Applied Meteorology Unit (AMU)

Quarterly Update Report

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If anyone on the current distribution would like to be removed and instead rely on the WWW for information regarding the AMU's progress and accomplishments, please respond to Frank Merceret (phone: (407) 853-8200 email: fmerceret@tmoffice.ksc.nasa.gov) or Robin Schumann (phone: (407) 853-8205 email: rschumann@fl.ensco.com).

1. BACKGROUND

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

2. AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

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

2.1 TASK 001 OPERATION OF THE AMU

HARDWARE / SOFTWARE INSTALLATION AND MAINTENANCE

Ms. Yersavich installed version 2.1 and 2.101 of McIDAS-X and the latest version of the Motif-IRAS NEXRAD level II data emulator on one of the AMU's IBM RISC/6000 Model 320H workstations. The Motif-IRAS emulator software is being used extensively in the WSR-88D Evaluation task.

Near the end of July 1995, one of the Stardent computer's four CPU's failed. This hardware problem was resolved in less than two days by replacing the bad CPU with a new one shipped from Picker International, Inc.

Early in August, one of the two 5-GB 8-mm tape drives malfunctioned and began destroying tapes. Troubleshooting procedures determined that the microcode internal to that particular tape drive was at the lowest possible level and needed to be upgraded. The same procedures were conducted on the other 5-GB 8-mm tape drive, and it was also noted that the microcode was not at the most recent level. At the request of the AMU, IBM sent the upgrade that fixes a timing error in the drives' microcode which had been reported to damage tapes as well as cause input/output errors.

Mr. Wheeler installed McIDAS-OS2 v6.10 on the AMU's IBM Model 80 and Wide Word Workstation. This upgrade fixes several problems including the Wide Word Workstation's problem with mapping images from the mainframe at the local level. Also, an IBM PC was upgraded and configured to display Lightning Location and Protection (LLP) data full time. Previously, the AMU hosted LLP on a computer used for several other functions and only ran LLP during thunderstorms. Having LLP running continuously enables the AMU to keep LLP on-line and collect a continuous data set.

HURRICANE PREPAREDNESS PLAN

To comply with NASA/KSC regulations, Ms. Yersavich developed a hurricane preparedness plan for the AMU. Since the AMU is located on the Cape Canaveral Air Station (CCAS), the AMU hurricane preparedness plan is based on the CCAS Disaster Preparedness Hurricane Coordinators Guide (June 1994). The US Air Force 45th Weather Squadron (45WS) provides general information concerning the development of a storm (intensity, direction and speed of movement) which is then used by the Commander to determine hurricane conditions (HURCON). HURCON levels are based on the arrival of hurricane associated winds of 50 knots or greater and are simply an indication of how soon to expect these winds to affect the CCAS area. The AMU plan documents the actions to perform at the various HURCON levels along with the detailed procedures for performing software and data backups and hardware shutdowns. This plan will be revised annually in May followed by a dry run the first week of June.

MISSION IMMEDIATE TASKS

The AMU assisted in configuring terminals when the RWO was scheduled to support several operations during a Shuttle launch countdown on 28 September 1995. These operations included the Shuttle countdown, Ferry Flight support, and an Atlas simulated launch operation. To relieve congestion around and possible contention for McIDAS terminals, the RWO made use of the AMU's McIDAS Wide Word Workstation (WWW) to perform the DDMS function for the Shuttle support. The F-key menu systems made it easy for Mr. Wheeler to load the applicable menu and associated utilities onto the AMU WWW and allow the DDMS support staff to work in a familiar computer environment.

2.2 TASK 003 IMPROVEMENT OF 90 MINUTE LANDING FORECAST

DEVELOPMENT OF FORECASTER APPLICATIONS (MR. WHEELER)

MIDDS Support

Mr. Wheeler implemented a few minor changes to the Launch Weather Officers' (LWOs') F-Key menus. These changes include:

- Making the menu load procedures more efficient,
- Improving the way the menu accesses McIDAS MD files,
- Correcting minor problems in the Atlas and Delta support menus with regards to how the menus access and display local wind tower data, and
- Adding user options to the x-y plotting routines that plot temperatures and wind speeds.

The F-key menu software on all RWO terminals was backed up and magnetic copies were moved off site to support hurricane evacuation procedures.

Mr. Wheeler and Ms. Schumann continued the documentation effort for the McIDAS F-key menu systems. The level of detail originally proposed was intended to be used by a menu-system maintenance staff. Since the current McIDAS system is scheduled to be upgraded likely making the menu system unnecessary in the long term, the documentation effort has been narrowed to include less detail. This will result in the 45 WS receiving the documentation much sooner than would otherwise be possible. The documentation will still provide users with considerable information regarding effective use of the menu system and McIDAS as a whole and guidance in tracking down any errors or problems. The AMU will continue to provide maintenance support for the menu systems until the McIDAS upgrade is complete.

