Hydrodynamics Of Artificial Coral Colonies Using A Turbulence-Resolving Computational Framework

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**Abstract.**

Coral reefs play a crucial role in marine ecosystems by promoting biodiversity and facilitating nutrient cycling through wave energy dissipation and hydrodynamic interactions. While extensive research has examined natural and artificial coral reef interactions with surface waves, the turbulent flow dynamics within coral canopies remain understudied due to their geometric complexity. This study addresses this gap using a turbulence-resolving computational framework based on the volume-penalizing immersed boundary method (vIBM). The framework captures flow characteristics over flat topography under oscillatory wave forcing by solving the Navier-Stokes equations over synthetically generated coral reefs. The simulations incorporate coral geometries representing a variety of geomorphic and ecological conditions generated from the Smithsonian Coral Archive. Our results show that the turbulence is primarily confined to the coral canopy, where streamwise turbulent components dominate due to oscillatory pressure gradient. Variations in roughness influence wave velocity profiles, with notable effects on vertically integrated phase-averaged velocities. These findings validate the model’s ability to resolve turbulence within coral canopies and highlight its potential for exploring hydrodynamic parameters governing coral flow dynamics.

**Keywords:** Coral Reefs, Canopy Turbulence, Direct Numerical Simulations, Immersed Boundary Method.

1. First Section
   1. A Subsection Sample

Please note that the first paragraph of a section or subsection is not indented. The first paragraphs that follows a table, figure, equation etc. does not have an indent, either.

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**Table 1.** Table captions should be placed above the tables.

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| Heading level | Example | Font size and style |
| Title (centered) | **Lecture Notes** | 14 point, bold |
| 1st-level heading | **1 Introduction** | 12 point, bold |
| 2nd-level heading | **2.1 Printing Area** | 10 point, bold |
| 3rd-level heading | **Run-in Heading in Bold.** Text follows | 10 point, bold |
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Displayed equations are centered and set on a separate line.

*x* + *y* = *z* ()

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**Fig. 1.** A figure caption is always placed below the illustration. Short captions are centered, while long ones are justified. The macro button chooses the correct format automatically.

For citations of references, we prefer the use of square brackets and consecutive numbers. Citations using labels or the author/year convention are also acceptable. The following bibliography provides a sample reference list with entries for journal articles [1], an LNCS chapter [2], a book [3], proceedings without editors [4], as well as a URL [5].

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