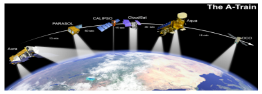
Dusty Cloud Properties and Warming Effect Determined from A-Trian Satellite Observations during PACDEX



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1. Introduction

➢The impact of long range transport of dust and air pollution from their continental sources to oceanic regions is an outstanding problem in regional and global climate change.

➢Dust mixed with air pollution leads to a brownish haze, which absorbs and scatters sunlight and leads to large reductions in sunlight at the surface (Ramanathan et al., 2001) resulting in so-called "global dimming."

➢Dust mixed with clouds leads to dusty clouds causing a large reduction in cloud radiative cooling resulting in warmer air (Huang et al., 2006).

➢Overall impact is inadequately quantified because optical & radiative properties of dusty clouds are poorly understood due to lack of observations.

➢In this study, the dusty cloud properties and warming effects are analyzed using A-Train satellite measurements. The A-Train satellite constellation consists of six satellites flying in formation around the globe (Aqua, CloudSat, CALIPSO, PARASOL and OCO).

2. Data

Aqua CERES SSF:

CERES (Clouds and the Earth's Radiant Energy System) Aqua SSF (Single Scanner Footprint) data provide combined CERES broadbabnd radiation measurements and CERES-MODIS cloud properties at 20 km resolution

CloudSat:

Cloud vertical profile, cloud classification, cloud liquid/ice water content, and cloud optical depth are provided by CloudSat level 2 data within CERES footprints

CALPISO:

Lidar measurements from CALIPSO used to identify dusty clouds and provide vertical profiles of dust aerosol optical depth within CERES footprints

3. Radiation Transfer Model

The Fu-Liou radiation transfer model (Fu and Liou, 1992 &1993) is a delta-four stream radiative transfer code with 15 spectral bands from 0.175 to 4.0 μm in SW and 12 LW spectral bands between 2850 and 0 cm^{-1}. The correlated *k*-distribution method is used to treat non-gray gaseous absorption due to H_2O, CO_2, O_3, N_2O, and CH_4 (Fu and Liou, 1992). Surface albedo spectral dependencies are taken into account using a lookup table based IGBP scene type. Calculations are use to estimate layer radiative heating rates

4. PACDEX cases study of dusty cloud properties and heating rate using CALIPSO, CloudSat and CERES data

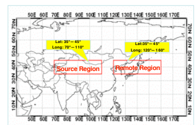

Fig. 1. Selected dust source & remote analysis regions.

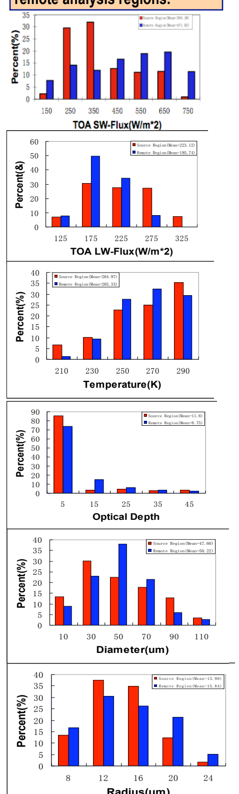

Fig. 2. Comparison of dusty cloud properties between source and remote region for TOA SW and LW flux, cloud top temperature, optical depth, diameter, and radius.

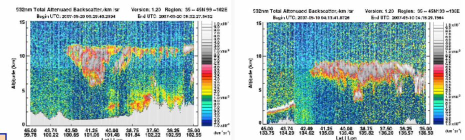

Fig 3. Altitude-orbit cross-section of total attenuated backscattering intensity over source region (left: May 20, 2007) and remote region (right: May 10, 2007).

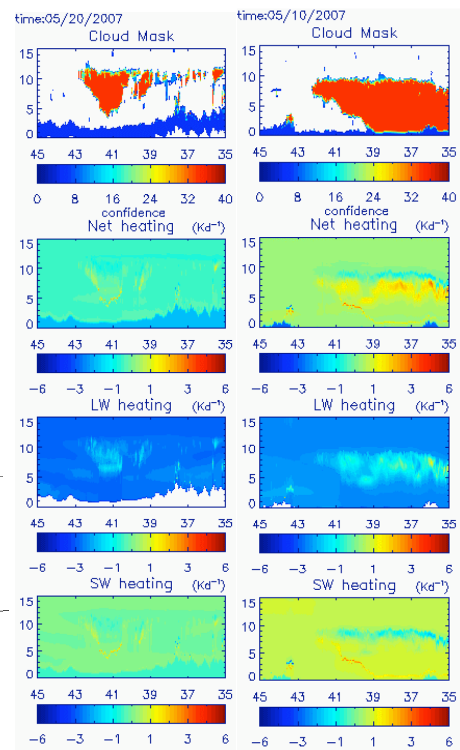

Fig. 4. Vertical cross-sections of Cloud Mask, Net, LW and SW radiative heating rates derived from CloudSat 2B-FLXHR data for source region (left: May 20, 2007) and remote region (right: May 10, 2007).

5. Case study statistics from analysis of dusty cloud radiation forcing & contribution of direct and indirect/ semi-direct effects using 2001-2004 CERES data

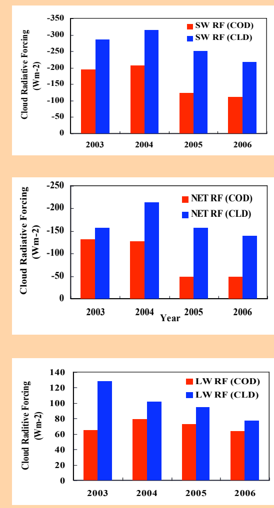

Fig. 5. Annual mean instantaneous TOA dusty (COD) and dust-free (CLD) cloud radiative forcing for SW forcing, LW forcing and Net forcing.

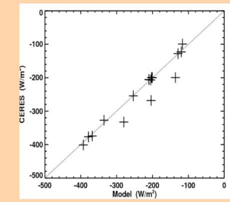

Fig. 6. Comparison of dust-free cloud CRF value of CERES measurements with Fu-Liou model simulation.

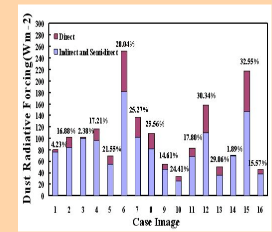

Fig. 7. Mean values of direct and combined indirect and semi-direct instantaneous SWRF at TOA. Numbers represent the percentage of contribution of direct (direct/total) .

6. Conclusions and Discussion

1. Significant differences found in cloud optical depth, effective particle size, liquid water path and radiative forcing between dusty and dust-free clouds.
2. Net radiative forcing at the top of atmosphere (TOA) for dusty clouds is reduced compared to that for dust-free clouds. The reduced cooling effects may lead to a net warming.
3. Semi-direct effect may be dominated by interactions between dust aerosols and clouds over arid and semi-arid areas and might contribute to reduced precipitation.

References

Ramanathan, V. et al. (2001), Indian Ocean experiment: An integrated analysis of the climate forcing and effects of the great Indo-Asian haze. J. Geophys. Res. 106, doi:10.1029/2001JD900133 (2001).

Huang, J., et al. (2006), Possible influences of Asian dust aerosols on cloud properties and radiative forcing observed from MODIS and CERES, *Geophys Res. Lett.*, *33*, 2005GL024724.

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