Méthodes expérimentales avancées

Master Turbulences : Méthodes et Applications

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9/09/2025

Advanced experimental methods in turbulence (3ECTS)

- Introduction and Jupyter Notebook + open data (1h30): Today

  + Introduction to LaTeX (1h30): Today

- 3 Turbulence Practical Works (TP) by your choice in groups of 3-4 (9h):

  Mardi 16 septembre 13h30-16h45 : TP1, TP6 ou 8h00-11h15 : TP2

  Mardi 7 octobre 13h30-16h45 : TP1, TP6, TP9

  Mardi 25 novembre 13h30-16h45 : TP2, TP9, TP14

- Each TP is followed by a TD for data treatment (9h):

  Mardi 30 septembre 13h30-16h45

  Mardi 14 octobre 13h30-16h45

  Mardi 2 decembre 13h30-16h45

- 4 TP démonstration (in the timetable): TP4a, TP5, TP10, TP13

- Followed by 2 TD for TP demos (6h):

  Mardi 4 novembre TD du TP13

  Mardi 9 decembre TD du TP4a

List of TPs

- TP 1 soufflerie aérodynamique : sillage turbulent
- TP 2a soufflerie grille active : Turbulence Homogène Isotrope
- TP 2b data soufflerie grille Modane : Turbulence à très haut nombre de reynolds (2025)
- TP 3 soufflerie axisymétrique libre : jet turbulent (2026)
- TP 4a démonstration plaque tournante Coriolis LEGI : Turbulence stratifiée en rotation
- TP 4b plaque tournante ISTERRE (2026)
- TP 5 démonstration canal à houle LEGI : Turbulence d'ondes (archives 2024)
- TP 6 plaques vibrées/gongs : Turbulence d'ondes
- TP 7 canal à pente variable : couche limite turbulente rugueuse (2026)
- TP 8 canal à écoulement gravitaire stratifié : turbulence stratifiée sur pente (archives 2023)
- TP 9 couche limite atmosphérique en montagne : couche limite atmosphérique turbulente
- TP 10 démonstration couche de mélange avec cavitation : Turbulence compressible (archives 2023)
- TP 11 colonne à bulle : Turbulence diphasique (archives 2023)
- TP 12 suivi lagrangien : Turbulence diphasique (archives 2023)
- TP 13 démonstration atomisation de jet : Turbulence diphasique
- TP 14 démonstration turbulence grille oscillante (H20 / Helium)

Main Tps
TP demos
Not available

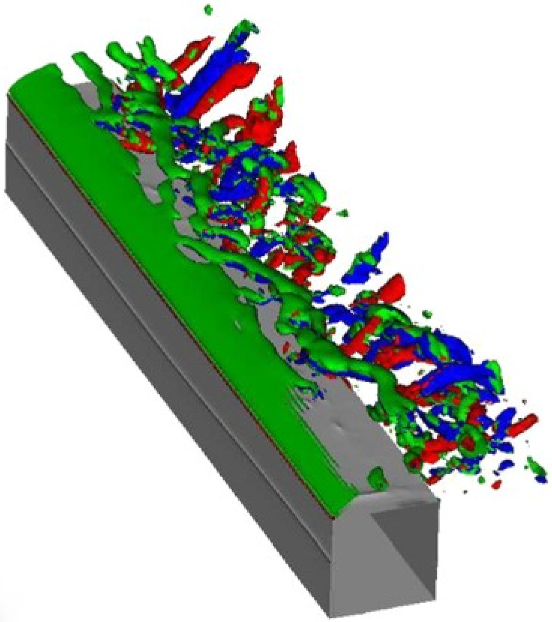
TP 1 soufflerie aérodynamique : sillage turbulent

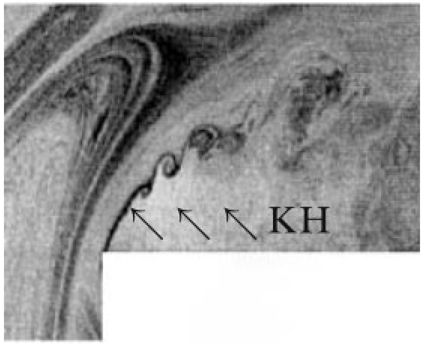
- Kelvin-Helmholtz instability vs Karman instability
- the near wake generated behind a cylinder will be studied using hot-wire anemometry and multi-hole pitot tubes
- Hot wire measurements:

