# Dust storm monitoring over Arabian Sea

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**ABSTRACT**

Dust Storm is a meteorological feature common in deserts. Deserts Surrounding the Arabian Sea are the major sources of the dust aerosols. Desert dust is rich in nutrients, which is beneficial for the growth of the Phytoplankton's over the Arabian Sea. This paper highlights the effect of dust storm on chlorophyll concentrations of phytoplankton, which occurred on 5 December 2010 over the Arabian Sea. Results from observation of satellite images revealed that due to dust storm of 5 December 2010 there was increase in chlorophyll concentrations of Phytoplankton's. This increase in chlorophyll concentrations was more prominent on 8 December 2010.

**Keywords:** Dust storm, Chlorophyll concentration, MODIS Ocean color data.

## 1. Introduction

Dust storms originating over the world's arid regions contribute a large fraction of aerosols in the atmosphere. Dust storm arise when strong wind blows loose sand or dirt lifted from a dry surface and transported from point of origin to another places. Deserts surrounding the Arabian Sea are the main sources of Dust Storms. The Arabian Sea is surrounded by arid and semi-arid areas which are dominant sources of atmospheric dust. The largest one Rub Al khali desert located in Saudi Arabia. Other sources are located in Afghanistan, Pakistan and north-west India.

This dust is of scientific interest because of to its ability to alter climate, reduce local visibility, cause respiratory problems in humans, and affect biogeochemical cycles in the world's oceans (Redmond et al., 2010). The oceans which cover about 70% of the earth's surface play an important role in controlling the climate on regional and global scales through their various physical and bio-geo-chemical processes. Therefore, the real-time monitoring of dust storms is essential for sustainable development, and for climate change and environmental research in the world.

Phytoplankton's are autotrophic components of the Plankton community, live in the sunlit layer of the ocean. They consume carbon dioxide ($CO_2$) and release oxygen. Phytoplankton's growth depends on the availability of CO2 sunlight, and nutrients. When all these conditions are required sufficiently Phytoplankton's can grow explosively, a phenomenon called the Bloom. Blooms in the ocean may cover 100's of square Km's and are easily visible in the satellite images.

## Study Area

The study area covering the northern part of the Arabian sea is located between latitudes 25°N and 20°N and longitudes 57°E and 68°E bordered by India, Pakistan, Iran, Somalia, Arabian Peninsula, Oman. Arabian Sea, surrounded by one of the world's major sources of dust storms (Africa, Middle East, Iran, and Afghanistan), are very important in understanding the productivity and the biogeochemical cycles of the marine ecosystem.

