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Turbulence, Droplets, and Hurricanes: Understanding Complex Physics in the Environment

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Room 2540 GGB

ME Seminar Link
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Abstract:

In the environment, air and water transport a wide variety of constituents, including nutrients, pollution, droplets, aerosols, dust, and even bugs. Predicting where these things end up, and in what abundance, is a difficult enterprise; this difficulty impacts a huge range of scientific disciplines, and limits our ability to predict future environmental conditions and engineer solutions. In particular, turbulent motions are a highly nonlinear and small-scale phenomena that form the foundation on which environmental transport is based. Making matters worse, often it is hazardous or simply impossible to observe these motions in nature or recreate them in the laboratory.

Here I will focus on one such effort of leveraging high-resolution, high-fidelity simulations to explore complex flows and their accurate representation in coarse-scale models: tropical cyclones and the problem of air-sea interaction. It has long been hypothesized that sea spray generated at the ocean surface plays a large role in the transfer of heat, moisture, and momentum at the air-sea interface. In high winds, it is well-known that spray is produced in abundance, but it is much less clear how spray may mediate air-sea transfer in these conditions. A turbulence and droplet-resolving framework is used as an idealized testbed to examine the assumptions and premises of commonly used bulk spray flux parameterizations. In multiple respects, spray droplets limit their own ability to enhance air-sea heat and moisture transfer due to the complex thermodynamic feedbacks that occur during their exchange with the surrounding air. Ultimately, the primary factors determining whether or not spray can modulate air-sea energy and momentum fluxes are the spray lifetimes and airborne concentrations -- both of which are quantities that are largely unknown or uncertain in high-wind conditions.

Bio:

Dr. Richter is an Associate Professor of Civil and Environmental Engineering and Earth Sciences at the University of Notre Dame. He received his B.S. in Mechanical Engineering from the University of Massachusetts in 2002, and his M.S. and Ph.D. in Mechanical Engineering from Stanford University in 2011. His dissertation focused on the turbulent transition of viscoelastic flows using numerical simulations – something completely unrelated to this talk. Following his Ph.D. he received the Advanced Study Program Postdoctoral Fellowship from the National Center for Atmospheric Research in Boulder, CO, where he shifted his research focus towards turbulent, multiphase processes in the environment. He is a recipient of the Office of Naval Research Young Investigator Award, multiple teaching awards within Notre Dame, and his current research attempts to understand phenomena including air-sea interactions within hurricanes, dust transport in the atmosphere, and cloud microphysics. He is the lead PI on a recent ONR MURI aimed at studying air-sea fluxes in high winds.