Applied Meteorology Unit (AMU)

Quarterly Report

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ENSCO, Inc.
445 Pineda Court
Melbourne, Florida 32940
(407) 853-8105 (AMU)
(407) 254-4122

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If anyone on the current distribution would like to be removed and instead rely on the WWW for information regarding the AMU's progress and accomplishments, please respond to Frank Merceret (407-853-8200, francis.merceret-1@ksc.nasa.gov) or Ann Yersavich (407-853-8217, anny@fl.ensco.com).

1. BACKGROUND

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

2. AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

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

2.1 TASK 001 AMU OPERATIONS

During January, AMU personnel observed one expendable launch vehicle (ELV) and one Shuttle mission at Range Weather Operations (RWO). In addition, Dr. Taylor traveled to Johnson Spaceflight Center (JSC) to observe Spaceflight Meteorology Group (SMG) operations prior to and during the launch of STS-81 on 12 January. The purpose of Dr. Taylor's visit was to gain additional insight into the duties and responsibilities of SMG forecasters during Shuttle launch operations. Dr. Taylor's visit included attending the MMT L-2 Briefing and observing SMG operations and forecast briefings during the period L-2 through launch.

On 28 January, AMU personnel conducted a briefing entitled "AMU Contributions to 45 Weather Squadron Operations" for the 45th Weather Squadron (45 WS) as part of their Technical Training Briefing Series. The briefing consisted of short presentations designed to provide a history of the AMU formation and operations, and highlight past, current, and future taskings as they relate specifically to 45 WS operations. The speakers included Drs. Merceret, Taylor, and Manobianco, Messrs. Nutter and Wheeler, and Ms. Lambert. In addition, the presentation was video taped for later viewing by forecasters and other current and future 45 WS personnel.

Based on suggestions by Capt. Scot Heckman (45 WS) and Mr. Roeder (45 WS), the AMU is exploring the possibility of configuring a PC and UNIX workstation in an area adjacent to the RWO and AMU laboratory. The PC would be used by 45 WS personnel to view training material while the workstation would be used to access AMU data and displays such as the graphical animations of the 29 km eta model output. During Dr. Taylor's visit to SMG in mid-January, he had similar discussions with Mr. Tim Oram (SMG) and Mr. Brian Batson (USA) about establishing connectivity between SMG and AMU computers to facilitate information exchange in the form of displays, model data, graphical products, etc.

HARDWARE/ SOFTWARE INSTALLATION AND MAINTENANCE (MS. YERSAVICH)

During January and February, Ms. Yersavich has submitted numerous purchase requests to NASA for hardware and software items. These requests included upgrading the operating systems, memory, and disk space for the IBM RS/6000 workstations and Macintosh PCs, a color PC laptop, a desktop projector, and various external tape drives, cables, transceivers, and software. Many of the items were procured in order to keep up with standards and up-to-date with latest versions of software. The color PC laptop and desktop projector will be used for presentations given locally or while on travel. The cables and ethernet transceivers will be used to transfer the Macintosh Appletalk network to a thinnet ethernet network which will allow a faster mail transfer and system backup rate.

2.2 TASK 004 INSTRUMENTATION AND MEASUREMENT

SUBTASK 1 NEXRAD EXPLOITATION

The NEXRAD Exploitation task final report was distributed to SMG, NWS MLB, 45 WS, and other interested parties in February. Also in February, Mr. Wheeler presented a poster on the NEXRAD Exploitation task at the Annual AMS Conference in Long Beach, CA. Anyone else interested in obtaining a copy please contact Ms. Yersavich. During March, Mr. Wheeler and Ms. Lambert briefed the results of the 88D Exploitation Task to the staff of the NWS Melbourne (NWS MLB) office. The briefing highlighted why clear-air mode operation is essential for monitoring convection initiation and also covered the results of the severe/non-severe portion of the report.

Mr. Wheeler received a beta release of WATADS Build 9 in late March. The software package is needed for the Build 9/WATADS Cell Trend Comparison Task. The official software package of Build 9 for WATADS is expected to be released by the end of April 1997.

SUBTASK 2 915 MHZ BOUNDARY LAYER PROFILERS (DR. TAYLOR)

Dr. Taylor and Ms. Lambert discussed the task objectives with SMG and NWS MLB and combined their task objective suggestions with those of the 45 WS. A memorandum describing the task objective suggestions from SMG, 45 WS, and NWS MLB was distributed to all three groups in February. The purpose of this memorandum was to consolidate those suggestions in one document and to confirm that the AMU understands each of the suggestions.

The suggested objectives for this task from each group are as follows.

45 WS:

- Develop thunderstorm forecasting techniques through the
    - Use of 4-D wind data for detection of sea, land, and river breezes, and
    - Use of RASS virtual temperature profiles.
- Develop high wind forecasting techniques by
    - Characterizing the downward momentum flux of low-level jets, and
    - Determining the quality of the wind estimate.
- Characterize the 2-D and 3-D structure of the sea breeze.

SMG:

- Determine the quality of the wind estimate to improve wind direction forecasts for low-level cloud advection for shuttle landing forecasts.
- Determine if the atmosphere's moisture content affects the profilers' range (height).
- For the < 3 hour forecast period, determine the profilers' virtual temperature and wind data application to
  - Convective initiation,
  - Fog formation, and
  - The SLF 30' wind tower forecast.
- Develop persistence tables for L-2, L-4 and L-6 hours for JSC descent flight design.
- Determine the optimum scan strategies and data processing for the most accurate data.
- Determine the utility of calculating divergence trends or profiles from the data and its application to convective initiation and persistence.

