10.3 Seven day fire danger forecasts from the National Digital Forecast Database

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1. INTRODUCTION

The United States National Fire Danger Rating System (NFDRS) is used throughout the country to support a variety of fire management decisions (Deeming et al. 1977, Burgan 1988). Operationally the NFDRS is hosted by the Weather Information Management System (WIMS) and incorporates both the 1878 and 1988 fuel models (USDA Forest Service 1993, 1995). The system operates on a network of remote weather stations and provides up-to-date information about current fire danger conditions in the vicinity of the weather station. Current and antecedent weather variables are used to estimate fuel moisture and fire danger indices.

These fire danger metrics are used to guide decision making across multiple spatial scales. Weather observations are provided to the National Weather Service who generates a next-day fire weather forecast that is used to assess fire danger for the next operational period. Currently, there are no standard products that provide managers with fire danger forecasts beyond the next 24 hours.

The National Digital Forecast Database (NDFD) is an operational gridded forecast produced by the National Weather Service. It provides spatially consistent forecast information across the United States at five kilometer resolution for the next seven days (Glahn and Ruth 2003). The data are updated at least twice daily by each weather forecast office and assembled into a continuous national grid. It offers all the sensible weather variables required to forecast fire danger indices into the future.

Here we use the National Digital Forecast Database to generate seven day forecasts of the Energy Release Component, a key index in the US National Fire Danger Rating System that is not affected by winds. We compare the results of this forecast to the fire danger estimated at Remote Automated Weather Stations across the continental United States and we examine the daily forecast skill for each of the seven day forecast periods. These forecasts can be used to provide land managers with more advanced notice about changing fire danger conditions and to assist in strategic fire planning across a variety of spatial scales.

2. Methods

The National Digital Forecast Database data were obtained each morning at 0545 hrs CST. Rasters were extracted from the native GRIB2 format using the using the DEGRIB NDFD GRIB2 decoder (National Weather Service 2009). The following fields were extracted for use:

- Maximum / minimum temperature
- Relative humidity
- Air temperature
- Sky cover
- Probability of precipitation (POP)
- Quantitative precipitation forecast (QPF)
- Windspeed

Daily summaries of the three or six hour forecast period values were calculated to provide the necessary daily inputs to estimate NFDRS fuel moistures and fire danger indices. POP and QPF were combined to estimate precipitation duration. If the probability of precipitation was greater than 50%, 1 hour of precipitation duration was assigned for each 3 hour forecast period.

Similarly, 2 hours of precipitation was assigned for each 6 hour forecast period that had a QPF value above 0.01” rainfall. State-of-the-weather was estimated from cloud cover using the logic shown below:

Table 1 – Relationship used to estimate state-of-the weather from NDFD cloud cover forecast.

Cloud Cover (%)	State-of-the-Weather
> 90	3
<=90 and > 50	2
<=50 and > 10	1
<= 10	0

Heavy dead fuel moisture were initialized using interpolated 100 hour and 1000 hour fuel moisture maps from the Wildland Fire Assessment System (WFAS)(Jolly et al. 2005). WFAS retrieves fuel moistures from WIMS and interpolates those values calculated at ~1400 remote automated weather stations (RAWS) throughout the continental United States. An example 1000 hour fuel moisture map is shown in Figure 1. These gridded fuel moistures were used to initialize the antecedent heavy dead fuel moisture values in the NFDRS algorithms and daily weather forcasts were used to project fire danger for the next seven days. All indices were calculated using a fuel model G for standardization.

Daily ERC forecasts were compared to daily calculated ERC values from observed weather at remote automated weather stations throughout the continental United States for August 2009 (daily n: ~1400 / day, total n=40088). Grid cell values that were coincident with point locations were extracted for comparison. These comparisons were stratified by each of the seven valid forecast periods to assess the predictability of Energy Release Component up to seven days in advance.

In addition to the NDFD forecast values, ERC values were also compared to a persistence forecast that predicts that the next seven day's ERC values will be equal to the previous day's value. Persistence forecasts are commonly used in meteorological forecasting to assess improvements in forecast skill.

