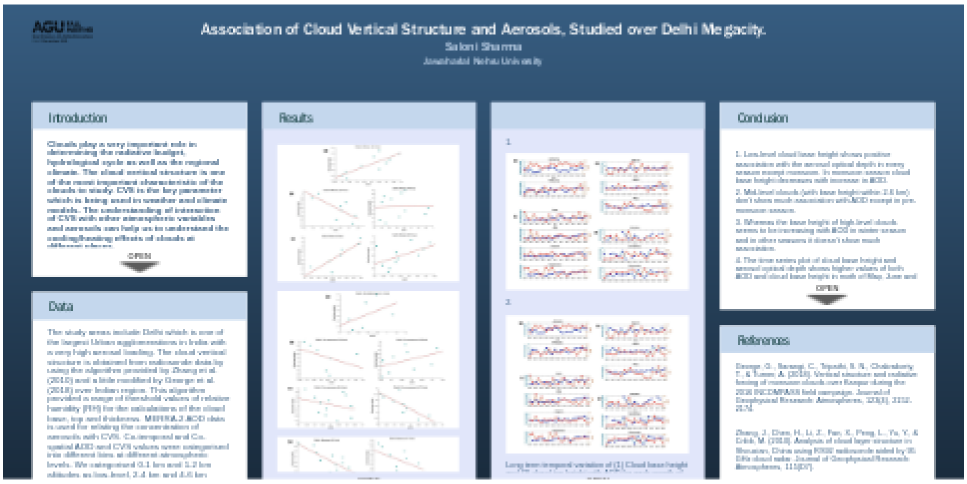
[1]Jawaharlal Nehru University

November 23, 2022

Abstract

The understanding of the atmospheric dynamics and thermodynamics in the time of climate change has become an unavoidable necessity for survival of humanity. We need to fill the research gaps with a more thorough and urgent research approach in the required domains. One of a major research gap whose filling could enrich our understanding of atmospheric dynamics and hydrological cycle is the vertical structure and distribution of cloud in atmosphere. Cloud vertical structure (CVS) significantly influences the quantity of solar radiation coming inside the atmosphere of Earth and thus it modulates the atmospheric adiabatic heating. It has also been found to be the major source of uncertainties in the global climate and weather models. In India the rural population is shifting to urbanized areas which are hub of intense economic activities and have high level of pollution. We witness high loading of anthropogenic aerosol in these highly urbanized areas which also varies seasonally. The association of these aerosols concentration with CVS has not been studied so far. Delhi is one of such large urban settlement and is also the most polluted Indian megacity. Therefore we have studied the CVS over Delhi using multi-year radiosonde and active satellite based data and also correlated it with aerosols concentration in the same region. The study includes a time series analysis of cloud base and top height with co-temporal and co-spatial AOD values for low-level, middle-level and high-level clouds. Significant trend in variation of cloud base and top height is found in our study. We have done the seasonal comparison of aerosols concentration with the CVS. And the study is showing that aerosols are influencing the CVS to a notable extent. The cloud vertical structure and aerosols also significantly influences the atmospheric temperature and the precipitation pattern and thus the hydrological cycle .Therefore, the effect of aerosol on clouds vertical structure in these polluted megacities could be very helpful for future climate projection and for understanding the hydrological cycle in these areas.

Association of Cloud Vertical Structure and Aerosols, Studied over Delhi Megacity.



Saloni Sharma

Jawaharlal Nehru University

PRESENTED AT:

INTRODUCTION

Clouds play a very important role in determining the radiative budget, hydrological cycle as well as the regional climate. The cloud vertical structure is one of the most important characteristic of the clouds to study. CVS is the key parameter which is being used in weather and climate models. The understanding of interaction of CVS with other atmospheric variables and aerosols can help us to understand the cooling/heating effects of clouds at different places.

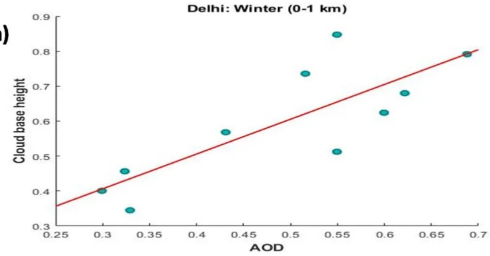
In polluted condition when there is a high loading of aerosols the effective cloud droplet radius decreases which implies a higher number of smaller cloud droplets with the same amount of moisture. Depending upon the availability of moisture such condition gives rise to either thick stable clouds or thin volatile clouds. Aerosols also modify the cloud microphysical properties which also influences its lifetime. All of such processes have significant impact on cloud radiative forcing. This work shows an attempt to understand the effect of aerosols on Cloud base height and cloud top height.

