



DTO CB.55
Chemical and Biological Hazard
Environmental Prediction



Chemical and Biological
Hazard Environmental Prediction

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Outline

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- **Task 1: MESO**
 - MESO Background
 - MESO FY05 Objectives
 - MESO Achievements
- **Task 2: CBW-CFX/CBW Libraries (CBWLIB)**
 - CBW-CFX Background
 - Work Transition from CBW-CFX to CBWLIB
 - CBWLIB FY05 Objectives
 - CBWLIB Achievements
- **FY06 Objectives**
- **Questions?**



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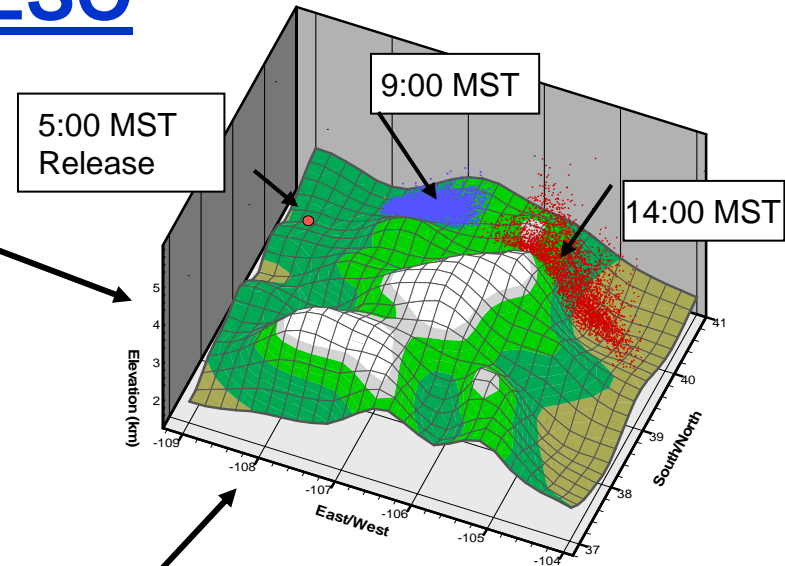
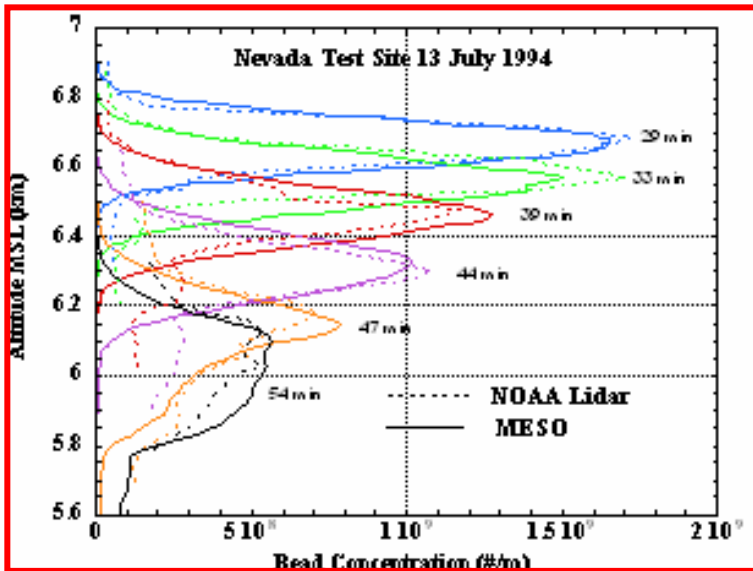
Description of Effort

- **Improve the state-of-the-art of CB hazard prediction modeling beyond Gaussian puff by:**
 - **Developing a Lagrangian particle transport model for rapid analysis of atmospheric releases [MESO]**
 - **Developing CB libraries to support a computational fluid dynamics based model for high resolution analysis around buildings and ships [CBW-CFX]**
- **Address the physical and CB processes affecting CB agents released**
- **Transition physics into libraries that will be tested in CBW-CFX**
- **Provide MESO and the libraries for transition to the Joint Effects Model (JEM) and the Joint Operation Effects Federation (JOEF)**

Develop hazard prediction models and CB libraries for transition to JEM and JOEF.

