A New Tool for Fire Management Decision Support

Combining Fuel Dryness and Lightning Probability

Chris Gibson, Science and Operations Officer, Missoula, Montana

Shelby Sharples, Predictive Services Meteorologist, Salt Lake City, Utah

Introduction – During the summer of 2008, meteorologists from the National Weather Service Forecast Office at Salt Lake City (NWS-SLC), the Eastern Great Basin Predictive Services Office (EGBCC), and the National Weather Service National Centers for Environmental Prediction Storm Prediction Center (NWS-SPC) developed a new forecast product for the fire weather community. This collaboration combines a lightning probability forecast from the NWS with a wildland fuel dryness forecast from the EGBCC, and is updated daily on the internet. Motivation, components and preliminary verification results are presented below.

Motivation – Forecasting and verifying lightning episodes is one of the more difficult forecast office duties. Meteorologists routinely examine atmospheric stability and moisture values to attempt to discriminate between dry and wet lightning outbreaks. Research by the EGBCC from 2007 seemed to indicate that the fuel conditions may be more important in determining when lightning (either wet or dry) would lead to many fire starts and taxing of initial attack fire-fighting resources.

For the fire season of 2008, the NWS-SLC and EGBCC meteorologists introduced a new product to convey the probability of lightning combined with fuel conditions information. This product would assist in decision support for fire-fighting resource managers across Utah.

Product Components – The new product is based on two separate components representing the lightning probability and wildland fuel dryness conditions.

Dryness Levels – The Dryness Levels are used by the EGBCC, and other Geographical Area Coordination Center's (GACC's) to represent daily large fire potential for sub-geographic areas called Predictive Services Areas (PSA's). PSA's were created to represent generally homogeneous fire conditions: topography, climate, fire occurrence and vegetation. The Dryness Level forecast is created daily during fire season and extends out 7 days for each PSA. There are three possible dryness values: Moist (green), dry (yellow) and very dry (brown). Dryness Levels were developed using a statistical relationship between fire occurrence, specifically large fire occurrence, and Fire Danger Indices calculated from Remote Automatic Weather Station (RAWS) observations. The Fire Danger indices used in Eastern Great Basin are the Energy Release Component (ERC) and the 100 Hour Fuel Moisture. Both of these indices use fuel model G, which includes both live and dead fuels and are part of the National Fire Danger Rating System (Bradshaw et. al 1984).

Each PSA has a matrix which defines the thresholds of ERC and 100 hr FM for each Dryness Level. Figure 1 illustrates the relationship of large fires with 100 hour fuel moisture and ERC for PSA EB07, which is located in northwest Utah. Large fire occurrence is closely related to high ERC values and lower fuel moisture values. An example of a PSA Dryness Level forecast for the EGBCC is presented in figure 2.

Lightning Forecast – For the lightning component of the new product, a decision was made to leverage the work of Dr. Phillip Bothwell NWS-SPC. Dr. Bothwell has developed forecasts for the probability of cloud to ground lightning strikes for various frequencies and over different sized areas (see Bothwell 2008, for example). The forecasts are made for the CONUS four times a day, based on the operational NCEP models. For 2008, this product utilized the North American Model (NAM12) and used the 1200 UTC cycle of the model each day. The lightning forecasts generated by the SPC have recently been expanded to include forecasts for Alaska and to utilize the Global Forecast System (GFS) model in addition to the NAM12.

The technique developed for creating the lightning forecasts utilizes a "perfect prog" approach. Regression equations have been developed for lightning occurrence on a grid by comparing detected lightning strikes and upper air atmospheric variables. Data from the latest model runs are used as input to the equations and the output of the equations is the probability of lightning within a grid box. This approach is similar to a Model Output Statistics (MOS) approach which is widely used for forecasting various surface weather parameters. **For this product, the probability of 10 or more lightning strikes is forecast for each 40 km by 40 km grid box for each forecast time period.**

Dissemination - This new product was disseminated on the NWS-SLC fire weather web site. The NWS-SLC forecaster combined the various components of the product and managed the data within the NWS Graphical Forecast Editor (GFE). Once a day, the NWS forecasters ran a GFE procedure to populate grids of Dryness Level and Lightning Probability. After examination and possible editing, another GFE procedure was run to generate the graphics, and the web page and to transfer all of the needed files to the web farm. A text discussion was also provided within the product for the Dryness Level and meteorological situation. If editing of the forecast parameters was not needed, the process could take as little as 10 minutes. The web product could be updated at any time if lightning or dryness conditions changed. An example of the web page is provided in figure 3.

