Center for Environmental & Applied Fluid Mechanics

Weekly Seminar: Spring 2011

Date: **Friday, April 1, 2011**

Time: **11:00 AM**

Location: **Gilman Hall 50 (Marjorie M. Fisher Hall)**

Speaker: **Dr. Di Yang**
JHU | Civil Engineering

Title: **"NUMERICAL STUDY OF TURBULENCE OVER WATER WAVES."**

Abstract

The interaction between wind turbulence and water waves has been an important research topic for several decades. Previous studies focus on the parameterizations of wind-wave energy transfer and wave growth rate by means of theoretical analyses, field and laboratory measurements, and Reynolds-averaged Navier-Stokes modeling. In recent years, the continuous increase of computing power and improvement of numerical algorithms enable the direct numerical simulation (DNS) and large-eddy simulation (LES) of wind-wave interaction. In this talk, a numerical method for the simulation of viscous flows with undulatory walls and free surfaces is introduced. The simulation domain is discretized by a boundary-fitted and time-dependent grid with a hybrid pseudo-spectral and finite difference scheme. The Navier-Stokes equations subject to nonlinear kinematic and dynamic boundary conditions at the free surface and no-slip boundary condition at the wall are solved by a semi-implicit fractional-step method. With this numerical tool, a DNS of wind turbulence over progressive water wave train is performed in order to obtain an understanding of the detailed flow structures. Mechanistic study is performed through systematic investigation of different wave conditions. Examination of turbulence field shows large variation with wave phase and this variation is found to be highly dependent on wave age and wave steepness. The near-surface coherent vortical structures are examined using conditional averaging approach. Quasi-streamwise and reversed horseshoe vortices are found dominant for slow wave case, and vertically bent quasi-streamwise vortices are dominant for intermediate and fast wave cases. The numerical method is also extended to LES of wind over broadband wave field by means of subgrid-scale modeling and coupling of wind simulation with a high-order spectral method (HOSM) based wave simulation. An example for the application of this LES-HOSM coupled approach to the study of offshore wind turbine array will be presented.

Bio

Dr. Di Yang is a Postdoctoral Fellow in the Department of Civil Engineering at Johns Hopkins University. He graduated from the University of Science and Technology of China with a Bachelor degree in Theoretical and Applied Mechanics in June, 2004. In September, 2004, he came to Johns Hopkins to pursue his Ph.D. study under the supervision of Professor Lian Shen. In 2009, he received a M.S.E. degree in Mechanical Engineering through the CEAFM Dual Degree Program. He received a Ph.D. degree in Civil Engineering in October, 2010. Dr. Di Yang recently received the "Corrsin-Kovasznay Outstanding Paper Award" who is lead author of a recent paper in fluid mechanics for the work's excellence, originality and potential impact for his paper "Direct-simulation-based study of turbulent flow over various waving boundaries", published in the Journal of Fluid Mechanics (volume 650, pages 131-180, with L. Shen).