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MEASUREMENTS OF ATMOSPHERIC AEROSOLS, DATA ANALYSIS AND REMOTE SENSING

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Abstract : **Cloud, remote sensing of tropospheric aerosol properties and quantitative understanding,dynamical processes remain at the core of uncertainties about atmospheric aspects of climate and it continue to be the subject of detailed research. The intent of this paper is to describe scattering and absorption by aerosols and review the various national and international satellite sensors with respect to earth atmosphere ocean system. It enable the remote sensing of tropospheric aerosols and provides an easy path from theory to practical algorithms in Aerosol Remote Sensing. The various aerosol types and contribution to the Aerosol Optical Thickness (AOT) or Aerosol optical depth (AOD), reflectance from each mode, effective radius for different regions which are estimated by a global aerosol models with different graphs and Pie charts from existing aerosol sensor network. These graphs provide a fairly accurate spatio-temporal distribution. Laboratory measurements of the aerosol are significant in an idealized environment in order to look at the properties and behavior of the aerosol in isolation. Study also attempt to determine measurable procedures of elemental mass in individual cloud droplets. Furthermore, this will be a key practice for understanding the rainout mechanisms of pollutants and optical properties of clouds. Reviewed recent results in Aerosol Remote Sensing inspire for further research in aerosol imaging.**

IndexTerms - ***Aerosol, Remote Sensing, AOD, remote sensor network.***

I. INTRODUCTION

Aerosols, the small, suspended liquid and solid particles in the atmosphere. They are important components of Earth's climate system and have been an integral part of the atmosphere, and they play an important role in a wide range of weather and climate phenomena which determines the concentration gradients on local, regional, and global scales. Among their many roles, they force the global energy budget [1]. Tropospheric aerosols are important geophysical parameters of the earth–atmosphere–ocean system, affecting climate through important primary mechanisms. Atmospheric aerosols are suspensions of liquid, solid, or mixed particles with highly variable chemical composition and size distribution .Their variability is due to the numerous sources and varying formation mechanisms. The interaction processes between atmospheric aerosols and the downwelling and upwelling radiation fluxes of solar and terrestrial radiation, at the surface play a most important role in defining the radiation budget of our planet and, hence earth's energy balance ,hydrological cycle [2,3]. Furthermore, the Intergovernmental Panel on Climate Change (*IPCC*) was created to provide reports which indicates the aerosol cooling effect and warming from greenhouse gas increase.

There are many satellite sensors are able to retrieve information about cloud, atmospheric aerosols. The ground networks and other suborbital instruments has advanced the observations of aerosol properties on both local and global scales and systematically using remote sensing techniques to measure and derive aerosol products . these products are freely available to the public [39]. Diseases can also spread by means of small droplets in the breath, also called aerosols (or sometimes bioaerosols) and they also perturb the hydrological cycle and in large concentrations are detrimental to human health [4,5]. Recent advancements in the field of sensors and refinements in remote sensing algorithms for particle size distribution measurements are based on electrical mobility determination. Available instruments for particle size measurement include an electrical aerosol spectrometer (EAS), bipolar charge aerosol classifier (BCAC), an engine exhaust particle sizer (EEPS), fast aerosol spectrometer (FAS) differential mobility spectrometer (DMS), and CMU electrical mobility spectrometer (EMS), scanning mobility particle sizer (SMPS)[6,7,8]. Measurements of aerosol physical and optical properties, including the aerosol optical depth (AOD) ,aerosol extinction coefficient (AEC), and single scattering albedo (SSA), provide information for a better understanding of the role of aerosols in atmospheric processes. Various measurements , data analysis methodologies such as light detection and ranging (LIDAR) are discussed in [34]. Fig.1 shows the general components of an integrated aerosol climate research program

