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Laboratory

FastEddy®: Pioneering the Weather Frontier

Setting the Standard for Microscale Weather at Speed

Serving a societal need for detailed weather, where and when it matters most.

Enabling Trustworthy First-Principles Microscale Weather Modeling

Weather modeling products and practices continue to become more sophisticated, yet many atmospheric processes that matter to people and infrastructure occur at scales conventional weather models cannot resolve. Winds around buildings, turbulence near the surface, pollutant transport, wind energy, wildfire behavior, and interactions with complex landscapes, including complex terrain, forest canopies, mixed urban and natural environments, are shaped by microscale processes occurring over minutes and meters.

FastEddy® is a GPU-accelerated large-eddy simulation (LES) model designed to provide high-fidelity simulations at speeds that define new standards for research, forecasting, and decision support while maintaining conservative physics and rigorous mathematical formulations. As AI approaches complement weather modeling and forecasting, FastEddy® provides a first-principles foundation for next generation AI-enabled atmospheric applications, supplying high-fidelity physical simulations for developing and evaluating such emerging approaches.

Research through Practical Tooling

The FastEddy® team is expanding fine-scale process representation while delivering game-changing performance that makes microscale modeling more practical and useful. GPU computing reduces

Benefits & Impacts

- Harnessing the speed of GPUs
- Transforming research, forecasting, and education in microscale meteorology
- Now downscaling for sharper, localized forecasts
- Fueling next-generation AI/ML weather model development
- A continuously advancing, open-source model

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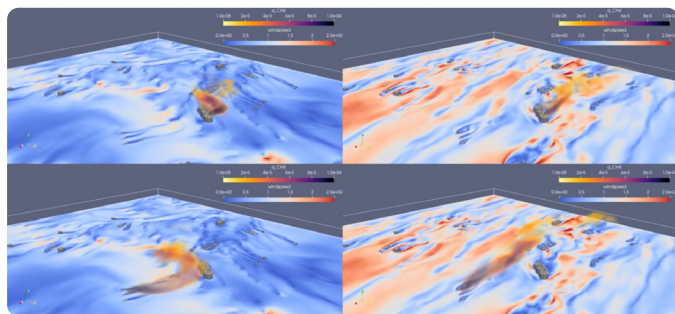
computational time and energy requirements, enabling larger domains, more simulations, and studies at previously impractical speeds.

The team is also developing tools and workflows for broader community use, including AI-enabled products, high-performance computing and GPU environments, and software infrastructure for testing, reproducibility, and continued development.

High-fidelity, first-principles microscale modeling, made practical through GPU computing, to support trustworthy weather research, forecasting, and next-generation decision making.

Supporting Impactful Science

FastEddy® connects weather information from mesoscale numerical weather prediction through sub-meter scale LES. Current capabilities include downscaling from the Weather Research and Forecast (WRF), the Model for Prediction Across Scales (MPAS), and LES-to-LES nesting. These unique capabilities allow researchers to examine how larger-scale weather drives localized winds, turbulence, and other microscale phenomena in real-world scenarios.

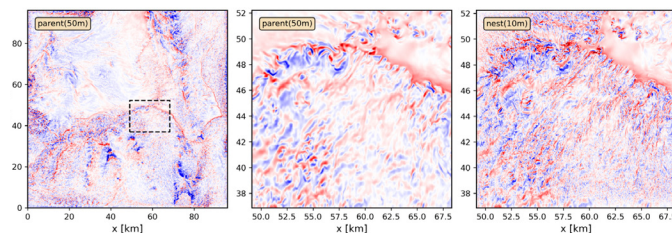


Methane dispersion from two wellpad emission sources, storage tank hatch (top) and separator valve (bottom)

The team is applying these capabilities to a growing range of scientific and societal challenges:

- **Urban weather:** Simulating how buildings and urban environments influence winds, turbulence, clouds, and precipitation
- **Renewable energy:** Improving wind-resource assessment, turbine siting, and understanding of wind-farm environments

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Vertical velocity at Jornada Experimental Range: 50m parent (left), cropped parent (center), and nested 10m inset (right).

- **Aviation and uncrewed systems:** Characterizing fine-scale winds and turbulence
- **Wildfire:** Investigating interactions between atmospheric flows, terrain, and wildfire behavior
- **Atmospheric transport:** Modeling how pollutants and other airborne materials move through complex urban environments
- **Convective storms and severe weather:** Resolving cloud dynamics and microphysical processes over regional scales
- **Boundary-layer science:** Advancing understanding of turbulence and atmosphere-surface interactions
- **Education and workforce development:** Providing a high-resolution platform for exploring atmospheric processes and computational modeling

These efforts are complemented by continued improvements in GPU performance, scalability, portability, model physics, validation, and community software practices. FastEddy® is an open-source community model shaped by researchers, stakeholders, and user feedback.

Building the Next Generation of Microscale Modeling

FastEddy® convenes scientific capabilities, computational tools, workflows, and expertise to enable new approaches to high-resolution atmospheric modeling. By combining advances in atmospheric science with GPU computing and community-focused software development, the team is helping make microscale weather modeling faster, more capable, and more broadly useful for tomorrow's research, forecasting, and decision-support needs.

