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# DarkMix: Towards a three-dimensional observation system for resolving the weak-wind boundary layer

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Turbulence in the weak wind, stable boundary layer presents a fundamental challenge to boundary layer meteorology, violating similarity theory and breaking the assumptions necessary for interpreting turbulence observations (e.g., Taylor's Hypothesis). While models predict turbulence to be suppressed and vanish in strong stability, observations confirm the presence of very weak, but finite turbulence of temporally varying strength even for strongest stabilities. The long-term scientific goal of the project is to find the physical mechanisms generating the weak, but finite turbulence in the near-surface layer when strong synoptic forcing is absent. The weak-wind boundary layer has remained the largely unexplored 'dark side' of surface meteorology despite its significance and prevalence across large fractions of the earth surface such as valleys, forests, cities, and snow-covered surfaces. The failure of models during weak-wind conditions and the limitations of current observational techniques motivates the development of new methods for observing the weak-wind boundary layer. We are developing a new approach based on fiber optic (FO) distributed temperature sensing (DTS). The goal of this new system is to observe the distributed three-dimensional structure of turbulence within the weak-wind and/or stable boundary layer at 1s temporal and 1m spatial resolution. Our studies to date demonstrated that FO-DTS is a promising avenue for developing the new observation platform as it can resolve atmospheric temperature at fine temporal and spatial resolution ($\sim$1s and $\sim$10cm). Additionally, paired heated/unheated cables can be used to determine the wind speed normal to the FO cables at a similar resolution.

Here, we present results from two necessary first steps in developing this new observational method 1) understanding how the derived wind speed depends on the angle of attack between the angle normal to the heated fibers and the direction of the mean wind and 2) to characterize the time response of the DTS system. The wind speed derivation will be tested using the paired heated/unheated cables within a wind tunnel. Results will be used to inform the angular dependence of the derived wind speed. Additionally, initial field tests characterizing the time response for various cable type and DTS instrument pairings yield a temporal response time of approximately 2s. Finally, we present early prototype results of using small, oriented shapes attached to the fiber in order to determine wind direction. Small barbs, or other asymmetric shapes, may impart a directional sensitivity to wind speed, which is a desirable trait when designing a three-dimensional observation system.