Special Section Guest Editorial: Atmospheric Propagation

Steven Fiorino,[a] Alexander M. J. van Eijk,[b] Stephen Hammel,[c] and Alexander Berk[d]
[a]Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, United States
[b]TNO Waalsdorp, The Hague, The Netherlands
[c]Naval Information Warfare Center Pacific, San Diego, California, United States
[d]Spectral Sciences Inc., Burlington, Massachusetts, United States

The Special Section on Atmospheric Propagation is a forum for the presentation of research on the physics of light propagation, optical remote sensing, and EO/IR effects in the atmosphere, to include distributed volume turbulence, gravity waves, vortex shedding, stably stratified turbulence, persistent eddies, and cloud/aerosol/molecular scattering and absorption, refractive effects such as mirages and over-the-horizon viewing, as well as characterization of these phenomena.

Research was solicited on distributed volume turbulence in terms of Kolmogorov and non-Kolmogorov turbulence, optical beam properties, scintillation effects, phase variance, branch points, etc. Also sought were studies on the effects of meteorological phenomena such as refractive layers, boundary layer measurements, stratified turbulence, gravity waves, vortex shedding, large scale eddies, micro-meteorology, and cloud/aerosol extinction. Methods to address these turbulence and extinction effects can be, and have been to some extent, addressed with atmospheric modeling and simulation (M&S) that include multi-phenomena atmospheric characterizations and computationally efficient methods to incorporate physically realistic characterizations into M&S. The M&S techniques exploit numerical weather prediction (NWP) modeling and attempt to enhance it with turbulence and aerosol content characterizations that are not common NWP products. Further improvement of NWP is expected from atmospheric measurement devices that go beyond standard pressure, temperature, humidity, and wind sensors and include the potential implementation of turbulence measuring devices such as sonic anemometers, scintillometers, time-lapse imagers, digital holographic instruments, and aerosol/particle measurement devices such as water and alcohol-based condensation particle counters and particle sizers.

Al-Younis et al. developed and studied two approaches for the prediction of optical refraction effects in the lower atmosphere. Low-cost, time-lapse camera systems were deployed to measure image displacements of mountain ridge targets due to atmospheric refraction. Measurements were compared with image displacement predictions provided by (1) a ray-tracing evaluation of NWP data and (2) a machine learning algorithm with measured meteorological values as inputs. The displacement prediction results for both methods were found to be consistent with the field imagery in overall amplitude and phase.

Mark Spencer submitted two papers that used wave-optics simulations to look at the Monte Carlo averages associated with turbulence and steady-state thermal blooming (SSTB). The first implemented steady-state simulations; the second considered time-dependent simulations. The goal was to investigate turbulence thermal blooming interaction (TTBI). At wavelengths near 1 μm, TTBI increases the amount of constructive and destructive interference (i.e., scintillation) that results from high-power laser beam propagation through distributed-volume atmospheric aberrations.

Abdullah-Al-Mamun and Voelz described the effects of a temperature inversion layer in the lower atmosphere on dispersion and angle of arrival of highly directional beams such as those associated with near-surface free space optical communications systems. For a single wavelength, a linear increase of angle of arrival with initial launch angle was found for the standard atmosphere, but this trend was significantly altered in the presence of an inversion layer.

Continuing along the free space optical communications research effort, Beason et al. studied the impact of probability density function (pdf) model choice on intensity-modulation direct-detection free-space optical communication analyses. They concluded that the shape (skewness) of the pdf can have a profound effect on the predicted system performance. Fiorino et al. demonstrated how many years' worth of NWP data could be used to assess free space optical communication system link performance at any location using a bit error rate (BER) metric. The BER metric used NWP to calculate turbulence and extinction effects, to include cloud free line of sight (CFLOS). A surprising result was that the BER metric was useful in characterizing weather phenomena even at BERs far too high to be considered useful for laser communications.

McCrae et al. described an experiment that was conducted to study turbulence along a 149 km path between the Mauna Loa and Haleakala mountain tops using digital cameras and LED beacons. Much of the path is over the ocean, and a large portion of the path is 3 km above sea level. Long-range time-lapse photography captured how turbulence along the path induced tilts on the wavefronts which resulted in displacements of the LED spots in the images. Weighting functions allowed for an optical calculation of the turbulence at a point along the path over water. This was compared to the turbulence value derived from NWP calculations.

Finally, Zuraski et al. developed a method for extracting tomographic turbulence strength estimations from a dynamically ranged Rayleigh beacon system that uses a Shack–Hartmann sensor as the phase measurement device. They presented the chosen processing algorithm's foundation and provided a discussion of the utility of this algorithm as an atmospheric turbulence profiling methodology.