Program for Climate, Ecosystem and Fire Applications

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

Annual Report

Timothy J. Brown
Beth L. Hall

Desert Research Institute
Division of Atmospheric Sciences

CEFA Report 02-03

December 2002

Forward

In November 2000 an Assistance Agreement 1422RAA000002 was established between the Bureau of Land Management National Office of Fire and Aviation and the Desert Research Institute. This report describes the activities at the DRI Program for Climate, Ecosystem and Fire Applications (CEFA) under this Agreement during the period 1 October 2001 - 30 September 2002. For further information regarding this report or the projects described, please contact either:

Dr. Timothy Brown
Program for Climate, Ecosystem and Fire Applications
Desert Research Institute
2215 Raggio Parkway
Reno, NV 89512-1095
Tel: 775-674-7090
Fax: 775-674-7016
Email: tbrown@dri.edu

Paul Schlobohm
Bureau of Land Management
Desert Research Institute
2215 Raggio Parkway
Reno, NV 89512-1095
Tel: 775-674-7170
Fax: 775-674-7016
Email: pschlobo@dri.edu

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Annual Report to the Bureau of Land Management

by
Timothy J. Brown and Beth L. Hall
Program for Climate, Ecosystem and Fire Applications
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Introduction

This annual report is the second under the Bureau of Land Management (BLM) national Office of Fire and Aviation and the Desert Research Institute (DRI) cooperative Assistance Agreement (AA) 1422RAA000002, and covers the federal fiscal year 2002. The 5-year AA was signed by BLM and DRI during November 2000. The overall scope of the AA is climate and ecosystem studies and product development for wildland fire and resource management. Its objective is to establish and maintain a partnership between BLM and DRI that allows for product development, applied research, training, education and consultation using DRI scientific expertise in climatology, meteorology and terrestrial ecology. The deliverables under this AA are intended to have high interagency value in addition to specific BLM agency needs. The target audience varies depending upon the product or information, but includes among others fire management, Geographic Area Coordination Center (GACC) meteorologists, GACC intelligence officers, fire behavior analysts, fuels specialists and fire specialists. Project concepts can originate at all levels including local, state and national offices as well as at DRI.

This report describes activities and accomplishments under the AA for the period 1 October 2001 – 30 September 2002. 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).

Unfortunately, despite a number of new and significant projects, accomplishments, and established relationships with the field, future national BLM funding of the CEFA partnership with the agency is in a state of flux, particularly beginning in FY04. Though it is recognized that changes in national funding and priorities can strongly impact Assistance Agreements such as this one, we hope that the agency will seriously consider maintaining our existing partnership at the national level by providing the necessary support to continue existing projects and establish new ones that have a strong likelihood of success with the field as support tools for decision-making and strategic planning.

Tasks

This section describes AA tasks specific to BLM that were in progress during federal FY2002. Administrative task order 1 began in the first half of calendar year 2001 and is ongoing; project task orders 4, 5 and 7 began in the early fall of 2001, and are in their second year; new task orders 8 and 9 began in summer 2002. Task orders 6 and 10 will begin in October 2002.

Task Order 1: CEFA Infrastructure and Administration

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

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

The short-term projects during this reporting period included assisting in the development of the Southwest GACC seasonal outlook, providing climate information for the Great Basin 2002 Assessment, providing some monthly/seasonal climate forecast information for the Eastern GACC, and developing a climate/fire danger lesson plan for the Advanced National Fire Danger Rating System course.

The primary computer hardware upgrades during this reporting period included the purchase of a 180Gb fixed storage drive for CEFA's Silicon Graphics, Inc. (SGI) Origin 200 workstation, and the purchase of a new laptop computer. Several software license renewals and updates were administered. This upgrade supports all CEFA tasks.

Web administration is an ongoing process. Significant new additions to the web site include a section for the California and Nevada Smoke and Air Consortium (CANSAC), and sections for near real-time climate monitoring (both western U.S. and the monsoon region). CANSAC is discussed in more detail under task order 8 below. The current CEFA web site address is http://cefa.dri.edu.

Travel and publications under Task 1 are listed in separate sections below. Some hourly student support was utilized in developing a scientific publication bibliography.

Task Order 4: Utilization and Evaluation of Climate Information and Forecasts for Fire Management

This task officially began in September 2001. The overall project goal is to develop climate forecast products and information that can be utilized for wildfire, prescribed fire and fire use strategic planning and decision-making. It is anticipated that two years will be required to fulfill all of the project objectives (scaled back from initially three-years). A Masters level graduate student is assigned to the project, along with involvement from other CEFA personnel. This project is collaborative with the Scripps Institution of Oceanography Experimental Climate Prediction Center (ECPC), Scripps California Applications Program (CAP) and the International Research Institute (IRI) for Climate Prediction. The following specific tasks were planned for the first year:

1. Develop a system for producing weekly and monthly climate anomaly maps of surface maximum/minimum temperature and relative humidity using RAWS and upper-level wind streamlines (in particular 500 mb) using National Centers for Environmental Prediction (NCEP) reanalysis model grids.
2. Perform analysis of critical fire weather patterns associated with BLM Nevada field offices.
3. Perform an evaluation of ECPC weekly, monthly and seasonal forecasts of fire climate variables (i.e., temperature, relative humidity, wind speed and precipitation) by comparing model output with observations from RAWS.
4. Develop displays of fire danger forecasts from the ECPC models.
5. Acquire IRI monthly climate forecasts, combine ensemble forecasts into a probabilistic forecast for temperature and precipitation, provide forecast anomalies and probabilities via the CEFA web site in the form of a model and forecast matrix.
6. Provide training to GACC meteorologists and intelligence personnel on the use of experimental climate forecasts.

Accomplishments for each task above are as follows:

<u>1. Near real-time climate monitoring</u> – The Western Regional Climate Center (WRCC) receives Remote Automatic Weather Station (RAWS) data in near-real time from BLM/National Interagency Fire Center (NIFC) in Boise, Idaho, and also maintains a historical archive of RAWS observations. CEFA extracted historical data for all western U.S. RAWS that have at least seven years of records and computed a daily climatology of maximum and minimum temperature and relative humidity for each RAWS. This serves as the basis for computing anomalies, or departures from average. A computer program is run once daily that calculates the most recent 10- and 30-day average of maximum and minimum temperature and relative humidity, and then the 10- and 30-day climatological average is subtracted from this value to produce departures from average for the respective periods. The departure values are color coded and plotted on a map made available at the CEFA web site in the assessment section. Figure 1 provides an example of the maps made available on the CEFA web site.

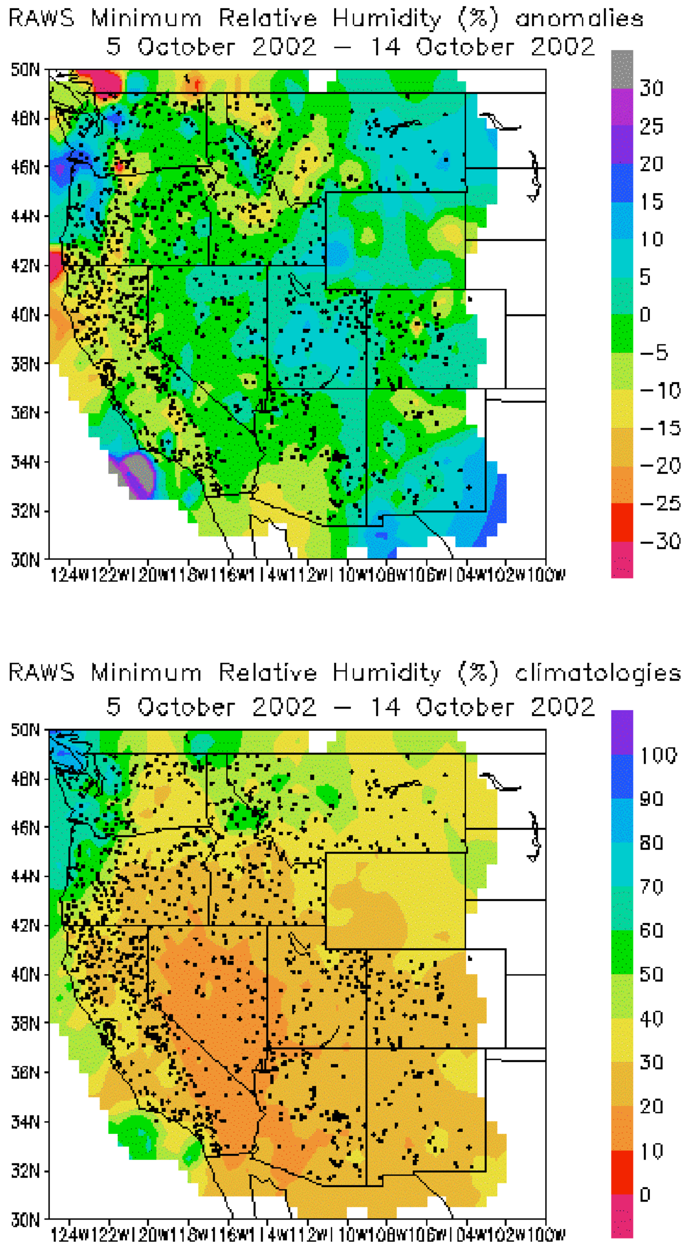

Figure 1. Example maps from the CEFA near real-time climate monitoring of RAWS minimum relative humidity anomalies (top) and climatology (bottom) for a 10-day period in October 2002.

