

**Applied Meteorology Unit (AMU)**  
**Quarterly Update Report**  
**Third Quarter FY-94**

**Contract NAS10-11844**

**31 July 1994**

**ENSCO, Inc.**

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*ENSCO*

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## **1. Background**

The AMU has been in operation since September 1991. A brief description of the current tasks is 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)**

#### **Shuttle Training Aircraft (STA) Downlink (Mr. Wheeler)**

The AMU delivered the antenna and modem that were used in the STA downlink system demonstration to NASA.

#### **Development of Forecaster Applications (Mr. Wheeler)**

The AMU installed the X-Windows version of the Man computer Interactive Data Access System (McIDAS-X) on one of the IBM RISC 6000 computer systems in the AMU lab area and performed some minor testing of the system. The AMU does not have a TCP/IP connection to the Meteorological Interactive Data Display System (MIDDS) mainframe computer, so data must be shared with the IBM model 80 computer which receives data via the ProNet connection. Preliminary review of satellite imagery indicates the resolution of the McIDAS-X display is significantly better than the McIDAS Wide Word workstations. The AMU recently received a McIDAS-X Graphical User Interface (GUI) from SSEC in late June and hopes to further evaluate the GUI during the next quarter.

Throughout this quarter, the AMU has continued to make corrections to and enhance the Range Weather Operations (RWO) MIDDS F-key menu shell. Presently an F-key menu has been installed on three of the four RWO workstations. Modifications installed in the menu system include:

- A user sub-menu that provides an interface to prognostic products from the National Meteorological Center (NMC) model and point data,
- An analytical sub-menu that provides a user interface for synoptic scale and mesoscale product generation (The products available range from cross sections to detailed analysis packages of local information such as wind tower and lightning data.),
- A local information sub-menu enabling the forecasters to quickly access thunderstorm related information including thermodynamic analysis products, lightning text information and graphical displays,

range ring overlays, and verification tools for lightning and wind advisories or warnings, and

- Redistribution of satellite image ingestion between the forecaster, DDMS, and Launch Weather Officer (LWO) terminals to reduce load on system resources (Thus far, this has reduced the system load on the primary system CPU by 10 to 12%. The AMU expects to reduce the system load due to satellite image loading by 15 to 20% after updating the last RWO MIDDS terminal.).

The AMU also began development of the LWO F-Key menu shell. This menu will be configurable by the user for day-to-day forecasting and all launch operations (i.e. Shuttle, Titan, Atlas, Delta, Navy and others). When the user requests one of the launch support menus, the satellite and radar images and the briefing graphics will be customized appropriately for the specified operation.

Finally, Mr. Wheeler began updating the McBasi utilities that use data from the Kennedy Space Center (KSC)/Cape Canaveral Air Station (CCAS) local wind tower network. All McBasi programs that access the tower data will need to be updated once the new MIDDS Weather Information Network Display System (WINDS) decoder is certified and running in real-time on the MIDDS.

## **2.2. Task 002 Training (Dr. Taylor)**

No significant training activities were undertaken this past quarter.

## **2.3. Task 003 Improvement of 90 Minute Landing Forecast (Dr. Taylor)**

### **Sub Task 1: Two - Tenths Cloud Cover Study (Ms. Schumann)**

The AMU has completed and distributed the final report documenting the performance of the neural network to forecast cloud cover. The results contained in the report were documented in the AMU Quarterly Update Report, First Quarter FY-94.

### **Sub Task 2: Fog and Status at KSC (Mr. Wheeler)**

On June 14, 1994, Mr. Wheeler briefed the Melbourne National Weather Service (NWS) Office on the AMU's evaluation of fog development at the Shuttle Landing Facility (SLF).

The final report of the AMU's evaluation of fog development at the SLF has been distributed to all interested organizations. The MIDDS McBasi tools and fog decision trees have been transitioned to operations at the Spaceflight Meteorology Group (SMG) and the RWO.

## **2.4. Task 004 Instrumentation and Measurement (Dr. Taylor)**

### **Sub Task 3: Doppler Radar Wind Profiler**

#### **Implementation of MSFC DRWP Wind Algorithm (Ms. Schumann)**

At the request of the Titan IV community, Ms. Schumann provided operational wind profiler support for launch attempts on April 21, 23 and 26 and the actual launch on May 03. The AMU launch support for the Titan IV consisted of comparing the jimsphere and rawinsonde wind profiles with the MSFC wind algorithm profiles for consistency and to alert the Air Force Staff Meteorologist responsible for balloon quality control and the Titan IV (SPO) representative in Weather Station A (where the upper air launch support is performed) of any shear detected by the profiler but not by the balloons. The AMU also informed them of any side lobe returns in the profiler data, detectable in the interactive quality control display.

The implementation of Marshall Space Flight Center's (MSFC) Doppler radar wind profiler (DRWP) wind algorithm on the 50 MHz wind profiler was completed last quarter with the final testing of the data communications scheme. The MSFC algorithm will become operational when the Eastern Range certification of the decoding software written and tested by JSC is completed. If required, the AMU will assist with the certification testing as part of the transition of the new algorithm to operational use.

