Applied Meteorology Unit (AMU)

Quarterly Report

Second Quarter FY-00

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Executive Summary

This report summarizes the Applied Meteorology Unit (AMU) activities for the second quarter of Fiscal Year (FY) 00 (January – March 2000). A detailed project schedule is included in the Appendix.

Ms. Lambert completed the Improved Anvil Forecasting Phase I task in this quarter. The work on this task was separated into three steps: literature search, forecaster discussions, and determination of the feasibility to continue with Phase II. The literature search did not reveal any previous work on this topic. The forecasters discussed the current products used for anvil forecasting and had suggestions for new techniques. Descriptions of those suggestions are provided in this report and include using observational data and model output. Based on the information gathered in the discussions with the forecasters, the technical feasibility conclusion is that it is possible to develop an anvil forecasting technique that will contribute to the confidence in anvil forecasts. The AMU recommends that a Phase II task start with data collection for an observations-based study.

Dr. Short completed Phase I of the Interactive Radar Information System (IRIS) SIGMET Processor Evaluation task in February and wrote a final report. A summary of the results is given in this report. Dr. Short analyzed the vertical resolution of the current radar scan strategy over Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS). He determined that the vertical resolution could be increased and proposed two alternative scan strategies. He then analyzed the vertical temperature profiles from CCAFS soundings and provided values for average height of certain temperature levels and their variability. Finally, Dr. Short described the IRIS System and provided suggestions for operational products that could be developed in that system.

Mr. Case completed the warm season evaluation of the Regional Atmospheric Modeling System (RAMS) in the Eastern Range Dispersion Assessment System (ERDAS). He compiled the objective and subjective results for the months of May through August 1999 into an interim report that is currently in review. Only a small portion of the objective results is given in this report. The objective results shown are from a sensitivity study to measure the impact of a decrease in horizontal resolution of the innermost grid on subsequent model errors. This experiment compares the operational 4-grid configuration of RAMS to a 3-grid configuration, which was created by simply excluding the innermost grid. The model errors for surface temperature and dew point temperature are significantly smaller in the 4-grid simulation. However, only negligible differences in wind speed and direction errors occur between the two configurations.

Mr. Wheeler continued to document the locations of all suspected chaff returns in an effort to detect chaff source regions during the 1999-2000 winter months. Several chaff drop events were documented and archived by Mr. Wheeler during the quarter. Mr. Wheeler continued to monitor products from the National Weather Service Weather Surveillance Radar-1988 Doppler (WSR-88D) sites in the region for chaff release signatures. A total of 31 cases were documented during the quarter.

Mr. Case began work on the Local Data Integration System (LDIS) Phase III task during the second quarter. He transitioned and compiled the Advanced Regional Prediction System (ARPS) software on an AMU workstation, and worked with personnel from the National Weather Service in Melbourne (NWS MLB) on data ingest issues that must be resolved before final implementation of a real-time LDIS.

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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 (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 003 SHORT-TERM FORECAST IMPROVEMENT

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

The 45th Weather Squadron (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. The Spaceflight Meteorology Group (SMG) forecasters reiterate this difficulty when evaluating Space Shuttle Flight Rules (FR). However, there are no forecast schemes in existence to help determine whether anvils will form from existing thunderstorms or the length and thickness of anvils that do form. The purpose of the task is to determine the technical feasibility of creating anvil-forecasting tools. During this quarter, Ms. Lambert completed the task and the final report. A summary of the final report is given in the following sections.

Task Methodology

The work on Phase I was separated into three steps: literature search, forecaster discussions, and determination of the feasibility to continue with Phase II. The literature search was done to reveal any previous work on this topic. Forecaster discussions were necessary to help determine the details of the forecasting problem and to gather ideas on how such a technique could be developed. In the final step all the information was assimilated in order to make a final determination of the feasibility of developing an anvil forecasting technique.

Literature Search Results

No articles were found in which a tested and proven anvil forecasting technique was described. The articles that were found relating to anvils can be broadly separated into the two categories of observational and modeling studies. Several studies were concerned with the effect anvil microphysical properties have on incoming solar and outgoing terrestrial radiation. These studies were done with the eventual goal of developing anvil microphysical parameterization schemes for global climate models. Two articles examined anvil electrification, and one article proposed that ingested anvil particles could be the cause of aircraft engine problems. Of the three modeling studies, two attempted unsuccessfully to model the microphysics and location of anvils and the other proposed a cirrus parameterization scheme for more accurate representation of cirrus and anvils in models. Most of the studies in both categories concluded that more operational and modeling studies of anvils and anvil parameters must be done to fully understand their behavior.

Although no anvil forecasting techniques were found in the literature, it is important to mention that there appears to be growing interest in anvil parameters in recent years. Most of the articles are dated 1989 or later. If the interest in anvils grows and more articles are written, more information will be available to aid in developing a reliable anvil-forecasting tool. Likewise, knowledge of how anvils form will naturally come from developing such a tool, and this knowledge would contribute to the general understanding of anvils in the scientific community.

Forecaster Discussion Results

Discussions were held with forecasters from the 45 WS, SMG, and the National Weather Service in Melbourne, Florida (NWS MLB). They described how forecasts for anvils are currently made and offered ideas on how a forecasting technique could be developed. Similarities exist in the way all three groups currently make anvil forecasts. In the days prior to an operation they use model forecasts of thunderstorm location/motion and upper-level wind speed/direction to help determine if anvils will be over the area. On the day of the operation, rawinsonde data are used to analyze upper-level winds and relative humidity (RH). Satellite and radar data are used for locating thunderstorms and anvils and determining their direction and speed of movement. Finally, as the time for the operation approaches, human observations of an anvil over the area are taken from the ground and/or aircraft to deduce anvil thickness and transparency. Although they are commonly used, all forecasters agree that these procedures are not adequate for forecasting anvils and an objective method is needed.

45TH WEATHER SQUADRON

During the 1999 warm season, Mr. Jim Sardonia, the Atlas LWO, collected and analyzed a small data set to see if any correlations existed between the data and anvil formation and growth. The data set included Geostationary Operational Environmental Satellite (GOES) visible (VIS) data, GOES sounding data, forecast data from the Medium Range Forecast (MRF), Rapid Update Cycle (RUC), and the 32-km Eta models, and Cape Canaveral Air Force Station (CCAFS) weather station (XMR) rawinsonde data.

Mr. Sardonia concluded that three primary factors are important in anvil formation:

- Average wind speed and direction in the anvil layer,
- Moisture content of the environment in which the anvil is forming, and
- Thunderstorm intensity.

Mr. Sardonia began an examination of GOES VIS data for anvil formation. He monitored the anvil growth through successive images until the anvil no longer increased in length. He then determined the distance from the parent storm to the edge of the opaque part of the anvil and defined this length as the transport distance. Mr. Sardonia's determination of the edge of the opaque anvil was subjective and based on personal experience. He estimated a transport lifetime using the transport distance and the average wind speed in the 300–150 mb (approximately 30 000 to 45 000 ft) layer calculated from GOES sounder winds. He used GOES sounding data to determine correlations between the observations and anvil transport distance and lifetime derived. Mr. Sardonia used the sounding from the location nearest to the parent storm and calculated the means for wind speed, wind direction, and dew point depression (DD) in the upper levels of the troposphere. Figure 1 shows the relationship between anvil transport lifetime and the average DD in the 300–150 mb layer. Only a small number of cases were used, but there appears to be an inverse linear relationship between the values. The transport lifetime tends to be ≥ 2 hours when the DD is < 10°F and < 2 hours when the DD is > 10°F.

