Program for Climate, Ecosystem and Fire Applications

8-km Historical Datasets for FPA

Project Report

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CEFA Report 09-04 June 2009

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June 2009

Foreword

In November 2000 an Assistance Agreement 1422RAA000002 was established between the Bureau of Land Management National Office of Fire and Aviation and the Desert Research Institute (DRI). One of the primary Task Orders begun under this agreement was Task Order 17 (RAF04-002) – RAWS Data Quality Check and Estimation. The DRI program for Climate, Ecosystem and Fire Applications (CEFA) has been responsible for the work done in this Task Order. This report describes the results of a modification of the Task Order to produce weather scenarios to be used by FPA for fire planning. For further information regarding this report or the project described, please contact either:

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EXECUTIVE SUMMARY

The objective of this project was to develop a 29-year record of high-resolution gridded daily weather observations for the Fire Program Analysis system (FPA). Previous work in developing gridded weather observations for FPA utilized output directly from the North American Regional Reanalysis (NARR) at a horizontal resolution of 32-km. Several improvements are made to previous efforts in improving the horizontal resolution through physical based interpolation methods and bias correction with Remote Automated Weather Stations. The resulting product is a historical 8-km resolution gridded weather dataset covering the continental US and Alaska from 1980-2008. Output was provided in the fw9 format for fire weather software (e.g., Fire FamilyPlus (FF+)). This dataset provides an improved means to assess high spatial resolution historical weather for use in fire planning and management.

1. Introduction

This work builds on a current task to develop an archive of spatially and temporally complete gridded dataset of surface weather data over North America covering the period 1980-present for use in fire planning and management. The National Centers for Environmental Prediction (NCEP) North American Regional Reanalysis (NARR) dataset, providing high temporal (3-hourly) and spatial (32-km) resolution, was used in this analysis. NARR data infills gaps in the observation network by providing dynamically consistent data where Remote Automated Weather Station (RAWS) and other observations are not available. Initial analysis shows that NARR does a reasonable job in capturing observed surface variables (e.g., temperature, humidity), though suffers from a number of significant biases, particularly in regions of varied terrain.

Although the gridded meteorological dataset from NARR represents a significant advancement in assessing weather and climate information for fire business across vastly under instrumented parts of the country, several inadequacies were identified in the data. Initial analysis shows that the original 32-km NARR dataset suffers from (a) significant biases in relevant variables for assessing fire weather (e.g., RH), and (b) inability to resolve topographic features at subgrid scales (< 32-km). The later component is particularly problematic in the western US where topography is varied, therein forcing physical differences between weather aggregated over a 32-km by 32-km parcel, and that at a specific site on the ground. Separate FPA related work is underway to perform a bias correction on the 32-km grid for the proxy point locations, but this work is independent of this proposed effort, and not necessary to complete prior to producing the 8-km grid.

This project was completed under CEFA/BLM Task Order RAF04-002 Task 17.

2. Development of 8-km Historical Dataset

Daily data was acquired from NARR to provide 1300 local time observations as needed for implementation in fire weather analysis. Because NARR is only provided at 3-hourly intervals, temporal interpolation was applied to estimate 1300 observations across all time zones in the continental US and Alaska from 1980 through 2007. Twenty-four hour maximum and minimum temperature and relative humidity, accumulated precipitation and precipitation duration, as well as 1300 observations of temperature, relative humidity, wind velocity and state of the weather (SOW) were generated. For every 3-hourly NARR value that had precipitation ≥ 0.01", one-hour duration was accumulated. Therefore, a 24-hour period does not exceed 8 hours of precipitation duration. State of the weather (SOW) was given only three categories (clear=0, overcast=3 and precipitating=6), and was based upon the ratio of actual downward shortwave radiation (DSW) with the potential DSW on a clear day. The maximum observed DSW is a function of day of year and latitude after being smoothed by a three term Fourier series. If the ratio (i.e., actual DSW / maximum DWS) was ≥

75%, then a SOW of 0 (clear) was assigned. If it was < 75%, a SOW of 3 (overcast) was assigned. If the 3-hourly NARR precipitation amount closest to 1300 LT was ≥ 0.02”, then a SOW of 6 (rain) was assigned.

Initial analysis showed that NARR contained a substantial amount of bias in capturing observed surface variables. To this end, a set of bias correction and downscaling methods were applied to achieve an improved match between the desirable qualities of a spatially and temporally complete dataset, and the in situ conditions observed on the ground and realized in fire weather.

