ECPC's Seasonal Fire Danger Forecasts

John Roads
Experimental Climate Prediction Center (ECPC)
Scripps Institution of Oceanography, UCSD, 0224 La Jolla, CA, US
jroads@ucsd.edu

1. Background

Predicting the influence of weather on fire ignition and spread is an operational requirement for national and global fire planning by the National Interagency Coordination Center (NICC), which is the US's support center for wildland firefighting. NICC is home to seven federal agencies including the Bureau of Land Management, National Park Service, Fish and Wildlife Service, and Bureau of Indian Affairs, all in the Department of the Interior; and the Forest Service, in the Department of Agriculture. NICC's Predictive Services produces national wildland fire outlook and assessment products at weekly to seasonal time scales. This is currently done by considering standard National Weather Service seasonal forecast products of temperature and precipitation along with other indicators, and carefully exercised human judgment.

By contrast, nowcasts of fire danger potential at individual locations have been carried out for decades at individual station locations using the US Forest Service (USFS) National Fire Danger Rating System (NFDRS; Deeming and others 1977). This process has been automated and implemented nationwide, resulting in web-based displays of the NFDRS indices. The NFDRS explicitly describes the effects of local topography, fuels and weather on fire potential. Fuel moisture models relate moisture content to cumulative precipitation, precipitation extent and variation, temperature, and relative humidity. These fire danger nowcasts are updated almost daily, but they only allow fire managers to react to the current weather and climate conditions, rather than plan for the upcoming fire season.

The goal our work has therefore been to assess whether the NFDRS indices could also be forecast with a state of the art dynamical seasonal prediction model. As described previously by Roads *et al.* (2001*)* the Scripps Experimental Climate Prediction Center (ECPC) has been routinely making experimental, near real-time, long-range dynamical forecasts since Sept. 27, 1997 of a number of additional variables relevant to fire danger forecasts. Images from these forecasts are regularly shown on the worldwide web (WWW) site (http://ecpc.ucsd.edu/). The global model is a version of the National Centers for Environmental Prediction's (NCEP's) global spectral model (GSM; Kalnay *et al.* 1996) used for the NCEP/NCAR reanalysis. With the GSM forecasts as boundary conditions a higher resolution regional spectral model (RSM; Juang *et al.* 1997) is also run for various regions (US, SW, CA, BZ; see e.g. Roads *et al.* 2003*a,b*) to provide increased geophysical detail. The initial conditions and SST boundary conditions for these experimental global forecasts come from the NCEP Global Data Assimilation (GDAS) 00UTC operational analysis, which is available nearly every day in near real time on NCEP rotating disk archives, to interested researchers. Transforming NCEP's higher-resolution operational global analyses to lower (vertical and horizontal) resolution initial conditions for the global model, 7-day global and regional forecasts are made every day and every weekend these global and regional forecasts are extended to 16 weeks.

In particular, we have now developed routine experimental NFDRS forecasts in order to augment current USFS nowcasts from station observations and current seasonal forecast output of only temperature and precipitation. Basically, since our dynamical models have demonstrated some skill for forecasting various meteorological variables like temperature, relative humidity, and mean wind speed at seasonal time scales, we have investigated whether the perceived meteorological forecast skill can carry over to forecasts of fire danger and whether the federal fire agencies should develop a more comprehensive seasonal fire danger forecasting capability. Encouragingly, Roads *et al.* (2001) did previously show that a simplified measure of fire danger, namely the Fosberg (1978) Fire Weather Index (FWI) was capable of being predicted at seasonal time scales over many global regions, mainly because of the inherent predictability of relative humidity, which is a significant component of the FWI, and as we shall see, other NFDRS indices.

2. System for Predicting Fire Danger

The NFDRS indices describe characteristics of fire danger, given the conditions of fuel, topography, and weather. The basic inputs to the NFDRS include precipitation, temperature, relative humidity, and wind speed as well as fuels and slope. The standard weather input to the NFDRS comes from weather station data, which is assumed to apply to a large, but undefined area surrounding each weather station; vegetation (fuel) types and slope are also defined for each weather station and assumed to apply to the same surrounding area. The major difference from standard NFDRS calculations is that here gridded fuels, weather forecasts and topography data are used. The fuels and orography (slope) data were initially defined at 1km spatial resolution and then the nearest 1km grid point was used for a coarser-scale 100 km grid. The observed precipitation (25 kms) and forecast model output (60 kms) was similarly interpolated to the 100 km grid. Ultimately, the NFDRS indices calculated on the 100 km grid were interpolated back to the standard RSM 60 km grid. The NFDRS indices are:

