Simulation Study of SARS-CoV-2 (COVID-19) Spread by Breathing, Coughing and Sneezing

i9MASKS

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Introduction

According to the World Health Organization, 11 months after the first reported case, the SARS-CoV-2 (COVID-19) pandemic has infected more than 40 million people worldwide, with a mortality rate around 2,8 % [1]. The scientific community recognized transmission by airborne particles as the primary route of infection. These particles can be distinguished in droplets, with diameter > 10 - 20 µm, composed of water, which do not travel more than 2 m. When they evaporate, these particles become aerosols, with diameter < 10 - 20 µm, that can remain suspended in the air for more than 6 m [2].

This work aims to simulate the flow of COVID-19 infectious particles suspended in airborne particles, expelled by breathing, coughing and sneezing, with velocities of 5 m/s, 15 m/s and 40 m/s, respectively, using COMSOL Multiphysics software. Water droplets and water vapor aerosols, with 100 µm and 10 µm diameters, respectively, will be considered.

Materials and methods

In this work, the COMSOL laminar flow and particle tracing physics modules were used to release 10 droplets of water with 1000 kg/m^3 density and 100 µm diameter and 10 aerosols of water vapor with 0.013 kg/m^3 density and 10 µm diameter. For the 2D domain, a 10 min study was simulated, with particle releases at 0 s, 1 s and 2 s, while in the 3D geometry, it was performed a 20 s simulation, under the same release conditions.

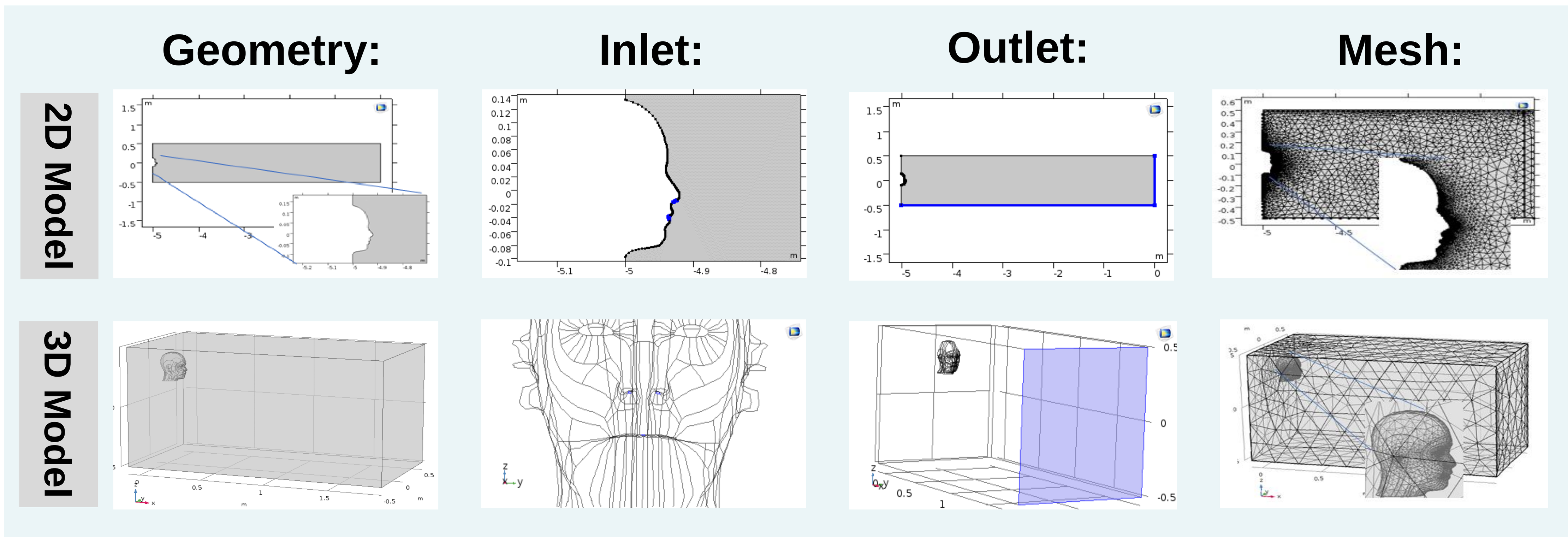

Figure 1 – Geometry, inlets, outlets and mesh defined for both models. The inlets were choosen taking into account the mouth and nose area, while the outlets correspond to the opposite side of the release.

