Applied Meteorology Unit (AMU)

Quarterly Update Report

Third Quarter FY-92

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1. Background

The AMU has been in operation since September 1991. The five tasks which were issued during the first three months of the contract are briefly stated for reference in the Attachment 1 to this report. A detailed description of the work planned for each task was contained in our first quarterly report and will not be repeated in this report. The progress being made in each task is discussed in section 2.

2. AMU Accomplishments During the Past Quarter

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

2.1. Task 001 Operation of the AMU (Dr. Warburton)

Purchase of IBM RISC 6000 Class Computer for the AMU (Ms. Schumann)

In April, the AMU began working closely with the Kennedy Space Center Procurement Office by providing product evaluation summaries first comparing the performance of the IBM RISC System/6000 model 560 with other high end workstations and then evaluating the features offered by several different data analysis/visualization software packages. The hardware comparison included each system's MIPS, MFLOPS, and SpecMarks rating, as well as its suitability for the AMU's needs. None of the other vendors could provide a single processor workstation which matched the performance of IBM's 560. Of those that came close, none were supported by the University of Wisconsin as McIDAS-X platforms.

The software comparison evaluated the features offered by SAS, S+, and PV-Wave. Of those three, SAS offered the most versatility by providing data base, statistical data analysis, and data visualization functionality.

After the PR was approved, the AMU continued to work closely with the NASA buyer helping him prepare the Intent to Purchase equipment which was published in the CBD in May. During this effort, more funds were made available to purchase an additional low-end workstation bringing the total workstation count to three, one high-end workstation for CPU intensive model evaluation, and two lower end workstations for data analysis. IBM was the only bidder for providing the equipment and the order was placed to them after the deadline for other bidders expired.

The equipment began arriving in the AMU in mid June and the last shipment arrived in early July. AMU personnel and ENSCO, Inc.'s systems expert, Mike Shannon, have been working with IBM's system administration experts in setting up the equipment for the AMU's use. The AMU's final configuration consists of three IBM RISC/6000 workstations, one 560 and 2 320Hs, all connected through ethernet and TCP/IP(see figure 5.1). The disk space on each workstation is accessible to each of the other workstation through NFS running over the ethernet. The workstations are also connected through ethernet and TCP/IP to the IBM PS/2 Model 80 running McIDAS. This will give the RISC 6000's the capability of accessing data on the McIDAS system via the pronto and the ethernet. Table 1 below describes the memory, disk space, and software configuration associated with each machine.

Included in the hardware purchase were a 10 page per minute laser printer, an 8 mm tape drive, and a 1/4 inch tape drive. All of the peripherals are accessible from all of the workstations via the ethernet. To facilitate handling data from meteorological data archive sources still utilizing 9-track tapes for data storage, the AMU has submitted a purchase request for a 9-track tape drive. Since many of the meteorological data archives still exist on 9-track tape, and in fact are still archived on 9-track tape, the AMU will benefit greatly from having access to a 9-track tape drive in house.

	IBM RISC System 6000 Model 560	IBM RISC System 6000 Model 320H (1)	IBM RISC System 6000 Model 320H (2)
Hard Disk Space	1.6 GBytes	800 MBytes	800 MBytes
Memory	124 MBytes	64 MBytes	64 MBytes
Software	AIX (IBM's UNIX) ANSI C compiler AIX-Windows (IBM's version of X-Windows) AIX FORTRAN Compiler NCAR Graphics	AIX ANSI C Compiler AIX-Windows AIX FORTRAN Compiler SAS Packages: BASE SAS, STAT, FSP, and INSIGHT	AIX ANSI C Compiler AIX-Windows AIX FORTRAN Compiler SAS Packages: BASE SAS, STAT, FSP, and INSIGHT

Table 1: System Configuration for the AMU RISC System 6000 Network.

Development of Forecaster Applications Using NGM Point Analysis (Mr. Wheeler)

The AMU has developed two utilities which allow the quick and easy display of several products using the NGM Point Analysis data sets. The first one sets up a display of seven graphic frames of data containing:

Relative Humidity	1000 - 400 mbs
Temperature	1000 - 400 mbs
Wind vectors with isotac overlay	1000 - 300 mbs
Isotacs	1000 - 300 mbs
Accumulated Precipitation	
Wind vectors with RH overlay	1000 - 400 mbs
Metrogram	

Program inputs consist of the site location (X68[XMR], JAX, TLH, PBI, EDW, or E28), the model run time, 00 or 12 GMT and the beginning graphic number. The program uses a total of 7 graphic frames.

The second program displays forecast skew-t diagrams using the NGM Point Analysis data for the site selected. Since the software needed for this display is only available on the CCFF Test system, CCFF forecasters may view this data on the AMU WideWord Workstation by pressing the Shift - F1. The defaults for the utility are to plot X68 skew-t diagrams starting at the plus 6 hour time from initialization (00 or 12 GMT) and then every three hours to 24 hours, using 6 graphic frames. The command line options allow the user to start at the zero point and plot a skew-t every hour using 48 graphic frames if requested. The display and looping of forecast skew-t diagrams can help forecasters visualize how the model dynamics are predicting the local stability and moisture to change over the next 48 hours.

STS 48 Case Study (Mr. Atchison)

The STS 48 Case Study covering the landing weather for STS 48 on 17-18 September 1992 was distributed in June. Additional copies are available from the AMU.

Development of Forecaster Displays of Wind Profiler Data (Dr. Warburton)

The AMU began exploring ideas for additional MIDDS displays using data from the KSC 50 MHz Doppler Radar Wind Profiler. Suggestions for displays were developed by Dr. Greg Forbes of Penn State University. As soon as the AMU receives feedback on the suggestions, it is hoped Dr. Forbes will assist in developing the necessary algorithms and in interpreting the displays. The potential products are divided into short term and long term development categories based on the difficulty of acquiring needed data and implementation of the product. Products listed under the short term list would not be too difficult to generate within the MIDDS test library; the major stumbling block for implementation at KSC will be certification.

Short Term Product Development:

- Display of velocity change profile, measured since the last rawinsonde or jimsphere launch. Display would show vector change, current profiler wind minus latest rawinsonde.

- Display of velocity difference profile, measured as vector departure from numerical guidance wind profile. Display would show vector difference, current profiler wind minus NGM, MRF, or local mesoscale model.

- Real-time hodograph program to display wind profile in hodograph form and also compute and display related products: helicity, geostrophic temperature advection profile, stability gradient profile, stability tendency profile.

- Generate operational display of approximate Richardson number profile using latest profiler winds with latest rawinsonde thermodynamic data or prognostic thermodynamic data.

Long Term Product Development:

- Use VAD scan data from WSR-88D at Melbourne to compute mean divergence in the area around Melbourne, and attempt to relate to development or dissipation of low and convective clouds.

- Use time-space conversion techniques with WSR-88D data and retrieve approximate 2-dimensional wind fields over/surrounding KSC when identifiable traveling weather features can be identified on radar.

Support to KSC Safety

The AMU provided data to the KSC STS Landing Visitor Protection Working Group. The five year database of surface observations was used to study the frequency of occurrence of winds in several sectors. Charts showing frequency of occurrence by hour and by month for each sector were provided to the group.

2.2. Task 002 Training (Dr. Warburton)

AMU personnel received a tour of STS facilities at KSC, including a visit to Pad 39B and a look at the wind sensors at the 275 foot level. During the tour, a visit was made to tower 313 and the VAB. Captain Mike Adams of the 45th Weather Squadron was our guide.

In May, AMU personnel were given a Cape Canaveral facilities orientation which included a meteorological rocket launch with Mr. Jan Zysko serving as Launch Director.

On 7 May, AMU personnel visited the Melbourne WSO for an orientation to AFOS and NEXRAD, including the NEXRAD archival capabilities. The meeting provided a great opportunity for exchange of ideas and while there, the AMU was able to pass on some insight into some of the more useful MIDDS commands.

In June, AMU personnel completed NASA Automated Information Systems (AIS) security training.

2.3. Task 003 Improvement of 90 Minute Landing Forecast (Dr. Taylor)

Sub Task 1: Two - Tenths Cloud Cover Study (Mr. Atchison)

The purpose of this task is to develop databases, analyses, and techniques leading to the improvement of the 90 minute forecasts for Space Transportation System (STS) landing facilities in the continental United States and elsewhere. This sub task addresses the two tenths cloud cover rule which is in effect for End Of Mission (EOM) STS landings at KSC. The rule states the following:

> *"For scattered cloud layers below 10,000 feet, cloud cover must be observed to be less than or equal to 0.2 at the de-orbit burn go/no-go decision time (approximately 90 minutes before landing time) ".*

Although this study was aimed at the shuttle landing rule stated above, its results could be applied to other STS operations such as Return To Launch Site (RTLS) or aid in further understanding of cloud conditions at KSC for launch support. This study also has direct implications for other operations where a climatological database is needed for cloud trend forecasts. The work performed thus far has consisted of developing a surface observation database for the X68 Shuttle Landing Facility (SLF) and during the past quarter a statistical analysis of this data with respect to the weather conditions associated with the two-tenths cloud cover rule at KSC was performed. The statistical analysis was included in a interim report on the two tenths cloud cover study which was distributed for review during June. A brief summary of this statistical analysis along with further work to be performed on the two-tenths cloud cover study will be discussed below.

Data used in the two-tenths analysis has been the hourly surface observations for the period 1986-90 from the Shuttle Landing Facility (X68). This data included standard meteorological parameters (e.g.,. temperature, pressure, wind speed, direction , etc.) along with cloud amounts in below 10,000 feet. These cloud amounts were determined from Forms 10a and 10b for hours in which there were no shuttle landing weather violations (i.e.., ceilings less than 10,000 feet, cross-wind greater than 10 kts, and precipitation observed at station) .

