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Meteorological Support at the Savannah River Site

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Abstract – *The Department of Energy (DOE) operates many nuclear facilities on large complexes across the United States in support of national defense. The operation of these many and varied facilities and processes require meteorological support for many purposes, including: for routine operations, to respond to severe weather events, such as lightning, tornadoes and hurricanes, to support the emergency response functions in the event of a release of materials to the environment, for engineering baseline and safety documentation, as well as hazards assessments etc. This paper describes a program of meteorological support to the Savannah River Site, a DOE complex located in South Carolina.*

I. INTRODUCTION

The Savannah River Site (SRS) is an 800 km^2 (310 mile^2) nuclear facility owned by the U.S. Department of Energy and operated by the Westinghouse Savannah River Company. SRS is located in western South Carolina, 12 miles south of Aiken, bordered on the west by the Savannah River (Fig. 1). Established in 1950, SRS produced tritium and plutonium in support of the Nation's defense. Since the end of the cold war, the mission has changed to emphasize environmental cleanup, nuclear materials disposition, and nuclear weapons stockpile stewardship. The Department of Energy has identified other potential missions for SRS, such as the Mixed Oxide (MOX) Fuel Fabrication Facility to blend plutonium with uranium for reactor fuel, a plutonium pit manufacture facility, a teaching and research nuclear reactor, and a nuclear energy park. Whether the site is operating nuclear reactors, or cleaning up nuclear wastes, there has been, and continues to be, a need for meteorological support of these activities. This paper will provide an overview of the meteorological program at SRS with particular emphasis on its application to emergency response activities.

The meteorological program at SRS is operated by the Savannah River National Laboratory, and supports site operations, emergency response, employee and public health and safety, environmental programs such as forestry management, facility engineering, future SRS missions, and work for other US Federal government agencies. The meteorological program includes a comprehensive meteorological monitoring program, a fully equipped weather center, which provides access to local and world-wide weather data, advanced atmospheric modeling capabilities that provide operational numerical weather forecasts and atmospheric consequence assessments for emergency response and nonproliferation. In addition, meteorological field programs are designed and operated in support of research programs, such as determining ground truth for remote sensing.

Fig. 1: The Savannah River Site is located in South Carolina.

II. SRS METEOROLOGICAL MONITORING PROGRAM

The meteorological monitoring program at SRS includes real-time data acquisition from (Fig. 2):

- nine (9) 62 m (200 ft) instrumented towers at SRS,
- instrumentation to 304 m (1000 ft) on a recently constructed TV tower,
- a climatology facility
- four (4) instrumented towers in a nearby county
- specialty instrumentation for field programs.

