Applied Meteorology Unit (AMU)

Quarterly Report

Second Quarter FY-99

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Executive Summary

This report summarizes AMU activities for the second quarter of FY 99 (January - March 1999). A detailed project schedule is included in the Appendix.

Mr. Evans completed the Delta explosion analysis. The draft final report is completed and is currently undergoing external review. The major conclusions from the analysis are as follows:

- The WSR-88D (NEXRAD weather radar) is a good tool for providing plume tracks from rocket explosion plumes.
- The RAMS (Regional Atmospheric Modeling System) model accurately predicted the strength and height of the inversion for this case.
- Characterizing the REEDM (Rocket Exhaust Effluent Diffusion Model) source term for post-launch rocket explosions is difficult.
- The trajectory, diffusion and timing of HYPACT-modeled plumes showed similarities to the observed plume.

Ms. Lambert and Dr. Manobianco continued development of a suite of statistical forecast tools. To provide the data necessary for the project, they decoded and processed surface observation, wind tower, and rawinsonde data sets. Data sets for individual surface observation stations were displayed graphically in order to aid in the development of simple quality control routines. Investigations into possible climate changes due to small station moves were begun.

Based on the AMU mid-course review in January 1999, the meso-model task was modified to include an evaluation of the Eastern Range Dispersion Assessment System (ERDAS) Regional Atmospheric Modeling System (RAMS). The evaluation will consist of an objective and subjective component. The objective evaluation will focus on gridded and point error statistics and the sensitivity of model forecasts to soil moisture, resolution, and other factors. The subjective portion will verify RAMS forecasts of the onset and movement of the east coast sea breeze, precipitation, and low-level temperature. A draft of the evaluation protocol will be completed in early April and sent to all customers for review. The additional labor necessary for this task required postponing the Radar Atlas task until March 2000.

Mr. Case held a teleconference with all customers in January to discuss the technical details of the Local Data Integration System (LDIS) extension task. LDIS is expected to provide operational forecasts with more efficient methods of viewing and evaluating local atmospheric data in near real time. As part of the task, the AMU will identify the data types that cause observed discontinuities so users can recognize the influence of specific data types in LDIS. The AMU will also evaluate the performance of LDIS on the existing hardware and extrapolate system performance to determine the hardware necessary to run LDIS in real time.

In January, Mr. Case presented recent results from AMU work on the LDIS and the Weather Surveillance Radar-1988 Doppler (WSR-88D) Cell Trends Final Report at the 79th Annual American Meteorological Society meeting.

Dr. Merceret's paper on the vertical resolution of the KSC 50-MHz Doppler Radar Wind Profiler was accepted for publication as a note in the *Journal of Atmospheric and Oceanic Technology*. He also published a NASA Technical Memorandum describing the effects of sensor separation on the measurement of peak wind speeds at Launch Complex 39.

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If anyone on the current distribution would like to be removed and instead rely on the WWW for information regarding the AMU's progress and accomplishments, please respond to Frank Merceret (407-867-0818, francis.merceret-1@ksc.nasa.gov) or Ann Yersavich (407-853-8203, anny@fl.ensco.com).

1. BACKGROUND

The AMU has been in operation since September 1991. 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.

2. AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

2.1 TASK 001 AMU OPERATIONS

During the second week of January, Mr. Case attended the 79th Annual American Meteorological Society meeting. Mr. Case presented results from the AMU work on the Local Data Integration System (LDIS) and the Weather Surveillance Radar-1988 Doppler (WSR-88D) Cell Trends Final Report. Specific details of Mr. Case's trip were presented in a memorandum for record dated 22 January 1999.

2.2 TASK 003 SHORT-TERM FORECAST IMPROVEMENT

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

Ms. Lambert perused the decoded surface data files to determine which contained sufficient periods of record for the task. Out of 95 different station names, 28 were found to be actual surface stations with 25 years of data. Most of the other station names were identifiers for intermittent ship observations and will not be used. The period of record for the surface stations is January 1973 – March 1997.

Ms. Lambert also began testing the software to be used in this task: Microsoft Access and Excel, and UNISTAT, a statistical software package. During the tests, it was noted that certain changes in the surface data file format were needed for Access, Excel, and UNISTAT to work properly. One of those changes is to fill in missing data for any missing hourly observations, as was done for the buoy data. Dr. Manobianco made the necessary modifications to the decoder to make most of the format changes, and Ms. Lambert developed the software to fill in missing data.

When beginning to develop simple quality control (QC) algorithms for the data, display limitations were found in Excel and UNISTAT. Both Excel and UNISTAT have limits on the number of rows allowed in their spreadsheets. Excel allows 65536 rows while UNISTAT allows only 32600. There are approximately 220,000 hourly observations from one station in the period 1973 to 1997. Thus, the limitations do not allow the examination or display of data from one station. The ability to examine the data from one station over the entire period of record is important for QC and exploratory data analysis purposes. A display/graphing utility on the UNIX workstations called XMGR does not have these limitations, so the data were formatted for input into this program for display.

Ms. Lambert used the XMGR utility to display several data types from the entire periods of record for several surface stations. While most of the data appeared to be within normal limits and consistent with time-of-day and time-of-year, there were several obviously erroneous values. The erroneous values could have an adverse effect on the accuracy of the final statistical forecast equations. Therefore, two simple quality control checks were added to the decoders to eliminate the erroneous values. The first is a check that eliminates unrepresentative values, and the second is a time-consistency check. A cursory examination revealed that these checks eliminate most, if not all, of the erroneous data in each of the data sets. A third QC algorithm was developed that flagged data that were not within a certain number of standard deviations from the mean. That algorithm is still being tested. Dr. Manobianco and developed similar quality control checks for the rawinsonde and tower data sets.

Several of the surface stations moved during the period of record. Most of the moves were approximately 1 mile or less with minimal changes in elevation. Lakeland (LAL), however, moved 5 miles and experienced a 30-meter drop in elevation. Ms. Lambert constructed hourly climatologies for January and July at this station and found significant differences from before and after the move in January for visibility, temperature, dew point temperature, and altimeter setting. It is likely that data from this station will not be used in the analysis. Testing on other stations that moved will be done in the next quarter.

SUBTASK 6 RADAR ATLAS & WEATHER REVIEWS (MR. WHEELER)

Mr. Wheeler began work on the Radar Atlas portion of this task during January. During the period, he queried the three agencies on the task and requested their input for examples of radar signatures that they would like highlighted in the atlas. Mr. Wheeler met with Mr. Pinder of the 45th Weather Squadron (45 WS), Mr. Sharp of the Melbourne National Weather Service (NWS MLB), and by email, Mr. LaFosse of the Spaceflight Meteorology Group (SMG) to get their views of the atlas and review some of their examples. Mr. Lafosse volunteered SMG material on chaff and clear-air mode operation cloud signatures.