The first set of observations analyzed were the hourly surface observations (i.e., Climatology of the hourly data), which were in turn used as the T_0 conditions for studying the relationship between initial conditions and the weather conditions at T+1 and T+2 hours. These data were first examined as a whole and then categorized by each of the following:

- Individual month,

- Months grouped by season,
- Time of day (expressed in UTC), and
- Wind direction (Sectors were defined as: North : 339°- 023°, Northeast : 024°- 113°, Southeast : 114°- 158°, South : 159°- 203°, Southwest : 204°- 293°, Northwest : 294°-338°).

The trends in the percent occurrence of initial weather conditions reflect the well known trends in the weather patterns typical of Florida's East coast. The actual values of the percent occurrence within each of the categories, however, provide a climatological indication of the probability that landing conditions will be acceptable for a given time of day, season, or wind flow pattern.

Key results from these analyses are:

- Fall and winter have a weather violation occurrence percentage ranging from 30% to 40%, the highest within the seasonal categorization (Figure 3.1).
- The summer months have a weather violation occurrence percentage ranging from 15% to 20%, the lowest within the seasonal categorization (Figure 3.1).
- The highest percentage of weather violations (30%) occur around sunrise from about 1100 to 1300 UTC. After sunrise, the percent occurrence of weather violations drops to 20% to 25% for several hours (1300 to 1600 UTC) and peaks again in the early afternoon (1700 to 2100 UTC) at 25% to 30% (Figure 3.2).
- Southeast and South wind sectors have the lowest percent occurrence of weather violations at 15% (Figure 3.3).
- North and Northwest wind sectors have the greatest percent occurrence of weather violations at 25% - 30% (Figure 3.3).

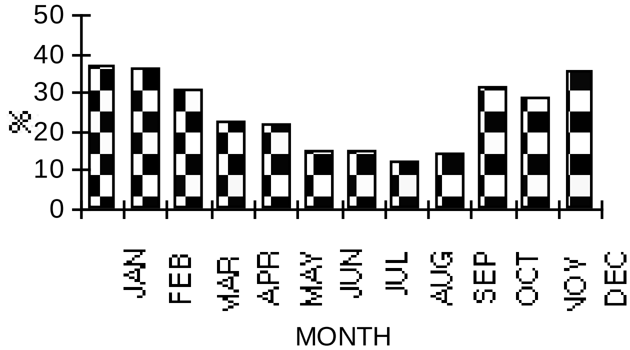


Figure 3.1. Percent Occurrence of Weather Violations by Month.

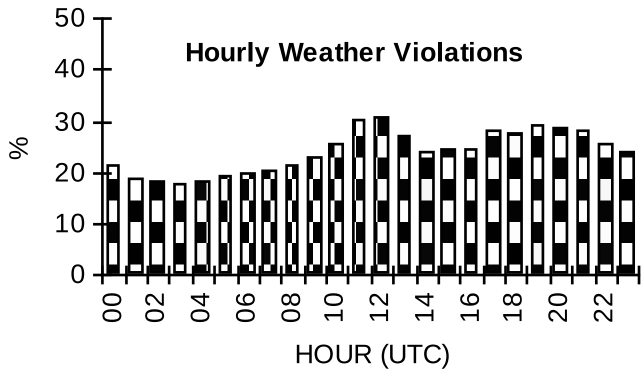


Figure 3.2 Percentage of Hourly Weather Violations.

The next step in the study was to analyze the observed conditions one and two hours (T+1 and T+2 hours) from a given initial weather condition. These data were analyzed for the same categorizations as for the initial weather conditions (i.e., all data, months, seasons, hours, and wind direction). Trends similar to those found for the hourly surface data as a whole are found in the observed conditions one and two hours (T+1 and T+2 hours) subsequent to a given initial condition.

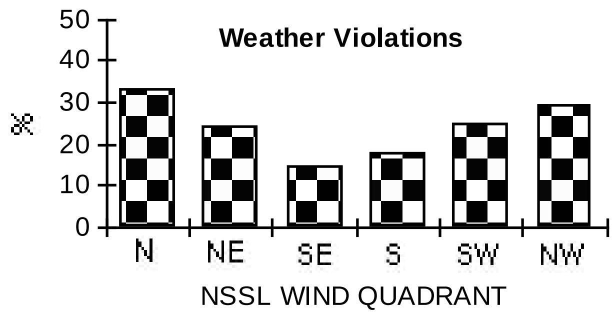


Figure 3.3 Percentage of Weather Violations by Wind Direction.

Key results from these analyses are:

- For initial cloud cover amounts of 0.0 to 0.3, there is at least a 75% to 80% chance of not having a weather violation one and two hours later (Figure 3.4).
- For initial cloud cover amounts of 0.1 through 0.5, the winter has the largest percent occurrence of weather violations, and the summer has the least one and two hours later.
- For initial cloud cover amounts of 0.1 through 0.5, the largest percent occurrence of weather violations one and two hours later occur from 1000 to 1300 UTC and the least from 2000 to 2300 UTC.
- For initial cloud cover amounts of 0.1 through 0.5, the highest percent occurrences of weather violations one and two hours later occur with a southwest (204°- 293°) wind.
- Given initial conditions of cloud cover amounts from 0.0 to 0.3, persistence of the initial condition is the dominating characteristic of the T+1 and T+2 weather conditions (Figure 3.4).

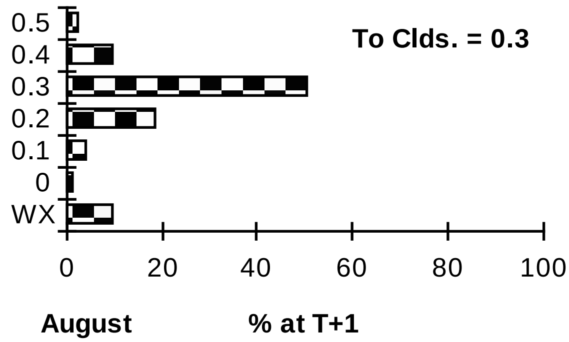


Figure 3.4 Percent occurrence of cloud and weather conditions at one hour after initial condition of 0.3 cloud cover.

The next component of the two-tenths cloud cover study focused on the comparison of the percent of observed weather violations subsequent (one and two hours later) to initial conditions of 0.2 and 0.3 cloud cover below 10,000 feet at X68. The sample statistics were computed in the following manner. For a given sample with initial conditions of 0.2 cloud cover, the number of weather violations and non-violations one and two hours subsequent to the initial observation were totaled. Then, a similar analysis was performed for initial conditions of 0.3 cloud cover and 2 ∞ 2 contingency tables were constructed. These data were then used to perform chi-square tests for homogeneity in the samples. The chi-square test for homogeneity was used to determine if the percent of weather violations subsequent to the two different initial conditions are the same.

The results of the homogeneity tests are important because they are indicative of the difference in the probabilities of a weather violation occurring at X68 subsequent to initial conditions of 0.2 and 0.3 cloud cover. If the homogeneity test indicates that the proportions of weather violations for the two samples are different, then the probability of a weather violation occurring at X68 subsequent to initial conditions of 0.2 cloud cover is different than the probability for initial conditions of 0.3 cloud cover. More importantly, if the homogeneity test indicates that the proportions of weather violations for the two samples are not different, then the probability of a weather violation occurring at X68 subsequent to initial conditions of 0.2 cloud cover is not different than the probability for initial conditions of 0.3 cloud cover. This result would suggest the 0.2 cloud cover might be overly conservative or inappropriate.

Key results from these analyses are:

- There is a significant difference in the proportions of weather violations one and two hours subsequent to initial conditions of 0.2 and 0.3 cloud cover for the majority of the data categorizations.

- The differences in the proportions of weather violations two hours subsequent to initial conditions of 0.2 and 0.3 cloud cover are not significant for the months October through December.

- The differences in the proportions of weather violations two hours subsequent to initial conditions of 0.2 and 0.3 cloud cover are not significant for the months of April and May.

- The differences in the proportions of weather violations one and two hours subsequent to initial conditions of 0.2 and 0.3 cloud cover are not significant during late morning (1500 and 1600 UTC).

Based on the results of this study thus far, there are three major sets of additional analyses which will be performed prior to the preparation and delivery of the final report in September 1992. These are:

- The first set of analyses involves re-examining the data after filtering the nighttime observations from the database. Since the accuracy of the cloud cover amounts during the night are suspect, this is a critical component of the investigation. It is possible the nighttime observations may be masking important relationships in the data or, conversely, may be responsible for false indications of significant relationships. This analysis will be performed only on the daytime data on a monthly basis.

- The second set of analysis will make use of CCAFS rawinsonde data to investigate the effect of lower atmosphere stability and wind flow patterns on the cloud cover amounts and weather violations at X68.

- Finally, the cloud cover data will be used to help develop climatological nomograms for use in cloud cover forecasting at KSC.

Since this type of cloud cover information has never been compiled for the shuttle landing facility, development of nomograms using this data should enhance the forecaster's knowledge in making cloud cover forecasts for EOM and RTLS at KSC. The climatology of the hourly data will give the SMG and CCFF forecasters as well as STS managers a good indication as to when is the best time of day, time of year and under what wind regimes to land the shuttle. In addition, nomograms developed from analysis of the observed weather conditions one and two hours from an initial condition will also aid the forecaster in understanding cloud cover trends for making 90-minute forecasts during various categorizations of the data (e.g., months, seasons, time of day, surface and upper-level winds).

In addition, future work involving the two-tenths cloud cover analysis could make use of Artificial Neural Network (ANN) software algorithms. These types of algorithms can be applied to forecasting by modeling the correlation between the future weather conditions and the previous and current weather conditions with a data association neural network. A proof of concept ANN could be developed to produce a probabilistic estimation of a constraint violation for the shuttle landing forecast. The shuttle landing forecast is an excellent test bed for ANN technology's application to meteorology in general. It involves assimilating large amounts of data and analyzing interactions between them These are key elements of any ANN application.