On the web page, users pass their mouse across the links within the table on the left to view the individual graphics. Two types of graphics are available for each day (Figure 4). The first graphic displays the PSA Dryness Levels as a background colorfill with isolined lightning overlaid. This graphic is viewable using the links on the left hand column of the web page table. The second graphic (viewed from the right hand column) shows just the lightning forecast as a collorfill image with isolines.

Verification – Subjective verification was conducted for the peak fire season of 2008. The fire season of 2008 was unusual in that snowpack was deep and slow to melt. As a result, overall fire activity was below normal. Two brief case studies

are presented of this limited verification. These dates were chosen due to the fire activity.

July 1, 2008 - The location of fires that started on July 1 is presented in Figure 5 as well as the observed lighting (blue dots) and the Dryness Levels. For July 1, all PSA's had Dryness Levels of "dry" or "very dry". The fire that started in far northern Utah was most likely human caused, but the majority of the fires were associated with observed lightning.

The SPC lightning forecast for the day is shown in Figure 6. The highest probability of 10 or more strikes on the 40 km grid was located over the lightning prone Boulder Mountain area of south-central Utah. Otherwise, the highest probability of lightning (generally 10-20 percent chance of 10 or more strikes) favored the high terrain of the central and northern Utah mountains. Very little lightning (less than 10 percent probability of 10 or more strikes) was forecast for the western Utah desert basins.

July 20, 2008 - A number of fires were started by lightning on July 20, 2008. Figures 7 and 8 present the forecast lightning, PSA Dryness Levels, observed lightning and fire occurrence. By this part of the fire season of 2008, deep moisture had moved north into eastern Utah as part of the typical southwest summer "monsoon" weather pattern. This resulted in lowering ERC and increasing fuel moisture which modofied the PSA Dryness Levels to "moist". Fuels in northern and western Utah remained drier. The lightning forecast (Figure 8) for July 20 again predicted higher probability of significant lightning for the higher terrain. The probability of lightning was probably too low for west central Utah but the area of lightning activity and resulting fires was indicated as an area of higher lightning probability for the day within the SPC forecast.

Verification Discussion – These two days illustrate a common theme to the lightning forecasts and fire occurrence over Utah for 2008. The new fire starts usually were within PSA's with Dryness Levels indicated as "Dry" or "Very Dry". In addition, the new fires usually were located in areas where the SPC lightning forecast was indicating a 10 to 25 percent probability of 10 or more lightning strikes for the day. Higher probabilities (20+ percent) were common in the SPC

forecasts, especially over the higher mountains, but these were typically not associated with significant fires. Even if the SPC lightning forecasts were perfect, a number of factors could have resulted in the most fire starts associated with 10-25 percent lightning forecast values. For example, the more vigorous storms over the higher terrain may have been associated with more widespread wetting rain as opposed to storms occurring over lower elevation areas. The spring and early summer was also unusually cool, which delayed snowmelt, keeping fuels green at the mid and high elevations late in the fire season. Over the entire Eastern Great Basin GACC area, there were 835 lightning caused fires in 2008 vs. the 10 year average (through 2007) of 2000 fires (EGBCC 2008 Fire Activity Report). Results for other fire seasons and other geo-graphic regions may be completely different than the results over Utah for the summer of 2008.

Conclusion and Future Plans – Feedback from the fire management community on the usefulness of this experimental approach was positive during 2008. The NWS and Predictive Services meteorologists will be expanding the approach to different geographical areas (GACC's) and WFO's. Dr. Bothwell has been working on higher resolution lightning forecasts. The new forecasts will be on a 12 km X 12 km grid across the conterminous United States and available from either the NAM12 or GFS model run by the NWS. In addition, the "training" dataset used for developing the lightning forecast equations will be greatly expanded, hopefully resulting in more accurate forecasts going forward. Finally, we plan to archive the lightning forecast at NWS Missoula for 2009 and to perform objective verification of the forecasts and relation to fire occurrence for the 2009 fire season. This verification work will be in addition to the verification performed by Dr. Bothwell at the SPC.

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References –

Bradshaw, Larry S.; Deeming, John E.; Burgan, Robert E.; Cohen, Jack D. 1984: The 1978 National Fire-Danger Rating System; technical documentation. General Technical Report INT-169. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 44 pp.

Bothwell, P. D. 2008: Predicting the location and intensity of lightning using an experimental automated statistical method., *Third Conference on Meteorological Applications of Lightning Data*, San Diego, CA, Amer. Meteor. Soc.