During February, Mr. Wheeler converted many hardcopy examples of radar signatures to images so that, if needed, they can be added to the atlas. Mr. Wheeler began developing the electronic version of the radar atlas that will contain three examples of radar signatures. When completed, all customers will then review this document and provide comments. Based on consensus reached during an out-of-cycle tasking review on 18 February, work on this task will be delayed so that Mr. Wheeler can perform the subjective component of the ERDAS (Eastern Range Dispersion Assessment System) RAMS (Regional Atmospheric Modeling System) evaluation (see Task 5, subtask 8 for details).

2.3 TASK 004 INSTRUMENTATION AND MEASUREMENT

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

There was no work performed on this task during this quarter.

2.4 TASK 005 MESOSCALE MODELING

SUBTASK 4 DELTA EXPLOSION ANALYSIS (MR. EVANS)

The primary goal of this study was to conduct a case study of the dispersing plume and cloud resulting from the Delta II explosion on 17 January 1997 at Cape Canaveral Air Station (CCAS). The study was conducted by comparing mesoscale and dispersion model results with available meteorological and plume observations and was funded by the Kennedy Space Center (KSC) under AMU option hours.

The models used in the study are part of the Eastern Range Dispersion Assessment System (ERDAS). These models include RAMS (Regional Atmospheric Modeling System), HYPACT (HYbrid Particle And Concentration Transport, and REEDM (Rocket Exhaust Effluent Dispersion Model).

The primary observations used for plume verification in the study were from the National Weather Service's WSR-88D radar. Radar reflectivity measurements of the resulting cloud provided good estimates of the location and dimensions of the cloud over a four-hour period after the explosion.

Meteorological data from local observations and sensors provided a basis for comparison with meteorological model output. Observed data was obtained from the WINDS tower network at CCAS/KSC, rawinsonde data from CCAS, 915-MHz and 50-MHz radar wind profilers at CCAS/KSC, and standard local station and buoy observations.

The conclusions of this study can be categorized according to the plume observation technique and according to the models used in the analysis. The findings of this study are:

WSR-88D Radar as a Plume Observation Tool

- The WSR-88D is a good tool for providing plume tracks from rocket explosion plumes. The radar provided excellent data on the location and track of the resulting cloud. The data was extremely useful for model verification as well since no ongoing program is in place to measure plume track or concentrations. Mr. Bud Parks of ACTA, Inc. is conducting a study to capture data from nominal and abort launch clouds and has been somewhat successful (Parks and Evans 1998).

- The WSR-88D does not provide concentration data. The only data obtained by the radar is the reflectivity value measured in dBz. While this measurement gives an estimate on the relative density of material (smoke particles, water, dust, or other particulate matter), a methodology is needed to convert dBz to concentrations of HCl, N_2O_4, or other materials of interest. One of Range Safety's main concerns is determining the exposure limit (concentration over a specified time) of certain toxic materials.

  A dark orange cloud at the very top of the large lower cloud was initially visible. The dark orange cloud most likely contained some amount of nitrogen tetroxide. Because it was located near the top of the cloud, it is unsure how much, if any, of the N_2O_4 mixed within the cloud and made it to the surface. Our analysis was not able to determine the concentration of N_2O_4 in the explosion cloud.

- Vertical plume height data for this case was not very accurate. The radar appeared to accurately track the clouds' trajectory in the x-y dimension. However, the vertical measurements appeared to be inaccurate for a couple of reasons. The first reason was that for long distances from the radar, such as the 35+ kilometers from Melbourne to Cape Canaveral, the radar beam widened enough to introduce inaccuracies in the vertical plume height measurements. The second reason for inaccurate vertical measurements was because of the strong inversion causing the radar beam to bend and bring about measurement inaccuracies.

RAMS Model

- The wind flow predictions in this case were fairly accurate. Both ERDAS and PROWESS (Parallelized RAMS Operational Weather Simulation System) configurations of RAMS produced wind flow measurements that matched closely with rawinsonde and profiler measurements and seemed to provide good input to HYPACT. The meteorological conditions on this day were strongly influenced by synoptic rather than local forcing.

- RAMS under-predicted onshore flow at the level of the Delta II cloud. RAMS predicted onshore flow in the 600- to 900-meter layer in the area south of Cape Canaveral. However, the northeast onshore flow was probably a little stronger than modeled as evidenced by the track of the actual cloud.

- RAMS accurately predicted the strength and height of the inversion for this case. The well-defined inversion that was measured by rawinsonde and had a significant influence on the explosion cloud was accurately predicted by RAMS in its strength and height. The inversion was determined by the vertical temperature profile.

REEDM Source Term

- Characterizing source term of unique explosions is difficult. If a rocket explosion occurs, the circumstances will be different each time it happens. For example: What was the flight time? How much fuel was consumed? What were the height, location and distribution of the explosion products? Were the hazardous and toxic materials separated or mixed within the cloud? Did the second stage ascend and then explode as with the Delta II? Did the solid rocket motors explode immediately or did they follow an errant path before they exploded? All of these questions make it difficult to develop a model that will accurately assess and characterize the source term. We were able to use information obtained after-the-fact from radar and video to characterize the source term but in a real-time scenario only estimates of the source term characterization can be made.

- Splitting the source into two sources for HYPACT model was a reasonable approximation. Splitting the source into two sources for HYPACT model was better for this case as opposed to using the source term single column that was generated by REEDM.

HYPACT Model

- Plume came onshore further to the north (sooner) than predicted. HYPACT moved the large lower cloud resulting from the Delta II explosion onshore at a point that was approximately 12 kilometers south of where it actually came onshore. HYPACT predicted the plume would come across the coastline in the Satellite Beach/Indian Harbour Beach area when it actually crossed the coastline in the Cocoa Beach area. The reason for this was that the actual winds affecting the cloud movement had a stronger easterly component than predicted by the RAMS winds. RAMS supplies wind and meteorological data to HYPACT. The effect of the missed plume movement was that the actual plume impacted the coastline sooner than HYPACT predicted.

- Trajectory, diffusion, and timing of HYPACT plumes showed similarities to the observed plume. Except for the problem mentioned above, the trajectory, diffusion, and the timing of the HYPACT plumes were similar to the plumes observed by radar. One favorable result was noted in the spread and diffusion of the lower cloud as it moved south. The cloud spread in the crosswind direction in a way similar to the observed.

- Range Safety's REEDM predicted the movement of plume to the south-southeast. The Range Safety version of the REEDM did not predict the onshore movement of the lower cloud. REEDM, using the 1613 UTC rawinsonde from Cape Canaveral, moved the plume to the south-southeast and kept it offshore. REEDM did not account for the winds with an easterly component that existed at a height of 700-800 meters in the area over the ocean to the south of Cape Canaveral.

