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Providing Meteorological Information for Controlled Burns at the Savannah River Site

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Introduction

Regional and local weather information are important for a variety of applications at the Savannah River Site (SRS), a Department of Energy (DOE) facility covering ~800 square kilometers of southwest South Carolina east of the Savannah River. For example, meteorological observations and forecasts are used to assess the consequences of an accidental radiological or chemical release. Traditionally, hazards posed by SRS operations have been associated with nuclear reactors, chemical reprocessing plants, fuel fabrication, or waste-vitrification facilities. However, recent events have shown site-specific meteorology to be a valuable tool to the United States Forest Service (USFS) in mitigating potential hazards from controlled burns that are conducted at the SRS.

Prescribed burns at the SRS are important for a variety of reasons. The removal of thick undergrowth allows wildlife to more easily feed and migrate, accelerates the growth of young pine stands, and controls certain diseases that affect local pine forests (e.g. Adams et al. 1973). In addition, the removal of twigs, pine needles, or leaves (a fuel source) reduces the chance of serious wildfire damage. However, the threat of smoke inhalation and reduced visibility requires careful planning on the part of the fire professionals. At the SRS, ~100 square kilometers of land per year are burned in a controlled manner, mainly in the spring.

To reduce the potentially harmful effects to any onsite activity, it is important that USFS personnel understand current and predicted weather patterns within the area. This paper discusses two sources of meteorological information that are provided to SRS-USFS personnel for use in planning forest burns: (1) a meteorological tower system which provides current data from a series of onsite locations, and (2) an operational prognostic mesoscale model used to generate forecast information. The forecast data supplements the basic National Weather Service (NWS) fire weather forecasts obtained from Columbia, South Carolina.

For each of these data sources, illustrations of products are presented.

Observed Data

The Savannah River Technology Center has developed and maintained a meteorological monitoring program for a number of years (Parker and Addis 1993). The monitoring network consists of a series of meteorological towers and computers that retrieve and log observations on a continuous basis. This information is then made available to the Weather Information and Display (WIND) system (Hunter 1990), a series of atmospheric

transport and dispersion codes used in emergency response situations. The WIND system also provides a menu-driven user interface to display various meteorological quantities.

There are eight towers with instrumentation at 61 meters above ground level that record temperature, moisture, winds, and turbulence, whose averages are then archived every 15 minutes. The location of these towers is shown in Fig. 1 and based on locations of highest potential onsite effluent release. In addition, a separate tower was erected near `C' area (Central Climatology, labeled `*CC*') that records meteorological data at 2, 18, 36, and 61 m to provide vertical profiles.

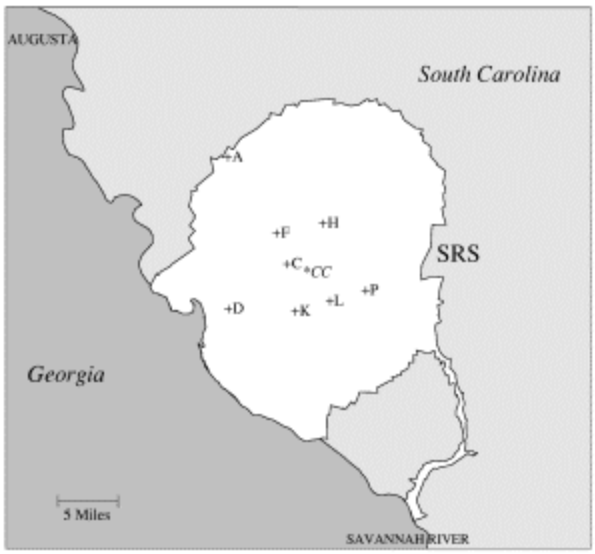

Figure 1: Outline of the Savannah River Site in southwestern South Carolina. Towers are labeled corresponding to the onsite area where measurements are obtained. "CC" denotes the Central Climatology tower.

