Program for Climate, Ecosystem and Fire Applications

Climate and Ecosystem Studies and Product Development for Wildland Fire and Resource Management

Annual Report

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Division of Atmospheric Sciences

CEFA Report 04-01 December 2004

Forward

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. This report describes the activities at the DRI Program for Climate, Ecosystem and Fire Applications (CEFA) under this Agreement during the period 1 October 2003 - 30 September 2004. For further information regarding this report or the projects described, please contact either:

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Annual Report to the Bureau of Land Management National Office of Fire and Aviation

by
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A. INTRODUCTION

This annual report is the third under the Bureau of Land Management (BLM) national Office of Fire and Aviation and the Desert Research Institute (DRI) cooperative Assistance Agreement (AA) 1422RAA000002, and covers the federal fiscal year 2004. The 5-year AA was signed by BLM and DRI during November 2000. The overall scope of the AA is climate and ecosystem studies and product development for wildland fire and resource management. Its objective is to establish and maintain a partnership between BLM and DRI that allows for product development, applied research, training, education and consultation using DRI scientific expertise in climatology, meteorology and terrestrial ecology. The deliverables under this AA are intended to have high interagency value in addition to specific BLM agency needs. The target audience varies depending upon the product or information, but include among others fire management, Predictive Services meteorologists, fuels analysts, intelligence officers, fire behavior analysts, and fire specialists. Project concepts can originate at all levels including local, state and national offices as well as at DRI.

This report describes activities and accomplishments under the AA for the period 1 October 2003 – 30 September 2004. Report sections include an overview of tasks during the year, other related activities, travel, presentations and meetings, and publications. For a brief history of the DRI Program for Climate, Ecosystem and Fire Applications (CEFA), see the annual report for federal FY2001 (CEFA Report 01-04).

Direct contributions to this report were provided by Ryan Kangas, Crystal Kolden, Greg McCurdy, Domagoj Podnar, Kelly Redmond, Hauss Reinbold and Paul Schlobohm. The CEFA staff are very appreciative of the agency support towards the Program, and the opportunity to work with the fire community.

B. TASK ORDERS

This section describes AA tasks specific to BLM that were in progress during federal FY2004. Administrative Task Order 1 began in the first half of calendar year 2001 and is ongoing through the AA 5-year period; project Task Orders 4, 5 and 6 began in September 2001 and ended in December 2003; Task Order 7 began in September 2001 and is in its third year; Task Order 9 began in summer 2002 and is in its third year; Task Order 10 began in October 2002 and is in its second year; Task Orders 11, 12, 13 and 14 began in September 2003 and are currently in their second year. New Task Order 16 began May 2004, and new Task Order 17 began in August 2004. Task Order 15 was originally intended to be a Yosemite NPS RAWS project, but this work was later tasked as a direct contract.

Task Order 1: CEFA Infrastructure and Administration (Sponsor: BLM)

This task order provides for some basic infrastructure required for CEFA general operations. The primary components include:

- Salary for CEFA administration and management by Director and Deputy Director (partially used to allow CEFA personnel to be available on short notice as if they were agency staff).
- Readily available funds for short-term projects requested by the field in support of fire season activity.
- Travel including field visit for training and discussion, working team meetings, workshops and scientific conferences.
- Materials and supplies including computer software upgrades and license fees, computer hardware related supplies (e.g., tapes, diskettes, printer toner, etc.), and books and reference materials.
- Computer hardware upgrades (e.g., disk storage drives).
- Publication charges related to conference proceedings, report printing, and scientific journal publications.
- CEFA web administration.
- Salary for GIS, specialized computer programming and hourly student support.

Notable accomplishments for the reporting period:

CEFA was co-organizer of two Predictive Services Seasonal Assessment Workshops. The first of these was held in Sheperdstown, WV during 27-29 January 2004 (Eastern and Southern areas), and the second was held in Phoenix, Arizona during 30 March – 2 April 2004 (Western States and Alaska). These workshops brought together climatologists, Predictive Service units, and fire managers from across the country to produce Geographic Area Coordination Center (GACC) seasonal fire outlook reports. For the eastern and southern area workshop, emphasis was placed on bringing together state agency representatives in addition to federal participants. The workshops are structured to foster communication between climate forecasters and fire specialists, and to enhance communication and cooperation between the representatives. Products from the workshops included a seasonal fire potential outlook, a two-page flyer providing outlook information for national fire directors and Washington, D.C. interests, and a final report. These workshops will be held again in 2005. See Garfin et al. (2004) in the publication section for workshop report references.

In December 2003 at the Whitefish, Montana Predictive Services meeting, Tom Wordell and Tim Brown presented a plan to implement scientific verification, validation and evaluation of the 10-day and monthly products produced by the GACCs. A white paper was prepared providing background information on these topics and a proposed plan (see publication section). One of the key issues facing Predictive Services is the quantitative definition of certain products, in particular, fire potential. Along with the need for formal definitions is a scientifically based and quantitative methodology for verifying forecasts and outlooks. Most of the products produced need formal validation procedures applied to them, and subsequent evaluation of the output by users of the information is needed. These topics were discussed at the meeting, and it was agreed upon that some prototype verification would be done on ERC-G during the 2004 season. These results would be presented and discussed further at the Predictive Services Portland meeting in November 2004.

CEFA continues to respond to agency questions regarding climate and meteorological data. CEFA responded to 17 data requests of which nine were RAWS related and eight were for lightning information. The RAWS requests mostly included data extraction from the Western

Regional Climate Center (WRCC) archive and reformatting into .fwx or .fw9 data formats, or applying a wind algorithm to adjust wind speeds for varying wind sensor heights above ground. CEFA responded to six media requests for fire climate related information, and appeared in at least one national newspaper article.

CEFA is now the national fire agency archive for lightning data. In conjunction with the new fire agency agreement with Vaisala, CEFA receives quarterly updates of national lightning occurrence from the National Lightning Detection Network®, which is added to a national archive extending back to 1990. As part of the national agreement, fire agencies in need of lightning information can fill out a user request form at NIFC, and if approved, will be forwarded to CEFA for processing. Simple requests for data may be handled in this manner, but actual analysis of lightning data may require a Task Order depending upon the resources required.

CEFA maintains a historical archive of federal fire occurrence data for the period 1970 to the most current year. Most of the Department of Interior reports begin in 1980. In 2002, an extensive quality control (QC) analysis was done on these data. Of the 657,949 initial reports, a little over 119,000 were flagged has having some kind of data issue, yielding 538,809 reports. A report describing the process is available in the CEFA online publications section (CEFA Report 02-04). Each year the QC process is run on the annual dataset and the archive updated correspondingly.

California and Nevada Smoke and Air Committee (CANSAC) funds via Task Order 10 were used to purchase the Silicon Graphics Inc. (SGI®) Altix® high-performance cluster in February 2004. This $250,000 system (after a substantial academic pricing discount) is comprised of 32 Itanium®-2 processors, and is used for running the MM5 model under Task Order 10. As required per annual basis, several software license renewals and updates were administered on the CEFA servers and desktop units.

Web administration is an ongoing process. Some new and updated CEFA products were added to the site (see tasks below). CEFA maintains an extensive website for science information delivery and outreach. The site currently consists of nearly 1026 web pages; 98,294 graphics files; and 5783 web links totaling 15.6 GB of information. The CEFA web site address is http://cefa.dri.edu.

Travel and publications under Task 1 are listed in separate sections below.

Task Order 4: Utilization and Evaluation of Climate Information and Forecasts for Fire Management (Sponsor: BLM)

This task officially began in September 2001 and ended in December 2003. All primary project results and deliverables were discussed in the 2003 annual report and a Master's thesis (see publication section), so this section is included primarily to reflect the official end of the project period. However, some follow up activities have occurred or are planned. A journal article describing results of climate model forecast quantitative verification has been prepared, and will be published in the International Journal of Wildland Fire (see publications section). Results of this study were presented at the American Meteorological Society 5th Symposium on Fire and Forest Meteorology in Orlando, Florida in November 2003 (see publications). It is planned during the 2005 fiscal year to prepare an agency report, primarily for Predictive Services meteorologists, describing the results in a manner to provide climate forecast skill guidance.

Within the domain of this project, CEFA continues to post monthly temperature and precipitation forecasts from several different models run at the International Research Institute for Climate Prediction (IRI). These are used in part for the seasonal outlook workshops, but are also made available to Predictive Services and other interested users for planning purposes. Figure 1 shows the current forecast matrix. Starting in January 2004, these products are effectively being done as a Task Order 1 element.

Related to this Task Order, CEFA continues to post climate monitoring information of interest to Predictive Services and other users. These products include 10 and 30-day anomalies of upper air patterns (600mb and 500mb relative humidity, 850mb and 500mb streamlines), RAWS maximum and minimum temperature and relative humidity, and lightning strikes. Starting in January 2004, these products are effectively being done as a Task Order 1 element.

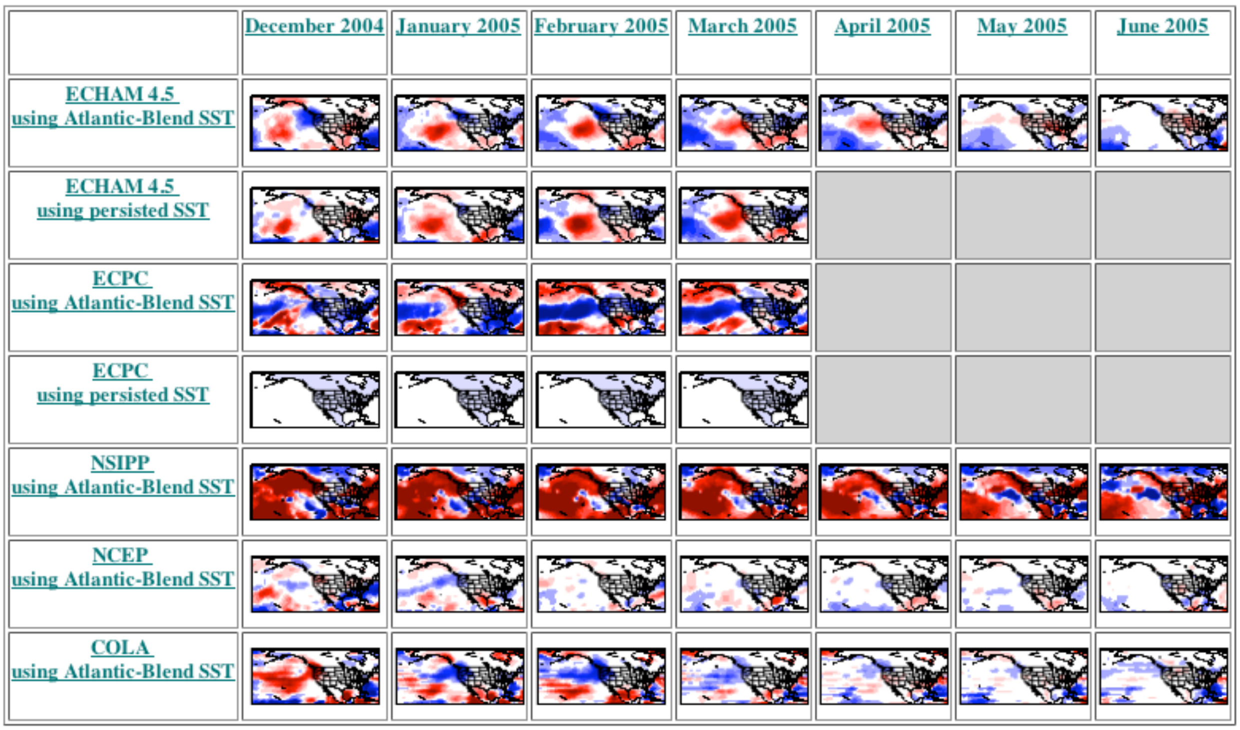


Figure 1. Example of forecast matrix of monthly precipitation forecasts from the International Research Institute for Climate Prediction.

A scientific journal article entitled "A statistical methodology for identifying fire occurrence potential from upper atmospheric anomalies" that is related to this Task Order is currently being prepared. Once completed (planned for calendar year 2005), the paper will describe a statistical methodology for identifying anomalies of upper atmosphere elements, such as 600mb relative humidity or 850mb temperature, that are statistically related to natural fire occurrence.

A left over task element from the project that was not completed due to time constraints is the preparation of a report on climate factors affecting the U.S. wildland fire seasons during the past six years (1999-2004). This period, a significant drought period for the West, has had some very interesting characteristics regarding the extent of fire activity and the spatial variability of fire occurrence. If this period represents the beginning of a trend, as some fire management individuals speculate, then an improved understanding of links between climate and fire would provide important information for strategic planning. This report will assess the role of climate during this period, and provide guidance as to what climate factors may be of particular relevance in near-term future years. This report is now planned for completion by September 2005.

Task Order 5: Analysis of the Southwest Monsoon in Relation to Fire Danger Characteristics (Sponsor: BLM)

This task officially began in September 2001 and ended in December 2003. All primary project results and deliverables were discussed in the 2003 annual report and a Master's thesis (see publication section), so this section is included primarily to reflect the official end of the project period. However, it is still desired and planned to prepare a report/paper synthesizing the results of the project. Results of this study were presented at the American Meteorological Society 5th Symposium on Fire and Forest Meteorology in Orlando, Florida in November 2003 (see publications). One outcome of the project was the realization that substantial additional work is needed to more fully understand the impact of the monsoon on southwestern fire business. Hence, a CEFA proposal co-written with Chuck Maxwell from Southwest Area Predictive Services was written and submitted to the Federal Emergency Management Agency (FEMA) Fire Prevention Program. The primary deliverables of the project are to define fire business impacts related to the monsoon, and define regional fire business thresholds. Status of acceptance of the proposal is expected in February 2005.

Task Order 6: A Comparison of Precipitation/Drought Indices Used in Fire Management (Sponsor: BLM)

This Task Order began in August 2002 and ended in December 2003. The project was scaled back considerably from its original inception due to budgetary constraints, and thus a very limited amount of research was undertaken. The primary focus was to assess the strengths and weaknesses of the standardized precipitation index (SPI), the Palmer drought severity index (PDSI and its derivatives), and Keetch-Byram Drought Index (KBDI) in relation to fire danger and fire activity. Project results and deliverables were discussed in the 2003 annual report (see publication section), so this section is included primarily to reflect the official end of the project period. Results of this study were presented at the American Meteorological Society 5th Symposium on Fire and Forest Meteorology in Orlando, Florida in November 2003 (see publications). However, some further analysis has continued on this project related to Ph.D. work being undertaken by Beth Hall. The results of the previous and current work will be summarized in a report/paper currently in preparation and expected for completion by September 2005.

Task Order 7: Web Access to RAWS Data and Products (Sponsor: BLM)

This task is being accomplished by WRCC with separate BLM funds, but using CEFA and the Assistance Agreement as a project conduit. The primary project objective is to build upon recent efforts to reconstruct the internal storage and access system for RAWS data and initiate system-wide improvements. The overall objective is to provide improved access to archived RAWS data and climatology applications of these data in order to fully serve the fire agencies as a historical RAWS archive. This work officially began in August 2001, and this reporting period represents the third year of the project through the period 30 June 2004. In June 2003, a year three Task Order was funded by BLM for the period 1 July 2003 – 30 June 2004. Statement of Work specific task elements during the project's third year included:

A) Data improvement

1. Data conversion. Continue reformatting of remaining RAWS station data from ASCII text to internal binary indexed format.

2. Station metadata. Development of a station selector and search function.

3. Quality Control. Mark suspicious data and rehabilitate sections of flawed data as much as possible. Quantify both the quality and the reliability of the receipt of data records and files. Explore the development of a quality indicator for each datum. Where possible, attempts will be made to fill gaps in historical records, with provisions for labeling such data.

B) Product development. Develop statistical summaries and other manipulations of the observations, the simplest product being a listing of the data themselves. Products can have either textual or graphical formats.

1. Climate summaries. These products consist mainly of hourly and daily climatologies. Derived data sets may be developed to provide information on daily extremes (max and min temperature, wind speed and gusts, relative humidity, etc) and totals (such as precipitation and solar radiation).

2. Monthly time series. These are listings, by individual month, of a desired statistical property of that month. Examples include: mean temperature, wind speed, total precipitation, or number of exceedances per month, or other monthly counts.

3. Daily time series. The analog is the Summary-of-the-Day data set from the National Climatic Data Center. Some property, or a variety of properties, of the 24 (or 25) hourly values, is summarized for each day, and all such properties presented as a listing.

4. Frequency distributions and probabilities. These products involve the ranking of data, and provision of information on the likelihood of occurrence. Distributions can be both empirical and fitted (e.g., Pearson III, Generalized Extreme Value, etc).

5. Threshold exceedance. The number of times that certain thresholds are exceeded (e.g., days over 92 F, number of hours below 19 percent humidity), or information on the likelihood that values will be exceeded, based on the available period of record.

