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Impact of Long-Range Transport Dust on Aerosol Optical Properties Over A Semi-Arid Region in Southern Peninsular India

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Abstract
The present paper investigates the results of a case study on the impact of an long range transport dust on the optical properties of aerosols at a semi-arid region in southern peninsular India using remote sensing techniques. Vertically resolved feature mask images from Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) on available days are utilized to monitor the smoke/dust vertical distributions during dust transport day. CALIPSO observations of the vertical profile of aerosols are in qualitative agreement with the values of MERRA-2 dust aerosol optical depth and Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol optical depths. CALIPSO derived Aerosol extinction coefficient suggested dominance of dust particle loading during dusty days compared to normal days. In addition, a long range transport of a widespread dust plume is observed over northwestern regions as evidenced by the MODIS imagery. The observed features are also explained on the basis of the results from the back trajectories.

Keywords: CALIPSO, MODIS, DUST

1. Introduction

Aerosols in the atmosphere are tiny liquid/solid particles in the air (excluding cloud particles) that have negligible terminal fall speed and which are injected by natural sources originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray or anthropogenic sources such as the burning of fossil fuels and the alteration of natural surface covers (Kaskaoutis *et al.*, 2007). Aerosol play an important role in the Earth's atmospheric processes due to their direct and indirect effect (Ranjan *et al.*, 2007; Badrinath *et al.*, 2008; Pawar *et al.*, 2012). Knowledge of characteristic of atmospheric aerosol on regional and global basis with a high spatial and temporal resolution essential (Smirnov *et al.*, 2002), particularly dust transported events. Satellite remote sensing is an essential tool for monitoring the global aerosol budget and their radiative effects on climate (Charlson, 1992; 1995; Kaufman et al., 1997, 2002).The inter-comparison and validation of satellite derived aerosol optical properties from different instruments is necessary to build a long term database for climatological studies and to improve the accuracy of the single sensor. Hence, in the present study, we analyzed for the optical aerosol parameters during the normal and dust transported days measured over a semi-arid location in southern peninsular

India.

2. Instrumentation and site description

The Moderate Resolution Imaging Spectroradiometer (MODIS) sensor is on board the polar orbiting NASA-EOS Terra and Aqua spacecrafts with equator crossing times of 10:30 and 13:30 Local Solar Time (LST), respectively (Levy et al., 2007). Aerosol retrievals from MODIS data are performed over land and ocean surfaces by means of two separate algorithms described in the literature (Kaufman and Tanre, 1998). The data used in this study both Terra and aqua MODIS aerosol products.As part of the A-train satellite constellation that includes the Aqua, CloudSat, Aura, Orbiting Carbon Observatory (OCO) and PARASOL satellites, Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) has a 981-inclination orbit and flies at an altitude of 705 km, providing the vertical distribution of aerosols and clouds. A detailed discussion of CALIOP data products can be found in the literature (Vaughan et al., 2004).Gridded surface meteorological and mass concentration data (0.625° × 0.5° longitude-by-latitude resolution) was retrieved from National Aeronautics and Space Administration (NASA's) MERRA-2 reanalysis data in normal and dust transported day.The Air Resources Laboratory's Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model is a complete system for computing both simple air parcel trajectories. Some of the applications include tracking and forecasting the release of radioactive material, volcanic ash, wildfire smoke, and pollutants from various stationary and mobile emission sources (Draxler & Rolph, 2012). Anantapur represents a semi-arid continental region and which is located in southern peninsular India (Fig. 1). Apart from the anthropogenic pollutants, mineral dust particles transported from northwestern regions contribute significantly to the frequently observed high aerosol loading over Anantapur. During the summer season, along with the mineral dust, the wind carries soot aerosols (absorbing nature) from northern India, causing severe air pollution.