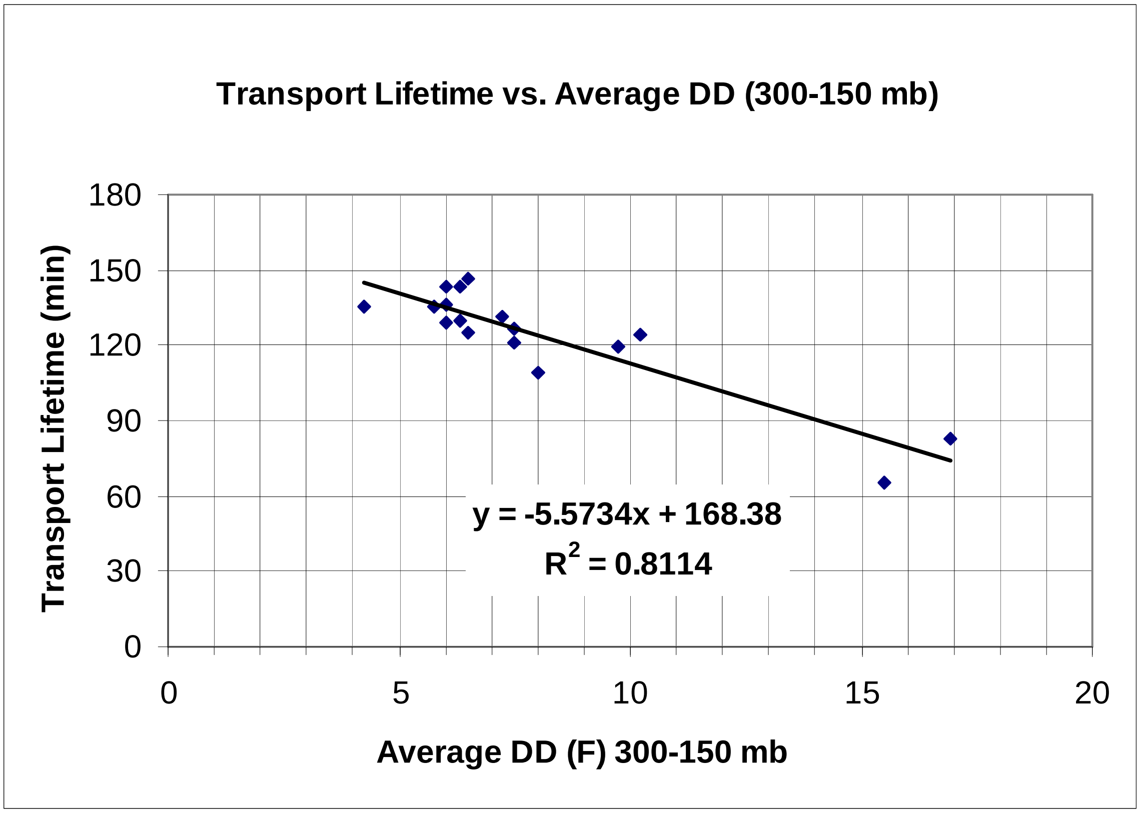

Figure 1. Graph showing the inverse linear relationship between the transport lifetime and the average dew point depression (DD) in the 300–150 mb layer. The diamonds represent the anvil cases. The equation of the line (y=mx+b) and the coefficient of determination (R^2) are also shown. The linear equation is preliminary and should not be used for anvil forecasting.

Figure 2 shows the relationship between anvil transport distance and the average wind speed in the 300–150 mb layer. The linear fit to the data is the thick line in the graph. There is a strong linear relationship between transport distance and wind speed. He also incorporated the data from the graph in Figure 1 to illustrate both relationships on one graph. The lines labeled with 1, 2, and 3 hours mark the lifetime ranges that are related to DD indicated between the lines. Anvils (diamonds in the graph) that formed in an environment with a DD range of 10–20°F had lifetimes in the range of 1–2 hours, while those in the 5–10°F DD range had lifetimes in the range of 2–3 hours. Even though the dataset is small, there is a strong indication that physically meaningful relationships exist between these observations.

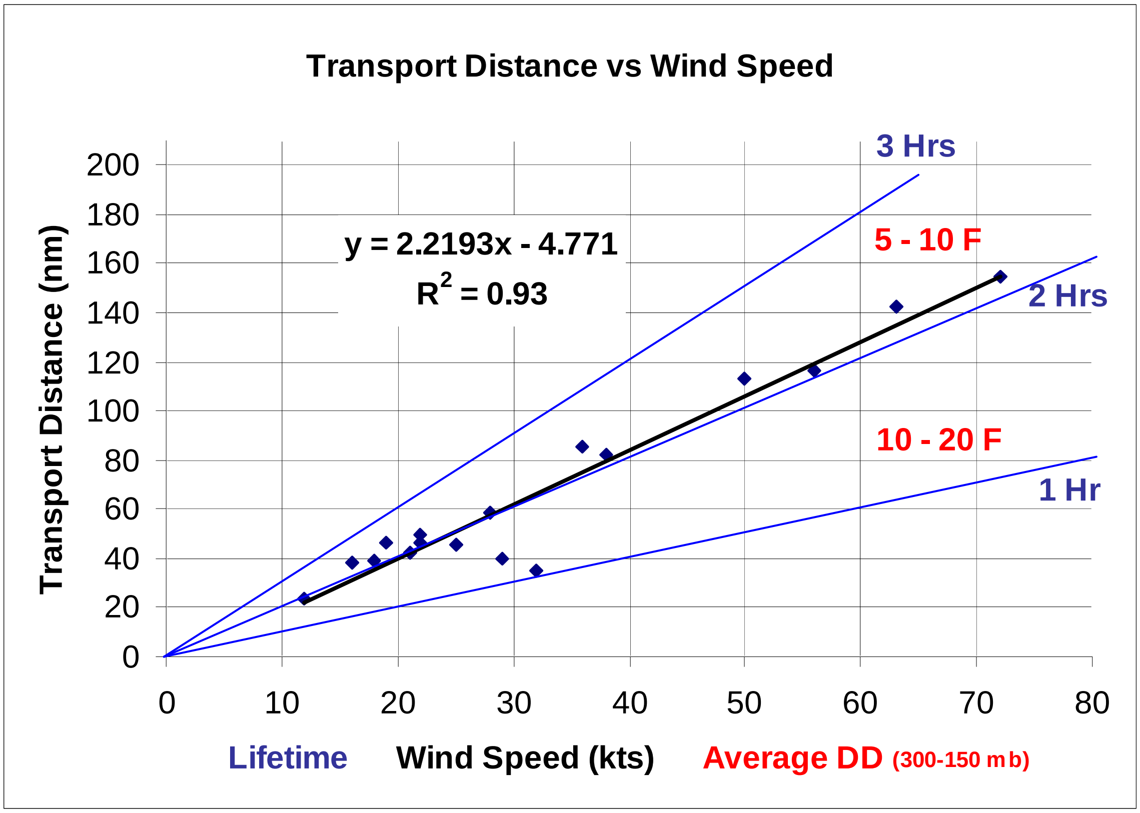

Figure 2. Graph showing the relationship between the transport distance (anvil length) and the average wind speed in the 300–150 mb layer. The diamonds represent the anvil cases. The thick black line is the linear fit to the data points, the other three black lines represent anvil lifetime, and temperatures represent the dew point depression (DD) ranges in the 300–150 mb layer. The equation of the line (y=mx+b) and the coefficient of determination (R^2) are also shown. The linear equation is preliminary and should not be used for anvil forecasting.

SPACEFLIGHT METEOROLOGY GROUP

The forecasters at SMG described three techniques they use to help forecast anvils: an anvil decision tree, an extrapolation/advection technique, and the use of operationally available data. They also had suggestions for how anvil-forecasting methods could be developed with a modeling study. All are described in the following four subsections.

Anvil Decision Tree

Garner et al. (1997) outlined the issues and problems involved in forecasting detached anvils. They described using a detached anvil decision tree developed by the 45 WS to derive probabilities of detached anvil occurrence over and near Kennedy Space Center (KSC)/CCAFS. The main strength of this technique is that it is quite simple to follow. However, the final probability is highly subjective since it will be ultimately based on forecaster experience and opinion.

Extrapolation / Advection

This technique requires an accurate analysis of the wind speed and direction in the upper-tropospheric layer that would contain the anvil cloud. Once the mean wind in the layer is determined, a circle with the location of interest as the center may be drawn using existing Meteorological Interactive Data Display System (MIDDS) applications. The radius of this circle should be the sum of two distances: 1) The distance defined by the FR or LCC, and 2) The distance over which an anvil would travel within the anvil age requirement, typically 3 hours. A wedge can be drawn in the upstream direction from the center to represent a region of interest based on the wind direction in the anvil layer. Once anvils form, their motion may be determined by analyzing satellite or radar data animation loops, and the circle and wedge can be modified as the time of the operation approaches and to reflect any change in wind direction or speed aloft.