Recommendations

- Develop methodology to correlate concentrations with radar reflectivity measurements. The WSR-88D has proved to be a valuable tool in tracking nominal and abort rocket plume. However, the radar provides no information on the concentrations within the clouds. What is needed is measurement of concentrations within the plumes using a sample collection method or another remote sensing technique such as lidar. This data could then be correlated with radar measurements of reflectivity in dBz.

- Improvements are needed in HYPACT plume dynamics algorithms. HYPACT currently treats plumes as non-buoyant, non-depositing entities. We recommend that future enhancements should be made to HYPACT to improve its ability to handle buoyant plumes and particle deposition. These improvements would allow HYPACT to model rocket exhaust plumes better than the current version of HYPACT.

- Conduct other studies of rocket explosion plumes. Since the explosion of the Delta II over two years ago, two other rockets have exploded after launch from Cape Canaveral - Titan IV on 12 August 1998 and Delta III on 26 August 1998. In both cases, the explosion clouds were tracked by WSR-88D radar. Detailed studies should be conducted to verify mesoscale models, diffusion models, and radar tracking techniques.

References

Parks, C. R. and R. J. Evans, 1998: Tracking nominal launch and abort rocket plumes using WSR-88D doppler radar. Presented at JANNAF SEP Subcommittee meeting, Houston, TX, May 1998, 10pp.

SUBTASK 5 MODEL VALIDATION PROGRAM (MR. EVANS)

Mr. Evans has completed all the HYPACT runs for all sessions. The data has been copied to tape and is being submitted to NOAA. A description of the data is being prepared and will be submitted and discussed in a teleconference during the MVP Workshop to be held in May 1999 at Oak Ridge, TN. Mr. Evans participated in a teleconference with the MVP team on 11 March.

SUBTASK 7 LOCAL DATA INTEGRATION SYSTEM / CENTRAL FLORIDA DATA DEFICIENCY (MR. CASE AND DR. MANOBIANCO)

In March, Mr. Case prepared and submitted a preprint paper for the 8th Conference on Mesoscale Processes to be held in Boulder, CO from 28 June to 1 July 1999. The presentation will consist of a poster that highlights the mesoscale processes associated with the significant outflow boundary from the 26-27 July 1997 warm-season case study as presented in the AMU final report. A portion of the submitted preprint is given in this quarterly report illustrating diagnostic quantities from the warm-season case that were not presented in prior AMU quarterly reports.

Analysis Configuration

Using the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS) software (Brewster 1996; Carr et al. 1996), a series of 15-minute analyses were generated on a 10-km and 2-km grid with the 60-km Rapid Update Cycle (RUC) model (Benjamin et al. 1998) providing the first-guess field. The 10-km analysis grid covers an area of 500 × 500 km and includes much of the Florida peninsula and adjacent coastal waters of the Gulf of Mexico and Atlantic Ocean. The 2-km analysis grid consists of a 200 × 200-km area centered on the KSC/CCAS. All available data in the greater KSC/CCAS area were ingested into ADAS for the 26-27 July 1997 case study.

Description of Case Study

The warm season case was selected from 26-27 July 1997 in order to investigate the capabilities and utility provided by ADAS. Both 10-km and 2-km grid analyses were generated for the warm season case at 15-minute intervals from 1800 UTC on 26 July to 0200 UTC on 27 July. However, only results from the 2-km analysis grid are presented in this section.

A typical, undisturbed warm season environment characterized the 26-27 July case. Early in the afternoon, scattered thunderstorms developed across the peninsula and a sea-breeze boundary was evident along the east coast (not shown). By 2212 UTC, strong thunderstorms developed southwest of KSC/CCAS and generated an outflow boundary that propagated northeastward as indicated by the Melbourne WSR-88D level II base reflectivity (Fig. 1a). The leading edge of the outflow boundary intersected the eastern tip of KSC/CCAS by 2242 UTC as shown in Figure 1b (counties and location of KSC/CCAS are given in Fig. 2a). This outflow boundary caused wind gusts greater than 15 m s^{-1} as noted on the KSC/CCAS mesonet towers around 2245 UTC (not shown). This case was chosen because the strong winds associated with the outflow boundary forced Atlas launch operation A1393 to be scrubbed for the day.

Diagnosis of an Outflow Boundary

Using the fine-scale results of the 2-km ADAS analyses, the evolution of the wind speeds and wind vectors at

480 m (Figs. 2a-d) illustrates the formation and intensification of the outflow boundary during the late afternoon of 26 July. Wind speeds greater than 8 m s^{-1} develop over the Brevard/Osceola County border at 2215 UTC 26 July (Fig. 2a) and spread radially over the next 45 minutes. The maximum winds (> 12 m s^{-1}) move northeastward into KSC/CCAS and offshore regions of central Brevard County by 2245 UTC (Fig. 2c), the approximate time that the Atlas launch was postponed.

Examination of level II radar reflectivity (Fig. 1) and radial velocity data (not shown) indicates that features present in the high-resolution wind analyses (Fig. 2) are consistent with the scale and motion of patterns associated with the observed thunderstorm. It should be noted that the detailed structure of horizontal winds associated with this outflow boundary would likely be easier to visualize in real-time using ADAS rather than WSR-88D radial velocity displays alone.

The evolution of the thunderstorm outflow can also be examined through the divergence of the horizontal wind on the 2-km ADAS grid. In Figure 3, plots of convergence (shaded), divergence (dashed lines), and horizontal winds are shown at 650 m for the same times as in Figure 2. At 2215 UTC, an area of low-level convergence is found over much of central Brevard County (Fig. 3a). Weak divergence is also found over northeastern Osceola County at this time. Fifteen minutes later, an extensive area of low-level divergence develops in southern Brevard County, behind the developing outflow boundary (Fig. 3b). Convergence along the outflow boundary spreads outward into central Brevard County (just south of KSC/CCAS), offshore of southern Brevard County, and into Indian River County. Divergence continues to intensify across much of interior Brevard County over the next 30 minutes beneath the dissipating thunderstorm (Figs. 3c and d), while the band of convergence spreads out radially along the leading edge of the outflow boundary.

By 2300 UTC, a well-defined band of convergence arcs from northern Osceola County, across eastern Orange and northern Brevard County, into the offshore waters of Brevard County, and then back onshore in Indian River County (Fig. 3d). Strong divergence exceeding 8×10^{-4} s^{-1} occurs over east-central Brevard County.

The vertical structure of the convection is indicated by north-south cross sections of divergence and the vertical velocity (w) field through the developing thunderstorm outflow (Fig. 4 and 5, respectively). According to Brewster (1996), w is derived within ADAS from the analyzed horizontal winds (via continuity) and a constraint that the wind velocity normal to the bottom and top boundaries is zero. Deviations from these boundary conditions are treated as errors in the horizontal divergence that vary linearly with height. The w field is adjusted once these errors are removed and the horizontal wind field is relaxed such that total mass divergence domain-wide is zero.

