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# ENVIS
## NEWS LETTER

# Acid Rain and Atmospheric Pollutant Modeling

(A project of the Ministry of Environment and Forests, Govt. Of India)

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Indian Institute of Tropical Meteorology PUNE

Contents

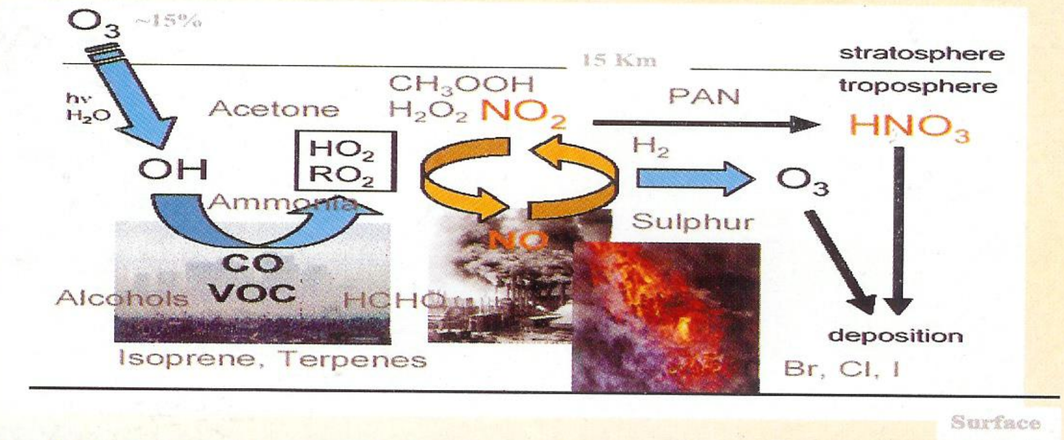


**Editors's Desk -** It is a matter of great satisfaction to note that the inaugural issues of the Newsletters in 2003 have been widely circulated, well received and appreciated. The encouraging comments and suggestions from the readers have been of great help in our efforts to further improve its format and contents.

This issue of the newsletter closely follows some of the fundamental scientific aspects related to atmosphere and ozone, which, we believe, are essential for general awareness of concerned persons. In addition, some discussion on basic common issues like Environment and Pollution Curriculum for Schools in India and need for fixing ozone pollution standards for our country, are included which reflect editor's personal views. The future vision in atmospheric chemistry and pollution modeling research as envisaged by us to the best of our understanding, are outlined. Lastly the active participation by ENVIS team in preparation of this edition is greatly appreciated.

We take this opportunity to request the scientific groups involved in various air pollution and related projects to send us the material to enrich the scientific content of this Bulletin. Brief descriptions of activities and highlights of the latest results, along with illustrations and feedback of earlier issues will be greatly appreciated.

(G.B. Pant) Editors (G. Beig)



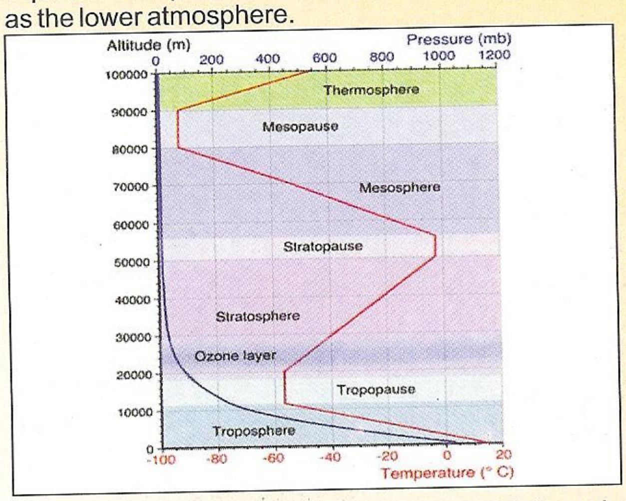

*The chemistry of pollutant ozone formation and destruction is schematically represented in the figure below. The CO and VOCs react with oxygen in the presence of Sunlight to form the ozone. The CO and VOCs are generated from the incomplete combustion of fossil fuel, wood burning and power plants etc where as Deposition of ozone and reaction with NO are the only ways to remove ozone from the system.*

## The Earth's Atmosphere

For a person, who is concerned about the atmospheric pollution and acid rain, it is essential that a basic knowledge about the structure of Earth's atmosphere be known. Because of the simple fact that these pollutants are not only harmful to the habitats at the earth's surface but regularly get transported upward in the earth's atmosphere - troposphere, stratosphere and beyond. Once at that altitude, they start altering the chemical balance of the atmosphere, which in turn can pose adverse effect to the human beings at the ground in several ways. How and why? A short journey to the structure of the atmosphere follows to know more about the basic

**The structure of the atmosphere:** Four distinct horizontal layers have been identified based on thermal and convective characteristics (temperature changes), chemical composition, movement, and density. Nomenclature of these layers varies depending on the criteria of classification. The most common among them is a classification based on the temperature change, which is as follows:

(a) The **Troposphere**, The column in which convection is often prominent and where temperature generally declines with height. It extends from surface to the tropopause at a variable height, generally about 8 km near the poles, 11 km over middle and higher latitudes and 18 km near the Equator. This part of the atmosphere is also known as the lower atmosphere.