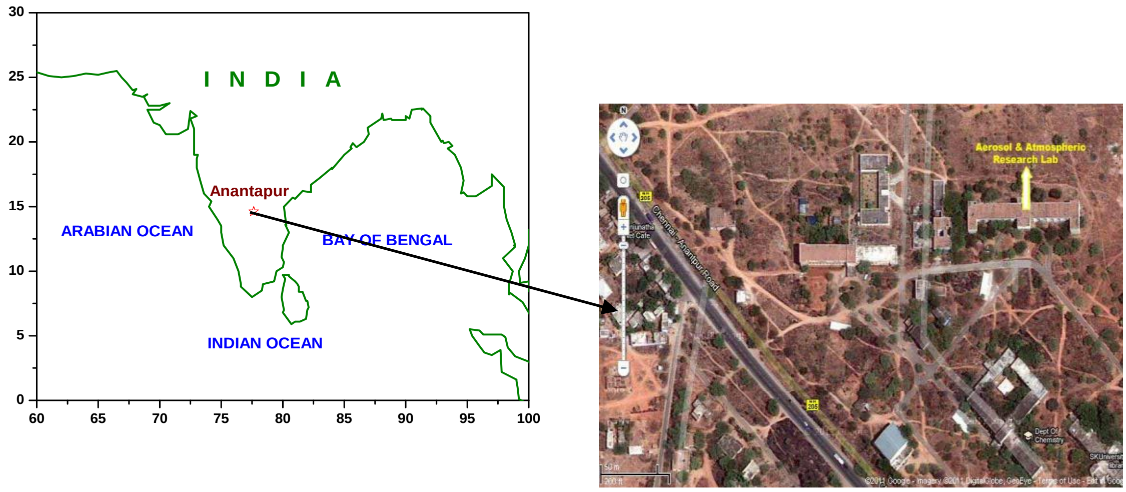

Fig.1. Location map of (top panel) the Sri Krishnadevaraya University campus area in Anantapur (bottom panel) satellite aerial view of monitoring site building in the SKU campus indicated with an arrow head.

3. Results and discussions

3.1 Daily variation of MODIS AOD

Fig. 2 shows the daily variations of MODIS aerosol optical depth (AOD_{550nm}) during before dust days and after days in the month of March, 2012.

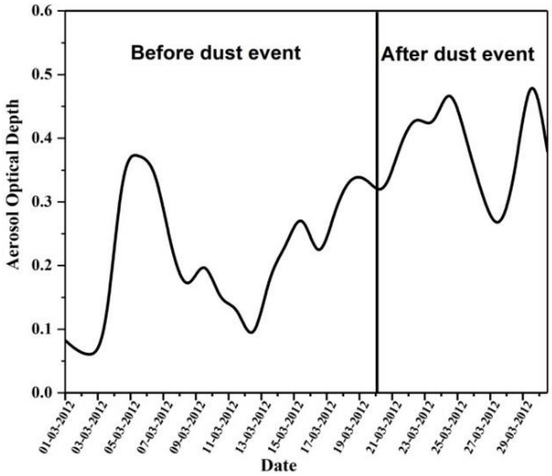

Fig. 2. Day-to-day variation of MODIS retrieved aerosol optical depth at 550 nm in the month

Observations revealed a substantial increase in AOD during dusty days (0.39 ± 0.09) compared to normal days (0.21 ± 0.09). CALIPSO vertical profiles of aerosol subtypes reveal the presence of polluted dust along with pure dust in the month of March in dust episode (Fig.3).

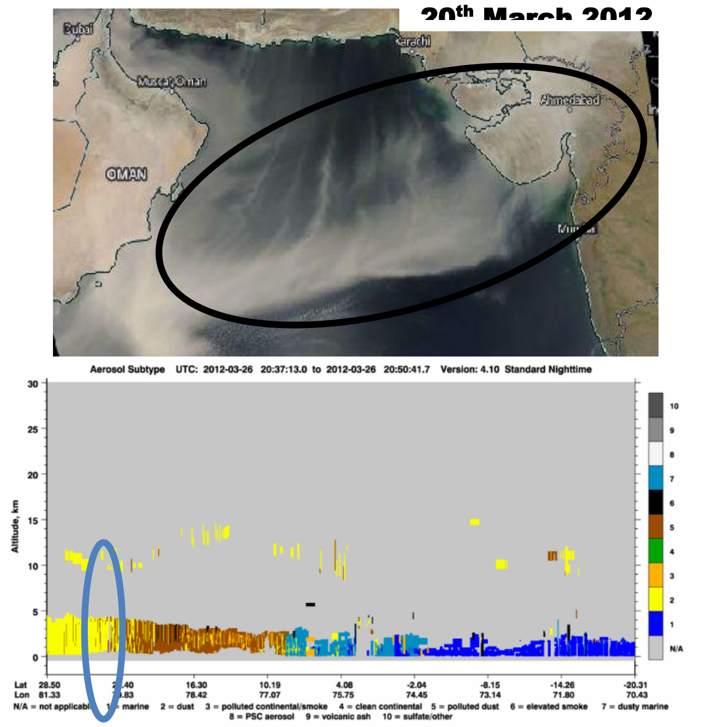

Fig. 3. Dust transport detection through MODS image on 20-03-2012 and CALIPSO-derived