On 14 June, Ms. Schumann briefed the NWS, Melbourne on NASA's 50 MHz profiler's capabilities and characteristics. Mr. Wheeler provided the NWS with the commands and McIDAS scripts used to view the profiler data on their MIDDS terminal.

#### **Sub task 4LDAR Evaluation and Transition**

In early June, Ms. Schumann, Dr. Taylor, and Dr. Merceret met with NASA KSC TE-CID personnel, the group responsible for the Lightning Detection And Ranging (LDAR) system's development, to discuss how the AMU work could complement and not overlap or duplicate work performed by Dr. Greg Forbes or within TE-CID. (Dr. Forbes of Pennsylvania State University, is at KSC this summer as part of the faculty fellowship program and will be analyzing LDAR data with respect to other lightning detection systems and weather radars.)

During the meeting, it was decided that the AMU would focus their data analysis efforts on winter storms while Dr. Forbes concentrated his efforts on summer electrical activity. The AMU will also develop on-line training tools for interpreting the electrical activity displayed by LDAR. The training tools will include the results of the AMU's and Dr. Forbes' data analysis as well as any LDAR engineering information that affects the way data are displayed. Further enhancement of the LDAR displays and the data reduction for providing LDAR data to the MIDDS will be addressed after the results of the data analysis have been assessed. Ms. Schumann will modify the preliminary evaluation plan based upon the division of labor between the AMU and TE-CID and then distribute the plan for customer review.

During the months April through June, Ms. Schumann worked with the Eastern Range to coordinate the LDAR workstation and its associated communication lines and equipment installation in the AMU to ensure the AMU complies with all configuration control requirements of the Range Operations Control Center. The installation was completed on 21 June and the system was up and running with real-time data on 22 June. Since then, Ms. Schumann and Mr. Wheeler have been gaining experience with the system in preparation for the evaluation and transition task.

### **Sub Task 10: NEXRAD / McGill Inter-Evaluation (Dr. Taylor)**

This past quarter, the AMU completed the NEXRAD (WSR-88D) / McGill Inter-evaluation subtask. The objective of the subtask is to determine whether the current standard NEXRAD scan strategies permit the use of the NEXRAD to perform the essential functions now performed by the Patrick Air Force Base (PAFB) WSR-74C / McGill radar for evaluating Shuttle weather Flight Rules (FR) and Launch Commit Criteria (LCC). The report documenting the results of this investigation has been completed and will be distributed after permission to release the document has been received from the NASA KSC Public Affairs Office. Excerpts from the report are presented below.

#### **Background**

The motivation for the weather radar scan strategy comparison is derived from the cost versus benefit analysis of continuing to maintain and operate the WSR-74C / McGill radar relative to using the Melbourne WSR-88D radar for Shuttle weather FR and LCC evaluations. This investigation is one component of the complex cost versus benefit analysis of the two radar systems.

The PAFB WSR-74C / McGill radar is a highly flexible weather radar which is controlled and operated by the Air Force with the primary function of supporting Eastern Range (ER) / NASA operations. However, the WSR-74C / McGill radar is also a 10 year old radar based on 20 to 30 year old technology and is a "one-of-a-kind" system because of the McGill Volumetric Scan Processor. All maintenance and operations costs for the radar are funded by the ER and NASA. Conversely, the Melbourne WSR-88D radar is less than 5 years old and is based on 10 year old technology. The majority of the operations and maintenance costs of the system are funded by the Air Force and the NWS through the Joint Systems Program Office. The system also has improved sensitivity (clear-air mode) and Doppler capability. However, the Unit Radar Committee, composed of Air Force, NWS and Federal Aviation Administration (FAA) representatives, controls daily operation of the Melbourne WSR-88D radar and the Operational Support Facility provides configuration control of the system. Furthermore, the radar supports not only the space launch / landing community but also the NWS and FAA requirements.

#### **Summary of Results**

This investigation compared the beam coverage patterns of the WSR-74C / McGill radar located at PAFB and the WSR-88D radar using VCP 11 located at the Melbourne

NWS Office relative to the area of concern for weather FR and LCC evaluations. The analysis focused on beam coverage within four vertical 74 km radius cylinders (1 to 4 km AGL, 4 to 8 km AGL, 8 to 12 km AGL, and 1 to 12 km AGL) centered on Launch Complex 39A. Key characteristics of the two radars' beam coverage are summarized in Table 1.

This analysis has shown that effective beam coverage is a function of both scan strategy and distance from the radar to the point of interest. For example, the results indicate that the advantages inherent in the scan strategy of the McGill radar (i.e., more elevation scans and higher elevation scans) relative to the WSR-88D are offset by the preferred location of the WSR-88D relative to the McGill radar and KSC / CCAS. Indeed, the beam coverage of the WSR-88D exceeds the beam coverage of the McGill radar over most of the KSC / CCAS area by 5 to 20% in the 4 to 8 km layer, by 5 to 10% in the 8 to 12 km layer, and by 5 to 10% in the 1 to 12 km layer.