This method is relatively easy to implement and explain to users. However, the mean wind estimates must be accurate, particularly at very short ranges close to the time of the operation. Its main disadvantage is that it accounts for anvil advection only, not anvil formation, diffusion, dissipation, time of detachment, opacity, etc. These anvil parameters must be subjectively determined by human observation.

Effective Tools and Products

SMG uses satellite imagery to monitor initiation, growth, and decay of anvils. They use animations of infrared (IR) and visible imagery and GOES Channel 2 images as a tool for determining which clouds are composed of ice. Weather Surveillance Radar-1988 Doppler (WSR-88D) products and animations are also useful for anvil analyses. High- to mid-elevation layer composite reflectivity data, high elevation angle base reflectivity images, vertical cross-sections of reflectivity, and composite reflectivity images are used for tracking anvils. SMG suggests that the 5 dBZ contour can be used to mark the location of a non-transparent anvil edge.

SMG forecasters use Nested Grid Model (NGM) and Eta model output to help forecast whether anvils will affect KSC/CCAFS. Model forecasts of convective precipitation are used to approximate the location of initial thunderstorm development 6 hours or more before a launch or landing. Model profiles of temperature, dew point temperature, wind speed and direction at certain locations, and model time/height series of RH, cloud parameters, wind speed and direction, and temperature are used as tools for predicting winds and the thermodynamic environment of anvil layers.

Modeling Study

The forecasters at SMG recommended a modeling study to develop an anvil forecasting technique, using observations for model validation. A model that can explicitly simulate thunderstorm and anvil clouds is required. One option is to use the Regional Atmospheric Modeling System (RAMS), currently running in real-time on the Eastern Range. During the real-time data collection, the AMU would identify cases when RAMS predicts thunderstorm and anvil clouds and record forecast parameters relating to anvil formation, propagation, and decay such as upper-level wind speed/direction and RH, storm updraft strength, and cloud particle concentrations. Another possibility is to simulate idealized cases using a model installed on an AMU workstation, such as RAMS or the Advanced Regional Prediction System (ARPS). Model input parameters could be controlled and changed for sensitivity studies to determine what meteorological parameters are important for anvil formation.

In any modeling study, it is important to verify the model forecasts with observations. The operational RAMS convection and anvil forecasts can be verified easily with VIS and IR satellite data, and the upper-level 5 dBZ contour in the WSR-88D data. Both the operational and idealized case study output can be verified with airborne field mill experiment data (summer 2000), should that experiment be successful in sampling anvils.

National Weather Service in Melbourne, Florida

Forecasters at NWS MLB are concerned with forecasting cirrus as it relates to high temperature and cloud cover forecasts. If opaque cirrus clouds are present, the surface temperature and any future convective development will be affected. They use all available model forecasts of RH, wind speed and direction, and divergence in the 350 – 200 mb layer. They can expect to find cirrus where the upper-level divergence is strongest, such as in jet-streak regions. They have found that the models produce fairly accurate wind field forecasts but do not do as well when forecasting locations of maximum RH in the upper-tropospheric levels. They advise that the upper-level wind fields (e.g. divergence, vertical motion) may be much more useful than RH when developing a cirrus and/or anvil forecasting technique using model output.

Phase I Conclusion and Phase II Recommendation

Based on the information gathered in the discussions with the forecasters, the conclusion of the Phase I final report is that it is technically feasible at this time to develop an anvil forecasting technique that will significantly contribute to the confidence in anvil forecasts.

The forecasters had two basic suggestions for methods and their development. The first is an observations-based study and the second is a modeling study. The modeling study can further divided into two separate studies: 1) analyze output from the operational RAMS, and 2) conduct idealized case studies with a model installed on an AMU workstation. Each of these studies can be done separately or in any combination. The AMU recommends that phase II of the task start with data collection for an observations-based study. The development of an observations-based technique has a high likelihood of success based on the promising relationships already found. The likelihood of success for a modeling component of this task is not known and should only be pursued after a subjective analysis of the models' ability to forecast convection and develop anvils.

For more information or a copy of the final report, contact Ms. Winifred C. Lambert by phone at 321-853-8130 or by email at lambert.winifred@ensco.com.

References

Garner, T., R. Lafosse, D. G. Bellue, and E. Priselac, 1997: Problems associated with identifying, observing, and forecasting detached thunderstorm anvils for Space Shuttle operations. *7th Conference on Aviation, Range, and Aerospace Meteorology*, Long Beach, CA, Amer. Meteor. Soc., 302 - 306.

2.2 TASK 004 INSTRUMENTATION AND MEASUREMENT

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

The AMU participated in a Range Standardization and Automation (RSA) Weather Requirements meeting held at KSC Headquarters in January. The purpose of the meeting was to review customer concerns with the proposed RSA weather components including the control and display, archive, network, and external data server as well as plans for transition, testing, and training on these systems. The Lockheed Martin Raytheon (LMR) proposal for AMU connectivity to the RSA weather system on the Eastern Range was also discussed. Dr. Manobianco attended the meeting in person and the remainder of the AMU staff monitored the proceedings remotely via teleconference. Mr. Wheeler reviewed several slides and other documentation and the attended the Eastern Range Weather Screen Review session in March. LMR presented examples of the weather system displays. Mr. Weems of the 45 WS also was present. Both Mr. Wheeler and Mr. Weems were not satisfied with what was presented. LMR took action items to resolve the problems that were noted. Another screen review will take place in May.

Dr. Manobianco participated in several teleconferences with representatives from 45 WS, NASA KSC Weather Office, and United States Air Force (USAF) Space Command. The purpose of these teleconferences was to discuss LMR's proposal for providing AMU connectivity to the RSA weather systems.

Table 1. AMU hours used in support of the I&M and RSA task in the second quarter of FY 2000 and total hours since July 1996.

Quarterly Task Support (hours)	***Total Task Support (hours)***
25.5	242.5

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

Dr. Short completed Phase I of the Interactive Radar Information System (IRIS) SIGMET Processor Evaluation task in February. IRIS provides display and analysis of radar reflectivity data from the Weather Surveillance Radar, model 74C, (WSR-74C) located at Patrick Air Force Base (PAFB). The purpose of the task is to evaluate capabilities of SIGMET Inc.'s IRIS System for meeting operational requirements of the 45 WS and SMG. These requirements include evaluating LCCs, FRs, and forecasting for ground operations.

The AMU Final Report on IRIS Product Recommendations includes recommendations for radar products emphasizing lightning and downburst tools for implementation on the IRIS System. The recommendations, based on discussions with weather support personnel from the 45 WS and SMG, are intended to provide a basis for discussions at meetings attended by 45 WS, SMG and AMU personnel. Products and capabilities selected during these meetings will be designed, implemented and tested on the IRIS workstations during Phase II. It is important to note that the SIGMET IRIS software is proprietary and cannot be changed by the AMU. Therefore, it may not be possible to develop some of the recommended products using the current IRIS software. In this case, new algorithms, procedures or software modifications required to develop the recommended products will be forwarded to SIGMET, Inc. for possible implementation in future system builds. A summary of the results from the final report is given in the following sections.

Background Information

Forecasting of lightning and downbursts with the aid of radar reflectivity data requires detailed observations of the vertical structure of convective cells, anvils, and debris clouds. Updrafts in convective cells that penetrate the 0°C level can produce mixed (liquid and ice) phase processes. This can lead to cloud electrification, in-cloud, cloud-to-cloud and cloud-to-ground lightning, and an environment in which triggered lightning could be initiated. Local experience at Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS) has shown that the reflectivity structure above the level of the -10°C isotherm and the amount of vertically integrated liquid (VIL) above the level of the 0°C isotherm are critically important for lightning forecasts (Pinder 1992; Pinder 1998; Roeder and Pinder 1998; Gremillion and Orville 1999). The "Pinder Principles" (Pinder 1992) emphasize the duration of high reflectivity layers above the level of the -10°C isotherm, with vertical extents greater than 3000 ft, for forecasting lightning.