1. SC is an index of the forward rate of spread at the head of a fire. The SC is sensitive to wind speed, and slope, especially if the fuel is dry.
2. ER is a number related to the available energy per unit area within the flaming front at the head of a fire. The ER is a cumulative or “build-up” type of index. As live fuels cure and dead fuels dry, the ER values get higher, thus providing a reflection of drought conditions. Daily variations in the ER are due to changes in moisture content of the live and dead fuels. ER is not affected a by wind speed, thus it is reasonably stable from day to day.
3. BI is a number related to the contribution of fire behavior to the effort of containing a fire. The BI is derived from a combination of the SC and the ER, so it is strongly affected by wind speed, and varies considerably from day to day. Computed BI values represent the near upper limit to be expected if a fire occurs in the worst fuel, weather and topography conditions for this fuel type.
4. IC is a rating of the probability that a firebrand will cause a signifcant fire. The IC is more than the probability that a fire will start (given a firebrand); it is also a measure of the spread potential. Therefore the SC values are part of the calculation of the IC. Because the IC is a function of both the moisture content of small dead fuel, and wind speed, it has significant daily fluctuations.
5. KB was not part of the original NFDRS but was added in a 1988 revision. It is a stand-alone index that can be used to measure the affects of seasonal drought on fire potential. The KB's relationship to fire danger is that as the index value increases, the vegetation is subjected to increased stress due to moisture

deficiency. At higher values desiccation occurs and live plant material is assumed to die, thus adding to the dead fuel loading on the site. Also, an increasing portion of the duff/litter layer becomes available fuel at higher index values.

6. FWI was derived by Fosberg (1978) who assumed constant fuel (vegetation=grass) characteristics (see also Roads *et al.* 1991, 1997) based upon equilibrium moisture content (a function of temperature and relative humidity) and wind speed. This index is not explicitly a part of the NFDRS and requires only instantaneous values of temperature, relative humidity and wind speed. Hence the FWI is most easily applied in practice and was included here because it had been previously used to assess the potential for seasonal fire danger forecasting not only over the US but also globally.

The anomaly correlations (monthly means removed) of these parameters with each other and a few meteorological parameters over the US West (land region west of 105 W) will be described in the talk. The standard fire danger indices (IC, BI, ER, KB, SC) all are fairly well correlated with the IC, BI, and ER having the highest correlations. By contrast the ER and SC have little correlation and the KB has little correlation with any of the other indices. The FWI is also well correlated with all indices, except for the KB. All indices (except for the KB) indicate strong correlation (negative) with RH and except for the KB and SC significant positive correlations with temperature. Precipitation is weakly correlated with all indices but does show a strong positive correlation with RH, which, again is more strongly related to the various indices (except for KB). In short, the ER, KB, SC and perhaps the FWI appear to be somewhat independent measures, whereas the other indices are strongly related to the ER, KB, or SC. It should be noted that these correlations change little for weekly and seasonal means and or for that matter, even when the entire US is taken into account. The correlations are also similar when forecasts rather than validation data are used. It should be noted that the data appear to follow a normal distribution for seasonal means but less so for weekly means and so it was somewhat surprising that the correlations among weekly means were comparable to correlations among monthly and seasonal means.

Further details will be described in the presentation and in Roads *et al*. (2003).

References

Deeming JE, Burgan RE, Cohen JD (1977) 'The National Fire-Danger Rating System-1978.' Gen. Tech. Rep. INT-39. Ogden, UT: U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 63 pp.

Fosberg MA (1978) Weather in wildland fire management: the fire weather index. In "Proceedings of the Conference on Sierra Nevada Meteorology' South Lake Tahoe, NV. pp. 1-4

Juang H, Hong S, Kanamitsu M (1997) The NMC nested regional spectral model. An update. *Bulletin of the American Meteorological Society* **78**, 2125-2143.

Kalnay E, Kanamitsu M, Kistler R, Collins W, Deaven D, Gandin L, Iredell M, Saha S, White G, Woolen J, Zhu Y, Leetma A, Reynolds R, Chelliah M, Ebisuzaki W, Higgins W, Janowiak J, Mo KC, Jenne R, Joseph D (1996) The NCEP/NCAR 40-Year Reanalysis Project. *Bulletin of the American Meteorological Society* **77**, 437-471.

Roads, J., J. Ritchie, F. Fujioka, R. Burgan (2003) Seasonal Fire Danger Forecasts. *International Journal of Wildland Fire*. (submitted)