OBSERVATION OF DUST LOADINGS FROM SPACE-BORNE MEASUREMENTS (2005-2016)

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ABSTRACT:

Dust particles of different size and origins, form major part of air pollution in the atmosphere. The qualitative and quantitative estimates of dust from ground-based measurements provide accurate information at regional scales. However, data from space-borne instruments provide continuous spatial information at a variety of different spatial scales. In this paper, we attempt to study signals of dust as observed from CALIOP (Cloud Aerosol Lidar with Orthogonal Polarization) sensor on-board CALIPSO satellite. Utilization of these freely available datasets can effectively contribute to the capacity building in the domain of aerosol science. This analysis is supplemented by absorbing aerosol levels as seen by OMI (Ozone Monitoring Instrument) sensor on-board AURA satellite. This study was conducted over the Middle-East and North Africa during JJA (June, July and August) season. For this study, we have used Level-3 AOD (Aerosol Optical Depth) due to dust from CALIOP at spatial resolution of 2°x5°and Level-3 Absorbing Aerosol Optical Depth (AAOD) data from OMI at spatial resolution of 1°x1°.The time frame for the study was 2005 to 2016.

1. INTRODUCTION

Aerosols are small particles found in the Earth's atmosphere. These aerosols are found both naturally (like dust, sea-salt, biogenic emissions) and also as a result of anthropogenic activities (like smoke, particulate air pollution). Aerosols affect the Earth's climate by scattering and absorbing the solar radiations in the atmosphere. The interaction of particles with clouds may change the cloud optical properties and their lifetimes (DeMott et al., 2003; Mahowald and Kiehl, 2003), as well as affect precipitation processes (Creamean et al., 2013).

There are evidences that small particles in the atmosphere can likewise adsorb onto micro-organisms, causing infectious diseases that can gradually cause blockage in lungs; and debase resistance to and immunity from diseases of the human body; thus harming human health and affecting the children's lung developments (Zhang et al., 2012 and references therein). Smaller the size of an aerosol, greater are its chances to be inhaled and get deposited in the lungs and cause greater adverse effects (Brunekreef and Holgate, 2002). In this context, there are studies which have revealed that increased aerosol levels in air might result in increase in chronic respiratory diseases like lung cancer (Tie et. al., 2009).Similarly, Honda et al., 2014 have studied the impact of aerosols on human health in East and Southeast Asia. *

Dust is one of the major pollutants that might alter the respiratory and climate systems. Globally, dust is mostly abundant over North Africa and Middle-East regions. Studies have shown that the long range transport of dust from North African region adds to almost 50% of worldwide dust emissions (Huneeus et al., 2011; Kaufman et al., 2005; Mehta et al., 2016). In this paper, we have studied the variability of dust signals as observed by Cloud Aerosol Lidar with Orthogonal Polarization (CALIOP) and Ozone Monitoring Instrument (OMI) sensors over North Africa and Middle-East regions for the time period spanning over 2005 - 2016.

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2. STUDY AREA

We have considered North Africa and Middle-East regions in this study. The coordinates of the study region correspond to 20°N - 12°N and 7.5°W - 17.5°E for North Africa; and 28°N - 20°N and 42.4°E - 52.5°E for Middle-East respectively. Figure 1 shows the study regions indicated by boxes overlaid on OMI Absorbing Aerosol Optical Depth (AAOD) data of July 2016.

We have studied the dust signals during JJA (June-July-August) season in this paper.

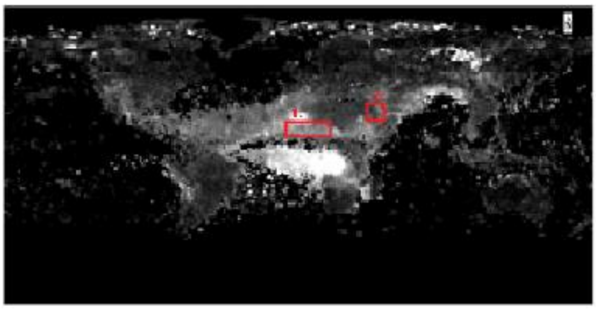


Figure 1 OMI AAOD data of July 2016. The two boxes represent the study areas;
1: Study area over North Africa
2: Study area over Middle-East

3. DATASETS

In this paper, we have used the freely available aerosol datasets from CALIOP and OMI sensors.

