Research Paper Environment

Methodology to Monitor Effective Optical Strength of Brown Cloud Layer

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ABSTRACT

Atmospheric Brown Cloud contains aerosols. This so called "cloud" causes absorption and scattering of incoming Solar radiation. As it affects health and weather, it is of a great concern now a days. Increase in its effective optical strength (dependent on concentration of aerosols and thickness of layer) will worsen the problems. A methodology is proposed herein to monitor any such change.

Keywords : Brown Cloud, Diffuse / Global solar radiation, Absorption, Scattering, Direct incoming Solar radiation.

Introduction :- Atmospheric Brown Cloud is a layer of pollution containing aerosols which absorb and scatter incoming Solar radiation. This so called "cloud" of pollution is of a great concern since last few years. The Asian Brown Cloud is a large aerosol formation over parts of South Asia, Northern Indian Ocean, India and Pakistan. The following prominent Brown Cloud regions have been identified lastly : East Africa, Indo – Gangetic Plain, Southeast Asia, Southern Africa and Amazon Basin. The layer extends from near earth's surface to an altitude of approximately 3 km. The Asian Brown Cloud appears hanging in air from November to May, prominently between January and March every year. During rains, pollutants are washed from the air. The cloud is created by airborne particles and pollutants due to combustion of fossil fuels and biomass, and also by processes with incomplete burning. Urban Brown Clouds are severely influenced by atmospheric thermal inversions. The Brown Cloud causes absorption and scattering of incoming Solar radiation by black carbon, fly ash, dust particles and different oxides of nitrogen, as well as sulphur dioxide etc. Aerosols of Brown Cloud are mainly constituted of black carbon and organic carbon. Both the components, chiefly black carbon, absorb a part of incoming Solar radiation. Such absorption causes increased Solar heating of atmosphere and lowering down of earth's surface temperature. Again, sulphates and nitrates scatter a part of incoming Solar radiation. So, the said aerosols reduce the amount of incoming Solar radiation reaching earth's surface. At present, Atmospheric Brown Cloud is a global phenomenon. Aerosols can also influence formation of (meteorological) clouds. Possible impacts of Brown Cloud are health hazards and weather change due to the mentioned physical incidents, in the way of hampering heat balance.

Pollution Meteorological discussion :- Rapid industrialization with improper process control has brought the problem of large scale atmospheric pollution. Meteorological parameters play a vital role in dispersion and transport of pollution. Wind and turbulence, thermal stability and inversion are the prime meteorological factors responsible for dispersion and transport of pollutants [1]. The principal pollutants considered in Pollution Meteorology are : SPM, RPM, Sulphur dioxide, oxides of nitrogen and carbon, and Pb particles. The hourly ratio of diffuse solar radiation (D) and global solar radiation (T) may be determined from continuous records. This ratio provides information in respect of variation of turbidity at various places, specially under clear sky condition. The study of Hamid Ali indicated the direct effect of industrialization and urbanization; Kolkata had highest value of D/T ratio, while Shillong had the lowest value [2]. Edward E. Hindman and Bidur P. Upadhyay studied combustion aerosol transport in the Himalayas of Nepal and Tibet [3].

Radiation Physical Discussion :- When any radiation falls on any matter, the following equation is satisfied : $r+a+t=1$, where r is the fraction of total energy reflected and scattered, a is that absorbed and t is that transmitted. Again, Biot's law [$I=I_0\exp(-kd)$, where the symbols have usual meaning] implies that amount of energy absorbed increases geometrically with the amount of absorbing material traversed provided that physical conditions are the same and the material is homogeneous; loss due to scattering also follows the same law although concerned coefficients are quite different [4]. We can consider $K=k+l$, where k stands for true absorption, l stands for scattering and K stands for extinction. Then, $I=I_0\exp(-Kd)$….(1).

Methodology :- Reduction in the amount of incoming Solar radiation reaching earth's surface leads to "dimming". NASA has reported that vertically averaged annual mean solar absorption in the troposphere has been increased and Solar heating at elevated levels over India (and also China) has also been increased. To monitor any change in Effective Optical Strength of Brown Cloud layer, we can follow the ideal model considered in the foregoing paragraph. The basic equation (1) assumes the following forms for a set of observations (1,2, …) at a particular location (with specifications mentioned below) : $I_1=I_0\exp(-Kd_2)$, $I_2=I_0\exp(-Kd_2)$, … , etc. Hence, $I_1/I_2=\exp[-(K_1d_1-K_2d_2)]$. So, $K_2d_2-K_1d_1=\ln I_1-\ln I_2$…(2). Kt (where t=thickness of layer) may be defined as the Effective Optical Strength of Brown Cloud layer. K depends on the concentration of the concerned aerosols and d is the length traversed by the radiation. Measurement of I (intensity of direct incoming Solar radiation) can give us the change in Effective Optical Strength. Specifications of observations are as the following. Observations taken on cloudless days will be only significant. Observations taken around local noon time will be appropriate because incoming Solar radiation traverses shortest length through the atmosphere at that time. Increase in concentration of the concerned aerosols increases absorption and scattering. Increase in thickness of Brown Cloud layer also increases absorption and scattering. But the effect of corresponding decrease in height of the remaining

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part of atmosphere is practically negligible in comparison. Apparent migration of the Sun is in between 23.5 degree N and 23.5 degree S. So, sometime(s) the Sun is on the exact vertical line at local noon time at a place within this belt, not always, and never on the exactly vertical line at noon time at a place beyond this belt. If the elevation of the Sun is E at a place at local noon time, t/d=sinE (d=t when E=90 degree). So, eqn. (2) assumes the form $K_2 t_2 \mathrm{cosec}E_2 - K_1 t_1 \mathrm{cosec}E_1 = \ln I_1 - \ln I_2$…(3). Observation taken on a calendar day at around local noon time may be compared to that taken on the same calendar day every year, for which $E_O=E_O=E$ (say). Mean of a period may be compared for better result. In this way, annual, half decadal, decadal comparison of the Effective Optical Strength of Brown Cloud layer may be made.

So far, we have considered direct incoming Solar radiation. It is also worth mentioning that increase in D/T ratio at non-industrial location will Also indicate increase in Effective Optical Strength of Brown Cloud layer.

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REFERENCES

(A) Books and Journals – | [1] A.A. Ramasastry, Weather and Weather Forecasting, Publication Division (G.O.I.), 1984. | [2] Hamid Ali, Distribution of D / T ratio of diffuse to global radiation over India, Vayu Mandal Vol. 18 No. 1 & 2 Jan. – Jun. 1988, The Indian Meteorological Society. | [3] Edward E. Hindman, Bidur P. Upadhyay, Combustion aerosol transport in the Himalayas of Nepal and Tibet, Vayu Mandal Vol. 29 No. 1 – 4 Jan. – Dec. 1999, The Indian Meteorological Society. | [4] M.N. Saha, B.N. Srivastava, A Treatise on Heat, The Indian Press Pvt. Ltd. (Allahabad), 1980. | (B) Links on Brown Cloud – | Wikipedia, the free encyclopedia; Encyclopaedia Britanicca; NASA |