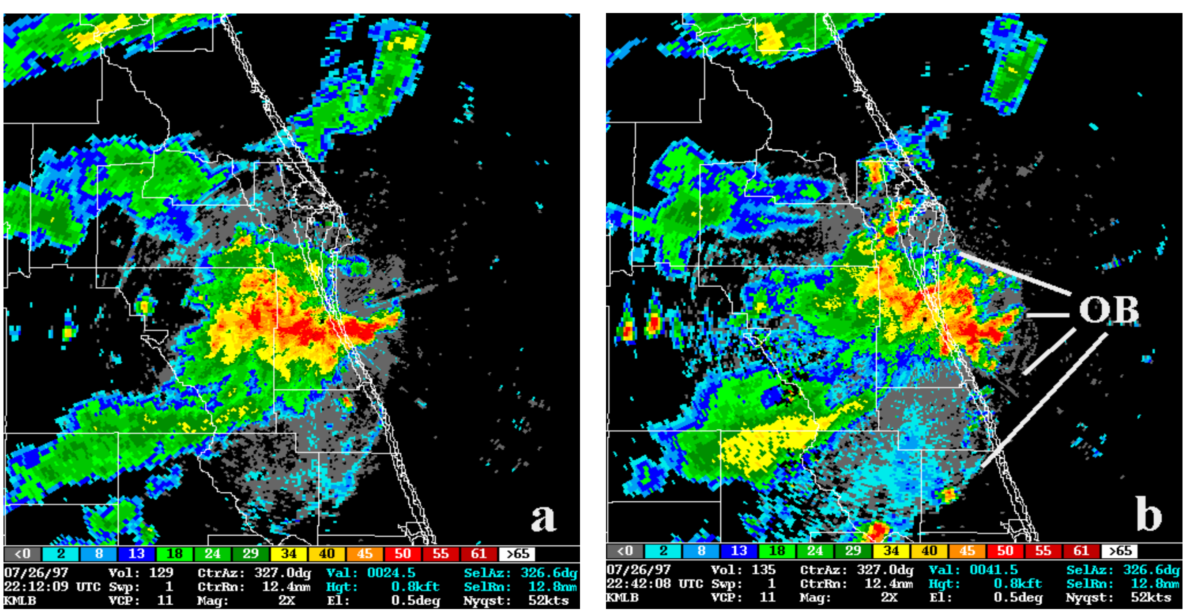

Figure 1. Base reflectivity images are shown from the Melbourne WSR-88D on 26 July at a) 2212 UTC and b) 2242 UTC. The leading edge of the outflow boundary is indicated by "OB" in panel b).

A deep column of convergence is prevalent at 2215 UTC (Fig. 4a) associated with the strong convection southwest of KSC/CCAS (Fig. 1a). The onset of the dissipating stage of the convection occurs at 2230 UTC when convergence transitions to divergence in the lowest 1000 m directly beneath the deep layer of maximum convergence (Fig. 4b). The leading edge of the outflow boundary is evident in Figure 4b given by the low-level convergence below 1000 m on either side of the newly-developed low-level divergence.

By 2245 UTC, the area of low-level divergence expands laterally and upward to 3000 m (Fig. 4c). The leading edge of the outflow boundary spreads rapidly north and southward (left and right, primarily below 1000 m) on either side of the intensifying low-level divergence maximum. Meanwhile, mid-level convergence remains strong, exceeding -6×10^{-4} s^{-1} in the 3500–5500-m layer. By 2300 UTC, a well-developed signature exists for a downburst-producing thunderstorm (Fig. 4d). Strong mid-level convergence in the 3000–6000-m layer overlies a maximum in low-level divergence which exceeds 8×10^{-4} s^{-1}.

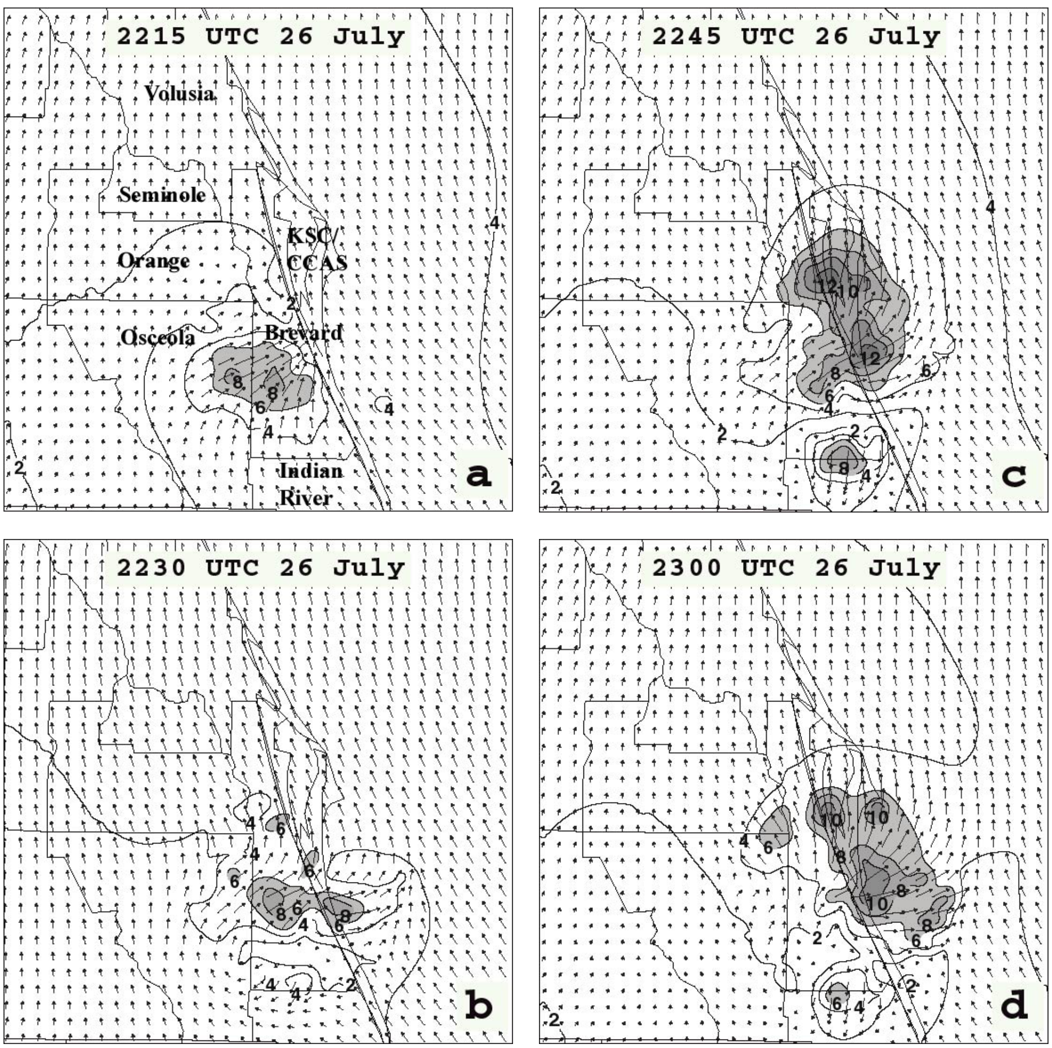

Figure 2. A display of the 2-km ADAS wind speed and wind vectors at 480 m. Wind speed is contoured every 2 m s^{-1}, shaded above 6 m s^{-1}, while wind vectors are denoted by arrows. Valid times are a) 2215 UTC, b) 2230 UTC, c) 2245 UTC, and d) 2300 UTC 26 July. Counties and the location of KSC/CCAS are labeled in a).