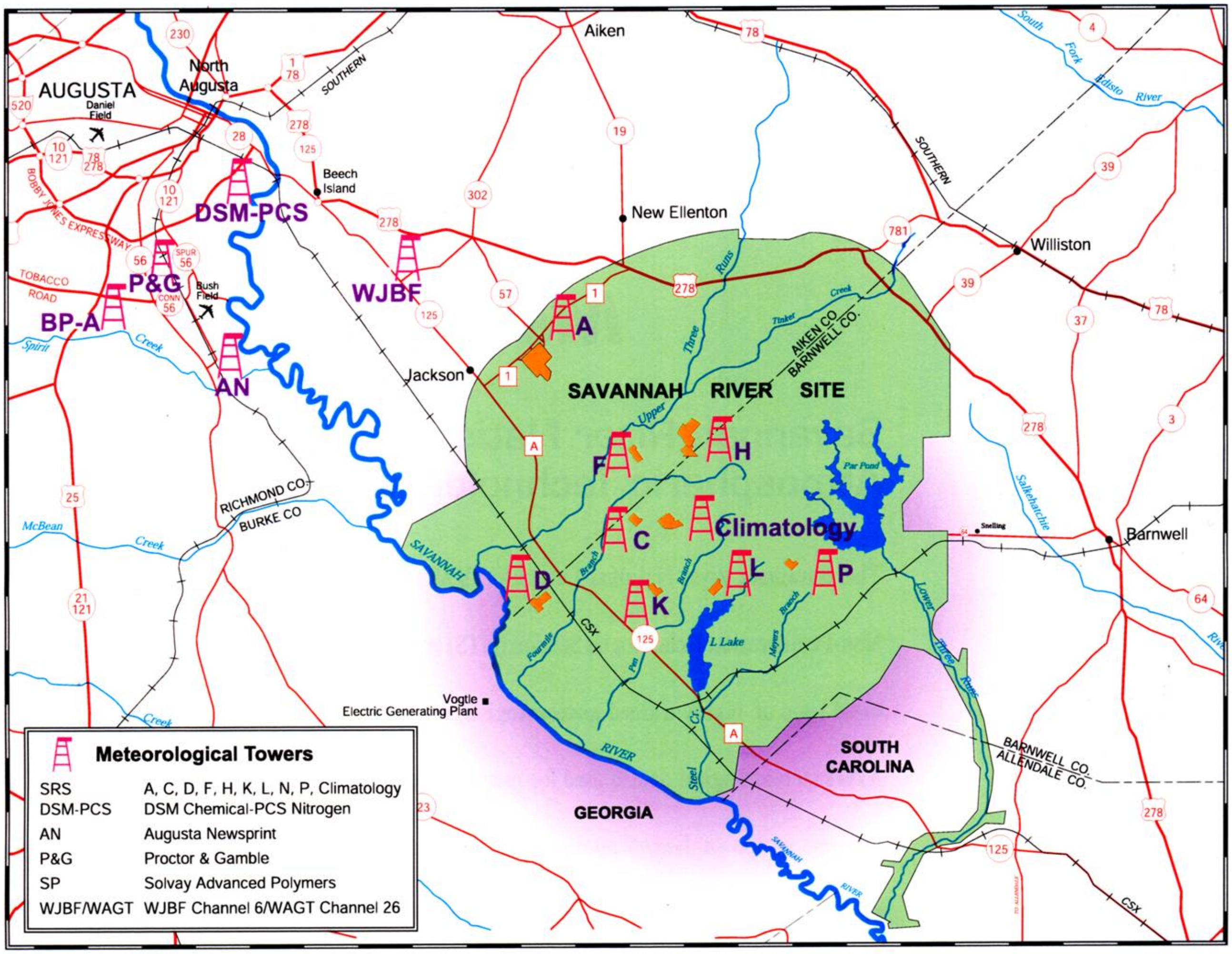


Fig. 2: Meteorological tower network at the Savannah River Site and surrounding counties. There are nine (9) 62 m (200 ft) towers on SRS, and four (4) towers of varying height located in Augusta – Richmond county. The SRS Tall Tower Facility is identified by the letters WJBF, located near Beech Island, SC.

Fig. 3 Typical 62 m (200 ft) Rohn tower with instrument platform being raised by an electrically driven elevator.

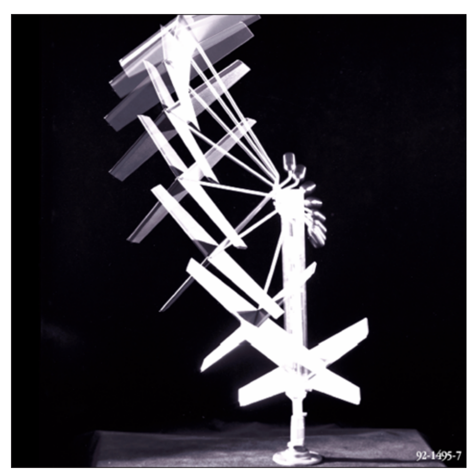


Fig. 4 Met 1 Bi-directional Vane measures atmospheric turbulence. Located on SRS and Richmond county towers.

