Applied Meteorology Unit (AMU)

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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

On 2 December 1996, Ms. Yersavich and Mr. Drape´ demonstrated the AMU's Lightning Detection And Ranging (LDAR) computer-based training course during the poster session of the National Weather Association meeting in Cocoa Beach, FL. A PC and monitor running the LDAR CBT were set up for participants to try out the CBT program, provide feedback, and ask any questions relating to LDAR and/or the CBT.

HARDWARE/ SOFTWARE INSTALLATION AND MAINTENANCE (MS. YERSAVICH)

During the past quarter, the AMU configured the Hewlett Packard (HP) J210XC workstation to run the WSR-88D Algorithm Testing And Display System (WATADS). In addition to WATADS, McIDAS-X version 7.1 and VIS5D version 4.2, a three-dimensional graphical package, were also installed on the HP workstation. The McIDAS-OS/2 software was upgraded to version 7.1 on the AMU Pentium PC during the past quarter.

2.2 TASK 002 TRAINING

Ms. Yersavich attended a Hewlett Packard (HP) training course the week of 30 September - 4 October. The course was on Informix data base management and was offered by PRC (through CSR) as part of the new Advanced MIDDS system upgrade coming to the Eastern Range.

2.3 TASK 003 SHORT TERM FORECAST IMPROVEMENT (MR. WHEELER)

SUBTASK 1 MIDDS MENU SYSTEM

Mr. Wheeler provided help in modifying the Range Weather Operations (RWO) forecasters terminal F-key menu system and support routines to generate and display graphics from the eta model data. Mr. Wheeler also updated an IBM mainframe utility that plots the local skewt and

ThetaE profile. The updated version allows the user to select one of the Florida rawinsonde sites to analyze and track the ThetaE profiles for other sites and monitor microburst potential across the state. In accordance with the consensus reached at the AMU mid-course review meeting held on 2 December 1996 as documented in Technical Directive 4-1001, all work on this task is terminated effective 11 December 1996.

2.4 TASK 004 INSTRUMENTATION AND MEASUREMENT

SUBTASK 1 NEXRAD EXPLOITATION

Mr. Wheeler and Ms. Lambert presented the results of the NEXRAD Exploitation task to the 45th Weather Squadron (45 WS) in October. Several modifications were made to the final report after receiving feedback from the presentation, including the addition of an Executive Summary. Copies of the Executive Summary were sent to personnel at Spaceflight Meteorology Group (SMG), the 45 WS, and NWS Melbourne office (NWS MLB) for review in November. Many of the suggested changes from this review were made to the Executive Summary and to the corresponding sections in the final report. Copies of the final report were sent to SMG, the 45 WS, and NWS MLB for external review at the beginning of December and were sent back to the AMU later that month. The review and modification process will be completed and the final report will be distributed in January 1997.

Summary of Results

The objectives of the AMU's NEXRAD Exploitation task are to determine what radar signatures are present prior to and at the time of convection initiation, and to determine radar signatures which will help distinguish whether the ensuing convection will become severe. Radar data from the WSR-88D radar located at NWS Melbourne (WSR-88D/KMLB) were collected between June and September 1995, and 16 convective case studies were analyzed for which the radar was operating during the entire period of interest. To meet the objectives, these data were analyzed with other radar data analysis tools besides the Principle User Processor (PUP) to bring further insight into the radar-detectable signatures associated with convection initiation and severe storm development.

All WSR-88D/KMLB products were scrutinized for their utility in detecting convection initiation signatures. The analysis was confined to base reflectivity, velocity, spectrum width, and composite reflectivity in which the features involved in convection initiation could be detected. Through process of elimination, it was found that the 0.5° reflectivity product with the lowest reflectivity values displayed is the best product to monitor for convection initiation signatures. Because most of the summertime convection in east central Florida is triggered by boundary layer rather than upper level dynamic processes, the upper level scans provided little information regarding the location of convection initiation signatures. Velocity components of the features which were weak or not parallel to the radial of the beam made them very difficult to detect. The spectrum width field had an overall noisy appearance and gave no indication of the existence of important features. In the composite reflectivity product, weaker convection initiation features can be hidden by scatterers aloft that have higher reflectivities.

There were seven features identified as convection initiation signatures in this study, most of which are already familiar to forecasters. The features identified were horizontal convective rolls (HCRs), the sea breeze, the Merritt Island convergence zone, the Indian River convergence zone, interlake convergence, storm outflow boundaries, and fires. Interactions between two or more of the features were always observed in the data (except for one case of Merritt Island convergence) before convection was initiated.

Many of these features were detectable on the PUP in the 5 to 15 dBZ range. Features in these reflectivity ranges are most easily detected when the radar is in clear air mode as the value range displayed is -28 to 28 dBZ. However, the radar is usually in precipitation mode during the summer. The lowest value displayed in precipitation mode is 5 dBZ. Weak boundaries with reflectivities ≤ 5 dBZ, which were often responsible for the initiation of convection, are not well defined or not detected in precipitation mode. This underscores the importance of monitoring the lowest levels of reflectivity values in precipitation mode. The weaker (radar-undetectable) boundaries can be monitored in the visible satellite image when clouds form above them.

