Applied Meteorology Unit (AMU)
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If anyone on the current distribution would like to be removed and instead rely on the WWW for information regarding the AMU's progress and accomplishments, please respond to Frank Merceret (phone: (407) 853-8200, email: fmerceret@tmoffice.ksc.nasa.gov) or Ann Yersavich (phone: (407) 853-8264, email: anny@fl.ensco.com).

1. BACKGROUND

The AMU has been in operation since September 1991. Brief descriptions of the current tasks are contained within Attachment 1 to this report. The progress being made in each task is discussed in Section 2.

2. AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

The primary AMU point of contact is reflected on each task and/or subtask.

2.1 TASK 001 OPERATION OF THE AMU

HARDWARE / SOFTWARE INSTALLATION AND MAINTENANCE

Early in October, one of the two IBM 5 GB 8-mm tape drives malfunctioned and was unable to eject tapes. IBM was called upon to help in the troubleshooting procedures and it was determined that the best solution was for IBM to replace the tape drive with a new one under the current maintenance agreement. The tape drive was replaced and has functioned properly since that time.

In November, McIDAS-OS/2 version 6.02 was re-installed onto the Wide Word Workstation. This had to be done after an error (screen would not refresh) showed up while doing the ESUM (Energy SUMmation) program certification. After the system reload no further errors occurred due to the operating system.

Early in December, the 5.8 GB external disk drive attached to one of the IBM RS/6000 workstations malfunctioned. Central Data Computer Centers determined that the output from the power supplies on both disks was very weak and not sufficient to operate the disks reliably. After the power supplies were replaced, the disks were reconfigured and the data were restored from the previous week's backup. Since then, the disk drives have been functioning properly.

In December, the IBM Model 80 began having software problems related to loading images and model data. Mr. Wheeler performed a check of the system and it was determined that the internal disk drive had numerous bad sectors. After a backup of the system was performed, the disk was reformatted and the entire operating system and McIDAS software were reloaded. No further errors have occurred since the disk was reformatted. Also, McIDAS-OS/2 version 6.102 was installed onto the Wide Word Workstation and the IBM Model 80 updating these systems to the most current version available from Space Science and Engineering Center (SSEC).

During the ESUM evaluation and certification (used for evaluation of the Shuttle low temperature LCC recovery algorithm), screen update problems began occurring. After a McIDAS software reload no further errors occurred due to the operating system. The Eastern Range certified version of ESUM was loaded on the AMU's Wide Word Workstation to be used operationally for the early January Shuttle launch. Mr. Wheeler also revised the McBasi routines that update Launch Complex 39 wind, temperature, and relative humidity values to the Meteorological Interactive Data Display System (MIDDS) display.

Ms. Yersavich installed version 2.102 of McIDAS-X on one of the AMU's IBM RS/6000 Model 320H workstations. She also installed version 6.11 of SAS (Statistical Analysis System) on the other IBM RISC/6000 Model 320H workstations. SAS will be used for data reduction for the Lightning Detection And Ranging (LDAR) data examples included in the LDAR computer based training system.

MISSION IMMEDIATE TASKS

Mr. Wheeler assisted in solving several MIDDS workstation problems that occurred after a major McIDAS upgrade to version 6.1. The Range Weather Operations (RWO) workstations were not operating correctly and were crashing after just a few hours of operation. Mr. Wheeler investigated the problems and noted that the RWO was using OS/2 version 2.00 on the workstations and SSEC had certified the McIDAS software version 6.1 with OS/2 version 2.11 or WARP. Since a Delta operation was in the near future, the 45 WS and Computer Science Raytheon (CSR) decided to reinstall McIDAS-OS/2 version 5.9 which had been certified under OS/2 version 2.00. After the Delta operation, CSR borrowed the AMU's copy of OS/2 version 2.11 and installed it and McIDAS-OS/2 version 6.1 onto the RWO MIDDS workstations. Since that installation, no additional MIDDS problems have been noted.

2.2 TASK 003 IMPROVEMENT OF 90 MINUTE LANDING FORECAST

MIDDS SUPPORT (MR. WHEELER)

During the past quarter, the RWO requested several changes be made to the forecaster terminal F-key menu. The changes added 200 and 850 mb wind streamlines graphics to show high and low level flow patterns over the U.S. for the Commander's briefing. The order of graphic frames displayed for briefings were also changed. During a Shuttle launch operation in November a problem showed up in the menu in support of Shuttle operations. After the launch, the problem was found in the menu system and corrected. An AMU memorandum was written detailing the error and corrective action. Also, procedures were written to document how to fix minor problems that may occur with the menu system. The memorandum and menu fix procedures were then forwarded on to the 45th Weather Squadron (45 WS). Monthly backups continued for the RWO F-key menus and all related utilities.

Mr. Wheeler worked with the RWO and PRC during several advanced McIDAS meetings in November. The main emphasis of these meetings were on the command, McBasi and F-key menu structures and utilization. Mr. Wheeler also attended the MIDDS replacement demonstration meeting at the PRC McLean, Virginia office. The meeting included detailed briefings on the status of their work and preliminary examples of their Graphical User Interfaces (GUI).

SUBTASK 6 MIDDS F-KEY MENU SYSTEMS DOCUMENTATION

Mr. Wheeler, Ms. Schumann, and Ms. Yersavich continued the documentation effort for the McIDAS F-key menu systems in December. The documentation will provide users with considerable information regarding effective use of the menu system and McIDAS as a whole and guidance in tracking down any errors or problems. See Figure 1 for an example of the Terminal 21 F-key menu logic flow diagram.

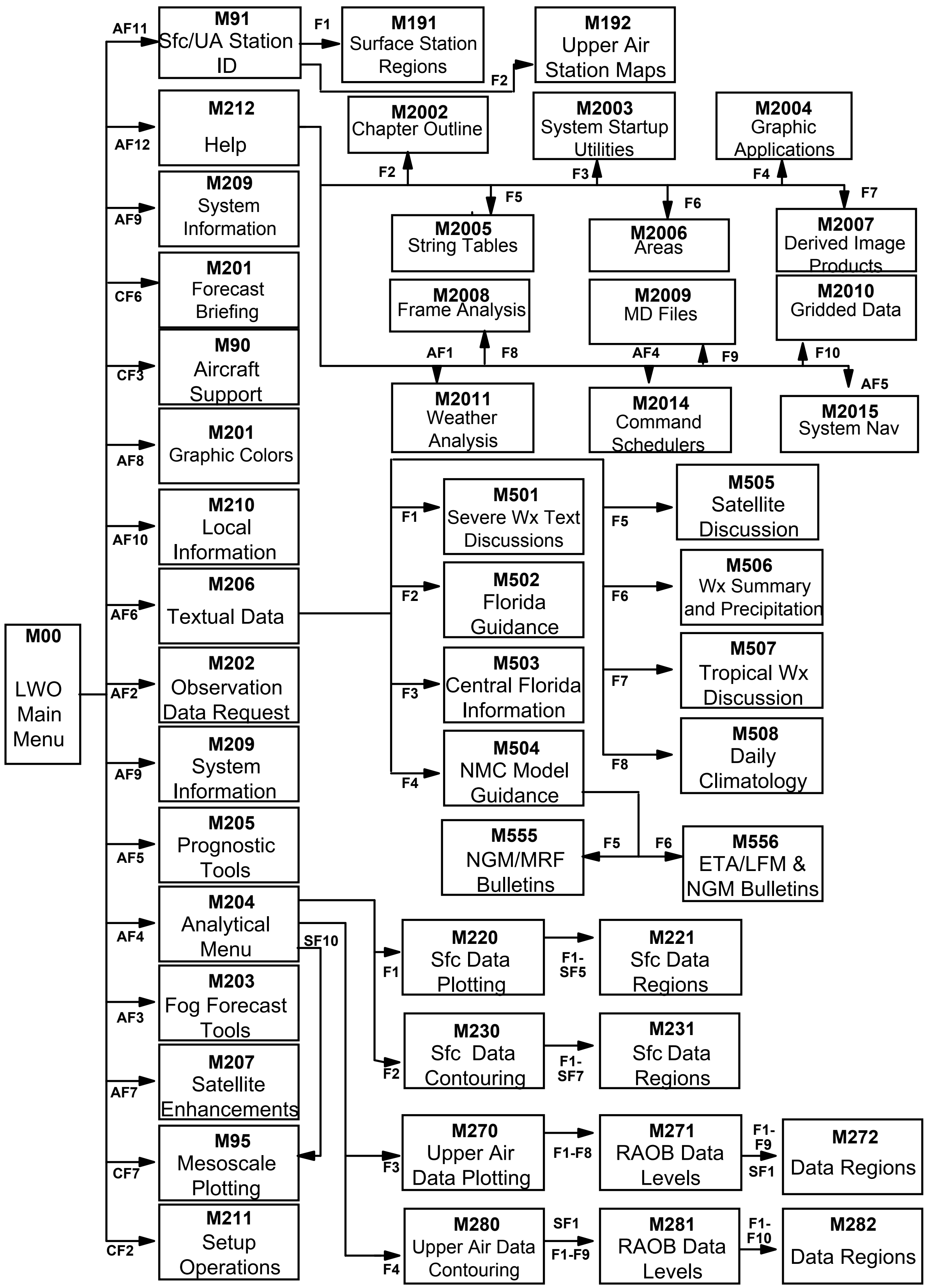

Figure 1. Terminal 21 top-down submenu logic flow.