II.A. SRS Area Tower Network

Meteorological towers (8) (62 m, 200 ft), called "area" towers, are located near all of the major SRS facilities (Fig. 2). Measurements of wind speed, direction, turbulence, air temperature and dew point/relative humidity are made at 62 m (200 ft) above ground on all of the SRS towers (Fig 3 and 4). The towers are located sufficiently near operating facilities to measure meteorological conditions representative of that area, but sufficiently distant from the facilities so as not to be influenced by the large structures that comprise these facilities (Fig. 5). Data are transmitted by dedicated phone lines to the Weather Information and Display (WIND) System, a computer based resource for predicting the consequences of an accidental release of hazardous material to the environment. Calibration and minor repairs are conducted every 6 months onsite. A comprehensive quality assurance program includes routine twice daily data checks, complete weekly systematic evaluations, and rigorous assessments to provide quality assured data sets for regulatory air quality and safety assessments. The SRS meteorology program meets or exceeds all federal and state standards and requirements.

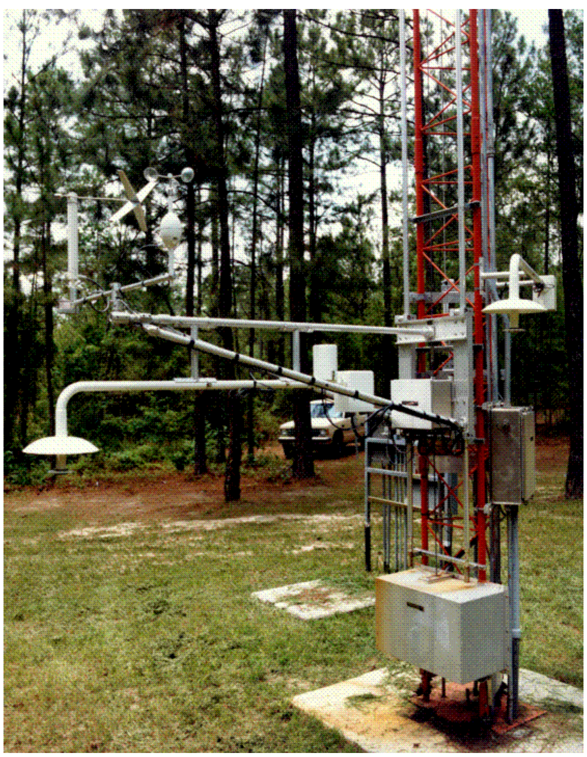


Fig. 5 SRS "area" towers are located within the forest that surround each major facility on SRS. The typical canopy height is approximately 20-30 m. The US Forest Service manages and maintains the health of the forests around the towers. The top instrument height is 62 m, well above the canopy. Trees are removed to protect the integrity of the tower and the guy wires.

II.B. Climatology Facility

The SRS Climatology Facility provides unique meteorological data for routine monitoring, special projects, research and operations at SRS. It also serves as a staging area for meteorological field programs. In contrast to the 8 "area" towers, which are located within the forest, the Climatology Facility and tower are located in a grassy field near the center of the SRS (Fig. 6).

An emphasis in recent years has been to install and test field instrumentation at the Climatology Facility, such as remote sensing equipment, in support of programs for offsite customers (e.g. a Multi-Filter Shadow Band Radiometer Fig. 7)

Fig. 6 The tower at the Climatology Facility tower with instrumentation at 4 levels to 62 m.

Fig. 7 A Multi-Filter Shadow Band Radiometer to measure direct and diffuse solar radiation – an example of instrumentation at the Climatology facility.

Under a 1996 Mutual Aid Agreement (MAA), four (4) additional tower sites were created in highly industrial corridors of Augusta/Richmond County (Fig. 2). The MAA was created to provide real-time meteorological monitoring and emergency modeling information beyond the boundary of the SRS. In addition, the MAA also allows for technical consultations and assistance by SRNL to local counties for emergency management. Measurements of wind speed, direction, turbulence, air temperature and dew point/relative humidity are made on towers of various heights above ground level on the Augusta /Richmond county towers (Fig 8).

