Applied Meteorology Unit (AMU)

Quarterly Update Report

Second Quarter FY-95

Contract NAS10-11844

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ENSCO Contracts/S. Leigh

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 (DR. TAYLOR)

National Lightning and Detection Network (NLDN) Computer (Mr. Wheeler)

Last summer, NASA decided to cancel its subscription to the NLDN data service. In response, the Range Weather Operations (RWO) requested the system be transferred to their unit. Since then, the AMU has assisted the Range Technical Services (RTS) contractor, Computer Science Raytheon (CSR), in their identification of system components, understanding of system capabilities and operation, and overall coordination with the Eastern Range configuration management community. After the Eastern Range approved the transfer of the NLDN computer equipment in January 1995, CSR moved the system from the AMU lab area to the RWO operational area. Since then, the NLDN system has been used for Shuttle Ferry Flight operations and in concert with the good sense rule during a Navy operation.

Development of Forecaster Applications (Mr. Wheeler)

Mr. Wheeler continued development of the F-Key menu shells for the Shuttle Weather Officer (SWO) Meteorological Interactive Data Display System (MIDDS) terminal. Thus far, menus in support of daily operations for the RWO and the BWS at Patrick AFB and launch operations for Titan, Delta, Atlas, and Shuttle vehicles have been completed. The F-Key menu in support of Shuttle ferry operations is about 80% complete and has been used during the last two ferry flights.

Mr. Wheeler made several enhancements to the MIDDS menu shells on all RWO terminals. Specifically, Mr. Wheeler:

- Added an event scheduler task to load GOES 8 satellite images on all terminals automatically,
- Developed a user defined 4-panel current surface analysis package,
- Developed and installed a new routine that automatically updates and changes colors on a Launch Commit Criteria (LCC) violation after the Launch Weather Officer (LWO) enters the change on the LWO terminal,
- Completed updating all of the menu routines that use the local wind tower and Launch Pad Lightning Warning System (LPLWS) data sets,
- Made necessary changes to and installed launch operations support menu systems on terminal 21 so that the terminal could serve as a backup terminal during launch operations,

- Added a menu option that allows users to switch between different launch operation menu systems without first returning the terminal to its original state, and

- Completed a 4-panel MOS forecast guidance package containing surface features, probability of precipitation and thunderstorms, maximum temperature, surface wind conditions and amount of precipitation accumulation for a user identified map area and forecast valid time.

Mr. Wheeler also enhanced the launch support menus on the SWO and LWO terminals. He added sections for NGM or MRF model plotting routines and enhanced the method of invoking the system editor where the LWO's update their operational forecasts. The editor is now available in a separate window which speeds up the process.

SLF Downrush Wind Event, 16 August 1994 (Mr. Wheeler)

Mr. Wheeler, in collaboration with Mr. Scott Spratt of the Melbourne NWSO, published a NOAA Technical Memorandum, NWS SR-163, "Forecasting The Potential For Central Florida Microbursts". The memorandum discussed a 27 July 1994 microburst event that occurred at Orlando, Florida and several microburst events that occurred at the Shuttle Landing Facility (SLF) at Kennedy Space Center, Florida on 16 August 1994.

2.2. TASK 004 INSTRUMENTATION AND MEASUREMENT (DR. TAYLOR)

Subtask 4 Lightning Detection And Ranging (Ms. Schumann)

The primary goal of the AMU evaluation and transition of the Lightning Detection And Ranging system (LDAR) is the development of a concept of operations for using LDAR in conjunction with other lightning detection systems and weather radar. Currently, the RWO and Melbourne NWSO have access to LDAR displays and are examining them in relation to their operational forecasts on a daily basis. Work is underway to provide an LDAR display to the forecasters at SMG. Dr. Gregory Forbes of Pennsylvania State University and the AMU will work collaboratively to lead a comprehensive meteorological evaluation and development of a proposed concept of operations for interpreting LDAR data integrated with weather radar, field mills, and LLP data. The concept of operations will be derived from research performed by Dr. Forbes during the 1993 - 1995 summer faculty fellowships and subsequent graduate student research as well as any analysis performed by the RWO, SMG, and Melbourne NWSO.