A prototype system would generate the probability of any type of landing constraint violation using single point forecasting information from station X68 as input. The data for training and testing the neural network is already available as a result of this study. The input data would consist of past and current surface conditions reported by X68 as well as past and current rawinsonde data. After initial prototype development, the neural network could be enhanced by including additional input data sources such as surface observations from surrounding stations and forecast grid data.

Sub Task 2: Fog and Status at KSC (Mr. Wheeler)

The AMU's direction for this sub task is develop a database of weather situations relating to marginal violations of the landing constraint. The AMU is also tasked to develop rules of thumb or forecast techniques.

During this quarter the AMU has completed documentation of the upper air and surface analysis for each of 38 selected fog cases. These analyses include weather for the day before and after each fog event. The analyses consist of synoptic features at 500, 700 and 850 mbs as well as upper air data and observations from X68, TIX, DAB, MCO, ORL, COF, VRB and AGR. Hourly surface charts were plotted using the observations from eight surrounding stations. These plots start the day before each event and continue until the fog or status has dissipated at X68. This added up to over 600 surface charts. Each case has been categorized and a brief summary developed for quick look reference. Data folders were developed for each case so that all the data (surface charts, skew-ts, upper air and surface analysis write up) can be easily viewed and analyzed.

Five years of XMR rawinsonde data were received from CSR in April. The data set had several gaps but the AMU was able to fill in most of the missing soundings with data available to ENSCO from another government contract. The rawinsonde data were then ingested into a database program developed using dBase IV. The AMU also acquired the local wind tower data for each fog day from CSR. The data were decoded and rewritten into an ASCII format using software developed by ENSCO during the Kennedy Atmospheric Boundary Layer Experiment (KABLE). Two programs were developed to allow the display and graphing of the skew-t and wind tower data sets. All of the skew-ts for each fog event have been plotted and most of the wind tower plots have been completed.

During the next month, the AMU plans to complete a detailed one page write up on each fog case using all of the generated data sets. These descriptions will key in on precursor parameters and elements common to each fog event and thus lead to the development of forecast rules of thumb. An example of the analyses being accomplished is given below.

January 20-22 1990 Case Study

At 1200 UTC on 20 January 1990, major synoptic features over the eastern United States included a low pressure system over northeast Nebraska with a trailing cold front south across Missouri, Western Tennessee, Mississippi, then extending southward into the Gulf of Mexico (see Figure 3.5). A warm front extended from this low across Kentucky to South Carolina and into the Atlantic. A weak high pressure ridge was located over northern Florida. This ridge was providing central and south Florida with a moist low-level southeasterly flow. At 500 and 700 mb the ridge was to the south of the Cape area which provided southwest flow at those levels. Over the northern sections of Florida the flow was from the south and southwest from the surface up to 500 mb. During the early morning hours on 20 January, temperatures and dew points were in the mid 60's over east-central Florida with fog being reported from Orlando to Daytona Beach and at many other areas of central and north Florida. During the afternoon of 20 January winds continued to be from the southeast at 8-15 kts with some gusts to 20 knots along the coast. Temperatures were near 80° along the coast to the mid-80s in the Orlando area with dew points remaining in the 60s.

During the afternoon of 20 January and early on 21 January the low-level surface ridge shifted to south Florida. As shown in Figure 3.6, at 1200 UTC on 21 January the surface ridge was located over south Florida with a cold front moving in the western panhandle of the state. Most areas of north and central Florida ahead of the cold front were experiencing a southwesterly low-level wind flow with widespread low stratus and fog conditions. Temperatures and dew points at this time were in the mid 60s.

Figure 3.6 Synoptic Conditions, 21 January 1992

During the early morning hours of 20 January, weather conditions varied considerably over the central sections of Florida. Between 0600 and 0900 UTC fog was forming from the Orlando area up to Daytona Beach. By 1200 UTC, some fog was reported at Titusville with visibility down to 4 miles. However, at the Shuttle Landing Facility (SLF) patchy ground fog was reported from 0700 to 1300 UTC but the visibility never dropped below 9 miles. In addition, areas to the south of KSC (i.e., Melbourne, Vero Beach, Patrick AFB, etc.) remained basically clear with no fog or low level stratus.

The low-level wind structure prevented fog formation at the SLF on 20 January. As shown by the CCAFS sounding at 1115 UTC (Figure 3.7), the low-level winds (1000 mb) were from the southeast at 15 knots. This southeast flow kept the lower boundary layer warmer with enough mixing to prevent fog formation near the coast from KSC southward. Sunrise temperatures at several of the coastal towers were in the upper 60s with winds 5-7 knots. To the west and north of the Cape, winds were weaker, allowing more substantial cooling and therefore, more fog formation. Both Daytona Beach and Orlando reported dense fog for several hours prior to and near sunrise. Winds at both of these sites were 2-3 knots with temperatures in the 60-65°F range.

Weather conditions were quite different at the SLF on 21 January. As the low-level surface ridge shifted southward the winds turned more to the south and eventually southwest and west. This change in wind flow is quite evident from the 1115 UTC CCAFS sounding (Figure 3.8). In addition, the low-level inversion on 21 January was approximately twice as strong as the 20 January inversion. On the 20th, the inversion was 20 mb deep with a +3°C increase in temperature from bottom to top while on the 21st, the inversion was 10 mbs deep with a +5°C increase in temperature. Fog on the 21st formed at Orlando at 0800 UTC, at Daytona Beach at 0830 UTC, and at the SLF at 0916 UTC. The low-level winds shifted from a SSW component to more westerly around 0900 UTC (see Figure 3.9). Simultaneously, temperatures dropped and the temperature-dew point spread decreased. This shift to a westerly wind allowed advection of cooler and more moist air from the mainland resulting in fog formation at the SLF. The westerly wind also may have allowed advection of thicker fog and stratus from the St. Johns River Valley.

Key Points (Precursors) for the Analysis of 20-22 January 1992:

- Low-level surface ridge shifts southward across Florida during 20-21 January 1990. This caused a shift in low-level winds at the SLF from SE on 20 January to SW on 21 January. This could have been detected by 3-hourly synoptic analysis of Florida surface observations.

- Fog occurred inland around Orlando and to the North at Daytona beach on 20 January. As the ridge shifted to the south of the SLF during the next 24 hours, it was apparent that a shift to more of an offshore westerly wind component could advect fog over the KSC area on 21 January.

- Fog formation on 21 January is related to a shift to westerly winds allowing the advection of cooler more moist air from the St. John's river basin. This westerly wind also helped advect fog and stratus from the mainland areas. The shift to westerly winds was apparent in the WINDS tower network.