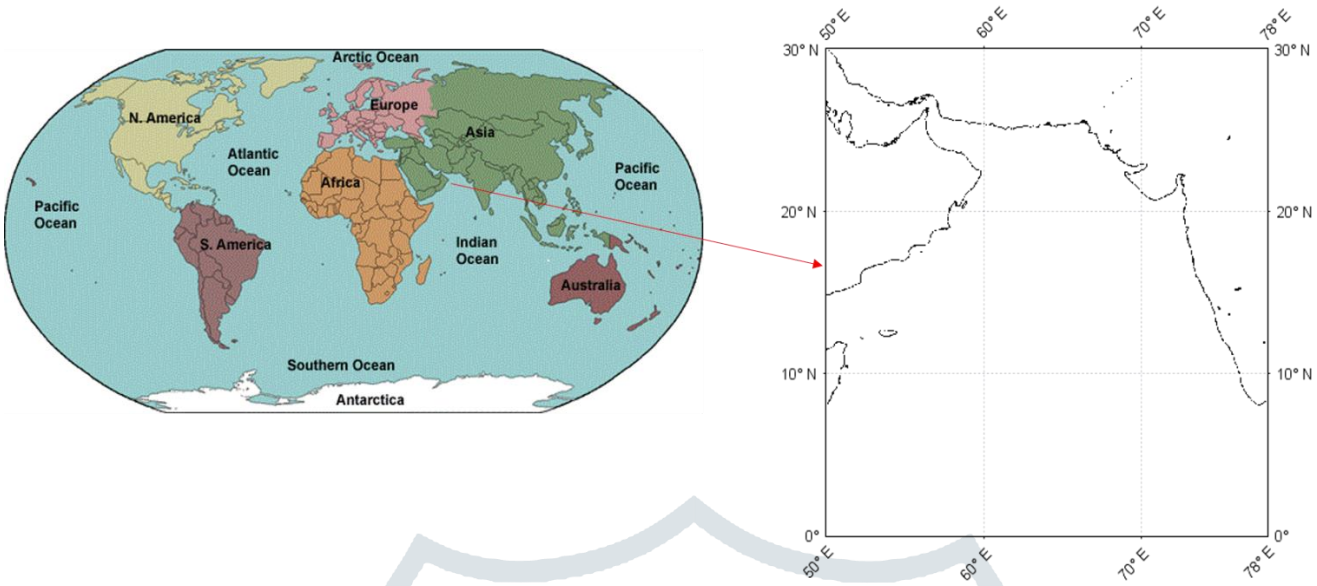


Fig 1: Study Area of the Arabian Sea.

## Materials and Methods

### Data and Methodology

The MODIS (Moderate Resolution Imaging Spectroradiometer) is a sensor on board the Terra and Aqua satellite by NASA. MODIS capture data in 36 spectral bands ranging from 0.4µm to 14.4µm wavelength at different spatial resolutions. Both Aqua and Terra image the entire Earth in every 1 to 2 days.

MODIS Aqua Level-3 daily datasets of 4 km resolution were taken to study the Chlorophyll Concentration over the Arabian Sea. These data sets were downloaded from Ocean Color website. By using SeaDAS weekly composites before and after dust storm event over the Arabian Sea were created to study the chlorophyll concentrations. MODIS Terra and Aqua true Color images were used to study the Dust storm migration from the point of origin to Arabian Sea. CALIOP Lidar backscatter data used to validate the existence of dust storm on 5 December 2010. CALIOP VFM (vertical feature mask) and aerosol sub-type used to detect the vertical extent of dust storm the Arabian Sea.

### Results and Discussions

MODIS Terra and Aqua true Color images were used to study the Dust storm migration from the point of origin to Arabian Sea. Dust storm originated on 4 December 2010 along the borders between Pakistan, Afghanistan, and Iran. Dust storm spread hundreds of kilometres across the borders between southern Afghanistan, Pakistan and Iran. One day after blowing over the borders between Pakistan, Afghanistan and Iran, a giant dust plume migrated southward. On 5 December dust storm blew over the Arabian Sea(Fig2).

After observing ocean color data in SeaDAS, it was found out that Chlorophyll Concentration increased after the Dust Storm when compared to before and during Dust Storm. Before Dust storm Chlorophyll Concentration was found to be 0.8 mg/$m^{3,}$ and after the Storm it was 13.67 mg/$m^3$ at $65^0 75^{'}$E Longitude over the Arabian Sea(Fig 2 & 3).