NWS MLB:

- Develop a prototype hodograph display for each profiler and an average hodograph with data from all profilers.
- Analyze the vector difference over a specified time period (e.g. 1 hour) and the perturbation wind at certain levels.
- Determine the quality of the wind estimates.

Once confirmed, Dr. Taylor and Ms. Lambert began to determine the work required to complete the suggested objectives during March. Their estimates will be distributed in a follow-up memorandum in April.

SUBTASK 4 WDSS EVALUATION AND TRANSITION ISSUES

Mr. Wheeler continued to have discussions with NSSL on Warning Decision Support System (WDSS) improvements and the possibility of reducing the data output (T1 communication) needed to run the system. NSSL is looking into reducing or compressing the data so a smaller communication path could be used. Mr. Wheeler reviewed NSSL's mid-course progress report concerning WDSS. An updated release of WDSS will be installed at NWS MLB in April 1997. This release has several improvements such as the ability to do cross sections and cell based VIL attributes. Several fixes to early problems such as color tables and auto-updates will also be included in this release. Final updates to the improvements of the downburst and hail algorithms will be completed by the end of June 1997.

The 13 August 1996 Patrick Air Force Base (AFB) severe weather event final report was completed and distributed at the end of March. Anyone else interested in receiving a copy of this report should contact Mr. Wheeler. Excerpts of the final report follow.

Summary and Recommendations

It has long been known that convergent boundaries (secondary convection) play a key role in thunderstorm intensification in east central Florida. Add a small intense cell, moving to the right of the environmental wind flow which develops a pendent echo on its southwest flank and the conditions exist for a severe storm cell that can cause severe damage. A cell of this type developed to the northwest of Patrick AFB on 13 August 1996 and caused major damage.

On this same day, multiple boundaries were colliding in the vicinity of West Melbourne and the collision produced intensification which was manifested as a landspout that caused minor damage.

The atmospheric conditions on 13 August 1996 indicated that deep convection would develop in the afternoon hours. The presence of a pronounced mid-level dry layer over a moist low-level layer should be considered a threatening situation, especially during the wet season (May-September). Data from the morning Cape Canaveral Air Station (CCAS) rawinsonde indicated the potential for severe weather. As the outflow boundaries developed they would likely collide and intersect with one another to rapidly form new updrafts. The east coast sea breeze (ECSB) would also likely be present over Brevard County to add to the boundary mix. All of these conditions indicated that storms would have the potential for convective wind gusts greater than 50 kt (See Table 1). As for tornadic activity, the environmental storm relative helicity (SRH) was low and not indicative of rotating updrafts. However, the location of the ECSB with the easterly low-level winds behind it did improve the helical character of the local environment along and east of the ECSB from CCAS down to Melbourne.

The analysis of thunderstorms should always be more critical when they are present along and behind the ECSB and the prevailing low-level flow is westerly because of the improved helicity. Morning assessment of vertical shear may not expose the afternoon potential for rotationally-organized convection behind the ECSB.

Table 1 Patrick AFB/RWO Issued Warnings and Watches on 13 August 1996

Office	Issued (UTC)	Valid at	Type	Remarks
PAFB	1800	1830	convective winds ≥ 35 kt	G44 at 2137 UTC
PAFB	2135-38	issue	convective winds ≥ 50 kt	G68 at 2141 UTC
RWO	1638	1800	Watch for tornado / waterspout/severe tstms	
RWO	1750	1750	convective winds ≥ 35 kt	G45 at 1835 UTC
RWO	1840	1840	convective winds ≥ 50 kt	G52 kt (tower 1500) at 2200 UTC

Understanding the Environment

An understanding of the dynamics of a developing weather situation is needed. Key points for the weather events on 13 August 1996 include:

- There was sufficient boundary layer moisture, positive buoyant energy, instability and converging boundaries to suggest a high probability of thunderstorm development.

- Colliding boundaries produced secondary convection which produced stronger updrafts and cell rotation.

- The location of the sea breeze boundary and its interaction with the environmental flow resulted in increased helicity values.

- The presence of a pronounced dry layer in the mid-levels during the wet season should alert forecasters to the potential for the formation of microbursts. The inspection of the numeric precipitable water (PW) value alone can be misleading. It is impressive that nearly 2 inches of PW was squeezed into the layer below 850 mb.

- It is essential to inspect the vertical profile of equivalent potential temperature to assess the possible effect of dry air in the mid-levels. The difference in the maximum low-level theta-e and minimum mid-level theta-e should be determined. Values greater than 20°K should be respected. Values greater than 30°K should stir concern. Inspection of successive theta-e profiles should be done to determine trends.

- Forecasters should make appropriate use of forecaster aids such as the Microburst Day Potential Index (MDPI) for quantifying microburst potential.

Nowcasting

Besides looking at the overall weather scenario, small cells that could affect the local area need to be monitored.

Key radar issues:

- Understanding the WSR-88D scan strategies (VCP 21 vs. VCP 11), that there is better vertical resolution of a cell with VCP 11. Need to be aware of the radar's cone of silence.

- Understanding of the strengths and weaknesses of current WSR-88D algorithms.

Forecaster nowcasting:

- Weather produced by earlier storms should be accounted for (i.e. there were several microbursts over South Brevard and East Orange Counties).

- Several boundaries were converging over Brevard County. When two boundaries are expected to interact under such vigorous circumstances forecasters should have heightened their awareness. When three or more boundaries are expected to interact (as in this case, over west MLB), a warning should be issued for wind gusts greater that 50 kt.

