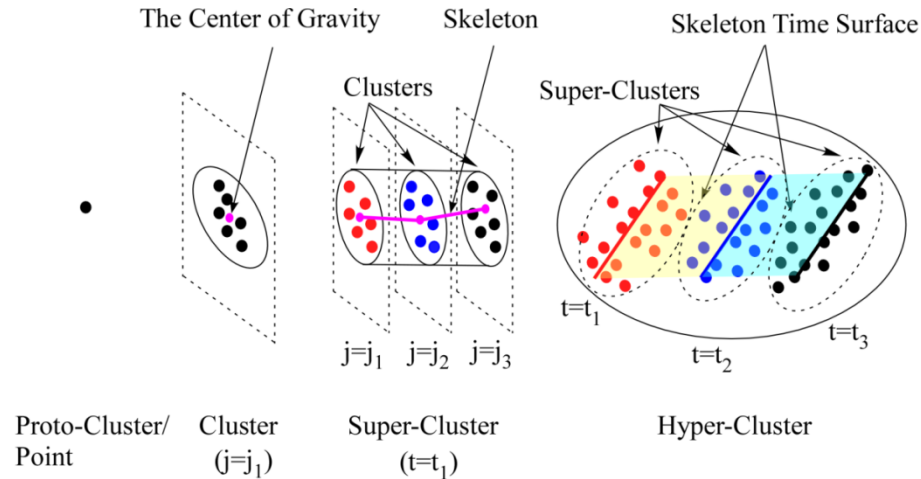


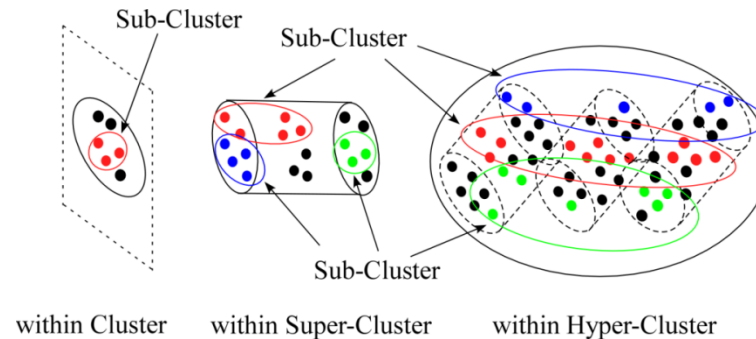
Hierarchical Vortex Clustering (4/5)

Hierarchical Clusters and Its Subsets Proposed in This Study: *p*-cluster (*p*: *proto*, *sub*, *super*, *hyper*)

(a) Fundamental clusters of various levels



(b) Subclustering within fundamental clusters

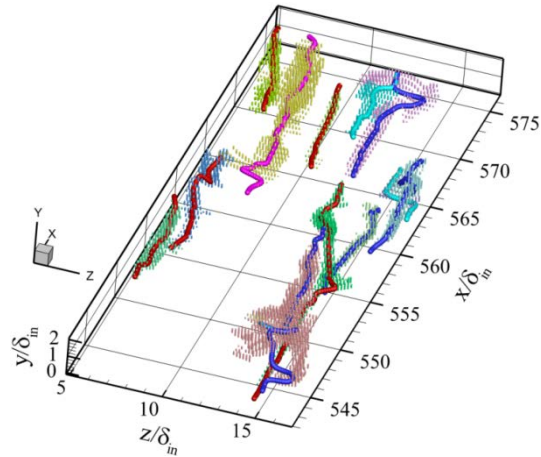


Hierarchical Vortex Clustering (2/4) - Uni-directional Clustering

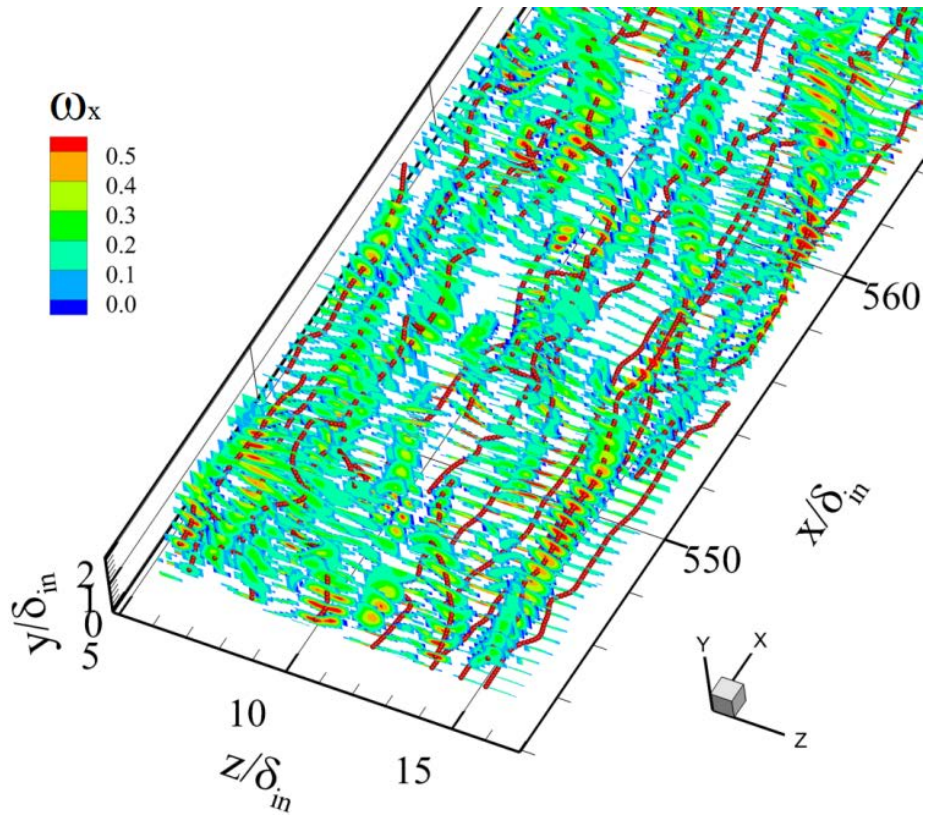
(c) Super-cluster elements and its skeletons at $t=0$.

