Applied Meteorology Unit (AMU)

Quarterly Report

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Executive Summary

This report summarizes the Applied Meteorology Unit (AMU) activities for the first quarter of Fiscal Year (FY) 00 (October - December 1999). A detailed project schedule is included in the Appendix.

Dr. David Short was hired this quarter to fill the AMU position that was created when Dr. Manobianco replaced Dr. Taylor as the AMU Project Manager last year. His area of expertise is satellite remote sensing of rainfall.

At the request of the Spaceflight Meteorology Group (SMG) at Johnson Space Center (JSC), Mr. Wheeler compared the Binary Universal Format Representation (BUFR) to that of the current Meteorological Interactive Data Display System (MIDDS) data format. BUFR is the Range Standardization and Automation (RSA) proposed format for the data provided to external customers in the RSA-designed weather system. Mr. Wheeler conducted the comparison using sample data files and documentation of data formats provided by SMG. He prepared and delivered a final memorandum that highlights issues regarding the MIDDS versus BUFR format and provides examples of potential concerns with the BUFR data.

Mr. Case completed and distributed the final report on the Local Data Integration System (LDIS) evaluation task. The results given in this report focus on the sensitivity of the LIDS output to the type of Weather Surveillance Radar – 88 Doppler (WSR-88D) radar data input. Due to the larger number and higher spatial resolution of level II data, more details in the wind fields (horizontal and vertical) were simulated than when using level III data.

Based on customer consensus, work on the Short Range Statistical Forecast Guidance task was suspended this quarter so that Ms. Lambert could begin work on the Improved Anvil Forecasting Phase I task. Operational forecasters have identified anvil forecasting as one of the most difficult tasks when attempting to predict the triggered lightning LCC and Flight Rule (FR) violation probability. The goal of this task is to identify or develop an objective technique to forecast anvil features to aid in the prediction of lightning LCCs. Phase I of this task will first determine the technical feasibility of developing such a technique. Ms. Lambert will conduct a literature review to see if any techniques currently exist and conduct forecaster discussions to help determine all aspects of the problem and to gather ideas on how such a technique could be developed.

Dr. Short began the SIGMET Open Integrated Radar Information System (IRIS/Open™) Processor Evaluation task in October. This task will explore the potential of the IRIS/Open™ system on the WSR-74C meteorological radar to meet the operational requirements of the 45th Weather Squadron (45 WS) and the SMG. Dr. Short completed a test of the system capabilities and found that there may be an upper-limit on the number of products generated within the volume scan time of 150 seconds. He then conducted a preliminary survey of vertical temperature profiles from Cape Canaveral Air Station soundings based on recommendations to monitor vertically integrated liquid (VIL) products above the 0°C level, which are currently used as tools for lightning forecasts. Finally, Dr. Short examined the scan sequence of the radar to determine scales of vertical gaps in coverage between certain levels at certain ranges from the radar.

Mr. Wheeler began work on the AMU task to detect chaff source regions. Military chaff drops in the northeastern Gulf of Mexico are suspected to be the source of radar returns in WSR-74C and WSR-88D data during the winter months when strong west-northwesterly upper level flow is prevalent. These radar returns are strong enough to cause concern to operational forecasters when evaluating Launch Commit Criteria (LCC) during a launch scenario. Previous efforts encouraging the military move chaff drops further west have been futile without proper documentation to prove the chaff source region. Therefore, this task will document the source regions of all suspected chaff returns during the 1999-2000 winter months. Several chaff drop events were documented and archived by Mr. Wheeler during the quarter.

Mr. Case continued work on the evaluation of the Regional Atmospheric Modeling System (RAMS) in the Eastern Range Dispersion Assessment System (ERDAS). He compiled the 1999 warm-season objective and subjective evaluation statistics to be presented in an upcoming interim report. He also developed and tested software to convert observational and model data to the appropriate formats for input into analysis programs. Finally, he prepared a worksheet and an evaluation methodology for the cool season evaluation.

SPECIAL NOTICE TO READERS

AMU Quarterly Reports are now published on the Wide World Web (WWW). The Universal Resource Locator for the AMU Home Page is:

http://technology.ksc.nasa.gov/WWWaccess/AMU/home.html

The AMU Home Page can also be accessed via links from the NASA KSC Internal Home Page alphabetical index. The AMU link is "CCAS Applied Meteorology Unit".

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 (321-867-0818, francis.merceret-1@ksc.nasa.gov) or Winifred Lambert (321-853-8130, lambert.winifred@ensco.com).

1. BACKGROUND

The AMU has been in operation since September 1991. Tasking is reviewed annually with reviews at least semi-annually. The progress being made in each task is discussed in Section 2 with the primary AMU point of contact reflected on each task and/or subtask. A list of acronyms used in this report immediately follows Section 2.

2. AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

2.1 TASK 001 AMU OPERATIONS

Dr. David Short was hired to fill the AMU position that was created when Dr. Manobianco replaced Dr. Taylor as the AMU Project Manager last year. He began working in the AMU in October. Dr. Short earned a Ph.D. in meteorology from Texas A&M University in 1988. His most recent position was as a visiting research fellow in the Institute for Hydrologic and Atmospheric Sciences at Nagoya University in Japan. Prior to that position he worked on the Tropical Rainfall Measuring Mission project with NASA for 18 years. His area of expertise is satellite remote sensing of rainfall.

Mr. Wheeler configured the AMU's email server to connect thorough ENSCO's Cocoa Beach office. AMU email was originally routed through ENSCO's Melbourne office. The connection through the Cocoa Beach office provides the AMU more control over email issues. There was no disruption of email during the change in routing. Mr. Wheeler also installed the most current FORTRAN compiler for the IBM RS-6000 Unix dual-processor system. This compiler will be evaluated before purchase.

Ms. Lambert attended the National Weather Association Annual Meeting in Biloxi, MS. She presented a poster showing the results from the Statistical Short-Range Forecast Tools task, and gave an oral presentation describing the Eastern Range Dispersion Assessment System (ERDAS) Regional Atmospheric Modeling System (RAMS) Evaluation task and some preliminary results from the AMU's ERDAS RAMS evaluation.

2.2 TASK 003 SHORT-TERM FORECAST IMPROVEMENT

SUBTASK 3 STATISTICAL SHORT-RANGE FORECAST TOOLS (MS. LAMBERT)

Ms Lambert presented preliminary results from testing of ceiling and visibility forecast equations in a teleconference to the Spaceflight Meteorology Group (SMG), 45th Weather Squadron (45 WS), and the National Weather Service in Melbourne (NWS MLB) in early October. These results were presented in the AMU Fourth Quarter FY99 Quarterly Report. The main conclusion of the testing was that the equations in their current form were not suitable for transition to operations.

The customers were given several options and were also asked for suggestions on how to proceed with the task. The final decision, reached by customer consensus, was to continue developing categorical cloud ceiling forecast equations using Shuttle Landing Facility (TTS) hourly surface data as well as hourly data from surrounding stations. The ceiling categories are based on shuttle flight rules, as shown in Table 1. Ms. Lambert began exploratory data analysis (EDA) with the Shuttle Landing Facility (TTS) data to determine if the data set should be stratified by time of day or year.

Table 1. List of predictands and binary thresholds. A predictand is set equal to 1 if the observation satisfies the binary threshold, otherwise it is set equal to 0.

Binary Threshold	*Flight Rule*
< 5000 ft	Return to Launch Site (RTLS)
< 8000 ft	End of Mission (EOM)
< 10 000 ft	Navigation Aid Degradation

Based on customer consensus, work on this task was suspended in November so that Ms. Lambert could begin work on the Improved Anvil Forecasting Phase I task.