Background – MESO

MESO prediction showing transport of hazard across complex terrain



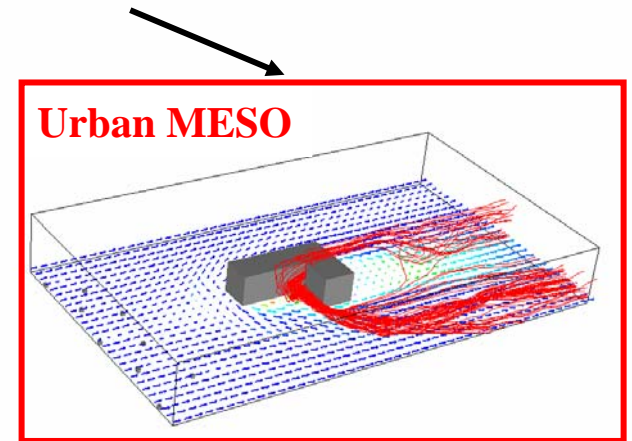
MESO Simulation With Meteorology provided by COAMPS (Coupled Ocean/Atmosphere Mesoscale Prediction System)

MESO validation using Crystal Mist data shows excellent performance at high elevations (up to 7 km)

MESO incorporates advanced meteorological and agent physics into a Lagrangian particle transport model to provide higher resolution simulations.

Background – MESO (cont.)

**High-resolution dispersion
calculation around buildings**



**More user-friendly
interface**

Past improvements to MESO (ease of use, improved atmospheric and CB physics, run-time enhancements, etc.) have been leveraged toward the urban environment.



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MESO: FY05 Objectives

- **Verification**
 - Complexity Analysis
 - Test of MESO GUI Inputs
 - Verification of Methodology in Code
 - Test of Subroutines
- **Validation**
 - Field Trial Comparisons
- **Documentation**
 - SDD
 - SUM
 - V&V Report

MESO needs V&V and documentation to support transition to JEM.



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MESO Verification of Code

- **Verification of Methodology in Code**
 - Developers verification of code complete
 - Work resulted in corrections to: BndryLayerUpdate3D, ClearAirTurb, VertDiffus, and DepositionVelocity
 - NSWCCD reviewing and spot-checking equations
- **Test of Subroutines**
 - Exercise every function
 - Qualitatively check each version
 - Test design complete

The MESO methodology was verified during the SDD development and is being independently checked. Test cases are being designed to exercise every function for initial check of new modifications.