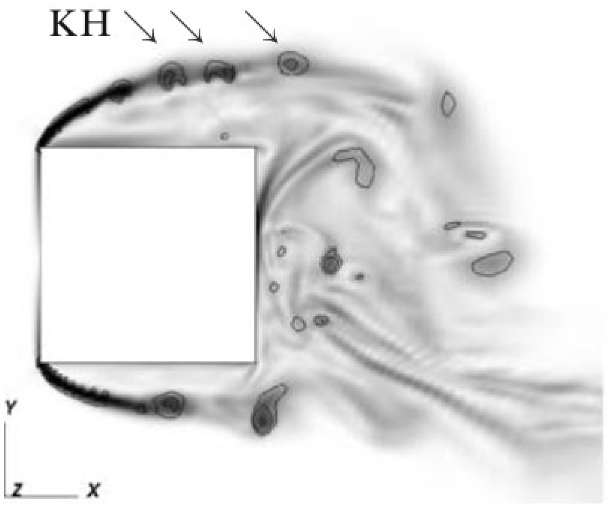
    U(t) (f=10 kHz)

- 3D pitot measurements:

    U(t),V(t),W(t) (f=1 kHz)





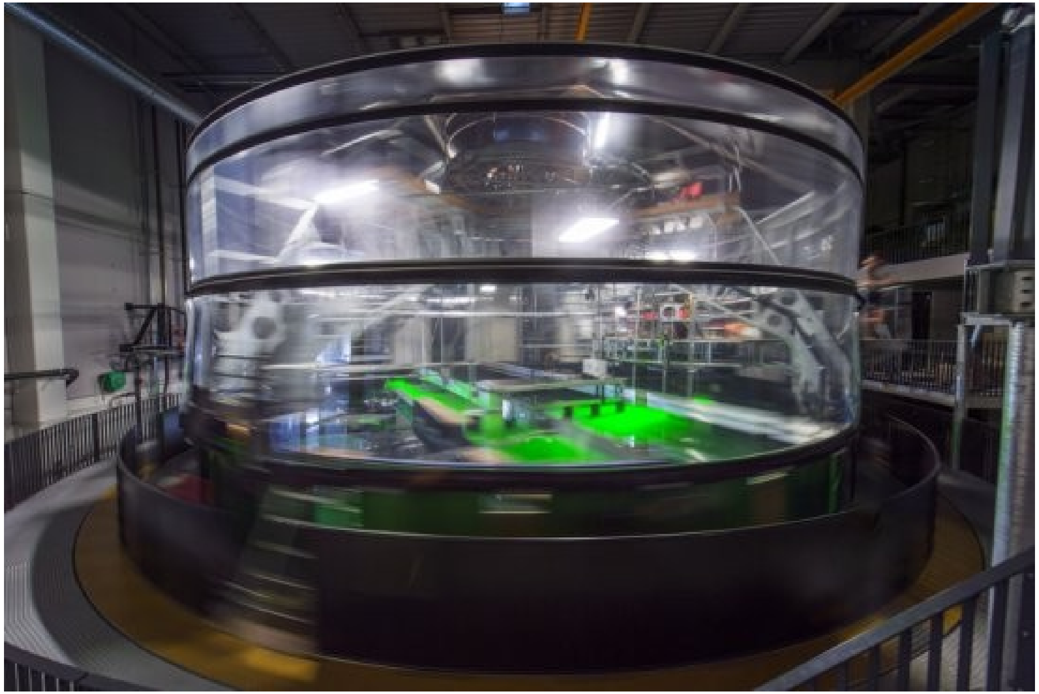


TP 2a soufflerie grille active : Turbulence Homogène Isotrope

- Grid-generated homogeneous isotropic turbulence
- Active grid is used to generate ideal homogeneous isotropic turbulence to study many predictions from Kolmogorov's phenomenology.
- Hot wire: U(t), Pitot: U(t) V(t) W(t) => Reynolds stress <u'_i u'_j>

