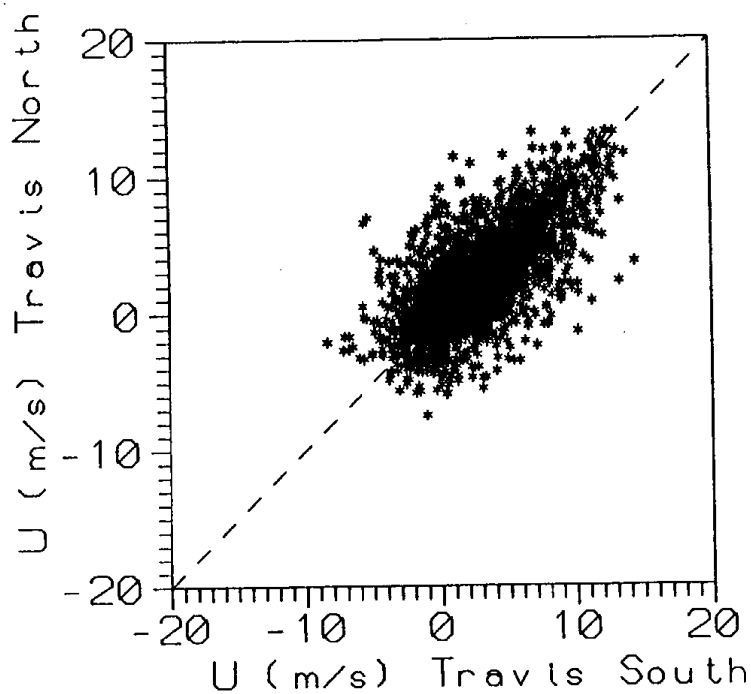
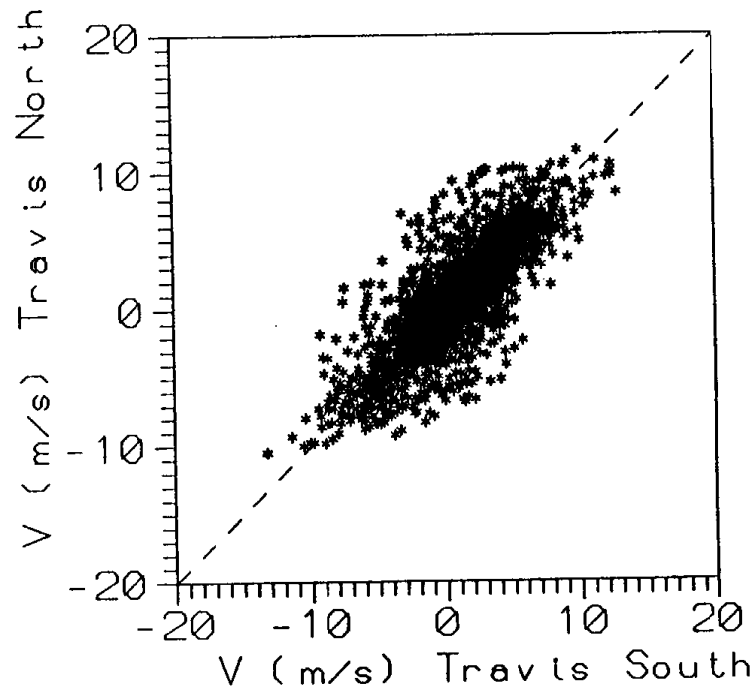
APPENDIX C

COMPARISON OF TRAVIS NORTH AND TRAVIS SOUTH PROFILERS
A COLLOCATION EXPERIMENT

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South





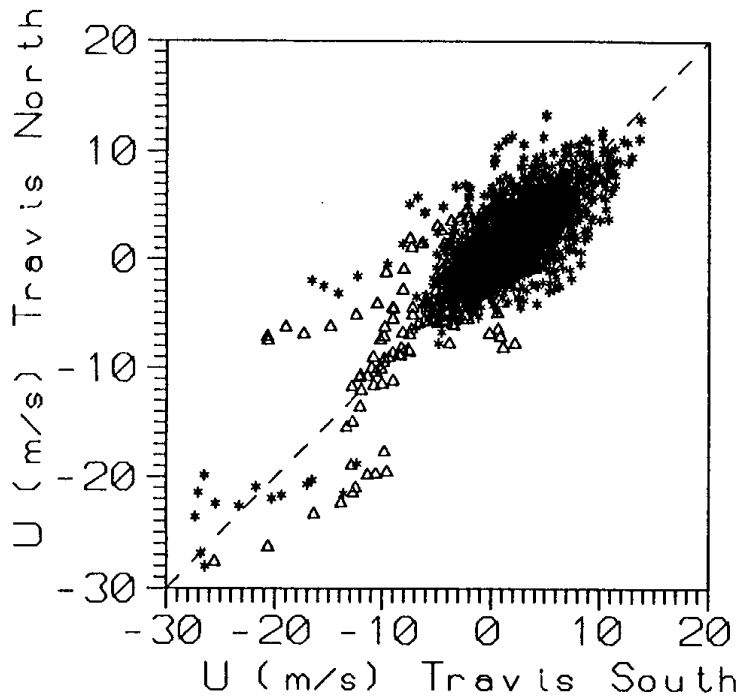
***** 0-3000 m

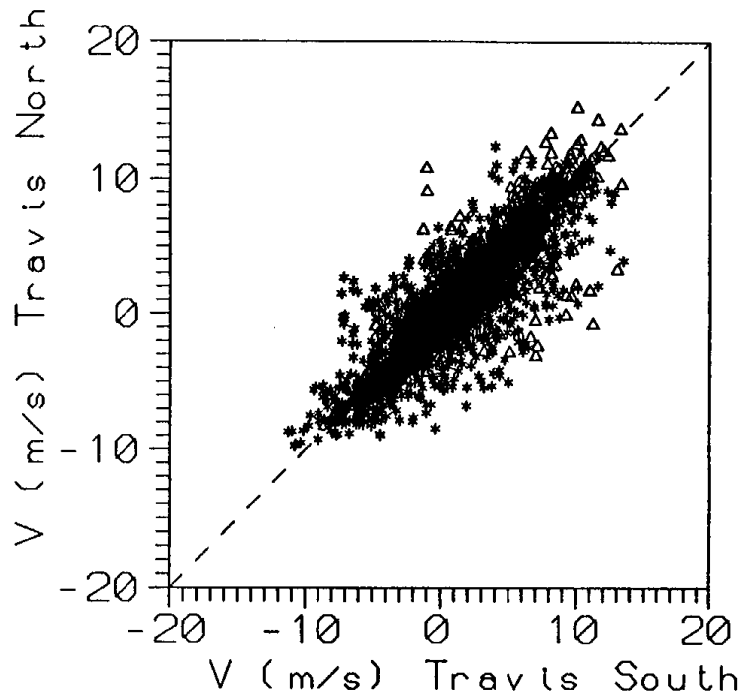
* RMSE for data <= 3000 m

Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	4151	-8	14	2.5	3.3	0.71	0.50	2.30	2.4
NU	4151	-7	13	2.3	3.1				
SV	4151	-13	13	0.9	3.3	0.82	0.68	1.85	2.0
NV	4151	-11	12	0.8	3.4				

Travis North and South (JD: 179 - 238)
Afternoon-Night: 1300 - 0100 PDT
Threshold/high res

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South





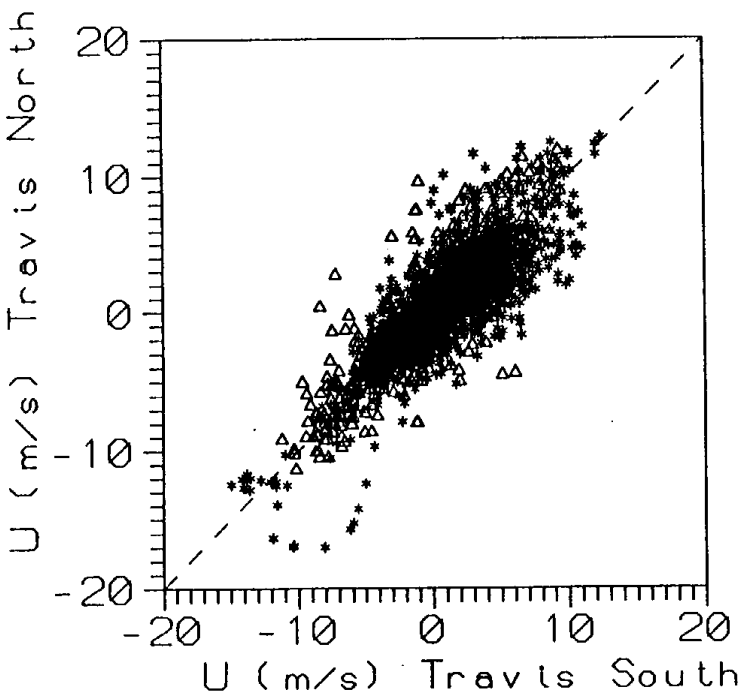
* * * * * 0-3000 m
△ △ △ △ △ > 3000 m

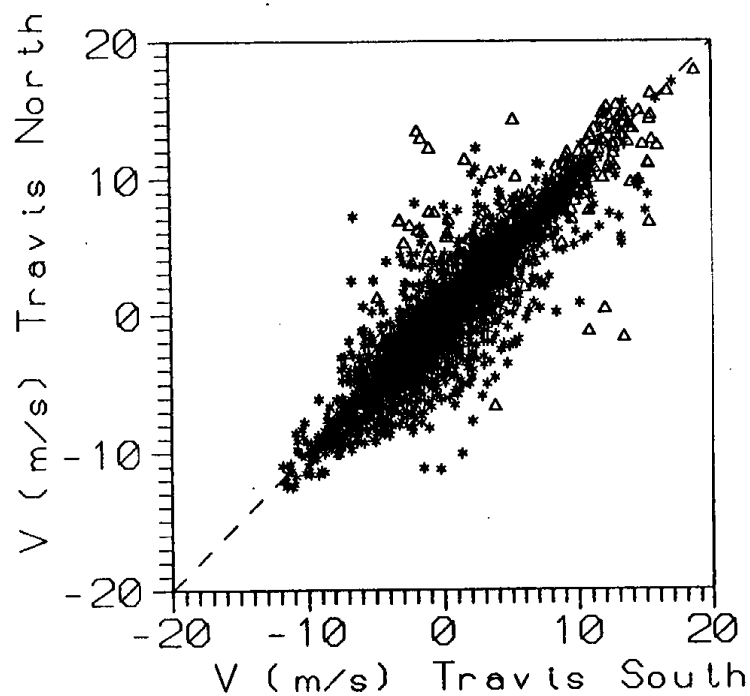
* RMSE for data <= 3000 m

Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	4349	-27	14	1.2	3.7	0.79	0.62	2.27	2.3
NU	4349	-28	13	1.2	3.5				
SV	4349	-11	13	1.6	4.0	0.87	0.76	1.95	2.0
NV	4349	-10	15	1.3	4.0				

Travis North and South (JD: 179 - 238)
Afternoon-Night: 1300 - 0100 PDT
Threshold/low res

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South





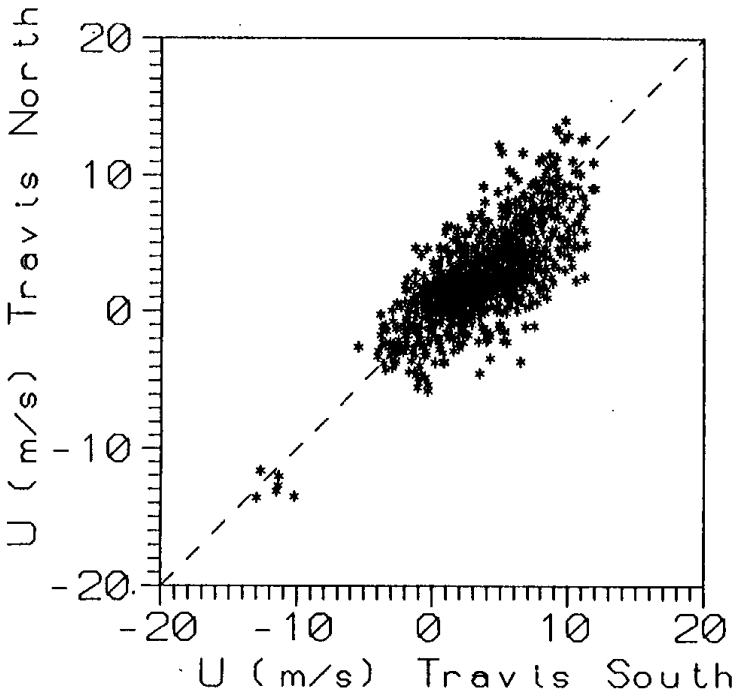
* * * * * 0-3000 m
△ △ △ △ △ > 3000 m

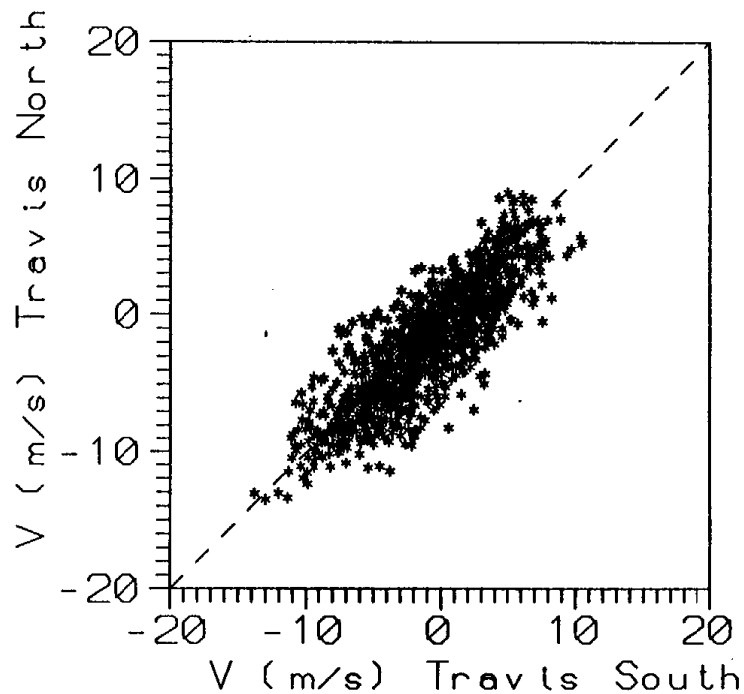
* RMSE for data <= 3000 m

Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	4767	-15	12	0.6	3.2	0.83	0.69	1.79	1.8
NU	4767	-17	13	0.5	3.2				
SV	4767	-12	19	0.8	4.5	0.92	0.84	1.80	1.9
NV	4767	-13	18	0.6	4.8				

Travis North and South (JD: 179 - 238)
Morning-Day: 0100 - 1300 PDT
Threshold/low res

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South

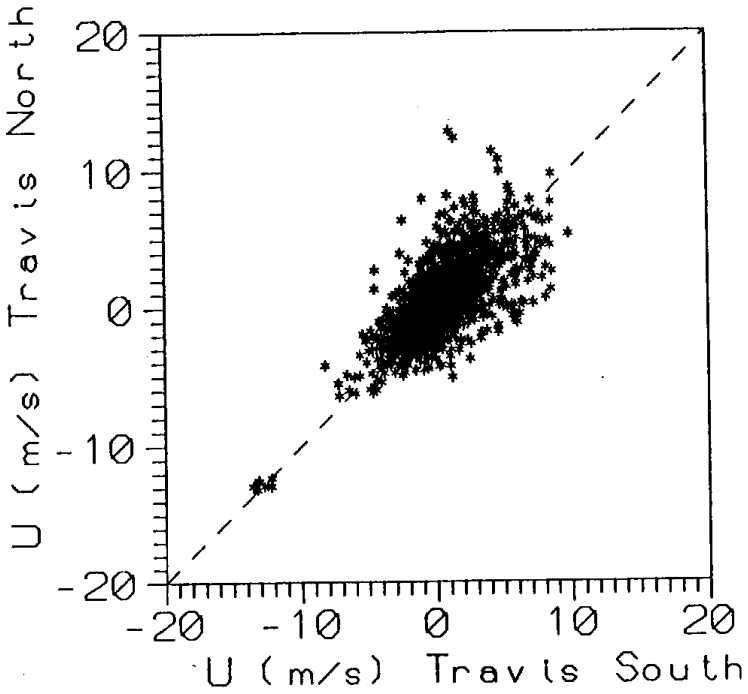


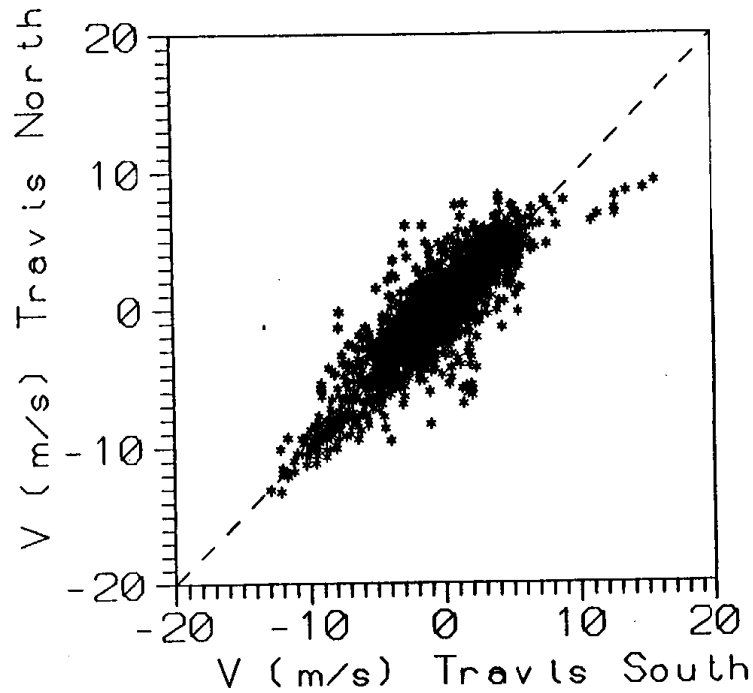


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	1556	-13	12	3.5	3.2	0.73	0.53	2.22	2.6
NU	1556	-14	14	2.4	3.1				
SV	1556	-14	10	-0.9	4.1	0.85	0.73	2.16	2.5
NV	1556	-14	9	-1.9	4.2				

Travis North and South (JD: 179 - 238)
Morning-Day: 0100 - 1300 PDT
Threshold/high res/btw 0 - .75 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travls North/South

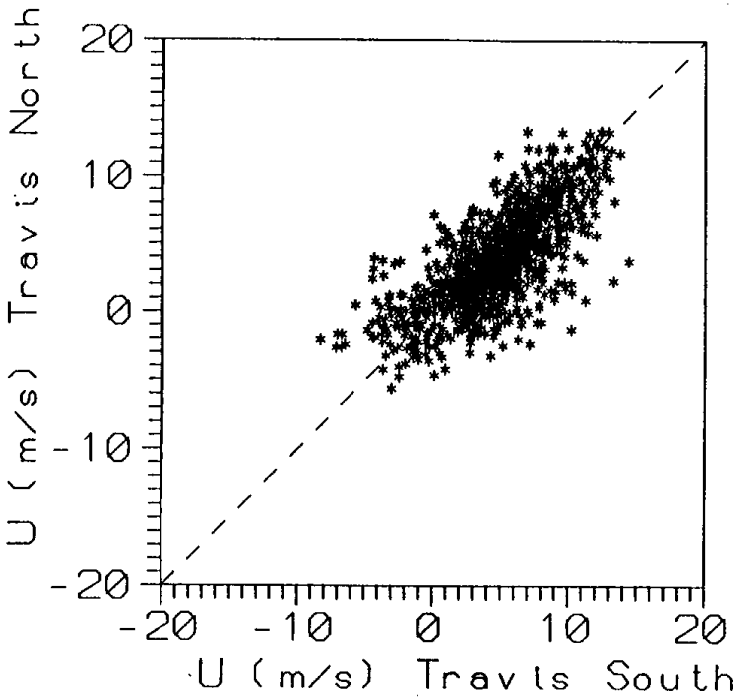


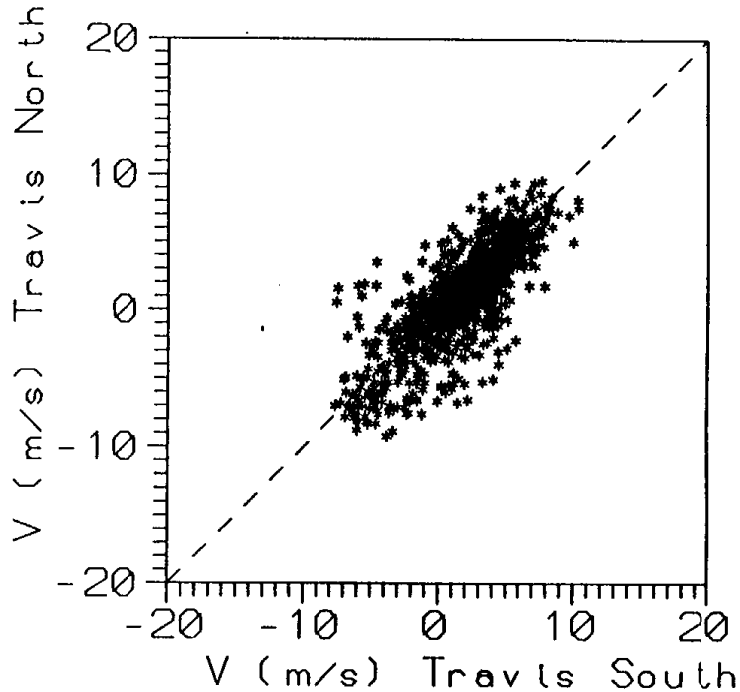


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	3108	-14	10	0.5	2.2	0.70	0.49	1.56	1.7
NU	3108	-13	13	0.5	2.3				
SV	3108	-13	16	-0.6	3.3	0.88	0.78	1.55	1.6
NV	3108	-13	9	-0.5	3.4				

Travls North and South (JD: 179 - 238)
Morning-Day: 0100 - 1300 PDT
Threshold/high res/btw .75 - 1.5 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South

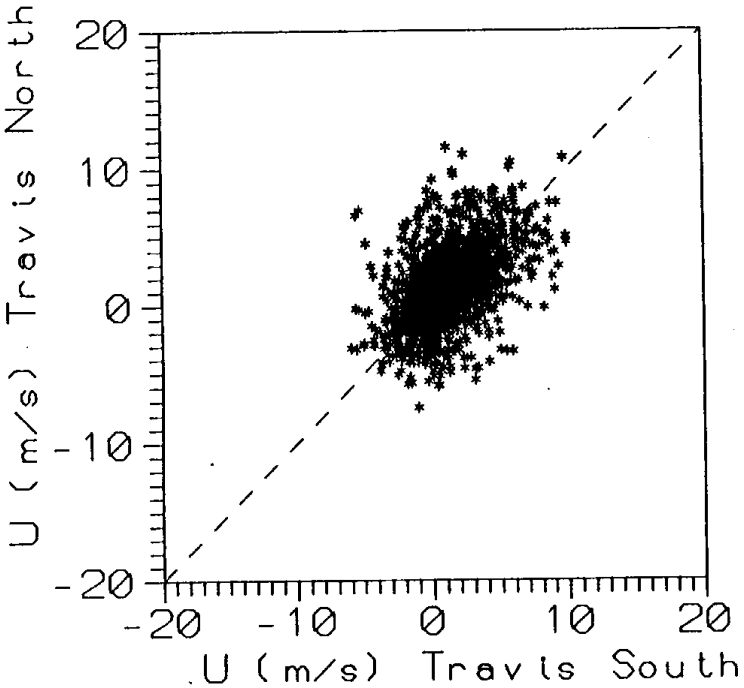


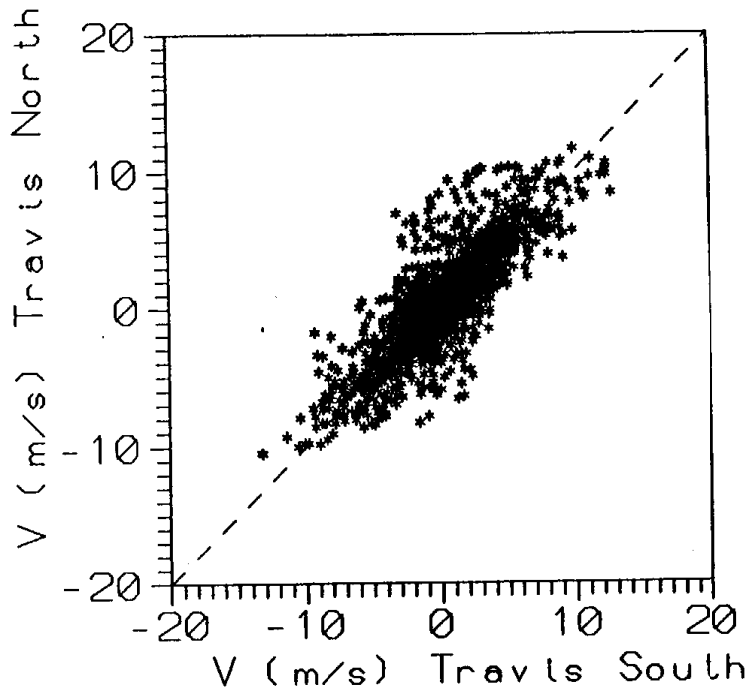


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	1480	-8	14	4.9	3.5	0.75	0.56	2.34	2.6
NU	1480	-6	13	3.9	3.5				
SV	1480	-8	10	2.0	3.1	0.80	0.64	1.84	2.1
NV	1480	-9	10	1.3	3.4				

Travis North and South (JD: 179 - 238)
Afternoon-Night: 1300 - 0100 PDT
Threshold/high res/btw 0 - .75 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South

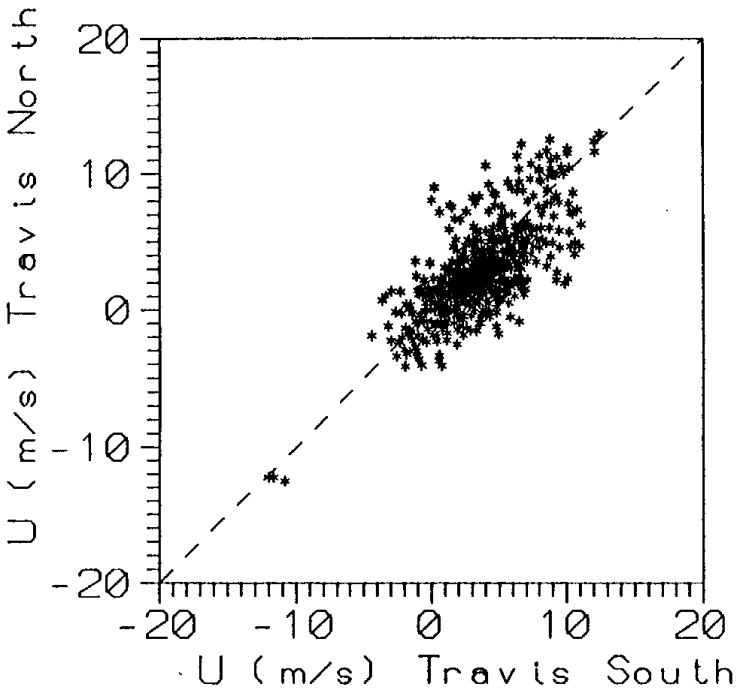


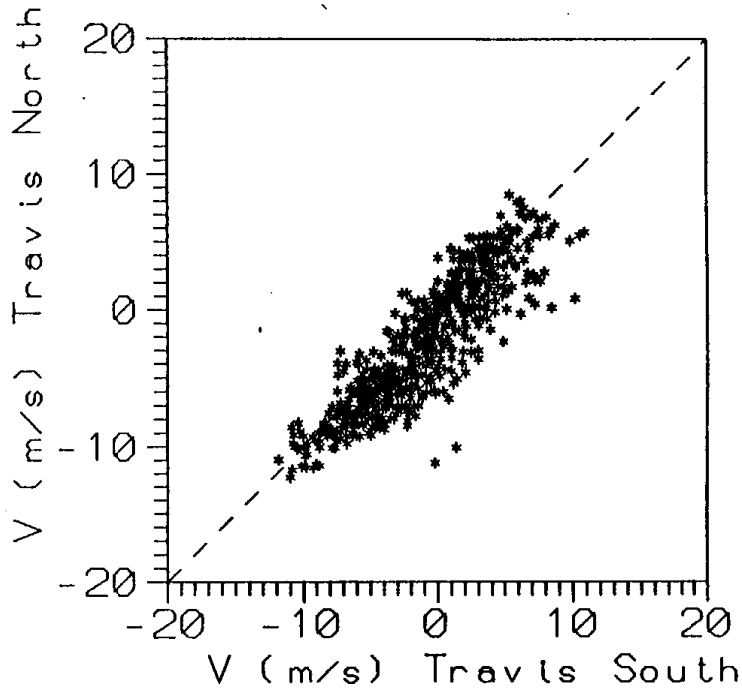


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	2671	-6	10	1.3	2.2	0.52	0.27	1.91	2.3
NU	2671	-7	11	1.4	2.5				
SV	2671	-13	13	0.3	3.2	0.84	0.71	1.74	1.9
NV	2671	-11	12	0.5	3.4				

Travis North and South (JD: 179 - 238)
Afternoon-Night: 1300 - 0100 PDT
Threshold/high res/btw .75 - 1.5 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South

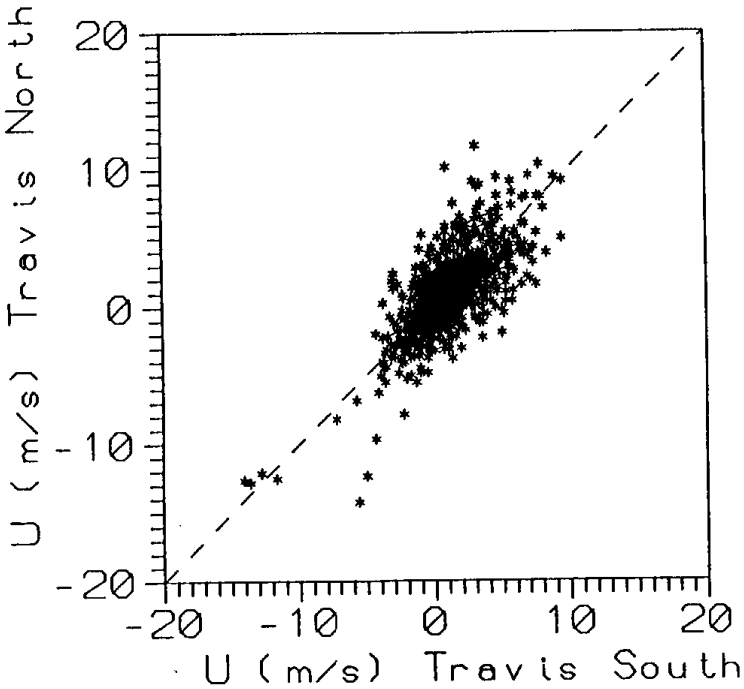


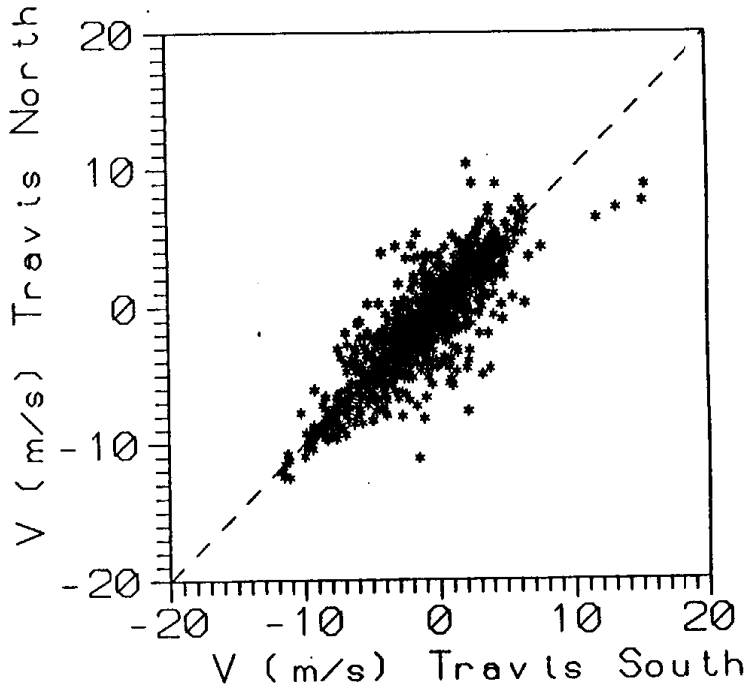


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	789	-12	12	3.5	2.9	0.73	0.53	2.00	2.3
NU	789	-13	13	2.7	3.0				
SV	789	-12	11	-1.2	4.2	0.89	0.79	1.93	2.4
NV	789	-12	8	-2.4	4.5				

Travis North and South (JD: 179 - 238)
Morning-Day: 0100 - 1300 PDT
Threshold/low res/btw 0 - .75 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South

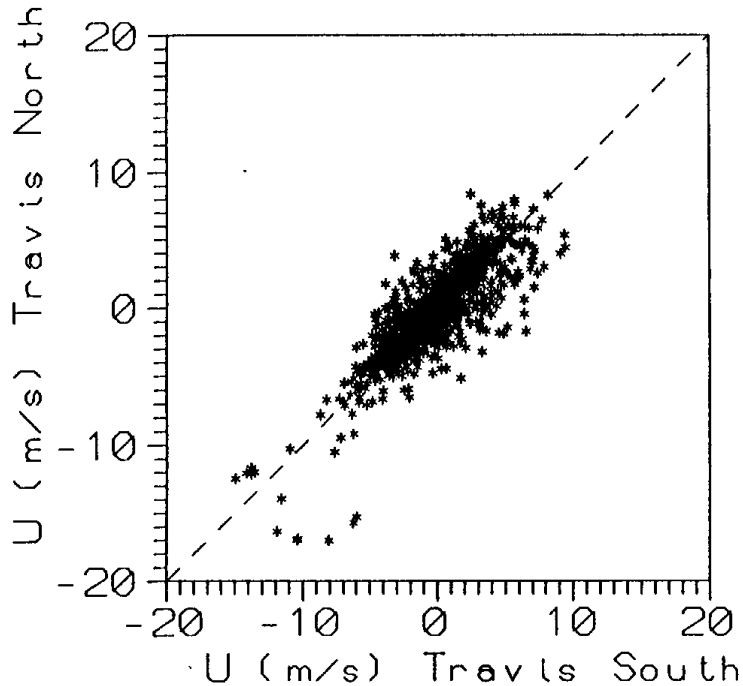


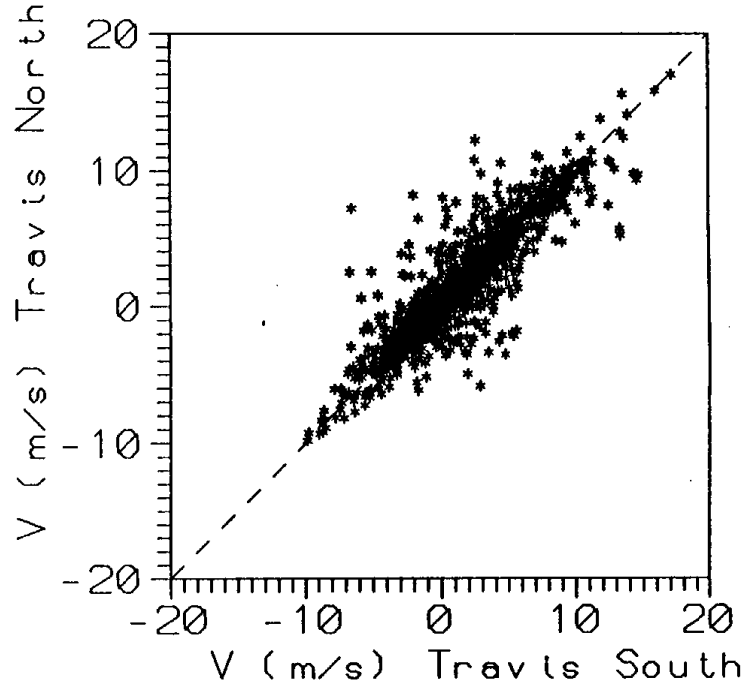


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	1443	-14	10	1.0	2.1	0.72	0.51	1.49	1.8
NU	1443	-14	12	0.8	2.4				
SV	1443	-12	15	-1.1	3.4	0.87	0.76	1.67	1.8
NV	1443	-13	10	-1.3	3.7				

Travis North and South (JD: 179 - 238)
Morning-Day: 0100 - 1300 PDT
Threshold/low res/btw .75 - 1.5 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South

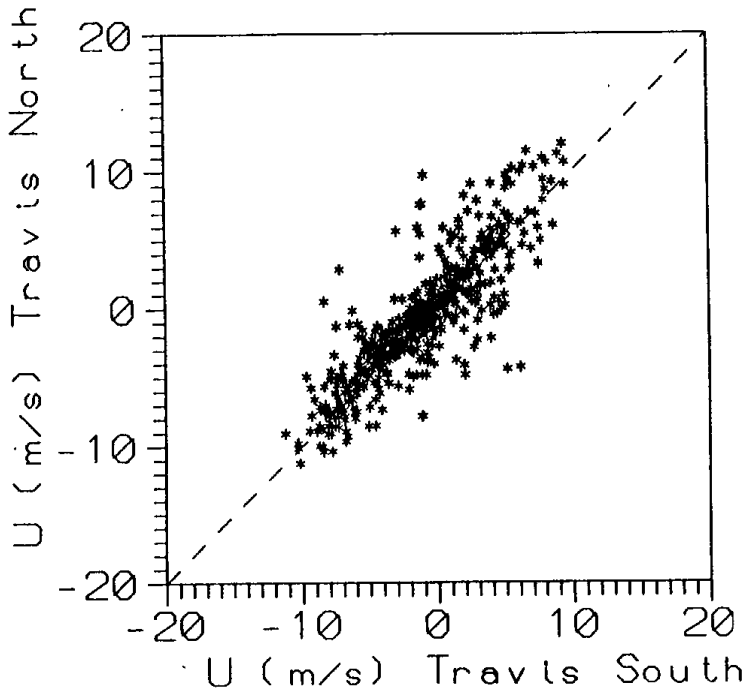


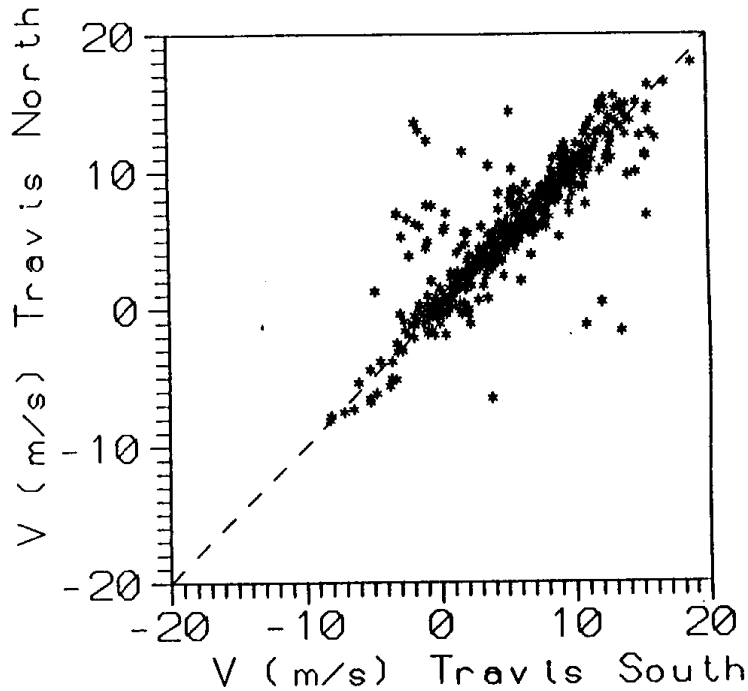


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	1857	-15	9	-0.3	2.7	0.85	0.70	1.49	1.6
NU	1857	-17	8	-0.3	2.8				
SV	1857	-10	17	1.3	3.9	0.91	0.83	1.60	1.7
NV	1857	-10	17	1.5	3.9				

Travis North and South (JD: 179 - 238)
Morning-Day: 0100 - 1300 PDT
Threshold/low res/btw 1.5 - 3.0 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South