(b) The **Stratosphere**, The column in which there is much less vertical motion, and which extends from the tropopause to about 50 km at the stratopause. The lowest region of this layer is usually isothermal, but the temperature then increases with height, maximizing at the top. The 'Strato-Pause' indicates the upper boundary of that layer where temperature remains constant for a certain vertical height.

(c) The **Mesosphere**, The column in which convection is again prominent, extending from the stratopause to a height of about 86-100 km at the mesopause. In this region, the temperatures again fall as low as -93°C as height increases. The chemicals in the region are in an excited state, as they absorb energy from the Sun.

The regions of the stratosphere and the mesosphere, along with the stratopause and mesopause, are called the Middle Atmosphere.

(d) The **Thermosphere**, extending from the mesopause to the effective limit of the atmosphere, at about 200-600 km. Temperatures in this region can go as high as 1,727°C. Chemical reactions occur much faster here than that on the surface of the Earth. This layer is known as the upper atmosphere.

(e) The region above 700 km, at which height, atoms may begin to escape into space, is known as the **Exosphere**.

With increasing height, air temperature within the lower atmosphere drop uniformly with altitude at a rate of approximately 6.5 degrees Celsius per 1000 meters - known as the environmental lapse rate. However, sometimes this normal overall decline is reversed mostly near ground. A point or layer at which the temperature increases with height is called **inversion** or **inversion layer**. In wintertime, temperature inversion occurs when a layer of warmer air traps cold air close to the ground. As the inversion continues, air becomes stagnant and pollution becomes trapped close to the ground. Therefore inversions often cause the formation of **smog.** When winds are calm and convection is less active, inversions and smog do also occur in summer and might turn into a serious **respiration hazard** over densely populated areas.

## Towards Characterizing Air Quality Standards for Ozone in India

The air we breathe today contains noxious substances in the form of trace gases (Oxides of Nitrogen -$NO_x$, Volatile Organic Compounds -VOCs, Sulfur Dioxide -$SO_2$, Carbon Mono-Oxide -CO) and fine suspended particles called aerosols. Whenever pollution is discussed whether regionally or globally, the main focus of discussion is above-mentioned pollutants emitted from the human activities like vehicular traffic, biomass burning, agricultural practice etc. Although ozone pollution is mainly formed in urban areas, it ends up in rural areas as well, carried by prevailing winds or resulting from transportation in the rural areas. Up to some considerable extent, VOCs emitted by trees also shows its presence in initiating the ozone pollution in rural areas. Ozone is identified as one of the most serious among these air pollutants. Ozone is an air quality problem today for much of the world's population.

### Understanding Air Quality Index (AQI) and Standards

The AQI is an index for reporting daily air quality of that species. It can be defined collectively for several pollutants as per certain defined rule. However, defining AQI for individual species seems more appropriate. The AQI tells you how clean or polluted your air is with respect to that species and what are the associated health concerns. The AQI focuses on health effects that can happen within a few hours or days after breathing polluted air and not a long term impact scale. AQI is a standard yardstick that runs from 0 to 500 as per the EPA. Higher the AQI value, greater the value of the species and greater the health danger. An AQI value of 100 generally corresponds to the national air quality standard (AQS) for the pollutant, which is the level EPA has set to protect public health. So, AQI values below 100 are generally thought of as satisfactory, if not good. When AQI values are above 100, air quality is considered to be unhealthyat first for certain sensitive groups of people, then for everyone as AQI values get higher. It should be mentioned here that so far no consensus has reached to freeze the range of yardstick of AQI and different pollution agencies in different countries fix it as per their convenience. As for example, Canadian pollution agency has fixed AQI range as 0-100 which roughly corresponds to 0-300 of EPA. However, the final message is more or less same when we broadly talk w.r.t. equivalent level of pollutant in terms of AQS. In this work we follow the AQI scale of EPA for characterizing AQS for India. The AQS has to be spelled out /fixed for a specific pollutant and region /country. Environmental Protection Agency (EPA), of United States of America and World Health Organization (WHO) have brought to resolution standard values as Ozone Air Quality Index, normally called, to fix the limit and its overall immediate effects. In the developed countries like United States of América, England and some of the European countries Ozone Air Quality Standards are designed through a combination of local emissions, meteorology favoring pollution episodes and the clean-air baseline levels of ozone upon which pollution builds.