Microburst Day Potential Index

Evaluation

Mr. Wheeler and Mr. Bill Roeder continued evaluating the utility of the Microburst Day Potential Index (MDPI). This task originated when an unforecasted wet microburst event with 33.5 m s^{-1} (65 knots) winds occurred at the Shuttle Landing Facility (SLF) on 16 August 1994. Upon request from the 45 WS, the AMU analyzed the local wind sensor data for the event and confirmed the wind event was indeed a wet microburst (Wheeler 1994). Mr. Wheeler based much of the analysis and subsequent wet microburst classification on work performed by Atkins and Wakimoto during the MIST project (1991). Based upon data from the MIST project, Atkins and Wakimoto proposed that if the difference of the θ_e surface value and the minimum value aloft is greater than or equal to 20˚ K, then there is a high potential for a wet microburst occurrence. If the difference is less than 13˚ K, then wet microbursts are not likely.

The 45th WS and AMU proposed the MDPI based on θ_e profiles to indicate the likelihood of microbursts on a given day (Roeder 1994). The MDPI is designed such that values of 1.0 or greater suggest a high likelihood of wet microburst, assuming development of heavy precipitation.

MDPI = (Maximum θ_e - Minimum θ_e aloft)/ CT.

- Maximum θ_e = Maximum θ_e in the lowest 150 mb of the rawinsonde.
- Minimum θ_e aloft = Minimum θ_e between 650 and 500 mb.
- CT = Critical Threshold (30° K).

Because of the large surface temperature lapse on the early morning (1100 UTC) CCAS sounding and more tropical air mass (Central Florida vs. Northern Alabama), the maximum θ_e was calculated using the lower 150 mb (rather than the surface value) and higher CT value (30˚ rather than 20˚) (Roeder 1995; Wheeler 1995). Analysis of another similar microburst event at the Orlando International Airport (MCO) on 27 July 1994 added credibility in using the θ_e profile as a forecasting tool to microburst potential (Wheeler and Spratt 1995). During the MCO event, a 32.95 m s^{-1} (64 kt) peak wind was recorded.

To verify the performance of MDPI as a categorical forecast for microburst potential at CCAS and KSC, data were archived from 01 June to 31 August 1995. Preliminary analysis indicated that there were a total of 28 possible microburst events in the CCAS/KSC area during that 3 month period. To determine the skill of the MDPI, the contingency table of MDPI versus observed conditions shown in Table 1 was developed. The analysis consisted of first checking to see if the Range Weather Operations (RWO) forecaster had forecast and observed a thunderstorm at the SLF. If so, then the MDPI was computed for the day. Archived wind sensor data were then analyzed for all days to check for peak wind speeds of 30 knots or greater.

Table 1 illustrates the ability of the MDPI to assist forecasters in differentiating between standard thunderstorms and those capable of producing microbursts. The cases included in the table consist of days that thunderstorms were both forecast and observed. For microbursts to be predicted in Table 1, the MDPI for the day was greater than or equal to 1. For microbursts to be considered observed, winds of 30 kts or greater were observed on the local meteorological tower network (51 towers spread over a 900 sq. mile area).

Table 1. Predicted vs. Observed Microburst.

		Microburst Observed	
		No	Yes
Microburst	No	(a) 14	(b) 1
Predicted	Yes	(c) 13	(d) 27

The following skill scores were calculated from the above data.

- Probability of Detection (d/b+d): POD = 96.4%
- False Alarm Rate (c/(c+d): FAR = 32.5%
- Critical Success Index (d/(b+c+d)): CSI = 65.5%

The MDPI shows good skill in alerting the RWO forecaster to microburst potential without giving an unreasonable false alarm rate.

For comparison, the skill scores were also computed based on the assumption that if the forecaster predicted thunderstorms, then this is also a positive forecast for microbursts.

- Probability of Detection: POD = 100%
- False Alarm Rate: FAR = 57.6%
- Critical Success Index: CSI = 44%

These results show that by using the MDPI as an additional qualifier (instead of assuming all thunderstorms will have microbursts), the probability of detection decreases slightly (from 100% to 96.4%) while the false alarm rate improves dramatically, from 57.6% down to 32.5%. Further performance improvements are expected once the MDPI is tuned for optimal performance after the summer 1995 data are analyzed.

Implementation

During the summer weather regime, early and late morning soundings are necessary to determine changes in the atmosphere that could affect forecasts of thunderstorm activity and severity. Using profiles of θ_e, a forecaster should be able to differentiate between environments conducive for wet microburst and non-microburst days.

The 45th WS formally requested that the AMU develop a means of providing the forecaster a display of the θ_e profile and MDPI threshold index using the McIDAS (Man computer Interactive Data Access System) weather system (Adang 1995). The MDPI would be based on the observed vertical θ_e range (near surface θ_e - the observed minimum θ_e aloft) divided by the threshold critical value of 30° K.

The AMU, using a set of utilities in McIDAS, developed a program that automatically computes the equivalent potential temperature for each level when new CCAS rawinsonde data are received. The program displays the current θ_e profile and the previous and current MDPI threshold values (see Figure 1).

