Quantify Global Airborne Mineral Dust Distribution and Properties with CALIPSO Measurements

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Abstract

Airborne mineral dust affects the climate by scattering and absorbing solar and thermal infrared radiation and by serving as active CCN or IN to alter cloud and precipitation formation. However, many of these dust impacts are still poorly understood. The polarization capability of CALIOP lidar on board CALIPSO satellite provides an unprecedented opportunity to study vertical mineral dust distribution globally[1,2]. Based on the first two-year CALIOP data, global height resolved mineral dust aerosol distributions in terms of occurrence, extinction coefficient, and mass loading can be provided. With these new results, issues in current model simulated mineral dust distributions, especially the cross-Atlantic transport of the Sahara dust, can be evaluated. Our results show that CALIPSO measurements together with other A-train data will significantly improve our understanding of mineral dust impacts on the climate.

Dataset and methodology

Taking the advantage of the synergy of the CALIPSO and CloudSat, the CALIPSO lidar L1B profiles within the CloudSat radar footprint (5 profiles) were averaged. The heavy aerosol layers (such as dust layers) mis-classified as clouds in the CALIPSO products can be correctly identified as aerosol by using the CloudSat radar signals (no radar echo). The collocated dataset from Jun. 2006 to Aug. 2008 was used in this analysis. The seasonal results shown below were averaged for two years except for the JJA which was for three years if it is not specified.

Global Airborne Mineral Dust Distribution

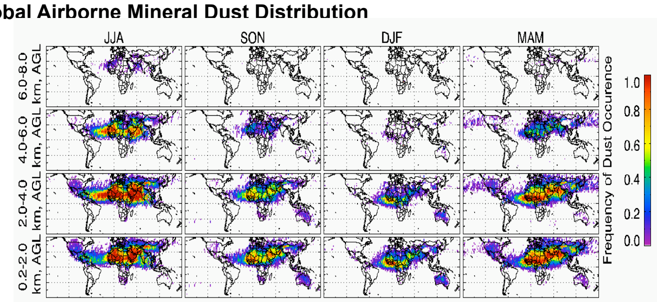

Fig. 1 Height resolved global view of dust aerosol distribution (2 degrees by 2 degrees)

The depolarization capability provided by CALIPSO lidar was successfully used to detect the dust aerosols globally in our previous work[3] by applying the threshold of volume depolarization ratio of 0.06. Fig. 1 is the updated results including dust above low clouds by using the new collocated dataset.

Dust Extinction Profile Retrieval

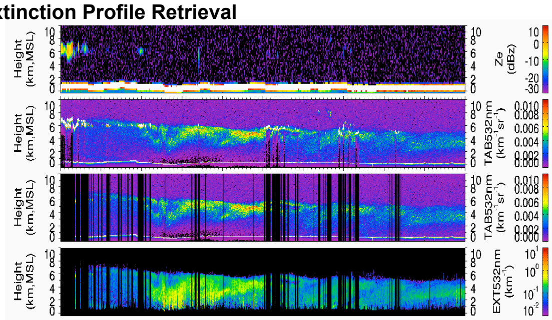

Fig. 2 A retrieval example of dust extinction coefficient profile

Here we use a new optical-depth-constrained extinction retrieval method by using a single collocated lidar profile. Given a initial lidar backscatter ratio (at a certain height) and a lidar ratio, the extinction profile can be retrieved from the attenuated backscatter profile by applying Fernald[4] backward iteration solution (ignoring multiple scattering). Because the attenuated backscatter coefficient for 532nm provided in L1B product are well calibrated, the ratio of backscatter coefficient and the attenuated backscatter coefficient at the initial height can be used to calculate the optical depth above this height. And this optical depth can be used to constrain the Fernald solution. Fig. 2 gives an example of this method using lidar ratio of 40Sr for dust aerosols.

Vertical Structures of Cross-Atlantics Sahara Dust

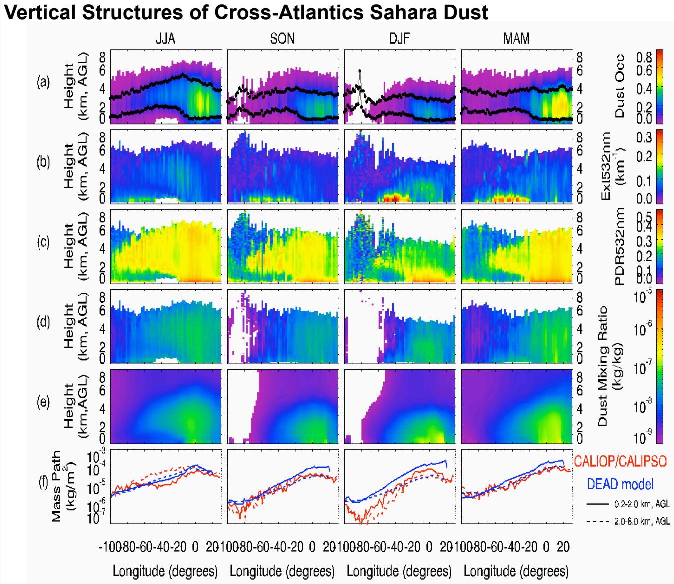

Fig. 3 Vertical structures of cross-Atlantics Sahara dust measured by CALIPSO lidar and comparison with the model simulation (averaged in the grid box latitude from -15^{O} to 45^{O} and longitude from -100^{O} to 30^{O}). (a) frequency of dust aerosols occurrence (b) dust extinction coefficient (c) dust aerosol particle depolarization ratio (d) dust mass mixing ratio (assuming the specific extinction coefficient is 0.7 m^2g^{-1}) (e) dust mixing ratio obtained from the DEAD dust model[5](1990-1999 ten year average) (f) dust column mass path

Meteorological Control of the Sahara Dust Transportation

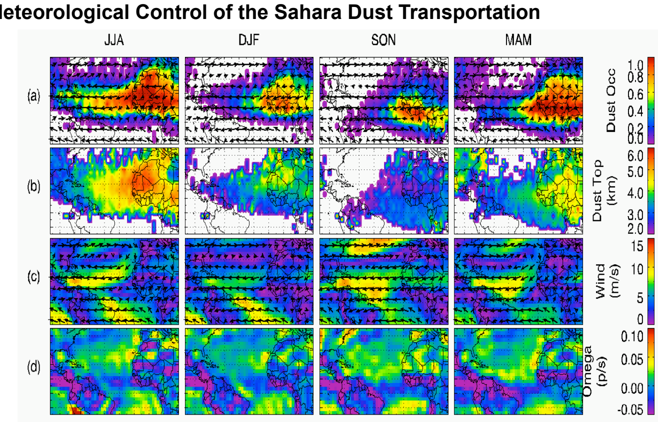

Fig. 4 Meteorological control of the Sahara dust transportation (2.5 degrees by 2.5 degrees) (a) frequency of dust aerosols occurrence overplotted with horizontal wind (b) averaged dust layer top height (AGL) (c) wind speed and direction[6](1000mb-850mb) (d) vertical velocity[6] (1000mb-850mb)

Reference

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