The AMU has discussed the priority of several potential tasks regarding evaluating and transitioning LDAR to operational use. There was a consensus among the RWO, Melbourne NWSO, SMG, and LDAR development team that the AMU begin by developing training materials. The emphasis on training resulted from the fact that Dr. Forbes has already begun investigating the relationship between LDAR detected activity and other lightning detection systems (e.g., LLP and field mill) and weather radar. The results from Dr. Forbes research as well as those from future investigations will be incorporated into a concept of operations for LDAR usage, thus avoiding duplication of effort.

In addition to the concept of operations, the AMU will develop LDAR training tools to ensure the LDAR display and the concept of operations for its use are well understood. The training tools will consist of the following:

- 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,

- A VHS video tape that briefly introduces first time users to LDAR, and

- A hard copy users manual that provides basic operating instructions for use of the system.

The AMU has begun developing the LDAR CBT course. The target platform is a 386 (or higher) PC with 4 or more MB of memory running Microsoft Windows 3.1 or higher. When complete, the CBT will contain the following:

- Instructions for the user interface (The CBT will mimic the functionality of the user interface allowing new users a chance to manipulate the display.),

- Explanation of the current display including illustration of how the 3-dimensional world maps to the 2-dimensional mappings,

- Technical description of how the system hardware works,

- Explanation of potential system problems and how they would affect the display (i.e., full memory buffers during severe thunderstorms or communications failure), and

- Examples and explanations of known signatures and interesting phenomena such as:
  - anvils,
  - storm life cycle as characterized by electrical activity,
  - storm tilting due to wind (usually during winter or early summer),
  - electrically noisy aircraft,
  - aircraft in an anvil,
  - noise at central site, and
  - radial scatter.

The AMU considered the development of the tools to display and manipulate examples of known signatures the most labor intensive part of the CBT development and has, therefore, concentrated its efforts thus far on development of software that duplicates the display functionality of LDAR. Fig. 1 illustrates the user interface that is used to display LDAR examples. Everything to the right of the gray vertical line in Fig. 1 duplicates the existing real-time LDAR display. As in the real-time LDAR display, the box on the lower left containing the map of Cape Canaveral displays the 2-dimensional view of electrical activity in the x-y projection. The box directly to the right of the x-y projection is the y-z projection, and the box directly above the x-y projection is the x-z projection. The box in the upper right corner is a histogram plot that shows the number of electric pulses detected within the map boundaries per minute. The menu button above the histogram box can be expanded to include buttons for all the functions available in the LDAR display system such as pan, zoom, toggle map objects such as roads, county lines, rivers, etc. on and off, and change the units displayed along the axes.