The following procedures are recommended for optimal detection of convection initiation signatures:

- Request that WSR-88D/KMLB operate in clear air mode as long as possible and monitor the 0.5° reflectivity product in order that any weak features responsible for initiating the first cells of the day be detected,
- Display the full range of reflectivity values in the 0.5° reflectivity product in order to detect most of the features responsible for initiating subsequent convection, and
- Monitor the visible satellite image in conjunction with the radar data as the very weak boundaries and HCRs may not be radar detectable in precipitation mode.

Monitoring the full range of reflectivity values (second recommendation) may be difficult for forecasters to implement consistently as they will also need to use other configurations which will help them determine the structure and severity of existing cells. Under these circumstances the 0.5° reflectivity product could be monitored as part of a 4-panel display in one of the PUP monitors.

All WSR-88D/KMLB products were scrutinized, both individually and in combination with other products, to determine their utility in detecting severe storm precursors and signatures. Severe storms possess at least one of the following three features: 1) winds ≥ 50 kt, 2) ≥ 3/4″ hail, and 3) tornadoes/waterspouts. In the data collected for this study, the most common severe weather element was that of high winds from microbursts. There were few instances of confirmed observations of 3/4″ hail and only one confirmed tornado. Thus, the WSR-88D products were only analyzed for precursors to high wind events.

The data were analyzed with WATADS which displays the values of the radar derived products in time series graphs for each individual cell. This analysis showed that both the parameter values and trends are essential to the prediction of a high wind event. The values and trends of storm maximum reflectivity, core aspect ratio, and vertically integrated liquid (VIL) proved to be important in predicting microbursts. Typically, the maximum reflectivity remains steady at ≥ 55 dBZ while the values of the other three parameters increase 15 to 20 minutes before the event then decrease sharply 5 to 10 minutes before high winds are observed at the surface. The values of these parameters depend on the operating volume coverage pattern (VCP) of the radar, which is either VCP 21 or VCP 11 when the radar is in precipitation mode. The VCP 11 beam coverage is more complete than that of VCP 21 and provides a better data set for input to the algorithms and, therefore, more accurate parameter values for the storms in question.

There are many other products, including the base data scans, which are helpful in determining the structure, intensity, and parameter trends of a storm. It is best to display these in the 4-panel display feature available on the PUP in specific combinations which will help the forecaster determine the characteristics and intensity of a potentially severe storm. Three sample 4-panel displays are given in the final report, and forecasters may wish to build additional displays tailored to their specific needs.

The following procedures are recommended for optimal prediction and detection of severe storms:

- Operate the radar with VCP 11 if deep convection is expected to develop from existing cells,
- Monitor the values of maximum reflectivity in the composite reflectivity product, the trends of VIL in the VIL product, and the trends of core aspect ratio (WDSS only) for microburst prediction (note: specific values and trends for these parameters are given in the final report), and
- Use the 4-panel displays given in the final report or develop displays to help determine the structure and intensity of existing cells.

Most of the recommended procedures given in the final report are already used by operational forecasters at the 45 WS, SMG, and NWS MLB. All the WSR-88D/KMLB products were thoroughly analyzed with three display tools for new ways to look at the data which would bring further insight into detecting convection initiation and severe storm signatures. These conclusions confirm that the operational procedures in current use are effective and should continue to be employed. The final report documents the effectiveness of those procedures and may serve as a training manual for new forecasters unfamiliar with the use of NEXRAD in the central Florida environment.

The final report also provides guidance for future research regarding the use of NEXRAD products for detecting convection initiation and severe storm signatures. Suggestions for new and improvements to existing NEXRAD products are provided. Until new products geared toward detecting convection initiation signatures are implemented in the NEXRAD system, no further study is needed for this objective. The severe storm signature objective, however, is not fully complete since analyses for two severe weather features, 3/4" hail and tornadoes, were not possible due to their lack of occurrence in the data. In addition, several new products are available in Build 9.0 whose value in forecasting and detecting severe storms in the central Florida environment is unknown. Future work should be structured such that the WSR-88D/KMLB data set will contain a sufficient number of confirmed occurrences of severe hail and tornadoes so the utility of all the products in forecasting and detecting severe storms can be determined.

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

During November, Dr. Taylor developed test data sets which are being used to verify the software NYMA is developing for the Enhanced WINDS Display Element (EWDE) workstation. These data sets are being used to verify NYMA's Barnes objective analysis code for the wind tower network and NYMA's divergence codes for both the wind tower network and the boundary layer wind profilers. These data sets were generated by writing independent objective analysis and divergence codes running on AMU computers. The test data sets have been provided to both NYMA and CSR personnel. In addition to the generation of the test data sets, Dr. Taylor assisted NYMA in debugging their Barnes objective analysis and divergence codes. At the end of December, there were still some unexplained differences in the results from the NYMA codes and the independent AMU codes. The attempt to determine the reason for these differences will be continued in January.