The 45th WS also instituted a new level of microburst potential support operations. Beginning with the early morning CCAS rawinsonde and computed MDPI index, the forecaster determines the potential for thunderstorm development, the timing of the thunderstorm occurrence, and the microburst threat. This is then briefed to the support staff and additional personnel tasking would be assigned if needed to handle the increased workload.

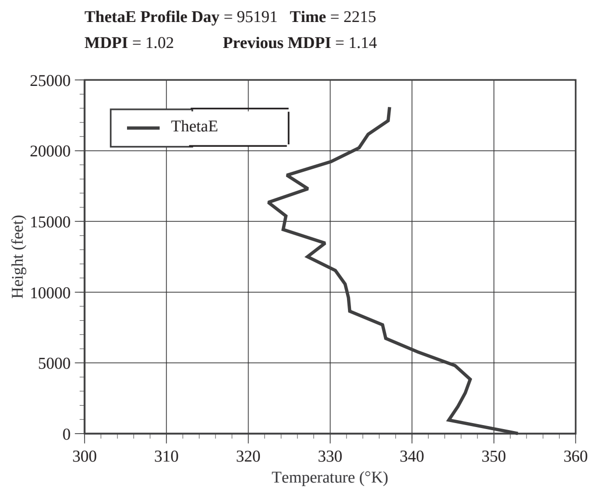

Figure 1. Example of McIDAS output of thermodynamic profile of equivalent potential temperature for 01 May 1995.

Additional microburst nowcasting (< 30 minutes) techniques (Atkins and Wakimoto 1991; Eilts and Oakland 1989; Isaminger 1988) were also developed for the WSR-88D Doppler radar. The forecaster monitors storms for the following:

- High dBZ and VIL indicating heavy precipitation,
- A precipitation core of 55 dBZ reaching the MDPI's level of minimum θ_e,
- A descending precipitation core and/or divergent storm top,
- Convergence at the storm's mid-levels (especially near minimum θ_e), and
- Storms possessing rotation.

Another nowcasting technique was to monitor for secondary convection by observing the following:

- Sea breeze movement and associated convergence areas and
- Colliding or intersecting convergent boundaries.

Future Plans

To increase the tools available for predicting microbursts, the AMU is testing a separate McIDAS routine that calculates and displays the Wind INDEX (WINDEX) gust value (McCann 1994). WINDEX calculates a potential surface gust strength. This program can be run hourly using updated surface data in the program's calculations. The program that calculates the WINDEX value displays a θ_e profile along with two WINDEX values, one based on the latest rawinsonde data and a second WINDEX value based on the rawinsonde data and most recent surface observation.

The MDPI profile and WINDEX value are new tools to be used to alert the KSC/CCAS community of the potential of microburst winds and increase the forecaster's vigilance for nowcasting signatures. After this summer's effort, the 45th WS and AMU will tune the MDPI and incorporate WINDEX into the routine 45th WS displays. Potential also exists to calculate the MDPI and WINDEX from the AMU's mesoscale model output currently under evaluation. This would allow forecasters to view forecast skew-t, MDPI, and WINDEX values out to 24 hours.

The AMU and 45th WS will continue to work together in further analyzing the data to tune the MDPI for optimal wet microburst forecasting and support to the 45th WS customers.

REFERENCES

Adang, T., March 29, 1995: AMU Prioritization Meeting. *Memorandum for NASA/ME.*

Atkins, N. T., and R. M. Wakimoto, 1991: Wet microburst activity over the Southeastern United States: Implications for Forecasting. *Wea. Forecasting*, **6**, 470-482.

Eilts, M. and S. Oakland, 1989: Convergence Aloft as a Precursor to Microburst. *24th Conference on Radar Meteorology*, P9.8, 190-193.

Isaminger M. A. 1988: A Preliminary Study of Precursors to Huntsville Microburst. *Lincoln Laboratory Project Report ATC-153*, 21 pp.

McCann, D., 1994: WINDEX - A New Index For Forecasting Microburst Potential. *Wea. Forecasting*; **9**, 532-541.

Roeder, W., November 24, 1994: Microburst Evidence. *Memorandum for 45th WS/DO.*

Roeder, W., January 27, 1995: McIDAS Microburst Utility. *Memorandum for AMU.*

Wakimoto, R. M., 1985: Forecasting dry microburst activity over the High Plains. *Mon. Wea. Rev.*, **113**, 1131-1143.

Wheeler, M., November 19, 1994: Analysis and Review of Downrush Wind Events on 16 August 1994. *AMU Memorandum, KSC FL*, 22 pp.

Wheeler, M. and S. Spratt, 1995: Forecasting the Potential for Central Florida Microbursts. *NOAA Technical Memorandum NWS SR-163*, 9 pp.