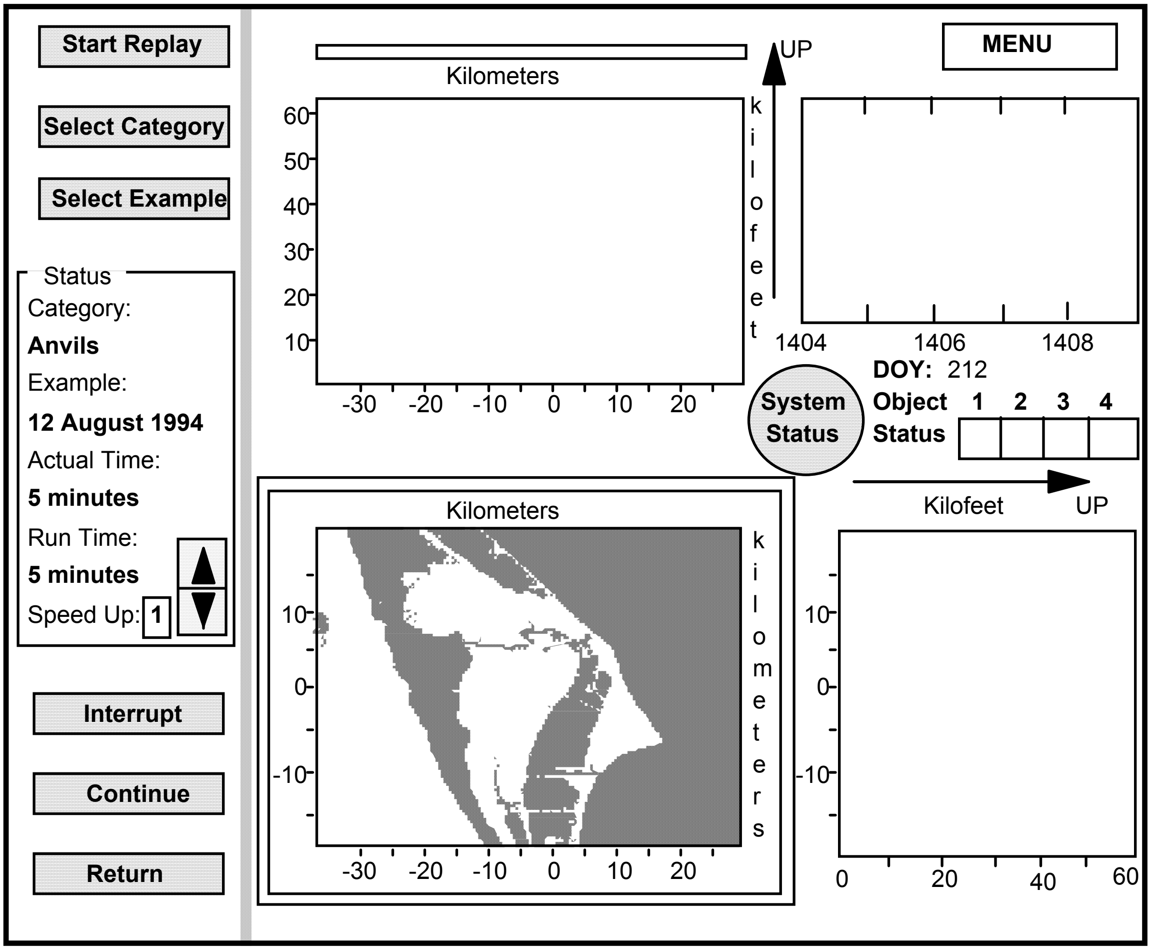

Figure 1. Graphical user interface for replaying examples of known LDAR signatures within the LDAR CBT.

The text and buttons to the left of the gray line on the display in Fig. 1 are the options available to the user to control the replay of the example data. The user has the ability to select the example category and the specific example displayed by the training system. The system then processes and displays LDAR data from that example as closely as possible to the way the data would be displayed with the real-time LDAR system. The timing between strikes is preserved so that storms and other signatures replayed on the training system have the same timing they had when they appeared on the LDAR system in real time. Some examples, such as entire storm life cycles, may have replay times as long as 15 minutes. In such cases, users may choose to speed up the replay by adjusting the speed-up factor. The speed-up factor reduces the time between strikes by the factor shown on the display. Users also have the ability to interrupt, continue, and restart the replay of an example at any time.

The rest of the training system will be fully integrated with the example replay program so that users may switch between LDAR textual information and example replays seamlessly.

2.3 TASK 005 MESOSCALE MODELING

Subtask 2 Install and Evaluate MESO, Inc.'s MASS Model (Dr. Manobianco)

Primary AMU activities during the past quarter on the Mesoscale Atmospheric Simulation System (MASS) model installation and evaluation include verification of coarse and fine grid forecasts of the sea breeze, diurnal maximum and minimum temperatures, convective precipitation, and tropospheric winds above 2 km. The following sections summarize the verification of explicit convective precipitation using Florida Water Management and KSC/CCAS rain gauge data.

Methodology

The AMU processed hourly precipitation data collected by the rain gauge network from the St. Johns River, Southwest Florida, and South Florida Water Management districts and the gauges distributed around KSC/CCAS. These data were provided to the AMU on floppy disks for the period 15 January 1994 through 15 October 1994 for the specific purpose of evaluating the MASS model's explicit precipitation forecasts. The precipitation data were analyzed to the 11 km and 45 km model grids using a two-pass Barnes objective analysis (OA) scheme and a bit-mask. The bit-mask was set up to prevent the OA scheme from extrapolating precipitation amounts in areas with few or no gauge measurements. An example of the 11 km bit-mask and rain gauge distribution for 16 July 1994 0100 UTC is shown in Fig. 2. The average distance between rain gauges is approximately 10 km. Since these data were collected only over the Water Management Districts and KSC/CCAS, the MASS precipitation forecasts were not verified along sections of the Florida coasts or over the Gulf of Mexico and Atlantic Ocean (see Fig. 2).

The hourly gridded precipitation analyses are summed over 12 h and compared with MASS forecast precipitation fields summed over the same 12-h period. An example of observed and forecast precipitation accumulated for the 12-h period from 1200 UTC 16 July to 0000 UTC 17 July is shown in Fig 3. The forecast precipitation was generated by the fine grid run initialized at 1200 UTC 16 July and is displayed only in the area of the bit-mask as given by the shading in Fig. 2. The MASS model produced precipitation over a larger area than was observed for this 12-h period during 16 July.