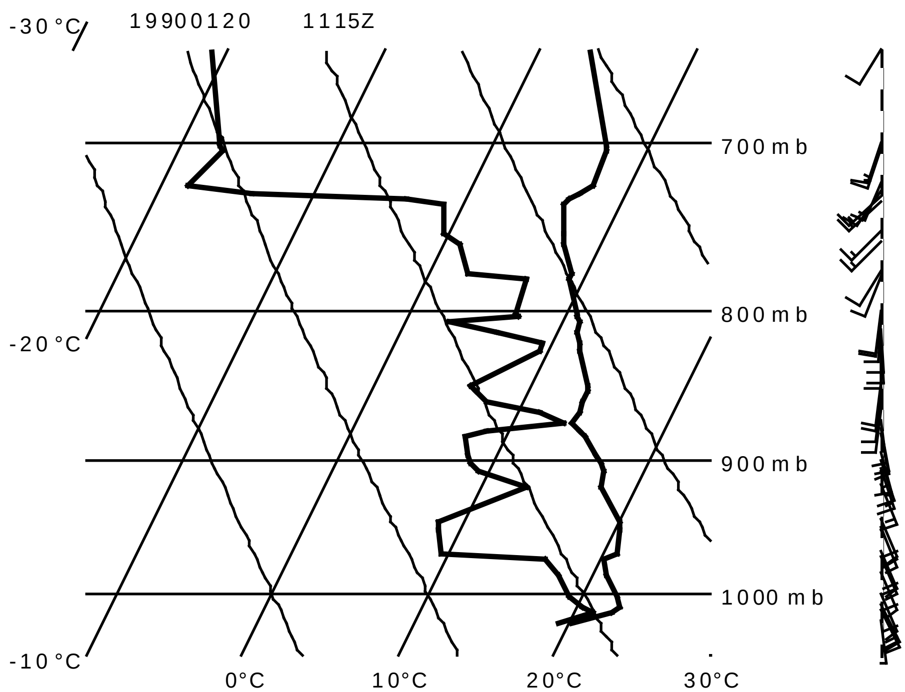


Figure 3.7. CCAFS sounding at 1115 UTC on 20 January 1990

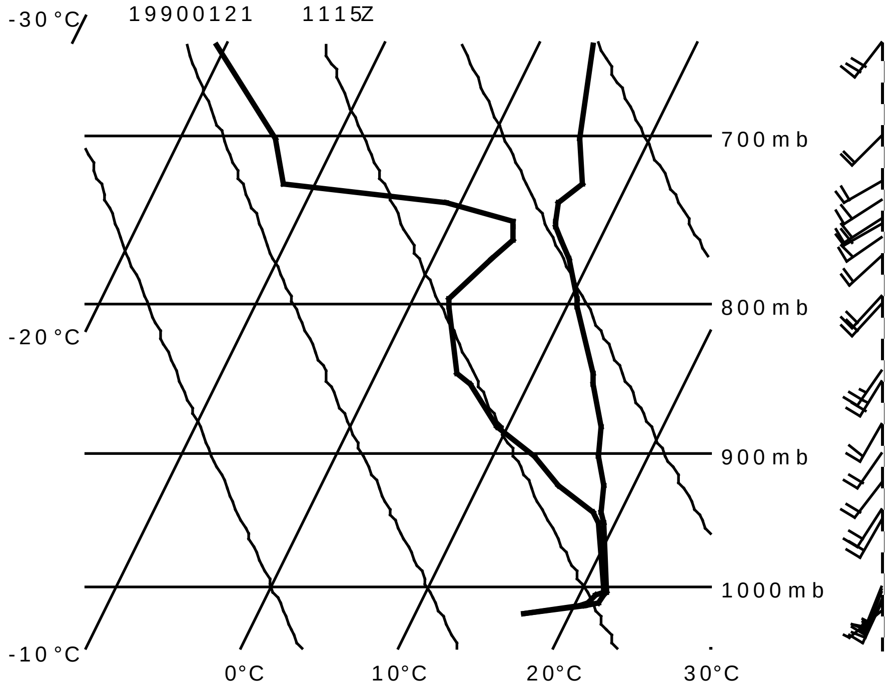


Figure 3.8 . CCAFS sounding at 1115 UTC on 21 January 1990

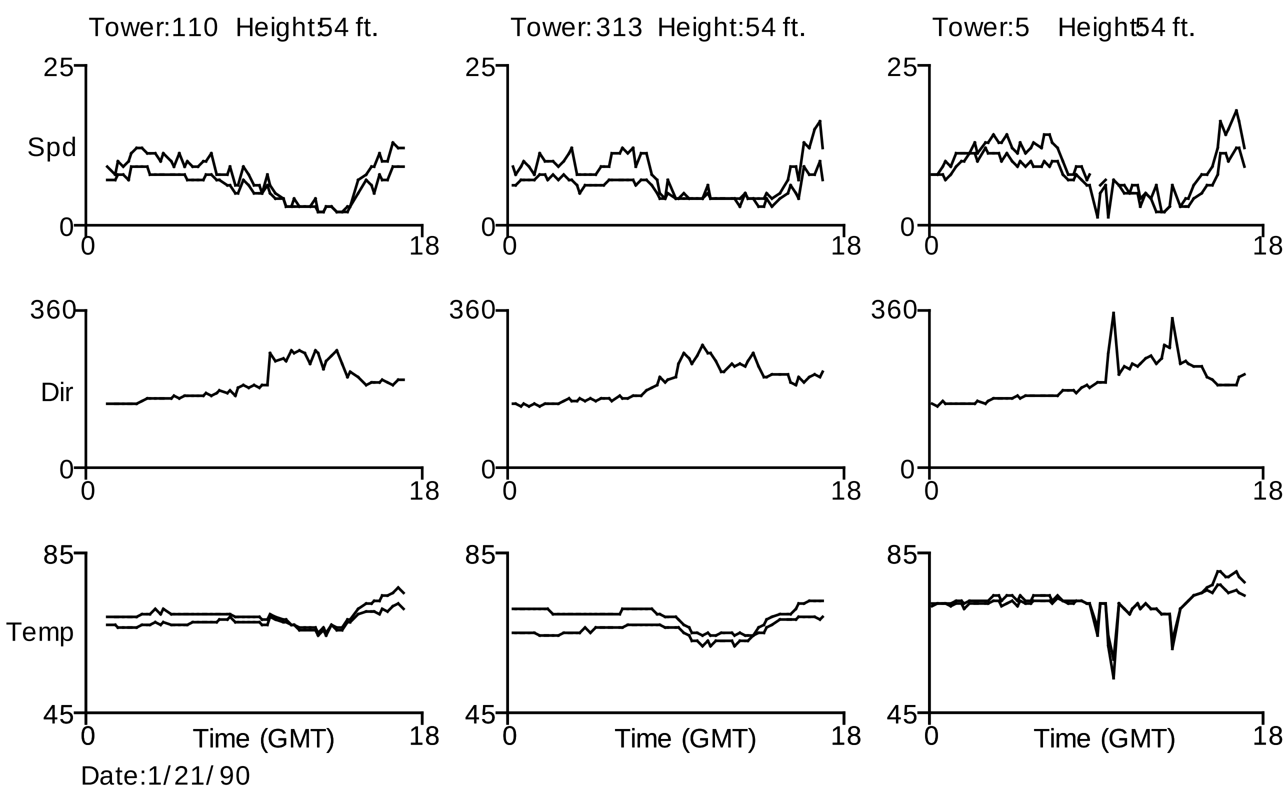


Figure 3.9 CCAFS Wind Tower Data for 00 - 18 UTC, 21 January 1990

2.4. Task 004 Instrumentation and Measurement (Dr. Taylor)

Implementation of MSFC DRWP Wind Algorithm

During the past quarter, considerable progress has been made on the integration of the new wind processing algorithm developed by MSFC into NASA's 50 MHz Doppler radar wind profiler (DRWP). The design for the wind velocity process which contains the new wind algorithm was completed and the code for the process was developed and tested.

One significant outcome of the design and coding phase of this task was the optimization of the MSFC code. The optimization resulted in an 83% reduction in the CPU time required to produce a velocity profile from the raw spectral data and is key to the successful implementation of the new wind algorithm. Initial performance testing of the wind velocity process indicates it will require approximately one minute of CPU time on the Post Data Handler computer of the DRWP to process one set of spectral data from the radar's three beams and output a velocity profile. Without the code optimization, this processing would require approximately six minutes of CPU time which is far too much to support update requirements being imposed on the DRWP.

Another major component of MSFC's new wind algorithm is the interactive quality control display. This display provides the analyst a view of the magnitude of the raw spectral data overlaid with the resulting velocity profile. By examining this display, the analyst can determine if the algorithm is correctly tracking the atmospheric radar return. If the algorithm is not, the analyst can then modify the first guess velocity profile so the algorithm will track the atmospheric signal.

The interactive quality control display is, like the wind processing algorithm, very computer intensive. For each velocity profile update the MSFC display requires the computation of more than one quarter million base 10 logarithms and then maps more than one quarter million data points to the screen. To facilitate use of this display in an operational setting, AMU personnel have attempted to optimize the performance of the display while preserving the salient features of the display. To date, all base 10 logarithm calculations have been removed from the processing and the number of points mapped to the screen has been reduced to an average of less than 10,000.

Progress has also been made on the design and code of the modifications to the Spectral Archive Process on the Post Data Handler. Currently, the Spectral Archive Process ingests the raw spectral data from the Real-Time Processor and outputs the data to tape. To support the new wind processing algorithm, the process is being modified to run continuously and to output the data to a global common. User action required to output the data to tape will remain unchanged. Based on progress to date, the coding and testing of these modifications on the development system should be completed by mid July.

DRWP Profile Analysis

As part of our testing procedures, AMU personnel compared DRWP profiles produced using the optimized AMU code to profiles produced using the MSFC code. Initial comparisons indicated differences between the profiles produced by the MSFC code and those produced by the AMU code. After some investigation, it was determined the differences resulted from an error in the computation of the temporal median filter in the MSFC code. Figures 4.1, 4.2, and 4.3 show an example of the differences in the east and north beams and the combined vector differences between two profiles. The first profile was produced by code with the correct temporal median filter and the second was produced using code with the incorrect temporal median filter.

As the figures indicate almost all of the differences are less than 1 m/sec. However, the mean vector difference is 0.29 m/sec and for a large number of range gates the difference exceeds 0.5 m/sec. This indicates the current implementation of the new wind algorithm is sensitive to the filtering of the raw spectra. Since it is desirable to reduce the sensitivity of the new algorithm, both AMU and MSFC personnel have begun analyzing data to enhance our understanding of the performance of the new algorithm. This knowledge will then be used to set the parameters within the new technique to reduce the sensitivity of the algorithm and improve the quality of the resulting profile. The following paragraphs present initial analyses performed by AMU personnel in support of this effort.

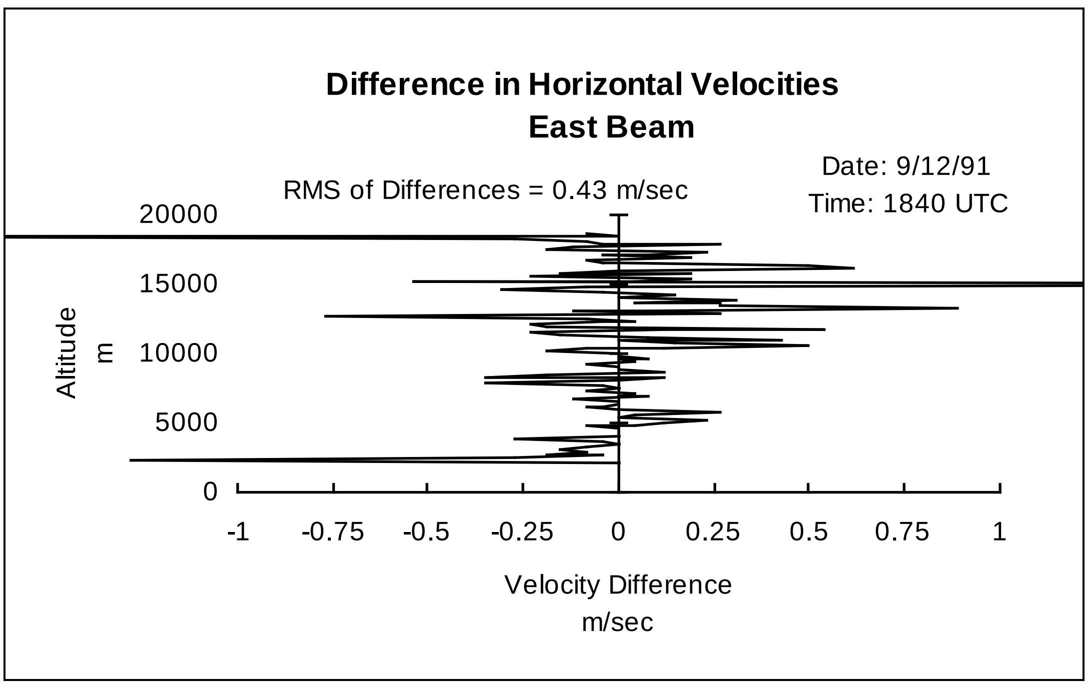


Figure 4.1. Differences in the east beam velocity between profiles produced using the correct median filter and the incorrect median filter.

