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Special Guest Lectures

High Performance Scalable Computations of Hurricane Driven Wind Waves, Storm Surge, and Flow in Integrated Ocean Basin to Shelf to Inland Floodplain Systems

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Johnston Hall 338
May 31, 2012 - 03:30 pm

Abstract:

Hurricane wind wave, storm surge, and current environments in the coastal ocean and adjacent coastal floodplain are characterized by their high energy and by their spatial variability. These processes impact offshore energy assets, navigation, ports and harbors, deltas, wetlands, and coastal communities. The potential for an enormous catastrophic impact in terms of loss of life and economic losses is substantial.

Computational models for wind waves and storm driven currents and surge must provide a high level of grid resolution, fully couple the energetic processes, and perform quickly for risk assessment, flood mitigation system design, and forecasting purposes. In order to accomplish this, high performance scalable codes are essential. To this end, we have developed an MPI based domain decomposed unstructured grid framework that minimizes global communications, efficiently handles localized sub-domain to sub-domain communication, applies a local inter-model paradigm with all model to model communications being kept on identical cores for sub-domains, and carefully manages output by assigning specialized cores for this purpose. Continuous Galerkin and Discontinuous Galerkin implementations are examined. Performance of explicit and implicit implementations of the wave-current coupled system on up to 32,000 cores for various platforms is evaluated.

The system has been extensively validated with an ever increasing amount of wave, water level and current data that has being collected for recent storms including Hurricanes Katrina (2005), Rita (2005), Gustav (2008), and Ike (2008). The modeling system helps understand the physics of hurricane storm surges including processes such as geostrophically driven forerunner, shelf waves that propagate far away from the storm, wind wave – surge interaction, surge capture and propagation by protruding deltaic river systems, and frictionally controlled inland penetration.

These models are being applied in the development of the hurricane risk reduction (formerly known as the hurricane protection) system in Southern Louisiana as well as for the development of FEMA Digital Flood Insurance Rate Maps (DFIRMS) for Texas, Louisiana, Mississippi, and other Gulf and Atlantic coast states.

Speaker's Bio:

Joannes Westerink is the Notre Dame Chair in Computational Hydraulics and the Henry J. Massman Chairman of the Department of Civil Engineering and Geological Sciences. He holds concurrent appointments in the Department of Applied and Computational Mathematics and Statistics and the Department of Computer Science and Engineering. He obtained his B.S. and M.S. degrees in Civil Engineering at the State University of New York at Buffalo and Ph.D. degree in Civil Engineering from the Massachusetts Institute of Technology. Westerink's research focuses on the development, analysis and application of coastal ocean and estuarine hydrodynamic, constituent transport and sediment transport models. This encompasses the multi-component multi-scale physics of these systems, particularly the linkages to weather and wind wave models; the underlying discretization algorithms; the discrete meshes; the development of high performance codes in vector and parallel computing environments; the verification, validation and uncertainty quantification of codes applied to oceans, continental shelf regions, estuaries, rivers, coastal flood plains and lakes. Westerink's models are extensively applied by the U.S. Army Corps of Engineers and FEMA to design levees and evaluate hurricane risk in the U.S. Gulf and East coasts. NOAA applies the models both to analyze tides as well as in storm forecasting systems. Westerink was a co-lead in the U.S. Army's post Hurricane Katrina IPET Investigation and led the post Katrina storm surge model development efforts for the Corps and FEMA. He also serves as a commissioner on the Southeast Louisiana Flood Protection Authority-West and as an International Expert for the UNESCO Joint World Meteorological Organization – Intergovernmental Oceanographic Commission (WMO-IOC) Technical Commission for Oceanography and Marine Meteorology (JCOMM) on Enhancing Forecasting Capabilities for North Indian Ocean Storm Surges.

This lecture has refreshments @ 03:00 pm