J12.6 NATIONAL FIRE PLAN – EASTERN AREA MODELING CONSORTIUM: RESEARCH, PRODUCT DEVELOPMENT, AND PARTNERSHIPS

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1. INTRODUCTION

The high profile severe wildland fires that occurred over the western U.S. in 2000 and 2002 and the political debate over the most effective means to manage ecosystems at risk to severe fires have raised public awareness of the wildland fire problem in the U.S. Following the severe fires in 2000 that burned 8.4 million acres nationwide, the President of the United States requested that the Secretaries of the Department of Agriculture and Department of the Interior develop a plan to respond to the severe fire season, reduce the impacts of wildland fires on rural communities, and ensure sufficient firefighting resources in the future. Out of that request, the U.S. National Fire Plan (NFP) was born. The language in the NFP called for Federal agencies to cooperate with States and local communities to take actions to reduce immediate fire hazards to communities in the wildland-urban interface and ensure the preparedness of fire management and firefighter personnel and resources for future extreme fire conditions. The key components of the NFP include: (1) enhancing the country's preparedness for firefighting in future years, (2) restoring landscapes and rebuilding communities damaged by wildfires, (3) investing in projects to reduce fire risk, and (4) assisting communities to ensure adequate fire protection.

Although the majority of the Federal funds to support the NFP is dedicated to fire-management related activities across the U.S. that address the above four components, the NFP is also providing funds for research and product development efforts to support the fire management community. In September 2000, the USDA Forest Service's Deputy Chief for Research issued a request for NFP research proposals to the Research branch of the Forest Service. The request called for research proposal submissions that related to the four NFP components listed above. One critical area of research and product development called for in the NFP request for proposals was the development, improvement, and validation of models for fire-weather, fire danger, fire behavior, fire hazard rating, and smoke management in wildfires and prescribed fires.

In response to this proposal request and these research and product development needs, the atmospheric research program within the USDA Forest Service developed a research and product development strategy built around the concept of regional modeling consortia. Scientists at five USDA Forest Service Research Stations submitted proposals and secured funding for the development of five regional Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS) (http://www.fs.fed.us/fcamms), as shown in Figure 1. They include the Northwest Regional Modeling Consortium (NWRMC) in Seattle, WA; the California and Nevada Air Consortium (CANSAC) located in Reno, NV and at the Riverside Fire Laboratory in Riverside, CA; the Rocky Mountain Center (RMC) located in Fort Collins, CO; the Southern High Resolution Modeling Consortium (SHRMC) located in Athens, GA; and the Eastern Area Modeling Consortium (EAMC) located in East Lansing, MI. Each regional Consortium has been built as a multi-agency coalition of researchers, fire managers, air-quality managers, and natural resource managers at the Federal, State, and local levels to conduct research and develop products focused on improving our understanding of fire-atmosphere interactions and our ability to predict those interactions (USDA Forest Service 2002, 2003).

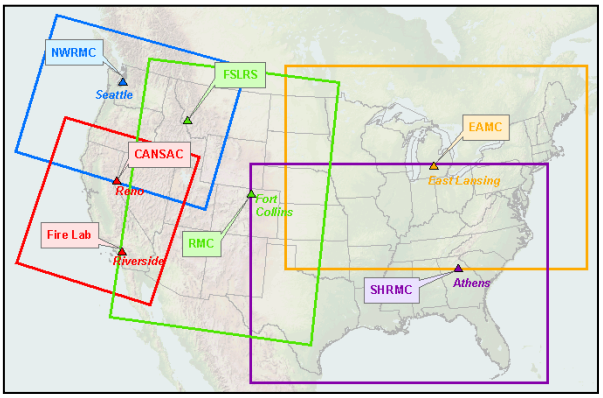

Figure 1. Locations of the five FCAMMS established by the U.S. NFP and the geographic domains (12 km grid-spacing) covered by the individual Consortium modeling efforts.

This paper provides an overview of the EAMC research and product development strategy, EAMC membership, the computational environment developed for the EAMC, research and end-user partnerships, and initial research and development progress of the EAMC in addressing fire weather, fire danger, fire behavior, and smoke transport/diffusion problems in the north central and northeastern U.S.

