Applied Meteorology Unit (AMU)

Quarterly Update Report

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ENSCO, Inc.

445 Pineda Court
Melbourne, Florida 32940
(407) 853-8201 (AMU)
(407) 254-4122

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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 sub task.

2.1. Task 001 Operation of the AMU (Dr. Taylor)

Briefings to SMG and Ascent/Entry Flight Techniques Panel

On January 20-21, Mr. Wheeler visited SMG and presented the results of two projects, the ASOS evaluation and the analysis of rapidly developing fog at KSC, to the SMG staff. These briefings updated SMG staff on the progress and results of the two projects and provided a forum for positive interaction between AMU and SMG personnel. Mr. Wheeler also provided SMG staff with an overview of the AMU's NEXRAD exploitation task and a list of potential AMU NEXRAD subtasks.

On January 21, Mr. Wheeler also participated in a briefing to the Ascent/Entry Flight Techniques Panel. During this briefing, Mr. Wheeler presented a summary of the results of the AMU's 2/10 cloud cover project in conjunction with SMG's presentation on their forecast skill related to the 2/10 cloud cover flight rule.

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

The AMU demonstrated the STA downlink system to the Range during February. The downlink system displays the aircraft track and aircraft wind estimates on a PC and the aircraft track overlaid on McGill radar products.

Development of Forecaster Applications (Mr. Wheeler)

In January, the AMU completed a McBasi routine which computes and displays the two hour velocity change using data from NASA's 50 MHz Doppler Radar Wind Profiler (DRWP). The product allows users to monitor short-term temporal changes in the upper-level winds. Another McBasi routine was developed which displays temperature, relative humidity and wind speed data from Launch Complex 39. The information displayed by the routine was used in the evaluation of the Shuttle Minimum Temperature Launch Commit Criteria (LCC) for STS-60.

The AMU installed McIDAS-X on one of the AMU's IBM RISC 6000 computer systems during March. Preliminary review of satellite imagery indicates the resolution of the McIDAS-X display is better than the McIDAS WIDE WORD workstations. The AMU has not yet worked with the system enough to provide further evaluation.

During March, the AMU supported the RWO during the 45th Space Wing Operational Readiness Inspection. The AMU received several letters of appreciation for the technical assistance provided to the RWO during this inspection.

Throughout this quarter, the AMU enhanced and made corrections to the RWO MIDDS F-key menu systems. Modifications installed in the menu system include

- A User Help sub-menu that provides guidance for the menu system and an interface for the McIDAS help command.
- A System Information sub-menu that provides information about the data currently available within MIDDS.
- Additional sub-menus to facilitate analysis of data and model output.
- Redistribution of the ingest of satellite images between the forecaster and DDMS terminals to reduce load on system resources. This has reduced system load on the primary system CPU by 5%. The AMU expects to reduce the system load due to satellite image loading by 15 to 20% after updating the other two RWO MIDDS terminals.
- Enhancements to the RWO Daily Commander Slide Briefing sub-menu included
    - Capabilities to re-draw the satellite maps and quickly update the briefing slides.
    - An option that allows the user to setup the sequence of images and briefing slides.
    - An error in the menu system which caused the system to “freeze” was discovered and corrected.
- Enhancements to the Aircraft Support sub-menu included
    - Capabilities for the user to select new center points for maps and range rings.
    - Customization of satellite images and maps for either launch or normal operations.

ROCC Configuration Management of AMU Equipment

Although the AMU Memorandum of Understanding (MOU) with the Air Force specifies that AMU systems interactively connected to Range Systems will be configuration managed, that provision has not previously been enforced. With the Range operations Control Center (ROCC) now a fully secure facility, the Air Force announced its intention to enforce that provision of the MOU in order to protect Range assets, ensure systems security, and facilitate maintenance and installation of ROCC systems (including AMU systems).

To ensure that this was accomplished with minimum disruption to AMU operations while offering maximum protection to Range systems, the AMU and Range configuration management (CM) officials met and agreed on which AMU systems will be subject to CM and which are exempt, and also on procedures for future AMU equipment installations or changes.

Generally, (with exceptions) AMU hardware is subject to Range CM while AMU software is exempt. The AMU is currently developing and implementing an internal configuration management plan for software developed or used in house.

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 completed the first draft of the final report documenting the performance of the neural network to forecast cloud cover. The document has undergone internal review and is currently in the revision process. The next draft will be ready for external review in May.

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

The AMU has revised the evaluation of fog development at the SLF final report according to suggestions by the reviewers. After permission to distribute the report is received from the NASA KSC Public Affairs Office, the report will be distributed to all interested organizations. After the final report is distributed, the AMU will, if requested, deliver the MIDDS McBasi tools and fog decision trees to the SMG and RWO for operational implementation.

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

Sub Task 3: Doppler Radar Wind Profiler

Implementation of MSFC DRWP Wind Algorithm (Ms. Schumann)

The AMU completed and distributed all documentation for the implementation of the MSFC wind algorithm in the 50 MHz Doppler radar wind profiler. The documentation included the maintenance manual, users’ manual, test procedures, and final test report.

At the request of the Titan IV community, the AMU provided operational wind profiler support for the Titan IV launch attempt on February 5 and the launch on February 7 and for the launch attempts on April 21, 23 and 26. 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 upper air wind community of any shear detected by the profiler but not by the balloons. The AMU also informed the upper air wind community of any side lobes returns in the profiler data, detectable in the interactive quality control display.

The AMU, in conjunction with MSFC and the NASA/KSC Instrumentation and Measurement Branch, gave a briefing at the Titan IV Day of Launch Working Group Meeting on 10 March. The briefing included detailed information about the 50 MHz Doppler Radar Wind Profiler capabilities as well as the capabilities of the new MSFC data reduction algorithm. The Titan IV community is re-evaluating its wind information requirements.

DRWP Meteorological Evaluation (Dr. Taylor)

The AMU received authorization to distribute the final report on the AMU's evaluation and implementation of the MSFC wind algorithm from the NASA KSC Public Affairs Office in late January. The AMU then distributed the report to interested parties in February.

Sub task 4LDAR Evaluation and Transition

The LDAR evaluation and transition task began in March. Dr. Taylor and Ms. Schumann have toured the LDAR site and has been briefed on the data archive capabilities. The AMU is in the process of investigating the archives of the other lightning detection systems in order to perform statistical comparisons and case study analyses.

The AMU has solicited the RWO and SMG for their particular areas of interest regarding the evaluation. Thus far, RWO has responded with the following items to examine:

- The time lag between when LDAR detects electrostatic discharges and the first cloud-to-ground strike.
- The correlation, if any, between the height of the storm and the likelihood of a cloud-to-ground strike.
- The correlation between the length of time since the last LDAR detected electrostatic discharge and the probability of another cloud-to-ground strike.
- The correlation between electrostatic discharges detected by LDAR and data collected by the other lightning detection systems, especially the field mills.
- Are there signatures in the LDAR data that reveal which storms produce ground strikes and which do not?

Dr. Gregory Forbes (Pennsylvania State University) provided a preliminary review of some of the above items during his 1993 summer faculty fellowship and will continue to investigate them this summer. The AMU is in the process of writing an evaluation plan to ensure that the LDAR evaluation is complete and that the AMU work complements rather than overlaps Dr. Forbes efforts. The evaluation plan should be distributed to the SMG, RWO, NASA/KSC Instrumentation and Measurements Branch, and NASA/ME for their comments in early May.

Given the areas of interest already expressed, the evaluation will require the assimilation of data from several sources. The AMU has had considerable experience assimilating data bases and has found it to require far more resources than the actual analysis itself. In some cases, the data archives were difficult to decode or incomplete. Since most of the analysis will be performed on the 1994 summer data, the necessary steps can be put into place ahead of time to reduce the risk of loss of data. These steps include ensuring robust archive procedures are in place at each of the appropriate sites and ensuring the data the AMU receives are reliably archived for later analysis.

Since it is planned that Dr. Forbes will be here this summer, the AMU will maintain close communications with him to ensure the AMU evaluation does not overlap his work and that any duplication of effort (i.e. data base development) is avoided.

The NASA/KSC Instrumentation and Measurement Branch has already provided the communications end equipment and intends to deliver the LDAR workstation to the AMU in either late May or early June. The AMU is currently working with SMC/OLAK to get the T-1 communication line and end equipment installed and tested prior to delivery of the LDAR workstation.

Sub task 5: Melbourne NEXRAD Evaluation (Dr. Taylor)

During January, the AMU contacted the Operations Support Facility (OSF) to discuss the list of issues and possible AMU tasks identified during meetings with the Melbourne office of the National Weather Service, the RWO, and the SMG during December. The discussion with OSF was primarily to remove from the list any tasks the OSF or other organizations are already addressing, identify high-risk tasks, and determine which tasks have near-term results. Based on the discussion with the OSF, the potential task list was revised and distributed to the three groups for review and prioritization.

By mid-March the AMU had received all responses to the AMU request for prioritization of potential NEXRAD Exploitation tasks. The priority values given by each organization for each item in the potential task list were then added together to determine each item’s overall priority. The AMU is currently in the process of defining the specific subtasks of the AMU's NEXRAD Exploitation effort. Once the subtasks have been clearly defined and all the technical issues have been resolved, the AMU will distribute a memorandum to the three organizations regarding the details of the subtasks for their review and then hold a project review meeting to finalize the subtasks and ensure there is no duplication of efforts.

An Air Force provided NEXRAD PUP was installed in the AMU laboratory during the week of 21 March. Although numerous roadblocks arose during the installation, Air Force, CSR, Harris, Paramax, and JSPO personnel worked together as a cohesive team to resolve significant issues and successfully complete the installation of the PUP. Although the entire acceptance test could not be performed because of the lack of a dedicated communications line to the MLB WSR-88D, the components of the acceptance test which were performed were successfully completed.