- Movement of storms in the vicinity of boundaries need to be monitored. Look for intense right moving thunderstorms as they likely are in an area of greater SRH.

- With westerly low-level flow, any thunderstorm that is present behind the ECSB should be monitored and evaluated for rotational organization of the updraft. Check for mesocylonic rotation in the low-levels, as well as hook/pendant echoes.

- Cells that have that have strong mid-level rotation should be monitored closely.

- Colliding boundaries and cells increase the low level inflow and moisture available for rapid cell growth.

- Small scale, short lived phenomenon need to be watched. Zooming in can detect smaller cell characteristics of developing severe weather.

- All radar reflectivity data are needed (do not blank lower reflectivity levels out), lowest reflectivity values colors should be changed for better contrast.

SUBTASK 5 I&M AND RSA SUPPORT

At the request of Mr. Billie Boyd (45 WS), Dr. Manobianco and Mr. Wheeler reviewed the RSA Phase IIA A-Level Specification document. Dr. Manobianco compiled and edited all comments from the reviews and forwarded them to Mr. Boyd.

Mr. Wheeler participated in a working meeting between the RWO and PRC to detail the structure and functionality of the "top 100" McBASI programs. PRC requested the meeting to gain an understanding of the McBASI utilities and how they work in order to provide similar functionality in the new advanced weather display system.

In early March, Dr. Taylor attended radar briefings (for a weather radar) presented to the 45 WS by Kavouras Inc. and Enterprise Electronics. He attended a subsequent 45 WS meeting to decide on the 45 WS response to Lockheed Martin Hughes for their needs for a weather radar as part of RSA II.

At the request of Mr. Billie Boyd, Dr. Manobianco attended a two-day meeting held by Eastern Range Safety to define their toxic functions and requirements for RSA. Dr. Manobianco's attendance was limited to the general introductory session on day 1 and the demonstration of the MARSS replacement conducted by Mr. Allan Dianic (ENSCO, Inc.) on day 2.

Mr. Wheeler participated in a working meeting between PRC and the 45 WS to explain how PRC would solve the "McBASI" functionality in the new weather display system. PRC proposed using TCL/Tk programming and toolkit as the solution. The use of these scripts would allow the RWO to manipulate data and develop graphics. The TCL/Tk interface would allow a knowledgeable user to interface with the database and perform functions on the data and then display the results or develop a product similar to what can be done on the existing system. However, the programming language is more advanced than BASIC and would be harder for the duty forecaster to use. Mr. Weems of the 45 WS was concerned with the complexity of the language and requested PRC further investigate how best to port the McBASI functionality to the new system.

SUBTASK 7 LDAR DATA AND DISPLAY (MS. LAMBERT)

During January and February, Ms. Lambert consulted with personnel in SMG, NASA, CSR, and PRC, Inc. on the LDAR system, the current MIDDS, and the future McIDAS-X and Advanced McIDAS systems at SMG and the 45 WS, respectively. A list of data compression and reduction methods was compiled based on a literature review and these consultations. Two internal reviews of the final report were completed. It was then sent to LDAR and MIDDS experts for review to ensure the technical accuracy of the report. When their comments are returned, the report will be revised and distributed for external review. The conclusions as written in the first draft of the report are given below.

Introduction

LDAR data are not currently available to SMG and are not integrated with other meteorological data sets in MIDDS because the volume of data output by the LDAR system is too large to be transmitted across the current 224 Kbps communication line. Although the focus of this study is on how to make LDAR data available to SMG, processing the data and making it available on the Advanced McIDAS will benefit the 45 WS and NWS MLB in two ways. First, it will allow displays to be built which can be integrated with other data sets and, secondly, it will allow the archive of LDAR data use much less storage space than the current LDAR archive.

Real-time LDAR data events are recorded in two types of packets that are 64 and 22 bytes (8 bits/byte) in length. The 64-byte packet contains information that is valuable for system quality checks, trouble shooting, and research. These packets are only transmitted when the data are being monitored for these purposes. Much of this information is not needed for data display and would needlessly slow down the display system. Therefore, these data are filtered into 22-byte packets such that only the information needed for display (Table 2) are sent. The 22-byte packets are sent in real time whenever the LDAR system locates an event. Both types of packets are transmitted on the communication line at the same time when the 64-byte packets are being accessed.

Table 2 Format of LDAR Event 22-byte Packet

Byte Number	Byte Description
1	Status (LDAR, LLP, bad)
2	Hour
3	Minute
4	Second
5 - 8	Microsecond
9 - 10	Julian Day
11 - 14	X Coordinate (meters)
15 - 18	Y Coordinate (meters)
19 - 22	Z Coordinate (meters)

LDAR has been observed to detect 1000-2000 events/s for several minutes from intense storms which produced a great amount of lightning. As much as 50 MB of data in a half hour (average 1300 events/s) and 1 GB a day (average 500 events/s) have been produced from these events. The real-time data are transmitted to each display location at KSC, the ROCC (RWO and AMU), and NWS MLB on separate dedicated T1 communication lines which are capable of transmitting 1.544×10^6 bits per second (or 1.544 Mbps). It is important to note that when the 64 byte packets are being monitored, the Mbps rates given are increased by a multiple of 3.9. Table 3 shows the transmission rates for the real-time 22-byte data and when the 64-byte data are included for the LDAR event detection rates just discussed. The transmission rates were calculated using 8 bits/byte. It is clear from this table that the transmission capability of a T1 line is needed for unprocessed LDAR data during intense storms.