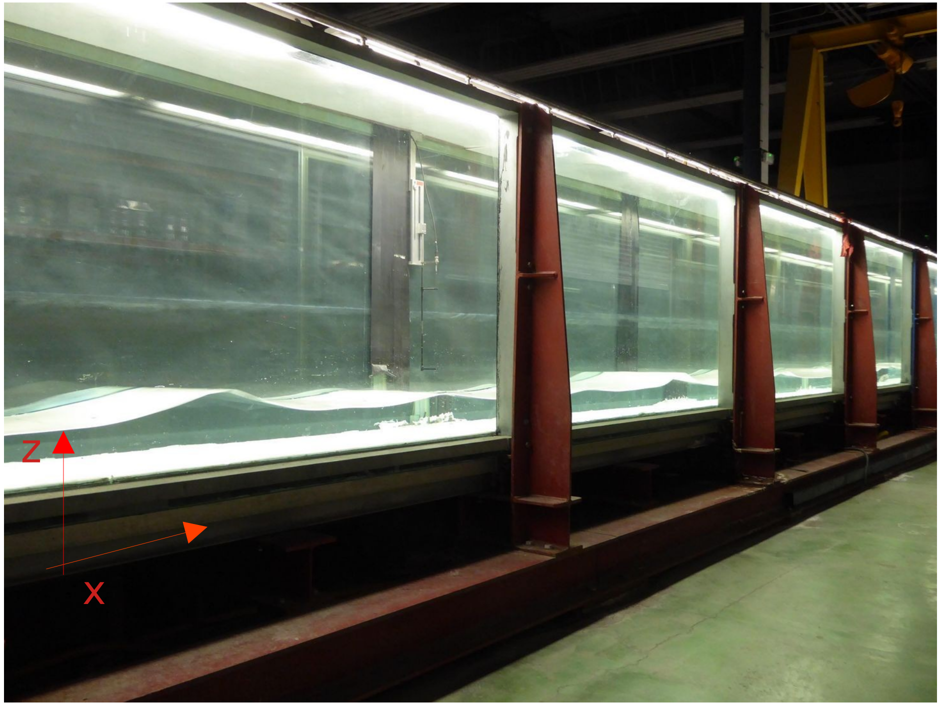
TP 4a démonstration plaque tournante Coriolis LEGI : Turbulence stratifiée en rotation (demo)

- The Coriolis platform
- a unique infrastructure to model experimentally atmospheric and oceanic flows close to what occurs in nature
- using PIV and ultrasonic probes to demonstrate this mechanism for coastal eddy generation in two-layer flow
- PIV: U(x,y,t) V(x,y,t)



TP 5 démonstration canal à houle LEGI : Turbulence d'ondes (demo)

- 36 m wave channel of the LEGI
- The free surface elevation is recorded over a 16 m portion with 8 cameras providing sub-millimeter resolution.
- Camera: elevation z(x,t)