The dust AOD using MERRA-2 datasets also reveal a clear distinction between the dust episode (26th March 2012) and the rest of the day (03rd March 2012) in the month of March 2012 (Fig.4), and the dust episode is due to long-range transport from North West region reaching the measurement location. The MERRA-2 dust AOD values were 170% higher on a dust transported day compared to a normal day, revealing additional potential source causing high aerosol loading over the measurement location. MODIS satellite image and HYSPLIT trajectories also captured the transport of dust plume towards the North aWestern regions and aerosols transported in the downwind direction towards the measurement location.

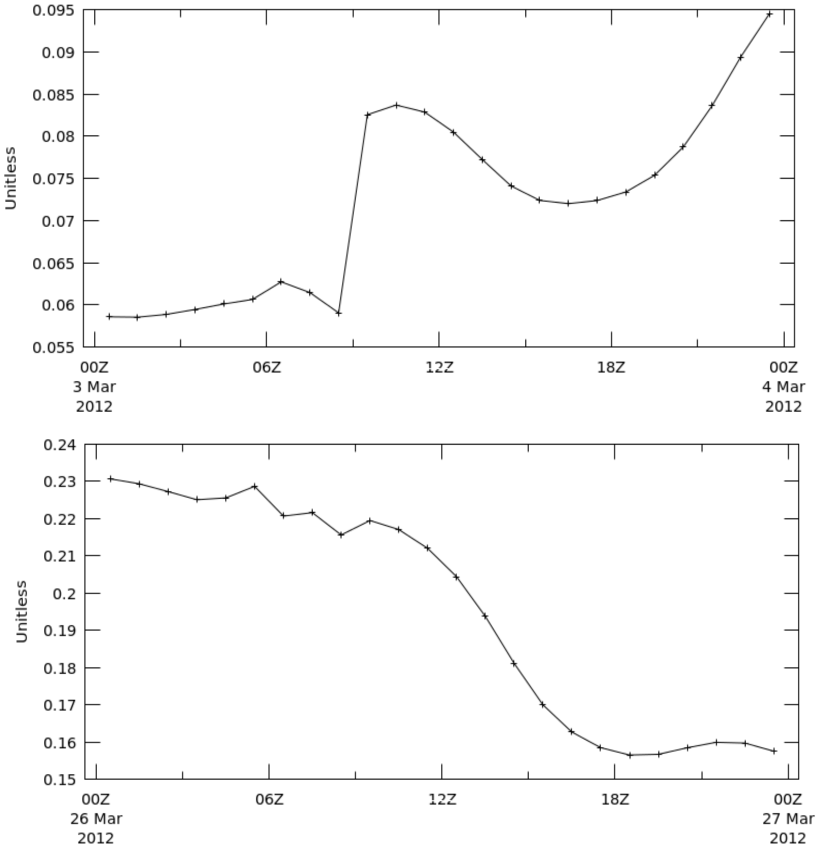

Fig. 4. Diurnal Comparison of Dust AOD obtained from MERRA-2 model on 03rd March 2012 and 26th March 2012.

Overall, the results of this study provided scientific evidence on the physical processes of dust aerosol particles during their transport in the atmosphere.

3.2 Vertical profiles aerosol extinction coefficient retrieved from CALIPSO

Fig. 5 illustrates the CALIPSO-derived vertical profiles of aerosol extinction coefficient at 532 nm during the dust event day (26th -03-2012) and normal day (03rd -03-2012) in the month of March, 2012. Since the spatial coverage of CALIPSO is minimal, the exact overpass for the present measurement location is not available; the overpass on 03rd March and 26th March is only available for the current analysis. During the dust episode, there is an elevated aerosol layer above 1 km with a peak height of 1.8 km. From both profiles, it can be seen that the dust is ubiquitously present over the measurement location during episodic day. These dust episodes have also been observed by CALIPSO vertical feature mask profiles, with dust/polluted dust being reached as high as 4.0 km during 26th March,2012 (Fig.3)