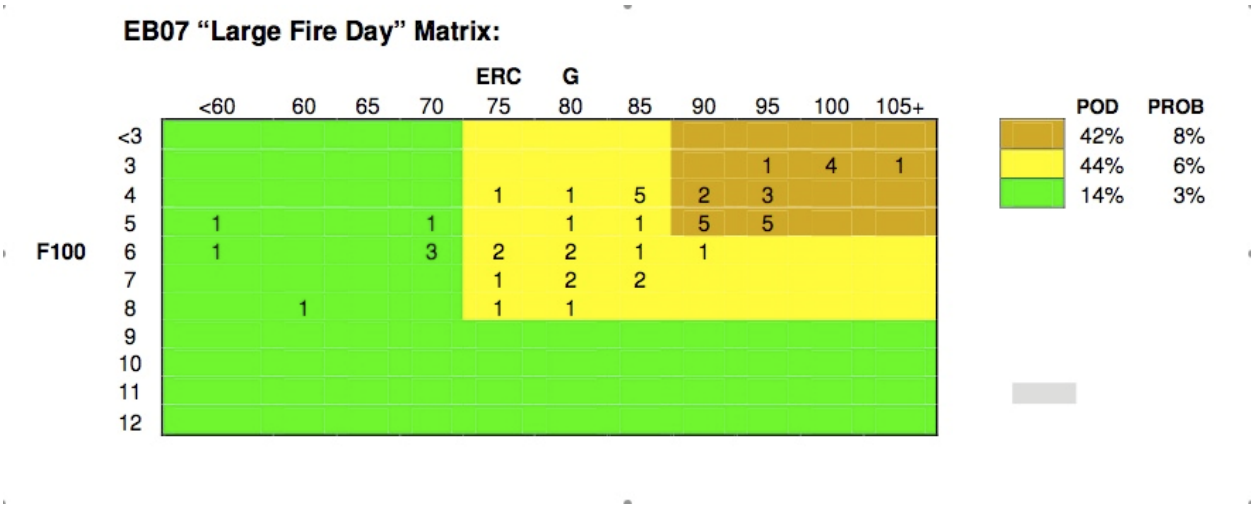

Figure 1. Large fire occurrence as related to ERC and 100 hour fuel moisture for PSA EB07

