Applied Meteorology Unit (AMU)

Quarterly Update Report

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ENSCO, Inc.

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

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1. Background

The AMU has been in operation since September 1991. A brief description of the current tasks is contained within Attachment 1 to 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. Taylor)

Development of Forecaster Applications (Mr. Wheeler)

The AMU requested and received from the National Severe Storm Forecast Center (NSFFC) their Man Computer Interactive Data Access System (McIDAS) keyboard handler, a friendlier user interface for McIDAS. The AMU will evaluate it next quarter.

The AMU has also begun development of an F-Key Menu system to facilitate the recall and display of text data. After the menu system is developed, it will be demonstrated to the CCFF and forwarded to SMG for their review, comments and suggestions. After comments are received from CCFF and SMG, the menu system will be modified and distributed to both facilities for operational use.

AMU Workstations and Equipment Racks

By mid March all AMU computer and communications equipment was installed and operating in the new racks and consoles provided by the Air Force. Harris Corporation also completed their work installing new communication lines and telephones for the AMU laboratory and personnel workstations. The AMU facilities are now better organized and the environment is more conducive to productive work.

2.2. Task 002 Training (Dr. Taylor)

In March, Ms. Schumann attended NeuralWare's Advanced Neural Network Application training class in Pittsburgh. The class was well organized and provided much information about implementing artificial neural networks to solve specific problems. The details regarding how a network is implemented (i.e., what the inputs are, how they are scaled, etc.) are usually omitted from the neural network literature making this class very useful and worthwhile.

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

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

The AMU received comments and suggestions from the AMU's draft Two Tenths Cloud Cover Report distributed in late November 1992. In response to these suggestions, several modifications have been made to the report. Some modifications required additional statistical analyses of the differences in frequencies of weather violations subsequent to 0.2 and 0.3 initial cloud cover conditions for several categories. Following final review, the report will be published as a NASA contractor report and delivered to all interested organizations. The major modifications are discussed below.

Evaluation of Two-Tenths Cloud Cover Rule

One of the primary goals of this study was to determine the validity of the 0.2 cloud cover rule for all stratifications of the data (i.e., seasons, months, time of day, wind direction, etc.). To address this question, analyses focused on comparing the percent of observed weather violations one and two hours subsequent to initial conditions of 0.2 and 0.3 cloud cover below 10,000 feet at X68. These comparisons were performed by using chi-square tests for homogeneity to determine if the percent of weather violations subsequent to the two different initial conditions were the same.

Statistical tests were performed on the proportions of weather violations one and two hours subsequent to initial conditions of 0.2 and 0.3 cloud cover for all data categorizations (i.e., seasons, months, time of day, daytime only, surface and upper-air wind direction). For the majority of these data categorizations 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. However, for the following categories:

- May,
- October,
- 700 mb northerly wind,
- 1500 UTC, and
- 1600 UTC,

there is evidence the proportions of weather violations subsequent to 0.2 and 0.3 initial cloud cover may not be significantly different. Thus, there is some evidence the 0.2 rule may be overly conservative for these five categories. Additional investigation is required to determine whether or not the proportions of weather violations for these five categories are significant, and therefore, whether or not the 0.2 cloud cover rule should be relaxed to 0.3 for any of the five categories.

If the rule changes were made, the question then arises, "*How many more landing opportunities will occur for KSC landings?*". To answer this question, a comparison of landing opportunities (i.e., no weather constraint violations) using both a 0.2 and 0.3 cloud cover rule is shown in Table 1. The current 0.2 rule assumes landing opportunities for initial cloud cover of 0.0 to 0.2 while a 0.3 rule would mean landing opportunities for initial cloud cover of 0.0 to 0.3. Changing to a 0.3 cloud cover rule for each of these categories will increase the number of landing opportunity hours by approximately 60-70 hours per year per category. The largest increase in hourly opportunities occurs during

May with about 80 hours per year. Even though the increases in the numbers of hours are not large, they could result in additional landings opportunities at the SLF.

Development of Nomograms

To assist SMG and CCFF forecasters, nomograms have been developed for use by forecasters in making cloud cover forecast for EOM and RTLS at KSC. The nomograms have been developed from analysis of the observed weather conditions one and two hours subsequent to initial conditions. These nomograms display the percent occurrence of ceiling and precipitation weather violations for a given initial cloud cover by month and groups of hours. An example of a nomogram for 0.2 initial cloud cover (based on ceiling and precipitation violations only) is shown in Table 1.

TABLE 1. WEATHER VIOLATIONS FOR T=0.2 Initial Cloud Cover

TIME (UTC)		0900-1400		1500-2000		2100-0200		0300-0800	
HOURS FROM T		T+1	T+2	T+1	T+2	T+1	T+2	T+1	T+2
(Month)	# of Events	65	63	85	85	94	92	58	58
January	% Violation	11	14	5	9	1	2	14	17
	# of Events	36	34	95	96	83	82	48	47
February	% Violation	6	24	4	6	4	4	6	19
	# of Events	86	85	114	113	105	106	81	80
March	% Violation	10	19	0	2	2	6	1	9
	# of Events	65	63	85	83	77	77	67	67
April	% Violation	6	14	1	5	4	6	4	7
	# of Events	107	107	177	177	156	158	112	109
May	% Violation	4	8	2	4	3	6	4	6
	# of Events	161	159	181	181	177	176	131	127
June	% Violation	4	8	6	12	4	6	2	6
	# of Events	133	132	239	238	181	181	88	87
July	% Violation	3	3	3	10	4	6	7	3
	# of Events	139	139	249	249	188	188	85	85
August	% Violation	1	4	5	8	4	5	4	5
	# of Events	192	191	206	209	200	200	172	171
September	% Violation	3	5	2	4	2	4	3	7
	# of Events	104	100	121	122	152	152	99	96
October	% Violation	6	12	5	7	4	8	5	10
	# of Events	81	80	123	123	124	121	64	63
November	% Violation	4	9	2	5	0	4	8	16
	# of Events	75	75	126	124	85	84	55	54
December	% Violation	3	11	2	6	5	7	13	24

Two Tenths Cloud Cover Data Base

During February and March the AMU began updating the two tenths cloud cover data base for the period January 1991 to December 1992 by including the following:

- Hourly estimates of tenths of cloud cover below 10,000 feet at the SLF (X68).

- X68 hourly surface observations, and
- Cape Canaveral Air Force Station (CCAFS) rawinsonde data.

The tenths of cloud cover below 10,000 feet were obtained by analyzing surface weather forms 10a and 10b for both 1991 and 1992. Since forms 10a and 10b were not available for September 1991, cloud cover amounts have not been determined for this month. These forms are being ordered from the National Climatic Data Center (NCDC) and the cloud information will be added to the data base.

Rawinsonde data were obtained for the period January 1991 and to December 1992 from Computer Sciences Raytheon (CSR). The data were converted from the archived format to a SAS readable format on the IBM RISC/6000. During the conversion process the data were checked for duplicate and missing records. Once this was accomplished, the data were appended to the existing upper-air data base.

X68 hourly observations for 1991 and 1992 obtained from NCDC contained some missing data. Once this problem is resolved, the remainder of the hourly observations for this period will be appended to the data base.

Wintertime Northeast Flow Case Study

Northeasterly flow cases along the east coast of Florida pose many weather problems for launches and landings at the Kennedy Space Center (KSC). Among these problems are low-level stratocumulus ceilings, showers, and cross-wind violations for Space Transportation System (STS) landings. On 9 December 1992 a relatively weak easterly flow case occurred at KSC with bands of stratocumulus clouds advecting from the Atlantic Ocean. This case was characterized by relatively stable conditions with a very strong low-level inversion near 850 mb. Because of the low-level hydrostatic stability, several tools could be successfully employed to forecast the movement of cloud bands from the Atlantic Ocean. These tools could also be used for other similar easterly flow cases.

The primary forecast challenge on 9 December 1992 was to predict the movement of stratocumulus cloud bands and to determine whether there would be any development between the bands. The AMU has demonstrated two forecast techniques which successfully forecast the movement of these cloud bands. The first technique, a simple extrapolation procedure, predicts the future location of the individual cloud bands by estimating cloud movement from previous satellite images and extrapolating this motion into the future. The second method is based on the Meteorological Interactive Data Display System (MIDDS) program “TRNIMG”. This function translates pixels of any given image at a specified direction and movement. Both techniques worked well in this case because of several factors:

- This event was characterized by hydrostatically stable conditions with a very strong capping inversion around 5000 feet. This prevented any significant vertical development of the clouds.

- The air mass flowing over the warm Atlantic ocean was not very cold relative to the ocean surface temperatures. Consequently, the low-levels of the atmosphere did not destabilize as the air moved across the ocean trajectory.

- The stratocumulus clouds were organized in well-developed bands perpendicular to the flow. There was also very little development between these bands.

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

During this quarter the AMU has been revising the preliminary report on Analysis of Rapidly Developing Fog at the Kennedy Space Center based on comments and suggestions regarding the first draft of the report. The revised report should be completed and distributed next quarter. Key information from the preliminary report is presented below.

Table 2 presents key aspects of each of the fog events included in this analysis. Although only 36 events over a 5-year period were analyzed, some important trends in fog formation were noted. The fog events fell into three categories: advection, pre-frontal, and radiation. Category definitions are listed in Table 3.

The typical advection fog event is characterized by fog developing west of X68, sometimes over to Orlando or north toward the Daytona Beach area and generally north of a surface ridge line. The surface wind directions reported by the tower network are generally westerly, 180-360° and, in time, gradually veer to a more northwesterly direction prior to the fog moving into X68.

Pre-frontal fog events are very similar to the advection fog events. A pre-frontal event is characterized by a slight veering in the surface winds from southwest to west-northwest as the front moves closer to X68. In many of the events, a weak surface ridge moves south of the Cape Canaveral area several hours before the fog moves into X68.

Radiation fog generally forms near sunrise (the time of occurrence of the two radiation fog events in the study are 1141 UTC and 1248 UTC). Surface winds are typically light (3 to 5 knots) and variable. If the speed is at or above 3 knots the direction is generally from 180° to 360°. The Cape Canaveral or Tampa rawinsonde data typically indicate low level moisture (at or below 900 mb) and dry air aloft.

Some general statements on fog formation (i.e., moisture distribution, low leveling mixing, etc.) are also included in this report for those unfamiliar with fog development.

Advection and pre-frontal fog events have similar basic characteristics and are generally associated with:

- The advection of fog into the X68 area from the west.

- Moist environments (dew point depression of 3° C or less) at and below 900 mb on the Cape Canaveral rawinsonde.

- X68 surface and the local tower wind directions generally from 180° to 360°.

The main differences between advection and pre-frontal fog events are:

- Moisture above 850

    - Prefrontal fog conditions may be moist (temperature - dew point spread of 3° C or less) above the low levels due to the advection of clouds ahead of the front.

    - Advection fog is generally associated with dry conditions (temperature - dew point spread of 5° C or more) above 850 mb.

- Fog development area

    - Advection fog development area is just west of X68 (the St. Johns river basin); at times can be further to the west or north, in the Orlando and/or Daytona Beach areas.

    - Prefrontal fog, depending upon the frontal position at the time of formation, will form northwest of X68. Depending upon the frontal position, the fog formation area may be near Orlando and/or Daytona Beach for some events.