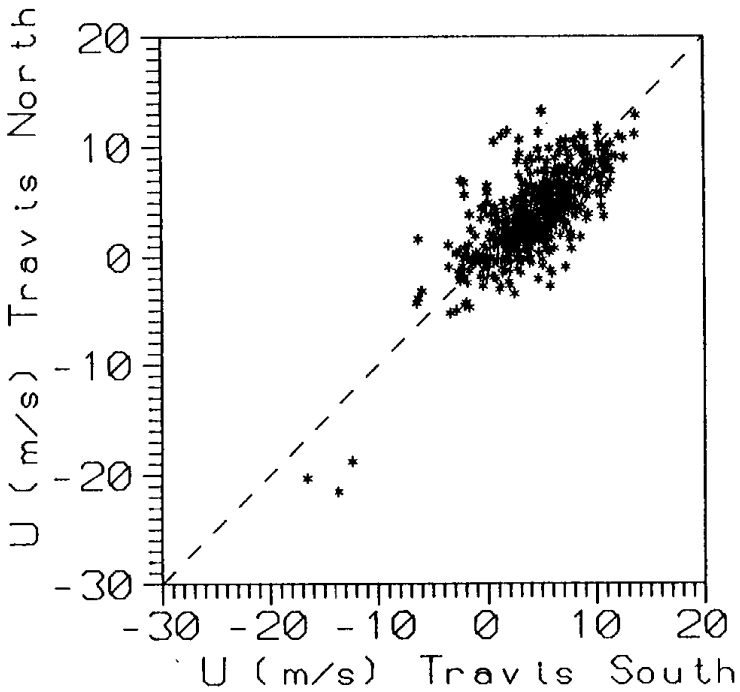


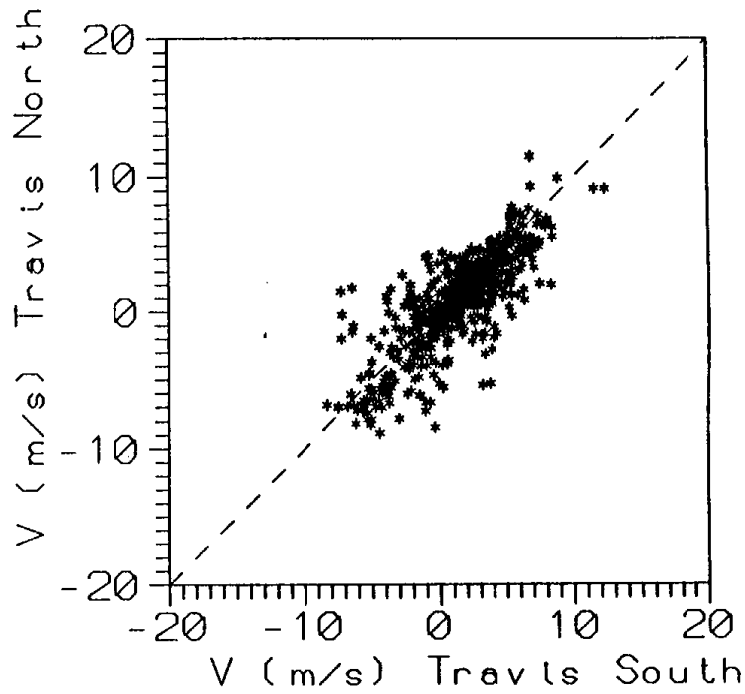


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	678	-11	9	-1.2	4.0	0.87	0.76	1.98	2.2
NU	678	-11	12	-0.8	4.2				
SV	678	-8	19	5.7	4.5	0.88	0.78	2.11	2.2
NV	678	-8	18	6.0	4.5				

Travis North and South (JD: 179 - 238)
Morning-Day: 0100 - 1300 PDT
Threshold/low res/above 3 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South

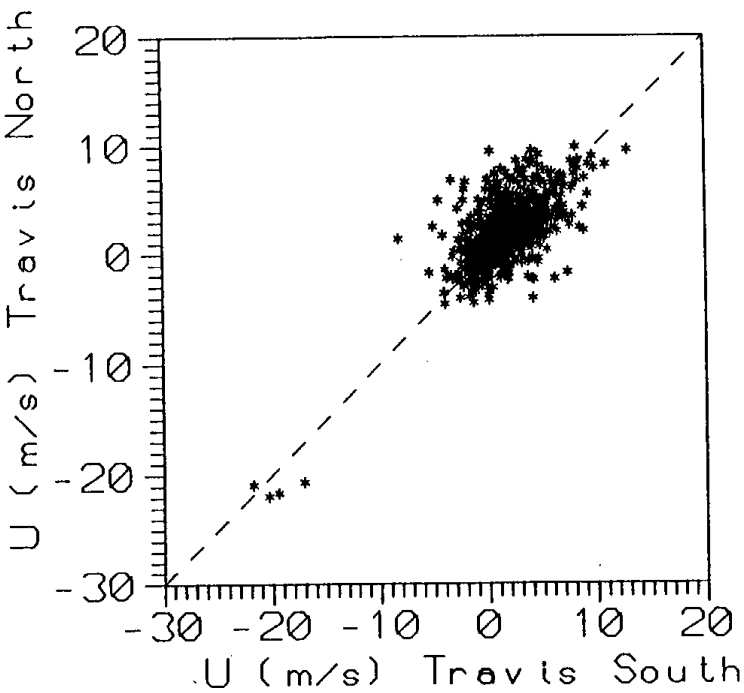


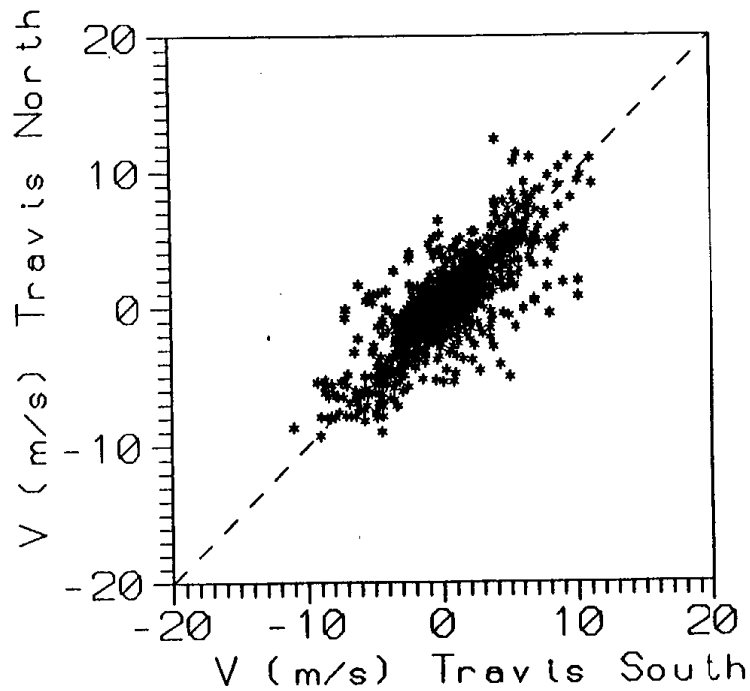


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	810	-17	14	4.2	3.4	0.74	0.55	2.29	2.6
NU	810	-22	13	3.6	3.4				
SV	810	-8	12	1.7	3.2	0.81	0.66	1.84	2.1
NV	810	-9	11	1.1	3.3				

Travis North and South (JD: 179 - 238)
Afternoon-Night: 1300 - 0100 PDT
Threshold/low res/btw 0 - .75 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South

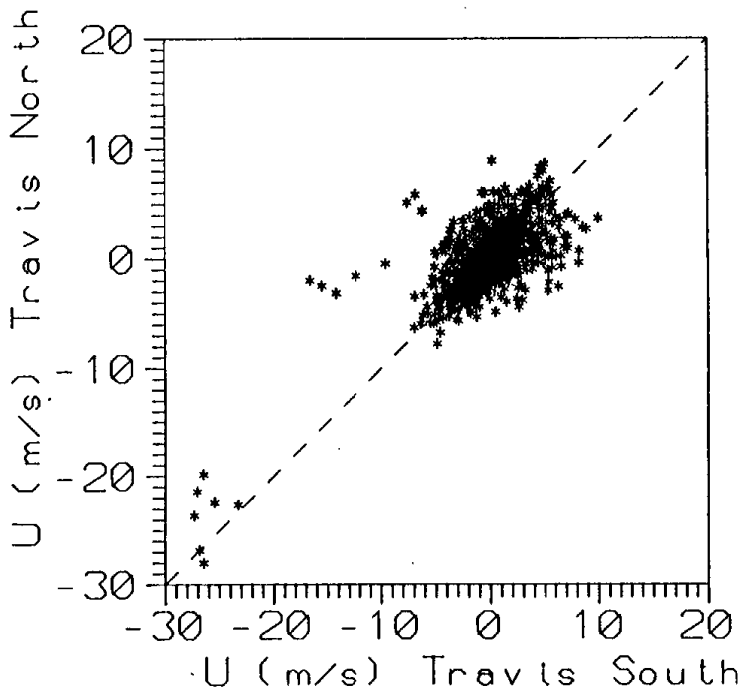


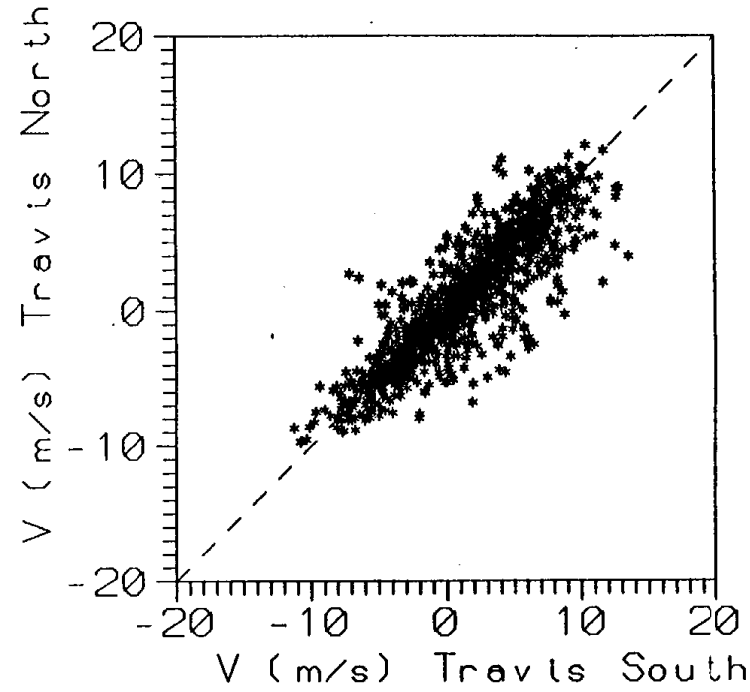


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	1342	-22	13	1.6	2.5	0.66	0.44	1.91	2.2
NU	1342	-22	10	1.8	2.7				
SV	1342	-11	11	0.5	3.2	0.83	0.68	1.81	1.9
NV	1342	-9	12	0.3	3.2				

Travis North and South (JD: 179 - 238)
Afternoon-Night: 1300 - 0100 PDT
Threshold/low res/btw .75 - 1.5 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South

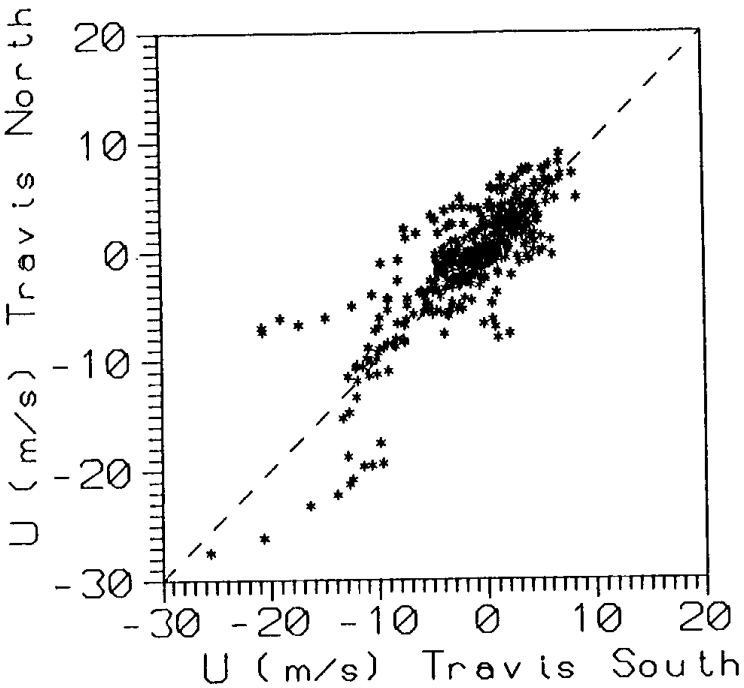


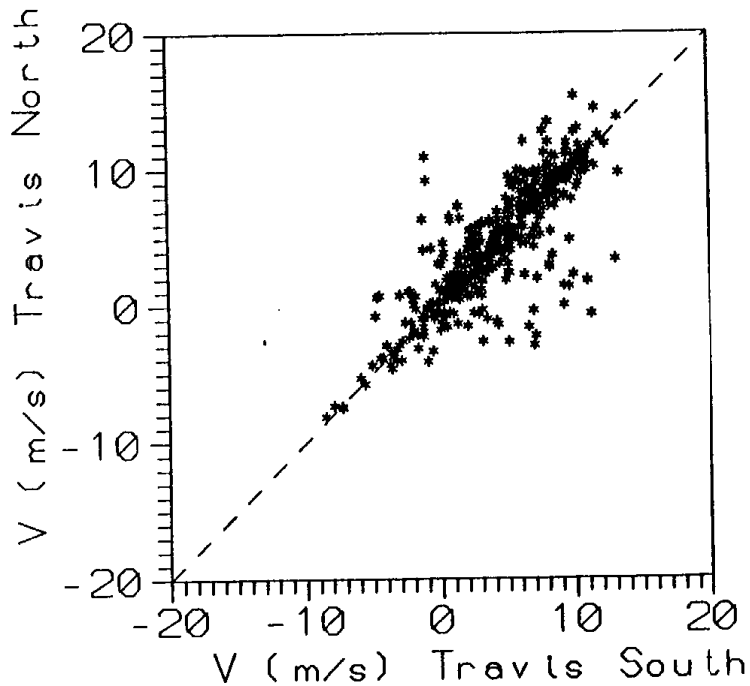


Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	1608	-27	10	0.0	3.1	0.72	0.51	2.13	2.2
NU	1608	-28	9	0.1	2.8				
SV	1608	-11	13	1.4	4.3	0.89	0.79	1.97	2.1
NV	1608	-10	12	1.0	4.3				

Travis North and South (JD: 179 - 238)
Afternoon-Night: 1300 - 0100 PDT
Threshold/low res/btw 1.5 - 3.0 km

NORTHERN CALIFORNIA TRANSPORT (NCT) 1991
915 MHz WIND PROFILER COMPARISON: Travis North/South





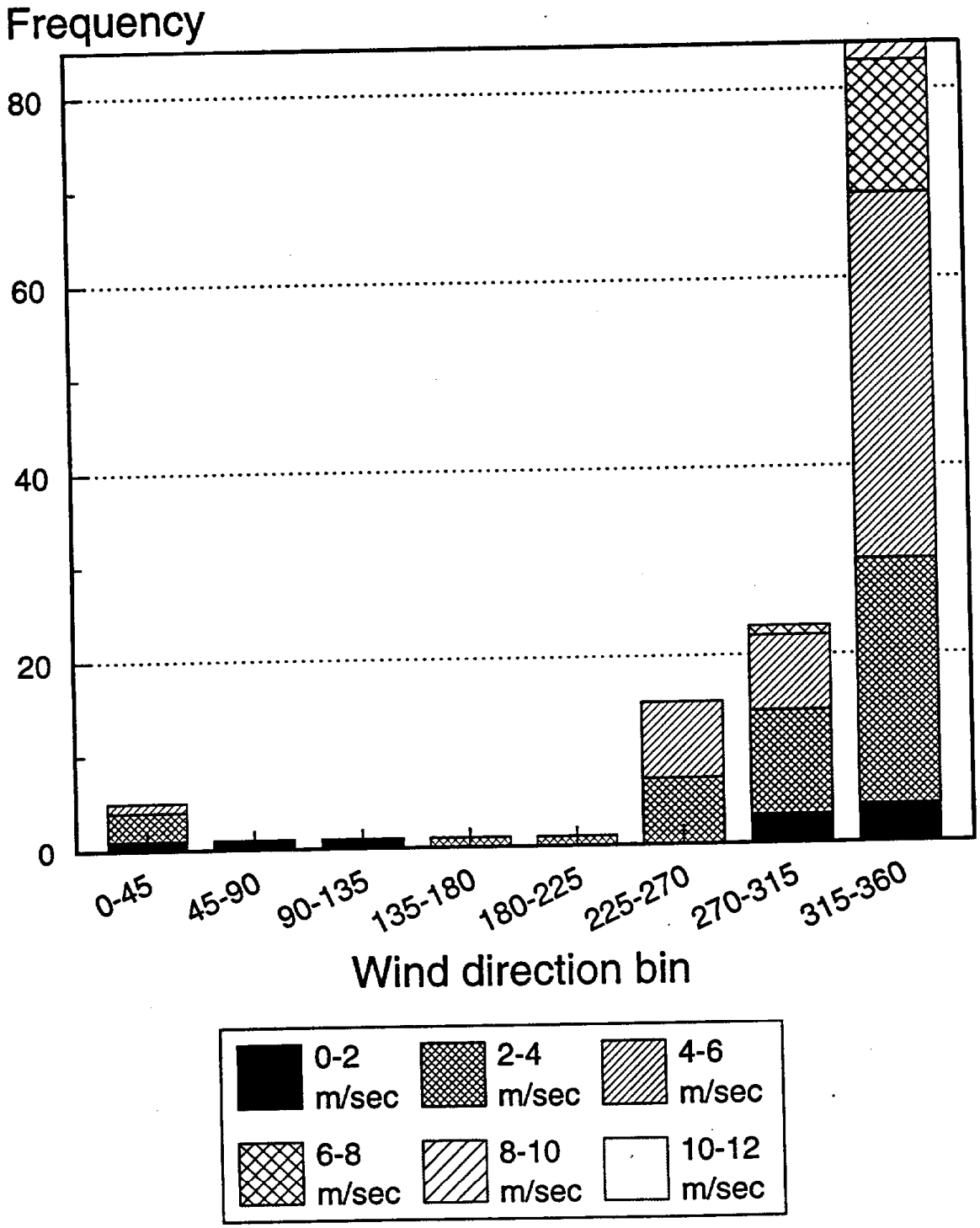
Var	n	min	max	Mean	SD	r	r^2	SE	RMSE
SU	589	-26	8	-1.0	4.6	0.83	0.68	2.56	2.8
NU	589	-27	9	-0.5	4.7				
SV	589	-9	13	4.4	4.0	0.85	0.72	2.10	2.3
NV	589	-8	15	4.7	4.2				

Travis North and South (JD: 179 - 238)
Afternoon-Night: 1300 - 0100 PDT
Threshold/low res/above 3 km