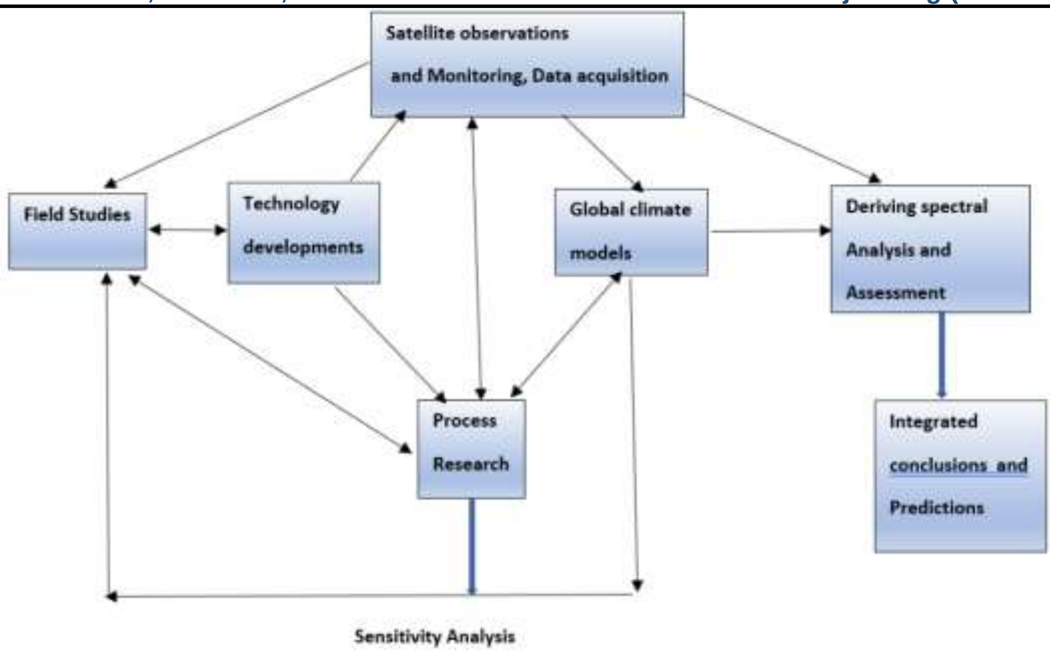

Fig. 1 General components of an integrated aerosol climate research.

It has unified in a multidisciplinary way. This common platform is essential to investigate the role of aerosol on climate and air quality.

Section II gives information and understanding of the basics of aerosols and composition of aerosols. To understand the sensitivities and limitations of aerosol sensor products, one must return to the basics of the physics and begin from first principles. Hence section III will focus on the background of scattering and absorption by aerosols. section IV focus on the Aerosol size distribution concentration measurement. Systematic research analysis and measurements produces accurate quantitative calculation of aerosol radiative forcing Section V gives idea of the satellite based measurements and Ground-based measurements. It also provide accurate spatio-temporal distribution or wide spatial coverage, and study of retrieval algorithms for sensors which are based on rigorous remote sensing theory.

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II. SOURCE AND COMPOSITION OF THE AEROSOLS

Aerosol types

Aerosols are ubiquitous specks of matter and they can be found in the air over oceans, mountains, forests, deserts, ice, and every ecosystem in between. Depending on their sources, aerosols appear in different sizes and have different physical and chemical properties. The coarse aerosols have short atmospheric lifetimes, typically only a few days .Aerosols play a significant role in the Earth's climate system and are a major contributor to air pollution. They are originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Key aerosol groups include sulphates, organic carbon, black carbon, nitrates, mineral dust and sea salt. Aerosol particles are either emitted directly to the atmosphere are treated as primary aerosols or produced in the atmosphere from precursor gases known as secondary aerosols [9]. Concentrations of Polluted air is more compared to concentrations of water-soluble particles. So pollution-rich clouds tend to have more plentiful, but smaller, droplets. Factories and power plants which produces aerosol particles ,pollute the clouds and retain their water. This phenomena will not produce rain. Inorganic and organic components are the main constitutes of primary aerosols. Inorganic primary aerosols are comparatively larger than 1 μm. Aerosol particles lager than 1 μm formed by sea salt and windblown dust. About 90 percent of the bulk aerosols from volcanoes, eject huge columns of ash into the air, as well as sulphur dioxide and other gases. Combustion processes, biomass burning, and plant/microbial materials are sources of carbonaceous aerosols. They also include both Organic Carbon (OC) and solid Black Carbon (BC). Fossil fuels such as gasoline, oil, and coal are also the main sources. Aerosols can influence climate by scattering light and changing Earth's reflectivity and they alter the climate via clouds. But precipitation elements like rain droplets, snowflakes, and ice crystals are not classified as aerosols. . Primary BC and OC containing aerosols are normally smaller than 1 μm.

Secondary aerosol particles are produced in the atmosphere from precursor gases. Magnitude of cooling depends on size and composition of aerosol particles. Reflective properties of unerlying surface also an important parameter in cooling. A significant fraction of the mass of secondary aerosols is formed through cloud processing [10,11,12,13] . Secondary aerosols are small. Their size varies from a few nanometres up to 1 μm.

TABLE 1.Model-based estimate of sulphate production (secondary aerosol sources (in Tg substance/yr))[13] .