Wheeler, M., July 20, 1995: MDPI Guide. *AMU Memorandum for 45th WS.*

2.4 TASK 004 INSTRUMENTATION AND MEASUREMENT (DR. TAYLOR)

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

KSC has made considerable progress repairing the 50 MHz DRWP. Ms. Schumann has continued to monitor the 50 MHz profiler's data quality and now makes a deliberate attempt to monitor the profiler daily and record performance characteristics with regards to signal-to-noise ratio and sidelobe and reflection interference. The performance records are forwarded to Ms. Launa Maier (TE-ISD-3) and NYMA corporation on a daily basis for use by the profiler maintenance personnel. Ms. Maier is also examining the local rawinsonde data to see if she can correlate the profiler's performance with atmospheric conditions.

On 03 and 25 October, Ms. Schumann quality controlled the DRWP profiles in support of Titan IV simulations. The data were provided to Lockheed-Martin on the condition that they not be used for loads evaluation purposes in real time. For each 5 minute profile, Ms. Schumann recorded any interference signals that were evident, whether or not the interference signals affected the profile, the quality of the signal, and whether or not the profile would have been released for distribution. Capt. Scot Heckman and Capt. Jim Sardonia each trained during one of the simulations. The data quality for both these simulations was very good.

The profiler appeared to operating nominally, and the simulations should provide an excellent example of using the profiler during operations. In many cases, however, the resolution of the terminal used to quality control limited the ability to discern the wind signal in the spectra. Some minor modifications to the display would help considerably by improving the resolution of the individual signal strength versus height plots.

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

Mr. Wheeler and Ms. Lambert continued their data collection, review and analysis of WSR-88D data for convection initiation and severe/non-severe storm determination. Clear-air mode operation of the WSR-88D was minimal during the collection period due to USAF and NWS operational concerns. This will limit the convection initiation portion of the tasking to analysis of the precipitation-mode data which do not exhibit boundaries in as much detail or as early as clear-air mode data.

Two types of radar data were collected: Archive Level II, which is the raw radar data, and Archive Level IV, which is the base reflectivity, velocity, and spectrum width data along with products derived from the base data. In addition to radar data, satellite (infrared, visible, water vapor), surface observational, KSC/CCAS local meteorological tower wind sensor, upper air (rawinsonde), LLP (Lightning Location and Protection), along with ship and buoy data were archived to aid in the analysis. The data collection period ended in September with a total of 26 cases highlighted as potential case study candidates for convection initiation and/or non-severe/severe classification. The dates of the cases, along with their times and types of data collected, are shown in Table 2.

Ms. Lambert worked with the Motif-IRAS software, developed by Mr. Dave Priegnitz at the South Dakota School of Mines and Technology, to determine its capabilities and to make modifications to it as needed. A few bugs were discovered in IRAS, and the developer was contacted for help in fixing them. In order to improve the Florida map background in IRAS, the Lightning Detection and Ranging (LDAR) latitude/longitude data for Florida county boundaries, coastlines, roads, and rivers were obtained from Ms. Launa Maier (TE-ISD-3) and reformatted into a file that was readable by IRAS. This produced a high-resolution outline of the Florida east-central coastline needed for the NEXRAD data evaluation.

Mr. Steve Hoffert and Mr. Matt Pearce, graduate students at Pennsylvania State University, provided the AMU with NEXRAD display software they had written during the summer while working with the Melbourne NWSO on LDAR system usage and interpretation (Hoffert and Pearce 1996; Pearce and Forbes 1996). Mr. Hoffert and Mr. Pearce used several Motif-IRAS routines in their software, which has the added capability to calculate and display radar derived products in addition to the base data and many other features making it much more efficient to use. Ms. Lambert successfully ported the new software from HPUX (HP's version of UNIX) to AIX (IBM's version of UNIX). A NEXRAD PPI display and cross-section produced from this software package are shown in Figure 2 and Figure 3, respectively. An important feature of this software package is that it is able to display negative reflectivity values. This may partially offset the loss of information incurred when the radar was not in clear-air mode.

REFERENCES

Hoffert, S. G., and M. L. Pearce, 1996: The 29 July 1994 Merritt Island, FL microburst: A case study intercomparing Kennedy Space Center three-dimensional lightning data (LDAR) and WSR-88D radar data. Preprints from the 18th Conference on Severe Local Storms, February 19-23, 1996, San Francisco, CA. Published by the American Meteorological Society (in press).

Pearce, M. L., and G. S. Forbes, 1996: Applications of VAD-derived kinematic quantities to studies of coastal mesoscale processes using WSR-88D data. Preprints from the Conference on Coastal Oceanic and Atmospheric Prediction, January 28 - February 2, 1996, Atlanta, GA. Published by the American Meteorological Society (in press).