The precipitation skill scores are computed from four-cell contingency tables shown in Table 1 for five precipitation thresholds of 0.01", 0.10", 0.25", 0.50" and >1.00". The contingency tables are filled by comparing observed and forecast precipitation for each threshold at every grid point within the 11 km and 45 km bit-mask for all model runs from January through October 1994. The four skill scores computed for each precipitation threshold are the bias, false alarm rate (FAR), probability of detection (POD), and equitable threat score (ETS). The definitions of bias, FAR, and POD are given in Table 1 and follow Schaefer (1990). The bias is greater (less) than unity for systematic overpredictions (underpredictions) at each precipitation threshold. The ETS, as defined by Gandin and Murphy (1992), has a value of unity for perfect forecasts and accounts for the probability of occurrence for each event. As a result, an ETS for rare events is higher than an ETS for common events. Unlike the conventional threat score or critical success index (CSI), the ETS can be negative because the off-diagonal terms in the contingency table (Y and X) are weighted by a factor of -1 (e.g. see definitions of ETS and CSI in Table 1).

Figure 2. Map depicting the locations of rain gauge observations (triangles) from the St. John's River, Southwest Florida, and South Florida Water Management Districts and the KSC/CCAS region for 16 July 1994 0100 UTC. The gray shading shows the bit-mask for the 11 km MASS grid. The observed precipitation is analyzed to the 11 km model grid only at points contained within the bit-mask.

Figure 3. Accumulated precipitation (inches) for the 12-h period from 1200 UTC 16 July 1994 to 0000 UTC 17 July 1994. The observed precipitation is shown in panel (a) and the forecasted precipitation is shown in panel (b). The forecasted precipitation was generated by the fine grid run initialized at 1200 UTC 16 July and is displayed only in the area of the bit-mask shown in Fig. 2. The shading intervals are given by the color bar in each panel for precipitation thresholds of 0.01″, 0.10″, 0.25″, 0.50″, and 1.00″.

Table 1. Example of four-cell contingency table used for gridded precipitation verification

		Observed Precip ≥ Threshold	
		Yes	No
Forecast Precip ≥ Threshold	Yes	W	X
	No	Y	Z

bias = (W + X) / (W + Y)

false alarm rate (FAR) = X / (W + X)

probability of detection (POD) = W / (W + Y)

equitable threat score (ETS) = $(c_{11}W + c_{22}Z + c_{12}X + c_{21}Y) / (W + X + Y + Z)$

$c_{11} = (1\text{-}P)/P$; $c_{22} = P/(1\text{-}P)$; $c_{21} = c_{12} = -1$

$P=(W+Y)/(W+X+Y+Z)$

The ETS, bias, POD, and FAR from all 1200 UTC and 0000 UTC 11 km forecasts for each month and precipitation category from May through September 1994 are shown as bar graphs in Fig. 4. With the exception of the >0.10″ threshold in May, the ETS are less than 0.2 for all other thresholds and months (Fig. 4a). The model tends to overpredict (underpredict) the precipitation at the lower (higher) thresholds as indicated by bias scores in Fig. 4b. The FAR is at or above 0.4 (i.e. 40%) for May through September at all precipitation thresholds and greater than 0.7 (70%) at the 0.50″ and >1.00″ thresholds (Fig. 4c). The POD is greater than 0.5 (50%) for the lowest threshold of 0.01″ and decreases rapidly to less than 0.1 (10%) at the 0.50″ and 1.00″ thresholds (Fig. 4d). The high POD at the 0.01″ threshold is not that encouraging because the model overforecasts the precipitation at this threshold as evidenced by the bias scores >1.

The skill scores shown in Fig. 4 indicate that the fine grid (11 km) MASS runs show little objective skill in predicting the exact location and amount of precipitation during May through September 1994. However, the 11 km runs from January through May 1994 yield higher ETS at the 0.01″ and 0.10″ thresholds (not shown). These results suggest that the MASS model provides more accurate explicit precipitation forecasts when synoptic-scale weather systems and non-convective precipitation dominate the weather in Florida. It is well known that operational models such as NMC's Nested Grid Model also show less skill in forecasting warm season precipitation associated with small scale convective-type weather systems.