Table 2 Individual Fog Case Data

Date	Type of fog	Fog West Prior to X68 Onset	Hrs Prior to X68 Onset	Fog/ Stratus	X68 Fog Onset Time (UTC)	Fog Break-up Time (UTC)	NW wind shift at Towers	Prevail Wind Direction	Prevail Wind Speed (kts)	Inversion Strength (°C)
7-Feb-86	P	yes	2	F/S	1009	1825	yes	210	7	4
25-May-86	A	no	0	F	0834	1208	yes	280	2	6
7-Sep-86	P	yes	3	F/S	0719	1450	no	230	4	1
15-Nov-86	P	yes	1	F/S	0707	2255	yes	310	5	3
18-Nov-86	A	yes	2	F/S	0913	1314	yes	300	2	*3
20-Dec-86	A	yes	1	F/S	1109	1555	yes	220	3	3.5
24-Apr-87	P	yes	3	F/S	1025	1345	no data	240	5	*3
27-Oct-87	P	yes	1	F/S	0648	1338	yes	270	4	1
28-Nov-87	A	yes	1	F/S	0634	1430	no	340	3	*1.5
27-Dec-87	A	yes	2	F	0809	1407	yes	320	2	8
17-Feb-88	A	yes	2	F	1028	1245	no	340	4	11
1-Mar-88	A	yes	2	F/S	0742	1542	yes	280	9	*4
6-Apr-88	P	no	0	F	0500	1140	yes	180	3	11
24-Apr-88	A	yes	2	F/S	0932	1318	no	200	4	2
15-Jul-88	A	yes	2	F/S	0907	1318	no	240	5	*1.5
4-Oct-88	P	yes	2	F/S	0807	1200	yes	260	4	1.5
9-Dec-88	A	yes	1	F	0918	1430	no	310	1	9
11-Jan-89	P	yes	2	F/S	0500	1408	no	350	6	0
8-Feb-89	P	yes	2	F/S	1203	1539	yes	260	1	1
13-Mar-89	A	yes	2	F/S	1011	1410	yes	250	6	6
14-Mar-89	A	yes	1	F/S	0740	1710	no	250	6	*6
9-Apr-89	P	yes	1	F/S	0943	1423	no	210	4	5
27-Apr-89	A	yes	1	F	0905	1236	yes	0	0	*4
17-May-89	P	no	0	F/S	0546	1249	yes	250	1	5
2-Sep-89	A	yes	3	F	0950	1115	yes	240	1	4
15-Oct-89	A	no	0	F/S	0523	1420	yes	320	2	2
30-Oct-89	P	yes	2	F/S	0850	1540	no	340	6	0
22-Nov-89	A	yes	1	F/S	0813	1710	yes	290	7	*4
27-Dec-89	R	yes	1	F/S	1141	1530	yes	280	3	6
1-Jan-90	P	yes	3	F/S	0906	1215	yes	210	8	*12
7-Jan-90	A	yes	2	F/S	0718	1640	yes	40	2	3
21-Jan-90	A	yes	1	F/S	0916	1550	yes	270	3	4
10-Feb-90	R	no	0	F/S	1248	1401	no	200	8	0
29-Apr-90	A	yes	3	F/S	0910	1423	yes	220	5	3
16-Dec-90	A	yes	1	F	0524	1330	yes	250	1	7
23-Dec-90	A	no	0	F	0930	1337	yes	220	2	5

P = Prefrontal Fog
R = Radiation Fog
A = Advection Fog

F = Fog
S = Stratus
* Subsidence Inversion

Table 3 Fog Classification

Classification	Criteria	Description
Advection (21 events)	Weak high pressure over Florida. Surface ridge axis needs to be south of X68. Sounding is moist below 900 mb and dry above 850 mb. Fog develops west of X68 (St. Johns River valley - Orlando - Daytona Beach) first. Prevailing surface wind direction is 180° - 360° and local tower data shows a NW shift. Tower 313, 6 to 492 ft inversion of 3 to 5 °F.	Fog forms west of X68 (St. John River valley - Orlando - Daytona Beach) first, generally to the north of a surface ridge line (1 - 2 hours). Local tower data shows a westerly wind component (180° - 360°) and in time the data will show a shift to a more northwesterly component prior to the fog moving into X68.
Pre-Frontal (13 events)	Presence of a moving frontal boundary, Florida panhandle to X68. The front will pass through X68 during the fog event day. X68 sounding is moist below 900 mb and may have moisture above. Weak surface pressure gradient ahead of front.	Fog occurs ahead of front. First indications are reports of fog west of X68, (Orlando and/or Daytona Beach) and the KSC/CCAFS wind tower data will report a westerly wind component (180° - 360°) at 54 feet.
Radiation (2 events)	Sounding has low level moisture (900 mb and below) and will be dry aloft (above 850 mb). Fog occurs at or near sunrise. Surface winds will be light. Land breeze may develop, (240° - 340°) on local towers just prior to fog development. Some central Florida stations may report 4 to 6 miles visibility due to fog.	Fog forms near sunrise and becomes more dense with initial heating and mixing of the lower atmosphere. Surface winds are light and variable, from 180° - 360° for speeds above 3 knots.

Key similarities and differences between the fog types are illustrated in Table 4.

The Fog Stability Index (FSI) developed by the Air Weather Service was modified for use in the Cape Canaveral area. Using the equations in the Air Weather Service Forecaster Memo 90/001, the FSI was computed for all 36 fog events. The FSI uses several parameters to assess the likelihood of radiation fog development. According to the guidelines provided in the report (see Risk of Fog Formation below), all 36 fog events were associated with a moderate to high risk for fog development. The FSI formula is:

$$FSI = 4 * T_s - 2 * (T_{850} + T_{ds}) + W_{850}$$

where T_s = surface temperature in °C,

T_{850} = temperature at 850 mb in °C,

T_{ds} = surface dew point in °C, and

W_{850} = 850 mb wind speed in knots.

The Air Weather Service memorandum lists the following guidelines for radiation fog forecasting:

Calculated FSI Value	**Risk of Fog Formation**
> 55	Low
31 - 55	Moderate
< 31	High

Table 4 Fog Type Characteristics

Fog Characteristic	Advection	Pre-Frontal	Radiation
Moist (Dew point depression < 3° C) below 900 mb	√	√	√
Dry (Dew point spread > 5° C) above 850 mb	√		√
Frontal system in area		√	
Surface dew point depression spread of 0-3°F	√	√	√
Local wind towers indicate direction from 180-360° (tower data)	√	√	
Advects from west	√	√	

The FSI formula is limited because it can only be updated with a new rawinsonde sounding. Generally, there are three soundings per day during the week and only one or two per day during the weekends at Cape Canaveral. This means a FSI estimate could be computed around 1200, 1600 and 2300 UTC on a typical day. KSC/CCAFS has additional higher temporal resolution information on the stability and moisture distribution of the lower atmosphere (Tower 313 has sensors from 54 to 492 feet). This investigation concluded that atmospheric conditions in the lower 500 feet of the atmosphere are closely related to fog formation potential. Consequently, the AMU developed a new Fog Susceptibility Index (FSI313) using data from tower 313. This index can be computed or updated at least hourly giving the forecaster additional insight into both the fog potential and the change in fog potential.

The new FSI (FSI313) formula is based on replacing the 850 mb data with the temperature and wind speed from the 492 foot sensor on tower 313. This allows the forecaster to update the FSI313 with every new X68 observation or every hour. The forecaster could also compute a new FSI313 every 5 minutes based on new tower data and the hourly X68 observation. The FSI313 formula is:

$$FSI313 = 4 * T_s - 2 * (T_{313} + T_{ds}) + W_{313}$$

where T_s = X68 surface temperature in °C,

T_{313} = temperature from tower 313 at 492 feet in °C,

T_{ds} = X68 surface dew point in °C, and

W_{313} = wind speed in knots from tower 313 at 492 feet.

During the 1992 - 1993 fog season (December 1992 through late April 1993) the FSI and FSI313 is being routinely computed. The two data sets will be analyzed and compared and the results of this analysis incorporated into the final fog evaluation report. If the indices prove valuable, they will be transitioned to the operational forecast units along with recommendations for their use.

The following paragraphs present the results of preliminary analyses of the FSI and the FSI313. Since rawinsonde data from the evening prior to the fog event was not always available, the FSI was computed using the 1200 UTC rawinsonde data from the morning of the fog event along with the surface observation from X68 at the time of fog onset. The FSI313 was computed using data from tower 313 and the X68 surface observation at the time of fog onset.

The relationship between the FSI and the FSI313 for 27 of the 36 fog events is presented in Figure 1. The FSI estimates for all events were in the moderate to high risk range. Furthermore, 26 of the 36 events were in the high risk category. Nine of the fog events were not included in this analysis because not all the data necessary to compute the FSI and the corresponding FSI313 were available. Although certainly not a perfect linear relationship, the graph does indicate some correlation between the two indices. Consequently, regression analysis was employed to test the significance of the correlation between the two fog indices.

The regression analysis indicated a coefficient of determination (r^2, the ratio of explained variance to total variance) of 0.35 between the two indices which, based on the degrees of freedom, is a statistically significant correlation for $\alpha = 0.01$. The degree of correlation increased ($r^2 = 0.50$, statistically significant at $\alpha = 0.01$) if one outlier is removed from the analysis. Based on this correlation, the FSI313 may prove to be a valuable forecast tool and further investigation is warranted. The two events with high FSI estimates were examined. In both instances, strong winds at 850 mb level were responsible for the large FSI estimates. As stated earlier, one important outcome from the two events is that significant fog can develop at X68 in the presence of strong winds at the 850 mb level. This is permitted by a decoupling of the surface and the planetary boundary layer winds as a stronger inversion forms.

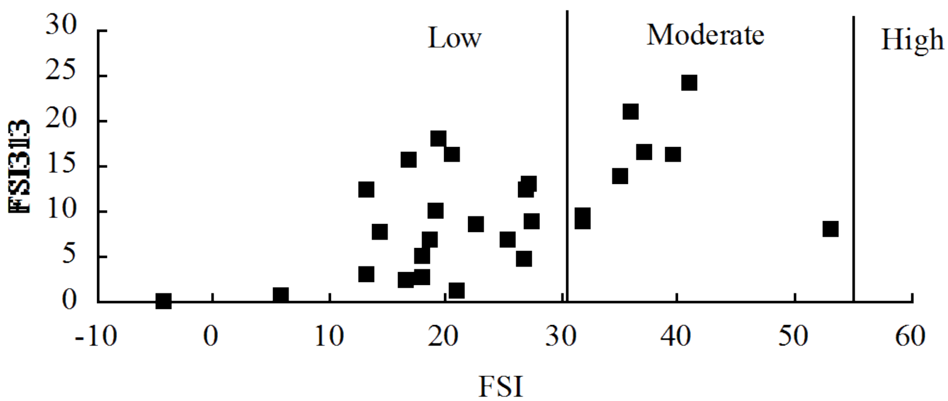


Figure 1. Scatter diagram of the calculated FSI313 versus FSI for 27 fog events.

As part of the fog study, the AMU developed fog forecasting tools to improve forecasters' skill. The AMU is currently testing and revising these tools and will document the results in a final report to be completed in summer 1993. One further enhancement the AMU plans on developing is using NGM point analysis data to forecast the FSI through the 48 hour NGM model period. This will give the forecaster a value to use and track in forecasting the potential for fog development at X68.

It is important to acknowledge that all the data analyzed thus far are associated with fog events. Consequently, the precursors identified in this study have not been subject to a false alarm evaluation. As part of the completion of this investigation, X68 surface data will be examined to determine how often the precursors are present when fog does not develop. Undoubtedly, this will lead to a refinement of the precursors and information about the false alarm ratio of the precursors. The results of the investigation will be included in the final report.

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

Implementation of MSFC DRWP Wind Algorithm

The major emphasis this quarter was to improve the timing performance of the new software. Initial timing tests performed immediately after the wind algorithm software was installed on the wind profiler's MicroVAX indicated the new wind algorithm implementation would just barely be able to support the required 5-minute cycle time and would not support the standard 3-minute cycle time for 3 mode operation or the 6 minute cycle time for 6 mode operation.

In order to improve the timing performance of the system, the AMU modified the format of the files output by the system to improve input/output processing, which is often a bottle neck in near real-time systems. The AMU also completely overhauled the interprocess communications scheme with some assistance from DEC technical support. Both modifications resulted in significant time savings, and the software is now able to easily support the required 5 minute cycle time for 3 mode operation.

Internal testing of the system is near completion and several minor modifications have been made to correct errors discovered during the tests. Dry run testing of the formal test procedures will be performed during April and formal testing will be performed in May.

The Software Requirements Specification for the New Wind Algorithm in NASA's 50 MHz Doppler Wind Profiler has been completed and will be distributed in late April. The first draft of the Test Procedures for the New Wind Algorithm in NASA's 50 MHz Doppler Wind Profiler has been completed and is currently in internal review. The final test procedures will be delivered after completion of internal dry run of the formal test procedures.

DRWP Meteorological Evaluation

The meteorological evaluation of the MSFC wind algorithm is nearing completion. All of the analyses have been performed and interpretation of the results is currently underway. The data analyzed includes 16 hours of profiler data from three different time periods. The data set contains:

- 5 hours of profiler data from 12 September 1991.
- 5.5 hours of profiler data from 23 January 1992.
- 5.5 hours of profiler data from 20 February 1992.