2.4 TASK 004 INSTRUMENTATION AND MEASUREMENT

SUBTASK 3 50 MHZ DOPPLER RADAR WIND PROFILER (DRWP) (MS. YERSAVICH)

In October, NASA/KSC requested that the Range contractor, CSR, archive all profiler data from the MIDDS for the months from October 1995 through April 1996. Ms. Schumann wrote and tested the software to retrieve the data from the archive tapes and generate standard ASCII data files. Dr. Merceret will then perform a climatological analysis to evaluate the frequency with which significant wind changes occur within 15 min, 1 h, 2 h, and 4 h. Thus far, CSR has provided the AMU with the archived data from the end of September through mid January. Ms. Yersavich has processed all the archived data and some of these data have been transferred to Dr. Merceret for use in his climatological analysis of profiler data.

Since Ms. Schumann's transfer to another project at ENSCO in November, Ms. Yersavich has assumed the data quality monitoring of the 50 MHz profiler. When operational, the profiler is monitored daily and performance characteristics with regards to signal-to-noise ratio and sidelobe and reflection interference are recorded. The performance records are forwarded to Ms. Maier (NASA/KSC) on a daily basis for use by the profiler maintenance personnel.

Ms. Yersavich quality controlled the 50 MHz profiler data on 12, 17, 18, and 29 December for four of the ten day Titan tests. Ms. Yersavich received training during the first two days from Ms. Schumann. Ms. Yersavich maintained detailed notes during the test days that described overall data quality, identified interference signals and whether or not they affected the radial velocity trace, and whether or not individual profiles would have been released for distribution. These notes were then distributed to Ms. Maier of NASA/KSC, Mr. Crisler of Lockheed Martin, and Mr. Bostick of Aerospace Corp. Ms. Yersavich also provided Mr. Crisler and Mr. Bostick with standard ASCII data sets for the 12, 14, 17, and 18 December test days. These ASCII profiler data sets were produced using the same software which is used to generate the profiler data files for Dr. Merceret's climatological analysis.

SUBTASK 4 LIGHTNING DETECTION AND RANGING (MR. DRAPE)

One of the primary goals of the Lightning Detection and Ranging (LDAR) subtask is to develop training tools to ensure the LDAR display and the concept of operations for its use are well understood. It was determined that one of the training tools should be a computer based training (CBT) system for LDAR that explains how the system works, illustrates how to interact with the system's user interface, and identifies and explains known LDAR signatures. In late November, the AMU continued its earlier work on building the CBT course for LDAR. This effort involves using a commercial CBT authoring package to produce an interactive courseware program presenting textual and graphics information about the LDAR system. The courseware will also provide links to the software programs to emulate the functionality of the LDAR display system and to show examples of known LDAR signatures.

The target audience of the training program consists of new users of the LDAR system, who are primarily weather forecasters of the 45 WS and the NWS MLB office. Users may be assumed to understand the physical principles of lightning and lightning warning systems in general, but may not have any specific knowledge of the LDAR system. A secondary audience includes meteorologists or weather systems personnel who need general information about LDAR and/or a rudimentary understanding of LDAR operational concepts. Thus, the CBT is being designed for a professional audience, but one which has varying informational needs.

Thus far, the overall design of the course has been finalized and the AMU is in the process of developing the content. The CBT development software selected for this task is comprised of two commercial products for authoring interactive CBT programs and creating animated graphics displays. A set of storyboards was developed which identified design requirements for the course. By mid-December, the AMU began preparing the instructional content for the initial prototype of the course. Several LDAR data sets were obtained which will provide good examples of typical signatures for interpretation by forecasters. During late December, the program development phase of the project began, beginning with the main program controlling the overall navigation through the course lessons. Modifications were also made to programs written earlier which will display the LDAR data examples. Completion of the first operational prototype is scheduled for the end of January 1996.

When completed, the CBT program will contain four lessons, each of which satisfies a major course objective. The lesson titles and objectives are as follows:

- System Overview -- provides an overview of the LDAR system and a technical description of how the system works,
- Display Operation -- provides instruction on the operation of the LDAR display system interface,
- Data Interpretation -- allows the user to display examples of past LDAR data sets illustrating known signatures associated with storm development as well as false signatures, and
- What's New? -- makes the user aware of new developments and research findings which will enhance the LDAR system's capabilities and operational effectiveness.

The flow chart in Figure 2 shows the high-level structure showing how the user would proceed through the different course modules. Notice after the Course Introduction module, the user is free to select any of the four lessons in any sequence. New users of LDAR will probably want to complete Lessons 1 through 4 in that order, but experienced users or other personnel with particular interests may want to "pick and choose" according to their needs. The non-linear presentation scheme was designed to accommodate the rather heterogeneous target audience anticipated for this course.

Once inside a particular lesson, the user will be able to select different topics and then display instructional screens containing text and graphic images or illustrations. An example of the design of an instructional screen is provided in Figure 3, which shows one of the storyboards for the System Overview lesson. The information on each screen will be controllable by the user through scrollbars, pushbuttons, and hotwords embedded in the text which activate the graphic displays associated with a term or concept. This level of interactivity allows the user to control the pace and level of detail being presented. The use of both still and animated color graphics enables a realistic portrayal of LDAR hardware and software operation.

The LDAR CBT course will operate on a PC running Microsoft Windows. Having a PC-based design allows the courseware to be run outside of the LDAR operating environment at a time convenient for the user. Because the CBT presentation includes numerous graphics displays and requires several LDAR data sets, the course will probably be distributed on CD-ROM to encompass all the information. The current CBT prototype will require at least a 386 PC with 4 MB or more of RAM, but will not need any additional hardware to run (other than a CD-ROM drive). With the steady price reductions of PC's experienced over the past few years, the CBT course should be readily accessible to all of the user community.