C) RAWS Advisory Group. An interagency RAWS advisory group has been formed to provide focused feedback as a guide to product development, and some of the products already developed are a direct result of that feedback. The group consists of 10-15 individuals involved in a cross section of fire-related disciplines.

D) RAWS web page. A RAWS web page http://www.wrcc.dri.edu/wraws has been created to allow access to the data, and is now open to public access. The only restriction, to prevent web crawlers, is that a web code ("password") is needed for the lister product (only) for data more than 30 days old, something that will be shared readily.

E) ASCADS re-engineering. Developments in the re-engineering of ASCADS are critical to the success of the infrastructure and products of this Task Order.

F) Associated with ASCADS, but enough of an activity to merit splitting out separately, the Department of Interior has mandated that there be secure and encrypted access into the ASCADS system.

G) Technology transfer/Training. Products will be presented in several formats to appropriate groups.

H) Emergency response. At the discretion of the Administrative Representative, emergent situations may require a rapid response to develop a new capability or focus on special stations or situations.

Accomplishments for the reporting period are as follows:

A1. RAWS data conversion

Conversion of historical RAWS station data from ASCII text to internal binary indexed format was completed for the main RAWS database. This is an ongoing process and takes place on a near-real time basis (approximately 15 minutes upon receipt of data). All data in the incoming data stream are both retained in the original and binary formats. An additional set of stations that arrive via the FTS hub in Boise are undergoing the same scrutiny that the other RAWS station records have received, with about 30-40 of the total 150-200 stations having been processed. This laborious and tedious process must be undertaken (once) for each station.

New stations are brought online typically within a week of receipt of first data. The one-week delay allows for verification and entry of all metadata parameters for the new station. At least 150 stations (brand new or transitioned from WIMS to ASCADS) were brought online in FY04.

The communications and ingest system is fairly well automated and has very little down time, but needs occasional babysitting to free up stuck processes and troubleshoot problems with data flow.

A2. Station metadata

Updating station metadata in the internal database is an ongoing process. As of this reporting period, there were 52,792 station records in the database. Approximately 100-200 new records are added each month.

There are currently two ways that metadata are stored. One contains all the details as entered, retains all original flaws, and covers the history of each station. The second contains the most recent “snapshot”, and has some degree of quality control. A complete cleanup of the station history metadata is a major chore. The recent metadata are somewhat more cleaned up. Neither is in shape yet for public access, though there are tools that allow good internal access. These will form the basis for an eventual public access.

A3. Quality control

Began development of tools to improve ability to access data quality. Quality controlled data from prior projects is available through the system. A few station records have been rather completely examined and repaired.

A multiple linear regression approach is being prepared to check for self-consistency among a single station's elements, and between similar elements at adjoining RAWS stations. This technique also allows a time lag, in case conditions take time to translate across space from one station another.

The internal binary files originally had limited capacity for flagging of each datum. This system is being redesigned to allow a much more robust and extensive set of flags.

B1. Climate summaries

This is quite complex, so the components of a comprehensive climate summary are being developed one at a time. This set was begun with a product that consists of hourly averages. This now works for individual years but must be slightly modified to cover multiple years. There is still quite a bit of work to complete this set of products, and were given a lower priority than B2.

B2. Monthly time series

A software program to produce monthly time series of selected station elements has been completed, but needs optimizing as it currently requires an unsatisfactory amount of time as a web application. A coding problem is suspected. There is very considerable demand for this, so it was given top priority.

B3. Daily time series

This product is also under development, but not ready for public consumption. The dates list correctly but the data values do not appear. The current output option is HTML format, and an ASCII text version is being prepared, along with options for dates and delimiters. An internal version of this is working quite well.

B4. Frequency distributions and probabilities

The option of fitting was deferred in order to work on other products. For some reason there are still some bad values in the data set (wind speeds and directions reversed), and an option was added to allow the user to exclude all values greater than or less than user-specified limits.

B5. Threshold exceedance

This task element was deferred to FY05.

C. RAWS advisory group

The RAWS advisory group was established in Spring 2003. Its function is to provide feedback as products become available, and to recommend potential new products and existing product modifications. The group consists of ten interagency members that actively use RAWS information. Individuals are responsible for providing feedback to WRCC. Some individual feedback was provided and acted on during this reporting period.

D. Web page design

Web page design is still much needed but was deferred to FY05 work.

E. ASCADS re-engineering

Software reprogramming was undertaken for proper communication in response to the ASCADS computer system changeover in March 2003. Greg McCurdy participated in an ASCADS/WIMS evaluation meeting in Boise during spring 2004. However, no significant BLM progress occurred in FY04 in terms of ASCADS re-engineering.

F. Security

A secure data transfer connection for ASCADS has been implemented and is working well.

G. Technology transfer/training

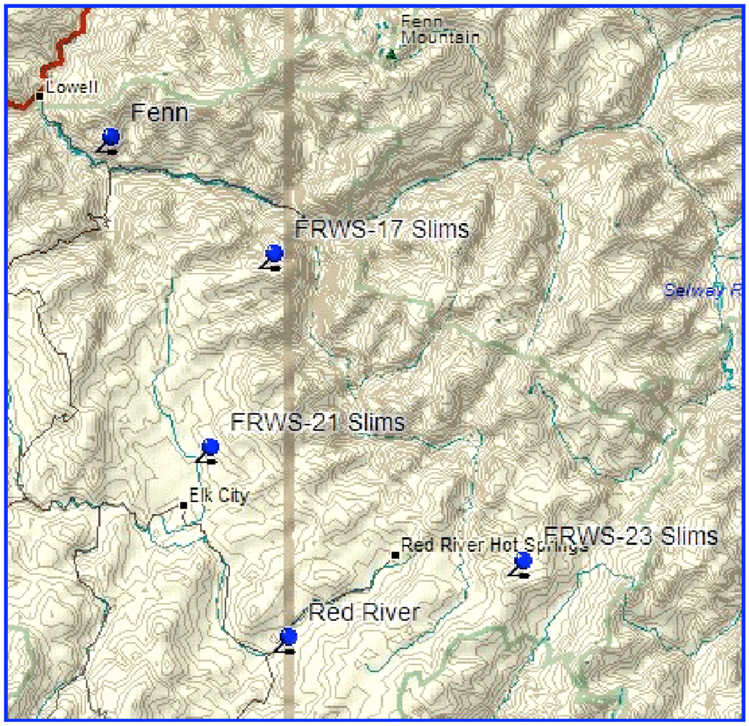
Greg McCurdy and Kelly Redmond demonstrated the new RAWS capabilities in a BLM northern Great Basin meeting in Reno in December 2003. Greg McCurdy demonstrated improvements and how to obtain various products at the Fire Weather Working Team meeting in Alaska in March 2004.

H. Emergency response

Many of the deferred activities mentioned above were a consequence of a number of fires, which required preparation of specific web pages on short notice. These can be found at www.wrcc.dri.edu/PROJECTS.html. They included the Hot Creek, Canyon Creek, Slims, Robert, Fish Creek, Cherry Creek, Cathedral, Booth, Fawn Peak, Northern Bighorn Complex, Wedge Canyon -Trapper Creek, Marble – North Fork Lick, Beaver Lake, Crazy Horse, and Burnt Ridge Complex Fires, a total of 15 web pages showing available long term RAWS and short term Fire Weather RAWS stations, as a very active fire season flared up. Figure 2 shows an example map for the Slims fire.

WRCC web usage

In addition to the specific RAWS data and information, WRCC makes available a vast amount of climate data via their web site http://www.wrcc.dri.edu. Web tracking statistics indicates substantial usage by federal land management agencies. For example, during federal FY04, BLM, USFS, NPS and FWS had a combined total 220,500 unique hits on the WRCC web site, of which BLM accounted for 124,717 of these. The total number is known to be low because of the various IP names used by the Forest Service.



Map Courtesy of DELORME Topo USA

Figure 2. Example WRCC “quick response” map for the Slims fire. Blue pin locations are clickable to obtain climatology information.

Task Order 9: Development of U.S. Operational Fire Danger 15-Day Forecasts (Sponsor: USDA Forest Service)

One of the primary objectives of Predictive Services at the National Interagency Coordination Center (NICC) is to provide relevant information about weather, climate and fuels for decision-making and planning for resource allocations and the determination of national preparedness levels. Prediction needs of weather, climate and fuels include short-term (1-2 days), medium-term (3-10 days), and long-term (30-90 days) forecasts. Operational daily forecasts from NWS provide much of the needed weather and climate forecast information for these periods, and there are also a number of experimental climate forecasts available that offer monthly and seasonal climate predictions. Forecasts of vegetation and fuel conditions at these various time scales are much more difficult to generate. Indices from NFDRS are often projected forward (e.g., via Fire Family Plus) as an indicator of future fire danger and then related to fire business, especially in terms of severity potential and resource demands. In order to predict preparedness levels and assess resource demands on daily and longer time scales at the national level, information needs include forecasts of weather, climate, fire danger, fire severity and fire potential along with how these factors relate to the various aspects of fire business. This project addresses a component of these needs - forecasts of weather and fire danger as an aid in assessing national preparedness levels and resource allocations.

The overall goal of the project is to develop a prototype system for producing operational forecasts of fire danger on a daily basis out to fifteen days. It incorporates national needs at NICC with operational forecast products produced by NWS. Techniques developed at the Missoula Fire Sciences Laboratory (MFSL) were used for producing national gridded predictions of ERC using fuel model G (ERC-G) by inputting NCEP/NWS Global Forecast System (GFS) model forecasts of temperature, relative humidity, wind, cloud cover and precipitation into NFDRS algorithms. To facilitate the standardized ERC concept, an ERC-G gridded national climatology was produced by MFSL. National maps of standardized ERC-G are currently produced by CEFA on an experimental and operational basis for use at NICC and the GACCs. Fifteen-day forecasts have been chosen for the prototype in part based upon information requests for preparedness level planning requirements at NICC and by GACC Predictive Services. The GFS model has been chosen for the prototype as an NCEP/NWS operational product meeting the 15-day requirement. This project is a collaborative effort with MFSL and NICC.

One of the needed components for producing a gridded ERC-G forecast is a gridded climatology of ERC-G. This climatology provides the mean and standard deviation information necessary to produce standardized values. A daily 8km ERC-G grid was produced at the University of Montana, Numerical Terradynamic Simulation Group (NTSG) under direction of MFSL. The DAYMET model provided the underlying high-resolution climatology of 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 calculation of ERC requires fuel moisture, state of the weather and precipitation duration. These values had to be estimated for input into the model. Woody and herbaceous fuel moisture was estimated from NDVI data. NFDRS state of the weather was estimated utilizing a cloud cover condition based on solar radiation provided by DAYMET. Precipitation duration was estimated using a combination of climate class and season. Details of the methods are provided in Hall et al (2003; see publication list). The ERC-G climatology was calculated on a daily 8 km grid for the period 1982-1997. These 8km grids were then averaged to match the available GFS forecast grids of 1 and 2.5 degrees.

In December 2003, the project was extended and additional task elements were developed primarily to perform a validation of the algorithms used to produce the standardized ERC values. Also, the development of ensemble forecasts was also extended over to another year. Please refer to the 2003 annual report for previous task accomplishments. Specific task elements for this reporting period are:

1) Define missing data criteria and acquire daily RAWS from WIMS for a set of stations meeting the criteria. These data will be used to generate station climatologies of ERC-G.
2) Acquire daily historical RAWS from WIMS for stations that meet the defined criteria.
3) Acquire daily DAYMET climatology for grid points that match the selected RAWS.
4) Acquire daily NCEP GFS initialization grids for the period 1 May – 30 Sep 2003.
5) Generate RAWS climatology.
6) Perform statistical analysis that compares the RAWS and DAYMET climatologies.
7) Perform statistical analysis that compares GFS and RAWS observed values for the study period.

Accomplishments for the reporting period are as follows:

1. Define missing data criteria

This task element defines what data observation criteria will be used to determine whether a station can be included in the analysis. This is typically a determination of acceptable number of hours, days or years of missing values, such that sufficient climatology information can be computed from the record. At the time the analysis was performed, there were 1,298 potential

RAWS to work with. Validation was done at a monthly time scale, so it was arbitrarily decided that each station needed at least 15 years of 20 or more days of data for each month to be considered. These numbers should allow for a representative climatology to more closely match the DAYMET climatology. A monthly time scale was chosen in order to maximize data points and still capture seasonal variations. This meant that some months had far fewer than the maximum possible 1,298 stations available for an adequate spatial interpretation of the validation.

2. Acquire daily historical RAWS from WIMS

Though the original work plan indicated using RAWS from WIMS, the WRCC RAWS archive was utilized and all of useable data were extracted from this archive. The primary reason to utilize the WRCC archive was to extract hourly values from RAWS that could be better matched to the NCEP GFS model output time of 00 UTC. Depending on time zone, this meant 1600, 1700, 1800 or 1900 for Pacific, Mountain, Central and Eastern zones, respectively. The WRCC RAWS archive is stored in local standard time, so daylight savings time was not an issue. Computer software code written for the project examined each RAWS historical record based on the climatology criteria described above, and from this checking process a working dataset was developed. Most RAWS locations are in the West, and because most RAWS are seasonal, more stations were available for the summer season analysis compared to winter. For example, nearly 400 stations were available for analysis in July and August compared to less than 50 in January and February.

3. Acquire daily DAYMET climatology

Once the dataset of RAWS was established, computer software written for the project matched RAWS spatial locations with DAYMET 4 km grid cells. This allowed for the development of a DAYMET working dataset for subsequent analysis. The actual locations of DAYMET grid cells used for validation are shown in some analysis maps below. DAYMET climatology fields examined included temperature, relative humidity and ERC-G. The University of Montana Numerical Terradynamic Simulation Group (NTSG) provided the DAYMET data in their collaboration with the Missoula Fire Sciences Laboratory.

4. Acquire NCEP GFS grids

A similar process to DAYMET in task element 3 was needed to develop a working dataset of NCEP GFS data. In this case, computer software written for the project was used to develop a dataset of GFS grid cells corresponding to RAWS and DAYMET locations. Daily 00Z historical GFS initialization grids from 2001 through 2003 were acquired from the Cooperative Program for Operational Meteorology and Training (COMET) – University Corporation for Atmospheric Research (UCAR). The 2001 and 2002 initialization grids are at a 95 km spectral grid resolution, whereas the 2003 grids are on an even 1° spatial resolution. For the 2001 and 2002 grids, interpolation of the initialization data to the RAWS station was done using a nearest natural neighbor interpolation. Since the 2003 model grids were on an evenly spaced geographical grid, a bilinear interpolation scheme was used. All interpolation was computed using built-in routines from the National Center for Atmospheric Research (NCAR) Command Language (NCL) software package (http://ngwww.ucar.edu/ncl).

5. Generate RAWS climatology

Following the creation of the RAWS working dataset, computer software written for the project was used to generate monthly climatologies of RAWS temperature, humidity and ERC.

These values were used in the subsequent analyses to assess DAYMET and GFS correlations and bias.

6. RAWS and DAYMET analysis

A more detailed report will be prepared at the project conclusion, but the key points of the DAYMET climatology compared to RAWS validation process are provided here. Figure 3a shows the monthly ERC-G Pearson correlation coefficients for DAYMET and RAWS. Correlation values are denoted by color symbols representing ranges. For example, the largest positive correlations would be shown by a purple solid circle symbol, and the largest negative correlations shown by purple open circle symbol. Most of the correlations shown on the maps are positive. More symbols are given during June-September since this represents the primary western fire season and hence seasonal RAWS data. Larger correlations would indicate a better linear relationship between RAWS and DAYMET. Correlations between the two datasets generally exceed +0.5 (ideally they would be +1.0). There does appear to be some spatial coherency in the correlations, that is, regional groupings of similar correlation values. This is likely a function of the algorithms used to generate DAYMET, but these patterns by themselves do not reflect a specific problem. Lower correlation values imply higher variance between the two datasets, and at least for southern California, this turns out to be a problem of special interest as discussed below.

Figure 3b shows monthly ERC-G bias by subtracting the DAYMET values from RAWS. No bias would be indicated by a zero value. During the summer season there is clearly a positive bias from DAYMET having larger values than RAWS with some spatial coherency. There appears to be seasonality in the bias. For example, July shows a smaller bias (a dominance 5-10 unit values), whereas September shows a larger bias (> 10 units). Bias is not especially problematic if it is known. For example, subtracting the bias from DAYMET allows for matching the DAYMET values with RAWS more closely. As a result of this analysis, bias is removed from DAYMET in generating the mean and standard deviation values used in computing the standardized ERC-G values.

7. RAWS and GFS analysis

A similar analysis was performed by comparing RAWS with the GFS initialization grid data. Since these grids are used to produce the forecasts, it is relevant to determine if they show bias that can be accounted for. In other words, it is an analysis to determine how well the GFS model grid "observations" match with RAWS. However, this is not a verification of the GFS forecasts.

