Program for Climate, Ecosystem and Fire Applications

CANSAC-CEFA Operations and Products for the California and Nevada Smoke and Air Committee

Annual Report

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Annual report on CANSAC-CEFA Operations and Products for the California and Nevada Smoke and Air Committee

by
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EXECUTIVE SUMMARY

The California and Nevada Smoke and Air Committee (CANSAC) is a consortium of multi-agency fire weather and air quality decision-makers, managers, meteorologists and scientists in partnership to provide operational meteorological support for wildland fire and smoke management, and advance the scientific understanding of atmosphere and fire interactions. The operational component of CANSAC is implemented at the Desert Research Institute (DRI) program for Climate, Ecosystem and Fire Applications (CEFA) in Reno, Nevada in collaboration with the CANSAC constituents. CEFA consists of a team of scientists and technical experts whose purpose is climate and ecosystem studies and product development for wildland fire and resource management.

CANSAC is organized into three groups for oversight, technical components and product development. The Board of Directors (BOD) is comprised of representatives of those agencies that provide funding for CANSAC. The Technical Advisory Group (TAG) is appointed by the BOD and is comprised of members with technical backgrounds in atmospheric modeling and research. The Operational Applications Group (OAG) is appointed by the BOD and is comprised of users of the CANSAC products. All facets of the community are represented, including federal, state, and local air pollution meteorologists, air quality modelers, and prescribed fire managers.

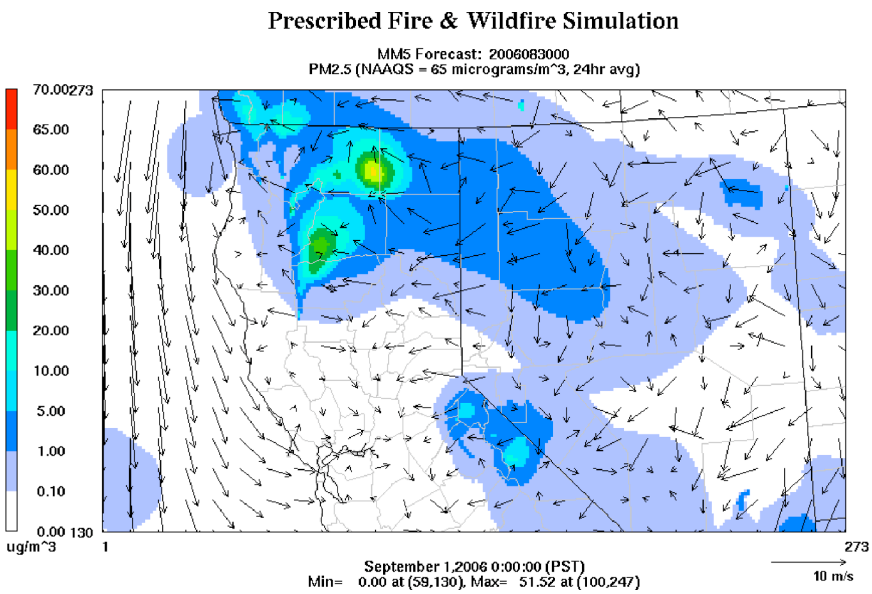
As of June 2007, CANSAC is comprised of ten members:

- USDA Forest Service Region 5
- USDA Forest Service Pacific Southwest Research Station
- Bureau of Land Management California
- Bureau of Land Management Nevada
- National Park Service
- U.S. Fish and Wildlife Service
- California Air Resources Board
- California Department of Forestry and Fire Protection
- Los Angeles County Fire Department
- San Joaquin Air Pollution and Control District

CANSAC is linked to the Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS) consortia through the Forest Service Pacific Southwest Research Station. FCAMMS is comprised of the US Forest Service research stations and partners whose purpose is to study the atmospheric component of the fire environment across space and time scales, and its interaction with other components, using a balance of basic and applied science to provide tools to the field now, and to create a basis for future science applications. The regional structure of the FCAMMS allows better coordination with land management needs and locally unique fire problems, but the science developed by the FCAMMS is globally relevant and shared among the regions as needed and appropriate.

CEFA manages and maintains the computing infrastructure used to produce the CANSAC products. Operational meteorological forecasts are generated using the Fifth Generation Penn State/NCAR Mesoscale Model (MM5) on a three-nested domain covering a large area of the Western US, and focusing on California and Nevada at the highest resolution (4-km). The MM5 model is initialized twice daily with the North American Meso (NAM) model 00 and 12 UTC forecast outputs. Hourly forecasts are made out to 72-hours (60-hours for the 4-km domain).

BlueSky, a coupled modeling framework to predict smoke ($PM_{2.5}$ concentration) impact from wildland, agricultural and prescribed burns, is used to produce smoke forecasts. Bluesky produces emissions using standard emission factors, and predicts concentrations by applying Calpuff, an EPA approved dispersion model. Bluesky is currently linked to agency Form 209 wildfire reports that include geographic and other information about a fire. Prescribed fire information can also be input into BlueSky via a web-based form to indicate date, location, size and emission parameters including fuel type and fuel amount. Bluesky will be linked to the CARB Prescribed Fire Incident Reporting System (PFIRS) when it becomes available. This system will be used to log, track and archive prescribed fires across the state.



Example forecast map of smoke concentration from Bluesky.

Currently, the set of visual meteorology products from CANSAC includes plots of ventilation index, Haines index (high and mid levels), lifted index, cloud water, planetary boundary layer height, precipitation, absolute vorticity and sounding plots/text files along with other standard parameters used in weather forecasting and atmospheric assessment applications.

The Fire Weather Centers (FWCs) of Predictive Services in California use a host of CANSAC forecast graphics regularly to support agency prescribed burn programs. Value in the CANSAC products include:

- Refined weather predictions from CANSAC models increase the situational awareness necessary for sound decision making by fire management
- Smoke modeling products can identify risk to the public as a key component in Appropriate Management Response

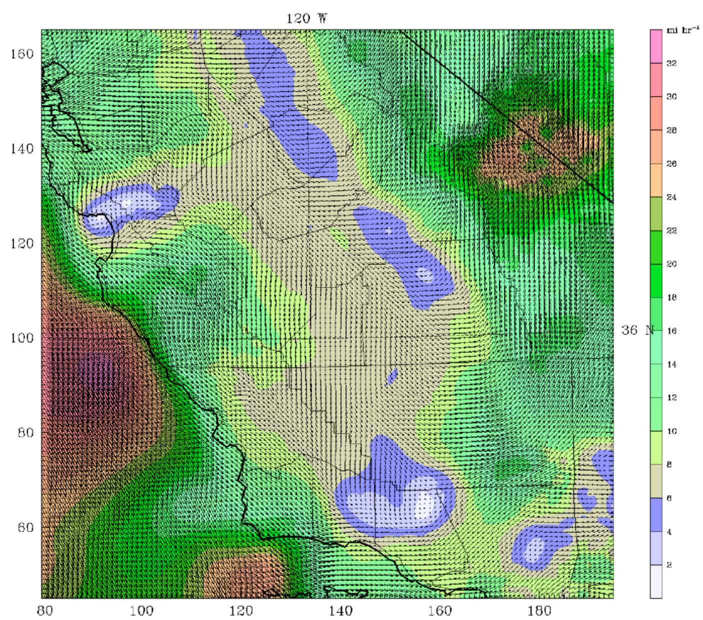
The graphics:

- Provide guidance for predictions in our site-specific (Spot) forecast
- Build increased forecaster confidence compared to other methods

- Are referenced in Daily 1300 PDT Smoke Coordination calls

The California Air Pollution Control districts have identified a number of important uses of CANSAC products. Many of these are considered when making prescribed burn determinations and WFU recommendations.

- Prescribed fire declarations and Wildfire Use advisories
- State lands and pile burn declarations
- Forecasting of Ozone and Particulate Matter influencing fire emissions management decisions
- Pollutant forecasts for public information
- Agricultural burn declaration and allocation
- Forecasting and retrospective analysis of wind driven particulate events under EPA's Natural Event Action Plans
- Forecasting of upslope and downslope timing and duration to determine smoke impacts in canyon areas
- Forecasting of regional impacts of fire emissions on particulate and ozone
- Residential wood combustion determinations
- Spare the air day determinations
- Health advisory declarations
- Forecasting of intensive measurement days for the Photochemical Assessment Monitoring Site (PAMS) program



Example CANSAC forecast map of high-resolution wind speed and direction for southern California.

Agency interest in CANSAC has grown since operations began in 2004. Feedback from users of the products has been positive. CANSAC has demonstrated a successful partnership early in its existence. CEFA is currently seeking research-funding opportunities to help provide new and improved products, and support infrastructure. For CANSAC to be sustainable, consistent funding support is required. This is achievable through recognition of agency usage and value of products, as well as increasing CANSAC membership by bringing on board more air quality agencies in both California and Nevada.

Introduction

The California and Nevada Smoke and Air Committee (CANSAC) is a consortium of multi-agency fire weather and air quality decision-makers, managers, meteorologists and scientists in partnership to provide operational meteorological support for wildland fire and smoke management, and advance the scientific understanding of atmosphere and fire interactions. The operational component of CANSAC is implemented at the Desert Research Institute (DRI) program for Climate, Ecosystem and Fire Applications (CEFA) in Reno, Nevada in collaboration with the CANSAC constituents. Though the operations have been underway for 2 years, this is the first formal report prepared on behalf of CANSAC for the fire and air quality community. This report includes sections providing background, organization, supporting agencies, infrastructure, accomplishments, partnership, CANSAC needs and its future, product examples and personnel.

Background

In the spring of 1999, the California FIRESCOPE Fire Weather / Fire Danger Group (hereafter referred to as the California Wildfire Agencies (CWA)), met in a special meeting to discuss the possibilities of forming a consortium of federal, state, county, and local fire and air quality agencies that would utilize value-added products from an operational mesoscale meteorology model for decision-making purposes. These products would include standard meteorological elements (e.g., temperature, humidity, wind, precipitation), and value-added information of smoke dispersion and transport, fire danger and fire behavior.

