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Army Research Lab and WRF

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Chief (A)

Battlefield Environment Division

U.S. Army Research Laboratory

Presented to the WRF Executive Oversight Board, 13 Apr 2005

Mission: Battlefield Weather for C4ISR

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Vision

Tailored weather intelligence to ensure the warfighter's combat effectiveness

Major Research Areas

Atmospheric Sensing

Atmospheric Modeling

Atmospheric Effects

Battlefield Environment Division Organization

Battlefield Environment Division

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Atmospheric Sensing Branch
- Acoustic propagation
- Infrasonic sensing
- Aerosol characterization
- Optical imaging
- E-O propagation

Dr. David Ligon (A)

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Meteorological Modeling Branch
- Micro-scale modeling
- Nowcasting
- Data assimilation/fusion
- Transport and diffusion
- Distributed processing

Dr. James Cogan

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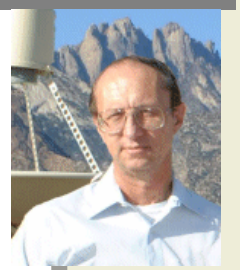
Atmospheric Effects Branch
- Met field measurements
- Propagation effects models and experiments
- Tactical Decision Aids
- Bandwidth compression



Dr. Donald Hoock

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Focused Expertise

- Developing technologies that directly transition to the Army's fielded tactical weather system Program Managers
  - Battlefield environmental data for C2 and ISR - Current Army IMETS, future Army DCGS-A and Air Force JET, with interfaces to FCS and Joint METOC services
  - Army Artillery-Meteorology profiling systems and the Marine Corps mobile hand held artillery firing solution system
- Developing Tri-service physics-based models that quantify atmospheric effects on military systems
- Fine scale meteorological modeling for the complex battlefield terrain affecting today's soldiers and systems
  - Urban wind flow models down to street level scales for timely CB defense, smoke, UAV, and emergency operations
  - Fine scale "nowcasts" and analyses, 0-3 hrs and down to 10 meters to update forecasts and data fusion applications

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Modeling Specialty Areas

- Mesoscale and microscale modeling applications to solve Army battlefield weather problems.
- Boundary layer measurements across night time and day time stability conditions in complex terrain (incl. “urban” terrain) for 4-D Data Assimilation, model initialization, and validation
- Model verification and validation including confidence indices and display of uncertainty to support user confidence
- Developing new fusion methods for real time, 3D atmospheric wind field monitoring exploiting LIDAR remote sensing, environmental models, and networked conventional/unconventional met sensors
- Transport and diffusion modeling

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Atmospheric Modeling

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GOALS

- **Provide modeling and data fusion tools to enhance operational effectiveness and survivability.**
- **Provide essential atmospheric intelligence for tactical decision aids.**

APPROACH

- **Characterize the Army-scale boundary layer atmosphere using observation-based numerical models running in near real-time for the specific unit of action.**
- **Develop and apply techniques to ingest met data from non-traditional sources such as UAV's, UGS, and individual soldier observations.**
- **Design techniques for the distribution and dissemination of model output tailored for the net-centric Army.**

Atmospheric Modeling Evolution

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0 - 3 Years

3 - 5 Years

> 5 Years

Basic Mesoscale Nowcast

Advanced Meso/Microscale Nowcast

Artillery Met upgrades

Near real-time urban microscale wind field and dispersion models

Advanced assimilation of non-traditional data

Multi-scale combined model and measurement system

- IMETS
- C2CUT ATO
- MMS-P
- Marines
- DCGS-A (Spiral 4)

- DCGS-A (Spiral 5)
- JET (Air Force)
- NITES (Navy)
- JEM (DTRA)

- DCGS-A (Spiral 6)
- Block 3 MMS-P
- JWARN (DTRA)

Critical Modeling Technologies & Interests

- **Urban wind flow and dispersion in near real-time**
- **Nowcasting at very fine scales**
- **Very high fidelity modeling and measurement of 4D atmospheric dynamics and effects on Army systems**
- **Uncertainty Techniques - How good are the model results?**
  - **When the model predicts weather conditions which will adversely impact a specific mission at a planned time, how "certain" is that forecast?**

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Climatology, Forecasts and Nowcasts -- higher resolution as the mission approaches

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Climatology
(historical data)

Long-Range Forecasts
(GFS 36 -120 hr forecasts,
5-10 day forecasts)

Synoptic Forecasts
(Global GFS 0-36 hr forecast)