	Northern Hemisphere	Southern Hemisphere	Global	Low	High
Sulphate (as NH_4HSO_4)	145	55	200	107	374
Anthropogenic	106	15	122	69	214
Biogenic	25	32	57	28	118
Volcanic	14	7	21	9	48
Nitrate (as NO_3^-)[b]					
Anthropogenic	12.4	1.8	14.2	9.6	19.2
Natural	2.2	1.7	3.9	1.9	7.6
Organic compounds					
Anthropogenic	0.15	0.45	0.6	0.3	1.8
VOC					
Biogenic VOC	8.2	7.4	16	8	40

Also they can have lifetimes of days to weeks. Secondary aerosol consists of mixtures of compounds and the main components are sulphate, nitrate, and OC. Occasionally volcanic eruptions result in huge amounts of primary and secondary aerosols both at the ground and in the stratosphere . Depending on the season and weather conditions, surges of aerosols can make their way into the atmosphere almost everywhere on earth. Particles may grow by uptake of water, a process that depends on chemical composition, particle size, and ambient relative humidity. Different aerosols scatter or absorb sunlight to varying degrees, depending on their physical properties. They have a direct radiative forcing because they both scatter and absorb solar and IR radiation in the atmosphere. Climatologists describe these scattering and absorbing properties as the "direct effect" of aerosols on Earth's radiation field. Salt particles tend to reflect all the sunlight they encounter. Dark aerosols dramatically change the reflectivity of the Earth's surface when they land on snow.

Despite considerable advances in recent decades, significant gaps still remain in our knowledge of aerosols and their impacts on our planet and human health. The air pollution is harmful to the environment and human health, notably as the particulate matter (PM) in the fraction PM2.5(*Particulate matter* is the sum of all solid and liquid *particles* suspended in air). This fraction refers to particle sizes less than 2.5 μm in aerodynamic diameters

Sources and compositions

The composition, numerous sources and large range in size distributions of aerosols impact in the atmosphere. Aerosols are liquid or solid particles and have a direct radiative forcing. Both particle growth and the mixing of different particle types impact the climate effect of aerosols. Knowledge of the chemical compositions of cloud condensation nuclei (CCN) particles and of the gaseous materials dissolved into droplets is essential. The most important atmospheric sulphur gases are sulphur dioxide (SO_2), hydrogen sulphide (H_2S), dimethyl sulphide CH_3SCH_3, carbonyl sulphide (COS), and carbon disulphide (CS_2). Among them, COS, H_2S and dimethyl sulphide CH_3SCH_3 are reduced sulphur gases of biogenic origin which are most important in the formation of sulphate aerosols. H_2S is produced by sulphate-reducing bacteria. It is mainly emitted from sediments and swamps. Dimethyl sulphide CH_3SCH_3 is emitted from marine phytoplankton together with dimethyl disulphide and is then oxidized to SO_2 and sulphate aerosols to SO2. COS is released in much smaller amounts from the biosphere but they remain in the atmosphere during much longer lifetimes of 44 years on average. The principal natural sources of SO_2 are the oxidation processes of dimethyl sulphide and H_2S. Volcanoes, biomass burning, and forest fires are also natural sources of tropospheric SO_2, although the strongest source of SO_2 all over the world is fossil fuel combustion, estimated to yield an annual average global flux Φe =75Tg(S) per year of sulphur, against Φe =10Tg(S) per year of volcanic sulphur, and Φe =3Tg(S) per year of sulphur from biomass burning. The estimates of atmospheric content of sulphur compounds (H_2S, SO_4 , SO_2, CS_2, COS) are given together with those of the emission and removal annual global fluxes from the principal sources and sinks of sulphur-containing species. Principal sources and sinks of sulfur-containing species on a global scale, defining the sulfur reservoirs of the surface–troposphere system where continents contain 2 × 1010 Tg(S) and oceans 1.6 × 109 Tg(S) (being 1 Tg=106 t)[14] .

Nitrogen molecules (N2) constitute more than 99.99% of the nitrogen present in the atmosphere and have an overall atmospheric content of 2 × 109 Tg(N). Ammonium (NH3), for example, is the only basic gas in the atmosphere responsible for neutralizing acids produced by the oxidation of SO2 and NO2. Aerosol nitrate is closely tied to the relative abundances of ammonium and sulphate. If ammonia is available in excess of the amount required to neutralize sulfuric acid, nitrate can form small-size radiatively efficient aerosol particles. Stratospheric aerosols are composed of an aqueous solution of 60–80% sulfuric acid for temperatures varying from −80 to −45 ∘C, respectively.

III. SCATTERING AND ABSORPTION BY AEROSOLS

Aerosols particle can scatter and absorb electromagnetic radiation at different wavelengths. Aerosol optical properties are characterized by their size, shape, total concentration and chemical compositions. Aerosol extinction coefficient σ_e is calculated as the sum of the aerosol scattering coefficient σ_s and absorption coefficient σ_a .

$$\sigma_e\ (\lambda) = \sigma_s\,(\lambda) + \sigma_a\ (\lambda) \qquad (1)$$

Since both gases and aerosol are responsible for the scattering and absorption it can be calculated as

$$\sigma_s\ (\lambda) = \sigma_{sp}\ (\lambda) + \sigma_{sg}\ (\lambda) \qquad (2)$$

$$\sigma_a\ (\lambda) = \sigma_{ap}\ (\lambda) + \sigma_{ag}\ (\lambda) \qquad (3)$$