The interest in developing an operational facility to provide these products, and incorporating them in decision-making processes, had been growing over recent years with the realization that new tools and methods were becoming available that could improve forecasts and add substantial information value. A consortium of user groups at the University of Washington was looked upon as a desirable framework (see the web site http://www.atmos.washington.edu/~cliff/consortium.html).

The catalyst came in 2000 when the California Air Resources Board began public hearings on amendments to Title 17 of the California Code of Regulations regarding Agricultural Burning Guidelines (see http://www.arb.ca.gov/regact/agburn/45daynotice.doc/ for the proposed changes announcement, and http://www.arb.ca.gov/regs/title17/toc17.htm/ for legal text). Four of the five general new guidelines directly relate to prescribed burning, which is a subset of agricultural burning in the Title.

The first new guideline is the implementation within each air district of a smoke management program "that minimizes or avoids the health impacts of smoke from agricultural burning, including prescribed burning, on smoke sensitive areas". Each program will also contain "a daily system for regulating the amount, timing and location of burn events to minimize smoke impacts". The second guideline requires the submittal of a smoke management plan, with the amount of information required for each plan dependent on the size of the burn. The larger the burn, and hence the more likely a sensitive area impact, the more information is required, such as detailed reporting, monitoring and contingency plans. The third guideline emphasizes smoke prevention and reduction, and doing so by determining "the appropriate amount, location and scheduling of burn projects, considering daily weather and air quality conditions". The fourth guideline calls for improving "meteorological data and tracking techniques to accommodate necessary increases in prescribed burning". This is designed to improve burn day declarations. At the time, the only specifically required meteorological assessment was 500 mb height. Though not completely void of weather considerations, the fifth guideline addresses non-burn alternatives to meet management objectives.

Another factor that helped crystallize the operational concept is that the fire weather meteorologists at the California Interagency Fire and Forecast Warning Units of Redding and Riverside were cognizant from everyday experience that improved information would be beneficial and was obtainable in principle. CWA fire management, and fire and fuels specialists around the state agreed, and consensus was reached that an operational facility was desired to meet the new demands for information and decision accountability. Over the next 1.5 years, several meetings in California were convened to define partners that would comprise a consortium of interested parties from both fire and air quality agencies.

By mid-2001, a dozen federal, state, county and local agencies were identified as potential partnership members. In the fall of 2001, a draft charter was composed that effectively was a Memorandum of Understanding (MOU) amongst the agencies that would be directly involved in the project and could provide funding. During the following winter and spring, efforts continued on establishing charter members, and in July 2002, a consortium Board of Directors was formed and given the name California and Nevada Smoke and Air Committee (CANSAC)[1]. The board members were representatives of their respective agencies, and linkages to the necessary start-up and continued support funding required for the project on an annual basis.

Reaching consensus on doing something is one thing and often easy, but finding the funding to support it is most of the time another matter. Over $600K was required during the first year to implement the project and maintain it for one year. Nearly half of this included funds for computer hardware needed to run the high-resolution meteorology model and produce all of the desired output. Earlier in 2001, the California Department of Forestry and Fire Protection (CALFIRE) developed a grant proposal to the U.S. Fish and Wildlife Service (FWS) to fund the hardware portion of the project. The operational costs were to be combined from the other committee members. In early 2002, the grant was awarded, and CANSAC appeared well on its way to being operational. But for the next 18 months, a number of events happened, including a series of bureaucratic obstacles, politics and legal rule changes, all interconnected in some manner that impeded the hardware grant process until it stopped completely.

However, in July 2003, a breakthrough occurred via a combination of previous funding commitments, year-end funds and a significant grant from FWS. Enough funding was secured to finally begin the implementation and operations of the facility starting in September 2003. Computer hardware was reviewed and specified, and project personnel were identified during the next few months. In February 2004, orders were placed for the hardware and personnel hired to implement the system. In May 2004, an official dedication ceremony was held at DRI. June 1st was designated as the official start-up date, though more consistent output did not begin until July. Model forecasts and value-added products have been produced in a quasi-operational mode up through the present. A presentation describing CANSAC was given by at the American Meteorological Society Fifth Symposium on Fire and Forest Meteorology (Brown *et al* 2003).

[1] It was recognized early on that though primarily driven within California, Nevada as an immediate neighbor should also be a partner in the endeavor; Oregon was already part of the Pacific Northwest consortium and thus not considered. Also, model grids are required to be rectangular, and California and Nevada together form a basic rectangle shape.

CANSAC organization

During the formation of CANSAC, it was recognized that three separate, but linked groups should be formed for oversight, technical components and product development.

The Board of Directors (BOD) is comprised of representatives of those agencies that provide funding for CANSAC. Board members have voting rights on relevant CANSAC issues. The BOD primary responsibilities include developing necessary MOU's, approving annual operational plans, submitting to funding agencies an annual program and progress report, providing overall management of CANSAC, and reviewing recommendations of the Technical Advisory and Operational Applications Groups.

The Technical Advisory Group (TAG) is appointed by the BOD and is comprised of members with technical backgrounds in atmospheric modeling and research. For continuity, there is one member from the operational group. The primary tasks of TAG include monitoring MM5 output and making recommendations for improved model performance, coordinating with other modeling centers, reviewing research projects and assessing products for applicability for field use, working with the Pacific Northwest consortium to implement "Bluesky", and submitting recommendations and reports to the BOD.

The Operational Applications Group (OAG) is appointed by the BOD and is comprised of users of the CANSAC products. All facets of the community are represented, including meteorologists, prescribed fire managers, air quality officials, etc. One member of TAG is assigned to the group for continuity. The tasks of OAG include representing the potential end user, recommending new graphics and visualizations for field use, communicating to groups within their respective agencies to disseminate information and market products, and submitting recommendations and reports to the BOD.

All three groups meet semi-annually either in person or via conference calls. CEFA has a representative within each group to present new information, answer questions and collect feedback.

Supporting Agencies

As of this report, there are ten members of CANSAC:

- USDA Forest Service Region 5
- USDA Forest Service Pacific Southwest Research Station
- Bureau of Land Management California
- Bureau of Land Management Nevada
- National Park Service
- U.S. Fish and Wildlife Service
- California Air Resources Board
- California Department of Forestry and Fire Protection
- Los Angeles County Fire Department
- San Joaquin Air Pollution and Control District

CANSAC is linked to the Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS) consortia through the Forest Service Pacific Southwest Research Station. Figure 1 highlights the CANSAC spatial domain relative to the other FCAMMS consortia members.

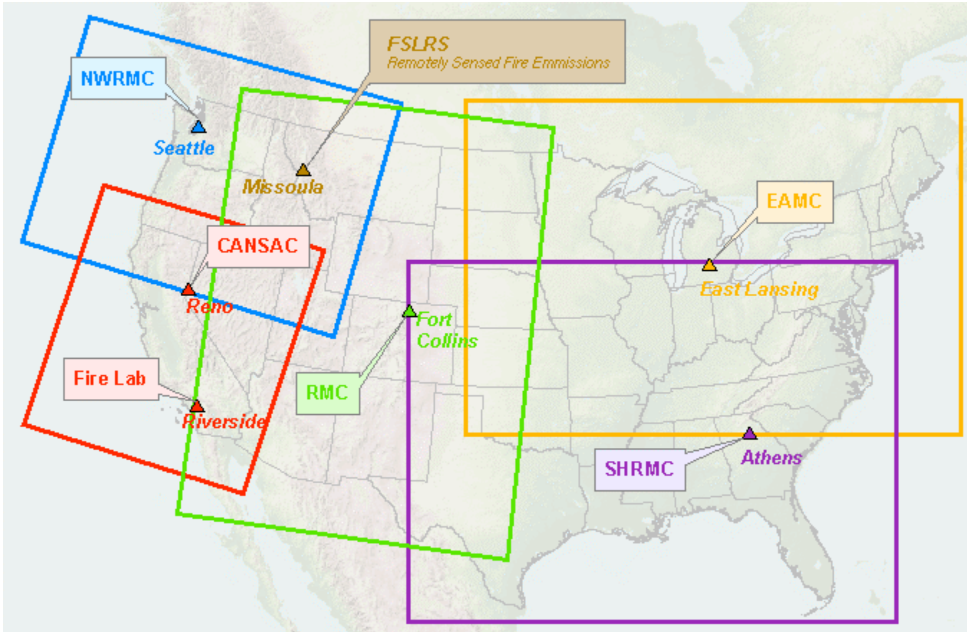


Figure 1. Primary spatial domains of the five FCAMMS.

Infrastructure

The initial decision of hardware choice to run the model was made given expert opinion from outside the CANSAC community and runtime tests. The ultimate choice was between a PC cluster and an SGI server. Given that initial costs were fairly similar, a final decision of utilizing the SGI system by the expert committee was based on performance and system maintenance. Though there have been some brief troubling times with hardware and software, the current system performance is very satisfactory.

Hardware

Substantial investment has been put into the computer hardware infrastructure necessary to run the MM5 model and products. DRI remodeled a room to accommodate the power and air handling, and purchased a UPS and backup generator system. Though this effort was not strictly for the CANSAC project, 50% of the investment was related to CANSAC.

The current hardware/software configuration includes:

- SGI® Altix® 3700 Linux machine with 48 processors (Itanium®2 1.3 GHz) and 96 GB RAM, SuSE/SGI Propack 4 OS
- Tape library (20 slots, LTO2, two drives)
- Fibre channel 2.6 terabyte RAID
- Workstation with dual Intel Xeon 3.6 GHz processor, 4 GB DDR2 RAM, 500 GB system disk in RAID1 and 6 TB dedicated RAID system

Postprocessing

The MM5 run takes about 1.5 hours with an additional 1 to 1.5 hours for post-processing. Under optimal conditions, the forecasts and all associated post-processing can be completed in approximately 2.5 hours. While the postprocessing work is assigned to a relatively faster (3.2 GHz) workstation, the SGI computer workload is divided amongst the forecast runs and development work.