The only significant issue with the AMU PUP still unresolved is the lack of a dedicated communications line to the MLB WSR-88D. The Air Force is currently working this issue and may get the dedicated communications line turned on as early as May 1994. Until the AMU PUP receives the dedicated communications line, the AMU PUP will be able to replay data archived on the RWO and/or MLB PUP and access the MLB RPG via a dial-up line for real-time capability. Consequently, the AMU will be able to address technical issues associated with the NEXRAD Exploitation task by reviewing archived data and displaying real-time data using the dial-up communications line.

Sub Task 7: ASOS Evaluation (Ms. Yersavich)

During the last quarter, the AMU incorporated the comments and suggestions received from the reviewers and completed the final version of the report *Evaluation of ASOS for the Kennedy Space Center's Shuttle Landing Facility*. The final version of the report was approved for publication as a NASA contractor report and was delivered to all interested organizations during March.

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

This past quarter, the AMU began work on the NEXRAD / McGill inter-evaluation subtask. The objective of this 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 weather Flight Rules (FR) and Launch Commit Criteria (LCC).

Products from the two weather radars are currently used by Range Weather Operations (RWO) and Spaceflight Meteorology Group (SMG) to support evaluation of a number of weather FR and LCC. Specifically, the weather radars are used to evaluate rain showers, cumulus clouds, thunderstorms, anvils, and debris clouds which are near the launch / landing site or near the projected flight path of the vehicle. Although each weather phenomena has unique proximity requirements relative to the launch / landing site or the projected flight path, RWO and SMG forecasters are generally concerned with the presence of any of the aforementioned weather phenomena within a 85 km (40 nautical mile) radius cylinder from the launch / landing site. The 85 km radius cylinder encompasses the proximity requirements of all the weather FR and LCC plus provides for a buffer zone for phenomena which are close to but not within the critical region.

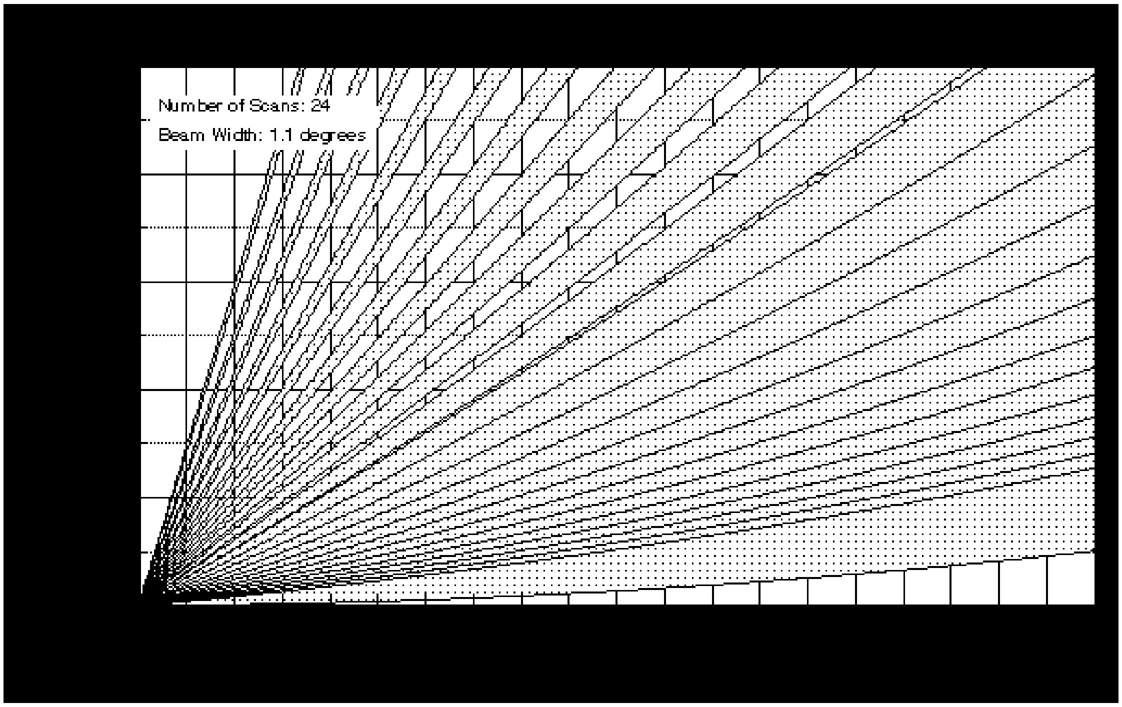

Figure 1. Radar beam coverage of the WSR-74C / McGill radar located at Patrick Air Force Base.

The McGill radar under evaluation is a WSR-74C (5 cm radar) located at PAFB (Figure 4). It has a five minute update rate, a beam width of 1.1°, and uses 24 different scans from 0.6° to 35.97° elevation. The radar beam coverage of the McGill radar is illustrated in Figure 1. Although the lowest elevation scans provide good coverage, they are not efficient since they have considerable overlap. In addition, although the McGill radar uses 24 scans, the higher elevations scans are not contiguous resulting in gaps in radar coverage at higher altitudes near the radar.

The WSR-88D radar under evaluation is the National Weather Service (NWS) radar located at the Melbourne NWS Office in Melbourne, Florida (Figure 5). The WSR88D is a 10 cm radar with a 0.95° beam width and has two standard precipitation volume coverage patterns (VCP), the precipitation/severe weather scan (VCP 11) and the alternative precipitation scan (VCP 21).

The alternative precipitation scan strategy uses 9 scans from 0.48° to 19.51° elevation and has a six minute update rate. The lowest five elevation scans are contiguous; however, there are severe coverage gaps at most altitudes near the radar. VCP 21 is used primarily to reduce processing load on the Radar Products Generator (RPG) when the precipitation echoes of interest are far from the radar (e.g., of the order of 150 km). This VCP is not adequate for use in the evaluation of weather FR and LCC.

The precipitation/severe weather scan strategy uses 14 scans from 0.48° to 19.51° elevation and has a five minute update rate. The radar beam coverage of the VCP 11 is illustrated in Figure 2. The lowest seven elevation scans are contiguous, provide good radar coverage, and are more efficient (i.e., no overlap) than the corresponding McGill scans. The highest seven elevation scans are not contiguous resulting in gaps in radar coverage at higher altitudes near the radar.

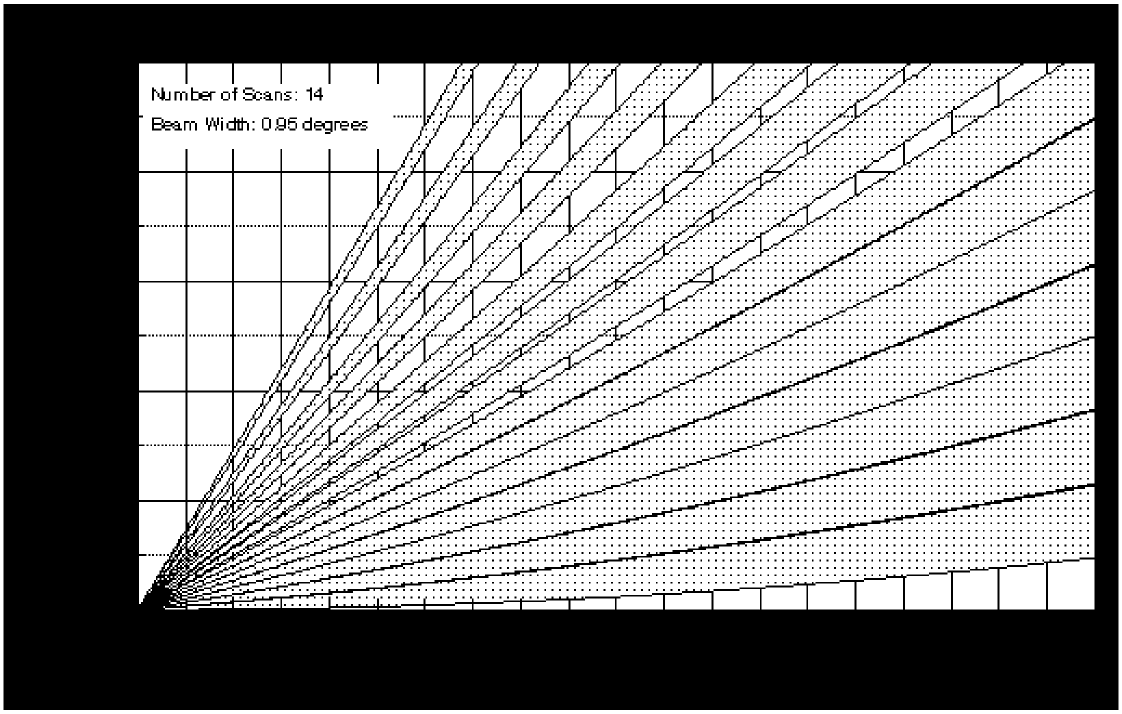

Figure 2. Radar beam coverage for VCP 11 of the WSR-88D radar.

Although the data in Figures 1 and 2 illustrate the radar beam coverage of the two weather radars, it is not easy to infer the differences in radar beam coverage between the two radars from these two diagrams. Consequently, the percent of the atmosphere sampled by the radar as a function of horizontal distance from the radar has been generated. One example of this type of analysis, using the 4 to 8 km layer of the atmosphere, is presented in this report. The 4 to 8 km region was selected for evaluation since the presence of precipitation echoes in this region of the atmosphere is associated with the development of lightning potential.

