Aerosol Optical Depth Variation over European Region during the Last Fourteen Years

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Abstract- AOD is the single most catholic variable to remotely determine the aerosol burden in the atmosphere. AOD in European region has halted in the past few decades due to control in biomass emissions. In this study, European region is divided into four sub-regions i.e. North Europe, South Europe, East Europe and West Europe. This document presents the temporal study of AOD in European region carried out using Level-3 monthly data from the two satellite sensors i.e. MODIS (Moderate-Resolution Imaging Spectrometer) and MISR (Multi-angle Imaging Spectrometer) for last fourteen years. The current work discusses both annual and seasonal variation along with percentage change in AOD.

Keywords- Aerosol, Aerosol optical depth (AOD), MODIS, MISR, Europe

I. INTRODUCTION

Europe is the world's second-smallest continent by surface area, covering about 2% of the Earth's surface and about 6.8% of its land area. Europe is home to world's fifty countries, and is the third-most populous continent after Asia and Africa, with about 11% of the world's total population. In Europe, emissions of many air pollutants have decreased substantially over the past decades, resulting in improved air quality across the region. However, air pollutant concentrations are still too high, and air quality problems persist. This study focuses on Europe which is influenced by emissions from the densely populated surroundings.

Aerosols are the microscopic particle suspended in the Earth's atmosphere, when these particles become sufficiently large their presence can be noticed as they scatter and absorb light. These particles have their origin mainly in terms of two sources, either by anthropogenic activities (man-made activities) or by natural phenomenon. The anthropogenic aerosols (organic particles, black carbon etc) can be controlled and monitored easily whereas the natural sources (soil dust, sea salt, volcanic dust) are hard to control and monitor. Aerosols interact both directly and indirectly with the Earth's radiation resulting in climate change. As a direct effect the aerosols scatter sunlight directly back into the space, whereas an indirect effect the aerosols in the lower atmosphere modify the size of the cloud particle thus affecting the climate change. Aerosols not only effects climatic change but also have adverse effects on human health. AOD (Aerosol Optical Depth) is the measure of aerosols distributed within a column of air from the instrument (Earth's surface) to the top of the atmosphere. Satellite remote sensing of aerosols plays significant role in characterizing and analyzing aerosols locally, regionally and globally, which is the main requirement to estimate the nature and impact of aerosols. In the last two decades, many airbrone (aircraft, balloons) and spacebrone (satellite, space shuttle) remote sensing systems have been employed for studying the Earth's atmosphere and surface. Presently our knowledge about the aerosol variation in Earth's atmosphere has increased by the availability of the several satellite sensors like MODIS, MISR, OMI, POLDER, CALIPSO, AVHRR, TOMS etc. [1].This paper presents the seasonal and annual variation of AOD over European region calculated over the period of 2001-2014 as seen by two sensors of NASA, i.e. MODIS and MISR.

Several ground-based instruments together with satellite data are used for measuring the total aerosol optical depth over a particular location. The measurement thus obtained provides precise information about the aerosol loadings. For instance, some of the studies reported that aerosol optical depth over the European region has shown a decrease during last two decade[2,3]. The other study shows the modeled AOD is overall acceptable over land in northern Europe, but is quite low over ocean due to low sea salt emission during 2004-2012 [4]. Yet another study displays the positive higher values over central Europe during the midweek, while a strong negative higher values during the weekend over the north-eastern Europe [5] .Other study carried out in 2003 presents a comparison for Europe of spatio-temporal variations with those of aerosol optical thickness (AOT) measured by the MODIS satellite instrument [6]. In one of the studies AOD for relatively clean areas is around 0.1 while in strong industrialized areas the AOD can be 0.5 or higher[7]. In European region the high AOD values hinted in cloud contamination [8].

In this study European region is divided into four sub regions i.e. North Europe, South Europe, East Europe, and West Europe. North European region comprising of Sweden, Norway, Denmark etc. South European region consists of countries like Austria, Italy, Spain and Turkey. East European sub-region comprising of Russian Federation commonly known as Russia, is a transcontinental country extending over much of northern Eurasia (Asia and Europe), located in Eastern Europe and Northern Asia. It has the world's ninth-largest population, whereas West European sub region consists of nations like Ireland, and United Kingdom (Figure 1).