SUBTASK 5 IMPROVED ANVIL FORECASTING: PHASE I (MS. LAMBERT)

45 WS Launch Weather Officers (LWO) have identified anvil forecasting as one of the most difficult tasks when attempting to predict the triggered lightning Launch Commit Criteria (LCC) violation probability. There are no forecast schemes in existence that help determine whether anvils will form from existing thunderstorms or the length and thickness of anvils that do form. The goal of this task is to identify or develop an objective technique to forecast anvil features to aid in the prediction of lightning LCCs.

Due to the uncertainty in the possibility of developing anvil-forecasting techniques, the task is divided into two phases. The goal of Phase I is to determine the technical feasibility of developing techniques and tools for forecasting the probability of anvil occurrence. If the results from the first phase are favorable, the task will continue with product development in Phase II.

Ms. Lambert began work on this task in November. A brief outline of the work in Phase I is provided in this report, followed by information on Ms. Lambert's progress on the task during the quarter.

Phase I Overview

Phase I is separated into three steps: literature search, forecaster discussions, and determination of the feasibility to continue with Phase II. The literature search is employed to reveal any previous work that has been done on this topic. Forecaster discussions are necessary to help determine all aspects of the forecasting problem and to gather ideas on how such a technique could be developed. In the final step all the information is assimilated and a final determination of the feasibility of developing an anvil forecasting technique is made.

Literature Search

The task will begin with a search for all applicable literature on the topic of anvils with special consideration given to articles discussing anvil forecasting, if they exist. If research experiments to analyze and/or forecast anvil have taken place, any results that are published will be analyzed for their utility in forecasting anvil over the Kennedy Space Center/Cape Canaveral Air Station (KSC/CCAS) area. This part of the task will be instrumental in determining if anvil-forecasting techniques and tools already exist or if they must be developed from scratch.

Forecaster Discussion

The issue will be discussed with operational forecasters. These discussions will provide insight to the details of the forecasting problem and will be invaluable in developing a forecasting technique.

The forecasters will first be asked how the forecast is currently made. A list of data sources used will be compiled along with any specific variables that the forecasters think are important in making an anvil forecast. These data may include model output, satellite images, radar data, and upper-air soundings. The next piece of information needed will be the forecast interval or intervals necessary to make lightning LCC forecasts. The original task proposal suggests the intervals 0 – 8 hours and 24 – 30 hours. These will be considered along with other specific requests by the forecasters. Finally, forecasters will be asked if they have any ideas for products or techniques that would be helpful in making this forecast. These ideas may include anything from statistical techniques to graphical displays.

Discussions with forecasters on this topic can also include any aspect not outlined in the paragraph above. Any and all information and opinions will be accepted and considered. It is these discussions that will likely provide the most important information regarding the development of anvil forecasting techniques and tools.

Determine Technical Feasibility

In the final step, all information gathered from the literature search and the forecaster discussions will be assimilated to determine the feasibility of continuing with Phase II. It is difficult to define the procedures in this step as they depend heavily on the outcome of the literature search and forecaster discussions. It is likely that one of following three scenarios will be followed:

- If previous studies exist on anvil forecasting with promising results, the information from the forecaster discussions will be used with the information in the literature to outline a possible procedure for technique development. The outline will include information on the data types needed, the necessary steps in development of the technique, and the form of the final product (e.g. graphical output, statistical equations, etc).

- If no former studies on anvil forecasting are found in the literature, then the task will focus on determining what must be done to develop a technique from scratch and if it is technically possible. Input from the forecaster discussions will be absolutely necessary in this case to determine the exact data types and products needed. A case study analysis may be necessary to determine the possibility of developing a reliable technique.

- If there are no former studies in the literature and if the forecaster discussions do not reveal any probable solutions, the development of operationally useful anvil forecasting techniques may be unfeasible.

Task Progress

Ms. Lambert began the literature review in November by searching through the American Meteorological Society (AMS) on-line journal abstracts at their web site, and the Meteorological and Geoastrophysical Abstracts (MGA) CD-ROM. She did not find articles directly related to anvil forecasting, but did find some that addressed the issue of anvil formation, structure, and electrification. One article describes an attempt to model cirrus clouds and anvils that was not very successful. Limited field studies have measured water content, optical thickness, droplet concentrations, and electrical fields in anvils. Some of the results were contradictory, but most authors stated that too few studies on anvils have taken place in order to make any definite conclusions on their structure and development.

While continuing with the literature review, Ms. Lambert also began the forecaster discussion step of the task. Her first discussion was with Mr. Jim Sardonia of the 45 WS, the Atlas LWO. During the past warm season, Mr. Sardonia analyzed satellite, upper air, and model output wind speed/direction and relative humidity (RH) data to help determine anvil length and lifetime. Although his data set was limited, he was able to find a correlation between anvil length/lifetime and average RH/winds in the 300 – 150 mb layer. Forecaster discussions with the other LWOs will continue in the next quarter.

2.3 *TASK 004 INSTRUMENTATION AND MEASUREMENT*

SUBTASK 5 I&M AND RSA SUPPORT (DR. MANOBIANCO AND MR. WHEELER)

Mr. Tim Oram (SMG) requested that the AMU compare the Binary Universal Format Representation (BUFR) to that of the current Meteorological Interactive Data Display System (MIDDS) data format. BUFR is the Range Standardization and Automation (RSA) proposed format for the data provided to external customers in the RSA-designed weather system. The purpose of the BUFR evaluation is twofold. First, it will identify as early as possible potential problems with the RSA design that will negatively impact Johnson Space Center (JSC) personnel's use of the data for their upper winds loads and descent flight design analyses. Second, it will provide an independent analysis to verify or refute the SMG analysis of RSA design issues.

After receiving concurrence from 45 WS on the use of I&M/RSA hours for this effort, Dr. Merceret approved using up to 0.1 FTE for one quarter to complete the task. Mr. Wheeler began the comparison using sample files and documentation of data formats supplied by SMG. The specific data sets analyzed were from the wind tower network, Automated Meteorological Profiling System (RTAMPS), 50 and 915 MHz profilers, and Cloud to Ground Lightning Surveillance System (CGLSS, aka Lightning Location and Protection or LLP). He documented the differences in format in a memorandum.

Two issues raised in the memorandum regarding the MIDDS versus BUFR format are

- Questions concerning how changes to the data sets or additions of new data sets will be handled in the future, and
- Whether the weather community would have access to and be able to change the data format schemes.

Mr. Wheeler also provided examples of potential concerns including incorrectly labeled units, missing data types, and incorrect values for data heights in the BUFR data.

Ms. Lambert monitored two RSA teleconferences that described the proposed 50 MHz Doppler Radar Wind Profiler (DRWP) and RTAMPS quality control (QC) procedures. She was available to answer questions on technical aspects of the current DRWP QC procedures. In the days previous to one of the teleconferences, Ms. Lambert reviewed the slides to be presented. She provided input to 45 WS personnel on incorrect or questionable statements in the slides that needed to be addressed by teleconference participants.

Table 2 shows the AMU hours used in support of this task for the quarter and since the beginning of the task in July 1996.