Table 3 Transmission Rates Based on LDAR Event Detection Rates

LDAR events per second	Kilobytes (KB) per second for 22-byte data	Transmission Rate for 22-byte data	Transmission Rate including 64-byte data
500	11	.09 Mbps	.351 Mbps
1000	22	.17 Mbps	.663 Mbps
1300	28	.22 Mbps	.858 Mbps
2000	44	.35 Mbps	1.36 Mbps

Discussion of Possible Solutions

There are two communication line possibilities for transmitting LDAR data to SMG. The first is to install a dedicated T1 line from the LDAR system to SMG, and the second is to use the current 224 Kbps line between SMG and the MIDDS at the ROCC. The LDAR data can be transmitted without modification if a T1 line is used, but the data must be compressed or filtered if it is to be transmitted across the current communication line. Two methods of data compression and two methods of data filtering are outlined in the report.

Data Compression

The first data compression method is to use a data compression routine. LDAR data are written in binary format. Data can be easily read or written in ASCII or binary format, but binary format allows for a much more efficient use of disk space and memory than ASCII. Therefore, LDAR data already use the least amount of disk and memory space possible while still being easy to read and write in data processing and display routines. Several experts in the area of computer programming and data compression and transfer were consulted regarding the compression and transmission of LDAR data files created at the high rates discussed previously. None were aware of compression routines that could reduce the LDAR data by the amount needed for transmission, but all stated that tests with the 22-byte packet data would have to be conducted to be assured of an answer. If this becomes a desired solution, the search for an appropriate compression/decompression routine should be continued.

The second data compression method is that of image capture. An image capture routine does not compress and preserve the raw data, rather it captures the image that was created with the raw data. The size of an image file would depend on the format. It should be smaller than a display of the raw data and essentially make available all LDAR data that are displayed. Software to automatically capture the image should be written to avoid problems that can be created from manual capture by personnel, such as not capturing the image at the proper moment or not having time to capture the image due to other responsibilities in times of severe or potentially severe weather.

Data Filtering

As previously stated, there are two filtering methods suggested in the report that reduce data volume by removing certain portions of the data. Both divide the atmosphere into discrete volumes in a three-dimensional grid centered at the LDAR central site. The spatial resolution of the volumes as well as the temporal resolution of the data would be based on operational needs and the amount of data reduction required.

In the first method, each grid volume would have a simple 'on/off switch' that would indicate whether LDAR events occurred within the volume. As LDAR events are detected over the selected time period, their x, y, z locations would be used to determine which grid volumes contain data and their 'switches' would be turned on. This would be done without regard to the number of LDAR events in a given volume. Once a switch is on within a volume, no other action for that volume need be taken. Rather than transmitting every individual LDAR event, this method reduces data volume by transmitting one value with its associated grid x, y, z information to represent the existence of LDAR data points in a particular volume.

The second method is currently being developed by NASA personnel. It goes a step further than the previous method by counting the number of LDAR data events per grid volume per time period to determine the data density. At the end of the specified time period the number of LDAR events along with the x, y, z grid volume location will be available for transmission as opposed to the individual events. For display, the data are further manipulated by taking the logarithm (base 10) of the density value and multiplying it by 10. A color-fill routine is then used to display the data. An example of the display is seen in Figure 1.

Conclusions

Several methods of transmitting LDAR data to SMG have been presented in this report, each with a distinct set of advantages and disadvantages. Consideration must be given to the amount of reduction achieved so that the LDAR data can be transmitted with other data sets across the current communication line, the processing time of the routines to ensure timely display of the data, and what data display format will be most valuable to operational personnel.

SUBTASK 8 RADAR / PIREP INVESTIGATION

Mr. Wheeler finished his analysis and writing on the radar and pilot report cloud top inconsistencies report. Presently the report is in external review and is expected to be published by the end of April 1997. A summary follows.

The report documents the results of the AMU's investigation of inconsistencies between pilot reported cloud top heights and weather radar indicated echo top heights (assumed to be cloud tops) as identified by the 45 WS. The objective for the study was to document and understand the differences in echo top characteristics as displayed on both the WSR-88D and WSR-74C (McGill) radar and cloud top heights reported by the contract weather aircraft in support of space launch operations at CCAS, FL. These inconsistencies are of operational concern since various Launch Commit Criteria (LCC) and Flight rules in part describe safe and unsafe conditions as a function of cloud thickness.

The study focuses on:

- Cloud top (or echo top) height inconsistencies between the contract weather aircraft reports and those observed on the two weather radars (WSR-88D and McGill) and

- Identification of atmospheric conditions that may produce anomalous propagation of radar signals which result in misleading user display products (e.g. echo top heights).

