NEXT GENERATION CB HAZARD PREDICTION AND CONSEQUENCE ASSESSMENT WITH MULTI-ECHELON DECISION SUPPORT APPLICATIONS

The Joint Outdoor-indoor Large Eddy Simulation (JOULES) For Numerical Weather Prediction Forecasting And Analysis In Urban Environments

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Predicting human exposure to airborne contaminants in urban environments requires numerical models that can resolve both urban atmospheric transport and dispersion (AT&D) and exchanges between indoor and outdoor spaces. While a range of modeling capabilities exist to address airborne material transport in urban areas, few possess the capability to efficiently and accurately simulate AT&D scenarios within operational timeframes. The Hazard Prediction and Analysis System (HPAC) and the Joint Effects Model (JEM) are two such modeling tools used in the chemical and biological (CB) defense community. Even though these tools are computationally efficient, they provide statistical solutions that are rarely, if not ever observed in real environments. Continued advances in scientific computing on graphics processing unit (GPU) hardware have allowed a building-aware Large Eddy Simulation (LES) atmospheric modeling system to be implemented on a GPU-based computing platform. Unlike the statistical models, LES modeling directly solves for the turbulent flow field that produces the high-frequency fluctuations that are present in operational environments. In recent years the Defense Threat Reduction Agency has supported the development of a high-fidelity CB hazard prediction system based on this technology called the Joint Outdoor-indoor Urban Large Eddy Simulation (JOULES) system.

Traditionally LES models are driven by periodic lateral boundary conditions. These types of simulations have proven useful as they allow the user to simulate a full spectrum of turbulence with a single initial atmospheric profile and can provide detailed statistical distributions of atmospheric conditions, or an ensemble realization, at discrete points in space simply by aggregating across model time. As such, the JOULES has served the CB defense community for years being run in this way. However, recent improvements to the JOULES model have enabled the implementation of an open boundary condition mode that allows for the simulation of time-varying meteorology, in particular, driving the advective tendencies of the high-resolution LES fields with a coarser resolution mesoscale weather model. Because the JOULES model is natively a GPU code and can run at faster than real-time speeds, it can be coupled to forecast mesoscale products as they become available either publicly or as they are created by a user's forecasting pipeline.

In this presentation we will describe the key enabling technology within JOULES, a LES model that has been implemented on a graphics processing unit (GPU) computing platform, examples of results from evaluations showing that this GPU-LES model can accurately simulate winds, turbulence, and atmospheric dispersion. Examples where JOULES is currently being utilized to support CB defense applications ranging from the development of new approaches for improving the accuracy of human effects calculations in urban and interior environments, high-fidelity CB training and mission planning, testing and evaluation of CB information systems, and the development of synthetic datasets representing CB contested battlespace environments for advance technology demonstrations will also be provided. Our presentation will conclude with a summary of recent and planned advancements of this technology, improved visualizations of data from JOULES, in further integration into CB defense technologies being developed to support our nations warfighters.

The authors wish to acknowledge the support of DTRA Science and Technology manager Rick Fry and A&AS support Bruce Trask.