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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CEFA Report 06-01 December 2006

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 (DRI). This report describes the activities at the DRI Program for Climate, Ecosystem and Fire Applications (CEFA) under this Agreement during the period 1 October 2005 - 30 September 2006. For further information regarding this report or the projects described, please contact either:

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

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

by
Timothy J. Brown and Beth L. Hall

Program for Climate, Ecosystem and Fire Applications
Desert Research Institute

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A. INTRODUCTION

This annual report covers federal fiscal year 2006 and represents accomplishments, deliverables and activities under the Bureau of Land Management (BLM) national Office of Fire and Aviation and the Desert Research Institute (DRI) cooperative Assistance Agreement (AA) 1422RAA000002. The 5-year AA was signed by BLM and DRI in November 2000 for the period through November 2005. The overall scope of the AA was climate and ecosystem studies and product development for wildland fire and resource management. Its objective was 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, terrestrial ecology and fire management "expertise" from BLM and other land management agencies. The deliverables under this AA were intended to have high interagency value in addition to specific BLM agency needs. The target audience varied depending upon the product or information, but included fire management, Predictive Services meteorologists, fuels analysts, intelligence officers, fire behavior analysts, and fire specialists. Project concepts could originate at all levels including local, state and national offices as well as at DRI.

In November 2005, the Assistance Agreement expired and was not renewed due to changes in federal Grants and Agreements policy. However, Task Orders begun within the AA are allowed to be ongoing for a period of five years from their start date. This report describes activities and accomplishments under the AA and for ongoing Tasks and other CEFA projects for the period 1 October 2005 – 30 September 2006. 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). In May 2003 an interagency program review of CEFA was conducted for the BLM. The purpose of the review was "to clarify the program's relevance, quality and performance". The review recommended, among other things, that the CEFA program continue and that a "Stakeholder Oversight/Advisory Panel" be developed "to ensure the continuing relevance and performance of CEFA work". During FY06, the National Interagency Fuels Coordination Group (NIFCG) had the role of the CEFA Oversight Group.

Contributions to this report were provided by Julide Koracin, Crystal Kolden, Greg McCurdy, Domagoj Podnar, Kelly Redmond, Hauss Reinbold and Paul Schlobohm. The CEFA staff members 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 tasks conducted under the AA that were in progress during federal FY2006. Task Order 7 began in September 2001 and is in its fifth and final year; Task Order 10 began in October 2002 and is in its fourth year; Task Orders 13 and 14 began in September 2003 and are currently in their fourth year; Task Order 15 began in June 2005 and is in its second year; Task Order 16 began May 2004 and is in its third year; and Task Order 17 began in August 2004 and is in its third year.

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

The Western Regional Climate Center (WRCC) manages this task with BLM funds utilizing the Assistance Agreement. The report in this section was provided by WRCC.

The level of funding for this project allows for progress in building 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 fourth year of the project through the period 30 June 2006. In July 2006, funding was provided through January 2007. In 2007, a transition to a new funding mechanism through the National Climatic Data Center is planned. Statement of Work specific task elements and accomplishments during the project period are given below, which also includes a modification of Task Order 7 dated 30 May 2006.

A) Data improvement

Task element A1: Data conversion. Continue reformatting of remaining RAWS station data from ASCII text to internal binary indexed format.

Accomplishments: The primary task of converting the historical data has been completed. 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 50 stations (brand new or transitioned to GOES telemetry through ASCADS) were brought online from July 2004 through June 2005. The communications and ingest system has functioned fairly well in an automated fashion. Occasional babysitting is still needed to deal with hiccups in data flow or data processing.

Implemented software to access maintenance records from ASCADS and a local database now contains these records. This database has been built to be portable on a laptop computer. Records retrieved from ASCADS include historical maintenance, route information and detailed site contact information. This information will not be released for public use. WRCC uses this information only for QC purposes.

Task element A2: Station metadata. Development of a station selector and search function.

Accomplishments: Updating station metadata in the internal database is an ongoing process. As of this reporting period, there were 53,000 station records in the database. Approximately 100-200 new records are added each month. Metadata continues to be loaded into a locally searchable database. First steps to integrate the RAWS network into ACIS (Applied Climate Information System) have been taken. See www.acis.org for information about ACIS. During fall 2006, basic metadata information from the RAWS network was inserted into the ACIS metadata system. These steps will eventually allow all the tools being developed for ACIS to be applied to the RAWS network.

ACIS is a distributed and synchronized system that provides consistent and timely climatic products. The system is implemented at multiple climate data centers to provide redundancy and timely availability. The synchronization and standardization ensures that users will receive the same information regardless of the point of contact.

<u>Task element A3</u>: 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.

<u>Accomplishments</u>: Two tools to deal with quality control issues have been developed. One tool allows a user to screen the data by setting limits. A report is then generated which displays the occurrences when the limits were exceeded. The second tool allows periods of missing data to be estimated using methods of multiple linear regression. Nearby stations, with similar data behavior, may be used to estimate for missing periods. The program also computes correlation confidence values, so that the user can determine what degree of correlation exists. The system has been redesigned to allow a much more robust and extensive set of flags. Figure 1 shows example hourly output for a RAWS site including flag values for each element based on a data quality check.

Grace Idaho

: LST	in		mph		Deg		Deg F		Deg F		%		volts		Deg		mph		ly	
: Date/Time	Precip		Wind		Wind		Av Air		Fuel		Rel		Battery		Dir		Mx Gust		Solar	
:YYMMDDhhmm		flg	Speed	flg	Direc	flg	Temp	flg	Temp	flg	Humidty	flg	Voltage	flg	MxGust	flg	Speed	flg	Rad.	flg
0502040000	12.24	0	1	0	221	0	26	0	25	0	61	0	12.8	0	317	0	5	0	0	0
0502040100	12.24	0	1	0	75	0	27	0	24	0	54	0	12.8	0	228	0	6	0	0	0
0502040200	12.24	0	1	0	167	0	27	0	24	0	56	0	12.7	0	210	0	6	0	0	0
0502040300	12.24	0	0	0	188	0	26	0	23	0	59	0	12.7	0	189	0	4	0	0	0
0502040400	12.24	0	0	0	203	0	24	0	23	0	63	0	12.7	0	202	0	5	0	0	0
0502040500	12.24	0	0	0	301	0	24	0	23	0	64	0	12.7	0	203	0	4	0	0	0
0502040600	12.24	0	1	0	306	0	23	0	22	0	65	0	12.7	0	309	0	4	0	0	0
0502040700	12.24	0	0	0	36	0	20	0	22	0	72	0	12.6	0	319	0	4	0	0	0
0502040800	12.24	0	0	0	73	0	22	0	21	0	74	0	12.6	0	194	0	6	0	0	0
0502040900	12.24	0	0	0	194	0	30	0	21	0	59	0	13.6	0	192	0	7	0	5.247	0
0502041000	12.24	0	6	0	186	0	34	0	22	0	55	0	13.5	0	163	0	11	0	21.33	0
0502041100	12.24	0	4	0	191	0	38	0	22	0	47	0	13.4	0	199	0	12	0	32.51	0
0502041200	12.24	0	1	0	66	0	40.7	E	22.9	E	43	E	-9999	M	-9999	M	-9999	M	42.84	E
0502041300	12.24	0	5	0	131	0	42	0	25	0	42	0	13.3	0	124	0	12	0	49.37	0
0502041400	12.24	0	5	0	150	0	43	0	25	0	44	0	13.4	0	173	0	13	0	49.54	0
0502041500	12.24	0	7	0	128	0	40	0	27	0	48	0	13.4	0	136	0	12	0	44.55	0
0502041600	12.24	0	7	0	140	0	39	0	27	0	43	0	13.4	0	125	0	12	0	35.01	0
0502041700	12.24	0	6	0	137	0	37	0	28	0	51	0	13.5	0	137	0	11	0	19.35	0

Figure 1. Example data output including a quality control report. Flag codes are 0 = data okay; M = data missing; E = estimated value.

B) Product development.

<u>Task element B1</u>: Daily time series. The analog for this product is the Summary-of-the-Day data set from the National Climatic Data Center [http://www.ncdc.noaa.gov/oa/climate/onlineprod/drought/xmgr.html]. 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. For example: max and min temperature, total solar radiation, mean scalar wind speed, peak gust for the day, daily precipitation, vector mean wind direction and speed, number of hours exceeding some value (e.g., greater than 81 degrees, less than 7 percent humidity), and the like, again with user control of what is acceptable, and what is not, in terms of data availability.

Accomplishments: This product was developed and is available for use. Hourly or sub-hourly values are utilized to produce daily averages, daily sums, or number of hours exceeding some threshold value. Missing data can be represented in a variety of ways. A number of different output formats are available.

Task element B2: Climate summaries. These products consist mainly of hourly and daily climatologies. Of greatest interest are measures of central tendency (averages or medians), by hour, by day, by month, or by year. 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).

Accomplishments: The main component of the climate summaries that is most needed is the monthly time series summary and lister. This has been a difficult and complicated program to write, because there are many ways that summary data can be formed from the original values, and there is a strong need to be able to do all of them. Among many other reasons is the need to be able to debug basic problems with a given station record, and to debug other products. Work continues on the time series summary lister software.

Task element B4: Selective lister. To hold down data volume, many users only want data records from days or hours where thresholds exceed certain user-defined values, perhaps following Boolean criteria (for example, list all records with winds over 27.4 mph, or all days or hours with temperatures above 90ºF and humidity below 9.3 percent).

Accomplishments: This option has been deferred in order to work on other products.

Task element B5: Data products. Products consist of summarized or manipulated versions of the basic data. Examples include data listings, wind roses, frequency distributions, time series summaries, climatologies, and derived indices for specific sectors. Work collaboratively with Advisory Group to develop new applications, as appropriate. Address a wide range of user interests, technical capabilities, nested levels of sophistication in user needs, simple to complex options. Prioritize on the basis of usefulness, uniqueness, size or importance of audience, and related needs.

Accomplishments: In 2006, a new routine was developed to allow simple estimation of short periods of missing data. Currently, the routine does simple linear interpolation of missing data. This routine is intended as a first step to filling short (1 to 5 hours) missing periods. The user is prompted for a one-month period and allowed to specify the element and the maximum number of missing intervals (hours) to interpolate. All new values are tagged as estimated in the database. Possible future development would be to include other estimation methods, such as a spline technique or coupling the estimation to a physical model, to estimate the missing values. Due to the nature of the RAWS data delivery, this tool could change several stations into complete records each month. Currently, the usefulness of this routine is being evaluated.

A basic monthly time series lister is now available. The program allows the user to select any of the common elements and the desired time period. Figures 2 and 3 show example numeric histogram output and table displays from the lister, respectively.

Task element C: RAWS Advisory Group. Continue to utilize the feedback from this user group and others.

Accomplishments: This group has provided minimal formal feedback in the past year. One request from the advisory group that was completed was the ability to dump some reports to a non-html format. Efforts are underway to formalize the Fire Weather Committee under the

NWCG Fire Environment Working Team as the RAWS Advisory Group. We do continue to hear from a variety of users with suggestions for improvements to products, either new products, or augmentations to existing products. One suggestion was for the addition of new data output formats in the data lister. Specifically, we added the ability to dump directly into an excel spreadsheet.

Task element D: RAWS web page improvements. The web page that provides access to RAWS data seems to be functioning well, but will be improved according to user requests and internal needs [http://www.wrcc.dri.edu/wraws]. A new home page for RAWS, incorporating this page, still needs to be developed, that directs a user to data, metadata, news and existing products, other RAWS information at WRCC and elsewhere, and related agency links, including ASCADS and others. The goal remains to develop a "one-stop shopping" page that agency activities can easily link to.

Accomplishments: Major improvements were done this past year to pages that display basic metadata. Inclusion of station photos and other location information was improved to show more clearly the station setting. Links are also included to access the NWS current 7-day forecast for the station location using the new NWS 7-day point forecast.

A new interface is anticipated for deployment in December 2006.[1] Several new products will be included such as new statewide daily summaries. One of the new links includes access to fire RAWS portables with immediate access to any data transmitted. Other additional links will be added in the future such as ROMAN.[2]

Task element 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. This task places a priority on close coordination between WRCC and BLM ASCADS redesign efforts. WRCC will work in conjunction with BLM and other NIFC agencies to insure that the system jointly developed has the proper attributes for future use and expansion.

Accomplishments: Adaptation to the requirements of secure shell connections was completed without interruption of data flow. WRCC also looked at the possibility of retrieving data from Wallops Is. during NIFC outages (periods when data was lost). As long as periods are kept minimal (a day or 2 at most), WRCC can retrieve the missing data. WRCC has yet to build the data decoders to ingest data retrieved directly from Wallops, but the need to do so is present. (Required by another project)

Task element F: Ties to ISOS and the National Cooperative Mesonet. There is increasingly widespread recognition of the need to bring together data from all the federal networks in support of the next generation of weather and climate prediction models and for addressing local and regional scale issues. In June 2004 NOAA formally initiated the Integrated Surface Observing System and associated National Cooperative Mesonet. There is great interest from many quarters in the RAWS network, and WRCC is frequently approached to help make this information more available and useful. We will be working to find ways that RAWS can play a significant role in the developing national system of atmospheric and climatic observations.

Accomplishments: The utilization of RAWS data as part of an Integrated Surface Observing System (ISOS), spanning all federal agencies, has been promoted in a variety of venues. The ISOS concept has advanced only modestly within NOAA during the last year because of budgetary constraints.

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[1] The new interface was released in December 2006.
[2] The ROMAN link was added in December 2006.

Task element G: Emergency response. At the discretion of the Administrative Representative, assist NIFC in providing timely and user-friendly, event-specific access to RAWS data in response to emerging situations.

Accomplishments: An initial method for access to portable station data with specific access to fire RAWS stations was implemented. This new tool is part of the interface to be released December 2006.[3]

Fish Springs Nevada

Latitude : 38° 56' 10" N
Longitude : 119° 39' 07" W
Elevation : 5120 ft.
Report Generated on: Mar. 9, 2007

Start Date : Jan. 1, 2006
End Date : Aug. 31, 2006
# of Days : 243 of 243
obs : poss : 5820 of 5832

Sub Interval Windows	Start	End
Month	Jan.	Dec.
Day	01	31
Hour	00	23

Average Air Temperature

Percent of Hourly Observations
Greater than or equal to initial interval value and Less than ending interval value.