Similar type maps are also being generated for upper-atmosphere or pressure level elements. In particular, 500 and 600 mb 10- and 30-day relative humidity anomaly maps are being produced, along with 500 and 850 mb streamlines. The streamlines show wind flow patterns that have occurred for the respective period. The NCEP/National Center for Atmospheric Research (NCAR) reanalysis pressure level data are being provided to CEFA by the National Oceanic and Atmospheric Administration (NOAA)/Cooperative Institute for Research in Environmental Sciences (CIRES) Climate Diagnostics Center (CDC) in Boulder, Colorado. Figure 2 shows example relative humidity maps from the near real-time climate monitoring system.

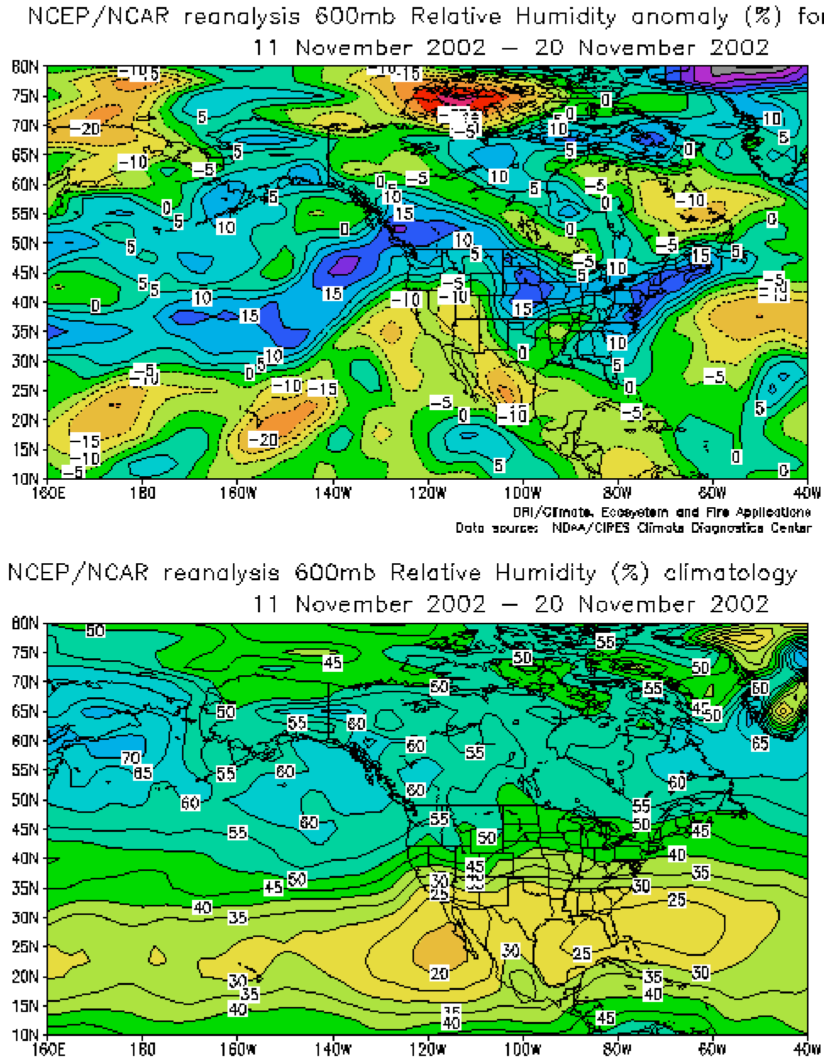

Figure 2. Example maps from the CEFA near real-time climate monitoring of NCEP/NCAR reanalysis 600 mb relative humidity anomalies (top) and climatology (bottom) for a 10-day period.

Lightning anomaly information for 10- and 30-day periods are also being provided in near-real time. Three maps are produced once daily for the respective time period showing what was observed, the departure from average, and the climatological average for the period. These data are provided by Vaisala-GAI, Inc. and are proprietary. Therefore, only federal fire agencies associated with the national lightning data contract have access to this information. Figure 3 shows an example set of lightning maps available on the CEFA web site.

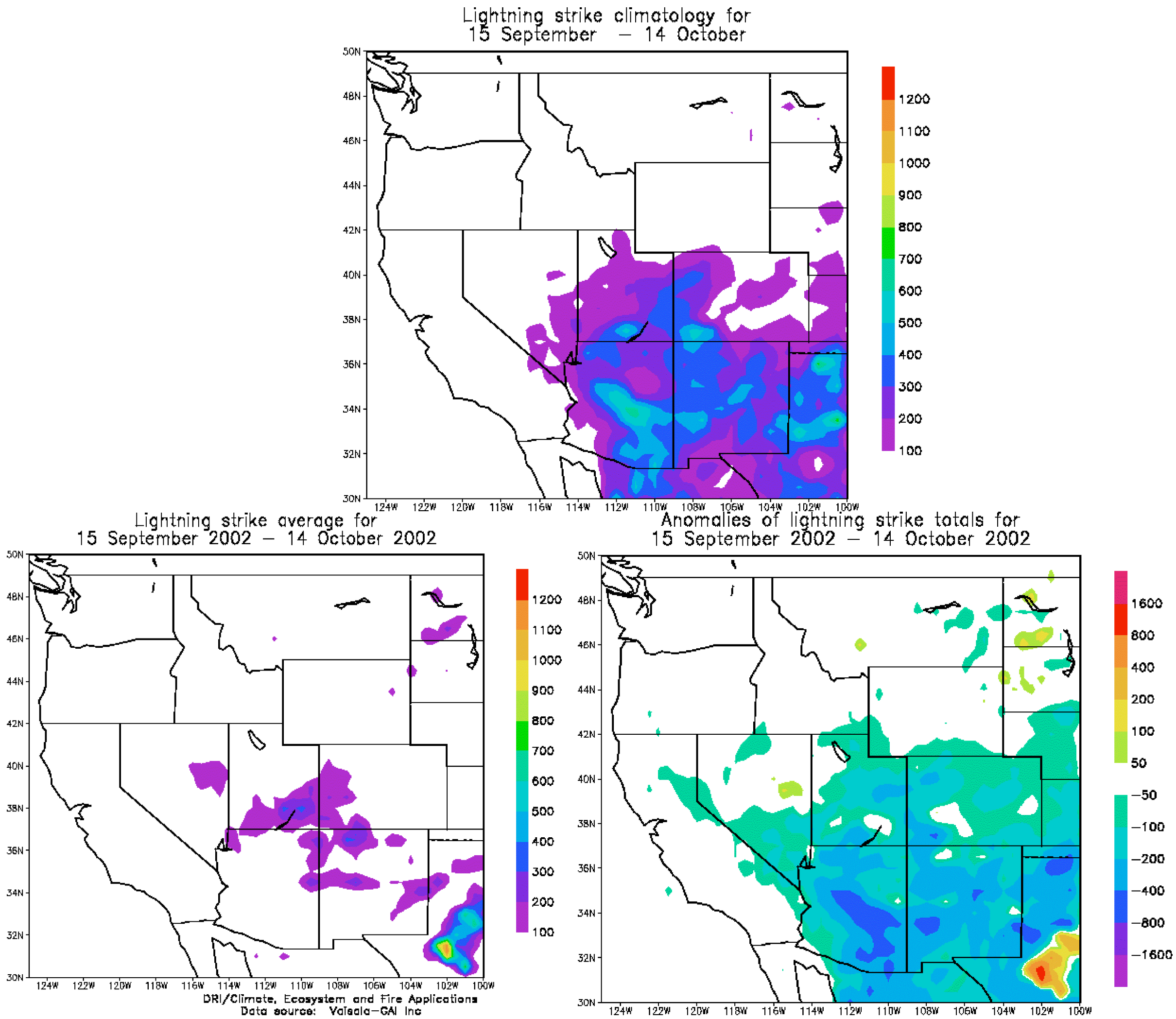

Figure 3. Example CEFA near real-time climate monitoring maps of Vaisala-GAI National Lightning Detection Network western U.S. lightning strike climatology (top), average (bottom left) and anomalies (bottom right) for a 30-day period.