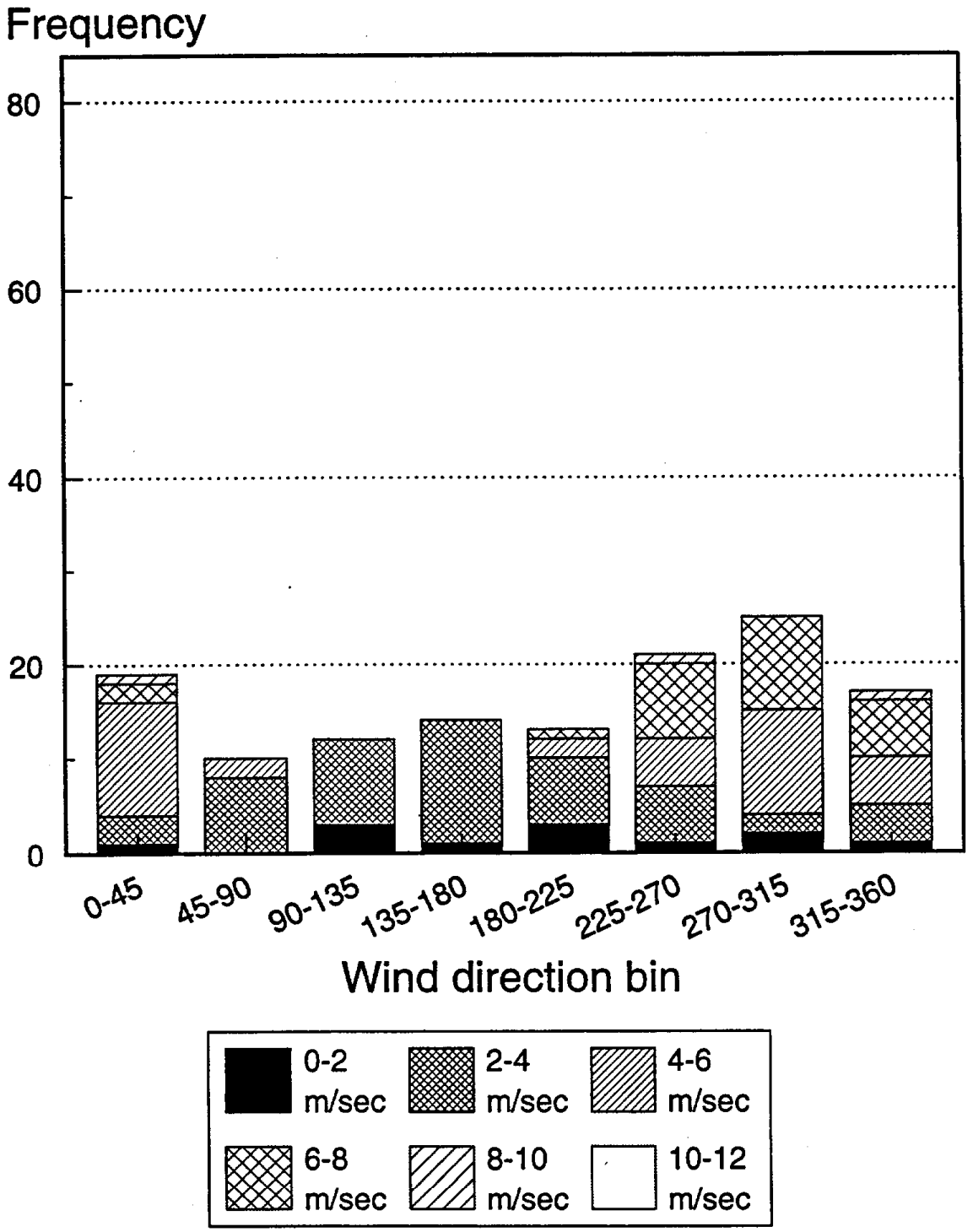
APPENDIX D

SUMMARY WIND DISTRIBUTIONS FOR
UPPER-LEVEL RIDGE AND TROUGH CASES

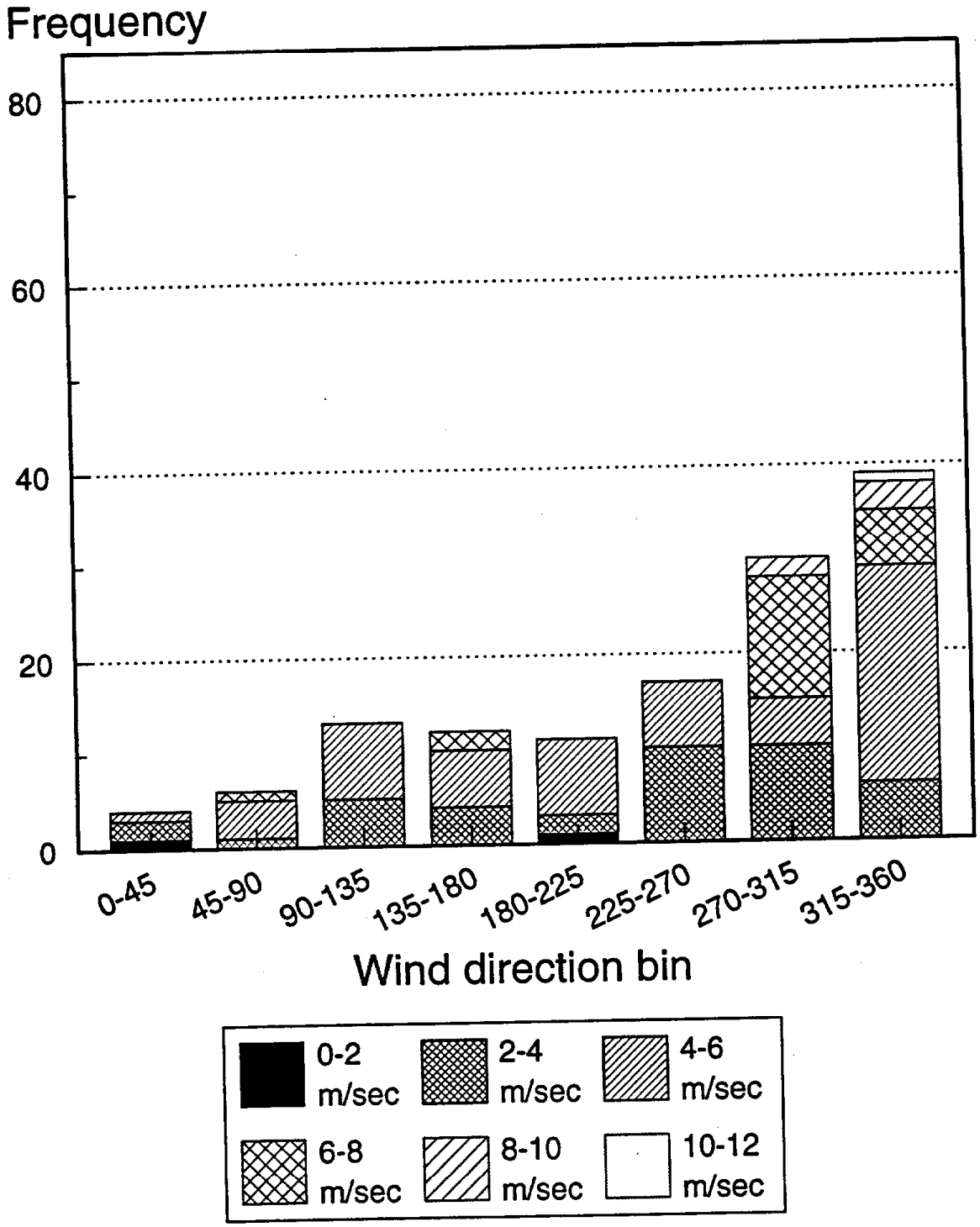
DEL Ridge Case Level 1



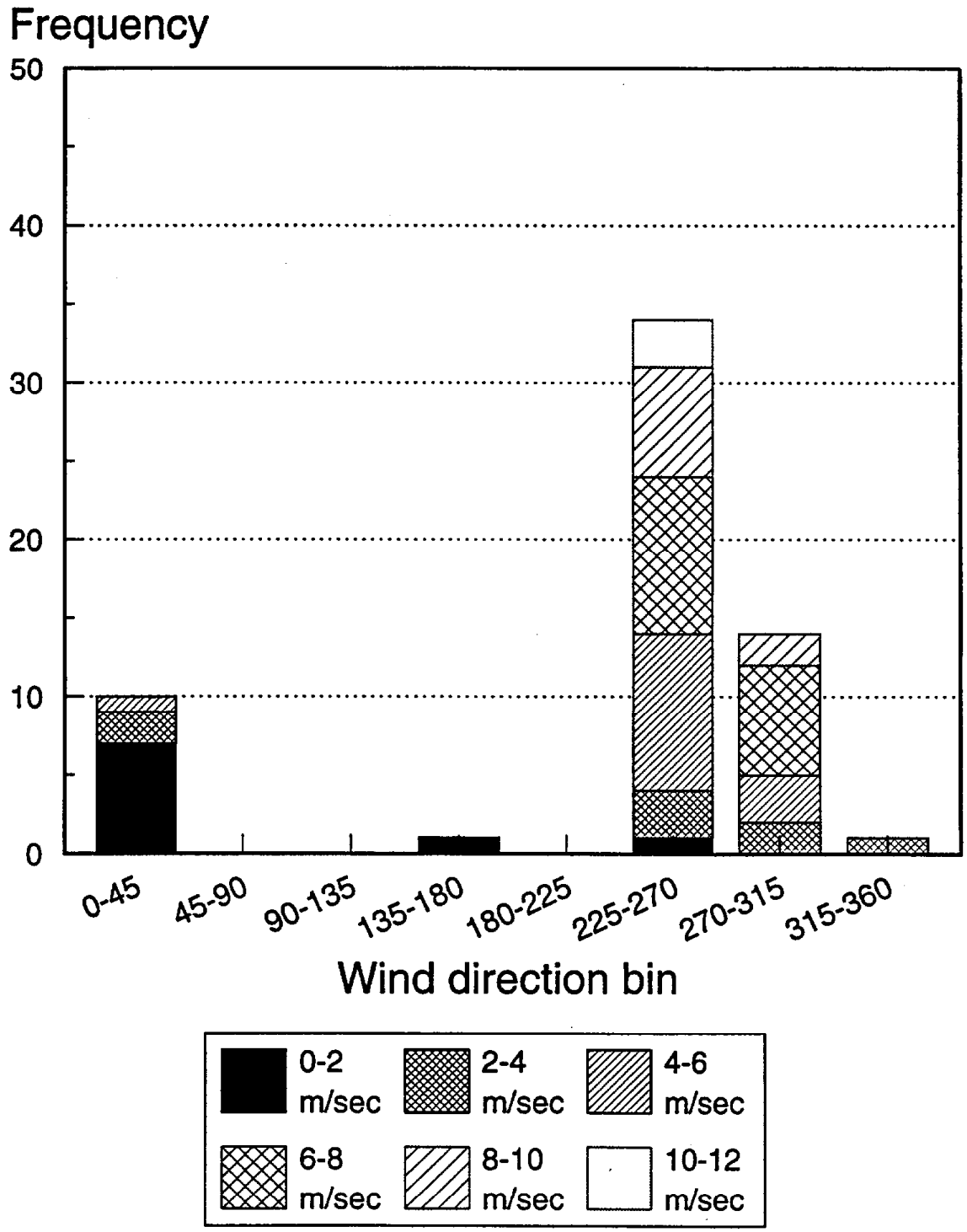
DEL Ridge Case Level 2



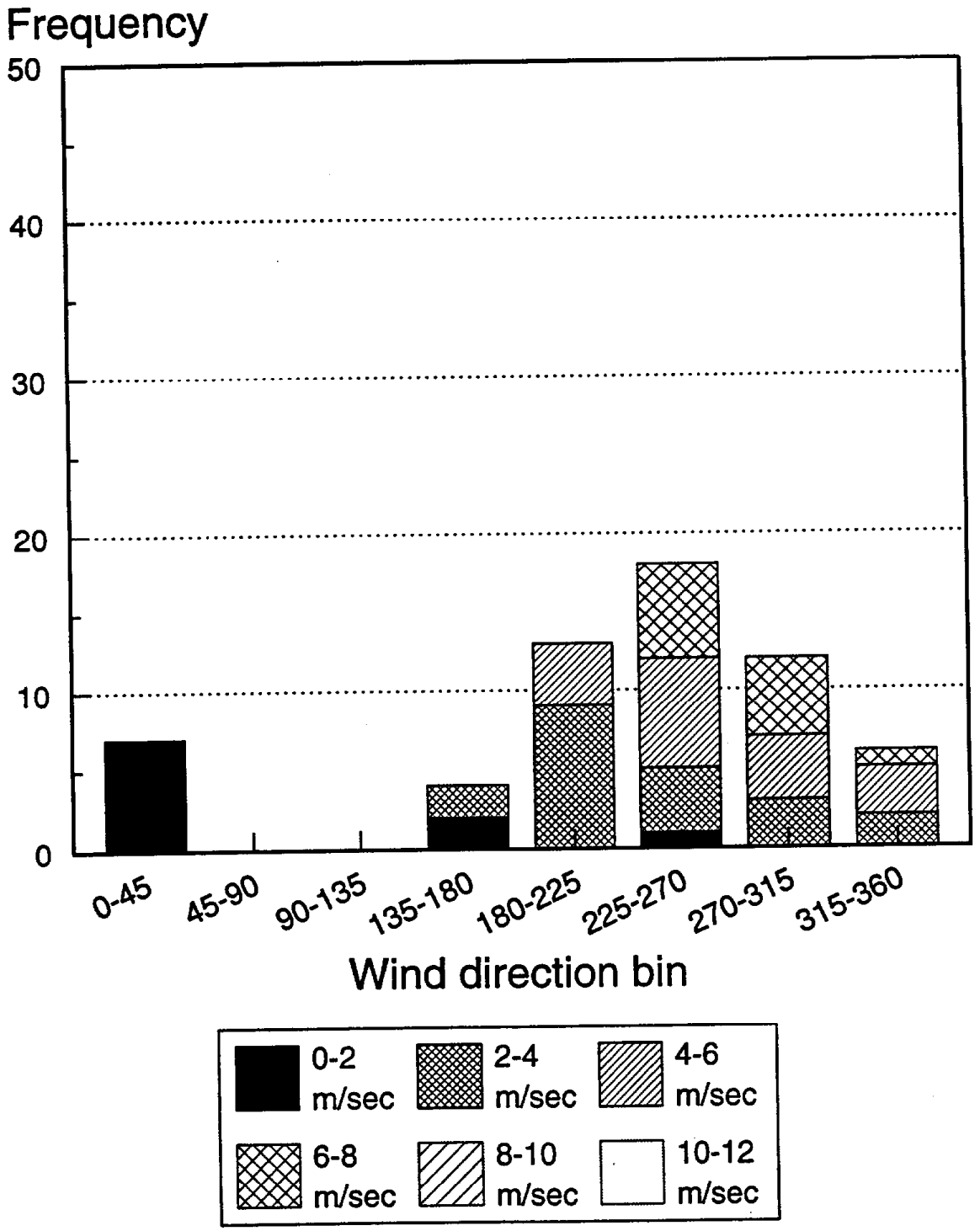
DEL Ridge Case Level 3



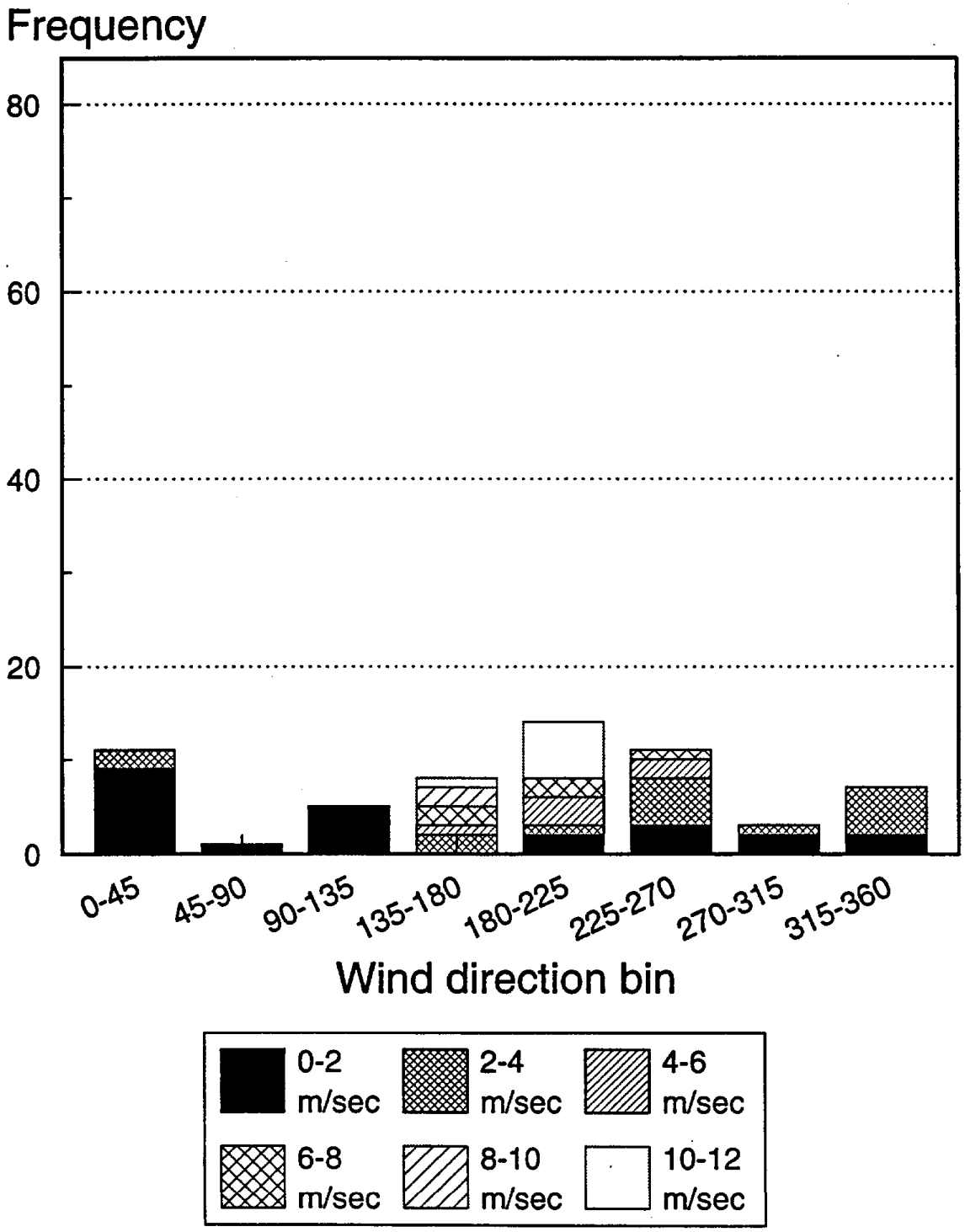
DEL Trough Case Level 1



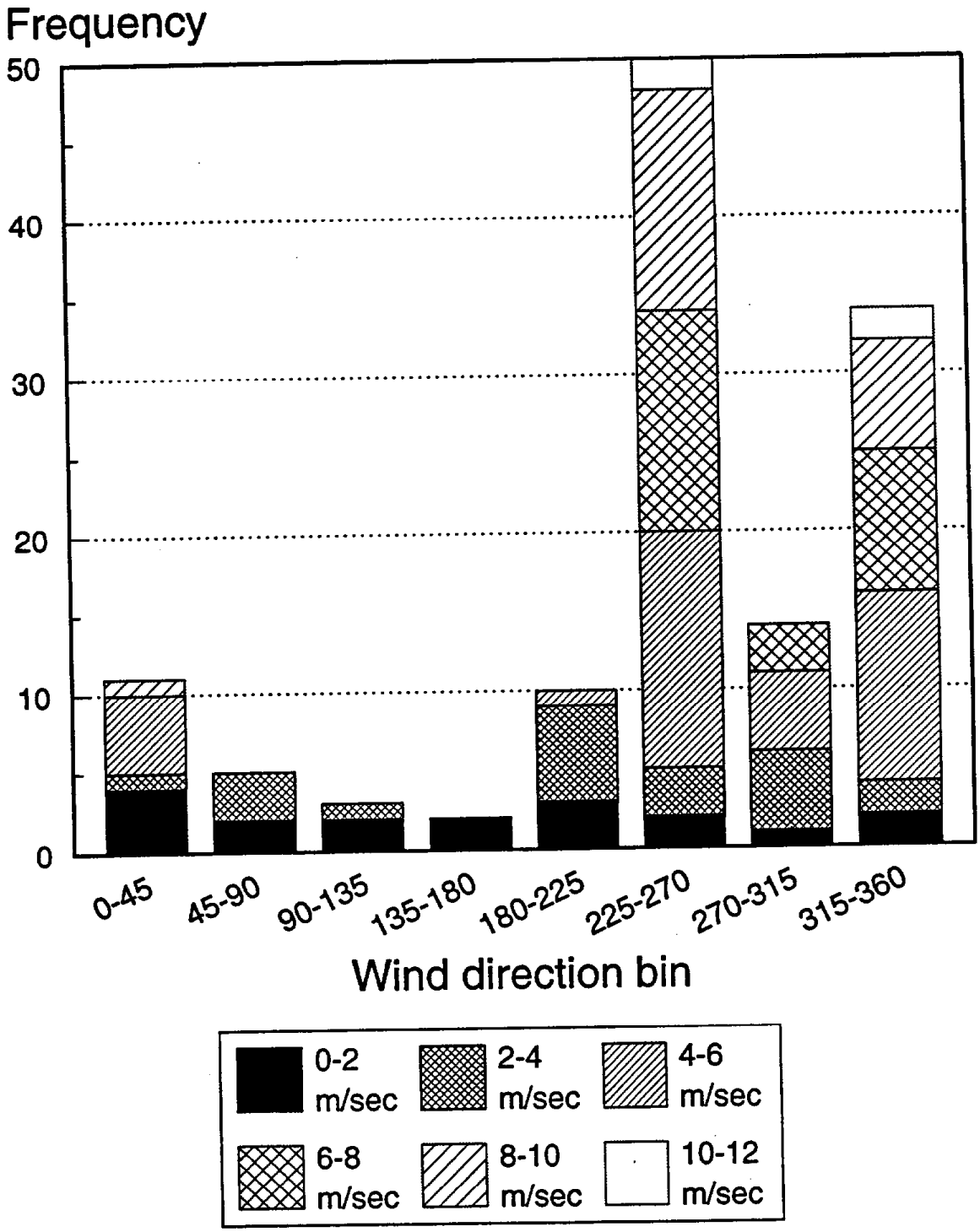
DEL Trough Case Level 2



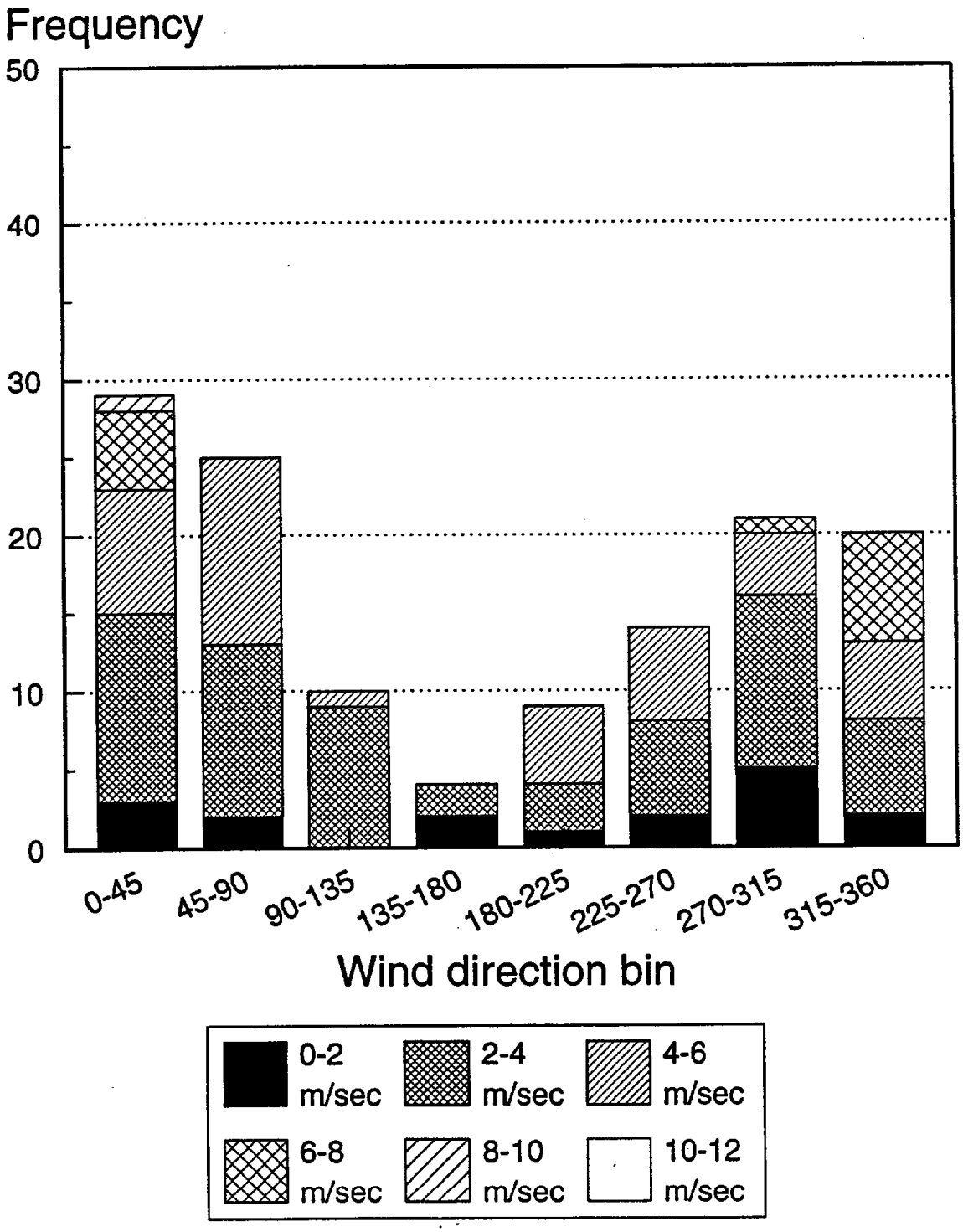
DEL Trough Case Level 3



TRS Ridge Case Level 1



TRS Ridge Case Level 2



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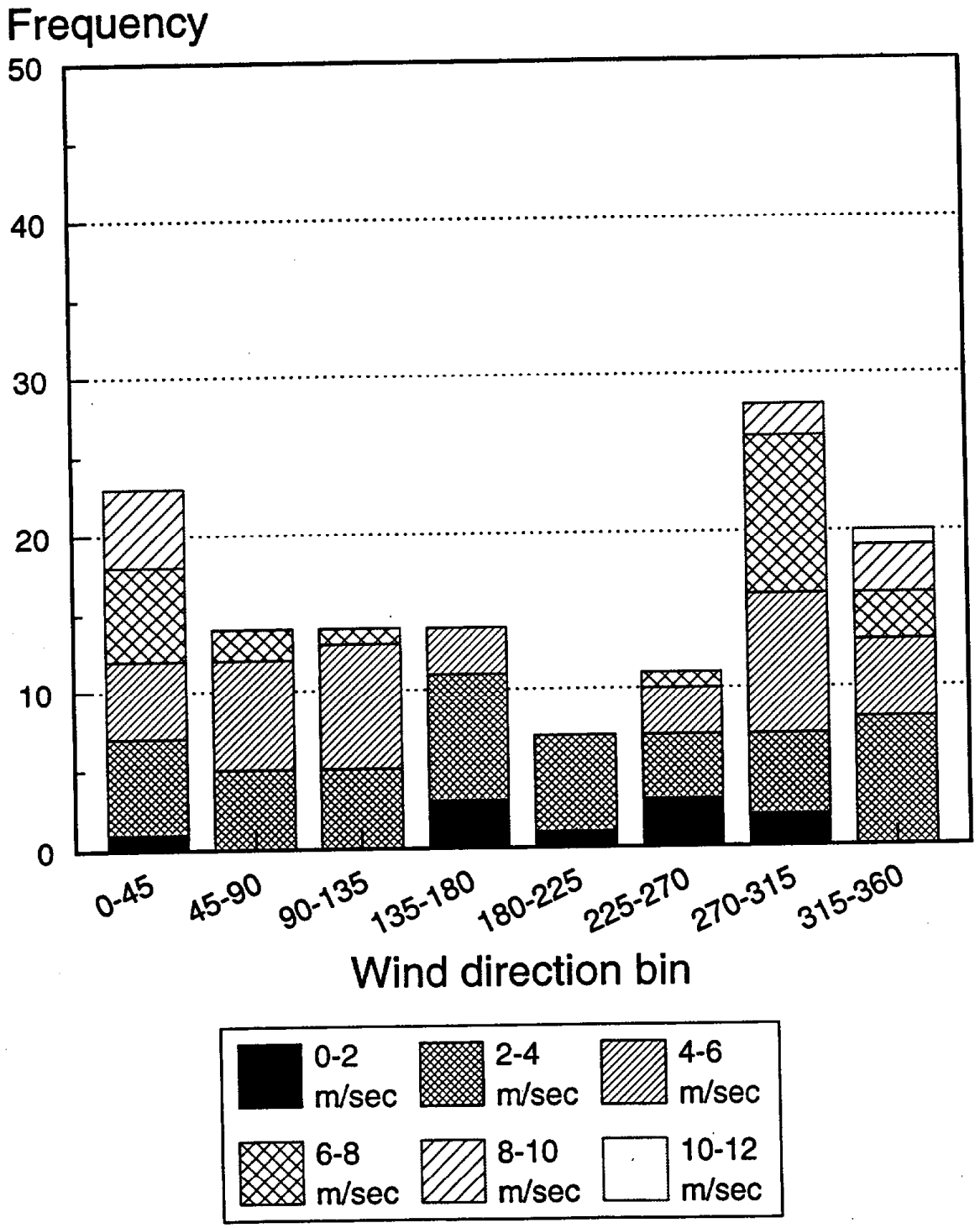

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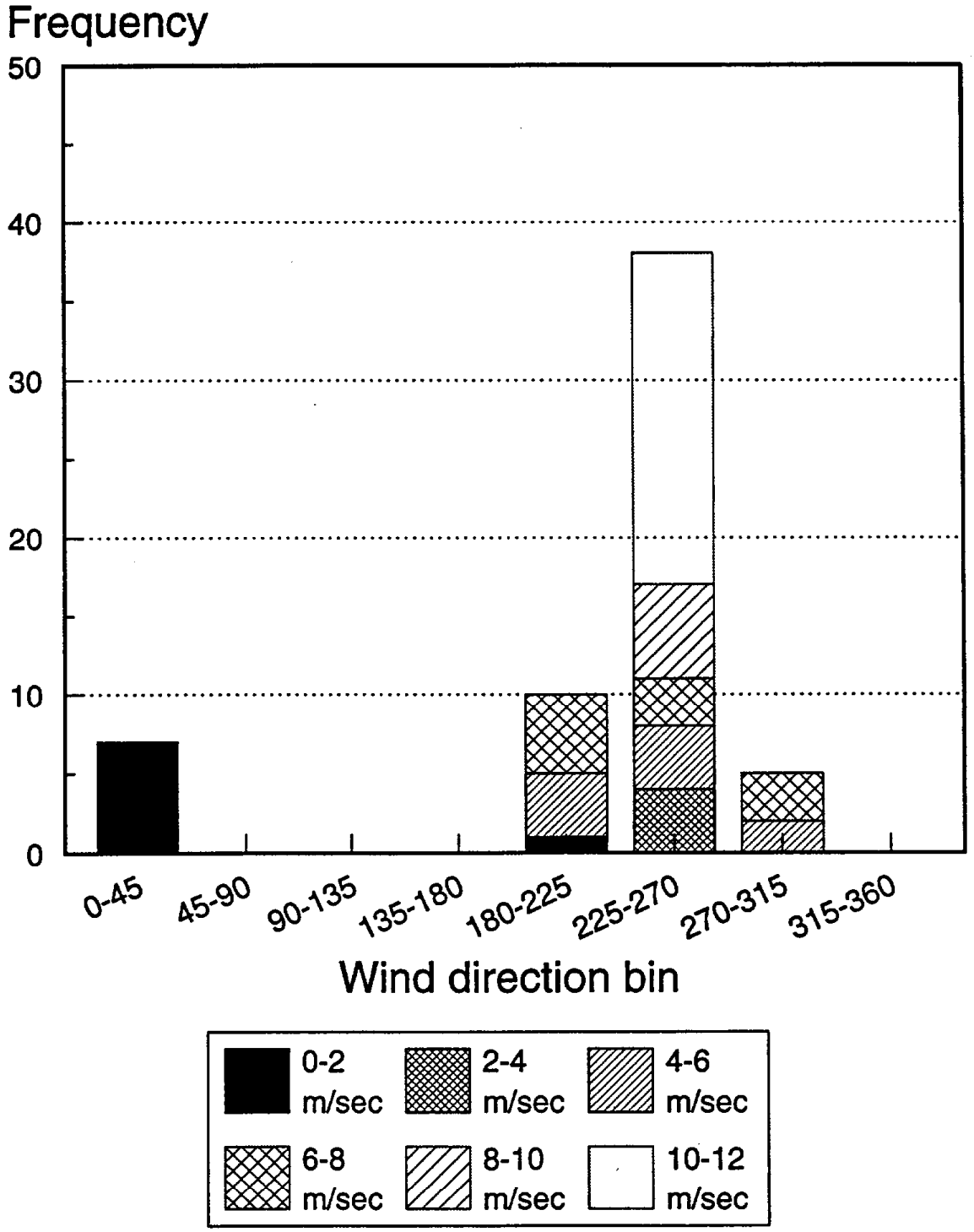

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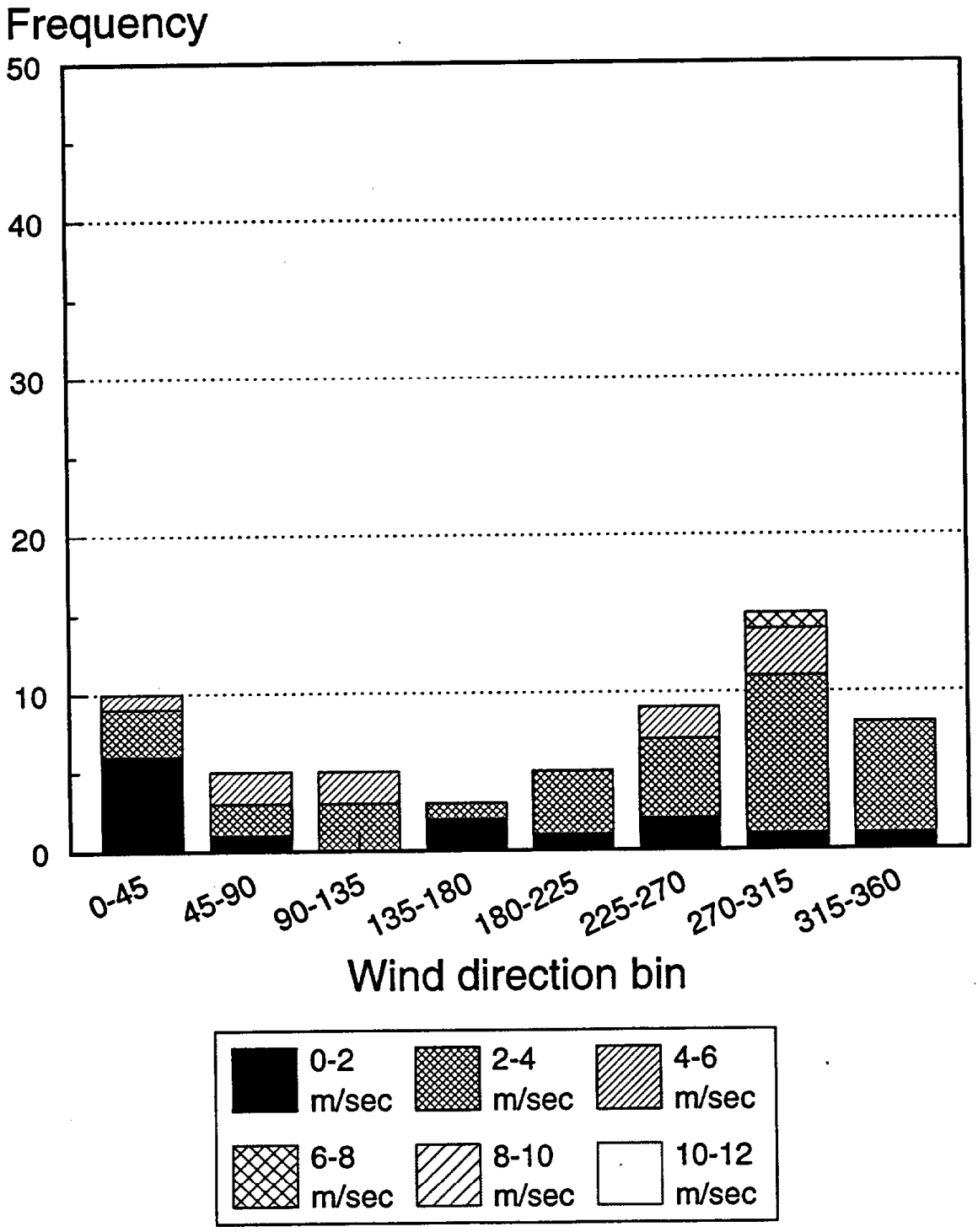

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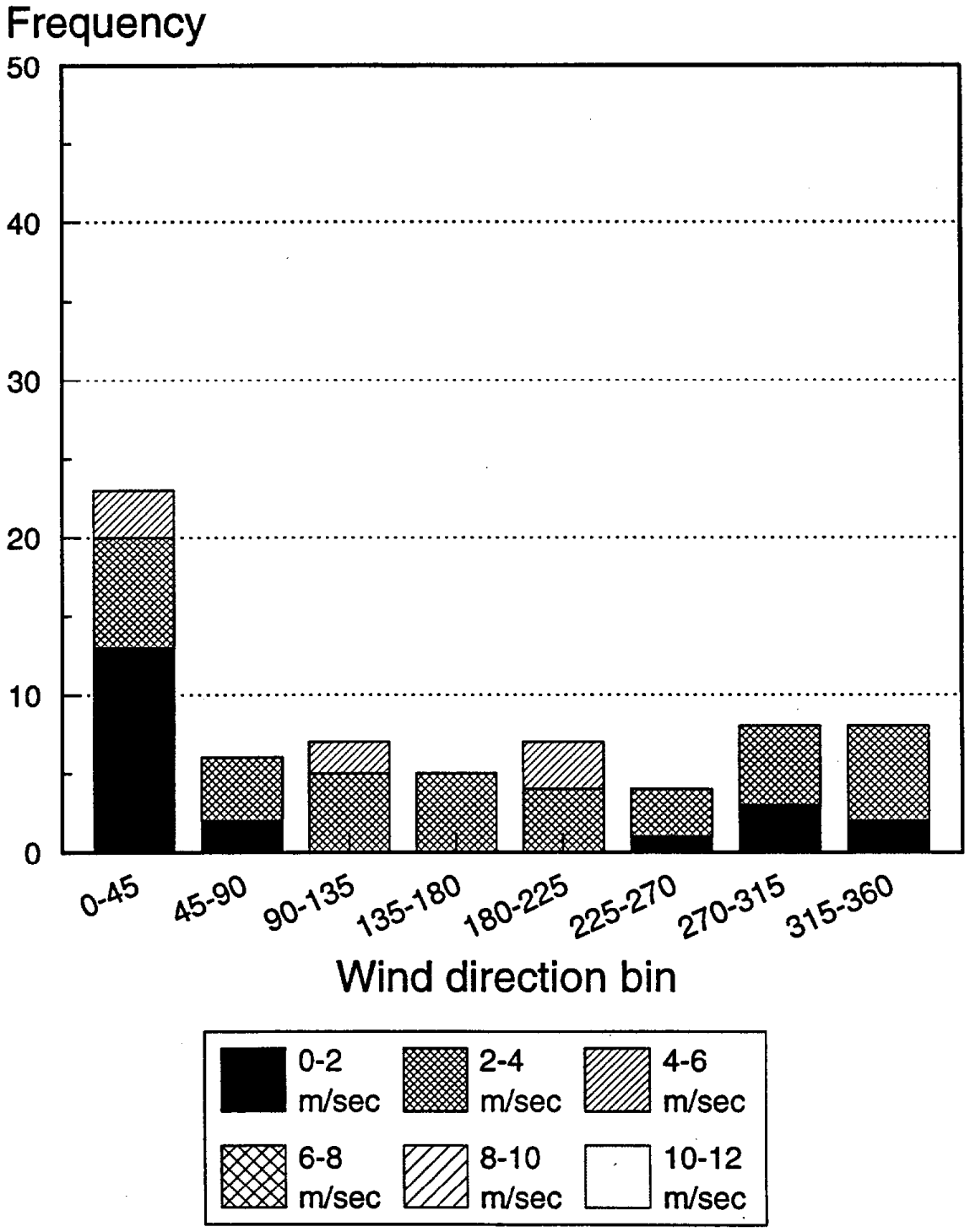

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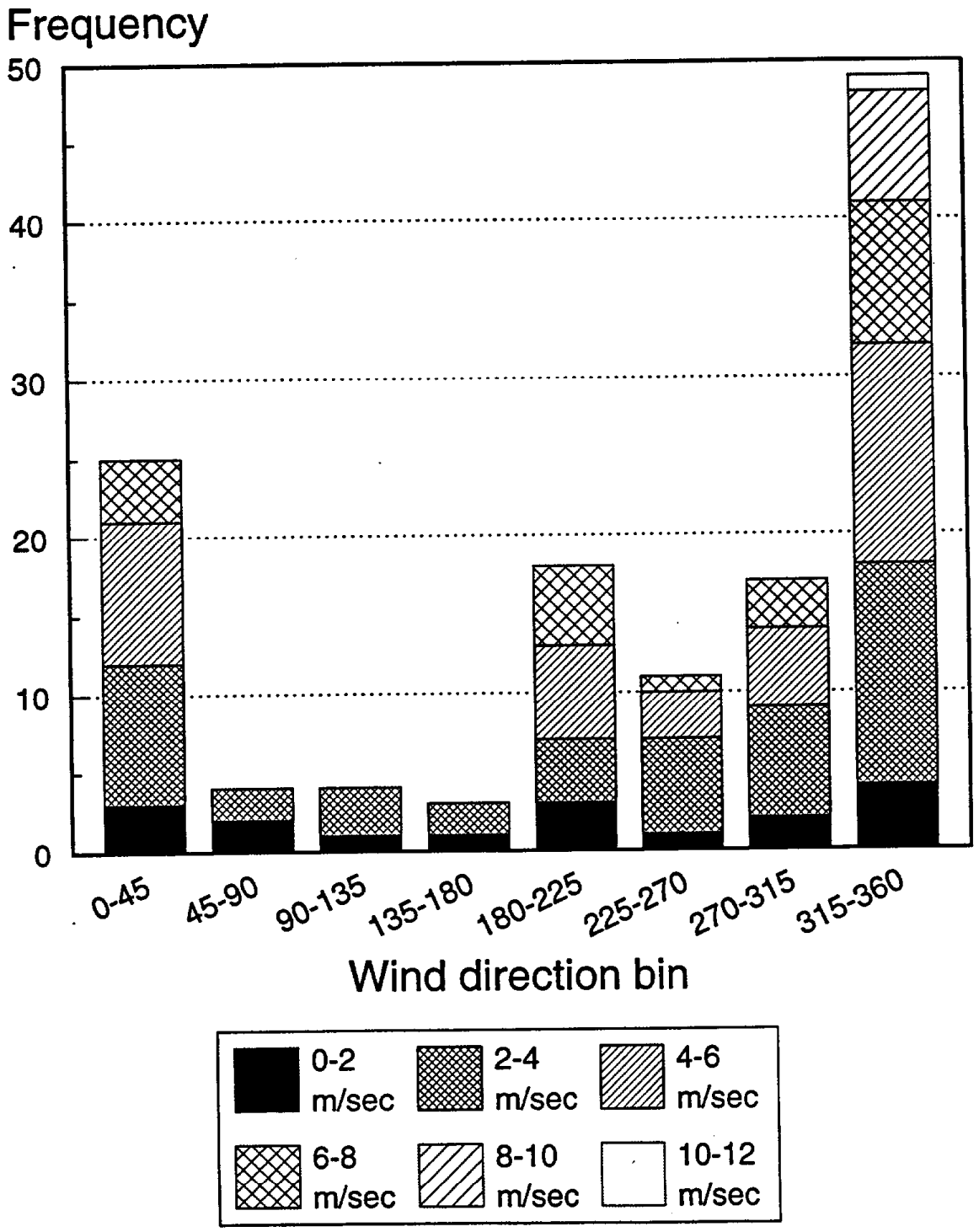

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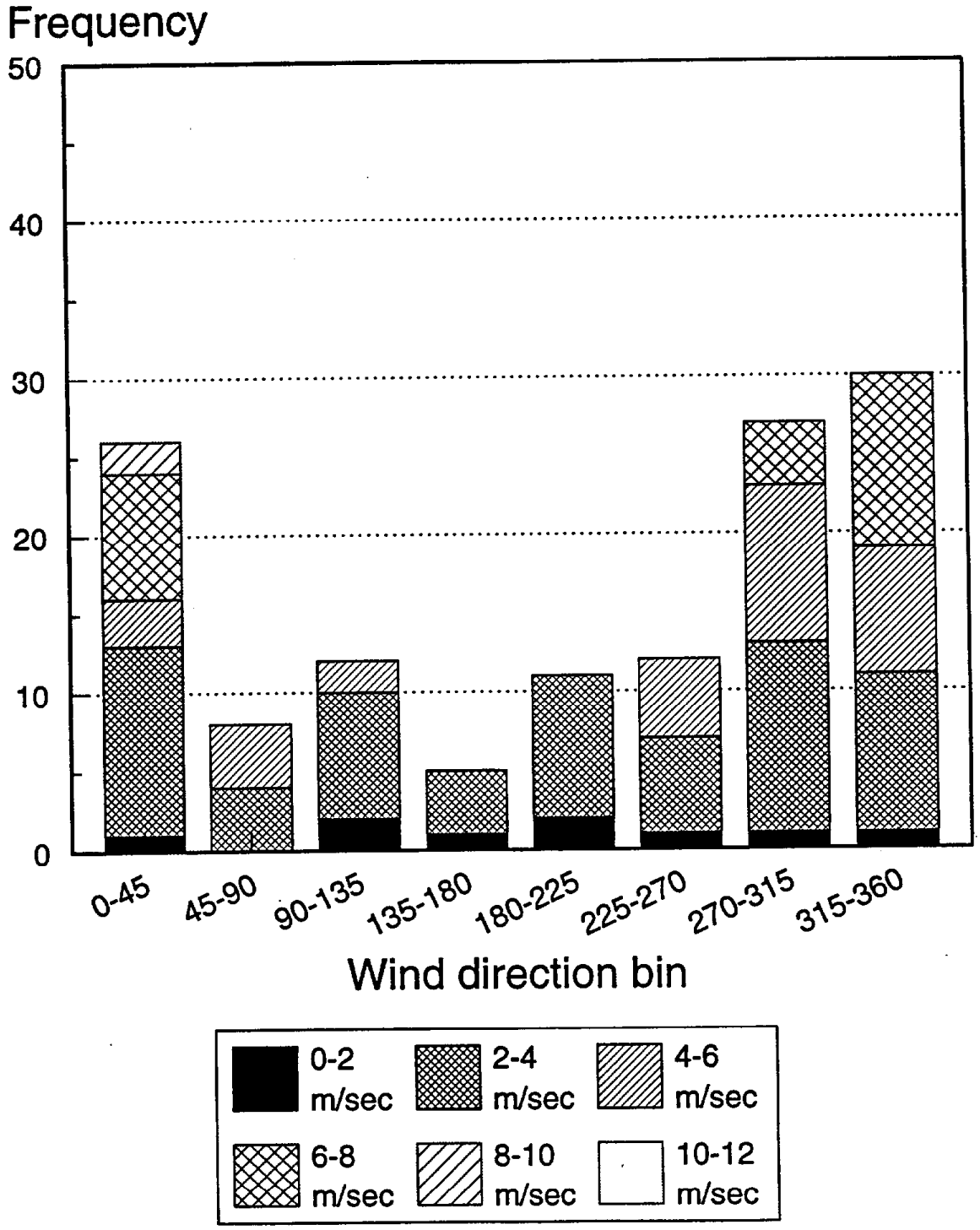

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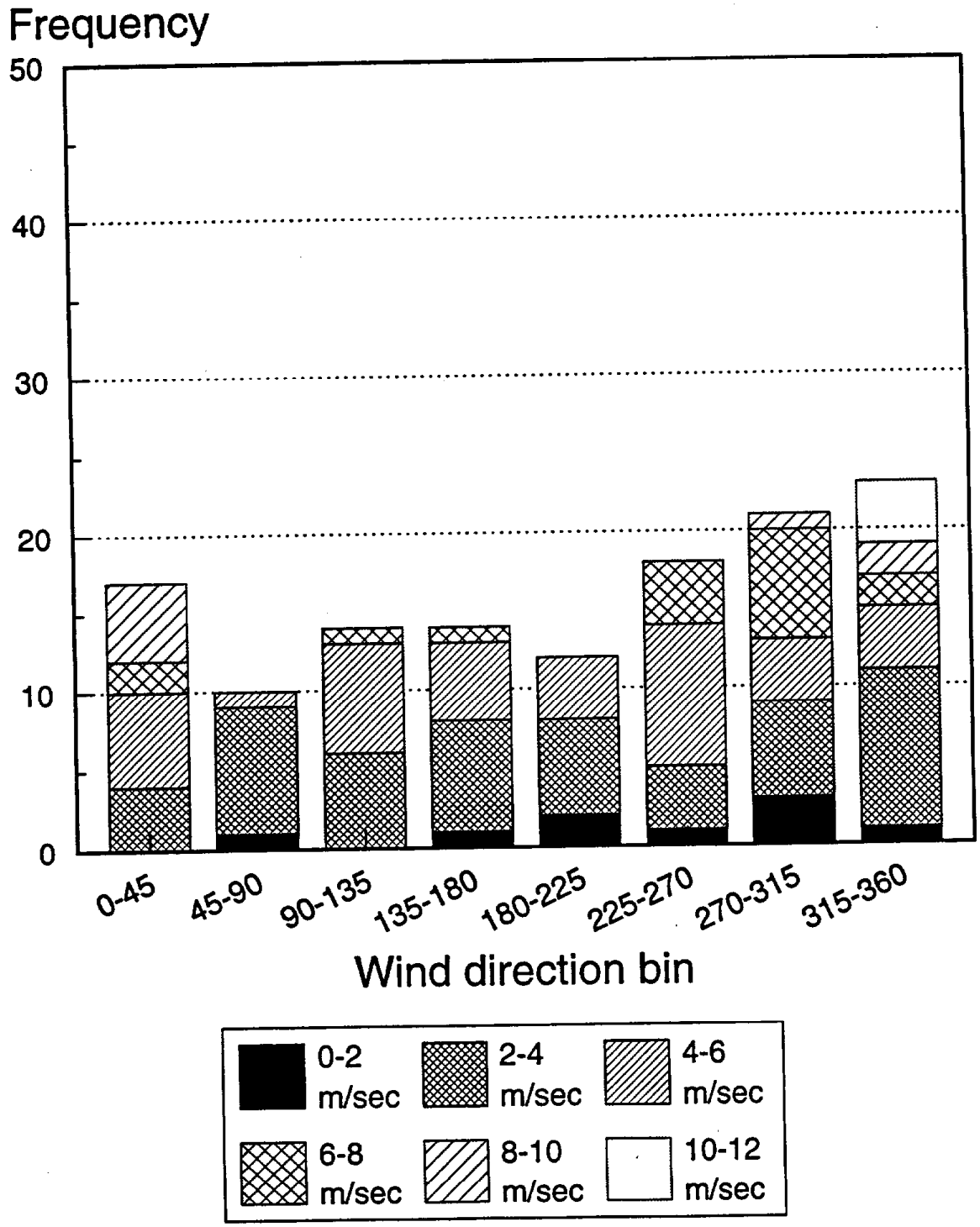

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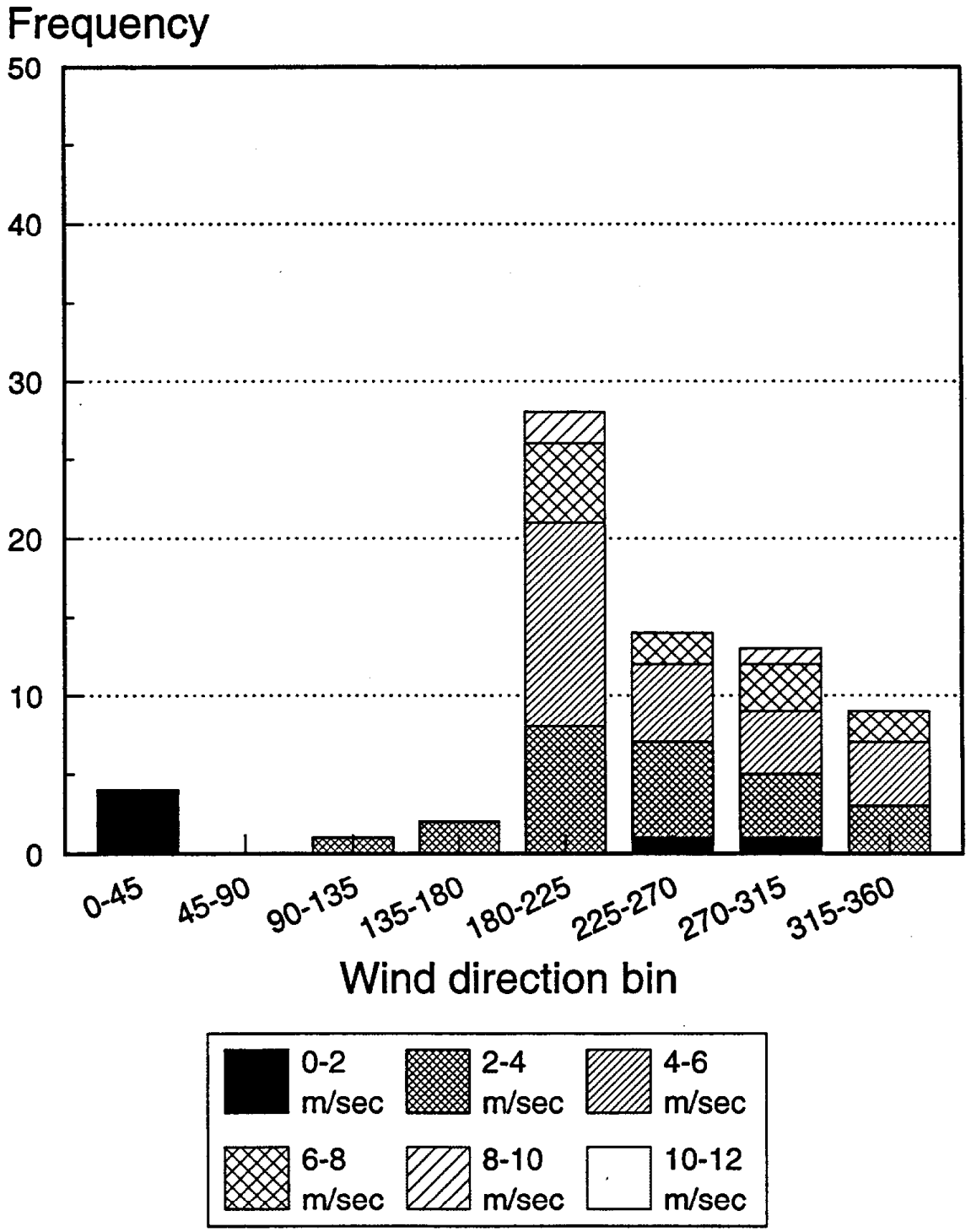

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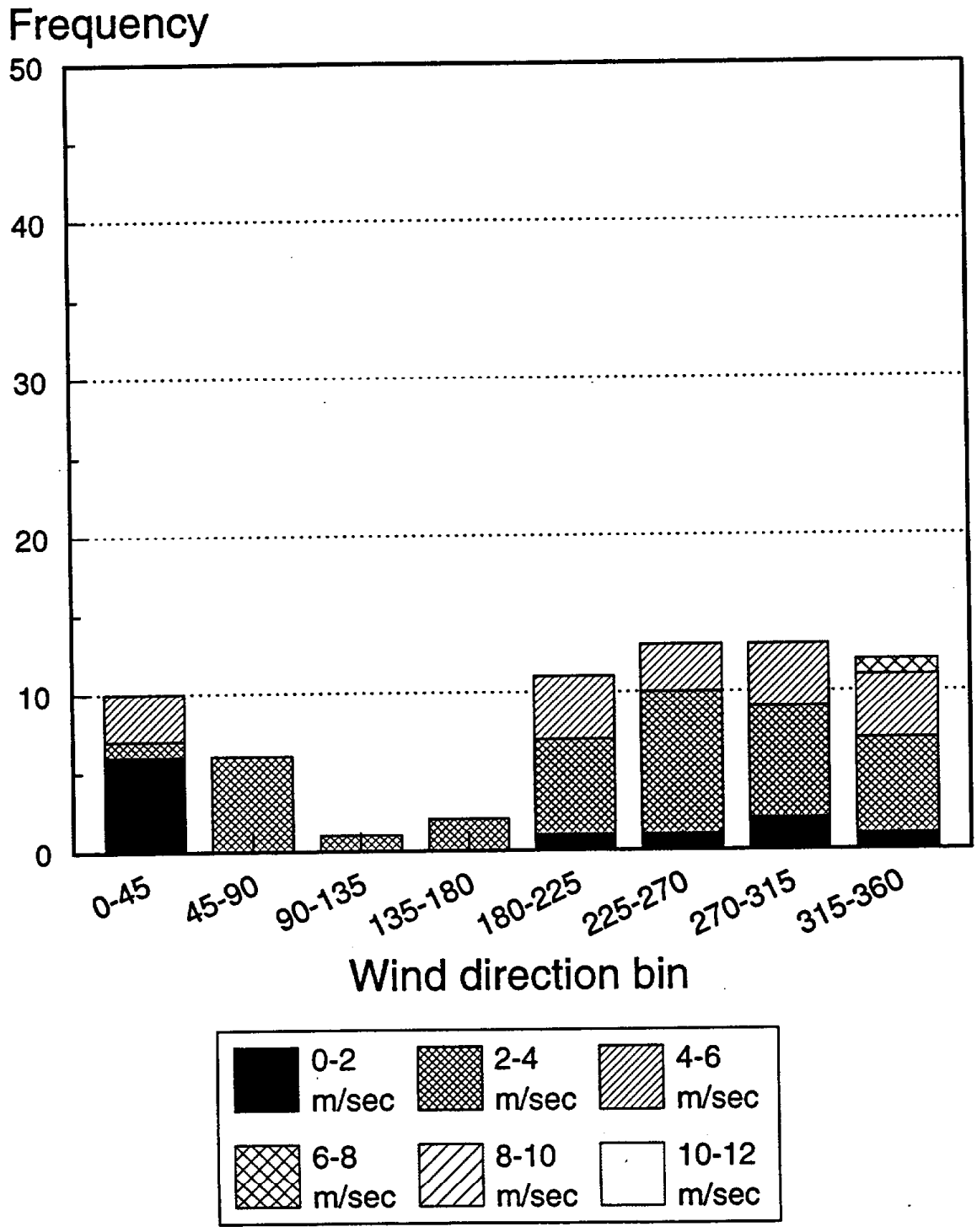

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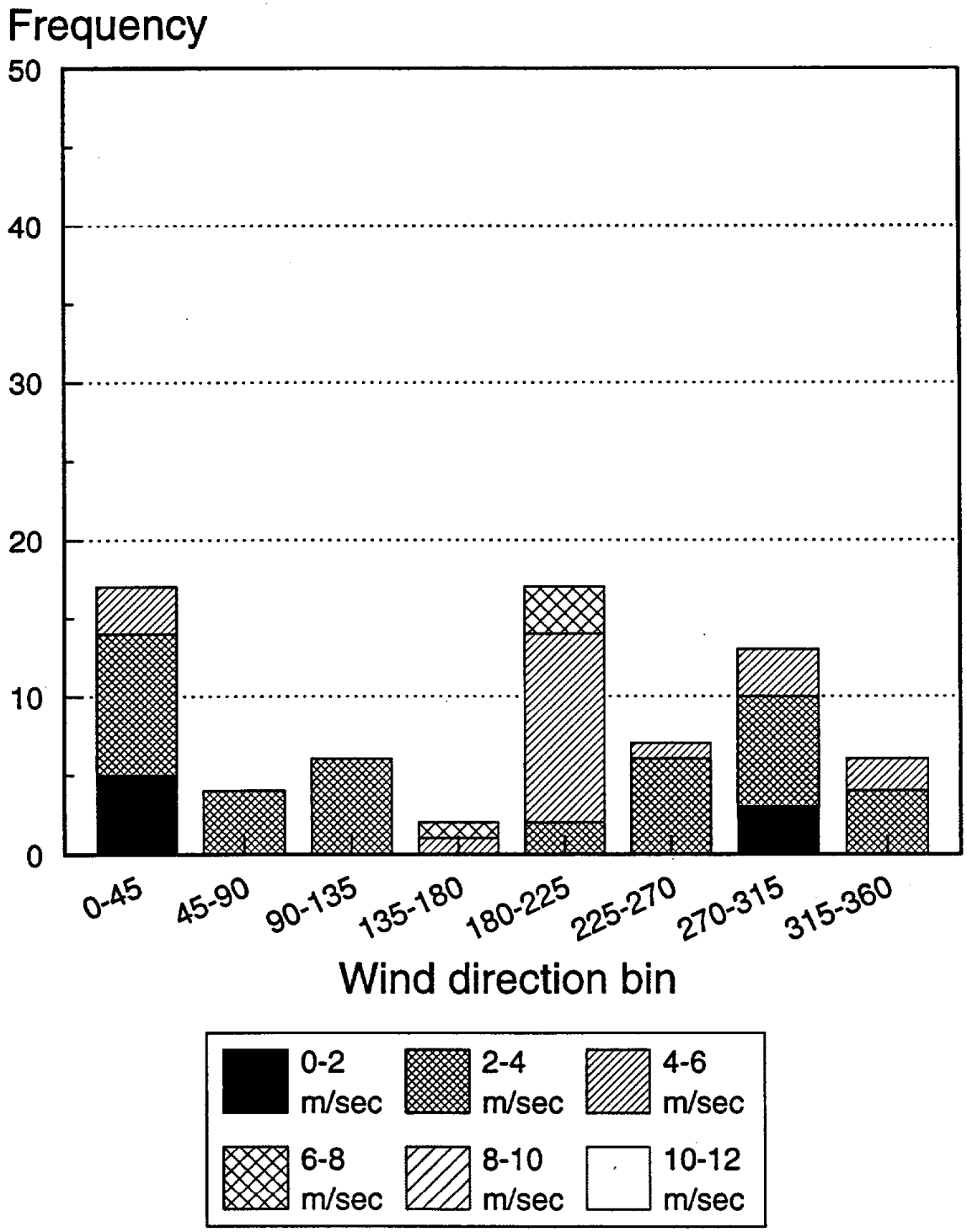
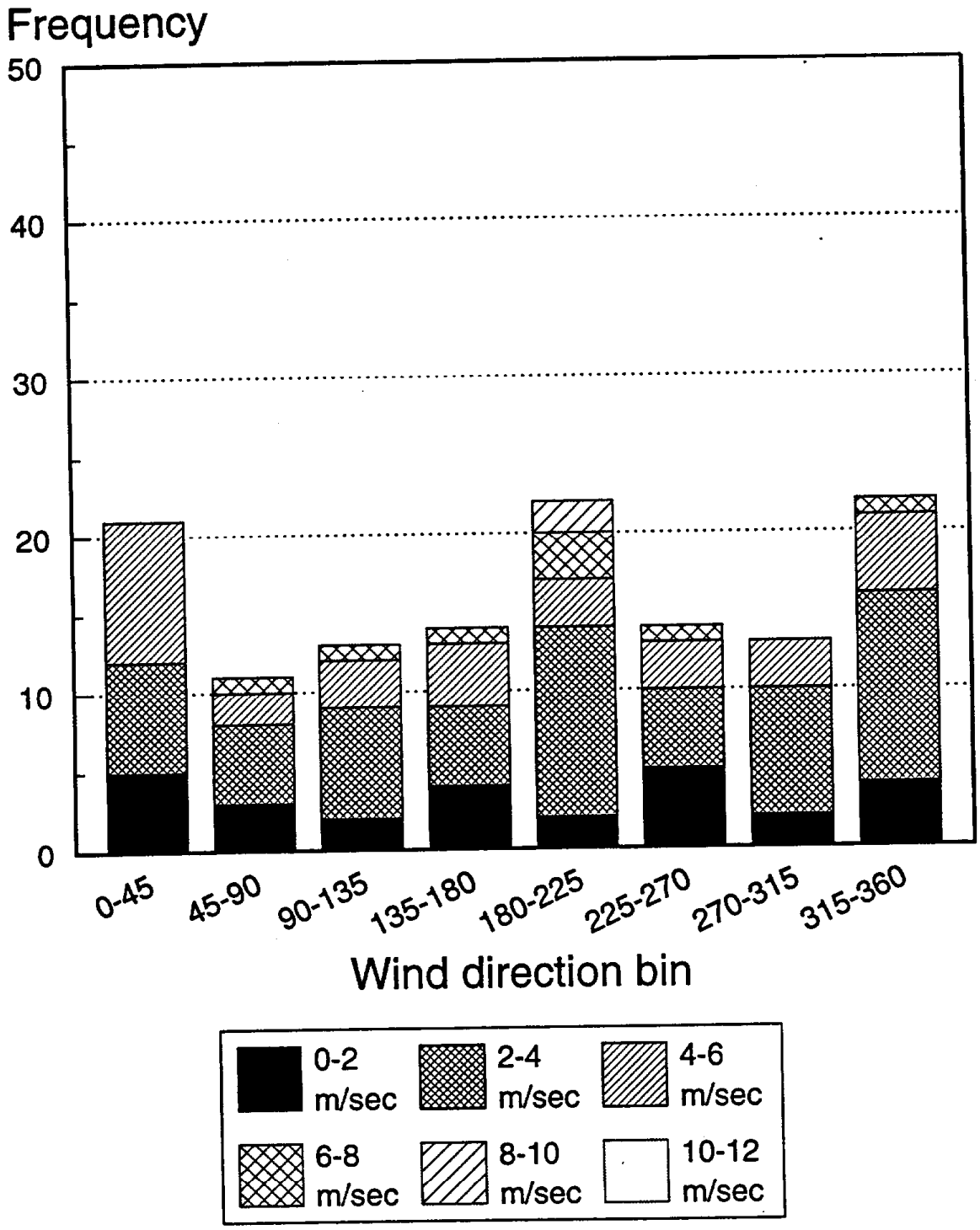