DATA

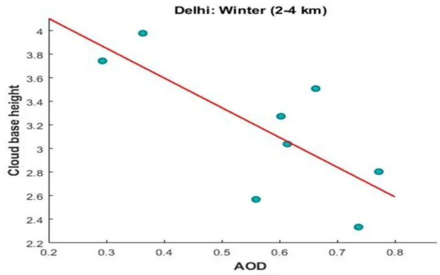
The study areas include Delhi which is one of the largest Urban agglomerations in India with a very high aerosol loading. The cloud vertical structure is obtained from radiosonde data by using the algorithm provided by Zhang et al. (2010) and a little modified by George et al. (2018) over Indian region. This algorithm provided a range of threshold values of relative humidity (RH) for the calculations of the cloud base, top and thickness. MERRA-2 AOD data is used for relating the concentration of aerosols with CVS. Co-temporal and Co-spatial AOD and CVS values were categorised into different bins at different atmospheric levels. We categorised 0-1 km and 1-2 km altitudes as low-level, 2-4 km and 4-6 km altitude as mid-level and 6-8 km and 8-12 km altitude as high-level.

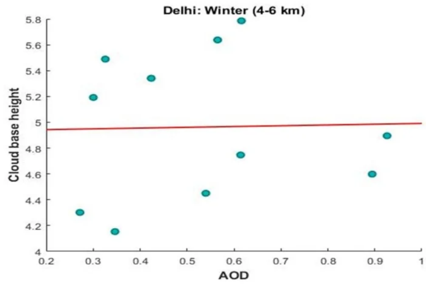
RESULTS

(a)

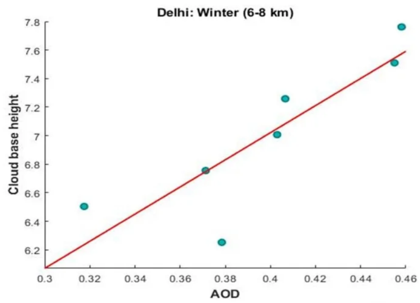

Delhi: Winter (0-1 km)
Cloud base height
AOD

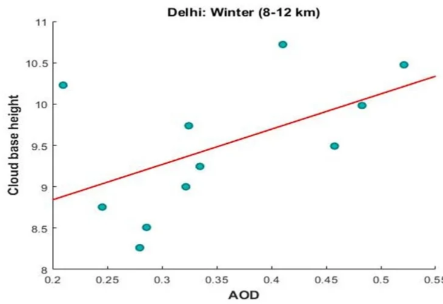
(b)


Delhi: Winter (2-4 km)
Cloud base height
AOD

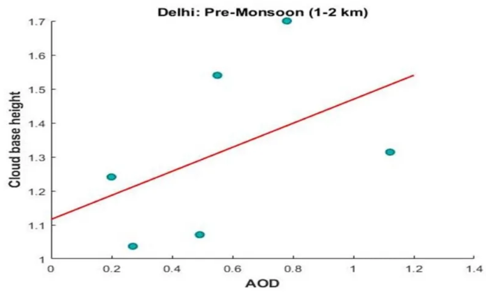

Delhi: Winter (4-6 km)
Cloud base height
AOD

(c)

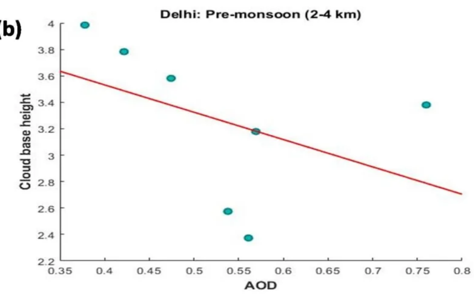

Delhi: Winter (6-8 km)
Cloud base height
AOD

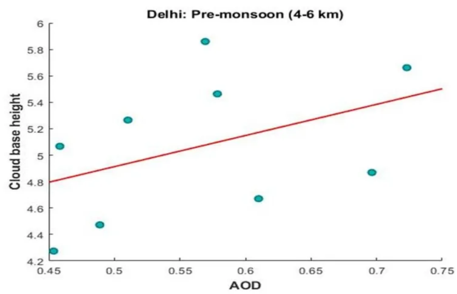

Delhi: Winter (8-12 km)
Cloud base height
AOD

(a)

