Applied Meteorology Unit (AMU)

Quarterly Update Report

Fourth Quarter FY-92

Contract NAS10-11844

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ENSCO, Inc.

445 Pineda Court
Melbourne, Florida 32940
(407) 853-8201 (AMU)
(407) 254-4122

Distribution:

NASA HQ/ME/Dr. J. Ernst (2)

NASA HQ/Q/F. Gregory

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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)

Development of Forecaster Applications (Mr. Wheeler)

The AMU developed several helpful command enhancements for MIDDS applications during this quarter. The programs were updated after receiving feedback from the CCFF.

One of the applications allows the user to plot the KSC local wind tower network along with other synoptic winds from central Florida stations and buoys if available. The graphic plot of the winds can be over any image (i.e. radar or satellite) or just plotted on a graphics frame. The usefulness of the program is that it allows the forecaster to merge several data sets into one more detailed display of the wind flow. It also is a very good briefing aid to operation managers.

Another useful utility that was developed is called “MORNING”. It gathers data from three different bulletins or data sets and displays the data to one screen to help with the daily summer thunderstorm forecast. The program looks for the morning CCAFS rawinsonde, the HUGE analysis generated from the rawinsonde and the Neuman Pfeffer Thunderstorm Forecast and then displays the data to the user.

The AMU assisted the CCFF in several other MIDDS/McBasi issues. After Hurricane Andrew devastated the Homestead AFB area the CCFF was tasked to provide Met Watch support and issue forecast for that area. As part of this effort, the AMU provided assistance in two important areas - lightning monitoring and MIDDS utilization. The AMU suggested the National Lightning Detection Network (NLDN) could be used to monitor cloud to ground lightning in south Florida by using a remote display connected to the AMU’s NLDN system into the CCFF area. Several new maps with range rings and other features keyed to the Homestead area to facilitate lightning monitoring were developed. The AMU also advised and assisted in the configuration of a Wide Word Workstation for the CCFF area.

Visits to Space Meteorolgy Group (SMG)

Kevin Atchison of the AMU visited the Spaceflight Meteorology Group (SMG) during the STS-46 shuttle mission (29 July-8 August 1992). Mr. Mark Wheeler visited the SMG during STS-47 shuttle mission (17-20 September 1992). The goal for these trips was to meet the SMG forecasters and become more familiar with their operations during shuttle missions.

During the first two days at SMG for STS-46, launch Day - 1 and day of launch, Mr Atchison worked with the ascent crew. Dan Bellue and Jeff Tongue gave an overview of the duties of the Lead forecaster and their overall reponsibilities. They discussed the types of weather information they have available at SMG and how they use this information in preparing their CONUS site forecasts. Also during the first two days, Mr Atchison spent several hours talking to Gene Hafele about TAL weather. This was enlightning since the AMU has not been directly involved with any TAL weather support. Gene provided a detailed overview of the types weather products TAL meteorologists use to prepare their forecasts. It was also useful to learn about some of the weather aircraft flights for TAL weather support and to learn about the NASA automated meteorological stations that provide data at some of the sites.

During the On-Orbit phase of the STS-46 shuttle mission, Mr. Atchison worked a couple of hours each day with the Lead Forecaster in discussing the current day's weather and talking about the outlook for landing day. After the daily MMT breifings, Mr Atchison spent some time with several of the forecasters talking about forecast problems and concerns for shuttle support. In addition, he also spent some of his time talking to Frank Brody, Laurie Hermes, and Steve Sokol about the 2/10 cloud cover report. They provided some useful suggestions regarding potential forecast tools for the 2/10s cloud cover rule. Ms. Hermes had several good suggestions for a nomogram format.

During the landing, Mr. Atchison worked with the SMG landing crew starting at approximatley TD-9 hours. Mr Atchison made note of the types of products the Lead forecaster used in his prepration for the KSC landing. During the shuttle landing support, a few things did arise that were of minor concern to SMG. First, there was concern over how the supplementary cloud cover data is reported at the Shuttle Landing Facility. The observers have been tasked to report the amount of cloud cover for each individual layer; however, observing rules state if there is a trace of cloud it must be reported as at least 1/10. Prior to the landing, the SLF observer did report three individual layers at 1/10 each below 10,000 feet. By looking at the SLF observation this would give a total of 3/10 cloud cover less than 10000 feet. According the the 2/10s cloud cover rule, this would have been a violation. However, CCFF contacted the observer and reported back to SMG that there was approximately 1/10 total cloud cover for all three layers. Thus, the rule was not violated. To help solve this problem it was suggested by both SMG and CCFF the observer give an estimate of the total cloud coverage below 10,000 feet.

Another concern that several of the SMG meteorologists expressed was the lack of a dedicated weather aircraft for shuttle support at KSC. In addition, a few of the meteorologists mentioned that it would be nice to have access to a roof top camera at KSC to monitor sky condtions and cloud development for RTLS and landings.

Mr. Mark Wheeler visited the SMG for the return of STS 47 to KSC. During this trip several discussions were held with Mr. Frank Brody, Ms. Doris Rotzoll, Mr. Gene Hafele (Lead Forecaster) and other mission support members. It was an informative trip, allowing the interchange of ideas and information. The STS 47 recovery was scheduled near sunrise. Easterly flow was predominant; therefore, rain showers within 30 miles was the main criteria of concern. This had also occurred on the previous mission. From observation of landing operations, it is apparent the 90 minute de-orbit decision is really a 4-5 hour decision because of concern with closing the payload doors and water usage for cooling. Certainly, emphasis on the 90 minute forecast is important but we must also consider forecast problems in the 4-6 hour time span. The Lead Forecaster and team did an excellent job of keeping the managers informed of the changing weather pattern. On the second opportunity STS 47 was successfully recovered back at KSC.

The visit afforded the opportunity for Mr. Wheeler to interact with the SMG regarding MIDDS applications. While there, several McBasi programs were modified for SMG use. One gives them a tabular listing of the Cape/KSC detected lightning (LLP), another plots the WINDS data over satellite imagery, and the third plots the KSC GBFM display. Additionally, some help was given in how to find bulletins in the new filing system. This seems to be a problem at both SMG and CCFF.

2.2. Task 002 Training (Dr. Warburton)

During September, five AMU members attended two days of training by IBM on the AIX operating system used in the RISC 6000 computers. One member of the staff attended the three day System Administrator Course also taught by IBM.

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 the End Of Mission (EOM) STS landings at KSC. A preliminary report on the two-tenths cloud cover analyses was delivered during June 1992 (Third Quarter). Based on the results of this study, three sets of additional analyses were to be performed before preparation and delivery of the final report.

- The data were re-examined after filtering the nighttime observations from the database. This analysis was performed only for the daylight hours on a monthly basis.

- CCAFS rawinsonde data were used to investigate the effect of lower atmosphere wind flow patterns on the cloud cover amounts and weather violations at X68.

- Cloud cover data were used to help develop climatological nomograms for use in cloud cover forecasting.

Each analysis was completed during this quarter and the results will be discussed in the following paragraphs.

Daytime Only Analysis

During analysis of the hourly data a question arose concerning the validity of the nighttime cloud observations. It is possible the data may be biased towards lower amounts of cloud cover due to the lack of visibility of the celestial dome. In addition, cloud ceilings could only be measured accurately up to 3700 feet because a laser ceilometer was not installed at X68 until 1991. On the basis of this information, 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. In order to test the effects of the nighttime observations, the monthly data were re-analyzed eliminating the nighttime hours. The daylight hours were determined from X68 sunrise/sunset tables with the 15th of the month assumed to represent everyday of the month.

The climatology of weather conditions with the nighttime data removed show many of the same types of trends that occurred for the full monthly data.

Key results from the Climatology analysis of the Daytime Monthly data are:

- Highest occurrence of weather violations in the winter (30-40%) and lowest in the summer (15-20%).

- Less occurrence of clear skies (0.0 cloud cover) less than 10,000 feet for the daytime data compared to the full monthly data.

- Higher percentage of clouds in the 0.1 to 0.3 clouds categories for the daytime data compared to the full monthly data.

The only major difference between the monthly daytime and full monthly data sets for cloud cover climatology is the decrease in the percent occurrence of clear skies (0.0 cloud cover less than 10,000 feet) and an increase in percent occurrence in the 0.1-0.3 cloud cover categories. This is expected since heating during the daylight hours causes more clouds to develop, especially in the summer. For example, during June (Figure 3.1) the percent occurrence of clear skies (0.0 Cloud Cover) for the full monthly data is around 20% but with the nighttime hours removed the percentage decreases to less than 10% (Figure 3.2). In addition, an increase in cloud cover can also be seen in both the 0.2 and 0.3 cloud cover categories. The full monthly data set has about 15% occurrence for the 0.3 cloud cover group while the daytime data increases to about 20%.

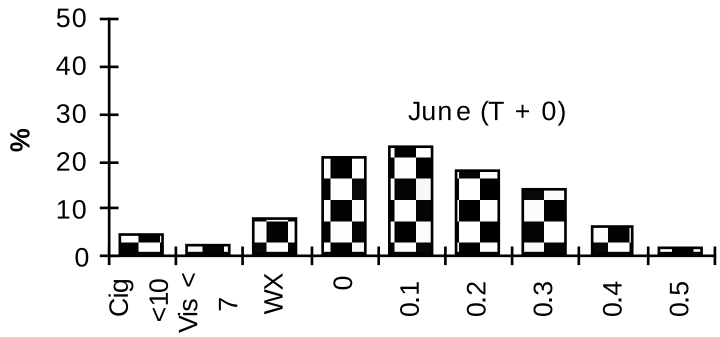


Figure 3.1. Climatology of Weather Conditions for June Using Full Monthly Data.

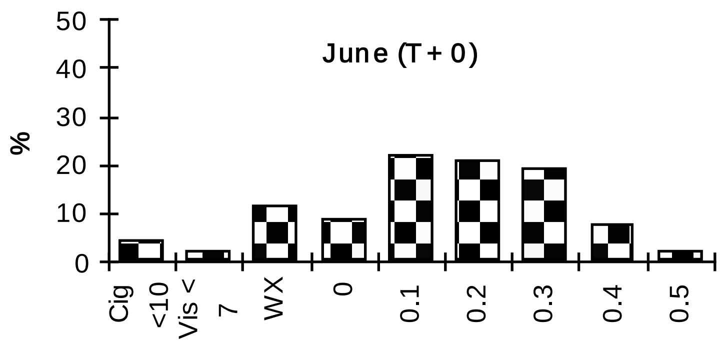


Figure 3.2. Climatology of Weather Conditions for June Using Monthly Daytime Data.

