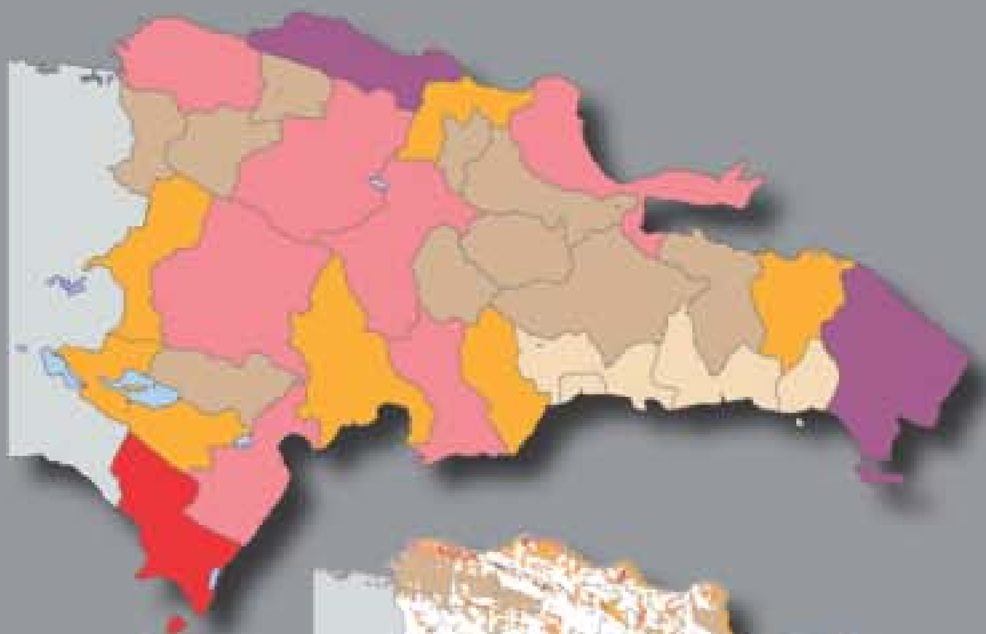
Wind Energy Resource Atlas of the Dominican Republic



D. Elliott, M. Schwartz, R. George, S. Haymes, D. Heimiller, G. Scott

National Renewable Energy Laboratory

J. Kline

RAM Associates

October 2001 • NREL/TP-500-27602

Wind Energy Resource Atlas of the Dominican Republic

D. Elliott
M. Schwartz
R. George
S. Haymes
D. Heimiller
G. Scott
National Renewable Energy Laboratory

J. Kline
RAM Associates

Prepared under Task Nos. WER11050 and DO059999

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: reports@adonis.osti.gov

Available for sale to the public, in paper, from:
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

Printed on paper containing at least 50% wastepaper, including 20% postconsumer waste

Table of Contents

List of Figures

List of Tables

Executive Summary

The Wind Energy Resource Atlas of the Dominican Republic identifies the wind characteristics and the distribution of the wind resource in this country. This major project is the first of its kind undertaken for the Dominican Republic. The information contained in the atlas is necessary to facilitate the use of wind energy technologies, both for utility-scale power generation and off-grid wind energy applications. A computerized wind mapping system developed at the National Renewable Energy Laboratory (NREL) generated detailed wind resource maps for the entire country. This technique uses Geographic Information Systems (GIS) to produce high-resolution (1-square kilometer [km^2]) annual average wind resource maps.

An accurate wind resource assessment is highly dependent on the quantity and quality of meteorological data used by the mapping system. The quality of the meteorological input depends on understanding the wind characteristics in the study region, including the seasonal and diurnal variability, and the wind direction frequency. NREL used innovative assessment methods on existing climatic data sets to develop a detailed understanding of these key wind characteristics. NREL's approach depended upon the critical analysis of all available (surface meteorological and upper-air) climatic data sets for the Dominican Republic and the surrounding areas. The surface and upper-air (weather-balloon) data used in this project usually covered many years of record, with up to 40 years for some of the data sets. Global data sets maintained at NREL were supplemented with data sets obtained from the Dominican Republic. We processed the data to generate wind characteristics summaries for numerous surface and upper-air locations. These summaries were cross-referenced to aid in understanding the prevalent wind characteristics throughout the Dominican Republic.

This critical data analysis is particularly important because NREL's wind mapping system uses a "top-down" method in the adjustment of much of the available wind data. The NREL approach takes the ambient wind profile in the lowest kilometers above the surface and adjusts it down to the surface layer. This method enables NREL to produce reliable wind resource maps without having high quality surface wind data for the study region.

Two major inputs to the mapping system were meteorological data and 1-km^2 gridded terrain data. The final meteorological inputs to the mapping system were vertical profiles of ambient wind power and wind power roses (the percentage of total potential wind power by direction sector), and the ocean wind power density for coastal areas. The GIS uses a combination of the meteorological and terrain data to calculate the wind power value for each 1-km^2 grid cell. The primary output of the mapping system was a color-coded map containing the estimated wind power and equivalent wind speed for each individual grid cell.

The values on the wind resource maps in the atlas are based on the estimated wind power density, at 30 m above ground level, not wind speed. Wind power density is a better indicator of the available resource than the average wind speed. Wind power density, expressed in watts per square meter (W/m^2), incorporates the combined effects of the wind speed frequency distribution, the dependence of the wind power on air density, and the cube of the wind speed. Six wind power classifications, based on ranges of wind power density, were used in the atlas. Each of the classifications was defined for two categories: utility-scale applications and rural power applications (ranging from moderate to excellent). In this atlas, the 30-m height was chosen as a compromise hub height between large utility-scale wind turbines (primarily between 30 m and 80 m) and small wind turbines (generally between 10 m and 30 m) used for rural power applications. In general, locations with an annual average wind resource greater than 300 W/m^2 or 7.0 m/s at turbine hub height are the most suitable for utility grid-connected wind energy systems. Rural or village power applications can be viable at locations with a wind resource as low as 100 W/m^2 or 4.9 m/s.

Dominican Republic Wind Resource

The wind resource in the Dominican Republic is strongly dependent on elevation and proximity to the coastline. In general, the wind resource is best on hilltops, ridge crests, and coastal locations that have excellent exposure to the prevailing winds from the east. The extreme southwestern and northwestern regions of the country are estimated to have the greatest number of areas with good-to-excellent wind resources for utility-scale applications, because the upper-air winds and ocean winds are greatest in these regions.

The wind mapping results show many areas of good-to-excellent wind resource for utility-scale applications or excellent wind resource for village power applications, particularly in the extreme southwestern and northwestern regions of the country. The best wind resources are found in the southwestern provinces of Pedernales and Barahona and the northwestern provinces of Puerto Plata and Monte Cristi. Significant areas of good-to-excellent wind resource can be found in many other locations, such as well-exposed hilltops and ridge crests of the Samana Peninsula and other near-coastal locations throughout the Dominican Republic and the major mountain ranges including Cordillera Septentrional, Cordillera Oriental, Cordillera Central, and Sierra Neiba. The mapping results show many additional areas of moderate wind resource for utility-scale applications or good wind resource for village power applications, including many east-facing coastal locations along the eastern and northern coasts of the Dominican Republic.

The seasonal and diurnal (time-of-day) variability of the wind resource depends on several factors including proximity to coastline and exposure to ocean winds, elevation above sea level and surrounding terrain, and geographic location. High ridge crests that have excellent exposure to the winds are expected to have the highest wind resource from June to August and December to February, with a maximum in July and a minimum in October. The diurnal pattern of wind speeds on exposed ridge crests tends to have the highest speeds during the night and early morning hours and lowest during midday.

At most inland locations, the wind resource is typically highest from June through August due to greater winds aloft and greater vertical mixing, with a secondary seasonal maximum from March through May. The wind resource at inland locations is usually lowest from October through December. The wind resource at inland locations is typically highest during late morning and afternoon and is lowest from late night to early morning. In most coastal areas where land-sea breeze effects and other land-based influences are prominent, the seasonal and diurnal variations of the wind resource are usually similar to those for inland areas.

Coastal points on capes and peninsulas that are well exposed to the ocean winds are expected to have the highest wind resource from June to August and December to February. Generally, these types of locations will exhibit very small diurnal variations in the wind resource and are not significantly influenced by land-sea breeze flows and other types of land-based effects on the wind flow.

Conclusions

About 1500 km^2 of windy land areas have been estimated to exist with good-to-excellent wind resource potential. This windy land represents less than 3% of the total land area (48,442 km^2) of the Dominican Republic. Using conservative assumptions of about 7 megawatts (MW) per km^2, this windy land could potentially support more than 10,000 MW of installed capacity and deliver over 24 billion kilowatt-hours (kWh) per year. Considering only these areas of good-to-excellent wind resource, there are 20 provinces in the Dominican Republic with at least 100 MW of wind potential and 3 provinces with at least 1000 MW of wind potential. However, additional studies are required to more accurately assess the wind electric potential, considering factors such as the existing transmission grid and accessibility.

If the additional areas with moderate wind resource potential (or good for rural power applications) are considered, the estimated total windy land area increases to more than 4400 km^2, or slightly more than 9% of the total land area of the Dominican Republic. This windy land could potentially support more than 30,000 MW of installed capacity and deliver over 60 billion kWh per year. There are 12 provinces with at least 1000 MW of wind potential, and all except for 3 provinces have at least 100 MW of wind potential.

The wind resource maps and other wind resource characteristic information will be useful for identifying prospective areas for wind energy applications. However, very limited data were available to validate the wind resource estimates. Therefore, we strongly recommend that wind measurement programs be conducted to validate the resource estimates and refine the wind maps and assessment methods where necessary.

1.0 Introduction

The United States Department of Energy (DOE) and the United States Agency for International Development (USAID), in collaboration with Winrock International and the United States National Rural Electric Cooperative Association (NRECA), sponsored a study to facilitate and accelerate the large-scale use of wind energy technologies in the Dominican Republic through the development of a wind energy resource atlas of the Dominican Republic. NRECA and Winrock/REGAE (Renewable Energy Growth Assistance Entity) supported the project by contributing wind monitoring data collected at prospective wind energy sites and by providing other technical assistance, such as obtaining summaries of wind data from agencies in the Dominican Republic. The Dominican Republic agencies, the Oficina Nacional de Meteorologia - Division de Climatologia (ONM) and Instituto Nacional de Recursos Hidraulicos (INDRHI), provided data collected at their meteorological stations.

DOE's National Renewable Energy Laboratory (NREL) had the lead responsibility in administering and conducting this project and in collaborating with USAID, NRECA, and Winrock on project activities. The primary goal of the project was to develop detailed wind resource maps for all regions of the Dominican Republic and to produce a comprehensive wind resource atlas documenting the mapping results.

This document, the "Wind Energy Resource Atlas of the Dominican Republic", presents the wind resource analysis and mapping results for the Dominican Republic. The wind resource maps were created using a Geographic Information System (GIS)-based program developed at NREL. The mapping program combines high-resolution terrain data and formatted meteorological data, and is designed to highlight the most favorable wind resource areas for wind energy projects based on the level of wind resource.

This atlas is the latest in a series of wind energy resource atlases and assessments produced by NREL. In addition to the Dominican Republic, NREL has applied its new wind mapping system to produce wind resource assessments of Mongolia (Elliott et al. 1998) and the Philippines (Elliott 2000), and specific regions of Chile, China, Indonesia, Mexico, and the United States (Schwartz 1999; Elliott et al. 1999).

The report is divided into seven sections. An overview of the geography and climate of the Dominican Republic is presented in Section 2.0. The wind resource information used to create the meteorological input files is highlighted in Section 3.0. A description of the mapping system is presented in Section 4.0. The wind resource characteristics of the Dominican Republic and the wind mapping results are presented in Section 5.0 and Section 6.0, respectively. The results of the wind electric potential assessment are given in Section 7.0.

Appendices are included that highlight the analysis results from selected USAID wind monitoring sites where sufficient data were available, selected surface and upper-air meteorological stations, and maps and monthly summaries of satellite ocean wind data in the Dominican Republic region.

2.0 Geography and Climate of the Dominican Republic

2.1 Geography

The Dominican Republic occupies the eastern two-thirds of the island of Hispaniola, located in the Greater Antilles chain of the Caribbean region in the western Atlantic Ocean. Haiti is west of the Dominican Republic. Puerto Rico is east of the Dominican Republic, across the Mona Passage. The Caicos Islands and Grand Turk Island are north, in the Atlantic Ocean, and the Caribbean Sea is south. The Dominican Republic has a maximum length in the east-west direction of approximately 380 km and a maximum width in the north-south direction of approximately 265 km. The land area is 48,442 km^2 (18,703 mi^2), with approximately 1600 km of coastline. The coastline is irregular and indented into many bays, capes, and points. The Dominican Republic is centered approximately at 70 degrees west longitude and 19 degrees north latitude.

Figure 2.1 is a political map of the Dominican Republic, showing the internal political boundaries of the 29 provinces, the National District of Santo Domingo, and major cities. The population of the Dominican Republic is estimated to be 8 million (1997). The capital, largest city, and chief seaport is Santo Domingo.

The terrain, shown in Figure 2.2 and Figure 2.3, is varied, ranging from high mountains and rocky cliffs to valleys and coastal plains. Figure 2.3 in particular portrays the dramatic transitions from the valleys to rugged mountains in the western half of the Dominican Republic. Approximately 80 percent of the country is covered by rugged mountain ranges separated by valleys, which bisect the country in a northwest to southeast direction. The northern part of the Dominican Republic features a relatively narrow mountain range, the Cordillera Septentrional, separated from the largest mountain range, the Cordillera Central, by the Valle del Cibao to the west and the Vega Real to the east of a divide near Santiago. The Cordillera Central contains the Caribbean's highest peak, Pico Duarte, rising over 3,175 m (10,417 ft) high. The Valle de San Juan separates the Cordillera Central from the Sierra de Neiba. The Valle de Neiba separates the Sierra de Neiba from the southernmost mountain chain, the Sierra de Baoruco, and contains Lake Enriquillo, a saltwater lake 40 m below sea level, and the lowest point in the Caribbean. The eastern region of the Dominican Republic is dominated by a lower mountain range, the Cordillera Oriental, and by a broad coastal plain, the Llanura Costera del Caribe.

2.2 Climate

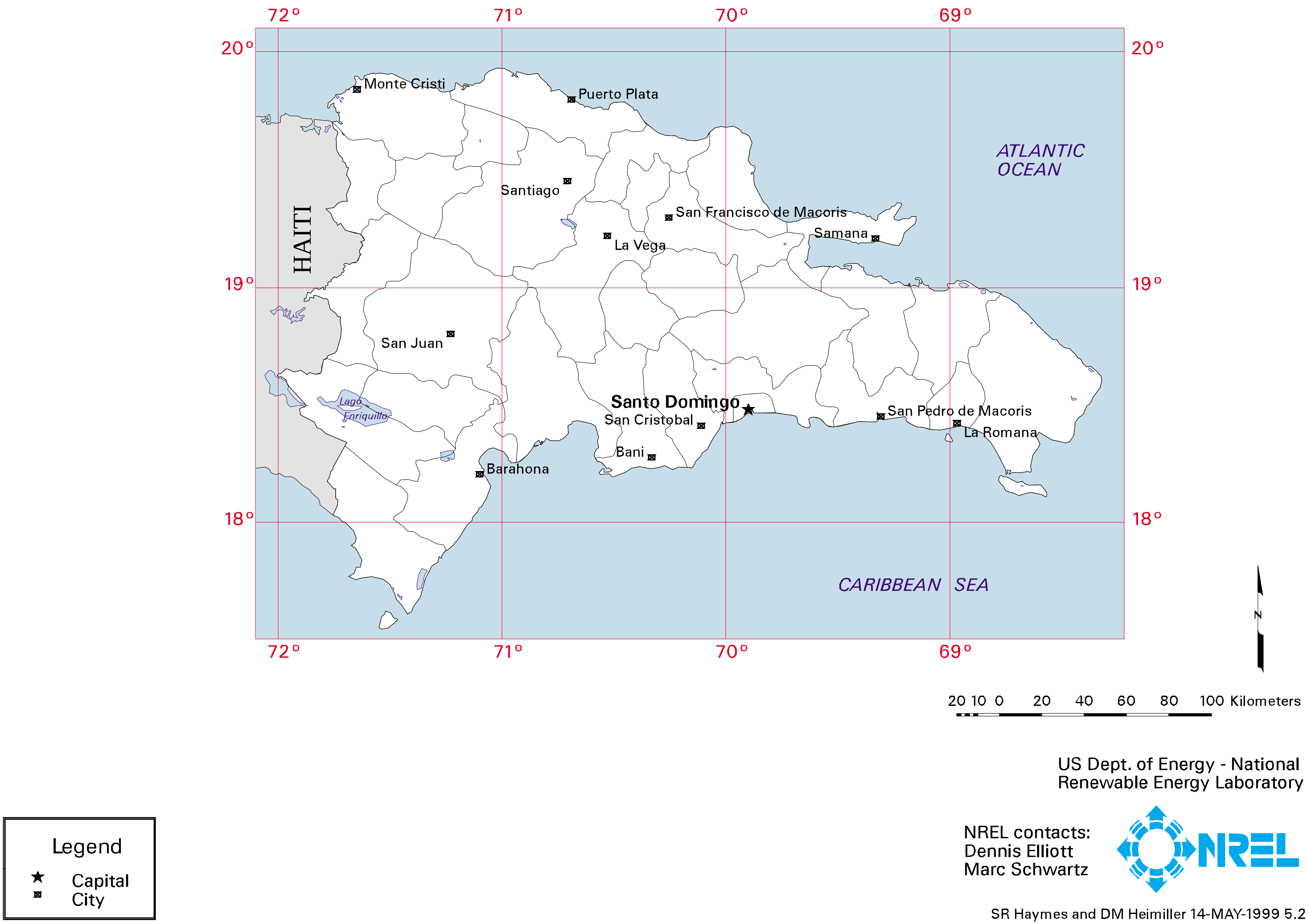
The Dominican Republic has a primarily tropical climate, with more diurnal and local variations in temperature than seasonal variation. The average annual temperature is 25 degrees Celsius (°C), ranging from 18°C at altitudes over 1,200 m to 28°C at the lowest elevations. In general, August is the hottest month, and January and February are the coldest months.

Seasons are defined more by rainfall than by temperature. Along the northern coast, the rainy season lasts from November through January, but in the rest of the country the season runs from May through November. The dry season lasts from November through April in most of the country. The average annual rainfall for the Dominican Republic is 150 cm. This varies from region to region, and ranges from 35 cm in the Valle de Neiba to 274 cm in the Cordillera

Oriental. Generally, the western part of the country, including the interior valleys, receives the least rain.

Tropical cyclones (tropical depressions, tropical storms, and hurricanes) hit the Dominican Republic an average of once every two years, and usually have the greatest impact along the southern coast. The season for cyclones lasts from the beginning of June to the end of November, with August, September, and October as the peak months.

Dominican Republic - Political Map



US Dept. of Energy - National
Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-MAY-1999 5.2

Figure 2-1

Dominican Republic - Elevation Map

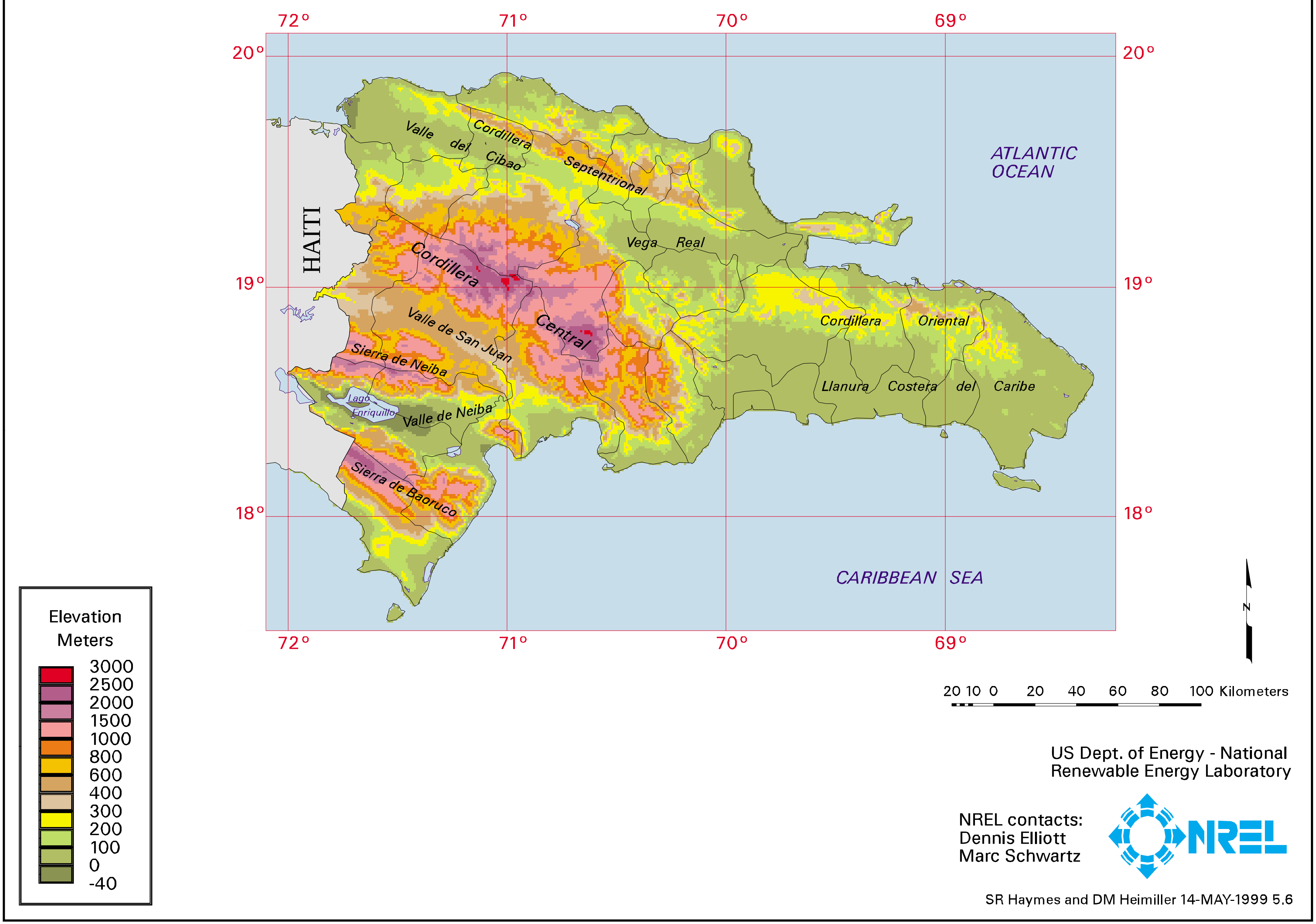
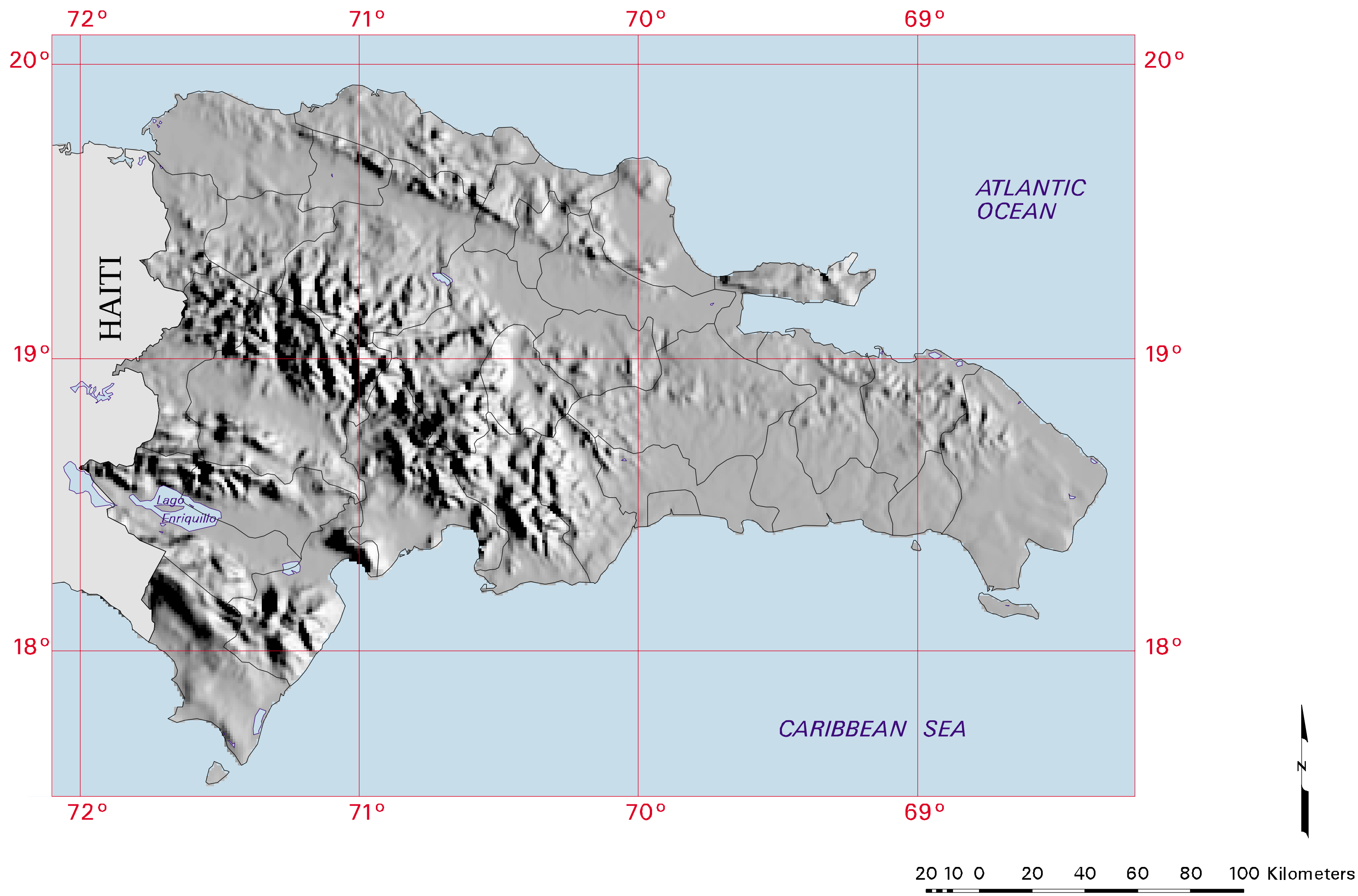


Figure 2-2

Dominican Republic - Shaded Relief Map



US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-MAY-1999 1.2

Figure 2-3

3.0 Wind Resource Information

3.1 Introduction

An accurate wind resource assessment is highly dependent on the quantity and quality of the input data. NREL reviews numerous sources of wind speed data and previous wind energy assessments as part of its overall evaluation. We used several global wind data sets that have recently become available in this assessment. These data sets included land surface observations, marine data, and upper-air data. Multiple data sets are used because the quality of data in any particular data set can vary, and because high-quality data can be quite sparse in many regions of the world. Each data set plays an integral role in the overall assessment. This chapter summarizes the data sets analyzed in the wind resource mapping effort for the Dominican Republic.

3.2 Surface Data

High-quality surface wind data from well-exposed locations can provide the best indication of the magnitude and distribution of the wind resource in the analysis region. The following sections present a summary of the surface data sets used in the assessment.

3.2.1 USAID

USAID has been conducting a wind measurement program in the Dominican Republic since October 1996. The locations of the USAID wind measurement sites can be seen in Figure 3.1.

Data loggers are usually mounted on a 30-m meteorological tower, but in some cases are mounted on existing towers (e.g., antenna towers). The standard configuration consists of two anemometers and a wind vane at 30 m, in addition to another anemometer at 20 m. However, not all stations conform to this configuration.

3.2.2 ONM

Historical wind speed data for 16 stations, consisting of mean monthly wind speeds for each year of record, were provided by ONM. Meteorological station locations are shown in Figure 3.2.

3.2.3 INDRHI

INDRHI collects climatological data at a network of stations covering most of the Dominican Republic. The INDRHI stations record rainfall, evaporation, temperature, and solar radiation as well as wind speed and direction. The typical anemometer height is 3 m, although some stations apparently have anemometers at 1 m or 10 m. The locations of these stations are shown in Figure 3.3.

For this project, NREL obtained data from 63 stations to process the wind data. The periods of record of these data files range from 2 to 20 years. Most files start between 1967 and 1986, and end between 1977 and 1988.

Dominican Republic - USAID Wind Measurement Sites

US Dept. of Energy - National Renewable Energy Laboratory

NRELcontacts:
Dennis Elliott
Marc Schwartz

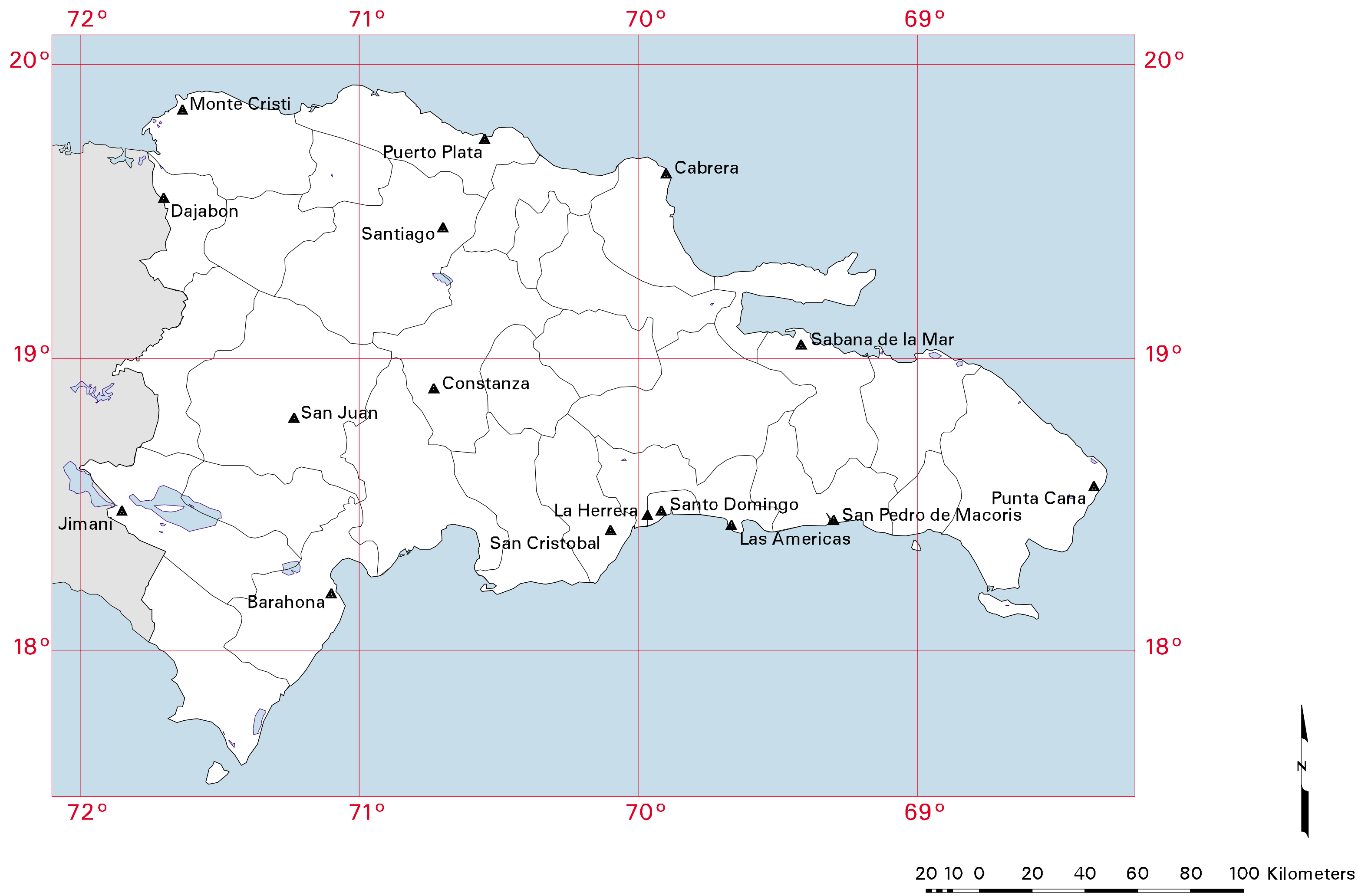
Legend
× USAID Wind Measurement Site

The data for USAID's wind measurement sites were collected in collaboration with NRECA and REGAE/Winrock.

SR Haymes and DM Heimiller 14-MAY-1999 2.2

Figure 3-1

Dominican Republic - ONM Meteorological Stations with Surface Wind Data



US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

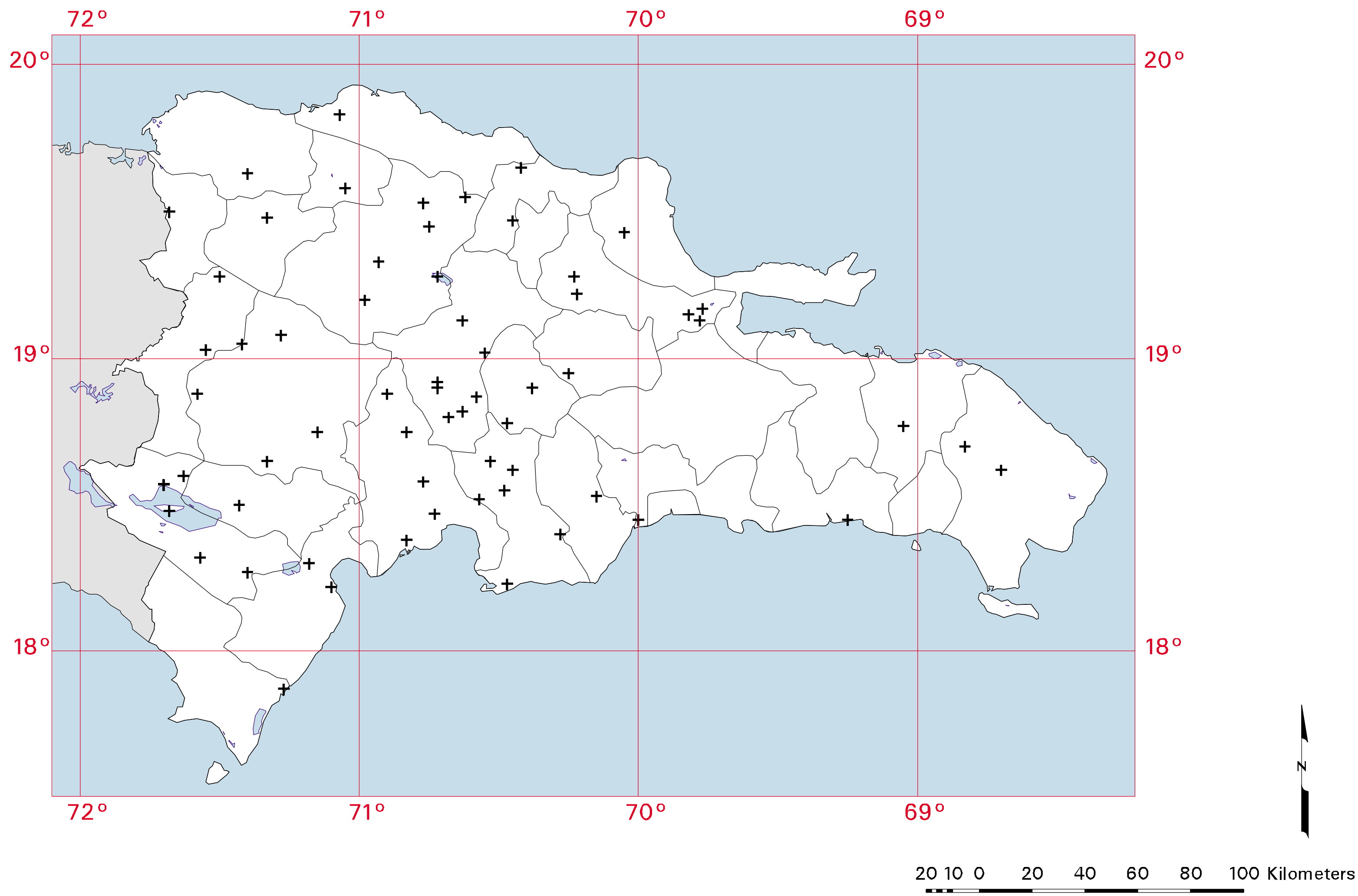
Legend
▲ ONM Meteorological Station

Mean monthly wind speeds for the meteorological stations were provided by the Oficina Nacional de Meteorologia Division de Climatologia (ONM).

SR Haymes and DM Heimiller 14-MAY-1999 3.2

Figure 3-2

Dominican Republic - INDRHI Meteorological Stations with Surface Wind Data



US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

Legend
+ INDRHI Meteorological Station

The wind data for the meteorological stations were provided by the Instituto Nacional de Recursos Hidraulicos (INDRHI).

SR Haymes and DM Heimiller 14-MAY-1999 4.2

Figure 3-3

3.2.4 DATSAV2

This global climatic database, obtained from the U.S. National Climatic Data Center (NCDC), contains the hourly surface weather observations from first-order meteorological stations throughout the world that transmit data via the Global Telecommunications System (GTS). NREL currently has 24 years of DATSAV2 data in its archive, spanning the period 1973 to 1996. Meteorological parameters such as wind speed, wind direction, temperature, pressure, and altimeter setting are extracted from the hourly observations and used to create statistical summaries of wind characteristics. Most of the stations in the Dominican Republic typically transmitted observations every 3 hours during operation hours, except that the international airports at Santo Domingo and Puerto Plata often transmitted observations every hour. Many stations did not transmit during late-night hours. At many stations, the transmission frequency changed over the years and was generally better in the 1970s and 1980s than in the 1990s. A unique six-digit number based on the World Meteorological Organization (WMO) numbering system identifies each station in the DATSAV2 data set.

There are eight stations with data that were used in the analysis. Their locations and number of observations are shown in Figure 3.4.

3.2.5 Marine Climatic Atlas of the World

This is one of two global marine wind data sets used by NREL to provide estimates of the wind resource for offshore areas as well as coastal and inland sites that are well exposed to the ocean winds. This data set, compiled from historical ship observations, presents summarized wind statistics for a 1-degree-latitude by 1-degree-longitude grid. Measurements are concentrated along the major shipping routes. Included are summaries of the monthly means and standard deviations of wind speed, pressure, temperature, and wind direction frequency and speed.

3.2.6 Satellite Ocean Wind Measurements (SSMI)

The SSMI, which is part of the Defense Meteorological Satellite Program, provides 10-m ocean wind speed measurements. This data set provides much more uniform and detailed coverage of oceanic wind speeds than the *Marine Climatic Atlas of the World*. Comparisons of satellite-derived winds with ship observations along major shipping routes indicate consistent results. NREL currently has nine years of SSMI data covering the period 1988 to 1994.

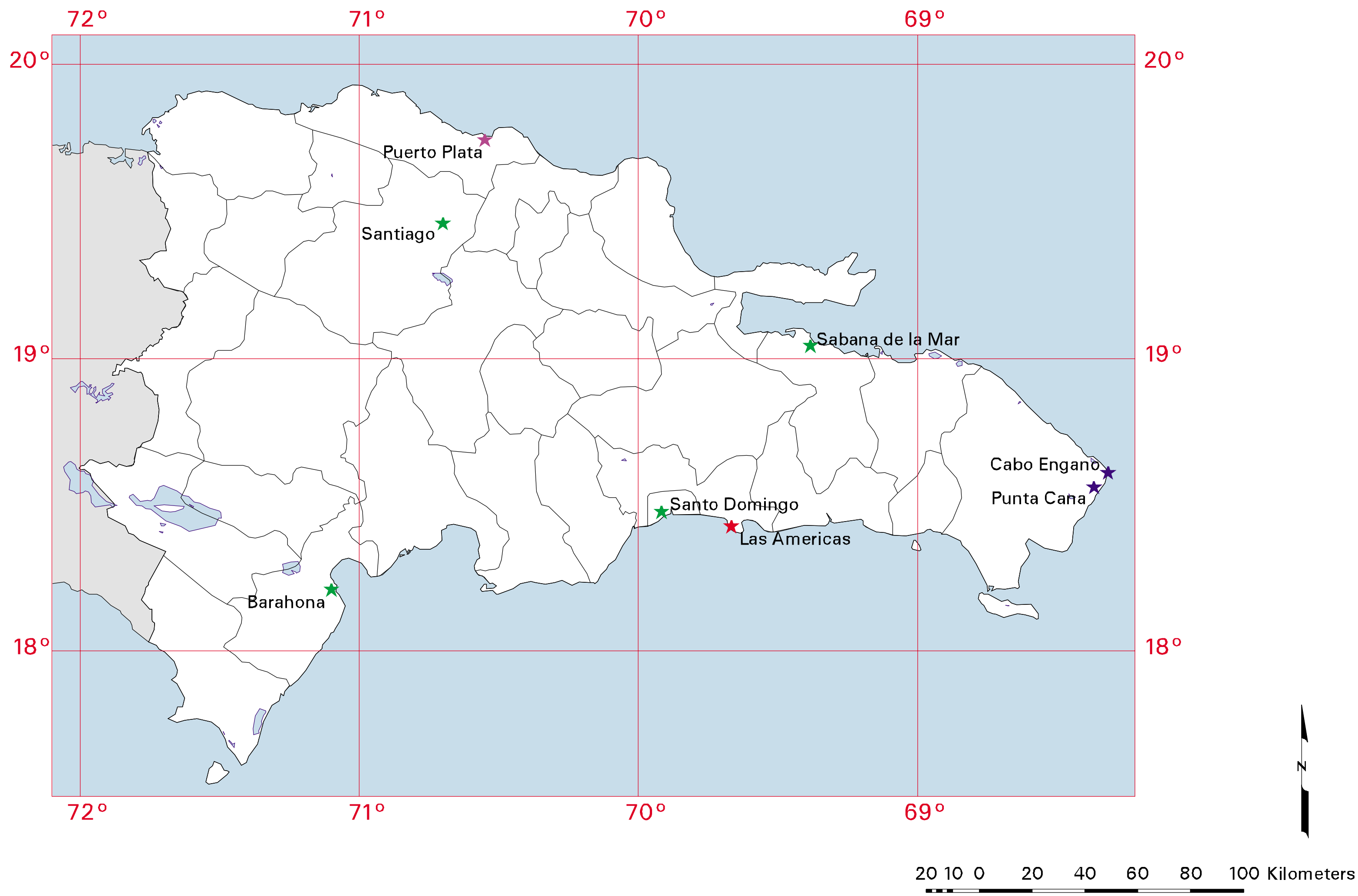
3.3 Upper-Air Data

Upper-air data can provide an estimate of the wind resource at low levels in the atmosphere and contribute to the understanding of the vertical distribution of the wind resource. This is useful in estimating the winds on elevated terrain features and for estimating the wind resource at exposed locations in areas without reliable surface wind observations. The following two upper-air data sets were employed in the assessment.

3.3.1 Automated Data Processing Reports (ADP)

This data set contains upper-air observations from rawinsonde instruments and pilot balloons for approximately 1,800 stations worldwide. Observation times include 00, 06, 12, and 18

Dominican Republic - GTS Meteorological Stations with Surface Wind Data



Meteorological Stations
Total Observations

- ★ 100,000 to 145,000
- ★ 50,000 to 100,000
- ★ 20,000 to 50,000
- ★ 5,000 to 20,000

The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database.

US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-MAY-1999 1.2

Figure 3-4

Greenwich Mean Time (GMT). Wind information is available from the surface, from mandatory pressure levels (1,000 mb, 850 mb, 700 mb, and 500 mb), from significant pressure levels (as determined by the vertical profiles of temperature and moisture), and from specified geopotential heights above the surface. The significant pressure levels and geopotential heights are different for each upper-air observation. The data set housed at NREL has approximately 25 years of observations, beginning in 1973.

Five stations were used in the analysis. Their locations and number of observations are shown in Figure 3.5.

3.3.2 Global Gridded Upper-Air Statistics

This data set contains monthly means and standard deviations of climatic elements for 15 atmospheric levels on a 2.5-degree global grid. We obtained the data, which covers the period 1980 to 1991, from the NCDC. This data set is used to supplement the ADP information in areas where upper-air data are scarce.

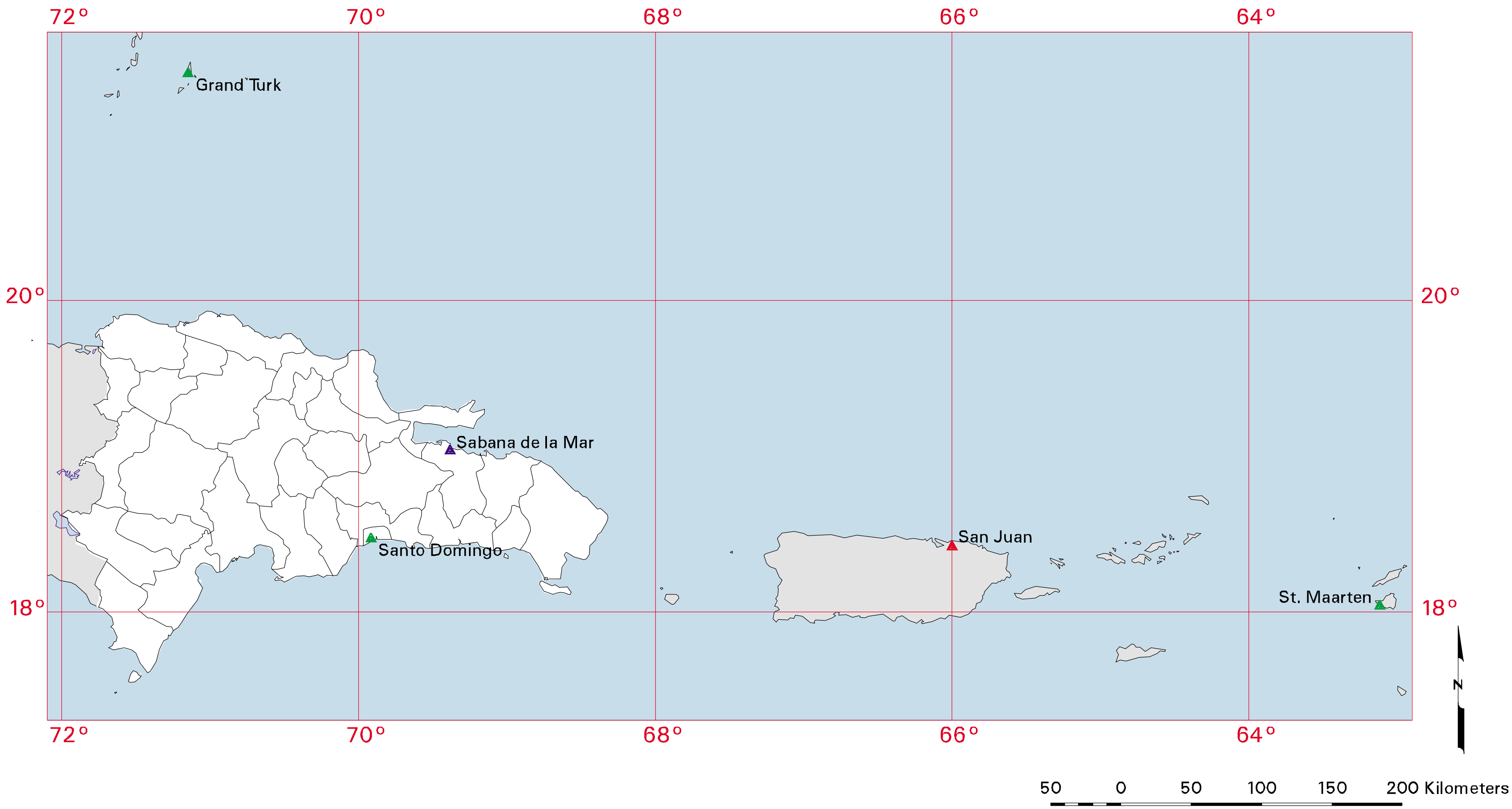
3.4 Data Screening

The reliability of the meteorological input data is the most important factor in creating an accurate wind resource map. A recent NREL paper (Schwartz and Elliott 1997) describes the integration, analysis, and evaluation of different meteorological data sets for use in wind resource assessment. Known problems associated with observations taken at many meteorological stations around the world include a lack of information on anemometer height, exposure, hardware, maintenance history, and observational procedures. In addition, many areas of the world with the potential to have good or excellent wind resource sites have very little or no meteorological stations to provide guidance on assessing the wind magnitude and characteristics.

An analysis of the meteorological data is performed using techniques developed by NREL specifically for wind resource analysis. We used a comprehensive data-processing package to convert the surface and upper-air data to statistical summaries of the wind characteristics. The summaries, presented as a series of graphs and tables in the appendices, were used to highlight the regional wind characteristics. The DATSAV2 summaries include the interannual variability of the wind speed and wind power, the average wind speed and power on a monthly basis, the diurnal distribution of the wind resource, and the mean wind speed and frequency by direction sector. The wind power density is also computed and analyzed because it provides a truer indication of the wind resource potential than wind speed. We generated similar types of summaries for the upper-air data at specific geopotential heights or pressure levels of interest. We also generated monthly and annual average vertical profiles of wind speed by geopotential height or pressure level from the upper-air data.

Site-specific products are screened for consistency and reasonableness. For example, we evaluate interannual wind speeds to identify obvious trends in the data, or periods of questionable data. Only representative data periods are selected from the entire record for the assessment. We also cross-reference the summarized products against each other to select sites that apparently have the best exposure and to develop an understanding of the wind characteristics of the study region. This is important because of the variable quality of the data and, in most cases, the lack of documentation of the anemometer height and exposure. For assessment purposes, NREL assumes an anemometer height of 10 m (the WMO standard height) unless specific height information is provided. When there is a conflict in the information as to certain wind

Dominican Republic - Regional Meteorological Stations with Upper-Air Wind Data



Meteorological Stations
Total Observations

- 10,000 to 20,000
- 6,000 to 10,000
- 3,000 to 6,000

The upper air meteorological stations are part of NREL's global database.

US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 17-MAY-1999 5.2

Figure 3-5

characteristics in the analysis region, the preponderance of meteorological evidence from the region serves as the basis of the input. The goal of the data analysis and screening process is to develop a conceptual model of the physical mechanisms, both regional and local in scale, that influence the wind flow.

3.5 Weibull Distribution Function

The Weibull Distribution Function is a generally accepted methodology used to estimate the wind speed frequency distribution. The Weibull Function is defined as follows:

$$f(V) = (k/c)(V/c)^{k-1}\exp(-V/c)^{k}$$

where *f(V)* is the Weibull probability density function where the probability of encountering a wind speed of V m/s is *f(V)*; *c*, expressed in m/s, is the Weibull scale factor, which is typically related to the average wind speed through the shape factor; and *k* is the Weibull shape factor, which describes the distribution of the wind speeds. Detailed explanations of the Weibull Distribution Function and its application are available in many texts, such as that by Rohatgi and Nelson (1994).

3.6 Wind Power Density

The wind resource at a site can be described by the mean wind speed, but the wind power density (WPD) provides a truer indication of a site's wind energy potential. The power density is proportional to the sum of the cube of the instantaneous or short-term average wind speed and the air density. The wind power density, in units of W/m^2, is computed by the following equation:

$$WPD = \frac{1}{2n}\sum_{i=1}^{n}\rho \cdot v_i^{3} \quad (\mathrm{W/m^2})$$

where

n = the number of records in the averaging interval
ρ = the air density (kg/m^3) at a particular observation time
v_i^3 = the cube of the wind speed (m/s) at the same observation time.

This equation should only be used for instantaneous (n = 1) or multiple average wind speed values (n>1) and not for a single long-term average, such as a yearly value.

The air density term is dependent on temperature and pressure and can vary by 10% to 15% seasonally. If the site pressure is known, the hourly air-density values, with respect to air temperature, can be calculated using the following equation:

$$\rho = \frac{P}{R \cdot T}\ (\mathrm{kg/m^3})$$

where P = the air pressure (Pa or N/m^2)
R = the specific gas constant for air (287 J/kg·K)
T = the air temperature in degrees Kelvin (°C + 273).

If site pressure is not available, air density can be estimated as a function of site elevation (z) and temperature (T) as follows:

$$\rho = \left(\frac{\mathbf{P_0}}{\mathbf{R \cdot T}}\right) \varepsilon^{\left(\frac{-\mathbf{g \cdot z}}{\mathbf{R \cdot T}}\right)} \ (\mathbf{kg / m^3})$$

where

- P_0 = the standard sea level atmospheric pressure (101,325 Pa), or the actual sea-level adjusted pressure reading from a local airport
- g = the gravitational constant (9.8 m/s^2)
- z = the site elevation above sea level (m).

Substituting in the numerical values for P_0, R, and g, the resulting equation is:

$$\rho = \left(\frac{\mathbf{353.05}}{\mathbf{T}}\right) \varepsilon^{-0.034\left(\frac{z}{T}\right)} \ (\mathbf{kg/m^3})$$

This air-density equation can be substituted into the WPD equation for the determination of each instantaneous or multiple average value.

3.7 Wind Shear and the Power Law

Wind shear is the change in horizontal wind speed with height. The magnitude of the wind shear is site-specific and dependent on wind direction, wind speed, and atmospheric stability. By determining the wind shear, one can extrapolate existing wind speed or wind power density data to other heights. The following form of the power law equation is used to make these adjustments:

$$\mathbf{U = U_0 \, (z/z_0)^{\alpha}} \qquad \text{[Wind Speed]}$$

$$\mathbf{P = P_0 \, (z/z_0)^{3\alpha}} \qquad \text{[Wind Power Density]}$$

where

- U = the unknown wind speed at height z above ground
- U_0 = the known speed at a reference height z_0
- P = the unknown wind power density at height z above ground
- P_0 = the known wind power density at a reference height z_0
- α = the power law exponent.

An exponent of 1/7 (or 0.143), which is representative of well-exposed areas with low surface roughness, is often used to extrapolate data to higher heights.

4.0 Wind Resource Mapping System and Methodology

4.1 Introduction

NREL has been developing its GIS-based wind resource mapping technique since 1996. This technique replaces the manual analysis techniques employed in previous mapping efforts, such as the *Wind Energy Resource Atlas of the United States* (Elliott et al. 1987) and the *Wind Energy Resource Assessment of the Caribbean and Central America* (Elliott et al. 1987). NREL developed the system with the following two primary goals:

1) To produce a more consistent and detailed analysis of the wind resource, particularly in areas of complex terrain
2) To generate user-friendly, high-quality map products.

4.2 Description of Mapping System

The mapping procedure uses a GIS advanced computerized mapping system. The main GIS software is ArcInfo®, a powerful and complex package featuring a large number of routines for scientific analysis. None of the ArcInfo® analysis routines is specifically designed for wind resource assessment work, so NREL's mapping technique requires extensive programming in ArcInfo® to create combinations of scientific routines that mimic direct wind-resource assessment methods. The mapping system is divided into three main components: input data, wind power calculations, and the output section that produces the final wind resource map. These components are described below.

4.2.1 Input Data

The two primary model inputs are digital terrain data and formatted meteorological data. The elevation information consists of Digital Elevation Model (DEM) terrain data that are used to divide the analysis region into individual grid cells, each having its own unique elevation value. The United States Geological Survey and the Earth Resource Observing Satellite Data Center recently produced updated DEMs for most of the world from previously classified Department of Defense data and other sources. The new data sets have a resolution of 1 km^2 and are available for large parts of the world. This represents a significant improvement in elevation data used by the mapping system. It previously relied on 1:1,000,000 scale maps and 305-m (1,000-ft) elevation contours. Most of the final wind resource maps are gridded to 1 km^2.

The final meteorological inputs to the mapping system, following the data-screening process, are vertical wind profile(s), wind power rose(s) (the percentage of total potential power from the wind by direction sector), and the open-ocean wind power density, where appropriate. The data are brought in as ARC/INFO-compatible files and used in the power calculation algorithms. The vertical profiles are broken down into 100-m intervals centered every 100 m above sea level (asl), except for the lowest layer, which is at 50 m asl. The wind power rose is used to determine the degree of exposure of a particular grid cell to the power-producing winds. The open-ocean wind power density is derived from the SSMI and ship wind speed observations, converted to wind power density, and extrapolated to 30 m for use by the model.

4.2.2 Wind Power Calculations

We presented the wind power calculation methodology in Section 3.6. The factors that either decrease or increase the base wind power value for a particular grid cell are terrain considerations, relative and absolute elevation, aspect (the slope of the terrain relative to the prevailing wind direction), distance from ocean or lake shorelines, and influence of small-scale wind flow patterns. The factors that have the greatest influence on the adjustment of the base wind power for a particular grid cell are the topography of the area in the vicinity and a combination of the absolute and relative elevation. The wind power calculation modules use the wind power rose and vertical wind profile of a region to account for the effects of short-range (less than 10 km), medium-range (10-50 km), and long-range (greater than 50 km) blocking of the ambient wind flow by the terrain; the slope and aspect of the terrain surrounding a particular grid cell; and the relative elevation of a grid cell compared to its surroundings.

The wind power calculations are performed in three modules, depending upon the existence or proximity of oceans or large lakes to the mapping region. These include “land,” “ocean,” and “lake” modules. The land module is run for the entire area only if there is no ocean present in the mapping region. Likewise, the ocean module is run for the entire area in instances where there is an ocean shoreline present in the mapping region. The lake module is run only if there are lakes, estuaries, or fjords with an area of 50 km^2 or greater. This module only calculates the wind power for the area within 5 km of any non-ocean body of water in the mapped region. If more than one module is run for a particular region, the results are combined to produce the final wind map. Each of the three modules contains identical routines that use a general topographical description to adjust the base wind power density. The topographical description can be classified as either complex terrain (hills and ridges), complex terrain with large flat areas present, or areas that are designated as flat. The adjustment to the base wind power density depends on which terrain routine is activated during the mapping run.

4.2.3 Mapping Products

The primary output of the mapping system is a color-coded wind power map in units of W/m^2 and the equivalent mean wind speed for each individual grid cell. The wind power classification scheme for the Dominican Republic maps is presented in Table 4-1. We used the one-seventh-power law (see Section 3.7) to adjust the power densities to a height of 30 m above ground, used as the reference height in the classification. We chose 30 m as a compromise hub height between large utility-scale wind turbines (which may range between 30 and 60 m) and small wind turbines (which may range between 15 and 30 m) for rural power applications.

Wind power is calculated only for those grid cells that meet certain exposure and slope requirements. As a result, only the most favorable wind resource areas are highlighted. For example, a grid cell is excluded if there is major blocking of the ambient wind flow by local terrain features. The exposure must be at least 70% to be included. A grid cell can also be excluded if the slope of the terrain is too steep. To be included, the slope must not exceed 20%. The wind resource values presented are estimates for low surface roughness (e.g., grassland with no major obstructions, such as trees or buildings).

The output portion of the mapping system also includes software to produce the proper map projection for the region. It labels the map with useful information, such as a legend, latitude and longitude lines, locations of meteorological stations, prevailing wind direction(s), important cities, and a distance scale. The DEM data can also be used to create a color-coded elevation

Table 4-1. Wind Power Classification

Class	Resource Potential Utility	Resource Potential Rural	Wind Power Density (W/m^2) @ 30 m	Wind Speed [(a)] (m/s) @ 30 m
1	Marginal	Moderate	100–200	4.9– 6.1
2	Moderate	Good	200–300	6.1– 7.0
3	Good	Excellent	300–400	7.0– 7.7
4	Excellent	Excellent	400–600	7.7– 8.9
5	Excellent	Excellent	600–800	8.9– 9.8
6	Excellent	Excellent	800–1000	9.8–10.5

[(a)] Mean wind speed is estimated assuming a Weibull distribution of wind speeds with a shape factor (k) of 3.0 and standard sea-level air density. The actual mean wind speed may differ from these estimated values by as much as 20 percent, depending on the actual wind speed distribution (or Weibull k value) and elevation above sea level.

map, a hill-shaded relief map, and a map of the elevation contours. When combined with the wind power maps, these products enable the user to obtain a feel for the three-dimensional distribution of the wind power in the analysis region.

4.3 Limitations of Mapping Technique

There are several limitations to the mapping technique, the first being the resolution of the DEM data. Significant terrain variations can occur within the DEM's 1 km^2 area; thus, the wind resource estimate for a particular grid cell may not apply to all areas within the cell. A second potential problem is the development of the conceptual model of the wind flow and its extrapolation to the analysis region. There are many complexities in the wind flow that make this an inexact methodology, including the structure of low-level jets and their interaction with the boundary layer, and localized circulations, such as land-sea breezes, mountain-valley flows, and channeling effects in steeply sloped areas. Finally, the power estimates are valid for areas with low surface roughness. Estimates for areas with a higher surface roughness need to be adjusted accordingly.

5.0 Wind Resource Characteristics of the Dominican Republic

5.1 Introduction

An accurate wind resource assessment is highly dependent on the quantity and quality of the input data. NREL reviews numerous sources of wind data and previous wind assessments as part of its overall evaluation. Several global data sets maintained at NREL, including surface and upper-air observations spanning many years of record, were used in this assessment. Multiple data sets are used since the quality of data in any particular data set can vary and because high quality data can be quite sparse in many regions of the world. Each data set plays an integral role in the overall assessment. This chapter summarizes the data sets used in preparation for the wind resource mapping of the Dominican Republic.

All data sets were analyzed and evaluated in accordance with the procedures outlined in section 4.0.

5.2 Surface Data

5.2.1 USAID

USAID, in collaboration with NRECA, Winrock/REGAE, and NREL, has been conducting a wind measurement program in the Dominican Republic since October 1996. Figure 3.1 shows the location of the monitoring sites, and Tables 5-1 and 5-2 provide a description of each site. Wind measurement equipment was installed at 20 sites at various times between October 1996 and April 1999. NREL obtained and processed the hourly wind speed and wind direction data for the 14 sites listed in Table 5-1. The six sites listed in Table 5-2 were just recently installed, and the wind data from these sites are not yet available.

Instrumentation at most sites consists of two anemometers at 30 m and one at 20 m, with a single wind vane at 30 m. The site at Las Galeras 2 does not have a second anemometer at 30 m. The towers at Los Hidalgos, Blanco Arriba, and Los Montones are only 10 m tall. The instruments at Optima FM are mounted on a 56-m radio tower.

NREL also received data from two sites operated by Southwest Technology Development Institute (Las Cruces, NM) for USAID. The data are transmitted via satellite telemetry. One of these sites is currently in operation on the northern tip of Isla Beata (off the southwestern tip of the Dominican Republic). The other site was installed at Cabo Engaño on the eastern tip of the Dominican Republic. This system was damaged by a hurricane in September 1998, and was replaced with a non-satellite data collection system in November 1998.

NREL processed the wind data to produce estimates of monthly average power and monthly average wind speed as well as average speed and power by hour of the day, and joint frequencies of wind speed and wind direction (see Appendix A). Annual average wind speed and power for the sites are included in Table 5-1.

In the southwestern peninsula region, data were processed and analyzed from four sites – Isla Beata, Oviedo, Nueva Rosa, and Las Mercedes, all located in Pedernales Province. The site "Isla Beata" is near the northern tip of that island, which is expected to have excellent wind resource

Table 5-1. USAID Measurement Sites

Region	Station Name	Lat.	Lon.	Elev. (m)	Start Date	End Date	Data %	Anem. Height (m)	Wind Speed (m/s)	Wind Power (W/m^2)
SW	Isla Beata	17 37	71 31	4	08/98	03/99	98	30,20	7.6	381
SW	Las Mercedes	18 05	71 40	416	10/96	10/97	91	30,20	2.9	41
SW	Nueva Rosa	17 52	71 22	112	11/96	04/98	72	30,20	6.4	248
SW	Oviedo	17 47	71 27	109	10/96	03/98	64	30,20	5.5	174
NW	Botoncillos	19 43	71 25	75	04/97	02/98	86	30,20	4.7	116
NW	Guzmancitos	19 54	70 50	60	03/97	06/98	79	30,20	7.4	440
NW	La Loma	19 34	70 44	850	10/97	12/98	59	30,20	5.1	106
C	Blanco Arriba	19 31	70 17	180	02/98	06/98	100	10	2.5	22
C	Los Cacaos	19 36	69 57	410	12/96	11/98	76	30,20	6.0	161
C	Los Hidalgos	18 54	69 38	193	10/97	08/98	100	10	2.5	23
C	Optima FM	19 23	69 53	63	10/98	01/99	100	56,20	4.5	102
E	Cabo Engaño	18 37	68 20	10	06/98	01/99	70	30,20	6.3	233
E	Las Galeras 1	19 17	69 11	80	02/97	10/98	86	30,20	5.1	122
E	Las Galeras 2	19 16	69 10	180	04/97	02/98	74	30,20	6.0	185

Latitude (Lat.) and longitude (Lon.) are in degrees and minutes.
Wind speed and power are shown for the upper anemometer height (Anem. Height).
Data % is computed by comparing the number of hourly records to the number of hours between the start and end date.
Region: NW – Northwestern
SW – Southwestern
C – Central
E – Eastern

Table 5-2. New USAID Measurement Sites

Region	Name	Lat.	Lon.	Elev. (m)	Installed	Province	Anem. Ht. (m)
SW	Proyecto Macapi	18 47	71 42	1160	Mar 01,1999	Elias Piña	20
NW	Colegio Villamil	19 28	70 40	200	Aug 28, 1998	Santiago	30,20
NW	Hatillo Palma	19 41	71 11	60	Apr 15,1999	Monte Cristi	20
NW	Juncalito	19 14	70 48	800	Dec 18,1998	Santiago	30,20
NW	Los Montones	19 17	70 56	700	Jun 30, 1998	Santiago	10
NW	Yerba Buena	19 18	70 58	600	Apr 16,1999	Santiago	20

Latitude (Lat.) and longitude (Lon.) are in degrees and minutes.
Region: NW – Northwestern
SW – Southwestern

potential based on the ocean-satellite and ship data. This site was installed in August 1998. The average wind speed and power measured for the first eight months of data collection are 7.6 m/s and 381W/m^2, respectively. The highest monthly average wind speeds were in December at 9.2 m/s and January at 9.0 m/s, which is comparable to the outstanding wind resource predicted for those months by ocean data in that area. The diurnal variation at the site is relatively small, varying less than 2 m/s with highest wind speeds during midday and lowest winds during the night. The most frequent wind direction is from the east, with a secondary occurrence from the east-southeast.

The Oviedo site is located in flat-to-rolling tree-covered terrain about 6 km west of the village of Oviedo and about 10 km west of the coast. The data collected at this site are not sufficient to estimate the annual average wind resource, because little data are available for the period April through September. About 85% of the data are from November through March. The average speed and power measured are 5.5 m/s and 174 W/m^2. We suspect that trees 10-15 m tall in the vicinity of this site reduce the wind resource significantly. Oviedo has a large diurnal variation, with highest winds during midday and lowest winds at night. The prevailing wind is from the east.

Nueva Rosa is located in flat-to-rolling terrain about 12 km northeast of the Oviedo site and about 10 km west of the coast. The data collected at this site are not sufficient to estimate the annual average wind resource, because little data are available from the period July through September. The average speed and power measured are 6.4 m/s and 248 W/m^2, respectively. The average wind speeds at Nueva Rosa are about 1 m/s higher than those at Oviedo. We believe the better wind resource at Nueva Rosa can be attributed to lower surface roughness and better exposure to the prevailing wind direction than that at Oviedo. Nueva Rosa, like Oviedo, has large diurnal variations of wind speed, with highest winds during midday and lowest winds at night. The wind direction data for Nueva Rosa are incorrect. The data show the prevailing wind is from the northwest, but it should be from the east as with Oviedo.

