Observations of Tall-Building Wakes in Berlin's Urban Boundary Layer Using Two Doppler Wind Lidars

Matthew Clements[1], Janet F. Barlow[1], Sue Grimmond[1], Daniel Fenner[2], William Morrison[1,2], Andreas Christen[2]

[1]Department of Meteorology, University of Reading [2]Environmental Meteorology, University of Freiburg

As the population of urban areas increases, they grow horizontally and vertically, with tall building clusters now a characteristic feature of many large cities. The presence of tall buildings affects airflow both locally and downwind, therefore impacting on the dispersion of heat, pollutants and moisture generated by anthropogenic activities. Much of the current understanding concerning flow processes around tall buildings comes from modelling work, both numerical (e.g. Large Eddy Simulation models) and physical (e.g. wind tunnel experiments), with limited observations of tall building wakes in real urban areas. This project aims to address this issue using measurements from two doppler wind lidars (DWLs) deployed close to a tall building cluster in Berlin.

A DWL is a remote sensing instrument that measures the doppler shift of a backscattered laser beam, from which the line-of-sight (radial) velocity of the scattering particles (e.g., aerosols, clouds) can be determined. The instrument can be configured to perform a variety of scan types, each of which yields valuable information regarding the state of the atmospheric boundary layer; for example, stare scans (90° beam elevation) provide vertical profiles of velocity and aerosol backscatter, whilst Velocity Azimuth Display (or VAD) scans (i.e., a conical scan around zenith at a set elevation and range of azimuth angles) can be used to obtain vertical profiles of the horizontal wind components. DWLs can also perform 'flat' scans (0° elevation through a range of azimuth angles) which have been used in previous urban studies to observe the wake effects of tall building clusters.

From June to September 2022 two DWLs were deployed in central Berlin. One was approximately 1 km to the northwest and the other 1 km to east of a tall building cluster. The DWLs were configured with identical scan schedules, including: (i) VAD scans for wind profiles taken at 5-minute intervals, (ii) flat scans aimed at observing the wake effects of the tall building cluster at 5-minute intervals, and (iii) continuous vertical stare scans at all other times.

Data processing, using the Finnish Meteorological Institute (FMI) Python/MATLAB toolkit, involves background correction and instrument focus (for the DWL east of the tall building cluster, this correction is manual) and signal-to-noise (SNR) filtering to ensure good data quality. Radial velocity and backscatter measurements from the flat scans are averaged for the observation period by wind direction (obtained from the conical scans) to identify characteristic features of the wakes under different background flow conditions. The results provide a unique insight into the flow around a tall building cluster, as this is the first study to observe wake effects from two DWLs operating simultaneously.