Using the 16 hours of profiler data, wind profiles were produced using five different configurations (Table 5) of the MSFC wind algorithm. For each configuration, 256 wind profiles were produced for a total of 1280 wind profiles. A subset of these wind profiles have been inter-compared to determine the optimum configuration of the MSFC wind algorithm parameters for operational use. In addition to the inter-comparisons, the MSFC wind algorithm profiles have been compared to 34 time proximate consensus averaged DRWP wind profiles and 11 time proximate jimsphere profiles. In order to compare the DRWP and jimsphere profiles, the jimsphere data were interpolated to the DRWP profile reporting levels.

Table 5 DRWP Configurations

Configuration Number	First Guess Window Width (Frequency Bin #)	Integration Window Width (Frequency Bin #)	Minimum S/N Ratio (dB)
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

A representative sample of the results from each of the three time periods is presented below. Only wind profiles produced using DRWP configuration number 3 (Table 5) are included in this report.

One set of time proximate jimsphere, consensus averaged DRWP, and MSFC wind algorithm DRWP profiles from 12 September 1991 is presented in Figures 2 and 3. The large scale features present in the three profiles are very similar; however, the small scale features exhibit considerable differences particularly between the two DRWP profiles and the jimsphere profile. The differences in the small scale features are not surprising in light of the spatial and temporal differences in the data collection between the jimsphere and the DRWP.

The relatively large east beam velocity shear zones between 6 km and 9 km and between 14 km and 15 km are described similarly by all three profiles. The same is true of the relatively large north beam velocity shear zone from 13 km to 15 km. The major difference among the profiles occurs in the east beam velocities between 9 km and 14 km. The differences at these altitudes may be due to the spatial separation between the jimsphere balloon and the DRWP.

The degree of correlation between the jimsphere profile and the MSFC wind algorithm DRWP profile was quantified by coherency analysis (Figure 4). The data in Figure 4 indicate both components of the two profiles are highly coherent (i.e., coherency squared values of ~ 0.7 or greater) to wavelengths as short as 1200 meters (i.e., wave number equal to 5×10^{-3} where wave number = 2π / wavelength). At shorter wavelengths, the coherence of both components is generally less. This is expected in light of the data collection differences between the jimsphere and the DRWP.

The RMS velocity differences between the MSFC wind algorithm DRWP profiles and the jimsphere profiles for 12 September 1991 are contained in Table 6. When evaluating the magnitude of the RMS velocity differences, it is important to note the temporal and spatial differences in data collection between the jimsphere and the DRWP. The sampling period of the DRWP is three to five minutes and the volume of air sampled is almost directly above the antenna field. In contrast, the jimsphere sampling period is of the order of 45 minutes and the balloon travels downwind as it rises. Thus, in addition to a relatively long sampling period, the jimsphere is likely to be sampling air many kilometers downwind from the release site at higher altitudes. Because of the sampling differences between the two systems, RMS velocity differences between two jimsphere profiles separated by 50 minutes were computed to provide a reference measure to facilitate evaluation of the RMS velocity differences between the MSFC wind algorithm DRWP profiles and the jimsphere profiles.

RMS velocity differences between two jimsphere profiles from 12 September 1991 separated by 50 minutes are approximately 1.7 meters per second, which is very similar to the magnitude of the RMS velocity differences between the MSFC wind algorithm DRWP profiles and the jimsphere profiles (see Table 6). Consequently, the magnitude of the RMS velocity differences between the MSFC wind algorithm DRWP profiles and the jimsphere profiles appear reasonable and suggest the two systems are providing similar quality data.

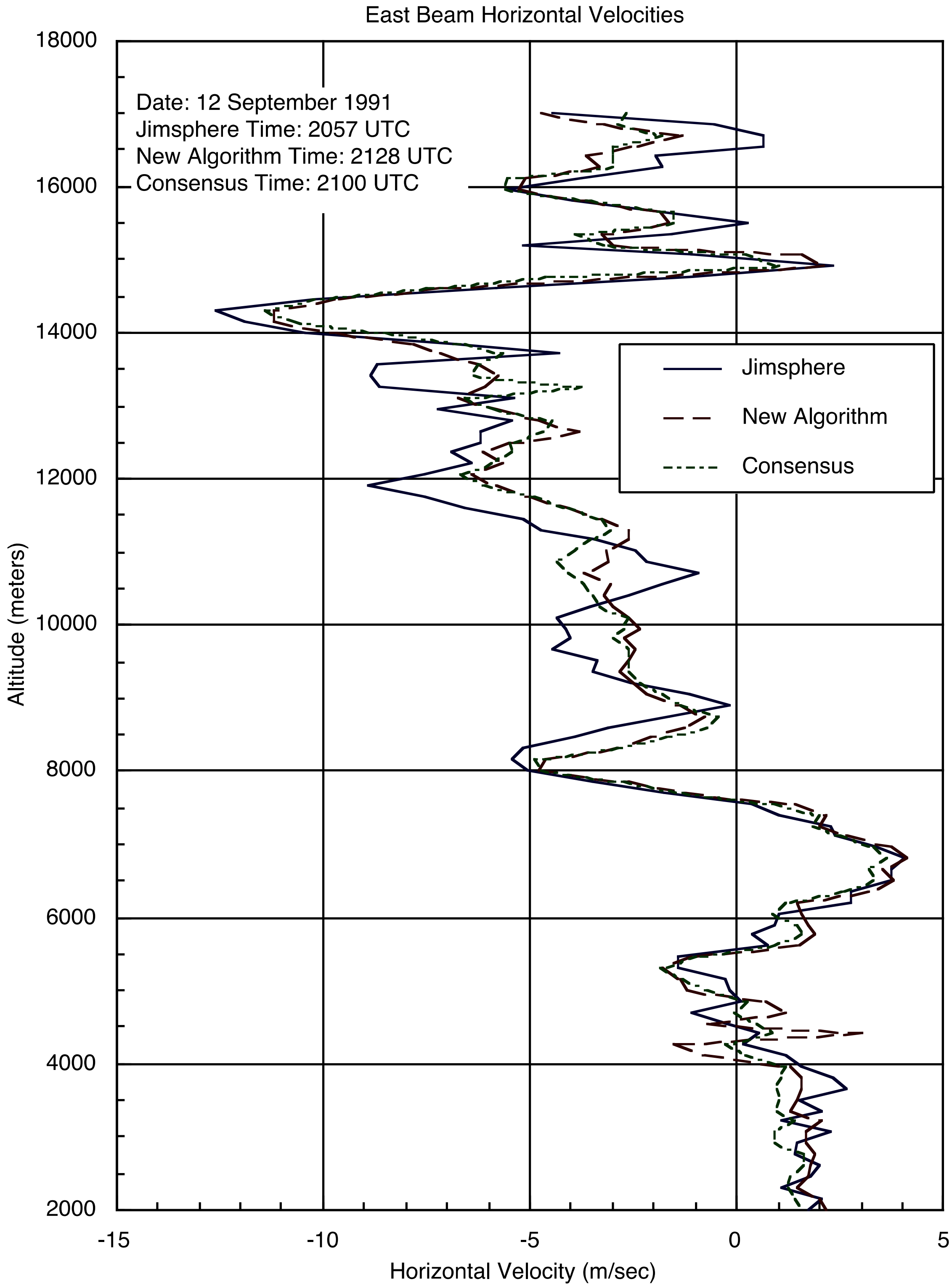


Figure 2. East beam velocities for 12 September 1991. MSFC wind algorithm DRWP profile is identified as new algorithm profile.

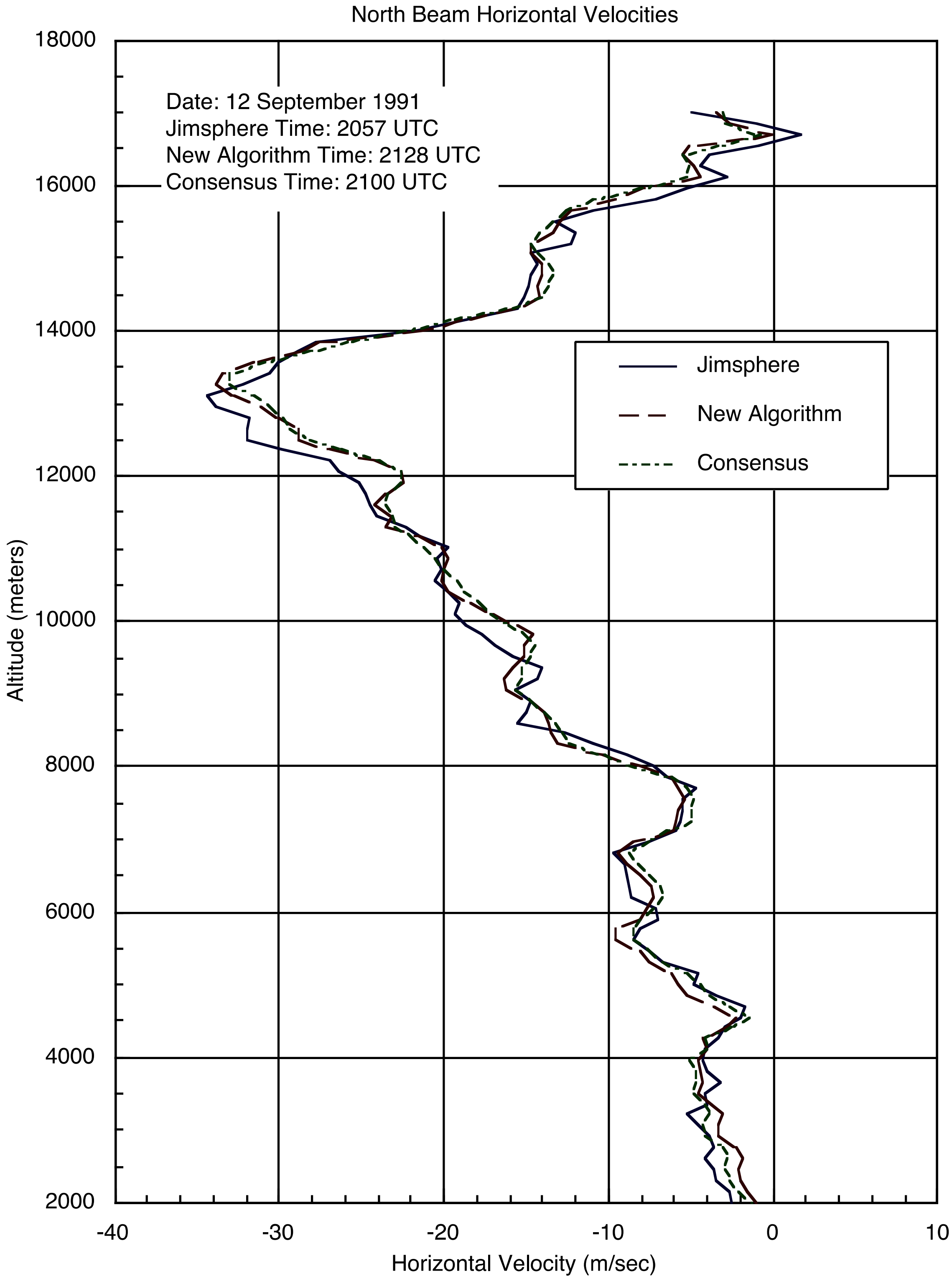


Figure 3. North beam velocities for 12 September 1991. MSFC wind algorithm DRWP profile is identified as new algorithm profile.