Convective updrafts are also capable of suspending hydrometeors above the surface, possibly leading to downbursts generated and sustained by evaporative cooling of the air surrounding the hydrometeors and by precipitation loading. Recent AMU reports on cell trends (Lambert and Wheeler 1997; Wheeler 1998) have shown that temporal trends of VIL and reflectivity structure associated with convective cells are useful for forecasting downbursts and hail.

Volume Scan Strategy

Radar reflectivity data from the WSR-74C is recorded on the IRIS System during the radar Volume-Scan Task, which is presently configured to make 360° sweeps at 12 elevation angles every 2.5 minutes. Data are recorded at 1° azimuth intervals, providing high resolution information in the horizontal dimension. Resolution in the vertical dimension is determined by the sequence of elevation angles and the width of the radar beam, which is 1.1°.

The present scan sequence of the WSR-74C radar was examined to determine the scales of vertical gaps in coverage between the levels of the 0°C and -20°C isotherms, important altitudes for evaluating radar reflectivity and VIL structure within clouds. Gaps were determined between adjacent elevation angles at ranges of 3 nm to 60 nm from the radar, at altitudes between 10 000 ft and 25 000 ft and above the 5° elevation angle. These points approximate the domain where the accurate analysis of reflectivity structure is required to evaluate potentially hazardous weather conditions such as lightning and downbursts. The average vertical gap between elevation angles for the current scan sequence is 4924 ft.

A different approach to calculating gaps in radar coverage takes into account the radar beamwidth. This method recognizes the radar's ability to detect targets that are not along the beam axis. The average vertical gap between half-beamwidth points for the present scan sequence is 3190 ft between 10 000 ft and 25 000 ft and above the 5° elevation angle. The radar may not detect features above the 5° elevation angle with a thickness less than this value.

Alternative Strategies

Two alternative scan strategies, known as "center-to-center" and "half-beamwidth-to-half-beamwidth", have been designed to minimize gaps in beam coverage (Table 2). The characteristic common to both scan strategies is the requirement that vertical gaps are constant with range at a fixed altitude. What differs is whether the gaps are measured between beam centers (Brown et al. 2000), a conservative approach, or between the half-beamwidth points, recognizing that the radar can detect features that are off the beam axis.

Table 2. Elevation angles of the current WSR-74C scan strategy compared with those of two alternative scan strategies known as "center-to-center" and "half-beamwidth-to-half-beamwidth".

Beam Number	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***
Current	0.4°	1.0°	2.0°	3.0°	4.0°	5.0°	7.5°	10.0°	13.0°	16.0°	20.0°	26.0°
Center-to-Center	0.4°	1.4°	2.0°	2.8°	3.8°	5.1°	6.8°	9.0°	11.9°	15.6°	20.3°	26.0°
Half-Beamwidth	0.4°	1.8°	3.2°	4.8°	6.6°	8.6°	10.9°	13.4°	16.1°	19.1°	22.4°	26.0°

Center-to-Center

This volume scan is designed to have vertical gaps between beam centers that are constant with range from 0 to 60 nm at a given altitude. This design is based on the criteria in Brown et al. (2000). Their objectives in designing this type of scan sequence are to generate radar products whose errors are independent of range. They used simulation studies to show that the center-to-center scan strategy results in VIL errors that are uniform in range.

The constraints in developing this strategy were to retain 12 elevation angles, keep the minimum and maximum elevation angle values at 0.4° and 26.0°, respectively, and specify elevation angles to the nearest 0.1°. The IRIS software imposes the last constraint in addition to requiring that the ratio of the highest-to-lowest elevation angles be greater than about 60. The elevation angles in the center-to-center scan strategy are given in Table 2 above. The average gap between beam centers in the 10 000 ft and 25 000 ft layer above the 5° elevation angle is 4875 ft, a slight reduction from the current scan strategy (4924 ft). The average gap between half-beamwidths is 3043 ft, which is also a slight reduction from the current scan strategy (3190 ft).

Half-Beamwidth-to-Half-Beamwidth

This volume scan is designed to have vertical gaps between half-beamwidths that are constant with range from 0 to 60 nm at a given altitude. The elevation angles in the half-beamwidth-to-half-beamwidth scan strategy are given in Table 2. This method of calculating gaps takes into account the width of the radar beam and its effect on detection of features that are near to, but not exactly on the beam center. The average vertical gap at altitudes between 10 000 ft and 25 000 ft and above the 5° elevation angle is 2020 ft, a 37% reduction from the present scan. In addition, the average gap between beam centers is 4216 ft, a 15% reduction from the present scan strategy.

This half-beamwidth scan strategy provides a higher density of observations above the 5° elevation angle compared to the center-to-center strategy. This results in higher resolution data over the KSC/CCAFS complex. If the constraint regarding the ratio of highest-to-lowest elevation angles could be overcome, one could attain even higher vertical resolution data over the KSC/CCAFS complex by increasing the elevations of the lowest scans, at the cost of missing shallow convective cells at farther ranges.

Scan Strategy Comparison

Figure 3a shows vertical gaps between beam centers at an altitude of 20 000 ft as a function of range for the current, center-to-center, and half-beamwidth-to-half-beamwidth scan strategies. The present scan strategy has the largest gap at the 29 nm range, occurring between the 5.0° and 7.5° elevation angles. The center-to-center strategy has vertical gaps of 5560 ft, independent of range. The half-beamwidth strategy has vertical gaps increasing from 3400 ft at the 7 nm range to 7500 ft at the 44 nm range. For ranges less than 27 nm the half-beamwidth strategy has smaller gaps than the present and center-to-center strategies. At lower altitudes the vertical gaps are smaller for all strategies, decreasing approximately in proportion to altitude. Gaps at 10 000 ft are about one-half the size of those at 20 000 ft.

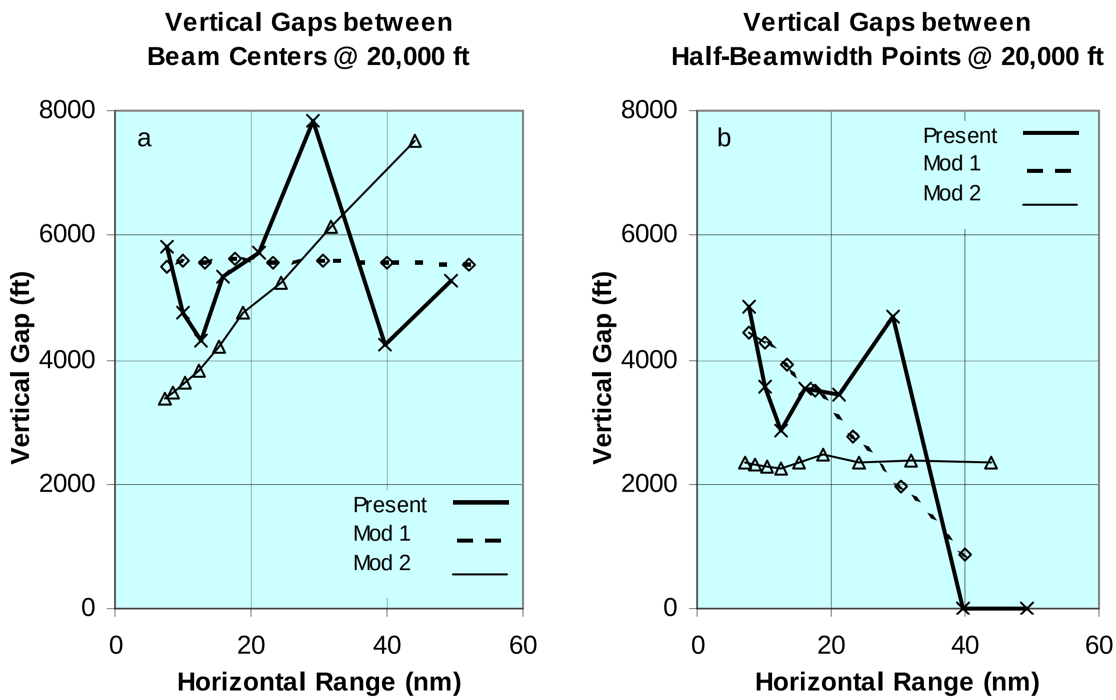

Figure 3. Vertical gaps between (a) beam centers and (b) half-beamwidth points at 20 000 ft altitude versus range for the present (thick line), center-to-center (Mod 1 - dashed thick line) and half-beamwidth-to-half-beamwidth (Mod 2 - thin line) scan strategies.