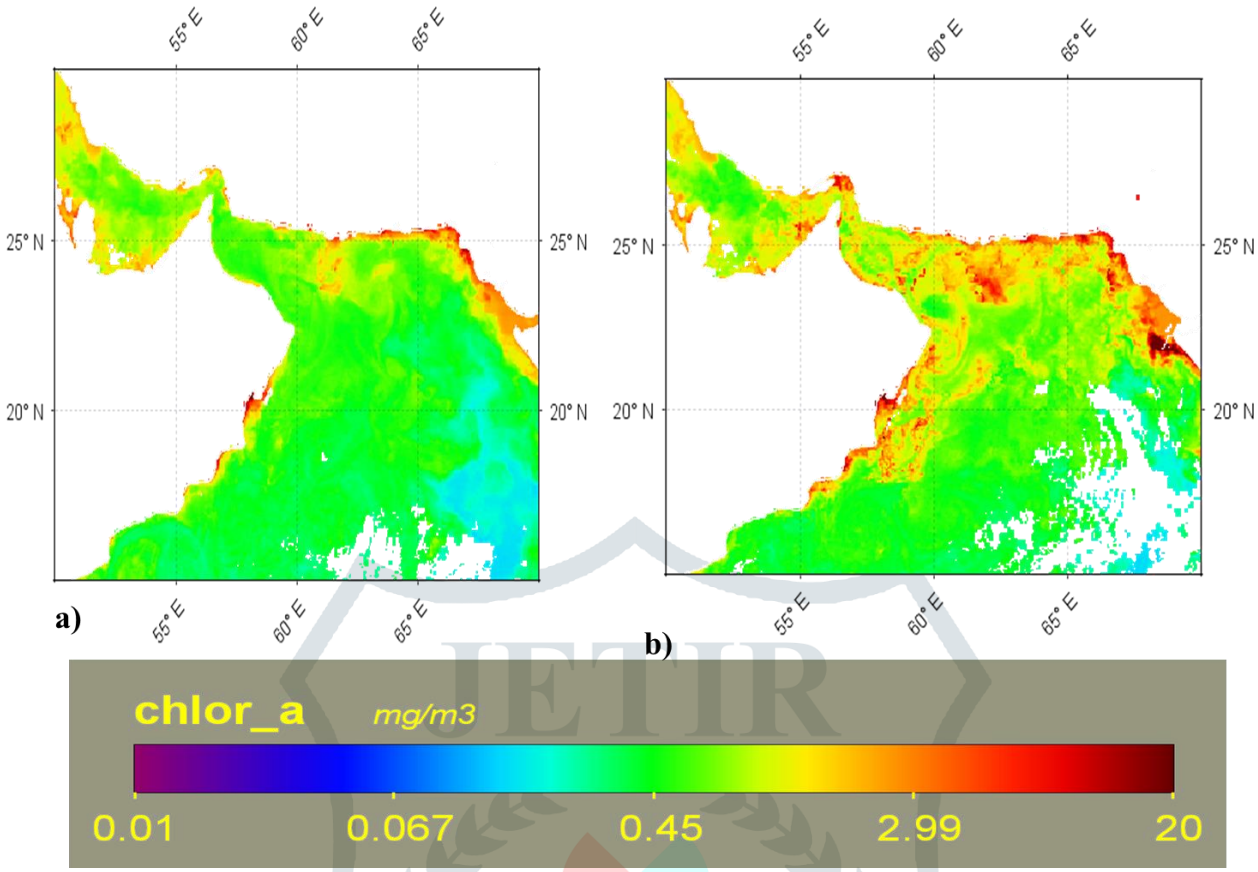


Fig 2: a) weekly composite of Chlorophyll Concentration (mg/m$^3$) before dust storm b) weekly composite of Chlorophyll Concentration (mg/m$^3$) after dust storm.

