IS WINTER FOG A MENACE OR DISASTER?*

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The vast Indo-Gangetic Plains covering a large area south of the Himalayas in northern India is a zone, which is affected by dense fog and smog (smoke+fog) every year during winter, mostly in the months of December, January and February. The typical meteorological, environmental and prevailing topographic conditions and increasing pollution over the Indo-Gangetic Plains are the common factors favouring fog formation. In this study, the North Indian fog is mapped and analyzed using NOAA-AVHRR satellite data. The dissipation and migration pattern of fog in the study area is also interpreted on the basis of the analysis of both meteorological and satellite data. A classification of the fog-affected area is also performed and the more fog prone zones in the belt are identified. From GIS based analysis of different parametric surfaces derived through interpolation of meteorological and elevation data, the favourable condition for fog formation is ascertained as: air temperature between 3-13°C, relative humidity > 87%, wind speed < 2m/s and elevation < 300 m. Using these parameters forecasting is done in both forward and backward time frames with the help of GIS. The predicted fog was then verified with the observed fog depicted by the NOAA images and found a close relationship.

Among the techniques and tools capable of assisting continuous monitoring of different environmental phenomena, remote sensing and GIS is proved to be the most spectacular in effectively keeping a close view on earth's dynamic processes. Fog in northern India is one such phenomena occurring every year over the Indo-Gangetic Plains affecting normal human activities, especially driving on the roads, agriculture, aviations and also health.

Fog and Smog (smoke+fog) is observed to be frequently affecting the area in the winter months of December to February every year. The Indo-Gangetic Plain is a vast stretch of land in South Asia, spread over parts of Pakistan, India and Bangladesh and houses about one thirds of the population of South Asia. Meteorologically, fog is very low stratus cloud, which even touches the ground. The basic requirements for fog to form are moisture in the air with high relative humidity, optimum air temperature and very low wind speed.

There must also be condensation nuclei – or something onto which the water can condense. Condensation nuclei can be dust particles, aerosols, pollutants etc. When the air is saturated, additional moisture will condense onto this nucleus. Fog so often forms after sunset because that is when the air begins to cool and condensation replaces evaporation. Air cools best with clear skies as there are no clouds to trap the heat and other particulate matters floating in the atmosphere. The typical meteorological, environmental and prevailing topographic conditions and increasing pollution over the Indo-Gangetic Plains are the common factors favouring fog formation. The high concentration of aerosol content in the lower atmosphere over the study area also enhances the formation and permanence of fog. Smog, which is a toxic cocktail of ash, acids, aerosols and other particles, is damaging agriculture and rainfall patterns across the region. The lives of millions of people are at risk from drought and flooding, as rainfall patterns are radically altered, with dire implications for economic growth and

health. So along with other environmental characteristics, the study of fog also has immense socio-economic importance in Northern India.

During the past decades, fog studies using remote sensing data have proved to be one of the most popular fields of research in the scientific community. Several studies have been conducted for detection of fog and fog dissipation and forecasting using satellite data. However, in India very few studies have been done till date. The present study mainly focuses on the identification of the fog prone zones, mapping of fog, its dissipation and migration patterns and forecasting particularly over northern India.

NOAA-AVHRR multispectral images provide an excellent database for mapping and analysis of fog in Northern India. Both daytime and night time coverages provide more means for choosing these datasets for the present study. Clouds and fog can be easily differentiated in NOAA daytime false colour images. In the night time scenes infrared channels 3 and 4 are very useful for identifying the same. However, METEOSAT data are also useful for fog studies. In the present study NOAA-AVHRR data are mainly used in order to carry out the analysis and mapping of the fog-affected areas. METEOSAT-VISSR data have been utilized only for verifying the affected area in the scenes where the coverage of NOAA was poor. MODIS (Terra and Aqua) could not be used in this case owing to the poor coverage of northern India in a single scene inspite of getting high spatial resolution (250 m). In mapping and finding out the dissipation patterns and other movement patterns of fog, better coverage of the study area is more necessary than that of the spatial resolution. From all these aspects NOAA images were found to be more suitable. The orbits of NOAA are set up in such a manner that, an active pair of satellites provides coverage of almost the Earth's entire surface twice daily during morning, afternoon, early evening and night passes. The cloud-free NOAA-AVHRR images used in the present study are acquired and archived regularly by the Indian Institute of Technology Roorkee - Satellite Earth Station (IITR-SES) since October 2002.

Mapping of fog-affected area is performed for the winter months of the years 2005-06, 2006-07 and 2007-08. The areas affected by fog were about 575800 km², 594100 km² and 478000 km² respectively for the years 2005-06, 2006-07 and 2007-08. While in the years 2002-03, 2003-04 and 2004-05 the fog affected areas were found to be about 867000 km², 625000 km² and 706800 km² respectively. From the calculated area an overall decreasing trend of the total fog affected area is observed. The year 2007-08 is found to be the least fog affected year. Less fog in 2007-08 may be the consequence of high fluctuations in the meteorological parameters like temperature, relative humidity etc.

The processes of fog formation and dissipation are controlled by a complex combination of meteorological processes and no single process dominates. Air temperature, relative humidity, wind speed and elevation are the parameters having critical importance in this process. In the present study all fog occurrences over Northern India during 2002-2008 were studied with the help of NOAA-AVHRR satellite images. After mapping the fog zones for these years an interesting decreasing trend in affected area was obtained. Remarkable decrease in fog occurrence in the year 2007-2008 is found to be attributed to high temperature fluctuation and non-uniform wind speed as well as the humidity. Although high fluctuations in meteorological parameters may be one of the reasons for this yet, more studies are required to understand and explain such trends. The forecasting model developed on the basis of analysis of satellite data as well as meteorological data gives sufficiently promising results. The predicted fog was found to be in close match while comparing with that of fog occurrence as depicted on satellite images. Based on the above study it has now become possible to make forecasting of fog occurrence during winter periods, if all required meteorological parameters are available at least one day before and satellite data analysis can be performed in near real time. However, for more accurate forecasts a thorough diagnostic study is still going on.

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