Dr. Taylor and Ms. Lambert met with Mr. Roeder and Capt. Heckman of the 45 WS to discuss the task objectives. Similar meetings to discuss the task objectives will be held with SMG and NWS MLB in January. As one result of the meeting with 45 WS TSgt. Bob Kane (RWO forecaster), was assigned as the RWO point-of-contact for this task. They also visited the South Cape profiler to become familiar with the site hardware orientation and met with NYMA personnel for assistance in displaying archived spectral data. Ms. Lambert became familiar with the available functions in

NYMA's Enhanced Winds Display Element (EWDE) located in the RWO for eventual operational use, and conducted a literature search on articles relating to the use and analysis of 915 MHz profiler and RASS data. The literature search is ongoing.

SUBTASK 3 ADVANCED MIDDS WEATHER SYSTEM UPGRADE (MR. WHEELER)

In accordance with the consensus reached at the AMU mid-course review meeting of 2 December 1996 as documented in Technical Directive 4-1001, all work on this task is terminated effective 11 December 1996.

SUBTASK 4 WDSS EVALUATION AND TRANSITION ISSUES

During October Dr. Manobianco and Mr. Nutter visited the AMU south at the NWS MLB for one afternoon during the first week to view the real-time operation of the WDSS, examine its capabilities, and test its functionality. Their comments were forwarded to Mr. Wheeler for inclusion in the memorandum regarding the AMU's Proof-of-Concept evaluation of the Warning Decision Support System (WDSS). Mr. Wheeler finished the memorandum which summarizes the evaluation and includes recommendations regarding WDSS and its potential for implementation into operations. Mr. Wheeler, Ms. Lambert, and Mr. Dave Sharp of the NWS MLB reviewed and prioritized the WDSS recommendation list. The updated list was presented to NSSL during the National Weather Association meeting in early December. The WDSS prioritized list contains requests for changes to the current system, new features, and work on important central Florida algorithms (i.e. microburst and hail). The list was well received by NSSL and they were quite interested in several of the recommended changes. NSSL will review the list internally and a teleconference will be setup in January to discuss the WDSS recommendation list.

Also in December, Mr. Wheeler received the requested satellite imagery from National Climate and Data Center (NCDC) for inclusion in the 13 August 1996 Patrick AFB severe weather event report. Mr. Sharp of the NWS MLB is completing his assessment of the WSR-88D PUP data set to determine if a mesocyclone was detected close (in time and space) to the weather event. Once these requests are completed, the report will be finalized and distributed.

SUBTASK 5 I&M AND RSA SUPPORT

The AMU review of vendor briefings, documents, and products in support of I&M and RSA helps to ensure that the deliverables resulting from these efforts are operationally useful and satisfy customer requirements including functionality, data communication, and data compatibility. For example, the weather systems delivered under RSA Phase IIA must collect, display, and archive data that meets RWO and SMG operational requirements.

At the request of Mr. Billie Boyd (45 WS), Dr. Manobianco reviewed the Baseline Configuration Documentation (BCD) for the entire RSA Phase IIA in preparation for the Hughes Weather Team visit with the AMU on 6 November 1996. Dr. Manobianco's review focused on aspects of the BCD dealing with Hughes' proposed configurations for the Eastern Range weather instrumentation, weather radar, and local mesoscale model. Drs. Merceret, Manobianco, and Taylor and Mr. Nutter met with members from the Hughes Weather Team during their 6 November site visit of the Eastern Range. This meeting provided a forum for technical interchange on issues relating to instrumentation, radar, and modeling as proposed by Hughes in the RSA Phase IIA Baseline Configuration Document.

On 4 December, Lockheed Martin Hughes (LMH) conducted design "vignettes" at the ROCC to educate the range operators on the design concepts that LMH plans to employ in order to meet the Technical Requirements Document as well as the requirements derived by LMH and to solicit feedback from the operators. At the request of Mr. Billie Boyd, Dr. Manobianco attended the "vignette" dealing with the weather portion of RSA Phase IIA.

Also in December, Drs. Manobianco and Taylor, Messrs. Nutter and Wheeler, and Ms. Lambert reviewed the Radar Trade Study for the Eastern Range prepared by Ms. Magda Hashem of Hughes for RSA Phase IIA. Dr. Manobianco compiled and edited all comments from these reviews and forwarded them to Mr. Boyd.

SUBTASK 7 LDAR DATA AND DISPLAY (MS. LAMBERT)

This task involves investigating data reduction methods for providing LDAR data to MIDDS for transmission to RWO and SMG. In addition, the AMU will identify options for MIDDS display of LDAR data that are less data intensive than the current LDAR system display yet preserve information. 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 ingested by MIDDS. In order to facilitate the ingest of LDAR data into MIDDS so that it is available to SMG, data reduction methods will be investigated. The analysis will focus on two different data reduction techniques:

- Data compression techniques which would preserve all (or nearly all) data content yet facilitate data transfer, and

- Data filtering or reduction techniques which would preserve information content yet reduce data volume.