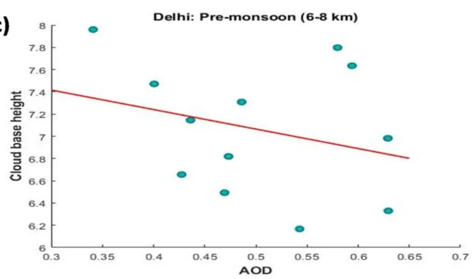

Delhi: Pre-Monsoon (1-2 km)
Cloud base height
AOD

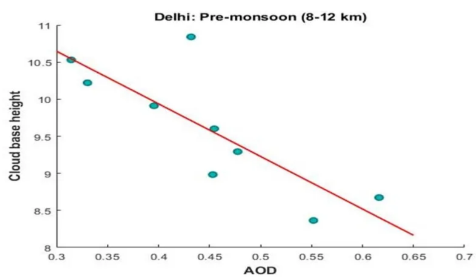
(b)


Delhi: Pre-monsoon (2-4 km)
Cloud base height
AOD

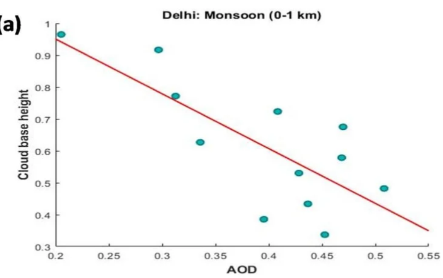

Delhi: Pre-monsoon (4-6 km)
Cloud base height
AOD

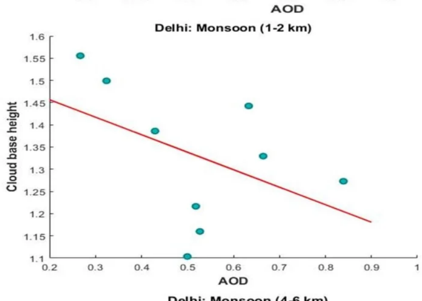
(c)


Delhi: Pre-monsoon (6-8 km)
Cloud base height
AOD


Delhi: Pre-monsoon (8-12 km)
Cloud base height
AOD

(a)