Mesoscale Forecasts
(Regional MM5/WRF 0-12, 0-24 hr forecast)

Mesoscale Nowcasts
(Local 0-3, 0-6 hr MM5/WRF forecast)

Local Analysis
(LAPS, Near real-time, current weather)

Microscale analysis in embedded applications [Urban 3D Wind Field (3DWF), HPAC Urban Dispersion Model, …]

Operations Planning

Mission Planning

Mission Rehearsal

Mission Execution

Evolving CROP

UE

IMETS

DCGS-A / FCS

UA

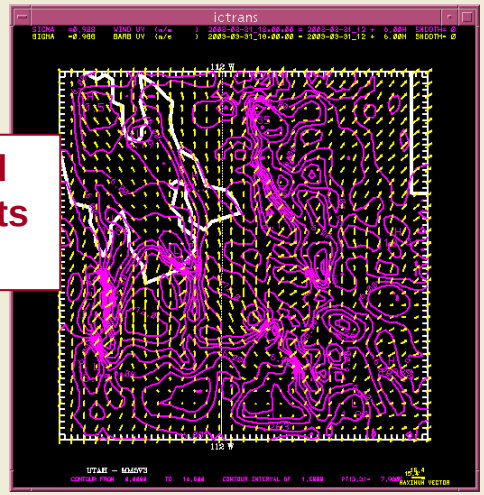
AF/Joint DoD Centers Supply Model Grids

Army-created grids

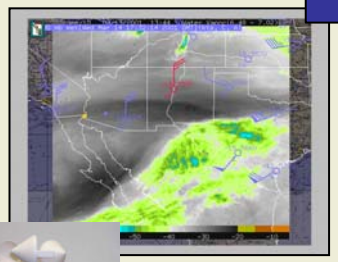
Hierarchy of new nowcast models to update the local forecasts

Forecast - Operational Center (AFWA) MM5/**WRF** Forecast for next 24-48 hours, 2-4 times daily, 15-5 km resolution on “regional” domain

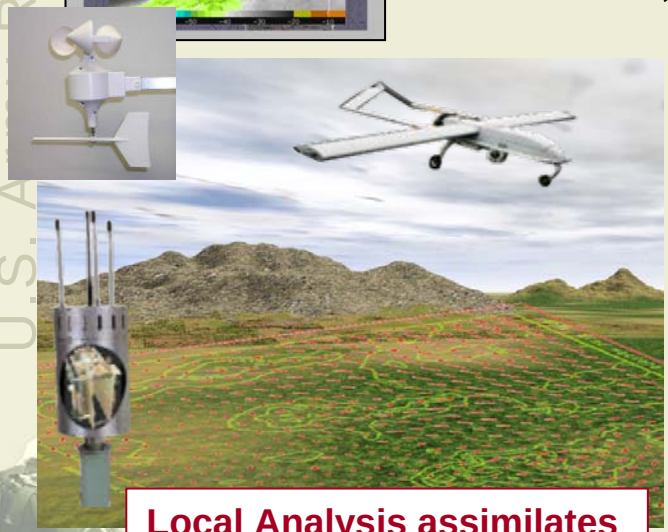
Nowcast runs local short term forecasts at UE (IMETS/JET)



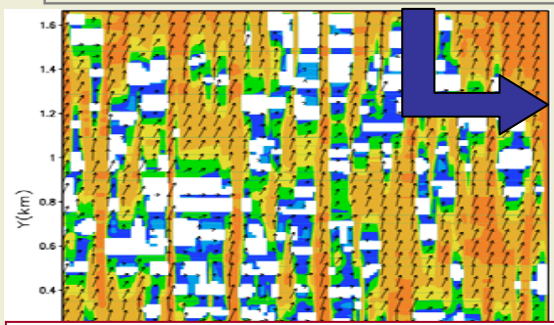
Nowcast - run hourly, **WRF** forecasting the next 3 hours on 2-3 km grid over 150 x 150 km or smaller domains



Advanced Local Analysis – run every 15-30 minutes on1 km grid and up to a 150 km domain - Integrates local and non conventional observations (METSAT, UAV sensor data, robotic wind sensors) into current nowcast – example is LAPS objective analysis in development at the University of North Dakota



Local Analysis assimilates data at UA (DCGS-A)



Diagnostic urban wind model running as embedded client on UA DCGS / FCS

Diagnostic High Resolution Models – fast running (5-10 min) boundary layer wind model 10-100 m resolution for complex and urban terrain effects on average wind flow – can use local observations