Meteorological data from the Augusta/Richmond county towers are communicated by phone lines to the SRNL Weather Information and Display System (WIND System) for inclusion in the SRS meteorological data base. These data are then sent beyond the SRS computer security firewall for access by the emergency management of the local county's and states. The data, along with forecast wind information, are automatically ingested into consequence assessment models to provide emergency managers consequence assessments to aid decision makers in an emergency for public safety considerations.

Fig. 8 The meteorological tower at the Proctor & Gamble Augusta plant. Data is transmitted every 15 minutes to the SRS meteorological Weather Information and Display (WIND) System. Data is available to the surrounding county and state emergency managers.

Since the mid 1960's, SRNL has operated meteorological instrumentation at several levels to 304 m (1000 ft) on a TV tower in Beech Island, SC near SRS (Fig 2). It is identified as WJBF on Fig 2. The previous system was retired in 1998 at the request of the tower owner, but SRNL was invited to install a new system on a new tower being built to house high-definition TV transmitters. Construction of the tower was completed in late 2003. In early 2004, Applied Technologies Incorporated installed a state of the art meteorological monitoring system on the new tower (Fig 9).

Measurements from the SRNL Tall Tower Facility are designed to determine several terms of the classical turbulence kinetic energy (TKE) equation, such as the buoyant production, shear production, and turbulent transport terms. Additionally, various forms of the Richardson Number and Monin-Obukov Length are calculated. TKE can be used to approximate turbulence diffusion in the atmospheric boundary layer.

The system utilizes three dimensional sonic anemometers (Fig. 10), fast response water vapor, barometric pressure sensors, slow response temperature, and relative humidity sensors. Data is transmitted by radio to a tower at SRS and then to the SRNL WIND System.

The primary purpose of the new tall-tower meteorological monitoring system is to enhance SRS' operational emergency response capability for unplanned atmospheric releases for both on- and off-site locations. Data from this system is also available for meteorological forecast support (including fire weather forecasting) and other research applications.

Fig. 9 The SRS Tall Tower Meteorological Monitoring System has instrumentation at three levels: 31 m (100 ft), 62 m (200 ft) and 304 m (1000 ft).

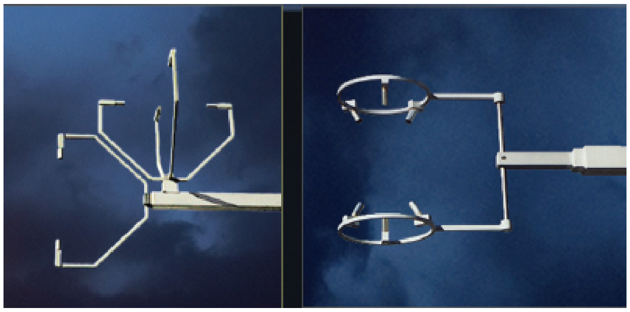


Fig. 10 Left: an orthogonal three dimensional sonic; Right: a non-orthogonal three dimensional sonic anemometer manufactured by Applied Technologies, Inc.

The new tower has an electrically driven elevator to carry technicians to the measurement platforms to conduct onsite maintenance, repairs and calibrations. Figure 11 shows the large booms flexing to allow technician access for instrument change out.

Fig.11 Instrument boom flexed in the middle to demonstrate instrument change-out for calibrations. These booms were designed and constructed by Kline Towers Inc., the company that designed and built the WJBF-WAGT-TV tower.
Insert: close-up of instrumentation on boom-
3-D sonic anemometer, H_2O/CO_2 flux sensors, T&RH sensors

IIE Meteorological Engineering Facility

The SRNL Meteorological Engineering Facility houses a wind tunnel for calibration, instrument testing and development. The wind tunnel has a 1x1x2 m test section, with customized rigs designed and installed for testing and calibrating a variety of meteorological instruments. This facility enables electronic and mechanical trouble shooting and minor equipment repair and calibration. The wind tunnel operates to 25 m/s (50 mph), and baffles may be added to investigate low wind speeds.