In general and broad sense, the WHO certifies the Ozone Air Quality Index standard as 60 ppb for 8 Hr average values. Whereas on the other side EPA in USA has announced Ozone Air Quality Index standard level limit as 80 ppb for 8 Hr average. There are many factors required for fixing up the AQI standards for ozone, which are highly sensitive to the overall socio-scientific environment of a particular geographical location or country. Hence the AQI standardization of ozone needs to be worked out independently for a region /country. India has Air Quality Standards for $SO_2$, $NO_2$ and aerosols but National Ambient Air Quality Monitoring Programme in India has not yet scaled out any AQS and AQI levels for the Ozone over the region of India.

**Initiatives and Challenges**

Ozone Pollution group at Indian Institute of Tropical Meteorology, Pune has initiated a sincere effort to study in depth various aspect of ozone and secondary pollutants and attempts are being made to answer several challenging questions. One of the challenging initiatives is to make an attempt for designing the ozone Air Quality Standards for India. Under the project, simulations for the temporal and long-term trends in ozone and its precursors are made on regional scale using the three dimensional chemistry transport model. Theoretical work is being complemented by regular observations (Round-the-clock) of ozone and its precursors. It is noticed that the high levels of ozone in this region are usually reported in the afternoon and early evening. In a typical Indian urban site, ozone variations during summer and winter are 30-75 ppb and 10-85 ppb respectively (here 'ppb' indicates part per billion of ozone molecule in total volume of air). During the monsoon season these level shows the significant decrease because of insufficient photochemical energy for the production of ozone and other wash out effects of the ozone precursors, varying between 10 ppb to 30 ppb.

**Realistic assessment for Ozone AQI:**

Realistic assessment of human health hazards, however, necessitates a distinction between absolute safety and acceptable risk. To produce the guideline for AQI with high probability of absolute safety, one would need a detailed knowledge of dose-response relationship in individuals in relation to all sources of exposure, the types of toxic effect elicited by specific pollutants of their mixture, the existence or nonexistence of "thresholds" for specified toxic effects, the significance of interactions, duration of exposure and the variation in sensitivity and exposure levels within the human population. In conjunction with these parameters (listed above) regional meteorology plays an important role in fixing the AQI limits.

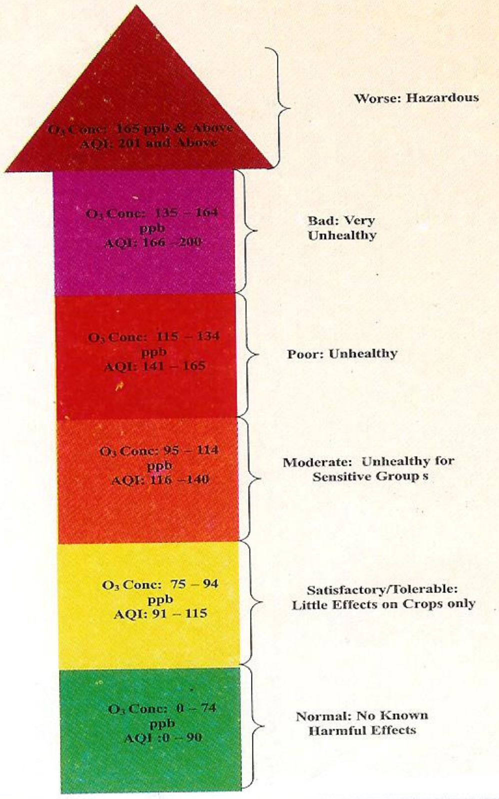
In this chain, the first link factor, which needs to be firmly assessed while characterizing AQI standards, is fixing up the time duration for peak exposure of that species. This period should be fixed based on the time duration for which maximum of the population will be exposed to the ozone (Effects on Health). This requires the precision about the limits of that species which may be considered under peak exposure. This effectively depends on the chemical or dynamical properties of the species. In case of ozone, peak refers to the window when ozone production is high during the day, which is related to the maximum photochemical energy available that accelerates the photolysis rate in catalytic production mechanism of ozone. Finalizing the norms for the fixation of time duration itself, is a tedious task? Along with this average time factors there are some other parameters, which should be considered during the standardization of Ozone AQI such as the regional temperature and other meteorological parameters, where temperature should be given exceptional mindset; duration of availability of solar radiation for photochemical production of ozone; wind patterns; humidity; concentrations of other pollutants mainly ozone precursors and period of their peak concentration. These factors also play an important role in peak time fixation itself. These considerations enable to reach very close to the fixation of limits of exposure, which will distinguish effects of it on human being, crops and vegetations.