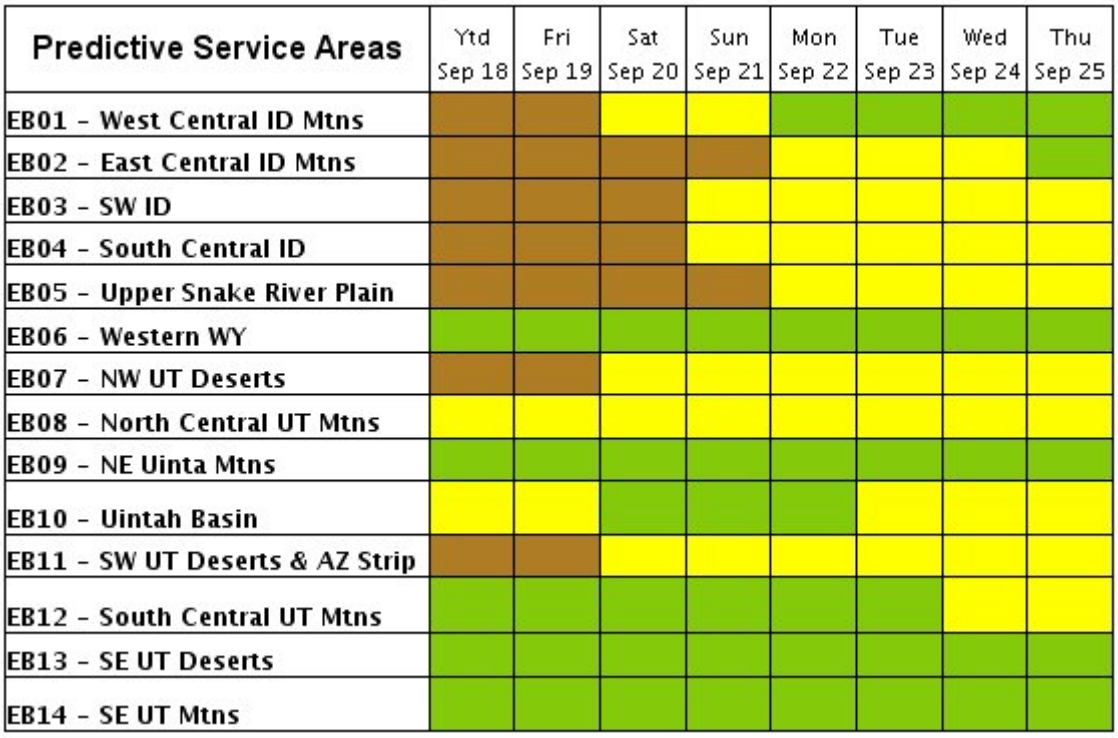

Figure 2. Example of a EGBCC PSA Dryness Level forecast Matrix

Green – Moist, Yellow – Dry, Brown – Very Dry

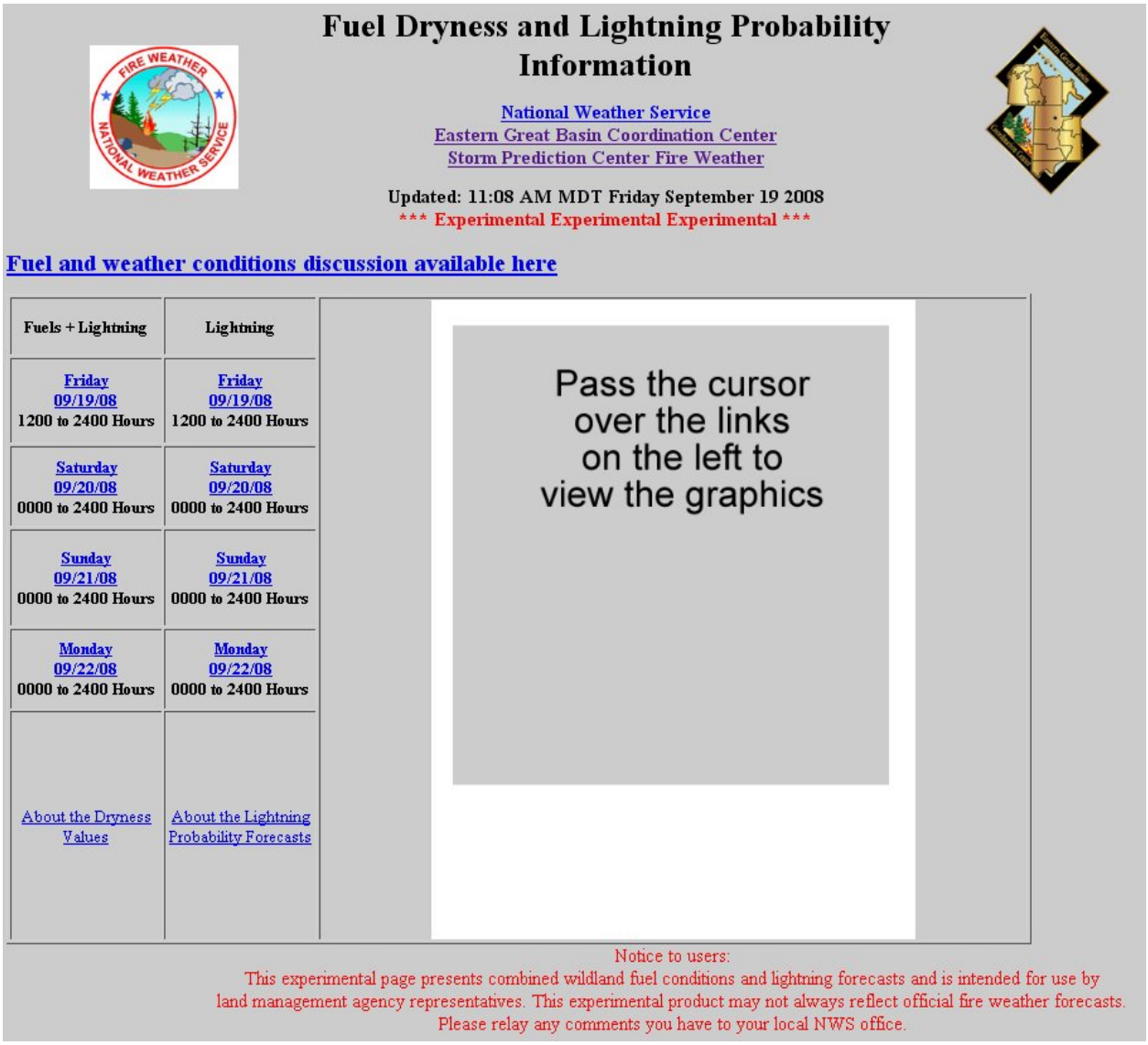

Figure 3. Example of the Dryness and Lightning web page.