Variability of Atmospheric Temperatures

Natural and triggered lightning LCCs and shuttle FRs require monitoring of convective cloud characteristics at altitudes corresponding to the +5°C, -5°C, -10°C and -20°C isotherms. For example, LCCs prohibit a launch if the flight path will carry the vehicle within 10 nm of any cumulus cloud with its cloud top higher than the -20°C level. Radar observations provide the primary means for determining the height of clouds and for monitoring their vertical structure. The height of the 0°C isotherm is also required for interpretation of VIL signatures associated with potentially hazardous weather. Therefore, proper interpretation of radar data requires knowledge of the atmospheric temperature structure. The vertical temperature profile is obtained from local temperature soundings, taken 2 or more times per day at XMR (World Meteorological Organization Identifier 74794). A climatology of the monthly and annually averaged temperature profiles and their variability are available from the Edwards Air Force Base website (http://www.edwards.af.mil/weather/). Temperature statistics are available for each month. The period of record for the observations is January 1973 through December 1992.

The annual average altitudes of the +5°C, -10°C and -20°C are at 10 969 ft, 19 299 ft, and 24 126 ft, respectively. Therefore, maps of radar reflectivity patterns at the 10 000, 20 000, and 25 000 ft levels give the radar operator a quick look at cloud characteristics near the average height of the critical temperature levels, +5°C, -10°C and -20°C. However, the altitude of the critical temperature levels can vary considerably, as indicated by the standard deviations. For example, the average height of the +5°C isotherm is found at 10 969 ft and its standard deviation is 1831 ft. These statistics can be used to estimate that the +5°C isotherm is located between 7307 ft and 14 631 ft 95% of the time, assuming a normal distribution.

Variability of the Height of Selected Isotherms

The degree of variability in atmospheric temperatures can be more accurately characterized by dividing the year into warm (May, June, July, August, September; MJJAS) and cool (November, December, January, February, March; NDJFM) seasons. April and October are considered to be transition months. Figure 4 shows the estimated probability distribution of the height of the 0°C isotherm for the warm and cool seasons. The degree of variability in atmospheric temperatures at XMR suggests that radar products designed to convey information about cloud characteristics at specific temperatures could be improved by routine reconfiguration based on sounding data.

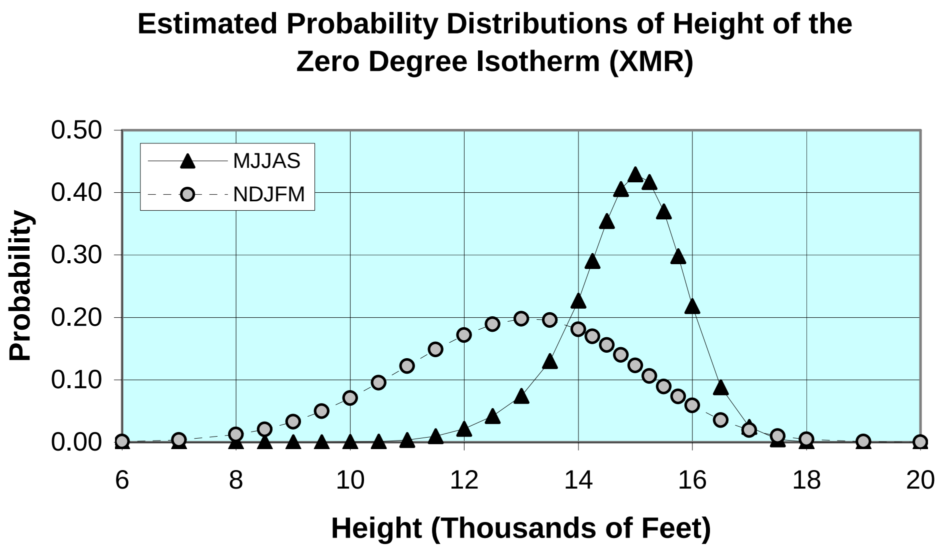

Figure 4. Estimated probability distributions of the height of the 0°C isotherm based on the climatology of soundings from XMR. The period of record for the observations is January 1973 through December 1992. The estimated seasonal probability distributions during the warm (MJJAS) and cool (NDJFM) seasons were obtained by first using the long-term mean and standard deviation for each month to construct normal distributions. The estimated seasonal distributions were then constructed as composites of the monthly normal distributions.

During the warm season the height of the freezing level is less variable, with a mean near 15 000 feet and a standard deviation of about 1000 ft. During the cool season the mean is near 13 000 ft and the standard deviation is about 2000 ft. These statistics suggest that products sensitive to the height of the 0°C isotherm may have to be reconfigured more often during the cool season than the warm season.

Recommendations for Products

The 45 WS has a reservoir of 130 IRIS products configured to provide the radar operator with a comprehensive array of information required for evaluation of LCCs, shuttle FRs, and daily operational forecasts. The AMU Final Report on IRIS Product Recommendations lists 18 additional products, based on discussions with the 45 WS (Mr. Roeder and Mr. Pinder) and SMG (Mr. Lafosse) personnel. The recommended products are designed to accomplish two goals. One is to provide the radar operator with additional tools for analysis and forecasting of potentially severe weather. The second is to fine-tune temperature sensitive products to day-to-day variations in the atmospheric temperature profile. The second type includes 7 products that are sensitive to variations in the heights of the +5°C, 0°C, -10°C and -20°C isotherms. These products include 3-layer VIL products, one reflectivity maximum (MAX) product and 3 constant altitude plan position indicator (CAPPI) products that can be reconfigured at the IRIS console in Range Weather Operations (RWO).

The additional 11 recommended products would require development and testing using the User Product Insert (UPI) capability before implementation. One of these products is a cell trends display designed after the WSR-88D cell trends display (Wheeler 1998) that shows the time evolution of cell based VIL, height of maximum reflectivity, maximum reflectivity, cell top and core aspect ratio. A minimum requirement for implementation of a given suite of products is that they can be generated and interpreted during the database refresh cycle, currently every 2.5 minutes. Because the time required for generating a cell trends product on IRIS is unknown, it may be prudent to develop 2-panel displays as opposed to the WSR-88D 4-panel displays. Operational applications of some of the new products may require the development of guidelines for appropriate use.

The IRIS Product generator in use within the RWO is a state-of-the-art system, allowing a wide range of flexibility for production and display of radar products derived from the WSR-74C reflectivity observations. IRIS allows reconfiguration of standard products in real-time by utilization of graphical user interface (GUI) driven configuration menus. In addition, IRIS is an "open architecture" system, with provisions for addition of customized products by utilization of the UPI feature. The UPI feature requires use of an IRIS specific programming language, described in the IRIS Programmer's Manual, in addition to the C programming language.

For more information or a copy of the final report, contact Dr. David Short by phone at 321-853-8105 or by email at short.david@ensco.com.

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SUBTASK 15 DETECTING CHAFF SOURCE REGIONS (MR. WHEELER)

Military chaff drops in the northeast Gulf of Mexico west of 85° W are suspected to be the source of chaff radar returns over KSC/CCAFS 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 LCCs and FRs during launch and landing operations. Current restrictions on chaff drops are confined to 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.

During this quarter, Mr. Wheeler continued to monitor Next Generation Radar (NEXRAD) products from the National Weather Service offices in Melbourne FL, Slidell MS, Mobile AL, Pensacola FL, Tallahassee FL, and Tampa FL WSR-88D sites for chaff release signatures. A total of 31 cases have been documented since January with several of the events lasting over 10 hours. A few of the cases showed chaff release signatures from both the northwest Gulf of Mexico and east of Jacksonville, FL. This task will be completed at the end of April with a final report being delivered by June.

2.3 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. The primary goal of this task is to conduct a case study of the explosion plume using the RAMS, Rocket Exhaust Effluent Dispersion Model (REEDM), and Hybrid Particle and Concentration Transport (HYPACT) model and compare the model results with available meteorological and plume observations. There are two reasons for the modeling exercise of comparing the observed and predicted plumes. The principal of the two reasons is to determine how well the modeled plume trajectories compare with the observed plume trajectories. The secondary reason is to determine how the REEDM-predicted source term compares with the actual source term.