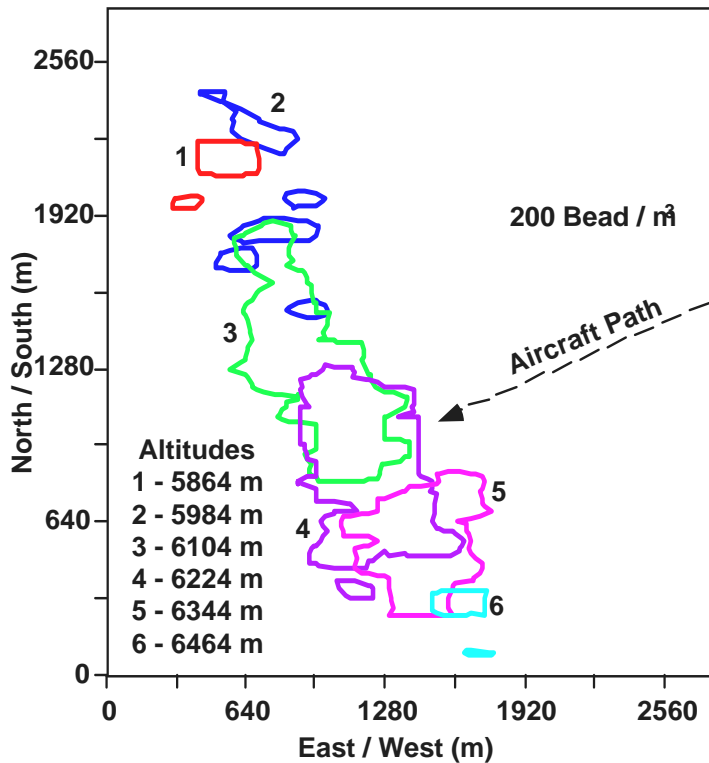
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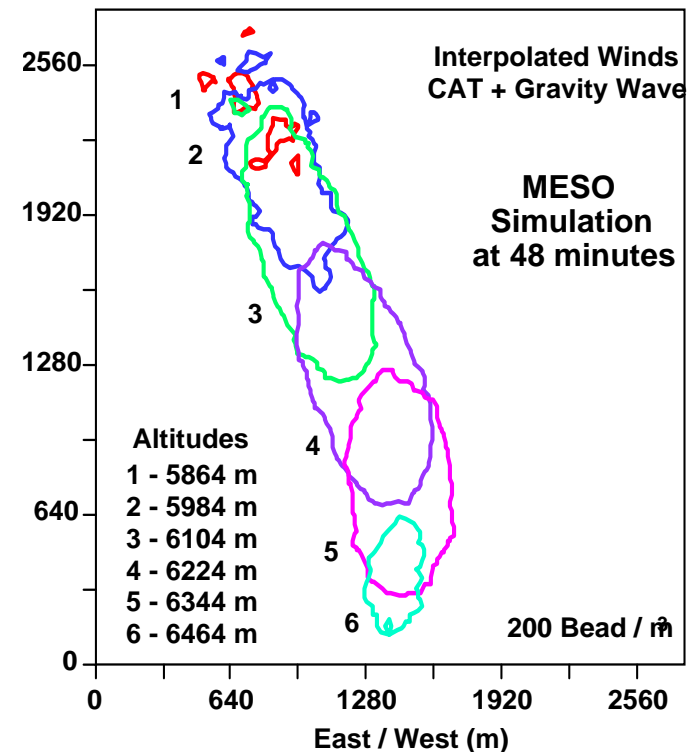


MESO Validation

NOAA Lidar



MESO Simulation



A subset of cases run during the VLSTRACK validation is being used to validate MESO in a three-way comparison.



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MESO Documentation

- **Software User's Manual**
 - Needs minor updates for new version
 - In review
- **Software Design Description**
 - 900 page document
 - In review
- **Verification and Validation Report**
 - Forward sections complete
 - Field trial sections in progress

The V&V reports are awaiting completion of the V&V tasks.



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MESO Status

- **Verification**
 - Complexity Analysis **Complete**
 - Test of MESO inputs **90%**
 - Verification of Methodology in Code **85%**
 - Test of Subroutines **90%**
- **Validation**
 - Field Trial Comparisons **70%**
- **Documentation**
 - SDD **In review**
 - SUM **In review**
 - V&V Report **45%**

V&V progressing, but at a slower pace than expected.



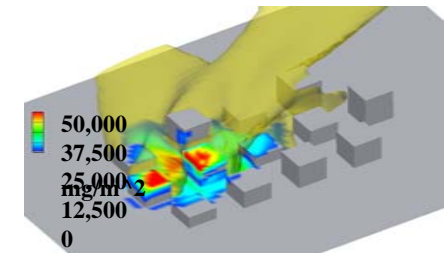
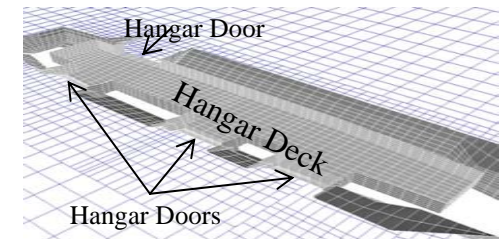
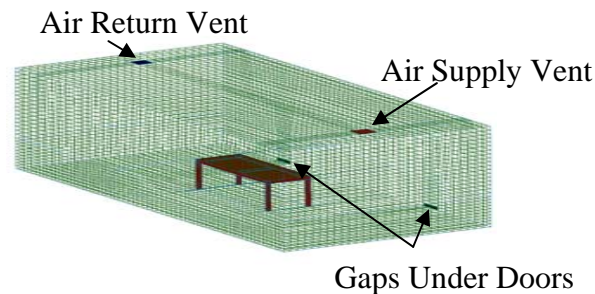
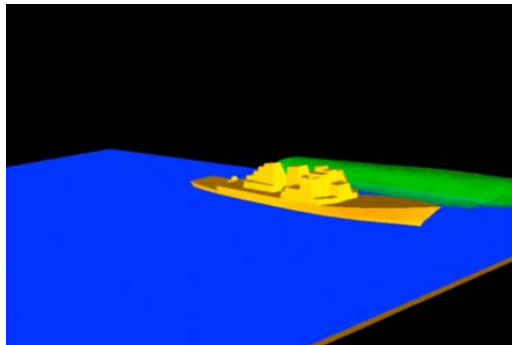
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Background - CBW-CFX