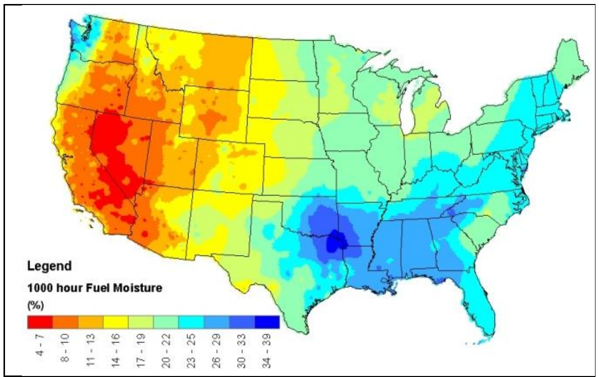

Figure 1 – Example interpolated 1000 hour fuel moisture maps derived from ~1400 fuel moisture values calculated at surface remote automated weather stations.

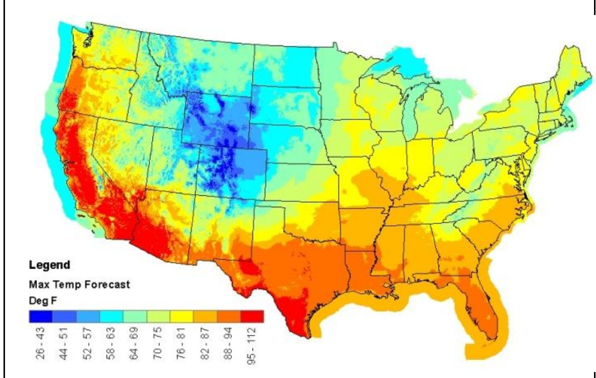

Figure 2 – Example gridded maximum temperature forecast from the National Digital Forecast Database.

3. Results and Discussion

Mean absolute error (MAE), coefficients of determination (r^2) and bias between observed and predicted values are shown in Table 2. Graphs of MAE and r^2 are shown in Figure 4 and Figure 3. Mean absolute errors were similar between the NDFD and persistence forecasts.

However, NDFD had lower MAE for forecast days 3 and 4 suggesting that the NDFD was a better forecast than persistence at these forecast periods. A typical seasonal range of ERC for a station in the west (Libby, MT 240107) might be from zero to 80, therefore forecast mean absolute errors of 4 to 8 ranged from ~5% to 10% of seasonal variability. This is further strengthened by the lower bias for those days. However, overall the NDFD method had consistently higher r^2 values suggesting that the NDFD method was better at predicting the actual values over the range of observations even though the two methods had similar

average errors and bias. An example map of Energy Release Component is shown in
.

	NDFD Forecast			Persistence		
Period	MAE	r^2	Bias	MAE	r^2	Bias
1	4.0	0.94	-0.83	3.5	0.93	-0.2
2	4.9	0.92	-0.12	4.9	0.90	-0.3
3	5.5	0.90	-0.03	5.9	0.87	-0.4
4	6.4	0.88	0.63	6.5	0.85	-0.4
5	7.0	0.86	0.19	7.0	0.84	-0.5
6	7.5	0.84	-0.30	7.3	0.84	-0.6
7	7.8	0.83	-0.77	7.5	0.83	-0.7

Table 2 – Mean absolute error, coefficients of determination and ordinary bias derived by comparing observed and forecast Energy Release Component across the continental United States for each daily forecast period available from the NDFD and by comparing observed values to a persistence forecast.

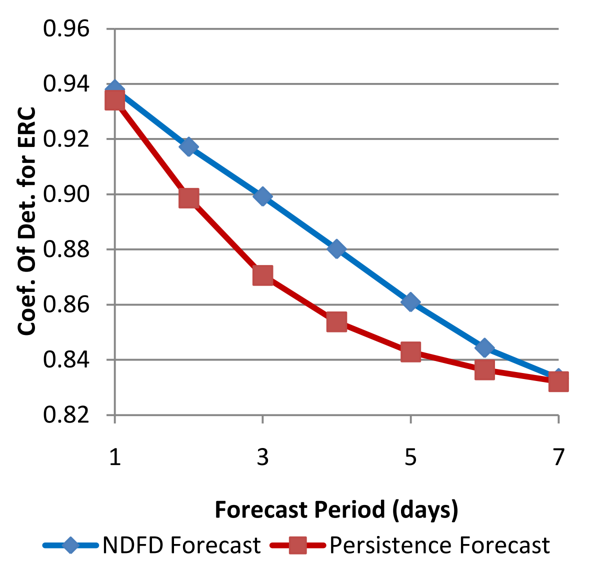

Figure 3 – Coefficient of determination (r^2) between observed and forecast Energy Release Component for stations across the continental United States for both the NDFD and persistence forecasts. NDFD forecasts show consistently better relationships between observed and forecast values over the seven day forecast lead times.

