Long-term memory of atmospheric aerosols over India

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Abstract

Long-term memory of atmospheric variables is a least understood facet in atmospheric science. The temporal and spatial distribution of atmospheric aerosols depends largely on the atmospheric parameters. Time series analysis using a stochastic model reveals that atmospheric aerosols over India exhibit a long-term memory. Our analysis confirms that by using Autoregressive Integrated Moving Average (ARIMA) model we can parsimoniously model the aerosol optical depth (AOD) over the Indian region with a reasonably good accuracy. This major advantage of this method is that by using past observations from MISR level 3 datasets, forecasts were generated for next 3 years. The AOD forecasts thus generated shows a good fit with the observations. This is due to the long memory of atmospheric aerosols over the region, which is evident from the temporal dependence between successive observations.

Introduction

Atmospheric aerosols are vital for the initial formation of clouds whose temporal and spatial distribution is concomitant with the changes in atmospheric variables. Recent studies has shown that atmospheric aerosols are capable cooling the upper troposphere thereby inducing a negative feedback on the prevailing upper tropospheric winds (eg. Jetstreams). This can cause a change in the progress and the outcome of the south-west monsoon. Though it is of great importance in atmospheric science, no studies has been done on the long term persistence of aerosols. Since aerosol concentrations and cloud cover are closed tied (Albrecht, 1989), the inhomogeneity in cloud cover and aerosol content has to be taken into account when parameterizing cloud-aerosol-radiation interactions in climate models (Varotsos et al., 2006). In a recent work, Abish and Mohanakumar (2013a) had shown that aerosol transport and distribution over the Indian subcontinent is dependent on the strength of the zonal winds at 700 hPa. Therefore, the aerosol concentration over India exhibits a definite pattern, which shows a progressive enhancement during the summer season and declines during monsoon season .

Objective

Using ARIMA model Abish and Mohanakumar (2013b) predicted the AOD for June 2011 to December 2011. The predictions were later found to hold a good fit with the observed data. So, to verify the consistency of the model and memory of the atmospheric aerosols, the forecasts were extended to further 24 months using the same ARIMA $(0,1,1)(2,0,2)_{12}$ model. The forecasts were made for the Indo-Gangetic Plain (IGP), a meteorologically sensitive region due to the presence of Inter Tropical Convergence Zone (ITCZ) and monsoon trough during the Indian summer monsoon season (Fig 1).

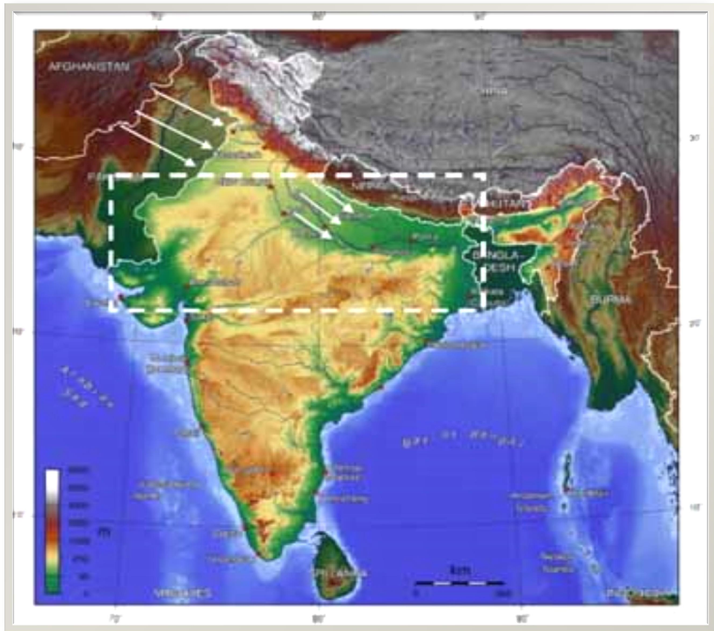
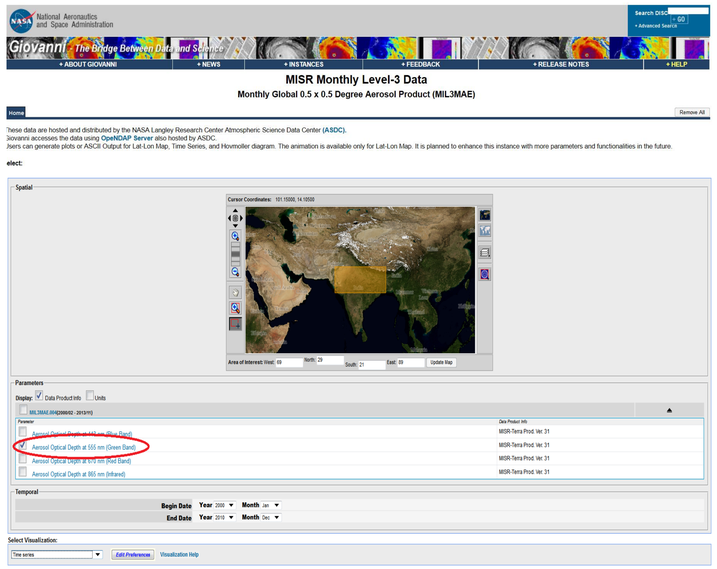