Table 2. AMU hours used in support of the I&M and RSA task

Quarterly Task Support (hours)	***Total Task Support (hours)***
23.0	217.0

SUBTASK 12 SIGMET IRIS/OPEN PROCESSOR EVALUATION (DR. SHORT)

Dr. Short began the SIGMET Open Integrated Radar Information System (IRIS/Open™) Processor Evaluation task in October. This task will explore the capabilities of the IRIS/Open™ system on the WSR-74C meteorological radar for meeting operational requirements of the 45 WS and SMG. The specific focus is on current and potential characteristics of IRIS/Open™ products and capabilities for use in forecasting lightning and microbursts. Local experience by Mr. Clark Pinder of Range Weather Operations (RWO) indicates that the temporal evolution of radar reflectivity and vertically integrated liquid water content (VIL) above the 0°C isotherm within convective cells are key indicators of lightning occurrence. Previous studies have also shown reflectivity and VIL patterns to be indicators of microburst events.

With the cooperation of Computer Sciences Raytheon (CSR) personnel, Dr. Short and Mr. Wheeler configured the AMU IRIS/Open™ system to mirror the RWO configuration as much as possible. One limitation was that there is only one monitor connected to the AMU system, whereas there are two monitors connected to the RWO system. This prevents the actual real-time simulation of the RWO operational configuration within the AMU. Dr. Short explored this configuration and scheduling of IRIS/Open™ Products on both the AMU and RWO workstations. There were 142 products configured on the AMU workstation and 112 on the RWO workstation. On both workstations, the same 42 products were available on their respective schedulers and the same 26 products were routinely run. Run-time for the 26 products was about 80 seconds during clear weather (no echoes) and about 100 seconds with scattered echoes. Local warning and VIL products were generated first, within about 15 seconds after the volume-scan completed, while echo tops products were generated last in accordance with the product scheduling priorities. He found that there may be a practical upper-limit on the number of products that can be generated before their information content is outdated by the next volume-scan since volume scans are run every 150 seconds.

Dr. Short then conducted a preliminary survey of vertical temperature profiles from Cape Canaveral Air Station (XMR) soundings for the months of June and August 1999 as a prerequisite for recommendations concerning the monitoring of VIL products above the level of the 0°C isotherm. RWO forecasters currently monitor VIL above the 0°C isotherm as a tool for lightning forecasts. Mr. Roeder of the 45 WS has suggested that additional VIL products for multiple layers above the 0°C isotherm may provide information for the improvement of lightning and microburst forecast techniques. Table 3 lists the average and standard deviation of heights of the 0, -10, and -20°C isotherms as determined from the XMR soundings. Through linear interpolation Dr. Short determined that layered VIL products between the 0, -5, -10, -15, and -20°C levels would require vertical integration over 4 layers with an average thickness of 2700 ft (0.8 km).

Table 3. Average heights and standard deviations in feet (kilometers) of the given temperatures (°C) from XMR soundings for June and August 1999.

TEMPERATURE	***June 1999***		***August 1999***	
	AVERAGE HEIGHT	STANDARD DEV	AVERAGE HEIGHT	STANDARD DEV
0	14 760 (4.50)	450 (0.14)	15 880 (4.84)	810 (0.25)
-10	20 580 (6.27)	510 (0.16)	21 640 (6.60)	610 (0.19)
-20	25 760 (7.85)	560 (0.17)	26 470 (8.07)	550 (0.17)

Dr. Short examined the scan sequence of the WSR-74C radar to determine scales of vertical gaps in coverage between the levels of the 0°C and -20°C isotherms at ranges of 10 to 60 nm from the radar. The average vertical gap is 4680 ft, indicating that VIL products for layers having a thickness of 5°C (about 2700 ft) would be based entirely on interpolation at ranges where the gap between elevation angles intersects the given temperature interval. He also determined that the average vertical gap could be reduced to 2780 ft by a simple modification of the scan sequence that still maintains 12 elevation angles per scan.

SUBTASK 15 DETECTING CHAFF SOURCE REGIONS (MR. WHEELER)

Military chaff drops in the NE Gulf of Mexico west of 85° W are suspected to be the source for chaff radar returns over KSC during the winter months when strong west-northwesterly upper level flow is prevalent. These radar returns are strong enough to cause concern to operational forecasters when evaluating Launch Commit Criteria (LCC) during a launch scenario. Current restrictions on chaff drops to protect launch and landings at KSC are confined to the Gulf east of 85° W. Previous efforts encouraging the military to extend this restriction west to 90° W have been futile without proper documentation to prove the chaff source region. Therefore, the objective of this task is to document the source regions of all suspected chaff returns during the 1999-2000 winter months.

Mr. Wheeler will archive data for suspected occurrences of chaff signatures from the northeast Gulf of Mexico into western and Central Florida, including the CCAS/KSC area from 1 November 1999 to 30 April 2000. He will use real-time data from several Southern Region radar sites for the evaluation. He will identify chaff signatures based on patterns and magnitude of reflectivity. Once an event is identified as a chaff release, the data will be analyzed to determine, if possible, the source region of the chaff by using all available Weather Surveillance Radar – 88D (WSR-88D) data.

Mr. Wheeler began work on this task in October. Rather than searching through archived data to find chaff cases, he will archive and analyze events as they occur during the 1999-2000 cool season. Mr. Wheeler configured the AMU's Next Generation Radar (NEXRAD) Principle User Processor (PUP) to archive several base reflectivity products. The Operational Support Facility (OSF) approved a request by Mr. Wheeler to allow the AMU to retrieve NEXRAD products from the Slidell MS, Mobile AL, and Pensacola, Tallahassee, and Tampa FL sites. The NEXRAD data sets from these sites will be used to identify and classify the chaff source regions. Base maps of the selected sites were loaded into the AMU's PUP.

The first documented chaff event occurred on 30 November 1999. Several other chaff release cases have also been documented. With SMG coordination, the AMU will monitor, analyze and document one coordinated and scheduled military chaff drop prior to April 2000.

2.4 TASK 005 MESOSCALE MODELING

SUBTASK 4 DELTA EXPLOSION ANALYSIS (MR. EVANS)

The Delta Explosion Analysis project is being funded by KSC under AMU option hours. External reviews of the final report were completed in December, and Mr. Evans began making the final revisions.

SUBTASK 8 MESO-MODEL EVALUATION (MR. CASE)

This section contains an update of the work done during the quarter by Mr. Case on the AMU's evaluation of the Eastern Range Dispersion Assessment System (ERDAS) Regional Atmospheric Modeling System (RAMS). ERDAS is designed to provide emergency response guidance for operations at KSC/CCAS in the event of a hazardous material release or an aborted vehicle launch. The prognostic gridded data from RAMS is available to ERDAS for display and input to the Hybrid Particle and Concentration Transport (HYPACT) model. The HYPACT model provides three-dimensional dispersion predictions using RAMS forecast grids. Therefore, the accuracy of the HYPACT model is highly dependent upon the accuracy of RAMS forecasts. The primary goal of the evaluation is to determine the accuracy of RAMS forecasts during all seasons and under various weather regimes. The evaluation protocol is designed to provide specific information about the capabilities, limitations, and daily use of ERDAS RAMS for operations at KSC/CCAS. The ERDAS RAMS evaluation primarily concentrates on wind and temperature (stability) forecasts required for dispersion predictions.

A description of the RAMS configuration in ERDAS and preliminary results from the 1999 warm season evaluation can be found in the Fourth Quarter FY-99 AMU Quarterly Report.