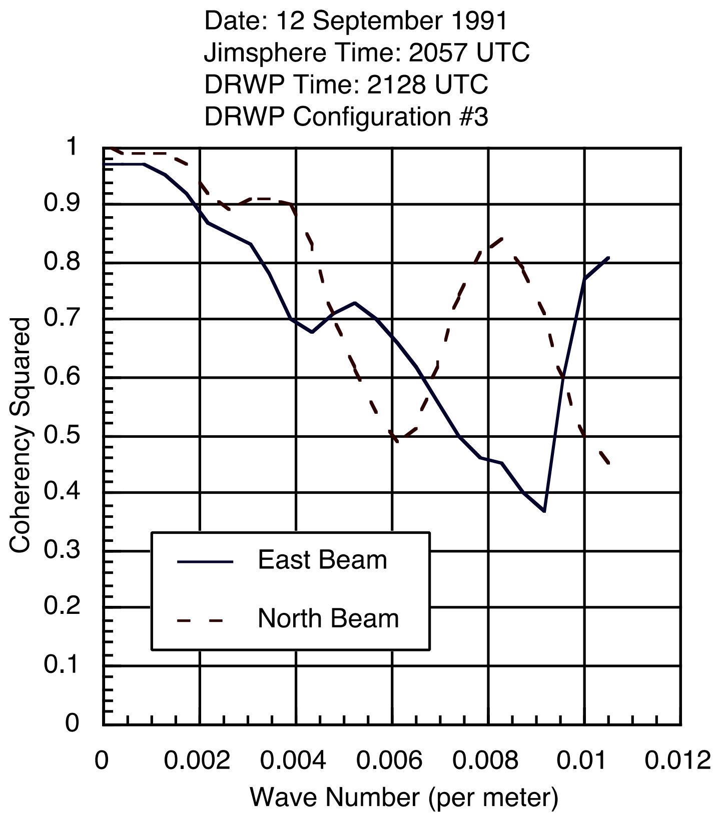


Figure 4. Coherency analysis for jimsphere and MSFC wind algorithm DRWP profiles for 12 September 1991.

Table 6 Jimsphere And MSFC Wind Algorithm DRWP Velocity Comparisons For 12 September 1991

Jimsphere Profile Time (UTC)	MSFC Algorithm Profile Time* (UTC)	RMS Differences East Beam (m/sec)	RMS Differences North Beam (m/sec)
1842	1912	1.47	1.56
2009	2038	1.79	1.56
2057	2128	1.42	1.54
2147	2217	1.78	1.89
2326	2358	1.60	1.39

* The MSFC wind algorithm DRWP profiles were generated using configuration #3.

The RMS velocity differences between the MSFC wind algorithm DRWP profiles and the consensus averaged DRWP profiles for 12 September 1991 are contained in Table 7. The RMS differences in Table 7, which are typically of the order of .75 meters per second, are less than the RMS velocity differences between two MSFC wind algorithm DRWP profiles from 12 September 1991 separated by 30 minutes which are approximately 1.3 meters per second. This indicates the profiles produced by the MSFC wind algorithm are comparable to the consensus averaged wind profiles. In this particular case, the main advantage of the MSFC wind algorithm is the time resolution. The update rate of the consensus averaged profiles is 30 minutes. Conversely, the update rate of the MSFC wind algorithm is 3 minutes.

Table 7 Consensus Averaged And MSFC Wind Algorithm DRWP Velocity Comparisons For 12 September 1991

Consensus Profile Time (UTC)	MSFC Algorithm Profile Time* (UTC)	RMS Differences East Beam (m/sec)	RMS Differences North Beam (m/sec)
1900	1915	0.79	0.57
1930	1946	0.87	0.71
2000	2015	0.87	0.71
2030	2044	0.80	0.80
2100	2116	0.70	0.63
2130	2145	0.72	0.85
2200	2214	0.76	0.76
2230	2246	0.72	0.59
2300	2314	0.91	0.81
2300	2346	0.51	0.40

* The MSFC wind algorithm DRWP profiles were generated using configuration #3.

One set of time proximate jimsphere, consensus averaged DRWP, and MSFC wind algorithm DRWP profiles from 23 January 1992 is presented in Figures 5 and 6. The large scale features present in the three profiles are very similar; however, the small scale features represented by the three profiles exhibit notable differences.

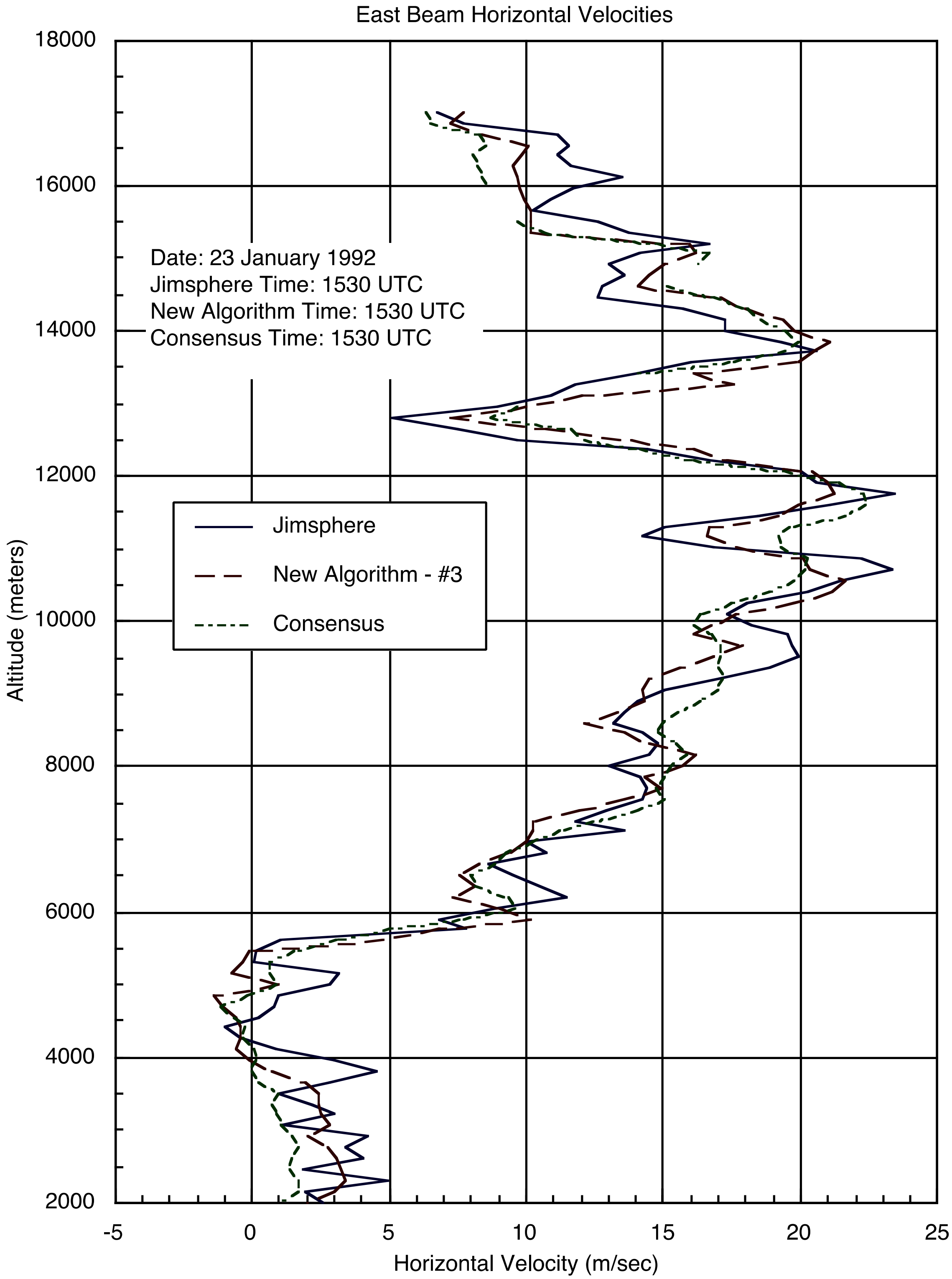


Figure 5. East beam velocities for 23 January 1992. MSFC wind algorithm DRWP profile is identified as new algorithm profile.

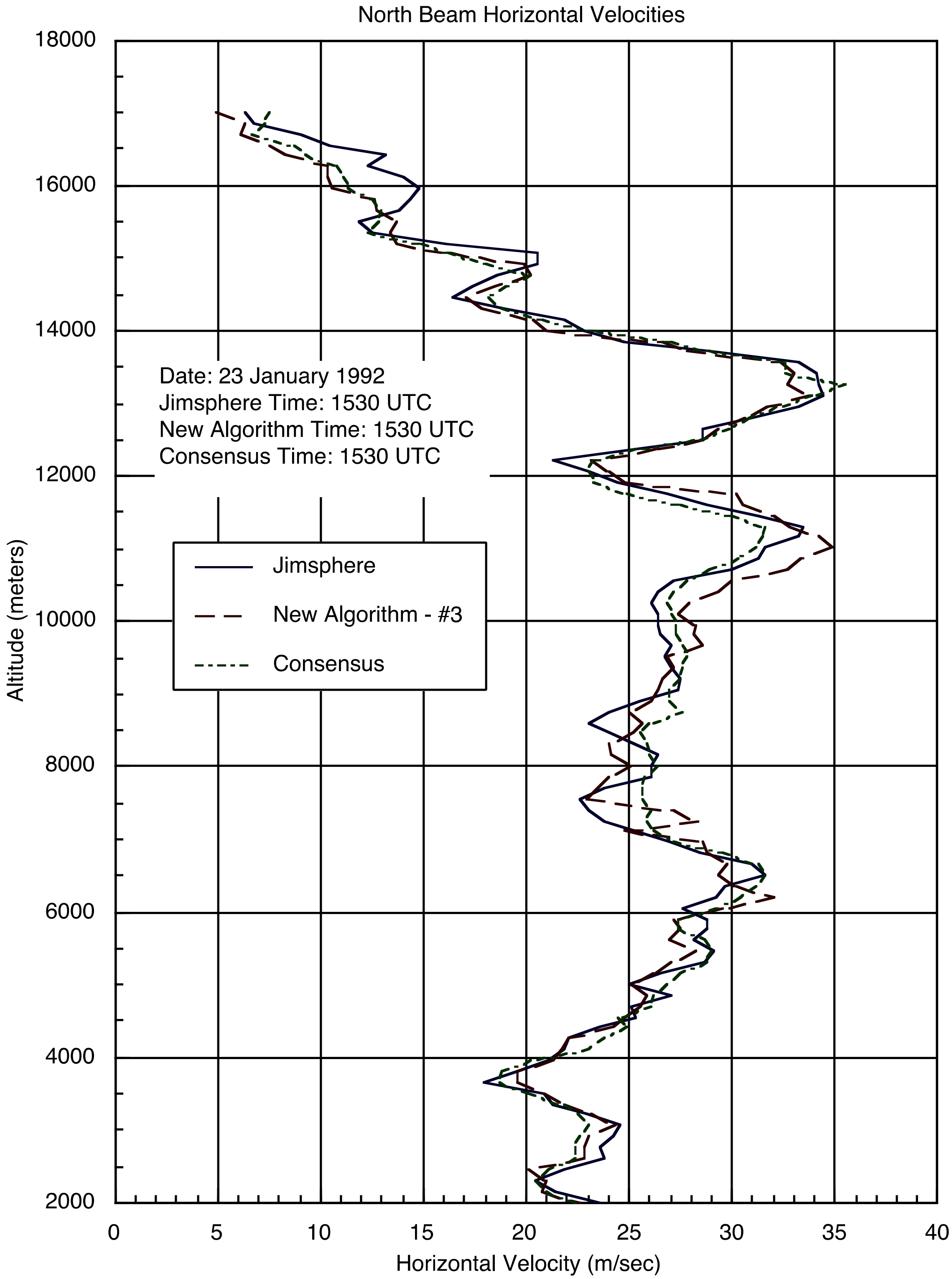


Figure 6. North beam velocities for 23 January 1992. MSFC wind algorithm DRWP profile is identified as new algorithm profile.

In this particular case, all three profiles describe the shear zones in the north beam component between 10 km and 15 km similarly. This is also true of the shear zone in the east beam component from 12 km to 14 km. However, the consensus average profile exhibits considerably less shear in the east beam component from 8 km to 12 km than either the jimsphere profile or the MSFC wind algorithm DRWP profile. It is likely that the time scale of the shear in this region is less than the time scale of the shear in the region from 12 km to 14 km. Consequently, the averaging procedures employed in the consensus averaging technique smooth the shear in the 8 km to 12 km zone.