Mr. Evans continued to make revisions to the final report during the quarter.

SUBTASK 8 MESO-MODEL EVALUATION (MR. CASE)

This section summarizes the work performed this past quarter by the AMU in support of the evaluation of RAMS component of the Eastern Range Dispersion Assessment System (ERDAS). ERDAS is designed to provide emergency response guidance for operations at the KSC and CCAFS in the event of a hazardous material release or an aborted vehicle launch. The primary goal of the evaluation is to determine the accuracy of RAMS forecasts during all seasons and under various weather regimes. The ERDAS RAMS evaluation primarily concentrates on wind and temperature (stability) forecasts required for dispersion predictions.

Mr. Case presented a paper at the Joint Army-Navy-NASA-Air Force (JANNAF) 18th Safety & Environmental Protection Subcommittee Joint Meeting, held on 8–12 May in Cocoa Beach, FL. A portion of the results from the JANNAF paper is presented in the following sections.

Background

Mission Research Corporation/ASTER Division developed ERDAS for the USAF. ERDAS was delivered to the Eastern Range at CCAFS in March 1994 and was designed to provide emergency response guidance for operations at KSC/CCAFS in the event of a hazardous material release or an aborted vehicle launch. Under option-hours funding from the USAF Space and Missile Center (SMC), the AMU was tasked to evaluate the prototype ERDAS during the period March 1994 to December 1995. The evaluation report concluded that ERDAS provided significant improvement over current toxic dispersion modeling capabilities but contained a number of deficiencies. These deficiencies were corrected in the next generation of ERDAS that is part of the newly upgraded Meteorological And Range Safety Support REPLacement (REPL) system.

The ERDAS-REPL system contains an upgraded version of RAMS that is designed to run on workstations with multiple processors. RAMS is a dynamical numerical weather prediction model with optional parameterization schemes for representing physical processes in the atmosphere. Details on the history, overview, and applications of RAMS can be found in Pielke et al. (1992) whereas a description of ERDAS can be found in Lyons and Tremback (1994).

There are two main differences between the original and upgraded versions of the RAMS configuration in ERDAS. First, the original configuration of RAMS did not include cloud or precipitation forecasts whereas the new configuration uses full cloud microphysics on all grids. Second, the areal extent of the innermost, nested grid was expanded and the horizontal resolution was improved from 3 to 1.25 km. While the previous configuration of RAMS in ERDAS was validated, a systematic evaluation of the new configuration has not yet been performed. For this reason, representatives from the 45th Space Wing (45 SW), 45th Range Safety (45 SE) and 45 WS requested that the upgraded version be evaluated.

RAMS Configuration in ERDAS

RAMS is run in three-dimensions over four nested grids with resolutions of 60, 15, 5, and 1.25 km (Figure 5). The lateral boundary conditions on grid 1 are nudged (Davies 1983) by 12–36-hour forecasts from the National Centers for Environmental Prediction (NCEP) 32-km Eta model that have been interpolated onto an 80-km grid. Output from the Eta model is available every 6 hours for the boundary conditions in RAMS. Therefore, the timing and accuracy of weather features in RAMS are dependent on the timing and accuracy of features in the Eta model forecasts.

Figure 5. The real-time RAMS domains are shown for the 60-km mesh grid (grid 1) covering much of the southeastern United States and adjacent coastal waters, the 15-km mesh grid (grid 2) covering the Florida peninsula and adjacent coastal waters, the 5-km mesh grid (grid 3) covering east-central Florida and adjacent coastal waters, and the 1.25-km mesh grid (grid 4) covering the area immediately surrounding KSC/CCAFS.

RAMS is initialized twice-daily at 0000 and 1200 UTC using the Eta 12-hour forecast grids and operationally-available weather data including the XMR rawinsonde, surface reporting stations (METAR), buoys, and KSC/CCAFS wind-tower, 915-MHz Doppler Radar Wind Profilers (DRWP), and the 50-MHz DRWP data. RAMS is initialized from a cold start, which simply integrates the model forward in time from an initial gridded field without any dynamic balancing or data assimilation steps. A more sophisticated model initialization scheme could be used to take advantage of all data sources available in east-central Florida, including WSR-88D data.

The RAMS cycle is run in real-time for a 24-hour forecast cycle. The operational cycle requires approximately 15 minutes to analyze observational data for the initial conditions and 10–12 hours to complete the forecast cycle. When the model produces extensive precipitation, a 24-hour forecast takes longer than 12 hours to complete due to the calculations associated with the cloud scheme. In these instances, the RAMS run is terminated before the 24-hour simulation is completed and the new simulation begins. Consequently, RAMS data are occasionally missing from the 22–24-hour forecasts. In the event of a premature termination, the forecast data from the previous forecast cycle are available for analysis.

Methodology

The AMU evaluation of ERDAS RAMS is made up of objective and subjective components. The objective component focuses on point error statistics at many observational locations on all four forecast grids. The 0- to 24-hour point forecasts of wind, temperature, and moisture were compared with surface METAR and buoy stations, the XMR rawinsonde, and KSC/CCAFS wind-tower, 915 MHz DRWP, and 50 MHz DRWP data at all available observational locations on grid 4, and selected surface and rawinsonde stations on grids 1–3. The point statistics include the root mean square (RMS) error, bias (or mean model error), and error standard deviation (SD) of wind direction, wind speed, temperature, and dew point temperature (dew point) for May–August 1999. In addition, the average values of forecasts and observations for these variables were computed as a function of forecast hour for the entire four-month evaluation period.

As part of the objective component, the AMU performed a sensitivity study to measure the impact of a decrease in horizontal resolution of the innermost grid on subsequent model errors. This experiment compares the full 4-grid configuration of RAMS to a 3-grid configuration, which was conducted by simply excluding grid 4 and rerunning RAMS only with grids 1, 2, and 3. The statistics were computed separately for the 4- and 3-grid data for all forecast times in which both models runs were available.

The purpose of the subjective verification is to provide an assessment of the forecast timing and propagation of the East coast sea breeze (ECSB) and subsequent precipitation. The subjective evaluation verifies RAMS forecasts of the onset and movement of the ECSB, precipitation, and low-level temperature on grid 4. The subjective verification was conducted for both the 0000 and 1200 UTC forecast cycles, but only during working days and for model runs that terminated normally. Only results from the objective verification are shown in this quarterly report. For those interested, the AMU will soon be distributing an interim report on the complete 1999 warm-season evaluation.

Objective Verification of 4-grid and 3-grid Configurations

This section presents a small portion of the objective results that were compiled for the RAMS evaluation. The objective error statistics for the 4- and 3-grid configurations, computed at KSC/CCAFS wind tower network locations, are presented for the 0000 UTC forecast cycle. Mean quantities and point error statistics at the KSC/CCAFS wind towers for both the 4- and 3-grid configurations of RAMS are shown for May–August 1999. With an average station spacing of 4 km, the wind tower network provides 5-minute temperature, dew point, wind direction, and wind speed observations at several levels near the surface. The RAMS evaluation uses temperature and dew point observations at 1.8 m (6 ft) and 16.5 m (54 ft), and wind direction and speed observations at 3.7 m (12 ft) and 16.5 m (54 ft). Hourly model forecast temperature and dew point are verified at 1.8 m and winds are verified at 16.5 m.

Cumulative results are shown for the entire period rather than for each individual month. For purposes of interpretation, total model error (RMS) includes contributions from both systematic and non-systematic errors. Systematic error (bias) can be caused by a consistent misrepresentation of physical parameters such as radiation or model-generated convection. Nonsystematic errors (error SD) represent the random errors caused by uncertainties in the model initial condition or unresolveable differences in scales between the forecasts and observations.

The most substantial difference between the 4- and 3-grid RAMS forecasts is the magnitude of the near-surface temperature and dew point errors. These model errors are both larger in the 3-grid forecasts. For nearly all forecast hours, the difference in near-surface wind forecasts are negligible. Figure 6 illustrates the differences and similarities in the error characteristics of the 4- and 3-grid RAMS configurations for temperature and dew point, respectively.