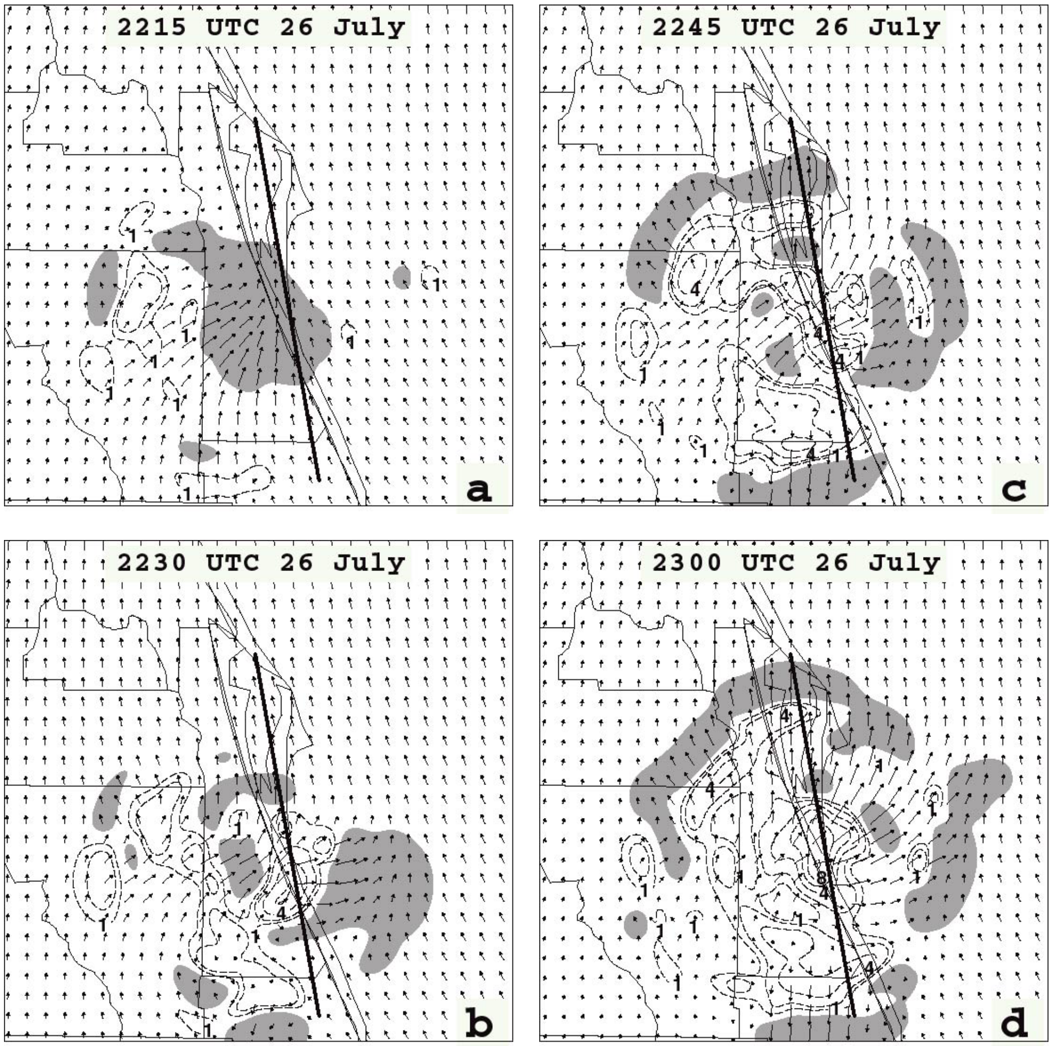

Figure 3. Divergence of the horizontal wind ($\times 10^{-4}$ s^{-1}) and wind vectors at 650 m derived from the 2-km ADAS grids. Dashed lines indicate divergence and shading indicates convergence. Valid times are a) 2215 UTC, b) 2230 UTC, c) 2245 UTC, and d) 2300 UTC 26 July.