Results

Regarding the results, it was found that, in all events, the droplets moved only in the vertical direction due to gravity, unlike aerosols that have low density and, therefore, gravity can be neglected. It was also observed that after 10 min, aerosols can spread about 75 cm horizontally when breathing, about 1.5 m when coughing and about 2 m when sneezing, which is the distance defined by health organizations as a minimum for social distancing. The maximum velocity and pressure were, respectively, 0.11 m/s and 10 mPa for breathing, 0.32 m/s and 47 mPa for coughing and 0.86 m/s and 0.13 Pa for sneezing.

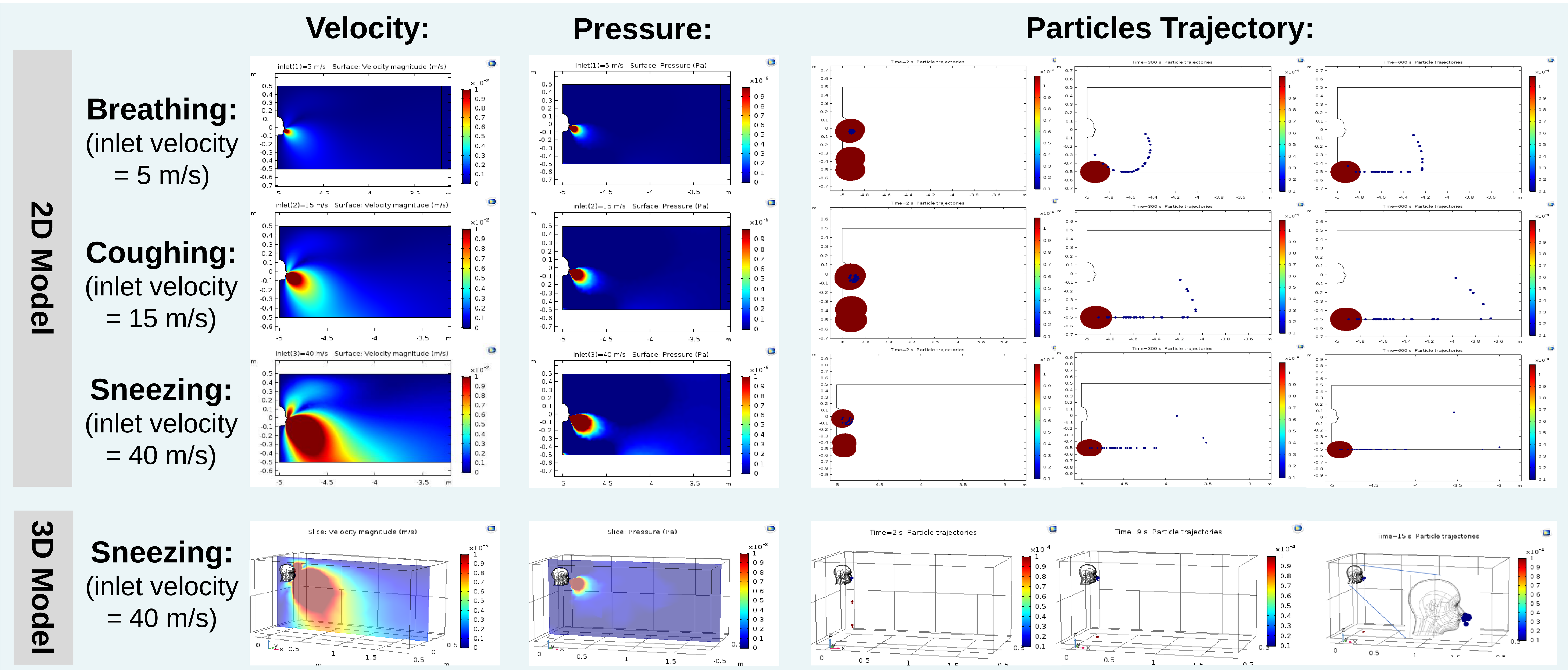

Figure 2 – Results obtained for both models, where velocity and pressure plots have, for visualization purposes, a maximum color scale adjustment at 0.01 m/s and 0.1 mPa, respectively. In the trajectories plots, for better visualization, the particles were magnified with a radius scale factor of 1200. The 100 µm water droplets are represented in red, while the 10 µm water vapor are represented in blue.

References

[1] World Health Organisation. (2020). *Coronavirus disease (COVID-19) pandemic*.
[2] Jayaweera, M. et al. (2020). *Transmission of COVID-19 virus by droplets and aerosols: A critical review on the unresolved dichotomy.* Environmental Research.

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UMINHO CMEMS CENTER FOR MICROELECTROMECHANICAL SYSTEMS
METRICS Mechanical Engineering and Resource Sustainability Center