Laser communication through the atmosphere: role of aerosols and atmospheric boundary layer dynamics

Laser communication through atmospheric channels is an emerging wireless technology, commonly known as Free-Space Optical (FSO) communication. It facilitates unprecedented channel capacity and very large bandwidth, favouring huge-volume wireless data transfer across spatially separated locations. The performance of FSO links depend largely on the channel properties such as atmospheric scattering, absorption, and refractive index fluctuations (represented using its structure parameter C_n^2). The focus of this talk will be on the role of tiny solid/liquid particles suspended in the atmosphere, commonly known as aerosols, on atmospheric refractive index fluctuations (optical turbulence) and their implications for FSO communication. Absorption of solar radiation by aerosols such as Black Carbon (BC) will heat the atmosphere and induce perturbations in C_n^2. Large concentration of BC aerosols at high altitudes are observed to reduce C_n^2. Hence, BC aerosols, usually looked upon as a bane in FSO communication, can be a boon in aerial FSO communication links. Comprehensive in-situ characterization of near-surface optical turbulence, simultaneous with aerosol measurements, will be discussed to delineate the combined effects of aerosols and atmospheric boundary layer (ABL) dynamics on C_n^2 and FSO communication. An inverse relationship between aerosols and C_n^2 has been observed, which is dependent on the aerosol concentration, ABL dynamics, and time of the day. The merits of reduced C_n^2 during nighttime are vitiated by the high aerosol extinction, due to which the nighttime performance of FSO links will not be as high as expected. The results from this talk will highlight the immediate requirement of incorporating the effects of aerosols in C_n^2 models, and while estimating the FSO communication link budget.