Subscripts p and g denotes particles and gas respectively. Global climate change is uncertain because of the particles can be cool or to warm depending on their optical properties. The relative contribution of absorption to the extinction by aerosol particles is treated as an important parameter in assessment of radiative effect due to aerosols and it is known as Single Scattering Albedo (SSA). ω_0 is the single scattering albedo (ratio of the scattering optical thickness to the total optical thickness) defined as

$$\omega_0 = \frac{\sigma_{sp}\,(\lambda)}{\sigma_{ep}\,(\lambda)} \qquad (4)$$

Where $\sigma_{ep}\ (\lambda)$ is the particle extinction coefficient. Single scattering albedo (SSA) is the wavelength dependent and visible part of solar radiation is largely unaffected by atmospheric gases. But it is influenced by particle scattering. Aerosol optical depth (AOD) is defined as the aerosol extinction coefficient integrated over a vertical path from the ground to the top of the atmosphere.

$$AOD(\lambda) = \int_0^{TOA} \sigma_{ep}(\lambda, h)\, dh \quad (5)$$

Typical range of aerosol optical properties of lower tropospheric aerosols are given in Table 1.

TABLE 2. Aerosol optical properties of lower tropospheric aerosols .

Parameter	Polluted Continental	Clean Continental	Clean Marine
Aerosol Optical Depth	0.2 - 0.8	0.02 - 0.1	0.05 - 0.1
Single Scattering Albedo	0.8 - 0.95	0.9 - 0.95	close to 1
Scattering Coefficient (1×10^{-4} m^{-1})	0.5 - 3	0.05 - 0.3	0.05 - 0.2
Back/Total Scattering	0.1 - 0.2	not available	0.15

Oxygen is strongly absorbing at 760nm and water vapour is absorbing at multiple wavelength bands in near IR (940nm, 1380nm, etc.) Transmission = 1 (100%), indicates atmosphere is totally transparent (no extinction of light either from absorption or scattering) Transmission = 0, indicates atmosphere is totally opaque. Impact of atmospheric gases absorption on transmittance spectrum is shown in fig (2). Particles with sizes smaller than 20–30Å are usually classified as clusters or small ions and mineral and tropospheric volcanic dust particles with sizes greater than a few hundred microns are not considered to belong to the coarse aerosol class, since they have very short lifetimes.[14]

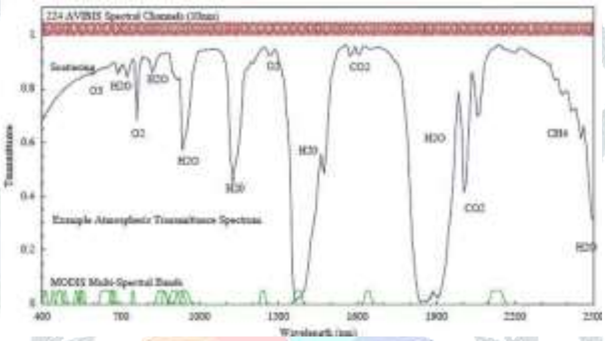

FIG. 2. Impact of atmospheric gases absorption on transmittance Spectrum [14].

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IV. AEROSOL SIZE DISTRIBUTION AND CONCENTRATION MEASUREMENT

Recent investigation in the development of instrumentation allow the size distribution measurement of nanometre particles in the size range from 1 to 10,000 nm. The electrical mobility techniques are used in the size measurements. Aerosols are generally measured as single particle measurements or ensemble measurements. Single particle measurements are simply the measurement of the properties of individual droplets of the aerosol. Single particle measurement are more accurate and provide a more in-depth analysis of the aerosol's mass and heat transport kinetics. The ensemble measurements considers the entire aerosol dispersion and then average out the properties of all the droplets. Based upon the applications, collected data is analyzed to calculate a precise size of the droplets. Recently, fears over particulate air pollution have emphasized monitoring and measuring these fractions of PM. Quantitative analysis for a large variety of *elements* gives elemental compositions in individual droplets and also provides new and interesting information on the impacts of aerosol on global cloud formation. This phenomenon known as the "aerosol indirect climatic effect". The machine should be so precise that it can take readings of aerosol particle sizes from 0.1 to 900µm through to 2 to 2000µm, to an accuracy of better than 1%. Single particle measurements produces a better understanding of the thermodynamic equilibrium state of the aerosol. Also, the liquid droplet phase is important for proper performance of the heterogeneous multiphase processes of the troposphere in real time the system comes with software that controls the measurement process and analyses the light scattering data.

AOD is the measure of aerosols (e.g., smoke particles, urban haze, , sea salt desert dust,) distributed within a column of air from the instrument (Earth's surface) to the top of the atmosphere. The voltage (V) measured by a sun photometer is proportional to the spectral irradiance (I) reaching the instrument at the surface. The estimated top of the atmosphere spectral irradiance (I_o) in terms of voltage (V_o) is obtained by sun photometer measurements [15].