Las Mercedes is located in the northern part of Pedernales Province, about 10 km northeast of the town of Pedernales and in the foothills of the Sierra de Baoruco. The average wind speed and power measured at this site are quite low, at only 2.9 m/s and 41 W/m^2, based on about 11 months of data. Although the free-air winds are estimated to be strong in the southwestern peninsula, it appears that Las Mercedes is sheltered from these strong winds by the Sierra de Baoruco. The wind directions at Las Mercedes are quite variable for a trade wind regime. The most frequent wind is from the north-northeast, averaging only 2 m/s. This is evidently a light drainage wind from the Sierra de Baoruco. The strongest winds are from the east, averaging 6 m/s, but these winds are infrequent. Winds at this site are considered too low for any practical wind energy applications.

In the northwestern region, data were processed and analyzed from three different types of sites– Guzmancitos, Botoncillos, and La Loma. Guzmancitos is located on an exposed coastal hilltop about 20 km northwest of the city of Puerto Plata. The hill rises about 60 m above the ocean, and the site has excellent exposure to the prevailing ocean winds from the east. The village of Guzmancitos is located near this site. Strong winds are evident from the many wind-deformed trees in this area. The average wind speed and power measured at this site are 7.4 m/s and 440 W/m^2, based on about 10 months of data. Average wind speeds exceeded 9 m/s in July and August, the windiest months. Data indicate that this site has excellent wind resource potential, even for utility-scale applications. Ocean-satellite data indicate that exposed coastal sites in this area should have excellent wind resource. Diurnal variations are large at Guzmancitos, with average wind speeds ranging from a low of about 5 m/s near sunrise to high of about 9 m/s between noon and 8 p.m.

Botoncillos is located in the western part of Valle del Cibao, about 25 km southeast of the city of Monte Cristi. The site is located in the flat river plain of Rio Yaque del Norte. The land in the vicinity of the site is used mostly for irrigated agriculture. The site was chosen to investigate if wind power was sufficient for irrigation pumping, either as a supplement or alternative to diesel-generated power. The average wind speed and power measured are 4.7 m/s and 116 W/m^2, based on about 9 months of data. The diurnal and wind direction data for this site (see Appendix A) are not correct. The winds probably peak during afternoon, not late night. In addition, prevailing winds are from the east, not from the west.

La Loma is located on a ridge in the Cordillera Septentrional, about 15 km north of the city of Santiago. The site elevation is about 850 m. The ridge steeply rises to a peak elevation of 1250 m about 3 km northwest of the site. There are about 6 months with sufficient data – October through April. The average wind speed and power measured are 5.1 m/s and 106 W/m^2. This is considerably less than expected, considering the strong free-air winds estimated at that elevation. We anticipate that the wind resource may be reduced at this site by the high roughness in the vicinity of the site and by the influence of the steep terrain and higher peaks near the site.

In the central region, data were processed and analyzed for four sites – Los Cacaos, Blanco Arriba, Emisora, and Los Hidalgos. Los Cacaos is located on a broad ridge about 5 km southwest of the coastal town of Cabrera. The site elevation is about 410 m. The ridge rises to a maximum elevation of 450 m about 1 km north of the site. The average wind speed and power measured at a 30-m height are 6.0 m/s and 161 W/m^2. The measured wind resource is less than expected, considering the strength of the coastal trade winds estimated for this elevation in this region. Annual average wind speeds measured at the meteorological station in Cabrera on the coast were about 5.5 m/s at a 10-m height. Extrapolation of the Cabrera winds to 30 m indicates that the coastal site may have slightly higher wind resource than the ridge-top site at Los Cacaos located only 5 km away. We anticipate that the high roughness in the vicinity of the Los Cacaos site and the influence of the higher terrain near the site may be responsible for reducing the wind resource at the site. The wind direction data for Los Cacaos (see Appendix A) are not correct. The prevailing winds are from the east, not the north-northeast.

Blanco Arriba is located in a sheltered valley of the Cordillera Septentrional, about 25 km north of San Francisco de Macoris. The site elevation is about 180 m. Higher terrain exists in almost all directions around the site, with elevations rising to more than 600 m within 5 km to the east and west of the site. Consequently, the average wind speed and power measured are quite low, 2.5 m/s and 22 W/m^2. After five months of data collection, this site was removed.

Emisora is located about 5 km west of the coastal town of Nagua. Anemometers were installed in October 1998 on a communication tower at heights of 20 and 56 m. No site description has been provided, and insufficient data have been collected for an evaluation of this site.

Los Hidalgos is located on gently sloping terrain on the south slopes of the Cordillera Oriental, about 50 km northeast of Santo Domingo. Site elevation is 190 m. Within 5 km to the north, the terrain rises to a plateau elevation of 300-400 m. No information was provided on the roughness (trees, etc.) and local terrain features in the vicinity of the site. The anemometer height at this site was only 10 m, so the measured winds would be strongly influenced by any obstructions, particularly in the prevailing wind directions. The average wind speed and power measured are only 2.5 m/s and 23 W/m^2, during the nine months of data collection. The wind was calm almost 20% of the time.

In the eastern region, data were processed and analyzed for three sites – Las Galeras 1 and 2 and Cabo Engaño. The Las Galeras sites are located near Cabo Samana about 15 km northeast of the town of Samana. Las Galeras 2 is located on a coastal hill with an elevation of about 180 m, with good exposure to the prevailing ocean winds from the east. The average wind speed and power are 6.0 m/s and 185 W/m^2, based on about eight months of data. The diurnal variation at this site is relatively small, with higher winds during the day than night. Considering the many wind-deformed trees present at the site and excellent exposure of the site, the measured wind resource is lower than expected. However, the data are limited, and more data should be collected to more accurately estimate the site's wind resource potential. Las Galeras 1 is located about 2 km to the west of Las Galeras 2, on the west side of the hill and about 100 m lower in elevation. The average wind speed and power measured are 5.1 m/s and 122 W/m^2. As expected, the winds at Las Galeras 1 are significantly lower than those at Las Galeras 2, because Las Galeras 1 is located on the lee side of the hill in a more sheltered location. The wind direction for Las Galeras 1 appears questionable, with most frequent winds from the south and west. We anticipate that the most frequent winds are from the east. At Las Galeras 2, we anticipate the most frequent wind should be more from the east than the south.

Cabo Engaño is a coastal site located on the extreme eastern tip of the country. Hurricane Georges destroyed the first tower, installed in June 1998, in September 1998. A new tower was installed at the same site in late November 1998. About six months of data were processed for the site. The average wind speed and power measured are 6.3 m/s and 233 W/m^2. Diurnal variations are small, and in some months the average wind speed is slightly greater at night than day. No site description information has been provided. This site may be located at or near the previous Cabo Engaño meteorological station, which operated for many years before it was apparently relocated to Punta Cana.

5.2.2 ONM

Two previous studies have used ONM data to evaluate the wind energy resource in the Dominican Republic. The *Renewable Energy Market Survey of the Dominican Republic* (IT Power 1987), a study prepared for the U.S. Export Council for Renewable Energy, used data from eight meteorological stations in the Dominican Republic to describe the wind resources. This study concludes that the potential for major wind energy development is low in the Dominican Republic, based on the available information, which showed relatively low average wind velocities.

The report *Evaluacion de los Recursos Solar y Eolico en la Republica Dominicana* (Acosta and Llenas 1983) is more optimistic about the potential for wind energy. This study used data from 14 meteorological stations around the country. It recognizes the fact that meteorological stations are not typically placed in the best sites for energy production and therefore often underestimates the wind resource in the surrounding region. It further concludes that the areas around Cabrera, Cabo Engaño, Barahona, and Monte Cristi are promising sites for wind energy production, and recommends the installation of more measurement sites around the country to better define the national wind resource.

These reports represent a good starting point in understanding the wind resource in the Dominican Republic; however, the studies do have some significant limitations:

- The conclusions are based largely on the average wind speed data from meteorological stations.
- There is no information on the exposure of the instruments at these 14 stations. This knowledge is extremely useful in judging the quality of the data used in the study.
- There is no information regarding the quality of the measurements at each of the sites. Failure to properly maintain the anemometer, location changes, urbanization, and vegetation changes surrounding the anemometer site can affect the measurements.
- The analysis did not take into account the topography of the country or other factors that may accelerate or retard the wind.

The wind data set obtained by NREL from ONM includes monthly wind speeds on a yearly basis from 16 stations. Station locations and historical averages of wind speed are summarized in Table 5-3. The anemometer height was not indicated. Periods of record ranged from 9 years to 47 years, with data coverage of 71% to 100%.

The locations of these sites were previously shown in Figure 3.2. The available wind speed data consisted of monthly average wind speeds and dates back as early as 1941. The site with the longest history of wind speed data was Santo Domingo, with more than 40 years of data. Sites with the shortest history had just less than 10 years of data.

The historical wind speed averages are quite low at most stations, with only Punta Cana and Cabrera having average speeds of greater than 4 m/s. Wind power was not calculated for these stations, because ONM provided no wind speed distribution information.

Although the average wind speeds are presented in Table 5-3 for each ONM station, these data may not be a reliable indicator of the area's wind resource because of problems with the data. Unfortunately, information on exposure of the wind measurement equipment and maintenance of the equipment is not available for meteorological stations in the Dominican Republic (nor for most countries of the world). Because of the lack of reliability of the surface data from meteorological stations, using the appropriate upper-air data and ocean-satellite data to characterize the ambient wind flow characteristics and to develop the meteorological inputs for the wind mapping system becomes even more important. Nevertheless, screening the available surface data is beneficial in identifying the most reliable data for evaluating the wind characteristics, and for possible use in validation of the resource estimates generated by the mapping system.

Table 5-3. ONM Meteorological Stations

Station Name	Lat.	Long.	Elev. (m)	Start Month	End Month	Data %	Wind Speed (m/s)
Barahona	18 11	71 05	10	Jan-61	Dec-96	84	3.8
Cabrera	19 37	69 54	15	Aug-75	Dec-84	95	4.7
Constanza	18 53	70 43	1164	Jul-66	Aug-91	87	2.9
Dajabon	19 32	71 42	36	Jan-59	Dec-68	88	2.0
Jimani	18 28	71 50	31	Sep-79	Dec-96	90	2.2
Monte Cristi	19 51	71 37	7	Apr-76	Apr-89	71	2.9
Puerto Plata/La Union	19 45	70 31	5	May-77	Dec-96	98	2.8
Punta Cana	18 34	68 22	122	Aug-51	Dec-96	82	4.3
Sabana de la Mar	19 03	69 25	3	Jan-57	Oct-96	97	2.7
San Cristobal	18 25	70 05	44	Jan-41	Sep-88	73	3.7
San Juan	18 48	71 13	415	Mar-76	Nov-96	74	2.3
San Pedro Macoris	18 26	69 17	3	Jan-57	May-93	98	2.7
Santiago	19 26	70 42	183	Feb-59	May-93	100	2.7
Santo Domingo	18 28	69 55	14	Jan-51	Dec-96	88	2.8
Santo Domingo/Las Americas	18 25	69 40	17	Apr-57	Apr-90	85	3.4
Santo Domingo/Herrera	18 28	69 58	61	Aug-83	Dec-96	98	3.7

Latitude (Lat.) and longitude (Long.) are in degrees and minutes.
Data % is computed by comparing the number of monthly records to the number of months between the start date and end date.

Plots of the average wind speed for each year and month of record are shown in Appendix B for the ONM stations. A visual inspection of the plots of the interannual (year-to-year) wind speeds revealed many trends and peculiarities in the data. For example, the long-term average wind speed at Santo Domingo International Airport (Las Americas) from 1957 to 1987 was 3.4 m/s, a figure rendered essentially meaningless considering the peculiar trends observed at the station. An inspection of the yearly wind speeds reveals that the wind speeds averaged about 5.5 m/s in the late 1950s, 4.0 m/s in the mid-1960s, 3.5 m/s from 1969-79, and 2.3 m/s from 1980-86. Reasons for these peculiar trends are unknown but may be due to changes in the anemometer location and/or the environment around the anemometer, a degradation of the anemometer resulting from lack of maintenance or improper maintenance, or any combination of the above. These types of problems, which exist at many meteorological stations, complicate the use of the historical wind data in assessing an area's wind energy resource, particularly because changes of a factor of 2 in wind speed are approximately equivalent to a factor of 8 in wind power density. Moreover, because of these problems, the data from the meteorological stations should not be used for climatological adjustment of short-term data collected at prospective wind measurement sites.

Examples of the peculiar trends in yearly wind speeds observed at some other meteorological stations in the Dominican Republic are given below, including Punta Cana (or Cabo Engaño for many years), Cabrera, Santo Domingo (city meteorological station), Barahona, Santiago, and Jimani.

At Punta Cana, wind speeds averaged 3.2 m/s from 1969-74, 5.5 m/s from 1976-88, and 3.5 m/s from 1989-94. According to NREL's DATSAV2 data set, data were transmitted from a location called Cabo Engaño from 1973-92 and from a location called Punta Cana from 1992-96. The location coordinates transmitted indicated that the Cabo Engaño station was located about 25 km to the north-northeast of the Punta Cana station. However, the location coordinates provided by OMN indicate that the station was located at Punta Cana from 1951-96. For this assessment, we assumed that the data from 1976-88 are most representative of the location's average wind speed at 10 m, and that the station was located at Cabo Engaño from 1976-88.

At Cabrera, wind speeds averaged 5.5 m/s from 1977-80 and 3.5 m/s from 1983-84. It appears that this station was closed in 1985. We assumed that the data from 1977-80 are most representative of the location's average wind speed at 10 m.

At Santo Domingo, the city meteorological station, the average wind speed has decreased from 3.2 m/s in the 1950's to 2.0 m/s by the mid-1980s and is about 2.0 m/s in the 1990s. An inspection of the station's anemometer in 1996 showed that taller buildings and obstructions surrounded the anemometer. Most likely, increased urbanization and construction around the station has caused the rather steady decline in the wind speeds measured at a 10-m height.

At Barahona, wind speeds averaged 2.7 m/s from 1966-74 and 4.4 m/s from 1976-96. We have assumed that 4.4 m/s is the most representative wind speed at 10 m for this location.

At Santiago, yearly wind speeds exhibited several major up-and-down trends. They averaged about 3.4 m/s from 1959-66, a sharp downward trend from 1966-69, 2.0 m/s from 1969-75, 3.0 m/s from 1977-80, a sharp downward trend from 1980-84 to only 1.4 m/s in 1984, a sharp upward trend from 1984-87, and 3.4 m/s from 1987-92.

At Jimani, wind speeds averaged about 3.2 m/s from 1980-85 but only 1.6 m/s from 1987-96. Evidently, there must have been a major relocation of the anemometer in 1986 or perhaps a major change in the environment around the anemometer. An inspection of the monthly wind speeds indicates that this major change could have occurred in early April 1986.

5.2.3 INDRHI

Climatological data in electronic form were received from INDRHI. The INDRHI data included information on wind speed and direction, as well as rainfall, evaporation, temperature, cloud cover, and solar insolation. Unfortunately, this potentially valuable data set was supplied without any documentation. Information on scale factors and units was lacking, so it was impossible to retrieve useful wind data from these files.

Another problem with the INDRHI data set is that most of their stations record the wind speed at only 3 m above the surface, with some anemometers as low as 1 m above ground. Very few wind speeds at 10 m are available, and none at the 30-m height that is most useful for this study. The location of the 63 INDRHI stations was shown in Figure 5.3, and a description of the stations is given in Table 5-4.

Table 5-4. INDRHI Meteorological Stations

Station ID	Station Name	Latitude	Longitude	Elev. (m)
000101	Donmiguel	19 30	71 41	45
000401	Jarabacoa	19 08	70 38	500
000402	Tavera	19 17	70 43	300
000403	San Jose de las Matas	19 20	70 56	530
000404	Santiago – ISA	19 27	70 45	160
000405	Quinigua	19 32	70 46	138
000406	Mao – Valverde	19 35	71 03	60
000407	Santiago Rodriguez	19 29	71 20	120
000408	La Antona	19 38	71 24	48
000411	Mata Grande	19 12	70 59	1000
000602	La Isabela	19 50	71 04	30
001002	Cuesta Barrosa	19 39	70 25	10
001003	La Cumbre	19 33	70 37	600
001501	Los Jengibres	19 26	70 03	15
001801	San Francisco de Macoris	19 17	70 14	110
001802	Juma - Bonao	18 54	70 23	178
001803	El Limon	19 09	69 49	8
001806	Hatillo-Yuna	18 57	70 15	80
001814	Barraquito	19 08	69 47	8
001815	La Angelina	19 13	70 13	48
001816	Jose Contreras	19 28	70 27	685
001817	Los Botados	18 52	70 35	1200
001830	El Novillo	18 47	70 28	1225
001843	El Aguacate	19 10	69 46	20
001852	Casabito	19 01	70 33	1420
002401	Higuey	18 37	68 42	90
002603	Naranjo de China	18 42	68 50	130
003001	El Seybo	18 46	69 03	120
003004	El Pezon S.P. Macoris	18 27	69 15	10
003401	Engombe	18 27	70 00	10
003402	Medina	18 32	70 09	150
003801	Nizao	18 37	70 27	580

Table 5-4. INDRHI Meteorological Stations (continued)

Station ID	Station Name	Latitude	Longitude	Elev. (m)
003802	Valdesia	18 24	70 17	160
003809	Quija Quieta	18 14	70 28	19
003813	Alto Bandera	18 49	70 38	2842
004401	El Naranjal-Ocoa	18 33	70 29	600
004425	El Memiso	18 31	70 34	530
004426	Los Arroyos	18 39	70 32	1000
004601	Peralta	18 35	70 46	500
004602	Resoli	18 28	70 44	140
004701	El Sisal	18 23	70 50	40
004901	Valle Nuevo	18 48	70 41	2300
004902	Constanza	18 55	70 43	1215
004903	San Juan de la Maguana	18 45	71 09	378
004904	El Pezon	18 18	71 11	4
004911	El Tetero	18 53	70 54	1340
004915	Vallejuelo	18 39	71 20	660
004916	Guayabal P Las Casa	18 45	70 50	710
004924	Los Valencio	19 05	71 17	1160
004983	El Valle-Constanza	18 54	70 43	1200
004986	Barahona	18 13	71 06	35
005102	Juancho	17 52	71 16	10
005301	Neyba	18 30	71 26	100
005302	Puerto Escondido	18 19	71 34	400
005312	Angostura	18 16	71 24	35
005313	Guayabal-Postref Rio	18 36	71 38	225
005315	Isla Cabritos	18 29	71 41	0
005323	Lago Enriquillo	18 34	71 42	-41
005324	Lago Enriquillo (SAL)	18 34	71 42	-41
005401	Matayaya	18 53	71 35	430
005408	Catanamatias	19 03	71 25	1215
005410	Naranjito	19 17	71 30	900
005411	Sabana Mula	19 02	71 33	518

5.2.4 DATSAV2

There are eight stations in the Dominican Republic with sufficient meteorological data available from the climatic data set known as DATSAV2. This data set was obtained from the United States National Climatic Data Center and consists of surface observations of meteorological variables. These observations were transmitted via the GTS. A map of the station locations, and total number of observations for each station, are provided in Figure 3.4.

The number of observations within each year and from year to year for the individual sites is highly variable. Most stations in the Dominican Republic typically transmitted observations every 3 hours during operation hours, except that the international airports at Santo Domingo and Puerto Plata often transmitted observations every hour. Many stations did not transmit during late-night hours. At many stations, the transmission frequency changed over the years and was generally better in the 1970s and 1980s than in the 1990s.

Table 5-5. Dominican Republic Stations from DATSAV2 Files

WMO	Station	Lat.	Long.	Elev. (m)	From	To	Number of Observations	Wind Speed (m/s)	Wind Power (W/m^2)
784570	Puerto Plata	19 45	70 33	15	01/73	12/96	51,403	2.7	41
784600	Santiago	19 28	70 42	183	01/73	12/96	35,049	2.8	30
784670	Sabana de la Mar	19 03	69 23	10	01/73	12/96	22,691	3.0	51
784780	Cabo Engaño	18 37	69 19	2	01/73	11/96	17,856	4.6	118
784790	Punta Cana	18 34	68 22	12	10/92	12/96	5,820	4.1	71
784820	Barahona	18 13	71 06	26	01/73	12/96	34,013	4.1	93
784850	Las Americas	18 26	69 40	18	01/73	12/96	143,172	3.0	30
784860	Santo Domingo	18 26	69 53	14	01/73	12/96	43,223	2.5	24

Latitude (Lat.) and longitude (Long.) are in degrees and minutes.
Num Obs is the number of observations during the period of record.

We processed the data records for each of these stations to produce monthly and annual averages of wind speed and wind power. These summarized data are presented in Table 5-5, and copies of the processed files are presented in Appendix B for selected stations. These data are useful for evaluating the interannual variability of wind speed and wind power, the monthly variability of wind speed and wind power, the diurnal distribution of wind speed and wind power, and the joint frequency of wind speed and wind direction by month and year.

5.3 Upper-Air Data

The upper-air data, consisting of wind speed and direction profiles, are an important component in the development of the wind resource projections. These data are available in either the ADP database or the Global Upper Air Climatic Atlas.

5.3.1 ADP

The ADP upper-air database consists of information obtained from surface-launched meteorological instrument packages. These packages are usually launched via balloon once or twice daily, at 0000 GMT and 1200 GMT, and are managed under WMO guidance and procedures. There are only two locations in the Dominican Republic where upper-air wind data are available from the ADP database: Santo Domingo and Sabana de la Mar (no longer reporting). For our analysis, we also used data from three ADP stations in nearby countries. These stations are listed in Table 5-6 and their locations were shown in Figure 3.5.

Vertical profiles of wind speed and wind direction are an important meteorological input parameter for the wind mapping. Therefore, the vertical profiles must reflect ambient regional atmospheric flow and not be subject to major blocking effects from terrain features.

The ADP data yielded profiles of monthly and annual average wind speed and frequency distributions of wind speed and wind direction for a number of pressure levels and height levels from the surface through 700 millibar (mb), or approximately 3000 m. Summaries of the wind data for the upper-air stations are presented in Appendix C.

Table 5-6. Regional Upper-Air Stations

WMO #	Name	Country	Lat.	Long.	Elev. (m)	Start Date	End Date	Number of Observations
784670	Sabana De La Mar	DR	19 03	69 23	10	Jun 57	Aug 62	3,557
784860	Santo Domingo	DR	18 26	69 53	14	Jan 73	Mar 97	8,812
781180	Grand Turk	TC	21 27	71 09	10	Jun 57	May 70	7,304
781180	Grand Turk	TC	21 27	71 09	10	Jan 73	Dec 78	1,127
785260	San Juan	PU	18 26	66 00	19	Jan 73	Mar 97	17,062
788660	St. Maarten	NA	18 03	63 07	3	Jan 73	Mar 97	7,521

Latitude (Lat.) and longitude (Long.) are in degrees and minutes.
Country: DR – Dominican Republic
TC – Turks and Caicos Islands
PU – Puerto Rico
NA – Netherlands Antilles
Num Obs is the number of observations during the period of record.

5.3.2 GUACA

The ADP data were supplemented by the GUACA data, which consist of monthly means and standard deviations of upper-air parameters for the mandatory pressure levels on a 2.5° global grid. The mandatory levels of interest include surface, 850 millibar (mb), 700 mb, and 500 mb.

5.4 Ocean Wind Data

Because the Dominican Republic covers the eastern part of the large Caribbean island known as Hispaniola, there is a large amount of water surface surrounding all but the western side of the country. Both the satellite SSMI data set and the marine data set (which is based largely on state-of-sea observations and some wind measurements by marine vessels) contain estimates of 10-m ocean wind speeds. These data also provide an excellent overview of the ambient wind conditions in the ocean areas off the coasts of the Dominican Republic.

The annual satellite-based wind speed data for the 7-year period from 1988 to 1994 are presented in Figure 5.1 and summarized in Appendix D for 10 specific areas around the Dominican Republic. The best wind speeds (8.0-9.0 m/s) are near the southwestern-peninsula coast, with highest wind speeds of almost 9.0 m/s near the southern tip of the southwestern peninsula. Although wind speeds are also high (8.0 m/s) near the south-central peninsula, ship wind rose data indicate the winds may be reduced substantially along the southern coast of this peninsula because the winds frequently blow offshore rather than onshore. Wind speeds are 7.5-8.0 m/s near the northwestern coast, west of Puerto Plata. The wind speeds near most of the northeastern and southeastern coasts are between 7.0 and 7.5 m/s.

The wind speed patterns of the marine data are similar to those of the satellite data. However, the marine wind speeds are in general about 10% lower than the satellite wind speeds. We believe that the satellite wind speeds may be high in this region, due to the following reasons. Satellite measurements are not available for periods of rainy or inclement weather when thick clouds exist. We estimate that, in this trade wind region, the average wind speeds are higher for good weather than for inclement weather, because the strength of the easterly trade wind flow is reduced by low-pressure disturbances that usually bring inclement weather. Moreover, the limited data from exposed coastal sites is more in agreement with the marine data than the satellite data.

Because we estimate the satellite wind speeds at the 10-m height to be about 10% high, we will assume that the satellite wind speeds are representative of a 30-m height because the wind speed over ocean areas is estimated to increase about 10% from 10 to 30 m.

The satellite wind power density map (see Figure 5.2) parallels the annual wind speed patterns with the highest density (500-600 W/m^2) near the southwestern coast. The data indicate that the wind power density is about 400 W/m^2 near the northwestern coast, as shown in Appendix D. Near most of the northeastern, eastern, and southeastern coast, the wind power density is in the range of 300-350 W/m^2. The lowest wind power density (260 W/m^2) is east of Isla Saona and the southeastern tip of the Dominican Republic and is caused by the blocking effect of Puerto Rico on the easterly trade wind flow. Patterns of wind power based on the marine data are similar to those of the satellite data; however, the wind power density for the marine data is about 30% lower than that for the satellite data. For reasons discussed above, we will assume that the satellite wind powers are representative of a 30-m height.

The SSMI data was also used to determine the Weibull k (shape) factor for the ocean areas. The k-values, shown in Figure 5.3, exhibit a sharp gradient in the near-coastal areas. One might infer that the k-value could be in the range of 2.4-2.7 in many of the coastal areas. Limited measurement data from well-exposed coastal locations indicate that k-values can vary from 2.5-4.0. We have assumed a k-value of 3.0 to be generally representative of coastal areas. This is consistent with estimates of k-values from the marine data for this region.

The seasonal variation in wind resource for 10 specific ocean areas near the Dominican Republic is illustrated in figures presented in Appendix D. There are generally two high-wind seasons. One high-wind season is from November to February, with the maximum wind resource mostly in January. The other high wind season is from June to August, with the maximum resource mostly in July. The lowest wind resource months are mostly April and October.

5.5 Wind Resource Distribution and Characteristics

5.5.1 Annual Wind Resource Distribution

The wind resource over the Dominican Republic varies considerably and is strongly dependent on several factors: ambient characteristics of the trade wind flow, topographical influences on the ambient wind flow, elevation, and proximity to the coastline. The wind resource in the Dominican Republic also depends strongly on elevation and proximity to the coastline. In general, the wind resource is best on hilltops, ridge crests, and coastal locations that have excellent exposure to the prevailing winds that blow from the east. The extreme southwestern and northwestern regions of the country are estimated to have the greatest number of areas with good-to-excellent wind resources for utility-scale applications, because the upper-air winds and ocean winds are greatest in these regions.

Based on the ocean wind data, the extreme southwestern region of the Dominican Republic has the best wind resource in the country. Estimates of ocean wind speed and power density range from 8.5-9.0 m/s and 500-600 W/m^2, respectively. Thus, exposed east-facing coastal sites on the southwestern tip should have excellent wind resource. Data from one well-exposed USAID site in this region, located on Isla Beata, indicate excellent wind resource, although less than 1 year of data are available. Data from the two inland sites located in relatively flat terrain in this region (Nueva Rosa and Oviedo) indicate moderate wind resource, as might be expected due to wind

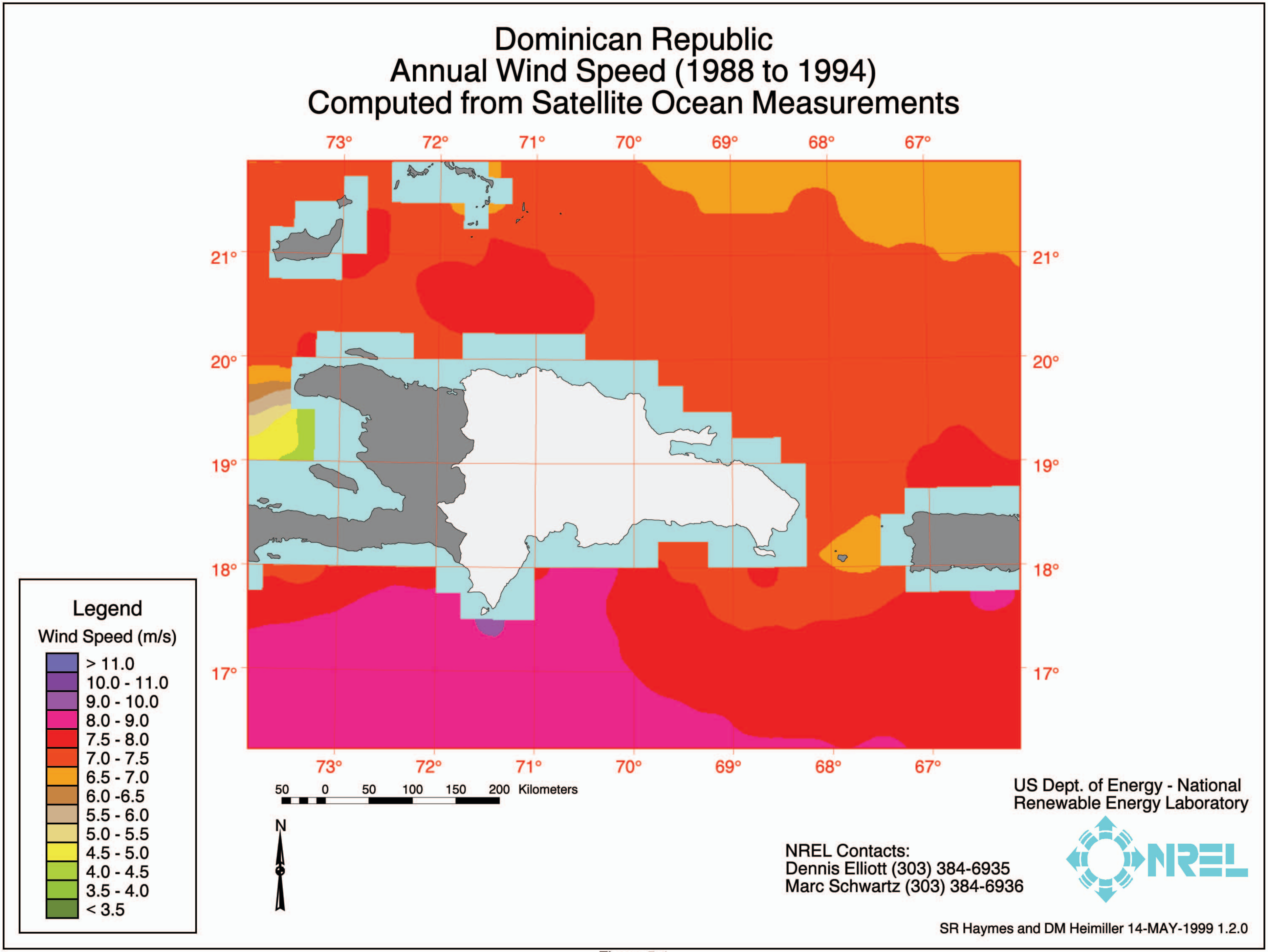

Dominican Republic
Annual Wind Speed (1988 to 1994)
Computed from Satellite Ocean Measurements
73°
72°
71°
70°
69°
68°
67°
21°
20°
19°
18°
17°
Legend
Wind Speed (m/s)
> 11.0
10.0 - 11.0
9.0 - 10.0
8.0 - 9.0
7.5 - 8.0
7.0 - 7.5
6.5 - 7.0
6.0 -6.5
5.5 - 6.0
5.0 - 5.5
4.5 - 5.0
4.0 - 4.5
3.5 - 4.0
< 3.5
50 0 50 100 150 200 Kilometers
N
US Dept. of Energy - National
Renewable Energy Laboratory
NREL Contacts:
Dennis Elliott (303) 384-6935
Marc Schwartz (303) 384-6936
NREL
SR Haymes and DM Heimiller 14-MAY-1999 1.2.0

Figure 5-1

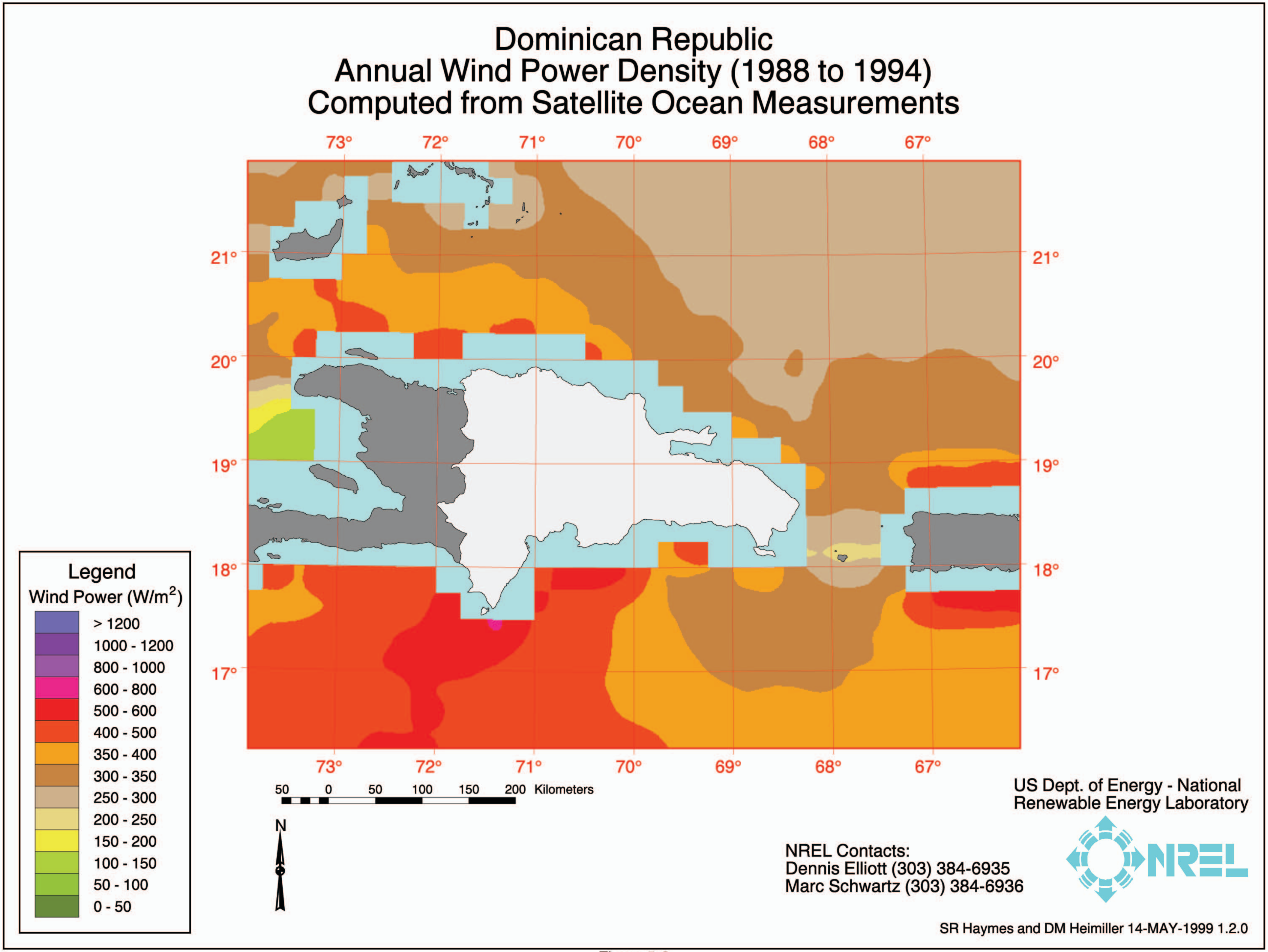
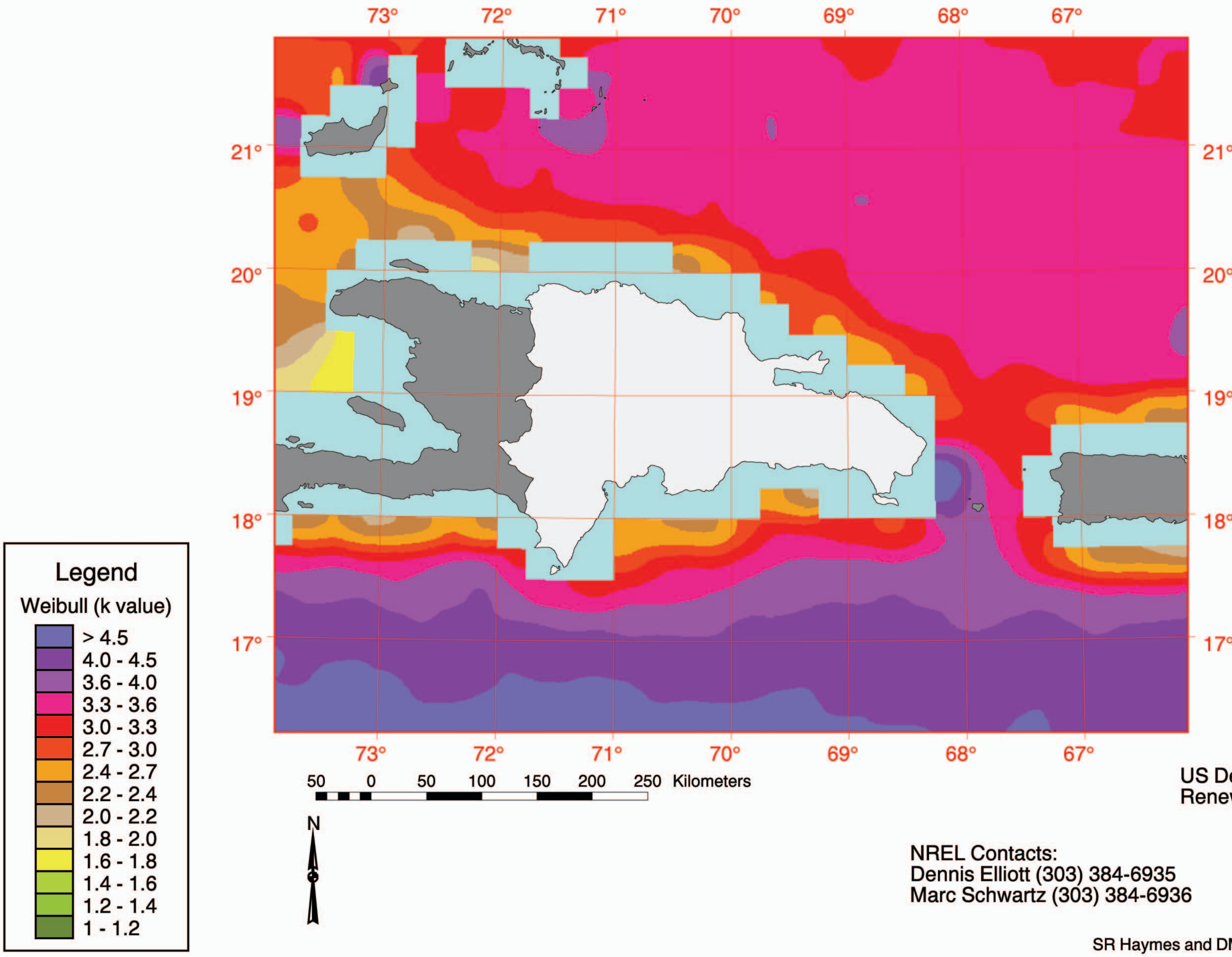

Dominican Republic
Annual Wind Power Density (1988 to 1994)
Computed from Satellite Ocean Measurements
73° 72° 71° 70° 69° 68° 67°
21° 20° 19° 18° 17°
Legend
Wind Power (W/m2)
> 1200
1000 - 1200
800 - 1000
600 - 800
500 - 600
400 - 500
350 - 400
300 - 350
250 - 300
200 - 250
150 - 200
100 - 150
50 - 100
0 - 50
50 0 50 100 150 200 Kilometers
N
US Dept. of Energy - National Renewable Energy Laboratory
NREL Contacts:
Dennis Elliott (303) 384-6935
Marc Schwartz (303) 384-6936
SR Haymes and DM Heimiller 14-MAY-1999 1.2.0

Figure 5-2

Dominican Republic
Annual Weibull k Value (1988 to 1994)
Computed from Satellite Ocean Wind Measurements



US Dept. of Energy - National Renewable Energy Laboratory

NREL Contacts:
Dennis Elliott (303) 384-6935
Marc Schwartz (303) 384-6936

SR Haymes and DM Heimiller 14-MAY-1999 1.2.0

Figure 5-3

speed reductions caused by stability and surface-roughness effects. Ridge crests on this southwestern peninsula could have substantially greater wind power than coastal sites. Based on available upper-air wind data, we estimate that the highest wind resource may occur at elevations of 800-1200 m in this region. Although the free-air winds are very strong on the southwestern peninsula, there are sheltered sites with low wind resource, as evident from the USAID site at Las Mercedes.

The second best region is the near-coastal area of northwestern Dominican Republic, based on the ocean wind data. Estimates of ocean wind speed and power density are about 7.7 m/s and 400 W/m^2, respectively. Exposed east-facing coastal sites in this region should have good-to-excellent wind resource, which is confirmed by the USAID measurement site at Guzmancitos. A low-level jet, with peak wind speeds at 200-600 m above sea level, is hypothesized to occur in this region. The height of the jet is believed to be similar to that observed at Grand Turk but with stronger winds. Therefore, the greatest wind resource in this region may exist on near-coastal ridge crests at elevations between 200 and 600 m; however, no data are available to verify this resource.

In northeastern and eastern areas of the Dominican Republic, the ocean data indicate that the exposed east-facing coastal sites or near-coastal hilltops can be expected to have moderate-to-good wind resource, depending on elevation and proximity to the coast. This appears to be confirmed by limited measurement data from two USAID sites (Los Cacaos and Las Galeras) and data for selected periods from two meteorological stations (Cabo Engaño and Cabrera).

Inland, the wind resource is expected to be generally low to marginal, except on exposed ridge crests or mountain summits and some wind corridors that may have accelerated wind flow. The magnitude of the free-air wind resource decreases from eastern to central areas of the interior of the Dominican Republic, as evidenced by the lower free-air wind speeds at Santo Domingo as compared to those at Sabana de la Mar. Furthermore, the wind resource is expected to decrease significantly with height at elevations above about 1500 m, so that high-elevation ridge crests and mountain summits in the Cordillera Central are expected to have less resource than many of the lower-elevation ridge crests in the Dominican Republic.

There are two wind corridor areas that are believed to have moderate wind resource, at least for rural power applications. Hilltops or elevated terrain areas within these corridors should have even better wind resource. One of these wind corridors is Valle del Cibao in northwestern Dominican Republic, starting west of Santiago and stretching westward to near Monte Cristi. The other wind corridor is Valle de Neiba, which begins near Barahona and extends westward to Lago Enriquillo and also possibly to the Haitian border. These wind corridor areas are expected to have quite strong afternoon winds, particularly from March through August.

5.5.2 Seasonal Wind Resource Distribution

The seasonal variability of the wind resource depends on several factors, including proximity to the coastline and exposure to ocean winds, elevation above sea level and surrounding terrain, and geographic location.

Monthly profiles of wind resource versus elevation are shown in Appendix C for the upper-air stations. In free-air elevations of 500 to 2000 m, the highest wind resource occurs from June through August and December through February. Historically, July is the month with the highest wind resource and October the month with the lowest wind resource. Therefore, high ridge crests that have excellent exposure to the easterly trade winds can be expected to have the highest wind resource from June to August and December to February, with the highest resource in July and lowest in October. There are only slight variations in the free-air wind directions by season. Although the most frequent direction is east, there is an increased frequency of east-southeast winds during the period from June to August and an increased frequency of east-northeast winds during the period from November to February.

Ocean areas in the vicinity of the Dominican Republic are estimated to have similar seasonal variability as the free-air winds, based on ship and satellite wind data. The seasonal variation in wind resource for 10 specific ocean areas near the Dominican Republic is illustrated in figures presented in Appendix D. There are generally two high-wind seasons. One high-wind season is from November to February, with the maximum wind resource mostly in January. The other high wind season is from June to August, with the maximum resource mostly in July. The lowest wind resource months are generally April and October.

However, there are some minor differences between the ocean data and free-air data. The ocean data indicate that January is the windiest month in all regions, whereas the free-air data showed that July was the windiest month. For most areas, the ocean data indicate that the period November through February has greater wind resource than the period June through August, whereas the free-air data indicate that the period November through February has significantly less wind resource than the period June through August. A possible explanation could be that there is more mixing and downward transport of the winds aloft over the ocean areas during the cooler months, such as December to February, than during the warmer months. The air is more stable over the ocean areas during the warmer months of June to August, so that the wind shear is greater in the lowest few hundred meters above the ocean surface. Evidence of this seasonal effect is observed at some stations that have both upper-air wind data and well-exposed surface wind measurements. For example, the 10-m wind power measured at St. Maarten is slightly greater in January than in July, even though the free-air wind power at 1000 m is significantly less in January than in July.

Therefore, coastal points on capes and peninsulas that are well-exposed to the ocean winds can be expected to have the highest wind resource from November to February and June to August, with the lowest in October. Generally, these types of locations will exhibit very small diurnal (time-of-day) variations in the wind resource and are not significantly influenced by land-sea breeze flows and other types of land-based effects on the wind flow.

In coastal areas where land-sea breeze effects and other land-based influences become more prominent, the seasonal variations of the wind resource will be modified and become more similar to those of inland areas. The wind resource will decrease in months with lower sun angle and reduced mixing down of the winds aloft (such as November through January) and increase in months with higher sun angle and greater vertical mixing (such as March through August). As a consequence, many coastal and inland locations may have greater wind resource in March and April than in December and January, even though the winds aloft and ocean winds are greater in December and January. At many locations, the wind resource is highest from June through August, with a secondary seasonal maximum from March through May. At many locations, the wind resource is lowest from October through December.

5.5.3 Diurnal Wind Speed Distribution

The magnitude of the diurnal variation, or wind speed versus time of day, is a function of the relative elevation, influence of the ocean, season, and free-air wind flow characteristics. The distribution at low elevation, inland sites in simple terrain typically is a maximum wind speed during the afternoon and a minimum near sunrise. The primary forcing mechanism for this pattern is daytime heating, which destabilizes the lower levels of the atmosphere, resulting in a downward transfer of momentum to the surface. The near-surface winds tend to peak in the afternoon, which corresponds to the time of maximum heating. In the evening, the declining supply of sunshine leads to surface cooling, more stability, and a reduction of wind speed. The minimum in surface wind speed near sunrise corresponds to the time of maximum atmospheric stability. The chart of speed and power by hour in Appendix A for the USAID sites and Appendix B for DATSAV2 stations shows this phenomenon. From an early-morning minimum, wind speeds increase rapidly following sunrise, reaching a peak in the afternoon or by late morning in some cases. Winds decrease in the evening and then remain fairly steady during the late night and early morning hours.

On high mountain summits and ridge crests, diurnal distributions differ from those of low-elevation sites. The strongest winds occur at night whereas the lowest wind speeds are observed during the midday hours. On lower-elevation ridge crests or ridge crests that are influenced significantly by an elevated plateau, the diurnal profile will be modified and the wind may be greater during the day than the night. At some elevated sites, the diurnal variations may be quite small and vary little between day and night. Appendix A for USAID sites includes some data for one elevated site located on a ridge crest – La Loma, which has an elevation of about 800 m above sea level. The chart of speed and power by hour in Appendix A for this site indicates that the wind resource does not vary significantly between day and night.

Over the ocean, the diurnal variation of the atmospheric instability is typically reversed, resulting in a wind speed maximum at night and a minimum in the afternoon. However, diurnal wind speed changes between day and night at ocean sites are typically quite small, in comparison to those found at inland sites. The data for Cabo Engaño in both Appendix A and B show the marine influence observed at this location, where the nighttime wind resource is slightly greater than the daytime wind resource. At another exposed coastal point, Las Galeras at the eastern end of the Samana peninsula, the daytime winds are greater than the nighttime winds, although the diurnal variation is relatively small compared to that of inland sites.

Guzmancitos, one of the USAID sites located on a coastal hilltop in northwestern Dominican Republic, has a very large diurnal variation with lowest winds near sunrise and greatest winds between noon and 8 p.m. A strong sea breeze circulation, energized by a powerful low-level wind jet, is believed to be responsible for the strong afternoon and evening winds that are observed at this location, and may exist at many other exposed locations in near-coastal areas of the northwestern portion of the Dominican Republic. At the Guzmancitos site, these powerful afternoon and evening winds average almost 9 m/s on an annual basis and about 11-12 m/s during the peak wind months of July and August.

6.0 Wind Mapping and Identification of Resource Areas

6.1 Introduction

In this section, we present the results of the wind mapping, and wind power density estimates for the Dominican Republic. Two classification schemes for wind power density are used, one for wind power technology in rural areas and one for utility-scale applications.

In addition to a national wind resource map, NREL also produced four regional maps. The regional divisions were determined principally on the geography of the country and the desire to maintain the same map scale for each region.

6.2 Wind Power Classifications

The wind power classifications for the Dominican Republic are presented in Table 6-1. Two different classifications are used in the analysis: one for utility-scale applications and one for rural power applications. For utility-scale applications, areas with a Class 2 and higher resource potential are considered suitable for wind power development. For rural applications, areas with a Class 1 rating or higher are considered suitable for wind power development. In reviewing the mapping results, it is important to keep these classifications separate, because an area considered marginal from a utility-scale-application point of view is considered moderate from a rural power application point of view.

Table 6-1. Wind Power Classification

Class	Resource Potential		Wind Power Density (W/m^2) @ 30 m	Wind Speed [a] (m/s) @ 30 m
	Utility	Rural		
1	Marginal	Moderate	100-200	4.9–6.1
2	Moderate	Good	200-300	6.1–7.0
3	Good	Excellent	300-400	7.0–7.7
4	Excellent	Excellent	400-600	7.7–8.9
5	Excellent	Excellent	600-800	8.9–9.8
6	Excellent	Excellent	800-1000	9.8–10.5

[a] Mean wind speed is estimated assuming a Weibull distribution of wind speeds with a shape factor (k) of 3.0 and standard sea-level air density. The actual mean wind speed may differ from these estimated values by as much as 20 percent, depending on the actual wind speed distribution (or Weibull k value) and elevation above sea level.

6.3 Approach

We previously presented the description of the mapping methodology in Section 4.0. NREL prepared the digital terrain data set from the DEM information for the Dominican Republic. NREL also prepared the meteorological data files necessary for the modeling analysis. These meteorological data files included vertical wind profiles, wind power roses that express the percentage of total wind power density by direction sector, and open-ocean wind power density. The vertical profiles are broken down into 100-m intervals and centered every 100 m above sea level, except for the lowest layer, which is at 50 meters.

The vertical profiles were carefully determined, based primarily on the upper-air data, and then subjectively modified to derive the final profiles for 22 specific geographic zones. We also developed wind roses to account for the effects of short-range (less than 10 km), medium-range (10–50 km), and long-range (>50 km) blocking of the ambient wind flow by terrain.

6.4 Mapping Results

The wind resource in the Dominican Republic is strongly dependent on elevation and proximity to the coastline, as can be seen in Figure 6.1. In general, the wind resource is best on hilltops, ridge crests, and coastal locations that have excellent exposure to the prevailing winds that blow from the east. The extreme southwestern and northwestern regions of the country are estimated to have the greatest number of areas with good-to-excellent wind resources for utility-scale applications, because the upper-air winds and ocean winds are greatest in these regions.

The wind mapping results show many areas of good-to-excellent wind resource for utility-scale applications or excellent wind resource for village power applications, particularly in the extreme southwestern and northwestern regions of the country. The best wind resources are found in the southwestern provinces of Pedernales and Barahona, and the northwestern provinces of Puerto Plata and Monte Cristi. Significant areas of good-to-excellent wind resource can be found in many other locations, such as well-exposed hilltops and ridge crests of the Samana Peninsula and other near-coastal locations throughout the Dominican Republic and the major mountain ranges including Cordillera Septentrional, Cordillera Oriental, Cordillera Central, and Sierra Neiba. The mapping results show many additional areas of moderate wind resource for utility-scale applications or good wind resource for village power applications, including many east-facing coastal locations along the eastern and northern coasts of the Dominican Republic.

To better portray the mapping results in more detail, the Dominican Republic was divided into four regions – southwestern, northwestern, central, and eastern. Each region covered an area of approximately 160 km by 160 km. We determined the regional divisions principally on the geography of the country and the desire to maintain the same map scale for each region. The boundaries of these regions are presented in Figure 6.2.

6.4.1 Southwestern Region

The Southwestern Region consists primarily of the provinces of Pedernales, Barahona, Independencia, Baoruco, Azua, and San Juan. The political, geographic, and wind energy potential of this region are shown in Figures 6.3, 6.4, and 6.5. This region has the best wind energy resource in the Dominican Republic.

Geographically, this region is dominated by three mountain ranges (Sierra de Baoruco to the south, the Sierra de Neiba and the southwestern portion of the Cordillera Central), the valleys between them (Valle de Neiba and Valle de San Juan), and coastal plains.

The areas with the most energetic wind resource are located in the Sierra de Baoruco and along the southern coastal plains. The best wind resource of any coastal area is found in the vicinity of Cabo Beata and Isla Beata. These locations have sufficient resource to support utility-scale projects as well as rural applications. The eastern coasts of the peninsula and the island show excellent resource, with average speeds greater then 7.7 m/s and power densities between 400 and 600 W/m^2. The hills in the southern portion of the province of Pedernales produce enhanced flow and a better resource than the surrounding low-lying areas. The higher elevations in these hills have excellent wind resource (average wind speeds from 7.7 to 8.9 m/s), whereas the lower hills in the vicinity have a good-to-excellent resource, with average speeds from 7.0 to 7.7 m/s and wind power densities from 300 to 400 W/m^2. Much of the southeastern portion of the peninsula has at least moderate wind resource with average wind speeds from 6.1 to 7.0 m/s (power densities from 200 to 300 W/m^2).

The wind mapping analysis indicates that the very best wind resource in the entire country is within the Sierra de Baoruco. These mountains enhance the trade wind flow, producing some areas with average wind speeds in excess of 9.8 m/s, with power densities of more than 800 W/m^2. The locations with the best wind resource are not found in the highest elevation of this mountain range. The highest elevations are in excess of 2500 m, but the best winds are found on ridges with elevations below approximately 1500 m. Maximum wind speeds in this region occur at approximately 1000 m above sea level. The highest ridges in the province of Barahona are at elevations below 1500 m and have many areas with an excellent wind resource.

Although the wind resource in the highest elevations in the Sierra Baoruco is not as energetic as at the best sites in lower elevations, the ridges throughout these mountains have generally good-to-excellent wind energy potential. In fact, in the southwestern region as a whole, the ridges in mountainous terrain tend to have at least moderate-to-good resource. Most low-lying areas, with the exception of those along the coast, and mountainous terrain not on ridges, have poor wind resource, with limited potential for wind resource applications. The Valle de Neiba, which runs almost parallel to the prevailing trade wind flow, is one non-coastal low-lying area that shows potential for rural applications.

6.4.2 Northwestern Region

The Northwestern Region includes all or portions of the provinces of Monte Cristi, Puerto Plata, Valverde, Dajabon, Santiago Rodriguez, Santiago, Elias Piña, San Juan, La Vega, and Azua. The principal geographic features in this region are the Cordillera Central mountain range, the Valle de San Juan, the Valle del Cibao, and the Cordillera Septentrional. Figures 6.6, 6.7, and 6.8 show the political, terrain, and wind resource features in this region.

The Cordillera Central rise to their maximum elevations in the central portion of this region, more than 2500 m above sea level. A small amount of the ridgetop land is classified as excellent. The rest of the ridges in these mountains have moderate-to-good resource; however, their remote locations make them unlikely candidates for applications.

Useful wind resource is found along the northern coastal areas from Cabo del Morro in the west and eastward to around Puerto Plata. Many of the coastal sites have good-to-excellent wind resource (average wind speeds from 7.0 to 7.7 m/s). In this coastal zone, elevated terrain helps to enhance the wind flow and produce localized areas with excellent wind resource. This includes the northwestern foothills of the Cordillera Septentrional and the hills to the west of Luperón and southwest of Puerto Plata.

The ridgetops of the Cordillera Septentrional also have generally good-to-excellent wind resource. The highest of the mountains in this range reach elevations of more than 1000 m. Although these sites do not have as good a resource as in the hills closer to the coast, there are many locations suitable for both utility and rural applications.

In the Valle del Cibao, there exists a large area with a moderate wind resource for rural applications. In the foothills of the Cordillera Central, to the south of Valle del Cibao, there are localized areas with good-to-excellent wind resource and still more elevated areas with moderate-to-good resource. These are found in the hills with elevations over 200 m that are separated to some degree from the main range of the Cordillera Central.

6.4.3 Central Region

The Central Region of the Dominican Republic includes all or parts of the provinces of Puerto Plata, Espaillat, Maria Trinidad Sanchez, Santiago, Salcedo, Duarte, Samana, La Vega, Sanchez Ramirez, Monte Plata, Monseñor Novel, Azua, Peravia, San Cristobal, and the Distrito Nacional. The political, topographic, and wind resource features of the region are shown in Figures 6.9, 6.10, and 6.11.

The main topographic features of the Central Region (see Figure 6.10) include the eastern extent of the Cordillera Central and Cordillera Septentrional, the western portion of the Cordillera Oriental, the western end of the Samana Peninsula, and two large coastal plains, the Vega Real and Llanura Costera del Caribe.

In the Central Region, as in the Northwestern and Southwestern Regions, the majority of the best wind sites are close to the coast. Most areas within a few kilometers of the coastline have at least a moderate wind resource, suitable for rural applications. Terrain features such as hills or mountains enhance the wind flow, particularly near the coast. One can see this in the small areas with excellent wind resource in the hills near Cabrera, Sosua, and Puerto Plata along the northern coast. This pattern is repeated in the hills of the Samana Peninsula, where the highest ridges have good-to-excellent wind resource.

Further inland, terrain features such as hills or mountains are essential to having even moderate-to-good wind resource. The ridgetops of the Cordillera Septentrional show enhanced wind speeds. Many areas have good-to-excellent wind resource and a few localized areas have excellent wind resource. Further to the south, in the Cordillera Central, some of the ridges show excellent wind resource, although these are generally for ridges with elevations greater than 1000 m but less than 1500 m. In these inland areas there is not even marginal wind resource if the terrain elevation is below approximately 200 m. This is the case over large portions of the Llanura Costera del Caribe and Vega Real. Only along the coastline is there any useful wind resource at these lower elevations.

6.4.4 Eastern Region

This region includes all or parts of the provinces of Samana, Hato Mayor, Monte Plata, El Seibo, San Pedro de Macoris, La Romana, and La Altagracia. The political, topographic, and wind resource features of this region are displayed in Figures 6.12, 6.13, and 6.14.

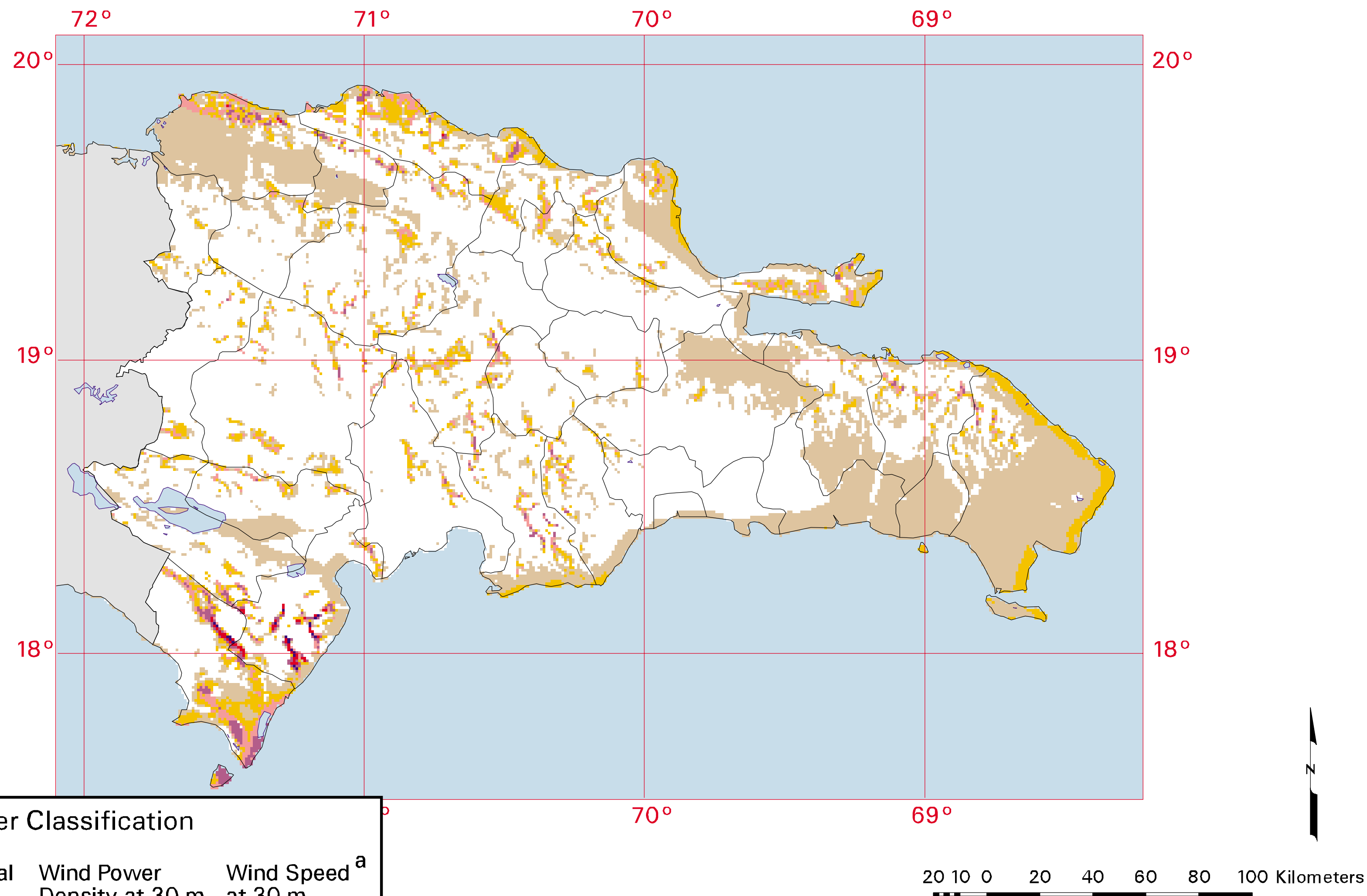
The most important topographic features of the Eastern Region are the Samana Peninsula, the Cordillera Oriental, and a large plain, the Llanura Costera del Caribe. The Cordillera Oriental is not a particularly high range of mountains. Peak elevations are only about 600 m, which just qualifies them as mountains. The Samana Peninsula has elevations of the same magnitude. The Llanura Costera del Caribe is extensive and has elevations below 100 m.

A large area of marginal-to-moderate resource in the Llanura Costera del Caribe dominates the wind resource distribution in the Eastern Region. Although the resource is not robust, some rural applications of wind energy would probably be feasible in a large portion of this region, even in the inland areas. Along the coast, particularly on the eastern, windward side, the winds are more energetic, with speeds and power density in the moderate-to-good range.

As has been the case elsewhere in the Dominican Republic, elevated terrain features enhance the wind flow and produce an improved wind resource. In the higher ridges of the Cordillera Oriental there are some locations with excellent wind resource and a fair number with good-to-excellent wind resource. Out on the Samana Peninsula, the higher-elevation sites show this same tendency, with an even higher density of sites with good-to-excellent or excellent wind power resource. Utility-scale projects may be possible in such areas.

However, similar to other parts of the country with mountains or elevated terrain of some kind, locations that are not on the ridges do not benefit from the higher elevation and can have a relatively poor wind resource.

Dominican Republic - Most Favorable Wind Resource Areas



Wind Power Classification

Resource Potential: Utility	Resource Potential: Rural	Wind Power Density at 30 m W/m^2	Wind Speed[a] at 30 m m/s
Marginal	Moderate	100 - 200	4.9 - 6.1
Moderate	Good	200 - 300	6.1 - 7.0
Good	Excellent	300 - 400	7.0 - 7.7
Excellent		400 - 600	7.7 - 8.9
		600 - 800	8.9 - 9.8
		800 - 1000	9.8 - 10.5

[a] Wind speeds are based on a Weibull k value of 3.0

The wind resource classification is specific for both utility scale and rural applications and applies to areas with low surface roughness.

US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-AUG-2001 5.2

Figure 6-1

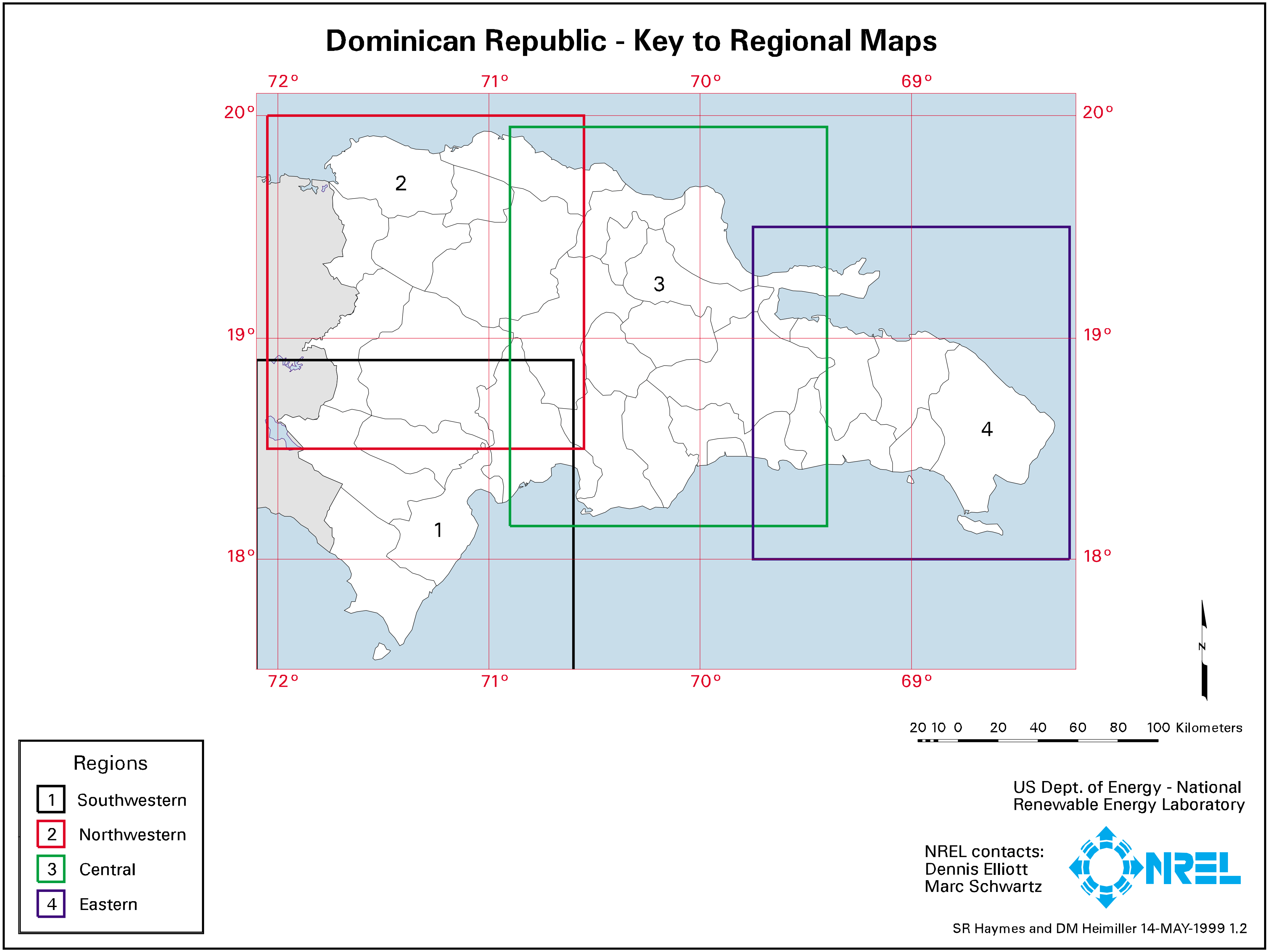
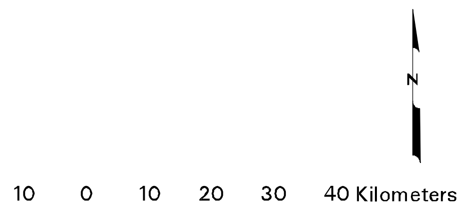

Dominican Republic - Key to Regional Maps
72°
71°
70°
69°
20°
19°
18°
1
2
3
4
N
20 10 0 20 40 60 80 100 Kilometers
Regions
1 Southwestern
2 Northwestern
3 Central
4 Eastern
US Dept. of Energy - National Renewable Energy Laboratory
NREL contacts:
Dennis Elliott
Marc Schwartz
NREL
SR Haymes and DM Heimiller 14-MAY-1999 1.2

Figure 6-2

Dominican Republic - Southwestern Region
Political Map



The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The Oficina Nacional de Meteorologia Division de Climatologia (ONM) provided mean wind speeds for all of their meteorological stations. The data for USAID's wind measurement sites were collected in collaboration with NRECA and REGAE/Winrock.