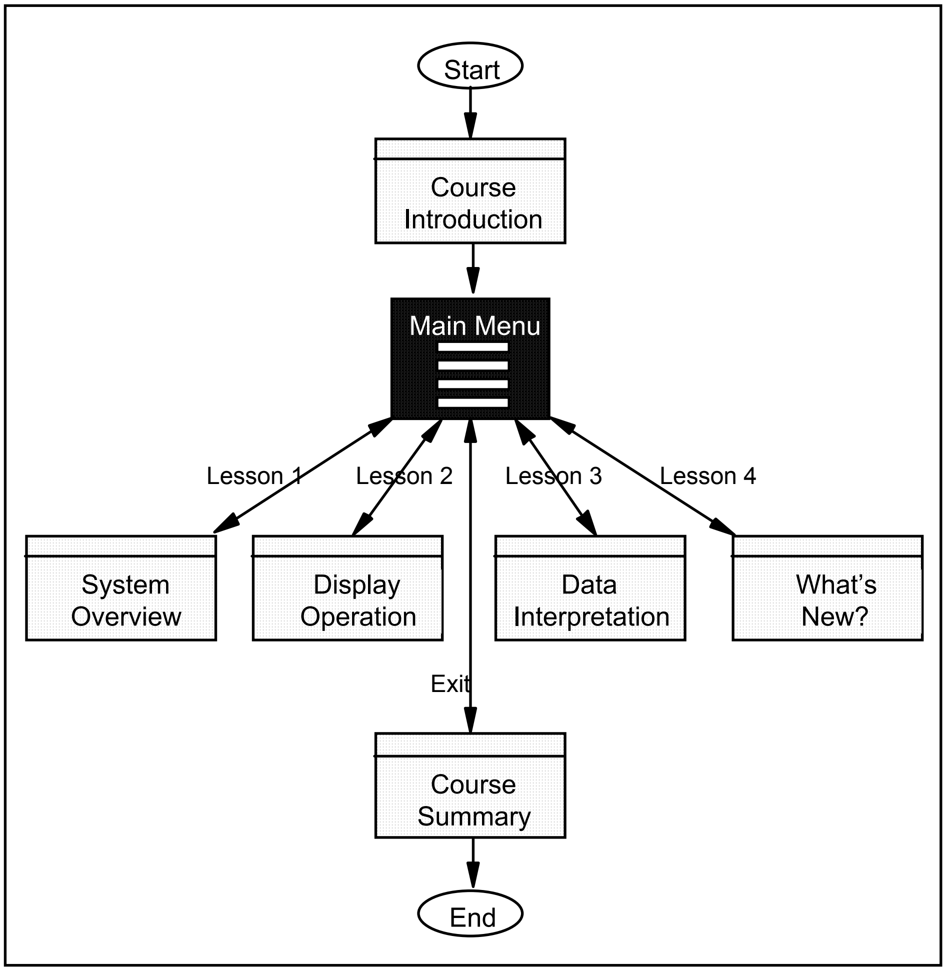

Figure 2. Flowchart depicting the structure of the LDAR CBT course.

The most important features of the CBT design is that it provides nonlinear, self-paced instruction, accessible 24 hours a day, allowing users to interact with the information in a highly visual manner. Producing the courseware using commercial authoring tools means that routine maintenance will not require a programming expert. The expected benefits of using CBT for training on LDAR versus either classroom instruction or paper-based manuals alone are:

- New users will learn to use LDAR faster and more effectively,
- Information about LDAR will be accessible to a larger audience,
- and LDAR information can be updated more easily.

Having better training materials will allow more people to become familiar with LDAR which should encourage its use as an operational tool in the assessment of lightning hazards.

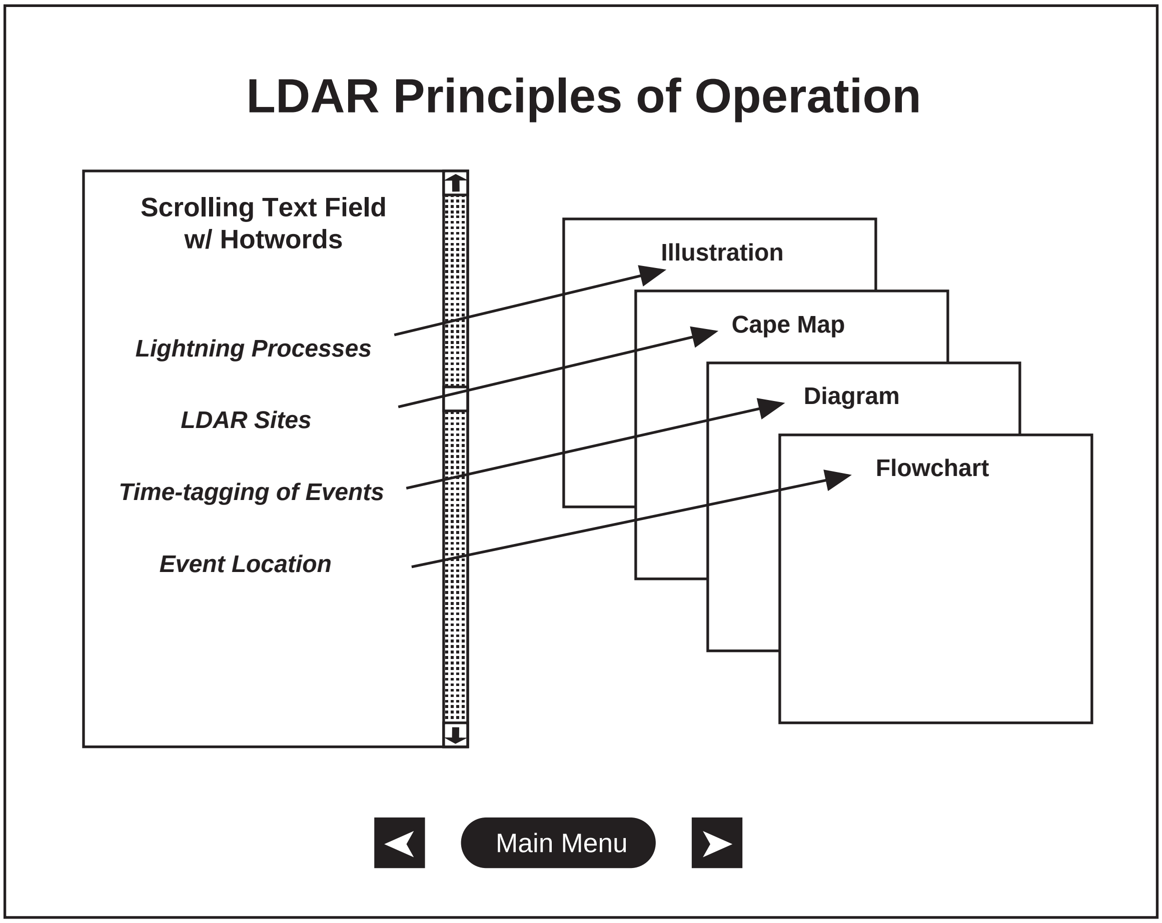

Figure 3. Storyboard of CBT screen for instruction of LDAR operating principles.

SUBTASK 5 WSR-88D EVALUATION (MR. WHEELER)

During this quarter, Mr. Wheeler and Ms. Lambert continued their review and analysis of WSR-88D data for convection initiation and severe/non-severe storm determination. Mr. Wheeler presented the results of the 20 July 1995 case at the 1995 National Weather Association meeting in Houston, Texas. Initial analysis has been completed on 10 of the 16 cases. Table 1 presents some preliminary information on each case used in the study.

2.5 TASK 005 MESOSCALE MODELING

SUBTASK 2 INSTALL AND EVALUATE MESO, INC.'S MASS MODEL (DR. MANOBIANCO)

Dr. Manobianco completed the rederivation and validation of Model Output Statistics (MOS). The coefficients were derived from the 1994 data and verified using 1994 data and independent data from 1995. The coefficients verified using 1994 data show a bias toward over prediction (i.e. an event was forecast to occur far more often than was observed). The bias toward over prediction is not related to any errors in the software. In fact, Dr. Manobianco discovered a similar bias when he ran the same verification procedure on the coefficients derived by MESO, Inc. using 1992 data. The bias is likely caused by the choice of predictors, the observed and/or model data used to compute the predictors, and the narrow space-time windows defined for the predictands. In its current form, MASS MOS is not suitable for use as a forecasting tool. The technique could be improved by using

NEXRAD data to define existing areas of convection, choosing different predictors from both model and observational data, and obtaining a complete data set that covers at least five warm seasons.

Table 1. Summary of Data Available for and Meteorological Highlights of the NEXRAD Case Study Days.