Range Deg F	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm	12 am	All Hrs
-5 to 0						0.4	0.4																		0.0
0 to 5			0.4	0.4	0.4			0.4																	0.1
5 to 10	0.8	0.8			0.8	1.2	1.2														0.4	0.4	0.4	0.8	0.3
10 to 15	1.2	1.2	2.5	2.9	2.1	2.5	1.2	1.7											0.4	0.8		0.4	0.4		0.7
15 to 20	3.7	3.7	5.8	7.8	9.9	10.3	10.7	8.3	0.4									0.4	0.4	0.4	1.7	1.6	1.6	2.9	2.9
20 to 25	7.9	10.7	8.6	8.6	8.6	7.4	7.0	5.8	3.7						0.4			0.8	1.6	4.5	3.3	5.3	8.2	8.7	4.2
25 to 30	9.9	7.9	9.1	8.2	7.0	7.0	4.9	5.4	4.5	2.1	0.8	0.4	0.8	0.8	0.8	1.6	2.9	4.1	7.0	5.3	8.3	7.4	8.6	10.0	5.2
30 to 35	8.7	9.9	8.6	9.9	12.3	12.3	9.1	6.6	10.3	6.2	5.8	5.4	3.3	4.1	3.7	2.9	6.6	7.8	8.6	12.8	14.0	13.6	12.3	8.7	8.5
35 to 40	12.0	14.0	14.0	16.9	16.5	14.8	7.0	5.8	9.9	8.2	6.2	4.1	5.8	4.6	4.9	6.2	5.4	8.6	12.3	10.3	7.4	8.2	7.0	8.7	9.1
40 to 45	11.6	12.8	17.3	15.2	16.9	16.9	4.9	6.2	8.6	13.2	10.3	10.0	9.1	8.3	7.0	11.1	9.9	9.1	8.6	7.8	8.7	9.5	9.9	13.7	10.7
45 to 50	14.0	13.6	14.0	14.4	14.0	13.2	8.2	7.9	6.6	8.6	10.7	8.7	7.4	8.7	11.1	8.6	9.9	9.5	5.3	5.8	7.9	7.4	8.6	11.2	9.8
50 to 55	13.2	13.6	10.7	9.1	5.8	7.8	9.5	2.1	4.1	7.4	7.9	10.0	9.9	7.1	6.6	6.2	6.2	5.8	3.3	3.7	5.8	8.6	12.8	11.2	7.8
55 to 60	7.9	7.0	5.3	3.7	4.1	4.5	10.3	4.5	3.3	3.3	5.8	7.9	6.6	9.1	9.1	7.4	6.2	2.5	2.5	5.8	9.1	12.3	11.1	13.7	6.8
60 to 65	6.2	2.1	2.1	2.1	1.2	0.8	12.3	6.6	5.3	4.1	4.1	4.6	6.6	5.8	3.7	4.9	3.3	3.7	6.6	7.4	12.4	11.1	10.7	6.2	5.6
65 to 70	2.5	2.1	1.6	0.8	0.4	0.8	9.5	11.6	5.8	5.8	5.4	4.1	4.5	4.6	5.3	2.9	4.5	5.3	7.0	11.9	10.7	9.5	6.6	2.9	5.3
70 to 75	0.4	0.4					3.7	14.5	11.5	6.6	4.1	4.1	4.5	4.1	4.5	5.8	6.6	7.4	8.6	14.0	7.4	2.9	1.2	1.2	4.7
75 to 80								9.1	14.8	13.6	10.7	6.6	4.1	3.3	4.5	5.8	6.2	8.2	14.4	6.6	2.9	1.6	0.4		4.7
80 to 85								3.7	8.6	11.5	12.8	11.2	9.5	10.0	9.5	11.1	12.4	15.2	8.2	2.9					5.3
85 to 90									2.5	7.8	9.5	12.9	14.8	13.7	13.2	13.2	11.6	7.0	4.1						4.6
90 to 95										1.6	5.4	7.9	8.6	11.2	11.5	7.8	6.2	4.1	0.8						2.7
95 to 100											0.4	2.1	4.5	4.6	3.7	4.5	2.1	0.4							0.9
100 to 105															0.4										0.0
Total # obs.	242	242	243	243	243	243	243	242	243	243	242	241	243	241	243	243	242	243	243	243	242	243	243	241	5820
Average Deg F	42.0	40.5	39.3	38.0	36.9	37.1	44.7	51.9	56.8	61.1	63.7	65.7	67.1	67.7	67.5	66.5	64.3	61.0	57.2	52.8	49.5	47.2	45.3	43.4	52.8

Data are subject to further review and editing. Please refer any questions to the Western Regional Climate Center.

Figure 2. Example numeric histogram output from the Fish Springs, Nevada RAWS.

[3] The web link was added in December 2006 [http://www.wrcc.dri.edu/cgi-bin/wea_daynetsumFR.pl].

Fish Springs Nevada

Monthly Data run on 3/9/2007 13:01

Show element table summaries

Wait until table downloads completely
before trying to display table summaries
Not doing so will result in an incomplete or broken table summary

n this table is stored on the server for 1 hour. Thus, summaries may be created for 1 hour after table is produced before the data is removed from the server. Reload the frame to regenerate the data table c
you want to recreate the tables after 1 hour.

	Solar Radiation	Mean Wind Speed	Mean Wind Direction	Maximum Wind Gust	Average Air Temperature			Ave Fuel Temp			Average Relative Humidity			Precipitation
Date	ly	mph	Deg	mph	Deg F			Deg F			%			in
mm/yyyy	Total	Ave.	Ave.	Max.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Total
01/2006	6280	2.822	153.4	35	34.78	63	6	33.37	66	1	64.23	100	18	1.1
02/2006	8700	1.899	118.3	42	34.76	65	-0.999	33.48	74	-4.999	58.39	95	10	1.75
03/2006	11751	4.13	194.7	41	36.26	66	13	36.05	78	9	53.42	98	13	0.67
04/2006	15331	3.837	178.5	40	46.81	79	18	47.04	89	15	54.63	100	15	1.74
05/2006	20266	3.031	215.5	31	57.64	88	24	56.77	95	20	41.91	89	10	0.12
06/2006	20573	2.857	264.1	33	67.5	99	33	66.26	111	27	34.3	90	7	0.03
07/2006	21167	2.997	228.3	29	74.79	101	39	74.9	113	33	31.38	100	7	0.29
08/2006	20093	2.628	84.13	32	68.37	94	34	67.78	108	28	27.77	85	6	0.04

Figure 3. Example table output from the Fish Springs, Nevada RAWS.

WRCC web usage

Web usage continued as in past years with well over 250,000 accesses from participating agencies. This number is suspected to be low as it represents only those users accessing the web from locations that identify them as from participating agencies as opposed to private or contract service providers.

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 2006 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, San Joaquin Valley Air Pollution Control District and Los Angeles County Fire Department. 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.

Current personnel

Primary CEFA-CANSAC personnel include Julide Koracin (operations and development manager), Domagoj Podnar (systems administration), Hauss Reinbold (graphics and web support), Beth Hall (OAG liaison) and Tesfamichael Ghidey (Ph.D. graduate student) under the project administrative direction of Dr. Tim Brown.

Production of operational forecasts

The official CANSAC dedication meeting was held at DRI on 19 May 2004. Real-time product generation began officially on 1 June 2004, and is now an ongoing process. Forecasts are generated twice daily based upon NCEP 00 and 12 UTC North American Meso (NAM) model initializations. New products and updates are developed and maintained under the guidance of the OAG. In December 2005, an OAG task request form for internal tracking was developed. The public product web page is [http://www.cefa.dri.edu/COFF/cansac_output.htm].

Assessment of 2006 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, this has not yet been developed and implemented. From a qualitative perspective, OAG and the CANSAC community have provided verbal and email reports indicating that the products are good and satisfactorily improving. The 4-km grid output is very good, especially at depicting fairly small scale features such as rain shadows, Venturi wind effects, wind channeling by terrain to a locally different direction and in some areas the locally light surface winds under nighttime/morning inversions. Output was used successfully in 2004 in association with a southern California Santa Ana fire.

Workshops

In 2006, two one-day CANSAC training workshops were held. Crystal Kolden from CEFA was instrumental in organizing both events. The first was in February at the Wildland Fire Conference and Training Center at the McClellan Business Park in Sacramento, California. Approximately 30 participants attended representing air quality and prescribed burning decision-making. The agenda included a CANSAC meteorological products interactive demonstration, CANSAC meteorological products for air pollution control districts needs, a CANSAC air quality products interactive demonstration, the mechanics of CANSAC, CANSAC in context of other activities on air quality and fire, and some round-table discussion. The workshop feedback was positive, and the primary suggestion was for another workshop focusing on using the CANSAC products.

The second workshop was held in May at the Forest Service Pacific Southwest Research Station in Riverside, California. The intent of this workshop was to focus more on CANSAC in relation to air quality issues in southern California; thus, primarily air quality agency representatives were invited, though one burner did attend. The turnout for this workshop was much smaller, but the program was very similar to the McClellan meeting. The smaller attendance did allow for more interactive discussion during the presentations.

It is likely that one or two workshops will be held again during 2007. It is also of interest to discuss CANSAC with Nevada air quality agencies.

Project Deliverables

The project deliverables include a suite of fire weather forecast products identified by OAG. Products fall into four categories: 1) fire weather; 2) smoke dispersion and transport; 3) fire danger; and 4) fire behavior. Of these four, three are operational (fire weather, smoke dispersion and transport, and fire danger). Smoke dispersion and transport is modeled based on the Bluesky framework developed at the Forest Service Pacific Northwest Research Station, and specifically using CALPUFF and CALMET. The output provides PM2.5 concentrations of smoke based upon form 209-wildfire reports, and a CEFA developed web form allows for burners to input prescribed burn information. Prototype fire danger forecast maps of energy release component, burning index, spread component and ignition component were introduced in the summer of 2005, but these products have not been fully validated. It is anticipated to develop some prototype fire behavior products in 2007; these will emphasize ultra-high resolution wind output.

Below are two examples of current products available from the CANSAC system. All products provided by the system are finalized by OAG for content and appearance. Figure 4 shows an example of Bluesky output of smoke concentration forecast for northern California fires in late August 2006. Figure 5 shows an example forecast map of high-resolution wind vectors for an area requested by the San Joaquin Valley Air Pollution Control District.

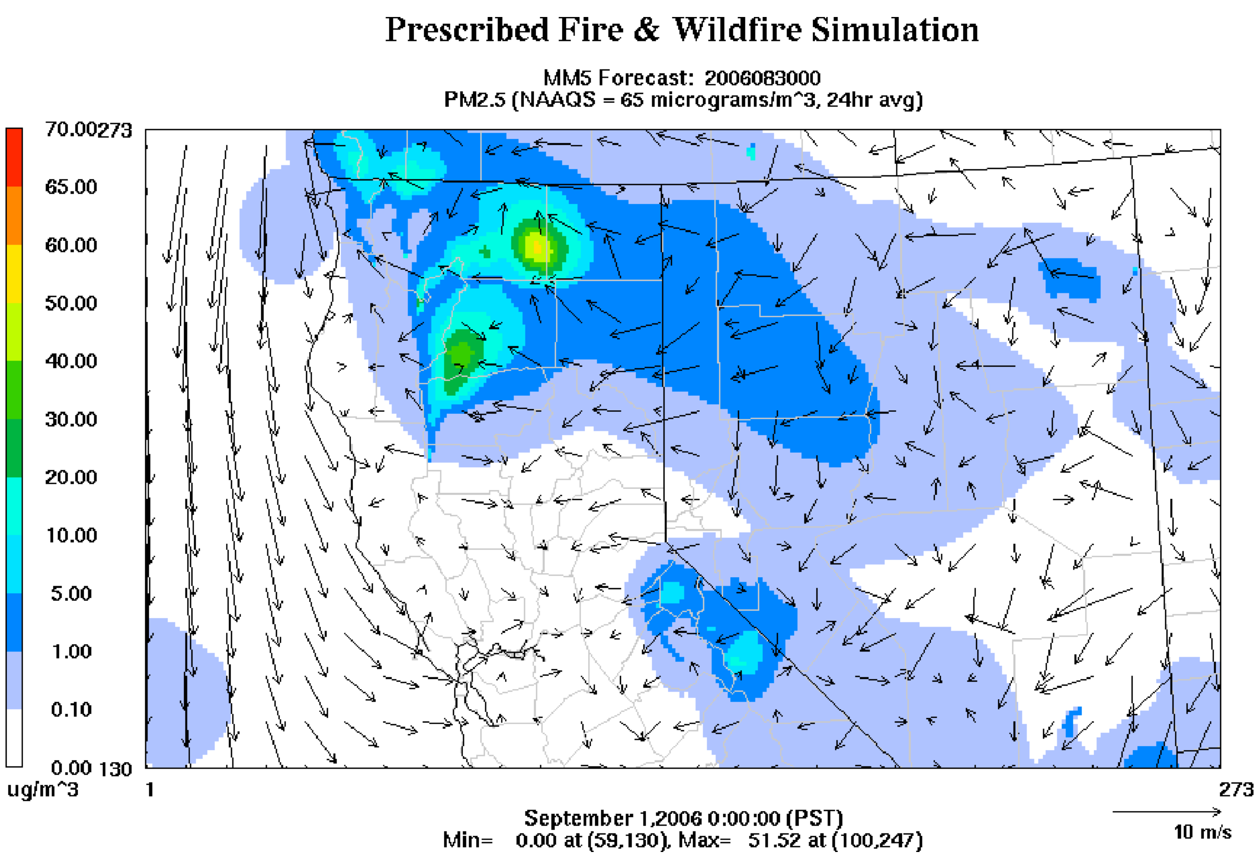

Figure 4. Example map of BlueSky predicted $PM_{2.5}$ concentrations from wildfire areas in northern California on 30 August 2006. Color bar denotes concentration amount and wind direction, and speed is given as vector arrows.