Figure 3 illustrates the percent of the atmosphere between 4 and 8 km above ground level sampled by the McGill radar and by the WSR-88D radar using VCP 11. The largest differences in percent of the atmosphere sampled occur within the first 20 km of the radar. This is a result of the higher elevation angles of the top scans within the McGill scan strategy as compared to the elevation angles of the top scans within VCP 11 of the WSR-88D. Within the band from 20 to 65 km of the radar, the McGill scan strategy samples approximately 10% more of the atmosphere than the VCP 11 scan strategy of the WSR-88D. Outside of 65 km, there is little difference in the percent of the atmosphere sampled by the McGill radar and the WSR-88D using VCP 11. The data in figure 3 indicate that the McGill radar provides good coverage (i.e., greater than 70% of the atmosphere sampled) of the 4 to 8 km region outside of 35 from the radar and the WSR-88D using VCP 11 provides good radar coverage of the 4 to 8 km region outside of 40 km from the radar.

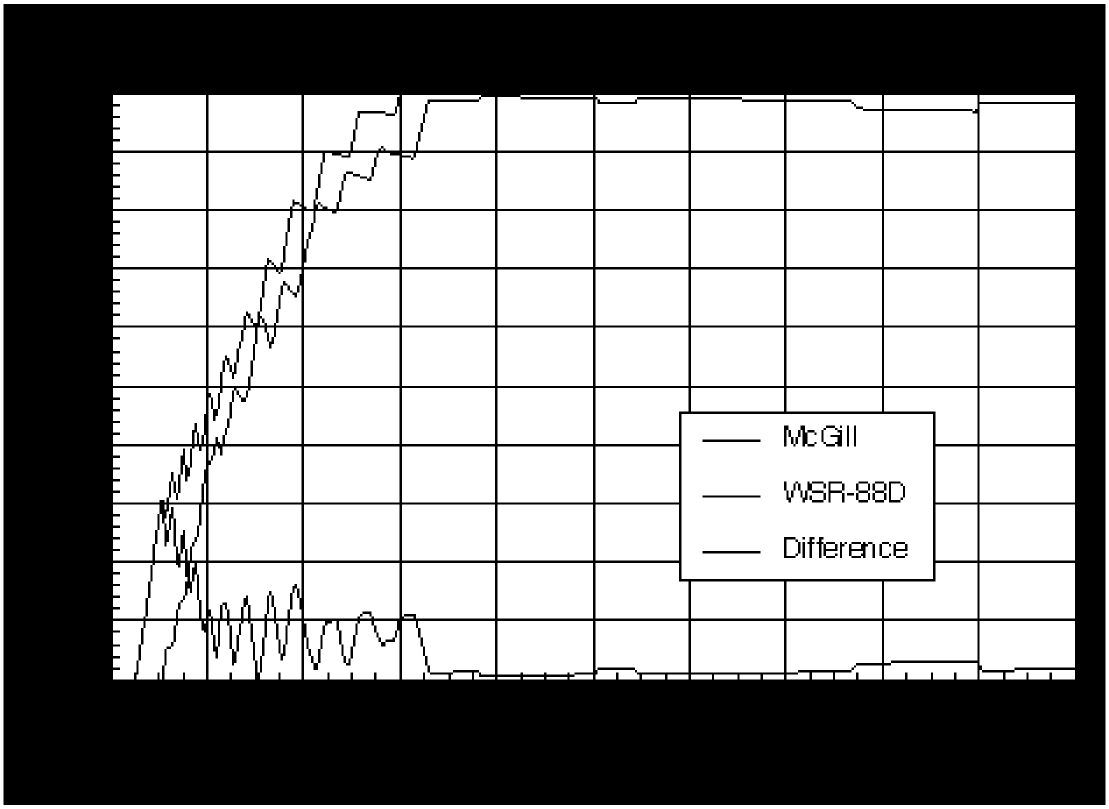

Figure 3. Percent of the atmosphere between 4 and 8 km above ground level sampled by the WSR-74C / McGill radar and the WSR-88D using VCP 11. The difference in percent of the atmosphere sampled is defined as the percent of the atmosphere sampled by the WSR-74C / McGill less the percent of the atmosphere sampled by the WSR-88D.

Although the data in Figure 3 provide valuable information regarding the beam coverage of the scan strategies of the two radars, they do not provide a complete analysis of the beam coverage of the two radars relative to the use of the radars for weather FR and LCC evaluations since the two radars are not co-located and the distance from the radar to areas of concern are not included in the analysis. Consequently, the radar beam coverage of the 4 to 8 km layer of the atmosphere of the McGill radar located at PAFB and the WSR-88D using VCP 11 located at the NWS at Melbourne, Florida, relative to the east coast of Florida is presented in Figures 4 and 5. In both figures, the shaded region represents the cylinder of the atmosphere within 85 km (40 nautical miles) of launch complex 39A which approximates the primary region of concern for use of the radars in weather FR and LCC evaluations. The data in the two figures indicate that the radar beam coverage is good (i.e., exceeds 70% sampled) for both radars for the majority of the area within the region of concern and exceeds 90% for both radars for almost all of the northern half of the area of concern. However, the radar beam coverage of both radars is poor (i.e., less than 50% sampled) for a limited area within the southern half of the region of concern.

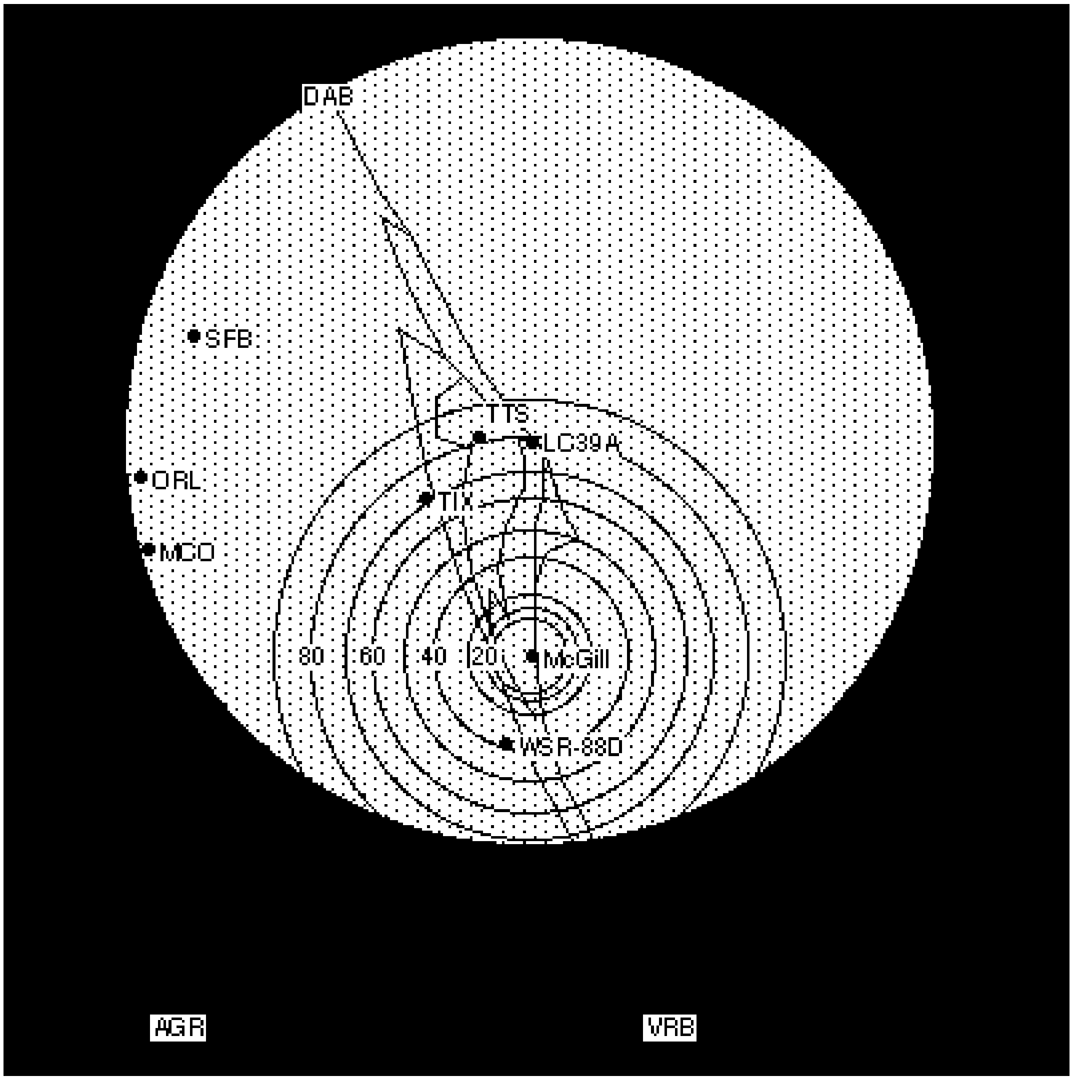

Figure 4. Isolines represent percent of the atmosphere between 4 and 8 km above ground level sampled by the WSR-74C / McGill radar located at PAFB. Shaded region represents the cylinder of the atmosphere within 85 km (40 nautical miles) of launch complex 39A. Acronyms and abbreviations used are: TTS = Shuttle Landing Facility, TIX = Tico Executive, DAB = Daytona Beach, SFB = Sanford, ORL = Orlando Executive, MCO = Orlando International, AGR = Avon Park, VRB = Vero Beach, LC39A = Launch Complex 39A.