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 conditions. Trends which were seen in the full monthly data set also show up in the daytime data (nighttime data removed).

Key results for Observed Weather Conditions Subsequent to Initial Conditions for the Monthly daytime data are:

- For initial cloud cover amounts of 0.0 to 0.3, there is a least a 75% to 80% chance of not having a weather violation one and two hours later.

- The differences in the proportions of the weather violations one and two hours subsequent to initial conditions of 0.2 and 0.3 cloud cover are not significant for the months of May and October (see Figures 3.3 and 3.4).

- For most all initial starting conditions weather violations at one and two hours do increase slightly for the monthly daytime data.

- Persistence continues to dominate weather conditions at both one and two hours for initial cloud amounts of 0.0 to 0.3.

Similar to the full monthly data, chi-square tests for the daytime data indicated no difference in the percent occurrence of weather violations between 0.2 and 0.3 for both May and October (see Figures 3.3 and 3.4). This is important because based on these statistics for these two months the 0.2 cloud cover rule is probably overly conservative and the rule could be changed to 0.3. If this rule was changed, there would be a significant increase in the total number of hours the cloud cover rule would not be violated. For example, during May and October (daytime only) changing 0.2 to 0.3 would increase the hourly landing opportunities for each month by another 13-14%. This would then increase the total percentages of occurrences for both categories to around 28-32% (see Table 3.1).

Table 3.1
Percent Occurrences of 0.2 and 0.3 Cloud Cover*

	0.2		0.3		0.2 and 0.3	
Month	Count	%	Count	%	Total Cts	Total %
May	387	18	310	14	697	32
October	304	15	254	13	558	28

* Statistics based on Daylight hours possible for both May and October.

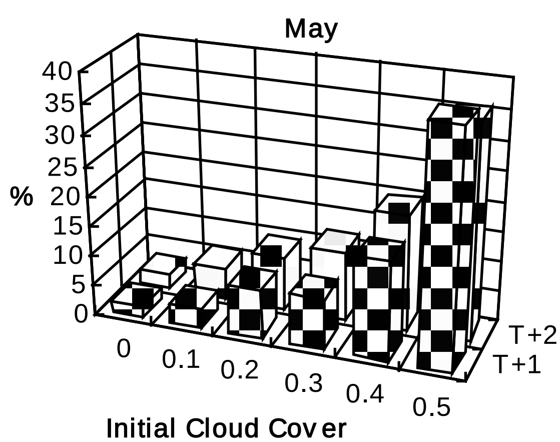


Figure 3.3 Weather Violations vs. Initial Cloud Cover for May

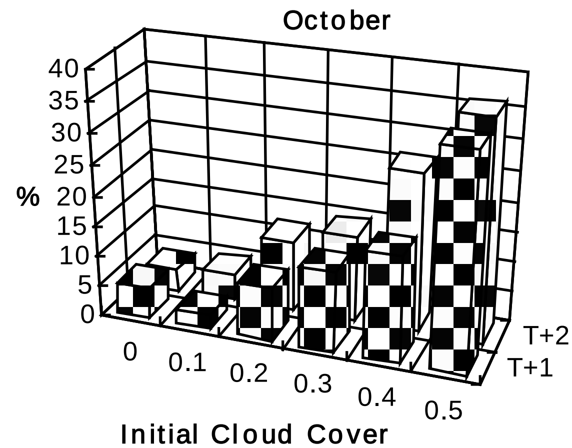


Figure 3.4 Weather Violations vs. Initial Cloud Cover for October.

Upper-air Analyses

The next component of the two-tenths cloud cover study focused on categorizing the data by upper-air wind direction sector. The wind sectors have been defined to fit the sectors used by National Severe Storms Laboratory in their analysis of total area divergence over the KSC/CCAFS area. The sectors have been defined as North (339° to 023°), Northeast (024° to 113°), Southeast (114° to 158°), South (159° to 203°), Southwest (204° to 293°), and Northwest (294° to 338°).

The data used for this analysis was the early morning rawinsonde release from the Cape Canaveral Air Force Station (CCAFS) for the period 1986-90. To simplify the analysis process, this data was assumed to be representative of wind flow characteristics over the 24-hour period centered at 1200 UTC. Each hour during this period was assigned the upper-level wind information from this sounding. The analysis performed concentrated on categorizing the weather conditions at X68 by 850mb and 700mb wind direction.

Key results from these analyses are:

- Climatology of 850mb and 700mb.
    - South and Southwest wind sectors for both 700mb and 850mb have highest percent occurrence of weather violations at 25% to 30% (Figures 3.4 and 3.5).

- •• North, Southeast, and Northwest wind sectors all have weather violation percentages of 18% to 22% (Figures 3.4 and 3.5).

- •• Minor peak in weather violations for the 850mb northeast wind sector at 22%.

- •• Clear skies (0.0 cloud cover) has highest percent occurrence for North and Northwest wind sectors, lowest for Northeast and Southeast winds.

- •• Highest percent occurrence of clouds in the 0.1 to 0.3 categories for Northeast, Southeast, and Southerly wind sectors.

- Observed Weather Conditions (T+1 and T+2 Hours) Subsequent to Initial Conditions.

    - •• For initial cloud cover amounts of 0.1 through 0.5, the highest percent occurrences of weather violations occur with a southwest 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.

    - •• Chi-square tests between 0.2 and 0.3 initial cloud cover for 700 North for both T+1 and T+2 hours show no difference in the percent occurrence of weather violations.

As stated above, the chi-square tests for 700mb north wind sector is showing no statistical difference between the percent occurrence of weather violations for 0.2 and 0.3 initial cloud cover. However, it is important to note the total percentage of time of observed northerly flow at 700mb at X68 over the five year period was only 7.5%. In addition, the percentage of time with northerly flow at 700mb and with observed cloud cover of 0.2 and 0.3 is less than 2% over the same period. Thus, based on this low percentage of occurrence of 700mb northerly flow nothing would be gained from changing the 0.2 cloud cover rule to 0.3.

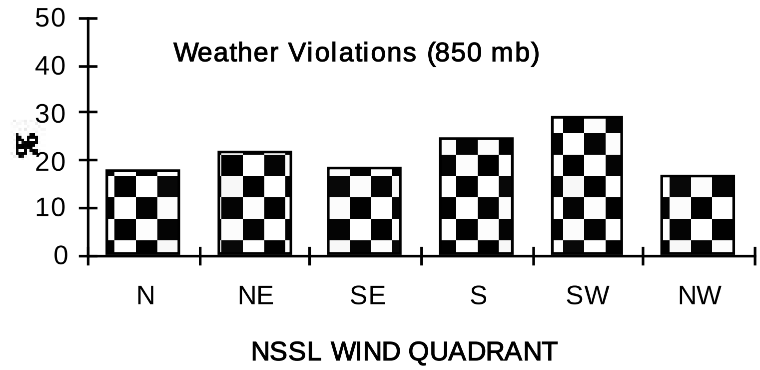


Figure 3.4. Percent Occurrence of Weather Violations for 850mb Wind Sectors

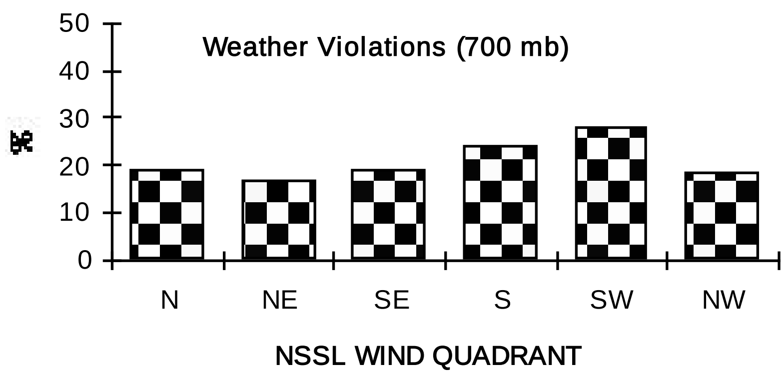


Figure 3.5. Percent Occurrence of Weather Violations for 700mb Wind Sectors

Nomograms

Since this type of cloud cover information has never been compiled for SMG or CCFF, the AMU developed nomograms using this data in order to enhance the forecaster's knowledge in making cloud cover forecasts for EOM and RTLS at KSC. Also, a climatology of weather violations by month vs. hour was developed in order to give the SMG and CCFF forecasters as well as the STS managers a good indication as to when is the best time to land the shuttle. In addition, the 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 (month and time of day).

Figure 3.6 shows an example of climatological information for percent occurrence of weather violations by month and hour. Several interesting features can be seen in these charts. First, the fall and winter months (January and October) have the highest percentage of weather violations at 30-40% while the summer (August) has the lowest at around 10-15%. Next, there is a peak in weather violations near sunrise 1100-1300 UTC.

This peak is mainly associated with fog and low clouds which develop during the early morning hours. Following this peak there is a decrease in weather violations around 1400-1600 UTC. This drop is linked to the burn off of any fog and low clouds which may be present near sunrise and it is also a time before the formation of convective type clouds. By late afternoon (1800-2200 UTC), there is a rise in weather violations which is associated with shower and thunderstorm development, especially during the summer months. Finally, for the early nighttime hours (0100-0600 UTC), all four charts in Figure 3.6 show a minimum in weather violations with August dropping to less than 10% during these hours.

Table 3.2 shows an example of nomogram table which relates the percent weather violations for a given initial cloud cover for months and groups of hours at T+1 and T+2 hours. The table also gives the total number of counts for each group. For the 0900-1400 UTC period during October, the weather violation is 12% for T+1 hour but increases to 21% for T+2 hours. For both of these categories there were 111 cases of initial cloud cover of 0.2. These charts have been created for initial cloud cover of 0.0 to 0.5 and will be made available to both SMG and CCFF forecasters via MIDDS.