The three differences which exceeded 1 m/sec were all from the east beam and were at altitudes 2309 m, 14,909 m and 18,359 m (see Table 4.1). The difference at the 18,359 m level was due to a weak signal at that level. In the current implementation, if the S/N ratio is less than -15 dB, the first guess velocity is propagated. For this particular level, the correctly filtered data resulted in a S/N ratio of -14.8 dB, just sufficient to return a velocity estimate. However, the S/N ratio from the incorrectly filtered data was -15.2 dB; consequently, the first guess velocity was propagated resulting in a large velocity difference between the two profiles.

The difference at the 14,909 m level is related to the difficulty in estimating wind speed near the zero Doppler shift. The correctly filtered and the incorrectly filtered spectra for the east beam (i.e., 135° beam) are presented in Figure 4. The large differences between the two spectra near the zero Doppler shift are immediately apparent. These differences are the result of two processes. First, the difference in spectral values at bin -2 is the result of the incorrect median filter calculation. This difference is then exacerbated by the logarithmic interpolation about the zero Doppler shift to remove ground clutter. This interpolation is based on the spectral values at bin numbers -2 and 2. The median filter error plus the ground clutter removal process results in four key bin numbers having very different spectral values. The resulting velocity estimate using the correctly filtered spectra is shifted to the negative side (i.e., positive velocity) of the zero Doppler shift while the velocity estimate using the incorrectly filtered spectra is shifted to the positive side (i.e., negative velocity) of the zero Doppler shift.

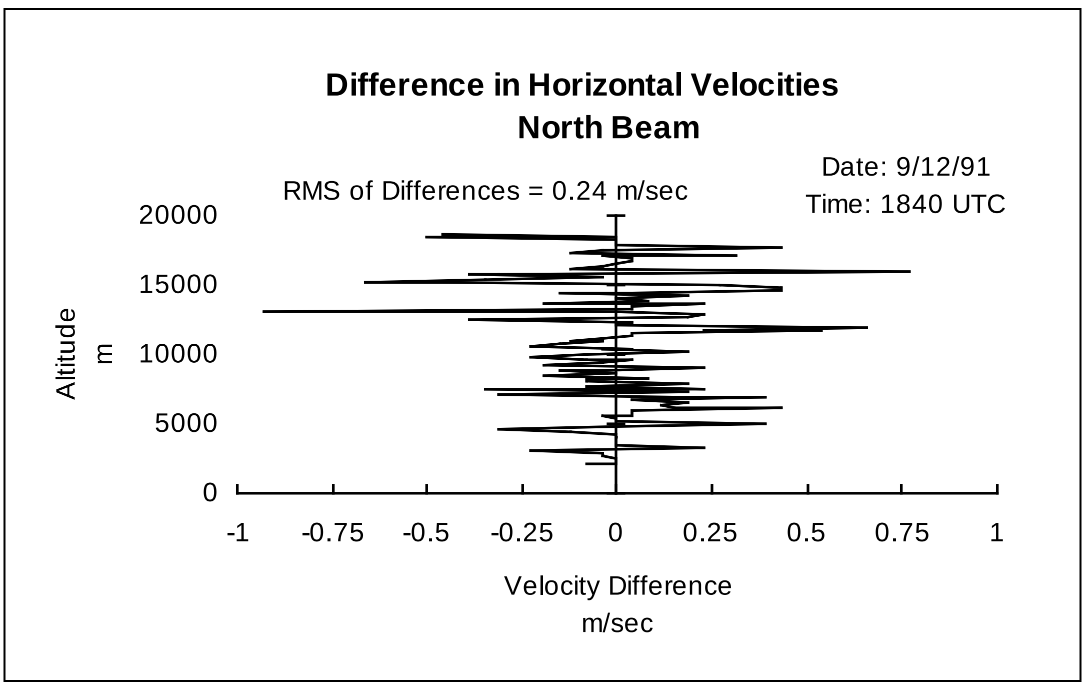


Figure 4.2. Differences in the north beam velocity between profiles produced using the correct median filter and the incorrect median filter.

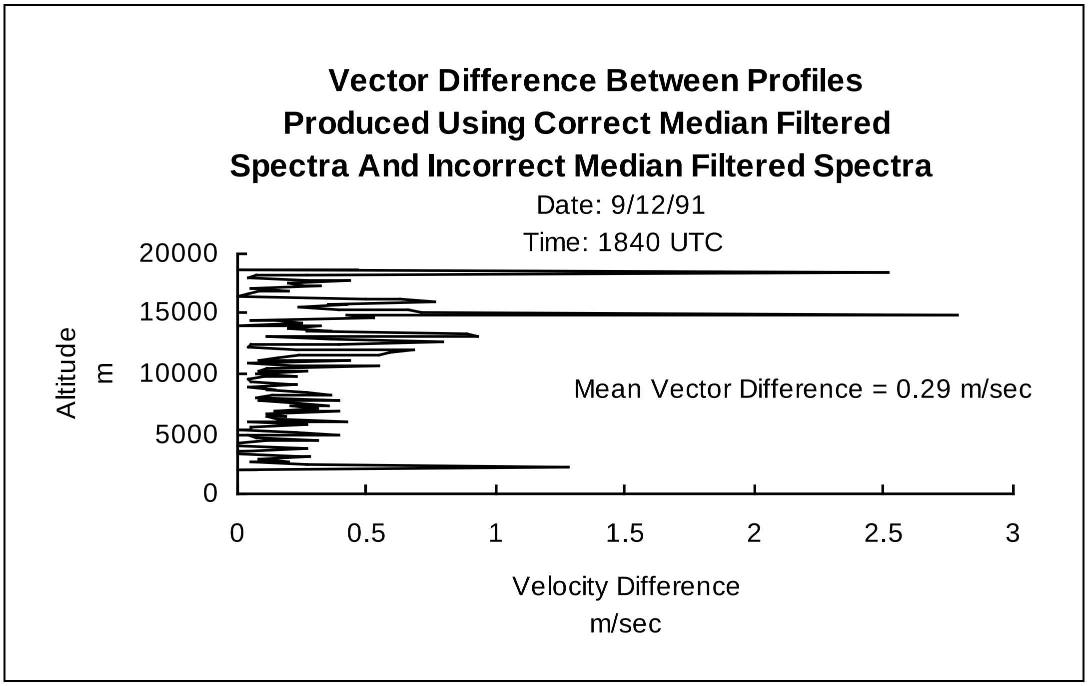


Figure 4.3. Differences in the velocity between profiles produced using the correct median filter and the incorrect median filter.

The large difference at the 2309 m level has not been investigated. However, since the east beam velocity at this level is low (e.g., ~ 1 m/sec), the large difference at the 2309 m level is likely due to the integration about the zero Doppler shift and the known problem with “ringing” in the lower gates.

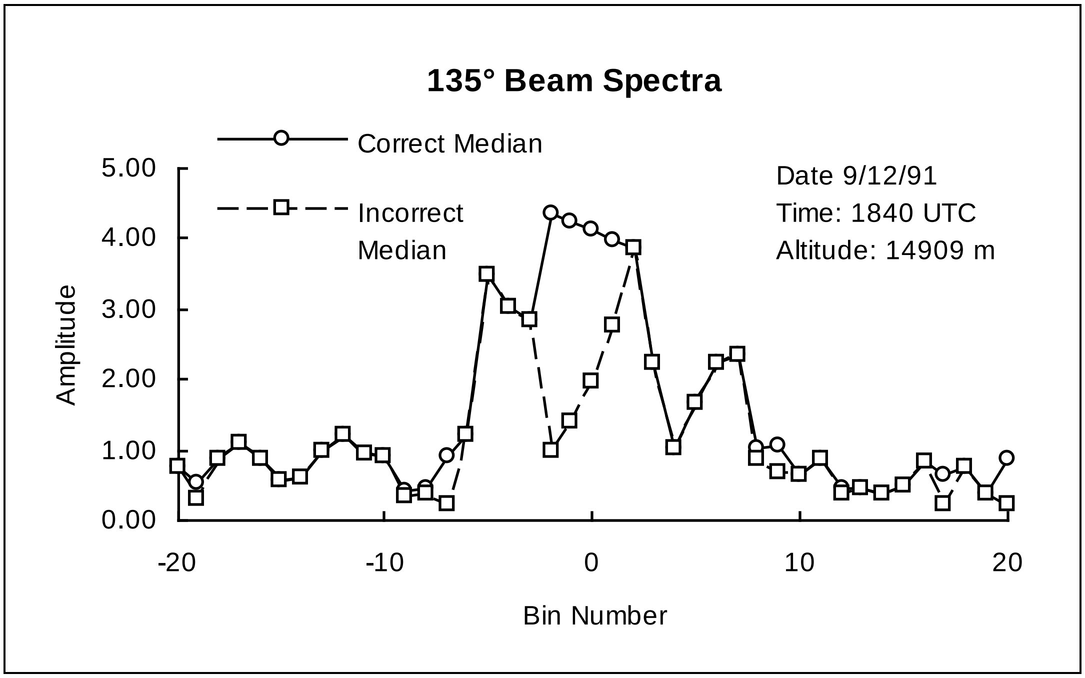


Figure 4.4. Correctly and incorrectly filtered spectra for the 135° beam for the 14,909 m level.

The largest difference in the north beam profiles, 0.93 m/sec, occurred at the 13,109 m level. This particular level is in the core of the jet stream and has a low S/N ratio (see Table 1) which, as noted by MSFC personnel, is typical of the core of jet streams. The correctly filtered and the incorrectly filtered spectra for the north beam (i.e., 45° beam) for this level are presented in Figure 4.5. In this case, although the S/N ratios are low, the primary reason for the difference in velocity estimates is the significant difference between the two filtered spectra. It is also important to note the S/N ratio resulting from the correctly filtered spectra is 2 dB higher than the S/N ratio resulting from the incorrectly filtered spectra.