- An integrated system of COTS and Government Computational Fluid Dynamics (CFD) technology for CBW Hazard Prediction



- Models transport of vapor and particles entrained in the air flow
- Models droplet evaporation, surface deposition, and weathering effects
- Implement additional CBW physics via user-defined subroutines

CBW-CFX provides high-fidelity CFD simulation over and through moving or stationary 3D structures such as ships and buildings.



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Work Transition: CBW-CFX/CBWLIB

- **The Past:**
 - Under CB.55, NSWCDD advanced the fidelity of hazard predictions through the development of CB capabilities within CBW-CFX
- **Current and Future:**
 - NSWCDD is now developing these capabilities to be useable as compiled generic library functions
 - Updated and extendable library framework
 - Easily interfaced and called from any general CFD code
 - Modularize legacy code with minimal rewriting
 - The libraries will be validated vs. experimental data (incl. field trials)
 - Dynamic library approach will **enhance transition to JEM** through dynamically linked library (.dll) or shared object library (.so)

CB capabilities developed, tested, and embedded in existing codes are being converted to libraries that will be easier to transition to JEM.



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CBWLIB: FY05 Objectives

- **Develop** CB-hazard-specific physics models into generic, **standalone library functions** with clean interfaces for ease of reuse and incorporation into evolving CFD-based transport and dispersion simulation tools
- **V&V of libraries** to ensure proper functionality and accuracy
- **Document libraries** and their functions to ensure ease of use and integration with candidate simulation codes
- **Execute configuration management practices** to ensure reliability

FY05 shifts toward library development to provide better mechanism for transition.



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CBWLIB: Achievements

- Developed a systematic approach to library development
- Implemented a robust configuration management process
 - Stress tested with 5 developers simultaneously working on the same 1500 line module
- Systematic peer review of legacy source code
- Created documentation standard and documented the existing CBW-CFX code
- Ported legacy capabilities into CBWLIB

A systematic approach is being used to port legacy capabilities into CBWLIB.