2. EAMC RESEARCH AND PRODUCT DEVELOPMENT STRATEGY

The EAMC was founded in 2001 to conduct basic and applied research, develop products, and transfer technology related to national and north-central/northeastern U.S. fire-weather and air-quality

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dynamics. Research products and associated technology transfer efforts developed and undertaken by the EAMC are meant to serve the needs of the fire management community, air resource managers, scientists, and policymakers at the Federal, State, and local levels.

As part of the USDA Forest Service's national framework for regional atmospheric modeling, the EAMC is collaborating with the other FCAMMS to initially address the following specific objectives:

- Develop effective atmospheric mesoscale predictions of fire-weather and fire-weather indices at the national and regional level.
- Link fire-weather prediction information with fuel loading and fire potential data obtained from the USDA Forest Service's Forest Inventory and Analysis (FIA) monitoring network to provide improved estimates of daily wildland fire potential.
- Develop improved atmospheric mesoscale model predictions of smoke transport and diffusion under different prescribed and wildland fire scenarios.

The above objectives address the critical need for better predictive models and decision support tools for the fire management and air quality management communities. Both regional and national fire-weather and smoke transport research and development needs are addressed. In recognition of the need for consistency in fire-weather and smoke transport models and decision support tools for fire managers across the U.S., the models and decision support tools developed within the EAMC are compatible with similar models and tools developed in the other FCAMMS.

3. EAMC MEMBERSHIP AND CHARTER

Six research and forest/fire/air-quality management organizations currently constitute the permanent core membership of the EAMC. They include the USDA Forest Service – North Central Research Station, USDA Forest Service – Northeastern Research Station, USDA Forest Service – Region 9 Fire and Aviation Management, USDA Forest Service – Region 9 Air Resources Program, USDA Forest Service – Northeastern Area State and Private Forestry, and the Interagency Eastern Area Coordination Center (Figure 2). As permanent core members, these organizations provide the primary personnel and infrastructure support for the EAMC, with funding provided by Federal appropriated dollars at $400-500k per year under the NFP.

In addition to the permanent core members, other research and natural resource/air quality related organizations have been identified as possible future members. They include but are not limited to universities, Regional Planning Organizations, State forest fire compacts, State departments of environmental quality and natural resources, the Nature Conservancy, and the National Weather Service.

The formal sanctioning of the EAMC has been accomplished through a consortium Charter and an Interagency Agreement among the core member organizations that identify and describe the purpose, the research and development approach, the deliverables, the programs and agencies served, and the oversight and advisory groups for the EAMC.

Figure 2. Core membership of the EAMC (within dotted box) and organizations identified for future membership.

4. EAMC COMPUTATIONAL ENVIRONMENT

The research, product development, and technology transfer activities carried out by the EAMC to address the listed objectives in Section 2 require a state-of-the-art computational environment that can support both a research and a quasi-operational endeavor, where predictive test products are provided to fire managers and air quality managers on a daily basis, 365 days a year. At the core of the EAMC research and quasi-operational endeavor is an atmospheric mesoscale modeling program utilizing the Penn State/National Center for Atmospheric Research (NCAR) Mesoscale Model Version 5 (MM5). The EAMC is using the MM5 to generate twice-daily (0Z and 12Z initialization times) 48-hour simulations of weather, fire-weather, and smoke transport/diffusion over a 36 km, a 12 km, and two 4 km grid spacing domains. Figure 3 shows the location and configuration of the nested grid domains. In addition to the quasi-operational mesoscale modeling for predicting fire-weather and smoke transport episodes on a daily basis, the EAMC is using the MM5 to conduct research on atmospheric mesoscale interactions with fire and the development of new and refined fire-weather indices to aid fire-weather forecasters.

To effectively carry out both a research and quasi-operational modeling program that emphasizes the transfer of model products and predictions to the user community, the EAMC has constructed a computational environment based on multiple Beowulf PC clusters, storage systems, and web servers linked to the Internet via the Michigan State University network (Figure 4). Currently, the EAMC utilizes two 16-node, dual-processor and two 8-node, single processor Beowulf clusters, as well as 6 massive storage systems (3.24 TB data archive capacity). One 16-node cluster is devoted

to the quasi-operational fire-weather simulations over the domains shown in Figure 3, with the other clusters devoted to research simulations (e.g. case studies, fire-weather index testing, building datasets for climatological studies, etc.), smoke transport and diffusion simulations, and specialized simulations requested by EAMC partners.