Date	Data Time (UTC)	Data Available	Features	Significant Events	MDPI (Microburst Day Potential Index)
20 June	1400 - 2300	All	Colliding Boundaries, Weak Sea Breeze	KSC Gust 20 kts	1.3
26 June	1830 - 2200	All	Sea Breeze, Secondary Convection, Strong Outflows	KSC Gust 38 kts, MLB Gust 34 kts	1.3
28 June	1530 - 2300	All	Many Boundaries, Unusual Features		1.1
10 July	1500 - 0000	All	Horizontal Convective Rolls (HCRs), Boundaries, Sea Breeze	KSC Gust 63 kts and Hail, St. Lucie Tornado	1.14
11 July	1600 - 2200	All	Strong Convection Develops from Colliding Boundaries Interacting with Smoke from a Fire	Complex 40 Tornado, KSC Gust 46 kts, Cape Canaveral Hail .75 "	1.2
12 July	1430 - 2300	All	Possible Microburst 22 km NW of Radar		.98
13 July	1730 - 2200	Radar Down 1537 - 1725Z, Missed Initial Convection	Boundaries, Possible Microburst 48 km N of Radar	Bartow Gust 35 kts	.93
17 July	1000 - 2000	Missing Some Level II Data	Severe - Non-Severe	KSC Gust 27 kts, VRB 31 kts	.7
20 July	1530 - 2100	All	HCRs, Boundaries, Melbourne Radar gets Zapped!!, Radar Terminated	KSC Gust 35 kts,	1.31
08 Aug	PUP down	No PUP Data	Sea/River Breeze, HCRs, Colliding Boundaries (NW Flow)		1.24
10 Aug	1700 - 2230	All	Late Day Colliding Boundaries, Microburst over Cocoa Beach		1.26
01 Sep	1400 - 1900	All	Convection Initiation		.91
06 Sep	1400 - 2100	All	Good Boundaries - Convection Initiation		.71
07 Sep	1630 - 2200	All	Convection Initiation - Heavy Precip, 88D in VCP 11	KSC Gust 35 kts, Flash Flood St. Lucie County,	1.06
08 Sep	1530 - 2100	All	Convection Initiation - Heavy Precipitation	KSC Gust 47 kts	.89

12 Sep	1330 - 2000	All	Convection Initiation - Merritt Island T-storm		.96

Dr. Manobianco received memorandum from RWO (Capt. Sardonia), SMG (Mr. Lafosse), and NWS MLB (Mr. Petersen and Mr. Sharp). The memoranda summarized each group's subjective evaluation of MASS and assessed what specific value-added information MASS provided especially in comparison with current operational products. Overall, RWO stated that MASS would be an asset to routine Eastern Range forecast operations. In addition, NWS MLB indicated that MASS showed reasonable utility and occasional improvement over the NCEP operational regional-scale models. SMG found that MASS was occasionally helpful in generating SMG forecasts, but most times MASS did not improve over data output from other models (Eta, NGM, MRF). SMG also noted several instances where MASS was far off base and could have adversely affected SMG forecasts. However, SMG noted that due to the limited number of days evaluated during the late summer/early fall time frame, SMG's evaluation may not be completely representative of the model's (MASS') capabilities.

Dr. Manobianco and Ms. Yersavich set-up jobs to down load gridded and point forecast data from the 29 km meso-Eta model. These data were transferred from NCEP's public access workstation to a Sun workstation at ENSCO's main office in Melbourne and then to the AMU IBM/RISC 6000's via a 14400 bps modem. The following section briefly compares forecasts from the MASS model at 45 km and 11 km with those from the 29 km Eta model for 9 January 1996 when the northern half of the Florida peninsula experienced minimum surface air temperatures at or below freezing.

Case Example

Beginning the week of 7 January 1996, an area of low pressure moved east across the southeast US and then tracked north-northeast along the coast deepening into a storm that became known as the Blizzard of 1996. The system produced record snowfalls for the middle Atlantic and northeast states and ushered in an Arctic airmass that affected the eastern US for several days. From 0000-1200 UTC 8 January, minimum temperatures in north-central Florida were recorded at or below 32˚F under sustained west-northwest winds of 5-10 kts with gusts of 15-25 kts. The west-northwest winds decreased to generally 5 kts or less during the subsequent night of 9 January. However, the wind speeds were still strong enough to prevent temperatures from falling much below those reported for the previous night across northern and central Florida.

The observed surface temperatures and winds for 0600 UTC 10 January 1996 are plotted in Figure 4. There is a pronounced land-water temperature gradient that is clearly evident from the 14˚F temperature difference between TTS (35˚F) and the buoy to the east of CCAS (49˚F). Additionally, there is a weak land breeze with offshore flow along both central and south Florida coasts that is likely due in part to the strong temperature contrast between the cooler land and warmer water. Finally, temperatures at or below 32˚F extend to almost the center of the state at 0600 UTC 9 January.

The surface temperature and wind forecasts from the 45 km and 11 km MASS runs and 29 km Eta run verifying at 0600 UTC 9 January are shown in the remaining panels of Figure 4. All three model runs predict a land breeze along both coasts in central and southern Florida at this time. The 45 km MASS run does not extend the freezing line (32˚F isotherm) far enough south while the 29 km Eta run extends it too far south (see the highlighted contour in Figs. 4b,c). In contrast, the 11 km MASS run has the freezing line penetrating into west-central Florida in reasonable agreement with the observations although forecast temperatures to the west and north of CCAS are 4-8˚F too high. It should be noted that the 11 km MASS run was initialized from the 12-h 45 km MASS run and updated with data at 0000 UTC while both the 45 km MASS and 29 km Eta runs were initialized using only data at 1200 UTC 8 January.

The most notable aspect of the MASS and Eta model forecasts is the land-water temperature gradient that varies considerably as a function of horizontal model resolution. The 45 km MASS surface temperature forecast at 0600 UTC 9 January shows a weak gradient that extends tens of km inland to just offshore on either coast (Fig. 4b). The 29 km Eta forecast exhibits a more narrow band of isotherms concentrated along the coast that is consistent with finer horizontal resolution of the 29 km Eta versus 45 km MASS model (Figure 4c). At a resolution of 11 km, the MASS model shows a well defined temperature gradient around the entire peninsula that agrees with the observed temperature contrast implied by the TTS and buoy observations (compare Figs. 4a,d). Nevertheless, forecast temperatures from the 11 km MASS run are in error by 6-8˚F at TTS and the offshore buoy because the model keeps the thermal zone too far inland along the east (and west) coasts.

A map showing the location of station TTS and the two land grid points closest to TTS on the MASS and Eta model grids is given in Figure 5a. The time series of observed and forecast temperatures (˚F) at these points from 1200 UTC 8 January - 1200 UTC 9 January are plotted in Figure 5b. Note that the F1 and F2 time series start when the 0000 UTC 9 January 11 km MASS forecast was initialized. Similarly, the E1 and E2 traces from the 29 km Eta model start at 1500 UTC 8 January and stop at 0600 UTC 9 January which correspond to the times available for this run on NOAA's Information Center workstation. Also, NCEP has interpolated the 29 km Eta model output to a 40 km grid which is used to extract the time series at points E1 and E2.

The TTS temperature trace in Figure 5b shows observed temperature minima of 31˚F at 1200 UTC 8 and 9 January and a maximum temperature of 44˚F beginning at 2000 UTC 8 January. The forecast temperature at 0600 UTC 9 January from the 45 km MASS run (point C1) is 6˚F too high while that from the 29 km Eta run (point E1) is 4˚F too low. The largest temperature error of nearly 11˚F occurs at point F1 from the 11 km MASS run which is partly related to the position error of the temperature gradient discussed above (Figure 4). In fact, it is clear from the F1 time series that the 11 km MASS forecast at this point is only representative of the observed temperature at the time of initialization (0000 UTC 9 January). There are a number of factors likely contributing to the temperature errors from the 11 km MASS run at point F1 including parameterization of the planetary boundary layer, surface energy budget, hydrology, and vegetation. Another potential factor is that point F1 is more representative of a water rather than land station on the 11 km grid as illustrated by examining the temperature trace at the next closest land point to TTS (F2; Figure 5b). At point F2, the temperature error at 0600 UTC 9 January is reduced to 4˚F despite the fact that trace after 0300 UTC 9 January resembles that at point F1 more closely than at TTS. The same argument applies to the 45 km MASS forecast as evidenced by comparing the time series at points C1 and C2 (Figure 5b). However, the temperature error at point E2 is slightly greater than that at point E1 indicating that perhaps E1 on the 40 km Lambert is more representative of station TTS.

The analysis of temperature forecasts at TTS from the MASS and Eta model runs is somewhat cursory and does not consider differences is model physics, initialization, or starting times for each run. Nevertheless, this example illustrates

- the impact that horizontal model resolution has on forecasts of parameters such as surface air temperature that exhibit mesoscale structure in association with land-water boundaries, and
- the potential problems in extracting, interpreting, and verifying point forecast information from mesoscale models such as MASS and Eta.

