Complex network analysis of wind tunnel experiments on the passive scalar dispersion in a turbulent boundary layer

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Abstract:
The characterization of pollutant transport is crucial for the analysis and modeling of the atmospheric boundary layer [1]. In this work, experimental data of passive scalar plumes in a turbulent boundary layer are investigated. The experiments are performed in a wind tunnel where the passive scalar is injected through an L-shaped tube located at $z/\delta = 0.24$, with δ the boundary layer thickness. Specifically, two source configurations are analyzed for two different tube diameters, $D = 3$ mm and $D = 6$ mm. The streamwise, u, and wall-normal, w, velocity components, and the concentration, c, are measured at different distances from the source and at various wall-normal and spanwise locations. The corresponding time-series are recorded for $T = 180$ s with a sampling frequency of 1000 Hz. A sketch of the experimental setup and representative time-series at fixed spatial location is reported in Fig. 1a.
By exploiting the recent advances of complex networks theory, the velocity and concentration time-series are mapped into networks, where each time-sample corresponds to a node. Different algorithms to construct a network from a time-series are explored. One of the simplest and most adopted approaches is the *visibility algorithm* [2, 3]. In a visibility-based network a link exists if the straight line connecting two data-samples lies above the other in-between data. Accordingly, a visibility network is built for each velocity and concentration time-series at different measurement locations (e.g., see Fig. 1b). The resulting network topology inherits the temporal features of the mapped time-series, revealing non-trivial information of the underlying transport process. Due to their versatility, complex networks offer a powerful and synthetic tool for the analysis of turbulent transport and mixing.

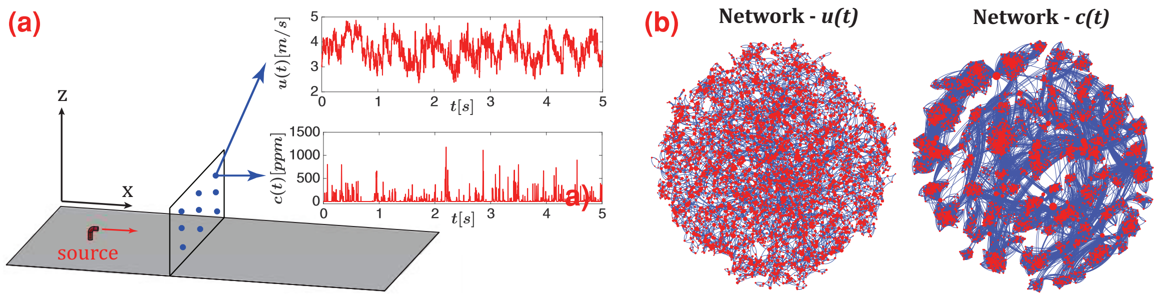

Figure 1: *(a) Sketch of the wind tunnel set-up and representative velocity and concentration time-series; (b) Networks built from the time-series shown in panel (a).*

References

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