PLG Ridge Case Level 1



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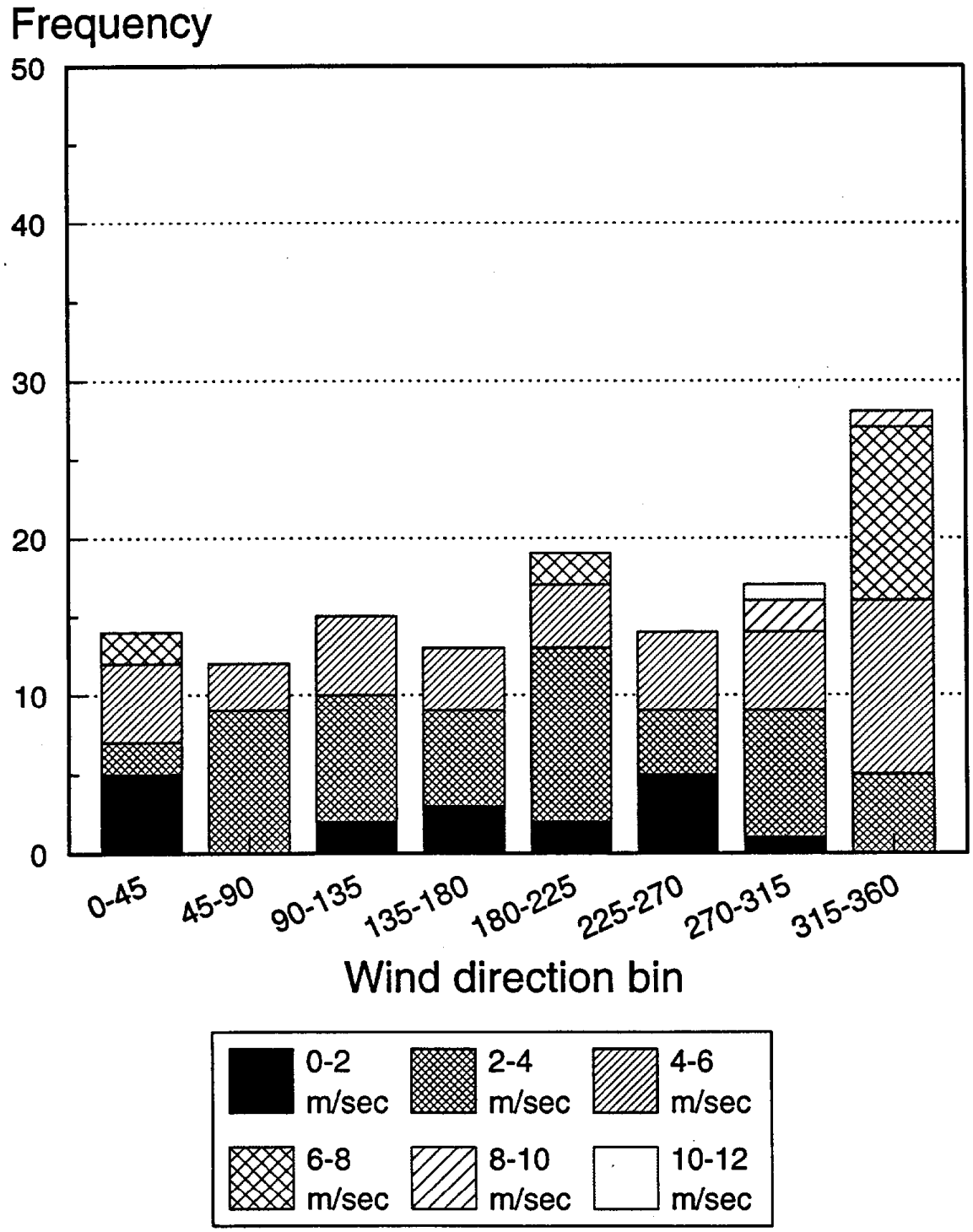

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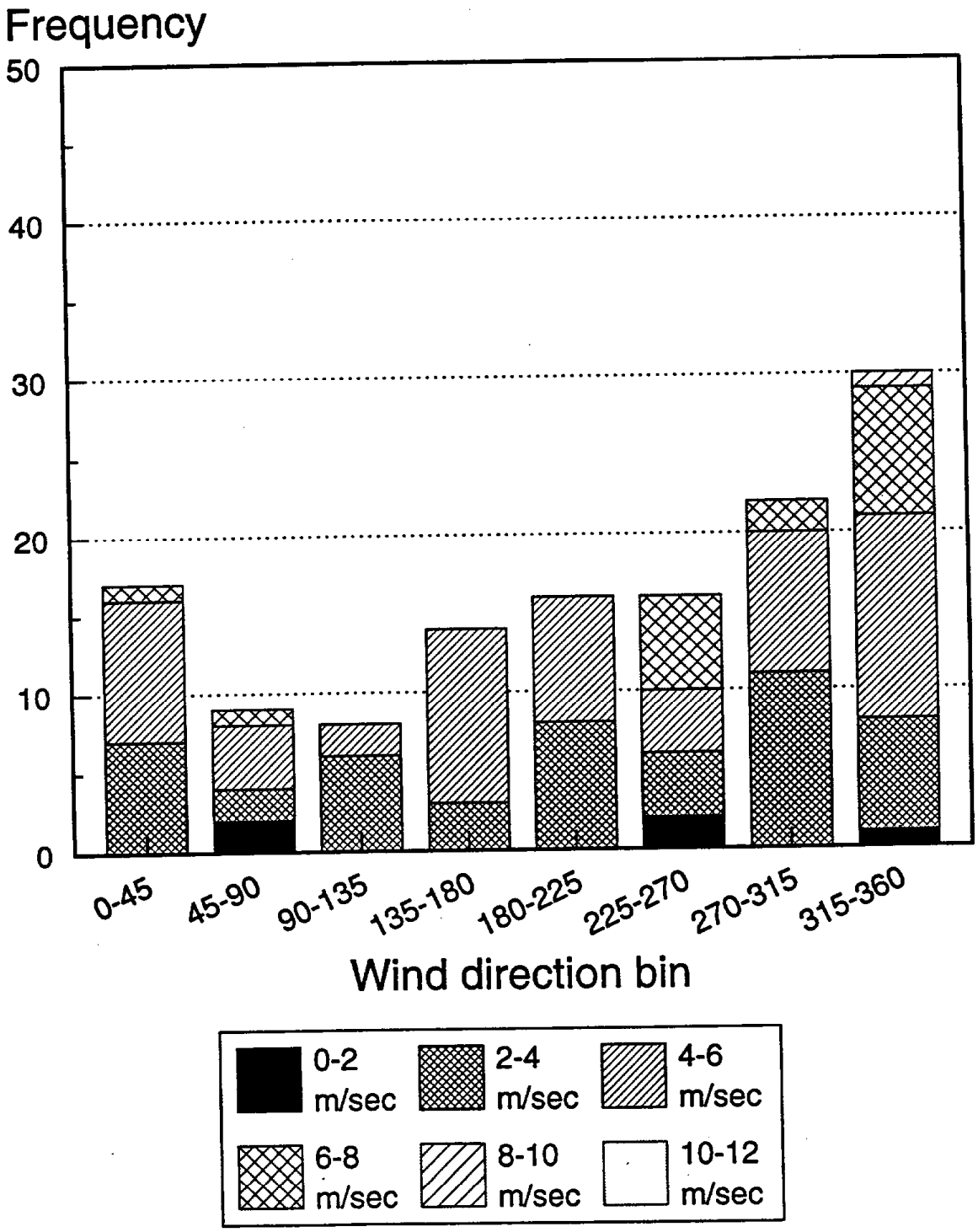

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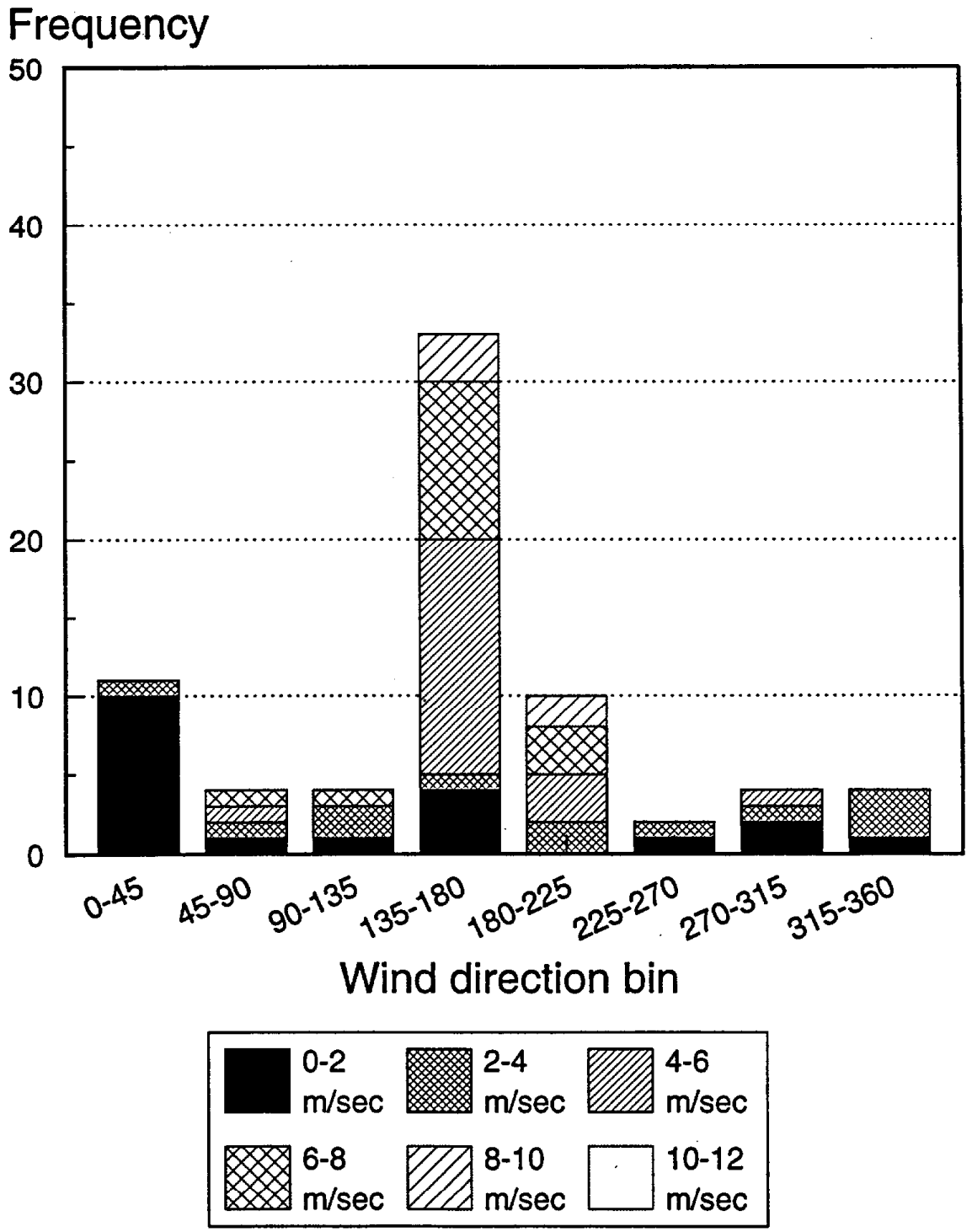

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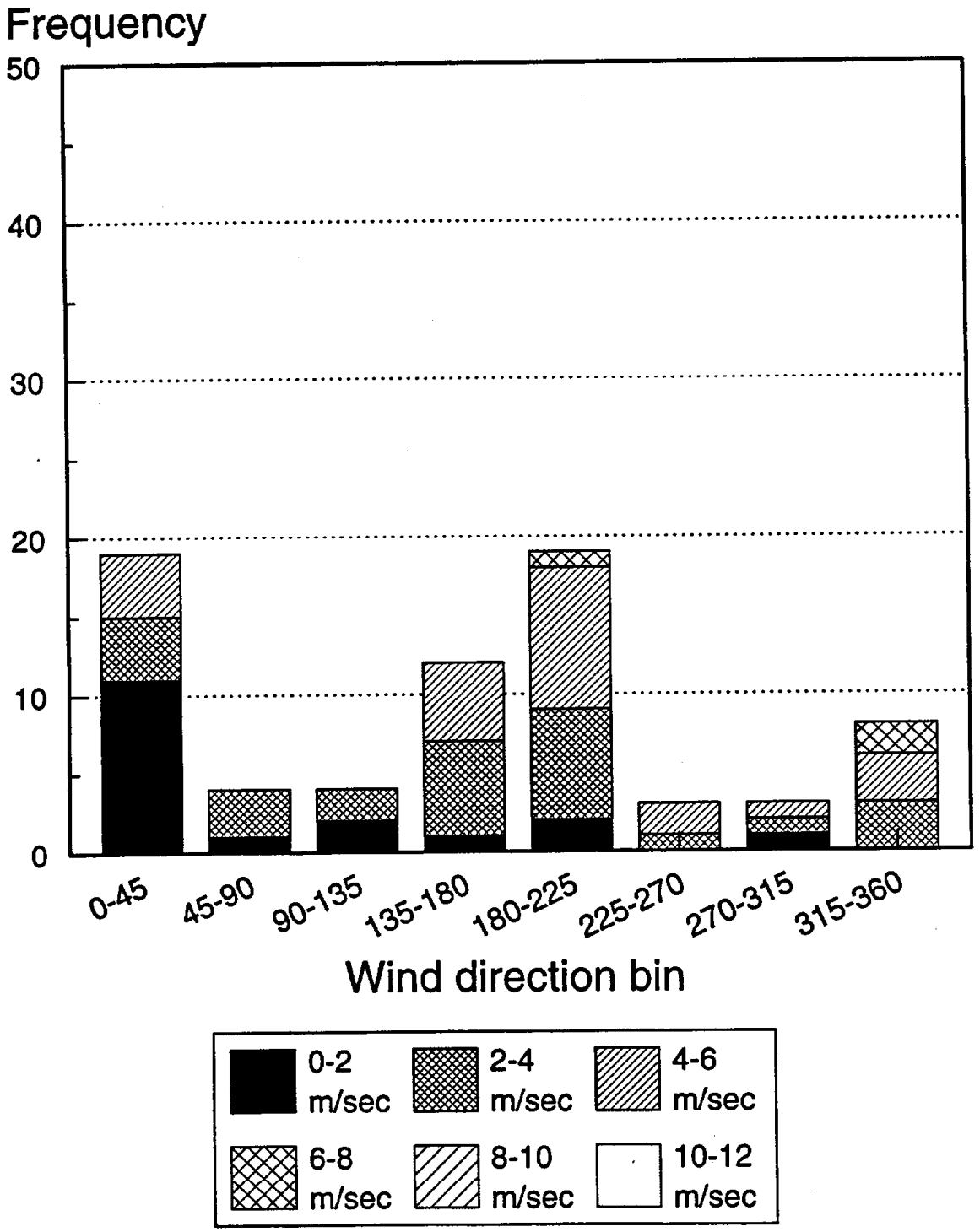

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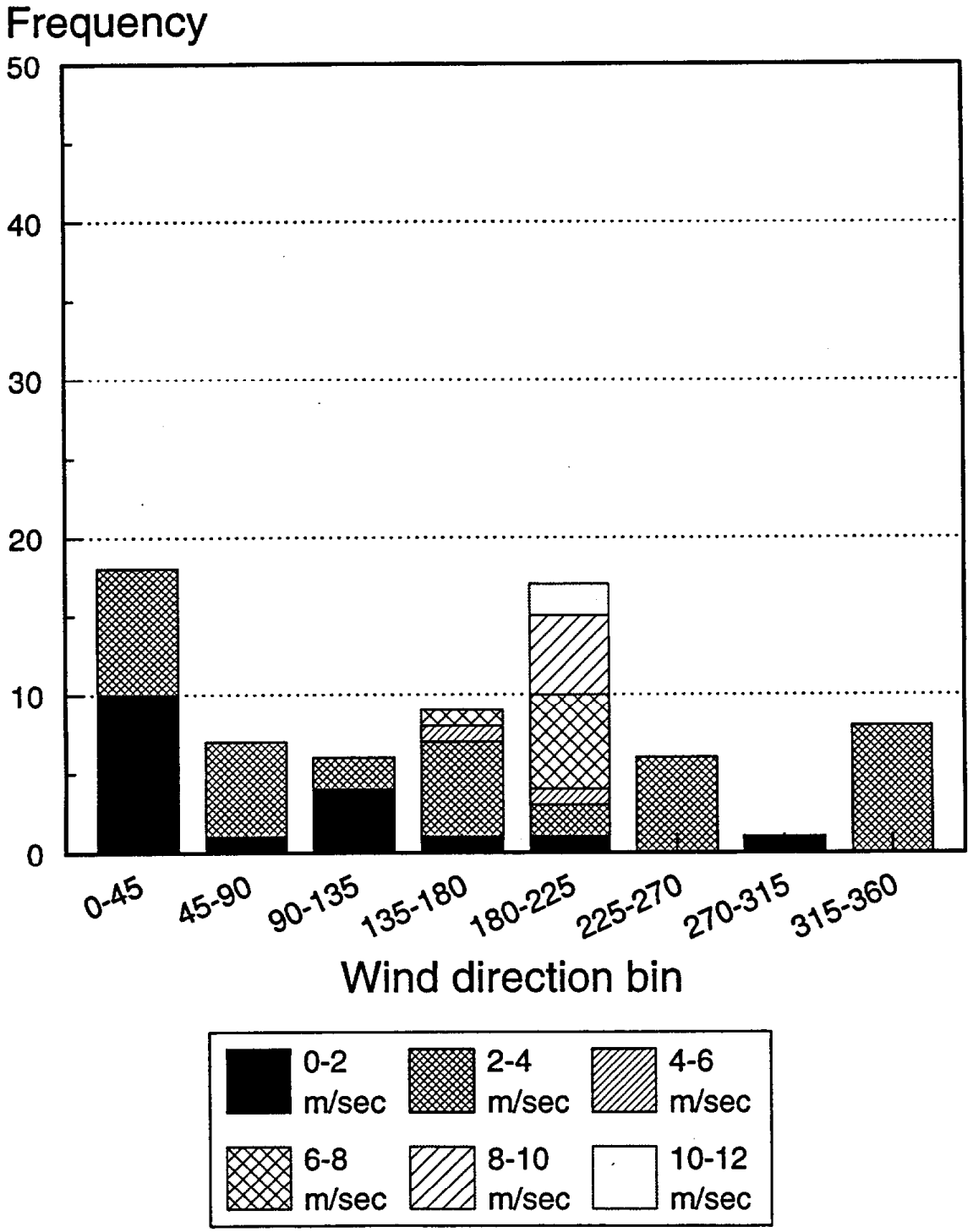
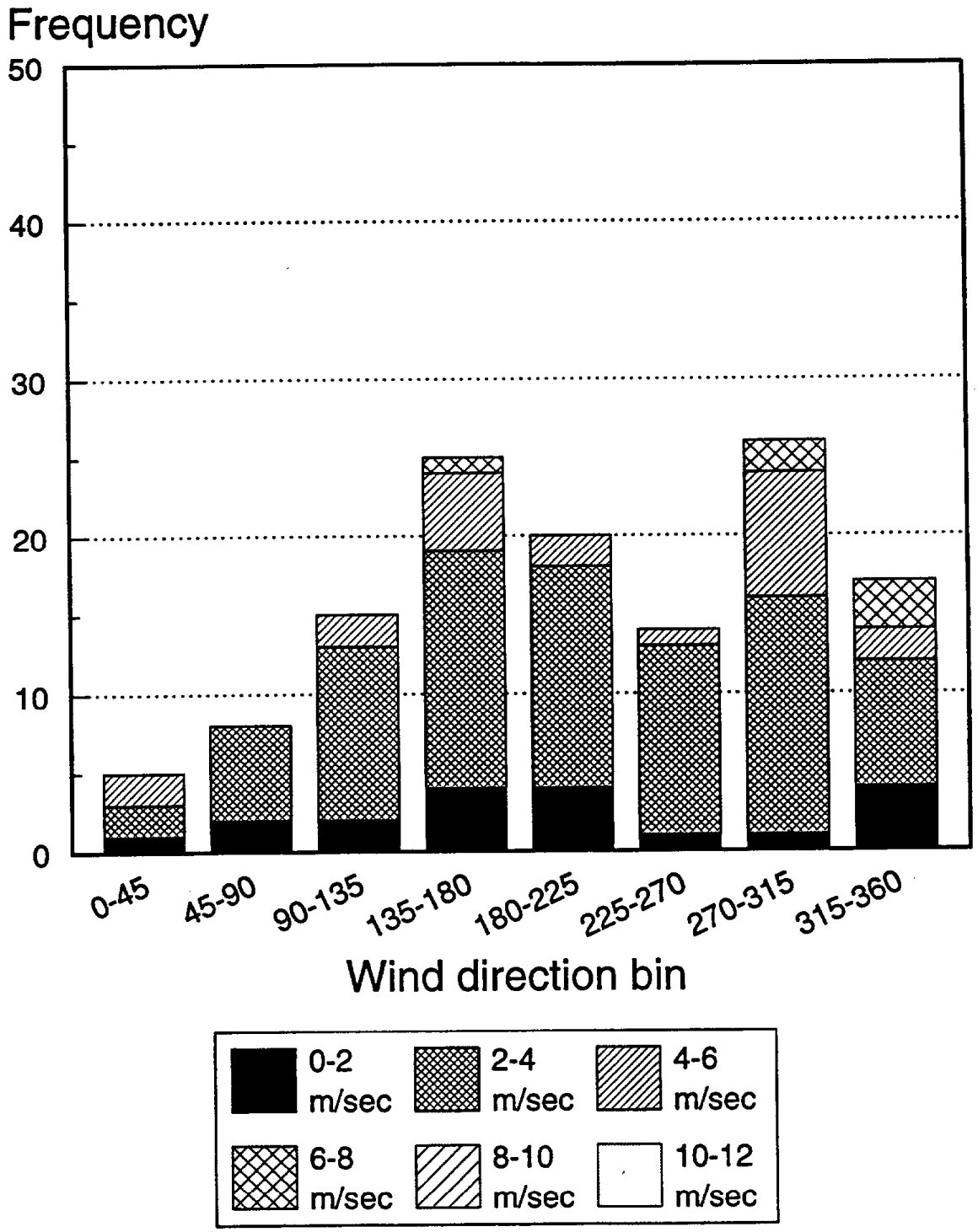
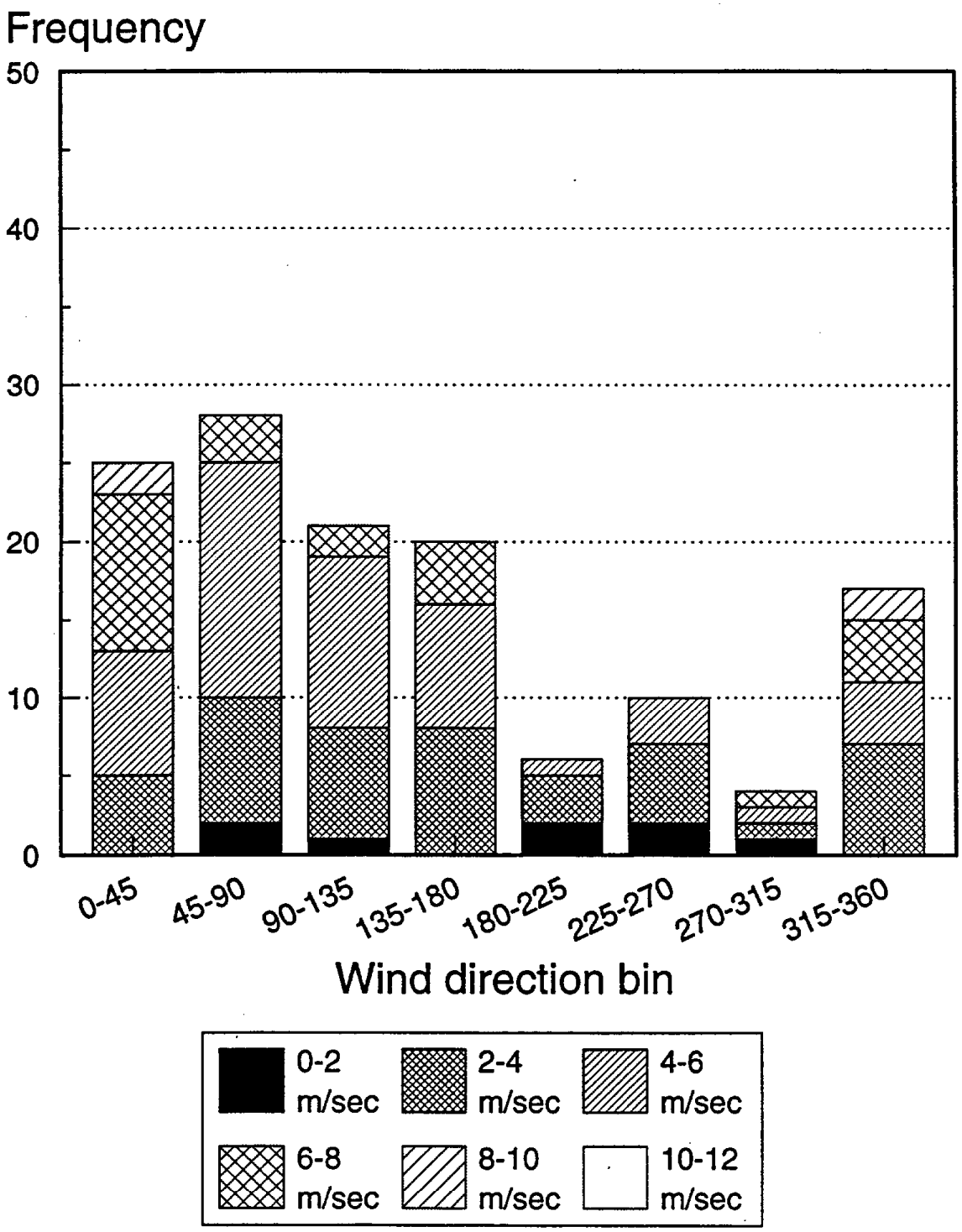


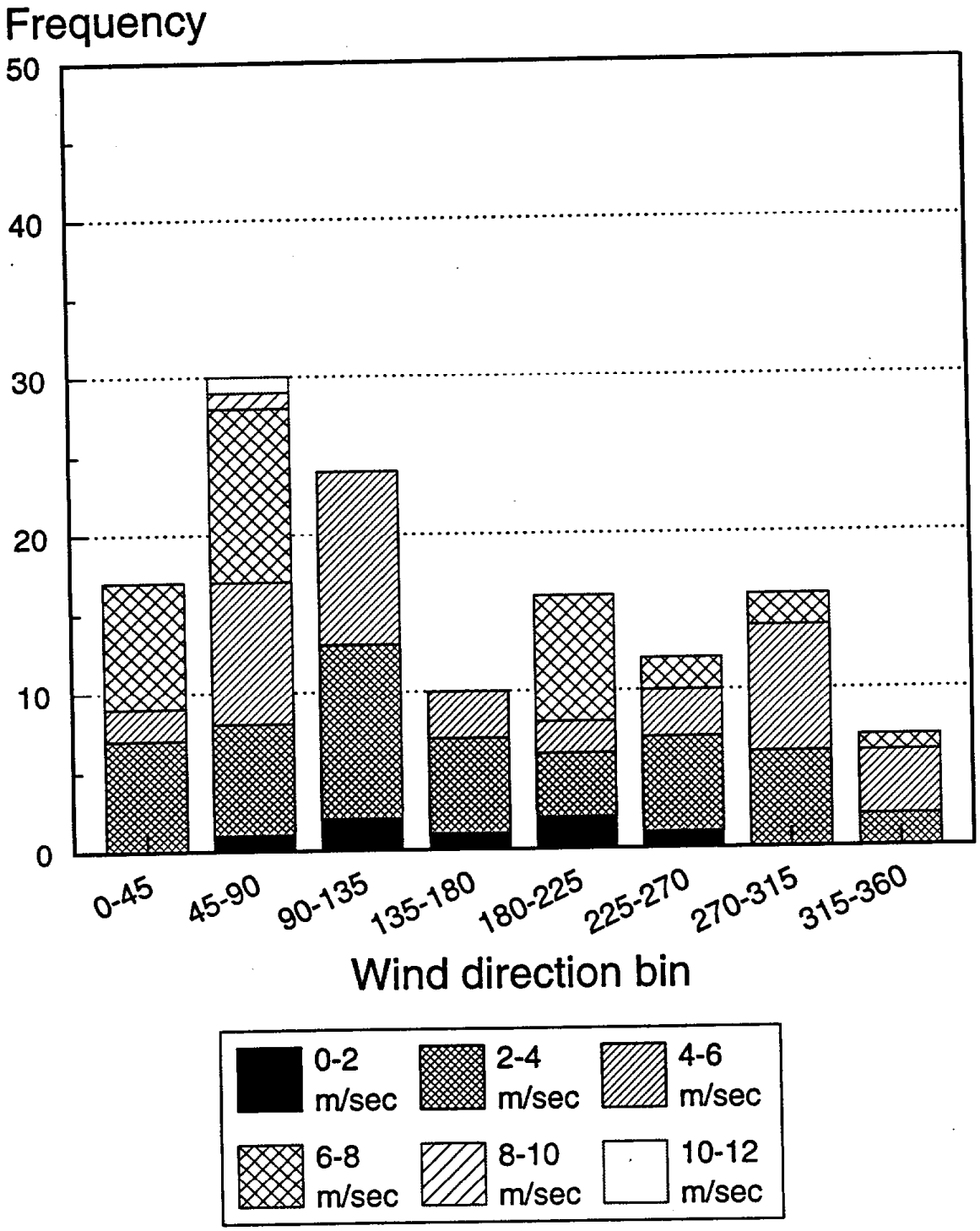
Oroville Ridge Case - Level 1



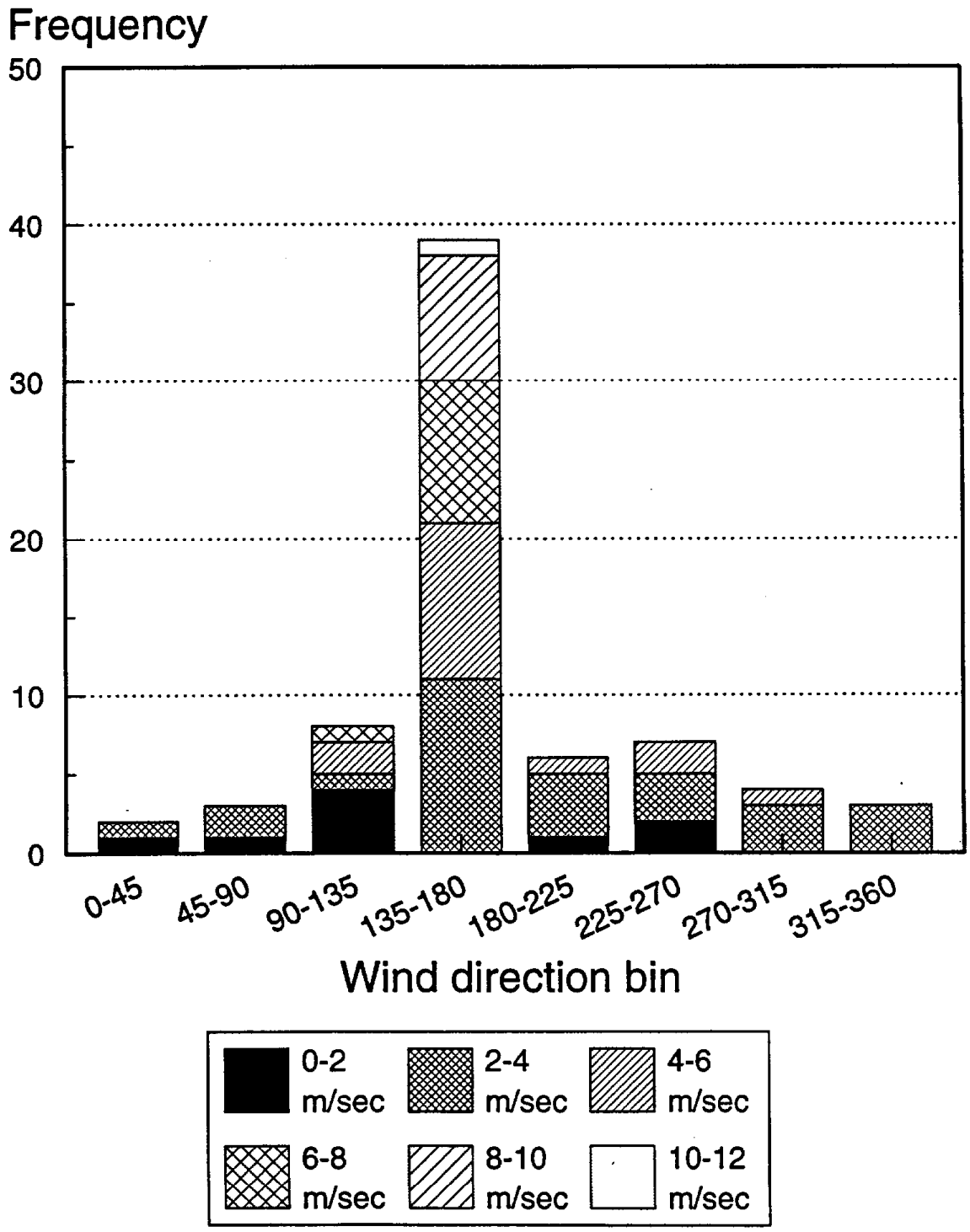
Oroville Ridge Case - Level 2



Oroville Ridge Case - Level 3



Oroville Trough Case - Level 1



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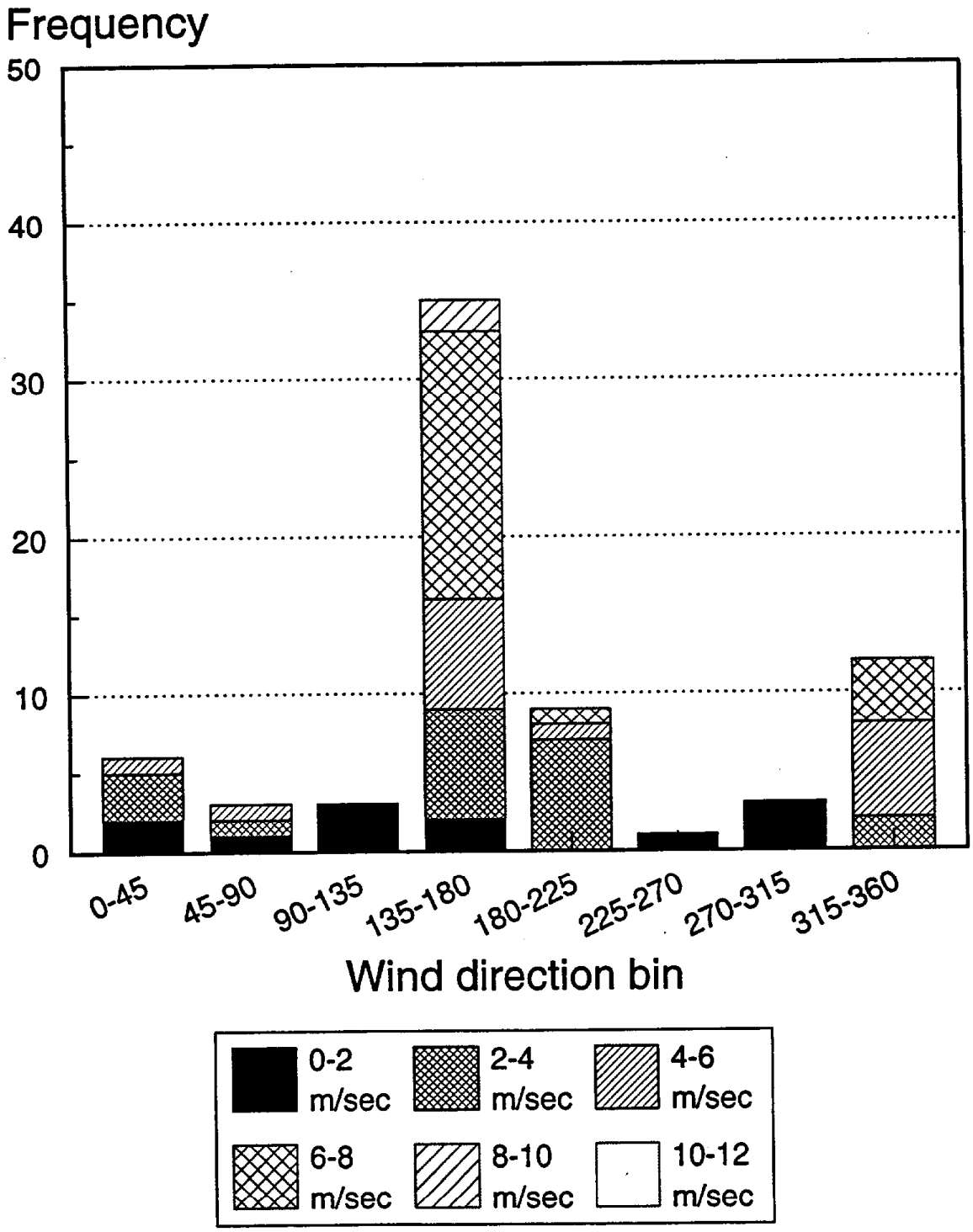