Fig. 12 SRNL Wind tunnel for instrument testing and calibration.

III. ATMOSPHERIC TECHNOLOGIES CENTER (ATC)

The SRNL Atmospheric Technology Center (Fig. 13) is fully equipped to enable researchers to provide:

- weather forecasts, analyses and consultations for developing response actions to severe weather threats, and for planning weather sensitive industrial operations, construction, and forest management activities;
- real-time modeling and assessment of unplanned releases of hazardous material to the environment for emergency response and nonproliferation activities,
- customized meteorological data sets and climate statistics for applied research, engineering design, operations planning, safety analyses, and law enforcement.

To meet diverse operational needs, the ATC is equipped to access a variety of real-time sources of local, national, and international meteorological information. Local meteorological data collected from the WIND System tower network, are available in real-time in the ATC. Satellite communications are used to provide the ATC with a continuous feed of regional, national, and international meteorological information from the National Weather Service (NWS) and other government agencies.

Fig. 13 SRNL's Atmospheric Technology Center.

Routine regional and local numerical weather forecasts are generated in support of emergency response, site operations, as well as US Forest Service prescribed burns of forest under growth. These routine numerical forecasts are described in another paper in this meeting.

To ensure that the SRS workforce is well informed on developing hazardous weather situations, or can plan effectively for conducting outdoor work, the ATC provides access to current local weather conditions and forecasts through an onsite local intranet web site. Displays from a local Doppler weather radar (Fig. 14) are updated every 5 minutes, and continuously updated and recycling movie loops of the radar are available to all site employees on their desktop computers. In addition, NWS severe weather watches and warnings, as well as information regarding other severe weather observed in the vicinity of the SRS (such as lightning), are automatically sent to the Emergency Operations Center to warn site employees, especially remote workers.

Selected data streams are forwarded to computer resources for use as input to modeling systems that can be configured to generate near real-time predictions of contaminant transport following unplanned releases of hazardous materials anywhere in the world.

Fig. 14 WSRC-WJBF Doppler Radar, located at the Augusta Bush Field airport, provides vital information for tracking and forecasting local severe weather.

Budgetary reductions in recent years caused the SRS Industrial Hygiene to reassess the methodologies it had long employed to measure heat stress exposure for employees. Through the 1990's, routine measurements were made of wet bulb globe temperature (WBGT) manually with a portable instrument. This routine was highly labor intensive, requiring trained technicians and did not provide widespread distribution (Fig. 15).

SRNL provided an alternative methodology to determine potential heat stress to ensure continued compliance with programmatic requirements. A computer algorithm was developed to use input from routinely operating meteorological instrumentation to emulate the WBGT output. This data, along with customized forecasts are available on the SRNL weather web page to inform employees and for planning outside work in the severe summer months at SRS.

Fig. 15 Labor intensive Wet Bulb Globe Thermometer.

IV. EMERGENCY RESPONSE TECHNOLOGIES

SRNL supports DOE with emergency response technologies and expertise.

- Provide detailed consequence assessments for emergency response (events & exercises)
- Ensure reliable availability of real-time quality assured meteorological measurements at SRS and surroundings in support of emergency response.
- Ensure modeling resources capable of supporting a full spectrum of events for emergency response consequence assessments that reflect changing operational needs.
- Provide trained and knowledgeable personnel as Emergency Response Organization (ERO) members for dispersion modeling / dose assessments
- Design and provide technological solutions to provide real-time weather data, forecasts, watches and warnings to the Emergency Duty Officer in the EOC and SRSOC (SRS Operations Center).
- Design and provide technologies to link the Tracking Atmospheric Contaminants (TRAC) Vehicle to the ATC & EOC for two-way communications (plume model results and field measurements).
- Design and provide technologies to utilize geographic information systems (GIS) for emergency response applications.