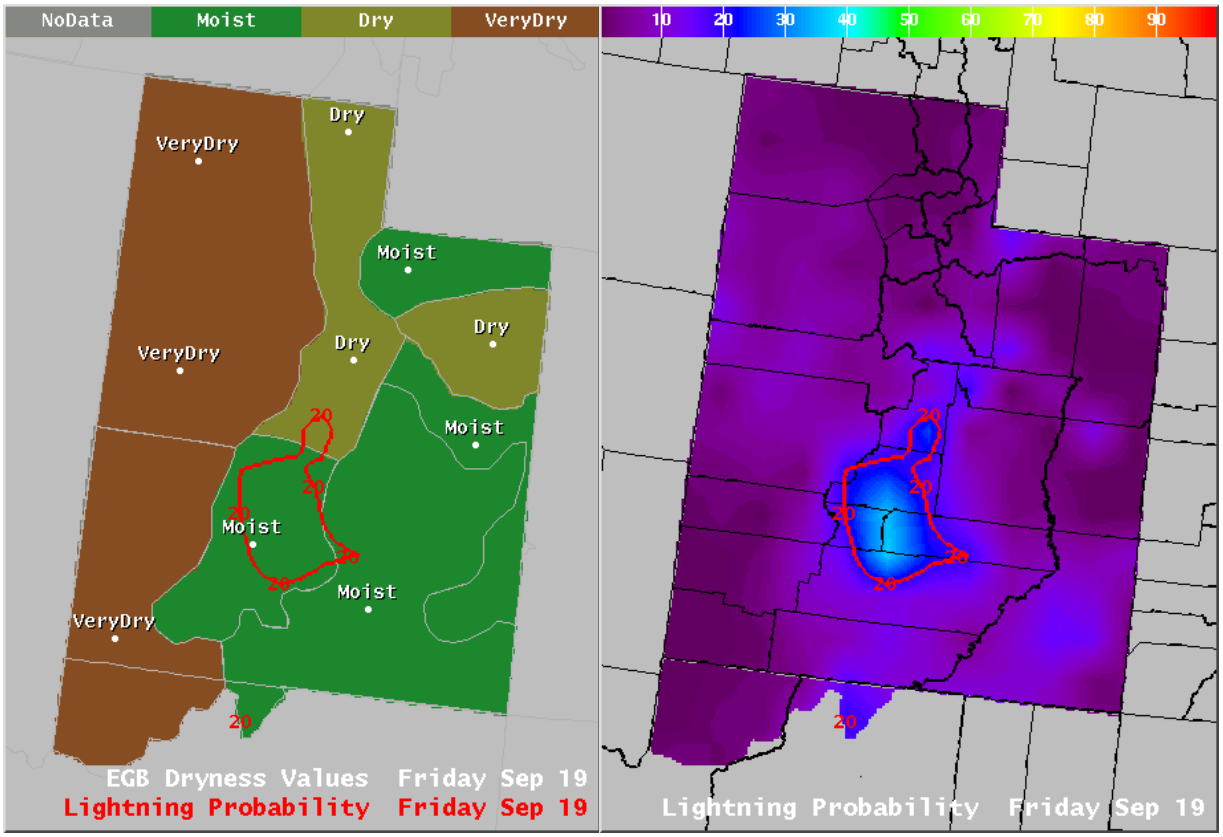

Figure 4. Example of a Dryness Level and Lightning probability graphics from the Dryness and Lightning fire weather web page.