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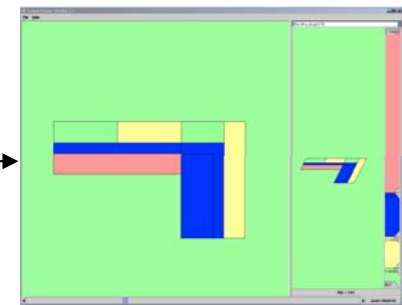
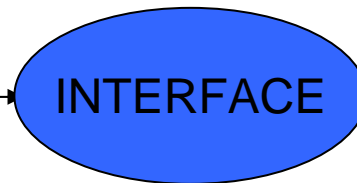
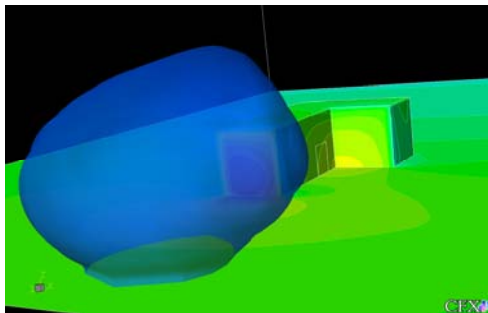
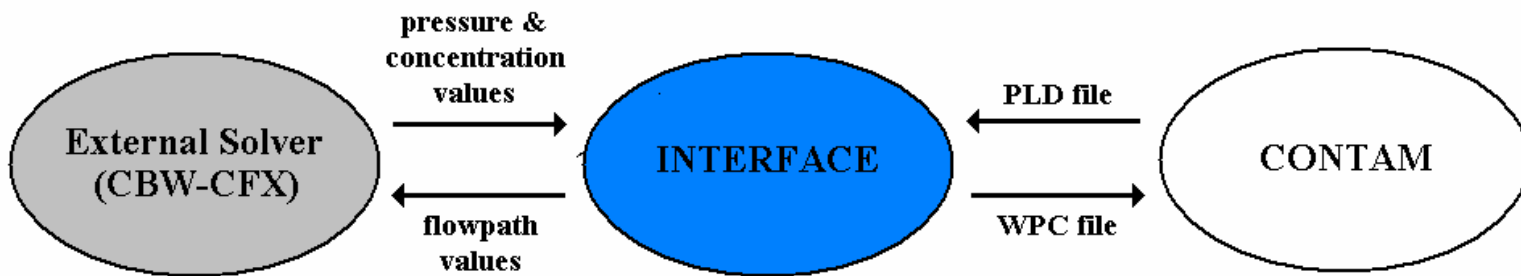


CBWLIB: Contributors

- Leverages multiple projects
 - DARPA Immune Building
 - JEM
 - Agent Fate
 - MESO
- International collaboration
 - Missile Intercept (NL)
 - Explicit Uncertainty (UK)

CBWLIB has contributors and users among many DoD projects and the CB community.

CONTAM Interface



A new technology developed within the CBWLIB framework and utilized by several outside projects.



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FY06 Objectives

- **MESO Model Standardization Effort (atmospheric and urban versions)**
 - MESO Atmospheric and Urban Model Integration
 - MESO GUI and document standardization
- **CFD Library Development Effort**
 - CBWLIB Development
 - Continue CBW-CFX Methods Integration
 - Integrate JEM High Altitude Intercept Library
 - Integrate Relevant ADVEDS Modules
 - Integrate Surface Evaporation Functionality
 - CFD Model Comparison
 - Module Validation vs. Legacy Benchmark
 - CBW-CFX vs. CFX (with library) Verification
 - Sample FLUENT (with library) Runs vs. Benchmark
 - Library Documentation

FY06 plans are to merge and standardize the two MESO models and complete CFD Library development for transition to JEM.



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Currently Two Slightly Different MESO Models

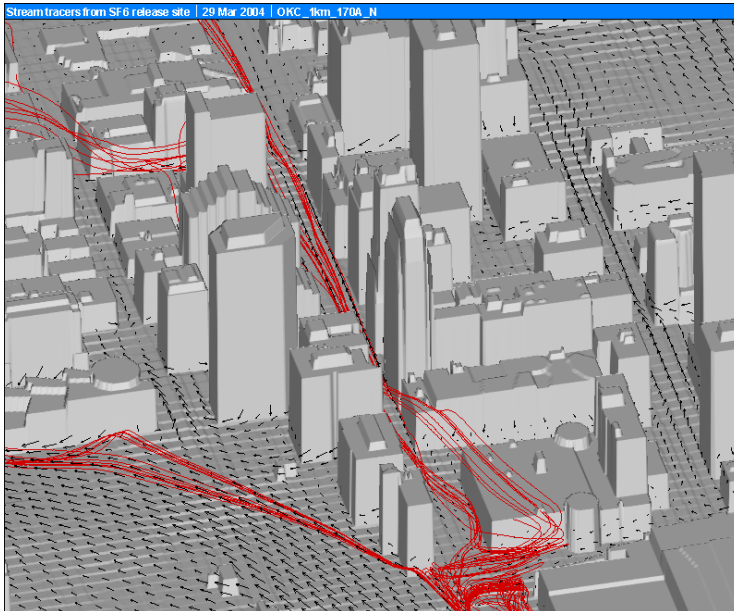
- **Atmospheric MESO - NSWCCD has been developing the MESO Lagrangian model for atmospheric releases**
- **Urban MESO - Urban capabilities were added to NSWCCD developed model through leveraging by other DoD organization**
- **FY06 will standardize the models**
 - **Common call**
 - **Code reuse**
 - **Documentation**
 - **GUI**

Work under CB55 was leveraged and configuration management is necessary to control the final product.