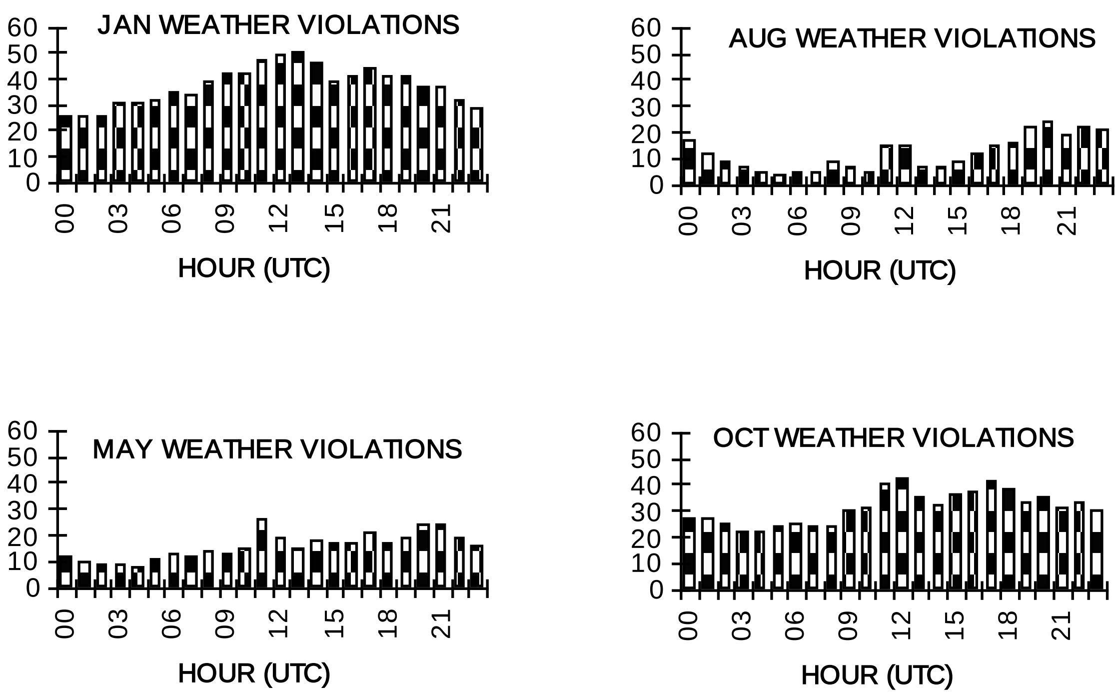


Figure 3.6 Percent Occurrence of Weather violations by Month and Hour.

Table 3.2 WEATHER VIOLATIONS FOR To=0.2									
TIME (UTC)		**0900-1400**		1500-2000		2100-0200		0300-0800	
HOURS FROM To		**T+1**	**T+2**	T+1	T+2	T+1	T+2	T+1	T+2
(Month)	To Count	66	66	93	93	95	95	58	58
January	% Violation	12	18	13	17	2	5	14	17
	To Count	38	38	97	97	83	83	51	51
February	% Violation	11	32	6	7	4	5	12	25
	To Count	89	89	120	120	107	107	81	81
March	% Violation	13	22	5	8	4	7	1	10
	To Count	68	68	89	89	77	77	67	67
April	% Violation	10	21	6	11	4	6	4	7
	To Count	114	114	187	187	158	158	112	112
May	% Violation	10	14	7	9	4	6	4	8
	To Count	163	163	184	184	179	179	132	132
June	% Violation	5	10	8	13	5	7	3	9
	To Count	134	134	240	240	182	182	88	88
July	% Violation	4	4	3	11	4	6	7	5
	To Count	139	139	252	252	189	189	85	85
August	% Violation	1	4	6	10	4	5	4	5
	To Count	192	192	213	213	201	201	173	173
September	% Violation	3	6	6	6	2	4	4	8
	To Count	**111**	**111**	128	128	153	153	101	101
October	% Violation	**12**	**21**	10	12	5	9	7	15
	To Count	83	83	127	127	124	124	66	66
November	% Violation	6	12	5	8	0	6	11	20
	To Count	75	75	128	128	86	86	55	55
December	% Violation	3	11	4	9	6	9	13	25

Suggestions for Future Work

As our understanding of the EOM forecast problem has increased, so has our knowledge and understanding of the meteorological conditions at X68; it has become apparent artificial neural network (ANN) technology could successfully be applied to this problem. ANN technology has proven itself as a powerful tool in the area of pattern recognition and data association. Artificial neural networks have been successfully applied to thunderstorm forecasting by the NWS. ANN software algorithms can be applied to forecasting potential shuttle landing violations 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 - key elements of any ANN application.

There are many different artificial neural network models to encompass the many areas of application (i.e., pattern recognition, data association, data categorization, constraint satisfaction, and process control). Backward error propagation networks are easy to implement and have been applied to solve many different types of problems; they are, therefore, one of the more commonly used neural network models. A simple backward error propogation network is illustrated in Figure 3.7.

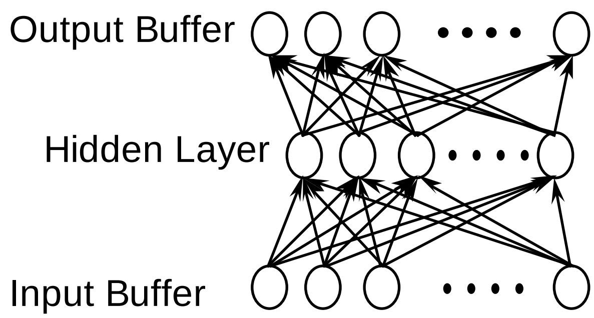


Figure 3.7: Backward Error Propagation Neural Network Architecture

Back-propagation neural networks consist of an input layer, an output layer, and one or more hidden layers. Each of the layers is made up of continuous valued units often referred to as neurons. Each neuron is connected to each of the neurons in adjacent layers with a given connection strength. The stronger the connection strength, the more influence the two units have on each other’s values. The network learns by example. First, the network is presented with a set of inputs which flow through the connection strengths to the hidden layer(s) and then through the next set of connection strengths to the output layer. The values of the output layer units are then compared to the values of the desired output units. The error is then back-propagated through all the connection strengths in the network. This process is iterated until the difference between the output generated by the network and the desired output is below a given threshold.

A neural network for predicting the probability of landing constraint violations would use single point forecasting information from station X68 as inputs and the type(s) of violations (if any) existing at the time of landing as outputs. 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 weather conditions reported by X68 as well as past and current rawinsonde data. Including both past and current surface weather conditions in the input buffer allows the artificial neural network to take into account both temporal and spatial relations between input data and the probability of violations. 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.

As with any other forecast model or tool, the output produced by an artificial neural network is only representative of the data input to it. In this application, the artificial neural network is meant strictly as a forecasting tool and should be used in the same way outputs from other numerical models are used. Artificial neural network technology attempts to improve computers' ability to perform tasks involving the assimilation and organization of data by mimicking the brain's massive parallelism and connectivity. ANN's have made great strides in this area in recent years and have great potential for contributing to scientific discovery in many disciplines. They are, however, not intended to be replacements for scientists who have access to all the data affecting the problem.

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

The AMU's goal for this sub-task was to determine precursors for fog formation and develop rules of thumb or forecast techniques.

During this quarter the AMU completed analysis of the 37 selected fog cases. The 37 cases were extracted from the X68 surface database file by searching the file for advection fog that formed rapidly at X68. A data folder was developed for each case containing upper air and surface analysis summaries, skew-t diagrams, local wind tower plots, central Florida surface charts, and a case review highlighting the key-points or precursors.

A program to extract the temperature and dewpoint data from tower 313 at 6, 54 and 492 foot levels to facilitate assessing the beginning of the low level inversion as well as the time of breakage of that inversion was developed.

The precursor and key information for each case was documented. This data includes: type of fog, whether the case is fog only or fog and stratus, occurrence of fog at Orlando or Daytona prior to occurrence at X68, time of onset at X68, time X68 visibility equaled 7 miles, time inversion formed at tower 313, surface wind direction at X68 at time of onset, Skewt surface temperature, strength of inversion, prescense or absense of an inversion the day before, and prescense or absense of fog at Orlando and Daytona Beach the day before.

Preliminary case results:

Fog developed at ORL to DAB at least 1 hour prior to development at X68:	83%
Local wind towers had a prevailing westerly wind direction:	92%
Local wind towers showed a shift to a more westerly flow:	67%
Time of onset of fog at X68 between 0800 and 1000 UTC:	51%
X68 wind speed 2-6 kts at time of fog onset:	69%
Prefrontal type cases:	39%
Prefrontal cases, fog reported Orlando or Daytona, day before:	62%

These cases indicate that the typical fog event at X68 starts with fog developing west of X68 (probably in the marsh areas of the St. Johns river) then as the surface winds switch to a more westerly flow (drainage wind), the observer begins to note a reduction in the visibility around 0800 UTC, then finally as the winds shift more northwesterly the fog forms, reducing the visibility to less then 7 miles.

The wind tower data will need to be studied this year to determine if there is an indication of a westerly wind shift prior to the fog formation at X68. Other data shows that of the nine fog only cases, the reported wind speed at X68 was 3 knots or less. For the fog and stratus cases 69% reported wind speeds of 2 to 6 knots. In addition 62% of the pre-frontal cases showed fog developing in the Orlando or Daytona Beach area the day before it formed at X68.

To help the forecaster monitor the local wind towers and other precursor information, a MIDDS application utility was developed. This McBasi program plots wind direction and speed on a 4-panel graphic frame for selected wind towers. The display also includes: tower ID, temperature, relative humidity, inversion strength, wind direction, wind speed, and temperature for tower 313 at the 6 and 492 foot levels. In addition to the MIDDS display, a fog worksheet is being developed to facilitate fog forecasting.

After analyzing all of this information and noting some of the trends in the formation of the fog at X68, it is apparant there is a lack of data to the west of X68 in the St. Johns river basin area. Based on this observation, two preliminary recommendations are:

- Add temperature and dewpoint sensors to all of the KSC extended towers (mainland)
- Consider installing two or one automatic observation sites in the same area.

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

Implementation of MSFC DRWP Wind Algorithm

Modification of the Spectral Archive Process on the development system has been completed. The process will now continuously ingest data from the Real Time Processor (simulated on the development system) and then output the spectral data to disk for use by the new Wind Processing Algorithm. After the modifications to the Spectral Archive Process were completed, the code for new Wind Processing Algorithm was implemented on the developmental MicroVAX computer and then integrated with the Spectral Archive Process.

The code for the spectral data quality control display was then developed and integrated with the new Wind Processing Algorithm. The quality control display depicts the three most recent velocity profiles in relation to the spectral data they represent. The display updates itself automatically each time a new velocity profile is generated by the new Wind Processing Algorithm (approximately every three minutes). Timing tests performed on the development system (ENSCO, Inc.'s MicroVAX) indicate that the DRWP can continue to support 3-minute updates to MIDDS when it is in the 3-mode configuration. It does not appear, however, that 3-minute updates will be possible when the DRWP is in the 6-mode configuration.

