The Burgers Program for Fluid Dynamics

Fourteenth Annual Symposium

Wednesday, November 15, 2017
1:00 to 6:00 p.m.
Jeong H. Kim Engineering Building
Rooms 1107 & 1111

Institute for Physical Science and Technology
College of Computer, Mathematical and Natural Sciences
A. James Clark School of Engineering
University of Maryland, College Park

UNIVERSITY OF MARYLAND

Program

1:00 - 1:15

Welcoming Remarks

Jim Wallace
Director, The Burgers Program for Fluid Dynamics
Emeritus Professor, Department of Mechanical Engineering &
Insitute for Physical Science and Technology
University of Maryland

1:15 - 2:15

Burgers Lecture

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

Fuqing Zhang
Center for Advanced Data Assimilation and Predictability Techniques
Pennsylvania State University

2:15 - 2:50

What fins and wings can teach us about vehicle design

Daniel Quinn
Department of Mechanical and Aerospace Engineering
University of Virginia

2:50 - 3:50

Graduate and post-doctoral poster session with refreshments

3:50 - 4:25

Flow around eukaryotic flagella

Daniel Tam
Department of Mechanical, Maritime and Materials Engineering
Technical University of Delft, The Netherlands

4:25 - 5:00

What drives northward propagation of intraseasonal oscillations in the Indian Ocean during boreal summer?

Raghu Murtugudde
Department of Atmospheric and Oceanic Science
University of Maryland

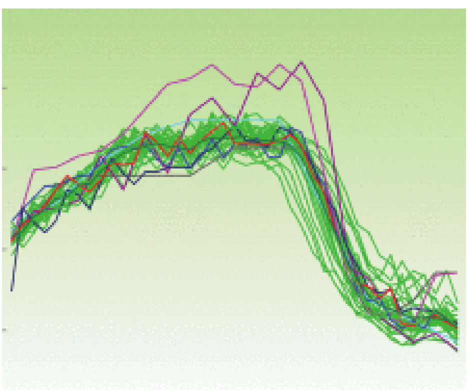
5:00 - 6:00

Reception and announcement of best poster awards

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

Fuqing Zhang

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.

What fins and wings can teach us about vehicle design

Daniel Quinn

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.

Flow around eukaryotic flagella

Daniel Tam

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.

What drives northward propagation of intraseasonal oscillations In the Indian Ocean during boreal summer?

Raghu Murtugudde

As the peak MJO season comes to an end during April, the Indian summer monsoon begins to take shape in May. This transition is characterized by a northward steering of the eastward propagating intraseasonal variability. Heating of the land and a coupling of baroclinic-barotropic modes and large-scale dynamics have been posited as key processes in the past. It is now shown that a coupled Central Indian Ocean mode exists and the key driver is the subsidence over central India associated with convection over the Western Pacific warm pool. The meridional SST-PV structure clearly capture the regional coupled mode which explains the northward propagation and the associated rainfall over the Bay of Bengal and the Indian subcontinent. A kinetic energy budget is performed to quantify the seasonal to interannual variability of the Central Indian Ocean mode. Performance of CESM in simulating the CIO is investigated to highlight the model biases in terms of the monsoon, MJOs and CIO.

UNIVERSITY OF MARYLAND 1856

Burgers Board

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FLUID DYNAMICS

Institute for Physical Science and Technology

Institute for Physical Science & Technology
IPST

4211 Atlantic Building
University of Maryland
College Park, MD 20742-2431
Phone: +1 (301) 405 4889
http://ipst.umd.edu