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3DSeaVizKit: An Interactive Spatiotemporal Visualization Toolkit for Ocean Data

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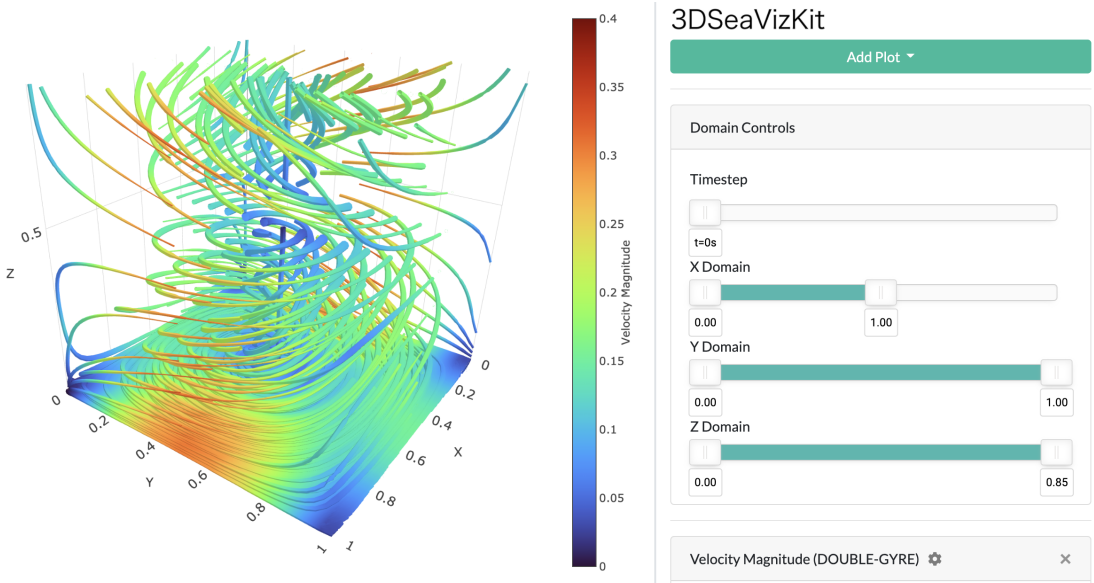

Fig. 1: Streamtube visualization of the helical velocity field from canonical 3D double-gyre flow, interactively visualized on a domain subsection using the 3DSeaVizKit Graphical User Interface.

Abstract—The final result of an ocean simulation or observation campaign is the interpretation in the mind of the researcher or scientist. Such interpretation would be greatly facilitated by an advanced, efficient, and interactive visualization tool for dynamic 3D ocean data. The vast majority of visualizations for spatiotemporal simulation data rely on static rendering of 2D cross-sectional representations, excluding at least one spatial dimension, hindering interpretation. A toolkit that can create interpretable, interactive 3D visualizations of the ocean is required to remove the limitations of aggregated 2D representations, a need magnified by the increasing prevalence of high-resolution spatiotemporal ocean simulation technology and large observed data sets available in oceanography. In this work, we present a new visualization toolkit that processes multidisciplinary oceanographic data in a modular and computationally efficient manner to create cohesive, portable, and interactive 3D visualizations of the ocean. 3DSeaVizKit makes extensive use of the Plotly JavaScript library and runs in a web browser, allowing for easily-interpretable, exploratory ocean data analysis. We provide a software pipeline tailored to the computational needs of 3D interactive visualization of multiple dynamic ocean fields and demonstrate the generality of the tool by showcasing use cases of the toolkit applied to high-resolution ocean simulation data. Our toolkit supports the visualization of scalar data such as temperature, salinity, and biogeochemical concentrations, as well as vector-valued data such as velocity and vorticity, and Lagrangian data in the form of trajectories and coherent structures. We highlight dynamical studies in the Gulf of Mexico and the Alboran Sea, as well as the analysis of biogeochemical data and transport phenomena in the coastal ocean regions around the state of Massachusetts in the United States.

Index Terms—Ocean visualization, interactive visualization, flow visualization, three-dimensional, spatiotemporal data

1 Introduction

The final practical output of an ocean model or simulation is the interpretation in the mind of a researcher or scientist; therefore, the effective visualization of oceanographic data is an often neglected but critical component in understanding ocean phenomena. Indeed, given the large computational costs and software development time associated with running numerical ocean simulations, the marginal utility of developing an effective visualization tool can be enormous. In particular, there is a need for efficient, interactive, three-dimensional (3D) visualization of spatiotemporal data to aid researchers in interpreting and analyzing ocean data. Apart from ocean scientists and engineers, visualizations of oceanographic data are of practical concern to those working in shipping [58], disaster management [55], off-shore oil operations [22], and aquaculture [52].

Visualization of oceanographic data is not without its challenges: oceanographic data sets are often large, highly multivariate, and may contain uncertainties and discontinuous data [9, 10, 26, 38, 47]. These complexities necessitate an oceanographic visualization toolkit with

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