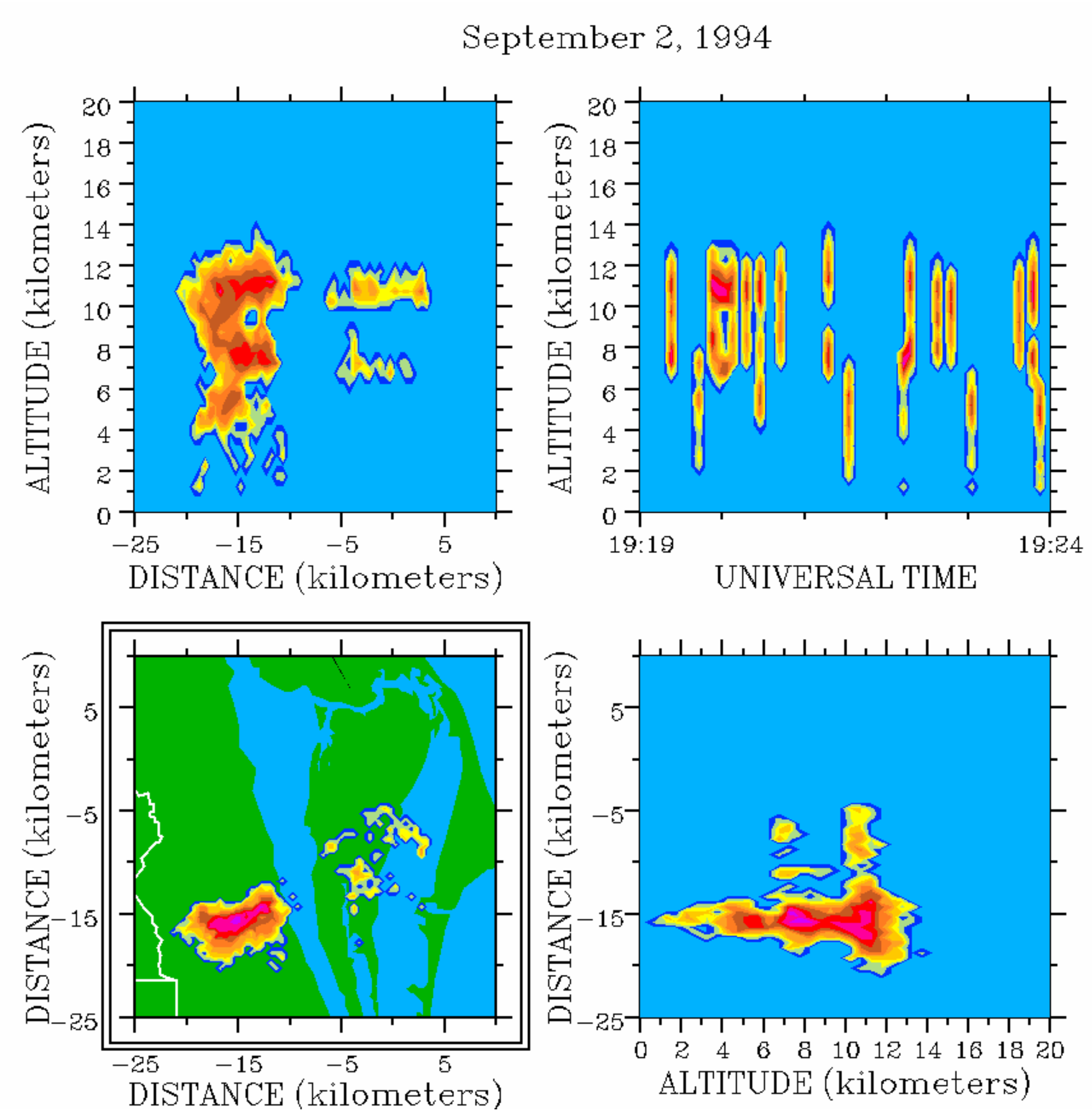

Figure 1 Example of the data density display showing LDAR event intensities over the 5 minute period from 19:19 to 19:24 UTC on 2 September 1994. An intensity scale is not provided.

The 45 WS documented two cases where radar-detected echo tops and weather aircraft reports of cloud top heights differed by as much as 1.2 km (4000 ft). The two cases were during launch operations on 30 December 1995 between 1000 and 1348 UTC and 12 September 1996 between 0500 and 0849 UTC.

The AMU examined the two cases of reported cloud/echo top discrepancies and attributed the differences to atmospheric conditions. Much drier air in the mid-levels advected into the CCAS area over a lower moist layer in the atmosphere. Some background radar information was presented. Scan strategies for the McGill and WSR-88D were reviewed along with a description of normal radar beam propagation influenced by the Effective Earth Radius Model. Atmospheric conditions prior to and leading up to both launch operations were detailed. Through the analysis of rawinsonde and radar data, atmospheric refraction or bending of the radar beam was identified as the cause of the discrepancies between reported cloud top heights by the contract weather aircraft and those as identified by both radars.

Figure 2 is a profile of the Δ Index of Refraction (IR) (change in N units every 1000 ft in height) plotted for the Delta launch operation on 30 December 1995 at 0548 and 1308 UTC which was just prior to the Delta launch. Notice the jump in the IR delta between 13000 and 15000 ft. This abrupt change in the gradient can be attributed to the very strong inversion and is indicative of AP that developed at this level. The contract weather aircraft reported cloud tops near the 13000 - 15000 ft level. However, both weather radars were showing higher tops (16000 - 18000 ft), above the strong inversion layer. This is because the radar beam was being trapped or bent back toward the Earth displacing the actual and displayed echo tops.

The atmospheric refraction caused the radar beam to be further bent toward the Earth than normal. This radar beam bending causes the radar target to be displayed erroneously, with higher cloud top heights and a very blocky or skewed appearance.