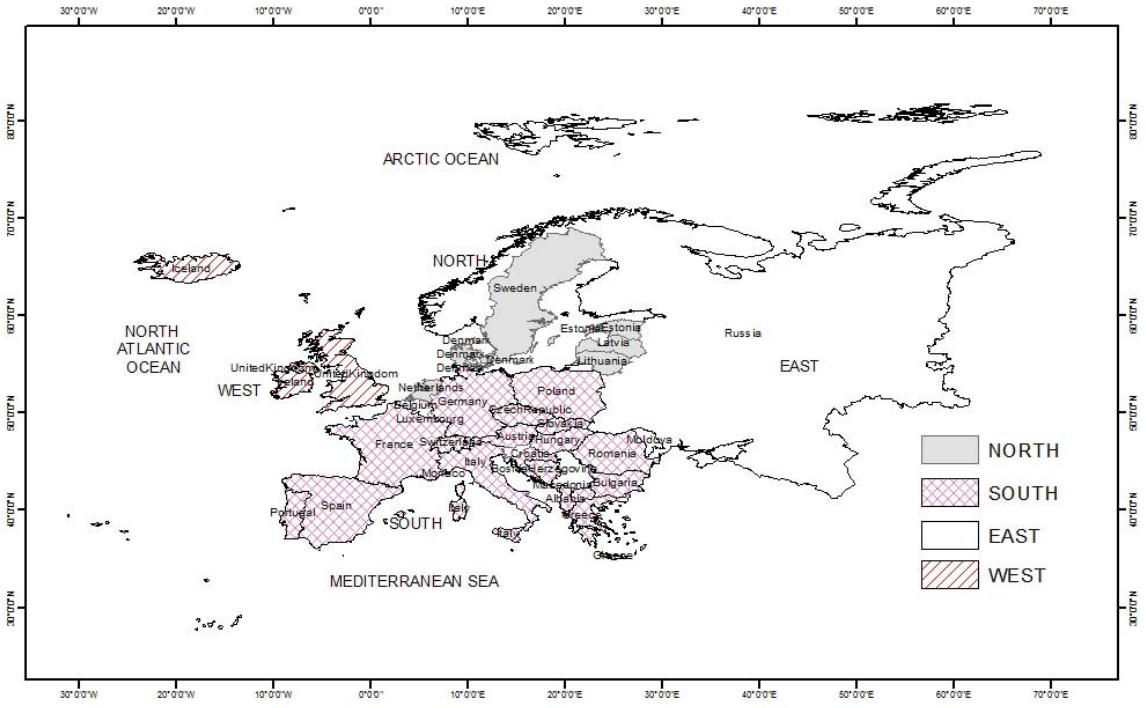

Figure1 Study area, divided into four sub-regions

Aerosol monitoring from satellite data provides the opportunity to quickly and precisely overview polluted areas. In the study, Level 3 monthly datasets i.e. MOD_08_M3 at 1º×1º and MISR_AM1_CGAS at 0.5º×0.5º are used. MODIS (MODerate Imaging Spectroradiometer) is a sensor which has 36 channels, spectral range from 0.41µm to 14.235 µm with spatial resolutions between 250m and 1km [9]. The swath of the sensor is 2330 km. MODIS aerosol retrieval algorithm uses look-up table (LUT) approach with a predefined set of aerosol loadings and geometry [10]. MISR is a scientific instrument which consists of 9 digital cameras in 4 different spectral channels, one nadir and four backward looking (70.5º, 60.0º, 45.6º, 26.1º and 0º) and has four spectral channels i.e. blue, green, red and near-infrared [11]. Its global coverage time is every 9 days with repeated coverage between 2 and 9 days depending on the latitude.

Figures 2 and 3 show the annual and seasonal variations and relative change in AOD over the European region. Northern Europe receives low aerosol loading whereas high loading is spotted at France and south Germany. Moderate aerosol optical depths are observed in other parts of Russian region and West Europe.

In winter and post-monsoon seasons, aerosol loadings are lower as compared to the other two seasons i.e. pre-monsoon and monsoon respectively. In south Germany, Poland and Austria, however, aerosol loadings remain high as compared to the other two regions. Both MODIS and MISR record increasing aerosol tendencies in monsoon and pre-monsoon seasons in parts of middle-east Europe, which is an indicative of increasing anthropogenic activities in these regions. In pre-monsoon and monsoon seasons, MISR records high aerosol optical depth values in middle European main land. The tendencies of aerosol optical depth are found to be decreasing in most of the parts of Russia during this period which could be linked to decreasing biomass burning events.