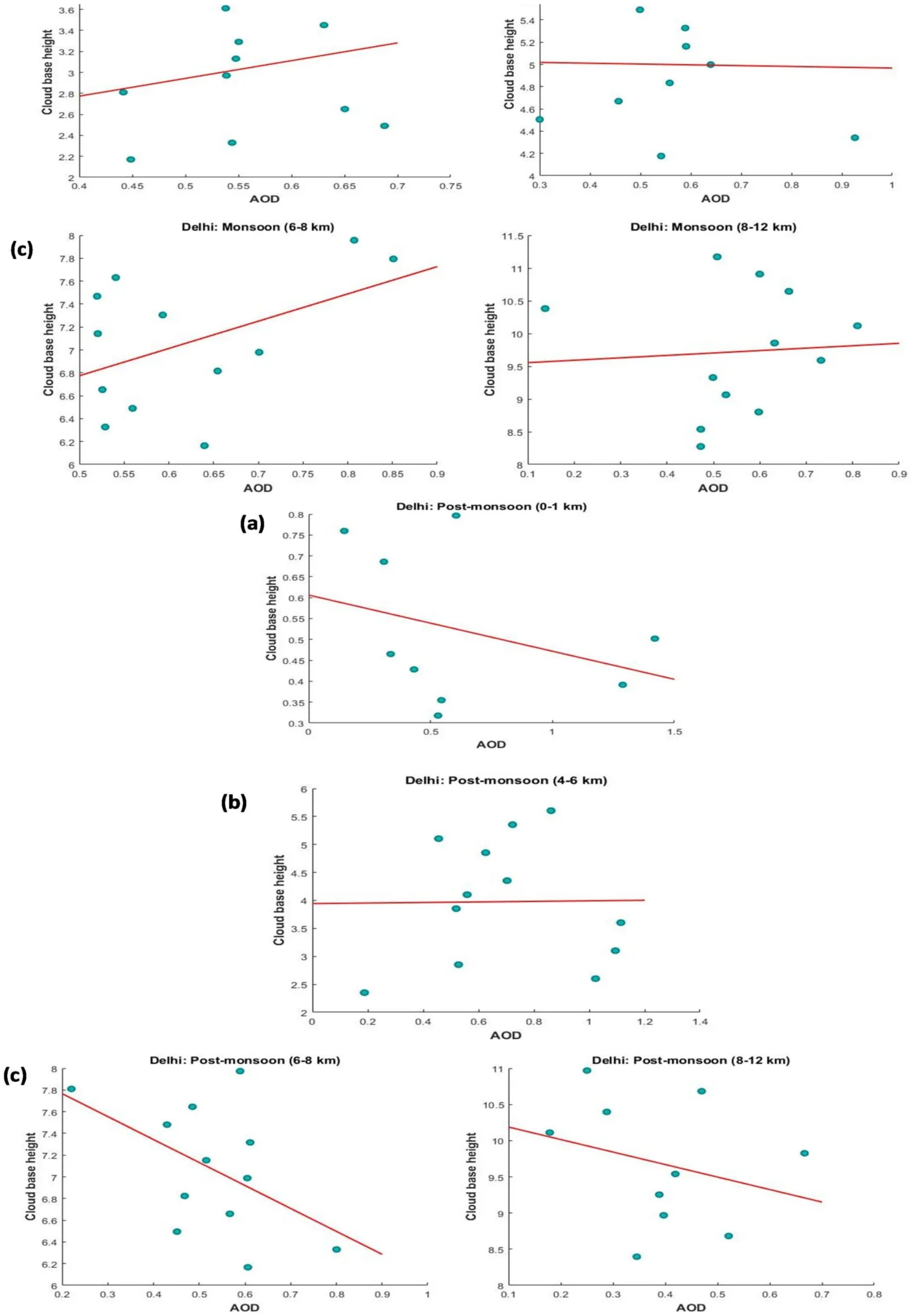

Delhi: Monsoon (0-1 km)
Cloud base height
AOD


Delhi: Monsoon (1-2 km)
Cloud base height
AOD

(b)

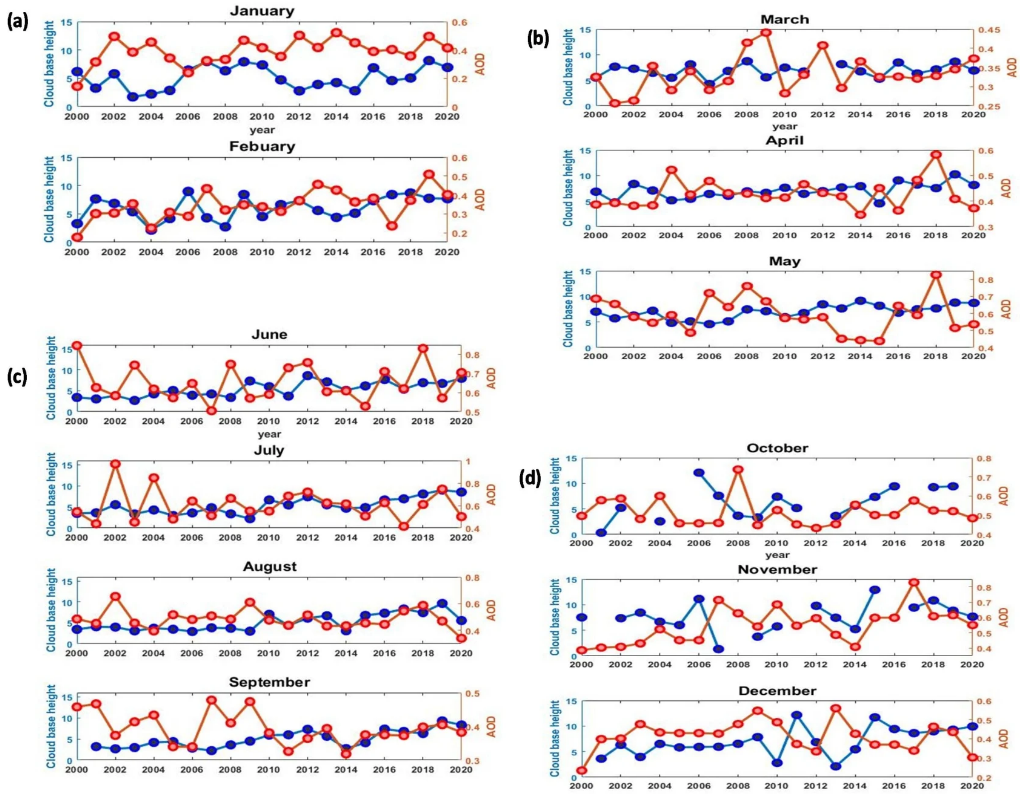

Delhi: Monsoon (2-4 km)