3.1. CALIPSO level 3 aerosol product

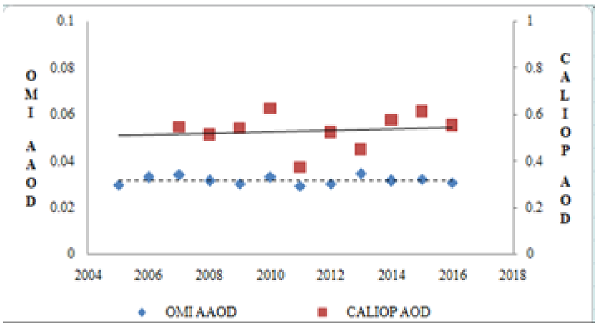
Cloud-Aerosol Lidar with Orthogonal Polarization(CALIOP) onboard Cloud-Aerosol Lidar and Infrared Path-Finder Satellite Observations (CALIPSO) provides the vertically distributed data of aerosols and clouds from 2006 onwards (Hunt et al., 2009;Winker et al., 2009). CALIPSO forms a part of A-train satellites in near sun synchronous orbit at an altitude of 705 km. The repeat cycle of the spacecraft is 16 days. The CALIOP Lidar captures the data at two wavelengths, i.e., 532 nm and 1064 nm. The sensor provides the columnar and vertically distributed data of aerosols along with the information on major aerosol types. In this study, we have used CALIOP Level 3 night-time global gridded monthly aerosol optical depth (AOD) datasets at spatial resolution of 2°×5° (Winker et al., 2013).

3.2. AURA/OMI level 3 Aerosol product

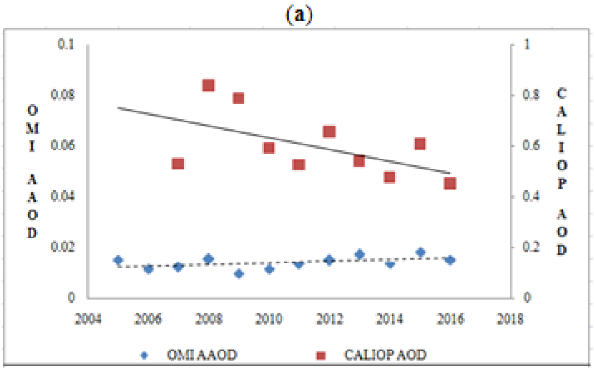
The Ozone Monitoring Instrument (OMI), onboard AURA spacecraft is able to monitor aerosols along with ozone. Similar to CALIPSO, AURA is also a part of A-train satellites in near sun-synchronous orbit. The OMI spectrograph records the data in UV/Visible region. In this paper, we have used daily Level 3 OMI/Aura near-UV Absorbing Aerosol Optical Depth datasets available at spatial resolution of 1°x1°.

4. RESULTS AND DISCUSSION

From the daily datasets available from OMI we have computed the seasonal averages followed by extraction of data. Similarly, the monthly datasets from CALIOP were seasonally averaged and the required data was extracted for the considered study regions. This procedure was followed by zonal analysis for the respective time frames.



(a)



(b)

Figure 2 (a) Shows the trends of CALIOP AOD and OMI AAOD over North Africa
(b) Shows the trends of CALIOP AOD and OMI AAOD over Middle-East

Figure 2 shows the variability of AAOD from OMI and AOD due to dust from CALIOP sensors over North Africa and Middle-East respectively. Whereas CALIOP retrievals utilized in the study are specific to dust particles only, the absorbing aerosol levels retrieved from OMI are inclusive of different aerosol types which are absorbing in nature. This fact should be considered while interpretation of the results.

We observe from the figure that the order of dust loadings retrieved by CALIOP over North African region are comparable to that over Middle-East. Further, we see that dust over North Africa has increased as seen by CALIOP during the last 10 years which is also supported by the slightly increased absorption aerosol levels as observed using OMI data. As the study region considered over North Africa is mainly dominated by dust particles, hence, the agreement in the results from the two different sensors is indicative of enhancement of dust particles in the considered study zone.

Similar results have been reported in a recent study by Mehta et.al, 2018 and references therein. However, considering the Middle-East region, while CALIOP reports declining dust levels across the Middle-East region, on the contrary OMI reports slightly increasing absorption aerosol levels. Here it is important to note that the Middle-East region is dominated not only by the dust particles but also by high levels of anthropogenic pollution. Hence, the small increasing trends of AAOD as observed by OMI sensor should be investigated with respect to specific aerosol type prevalent over Middle-East.

5. CONCLUSION

This paper focused on changing levels of dust particles over Middle-East and North Africa. Using CALIOP retrievals we found increasing and decreasing trends of dust over North Africa and Middle-East respectively. The analysis was supplemented by Absorbing Aerosol trends using OMI datasets. Over North Africa mainly dominated by dust particles, absorbing aerosol levels have found to be slightly increased. However, over Middle-East, where dust as well as anthropogenic pollution form the major aerosol types, we found small increasing AAOD trends. We strongly recommend a detailed investigation of major aerosol types using different ground based, air-borne and space-borne instruments over this region.