The beam coverage of the scan strategy employed by the McGill radar and the VCP 11 scan strategy of the WSR-88D exceeds 70% in the 1 to 4 km, 4 to 8 km, and 1 to 12 km layers for most of the area of concern. However, the extent of good beam coverage (coverage equal to or greater than 70%) is less in the 8 to 12 km layer for both radars because of the gaps in radar beam coverage in the higher elevation scans. Indeed, neither radar provides good beam coverage in the 8 to 12 km layer over most of the KSC / CCAS area.

The difference in percent of the atmosphere sampled between the two radars is less than 10% for more than half of the area of concern for all four layers. However, there are significant differences in beam coverage between the two radars in the near vicinity of the radars. This is a result of the cone of silence directly above and near the radars which is a function of the radar's scan strategy. This limitation is slightly more severe for the WSR-88D since the highest elevation angle of VCP 11 is  $19.51^\circ$  whereas the highest elevation angle of the McGill scan strategy is  $35.97^\circ$ . For all four layers, the McGill radar provides better beam coverage than the WSR-88D radar at and in a small region to the south-southwest of the WSR-88D radar. Conversely, the WSR-88D radar provides better beam coverage than the McGill radar at and in a small region to the north-northeast of the McGill radar.

### **Conclusions and Recommendations**

The results of this investigation indicate that the beam coverage of the WSR-88D using VCP 11 located at the Melbourne NWS Office is comparable (difference in percent of the atmosphere sampled between the two radars is 10% or less) within the area of concern to the beam coverage of the WSR-74C / McGill radar located at PAFB. Both radars provide good beam coverage over much of the atmospheric region of concern. In addition, both radars provide poor beam coverage (coverage less than 50%) over limited regions near the radars due to the radars' cone of silence and gaps in coverage within the higher elevation scans. In conclusion, based on an analysis of scan strategy alone, the WSR-88D located at Melbourne NWS Office could be used to perform the essential functions now performed by the PAFB WSR-74C / McGill radar for evaluating Shuttle weather FR and LCC.

It is important to note there are other characteristics of the two radars that should be considered in the process of determining if the WSR-88D located at the Melbourne NWS Office could be used to perform the essential functions now performed by the PAFB WSR-74C / McGill radar for evaluating Shuttle weather FR and LCC. A partial list of additional radar system characteristics which deserve consideration include:

- Radar digitizers,
- Radar side lobe patterns,
- Ability and cost of customizing radar system capabilities,
- Ease of use of system,
- Life cycle costs,
- Other system limitations (e.g. load shedding by the WSR-88D), and
- Other user requirements (e.g. dual Doppler capability).

Table 1. Key Characteristics of the McGill and WSR-88D Radars' Beam Coverage	
Layer of the Atmosphere	Beam Coverage of the PAFB WSR/74C / McGill Radar and the Melbourne WSR-88D Radar
1 to 4 km above ground level	<p>Radar beam coverage exceeds 90% for both of the radars for the majority of the area within the region of concern.</p> <p>The difference in beam coverage between the two radars is less than 10% for most of the region of concern.</p> <p>The McGill radar's beam coverage exceeds the WSR-88D radar's beam coverage by 10 to 60% in the extreme southern portion of the region of concern.</p> <p>The WSR-88D radar's beam coverage exceeds the McGill radar's beam coverage by 5 to 40% in the region extending from the McGill radar site to Cape Canaveral.</p>
4 to 8 km above ground level	<p>Radar beam coverage exceeds 70% for both of the radars for the majority of the area within the region of concern.</p> <p>Radar beam coverage exceeds 90% for both of the radars for almost all of the northern half of the region of concern.</p> <p>The difference in beam coverage between the two radars is less than 10% for most of the region of concern.</p> <p>The McGill radar's beam coverage exceeds the WSR-88D radar's beam coverage by 10 to 50% in the extreme southern portion of the region of concern.</p> <p>The WSR-88D radar's beam coverage exceeds the McGill radar's beam coverage by 5 to 20% in the region extending from the McGill radar site to Cape Canaveral and Merritt Island.</p>
8 to 12 km above ground level	<p>Radar beam coverage exceeds 70% for both of the radars for most all of the area within the northern half of the region of concern.</p> <p>Radar beam coverage is less than 70% for both radars for most all of the KSC / CCAS region.</p> <p>The difference in beam coverage between the two radars is less than 10% for more than half of the region of concern.</p> <p>The McGill radar's beam coverage exceeds the WSR-88D radar's beam coverage by 10 to 40% in the extreme southern portion of the region of concern.</p> <p>The WSR-88D radar's beam coverage exceeds the McGill radar's beam coverage by 5 to 10% in the region extending from the McGill radar site to Cape Canaveral and Merritt Island.</p>

1 to 12 km above ground level	<p>Radar beam coverage exceeds 70% for both of the radars for the majority of the area within the region of concern.</p> <p>The difference in beam coverage between the two radars is less than 10% for more than half of the region of concern.</p> <p>The McGill radar's beam coverage exceeds the WSR-88D radar's beam coverage by 10 to 40% in the extreme southern portion of the region of concern.</p> <p>The WSR-88D radar's beam coverage exceeds the McGill radar's beam coverage by 5 to 20% in the region extending from the McGill radar site to Cape Canaveral and Merritt Island.</p>
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**2.5. Task 005 Mesoscale Modeling (Dr. Manobianco)**

**Sub task 2 Install and Evaluate MESO, Inc.'s MASS model (Dr. Manobianco)**

Primary AMU activities during the past quarter on the MASS model installation and evaluation include the development of software to reformat forecast and observed data for computing model performance statistics and to transfer model initialization and forecast products back to the AMU's IBM PC/Model 80 and ultimately to the IBM mainframe for access through the MIDDS.

