Course offered for the PhD program in Civil, Chemical and Environmental Engineering
Curriculum in Fluid Dynamics and Environmental Engineering
(Possibility of participation for students in other PhD cycles or other PhD courses)

1. Title
Mixing Processes in Fluids

2. Course Description
The course initially provides the general ideas of the concept of eddy diffusivity in the realm of turbulent transport. Heuristics arguments will be accompanied to quantitative analysis mainly based on asymptotic methods. The so-called homogenization strategy, based on a formal multiple-scale expansion, will be carried out and the resulting effective equation for the pollutant concentration will be discussed and analyzed. This effective equation has the structure of a diffusion equation with an effective diffusivity (the eddy diffusivity). Examples where the eddy diffusivity can be obtained analytically will be also discussed. Generalizations to situations where the eddy diffusivity is a field (i.e. it depends on spatial coordinates) will be considered. The course proceeds introducing the theoretical basis of absolute and relative dispersion. The first one mainly concerns with predicting the path of a single fluid particle or the path the centroid of a cluster of particles in a turbulent flow. The statistical analysis of the absolute dispersion provides valuable information regarding the mixing regimes related to a particular turbulent flow. Relative dispersion, instead, is the analysis of the spreading of an initially close cluster of fluid particles, which is strongly related to the turbulent flow scales involved. Several examples to real flows will be discussed during the lessons, e.g. riverine flows, atmospheric and oceanographic flows. The course ends with an introduction to the concepts of Finite Size and Time Lyapunov Exponents and Lagrangian Coherent Structures (LCS), which are becoming a reliable tool applied to the description of the main mixing processes in a real turbulent flow context.

3. Course Organization
The course consists of frontal lectures and some computer-based tutorials.

4. Teacher
Andrea Mazzino andrea.mazzino@unige.it
Giovanni Besio giovanni.besio@unige.it

5. Duration and credits
20 hours/4 credits
10 hours - Eddy-diffusivity via multiple-scale expansion (homogenization)
10 hours - Relative and Absolute Dispersion, single and multiple particles statistics, Finite Size and Time Lyapunov Exponents, Lagrangian Structures

6. Deadline for registration
Registration within the 5th of May 2025
Please register here https://forms.gle/FEiwNVFwSg3AfDoKA

7. Teaching period Schedule June 2025

	Mon	Tue	Wed	Thu
9.00-11.00	-	Room A13	Room A12	Room A6
11.00-13.00	Room A12	Room A13	Room A12	Room A6
14.00-16.00	Room A12	Room A13	Room A12	
16.00-18.00				-

8. Final exam
Personal project based on a tutorial proposed by the teachers.