The degree of correlation between the jimsphere profile and the MSFC wind algorithm DRWP profile was quantified by coherency analysis (Figure 7). The results of this analysis are similar to the coherency analysis performed on the 12 September 1991 profiles. The data in Figure 7 indicates both components of the two profiles are highly coherent (i.e., coherency squared values of ~ 0.7 or greater) to wavelengths as short as 1200 meters (i.e., wave number equal to 5 X 10^{-3}). Again, at shorter wavelengths, the coherence of both components is generally less; this is expected in light of the data collection differences between the jimsphere and the DRWP.

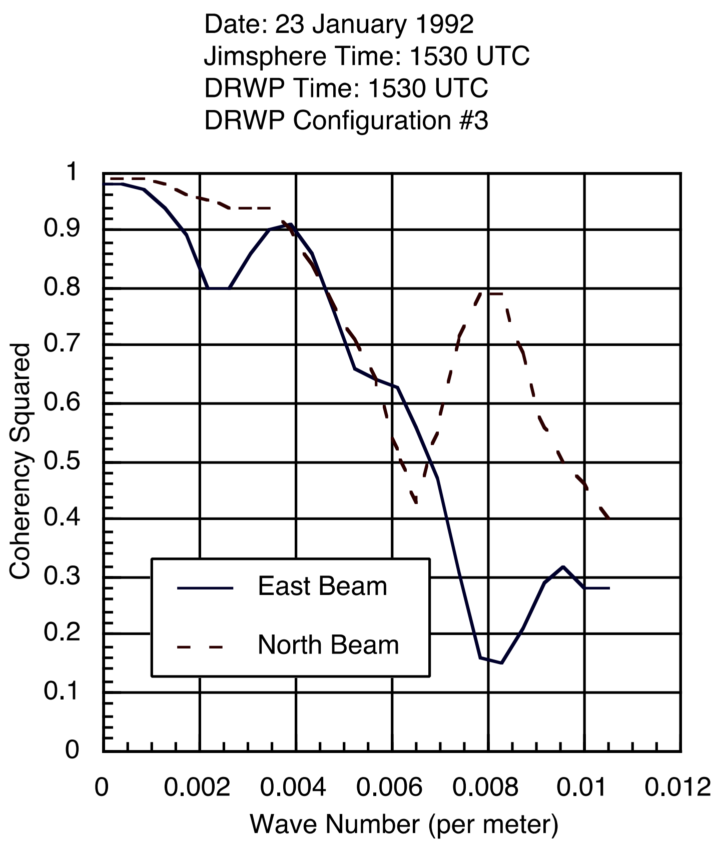


Figure 7. Coherency analysis for jimsphere and MSFC wind algorithm DRWP profiles for 23 January 1992.

The RMS velocity differences between the MSFC wind algorithm DRWP profiles and the jimsphere profiles for 23 January 1992 are contained in Table 8. In this case, the RMS velocity differences are slightly larger than the RMS velocity differences for 12 September 1991 (see Table 6). Since jimsphere data separated by approximately 50 minutes were not available for this day, RMS velocity differences between temporally separated MSFC wind algorithm DRWP profiles were used to infer the reason for the slightly larger RMS velocity differences between MSFC wind algorithm DRWP profiles and the jimsphere profiles on 23 January 1992 as compared to the differences on 12 September 1991.

Table 8 Jimsphere And MSFC Wind Algorithm DRWP Velocity Comparisons For 23 January 1992

Jimsphere Profile Time (UTC)	MSFC Algorithm Profile Time* (UTC)	RMS Differences East Beam (m/sec)	RMS Differences North Beam (m/sec)
1400	1408	1.90	1.52
1530	1530	2.06	1.76
1730	1729	2.21	1.93

* The MSFC wind algorithm DRWP profiles were generated using configuration #3.

The RMS velocity differences between two MSFC wind algorithm DRWP profiles from 12 September 1991 separated by 30 minutes are approximately 1.3 meters per second. In contrast, the RMS velocity differences between two MSFC wind algorithm DRWP profiles from 23 January 1992 separated by 30 minutes are approximately 2.2 meters per second. This indicates either increased atmospheric variability or increased temporal changes or a combination of the two. In either case, based on the substantially larger RMS velocity differences in the temporally separated MSFC wind algorithm DRWP profiles on 23 January 1992, the larger RMS velocity differences between the MSFC wind algorithm DRWP profiles and the jimsphere profiles for 23 January 1992 appear reasonable.

The RMS velocity differences between the MSFC wind algorithm DRWP profiles and the consensus averaged DRWP profiles for 23 January 1992 are contained in Table 9. The RMS velocity differences in Table 9 are generally considerably less than the RMS velocity differences between two MSFC wind algorithm DRWP profiles from 23 January 1992 separated by 30 minutes (i.e., 2.2 meters per second). This indicates the profiles produced by the MSFC wind algorithm are generally comparable to the consensus averaged wind profiles. However, there are some notable exceptions. In particular, Figure 5 indicates there are regions (e.g., from 8 km to 12 km) where the temporal averaging in the consensus technique produces a “smoother” wind profile than the MSFC wind algorithm. In addition, the RMS velocity differences between the 1800 UTC and

1830 UTC consensus averaged DRWP profiles and the corresponding MSFC wind algorithm DRWP profiles (Table 9) are considerably larger than the other RMS velocity differences for 23 January 1992. The larger RMS velocity differences at 1800 UTC can be attributed to poor profiler returns from 1815 UTC to 1830 UTC. Since the poor signal regime affected half of the data used to produce the consensus averaged profile, the resulting profile was of poorer quality and; consequently, the RMS differences between the MSFC wind algorithm DRWP profile and the consensus averaged DRWP profile for this period were larger. The relatively large RMS difference between the east beam component of the 1830 UTC consensus averaged DRWP profile and the east beam component of the corresponding MSFC wind algorithm DRWP profile is as of yet unexplained.

Table 9 Consensus Averaged And MSFC Wind Algorithm DRWP Velocity Comparisons For 23 January 1992

Consensus Profile Time (UTC)	MSFC Algorithm Profile Time* (UTC)	RMS Differences East Beam (m/sec)	RMS Differences North Beam (m/sec)
1300	1314	0.80	0.60
1330	1343	0.96	0.81
1400	1416	0.98	0.84
1430	1445	0.91	0.64
1500	1518	0.93	0.77
1530	1546	0.73	0.93
1600	1615	1.04	0.91
1630	1652	1.18	1.12
1700	1717	1.07	0.75
1730	1746	1.03	0.92
1800	1815	1.85	1.65
1830	1843	1.70	1.10

* The MSFC wind algorithm DRWP profiles were generated using configuration #3.

One set of time proximate jimsphere, consensus averaged DRWP, and MSFC wind algorithm DRWP profiles from 20 February 1992 is presented in Figures 8 and 9. As with the other two cases, the large scale features present in the three profiles are very similar; however, the small scale features represented by the three profiles exhibit some differences.

The north beam profiles are very similar in the lowest 8 km. Above that level, the differences among the three profiles are more pronounced. In particular, there are differences in the north beam component short wavelength features among the three profiles between 8 km and 10 km. In addition, although the profile shapes are similar, the magnitude of the two north beam velocities from the DRWP from 10 km to 12 km are larger than the corresponding jimsphere velocities. Finally, a the MSFC wind algorithm DRWP profile and the jimsphere profile indicate a small jet feature in the north beam component at approximately 15.5 km. This feature is not present in the corresponding consensus averaged profile. This difference is probably a result of the temporal averaging inherent in the consensus algorithm.

The east beam profiles exhibit notable differences in small scale features at many levels. The differences in small scale features among the profiles are most pronounced present near the east beam component maximum at 15 km, between 5 km and 8 km, and in the lowest 2 km.

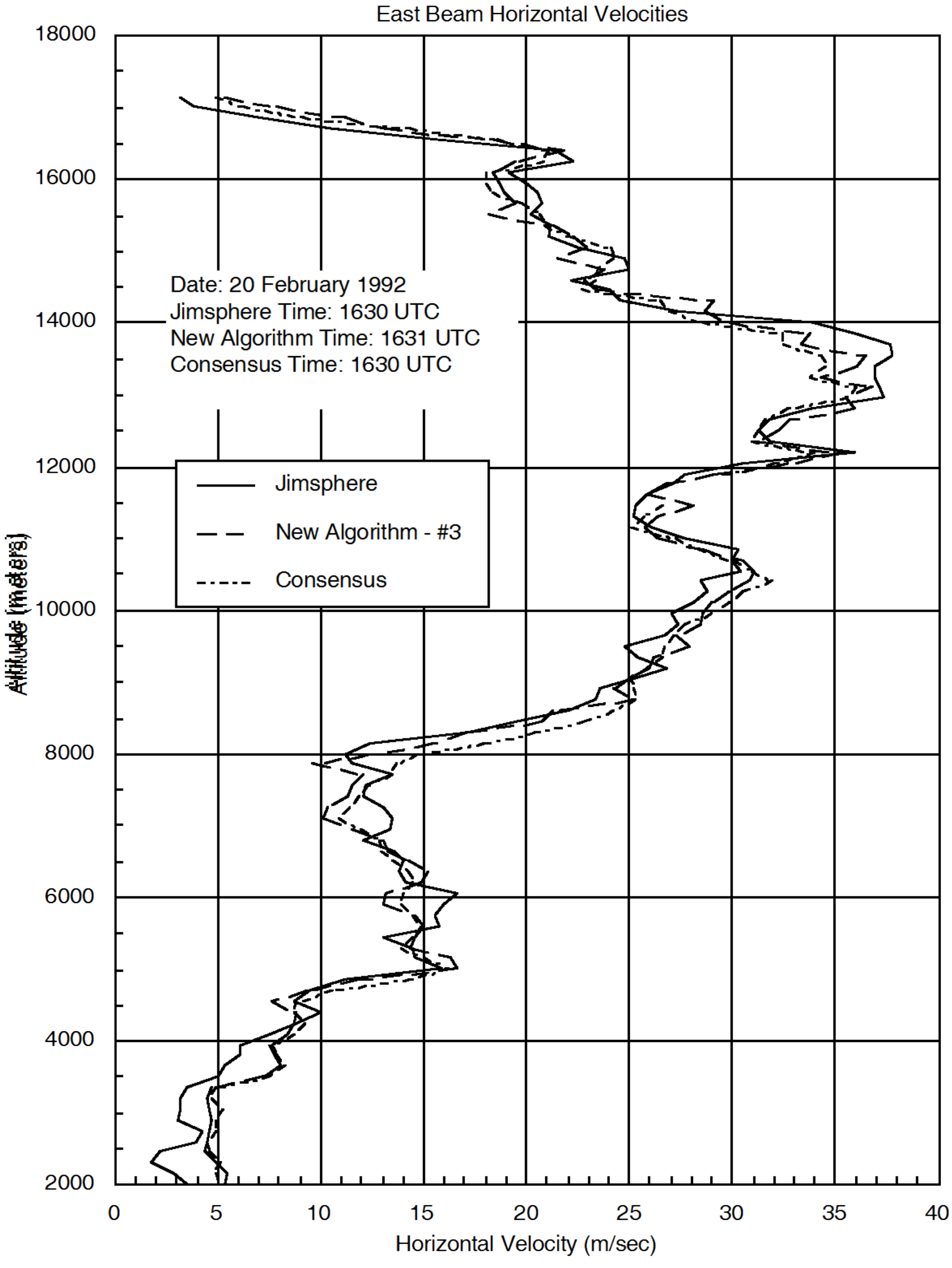


Figure 8. East beam velocities for 20 February 1992. MSFC wind algorithm DRWP profile is identified as new algorithm profile.