SRNL has developed and adapted technologies to provide customized products to meet the needs of SRS operations for emergency response applications.

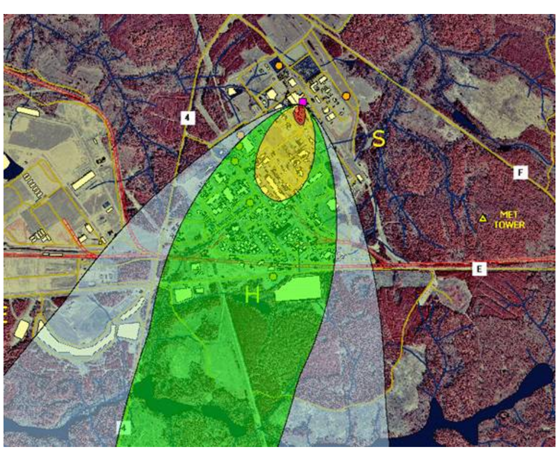


Fig. 16 An example of an atmospheric consequence assessment for an air-borne release of material at SRS.

Recently, SRNL provided support to local emergency managers and other decision makers in response to a deadly chlorine release due to a train accident and rail car derailment. Having regional data bases, local meteorology, and local detailed numerical weather forecasts, combined with existing close working relationships with local and state agencies and personnel, facilitated timely and targeted consequence assessments. This was far more beneficial to the decision makers than simply providing a canned plume from a remote location.

SRNL used a suite of atmospheric and dispersion models to provide decision makers with likely consequences to many “what if?” scenarios. This response is described in depth in two other papers in this meeting.

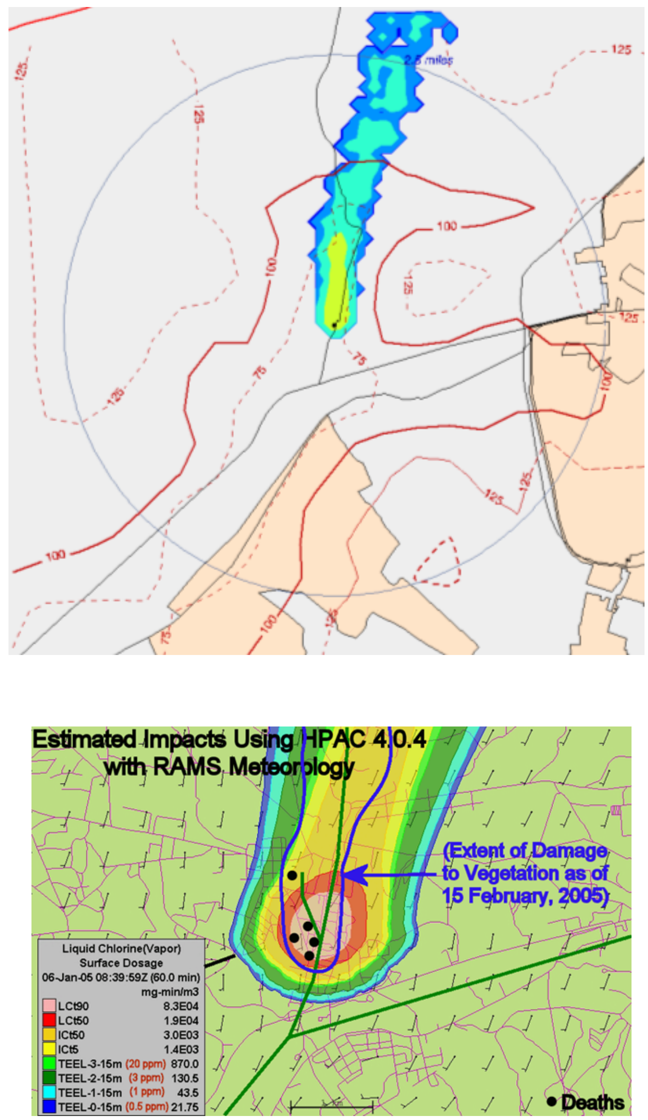
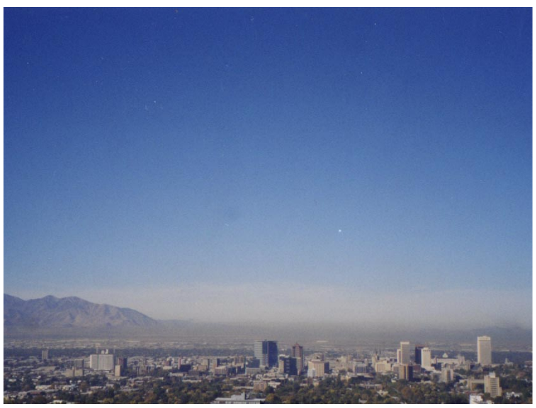