SRTC WIND SYSTEM

SRS METEOROLOGICAL DATA SUMMARY

15 - MIN PERIOD ENDING : 8:30 AM EDT 9/02/99

Area Towers

	WSpeed @200 FT (mps/MPH)	WSpeed @33 FT* (mps/MPH)	WDir (Degrees From)	Stability Class
A	1.7/ 3.9	1.3/ 3.0	329 (NNW)	D
C	2.1/ 4.7	1.6/ 3.6	341 (NNW)	D
D	2.4/ 5.3	1.8/ 4.1	338 (NNW)	D
F	1.8/ 4.1	1.5/ 3.4	351 (N)	C
H	3.0/ 6.7	2.3/ 5.1	6 (N)	D
K	3.1/ 6.9	1.6/ 3.7	341 (NNW)	E
L	3.0/ 6.7	2.5/ 5.6	4 (N)	C
P	4.3/ 9.7	1.6/ 3.6	13 (NNE)	G
SAM	2.6/ 5.8		354 (N)	D

* Interpolated Values

Central Climatology

(2 Meters)

WSpeed: 1.6 mps/ 3.5 MPH

Temp: 68.0 Deg F

Rel Humidity: 59 %

Bar Pressure: 1007.2 mb

Sky Cover*: 0.25

* Decimal Fraction is based on ratio of (Observed/Theoretical) Solar Radiation.

PRINT SCREEN QUIT

Figure 2: Tabular data values from the area towers and Central Climatology averaged over a 15-minute period ending at 08:30 EDT, 02 September 1999.

Software has been written to provide both tabular and graphical displays of the most recent 15-minute average of the tower data. Figure 2 illustrates a screen image from a graphical user interface that is available for SRS-USFS personnel when they decide where to perform a prescribed burn and to monitor conditions during the burn period. The wind speeds and directions at 200 ft (61 m) are shown for each tower on the left-hand side of the figure, along with the stability class. (Interpolated speeds near the surface are also provided). On the right side of the figure are measurements at 2 m from the tower at Central Climatology, indicating winds, temperature, relative humidity, barometric pressure, and fractional cloud sky coverage.

In addition to the tabular information, a graphical depiction of the current conditions (wind speed and direction) for the central Savannah River area is available (Fig. 3). This screen image is also part of a graphical user interface. Wind barbs depicting wind direction and speed for the area towers, along with several meteorological stations located in the Augusta area, are displayed. A site area mean (SAM) value denotes an average of the eight site tower wind values and is arbitrarily placed in the upper-right corner of the SRS. An abbreviated tabular format is available by selecting the appropriate button. It is important to note that this information is updated automatically at 15-minute intervals.