Testing of the software to transfer MASS output to MIDDS should be completed in early August. Final implementation of the transfer process will be completed pending approval from the Eastern Range. Until the model evaluation has been completed and its validity established, the AMU will delay the transmission of the forecast grids to MIDDS long enough so that the output cannot be used for operational decisions.

**MASS Evaluation**

In March 1994, the AMU distributed a document presenting a plan for evaluating the MASS model. (Selected sections from this evaluation plan are included in the AMU's Quarterly Report for the Second Quarter of FY 1994.) The AMU solicited comments, questions, and concerns from the RWO, SMG, and NWS. The AMU has received written input from Major Robert Thorp (RWO) and Mr. Daniel Petersen (NWS), and verbal input from Mr. James Keller (SMG) regarding the proposed evaluation plan. RWO, SMG, and NWS concurred with the AMU's recommended strategy for evaluating the model. Specific comments and concerns are as follows.

- SMG indicated that Richard Grumm at the National Meteorological Center has accumulated many of the known systematic biases for the Nested Grid Model and published them in *Weather and Forecasting*.
- SMG is concerned that there may be too few cases available for derivation of the Model Output Statistics.
- SMG recommended computing gridded error statistics for moisture at more levels below 850 mb.

- NWS suggested that standard indices such as the lifted index, K-index, and quantities such as precipitable water be computed from model forecast data and compared with the same parameters derived from observed soundings.

A preliminary step in the MASS evaluation requires model forecast data to be interpolated to station locations such as rawinsonde sites over Florida for comparison with observed soundings at these locations. This process has been completed for West Palm Beach, FL and Tampa Bay, FL for the months of February and April using archived forecast data stored on 8 mm tapes. The two months were selected at random in order to test the routines and UNIX shell scripts that are being developed as part of the complete model evaluation software package.

The time series of all available 1200 UTC rawinsonde observations for West Palm Beach, FL during April 1994 at 850 mb, 500 mb, and 300 mb are shown in Figures 1, 2, and 3, respectively. The observations of wind speed ( $\text{ms}^{-1}$ ), wind direction (deg.), temperature ( $^{\circ}\text{C}$ ), and dew-point depression ( $^{\circ}\text{C}$ ) are given by the open squares in panels (a) through (d) of Figs. 1-3. The corresponding 12-h 11 km (fine grid) forecasts initialized at 0000 UTC and verifying at 1200 UTC are interpolated to the West Palm Beach sounding location and displayed as solid lines in Figs. 1-3. Note that the lines connect a series of 28 sequential 12-h 11 km forecasts that are initialized at 0000 UTC and run during the month of April. Only two forecasts at the beginning of the month are missing (i.e. on 1 April and 2 April 1994).

A quantitative comparison of the time series of observed and forecast data at West Palm Beach, FL from the 0000 UTC 12-h fine grid runs indicates that:

- Temperatures at 850 mb, 500 mb, and 300 mb show the least variability compared with winds and moisture during the month of April. On many days, the 12-h temperature forecasts and observations differ by less than one degree which is within rawinsonde instrument error.
- The model predicts changes in wind speed and direction better at 500 mb and 300 mb than at 850 mb (compare Figs. 1a, 2a, and 3a).
- There is large variability in low-level (850 mb) moisture during the first half of April as shown by the dew-point depressions in Fig. 1d. The 12-h model forecasts of 850 mb dew-point depression do not reflect these changes. Qualitatively, the model appears to exhibit more skill in forecasting changes in dew-point depression at 500 mb and 300 mb during the month of April.

The time series shown in Figures 1-3 are similar to those for observed and forecast sounding data at other stations (e.g. Tampa Bay, FL) from the same 12-h 11 km fine grid runs. Additionally, the time series at West Palm Beach from both 12-h coarse and fine grid forecasts during February exhibit the same features as shown in Figures 1-3. In

general, the model does reasonably well in simulating large-scale changes in temperature, wind, and moisture as measured by 12-hourly rawinsondes.

It is important to point out that these comparisons are qualitative and are based on a very preliminary examination of a small sample of model output. A more rigorous quantitative evaluation of model forecast skill requires computing statistics such as root mean square error and bias for many stations during the entire archiving period from January through October 1994. The AMU is currently developing software needed to compute these quantities based upon details described in the model evaluation plan.