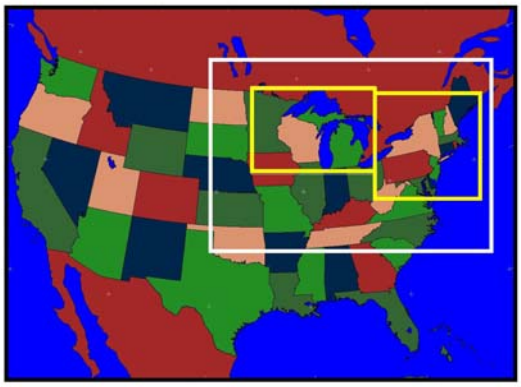

Figure 3. The 36 km (black), the 12 km (white), and the two 4 km (yellow) grid spacing domains used in the quasi-operational MM5 simulations for the EAMC.

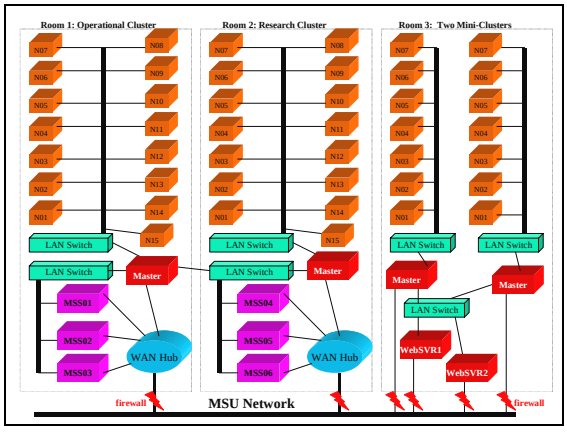

Figure 4. Computational environment of the EAMC, including Beowulf PC cluster nodes (red), local area network (LAN) switches (green), wide area network (WAN) hubs (blue), web servers (WebSVR1 and WebSVR2), storage stations (purple), and firewalls between the hardware and the Michigan State University network.

5. RESEARCH AND END-USER PARTNERSHIPS

We recognize that the long-term success of the EAMC in addressing the objectives in Section 2 and ultimately in providing new predictive tools that are needed and usable by fire and air quality managers hinges on the development of strong collaborative partnerships with internal and external researchers and end users. Towards that goal, the EAMC has undertaken a focused effort to develop and fund numerous collaborative research studies with internal and external research groups, and more importantly, to seek out and listen to user groups in the north central and northeastern U.S. that are involved in fire and air quality management in the region and are seeking new tools to aid their efforts.

The EAMC has developed a basic and applied research program that addresses fire-atmosphere interactions across a multitude of spatial and temporal scales. Current external and internal collaborative research projects include:

1. **University of Utah**: *"Physically Based Wildland Fire Modeling and its Integration in Large Eddy Atmospheric Models"*
2. **University of Utah**: *"Relationships Between Fire Behavior and Atmospheric Stability and Humidity Using a Coupled Fire-Atmosphere Model"*
3. **NOAA Air Resources Laboratory**: *"Development of a Resolved Forest Canopy Submodel within a Large-Eddy Simulation Model to Investigate Fire-Atmosphere Interaction"*
4. **USDA Forest Service – North Central Research Station**: *"Fuel Moisture Impacts on Fire-Atmosphere Interactions"*
5. **North Carolina State University**: *"Developing a Predictive Atmospheric Fire-Spread Index for Use in an Operational Mesoscale Numerical Model"*
6. **USDA Forest Service – Northeastern Research Station**: *"Regional Climate and Fire Danger Modeling for the New Jersey Pine Barrens"*
7. **USDA Forest Service – Northeastern Research Station**: *"Fuels and Fire Behavior in the Central Hardwoods"*
8. **USDA Forest Service – North Central Research Station**: *"Case Studies of Fire-Weather Events Using High-Resolution Mesoscale Model Simulations"*
9. **State University of New York – Albany**: *"Objective Identification of Mesoscale Boundaries in the Planetary Boundary Layer and their Potential Impact on Fire Weather in the Northeastern United States"*
10. **University of Wisconsin**: *"Haines Index Relationship with Synoptic Scale Atmospheric Circulations"*
11. **NOAA Air Resources Laboratory**: *"Regional Mesoscale Meteorological and Smoke Trajectory/Air Quality System"*
12. **University of Houston**: *"Developing an Air Quality Prediction System for Studying the Impact of Forest Fires on Regional Air Quality"*
13. **Northwest Regional Modeling Consortium**: *"Implementation of the BlueSky Smoke Modeling System for Prescribed and Wildland Fires in the NC and NE U.S.*
14. **USDA Forest Service – Forest Inventory and Analysis**: *"Modification of Fine Fuel Moisture Maps using Mesoscale Model Output"*
15. **USDA Forest Service – North Central Research Station**: *"Theoretical Development of Dynamics-Based Fire-Weather Indices"*