MESO/RUSTIC is a New Generation Model That Provides Accurate 3D Urban Hazard Definitions

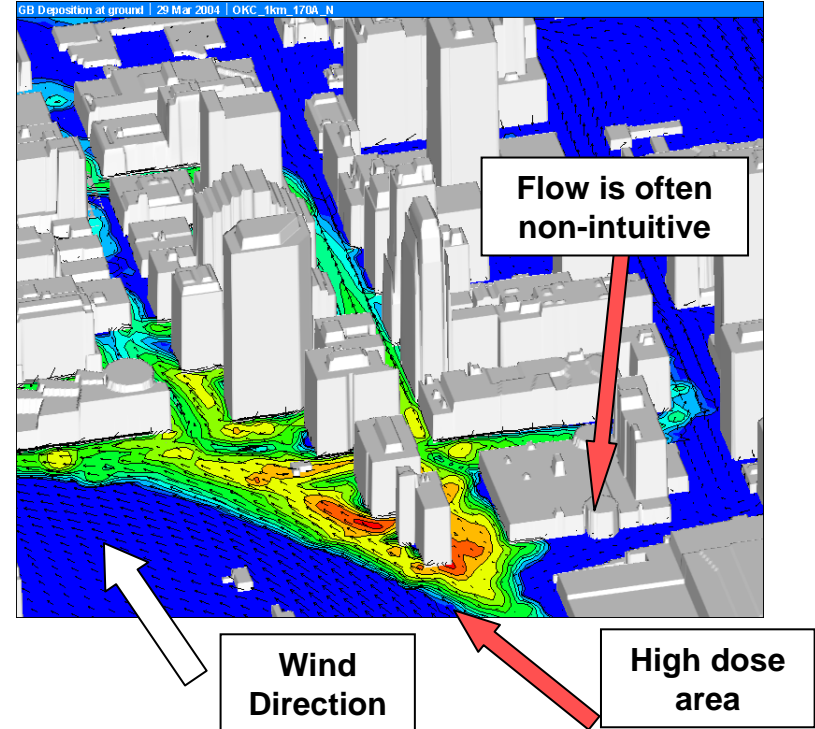
Two Steps for Urban CBR Hazard Definition with MESO/RUSTIC

1. Compute turbulent “wind flow” with **RUSTIC** for urban scenarios.
2. Use **MESO** to compute contaminant dispersion with flow and turbulence predicted by RUSTIC.



Downtown Oklahoma City July 2003

Approved for Public Release, Distribution Unlimited, DARPA
(MESO/RUSTIC Case 2585)



Results from the leveraged MESO effort in an urban environment.



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Questions?



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Summary

The models being developed address a variety of challenges:

- **Wide range of scales (meters to many kilometers)**
 - **MESO developed for large open areas and CFD codes for urban and ships**
- **Wide variety of interacting processes involved and variety of operational environments that must be addressed**
 - **Models that include full CB physics**
- **Interaction between models for various purposes, domains**
 - **Libraries that help interface VLSTRACK to CBW-CFX and CBW-CFX to CONTAM**
- **Supporting databases (e.g., buildings) and enabling technologies (e.g., weather)**
 - **urban-MESO grid generator; MESO interface to COAMPS meteorological data**
- **Computation time vs. resolution**
 - **Speed enhancements to MESO; use of CFD codes for sensor placement, studies, or validation of other models**
- **V&V - verification reviews, data collection, validation studies**
 - **V&V of MESO and CBWLIB**

The model development addresses many challenges while advancing the state-of-the-art.