INTERACTION OF A TURBULENT, SUBMERGED JET WITH A FREE SURFACE

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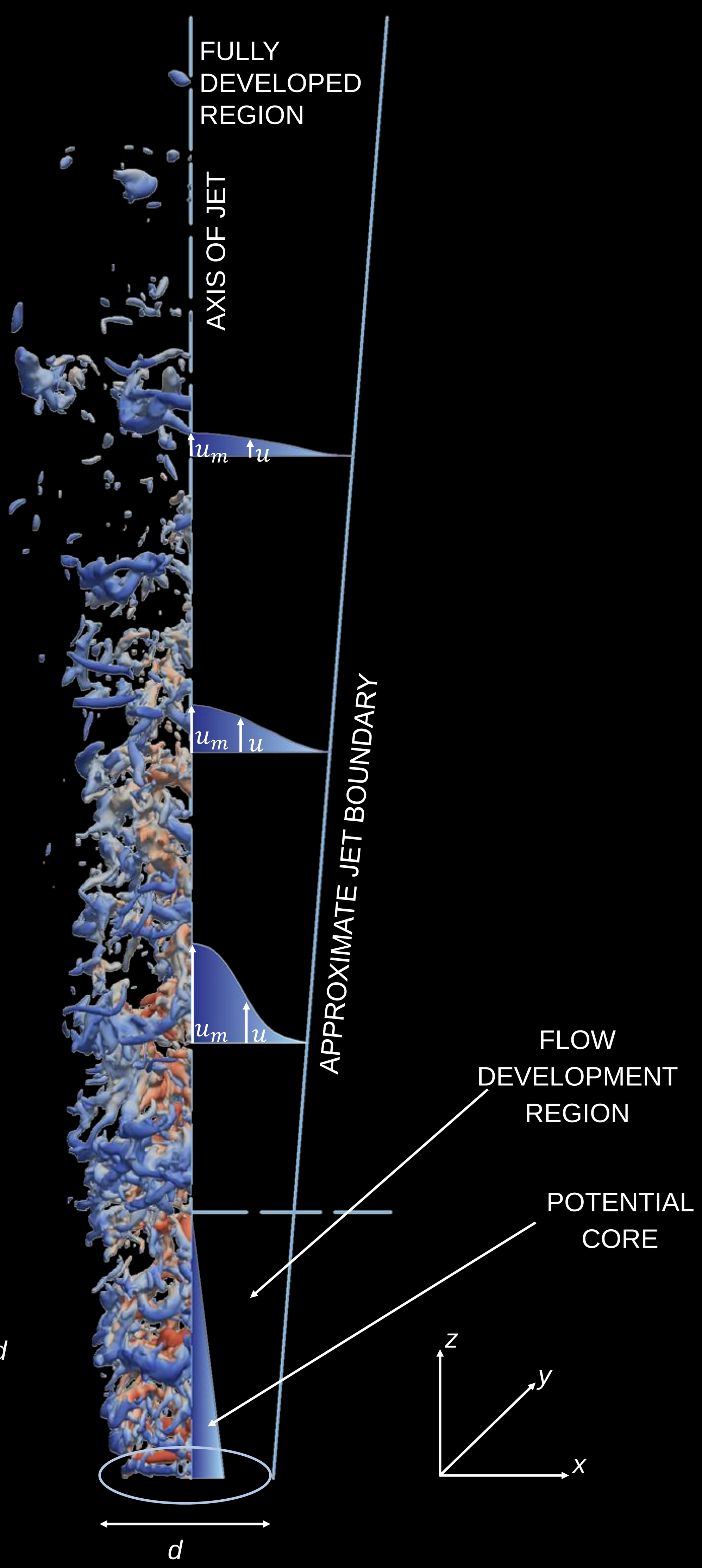
INTRODUCTION

Jets play an important role in a number of environmental and industrial flows. For example, in the marine environment, wastewater is usually discharged as a free, turbulent jet, which mixes with the large water mass of the recipient fluid body and gets diluted in order to minimize pollution effects. Thus, the study of the behaviour of jets is important to accurately assess their impact on the surrounding environment.

Previous investigations show that, for a circular, turbulent jet, its size increases steadily with the distance from the nozzle; in the region closer to the nozzle, there is a cone-shaped core of flow (known as potential core) with axial velocity equal to the jet inlet velocity U_0. At a certain distance from the nozzle, the turbulence generated on the boundaries penetrates to the axis and the mean velocity u_m on the axis begins to decay with *z*, being *z* the axial distance from the nozzle. The region from the nozzle to the end of the potential core is known as the flow development region, while the region away from the end of the potential core is known as the zone of fully established flow. In the region of fully developed flow we find that, at any section, *u* decreases continuously from the maximum value of u_m on the axis to 0 for large values of *r*, being *r* the radial distance from the axis.