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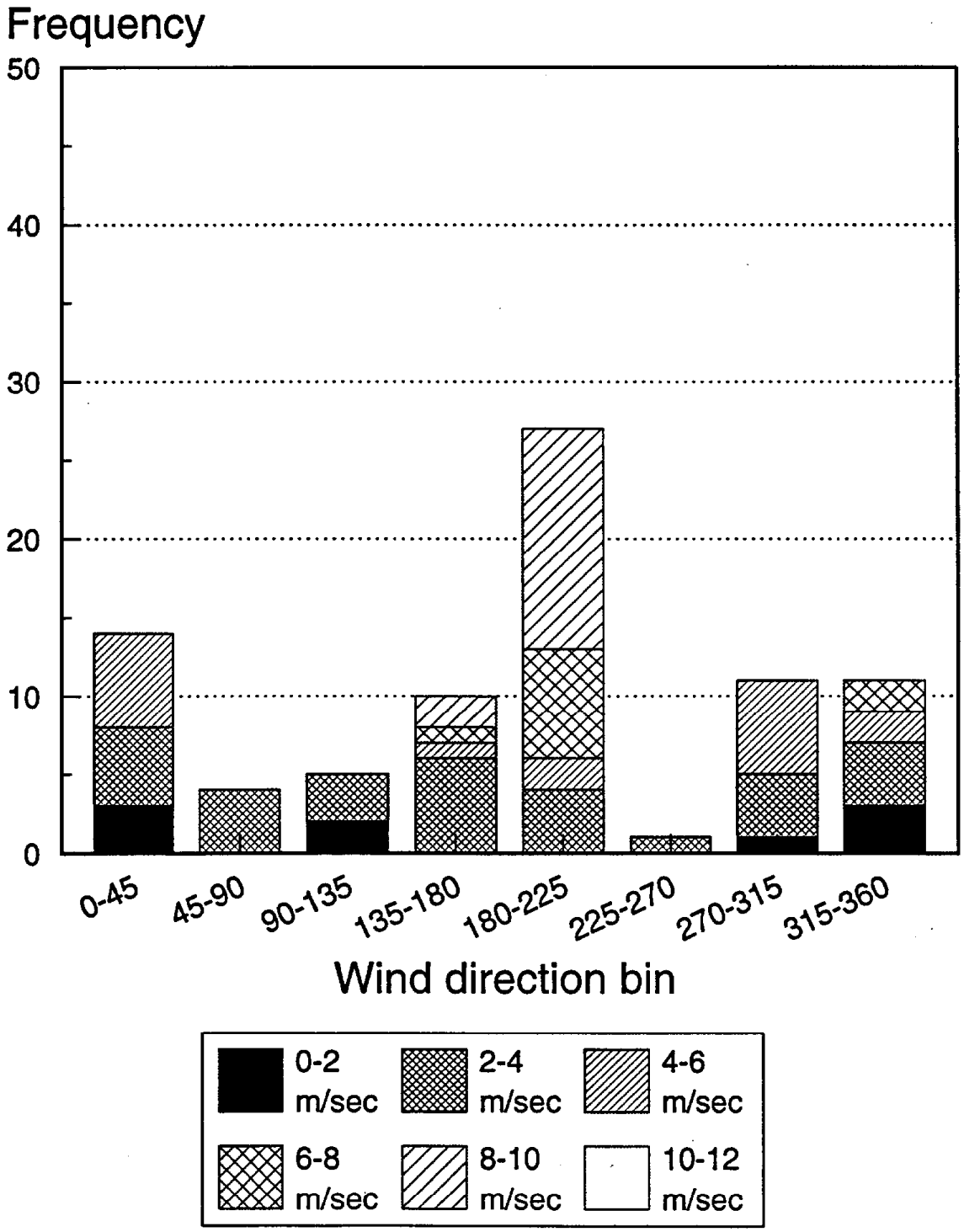
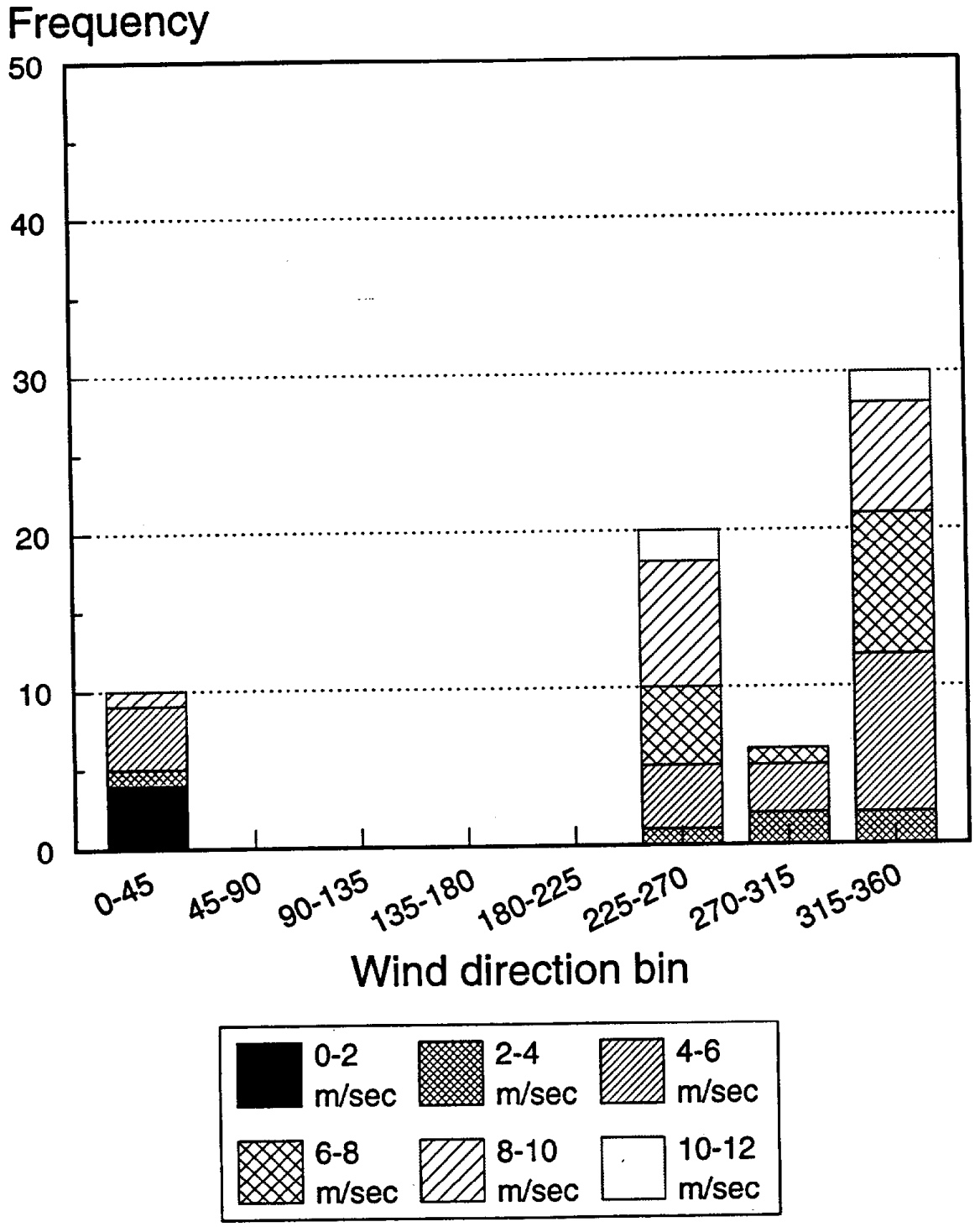


APPENDIX E

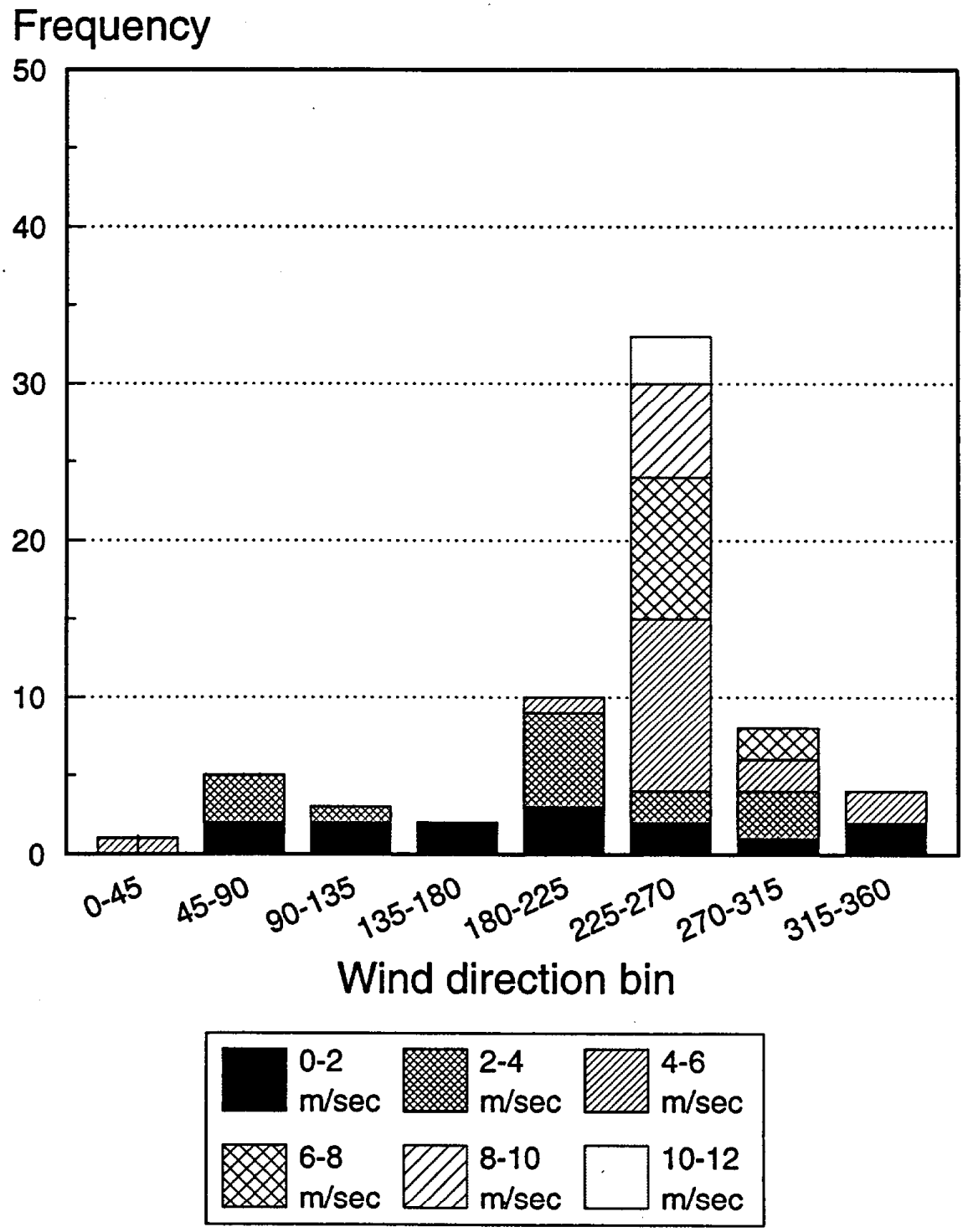
SUMMARY WIND DISTRIBUTIONS FOR UPPER-LEVEL RIDGE CASE

COMPARISON OF MORNING AND AFTERNOON DISTRIBUTIONS

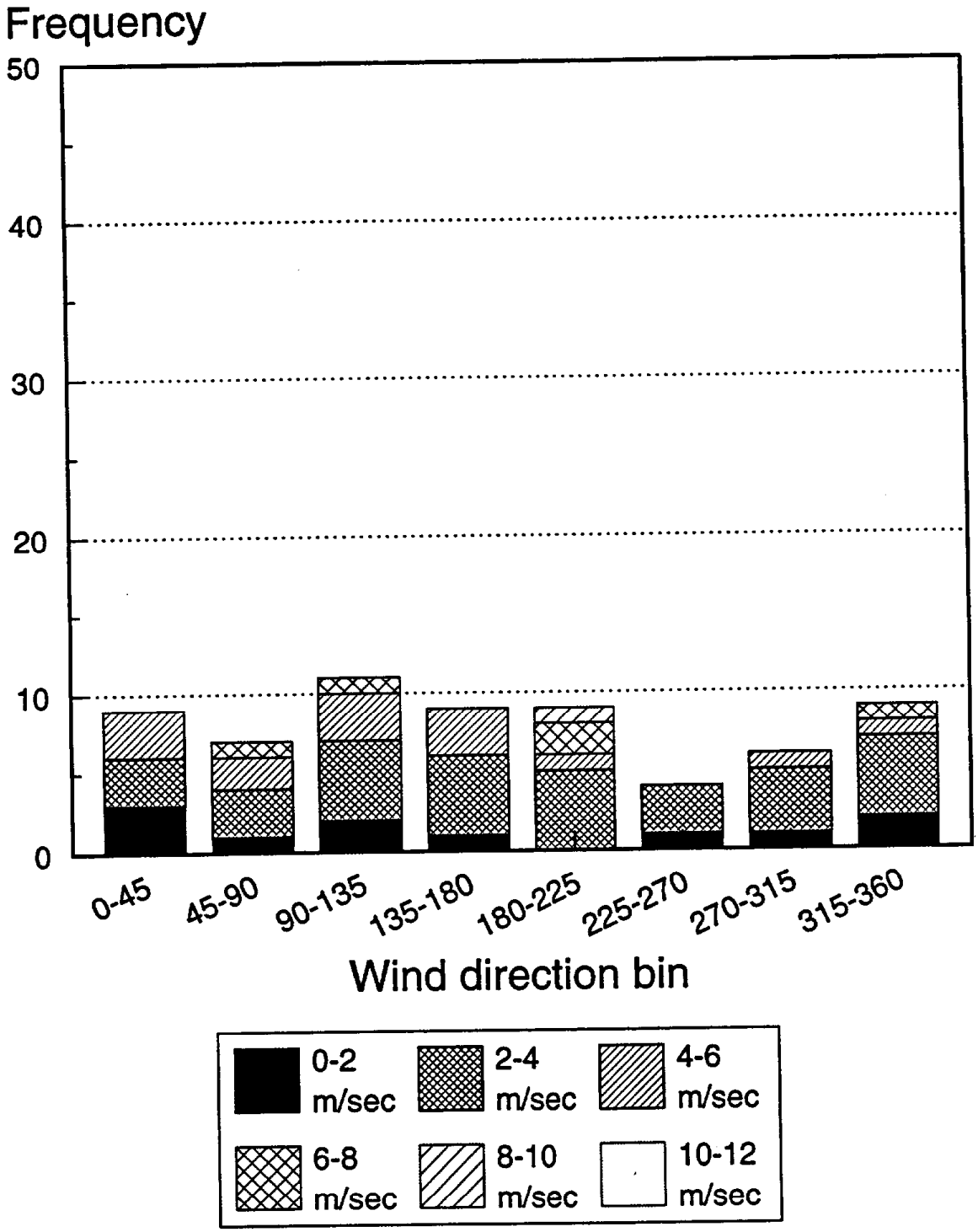
TRS Ridge Morning Case Level 1



TRS Ridge Afternoon Case Level 1



PLG Ridge Morning Case Level 1



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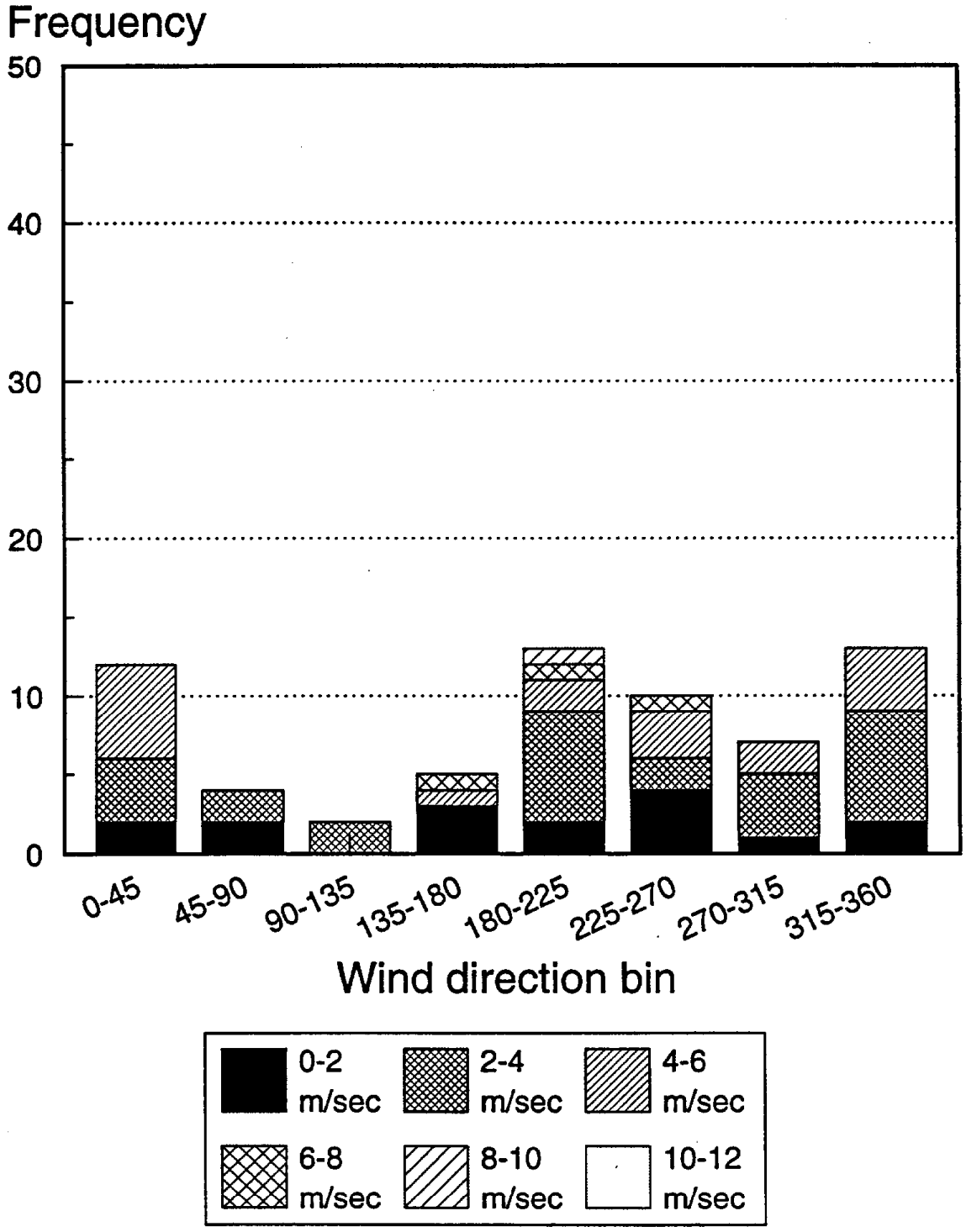
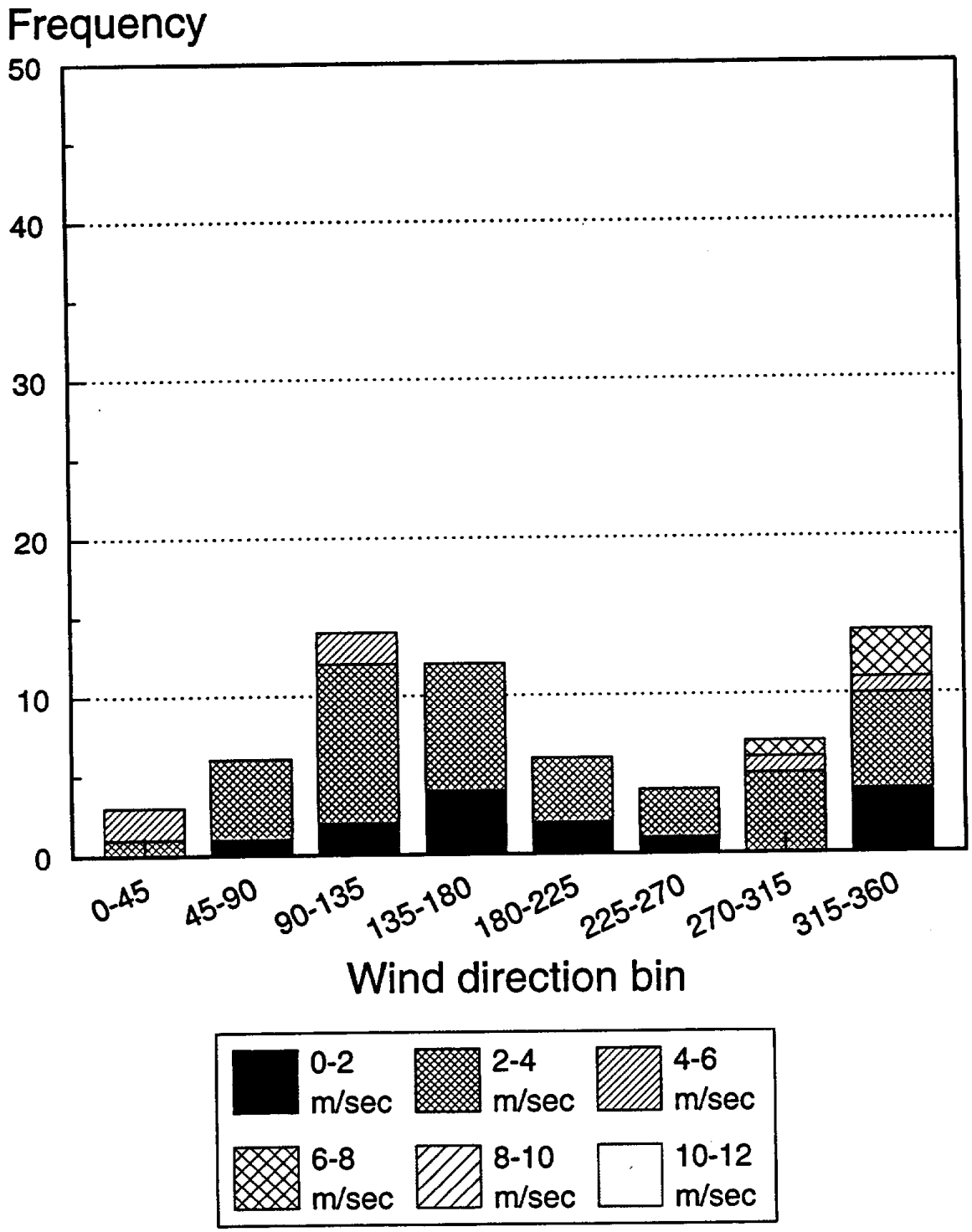
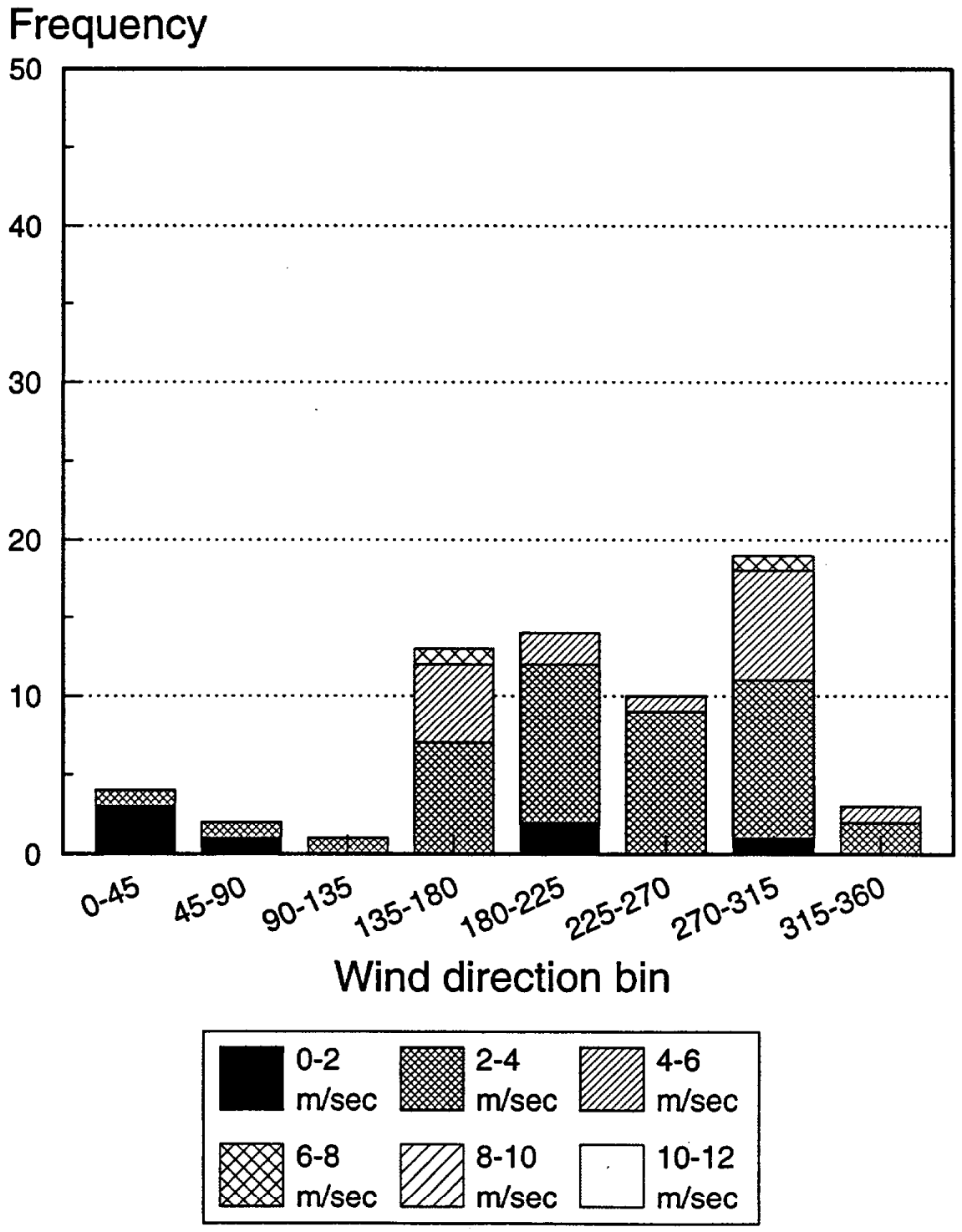