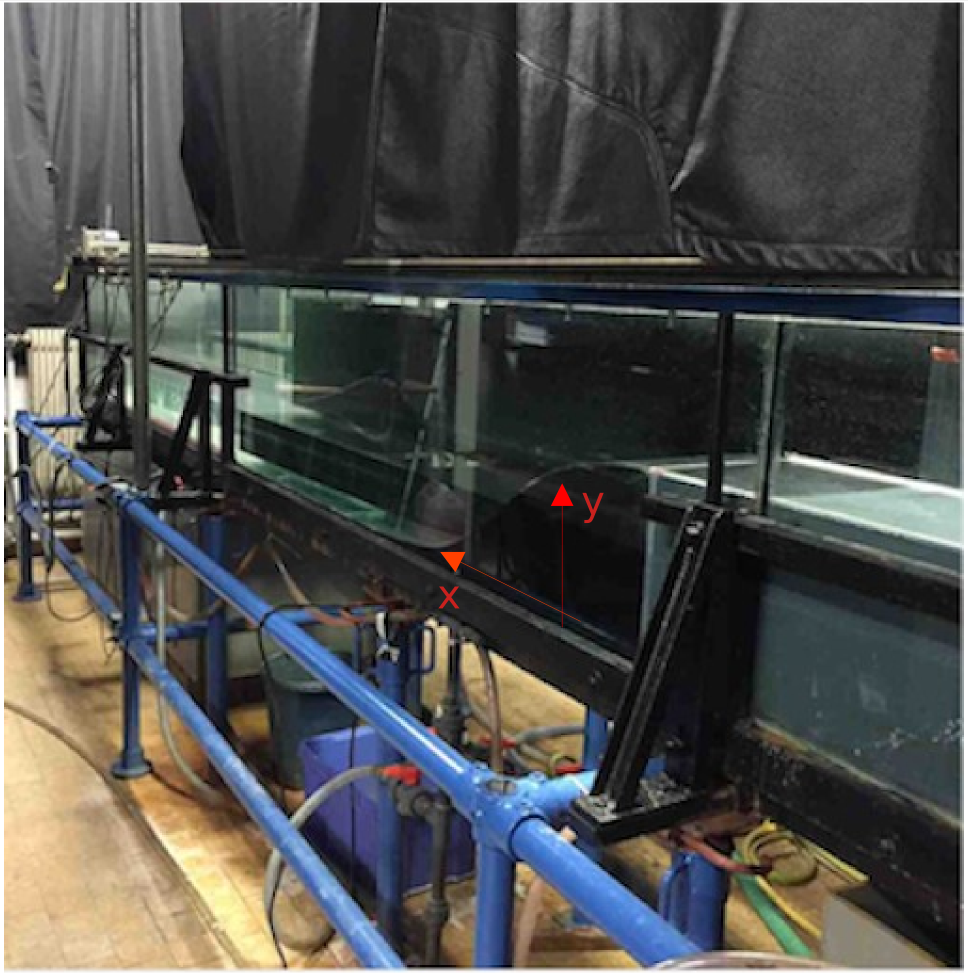


TP 6 plaques vibrées/gongs : Turbulence d'ondes

- Turbulence of waves on a vibrated plate
- Turbulence of bending waves propagating in a vibrated thin plate or a gong.
- The statistical properties will be characterized by simple acoustic measurements of the noise emitted and then a direct measurement of the vibration will be carried out using a profilometry technique using rapid imaging.
- z(x,y,t)

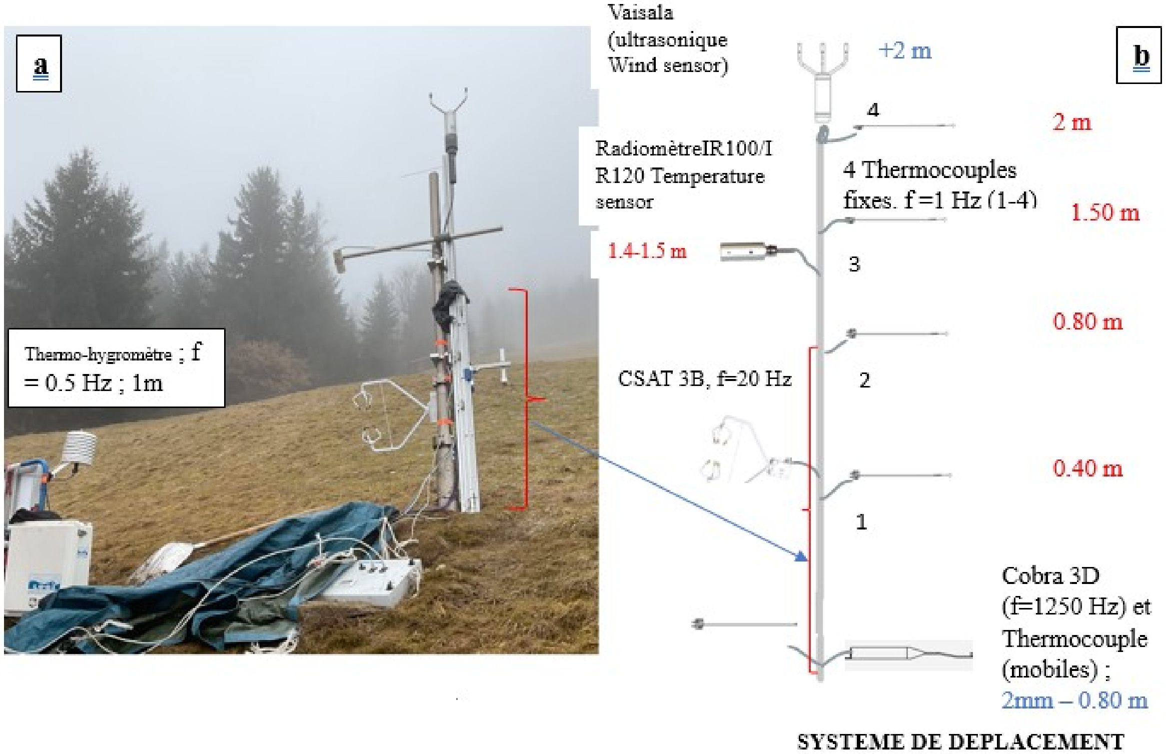
TP 8 canal à écoulement gravitaire stratifié : turbulence stratifiée sur pente