The difference in percent of the atmosphere sampled by the WSR-74C /McGill radar located at PAFB and the WSR-88D located at the NWS Office in Melbourne relative to the east coast of Florida is illustrated in Figure 6. The data indicate that the difference in percent of the atmosphere between 4 and 8 km sampled by the two radars is less than 10% for most (i.e., greater than 50%) of the area of concern. However, because of the different scan strategies employed by the two radars and the different locations of the two radars, there are limited regions of significant differences in radar beam coverage between the two radars within the area of concern. For example, the McGill radar provides better radar beam coverage in the extreme southern region of the area of concern. Conversely, the WSR-88D provides slightly better radar beam coverage over the region extending from the McGill radar site to Cape Canaveral.

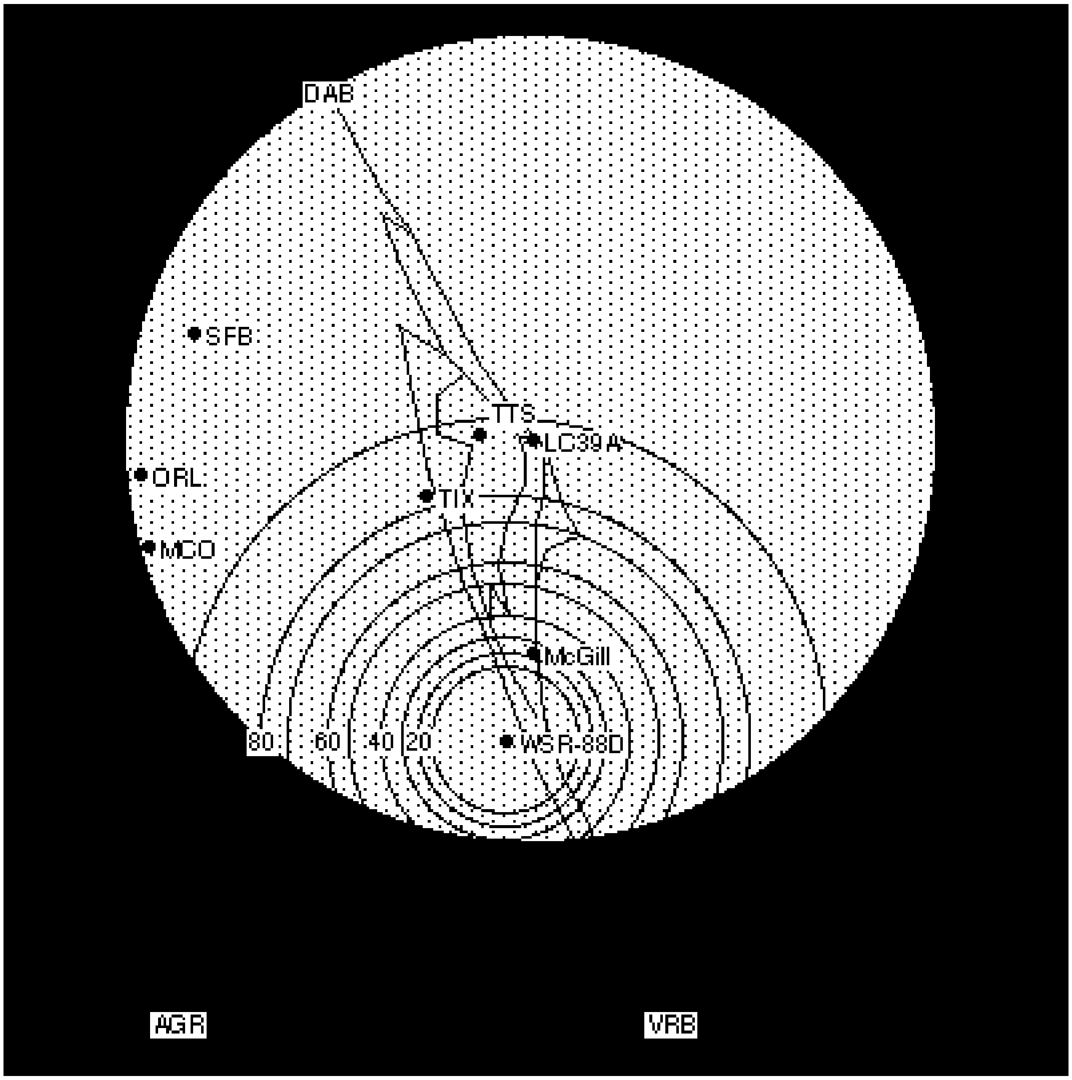

Figure 5. Isolines represent percent of the atmosphere between 4 and 8 km above ground level sampled by the WSR-88D located at the NWS Office in Melbourne, FL, using VCP 11. Shaded region represents the cylinder of the atmosphere within 85 km (40 nautical miles) of launch complex 39A. Acronyms and abbreviations used are as in Figure 4.

The data examined thus far indicate that there are differences in the radar beam coverage patterns of the WSR-74C / McGill radar located at PAFB and the WSR-88D located at the NWS Office at Melbourne, Florida, relative to the use of the radars for weather FR and LCC evaluations. The differences in radar beam coverage are due to both the differences in the scan strategies employed by the two radars and the locations of the radars relative to the area of concern. Both radars provide good radar beam coverage within the 4 to 8 km layer for most of the area of concern. However, both radars also provide poor radar beam coverage in the 4 to 8 km layer within limited regions in the area of concern.

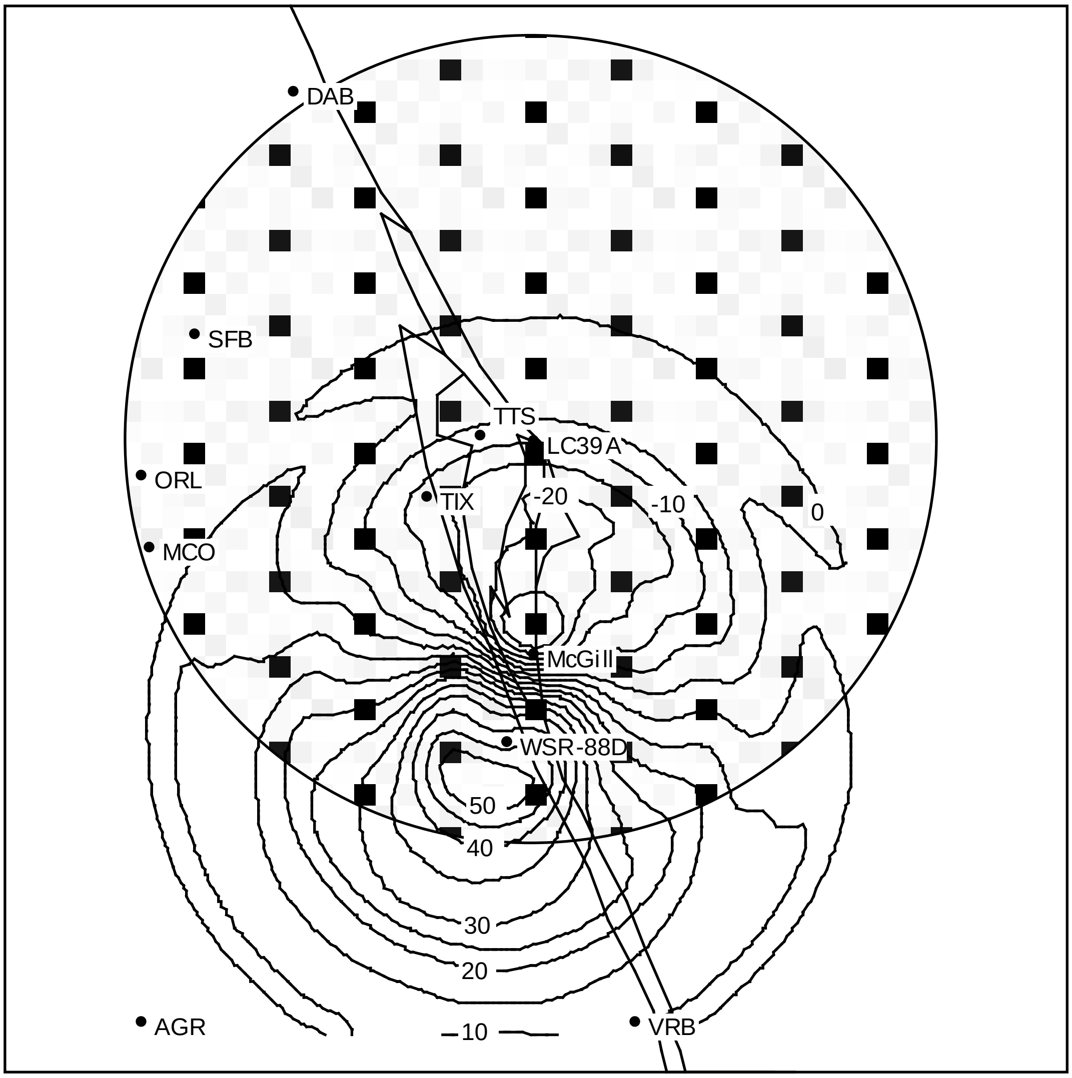

Figure 6. Isolines represent the difference in percent of the atmosphere between 4 and 8 km above ground level sampled by the WSR-74C / McGill radar located at PAFB and the WSR-88D located at the NWS Office in Melbourne, FL, using VCP 11. The difference in percent of the atmosphere sampled is defined as the percent of the atmosphere sampled by the WSR-74C / McGill less the percent of the atmosphere sampled by the WSR-88D. Thus, positive values indicate superior coverage by the McGill radar. Shaded region represents the cylinder of the atmosphere within 85 km (40 nautical miles) of launch complex 39A. Acronyms and abbreviations used are as in Figure 4.