Oroville Ridge Morning Case - Level 1



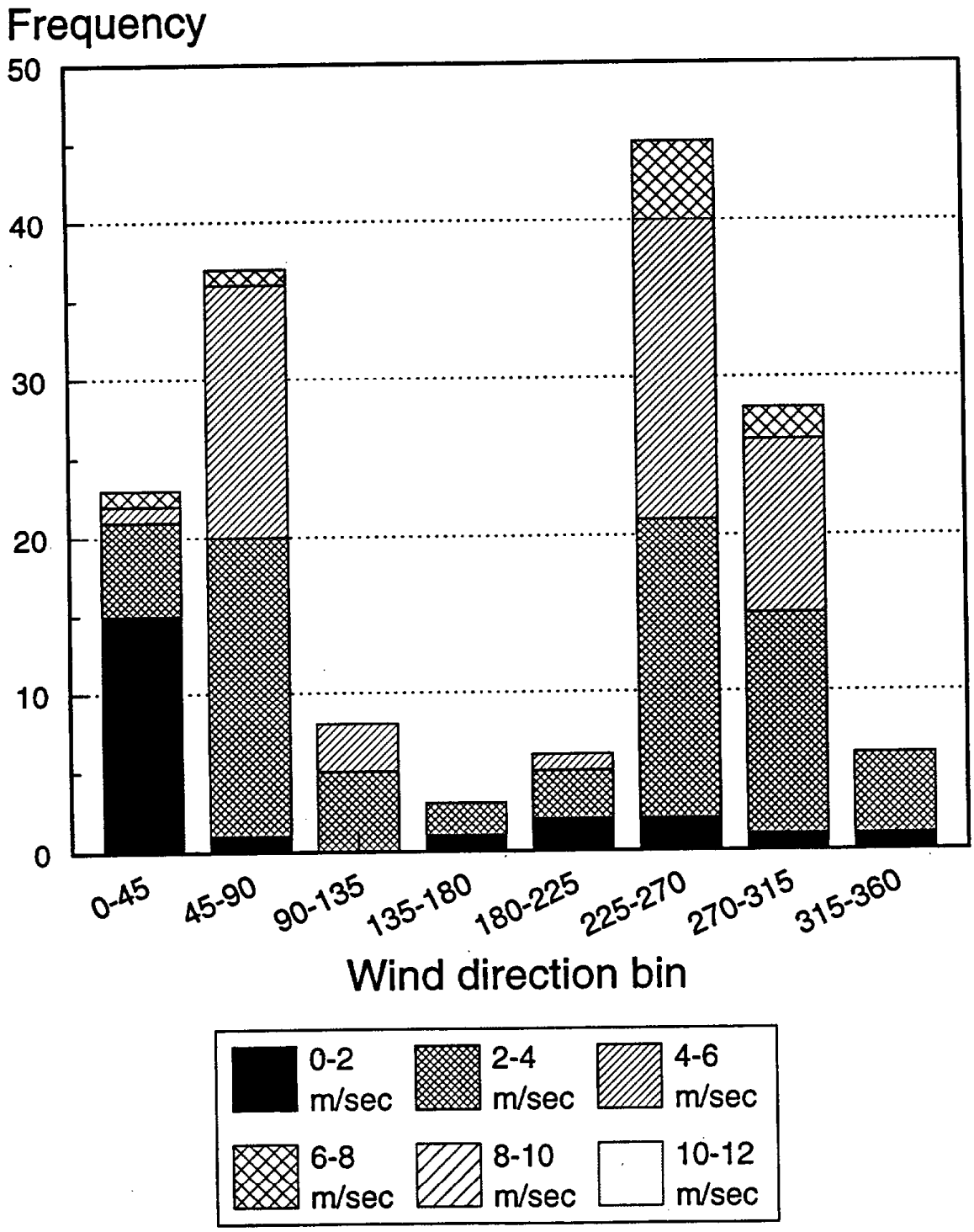
ORO Ridge Afternoon Case Level 1



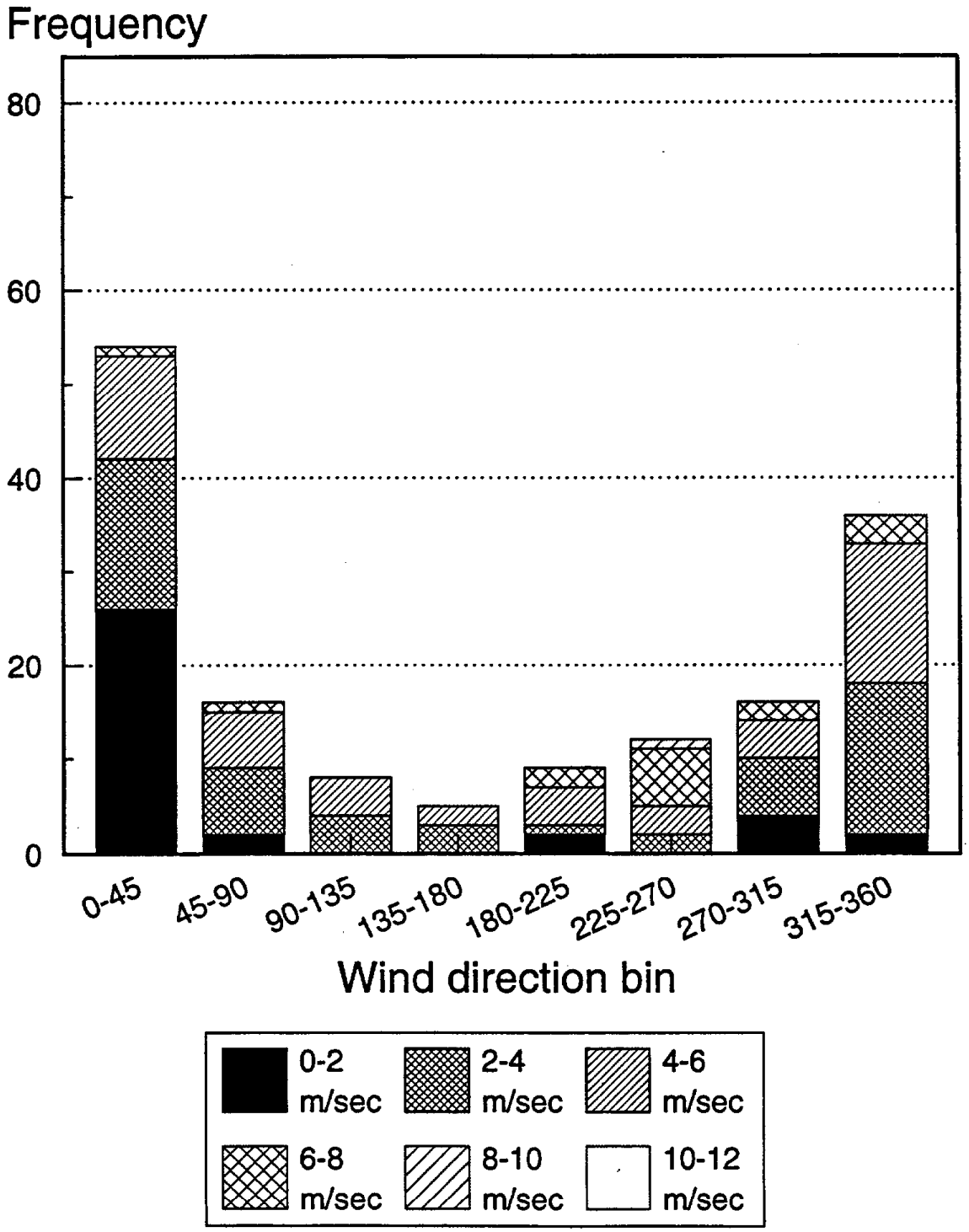
APPENDIX F

SUMMARY WIND DISTRIBUTIONS FOR
HIGH- AND LOW-OZONE EPISODES FOR THE
NORTH CENTRAL COAST AIR BASIN

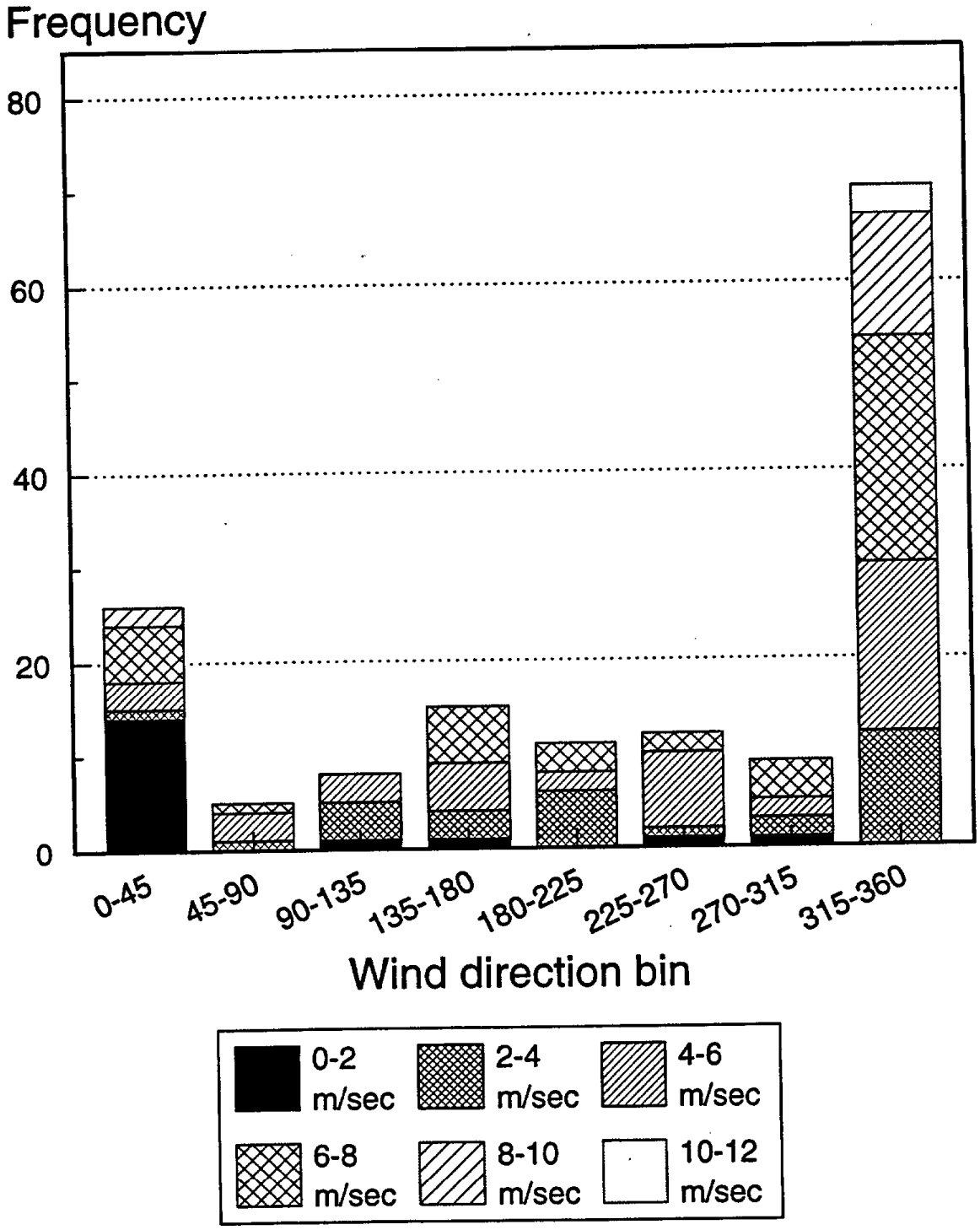
MOS High Ozone Case Level 1



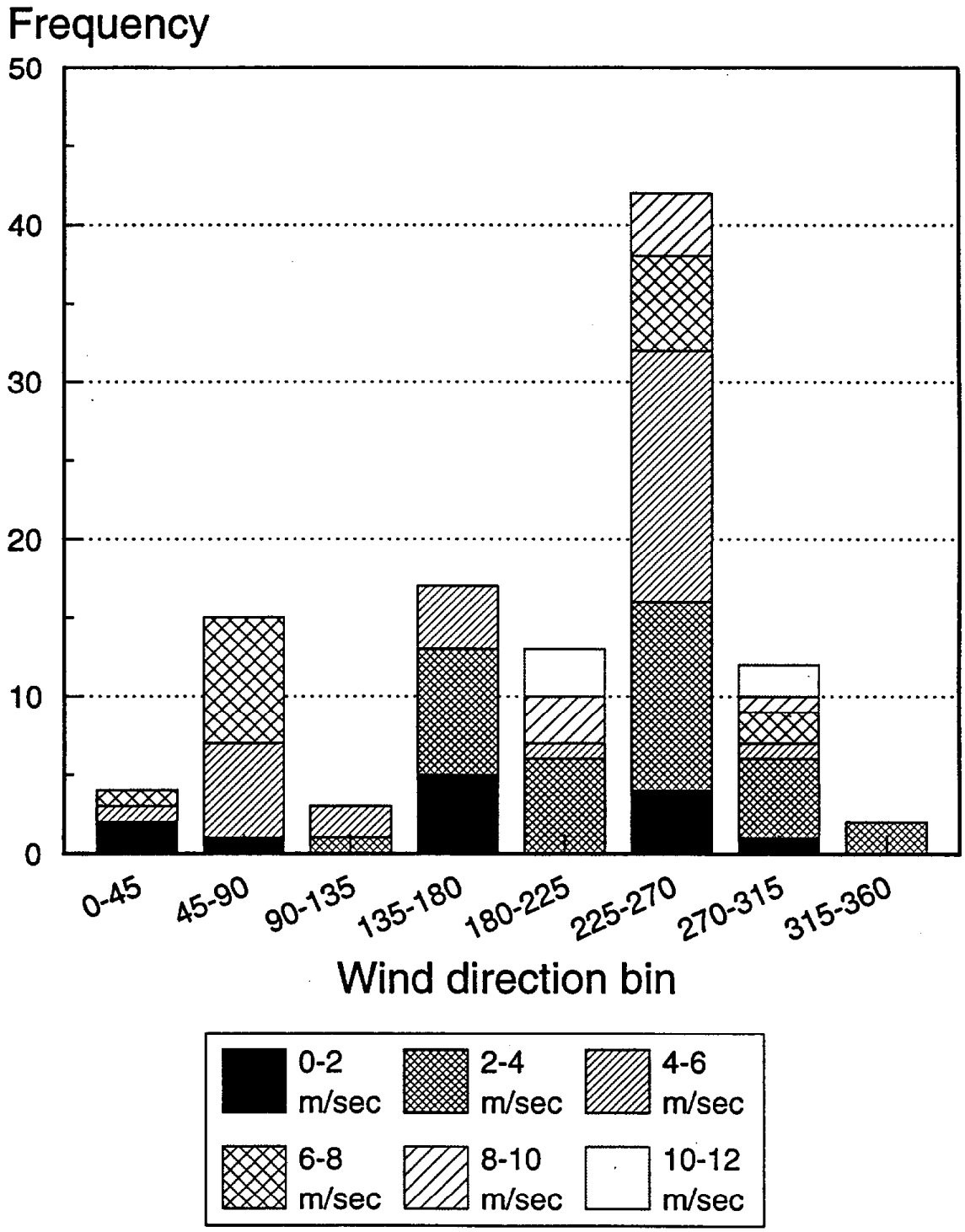
MOS High Ozone Case Level 2



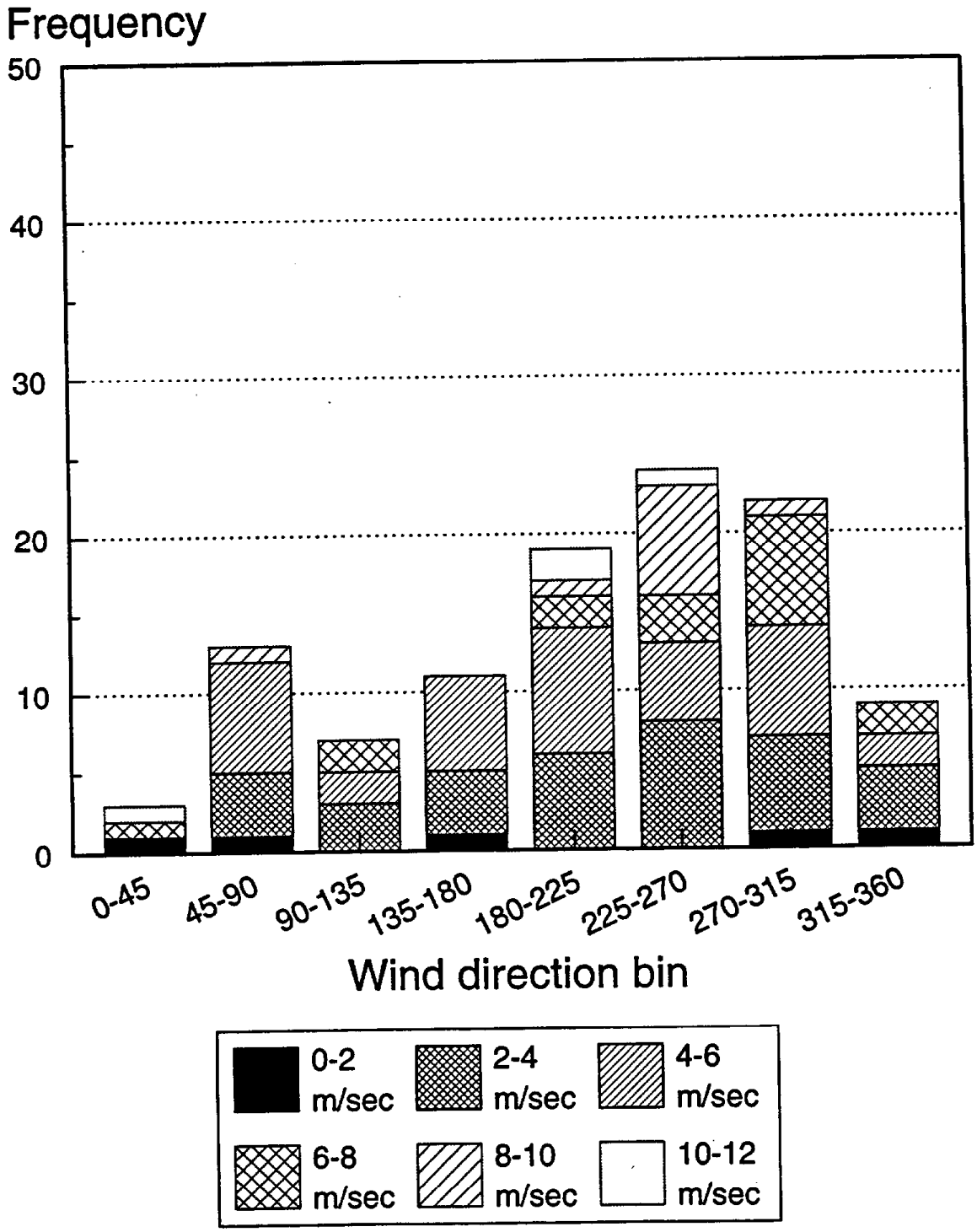
MOS High Ozone Case Level 3



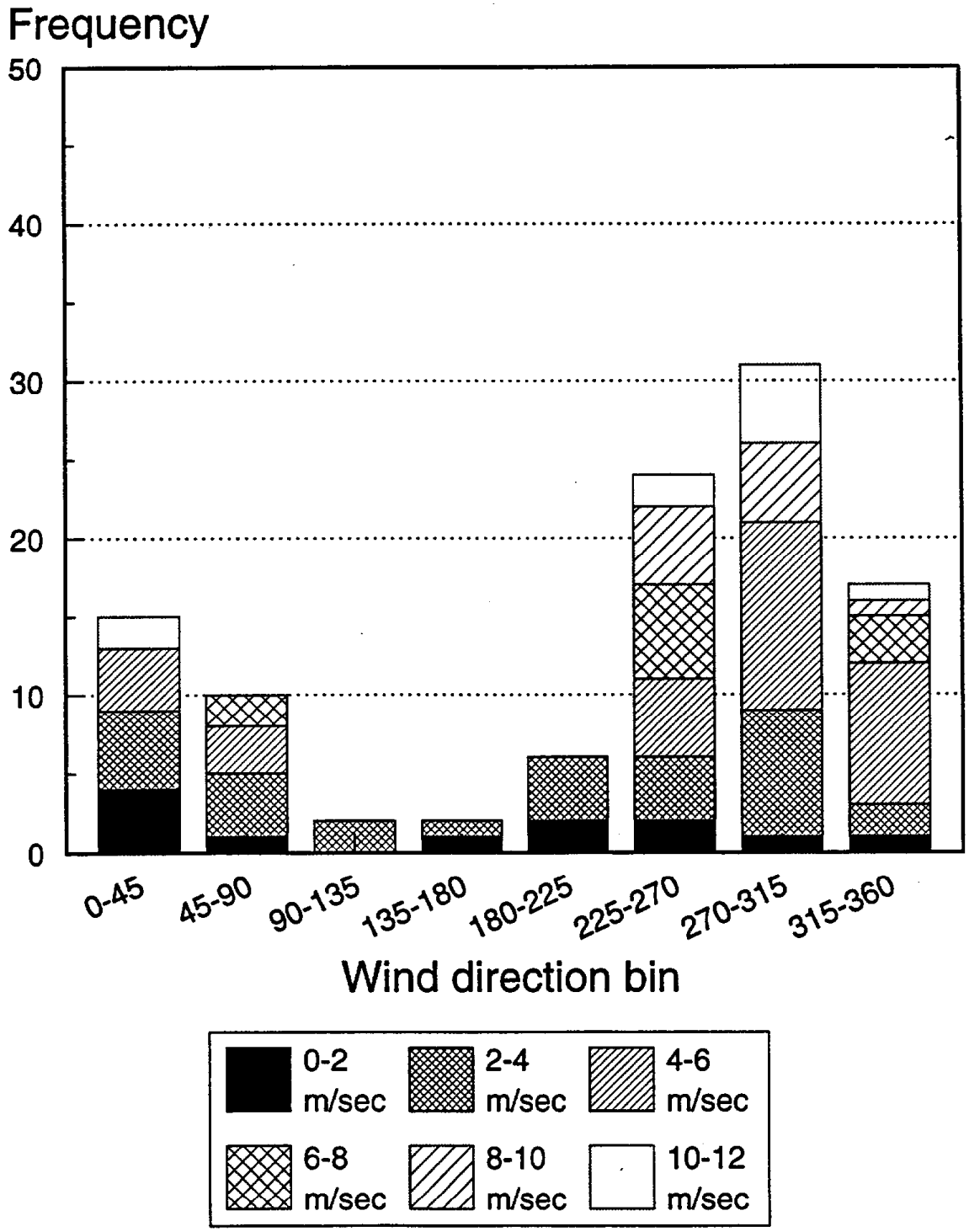
MOS Low Ozone Case Level 1



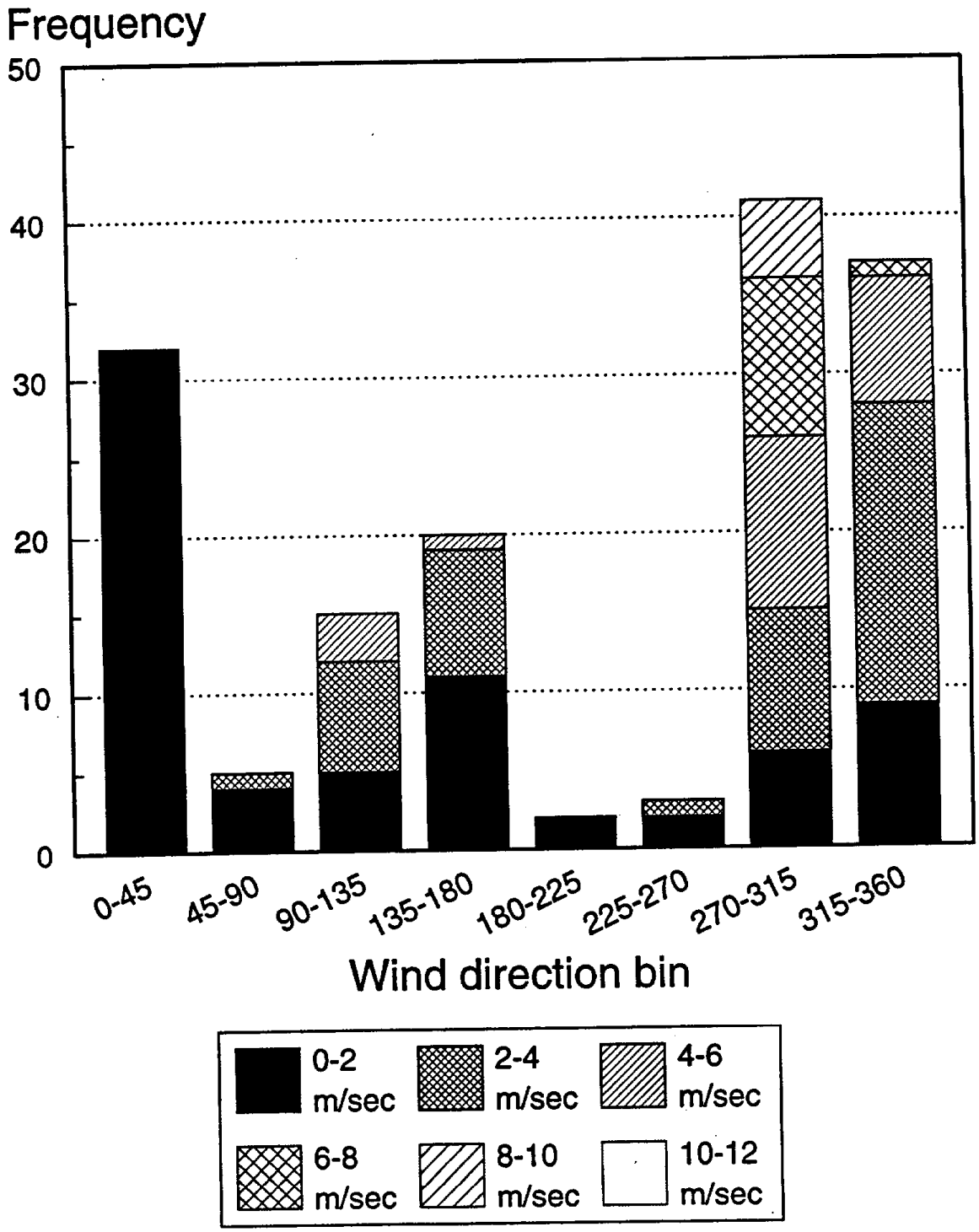
MOS Low Ozone Case Level 2



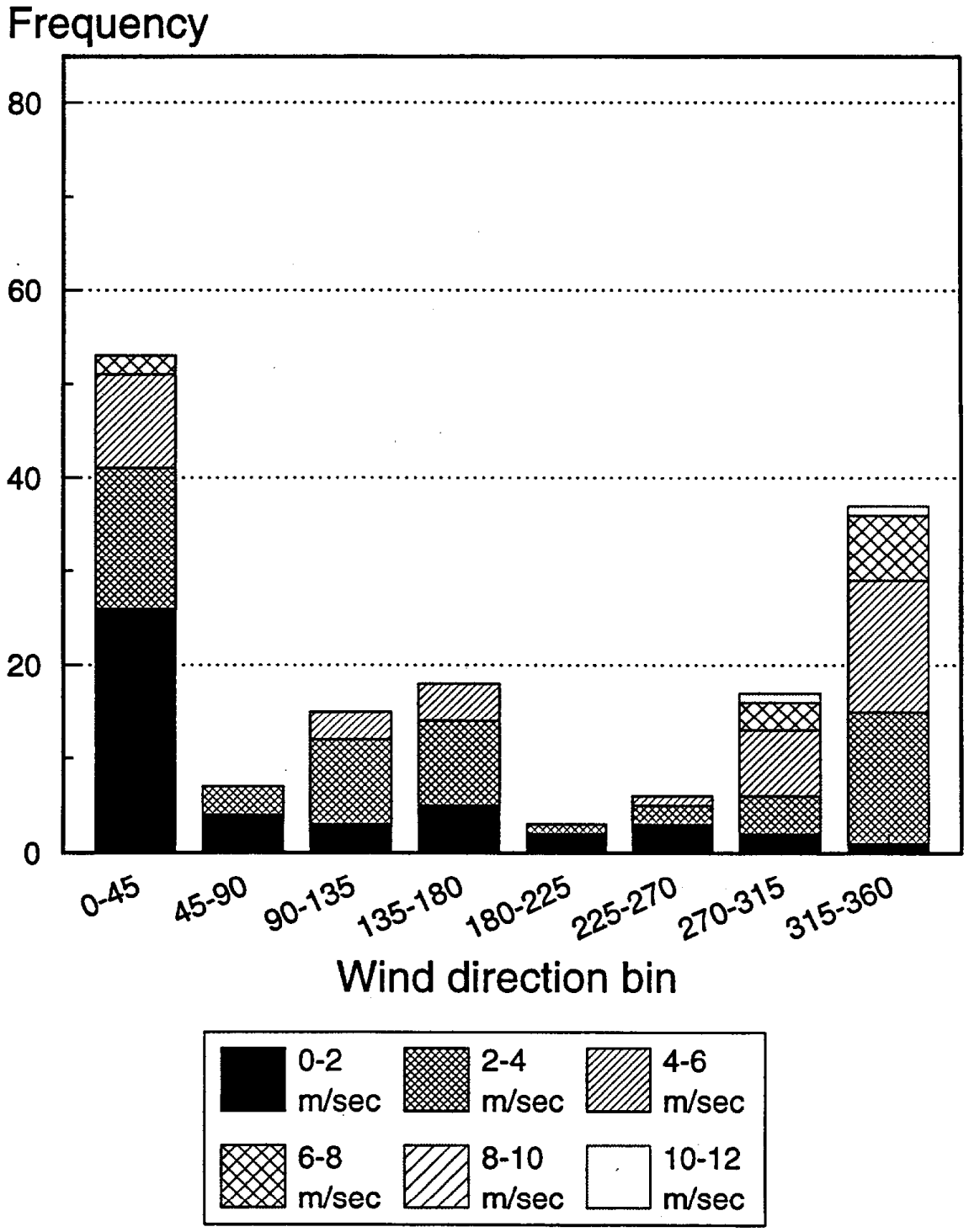
MOS Low Ozone Case Level 3



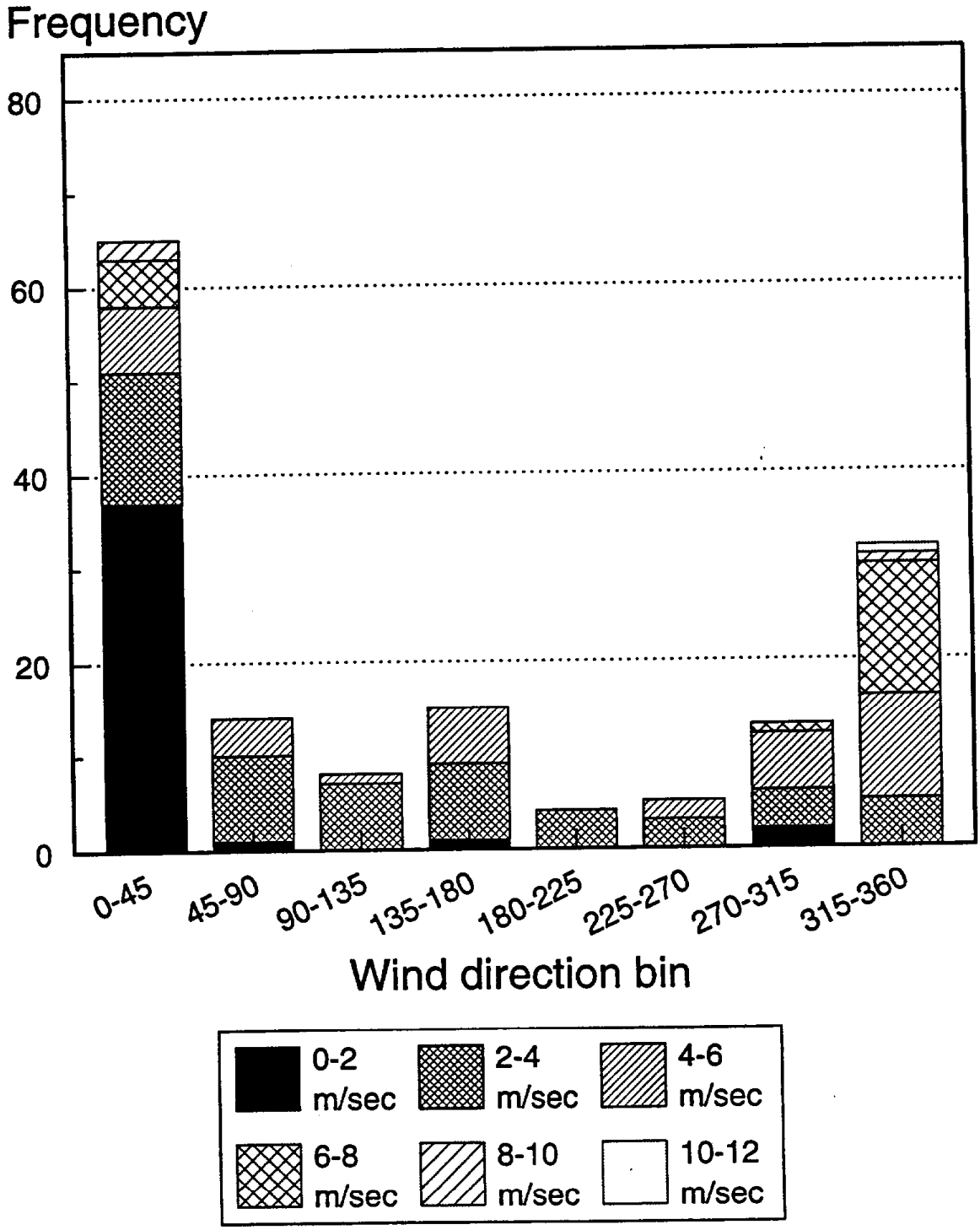
HOL High Ozone Case Level 1



HOL High Ozone Case Level 2



HOL High Ozone Case Level 3



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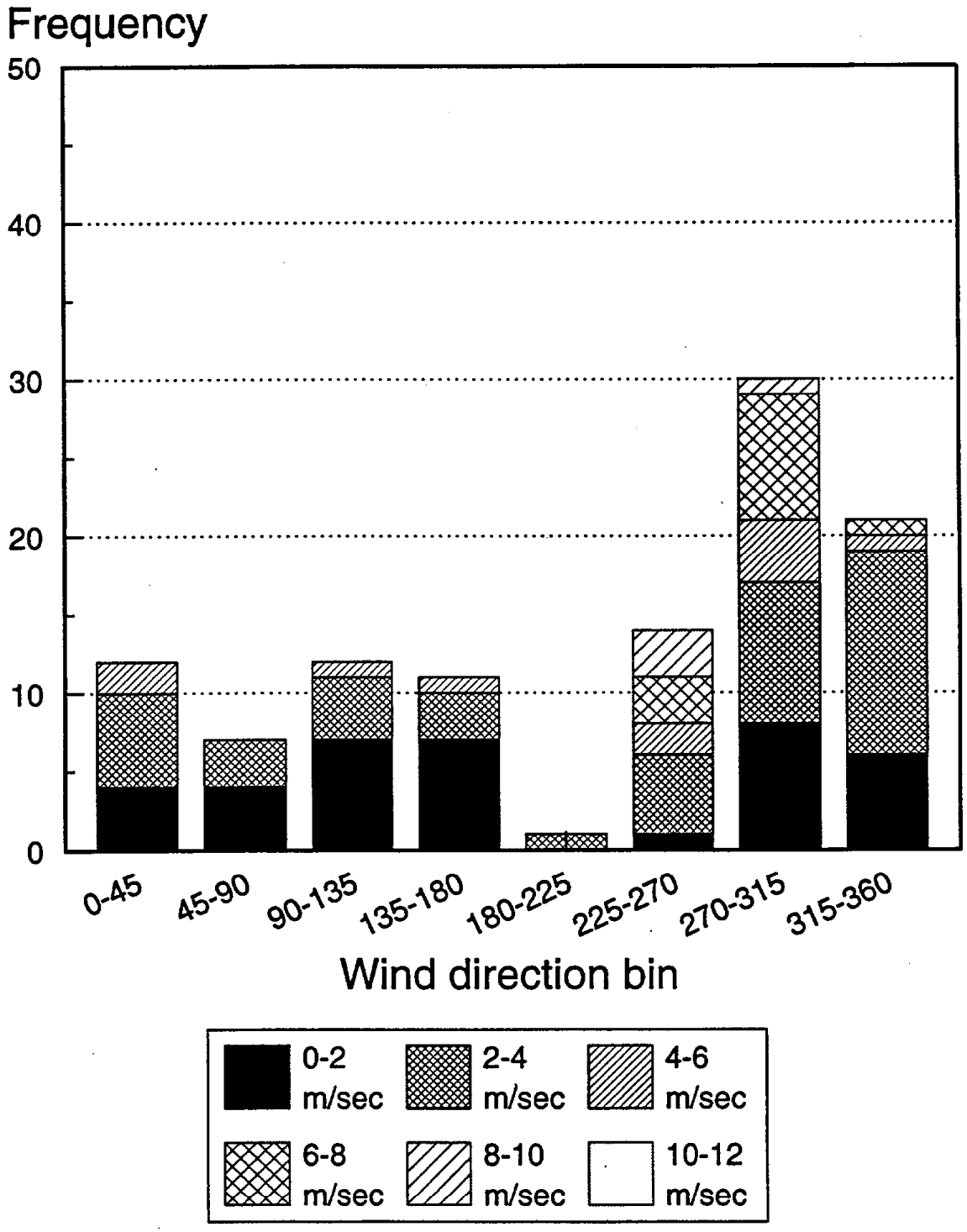
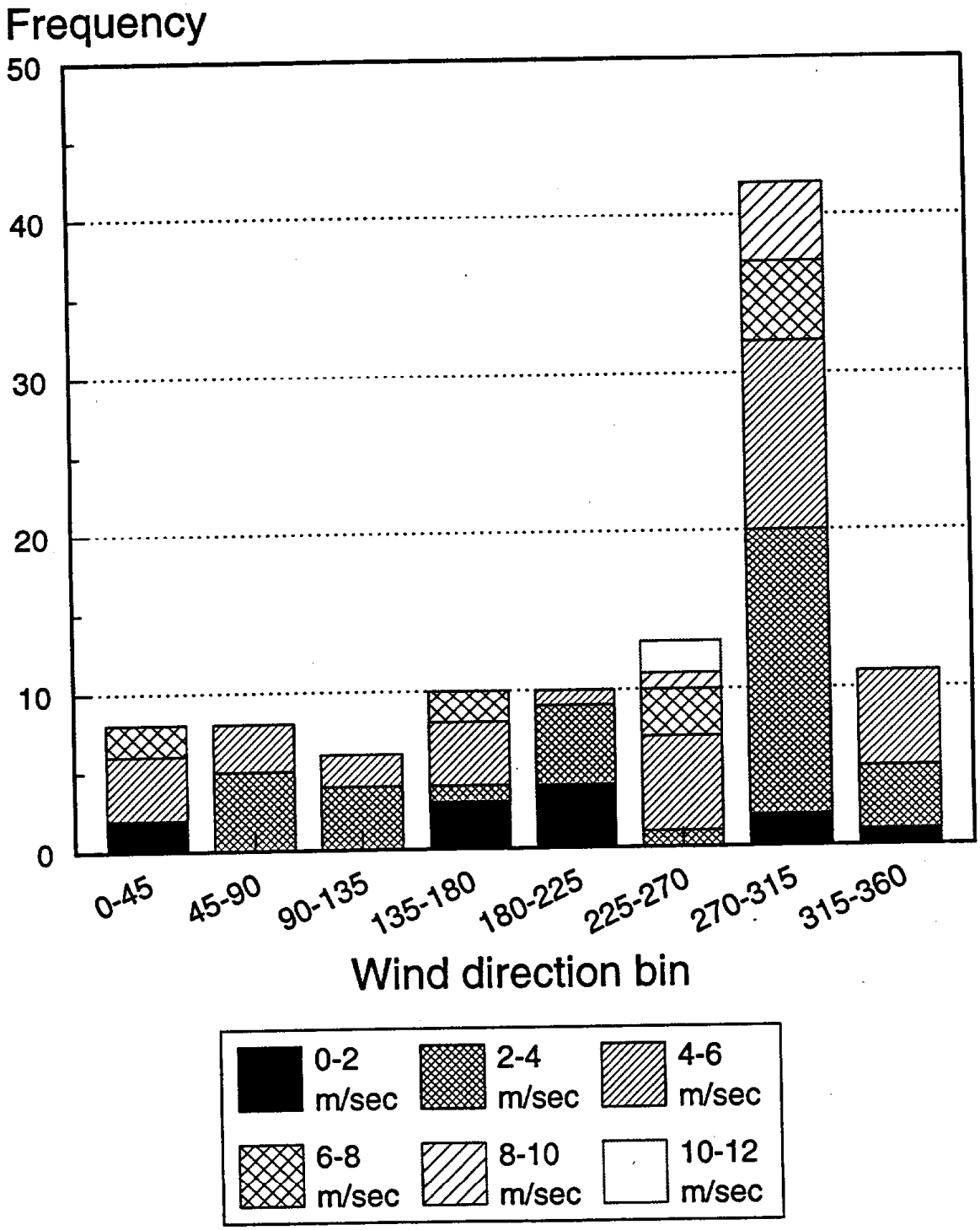
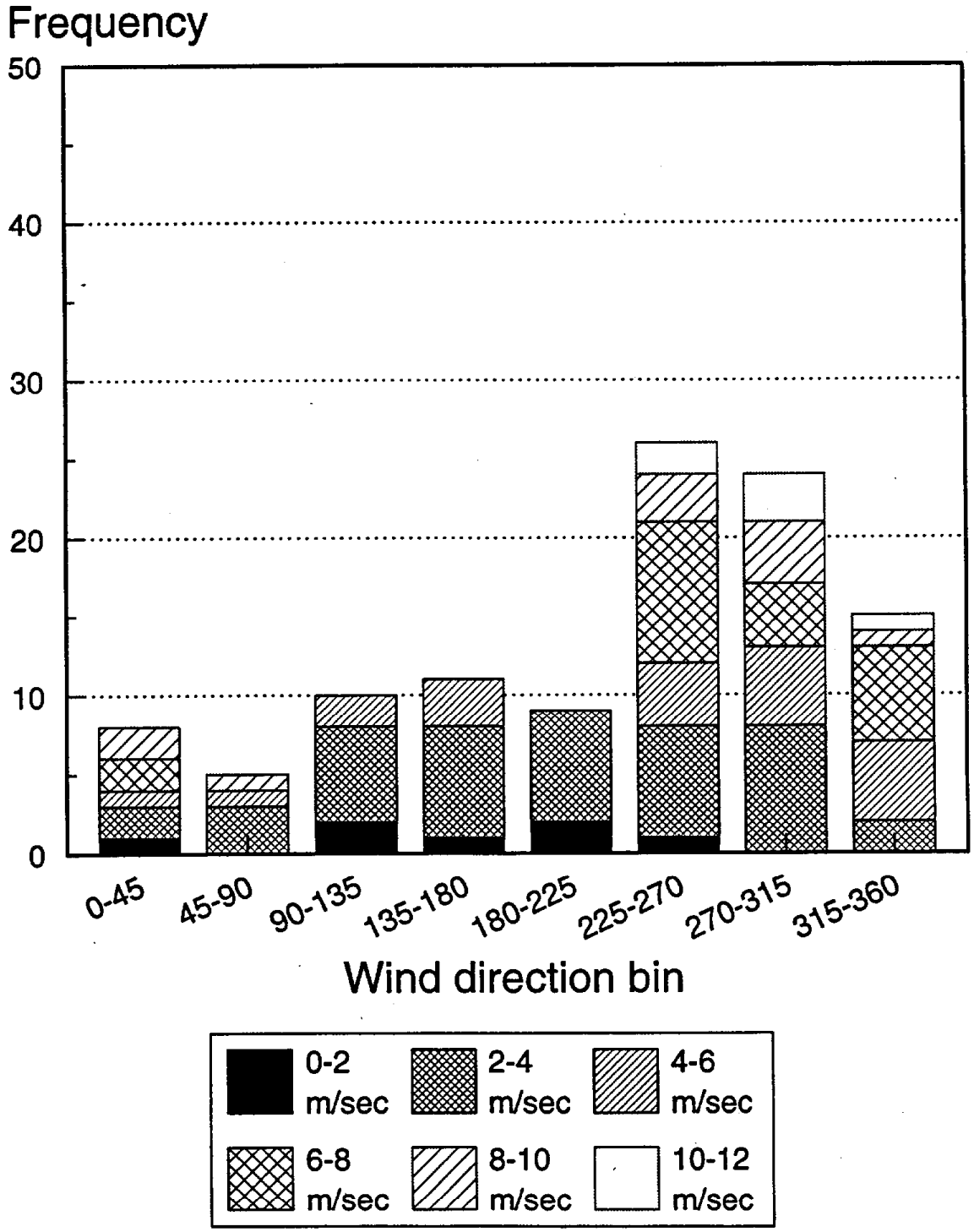


