Nowcasting and Urban Interactive Modeling Using Robotic and Remotely Sensed Data

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OUTLINE

1. Overall System Concept
2. Met Spaces
3. Platforms
4. Sensors
6. One Concept of Distributed Operation
7. Summary
Block diagram of a possible configuration of a mobile distributed meteorological system

- Wind profiling radar, lidar, or sodar with computer on-board.
- Temperature and moisture MW radiometer with computer on-board.
- Portable meteorological sensors mounted on UAV and UGV.
- Deployable surface sensors and meteorological towers with sensors (e.g., sonic anemometers).
- Meteorological satellite receiver.
- Interfaces to other systems, mobile centers, and EOC.
- On site or remote mesoscale model (e.g., WRF, MM5).
- On site or remote microscale model (e.g., 3DWF).
- On site or remote dispersion “Tool” (e.g., ARL_DAT).
- Other models as required at local site or distributed.
- GUI and other user interfaces.

All connections 2-way via the Met Space.
Sample data flow using a networked Met-Space environment.

Notes: (1) the Met Space Environment may be hosted in any available computing environment. (2) MSA = Met Space Agent.
UAV and UGV

PACBOT

Shadow UAV

Short-range UAV

Acoustic Sensor Test-bed
The Metprobe: 1990 Technology

Dectects and determines:
- Ice presence
- Median and peak turbulence
- Static pressure and pressure altitude
- Air temperature (Mach corrected)
- Relative humidity
- Indicated and true airspeed
- Wind speed and direction
- Built-in GPS

Future: Detection of atmospheric chem/bio/radiation presence.
Dual lidar winds south of OKC, July 2003

ARL Lidar

ASU Lidar
Boundary Layer Evolution at Oklahoma City under clear skies from the ARL Doppler Lidar

Wind From SW
Weather Running Estimate – Nowcast (WRE-N)

The interactive combination of a rapid data assimilation and analysis tool with a fine resolution mesoscale short range prediction model.

Example: modified LAPS with WRF.
**Hierarchy of models for high resolution updates to forecasts**

- **Forecast** - Operational Center (AFWA)
  Mesoscale MM5 Forecast for next 36-72 hours, 2-4 times daily, 45 to 15 km resolution on a “global” domain

- **Nowcast (short term forecast)** - run hourly, forecasting the next 3 hours on a 2.5 km grid over 150 x 150 km or smaller domains.

- **Local short term forecasts at BCT (IMETS/JET)**

- **Diagnostic High Resolution Models** – fast running (5-10 min) boundary layer wind model at 10-100 m resolution for complex and urban terrain effects on average wind flow – can use local observations
  Provides input to advanced applications on DCGS-A.

- **Local Analysis Prediction System (LAPS) assimilates data at BCT (DCGS-A)**

- **WRE (advanced local analysis)** – run every 15-30 minutes on a 1 km grid over a domain within the Nowcast - Integrates local and non-conventional observations (METSAT, UAV sensor data, robotic wind sensors) into current nowcast – example: LAPS objective analysis in development at the University of North Dakota

- **Diagnostic urban wind model running as embedded client on BCT DCGS / FCS**
Tactical Army WRE-N Strategy: Multi-component

WRE-N (BCT MM5/ WRF) Domain
~ 150 x 150 km
Runs every hour
Meso-gamma NWP with data assimilation – uses “hot start” method.

Nested WRE domain:
< 150 x 150 km
Objective analysis (e.g., modified LAPS, 4DDA)

Multiple nested WRE domains may lie within the WRE-N domain

Microscale tools running on mobile platforms (e.g., PDA).
1. MM5 forecast of the near surface wind field (3.3 km) for area over White Sands Missile Range (WSMR), NM.

2. Current wind field observations over the area of interest.

3. Wind field modified by fusion of observations into the forecast.
Hierarchical Meteorological Analysis “System” for Microscales

Short range NWP data assimilation cycling and advanced analysis for about 1-2 km scale

Computationally fast dispersion tools for rapid plume fate assessment in urban areas

Computationally fast diagnostic micro and urban scale models to nest within the 1-2 km resolution analyses

Microscale analysis tools running on PDA platforms
3-D Wind Field (3DWF) with Lagrangian dispersion model showing change of dispersion with time over an urban area.
ARL DAT output display showing the deposition field after six hours following a release of hazardous material.
One concept of distributed operation (WSMR and Playas, NM)

- Instrumentation (towers, surface stations, lidar, profiling radar, sodar, radiometers, UAV, UGV, etc.) at Playas, NM site.
- Network connection to BED-WSMR.
- Command and control of instrumentation at BED-WSMR.
- Models and tools run at BED-WSMR.
- Network connection to Playas, NM.

After setup, personnel travel to Playas for:
- Scheduled and emergency maintenance,
- Setup/test new instrumentation,
- Remove old or obsolete instrumentation.

- Measurements feed analysis and forecast models in near real time.
- Analysis and model output, and user input, help determine instrumentation parameters (frequency of observations, data format, etc.). [Targeted observations.]
- New measurements provide near real time input to models that in turn help determine instrument parameters, ..., and so forth in a feedback loop.
CONTINUATION
(Not the Conclusion)

• Proposal paper on work required to accomplish the goals of this presentation already prepared and available.
• Proposal paper on closely related work that would allow simulation of a distributed meteorological system using certain HPC facilities already prepared and available (not directly discussed in this presentation).
1. A combined multi-model and sensor system can provide essential information on the state of the atmosphere and short term predictions for operations, CBNRE defense, and natural or man-made emergencies.

2. The system can serve as an R&D test-bed, a means for rapid testing of sensor or model prototypes, or as a local meteorological center.

3. The technology for such a system exists today and will not require a technological breakthrough.

4. The modular design allows the flexibility to handle the addition, subtraction, or replacement/upgrade of sensors, models, or other software with minimal disruption.