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Imaging through the Atmosphere

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Atmospheric optics probably started in the 1700s in response to the early curiosity of why the sky was blue. The color of the sky was explained by the clear air and the fact that air molecules scatter more blue light than yellow or red. We have made progress in our understanding of scattering by looking at absorption of the spectrum, C_n^2, water vapor profiling, and scattering through a turbulent medium. Although the initial studies centered around fundamental understanding of light and scattering, we have advanced to the need and ability to image through the atmosphere.

Turbulent layers in the atmosphere can cause plane waves from a distant point source to become perturbed and distorted. This turbulence is a result of a randomly varying refractive index in the propagation layer of the earth's atmosphere and is affected by many parameters including wind, diurnal conditions, humidity, and altitude. In astronomical imaging, this is the effect that is observed when a star appears to be twinkling or scintillating. When atmospheric phase distortions are severe, the resolution of the imaging sensor is severely limited. At low altitude extended ranges, large f-number imaging systems are very susceptible to these atmospheric effects. In desert conditions specifically, turbulence can become very high causing a significant degradation in image quality. In some scenarios, the turbulence is so severe that objects of interest can be completely lost. The impact of the atmosphere on an imaging system's performance is critical, and therefore understanding, modeling, and mitigating the effects of it are of significant interest to optical researchers.

The papers in this special section cover numerous approaches to imaging through the atmosphere, including characterizing, modeling, classifying, determining system performance, and measurement of optical turbulence. Measurements range from the use of adaptive optics presented by Dong et al. to traditional atmospheric imaging as a function of outer scale turbulence provided by Xie et al. Modeling has become a very important method for simulating system configurations and atmospheric effects on imaging as demonstrated by Charnotskii et al., Lim et al., and Bos et al. Classification and quality of objects as a function of the atmosphere is provided by Yitzhaky et al., Tan et al., and Lukin et al. In addition to classification of objects, performance characterization of imaging systems is important as outlined by Nairat et al. and Marino et al. Characterization and measurement of the atmosphere is provided by Gimmestad et al. using a lidar technique, while Zhang et al. provide a Michelson interferometer approach.

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