The ozone standards in USA by EPA and in some of the European countries are fixed on the basis of 8 hr average values. For the Indian region to a great extent, conditions are of diverse quality. These includes availability of solar radiation (Day Time) which varies to very high extend according to season, solar flux is more due to tropics, average temperature is comparatively higher from western countries and average humidity is also relatively high. This temperature and humidity difference will decrease the overall lifetime of ozone in the Indian sub-continent. The duration for which population is exposed to the ozone is different in Indian region. All these considerations are leading toward the conclusion that, more ozone average time should be considered over the Indian region for generating the Ozone Air Quality Index. As far as Indian sub-continent is concern 11 Hr average ozone starting from 0700 Hrs to 1800 Hrs should be taken in to account, because during this period of time the ozone production is maximum, through out the year for all the seasons. A box model has been prepared which includes all the above-mentioned factors analytically and derives AQI equivalent for ozone, valid for the Indian region.

**Categorization for Ozone AQI:**

The need of AQI is to fulfill the requirement of easier understanding of quality of air and effects on health, to the community. The purpose of the AQI is to help you understand what local air quality means to your health. To make the AQI as easy to understand as possible, we have divided the AQI scale into six categories as shown in a schematic diagram 1. In this figure, a specific color scheme is adopted and particular colour is assigned to each AQI category, to make it easier for community to understand the effect of pollution.

In this Figure, the first category is represented as "**Normal**" (AQI: 0-50) for which ozone volume mixing ratio (VMR) is specified as **0-67 ppb** (here 0 and 67 are called as lower and upper breakpoints respectively). For this category, the quality of air is considered to be within the acceptable limit and do not poses any health risk. The next category which is labeled as "**Satisfactory**" corresponds to the AQI range 51-100 for which ozone VMR is specified as **68-87 ppb.** This category is close to the level of little concern and may not be harmful to human being but it is adversely sensitive to some plants. The 3rd category is stated as "**Moderate**" (AQI: 101-150) having the corresponding ozone value in the range **88-113 ppb** and affects the health for sensitive groups of inhabitants. To be more precise, this group is likely affects those with lung and heart disease and general healthy public may not get affected. The 4th category is **"Poor"** (AQI: 151-200) with ozone value ranges between **114-138 ppb** where everyone is under risk on health effects. Under such conditions, sensitive groups may experience more serious health concerns. The fifth category is "**Bad**" (AQI: 201-300) which corresponds to ozone range **139-168 ppb** which poses an alarm for everyone, concerning the more serious health effects. The last category is called "**Worse**" (AQI: 301 and above) where ozone VMR may touch **169 ppb and above** and




considered to be dangerous to all inhabitants. The majority of the existing population is more likely to be affected under this category.

**A Word of Caution**

It should be stressed at last that the scientific judgment and consensus play an important role in establishing guidelines that can be used to indicate the acceptable levels of population exposure. Hence, it should be noted that the ozone AQI standard value of 87 ppb as threshold for the Indian environment (and subsequent categorization) is generated as preliminary, based on our understanding and knowledge of the subject and in no way should be considered as a final standard, which requires much more elaborate and in depth study based on network of data spread all over the country. However, authors feel that at present 87 ppb limit for ozone standard is the best estimate under the given constraints for our country.

(Originally Contributed by- Gufran Beig and Sachin Gunthe, Ozone Pollution Group, IITM, Pune)

## Atmospheric Chemistry and Pollution Research: Road Ahead

The Earth's atmosphere is a chemically complex system interacting both internally, principally within the troposphere and stratosphere, and with the oceans, land and living organisms. Its composition is known to have changed continuously since the formation of the Earth some 4.6 billion years ago. Changes have accelerated after the industrial revolution, in particular, during the last century as the result of human activities. It is, for example, well established that the formation of an ozone hole over Antarctica since the late 1970's has been caused by emission to the atmosphere of industrially manufactured chlorofluorocarbons (CFCs). These CFCs are also believed to be responsible for the substantial depletion of ozone observed in the Arctic since the early 1990's and even at mid-latitudes in the Northern hemisphere. Ozone depletion is leading to increased UV-B levels at the Earth's surface with potential biological and health effects. Another example is provided by the release in the atmosphere of reactive compounds (popularly known as **Atmospheric Pollutants**) such as nitrogen oxides, carbon monoxide, and a variety of hydrocarbons resulting from the combustion of fossil fuel and from biomass burning.

These gases affect the oxidizing capacity of the atmosphere, i.e.. the ability of the atmosphere to convert chemical species (including pollutants) into compounds that can be more readily removed from the atmosphere. They also lead to the formation in the troposphere of additional amounts of ozone, a gas with severe consequences on biological productivity (e.g., crops) and human health. A third example is provided by the formation of acidic precipitation **(Acid Rain),** resulting from the release in the atmosphere of sulfuric and nitrogen oxides associated with energy production.

The formation of aerosols associated with these and other anthropogenic emissions affect the transmission of solar radiation into the atmosphere as well as cloud properties, hence the climate system. Aerosols are also a major factor of air pollution with consequences on public health.

Finally, the increasing atmospheric abundance of climatically important gases such as carbon dioxide, methane, and nitrous oxides contribute to the greenhouse effect of the atmosphere and may lead to global warming and other climatic changes.