This investigation will be completed during the next quarter. Additional analyses to be performed include the evaluation of radar beam coverage within different layers of the atmosphere.

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 preparation of two documents describing proposed and recommended configurations for running the MASS preprocessor and model and the evaluation plan for the MASS model.

The following sections present selected material from these documents.

Recommended MASS Configuration

The AMU proposed three configurations for running the MASS model, listed the advantages and disadvantages of each configuration, and then recommended one of the three configurations be used to run MASS and archive cases for model evaluation. This section discusses the recommended MASS pre-processor and model configuration including a description of the initialization data sources, the daily model forecast and data assimilation cycles, and the approximate times model output would be available to forecasters.

Daily Pre-Processor Cycle

The pre-processor currently uses rawinsonde, surface, KSC tower, buoy, ship, infrared (IR) satellite, and manually digitized radar data to initialize coarse and fine grid simulations. The first guess fields for objective analyses and boundary conditions for coarse grid runs are derived from NMC's 6-hourly Nested Grid Model (NGM) output. In contrast, the first guess fields and boundary conditions for fine grid runs are derived from 1-hourly coarse grid output.

Daily Model Forecast and Data Assimilation Schedules

The MASS model is set-up to run with a coarse grid of 45 km covering the southeastern United States and a fine grid of 11 km covering the Florida peninsula, and the eastern Gulf of Mexico and western Atlantic Ocean. The vertical spacing of the model's 20 sigma layers used for both coarse and fine grid runs varies from ~20 m at the lower boundary (i.e. the surface) to ~2 km at the upper boundary (i.e. 100 mb).

The daily model forecast and data assimilation schedule consists of two 24-h coarse grid and two 12-h fine grid runs per day. The 24-h coarse grid run designated C00 is initialized with 0000 UTC data and assimilates hourly surface and MDR data from 0000-0400 UTC. The 12-h fine grid run designated F12 is initialized with 1200 UTC data and assimilates 1300 UTC surface and MDR data. The 12-h forecast from C00 (valid at 1200 UTC) provides the first guess fields for the objective analysis of 1200 UTC data used for F12 initialization. Additionally, the 12-24 h forecast fields from C00 are used to specify boundary conditions for the F12 run.

The cycle is repeated using 1200 UTC data to initialize the 24-h coarse grid run designated C12 and 0000 UTC data to initialize the 12-h fine grid run designated F00. The C00-F12 and C12-F00 run cycles are identical with respect to the length of the forecasts, use of first guess initialization and boundary condition data, and length of data assimilation periods. The time table for the C12-F00 run cycle differs from the time table for the C00-F12 run cycle by approximately 12 h.

Some forecast products from C00 are available as early as 1030 UTC whereas all forecast products from C00 are available by 1230 UTC. Some forecast products from F12 are available as early as 1630 UTC whereas all forecast products from F12 are available by 1830 UTC. The attributes and time table for the MASS configuration are summarized in Figure 7.

The first half of Figure 7 illustrates the data assimilation and forecast schedule for the model runs. The thick lines represent the period during which data are assimilated into the model and the thin lines represent the forecast period. The second half of the figure depicts the cycle start times associated with each model run and the times when its associated forecast products become available. The total cycle execution time (i.e. cycle start time subtracted from time all products are available) includes the cycle's preprocessor and model run-times .

The advantages of the MASS configuration are that:

- The F00 and F12 fine grid simulations utilize all available 1200 UTC or 0000 UTC data and begin at the earliest time that these data are available to the Stardent 3000.
- The first guess fields used to initialize 24-h coarse grid runs (C00 and C12) are obtained from the current NGM analyses (e.g. 1200 UTC coarse grid runs are initialized using 1200 UTC NGM analyses).
- Model output from the 1200 UTC or F12 fine grid run will be available by 1630 UTC for use in evaluating the potential for convective activity during the active thunderstorm season (June-August).

The disadvantages of the MASS configuration are that:

- All forecast products from the C00 (C12) run are not available until about 12.5 h after the 0000 UTC (1200 UTC) initialization time (see Figure 7) indicating that only about 11.5 h of the coarse grid runs are useful for forecasting *after the runs have been completed.*
- All forecast products from the F00 (F12) run are not available until roughly 6.5 h after the 0000 UTC (1200 UTC) initialization time (see Figure 7) indicating that only about 5.5 h of the fine grid runs are useful for forecasting *after the runs have been completed.*

- The C00 and C12 coarse grid simulations begin much later than is necessary based upon the availability of NGM gridded fields and observational data. Note that the C00 and C12 run cycles start more than 7 h after initialization time due to the processing time required for the F00 and F12 runs.

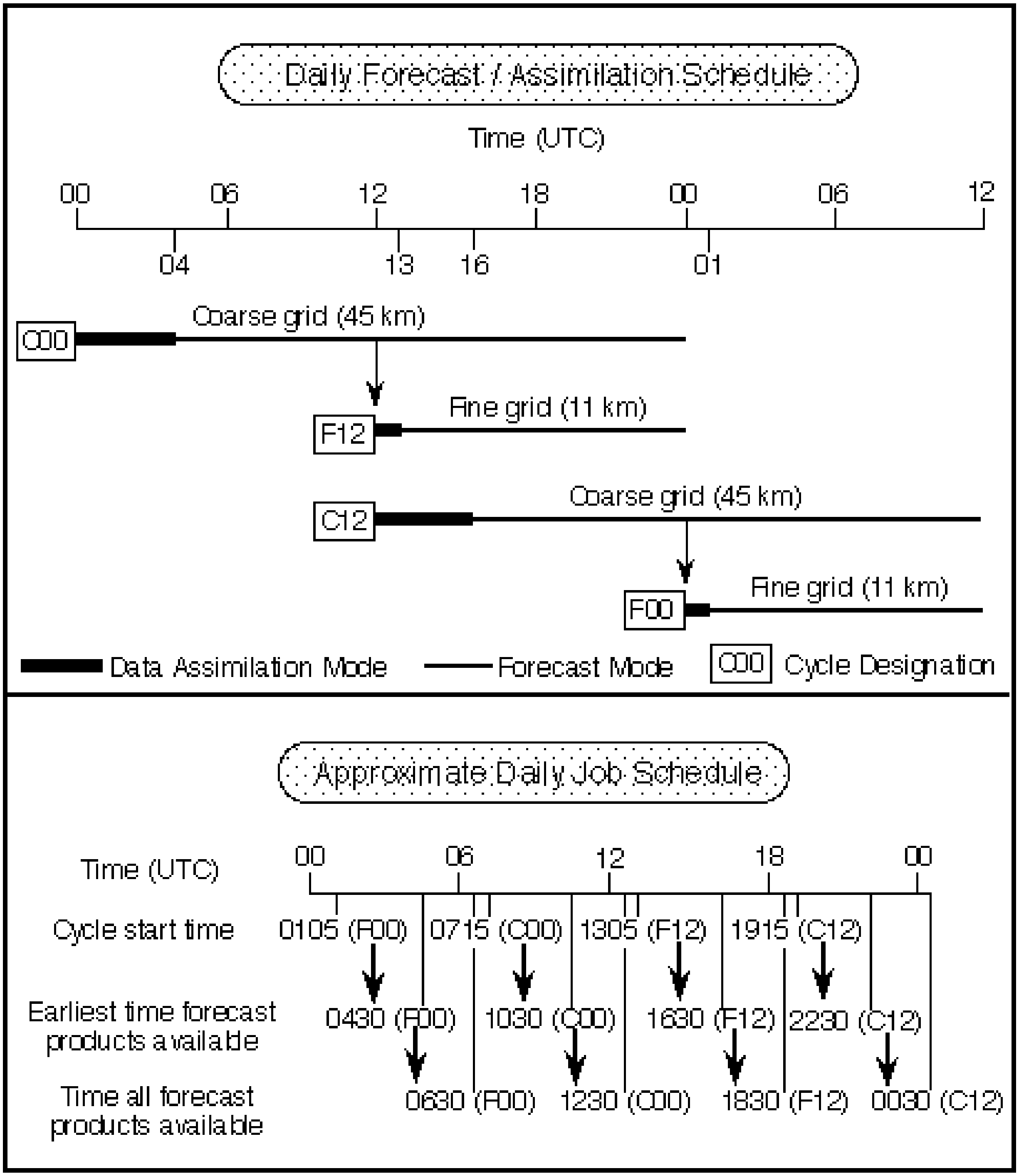

Figure 7. A schematic of the real-time daily forecast, data assimilation, and job schedule for the MASS pre-processor and model.

There are many possible MASS pre-processor and model configurations that can be specified. MESO, Inc. had originally designed MASS to provide short-range (< 24 h) localized and accurate forecasts of thunderstorm-related phenomena over small space-time windows (11 km; 1-2 h). The recommended MASS configuration provides this capability. In addition, the C00-F12 and C12-F00 run cycles are identical so that the most current MASS model run will be available to provide year-round guidance for weather forecasting during any ground or spaceflight operations at KSC/CCAFS.

The configuration focuses on initializing the fine grid simulations with current data since these runs will provide the most useful guidance over the central Florida area for the occurrence of convective precipitation, clouds, winds, fog, etc. Without additional observational data, the fine grid runs are only continuations of the coarse grid runs starting from the 12-h coarse grid forecasts. Rather than begin the F00 and F12 run cycles earlier and sacrifice opportunities to include current data, the AMU is exploring ways to provide more timely forecast products by reducing all cycle execution times.