The AMU will be ready to install the first build of the new wind profiler software on the DRWP MicroVAX by mid October. The first build will consist of the new Wind Processing Algorithm fully integrated with the spectral data ingest routines and the spectral data quality control display software. Installation of the first build will require some software modifications because of differences between the way the development system and the DRWP MicroVAX handle the ingestion of the spectral data. Installation of the first build will ensure differences in the development environment and the target environment (e.g., different versions of VMS, GKS, and C) do not affect system performance and will enable testing of the modified Spectral Archive Process with the parallel interface.

After the first build is installed and tested, software for the second and final build will be completed. The additional software in the second build will enable user control of the new wind algorithm and communications between the new Wind Processing Algorithm and the MIDDSOUT Process.

DRWP Meteorological Evaluation

This section of the quarterly report contains an overview, including procedures and results, of the AMU's preliminary meteorological evaluation of NASA's 50 MHz Doppler Radar Wind Profiler. This evaluation has focused on optimizing key parameters (i.e., first guess window width, integration window width, and minimum acceptable signal-to-noise ratio) within the MSFC new wind algorithm.

The MSFC wind algorithm uses the first guess window width in conjunction with the first guess velocity to constrain the range of spectral bins that are searched for the maximum signal (Fig 4.1). This first guess approach has the advantage of increasing the probability of the selected maximum signal being related to the wind velocity and decreasing the probability of the selected maximum signal being related to a side lobe or transient signal not of interest. Since the width of the first guess window affects the performance of the first guess technique, this evaluation has examined the impact of using different first guess window widths.

After the maximum signal has been selected, the MSFC algorithm computes the average Doppler shift based on the maximum signal strength and the integration window width (Fig 4.1). As with the first guess window, the width of the integration window affects the resulting average Doppler shift. If the window is too narrow, the peak of the wind velocity signal may not be included in the average Doppler shift integration. In contrast, if the window is too wide, side lobe and/or transient signal data may be included in the average Doppler shift computations. Since the width of the integration window affects the performance of the new wind algorithm, this evaluation has examined the impact of using different integration window widths.

The third and final parameter examined in this preliminary analysis is the minimum acceptable signal-to-noise ratio. After the average Doppler shift has been calculated, the signal-to-noise (S/N) ratio is computed. If the S/N ratio does not exceed the minimum acceptable value, the average Doppler shift and the other moments are recomputed using alternative approaches (e.g., using a different first guess velocity and/or smoothing the spectra). If the new S/N ratio still does not exceed the minimum acceptable value, the first guess velocity is propagated. Thus, the minimum acceptable S/N ratio does impact the results under weak signal conditions.

The preliminary analysis is based on DRWP and jimsphere profiles from September 12, 1991. These data were collected in support of the launch of STS-48. The data examined include 5 jimsphere profiles spanning a time period from 1842 UTC to 2326 UTC and a series of DRWP from 1840 UTC to 2358 UTC. The first guess used to initialize the new DRWP wind algorithm is based on the 1842 UTC jimsphere profile.

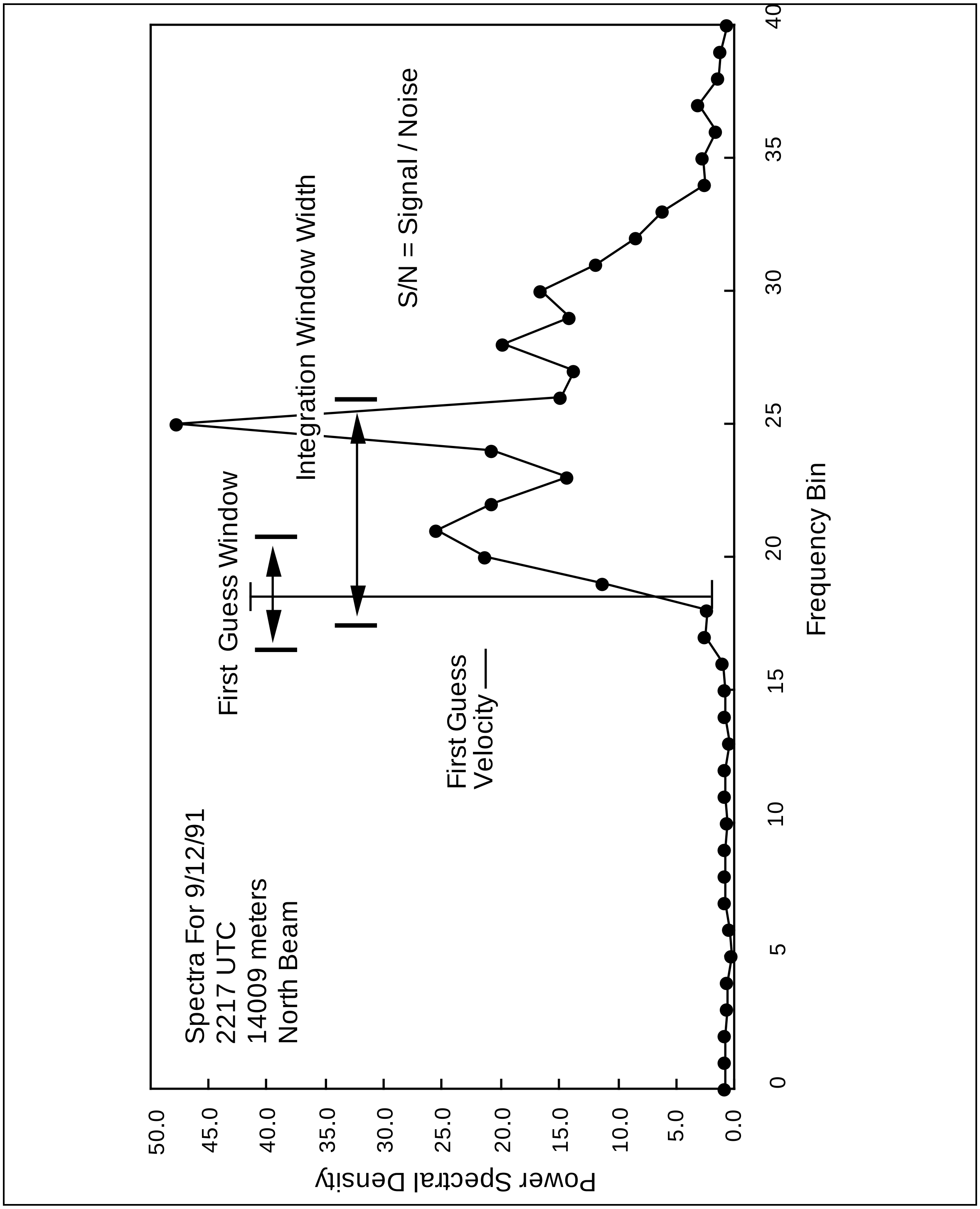


Figure 4.1. Sample spectra depicting how algorithm parameters affect solution.

The analysis procedure utilized included the inter comparison of DRWP profiles produced using different values of the three aforementioned parameters and the comparison of DRWP profiles to jimsphere profiles. The five different wind algorithm configurations used in this analysis are presented in Table 4.1.

Table 4.1
DRWP Configurations

Configuration Number	First Guess Window Width	Integration Window Width	Minimum S/N Ratio
DRWP #1	6	10	-15
DRWP #2	6	20	-15
DRWP #3	12	10	-15
DRWP #4	6	10	-8
DRWP #5	12	20	-8

In order to compare the DRWP and jimsphere profiles, the jimsphere data were interpolated to the DRWP profile reporting levels. The jimsphere data were not filtered prior to the interpolation in order to preserve the detail present in the original profile.

After the jimsphere data were interpolated to the DRWP reporting levels, root mean square (RMS) differences between the jimsphere and DRWP profiles were computed and analyzed. In each case, a jimsphere profile was compared to a DRWP profile 30 minutes subsequent to the time of the jimsphere profile. This temporal difference in the data time stamps was incorporated into the analysis procedure to reduce the impact of the significantly different data collection periods of the two systems (i.e., 60 minutes for the jimsphere profile and 3 minutes for the DRWP profile).

In addition to the analysis of RMS differences, cross-spectrum analyses of jimsphere and DRWP profiles were performed to investigate the coherency between wind profiles from the two systems. Similar analyses were also conducted among the DRWP profiles to examine how changing the configuration of the new wind algorithm affected the coherency of the resulting profiles.

The final component of this preliminary evaluation focused on analyzing spectra from selected range gates where the resultant wind velocities differed significantly among the five wind algorithm configurations. The intent of the investigation was to glean information relevant to optimizing the configuration of the new wind algorithm.

The following paragraphs present a summary of the results from the preliminary meteorological evaluation of the new wind algorithm. A more detailed description of the results will presented in the preliminary report of the AMU’s meteorological evaluation of NASA’s 50 MHz Doppler Radar Wind Profiler. The preliminary report will be written and delivered in November 1992.

The RMS differences between the jimsphere profiles and the DRWP profiles are shown in figures 4.2 and 4.3. Three key points can be gleaned from the two figures. First, the RMS differences between the jimsphere and the DRWP profiles are very similar for the five different wind algorithm configurations. Second, the RMS differences are comparable to ensemble jimsphere / DRWP RMS differences computed by MSFC. And third, there does not appear to be a trend over time in the RMS differences.