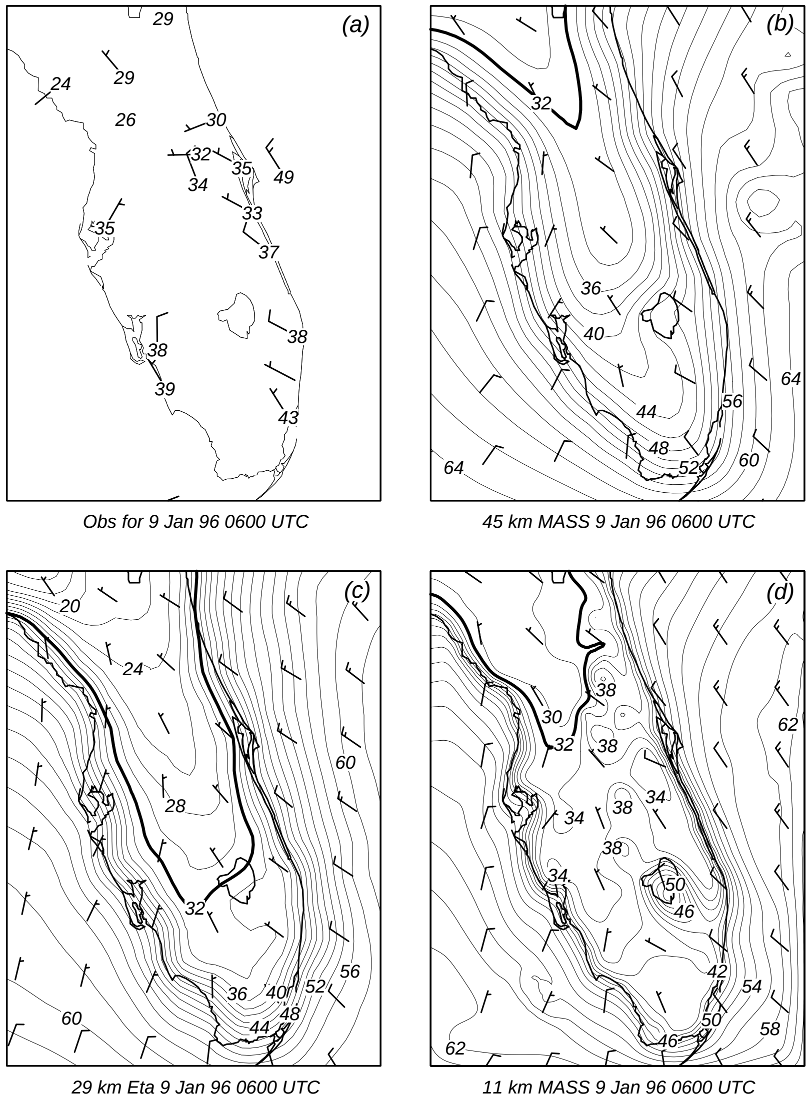

Figure 4. Surface temperature (˚F at shelter height) and wind (knots at 10 m) for 0600 UTC 10 January 1996. The surface and buoy observations are plotted in panel (a). The 18-h forecast from the 45 km MASS run initialized at 1200 UTC 8 January is shown in panel (b). The 15-h forecast from the 29 km Eta run initialized at 1500 UTC 8 January is shown in panel (c). Finally, the 6-h forecast from the 11 km MASS run initialized at 0000 UTC 9 January is shown in panel (d). The isopleth interval is 2˚F and the 32˚F isotherm is highlighted with a thick solid line. The long (short) wind barbs represent 10 kt (5 kt).

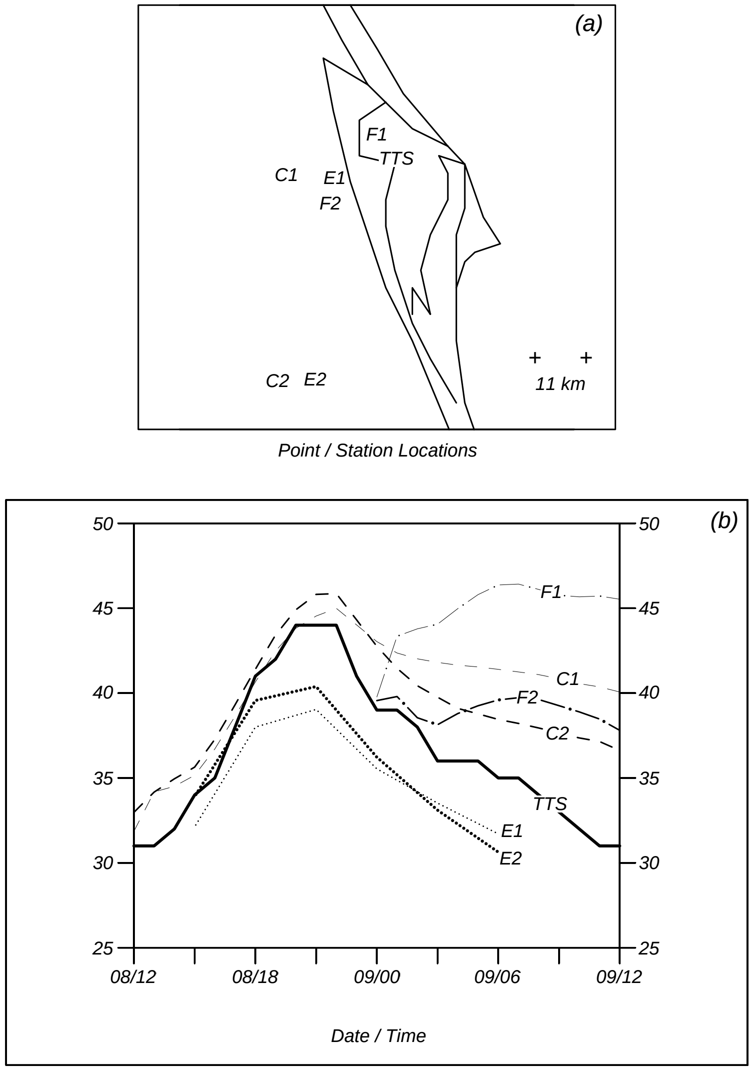

Figure 5. Panel (a) shows locations of the Shuttle Landing Facility (TTS), 45 km MASS model grid points C1 and C2, 11 km MASS model grid points F1 and F2, and 29 km Eta model grid points E1 and E2. Points C1 and F1 are land points on the MASS grids closest to TTS while points C2 and F2 are the land points on the MASS grids next closest to TTS. Note that the 29 km Eta model fields have been interpolated to a 40 km Lambert grid so that E1 and E2 are the points closest to TTS on the 40 km grid. Panel (b) depicts time series of temperature (˚F) from the points shown in panel (a) from 1200 UTC 8 January to 1200 UTC 9 January 1996. The temperature traces are labeled according to the points shown in panel (a).

SUBTASK 4 INSTALL AND EVALUATE ERDAS (MR. EVANS)

Comparison of Dispersion from the Ocean Breeze Dry Gulch Model and the RAMS/HYPACT Model

The AMU has been evaluating the Emergency Response Dose Assessment System (ERDAS) since it was installed in the AMU in March 1994. The evaluation has focused on the assessment of:

- the meteorological predictions made by the Regional Atmospheric Modeling System (RAMS) mesoscale model,
- the diffusion predictions made by the Hybrid Particle and Concentration Model (HYPACT) and Rocket Exhaust Effluent Dispersion Model (REEDM) dispersion models, and
- the overall ERDAS system performance.

As part of the evaluation of the diffusion models, the AMU was tasked to compare the diffusion predictions made by the ERDAS models with those made by the Ocean Breeze Dry Gulch (OBDG) model. While the OBDG model and the HYPACT model both produce maps with concentration isopleths, they are extremely different in the methodology they each employ to compute them.

The OBDG model is the model currently certified by the Air Force for predicting downwind toxic corridors resulting from accidental spills of hazardous materials at Cape Canaveral Air Station/Kennedy Space Center (CCAS/KSC). Range Safety personnel run the OBDG model using the Meteorological and Range Safety Support (MARSS) system.

Recent studies have determined that the OBDG model is deficient for use as the primary model for modeling accidental hazardous releases. Hosker et al. (1993) has stated that "given recent advances in dispersion modeling and computer technology, the NOAA review team considers the empirical/statistical OBDG model to be obsolete. The model has only a rudimentary ability to take advantage of the extensive meteorological data available at KSC, and no ability to account for vertical variations in the wind. Moreover, its applicability is limited to daytime periods of unstable onshore flow. Also, OBDG is unable to deal with elevated releases of effluents, for operational uses such as launch vehicle fueling."