Only a few clusters are shown for clarity.

Red/Pink: the skeletons of super-clusters with $\omega_x > \omega_{x,0}$,
 Blue/Cyan: those with $\omega_x < -\omega_{x,0}$

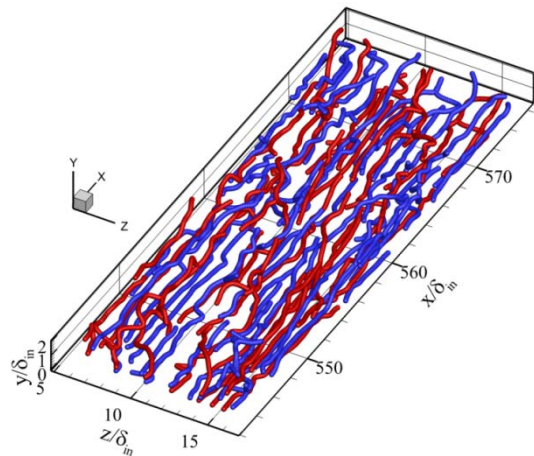


Distribution of ω_x on the streamwise series of x-planes, and the skeletons of super-clusters with $\omega_x > \omega_{x,0}$ at $t=0$. Only the regions with $\omega_x > \omega_{x,0}$ are shown for the series of x-planes



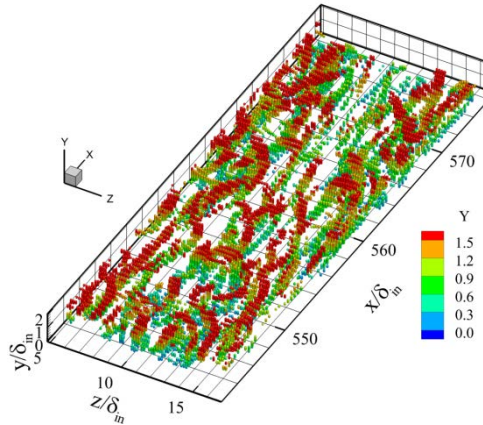
All skeletons of super-clusters with $|\omega_x| > \omega_{x,0}$ at $t=0$.

Red: $\omega_x > \omega_{x,0}$, Blue: $\omega_x < -\omega_{x,0}$

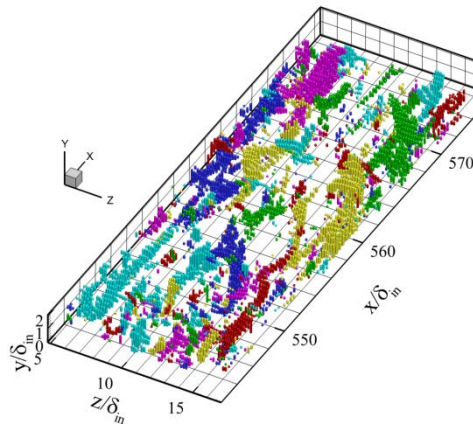


Clustering based on a vortex axis

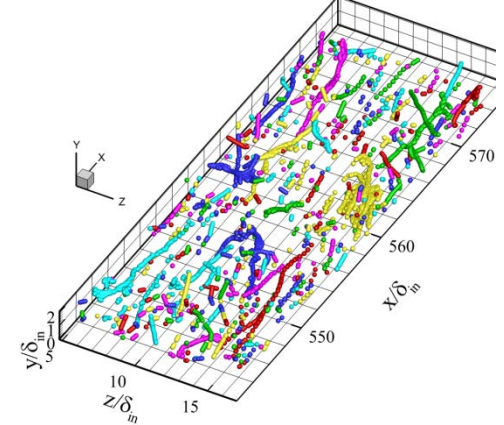
Proto-clusters/Points



Super-clusters

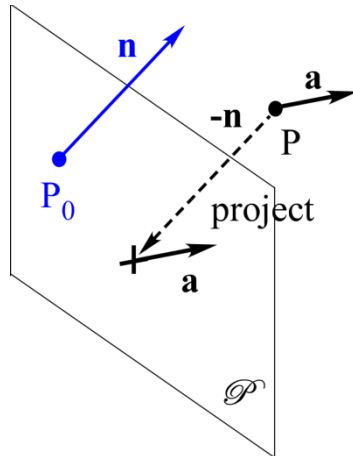


Skeletons



Evaluation of CGs

Projection of Point P to Plane \mathcal{P} going through the selected Point P_0 and having the normal vector \mathbf{n} . Here, \mathbf{n} is the vector averaged around Point P_0 .



Clustering of Points P_1' , P_2' and P_3' on Plane \mathcal{P} , the CG and the averaged vector at the CG