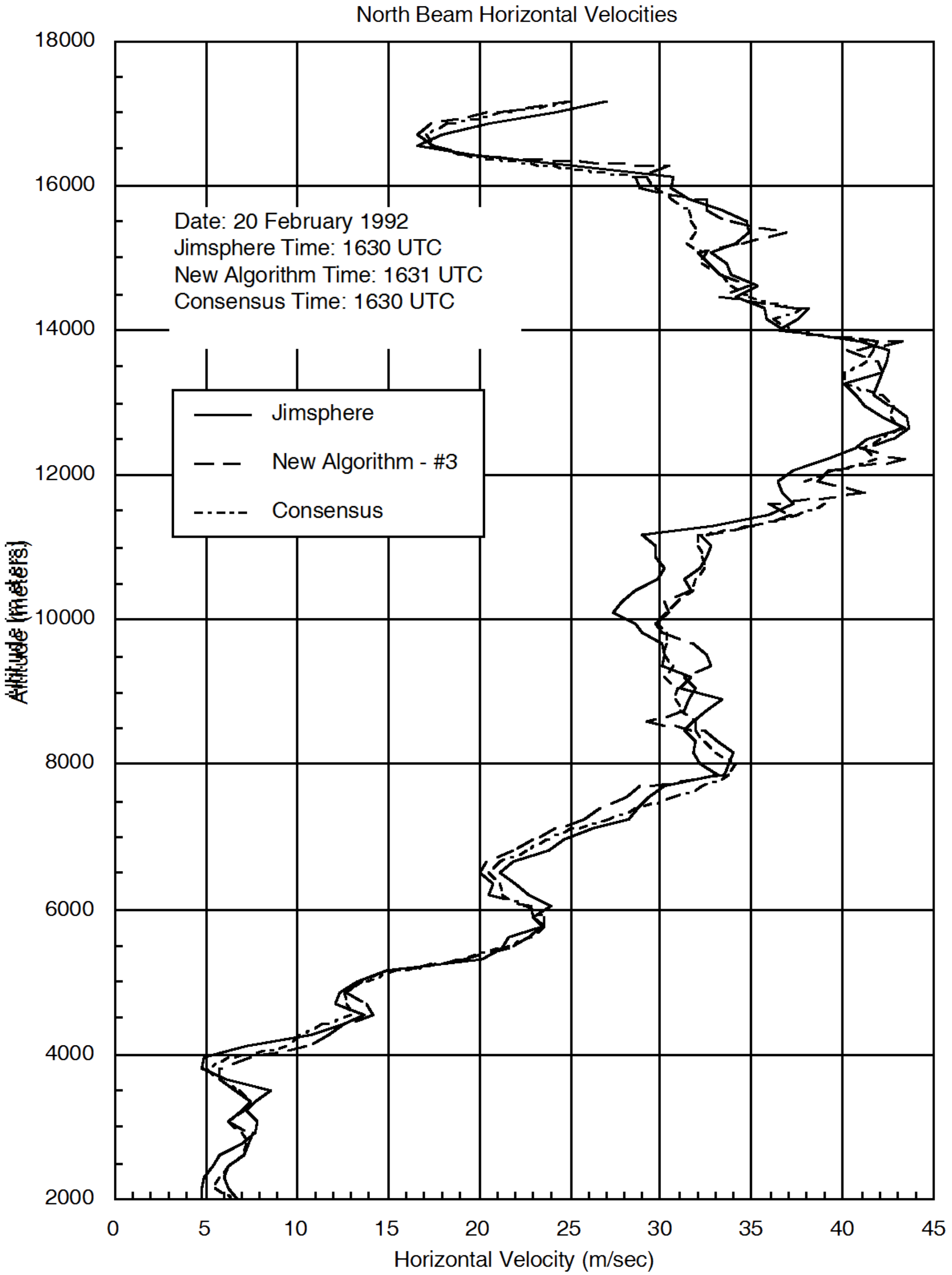


Figure 9. North beam velocities for 20 February 1992. MSFC wind algorithm DRWP profile is identified as new algorithm profile.

The degree of correlation between the jimsphere profile and the MSFC wind algorithm DRWP profile was quantified by coherency analysis (Figure 10). The results of this analysis are somewhat different from the analyses performed on data from 12 September 1991 and from 23 January 1992. The data in Figure 10 indicate the north beam components of the two profiles are highly coherent (i.e., coherency squared values of ~ 0.7 or greater) to wavelengths as short as 600 meters (i.e., wave number equal to 1 X 10^{-2}). This is in contrast to the other two cases where the coherence between the north beam components is generally lower for the shorter wavelengths. The higher degree of coherence at short wavelengths for this case is associated with the high degree of similarity between the north beam components of the MSFC wind algorithm DRWP profile and the jimsphere profile in the lowest 8 km (Figure 9).

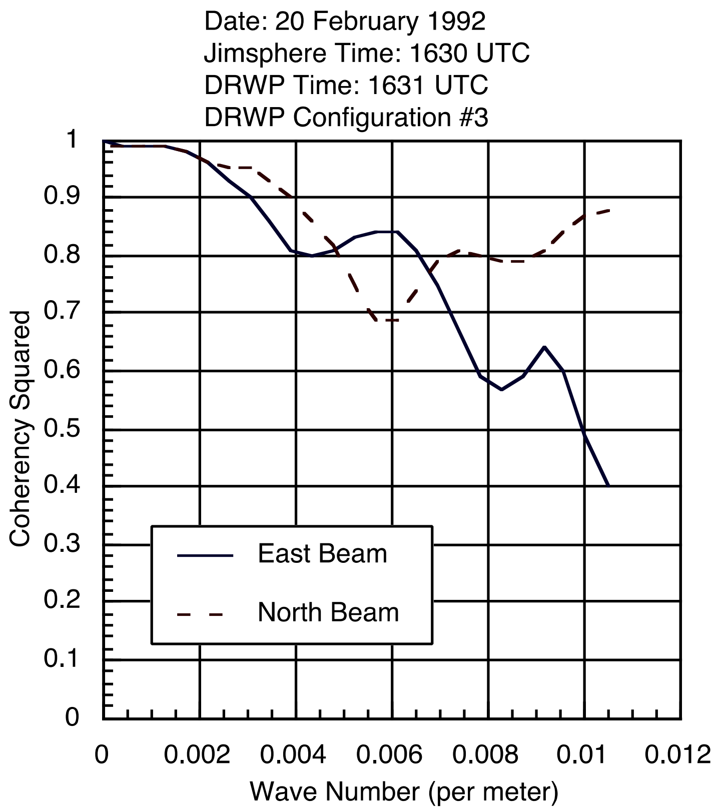


Figure 10. Coherency analysis for jimsphere and MSFC wind algorithm DRWP profiles for 20 February 1992.

The east beam components are highly coherent (i.e., coherency squared values of ~ 0.7 or greater) to wavelengths as short as 1000 meters (i.e., wave number equal to 6 X 10^{-3}). At shorter wavelengths, the coherence of the east beam components decreases. This coherence profile is similar to the other two cases and is expected in light of the data collection differences between the jimsphere and the DRWP.

The RMS velocity differences between the MSFC wind algorithm DRWP profiles and the jimsphere profiles for 20 February 1992 are contained in Table 10. In this case, the RMS velocity differences are very similar to the RMS velocity differences for 23 January 1992 (Table 8). As with the 23 January 1992 data, RMS velocity differences between temporally separated MSFC wind algorithm DRWP profiles were used to infer the reason for the slightly larger RMS velocity differences between MSFC wind algorithm DRWP profiles and the jimsphere profiles on 20 February 1992 as compared to the differences on 12 September 1991.

The RMS velocity differences between two MSFC wind algorithm DRWP profiles from 12 September 1991 separated by 30 minutes are approximately 1.3 meters per second. In contrast, the RMS velocity differences between two MSFC wind algorithm DRWP profiles from 20 February 1992 separated by 30 minutes are approximately 2 meters per second. As with the 23 January 1992 data, this indicates either increased atmospheric variability or larger temporal changes or a combination of the two. In any event, based on the substantially larger RMS velocity differences in the temporally separated MSFC wind algorithm DRWP profiles on 20 February 1992, the larger RMS velocity differences between the MSFC wind algorithm DRWP profiles and the jimsphere profiles for 20 February 1992 appear reasonable.

Table 10 Jimsphere And MSFC Wind Algorithm DRWP Velocity Comparisons For 20 February 1992

Jimsphere Profile Time (UTC)	MSFC Algorithm Profile Time* (UTC)	RMS Differences East Beam (m/sec)	RMS Differences North Beam (m/sec)
1500	1500	2.30	2.25
1630	1631	1.84	1.82
1830	1830	2.04	1.85

* The MSFC wind algorithm DRWP profiles were generated using configuration #3.

The RMS velocity differences between the MSFC wind algorithm DRWP profiles and the consensus averaged DRWP profiles for 20 February 1992 are contained in Table 11. The RMS velocity differences in Table 11 are considerably less than the RMS velocity differences between two MSFC wind algorithm DRWP profiles from 20 February 1992 separated by 30 minutes. This indicates the profiles produced by the MSFC wind algorithm are comparable to the consensus averaged wind profiles.

In addition to the velocity comparisons between the MSFC wind algorithm DRWP profiles and the consensus averaged DRWP profiles, the number of levels where the velocity extraction techniques are either unable to produce a velocity estimate or produce an erroneous velocity have been catalogued and are being analyzed. This data is important in evaluating the relative performance of the two techniques and is also an important measure of the data quality.

Table 11 Consensus Averaged And MSFC Wind Algorithm DRWP Velocity Comparisons For 20 February 1992			
Consensus Profile Time (UTC)	MSFC Algorithm Profile Time* (UTC)	RMS Differences East Beam (m/sec)	RMS Differences North Beam (m/sec)
1400	1419	0.87	0.71
1430	1444	0.80	0.99
1500	1517	0.92	0.74
1530	1546	0.91	0.88
1600	1614	1.04	0.96
1630	1643	0.93	0.80
1700	1716	0.85	0.87
1730	1745	0.80	0.74
1800	1814	0.84	0.70
1830	1843	0.80	0.82
1900	1916	0.79	0.82
1930	1944	0.88	0.70

* The MSFC wind algorithm DRWP profiles were generated using configuration #3.

Table 12 contains the number of levels where the consensus averaging technique was unable to produce a velocity estimate or produced an erroneous velocity for the data from 12 September 1991. The table also contains the number of levels where the first guess velocity has been propagated more than two times consecutively by the MSFC wind algorithm. The critical value for the number of first guess propagations has been selected in relation to the proposed use of the DRWP in support of shuttle operations. At this time, proposed use of the DRWP calls for a wind profile to be distributed to the customer every fifteen minutes. With a cycle time of five minutes, this means every third profile would be transmitted to the customer. Therefore, if the first guess velocity is propagated three or more times consecutively, the customer is not provided with a new estimate of the wind at that particular level. Hence, the critical value for the number of first guess propagations was set at two.

The data in Table 12 indicate both velocity extraction techniques were able to produce reasonable velocity estimates at most all levels throughout the five hour period on 12 September 1991 and does not suggest one procedure is performing better than the other. The results from 23 January 1992 data, however, are not quite as favorable (Table 13). In this case, the signal returns from the profiler were generally weaker above 13 km than the signal returns from 12 September 1991. Consequently, the number of levels where the consensus averaging technique was unable to produce a velocity estimate or produced an erroneous velocity and the number of levels where the first guess velocity has been propagated more than two times consecutively by the MSFC wind algorithm are greater for the 20 January 1992 data than for the 12 September 1991 data. The data in Table 13 do not suggest one velocity extraction technique is generally performing better than the other. There is, however, one significant exception.

Table 12 Consensus Averaged And MSFC Wind Algorithm DRWP Profile Comparisons For 12 September 1991

Consensus Profiles		MSFC Algorithm Profiles*	
Time (UTC)	Number of Levels**	Time (UTC)	Number of Levels***
1900	0	1915	0
1930	0	1946	1
2000	0	2015	1
2030	0	2044	1
2100	0	2116	1
2130	0	2145	2
2200	1	2214	0
2230	0	2246	1
2300	2	2314	1
2300	3	2346	3

Table 13 Consensus Averaged And MSFC Wind Algorithm DRWP Profile Comparisons For 23 January 1992			
Consensus Profiles		New Algorithm Profiles*	
Time (UTC)	Number of Levels**	Time (UTC)	Number of Levels***
1330	0	1343	1
1400	5	1416	1
1430	3	1445	4
1500	2	1518	4
1530	5	1546	3
1600	7	1615	5
1630	0	1652	1
1700	2	1717	4
1730	1	1746	2
1800	25	1815	3
1830	1	1843	0

* The MSFC wind algorithm DRWP profiles were generated using configuration #3.

** The number of levels with either erroneous data or missing data.

*** The number of levels with the number of first guess velocity propagations for the east beam and/or the north beam greater than two (2).