The cases presented thus far were characterized by relatively large velocity differences between the two profiles. It is also important to examine cases which are more typical of the mean vector difference between the two profiles. The case selected for this analysis is the north beam at the 6059 m level. This case is characterized by large S/N ratios (see Table 4.1) and a north beam velocity difference between the two profiles of 0.43 m/sec.

The correctly filtered and the incorrectly filtered spectra for the north beam (i.e., 45° beam) for this level are presented in Figure 4.6. Although the peaks in the spectra do not appear significantly different, the amplitude scale for this chart is logarithmic and the peak in the correctly filtered spectra is actually 3 times larger than the corresponding peak in the incorrectly filtered data. In this case, the difference in velocity estimates is attributed to the difference between the two filtered spectra.

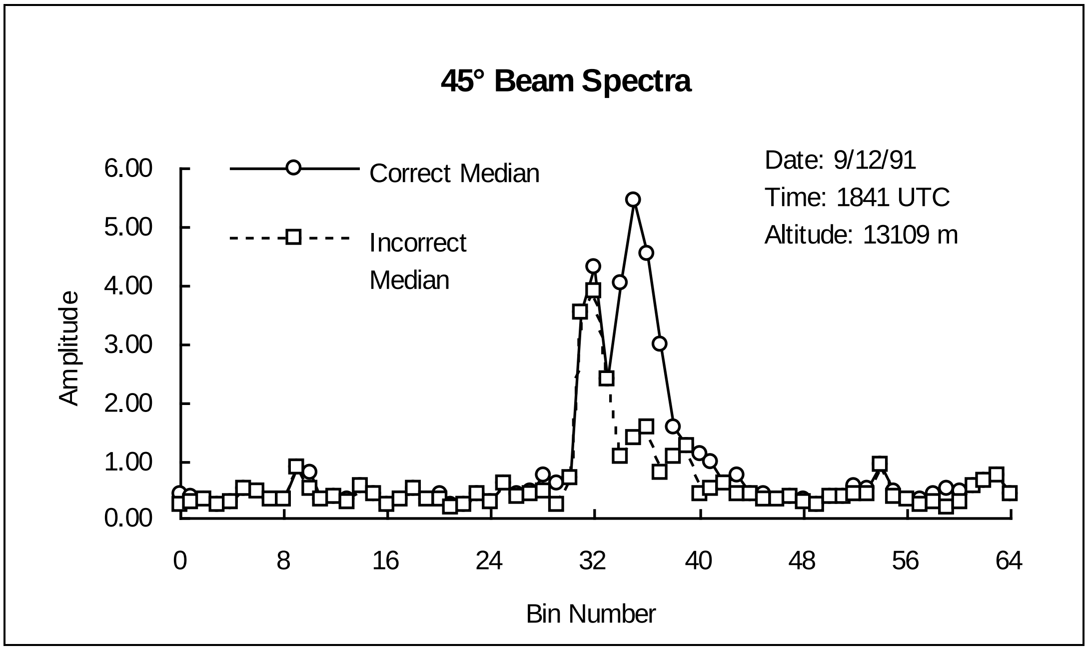


Figure 4.5. Correctly and incorrectly filtered spectra for the 45° beam for the 13,109 m level.

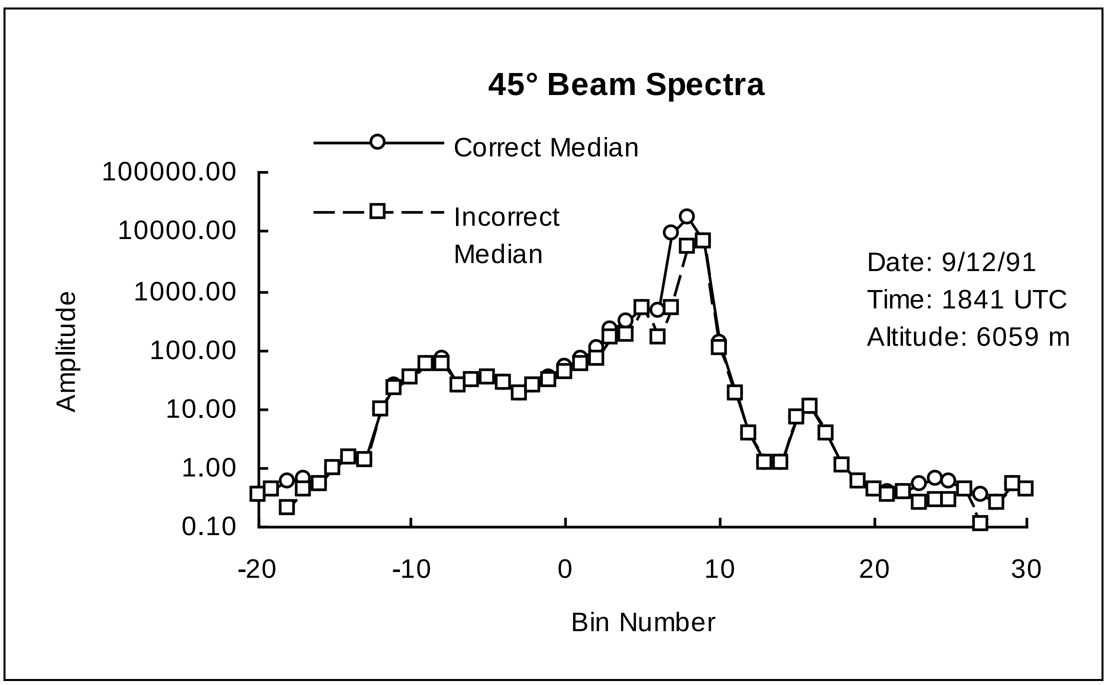


Figure 4.6. Correctly and incorrectly filtered spectra for the 45° beam for the 6059 m level.

Table 4.1
Comparison of Results Using Correct and Incorrect Median Filter
Based on 10 Point Integration Window Width

Altitude m	Correct Median Filter				Incorrect Median Filter			
	135° Beam		45° Beam		135° Beam		45° Beam	
	Velocity m/sec	S/N Ratio dB	Velocity m/sec	S/N Ratio dB	Velocity m/sec	S/N Ratio dB	Velocity m/sec	S/N Ratio dB
2309	-1.08	26.5	-1.28	21.7	0.19	22.3	-1.28	24.0
6059	-0.54	10.6	-6.99	24.9	-0.46	11.2	-7.42	21.9
13109	-2.43	-6.6	-30.95	-6.3	-2.51	-6.6	-30.02	-8.2
14909	0.93	-8.3	-11.24	0.8	-1.85	-9.3	-11.51	0.8
18359	-7.11	-14.8	1.35	-12.4	-4.64	-15.2*	1.85	-12.4
RMS of Velocities Differences			135° Beam	0.43		45° Beam	0.24	
Mean of Vector Differences			0.29					

* Since S/N Ratio was less than -15 dB, the first guess velocity was propagated. This accounts for the large velocity difference in the 135° beam.

Initial efforts to reduce the sensitivity of the wind processing algorithm focused on adjusting the integration window width. This modification was suggested by MSFC personnel. The results presented in the first 6 figures and in Table 4.1 are based on using an integration window width of 10 spectral bins. Table 4.2 presents data from the two velocity profiles generated from the same spectral data used to produce the profiles presented in Table 4.1. The only difference in the processing is the integration window width used to produce the profiles in Table 4.2 is 20 spectral bins whereas the integration window width used to produce the profiles presented in Table 1 is 10 spectral bins.

The modification to the integration window width made a substantial reduction in the RMS velocity differences in the east beam, but did not substantially reduce the RMS velocity differences in the north beam or the mean of the vector differences. The reduction in the east beam RMS velocity difference is attributed primarily to the reduction in the large velocity differences at 14,909 and 18,359 m levels. Increasing the integration window width stabilized the integration about the zero Doppler shift at the 14,909 m level resulting a substantial reduction in the velocity difference at that level (see Table 4.2). In addition, the increased integration window width improved the S/N ratio of the east beam at the 18,359 m level so the first guess velocity was not propagated in the profile developed from the incorrectly filtered spectra. This substantially reduced the difference in the east beam velocities at the 18,359 m level.

Table 4.2
Comparison of Results Using Correct and Incorrect Median Filter
Based on 20 Point Integration Window Width

	Correct Median Filter				Incorrect Median Filter			
	135° Beam		45° Beam		135° Beam		45° Beam	
Altitude m	Velocity m/sec	S/N Ratio dB	Velocity m/sec	S/N Ratio dB	Velocity m/sec	S/N Ratio dB	Velocity m/sec	S/N Ratio dB
2309	-1.08	26.5	-1.28	21.7	0.19	22.3	-1.28	24.0
6059	-0.54	10.7	-6.99	24.9	-0.46	11.3	-7.34	22.0
13109	-1.82	-6.1	-31.30	-6.1	-1.93	-6.1	-30.33	-8.1
14909	-0.08	-7.5	-11.24	0.8	-0.58	-7.8	-11.51	0.8
18359	-8.08	-14.0	1.35	-12.4	-8.46	-12.7	1.85	-12.4
RMS of Velocities Differences			135° Beam 0.24			45° Beam 0.23		
Mean of Vector Differences			0.25					

Increasing the integration window width did not reduce the velocity difference in the east beam at the 2309 m level. This is because the S/N ratio is high (see Table 4.1 and 4.2). In this case, increasing the integration window width did not affect the resultant velocity because no additional spectral bins met the criteria for inclusion in the integration. Consequently, the resultant velocities did not change.

Increasing the integration window width did not substantially reduce the velocity differences in the north beam at the 6059 and 13,109 m levels. In both cases, increasing the window width resulted in small changes in the output north beam velocities (exception - the north beam velocity at the 6059 m level produced from correctly filtered data did not change). The velocity changes at these two levels did not, however, result in substantial changes in the velocity differences.

The results indicate increasing the integration window width does reduce the new wind algorithm's sensitivity to changes in the input spectra data when the S/N ratio is very low and, in some cases, when integrating about the zero Doppler shift. Additional analyses will be performed to further our understanding of the performance of the new wind algorithm and to establish optimum values for the algorithm's parameters.