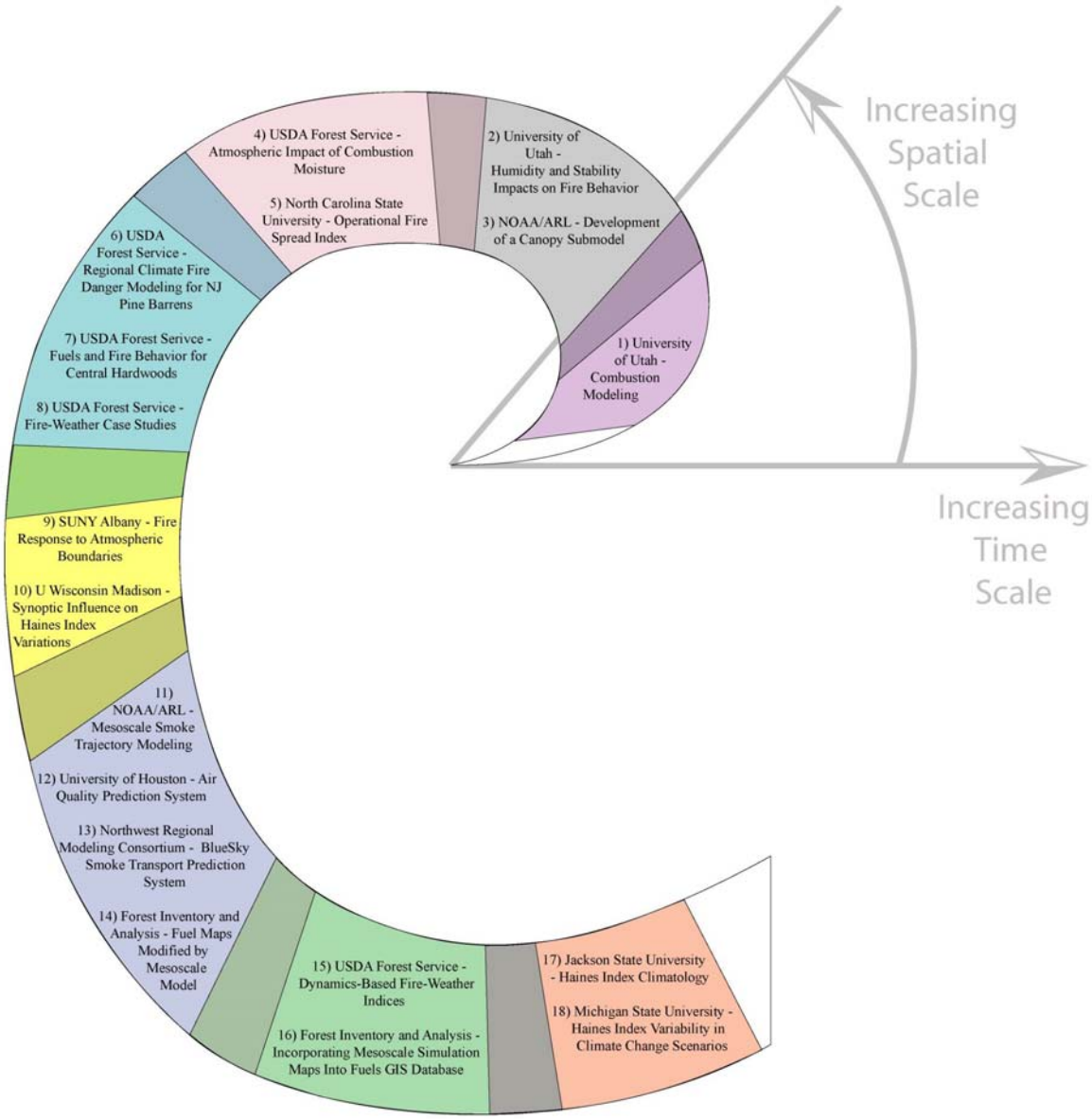

Figure 5. Current EAMC internal and external research and product development studies and their spatial and temporal relationships. The number for each study is referenced to the numbered listing of studies in Section 5. The spatial and temporal scales of fire-atmosphere interactions addressed by each study increase with increasing reference number.

16. **USDA Forest Service – Forest Inventory and Analysis**: "*Incorporating Mesoscale Fire-Weather Simulation Maps into a Fuels GIS Database*"
17. **Jackson State University**: "*Haines Index Climatology for the United States and Puerto Rico*"
18. **Michigan State University**: "*Atmospheric Fire Risk (Haines Index) in a Changed Climate*"

Figure 5 depicts the spatial and temporal scale relationships among these studies. Overall, the suite of studies underway in the EAMC encompasses a wide range of important fire-atmosphere interaction problems, from the small-scale turbulent environment within forest vegetation layers to the atmospheric synoptic and climatic scale impacts on fire-weather occurrence.

In support of the collaborative research studies underway, the EAMC has targeted numerous fire and air quality related user groups throughout the north central and northeastern U.S. Via one-on-one discussions, focused meetings, conferences, email, and phone communications, the EAMC has engaged the user community in discussions about needed fire-weather, fire behavior, fire emissions, and air quality predictive tools. Groups in this user community include the Midwest Regional Planning Organization, Northeast Forest Fire Supervisors, the Nature Conservancy, Michigan Departments of Natural Resources and Environmental Quality, New Jersey Division of Parks and Forestry, New Jersey State Climatologist, Northeast Forest Fire Compact, Middle Atlantic Interstate Forest Fire Protection Compact, Great Lakes Forest Fire Compact, Natural Resources Canada, and the National Wildfire Coordinating Group.

