

Temporal Evolution of Wavelength and Orientation of Atmospheric Canopy Waves

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Atmospheric canopy waves are small-scale vertical oscillations of the stable boundary layer that occur near the top of forest canopies due to the drag exerted by the trees. An inflection point in the mean wind speed profile causes Kelvin-Helmholtz instability which excites the waves. If the waves increase in amplitude over time, they may break and generate turbulence that is an efficient transporter of heat, trace gases, and momentum. Therefore, we are studying the temporal evolution of atmospheric canopy waves using scanning lidar data.

We apply an algorithm to horizontally scanning aerosol lidar images and objectively determine canopy wave wavelength and wave crest orientation. We apply the algorithm (described by Mifsud et al., 2021) to scans from the Raman-shifted Eye-safe Aerosol Lidar (REAL) from the Canopy Horizontal Array Turbulence Study (CHATS). The data set includes 53 episodes of canopy waves distributed over a three-month period (Mayor, 2017). Episodes ranged from a few minutes in duration to more than an hour in some cases. Therefore, the number of scans (or frames) in an episode ranged from 7 to 148. The algorithm determines a single salient wavelength and orientation angle of the waves from a square subset of pixels that is typically hundreds of meters wide in both horizontal directions in a single lidar scan.

Mifsud et al. (2021) demonstrated that the objectively determined wavelengths and orientations were very close to subjectively determined values. In that work, only one frame per episode was examined. In the present work, we apply the algorithm to all frames of all episodes in an effort to monitor the temporal evolution of wavelength and orientation. However, in doing so, our preliminary results indicate that some case-to-case adjustment of the algorithm's interrogation window is necessary in order to prevent it from being distracted by other image features such as hard-target reflections and other non-wave aerosol structures. However, some episodes do not require adjustment of the default interrogation window and in these cases, we have observed small, gradual, natural changes in canopy wave wavelength and orientation.

By carefully applying the algorithm to all frames in an episode we can efficiently and objectively monitor the wave characteristics over time. We plan to show how wavelength and wave crest orientation evolve over all episodes and compare those results with in situ measurements from coincident tower-mounted ultrasonic anemometers and other fast-response sensors.