To compare the predictions made by OBDG and HYPACT, the AMU designed a study for comparing OBDG model predictions with HYPACT model predictions. This OBDG/HYPACT comparison study consisted of selecting ten case days and then producing maps comparing predicted ground level concentrations. These maps were analyzed and the different runs were compared. The following model configurations were used in this study:

- <u>OBDG-Observed</u>. The OBDG model was run in its normal configuration. Meteorological input data were provided by Weather Information Network Display System (WINDS) 5-minute average tower data.
- <u>OBDG-RAMS</u>. The OBDG model was run with RAMS wind speed and direction data and WINDS tower data. Varying-levels of wind data obtained from RAMS were substituted for the observed winds in the tower data files. Wind levels were chosen based on model-predicted vertical motion.

- HYPACT-RAMS. The HYPACT model was run in its normal ERDAS configuration. RAMS provided HYPACT with the required meteorological input data. HYPACT produced maps showing 3-dimensional plume locations and predicted surface concentrations.

Procedures

The AMU conducted this comparison study by following several steps to select, process and analyze the meteorological and diffusion data. A description of these steps is provided in this section.

Data and Selection of Case Studies

Ten case study days for the comparison were chosen using the Shuttle Landing Facility surface observations. Since in ERDAS the RAMS model is run with the precipitation and cloud formation microphysics inactive, the days used in the analysis are characterized by no occurrence of precipitation and very little cloud cover. At least one day from each month between January and July 1995 were chosen. A sea breeze occurred on six of the ten days (Table 2). Each 'day' covers the 24-hour period from 1200 UTC to 1200 UTC. In order to analyze how the models perform during certain times of the day, three 2-hour periods were chosen for each day: 1500 - 1700 UTC (midday), 2100 - 2300 UTC (late afternoon), and 0500 - 0700 UTC (nighttime).

Table 2. Classification of the 10 Days Analyzed in this Study.

Sea Breeze Days	**Non-sea Breeze Days**
April 13-14	January 31- February 1
May 29-30	February 6-7
June 9-10	March 26-27
June 19-20	May 7-8
July 5-6	
July 15-16	

Diffusion Analyses

Three different diffusion analyses were conducted for this study and each one is described in the following sections. Figure 6 presents a block diagram of the configuration of the three different diffusion runs and their input and output.

OBDG with WINDS Tower Observations (OBDG-Observed)

To conduct the analyses for this study, the AMU used the OBDG function of the Meteorological Monitoring System (MMS) at ENSCO's Melbourne office. This OBDG function is the same as the one in the Meteorological Range Safety Support System (MARSS) used at CCAS and PAFB. Five-minute data obtained from the WINDS system for the periods of interest were input into the MMS and plots were produced. These plots showed the predicted plume with two levels of isopleths and two levels of toxic corridor sectors. The plots were used for comparison with the other diffusion analyses.

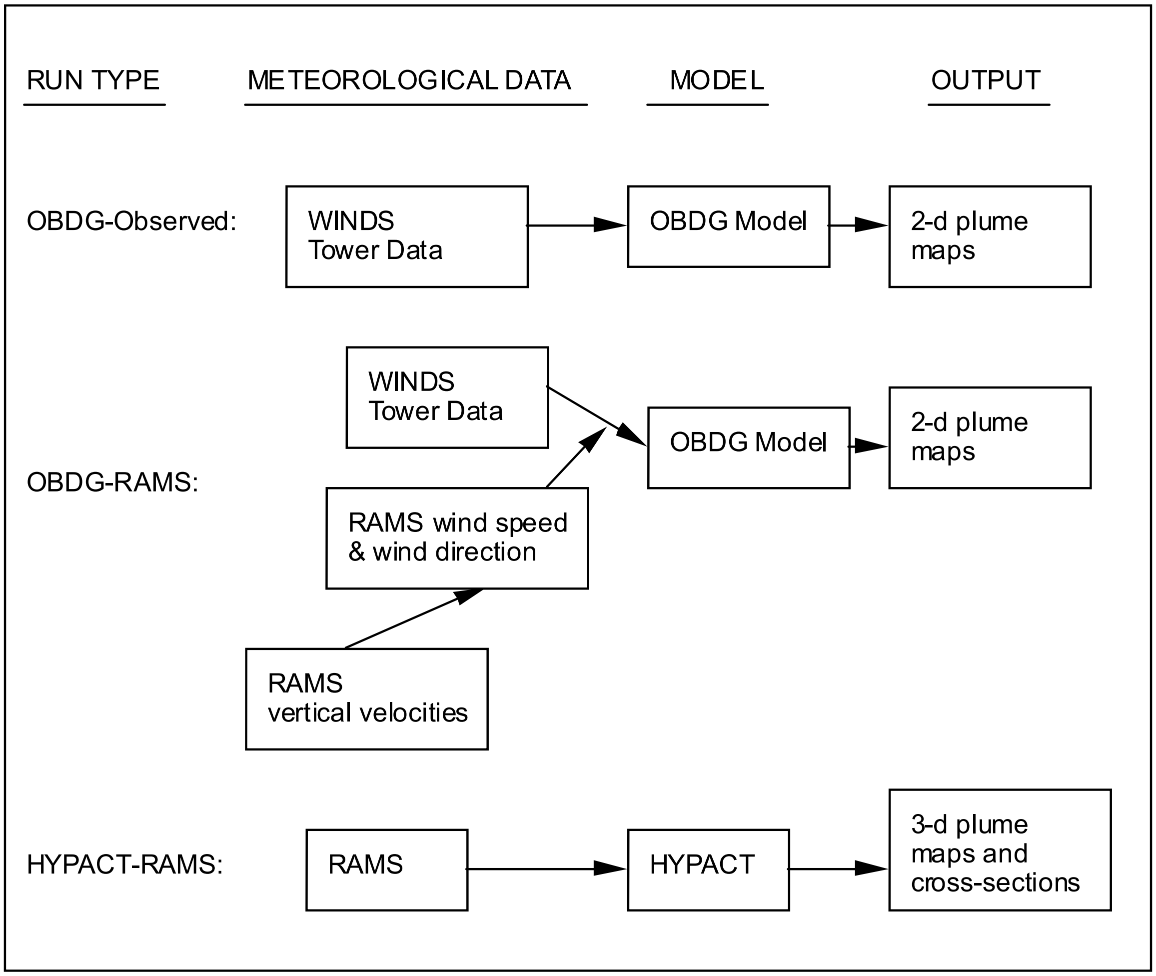

Figure 6. Configuration of the three different runs in this study.

OBDG with RAMS Wind Predictions (OBDG-RAMS)

The AMU generated OBDG analyses using winds extracted from RAMS forecasts. The RAMS winds replaced the wind speeds and directions at the 54-ft level of the WINDS tower files. The RAMS winds which were inserted in place of the observed winds were obtained from different levels of the RAMS model.

This new data set provided the OBDG model with a two-dimensional wind field that contained some characteristics of the 3-dimensional wind structure. For cases where the wind direction varied with height and there was upward vertical motion above the release point, this new data set would cause OBDG plume directions to follow the RAMS-predicted upper level winds. The plume width and length would not change however since the OBDG model with RAMS winds was still run with the same observed σ_θ and ΔT as in the OBDG-Observed runs.

Plots showing the OBDG predicted plume were produced for the same times as the OBDG-Observed times. These plots were compared with the OBDG-Observed plots and with the plume predictions of HYPACT.

HYPACT with RAMS Predictions (HYPACT-RAMS)

For this study, HYPACT was run to simulate a cold spill at a Titan launch complex resulting from the release of nitrogen tetroxide (N_2O_4) from a fueled Titan IV rocket. This scenario was chosen because an accidental release of N_2O_4 from the Titan IV is potentially one of the most dangerous due to the amount N_2O_4 and the concentration levels which are of concern to safety personnel.