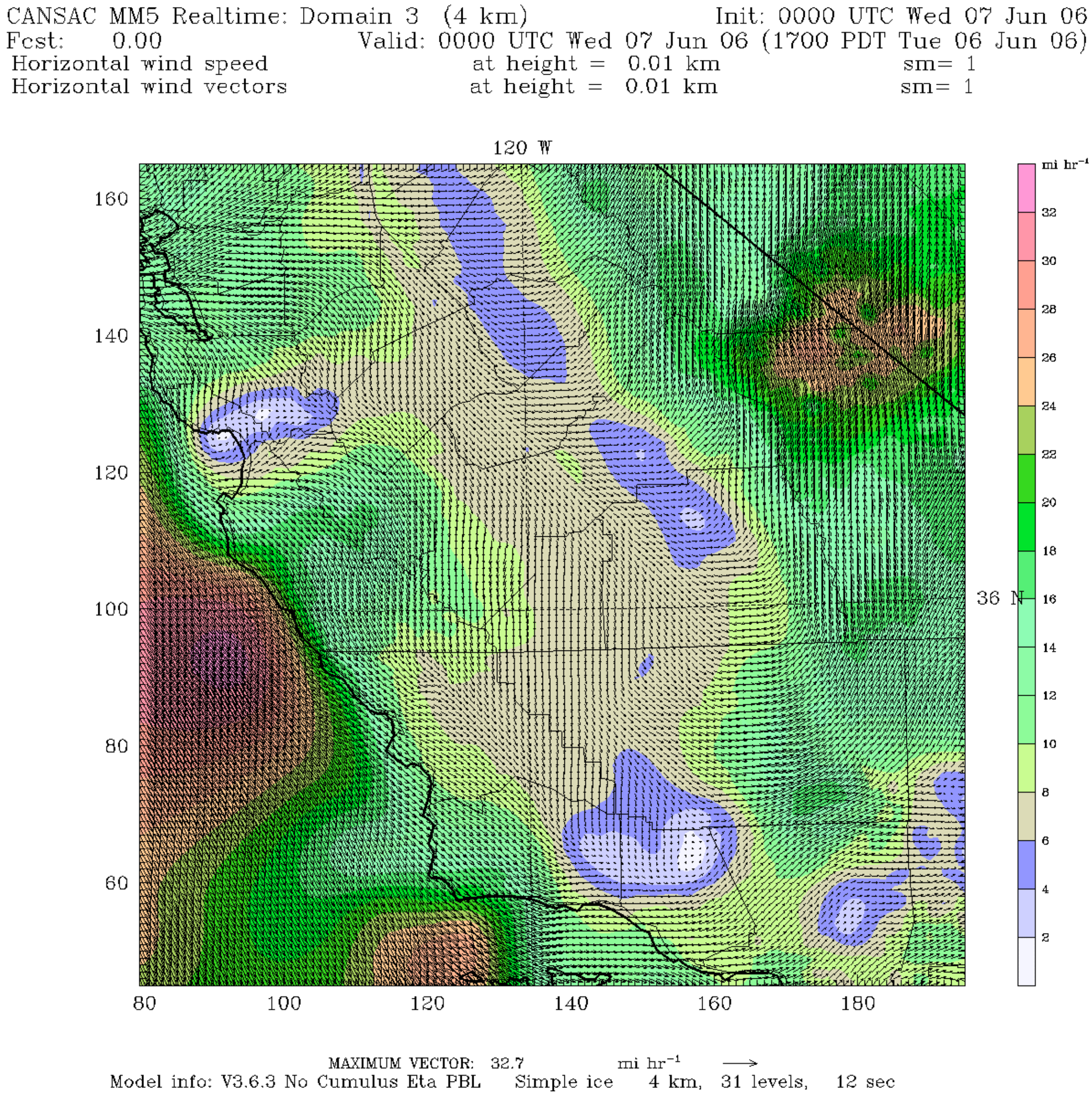

Figure 5. Example high-resolution wind direction and speed map for south-central California requested by the San Joaquin Valley Air Pollution Control District (a CANSAC member). Color shading indicates wind speed (see color bar) and vector arrow indicates direction at each 4 km grid point location within the map domain.

FY07 Work Plan

The major elements of the CANSAC project work plan in FY07 include continuation of real-time products and product development per OAG recommendations, further development of a real-time verification system, refine NFDRS products as appropriate, develop prototype fire behavior products and capitalize on relevant research opportunities as they become available. The real-time verification system updates will include time series of forecasts versus station and sounding observations. Fire behavior products will be a product of MM5 ultra-high resolution wind field grids for input into FARSITE or FlamMap.

Task Order 13: Understanding Drought for Interagency Fuels and Fire Business (Sponsor: National Interagency Fuels Coordination Group)

Task Order 13 began 1 September 2003 and is intended to be a multi-year project. The specific task elements for this year's 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.

Specific task elements and accomplishments for this Task Order during the reporting period are given below.

Task element 1: Develop NARR climatology. Using gridding methods for NFDRS previously developed at the Missoula Fire Lab and from the Task Order 9 project of producing gridded national forecasts of standardized ERC, a daily climatology of ERC for NARR data period (1979-2005) will be developed. Relevant climatology information from NARR will also be extracted and a database generated in association with task elements 1) and 2) in Task Order 14 in conjunction with the escaped burns and fuels management business thresholds, respectively, and task element 3) below.

Accomplishment: The North American Regional Reanalysis (NARR) dataset has become very beneficial for several CEFA projects. It is being used extensively for Task Order 17, which is estimating missing RAWS data and creating a gridded RAWS-like dataset for the FPA project (see below). Based upon this work, it was thought that NARR could be successfully used to create some climatology information relevant to fuels management.

The National Centers for Environmental Prediction (NCEP) NARR is a long-term dynamically consistent high spatial resolution and high time frequency atmospheric and land surface hydrology dataset for the North American domain (Figure 6). NARR incorporates data from rawinsondes, dropsondes, pibals, aircraft, selected surface stations and geostationary satellites, and high-resolution data from a variety of other sources such as the NCEP / Climate Prediction Center (CPC), Canadian and Mexican precipitation network including modeled data from the Parameter-elevation Regression on Independent Slopes Model (PRISM). Output is available for numerous surface and upper-atmosphere variables at 3-hourly time intervals over a 32-km spatial resolution beginning in late 1979 to near present.

The development of a NARR ERC climatology dataset is collaborative with Dr. Matt Jolly at the Missoula Fire Sciences Laboratory. NARR surface variables of temperature, relative humidity, wind speed/direction and solar radiation were extracted from the full dataset and shipped to the Fire Lab. These values were input into a version of NFDRS modified to work on a grid. Fuel model G was used in the calculations. The Nelson model was used at sub-daily intervals to track temperature and humidity at the fuel interface and thus provide a surrogate for fuel moisture. The growing season index (GSI) was used as a surrogate for green-up date.

NARR was used to generate a 26-year (1980-2005) daily climatology of the energy release component (ERC) on a 32-km grid for the domain shown in Figure 7, which shows an example ERC climatology map for July 1. Note that because of the area covered, Alaska and Hawaii are also included in the analysis. An initial qualitative assessment of the climatology has indicated very realistic results; that is, high and low values of ERC where they would be expected, and realistic characteristics of the annual cycle of fire danger. The next section discusses more formal validation of the data.

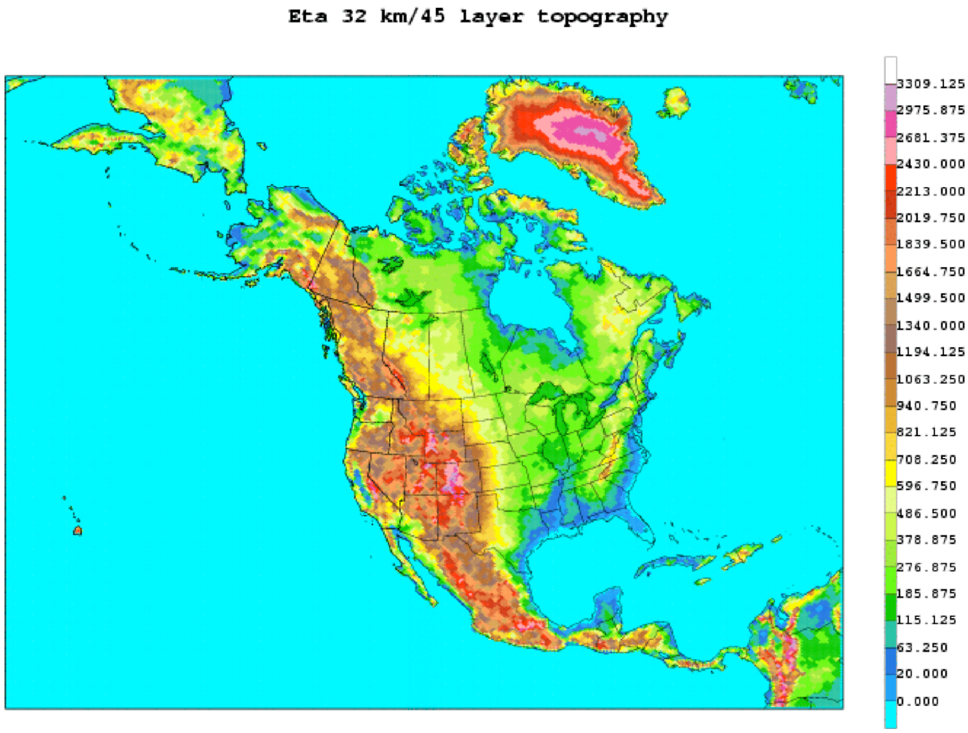

Figure 6. Map of the NARR spatial domain based up the terrain used in the model. Color bar denotes elevation in meters. (Map source: http://www.emc.ncep.noaa.gov/mmb/rreanl/)

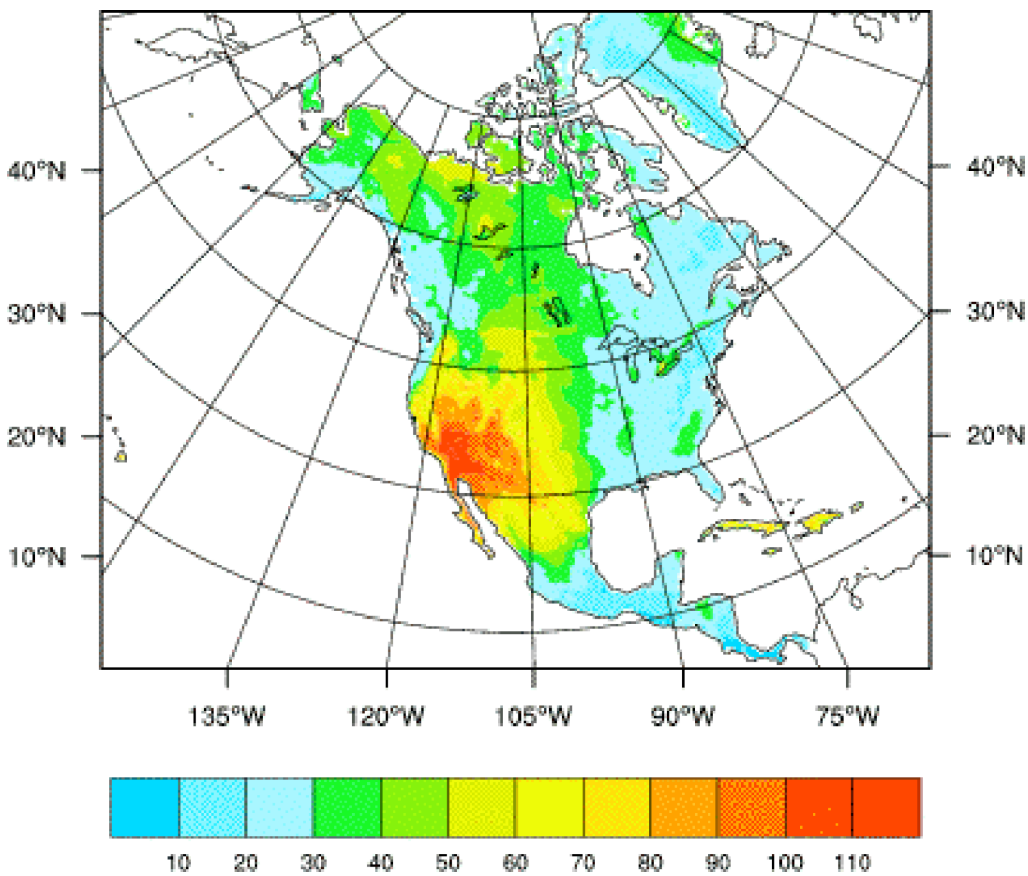

Figure 7. Example NARR ERC-G climatology map for July 1 based upon the 1980-2005 historical period.

Task element 2: Analysis of gridded NARR data. Once the climatology has been developed, statistical analysis will be undertaken to examine temporal and spatial patterns of the relevant variables including ERC and soil moisture. The purpose of this analysis is to provide quantitative information to fuel and fire managers regarding regional variability and patterns of climate factors directly impacting fuels during the past 25-year period. This information will be useful for strategic fuels management planning.

Accomplishments: The validation of ERC based on the climatology is on-going. Initial quantitative validation of RAWS ERC station data compared to NARR at co-located grid points indicates occurrences that are well matched, but for other locations there appears to be a bias in NARR of about 20 ERC units. To begin to address these differences, a correlation analysis was performed at the hourly, daily, 10-day and 30-day time scales for temperature, relative humidity, wind and precipitation.

Figure 8 shows box plot distributions of correlations between approximately 600 RAWS and corresponding NARR grid points. The box represents the middle 50% of the data distribution, and the line through the box indicates the median value. The dashed lines extend to the maximum and minimum values. For all variables, the correlation improves with longer time periods. Key findings of this analysis include:

1. Hourly surface temperature has a correlation of over .90 for most locations across the US.
2. Hourly surface relative humidity has a correlation of over .70 for most locations.
3. Hourly wind speed has a correlation over .10 for most locations. This is considered to be poor; however, the actual difference in wind speed is often less than 5 mph at the hourly time scale.
4. 3-hour accumulated precipitation totals have a correlation over .25 for most locations. Though this is considered to be poor, compensating methods such as binning the precipitation from NARR into controlled amounts (e.g., 0.0”, > 0.0” and <0.1”, etc.) shows promise of increasing the correlations to over .65.

Incoming solar radiation is an important parameter that can be used to determine state of the weather. Future work is planned that will determine the correlation between NARR and RAWS downward short-wave radiation.

Task element 3: Burn/air quality windows. Burn windows based upon fire environment (weather and fuel moisture) thresholds are determined for every prescribed burn event. However, for many locations, air quality standards must also be considered for a go/no-go burn decision. An air quality district or agency typically makes this decision based upon criteria that they have established. There are numerous instances when the fire environment and air quality burn windows do not sufficiently overlap, leading to missed target goal opportunities among other frustrations. This task element will initially focus on the southeastern U.S. for which a climatology of fire environment and air quality burn windows will be computed utilizing the gridded NARR data, station data and agency threshold input. This information will be provided to the agencies and assessed in terms of its effectiveness as a decision-support tool in burn planning.

Accomplishments: A prototype web page and analysis system was developed to provide a decision maker with climatological information relevant to threshold inputs associated with a particular burn. For example, a burner would select a RAWS, enter threshold values for temperature, relative humidity and wind, then select desired output values including climatological number of burn window days per year, standardized departures from average, average burn days per month, variability of burn windows by month, and a 7-day forecast for the burn window based upon data generated for Task Order 15. This system is still under development, and will require user input and testing. Figure 9 shows an example of the web form developed for threshold input.