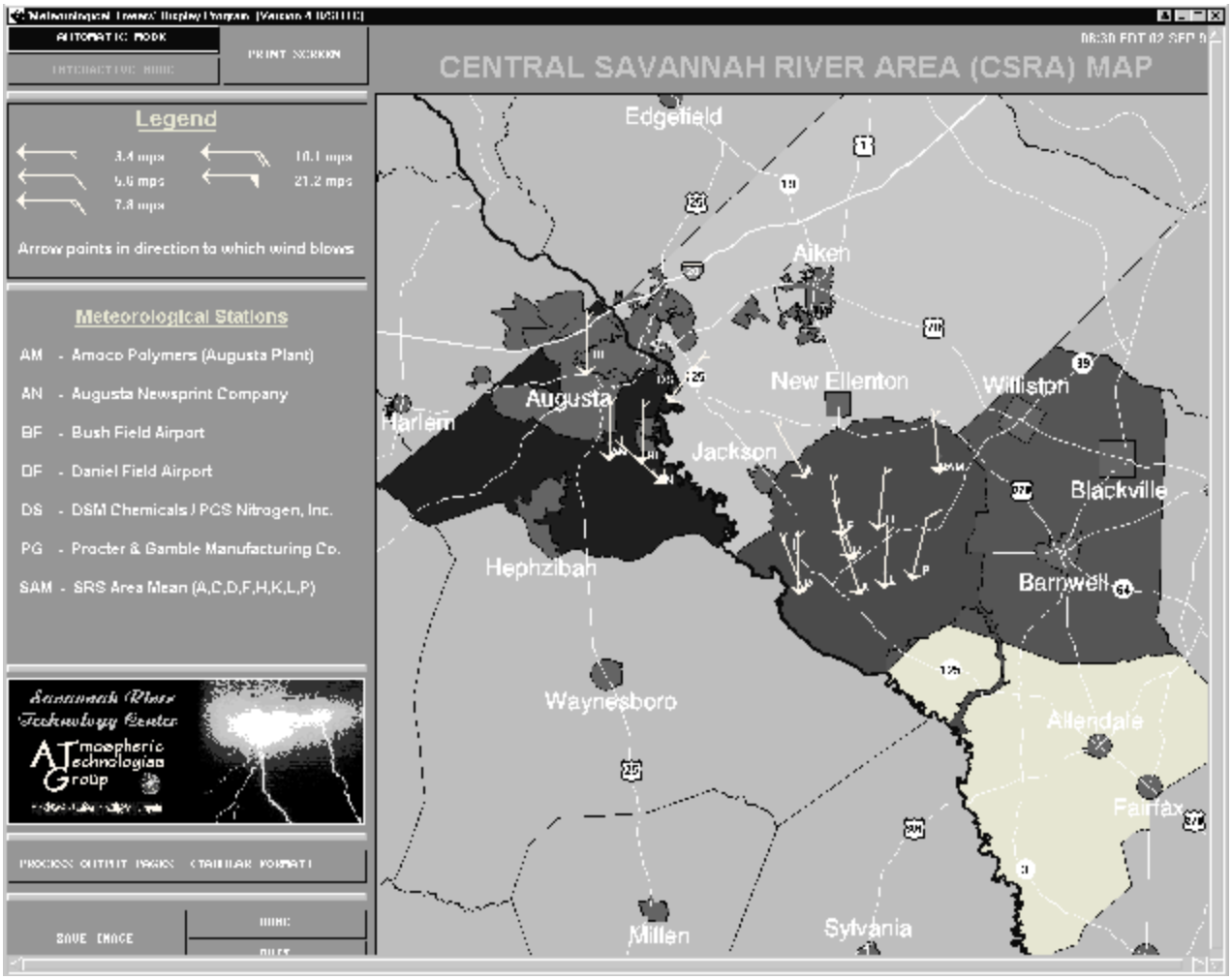

Figure 3: Graphical wind data from the area towers from the same time period as Fig. 2.

Forecast Data

The meteorological forecasts are provided by the Regional Atmospheric Modeling System (RAMS Pielke et al. 1992), a prognostic mesoscale numerical model. This three-dimensional, primitive equation, finite-difference model may be used to study a wide variety of atmospheric motions ranging in size from synoptic-scale phenomena such as cyclones and hurricanes, to large eddy simulations. Basic features of the model include the

use of nonhydrostatic, quasi-compressible primitive equations and a terrain-following coordinate system with variable vertical resolution.

The model domain is centered about the Savannah River Site, and forecast products tailored to the SRS are currently being generated. Use of the mesoscale model allows for incorporation of mesoscale features such as the sea breeze and mountain slope-flows that commonly affect local weather conditions.

The three-dimensional lateral and initial boundary conditions for RAMS are generated using coarser National Weather Service gridded data, generated twice daily. The current RAMS configuration consists of a single grid covering a region roughly 800 km per side (Fig. 4), with a horizontal grid spacing of 20 km. A two-way nested grid system may also be incorporated allowing for finer details in user-selected areas. The vertical coordinate system telescopes from roughly 50 m grid spacing near the surface to ~1 km at the model domain top (~18 km above ground level). This permits an improved definition of features within the atmospheric boundary layer. Surface characteristics are determined using variable fractional land coverage, sea-surface temperature, and vegetation. Incorporation of topography and land-sea surface characteristics at finer resolution provides more information than can be obtained from National Weather Service products alone.

The simulation of atmospheric conditions is performed for a 30-hr period. However, the initial six hours of simulation are discarded to allow for model `spinup' of the atmospheric boundary layer. Therefore, data from the model are saved for a 24-hr period. The entire process is automated using a series of scripts and shell commands on the SRS Cray Supercomputing System, while post-processing is performed on a personal computer operating under Windows NT.

Figure 4: Domain for the current RAMS simulations. Also shown are contours of topographic height [m, above ground level] and an outline of the Savannah River Site (SRS).

The data generated by RAMS must be put into a form useful for forest service personnel. Figure 5 illustrates a time-height contour plot of temperature valid for a location in the central SRS over the 24-hr forecast period. This diagram gives the user a quick interpretation of predicted temperature inversions, which is an important factor in properly controlling and predicting fire behavior.

Figure 6 depicts a meteogram generated from RAMS data for the same SRS location. The top panel shows model predicted temperature (°C), dew-point temperature (°C), and relative humidity (%) over the 24-hr forecast period. The middle panel shows the surface pressure (mbar), while the bottom panel illustrates winds (m s^{-1}) in the lowest 3000 meters over time, with a mixing-height (m) estimation superimposed over the wind field. The mixing-height is calculated from turbulence generated within RAMS during the daylight hours.