Each spring, the EAMC hosts a research and user community workshop where EAMC researchers, partners, and customers have an opportunity to present and learn about the latest research findings and their potential applications. The workshops provide an excellent opportunity for feedback from the user community on what types of fire weather, fire behavior, fire emissions, and smoke transport predictive tools are needed for managing fire and air quality in the region. The user community also has a strong voice in developing the annual programs of work that set the research and product development directions for the EAMC.

6. RESEARCH AND PRODUCT DEVELOPMENT PROGRESS

Over the last three years (2001-2003), the EAMC has focused on developing the cornerstone of its research, product development, and technology transfer program, namely the quasi-operational fire-weather predictions for researchers and user groups in the north central and northeastern U.S., as well as nationally. As described in Section 4, the PSU/NCAR MM5 modeling system is generating 48-hour predictions of fire-weather for the north central and northeastern U.S. Making these predictions available to researchers and user groups has been accomplished via a user-friendly EAMC web site (http://www.ncrs.fs.fed.us/eamc) that provides access to a variety of predictive fire-weather maps and other general information about the EAMC (Figure 6). Access is also provided via the Interagency Eastern Area Coordination Center (EACC) web site (http://www.fs.fed.us/eacc/). Predicted fire-weather variables available on the EAMC web site include the Haines Index, Fosberg Fire-Weather Index, ventilation index, planetary boundary layer height, surface relative humidity, accumulated precipitation, 3-hour precipitation 10-m wind speed and direction, 2-m temperature, sea-level pressure, and average surface-850 mb mixing ratio, relative humidity, and wind speed.

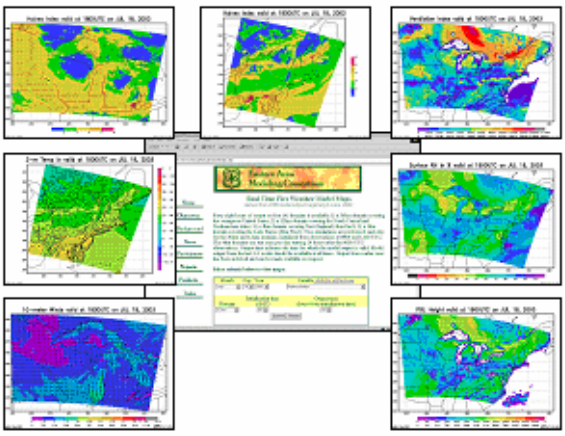

Figure 6. EAMC web-based product delivery system and example fire-weather maps available from web site (http://www.ncrs.fs.fed.us/eamc/products/maps.asp).