Dr. Manobianco presented the comparisons of 12-h fine grid model forecasts and observations discussed here at the Tenth Conference on Numerical Weather Prediction (NWP) in Portland Oregon on 21 July 1994. His attendance at this conference provided the opportunity to interact with meteorologists who presented papers that are closely related to the AMU's modeling tasks. For example, there were two papers presented in Session 1B: Cloud and Precipitation Forecasting dealing with aviation impact variables such as cloud and ceilings generated from numerical model output. It appears that diagnostic relationships for deriving fog and visibility indices from model variables show considerable potential. These results may prove useful, especially at high resolutions ( $\leq 10$  km grid spacings), and could be explored in the context of our modeling efforts with MASS and RAMS here at KSC/CCAS.

Figure 1. Time series of all available 1200 UTC rawinsonde observations (open squares) for West Palm Beach, FL at 850 mb during April 1994. Wind speed ( $\text{ms}^{-1}$ ), wind direction (degrees), temperature ( $^{\circ}\text{C}$ ), and dew -point depression ( $^{\circ}\text{C}$ ) are shown in panels (a), (b), (c), and (d), respectively. The corresponding 12-h 11 km (fine grid) forecasts initialized at 0000 UTC and verifying at 1200 UTC are interpolated to the West Palm Beach sounding location and displayed as solid lines.

Figure 2. Time series of all available 1200 UTC rawinsonde observations (open squares) for West Palm Beach, FL at 500 mb during April 1994. Wind speed ( $\text{ms}^{-1}$ ), wind direction (degrees), temperature ( $^{\circ}\text{C}$ ), and dew -point depression ( $^{\circ}\text{C}$ ) are shown in panels (a), (b), (c), and (d), respectively. The corresponding 12-h 11 km (fine grid)

forecasts initialized at 0000 UTC and verifying at 1200 UTC are interpolated to the West Palm Beach sounding location and displayed as solid lines.

Figure 3. Time series of all available 1200 UTC rawinsonde observations (open squares) for West Palm Beach, FL at 300 mb during April 1994. Wind speed ( $\text{ms}^{-1}$ ), wind direction (degrees), temperature ( $^{\circ}\text{C}$ ), and dew -point depression ( $^{\circ}\text{C}$ ) are shown in panels (a), (b), (c), and (d), respectively. The corresponding 12-h 11 km (fine grid) forecasts initialized at 0000 UTC and verifying at 1200 UTC are interpolated to the West Palm Beach sounding location and displayed as solid lines.

#### **Sub task 4 Install and Evaluate ERDAS (Mr. Evans)**

The Emergency Response Dose Assessment System (ERDAS) was installed in the AMU in March. The primary software system within ERDAS is the Regional Atmospheric Modeling System (RAMS). The AMU is presently evaluating ERDAS and its operational capabilities. In the AMU, RAMS runs automatically twice a day to produce hourly forecasts of wind, temperature, and humidity out to 24 hours.

The primary AMU activities during the past quarter on the ERDAS model evaluation include the preparation of a memorandum documenting RAMS' sensitivity to soil moisture and an addendum to the ERDAS System Check-Out Report that documents the initial performance of the ERDAS dispersion models.

#### **RAMS Soil Moisture Sensitivity**

The AMU tested the sensitivity of RAMS to soil moisture by varying the soil moisture parameter in RAMS for one 24-hour simulation over the KSC/CCAS. The sensitivity analysis was performed to provide information regarding the importance of soil moisture measurements to mesoscale modeling efforts to those developing the meteorological support instrumentation siting and modernization input to the Spacelift Range System Specifications. Table 2 contains the test parameters used in the soil moisture sensitivity test.

The gridded analysis of the surface data included surface weather station observations and tower data, but did not include buoy data. The AMU produced maps of the predicted and observed hourly surface wind fields for the period 1400 UTC to 2000 UTC for the Cape Canaveral area. The predicted wind fields were produced by the RAMS model using the lower and higher soil moisture values. The model run using the lower soil moisture is hereafter referred to as the LSM and the model run using the higher value is referred to as the HSM. The two modeled wind fields and the observed analyzed wind field for 1700 UTC are presented in Figure 4. At 1700 UTC, the LSM run produced a

well developed sea breeze with easterly winds and large vertical velocities across most of KSC/CCAS (see Figure 4a) . The HSM run produced the beginning of the sea breeze with easterly winds along the coast that did not penetrate very far inland (see Figure 4b). The observed wind field (see Figure 4c) showed the beginnings of a sea breeze with easterly flow in the southern part of the region.

The results from this one case clearly show that the RAMS model is very sensitive to the soil moisture parameter for predicting the location and intensity of the sea breeze at KSC/CCAS. We recommended that soil moisture measurements be included in the meteorological support input to the Spacelift Range System Specifications for KSC/CCAS.

Table 2. Sensitivity Test Description	
Test Parameter	Parameter Value
Simulation Start:	1200 UTC, 17 May 1994
Length of Simulation:	24 hours
Input Data:	Rawinsondes, surface data, buoy data, and tower data from 1200 UTC  Nested Grid Model (NGM) forecast grids from 0000 UTC, 17 May 1994
RAMS Configuration:	See attachment
Output Frequency:	Hourly
Experiment 1:	RAMS run with lower soil moisture (LSM), soil moisture parameter = 0.4
Experiment 2:	RAMS run with higher soil moisture (HSM), soil moisture parameter = 0.5  Note: Soil moisture is defined as the fraction of moisture present in a volume of soil relative to the total amount of moisture the soil can hold.