In laboratory measurements the aerosol will be measured in an idealised environment in order to look at the behaviour and properties of the aerosol in isolation. But field measurements focus on the behaviour and properties of the aerosol in the natural environment. These measurements normally emphasis an estimate of the droplet concentration and chemical composition. Different models techniques host many benefits as local and global effects of its use. Spectroscopy theory support to early quantum research in radiation and atomic structure. These theory uses X-ray and magnetic resonance imaging (MRI) machines and utilises a form of radio-frequency spectroscopy which measure the unique makeup and physical properties of distant astral bodies through their spectra and wavelength. The different types of spectroscopy are distinguished by the type of radiative energy involved in the interaction. In many applications, the spectrum is determined by measuring changes in the intensity or frequency of this radiative energy. The types of spectroscopy can also be distinguished by the nature of the interaction between the energy and the material. Transmission Electron Microscopy (TEM) and Scanning Transmission Electron Microscopy (STEM) are used to generate spatially resolved elemental analysis in areas as small as a few nanometres in diameter. **Spectrometry is the practical measurement in the balancing of matter in atomic and molecular levels .** and it is used to acquire a quantitative measurement of the spectrum. It helps in the quantification of absorbance, optical density or transmittance. An electrical aerosol analyzer and a Differential Mobility Analyzer (DMA) are capable of gauging the diameter to 10 nm - 1 µm.

[16,17,18,19]. Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopes (SEM/EDS) are normally used for the topographic image observation of materials down to the nanometer scale. SEM/EDS scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM/EDS) analyse many of the parameters on a single particle level, including size, number, shape, elemental composition, and mixing state as well as estimates on surface area.[21, 22]. Three-dimensional images produced by SEM provide topographical, morphological and compositional information. SEM/EDS is capable of performing qualitative and quantitative analyses within a few minutes for most samples. It is sensitive to light elements and inapplicable under atmospheric pressure(ultrahigh vacuum is not necessary). A set of batch experiments are conducted to analyse 3 types aerosols NaCl, Hallosite ,printex90 with atomizer ,brush generator[20] .

For a synchrotron radiation X-ray fluor essence (SRX_RF) Spectro microscope, the minimum detection limit is less than one femtogram and it is another elemental analysis instrument used in detecting the characteristic X-rays. SR_XRF is very much appropriate for detecting trace and microamounts of elements. In local measurement tunable beam size down to a sub_micrometer scale is very convenient in the analysis. It is mainly applicable under atmospheric pressure. Silicon-poor particles, mainly composed of mafic minerals such as olivine or pyroxene, were examined as an indicator of eolian dust particles from China, called the Kosa aerosol in Japan.
The SEM images of two representative Kosa aerosol particles (ca. 50 µm in diameter) are shown in Fig. 3. And these samples are collected at Shenyang ,Harbin University in March 2004 .

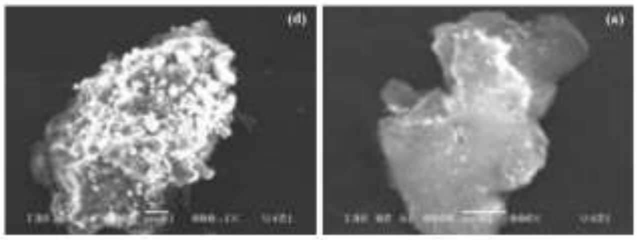

Fig. 3. Micrographs *to demonstrate* Kosa aerosol particles[23]

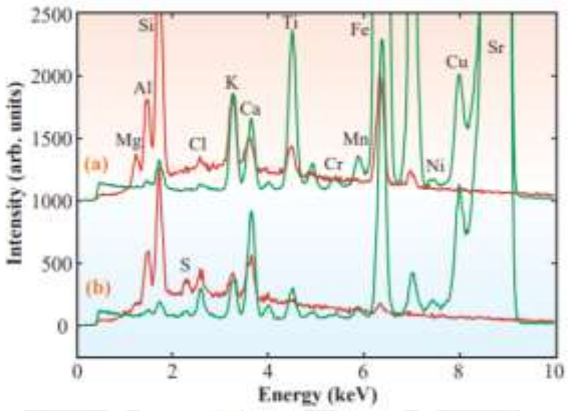

Fig. 4. SEM-EDS (red) and SR-XRF (green) spectra[23]

Fig. 4. shows SEM-EDS (red) and SR-XRF (green) spectra of Shenyang and Harbin University Kosa aerosol particles. Detailed SEM images utilizes elemental analysis result. Here atmospheric sulfur primarily adheres to calcium intrinsic to Kosa aerosol. The surface roughens as a consequence of the chemical reaction between the two elements ($CaSO_4$). A particulate air pollution sensor for measuring and detecting particle number developed and experimentally evaluated in [23]. The measuring method is based on unipolar corona charging and electrostatic detection of charged aerosol particles. In experimentation sensor is evaluated by using combustion aerosol with sizes in the range of approximately 50nm to several microns and number concentrations of approximately 1010-1014 particles/m3 · sensors detects particle number concentrations in the range of 2.02×1011 and 1.03×1012 particles/m3 with a resolution of approximately 100ms.Comparison of available instruments for different aerosol particles are studied in [24] .solidification and synchrotron radiation techniques are used to study and quantify the elemental compositions in individual microdroplets[25]. The software that influences the technology which provides technical compliance to the requirements of 21 CFR Part 11 and ISO 13320:2009. international standards are followed for laser diffraction measurements.