- Stratified gravity currents
- study the dynamics of the gravity current, determining their speed and height evolution, the shear instabilities that induce turbulent mixing.
- Particle Image Velocimetry for the 2D velocity fields and fluorescent dye injections for the visualizations.
- PIV: U(x,y,t) V(x,y,t)



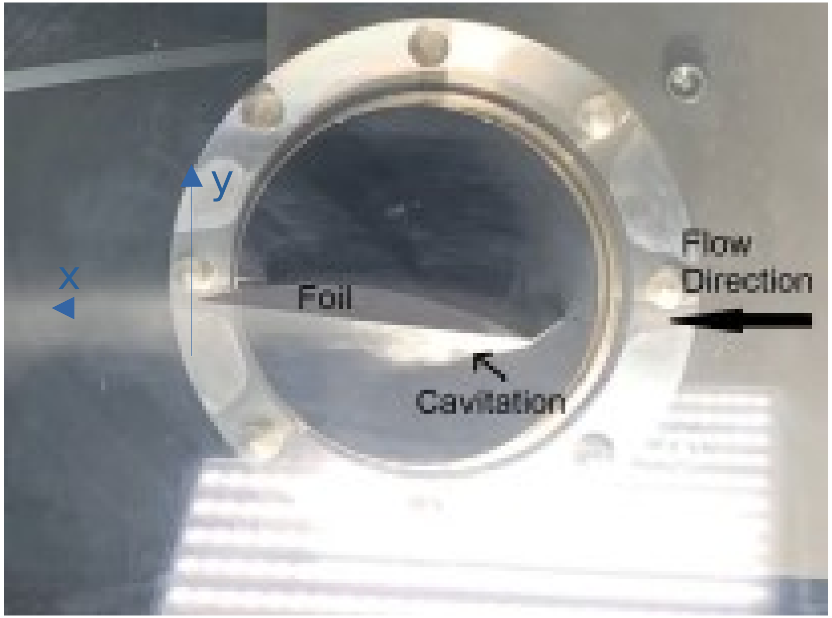
TP 9 couche limite atmosphérique en montagne : couche limite atmosphérique turbulente

- In situ measurement of the atmospheric boundary layer
- various means of measurements and analyze the profile of boundary layers
- Sonic anemometer: u(t), v(t), w(t), T(t) (f=20Hz) + turbulence measurement



TP 10 démonstration couche de mélange avec cavitation : Turbulence compressible (demo)

- Cavitating flow analysis around a NACA profile
- visualization of the dynamics of a cavitation
- Analysis by PIV of the Velocity field around a profile
- U(x,y,t) V(x,y,t)