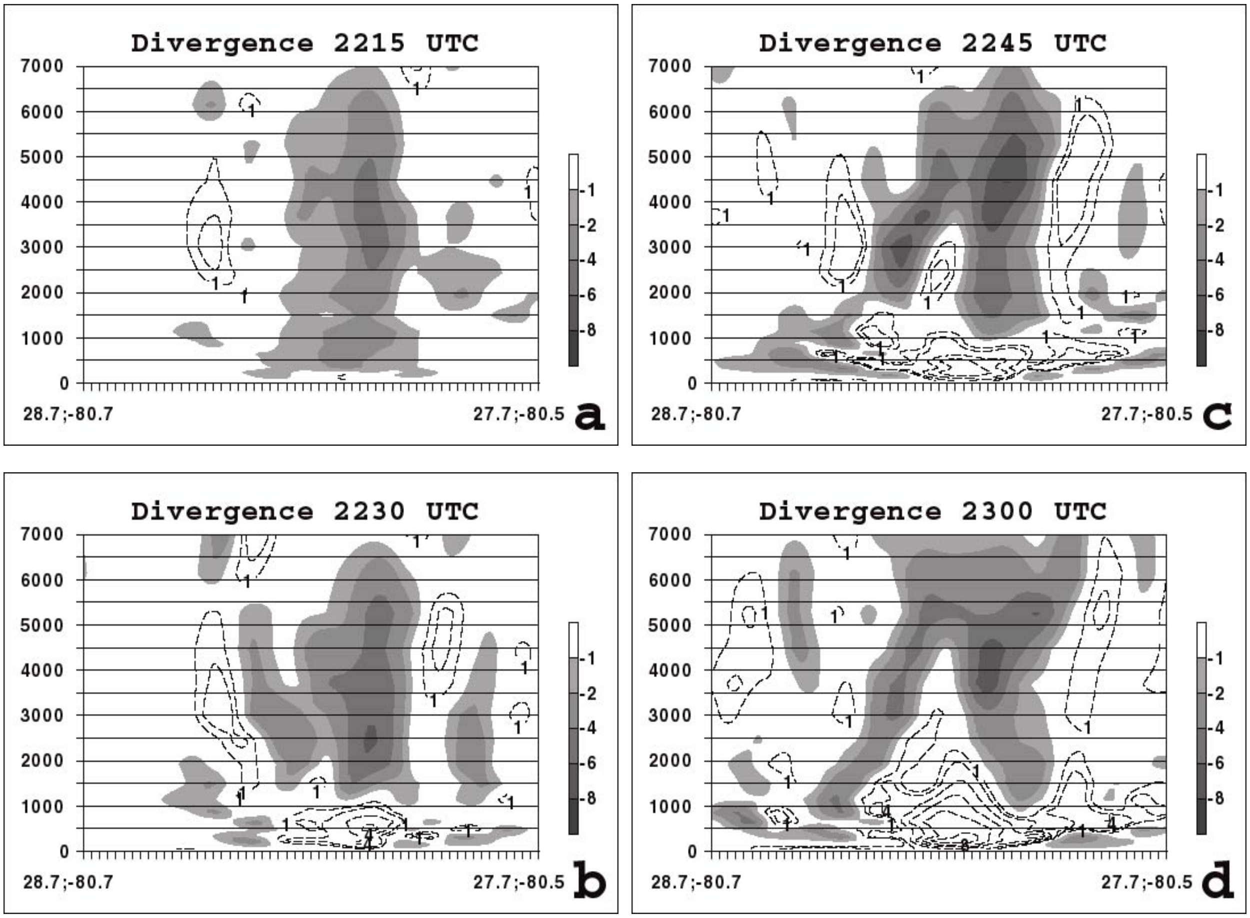

Figure 4. Cross sections of divergence of the horizontal wind ($\times 10^{-4}$ s^{-1}, derived from the 2-km ADAS grids) along north-south oriented lines indicated in Figure 3. Dashed lines indicate divergence while shading represents convergence according to the scale provided. Valid times are a) 2215 UTC, b) 2230 UTC, c) 2245 UTC, and d) 2300 UTC 26 July. The ordinate ranges from 0 to 7000 m whereas the latitude and longitude are labeled at the endpoints of the abscissa.

Finally, the vertical structure of the kinematically-derived vertical velocity field associated with the dissipating convection is depicted in Figure 5. Also shown in Figure 5 is the evolution of the derived circulation (arrows) in the plane of the cross section. At 2215 UTC, a strong updraft greater than 200 cm s^{-1} occurs above 5500 m (Fig. 5a) in conjunction with the deep column of convergence in Figure 4a. Rising motion prevails throughout much of the depth of the convective cell with values of *w* exceeding 10 cm s^{-1} from 750 m up to the top of the cross section. Also, a southerly wind component prevails across the southern (right) half of Figure 5a (most notably below 3000 m) which feeds the updraft of the storm.

During the transition phase of the thunderstorm, an area of sinking motion is indicated in the lowest 2-3 km beneath the still strong updraft (Fig. 5b). Notice that the prevailing southerly wind component has weakened below 1000 m in the southern (right) portion of Figure 5b. By 2245 UTC, a significant but narrow downdraft has developed from near the surface up to 6000 m between two updrafts (Fig. 5c). Sinking motion reaches 75 cm s^{-1} by this time at roughly 3500 m. In the lowest 1000 m of Figure 5c, southerlies increase in intensity to the north (left) of the strengthening downdraft whereas winds have turned around to a slight northerly component below 1000 m to the south (right) of the downdraft.

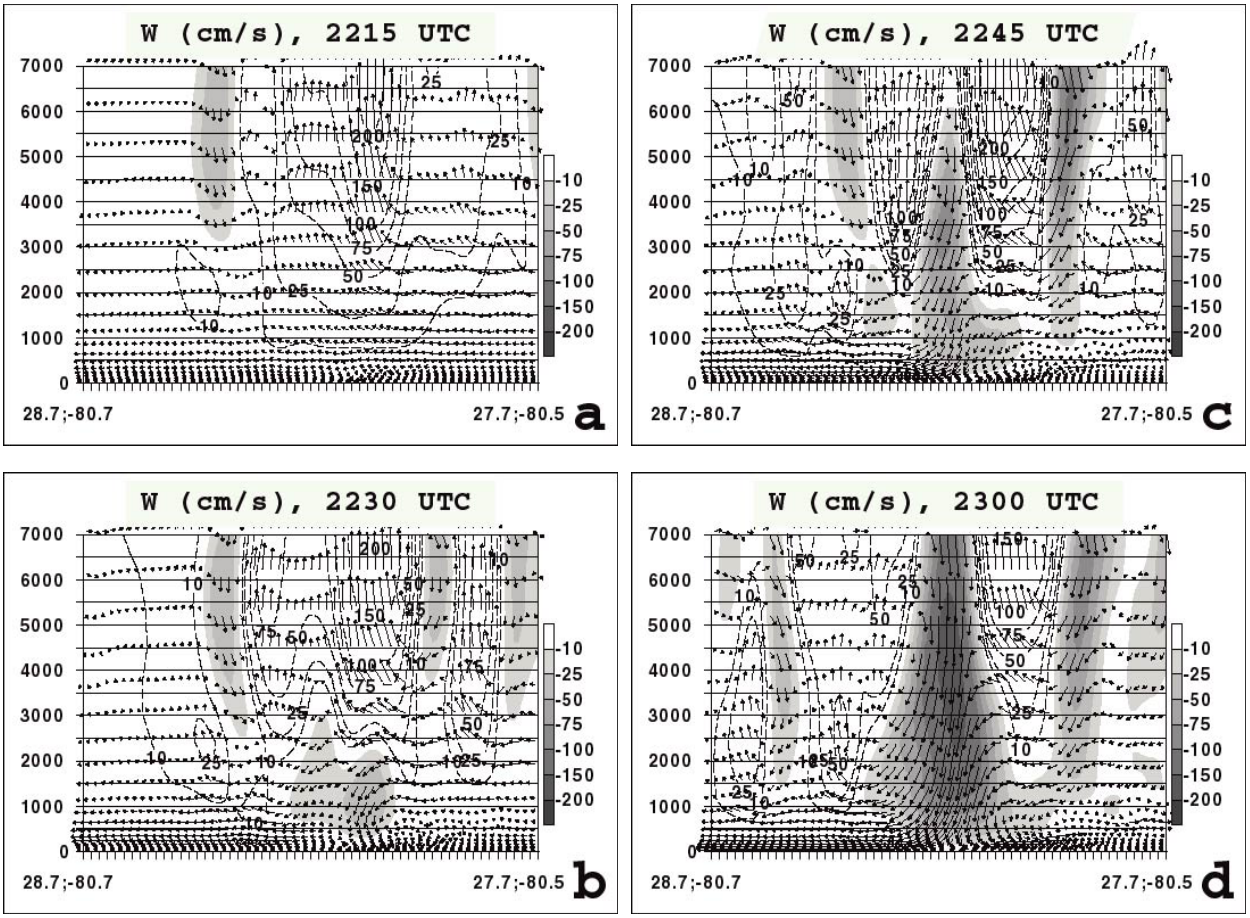

Figure 5. Cross sections of vertical velocity (cm s^{-1}, derived from the 2-km ADAS grids) along north-south oriented lines indicated in Figure 3. Dashed lines indicate rising motion whereas shading represents sinking motion according to the scale provided. Valid times are a) 2215 UTC, b) 2230 UTC, c) 2245 UTC, and d) 2300 UTC 26 July. The ordinate ranges from 0 to 7000 m whereas the latitude and longitude are labeled at the endpoints of the abscissa.