Because only three years (2001-2003) were used in the analysis, many more RAWS were available year round. For example, around 1000 stations were usable for both July and August, and around 700 stations in January and February. Figure 4a shows the correlation between the 00 UTC GFS initialization temperature and 00 UTC RAWS observed temperature. In July and August, for example, correlations tend to exceed .65 in California, Oregon and Washington, but are lower for most of the interior and mountainous West. It is not necessarily surprising to have a large range of correlation values given the various elevation, slope and aspect locations of RAWS in comparison to a smoother 1-degree model output grid. Smaller correlation implies reduced linearity between GFS and RAWS, and is an indication of larger covariance of the two datasets. This suggests that using GFS surface variables directly as a predictor of a single RAWS without a model output type equation will often not be successful. However, since the goal of the project is to produce gridded forecasts, and not point forecasts, it is more of interest to assess bias and variance.

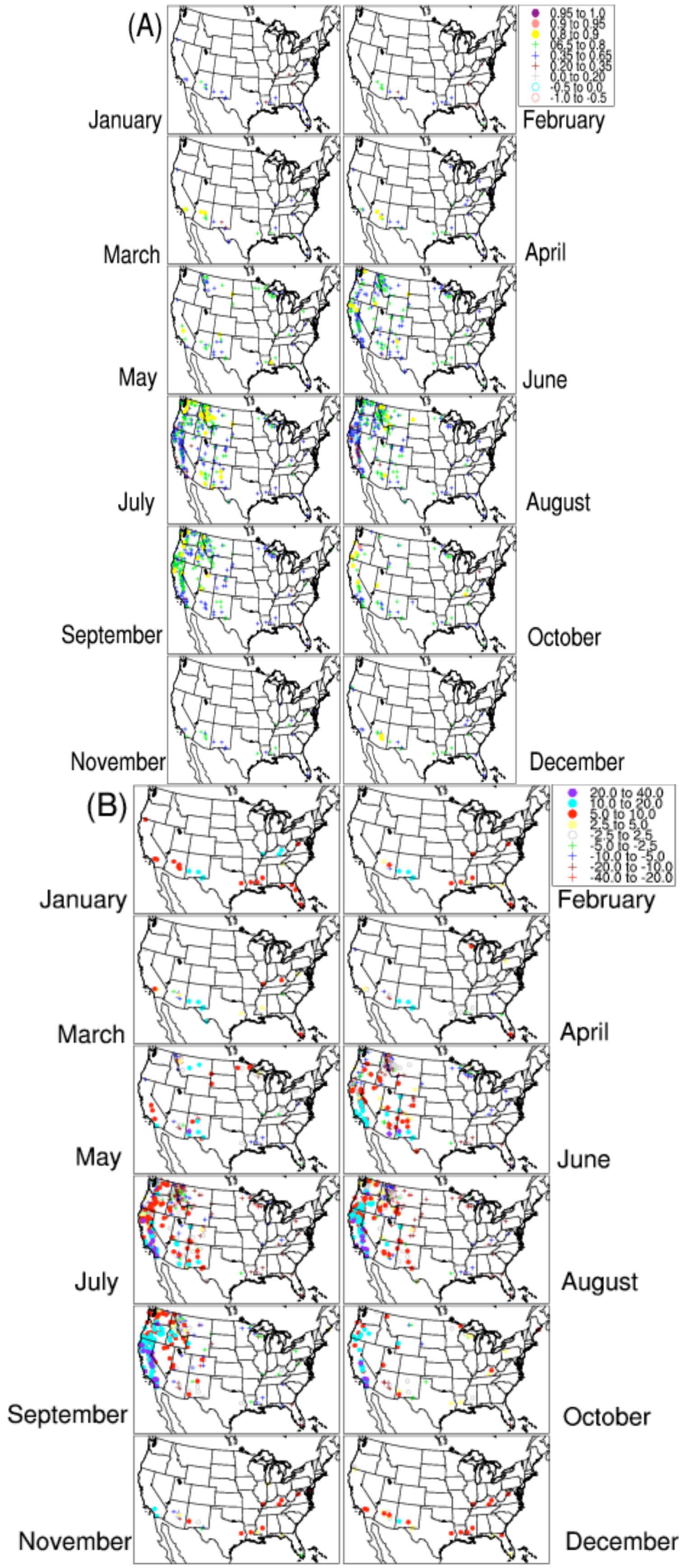


Figure 3. Monthly ERC-G Pearson correlation (a) and bias (b) between DAYMET and RAWS. Symbol legend is shown in upper right.

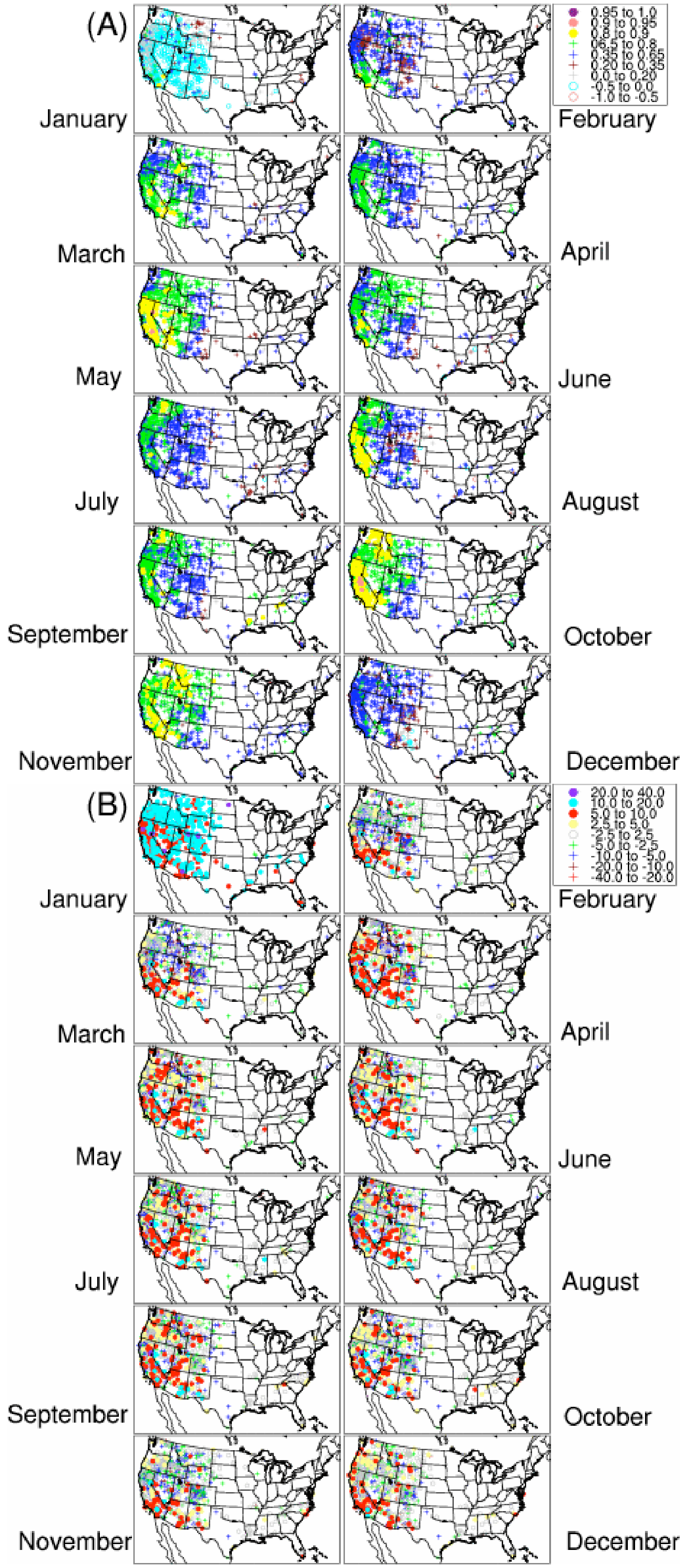


Figure 4. Monthly correlation (a) and bias (b) for GFS 00 UTC initialization temperature and RAWS 00 UTC observed temperature from 2001 through 2003. Symbol legend is shown in upper right.

As part of FY05 work, assessment of gridded fields will be undertaken. Prior to this, however, individual station bias was examined such as shown in the example of Figure 4b. While several stations exhibited minimal bias, a large fraction showed a range of 5-10ºF with others having an even larger difference. Given an assumption that bias is a constant factor, it is easy to account for. In the current available online product, bias is subtracted from the model in an attempt to improve the actual ERC-G forecast, and subsequently the standardized values.

Product monitoring during the 2004 fire season revealed a potential forecast problem, particularly in southern California, where a large negative standardized value was appearing on a persistent basis (see Figure 5b for an example). Initial analysis of this pattern suggests that there might be a variance bias in DAYMET leading to large standardized values. This will be further analyzed and a solution sought to correct for this variance bias if it is indeed present.

Product examples

Three primary forecast maps are updated daily; these include actual ERC-G (Figure 5a), standardized ERC-G (Figure 5b) and ERC-G anomaly (not shown). For these example maps, the color scale legend is shown at the bottom of each map, and the “block” appearance represents the unsmoothed model grid. Fifteen-day forecasts are available on the CEFA web site (http://www.cefa.dri.edu/data/NatlERC/natlErc.html).

Deliverables

Once the project is completed, two primary operational products will be available for fire management at NICC and regional levels: 1) GFS 15-day forecasts of standardized, actual and anomaly ERC-G for the contiguous U.S.; and 2) GFS 10-day ensemble forecasts of standardized ERC-G.

FY05 planned work

Project development work will continue in federal FY05, and it is anticipated to have the final forecast products ready for implementation in late spring 2005. There are two primary tasks to complete:

1. Assessment of the large standardized values (especially large negative values in southern California).
2. Ensemble GFS output will be used to produce ensemble standardized ERC-G forecasts. These forecasts will be assessed for improvements in depicting the uncertainty of standardized value forecasts.

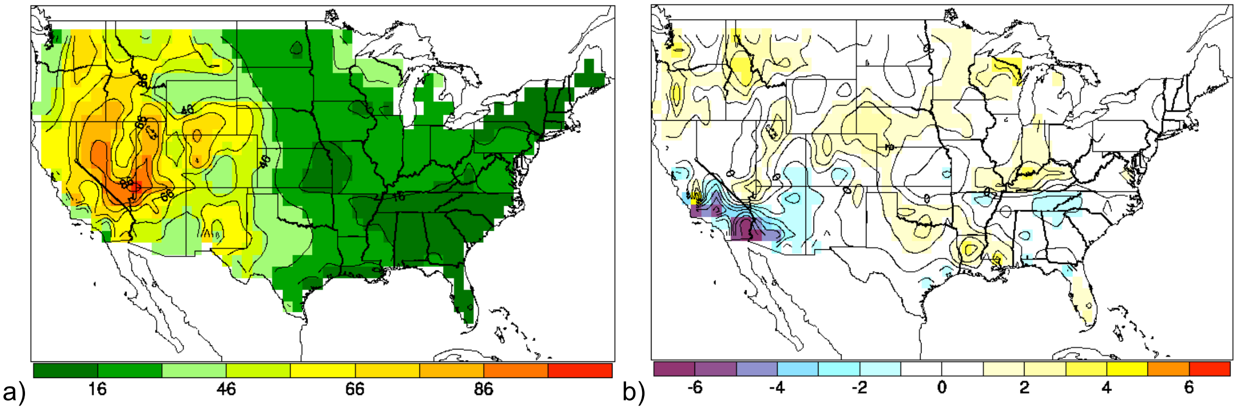


Figure 5. Example maps of a) ERC-G forecast and b) standardized ERC-G. Color scale shown at bottom of each map, respectively.

Task Order 10: Operations of the CEFA Operational Forecast Facility (Sponsor: CANSAC)

In May 2004, the California and Nevada Smoke and Air Committee (CANSAC) dedicated its facilities at DRI and began product generation. For an overview of CANSAC, please see the CEFA FY03 annual report (CEFA 03-02). The CANSAC web site (http://www.cefa.dri.edu/COFF/coffframe.php) contains a description of the facilities and products. Agency membership as of the end of September 2004 included USDA Forest Service Region 5, USDA Forest Service Pacific Southwest Research Station, Bureau of Land Management (California and Nevada State Offices), U.S. Fish and Wildlife Service, National Park Service, California Department of Forestry and Fire Protection, California Air Resources Board, and San Joaquin Valley Air Pollution Control District. CANSAC organizational structure includes the Board of Directors (BOD), Operational Applications Group (OAG) and the Technical Advisory Group (TAG). General deliverables from the CANSAC project include:

1) Meteorological model forecast output as defined by OAG.
2) Web based application products as defined by OAG.
3) Reports and/or presentations describing the functions and operations of CANSAC.

Several task elements were planned for the first year, including designing and building the computing infrastructure, putting in place required personnel, establishing product requirements and specifications, testing the MM5 model, and begin developing a real-time verification system. The primary task elements included:

1) Hire necessary personnel to operate the facility.
2) Determine final computer hardware specifications and purchase system components.
3) Develop an annual operating plan in conjunction with CANSAC.
4) Establish first year product requirements and specifications.
5) Build and test the high-performance computing cluster.
6) Implement and test the MM5 model.
7) Begin development of the real-time verification system.
8) Begin producing operational forecasts.
9) Assessment of 2004 fire season products.

<u>1. Personnel</u>

Two new personnel were hired exclusively for the CANSAC project. In November 2003 Domagoj Podnar began work in determining final hardware specifications, testing the system and implementing the MM5 model. In September 2004, Julide Koracin accepted an offer to work on the CANSAC project as a post-doc. Ms. Koracin expects to complete her Ph.D. in December 2004. In September 2004 Ph.D. graduate student Tesfamichael Ghidey entered the University of Nevada Atmospheric Sciences Program and will be assisting in the development and implementation of CANSAC products as well as performing research in support of the project. Current CEFA staff members working on the project include Hauss Reinbold (post-processing and web support) and Beth Hall (OAG liaison).

2. Computer Hardware

A critical component to the success of CANSAC was the appropriate selection of computing hardware to run the MM5 mesoscale model. Though it was thought early on that the system solution would be a PC cluster, an SGI® Altix® machine became a viable alternative when DRI was offered a substantial purchase discount. A full report of the testing and recommendation was made available to BOD and TAG. Here, a brief summary of the report is provided.

A test case was designed using the 36, 12 and 4 km area domains provided by OAG. Figure 6 shows the current domain, which is nearly similar to the one tested. Slightly over 108,000 surface grid points make up all three domains. The inclusion of 32 upper-atmosphere levels brings the total number of grid points to 3,462,432. It was desirable to have the test run completed in approximately two hours real-time in order to deliver products in a timely manner to the field.

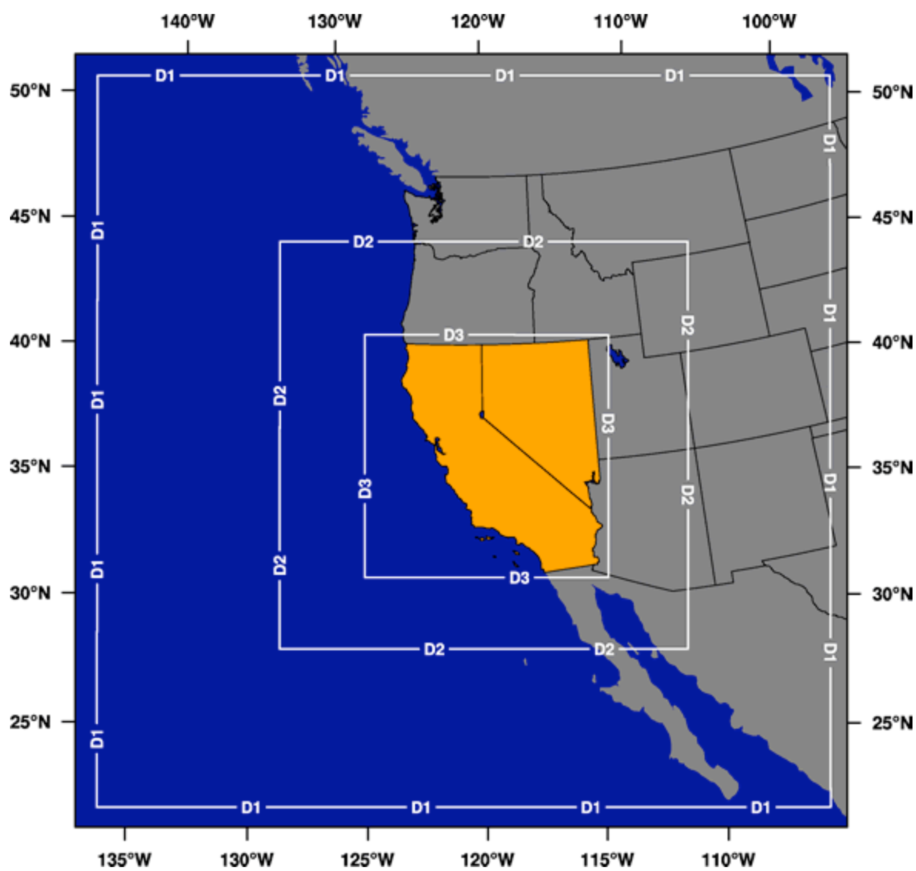


Figure 6. The three modeling domains for the CANSAC project (D1 – 36 km, D2 – 12 km, D3 – 4 km).