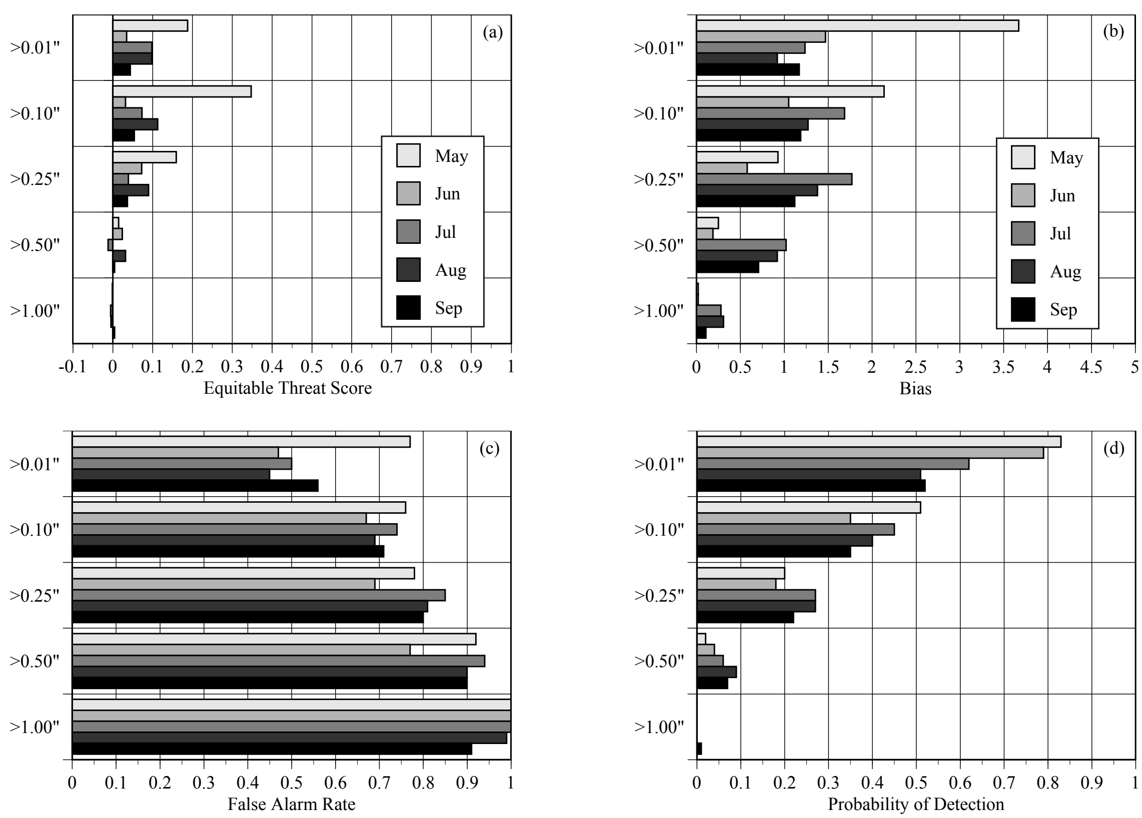

Figure 4. Objective skill scores from all 1200 UTC and 0000 UTC 11 km from May through September 1994 for precipitation thresholds of 0.01″, 0.10″, 0.25″, 0.50″, and 1.00″. The Equitable Threat Score (ETS), Bias, False Alarm Rate (FAR), and Probability of Detection (POD) are shown in panels (a), (b), (c), and (d), respectively.

It is important to point out that the skill scores such as the ETS do not account for the spatial or temporal errors in precipitation forecasts. For example, the model may predict the correct amount of precipitation 2 h later and 20 km farther west than observed. In this case, the ETS score would indicate little or no skill in predicting the event, whereas the actual utility of the forecast may be quite good considering the spatial and temporal displacement of forecast precipitation. However, the AMU examined maps of analyzed and forecast precipitation accumulated for 3-h periods from all 1200 UTC 11 km forecasts during July 1994. This qualitative analysis revealed that the MASS model did not routinely produce the correct distribution of precipitation at any time in the forecast period over any area of the domain.