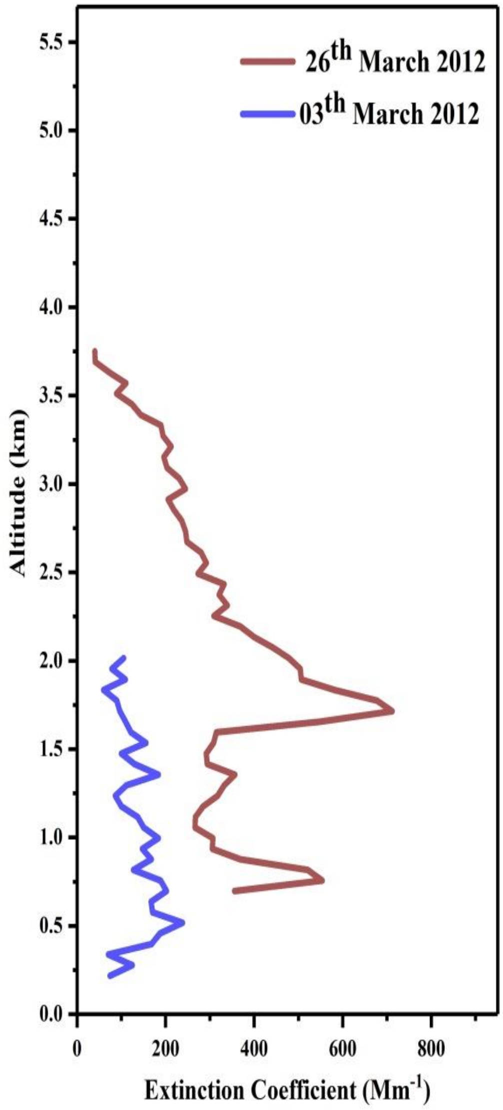

Fig. 5. Vertical distribution of aerosol extinction coefficient at 532 nm retrieved from CALIPSO on 03rd March 2012 and 26th March 2012.

3.3 Air mass back trajectory Analysis

For the days when the presence of aerosols from dust transport was detected by the sensors on board CALIPSO and MODIS satellites, air mass trajectories were generated using a HYSPLIT model (Draxler & Hess, 1998). The HYSPLIT trajectories are computed based on the Global Data Assimilation System (GDAS), an operational system from the National Weather Service of the National Centres for Environmental Prediction (NCEP). The purpose of using this trajectory model is to constrain the direction of the air masses to improve the correlation between the optical properties (i.e., AOD) measured by two different instruments spatially separated, i.e., MODIS sensor and CALIPSO. It can be noted from these trajectories that the winds above the boundary layer height (1.5 km) are originating from the North Western regions (Fig.6), significantly influenced by the observed AODs on these days. This corroborates the higher and lower Dust AODs observed on 03rd March, 2012 and 26th March 2012 (as shown in Fig. 4 from MERRA-2.

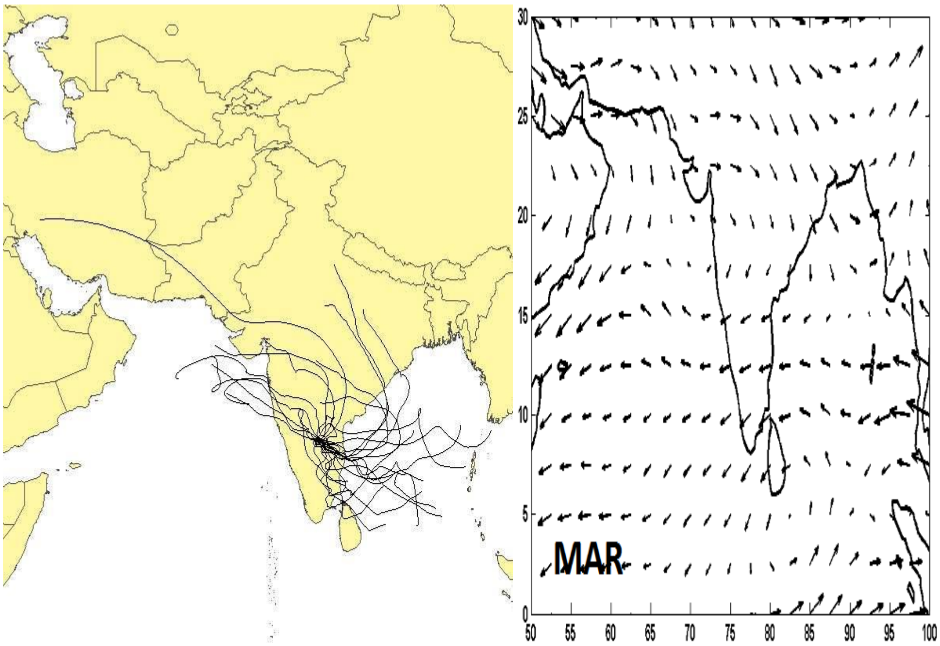

Fig.6. Air mass back trajectories and NCEP winds in the month of March 2012

MODIS image showed the occurrence of dust plume towards the north western regions on 20th March, 2012. National Centers for Environmental Prediction (NCEP) winds also suggested the occurrence of North Western winds towards the measurement location.