Summary

Results from the 26-27 July 1997 case demonstrate that subsequent 15-min analyses of horizontal winds and its associated divergence and derived vertical motion fields on the 2-km ADAS domain can depict the formation and propagation of a thunderstorm outflow boundary. LDIS has the potential to provide added value because it can incorporate data which are currently available only at KSC/CCAS and run at finer spatial and temporal resolutions over smaller domains than current national-scale, operational models such as the RUC and Eta. Furthermore, it is noticeably easier to diagnose and visualize the vertical motion fields and outflow boundary using ADAS analyses rather than strictly radial velocity data at multiple elevation angles.

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SUBTASK 8 MESO-MODEL EVALUATION (MR. WHEELER AND DR. MANOBIANCO)

In December 1998, Dr. Manobianco circulated a memorandum outlining five options for the meso-model task. All customers expressed an interest in option #5 that includes an evaluation of the Department of Forestry (DOF) MM5 model for the 1998 warm season and a 12-month evaluation of the Eastern Range Dispersion Assessment System (ERDAS) Regional Atmospheric Modeling System (RAMS). The options and issues relating to the meso-model task were discussed during the AMU mid-course tasking review on 8 January. Option #5 was approved by consensus during the mid-course review.

ERDAS RAMS Evaluation

Following the AMU mid-course review, ENSCO AMU and PET&S (Performance Evaluation, Test and Simulation) personnel drafted a plan for the ERDAS RAMS evaluation. On 4 February, ENSCO AMU and PET&S personnel met with 45th Weather Squadron (45 WS), 45th Range Safety (45 SE), and NASA KSC representatives to discuss ENSCO's proposed evaluation plan. The 45 WS specified that the evaluation should include a daily, "hands-on" assessment of the RAMS model. However, a subjective evaluation requires an additional 0.5 Full-Time Employee (FTE) and should be performed by a meteorologist preferably with forecasting experience. The additional labor (0.5 FTE) was not considered when the task was first scoped out. Furthermore, ENSCO PET&S does not have a meteorologist to perform the subjective evaluation.

Dr. Manobianco proposed two solutions to accomplish the subjective component of the RAMS evaluation using existing AMU resources. These options were discussed during an out-of-cycle AMU tasking review on 18 February. The first option was approved by consensus during the out-of-cycle review. Under this option, Mr. Wheeler will delay his work on the current Radar Atlas and Weather Reviews task to perform the subjective evaluation of the RAMS forecasts.

During March, Mr. Wheeler and Dr. Manobianco began writing the ERDAS RAMS evaluation protocol. The evaluation will consist of an objective and subjective component. Mr. Wheeler will perform the subjective component of the evaluation. The evaluation will verify RAMS forecasts of the onset and movement of the central Florida east coast sea breeze (ECSB), precipitation, and low-level temperature. The objective component will be performed by Mr. Allan Dianic (ENSCO, Inc.) on the PET&S contract. The objective evaluation will focus on gridded and point error statistics and the sensitivity of model forecasts to soil moisture, resolution, and other factors. A final draft of the evaluation protocol will be completed in early April and sent to all customers for review.

MM5 Evaluation

The main focus for this portion of the meso-model task is to compare and benchmark forecasts of the sea breeze and convective precipitation during the 1998 warm season from the DOF MM5 meso-model with those from NCEP's 32-km Eta model. Dr. Manobianco started processing GOES visible and infrared satellite data and hourly precipitation composites derived by NCEP using Office of Hydrology rain gauge and WSR-88D-derived rainfall. These data will be used to determine the occurrence of observed sea breezes and convective precipitation. Any additional progress on the MM5 meso-model evaluation task is delayed until Dr. Herbster (DOF representative) provides the archive of DOF MM5 and Eta model forecast gridded data.

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

A teleconference was held with all customers on 6 January to discuss the technical details of the Local Data Integration System (LDIS) extension task. The teleconference addressed issues relating to temporal continuity of analyses, configuration changes (if any) for this task extension, the proposed two-week simulation, and the determination of deficiencies and sensitivities of the analysis process. All customers agreed that little additional time should be spent on improving the temporal continuity of analyzed variables using blending, prognostic fields from models, etc. Instead, the AMU should identify the data types that cause observed discontinuities so users can recognize the influence of specific data types in LDIS. No modifications to the hardware and software configuration from subtask 7 were suggested. Instead, the AMU should evaluate the performance of LDIS on the existing hardware and extrapolate system performance to determine the hardware necessary to run LDIS in real-time.

Currently, SMG receives degraded level III WSR-88D products instead of the full-volume level II data. For this reason, it was decided that the AMU shall report on the impact of using level II versus level III radar data and the possible benefits of analyzing level III data from multiple WSR-88D sites. The AMU will perform the level II versus level III WSR-88D comparisons on case studies selected from the new data set.

Also addressed in the 6 January teleconference were the data archiving and selection strategies for the two-week data set. All real-time data were archived at SMG except Aeronautical Radio, Inc. (ARINC) Communications, Addressing, and Reporting System (ACARS) data (saved by the AMU) and WSR-88D level II data (saved by NWS MLB). Data were saved continuously until a sufficient two-week period was identified. Finally, it was decided in this teleconference that the AMU should report on the general reliability of LDIS and offer specific recommendations as to the derived meteorological products that would be most helpful to weather forecasters.

By 1 March, a sufficient two-week data set was identified and archived by SMG for the period from 15–28 February 1999. All data were received and uploaded to the AMU laboratory by the end of March except level II WSR-88D data for the first six days. These radar data have been ordered by NWS MLB from the National Climatology Data Center.

Another teleconference was held on 12 February to address data ingest strategies concerning data sources with large real-time lags, problems with the level III WSR-88D data at SMG as supplied by Kavouras, and archiving plans for the 2-week data window. In order to closely simulate a possible real-time configuration, it was decided that LDIS should be run on the two-week archive by initially withholding the data sources with large real-time lags (e.g. national network of rawinsondes, satellite soundings, and satellite-derived winds). The Cape Canaveral sounding (XMR) will be included in the real-time simulations since these rawinsonde data can be obtained much more promptly compared to the national rawinsonde network. In order to measure the impact of the excluded data sources that experience significant lag times, the AMU will identify case studies from the two-week window and re-run LDIS selectively for each withheld data source.