Software Development

Objective statistics under the PET&S contract

Under the Performance Evaluation, Test and Simulation (PET&S) contract, Mr. Dianic developed a statistical program that objectively verifies output from ERDAS RAMS. The software calculates average and error statistics at point locations for both surface and upper-air observational sites. During this past quarter, Mr. Dianic completed work on the statistical analysis tool for verifying RAMS at upper-air observational locations including rawinsonde and wind profiler sites. He also added routines to extract forecast precipitation from RAMS grids 2, 3, and 4 (with horizontal resolutions of 15 km, 5 km, and 1.25 km respectively), including convective precipitation on grids 2 and 3, and explicit precipitation on grids 2, 3, and 4. Finally, Mr. Dianic upgraded and streamlined data extraction tools on ERDAS RAMS for improved unattended operation.

In preparation for the interim report focusing on the 1999 Florida warm-season (May through August) evaluation of RAMS, Mr. Dianic ported over his statistical analysis program and all data from the Range-Safety workstations to the HP workstation in the AMU computer laboratory. As a result, Mr. Case will be able to generate and analyze ERDAS RAMS error statistics for the warm-season evaluation in addition to generating any future statistics for the upcoming 1999-2000 cool season and 2000 warm season evaluations. Mr. Case tested all the output from the statistical analysis program in order to verify that the results are generated correctly on the AMU HP workstation. A few corrections to the software configuration on the AMU workstation are required before the 1999 warm-season error statistics can be collectively compiled.

AMU conversion code

Mr. Case will examine the ERDAS RAMS error statistics and present them in future reports using the General Meteorological Package (GEMPAK) software. Mr. Case developed several programs to convert the ERDAS RAMS statistical output to GEMPAK format. He chose GEMPAK for its features that allow for concise displays of temporal and spatial characteristics of the model error data.

Also in this quarter, Mr. Case prepared several programs to process RAMS gridded forecasts of precipitation, wind, and temperature data. Beginning on 14 July 1999, RAMS forecasts of u- and v-winds and temperature at 11 m from grid 4 were archived in order to perform gridded comparisons between observed KSC/CCAS tower data and forecast wind and temperature data. The archive of precipitation grids began on 20 October in order to perform gridded comparisons between observed rain gauge data and forecast convective and explicit precipitation for the cool season (November–March). The software converts all of the above-mentioned RAMS grids into the GEMPAK format for ease of analysis and computations.

Finally, Mr. Case constructed a program to convert the observed KSC/CCAS wind tower data at 1.8 m (6 ft) and 16.5 m (54 ft) of temperatures and winds, respectively, to GEMPAK format. A Barnes objective analysis will be performed on the KSC/CCAS tower data to analyze the observational data to the points on grid 4, but only over the limited area of the KSC/CCAS tower network. Gridded comparisons will then be performed between the RAMS forecasts from grid 4 and the objectively analyzed grid. Unfortunately, RAMS forecast grids of winds and temperature are only archived from mid-July onward, thus limiting the sample size of the gridded comparisons for the 1999 warm-season evaluation.

Warm-Season Evaluation

Mr. Case continued to compile the 1999 warm-season error statistics to be presented in the upcoming interim report. Because ERDAS RAMS could not be run for most of September due to changes in data formats and Y2K tests, results will be presented only for the months of May–August 1999. The interim report will summarize the objective error statistics at point locations and the subjective verification of the east-central Florida East Coast Sea Breeze (ECSB) and RAMS precipitation forecasts on grid 4.

In this past quarter, Mr. Case compiled the results of the subjective precipitation verification on RAMS grid 4 for the months of June–August. The subjective precipitation evaluation verifies 0000 UTC and 1200 UTC ERDAS RAMS precipitation forecasts for 6 pre-defined zones on grid 4 at every forecast hour valid from 1300 UTC to 0200 UTC. The results will be summarized in terms of contingency tables, categorical scores, and skill scores to illustrate the level of skill that ERDAS RAMS demonstrates in forecasting warm-season precipitation on grid 4.

Cool-Season Evaluation

In preparation for the cool-season evaluation of the RAMS component of ERDAS, Mr. Case developed an evaluation worksheet designed to assess the performance of ERDAS RAMS with respect to cold-frontal/boundary passages. The worksheet also provides a means for verifying the occurrence and magnitude of low-level temperature inversions for the 1200 UTC XMR rawinsonde on a daily basis. Furthermore, the worksheet is used to classify the wind and stability regime for every model initialization time in order to segregate ERDAS RAMS model errors according to specific observed weather regimes. The worksheet will be utilized for verification and post-analysis of cold-frontal and boundary passages and their accompanying precipitation systems across the Florida peninsula.

During November and December, Mr. Case began the daily cool-season wind regime and stability classification as well as the daily low-level temperature inversion verification at XMR. For classifying the daily wind regimes, Mr. Case is recording the observed winds at the surface, 850 mb, 700 mb, 500 mb, and 250 mb at the Shuttle Landing Facility (TTS) and XMR rawinsonde at both 0000 UTC and 1200 UTC. In addition to winds at specific mandatory levels, Mr. Case is also documenting selected stability indices at 0000 UTC and 1200 UTC including the Lifted Index, Total Totals, K-index, and Convective Available Potential Energy. The precipitable water is also recorded at 0000 UTC and 1200 UTC for the XMR sounding. When TTS observations are missing, surface reports are taken from either Patrick Air Force Base (COF) or Melbourne (MLB). When XMR data are not available, the Tampa Bay (TBW) rawinsonde is utilized.

For the low-level temperature inversion verification, Mr. Case is using the Graphical User Interface (GUI) verification tool developed by Mr. Dianic as part of the Meteorological And Range Safety Support (MARSS) System display. The verification GUI allows the user to verify not only RAMS forecast temperature and wind at observed rawinsonde levels, but also RAMS forecast temperature, dewpoint, and/or wind at surface stations, KSC/CCAS wind towers and profilers, and selected buoys. When available, both the 12-h and 24-h RAMS forecast temperature profiles from their respective 0000 UTC and 1200 UTC model runs are compared to the observed 1200 UTC XMR rawinsonde in the lowest 4 km. If an inversion layer occurs in the lowest 4 km, Mr. Case documents the magnitude, depth and height of the layer. Correspondingly, if RAMS predicts an inversion, the forecast magnitude, depth and height of the forecast inversion layer is also recorded. Finally, if more than one inversion layer is observed or forecasted, only the lowest inversion layer encountered is used for verification.

Finally, Mr. Case met with Drs. Manobianco and Short to determine the best method for verifying ERDAS RAMS forecast precipitation. The AMU currently receives a gridded 4-km, composite precipitation product derived from rain gauge and WSR-88D radar-estimated rainfall rates from the National Centers for Environmental Prediction (NCEP). In order to avoid validating radar-derived rain rates, the AMU will verify ERDAS RAMS forecast precipitation by using only rain gauge data across the Florida peninsula. The Goddard Space Flight Center (GSFC) can provide quality-controlled rain gauge data from the St. John's River basin, the South Florida Water Management Districts, and KSC/CCAS. These observational data will not be available in real-time and must be obtained from GSFC once processed and quality-controlled.

SUBTASK 9 LOCAL DATA INTEGRATION SYSTEM EXTENSION (MR. CASE)

During this quarter, Mr. Case incorporated the customer revisions into the final report titled "Simulation of a Real-time Local Data Integration System over East-Central Florida". He distributed the final report in December 1999. A small excerpt of the final report is given below, which focuses on one of the significant data sensitivity issues of the Local Data Integration System (LDIS).

The AMU simulated a real-time configuration of LDIS over the Florida peninsula including KSC/CCAS using a two-week archived data set from 15-28 February 1999. The task objectives were to

- Assess the utility of a real-time LDIS by simulating a real-time configuration for a period of two weeks,
- Evaluate and extrapolate system performance to identify the hardware necessary to run LDIS in real-time,
- Determine the sensitivities and deficiencies of the simulated real-time LDIS configuration, and
- Suggest and/or test improvements.