Delhi: Monsoon (4-6 km)

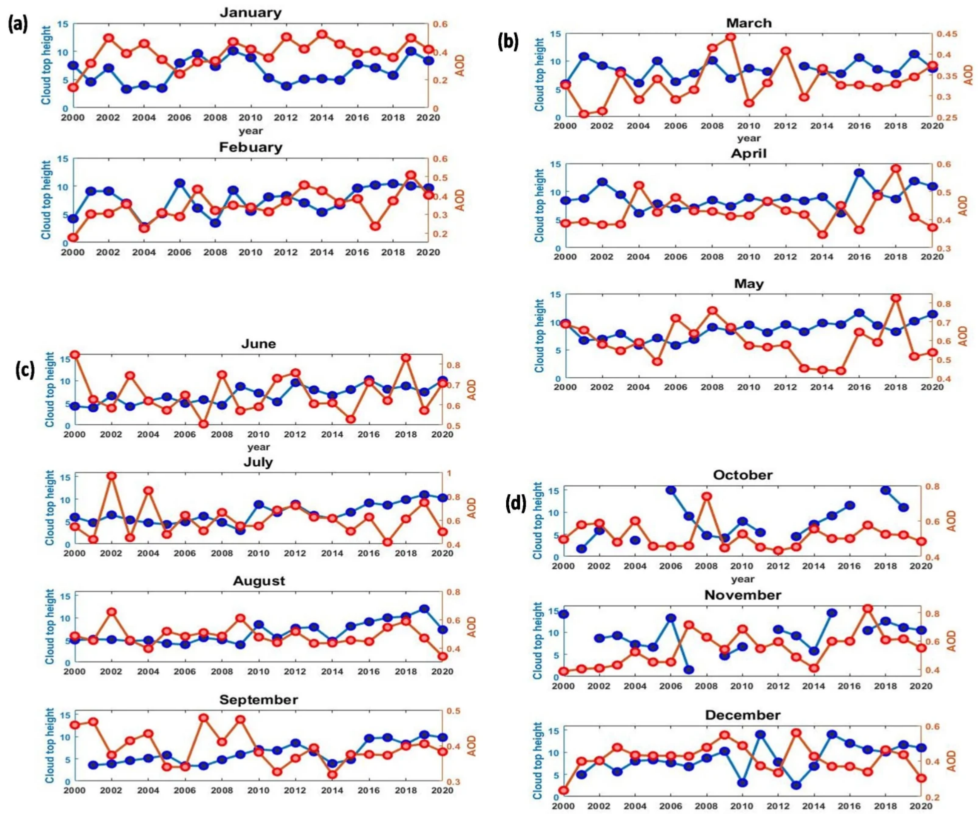


Scatter plots (with regression line) of cloud base height and aerosol optical depth categorized into various bins in different seasons (winter, pre-monsoon, monsoon and post-monsoon season from top to down above) for (a) low-level, (b) mid-level and (c) high-level clouds.

1.



2.



Long term temporal variation of (1) Cloud base height and (2) cloud top height with AOD for each month of different seasons i.e., (a) winter, (b) pre-monsoon, (c) monsoon and (d) post-monsoon.

CONCLUSION

1. Low-level cloud base height shows positive association with the aerosol optical depth in every season except monsoon. In monsoon season cloud base height decreases with increase in AOD.

2. Mid-level clouds (with base height within 2-6 km) don't show much association with AOD except in pre-monsoon season.

3. Whereas the base height of high-level clouds seems to be increasing with AOD in winter season and in other seasons it doesn't show much association.

4. The time series plot of cloud base height and aerosol optical depth shows higher values of both AOD and cloud base height in moth of May, June and then October and November. These months characterised by dust storms and crop burning seasons. High pollution in these months seems to associated with high cloud base height as well as higher cloud top height.

REFERENCES

George, G., Sarangi, C., Tripathi, S. N., Chakraborty, T., & Turner, A. (2018). Vertical structure and radiative forcing of monsoon clouds over Kanpur during the 2016 INCOMPASS field campaign. Journal of Geophysical Research: Atmospheres, 123(4), 2152-2174.

Zhang, J., Chen, H., Li, Z., Fan, X., Peng, L., Yu, Y., & Cribb, M. (2010). Analysis of cloud layer structure in Shouxian, China using RS92 radiosonde aided by 95 GHz cloud radar. Journal of Geophysical Research: Atmospheres, 115(D7).