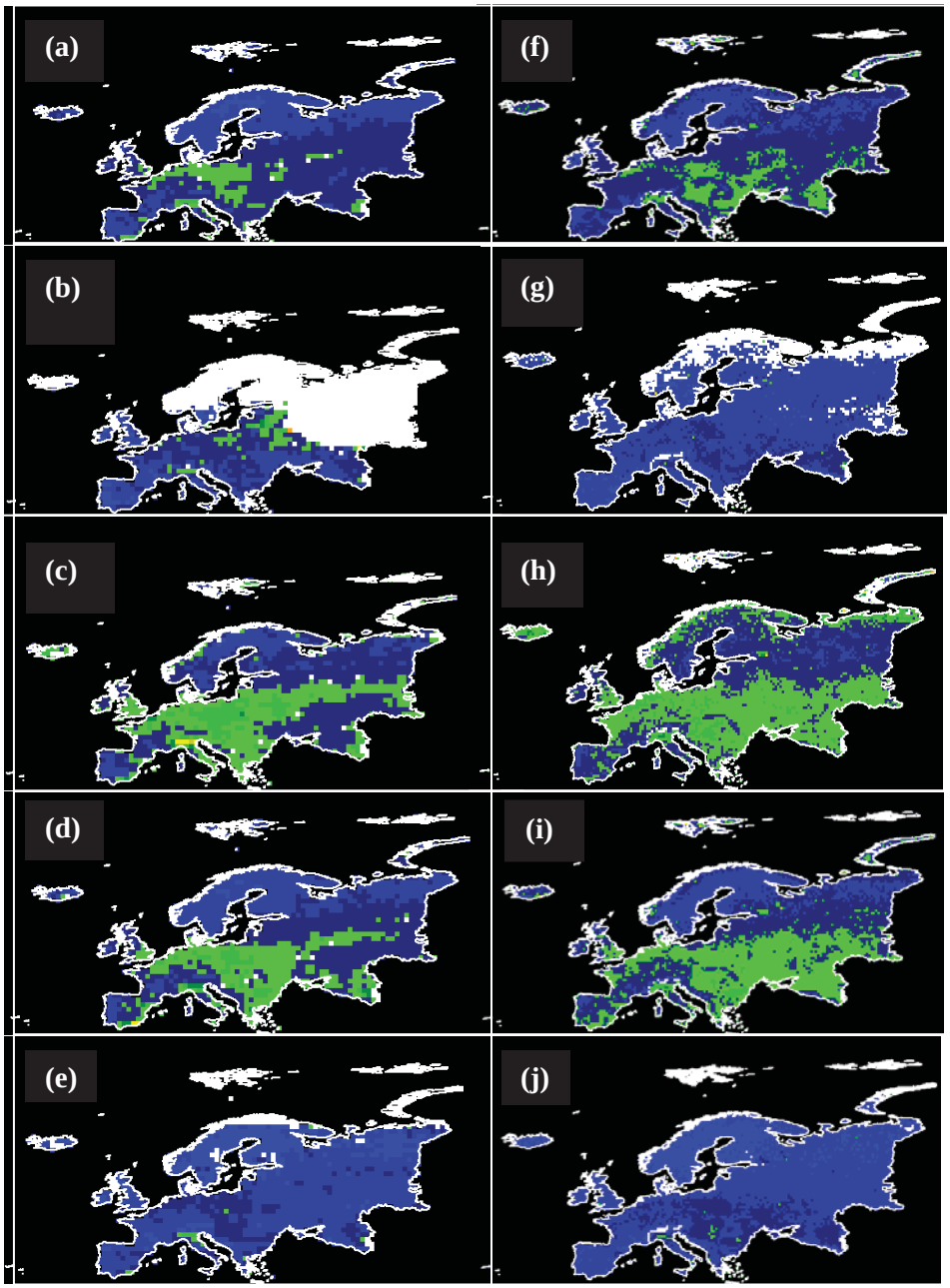

Figure 2 AOD annual and seasonal variations;