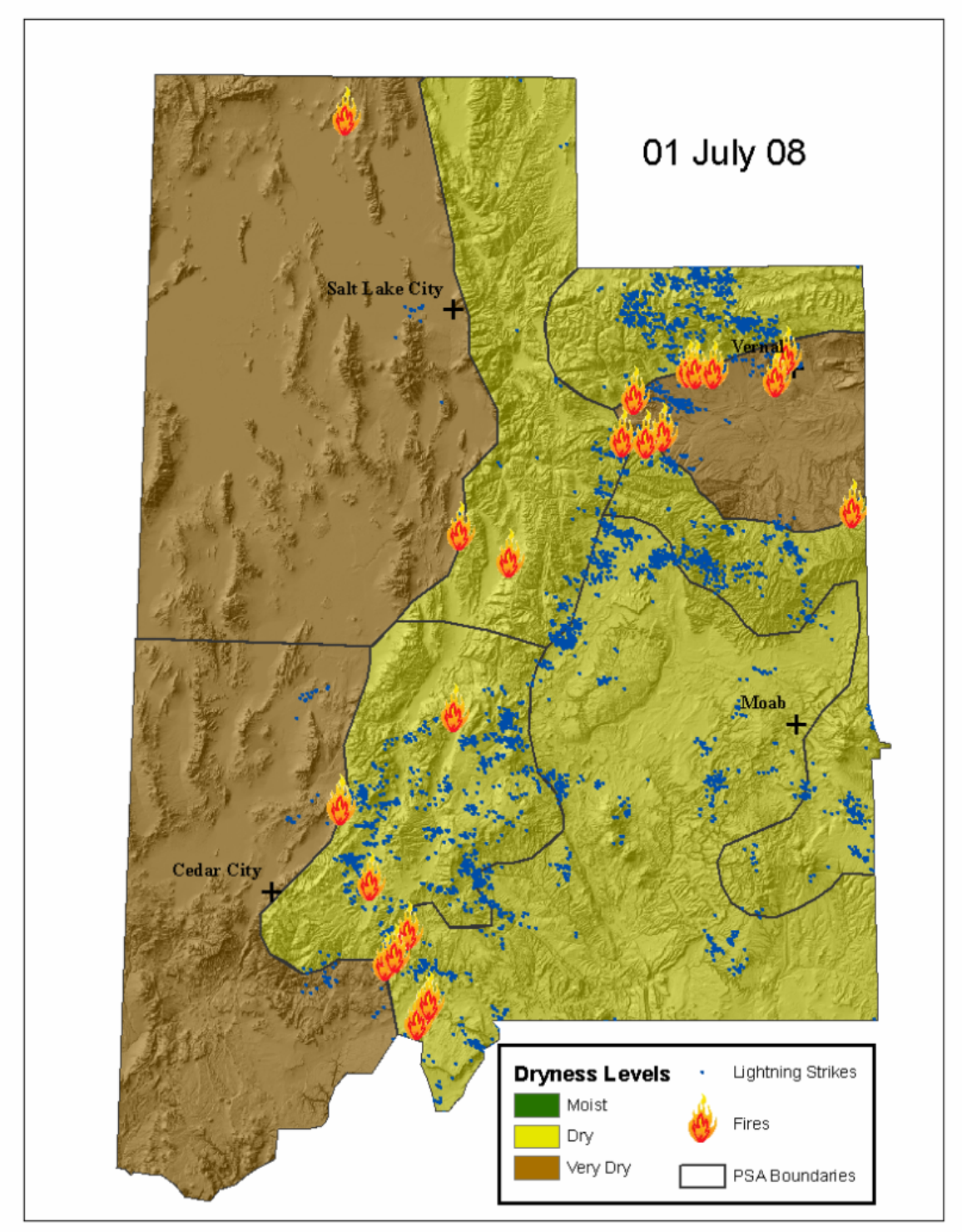

Figure 5. Dryness information, location of new fires on July 1, 2008 and lightning strikes (blue dots).