The AMU ran the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS) software on an IBM RS/6000 workstation to generate high-resolution analyses in space and time for the two-week period. Analyses were generated using a nested grid configuration. The outer grid consists of a 10-km horizontal resolution and covers most of the Florida peninsula and surrounding coastal waters. The inner grid contains a 2-km horizontal resolution and covers east-central Florida including KSC/CCAS and surrounding oceanic regions (not shown).

Due to limited bandwidth, SMG cannot receive the complete volume of WSR-88D level II data directly from the NWS MLB radar site in real-time. Instead, SMG receives WSR-88D processed data (level III data) from a private vendor. Level II data contain 14 elevation scans under volume coverage pattern 11. Level III data consist of the 4 lowest elevation scans at the Melbourne (MLB) WSR-88D site and the 2 lowest elevation scans at all other Florida radar sites. Also, level III data have a coarser horizontal resolution compared to level II data and are categorized into discrete bins, thereby reducing the file sizes substantially. Thus, level III data can be transmitted to SMG in real-time for all Florida radar sites.

The results shown in this section focus on the sensitivity of the ADAS analyses to the type of WSR-88D data that are ingested. Specifically, the differences between level II and level III WSR-88D data on the subsequent ADAS analyses are addressed. The deficiencies of ADAS as a result of using level III WSR-88D data are examined and the improved analysis fields are shown when utilizing the full-volume level II data.

Comparison of number of radial velocity observations

This sub-section illustrates the impact that level III WSR-88D data have on the subsequent ADAS analyses as compared to level II WSR-88D data. The comparison is conducted for 28 February 1999, when a pre-frontal squall line propagated through east-central Florida. This day contained the greatest number of radar returns from the two-week archive, and therefore provides a good basis for the comparison study. The ADAS control simulation used level III WSR-88D data from all Florida radar sites. The analysis programs were then re-run for a nine-hour period (1500–2345 UTC) using level II data from only the MLB WSR-88D. Because the 2-km analysis grid contains radar data primarily from the MLB WSR-88D, all comparisons are made on the 2-km grid only, thereby isolating as much as possible the differences purely due to level II versus level III WSR-88D data.

In the LDIS extension final report, a brief discussion was provided on the algorithm that re-maps WSR-88D data onto the ADAS analysis grids. Insufficient volume coverage and large variances in reflectivity and radial velocity values in an analysis grid box result in rejection of data at a particular grid location. Three factors lead to fewer re-mapped reflectivity and radial velocity observations using level III data compared to level II data:

- Because level II data contain many more elevation angles than level III data, the horizontal and vertical coverage at a particular location on the ADAS grid is more substantial using level II data.
- More level II data are available at upper levels due to the higher elevation angles not found in level III data.
- Level III data experience larger variances because of the categorization of reflectivity and radial velocity into discrete bins.

Figure 1 illustrates the number of re-mapped radial velocity data points on the 2-km ADAS grid for both level II and level III WSR-88D data at each analysis time within the nine-hour comparison window. In general, the number of radial velocity observations on the 2-km ADAS grid using level II data greatly exceeds the number of radial velocity observations using level III data. The maximum number of re-mapped radial velocity observations is 7968 for level III data at 1930 UTC and 19631 for level II data at 1945 UTC (Fig. 1).

A secondary maximum of re-mapped level III radial velocity observations occurs at 1800 UTC but is not evident in the level II data. As the pre-frontal squall line moved eastward across the Florida peninsula, radar echoes were simultaneously detected by the TBW, Jacksonville (JAX), and MLB radar sites. This secondary peak at 1800 UTC results from TBW and JAX level III data that are re-mapped onto the 2-km analysis grid in addition to the Melbourne level III data. However, this secondary maximum is not seen in the level II plot because only the MLB radar site was used to determine the number of remapped level II radial velocity observations. Thus, additional horizontal coverage is gained by re-mapping level III radial velocity data from multiple radar sites.

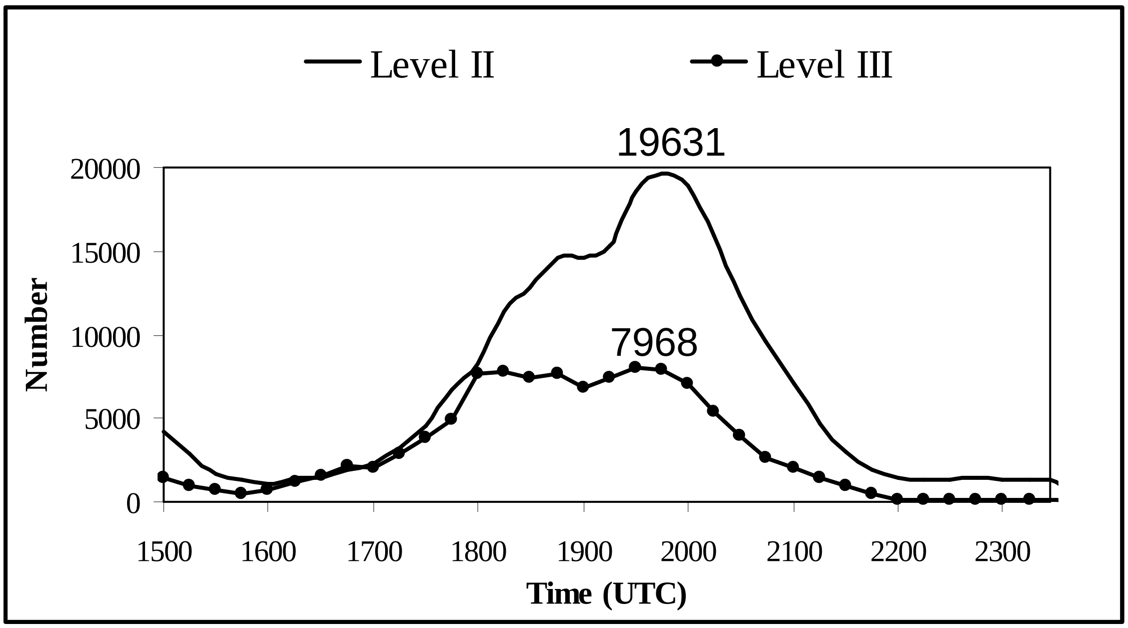

Figure 1. A plot of the number of radial velocity points remapped onto the 2-km ADAS analysis grid is given every 15 minutes on 28 February 1999 using all six Florida level III WSR-88D sites (dotted line) and level II data for the MLB WSR-88D site only (plain line).

Comparison of low-level frontal diagnosis

A result of the increased number of re-mapped radial velocity observations associated with level II data is the ability to detect more subtle boundaries and wind shift lines. This statement is supported by a diagnosis of the low-level cold frontal passage and its associated wind shift line that occurred on 28 February using ADAS analyses ingesting level II versus level III WSR-88D data. A pre-frontal line of thunderstorms propagated through KSC/CCAS between 1900 UTC and 2000 UTC 28 February. The low-level cold front moved through KSC/CCAS at about 2200 UTC accompanied by a wind shift from southwest to west and no significant weather features (not shown).

Figures 2 and 3 contain plots of low-level convergence/divergence patterns at 870 m associated with the individual thunderstorms using level II and level III data. At 2015 UTC, when a severe thunderstorm propagated through central Brevard County just south of KSC/CCAS, a small region of low-level convergence is depicted in the vicinity of the severe convection when using level III data (Fig. 2a). Between 2030 UTC and 2100 UTC, small couplets of convergence and divergence are associated with the southeastward-moving line of convection (Figs. 2b, 3a-b). No other features in these plots suggest the approach of a low-level cold front and wind-shift line.