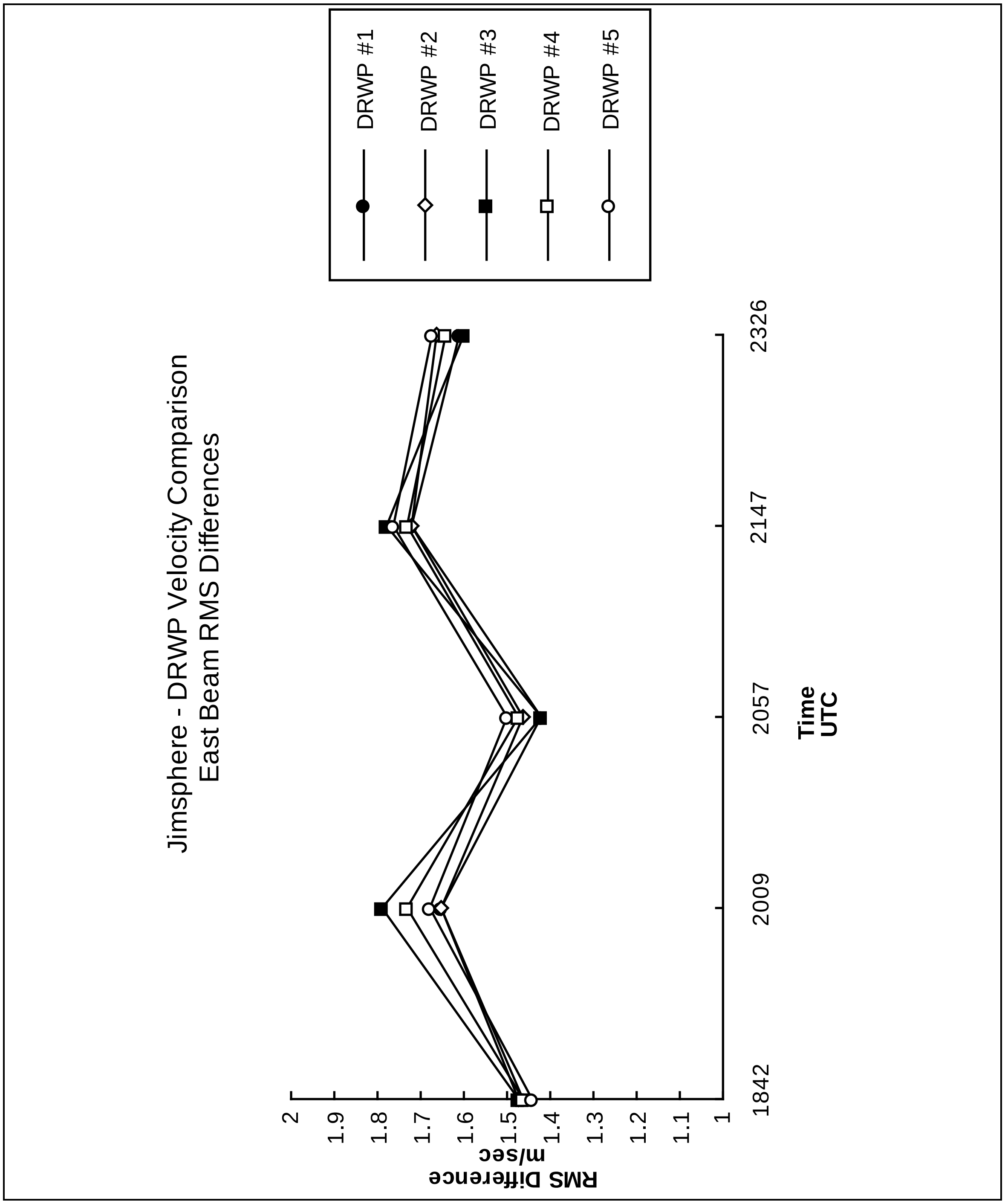


Figure 4.2 Jimsphere / DRWP east beam RMS differences for September 12, 1991.

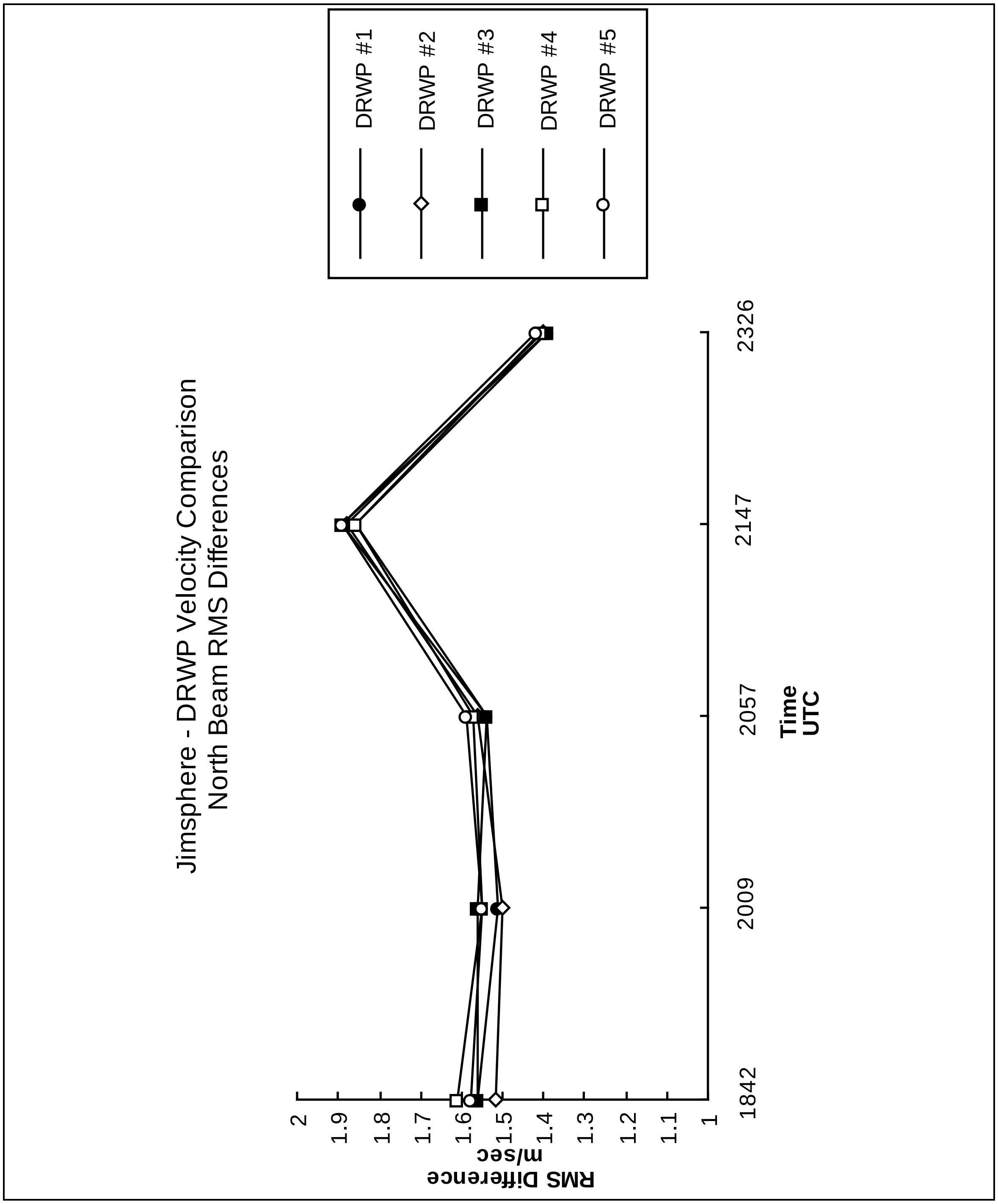


Figure 4.3 Jimsphere / DRWP north beam RMS differences for September 12, 1991.

Since the RMS differences are similar among the five wind algorithm configurations, this analysis does not indicate a preference of one configuration over any other. However, the absence of any significant trend over time in the RMS differences does reveal two positive aspects of the new wind algorithm. The first guess technique does not over-constrain the solution (recall the initial first guess is based on a jimsphere profile) and the profiles produced by the new algorithm do not tend to diverge from the jimsphere profiles.

One example of the cross-spectrum analyses performed between the jimsphere and DRWP profiles is shown in figure 4.4. Although this is only one of the 25 coherency squared charts generated, the major trends present on this chart are similar to the trends on the other charts. Thus, only one chart will be presented and discussed in this report.

The chart indicates both components of the two profiles are highly coherent to wavelengths as short as 1200 meters (i.e., wave number ~ 5×10^{-3}). At shorter wavelengths, the coherency in the east component velocities rapidly decreases indicating minimal coherence between the two profiles at wavelengths less than 800 meters (i.e., wave number ~ 8×10^{-3}). Although the coherency decreases for both components from wavelengths of ~ 1200 meters to 900 meters (i.e., wave number ~ 5×10^{-3} to ~ 7×10^{-3}), the coherency for the north beam increases at still shorter wavelengths indicating significant coherence at wavelengths as short as 600 meters.

Since the two systems are not sampling the same volume of air, it is not surprising that the degree of coherency is less for shorter wavelengths. However, the large difference in coherency between the north and east components for wavelengths of ~ 600 meters (i.e., wave number ~ 1×10^{-2}), is of interest. One potential explanation for this difference is the fact that the wind direction throughout a large portion of the profile was northeasterly. Consequently, the east beam (145°) velocities were often near zero which is difficult for the DRWP to accurately estimate. This may have resulted in some small scale perturbations in the east beam velocities and reduced the coherency with the jimsphere profile. Analysis of different time periods should help resolve this disparity.

Two examples of the coherency between DRWP profiles produced using different wind algorithm configurations are shown in figures 4.5 and 4.6. As with the jimsphere coherency analysis, additional charts will be included in the preliminary evaluation report.

The profiles produced by DRWP configurations #1 and #2 are highly coherent to wavelengths as small as 600 meters (i.e., wave number ~ 1×10^{-2}). This indicates that the two different configurations produced very similar profiles from this particular spectral data. However, the coherency values for DRWP configurations #1 and #4 for the same spectral data are quite different (Figure 4.6). Although the north beam velocities are highly coherent and are very similar to the north beam coherency values for configurations #1 and #2, the east beam velocities are less coherent in the shorter wavelengths. The lower coherency values are a result of a larger number of east beam first guess velocity propagations in DRWP configuration #4. The difference in the number of east beam first guess propagations is directly related to the difference in minimum acceptable S/N ratio between the two configurations.