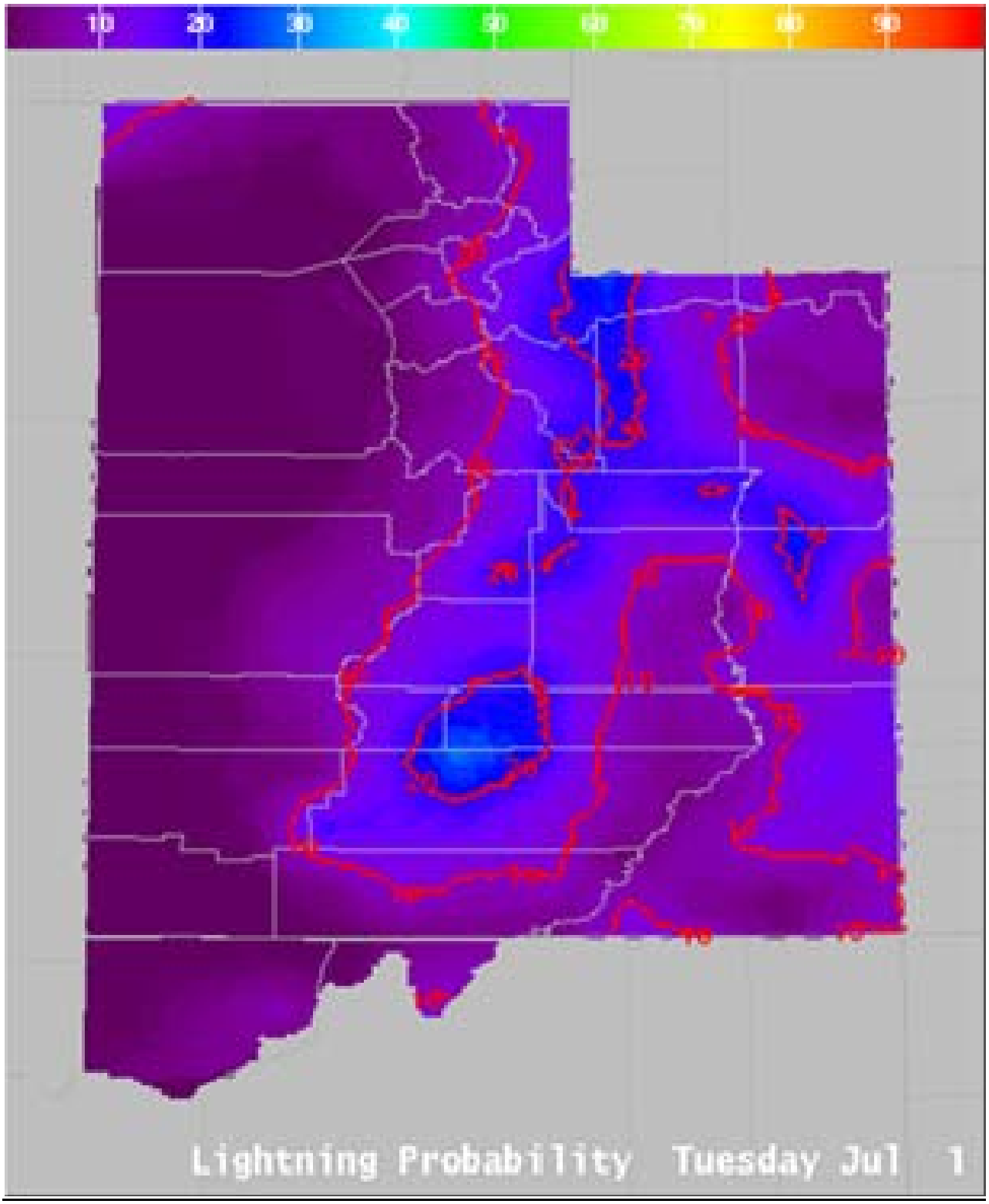

Figure 6. SPC Lightning Probability forecast of 10 or more lightning strikes within 40 km X 40 km grid boxes for July 1, 2008.

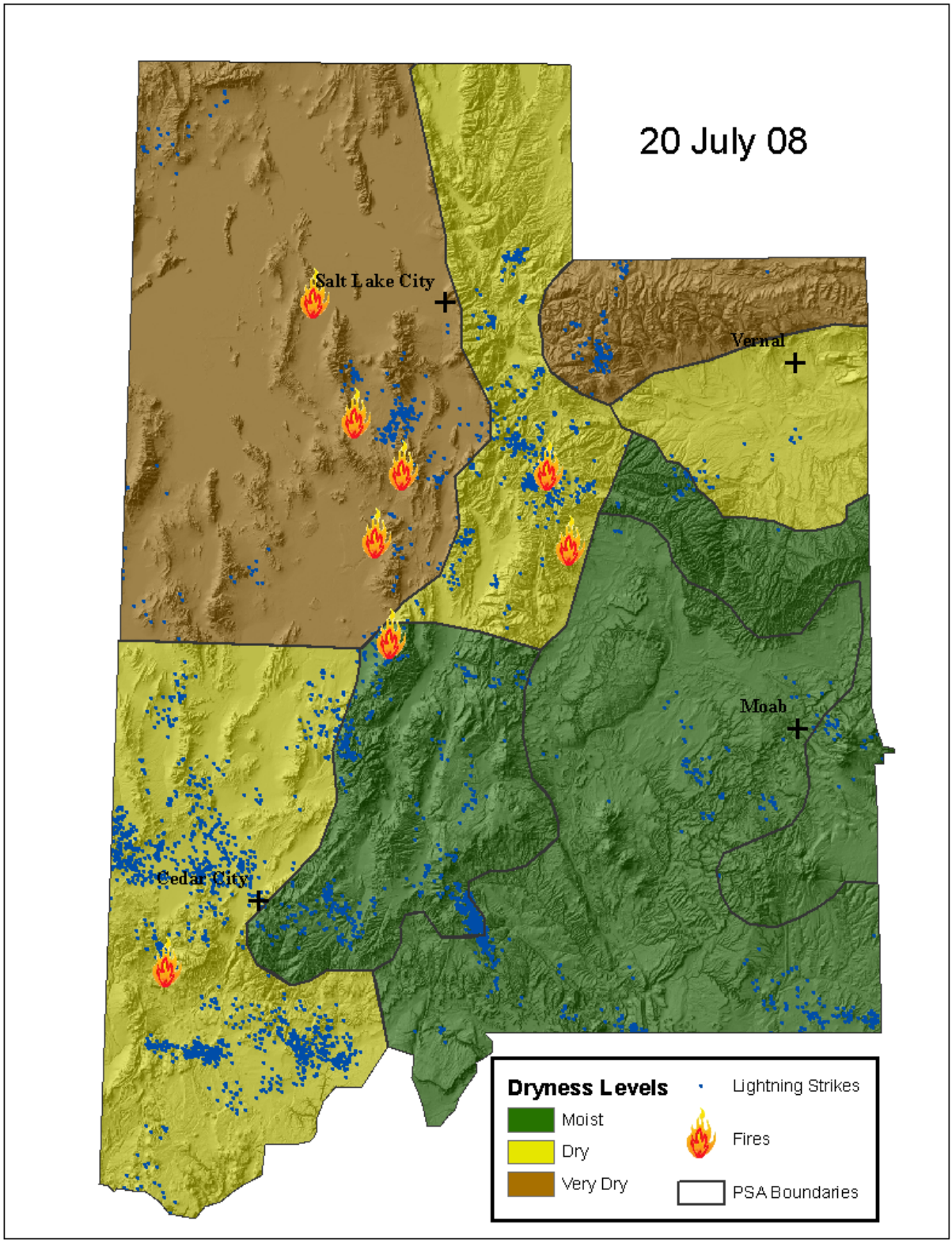

Figure 7. Dryness information, location of new fires on July 20, 2008 and observed lightning strikes (blue dots).