The AMU solicited comments, questions, and concerns from the Range Weather Operations (RWO), Spaceflight Meteorology Group (SMG), and National Weather Service (NWS), Melbourne regarding the proposed and recommended MASS configurations. The AMU has received written input from Major Robert Thorp (RWO), and verbal input from Mr. James Keller (SMG) and Mr. David Petersen (NWS). Most of the feedback from RWO, SMG, and NWS consisted of questions and clarifications regarding the proposed configurations. RWO, SMG, and NWS concurred with the AMU's recommended configuration for running MASS. Specific comments and concerns are as follows:

- SMG suggested that Eta or Rapid Update Cycle (RUC) grids rather than coarse resolution (1.25° x 2.5°) NGM grids be used for model initialization. The pre-processor and model are designed to use Eta or RUC grids when they become available in MIDDS.

- SMG would like the 0000 UTC fine grid forecast length extended by 6 h to provide 11 km guidance for Shuttle landings that are scheduled after 1200 UTC. The length of model runs can be extended when the cycle execution times are reduced.

- NWS suggested that 12-h NGM forecasts from previous NGM run cycles rather than current NGM analyses be used for model initialization. The primary motivation for using 12-h NGM forecasts is that the NGM underestimates precipitation and vertical motion for approximately the first 12 h of each forecast cycle.

MASS Evaluation Plan

The MASS is running in real-time using the pre-processor and model configuration described in the preceding sections. The archiving of real-time model runs began on 15 January 1994 and will continue until 15 October 1994. There are potentially 544 coarse and 544 fine grid runs available for model evaluation in this ten month period covering the winter, spring, summer, and fall seasons of 1994. The AMU completed and distributed a document in March 1994 describing a plan for evaluating the MASS model. The AMU is presently waiting for verbal and/or written comments, questions, and concerns from the RWO, SMG, and NWS regarding the plan. The following sections present highlights of the evaluation plan.

Objective Evaluation Strategy

The objective verification of the MASS model will include both gridded and point (or station) comparisons of predicted and observed variables. The coarse and fine grid MASS analyses are generated every 12-h. First guess fields for the coarse grid objective analyses and boundary conditions are derived from Nested Grid Model (NGM) output. Similarly, first guess fields for the fine grid objective analyses and boundary conditions are derived from coarse grid output. Therefore, coarse grid forecasts are highly dependent on NGM forecast errors and fine grid forecasts are highly dependent on coarse grid forecast errors. For these reasons, it is important to quantify and compare coarse grid and NGM forecast errors. Tables 1, 2, and 3 summarize the key aspects of the objective evaluation criteria..

Table 1. NGM objective evaluation criteria

	Variable	Level	Forecast time	Verification Data
Gridded	T, q^1, u, v	850, 500, 300 mb	12-h, 24-h	NGM analyses

[1]q = specific humidity (gm kg^{-1})

Table 2. 45 km coarse grid objective evaluation criteria

	Variable	Level	Forecast time	Verification Data
Gridded	T, q^1, u, v	850, 500, 300 mb	12-h, 24-h	MASS analyses
	T, T_d^2, u, v	10 m	12-h, 24-h	MASS analyses
	$MSLP^3$	-	12-h, 24-h	MASS analyses
	precipitation	surface	hourly	rain gauge analyses
Station	T, T_d, u, v	mandatory levels	12-h, 24-h	rawinsondes
	u, v	2 km, 3 km, etc.	hourly	KSC wind profiler
	T, T_d, u, v, MSLP	surface	hourly	surface stations
	precipitation	surface	hourly	rain gauges
	T, u, v	54 ft	hourly	KSC towers

[1]q = specific humidity (gm kg^{-1})
[2]T_d = dew point temperature
[3]MSLP = mean sea level pressure

Table 3. 11 km fine grid objective evaluation criteria

	Variable	Level	Forecast time	Verification Data
Gridded	precipitation	surface	hourly	rain gauge analyses
Station	T, T_d[1], u, v	mandatory levels	12-h	rawinsondes
	u, v	2 km, 3 km, etc.	hourly	KSC wind profiler
	T, T_d, u, v, MSLP[2]	surface	hourly	surface stations
	precipitation	surface	hourly	rain gauges
	T, u, v	54 ft	hourly	KSC towers

[1]T_d = dew point temperature
[2]MSLP = mean sea level pressure

45 km (Coarse) Gridded Verification

The 12-h and 24-h coarse grid MASS model forecasts will be compared with the corresponding MASS analyses over the entire coarse grid domain. Additionally, the 12-h and 24-h NGM forecasts will be compared with the corresponding NGM analyses over the same domain. For grid point comparisons, standard statistics such as the root mean square (RMS) error and bias will be used to verify temperature (°C), specific humidity (gm kg^{-1}), and vector wind (m s^{-1}) at 850 mb, 500 mb, and 300 mb, temperature, dewpoint, and vector wind at 10 m, and mean sea-level pressure (MSLP).

The verification of MASS model precipitation forecasts requires observed data that can accurately sample the highly variable spatial and temporal patterns of precipitation. The MASS model precipitation forecasts will be verified using hourly rain gauge observations collected by the Florida water management districts over the entire state (excluding the panhandle). These data are available in digital form from each district approximately two months after the observations are collected.

11 km (Fine) Gridded Verification

The 12-h gridded forecasts from the 11 km fine mesh MASS model runs will not be verified against the corresponding 11 km MASS analyses at or above the surface. The 11 km gridded statistics will not be computed because, at this resolution, the model will generate features such as mesolows and mesohighs associated with areas of convection that will often be poorly resolved or not resolved by the analysis of surface and rawinsonde observations.

However, 11 km gridded precipitation forecasts can be verified using the high spatial and temporal resolution rain gauge data that will be obtained from the water management districts. The rain gauge data will be objectively analyzed to the model's fine grid over the Florida peninsula for comparison with the 11 km gridded precipitation forecasts. The statistics and procedures used to verify fine grid precipitation will be analogous to those described above for verifying coarse grid precipitation.

Station Verification

The skill of coarse and fine grid temperature, moisture, and wind forecasts at individual stations or points will be assessed by interpolating the model data to the observation locations and then computing statistics such as RMS errors, bias, etc. The coarse (45 km) and fine (11 km) grid forecast output will be compared with temperature, dewpoint, and wind at mandatory levels from 0000 UTC and 1200 UTC rawinsondes, 50 MHz profiler winds at specified heights (2 km, 3 km, etc.), hourly temperature, dewpoint, wind, and MSLP from surface stations, hourly precipitation from the water management district rain gauges, and hourly temperature and wind at the 16.6 m level from KSC/CCAFS instrumented towers.

The comparisons of model forecasts with station observations will be restricted to land grid points only within a subset of the 11 km domain since, with the exception of precipitation data, mesoscale data are available primarily around KSC/CCAFS. Additionally, the comparison of 45 km and 11 km grid forecasts at the same location is only possible during the 12-h fine grid forecast period over the smaller fine grid domain. However, point forecasts will be evaluated using coarse grid output from the 12-24 h period of the coarse grid runs.

Subjective Evaluation Strategy

The subjective or phenomenological verification of the MASS model will use a case study approach to document the success and failure of model forecasts during specific weather regimes. Individual forecasts will be examined to reveal aspects of model performance in different regimes which are masked by compositing error statistics over many cases. At least two case studies from winter and summer will be performed to assess model skill in forecasting events such as the (1) location and movement of fronts, (2) timing, location, and intensity of convective precipitation, and (3) onset, depth and propagation of land- and sea-breezes. In addition, sensitivity experiments will be performed on the selected cases to isolate how and why various attributes of MASS (such as initial or assimilated data, physics, resolution, etc.) affect model forecast skill.

Derivation of Model Output Statistics (MOS)

MASS was designed specifically for short-range weather forecasting in support of spaceflight and ground operations at KSC/CCAFS. As part of this system, MESO, Inc. combined model output with observed variables to develop a Mesoscale Statistical-Dynamical Thunderstorm Prediction System (MSTPS) capable of generating hourly probability forecasts of specific thunderstorm-related events at KSC over small space-time windows (11 km; 1-2 h). The development of the statistical model equations and the application of the MSTPS are discussed at length in MESO, Inc.'s final report that was delivered to NASA KSC in June 1993. The results indicated that the MSTPS has the potential to provide a substantial gain in the ability to forecast objectively thunderstorm events over small space-time windows. However, MESO, Inc. identified two deficiencies with their version of the MSTPS relating to:

- the difficulty in obtaining complete daily data sets of observations from MIDDS via modem connection through KSC, and
- the size and scope of the real time forecast data base.

The AMU's current archiving procedure is extremely reliable which should produce a very complete observational data set. Furthermore, the real-time data base being collected for the evaluation of MASS during 1994 will contain observations and model forecasts for more than 500 cases. Given a more complete and extensive data base, the AMU will:

- derive similar model output statistics (MOS) using the procedures followed by MESO, Inc. from a dependent data set consisting of roughly one half of the archived cases during the active thunderstorm season (June-August), and then
- apply the MOS to an independent data set consisting of the remaining cases during the June to August period.

During the evaluation, the AMU will review the MSTPS approach, make modifications and/or enhancements as required, and then evaluate the skill of the system in forecasting thunderstorm probabilities for KSC/CCAFS over short space-time scales.

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

The Emergency Response Dose Assessment System (ERDAS) is a prototype, turn-key software and hardware system that produces mesoscale meteorological forecast and dispersion estimates for the KSC/CCAS region. ERDAS includes the following two major software systems:

- RAMS (Regional Atmospheric Modeling System) to produce three-dimensional wind field forecasts and
- HYPACT (Hybrid Particle and Concentration Transport) to produce pollutant trajectories and concentration fields.