Table 2. NEXRAD Task Data Summarization

Date/Time of Activity	Data Collected	Date/Time of Activity	Data Collected
9 June / 16 - 23 Z	all (Arch IV, Sat, Obs, Arch II)	1-2 Aug / Hurricane Erin	no Arch IV
11 June / 15 - 21 Z	no Arch IV	8 Aug / 16 - 21 Z	no Arch IV
12 June / 14 - 23 Z	missing some Arch IV	10 Aug / 17 - 23 Z	all
20 June / 14 - 23 Z	all	18 Aug / 17 - 22 Z	all
26 June / 15 - 21 Z	all	21 Aug / 15 - 22 Z	all
28 June / 15 - 21 Z	all	23 - 24 Aug / T.S. Jerry	missing some Arch IV
10 July / 17 - 22 Z	all	30 Aug / 11 - 22 Z	all
11 July / 15 - 21Z	all	31 Aug / 11 - 17 Z	all
12 July / 14 - 18 Z	all	1 Sep / 14 - 19 Z	all
13 July / 17 - 21 Z	all	6 Sep / 14 - 21 Z	all
14 July / 7 - 14 Z	all	7 Sep / 16 - 22 Z	all
17 July / 9 - 20 Z	all	8 Sep / 15 - 21 Z	all
20 July / 14 - 20 Z	all	12 Sep / 13 - 20 Z	all

Figure 2. 0.5˚ PPI scan from the WSR-88D radar in Melbourne, FL. The line with endpoints A and B denotes the location of the cross-section shown in Figure 3.

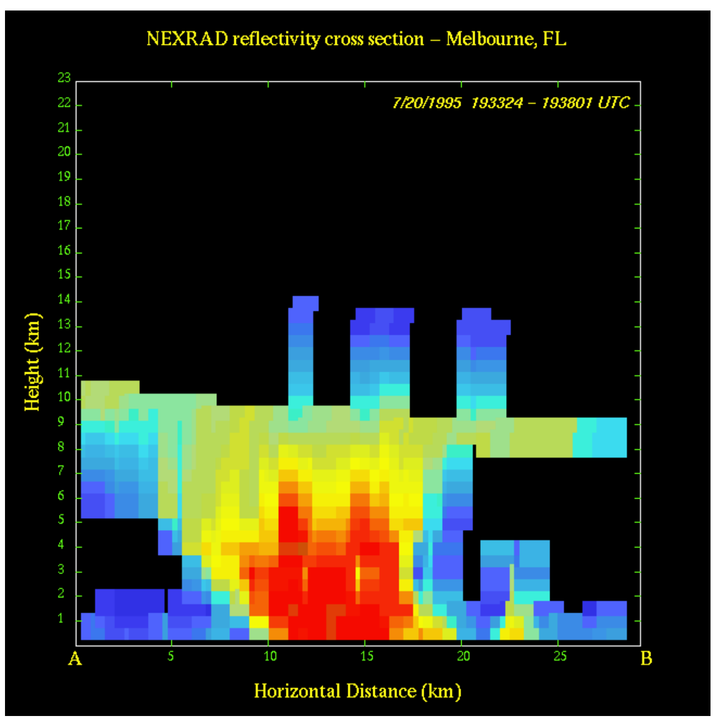

Figure 3. Cross-section from the WSR-88D radar in Melbourne, FL. Cross-section location is shown by the line in the PPI scan in Figure 2. Endpoints A and B in the cross-section correlate with the locations of A and B in the PPI display.

2.5 TASK 005 MESOSCALE MODELING

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

Dr. Manobianco and Ms. Yersavich have completed processing MASS model and observational data required for the rederivation of Model Output Statistics (MOS). Based on the recommendations of Dr. John Zack at MESO, Inc., Dr. Manobianco will initially rederive the MOS equations using only 1994 warm season data and verify the new equations using an independent data set from the 1995 warm season.

Ms. Yersavich completed processing data required for case studies that represent a portion of the AMU's evaluation of the MASS model. Dr. Manobianco and Ms. Yersavich began analyzing the observations and MASS model forecasts from 13 July 1994 (sea breeze), 28 July 1994 (no sea breeze), and 20 May 1995 (Atlas-Centaur launch with GOES-J payload). In addition, Drs. Manobianco and Zack completed the analysis for an additional case from 19 February 1992. The following section summarizes the results from the 19 February 1992 case study.

Case example

The 19 February 1992 case provides an illustration of the improved forecast guidance that could potentially be gained by executing a mesoscale model over the Florida peninsula. This case is important from an operational perspective because the Air Force scrubbed the second launch attempt of a Delta II rocket from Launch Complex 17B at CCAS due to thick clouds (> 4500 ft thick) and disturbed weather (i.e. any meteorological phenomena producing moderate or greater precipitation). The adverse weather was related to an area of thunderstorms that developed to the southwest of KSC/CCAS during the afternoon hours in advance of a dissipating frontal band. The forecasters at CCAS set the overall probability of weather constraint violation for the operation to 30% just 90 minutes (2029 UTC) prior to the beginning of the launch window. The initial development of this isolated convection was not predicted by the NGM but was simulated by the MASS model. The performance of MASS for this case was not spectacular, but it demonstrates the skill that the model can exhibit when mesoscale circulations are an important contributor to the initiation and evolution of convective storms.