2.1 Downscaling: Decomposition-Interpolation-Composition Method

The horizontal resolution of NARR is 32-km, which is clearly insufficient for examining meteorological parameters in regions of complex physiographic features. Disparities between NARR and ground observations (e.g., RAWS) are problematic when trying to compare gridded output to ground conditions. To improve upon the spatial resolution of NARR, we make use of the PRISM (Parameter-elevation Regressions on Independent Slopes Model) dataset. PRISM uses point measurements of precipitation and temperature, and considers various physical geographic factors (topography, aspect, distance to water bodies) to create a continuous gridded dataset with 4-km horizontal resolution and monthly temporal resolution covering the continental United States.

At present, PRISM is only available on monthly time scales. However, a high spatial resolution footprint of monthly data from PRISM can be effectively employed, with the high temporal resolution data from NARR used to create estimates of daily temperature and precipitation on an 8-km grid using equations 1 and 2, where the subscripts *P* and *N* refer to the PRISM and NARR datasets, respectively. Transforming the data from monthly (PRISM) to daily (NARR) requires the assumption that within a 32-km grid, the day-to-day variability is determined by NARR, but that subgrid scale values are determined via PRISM. Equation 1 is used to downscale precipitation fields, while equation 2 is used for temperature fields. We note that this downscaling method may be unable to capture fine-scale inversions on spatial scales < 4-km in the complex terrain regions of the western US as PRISM and the surface fields of NARR both cannot fully depict such features.

$$P_R(x,y,m,d) = \left[\frac{P_N(x,y,m,d)}{\sum_{d=1}^{nd} P_N(x,y,m,d)} \right] * P_P(x,y,m) \qquad \text{Eq. 1}$$

$$T_R(x,y,m,d) = T_N^*(x,y,m,d) + T_P(x,y,m) \qquad \text{Eq. 2}$$

2.2 Empirical cumulative distribution function bias correction

The downscaling method above proved useful in eliminating most of the seasonally varying temperature and precipitation biases found in NARR. However, it was deemed that the relative humidity still suffered from substantial biases such that NARR tended to under predict maximum RH and over predict minimum RH. A secondary method was used to bias correct the relative humidity fields in NARR using an empirical distribution matching technique where RAWS stations provide ground truth data. This method seeks to fit the data along its entire cumulative distribution, as opposed to fitting it at just certain quantiles. This method is preferred when trying to fit distributions near their tails.

Data from all available RAWS for the years 2004-2006 (900+ stations) serve as the observations, and collocated NARR pixels serve as the model datasets. The empirical cumulative distribution function (CDF) method fits the distribution of the RAWS and NARR datasets. The CDF of the modeled data is then interpolated to the empirical CDF of the observed data, therein forcing the modeled data to conform to the distribution of the observed data. The transformation is calculated on an FPU-by-FPU basis taking into consideration all RAWS that exist in each FPU. For regions not covered by an FPU, a region wide fit was assumed. Bias correction is performed for two time periods, cool season (Nov-Apr) and warm season (May-Oct) to account for potential seasonal biases in the model.

2.3 Elevation Correction

One further addition was to account for discrepancies in the elevation of the 8-km grid compared to the 32-km grid for relative humidity fields. Differences of up to 2-km were identified between 32-km surfaces from NARR and 8-km smoothed digital elevation maps. Substantial differences in RH can exist in such varied topography due to the height of the boundary layer and moisture profile of the atmosphere. To correct for this problem, vertical profiles of free air relative humidity are examined from NARR for the cool and warm season. Changes in relative humidity with height near the topography are calculated and then multiplied by elevation differences (32-km resolution minus 8-km resolution). These correction factors are then applied to the relative humidity fields, leading to physically based corrections in the 8-km grids.

3. Deliverables

This project created an 8-km historical weather database for the US that provides an improved representation of weather conditions on the ground. Daily weather *.fw9 files for the 29-year period 1980-2008 are provided covering the continental US and Alaska. Station identifiers for Alaska and the US with their associated latitude-longitude coordinates can be found at:

http://www.wrcc.dri.edu/research/jtwrcc/CEFA/FPA/DATA/FPA_8KM_USALASKA_ID.txt
http://www.wrcc.dri.edu/research/jtwrcc/CEFA/FPA/DATA/FPA_8KM_USCONTINENTAL_ID.txt

Acknowledgements

We would like to thank Howard Roose for project support and ideas, and acknowledge the funding support of the FPA program.