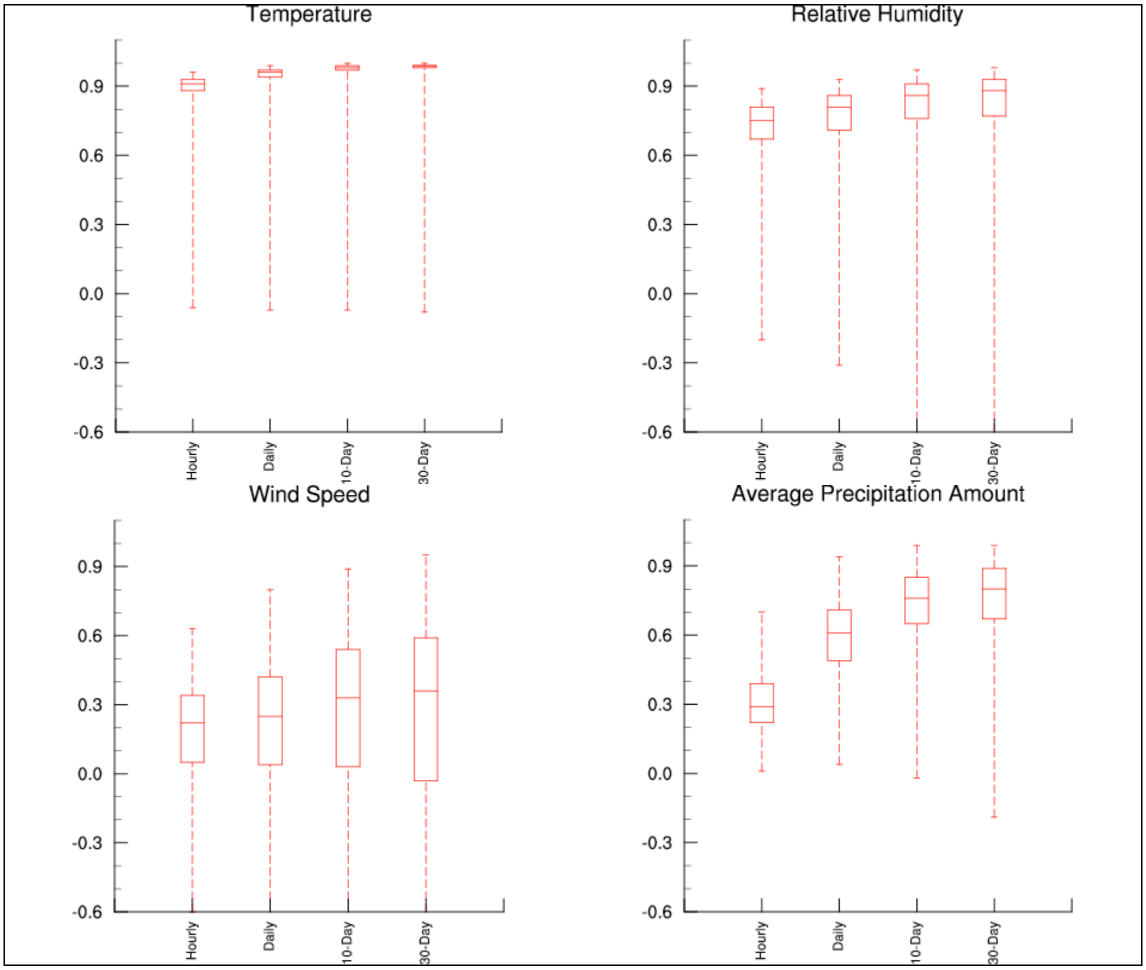

Figure 8. Box plots showing the distribution of correlations among 591 RAWS stations with the nearest grid value from NARR.

Another component of the burn window analysis is to compare fire environment thresholds to air quality agency thresholds in terms of overlaps and opportunities based upon historical climatology data. For example, an air quality agency might use mixing height and 850 mb winds as critical determinants of smoke transport, and the burning agency would have a set of surface thresholds based upon temperature, humidity and wind. The analysis is to take these known values, and determine from historical surface and upper-air data how often and during what times of the year do all of these thresholds overlap.

The original task element indicated that the southeast U.S. would be the initial focus location; however, Yosemite National Park managers have expressed a direct interest to have a similar analysis done for their area. Thus, it was decided to focus on this area first, and then perform a similar analysis for the Southeast. Both of these regions are of particular interest due to their aggressive prescribed burning programs and air quality issues. This work is currently in progress.

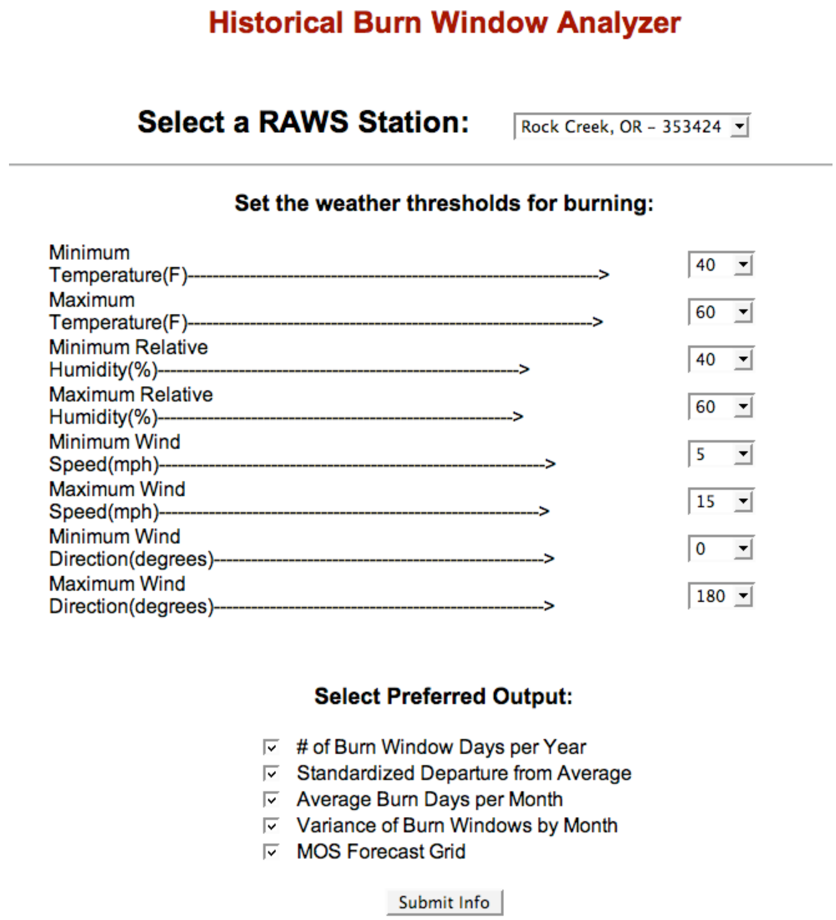

Figure 9. Example snapshot of the prototype web page where a user can select a RAWS site and meteorological parameters in order to assess the frequency and distribution of how often these events historically occurred.

<u>*Task element 4*</u>: Prepare report.

<u>*Accomplishments*</u>: Upon completion of the task elements, a report will be prepared. A conference proceeding paper for the American Meteorological Society 14th Symposium on Meteorological Observations and Instrumentation was prepared describing the correlation analysis with NARR and RAWS surface values. The presentation associated with this paper will be given in January 2007. It is anticipated that a journal paper will be prepared related to the ERC climatology work. From the previous year's work of creating a high-resolution gridded climatology of SPI and PDSI indices, a Master's thesis was completed, and a journal paper was accepted in the International Journal of Climatology.

<u>*Deliverables*</u>

The primary deliverables for this reporting period include 1) a gridded ERC climatology database; 2) a climatological analysis of burn windows for selected regions; 3) a web-based system for accessing climatological burn window statistics. The gridded ERC climatology will be available following completion of the validation work. The web-based burn window system will need to be user tested before it can be fully utilized. The climatological analysis of burn windows for the two regions is in progress.

Future work

The project is planned to continue in FY07. The next phase of the project will focus on analyzing the ERC climatology in terms of fire danger statistics, trends and relationships to climate factors such as sea surface temperatures and atmospheric indices. This latter analysis will determine areas in the U.S. that may have monthly to seasonal fire danger predictability based upon forecasted climate factors. Continued work is also planned that will relate the high-resolution gridded precipitation index dataset produced last year to wildfire and prescribed burning data.

Task Order 14: Role of Climate in Fuels Management (Sponsor: NIFCG)

Task Order 14 began in January of 2004 and is intended to be a multi-year project. The primary purpose of this project is the linking of climate to vegetation and fuels management business. Thus far, this project has focused on assessing utilization of climate information, examining how climate and fuels management business might be linked and developing a prototype escaped burn index.

The initial work performed under the Task Order included a survey of how prescribed fire managers utilized climate information for prescribed fire decision-making. The additional tasks performed under this Task Order included a survey of how Wildland Fire Use (WFU) fire managers utilize climate information for development of a WFU fire prediction system, an exploration of escaped prescribed fires in California to assess the role of wind events in facilitating escapes and further development of tools designed to assist fire managers in making decisions about fire use.

Specific task elements and accomplishments for this Task Order during the reporting period are given below.

Task element 1: California escaped burn index. This task element follows-up on work undertaken during the previous project year. It is hypothesized that east wind events all along the western Sierra range in California (not just Santa Ana winds) are a critical element for escaped burns. A predictive model for east wind events (based upon statistical relationships between weather, fuel moisture and known escaped burns) will be developed. Expected output includes relevant maps and tables showing thresholds for fire danger ratings and associated fuel moisture thresholds in conjunction with escaped burns.

Accomplishments: The goal of this project is to determine if there was a distinctive change in weather elements prior to the escape of a prescribed burn for some cases in northern California. A small database based of escaped prescribed fires has been developed based upon fire type coded within the federal wildfire occurrence database. Developing this database has been problematic, because records of escaped prescribed fires are poorly kept and difficult to separate from the federal fire database.

Thus far, 25 escaped fires have been identified for the 1990 through 2000 period that had a RAWS station within 0.1 degrees of its discovered location. The discovery time (which was assumed to be the escaped time) was used to collect weather data hours leading up to the escape. Several fires show a distinctive change in wind speed and direction for one to three hours prior to the escape. The original theory put forth by Northern California Predictive Services was that east wind events play a significant role. It is interesting to note that since Santa Ana winds in southern California clearly impact fires in this region, east winds may be an important factor all along the California Sierra Nevada. It is also of interest to use NARR data in assessing general weather patterns for these events. The analysis of comparing NARR and RAWS (see Task Order 13) has shown that this dataset will be useful for this analysis, but NARR might be temporally too coarse. Upper-air data from NARR will also be utilized to analyze synoptic scale circulation patterns. This work is in progress.

Task element 2: Climate-fuels management business thresholds. Build a database of prescribed fire events that includes date, location, management objectives and fuel model. The southeastern U.S. will be one of the focus areas; however, data from other locations will be collected. It is of interest to collect data from all federal fire agencies in the region. NIFCG may provide guidance as to specific locations of interest. This is not meant to be a comprehensive database at this time, but a sufficient one to relate burns and climate conditions and build upon with the addition of other locations. Once the database is constructed, the burn information will be correlated with several climate indices to determine the background climate conditions leading up to and at the time of the initial burn. This effectively establishes a climate index that can be directly related to fuels management business given management objective and fuel model.

Accomplishments: The development of prescribed fire thresholds in relation to climate is still in progress. The first component of this task was to collect prescribed fire records for the entire southeastern US, the region that implements the most extensive prescribed fire planning each year. Federal prescribed fire records in this region were obtained and organized in a database. State records of prescribed fire have been more difficult to obtain due to two factors:

1. Winter 2005-2006 saw one of the worst wildfire seasons ever experienced in the southeast. Fire managers and personnel in this region were difficult to reach during this period, and the winter fire season transitioned straight into the western fire season.

2. The majority of prescribed fire in the southeast is performed on state lands, and some state and local level records are kept, but not in a digital format. Some state paper records have been obtained, but need to be digitized. It is anticipated in FY07 to collect more state data, and have it digitized so that the analysis can be more complete.

Task element 3: Climate-Wildland Fire Use survey. Similar to the prescribed fire survey undertaken as previous work on this project, a formal fire use survey will be developed and implemented nationally, directed towards the fire use community. Survey questions will focus on climate data and information issues relevant to planning and implementation of fire use activity.

Accomplishments: This task element was a major component of the work completed during this reporting period. The WFU survey was designed based on the results of the Prescribed Fire Survey completed in FY 2005. The survey asked 26 questions to determine: 1) how much educational and professional experience WFU fire managers draw upon; 2) the extent of their pre-season planning for WFU fire potential; 3) how climate information is or is not utilized for WFU Risk Assessments; 4) general management of WFU fires; and 5) what external influences impact the decision to convert a WFU fire to a full suppression incident. The University of Nevada-Reno Human Subjects Committee approved the survey for implementation. The survey was administered to 31 WFU fire managers from the four federal agencies that currently participate in the national WFU program (BLM, NPS, USFS, USFWS). The WFU coordinators for each agency were contacted and asked for recommendations of individuals who had experience managing WFU fires (i.e., they had participated in WFU fire management for at least 2-3 years and had sufficient experience to draw upon). Agency coordinators recommended 50 individuals total, resulting in a 62% response rate for the survey. The respondents represented nine western states (Alaska, California, Colorado, Idaho, Montana, Oregon, Utah, Washington, Wyoming), as well as Tennessee and the Great Lakes Region. This dispersion is consistent with the spatial frequency of WFU fires, with the exception of Arizona and New Mexico. The exclusion of the southwest region was due to fire managers' failure to respond to the survey, as the timing coincided with an active 2006 WFU year for this region. Some the survey results are summarized below.

Five questions were asked to determine the level of expertise in WFU (both professional and educational) of survey participants. On average, respondents had 25 years of general fire management experience, with an average of 12 years in WFU fire management (Prescribed Natural Fire management experience, the precursor to WFU, was included in this total). Respondents were also asked to estimate the total number of WFU fires they had played some management role on. Only four respondents (13%) had worked fewer than 10 WFU fires, while the average estimate of WFU incidents managed was 40. Six respondents (19%) estimated that they had managed over 100 WFU events. Over half (52%) of the respondents are Fire Use Managers (FUM1)-qualified in the Incident Command System, while 42% are FUM2-qualified. Only eight (26%) of the respondents had taken any advanced climatology education or training. The group of respondents, therefore, might be characterized as having a high level of expertise, but the expertise is attributed primarily to professional experience and longevity of the individuals in the WFU programs. It should be noted that over half of the respondents indicated that they were originally trained in WFU management at one of the two long-running WFU programs in the Northern Rockies region: the Selway-Bitterroot Wilderness and the adjacent Frank Church/River of No Return Wilderness.

Seven questions were asked to determine how much pre-season planning occurs with regards to WFU. Almost all respondents (94%) indicated that they meet with their Fire Use Management Team, both locally and nationally where applicable, prior to the start of the fire season to discuss current conditions and how those conditions may impact the potential to use WFU. Respondents indicated that the tools and products they utilize most to help them assess conditions include Seasonal Assessment Outlooks from Predictive Services (87%), the Keetch-Byram Drought Index (65%), the Palmer Drought Indices (74%), historical data (94%) and other tools from the Wildland Fire Assessment System (WFAS) website (65%) (Figure 10). Respondents were also asked the relative importance of information on climatological factors such as the El Niño Southern Oscillation, drought, pluvial events and anomalous conditions in the pre-season planning stages. Most respondents (74%) indicated that climate information was very important to them for assessing WFU potential, while 23% felt that it was somewhat important. Only one individual did not feel that climate information was important for WFU planning.

Fourteen questions were asked relating to management of WFU fires with regards to utilization of climate and weather information at various stages of the event. During Strategic Fire Size-up, 90% of respondents consider the current climatic conditions to help them make decisions. Respondents were specifically asked about the importance of climate conditions in designating the Maximum Manageable Area (MMA); 48% indicated that climate conditions are very important in designating the MMA, 39% felt that climate conditions are slightly important, and the remaining 13% did not think information on climate conditions was important or should be utilized in designating the MMA.