At 1800 UTC the consensus averaging procedure was unable to produce a velocity estimate or produced an erroneous velocity at 25 of the 112 levels. This is a result of the poor signal returns during the period from 1815 to 1830 UTC. Conversely, the first guess velocity was propagated more than two times consecutively by the MSFC wind algorithm at only 3 levels on the 1815 UTC wind profile. Strictly speaking, this is not a truly fair comparison since the poor signal return was from the period 1815 UTC to 1830 UTC or just after the 1815 UTC MSFC wind algorithm profile. However, it does highlight an important difference between the two velocity extraction techniques. Poor signal returns for as brief a period as 15 minutes may result in a one hour time span between two consecutive high quality wind profiles from the consensus averaging algorithm. In contrast, poor signal returns for a 15 minute period would result in only a 20 minute time span between two consecutive high quality wind profiles from the MSFC wind algorithm.

The results from the data quality profile comparison for 20 February 1992 (Table 14) are different from the results from the other two days. Except for the time period associated with the poor signal returns (i.e., 1800 UTC on 23 January 1992), the results of the data quality profile comparisons for 12 September 1991 and for 23 January 1992 do not indicate one of the two algorithms generally performs better than the other. However, this is not true for the 20 February 1992 case. In this case, the MSFC wind algorithm performs as well as or better than the consensus technique for all time periods from 1600 UTC through 1930 UTC.

Table 14 Consensus Averaged And MSFC Wind Algorithm DRWP Profile Comparisons For 20 February 1992			
Consensus Profiles		New Algorithm Profiles*	
Time (UTC)	Number of Levels**	Time (UTC)	Number of Levels***
1430	3	1444	6
1500	3	1517	4
1530	1	1546	3
1600	3	1614	0
1630	3	1643	0
1700	0	1716	1
1730	0	1745	1
1800	3	1814	0
1830	6	1843	0
1900	6	1916	0
1930	4	1944	0

* The MSFC wind algorithm DRWP profiles were generated using configuration #3.

** The number of levels with either erroneous data or missing data.

*** The number of levels with the number of first guess velocity propagations for the east beam and/or the north beam greater than two (2).

The number of times the first guess velocity was propagated by the MSFC wind algorithm for each range gate for the three days are presented in Figures 11, 12, and 13. Not surprisingly, the data indicate first guess velocity propagations are rare below 10 km. Above that level, the number of first guess velocity propagations is highly dependent upon atmospheric conditions and can be quite high. For example, the first guess velocity for the east beam at the 18.4 km level on 12 September 1991 was propagated in approximately 40% of the 109 profiles. Similarly, the first guess velocity for the north beam at the 15.7 km level on 20 February 1992 was propagated in approximately 50% of the 76 profiles.

Also of interest, is the large number of first guess velocity propagations for both beams at around 13 km on 23 January 1992. The 13 km level corresponds to the jet stream level and, in this case, is a region of relatively weak signal returns resulting in a large number of first guess velocity propagations. For example, the first guess velocity for the east beam at the 13.1 km level was propagated in approximately 45% of the 71 profiles. This is particularly significant since the jet stream is a region of relatively strong shear which is of importance to the shuttle program.

Based on these analyses, key preliminary results are:

- The large scale features (e.g., wavelengths greater than 1000 meters) present in the DRWP profiles and the jimsphere profiles are very similar.

- The small scale features (e.g., wavelengths less than 1000 meters) present in the DRWP profiles and the jimsphere profiles frequently exhibit considerable differences. These differences are not surprising in light of the spatial and temporal differences in the data collection between the jimsphere and the DRWP.

- The MSFC wind algorithm DRWP profiles and the jimsphere profiles are coherent to wavelengths as short as 1200 meters. This result is similar to the coherence between nearly simultaneous profiles from jimsphere and windsonde releases (Smith, 1988).

- The profiles produced by the MSFC wind algorithm and the consensus algorithm are generally similar; however, there are some differences in the small scale features and in the number of levels with high quality data.

- Advantages of the MSFC wind algorithm as compared to the consensus technique include:

    - The MSFC wind algorithm provides more frequent profile updates.

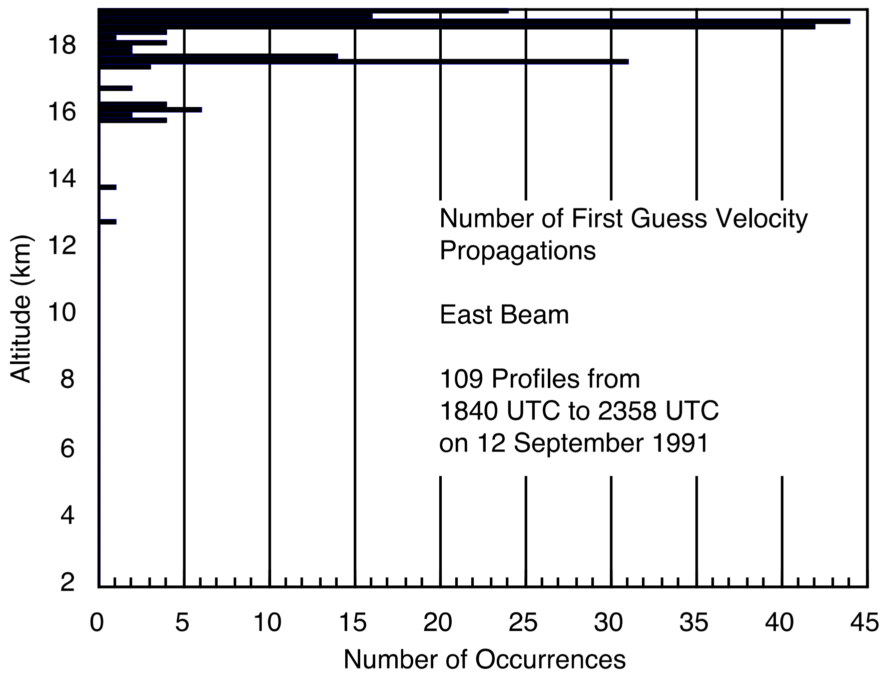
    - The MSFC wind algorithm is able to resolve some small scale features that are heavily smoothed by the consensus averaging technique.

    - The MSFC wind algorithm generally returns the same (or more) number of levels with high quality data.

- Disadvantages of the DRWP (both velocity extraction techniques) include:

    - The DRWP has difficulty accurately estimating the component wind speed when the component speed is near zero.

    - The DRWP has difficulty accurately estimating the component wind speed when the returned signal is weak. This can occur in the higher levels (e.g., above 16 km) and in the core of jet streams.



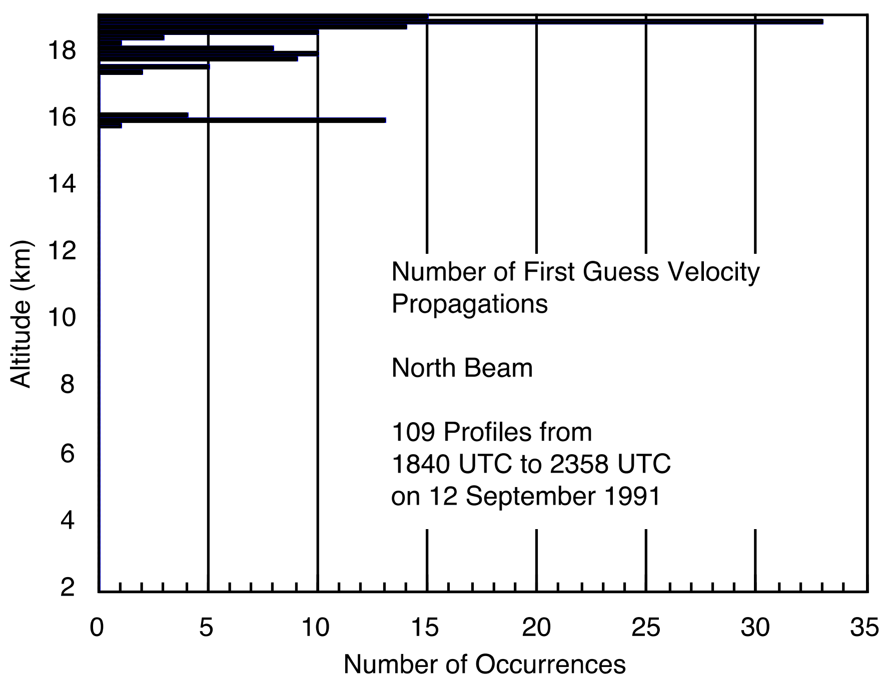
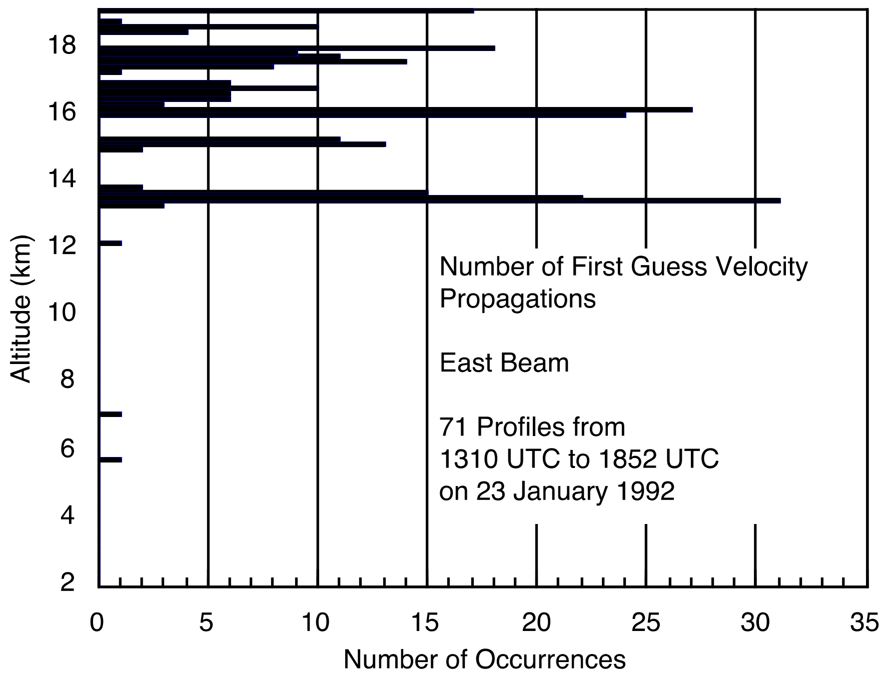


Figure 11. Number of first guess velocity propagations for the 109 MSFC wind algorithm DRWP profiles from 12 September 1991.