During much of February and March, Mr. Case modified existing converters for the following data types: surface METAR, ship, and buoy observations, 915-MHz and 50-MHz KSC/CCAS profiler, Pilot Reports (PIREPs), rawinsonde, satellite-derived winds, satellite soundings, KSC/CCAS tower, and WSR-88D level III data. All the above data types except WSR-88D level III data were adapted according to the McIDAS textual output of SMG's data. By the end of March, all data converters were operating sufficiently.

The level III WSR-88D data from Kavouras is received by SMG in an image format that cannot be converted to the ADAS analysis grids using the existing remapping code. Thus, Mr. Case developed/modified code to uncompress and convert the level III WSR-88D data to a format that is compatible with the ADAS ingestor. Several modifications to the ADAS software were required in order to remap WSR-88D level III data onto the ADAS analysis grid. With help from Mr. Tim Oram of SMG and Mr. Keith Brewster of the University of Oklahoma, the appropriate changes were implemented and tested during March. Mr. Case verified the functionality of the modified level III remapping algorithm by utilizing WSR-88D data from 28 February 1999 in which a line of thunderstorms accompanied by strong winds propagated through central Florida. Both the reflectivity and radial wind fields compared favorably to the level III image data and also closely resembled the level II remapped data which uses the original ADAS code. A formal assessment and comparison between level II and level III data will be included in the LDIS extension final report.

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

Dr. Merceret continued investigating the lifetime of upper-air wind features as a function of their size. He revised and resubmitted the manuscript on the vertical resolution of the KSC 50-MHz Doppler Radar Wind Profiler. The revised manuscript was accepted for publication as a note in the *Journal of Atmospheric and Oceanic*

Technology. He also published a NASA Technical Memorandum describing the effects of sensor separation on the measurement of peak wind speeds at Launch Complex 39.

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Acronym List

30 SW	30th Space Wing
30 WS	30th Weather Squadron
45 LG	45th Logistics Group
45 MXS	45th Maintenance Squadron
45 OG	45th Operations Group
45 SE	45th Range Safety
45 SW	45th Space Wing
45 WS	45th Weather Squadron
ACARS	Aeronautical Radio, Inc. (ARINC) Communications, Addressing and Reporting System
ADAS	ARPS Data Assimilation System
AFMC	Air Force Materiel Command
AFRL	Air Force Research Laboratory
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
CCAS	Cape Canaveral Air Station
CSR	Computer Science Raytheon
DOF	Department of Forestry
ECSB	East Coast Sea Breeze
ER	Eastern Range
ERDAS	Eastern Range Dispersion Assessment System
FSL	Forecast Systems Laboratory
FSU	Florida State University
FTE	Full-Time Employee
FY	Fiscal Year
GOES	Geostationary Orbiting Environmental Satellite
HYPACT	HYbrid Particle And Concentration Transport
I&M	Improvement and Modernization
JSC	Johnson Space Center
KSC	Kennedy Space Center
LAL	Lakeland
LDIS	Local Data Integration System
McIDAS	Man computer Interactive Data Access System
METAR	Aviation Routine Weather Report
MSFC	Marshall Space Flight Center
MVP	Model Validation Program
NASA	National Aeronautics and Space Administration

Acronym List

NCAR	National Center for Atmospheric Research
NCEP	National Center for Environment Prediction
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NWS MLB	National Weather Service Melbourne
OB	Outflow Boundary
PET&S	Performance Evaluation, Test & Simulation
PIREP	Pilot Report
PROWESS	Parallelized RAMS Operational Weather Simulation System
PSU	Penn State University
QC	Quality Control
RAMS	Regional Atmospheric Modeling System
REEDM	Rocket Exhaust Effluent Diffusion Model
RSA	Range Standardization and Automation
RUC	Rapid Update Cycle
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
USAF	United States Air Force
WSR-88D	Weather Surveillance Radar - 88 Doppler
WWW	World Wide Web
XMR	Cape Canaveral sounding identification

Appendix A

AMU Project Schedule 10 April 1999				
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	
	Equation Development	Feb 99	Jun 99	Delayed 2 months-problems collecting & processing data sets
	Tests with Independent Data	Apr 99	May 99	On Schedule
	Tests with Individual Cases	May 99	Jun 99	On Schedule
	Prepare Products, Final Report for Distribution	May 99	Jul 99	On Schedule
LDIS Extension	Optimize Temporal Continuity of Analyses	Oct 98	Dec 98	Completed
	Determine Configuration Changes Required for Simulated Real-time Runs	Nov 98	Feb 99	Completed - implementing the changes
	Simulate Real-time Runs	Feb 99	Apr 99	On Schedule
	Determine Deficiencies /Sensitivities of Simulated Real-time Runs	Apr 99	May 99	On Schedule
	Final Report	May 99	Jun 99	On Schedule
Meso-Model Evaluation	Recommend Models for Evaluation	Jul 98	Dec 98	Completed
	Perform MM5 Benchmark/Evaluation	Jan 99	Apr 99	Delayed until MM5 and Eta gridded data received from DOF representative
	Final MM5 Report	May 99	Jun 99	Delayed until MM5 and Eta gridded data received from DOF representative
	Develop ERDAS/RAMS Evaluation Protocol	Feb 99	Mar 99	Ready for internal review
	Perform ERDAS/RAMS Evaluation	Apr 99	Dec 99	On Schedule
	Final ERDAS/RAMS Report	Dec 99	Jan 00	On Schedule
Delta Explosion Analysis	Analyze Radar Imagery	Jun 97	Nov 97	Completed
	Run Models/Analyze Results	Jun 97	Jun 98	Completed

AMU Project Schedule 10 April 1999				
AMU Projects	Milestones	Actual / Projected Begin Date	Actual / Projected End Date	Notes/Status
	Final Report	Feb 98	Jan 99	Ready for external review in April
Delta Explosion Analysis (con't)	Launch site climatology plan	Apr 98	May 98	Completed
Model Validation Program	Inventory and Conduct RAMS runs for Sessions I, II, and III	Jul 97	Mar 99	Completed
	Run HYPACT for all MVP Releases	Aug 97	Feb 99	Completed
	Deliver Data to NOAA/ATDD	Oct 97	Apr 99	All data will be submitted in Apr
	Acquire Meteorological Data for Titan Launches	Jul 97	Apr 99	
Local Radar Atlas	Develop Atlas on Significant Local Radar Signatures	Jan 99	Mar 00	Postponed to perform subjective eval. of ERDAS RAMS
Weather Event Studies	As Tasked, Analyze Significant Weather Events	Jan 99	Jul 99	On Schedule