Temperature and Dew Point

The results from the 0000 UTC forecast cycle show that the 1.8-m temperature errors at the KSC/CCAFS towers are larger in the 3-grid configuration of RAMS, particularly during the daylight hours. Both mean forecast traces follow the mean observed temperature closely until the 11-hour forecast (Figure 6a). After 11 hours, both forecast traces diverge from the observed temperature. The 4-grid mean forecast temperature shows some diurnal increase after 11 hours, however, the 3-grid mean forecast temperature barely increases above the early morning mean minimum temperature. As a result, the 3-grid temperature RMS error is substantially larger than the 4-grid RMS error, peaking at nearly 8°C at 17 hours compared to a 4.5°C maximum 4-grid RMS error at 19 hours (Figure 6b). A cool daytime bias exists in both configurations, however, the 3-grid cool bias exceeds -6°C between 17–18 hours compared to a -3 to -4°C bias in the 4-grid configuration (Figure 6c). In addition to a larger cool bias, the non-systematic error is also larger in the 3-grid configuration as shown in Figure 6d. The 3-grid SD is about 2°C larger than the 4-grid SD between 15–18 hours.

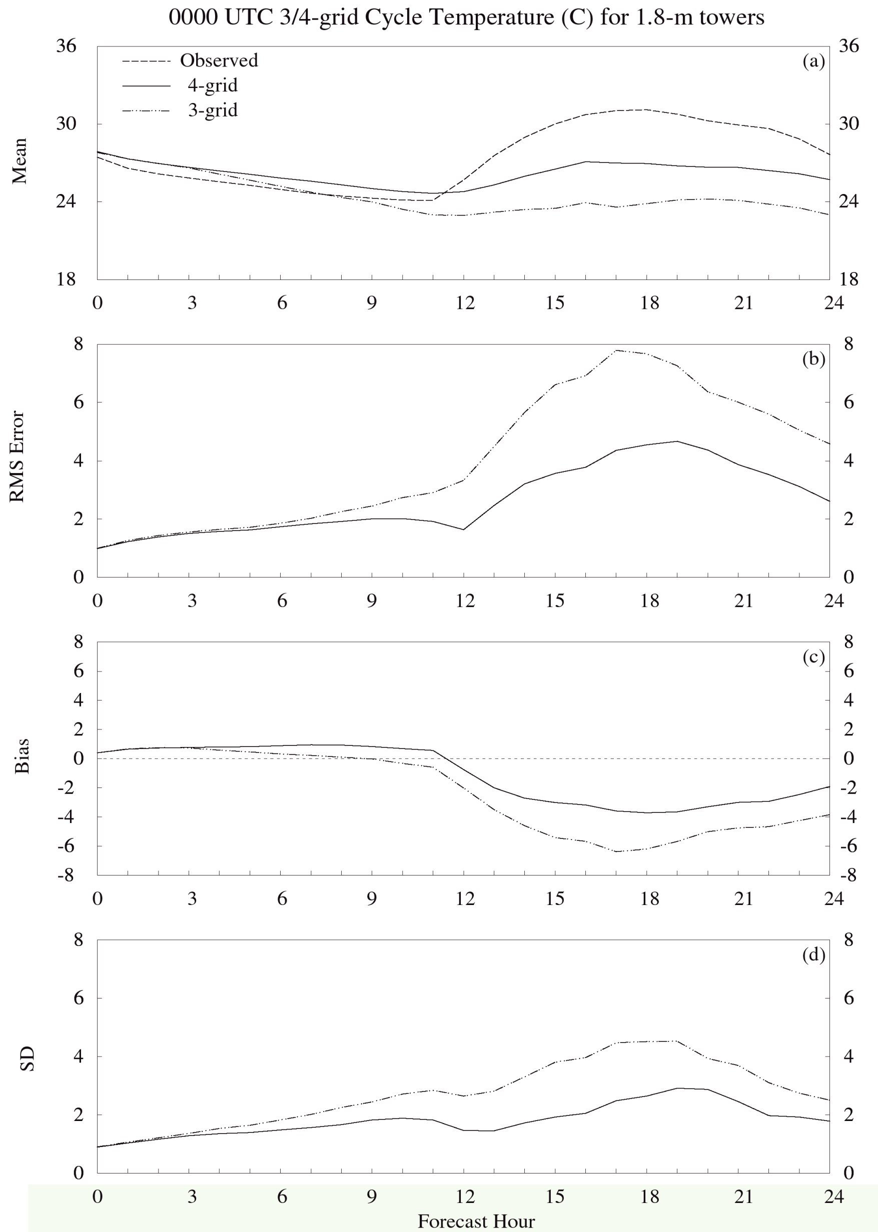

Figure 6. Comparison between the 4- and 3-grid RAMS configurations of the 0000 UTC forecast cycle surface temperature errors (°C). Surface temperatures are verified at the 1.8-m level of the KSC/CCAFS wind tower network. Parameters plotted as a function of forecast hour for both the 4- and 3-grid RAMS configurations include: a) mean observed, 4-grid forecast, and 3-grid forecast temperatures, b) RMS error, c) bias, and d) error standard deviation (SD). The plotting convention is a solid line for the 4-grid configuration, dot-dashed line for the 3-grid configuration, and a dashed line for observed values.

The magnitudes of the RAMS dew point errors at the 1.8-m level of the wind towers are also larger in the 3-grid forecasts (not shown). The mean 3-grid forecast dew point is as much as 7°C lower than the observed dew point by the 17-hour forecast. Both configurations have a negative (dry) bias, but the bias is more pronounced in the 3-grid configuration. The 3-grid dew point RMS error approaches 8°C at its maximum composed of a dry bias exceeding -6°C at 15–17 hours. Each of the 3-grid dew point errors exceeds the 4-grid errors by 2–4°C or more after the 3-hour forecast.

The 3-grid temperature errors in the 1200 UTC cycle are not as large as in the 0000 UTC cycle but the 3-grid errors are still larger than the 4-grid temperature errors. However, the 3-grid dew point errors in the 1200 UTC cycle exhibit similar characteristics to the 0000 UTC cycle in comparison to the 4-grid errors (not shown).

Wind Direction and Speed

The 0000 UTC forecast cycle comparison between the 4- and 3-grid wind direction forecasts at the 16.5-m tower level reveals that only negligible differences occur in the RMS error and bias for forecast wind direction (not shown). With the exception of forecast hours 21–24, the 3-grid RMS error is generally within 5° of the 4-grid error. Both model configurations have a maximum wind direction RMS error of about 60° between forecast hours 6 and 18. Much of this error is composed of random variability since the magnitude of the bias is much less than the magnitude of the RMS error. The RMS error in wind direction may be reduced when a more sophisticated model initialization is incorporated into the forecast cycle.

The comparison between the 4- and 3-grid forecast wind speeds also reveals that only small differences occur between the two configurations (not shown). The RMS error and SD are nearly identical throughout all 24 hours. The most significant difference between the 4- and 3-grid forecast wind speeds is that the 3-grid wind speed has virtually no bias after 12 hours whereas the 4-grid configuration experiences about a +1 m s^{-1} bias after 12 hours. In the 1200 UTC forecast cycle, the 4-grid/3-grid differences in wind direction and speed errors are even smaller than the 0000 UTC cycle.

Summary and Future Work

This section presented results from the objective portion of the ERDAS RAMS evaluation during the Florida warm-season months of May–August 1999. The objective evaluation of RAMS included a comparison of the operational 4-grid configuration of RAMS to a 3-grid configuration. In the 3-grid configuration, grid 4 was withheld in order to measure the effects of a decrease in horizontal resolution of the innermost grid on subsequent model errors. Based on the point error statistics computed at the KSC/CCAFS wind towers, both configurations of RAMS exhibit a cool, dry bias within the tower network. However, the 3-grid forecasts contained a larger RMS error and bias in temperature and dew point, particularly during the daylight hours. The differences in forecast wind direction and speed were generally small. Both configurations exhibited about a 60° RMS error in wind direction and a 2 m s^{-1} RMS error in wind speed. However, the 3-grid configuration was nearly unbiased whereas the 4-grid configuration had a 1 m s^{-1} bias during the daylight hours.