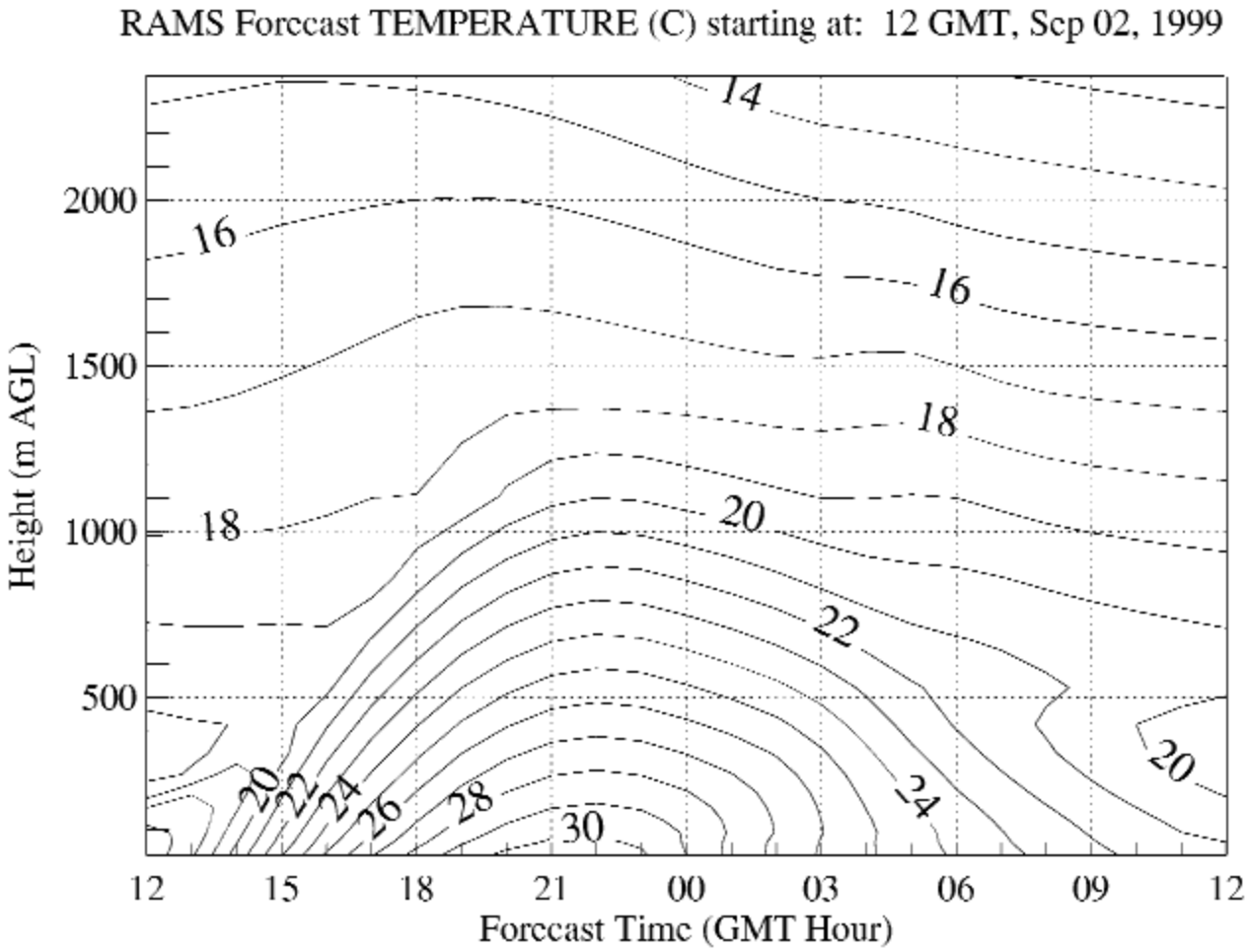

Figure 5: Time-height temperature profile forecast product generated from RAMS for 02 September, 1999.

For the nocturnal period, the greater value as determined from a climatologically-determined mixing height as a function of the hour of day, and the product of a constant times the surface wind speed at SRS, is used. This information is used by SRS meteorologists as an aid in making daily local forecasts of SRS conditions, which are in turn utilized by site personnel before performing a variety of operations. Performance of prescribed burns clearly depends on the wind direction and atmospheric moisture conditions contained within this plot. The ventilation potential (the product of wind speed and mixing height) is also readily obtained from the lowest panel. Although this information is currently used for controlled burns at SRS, it may also be generated for other locations within the regional RAMS grid if so desired.