The Federal Wildland and Prescribed Fire Management Policy Guide states that once a WFU event has progressed to Stage III (long-term planning), a Wildland Fire Relative Risk Assessment must be completed. Three specific components of this Risk Assessment address climatic influences on fuel conditions and resulting fire risk. WFU managers must determine Probability Levels for Time of Season (whether the incident is occurring in the early, middle, or late part of the fire season), Probability Levels for Seasonal Severity (whether severity conditions are low, high, or extreme) and the type of drought that is currently being experienced (this is a component of the Probability Levels for Seasonal Severity). For each of these three components, respondents were asked what information sources they find most useful or utilize most frequently to complete these sections of the Risk Assessment.

To determine Probability Levels for Time of Season, respondents reported that they utilize several sources of information with local knowledge (52%), historical data (48%) and the Energy Release Component (ERC) (39%) being the most frequent answers given. ERC (65%) is also the most utilized information source for determining Probability Levels for Seasonal Severity, followed by historical data (29%) and the Burning Index (BI) (29%). PDSI (45%) is the most utilized resource for determining the type of drought currently being experienced, followed by KBDI (42%), Predictive Services forecasts (23%) and BI (23%).

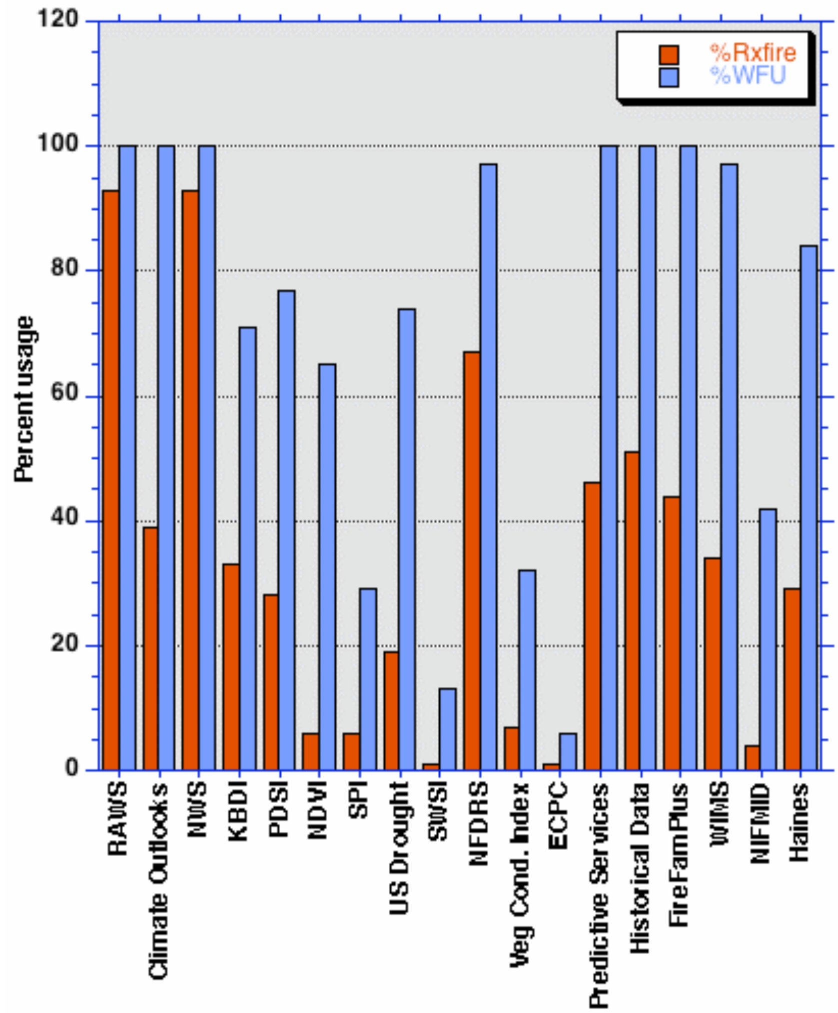

Figure 10. Percentage use of climate related information for WFU planning.

Respondents were also asked about specific resources that are widely used in fire management and are available to help with assessing current conditions. First, respondents were asked if they collect fuel moisture samples on WFU fires. One-, ten- and hundred-hour fuels are regularly collected by 52%, 55% and 45% of respondents, respectively. Thousand-hour fuels are collected by 77% of respondents. Live herbaceous fuel moistures are collected by 74% of respondents, while 65% collect live woody fuel moistures as well. Second, fire managers were asked if they use a variety of resources to assist them with making decisions about and management of WFU incidents. Several resources have a 100% use-rate among respondents (RAWS data, Seasonal climate forecasts, National Weather Service forecasts, Predictive Services forecasts, Historical weather data, FireFamilyPlus and Local Knowledge), while seven additional resources had high (>70%) rates of use. These included NFDRS indices (97%), Seasonal severity maps (87%), the Haines Index (84%), PDSI (77%), the US Drought Monitor (74%) and KBDI (71%).

Finally, respondents were asked two questions about a wider range of external influences that impact WFU decision-making. First, they were asked to rank the top influences on WFU decision-making, particularly with reference to the MMA designation and management actions taken. Figure 11 shows the percentages of the impacts for the top two responses combined. For example, a 68% for political climate would mean that 68% of the respondents has politics as one of their top two impacts. Over half (52%) of the respondents indicated that public input and the local political concerns (both within the agency and in the locality) have the greatest impact on management of WFU. The second most cited influence on WFU management was the location of the ignition and the time of year. Several respondents noted this as a reference to both physical conditions (i.e., spatial location, climatic conditions, seasonality) and political conditions (i.e., impacts to communities, whether there are multiple WFU events or suppression wildfires already going and resources are unavailable). Second, respondents were asked about reasons why a WFU event converts to a suppression incident. The primary reason cited by respondents was that the fire exceeded the MMA (58%).

In comparison to the results of the Prescribed Fire Survey administered in 2005, WFU fire managers are able to better utilize climate information for planning and decision-making on WFU incidents. This stems from their vastly greater experience in managing WFU fires and fewer political obstacles to using WFU, as compared to using Prescribed Fire. WFU managers have a better overall understanding of climate impacts on WFU, and the majority expressed a desire to have even more tools available to them for assessing climatic situations and the potential for WFU. This desire for more tools is partly due to the lack of standardized tools targeted specifically to WFU management, but also based on their own acknowledgement of the role that apprenticeship and the oral tradition has played in the training of WFU managers. A few respondents actually noted that they regularly consult the retired personnel that founded the early WFU programs, and they will lose an immense resource in the near future when these personnel are no longer accessible.

Task element 4: Educational material. The technology transfer component is critical to making fire and fuels managers aware of how climate influences their prescribed fire and fuels management programs, and how they can better utilize available climate information and decision-support tools to meet management objectives. This task element continues with work undertaken in FY05. Depending upon the intended audience, deliverables may include written material (e.g., white papers, Fire Management Today) and presentations with handouts.

Accomplishments: CEFA hosted the Nevada Wildland Fire Research and Outreach conference in May 2006 and hosted two workshops to introduce fire and smoke management professionals to CANSAC (with numerous attendees coming from prescribed fire management and being introduced to CANSAC tools for prescribed fire planning) (see Task Order 10). CEFA personnel presented climate related project information at two professional conferences for fire managers and to a group of local forest managers in Reno. A detailed report is being completed specifically on the results of the Prescribed Fire and WFU surveys completed by CEFA as part of Task Order 14. This report will be sent to all survey participants and made available on the CEFA website to the public. CEFA is also completing journal articles and management literature detailing the importance of using climate information in fire use planning and implementation.

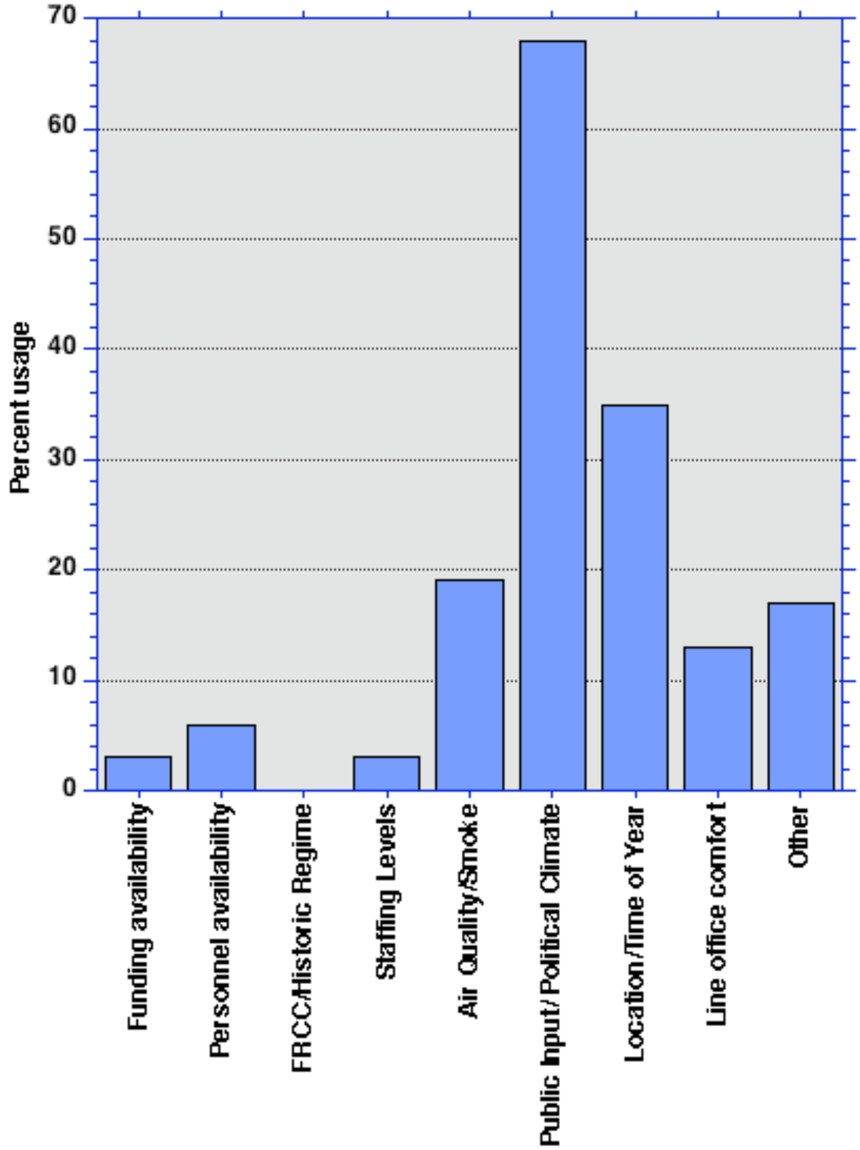

Figure 11. Percent of factors indicated by the respondents that impact WFU decision-making based on the top two influences from the categories listed in the Figure.

Task element 5: Prepare report.

Accomplishments: Upon completion of the task elements, a report will be prepared. Results of the survey were presented to the National Interagency Fuels Coordination Group in September 2006.

Deliverables

A prescribed federal fire database from the Southeast has been developed; however, it is desirable to expand this with digitized state records. Though some effort has been undertaken in relating the current database to precipitation indices, further analysis is necessary to complete this task element. Analysis of the key factors associated with escaped burns in

California is also in progress. Outreach completed during this reporting period was described in the previous section.

Future work

The project is ongoing in FY07. Increasing the prescribed fire database and completing the escaped burn index analysis will be carried over from FY06. FY07 emphasis will be placed on relating the prescribed fire database and some WFU fires to climate indices. Production of educational material will continue. In relation to outreach, DRI in considering hosting a workshop on climate data and information for Long-Term Analysts (LTANs).

Task Order 15: Development of Model Output Statistic Products for the Predictive Services Group (Sponsor: National Predictive Services Group)

Task Order 15 is for the period 14 June 2005 through 6 June 2010. This project logically follows Task Order 11 that produced RAWS model output statistic (MOS) data for California and Rocky Mountain Predictive Services in support of the 7-day fire potential product. In the original Task Order 15, the MOS project was expanded to include the Northern Rockies, the Western Great Basin, the Southwest and the Southern area Predictive Services group areas. In August 2005 a modification of this Task Order was developed to provide partial support for the Eastern area Predictive Services. Further funds are anticipated in FY07 to complete the Eastern area and Alaska.

The primary objectives of this project are to: 1) develop RAWS-MOS equations for all of the remaining GACCs excluding the Pacific Northwest and Eastern Great Basin areas where they have developed their own MOS equations; 2) provide operational output of RAWS-MOS forecasts via electronic transmission and web interface; and 3) continue to provide operational gridded output of GFS model fields that were determined in Task Order 11. The project is a collaborative effort between CEFA, Southern California Predictive Services (SCPS), and each GACC that the product is being done for. Specific task elements from the original Statement of Work (SOW) include:

1) Development of RAWS-MOS equations based on GFS model output. Methods used in Task Order 11 will provide the framework for statistical regression techniques utilized in developing the equations. However, one change from the previous work is that GFS output will be transformed to a fixed predictor grid that will allow other models (e.g., Eta) to potentially be used in the MOS process. Historical GFS and RAWS data will be used for the 2001-2002 period to generate the equations. Cross-validation will be done on 2003 data. Analysis will be done for four GACCs with priority given as: 1) Northern Rockies; 2) Southwest; 3) Western Great Basin; and 4) to be determined by NPSG. The operational product will be comprised of 10-day forecasts from the GFS model. Validation on wind speed and direction, 10-hour fuel, BI and IC will be undertaken if time permits. Validation priority will be given to temperature, relative humidity, 100-hour fuel moisture, 1000-hour fuel moisture and ERC. The remaining elements will be examined in detail if project funding resources are available after the priority work is completed or new funding is available to the project. This task element requires interaction and feedback from the agencies in regards to the validation and operational testing of the equations. Specific predictand elements will include:
    - Maximum and minimum temperature, relative humidity and dew point. 00 and 12 UTC times will serve as proxy max/min model values.
    - 00 and 12 UTC wind speed and direction
    - 00 and 12 UTC 10-hour, 100-hour and 1000-hour fuel moisture.

- 00 and 12 UTC ERC, BI, and IC

2) Development of RAWS climatologies. Climatologies will be developed for all of the predictand elements. These will be used for task element 3 below.

3) Development of value-added products from the MOS type output. Forecast tables of value-added climatology information will be provided in the product output. These 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.

4) Prepare report. At the end of the project, a report will be prepared documenting the task element activities, products and deliverables.

This work is ongoing as of this reporting period. Details of how the regression equations were developed are given in the 2005 CEFA annual report. Additionally, that report provides validation results and a discussion on the development of RAWS climatologies and value-added products.

Accomplishments

The accomplishments for this reporting period include completing the sets of RAWS-MOS equations for the Western Great Basin, Southwest Area and Southern Area. The remaining areas to be completed include Eastern, Southern, Eastern Great Basin and Alaska areas. A brief overview of the steps taken to produce equations for each area include:

1. Get list of RAWS sites from the GACC
2. Retrieve RAWS data and determine those sites having enough data between 2001-2002 to develop the equations
3. Retrieve and match (temporally and spatially) GFS model data from 2001-2002 to RAWS locations and observations
4. Pre-process RAWS and matched GFS data for regression analysis in S-plus
5. Run S-plus regressions
6. Check results of regression analysis and cross-validate forecasts using 2003 data
7. Once confident that forecasts are performing reasonably, make them operational

Figure 12 shows example output for a RAWS-MOS forecast.