METHODOLOGY

We have used Large Eddy Simulation (LES) to study a submerged, turbulent, round jet discharging into a cubical domain, delimited by a top surface that should mimic the surface of the general recipient water body. The Reynolds number at the jet inlet is $2x10^4$, while the ratio between the height of the domain *h* and the jet diameter *d* is equal to 17.5.



Left: Pressure isosurfaces (colored by the magnitude of the velocity).

Right: Defining sketch of the jet flow

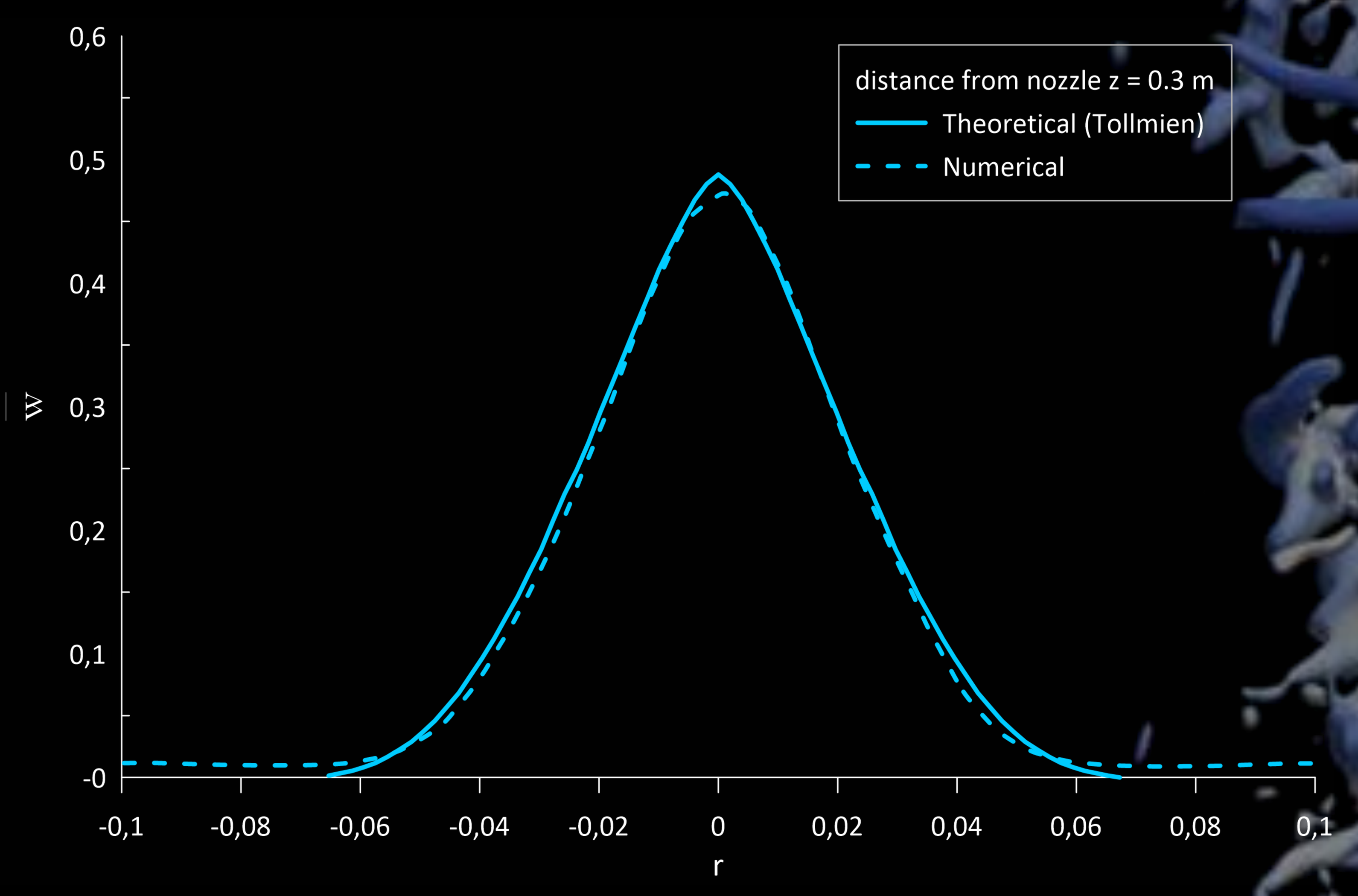
EQUATIONS OF MOTION

The LES governing equations are obtained applying a filtering process to the Navier-Stokes equations so that large and small structures are clearly separated, and the latter are then simulated using a sub-grid scale model. Assuming that the flow is incompressible, the spatially filtered Navier–Stokes equations can be written as:

