Geophysical Research Abstracts
Vol. 21, EGU2019-8728, 2019
EGU General Assembly 2019

Toward spatial eddy covariance using high-resolution fiber-optic distributed sensing: adding wind direction to measure full three-dimensional turbulent flows

Karl Lapo (1,2), Anita Freundorfer (1), Lena Pfister (1), Johann Schneider (1), Christoph Thomas (1,2)

(1) Universität Bayreuth, Micrometeorology, Bayreuth, Germany (karl.lapo@uni-bayreuth.de), (2) University of Bayreuth, Bayreuth Center of Ecology and Environmental Research (BayCEER), Bayreuth, Germany

Distributed Temperature Sensing (DTS) allows for spatially-distributed observations of temperature at a fine spatial ($\sim$10cm) and temporal ($\sim$1s) resolution. This technique has been used to observe a wide range of geophysical processes on a spatially distributed basis including air temperature, wet bulb temperature, solar radiation, and wind speed. We refer to this broader application of DTS technology as Fiber Optic Distributed Sensing (FODS). Here we aim at filling a missing gap in the capabilities of FODS by demonstrating the ability to observe wind direction in addition to wind speed and air temperature at submeter and second scales. One of the goals the project DarkMix, funded by the European Research Council (ERC), is the development of a FODS which is capable of taking spatially resolved full 3-dimensional flow observations and temperature to enable computation of flow statistics including true spatial eddy covariance flux densities. The focus of DarkMix is observing atmospheric turbulence during the weak-wind regime. Stable and weak-wind boundary layers break many of the assumptions that underlie time-domain eddy-covariance techniques as well as common similarity theories, which forms an obstacle for understanding the dynamics during weak-wind conditions. One viable pathway of developing this full 3-D FODS sensor is using artificial microstructures applied to a pair of actively heated cables to create a convective heat loss, and thus temperature difference, that is sensitive to wind direction.

We present results of the FODS approach of observing wind speed from 1) wind tunnel experiments and 2) an atmospheric deployment. The first set of experiments was used to identify the best performing microstructure design. The second experiment was performed using the optimal design in order to characterize the ability of the microstructures technique for determining wind direction at turbulence length- and time-scales. Finally, we discuss the potential of applying FODS to the development of a fully-3D flow sensor of the atmosphere that can observe atmospheric processes across multiple scales and on a spatially-distributed basis. FODS of wind direction opens the door for observing these conditions without relying on the oft violated assumptions (e.g., stationary flows). We demonstrate the potential of this new technique by characterizing turbulent flows under a variety of conditions for both horizontal and vertical winds.