The twice-daily 48-hour fire-weather predictions are also providing the foundation data upon which new and revised dynamics-based fire-weather indices are being developed and tested. For example, EAMC scientists are testing the application of a variety of indices based on the parcel exchange potential energy (PEPE) (Potter 2002), surface turbulent kinetic energy (Heilman et al. 2003), descent mixed layer wind speeds and vapor pressure deficits, surface wind speeds and vapor pressure deficits, and the ventilation index. The testing and application of these new and revised indices are accomplished through close collaboration with fire-weather meteorologists in the Geographic Area Coordination Centers (GACCs) and fire managers throughout the region.

Using the MM5 modeling system, EAMC scientists have successfully conducted case studies of past fire-weather events that occurred in the north central and northeastern U.S (Charney et al. 2003). In particular, the atmospheric conditions before and during the 1980 Mack Lake fire in Michigan and the 2002 Double Trouble State Park fire in New Jersey have been simulated. Results from those simulations suggest that the downward propagation of high momentum winds and dry air from aloft played a major role in the extreme fire behavior exhibited during both fire events. Furthermore, the high-resolution simulations were able to capture atmospheric processes that were not observed or known at the time of the events because of

limited observational data and available fire-weather modeling products. The case studies demonstrate the utility of applying high-resolution atmospheric models for fire-weather predictions like those used by the EAMC and the other FCAMMS. The New Jersey Double Trouble State Park case study has been presented to the New Jersey Forest Fire Service and has provided the impetus for developing specialized EAMC high-resolution fire-weather predictions for the New Jersey Pine Barrens. The high-resolution fire-weather predictions are also providing real-time atmospheric data for a NFP study to revise the National Fire Danger Rating System for application in the Pine Barrens region of New Jersey (Hom et al. 2003).

In the area of air quality, the EAMC is collaborating with the Northwest Regional Modeling Consortium to implement the BlueSky smoke trajectory and concentration prediction system (Ferguson et al. 2001) for predicting smoke trajectories and concentrations from prescribed and wildland fires in the north central and northeastern U.S. BlueSky simulations will be available on the EAMC web site in late 2003 or early 2004. As a precursor to the comprehensive BlueSky smoke trajectory and concentration modeling system, EAMC scientists collaborated with scientists at NOAA's Air Resources Laboratory to provide smoke trajectory predictions for the north central and northeastern U.S. via the coupled Regional Atmospheric Modeling System (RAMS) (Pielke et al. 1992) and HYbrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) modeling system (Draxler and Hess 1997). The RAMS/HYSPLIT trajectory predictions are currently available as part of NOAA's Real-time Environmental Applications and Display System (http://www.arl.noaa.gov/ready).

Specific research results from many of the listed EAMC funded and supported studies in Section 5 are being presented at this conference. Results from some of the newer studies will be presented at future conferences related to fire and forest meteorology.

7. SUMMARY

The EAMC along with the other FCAMMS established under the NFP now represent the most comprehensive fire-atmosphere interaction research effort in the world and are making great strides in developing new science-based products and tools for the fire management and air quality management communities both nationally and internationally. The EAMC has developed a multi-scale approach in its research and product development program, with investigations of fire-atmosphere interactions taking place across many spatial and temporal scales. Strong partnerships have been established with user groups throughout the north central and northeastern U.S. as well as nationally, thereby enhancing the effectiveness of EAMC's product-driven research program. With funding from the NFP, the EAMC has developed a state-of-the-art computational environment to support its atmospheric mesoscale and boundary layer modeling programs, including a quasi-operational fire-weather prediction program for developing new operational fire-weather indices. Finally, the EAMC is working closely with the other FCAMMS to develop nationally consistent products for fire and air-quality management applications, and is providing a critical link between researchers and managers in transferring new science-based information and technology from the research community to end-users in the north central and northeastern U.S.

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