The CANSAC real-time system uses the {RIP version3.0} (Read/Interpolate/Plot) visualization program with NCAR Graphics for the all post-processing products. The code is being continuously improved to meet the needs of CANSAC users. Currently, the set of visual products includes plots of ventilation index, Haines index (high and mid levels), lifted index, cloud water, planetary boundary layer height, precipitation, absolute vorticity and sounding plots/text files along with other standard parameters used in weather forecasting and atmospheric assessment applications.

The post-processing graphical conversion is completed in two steps with different speed and quality. After the first faster conversion (takes about half an hour) the visual products are immediately posted on the web and exchanged with the higher density products once the second and slower step is finished. This provides more timely access to the users.

MM5 model

Operational meteorological forecasts are generated using the Fifth Generation Penn State/NCAR Mesoscale Model (MM5) (Grell *et al* 1995) on a three-nested domain covering a large area of the Western US, and focusing on California and Nevada at the highest resolution (Figure 2). The domains consist of 97x97x32, 154x154x32 and 274x274x32 cells with 36-, 12- and 4-km horizontal grid spacing for the outer, nested and innermost domains, respectively (see Table 1 for geospatial coordinates).

The geophysical input was derived using 10’, 5’ and 2’ USGS terrain and land use data for the outermost, nested and innermost grids, respectively. MM5 model version 3.3.6 is used in a non-hydrostatic mode with two-way nesting. The vertical layers consist of 32 full sigma levels for each grid (Figure 3).

Specific sigma layers include: 1.00000, 0.99701, 0.99344, 0.98916, 0.98405, 0.97794, 0.97065, 0.96196, 0.95161, 0.93931, 0.92472, 0.90745, 0.88706, 0.86306, 0.83493, 0.80212, 0.76406, 0.72020, 0.67008, 0.61334, 0.54988, 0.47987, 0.40550, 0.33873,0.27881, 0.22501, 0.17671, 0.13336, 0.09445, 0.05951, 0.02815, 0.00000.

The model is initialized twice daily with the North American Meso (NAM) model 00 and 12 UTC forecast outputs (Grid 212-40 km resolution). Observational initial conditions are obtained from a Unidata LDM data stream. Physics options used in the model are given in Table 2.

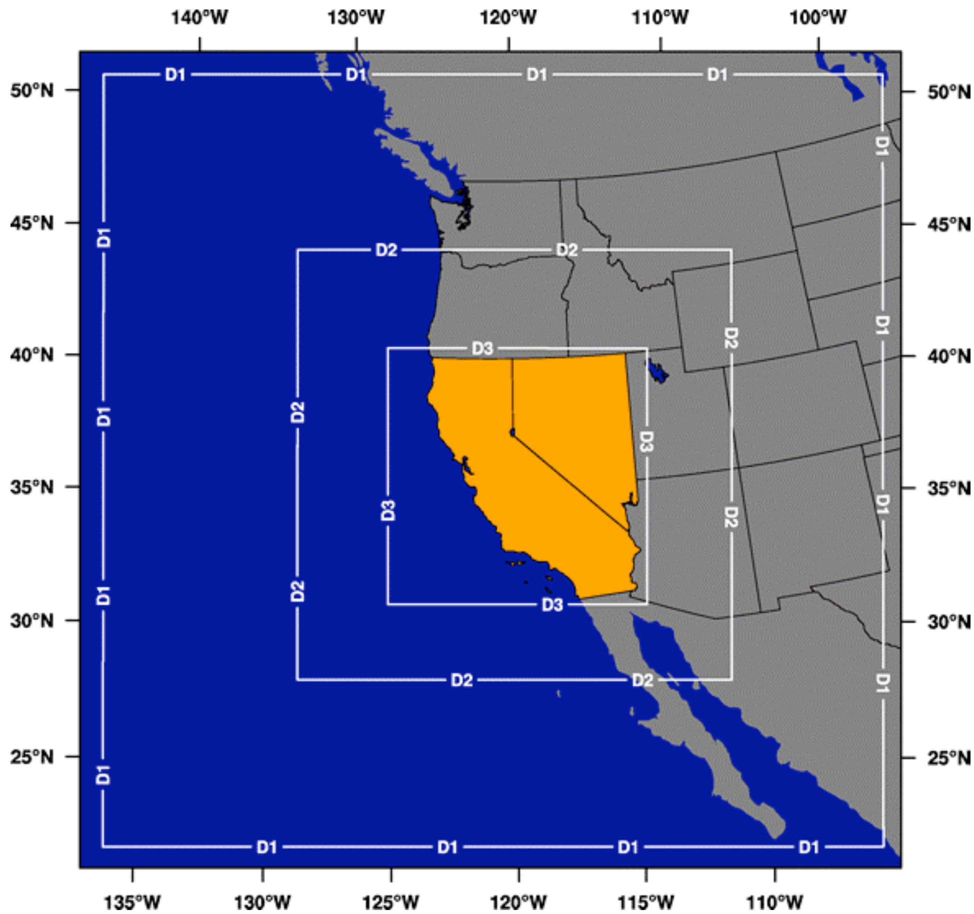


Figure 2. Three-nested domain for the CANSAC MM5 forecasts. D1, D2, and D3 represent the borders of 36-, 12-, and 4-km grids, respectively.

Table1. Geographical coordinates of each model grid domain.

Corners	Outermost Grid (D1)	Nested Grid (D2)	Innermost Grid (D3)
SW	21.91°N, 136.29°W	29.13°N, 129.45°W	32.29°N, 125.75°W
NW	50.88°N, 145.46°W	45.78°N, 132.01°W	42.29°N, 126.56°W
NE	50.88°N, 96.54°W	45.52°N, 107.62°W	42.27°N, 112.89°W
SE	21.91°N, 105.71°W	28.94°N, 110.72°W	32.16°N, 114.07°W

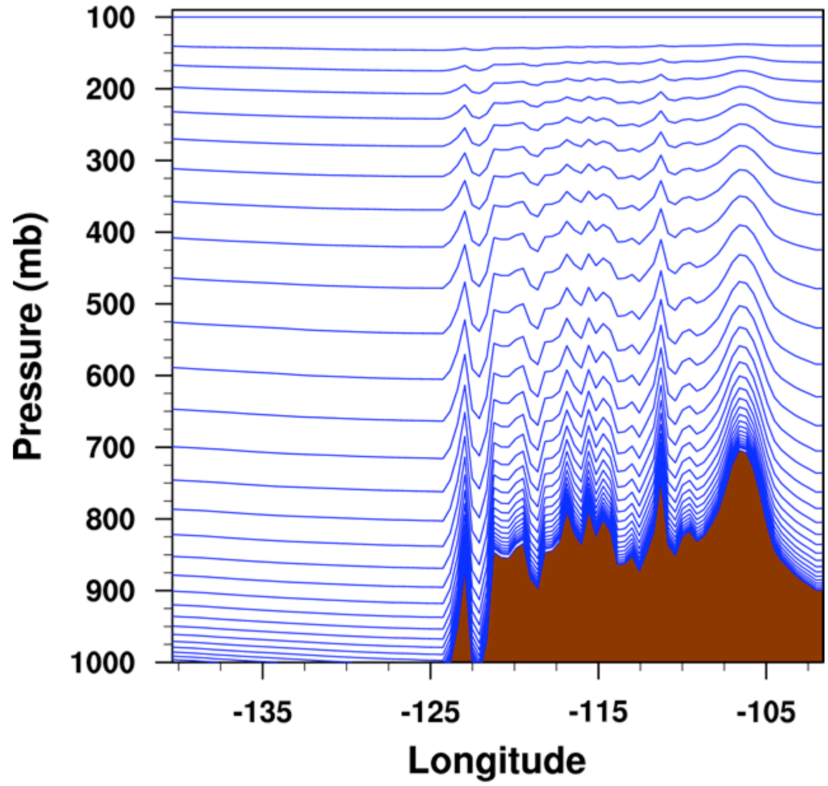


Figure 3. This cross-section of the MM5 shows the vertical profile of the model for Domain 1 (36-km horizontal resolution). The blue lines represent the vertical layers (or sigma levels) of the horizontal model grids. The model terrain is represented by the brown silhouette.

Table 2. The MM5 model physics options currently used.

Physics Schemes	Methods
Moisture	The simple ice moisture scheme with MPHYSTBL=1 for all three grids (Dudhia 1989).
Cumulus	The Grell Cumulus parameterization (Grell *et al* 1995) is used for the outermost and nested grids. No cumulus schemes are engaged for the innermost grid.
Planetary Boundary Layer (PBL)	The ETA PBL scheme (Janjic 1994) with turbulence kinetic energy.
Radiation	Cloud (FRAD=2) radiation cooling of atmosphere, used only for D1.
Soil temperature	Five layer soil model (ISOIL=1) (Dudhia 1996).

Bluesky

BlueSky is a coupled modeling framework to predict smoke ($PM_{2.5}$ concentration) impact from wildland, agricultural and prescribed burns. Developed by the USDA Forest Service AirFire Team in collaboration with land management and air quality regulator users, this framework is comprised of modeling components combining emissions, meteorology and dispersion models. The system requires input information of fire characteristics, meteorological conditions and emissions to drive the dispersion and transport model. A detailed description of BlueSky is given by O'Neil *et al* (2005).