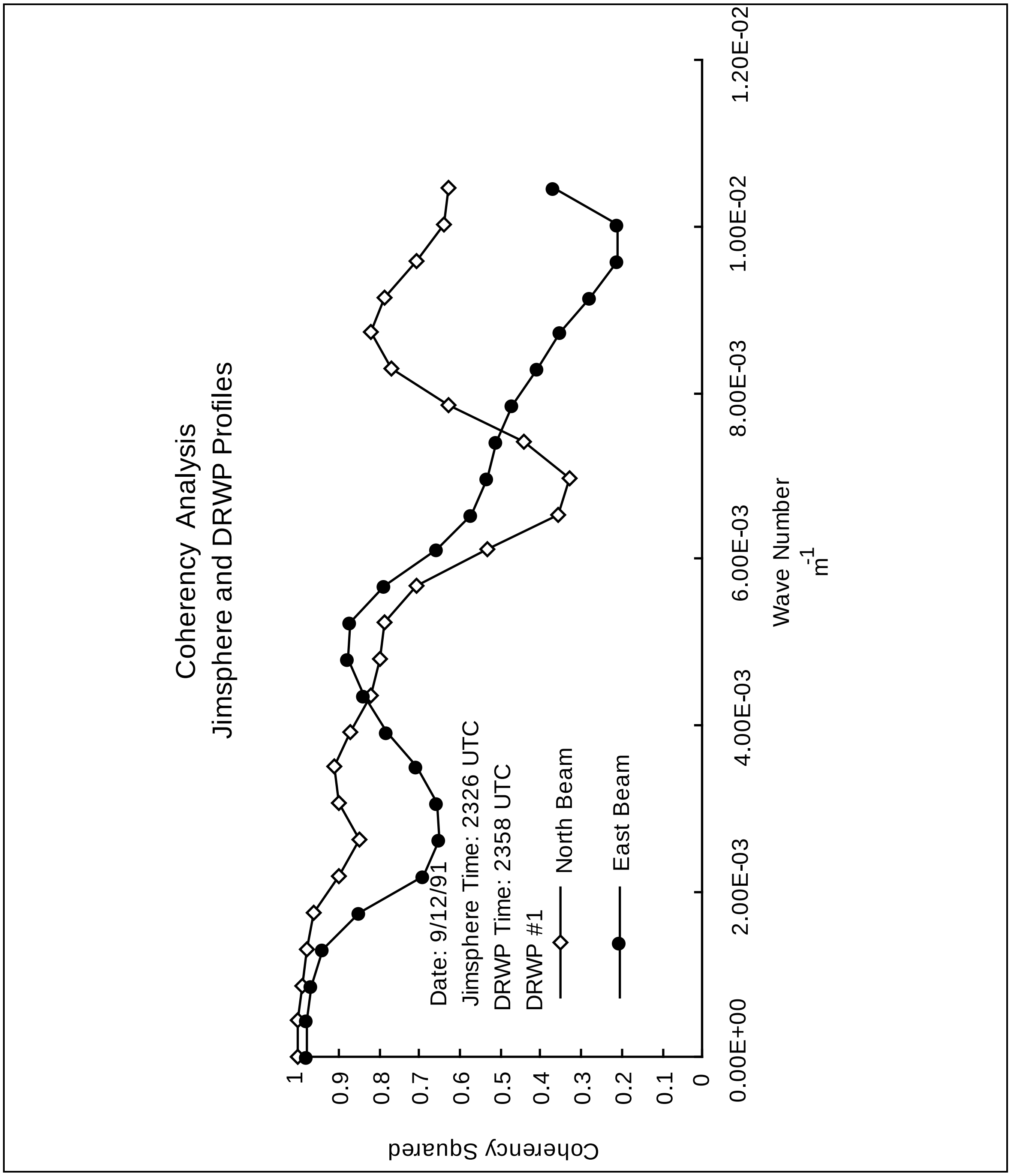


Figure 4.4 Cross-spectrum analysis for jimsphere and DRWP profiles for September 12, 1991. Data times are 2358 UTC for the DRWP profile and 2326 UTC for the jimsphere profile.

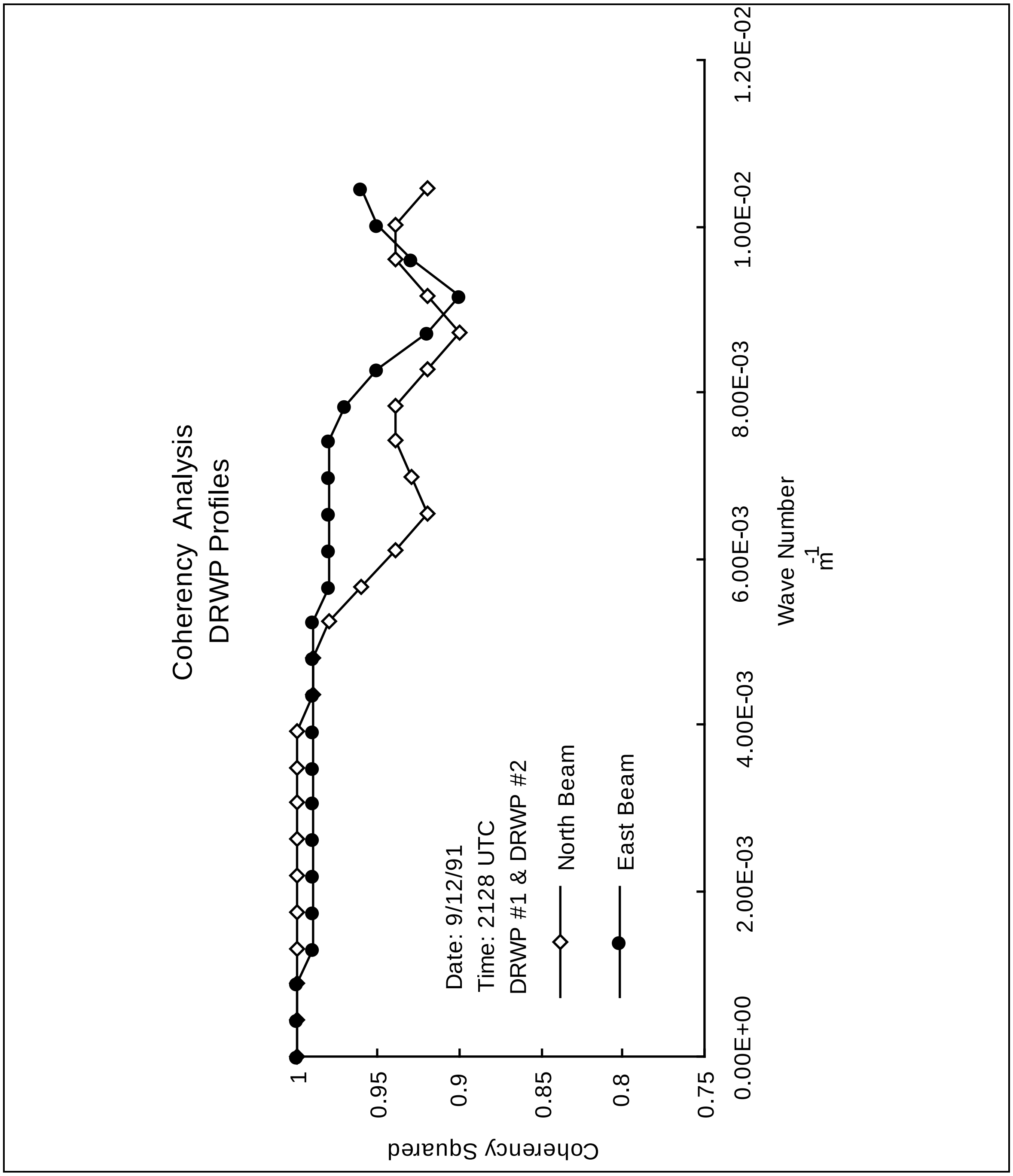


Figure 4.5 Cross-spectrum analysis for profiles from DRWP #1 and from DRWP #2 for September 12, 1991, at 2128 UTC.

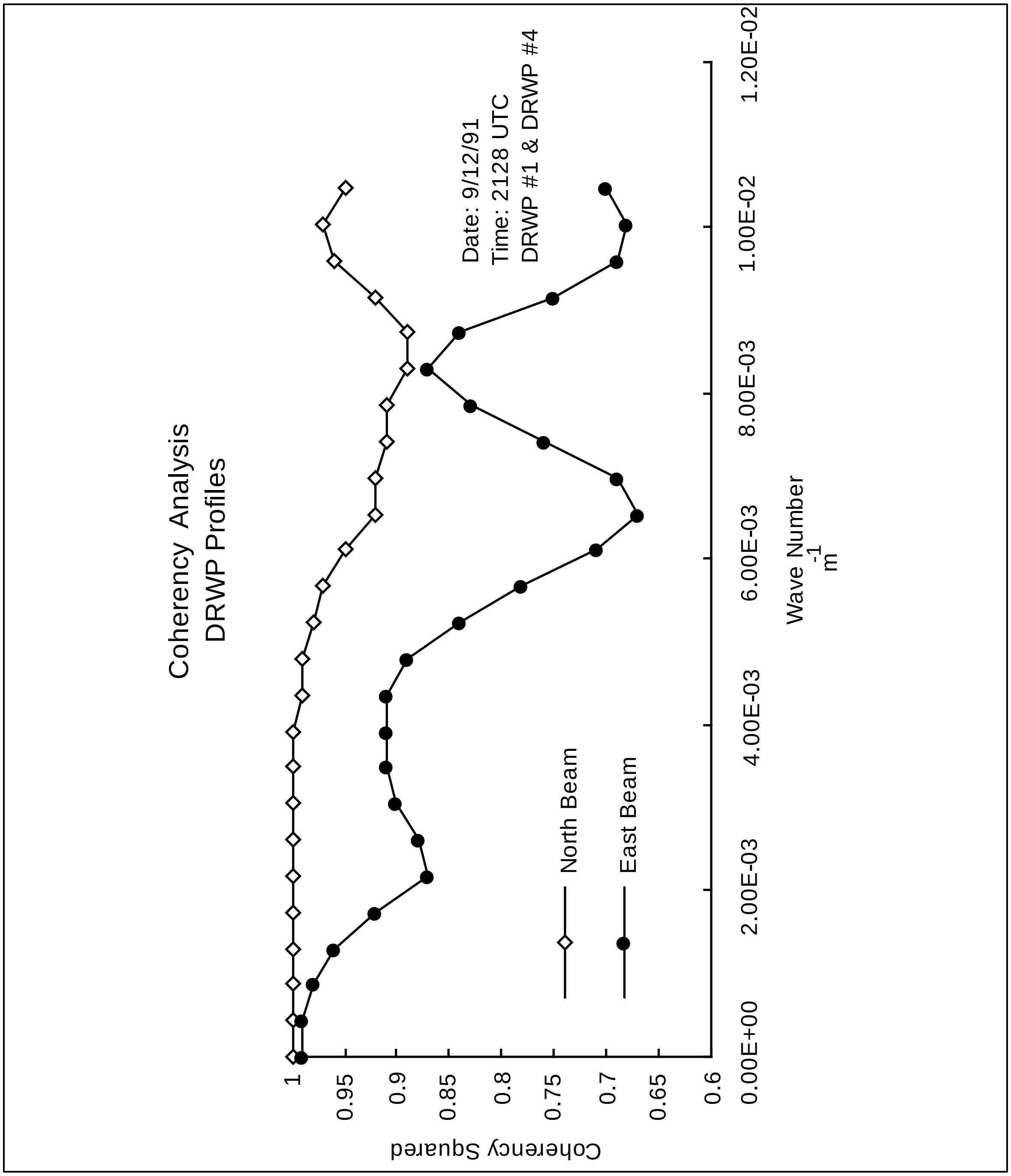


Figure 4.6 Cross-spectrum analysis for profiles from DRWP #1 and from DRWP #4 for September 12, 1991, at 2128 UTC.