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IV. AEROSOL REMOTE SENSING

The satellite-based components have enormous potential to ensure complex evaluation of global aerosol distribution. The aerosol monitoring system consists of a variety of sensors on multiple platforms. Planned national and international satellite sensors are used in study of tropospheric aerosol properties. The aerosol monitoring system consists of satellite based and ground-based components. The satellite-based sensors provide global coverage. These sensors include U.S., Japanese, and European sensors, ranging from the National Oceanic and Atmospheric Administration's (NOAA's) Geostationary Operational Environmental Satellite (GOES) first used for regional aerosol studies in 1980 to the NOAA Advanced Very High Resolution Radiometer (AVHRR), first used for aerosol studies in 1981. The largest ground-based system for monitoring aerosols: AErosol RObotic NETwork (AERO NET). Today, AERONET includes approximately 500 automated instruments distributed around the world [27]. NASA's Earth Observing System (EOS), the National Space Development Agency of Japan's (NASDA) ADEOS (Advanced Earth Observing Satellite) series of satellites, and the European Space Agency's (ESA) Envisat-1 program developed sophisticated sensors . The MODerate Resolution Imaging Spectroradiometer (MODIS) deployed on the Terra and Aqua satellites of NASA's Earth Observing System (EOS) . CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) a lidar system

CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) and imaging radiometer is a joint mission of NASA the French CNES French CNES and provides high resolution vertical profiles of elastic backscatter at 532 and 1064 μm.

Today, AERONET the most commonly used networks of autoland atmospheric monitoring. It is deployed to obtain online large volumes of data, its accumulation and subsequent processing aimed at formation of a map of aerosol distribution over the globe. NASA Earth Observing System's MODerate resolution Imaging pectroradiometer (MODIS) instruments, and the aerosol scientist for the Multi-angle Imaging Spectro Radiometer (MISR) [26]. In MISR instrument, there are 9 viewing cameras 4 in backward direction and 4 in forward direction, and one at nadir and its shown in Fig.5

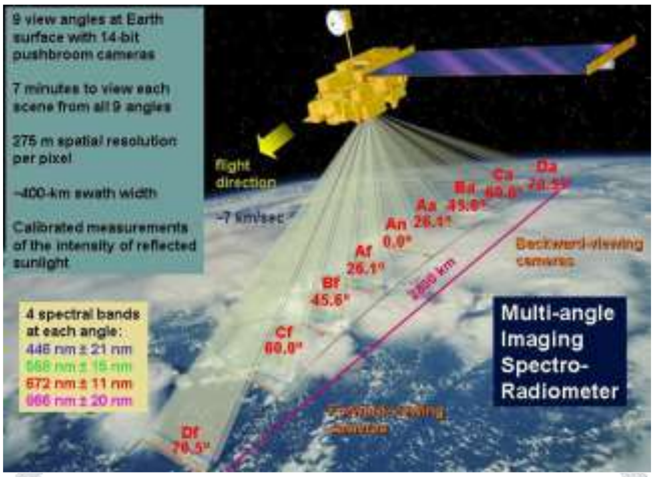

Fig. 5.Multi-angle Imaging Spectro Radiometer (MISR)[26]

. Having multiple views of the same region of the earth better characterizes the scattering due to atmospheric constituents like clouds, aerosols, clouds. NASA also contribute to the Total Ozone Mapping Spectrometer (TOMS) the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and the Suomi National Polar-orbiting Partnership's Visible Infrared Imaging Radiometer Suite (SNPP-VIIRS) aerosol retrieval algorithms. Aerosol optical depth (AOD) retrieved by remote sensing from space is highly inhomogeneous shown in fig 5 with the largest values in Asia and the tropical regions of Africa. Ground-based sensors provide local measurements that can be related to in situ collections of aerosol samples. Some aerosol types Sul (sulphate), Bio (OC and BC from biomass burning), Nitrate, Sea (sea salt), and Min (mineral dust) have contributions to AOD. Gray areas indicate lack of MODIS data. Some aerosol types, e.g. sulphate, have enhanced contributions to AOD due to hygroscopic growth. Satellite retrieval of the surface reflectance and the AOD over land are carefully studied as the additional data from surface measurements and other satellite observations or aerosol transport models. One and two channel methods, which allow retrieving AOD at a spatial resolution of about 5 × 5 km and at a frequency of once every 15 min are described in [38] .