Results

Summary tables were compiled for each of the three different model runs for the three different time periods of the ten case days. Information on plume direction during the 2-hour period was compiled at 15-minute intervals for the OBDG runs and at 20-minute interval for the HYPACT runs. The release point for all of the model runs was Launch Complex 40 (see Figure 7 for location). A one-page table showing the key data from each of the 30 cases is presented in Table 3.

For the OBDG-RAMS runs, data on the height of the RAMS sigma-level are provided. The sigma levels are the vertical grid points in RAMS where winds are computed. The sigma levels were selected for the OBDG-RAMS runs based on the vertical velocities. For the OBDG-RAMS runs, the RAMS winds replaced the observed winds.

OBDG-Observed /OBDG-RAMS Comparison

The comparison of the OBDG-Observed plume directions with the OBDG-RAMS plume directions indicates that for the 252 comparison times, the directions agree within 11.25° 34% of the time. The plume directions were within 90° of each other for all of the 252 comparison times. These results indicate the wind directions predicted by RAMS agreed fairly well with the observed wind directions. RAMS did fairly well at predicting wind direction shifts from one 2-hour period to the next. For example, on 13 April 1995 the OBDG-RAMS plume direction was modeled to move offshore during the midday runs, onshore during the late afternoon runs with the sea breeze, and then offshore again during the nighttime runs. The OBDG-RAMS plume directions followed the same pattern as the OBDG-Observed runs which showed offshore flow during the midday, onshore flow with the sea breeze during the late afternoon, and then back to offshore flow during the nighttime.

The vertical velocity algorithm which was used to adjust the height of the RAMS winds used in the OBDG-RAMS runs was not a significant factor in determining plume direction in most of the runs. This vertical velocity algorithm caused the RAMS winds above 300 meters to be used in only four of the 29 different periods. During these four periods, RAMS predicted enough heating over the land to produce upward vertical motions in the vicinity of Launch Complex 40. As vertical velocities increased, the upper level wind caused OBDG-RAMS to move the plume in the same direction as OBDG-Observed. If the upper-level winds were not used, the direction of the OBDG-RAMS plume would have differed from the OBDG-Observed direction.

OBDG/HYPACT-RAMS Comparison

The direction of the HYPACT plumes were analyzed to see how they compared with the OBDG plumes and to determine if launch processing would be increased or decreased if the HYPACT model was used instead of the OBDG model. Of the 26 cases analyzed launch processing would have increased for 2 of the cases, decreased for 1 of the cases, and stayed the same on the rest. A change in launch processing was determined by comparing the length and location of the ground level plume as indicated by the 5 and 25 ppm isopleths. If there was a significant change in the length or location (in relation to populated areas), then it was inferred that there was a change in the launch processing.

Even though most of the cases showed no change in launch processing, the HYPACT analyses provided valuable information on the 3-dimensional structure of the plume for 15 of the 26 cases. For these 15 cases, which were all from the midday and late afternoon runs, the plumes were lofted up above 300 meters at some point along its trajectory causing material to be transported upward. This material could eventually mix downward to the surface under the right conditions although the two-hour simulations run for this study did not show downward plume mixing. Of the 15 cases in which plumes were lofted upward, 13 of them occurred with on-shore easterly flow. RAMS accounts for the heating over the land and generates the strongest upward motions over the inland areas.

Case Study: 13 April 1995

The modeling analyses of the midday runs on 13 April 1995 provided a case study of the onset of the sea breeze during the late morning and early afternoon. During the two-hour period from 1500 to 1700 UTC, the OBDG-Observed and OBDG-RAMS runs agreed closely with each other (Figure 7). The observed winds during this entire period were generally light and from the west at all the tower locations across CCAS/KSC and the RAMS-predicted winds agreed. Therefore, the plumes predicted by both OBDG runs extend eastward into the Atlantic Ocean and showed no threat to any populated areas resulting from a potential toxic spill of N_2O_4 at Launch Complex 40.

The HYPACT-predicted plume was very similar to the OBDG plumes for this period since HYPACT moved the plume eastward over the ocean and did not indicate that it would affect any populated areas during the two-hour period. However, the HYPACT runs clearly showed the start of the sea breeze that moved onshore after 1700 UTC. HYPACT moved the plume approximately 6 km offshore until 1610 UTC when the plume encountered low level flow from the east. The opposing flow produced a line of convergence which produced upward vertical motion and forced the HYPACT plume upward. By 1650 UTC, HYPACT lifted the plume upward to 600 meters (Figure 8). HYPACT also began moving the plume westward back toward the coastline after it had originally moved the plume eastward at the beginning of the simulation.

The value the HYPACT analyses provides to safety personnel is the forecast of the wind shift. HYPACT correctly predicted that the plume shown by OBDG to be located offshore would move back onshore and that the offshore flow present during the morning would change.

Conclusions

A special study was conducted to compare the currently certified OBDG model with the ERDAS models to determine if the ERDAS models changed launch processing. The study was limited in that it looked at dispersion during 30 2-hour periods over a 6-month period. These periods included late afternoon periods similar to the original OBDG study but it also included a higher percentage of late morning cases than the original OBDG study and included nighttime cases which were not included in the original OBDG study. The results of the study showed that

- Cases where the winds shifted over time were the ones where differences existed between the OBDG model and the ERDAS model. Currently certified OBDG model did not adequately handle wind shifting situations while the ERDAS models provide a truer picture of dispersion when wind shifts occur.

- The ERDAS models could provide safety personnel with a better understanding of the 3-dimensional dynamics causing plume dispersion resulting from a potential toxic spill. Information on vertical plume development is not available from the OBDG model. This information can help safety personnel in making evacuation decisions and answer questions such as:

  - Will potential toxic plumes which have lofted upward eventually mix back down to surface? Are concentrations aloft large enough to pose a threat to populated areas if they reach surface?

  - Will potential toxic plumes which have moved offshore eventually move back onshore?

- Comparing diffusion model predictions made by the OBDG model and the ERDAS models produced results which showed that using the ERDAS models increased launch processing availability by approximately 3% for the meteorological conditions in this special limited comparison study.

References

Hosker, Jr., R.P., K.S. Rao, R.M. Eckman, J.T. McQueen, and G.E. Start, 1993: "An Assessment of the Dispersion Models in the MARSS System Used at the Kennedy Space Center", NOAA Technical Memorandum ERL ARL-205, 91pp.

2.4. AMU CHIEF'S TECHNICAL ACTIVITIES (DR. MERCERET)

WIND PROFILING CLIMATOLOGY

Dr. Merceret designed an analysis strategy and wrote software to conduct a climatology of wind changes detected by the KSC 50 MHz Doppler Radar Wind Profiler (DRWP). The climatology will be used by the Shuttle Program to evaluate the contribution of the DRWP data to flight safety and launch processing in comparison to its cost. The automated quality control algorithm included in the software will be tested and refined during the next quarter and mass processing of the data will begin.

Table 3. Summary of the Comparison Summaries which were Compiled for each of the 30 2-hr Time Periods Analyzed in this Study.

Date	Time Period	Plume Direction OBDG-Observed vs. OBDG-RAMS Largest Difference Direction	Largest Difference Degrees	Smallest Difference Direction	Smallest Difference Degrees	Max Height of RAMS Winds (m)	HYPACT Plume Direction	Max Height of HYPACT Plume (m)
31 Jan 95	midday	ESE-SE	22.5	SE-SE	0	11	SE	200
	late afternoon	E-S	90	E-E	0	910	S->E	500
	nighttime	E-ESE	22.5	ESE-ESE	0	11	ESE	100
06 Feb 95	midday	SE-ESE	22.5	SE-SE	0	11	SE->SSE	200
	late afternoon	S-SW	45	SSW-SSW	0	320	SW->S	600
	nighttime	ESE-NE	67.5	ENE-NE	22.5	11	NE	100
26 Mar 95	midday	W-SSW	67.5	W-W	0	910	SW->W	1000
	late afternoon	W-WNW	22.5	WNW-WNW	0	142	WNW	300
	nighttime	-	-	-	-	-	-	-
13 Apr 95	midday	ENE-ENE	0	ENE-ENE	0	1053	E	600
	late afternoon	WNW-WSW	45	NW-WNW	22.5	94	W	200
	nighttime	ESE-SE	22.5	SE-SE	0	11	SE	200
07 May 95	midday	WSW-SW	22.5	SW-SW	0	94	SW->W	150
	late afternoon	WSW-W	22.5	WSW-WSW	0	94	W	300
	nighttime	WSW-NW	67.5	W-NW	45	60	NW	100
29 May 95	midday	NW-SW	90	WNW-WSW	45	142	SW->W	900
	late afternoon	WNW-W	22.5	WNW-WNW	0	142	W	200
	nighttime	NNW-NW	22.5	NNW-NNW	0	34	NW	200
09 Jun 95	midday	SSW-W	67.5	SW-SW	0	60	W->SW	1300
	late afternoon	W-WSW	22.5	WSW-WSW	0	196	WSW	400
	nighttime	ENE-NNE	45	NNE-NNE	0	11	NNE	100
19 Jun 95	midday	SSE-SW	67.5	SSW-SW	22.5	142	SW	1500
	late afternoon	SW-W	45	SW-SW	0	142	WSW	400
	nighttime	ENE-NNE	45	NNE-NNE	0	11	NW	100
05 Jul 95	midday	W-WSW	22.5	W-W	0	34	WSW	900
	late afternoon	WNW-W	22.5	W-W	0	142	W	300
	nighttime	NW-NNE	67.5	NNW-N	22.5	11	N	100
15 Jul 95	midday	W-SW	45	WSW-SW	22.5	60	SW	1100
	late afternoon	WNW-W	22.5	W-W	0	142	W	300