<u>2. Critical fire climate patterns</u> – The main goal of this task was to develop a comprehensive and objective statistical method to assess pressure level weather elements that can potentially be associated with natural fire occurrence. A method to determine upper-air (pressure) level patterns in association with periods of low and high fire start activity was developed. This was done in part to update and add value to fire weather patterns published in 1969 by Mark Schroeder. In identifying longer-term patterns of more than a two-week period, the term fire climate pattern is proposed, rather than fire weather pattern. The method utilizes median map composites accounting for variance, statistical significance via randomization, and an assessment of predictability using contingency table analysis. In order to develop the method, the number of natural fires during July and August separately for five Nevada BLM field districts were ranked from low to high for the period 1970-2000. The first eight and last eight years represent low and high fire start years, respectively. Pressure level (e.g., 850, 700, 600, 500 mb) elements of temperature, relative humidity, geopotential height and wind speed from the NCEP/NCAR reanalysis data set were used to develop composite maps of anomalies for each

element separately for the eight years comprising either the low or high fire start years. The statistical methodology was then applied to determine if a particular composite pattern was significantly associated with the active or non-active fire period. Figure 4 shows an example pattern of geopotential heights for the Ely district. Composite cases that are statistically significant provides information for fire weather meteorologists regarding pressure level patterns and anomalies associated with low and high levels of fire start activity over a region. Thus, confidence in a forecast of these patterns or anomalies yields a more confident forecast of fire start activity. A description of the procedure along with examples for Nevada is currently being documented for publication.

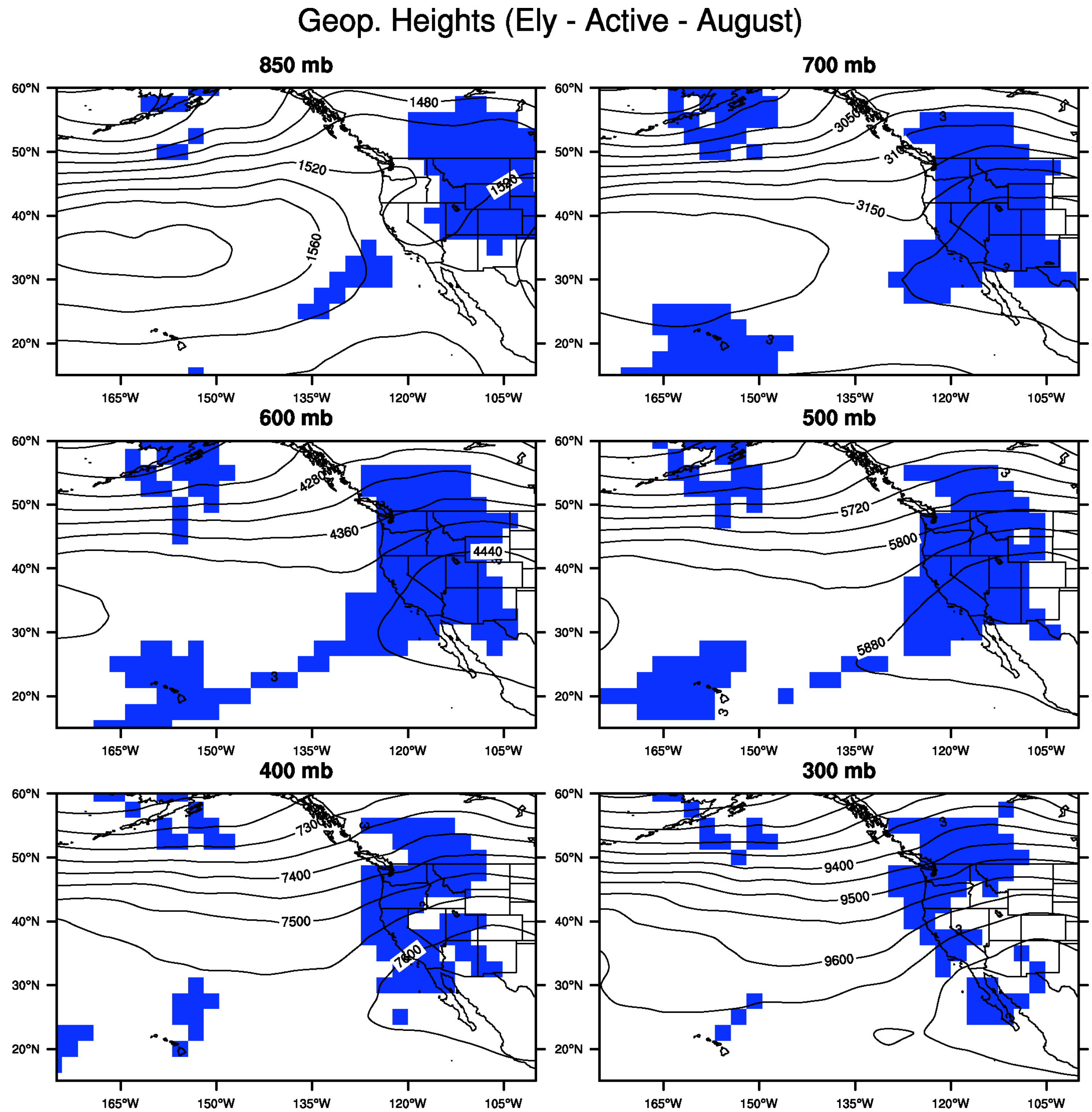

Figure 4. Example maps showing composite August geopotential height fire climate patterns for the Nevada Ely district active fire start years. The blue boxes represent grid cells that met the various statistical criteria to determine significance of the composite pattern.

3. Climate forecast evaluation – Two academic research groups noted above that are producing experimental monthly and seasonal climate forecasts are ECPC and IRI. IRI primarily produces forecasts of temperature and precipitation, while ECPC produces forecasts of these elements along with several others relevant to fire management such as relative humidity, wind speed and National Fire Danger Rating System (NFDRS) fire danger indices. These forecasts are being made available to fire weather meteorologists and others for use in monthly and seasonal outlooks and assessments. However, the skill of these forecasts for this purpose has not been quantified, and therefore it is highly desired to assess the quality and uncertainty associated with the forecasts. Forecast skill information is useful for two primary purposes: 1) it informs the decision-maker as to forecast performance; and 2) it provides information for the model developer so that changes in model physics and processes can be addressed in order to improve the predictions. During this first year phase of the project, the primary emphasis has been on running and archiving model forecasts that will be used in a skill analysis. Also, a number of RAWS locations have been identified that potentially can be used to evaluate climate forecasts (Figure 5). This process required addressing quality issues of RAWS data for the study region. For example, a minimum of four years of nearly continuous data is required for the analysis. Also, some emphasis has been placed on using stations that have a special relevance to each GACC. Temperature, relative humidity, wind speed and NFDRS fire danger indices will be verified against ECPC weekly, monthly and seasonal forecasts.

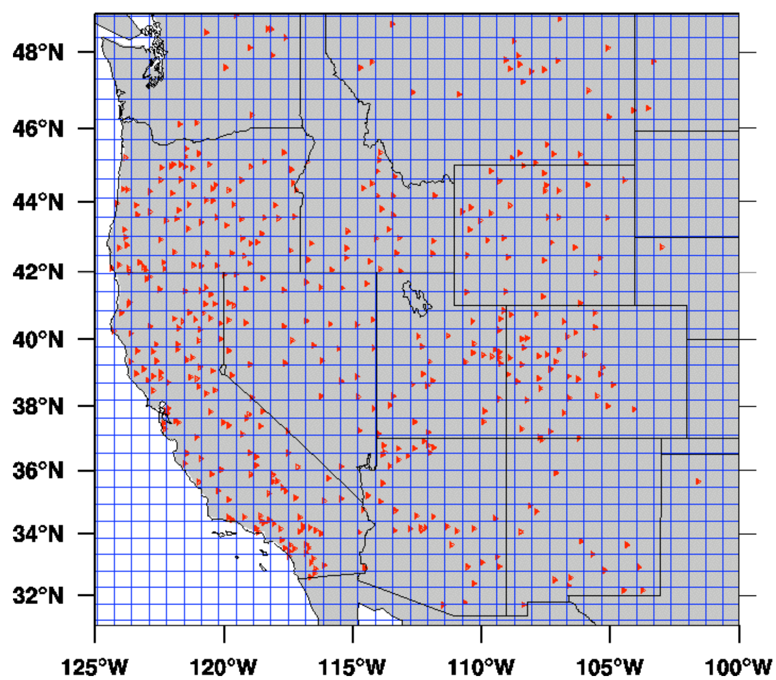

Figure 5. Map showing region of climate model forecast evaluation for the Scripps ECPC regional spectral model. Red symbols indicate locations of potential RAWS data, and the grid lines represent the model grid resolution (60 km).

4. ECPC fire danger forecasts – During the 2002 fire season, ECPC produced experimental NFDRS fire danger forecasts and made them available on their web site. The model runs are done once per week, and forecasts are made available for periods of daily out to 7

days, weekly out to 4 weeks, and monthly out to 3 months. Figure 6 provides an example fire danger forecast map graphic.