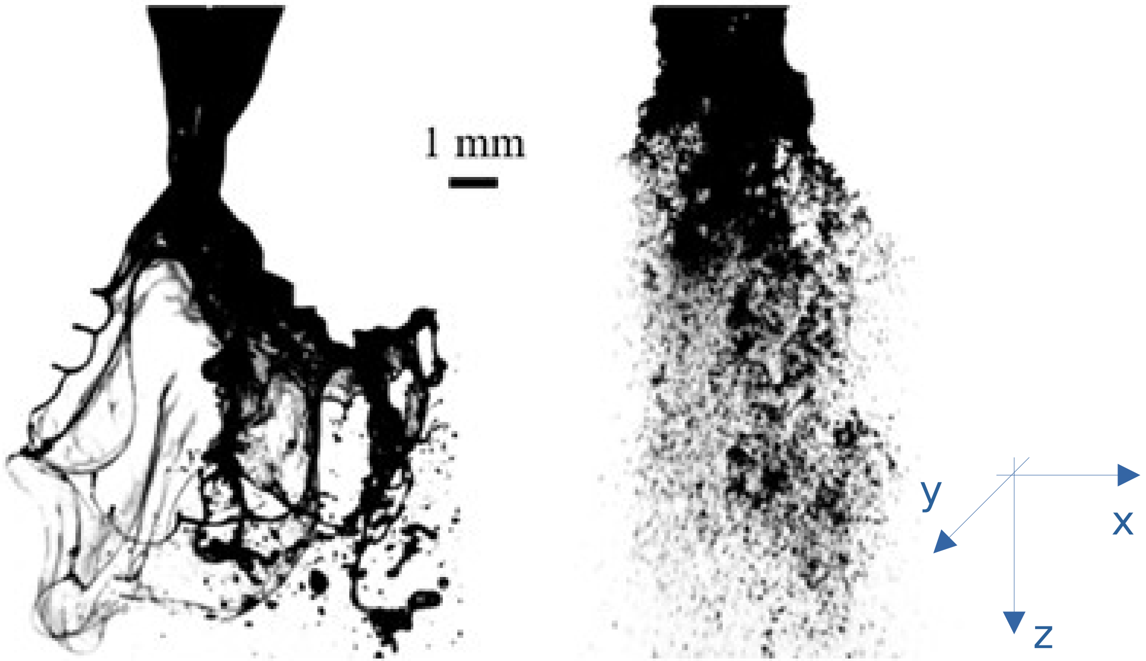


TP 12 suivi lagrangien : Turbulence diphasique

- Using an imaging system with a high-speed camera
- Image processing (size of bubbles, trajectories of bubbles with different sizes, …)
- Z(x,y,t)

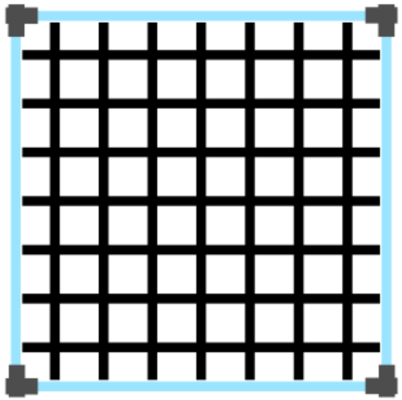
TP 13 démonstration atomisation de jet : Turbulence diphasique (demo)

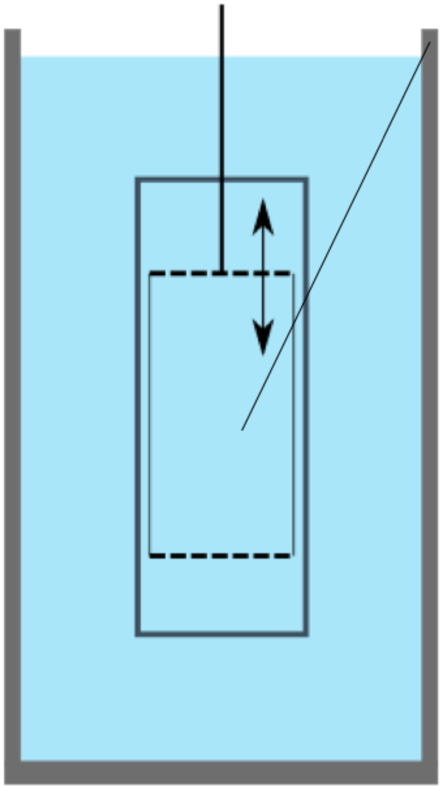
- Study the destabilization of a round liquid jet by an annular gas jet surrounding it
- use image analysis to find the boundaries of the liquid jet and measure the location of the break-up location on each snapshot