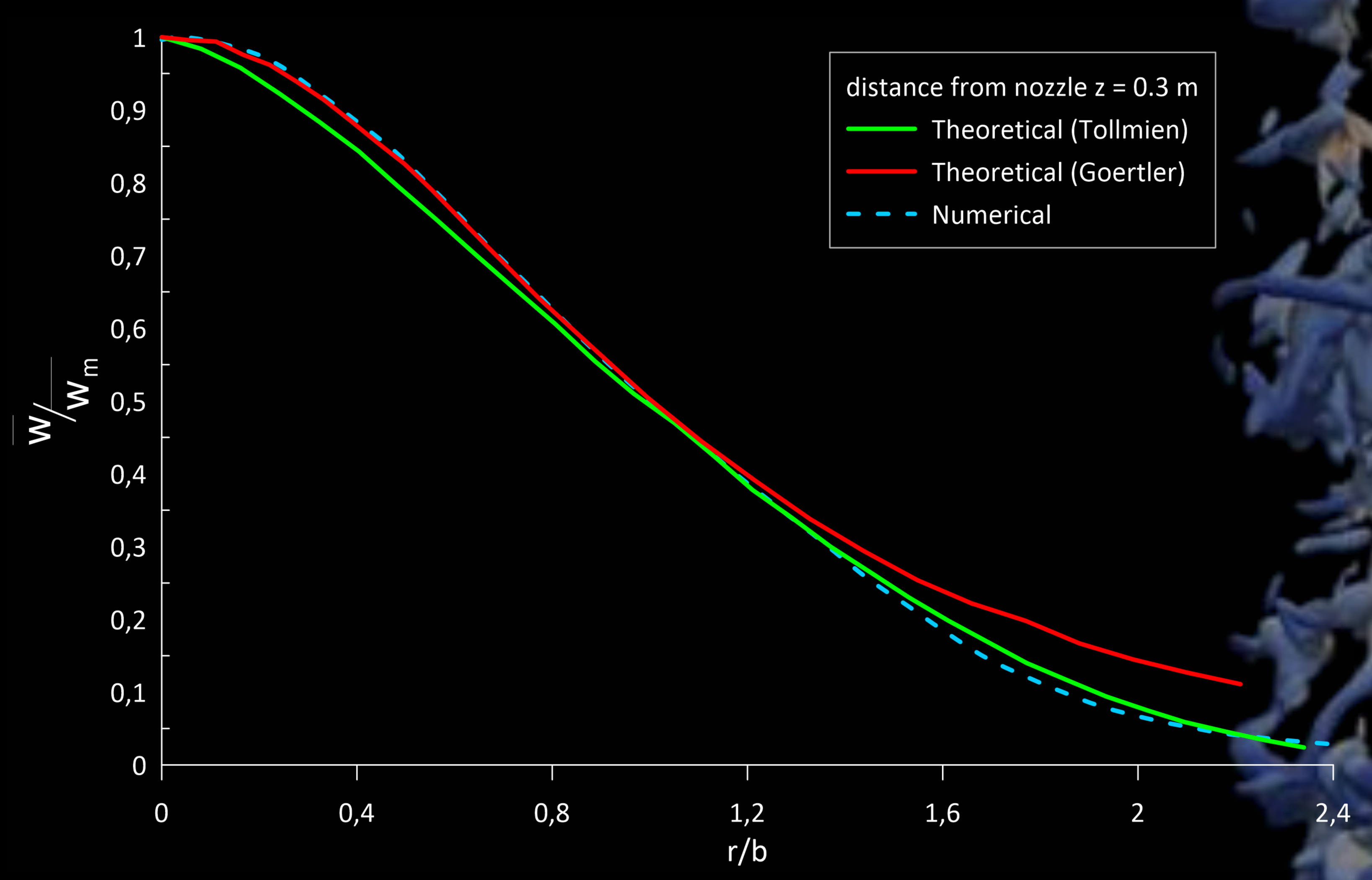
$$\frac{\partial \bar{u}_i}{\partial x_i} = 0$$

$$\frac{\partial \rho \bar{u}_i}{\partial t} + \frac{\partial \rho \bar{u}_i \bar{u}_j}{\partial x_j} = -\frac{\partial \bar{p}}{\partial x_i} + \rho g_i + \mu \frac{\partial^2 \bar{u}_i}{\partial x_j \partial x_j} - \frac{\partial \tau_{ij}}{\partial x_j}$$

VELOCITY PROFILES



Radial distribution of time-averaged axial velocity $\overline{w}$ at a distance z = 0.3 m. from the nozzle



Radial distribution of dimensionless time-averaged axial velocity $\overline{w}$ at a distance z = 0.3 m. from the nozzle

FUTURE DEVELOPMENTS

A wave motion will be added on the top surface of the domain in order to study the influence of the wave motion field on the jet diffusion process.

REFERENCES

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