4 Conclusions

Satellite measurements together with a back trajectory model have been used to characterize dust transport aerosol during March, 2012 over a Semi-arid location in the Southern peninsular India. It is found that the measurement location experiences North western windy patterns in March, which lead to large temporal variations in aerosol characteristics. Transport of aerosols in the down-wind direction, as reflected in MERRA-2 reanalysis, causes considerable increase in dust aerosol optical depth (170%) during dusty day than normal days.

References

1. Badarinath, K.V.S., Kharol, S.K., Prasad, V.K., Sharma, A.R., Reddi, E.U.B., Kambezidis, H.D. and Kaskaoutis D.G. (2008). Influence of Natural and Anthropogenic Activities on UV Index Variations—A Study over Tropical Urban Region Using Ground Based Observations and Satellite Data. J. Atmos. Chem. 59: 219–236.
2. Charlson, R. J., Schwartz, S. E., Hales, J. M., Cess, R. D., Coakley Jr., J. A., Hansen, J. E., and Hofmann, D. J.: Climate forcing by anthropogenic aerosol, Science, 255, 423–430, 1992.

3. Draxler, R.R., & Rolph, G.D. (2012). HYSPLIT – Hybrid Single Particle Lagrangian Integrated Trajectory Model. NOAA Air Resources Laboratory, Silver Spring, Maryaland: USA.
4. Kaskaoutis, D.G., Kambezidis, H.D., Hatzianastassiou, N., Kosmopoulos, P.G. and Badarinath, K.V.S. (2007). Aerosol Climatology: On the Discrimination of the Aerosol Types over four AERONET Sites. Atmos. Chem. Phys. Discuss. 7: 6357–6411.
5. Kaufman, Y. J., Tanr´e, D., and Boucher, O.: A satellite view of aerosols in climate system, Nature, 419, 215–223, 2002.
6. Kaufman, Y. J., Tanr´e, D., Gordon, H. R., Nakajima, T., Lenoble, J., Frouin, R., Grassl, H., Herman, B. M., King, M. D., and Teillet, P. M.: Passive remote sensing of tropospheric aerosol and atmospheric correction for the aerosol effect, J. Geophys. Res., 102, 16 815–16 830, 1997.
7. Kaufman, Y.J., & Tanré, D. (1998). Algorithm for Remote Sensing of Tropospheric Aerosol from MODIS, Algorithm Theoretical Basis Document. ATBD-MOD-02, NASA Goddard Space Flight Center 85.
8. Levy, R.C., Remer, L.A., & Dubovik, O. (2007). Global aerosol optical properties and application to Moderate Resolution Imaging Spectroradiometer aerosol retrieval over land. Journal of Geophysical Research, 112(D13210).
9. Pawar, G.V., Devara, P.C.S, More, S.D., Pradeep Kumar P. and Aher G.R. (2012). Determination of Aerosol Characteristics and Direct Radiative Forcing at Pune. Aerosol Air Qual. Res. 12: 1166–1180.
10. Ranjan, R.R., Joshi, H.P. and Iyer, K.N. (2007). Spectral Variation of Total Column Aerosol Optical Depth over Rajkot: A Tropical Semi-arid Indian Station. Aerosol Air Qual. Res. 7: 33–45.
11. Smirnov, A., Holben, B.N., Kaufman, Y.J., Dubovik, O., Eck, T.F., Slutsker, I., Pietras, C. and Halthore, R.N. (2002). Optical Properties of Atmospheric Aerosol in Maritime Environments. J. Atmos. Sci. 59: 501–523.
12. Vaughan, M., Young, S., Winker, D., Powell, K., Omar, A., Liu, Z., Hu, Y., & Hostetler, C. (2004). Fully automated analysis of space-based Lidar data: an overview of the CALIPSO retrieval algorithms and data products. Proceedings of SPIE, 5575, 16–30.