MODIS: (a) Annual (b) Winter (c) Pre-Monsoon (d) Monsoon (e) Post-Monsoon

MISR: (f) Annual (g) Winter (h) Pre-Monsoon (i) Monsoon (j) Post-Monsoon

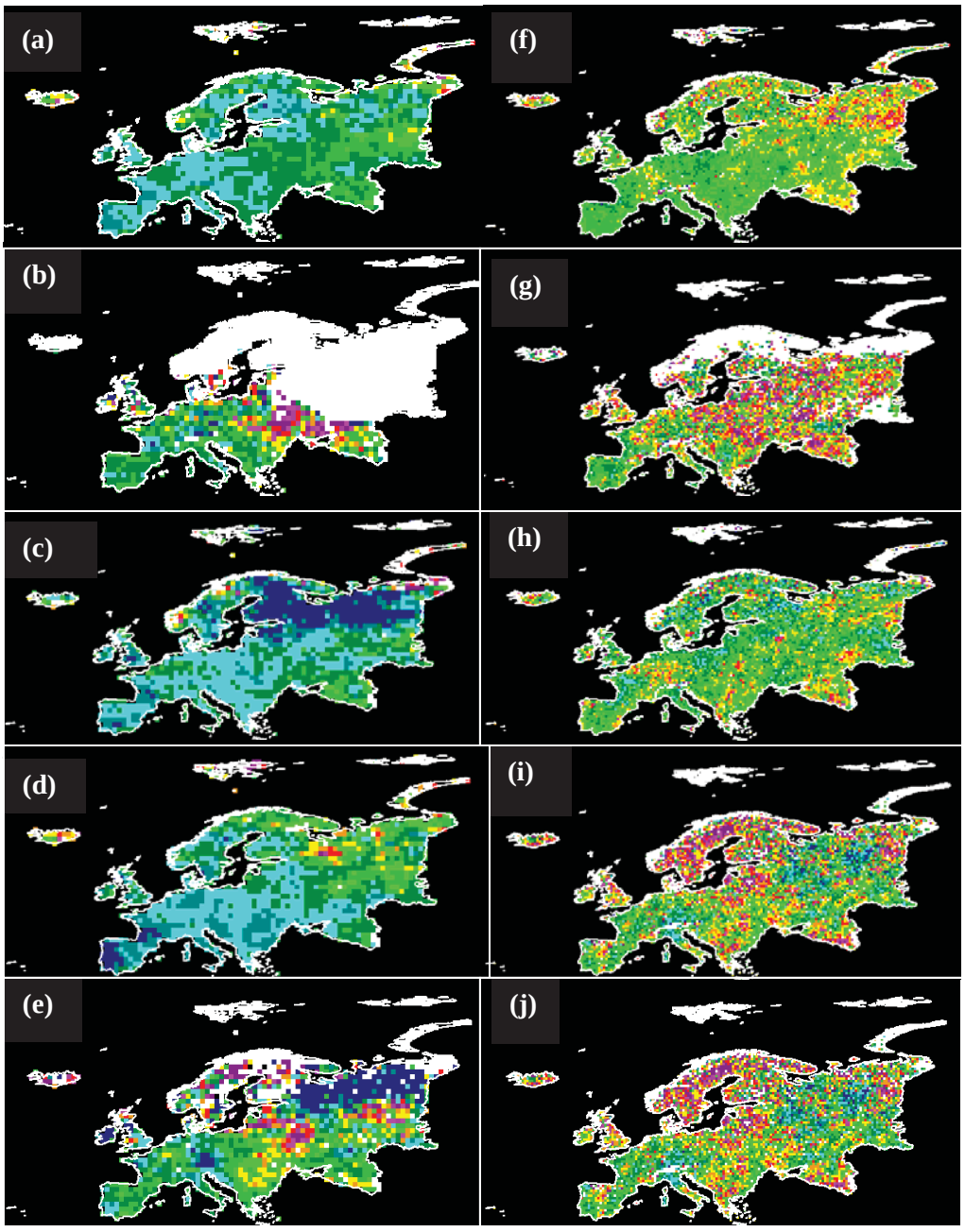

Figure 3 AOD percentage relative variations;

MODIS : (a) Annual (b) Winter (c) Pre-Monsoon (d) Monsoon (e) Post-Monsoon

MISR: (f) Annual (g) Winter (h) Pre-Monsoon (i) Monsoon (j) Post-Monsoon

The study presents annual and seasonal variation of aerosol optical depth over European region during the last fourteen years using data from two different satellite sensors. The aerosol retrieval methods used by MODIS and MISR are based on look-up table approach, but are based on different algorithms. It can be noted that when MODIS fails to retrieve the data in East European region in winter season, MISR provides the same at higher spatial resolution. Though there are places of disagreements in case of relative changes, the overall annual and seasonal variation reported by both the sensors match quite well. This work can be extended by considering other aerosol properties e.g. single scattering albedo, angstrom exponent, absorbing index etc. Such studies are crucial to estimate quantitatively the spatial distribution of aerosols over a longer period of time in addition to in situ observations specific over particular locations.

ACKNOWLEDGEMENT

The authors are thankful to Director, Meerut Institute of Engineering and Technology, Meerut for his support and guidance. Authors are also grateful to Director, Indian Institute of Remote Sensing, Dehradun for allowing them to carry out the research work at the institute. The authors sincerely appreciate the MODIS and MISR team for providing the data that is used in the analysis.

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