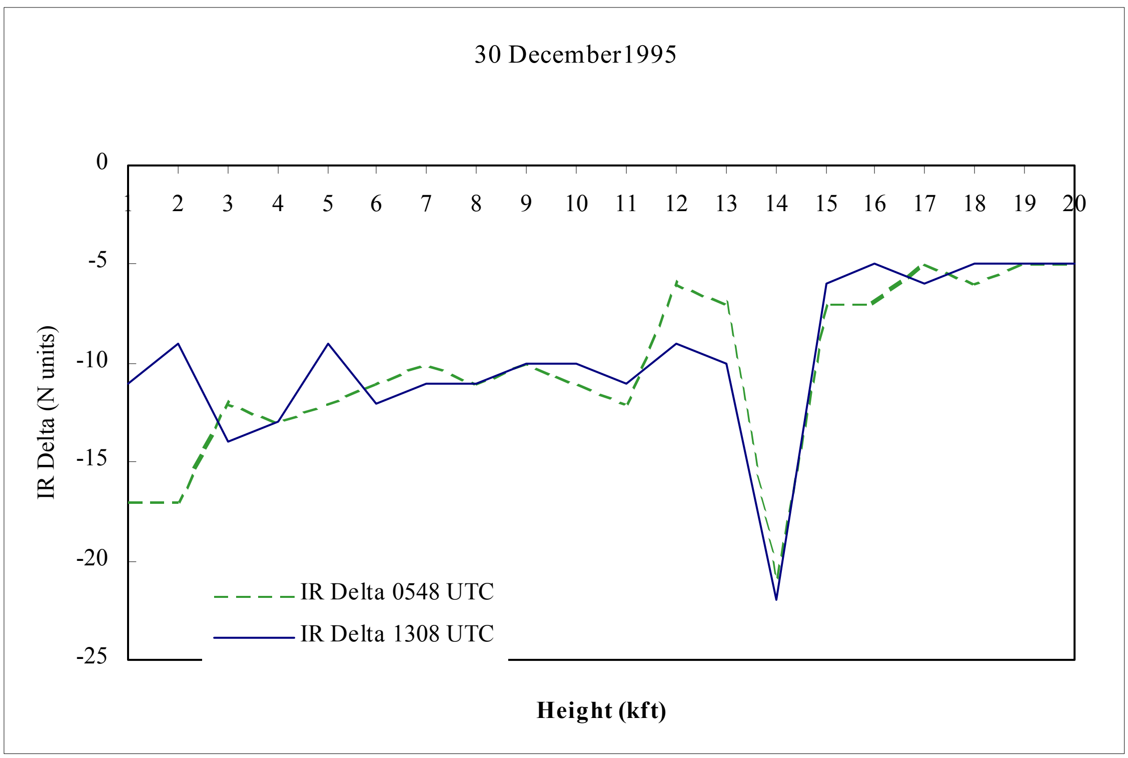

Figure 2 Profiles of the change in IR per 1000 ft on 30 December 1995 at 0548 and 1308 UTC. A strong substance inversion caused rapid change in IR values from 13000 to 15000 ft. The abrupt change is indicative of AP.

Using the WSR-88D level II data from the NWS Melbourne office, a cross-section along a SE-NW line to the northwest of Complex 17 was done. The showers analyzed have a very stretched and truncated appearance. This can be attributed to AP, superrefraction or ducting, where the radar beam is being trapped and bent back toward the Earth due to the very dry air advection above 10000 ft. Just prior to this time the weather aircraft was reporting cloud tops at about 3 km (10000 ft).

Based on the analysis of differences between the radar detected echo top and the observed aircraft cloud top for the two cases. It appears that anomalous propagation (superrefraction and/or ducting) was the cause of the reported inconsistencies. The cloud top difference between an area of precipitation as shown on either radar and its observed altitude as determined by aircraft can be attributed to atmospheric conditions (strengthening inversion or areas of temperature and water vapor discontinuity) that causes the radar beam to be bent downward or trapped (i.e. superrefraction or ducting) (Figure 3).

Both of these cases illustrate the problems that changes in the "standard" atmospheric conditions can cause AP of radar beams resulting in misleading radar returns. Instead of following the projected 4/3 earth's radius model, the radar beam is bent further downward toward the earth because of change in the vertical gradient of IR with height. When the radar beam is abnormally bent in this fashion the radar data will be displayed abnormally (i.e. blocky, stretched) and the calculated echoes tops will probably be higher than normal due to the abnormal bending of the radar beam (Figure 4). The radar assumes that the beam has continued in space along its projected path instead of being bent downward.

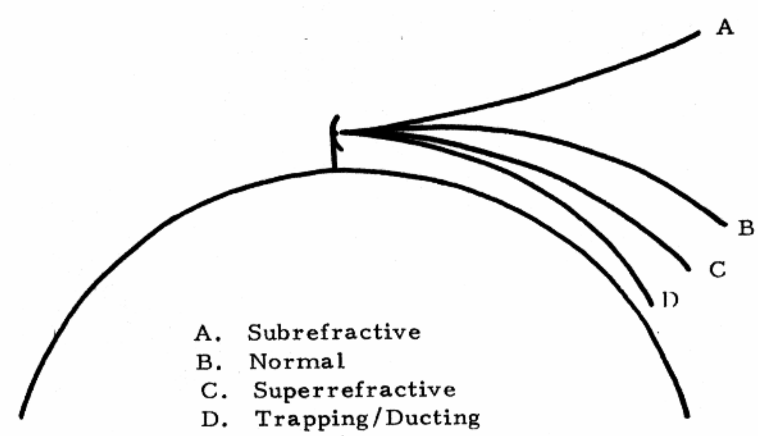

Figure 3 Radar beam paths through various atmospheric refractive conditions.