The Air Force has provided funding for an additional person in the AMU to evaluate the operational viability of the ERDAS. ERDAS was installed in the AMU laboratory in March. Mr. Evans joined the AMU at that time and began a system functional check-out to produce a list of system deficiencies. The following paragraphs contain a summary of the results from the initial check-out and operation of ERDAS.

Following system installation, ASTER configured ERDAS to automatically obtain the required meteorological input data from MIDDS and run the RAMS model twice a day. During the first six weeks of operation, ERDAS has experienced several hardware and software problems. ASTER and AMU personnel have worked together to fix the problems and the system is now running and producing regular RAMS output.

The AMU conducted the system functional check-out by:

- Ensuring that the RAMS model automatically executed and that all data files, scripts, modules, and programs existed and were properly configured.

- Exercising the following different ERDAS functions:

  - ERDAS User Interface
  - Forecast Preparation
  - RINGI (RAMS Interactive NCAR Graphics Interface)
  - Diffusion models

The following paragraphs contain the significant as well the minor deficiencies discovered during the initial system checkout. Also included are AMU recommendations for system improvements which are not necessarily remedies to system deficiencies but which are related to making ERDAS more robust for operations support.

Significant Results

Successes

During the initial ERDAS system check-out the AMU observed the following successes:

- **The RAMS model automatically runs twice a day beginning at 00Z and 12Z.** Some initial hardware and software problems prevented these runs during the first month. These problems have since been corrected and RAMS now produces output which can be displayed within the ERDAS user interfaces.

- **A subjective look at a few of the RAMS forecasts indicates that they compared reasonably well with observations.** RAMS produces 3-dimensional hourly forecasts of basic meteorological parameters (e.g. pressure, winds, temperature and humidity) for each of three different sized grids. An objective verification of the RAMS forecast will be conducted as part of the AMU's task on ERDAS evaluation.

- **Initial hardware and disk problems that occurred during the first month of ERDAS operation were fixed.** The primary problems which were fixed were:

  - The RAMS model was modified to allow for missing NGM grids. (However, some problems still occur when the 12-hr NGM grids are missing. See the Deficiencies section below.)

- Scripts were modified to allow successful model execution.
- The AMU's Stardent computer hard disk was repaired after it crashed and prevented ERDAS from obtaining meteorological input data.
- The ERDAS external hard disk which stores RAMS output and critical libraries was fixed by replacing a cable and restoring its data.

Deficiencies

During the initial ERDAS system check-out the AMU discovered the following deficiencies:

- **The RAMS model produces erroneous results when there is a missing NGM 12-hr forecast grid.** ERDAS is currently configured to start running the RAMS model twice daily with start times of 00Z and 12Z. To produce forecasts, RAMS requires NGM grids to initialize and to provide boundary conditions for the forecast times. The best initialized grid which RAMS could use would be the NGM initial analysis grids. However, the NGM initial analysis grids which are valid at the start time of the RAMS runs are not available until approximately 3 hours after RAMS starts running. Therefore, ASTER and the AMU decided to use the 12-hr NGM forecast grids produced from the previous 12-hr NGM run as the initial NGM grid in the RAMS run. This 12-hr NGM forecast grid is used to initialize the RAMS model. The NGM forecast grids for the other time periods (6-hr, 12-hr, 24-hr, etc.) provide RAMS with boundary conditions for its forecast periods.

  As discussed in the Forecast Preparation section below, it was discovered during ERDAS installation that RAMS would not run if any NGM grids or the different time periods were missing. It is not uncommon for approximately one to four NGM forecast grids out of a possible 368 to be lost during the transmission route from the National Meteorological Center to the MIDDS NGM database. After ERDAS installation, ASTER modified RAMS to allow for missing NGM grids. However, there is still a problem when the 12-hr NGM forecast grid, the NGM grid which RAMS uses for its initialization, is missing. RAMS will run with the missing grids but produces erroneous results in its initialization and subsequent forecasts.

- **The RAMS model produced erroneous initializations when bad data (temperature) from one of the CCAFS/KSC wind towers were input to the model.** An erroneous temperature was getting into the MIDDS tower data (Tower 398 had a temperature of 10˚F). This bad temperature caused the model to produce an anomalous initialized temperature field. A data quality control procedure is needed in ERDAS to prevent this problem. The current ERDAS data ingest program discards tower temperatures below -80˚F. We recommend putting a different check in the data ingest program. Another quality control procedure which could be implemented is a buddy check in the Barnes routine to quality control surrounding data. However, this check may be computationally intensive and could slow down the model runs. The issue of data quality control within ERDAS is something that should be investigated and discussed with the ERDAS evaluators, developers, and users.

- **In its present configuration, ERDAS is taking a little over 9 CPU hours to produce a 24-hr forecast.** Presently, the model is set to begin running at 1.5 hours after data initialization at 00Z and 12Z. The model then runs for approximately 9 hours with a ratio of CPU time to simulation time of 1 to 2.7. ASTER estimated in the System Design Document that the model would take 6 hours to run for a CPU to simulation ratio of 1 to 4. ASTER will need to reduce the number of grid points to reduce the RAMS computational time.

- **Presently, ERDAS has not been properly configured to run the diffusion models.** ASTER is currently working on this problem and should have the diffusion models connected and running soon. Therefore, the AMU has not yet evaluated the ERDAS diffusion models. Once ERDAS is properly configured the AMU will run and test the REEDM and HYPACT diffusion models. ASTER has not completed the coding of the OBDG and AFTOX diffusion models so they may not be available within ERDAS for some time.

- **The ERDAS user interfaces have numerous minor bugs.** These bugs are listed and discussed in the Detailed User Interface Deficiencies section.

- **ERDAS lacks complete documentation.** ASTER provided an unfinished ERDAS users manual, and they also did not provide adequate maintenance documentation. The users manual only discusses how a user interacts with the user interface and does not discuss how users manipulate the many files and scripts used to run RAMS and ERDAS. ASTER provided a RAMS users manual which discusses some of the procedures required to run RAMS, but it does not discuss features unique to ERDAS. ASTER should finish the users manual and provide maintenance documentation which would show flow charts and system organization.

Detailed User Interface Deficiencies

The AMU exercised many of the functions within the four main user interfaces of ERDAS and found some minor deficiencies. This section identifies these deficiencies and suggests improvements to the interfaces which would make the system easier to use.

ERDAS User Interface

- The eastern edge of the Cape is cut off in the detailed Grid 3 map.

- If zoom is selected on a region map which covers the Cape area it should default to the detailed map (MARSS map) rather than the CIA map as it currently does.

- Users cannot use the number keypad, when required to enter numerical data.

- The "Map Select" button is slow to show the CCAFS map (MARSS map). After selecting the "Map Select" button, the cursor should change to show that something is happening to keep the user from selecting other buttons inadvertently.

- The contour settings and slab statistics do not update until the second selection when a user first goes into ERDAS to select and plot the variables.

- The Forecast Preparation interface cannot be accessed directly from ERDAS. The link between the "Forecast Preparation" button and the interface needs to be implemented. Users can only access Forecast Preparation from outside of ERDAS.

- The "Observation" button in the Meteorology window does not produce a display of current observations. Users can presently only display RAMS output.

- The buttons in the quit window which pop up after pressing "Maintenance" are not aligned properly.

Forecast Preparation

- In forecast preparation, pressing "Zoom" after pressing "Select Observation" caused the program to crash occasionally.

- On several occasions a bad temperature got into the tower data file in MIDDS. When a user selected the bad tower for editing in forecast preparation it showed no data. When the user tried to reject this tower, ERDAS would not let the user do so because it assumed there were no data. However, there were data there and the model ran with the bad data and produced erroneous results.

- The rawinsonde hodograph displayed erroneous lines for wind speed/direction.

- Currently, the "Select Observations" button makes users select one observation at a time which takes considerable effort. A better and faster way to select and view multiple observations for editing is needed.

- If the user selects "Select Observation" to select a tower when no tower data are available, the last surface observation or rawinsonde data are displayed instead of tower data.

RINGI (RAMS Interactive NCAR Graphics Interface)

- In RINGI, setting the wind interval to 5 hangs the program.

- RINGI crashes when a user selects soil moisture or any soil parameter for Grid 3.

- In RINGI, the "Load" button for updating to currently available data is not linked to allow the update. Presently, users must quit and restart RINGI to update the displays.

Diffusion models

The AMU has not tested many of the features of the diffusion models since many of the links are missing. However, the AMU has tested some of the user interface. Some of the problems discovered are:

- If the user selects "zoom" too many times while in CCAFS map the program hangs.
- The "View" button causes the dispersion function to fail.
- The title in the "Vehicle Parameters" window in REEDM is Titan IV no matter which vehicle is selected.
- The dispersion scenario window needs units for Amount, Size, etc. in input fields.
- The "Chemical attributes" and "Release rate" do not get set after setting spill amount and pool size.

Recommendations

The following is a list of recommendations for improving ERDAS which the AMU has compiled based on the results of the functional check-out. The recommendations are prioritized based upon the importance in getting ERDAS to run in a quasi-operational mode.

Higher priority (should be fixed as soon as possible):

- Connect the links which would allow the diffusion models to run.
- Fix RAMS to run and produce reasonable results regardless of the missing NGM grids.
- Make changes to model configuration to reduce the run time for a 24-hr forecast from 9 hours to 6 hours.
- Develop a quality control procedure to allow ERDAS to exclude bad input data.

Lower priority (should be fixed within six months):

- Fix user interface bugs and modify user interface based on AMU suggestions.

- Complete the ERDAS documentation.