The RAMS evaluation will continue through the upcoming 2000 warm season and enhance the evaluation presented in this quarterly report. An evaluation of RAMS during the 1999-2000 Florida cool season will verify cold frontal timing and associated precipitation features. The extended warm season evaluation will include a verification of the first predicted thunderstorm of the day. Additional objective statistics will be computed for both the 1999-2000 cool season and the upcoming 2000 warm season. The additional components of the evaluation will be included in a final report to be distributed in early 2001.

For more information or a copy of the interim report, contact Mr. Jonathan Case by phone at 321-853-8264 or by email at case.jonathan@ensco.com.

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

The Local Data Integration System (LDIS) task emerged out of the need to simplify the generation of short-term weather forecasts in support of launch, landing, and ground operations. The complexity of creating short-term forecasts has increased due to the variety and disparate characteristics of the multitude of available weather observations. Therefore, the goal of the LDIS task is to generate high-resolution weather analysis products that may enhance a forecaster's understanding of the current state of the atmosphere, resulting in improved short-term forecasts. In Phase I, the AMU configured a prototype LDIS for east-central Florida that integrated all available weather observations into gridded analyses. In Phase II, the AMU simulated a real-time LDIS configuration using archived data. The LDIS Phase III task calls for AMU assistance to SMG and NWS MLB to install a working LDIS that generates routine high-resolution products for operational guidance.

During this past quarter, Mr. Case transitioned and compiled the ARPS software on the AMU's Hewlett Packard (HP) workstation. The ARPS software and its attendant programs must be compiled and tested on the HP UNIX platform because both the NWS MLB and SMG will be running the LDIS in real-time on an HP platform. Mr. Case could not optimize the ARPS Data Analysis System (ADAS) and other ARPS programs on the AMU's older workstation due to a memory limitation. As a result, further testing and optimizing of the ARPS/ADAS code will be done on the new NWS MLB workstation. NWS MLB installed the necessary C and FORTRAN compilers onto this workstation in order to compile and maintain ARPS/ADAS code locally.

Mr. Case collaborated with representatives from the NWS MLB on several data ingest issues that must be resolved before final implementation of a real-time LDIS. In order to ingest level II WSR-88D data into ADAS, a few libraries available from the National Severe Storms Laboratory (NSSL) are required to access and read the data from the Radar Interface and Data Distribution System (RIDDS). Currently, the NWS MLB is working with NSSL to acquire the necessary libraries for level II data ingest into ADAS.

Another issue involves ingesting the observational data that are available through the MIDDS. LDIS Phase II was designed to simulate a real-time configuration based on the data available through the SMG MIDDS, including the high-resolution KSC/CCAFS observations. In order to access all data available in MIDDS, Computer Sciences Raytheon (CSR) personnel installed the Man-computer Interactive Data Access System (McIDAS) software onto the NWS MLB HP workstation in February. The final step is to set up McIDAS so that it will ingest data directly from the external data server at SMG. Completion of this step awaits final approval from SMG and assistance from CSR. Once the real-time data feed from the SMG MIDDS is in place, Mr. Case will continue to assist NWS MLB in developing real-time data ingestors.

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

Dr. Merceret developed a new spectral technique for quantitatively comparing the similarity of two signals. Like coherence, it varies from -1 to 1 at each frequency or wavenumber. It is an improvement over coherence in that coherence only measures changes in phase while the new technique responds to changes in either phase or amplitude. Dr. Merceret and Amos Szpiro of Boeing, Inc. are preparing a paper on the new technique for the Aerospace Meteorology Conference in Orlando, FL in September 2000.

Dr. Merceret and Ms. Robin Schumann of ENSCO, Inc. prepared three papers for presentation at the Conference on Mesospheric, Stratospheric, and Tropospheric (MST) Wind Profiling scheduled for mid-March in Toulouse, France. Ms. Schumann presented the papers.

Dr. Merceret's paper on the lifetime of mid-tropospheric wind features as a function of their vertical scale was accepted for publication in the *Journal of Applied Meteorology*.

Dr. Merceret participated in discussions about weather support on Mars for the Mars Ascent Vehicle (MAV). The MAV will return samples from the Martian surface to orbit for return to earth. He provided expertise on electric field measurements and lightning detection.

2.5 TASK 001 AMU OPERATIONS

Mr. Wheeler developed the AMU's Information Technology (IT) equipment Buy Plan that identifies the planned and existing fiscal year IT procurements. He developed equipment and software requirements, researched possible hardware and software solutions, and received price quotes. Purchase requests (PR) for new equipment and services for the AMU were submitted to NASA. One PR for a RS/6000 UNIX system saved the government $26,000 by submitting and having the PR approved by the end of January. Mr. Wheeler also set up a new IBM RS/6000 UNIX system that was delivered to the AMU.

Ms. Lambert attended the 78th American Meteorological Society (AMS) Annual Meeting in Long Beach, CA. in January. She participated in the AMS Short Course on Data Mining and Knowledge Discovery from Databases and gave a presentation at the 11th Joint Conference on the Applications of Air Pollution Meteorology titled "Evaluation of RAMS in the Eastern Range Dispersion Assessment System".

During the last week of January, Mr. Case attended an ENSCO technology conference held in Santa Fe, NM. Mr. Case presented some of the results from the AMU's LDIS task extension and proposed a scheme to cycle LDIS analyses with regional short-range forecasts from the ARPS model.

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 SE	45th Range Safety
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
CAPPI	Constant Altitude Plan Position Indicator
CCAFS	Cape Canaveral Air Force Station
CSR	Computer Sciences Raytheon
DD	Dew Point Depression
DRWP	Doppler Radar Wind Profiler
ECSB	East Coast Sea Breeze
ERDAS	Eastern Range Dispersion Assessment System
FR	Shuttle Flight Rules
FSL	Forecast Systems Laboratory
FSU	Florida State University
FY	Fiscal Year
GOES	Geostationary Operational Environmental Satellite
GUI	Graphical User Interface
HP	Hewlett Packard
HYPACT	Hybrid Particle and Concentration Transport
I&M	Improvement and Modernization
IBM	International Business Machine
IR	Infrared GOES Image
IRIS	SIGMET Integrated Radar Information System
IT	Information Technology
JANNAF	Joint Army-Navy-NASA-Air Force
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LDIS	Local Data Integration System
LMR	Lockheed Martin Raytheon
LWO	Launch Weather Officer

List of Acronyms

McIDAS	Man-computer Interactive Data Access System
METAR	Aviation Routine Weather Report
MHz	Mega-Hertz
MIDDS	Meteorological Interactive Data Display System
MRF	Medium Range Forecast
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NEXRAD	NEXt generation RADar
NGM	Nested Grid Model
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NWS MLB	National Weather Service in Melbourne Florida
PAFB	Patrick Air Force Base
PR	Purchase Request
RAMS	Regional Atmospheric Modeling System
REEDM	Rocket Exhaust Effluent Dispersion Model
REPL	Meteorological And Range Safety Support Replacement
RH	Relative Humidity
RIDDS	Radar Interface and Data Distribution System
RMS	Root Mean Square
RSA	Range Standardization and Automation
RUC	Rapid Update Cycle
RWO	Range Weather Operations
SD	Standard Deviation
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
UPI	User Product Insert
USAF	United States Air Force
UTC	Universal Coordinated Time
VIL	Vertically Integrated Liquid
VIS	Visible GOES Data
WSR-74C	Weather Surveillance Radar, model 74C
WSR-88D	Weather Surveillance Radar - 88 Doppler
WWW	World Wide Web
XMR	CCAFS 3-Letter Identifier

Appendix A

AMU Project Schedule 30 April 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	Apr 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
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	May 00	Delayed, undergoing internal review
	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	Apr 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	Completed
	Phase I Interim Report	Feb 00	Apr 00	Delayed one month to expand Interim Report to Final Form
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

AMU Project Schedule
30 April 2000

AMU Projects	Milestones	Actual / Projected Begin Date	Actual / Projected End Date	Notes/Status
Improved Anvil Forecasting: Phase I	Literature search	Nov 99	Dec 99	Completed
	Forecaster discussions	Dec 99	Jan 00	Completed
	Determine technical feasibility	Jan 00	Feb 00	Completed
	Phase I Report	Feb 00	Apr 00	Delayed 1 month, undergoing external review
LDIS Extension: Phase III	Assistance in installation at NWS MLB	Jan 00	Apr 00	Delayed 1 month for logistical issues
	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