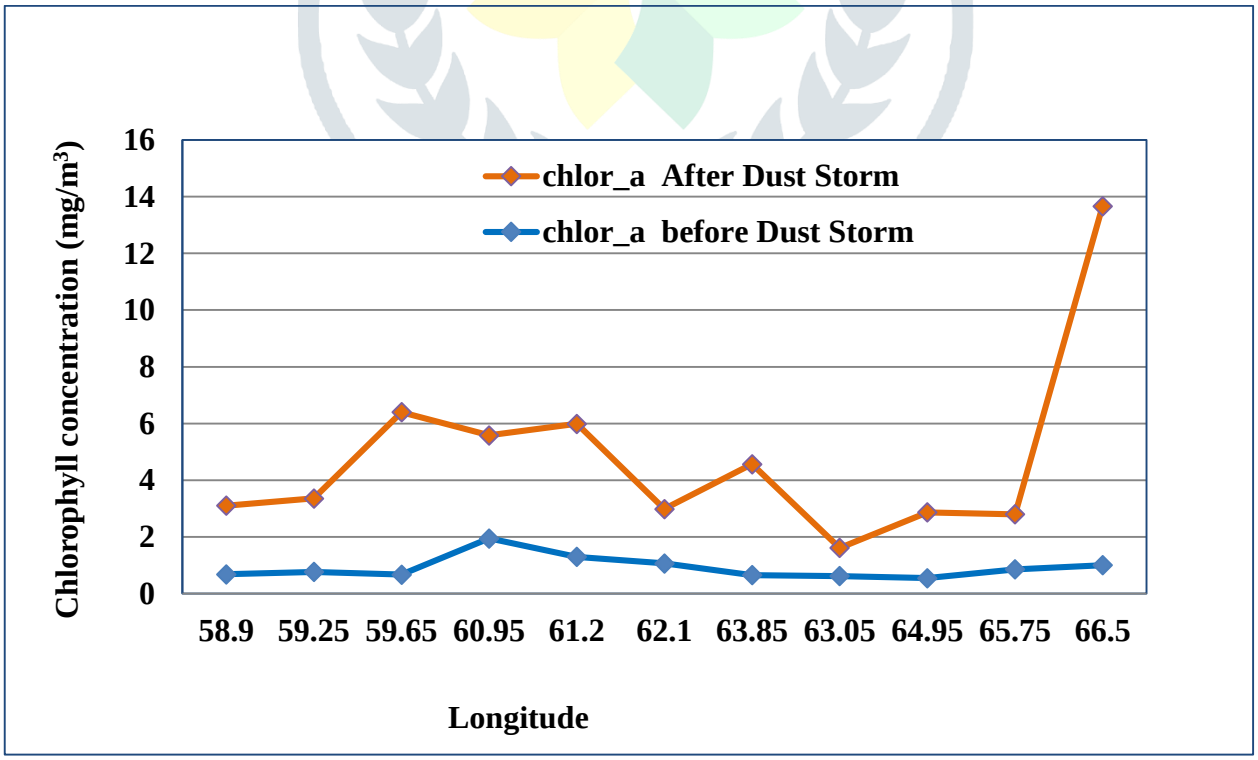


Fig 3: Graphical representation of Chlorophyll Concentration (mg/m$^3$) before and after dust storm

**Dust storm validation using CALIOP Lidar backscatter data at 532nm:**

CALIPSO (Cloud- Aerosol Lidar and Infrared Pathfinder Satellite Observations) is a satellite launched on April 2006. CALIPSO flies in the international "A-Train" Constellation for coincident Earth observations. CALIPSO comprises CALIOP Lidar (Cloud-Aerosol Lidar with Orthogonal Polarization) used to detect the vertical profiles of dust storm. Level 1 product of CALIOP data set contains total attenuated backscatter profile at 532nm.X-axis of the CALIOP data set represents the distance along the orbit track. Y-axis denotes the altitude of dust storms from 0-5 km. Clouds have high backscatter data than dust storms. So we can easily differentiate dust storms from other associates. The value of total attenuated backscatter at 532nm for clouds is in range of $6.5\times10^{-3}$ to $1\times10^{-1}$. The value of total attenuated backscatter at 532nm for dust particles are in range of $1.5\times10^{-3}$ to $2.5\times10^{-3}$. Dust storm floating at height of 2- 3 km above the ground (fig 4, 5&6).