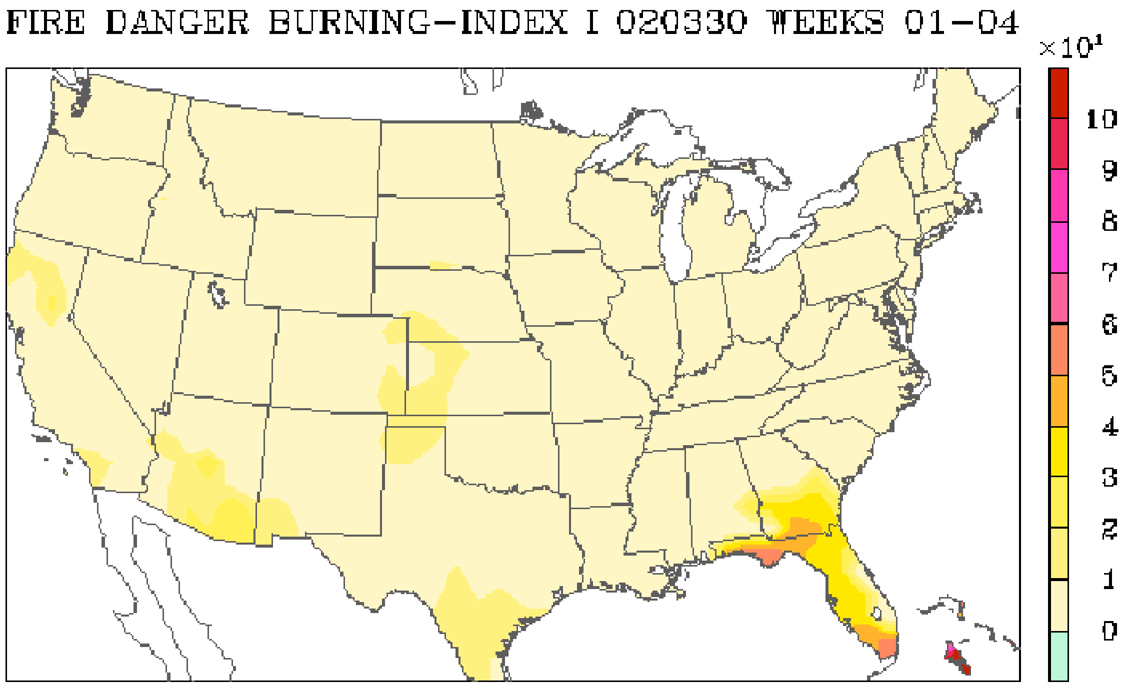

Figure 6. Example map showing a seasonal forecast of burning index fire danger from the Scripps Experimental Climate Prediction Center.

5. IRI monthly climate forecasts – CEFA receives over 3,500 forecasts per month from IRI. These include monthly predictions from three different climate models. For two of the models, persistent and predicted sea surface temperatures are used as the primary physical forcing of the models. There are between 9 and 24 ensemble (variations of the model initialization that produces slightly different forecast outcomes, but when combined produces an overall forecast) forecasts of temperature and precipitation out to 4 to 6 months (depending on the particular model). Using model climatology, CEFA computes temperature and precipitation anomalies for each forecast month and generates maps that are posted on the CEFA web site. Also, probabilities of monthly below or above average temperature and precipitation are computed and displayed. Additionally, some forecasts of wind and 500 mb height are made available. Figure 7 shows the IRI forecast matrix from the CEFA web site. Though each forecast is considered experimental, CEFA makes them available to the fire community for decision support use in monthly outlooks and assessments. Forecast maps are also made available to the Australian/New Zealand fire weather communities.

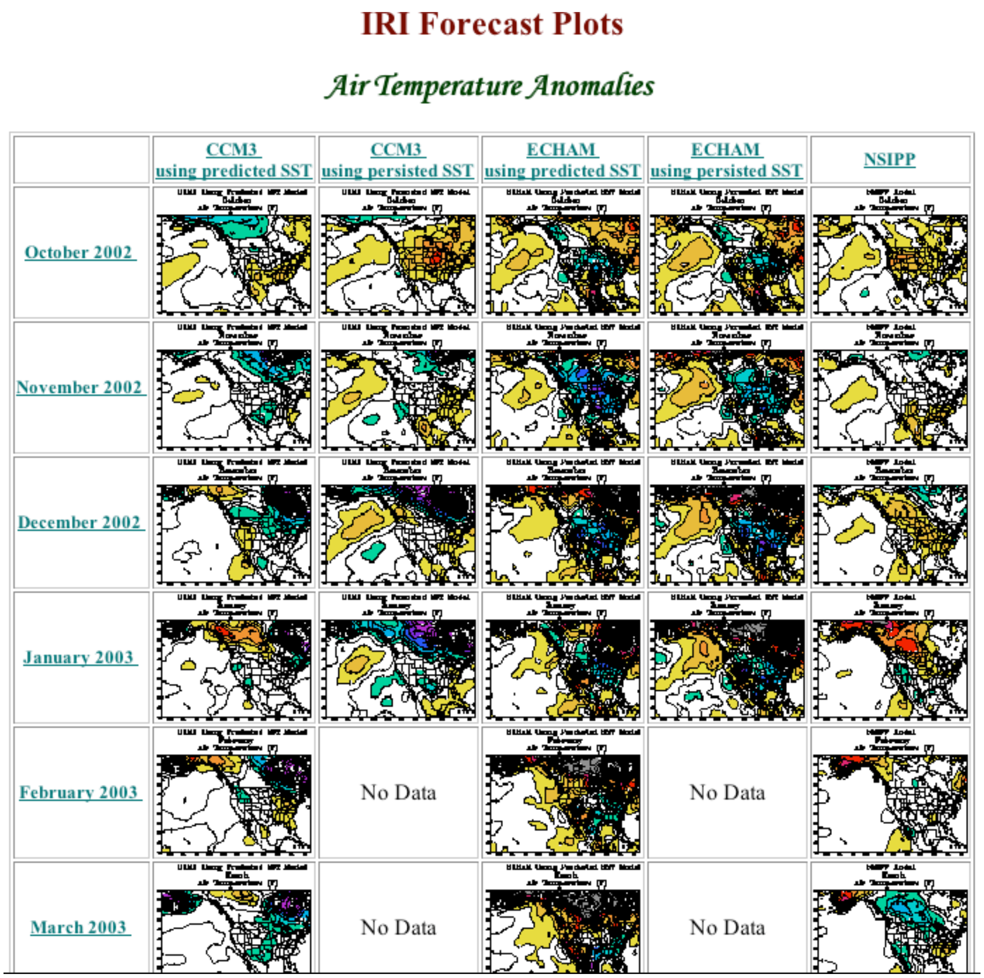

Figure 7. Screen image of the International Research Institute for Climate Prediction monthly climate forecasts available on the CEFA web site.

6. Training – CEFA provides knowledge/technology transfer via workshops and relevant meetings. Details about the products under this task were discussed at the spring 2002 GACC meteorologist meeting in Fort Collins, CO. The primary analyses of this study comprise a major part of a Master's student thesis project. When the final results of the study are complete, a thesis, scientific journal paper, and agency project report will be prepared. The results will be presented at relevant agency meetings and workshops and scientific conferences as warranted.

Task Order 5: Analysis of the Southwest Monsoon in Relation to Fire Danger Characteristics.

This task officially began in September 2001. The primary objective is to identify quantitative relationships between Southwest monsoon climate and weather elements and subsequent impacts on fire danger and fire occurrence. The products derived from the project will provide information for decision-making related to resource allocations and prescribed fire and fire use activities. It is anticipated that two years will be required to fulfill all of the project objectives (scaled back from initially three-years). A Masters level graduate student is assigned to the project, along with involvement from other CEFA personnel. The following specific tasks were planned for the first year:

1. Develop a system for producing daily and weekly climate anomaly maps of surface relative humidity using RAWS combined with other station data such as National Weather Service (NWS) stations specific to the monsoon region.
2. Collect and quality control fire occurrence data from the United States Department of Agriculture (USDA) Forest Service (USFS) and Department of Interior (DOI) national databases, and state agencies.
3. Analyze fire occurrence quantitatively to produce relevant occurrence characteristics that can be related to climate and weather patterns.
4. Analyze regional precipitation and relative humidity patterns.
5. Contact prescribed fire managers across the monsoon region to determine fire prescription ranges for relevant weather variables.
6. Results of the analyses will be presented at meetings, workshops and conferences as warranted.

Accomplishments for each task above are as follows:

1. Monsoon region near-real time climate monitoring – Utilizing some of the products and information from Task 4 above, a special monsoon region information section was established on the CEFA web site. This region is primarily Arizona, New Mexico, Colorado, Utah, western Nevada and southeastern California. Near real-time maps of RAWS maximum/minimum temperature and relative humidity and lightning strike information are provided. It was decided to only incorporate RAWS as a unique network in the map. However, other stations can be included if desired by the field. Figure 8 provides an example map highlighting the southwest region. Also included on the web site are links to other information relevant to the monsoon, such as precipitation observations and forecasts. As new products are developed and other links discovered, this information will be added to the site.

2. Collect fire occurrence data – An important and major first step in the analysis is the collection and quality control of fire occurrence data for the monsoon region. Using USFS 5100-29, DOI 1202, and state agency fire reports, a database of fire occurrence in the monsoon region was established. State reports include Arizona, California, Colorado, New Mexico and Utah. A quality control analysis of the data was done to check for erroneous, missing and duplicate reports.