The simulation case was setup for the period 1 August 2003 at 00UTC through 4 August 2003 00UTC (D3 stops at 12 UTC on 3 August 2003). This is a 72-hour forecast for D1 and D2, and a 36-hour forecast for D3. Vertically, 36 full sigma levels were used for all domains, starting with the 0.997 sigma level (the first level above the surface). The time step for the D1 grid was 108 seconds, 36 seconds for D2, and 12 seconds for D3. The physics options used were Simple Ice for moisture, Grell for convection, MRF for boundary layer, and Cloud for radiation parameterizations (see CANSAC web site for full references). Combining the total horizontal number of grid points with the number of levels yielded 3,715,056 total grid points for which a calculation was performed. Multiplying this number by the total number of time steps yielded 39,881,580,800 (nearly 40 billion) total calculations required at each grid point for each weather element (e.g., temperature, relative humidity, wind speed) in order to complete a full forecast run.

The test case was run on three independent hardware platforms including SGI® Altix®, SGI® Origin®, and PC Xeon® clusters with three different clock speeds and two different connectivity types. The number of processors varied depending on the machine type. On the SGI® Altix® machine the case was completed in 2.4 hours, and 2.5 hours on one of the clusters. These similar timing results required a decision of whether or not to purchase a PC cluster or the SGI® Altix® system. After considerable deliberation of information and facts, it was determined that the purchase of the SGI® Altix® system would be best suited for CANSAC needs. The system was purchased and ordered in February 2004, and installed and successfully tested in March 2004.

3. Develop annual operating plan

A formal annual operating plan (AOP) was not developed for the first year. Instead, OAG prepared a set of memos in conjunction with BOD that established and prioritized product development during the first year of CANSAC. After funds were collected near the end of FY04 for FY05 operations, it was recognized that it would be useful to have a formal AOP be a component of the annual Task Order. It is anticipated that an AOP will be included in the FY06 budget and Task Order.

4. Establish first year products and requirements

OAG provided the initial list of products and requirements to CEFA in February 2004. The initial list identified upper-level elements such as height and winds, Haines index and ventilation index for 36 and 12 km as being the priority starting products. Throughout the course of the year, additional product requests were sent to CEFA (e.g., model soundings), and some requests were made to modify existing products (e.g., color schemes, content). The operating plan has been that OAG coordinates desired products and sends CEFA a list. CEFA then replies to OAG with comment on the feasibility of the request and an anticipated time frame for completion.

5. Build and test cluster

This task element was in place given the assumption that a PC cluster would be chosen as the final hardware solution. Once the hardware testing was completed and it was realized that the SGI® Altix® system was the preferred hardware platform, building a cluster was not needed. The SGI® Altix® system was pre-built and installed by SGI® engineers.

6. Implement and test MM5 model

Once the computing hardware was installed, the next project phase was to install and test MM5 software on the system. This was begun in March 2004 and completed in April 2004. In line with the original testing, it was determined that the model run could be completed in approximately 2.4 hours real-time. Further system optimization later in the year improved this time to approximately 2.0 hours. Post-processing (production of maps and graphics) requires considerable additional time on the order of approximately 3.5 hours. Future work will assess whether or not this length of time can be reduced, however, it is largely dependent on the amount of products produced and graphics quality, and at what stage in the run-time they are produced.

7. Real-time verification system

It is highly desirable to develop a real-time verification system and make this quantitative information available to the CANSAC user community via a web interface. Initially, verification would comprise comparing MM5 forecasts to RAWS point data and upper-level forecasts to sounding observations. Development of this system was not begun during this reporting period, but is anticipated to begin development in FY05. Coordination of the verification system with TAG and OAG will be required.

8. Production of operational forecasts

The official CANSAC dedication meeting was held at DRI on 19 May 2004. Real-time product generation was considered to begin officially on 1 June 2004, and is now an ongoing process. Not surprisingly, there were some initial glitches, but the system and products have become acceptably stable. Though CEFA is not operating the system in a 24/7 mode, personnel are attempting to maintain the system so that as little as possible downtime will be experienced. The product web page is http://www.cefa.dri.edu/COFF/cansac_output.htm.

9. Assessment of 2004 products

From the very beginning of real-time production, OAG has been providing feedback on the usability of the products. This feedback has been in the form of email memos to CEFA and conversations with CEFA personnel. It would be desirable to establish a formal process of product assessment and documentation of this information. However, from a qualitative perspective OAG is pleased with the products.

CEFA Operations and Forecast Facility

The CEFA Operations and Forecast Facility (COFF) is simply the hardware and software systems and components infrastructure required to produce the CANSAC products. A description of the hardware and software components is provided below.

The Penn State/NCAR Mesoscale Model 5 (MM5) model employs the Lambert Conformal map projection centered at 38°N, 121°W and consists of three nested grids. The outermost grid (36 km horizontal resolution, 97x97x32 grid cells or 301,088 points) covers the western U.S., parts of Mexico/Canada, and the eastern Pacific. The nested grid (12 km horizontal resolution, 154x154x32 grid cells or 758,912 points) encompasses California, Nevada, Oregon, Utah, and parts of Idaho, Arizona, Wyoming, and Montana. The innermost grid (4 km horizontal resolution, 274x274x32 grid cells or 2,402,432 points) encapsulates the entire California and Nevada boundaries. Twice daily forecasts are initialized using the National Centers for Environmental Prediction ETA model 00/12 UTC forecast outputs (Grid 212 - 40 km resolution) at 7 AM/PM PST. First guest observational fields are obtained from LDM Unidata Conduit Data Stream. Currently, the real-time system generates 72-hr forecasts for the outermost and nested grids and 48-hr forecast for the innermost grid. The model outputs are saved in 3-hourly intervals. The CANSAC real-time system utilizes the MM5 model version 3.3.6 in a non-hydrostatic mode with two-way nesting. The vertical layers consist of 32 full sigma levels for each grid (Figure 7). See the CANSAC web site for a more complete description of the model physics options used in the current configuration.

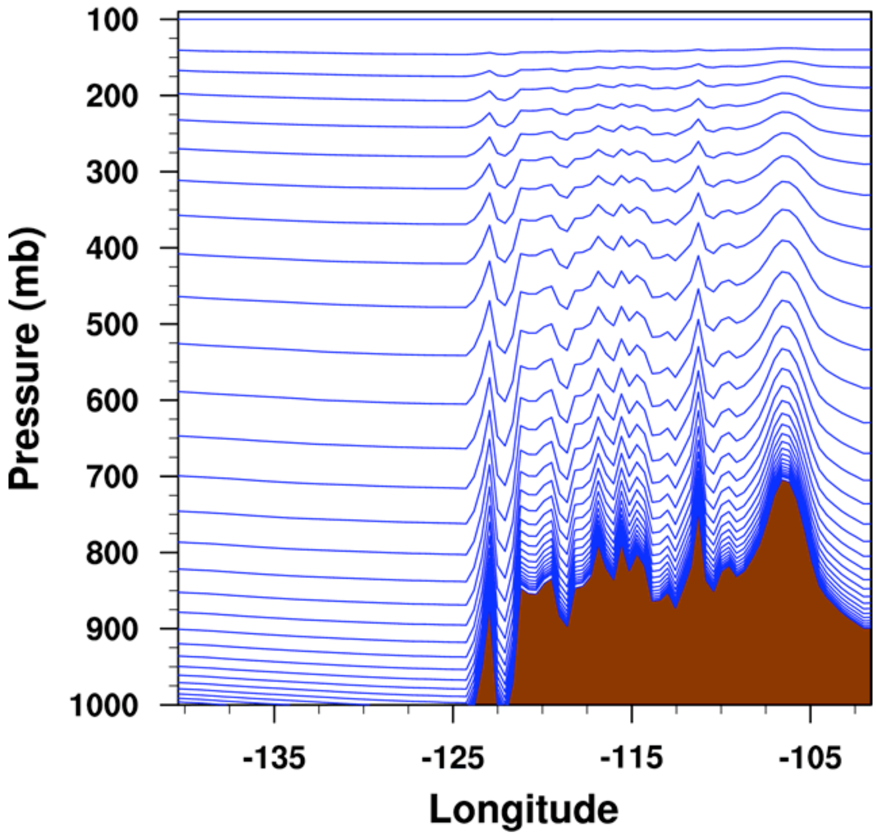


Figure 7. MM5 cross-section showing the vertical profile of the model for Domain 1 (36 km horizontal resolution). The blue lines represent the vertical layers (or sigma levels) of the horizontal model grids. The model terrain is represented by the brown silhouette, shown as the maximum elevation value for any model grid point in the domain.

The CANSAC real-time system uses the RIP version4.0 (Read/Interpolate/Plot) visualization program with NCAR Graphics for the all post-processing products. The code is being continuously improved to meet the needs of CANSAC users. Currently the set of visual products includes plots of ventilation index, Haines index (high and mid levels), lifted index, cloud water, planetary boundary layer height, precipitation, absolute vorticity and sounding plots/text files along with other standard parameters used in weather forecasting and atmospheric assessment applications. The post-processing graphical conversion is completed in two steps with different speed and quality. After the faster first conversion (takes about half an hour), the visual products are immediately posted on the web and exchanged with the higher density products once the second and slower step is finished. This provides more timely access to the users.

The CANSAC real-time forecast system is operated on an SGI® Altix® 3700 Linux machine with 32 processors (Itanium®2 1.3 GHz) and 80 GB RAM. Currently the real-time system runs and post-processing computations are all done on the same computational environment with Intel® version7.1/8.1 compilers. The capacity of the system is composed of a 1.7 TB SGI® InfiniteStorage TP9100 Fibre Channel RAID (146 GB 10K SCSI disks) and three other 36 GB hard disks. Benchmark results of the MM5 model run on this system can be found on the CANSAC web site.

Project Deliverables

The project deliverables include a suite of fire weather forecast products chosen by OAG. As the project progresses, products will fall into four categories of 1) fire weather; 2) fire danger; 3) fire behavior; and 4) smoke dispersion and transport.

FY05 Work Plan

The major elements of the CANSAC project work plan in FY05 include continuation of real-time products and product development per OAG recommendations, begin development of the real-time verification system, capitalize on relevant research opportunities as they become available, add NFDRS forecasts, and add the Bluesky component.

Task Order 11: Development of Model Output Statistic Products for California Predictive Services (Sponsor: Rocky Mountain/California Predictive Services)

Task Order 11 began 1 September 2003 and ended 30 September 2004. Both northern and southern California Predictive Services groups (CAPS) and the Rocky Mountain Predictive Services group (RMPS) produce meteorological forecasts and information in support of fire management activities. Reliable meteorological information and products are critical for many fire management needs involving decision-making and strategic planning. Associated with evolving information requirements is the need to produce new and improved meteorological products that support these demands. To meet these needs, CAPS and RMPS have developed some product priorities to aid in the 2004 fire season and beyond. The overall goal of the project is to extract and add value to relevant information from the National Weather Service numerical models for use by fire weather meteorologists and fire management. Primary objectives included: 1) developing computing software that will extract relevant meteorological elements from numerical weather models; 2) performing a regression analysis and developing model output statistic (MOS) type equations that relates model output to a specific set of Remote Automatic Weather Stations (RAWS); and 3) developing and providing value-added products and information from the MOS equations. This project was a collaborative effort with CAPS and RMPS. Specific task elements from the original Statement of Work (SOW) included:

1) Development of weather model grid point output.
2) Development of MOS type equations based on weather model output in relation to specific RAWS. The MOS type output based on regression equations for the specified RAWS within California will include:
    - 3-hourly forecasts of temperature, relative humidity, dewpoint, wind speed and wind direction from initialization to 48 hours.
    - 6-hourly Max/Min Temperature and Max/Min RH from initialization to 48 hours.
    - 3-10 day forecasts of 00 and 12 UTC temperature, relative humidity, dewpoint, wind speed and wind direction.
    - 1-10 day forecasts of BI, IC, SC, ERC, 100-hour and 1000-hour fuel moisture.
3) Development of RAWS climatologies.
4) Development of value-added products from the MOS type output. Specific text and graphical outputs will include:

- Forecast climatological anomalies (departures from average) for each forecast period for temperature, relative humidity, dewpoint, and wind speed.
- Forecast climatological percentiles (90^{th} or 97^{th} percentile) for each forecast period for temperature, relative humidity, dewpoint, and wind speed.
- Graphical displays in meteogram type format.
- 10-day forecast of Haines Indices (high level) for each RAWS grid point.

5) Prepare report.

1. Development of weather model grid point output.

The MOS equations were developed using historical weather model output from the National Centers for Environmental Prediction (NCEP) Global Forecast System (GFS) model. Three years (2001-2003) of twice daily (00 and 12 UTC) model runs were retrieved from a data archive at COMET/UCAR. The size of the dataset and personnel availability at COMET delayed the retrieval process longer than originally assumed. Nonetheless, the support of COMET personnel in providing these data is greatly appreciated. The first two years became available in April 2004, and the last year in May 2004. The full dataset included surface and upper-air initialization for all standard levels (e.g., 700, 500 mb), as well as all of the forecasts (these were not used in the analysis). The primary predictor elements of interest for MOS development were temperature, humidity and wind, though several other elements such as height were initially examined.

Obviously in order to produce MOS forecasts in real-time, it is necessary to acquire the real-time model output from NCEP. In April 2004, the Western Regional Climate Center established a Conduit LDM Unidata feed for the flow of model output from NCEP. This provides for a network high-speed and stable flow of model data. These data are now being archived at CEFA for current and future use.

Predictive Services asked as part of this project if they could be provided with text output from the GFS model. In early 2004, a standard set of output fields and data format was determined that includes 31 surface and upper-air elements such as temperature, wind and moisture. Each interested GACC then provided CEFA with model grid point locations they desired to receive. For each 00 and 12 UTC model run, the initialization and 12-hourly forecasts out to 240 hours are provided on the CEFA web site in text format. Figure 8 provides an example of the text output. Each GACC receives these data via an automated electronic retrieval process to the DRI FTP site. An archive of these data back to 2001 is also maintained on the CEFA web site. By September 2004, eight of the GACCs were accessing the real-time text data. It is anticipated that in 2005 all GACCs will be accessing these data.

2. Development of MOS equations

MOS equations were developed for several elements requested by Predictive Services – maximum/minimum temperature, maximum/minimum relative humidity, maximum/minimum dew point, wind speed, wind direction, 100-hour and 1000-hour time-lag fuel moisture, the fire danger indices of ERC, BI, SC, and IC (based on fuel model G), and the Haines index for three levels (low, medium and high). The model times of 00 and 12 UTC were used for proxy maximum and minimum times, respectively. All of the other elements are for the 00 and 12 UTC times. Dew point values are based upon an algorithm calculation from forecasts of temperature and relative humidity.