2.5. Task 005 Mesoscale Modeling (Dr. Warburton)

During this quarter, the AMU has continued preparing for the installation of modeling capabilities in the AMU. The installation of a network of 3 RISC 6000 workstations in the AMU facility has made mesoscale analysis and forecasting feasible in the near term.

The Figure 5.1 shows the systems and connectivity available in the AMU for modeling. Data will be received from the MIDDS mainframe through a MIDDS ProNet connection to the PS/2 Model 80 McIDAS PC Workstation in the AMU. Schedules can be established within the PS/2 to retrieve local observations as well as MIDDS gridded fields and satellite imagery. These data will be temporarily stored on the PS/2 hard drive. Since the PS/2 is connected to the RISC 6000 systems via ethernet, the NFS file system on the RISC 6000 systems will allow any of the workstations to mount the PS/2 drive for retrieval of MIDDS files. In that sense, the PS/2 will act as a file server for the three RISC 6000 systems. The Model 560 will be used for analysis and forecasting models while the two Model 320h workstations will handle output display and data analysis activities.

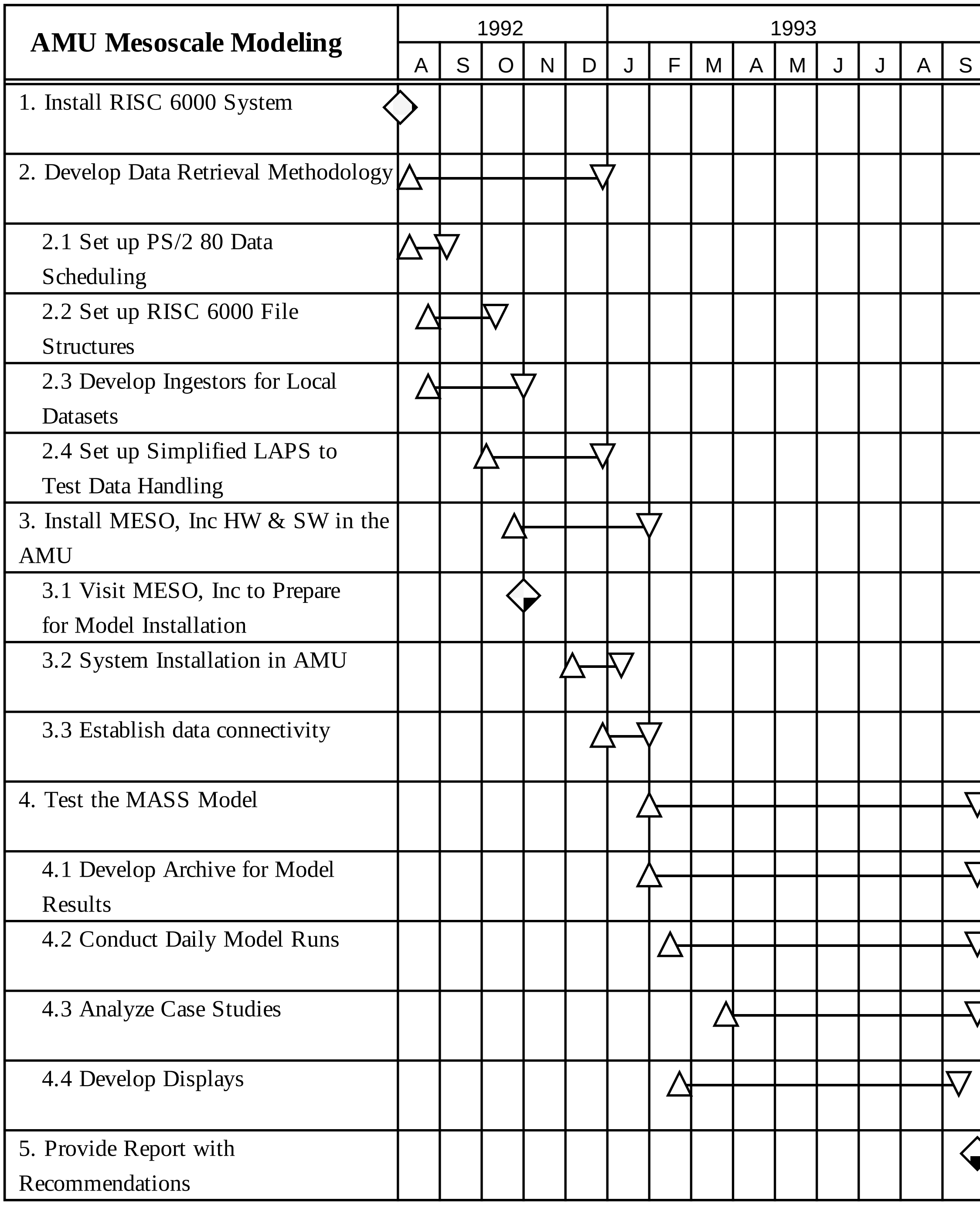
With the computer acquisition nearly complete, a realistic schedule has been completed for implementation of an analysis and forecasting system in the AMU. The schedule is dependent on the delivery of the MASS model and analysis system by MESO, Inc. in December of 1992. As shown in the schedule, there are five major tasks which must be accomplished:

1. Install RISC 6000 system. In addition to setup of the equipment, software must be installed, the network established and user accounts set up. This work should be completed by 1 August.

2. Develop Data Retrieval Methodology. In order for any model or analysis software to function, the system must be able to access all the local observations as well as NMC analyses and models.

   2.1. Set up PS/2 80 Data Scheduling. By using the scheduling feature of McIDAS, any data available within the local MIDDS can be moved to the PS/2 disk. We will create schedule entries which will move the required data at the appropriate time but spaced out so as not to cause undue loading on the back-up MIDDS 4381 system. Since the ProNet operates at 10 Mb per second, we do not anticipate any problems in this regard.

   2.2 Set up RISC 6000 File Structures. Data structures and files will be established on the IBM 560 to store the local datasets for access by the models.



2.3 Develop Ingestors for Local Datasets. Software will be written to open and unpack the MIDDS files for use by the models.

2.4 Set up Simplified LAPS Analysis to Test Data Handling. LAPS software received from NOAA/ERL will be used to analyze the local data and produce displays. This version of

LAPS will only use conventional data. Introduction of NEXRAD into the analysis will be attempted in the future.

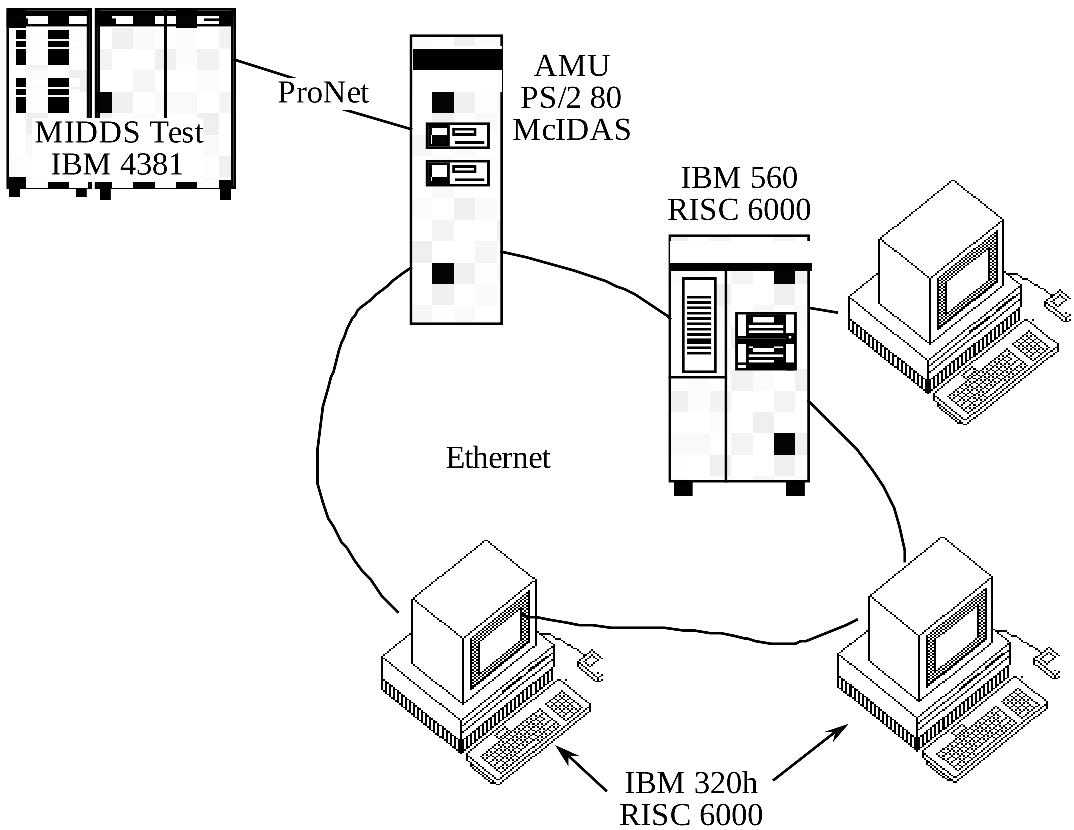


Figure 5.1 AMU Network

3. Install MESO, Inc. Hardware and Software in the AMU. At the completion of their SBIR contract, MESO, Inc. will deliver software and a Stardent 3000 workstation. This system is planned to be installed in the AMU for testing.

   3.1 Visit MESO, Inc. to prepare for model system installation. A 2-3 day visit to MESO, Inc. will allow the AMU to fully understand the data requirements for the system to be delivered by MESO, Inc.

   3.2 Install the Hardware and Software. This should be a fairly simple installation. The system is UNIX based and should easily connect into the AMU ethernet. The software will be loaded and tested. The AMU network with the MESO, Inc. hardware installed will appear as shown in Figure 5.2.

