REMOTE SENSING OF DUST STORMS OVER
THE INDO-GANGETIC BASIN

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Dust storms are naturally occurring events that take place in arid and semi-arid regions of the Earth, temperate, tropical and sub-tropical latitudes characterized by dry soil/sand. Arid regions around the Arabian Sea like Iran, Afghanistan, India and Pakistan usually experience a high frequency of dust storms, approximately 30 events per year. Dust storms are believed to be one of the most serious environmental hazards. In this paper, we show the usefulness of optical remote sensing data for monitoring dust storms. The Moderate Resolution Imaging Spectroradiometer (MODIS) and the Multiangle Imaging Spectro Radiometer (MISR) on board Terra/Aqua platforms can be used for the optical sensing of dust storms. The different viewing angles of MISR provide information about dust particles through their discrimination from other suspended particles. In this paper, we examine a dust event over the Indo-Gangetic basin, which occurred on June 9-10, 2003.

Occasionally dust storms can travel all the way to Asia with the seasonal summer monsoon. In the summer months, dust storms have a significant impact on the amount of solar radiation reaching the surface, producing a cooling effect that can affect as far away as North America (Liepert, 2002). The Indo-Gangetic basin experiences dust storms that take place during the pre-monsoon period. These dust storms originate in the western side in the pre-monsoon period and act as a major threat to agricultural resources and people living in the Indo-Gangetic basin. Satellite observations of dust storms utilize the behavior of the dust and haze in different parts of the electromagnetic spectrum. In the optical part of the spectrum, (e.g. used by NASA Terra/Aqua MODIS), dust particles have a very high albedo and hence appear quite bright (El-Askary et al., 2003). Solar radiation reflected by the land surface and the suspended dust cloud differs drastically in the relevant brightness. Sunlight in the visible and near infrared part of the solar spectrum is mostly reflected back into space by the dust cloud. Absorption takes place only in the blue and ultraviolet wavelengths, and the Total Ozone Mapping Spectrometer (TOMS) can be used to measure the amount of backscattered ultraviolet radiation. In the microwave frequency range (10.65 - 85.5 GHz) (sensor e.g. Tropical Rainfall Measuring Mission (TRMM)/ TRMM Microwave Imager or TMI), dust particles respond strongly to scattering and as a result the brightness temperature decreases.

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(El-Askary et al., 2003). Therefore, based on their origin, deposition, extent, speed and length of their occurrence, different dust events require the use of multi-sensor data based on their spatial, spectral, and temporal resolutions.

MODIS senses the entire Earth surface in 36 spectral bands, spanning from the visible (0.415 μm) to infrared (14.235 μm) spectrum, with spatial resolutions of 1000, 500 and 250 m, at nadir, and both land and atmospheric products can be derived with the same spatial and temporal coverage twice a day. MODIS has been used for monitoring dust storms successfully (El-Askary et al., 2000). Figure 1 shows the dust storm over India from MODIS measurements on June 10, 2003 where a large dust plume can be clearly seen. Moreover, MODIS aerosol products provide good global spatial and temporal coverage with regional dust properties.

Specially, MODIS detects ambient aerosol optical thickness over ocean and land simultaneously (Kaufman et al., 1998). The physics of remote sensing of aerosol optical thickness over a dark target can be understood using the single scattering approximation (King et al., 1999). Currently, MODIS monitors aerosol concentrations over the oceans globally and also over land regions.

MISR is the world’s first satellite sensor with multi-angle viewing capability on board Terra/Aqua. It is designed to improve our understanding of the Earth’s environment and climate, particularly of the atmosphere and land surface. It views the sunlit

![Fig. 1. Dust cloud over India-A large dust storm on June 10, 2003 is seen](http://daac.gsfc.nasa.gov/data/dataset/MODIS-Aqua/).
Earth simultaneously at nine different angles (NASA, 2003). Almost all the features on the Earth’s surface, including the clouds and suspended tiny particles floating in the atmosphere, reflect the sunlight differently when viewed from different angles (Martonchik, 1994). Therefore, multi-angle measurements can provide more information than traditional single angle remote sensing measurements, thus can enhance the fine discrimination between materials. It has been demonstrated that MISR can be used to detect large dust storms like the one over northwestern part of India (Fig. 2).

Using the new feature of MISR with different viewing angles, identification of dust storms can be greatly improved. For example, dust storm events, which are difficult to be detected by nadir viewing may be easily detected by off-nadir, angle views, because off-nadir sensors view thicker depth of the atmosphere. MISR has the potential to enhance the detection of small dust storms, thus it might be helpful in early detection of dust storms. In addition, combining the information from different angle views could be useful in discriminating between dust clouds and regular clouds. It could be beneficial in decreasing the background effects for desert regions by selecting suitable viewing angles as well.

We are currently developing useful indices by combining the spectral measurements at different viewing angles. For several storm cases available, we will relate these indices to the different intensities of dust storms. Different levels (generally level 1B2 and level 2 products) from MISR can be used to extract physical parameters for dust storms, such as optical thickness, dust particle size and its distribution, concentration, and land surface cover underneath to feed the simulation models. Such information can be provided to the public and government agencies for decision-making purposes.

Fig. 2. Different angle views of a large dust plume on June 9, 2003 over the northwestern part of India.
and also to the scientists for model simulation studies.

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References


NASA (2003), MISR, Multi-angle Imaging Spectroradiometer, http://terra.nasa.gov/About/MISR/about_misr.html