In December, Ms. Lambert began gathering and pursuing literature describing the LDAR and MIDDS systems. Meetings were also held with key individuals in the AMU, CSR, and NASA to discuss the functions and limitations of the two systems, including typical and maximum LDAR data rates and the data ingest capability of MIDDS. Data compression and reduction techniques were also discussed with ENSCO and NASA personnel. SMG personnel will be contacted in January for information regarding their present and future display and communication line capabilities, as well as ideas for LDAR data reduction and display. After the analyses are completed, the AMU will document the options and recommendations and provide an estimate of the AMU workload required to develop the recommended prototype algorithms, products, and displays. The final report is scheduled to be completed by March 1997.

SUBTASK 8 RADAR / PIREP INVESTIGATION

This new task is an investigation into the radar and aircraft reported cloud top inconsistencies reported by the 45 WS during launch support operations.

Mr. Wheeler began this investigation in December by gathering and pursuing Launch Weather Officer (LWO) reports, the WSR-74C and WSR-88D system specifications, and other related literature. After the analyses are completed, the AMU will document the findings and make recommendations if further investigation is warranted. A final report will be completed by 1 April 1997.

2.5 TASK 005 MESOSCALE MODELING

INSTALL AND EVALUATE ERDAS (MR. EVANS)

During October, Dr. Craig Tremback of MRC/ASTER successfully installed the modifications to the ERDAS and PROWESS software to allow RAMS to receive the Lambert Conformal grids for initialization. ERDAS is now receiving the eta grids twice daily and initializes the RAMS model with that data without any problems. Because the eta data is a finer resolution grid than the NGM data (which RAMS formerly used for initialization), the quality of the initialization should improve.

In support of the ERDAS transition from the AMU to operations, Mr. Evans completed and distributed the *Operations Manual* and the *Maintenance Procedures* to CSR for their submittal to the Air Force as part of the requirements for certification. Copies of existing ERDAS documentation were distributed along with a list of deficiencies and recommendations for future versions of ERDAS in a document providing inputs to the *System Segmentation Specification*.

On 18 October at the request of Dr. Ray Kamada of KSD (Kamada Science and Design) Inc., Mr. Evans produced and sent graphical plots of RAMS data collected during the Model Validation Program. The plots will be shown by Dr. Kamada at the Toxic Release Assessment Group meeting. The 18 October was also Mr. Evans' last day of ERDAS support in the AMU as he has transferred to ENSCO's Melbourne office.

During November, Air Force SMC/CWP and CSR representatives met with NASA KSC Weather and Contracting to decide whether ERDAS should be added to ENSCO's MARSS Replacement (MARSS-REPL) contract. The decision was made to add ERDAS to the MARSS-REPL contract, therefore, the next phase of transitioning ERDAS to operations is now underway in an effort beyond AMU tasking. The final tasking under the AMU transition was to develop the ERDAS System Specifications, however, this task is now being completed under the MARSS-REPL. Also during November, Mr. Evans met with SMC/CWP, CSR, ENSCO's MARSS-REPL personnel, Range Safety personnel, ACTA, and NASA Weather to modify the MARSS-REPL specifications documents to include the ERDAS specifications and make sure deficiencies determined during the AMU evaluation were addressed.

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

Mr. Nutter and Dr. Manobianco completed the preliminary analysis of statistics from observations and 29 km eta (meso-eta) model forecasts from 1 May through 31 August 1996. In addition, they completed the analysis of the model's ability to predict the occurrence of east and west coast Florida sea breezes, thunderstorms, tropical cyclones, and steady state winds in excess of 18 kt. At the 21st annual meeting of the National Weather Association held in Cocoa Beach, FL, Mr. Nutter presented an example of the model's ability to represent thunderstorm development. Subjective evaluation of cool season (1 October 1996 through 31 January 1997) events such as cold frontal passage and cloud ceilings and thickness continues on a daily basis.

The subjective component of the meso-eta model evaluation consists of daily, real-time forecasting exercises by AMU personnel and limited analyses of case examples. One goal of the real-time, warm season forecasting exercise is to determine if the 29 km eta model provides added utility for thunderstorm forecasts over east, central Florida. Moreover, the daily forecasting exercise provides an opportunity to determine effective ways of visualizing, interpreting, and using the meso-eta model for short range (< 24 h) forecasting. In subsequent sections, results from analyses of model forecast and observed thunderstorms are presented.

Thunderstorms

Warm season thunderstorms in Florida result primarily from interactions between mesoscale circulations. Because larger scale models commonly used in operations (i.e., NGM, early or 48 km eta) cannot resolve the spatial and temporal details of these circulations, forecasters must utilize observations and persistence to develop accurate short-term (< 6 h) thunderstorm forecasts. Given its 29 km grid point resolution, the meso-eta model is not expected to resolve features such as individual convective cells or thunderstorm outflow boundaries. Although thunderstorms are not explicitly forecast by the model, basic diagnostic quantities from its 3-hourly output provide utility by allowing users to follow trends and make inferences about developing weather events. In order to demonstrate this utility, an example of thunderstorm development and a verification of warm season precipitation are presented in the following sections.

Case Example

The example presented here is an analysis of thunderstorm development on 1-2 August 1996. The case represents a day when the 0300 UTC meso-eta adequately forecasted several features important for afternoon thunderstorm development. These features include surface temperature gradients associated with heating in clear versus cloudy areas and low-level wind convergence associated with a developing thermal trough. This example presents a best-case scenario since the meso-eta model did not forecast the evolution of convection as well for other cases during the warm season (May - September 1996).