The fine grid's poor performance in forecasting warm season explicit precipitation is likely due to a number of factors including insufficient horizontal resolution and deficiencies in the physical parameterizations, specifically the Kuo-Anthes convective scheme. In fact, MASS was not designed to provide accurate, explicit forecasts of convective precipitation. Instead, MESO, Inc. combined dynamical model output from MASS with observations to produce probability forecasts for the occurrence of precipitation, thunder, lightning and high winds at TTS (Shuttle Landing Facility). These model output statistics (MOS) were designed to account for deficiencies in the MASS model. The AMU will be evaluating the MOS coefficients derived by MESO, Inc. from their limited sample of 1992 warm season cases. In addition, the AMU will rederive and validate MOS using the more complete data base of 1994 warm season cases. This portion of the MASS model evaluation along with the objective and subjective verification is scheduled for completion by September 1995.

References

Gandin, L. S., and Murphy, A. S., 1992: Equitable skill scores for categorical forecasts. *Mon. Wea. Rev.*, **120**, 361-370.

Schaefer, J. T., 1990: The critical success index as an indicator of warning skill. *Wea. Forecasting*, **5**, 570-575.

Subtask 4 Install and Evaluate ERDAS (Mr. Evans)

The Emergency Response Dose Assessment System (ERDAS) was installed in the AMU in March 1994, and has been running automatically twice daily. The AMU's primary tasks on ERDAS have been to make sure ERDAS receives all its required input data, monitor its operation, determine any deficiencies, conduct an evaluation of the RAMS meteorological model, and evaluate the diffusion models HYPACT and REEDM. The evaluation of ERDAS has been ongoing since its installation, and we have documented some of the evaluation results in several interim reports. An extensive description of the meteorological evaluation will be provided in the AMU's ERDAS evaluation final report Mr. Evans will prepare in September.

The primary AMU activity during the past quarter on ERDAS model evaluation was the evaluation of the RAMS meteorological model. The evaluation period lasted from March 1994 to March 1995 with the most intensive evaluation covering the months of July and August 1994. The following paragraphs describe the AMU's evaluation of RAMS' performance for a representative week during July and August.

Model Configuration

The RAMS model configuration for ERDAS has been documented in several reports and papers written by Lyons and Tremback. The ERDAS Final Report (Lyons and Tremback 1994) presents details of the configuration (Section 2.1: Meteorological Modeling). Important features of the model configuration are:

- The horizontal grid spacing of the three nested grids are 60 km (38 x 36 points), 15 km (34 x 38 points), and 3 km (37 x 37 points).

- In the vertical, there are 22 telescoping layers extending to a height of 13.5 km for the large and medium size domain grids and to a height of 3 km for the small domain size grid.

- The model runs twice daily producing hourly forecasts for a total of 24 hours beginning at 0000 UTC and 1200 UTC.

- The model physics selected for ERDAS do not include clouds, condensation, or precipitation.

Evaluation Procedures

Dispersion models require accurate wind data to produce accurate concentration predictions. Therefore, we have focused our evaluation of RAMS on the accuracy of its predictions of wind speed and wind direction. We compared the RAMS predictions to the observed hourly wind speeds and directions from several towers and surface observation sites in the Cape Canaveral area. Fig. 5 presents graphs showing observed and predicted wind speed and wind direction for a representative seven-day period.

The analysis presented in this report compares the wind data collected at the 4-meter level of Tower 110 with the RAMS wind data from the lowest grid height of 11 meters interpolated to the Tower 110 location. Tower 110 is located between Launch Complexes 40 and 41, approximately 1 km west of the coastline. The example analysis period presented in this report is the seven-day period 15-21 July 1994.

To determine the effect of clouds and precipitation on the RAMS predictions, we produced graphs of hourly observed total sky cover and observed weather (thunder, rain, rain shower, and/or thunderstorm) from the Shuttle Landing Facility. Graphs with this data are included in Fig. 5.

Results

The graphs comparing observed and predicted winds are presented in Fig. 5. The primary goals of comparing the observed and predicted winds were to determine:

- How well RAMS predicted the sea breeze with regard to its timing and location,

- What effect did cloudy skies and thunderstorms have on RAMS predictions, and

- How well did RAMS predict the diurnal variability of wind speed.