At 1200 UTC 19 February 1992, a deep cyclone was located over the eastern Great Lakes. A frontal band extended southward through coastal South Carolina, across the northern portion of the Florida peninsula and into the Gulf of Mexico. The band is evident in the manually digitized radar (MDR) depictions shown in Figure 4. The band of echoes over northern Florida was a result of low to middle clouds and light precipitation associated with the frontal zone. This band moved very slowly southward and gradually weakened during the day. The weather to the south of the band was generally clear.

The development of the small area of thunderstorm activity to the southwest of KSC/CCAS was apparently forced by two mesoscale circulations which developed over the Florida peninsula during the daylight hours. One circulation was associated with a cloud boundary on the southern edge of the southwest-northeast cloud band over northern Florida. The atmospheric boundary layer was heated significantly in the region of nearly clear skies to the south of the cloud band while the low-level air within the cloud band remained relatively cool. This can be seen in Figure 5 by noting the increase in the surface temperature gradient from northern Florida to central Florida between 1500 UTC and 2100 UTC. The observational data in Figure 5 suggest that this north to south differential heating had a significant impact on the low-level pressure and wind fields.

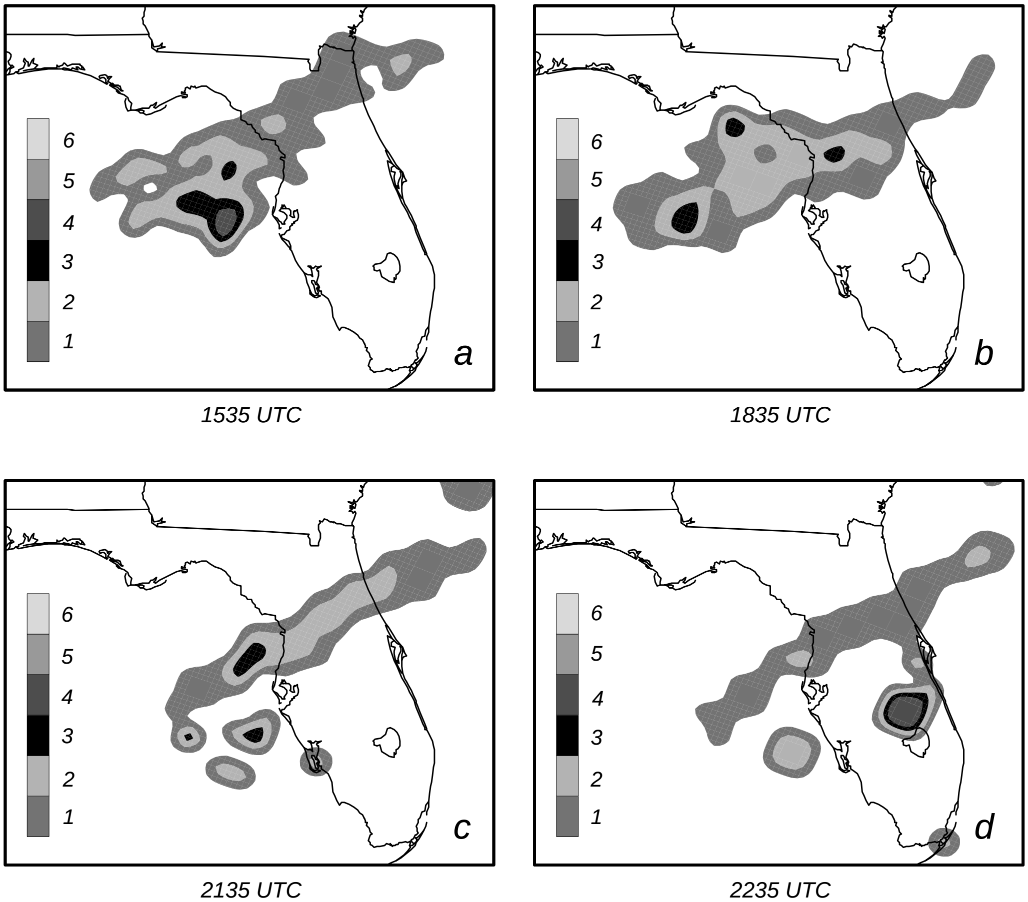

Figure 4. Manually digitized radar (MDR) depiction for 19 February 1992 at (a) 1535 UTC, (b) 1835 UTC, (c) 2135 UTC, and (d) 2235 UTC. Echo intensities (VIP levels) 1 through 6 are shaded gray according to the legend in each panel.

A nested MASS simulation was initialized at 1200 UTC 19 February 1992 by MESO, Inc. during the developmental phase of MASS. This simulation was executed over the same 45 km coarse mesh and 11 km fine mesh domains shown used for the daily real-time runs in the AMU. In addition, the model was initialized using only data which are routinely available to MASS from the MIDDS at KSC/CCAS.

