The Fourteenth Annual Symposium of the Burgers Program for Fluid Dynamics

1 - 6 pm, November 15, 2017, Wednesday

Kim Building 1107 & 1111

1:00 - 1:15 Welcoming Remarks
Jim Wallace
Director, Burgers Program for Fluid Dynamics
Emeritus Professor, Dept. of Mechanical Engineering & IPST
University of Maryland

1:15 - 2:15 Burgers Lecture
Fuqing Zhang
The -5/3' atmospheric energy spectra, and the ultimate limit of weather predictability
Center for Advanced Data Assimilation and Predictability Techniques
Pennsylvania State University

2:15 - 2:50
Daniel Quinn
What fins and wings can teach us about vehicle design
Department of Mechanical and Aerospace Engineering
University of Virginia

2:50 - 3:50 Poster Session with Refreshments

3:50 - 4:25
Daniel Tam
Flow around Eukaryotic flagella
Department of Mechanical, Maritime and Materials Engineering
Technical University of Delft, The Netherlands

4:25 - 5:00
Raghu Murtugudde
Indian summer monsoon: natural variability or a portent of what is to come?
Department of Atmospheric and Oceanic Science
University of Maryland

5:00 - 6:00 Reception

Abstracts

Fuqing Zhang

The -5/3' atmospheric energy spectra, and the ultimate limit of weather predictability

With high-resolution convection-allowing model simulations, I will first show moist convective systems, even triggered in a horizontally homogeneous environment with the Coriolis force, are able to generate a background mesoscale kinetic energy spectrum with a slope close to -5/3, which is the observed value for the kinetic energy spectrum at mesoscales. It is found that the buoyancy production generated by moist convection, while mainly injecting energy in the upper troposphere at small scales, could also contribute at larger scales, possibly as a result of the organization of convective cells into mesoscale convective systems. This latter injected energy is then transported by energy fluxes due to gravity waves and/or convection both upward and downward. Nonlinear interactions, associated with the velocity advection term, finally help build the approximate -5/3 slope through upscale and/or downscale propagation at all levels. I will then show moist convection, and their contribution to building the -5/3 energy spectra, are essential for rapid upscale forecast error growth, and eventually post an intrinsic limit on deterministic atmospheric predictability. Lastly, through high-resolution ensemble experiments with state-of-the-science global numerical weather prediction models, we investigate the ultimate predictability limit of day-to-day weather phenomena such as midlatitude winter storms and summer monsoonal rainstorms. Results suggest such a limit may indeed exist that is intrinsic to the underlying dynamical system and instabilities even if the forecast model and the initial conditions are nearly perfect. Currently, the practical predictability limit of midlatitude instantaneous weather is around 10 days; reducing initial-condition error by an order of magnitude will extend the deterministic forecast lead times of day-to-day weather by up to 4 days, with much shorter room for improving prediction of small-scale phenomena like thunderstorms. Achieving this additional predictability limit can have enormous socioeconomic benefits but requires coordinated efforts by the entire community to design better numerical weather models, to improve observations, and to make better use of observations with advanced data assimilation and computing techniques.

Daniel Quinn

What fins and wings can teach us about vehicle design

The efficiency and maneuverability of fish and birds has been inspiring vehicle design for decades. As such, many groups have explored steady swimming and flying in uniform flow. However, relatively little is known about complex maneuvers of fish and birds in cluttered environments. Birds, for example, innately yaw into lateral gusts when seeking a target perch, but we are only beginning to understand the mechanisms they use to do so. Bottom-dwelling fish cope with the hydrodynamic interaction between their fins and the substrate. Most fish coordinate several fins with diverse planforms to produce stable, efficient locomotion. While poorly understood, these complex conditions are commonplace in missions like search-and-rescue, mapping, or product delivery, where unmanned vehicles require precise control in high shear flows. We are exploring fin/wing maneuvers through direct observation, robotic testing, and low-order modeling. What we

are finding is that tuning fin/wing placement and kinematics can significantly improve thrust, efficiency, and/or maneuverability. Our results offer design tools for next generation bio-inspired vehicles which are quiet, efficient, and ultra-maneuverable.

Daniel Tam

Flow around Eukaryotic flagella

This talk will focus on different aspects of flagellar locomotion of green algae Chlamydomonas on the micrometric scale. First, we will discuss recent experimental attempts to externally control the beating dynamics of eukaryotic flagella by means of generating external flow fields around the flagellated cell. In these experiments, we dynamically interact with flagellated microorganisms in real time, by generating an externally controlled periodic forcing of hydrodynamic origin. The conditions under which we can externally control the beating frequency of the organism will be detailed. Second, we will focus on the flow velocity field generated by the motion of the flagella and characterize the hydrodynamic forces acting on the flagella. An experimental flow velocimetry technique based on the use of optical tweezers is developed to measure the unsteady flow velocity around a living organism. This study highlights the importance of an often forgotten term in the Stokes equation: the unsteady term.

Raghu Murtugudde

Indian summer monsoon: natural variability or a portent of what is to come?

Much discussion was focused this summer and fall on the series of hurricanes making landfall over Central and North Americas. While there is no clear attribution of hurricane frequencies to global warming, ocean warming is clearly playing a role in juicing up the hurricanes that are born. Or is it? Translating greenhouse gas increases to global warming can be hard because of secular warming slowdown due to natural variability. The Indian Summer Monsoon (ISM) offers a stark example of complexities of climate change detection and attribution in regions of high-vulnerability, low-resilience, and complicated geopolitics. The onset and withdrawal of ISM have changed in the recent decades leading to a change in the length of the rainy season as well as a change in rainfall distribution in space and time. No robust correlations exist between local warming and local extreme rainfall events but warming seas around India are pumping in excess moisture to support flash floods that have claimed over 500 lives this summer. What do we understand in terms of trends in mean rainfall and extremes? What is the state of predictions of these extremes? The summer of 2016 is used to address some of these critical issues in the context of decadal analysis of the monsoon variability and change.