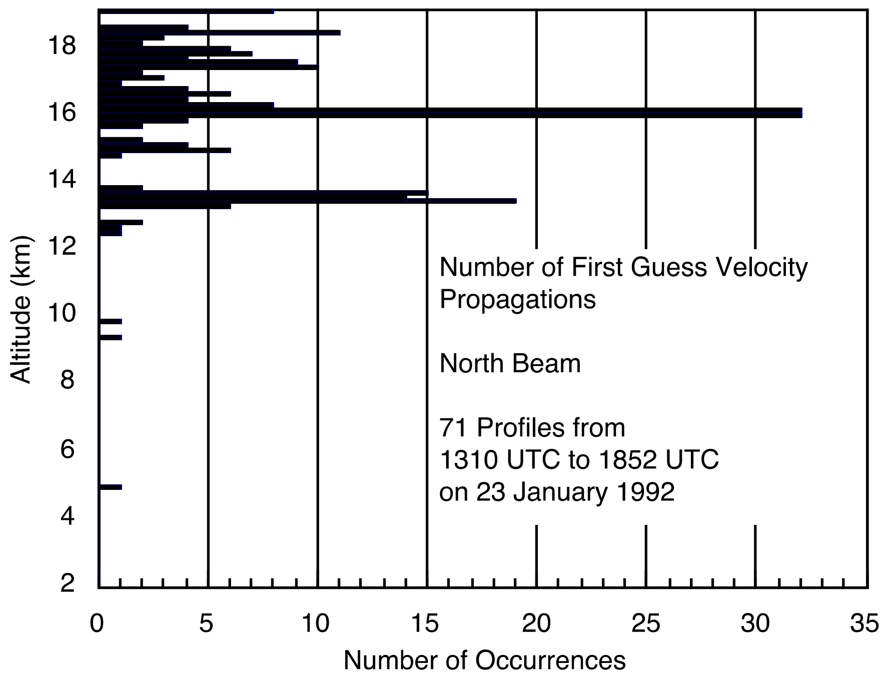
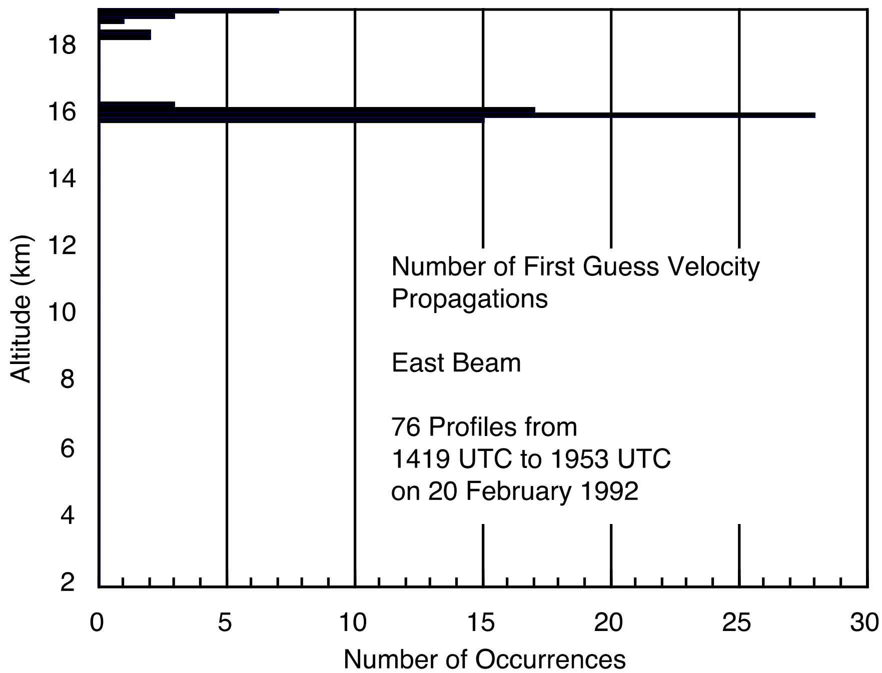


Figure 12. Number of first guess velocity propagations for the 71 MSFC wind algorithm DRWP profiles from 23 January 1992.



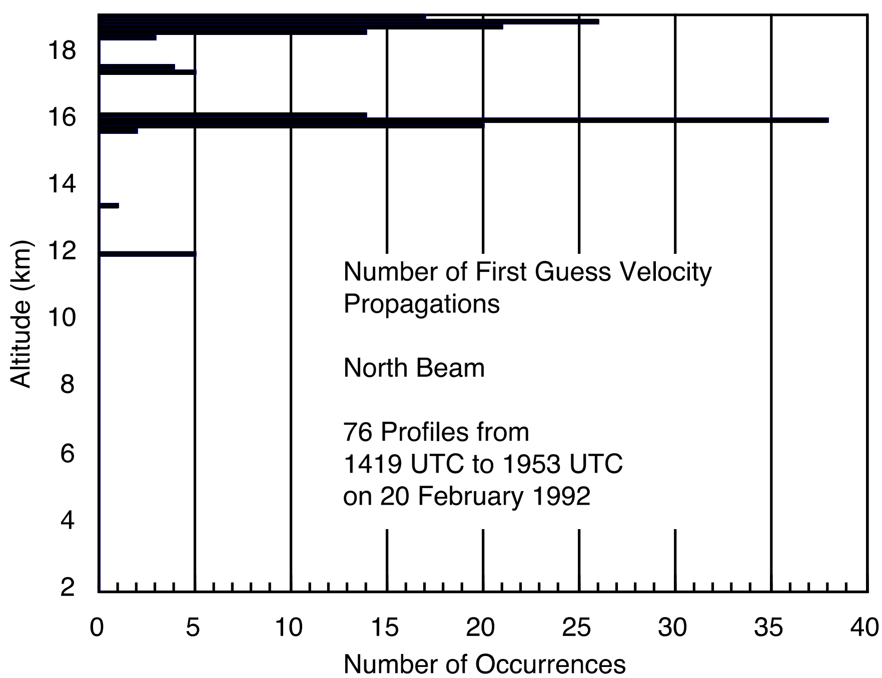


Figure 13. Number of first guess velocity propagations for the 76 MSFC wind algorithm DRWP profiles from 20 February 1992.

2.5. Task 005 Mesoscale Modeling

NASA/GSFC hosted a colloquium and workshop on multiscale coupled modeling 22-25 February 1993. The colloquium included several topics of interest to the AMU mesoscale modeling effort:

- Techniques and strategies for initializing and validating coupled multiscale models.
- Assimilating data from satellites, Doppler radars, wind profilers, and other mesoscale systems into the models.
- The parameterization of organized convection and other mesoscale flux sources in terms of model-resolvable bulk properties.
- The formulation of mutually consistent model treatments of water vapor, clouds, radiation, boundary layer physics, and precipitation.
- Coupling of mesoscale atmospheric models with non hydrostatic, cloud-resolving models and hydrological/chemical models.
- Making effective use of future computing architecture, networks, and visualization software in coupled modeling.

Although no AMU personnel were able to attend, we were fortunate that Dr. John Manobianco did attend with AMU interests in mind. Dr. Manobianco will join the AMU team later this spring as the resident numerical modeler.

MESO, Inc.'s MASS Model

MESO, Inc. delivered the Stardent 3000 computer and the MASS model to the AMU during the last week of March. These deliveries were part of their Phase II SBIR contract with NASA. From the AMU perspective, there are several positive aspects about the delivery but there are also several unexpected impacts. The model and associated software is very complete. On the positive side, there are several option files which can be used to adjust model parameters, turn various physics packages on and off, and specify the handling of input and output files. Furthermore, MESO, Inc. has been very responsive in assisting us by phone since the delivery of the model.

The two major impacts to the AMU are described below.

- We provided examples of rawinsonde, surface, MDR, tower, profiler, and NGM data as it is received into the AMU from MIDDS; however, MESO, Inc. did not make any accommodation for handling these data by the model preprocessor as we had anticipated. The AMU will need to modify the appropriate ingesters to accommodate these data.

- Although AVS graphics was supplied with the Stardent computer, MESO, Inc. only developed two display routines for model output data. The displays are insufficient to view and assess model performance. The AMU can improve this situation with the arrival of Dr. John Manobianco in early May. In his current position, he has been working directly with the MASS model and has developed some display routines for use with model output. Dr. Manobianco's expertise will speed up the process of developing proper model displays. As a first step, he will build displays which facilitate assessing model performance. After that, he will begin the process of developing displays which will facilitate use of the model output.

The AMU hopes to be able to make regular model runs by the end of June to allow model assessment to begin. The installation of TCP/IP on the MIDDS computers to facilitate direct transfer of data would greatly increase the likelihood of being able to reliably run the model in real-time. Unfortunately, it is not likely that TCP/IP will be available on the MIDDS computers within the next two years. Consequently, we try to determine other solutions for direct data transfer to facilitate running the model in real-time.

3. Project Summary

Based on an AMU Tasking and Priorities Meeting held on 8-9 October 1992 and subsequent teleconferences and memorandums, the AMU tasks and priorities for FY 1993 were established in late December 1992. The FY 1993 tasking includes the completion of tasks started in FY 1992 and a number of new tasks to be started in FY 1993. A brief description of the current tasks is contained in Attachment 1.

Most AMU efforts this past quarter focused on ongoing FY 1992 tasks. This includes the two tenths cloud cover investigation, the KSC fog and stratus study, the implementation and evaluation of the MSFC wind algorithm in NASA's 50 MHz DRWP, and the development of McBasi routines to enhance the usability of the MIDDS for forecasters at the CCFF and SMG. The two tenths cloud cover investigation and the DRWP effort should be completed within the next quarter. The KSC fog and stratus study will be completed in FY 1993. The MIDDS enhancement task is an ongoing effort with product deliverables as required.

Two of the new FY 1993 tasks were started this past quarter. The AMU began updating the two tenths cloud cover data base and also started the installation and evaluation of the MESO, Inc. mesoscale forecast model. The data base is being extended to include data from calendar year 1991 and 1992. This effort should be completed this next quarter. In addition, the mesoscale forecast model was installed in the AMU laboratory in late March. Efforts this next quarter will focus on modifications of the model ingesters to handle data from MIDDS. The AMU hopes to be able to make regular model runs by the end of June to allow model assessment to begin.

This next quarter the AMU will start work on a number of the new FY 1993 tasks including:

- ASOS evaluation.
- Development of forecaster guidance tools.
- LDAR evaluation.
- Melbourne NEXRAD evaluation.
- Acquisition of the RAMS.

4. References

Smith, S. A., 1988: Resolution and Accuracy of Balloon Wind Sounding Systems Used in Support of STS Accent Performance Assessments. *Memorandum to Claude Green, Chief, Atmospheric Effects Branch, Earth Sciences and Applications Division, MSFC.*

Attachment 1: AMU FY-93 Tasks

Task 1 AMU Operations

- Operate the AMU. Coordinate operations with NASA/KSC and its other contractors, 45th Space Wing 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.

- Design McBasi routine to enhance the usability of the MIDDS for forecaster applications at the CCFF and SMG. Consult frequently with the forecasters at both installations to determine specific requirements. Upon completion of testing and installation of each routine, obtain feedback from the forecasters and incorporate appropriate changes.

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.

Sub task 3 - Two Tenths Cloud Cover Data Base

•• The 0.2 cloud cover sub task is extended to include maintenance of its associated data base indefinitely. This shall include keeping the data base current and accessible.

Sub task 4 - Forecaster Guidance Tools

•• The 0.2 cloud cover sub task is extended to include development of forecaster guidance tools including those based on artificial neural net (ANN) technology.

Sub task 5 - PBL Post-Sunrise Winds

•• Commence a study of the PBL post-sunrise wind field at KSC by compiling the requisite data base.

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 3 - Doppler Radar Wind Profiler (DRWP)

•• Evaluate the current status of the DRWP and implement the new wind algorithm developed by MSFC. Operationally test the new algorithm and software. If appropriate, make recommendations for transition to operational use. Provide training to both operations and maintenance personnel. Prepare a final meteorological validation report quantitatively describing overall system meteorological performance.

• Sub task 4 - Lightning Detection and Ranging (LDAR) System

•• Evaluate the NASA/KSC Lightning Detection and Ranging (LDAR) system data relative to other relevant data systems at KSC/CCAFS (e.g., LLP, LPLWS, and NEXRAD). Determine how the LDAR information can be most effectively used in support of NASA/USAF operations. If appropriate, transition to operational use.

• Sub task 5 - Melbourne NEXRAD

•• Evaluate the effectiveness and utility of the Melbourne NEXRAD (WSR-88D) operational products in support of spaceflight operations. This work will be coordinated with appropriate NWS/FAA/USAF personnel.

• Sub task 6 - SLF Wind Sensor Siting

•• Commence a study of the siting of the wind sensors at the Shuttle Landing Facility (SLF) by assembling the appropriate data base.

• Sub task 7 - ASOS Evaluation

•• Evaluate the effectiveness and utility of the ASOS data in terms of spaceflight operations mission and user requirements.

Task 5 Mesoscale Modeling

• 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.

• Sub task 2 - Install and Evaluate the MESO, Inc. Mesoscale Forecast Model

•• Install and evaluate the MESO, Inc. mesoscale forecast model for KSC being delivered pursuant to a NASA Phase II SBIR. If appropriate, transition to operations.

• Sub task 3 - Acquire the Colorado State University RAMS Model

•• Acquire the Colorado State University RAMS model or its equivalent tailored to the KSC environment. Develop and test the following model capabilities listed in priority order:

1) Provide a real-time functional forecasting product relevant to Space Shuttle weather support operations with grid spacing of 3 km or smaller within the KSC/CCAFS environment.

2) Incorporate three dimensional explicit cloud physics to handle local convective events.

3) Provide improved treatment of radiation processes.

4) Provide improved treatment of radiation processes.

5) Demonstrate the ability to use networked multiple processors.

Evaluate the resulting model in terms of a pre-agreed standard statistical measure of success. Present results to the user forecaster community, obtain feedback, and incorporate into the model as appropriate. Prepare implementation plans for proposed transition to operational use if appropriate.