The typical sea breeze regime on Florida's east coast is characterized by an early morning, westerly, off-shore component wind (1200 UTC to approximately 1800 UTC) that switches to an easterly, on-shore component wind during late morning or early afternoon (approximately 1600

UTC to 2000 UTC). Of the seven days shown in Fig. 5, RAMS predicted a morning westerly component wind that switched to an east wind on six of the days. Of these six days, Tower 110 observed a westerly wind that switched to an east wind on five of the days. On 15 July 1994, the observed wind was easterly through the morning hours. RAMS consistently predicted a morning westerly wind for only one hour before switching the winds to easterly as shown on the wind direction graphs as gray spikes at 1300 or 1400 UTC on 15-19 July. On these days, the pressure gradient was relatively weak, and the model was most likely detecting the early morning land breeze sometimes referred to as a drainage flow.

Even though RAMS did a good job predicting the occurrence of the sea breeze for these seven days, it predicted the switch from westerly to easterly flow earlier than it occurred on all but one of the five days that it correctly predicted the sea breeze occurrence. Table 2 presents the times of the predicted and observed sea breeze passage at Tower 110.

Table 2. Time of sea breeze passage at Tower 110 for 15-21 July 1994.

Date	RAMS	Observed	Difference of Predicted–Observed
15 July 94	1500 UTC	Continuous easterly winds	-
16 July 94	1400 UTC	1600 UTC	-2 hours
17 July 94	1400 UTC	1600 UTC	-2 hours
18 July 94	1400 UTC	1500 UTC	-1 hours
19 July 94	1400 UTC	1700 UTC	-3 hours
20 July 94	No sea breeze predicted	No sea breeze observed	-
21 July 94	1500 UTC	1500 UTC	0 hours

In general, the graph comparing wind directions for the seven day period indicated that the wind directions from RAMS agree reasonably well with the observed wind directions except on 19 and 20 July. The graph of the sky cover and weather events at the bottom of Fig. 5 shows that on 19 and 20 July there was significant cloud cover through the morning hours. The other five days in the analysis period had minimal sky cover during the morning hours.

RAMS accurately predicted the wind direction on days that were not cloudy during the morning hours but was unable to predict wind direction during the cloudy conditions of 19 and 20 July. This result is not surprising since the model is configured to run in the "dry mode" meaning the microphysics module in RAMS that generates clouds and precipitation is turned off to reduce the model runtime. Therefore, the model was not expected to perform well during these cloudy conditions and the results of this analysis confirm this.

Comparing the modeled and observed wind speeds (middle graph, Fig. 5) indicates that RAMS predicted the diurnal increase and decrease of the wind speed. However, the predicted wind speeds were greater than the observed wind speeds during the afternoon hours. One explanation for the over estimates of predicted wind speed is that the RAMS winds at 11 meters are being compared with the observed winds at 4 meters. Wind speeds typically increase with height near the surface due to less friction. Therefore, wind speeds at 4 meters would tend to be less than those at 11 meters.

