J11.10 NATIONAL STANDARDIZED ENERGY RELEASE COMPONENT FORECASTS

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1. INTRODUCTION

By combining model predictions of atmospheric parameters and historical National Fire Danger Rating System (NFDRS) energy release component (ERC) data for the United States (US), forecasts out to 15 days can be produced that include standardized ERC and ERC anomalies. This is the first ever attempt at providing ERC forecasts in a manner that displays the potential of fire danger due to the effects of intermediate to long-term drying in a way that allows for improved cross-spatial comparison. Each area of the US for which ERC will be forecasted has a historical ERC data record that can be used to compute ERC averages and standard deviations. A standardized ERC value in Florida, for example, can be directly and relatively compared to a standardized ERC value in Nevada without an immediate knowledge of the local fuels, climate, or topography. These forecasts allow for improved planning of national fire suppression resource demands as monitored by the National Interagency Coordination Center in Boise, Idaho. Local fire weather meteorologists, fire and fuels specialists, and fire management may also use this information for local planning, including both suppression and prescribed fire needs.

2. DATA AND METHODOLOGY

To facilitate the standardized ERC forecast, a gridded national climatology of ERC using fuel model G was produced at the University of Montana, Numerical Terradynamic Simulation Group (NTSG) under direction of the Fire Sciences Laboratory, Missoula, MT. The NTSG has been working on building fine resolution daily meteorological and climatological data stores necessary for plant growth model inputs. The DAYMET model (Thornton, 1997) produces this particular data. This model generates daily surface temperature, precipitation, humidity and radiation over complex terrain using both a digital elevation model, and daily observations of minimum and maximum temperatures and precipitation from ground-based meteorological stations. The full DAYMET dataset contains 18-years (1980-1997) of daily temperature, precipitation, humidity and radiation estimates at 1 km resolution.

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NTSG has also developed modeling frameworks where process models can interface with high-resolution datasets. The Terrestrial Observation and Prediction System (TOPS) was designed to estimate daily biospheric mass and energy fluxes for the continental US (Nemani and others 2003). TOPS was used to integrate the NFDRS equations (Cohen and Deeming 1985) with gridded datasets to estimate the daily ERC for fuel model G (short needle pine, heavy dead loads) on an 8-km grid. Fuel model G was chosen because ERC-G, despite not being very sensitive to live fuel moisture, has been considered to perform well in terms of correlation with fire activity in many locations within the US.

The integration between NFDRS and TOPS required several adaptations and assumptions in four areas where NFDRS requires more explicit weather information than directly available from DAYMET.

2.1 *LIVE FUEL MOISTURE*

The standard NFDRS models for live fuel moisture require specification of fuel type and annual dates for greening up the live fuels. We chose to use an experimental method using satellite derived Normalized Difference Vegetative Index (NDVI) data that is used in a prototype next-day NFDRS forecasting scheme (Bradshaw and others 2000). This method uses the historical range and weekly relative greenness of a pixel to estimate the live woody and herbaceous fuel moisture.

2.2 *STATE OF THE WEATHER*

NFDRS uses a state of the weather (SOW) code to estimate fuel temperature from the observation height temperature base on cloud cover, and, if it is raining or snowing at observation time, to set some parameters to coded instead of computed values.

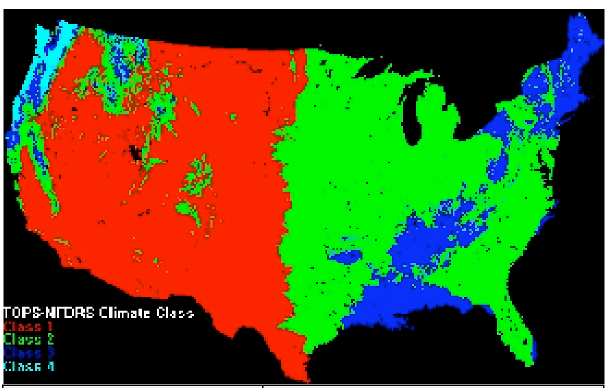
SOW was determined by the departure of daily short-wave radiation from the long-term mean radiation for that day. Using the DAYMET dataset, the long-term mean and standard deviation was calculated for each 8-km grid cell for each day over the period of record. The potential radiation was then defined as the daily mean plus two standard deviations. The departures of a given day's radiation from that long-term potential radiation were used to establish SOW thresholds as shown in Table 1.

Table 1. TOPS/NFDRS State of Weather based on percent of potential radiation.

SOW	Daily Percent of Potential
1	90 to 100
2	80 to 89
3	50 to 79
4	0 to 49

2.3 *PRECIPITATION RATE*

NFDRS uses precipitation duration, not precipitation amount, to estimate the effect of rainfall (and snow cover) on dead fuel moisture. The NFDRS processing algorithms have default precipitation rates for each of the system's four climate classes. NFDRS climate classes are roughly based on Thornwaite's (1931) climate classes. However, there is no GIS layer of those climate classes available for use in this effort. Instead, an objective climate classification system was developed to determine regional precipitation rates. The DAYMET dataset was used to estimate climate normals of solar radiation, precipitation and temperature for each 8-km square area. The ratio of average total precipitation and an estimate of potential evapotranspiration (PET) (Priestly and Taylor, 1972) was then used to create a four category spatial climate classification (Figure 1).