*Location 1	-135.0	25.0	20040730	00					
Fcst Hr	0	12	24	36	48	60	72	96	120
1000_Temp(F)	70.7	70.7	71.6	71.1	71.4	70.0	70.9	70.2	70.0
850_Temp(F)	60.4	61.5	62.4	60.6	59.5	58.1	57.4	56.7	57.9
700_Temp(F)	50.4	50.4	49.6	49.6	50.2	49.8	49.3	48.4	48.2
500_Temp(F)	25.9	25.7	24.4	23.2	23.5	21.7	22.3	21.7	20.3
1000_Rhum(%)	76.0	78.0	78.0	79.0	76.0	78.0	74.0	76.0	74.0
850_Rhum(%)	53.0	63.0	70.0	65.0	54.0	52.0	55.0	75.0	58.0
700_Rhum(%)	41.0	49.0	50.0	43.0	35.0	28.0	26.0	23.0	33.0
500_Rhum(%)	2.0	1.0	4.0	7.0	7.0	10.0	10.0	9.0	10.0
Mean_SLP(mb)	1016.3	1015.6	1016.2	1016.1	1016.3	1016.6	1017.4	1019.7	1019.9
1000_Hgt(m)	142.6	136.9	142.2	140.7	143.2	145.6	152.2	171.7	173.8
850_Hgt(m)	1528.9	1525.3	1533.8	1529.2	1528.6	1527.6	1534.6	1554.0	1556.7
500_Hgt(m)	5883.9	5879.3	5888.4	5873.5	5880.5	5871.2	5879.1	5893.7	5891.2
1000_Uwnd(knt)	-12.4	-13.2	-16.3	-12.0	-14.2	-13.8	-15.9	-16.5	-15.5
850_Uwnd(knt)	-14.2	-11.6	-9.3	-2.5	-10.7	-10.1	-10.3	-6.0	-8.3
700_Uwnd(knt)	-12.6	-11.4	-9.1	-10.9	-7.4	-5.8	-2.9	-2.9	-1.4
500_Uwnd(knt)	-5.0	-9.3	-9.9	-10.5	-9.5	-5.2	-4.3	-5.4	-0.4
1000_Vwnd(knt)	-9.5	-7.2	-7.6	-7.2	-7.0	-8.1	-5.8	-6.4	-4.9
850_Vwnd(knt)	-8.7	1.2	-1.9	-2.5	-7.8	-3.3	-4.5	1.4	-1.7
700_Vwnd(knt)	-5.4	4.3	-3.1	-1.9	-4.1	-1.4	0.2	1.0	2.9
500_Vwnd(knt)	-2.1	-13.2	-5.4	-11.6	-7.6	-9.1	-5.4	-1.0	4.3
Sfc_Cape(J/kg)	4.0	4.0	3.0	5.0	19.0	22.0	22.0	17.0	5.0
Pcp_Water(in)	1.2	1.3	1.4	1.3	1.2	1.1	1.0	1.1	1.1
Lift_Indx(K)	8.2	7.8	6.5	6.0	6.3	6.1	6.6	6.4	6.1
1000_WSpd(knt)	15.6	15.0	18.0	14.0	15.8	16.0	16.9	17.7	16.3
850_WSpd(knt)	16.6	11.7	9.5	3.6	13.2	10.6	11.2	6.2	8.5
700_WSpd(knt)	13.7	12.2	9.6	11.0	8.4	6.0	2.9	3.1	3.2
500_WSpd(knt)	5.5	16.1	11.3	15.7	12.1	10.5	6.9	5.5	4.3
1000_WDir	52.5	61.4	65.1	59.2	63.7	59.4	69.9	68.8	72.6
850_WDir	58.3	95.7	78.2	45.0	54.0	71.9	66.5	102.7	78.2
700_WDir	66.7	110.5	71.2	79.9	61.1	76.9	93.8	108.4	155.0
500_WDir	67.1	35.2	61.2	42.0	51.5	29.8	38.1	79.9	174.8

Figure 8. Example output GFS output information made available to each GACC. The first line provides a predetermined grid point location, latitude/longitude location and model run date/time. The second line provides the forecast hour. The first column provides abbreviated forecast elements. The remaining matrix columns contain the forecast values, respectively.

The statistical software package S-Plus® was used in developing the regression equations to produce the MOS forecasts. Initially, all GFS elements were considered potential predictors. However, after considerable testing, it was determined that only a smaller subset of elements was really needed to generate satisfactory equations. The final methodology adopted was largely that developed by Terry Marsha at the Pacific Northwest Predictive Services. Mr. Marsha was consulted on several occasions regarding results of this project, and his time and support are greatly appreciated. The final set of model elements for the four nearest surrounding model grid points to the station to be considered yielded a potential total of 324 predictor variables. Analysis was done for 212 RAWS as chosen by Predictive Services. After some testing, it was determined that two seasonal equations could satisfactorily represent the summer and winter seasons. An example of a typical regression equation is shown below. Given are the variable names used in the statistical software, and regression equation coefficients as determined from the equation development and diagnostics.

ERC = 0.4277*(pERC) -0.222* (pFuel1000) + 0.0588*(pMin.RH) - 0.0966(PR.Gr.1) + 0.2463*(850.temp4) - 0.3664*(850.RH.3) + 0.0137*(850.temp2) - 0.0424*(850.temp1) - 0.1113*(700.temp4) - 0.238*(850.RH.2) + 0.2153*(850.RH.1)

Lower atmospheric level elements of temperature and relative humidity serve as useful predictors of station temperature, relative humidity, ERC and fuel moisture. Lower-level wind serves as a useful predictor for wind speed and direction. For most cases, surface elements from the GFS model do not work well as predictors. This is primarily due to the fact the 1-degree gridded model field does not correlate well with individual RAWS given their variety of elevation, slope and aspect locations. Lower-level atmospheric fields (e.g. 925, 850 and 700 mb) serve as better predictors in part because they are smoother fields representing a generally free-air atmosphere compared to a high friction surface. It was determined in the analysis that the persistence for each predictand was also a very important predictor; that is for example yesterday's value often has significant weight in predicting today's value. In order to produce operational forecasts, it then became necessary to acquire the previous days values from WIMS. While these values could be obtained daily from WFAS, the problem emerged that not all of these stations are based on fuel model G, the preferred fuel model. Larry Bradshaw at the Missoula Fire Sciences Laboratory prepared a computer script that provided daily station output based on fuel model G. His effort in this project is greatly appreciated. This dataset along with the weather model output provides the input for the production of twice daily forecasts. Figure 9 provides an example of forecast output. The format of this table, as well as the other product tables and graphs, were determined by Predictive Services.

*Acton C	45438	-118.2	34.4	20040827	00					
Fcst Dy	08/27	08/28	08/29	08/30	08/31	09/01	09/02	09/03	09/04	09/05
Max RH (%)	61	59	52	45	46	48	73	76	72	87
Min Temp (F)	52	56	57	58	57	60	54	45	56	74
AM Dew Pt (F)	39	42	39	37	36	41	46	38	47	70
Min RH (%)	13	5	2	1	2	9	8	10	39	61
Max Temp (F)	91	94	95	95	94	91	82	86	87	83
PM Dew Pt (F)	34	14	-11	-20	-3	25	17	24	59	68
WDir	281	265	261	267	271	276	257	276	268	42
WSpd (knt)	8	8	9	10	9	9	10	4	3	4
BI	170	167	178	173	151	150	113	129	79	47
ERC	88	104	114	119	114	100	97	94	49	2
IC	90	100	100	100	100	97	97	97	54	8
SC	59	60	68	65	53	55	36	54	41	21
100-hr fuel (%)	11	10	8	8	7	8	8	8	10	13
1000-hr fuel (%)	8	8	8	8	8	8	9	9	9	9
Haines (high)	4	5	4	5	5	3	3	4	2	2
Haines (medium)	6	6	6	6	6	6	5	5	4	3
Haines (low)	5	5	5	5	5	5	5	5	4	3

Figure 9. Example forecast output from MOS equation. The first line provides the RAWS name and location information, and the model run date and time. The second line provides the forecasted date. The first column provides the abbreviated forecast element. The remaining matrix columns contain the forecast values, respectively.

The MOS equations were developed on 2001 and 2002 data and cross-validated using 2003 observations. The cross-validation procedure provides correlations to determine how well the regression equation predicts a given element. A correlation of 1.0 is a perfect prediction, but is rarely achievable in this type of real-world application. Generally, correlations greater than .90 were achievable for temperature and ERC, but tended to be lower for relative humidity. Other than ERC, maximum temperature and minimum relative humidity tended to yield the highest correlations and hence the best predictability. Systematic equation assessment was only done for temperature, humidity, fuel moisture and ERC. Correlations were acceptable for most stations, but there are a few that remain problematic. Examples of cross-validation correlation maps are shown in Figure 10a (Northern California maximum temperature) and Figure 10b (Rockies area ERC-G). Output is being produced for other elements (i.e., BI, SC, IC and Haines), but these values contain a higher-degree of uncertainty since they have not been statistically examined to the extent of the other elements.

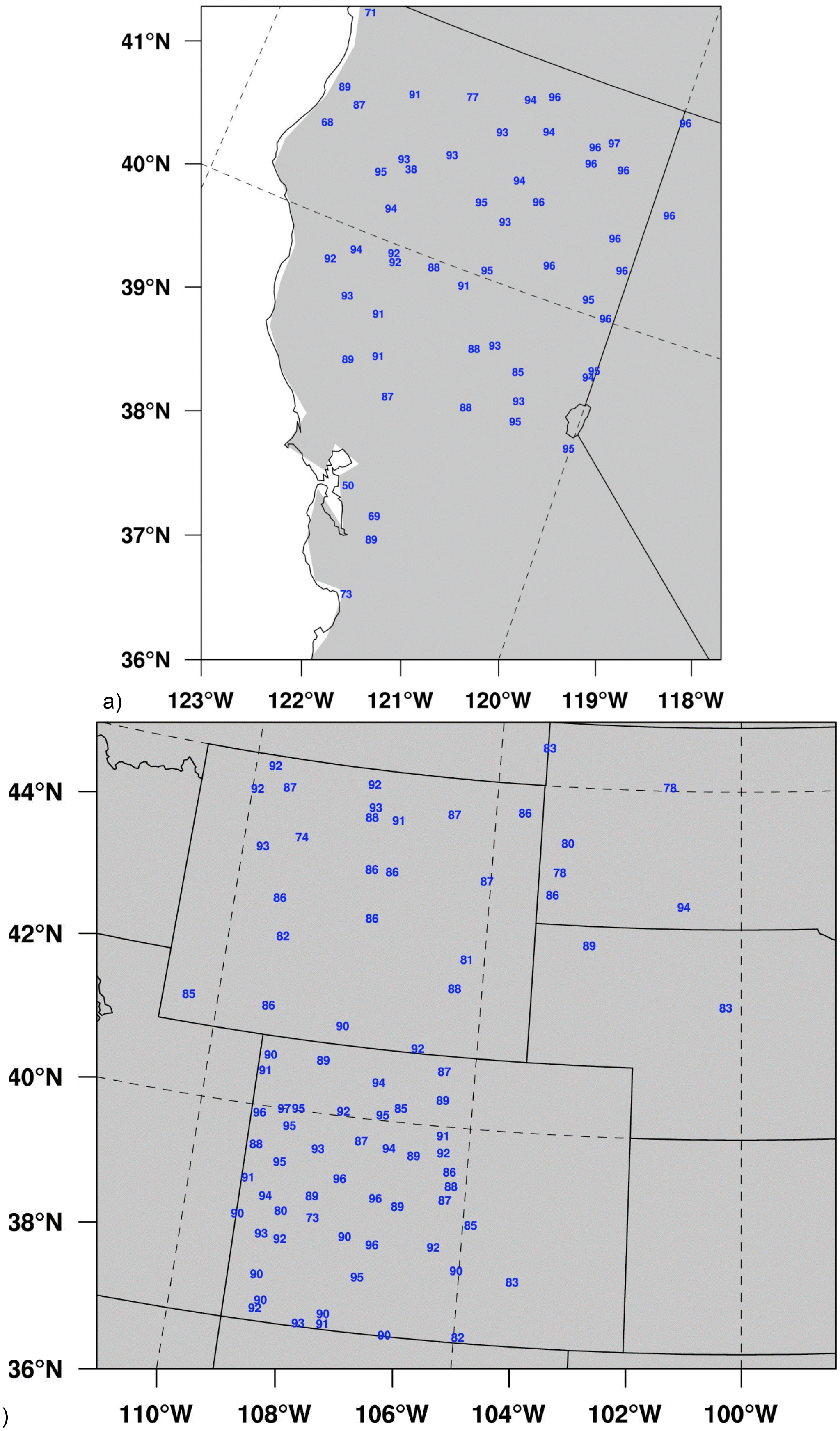


Figure 10. Cross-validation correlations (times 100) for a) northern California RAWS maximum temperature and b) Rockies ERC-G. May-October 2003 data were used for both maps.

While successful development of the equations was accomplished, the delay in waiting for the historical model data and unforeseen difficulties in generating and evaluating the regression equations delayed the production of operational products until July 2004. This was unfortunately later than originally desired from the user perspective, and the extra work needed to generate the most desired product used up the allocated financial resources for the project. Given this, one or more sub-task elements had to be cut from the project. The SOW described in the second task element the development of 3-hourly forecasts for several weather elements, and 6-hourly maximum and minimum temperature and relative humidity forecasts. There was some original thought that these might be derived from the NCEP Eta model. However, given the unanticipated complexity of the analysis and an expectation of cost overruns, it was decided that these sub-task elements could not be pursued as stated. Also described as sub-task elements were the production of 3-10 day forecasts of 00 and 12 UTC weather elements and 1-10 day forecasts of fire danger indices and fuel moisture. As a final product, these two sub-elements were combined into a single sub-element, and the final product was 1-10 day forecasts of 00 and 12 UTC weather, fire danger and fuel moisture from the GFS model.

It should also be pointed out that substantial assessment analysis was only carried out for temperature, relative humidity, fuel moistures and ERC. While it would be desirable to evaluate the other elements in more detail, this could not be done without incurring cost overruns. Predictive Services concluded that these other elements were less critical at this time. These remaining elements may be assessed in more detail in a future study.

3. Development of RAWS climatologies

This task element was a prerequisite for task element 4. For each of the RAWS chosen by Predictive Services, daily climatologies of temperature, relative humidity, dew point and wind speed were generated. Hourly RAWS data was acquired from the WRCC archive and processed to determine daily mean values for each weather element. This information is subsequently used in producing forecasts of anomalies (departures from average) for each weather element. A database was also generated of historical daily values that are used to produce forecast percentile values as one of the value-added products.

4. Development of value-added products

Four value-added products were included in the project based upon forecasted values from the GFS model. Forecast climatological anomalies and percentile matrices are produced for each RAWS based upon the climatology produced in task element 3. Figure 11a shows an example output matrix of anomaly forecasts, and Figure 11b shows a similar matrix except for percentiles. The tables correspond to the forecast of actual values shown in Figure 8. The value of these tables is that they provides the decision-maker with an indication of how far the forecasted value is from its climatological normal, or where it is ranked given a climatological history.

A fourth sub-task element in the SOW is the development of graphical displays in meteogram format. This work was not completed by the end of the reporting period, however it is planned for implementation during FY05.

5. Prepare report

Though the project officially ended September 2004, two elements need to be completed prior to finalizing a report. The first is the meteogram product noted above. The second is some further evaluation that was being done for the Rockies region near the end of the project.

Once these two efforts are deemed satisfactory, the project final report will be prepared. This is currently anticipated for Spring 2005.

a)

*Bailey	52001	-105.5	39.4	20040827	00					
Fcst Dy	08/27	08/28	08/29	08/30	08/31	09/01	09/02	09/03	09/04	09/05
Max RH (%)	13	4	3	-12	-11	-8	-27	-28	4	-2
Min Temp (F)	-8	-13	-8	-6	-1	-2	1	2	-1	2
AM Dew Pt (F)	-4	-10	-6	-9	-4	-4	-9	-8	1	3
Min RH (%)	21	4	-5	2	2	-10	-16	-3	8	8
Max Temp (F)	-20	-11	-4	-3	-2	2	5	-2	0	0
PM Dew Pt (F)	-1	-3	-4	3	4	-5	-11	-1	11	11
WSpd (knt)	-2	-2	-2	-1	-1	-2	-1	-4	-3	-2

b)

*Bailey	52001	-105.5	39.4	20040827	00					
Fcst Dy	08/27	08/28	08/29	08/30	08/31	09/01	09/02	09/03	09/04	09/05
Max RH (%)	70	59	58	42	43	47	24	22	58	52
Min Temp (F)	33	21	29	35	53	45	56	59	49	56
AM Dew Pt (F)	60	39	49	39	55	52	35	35	63	67
Min RH (%)	92	80	64	78	78	49	29	69	85	85
Max Temp (F)	11	22	38	41	44	54	71	41	47	44
PM Dew Pt (F)	70	64	59	75	78	57	38	64	92	92
WSpd (knt)	22	22	22	37	37	22	37	4	11	22

Figure 11. Example forecast output from a) MOS equation for climatological anomalies and b) climatological percentiles. First line provides the RAWS name and location information, and the model run date and time. The second line provides the forecasted date. The first column provides the abbreviated forecast element. The remaining matrix columns contain the forecast values, respectively.

<u>Deliverables</u>

The key deliverables from this project are:

- 10-day operational forecast tables of RAWS weather and fire danger elements
- 10-day operational forecast tables of RAWS climatological anomalies
- 10-day operational forecast tables of RAWS climatological percentiles
- 10-day forecasts of Haines indices
- Meteogram displays of forecast elements (planned for 2005)

The forecast tables of actual values are sent electronically to California and Rockies Predictive Services. In California, this information is then used in the generation of the large fire potential product (see http://www.fs.fed.us/r5/fire/south/fwx/Fire_Potential.html).

Task Order 12: Long-lead forecasting workshop (Sponsor: NICC Predictive Services)

Task Order 12 was delayed for another year in order for Predictive Services to determine when and where the workshop should be held. As of the end of this reporting period, the workshop is scheduled for March 2005 in conjunction with National Seasonal Assessment Workshop: Western States and Alaska in Boulder, Colorado.