3. Analysis of large fire occurrence – Once the fire occurrence database development was completed, analysis could begin on the characteristics of fire occurrence in the monsoon region. First, a database containing large fire occurrence was created. Large fires were defined as the number of acres burned at or above the 95^{th} percentile for each individual agency. This process yielded 7,108 large fires in the region for the period 1980-2000. These data will allow for the subsequent analyses of monsoon climate and fire relationships to occur. Figure 9 shows the relationship between large fire occurrence in Arizona and New Mexico based on the date of monsoon onset using the Tucson National Weather Service definition. This simple bar chart clearly shows that for most years, but not all, there is a decrease in large fire occurrence following the onset of the monsoon.

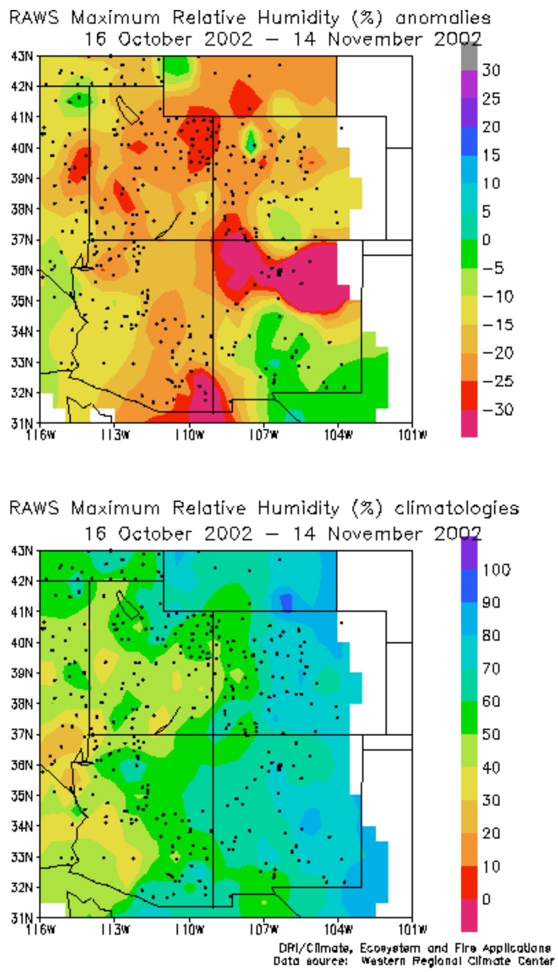

Figure 8. Example CEFA near real-time climate monitoring maps of RAWS maximum relative humidity anomalies (top) and climatology (bottom) for a 30-day period in the southwestern U.S.

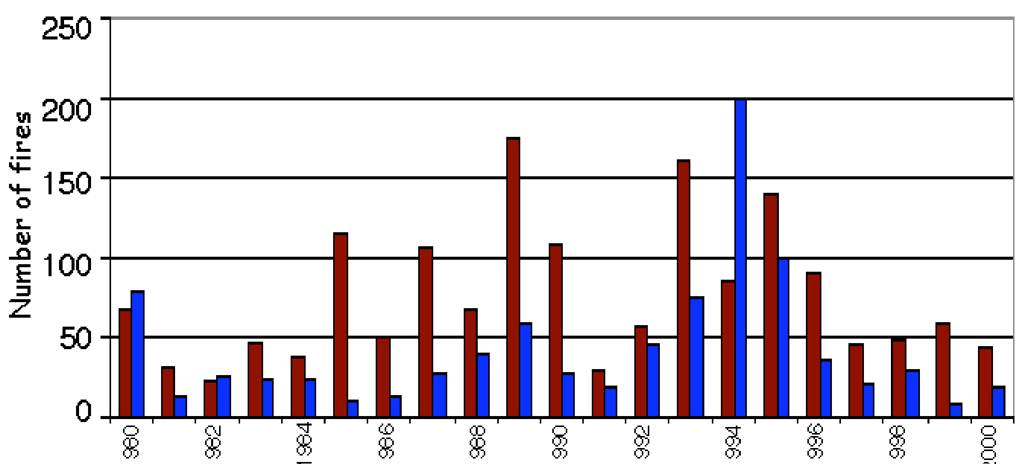

Figure 9. Histogram of Arizona and New Mexico large fire occurrence before (red bars) and after (blue bars) southwest monsoon onset as defined for the Tucson National Weather Service Office.

4. Analysis of monsoon region weather patterns – This task is the primary component of the study, and is expected to take two years to complete, with a majority of the results being realized in the second year. The analysis includes applying spatial and temporal statistical methods to determine monsoon weather and climate patterns over both space and time. This will include analyses to determine monsoon and fire threshold values over the monsoon region, and analyses to quantify and describe year-to-year patterns. For example, Figure 8 above shows a high degree of year-to-year variability of large fire occurrence. The analyses will provide information on the role of the monsoon in relation to this variability. Figure 10 shows an example climatology series of daily maximum and minimum relative humidity for the Roosevelt RAWS. The increase in humidity in late June and early July corresponds to the climatological onset of the monsoon for this site. One of the questions to be resolved in this study is what is the climatological threshold for humidity and other indices that relates large fire occurrence to the monsoon over the region.

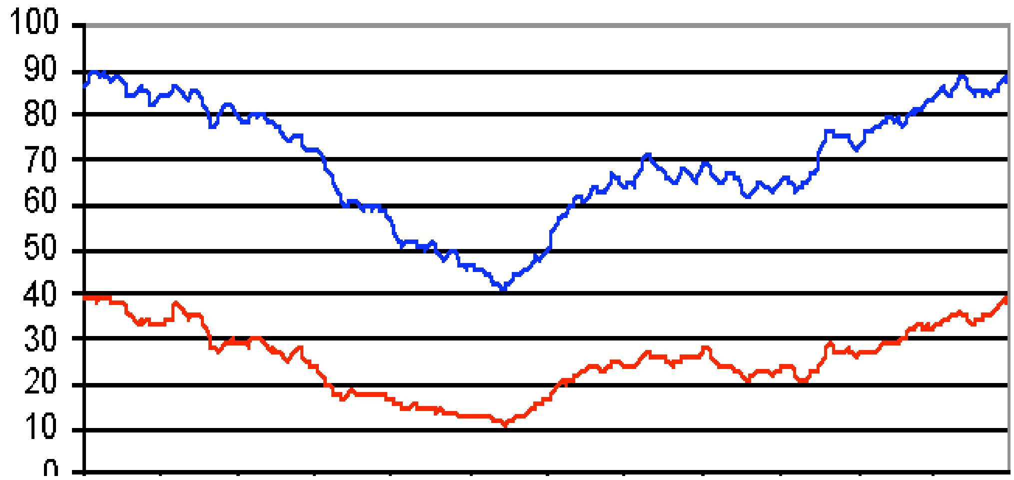

Figure 10. Five-day running climatological means of Roosevelt RAWS maximum (blue curve) and minimum (red curve) relative humidity.

5. Weather related prescription ranges – Some fuel and fire specialists in the monsoon region were consulted on the desired ranges of weather and fuel moisture elements related to the monsoon that are required to conduct prescribed fire. With this field knowledge in hand, maps and tables of prescription parameters will be constructed as part of the analyses in task 4 above. Example parameters include criteria of temperature ≤ 75 degrees F, relative humidity ≥ 15%, wind speed ≤ 15 mph. The primary remaining criteria relate to ranges in dead fuel moisture (i.e., 1, 10, 100 and 1000-hr fuels).

6. Presentation of results – The primary analyses of this study comprise a major part of a Master's student thesis project. When the final results of the study are complete, a thesis, scientific journal paper, and agency project report will be prepared. The results will be presented at relevant agency meetings and workshops and scientific conferences as warranted.

Task Order 6: A Comparison of Precipitation/Drought Indices Used in Fire Management.

This task order was approved during Fall 2000 by the state Fire Management Officers (FMOs), but specific project tasks and deliverables were not determined until summer 2002. The project will officially begin in federal FY03. The project was scaled back considerably from its original inception due to budgetary constraints. The primary focus is to assess the strengths and weaknesses of the standardized precipitation index, the Palmer drought severity index (and its derivatives), and Keetch-Byram drought index in the context of fire management decisions. Results will be presented in the form of an interagency report, a scientific journal article, and presentation at relevant meetings, workshops and scientific conferences.

Task Order 7: Web Access to RAWS Data and Products.

This task is being accomplished within WRCC by separate BLM funds but using CEFA as a project and collaboration conduit. The primary project objective is to build upon recent efforts to reconstruct the internal storage and access system for RAWS data and initiate system-wide improvements. This work officially began in August 2001. Specific project tasks during the first year included:

1. Finish conversion of RAWS station data from ASCII text to internal binary indexed format.
2. Finish conversion of RAWS station metadata to internal format.
3. Development of metadata display graphs.
4. Development of a RAWS station selection interface.
5. Adaptation of Cerro Grande display format to all RAWS stations (http://www.losalamos.dri.edu/index.html).
6. Development of web accessible data listing capability.
7. Development of web accessible wind rose program.

