An optical stereoscopic method for range-resolved retrieval of the cross-path wind velocity

Shiril Tichkule[1] and Andreas Muschinski[2]

[1] Department of Electrical, Computer, and Energy Engineering, 425 UCB, Boulder, Colorado 80309, USA

[2] NorthWest Research Associates, 3380 Mitchell Lane, Boulder, Colorado 80301, USA

The horizontal wind velocity close to the Earth's surface is a critical variable in the study of the planetary boundary layer (PBL) and hence, accurate and precise measurements of the wind velocity form an integral part of atmospheric studies. To study the remote retrieval of the localized horizontal wind velocity, we conducted a field experiment in August 2012 at the Boulder Atmospheric Observatory near Erie, CO, first results of which are presented and discussed here. One of the main objectives of this experiment was to explore the usefulness of stereoscopic measurements of turbulent angle-of-arrival (AOA) fluctuations of optical waves emitted from two, horizontally spaced test-light arrays for the retrieval of the horizontal wind velocity component transverse to, and at a designated range along the propagation path. This research builds on a previous study (Tichkule and Muschinski, 2012: Optical anemometry based on the temporal cross-correlation of angle-of-arrival fluctuations obtained from spatially separated light sources. *Appl. Opt.*, **51**, 5272-5282), where we retrieved path-averaged, beam-transverse wind velocities from a single light array-telescope pair.

The crux of our methodology lies in the cross-correlation function of the AOAs obtained from two test lights which have their lines of sight to two, spatially separated telescopes, intersecting at the the center of the propagation path. When a transverse wind cuts across light beams from two such sources, there are observable delays in the AOA fluctuations induced by eddies carried along the wind as they cut through the two beams. Moreover, the cross-correlation function of the AOA fluctuations can be expected to be dominated by the characteristics of turbulent eddies that advect across the the small intersection volume of the overlapping ray cones. If the geometrical parameters of the problem such as the dimensions and separations of the test-light arrays and the telescopes are known, then the AOA cross-correlation function can be used to retrieve the beam-transverse horizontal wind velocity at the intersection point along the propagation path. Optical data along with in-situ wind measurements for reference and calibration purposes was collected on the night of August 14, 2012 over a period of seven hours at the Boulder Atmospheric Observatory site near Erie, Colorado. Two arrays of four LED sources, each arranged in a square ($10\,\mathrm{cm} \times 10\,\mathrm{cm}$) positioned at 1.7 m above ground level, were observed with two Schmidt-Cassegrain telescopes having an aperture diameter of 36 cm, over a path length of 174 m. The two test-light arrays (TLAs) were laterally spaced by 2.03 m, and the two telescopes were laterally spaced by the same distance. The left telescope pointed to the right TLA, and the right telescope pointed to the left TLA, such that the two propagation paths intersected at the half-way point, i.e., at a range of 87 m. Each telescope was equipped with a 640×480 pixel CCD camera, each of which collected 60 images of the respective TLA per second. AOA-retrieved, path-transverse wind velocities are compared with those measured by collocated ultrasonic anemometers so as to provide a quantitative picture of the accuracy of this stereoscopic technique of range-resolved optical anemometry.