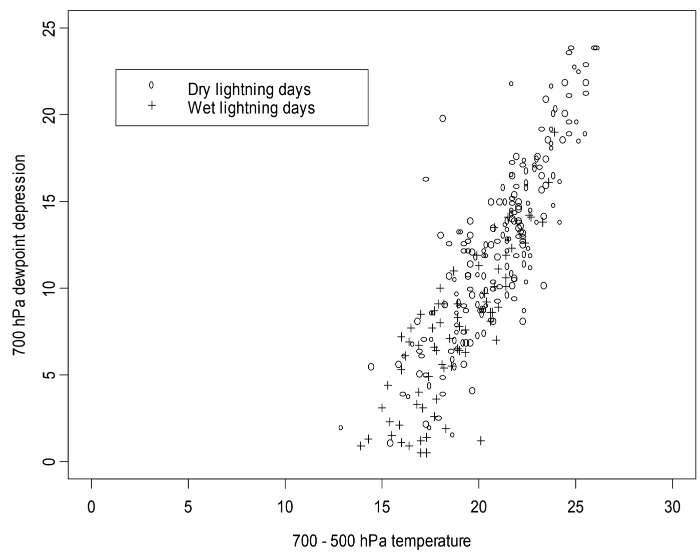
Forecasting Dry Lightning in the Western United States

Miriam Rorig, Sue Ferguson, and Steven McKay
USDA Forest Service
Pacific Northwest Research Station
400 N. 34th St., Suite 201
Seattle, WA 98103

Dry lightning events (those which occur without significant coincident rainfall) often lead to large wildfire outbreaks in the forested regions of the western United States. Millions of acres are burned each year, often resulting in devastating human and property losses. In recent years suppression costs have approached, and in some cases exceeded, one billion dollars per year. In the western U.S., the most critical situation for fire danger occurs when a dry cold front or upper-level disturbance generates convection after a relatively long period of dry weather. The airmass is unstable, but with an absence of low-level moisture, thunderstorms that form are high-based. Consequently much of the rain that falls evaporates before it reaches the ground. When lightning strikes the ground, it ignites dry fuels, and accompanying rainfall, if any, is not enough to extinguish incipient fires. In previous studies, we have shown the utility of a simple index to estimate the risk of "dry" lightning strikes in the Pacific Northwest. Using upper-air data from Spokane, WA, the temperature difference between 850 hPa and 500 hPa and the dewpoint depression at 850 hPa were used to develop a discriminant function to separate convective days into "dry" and "wet" categories (Rorig and Ferguson 1999, Rorig and Ferguson 2002). These variables were found to be useful and physically meaningful indicators for estimating the risk of dry convection.

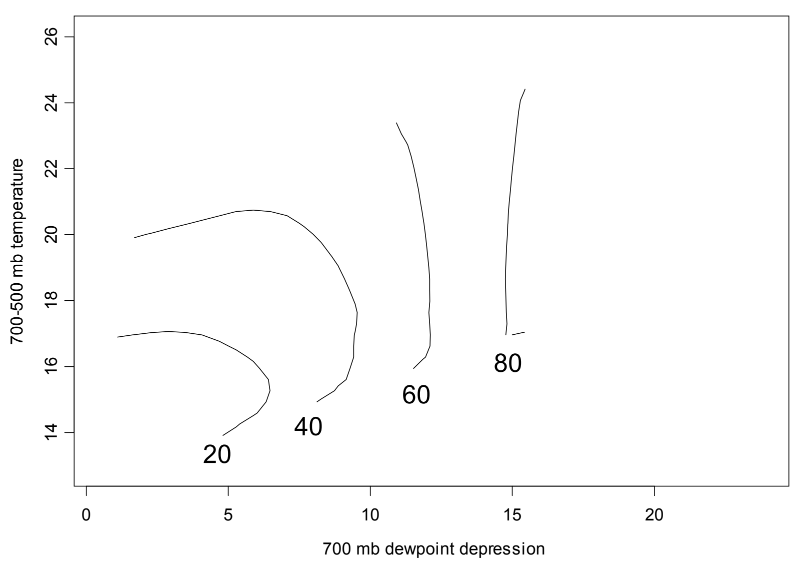
In the current study we are expanding the use of this index to the entire western US. To do so, we have acquired 15 years of lightning strike data from Global Atmospherics, Inc. (Cummins, et al. 1998), and 15 years of upper-air data from the National Climatic Data Center (NCDC). Because large regions of the mountainous west are above the 850 hPa level, the index was modified with inputs from other vertical levels. Albuquerque, NM, and Denver, CO were chosen as test sites because they are geographically distinct from Spokane, they both have surface elevations above the 850 hPa level, and there were complete data sets available (upper-air, surface, and lightning strike data). We found a