A snapshot of the observed and modeled evolution of the events on 1-2 August 1996 is depicted in Fig. 1. Throughout the following discussion, areas of colder cloud tops and strong gradients in cloud top temperatures in the infrared (IR) satellite images are used as a proxy for observed precipitation. IR satellite imagery at 1800 UTC (Fig. 1a) suggests that scattered shower activity was present over northern Florida. At the same time, thunderstorms were evident along the east coast sea breeze in southern Florida with relatively fewer clouds over central Florida. The meso-eta's forecast of accumulated precipitation between 1800 and 2100 UTC (1400 to 1700 EDT) appeared excessive in northern Florida since the 0.25 inch isopleth covered about one half of the Florida panhandle. Nevertheless, examination of IR satellite images between 1800 and 2100 UTC (not shown) reveals that transient, scattered showers covered the area within the 0.10 inch forecast precipitation isopleth. In this regard, the spatial distribution of observed precipitation over northern Florida was forecast reasonably well by the model. In other areas, the model adequately forecasted the spatial coverage of the developing thunderstorms over southeastern Florida while an absence of forecasted precipitation is noted over central Florida (Fig. 1).

At 2300 UTC, the large area of colder cloud tops in Fig. 1b indicates that thunderstorms were present across central Florida along a SW-NE oriented line. Smaller storms continued over the northern and southeastern parts of Florida. Later satellite images (not shown) indicate that 2300 UTC was the last hour for active convection. The meso-eta model precipitation shown in Fig. 1b was accumulated for the 3-h period from 0000 - 0300 UTC. Note this period begins 1 h after the 2300 UTC IR satellite image so precipitation greater than 0.25 inch was forecast to continue for 1 to 4 h after active convection was no longer evident from IR satellite imagery (Fig. 1b). Despite these temporal errors, the location and spatial extent of the convection over central and southern Florida were captured remarkably well by the model. As with the previous 3-h period from 1800 - 2100 UTC (Fig. 1a), forecast precipitation amounts over northern Florida between 0000 and 0300 UTC were still likely excessive in comparison with the areas of convection depicted on the IR satellite image (Fig. 1b).

Figs. 1a,b reveal that the meso-eta model is capable of generating accurate precipitation forecasts for broad areas of organized convection. Animation of the 3-hourly model output, that was performed routinely during the AMU's warm season forecasting exercise, provided additional value by helping to identify features that became important for developing convection. As an example, forecast 2 m temperatures (˚C) at 2100 UTC indicated that central Florida was warmer than surrounding land areas to the north and south (see shading in Fig. 1c). The forecast surface temperature gradient likely resulted from differential heating between the relatively cloud-free area over central Florida and the cloudy regions in the northern and southern sections of the peninsula. Corresponding surface temperature observations (˚C) are plotted as small numbers in Fig. 1c and corroborate the forecast temperature distribution. As forecast surface temperatures exceeded 31˚C, a thermal trough (not shown) developed in the surface pressure field in an orientation perpendicular to line X-X′. Streamlines of the forecast 10 m winds suggest a SW-NE line of low-level convergence associated with the developing thermal trough (Fig. 1c). The forecast 10 m streamlines in Fig. 1c clearly show the onshore flow and convergence associated with the thermal trough although they do not exactly match the observed wind directions shown by the wind barbs plotted in Fig. 1c.

A vertical cross section at 2100 UTC along the line X-X′ at 2100 UTC (Fig. 1c) is shown in Fig. 1d. The forecast potential temperature (K) and shading of the temperature gradient in the model highlight the fact that the strongest heating occurred over central Florida in the lowest model layers below 900 mb (Fig. 1d). The circulation vectors in Fig. 1d imply low-level convergence. The isopleths of vertical motion ($\mu b\ s^{-1}$) show rising motion over the center of the surface convergence zone and area of maximum heating while subsidence occurred on either side. This pattern depicts a thermally direct circulation that was associated with the development of forecast precipitation in the model across central Florida after 2100 UTC.

