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Aerosol Property Variations Over Global Oceans as Observed by the A-train Satellites

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Aerosol Property Variations over Global Oceans as Observed by the A-Train Satellites

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Abstract. Satellite observations show large marine aerosol property variations over global oceans. With new A-train satellite measurements, this study explores processes controlling these aerosol variations. Results show that marine aerosol optical depth is controlled by both wind-driven sea-spray process, and vertical transportation and mixing driven by turbulence. Furthermore, marine aerosol layer consists a well-mixed layer near surface and upper decoupled layer, and the whole boundary layer depth is mainly responded to surface heating and upper temperature inversion depression.

Keywords: marine aerosol property, boundary layer structure, A-Train Satellite

INTRODUCTION

This paper investigates the marine boundary layer aerosol property variations, and their vertical structures over global oceans. Marine aerosol is one of the largest natural aerosol sources and thus plays a significant role in global climate (IPCC, 2007). And marine aerosol dominates the marine boundary layer (MBL) particulate mass concentration in remote oceanic regions (Sievering et al., 2004), thus it could serve as a tracer to further study the MBL structure. A better understanding of the regional variations of marine aerosol distributions and the processes controlling them is fundamental to improve the simulations of aerosol property and process in climate models.

METHODOLOGY

Multiple satellite remote sensing and operational meteorological datasets over remote oceans during the period of Jun. 2006 to Dec. 2010 are used in this study. First, CloudSat 2B-GEOPROF product and CALIPSO level 1B data were combined to determine the cloud occurrence (Wang, et al, 2008, and Loknath et al, 2010). Second, related datasets (AMSR-E and CloudSat ECMWF-AUX) were collocated at 25km resolution and cloud-free CALIPSO Level 1B data within the 25km box are averaged. Then, a new threshold algorithm is developed to identify the aerosol layer using the collocated CALIPSO level 1B data based CALIPSO operational method applying at fine spatial resolutions (Vaughan and Power, 2005; Vaughan, et al., 2009). This new

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algorithm was also tested and verified with DOE ARM climate research facility ground-based lidar measurements. Furthermore, pure marine aerosol cases were identified by excluding long-range transported aerosol layers above the MBL. Finally, aerosol optical depth (AOD) at 532nm was retrieved by the forward iteration method.

RESULTS

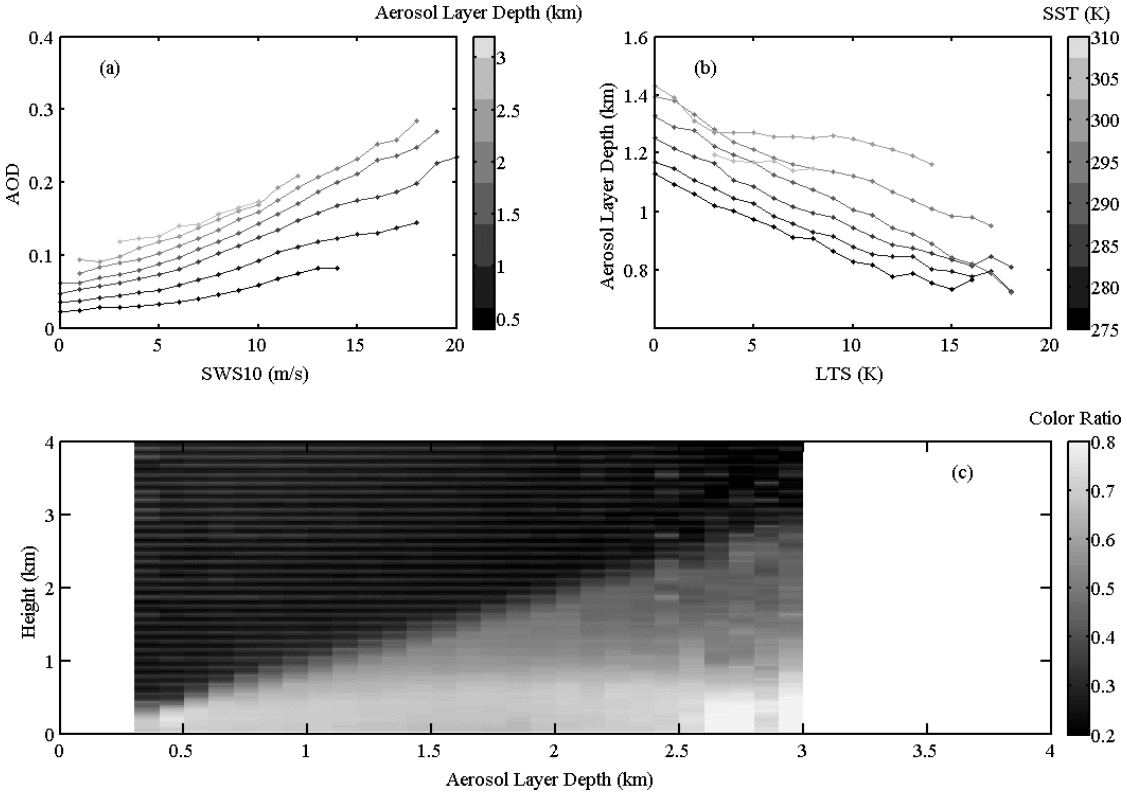

FIGURE 1. (a) AOD varies with SWS10 and aerosol layer depth; (b) Aerosol varies with SST and LTS; (c) Color ratio varies with aerosol layer depth for SWS10 within 10-12 m/s.

First we analyzed the global variations of marine aerosol characteristics and their controlling processes. The systematic regional, seasonal and day-night differences in marine AOD and marine aerosol layer depth were found. Several environmental parameters were selected to understand factors controlling these variations, including surface wind speed at 10m (SWS10) and sea surface temperature (SST) from AMSR-E measurements, and low-troposphere stability (LTS) calculated from the CloudSat ECMWF-AUX datasets. Results showed that, marine AOD is controlled by both wind-driven sea-spray process and vertical transportation and mixing driven by turbulence in boundary layer. The variations of marine AODs are characterized well with SWS10 and aerosol layer depth. Aerosol layer depth shows a good relationship with SST and LTS, which indicates that thermodynamic turbulence is driven by surface heating and upper temperature inversion depression respectively.

We further investigate marine boundary layer structure with the vertical distributions of marine aerosol properties. As illustrated in figure 1c, mean aerosol

color ratio (defined as the ratio of the attenuated 1064nm and 532nm backscatter) profiles are calculated as a function of marine aerosol layer depth within a given a small SWS10m range. A well-mixed layer near surface and an upper decoupled layer within the MBL can be easily identified with total attenuated backscatter at 532nm, extinction at 532nm and the color ratio. Comparing with the decoupled layer, the well-mixed layer has higher aerosol loading and larger aerosol size. This vertical structure may be resulted from several processes, such as turbulent transport, gravitational settling, and cloud-aerosol interactions, etc.

CONCLUSION

With multi-year A-train satellite measurements, we studied marine boundary layer aerosol property variations and their controlling processes over global oceans. Other than near surface wind speed, we found that marine aerosol layer depth is another major controlling factor of marine AOD. Furthermore, we showed that lidar measurements of marine aerosol layer structures offer important information of the MBL. These results are important to improve the simulations of marine aerosols and the MBL in numerical models.

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