Fig 1. The rectangular box indicates the study region

Data

Monthly mean AOD MISR data for the years 2000 to 2010 is used for the work. AOD data retrieved from MISR level 3 datasets has a high-resolution ($0.5^{\circ}\times0.5^{\circ}$) at 555 nm. The superior quality of the aerosol optical properties and continuous database of aerosol products makes MISR data highly reliable over a variety of terrains.



Results

Using the data available till 2010, the chosen ARIMA model ARIMA $(0,1,1)(2,0,2)_{12}$ model was able to generate the AOD with reasonable accuracy for the next three years also (Fig 2).

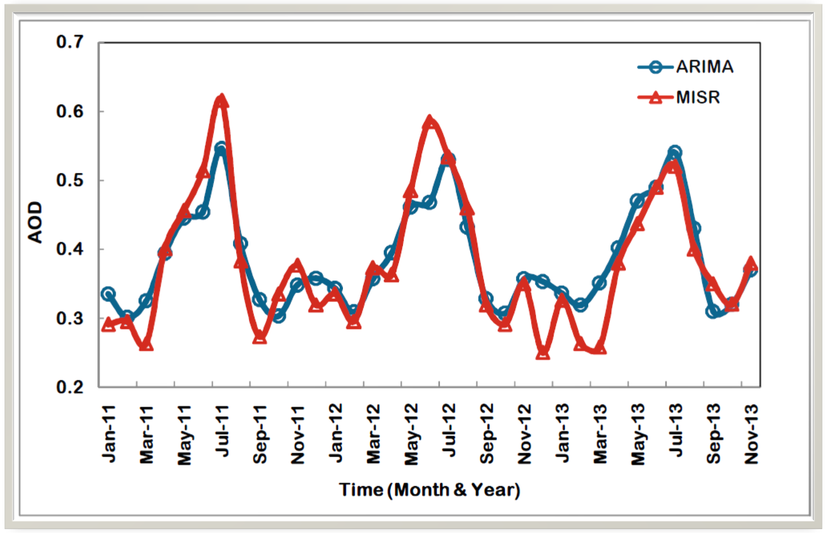


Fig 2. Time series plot showing the comparison between MISR observed data and ARIMA model

This indicates that the successive AOD observations are statistically dependent and their correlation decays very slowly. This long-term memory of the AOD shows that some properties of the AOD in the past continues to remain in the future. Time series analysis makes use of such dependencies to predict the AOD. This property of AOD can be make use in climate modeling studies where AOD is one of the input parameters.

References

Abish and Mohanakumar 2013a: Absorbing Aerosol Variability over the Indian Subcontinent and its Increasing Dependence on ENSO, Global and Planetary Change Doi: 10.1016/j.gloplacha.2013.02.007

Abish and Mohanakumar 2013b: A stochastic model for predicting aerosol optical depth over the north Indian region, International Journal of Remote Sensing, 34, 1449-1458.

Albrecht, B. A.: Aerosols, cloud microphysics, and fractional cloudiness, Science, 245, 1227–1230, 1989

Varotsos et al.2006: Long-range persistence in global Aerosol Index dynamics, International Journal of Remote Sensing, 27:16, 3593-3603