Atmospheric Boundary Layer Modeling

S&T Campaign: Information Sciences
Sensing and Effecting

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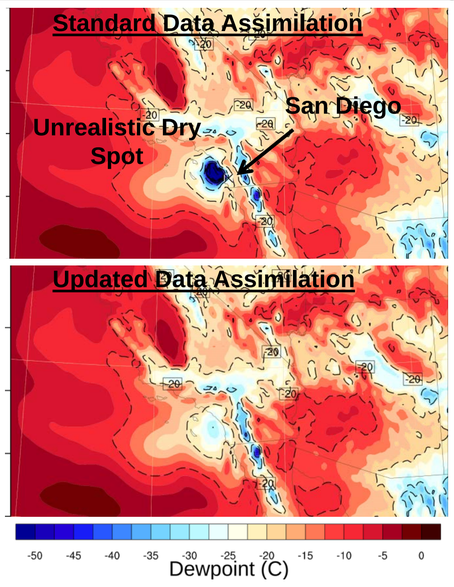
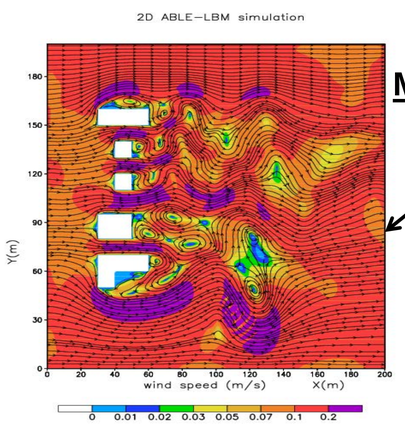
Research Objective

- **Provide the Warfighter with precise, localized, and actionable battlefield weather information/predictions**
  - **Improve microscale (2-2000 m, minutes) & mesoscale (2-200 km, minutes to hours) modeling capabilities.**
  - **Produce the most accurate high-resolution gridded atmospheric predictions for use in battlefield decision aids for atmospheric intelligence on the smallest fixed and mobile computers possible.**

Mesoscale Nowcast Modeling

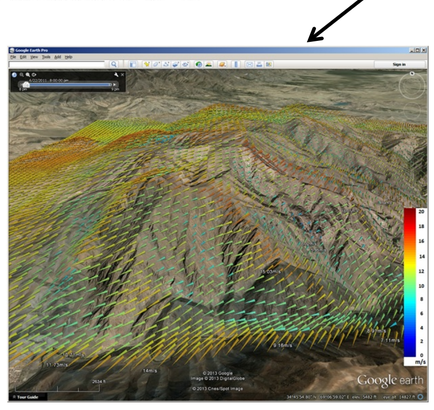


Microscale Modeling



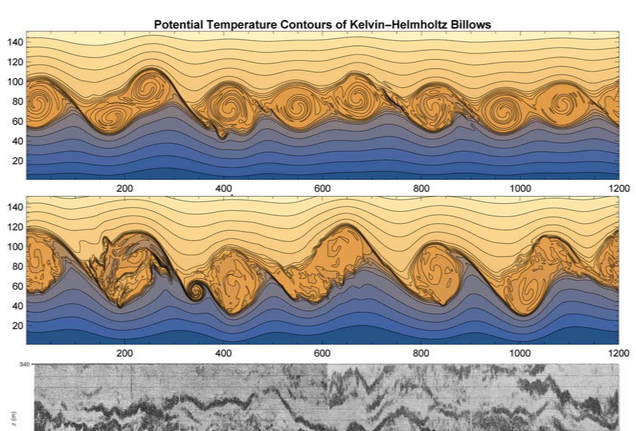
Urban Scales

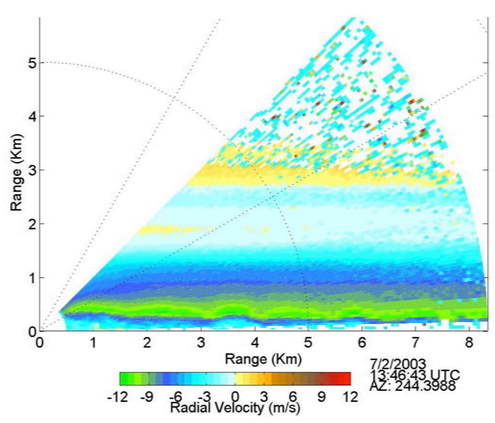
Complex Terrain Scales



Challenges

- **Requires near real time performance from the models relying on limited capabilities of tactical computers**
- **Assimilation of observations in high-resolution simulations – availability, methods, processes**
- **Forecasting mesoscale to microscale – e.g., terra incognita gap, using non-turbulent mesoscale as boundary conditions for turbulent microscale**
- **Representing chaotic turbulent flows in forest, urban, and mountainous terrain**





Idealized simulations of shear instability in a stably stratified medium (top left)
Related atmospheric phenomena observed by an acoustic sounder (bottom left) and a LiDAR (right).

ARL Facilities and Capabilities Available to Support Collaborative Research

- **High Performance Computing capabilities for model development, testing, validation, and transition.**
- **Microscale Atmospheric Boundary Layer Environment (ABLE) model prototype codes developed using both traditional finite volume (ABLE-CFD) and Lattice Boltzmann (ABLE-LBM) methods. ABLE-CFD mainly for complex terrain flow modeling; ABLE-LBM for urban flow modeling.**
- **Mesoscale Weather Running Estimate – Nowcast (WRE-N): WRF-based modeling system utilizing nudging data assimilation. System to provide all input data necessary for WRE-N simulations using nudging data assimilation has been developed → a real-time system is anticipated soon.**
- **Numerical modeling framework developed to manage source code complexity & increase development efficiency**
- **Coordinated triple-LIDAR algorithm developed for detection of turbulent flow over mountainous terrain. This algorithm is very useful for model validation.**

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- **Expertise on parallel/massive parallel computing including GPU and distributed computing**
- **Expertise on bridging the gap between mesoscale and microscale meteorological modeling**
- **Expertise in data assimilation techniques effective for high-resolution on-demand simulations using limited computational power**
- **Theoretical expertise on atmospheric turbulence modeling, complex microscale flows over mountains and in urban environments**
- **Laboratory capabilities (wind tunnel, water channel) for idealized fluid flow tests to evaluate the microscale numerical model**

List of Related Publications:

- MacCall, B, Y. Wang, W-Y Sun, 2015, A new semi-implicit time-integration scheme for the time-dependent Atmospheric Boundary Layer Environment (ABLE) model. In press, ARL-TR.
- Reen, B. P., R. E. Dumais, Jr., and J. E. Passner, In Press. Mitigating Excessive Drying from the Use of Observations in Mesoscale Modeling. *J. Applied Meteorology and Climatology*.
- Cai, H., and R. E. Dumais, Jr., Object-Based Evaluation of a Numerical Weather Prediction. Model's Performance through Forecast Storm Characteristic Analysis. *Weather and Forecasting*.
- Chiao, S., and R. Dumais, 2013: A down-valley flow event during T-REX 2006, *Meteorology and Atmospheric Physics*, **122**, 75-90.
- 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. Also part II: Serial and parallel output enhancements. ARL-TR-0646.
- Wang, Y., E. Creegan, M. Felton, D. Ligon, and G. Huynh, 2013, Investigation of nocturnal low-level-jet generated gravity waves over Oklahoma City during morning boundary layer transition period using Doppler wind lidar data. *J. Applied Remote Sensing.* ***Vol 7(1)***, 073487.