

Temperature rise in objects due to optical focused beam through atmospheric turbulence near ground and ocean surface

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When an optical beam is propagated through the atmosphere and is incident on an object, power is transmitted and transferred into the object causing a temperature rise. In clear air, the statistical characteristics of the optical beam transmitted to the object surface are influenced primarily by the effect of atmospheric turbulence which can be significant near the ground or ocean surface. This paper uses a statistical model to quantify the expected power transfer through turbulent atmosphere and provides guidance toward the threshold of thermal blooming for the considered scenarios. For metals, the absorbed power in the object is calculated using a Drude model for dielectric constant and published physical constants. For non-metals, published optical absorptance values are used. For both metals and non-metals the bulk thermal characteristics are used in a thermal diffusion model to determine the net temperature rise at the object surface due to the incident optical beam. These results of the study are presented in graphical form and are of particular interest to operators of high power laser systems operating over large distances through the atmosphere. Numerical examples include a mid-infrared CO₂ laser ($\lambda = 10.6 \mu\text{m}$) with: aperture size of 5cm, varied pulse duration, and propagation distance of 0.5 km incident on 0.1mm copper, 10mm polyimide, 1mm water, and 10mm glass/resin composite targets. To assess the effect of near ground/ocean laser propagation we compare turbulent (of varying degrees) and non-turbulent atmosphere.