Air quality is of major societal importance and will be one of the prominent environmental issues of the 21st Century. It is increasingly recognized that changes in the emission factor of chemicals associated with evolving land-use (including agricultural practices, biomass burning) and industrial development (including urbanization and transportation) are becoming major causes of global changes in the Earth System. Major challenges for the Atmospheric Chemistry group in the next decade at IITM will be to understand the processes that effect these changes, to assess their importance for the future evolution of the atmosphere, and to predict their consequences for other components of the planetary system (including the continental biosphere and the oceans), and for society. These challenges will be met through close collaborations with other leading groups working in this area.

## Towards the 21st Century

The recognition that the Earth was a sphere occurred in Antiquity, and in the 17th century, Isaac Newton recognized that gravity explained planetary dynamics. At the same time, John Evelyn suggested that coal burning in London affected buildings, plants and human health. A century later, Joseph Priestley, Carl Scheele, and Antoine-Laurent Lavoisier discovered oxygen, and Daniel Rutherford, nitrogen. In the 19th century, Charles Darwin established his theory of evolution, Christian Friedrich Schonbein discovered ozone, and John Tyndall and Svante Arrhenius suggested that fossil fuel burning would lead to global warming. With this background of fundamental discoveries, the scene was set for a quantitative study of the Earth system in the 20th century: Atmospheric dynamics and meteorology became a first focus of the expending scientific community because of the societal importance of weather prediction. In the second half of the century following the work of Arie Jan Haagen-Smit on the Los Angele smog and atmospheric chemistry became a second focus of atmospheric research and addressed the acute problems of air pollution in urban and industrialized regions. The scope of the field expanded when it was recognized by the scientific community including Nobel Prize winners Paul Crutzen, Mario Molina, and Sherry Rowland that industrial emissions of chemical compounds could impact the atmospheric composition (including stratospheric ozone) on the global scale. The past two decades have seen a revolution in our appreciation of the chemistry of the global environment, highlighting, following Eduard Suess, Vladimir Vernadsky and James Lovelock, the role of the biosphere and the importance of complex feedbacks among the different Earth's subsystems.

How will atmospheric chemistry and related disciplines evolve in the future and what are the strategic priorities for us? Clearly, several fundamental questions related to photochemical processes will have to be further investigated in the laboratory and in the field through carefully designed experiments. At the same time, the discipline will increasingly be regarded as a contribution to integrated Earth System Science, requiring a broader, interdisciplinary perspective. Future field campaigns will continue to focus, for example, on the chemistry of the free troposphere, but with an enhanced emphasis on the region close to the tropopause where changes in the chemical composition (gases and aerosols) have the largest influence on Earth's climate. The largest changes in tropospheric composition are expected to occur in the tropics, especially South and South East Asia, where rapid economic growth is expected in the next decades. Surface exchanges of chemical compounds remain important parameters for atmospheric processes, as they will increasingly be regarded as coupling mechanisms between the atmosphere and the continental biosphere or the ocean. At the same time, concern regarding air quality will likely increase, and adequate responses will require careful scientific assessments and appropriate predictive modeling tools. Finally, our perception of the Earth and its atmosphere will greatly benefit from future space observations, which will help in elucidating the mechanisms responsible for the Earth's evolution and the emergence of life. Our priorities should be directed towards these strategic goals.

**Ozone Pollution, Photo-oxidants and Aerosols: Some Challenges**

- What are the mechanisms responsible for regional (summertime) ozone episodes?
- Can we make reliable predictions of these events? What is the impact of regional ozone formation on tropospheric ozone at the global (hemispheric) scale?
- Is the abundance of tropospheric ozone changing on the *global* scale, and if so, what are the mechanisms involved?
- What are the impacts on the climate system?
- What are the changes expected in the future?
- What are the effects of human activities (fossil fuel burning, aviation emissions) on the abundance of ozone and other chemical constituents in the atmosphere?
- How will changing climate affect the abundance and distribution of photochemical oxidants in the atmosphere?
- What are the processes that lead to the formation, growth, hygroscopic qualities, and chemical composition of aerosols?
- What are the global distributions of aerosol properties and what controls these distributions?
- Do the large varieties of particles (sulfate, nitrate, organic, soot, ice, etc.) significantly perturb gas phase photo-oxidation processes in the troposphere?
- How are aerosols removed from the atmosphere?

## Evidence of Surface Cooling (Not Global Warming)

Man-made emissions over the Asian region have grown rapidly with increase in population and industrialization. Estimates of anthropogenic Sulphur-dioxide ($SO_2$) emissions from fossil fuels over the South Asian region reveal that emissions have more than doubled during the last twenty years as shown in Figure.1 .