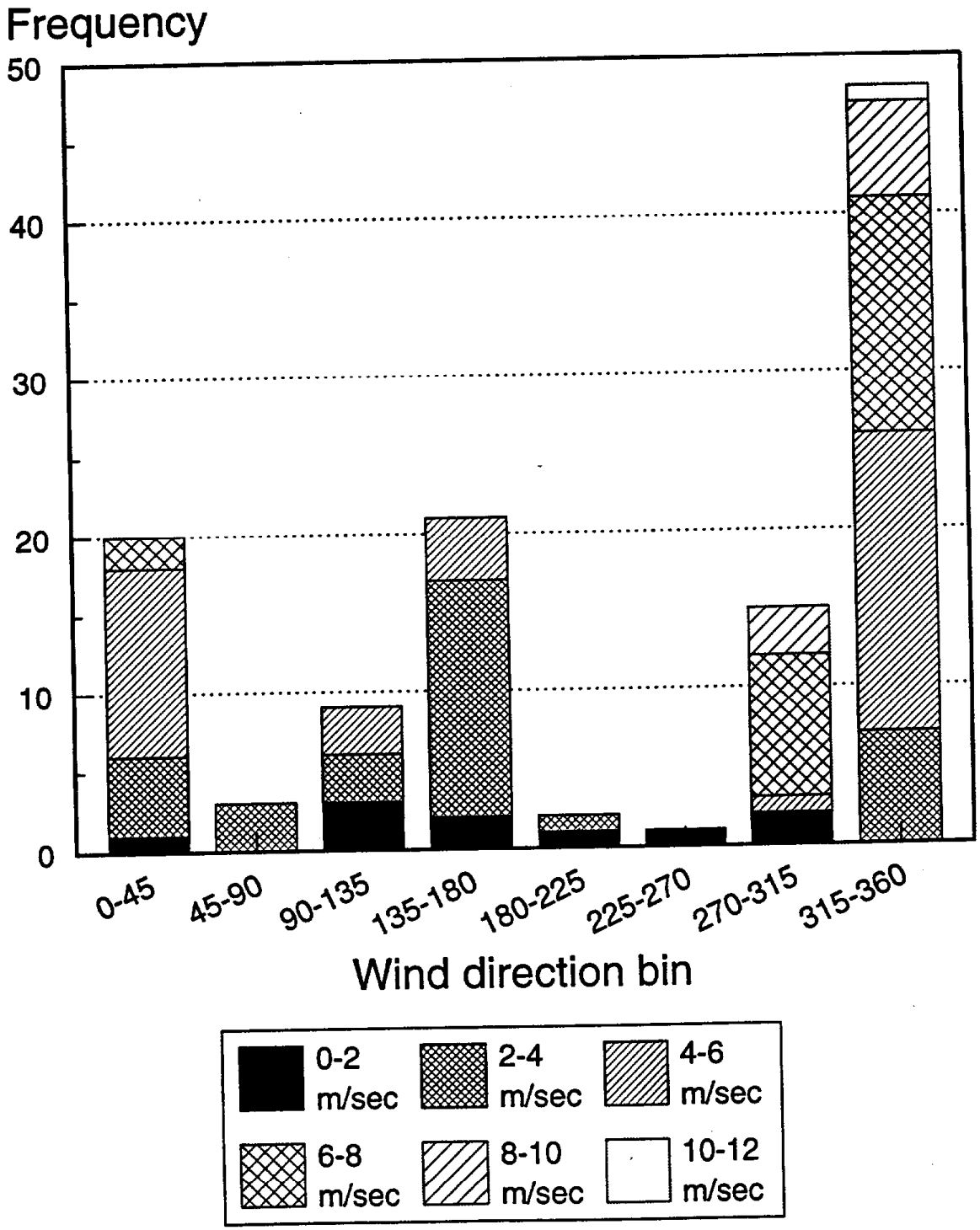
HOL Low Ozone Case Level 2



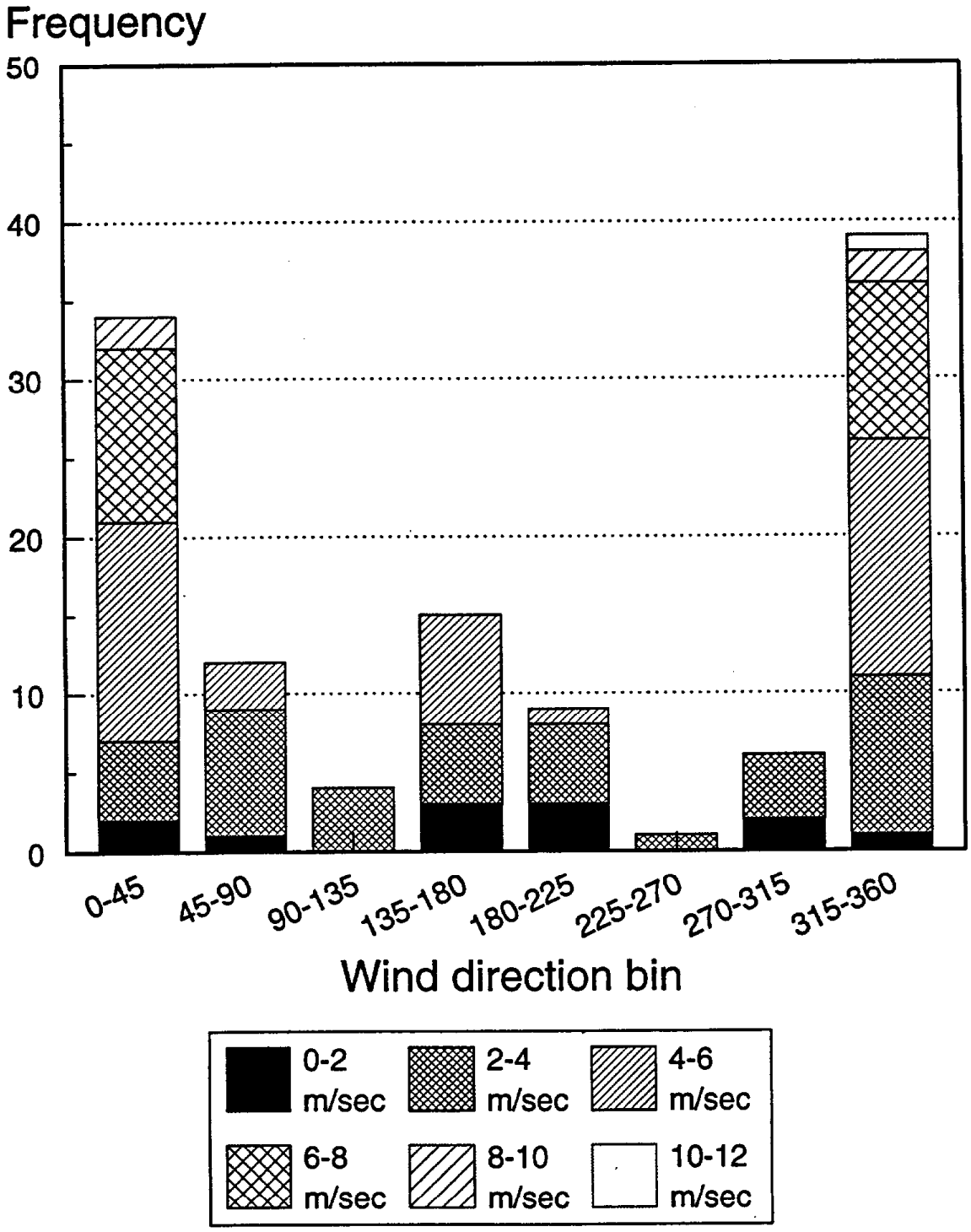
HOL Low Ozone Case Level 3



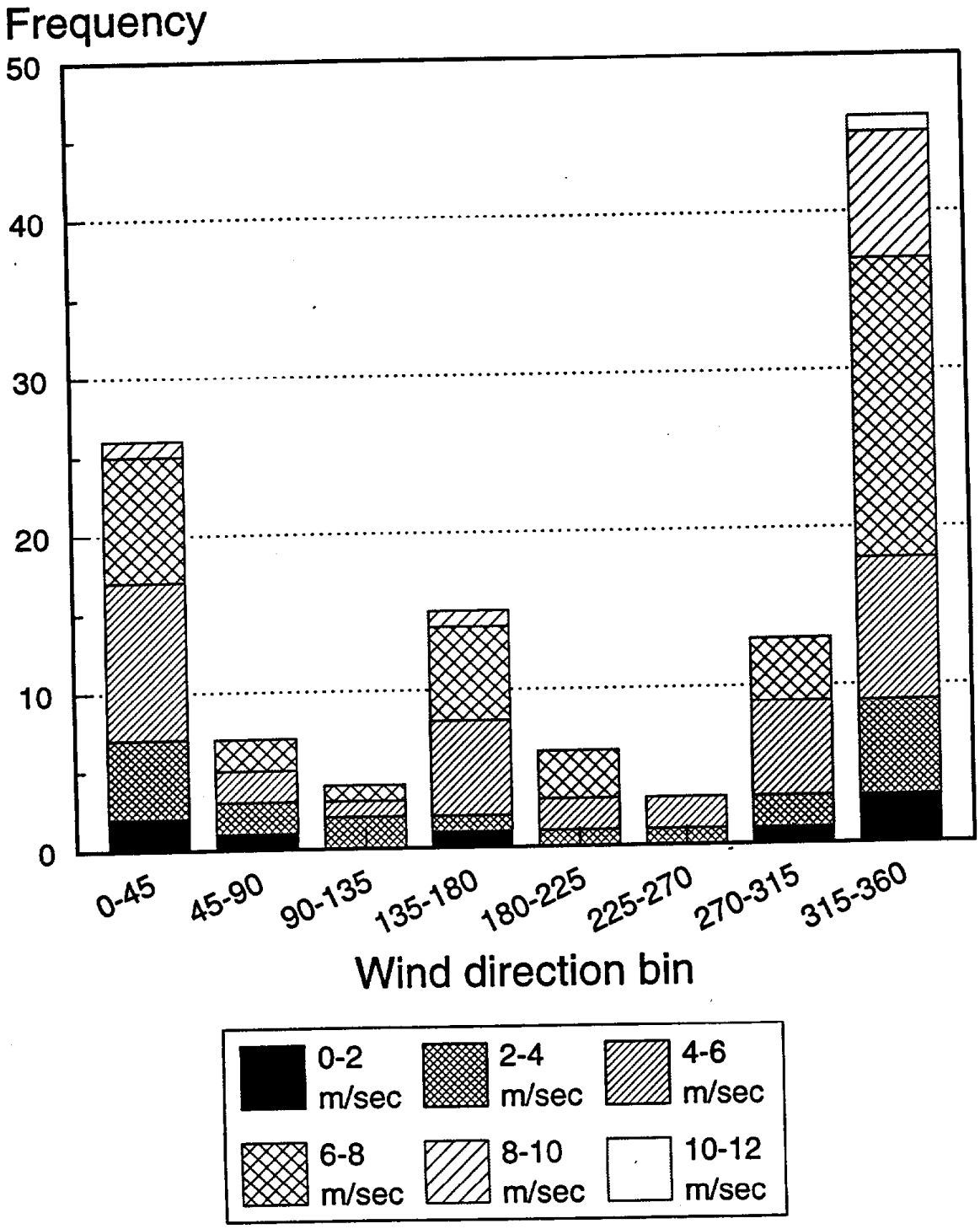
BEA high Ozone Case Level 1



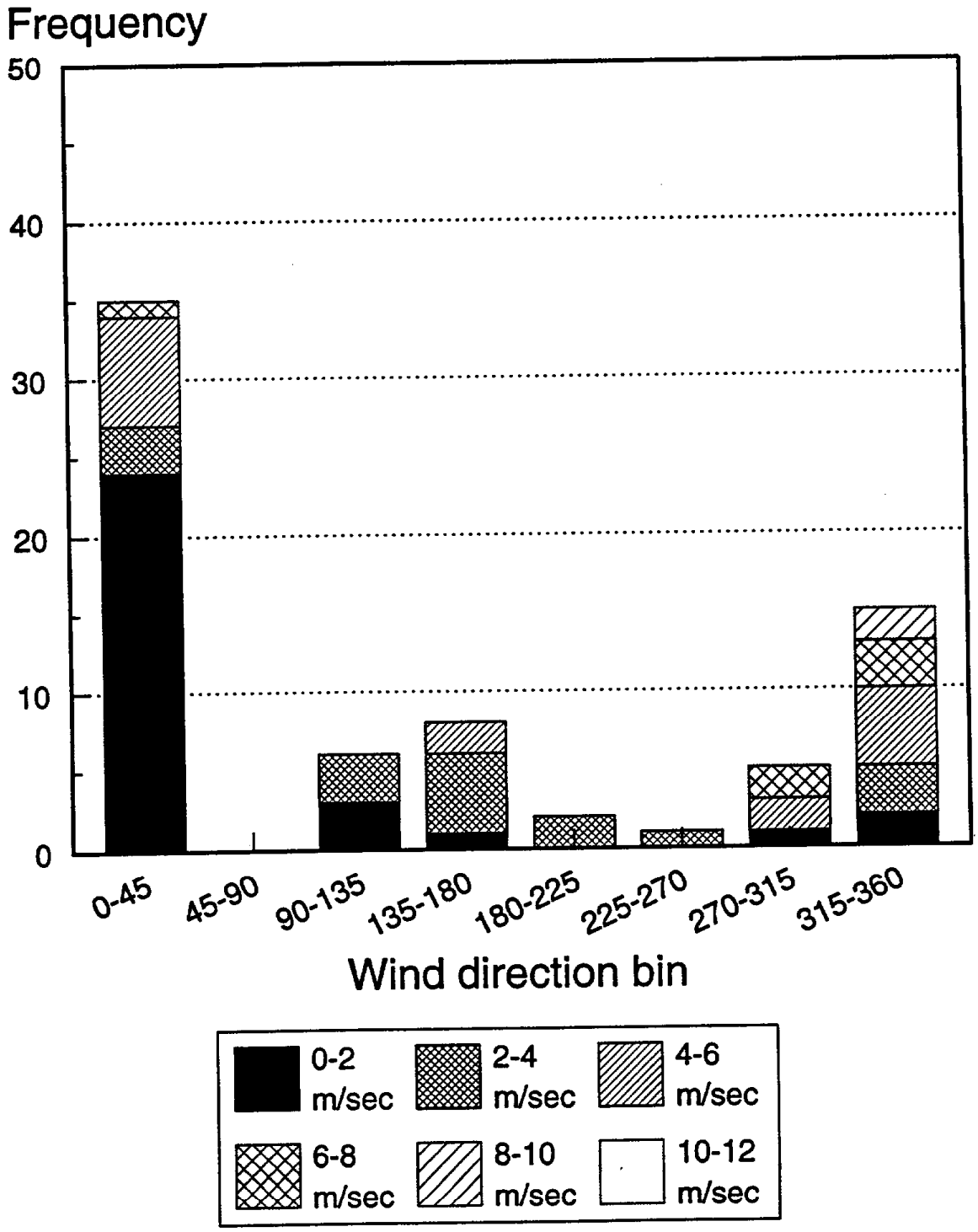
BEA high Ozone Case Level 2



BEA high Ozone Case Level 3



BEA Low Ozone Case Level 1



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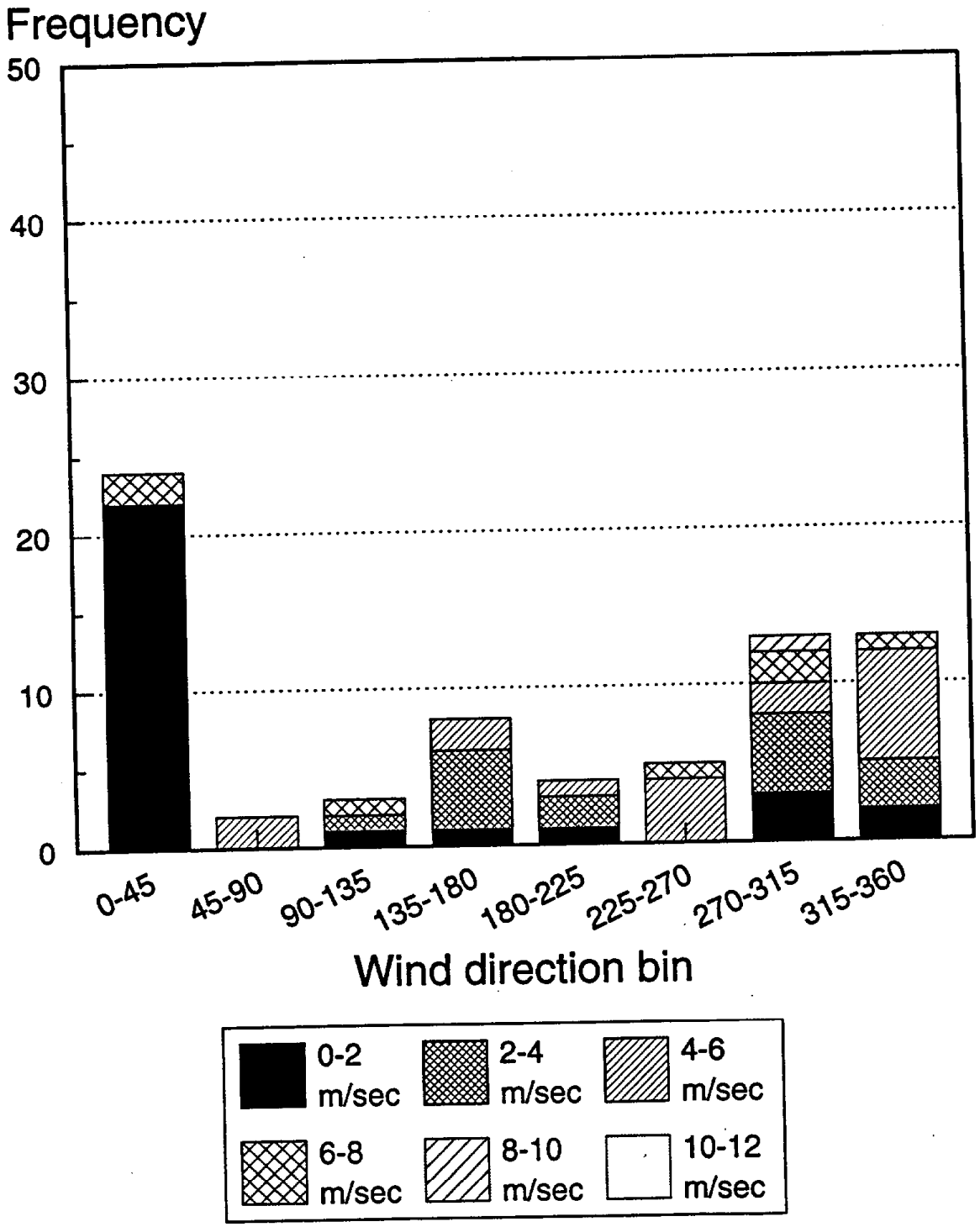
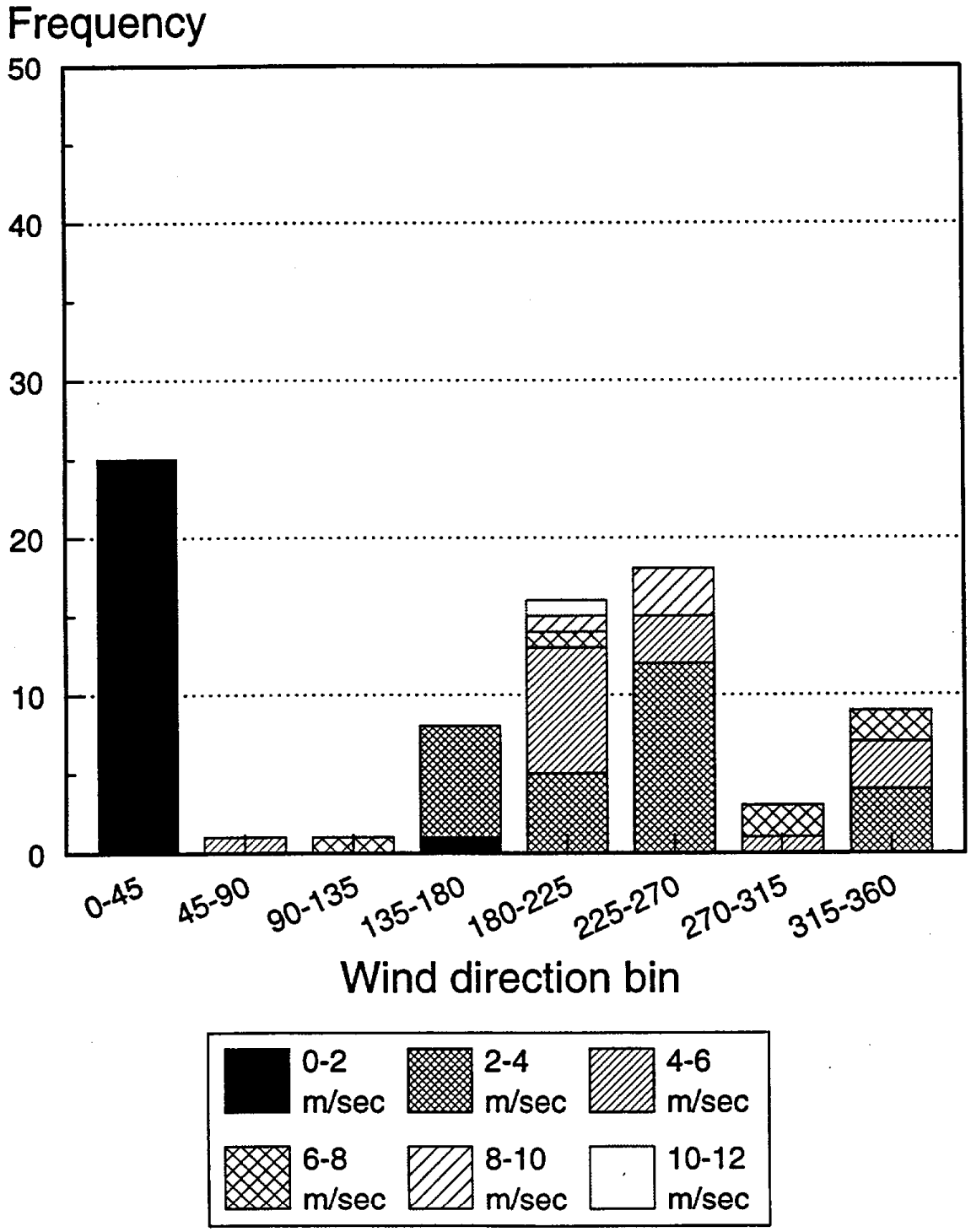


BEA Low Ozone Case Level 3



APPENDIX G

DRAFT NOAA TECHNICAL REPORT ON WORKSTATION
DEVELOPMENT IN SUPPORT OF THE CALIFORNIA PROFILER NETWORK

NOAA Technical Memorandum ERL ETL—

NEWLY DEVELOPED X WINDOWS TOOLS FOR ANALYZING THE BOUNDARY-LAYER STRUCTURE

L. K. Lewis and J. M. Wilczak
Environmental Technology Laboratory

A. B. White and Lingling Zhang
Cooperative Institute for Research in Environmental Sciences
University of Colorado/NOAA
Boulder, CO 80309

Environmental Technology Laboratory
Boulder, Colorado
April 1994

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratories

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Newly Developed X Windows Tools for Analyzing the Boundary-Layer Structure

L. K. Lewis, J. M. Wilczak, A. B. White[1], and Lingling Zhang[1]

ABSTRACT. This technical memorandum provides a collection of data analysis and visualization tools to give the Environmental Technology Laboratory users quick and easy access to data. The need to access large volumes of data without requiring any program changes drove the authors to develop this collection of tools. They followed specific guidelines in developing the packages, building many useful functions, and making the tools available on as many different hardware platforms as possible. They choose to make the packages available on any UNIX workstation with OPENLOOK installed. Because the packages have similar functions and give users a consistent means of accessing data, they insulate users from many access details, allowing them to focus on the data itself. Users can make individual selections without any programming effort or accumulating multiple copies of similar code. These tools have helped ETL scientists expand their understanding of how to handle the challenges associated with the 915-MHz and 404-MHz wind profiler data. In the process of using the visual aid tools, the scientists discovered the existence and extent of bird contamination in the 915-MHz and 404-MHz profiler data and formulated a process that eliminates it. Another useful application of the tools was in correcting wind profiler data taken aboard a ship during the TIWE, ASTEX, and TOGA COARE projects.

1. INTRODUCTION

The motivation for the design of the tools provided in this document was a widespread need for quick access to a variety of data in a simple, easily learned user environment. In the past, data was not subjected to strict error control because of its large volume and the inflexibility of the system. The need for error control helped shape the form of these visual aid tools and the philosophy behind their use.

The authors' primary goal was to insulate users from the programming details of data access, giving them the ability to focus on the data itself, rather than on the access method. Accordingly, we provided a variety of options within the operating environment that allow users to make choices about data access without exiting the program. We designed the programs using a Graphical User's Interface (GUI) builder (OpenWindows™ Developer's Guide) so that as new options were requested, they could be added without a lot of difficulty. The GUI builder allowed us to build user interfaces that included automatic error checking and a friendly, easy interface in a short amount of time. If we had developed these tools using a standard programming language, it would have increased the development and maintenance time. Certain philosophies determined the structure and set standards for different aspects of the tools.

[1]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado/NOAA, Boulder, CO 80309.

2. TOOL FUNCTIONALITY

2.1. Data Access Methods

The need to access data from many different sources pushed us to develop flexible access methods. When we first designed these tools, the data had to be located in a fixed directory and on the local machine. We concluded that the ideal design style is to let the user define the location of the data. On the systems in our lab, data can be accessed through the local disk, a networked disk, a read/writable CD-ROM (Maximum Storage Duette drive), or any other device that can be mounted on a UNIX workstation. The user does not have to know the physical location of the data because we mount the remote disk drives through NIS (Network Information System) onto a logical drive on the local system. To connect any tool to the logical drive, the user enters the path into a path text field. Each type of data has its own text field for entering the directory path, giving the user flexibility in data comparison. Each tool has its own routines for reading the data files created by the different instruments. When the data format is altered, we include the changes in these read routines so the user does not have to keep track of format changes. By following the set design rules, we have eliminated two burdens: tracking the locations of data and tracking the ever-changing data formats.

2.2. 915-MHz Profiler Data Access

The first stage in processing the 915-MHz profiler data (Ecklund et al., 1988) was to use the Aeronomy Laboratory's Profiler Data Access (PDA) library to read the binary files produced by the Profiler Operation Program (POP) and transfer the information to ASCII files. The ASCII files would be transferred over the ETL network to a UNIX workstation for further processing. While working on the MPS (Mobile Profiling System) project, a need arose to access the binary moment files directly from a UNIX workstation. We therefore converted the PDA library routines to operate on a UNIX workstation. This eliminated the first stage of the processing routine, saved time, and lowered the network load. The UNIX version of the PDA library can directly access the binary 915-MHz moment files within the visual aid tools, skipping the step of writing out the moments to an ASCII file and then reading it back in with our tools. ETL can now process months of 915-MHz profiler data on a UNIX workstation without any preprocessing steps. The time saved is applied to quality control and data analysis.

2.3. Data Availability Aspects

In the past, users who wanted to plot data had to search through long directory listings or wait and see if a plot would come out to discover whether the data existed. The new visual aid tools make this unnecessary. DATAVIEW shows what data is available for each hour out of a 24-hour period. MOMENTVIEW and MOMENTPROCESS display a calendar

that shows whether data exist for each day of the selected month. Users know quickly whether the day or hour they want to plot or process is available. The tools also alert the user monitoring the influx of data of any problems along the data flow process. This feature can also be used to log data availability at a given site. Users can now spend more time accessing data and less time determining whether it exists.

2.4. Data Visualization Features

In response to ETL's need to produce graphics suitable to each scientist's requirements, we developed user-driven visualization tools. We wanted tools that would create products using selectable graphics options without requiring the user to do any additional software engineering. We also wanted tools that would integrate the display of different data products.

We first wrote the graphic functions with SunView graphics library, then converted them to the XView graphics library, and finally converted them to XLib. We chose XLib because it compiles and runs on most UNIX workstations. We interfaced to graphical functions with OPENLOOK and MOTIF GUI, which provides options that let users personalize their data visualizations. All of the visual aid tools let users set the X, Y, and Z scales, the direction the X scales run (right-to-left or left-to-right), the color resolution, and the product(s) to display. Examples of graphics produced by the visual aid tools are shown in Appendix A. As we learn of new techniques to visualize boundary-layer data, we incorporate them into our tools. We added the feature of calculating and viewing range-corrected signal-to-noise ratio (snr) and C_n^2 into MOMENTVIEW and MOMENTPROCESS. We provided real-time integration of upper air soundings with 915-MHz wind profiler data. The collaborative efforts of computer specialists and scientists has produced a set of flexible, user-driven, time-saving, informative, and scientifically useful tools.

3. TOOL SUMMARY

3.1. DATAVIEW

DATAVIEW is a GUI that is designed to generate averaged wind and temperature profile graphics over height and time. It illustrates what data is available for each hour of a 24-hour period. It requires use of the site.dat database (example shown in Appendix B) as a guide to site availability and graphics heading information. The following graphics can be produced using DATAVIEW:

- Color wind barb profiles of radar consensus data
- Color wind barb profiles of Weber-Wuertz edited radar data (Weber et al., 1993)
- Color contoured radar wind speed
- Color contoured radar wind speed with barbs overlay

- Black and white contoured radar wind speed
- Black and white contoured radar wind speed with barbs overlay
- Color contoured 915-MHz RASS (radio acoustic sounding system) temperature profiles
- Color contoured 915-MHz RASS temperature profiles with barbs overlay
- Color wind barb profiles of upper air soundings
- Color contour profiles of upper air temperature soundings

DATAVIEW requires consensus wind and temperature data to be in the Aeronomy Laboratory's POP consensus format, and the edited data to be in a slightly modified version of the consensus format. Examples of these formats are in Appendix B. The only requirement for file location within the UNIX file system is that they be under the subdirectory SSS/arc for consensus files or the SSS/edit for Weber-Wuertz files. The file naming convention is as follows:

SSSYYJJJ.HH(w or t).
SSS = Three-letter site abbreviation found in site.dat
YY = Year
JJJ = Julian day
HH = Hour
w = Wind file
t = Temperature file

3.2. MOMENTVIEW

MOMENTVIEW is a GUI designed to generate radar moment graphics and display the availability of the moment data. Up to eight radar beams can be plotted, including six wind beams and two RASS beams. The RASS beams are plotted as temperature (°C) and vertical velocity. MOMENTVIEW accesses moments generated by both the POP program and the Weber-Wuertz editor and produces the following graphics output for both formats.

- Radial velocity (m s^{-1})
- Range-corrected signal-to-noise ratio
- C_n^2
- Spectral width (m s^{-1})
- Low-resolution wind barb profiles
- High-resolution wind profiles
- Upper air wind barb profiles
- Upper air temperature profiles

The user selects from the above list what products to display for each beam. One graphics window is opened per beam and displays the chosen products. The graphics window is scrollable in the product direction and in the time direction for up to 7 days. The color scale for each product can be set automatically by the program or manually by the user. The

new bird contamination identification algorithm can be visually tested on the data by setting the threshold values from the MOMENTVIEW threshold window. In the same threshold window, the quality control confidence levels can be selected.

3.3. DATAVIEWMET

DATAVIEWMET is a GUI designed to graphically display surface meteorological data. It also shows what met data are available for each hour of a 24-hour period. It requires use of sitemet.dat and site.dat databases, which list the met instruments installed at each site and gives site information. DATAVIEWMET displays a time series for each met instrument for up to a week of 1-minute data. Each met instrument is scaled to its minimum and maximum data values except for wind direction, which is set to 0-360, and wind speed, which is set to 0-30. Examples of DATAVIEWMET's products are shown in Appendix A. Examples of the formats DATAVIEWMET accepts are listed in Appendix B, as well as samples of sitemet.dat and site.dat files.

3.4. MOMENTPROCESS

MOMENTPROCESS is a GUI designed to extract data from POP-generated binary moment files and flag the data for noise and bird contamination. The program processes data beginning with the start month, day, and year and ending with the stop month, day, and year, as selected by the user. Thresholding techniques can be applied by flagging the data for high spectral width, and for high and low C_n^2. The threshold values can be applied within a user-selected time and height window. Using the UNIX version of GETMOM, the program reads the binary moment files from the input directory selected, and writes the ASCII files in the output directory selected. It can also calculate and output boundary-layer mixing depths. The site.dat database is used to extract site information and write it out to the ASCII moment files. This interface is used to create ASCII files to be used as input for the Weber-Wuertz editor. It can also be used as a transfer from binary to ASCII, or as a pre-editor and then a binary to ASCII transfer.

4. SCIENTIFIC APPLICATION

The challenge of software engineering is to transfer tools from a test version to the real thing. These new visual aid tools assist that transformation in several significant ways. Project coordinators use the tools daily to monitor data being transferred from the field site to our office, and to detect and quickly solve any problems that arise during the process.

4.1. Bird Contamination Elimination Algorithm

We collected 915-MHz boundary-layer data from northern, central, and southern California from 1990 through 1993. Using the visual aid tools provided, we noticed that the 915-MHz and the 404-MHz wind profiler data can be badly contaminated with migrating bird targets. We developed a possible solution to eliminating bird contamination by using MOMENTVIEW to visualize both the extent of the problem and the success of the data editing algorithm. This algorithm was implemented into MOMENTPROCESS, which has been vital in reprocessing entire sets of historical 915-MHz wind profiler data.

Winds measured with 915- and 404-MHz wind profilers frequently have nonrandom errors as large as 15 m s^{-1} when compared to simultaneously measured rawinsonde winds. Detailed studies of these errors, which occur only at night below about 4 km altitude and show a pronounced seasonal pattern, indicate that they are due to the wind profilers' detection of migrating songbirds. An important tool for determining whether profiler data are contaminated with birds is a graphical display of time-height cross sections of signal power, velocity, and spectral width for each radial beam. MOMENTVIEW was the tool used by ETL scientists to determine the existence and extent of bird contamination as well as to determine the best way to extract bird data from historical moments.

An automated technique has been found to be effective for the rejection of contaminated data in historical datasets. The technique, which is simple in concept, is to apply threshold limits to the signal power (or a related quantity such as C_n^2) and spectral width. This technique is based on the observation that during nighttime periods of bird migration the contaminated profiler data have substantially higher values of spectral width, and, at least at 915-MHz, considerably higher C_n^2 as well.

Threshold values that we have found to indicate bird contamination in 915-MHz boundary-layer profiler data are C_n^2 greater than $10^{-11.0}$ and spectral widths greater than 2.5 m s^{-1}. Thresholding is applied only during those hours when most songbirds migrate: between sunrise and sunset. Because a radar resolution volume does not have sharp boundaries but rather a Gaussian weighting distribution, a bird immediately outside of the nominal pulse volume can still contribute to the returned signal, but may do so with considerably less power. Rejection of these events (with low reflectivity and spectral width but the erroneous bird velocity) was achieved by eliminating the neighboring data points immediately preceding, following, above, and below a data point that exceeded the threshold values. Because the filter used in the radar receiver only approximates a matched filter, a single bird is generally found to produce a tear-drop shape with an elongation in the vertical. Thus, it was necessary to eliminate a second data point above any that met the threshold criteria. More about contamination of wind profiler data by migrating birds is documented in J. M. Wilczak et al. (1994). We implemented the above thresholding technique into MOMENTPROCESS. Days, months, and even years of contaminated bird data can be cleaned up easily by first selecting threshold values and time and height windows where the bird thresholding will take effect, then extracting the data with MOMENTPROCESS.

4.2. Shipboard Correction Formula

Allen White presented us with a set of 915-MHz wind profiler data collected aboard a ship and asked us to reprocess it using global positioning data. MOMENTVIEW and the UNIX version of GETMOM performed a key role in recovering the 915-MHz ship data.

The visual aid tools were used to address the problem of correcting shipboard-measured wind profiles for mean ship motion. The seagoing version of the NOAA/ETL/AL 915-MHz wind profiler employs a gyro-stabilized platform to keep the radar antenna level during pitch and roll events. However, no real-time corrections are made to the measured winds for changes in ship speed, heading, or course. A distinction is made here between course and heading since the ship may be moving (course) in a different direction than the ship bow is pointing (heading).

The radar control program used for the shipboard radar is similar to the program used for the land-based radars except that additional data are stored in the shipboard binary data files. These data include the outputs from the accelerometers mounted on the gyro-stabilized platform, as well as readings of ship speed and heading determined by the Global Positioning Satellites (GPS). However, because the GPS heading is not accurate when the ship is moving slowly, an additional device was used to measure heading. For the ASTEX field program, we used a gyro-compass. The gyro-compass data were stored in separate files associated with an atmospheric flux measurement system.

Although the wind profiler data were recorded using a DOS-PC and an optical disk drive, the visual aid tools allowed us to do the post-processing ship motion corrections on a much faster machine such as a Sun Workstation. The before/after results could then be displayed using the visualization tools. This capability was crucial in the debugging phase.

Three steps are involved in the correction algorithm. First, we produce a file containing values of ship speed, heading, and course corresponding to the times when radar moments were recorded. The gyro-compass data were used for heading, while the GPS data were used for speed and course. These data were linearly interpolated to fill gaps in the time series.

The second step is to recalculate the radial velocities measured by the radar. If we assume an aft and port beam configuration with beam azimuthal angles θ_a and θ_p relative to the ship bow, then

$$\theta_p = \theta_a + 90 , \qquad 0 \le \theta_a < 360 . \tag{1}$$

First we rotate the oblique radial velocities measured by the radar into a northeast (NE) reference frame. Next we elevate the ship vector and rotate it into a NE reference frame. Finally, we lower the vertical radial and rotate it into a NE reference frame (this last

step is done only if one wishes to correct the oblique radials for vertical air motion and/or precipitation). The following results are obtained:

$$R_N = R_a \cos(\theta_a + h) - R_p \sin(\theta_a + h) - U_s \cos(z)\cos(c) - R_v \sin(z)\left[\cos(\theta_a + h) - \sin(\theta_a + h)\right] \quad (2a)$$

$$R_E = R_a \sin(\theta_a + h) + R_p \cos(\theta_a + h) - U_s \cos(z)\sin(c) - R_v \sin(z)\left[\sin(\theta_a + h) + \cos(\theta_a + h)\right], \quad (2b)$$

where R_a, R_p, and R_v are the measured radar radial velocities (m s^{-1}); U_s, h, and c are the ship speed (m s^{-1}), heading (deg) and course (deg); and z is the elevation of the oblique beams (deg).

In the third and final step, the radial velocities calculated using (2a) and (2b) are subjected to the Weber-Wuertz pattern recognition algorithm and quality control editor to produce hourly averaged winds. For more information on this stage of the processing, see Weber et al. (1993). The entire process is illustrated in Figs. 4.2.1-4.1.3. Figure 4.2.1 shows a time-height cross section of the consensus winds from 27 June, calculated before the ship motion correction algorithm was applied. Figure 4.2.2 gives the ship speed, heading, and course data that were used to correct the contaminated radial velocities. Figure 4.2.3 shows the winds after the correction algorithm has been applied. During a period of rain (0500-0600), the winds were reprocessed using vertical correction at the moment level [i.e., including the last term on the right-hand sides of (2a) and (2b)]. Otherwise, vertical correction was not used.

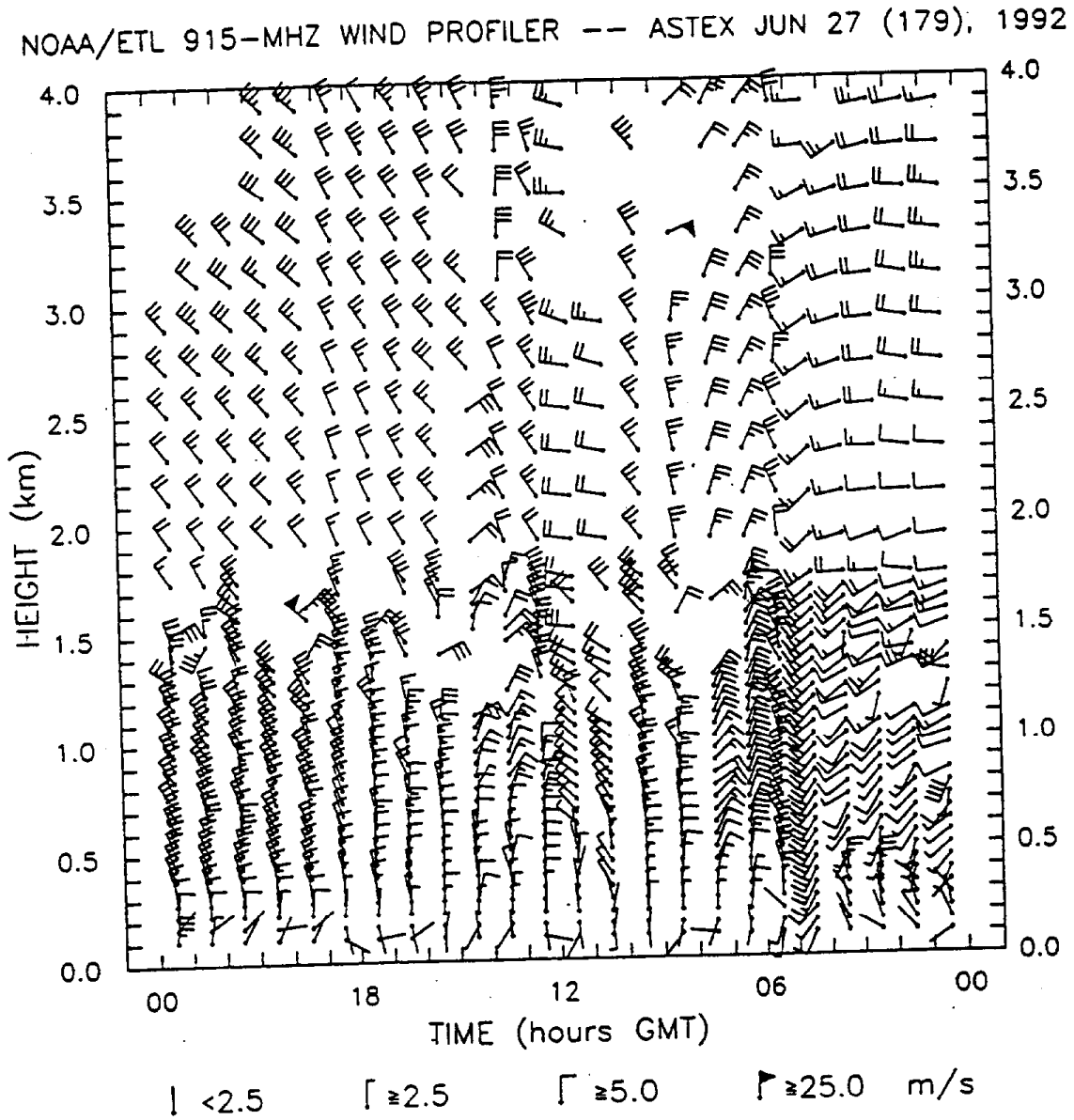

Fig. 4.2.1. Consensus wind profiles during ASTEX measured by the 915-MHz radar mounted onboard the research vessel Malcolm Badrige. The data have not been corrected for mean ship motion.

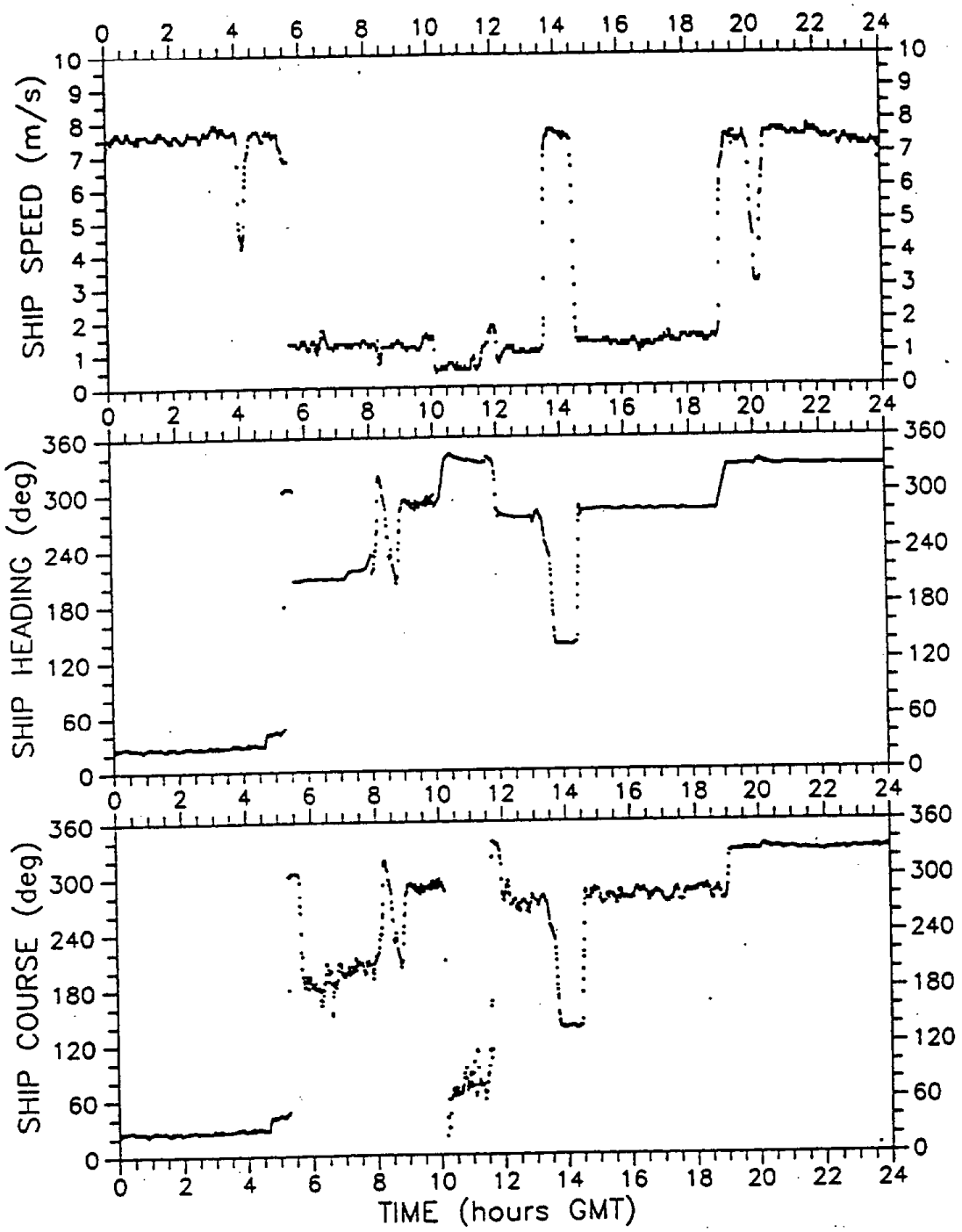

Fig. 4.2.2. Ship's speed, heading, and course data used to correct the radar-measured winds.

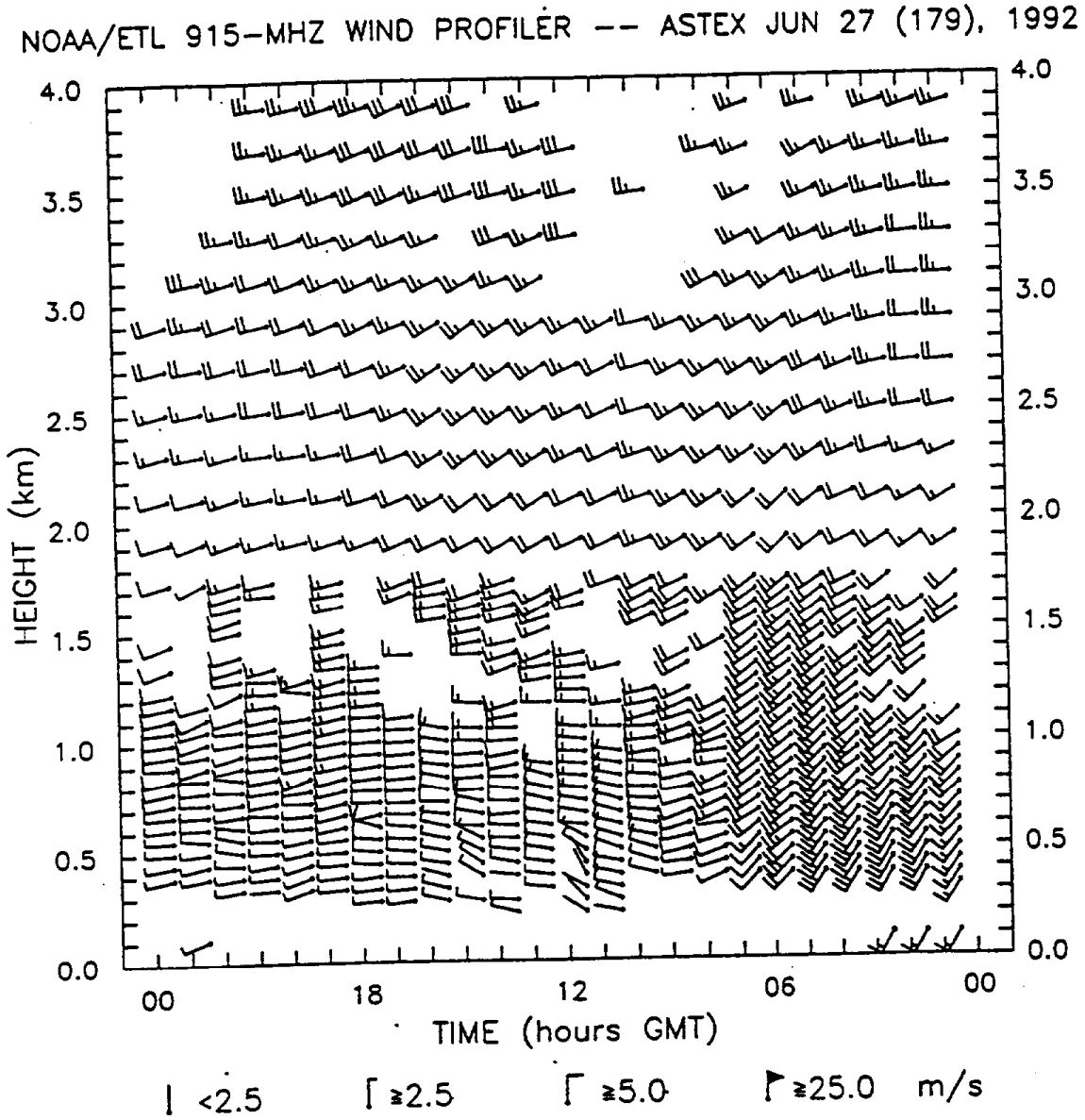

Fig. 4.2.3. Hourly averaged wind profiles after applying the ship motion correction algorithm and the Weber-Wuertz pattern recognition and quality control schemes.