The primary purpose of the workshop is to provide the Predictive Services meteorologists (and others with interests in climate) some background and training on climate system components relevant to fire weather and fire management. Proposed topics include drought, El Niño, climate forecasting and climate indices. The training workshop will likely require 1-1.5 days preceding the assessment and outlook workshop. Approximately 25 attendees are expected.

Task Order 13: Understanding Drought for BLM Business (Sponsor: BLM)

Task Order 13, anticipated to be a multi-year project, began 1 September 2003 with the hiring of Master's graduate student Ryan Kangas. The specific task elements for the first year project phase are provided below, but the ultimate goals of the project are to 1) provide an understanding of drought as an impact on fire and fuels management, and 2) assess the predictability of drought from seasonal to multi-year scales for strategic planning and budgeting. To achieve these goals, the project will require a multi-year effort, and the first year work reflects the beginning tasks needed to achieve the desired scientific understanding and develop relevant decision-support tools.

Specific task elements for the first year of the project included:

1) Review existing scientific literature. Numerous scientific studies have been done over the years that discuss drought and its impacts. Some of these may be specific to an agency or project, while others could be linked to agency business. Under this task, an extensive literature review on drought will be undertaken. Specifically utilizing library and electronic resources, all scientific studies on drought that may have potential benefit to BLM and other land management agencies will be sought and collected.
2) Synthesize literature review. Once the reports and papers are collected, they will be synthesized into a comprehensive report describing various aspects of what is, and what is not known, about drought in the context of BLM planning and policy. Agency current and future potential needs will be considered in the synthesis process. This task is effectively a literature analysis.
3) Prepare report. A report describing the literature review and synthesis will be prepared upon completion of the project. It is also intended that this will be a portion of a Master's thesis from this project.
4) Examine and assess drought prediction tools. This task will address a BLM agency request to examine and assess current drought prediction tools that the agency may utilize for planning purposes. These tools may include specific model forecasts, or concepts realized from the literature review process that could lead to providing prediction information.

1. Review existing scientific literature

This task element is somewhat broad and ongoing as new papers are published. The latter point is particularly noteworthy as there has been an increase in drought interest and awareness during the past few years. To date, CEFA has cataloged nearly 400 scientific drought papers of potential relevance to BLM business. Titles and descriptions of papers have been entered into an electronic database for cataloging and searching. Not all potential library databases have been examined to date, but it is planned to conduct further searches in FY05.

2. Synthesize literature review

The 1997 American Meteorological Society policy statement on meteorological drought identifies and defines four types of drought – meteorological or climatological, agricultural, hydrological and socioeconomic. Meteorological drought refers to the absence or reduction of precipitation. An anomalous dry period (can be short- or long-term depending upon impact) leads to the other drought types. Agricultural drought is a severe reduction in crop yield. Hydrological drought is a reduction in surface or subsurface water supply, streamflow, groundwater, reservoir, or lake level. Socioeconomic drought is the impact on the supply and demand of some economic good.

Each of these types can be translated to agency fire and fuels management. The starting point of drought will still be meteorologically based due to the absence or reduction of precipitation. The agricultural equivalent to fire and fuels would be vegetation stress and fuel dryness, however, tree harvesting could be considered a direct agricultural component. The hydrological equivalent would be a severe reduction in soil moisture. The socioeconomic impact could be a direct component (e.g., higher suppression costs during drought), but can also be thought of as the impact on the way agencies are having to implement fire and fuels management business, strategic planning and policy development. Implementation, planning and policy are key reasons highlighting the importance of determining a drought impact index for fire and fuels management.

The most significant result of the review so far is the emergence of a new scientific awareness of the role of the oceans (sea surface temperatures (SST)) in relation to drought. Empirical and modeling studies are suggesting that both Pacific and Atlantic SST anomaly patterns may drive large-scale hemispheric quasi-stationary circulation modes that subsequently enforce a dry pattern over large regions. Drying soil moisture and vegetation provides a positive feedback to this process, further enhancing the drought. Simple ocean indices, such as the Pacific Decadal Oscillation or the Atlantic Multi-Decadal Oscillation may be indicators of the SST forcing, but do not directly describe or indicate the physical mechanism that creates an atmospheric drought pattern. However, not only does this research begin to shed light on potential mechanisms of drought, but offers potential on drought forecasting since there is some predictability of SSTs, especially for seasonal scales. This research was summarized in 2004 by the CEFA Director for the agency cost-containment and quadrennial review panels. It appears in brief in the August 2004 independent panel report *Large Fire Suppression Costs – Strategies for Cost Management* for the Wildland Fire Leadership Council.

3. Prepare report

The purpose of this task element is to write a report containing a synthesis of the scientific literature in the context of how current understanding of drought may be utilized in agency planning and policy. This synthesis is also beneficial in outlining potential agency studies related to drought given what is already known or not known. This report, originally scheduled for completion in June 2004, has been delayed until 2005 in part so that more searching can be done with key words related to drought, such as soil moisture, vegetation moisture and fuel moisture. Within the current database, only approximately 10% of the papers are directly related to vegetation. The outline of the report contains three general sections 1) physical drought from an atmospheric perspective; 2) physical drought from an ecosystem/vegetation perspective; and 3) drought as an agency impact. Parts of the synthesis will also be reported in the Master's thesis manuscript.

4. Assess drought prediction tools

While there are numerous indices and information sources available for monitoring drought, predicting drought is a much more difficult problem. For example, the National Drought Mitigation Center discusses concepts and strategies for early warning systems for drought preparedness and management. The time scales of drought (rapid onset versus slow evolution) and varying spatial scales pose accurate prediction problems given the current quantitative low-skill state of climate forecasting. Persistence is generally a good forecast of drought once it has begun, but there remains the challenge of predicting when it will end (as well as when it will begin). For some fuel types (e.g., brush and grass), drought can occur as a rapid onset, while for timber fuels, the impact may be a more slowly evolving process.

Numerical climate prediction models provides a physics based approach to prediction, but are limited in part due to the inherent chaotic state of the atmosphere. Another simple approach might be the use of analogs, that is, other years or periods that appear to have all of the characteristics of the current event. However, this is rarely successful because while the patterns may look similar, they are not necessarily identical nor is the outcome guaranteed to be similar. For example, a twenty-five hundred year history of reconstructed precipitation from tree rings in Arizona shows a medieval drought period from around 1050 to 1300 years before present. Examining only a narrow window of years within this period does not yield the much larger time-scale drought.

While new research is making progress in linking climate system components to drought, effective prediction will require a good understanding of the mechanisms that cause drought and these mechanisms must have an acceptable level of predictability. There are currently no universally adopted drought prediction models in use, in part because this is a relatively new area of climate science research. Climate studies will continue to focus on this problem, and it is likely that prediction models will evolve in the near future, based on both physics and statistics. CEFA is planning to participate in a drought prediction workshop scheduled for May 2005.

Deliverables

The primary deliverables as of this reporting period include 1) the establishment of a literature database of scientific drought papers of potential relevance to fire and fuels management; and 2) the development of a historical high-spatial resolution database of drought index data for the U.S. Both of these products will be utilized and further expanded upon in the work undertaken during year two of the project.

Future work

While the title of the project specifically states understanding drought for BLM business, the drought problem, as with fire, is interagency. The National Interagency Fuels Coordination Group has strong interests in the problem from a fuels management perspective. To reflect this, the second year SOW indicated a more broad fuels management issue.

The next phase of the project will begin the work of defining drought as an impact on agency fire and fuels management, and building drought prediction and decision-support tools. A necessary first step is to quantify drought spatially and temporally in order to better understand historical patterns. Though not originally in the SOW, CEFA has begun this analysis during FY04 recognizing the priority of the work given newly identified agency needs. This will lead directly into the planned SOW work for FY05.

Drought from the instrumental record (approximately the past 100 years) typically has been assessed either by station precipitation data, or by integrating these data over climate divisions. A new dataset has recently been created by the Oregon State Climate Service Spatial Climate Analysis Service group utilizing parameter-elevation regressions on independent slopes model (PRISM). This dataset includes U.S. monthly precipitation at a 4 km spatial resolution for the period 1895-present. CEFA acquired this dataset and for each month computed the standardized precipitation index (SPI) for various integrated time scales (e.g., 1, 3, 12, 72 months). There are approximately 540,000 grid cells across the U.S. Multiplying this by 109 years times 12 months times 12 indices yields approximately eight billion data points being examined. The primary study is an analysis of the spatial and temporal distribution of drought given this model of historical drought occurrence. Figure 12 shows the PRISM SPI maps as of July 2002 for six different integrated time scales beginning with 1-month. Yellow and orange areas depict an SPI value ≤ -1.5. Note the drought areas in the West and Southeast. The southeastern drought is most evident at the longer-time scales (e.g., 12-48 months). This highlights the value of assessing the impact of various length droughts on different fuel types.

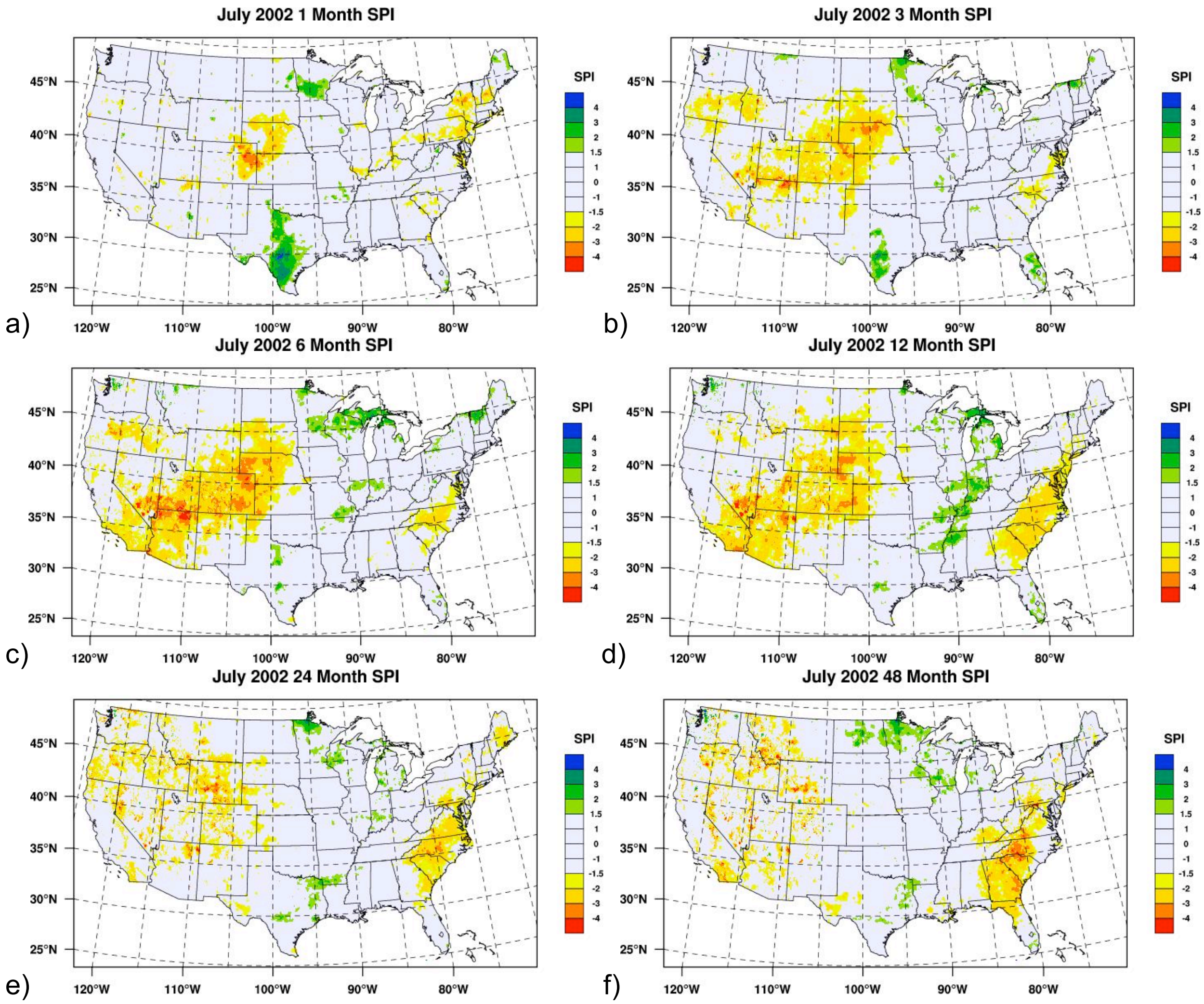


Figure 12. Example maps of SPI as of July 2002 from the PRISM gridded data. Integrated time scales include a) 1-month, b) 3-months, c) 6-months, d) 12-months, e) 24-months, and f) 48-months. Color bar indicates SPI value.

Specific task elements for the FY05 SOW include:

1. Determine spatial extent of drought. For SPI indices, a statistical method will be developed to determine the spatial extent of drought. Once a satisfactory method is developed, analysis will be undertaken to determine the spatial scales of drought for various SPI thresholds (e.g., -2.0 for the 12-month SPI).
2. Determine temporal extent of drought. Once spatial drought has been identified, how often these events occur will be analyzed. This will be done for several SPI time-scales.
3. Relate drought information to vegetation. A high spatial resolution national fuel map will be analyzed in relation to the spatial extent of drought determined in task element 2). This analysis will provide information on where and how often various vegetation types may have been impacted by drought. This is not meant to be a definitive study on the relation between drought and vegetation, but is intended to provide some fundamental

background on potential impacts that can be applied to future projects to assess drought for fuels management and budget planning.

Task Order 14: Role of Climate in Prescribed Fire (Sponsor: BLM)

Task Order 14 was scheduled to begin 1 September 2003 with the hiring of Master's graduate student Crystal Kolden. However, Ms. Kolden was not able to start on the project until January 2004 due to previous university commitments. During summer 2004, Ms. Kolden only worked on the project on a fractional part-time basis while working as a seasonal Forest Service firefighter.

The primary objective of this project is to perform and analyze a national survey of climate information utilization for prescribed fire. Federal and state agency personnel are being contacted for inquiry into their uses and needs of climate information for their prescribed fire activities. Summarization of this information will yield the key factors of climate information that are currently used or desired, as examined in regional agency contexts. The ultimate goal will be to have an improved understanding of the role of climate in prescribed fire, and to use this knowledge to help agencies establish effective burn policy and meet management objectives.

During the project's first year, specific task elements included:

1) Develop a climate information use survey. As a first step, it will be necessary to develop a survey that has the necessary and relevant questions to achieve the primary objective. The survey will be designed using scientific methodology, and will utilize other related findings and questionnaires where available and relevant.
2) Implement survey. Following completion of the survey development, the survey will be undertaken. A list of primary contacts will be developed, with the help of fire agency personnel. The survey will be conducted via phone interviews.
3) Survey analysis. Once the survey is completed, a formal quantitative analysis will be performed. This will identify key aspects of the information collected. The synthesis of the information will also include aspects of climate not being utilized effectively.
4) Prepare report. A report describing the completed tasks and deliverables will be prepared upon completion of the project. It is also intended to produce a Master's thesis from components of this project.

<u>1. Develop survey</u>

The survey was comprised of 33 questions that were approved by the University of Nevada Human Subjects Committee, and divided into seven sections. Parts 1 and 2 were used to acquire information to identify the agency and involvement in prescribed fire programs. If the response indicated wildland fire use only, no remaining information was requested. Part 3 asked a number of questions regarding the planning of prescribed burns; Part 4 focused on burn implementation; and part 5 addressed burn windows. Part 6 asked eight questions specifically related to climate and Part 7 referred to escaped burns. For space considerations in this report, only the climate questions are shown below as examples of the survey content:

1. Based on your experience, how far ahead can you usually tell how favorable the conditions are for your prescribed burning season?
   - ☐ Conditions are unpredictable at a seasonal level
   - ☐ Less than 2 weeks before the season begins
   - ☐ Usually within one or two months before the season begins
   - ☐ Usually within three to six months before the season begins

- Longer than 6 months before the season begins
- Don’t know/ Not applicable

2. Based on your experience, which of the following weather components is the hardest to predict/most variable for trying to come into/stay in prescription at your location? (check all that apply)
   - Relative humidity
   - When precipitation will occur
   - How much precipitation will fall
   - Wind speed
   - Wind direction
   - Temperature
   - 1-hr or 10-hr fuel moisture
   - Mixing height/transport wind/ventilation
   - Other ____
   - Don’t know/ Not applicable

3. Based on your experience, which of the following climate patterns have the greatest impact on prescribed burning in your location? (check all that apply)
   - High pressure ridges
   - Drought
   - Temperature departures from average
   - Precipitation departures from average
   - Variability of burn windows
   - El Niño Southern Oscillation (ENSO) or La Niña
   - Pacific Decadal Oscillation cycles
   - Snowpack
   - Santa Ana winds
   - Foehn or Chinook winds
   - Southwest Monsoon
   - Other ____
   - Don’t know/ Not applicable

4. In your experience, do long-term climate trends significantly affect your prescribed burning program?
   - Yes, they have a major impact on our prescribed burning program
   - Sort of, they have some impact on our prescribed burning program
   - No, they really don’t have any impact on our prescribed burning program
   - I’m not sure
   - Not applicable

5. How difficult is it to get forecasts or data on the long-term climate trends affecting your fuels and/or your prescribed burns?
   - Easy. I can get them with minimal effort, or someone else gets them for me.
   - Medium. Sometimes it takes me a while to find what I am looking for.
   - Difficult. It takes a lot of effort and time.
   - Climate data is not used in fuels assessment and burn decisions.
   - Don’t know/ Not applicable

6. Have you taken any college-level or agency-provided training courses in climatology?
   - Yes
   - No

7. Do you feel like you receive adequate climate education in agency training courses (such as the skills training series)?
    Yes No Don't know/ Not applicable

8. Does your agency provide you with seasonal climate forecasts or seasonal fire potential outlooks?
    Yes No Don't know/ Not applicable

2. Implement survey

The intended respondents to the survey were fire managers and burn bosses directly involved in implementing prescribed fire programs. A list of potential respondents was developed, and the survey was emailed to them followed by a phone call in which the survey form was completed in an interview. As of this report date, nearly 150 managers have been contacted nationwide, with approximately 90 of these in the California and Great Basin region. This geographic region received initial emphasis so that Ms. Kolden could prepare a Master's thesis based on regional results. It is intended to perform approximately 50 additional interviews across the country in FY05.