The CALMET/CALPUFF modeling system for smoke dispersion and transport is the primary modules utilized in Bluesky. CALMET/CALPUFF is a multi-species, multi-layer, non-steady-state Lagrangian puff air quality modeling system developed for regulatory use (Scire *et al* 2000a). CALMET is the diagnostic meteorological module of the modeling system that generates three-dimensional meteorological input fields and other micrometeorological parameters necessary for CALPUFF (Scire *et al* 2000b). It can also process the output of prognostic models such as MM5, and then combines them with observations through an objective analysis procedure. CALPUFF can use single station observations, as well three-dimensional variables. The model contains many features, including chemical transformation, wet and dry removal, buoyant area, line, point and volume sources, and can be applied to study areas extending from meters to hundreds of kilometers. Its buoyant area source algorithm was formulated to treat all temperature and wind stratifications, and radiative heat loss without a Boussinesq approximation; all key elements in simulations of plumes from large fires. The model can also accommodate multiple sources and species, and with all these capabilities, is recommended by the U.S. Environmental Protection Agency (EPA) for air quality regulatory use.

Bluesky is currently linked to agency Form 209 wildfire reports that include geographic and other information about a fire. These reports are received in the CANSAC system on a scheduled basis, and are used to produce $PM_{2.5}$ concentration forecasts from wildfires on the 12- and 4-km domains. Figure 4 shows an example concentration forecast map from 30 August 2006 for northern California. Color shaded areas denote forecast concentrations of $PM_{2.5}$.

Prescribed fire input information can also be input into BlueSky. Currently, a web-based form is available to input information such as date, location, size and emission inputs including fuel type and fuel amount. The California Air Resources Board is currently developing and testing the Prescribed Fire Incident Reporting System (PFIRS). This system will be used to log, track and archive prescribed fires across the state. Once the system is available, it will be integrated into CANSAC BlueSky.

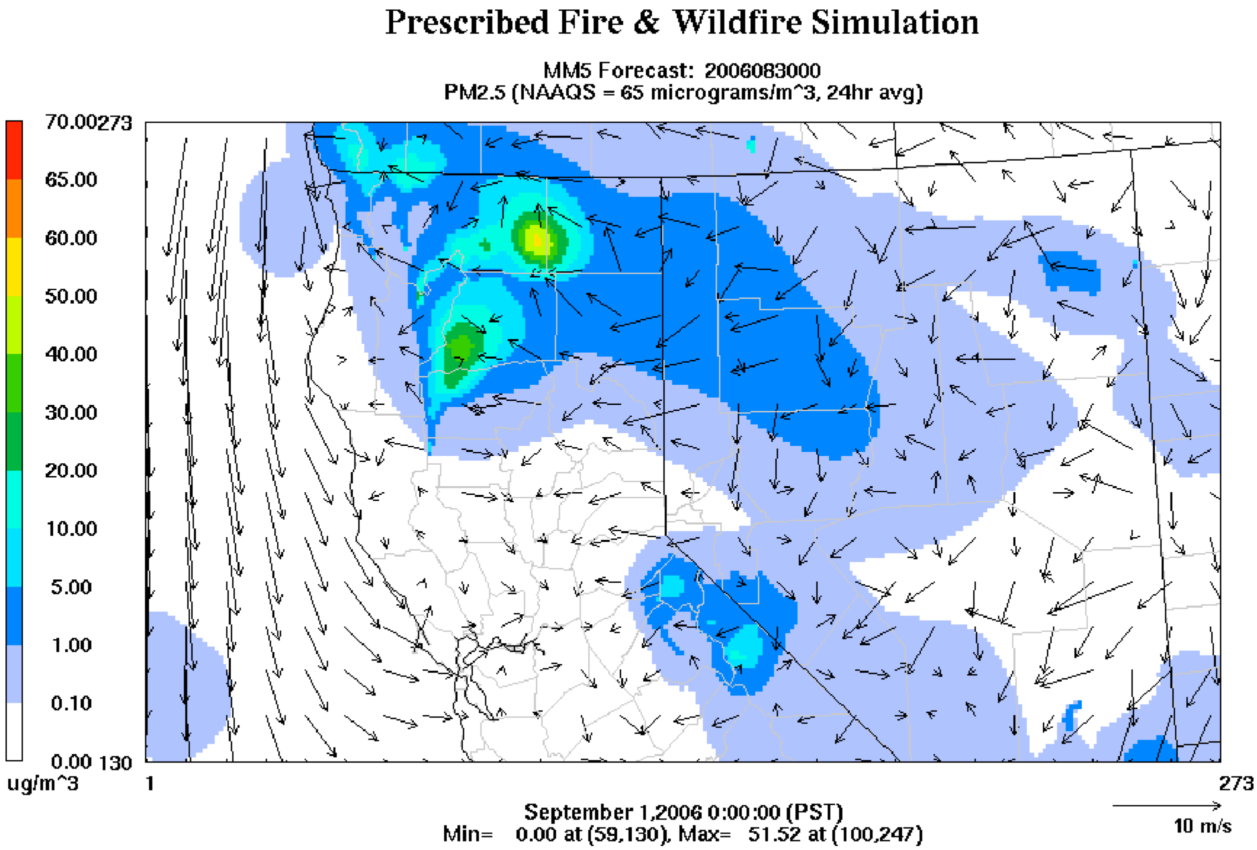


Figure 4. Example map of BlueSky predicted $PM_{2.5}$ concentrations from wildfire areas in northern California on 30 August 2006. Color bar denotes concentration amount and wind direction, and speed is given as vector arrows.

Activities and deliverables 2004

This section describes the significant activities and deliverables during the calendar year 2004.

Personnel

Two new personnel were hired exclusively for the CANSAC project. In November 2003 Domagoj Podnar began work to determine hardware specifications, testing the system and implementing the MM5 model. In September 2004, Julide Koracin accepted an offer to work on the CANSAC project as a post-doc to begin after completion of her Ph.D. In September 2004 Ph.D. graduate student Tesfamichael Ghidey entered the University of Nevada Atmospheric Sciences Program to assist in the development and implementation of CANSAC products as well as performing research in support of the project. Current CEFA staff members Hauss Reinbold (Web master; visualization; data management) and Beth Hall (OAG liaison) were both brought in to the CANSAC operations staff.

Computer Hardware

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

A test case was designed using the 36-, 12- and 4-km area domains originally provided by OAG. Slightly over 108,000 surface grid points made up all three domains. It was desirable to have the test run completed in approximately two hours real-time in order to deliver products in a timely manner to the field.

The simulation case was setup for the period 1 August 2003 at 00UTC through 4 August 2003 00UTC (D3 stops at 12 UTC on 3 August 2003). This was a 72-hour forecast for D1 and D2, and a 36-hour forecast for D3. Vertically, 36 full sigma levels were used for all domains, starting with the 0.997 sigma level (the first level above the surface). The time steps were 108 seconds for the D1 grid, 36 seconds for D2, and 12 seconds for D3. The physics options used were Simple Ice for moisture, Grell for convection, MRF for boundary layer and Cloud for radiation parameterizations. Combining the total horizontal number of grid points with the number of levels yielded 3,888,000 total grid points for which a calculation was performed. Multiplying this number by the total number of time steps yielded approximately 40 billion total calculations required at each grid point for each weather element (e.g., temperature, relative humidity, wind speed) in order to complete a full forecast run.

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

Currently, there is no backup computing system for CANSAC. It would be desirable to have a second computing system available should the primary system fail during operational runs.

Establish first year products and requirements

OAG provided the initial list of products and requirements to CEFA in February 2004. The initial list identified upper-level elements such as height and winds, Haines index and ventilation index for 36- and 12-km as being the priority starting products. Throughout the course of the year, additional product requests from OAG were sent to CEFA (e.g., model soundings), and some requests were made to modify existing products (e.g., color schemes, content).

Implement and test MM5 model

Once the computing hardware was installed, the next project phase was to install and test MM5 software on the system. This was begun in March 2004 and completed in April 2004. In line with the original testing, it was determined that the model run could be completed in approximately 2.4 hours real-time. Further system optimization later in the year improved this time to approximately 2.0 hours. Post-processing (production of maps and graphics) required considerable additional time on the order of approximately 3.5 hours. Later hardware upgrades and enhancements reduced this time by two-thirds; however, the time is largely dependent on the amount of products produced and graphics quality.

Assessment of 2004 products

From the very beginning of real-time production in June 2004, 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. Despite some start-up glitches, OAG was generally satisfied with results during the first six months of operation.

Activities and deliverables 2005

This section describes the significant activities and deliverables during the calendar year 2005.

Product development

By 2005, the primary fire weather products had been developed and in a full production mode. Prototype fire danger forecast maps of energy release component, burning index, spread component and ignition component were introduced in the summer of 2005. These are based upon work undertaken at the USFS PNW station. Smoke products from the Bluesky system were worked on in the latter months of 2005, but were not ready for implementation until 2006.

Most the primary graphical program development was done in 2005. Most of the user requests targeted image manipulation/additions. Some of the more major changes are listed below:

- Mixing height and transport wind maps were added; calculations are based upon the work of Fearon (2000).
- Quadrant maps were added for the 4-km domain for wind, temperature and relative humidity.
- The 4-km domain forecast was extended from 48- to 60-hours.
- Station forecast meteograms were added to the 4 km domain (see product examples section below).
- Sounding image modifications and additional sounding locations (see product examples section below).
- Lifted index forecast maps were added.
- Spatial forecast verification maps were added. These compare the initialization analysis map to the MM5 map for 12-hourly periods and the 4- and 12-km domains.
- Created an internal web form for tracking OAG requests

Assessment of 2005 products

Feedback to CEFA from OAG continued in the form of email memos and conversations with CEFA personnel. From a qualitative perspective, OAG was pleased with the products during the year.

Activities and deliverables 2006

This section describes the significant activities and deliverables during the calendar year 2006.

Product development

Product production continued through 2006. Significant highlights are given below.

Bluesky implementation – It was a significant effort to install, test and implement the Bluesky code provided by the Forest Service Pacific Northwest Research Station AirFire team. Most of the installation work took place during late 2005. Bluesky became operational during January 2006; however, the next few months were considered a testing phase. Output was used during the 2006 fire season; a notable example was the northern California fires during August 2006. Example Bluesky output is provided in Figure 5 above.