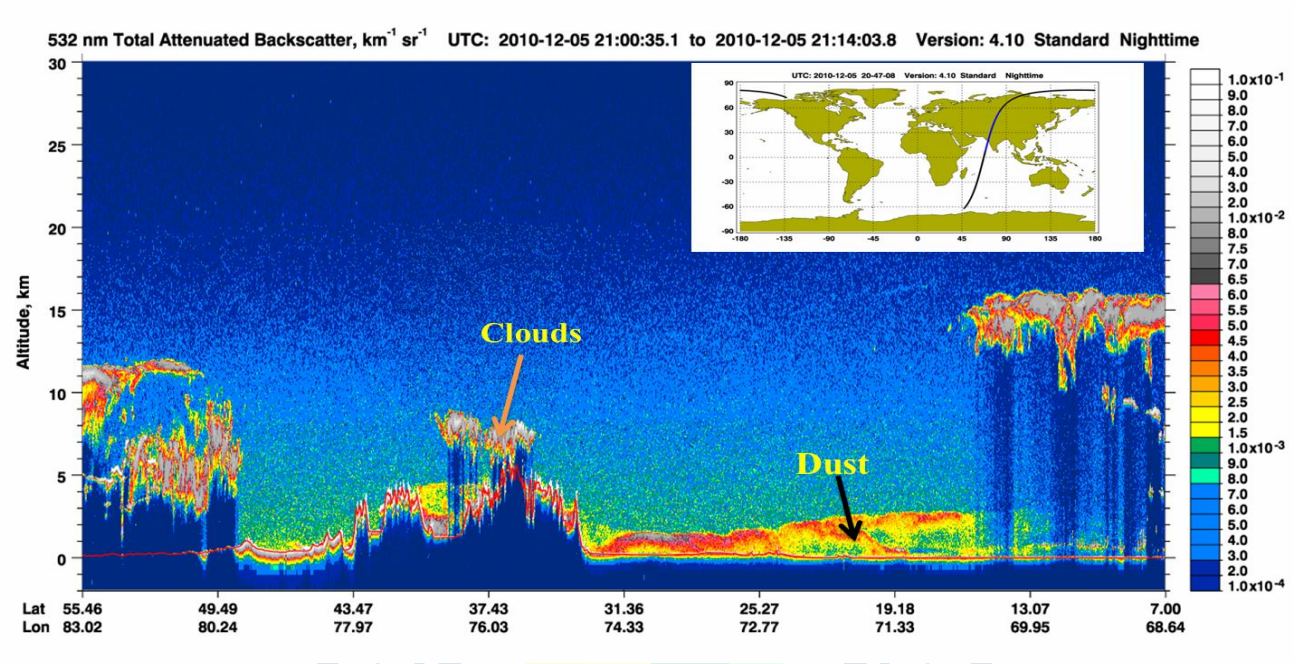


Fig 4: CALIOP Lidar backscatter data at 532nm on 5 December 2010.

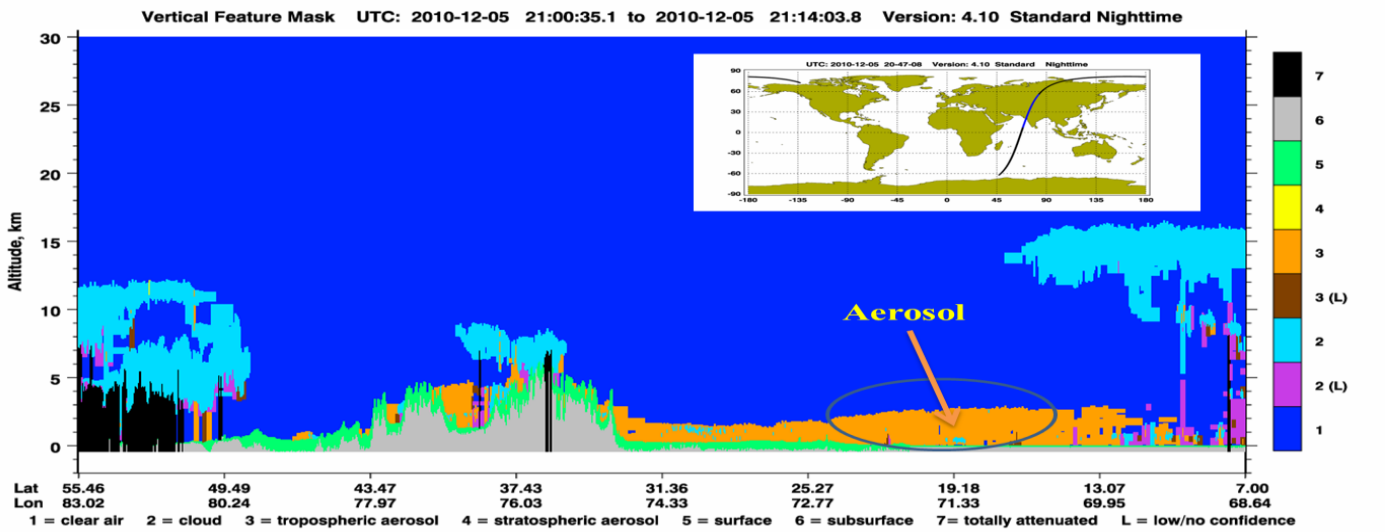


Fig 5: CALIOP Lidar VFM data on 5 December 2010.

