ASSESSING THE POTENTIAL FOR ATMOSPHERIC CONDITIONS ALOFT TO CONTRIBUTE TO EXTREME FIRE BEHAVIOR

Joseph J. Charney, Brian E. Potter, Warren E. Heilman, and, Xindi Bian
USDA Forest Service, North Central Research Station, East Lansing, MI

I. Introduction

With the creation of the Fire Consortia for the Advanced Modeling of Meteorology and Smoke (FCAMMS) (http://www.fs.fed.us/fcamms), the USDA Forest Service has begun to develop a deeper understanding of how a fire interacts with the overlying atmosphere. One of the FCAMMS, the Eastern Area Modeling Consortium (EAMC), has developed new products designed to improve atmospheric predictions around and above a fire using this new physical understanding (Heilman, et al, 2005). Two prototype products are now available: 1) a system that provides additional weather information for use in BEHAVE (Andrews, 1989) fire behavior calculations, and 2) an index that addresses the potential for deep plume growth and resulting erratic fire behavior.

II. New products currently under development

a. three-layer model

The BEHAVE fire behavior prediction system currently employs only surface values of wind, temperature, and humidity as weather input. In level terrain and stable weather conditions, these surface values may be good indicators of fire behavior. However, with changes in elevation and stability, different layers of the atmosphere can interact with fuels and the fire. Fig. 1 shows the three layers of the atmosphere that can potentially interact with a fire, depending on the size of the fire, fire intensity, and atmospheric conditions aloft (Potter, 2002).

The EAMC, by employing MM5 mesoscale atmospheric model fire weather predictions, can provide above-ground weather conditions to fire managers in real time for use in BEHAVE. BEHAVE can then provide information on the expected range of fire behavior as a fire moves up or down a slope and the potential for a fire to transport warmer, drier, and faster-moving air to the surface from various heights above the ground.

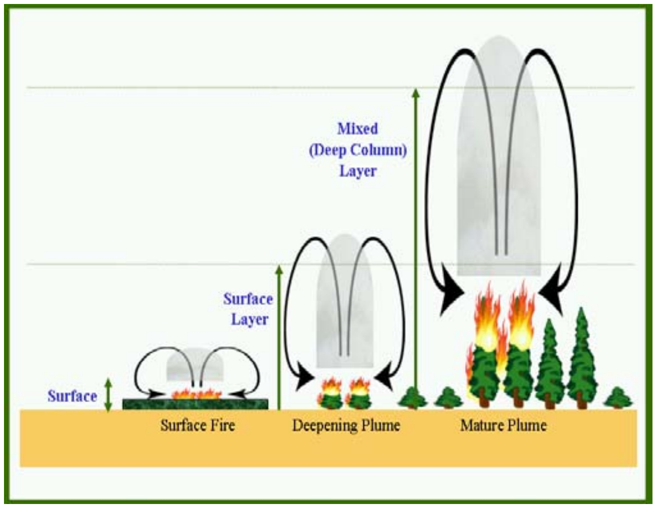

Figure 1: A conceptual representation of the three-layer fire-atmosphere interaction model.

b. combustion-produced moisture

The rate of growth and the height of smoke plumes are associated with certain types of fire behavior, and rapid changes in plume characteristics are known to be indicators of changes in fire behavior that can cause problems for firefighters (Potter, 2005). New methods of determining how fire-atmosphere interactions can alter the moisture conditions above the fire and, in doing so, alter the plume characteristics and, ultimately, the fire itself are being explored.

The MM5 simulations produced by the EAMC are used to compute the Convective Available Potential Energy (CAPE) throughout the model domain (Fig. 2). The CAPE, which is a measure of the amount of buoyant energy present in a surface air parcel, can be considered as an indication of the potential size of a fire plume based purely on atmospheric stability considerations. However, the since a fire produces heat and moisture as part of the combustion process, surface air parcels above a fire can be expected to have different heat and moisture characteristics than the background environment. The magnitude of these differences varies depending upon the size and intensity of the fire, the strength of the turbulent mixing that occurs above and around the fire, and other atmospheric factors.

The EAMC has implemented a product that approximates the effects of the fire on the surface air parcels by computing the CAPE using a surface parcel that is 2 °C warmer than the environment and 2 g/kg more moist. Fig. 3 shows the results of this calculation on the same day as the CAPE plot from Fig. 3. Fig. 4 shows the difference between these two plots, which is interpreted as the areas where the heat and moisture released from a fire can be expected to have the largest potential impact on plume/fire behavior on that date at that time.

Please note that this product is still undergoing testing at the EAMC, and is not yet available to the public.

III. References

Andrews, Patricia L. and C. H. Chase, 1989. BEHAVE: Fire behavior prediction and fuel modeling system-BURN subsystem, part 2, Gen. Tech. Rep. INT-260. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 93 p.