Report

A report will be prepared at the end of the project describing equation development and cross-validation results.

Deliverables

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

The forecast tables of actual values are sent electronically daily to each of the respective Predictive Services areas that are completed. This information is then used as part of the input to construct the 7-day significant fire potential product. Figure 13 shows an example of the product from Southern California Predictive Services. The color box shows fuel dryness for each of the forecast days for each Predictive Service area (see map and legend at right). Also shown are significant weather triggers and “high risk” days if relevant. A weather synopsis, fire potential discussion and California Weather Coordination Group (CWCG) preparedness level for the issue day are given in text format.

RAWS-MOS twice-daily forecasts are available online at http://cefa.dri.edu/Operational_Products/MOS/txtmosfcsts.php/. The 7-day significant fire potential product is available at each GACC Predictive Services website.

*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 12. Example forecast output from MOS equations. 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.

Future work

This project will continue through FY07. The lifetime of the project is through September 2010, so that any new equations can be developed as needed or problematic RAWS equations addressed. It is anticipated to complete equations for the Eastern, Southern, Eastern Great Basin and Alaska areas in FY07. The Canadian Fire Weather Index will be included for Eastern and Alaska areas.

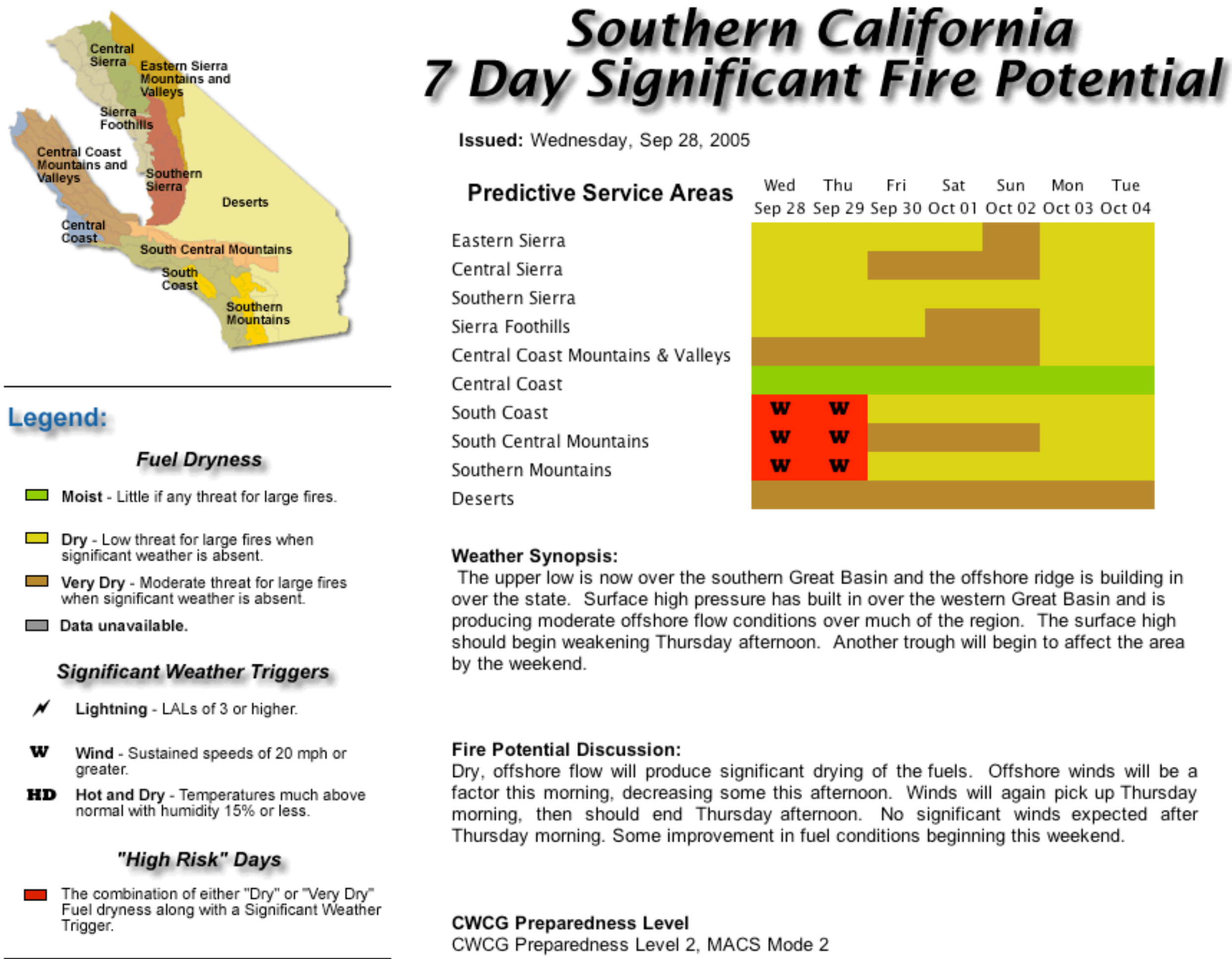

Figure 13. Example output from the Predictive Services 7-day significant fire potential product.

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

The Western Regional Climate Center (WRCC) manages this project in collaboration with and funding from the BLM-Idaho State Office utilizing the Assistance Agreement. The report in this section was provided by WRCC.

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 report here is 1 June 2005 – 30 September 2006. The task elements and accomplishments for this reporting period are:

Task element 1: Continue to develop and improve a system to automatically parameterize an Agriculture Research Service (ARS) plant growth model using daily weather data available at WRCC and typical soil and plant characteristics that is provided by the ARS and BLM-Idaho.

Accomplishments: Profiles of RAWS sites continue to be added to the web pages. Sites without existing profiles may be added by user input. Currently 11 sites have listed parameter descriptions. Sources for parameter descriptions of other stations have been identified primarily from Natural Resources Conservation Service (NRCS) web databases. Additional sources include local soil profile descriptions for some portions of Idaho where no NRCS survey has been done.

Task element 2: Continue to develop and improve 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; and typical soil types for at least five soil types.

Accomplishments: The web-based interface is currently available at [http://www.raws.dri.edu/rangetek.html].

Task element 3: Continue to develop numeric and graphical displays of the model's output.

Accomplishments: The numeric and graphical displays continue to be developed. These tools have also been valuable in finding and correcting data and programming errors. Several basic coding differences have been identified and corrected. Figures 14 and 15 show example numeric output from Rangetek for Horse Butte, Idaho.

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.

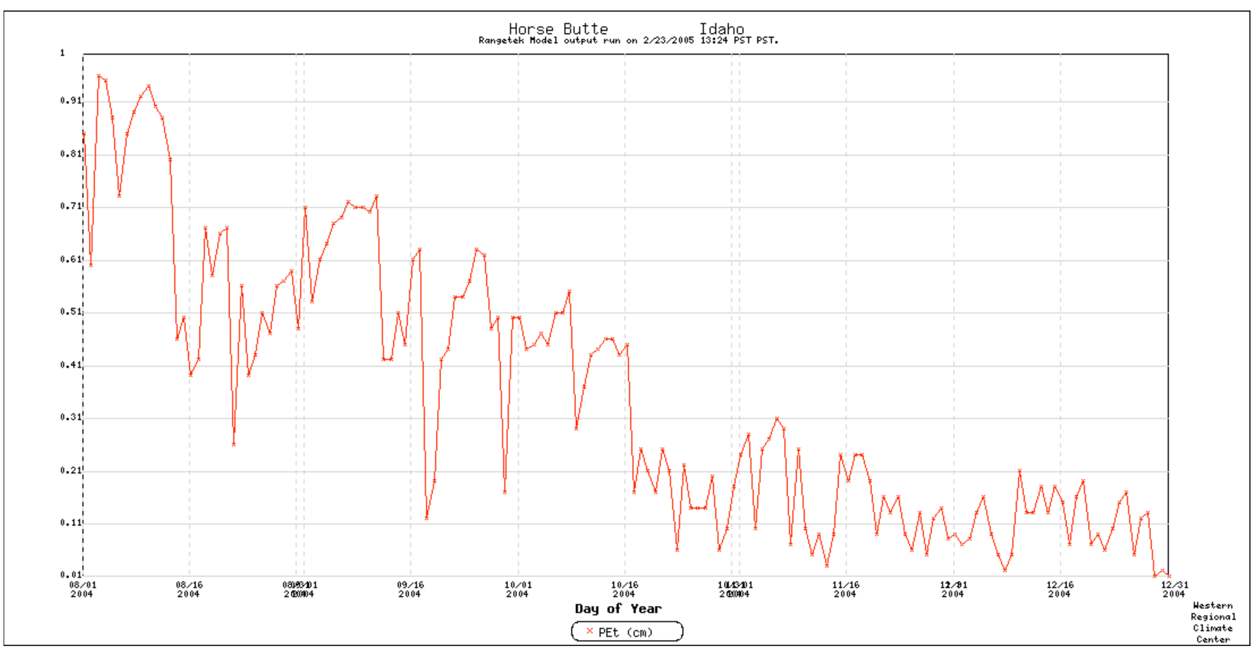

Figure 15. Example graph of potential evapotranspiration from Rangetek calculated output for Horse Butte, Idaho.

Task element 4: Develop flexibility in the system that will allow generated weather information to provide simulated output for lower, normal, and higher-than-normal precipitation.

Accomplishments: The 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.

Task element 5: Work with representatives from the ARS, BLM-Idaho, and NIFC to develop recommendations for refinement of the system.

Accomplishments: ARS provided minor coding improvement recommendations. BLM staff assisted in identifying sources for soil information (WRCC staff visit to the BLM-Idaho State Office). WRCC staff has been developing soil parameter files for approximately 150 western RAWS. WRCC has received interest from the Arizona state climatologist regarding implementation of the Rangetek program for Arizona.

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) was 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. Howard Roose, from BLM, is the FPA Business Team Lead and is CEFA's project coordinator. This report period represents Phase III of the project, which combines two Task Order modifications, and includes the primary objectives:

- Objective 1. 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.
- Objective 2. Build a web-based delivery system and user interface for the project Phase II qc'd and estimated dataset.
- Objective 3. Set-up the qc and estimation process in a quasi real-time mode to provide frequent updates to the database.
- Objective 4. Build upon and enhance the project Phase III work by performing additional validation analysis of the regional reanalysis dataset, allow for additional updates of the FPA weather dataset, provide for maintenance of the automated update system, add additional features to the web data interface.
- Objective 5. Perform an analysis to determine the feasibility of providing NIFMID type format for each regional reanalysis grid point.

Accomplishments of original task elements were provided in the CEFA FY04 and FY05 annual reports. Information regarding analysis and validation methods is provided in those reports.

Accomplishments from previous task elements carried over into FY06

A few tasks not finished in the previous year were completed during this reporting period. These include:

1. Completed hourly station processing for over 1100 hourly RAWS
   a. Used station start date; the final station processing will begin with 1980
   b. Delivered Feb 2006 in the fwx, fw9 and dat formats

2. Improved precipitation and state of weather (SOW) algorithms
   a. These were simplified by using data bins for precipitation and 0/3/6 for SOW. It is planned to do further analysis with these two fields

The task elements and accomplishments below refer to the FY06 Task Order modifications:

Task element 1: ACIS database: The final RAWS FPA qc'd and estimated dataset will be transferred into the Applied Climate Information System (ACIS) at the Western Regional Climate Center (WRCC). ACIS is a software and data structure framework for housing climate and weather datasets for both internal and public access. This task element will require script programming and database management.

Accomplishments: The initial FPA RAWS hourly dataset was converted into the ACIS database system. This system allows for more efficient data retrieval and processing. All of the planned FPA datasets will be put into the ACIS system.

Task element 2: Web-interface: To allow user access to the database, a web-based interface will be developed utilizing relevant software code. The usability of the interface will be developed and tested with a small number of FPA representative users to be determined.

Accomplishments: A web-interface was developed to allow FPA users to access the hourly data. Figure 16 is a screenshot of the data access homepage.

Task element 3: Develop update system: The qc and estimation software used in developing the phase II database will be programmed to operate in a quasi real-time mode. FPA will provide requirements for an appropriate update schedule.

Accomplishments: The automated update system will be developed after all of the initial hourly station and gridded data runs are completed.

Task element 4: Implement update system: The update system will be implemented at WRCC. Software will be set-up at WRCC that allows the qc and estimation programs to run on a Climate Center server that accesses both the regional reanalysis data and RAWS archive, performs the qc and estimation process, and then updates (appends) the master FPA RAWS database. The system will be refined for several months following implementation, and the web-based user interface will be modified as appropriate or recommended by the FPA user community.

Accomplishments: The automated update system will be implemented after all of the initial hourly station and gridded datasets are completed. The automated system will update these datasets on a time schedule to be determined (e.g., weekly, monthly, quarterly).

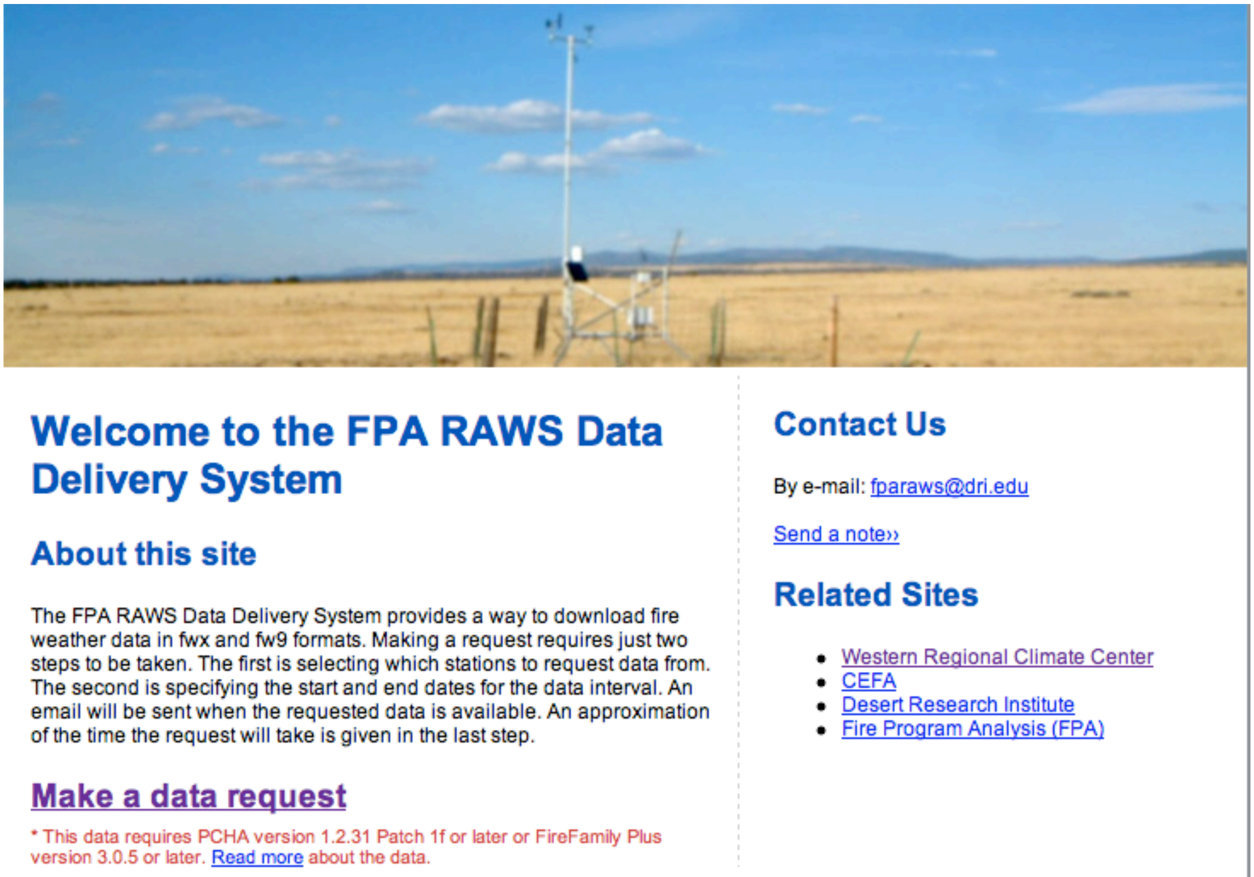

Figure 16. Homepage of the WRCC FPA data access page.