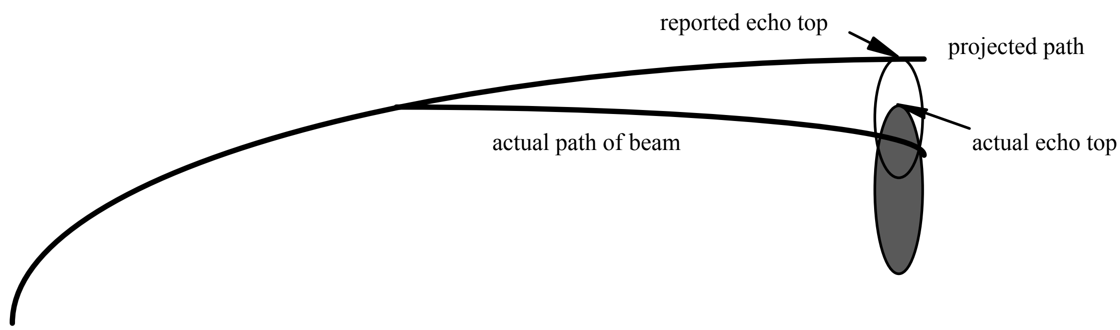

Figure 4 Model of project versus actual radar beam and calculated echo top.

In addition to the beam bending (refraction) due to atmospheric conditions, there are other characteristics of the two radars that should be considered when analyzing the radar data. A list of those considerations include:

- Beam filling - (1/2 power points) When the lower part of the radar beam intersects the top of a target, the center of the beam is 1/2 beam width higher than the lower edge of the beam. This will cause the target to be displayed 1/2 beam width higher, this can be up to 1200 ft from the radar to the CCAS area.
- Radars only detect water droplets (precipitation). Precipitation tops will be lower than actual cloud tops.
- Two radars viewing same target. May see differences in tops, intensities and patterns because of different viewing angles (VCPs), time of observation, distances, and radar calibrations (C-band, Doppler).

The report also highlights two major concerns:

- Since cloud top information and accuracy is extremely important in support of space launch operation, Launch Weather Officers (LWOs) need to be aware of atmospheric conditions at all times that could cause data to be misrepresentative. Each rawinsonde should be examined for AP signatures.
- Reported versus observed cloud tops or cloud structure can be different due to radar anomalies as detailed in this report.

A copy of the final report can be obtained from Mr. Wheeler.

2.3 TASK 005 MESOSCALE MODELING

Dr. Manobianco gave a short presentation entitled "Local mesoscale modeling at CCAS/KSC" to the modeling committee of the 81st Range Commander's Council (RCC) Meteorology Group (MG). Dr. Manobianco is also the chair of this modeling committee whose charter is to provide national ranges a forum to address common issues regarding data assimilation and mesoscale forecast systems. His presentation and the others given by Dr. Chris Crosiar (VAFB) and Mr. Randy Evans (ENSCO, Inc.) during the modeling committee meeting were designed to highlight past, present, and future local mesoscale modeling requirements and/or efforts at the Eastern and Western Ranges. This information was not formally briefed at the 80th RCC MG meeting in Boulder, CO last August 1996.

Following the presentations, the committee discussed a proposed task to identify common problems in data assimilation and mesoscale modeling at the national ranges. The committee chose not to adopt the task as written. Instead, the committee decided to collect and examine documentation describing the characteristics of models used in range and Department of Defense services in order to establish areas of commonality and problems. This information will provide a list to compare models for each of the services. By the next meeting in March 1998, the committee will determine if a task to provide a document summarizing these comparisons is useful.

SUBTASK 2 29 KM ETA MODEL EVALUATION (DR. MANOBIANCO)

The cool season data collection and subjective evaluation period from 1 October 1996 to 31 January 1997 has ended. Mr. Nutter and Dr. Manobianco are completing the analysis and figures for the warm and cool season objective and subjective components of the 29 km (meso-eta) model evaluation.

At the request of Dr. Merceret, Dr. Manobianco and Mr. Nutter conducted informal briefings for SMG, 45 WS, and NWS MLB to discuss the results from the meso-eta evaluation prior to outlining and writing the final report. The goals of the briefings were to (1) provide status of the year-long AMU evaluation of the 29 km eta model, (2) solicit feedback from each group, and (3) determine what aspects of the evaluation results are most operationally useful based on prioritization by SMG, 45 WS, and NWS MLB. The briefings were open to all interested parties, especially those people that helped design the model evaluation strategy. Prior to the briefing, Dr. Manobianco distributed detailed packages of results which were used as a guide for the discussions. All briefings were conducted face-to-face, including the one with Mr. Oram (USA) and Mr. Garner (SMG) who were attending the 81st Range Commander's Council meeting during the first week of March.

Dr. Manobianco and Mr. Nutter greatly appreciate the time and effort put in by SMG, 45 WS, and NWS MLB in providing comments and feedback on the results of the model evaluation. The briefings were very informative and every attempt will be made to incorporate as many of the suggestions and requests which are consistent with the original model evaluation protocol. Although the briefings were extremely valuable, preparing and conducting them has delayed the project completion. As a result, the final report should be completed 31 May 1997 instead of 1 April 1997.

Although the cool season data collection period ended 31 January 1997, the AMU continued to retrieve and decode meso-eta model gridded and point forecasts from either NOAA's Information Center FTP server or the National Weather Service (NWS) Gateway server. At the present time, 45 WS, SMG, Range Safety, and other groups who do not routinely retrieve and decode these data are very interested in examining output from the meso-eta model. Based on this interest and a specific request from Capt. Heckman (45 WS), Dr. Manobianco modified the AMU's automated jobs that decode and process the data. The modified scripts now create text bulletins and images of time-height cross section images of meso-eta point forecasts at TTS and EDW from the 0300 UTC and 1500 UTC model runs. These files are then emailed to selected PC's in the RWO and to Mr. Madura at KSC. In addition, the files are transferred directly to a data server at JSC for viewing by SMG. The files are not being sent to NWS MLB because they currently retrieve the meso-eta model point forecasts directly from the NWS Gateway server.