All of these tasks have been completed. The first two tasks required the vast time consumption of creating an internal database of all historical RAWS data and associated metadata. The bulk of effort was matching station NESS IDs to create a proper and continuous series of data for each RAWS. Once this was completed, the station data in text format was converted to an internal binary indexed format. This allows internal computer software to quickly reference and acquire historical data from the database. This is effectively database query software that has been internally and generically written for the sole purpose of maintaining and extracting RAWS data. In addition to the observed data, RAWS station metadata was organized and converted to an internal reference format. The result of this database organization and conversion process will allow users to extract requested information via the WRCC RAWS web site.

Metadata display graphs were developed in task 3. This allows WRCC personnel to quickly monitor and assess the historical archive for a particular RAWS, and provides external users with relevant metadata information about a selected station.

Tasks 4 and 6 dealt with developing a web based user interface system for query and acquisition of RAWS data. The prototype system has been built, and some limited user testing has taken place. Changes will likely be implemented based upon user comments over the coming months as the system becomes publicly available.

Tasks 5 and 7 were comprised of developing some value-added products based on the historical RAWS data. For example, basic climatology summaries and wind roses will be made available. WRCC has developed several web clickable maps for specific regions of interest per agency requests. For example, WRCC was requested to develop and make accessible a Cerro Grande region RAWS access map following the large fire event in 2000. This concept has been extended to other regions (see the WRCC web site at http://www.wrcc.dri.edu for current active regions).

During the summer of 2002, BLM provided equipment funding to WRCC to acquire high-end web server software in conjunction with this RAWS project. This will allow for faster accessibility to the database and value-added products. It is anticipated that the database will be generally accessible in early calendar year 2003. If users would like to participate in a beta-test of the web site, they should contact Greg McCurdy at WRCC (gmwrcc@dri.edu).

Task Order 8: Development and Implementation of the CEFA Operational Forecast Facility.

In October 2001, a concept proposal was submitted to the California and Nevada Wildfire Agencies to develop and implement an operational mesoscale meteorology forecast facility for smoke and fire management to be referred to as the CEFA Operational Forecast Facility (COFF). The purpose of the facility is to provide high-spatial resolution weather forecasts and value-added products for federal, state and local fire and smoke management agencies in California and Nevada. These forecasts will be made available on a grid covering all of California and Nevada at 36, 12 and 4 km spatial resolution, and 6-hourly out to 60 hours. Products from COFF will enhance and improve forecasts of smoke dispersion and transport, fire danger and fire behavior in addition to providing general meteorological forecast information over the two state area. Meteorologists from the Geographic Area Coordination Centers, air regulatory agencies, and the National Weather Service are the primary intended recipient of the products and information. However, users with knowledge of meteorological output will find value in the products, as well as others (e.g., FBANs, fuel specialists, fire specialists) for whom specific forecast information is generated.

The California Firescope Weather Working Group approved the concept proposal in 2001, and subsequently formed the California and Nevada Smoke and Air Consortium (CANSAC) currently comprising thirteen federal, state, county and local agencies. Figure 11 provides a flow chart of current consortium membership. The consortium is comprised of a governing board, a technical advisory committee, and a user advisory group.

The USFS Pacific Southwest Research Station (PSW) is a member of the CANSAC consortium as depicted in the Figure 11 chart, and is also an important research partner with COFF. PSW represents one of five USFS regional modeling consortia to support the National

Fire Plan, thus linking COFF to the Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS). See http://www.fs.fed.us/fcamms for more information.

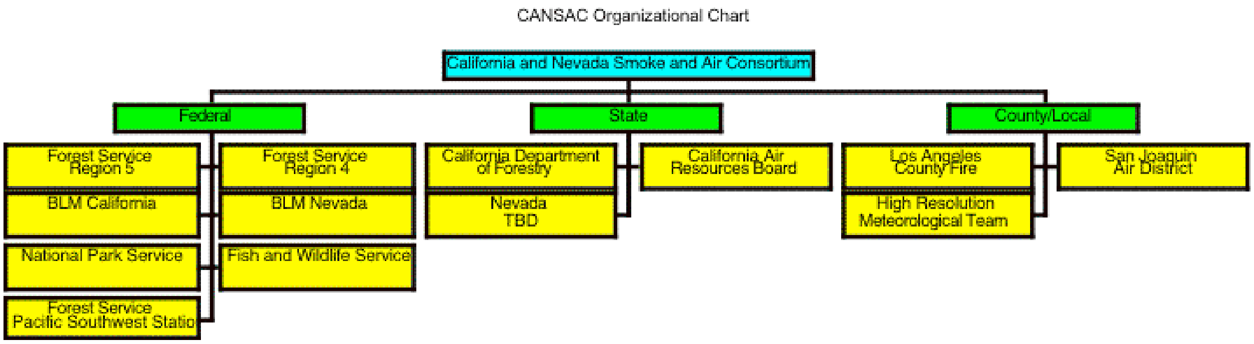

Figure 11. Membership chart for the California and Nevada Smoke and Air Consortium (CANSAC).

In order to operate COFF, each consortium member will provide the necessary funding. Annual funding is estimated to be on the order of $30-50K per member per year, with total operating costs expected to be approximately $375K per year (applied research costs are not included in this amount). The California Department of Forestry and Fire Protection (CDF) is providing a $300K grant that will allow for the purchase of the computer hardware infrastructure. Each participating agency will need to establish an arrangement to allow funding transfers to DRI. BLM, other DOI agencies, and agencies that can utilize a DOI funding transfer mechanism can utilize the existing BLM/DRI cooperative Assistance Agreement 1422RAA000002. The purpose of this task order is to begin the development and implementation of COFF starting 1 July 2002 utilizing BLM California and Nevada funds. However, the bulk of development is anticipated for fall and winter 2002-2003 with implementation in late spring or early summer 2003. The operation of COFF is expected to be multi-year.

Much of the first year will be devoted to building the computing infrastructure, putting in place required personnel, establishing product requirements and specifications, testing the MM5 model, and developing a real-time verification system. Primary tasks include:

1) Determine final specifications of required computer hardware and purchase system components.
2) Build and test the high-performance computing cluster.
3) Hire necessary personnel to operate the facility.
4) Implement and test the MM5 model.
5) Begin development of the real-time verification system.
6) Establish product requirements and specifications.
7) Begin producing operational forecasts.

The accomplishment of tasks 2-7 is largely dependent upon the first task. CEFA is anticipating the CDF hardware funding during fall of calendar year 2002. Also, DRI is remodeling and refurbishing facilities to house the PC cluster anticipated for completion during the fall. Some initial activities have been undertaken as part of this task order. These included developing a CANSAC web site (accessible via the CEFA web site), preliminary personnel searching, and some establishment of product requirements and specifications.

Task Order 9: Development of U.S. Operational Fire Danger 15-Day Forecasts.

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

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

Tasks required for this project include developing a gridded ERC climatology based on fuel model G, developing computer code that ingests gridded AVN forecasts into NFDRS algorithms, developing a system for producing daily operational forecasts, and developing desired output maps. Specific tasks include:

1) Develop gridded ERC climatology based on fuel model G. A U.S. 8 km gridded climatology of temperature, relative humidity and precipitation currently being developed at the University of Montana will be used to produce a 13-year (1989-2001) climatology of ERC. Fuel model G will be applied to all climatology grid

points. A mean and standard deviation value will be computed for each grid point that will be used to standardize the forecast values. The 8 km grid will be integrated to produce a climatology grid that matches the operational weather forecast grid.

2) Develop computer code linking NFDRS algorithms and AVN weather forecasts. The prototype gridded NFDRS code will be modified to interface with the AVN grids and run on a 15 day cycle instead of next-day.
3) Develop operational system for producing daily forecasts. This primarily involves putting in place computer code to access the operational daily forecasts, setting up the process to compute the daily ERC forecasts (including initializing the grid with real-time heavy and live fuel moistures), and producing the relevant output (e.g., map graphics).
4) Develop forecast output product. Web accessible forecast maps are the primary product output for the prototype forecast system. Initially these will consist of national maps of shaded contour ERC standardized values and percentiles for each forecast day. However, NICC will be strongly relied upon for suggestions in developing the output product, especially in regard to content and appearance.
5) Evaluation of forecast products. This will consist of evaluating the utilization of the prototype system, and not a quantitative verification of the forecast products. During this period, NICC will assess the product for its utility and value in determining national preparedness levels and resource needs. Some minor relevant changes to the prototype system and its output can occur during this phase.

Since this project began during mid-summer of calendar year 2002, the overall accomplishments are limited. MFSL is currently working on developing the fuel model G climatology. This should be completed near the end of the calendar year. CEFA has prepared the necessary computer code for ingesting the model forecast grids.

Task Order 10: Operations of the CEFA Operational Forecast Facility.

This task order is closely related to Task Order 8 and establishes the general deliverables of products and information once the CEFA Operational Forecast Facility becomes operational. This task order establishes a mechanism for CANSAC funding transfer to DRI for COFF operations. During the first year of operations, agency specific deliverables from operational forecast products will likely be limited. It is anticipated that some forecast products will be available based on 36 and 12 km resolutions, but 4 km products should probably not be planned on during the first year. Deliverables will include the categories of:

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

Other Activities

Other activities that are not directly associated with a task order, but are of relevance to BLM are provided in this section.