Task element 5: Additional NARR validation: The North American Regional Reanalysis (NARR) dataset is the primary tool for providing estimates of RAWS missing values. While considerable validation work has been completed, especially for temperature and relative humidity, additional work is needed on developing satisfactory statistical equations for estimating precipitation and state of the weather. Improved statistical estimation equations will be developed for these two weather elements.

Accomplishments: Even with the integration of the finer resolution NARR dataset, low correlations (< 0.5) were found to exist for wind speed and precipitation. Wind speed was later deemed to be not as critical since the actual difference in predicted versus observed wind speed values was usually less than 5 mph for most cases. Another concern was the estimation of the state of the weather (SOW) parameter that is necessary for most fire danger index calculations. Improvements were made for both the precipitation and SOW estimations through minimizing the number of categories or bins for each parameter's values. For example, instead of estimating actual precipitation amounts, ranges of amounts were identified (e.g., ppt=0.0, 0.0<ppt≤0.02", etc.). For SOW, the traditional 10 categories (e.g., clear, scattered, rain, snow, thunderstorms, etc.) were reduced to three categories (clear, overcast, precipitating).

Correlations improved to over 0.7 on average after these adjustments were made. Further validation is planned.

Task element 6: Database updates: The purpose of the validation work is to improve the statistical equations that produce estimated values. The validation work will yield one or two updated datasets prior to the implementation of an automated system. This task element provides for resources needed for WRCC personnel to update the current database.

Accomplishments: All missing data for the hourly RAWS were estimated beginning with the station activation date through 2004. The hourly data will be re-run with the new algorithms for precipitation and SOW when completed for the period 1980 through 2006. This will provide an improved period of record for analysis (27 years) for each RAWS even if the station was recently installed. Once the hourly database is completed, algorithms will be developed for the once-daily manual RAWS stations. WRCC uploads the hourly data to their ACIS system when available from CEFA.

Task element 7: Web data delivery modifications: Modifications to the web delivery system are desired and anticipated once the FPA user community fully utilizes access to the weather data. Primary modifications include accessing lists of stations, such as adding the ability to select stations by FPU.

Accomplishments: WRCC has all of the FPA produced RAWS data stored in raw format. The data are accessible via the web (http://www.wrcc.dri.edu/fpa/. FPA data users can click on a Fire Planning Unit (FPU) to request a list of RAWS stations that have been processed in that area. Once stations are selected, users can select the data format of preference. The format options include the once-daily *.fwx and hourly *.fw9 formats commonly used in fire danger software. They can also select a comma-delimited text file that provides information on those values that were the original observations and those that were estimated. Along with the data files, the users also receive a metadata file for the stations they selected and a statistics file that indicates the percentage of estimated data for each station.

Task element 8: NARR grid analysis: This analysis is to determine the feasibility of producing NIFMID formatted data for each of the relevant NARR grids for the U.S. (including Alaska). The RAWS estimation process relates station data to NARR via statistical equations. Producing station data directly from the grid requires additional validation work with additional data, such as NWS and FAA stations. Correlations between stations and grid points will be assessed to determine the feasibility of utilizing all relevant grid points for FPA purposes.

Accomplishments: This analysis was discussed in Task Order 13 above. NARR has been a versatile dataset for several CEFA projects. Further grid validation and analysis will take place in FY07.

Task element 9: Production of grid cell data: If the analysis from task element 4 above is successful, NIFMID formatted data files for each relevant NARR grid point will be generated and stored in the WRCC database system. WRCC will modify the current web delivery system user interface for FPA weather data to manage these new data. If for some FPA/DRI-agreed upon reason the NARR grid point data cannot be generated in a useable manner for FPA, project funds will not be spent on this task element and with the possibility of returning these funds to the appropriating agency.

Accomplishments: Due to emphasis on the hourly RAWS portion of the project, this task element will begin in 2007.

Task element 10: Maintenance of automated update system: Under Phase III of this project, an automated update system will be developed and implemented. This task element provides for modest resources to maintain and update the system as necessary by WRCC personnel.

Accomplishments: This task element will be ongoing once the automated update system is implemented.

Deliverables

Data for each station was temporarily made available via DRI's anonymous FTP site. Notification of the data availability was made to Howard Roose and Susan Weber. A web site was developed in the spring of 2006 that provided data access. Data were provided in three separate text/ASCII formats. Data files ending with an .fw9 extension consisted of all hourly data in the 1998 WIMS data format. Files ending with an .fwx extension consisted of the once-daily values for 1300 LT in the 1972 WIMS data format. The third data file format has a .dat extension and was comma delimited including all values and flags indicating whether (1) the value was the original, good observation, (2) the value was estimated, or (3) the value was made missing because the algorithm failed after 20 hours OR the estimation was physically unreasonable (e.g., relative humidity well above 100%).

Final report

A report on the phase II activities will be prepared once all of the processing is completed.

Future work

This project has been long and extensive due to processing large datasets and developing sufficient algorithms to perform data estimation. Several tasks will be continued including processing daily and manual stations. A gridded dataset will be produced in FY2007. Also, real-time updates are expected to be implemented in FY07. Future work should include further validation of gridded data and the creation of gridded "station" catalogues.

C. OTHER PROJECTS AND ACTIVITIES

This section describes CEFA projects and activities that are not funded through the AA, but are of relevance to interagency fire and fuels management. Brief reports are provided below.

CEFA Infrastructure and Administration

CEFA was co-organizer of two Predictive Services Seasonal Assessment Workshops. The first of these was held in Sheperdstown, WV during 17-20 January 2006 (Eastern and Southern areas), and the second was held in Boulder, Colorado during 4-7 April 2006 (Western States and Alaska). These workshops brought together climatologists, Predictive Services 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 2007. See Crawford *et al* (2006) in the publication section for workshop report references.

In addition to the National Seasonal Workshops, CEFA conceived the idea to hold a North American Seasonal Workshop, bringing together fire representatives and climatologists from both Canada and Mexico. This workshop was held in conjunction with the National workshop and co-organized with Greg Garfin, Climate Assessment for the Southwest, Institute for the Study of Planet Earth, University of Arizona. The BLM/NIFC International office and the NOAA Regional Integrated Science and Assessments program provided travel support for international representatives. A draft North American fire potential map was produced at the workshop, but was considered for internal use only. A round-table discussion during the workshop produced a number of recommendations, concerns and issues, but overall the workshop was deemed a success. It is planned to hold this workshop again in conjunction with the Western workshop in April 2007.

CEFA continues to respond to agency questions regarding climate and meteorological data. CEFA responded to 17 data requests for fire occurrence and lightning information. CEFA responded to two media requests for fire climate related information.

CEFA maintains the national fire agency archive for lightning data. In conjunction with the new fire agency agreement with Vaisala, CEFA receives monthly 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 separate contract 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, and reported 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 as data are made available annually from NIFC.

Most of the significant computer hardware upgrades were related to the CANSAC server and Task Order 10. These upgrades included adding a 20 slot, one drive LTO2 tape drive, upgraded from 32 to 48 processors, upgraded from 80 to 96 GB RAM and changed the operating system from Redhat/SGI ProPack 2.4 to SuSE/SGI ProPack 4. 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 1,205 web pages, 128,492 graphics files, 134,555 miscellaneous files, and 7,493 web links totaling nearly 20 GB of information. The CEFA web site address is http://cefa.dri.edu/.

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

This work s a research contract with the USFS Pacific Southwest Research Station (PSW) related to Task Order 10 (CANSAC). 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.

Objectives for this reporting period include:

1. Implement the National Fire Danger Rating System code to compute fire indices from gridded weather input fields.
2. Perform fire danger climatological analysis to obtain index statistics necessary to obtain adjective danger rating corresponding to a computed fire danger index.
3. Incorporate a GIS web interface to display weather, fire danger and air quality products.
4. Evaluate accuracy of GIS interpolation methods to obtain weather variables.

Objective 1. NFDRS indices for energy release component, burning index, spread component and ignition component are being produced for the 00 UTC forecast run. Maps are available for both the 4 and 12 km domains. This product is considered experimental, and requires further validation analysis.

Objective 2. It is of interest to produce a gridded adjective fire danger rating using the same national scales – low, moderate, high, very high and extreme. The rating would be based upon the burning index. It is desirable to compute class breakpoints based upon percentiles from a gridded climatology. However, there currently only exists about two years of experimental gridded forecasts. Therefore, work is underway to use interpolated breakpoints across the grid from RAWS data.

Objective 3. The original plan was to implement the ArcIMS system to provide maps from the CANSAC output. While this might still be accomplished (more CANSAC group feedback is needed first), at present, a few select forecast maps converted to GIS layers are being produced and evaluated by the California Department of Forestry and Fire Protection. The maps include surface temperature, relative humidity and wind forecasts. The maps are being displayed at the USGS fire planning web site; http://wildfire.cr.usgs.gov/fireplanning/.

Objective 4. Evaluation of GIS interpolation methods is dependent upon the implementation of ArcIMS. If this occurs, then the analysis will be a validation of interpolating weather element values using GIS “built-in” interpolation methods compared to station observations.

CEFA Initiated CANSAC Research

CEFA is part of a Joint Fire Science Program project entitled "Tools for Estimating Contributions of Wildland and Prescribed Fires to Air Quality in the Southern Sierra Nevada, California". The objectives of the research project are:

- Expand existing local networks of air pollution monitors into a regional network useful for spatial modeling of ozone and particulate matter concentrations in the southern Sierra Nevada region.
- Develop and implement mobile monitoring systems to measure ground level pollutant production from multiple fires.
- Implement BlueSky dynamic modeling system for the southern Sierra Nevada using local topography, weather conditions and fire history.
- Develop a statistical model to evaluate the BlueSky model as a forecasting tool for particulate matter from fires and to estimate the precision of its outcome.
- Develop a statistical model to forecast (with specified precisions) next day or next week prescribed fire effects on regional air pollution (O_3 and PM).

The CEFA-CANSAC role is to provide the project with Bluesky predicted PM2.5 for selected cases. The project has also allowed for making sensitivity runs to test the different parameters in the model. Hopefully, positive results here can be utilized during the 2007 fire season.

Aerospace Corporation funds a second research project in collaboration with CEFA to integrate a data assimilation system, three-dimensional variational (3DVAR), into real-time MM5 forecasts. To date, a process for ingesting satellite surface winds (Windsat) into MM5 has been developed and is being tested. Thus far, some improvement in forecast skill has been realized. Additionally, the project is in the early stages of ingesting satellite soundings (SSMI/SSMIS) into real-time runs.

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/. Some of the elements in Task Order 14 are also a CAP function.

The primary collaboration with CLIMAS during this year involved co-organizing the 2006 National Seasonal Assessment Workshop (Eastern and Southern areas in January 2006 and Western States and Alaska in March 2006). 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. A detailed report was 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 few years, in conjunction with several California wildfire agencies, CEFA has been developing a prototype experimental system for calculating and displaying hourly fire danger in California. Using hourly RAWS from WRCC and NFDRS algorithms provided by Larry Bradshaw at the Forest Service Missoula Fire Sciences Laboratory, 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 was begun in 2006 to quantitatively examine the hourly fire danger values and produce a climatology based on historical hourly fire danger. One accomplishment during 2006 was to implement a real-time RAWS quality graphical display for all stations within the product's region. For every hour, the web product is updated with not only the fire danger color-shading for each Fire Danger Rating Area (FDRA), but a symbol is used to represent the location and status of hourly data for each station (Figure 17). Individuals continue to evaluate the system for its operational utility. The web-based maps are available at http://cefa.dri.edu/HourlyFD/.

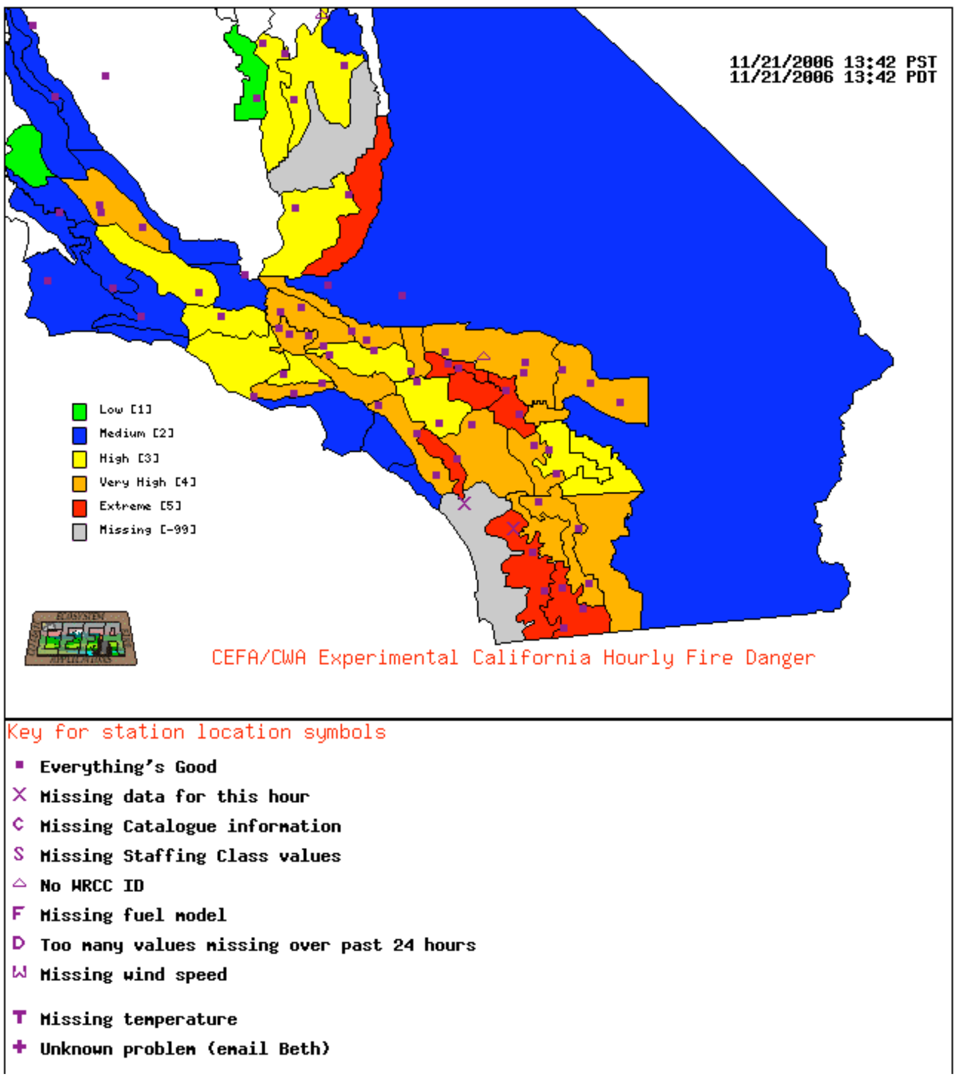

Figure 17. An example of hourly fire danger for each FDRA in southern California. Note that the station symbols indicate whether or not the algorithms could be applied to that station for that hour, and if not, the reason is indicated.