Legend

- × USAID Wind Measurement Site
- ▲ ONM Meteorological Station
- + GTS Surface Meteorological Station with Wind Data
- □ GTS Upper-Air Meteorological Station
- * Additional Wind Measurement Site
- ▪ City or **Provincial Capital**

US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-AUG-2001 1.2

Figure 6-3

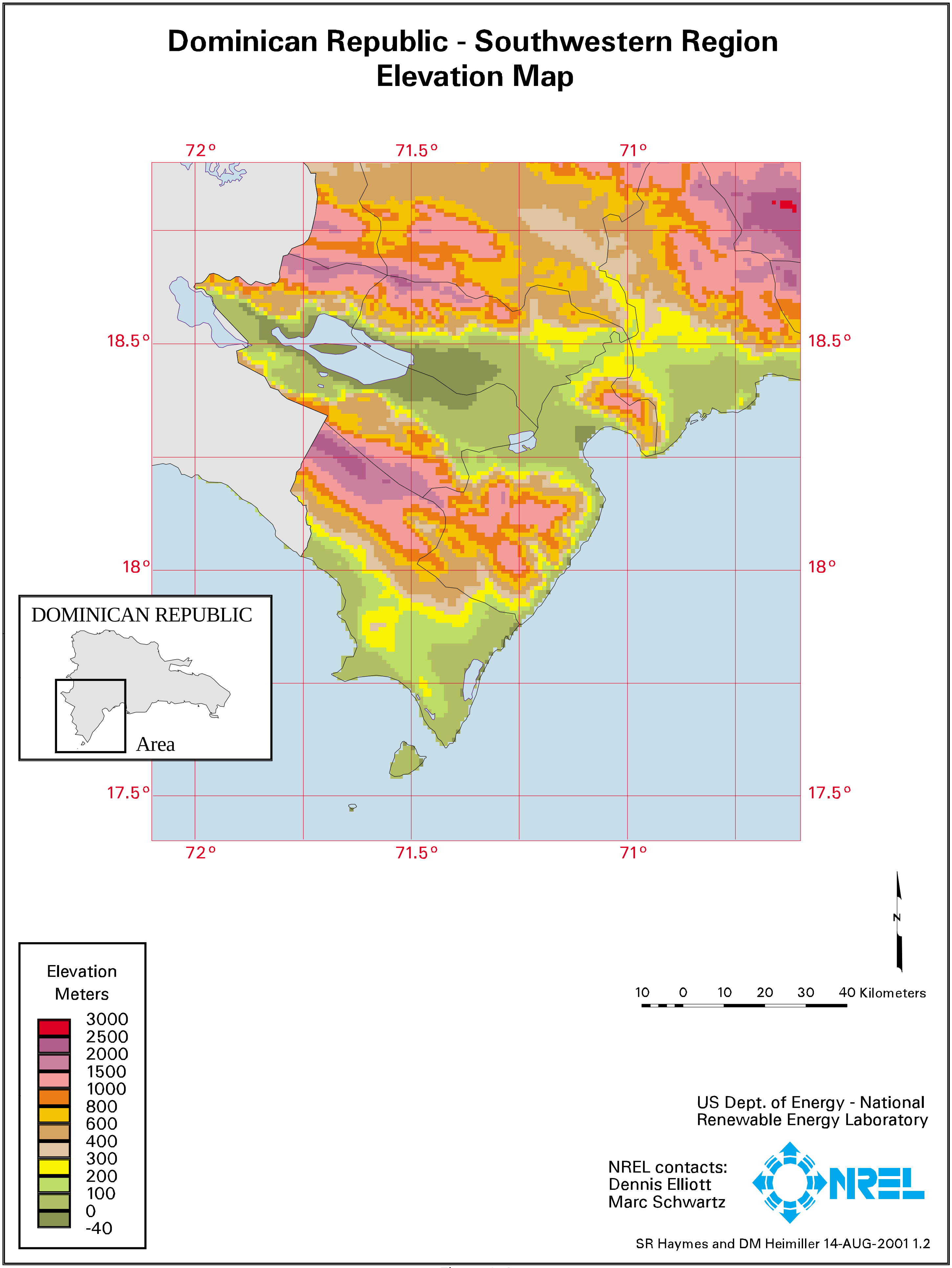
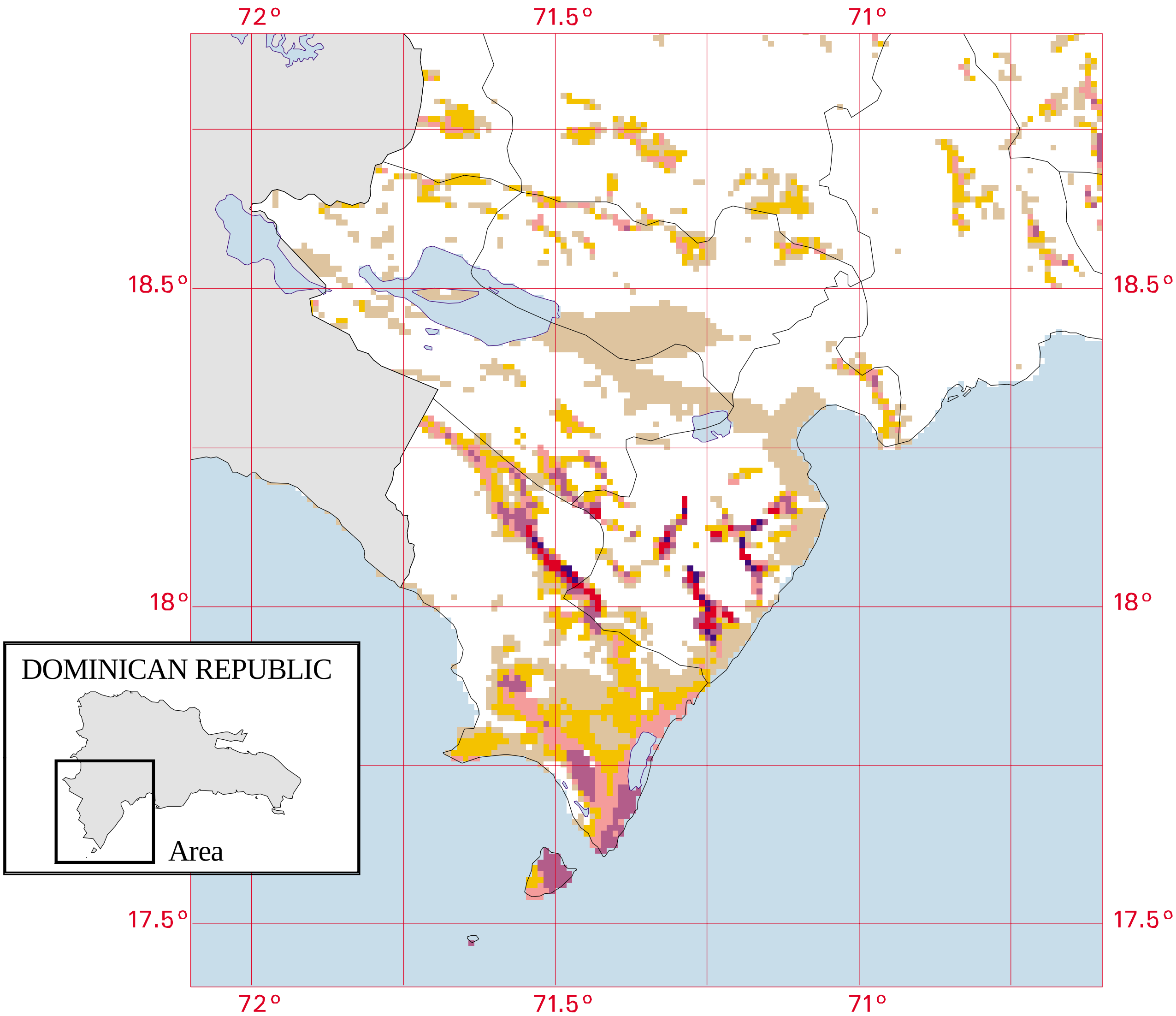

Dominican Republic - Southwestern Region
Elevation Map
72°
71.5°
71°
18.5°
18°
17.5°
DOMINICAN REPUBLIC
Area
Elevation
Meters
3000
2500
2000
1500
1000
800
600
400
300
200
100
0
-40
N
10 0 10 20 30 40 Kilometers
US Dept. of Energy - National
Renewable Energy Laboratory
NREL contacts:
Dennis Elliott
Marc Schwartz
NREL
SR Haymes and DM Heimiller 14-AUG-2001 1.2

Figure 6-4

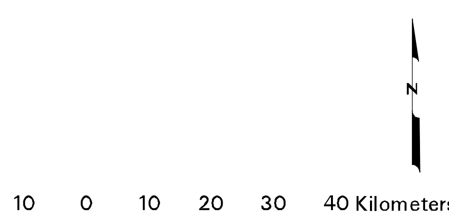
Dominican Republic - Southwestern Region
Most Favorable Wind Resource Areas



Wind Power Classification

Resource Potential: Utility	Resource Potential: Rural	Wind Power Density at 30 m W/m^2	Wind Speed[a] at 30 m m/s
Marginal	Moderate	100 - 200	4.9 - 6.1
Moderate	Good	200 - 300	6.1 - 7.0
Good	Excellent	300 - 400	7.0 - 7.7
Excellent		400 - 600	7.7 - 8.9
		600 - 800	8.9 - 9.8
		800 - 1000	9.8 - 10.5

[a] Wind speeds are based on a Weibull k value of 3.0



The wind resource classification is specific for both utility scale and rural applications and applies to areas with low surface roughness.

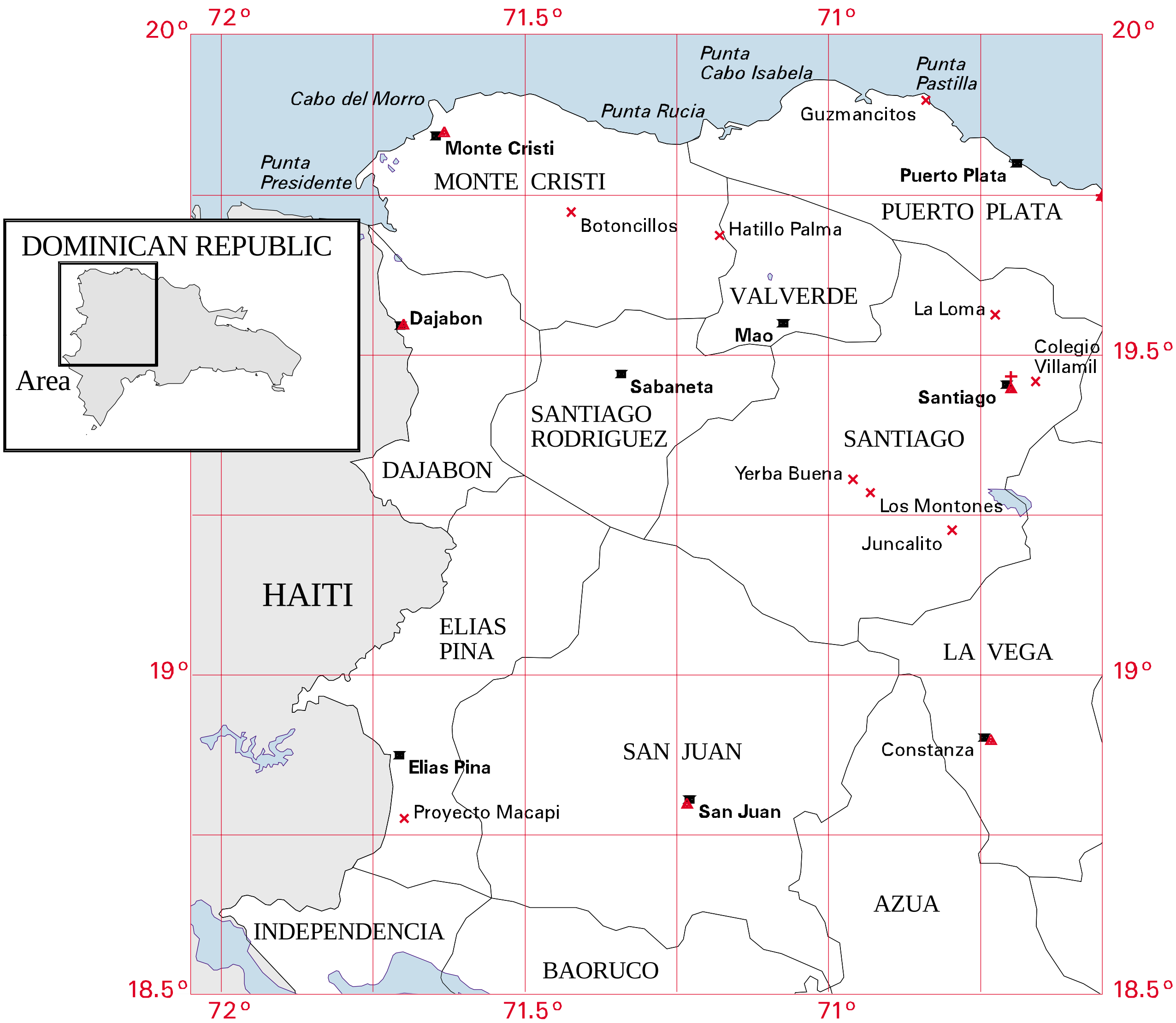
US Dept. of Energy - National Renewable Energy Laboratory

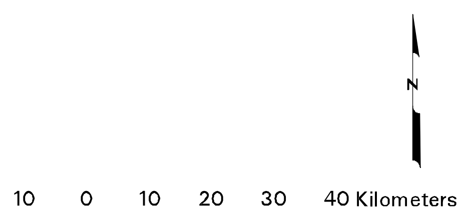
NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-AUG-2001 1.2

Figure 6-5

Dominican Republic - Northwestern Region
Political Map





The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The Oficina Nacional de Meteorologia Division de Climatologia (ONM) provided mean wind speeds for all of their meteorological stations. The data for USAID's wind measurement sites were collected in collaboration with NRECA and REGAE/Winrock.

Legend

- × USAID Wind Measurement Site
- ▲ ONM Meteorological Station
- + GTS Surface Meteorological Station with Wind Data
- □ GTS Upper-Air Meteorological Station
- * Additional Wind Measurement Site
- ■ City or **Provincial Capital**

US Dept. of Energy - National Renewable Energy Laboratory

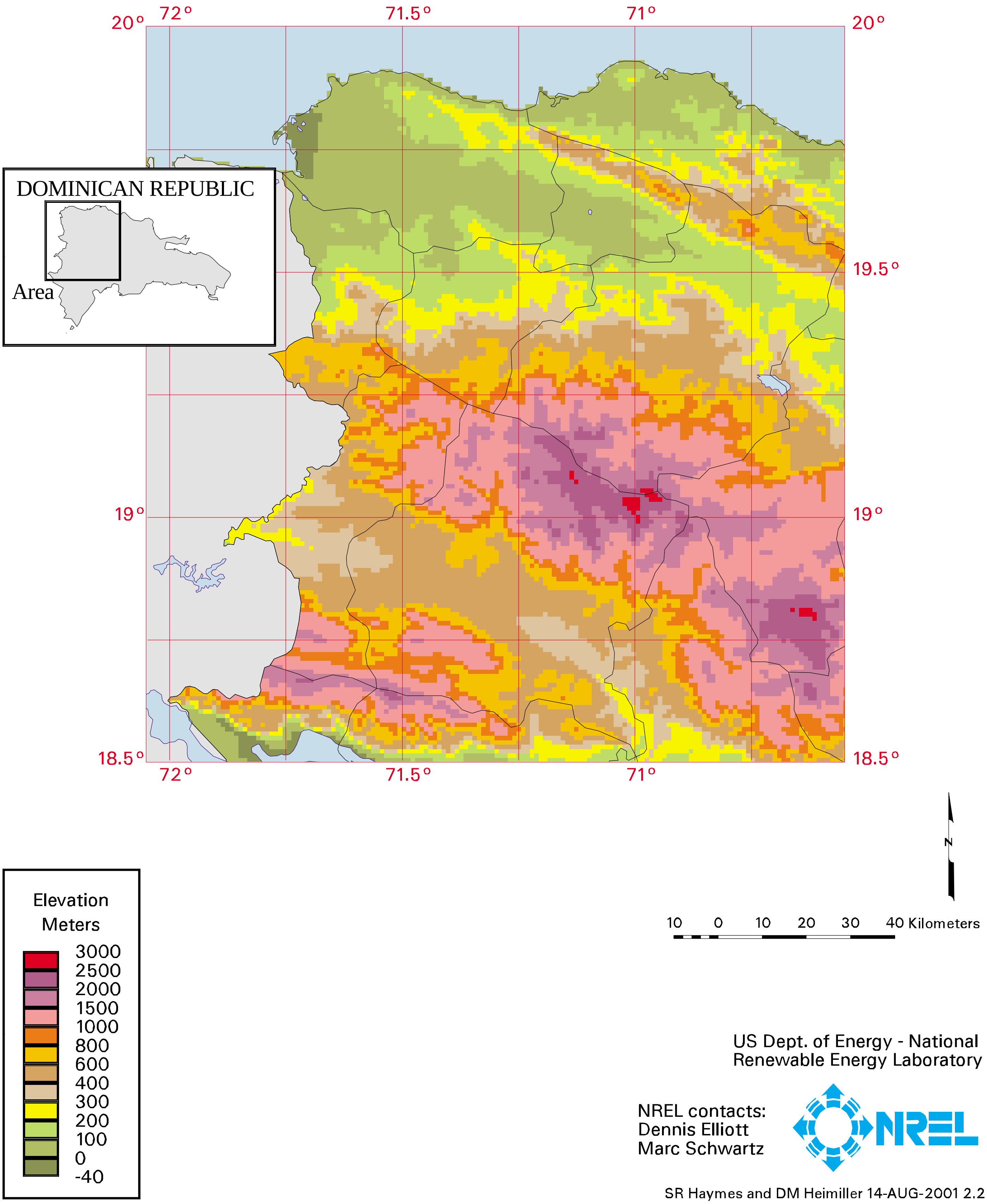
NREL contacts:
Dennis Elliott
Marc Schwartz

NREL

SR Haymes and DM Heimiller 14-AUG-2001 2.2

Figure 6-6

Dominican Republic - Northwestern Region
Elevation Map



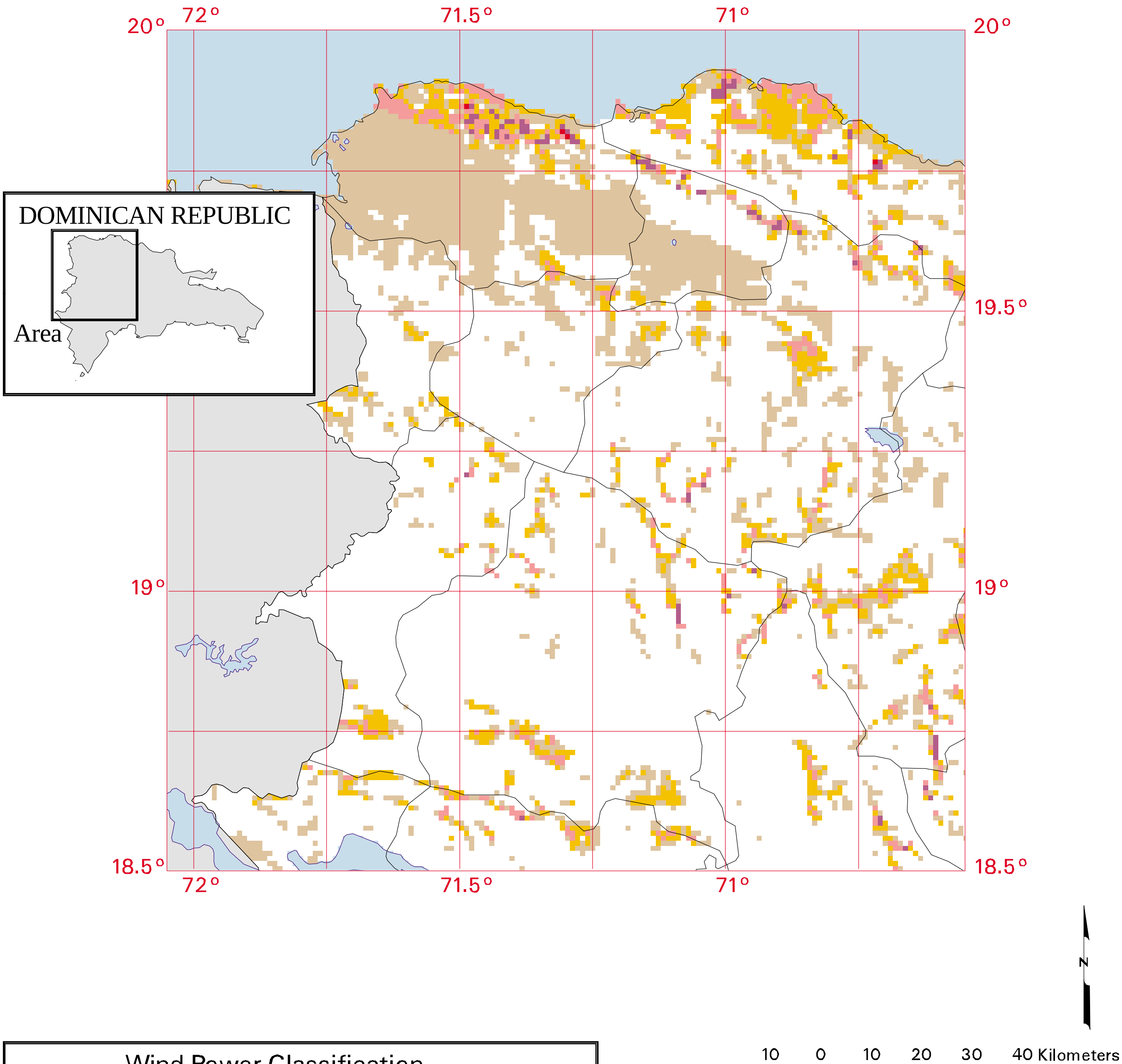
US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-AUG-2001 2.2

Figure 6-7

Dominican Republic - Northwestern Region
Most Favorable Wind Resource Areas



Wind Power Classification

Resource Potential Utility	Resource Potential Rural	Wind Power Density at 30 m W/m^2	Wind Speed[a] at 30 m m/s
Marginal	Moderate	100 - 200	4.9 - 6.1
Moderate	Good	200 - 300	6.1 - 7.0
Good	Excellent	300 - 400	7.0 - 7.7
Excellent		400 - 600	7.7 - 8.9
		600 - 800	8.9 - 9.8
		800 - 1000	9.8 - 10.5

[a] Wind speeds are based on a Weibull k value of 3.0

The wind resource classification is specific for both utility scale and rural applications and applies to areas with low surface roughness.

US Dept. of Energy - National Renewable Energy Laboratory

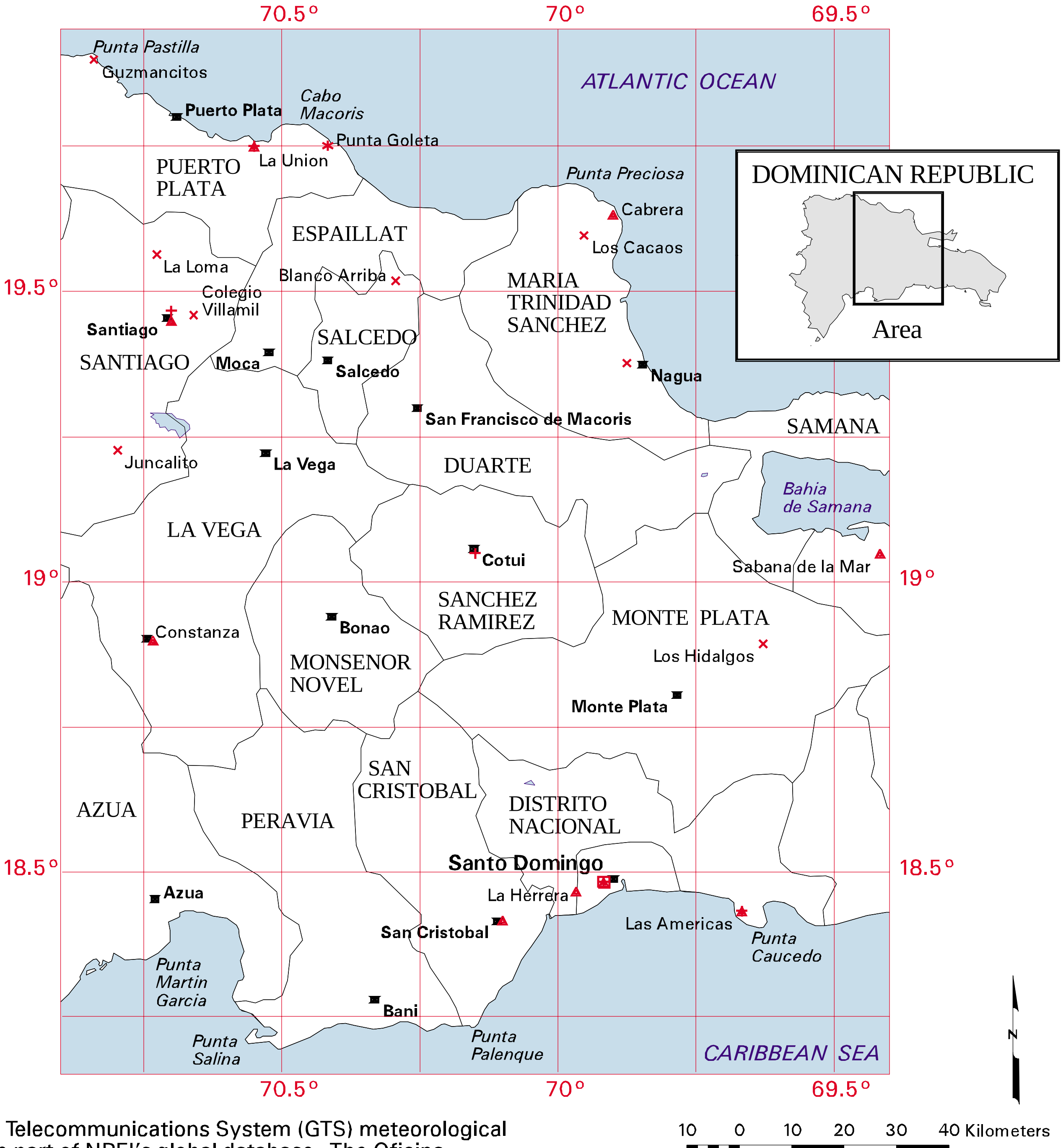
NREL contacts:
Dennis Elliott
Marc Schwartz

NREL

SR Haymes and DM Heimiller 14-AUG-2001 2.2

Figure 6-8

Dominican Republic - Central Region
Political Map



The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The Oficina Nacional de Meteorologia Division de Climatologia (ONM) provided mean wind speeds for all of their meteorological stations. The data for USAID's wind measurement sites were collected in collaboration with NRECA and REGAE/Winrock.

Legend

- × USAID Wind Measurement Site
- ▲ ONM Meteorological Station
- + GTS Surface Meteorological Station with Wind Data
- □ GTS Upper-Air Meteorological Station
- * Additional Wind Measurement Site
- ■ City or **Provincial Capital**

US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-AUG-2001 3.2

Figure 6-9

Dominican Republic - Central Region
Elevation Map

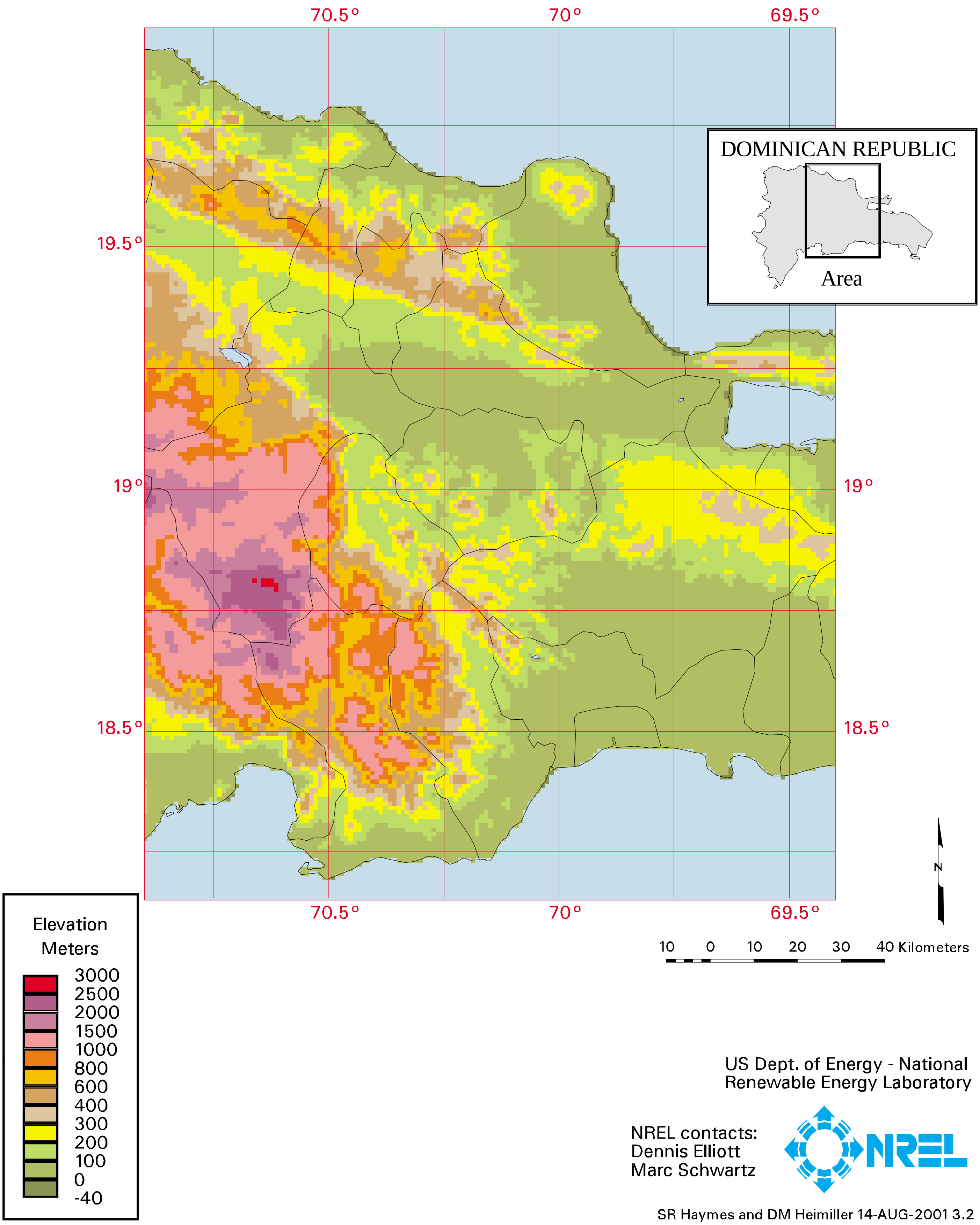
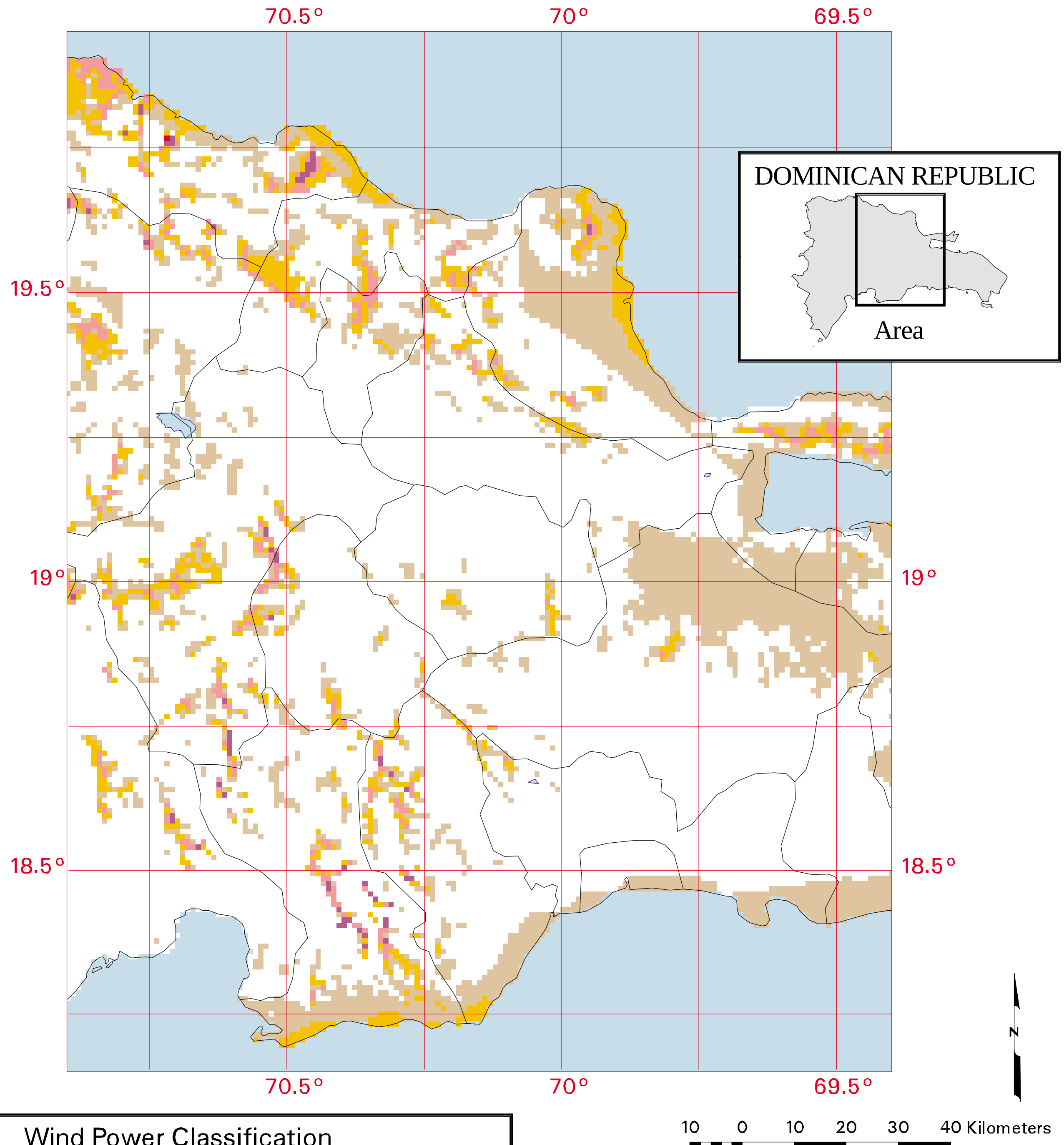


Figure 6-10

Dominican Republic - Central Region
Most Favorable Wind Resource Areas



Wind Power Classification

Resource Potential: Utility	Resource Potential: Rural	Wind Power Density at 30 m W/m^2	Wind Speed[a] at 30 m m/s
Marginal	Moderate	100 - 200	4.9 - 6.1
Moderate	Good	200 - 300	6.1 - 7.0
Good	Excellent	300 - 400	7.0 - 7.7
Excellent		400 - 600	7.7 - 8.9
		600 - 800	8.9 - 9.8
		800 - 1000	9.8 - 10.5

[a] Wind speeds are based on a Weibull k value of 3.0

The wind resource classification is specific for both utility scale and rural applications and applies to areas with low surface roughness.

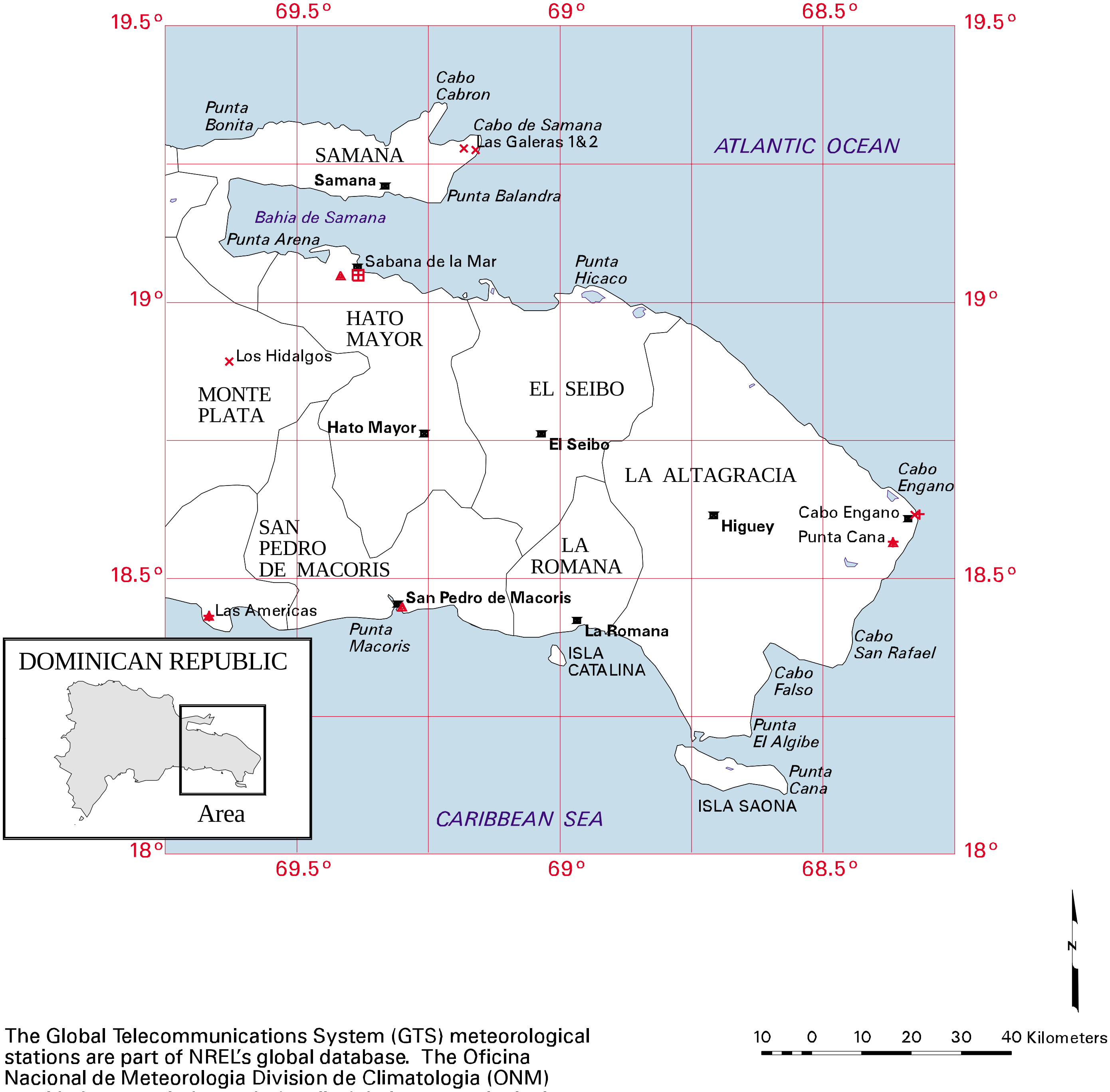
US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-AUG-2001 3.2

Figure 6-11

Dominican Republic - Eastern Region
Political Map



The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The Oficina Nacional de Meteorologia Division de Climatologia (ONM) provided mean wind speeds for all of their meteorological stations. The data for USAID's wind measurement sites were collected in collaboration with NRECA and REGAE/Winrock.

Legend

- × USAID Wind Measurement Site
- ▲ ONM Meteorological Station
- + GTS Surface Meteorological Station with Wind Data
- □ GTS Upper-Air Meteorological Station
- * Additional Wind Measurement Site
- ■ City or **Provincial Capital**

US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-AUG-2001 4.2

Figure 6-12

Dominican Republic - Eastern Region
Elevation Map

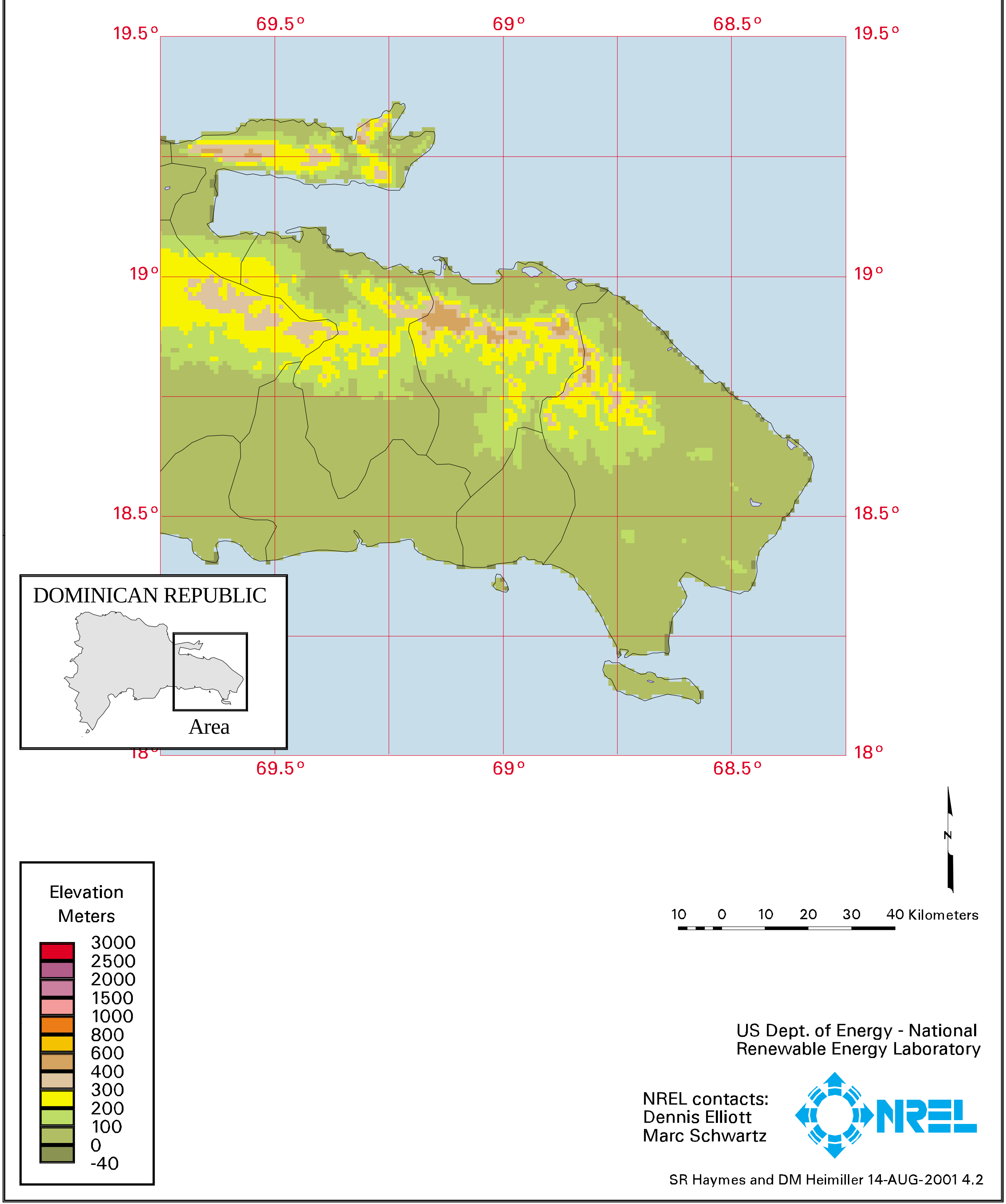
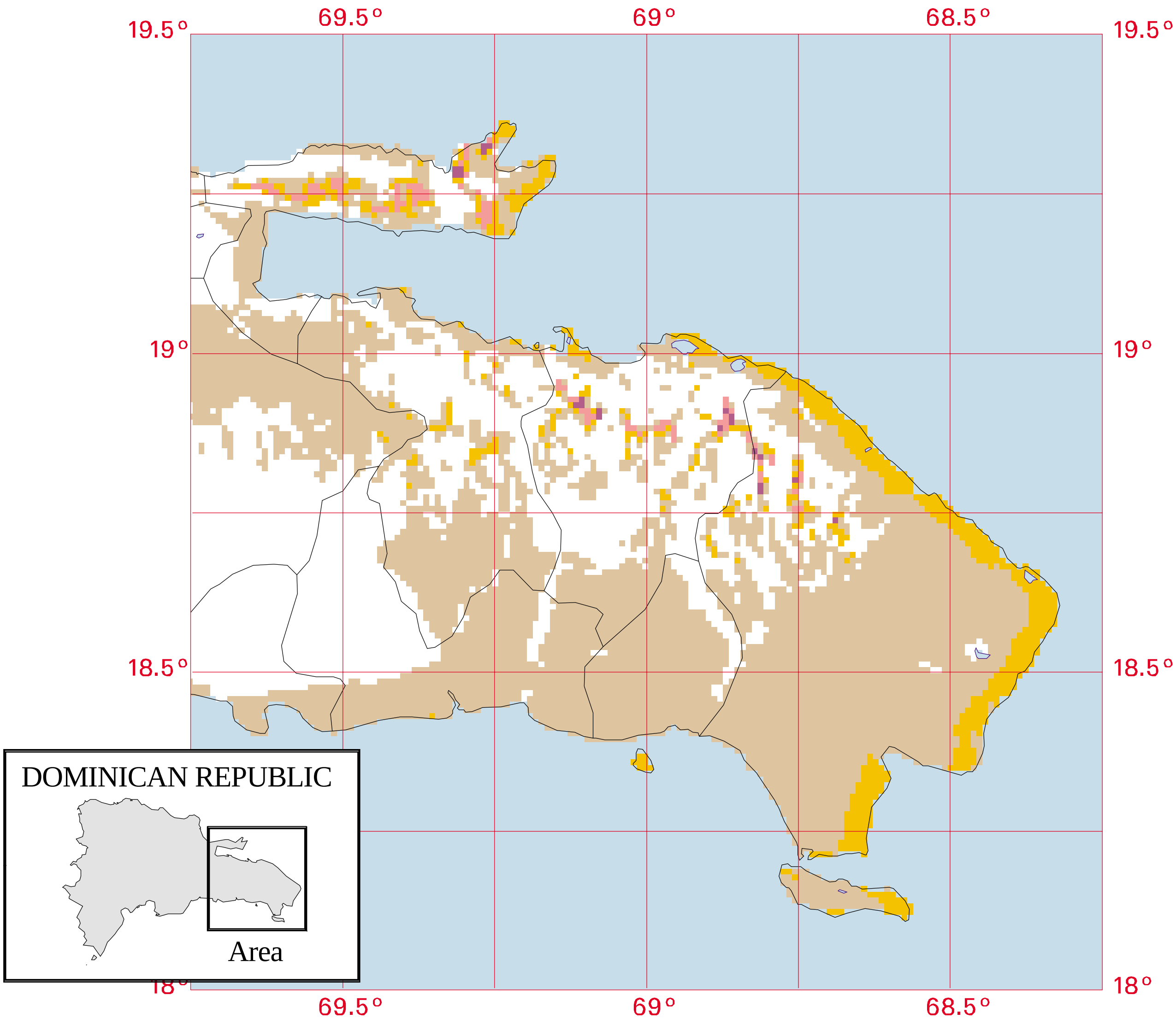


Figure 6-13

Dominican Republic - Eastern Region
Most Favorable Wind Resource Areas



N

10 0 10 20 30 40 Kilometers

Wind Power Classification

Resource Potential: Utility	Resource Potential: Rural	Wind Power Density at 30 m W/m2	Wind Speed [a] at 30 m m/s
Marginal	Moderate	100 - 200	4.9 - 6.1
Moderate	Good	200 - 300	6.1 - 7.0
Good	Excellent	300 - 400	7.0 - 7.7
Excellent		400 - 600	7.7 - 8.9
		600 - 800	8.9 - 9.8
		800 - 1000	9.8 - 10.5

[a] Wind speeds are based on a Weibull k value of 3.0

The wind resource classification is specific for both utility scale and rural applications and applies to areas with low surface roughness.

US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 14-AUG-2001 4.2

Figure 6-14

7.0 Wind Electric Potential

7.1 Introduction

The assumptions and methods for converting the wind resource to wind energy potential are based on those in the report *Renewable Energy Technology Characterizations* (DeMeo and Galdo 1997) and are listed at the bottom of Table 7-1. Each square kilometer on the map has an annual average wind power density, in W/m^2, at a 30-m height. We developed an equation to compute the total net annual energy delivery for each square kilometer of grid cells with an annual average wind power density of 200 W/m^2 or greater. If the wind power density was less than 200 W/m^2, the net energy potential was set equal to zero, because these grid cells have insufficient wind potential for the economic development of utility-scale wind energy. Although the areas with lower wind resource (100-200 W/m^2) are not economic for utility-scale wind and thus have been discounted, these areas have the potential for isolated use of small wind for rural electrification projects. Under another scenario (good-to-excellent resource levels), only grid cells with an annual average wind power of 300 W/m^2 or greater were included.

The wind resource levels in Table 7-1 are consistent with those on the wind resource maps for the Dominican Republic. The numbers in the table represent total net wind-energy potential, and they have not been reduced by factors such as land-use exclusions. The net energy is already reduced by about 15%–20% because of expected losses from downtime, wake effects, and other factors. When the wind energy potential is computed, the wind power density to the turbine-hub-height level is adjusted so the total wind energy potential is not dependent on the height used in our wind resource classification.

7.2 Wind Electric Potential Estimates

We estimate that there are about 1500 km^2 of land areas with good-to-excellent wind resource potential. The proportion of windy land and potential wind capacity in each wind power category is listed in Table 7-1. This windy land represents less than 3% of the total land area (48,442 km^2) of the Dominican Republic. Using conservative assumptions of about 7 MW per km^2, this windy land could support more than 10,000 MW of potential installed capacity, and potentially deliver over 24 billion kilowatt-hours (kWh) per year. Considering only these areas of good-to-excellent wind resource, Figure 7.1 shows there are 20 provinces in the Dominican Republic with at least 100 MW of wind potential and 3 provinces with at least 1000 MW of wind potential. However, additional studies are required to more accurately assess the wind electric potential, considering factors such as the existing transmission grid and accessibility.

If additional areas with moderate wind resource potential (or good for rural power applications) are considered, the estimated total windy land area increases to more than 4400 km^2, or slightly more than 9% of the total land area of the Dominican Republic (see Table 7-1). This windy land could support more than 30,000 MW of potential installed capacity and potentially deliver over 59 billion kWh per year. Figure 7.2 shows that there are 11 provinces with at least 1000 MW of wind potential and all except for three provinces have at least 100 MW of wind potential.

Table 7-1. DOMINICAN REPUBLIC - WIND ELECTRIC POTENTIAL
Moderate-to-Excellent Wind Resource at 30 m (Utility Scale)

Wind Resource Utility Scale	Wind Power (W/m^{2})	Wind Speed (m/s)*	Total Area (km^{2})	Total Capacity Installed (MW)	Total Power (GWh/yr)
Moderate	200–300	6.1–7.0	2,923	20,300	34,700
Good	300–400	7.0–7.7	1,022	7,000	15,600
Excellent	400–600	7.7–8.9	377	2,600	7,100
Excellent	600–800	8.9–9.8	61	400	1,400
Excellent	800–1000	9.8–10.5	22	200	500
Total			4,405	30,500	59,300

Good-to-Excellent Wind Resource at 30 m (Utility Scale)

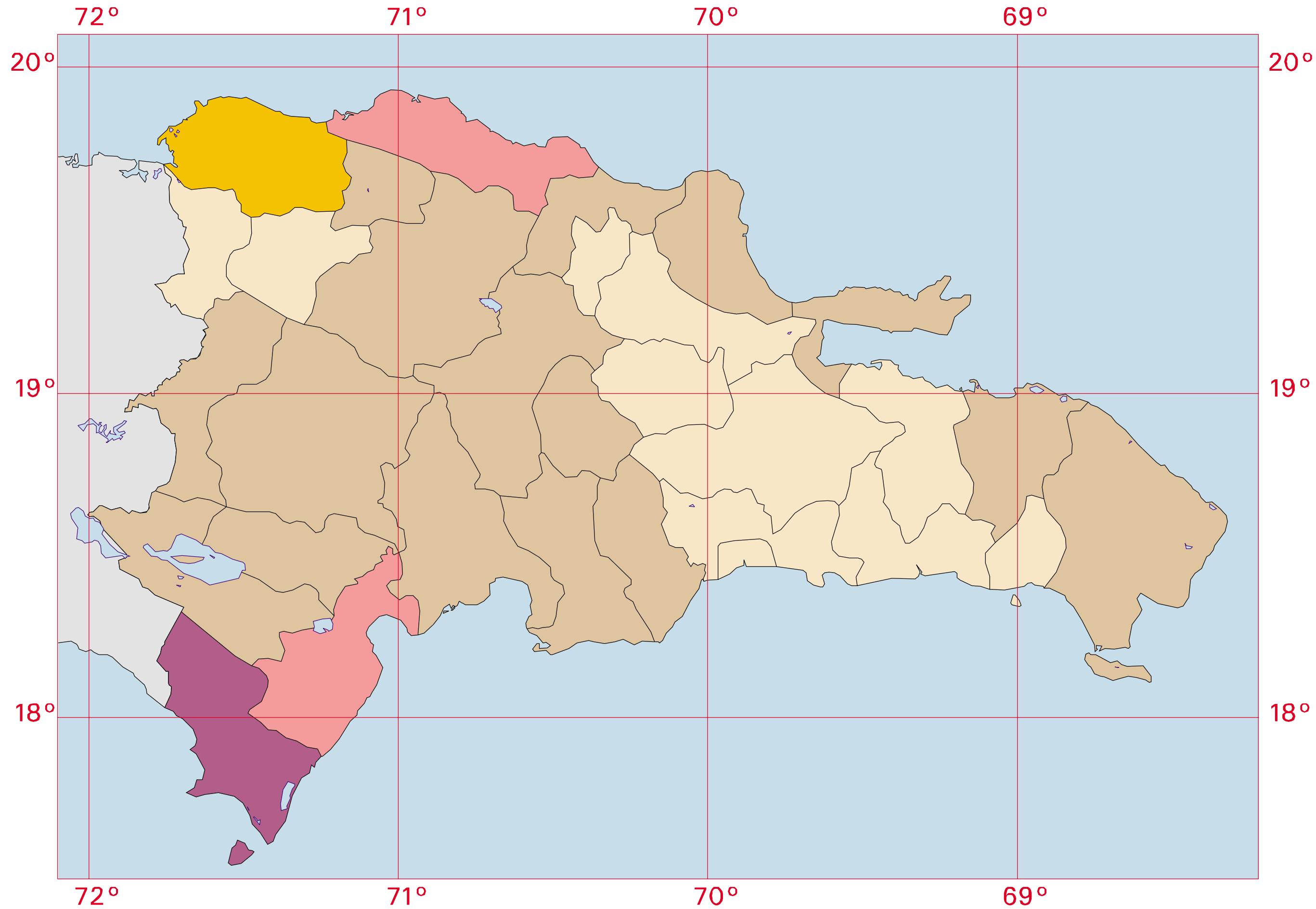
Wind Resource Utility Scale	Wind Power (W/m^{2})	Wind Speed (m/s)*	Total Area (km^{2})	Total Capacity Installed (MW)	Total Power (GWh/yr)
Good	300–400	7.0–7.7	1,022	7,000	15,600
Excellent	400–600	7.7–8.9	377	2,600	7,100
Excellent	600–800	8.9–9.8	61	400	1,400
Excellent	800–1000	9.8–10.5	22	200	500
Total			1,482	10,200	24,600

* Wind speeds are based on a Weibull k value of 3.0.

<u>Assumptions</u>
Turbine Size – 500 kW
Hub Height – 40 m
Rotor Diameter – 38 m
Turbine Spacing – 10D by 5D
Capacity/km^2 – 6.9 MW

Dominican Republic - Wind Electric Potential

Good-to-Excellent Wind Resource (Utility Scale Classification)



Dominican Republic
Total Potential - 10,300 MW

Wind Electric Potential
Megawatts

- < 100
- 100 - 500
- 500 - 1,000
- 1,000 - 2,000
- 2,000 - 3,000
- 3,000 - 5,000

The following assumptions were used in calculating the total potential wind electric capacity installed:

Minimum wind power - 300 W/m^2
Turbine size - 500 kW
Hub height - 40 m
Rotor diameter - 38 m
5D Side-to-side spacing - 190 m
10D Front-to-back spacing - 380 m
Swept area - 1134 m^2
Turbines/km^2 - 13.9
Capacity/km^2 - 6.9 MW

20 10 0 20 40 60 80 100 Kilometers

N

US Dept. of Energy - National Renewable Energy Laboratory

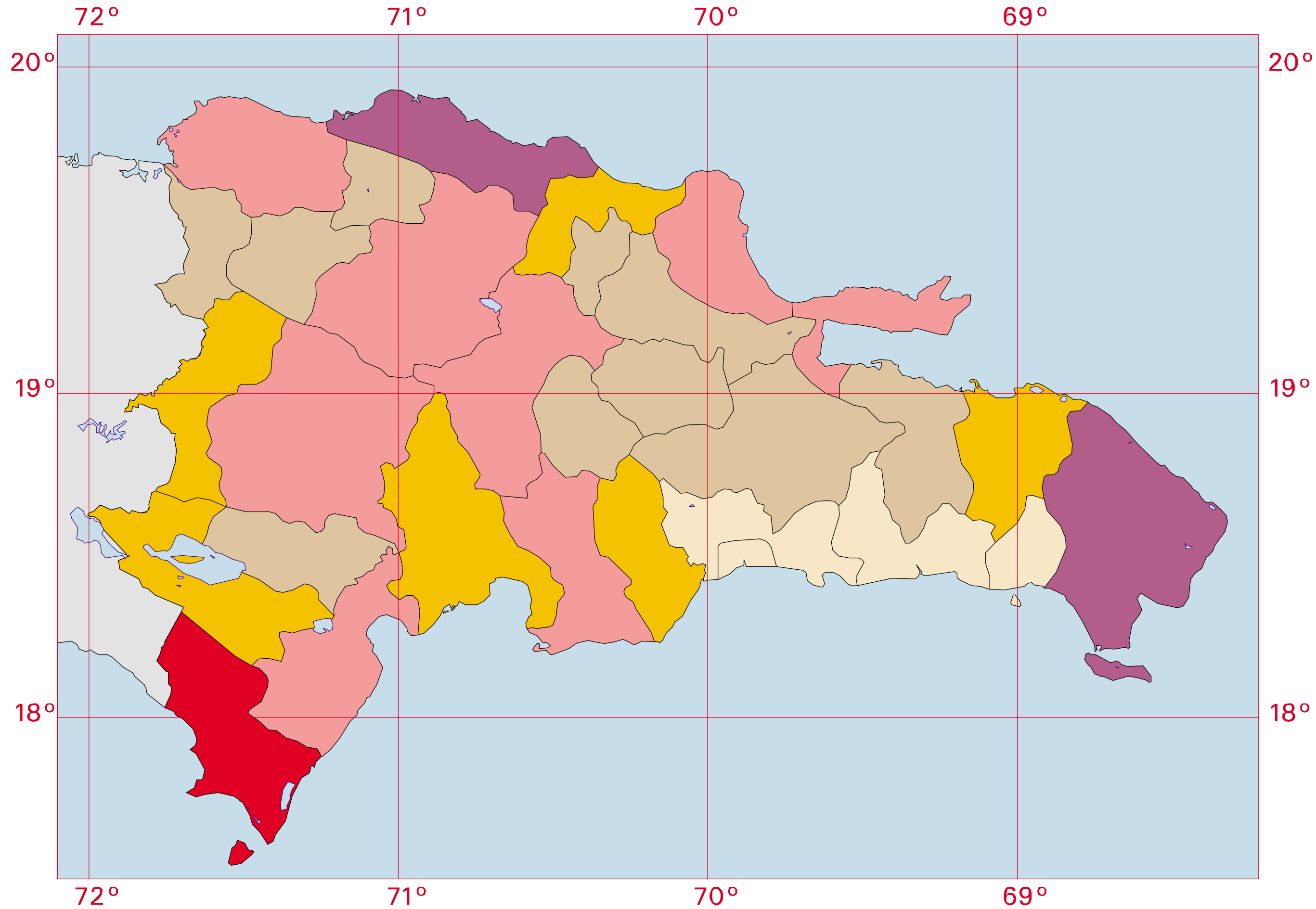
NREL contacts:
Dennis Elliott
Marc Schwartz

SR Haymes and DM Heimiller 09-JUN-1999 5.4

Figure 7-1

Dominican Republic - Wind Electric Potential

Moderate-to-Excellent Wind Resource (Utility Scale Classification)



Dominican Republic
Total Potential - 30,500 MW

Wind Electric Potential
Megawatts

- < 100
- 100 - 500
- 500 - 1,000
- 1,000 - 2,000
- 2,000 - 3,000
- 3,000 - 5,000

The following assumptions were used in calculating the total potential wind electric capacity installed:

Minimum wind power - 200 W/m^2
Turbine size - 500 kW
Hub height - 40 m
Rotor diameter - 38 m
5D Side-to-side spacing - 190 m
10D Front-to-back spacing - 380 m
Swept area - 1134 m^2
Turbines/km^2 - 13.9
Capacity/km^2 - 6.9 MW

20 10 0 20 40 60 80 100 Kilometers

US Dept. of Energy - National Renewable Energy Laboratory

NREL contacts:
Dennis Elliott
Marc Schwartz

NREL

SR Haymes and DM Heimiller 09-JUN-1999 5.3

Figure 7-2

References

Acosta, J.R.; Llenas, A. (October 1983). *Evaluacion de los Recursos Solar y Eolico en la Republica Dominicana*. Comision Nacional de Political Energetica (COENER). 228 pp.

DeMeo, E.A.; Galdo, J.F. (1997). *Renewable Energy Technology Characterizations*. Office of Utility Technologies, Energy Efficiency and Renewable Energy, U.S. Department of Energy, Washington, D.C.

Elliott, D.L. (2000) "Philippines Wind Energy Resource Atlas Development", NREL/CP-500-28903. Golden, CO: National Renewable Energy Laboratory.

Elliott, D.L.; Aspliden, C.I.; Gower, G.L.; Holladay, C.G.; Schwartz, M.N. (April 1987). *Wind Energy Resource Assessment of the Caribbean and Central America.* Richland, WA: Pacific Northwest Laboratory. 115 pp.

Elliott, D.L.; Chadraa, B.; Natsagdorj, L. (1998). "Mongolia Wind Resource Assessment Project." NREL/CP-500-25148. Golden, CO: National Renewable Energy Laboratory.

Elliott, D.L.; Holladay, C.G.; Barchet, W.R.; Foote, H.P.; Sandusky, W.F. (1987). *Wind Energy Resource Atlas of the United States.* Golden, CO: Solar Energy Research Institute.

Elliott, D.; Schwartz, M.; Nierenberg, R. (1999). "Wind Resource Mapping of the State of Vermont." NREL/CP-500-27507. Golden, CO: National Renewable Energy Laboratory.

IT Power. (February 1987). *Renewable Energy Market Survey: The Dominican Republic*. Prepared for the United States Export Council for Renewable Energy.

Rohatgi, J.S.; Nelson, V. (1994). *Wind Characteristics: An Analysis For The Generation of Wind Power*. Alternative Energy Institute, West Texas A&M University, Canyon, Texas, 239 pp.

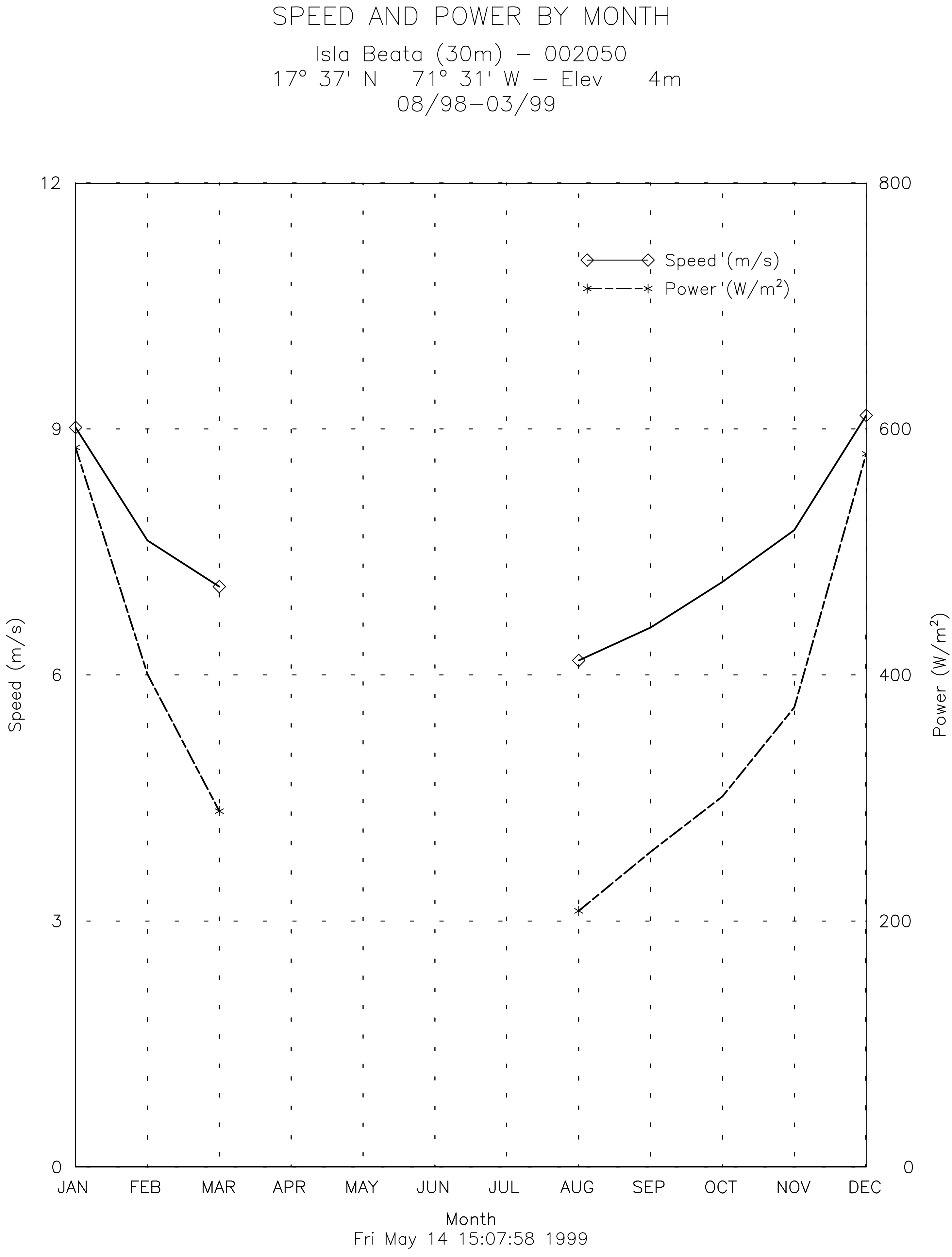
Schwartz, M.N. (1999). "Wind Resource Estimation and Mapping at the National Renewable Energy Laboratory."NREL/CP-500-26245, Golden, CO: National Renewable Energy Laboratory.