Evidence of the circulation associated with the cloud boundary can be clearly seen in the model output data in Figure 6. The predicted short wave transmissivity for 1800 UTC (Figure 6a) illustrates the simulated position of the cloud boundary. At this time, the model has already created a substantial north to south surface thermal gradient (Figure 6b) in the vicinity of the cloud boundary and there is an incipient mesoscale low pressure center located over central Florida on the southern edge of the thermal gradient. The model output fields for 2200 UTC (Figure 6c and Figure 6d) indicate that the cloud boundary feature is well-developed. There is pronounced diffluence in the low level wind field just to the north of the mesolow along the axis of a surface pressure ridge in the cloudy region. On the northern side of the ridge line, the simulated winds are from the southwest while to the south of this ridge, the winds have a weaker southerly component and a stronger westerly component which results in significant confluence further to the south in the vicinity of the simulated mesolow. The confluence is even stronger in the observed wind field because the observed winds between the ridge and mesolow (Figure 5d) have a stronger northerly component than the simulated winds (Figure 6c).

Figure 5. Surface weather observation data plotted in standard format at selected sites and a subjective analysis of altimeter setting (0.5 mb interval) for (a) 1500 UTC, (b) 1800 UTC, (c) 2100 UTC, and (d) 2200 UTC. Only a subset of the stations used to construct the analysis are shown.

The second significant mesoscale circulation was a classical sea breeze. Since the large scale winds on this day were from the west, it would be expected that the strongest sea breeze convergence would occur along the east coast of the peninsula where the sea breeze opposes the background large scale flow. The observations at 2200 UTC (Figure 5d) suggest that a sea breeze circulation was present along the southeast coast of Florida from Miami northward to Vero Beach. However, to the north of Vero Beach, the sea breeze was suppressed by the lack of boundary layer heating due to cloud cover. The simulated 2200 UTC wind field shows an onshore sea breeze flow present along the southeast coast of the peninsula up to the Vero Beach area with no onshore flow to the north of the KSC/CCAS area as observed (Figure 5c).

Figure 6. Simulated fields from an 11 km MASS simulation initialized at 1200 UTC 19 February 1992: (a) 1800 UTC short wave transmissivity; (b) 1800 UTC 10 m AGL temperatures (dashed lines; 1 °C interval) and mean sea-level pressure (solid lines; 0.5 mb interval), (c) 2200 UTC 10 m AGL wind vector and isotachs (1 ms^{-1} interval), (d) same as (b) except for 2200 UTC, (e) accumulated precipitation (0.5 mm interval) for the 2-hour period ending at 0000 UTC 20 February; and (f) same as (b) except for 0000 UTC 20 February 1992.

The small area of new thunderstorm activity that was of interest to the KSC/CCAS operational personnel developed between the 2135 UTC and 2235 UTC radar summaries (note Figure 4c and Figure 4d) near the intersection of the sea breeze convergence line moving westward from the east coast and the cloud boundary convergence line moving southward from the cloud boundary over north central Florida. The position of these two convergence zones can be readily inferred from the surface winds at 2200 UTC (Figure 5d). The model's moist convective parameterization scheme was triggered at approximately 2200 UTC at several grid points to the southwest of KSC/CCAS and very close to the location where the first radar echoes of the new system were observed. No precipitation was produced by the model anywhere over central Florida to the south of the cloud band before 2200 UTC. The simulated convection moved eastward and crossed the coast just to the south of KSC/CCAS by 0000 UTC 20 February as observed.

The simulated 2-h accumulated precipitation for the period 2200 UTC to 0000 UTC (Figure 6e) indicates the area affected by the simulated convective system. The maximum simulated precipitation is 1 to 2 mm just to the south of KSC/CCAS which compares very favorably with an observation of about 1 mm at Melbourne (not shown) and approximately 2.5 mm at a cooperative observational site just to the southwest of Melbourne. The simulated pressure and temperature pattern at 0000 UTC (Figure 6f) indicates that the system is accompanied by an area of downdraft cooling and a small mesohigh. The timing and magnitude of the observed pressure and temperature perturbations at Melbourne (not shown) were consistent with that of the simulated perturbations.

The 12-h precipitation forecasts produced by the operational NGM model and the 11 km MASS model are compared with observational precipitation data (not shown). At the relatively coarse horizontal grid resolution of 80 km on the C-grid, the NGM was unable to forecast any of the observed mesoscale variability of the precipitation over the central portion of the Florida peninsula. As a result, it drastically overpredicted the area covered by precipitation. In contrast, the mesoscale model was able to forecast a much more realistic precipitation distribution. It should be noted that current NMC operational analyses and forecasts (e.g. the 29 km version of the Eta model), which were not available when this version of the MASS was developed in 1992, employ finer horizontal resolution than the 80 km NGM shown in this comparison.

This example illustrates a case in which the development of moist convection was the result of well-defined mesoscale features that were attributable to differential boundary layer heating. The modeling system tends to perform well in this type of scenario since (1) many of the factors which control the differential boundary layer heating (land/water distribution, density of vegetation, soil moisture and cloud patterns) can be reasonably well mapped for initialization; and (2) the heating patterns themselves, with the possible exception of those due to cloud shading, do not drastically change during the course of the simulation. In contrast, the model does not perform as well in cases in which the evolution of convection is strongly controlled by the feedback from the convection itself (e.g. the development of new convection along thunderstorm outflow boundaries).

