Atmospheric Boundary Layer Environment (ABLE) Model

S&T Campaign: Computational Sciences
Predictive Simulation Sciences

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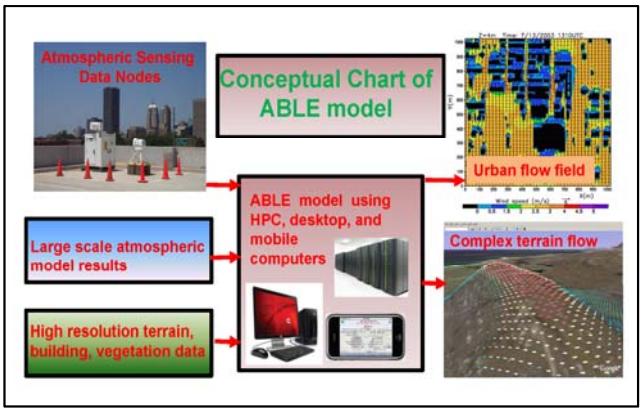
Research Objective

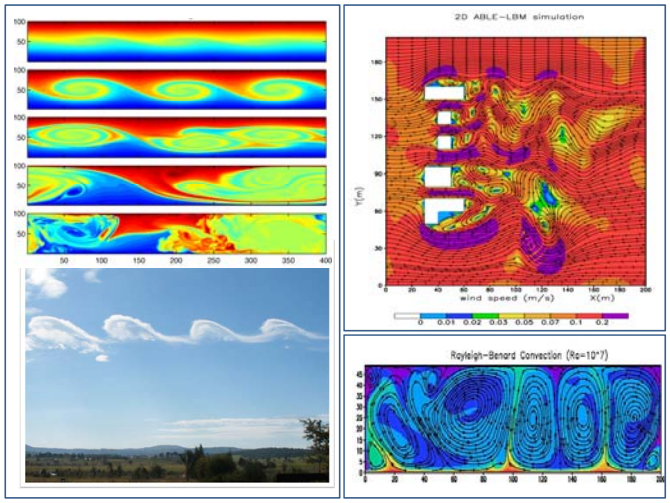
- Develop an advanced, high-resolution, microscale (spatial: 1-100m, 1-15 min.) atmospheric boundary layer environment (ABLE) model to predict wind, temperature and moisture over complex and diverse environments in near real time.



A conceptual picture to show the ABLE model components, data source, computing platform, and output results

Challenges

- The science of turbulent flows in forest, urban and mountain terrain is not well developed.
- Army operational applications will require near real time performance for the model requiring newly developed computing architectures.



Some preliminary results from ABLE model: (A) ABLE-CFD simulation of the Kelvin-Helmoholtz instability in which the bellow type waves appear; (B) ABLE-LBM modeling of flow around a 2D array of building where the multiple vortices shaded from buildings.; (C) ABLE-LBM modeling of Rayleigh-Benard convective cells forced by a warm surface boundary condition.

ARL Facilities and Capabilities Available to Support Collaborative Research

- We have developed a numerical modeling framework, named BMF, to manage source code complexity and increase development efficiency by reducing repetitive, error prone or tedious operations in source code.
- We have developed ABLE model prototype codes using both traditional finite volume (ABLE-CFD) and lattice Boltzmann (ABLE-LBM) methods. ABLE-CFD is mainly for the complex terrain flow modeling and ABLE-LBM is for urban flow modeling.
- We have developed a coordinated triple lidar detection algorithm for turbulent flow over mountainous terrain. This algorithm is very useful for model validation, data assimilation.
- ARL BE division has a strong group of experts in both microscale and mesoscale meteorological modeling.
- The DOD HPC computation center at ARL.
- ARL's remote sensing equipments such as Doppler wind lidars, distributed temperature system, tethering sensing system offers unprecedented validation tools for model development.

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- Expertise on the parallel/massive parallel computing such as GPU, distribute computing.
- Theoretical expertise on atmospheric turbulence modeling, complex microscale flows over mountains and in urban.
- Laboratory capabilities (wind tunnel, water channel) for idealized fluid flow tests to evaluate the numerical model.

List of Related Publications:

1. MacCall, B., G. Huynh, Y. Wang, 2014 The Battlefield Environment Division Modeling Framework (BMF) part I: Optimizing the atmospheric boundary layer environment model for cluster computing. ARL-TR-6813.
2. MacCall, B., and Y. Wang, 2014 The Battlefield Environment Division Modeling Framework (BMF) part II: Serial and parallel output enhancements. ARL-TR-0646.
3. Wang, Y., C. Williamson, B. MacCall, 2012, A description of the framework of the atmospheric boundary layer environment (ABLE) model. ARL-TR6149.
4. Huynh, G., Y. Wang, and C. Williamson, 2012, Visualization of wind data on Google Earth for the three- dimensional wine field (3DWF) model. ARL-TR6138.
5. Wang, Y., G. Huyhn, C. Williamson, 2013. Integration of Google Maps/Earth with Microscale Meteorology Models and Data Visualization *Computer and Geosciences. 61:* 23-31.
6. Wang, Y., E. Creegan, M. Felton, D. Ligon, and G. Huynh, 2013, An investigation of nocturnal low-level-jet generated gravity waves over Oklahoma City before the jet dissipation using Doppler wind lidar data. *J. Applied Remote Sensing. Vol 7:* DOI:10.1117/1.JRS.7.073487.
7. Wang, Y., C. Williamson, G. Huynh, D. Emmitt, and S. Greco, 2010, Diagnostic Wind Model Initialization over a Complex Terrain Using the Airborne Doppler Wind Lidar Data. *The Open Remote Sensing Journal. 3: 17-27.*
8. Wang, Y., C. Klipp, D. Garvey, D. Ligon, C. Williamson, S. Chang, R. Newsom, R. Calhoun, 2007. Nocturnal Low-level-jet Dominated atmospheric Boundary Layer Observed by Doppler Lidars over Oklahoma City during JU2003. *J. Appl. Meteorol and Climatology. 46: 2098-2109.*
9. Wang, Y., C. Williamson, D. Garvey, S. Chang, J. Cogan, 2005. Application of a multigrid method to a mass consistent diagnostic wind model. *J. Appl. Meteorol., 44:* 1078-1089.

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