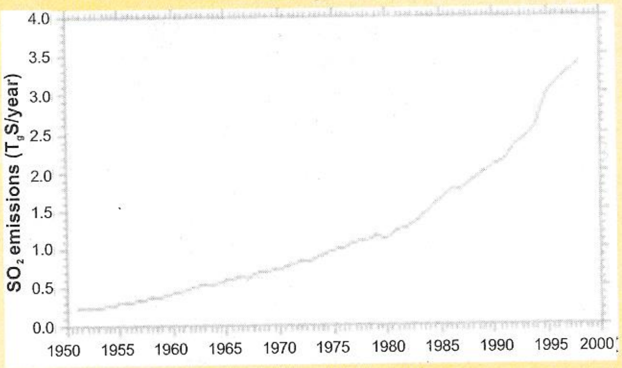



*Figure 1. $SO_2$ emissions ($T_gS$/year) over South Asia during (1951-98)[Smith Steven el al., 2001]. The back projection uses emission inventories & information on the regional consumption of fossil fuels to scale the emission components (coal, oil and gas) back in time. Long-period data of black carbon emissions over South Asia is not available & so the fossil $SO_2$ time-series is a surrogate for anthropogenic emissions. The burning of bio-fuels, such as wood, dung & agricultural waste is a major source of pollutants notably over rural areas of India, whereas in the urban areas the fossil fuel emissions are higher because of the increasing energy demand for industry and transport [ Lelieveld et al., 2001]*

Air-pollutants from this region lead to a brownish haze over most of the North Indian Ocean and South Asia during winter and spring months as revealed by the scientists of Indian Ocean Experiment (INDOEX) which had generated lot of debate. Measurements from the INDOEX during 1999, also demonstrated that the absorption of solar radiation due to the presence of air-pollutants like black carbon (i.e., the so-called absorbing aerosols) in this region resulted in a large decrease of solar radiation reaching the surface. While greenhouse gases (eg. Carbon-dioxide, Methane, Nitrous Oxide, Water Vapour, Halocarbons) are known to cause a rise in the surface temperature (popularly known as global warming), the impact of absorbing aerosols on climate is not yet fully understood.

The recent research work carried out by Dr. R. Krishnan, Indian Institute of Tropical Meteorology, Pune, India and Prof. V. Ramanathan, Scripps Institution of Oceanography, San Diego, USA, (Evidence of surface cooling. Geophy. Res. Lett, Vol 29, No.9, 54(1-4), 10.1029 / 2002GL014687, 2002) provided interesting observational evidence on the influence of absorbing aerosols on the surface-temperature variations over the Indian region.

In this work, the authors have presented an analysis of observed surface-air temperature records over the Indian region during the last 130 years. Their analysis is based upon the fact that the aerosol loading over this region exhibits a very clear seasonal cycle and has been extensively studied and experimentally demonstrated, most recently during the INDOEX. The aerosol loading over South Asia is highest during the dry season (Jan-May). Due to the washout effect of rainfall during the monsoon and post-monsoon seasons, the aerosol loading is low during (Jun-Dec). In contrast, the warming due to the greenhouse gases exhibits minimum seasonal dependence. In order to isolate the aerosol impact from the general warming trend, the authors contrast temperatures during the (Jan-May) dry season against the rest of the year. The green line in Figure.2a is the time-series difference of temperature variations over India between the dry season and rest of the year. It can be noticed that the green line in Figure.2a shows a significant decreasing trend during the post-1950s implying a surface temperature cooling in the dry season over South Asia as compared to other months. The blue line in Figure.2a is the difference in the dry-season temperature variations over India (TIND) and the global mean (TGLB). The blue line also shows a similar decreasing trend during the post-1950s. It may also be noticed from Fig.2b that the difference between TIND and TGLB do not show similar decreasing trends during the wet seasons. In short, the results indicate that the mean temperatures during (Jan-May) have declined by about 0.3°C over the three decades relative to the (June-December) values.

In addition, maximum temperature (day-time) records over India, available for the wet seasons. In short, the results indicate that the mean temperatures during (Jan-May) have declined by about 0.3°C over the three decades relative to the (June-December) values. In addition, maximum temperature (day-time) records over India, available for the period (1901-90) provide support for the direct effect of aerosols on the surface solar radiation. Figure.3a reveals that Tmax over India for the dry season steadily increased from the 1900s up to the mid-1950s in association with the global warming trend. However, the upward trend of the Tmax curve decelerated with the increasing importance of aerosol forcing after the 1950s. On the other hand, the time-series of Tmax for the monsoon and post-monsoon seasons (Figure.3b) considerably differ from that of the dry season and in fact show that the positive trend accelerated beyond the 1950s. Clearly, the above seasonal character of the Tmax variations over the Indian region provides additional support for the aerosol cooling effect.

Nevertheless, there are several open questions regarding the impact of absorbing aerosols on the regional climate and hydrological cycle, which remain a major challenge for the scientific community.