PFIRS – Related to Bluesky is the implementation of PFIRS. This system development advanced considerably during 2006. It is the intent to link CANSAC Bluesky to PFIRS. In the meantime, a web-based user input form of prescribed burning parameters was developed and tested during 2006. The input fields were determined by the Pacific Northwest Bluesky team and contain many of the same elements as PFIRS. Also, a map was developed on the CANSAC air quality web page that shows color symbols for fire locations from the Form 209 reports and prescribed fire from the web form. This map is updated once a day.

Numerous OAG requests were received and completed during the year; a few of these are listed below:

- More sounding location additions
- Added transport winds to the 4-km domain
- Added 4-km quadrant transport winds
- Increase image size of Bluesky maps
- Add county lines to Bluesky maps
- Improvements to map contours and labels
- Added 4-km precipitation maps
- Created process for generating GIS layers of RH and wind

Other activities during the year included:

- Continued work on RIP and visualization improvements
- Hardware upgrades
- Switched to MM5 V3.7 which improved operational run time by one hour
- Added cross-section maps
- Worked on movable grids and 1-km output
- Integrated, modified and tested all of the post-processing programs (NFDRS, Bluesky and map products) to a new workstation (see infrastructure above), which improved the run-time by about one hour.

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 (approximately 8), but the program was very similar to the McClellan meeting. The smaller attendance did allow for more interactive discussion during the presentations.

It is planned to hold one or two workshops in late 2007 or early 2008. It is also of interest to discuss CANSAC with Nevada air quality agencies.

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 (ozone and particulate matter).

The CEFA-CANSAC role is to provide the project with Bluesky predicted $PM_{2.5}$ 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.

A second research project is work funded by the Aerospace Corporation. CEFA is conducting research in collaboration with Aerospace 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.

CANSAC Partnership

Given the organizational structure and needs of CANSAC, it is of interest to assess the consortium in terms of a partnership, and hopefully, a sustainable one. In 2005, CEFA, in collaboration with Dr. Barbara Morehouse at the University of Arizona, conducted a formal survey of the BOD, OAG and TAG. A formal paper of the survey results will be submitted for publication in 2007; but the initial results were presented at the EastFire conference in 2005 (Brown *et al* 2005). Some results of the survey and an assessment of the partnership are given below.

Partnership structures have been defined as "one of the institutional forms through which urban (or rural) governance regimes may function." (Geddes 2000). The notion of partnerships involves a strong belief that benefits accrue from community-level participation in projects designed to provide benefits and/or service, and local acceptance of governance-related responsibilities. However, in reality, rather than being explicitly articulated in partnership planning activities and documents (Phillips 2001), such expectations are more likely to remain unexpressed assumptions.

Among the longstanding examples of efforts to bridge the gap between science and society are programs involving "technology transfer" *from* science *to* society. More recently, the recognition of the pitfalls of such top-down approaches to linking science with society has led to interest in alternative forms of collaboration in development and implementation of scientific initiatives. These are from the most basic "laboratory" activities through to ultimate applications in societal contexts. Ideally, the process is iterative both during and after implementation, allowing for refinement and adjustment as needed to attain mutually agreed upon goals and results (see, e.g., Lemos and Morehouse 2005). Ideally, through the process of building sustainable partnerships, "stakeholders" emerge who have the interest, social and economic capital, and motivation to sustain the enterprise.

Research indicates that synergy is an important component in successful collaborations, including partnerships. Lasker *et al* (2001) emphasize that synergy among participants can produce unique opportunities to explore differences in a constructive manner and to work toward solutions that transcend individual capacity to envision alternative possibilities. Synergistic relations also afford opportunities to combine resources in ways that lead to accomplishment of goals that otherwise could not be achieved alone. Synergy presents opportunities for creativity, challenging accepted wisdom and discovering innovative ways to approach shared problems. Structured partnerships provide a clear framework for achieving synergy, and ultimately for developing mutually agreed-upon strategies and products to address defined problems and needs.

The survey was constructed around metrics to assess the CANSAC synergy. Questions covered six general categories: partnership structure; organizational design; the availability of resources; CANSAC management; CANSAC leadership and CANSAC progress. The survey consisted of 45 statements/questions with scale rankings from 1 to 5 representing strongly disagree (1) to strongly agree (5) for the first three categories, and similarly very poor to very good for the last three categories. Some example statements were: 1) a sufficient level of trust exists among CANSAC members; 2) CANSAC has the flexibility to be innovative in how it approaches its work; 3) funding is sufficient; 4) management accountability; 5) ability to harmonize differences in members' perspectives; and 6) level of integration with stakeholders. Twenty-one respondents from the three groups completed the survey via a telephone interview process; stratification by group was BOD had 9, OAG had 7 and TAG had 5 responses, respectively.

Overall, the survey results indicate at least a moderate level of satisfaction in terms of a CANSAC partnership. Both BOD and OAG feel strongly that their organization's interests are well integrated into the partnership. TAG ranked this area as neutral. CANSAC resource issues appear to need improvement, as does the project and product evaluation process. Except for funding, there appears to be no significant breakdown in any category that would seriously impact the partnership. Funding was a concern indicated by all three groups. When the survey was taken, CANSAC operations were effectively only one year old. The overall moderate agreement should be considered quite good given short the amount of time. Generally, three to five years is more typical in building a partnership. However, to a large extent, a partnership had already been formed prior from California's Firescope. Multi-agencies have been working together for a long time in California, including transfers of funding.

CANSAC Needs

Personnel and computer hardware are obviously the two major needs for the productivity and sustainability of CANSAC. Thus, funding is a critical component in making CANSAC sustainable. The original CANSAC proposal requested $325K of agency support, and an additional $50K of DRI support (15% cost-share) for a total of $375K for salary, fringe, supplies, travel, operating and overhead costs. To date, the agencies have provided a total of $1,147,698 in support, of which $340K was allocated for hardware purchases and maintenance. DRI has contributed a total of $234,740 representing approximately 20% cost-share in addition to the total agency support. The first funding arrived at DRI in 2002, which was effectively meant for federal FY2003. Dividing the total amount minus the hardware amount by four fiscal years yields $260,609 per year, or approximately 69% of the proposed annual funding request. The total amount of funds have been sufficient during this period because of the irregular flow of agency funds and the ability to carry over some funds has effectively created distributed funding throughout the year. Also, the expenditures were not as high as originally expected.

Per the request of the CANSAC BOD, Table 3 provides requested funding estimates for the 5-year federal fiscal period 2008-2012. The amounts include salary, fringe, supplies, travel, operating and overhead costs. Also included in the 5-year budget are amounts for new hardware purchase and maintenance, and cost of living adjustments for subsequent years. Personnel (and estimated percentage of time) in this budget include the Director (17%), system administrator and operations support (42%), product development, graphics, web administrator and operations support (42%), and post-doc for operations support, model refinement, user interface, and product development (92%). This is equivalent to 1.93 FTE.

Two budget issues will potentially impact CANSAC in the near future. First, a major funding issue is possible in federal FY08 due to insufficient income compared to expected expenditures. To partially address this, CEFA will attempt to reorganize personnel and priorities to close the gap between costs and income, and to support more operational activities with limited system and product development. However, this first year amount (~ $284K) remains about $25K less than the previous 4-year average. Also during this federal FY, $40K will be needed for hardware maintenance, and $25K for a new RAID storage is highly needed.

Table 3. Five-year estimated budget for CANSAC operations in thousands of dollars.

Federal FY	2008	2009	2010	2011	2012
Personnel and operating	$287	$312	$313	$325	$344
Computing hardware	$65	$300	-	-	-
Total	$352	$612	$313	$325	$344
Average annual agency amount (rounded)	$36	$62	$32	$33	$35

Second, because of the aging computer hardware and the annual maintenance costs of $40K, it is proposed to purchase a new computing system at an estimated cost of $300K in federal FY09. This amount should include three years of hardware maintenance, so no additional hardware contracts will be required during this 5-year budget period.

The fifth row in Table 3 gives the average annual agency amount in requested contribution, assuming 10 supporting agencies. Over the 5-year period, these annual amounts average to $40K per year. It is anticipated that DRI will also provide some cost-share; however, these amounts are difficult to determine in advance until biennial state legislation allocations are known.

There are several bullet points listed below that are worthy of mention and hopefully some resolution that would help the funding situation considerably.

- The original plan called for more wide air pollution control district funding, not SJVAPCD alone.
- The original plan called for contract county fire departments, not LA County fire department alone.
- The original plan called for R4/R2 partner participation; this has not happened to date.
- There is currently some question as to BLM Nevada continued involvement.
- CALFIRE was not an active participant in 2006. They have been relying on grants to support the contribution rather than a line item in the budget.
- Increasing the support of the current representative partners to a more equal amount. The range for annual operations has been $7 to $60K.
- Increasing the annual support of all participating agencies from around $30K to $40K.

For the federal agencies, there will be a new mechanism put in place in 2007 for transferring funds from BLM to DRI. As of September 2007, the current Cooperative Agreement Task Order (10) will expire. Beginning July 2007, all federal funding will go through an Inter-Governmental Order. A critical point to note is that the federal funds should be collected and transferred to BLM no later than the second week in June. Any amounts after this will be problematic to transfer.

If CANSAC is to continue with its current operations, and improve current products and create new ones, the funding issues described above will have to be seriously addressed.

Future of CANSAC

Agency interest in CANSAC has grown since operations began. Feedback from users of the products has been positive. CANSAC has demonstrated a successful partnership early in its existence. CEFA is currently seeking research-funding opportunities to help provide new and improved products, and support infrastructure. A Joint Fire Science Program proposal is pending to allow for setting up CANSAC to run at 1-km for BlueSky, and 30-meter wind grids for fire behavior input and other analyses in response to all hazard incidents. The possibility exists to assign the CANSAC system to a specific incident. It would be desirable to bring on board more air quality agencies in both California and Nevada, not just for funding support, but because the output could be quite beneficial to their decision-making. CEFA is currently experimenting with the WRF model integrated with CMAQ; this system could provide forecasts of other chemical elements of interest (e.g., ozone). A current project funded by Yosemite National Park will model ozone production from fire and analyze BlueSky results given improved input emissions. The largest issue for CANSAC is providing steady funding support, keeping the infrastructure in place and overall sustainability.