3. Perform survey analysis

The analysis is initially being separated into two spatial components – Great Basin and California, and national (including Alaska). The final analysis will compare national regions as appropriate depending upon the survey responses. As of the end of the reporting period, nearly all of the desired Great Basin and California surveys were completed. The survey responses are turned into a quantitative number. However, since questions are actually open-ended (for many questions only some possible answers were provided in advance), the answers for each question were assigned a number based on the ordering of responses. For example, in question number two above relative humidity is response number one, and mixing height is response number eight. Indicators in the other category would be assigned additional numbers as needed.

The basic analysis is simple counts of the results in table form and histogram graphical displays. Since the group surveyed is not a random sample, there is no underlying population for comparison, and hence no formal statistical hypothesis testing is required. However, the data can be subdivided further into two categories of managers that have or have not experienced first hand an escaped burn. The relevance of this categorical analysis is to determine whether or not there are significant differences in information utilized given two distinct outcomes.

Figure 13 shows regional initial results of what fire managers believe is the number one influence of not being able to meet annual prescribed burn target goals. The left bars are for California and the right bars are for the Great Basin. Clearly, funding is indicated as the greatest factor. Weather is noted less than 10% of the time and climate reasons (either a direct climate factor or use of a seasonal climate forecast) were never mentioned. It has not been determined if managers consider "weather" to be all encompassing of climate. The air quality regulations (NEPA/Enviroregs) may also be a less obvious function of climate.

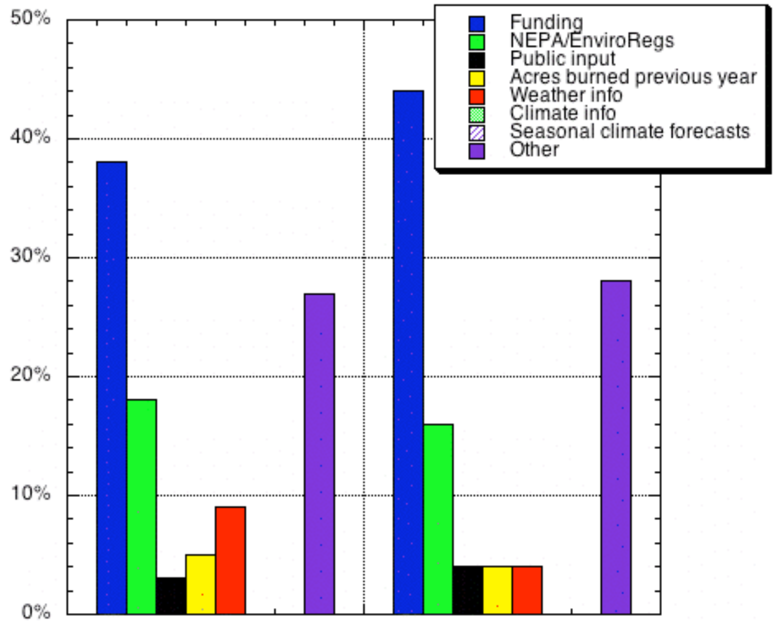


Figure 13. Histogram of percent occurrence of what fire managers believe to be the primary cause (see upper-right legend) of not meeting annual prescribed burn target goals. Left group is for California and right group is for Great Basin.

Though more work is needed in order to complete the survey analysis, the initial results indicate that climate information is used little in consideration of prescribed burn planning or implementation.

4. Prepare report

At the end of the project, a final report will be prepared. Parts of the analysis will also be reported in a Master's thesis manuscript.

Deliverables

The specific deliverables for this project phase are the agency report and Master's thesis manuscript. The anticipated completion is FY05 due to the four-month delay in starting the project and the part-time summer work.

Future work

The project is ongoing in FY05. In addition to completing the survey analysis, several new specific task elements are planned:

1. Climatological threshold tables and maps. Generate climatological tables and maps of prescribed fire thresholds based on survey information for the California-Great Basin region. This information will include descriptive summaries of basic meteorological elements (e.g., temperature, relative humidity, wind), and daily or weekly probabilities of threshold combinations being within prescription.
2. Prototype prescribed fire threshold forecast and display system. Utilizing prescribed fire threshold information from the user surveys and collected burn plans associated with the survey in the California-Great Basin region, develop a color-coded graphical forecast system for displaying when combinations of meteorological and fire danger thresholds are within prescription, near the boundaries of prescription, or outside of

prescription. Initially, NCEP model output will be utilized for the forecasts, but it is anticipated to tie this component into California and Nevada Predictive Services. The initial system will be for 10-day forecasts.

3. Develop escape burn index. Northern California Predictive Services (NCPS) believe that they have identified certain meteorological conditions (dryness factors in combination with wind) that can lead to an escaped burn. They have requested that an index be developed and tested, in anticipation of providing a useful prediction tool for escape burn probabilities. Interest in identifying climate/weather related escaped burn was also noted from the survey results. A statistical regression equation will be used to develop the index.
4. Develop education material. Results from the survey suggest for many fire managers a basic understanding of climate in relation to prescribed fire is lacking, and in many cases noted as desirable to have. One or two articles will be prepared for the publications "Fire Management Notes" and "Wildfire" to discuss and train on the relevant issues. This component is meant to provide a fire community outreach and education element of the project. A small report will be prepared for NWCG providing recommendations on how climate information should be better integrated in training courses and programs.

Task Order 16: Real-time Drought Assessment for Rangelands (Sponsor: BLM)

This task is being accomplished by WRCC with BLM funds, but using CEFA and the Assistance Agreement as a project conduit. The primary purpose of the project is to provide local predictions of plant-growth capability and disseminating this information via the WRCC web site. The project utilizes two primary components: real-time meteorological data from WRCC and rangeland plant modeling. The project period is 1 May 2004 – 30 September 2004. Statement of Work (SOW) specific task elements include:

1. Develop a system to automatically parameterize an ARS plant growth model using daily weather data available at WRCC and typical soil and plant characteristics that would be provided by the ARS and BLM.
2. Develop a web-based user interface allowing an on-line user to select: weather information from a geographical area showing station locations; typical plant characteristics for at least five rangeland communities (to be determined); and typical soil types for at least five soil types (to be determined).
3. Develop numeric and graphical displays of the model's output,
4. Develop flexibility in the system that will allow generated weather information to provide simulated output for lower, normal, and higher-than-normal precipitation.
5. Work with representatives from the ARS, BLM, and NIFC to develop recommendations for refinement of the system.

Project accomplishments include:

<u>1. Develop automated parameterization system</u>

The application allows the user to specify the soil and plant characteristics of any RAWS location via a web form (see http://www.wrcc.dri.edu/cgi-bin/wea_rangetekc.pl?idihsb). For locations with known characteristics, the user may retrieve a description and enter or alter the characteristics for the specific site. An example of these descriptions may be found at http://www.wrcc.dri.edu/cgi-bin/wea_rangetekd.pl?idihsb.

2. Develop web-based user interface

The user interface allows selection of any RAWS station. The interface is part of the general RAWS access provided by WRCC. Access to the product is on the station list of applications and labeled as "Rangetek". Currently, the product is undergoing review and approval. An example of the application interface can be found at http://www.wrcc.dri.edu/cgi-bin/wea_rangetek.pl?idihsb. Karl Gebhardt and Kyle Fend from BLM are providing site specific descriptions of soil and plant characteristics for each RAWS location for user reference (see http://www.wrcc.dri.edu/cgi-bin/wea_rangetekd.pl?idihsb).

3. Develop numeric and graphical displays

Once the user has executed a 'run', the output is shown in tabular form. Figure 14 provides an example output table for Horse Butte, Idaho. Column headings in blue lettering can be mouse clicked to obtain a time series graph of the data. Each element may be graphed individually, or multiple elements may be graphed. Figure 15 is an example graph of the Horse Butte, Idaho computed potential evapotranspiration.

Date	Year	Day of Year	Day of Run	Max T (C)	Min T (C)	Precip (cm)	Snow (cm)	Solar Rad (ly)	PEt (cm)	Transpiration effect	Energy limited P Soil Evap	Daily Transpiration (cm)	Actual Evap	Yield index	Cum Yield index	Cum Pot. Trans	Cum Trans	Drainage (cm)	Soil Water 1 (cm)	Soil Water 2 (cm)	Soil Water 3 (cm)
08/01/2004	2004	214	1	35.56	16.67	0.00	0.00	629.69	0.85	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
08/02/2004	2004	215	2	30.56	16.67	0.00	0.00	462.14	0.60	0.02	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
08/03/2004	2004	216	3	31.11	15.00	0.00	0.00	741.85	0.96	0.03	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
08/04/2004	2004	217	4	33.33	12.22	0.00	0.00	734.11	0.95	0.03	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00
08/05/2004	2004	218	5	31.11	16.11	0.00	0.00	671.49	0.88	0.03	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00

Figure 14. Example table of Rangetek calculated output for Horse Butte, Idaho.

4. Develop system flexibility

Work on allowing input of lower, normal and higher-than-normal precipitation has been delayed due to dealing with other issues such as data incompleteness and bad or missing data.

5. Develop system refinements

Refinement of the system continues through ARS providing more site descriptions and evaluation of the results. It is expected that the product will be ready for general use in early spring of 2005.

Deliverables

The primary deliverable to date is the user interactive web application for computing range conditions from the Rangetek model.

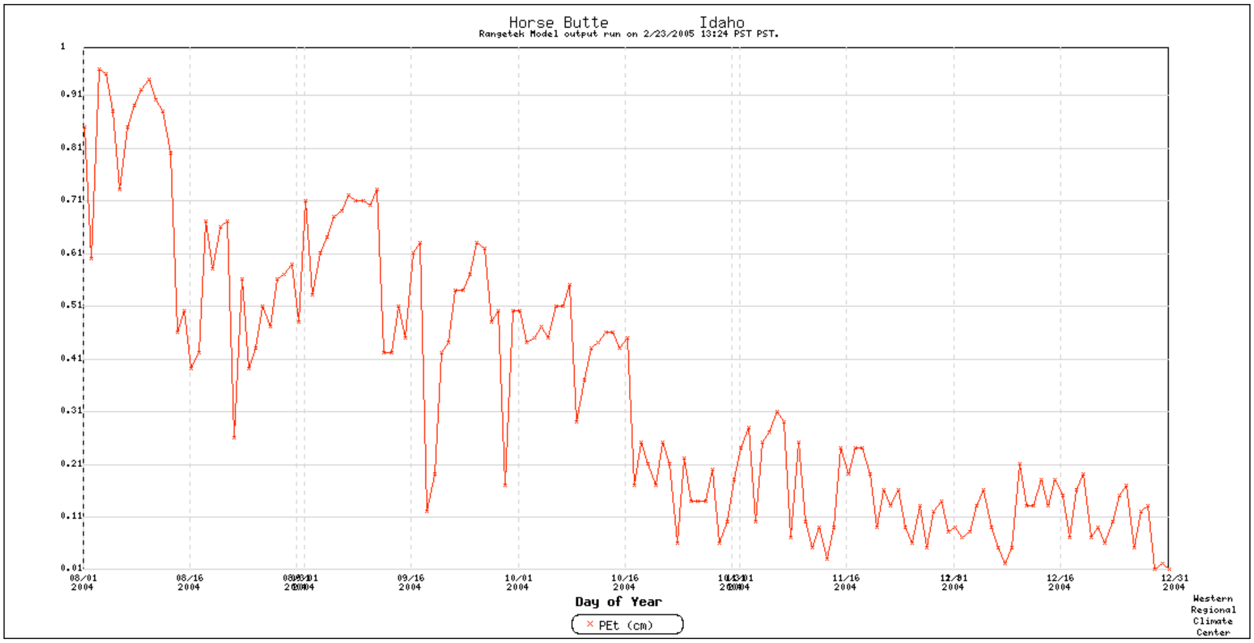


Figure 15. Example graph of potential evapotranspiration from Rangetek calculated output for Horse Butte, Idaho.

Task Order 17: RAWS Data Quality Check and Estimation (Sponsor: FPA/Interagency)

A new fire planning analysis process is being developed to assess the fire program needs of local fire agency units using an interagency approach. The first module of the Fire Program Analysis System (FPA) will be implemented in October 2004. Critical to this effort is the availability of high quality weather data. The primary sources of these data are the archives in the USDA-managed National Interagency Fire Management Integrated Database (NIFMID; daily) and the Western Regional Climate Center (WRCC; hourly). Neither of these archives applies a rigorous data quality filter to the original data, nor do they provide estimated values for missing fields. To optimize the performance of FPA, a process of data quality checking and estimation is necessary.

This project is a collaborative effort between the CEFA, WRCC and the five federal wildland fire agencies (BLM, BIA, FWS, NPS, USFS) as coordinated by the FPA national program office. The project period is 1 August 2004 through 30 September 2005. Howard Roose from BLM is the FPA Business Team Lead and is CEFA's project coordinator. Two primary objectives were identified for the first phase of the project:

Objective 1. Provide data analysis for the four prototype areas by 30 September 2004, as agreed to by the participating agencies after the examination of workload described in section 3.1 below. The priority will be assuring data quality for the 1300-hr observations for stations provided by the agencies.

Objective 2. Develop a prototype of a complete hourly archive for all federal fire agency fire weather stations containing QC'd original observations and, where needed, estimated data. Develop a prototype process that may be applied operationally in the future to meet agency needs (e.g. daily, annually) for maintaining dataset currency. Provide this archive and process at the WRCC for agency use.

Specific project task elements included:

1) Utilize lists of weather stations provided by participating agencies. This may include manual and non-satellite telemetered automatic fire weather stations as well as the more common RAWS. Create a working set of existing period of record data for these stations. This working set will be manipulated into the final clean dataset without compromising either source archive (NIFMID and WRCC). Station identification records will be matched with physical installation location to develop a complete site record.
2) Write and implement software code to perform an assessment of the data for impossible and unlikely values in order to establish the overall quality of the dataset and the resulting workload required to provide a complete quality record. It is anticipated that much of this code can be adapted from previous efforts mentioned earlier. Data will be categorized as Acceptable, Questionable, or Impossible, according to criteria defined in Brown et al (2002). For example, it is unreasonable to expect a relative humidity value of less than 0% or greater than 100%.
3) Acceptable data can be used as is. Impossible data is outside the realm of possibility and will be marked as missing. Further analysis is necessary to determine if Questionable data is actually Acceptable or Impossible. An example would be 24 consecutive hours of unchanging temperature, which is possible, but unlikely. Depending on the amount of Questionable data and the complexity of its analysis, this task can be intensive and impose a significant impact on the timetable of this project. For this reason, the assessment in this task and its projected impact on the project schedule will be reported prior to proceeding to task four. If necessary, the agencies will determine criteria for limiting the scope of this analysis in order to produce as much station data as possible within the schedule.
4) To produce a complete data set, missing data will be estimated. At a minimum, data will be estimated for the 1300-hour (daily) observation, where gaps exist. Hourly data will be addressed if time allows. Estimates will be made for state of the weather, dry-bulb temperature, relative humidity, wind direction, wind speed, 24-hour maximum temperature, 24-hour minimum temperature, 24-hour maximum relative humidity, 24-hour minimum relative humidity, precipitation duration, and precipitation amount.
5) Write and implement software code to place the complete dataset in data file formats required for agency use, including weather observation data transfer format (.fwx or .fw9) and text (comma delimited) files. The .fwx/.fw9 formats allows observations to be input into pcHA and Fire Family Plus.
6) Write a final report documenting the processes used, criteria employed, and descriptions of the confidence the agencies can place in the estimated data.