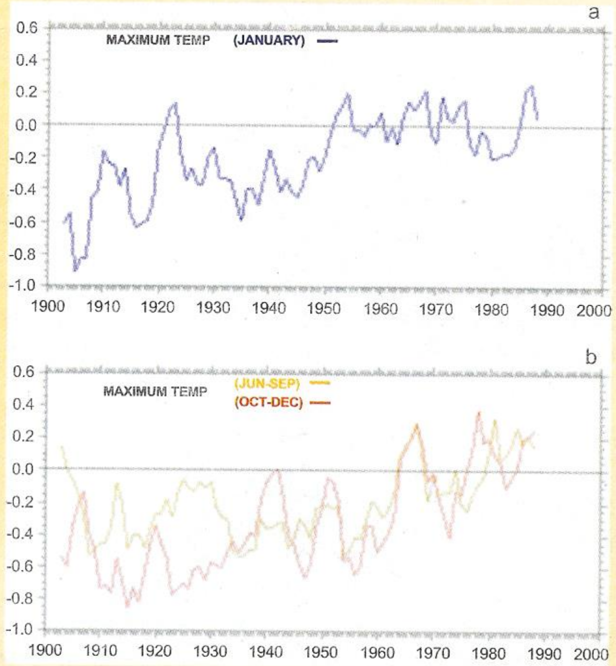



*Figure 2. Time series $T_{max}$ (°C) over India. (a) Dry season (Jan May) (b) Thick yellow curve is for (Jun Sep) season and the thin red curve is for (Oct Nov). The All-India temperatures based on an average of 121 (fixed) uniformly distributed stations covering the whole of India [Rupa Kumar et al., 1994] is available for the period (1901-90)*

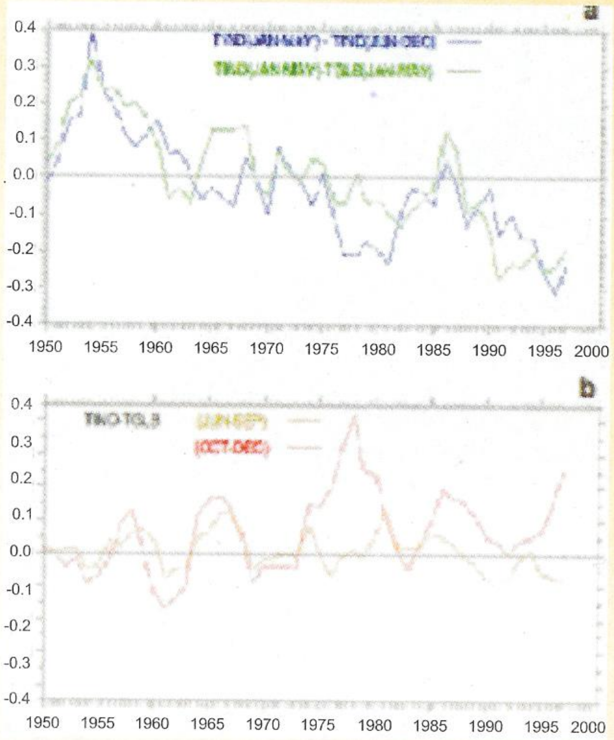



*Figure 3. (a) The thin green curve <T*> is the time series difference of temperature variations (°C) between the dry season (Jan-May) and the rest of the year (Jun-Dec) over Indian subcontinent. The thick curve [T'] is the difference between the variations of temperature (°C) over India and the global mean for the (Jan-May) season. (b) The thick yellow curve is [T'] for the Summer Monsoon (Jun-Sep) season; the thin red curve is [T'] for the Post-Monsoon (Oct-Dec) season.*

## Environment and Pollution Curriculum for Schools in India

**A Welcome Sign for Environmental Awareness Moment:** Environmental science has been a subject of great importance to us from ancient time. However, not much concern was expressed until some signs of its detritions are noticed as a result of human activities. Several governmental and non-governmental organizations have initiated programs to monitor and understand it better. Atmospheric chemistry, pollution, air quality are among the prominent environmental issues of the 21st century. Therefore awareness about it must begin at the grass root level through schools. Hence the Supreme Court of India's directive, mentioned below, comes as a welcome step to help the students across the country to make aware about the environmental science.