New York (Sponsor: New York State Department of Environmental Conservation)

The objectives of this project are to create a weather database based on estimates and reformatting of existing station data for specified locations in New York state, and build a database of fire occurrence from the mid-1980s to present. The New York State (NYS) Forest Rangers have kept paper records of fire occurrence for a number of years; however, these had to be digitized. NYS collected and shipped all of the written fire records to DRI to convert into an electronic spreadsheet format. This was completed June 2006. In order for the data to be importable into fire analysis software (e.g., Fire Family Plus), these data had to be reformatted, and a final database created. An electronic fire occurrence database was delivered to NYS in July 2006.

North Carolina (Sponsor: North Carolina Division of Forest Resources)

Mixing height is a critical consideration for planning prescribed burns. In the spring of 2006, the North Carolina Division of Forest Resources (NCDFR) launched approximately 20 soundings in association with prescribed burns or on other days of interest. The purpose of this project is to compare mixing height forecasts for North Carolina with mixing height based upon the sounding data. Three available forecast sources include the National Weather Service daily forecasts, National Centers for Environmental Prediction Eta numerical gridded forecasts produced at CEFA and MM5 model forecasts produced at the Athens, Georgia Forest Service Fire Consortia for Advanced Modeling of Meteorology and Smoke. In addition to the NCDFR soundings, NWS twice-daily soundings are also available for analysis. Analysis has yet to be undertaken for the NCDFR data; however, a CEFA Master's degree graduate student (Doug Pibal) has been working on verifying the NWS and Eta mixing height forecasts using the NWS sounding data. The project work is planned for completion in spring 2007.

Northeast (Sponsor: New Hampshire Division of Forests and Lands)

Using the framework of New York State project, New Hampshire has requested a similar analysis. Fire occurrence data was provided in September 2006 and will be reformatted for input into fire danger software. A weather stream for Manchester will be collected and formatted for input into Fire Family Plus. The analysis will include assessing fire occurrence breakpoints, and examining the criteria for red flag warnings.

Long-continuing current and Natural ignitions (Sponsor: Quasar Federal Systems and Vaisala)

Quasar Federal Systems has the technology to detect the presence of a long-continuing current (LCC). It has been theorized that it is the LCC as opposed to polarity or multiplicity that increases the likelihood of a lightning strike igniting a wildfire. A case study analysis has been funded to extract all the locations of natural ignitions to determine if there was an LCC at the time of ignition. A single blind study has been developed that will provide Quasar with several datasets that either include the locations of these ignitions or the locations of lightning strikes that did not have an ignition. Quasar will then provide the intensity of the LCC associated with each location. CEFA will then statistically determine if there is a significant association between the presence of and intensity of an LCC and a natural wildfire ignition. Results are anticipated by April 2007.

Virtual Reality Fire (Sponsor: Department of Defense)

The goal of this project is to develop a suite of virtual reality fire simulations that will be used for planning, training, education and research simulation of fire environments. Currently, a

4-wall virtual reality system has been installed at DRI, and a 6-wall system is planned for completion in 2008. Work was begun during the first project phase to build and link together a set of objects to visualize fire in landscape and wildland-urban environments. Terrain, vegetation and fire objects are being integrated to simulate a fire environment. The development area is Mt. Charleston, Nevada, located northwest of Las Vegas. Some tours for the wildland fire community have been given, and these are anticipated to substantially increase over the next year or two. It is envisioned that the visualization products will be utilized on a consistent basis by wildland fire agencies and community leaders. This project provides for the development of a visualization system for fire environments, and will be used by operational fire managers, fire directors, community leaders and congressional delegates. Figure 18 shows a graduate student working inside the visualization system. In this simulation, FARSITE was run for an example fire case, and is shown by the red boundaries.

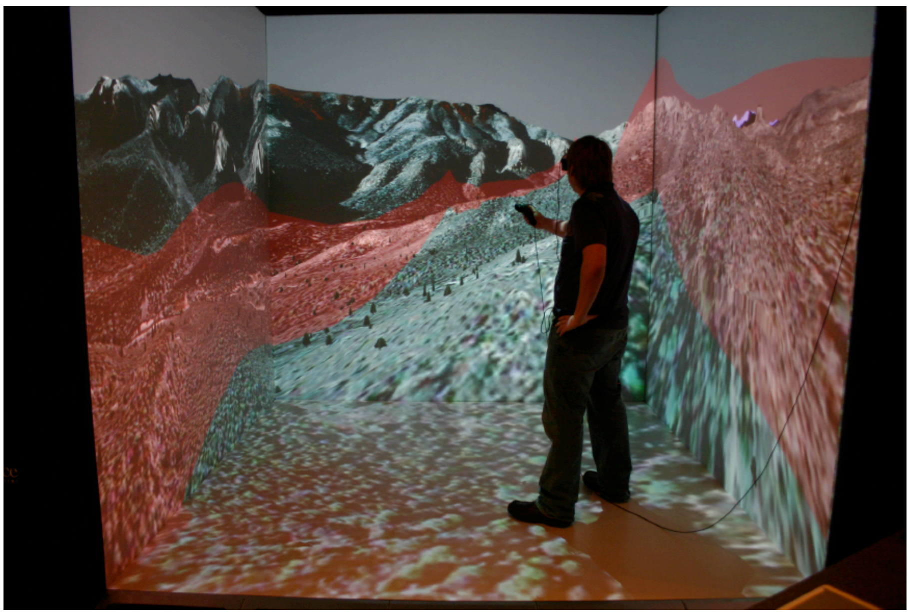

Figure 18. Photo of graduate student Michael Penick working in the visualization system. The red shading represents fire spread from FARSITE output.

CEFA Real-Time Products

Based on current and past projects, CEFA maintains a number of experimental operational products for the original sponsors and fire agencies at large. These include:

- Hourly-fire danger for California
- 15-day standardized ERC forecasts for the U.S.
- Eta model mixing height forecasts for the U.S.; specific text products for California Predictive Services
- Twice daily RAWS-MOS forecasts for all GACCs excluding the Pacific Northwest (run their own version), and Eastern and Alaska areas (under development)
- Twice daily GFS point forecasts for most GACCs
- Twice daily CANSAC fire weather, smoke and fire danger forecasts
- Recent 10- and 30-day climatology of RAWS temperature and humidity, NLDN lightning activity, and 850mb / 500 mb winds and 600 mb / 500 mb relative humidity from the from NCEP/NCAR Global reanalysis dataset run daily

D. 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 2005 through 30 September 2006.

October 13-14 (Hamilton, Bermuda): Tim Brown presentation at Climate Extremes Workshop.

October 25-27 (Canmore, Canada): Tim Brown, Beth Hall, Hauss Reinbold, Julide Koracin, Crystal Kolden presentations at the American Meteorological Society 6th Symposium on Fire and Forest Meteorology.

November 1-2 (Tuscon, AZ): Tim Brown presentation and participation at the annual Predictive Services meeting.

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

November 14 (Washington, D.C.): Tim Brown attendance at NOAA's Climate Change Science Program workshop.

November 15-16 (Sacramento, CA): Beth Hall presentation at Fall FIRESCOPE Predictive Services meeting.

December 7-8 (Denver, CO): Tim Brown attendance at FCAMMS Directors meeting.

January 18-19 (Tucson, AZ): Tim Brown lecture at the National Advanced Fire and Resource Institute.

January 30 – February 2 (Atlanta, GA): Tim Brown presentation at the American Meteorological Society annual meeting.

February 16 (Sacramento, CA): Tim Brown, Crystal Kolden, Julide Koracin co-organizers and participation at CANSAC users workshop.

February 23 (Phoenix, AZ): Tim Brown participation in Forest Service and Brookings Institution workshop on megafires.

February 27 – March 2 (Boise, ID): Tim Brown participation Fire Environment Working Team meeting and OFCM-JAG.

March 7-11 (Chicago, IL) Beth Hall presentation at annual Association of American Geographers meeting.

March 21-24 (Tucson, AZ): Tim Brown presentation at the NOAA Climate Prediction Applications Science workshop.

March 27-30 (Portland, OR): Crystal Kolden presentation at the 1st Fire Behavior and Fuels Conference

April 4-6 (Boulder, CO): Tim Brown presentation and co-organizer of National Seasonal Assessment Workshop: Western States and Alaska.

April 19-21 (Phoenix, AZ): Beth Hall and Hauss Reinbold presented at the BLM Resource Management and Tools Conference.

April 24-25 (Tucson, AZ): Beth Hall presentation at the International Conference on Lightning Detection.

May 8-9 (Yosemite National Park): Tim Brown presentation at the Yosemite Fire Science Symposium.

May 10 (Sacramento, CA): Beth Hall presentation at the spring FIRESCOPE Predictive Services meeting.

May 16 (Riverside, CA): Tim Brown, Crystal Kolden, Julide Koracin co-organizers and participation at CANSAC users workshop.

May 19 – July 15 (Melbourne, Australia): Tim Brown projects with Bushfire CRC.

June 28-30 (Boise, ID): Beth Hall presentation to NIFC on the quality of RAWS data.

September 11 (Riverside, CA): Tim Brown presentation at IUFRO Research Group 7.01 "Impacts of Air Pollution and Climate Change on Forest Ecosystems".

September 13 (Boise, ID): Tim Brown CEFA quarterly review briefing.

E. REPORTS AND PUBLICATIONS

Hall, B. L., 2006: Precipitation associated with lightning ignited wildfires in Arizona and New Mexico. Submitted (*International Journal of Wildland Fire*)

Hall, B. L., 2006: Fire ignitions related to radar reflectivity patterns in Arizona and New Mexico. Submitted (*International Journal of Wildland Fire*).

Hall, B. L., 2006: Relationship between the timing of precipitation and natural wildfire ignition pulses during the North American Monsoon season in Arizona and New Mexico. Submitted (*Physical Geography*).

Lucas, C., G. Mills, T. Brown, 2006: Seasonal Bushfire Assessment 2006-2007 – A Look Ahead at the Coming Fire Season. Bushfire Cooperative Research Centre, Program A: Fire Behaviour and Suppresion Report, Bureau of Meteorology, Melbourne, Australia, September 2006, 27 pp.

Kangas, R.S. and T.J. Brown, 2006: Characteristics of U.S. Drought and Pluvials from a High-Resolution Spatial Dataset, Submitted *International Journal of Climatology*.

Crawford, B., G. Garfin, R. Ochoa, R. Heffernan, T. Wordell, and T. Brown, 2006: National Seasonal Assessment Workshops: Western States & Alaska and Eastern, Southern & Southwestern States, Final Report, 42 pp. Available from http://www.ispe.arizona.edu/climas/conferences/NSAW/publications/NSAWproceedings_06.pdf.

Hall, B. L. and T. J. Brown, 2006: Climatology of positive polarity flashes and multiplicity and their relation to natural wildfire ignitions, *Proceedings of the 19th International Lightning Detection Conference*, Tucson, Arizona, April 24-25 2006, 5 pp.

Brown, T.J. and B.L. Hall, 2005: *Climate and Ecosystem Studies and Product Development for Wildland Fire and Resource Management*, Annual Report prepared for Bureau of Land Management, CEFA Report 05-03, December 2005, 49 pp.

Hall, B. L., T. J. Brown, and L. Bradshaw, 2005*: Development of U.S. operational fire danger 15-day forecasts*. Report prepared for Interagency Fire Management, CEFA Report 05-02, December 2005, 17 pp.

Hall, B. L., 2005: Precipitation associated with lightning ignited wildfires in Arizona and New Mexico. *Proceedings of the Sixth Symposium on Fire and Forest Meteorology*, American Meteorological Society, Canmore, Alberta, Canada, 25-27 October 2005, 8 pp.

Kennedy, J., B. L. Hall and T. J. Brown, 2005: New York state fire climatology. Sixth *Proceedings of the Sixth Symposium on Fire and Forest Meteorology,* American Meteorological Society, Canmore, Alberta, Canada, 25-27 October 2005, 3 pp.

Hall, B. L. and T. J. Brown, 2005: Estimating missing station weather data using North American Regional Reanalysis. *Proceedings of the Sixth Symposium on Fire and Forest Meteorology,* American Meteorological Society, Canmore, Alberta, Canada, 25-27 October 2006, 5 pp.

Koracin, J., and T.J. Brown, 2005: Implementation, visualization, and verification of CANSAC products. *Proceedings American Meteorological Society Sixth Symposium on Fire and Forest Meteorology*, American Meteorological Society, Canmore, Alberta, Canada, 25-27 October 2006, 3 pp.

Ghidey, T., J. Koracin, M.D. McAtee, and T.J. Brown, 2005: Implementation of WINDSAT data from NPOESS into 3DVAR for CANSAC real-time MM5 forecasting. *Proceedings American Meteorological Society Sixth Symposium on Fire and Forest Meteorology*, American Meteorological Society, Canmore, Alberta, Canada, 25-27 October 2005, 13 pp.

Reinbold, H. J., B. L. Hall and T. J. Brown, 2005: Development of model output statistic (MOS) products for predictive services. *Proceedings of the Sixth Symposium on Fire and Forest Meteorology*, American Meteorological Society, Canmore, Alberta, Canada, 25-27 October, 9 pp.

Kolden, C.A., and T.J. Brown, 2005: The use of climate information in prescribed fire planning and implementation. *Proceedings American Meteorological Society Sixth Symposium on Fire and Forest Meteorology*, American Meteorological Society, Canmore, Alberta, Canada, 25-27 October 2005, 4 pp.

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