Working with Mr. Paul Schlobohm

In addition to the regular interactions between CEFA and Mr. Schlobohm in conjunction with the AA and related task orders, personnel work with him on a frequent basis as part of his university training and graduate degree. For example, Dr. Tim Brown, Director of CEFA, provides Mr. Schlobohm with academic guidance and direction on his Masters thesis topic. Dr. Brown and Mr. Schlobohm also interact closely on other research projects and concepts. For example, the two individuals collaborated on a project to examine the relationship between the standardized precipitation index and fire occurrence in the Great Basin. Preliminary results of this work were presented at the American Meteorological Society Fourth Symposium in Fire and Forest Meteorology held in Reno, Nevada during November 2001. Beth Hall, Research Scientist and CEFA Deputy Director, continues to work with Mr. Schlobohm regarding data and computer programming training and issues.

Mr. Schlobohm's graduate work is also considered a CEFA project. His thesis is that satellite imagery can be used to determine live fuel conditions for NFDRS. More specifically, weekly maximum composite values of 1-km Normalized Difference Vegetation Index (NDVI) derived from multispectral NOAA satellite imagery capture the changes in fuel condition that are known as the greenup date and the length of greenup in the NFDRS (1978 version). These events can be identified both in the historical record and operationally as the year progresses. Currently NFDRS relies on the fire manager to estimate the initial timing of greenup (greenup date), and the length of greenup is a predetermined fixed number of days based on the climate of the area (represented by climate class). Mr. Schlobohm's proposal is that a method for determining greenup based on NDVI will provide greenup parameters at an appropriate spatial scale and temporal variability for the next generation of NFDRS. The focus of this work will be to determine the utility of NDVI for identifying the start and end of greenup. Completion of this work is anticipated during summer 2003.

Training

In February 2001 Dr. Brown presented a climate and fire danger lecture at the NARTC Advanced Fire Danger Rating System course.

CAP and CLIMAS Interactions

CEFA has an established partnership with CAP and the University of Arizona, Institute for Studies of Planet Earth, Climate Assessment for the Southwest (CLIMAS) 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, along with ECPC collaboration, 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 discussed below. Further CAP information can be found at: http://meteora.ucsd.edu/~meyer/caphome.html.

The primary collaboration with CLIMAS during this year involved co-organizing the 2002 Fire and Climate Workshop during March. This workshop brought together national and regional climate scientists, fire managers, and fuel and fire specialists to formally and informally discuss the utilization of climate information in fire business. One of the key products of this meeting was the development of a consensus seasonal climate forecast for the U.S. with emphasis on climate impacts for fire. CEFA and CLIMAS participated with the Southwest GACC in producing a southwest area seasonal outlook of climate and fire conditions that was distributed from the GACC. The forecast of continued dry conditions and high fire danger, along with extensive fire activity, verified quite well during the season. Further CLIMAS information CLIMAS is available at: http://www.ispe.arizona.edu/climas/index.html.

Hourly Fire Danger

Over the past couple of years and in conjunction with several California wildfire agencies, CEFA has been developing a prototype and experimental system for calculating and displaying hourly fire danger in California. Using hourly RAWS from WRCC and NFDRS algorithms provided by Larry Bradshaw at MFSL, fire danger indices are computed for each fire danger rating area across the state, and a fire adjective class calculated on an hourly basis. California wildfire agency personnel are currently evaluating the product. Before the prototype system can be considered official, considerable evaluation is required in order to determine that the adjective classification is computed correctly and as expected by users, and that the system is producing reasonable hourly values given that NFDRS was originally designed for once daily calculations. Figure 12 shows an example map from the prototype system.

Climate Prediction and Fire Danger

CEFA collaborated with the Scripps Institution of Oceanography (Drs. Dan Cayan, Tim Barnett, and Tony Westerling) on the Department of Energy (DOE) Accelerated Climate Prediction Initiative (ACPI) project. CEFA's role in the project was to incorporate climate model predictions for the period 1975 through 2089 into NFDRS algorithms and assess how fire danger in the western U.S. might change in response to regional climate change during the 21st Century. The results of this study have been submitted to the scientific journal Climatic Change. The paragraph below is the abstract of results taken from the submitted journal article.

"High-temporal resolution meteorological output from the Parallel Climate Model (PCM) is used to assess changes in wildland fire danger across the western United States due to climatic changes projected in the 21st Century. A business-as-usual scenario incorporating changing greenhouse gas and aerosol concentrations until the year 2089 is compared to a historically observed period 1975-1996. Changes in relative humidity, especially drying over much of the West, are projected to increase the number of days of high fire danger at least through the year 2089 in comparison to the base period. The regions most affected are the northern Rockies, Great Basin and the Southwest – regions that have already experienced significant fire activity early this century. By the year 2070, when the model climate CO_2 has doubled from presentday, the increase in fire danger is as much as two to three weeks in these regions. The Front Range of the Rockies and the High Plains regions do not show substantial changes in high fire danger. No change in fire season length is indicated anywhere in the West. For those regions where change is predicted, new fire management strategies and policies may be needed to address these added climatic risks, by changes in suppression and fuel treatment approaches, while also accommodating the complex and changing ecosystems and increasing human stresses and considerations on the region."

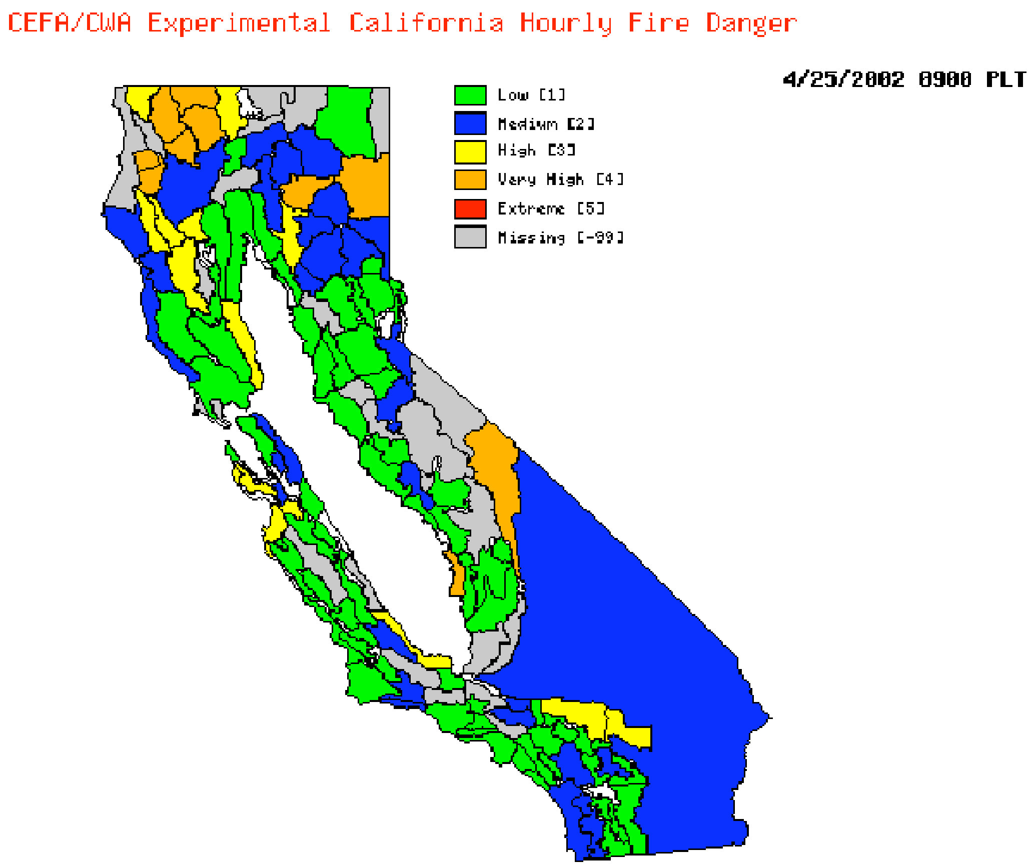

Figure 12. Example map from the California hourly fire danger prototype system. Boundaries indicate fire danger rating areas, and colors represent fire danger adjective class.

Operational mixing height forecasts

Based on graduate work from former graduate student Matt Fearon, an improved method for estimating the mixing height was developed. The method is being used operationally at CEFA in the production of real-time forecasts of mixing height and associated transport winds utilizing NCEP/NWS Eta model forecasts. The forecasts are 6-hourly out to 48 hours. Maps of both the western and eastern U.S. are provided on the CEFA web site. Special digital forecast information is forwarded to the California GACC's where it is implemented into their operational smoke management forecasts. In southern California, a clickable web site has been developed where users can click on an air basin to obtain the forecast information. Figure 13 provides an example western U.S. mixing height forecast map graphic. A scientific journal article of the study results and discussion is currently being prepared.