The Hon'ble Supreme Court in its Judgment delivered on 18th December 2003 in Writ Petition No 860 of 1991 has directed the NCERT to prepare a model syllabus for the Environmental Education to be taught at different grades. The Supreme Court directed all the states and educational agencies in the country to introduce environment as a compulsory subject in all classes in schools up to the higher secondary level from the academic year 2004-05. It directed the National Council for Educational Research and Training (NCERT) to frame a model syllabus for the schools keeping in view the 1991 judgment and submit it before the court on or before 14th April 2004 so as to enable them to consider the feasibility to introduce such syllabus uniformly through out the country. The direction No 4 issued by the Hon'ble Supreme Court as per its order dated 22nd November 1991 read thus: "We accept on principle that through the medium of education awareness of the environment and its problems related to pollution should be taught as a compulsory subject. Learned Attorney General pointed out to us that the Central Government is associated with education at higher levels and University Grants Commission can monitor only the undergraduate and postgraduate studies. The rest of it, according to him, is a state subject. He has agreed that the university Grants Commission will take appropriate steps immediately to give effect to what we have said, that is requiring the universities to prescribe a course on Environment. They would consider the feasibility of making this a compulsory subject at every level in college education. So far as education up to the college level is concern, we would require every State Government. and every Education Board connected with education up to the matriculation stage or even intermediate colleges to immediately take steps to enforce compulsory education on environment in graded way. This should be so done that in the next academic year there would be compliance with this requirement".

Hence, the above Supreme Court directive is a positive gesture for environmental science awareness campaign. The concept to save our environment will automatically follow once awareness is created about its importance in the main stream. Now it is left to the implementing agencies as to how fast and effectively they can act on it. In this direction, National Council of Educational Research and Training (NCERT) has initiated to consult and collect opinion of various experts / institutions regarding the perceptions in various dimensions of environmental education at different stages of school education. Some issues pertaining to overall implications like how one should introduce the course without increasing curriculum load and what are the implications of this in teacher's education, etc are basic issues which can be debated and may be kept aside for the time being. Because this may certainly require a proper balance in overall load on a student by shortening the syllabus of other subjects without compromising the important elements and at the same time full weightage should be given to the new subject. We should start working directly and more rigorously on the content and material to be tough in a systematic manner in different standards regarding the environment subject. The environmental science should be considered as compulsory subject irrespective of the selection of optional subject. In a later stage (say in intermediate or so), this may be included as specialized course rather than subject, which may cover different disciplines of environmental science in detail.

## Indo US Workshop "Modeling of Transport of Air Pollution"

An Indo US Workshop on "Modeling of Transport of Air Pollutants" has been organized jointly by National Environmental Engineering Research Institute, Nagpur and The Ohio State University, Ohio, USA at Nagpur, India during November 11-13, 2003. This workshop was sponsored by Indo-US, S & T forum, Department of Science and Technology, New Delhi. It was inaugurated by Shri. Suresh Prabhu, chirman, task force for linking of rivers and Ex-Environment Minister, Govt of India. There were number of leading research papers presented in this workshop by several experts from USA and India. The workshop covered vast area to address impact of pollutants on Agriculture, Health and Atmosphere. Dr. Moti L. Mittal and Dr Chhemendra Sharma (who were also the investigators and office bearers of the project) presented preliminary results on the distribution of chemical species (mainly pollutants like $O_3$, $NO_x$, CO, Peroxyacylnitrate) over the selective Indian cities using the Episodic Regional Chemical Transport Model called HANK Model. Hotspots with reference to these chemical pollutants were identified. However such results with 60 Km resolution scale could only present a rough idea about the distribution. The input to such model goes from general circulation models (like MM5), which are highly sensitive to several meteorological parameters. On the other hand regional pollution models suffer from several approximations. The weaker link is the emission inventories for various pollutants ($NO_x$, CO and VOC etc) from various sectors like biomass burning, transport, agricultural, residues, etc. Correct attribution of these inputs in pollution models is most critical for pollution forecasting. The status of emission inventories of various pollutants over India is in its initial stage. In this direction an exciting work on "**Gridding CO Emissions Over India using GIS Techniques and Modelling Ozone Pollutants**" has been presented by Dr. Gufran Beig (ENVIS Co-ordinator at IITM). The presented results on the gridded inventories of CO over the Indian region using the GIS based modeling, were the outcome of the joint venture of Indian Institute of Tropical Meteorology, Pune, Center for Development of Advanced Computing, Pune and National Physical Laboratory, New Delhi. This paper further elaborated upon the pollution forecasting and the sensitivity of emission inventories over the distribution of the concentration of ozone and secondary pollutants using the global three dimensional chemical transport model being operated at IITM, Pune. Presented result clearly demonstrated an urgent need of systematic gridded emission inventories over the Indian region. This needs to be done if any fruitful and meaningful pollution forecasting modeling has to be carried out for Indian region. In addition to this some more interesting presentations were made related to- Uncertainty Analysis in Air Quality Dispersion Modeling; Air Quality Prediction System; Transport of Particulate and Fine Particulate Matters; Effects of Air Pollution on Agriculture; Impact of Air Pollution on Soil Health and Productivity of Crops in urban Areas; Air Pollutants of Concern for Human Health; Health Impact of Air Pollution in Rural and Urban India; Indoor Air Pollutants Associated with Solid Fuel Use, etc. In conclusion, it was an exciting meet.

All queries and feedback regarding this newsletter should be addressed to:

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