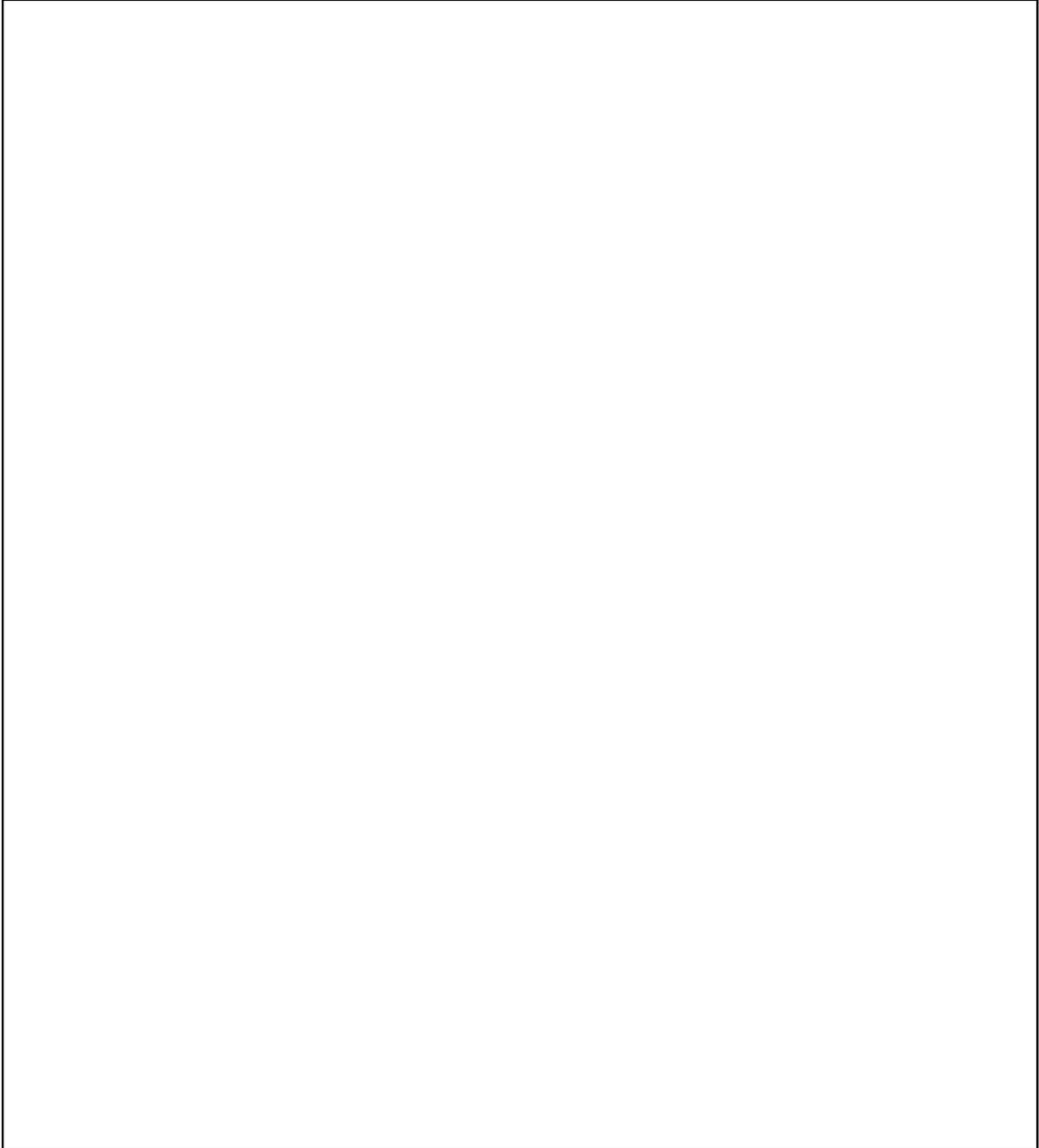


Figure 4. Illustrations of the hourly surface predicted and observed wind fields at 1400 UTC, 17 May 1994 for the Cape Canaveral area. Figure (a) shows the wind field for the lower soil moisture run with the overlaying contours showing vertical velocities at 10 meters. Figure (b) shows the wind field for the higher soil moisture run with the overlaying contours showing vertical velocities at 10 meters. Figure (c) shows the observed wind field derived from surface and tower data.

## **Functional Evaluation of the ERDAS Dispersion Models**

The initial effort in the AMU ERDAS task is to perform a system functional evaluation of ERDAS and to compile a list of system deficiencies. In April, we prepared a report which contained the AMU's findings resulting from our initial functional evaluation and operation of ERDAS. At that time, we were unable to conduct the functional evaluation of the dispersion models because they were not yet configured to run within ERDAS. Due to time limitations during the March ERDAS installation in the AMU, ASTER was unable to properly configure ERDAS to allow the dispersion models to run. ASTER corrected this configuration problem on April 22 and we then began the functional evaluation of the dispersion models HYPACT (Hybrid Particulate and Concentration Transport) and REEDM (Rocket Exhaust Effluent Diffusion Model). (The dispersion models OBDG and AFTOX do not run at this time.)