The particles having the largest direct environmental impact are sub-visible, ranging in size from about a hundredth to a few tenths the diameter of a human hair (about 0.1 to 10 microns). They typically remain in the atmosphere from several days to a week or more, and some travel great distances before returning to the Earth's surface via gravitational settling or washout by precipitation. validation studies on all these satellite aerosol products using ground-based remote-sensing aerosol measurements, such as those provided by the global Aerosol Robotic Network (AERONET) of Sun- and sky-scanning photometers and the Micro-Pulse Lidar Network (MPLNet). Through the Goddard Interactive Online Visualization ANd aNalysis Infrastructure (GIOVANNI), NASA scientists have participated in the development of web-based tools to collocate multiple satellite and AERONET products and to analyze them statistically [27]. In the evaluation of global aerosol distribution, MODIS coupled with AERONET and different types of AOD samples are used for probability distribution analysis.

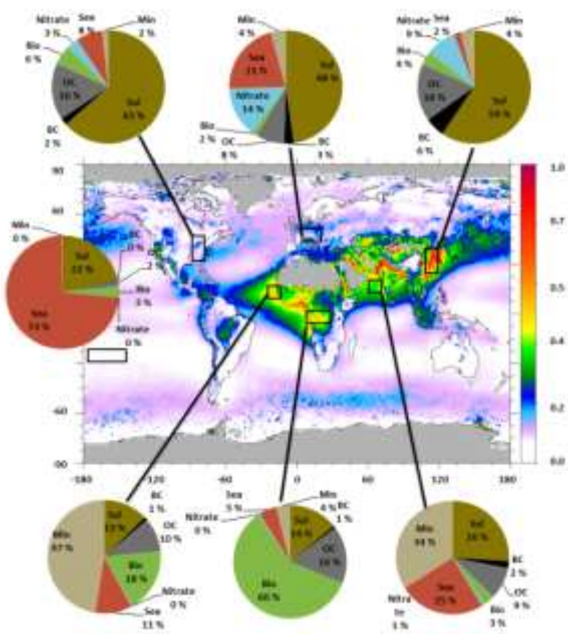

Fig.6. Aerosol optical depth (AOD) retrieved by remote sensing from space is highly inhomogeneous, with the largest values in Asia and the tropical regions of Africa.

MODIS aerosol product documents like ATBD-96 affords basis and formulation of land and ocean algorithms. .MODIS aerosol product provides daily observations of the optical depth of the aerosol (AOD) globally over the ocean and vegetation, as well as over other dark patches of earth based on Dark Target (DT) algorithm[30] and on bright terrestrial surfaces (for example deserts) based on a Deep Blue (DB) algorithm[29].

polarized radiative transfer model is used to compute the reflected intensity field is given in equation (6) and it is used to retrieve aerosol properties over land.

$$R(\mu, \mu_0, \varphi) = \frac{\pi I(\mu, \mu_0, \varphi)}{\mu_0 F_0} \qquad (6)$$

Where F_0 is the extra-terrestrial solar flux, μ_0 is the cosine of the solar zenith angle and R is the normalized radiance (or apparent reflectance), I is the radiance at the top of the atmosphere, μ is the cosine of the view zenith angle, ϕ is the relative azimuth angle between the direction of propagation of scattered radiation and the incident solar direction

Measurements of atmospheric optical parameters are made with sun photometers CIMEL every 15minutes in the range from 340 to 1020nm. The total estimated uncertainty in AERONET AOD constitutes ±0.01 for longer waves (>440nm) and ±0.02 for shorter waves[30,31]. New monitoring network of in situ instruments for NO_2, SO_2, CO, O_3, PM10 and PM2.5 has been operational in Madrid since 2010. This monitoring network comprises 24 automatic measuring stations and two additional sampling points for PM2.5 suspended particulates. The in situ PM2.5 concentrations are measured at six stations. The retrieval of aerosol extinction coefficient and resulting AODs from MAX-DOAS measurements carried out from March to September 2015 in the urban area of Madrid. The O4 absorption in the UV bands at multiple elevations angles served as input for the HEIPRO algorithm to retrieve aerosol extinction profiles in the lower troposphere[32]. Four years (2010-2014) of spectral aerosol optical depth (AOD) data from 4 Indian Space Research Organization's ARFINET (Aerosol Radiative Forcing over India) stations (Shillong, Agartala, Imphal and Dibrugarh) in the North-Eastern Region (NER) of India (lying between 22-30°N and 89-98°E) are synthesized to evolve a regional aerosol representation first time. Study in reference [33] analyses around 10 years (June 2006 to December 2016) of version 3 level 3 CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) spaceborne lidar (light detection and ranging) retrieved night time, cloud free vertical extinction profiles (at 532 nm) of composite aerosol, and its major species (dust, polluted dust and smoke) to understand the three-dimensional distribution of aerosols over India. The shape and vertical extent of the extinction profiles varied in space and time. The vertical extent of the aerosol distribution is shallower in the colder seasons compared to that of warmer seasons, which could potentially be due to suppressed convection during colder months. Over the north western and central India, dust aerosols contributed the most to the aerosol optical depths and extinction profiles during the summer and monsoon months. Smoke aerosols prevailed over the southern and north eastern parts of India, which are attributed to biomass, agricultural burning, and long-range transport [33].