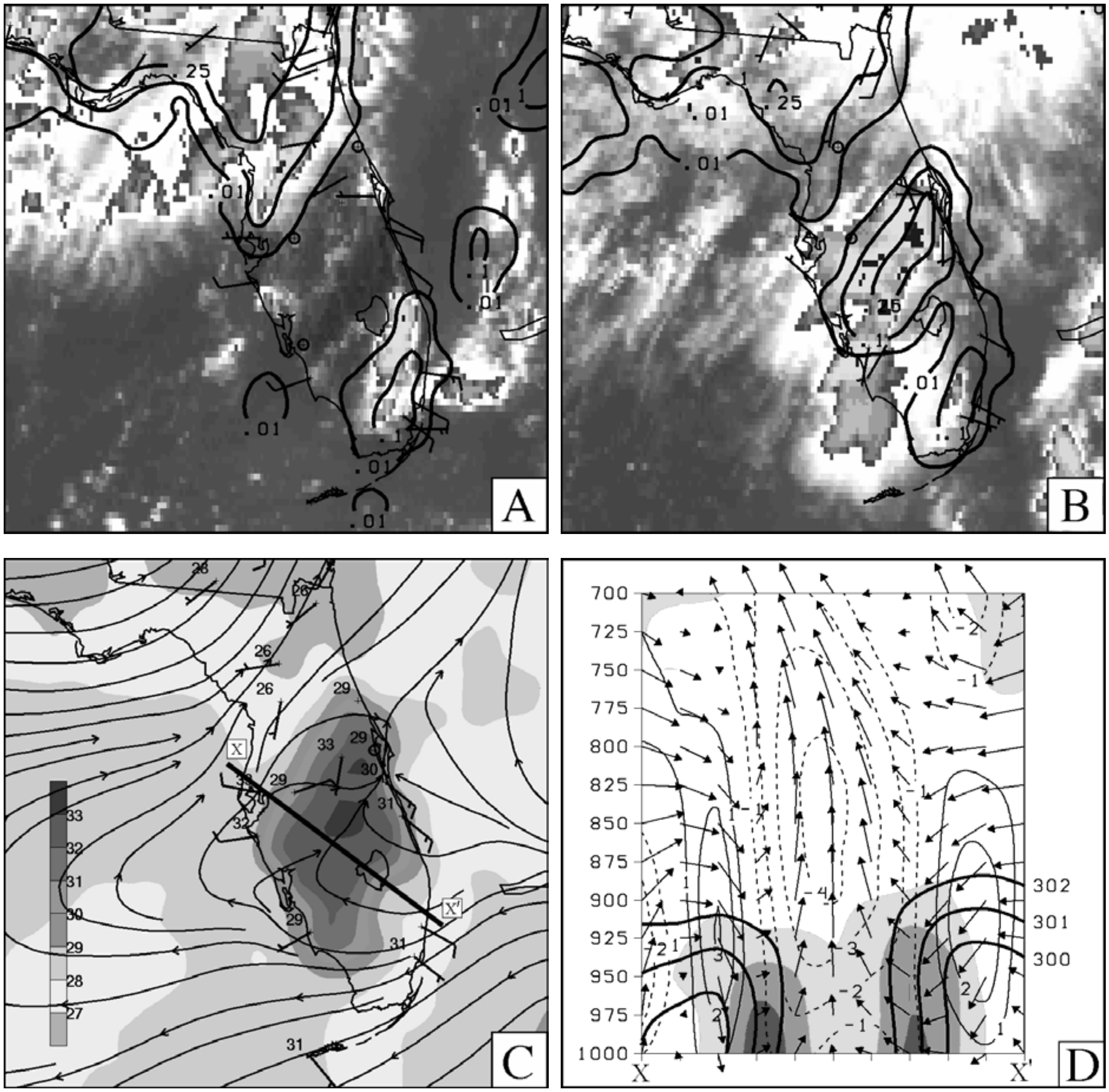

Figure 1. Case example of thunderstorm development on 1-2 August 1996. The 4 km IR satellite images and observed surface winds (where short barb = 5 kt and long barb = 10 kt) at 1800 and 2300 UTC are shown in panels (a) and (b), respectively. Also shown are meso-eta model forecasts of 3-hourly precipitation over the periods 1800-2100 UTC 1 August and 0000-0300 UTC 2 August with isopleths at .01, .10, and .25 inches (heavy solid lines). Panel (c) displays forecasts of 2 m temperature (˚C) and 10 m wind streamlines at 2100 UTC with corresponding surface temperature and wind observations. Panel (d) shows a vertical cross section along line X-X′ in panel (c) at 2100 UTC. Forecast potential temperature (K) is indicated by heavy solid contours while shading emphasizes the temperature gradient (darker shading = stronger temperature gradient). Positive or downward (negative or upward) vertical velocities ($\mu b\ s^{-1}$) from the model are indicated by thin solid (dashed) lines. Vectors indicate the circulation in the plane of the cross section.

There is one important feature on the 1800 UTC IR satellite image (Fig. 1a) which was *not* forecast by the meso-eta model. The small, bright area to the northwest of Cape Canaveral, FL reveals that a thunderstorm was present in the area around 1800 UTC. Surface weather observations from the Shuttle Landing Facility, FL (TTS) confirm the presence of thunderstorms which produced a 40 kt wind gust at 1819 UTC (Table 1). In fact, there were a number of other instances when the meso-eta model failed to predict the spatial and temporal evolution of individual thunderstorms that produced significant weather during the warm season evaluation period. However, experience from the warm season forecast exercises suggests that the broad areas of model-generated precipitation exceeding 0.10 inch as shown in Figs. 1a,b could be subjectively correlated with precipitation that was observed over much smaller sections of the same area. It would be necessary to compare objectively observed and forecast precipitation amounts using conventional threat scores to determine how accurately the meso-eta model forecasted warm season convective precipitation. This type of verification was not performed primarily because the 29 km eta model can not resolve thunderstorms and associated precipitation at such small scales.

Table 1. Surface weather observations at the Shuttle Landing Facility, FL for 1 August 1996.