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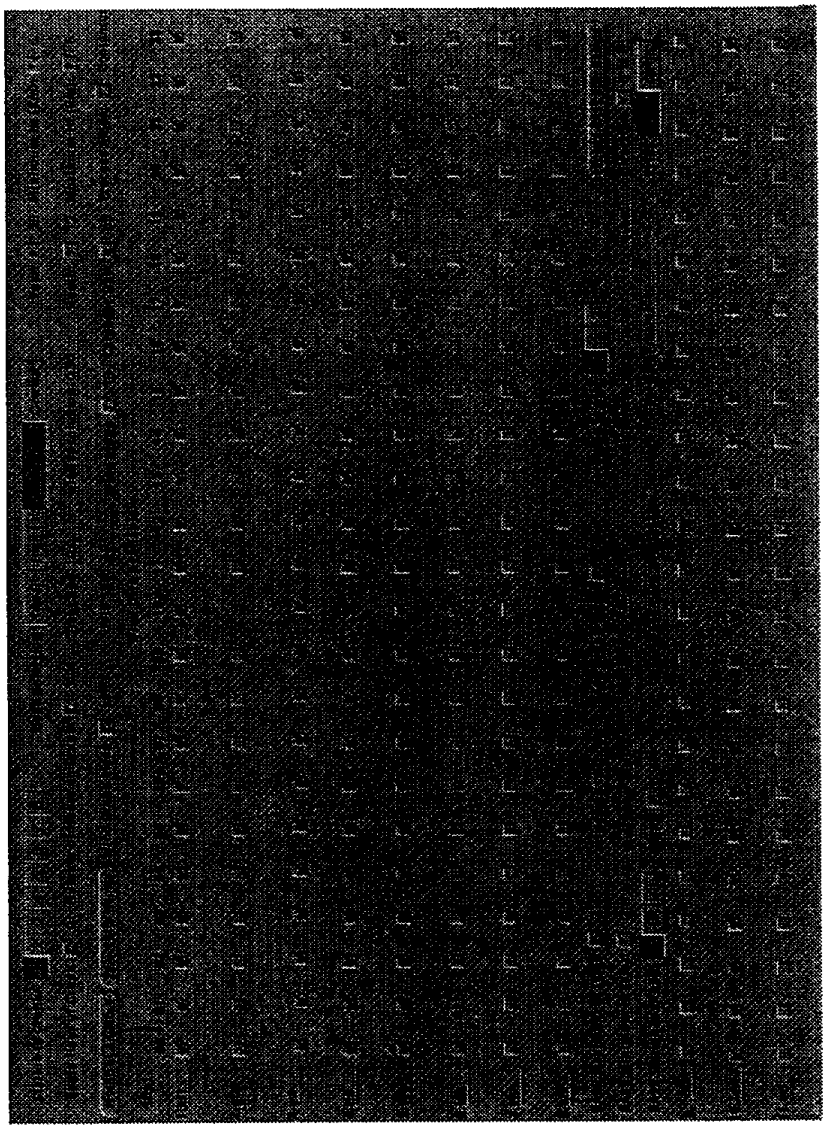
Wilczak, J. M., R. G. Strauch, B. L. Weber, D. A. Merritt, R. M. Ralph, J. R. Jordan, D. E. Wolfe, L. K. Lewis, D. B. Wuertz, J. E. Gaynor, S. McLaughlin, R. Rogers, A. Riddle, T. Dye, 1994. Contamination of radar wind profiler data by migrating birds: Characteristics of corrupted data and potential solutions. *Bull. Am. Meteorol. Soc.*

Appendix G-A: Sample Graphics Output

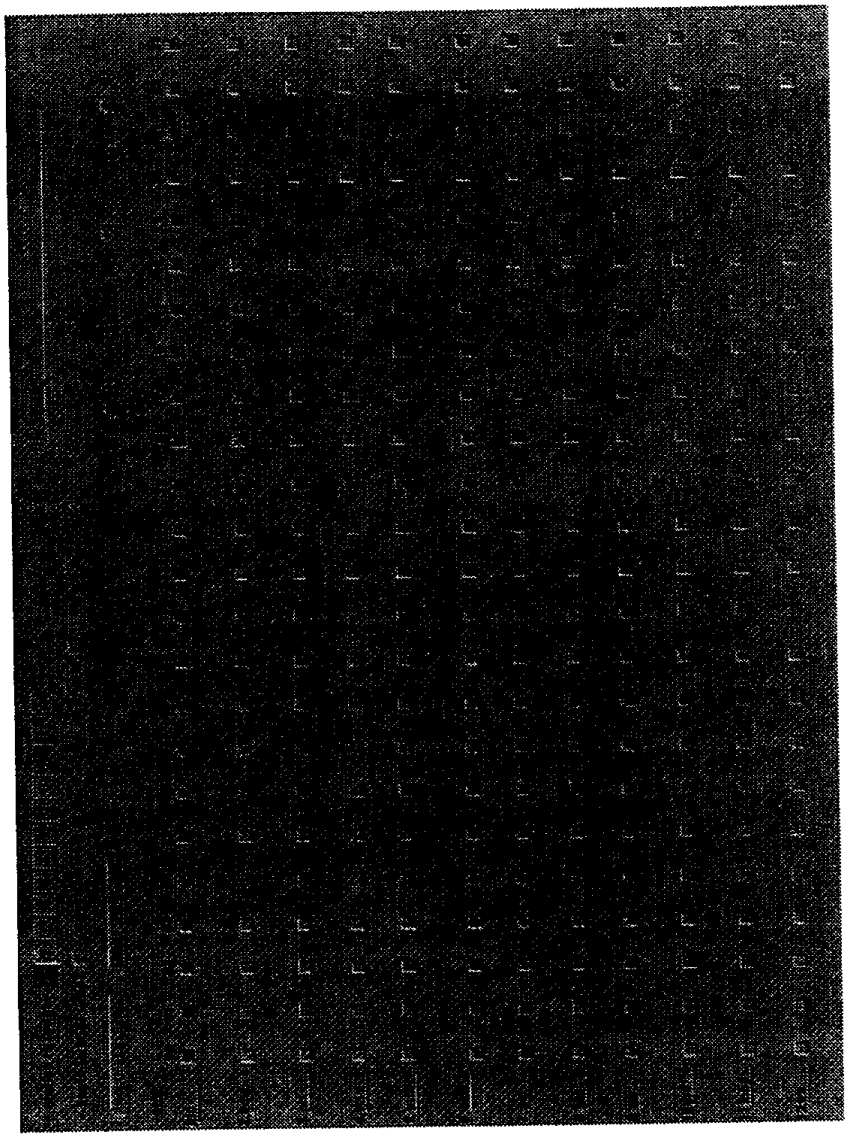
Pages

G-A1. GUI DESIGNS 14-17
G-A2. DATAVIEW GRAPHICS 18-25
G-A3. DATAVIEWMET GRAPHICS 26
G-A4. MOMENTVIEW GRAPHICS 27-28

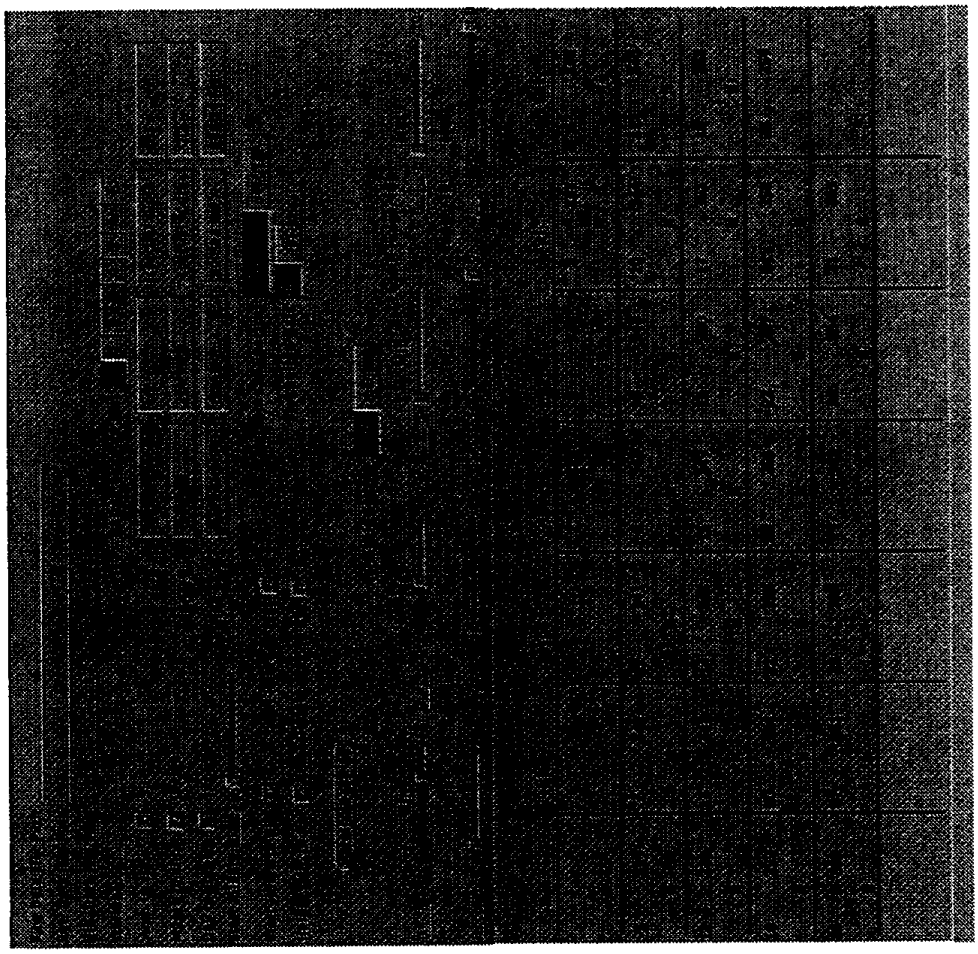
G-A1. DATAVIEW GUI



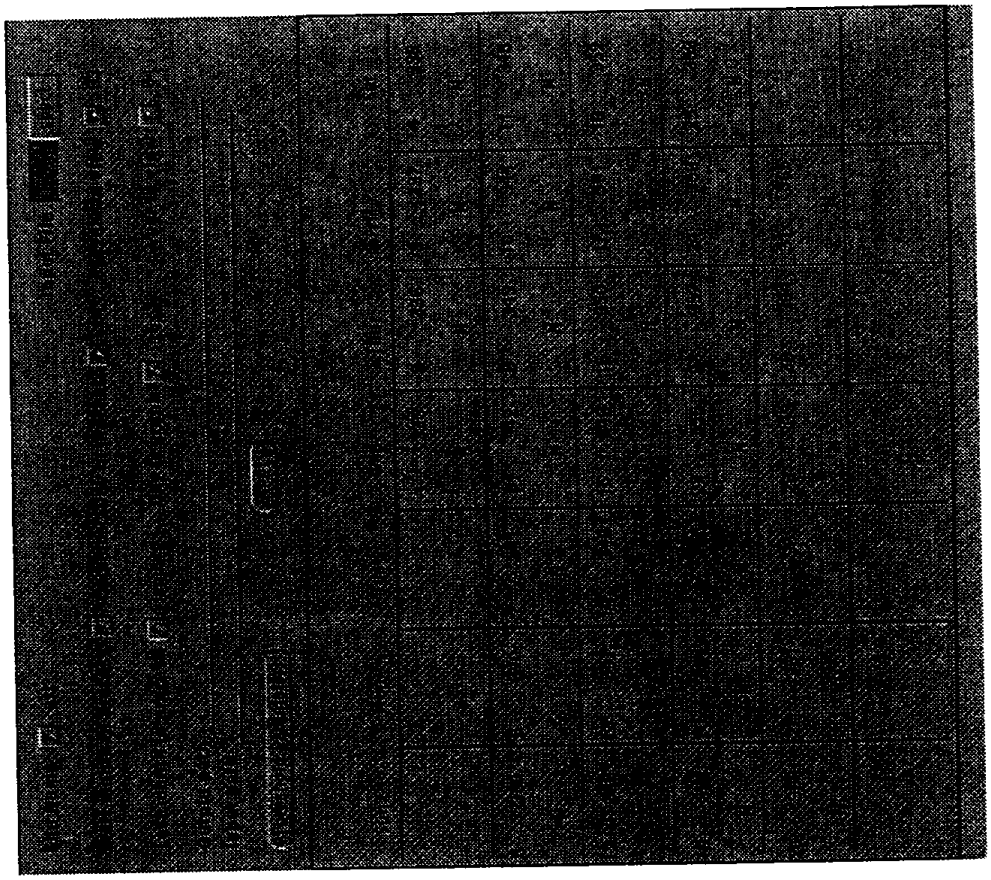
G-A1. DATAVIEWMET GUI



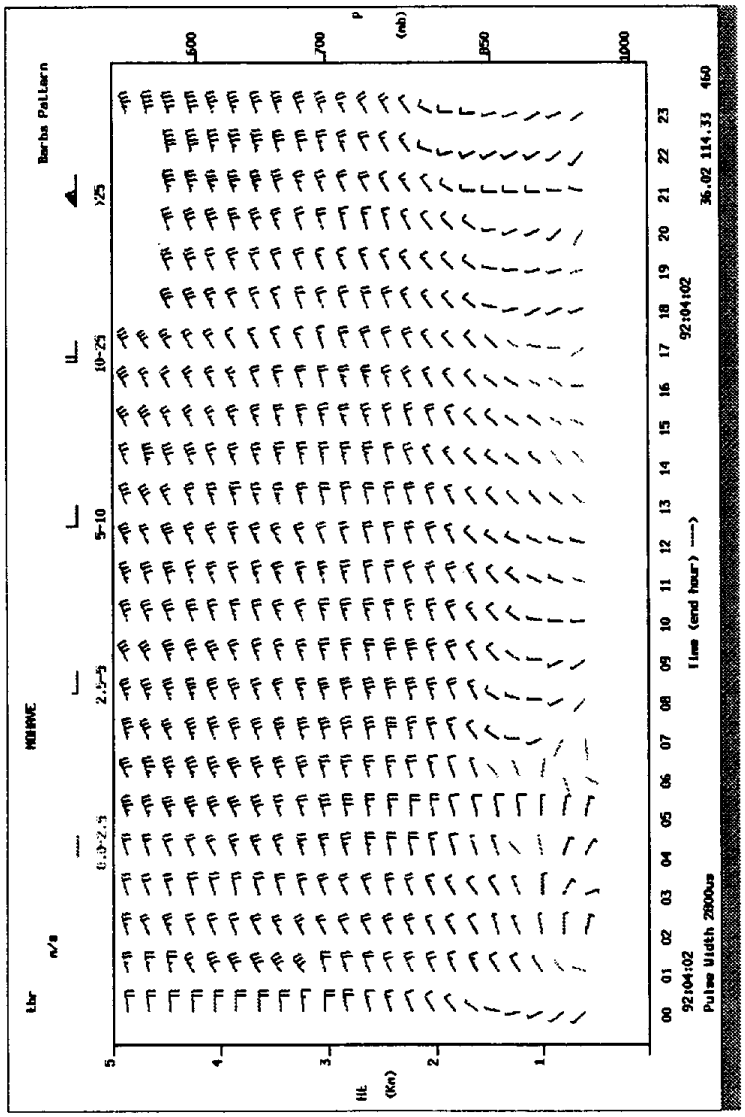
G-A1. MOMENTVIEW GUI



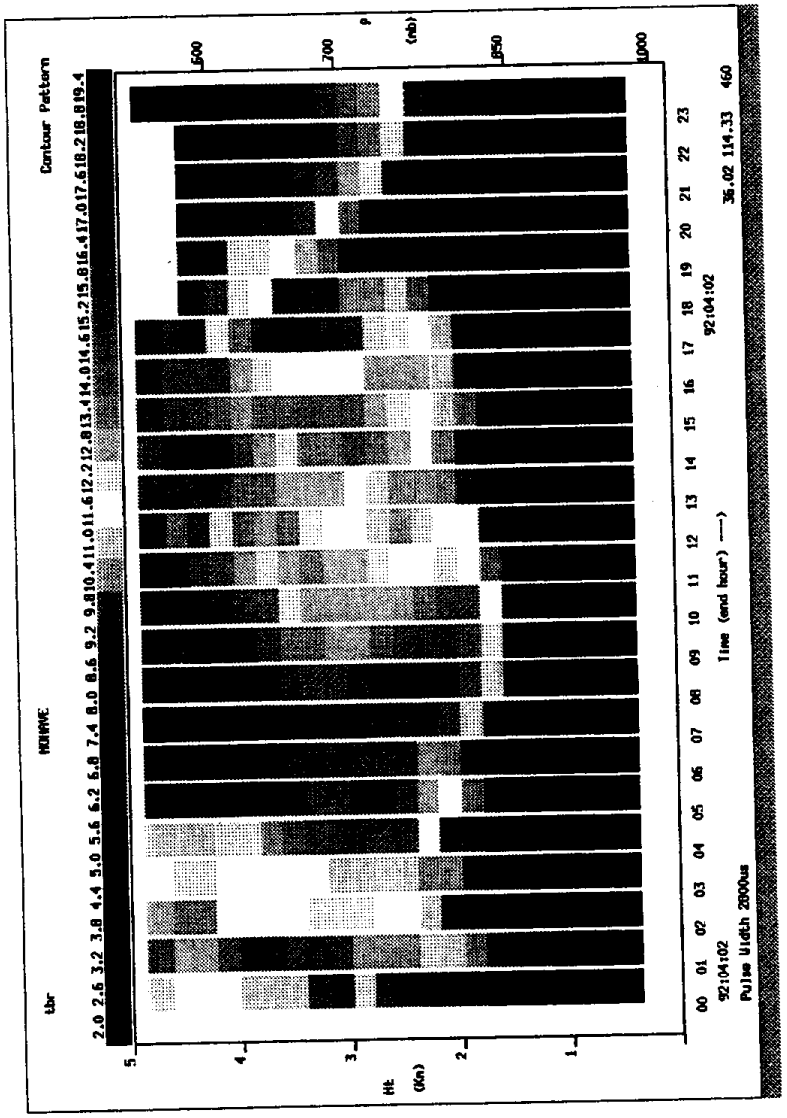
G-A1. MOMENTPROCESS GUI



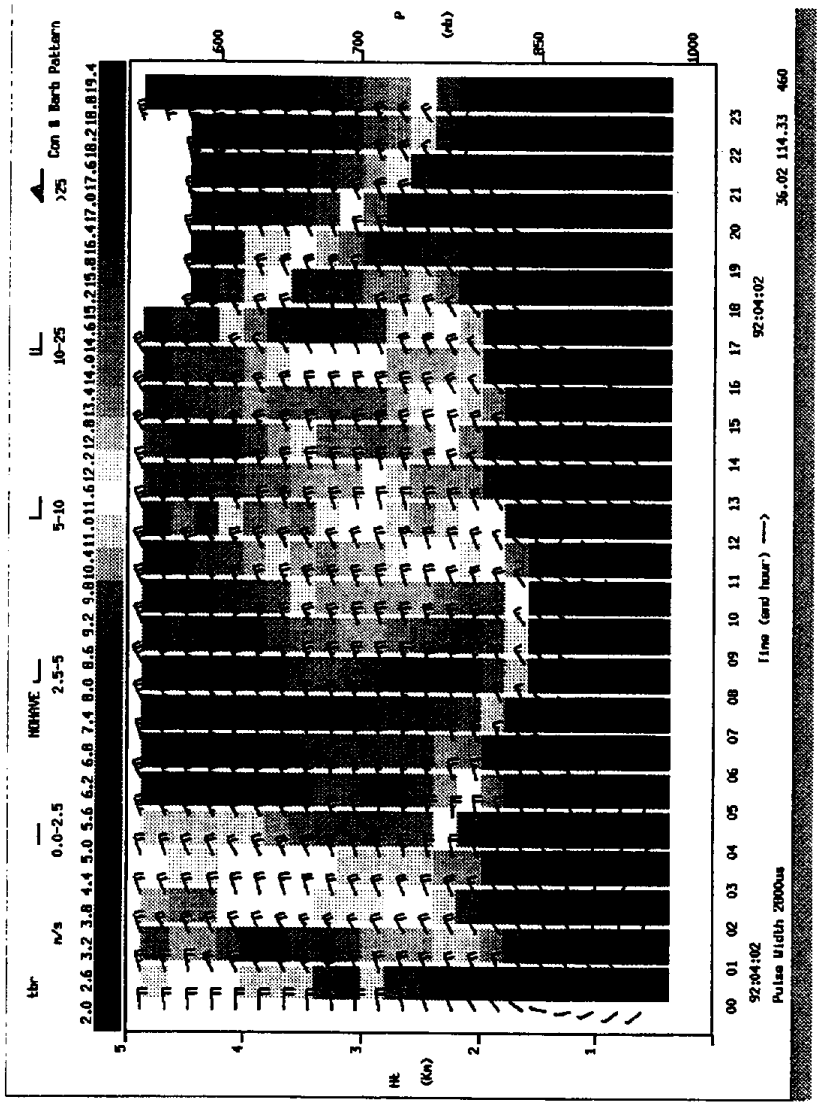
G-A2. Wind Barb Profiles



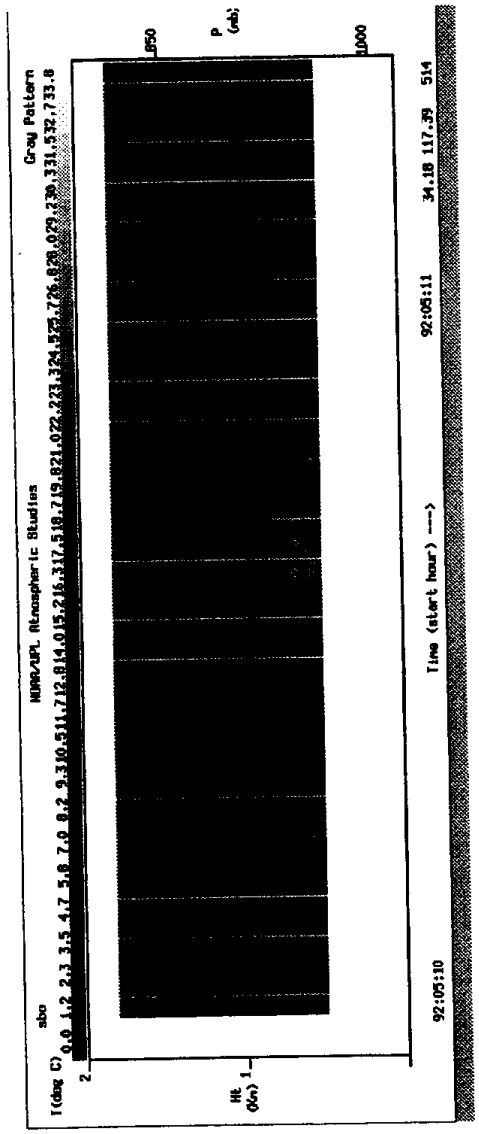
G-A2. Contoured Wind Speed Profiles



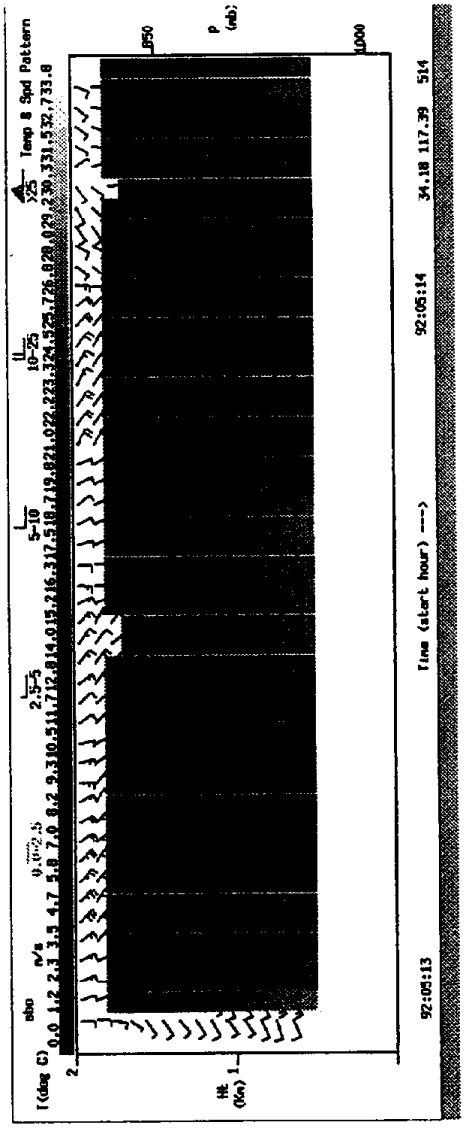
G-A2. Contoured Wind Speed with Wind Barb Profiles Overlay



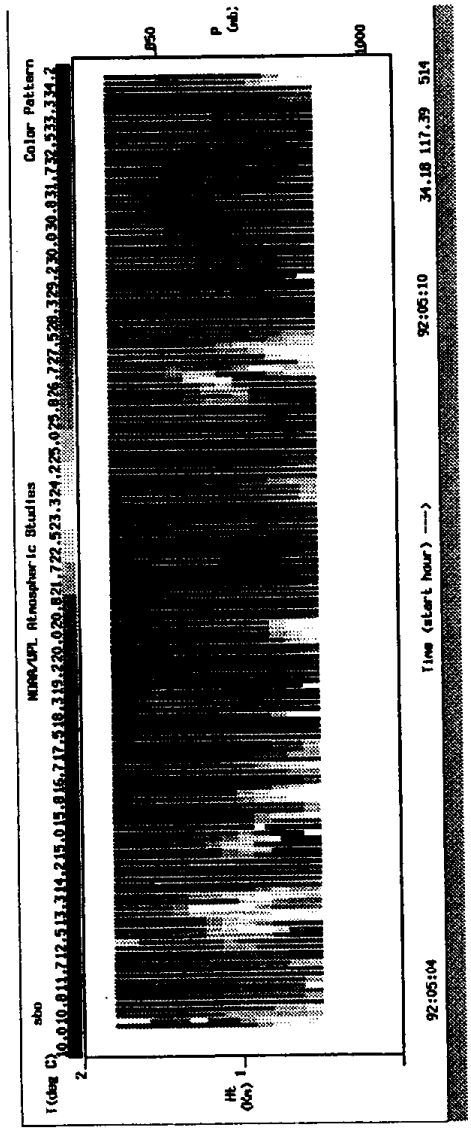
G-A2. Contoured Wind Speed



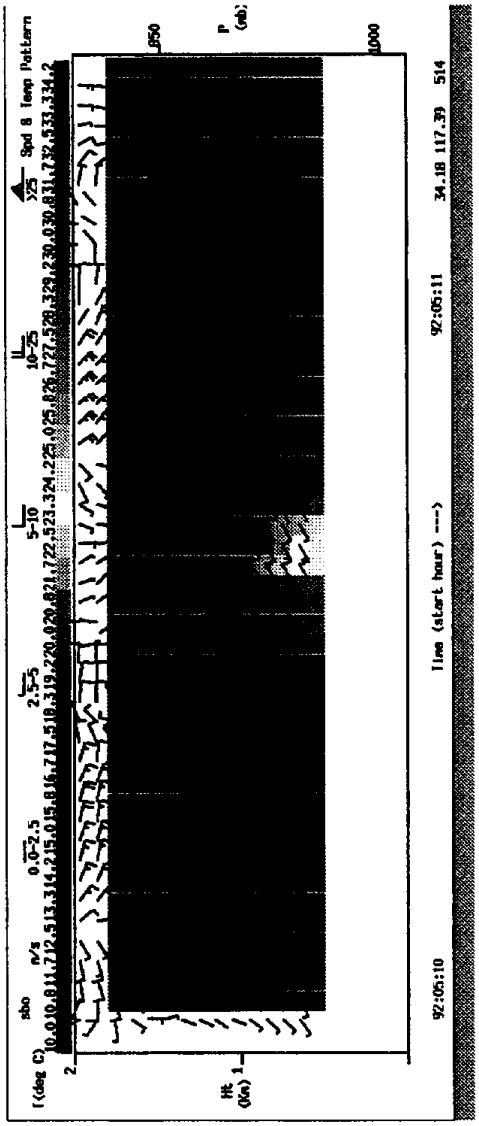
G-A2. Contoured Wind Speed with Wind Barb Profiles Overlay



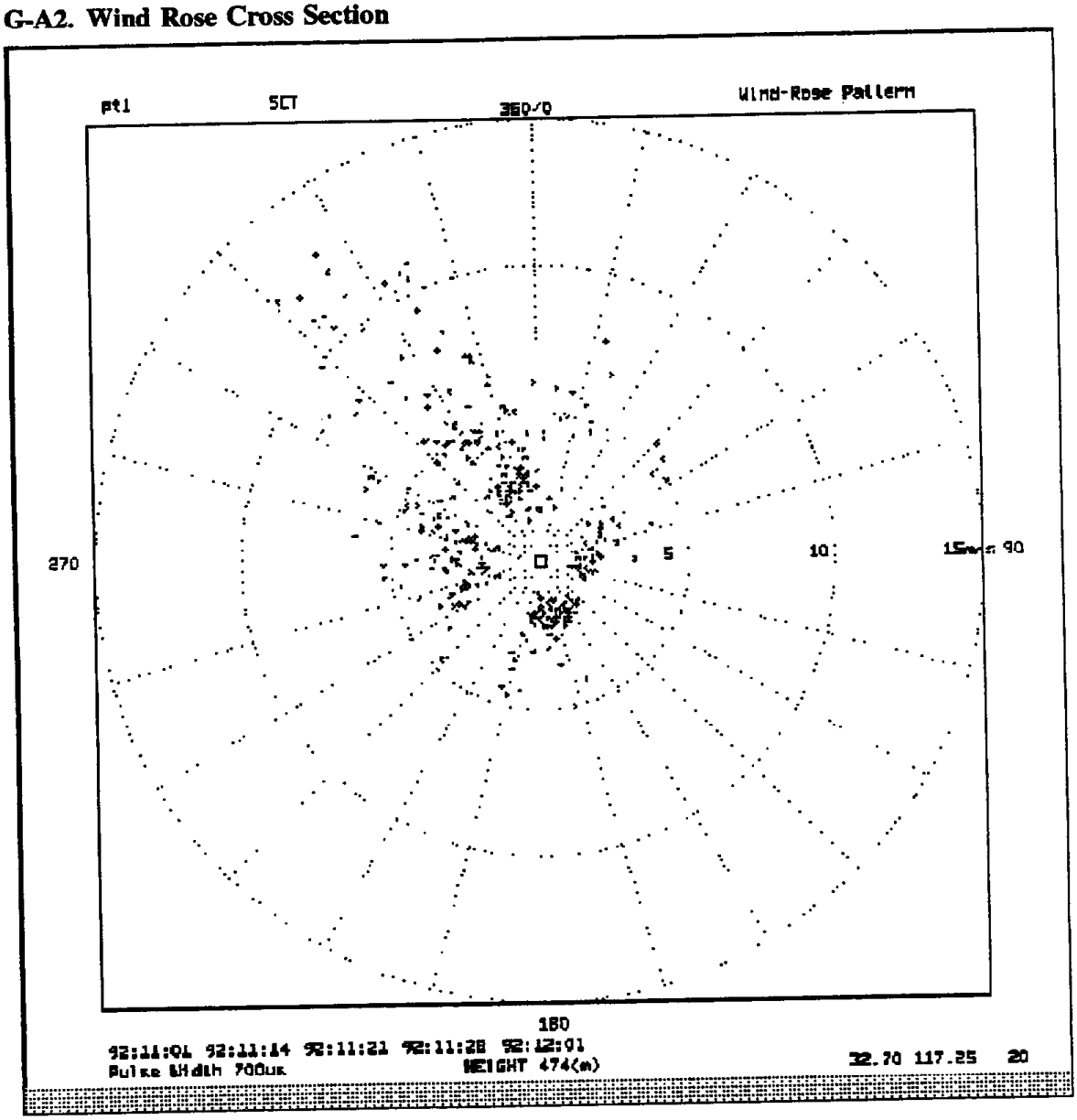
G-A2. Contoured Temperature Profiles



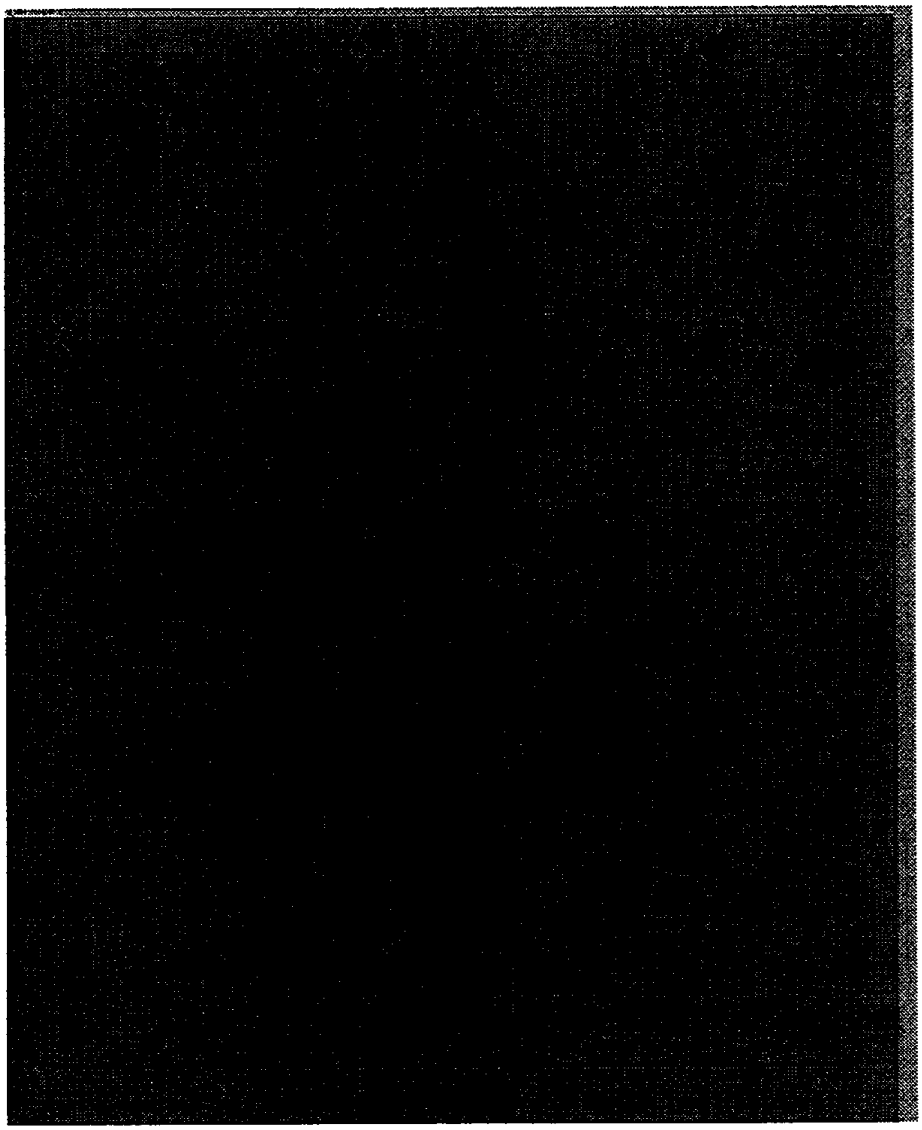
G-A2. Contoured Temperature Profiles with Wind Barb Overlay



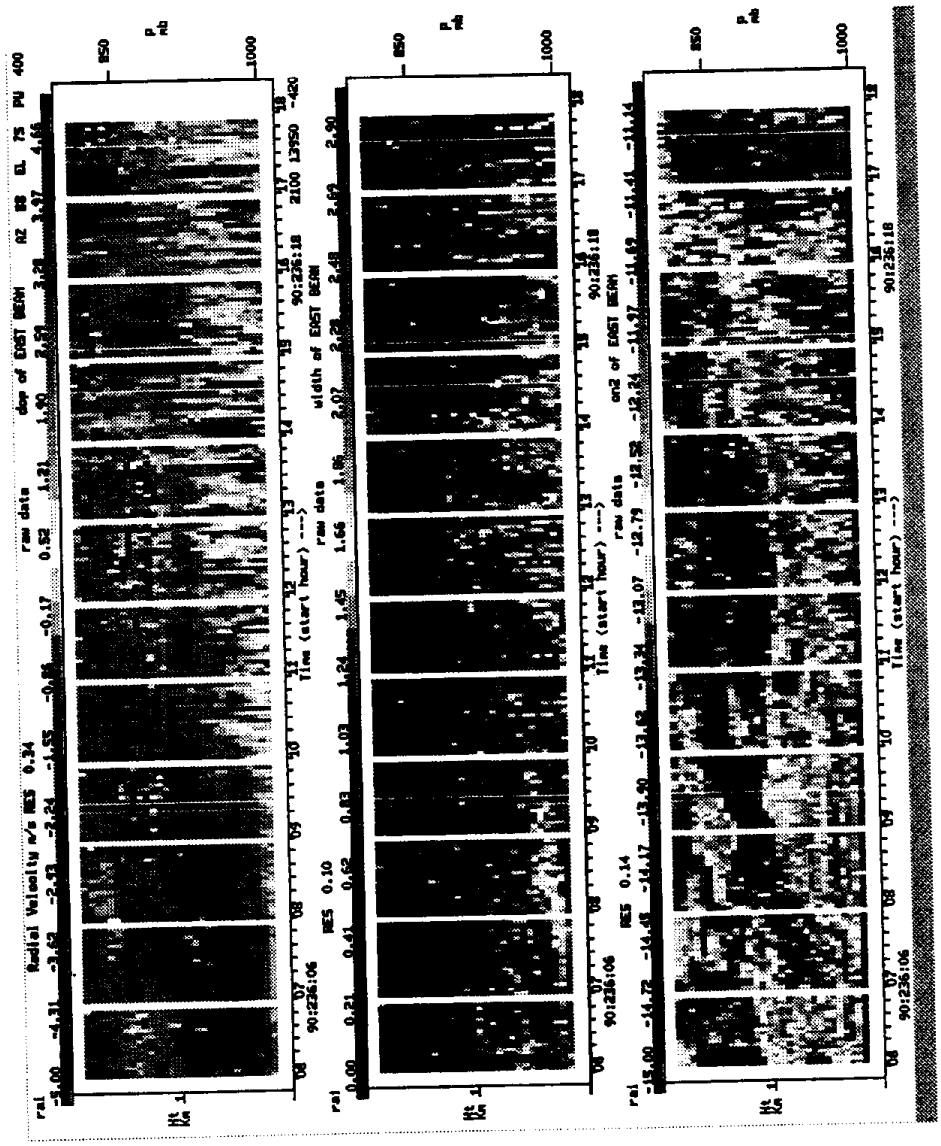
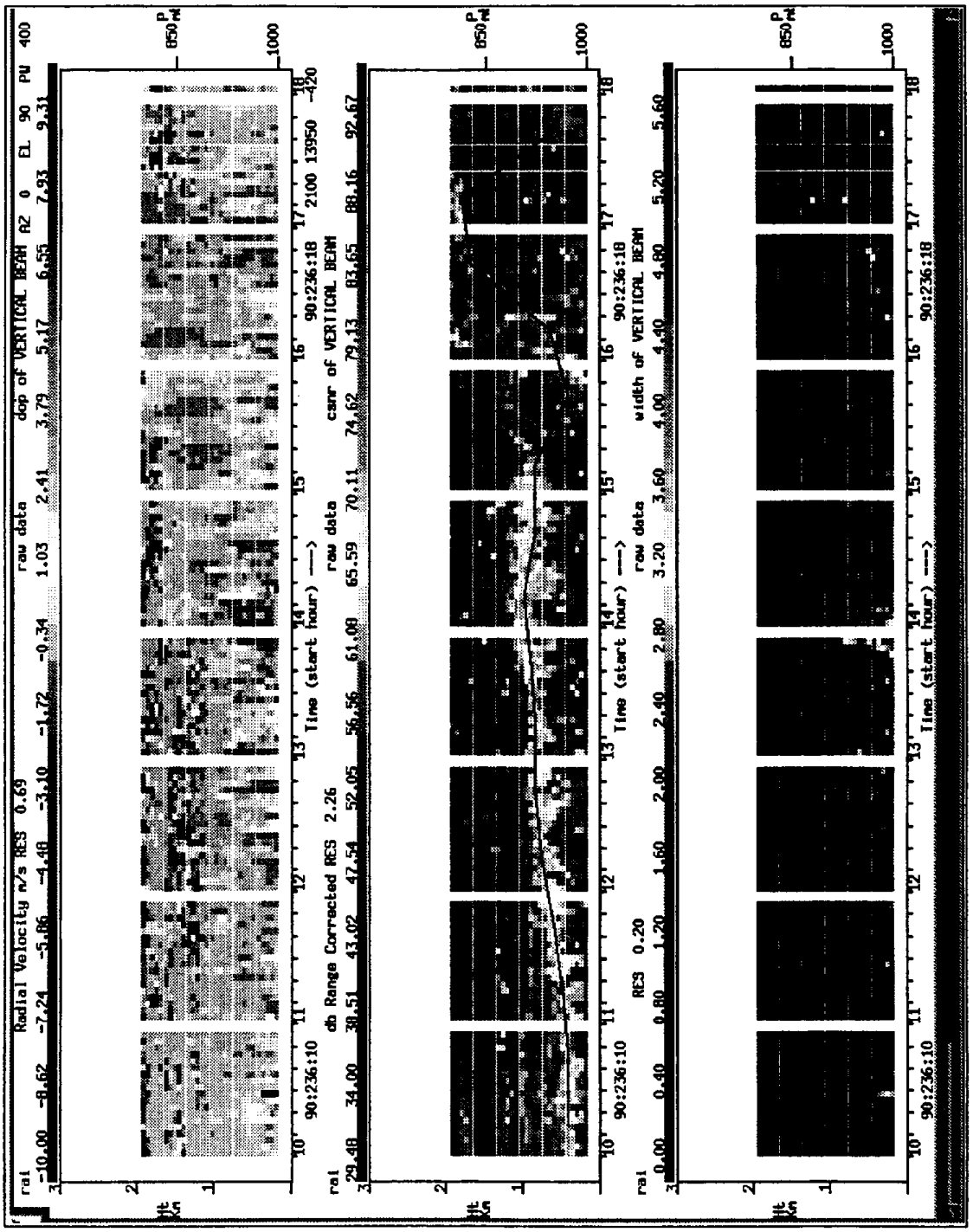
G-A2. Wind Rose Cross Section



G-A3. Time Series of Surface Meterological Data



G-A4. 915 MHz Moment Data



G-A4. 915-MHz Profiler Data with Boundary-Layer Mixing Depths Overlayed