Fig. 17 Results from 2 of several modeling tools employed to assist and guide decision makers.

V. MODEL EVALUATION AND DEVELOPMENT

SRNL has been actively involved with model evaluation field programs, statistical analyses and work shops since the early 1970's. Recent activities have involved evaluating model performances utilizing tracer releases, tracers of opportunity from facilities, and inter-comparisons with other models from around the world.

For example, SRNL has utilized data from the DOE Office of Science VTMX (Vertical Transport and Mixing) program, which conducted several intensive observation and modeling of the processes in the atmospheric boundary layer in the vicinity of Salt Lake City, Utah. SRNL utilized an evolutionary programming technique to optimize model parameters and investigate the relative value of model grid resolution versus parametric optimization.



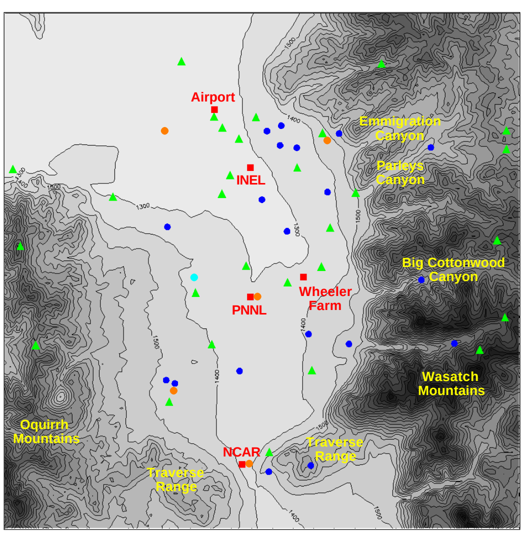


Fig. 17 Above: view haze over of Salt Lake City; Below: extensive instrumentation layout for VTMX

SRNL has represented the US in a variety of atmospheric model evaluation and comparison programs over the past decades from the ATMES[1] (Atmospheric Transport Model Evaluation Study) project, to ETEX[2] (the European Tracer EXperiment), RTMOD[3] (the Real-Time MODeling evaluation project) and the ENSEMBLE[4] program. The SRNL involvement with the European ENSEMBLE program is described elsewhere in this meeting.

VI. CONCLUSION

Large industrial nuclear and chemical complexes require a broad range of meteorological support. This support requires technologies and expertise that ranges from the simple and routine to the complex and highly technical. To ensure the safety and health of employees and the public, as well as to preserve the integrity of major public facilities from harm due to severe meteorological conditions, a healthy meteorological program is essential.

ACKNOWLEDGMENTS

This paper provides an overview of some of the work conducted in the meteorological program at SRNL. It represents the efforts of many members of the Atmospheric Technologies Group and Nonproliferation Technologies Section. To them goes the credit for the work conducted over many decades.

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