Schwartz, M.N.; Elliott, D.L. (1997). "The Integration of Climatic Data Sets for Wind Resource Assessment." *Preprints, 10th Conference on Applied Climatology,* Reno, Nevada, pp. 368-372.

Appendix A

USAID Wind Measurement Sites - Data Summaries

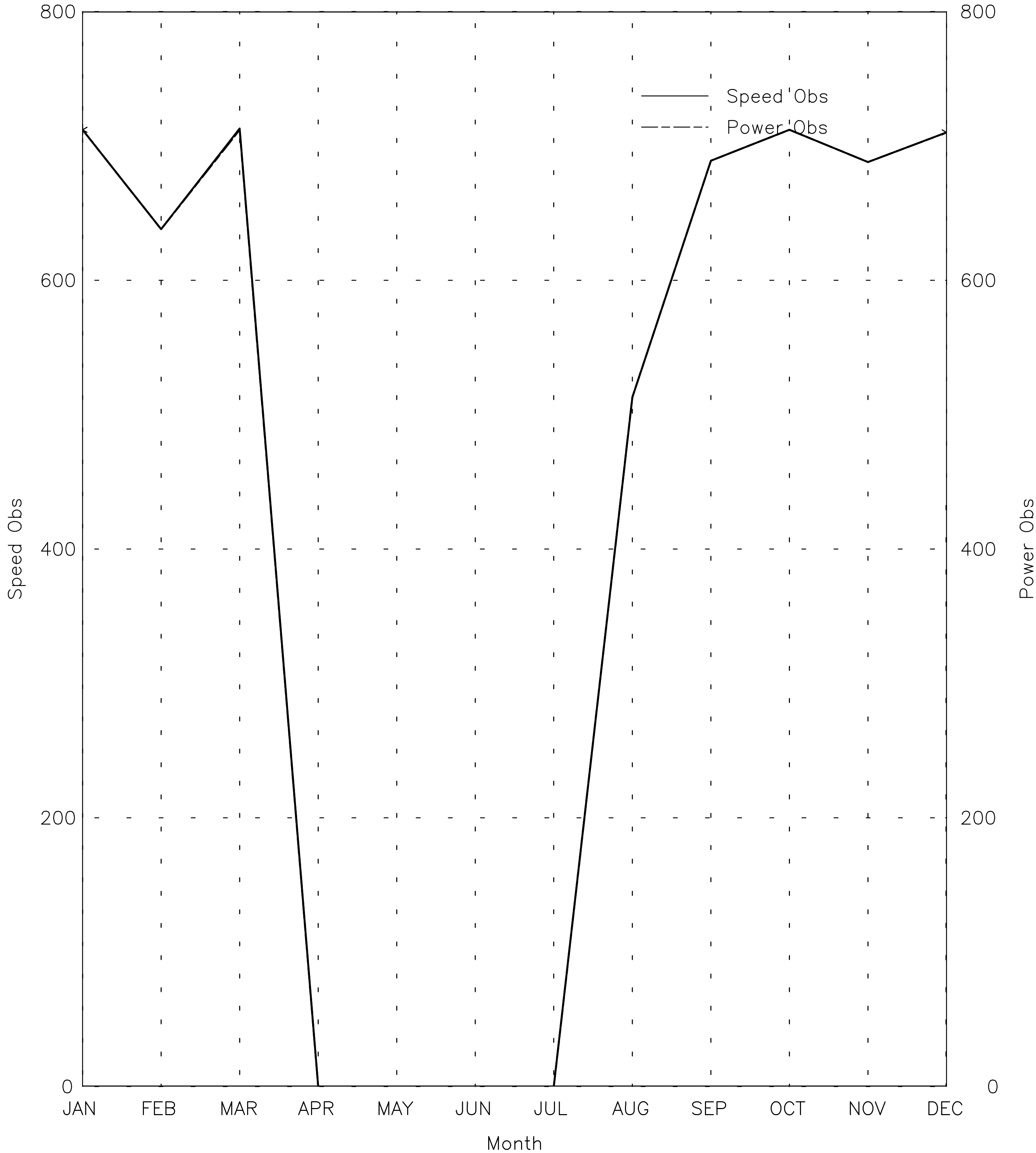
Isla Beata
Las Mercedes
Nueva Rosa
Oviedo
Botoncillos
Guzmancitos
La Loma
Blanco Arriba
Los Cacaos
Los Hidalgos
Emisora
Cabo Engaño
Las Galeras 1
Las Galeras 2



SPEED AND POWER BY MONTH
Isla Beata (30m) - 002050
17° 37' N 71° 31' W - Elev 4m
08/98-03/99
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Fri May 14 15:07:58 1999

OBSERVATIONS BY MONTH

Isla Beata (30m) - 002050
17° 37' N   71° 31' W - Elev   4m
08/98-03/99



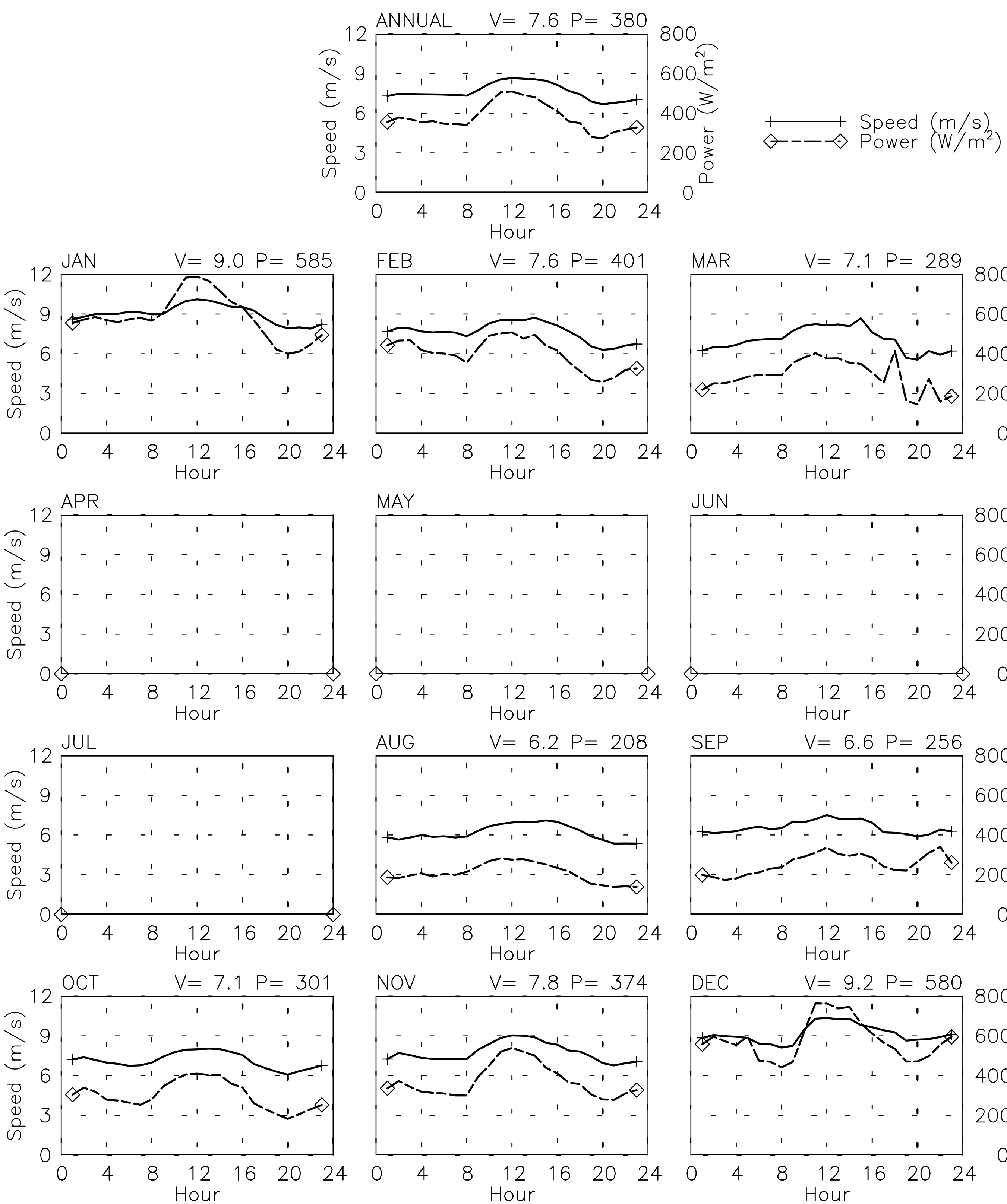
Fri May 14 15:08:00 1999

SPEED AND POWER BY HOUR

Isla Beata (30m) - 002050

17° 37' N 71° 31' W - Elev 4m

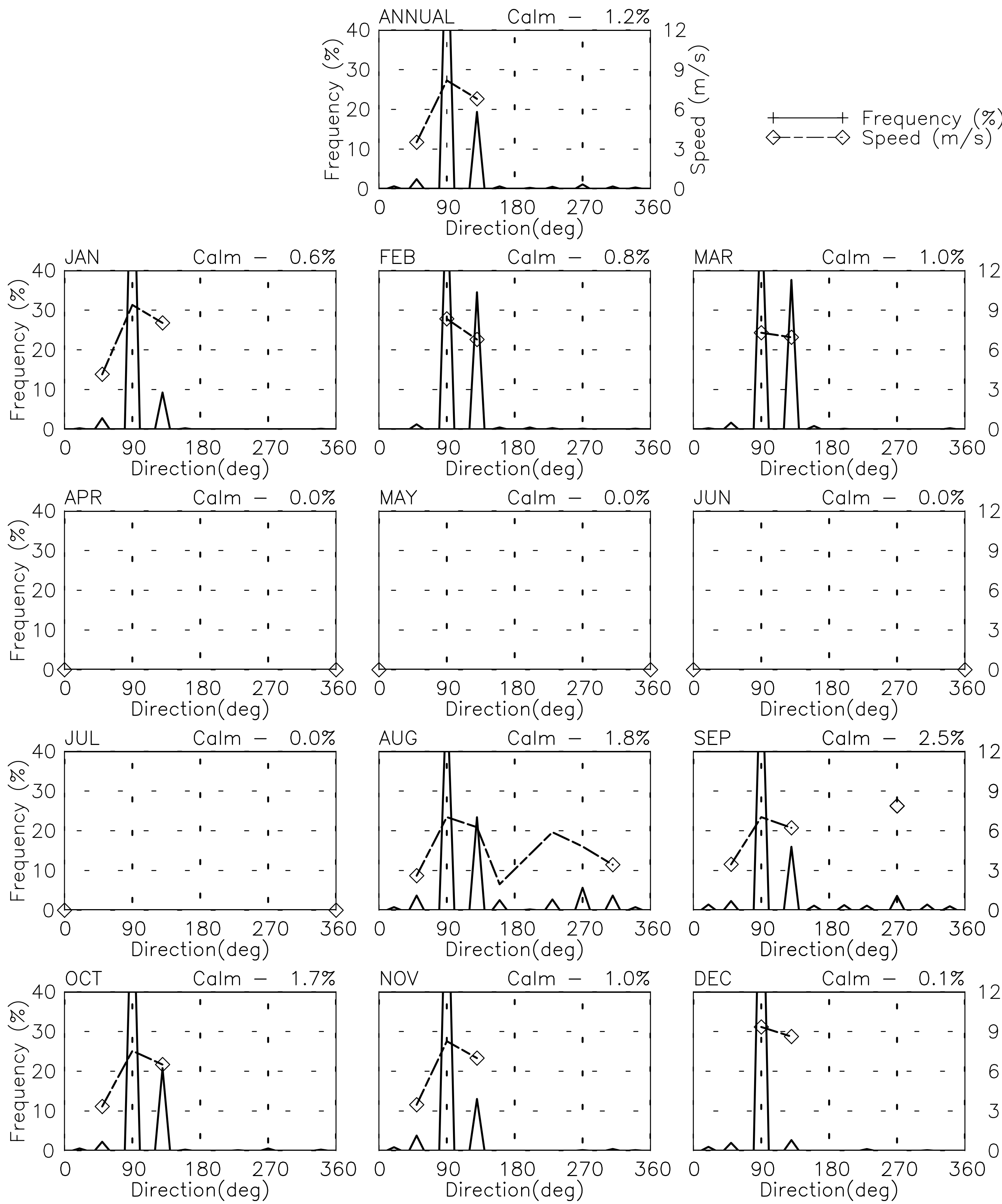
08/98-03/99



Fri May 14 15:08:02 1999

FREQUENCY AND SPEED BY DIRECTION

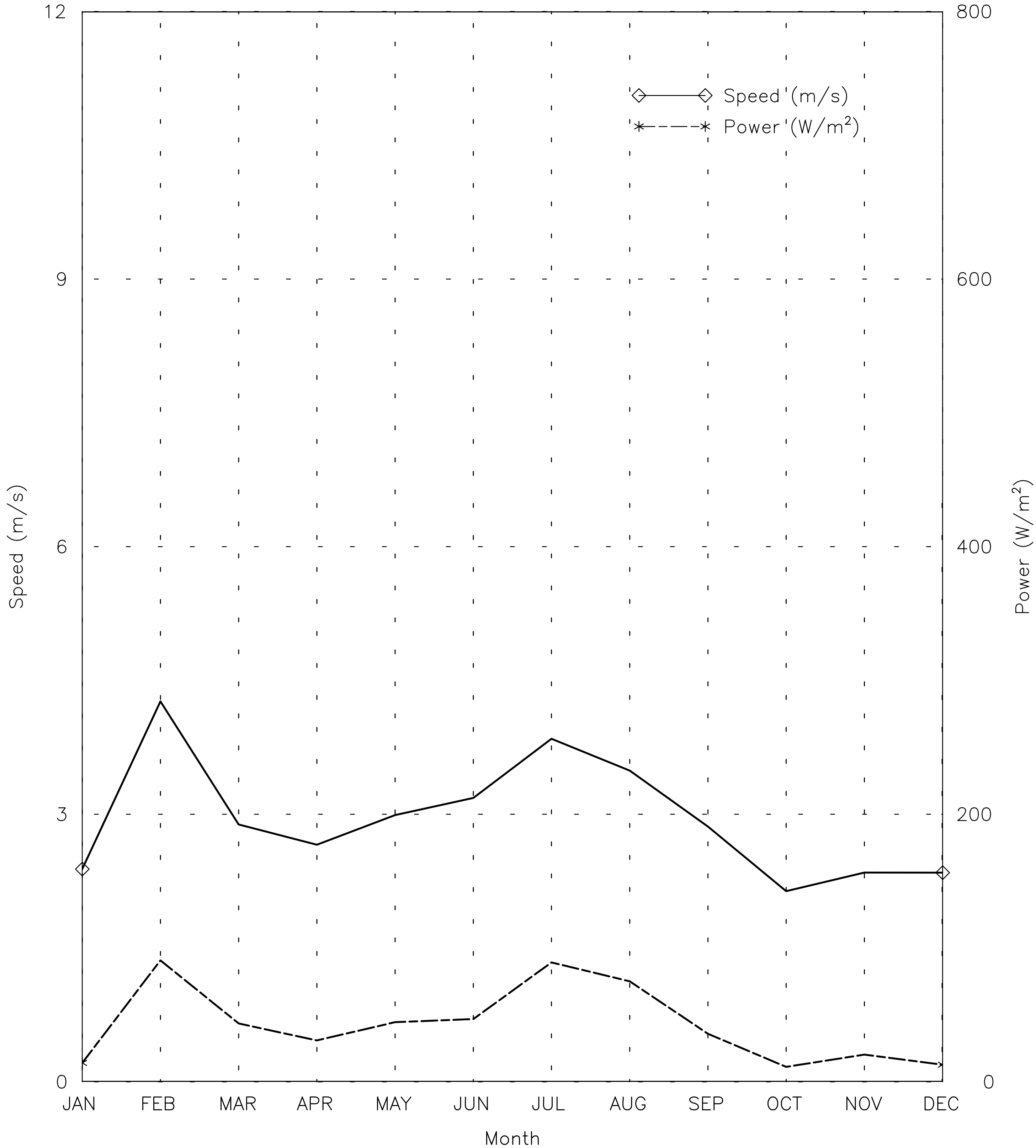
Isla Beata (30m) – 002050
17° 37' N 71° 31' W – Elev 4m
08/98–03/99



Fri May 14 15:08:05 1999

SPEED AND POWER BY MONTH

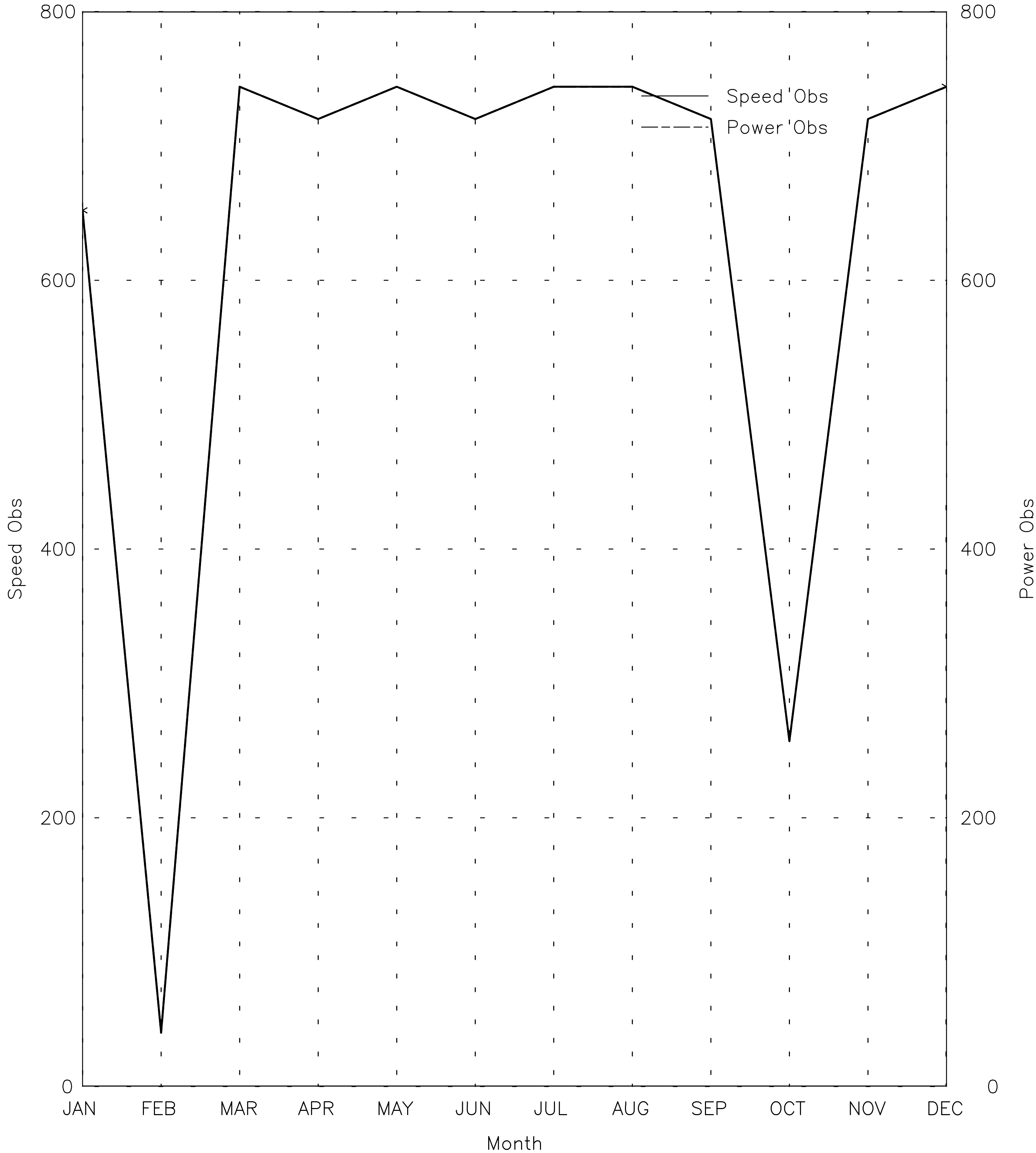
Las Mercedes (30m) - 002002
18° 05' N   71° 40' W - Elev 416m
10/96-10/97



Fri May 14 15:05:25 1999

OBSERVATIONS BY MONTH

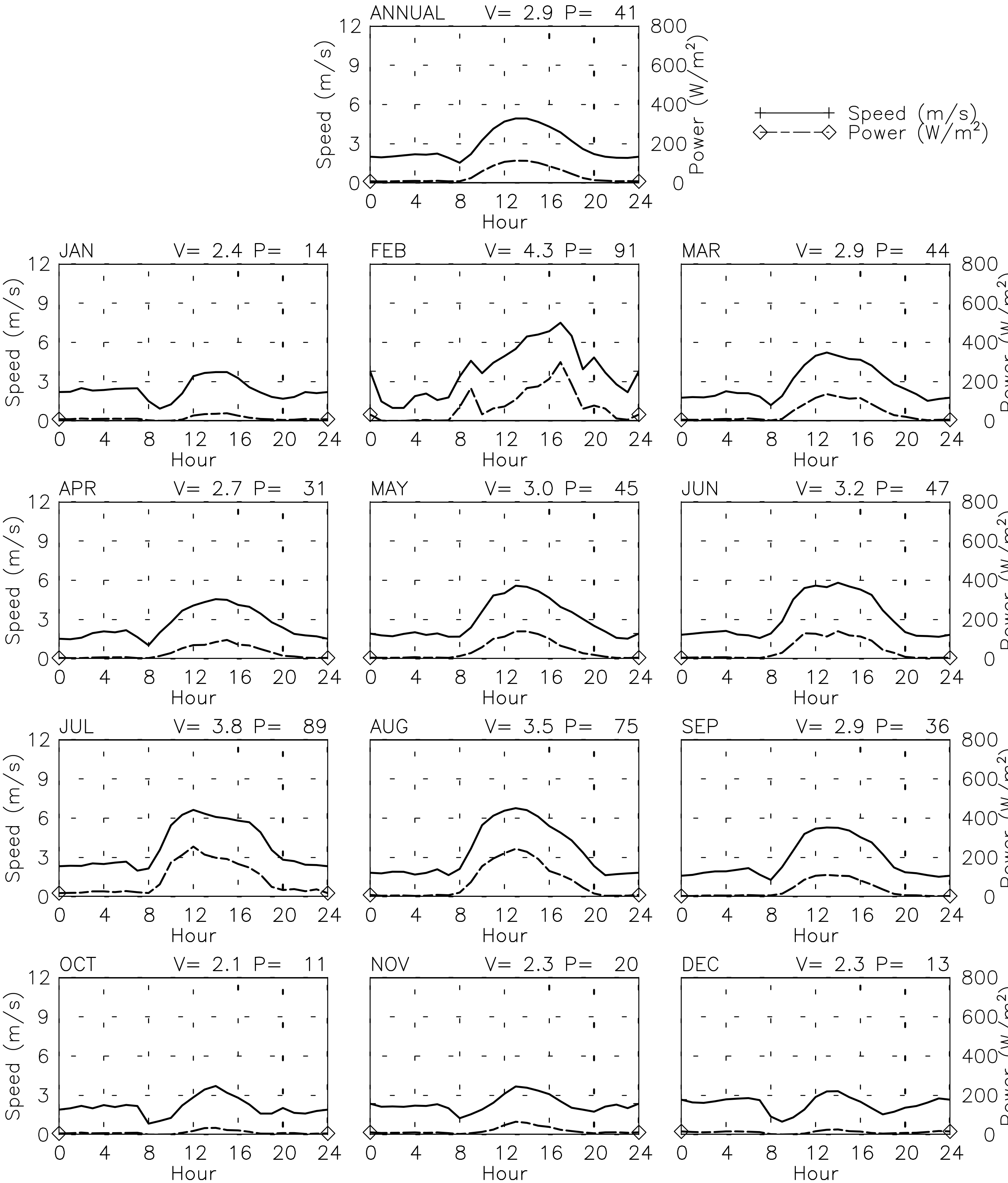
Las Mercedes (30m) - 002002
18° 05' N 71° 40' W - Elev 416m
10/96-10/97



Fri May 14 15:05:26 1999

SPEED AND POWER BY HOUR

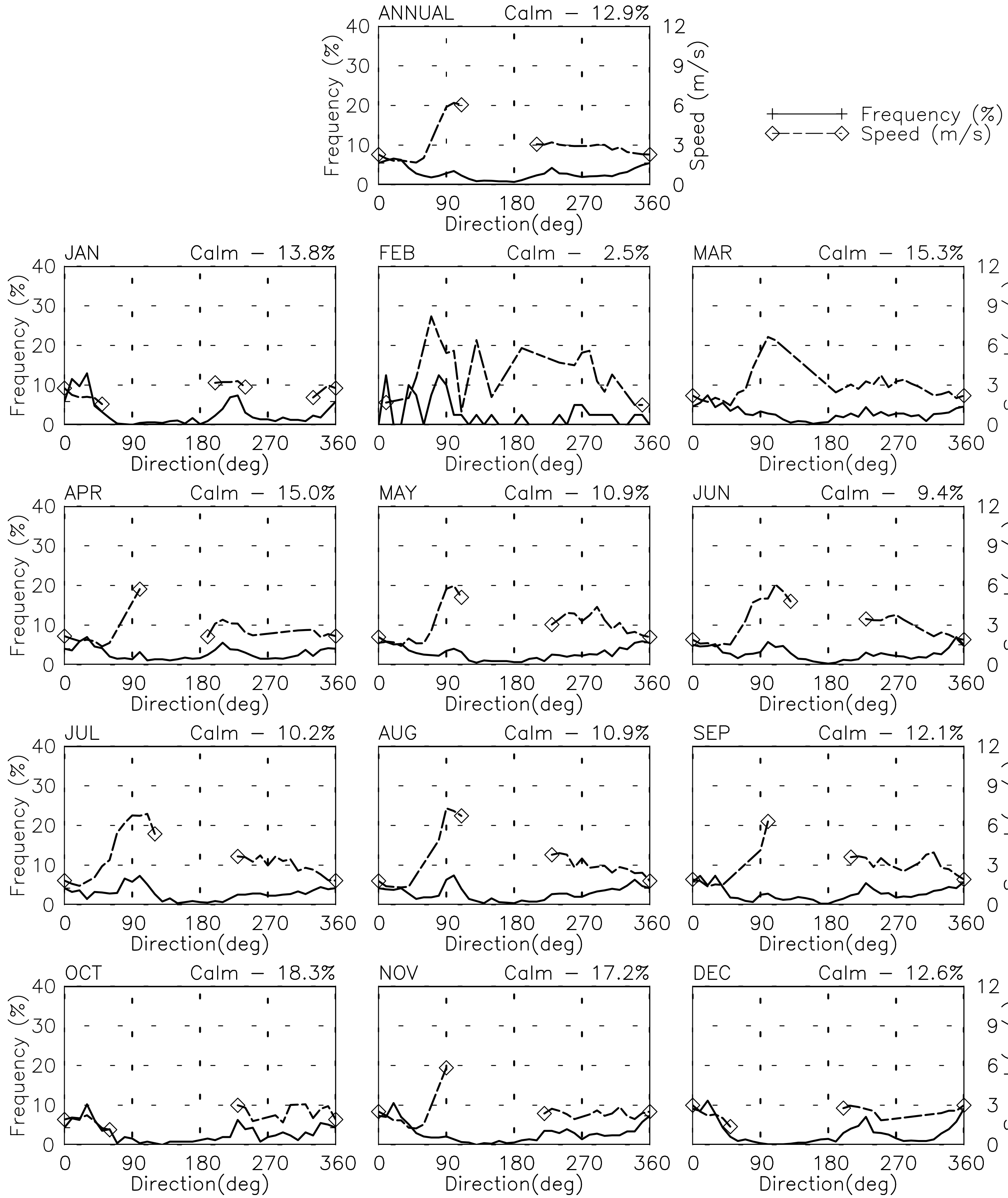
Las Mercedes (30m) – 002002
18° 05' N   71° 40' W – Elev 416m
10/96–10/97



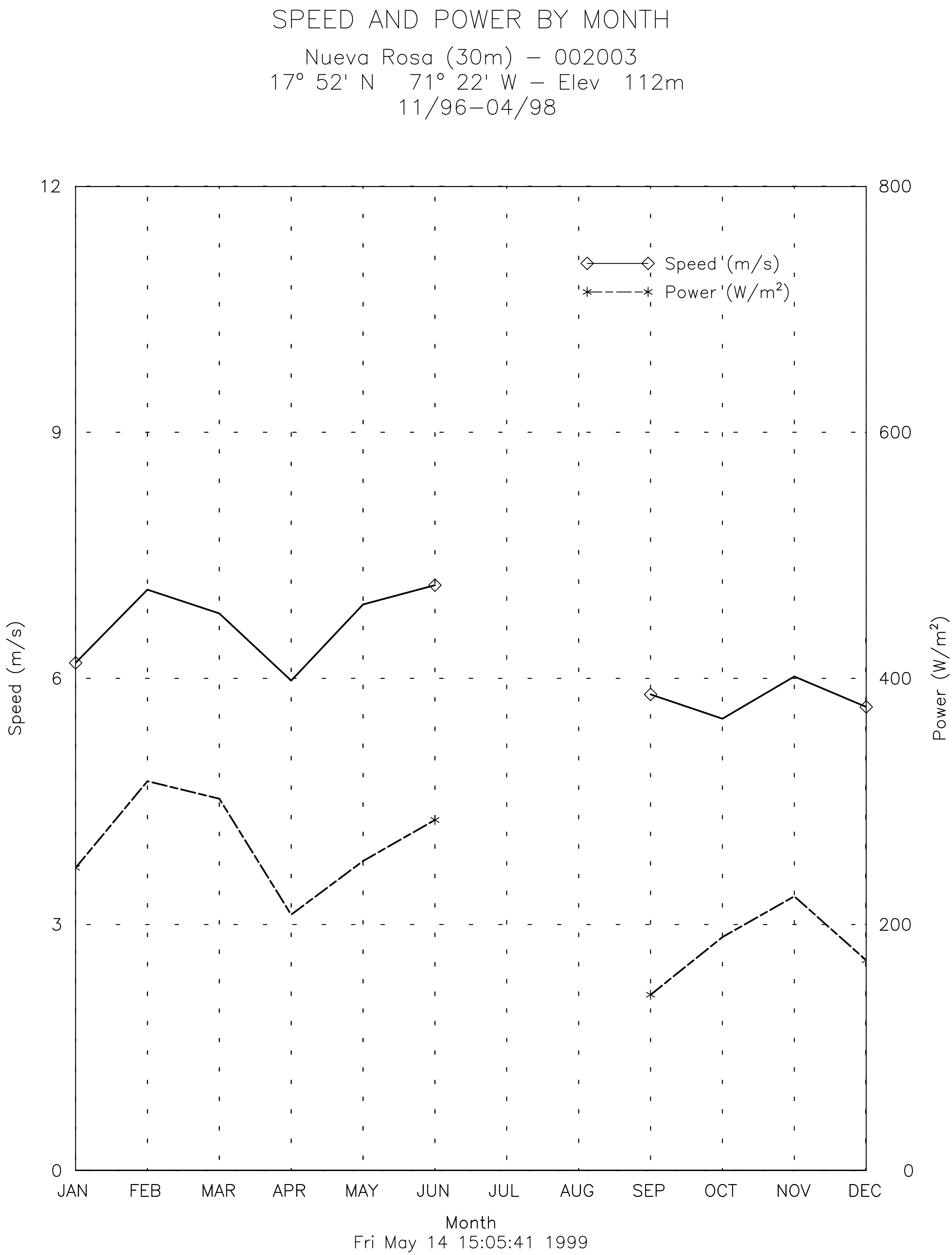
Fri May 14 15:05:28 1999

FREQUENCY AND SPEED BY DIRECTION

Las Mercedes (30m) – 002002
18° 05' N   71° 40' W – Elev 416m
10/96–10/97

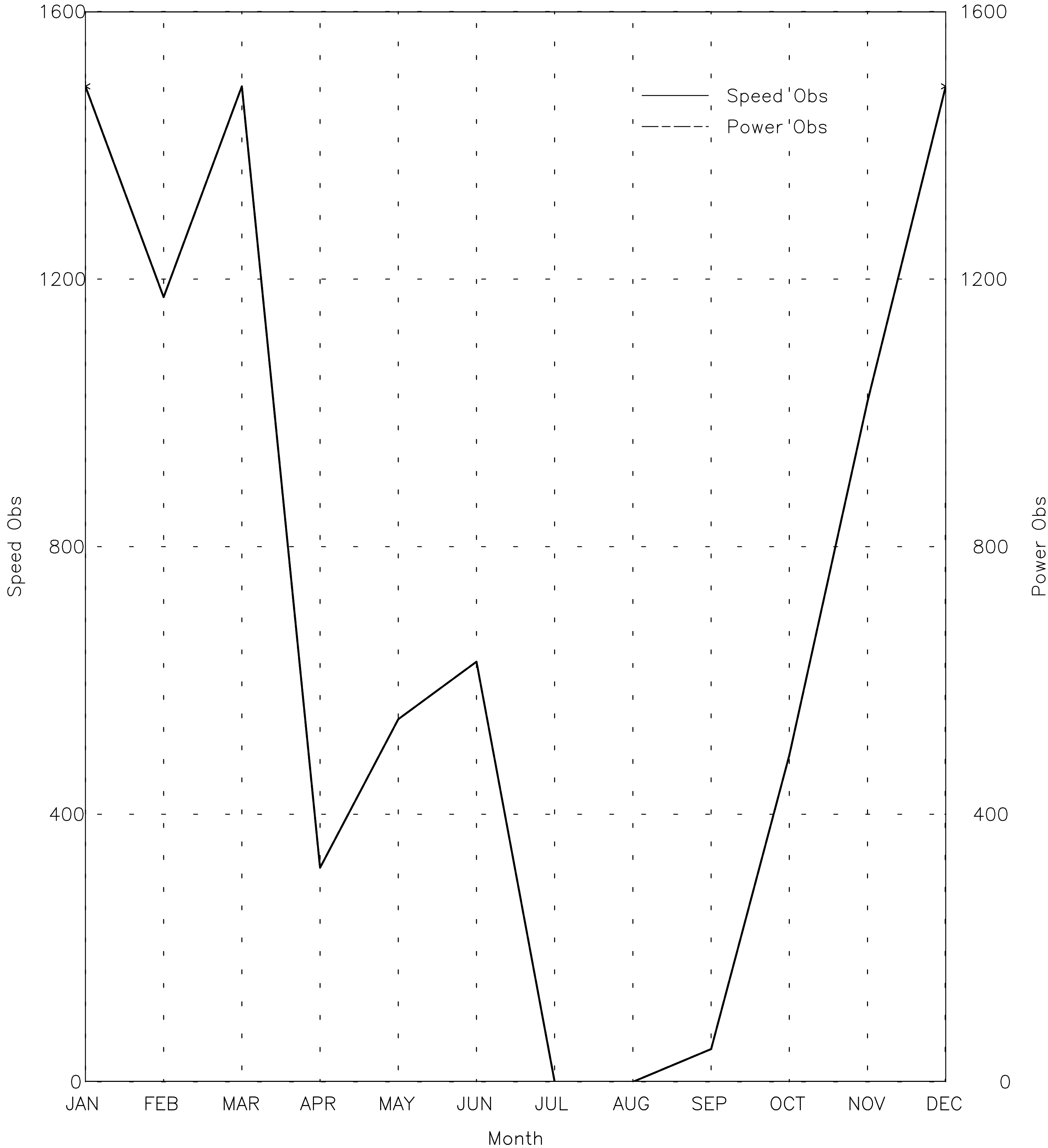


Fri May 14 15:05:32 1999


SPEED AND POWER BY MONTH
Nueva Rosa (30m) – 002003
17° 52' N 71° 22' W – Elev 112m
11/96–04/98
Speed (m/s)
Power (W/m²)
Month
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0 3 6 9 12
0 200 400 600 800
Fri May 14 15:05:41 1999

OBSERVATIONS BY MONTH

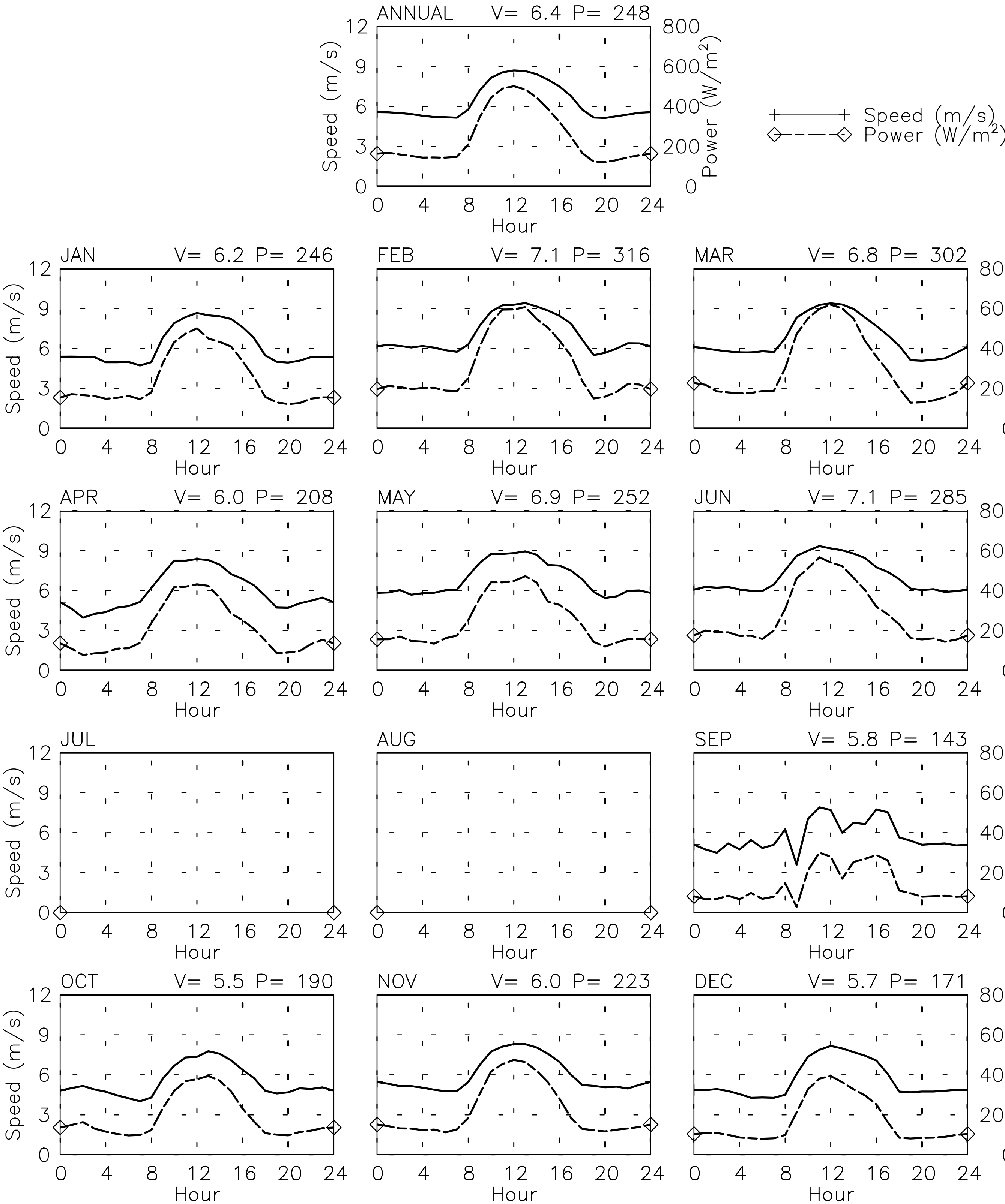
Nueva Rosa (30m) – 002003
17° 52' N   71° 22' W – Elev 112m
11/96–04/98



Fri May 14 15:05:43 1999

SPEED AND POWER BY HOUR

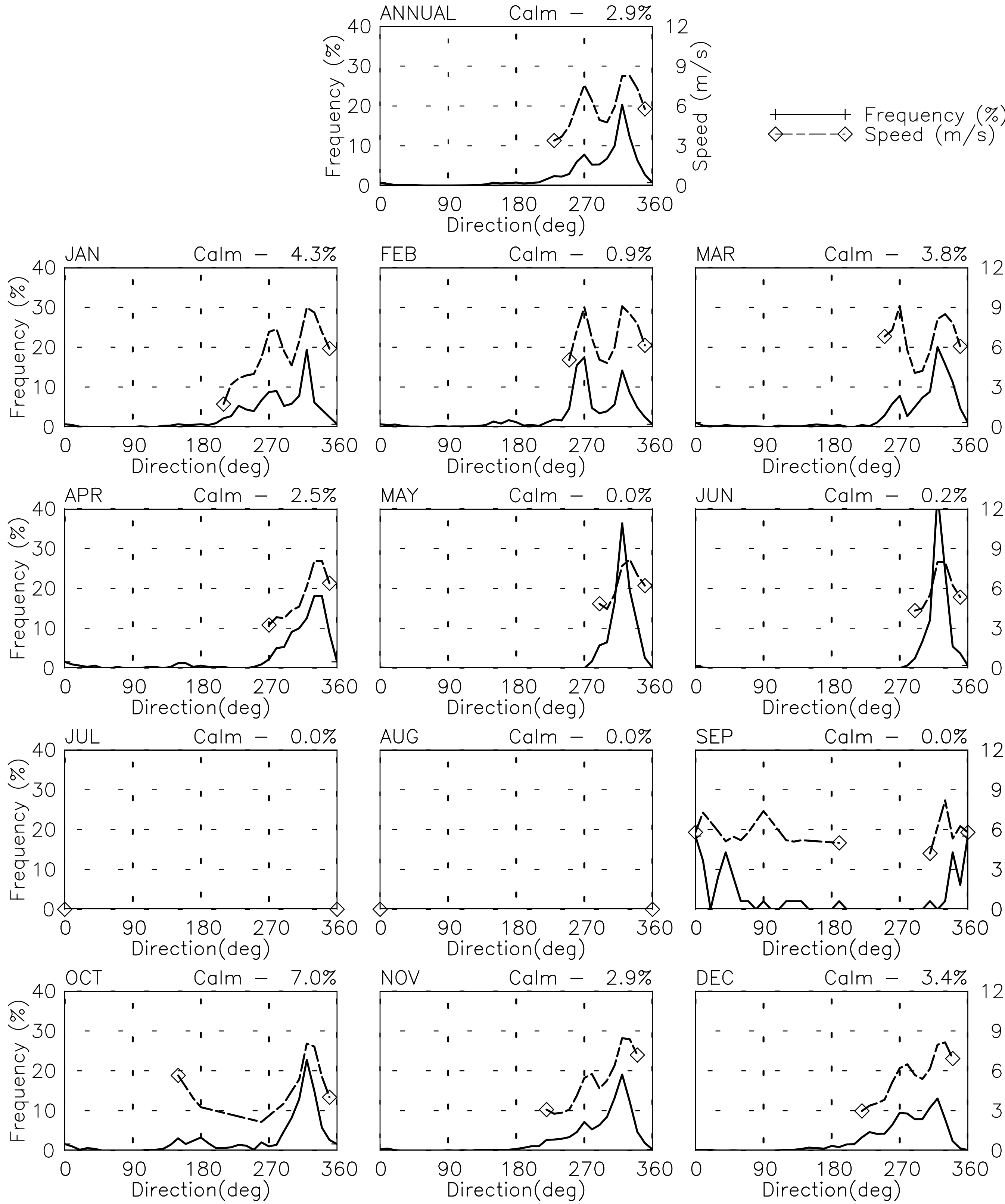
Nueva Rosa (30m) – 002003
17° 52' N 71° 22' W – Elev 112m
11/96–04/98



Fri May 14 15:05:44 1999

FREQUENCY AND SPEED BY DIRECTION

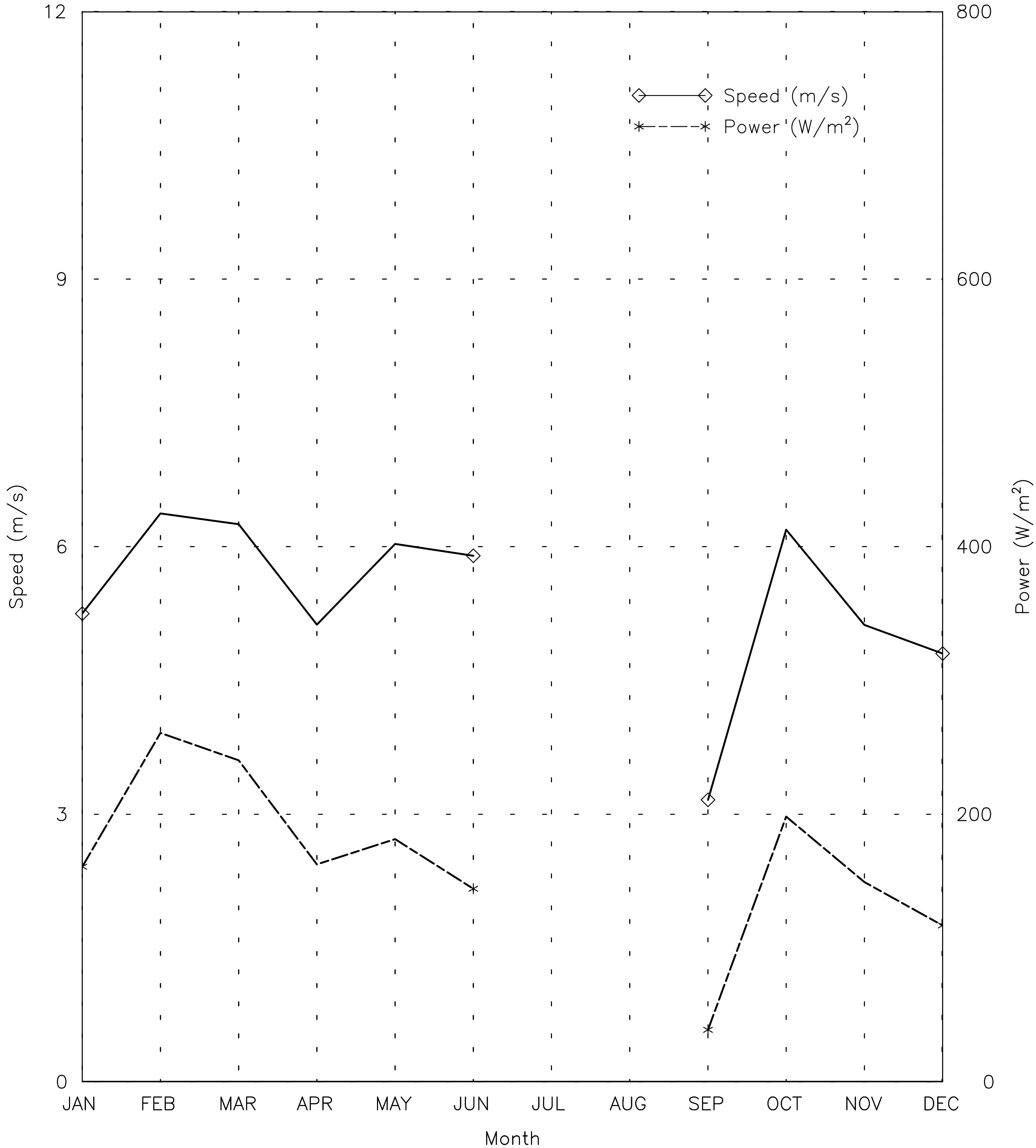
Nueva Rosa (30m) – 002003
17° 52' N 71° 22' W – Elev 112m
11/96–04/98



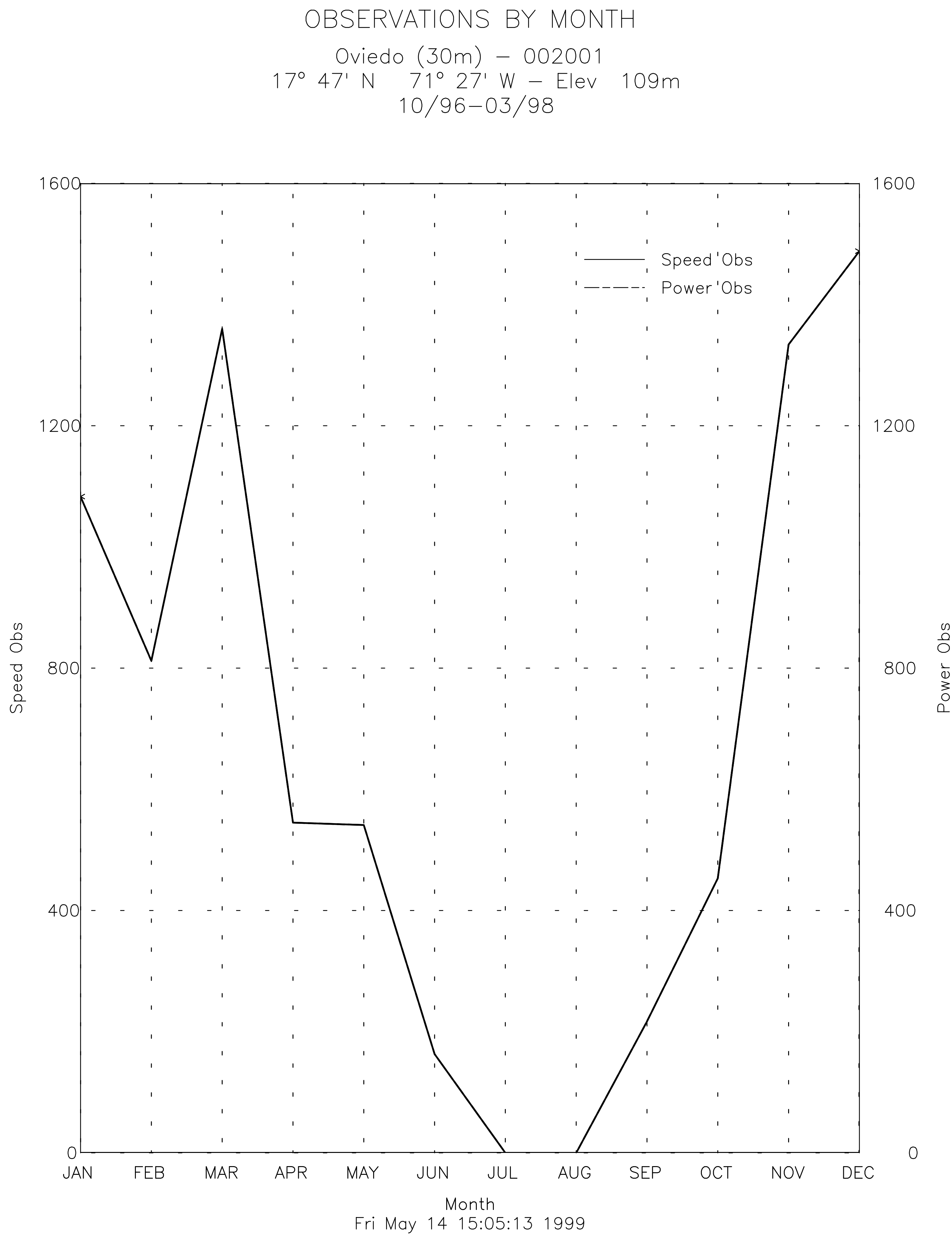
Fri May 14 15:05:48 1999

SPEED AND POWER BY MONTH

Oviedo (30m) - 002001
17° 47' N 71° 27' W - Elev 109m
10/96-03/98



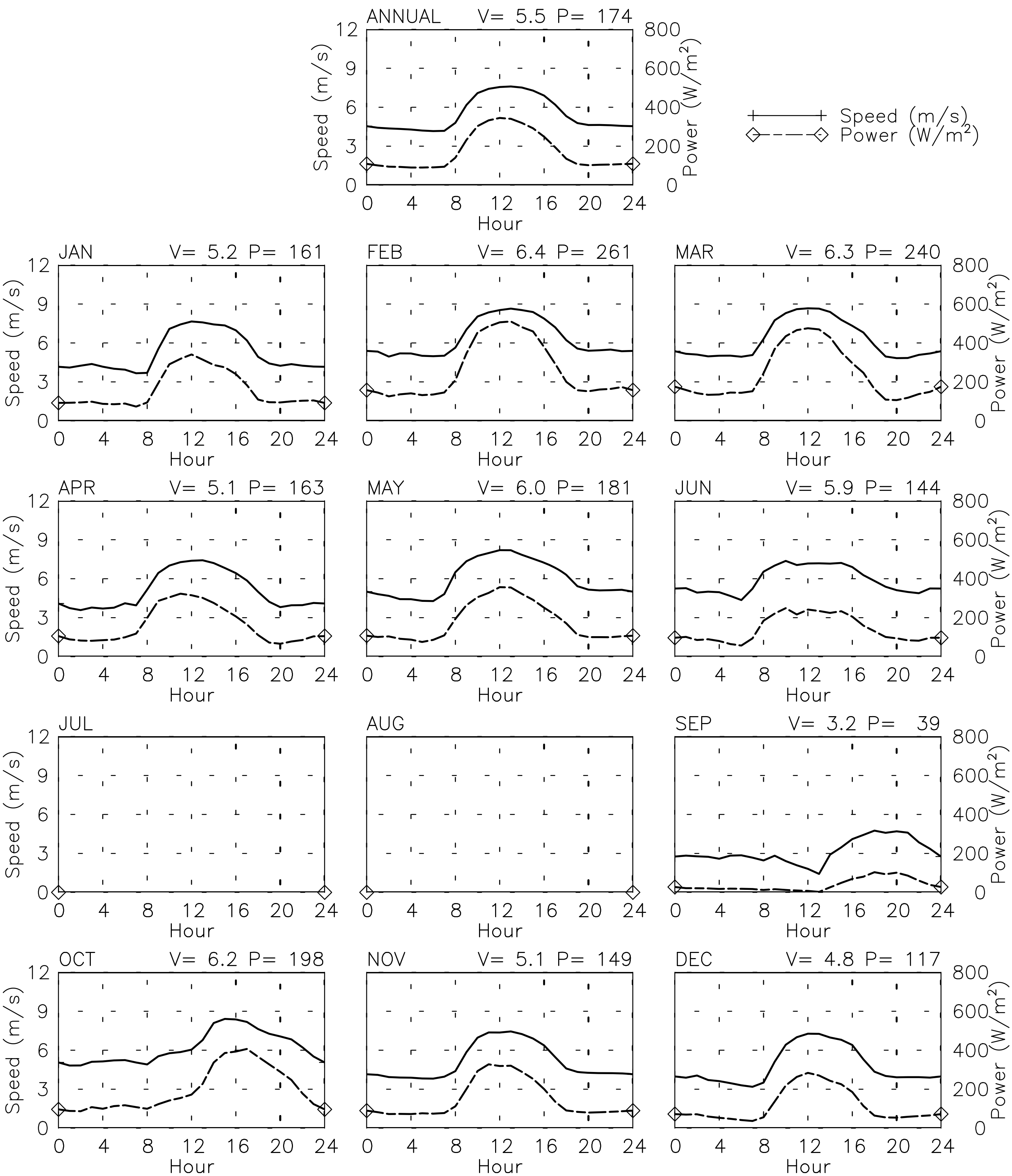
Fri May 14 15:05:11 1999



OBSERVATIONS BY MONTH
Oviedo (30m) - 002001
17° 47' N 71° 27' W - Elev 109m
10/96-03/98
Speed'Obs
Power'Obs
Speed Obs
Power Obs
1600
1200
800
400
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Fri May 14 15:05:13 1999

SPEED AND POWER BY HOUR

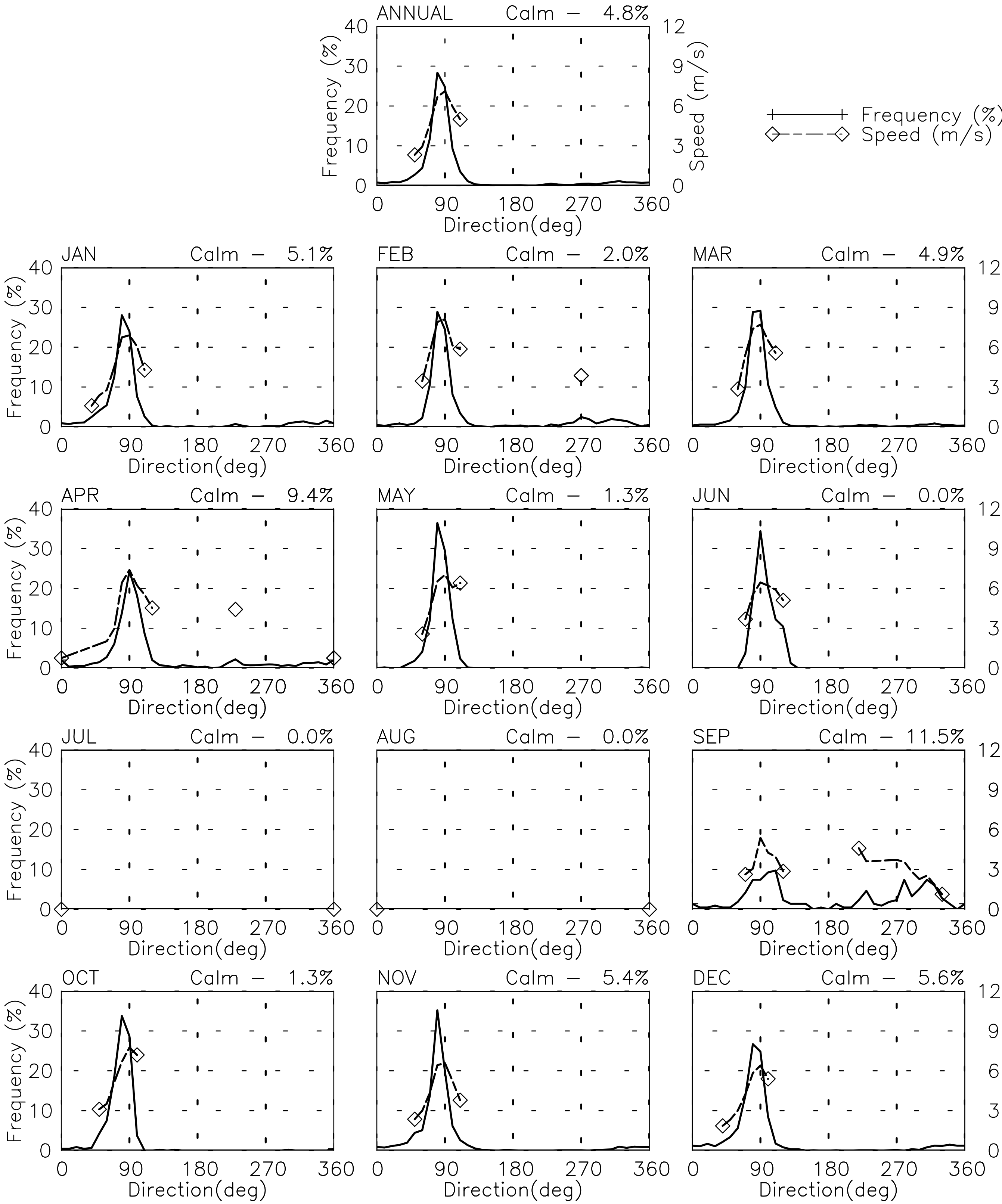
Oviedo (30m) – 002001
17° 47' N 71° 27' W – Elev 109m
10/96–03/98



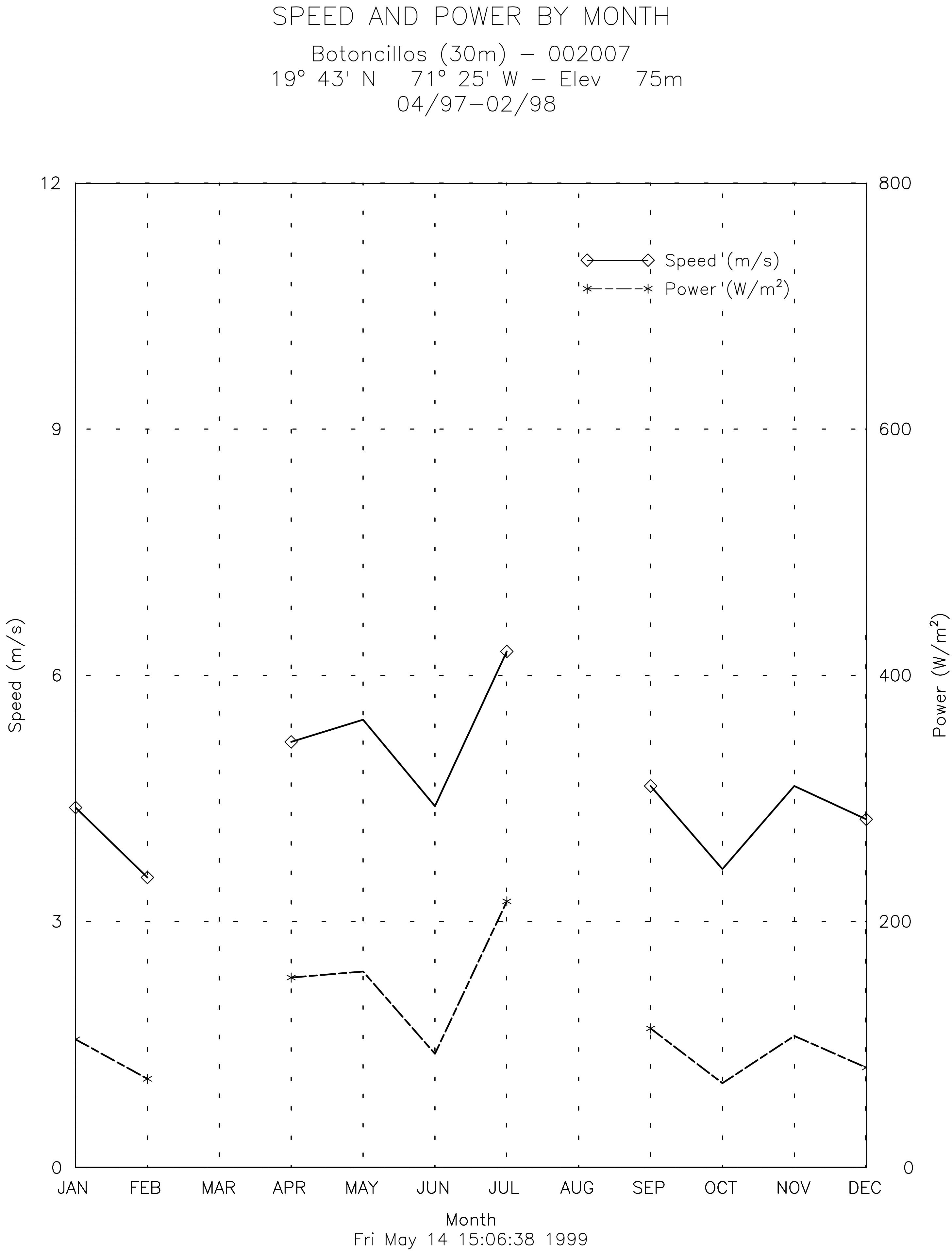
Fri May 14 15:05:15 1999

FREQUENCY AND SPEED BY DIRECTION

Oviedo (30m) – 002001
17° 47' N 71° 27' W – Elev 109m
10/96–03/98

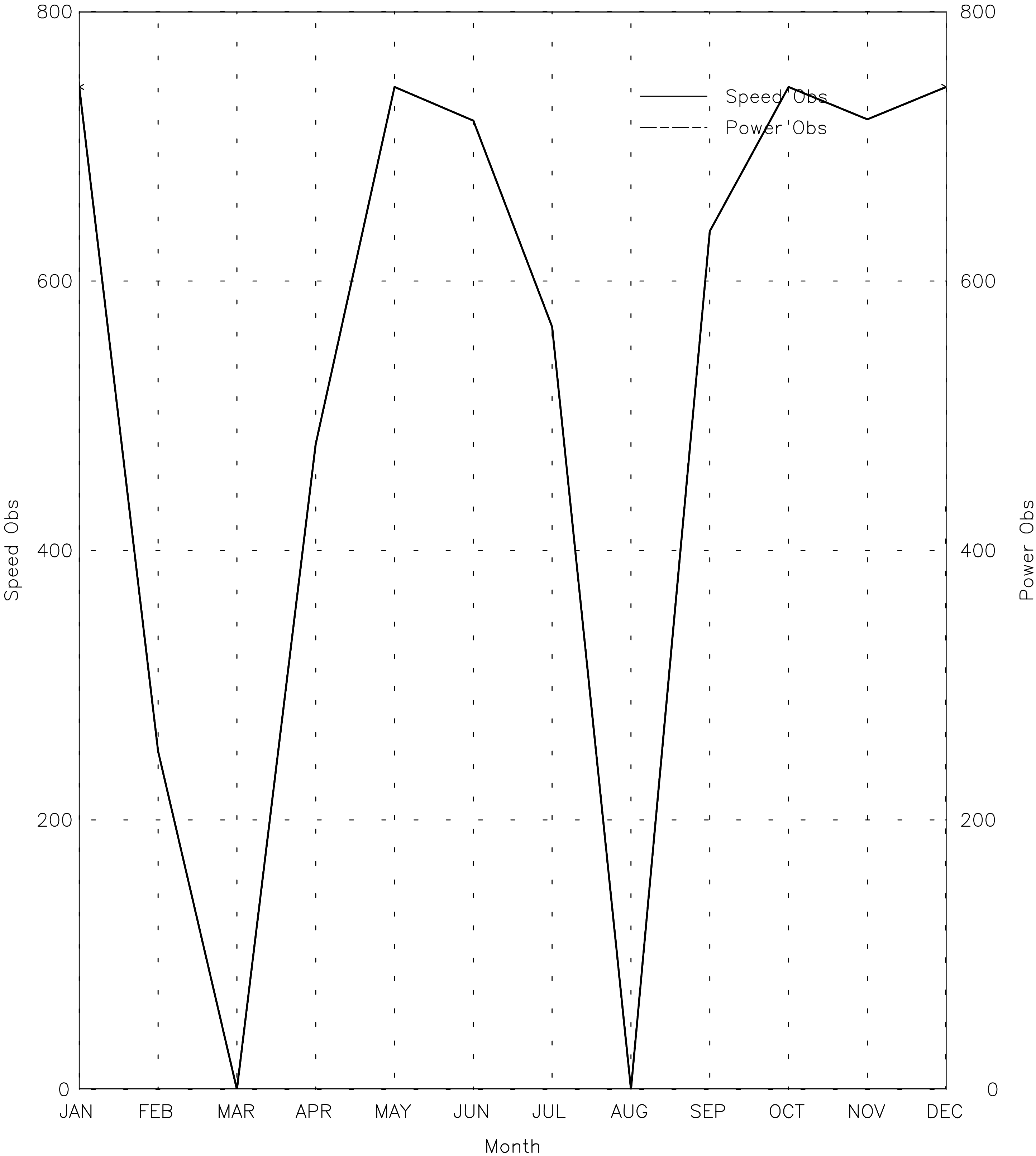


Fri May 14 15:05:18 1999


SPEED AND POWER BY MONTH
Botoncillos (30m) - 002007
19° 43' N 71° 25' W - Elev 75m
04/97-02/98
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Fri May 14 15:06:38 1999