Product Examples

The model forecasts are hourly out to 72-hrs for the two larger domains and 60-hrs for the inner-most California and Nevada domain, though only 3-hourly forecasts are provided on the product web page. Post-processing of the outputs is simultaneously performed during the model run, and the products are made available through the public CEFA web site (cefa.dri.edu/COFF/coffframe.php). The complete set of user defined meteorological products includes maps of upper air elements (e.g., 500, 700 and 850 mb), surface elements (e.g., temperature, relative humidity, wind), experimental fire danger indices (energy release component, burning index, spread component and ignition component) and smoke dispersion and transport concentrations. Soundings and meteograms of standard meteorological variables are currently available for 72 geographic point locations in California and Nevada. Output formats include graphic map images and some GIS-based output. On the web page users select the desired static map or forecast loop from meteorological elements specified by OAG. An evolving list of products and decision-support tools provides for continuous updates and new information. Several additional map examples are given in this section to offer a sample of the available products and their format (Figure 5 through 11).

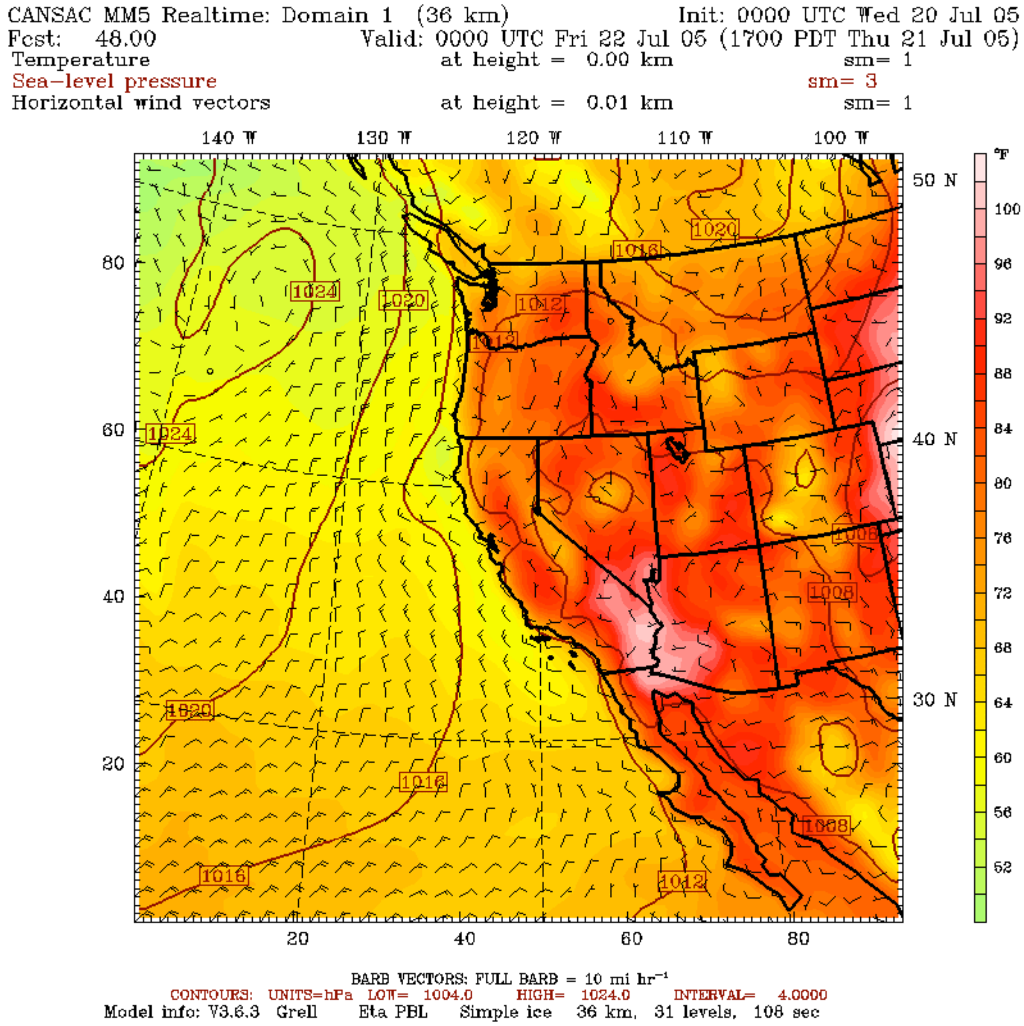


Figure 5. Example forecast map of surface temperature (color scale on right), sea level pressure (contours) and wind as shown by wind barbs indicating speed and direction.

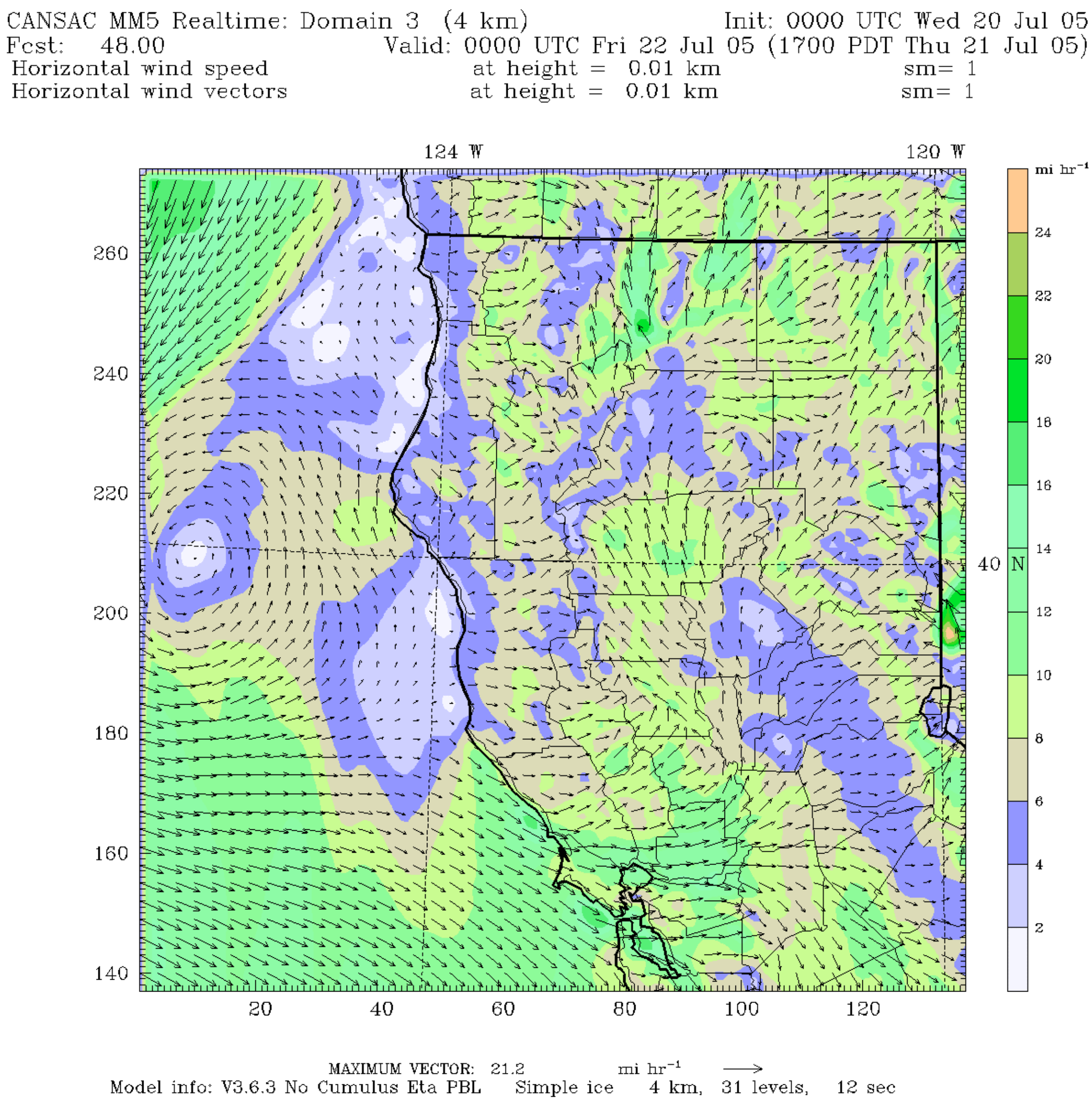


Figure 6. Example map of forecast wind speed (color bar at right) and wind direction (arrows) for the northwest quadrant of the CANSAC 4 km domain. These quadrant maps provide the highest detail for a particular meteorological variable.