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REFERNCES

Brunekreef, B., Holgate, S.T., 2002. Air pollution and health. *Lancet 360*, pp. 1233–1242. doi:10.1016/S0140-6736(02)11274-8.

Creamean, J.M., Suski, K.J., Rosenfeld, D., Cazorla, A., DeMott, P.J., Sullivan, R.C., White, A.B., Ralph, F.M., Minnis, P., Comstock, J.M., Tomlinson, J.M., Prather, K.A., 2013. Dust and biological aerosols from the Sahara and Asia influence precipitation in the western US. *Science 339*, pp. 1572–1578. doi:10.1126/science.1227279.

DeMott, P., Sassen, K., Poellot, M., Baumgardner, D., Rogers, D., Brooks, S., Prenni, A., Kreidenweis, S., 2003. African dust aerosols as atmospheric ice nuclei. *Geophysical Research Letters,* 30(14), pp. 1732, doi: 1710.1029/2003GL017410.

Honda, Y., Nakai, S., Ono, M., Tamura, K., Nitta, H., Ueda, K., 2014. Impact of aerosols on human health in East and Southeast Asia. *Earozoru Kenkyu,* 29, pp. 183-189, https://doi.org/10.11203/jar.29.s183.

Huneeus, N., Schulz, M., Balkanski, Y., Griesfeller, J., Kinne, S., Prospero, J., Bauer, S., Boucher, O., Chin, M., Dentener, F., Diehl, T., Easter, R., Fillmore, D., Ghan, S., Ginoux, P., Grini, A., Horowitz, L., Koch, D., Krol, M.C., Landing, W., Liu, X., Mahowald, N., Miller, R.L., Morcrette, J.J., Myhre, G., Penner, J.E., Perlwitz, J.P., Stier, P., Takemura, T., Zender, C.. 2011. Global dust model inter comparison in AeroCom phase I. *Atmospheric Chemistry and Physics,* 11, pp. 7781-7816, doi:10.5194/acp-11-7781-2011.

Hunt, W., Winker, D., Vaughan, M., et al., 2009. CALIPSO Lidar description and performance assessment, *Journal of Atmospheric and Oceanic Technology, 26*, pp. 1214–1228. http://dx.doi.org/10.1175/2009JTECHA1223.1.

Mahowald, N., Kiehl, L., 2003. Mineral aerosol and cloud interactions. *Geophysical Research Letters, 30(9),* pp. 1475, doi:10.109/2002GL016762.

Kaufman, Y. J., Koren, I., Remer, L.A., Tanre, D., Ginoux, P., Fan, S.. 2005. Dust transport and deposition observed from the Terra-Moderate Resolution Imaging Spectroradiometer (MODIS) spacecraft over the Atlantic Ocean. *Journal of Geophysical Research – Atmospheres, 110,* D10S12. http://dx.doi.org/10.1029/2003JD004436.

Mehta, M., Singh, R., Singh, A., Singh, N., Anshumali. 2016. Recent global aerosol optical depth variations and trends- A comparative study using MODIS and MISR level 3 datasets. *Remote Sensing of Environments 181,* pp. 137-150, https://dx.doi.org/10.1016/j.rse.2016.04.004.

Mehta, M., Singh, N., Anshumali. 2018. Global trends of columnar and vertically distributed properties of aerosolswith emphasis on dust, polluted dust and smoke - inferences from 10-yearlong CALIOP observations. *Remote Sensing of Environment 208,* pp. 120–132, https://doi.org/10.1016/j.rse.2018.02.017.

Tie, X., Wu, D., Brasseur, G. 2009. Lung cancer mortality and exposure to atmospheric aerosol particles in Guangzhou, China. *Atmospheric Environment 43,* pp. 2375-2377, doi:10.2016/j.atmosenv.2009.01.036.

Winker, D.M., Vaughan, M.A., Omar, A.H., Hu, Y., Powell, K.A., Liu, Z., et al., 2009. Overview of the CALIPSO mission and CALIOP data processing algorithms, *Journal of Atmospheric and Oceanic Technology,* 26, pp. 2310–2323. http://dx.doi.org/10.1175/2009JTECHA1281.1.

Winker, D.M., Tackett, J.L., Getzewich, B.J., Liu, Z., Vaughan, M.A., Rogers, R.R., 2013. The global 3-D distribution of tropospheric aerosols as characterized by CALIOP. *Atmospheric Chemistry and Physics, 13,* pp. 3345-3361, doi:10.5194/acp-13-3345-2013

Zhang, R., Ho, K., Shen, Z., 2012. The role of aerosol in climate change, the environment and human health. *Atmospheric and Ocean Science Letters, 5(2),* pp. 156-161, https://doi.org/10.1080/16742834.2012.11446983.