OBSERVATIONS BY MONTH

Botoncillos (30m) – 002007
19° 43' N 71° 25' W – Elev 75m
04/97–02/98



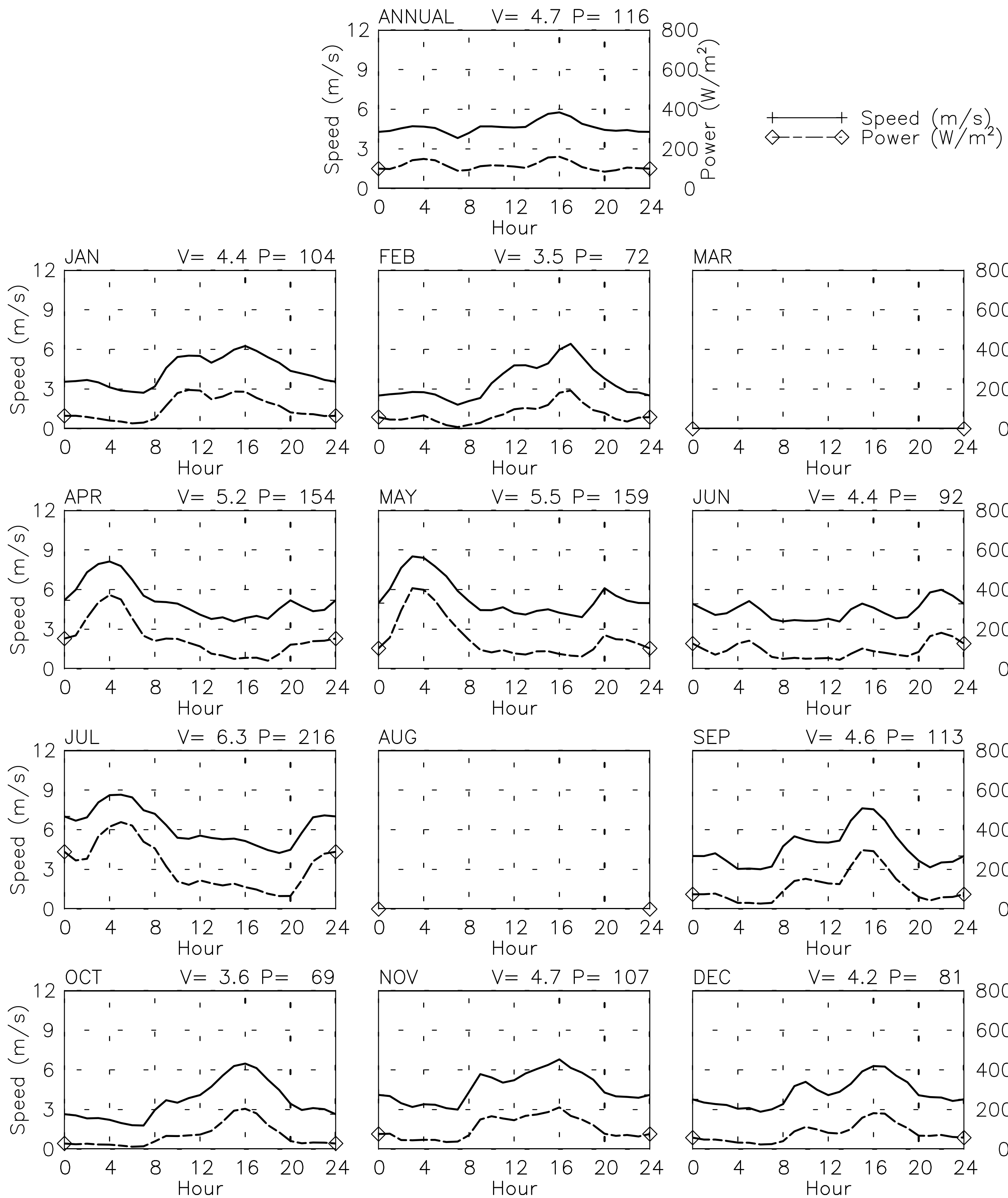
Fri May 14 15:06:40 1999

SPEED AND POWER BY HOUR

Botoncillos (30m) - 002007

19° 43' N 71° 25' W - Elev 75m

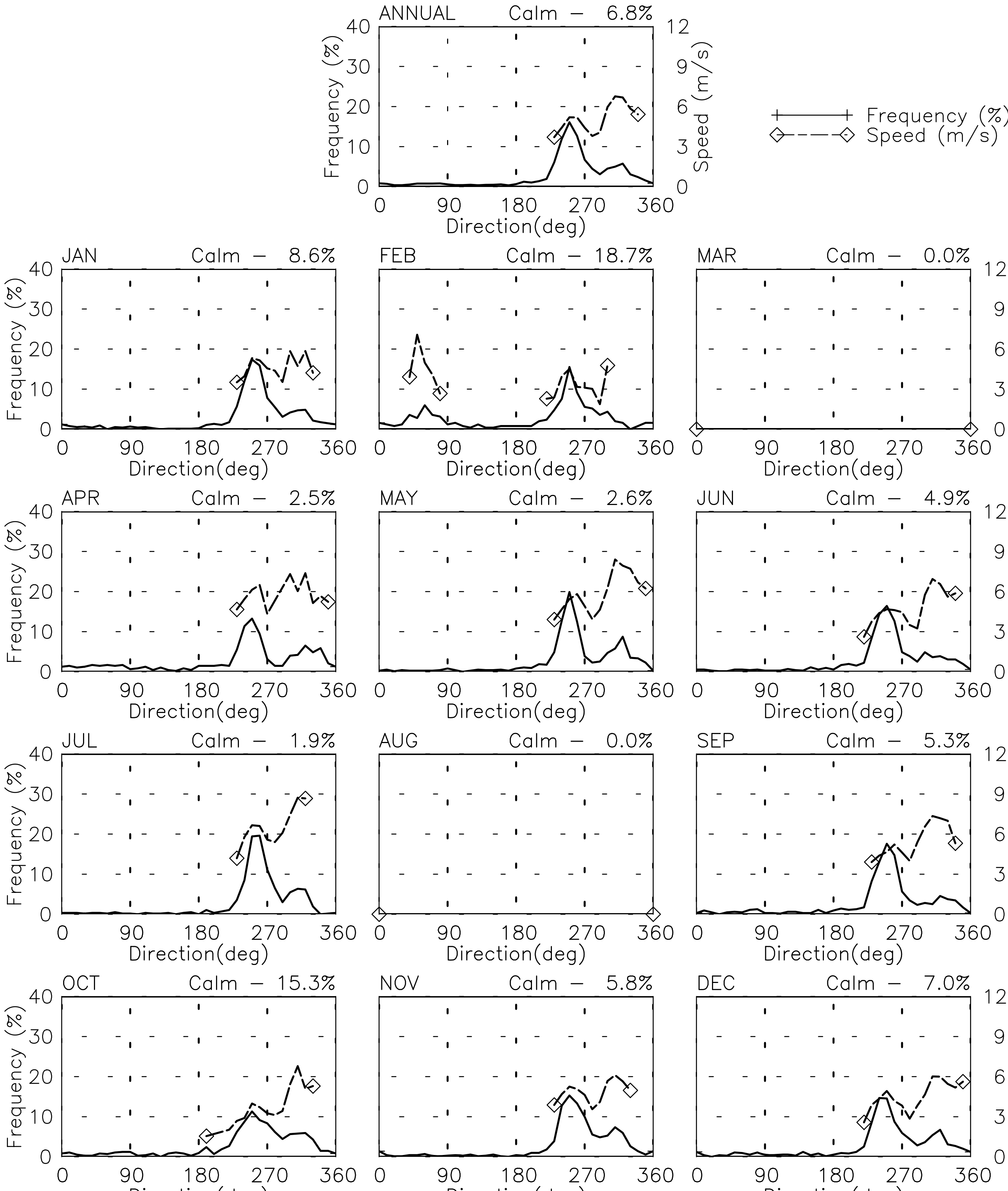
04/97-02/98



Fri May 14 15:06:42 1999

FREQUENCY AND SPEED BY DIRECTION

Botoncillos (30m) – 002007
19° 43' N 71° 25' W – Elev 75m
04/97–02/98



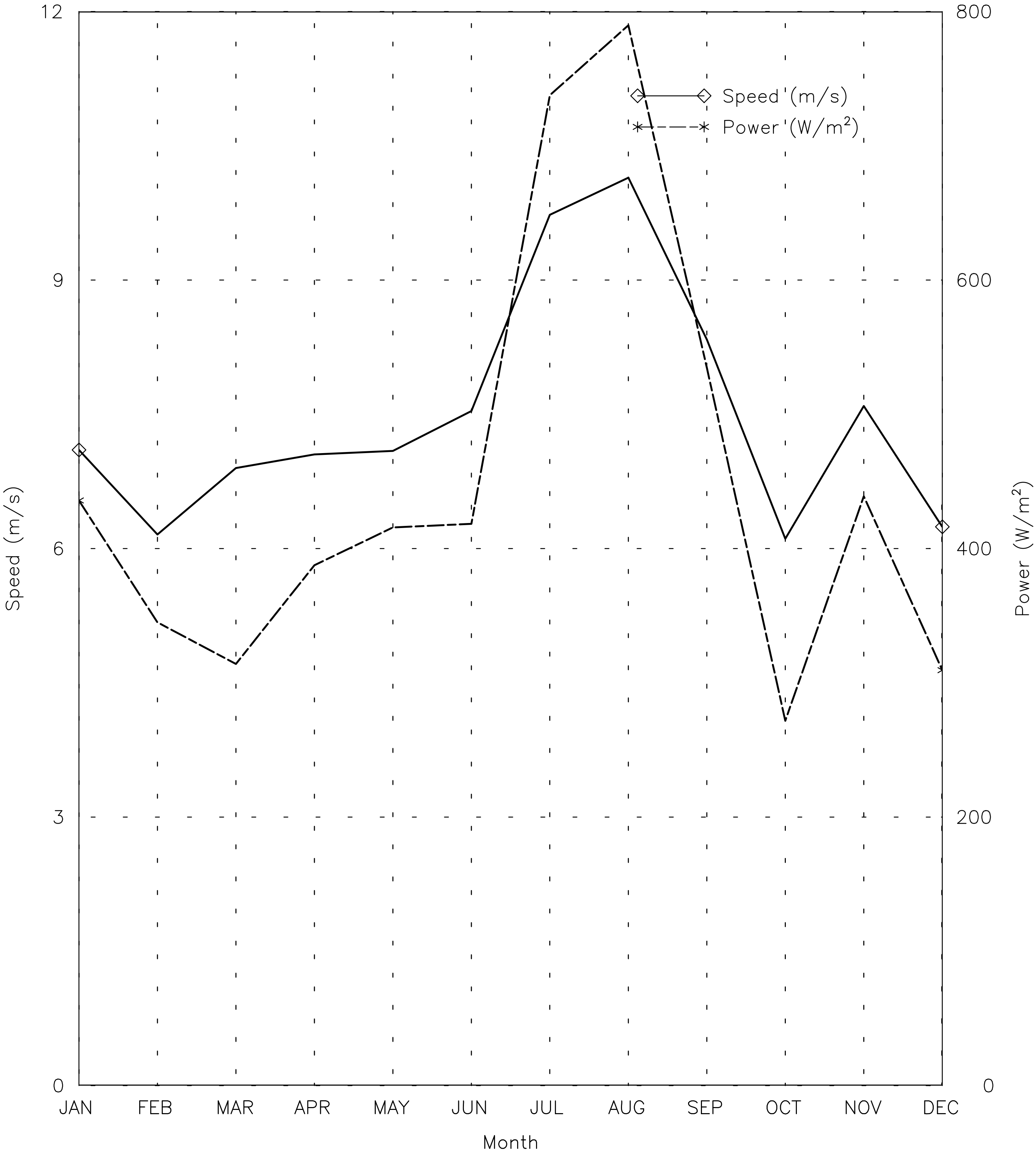
Fri May 14 15:06:46 1999

SPEED AND POWER BY MONTH

Guzmancitos (30m) – 002005

19° 54' N 70° 50' W – Elev 60m

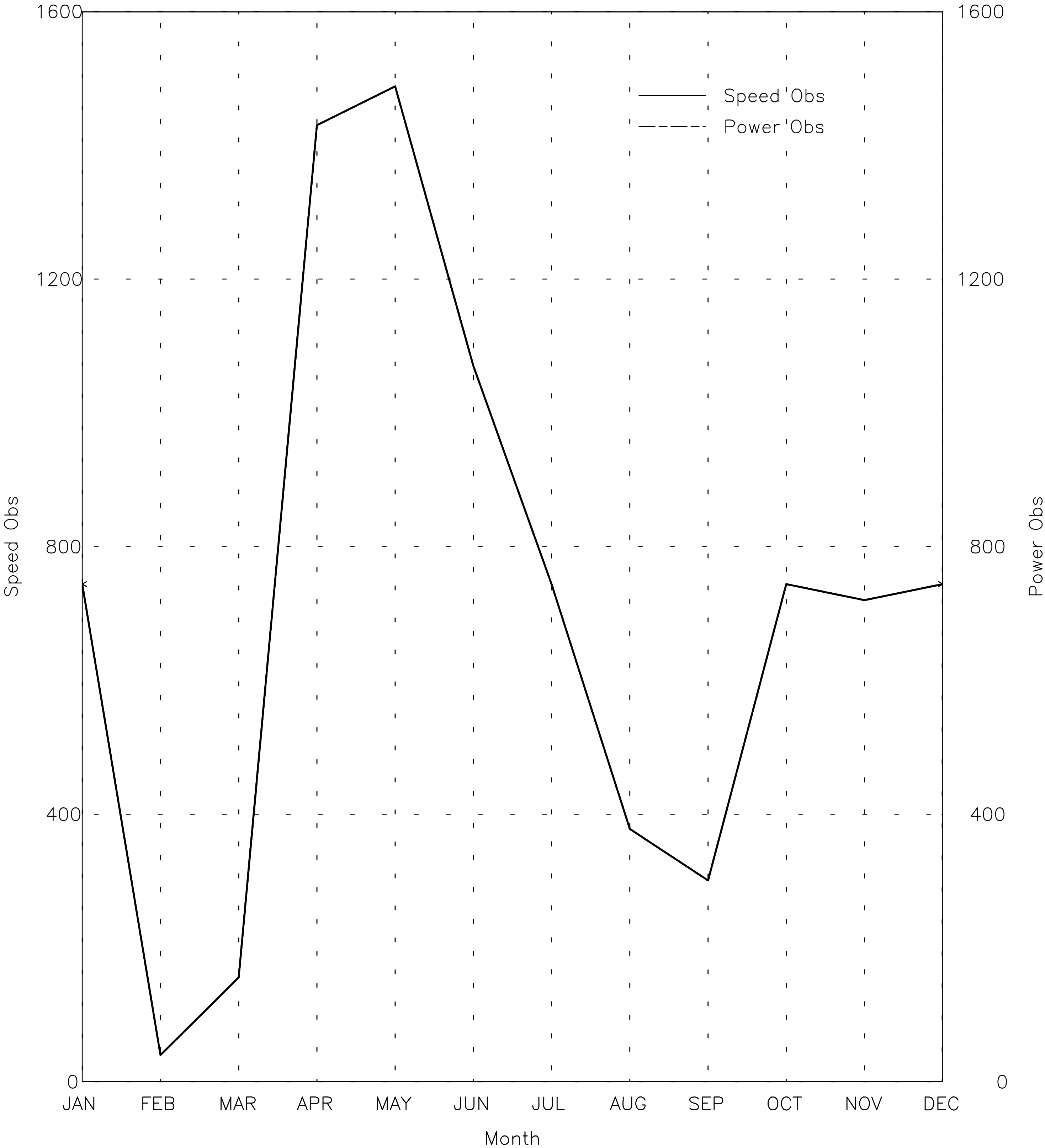
03/97–06/98



Fri May 14 15:06:11 1999

OBSERVATIONS BY MONTH

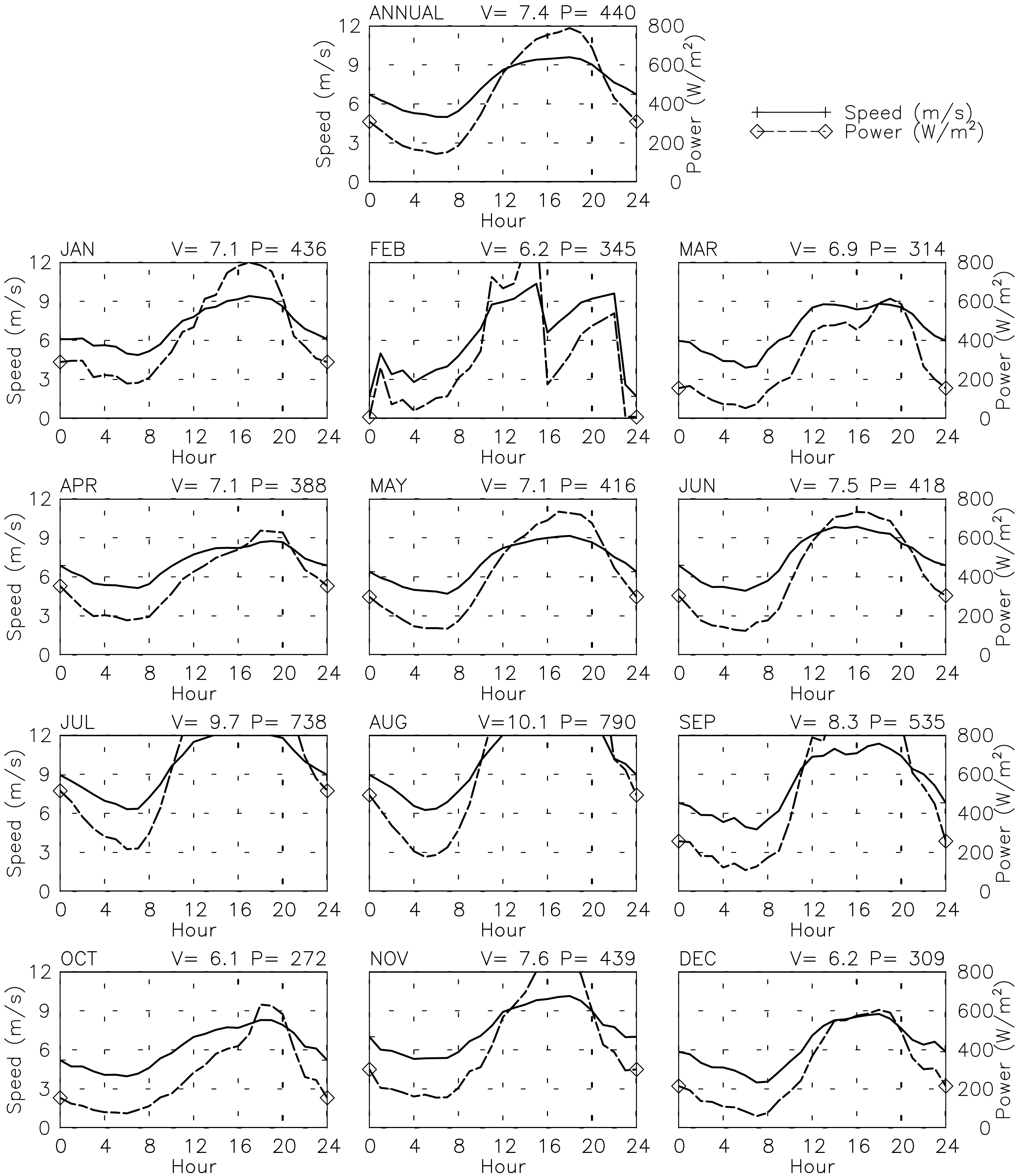
Guzmancitos (30m) – 002005
19° 54' N 70° 50' W – Elev 60m
03/97–06/98



Fri May 14 15:06:12 1999

SPEED AND POWER BY HOUR

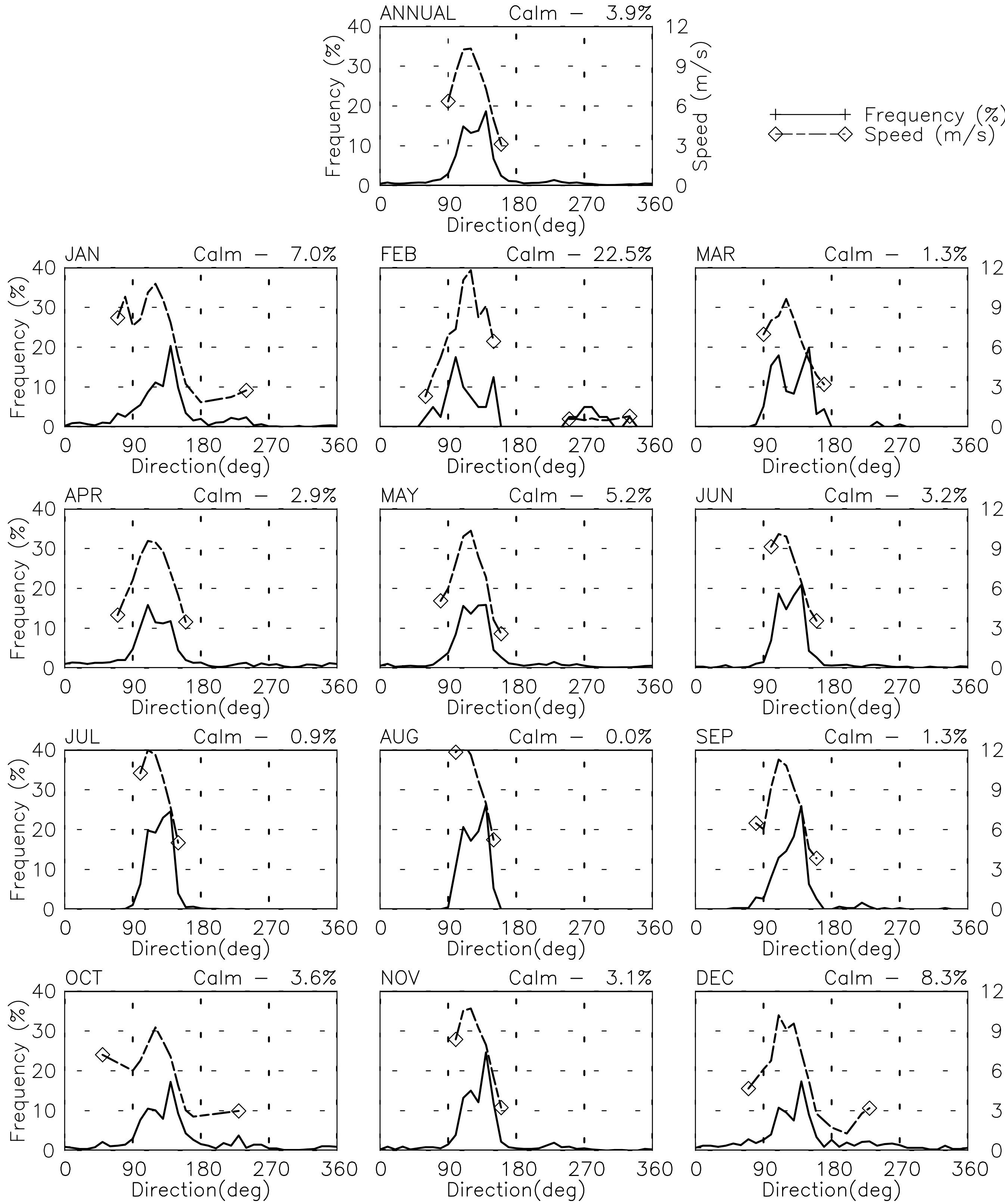
Guzmancitos (30m) – 002005
19° 54' N 70° 50' W – Elev 60m
03/97–06/98



Fri May 14 15:06:14 1999

FREQUENCY AND SPEED BY DIRECTION

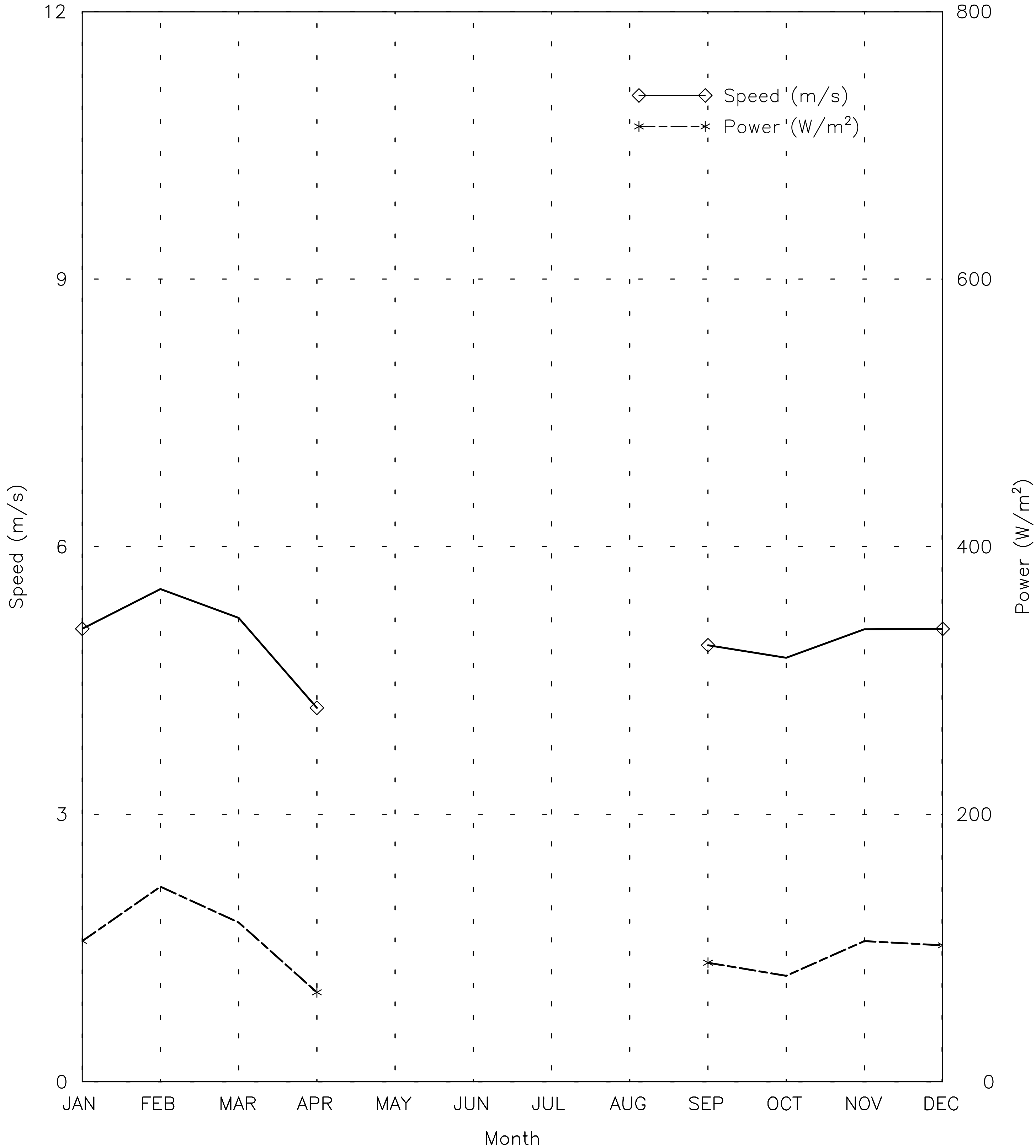
Guzmancitos (30m) - 002005
19° 54' N 70° 50' W - Elev 60m
03/97-06/98



Fri May 14 15:06:18 1999

SPEED AND POWER BY MONTH

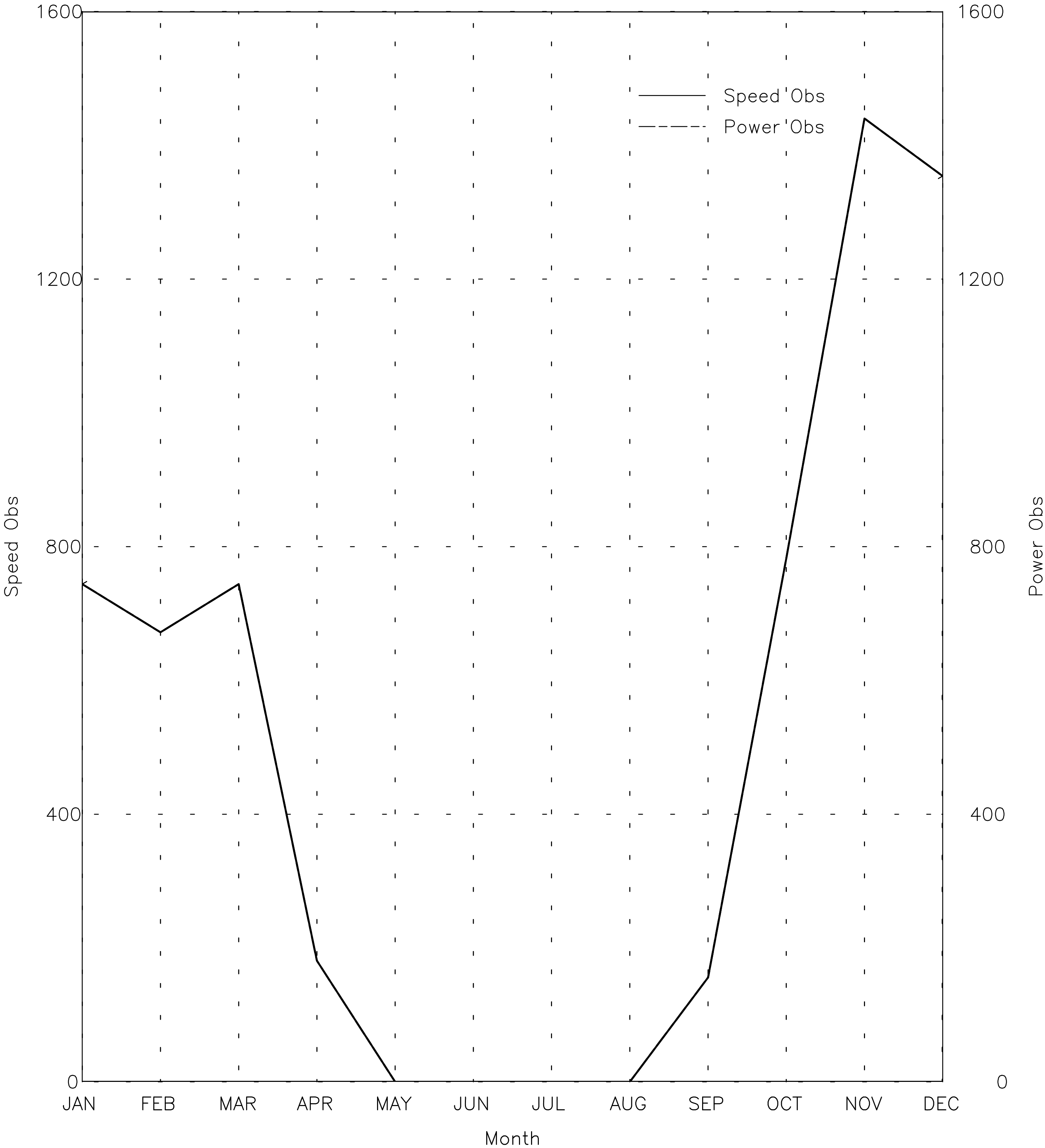
La Loma (30m) – 002010
19° 34' N 70° 44' W – Elev 850m
10/97–12/98



Fri May 14 15:07:05 1999

OBSERVATIONS BY MONTH

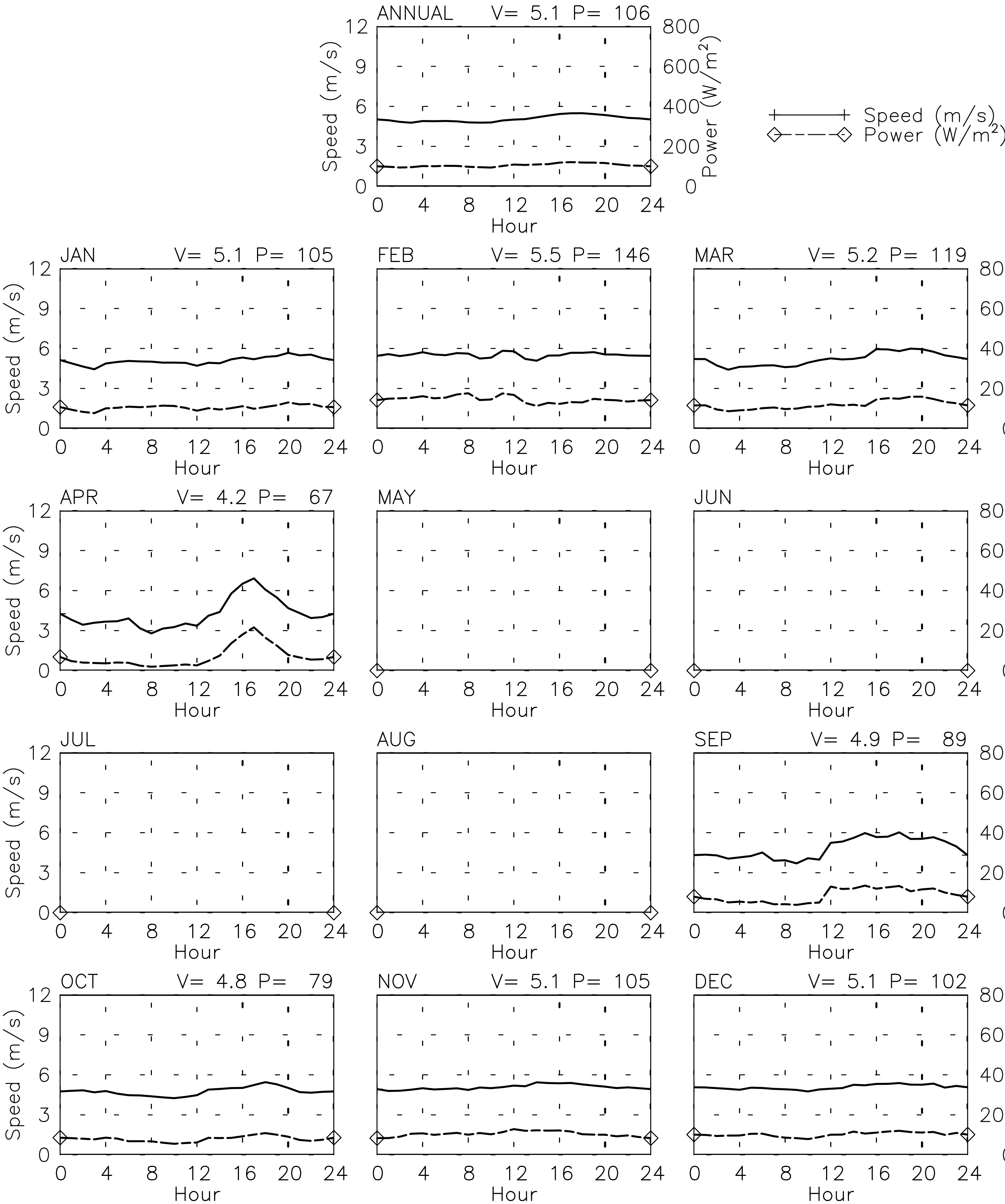
La Loma (30m) – 002010
19° 34' N   70° 44' W – Elev 850m
10/97–12/98



Fri May 14 15:07:07 1999

SPEED AND POWER BY HOUR

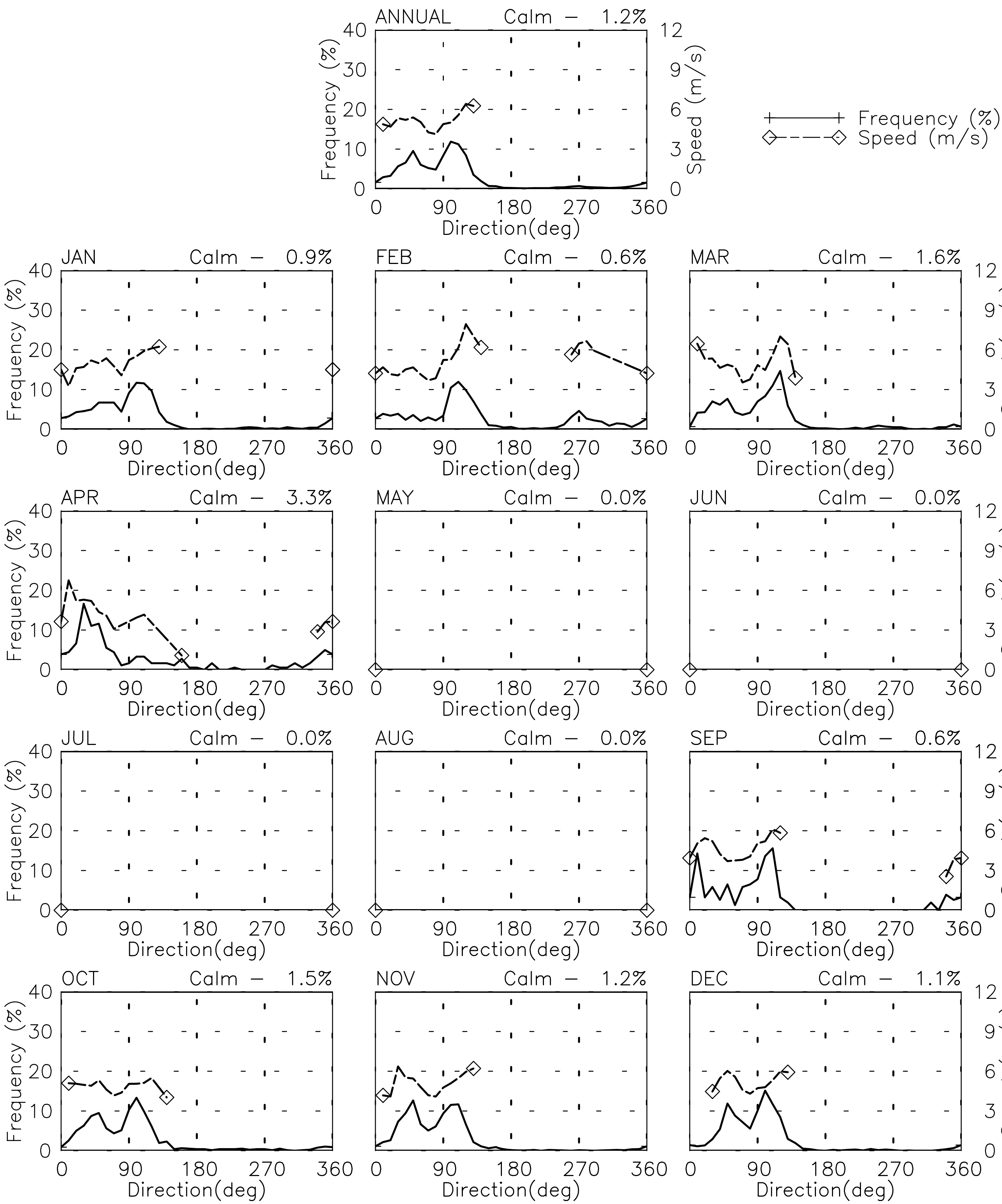
La Loma (30m) - 002010
19° 34' N   70° 44' W - Elev 850m
10/97-12/98



Fri May 14 15:07:08 1999

FREQUENCY AND SPEED BY DIRECTION

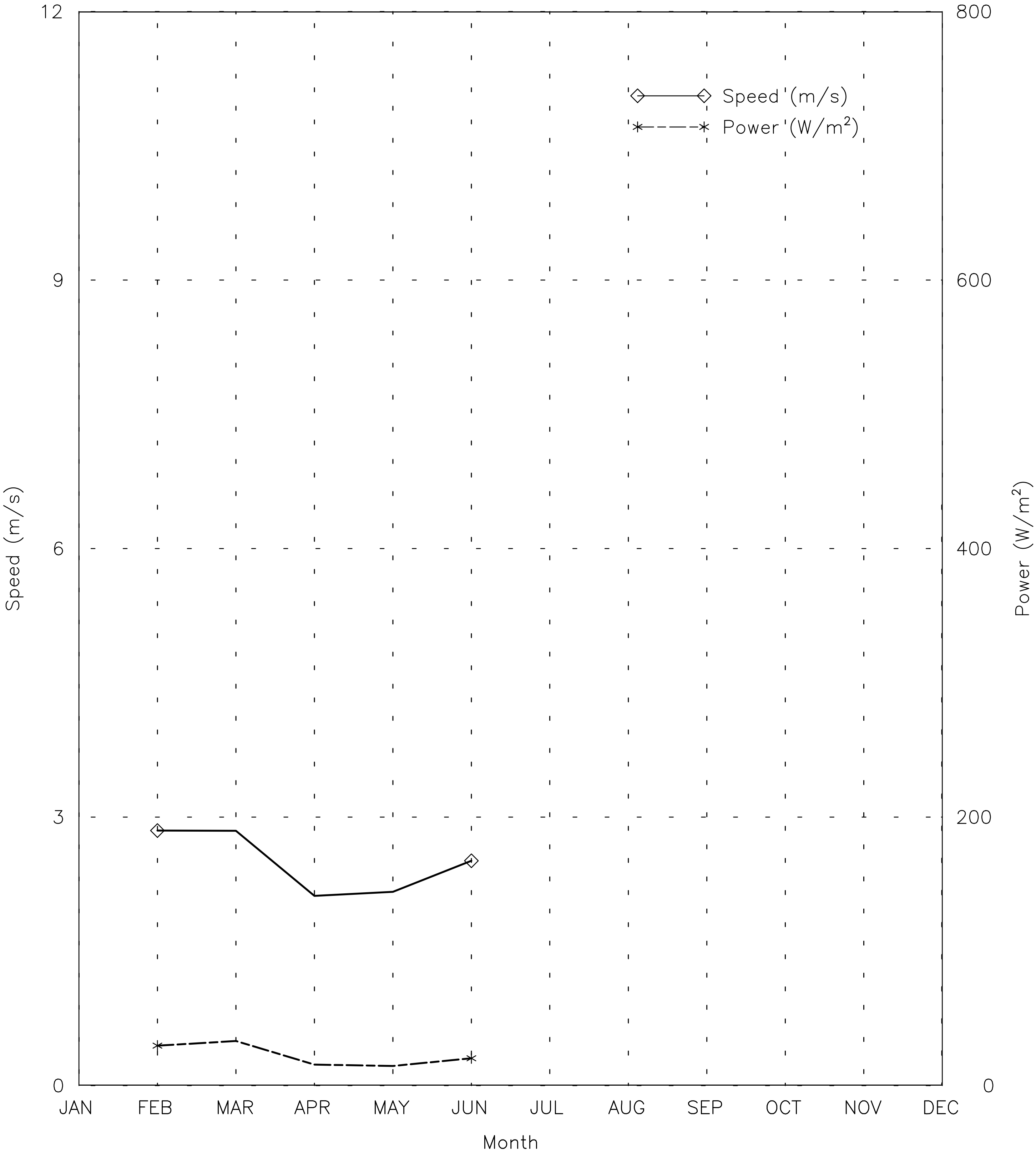
La Loma (30m) – 002010
19° 34' N   70° 44' W – Elev 850m
10/97–12/98



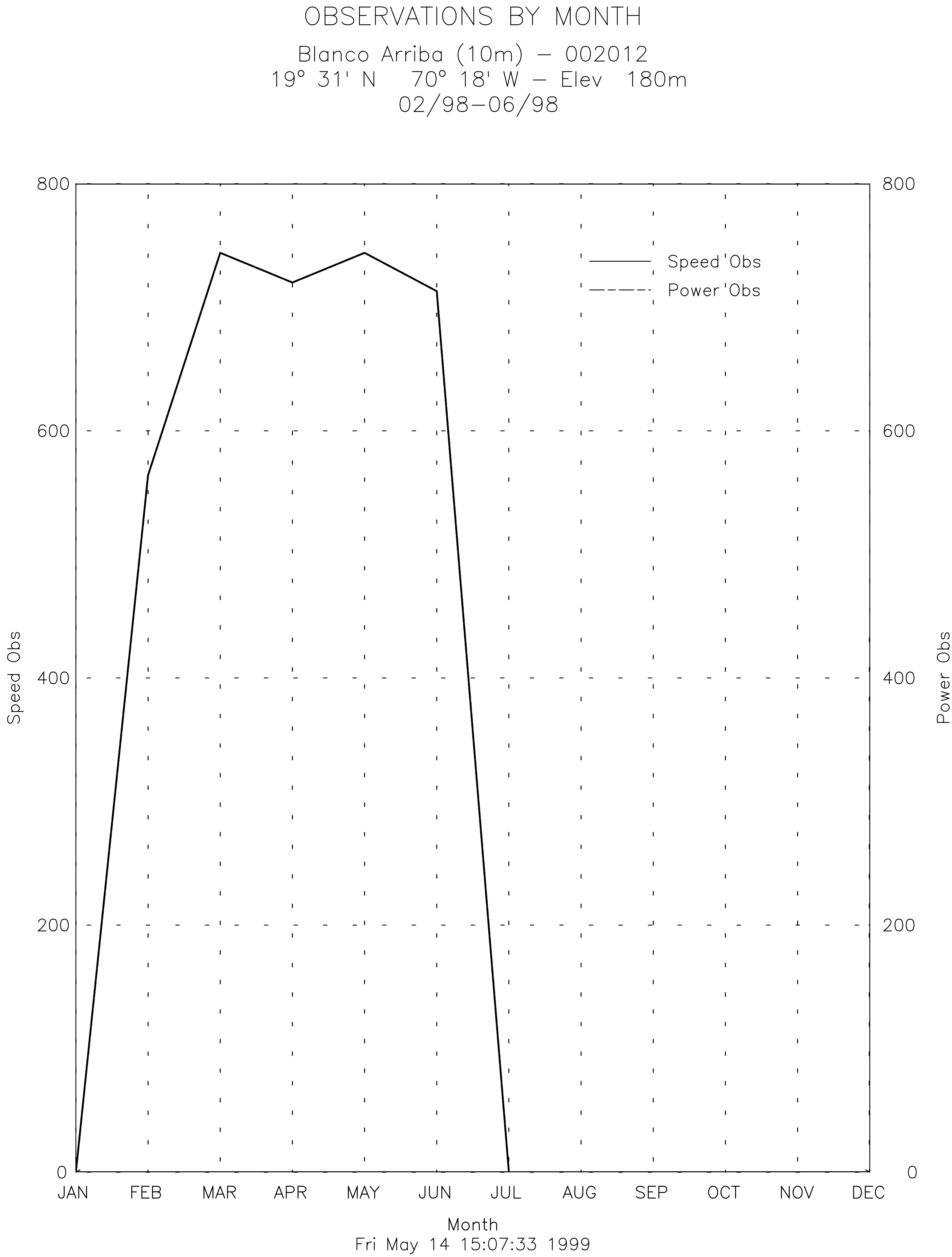
Fri May 14 15:07:12 1999

SPEED AND POWER BY MONTH

Blanco Arriba (10m) – 002012
19° 31' N 70° 18' W – Elev 180m
02/98–06/98



Fri May 14 15:07:32 1999

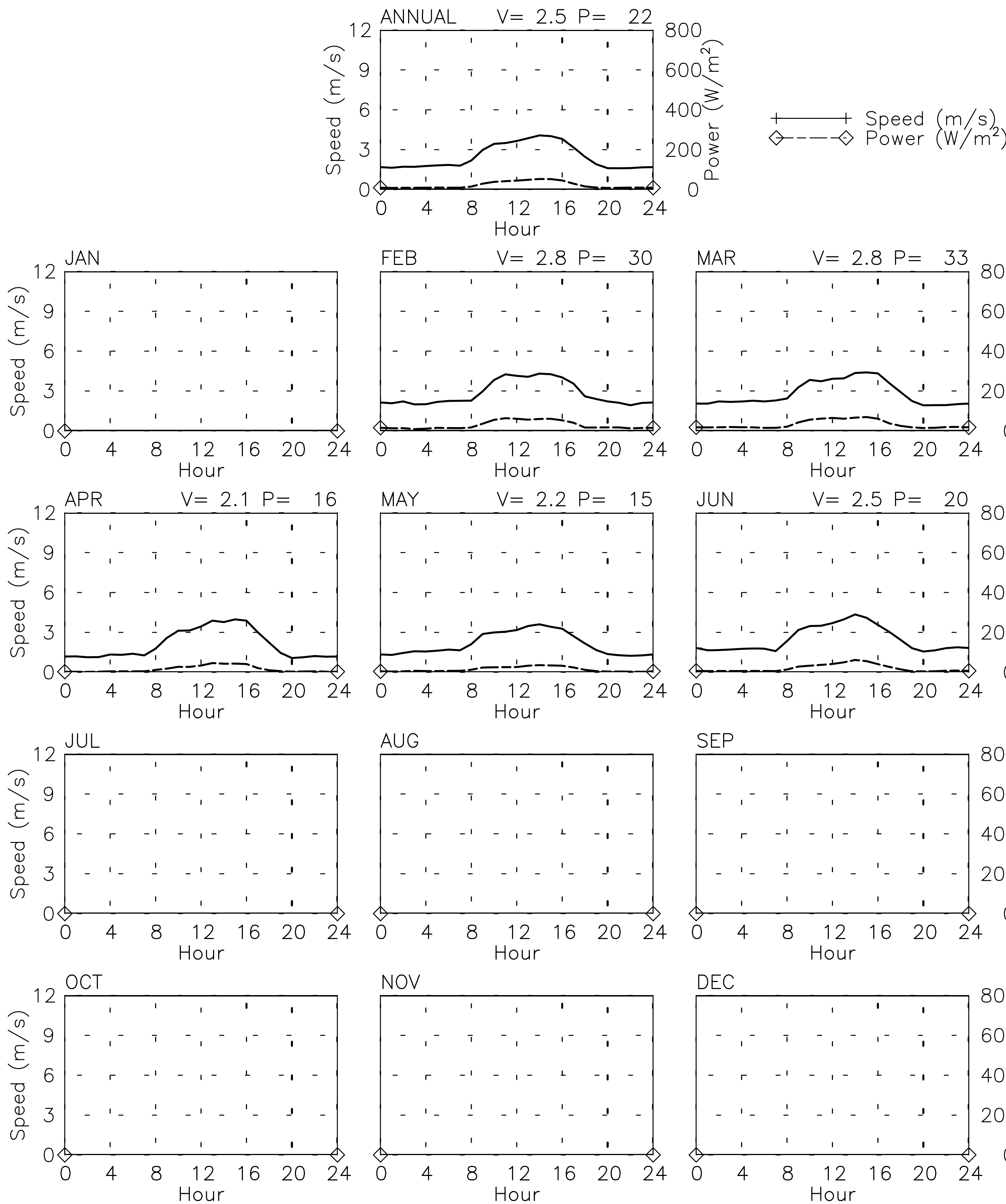

OBSERVATIONS BY MONTH
Blanco Arriba (10m) - 002012
19° 31' N 70° 18' W - Elev 180m
02/98-06/98
Speed'Obs
Power'Obs
Speed Obs
Power Obs
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Fri May 14 15:07:33 1999

SPEED AND POWER BY HOUR

Blanco Arriba (10m) - 002012

19° 31' N 70° 18' W - Elev 180m

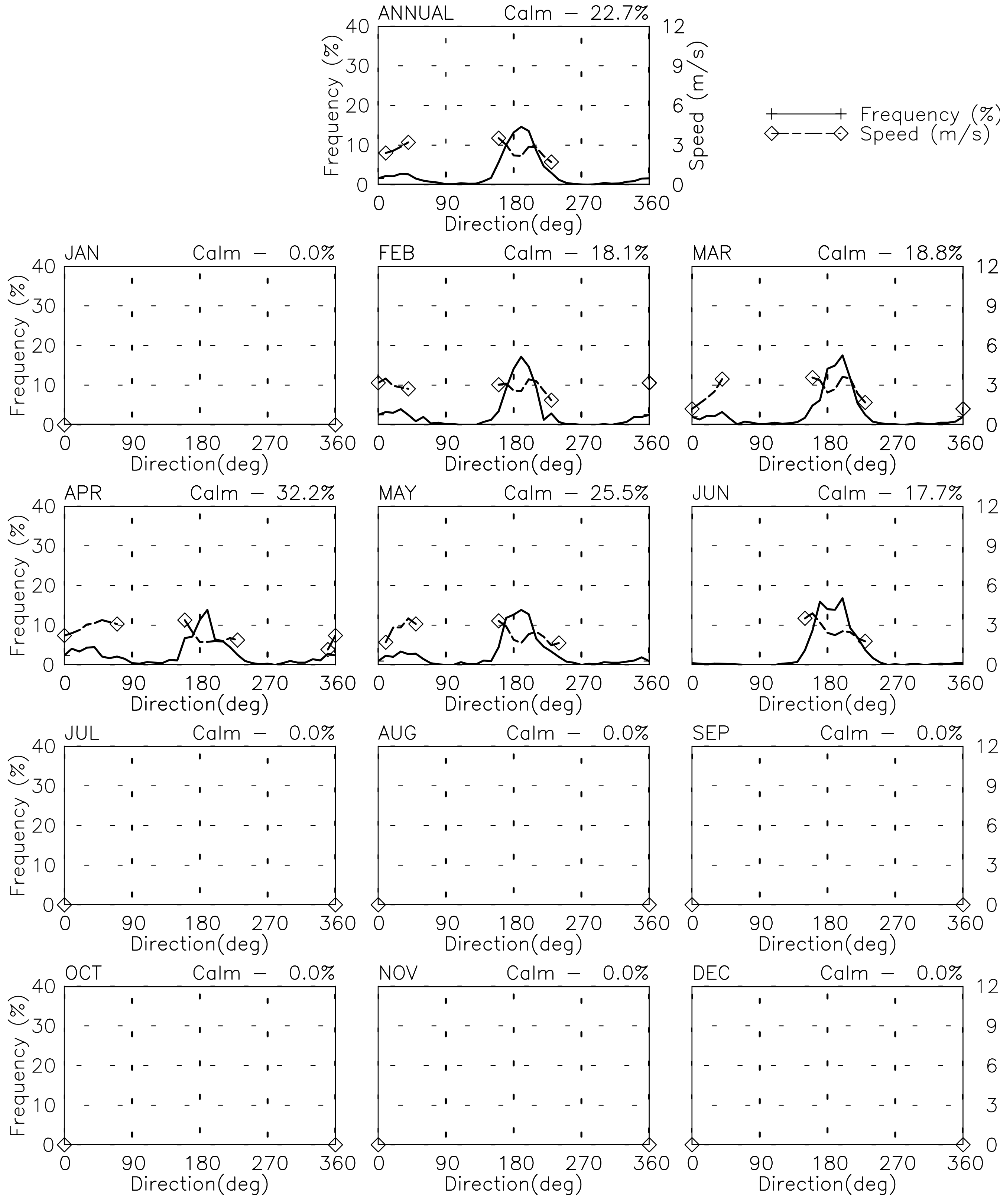
02/98-06/98



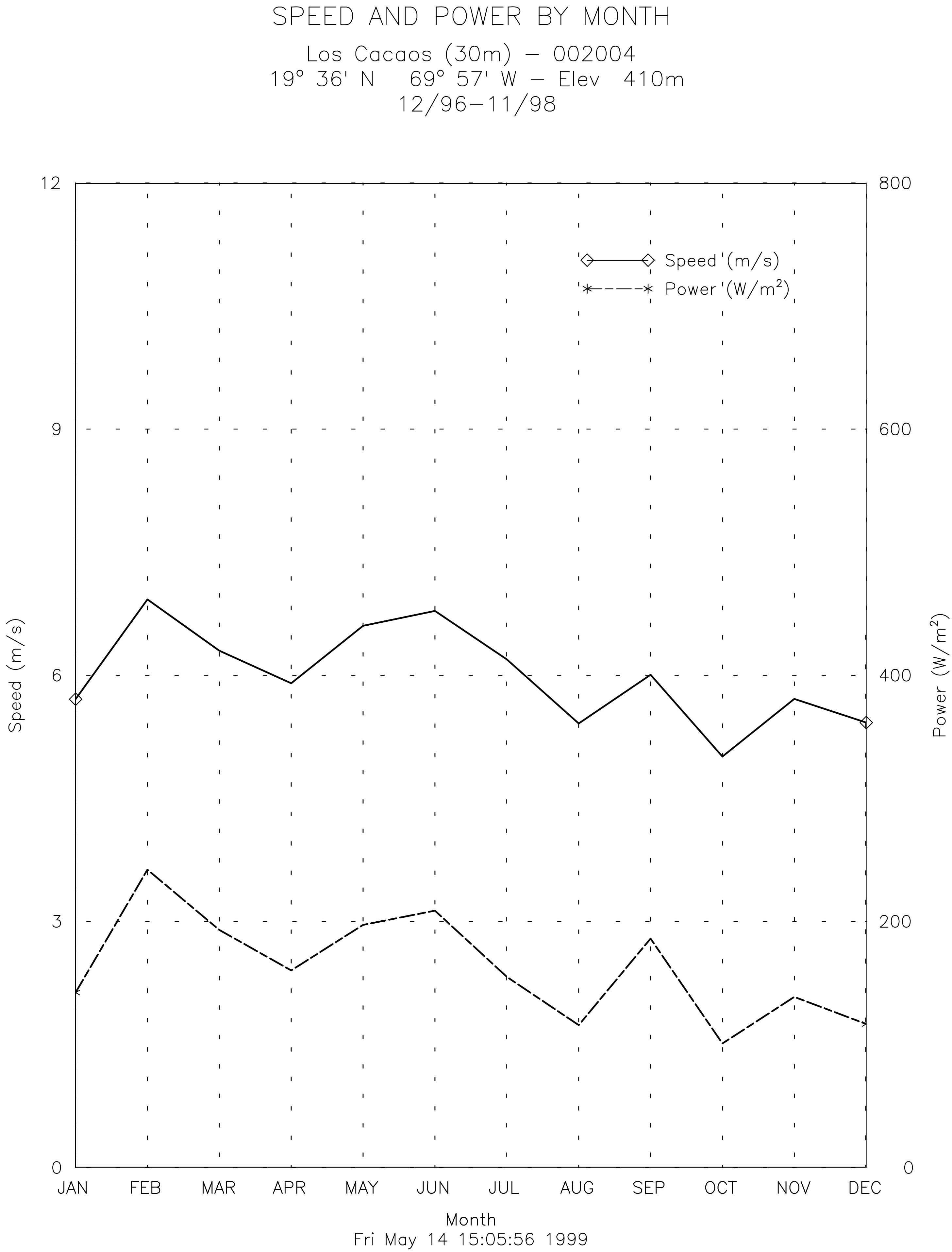
Fri May 14 15:07:35 1999

FREQUENCY AND SPEED BY DIRECTION

Blanco Arriba (10m) - 002012
19° 31' N   70° 18' W - Elev 180m
02/98-06/98

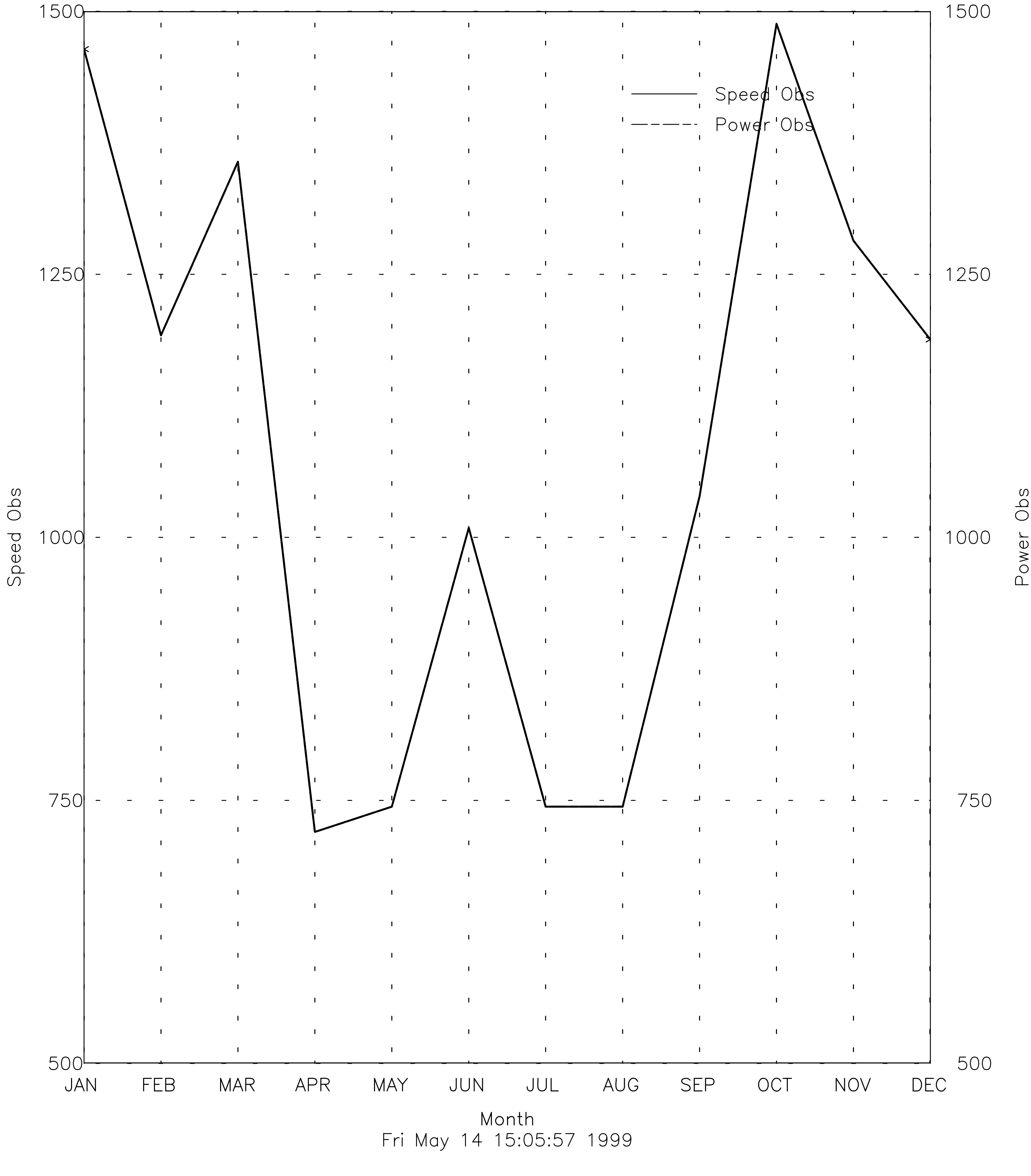


Fri May 14 15:07:38 1999


SPEED AND POWER BY MONTH
Los Cacaos (30m) – 002004
19° 36' N 69° 57' W – Elev 410m
12/96–11/98
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Fri May 14 15:05:56 1999

OBSERVATIONS BY MONTH

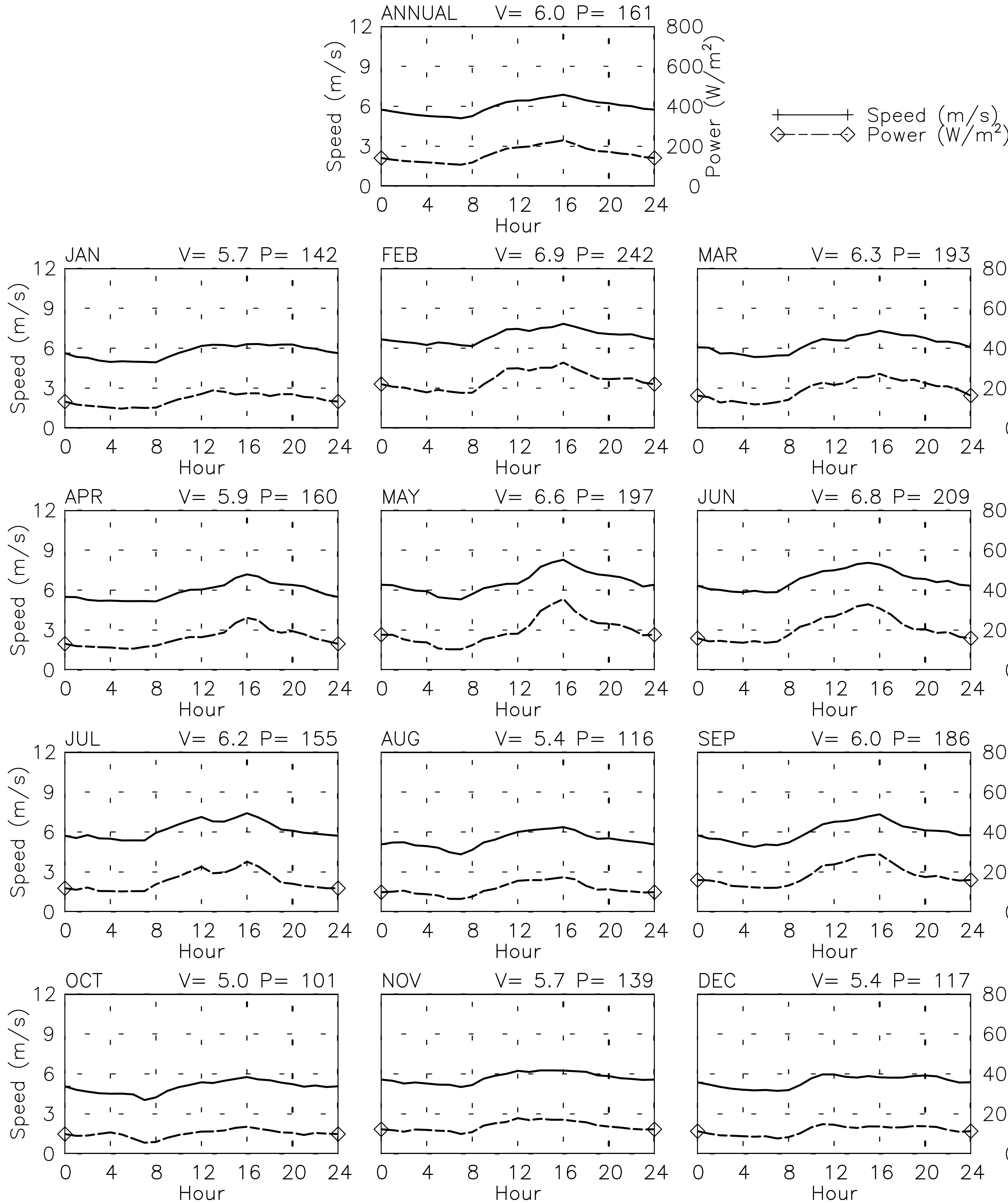
Los Cacaos (30m) – 002004
19° 36' N 69° 57' W – Elev 410m
12/96–11/98