Time (UTC)	Wind Direction/ Speed	Weather	Time (UTC)	Wind Direction/ Speed	Weather
1655	210/08	VCSH	1855	90/06	TSRA
1755	260/07	TS	1914	100/02	TS
1819	250/07G40	TS	1955	210/04	TS
1833	120/09	TSRA	2039	150/03	---

VC = In the Vicinity; SH = Showers; TS = Thunderstorm; RA = Rain

Verification of Precipitation Occurrence

The single case example from 1-2 August 1996 demonstrates that the meso-eta model has some utility in forecasting thunderstorms over Florida. However, there were a number of forecasts during the warm season that were much less accurate than those shown for the case presented here. The following analysis focuses on determining the skill of the model in forecasting thunderstorms over regions of the Florida peninsula during the entire warm season (May - September 1996). First, the state was divided into six verification zones shown in Fig. 2. The motivation for bisecting the state from north to south was to determine if the meso-eta model could forecast distinct areas of convection associated with the east and/or west coast Florida sea-breeze circulations. The remaining divisions along the 27° and 29° latitude lines were subjective and resulted in six zones of roughly equal area (not counting the western most area of the panhandle). It is interesting to note that the width of each zone over land is approximately 120 km. Since the 29 km eta model can only resolve features with wavelengths on the order $4\Delta x$ or 116 km, the zone width corresponds well with the model's smallest resolvable wavelength.

The next step in the precipitation verification was to count the occurrence of forecast and observed precipitation over land in each zone during 3-h periods from 1500 - 1800 UTC, 1800 - 2100 UTC, and 2100 - 0000 UTC. These time periods were chosen to verify the forecast occurrence of thunderstorms during the 9 h from 1100 - 2000 EDT (1500 - 0000 UTC) when convection is most often observed in Florida during the warm season. The occurrence of forecast thunderstorms was determined using meso-eta gridded fields of 3-h accumulated total precipitation and was based on total precipitation values exceeding 0.254 mm (0.01 inch) anywhere in a zone during the 3-h period. (Note that total precipitation in the model includes contributions from the Betts and Miller (1986) convective parameterization and from the explicit cloud prediction scheme that diagnoses rain as part of the cloud microphysics.) The verification of precipitation occurrence was determined using only gridded forecast data from the 0300 UTC initialization of the model since the gridded data from 1500 UTC initialization were not archived as part of the overall meso-eta model evaluation.

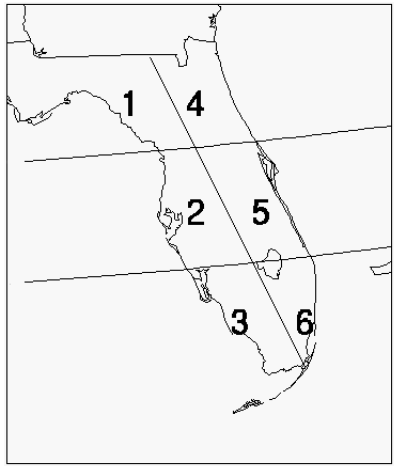

Figure 2. Map of Florida showing definition of precipitation verification zones. See text for details.

The occurrence of observed thunderstorms was determined subjectively from all available 4 km visible (VIS) and infrared (IR) GOES satellite data and from surface weather reports of rain and thunderstorms. The VIS and IR satellite images at every hour from 1500 - 0000 UTC were animated to locate distinct anvils in the VIS data and strong gradients of cold cloud top temperatures in the IR data. These features were used as a proxy for the occurrence of convective precipitation in each zone during the 3-h periods. It is likely that anvil debris, cirrus clouds, or the lack of well-defined anvils or cold cloud tops affected the accuracy of this satellite-based, subjective technique in delineating areas of actual precipitation. Therefore, routine surface airway observations of precipitation (i.e. rain or thunderstorms) were included to account for such deficiencies. It is important to point out that surface weather observations alone probably underestimate the occurrence of convective precipitation given the nonuniform distribution and relative coarse spacing of the stations. In cases where either satellite data or surface observations were missing for the entire 3-h period, the remaining available data were used to identify observed thunderstorms. When both satellite data and surface observations were available, observed thunderstorms were identified in the 3-h window if either data type indicated their presence based on the criteria discussed above

The occurrences of all forecast and observed thunderstorms as determined from available warm season data in the six zones over each 3-h period were counted and entered in four-cell contingency tables as shown in Table 2. In cases where forecast or observed precipitation was located on zone boundaries or across adjacent zones, these events counted as “yes” occurrences for each zone containing the specified area of precipitation. The data from these contingency tables were then used to compute the bias, false alarm rate (FAR), and probability of detection (POD) for each zone and time period. The definitions of the bias, FAR, and POD are given in Table 2 and follow Schaefer (1990).

Summary statistics for each of the zones are presented in Table 3. When all available data are pooled together the sample size of valid forecast/observed data ranges from 73 to 78 depending on zone number and 3-h verification period. Since the sample size is relatively small, it is difficult to determine if subtle differences between the scores in each zone are statistically significant. The following discussion focuses on scores from zone 5 that covers east central Florida and includes TTS (Fig. 2).

Table 2. Example of four-cell contingency table used for verification of precipitation occurrence.