Most of the controls and functions of the dispersion models and associated user interface work as they were intended. However, due to ASTER's time limitations in completing ERDAS, a few of the functions and controls of the user interface were not completely implemented.

In the previous functional evaluation report, we noted several deficiencies in the initial delivery of ERDAS. Of the six deficiencies documented, ASTER has provided us the software to

- Properly configure the dispersion models and
- Correct the problem with the missing 12-hr NGM forecast grids.

The deficiency in the ERDAS quality control of the tower data has been broadened to include deficiencies in the quality control of surface and rawinsonde data.

### **Dispersion Model Deficiencies**

The AMU evaluated the different functions available within the dispersion models' user interface by testing the associated controls, widgets and windows. The three major windows in the dispersion model user interface of ERDAS are:

- Dispersion Control,
- REEDM, and
- View (HYPACT Viewer).

Table 3 describes the deficiencies found during the testing of each of the three major windows available for the ERDAS dispersion models.

Table 3. Deficiencies found during the testing of each of the three major windows in the dispersion part of ERDAS.	
Dispersion Control	
Controls	Deficiencies
Run	An indicator such as a clock symbol is needed to show the user the status of the dispersion modeling. Presently, once the user selects run, (s)he does not know if the model is running and could inadvertently select any number of controls which will activate once the model finishes its computations.
View	No problems found.
Done	No problems found.
REEDM	No problems found.
Windows	Deficiencies
Dispersion Scenario	When the user selects “REEDM run”, nothing happens. A pop-up menu is needed which lists the REEDM runs available for display.  Unit labels are needed for the Spill Amount, Pool Size and Storage Temperature data entry fields.
Chemical Attributes	The Release Rate must be entered manually. The program should compute the Release Rate.  In Dispersion Control, there are no unit labels on the Release Rate.
Model	AFTOX and OBDG models have not been completed for ERDAS by ASTER.
Meteorology	The “Obs” and “Hybrid” controls do not work. These controls allow the dispersion models to use observations and a blend of observations and model output for dispersion calculations.
Release Time	No problems found.
Domain	Only a portion of this window is displayed. The problem appears to be a graphics problem.

Release Location	No problems found.
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Table 3.  
(Continued)

REEDM	
Controls	Deficiencies
Vehicle Parameters	The default window, which is shown when this control is selected, is the “Titan IV conflagration”. Also, all the data entry fields are zeroes. The default window should provide a menu of available scenarios.
Run	An indicator such as a clock symbol is needed to show the user the status of the REEDM modeling. Presently, once the user selects run, (s)he does not know if the model is running and could inadvertently select any number of controls which will activate once the model finishes its computations.
View	No problems found.
Done	No problems found.
Widgets	Deficiencies
Vehicle type	No problems found.
Launch type	No problems found.
Launch time	No problems found.
Cloud/ Ceiling	No problems found.
View (HYPACT Viewer)	
Controls	Deficiencies
Plot	The map always displays a time of 0000 UTC. It should change as the time of the displayed data changes.
Load	No problems found.
Save Plot	The Save Plot control does not work.
Quit	No problems found.

Table 3. (Continued)	
Windows	Deficiencies
Time	The time slide bar does not work and the data entry box will not allow the user to enter the time.
Options	No problems found.
Slab	<p>The locations cannot be selected using the XZ, YZ buttons.</p> <p>When the XZ view is selected, no particles get displayed.</p> <p>An indicator is needed to show the slab thickness for the slab coordinates.</p>
Concentration Grid	<p>ASTER purposely left the details of the Concentration Grid window unresolved so that they could be worked out based on inputs from potential ERDAS users. The zooming mechanism also needs to be resolved so that the zoom will work when the grid spacing does not change. Presently, the user must change the number of grid points and the grid spacing in order to zoom.</p> <p>The “Wide view” widget does not function.</p>

### **Previously Reported ERDAS Deficiencies**

The first functional evaluation report documents the deficiencies found in the initial examination of ERDAS. These deficiencies and their current status are listed in Table 4.

Table 4. Status of the deficiencies listed in first check-out report.	
Deficiency	Status
The RAMS model produces erroneous results when the 12-hr NGM forecast grids are missing.	Fixed, but not yet tested by AMU.
The RAMS model produced erroneous initializations when bad data (temperature) from one of the CCAFS/KSC wind towers were input to the model.	Broadened to include surface data and rawinsonde data.
In its present configuration, ERDAS requires over 9 CPU hours to produce a 24-hr forecast.	No change.
ERDAS has not yet been properly configured to run the dispersion models.	Fixed.
The ERDAS user interfaces contain numerous minor bugs.	No change.
ERDAS lacks complete documentation.	No change.