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Current/Future WRF Work at ARL

- **Led by the Meteorological Modeling Branch**
  - **20 meteorologists, engineers, and technicians focused on fine-scale modeling and Army applications.**
- **Interactions between ARL modelers and various WRF Working Groups**
- **Starting the transition, following AFWA's lead, towards WRF as the model-of-choice for Army/Air Force applications.**
- **WRF now running on AHPCRC (latest version 2.0.2)**
  - **Nested to 2km over southern California**
  - **Prep for data sets from T-REX -- Terrain-induced Rotor Experiment, Spring 2006**
  - **Small mixed-member ensembles a possibility – being researched – diurnal boundary layer evolution**
- **Use of WRF grids from AFWA to initialize nested fine-scale 3-hr LAPS/WRF nowcasts**
  - **Goal = Output over 150km x 150km domains, 1km horizontal resolution, 15-30 minute output interval, hourly cycling.**
  - **Fine-scale "data cubes" used to run Army-specific mission decision aids**
  - **Technology to be incorporated operationally into Air Force/Army battlefield weather software systems.**

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Potential ARL Roles in WRF Program

- Assist AF and Navy with DoD oversight (R&D and operational implementations)
- Work in collaboration with AF Weather to address Army/AF-specific WRF issues
  - Focus on microscale and “urban terrain” uses
  - Test new parameterizations (stable, urban, …)
  - Others?
- Boundary Layer Modeling improvement/applications
- WRF applied to Transport and Diffusion simulations
- WRF post-processing algorithms and verification
- WRF software configuration for DoD tactical PC/Laptop workstation platforms
- WRF testing and validation

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Summary

- **ARL views WRF as THE primary mesoscale model for research, development, and operational implementation focus → in line with AF Weather commitment to WRF as the operational regional and fine-scale model of choice.**

- **Thus, ARL's interest and enthusiasm to participate as a WRF AIP signatory.**

QUESTIONS?

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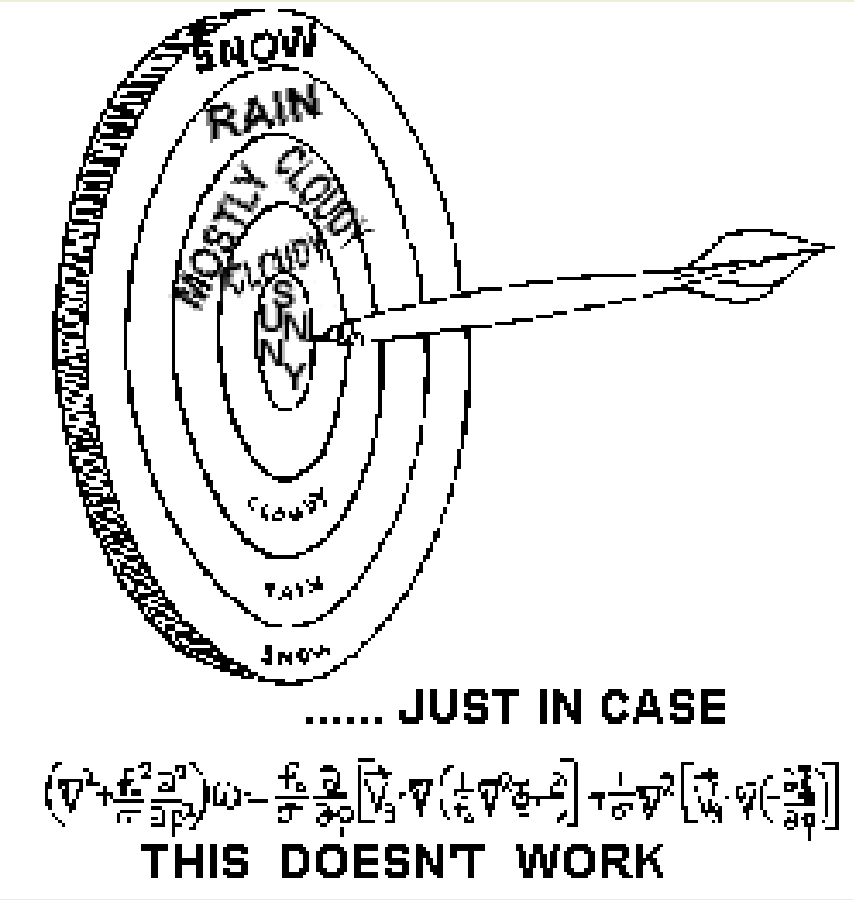

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