Many more small-scale details are present in the ADAS analyses using level II WSR-88D data. The convergence associated with the severe cell and nearby convection at 2015 UTC shows much more structure when using level II WSR-88D data (Fig. 2c). Beginning at 2030 UTC, a linear band of convergence develops to the northwest of KSC/CCAS with the approach of the cold frontal zone (Fig. 2d). This banded feature propagates slowly southeastward over the next 30 minutes reaching northern KSC/CCAS by 2100 UTC (Figs. 3c-d).

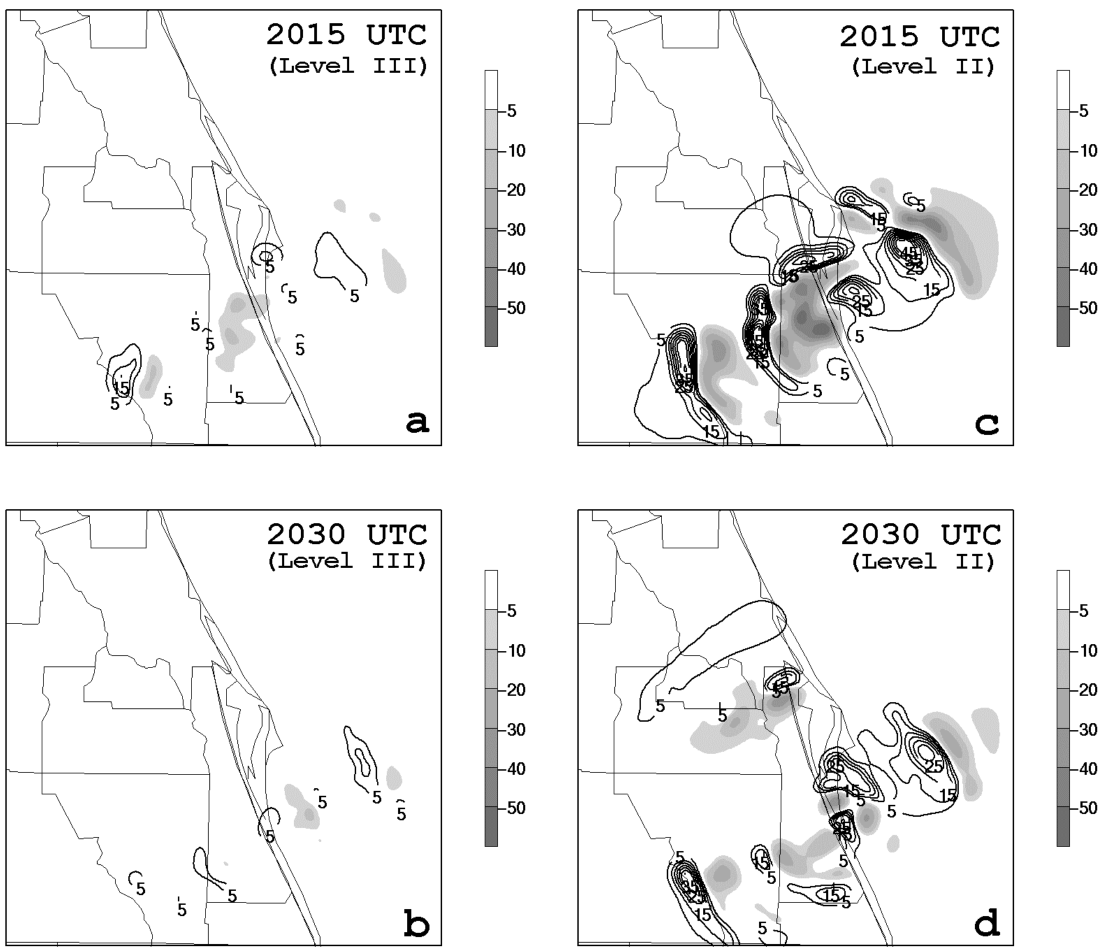

Figure 2. Plots of ADAS 2-km divergence ($\times 10^{-5}$ s^{-1}) at 870 m are compared using level III WSR-88D data in a) and b), and level II WSR-88D data in c) and d). Shading represents convergence according to the scale provided whereas solid contours denote divergence. Valid times on 28 February are 2015 UTC in a) and c), and 2030 UTC in b) and d).

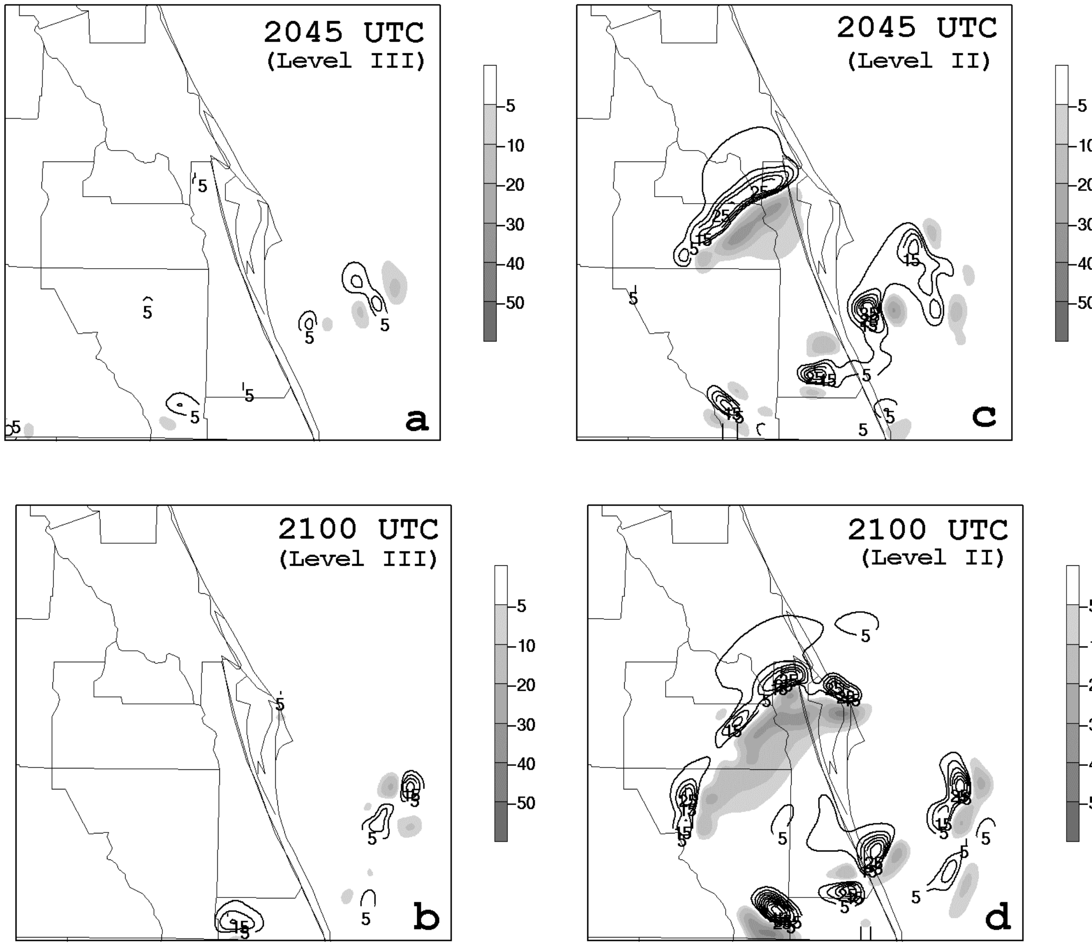

Figure 3. Plots of ADAS 2-km divergence ($\times 10^{-5}$ s^{-1}) at 870 m are compared using level III WSR-88D data in a) and b), and level II WSR-88D data in c) and d). Shading represents convergence according to the scale provided whereas solid contours denote divergence. Valid times on 28 February are 2045 UTC in a) and c), and 2100 UTC in b) and d).

