Tracking eddies in wall-bounded turbulence

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Summary:

Eddies, understood as regions of the flow which maintain spatial and temporal coherence, are widely used by the turbulence community as a conceptual model to organize of the flow. However, are they really there? Can they be identified and tracked in time? The present work deals with the temporal evolution of vortices and eddies responsible for the momentum transfer in turbulent channels, which are studied via time-resolved direct numerical simulation at high Reynolds numbers in a 500 Terabytes database. Eddies are identified as connected regions of the flow above a prescribed threshold, and tracked in time with novel method specifically designed for the task. Once the evolutions are properly organized, they provide all the necessary information to test the coherence of the eddies and to characterize their lives from birth to death. Finally, all the new information is compiled to build a new structural model for the logarithmic layer of wall-bounded turbulence based on self-similar sweep–ejection pairs embedded within streamwise rolls as the fundamental dynamical units of the flow.
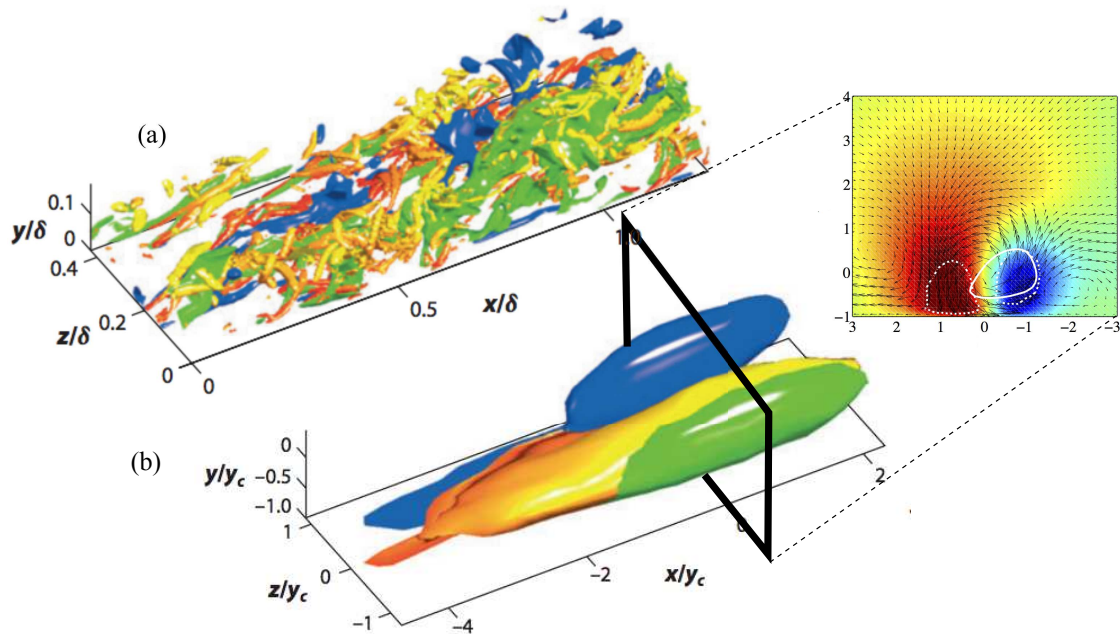
Figure 1: (a) Instantaneous sweep–ejection pair in the log-layer of a turbulent channel. Green (ejections) and blue (sweeps) surfaces are isocontours of intense Reynolds stress, and the yellow-red ones vortices. (b) Average sweep–ejection pair and conditional velocity in the cross section. Flow moves from bottom-left to top-right.