<u>1. Develop agency weather station list</u>

FPA personnel coordinated the establishment of the prototype station list. The original list included all hourly RAWS from the following fire planning units (FPUs):

AK_AK_001 (Alaska)
CA_CA_008 (CA FPU 8)
NW_OR_004 (Central Oregon)
SA_MS_002 (Southeast Mississippi)

Data from WRCC had to be matched with the station metadata for these four regions prior to processing. Due to differing naming conventions and problems with matching metadata, not all stations could be processed. Of the original list of 298 stations, only 119 could be processed. The remaining stations will be addressed in a later project phase.

2. Write and implement QC computer software code

Task elements 3 through 5 (below) required specifically written software code in order to perform the analysis and estimation, and to produce the final formatted data. Several programming languages were utilized depending upon which version best suited a particular need. Code types included FORTRAN 77, Perl and NCL.

3. Perform QC analysis

A coarse quality control scan of all the hourly RAWS data was performed that met the criteria used for an earlier California RAWS QC analysis project undertaken by CEFA. Temperature, relative humiditiy, wind speed, wind direction and precipitation for each observation hour was evaluated computationally and flagged depending upon how acceptable or questionable the observed value was determined to be. Data were not estimated at this phase. This part of the analysis was simply used to identify all observations that were considered originally to be acceptable.

4. Perform data estimation

From the output of the QC analysis, all data that was either missing since the start of the station's period of record or was not considered to be acceptable from the coarse QC evaluation was identified as needing to be replaced with an estimated value. Estimated values were derived statistically based upon relationships between acceptable observations and data from a complete atmospheric dataset. The NCEP/NCAR reanalysis dataset was chosen to provide these statistical correlations because of its continual spatial and temporal coverage that include the period of records of the RAWS. Variables from the 2.5 degree gridded reanalysis that were considered included:

Surface variables:
- Air temperature
- Relative Humidity
- Sea Level Pressure
- Precipitable Water Content
- U and V components of the wind
- Derived wind speed and direction
- Downward longwave radiation flux
- Downward shortwave radiation flux
- Precipitation rate
- Total cloud cover

Pressure level variables at 1000, 925, 850, 700, 600, 500, 400, and 300 hPa:
- Air temperature
- Relative Humidity
- U and V components of the wind
- Derived wind speed and direction

Reanalysis variables from the nine grid cell locations immediately surrounding each RAWS were considered for each equation. In addition to the reanalysis data, persistence values from the RAWS were included in the statistical regression analysis. The persistence values included the previous hour's value, yesterday's value and the current hour. There were 563 potential predictor variables for each RAWS. After initial screening, the list was reduced to no more than 44 variables for each estimated parameter.

The S-Plus statistical package was used to compute the equations for estimation (see Task Order 11 Section 2 for more details). There were 56 equations developed for each RAWS. The equations included two separate seasons (May through October and November through April) and four different daily time periods (00 to 05 UTC; 06 to 11 UTC; 12 to 17 UTC; 18 to 23 UTC) for each of the seven RAWS variables being estimated (temperature, humidity, wind speed, wind direction, u and v wind components and precipitation).

A validation assessment of the reliability of the estimates is scheduled for the second phase of this Task Order planned for FY05. Immediate concerns of the estimation method are 1) the occurrence of physically impossible estimated values (e.g., negative precipitation amounts), and 2) estimations that 'blew up' in a short period of consecutive hours due to the strong dependence upon persistence predictor variables that had been estimated (effectively the case of model error building upon itself and creating even larger error). Regarding the impossible value problem, it is not simply a case of rerunning the QC for checking these values, but ensuring that the estimation procedure does not produce them. The persistence problem will need to be further explored in Phase 2 of the project.

Codes for state of the weather were computed by combining the total cloud cover data from the gridded reanalysis with the estimated or observed precipitation and temperature values from the RAWS. These values will be examined in the validation phase of the project, and other methods for estimation will be examined (e.g., solar radiation).

5. Generate agency specific formatted data

Once each RAWS dataset had been screened for acceptable versus questionable or missing data, and a relatively clean and complete dataset could be produced from the set of statistically derived equations, several files were produced in different formats to meet the various user needs. Hourly data in the standard 1998 FW9 format and daily data in the standard 1970 FWX format were produced to provide easy input into agency fire weather software such as Fire Family Plus and PCHA. Neither of these formats, however, allow for identifying which values were the original observations and which were estimated. Therefore, a comma delimited text file was also produced that included numerical flags for each value indicating either an original observation or an estimated value. Summary text files were produced for each prototype region that included statistical information such as the percentage of each dataset that was estimated or had to be removed, and station metadata information that provided an indication as to whether or not that station from the original list could be processed and for what reason. This was used to inform users why particular stations were not processed during this round, and to provide an opportunity to identify and fix the problem in order to optimize how many stations could ultimately be processed.

6. Prepare report

A report will be prepared at the end of phase II of the project (see future work section below).

Deliverables

The primary deliverable for the first phase of this project was a dataset of RAWS built upon a QC analysis and an estimation process for the four prototype FPUs. However, a validation process needs to be undertaken to check and potentially improve upon the estimated values. Users of these data were cautioned that additional statistical analysis is necessary before the dataset is considered final.

Future work

In a planned phase II of the project, the two primary objectives will include:

1) Perform a QC and estimation data analysis for a comprehensive list of RAWS as agreed to and prioritized by the participating agencies (data will include both RAWS and manual stations)
2) Perform a comprehensive statistical validation analysis of the estimation process to ensure that the best estimates are made available, and that a scientific process has been undertaken in generating the final product.

OTHER ACTIVITIES

This section describes CEFA projects and activities that are not outlined in a specific Task Order, but are of relevance to BLM and interagency fire and fuels management.

Remote Automated Weather Station (RAWS) Data Retrieval for Input into the Weather Information Management System (WIMS) Yosemite National Park (Sponsor: Yosemite National Park)

This project was originally planned as Task Order 15, but was later decided to implement as a direct contract between Yosemite National Park and CEFA. This contract was finalized in mid-summer 2004. The work plan was conceived in early 2004 prior to knowledge of the FPA QC and data estimation project. However, there turned out to be significant similarities between the objectives of the two projects. Thus, the intended QC and estimation for the Yosemite stations was folded into the FPA process, and the work plan focus became validation analysis, which may in turn be utilized in phase 2 of the FPA project. The validation analysis will be undertaken in FY05.

CANSAC Research and Development (Sponsor: USFS Pacific Southwest Research Station)

Though this work is being undertaken as part of Task Order 10 (CANSAC), it is a separate research contract with the USFS Pacific Southwest Research Station (PSW). This is work in progress. The background and problem statement given in the Plan of Work is as follows:

Wildland fire problems and increased emphasis on air quality by regulatory agencies in California have generated a need for high-resolution weather forecasts for both fire and smoke management. In order for the California Wildfire Agencies (CWA) to meet this need, detailed forecasts for specific areas are necessary to enhance public and firefighter safety, decrease economic losses and meet regulatory requirements. Nevada agencies are currently under less regulation than California, but they still need high-resolution forecasts and value-added products for fire management. The rapid advancements in computer technology provide new opportunities to produce the desired products at relatively low cost compared to high-end supercomputing solutions. The work will be conducted in close coordination with users who represent fire management and air quality management in California and Nevada.

The four primary objectives of this project include:

1. Develop weather model-based fire danger rating forecasting system for California and Nevada, with guidance from the FIRESCOPE Weather Group.

2. Develop weather model-based air quality forecasting system for California, with guidance from Forest Service Research and regional modeling consortium members.
3. Develop web site for system products generated from (1) and (2).
4. Obtain feedback from users on systems performance, analyze systems effectiveness and provide remedies for problems whenever possible.

The initial fire danger rating forecast system that will be implemented is based upon research and development being undertaken at the USFS Pacific Northwest Research Station (PNW). This system will provide fire danger forecasts from MM5 model output. As of this reporting date, CEFA is anticipating receiving the computer software code from PNW in early FY05, upon which testing and analysis of the forecasts will be undertaken for the CANSAC area.

The plan to develop weather model-based air quality forecasts has been delayed until additional disk storage can be purchased for the CANSAC/COFF computing system. Bluesky software from PNW will be implemented once the hardware is installed (anticipated for spring 2005). A requirement for Bluesky is hourly output – current CANSAC forecasts are 3-hourly.

A CANSAC web site has been developed for distribution of products and information (see Task Order 10 above). Once implemented, both fire danger and Bluesky products will be available from this web site.

Obtaining feedback from users on various aspects of CANSAC (e.g., system performance, product usability, etc.) is critical for the effective utilization of the CANSAC products and services. This is an ongoing process, and largely falls within the responsibility of the Operational and Applications Group to provide the information (see Task Order 10 above).

Reaching the Ground: Developing Sustainable Partnerships between Scientists and Decision-Makers (Sponsor: NOAA Office of Global Programs)

This is a social science project in collaboration between CEFA and Dr. Barbara Morehouse at the University of Arizona. The project is CANSAC related and is also a part of CAP and CLIMAS interactions (see below), but is listed separately due to separate funding from the NOAA Office of Global Programs. This is work in progress.

The goal of this project is to document the successful development of the California and Nevada Smoke and Air Committee (CANSAC). CANSAC is a consortium of approximately nine federal, state, county and local wildland fire and air quality agencies formed to address short-term prediction issues of fire weather, fire danger, fire behavior, smoke dispersion/transport and air quality as related to wildland fire, prescribed fire and fire use. The study focus is on documenting steps and interactions in developing a sustainable partnership between scientific and decision-making communities. CANSAC provides a useful example case of a partnership between wildland fire, air quality and atmospheric science research sectors.

The structure of CANSAC is examined in part from social science theory of establishing partnerships. To date, a literature review of social science theory and findings on partnerships has been completed and synthesized. A formal survey has been prepared, and planned for implementation in FY05. The purpose of the survey is to examine the structure, organizational design, availability of resources, coordination and project management, leadership, progress of project, and other general issues related to the CANSAC partnership. Once the survey is completed and analyzed, these results along with the literature review will be synthesized into a journal paper and presented at relevant conferences and workshops.

CAP and CLIMAS Interactions (Sponsor: NOAA Office of Global Programs)

CEFA has an established partnership with the California Applications Project (CAP; Scripps Institution of Oceanography) and the, Climate Assessment for the Southwest (CLIMAS; University of Arizona, Institute for Studies of Planet Earth) project. Both CAP and CLIMAS are NOAA Regional Integrated Science and Assessment (RISA) programs. One objective of the RISAs is to improve integration between science and users of scientific information. The CAP interactions have involved developing products jointly with California wildfire agencies. Examples include climate forecasts, the formation of CANSAC/COFF, and the California hourly fire danger project. Further CAP information can be found at: http://meteora.ucsd.edu/cap. Several of the elements in Task Order 14 are also a CAP function.

The primary collaboration with CLIMAS during this year involved co-organizing the 2004 National Seasonal Assessment Workshop (Eastern and Southern areas in January 2004 and Western States and Alaska in March 2004). These workshops brought together national, regional and state climate scientists, fire managers, and fuel and fire specialists to formally produce regional and national seasonal fire potential assessments and outlooks. This information is utilized for both national and GACC planning. Special one-page outlook reports were distributed to fire directors and fire management. Detailed reports were published describing specific aspects of each workshop. Further information regarding CLIMAS is available at: http://www.ispe.arizona.edu/climas.

Hourly Fire Danger (Sponsor: California Interagency)

Over the past couple of years and in conjunction with several California wildfire agencies, CEFA has been developing a prototype and experimental system for calculating and displaying hourly fire danger in California. Using hourly RAWS from WRCC and NFDRS algorithms provided by Larry Bradshaw at MFSL, fire danger indices are computed for each fire danger rating area across the state, and a fire adjective class is calculated on an hourly basis. California wildfire agency personnel continue to evaluate the product as it is now being widely viewed within the state. A phase II of the project is being planned that will quantitatively examine the hourly fire danger values and produce a climatology based on historical hourly fire danger. In the meantime, the current product has been generally accepted by the California wildfire agencies. Individuals continue to evaluate the system for its operational utility. The web-based maps are available at http://cefa.dri.edu/HourlyFD.

Operational Mixing Height Forecasts (Sponsor: California Interagency)

CEFA continues to produce operational mixing height forecasts from the NCEP/NWS Eta model for the entire U.S. Regional maps are available for California. CEFA continues to provide California Predictive Services with a specific text product that is used as operational guidance for daily mixing height and transport wind forecasts. The forecast maps are available at http://www.cefa.dri.edu/Operational_Products/NCEP_Exp/exp_index.htm. An interactive map of smoke forecasts can be found at the Southern California Predictive Services web site http://www.fs.fed.us/r5/fire/south/fwx/smoke.shtml and at Northern California Predictive Services at the web site http://www.fs.fed.us/r5/fire/north/fwx/fwlrdd2.htm.

TRAVEL, PRESENTATIONS AND MEETING ACTIVITIES

This section provides brief information regarding travel, presentations and meeting activities as functions of CEFA and BLM during 1 October 2003 through 30 September 2004.

October 3-6 (Sydney, Australia): Tim Brown presentation of poster at the 3rd International Conference on Wildland Fire.

October 9-10 (Melbourne, Australia): Tim Brown presentation of CEFA research and operational activities at the Fire Weather Workshop, Bureau of Meteorology Research Centre.

October 13-14 (Canberra, Australia): Tim Brown attended meeting and discussion of fire behavior and ecology topics for southeastern Australia at the CSIRO Forestry and Forest Products and Sustainable Ecosystems Division.

October 21-22 (Sydney, Australia): Site visits to New South Wales Fire Brigade Headquarters and regional parks.

October 20 (Reno, NV): Beth Hall presentation at the Climate Diagnostics Workshop.

November 10 (Boise, ID): Tim Brown CEFA quarterly review briefing.

November 12 (Las Vegas, NV): Tim Brown attending meeting regarding establishment of Nevada Wildfire Coalition.

November 16-20 (Orlando, FL): Tim Brown, Beth Hall, Crystal Kolden, Charlie Mohrle, and Hauss Reinbold presentations at the American Meteorological Society 4th Symposium on Fire and Forest Meteorology.

November 24 (Vicksburg, MS): Tim Brown site visit at Army Corps of Engineers high-performance computing and visualization facility.

December 8-11 (Whitefish, MT): Tim Brown presentation at Predictive Services annual meeting.

January 12-14 (Seattle, WA): Tim Brown presentation at American Meteorological Society annual meeting.

January 27-29 (Sheperdstown, WV): Tim Brown presentation and co-organizer of National Seasonal Assessment Workshop: Eastern and Southern Areas.

January 22 (Sacramento, CA): Beth Hall attending CANSAC OAG/TAG meeting.

February 4 (Reno, NV): CEFA group meeting with Dr. Alan Taylor, Penn State University, to discuss CEFA projects and Sierra Nevada fire history.

February 9 (Boise, ID): Tim Brown CEFA quarterly review briefing.

February 18-20 (Marana, AZ): Tim Brown Advanced NFDRS lectures at National Advanced Resource and Training Center.

March 3-5 (Reno, NV): Tim Brown and Crystal Kolden poster presentation at 2004 National Fire Plan Conference.

March 15-17 (Philadelphia, PA): Tim Brown presentation at annual meeting of Association of American Geographers.

March 29-April 1 (Phoenix, AZ): Tim Brown presentation and co-organizer of National Seasonal Assessment Workshop: Western States and Alaska.

April 7 (Phoenix, AZ): Tim Brown presentation for regional fire suppression cost-containment panel facilitated by Brookings Institution.

April 13-14 (Reno, NV): Tim Brown facilitated Predictive Services/National Weather Service future planning meeting.

April 22-23 (Tucson, AZ): Tim Brown presentation at the North American Monsoon Experiment Workshop.

May 3 (Boise, ID): Tim Brown CEFA quarterly review briefing.

May 11-12 (Reno, NV): Tim Brown and Beth Hall presentations at CEFA hosted California Firescope meeting.

May 19 (Reno, NV): CEFA hosted CANSAC dedication meeting and ceremonies.

May 25-27 (Lake Tahoe, NV): Tim Brown facilitated discussion group at Mountain Climate Sciences Symposium.

June 10-11 (Helsinki, Finland): Tim Brown presentation at World Weather Research Program Nowcast Working Group on CANSAC.

June 29 (Flaggstaff, AZ): Tim Brown presentation for regional fire suppression cost-containment panel facilitated by Brookings Institution.

July 1 (Portland, OR): Tim Brown presentation for regional quadrennial review panel facilitated by Brookings Institution.

August 25 (Boise, ID): Tim Brown CEFA quarterly review briefing.

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