The coherency analysis illustrates that changing the minimum acceptable S/N ratio will, in weak signal areas, modify the resultant wind profile. The question regarding which is the better solution remains unanswered. To glean additional insight into this question as well as others, individual spectra from selected range gates were examined. In this report only two examples will be presented which illustrate the effects of varying the DRWP wind algorithm configuration.

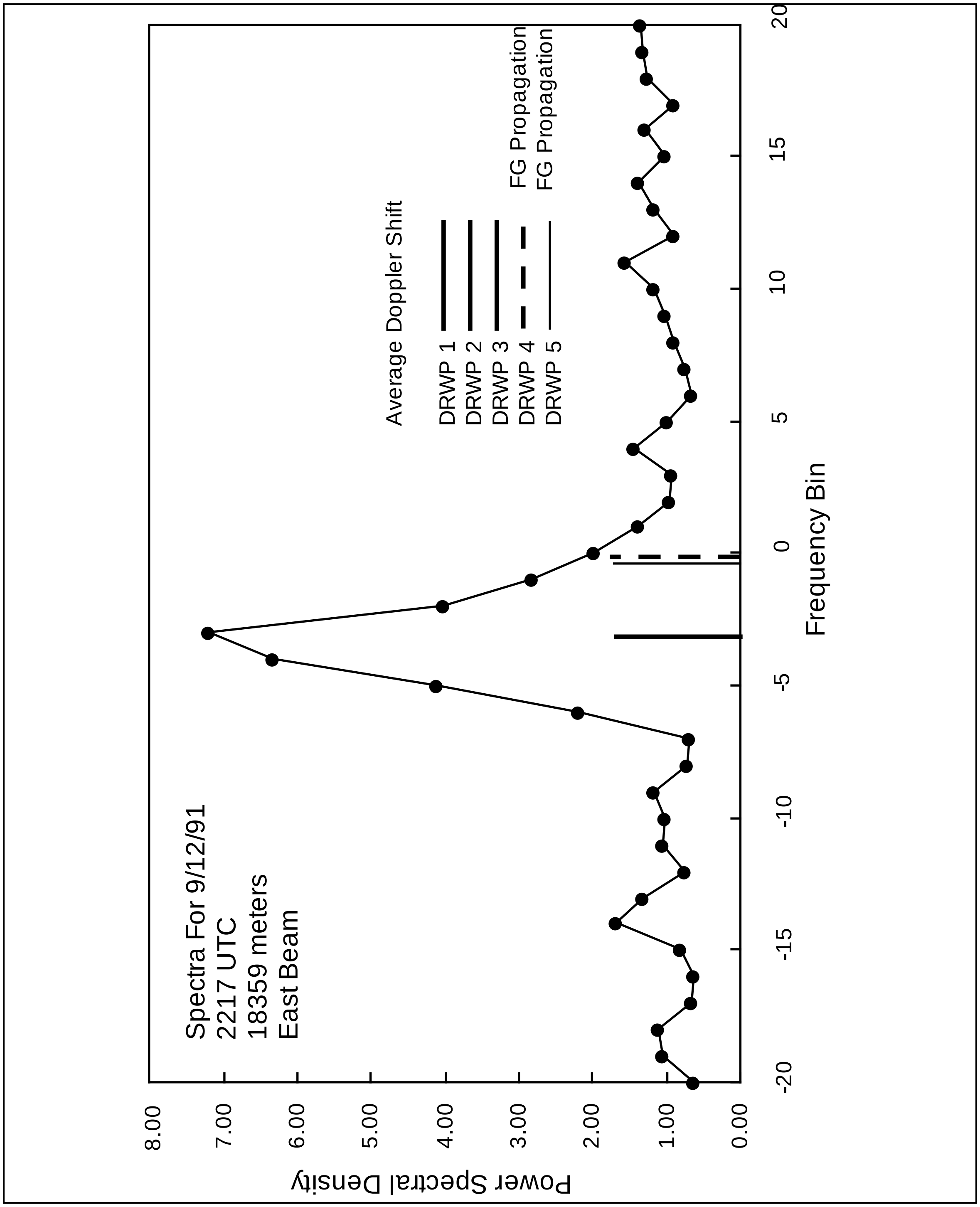


Figure 4.7 East beam spectra from 18359 meter level at 2217 UTC on September 12, 1991.

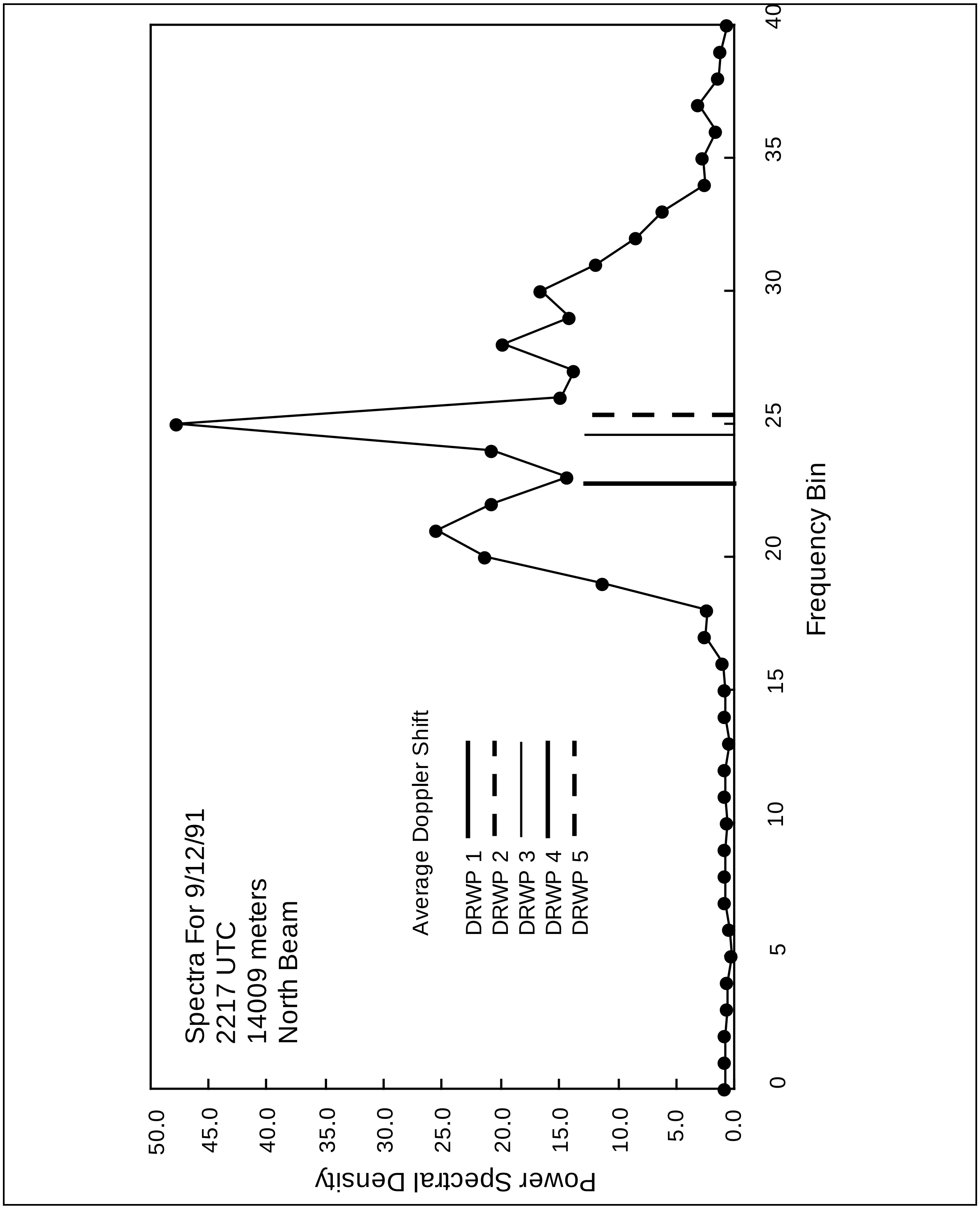


Figure 4.8 North beam spectra from 14009 meter level at 2217 UTC on September 12, 1991.

The spectra displayed in Figure 4.7 illustrate the impacts of varying the minimum acceptable S/N ratio in a weak signal regime. Configurations #1, #2, and #3 all correctly identify the weak signal near frequency bin -3. However, configurations #4 and #5 which have a higher minimum acceptable S/N ratio reject the solution and employ alternative technique in an attempt to increase the S/N ratio. These techniques are not successful and configurations #4 and #5 propagate the first guess velocity which is near frequency bin 0. In this example, the lower minimum acceptable S/N ratio is clearly superior. Other examples similar to this one have been examined. In addition, no cases have been found where the higher minimum acceptable S/N ratio produces a better product.

The spectra displayed in Figure 4.8 illustrate the impacts of varying the first guess window width and the integration window width. In this example, configurations #2, #3, and #5 which have larger first guess window widths and/or integration window widths produce a superior result. However, other cases examined indicate the smaller first guess window width and/or smaller integration window width configurations produce superior results in some instances. More data needs to be examined to resolve this issue.

Key preliminary results are listed below.

- The new wind algorithm produced good results without any modifications to first guess velocity during the 5 hour sample data period.

- There does not appear to be a trend over time in the jimsphere / DRWP RMS differences. This implies the first guess technique does not over-constrain the solution (recall the initial first guess is based on a jimsphere profile) and the profiles produced by the new algorithm do not tend to diverge from the jimsphere profiles.

- The DRWP and jimsphere profiles are coherent to wavelengths as short as 1200 meters.

- The DRWP configurations with the lower minimum acceptable S/N ratio produced superior results.