		Observed Precipitation Occurrence: Yes	Observed Precipitation Occurrence: No
Forecast Precipitation Occurrence	Yes	W	X
	No	Y	Z

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

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

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

Table 3. Summary statistics for the verification of precipitation occurrence within each of six zones shown in Fig. 2. See Table 2 for definitions of bias, False Alarm Rate (FAR) and Probability of Detection (POD).

Zone 1	15–18Z	18–21Z	21–00Z	Zone 4	15–18Z	18–21Z	21–00Z
Bias	2.44	0.91	0.98	Bias	1.57	0.91	1.28
FAR	0.62	0.20	0.23	FAR	0.52	0.31	0.37
POD	0.94	0.73	0.75	POD	0.76	0.63	0.81
Zone 2	**15–18Z**	**18–21Z**	**21–00Z**	**Zone 5**	**15–18Z**	**18–21Z**	**21–00Z**
Bias	2.05	1.05	1.31	Bias	1.76	1.00	1.22
FAR	0.60	0.24	0.32	FAR	0.52	0.30	0.27
POD	0.81	0.79	0.89	POD	0.84	0.70	0.89
Zone 3	**15–18Z**	**18–21Z**	**21–00Z**	**Zone 6**	**15–18Z**	**18–21Z**	**21–00Z**
Bias	1.74	0.88	1.04	Bias	1.69	0.86	1.00
FAR	0.53	0.19	0.21	FAR	0.53	0.18	0.27
POD	0.81	0.71	0.82	POD	0.79	0.71	0.73

Within the first 3-h period from 1500 - 1800 UTC, a bias of 1.76 indicates that forecast precipitation occurred 76% more often than actually observed. In later periods, the bias improves to 1.00 between 1800 - 2100 UTC before increasing slightly to 1.21 between 2100 - 0000 UTC. The FAR reflects similar trends evident in the bias scores. Between 1500 - 1800 UTC, the FAR in zone 5 was 0.52, indicating that the occurrence of precipitation was incorrectly forecast on 52% of valid days. In later periods, the FAR drops to a more respectable 0.30 (1800 - 2100 UTC) and 0.27 (2100 - 0000 UTC). While the bias and FAR show improvement with time, the POD fluctuates without any clear trend. Since values of POD in zone 5 are > 70%, the model tends to accurately forecast the occurrence of most observed rain events. However, these values *must* be viewed in context with values of bias and FAR; a high POD is only effective when the corresponding FAR is low and the bias near unity.

Examination of the contingency tables used for the analysis (not shown) reveals that precipitation was observed (forecast) in zone 5 on 32% (57%), 51% (51%), and 58% (70%) of valid days during the periods 1500 - 1800 UTC, 1800 - 2100 UTC, and 2100 - 0000 UTC, respectively. A comparison of these percentages indicates that the bias approaches unity during the last two times periods due to increases in the frequency of observed precipitation. While this discussion only focuses on scores for zone 5, Table 3 shows similar results for the other zones. In general, the 0300 UTC initialization of the meso-eta model forecasted precipitation too frequently during the first 3-h period from 1500 - 1800 UTC (1100 - 1400 EDT). However, within the later afternoon and early evening periods from 1800-2100 UTC and 2100-0000 UTC, the model shows more utility in delineating whether precipitation was likely to be observed in a specific zone.

Summary

As of January 1997, preliminary analyses for the warm season meso-eta evaluation have been completed. Daily forecasting exercises reveal that the meso-eta model is not capable of resolving the details of individual thunderstorm development. However, it does show utility in identifying the occurrence of precipitation in 3-h time periods over broad areas on the order of 120 km x 240 km. Experience from the warm season forecasting exercises suggested that the broad areas of model-generated precipitation could be subjectively correlated with precipitation that was observed over much smaller sections of the same area. More importantly, animation of the 3-hourly output helps to diagnose features which could become important for developing convection.

Although a preliminary assessment of tropical cyclone and sea breeze forecasts has been completed, further investigations are in progress. Initial results from the sea breeze analysis reveals that the model is capable of generating sea-breezes, but at a scale much larger than observed. In effect, the model’s version of the sea breeze is a peninsula-scale, thermally direct circulation similar to that shown in Fig. 1d.

References

Betts, A. K., and M. J. Miller, 1986: A new convective adjustment scheme. Part I: Observational and theoretical basis. *Quart. J. Roy. Meteor. Soc.*, **112**, 677-691.

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

2.6 AMU CHIEF’S TECHNICAL ACTIVITIES (DR. MERCERET)

In December, Dr. Merceret was appointed to “WIDE” - a technical advisory panel to the WIPT supporting RSA. Dr. Merceret will provide expertise in wind profiling technology to the panel.

MID-TROPOSHERIC WIND CHANGE CLIMATOLOGY

An article was submitted to the *Journal of Applied Meteorology* for publication.

NOTICE

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 1 - Local Analysis and Prediction System (LAPS)

•• Evaluate NOAA/ERL 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 - 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.

• Subtask 3 - Run MASS and PROWESS

•• Continue to run the MASS and PROWESS numerical weather prediction models on the AMU computer network on a non-interference basis.