Fri May 14 15:05:57 1999

SPEED AND POWER BY HOUR

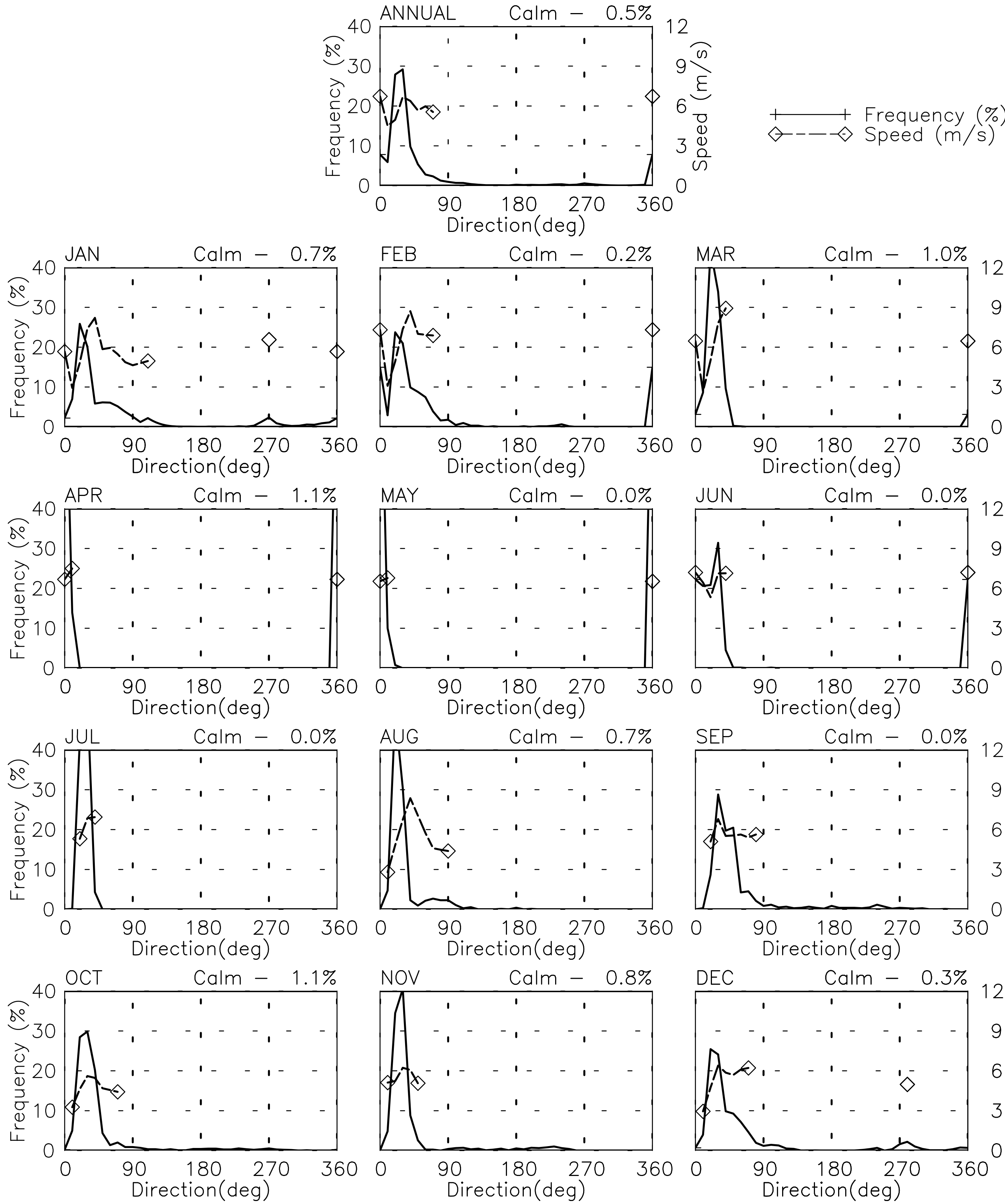
Los Cacaos (30m) – 002004
19° 36' N 69° 57' W – Elev 410m
12/96–11/98



Fri May 14 15:06:00 1999

FREQUENCY AND SPEED BY DIRECTION

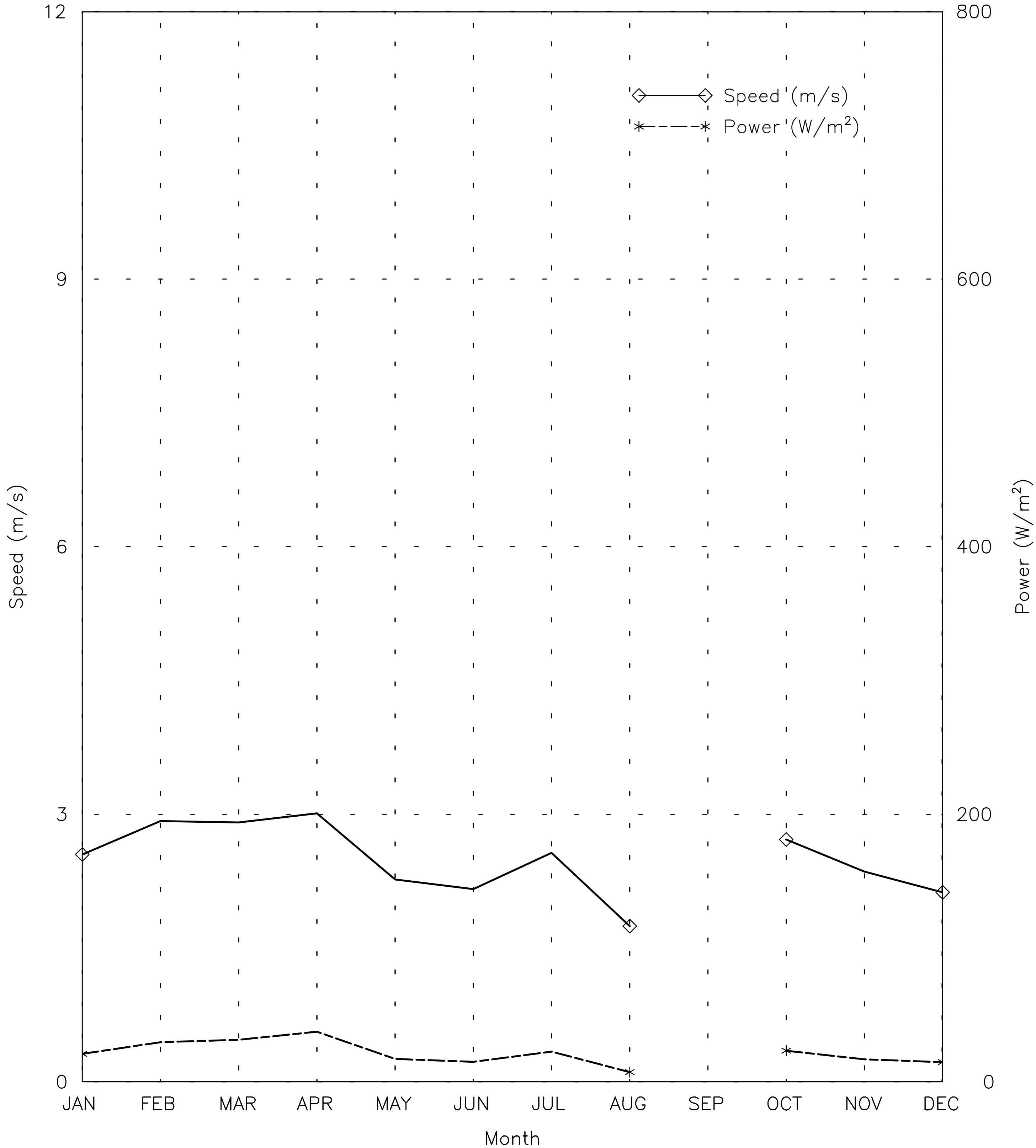
Los Cacaos (30m) – 002004
19° 36' N 69° 57' W – Elev 410m
12/96–11/98



Fri May 14 15:06:03 1999

SPEED AND POWER BY MONTH

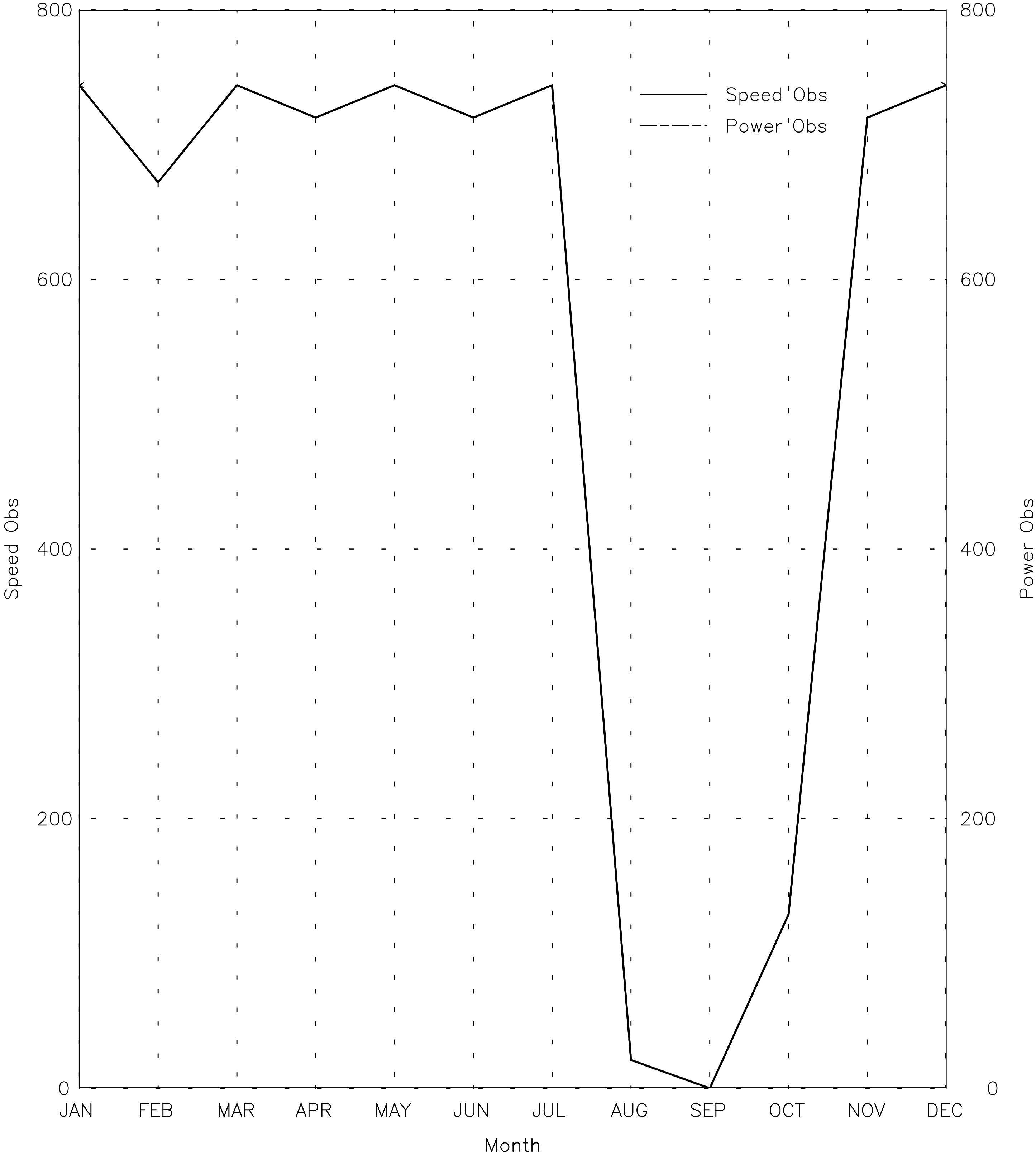
Los Hidalgos (10m) – 002011
18° 54' N 69° 38' W – Elev 193m
10/97–08/98



Fri May 14 15:07:19 1999

OBSERVATIONS BY MONTH

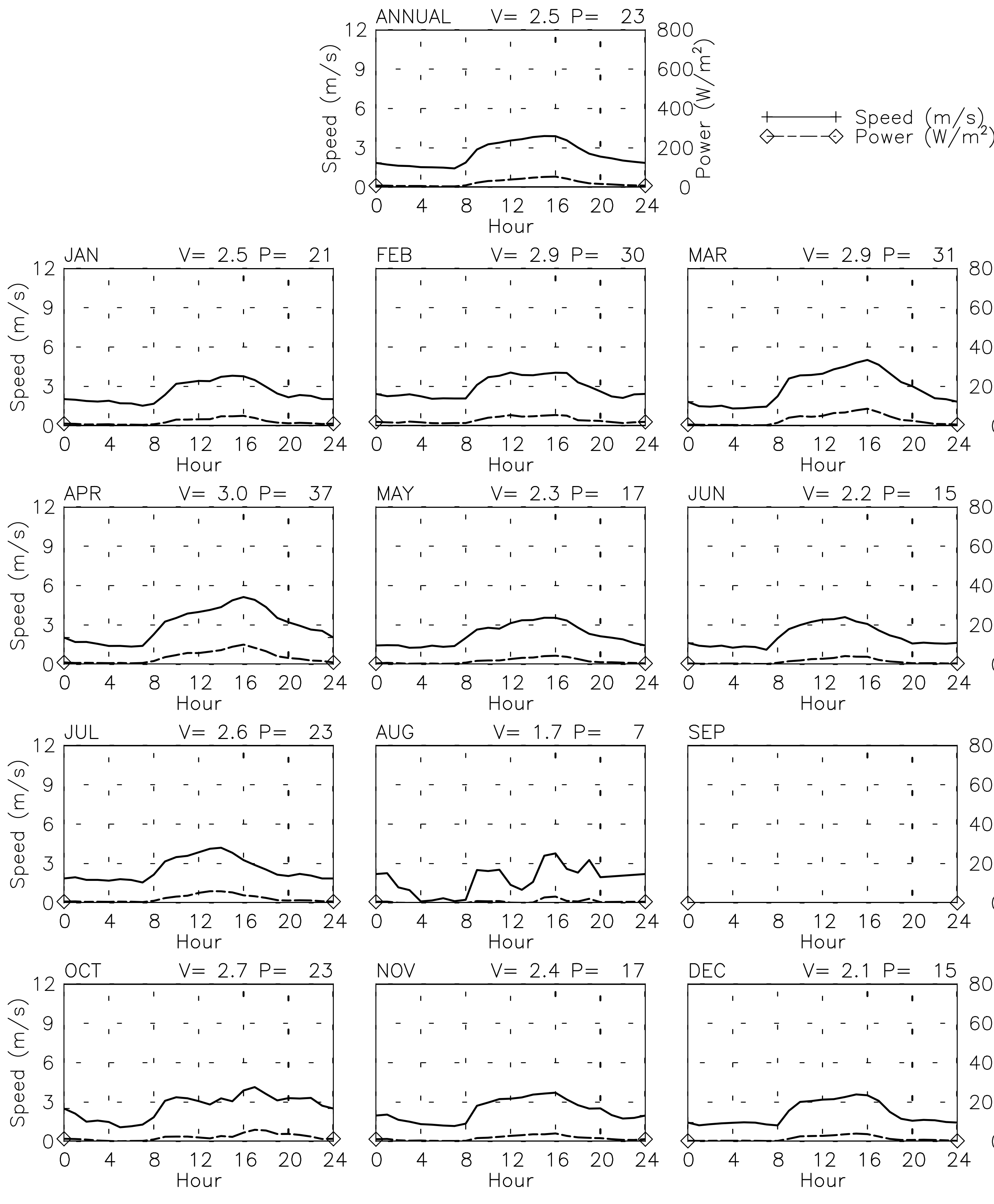
Los Hidalgos (10m) – 002011
18° 54' N 69° 38' W – Elev 193m
10/97–08/98



Fri May 14 15:07:21 1999

SPEED AND POWER BY HOUR

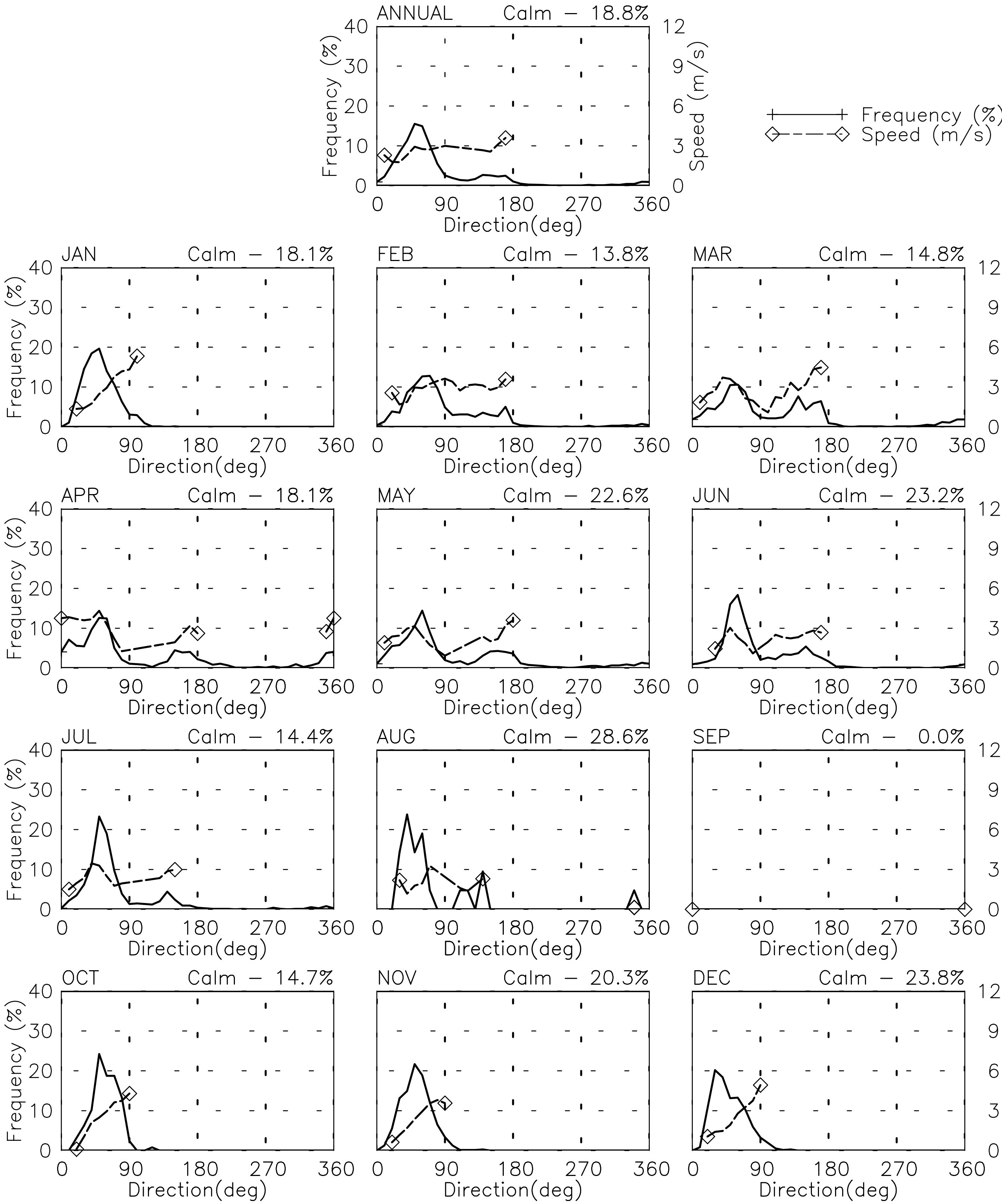
Los Hidalgos (10m) – 002011
18° 54' N 69° 38' W – Elev 193m
10/97–08/98



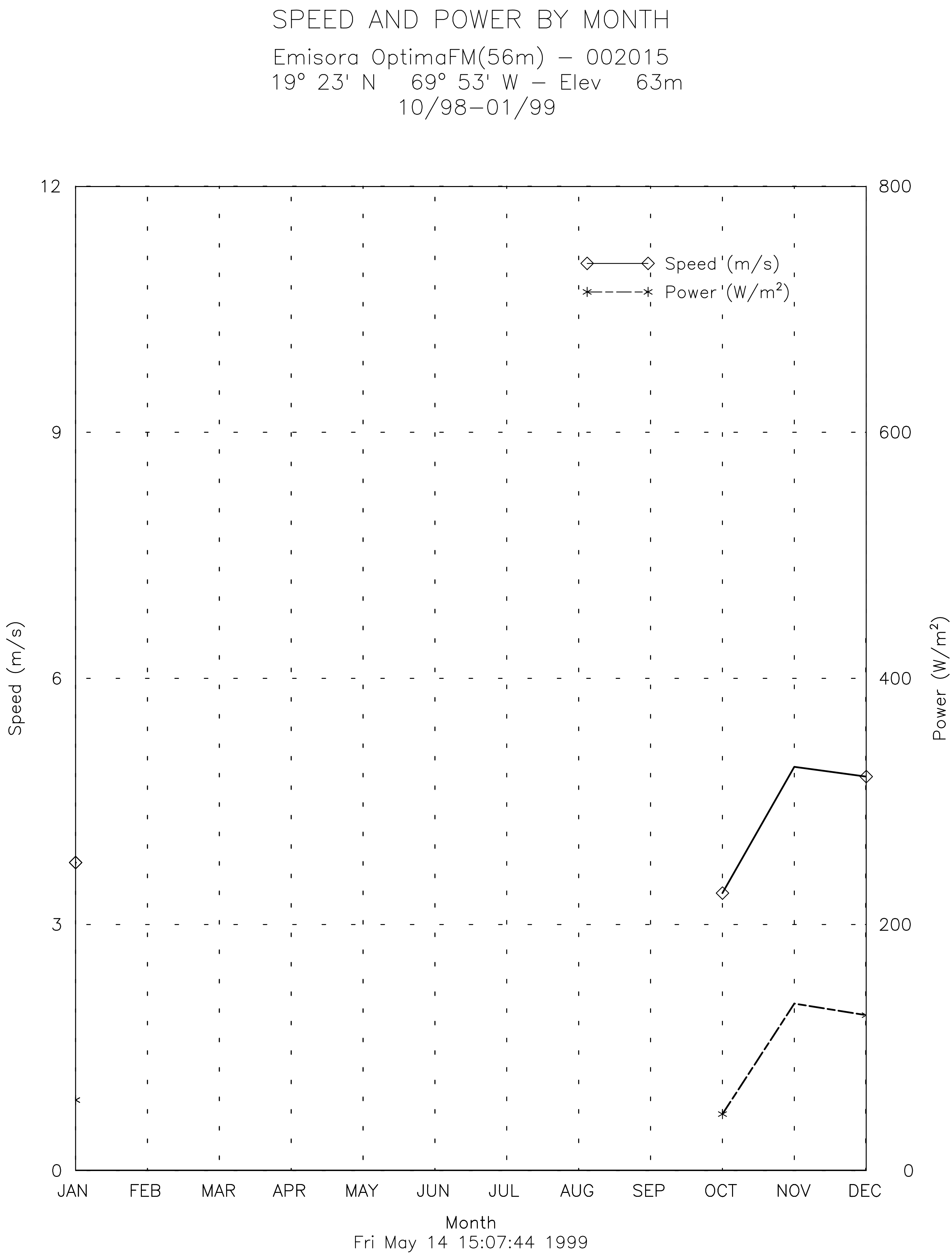
Fri May 14 15:07:22 1999

FREQUENCY AND SPEED BY DIRECTION

Los Hidalgos (10m) – 002011
18° 54' N   69° 38' W – Elev 193m
10/97–08/98



Fri May 14 15:07:26 1999

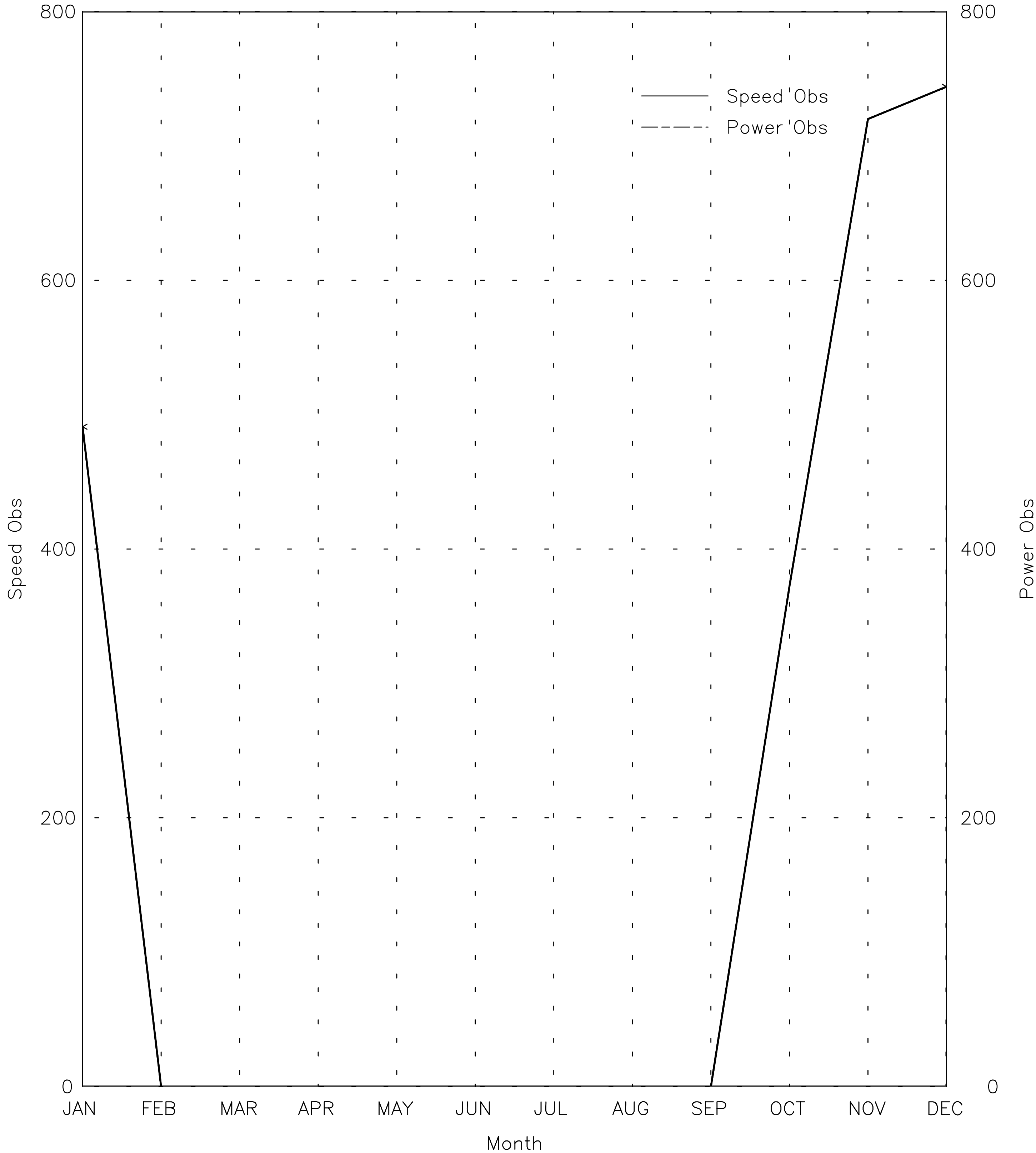

SPEED AND POWER BY MONTH
Emisora OptimaFM(56m) - 002015
19° 23' N 69° 53' W - Elev 63m
10/98-01/99
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Fri May 14 15:07:44 1999

OBSERVATIONS BY MONTH

Emisora OptimaFM(56m) - 002015

19° 23' N 69° 53' W - Elev 63m

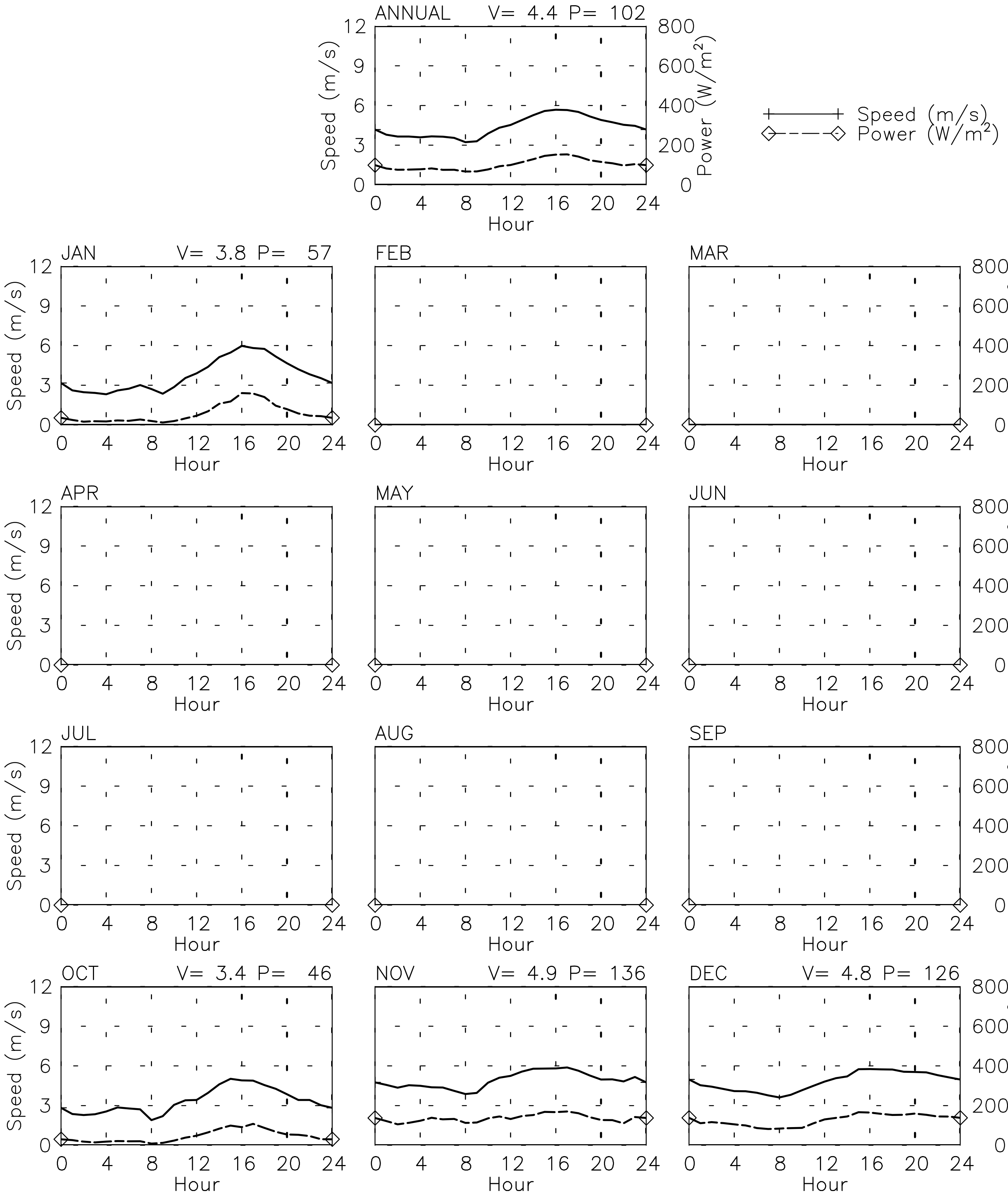
10/98-01/99



Fri May 14 15:07:47 1999

SPEED AND POWER BY HOUR

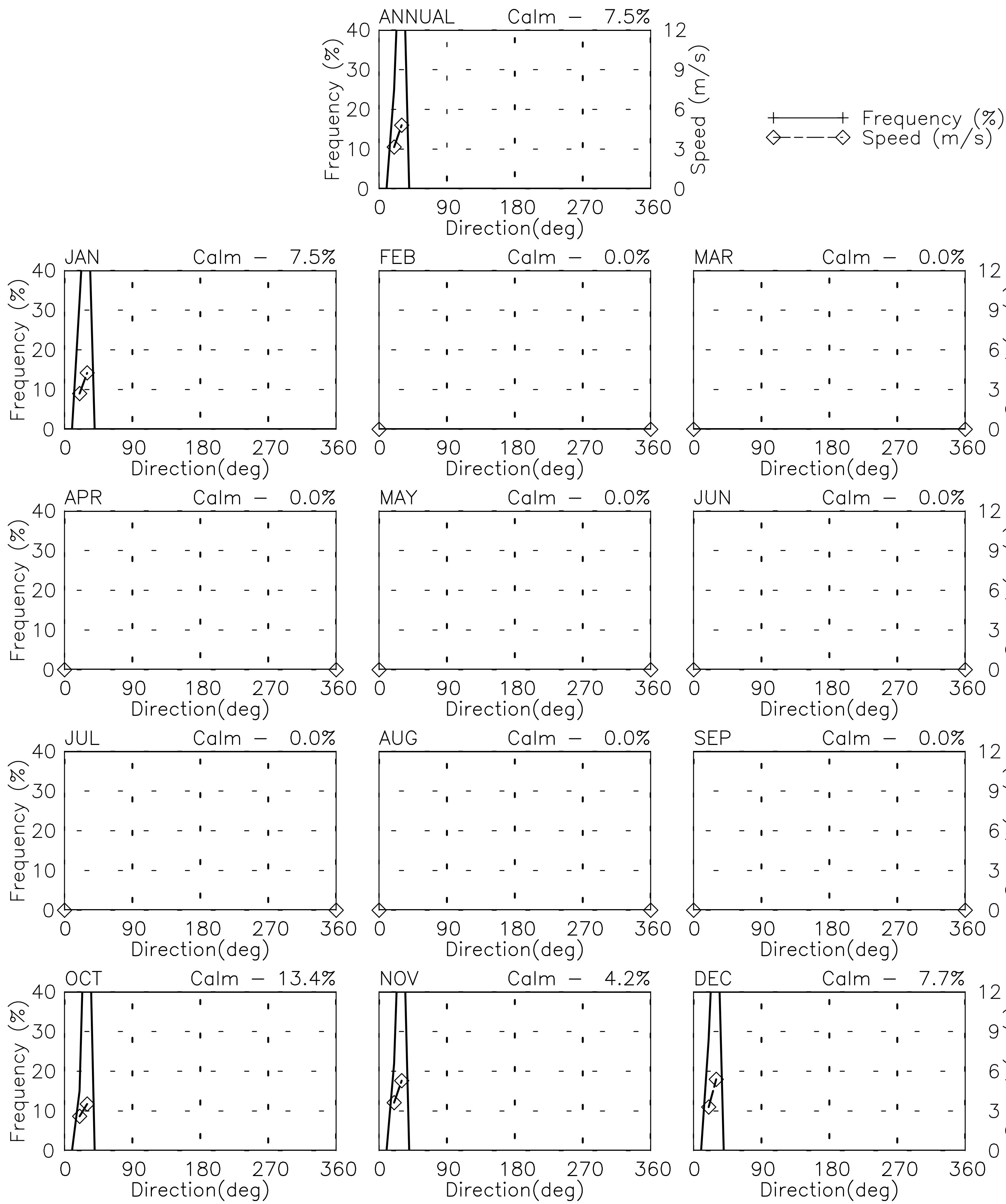
Emisora OptimaFM(56m) – 002015
19° 23' N 69° 53' W – Elev 63m
10/98–01/99



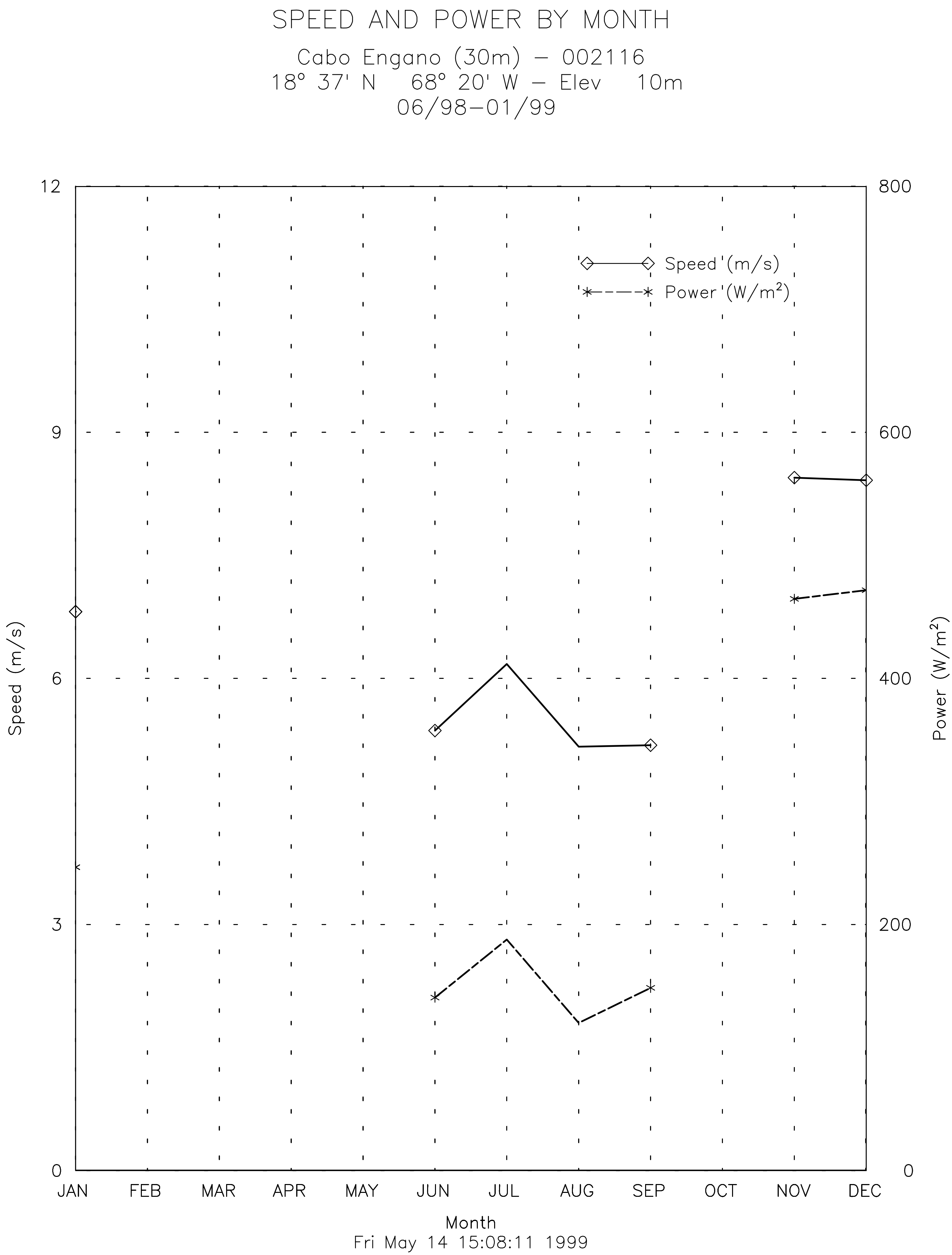
Fri May 14 15:07:49 1999

FREQUENCY AND SPEED BY DIRECTION

Emisora OptimaFM(56m) – 002015
19° 23' N   69° 53' W – Elev   63m
10/98–01/99

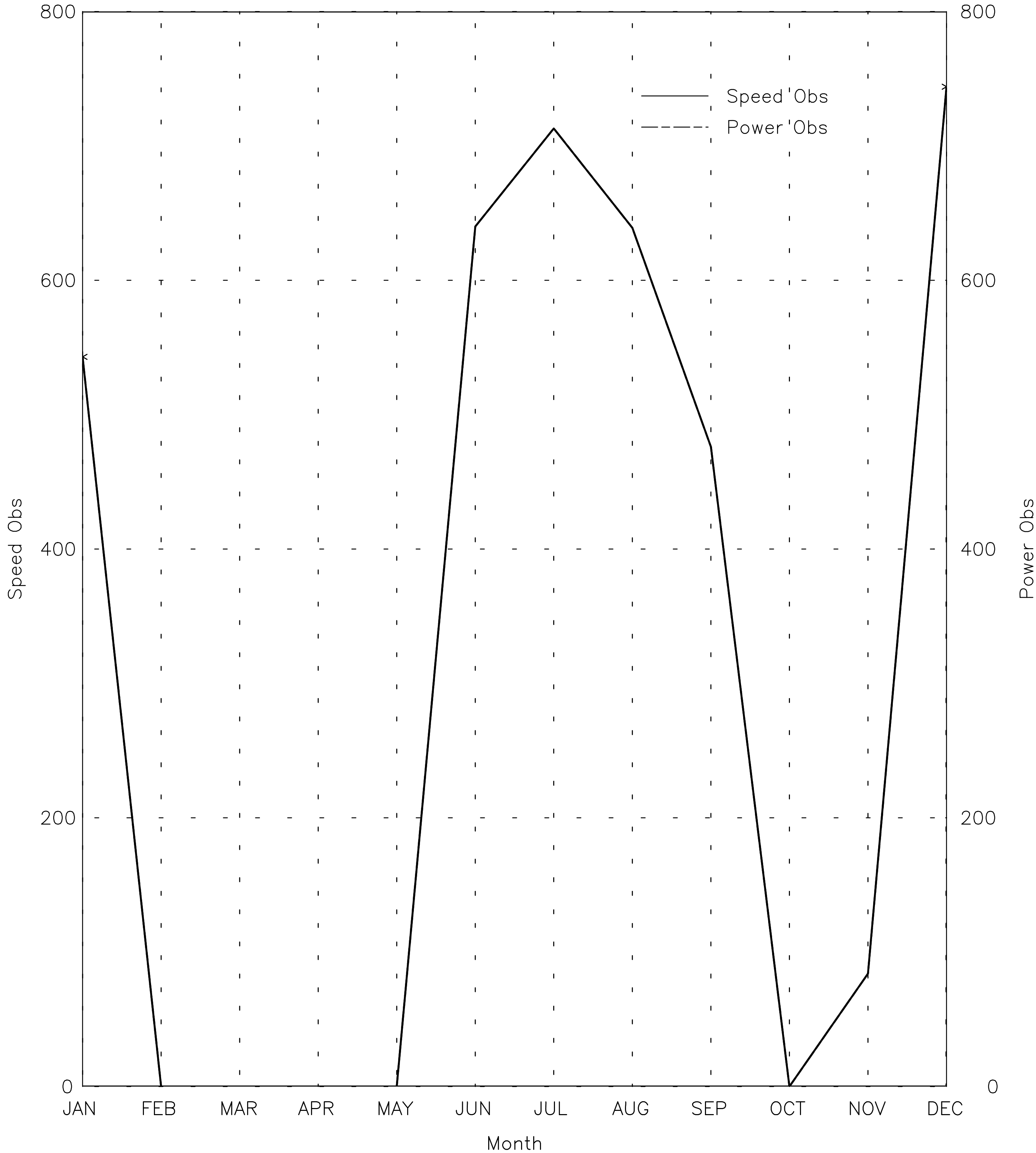


Fri May 14 15:07:52 1999


SPEED AND POWER BY MONTH
Cabo Engano (30m) - 002116
18° 37' N 68° 20' W - Elev 10m
06/98-01/99
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Fri May 14 15:08:11 1999

OBSERVATIONS BY MONTH

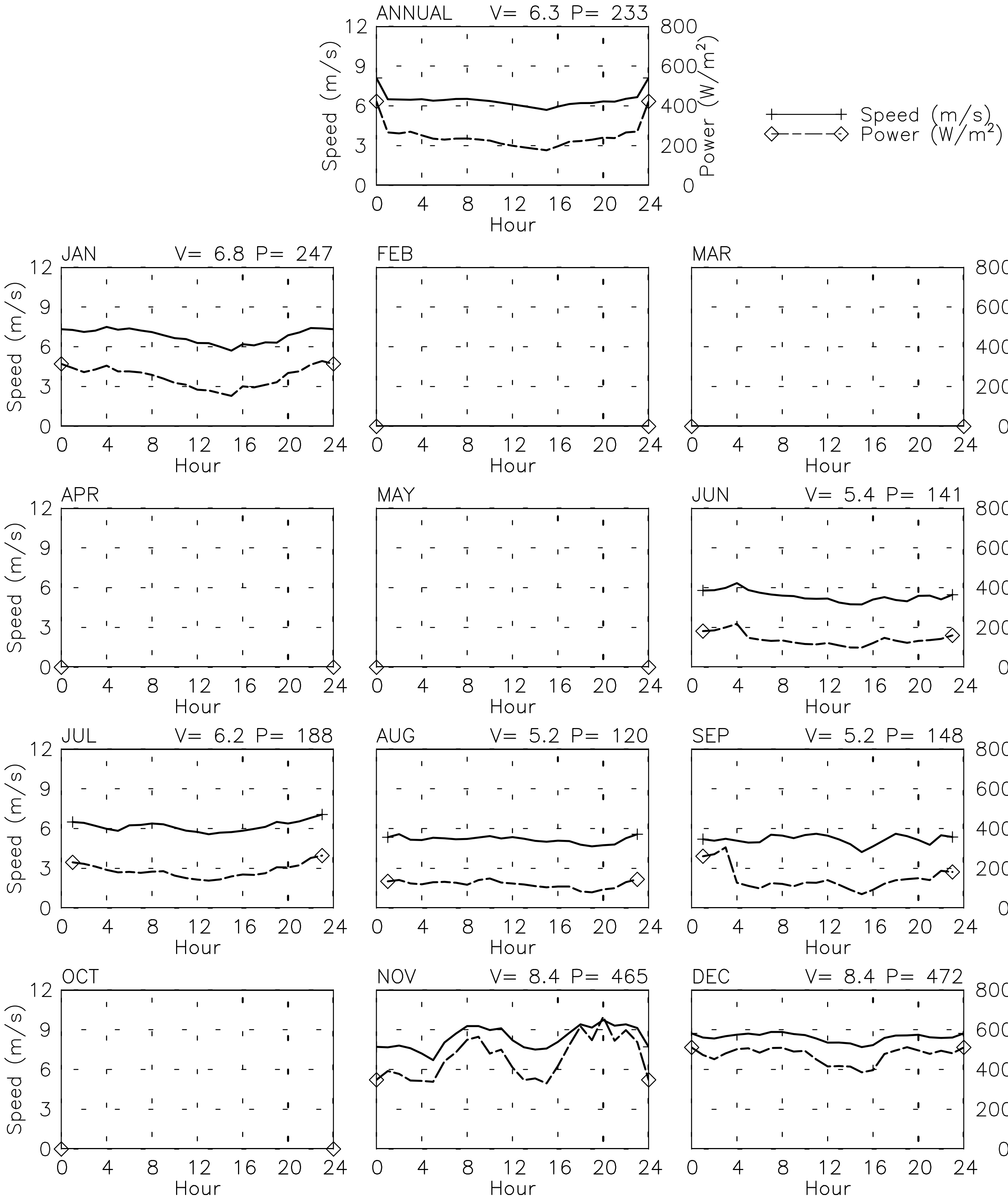
Cabo Engano (30m) - 002116
18° 37' N 68° 20' W - Elev 10m
06/98-01/99



Fri May 14 15:08:14 1999

SPEED AND POWER BY HOUR

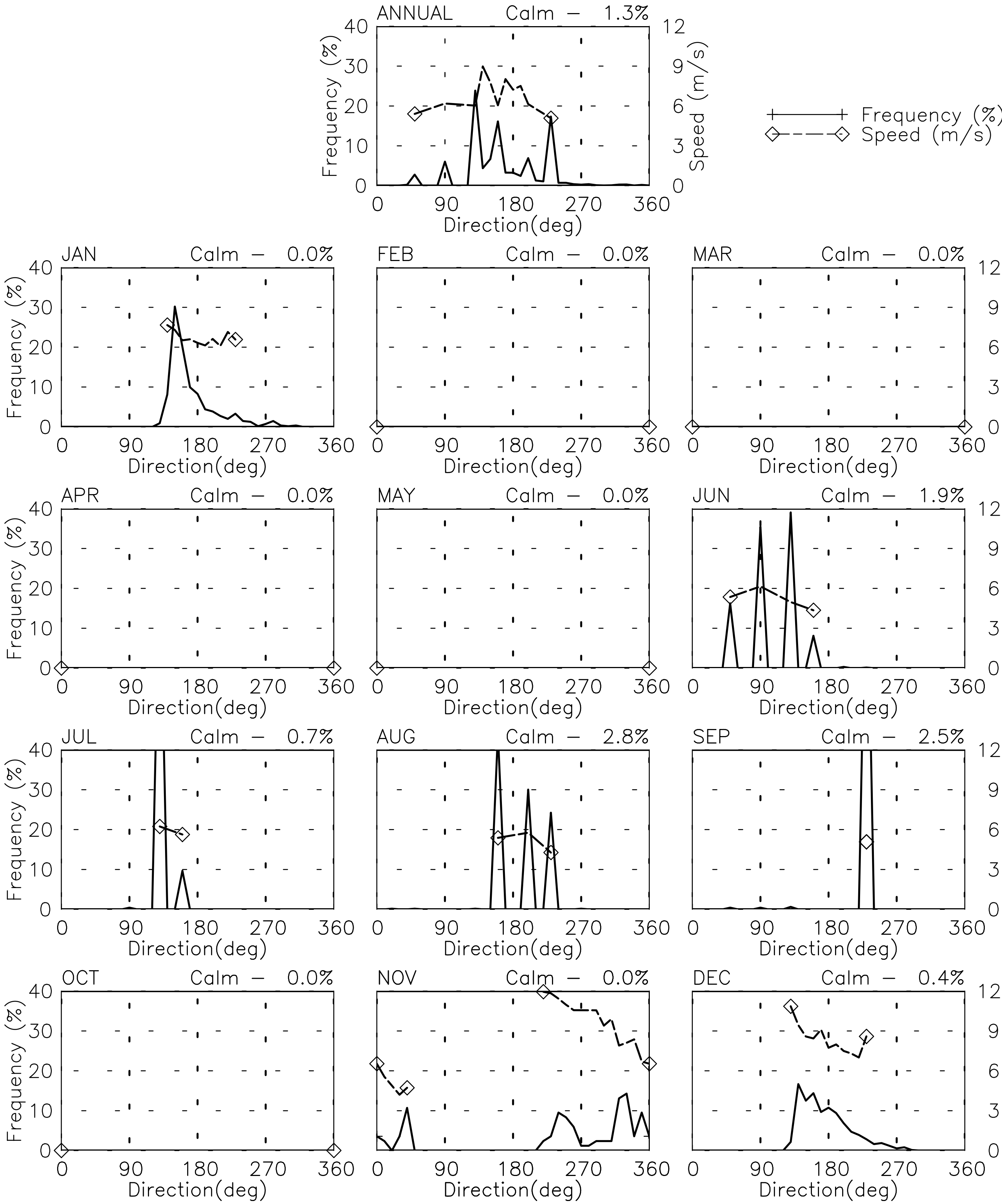
Cabo Engano (30m) – 002116
18° 37' N 68° 20' W – Elev 10m
06/98–01/99



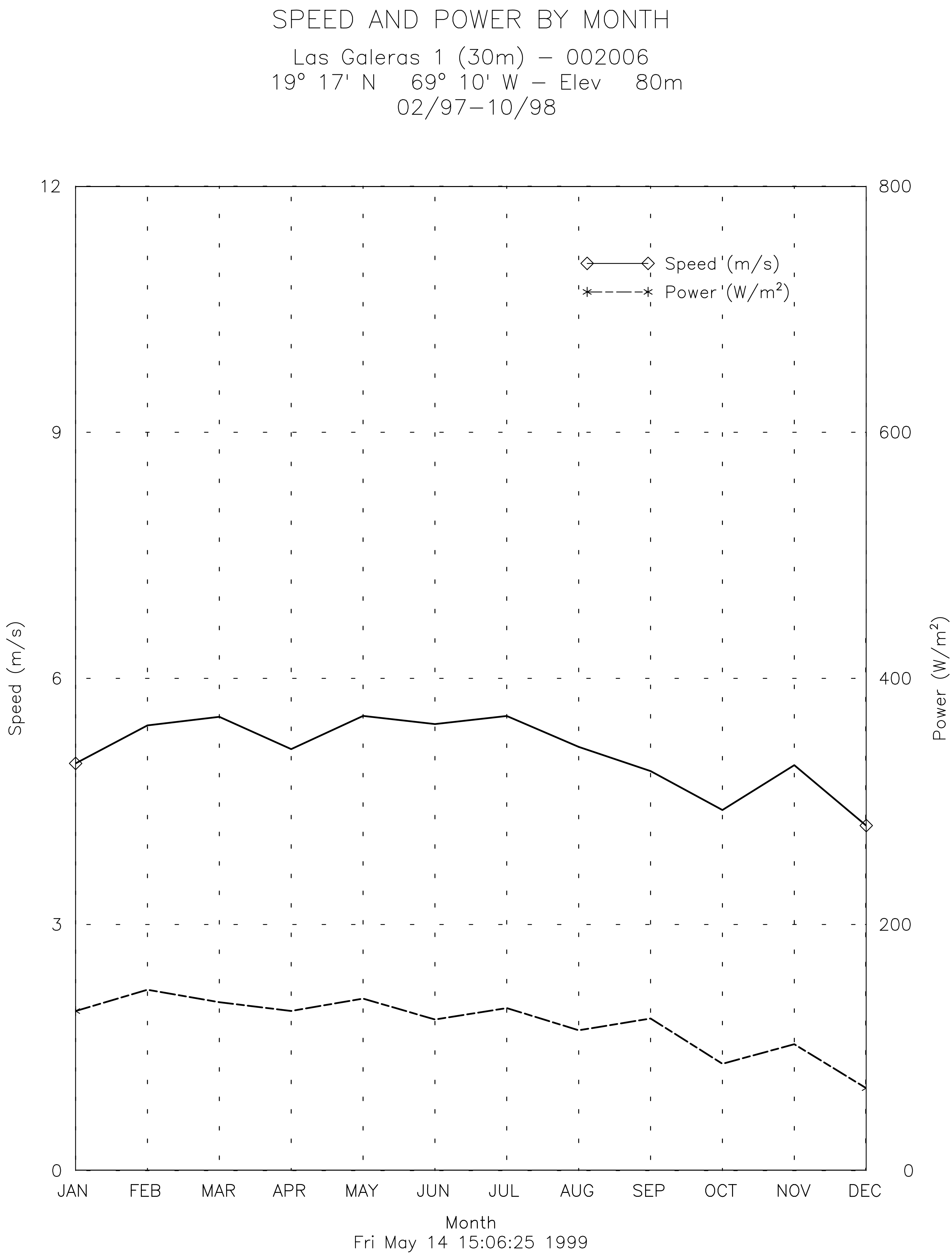
Fri May 14 15:08:16 1999

FREQUENCY AND SPEED BY DIRECTION

Cabo Engano (30m) – 002116
18° 37' N 68° 20' W – Elev 10m
06/98–01/99



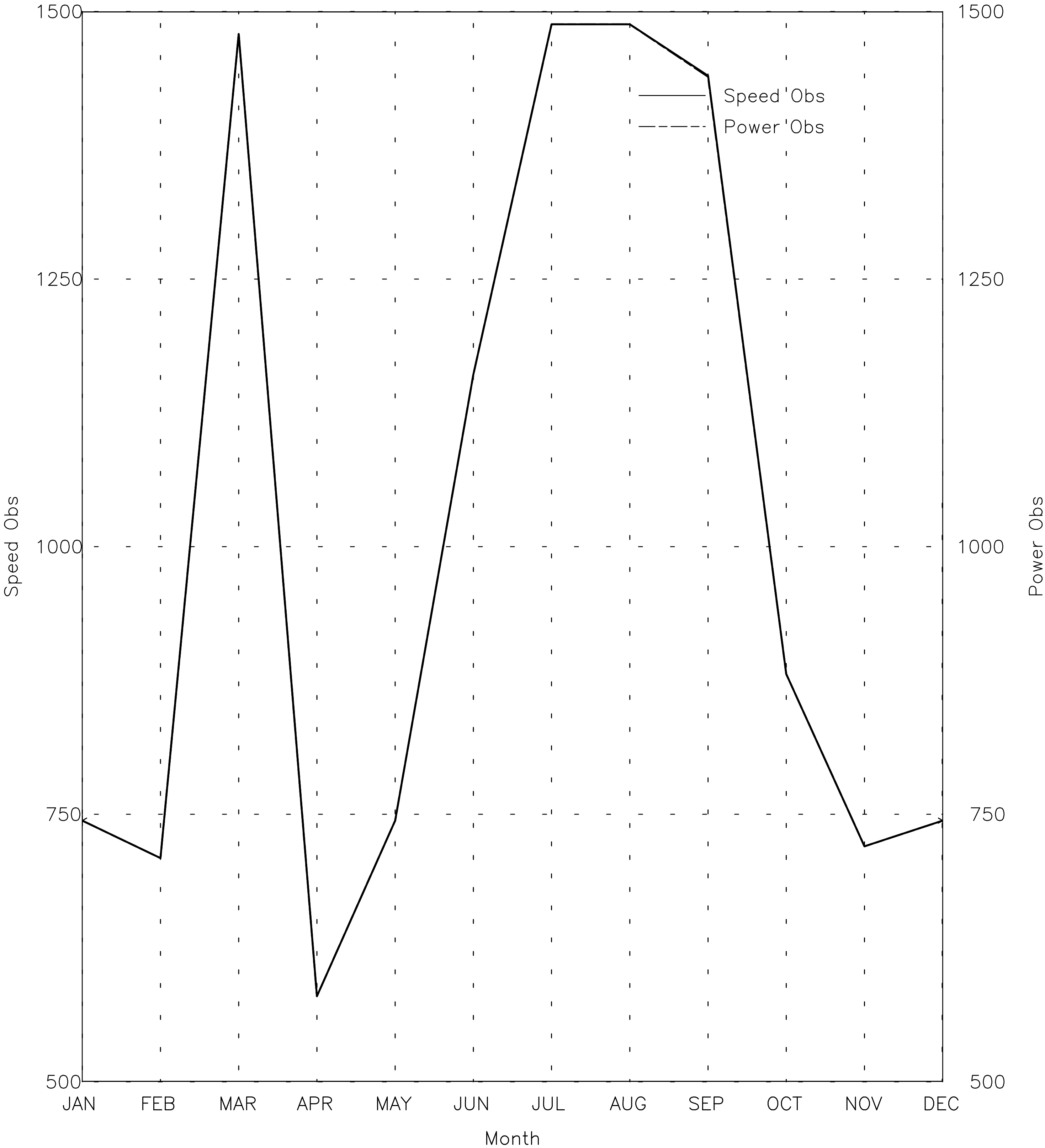
Fri May 14 15:08:20 1999



SPEED AND POWER BY MONTH
Las Galeras 1 (30m) - 002006
19° 17' N 69° 10' W - Elev 80m
02/97-10/98
Speed (m/s)
Power (W/m²)
Month
Fri May 14 15:06:25 1999
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

OBSERVATIONS BY MONTH

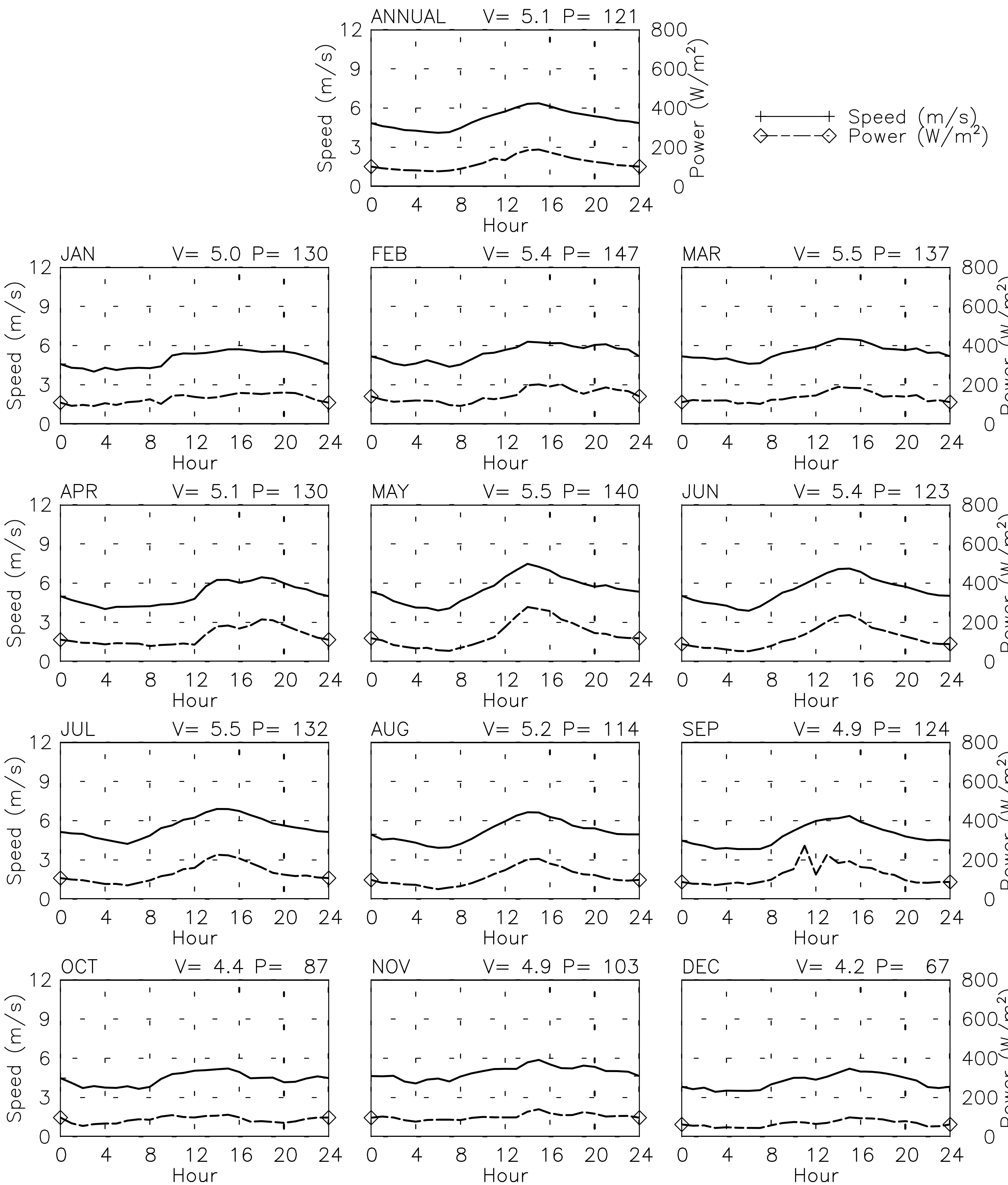
Las Galeras 1 (30m) – 002006
19° 17' N 69° 10' W – Elev 80m
02/97–10/98



Fri May 14 15:06:27 1999

SPEED AND POWER BY HOUR

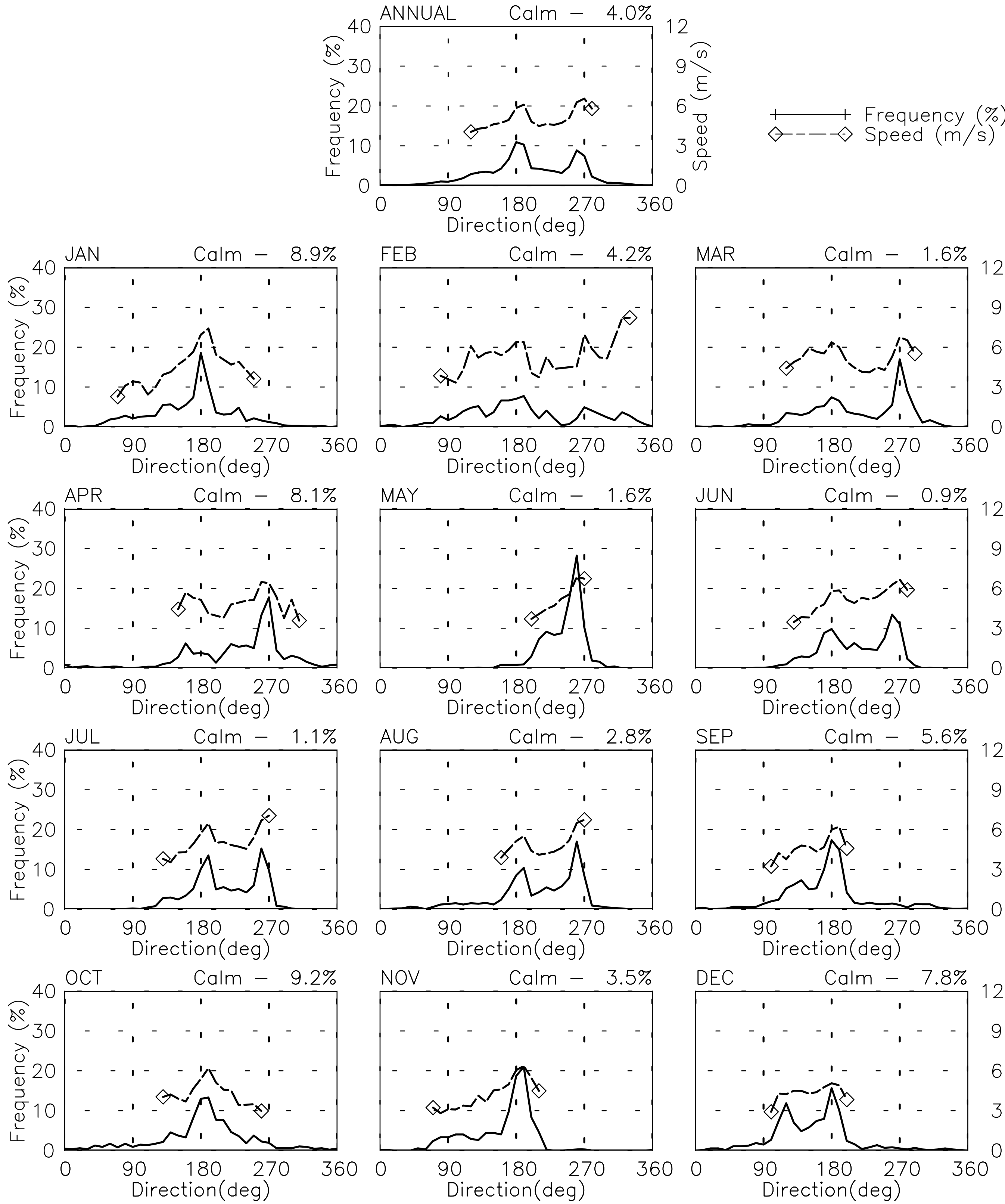
Las Galeras 1 (30m) - 002006
19° 17' N 69° 10' W - Elev 80m
02/97-10/98