	nighttime	N-NE	45	NNW-NW	22.5	11	N–>NE	200

Figure 7. OBDG plumes computed using observed data (top) and RAMS wind speed and direction data (bottom) for 13 April 1995 at 1645 UTC. Launch Complex 40 was the release point for all model runs.

Figure 8. Cross-section (top) and map (bottom) of HYPACT plume computed using RAMS data for 13 April 1995 at 1650 UTC.

Attachment 1: AMU FY-96 Tasks

TASK 1 AMU OPERATIONS

- Operate the AMU. Coordinate operations with NASA/KSC and its other contractors, 45th Space Wing and their support contractors, the NWS and their support contractors, other NASA centers, and visiting scientists.

- Establish and maintain a resource and financial reporting system for total contract work activity. The system shall have the capability to identify near-term and long-term requirements including manpower, material, and equipment, as well as cost projections necessary to prioritize work assignments and provide support requested by the government.

- Monitor all Government furnished AMU equipment, facilities, and vehicles regarding proper care and maintenance by the appropriate Government entity or contractor. Ensure proper care and operation by AMU personnel.

- Identify and recommend hardware and software additions, upgrades, or replacements for the AMU beyond those identified by NASA.

- Prepare and submit in timely fashion all plans and reports required by the Data Requirements List/Data Requirements Description.

- Prepare or support preparation of analysis reports, operations plans, presentations and other related activities as defined by the COTR.

- Participate in technical meetings at various Government and contractor locations, and provide or support presentations and related graphics as required by the COTR.

TASK 2 TRAINING

- Provide initial 40 hours of AMU familiarization training to Senior Scientist, Scientist, Senior Meteorologist, Meteorologist, and Technical Support Specialist in accordance with the AMU Training Plan. Additional familiarization as required.

- Provide KSC/CCAS access/facilities training to contractor personnel as required.

- Provide NEXRAD training for contractor personnel.

- Provide additional training as required. Such training may be related to the acquisition of new or upgraded equipment, software, or analytical techniques, or new or modified facilities or mission requirements.

TASK 3 IMPROVEMENT OF 90 MINUTE LANDING FORECAST

- Develop databases, analyses, and techniques leading to improvement of the 90 minute forecasts for STS landing facilities in the continental United States and elsewhere as directed by the COTR.

- Design McBasi routines to enhance the usability of the MIDDS for forecaster applications at the RWO and SMG. Consult frequently with the forecasters at both installations to determine specific requirements. Upon completion of testing and installation of each routine, obtain feedback from the forecasters and incorporate appropriate changes.

- Subtask 2 - Fog and Stratus At KSC

•• Develop a database for study of weather situations relating to marginal violations of this landing constraint. Develop forecast techniques or rules of thumb to determine when the situation is or is not likely to result in unacceptable conditions at verification time. Validate the techniques and transition to operations.

Subtask 6 - MIDDS F-key Menu Systems

•• Document the MIDDS F-key menu systems developed by the AMU.

Subtask 7 - WINDEX and Microburst Daily Potential Index (MDPI)

•• Evaluate the WINDEX and MDPI.

TASK 4 INSTRUMENTATION AND MEASUREMENT SYSTEMS EVALUATION

- Evaluate instrumentation and measurement systems to determine their utility for operational weather support to space flight operations. Recommend or develop modifications if required, and transition suitable systems to operational use.

- Subtask 3 - Doppler Radar Wind Profiler (DRWP)

•• Evaluate the current status of the DRWP and implement the new wind algorithm developed by MSFC. Operationally test the new algorithm and software. If appropriate, make recommendations for transition to operational use. Provide training to both operations and maintenance personnel. Prepare a final meteorological validation report quantitatively describing overall system meteorological performance.

- Subtask 4 - Lightning Detection and Ranging (LDAR) System

•• Develop training material for the NASA/KSC Lightning Detection and Ranging (LDAR) system which will include a computer based training (CBT) course, video, and user's manual.

- Subtask 5 - Melbourne NEXRAD

•• Evaluate the effectiveness and utility of the Melbourne NEXRAD (WSR-88D) operational products in support of spaceflight operations. This work will be coordinated with appropriate NWS/FAA/USAF personnel.

- Subtask 9 - Boundary Layer Profilers

•• Evaluate the meteorological validity of current site selection for initial 5 DRWPs and recommend sites for any additional DRWPs (up to 10 more sites). Determine, in a quantitative sense, advantages of additional DRWPs. The analysis should determine improvements to boundary layer resolution and any impacts to mesoscale modeling efforts given additional DRWPs. Develop and/or recommend DRWP displays for operational use.

TASK 5 MESOSCALE MODELING

- Evaluate Numerical Mesoscale Modeling systems to determine their utility for operational weather support to space flight operations. Recommend or develop modifications if required, and transition suitable systems to operational use.

- Subtask 1 - Evaluate the NOAA/ERL Local Analysis and Prediction System (LAPS)

•• Evaluate LAPS for use in the KSC/CCAS area. If the evaluation indicates LAPS can be useful for weather support to space flight operations, then transition it to operational use.

- Subtask 2 - Install and Evaluate the MESO, Inc. Mesoscale Forecast Model

•• Install and evaluate the MESO, Inc. mesoscale forecast model for KSC being delivered pursuant to a NASA Phase II SBIR. If appropriate, transition to operations.

- Subtask 3 - Acquire the Colorado State University RAMS Model

•• Acquire the Colorado State University RAMS model or its equivalent tailored to the KSC environment. Develop and test the following model capabilities listed in priority order:

1) Provide a real-time functional forecasting product relevant to Space shuttle weather support operations with grid spacing of 3 km or smaller within the KSC/CCAS environment.
2) Incorporate three dimensional explicit cloud physics to handle local convective events.
3) Provide improved treatment of radiation processes.
4) Provide improved treatment of soil property effects.
5) Demonstrate the ability to use networked multiple processors.

Evaluate the resulting model in terms of a pre-agreed standard statistical measure of success. Present results to the user forecaster community, obtain feedback, and incorporate into the model as appropriate. Prepare implementation plans for proposed transition to operational use if appropriate.

- Subtask 4 - Evaluate the Emergency Response Dose Assessment System (ERDAS)

•• Perform a meteorological and performance evaluation of the ERDAS. Meteorological factors which will be included are wind speed, wind direction, wind turbulence, and the movement of sea-breeze fronts. The performance evaluation will include:

1) Evaluation of ERDAS graphics in terms of how well they facilitate user input and user understanding of the output.
2) Determination of the requirements that operation of ERDAS places upon the user.
3) Documentation of system response times based on actual system operation.
4) Evaluation (in conjunction with range safety personnel) of the ability of ERDAS to meet range requirements for the display of toxic hazard corridor information.
5) Evaluation of how successfully ERDAS can be integrated in an operational environment at CCAS.
6) Evaluate the ability of ERDAS to predict cloud and plume dispersion. Factors to consider include cloud rise, bifurcation, trajectory, and horizontal/vertical dispersion.