Emergent Research:

The PIMS Postdoctoral Fellow Seminar

Pacific Institute *for the* Mathematical Sciences

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Using Observations to Accurately and Efficiently Model Turbulent Flows:

Parameter Recovery, Sensitivity Analysis, Nonlinear Data Assimilation Algorithms, and a Real-World Implementation

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ABSTRACT:

One of the challenges of the accurate simulation of turbulent flows is that initial data is often incomplete. Data assimilation circumvents this issue by continually incorporating the observed data into the model. A new approach to data assimilation known as the Azouani-Olson-Titi algorithm (AOT) introduced a feedback control term to the 2D incompressible Navier-Stokes equations (NSE) in order to incorporate sparse measurements. The solution to the AOT algorithm applied to the 2D NSE was proven to converge exponentially to the true solution of the 2D NSE with respect to the given initial data. In this talk, we present our tests on the robustness, improvements, and implementation of the AOT algorithm, as well as generate new ideas based off of these investigations. First, we discuss the application of the AOT algorithm to the 2D NSE with an incorrect parameter and prove it still converges to the correct solution up to an error determined by the error in the parameters. This led to the development of a simple parameter recovery algorithm, whose convergence we recently proved in the setting of the Lorenz equations. The implementation of this algorithm led us to provide rigorous proofs that solutions to the corresponding sensitivity equations are in fact the Fréchet derivative of the solutions to the original equations. Next, we present a proof of the convergence of a nonlinear version of the AOT algorithm in the setting of the 2D NSE, where for a portion of time the convergence rate is proven to be double exponential. Finally, we implement the AOT algorithm in the large scale Model for Prediction Across Scales - Ocean model, a real-world climate model, and investigate the effectiveness of the AOT algorithm in recovering subgrid scale properties.

SPEAKER BIO:

Elizabeth Carlson, is a homeschooler turned math PhD! She grew up in Helena, MT, USA, where she also graduated from Carroll College with a Bachelor's in mathematics and minor in physics. She became interested in fluid dynamics as an undergraduate, and followed this interest through her graduate work at the University of Nebraska - Lincoln in Lincoln, NE, USA, where she just earned my PhD in May 2021. Her research focus is in fluid dynamics, focusing on the well-posedness of systems of partial differential equations and numerical computations and analysis in fluid dynamics. In her free time, she enjoys hiking, playing piano, reading, and martial arts.

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