Conclusions

Performing controlled burns requires that locally sensitive targets be protected from the impact of both smoke and fire. Potentially harmful effects are mitigated when forest service personnel have access to current and predicted weather patterns. Current conditions are provided using a series of instrumented towers from various onsite locations, while a prognostic mesoscale model is used to provide forecast information, which enhances standard NWS fire forecasts. By providing detailed forecast wind, temperature inversion, and mixing layer height information for a given burn region, fuel and fire management agencies may develop strategies to reduce the risk to both humans and the environment for current and near-current burns at the local level.

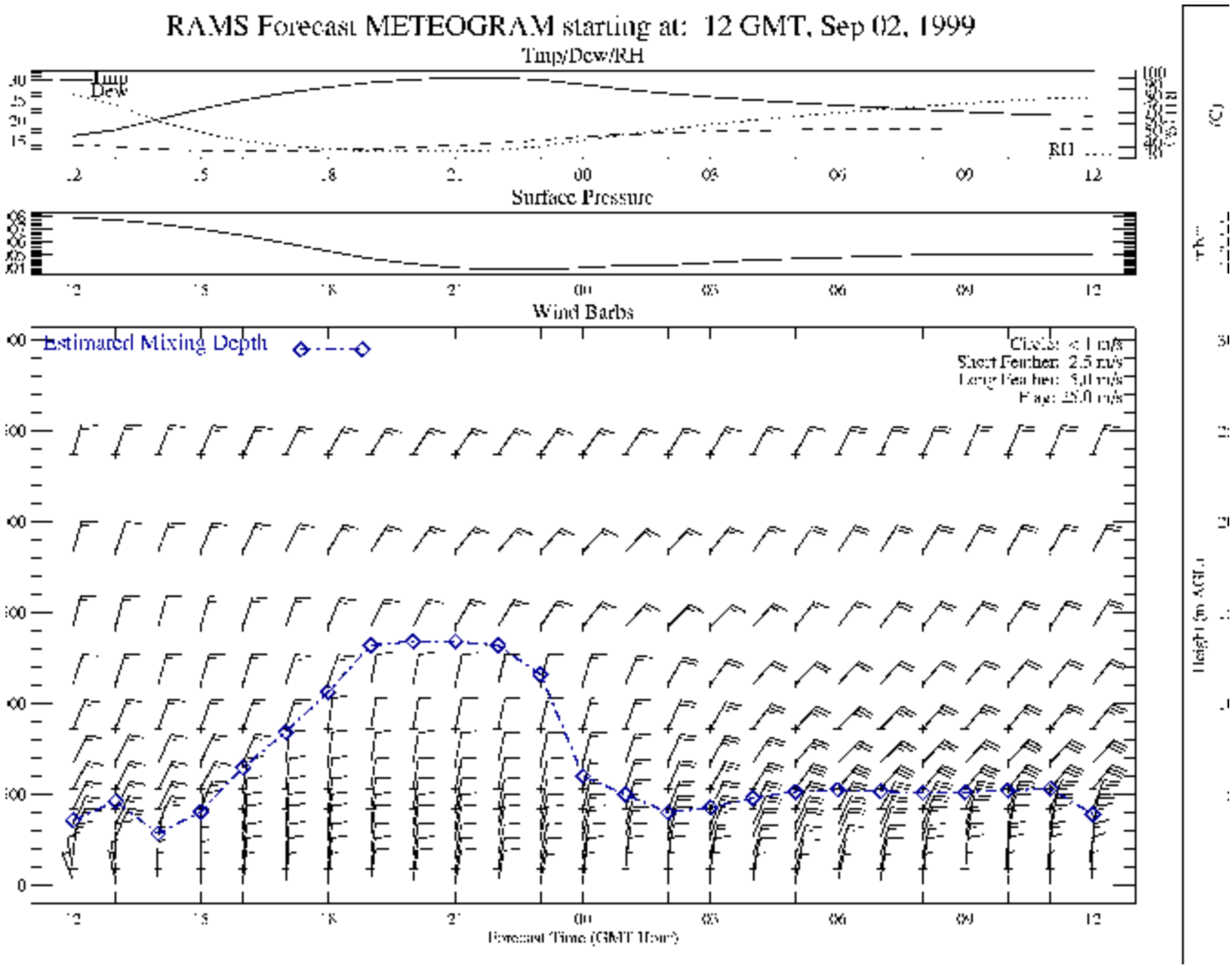

Figure 6: Example meteogram generated from RAMS data. Data are collected from the lowest model level (26 m AGL) at a point corresponding to the SRS central location beginning at 12 GMT, 02 September 1999.

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