Energy Release Component

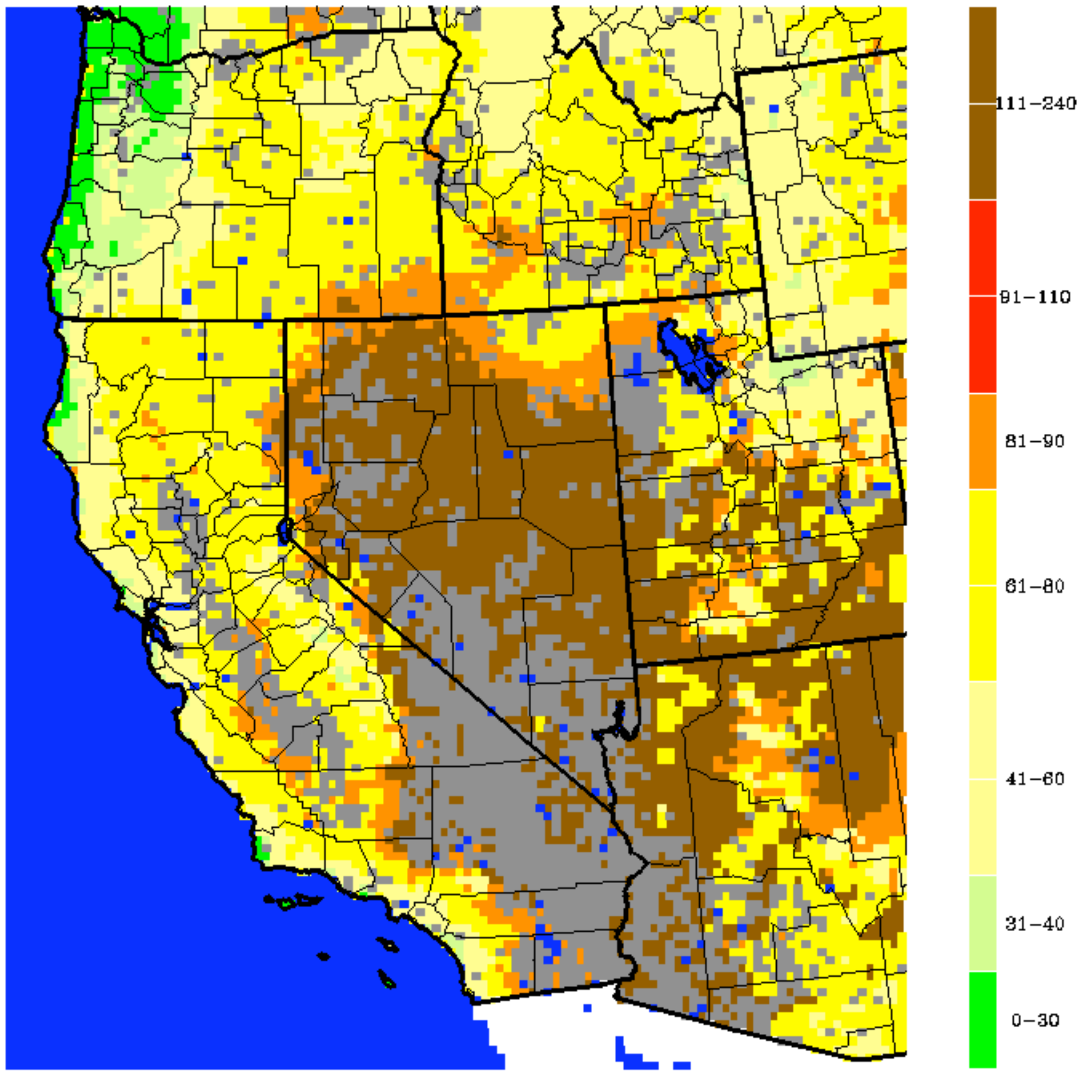


Figure 7. Example forecast map of NFDRS energy release component (ERC). Color scale denotes ERC range value.

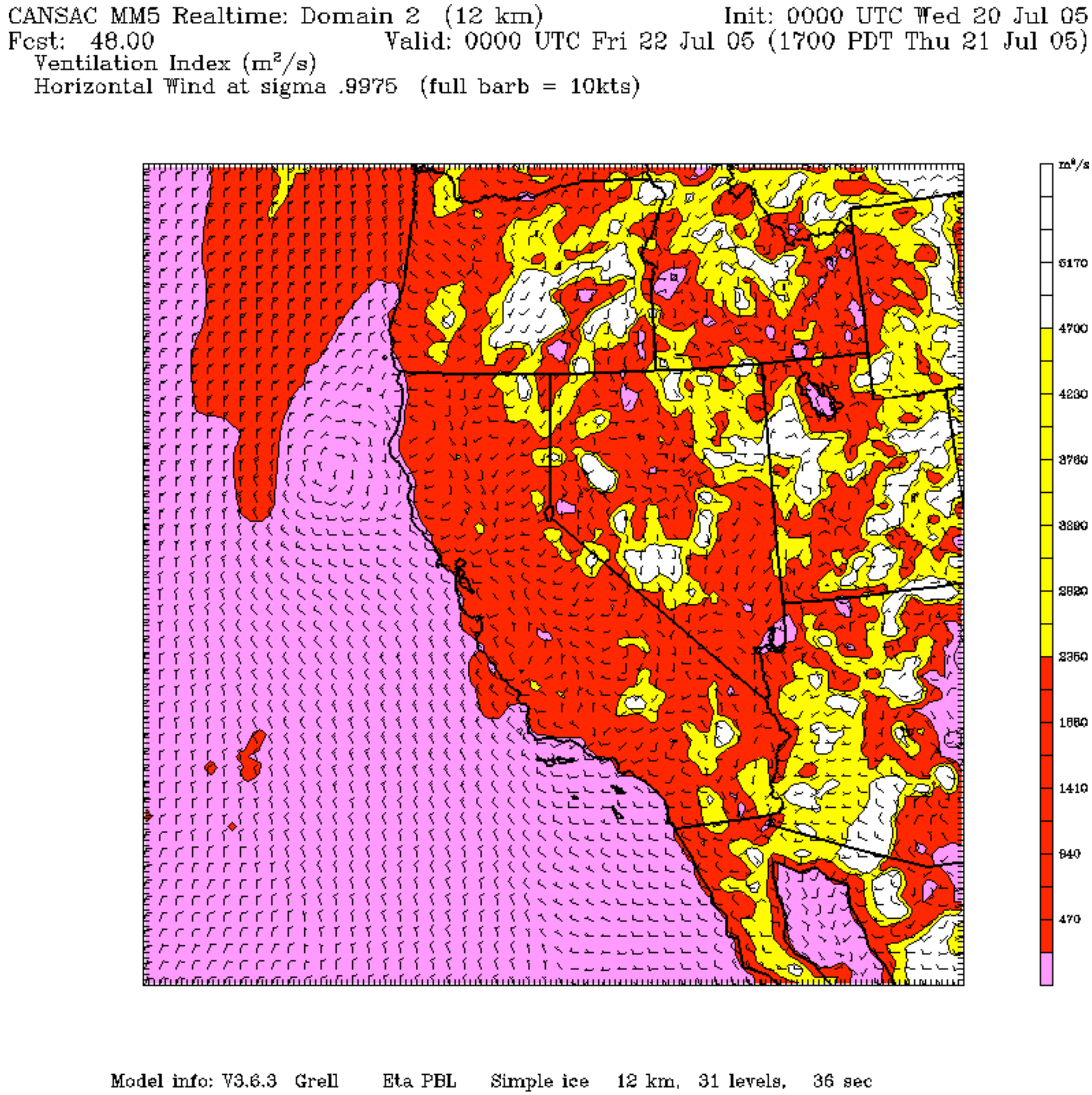


Figure 8. Example forecast map of the ventilation index. Color bar at right gives index values. Wind barbs are also shown on the map.

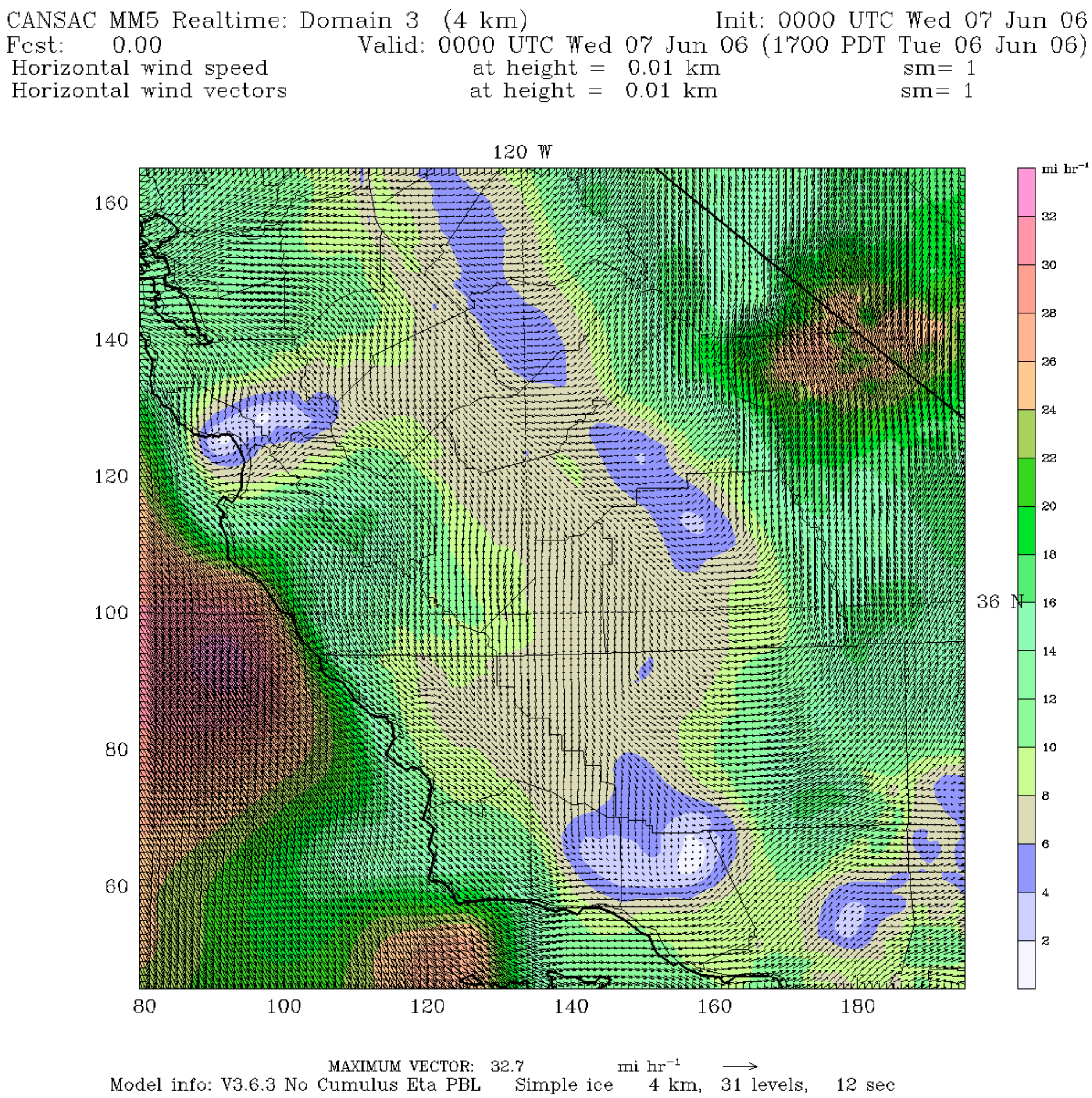


Figure 9. Example high-resolution wind direction and speed map for south-central California. Color shading indicates wind speed (see color bar) and vector arrow indicates direction at each 4-km grid point location within the map domain.