**2.6. AMU Chief’s Technical Activities (Dr. Merceret)**

**DTO 805**

At the request of JSC/GF, the AMU Chief processed the standard SLF met tower one second data and the data from the six portable towers for the STS-59 launch countdowns on April 8 and 9, 1994. The data showed some suggestion of sheltering on one of the portable towers and one of the standard towers, but were otherwise mutually consistent. Only the basic statistics were evaluated. A detailed analysis was not requested.

**SLF Wind Study**

The portable towers were deployed in a logarithmically spaced linear array at the north standard met tower site to study the effect of sheltering at that site by nearby foliage. Although the required weather conditions are not climatologically likely this time of year, good data were obtained on June 15, 22, and 23. The results clearly show that sheltering affects the measurements to at least 400 feet from the edge of the foliage.

A modification of the array will permit refinement of the location of the boundary between sheltered and unobstructed flow. This experiment will be run during the next quarter as DTO 805 operations and weather permit. Recommendations for properly clearing the site will be prepared.

A final report of the separation study is being prepared. An abstract of that work was accepted for the Sixth Conference on Aviation Weather, Dallas, TX, January 1995.

### **3. Project Summary**

The AMU completed several tasks this quarter including the artificial neural network to forecast cloud cover, the implementation of the MSFC wind algorithm on NASA's 50 MHz DRWP, the evaluation of fog and stratus at the SLF, and the NEXRAD/McGill Inter-evaluation. The AMU's investigation of the potential use of artificial neural network's was terminated last quarter. The AMU distributed the task's final report in June.

The evaluation and implementation of the MSFC wind algorithm in NASA's 50 MHz DRWP was completed last quarter. As part of the transition process, however, the AMU has continued to provide operational launch support for Titan IV launches. The Titan IV community is currently re-evaluating its upper air wind data requirements and is interested in the potential operational use of the profiler.

The AMU distributed the final report for the SLF fog and stratus evaluation as a NASA contractor report in May, and then provided the McIDAS McBasi utilities developed as part of the study to the RWO and SMG. Mr. Wheeler and Ms. Schumann briefed the Melbourne, FL NWS Office on the key findings from the fog study and on the capabilities and characteristics of NASA's 50 MHz DRWP.

The objective of the NEXRAD / McGill inter-evaluation subtask is to determine whether the current standard NEXRAD scan strategies permit the use of the NEXRAD to perform the essential functions now performed by the Patrick Air Force Base (PAFB) WSR-74C / McGill radar for evaluating Shuttle weather Flight Rules (FR) and Launch Commit Criteria (LCC). The report documenting the results of this investigation has been completed and will be distributed after permission to release the document has been received from the NASA KSC Public Affairs Office.

Other tasks that received attention this past quarter include the development of forecaster applications, the evaluation of the MASS mesoscale model, the Emergency Response Dose Assessment System (ERDAS) Evaluation, the Lightning Detection and Ranging (LDAR) Evaluation, the Boundary Layer Profiler Network Support, the DTO 805, and the SLF wind study.

The AMU continued to enhance the McIDAS menu system shell and developed a customized menu shell for the Launch Weather Officer terminal. This task is an ongoing effort with product deliverables as required.

The AMU is in the process of developing software to compute MASS model performance statistics and to transfer MASS model output back to the IBM mainframe for access through the MIDDS. Dr. John Manobianco presented the results of a preliminary qualitative analysis of the model's performance at the Tenth Conference on Numerical Weather Prediction in Portland Oregon on 21 July 1994. The preliminary

analysis was necessary to test the routines and UNIX scripts undergoing development as part of the complete model evaluation software package.

When the AMU performed the initial functional evaluation of the ERDAS last quarter, ERDAS was not yet configured to execute the diffusion models due to an oversight during installation. When alerted to the problem, MRC/ASTER immediately provided a fix which enabled the diffusion models to execute properly within ERDAS. The AMU then evaluated the diffusion models' functionality and distributed an addendum to the initial functional evaluation report documenting the deficiencies within their implementation. The AMU also tested and documented RAMS' sensitivity to the soil moisture parameter.

AMU personnel met with TE-CID, the group responsible for LDAR's development, to establish the division of labor between the AMU and TE-CID and to ensure the AMU does not duplicate work performed by Dr. Forbes (Pennsylvania State University) who is analyzing LDAR data as part of the summer faculty fellowship program at KSC. During the meeting, it was decided that the AMU would focus their data analysis efforts on winter storms while Dr. Forbes concentrated his efforts on summer electrical activity. The AMU will also develop on-line training tools for interpreting the electrical activity displayed by LDAR. The AMU also worked with the Eastern Range to coordinate the installation of an LDAR workstation and its associated communication line and equipment in the AMU lab area. The installation was completed on 21 June and the system was up and running with real-time data on 22 June.

The AMU Chief evaluated basic statistics on the SLF met tower one second data and the data from the six portable towers for the STS-59 launch countdown. The data showed some suggestion of sheltering on one of the portable towers and one of the standard towers. The AMU Chief also continued working on the SLF wind study to determine the sheltering effects of nearby foliage on the north met tower.

## **Attachment 1: AMU FY-94 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.