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AEROSOL-CLOUD INTERACTION INFERRED FROM MODIS SATELLITE DATA OVER INDIAN REGION

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1. Introduction

Aerosols are known to impact the formation and the life cycle of clouds. A wide range of measurements show that anthropogenic aerosol alter clouds and their optical properties (Ackerman et al. 2000; Rosenfeld et al. 2002). It is important to understand and quantify the microphysical impact of both natural and anthropogenic aerosols on clouds, in order to understand and predict climate change. It is natural to seek information of aerosol-cloud interactions in observations. However, this is not straightforward, as aerosols and clouds are related also in ways other than through microphysics, most notably by both depending on meteorological conditions. The identified aerosol indirect effects are several, complex and interlinked. The first indirect effect refers to the radiative impact of a decrease in droplet effective radius that results from increases in aerosols (Twomey, 1977). The second indirect effect refers to the radiative impact of a decrease in precipitation efficiency results from increases in aerosols (Albrecht, 1989). In this paper, we present relationships between aerosol optical depth (AOD) and cloud parameters derived from MODIS satellite over different regions in India.

2. Data and methodology

Aerosols and clouds interact strongly in microphysical processes and this interaction depends on meteorological conditions. Data from the MODIS instrument for aerosols and cloud parameters are used. For this study, we selected six regions over India according to different dominant types of aerosols and its sources. The selected regions include Northeast India, (R1, 24-30º N, 88-97º E), Bengal/Orissa (R2, 15-21º N, 81-88º E), Indo-Gangetic plains (R3, 22-28º N, 81-88 E), South (R4, 8-12º N, 75-81º E) and Northwest India (R6, 24-32º N, 62-78º E). Regions R1, R2 are dominated by biomass burning, and R3, R4 are dominated by fossil fuel and R6 is desert dust dominant.

MODIS satellite data products aerosol optical depth, cloud effective radius (both water and ice phase), cloud optical depth, cloud fraction were analyzed for 5-years period from 2001-2005 over six different regions in India. Data revealed significant variability in aerosol loading over different regions. Regions R3, R5 and R6 show higher aerosol optical depths (AOD) as compared to other regions. Over all, regional variability in cloud effective radius (CER) indicates lower CER over polluted regions.

3. Results and discussion

Figure 1 shows the co-variation between AOD and CER for different regions. It can be noted from the figure that lower water radius is found during polluted (winter and pre-monsoon) as compared to clean seasons (monsoon). Regression analysis between aerosol optical depth and cloud parameters for all the six regions was made. Aerosol loading shows significant positive correlation with cloud optical depth and cloud fraction. In some cases, it is observed that the increase in aerosol concentrations leads to concurrent increases in the cloud droplet concentrations and the relative dispersion of the cloud droplet spectrum. This in turn suggests that the increase in effective radius resulting from increased relative dispersion may substantially negate the aerosol indirect effect (AIE).

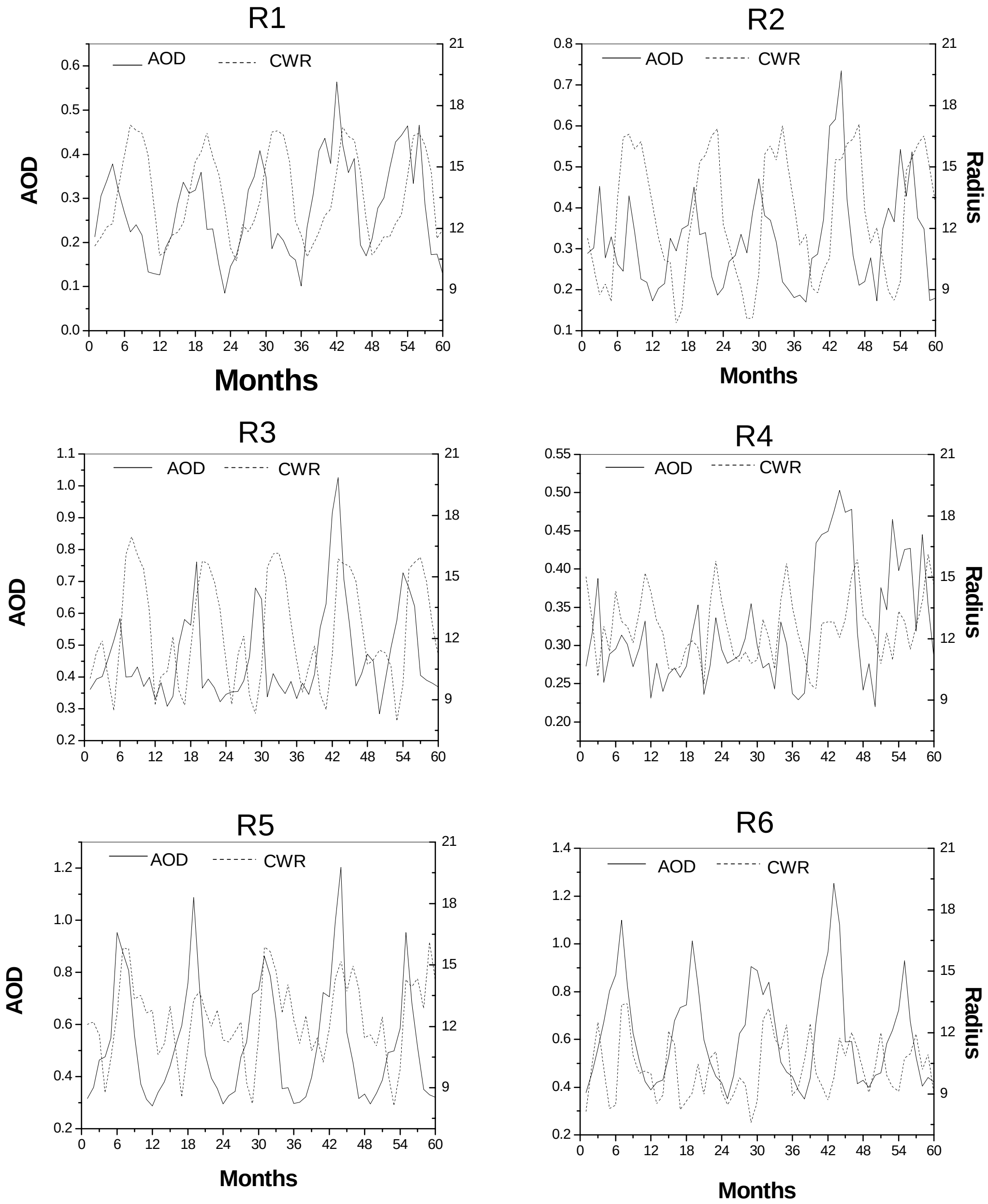

Figure 1. Co-variation between monthly mean AOD and water cloud effective radius (in µm) over different regions for the period 2001-2005.

The variation in the sign of AIE for both water and ice clouds exhibited under different atmospheric conditions and cloud regimes implies that the AIE must be understood in a broader context of atmospheric dynamics, thermodynamics and moisture conditions.

4. Summary

1. The effect of aerosols on cloud parameters have been studied by analyzing statistically significant relationships between AOD and cloud droplet effective radius. It is found that for water clouds, Twomey effect show a wide range of variation.
2. Uncertainty in the study of aerosol indirect effect can be caused by the factors such as lack of liquid water path measurements and the use of AOD as a proxy for aerosol size distribution and chemical composition.

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