Forecast Hour: 0 Location: FishSprings 38.27,-119.65
Initialized: 00 UTC 20 August 2006 Valid: 00 UTC 20 August 2006

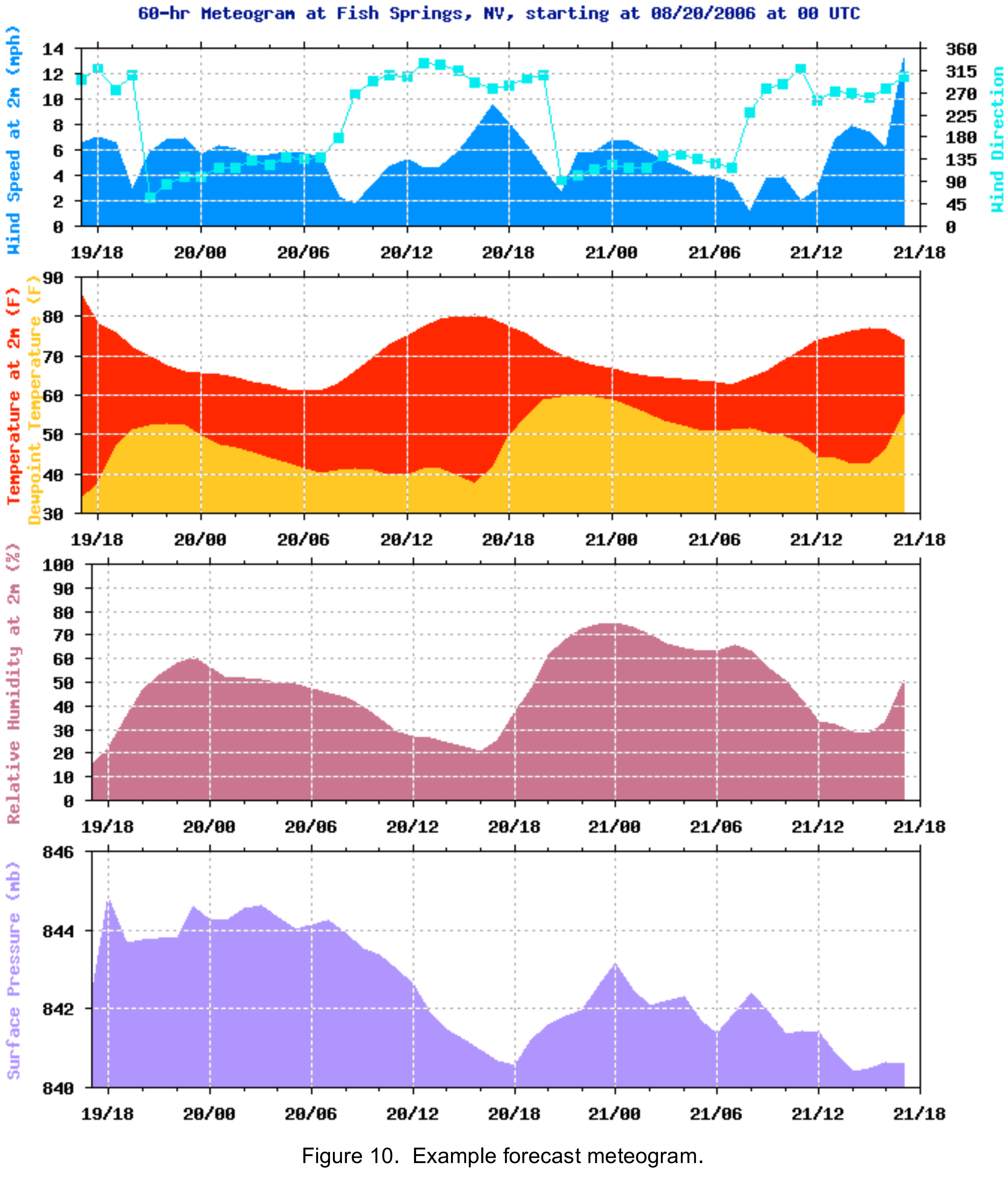


Figure 10. Example forecast meteogram.

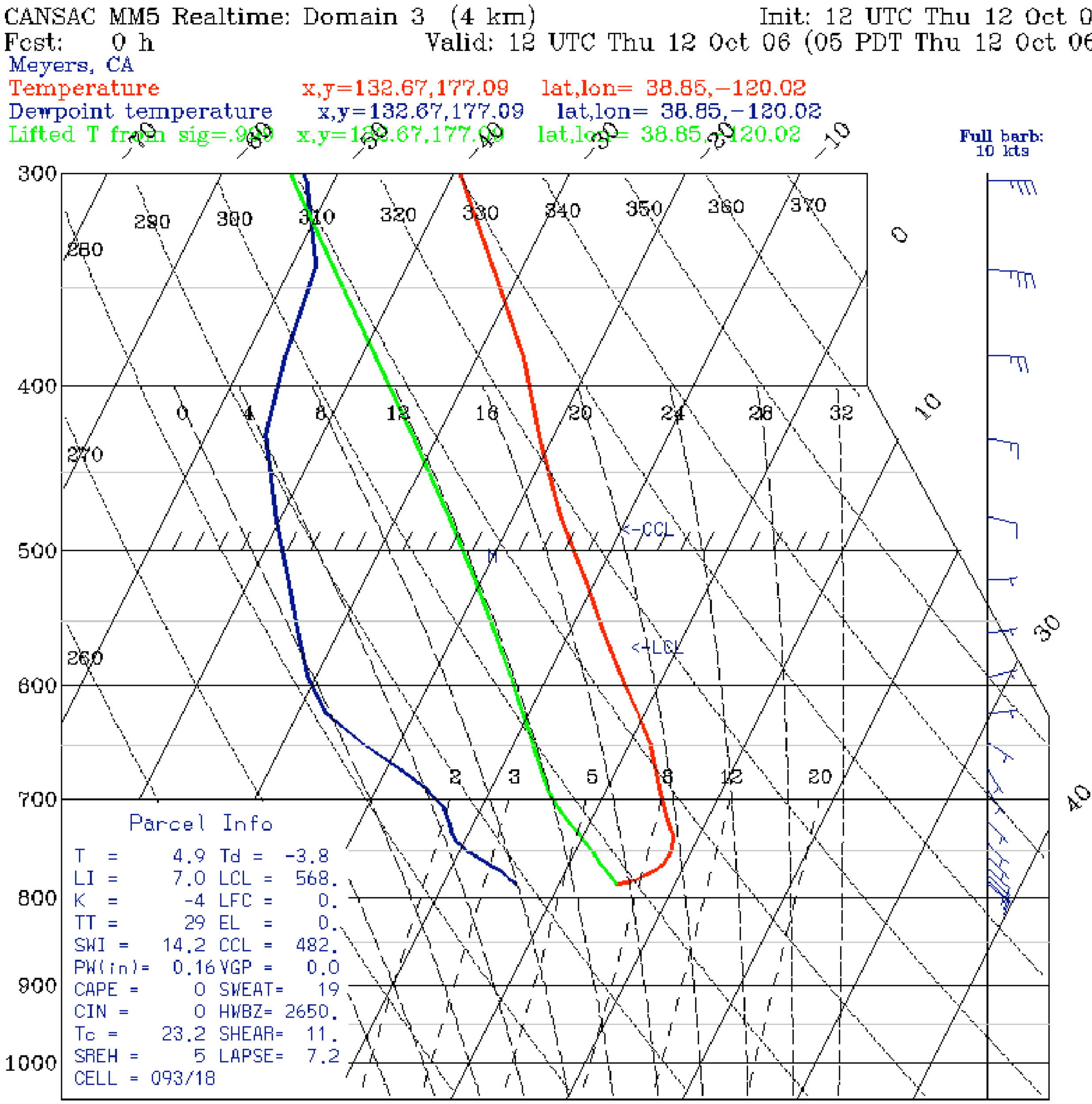


Figure 11. Example MM5 sounding chart.

Personnel

Current CANSAC personnel at DRI-CEFA include:

Dr. Timothy Brown – CEFA Director and CANSAC project manager
Dr. Julide Koracin – Operations manager; research and model development
Hauss Reinbold – Web master; visualization; data management
Domagoj Podnar – Systems administrator
Tesfamichael Ghidey – Ph.D. graduate student; research and assistant

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The consortium is user-driven, and it was the ambitious drive of a number of individuals that brought CANSAC to reality. CEFA would like to thank the individuals on the Board of Directors (past and present) that worked with great encouragement and diligence to bring the project together. A few of these individuals conceived the idea over six years ago, and have persisted through the realization of an operational facility. CEFA is very appreciative of the individuals within the federal, state and county agencies that are making the funding opportunities happen. Without this support, the project would still only be a concept and desire.

Paul Schlobohm, Bureau of Land Management in Boise, Idaho, has provided an important administrative liaison role between the federal agencies and CEFA during this project. Finally, but not least, Chris Fontana, retired fire weather meteorologist at California North Ops, deserves special gratitude for facilitating the process from conception to implementation.

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