Although not related to the new wind algorithm and already known within the wind profiling community, there are two aspects of the DRWP which surfaced during the analysis of this data. First, the DRWP has difficulty accurately estimating the wind speed when the speed is near zero for either beam. Second, DRWP has difficulty accurately estimating the wind speed when the signal is weak. These two system deficiencies must be kept in mind when using DRWP profiles.

The preliminary report of the AMU’s meteorological evaluation of NASA’s 50 MHz Doppler Radar Wind Profiler will be written and delivered in November 1992. Following the completion of that report, algorithm evaluation will be resumed. Completion of the algorithm evaluation will include:

- Expanding the current analysis to include additional time periods.
- Comparing profiles produced by the consensus technique and the new wind algorithm.
- Computing first guess velocity propagation percentages.

The evaluation will be completed by February 1993 and the final evaluation report will be written and delivered in March 1993.

2.5. Task 005 Mesoscale Modeling (Dr. Warburton)

Early this quarter, the AMU took delivery of three RISC 6000 systems to be used for the CPU intensive tasks such as mesoscale analysis and forecasting. Much effort was put into properly configuring the computers and networking them with the McIDAS PS-2/80 computer. The AMU configuration is shown in the figure below. The benefits of this arrangement is the AMU can directly access the MIDDS mainframe via PRONET to retrieve data for analysis. While this connectivity is not optimum, it will work for non real time applications. For long term planning, TCP/IP will need to be installed in the McIDAS mainframes to facilitate real time processing and model forecasts.

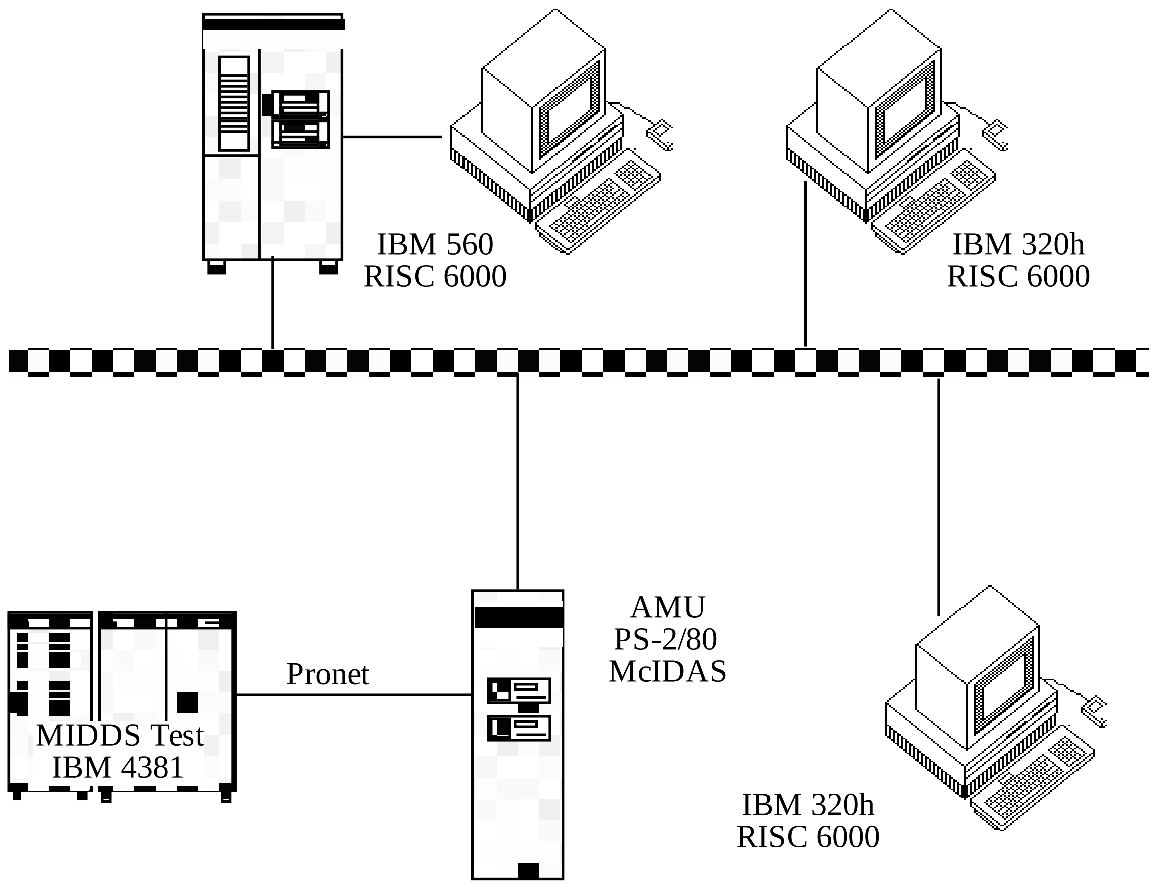
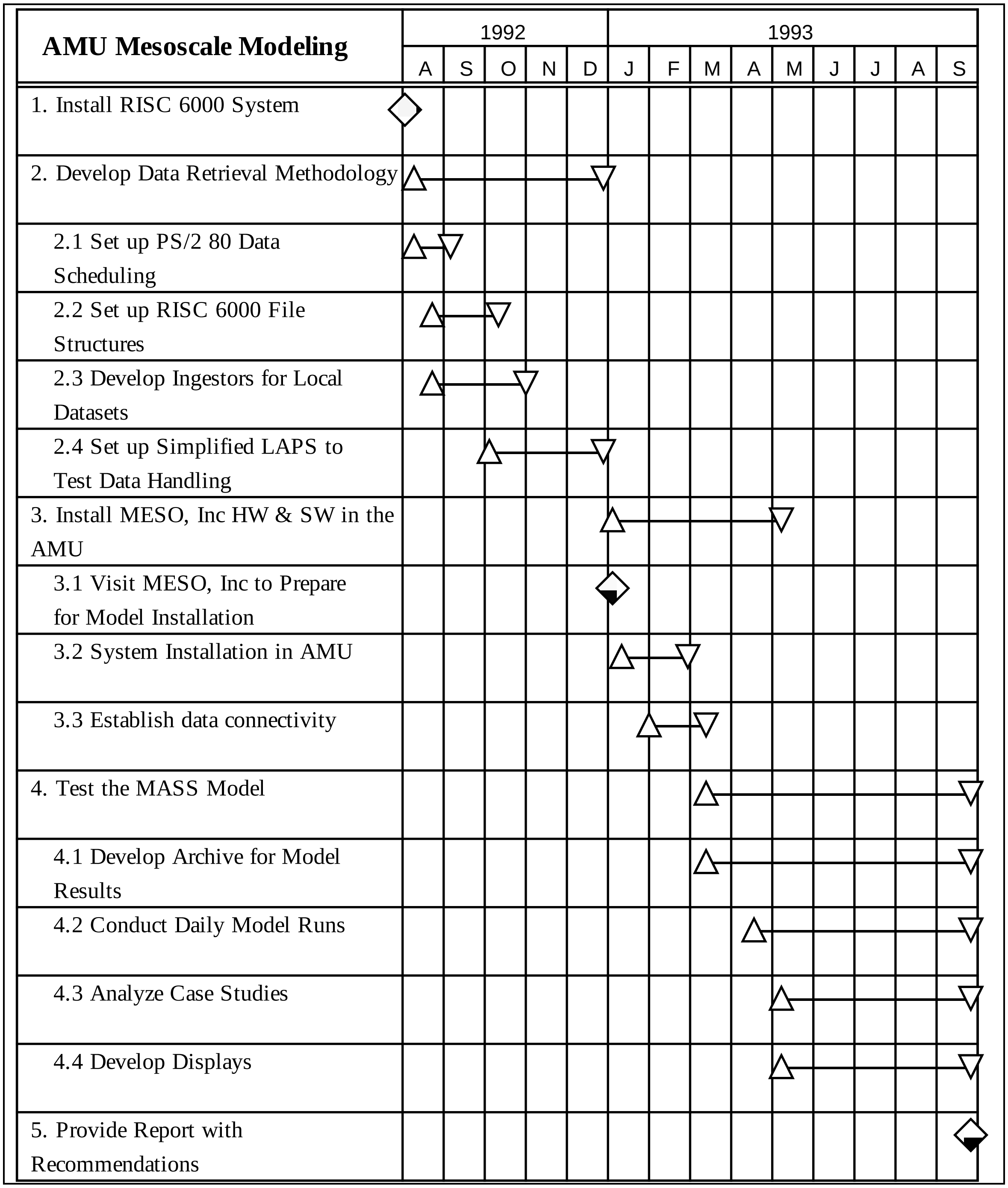


Figure 5.1 AMU Computer Configuration

The schedule for this task is shown below. This task is running slightly ahead of schedule. A map background has been installed on the AMU computers to facilitate viewing LAPS data. The map was derived from the Meteorological And Range Safety Support System and has sufficient detail for viewing data in the vicinity of the Cape area. For larger scale views, we plan to use the mapping capability supplied with NCAR graphics. A MIDDS schedule entry has been designed to move WINDS data from the MIDDS mainframe to the AMU PS-2 and then across the ethernet to the RISC 6000 system. This method works very well for the transfer of relatively small datasets (e.g. 5 minute wind tower update). A data ingest program was then developed to read the tower data and store it in preparation for analysis.



The FAA and Lincoln Lab hosted an open house and demonstration of the low level wind shear, terminal doppler weather radar, and the integration of all the local sensors into a version of the LAPS analysis. Dr. John McGinley of NOAA/ERL Forecast Systems Laboratory was also at the demonstration. The meeting facilitated a discussion of several aspects of the LAPS installation in Orlando and problems we may encounter at the Cape. One problem the Lincoln Lab encountered centered on the ingesting of raw moments data from the WSR-88D in Melbourne. UNISYS was asked to assist and spent considerable effort in trying to resolve problems with the WSR-88D data port. According to Wes Wilson of Lincoln Labs, a permanent solution may be 1-2 years in the future. Accordingly, until WSR-88D data are available, the LAPS installation at the AMU can at most be a Barnes analysis of the local data sources. This problem was addressed at a recent AMU Priorities Meeting held at the AMU and resulted in a lowering of the short term priority for development of the analysis capability.

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 was charted for the first year and the AMU has continued on that course. A meeting to set new AMU priorities was held on 8-9 October 92. As a result of that meeting, AMU priorities and tasks will be shifted over the next 30 to 60 days.

3.1. Short Range Goals for FY-92

- 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 Goals Identified in FY-92

- 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 FY-92 Tasks

(To be revised for FY-93)

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.