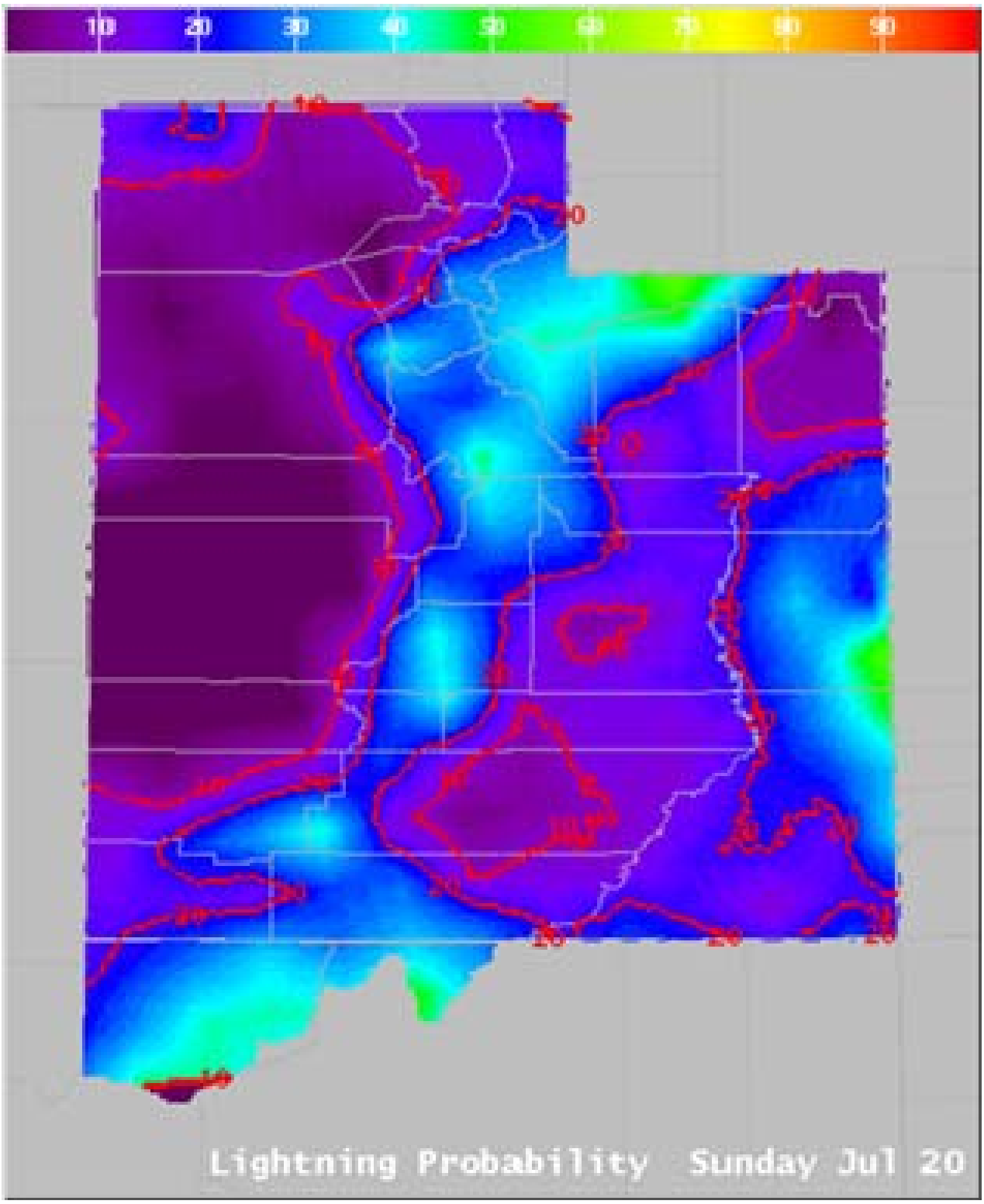

Figure 8. SPC Lightning Probability forecast of 10 or more strikes within 40 km X 40 km grid boxes for July 20, 2008.