Climate Class	R
1	0.0 to 0.49
2	0.5 to 0.99
3	1.0 to 1.5
4	> 1.5

Figure 1. TOPS/NFDRS climate thresholds based on the annual precipitation/PET ratio (R).

The standard NFDRS precipitation rates were initially assigned to the four climate classes. It was determined during validation trials that computed precipitation durations for some areas, particularly in the Southeast, were too long during summer convective rains. Actual precipitation rates were assessed from hourly data from the national fire weather network and assigned precipitation rates for the four climate classes based on two season categories as shown in Table 2.

Table 2. TOPS/NFDRS precipitation rates (inches/hour) by climate class and season

Climate Class	JUN 1 - SEP 30	OCT 1 - MAY 31
1	0.25	0.05
2	0.25	0.05
3	0.25	0.05
4	0.05	0.05

2.4 *CLIMATOLOGY*

Once all of the data were in place, it took about 15 hours to generate each day's ERC grids. The result was daily 8 km ERC values for the US for 1982 through 1997. Since the model output first used for the national standardized ERC forecasts had either a 1-degree or a 2.5-degree spatial resolution, each daily ERC grid was averaged and scaled to the two forecast model grid sizes. Daily means and standard deviations of the two model resolutions were then computed. This provided the climatological daily datasets needed in order to compute the standardized ERC forecasts. Figure 2 shows an example 1-degree resolution standard deviation map of ERC for September 3.

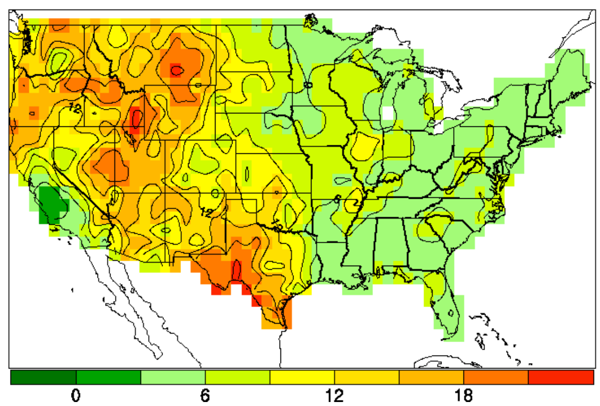


Figure 2. An example map of ERC 1-degree resolution standard deviations for September 3.

2.5 *ERC FORECASTS*

Operational ERC forecasts are computed using the Gridded Forecast System (GFS) model output. Global GFS 6-hourly output is available via ftp at 1-degree resolution out to 7 days and at 2.5-degree resolution from 8 to 15 days. The 00 UTC model run is downloaded daily using the 18 UTC forecast times for the daily temperature and relative humidity. 00, 06, 12 and 18 UTC forecasts are used to determine daily maximum and minimum temperatures and relative humidity along with precipitation duration. These variables are the inputs for computing daily ERC.

2.6 *STANDARDIZED ERC FORECASTS*

Once the daily forecasts for ERC have been produced, the GFS model grids are used with the historical mean and standard deviation ERC grids to compute the standardized ERC (SE) forecast using the following algorithm:

$$SE = \frac{(forecast - mean)}{st.dev.}.$$

3. RESULTS

National standardized ERC forecasts maps are produced daily and made available to NICC from the Desert Research Institute Program for Climate, Ecosystem, and Fire Applications (CEFA) web site. ERC value, anomaly and standardized forecasts are provided out to 15 days. Figure 3 shows an example map of a standardized ERC forecast for.

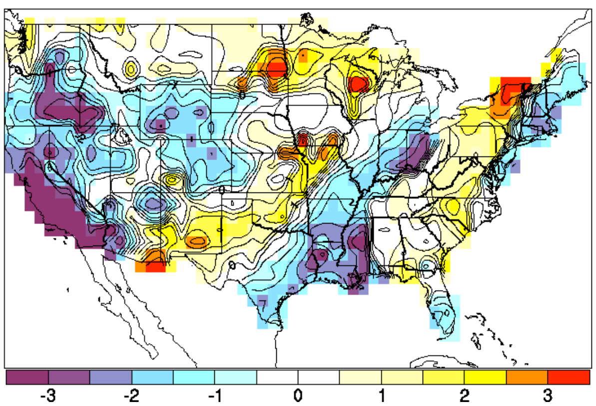


Figure 3. Example map of a standardized ERC forecast.

At present, the ERC forecasts are considered experimental and work in progress. Work is currently underway to validate the model initialization grids (00 UTC) as some regions appeared “suspicious” during the first few months that forecasts were provided internally to NICC. However, during the 2003 summer fire season, the concept of ERC-G forecasts was felt to be useful for the intended purpose of guidance for planning.

Future work will include forecast validation, and the utilization of other models such as Eta and GFS ensembles. Once more formal validation is complete, the forecasts will be recommended for more general use by fire management agencies. It is anticipated that the GFS forecasts should be fully operational for the 2004 fire season.

4. ACKNOWLEDGEMENTS

The vision of Tom Wordell, National Interagency Coordination Center, to foresee the need and value of this product, was vital in the project’s development. Tom was also instrumental in securing funding for the project and assessing the forecasts during the 2003 summer fire season experimental phase. This work was done under the Bureau of Land Management national Office of Fire and Aviation cooperative Assistance Agreement 1422RAA000002.

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