Heilman, W. E., B. E. Potter, J. J. Charney, and X. Bian, 2005: Fire-Weather and Air-Quality Research and Product Development in the Eastern Area Modeling Consortium. EastFIRE Conference, 11-13 May 2005, Fairfax VA.

Potter, B. E., 2002: A dynamics based view of atmosphere-fire interactions. *Int. J. Wildland Fire,* 11, 247-255.

Potter, B. E., 2005: The role of released moisture in the atmospheric dynamics associated with wildland fires. *Int. J. Wildland Fire*, 14, 77-84.

IV. Author Biography

Dr. Joseph J. Charney is a Research Meteorologist with the USDA Forest Service- North Central Research Station in East Lansing, MI. He has a B.S. degree in physics from the Pennsylvania State University, an M.S. degree in meteorology from the University of Maryland, and a Ph.D. in meteorology from the Pennsylvania State University. His graduate studies focused on frontal propagation responses to precipitation processes. His current research portfolio includes studies of small-scale fire-fuel-atmosphere interactions, the mesoscale prediction of smoke dispersion and regional air quality, and mesoscale modeling of fire environments.

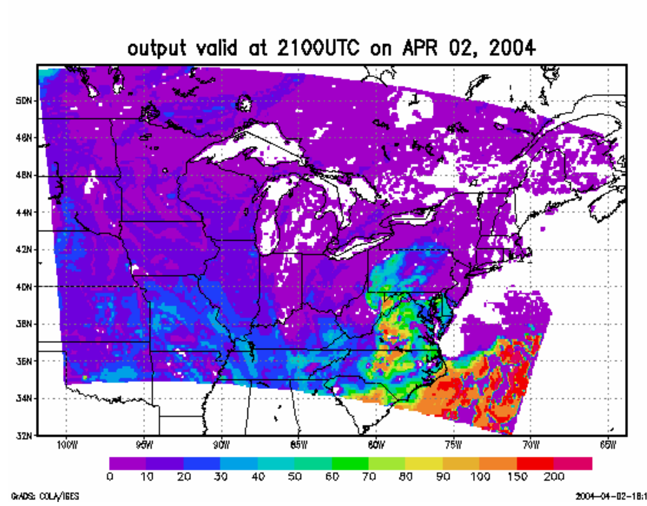

Figure 2: Convective Available Potential Energy in J/kg for April 2, 2004 at 2100 UTC.

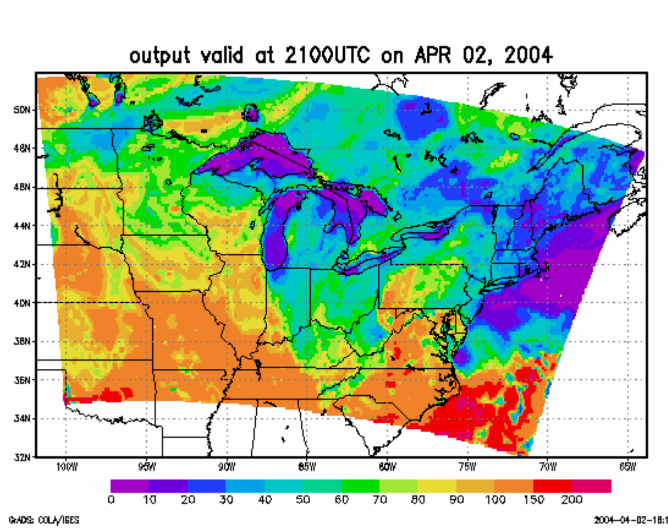

Figure 3: Fire-modified Convective Available Potential Energy in J/kg for April 2, 2004 at 2100 UTC.

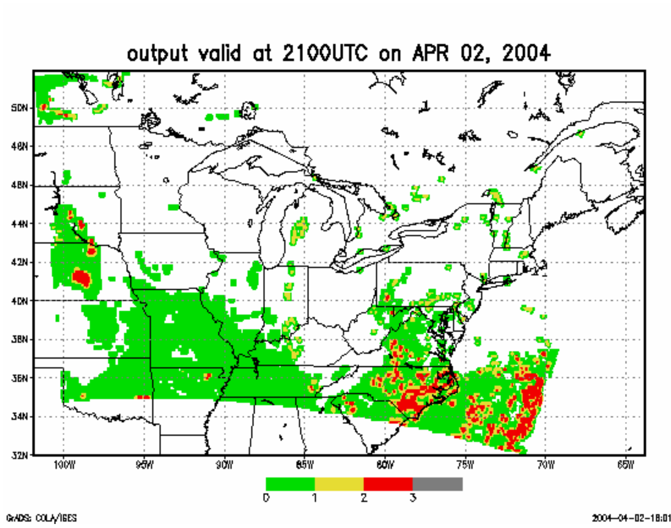

Figure 4: The difference between the Convective Available Potential Energy and the Fire-modified Convective Available Potential Energy in J/kg for April 2, 2004 at 2100 UTC.