The benefits of using level II WSR-88D data are quite obvious. Ingesting level II instead of level III data offers much more detail with regard to the wind features and areas of convergence associated with convection and the cold-frontal wind shift. The benefits of using level II data can be even more important during the Florida warm season when interactions between multiple outflow boundaries frequently occur.

Comparison of Cloud and Vertical Velocity Fields

Despite the greater volume of level II versus level III WSR-88D data, the impact of level II data on the cloud and moisture fields is rather insignificant on 28 February. This fact is illustrated through time-height cross sections of cloud liquid, cloud ice, and relative humidity fields at the Shuttle Landing Facility (SLF) using level II versus level III data. The cloudiness associated with the passage of the pre-frontal line of convection is depicted in Figure 4a-b using level III and level II WSR-88D data respectively. With level III data, the ADAS-derived cloud liquid field extends from the surface to 350 mb whereas cloud ice extends from 550 mb to above 250 mb between 1900 UTC and 2000 UTC 28 February (Fig. 4a). Qualitatively, the derived cloud fields using level II data are very similar to the fields using level III data except that the cloud concentrations are slightly greater and the cloud liquid field extends to a higher level (~275 mb, Fig. 4b). The relative humidity fields using level III versus level II data (shaded regions in Figs. 4c and d, respectively) are also nearly identical.

Since level II data have a greater influence on the horizontal winds than level III data, the impact on the vertical velocity field is more significant. In ADAS, vertical velocities are derived by integrating the continuity equation using the horizontal winds at all vertical levels and top and bottom boundary conditions (w=0 at boundaries). The horizontal wind field is then adjusted / relaxed in order to conserve total mass divergence (Brewster 1996). The differences in the ADAS-derived vertical velocity fields using level III versus level II data are shown in Figures 4c and d. At 1930 UTC, a deep area of rising motion associated with the squall line passage (maximum > 30 cm s^{-1}) is analyzed between 850 mb and 250 mb using level III data (Fig. 4c). The same time-height cross section using level II data reveals a much more intense updraft between 850 mb and 350 mb (maximum > 75 cm s^{-1}) as well as a downdraft on the trailing edge of the squall line (Fig. 4d). Sinking motion exceeds -100 cm s^{-1} in the mid-upper troposphere at 1945 UTC and extends down to near the surface at a lesser magnitude by 2000 UTC (dashed contours in Fig. 4d). Operationally, it is important to be able to diagnose regions of strong subsidence associated with convective activity because this sinking motion can lead to strong low-level horizontal winds as observed in this particular case.

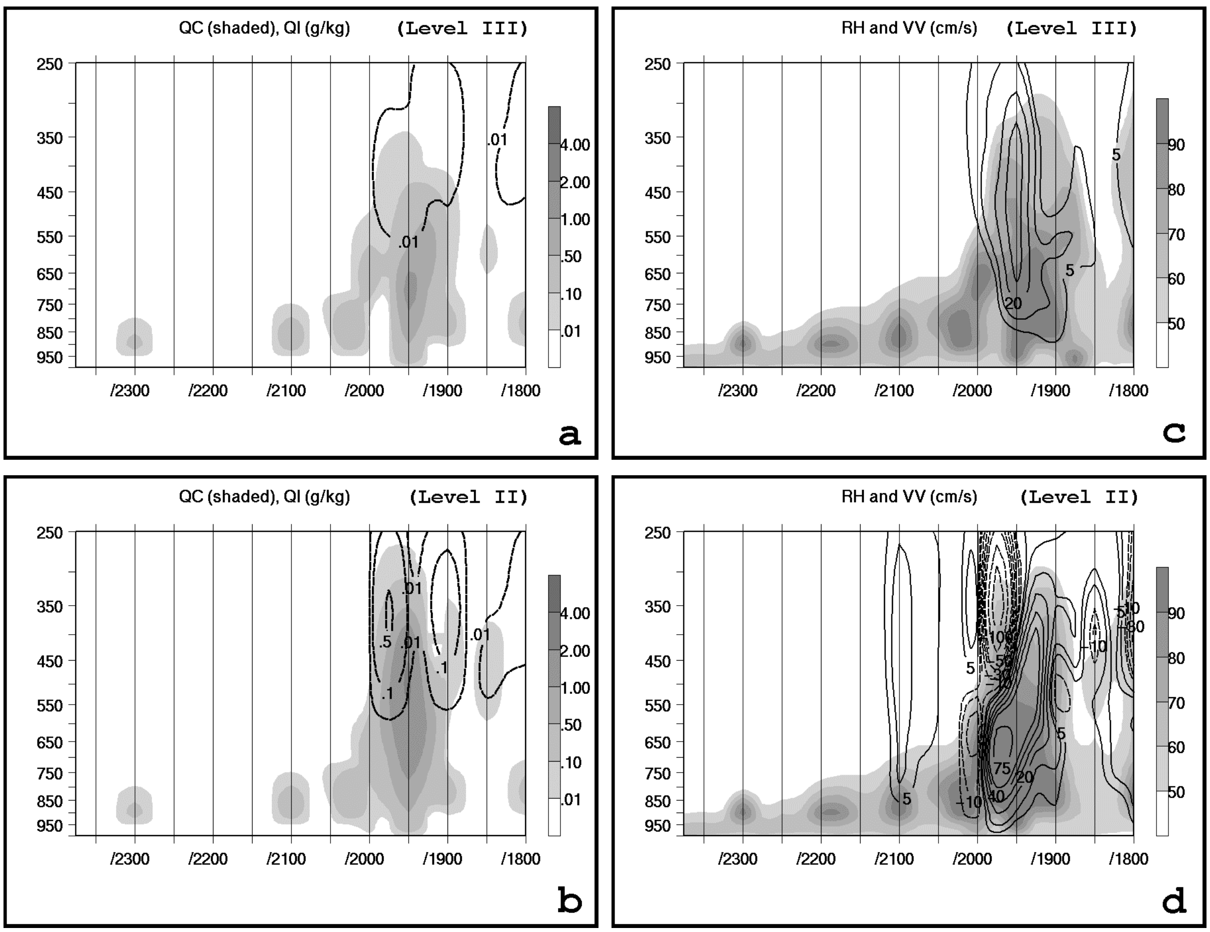

Figure 4. Time-height cross sections showing the influence of level II versus level III WSR-88D data are displayed from 1800 UTC to 2345 UTC 28 February. ADAS-derived cloud liquid (q_c, $\times$ 10^{-3} g kg^{-1}, shaded according to the scale provided) and cloud ice (q_i, contoured, $\times$ 10^{-3} g kg^{-1}) fields are shown using a) level III WSR-88D data and b) level II WSR-88D data. ADAS-derived relative humidity (RH, shaded in % according to the scale provided) and vertical velocity (cm s^{-1}, dashed contours indicate negative values or sinking motion) fields are shown using c) level III WSR-88D data and d) level II WSR-88D data.