Fri May 14 15:06:29 1999

FREQUENCY AND SPEED BY DIRECTION

Las Galeras 1 (30m) – 002006
19° 17' N   69° 10' W – Elev   80m
02/97–10/98



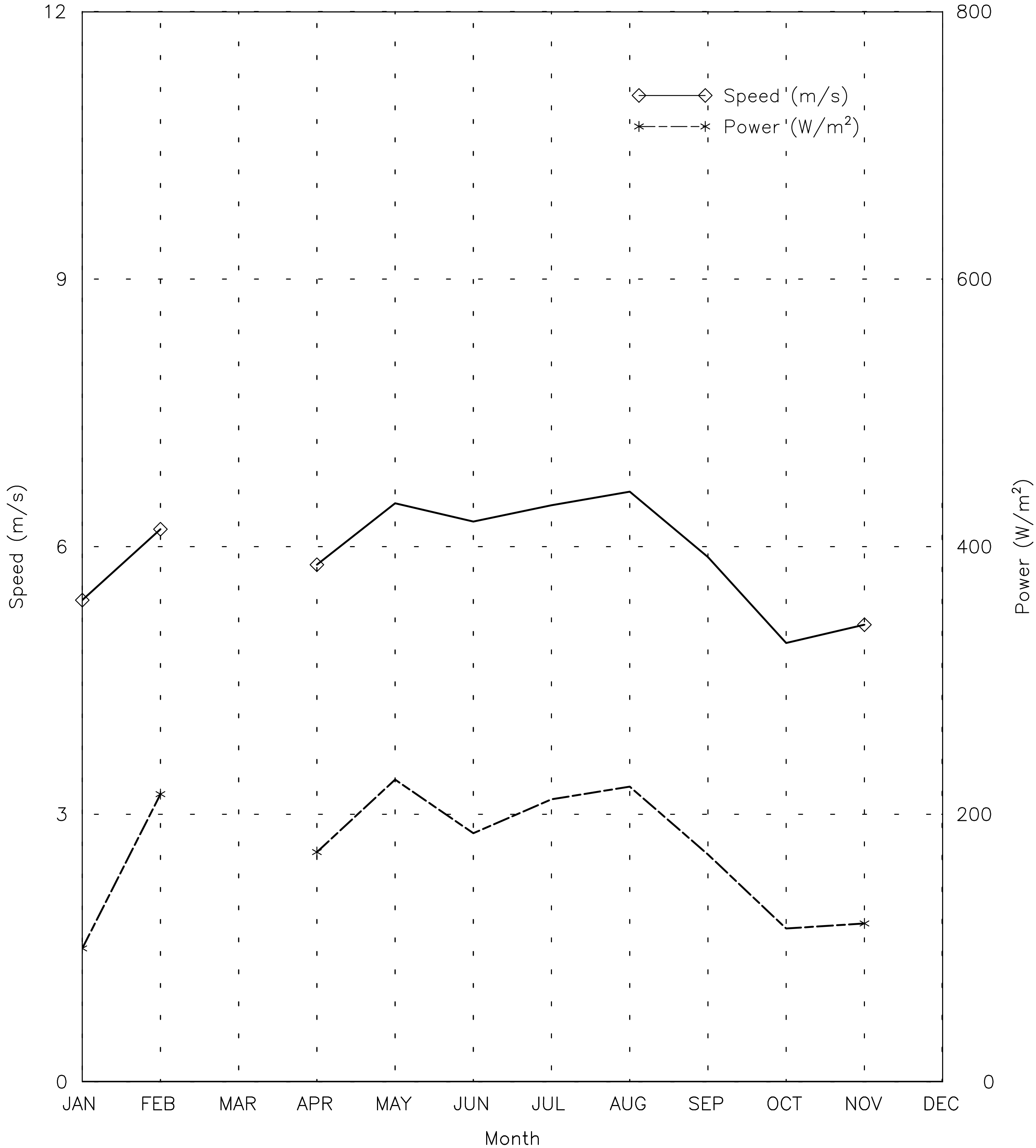
Fri May 14 15:06:32 1999

SPEED AND POWER BY MONTH

Las Galeras 2 (30m) – 002008

19° 16' N 69° 11' W – Elev 180m

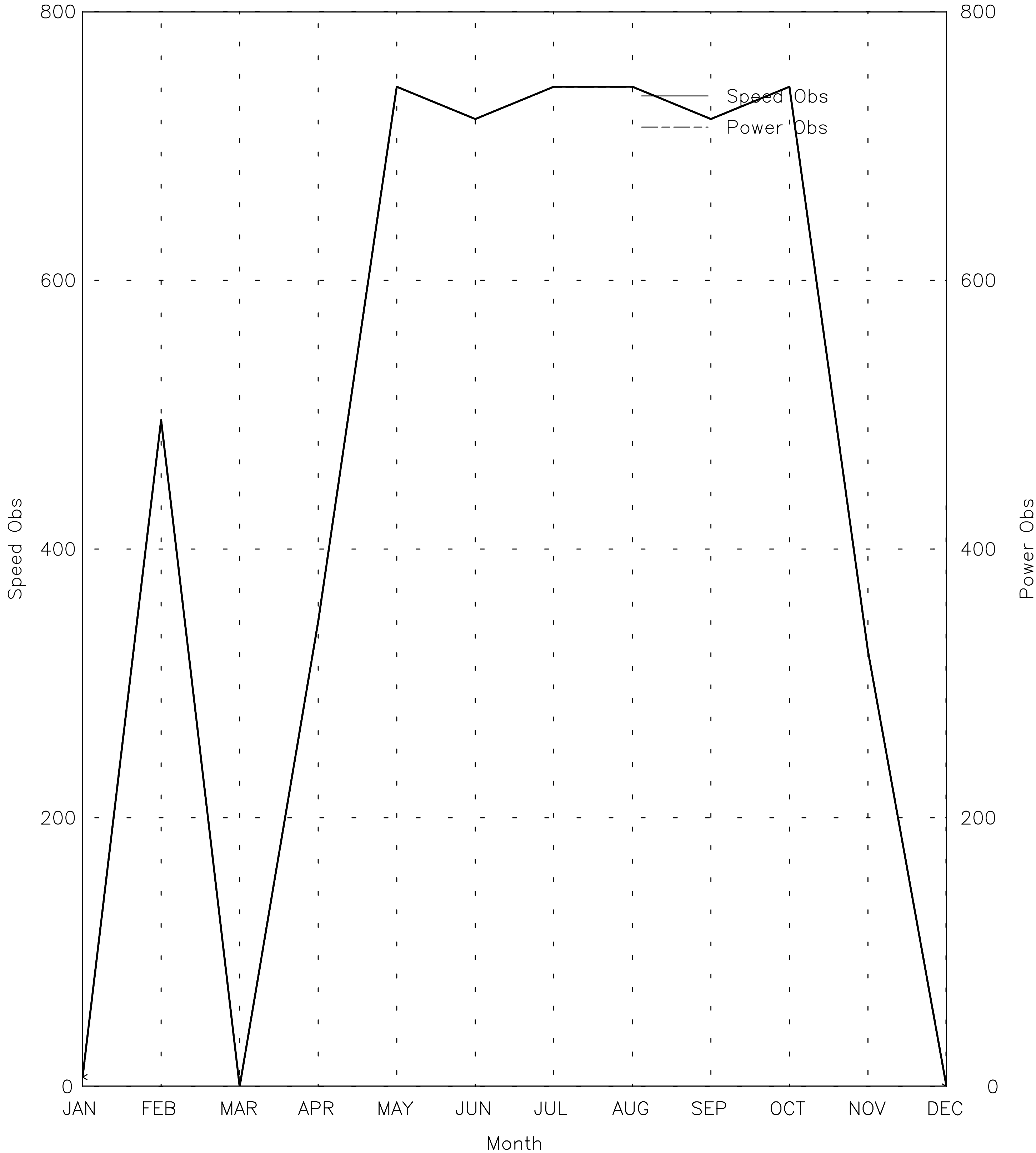
04/97–02/98



Fri May 14 15:06:51 1999

OBSERVATIONS BY MONTH

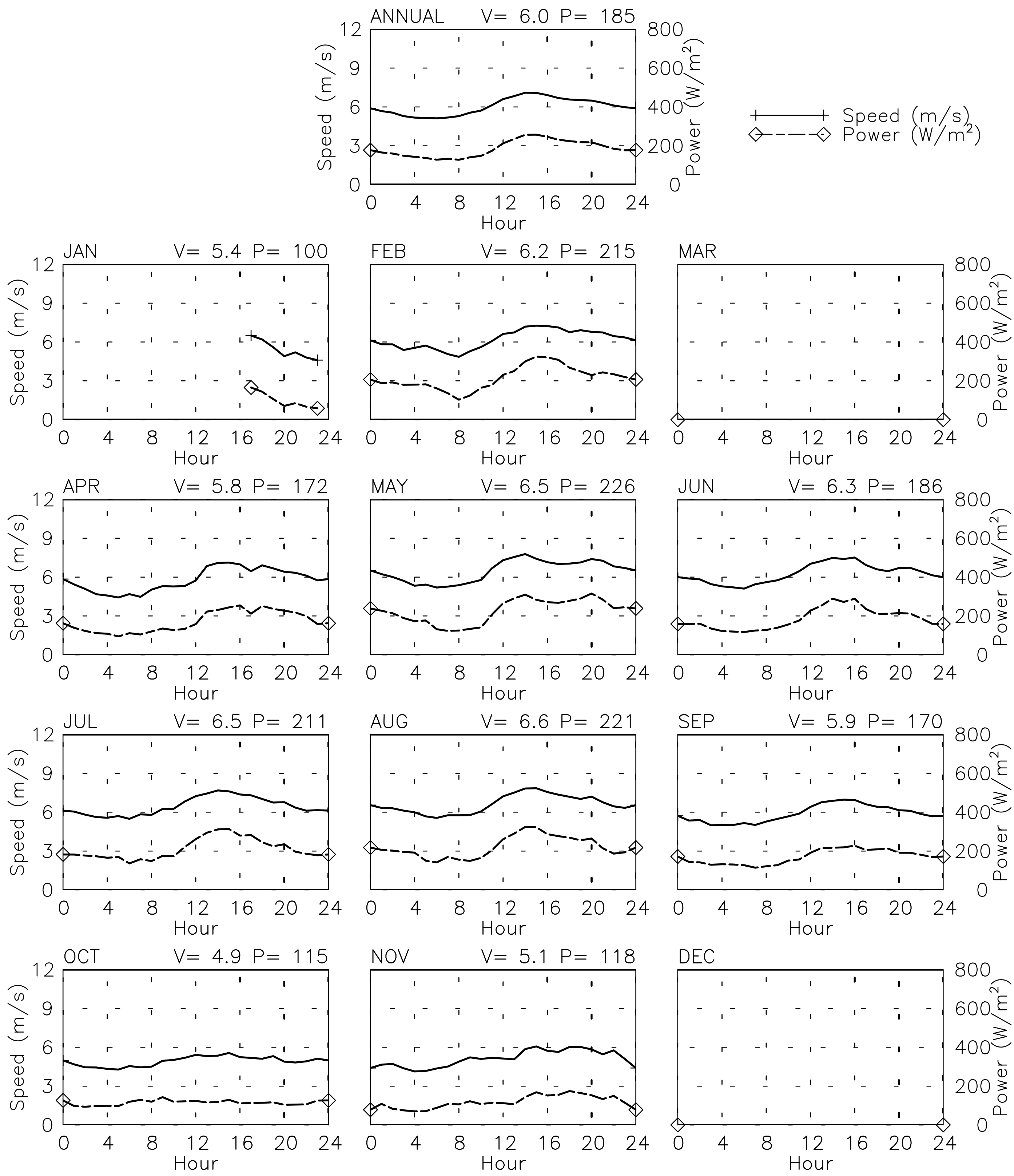
Las Galeras 2 (30m) - 002008
19° 16' N 69° 11' W - Elev 180m
04/97-02/98



Fri May 14 15:06:53 1999

SPEED AND POWER BY HOUR

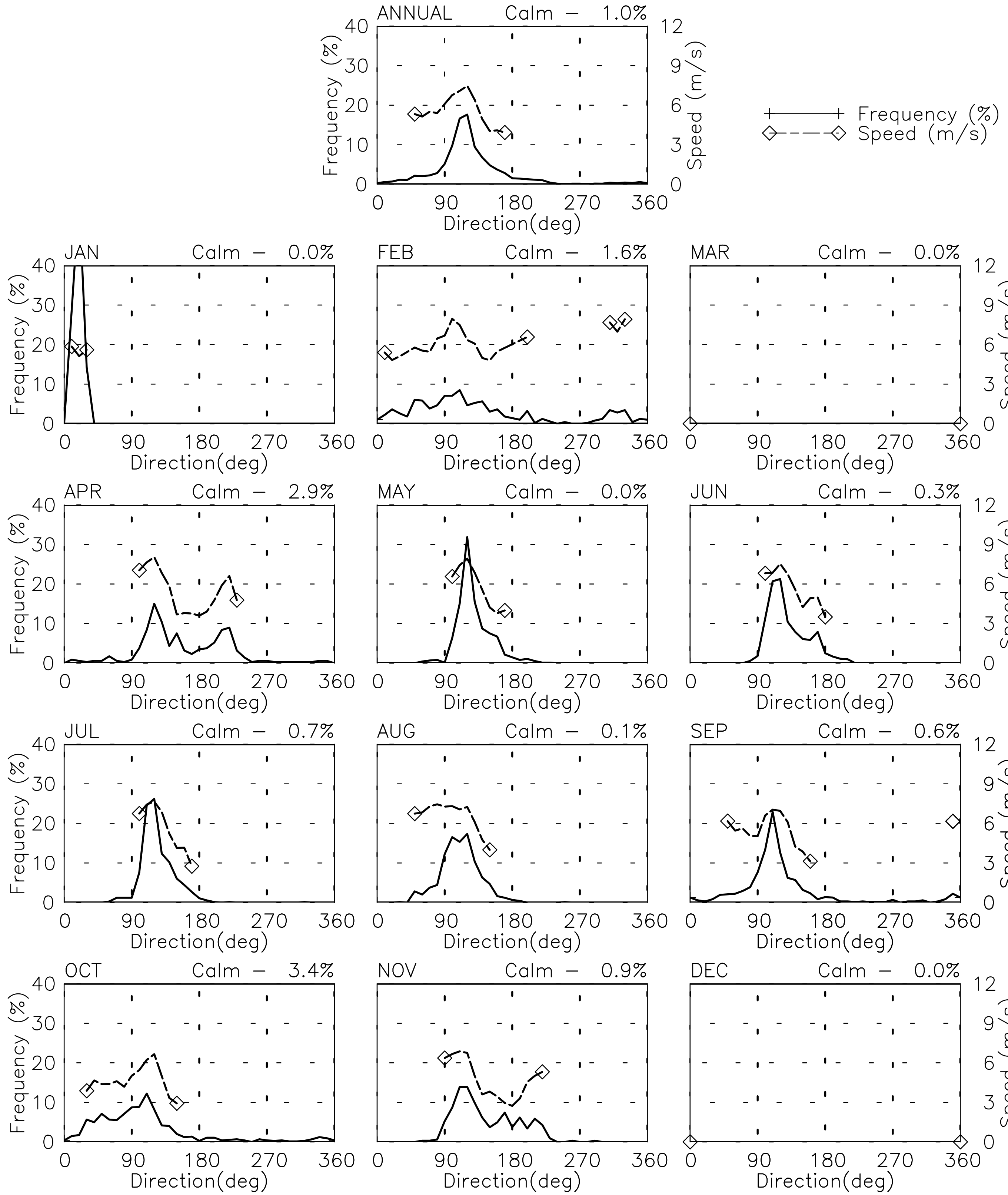
Las Galeras 2 (30m) – 002008
19° 16' N 69° 11' W – Elev 180m
04/97–02/98



Fri May 14 15:06:55 1999

FREQUENCY AND SPEED BY DIRECTION

Las Galeras 2 (30m) – 002008
19° 16' N   69° 11' W – Elev 180m
04/97–02/98



Fri May 14 15:06:59 1999

Appendix B

Surface Meteorological Stations - Data Summaries

ONM Stations:

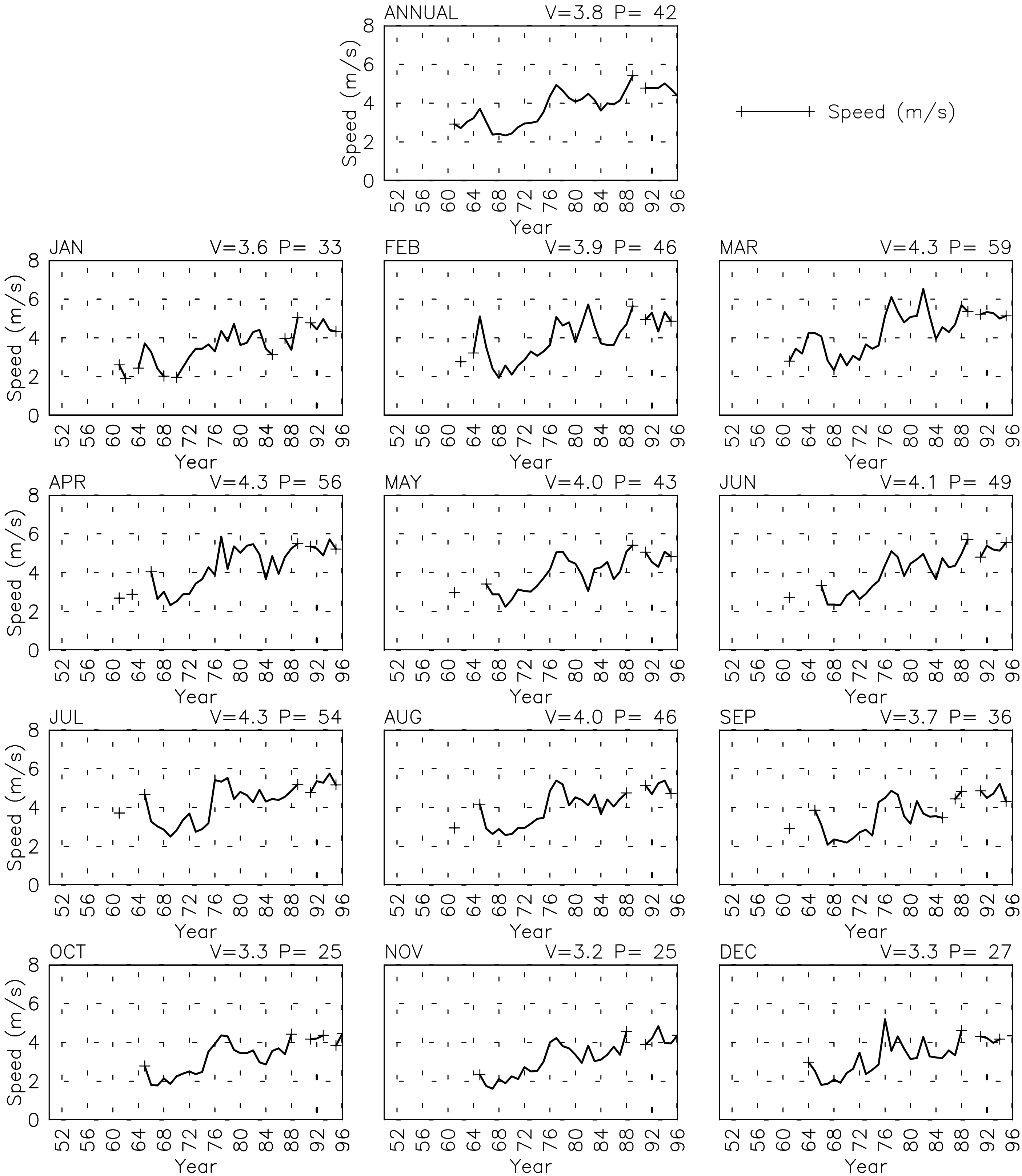
Barahona
Cabrera
Constanza
Dajabon
Jimani
Monte Cristi
Puerto Plata/La Union
Punta Cana
Sabana de la Mar
San Cristobal
San Juan
San Pedro de Macoris
Santiago
Santo Domingo
Santo Domingo/Las Americas
Santo Domingo/Herrera

DATSAV2 Stations:

Puerto Plata
Santiago
Sabana de la Mar
Barahona
Las Americas
Cabo Engaño
Santo Domingo

SPEED BY YEAR

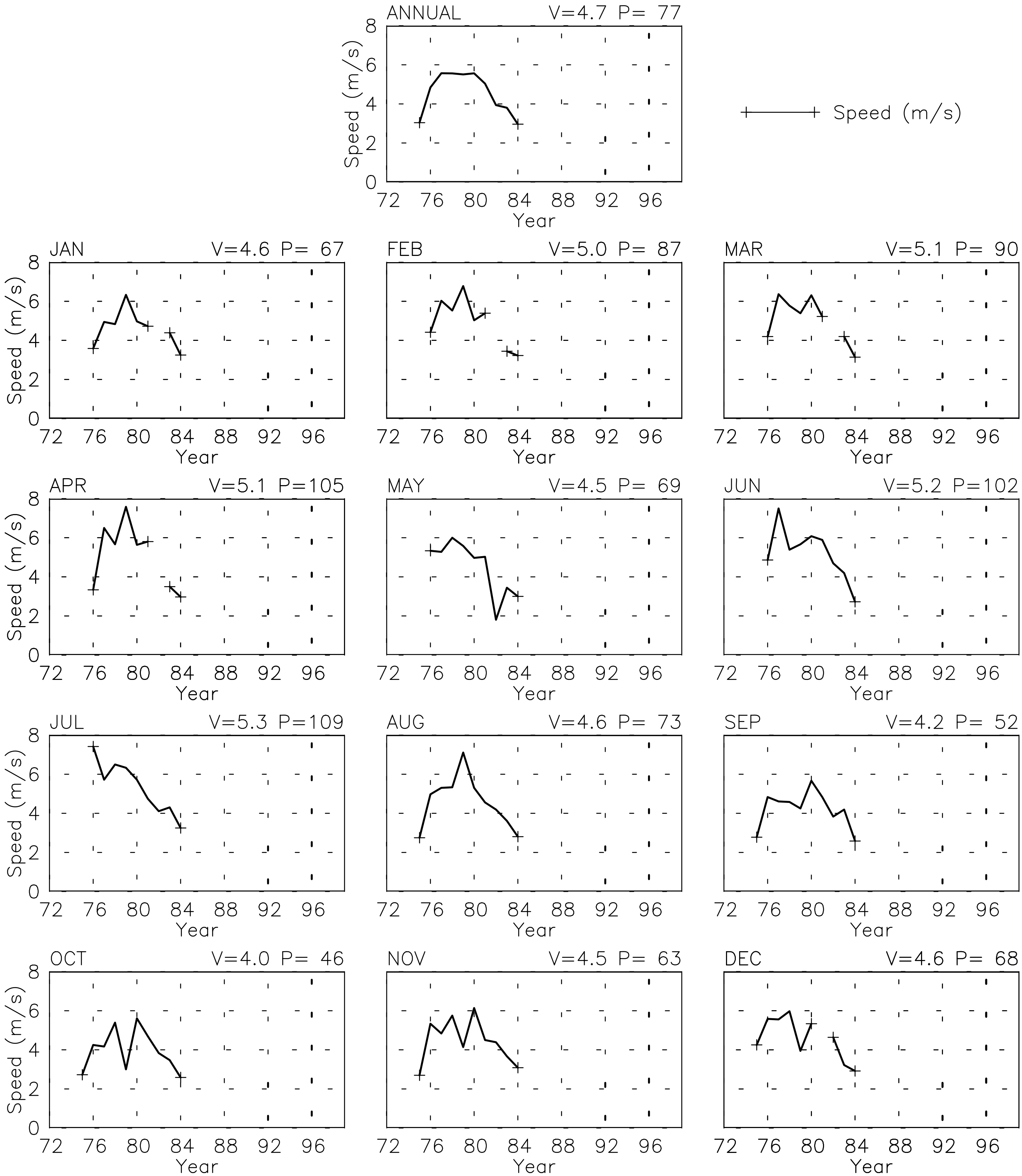
Barahona – 003010
18° 11' N 71° 05' W – Elev 10m
01/61–07/89 01/91–12/96



Fri May 14 15:29:29 1999

SPEED BY YEAR

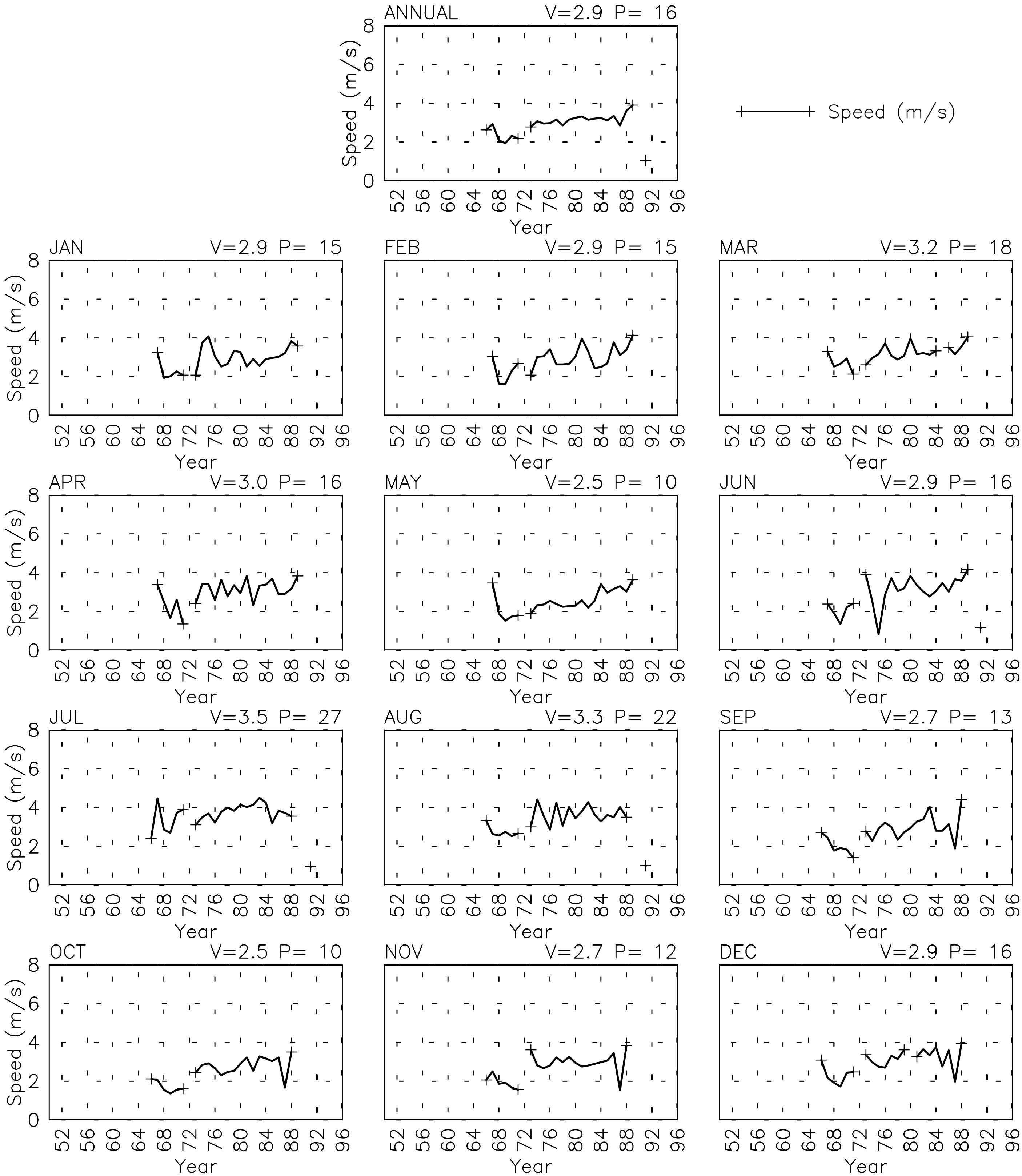
Cabrera - 003013
19° 37' N 69° 54' W - Elev 15m
08/75-12/84



Fri May 14 15:27:12 1999

SPEED BY YEAR

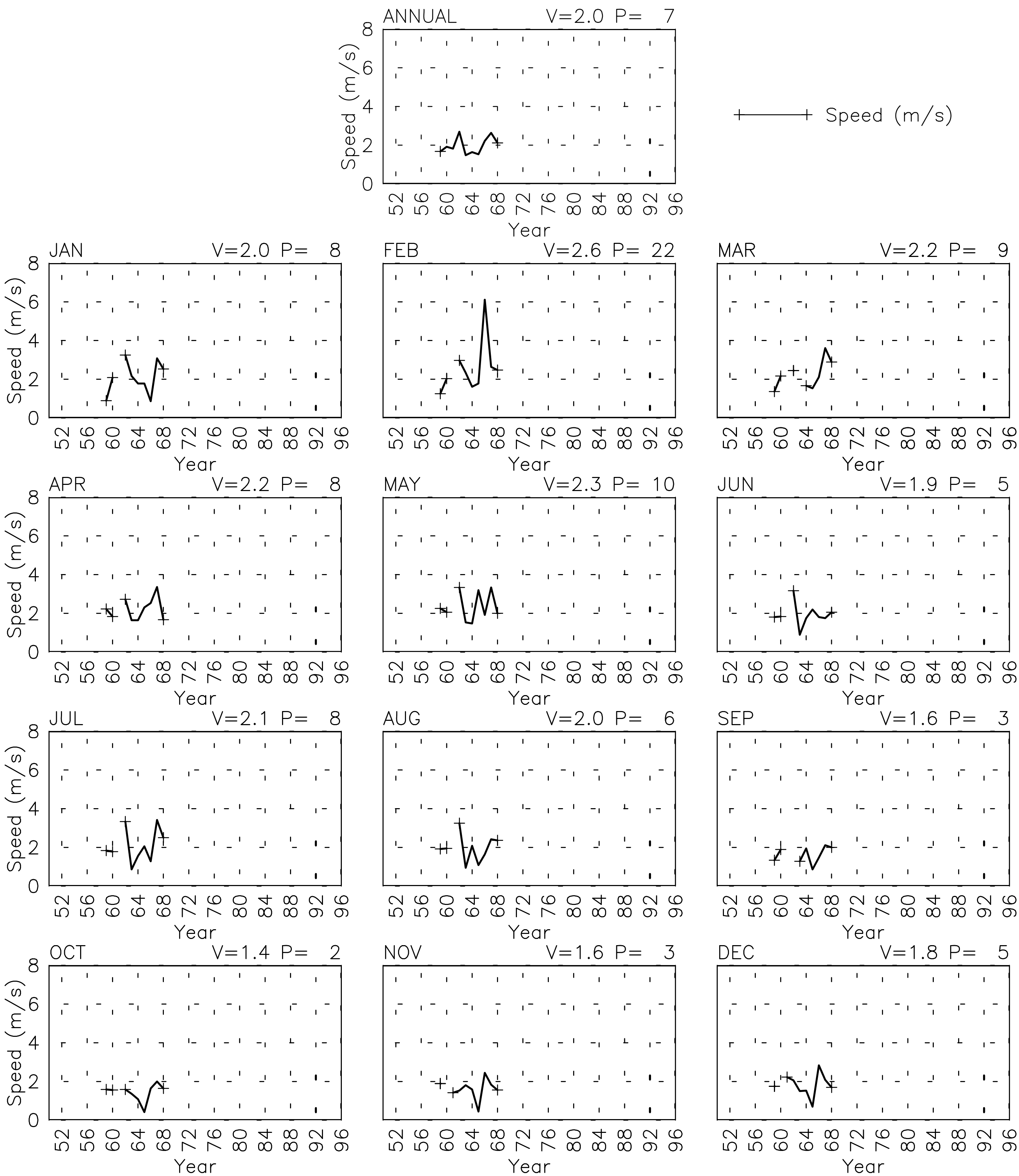
Constanza – 003012
18° 53' N 70° 43' W – Elev 1164m
07/66–12/71 01/73–06/89 06/91–08/91



Fri May 14 15:29:46 1999

SPEED BY YEAR

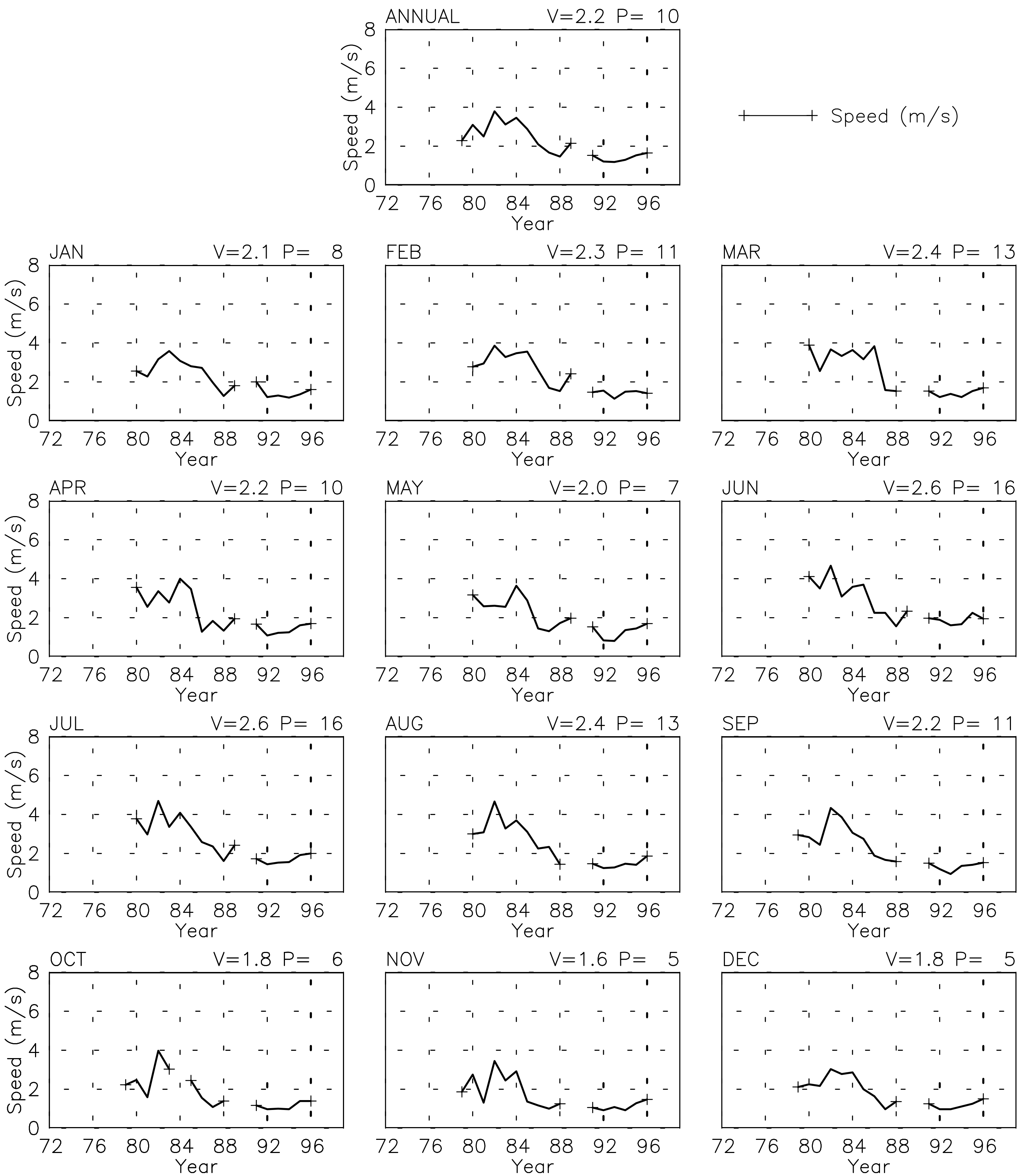
Dajabon – 003014
19° 33' N 71° 42' W – Elev 36m
01/59–12/68



Fri May 14 15:29:52 1999

SPEED BY YEAR

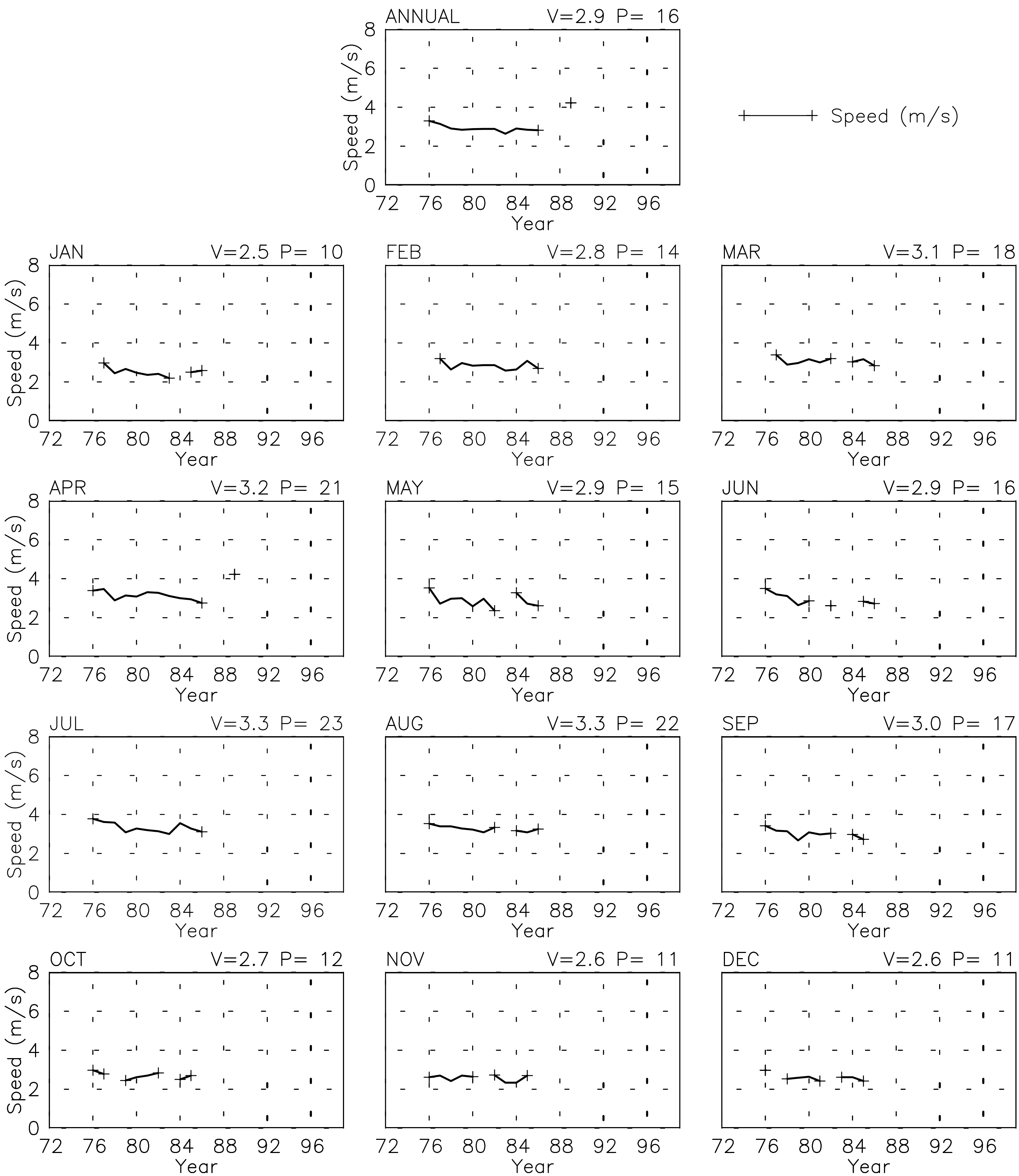
Jimani – 003015
18° 28' N 71° 50' W – Elev 31m
09/79–07/89 01/91–12/96



Fri May 14 15:27:16 1999

SPEED BY YEAR

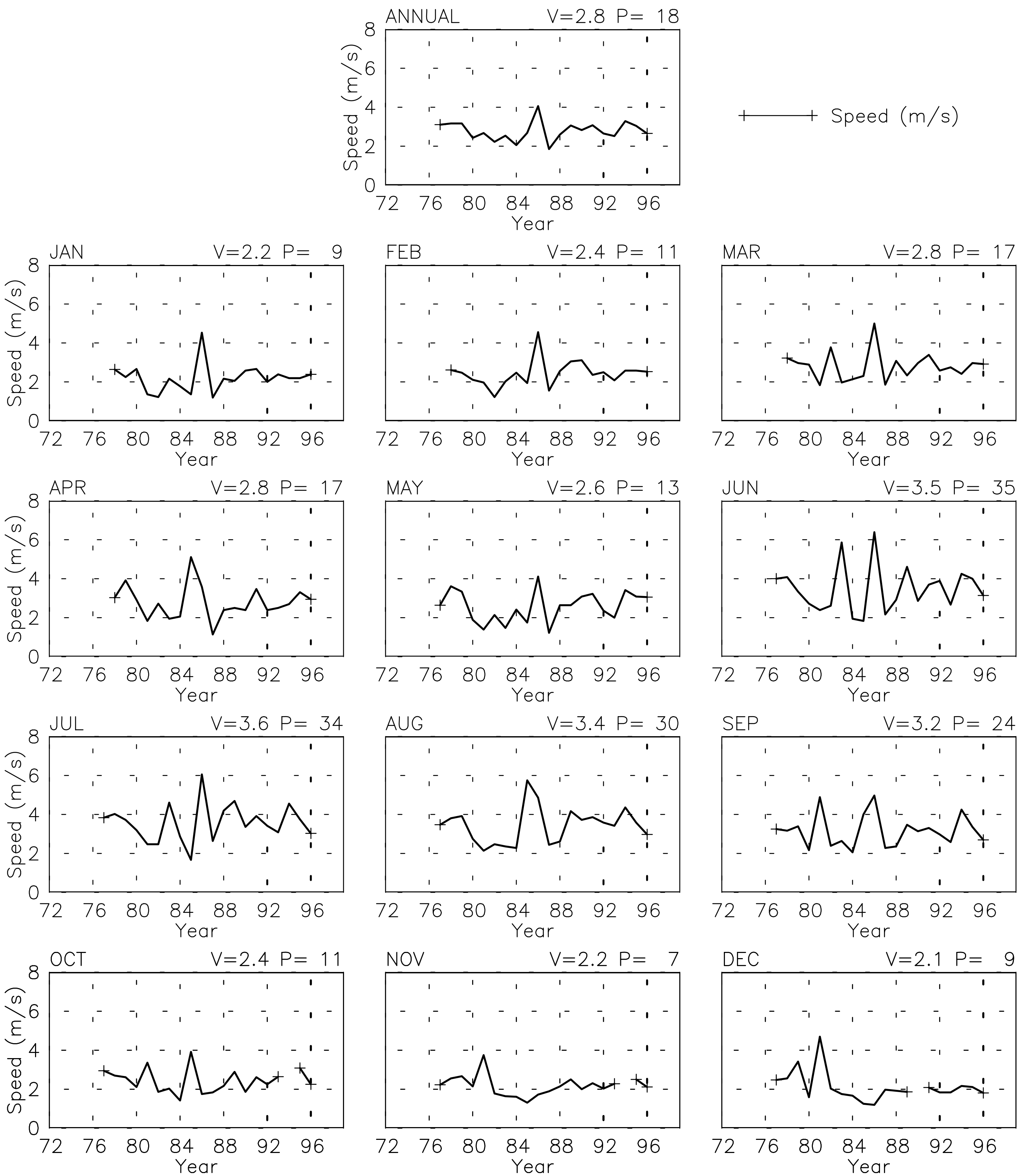
Monte Cristi - 003008
19° 51' N 71° 37' W - Elev 7m
04/76-08/86 04/89-04/89



Fri May 14 15:27:07 1999

SPEED BY YEAR

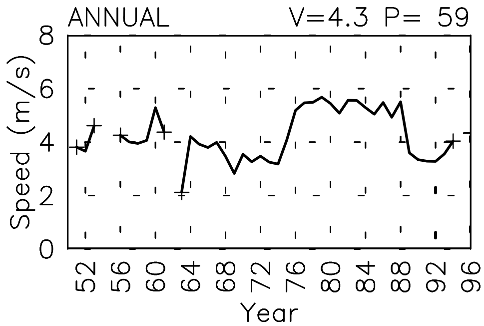
Puerto Plata/La Union - 003006
19° 45' N 70° 32' W - Elev 5m
05/77-12/96

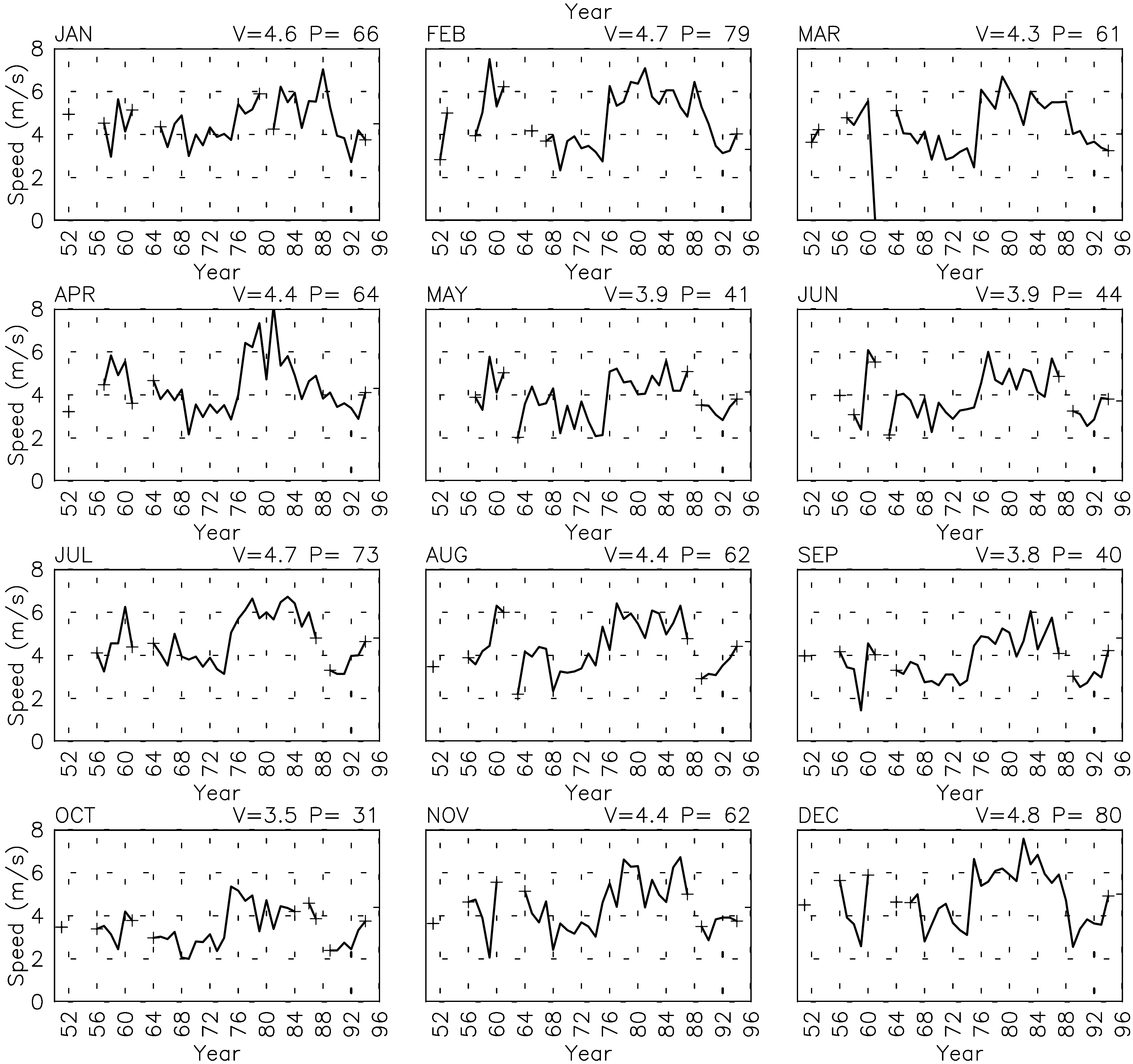


Fri May 14 15:27:03 1999

SPEED BY YEAR

Punta Cana – 003011
18° 34' N 68° 22' W – Elev 122m
08/51–03/53 06/56–10/61 05/63–12/94 01/96–12/96

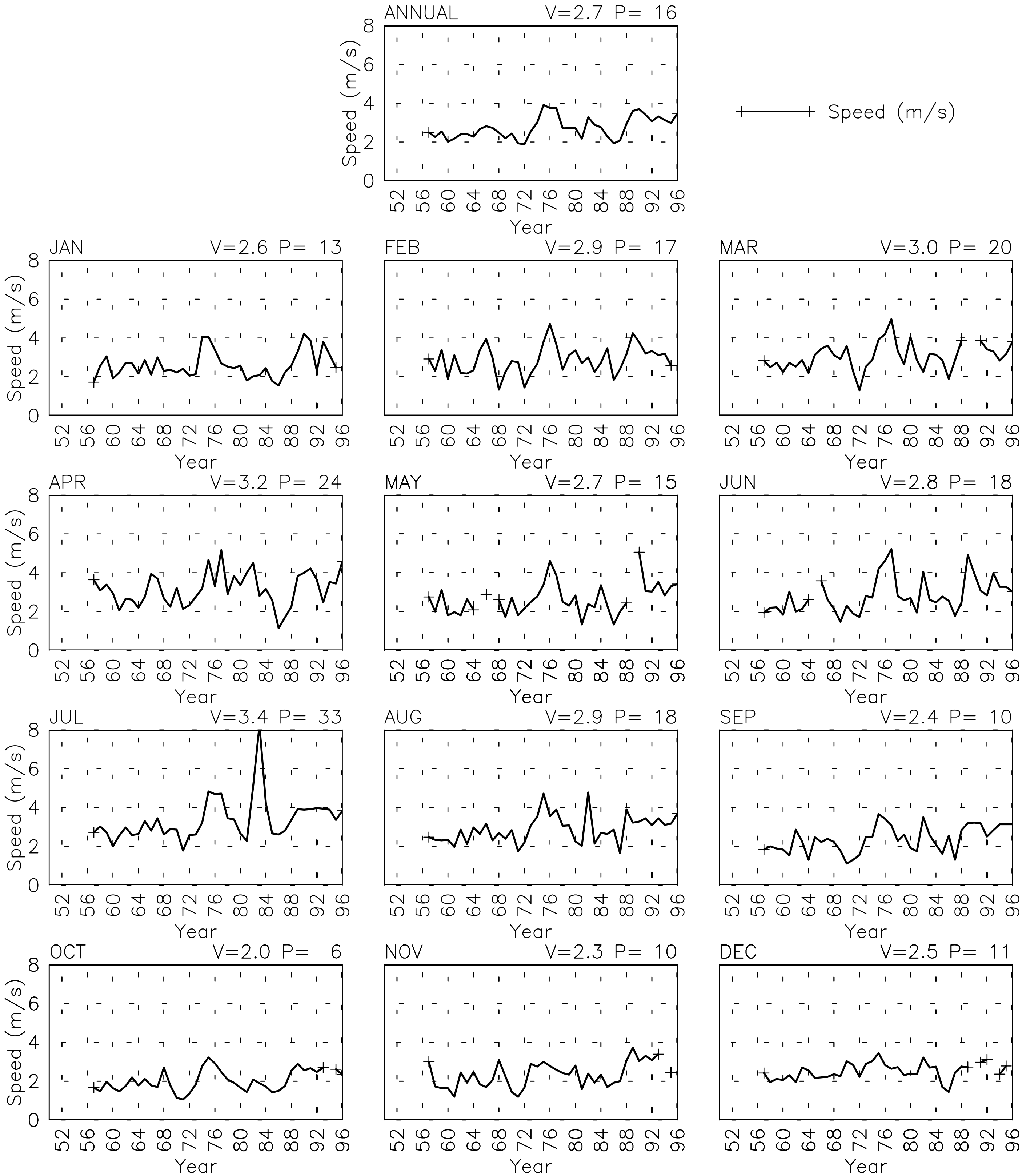




Fri May 14 15:29:37 1999

SPEED BY YEAR

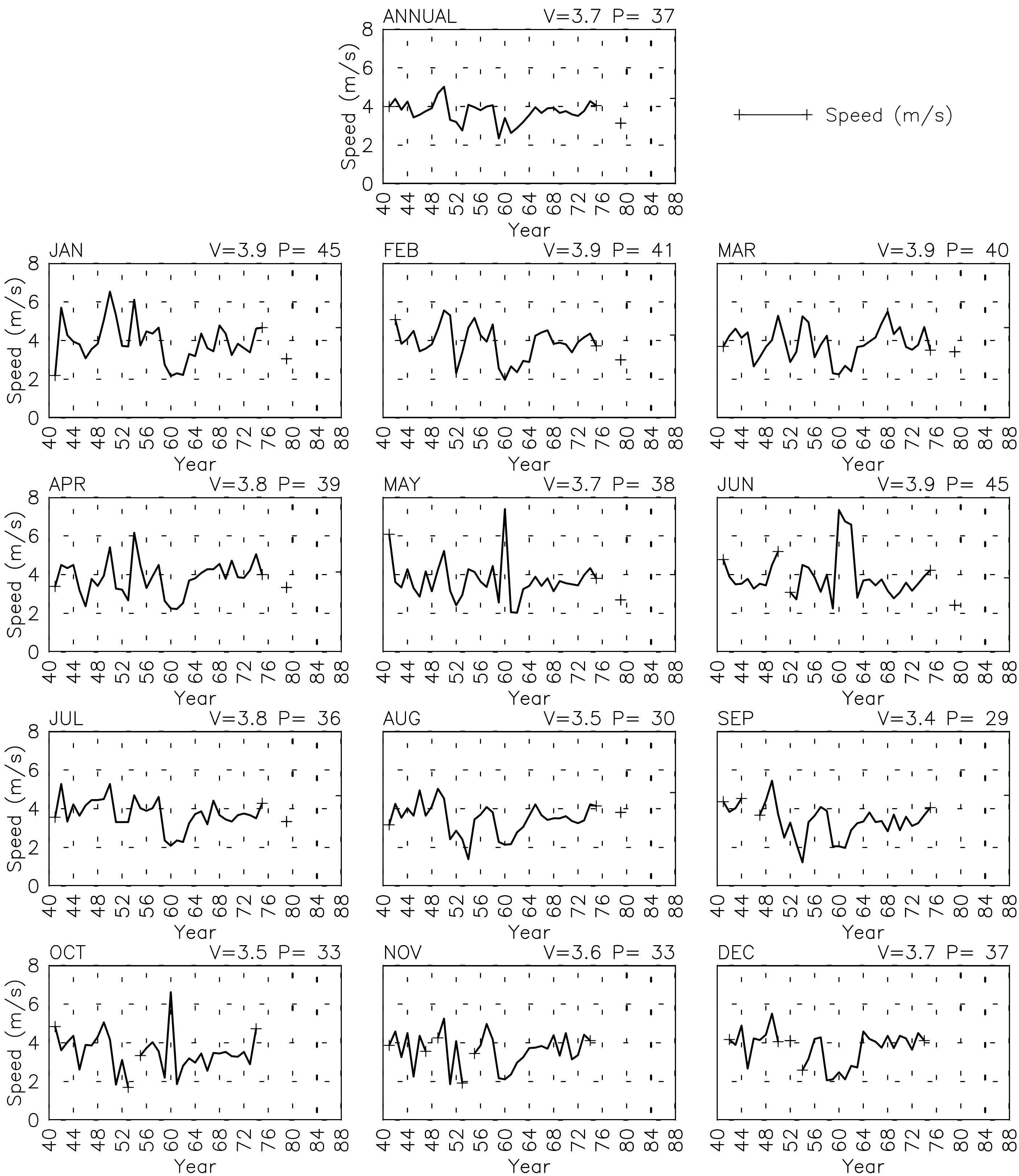
Sabana de La Mar - 003007
19° 03' N 69° 25' W - Elev 3m
01/57-10/96



Fri May 14 15:29:14 1999

SPEED BY YEAR

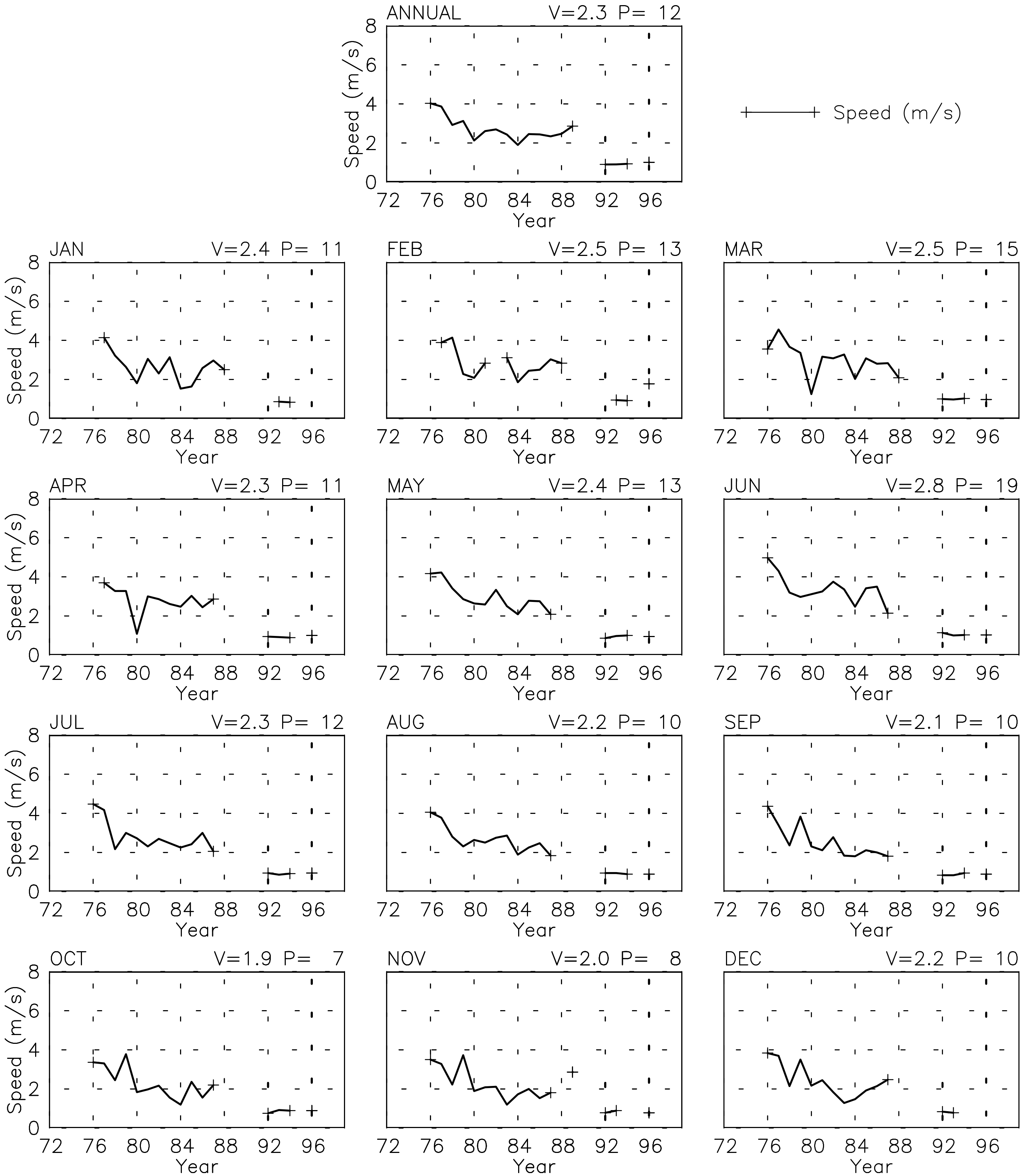
San Cristobal – 003003
18° 25' N 70° 05' W – Elev 44m
01/41–09/75 01/79–08/79 01/88–09/88



Fri May 14 15:28:21 1999

SPEED BY YEAR

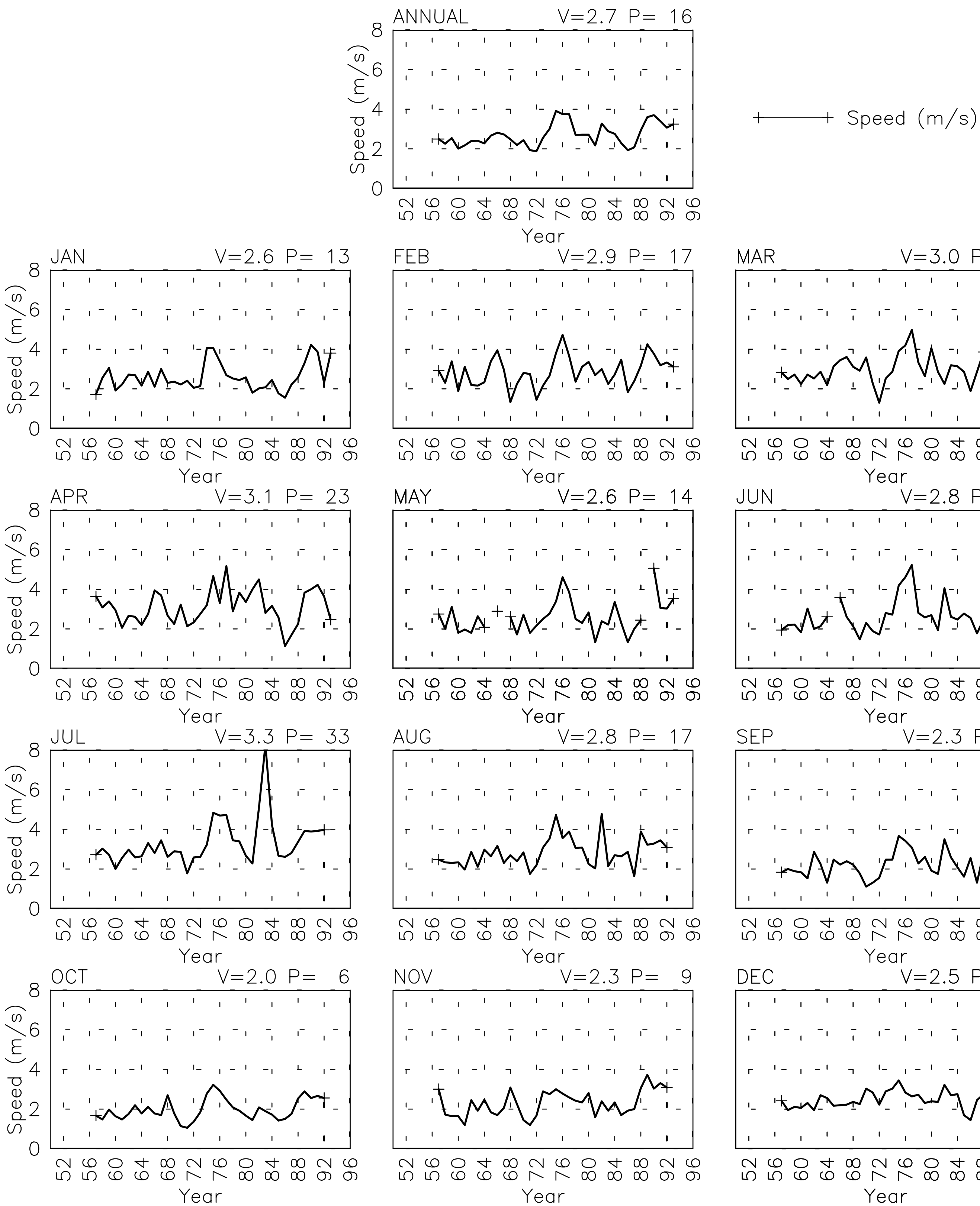
San Juan – 003001
18° 48' N   71° 13' W – Elev 415m
03/76–11/89 03/92–10/94 02/96–11/96



Fri May 14 15:26:53 1999

SPEED BY YEAR

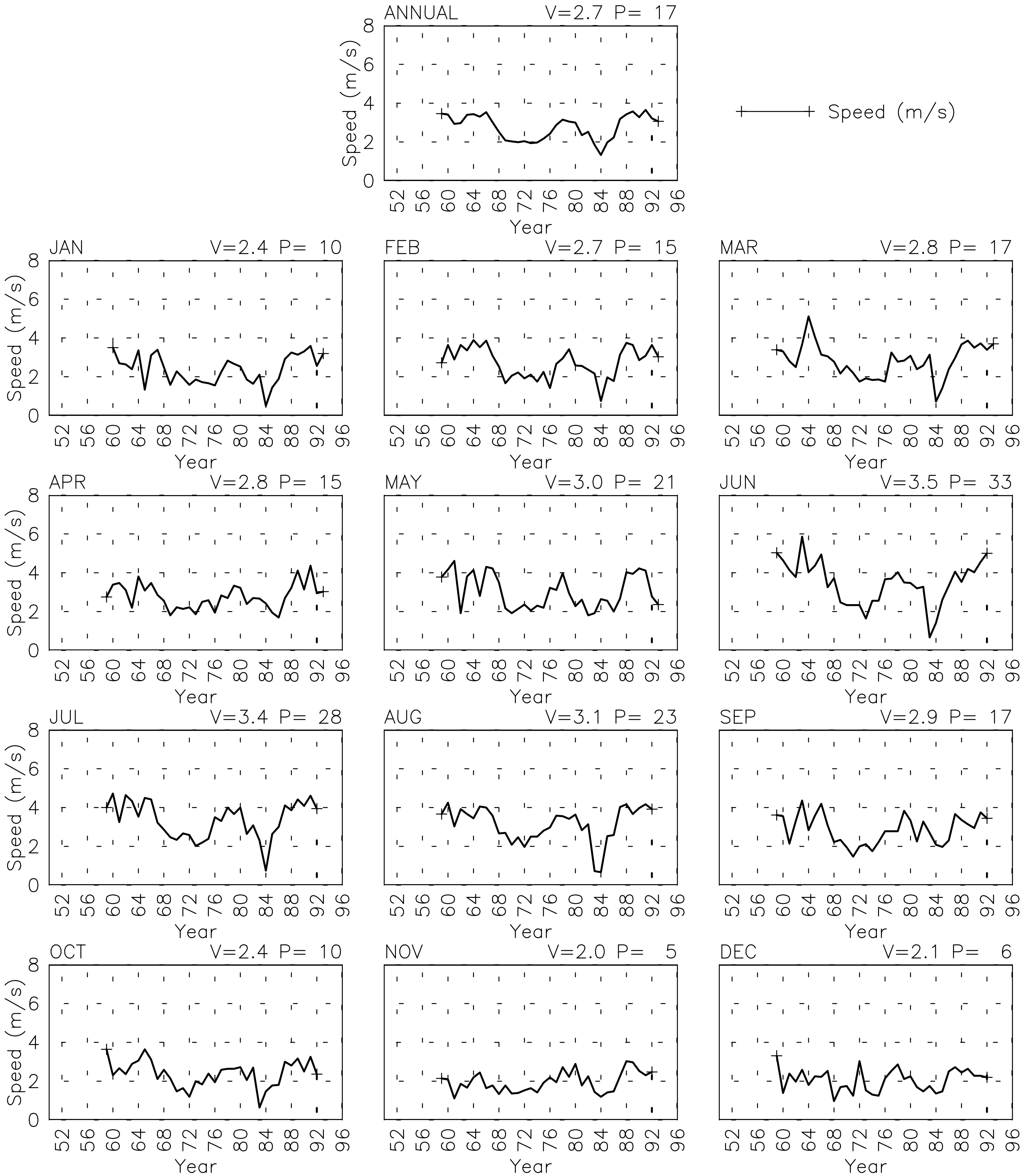
San Pedro Macoris - 003016
18° 26' N 69° 17' W - Elev 3m
01/57-05/93



Fri May 14 15:29:59 1999

SPEED BY YEAR

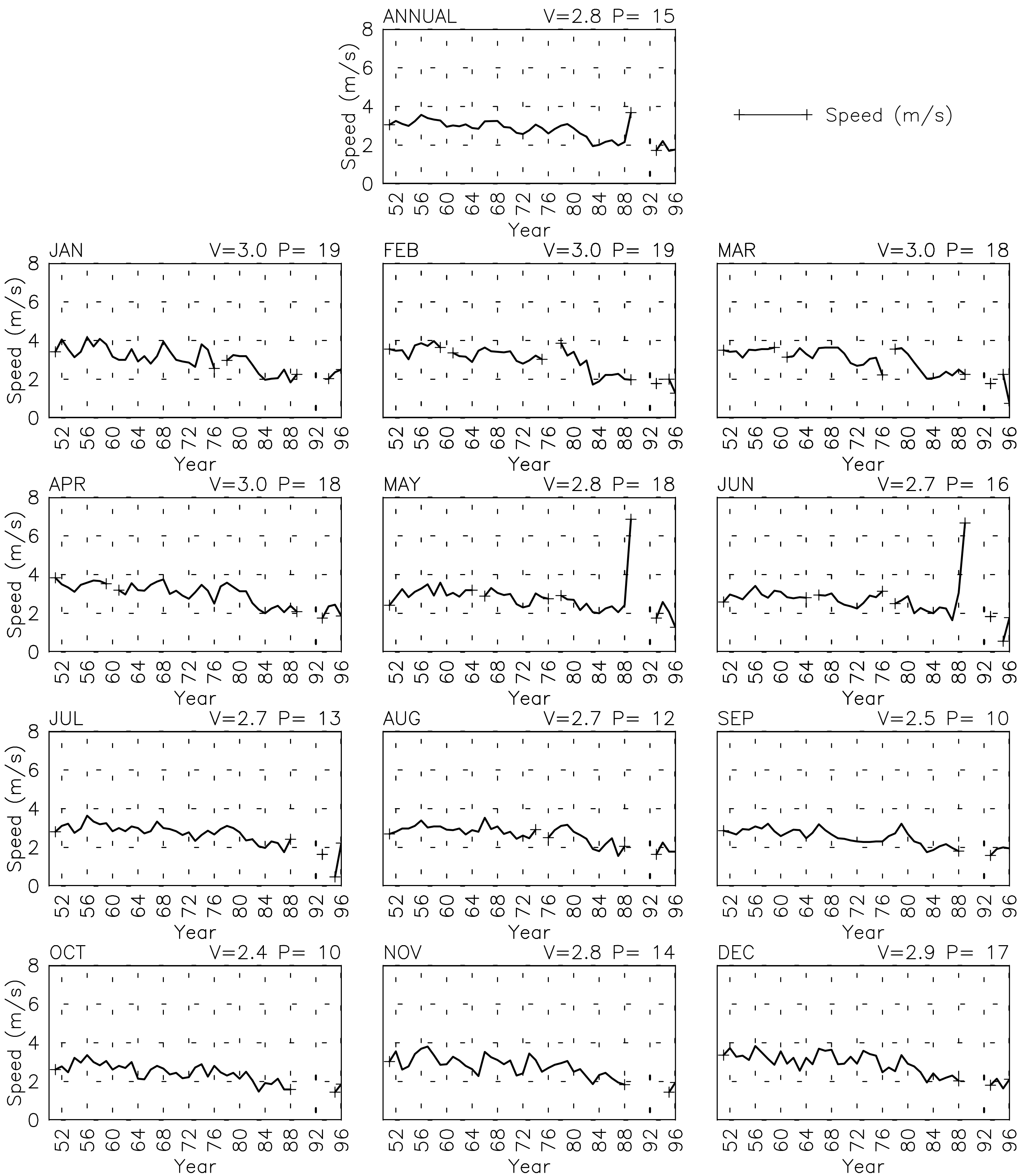
Santiago – 003004
19° 26' N   70° 42' W – Elev 183m
02/59–05/93