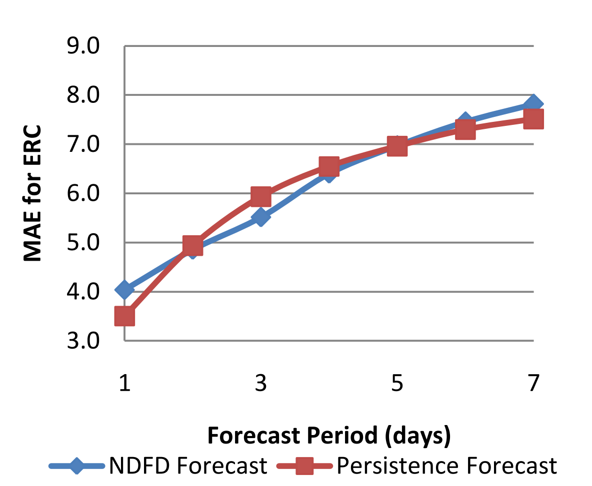

Figure 4 – Mean absolute errors between observed and forecast Energy Release Component for stations across the continental United States. Diamond markers (blue lines) show the comparison of the NDFD forecast values to the RAWS-observed values. Square markers (red lines) show the comparison of persistence forecast to the RAWS values.

shows an example Energy Release Component (fuel model g) grid for late September 2009. ERC values ranges from 0 to over 110 across the continental United States. Raw ERC values are difficult to compare spatially because each spatial location has an inherently different range of ERC values. Work is underway to develop a historical climatology from the North American Regional Reanalysis dataset to express each grid cell's value relative to historic normals for that cell. These normalized forecasts are easier

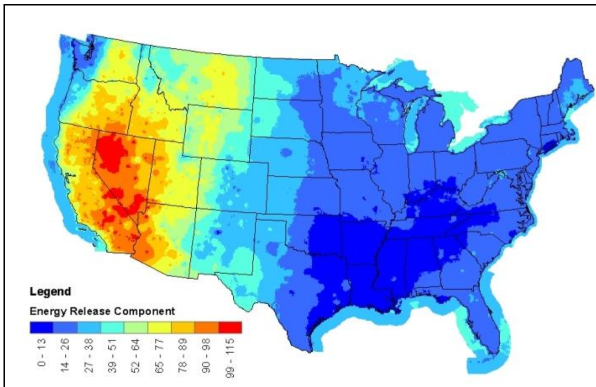

Figure 5 – Example Energy Release Component grid for the continental United States derived from interpolated heavy dead fuel moistures from WFAS and the National Digital Forecast Database.

to interpret and they facilitate more meaningful inter-regional comparisons (Hall et al. 2003).

4. Conclusions

Overall, the NDFD forecast performed better than persistence over the seven day lead time. Mean absolute errors and bias were either similar to or lower than the persistence methods across the range of values and correlations showed that predicted values from the NDFD were better matched with observed values.

Fire management decisions are made across a range of spatial and temporal scales and information is needed to support this wide range of decisions. Next day forecasts are adequate for some decisions but longer timeline information is useful to support strategic decisions such as fire fighting resource allocation or pre-positioning. Other systems are also in development to provide seasonal fire danger forecasts that would aid in pre-planning (Roads et al. 2005).

This was the fire evaluation of a prototype fire danger forecasting system using the National Digital Forecast Database. Future work will focus on evaluating forecast accuracy over an entire year rather than the fire season presented here in an attempt to determine seasonal and regional biases.

This system is the first of its kind to use the National Digital Forecast Database to produce short-term, spatially explicit forecasts of fire danger. It will provide fire managers with more information beyond their usual next-day forecast and it will supplement existing forecast systems to provide multiple timelines of fire danger information to support tactical and strategic fire management decisions nationwide.

5. Acknowlegements

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