Conclusions

The installation of ERDAS and the start-up of the AMU evaluation during the period of 7 March to 22 April has been marked with some successes and some problems. The successes have been that the RAMS model is automatically running twice a day and is producing apparently reasonable results most of the time. The problems have been due primarily to hard disk failures, unanticipated data input problems, and ASTER's incomplete installation and linking of parts of the software within ERDAS.

All of the deficiencies mentioned in this report are correctable. Up to this point in the ERDAS evaluation, ASTER has cooperated with the AMU and has provided software updates and consultations to fix problems as they were discovered.

ERDAS should soon be running in a mode similar to an operational mode. At that point the AMU will begin a rigorous evaluation which should show the viability of ERDAS as an operational system. As part of the AMU evaluation of ERDAS the AMU will continue to document and monitor the ERDAS system runs.

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

Chaff Interference To Weather Radar

The agency responsible for "de-conflicting" chaff drop over the Gulf of Mexico proposed to cease de-confliction for Shuttle launches after 1 March 1994. The AMU Chief was asked to evaluate the technical arguments supporting their proposal, and prepared a letter indicating that these arguments were unsound. The letter was provided to the 45 WS for use through the appropriate channels.

A test drop of chaff was arranged by those responsible for the de-confliction to empirically evaluate the various positions being asserted. The AMU monitored the drop on both the NEXRAD (10 cm) and McGill (5 cm) radars. The chaff signature was completely consistent with the theoretical calculations made last year by the AMU Chief. It has now been agreed that de-confliction will continue.

Low Temperature Recovery Algorithm

The AMU hosted operation of the Low Temperature Recovery Algorithm implemented on the MS-DOS PC by the AMU Chief. Operational support was provided in conjunction with the Thermal Analysis Branch, MSFC, for the launches of two shuttle missions during this quarter.

Lightning Launch Commit Criteria Revision

The AMU Chief participated in and provided technical assistance to the revision of Shuttle lightning-related Launch Commit Criteria (LCC). The centerpiece of the effort was a three-day meeting at KSC of the lightning LCC peer-review committee with participation from the Eastern and Western Ranges of the USAF, plus NASA HQ, JSC, and MSFC.

Range Standardization And Automation (RSA)

RSA is an Air Force effort to upgrade or replace the ancient and decaying infrastructure at the Eastern and Western Ranges, and to standardize them to the extent possible in the process. Weather is a significant part of that infrastructure, and the AMU has been assisting the efforts by reviewing draft specification documents, providing technical input during meetings and teleconferences, and suggesting technology alternatives for consideration.

SLF Wind Study

The SLF wind study is designed to determine the significance of two effects on the utility of the current SLF wind measurements for use by the Shuttle program: the separation between the sensors and the SLF centerline, and the sheltering of the sensors by nearby foliage.

Data were collected in December 1993 and March 1994 to address the first question. Appropriate analysis procedures were devised, software written, and the data processed. Informal briefings on the preliminary results were requested by Shuttle management and were provided.

The preliminary indication is that for spacings much beyond 300 feet, the flow field is essentially uncorrelated for one-second measurements. Significant and reliable correlation of one-second data requires spacing less than 100 feet. One-minute and five-minute averages are correlated to larger distances, but not to much larger distances.

The best measure of "goodness-of-measurement" is found not to be the correlation function, but the structure function. A method of scaling the data has been found which collapses the structure function at any spacing to a narrow predictable range. Since the structure function measures the mean square difference between two readings, it is a direct answer to the program's primary question: "How much do the readings tend to differ?"

Work in the next quarter will shift to measurements and analysis directed at the sheltering effect of foliage around the North site. Support will also be provided for the Crosswind Detailed Test Objective (DTO #805) if it is executed.

3. Project Summary

The FY 1994 AMU Tasking and Priorities Meeting was held on 1-2 July 1993 and new and revised tasking was issued to the AMU during the fourth quarter of FY 93. The AMU FY 1994 tasks were subsequently revised in January 1994. The current FY 1994 tasking includes the completion of tasks started in FY 1992 and FY 1993 and a number of new tasks which have already been started in FY 1994. A brief description of the current tasks is contained in Attachment 1.

Part of the AMU efforts this past quarter focused on ongoing FY 1992 tasks. This includes the KSC fog and stratus study, the implementation and evaluation of the MSFC wind algorithm in NASA's 50 MHz DRWP, and the development of McBasi routines to enhance the usability of the MIDDS for forecasters at the RWO and SMG. The implementation and evaluation of the MSFC wind algorithm in NASA's 50 MHz DRWP is complete. All software documentation has been distributed and the AMU has supported launch operations on several occasions as part of the user training and operational transition of the 50 MHz DRWP and new MSFC wind algorithm. The evaluation report has been completed and distributed to organizations both within and outside the NASA community that are interested in upper air wind measurements. The KSC fog and stratus study is also near completion. The final report has been approved for distribution by the KSC Public Affairs Office and distribution of the report is underway. The MIDDS enhancement task is an ongoing effort with product deliverables as required.

Fiscal year 1993 and 1994 tasks which have received attention this past quarter include the ongoing tasks: evaluation of the MASS mesoscale model, the ASOS evaluation, the development of forecaster guidance tools using artificial neural networks (ANN's), and the NEXRAD exploitation task and three new fiscal year 1994 tasks: the Emergency Response Dose Assessment System (ERDAS) Evaluation, the Lightning Detection and Ranging (LDAR) Evaluation, the NEXRAD/McGill Inter-evaluation, and the Boundary Layer Profiler Network Support, were also begun this quarter.

AMU efforts associated with the MASS mesoscale model this quarter included

- Identification of possible model run-time configurations and selection of the optimal run-time configuration,
- Exploration of potential data sources for model verification, and
- Development and distribution of the model evaluation plan.

Data archival for model evaluation is underway; actual evaluation will begin as soon as the evaluation plan is approved by the potential users and finalized.

The AMU completed the final report for the ASOS evaluation. The AMU has received KSC Public Affairs Office approval to publish the final report and has subsequently distributed it.

Work on developing and implementing ANN based forecaster guidance tools has been terminated. Though the ANN developed by the AMU demonstrated the ability to learn some general relationships, its performance was not sufficient for use as a forecaster guidance tool. The level of effort required to improve the ANN model's performance to that of an operational system is unknown, and the AMU's does not have resources to pursue this project given the level and priority of other tasking. The final report describing the ANN and its performance evaluation is currently undergoing internal review and will be distributed for external review next quarter.

The AMU has prioritized and narrowed the list of specific tasks within the NEXRAD Exploitation effort. This list has been distributed to potential beneficiaries of the AMU's work in this area for comment and approval. The Air Force provided NEXRAD PUP was installed in the AMU lab area during March. The only significant issue still unresolved with the AMU PUP is the lack of a dedicated communications line to the Melbourne WSR-88D. The Air Force is currently working this issue and the line may get turned on as early as May 1994. Until then, the AMU PUP will be able to replay archived data from the MLB WSR-88D. Consequently, the AMU will be able to address technical issues associated with the NEXRAD Exploitation task by analyzing archived data.

MRC/ASTER installed ERDAS in the AMU during March 1994. ASTER and AMU have since worked together to configure the system to run in a quasi-operational mode. The AMU has performed an initial system evaluation consisting of identifying system deficiencies that can be fixed prior to onset of the ERDAS evaluation. The AMU will deliver the system check-out report to the Air Force early next quarter.

The AMU began the LDAR evaluation and transition task in March. The AMU has queried the user community regarding their use of LDAR and is currently developing an evaluation plan. The LDAR workstation is scheduled to be installed in the AMU in the beginning of June. The AMU is awaiting installation of a communications line and end equipment. Since the AMU is now under Range configuration control, new equipment must be installed by the Range contractors. The AMU is working with the Air Force SMC/OLAK to get the communications line and end equipment installed prior to delivery of the LDAR workstation.

This past quarter, the AMU began work on the NEXRAD / McGill inter-evaluation subtask. The objective of this 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 weather Flight Rules (FR) and Launch Commit Criteria (LCC).

During this past quarter, the AMU has developed products which illustrate the radar beam coverage of the McGill radar, the radar beam coverage of the WSR-88D radar, and the difference in radar beam coverage between the two radars. This task will be completed during the third quarter of fiscal year 1994.

The AMU Chief evaluated a proposal to cease de-confliction by the agency responsible for "de-conflicting" chaff drops over the Gulf of Mexico and then prepared a letter indicating the justification for ceasing the de-confliction was unsound. The AMU then monitored a test drop of chaff arranged by those responsible for the de-confliction. The signatures on the NEXRAD and McGill radars were consistent with the theoretical calculations made last year by the AMU Chief. It has since been agreed that de-confliction will continue.

The AMU supported operation of the Low Temperature Recovery Algorithm implemented on the MS-DOS PC by the AMU Chief for two shuttle missions during this past quarter.

The AMU Chief participated in and provided technical assistance at a three day meeting at KSC to discuss the lightning LCC. The AMU Chief and other AMU personnel have been assisting the Air Force RSA effort to upgrade and standardize the weather systems at both the Eastern and Western Ranges. This effort has consisted of reviewing draft specification documents, providing technical input during meetings and teleconferences and suggesting technology alternatives for consideration.

The AMU Chief has begun work on an SLF wind study designed to determine the significance of two effects on the utility of the current SLF wind measurements for use by the Shuttle program: the separation between the wind sensors and SLF centerline, and the sheltering of the wind sensors by nearby foliage. Thus far, the data analysis has concentrated on the effects of the sensor separation. Preliminary data analysis indicates significant and reliable correlation of one-second data requires sensor spacing less than 100 feet. One minute and five minute averages are correlated to slightly larger distances.

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.