Figure 1. 700 hPa dewpoint depression vs. 700-500 hPa temperature, ABQ, 1991-1994.



significant difference between both the 700 hPa dewpoint depression and the 700 – 500 hPa temperature difference on “dry” days and “wet” days at both locations. Figure 1 shows the 700 hPa dewpoint depression vs. 700 – 500 hPa temperature for lightning days at Albuquerque, 1991-1994. Figure 2 depicts the probably of a lightning day being in the dry category, based on those two variables. While the 700 hPa dewpoint depression was an effective discriminator Denver and Albuquerque, it did not perform as well at Spokane as did the original 850 hPa variables. This is not surprising because it is the available moisture at low levels that is important in determining whether thunderstorms will produce significant rainfall that reaches the ground. At Spokane, the 700 hPa level is about 2300 meters above ground level, which is likely too high to be representative of the low-level moisture profile.

Figure 2. Probability of a lightning day belonging to the dry category, ABQ.



In order to forecast the risk of dry convection two to three days in advance, output from the Penn State/National Center for Atmospheric Research (NCAR) MM5 mesoscale model was also used to compute the index. The MM5 is currently run in real time by the Northwest Regional Modeling Consortium (NWRMC) through the University of Washington Department of Atmospheric Sciences, and output is available at http://www.fs.fed.us/pnw/airfire/sf. Using output from the real-time model allows us to generate forecasts of distributed lightning risk (rather than point forecasts). Also, by using the terrain-following sigma coordinates of the model grid, we were able to investigate a solution to the problem of using variables from constant pressure surfaces over such widely varying terrain. Because the goal is to forecast the risk of dry lightning episodes, a method was devised to interpolate the discriminant function over the MM5 domain. Unlike traditional stability indexes and other MM5-derived products like maps of convective available potential energy (CAPE), we have more confidence in the ability of the dry lightning algorithm to predict and locate potential fire start locations because it was specifically developed to distinguish between dry and wet convective days. We expect to have real-time predictions of dry lightning potential in the northwestern U.S. in autumn 2003. Also, through the nationally coordinated Fire Consortia for Advanced Modeling of Meteorology and Smoke (http://www.fs.fed.us/fcamms), we expect the algorithm to be implemented in other regions in the west by spring of 2004. When the Weather Research Forecast Model (WRF) becomes available sometime in late 2003 or 2004, we will use it to forecast the risk of dry lightning.

Real-time forecasts of dry lightning risk would provide a direct benefit for fire weather forecasting and allocation of resources during the fire season. In addition, because lightning activity level is part of the National Fire Danger Rating System (NFDRS) we have begun implementing NFDRS in the NWRMC (http://www.fs.fed.us/airfire/mm5case) and exploring ways to couple it with the dry lightning algorithm. With the ability to assess the atmospheric conditions that give rise to dry thunderstorms, coupled with forecast fuel and fire behavior conditions, land managers will be better equipped to anticipate episodes of extreme wildfire outbreaks.

LITERATURE CITED

Cummins, K. L., M. J. Murphy, E. A. Bardo, W. L. Hiscox, R. B. Pyle, and A. E. Pifer, 1998: A combined TOA/MDF technology upgrade of the U.S. National Lightning Detection Network. *J. Geophys. Res*., **103**, 9035-9044.

Rorig, M. L. and S. A. Ferguson, 1999: Characteristics of lightning and wildland fire ignition in the Pacific Northwest. *J. Appl. Meteor*., **38**, 1565-1575.

Rorig, M. L. and S. A. Ferguson, 2002: The 2000 fire season: Lightning-caused fires. *J. Appl. Meteor*., **41**, 786-791.

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