3.3 Establish Data Connectivity. Based on the earlier visit to MESO, Inc. and the work to move data from MIDDS, the AMU will need to provide links to the proper data sets for model initialization.

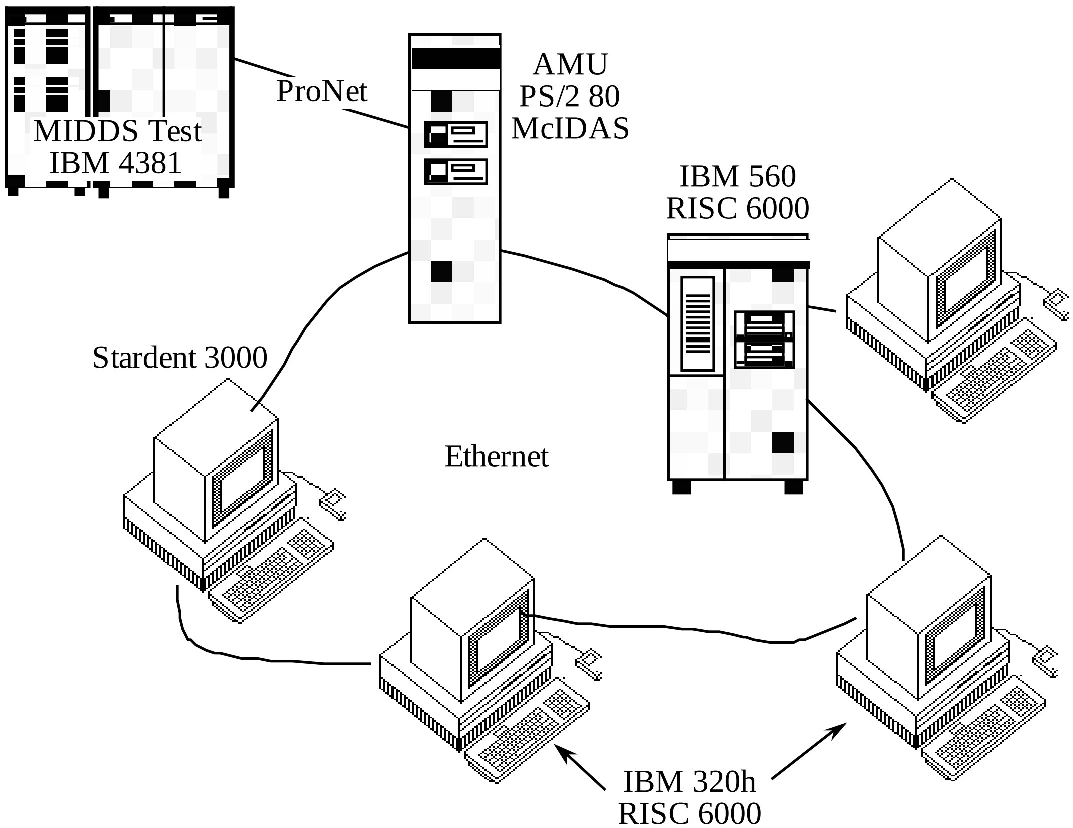


Figure 5.2 AMU Network with MESO, Inc. Equipment Included

4. Test the MASS Model, Analysis and Forecasts. The model will have been run by MESO, Inc. on over 100 cases. The AMU will continue with model testing through most of the warm months of CY93.

    4.1 Develop Archive for Model Results. One feature of the MESO, Inc. system is in addition to normal predictive fields produced by the model, weather parameters are produced using Model Output Statistics (MOS) methods. In order for the MOS forecasts to be meaningful, the model will need to be run over a long period of time so a climatology can be established.

    4.2 Conduct Daily Model Runs. The model will be set up for real-time execution. Once this is established, it will continue well into the future.

4.3 Analyze Case Studies. Interesting case studies will be evaluated. The emphasis will be on understanding model performance in different weather regimes; however, one aspect of this analysis could be to work with both SMG and CCFF forecasters after launch and landing operations at the Cape to examine how access to the model results during the operation may have influenced forecasting decisions (both pro and con).

4.4 Develop Displays. As the model is used in daily discussions by the AMU and the forecasters as described in 4.3, there will be interest in improving displays or adding additional displays.

5. Provide Report with Recommendations. Once approximately 7 months of experience has been gained, the AMU will generate a report with results to data and recommendations on the future of the model.

The US Army Atmospheric Sciences Laboratory hosted a mesoscale modeling workshop in El Paso, Texas on 16-18 June 1992. Several things were learned at this meeting which will be useful in the implementation of the MASS model in the AMU. The important points learned at the meeting are given below.

- Little is understood about modeling/parameterizing cloud physics, cumulus, and precipitation events in the 1 to 10 km grid spacing regime. Modelers agreed that these events which are subgrid scale processes in >10 km models are fairly well understood. No one is particularly comfortable in handling these processes in the 1 to 10 km range which is really a transition zone between regional models and cloud models.

- Soil moisture values at the initial time and how soil moisture is handled in mesoscale models is crucial to quality forecasting. The NCAR/PSU and RAMS models are very sensitive to soil moisture values. This is a common problem and is also an issue which is receiving a lot of attention by MESO, Inc. Observations of soil moisture are generally inadequate. One of the best hopes appears to be to derive soil moisture from NEXRAD precipitation data by combining this knowledge of rainfall with known information about soil types and vegetation.

- The use of 3rd order closure models in handling the boundary layer subgrid turbulent fluxes in models with 10 km resolution or greater is probably over-kill. Research by Dr. Paul Mason of the Meteorological Office has demonstrated that 2nd order models are adequate for 10 km resolution models and take at least an order of magnitude less computing time.

- The preferred method of initialization is data assimilation with Newtonian Relaxation or “nudging” used to bring the model into line with observed data. When normal mode initialization is used in a mesoscale model, critical divergence modes and vertical heating profiles are altered. Although normal mode initialization will allow the model to start up in a stable mode, the model may lose some important aspects of reality in the process. The forecast system used by MESO, Inc. in the MASS model is initialized through a 4-D data assimilation process which uses “nudging.” The RAMS model is initialized by interpolation from a 3-D isentropic analysis. Therefore, it is probable RAMS will require 6 to 12 hours of forecast time for spin-up before useful forecasts are produced. In contrast, the dynamic initialization used in the MESO, Inc. system means the model is already spun up at the start of the forecast period and should tend to produce more meaningful forecasts during the early period of the forecast.

- The AMU’s understanding was CSU was developing an advanced version of the RAMS to be known as ARAMS. In a conversation with Dr. Robert Walko, a colleague of Dr. Pielke, he stated that CSU has abandoned that idea. There will be one RAMS model which will continue to evolve.

- There appears to be little difference between the MASS, RAMS, and NCAR/PSU models other than initialization procedures. From all that was presented, one can conclude that the analysis/model system being delivered to NASA is state of the art.

- Most of the attendees at the conference agreed it takes several years to tailor a model to a specific area like Florida. By the time the MASS model is delivered by MESO, Inc., nearly four man-years of effort will have been expended to accomplish this tailoring.

3. Project Summary

Most of the short range (first year) and long range (first three years) goals expressed in the AMU’s last quarterly report are unchanged. A good course has been charted for the first year and the AMU is continuing on that course.

3.1. Short Range

- To complete the study and deliver a report on the 0.2 Cloud Cover flight rule. The report will contain recommendations on when the rule is applicable and when it is not. Additionally, it will provide CCFF and

SMG forecasters with guidelines for forecasting short term changes in cloud cover. A follow-up report will be issued after another year of verification activities.

- To complete the study and deliver a report on Winter fog forecasting at the SLF. The report will contain an algorithm or decision tree which will aid the CCFF and SMG forecasters in predicting this phenomena. A follow-up report will be issued after another year of verification activities.

- To complete the implementation of the MSFC DRWP wind calculation algorithm. This will include development of a user interface for the wind quality control position during STS launches. The implementation will be demonstrated at the end of the first year with testing, documentation, and final operational implementation by early 1993.

3.2. Long Range

- To complete the implementation of the MSFC wind algorithm on the DRWP and transition it to operational use.

- To implement and test the MASS model and analysis system to be delivered by MESO, Inc. by the end of 1992.

- To implement the wind analysis from NOAA/ERL's LAPS system in real time on the AMU RISC 6000 computer during 1993. This will be followed by implementation and testing of the entire LAPS system.

- To implement a three dimensional meso-beta analysis and forecast system which is initialized from LAPS, includes 4-D data assimilation, which will produces forecast products out to 18 hours, and transmits graphics to MIDDS.

Attachment 1: AMU Tasks

Task 1 AMU Operations

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

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

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

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

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

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

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

Task 2 Training

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

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

- Provide NEXRAD training for contractor personnel.

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

Task 3 Improvement of 90 Minute Landing Forecast

• Develop databases, analyses, and techniques leading to improvement of the 90 minute forecasts for STS landing facilities in the continental United States and elsewhere as directed by the COTR. Specific efforts will be designated as numbered sub tasks. The initial two sub tasks are specified below. Additional sub tasks will be of similar scope and duration, and will be assigned by technical directives issued by the COTR.

• Sub task 1 - Two Tenths Cloud Cover

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

• Sub task 2 - Fog and Stratus At KSC

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

Task 4 Instrumentation and Measurement Systems Evaluation

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

• Sub task 1 - STA Down link Test Support

•• Provide meteorological and data collection support to the NASA/JSC Shuttle Training Aircraft (STA) winds position data down link demonstration tests.

• Sub task 2 - Airborne Field Mill (ABFM) Test Support

•• Provide meteorological and data collection support to the NASA/MSFC ABFM FY92 winter deployment.

• Sub task 3 - Doppler Radar Wind Profiler (DRWP)

• Evaluate the current status of the DRWP and implement the new wind algorithm developed by MSFC.

Task 5

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

- Sub task 1 - Evaluate the NOAA/ERL Local Analysis and Prediction System (LAPS)

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