It is important to note that this method of providing 29 km eta model point forecasts to SMG and RWO is complex and involves a number of computers and pathways that are subject to failure. As a result, the text and image files containing meso-eta model point forecasts may be available less often than NGM and MRF point data obtained from MIDDS. These missing data may impact the utility of this method in providing data for real-time operational support.

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

In January, Dr. Merceret submitted the first draft of his contribution to the "WIDE" report on upper air wind measurement techniques being co-authored with Richard Waltersheid, Raymond Heidner, and Tim Wilfong.

In February, Dr. Merceret began wok on an examination of the probability distribution of vertical velocities (w) seen by the KSC 50 MHz profiler. This work is designed to test the validity of the assumption that w may be neglected in horizontal wind calculations. Also in February, a revised version of the wind change study was submitted to *Journal of Applied Meteorology*.

In March, Dr. Merceret briefed the Titan Day of Launch Working Group on current 50 MHz profiler issues. He also held profiler technical discussions with RSA contractors.

Attachment 1: AMU FY-97 Tasks

TASK 001 AMU OPERATIONS

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

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

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

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

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

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

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

TASK 002 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 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 003 SHORT TERM FORECAST IMPROVEMENT

• Develop, evaluate and, when appropriate, transition to operations databases, analyses, technologies and techniques leading to improvement of short-term forecasts to support spaceflight operations at KSC, CCAS, and Shuttle landing facilities in the continental United States and elsewhere as directed by the COTR.

• Subtask 1 - MIDDS Menu System

•• 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. In accordance with consensus reached at the AMU mid-course review meeting on 02 December 1996 as documented in Technical Directive 4-1001, all work on this task is terminated effective 11 December 1996.

- Subtask 2 - Microburst Day Potential Index (MDPI)

•• Complete the MDPI analysis for the month of June - September 1995 and 1996. The MDPI will be fine tuned if necessary based on the analysis.

TASK 004 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 1 - Melbourne NEXRAD

•• Perform a comparison of cell trend thresholds (cell-based VIL, Probability of Hail, and Height of Maximum Reflectivity) based on the WSR-88D PUP cell trends and the advanced NSSL algorithms on WDSS.

- Subtask 5 - Boundary Layer Profilers

•• Evaluate the meteorological validity of the current site selections for the initial 5 DRWPs and recommend sites for up to 10 more DRWPs. Determine in a quantitative sense where possible, the advantages of additional DRWPs. Develop and/or recommend DRWP displays for operational use. Develop forecast techniques using 915 MHz DRWP data for thunderstorm forecasting and high wind warnings.

- Subtask 3 - MIDDS Upgrade

•• Support the current 45 WS/ER MIDDS Upgrade Project. Review vendor documents and products and provide expert technical advice. Note that under Technical Directive 4-1001 issued 11 December 1996, all work under this task has been terminated.

- Subtask 4 - WSR-88D Exploitation: NSSL's Warning Decision & Support System (WDSS) Proof of Concept Demonstration

•• Support NSSL's WDSS Proof of Concept Demonstration at NWS MLB in the summer of 1996. This support shall include a one-month evaluation of the WDSS for potential transfer into operations.

- Subtask 5 - AF Improvement and Modernization (I&M) and Range Standardization and Automation (RSA) Support

•• The AMU will support AF I&M projects and AF RSA project. The AMU support will include 1) reviewing vendor documents, designs, prototypes, and products 2) reviewing system interoperability and data communications among system nodes (e.g., data types and formats), 3) testing vendor products and prototypes, 4) Attending vendor briefings and reviews, and 5) documenting our technical advice, comments, and suggestions.

- Subtask 6 - Data Integration and Display

•• Identify systems currently available for integrating and displaying east central Florida, White Sands, and Edwards AFB area mesoscale and synoptic data sets. After the systems are identified, the AMU shall analyze communications and hardware requirements for each system and determine if the infrastructure exists to run the system in the current or near-future MIDDS environment. Data sets to be processed by the systems include radar lightning, radar, satellite, profiler, rawinsonde, surface, and aircraft data.

- Subtask 7 - LDAR Data and Display

•• Investigate data reduction methods for LDAR data to facilitate its integration into MIDDS. In addition, identify option for MIDDS display of LDAR data that are less data intensive than the current LDAR system display yet preserve information.

- Subtask 8 - Radar / PIREP Investigation

•• Perform a preliminary investigation on the radar and aircraft reported cloud top inconsistencies to include a review of the past 2 occurrences of reported could top inconsistencies as documented by the 45 WS, perform literature search on the topic to see , if any, similar of supporting analyses have been performed, and review radar documentation for the WSR-74C and WSR-88D to examine how hardware/software characteristics may contribute to these inconsistencies.

TASK 005 MESOSCALE MODELING EVALUATION

• Evaluate numerical weather analysis and/or prediction 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 2 - 29 km Eta Model Evaluation

•• Evaluate the most effective ways to use the NCEP 29 km eta model to meet 45 WS, SMG, and NWS MLB requirements. The AMU shall determine the data acquisition requirements, and design and implement the evaluation protocol.