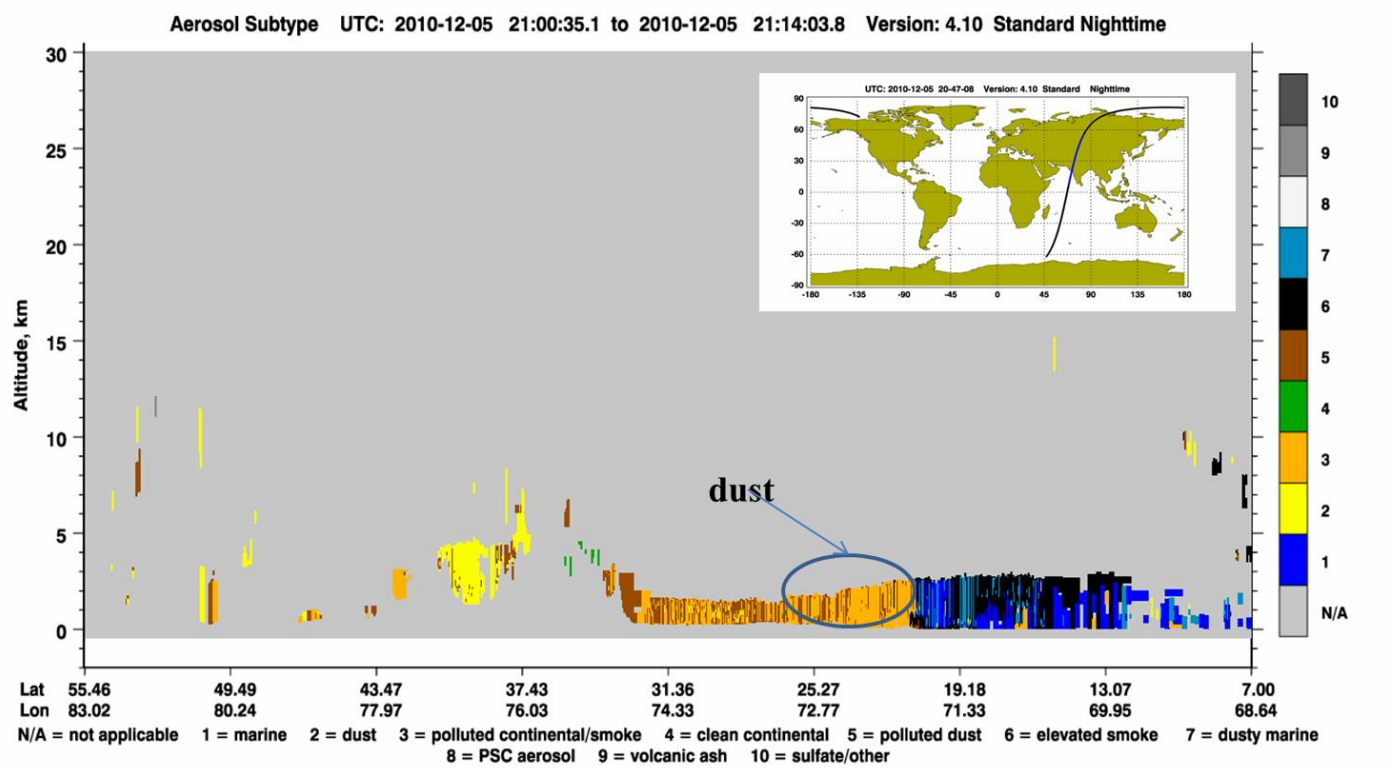


Fig 6: CALIOP Lidar Aerosol sub-type data on 5 December 2010.

**Conclusion**

Arabian Sea is found to be highly productive region during dust storm. After dust storm chlorophyll concentrations increased up to about 13.67 mg/m$^3$ at 65$^0$75'E Longitude over the Arabian Sea because of the growth of the Phytoplankton's. Phytoplankton's used nutrients from the Dust deposition, and $CO_2$ (inorganic carbon) from both Atmosphere and Ocean, and sunlight to produce organic compounds (carbon). Dust storm validated on 5 December 2010 by using CALIOP Lidar backscatter at 532nm, VFM and aerosol sub-type data.

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