Despite the degradation in horizontal resolution and fewer observed elevation angles, a significant benefit gained by ingesting level III WSR-88D data from all Florida radar sites is the increased horizontal coverage of radar data. As opposed to using level II data from only the MLB site, areal coverage of level III data includes most of the Florida peninsula and panhandle. This increase in coverage is most valuable on the 10–km analysis grid. Data from multiple radar sites on 28 February contributed favorably to the time-continuity of analyzed cloud and vertical velocity fields on the 10-km grid (not shown). The different aspects of level II versus level III WSR-88D data further supports the fact that an LDIS user should be aware of the characteristics of data ingested into the analysis system in order to utilize the results appropriately.

Reference

Brewster, K., 1996: Application of a Bratseth analysis scheme including Doppler radar data. Preprints, *15th Conf. on Weather Analysis and Forecasting*, Norfolk, VA, Amer. Meteor. Soc., 92-95.

SUBTASK 10 LOCAL DATA INTEGRATION SYSTEM PHASE III (MR. CASE)

Mr. Case's support for the LDIS Phase III task officially begins during the second quarter of FY 2000 for the NWS MLB and the third quarter of FY 2000 for SMG. However, he began preliminary preparations for LDIS Phase III during the first quarter of FY 2000. Mr. Case downloaded the latest version of ARPS/ADAS (4.5.0.2) from the ftp site provided by the University of Oklahoma. In addition, he began to organize and modify the files, scripts, and data converters required to run LDIS in real-time. Finally, Mr. Case spent half a day at NWS MLB testing and compiling ARPS/ADAS programs on one of the onsite HP workstations.

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

Dr. Merceret continued to serve as an expert advisor on upper air winds to the Shuttle, Titan and Delta programs during the quarter. He participated in both Shuttle and Eastern Range upper air systems meetings.

Dr. Merceret revised his manuscript describing the lifetime of wind features as a function of their vertical size for the Journal of Applied Meteorology based on the reviewers' comments. He also began an analysis of the use of 50 MHz profiler data for Shuttle day of launch decision-making.

NOTICE

List of Acronyms

30 SW	30th Space Wing
30 WS	30th Weather Squadron
45 LG	45th Logistics Group
45 OG	45th Operations Group
45 SW	45th Space Wing
45 WS	45th Weather Squadron
ADAS	ARPS Data Assimilation System
AFRL	Air Force Research Laboratory
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMS	American Meteorological Society
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
BUFR	Binary Universal Format Representation
CCAS	Cape Canaveral Air Station
CGLSS	Cloud to Ground Lightning Surveillance System
COF	Patrick Air Force Base 3-Letter Identifier
CSR	Computer Sciences Raytheon
DRWP	50 MHz Doppler Radar Wind Profiler
ECSB	East Coast Sea Breeze
EDA	Exploratory Data Analysis
EOM	End Of Mission
ERDAS	Eastern Range Dispersion Assessment System
FSL	Forecast Systems Laboratory
FSU	Florida State University
FY	Fiscal Year
GEMPAK	General Meteorological Package
GUI	Graphical User Interface
GSFC	Goddard Space Flight Center
IRIS/Open™	SIGMET Open Integrated Radar Information System
HP	Hewlett Packard
HYPACT	HYbrid Particle And Concentration Transport
I&M	Improvement and Modernization
IBM	International Business Machine
JAX	Jacksonville, Florida 3-Letter Identifier
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCC	Launch Commit Criteria

List of Acronyms

LDIS	Local Data Integration System
LLP	Lightning Location and Protection (same as CGLSS)
LWO	Launch Weather Officer
MARSS	Meteorological And Range Safety Support
MGA	Meteorological and Geoastrophysical Abstracts
MHz	Mega-Hertz
MIDDS	Meteorological Interactive Data Display System
MLB	Melbourne, Florida 3-Letter Identifier
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NE	Northeast
NEXRAD	NEXt generation RADar
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NWS MLB	National Weather Service Melbourne
OSF	Operational Support Facility
PET&S	Performance Evaluation, Test and Simulation
PUP	Principle User Processor
QC	Quality Control
RAMS	Regional Atmospheric Modeling System
RH	Relative Humidity
RSA	Range Standardization and Automation
RTAMPS	Automated Meteorological Profiling System
RTLS	Return To Launch Site
RWO	Range Weather Operations
SLF	Shuttle Landing Facility
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
TBW	Tampa Bay, Florida 3-Letter Identifier
TTS	Shuttle Landing Facility 3-Letter Identifier
UTC	Universal Coordinated Time
VIL	Vertically Integrated Liquid
WSR-88D	Weather Surveillance Radar - 88 Doppler
WWW	World Wide Web
XMR	CCAS 3-Letter Identifier
Y2K	Year 2000

Appendix A

AMU Project Schedule 31 January 2000				
AMU Projects	Milestones	Actual / Projected Begin Date	Actual / Projected End Date	Notes/Status
Statistical Short-range Forecast Tools	Determine Predictand(s)	Aug 98	Sep 98	Completed
	Data Collection, Formulation and Method Selection	Sep 98	Apr 99	Completed
	Equation Development, Tests with Independent Data, and Tests with Individual Cases	Mar 00	Nov 00	Delayed – FTE reassigned to Anvil Forecasting Task
	Prepare Products, Final Report for Distribution	Nov 00	Feb 01	Delayed – FTE reassigned to Anvil Forecasting Task
LDIS Extension	All	Oct 98	Oct 99	Completed
Meso-Model Evaluation	Develop ERDAS/RAMS Evaluation Protocol	Feb 99	Mar 99	Completed
	Perform ERDAS/RAMS Evaluation	Apr 99	Sep 99	Completed
	Extend ERDAS/RAMS Evaluation	Oct 99	Sep 00	On Schedule
	Interim ERDAS/RAMS Report	Dec 99	Jan 00	On Schedule
	Final ERDAS/RAMS Report	Oct 00	Dec 00	On Schedule
Delta Explosion Analysis	Analyze Radar Imagery	Jun 97	Nov 97	Completed
	Run Models/Analyze Results	Jun 97	Jun 98	Completed
	Final Report	Feb 98	Jan 00	Undergoing final revisions
	Launch Site Climatology Plan	Apr 98	May 98	Completed
Detecting Chaff Source Regions	Detect and analyze chaff signatures for source region	Oct 99	Apr 00	On Schedule
	Final Report	Apr 00	Jun 00	On Schedule
SIGMET IRIS Processor Evaluation Phase I	Investigate current and possible new capabilities of product development software	Oct 99	Jan 00	On Schedule
	Phase I Interim Report	Feb 00	Mar 00	On Schedule
SIGMET IRIS Processor Evaluation Phase II	Develop and transition new products to 45 WS IRIS station	Apr 00	Feb 01	On Schedule
	Final Report	Mar 01	Apr 01	On Schedule
Improved Anvil Forecasting: Phase I	Literature search	Nov 99	Dec 99	On Schedule
	Forecaster discussions	Dec 99	Jan 00	On Schedule
	Determine technical feasibility	Jan 00	Feb 00	On Schedule
	Phase I Report	Feb 00	Mar 00	On Schedule

AMU Project Schedule 31 January 2000				
AMU Projects	Milestones	Actual / Projected Begin Date	Actual / Projected End Date	Notes/Status
LDIS Extension: Phase III	Assistance in installation at NWS MLB	Jan 00	Mar 00	On Schedule
	Assistance in installation at SMG	Apr 00	Jun 00	On Schedule
	Memorandum	Jul 00	Jul 00	On Schedule
	Technical collaboration with SMG towards a conference paper	Aug 00	Sep 00	On Schedule