TP 14 Particle tracking in a turbulent oscillating grid flow (CEA)

- study the technique of Lagrangian particle tracking.
- the videos will be post-processed to access particle positions in time and then compute their velocity and accelerations





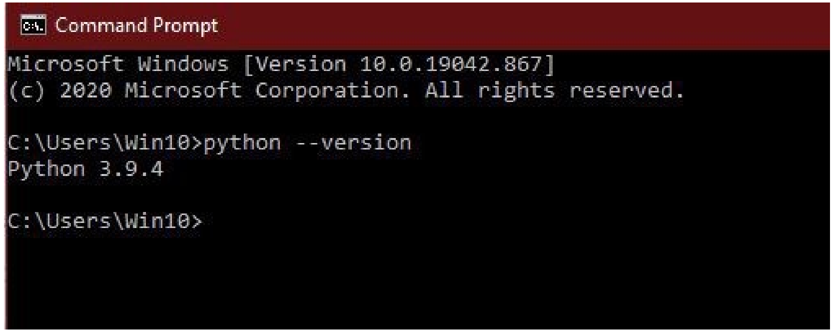
Python

- One of the most popular programming languages
- Availability of various libraries for every application

How to install:

(already installed in Linux)

- Go to www.python.org
- Download the latest python version
- Tick “Add Python 3.9 to PATH”



Jupyter Notebook

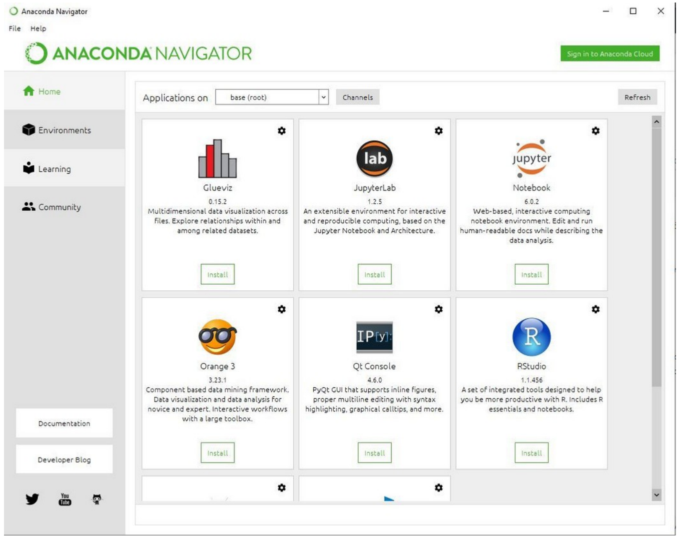
- Jupyter is a service for interactive computing for programming languages
- Jupyter Notebook is a web-based interactive computational environment for creating notebook documents
- contains an ordered list of input/output cells which can contain code, text (using Markdown), mathematics, plots and rich media.

How to install:

1) Using command line:

    >>pip install notebook or *>>pip install jupyter*

2) Install Anaconda (www.anaconda.com/products/distribution)



Context

1) Getting familiar with Python and Jupyter Notebook (workspace, libraries, tools, …) and open data
2) Read data/metadata
3) Plot figures
4) Store the data and save the figures
5) Working on an example(s) of experimental data

Open data

LEGI's server
(fsnet)

LEGI
LABORATOIRE DES ECOULEMENTS
GEOPHYSIQUES ET INDUSTRIELS

TP sessions

Open data

1) OPeNDAP (LEGI) (link)
2) Zenodo (example)

UGA
UFR PhITEM
Université Grenoble Alpes

TD sessions

Sample data 1: TP01_TURBULENT_WAKE

- Flow around a square cylinder
- Time dependent data of two components of velocity (2D) is measured.
- Measurements using hot-wire anemometry/laser doppler velocimetry
- U(t) and V(t)