SUBTASK 4 INSTALL AND EVALUATE ERDAS (MR. EVANS)

During the quarter, Mr. Evans and Ms. Lambert conducted the ERDAS evaluation tasks initiated by the KSC Weather Office. The primary purpose of these tasks was to compare the Ocean Breeze Dry Gulch (OBDG) model with the ERDAS models to determine if the ERDAS models increase launch availability and/or reduce false alarms. At NASA's request and in concurrence with Air Force Range Safety, the AMU defined the following tasks for the comparison of OBDG with ERDAS:

- Comparison of Ocean Breeze Dry Gulch (OBDG) using the standard operational two-dimensional Barnes wind field versus using OBDG with the three-dimensional ERDAS wind field.
- Comparison of OBDG using the standard operational two-dimensional Barnes wind field versus the ERDAS HYPACT "particle-in-cell" dispersion algorithm with three-dimensional wind field.

Mr. Evans and Ms. Lambert modified RAMS to obtain the necessary wind speed, wind direction, and vertical velocity data. These data were merged with Weather Information Network Display System (WINDS) data and then run through the OBDG model on ENSCO's developmental Meteorological Monitoring System (MMS) at the Melbourne office.

Ten case study days for the comparison were chosen using the Shuttle Landing Facility observations. There is at least 1 day from each month between January and July 1995, 6 of which are sea breeze days. Each 'day' covers the 24-hour period from 1200 UTC to 1200 UTC. In order to analyze how the models perform during certain times of the day, three 2-hour periods were evaluated for each day: 0500 - 0700 UTC (early morning), 1500 - 1700 UTC (noon), and 2100 - 2300 UTC (late afternoon). The RAMS meteorological model was run for all 10 days and the meteorological output was archived for later input to the diffusion models.

Mr. Evans and Ms. Lambert completed processing the RAMS and observed data for the comparison between the Ocean Breeze Dry Gulch (OBDG) model and the ERDAS diffusion models. The three types of runs made for the comparison were:

- OBDG model with observed data (WINDS towers),
- OBDG model with RAMS forecasted winds (from various levels depending on vertical motion), and
- HYPACT model with RAMS model input.

The results of this study are being compiled and report is being prepared. The results and conclusions will be included in the next quarterly report.

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

WIND SHELTERING STUDY

The final report for this study is complete and has been submitted to NASA/KSC for publication as a NASA Technical Memorandum. The final report is also available on NASA/KSC's WWW Home Page.

CROSSWIND DTO

Dr. Merceret continued consulting with Johnson Space Center (JSC) and Marshall Space Flight Center (MSFC) on the design of appropriate winds for use in the Shuttle simulator in preparation for the crosswind Detailed Test Objective (DTO 805). Wind data obtained from Shuttle Training Aircraft (STA) were evaluated against tower data to determine their representativeness.

WIND PROFILING CLIMATOLOGY

Dr. Merceret began designing an analysis strategy and writing software to conduct a climatology of wind changes detected by the KSC 50 MHz Doppler Radar Wind Profiler (DRWP). The climatology will be used by the Shuttle Program to evaluate the contribution of the DRWP data to flight safety and launch availability in comparison to its cost.

Attachment 1: AMU FY-95 Tasks

TASK 1 AMU OPERATIONS

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

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

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

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

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

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

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

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

TASK 2 TRAINING

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

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

- Provide NEXRAD training for contractor personnel.

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

TASK 3 IMPROVEMENT OF 90 MINUTE LANDING FORECAST

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

- Subtask 2 - Fog and Stratus At KSC

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

Subtask 4 - Forecaster Guidance Tools

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

TASK 4 INSTRUMENTATION AND MEASUREMENT SYSTEMS EVALUATION

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

- Subtask 3 - Doppler Radar Wind Profiler (DRWP)

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

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

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

- Subtask 5 - Melbourne NEXRAD

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

- Subtask 7 - ASOS Evaluation

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

- Subtask 9 - Boundary Layer Profilers

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

- Subtask 10 - NEXRAD/McGill Inter-evaluation

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

TASK 5 MESOSCALE MODELING

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

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

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

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

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

• Subtask 3 - Acquire the Colorado State University RAMS Model

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

1) Provide a real-time functional forecasting product relevant to Space shuttle weather support operations with grid spacing of 3 km or smaller within the KSC/CCAS environment.

2) Incorporate three dimensional explicit cloud physics to handle local convective events.

3) Provide improved treatment of radiation processes.

4) Provide improved treatment of soil property effects.

5) Demonstrate the ability to use networked multiple processors.

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

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

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

1) Evaluation of ERDAS graphics in terms of how well they facilitate user input and user understanding of the output.

2) Determination of the requirements that operation of ERDAS places upon the user.

3) Documentation of system response times based on actual system operation.

4) Evaluation (in conjunction with range safety personnel) of the ability of ERDAS to meet range requirements for the display of toxic hazard corridor information.

5) Evaluation of how successfully ERDAS can be integrated in an operational environment at CCAS.