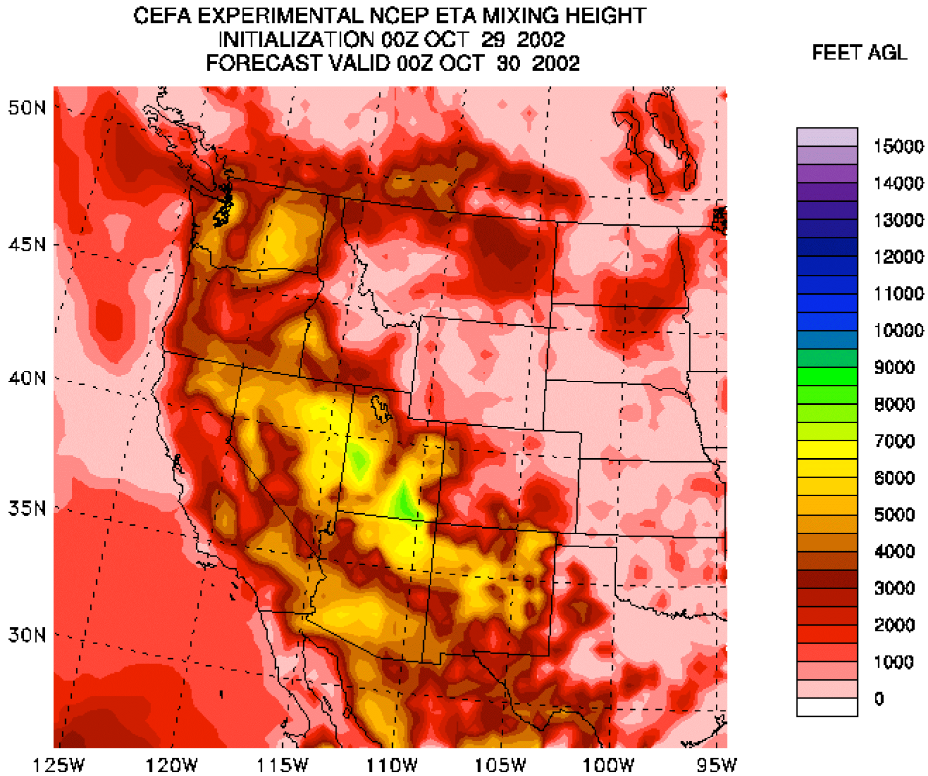

Figure 13. Example map of the real-time mixing height forecasts produced at CEFA.

Travel, Presentations and Meeting Activities

This section provides brief information regarding travel, presentations and meeting activities relevant to CEFA and BLM during 1 October 2001 through 30 September 2002 (FY02). In many cases, the travel costs were covered by the requesting agency or means other than Task Order 1.

October 22-25 (San Diego, CA): Tim Brown presentation (2001 fire and climate season) at the Climate Diagnostics Workshop.

October 30 (Sacramento, CA): Tim Brown and Beth Hall presentation at the California Fire Weather Working Group meeting.

November 6-7 (Minneapolis, MN): Tim Brown presentation at the GACC meteorologist fall meeting.

November 13-15 (Reno, NV): Tim Brown, Beth Hall and Paul Schlobohm presentations at the American Meteorological Society 4th Symposium on Fire and Forest Meteorology. T. Brown also co-program chair of symposium.

December 5-6 (Portland, OR): Tim Brown participation as technical advisor/consultant for the Joint Fire Science Program national fire preparedness proposal development.

January 8-9 (Austin, TX): Tim Brown presentation and the NWCG Fire Danger Working Team meeting.

January 15-17 (Minneapolis, MN): Tim Brown presentation at the Eastern Area Coordination Center meeting.

January 23 (Boise, ID): Tim Brown and Paul Schlobohm presentation at the NIFC science meeting.

February 21 (Tucson, AZ): Tim Brown lecture at the NARTC Advanced Fire Danger Rating System course.

February 26 (Corvallis, OR): Tim Brown at USFS meeting on climate model prediction of vegetation and fire danger.

February 28-March 1 (Washington, D.C.): Tim Brown presentation on fire and climate at the NOAA Office of Global Programs.

March 5-8 (Tucson, AZ): Tim Brown presentation at ISPE/CLIMAS Fire and Climate 2002 workshop. T. Brown also co-organizer of workshop.

March 14 (Sacramento, CA): Tim Brown attend USFS meeting on developing interagency operational mesoscale meteorology forecasts for California and Nevada.

March 20 (Los Angeles, CA): Tim Brown presentation annual meeting of Association of American Geographers.

March 22-28 (Tucson, AZ): Tim Brown presentation at international workshop on Fire and Climate History.

April 10-11 (Fort Collins, CO): Tim Brown presentation at the GACC meteorologist spring meeting.

April 23 (Sacramento, CA): Tim Brown and Beth Hall presentation at the California Fire Weather Working Group meeting.

May 20 (Sacramento, CA): Tim Brown attend USFS meeting on developing interagency operational mesoscale meteorology forecasts for California and Nevada.

June 25-27 (St. Petersburg, FL): Tim Brown presentation at the Southeast Climate and Fire Workshop.

July 23 (Sacramento, CA): Tim Brown attend USFS meeting on developing interagency operational mesoscale meteorology forecasts for California and Nevada.

August 22-23 (Iowa City, IA): Tim Brown visit at Iowa State University for discussions on high-performance computing.

September 18 (Sacramento, CA): Tim Brown attend USFS meeting on developing interagency operational mesoscale meteorology forecasts for California and Nevada.

Reports and Publications

Brown, T.J., 2001: Climate and Fire: Framing the Issues in Context of the 2000 Fire Season. *Proceedings 2001 Fire and Climate Workshops*, University of Arizona, Institute for the Study of Planet Earth, Climate Assessment for the Southwest, 3-7.

Brown, T.J., 2001: Fire Forecasts for 2001. *Proceedings 2001 Fire and Climate Workshops*, University of Arizona, Institute for the Study of Planet Earth, Climate Assessment for the Southwest, 12-14.

Brown, T.J., 2001: Program for Climate, Ecosystem and Fire Applications. *Proceedings 2001 Fire and Climate Workshops*, University of Arizona, Institute for the Study of Planet Earth, Climate Assessment for the Southwest, 44-47.

Hall, T.J., and T.J. Brown, 2001: Development of Lightning Climatology Information over the Western U.S. Report prepared for Bureau of Land Management, CEFA Report 01-03, October 2001, 4 pp.

Brown, T.J., and B.L. Hall, 2001: Assessing long-term fire danger variability and change from climate model output. *Proceedings American Meteorological Society Fourth Symposium on Fire and Forest Meteorology*, November 2001, 217-219.

Hall, B.L., and T.J. Brown, 2001: Development of lightning climatology information over the western U.S. *Proceedings American Meteorological Society Fourth Symposium on Fire and Forest Meteorology*, November 2001, 112-114.

Roads, J.O., F.M. Fujioka, and T.J. Brown, 2001: Development of a seasonal fire severity forecast for the contiguous U.S.: weather forecast and validation. *Proceedings American Meteorological Society Fourth Symposium on Fire and Forest Meteorology*, November 2001, 56-59.

Schlobohm, P.M., and T.J. Brown, 2001: Fire danger and the standardized precipitation index. *Proceedings American Meteorological Society Fourth Symposium on Fire and Forest Meteorology*, November 2001, 220-222.

Brown, T.J. and B.L. Hall, 2001: *Climate and Ecosystem Studies and Product Development for Wildland Fire and Resource Management*, Annual Report prepared for Bureau of Land Management, CEFA Report 01-04, November 2001, 13 pp.

Brown, T.J., B.L. Hall, and G.D. McCurdy, 2002: Quality Control of California Historical RAWS Data. Report prepared for the California Firescope Weather Working Group, CEFA Report 02-01, March 2002, 27 pp.

Brown, T.J., 2002: 2002 Seasonal Consensus Climate Forecast for Wildland Fire Management. Report prepared for Interagency Fire Management, CEFA Report 02-02, March 2002, 5 pp.

Brown, T.J., A. Barnston, J.O. Roads, R. Tinker, and K.E. Wolter, 2002: 2002 Seasonal Consensus Climate Forecasts for Wildland Fire Management. Experimental Long-Long Forecast Bulletin, Center for Land-Ocean-Atmosphere Studies, University of Maryland, March 2002.

Westerling, A.L, A. Gershunov, D.R. Cayan, and T.J. Brown, 2002: A western United States fire climatology. *Bulletin of the American Meteorological Society* (Accepted).

Brown, T.J., B.L. Hall, A.L. Westerling, 2002: The impact of twenty-first century climate change on wildland fire danger in the western United States: an applications perspective. Submitted to the journal Climatic Change.

CEFA Contact Information

Dr. Tim Brown, Director; 775-674-7090; tbrown@dri.edu
Beth Hall, Research Scientist/Deputy Director, 775-674-7174; bhall@dri.edu
Charlie Mohrle, Graduate Research Student; 775-673-7390; cmohrle@dri.edu
Hauss Reinbold, Graduate Research Student; 775-673-7386; reinbold@dri.edu
Paul Schlobohm, BLM/NIFC Fire Management Specialist; 775-674-7170; pschlobo@dri.edu

http://cefa.dri.edu

Desert Research Institute
2215 Raggio Parkway
Reno, NV 89512-1095