Analysis of the climatology of aerosol properties is performed over Hanle (4500 m) and Merak (4310 m), two remote-background sites in the western trans-Himalayas, based on eleven years (2008–2018) of sun/sky radiometer (POM-01, Prede) measurements[36] the seasonality of the vertical profiles of the aerosol size distribution and total number concentrations are addressed over seven selected sites in India during winter and spring seasons [37].

In [38] two algorithms used to derive Aerosol Optical Depth (AOD) from a synergy of satellite and ground-based observations, as well as aerosol transport model output.

One and two channel methods and algorithms allows to retrieve AOD at a spatial resolution of about 5 × 5 km and at a frequency of once every 15 min. In Fig 7 In both algorithms the surface reflectance is estimated for reference clear days (days with small AOD) from the SEVIRI top-of-atmosphere (TOA) reflectance and the spatial distribution of AODs obtained from MODIS observations or from the aerosol transport model (Spaceborne lidar retrieved composite and speciated aerosol extinction profiles and optical depths over India. Detailed study of retrieval of backscatter to extinction ratio (BER) (extinction to backscatter ratio, or so called lidar ratio, LR) for biomass burning (BB) and Marine Aerosols are listed in [35]. With Software MODTRAN5.2.2 can perform experiments with higher accuracy with deferent aerosol types located at deferent heights.

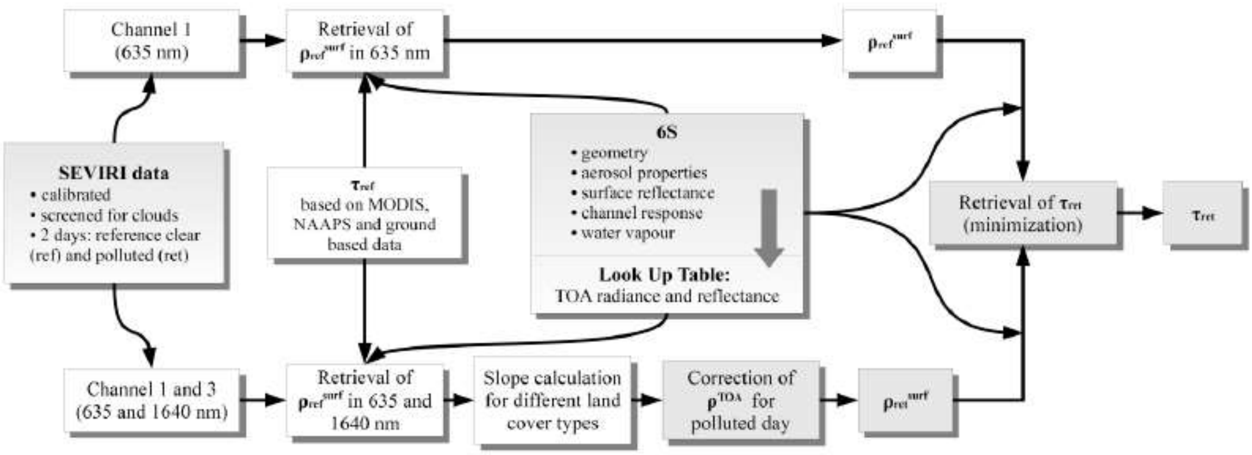

Fig. 7 .Flowchart of the algorithm to retrieve the aerosol optical depth (AOD)[38] .

VI Conclusions

Systematic research analysis and measurements produces accurate quantitative calculation of aerosol radiative forcing .The various aerosol types and contribution to the total Aerosol optical depth (AOD) for different regions which are estimated by a global aerosol models are discussed with different graphs and Pie charts from existing aerosol sensor network. As per the deliberations, many components of retrieval algorithm needed to be improved for the use of a static surface database to estimate surface reflectance. Consequently, the aerosol retrievals algorithms efficiency have been significantly improved over regions with mixed vegetated and nonvegetated surfaces such as urban areas, providing useful information for the study of air quality. , Accurate radiometric calibration at the blue bands is becoming a challenging task. Measurement error modelling are essential to study the advancement for the next generation of satellite-based air pollution models. The remote sensing technology creates a new map of air quality for environmental management

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