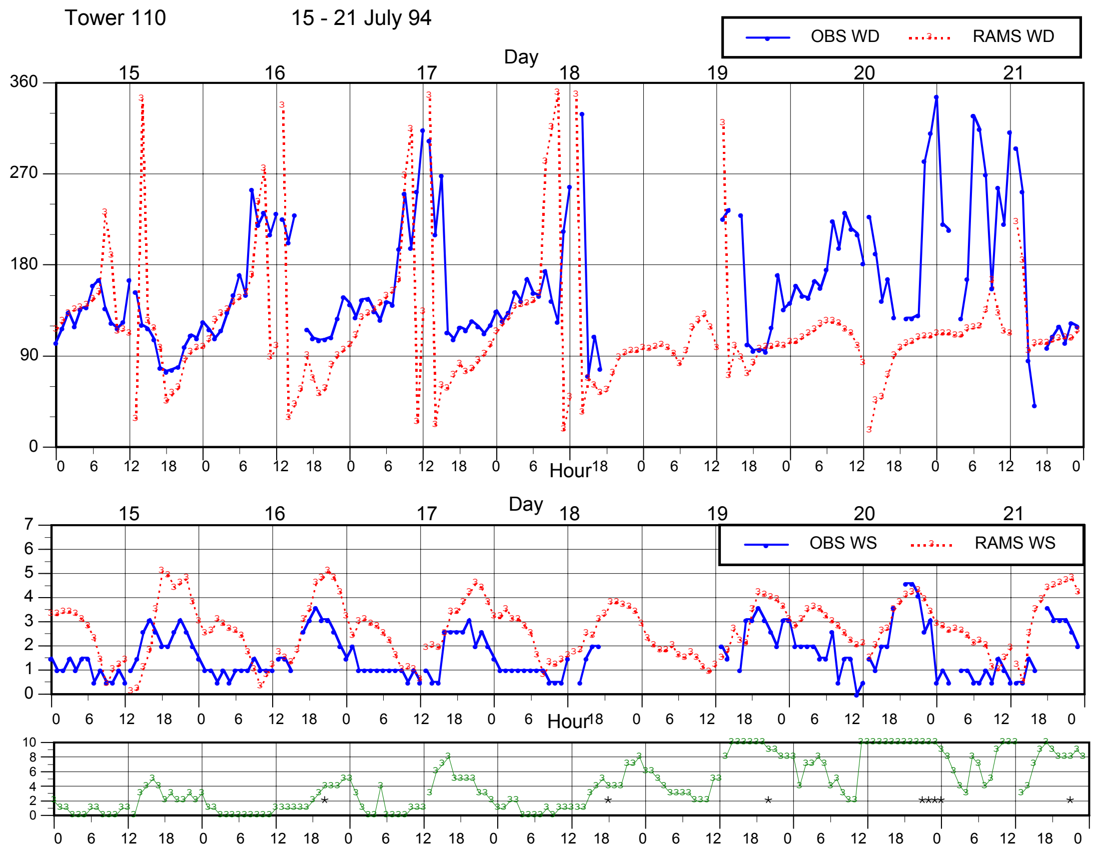

Figure 5. Graphs comparing the winds observed at Tower 110 (black) and predicted by RAMS (gray) for 15-21 July 1994. The top graph shows wind direction (deg.), the middle graph shows wind speed (ms^{-1}), and the bottom graph shows observed sky cover in tenths (gray diamonds) and observed weather (black asterisks) at the SLF. RAMS data were produced by daily RAMS runs which were initialized at 1200 UTC and which ran for 24 hours.

References

Lyons, W. A. and C. J. Tremback, 1994: Final Scientific and Technical Report: Predicting 3-D Wind Flows at Cape Canaveral Air Force Station Using a Mesoscale Model., Contract No. F04701-91-C-0058. Prepared by ASTER/MRC for US Air Force Space and Missile Systems Center, SMC/CLNE, 30 June 1994.

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

SLF Wind Measurements Separation Study

NASA Technical Paper 3529 was received from the printer and distributed. This study is complete.

Wind Sheltering Study

Dr. Merceret collected data for two days with the array extended to 2500 feet. Results are consistent with previous runs and indicate that cutting the foliage to meet Federal Standards for Siting of Meteorological Equipment at Airports is appropriate.

Dr. Merceret derived and successfully tested an empirical fit of the sheltering coefficient [WS(distance)/WS(820 feet)] versus distance using the hyperbolic tangent function.

At least one more run with the array extended to 3100 feet will be taken as soon as weather permits. A run with a sensor on the runway at the touchdown point with a nearly pure crosswind will complete the field phase of the study.

WSR-88D

Dr. Merceret has begun examining the WSR-88D base spectral width product for correlations with lightning and severe weather. This is an effort that will be conducted at a low level on an as-time-permits, non-interference basis.

World Wide Web (WWW) Access

Dr. Merceret installed MOSAIC on his PC at KSC and now has WWW access. Also, please note his new E-mail address: fmerceret@tmoffice.ksc.nasa.gov.

Attachment 1: AMU FY-95 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.

- 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.

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.

- 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 4 - Forecaster Guidance Tools

•• The 0.2 cloud cover sub task is extended to include development of forecaster guidance tools including those based on artificial neural net (ANN) technology.

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

•• Evaluate the NASA/KSC Lightning Detection and Ranging (LDAR) system data relative to other relevant data systems at KSC/CCAS (e.g., LLP, LPLWS, and NEXRAD). Determine how the LDAR information can be most effectively used in support of NASA/USAF operations. If appropriate, transition to operational use.

- 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 7 - ASOS Evaluation

•• Evaluate the effectiveness and utility of the ASOS data in terms of spaceflight operations mission and user requirements.

- 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.

- Subtask 10 - NEXRAD/McGill Inter-evaluation

•• Determine whether the current standard WSR-88D scan strategies permit the use of the WSR-88D to perform the essential functions now performed by the PAFB WSR-74C/McGill radar for evaluating Flight Rules and Launch Commit Criteria (including the proposed VSROC LCC).

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.