Fri May 14 15:29:08 1999

SPEED BY YEAR

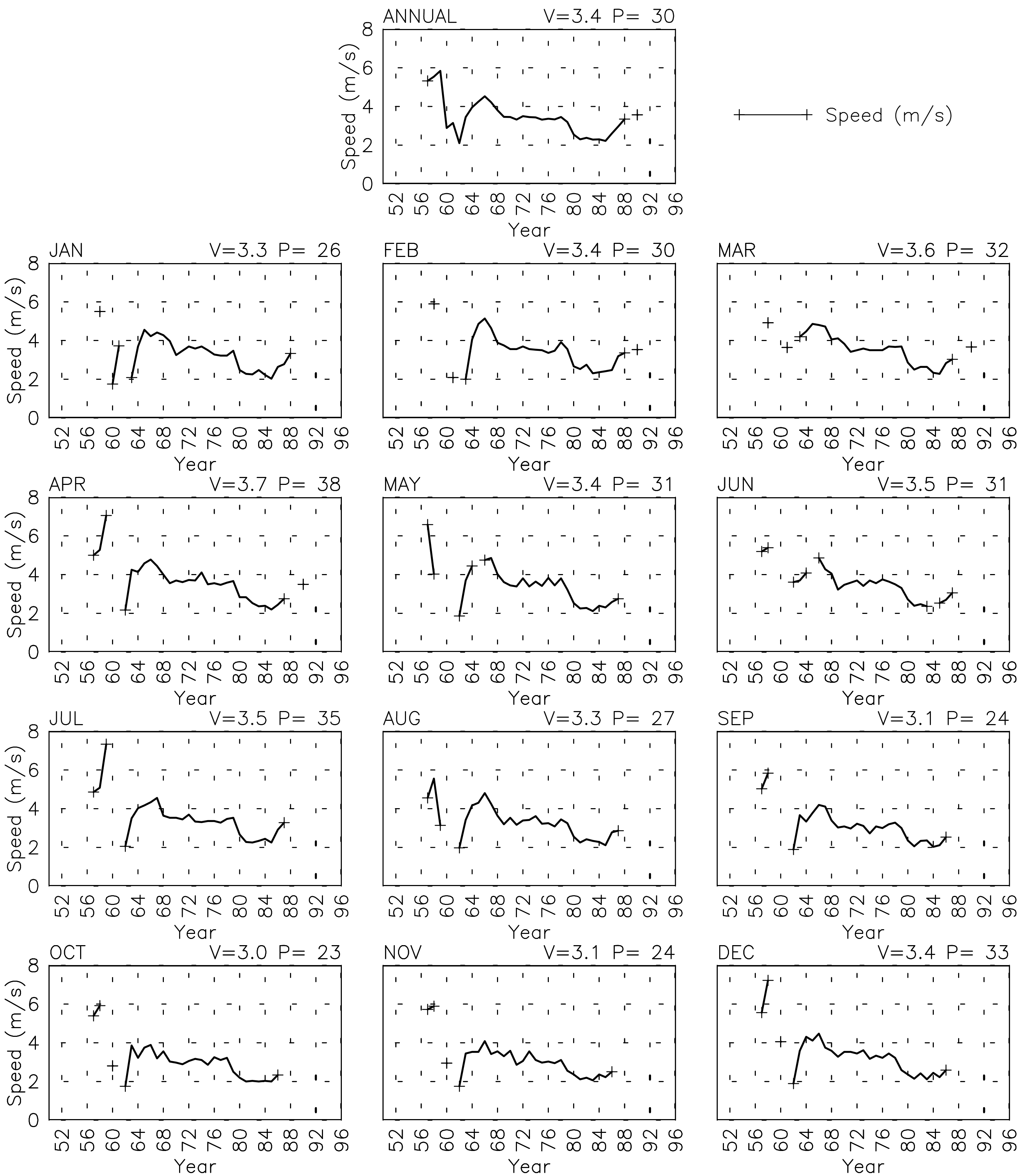
Santo Domingo - 003009
18° 28' N 69° 55' W - Elev 14m
01/51-06/89 02/93-12/96



Fri May 14 15:29:21 1999

SPEED BY YEAR

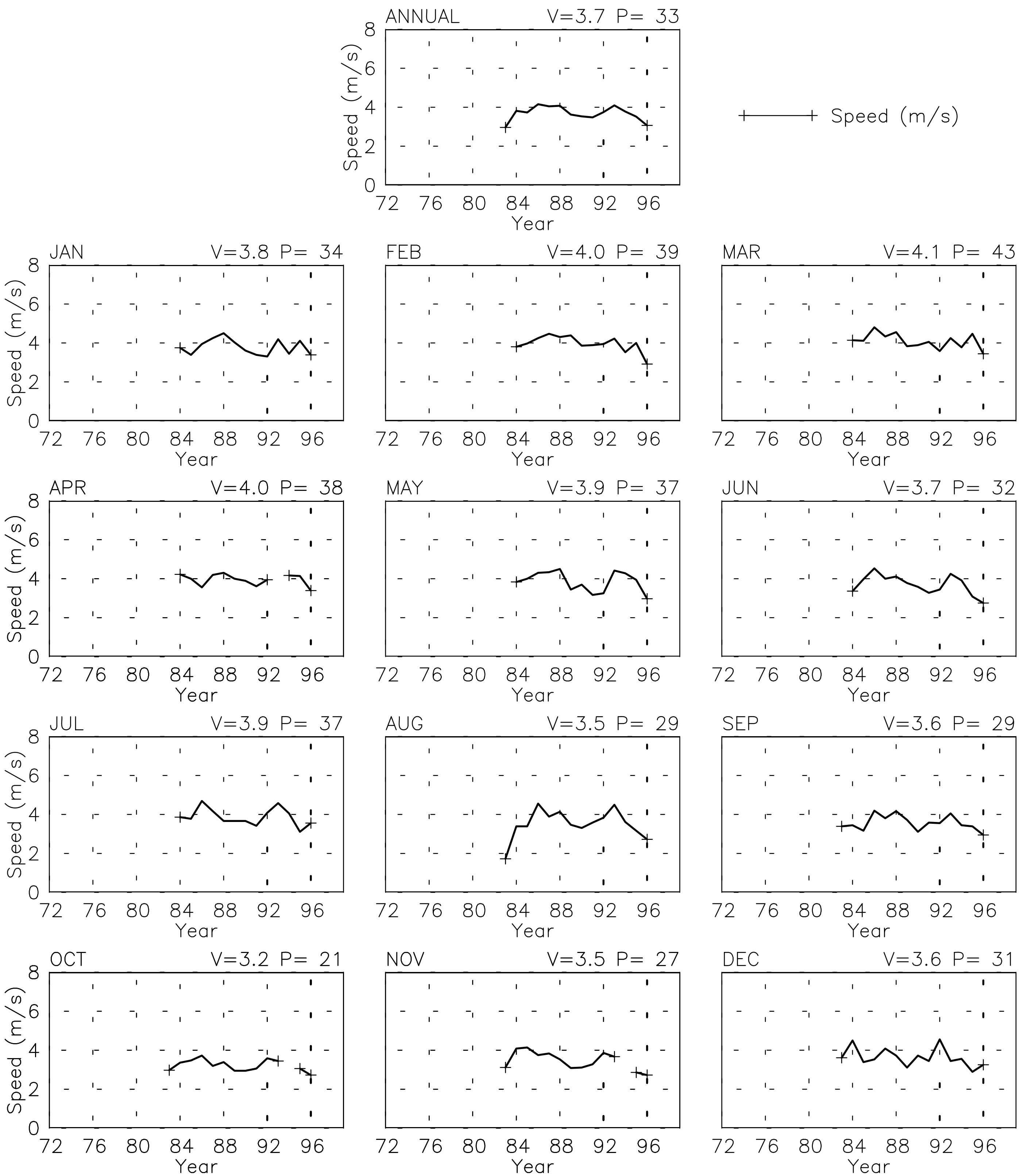
S. Dom./Las Americas – 003002
18° 25' N 69° 40' W – Elev 17m
04/57–02/88 02/90–04/90



Fri May 14 15:29:01 1999

SPEED BY YEAR

Sto. Domingo/Herrera – 003005
18° 28' N 69° 58' W – Elev 61m
08/83–12/96



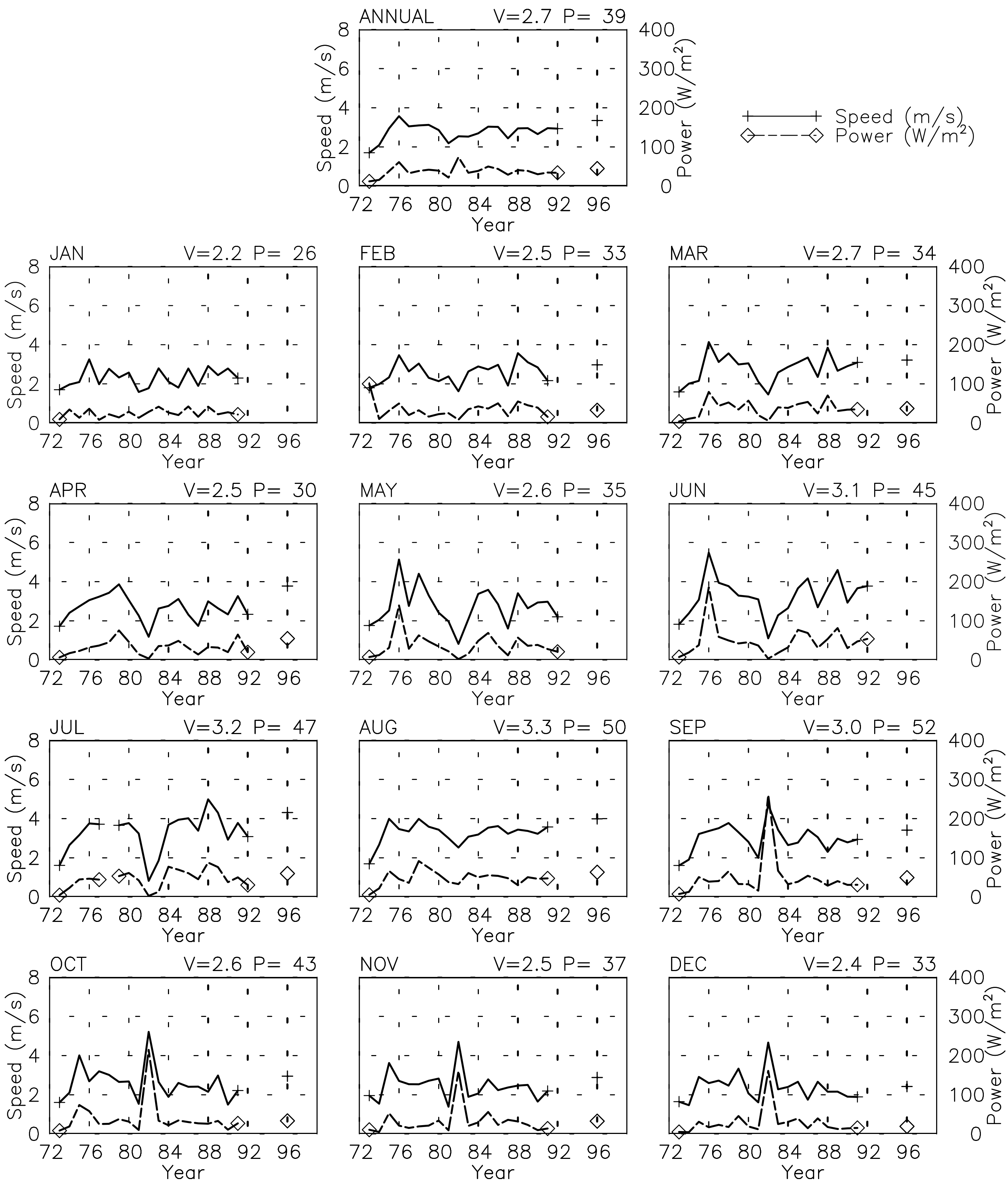
Fri May 14 15:26:59 1999

SPEED AND POWER BY YEAR

PUERTO PLATA DR - 784570

19° 45' N 70° 33' W - Elev 15m *LST=GMT -4 hours NT= -5

01/73-12/96



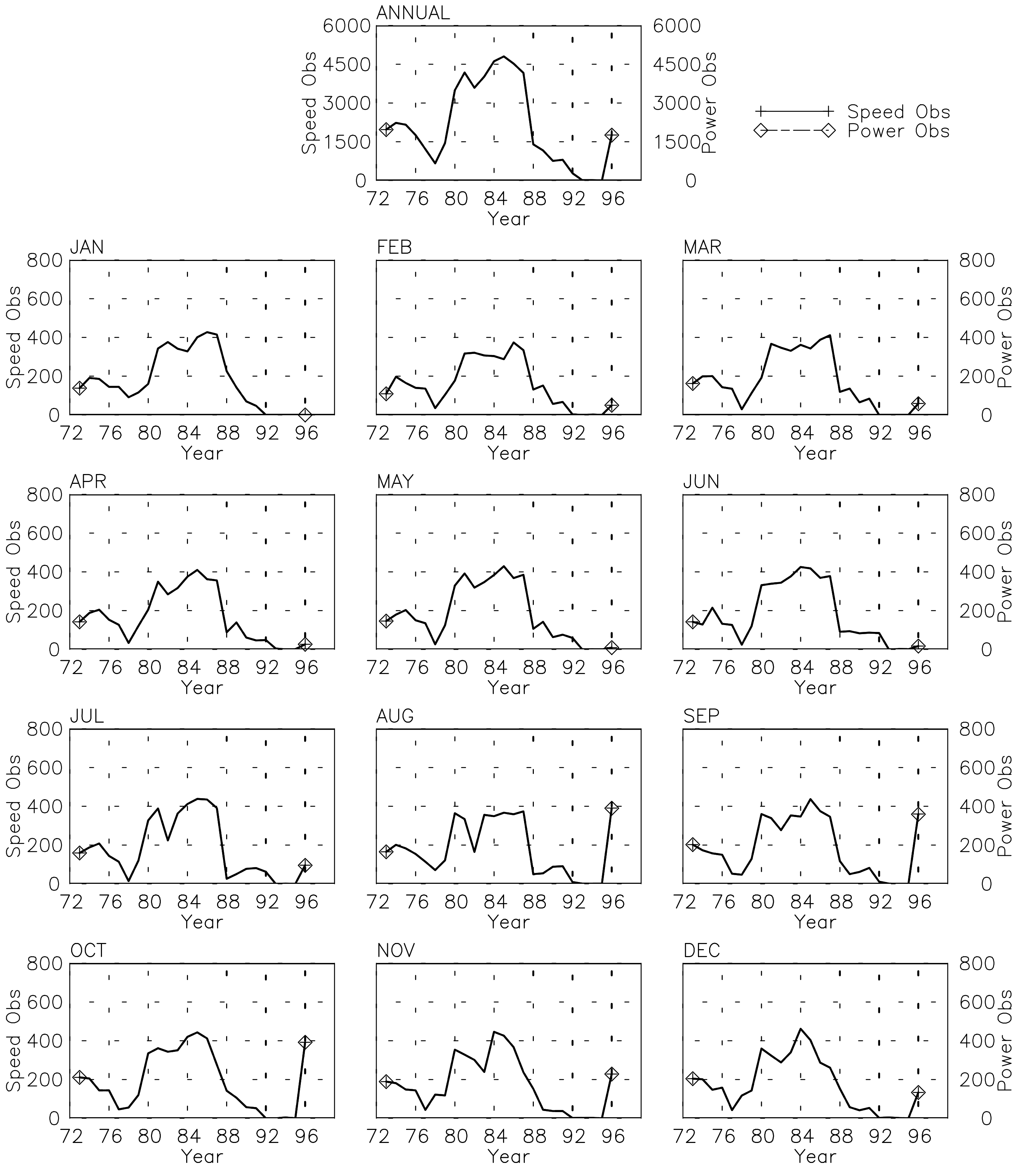
Fri May 14 16:11:47 1999

OBSERVATIONS BY YEAR

PUERTO PLATA DR - 784570

19° 45' N 70° 33' W - Elev 15m *LST=GMT -4 hours NT= -5

01/73-12/96



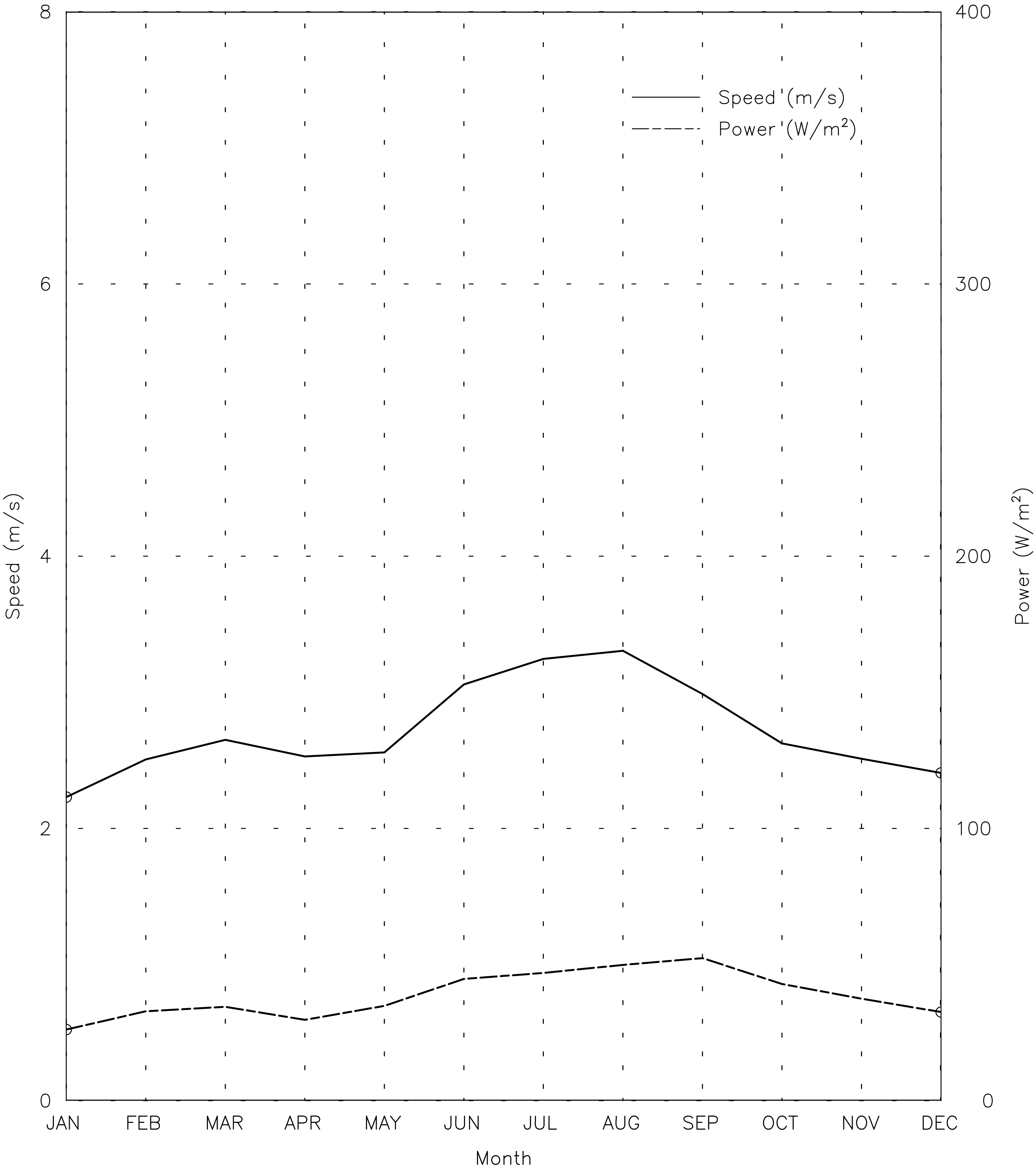
Fri May 14 16:11:52 1999

SPEED AND POWER BY MONTH

PUERTO PLATA DR – 784570

19° 45' N 70° 33' W – Elev 15m *LST=GMT –4 hours NT= –5

01/73–12/96



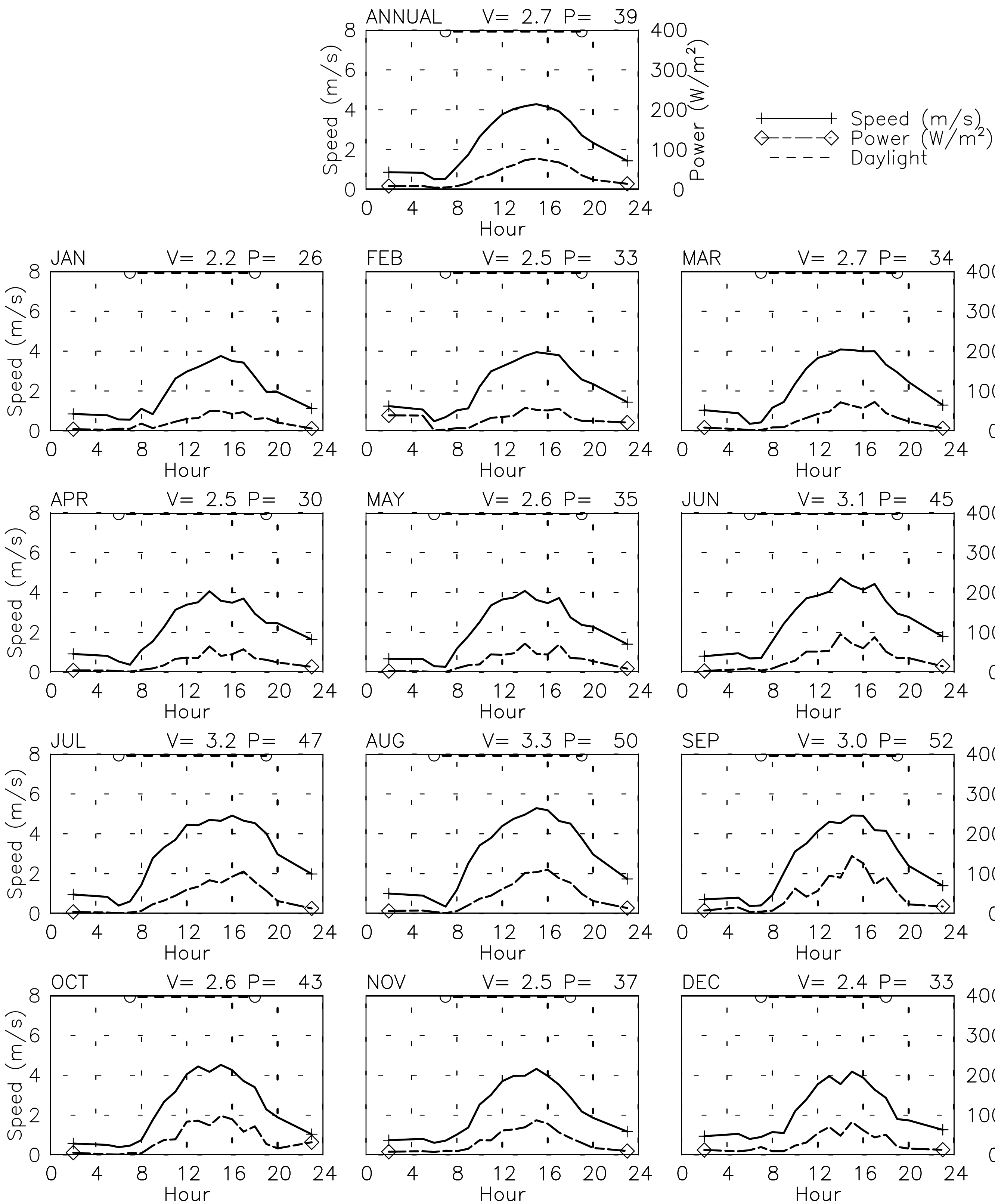
Fri May 14 16:11:55 1999

SPEED AND POWER BY HOUR

PUERTO PLATA DR – 784570

19° 45' N 70° 33' W – Elev 15m *LST=GMT –4 hours NT= –5

01/73–12/96



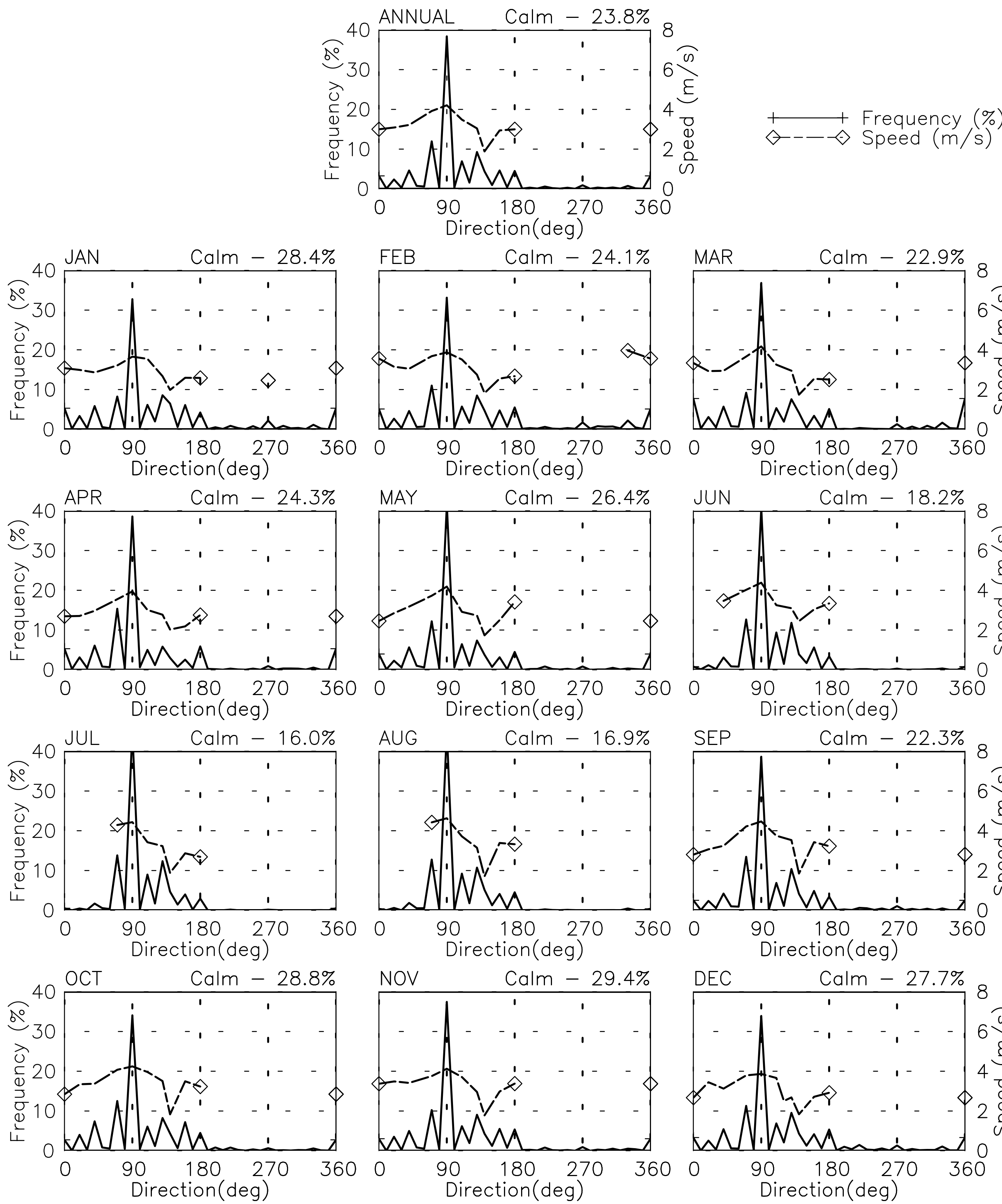
Fri May 14 16:11:56 1999

FREQUENCY AND SPEED BY DIRECTION

PUERTO PLATA DR – 784570

19° 45' N 70° 33' W – Elev 15m *LST=GMT –4 hours NT= –5

01/73–12/96



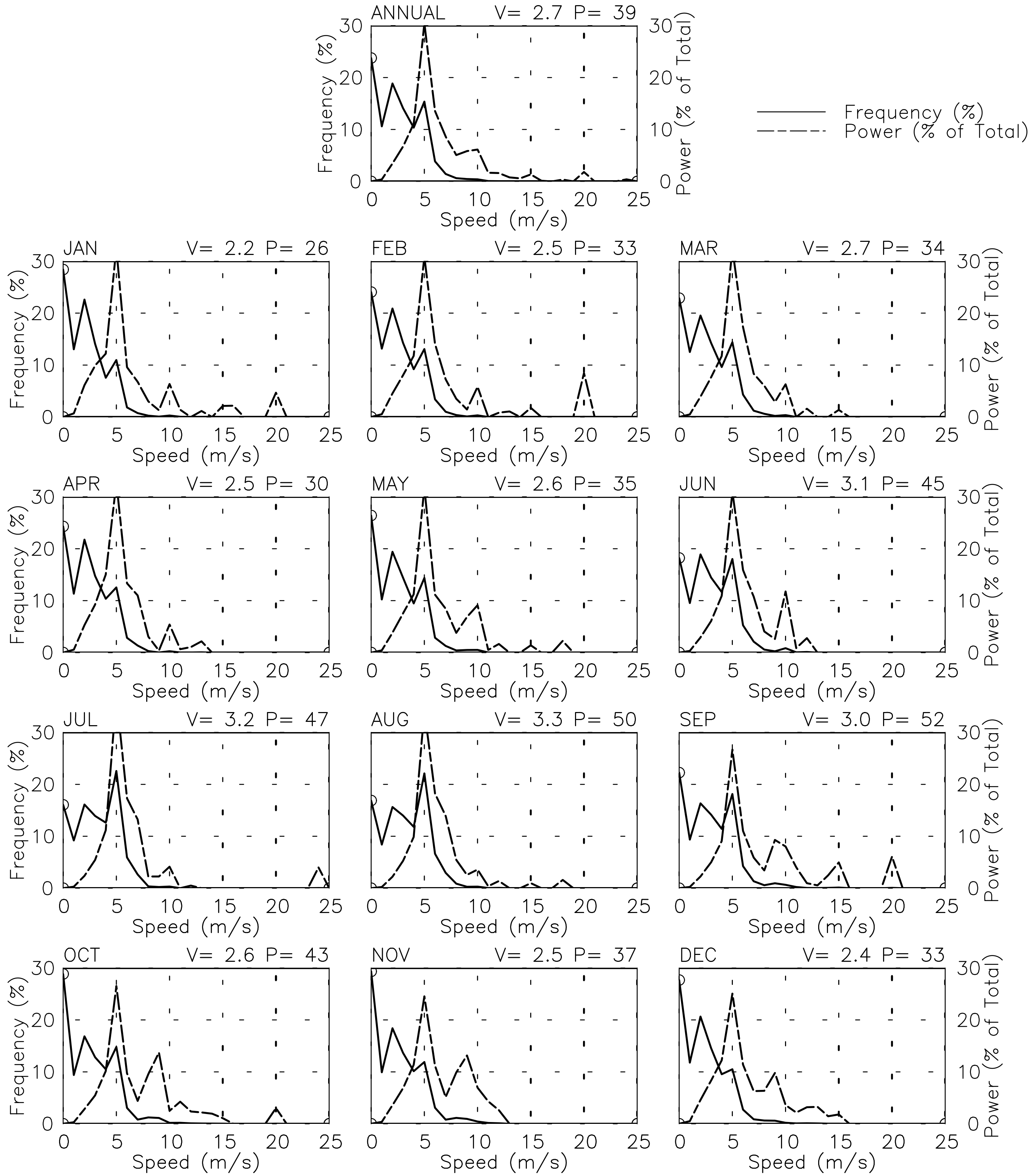
Fri May 14 16:12:01 1999

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

PUERTO PLATA DR – 784570

19° 45' N 70° 33' W – Elev 15m *LST=GMT –4 hours NT= –5

01/73–12/96



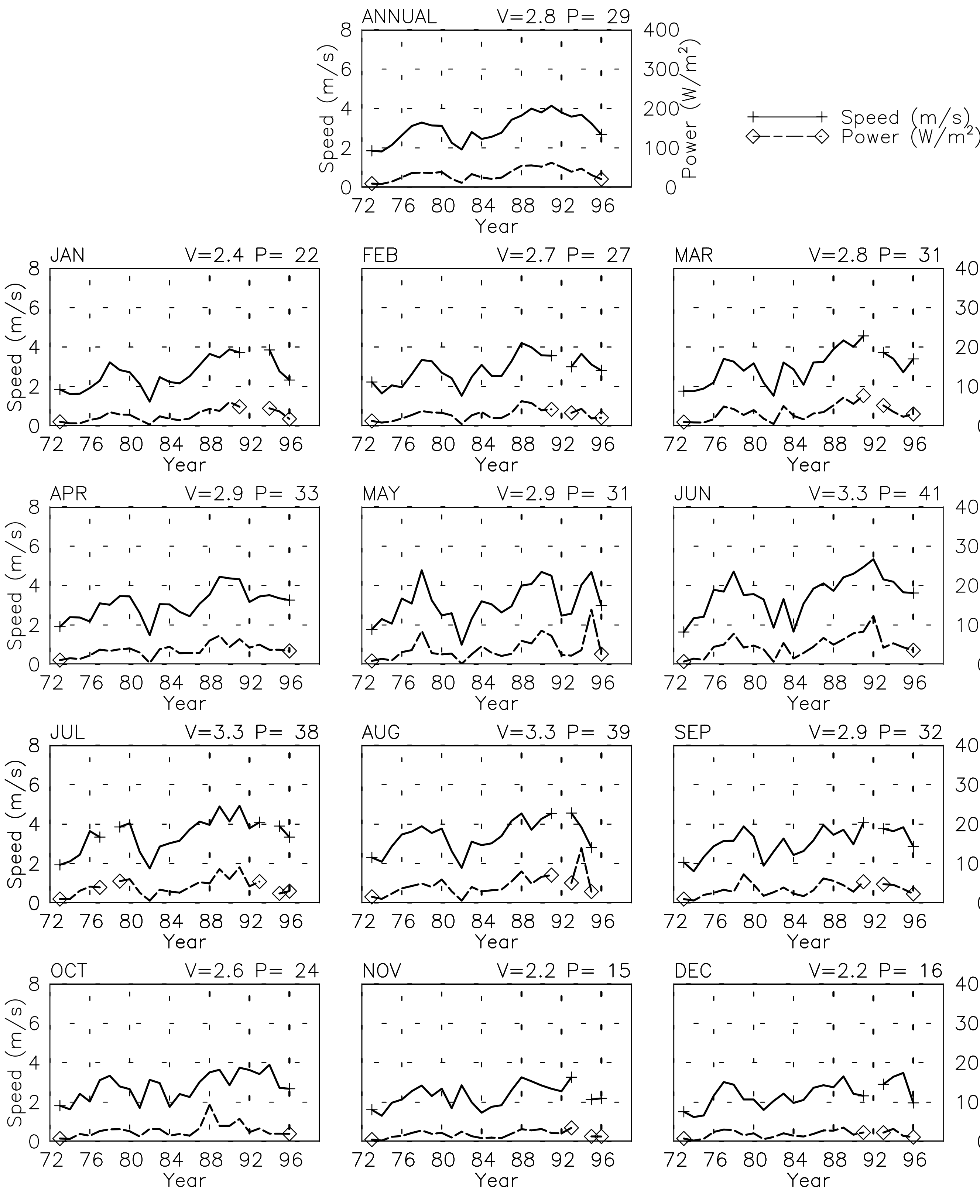
Fri May 14 16:12:05 1999

SPEED AND POWER BY YEAR

SANTIAGO DR – 784600

19° 28' N 70° 42' W – Elev 183m ∗LST=GMT –4 hours NT= –5

01/73–12/96



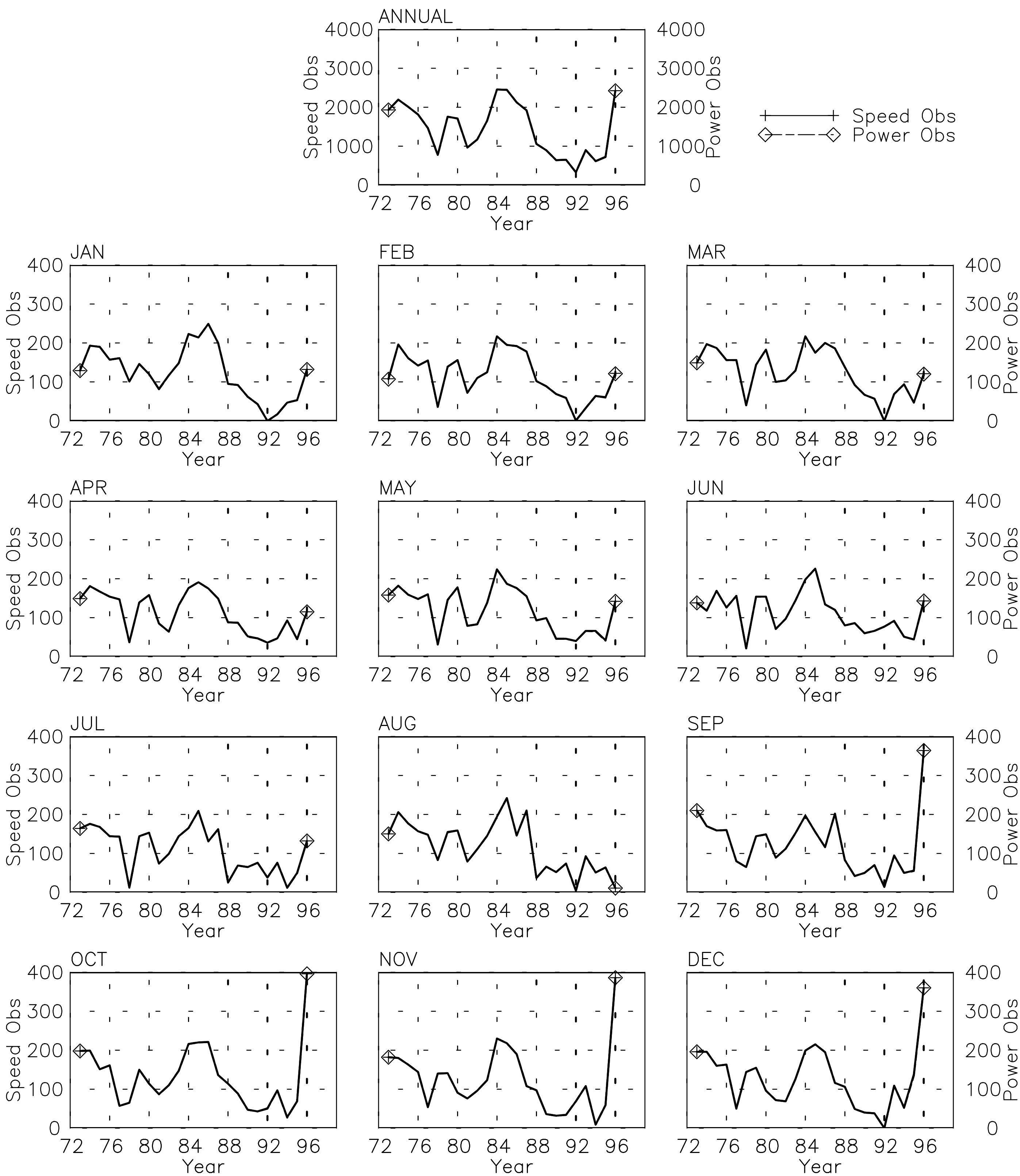
Fri May 14 16:12:18 1999

OBSERVATIONS BY YEAR

SANTIAGO DR - 784600

19° 28' N 70° 42' W - Elev 183m *LST=GMT -4 hours NT= -5

01/73-12/96



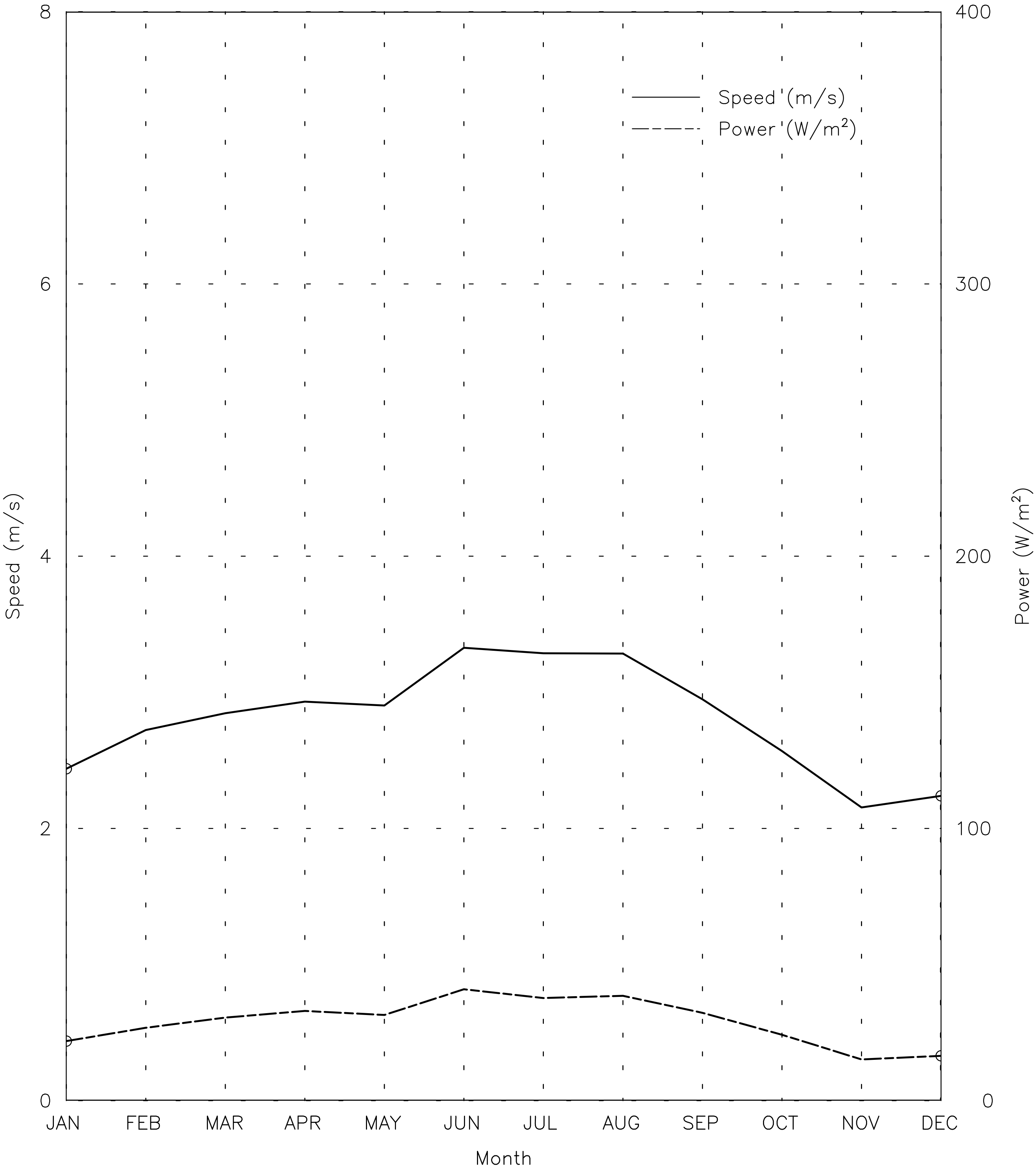
Fri May 14 16:12:23 1999

SPEED AND POWER BY MONTH

SANTIAGO DR – 784600

19° 28' N 70° 42' W – Elev 183m *LST=GMT –4 hours NT= –5

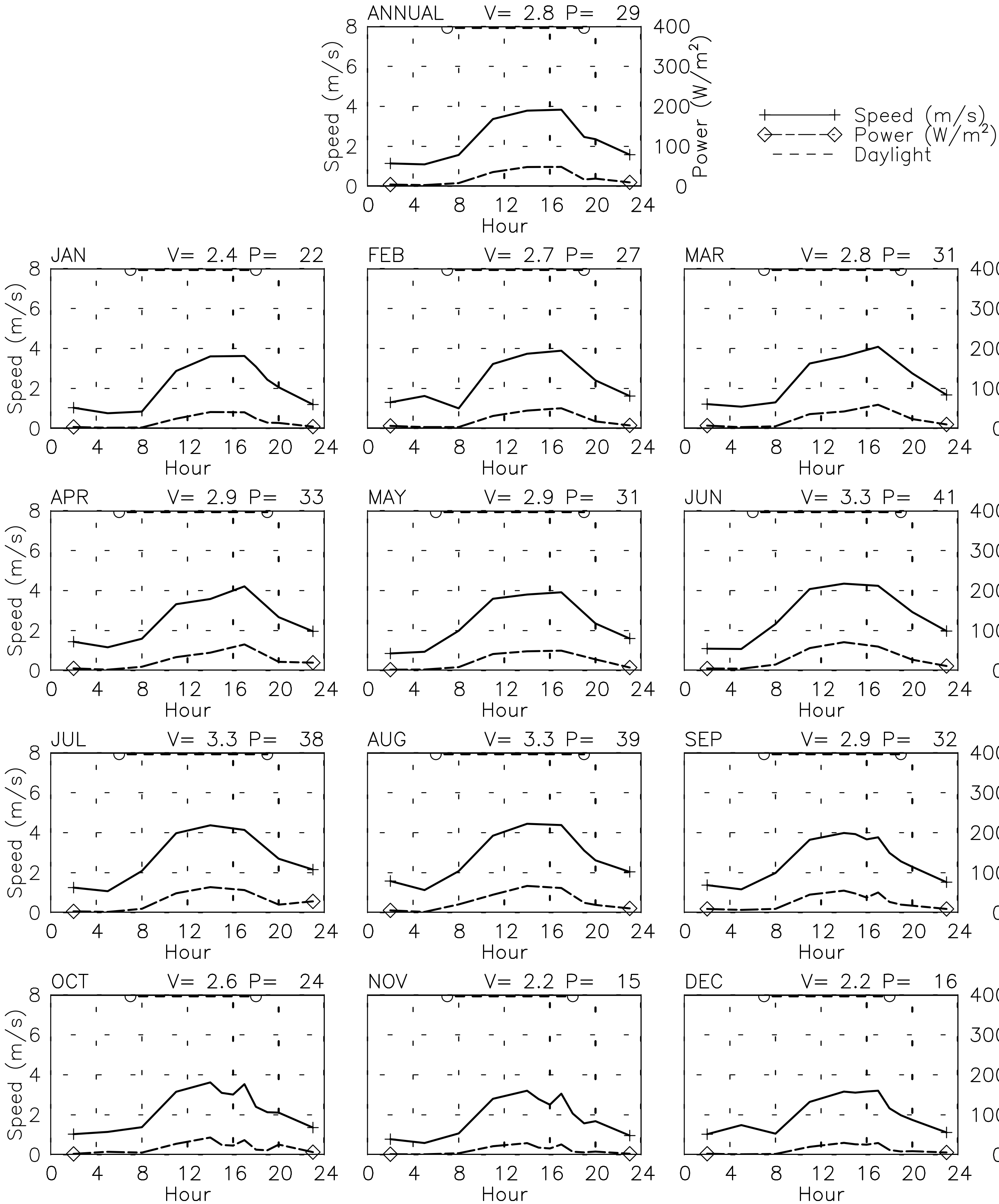
01/73–12/96



Fri May 14 16:12:26 1999

SPEED AND POWER BY HOUR

SANTIAGO DR – 784600
19° 28' N 70° 42' W – Elev 183m *LST=GMT –4 hours NT= –5
01/73–12/96



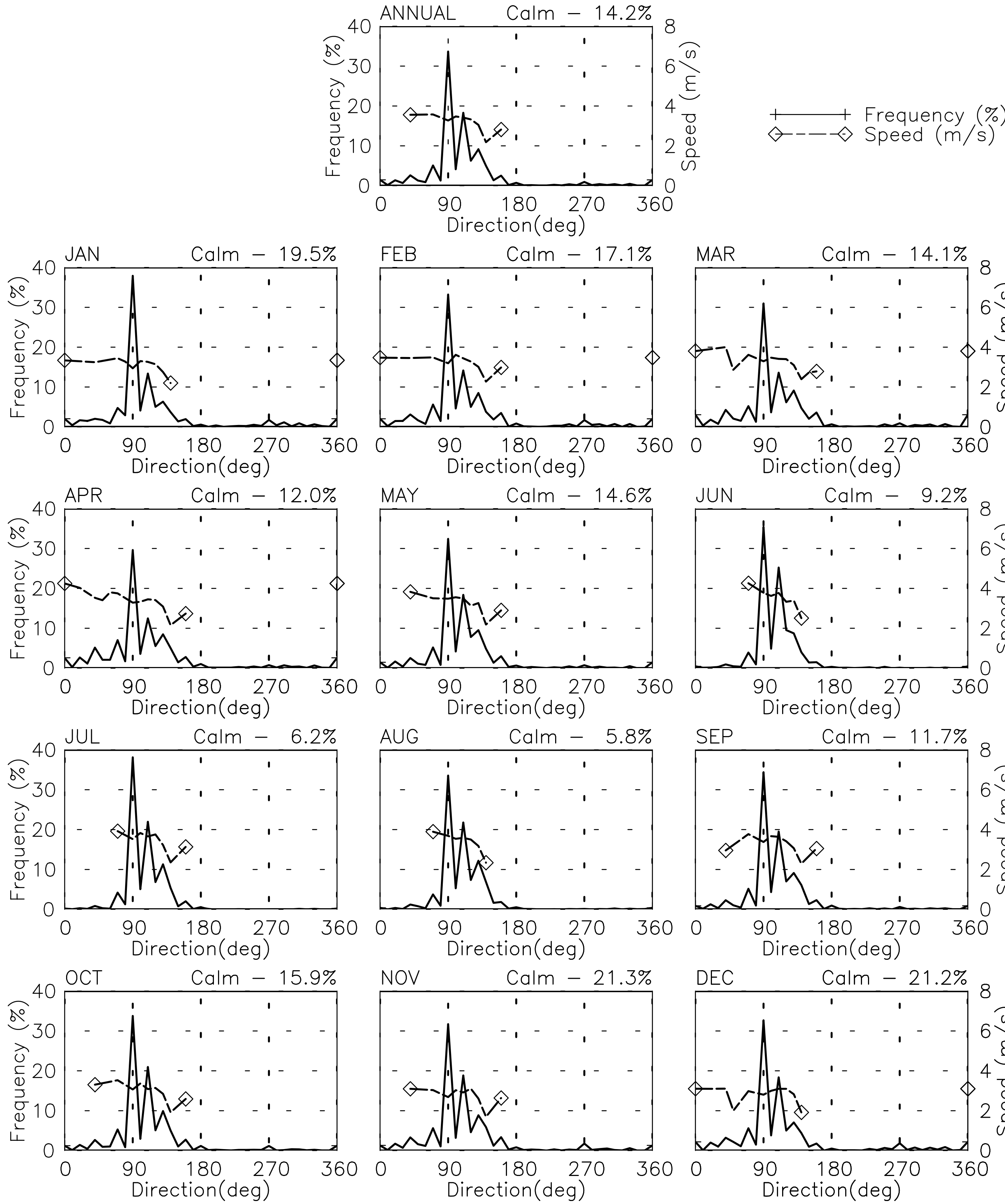
Fri May 14 16:12:27 1999

FREQUENCY AND SPEED BY DIRECTION

SANTIAGO DR – 784600

19° 28' N 70° 42' W – Elev 183m *LST=GMT –4 hours NT= –5

01/73–12/96



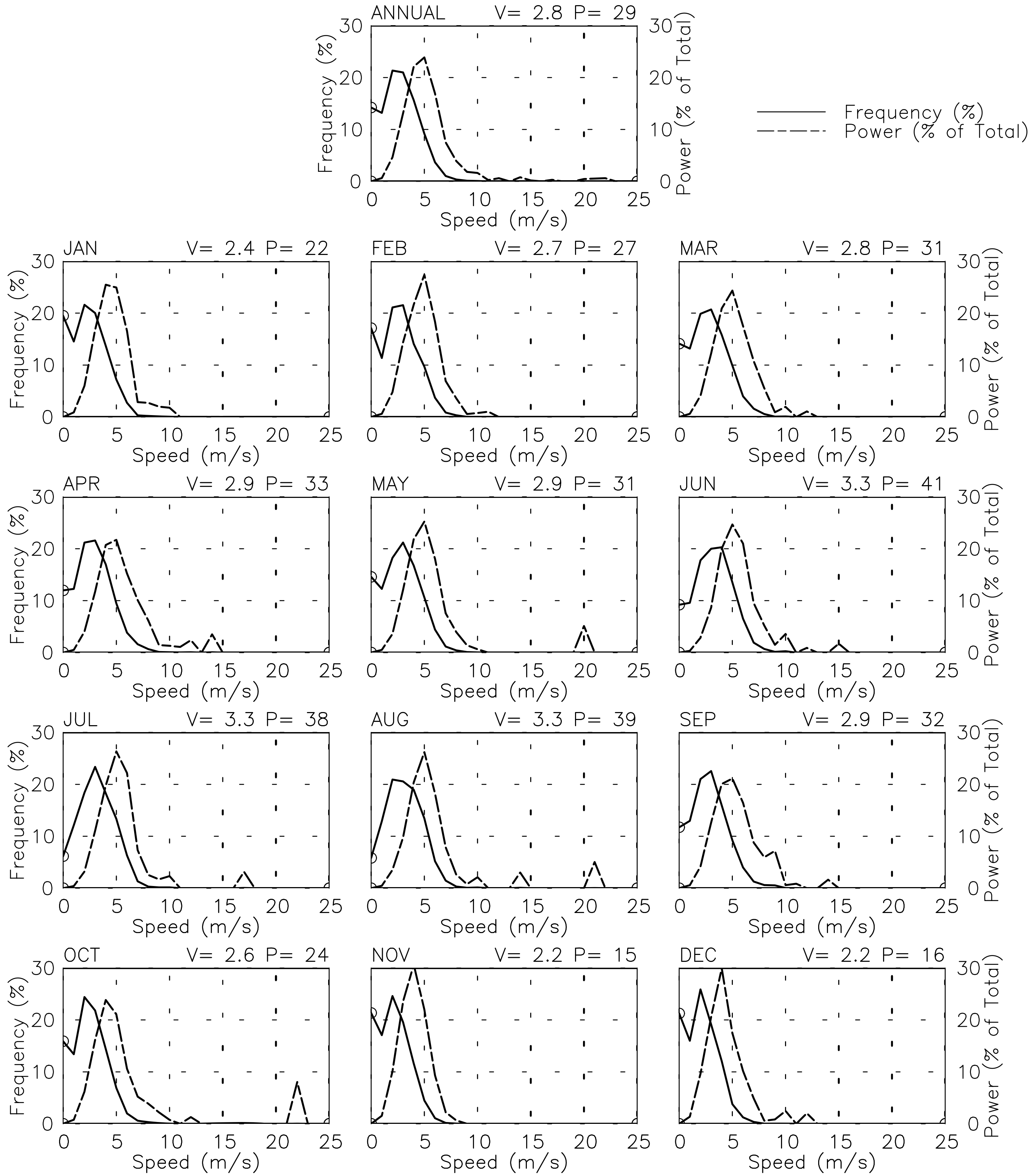
Fri May 14 16:12:32 1999

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

SANTIAGO DR – 784600

19° 28' N 70° 42' W – Elev 183m *LST=GMT –4 hours NT= –5

01/73–12/96



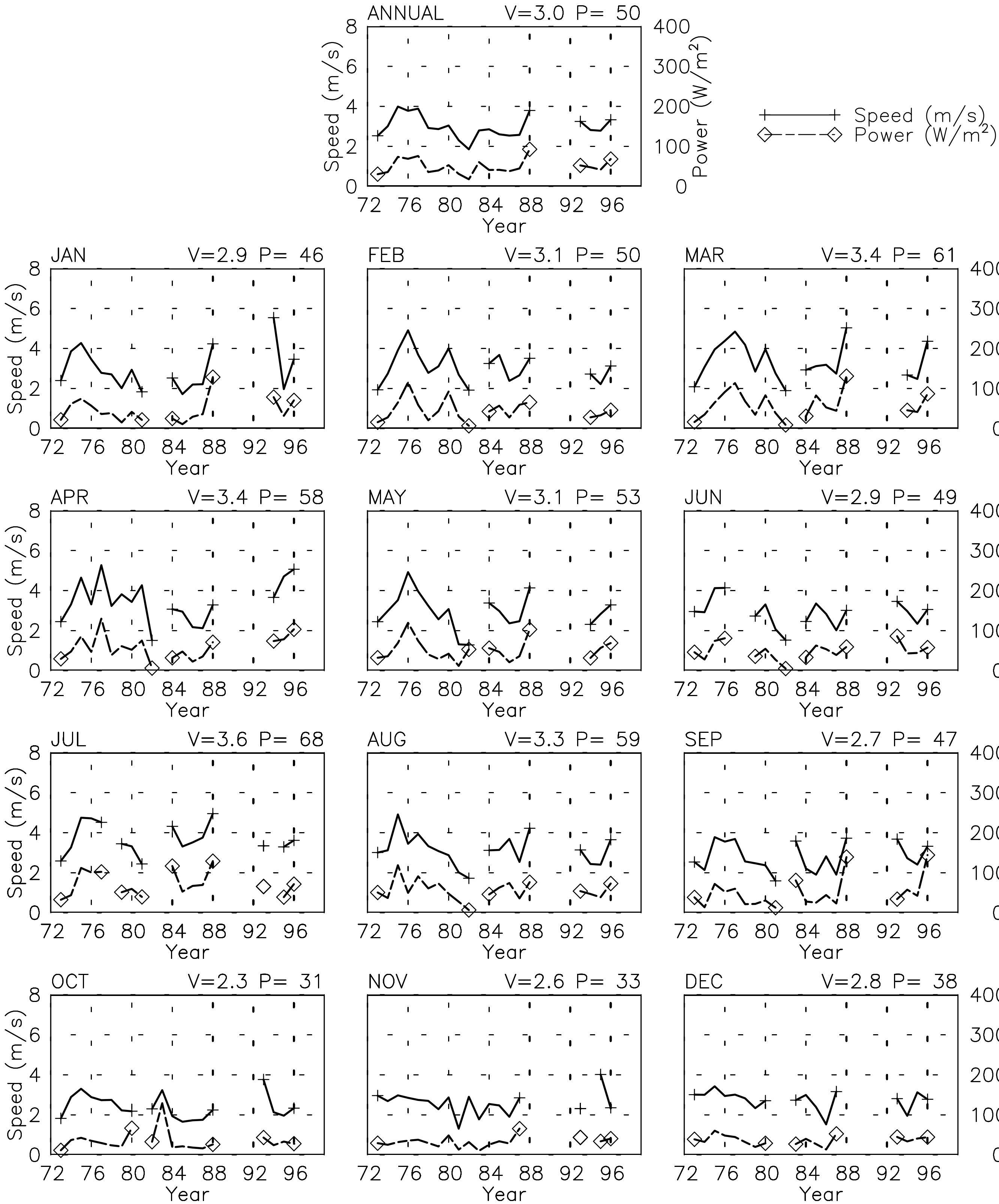
Fri May 14 16:12:37 1999

SPEED AND POWER BY YEAR

SABANA DE LA MAR   DR – 784670

19° 03' N   69° 23' W – Elev   10m *LST=GMT –4 hours   NT= –5

01/73–05/89 04/93–12/96



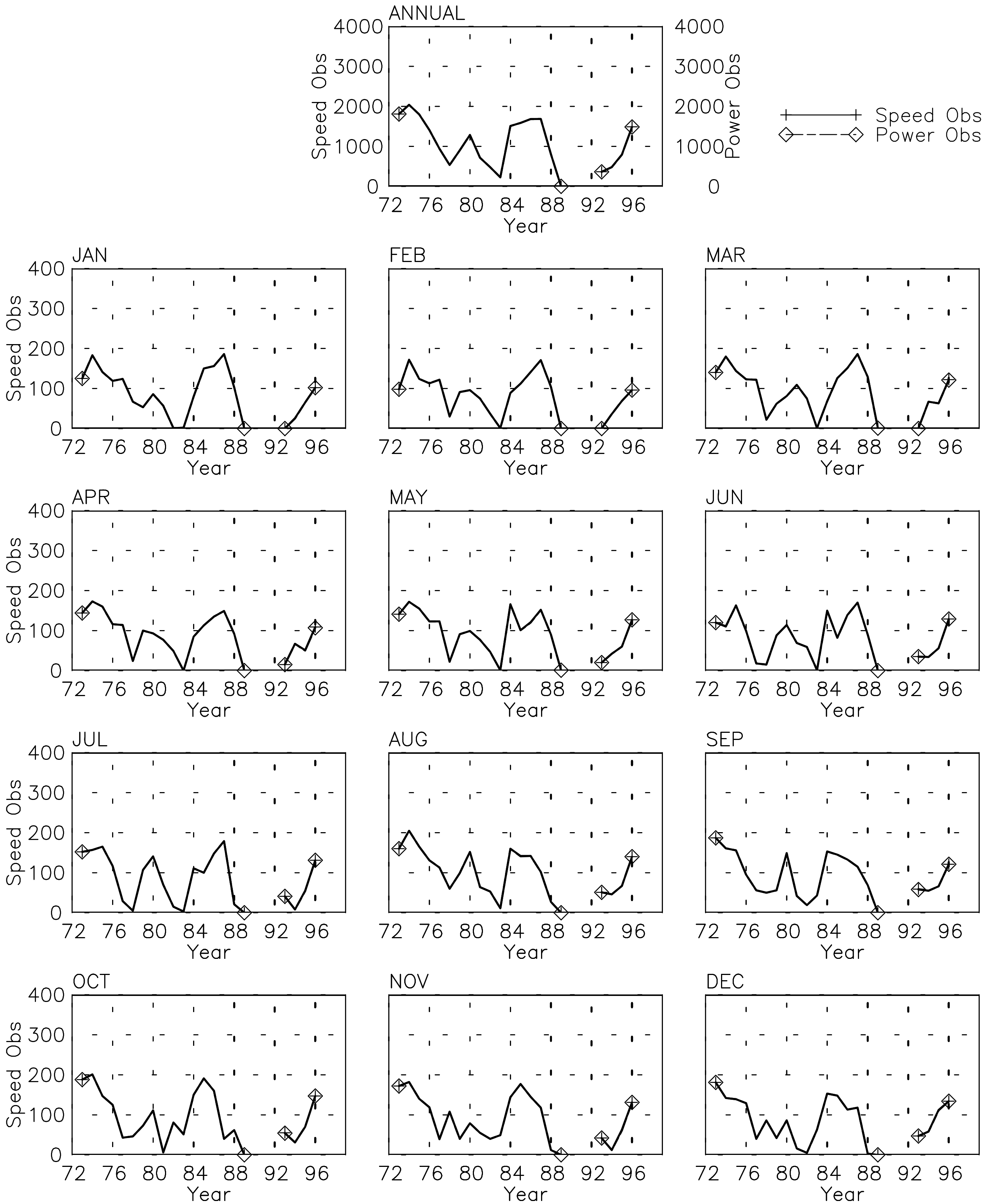
Fri May 14 16:12:47 1999

OBSERVATIONS BY YEAR

SABANA DE LA MAR   DR – 784670

19° 03' N   69° 23' W – Elev   10m *LST=GMT –4 hours   NT= –5

01/73–05/89 04/93–12/96



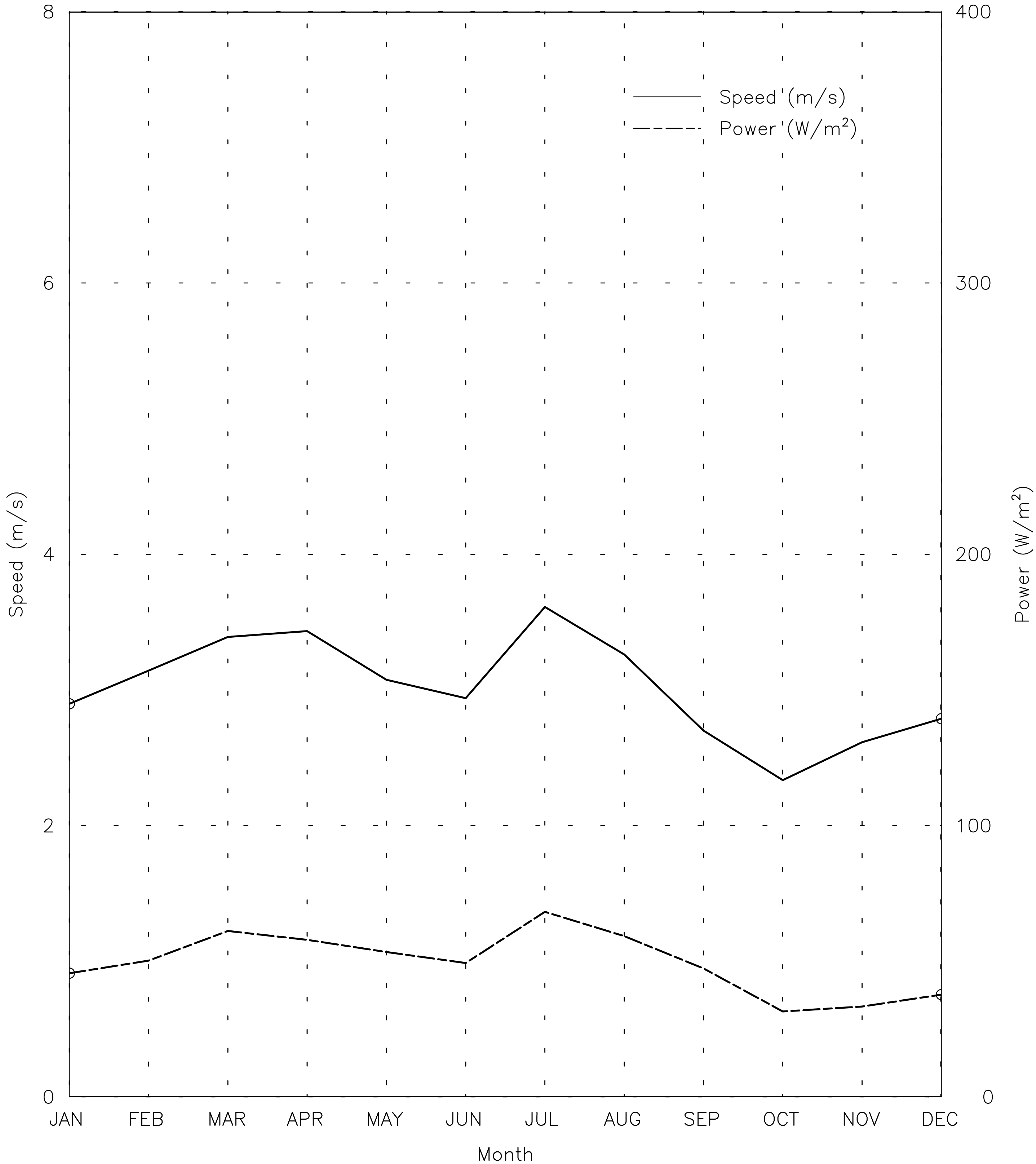
Fri May 14 16:12:53 1999

SPEED AND POWER BY MONTH

SABANA DE LA MAR DR – 784670

19° 03' N 69° 23' W – Elev 10m *LST=GMT –4 hours NT= –5

01/73–05/89 04/93–12/96



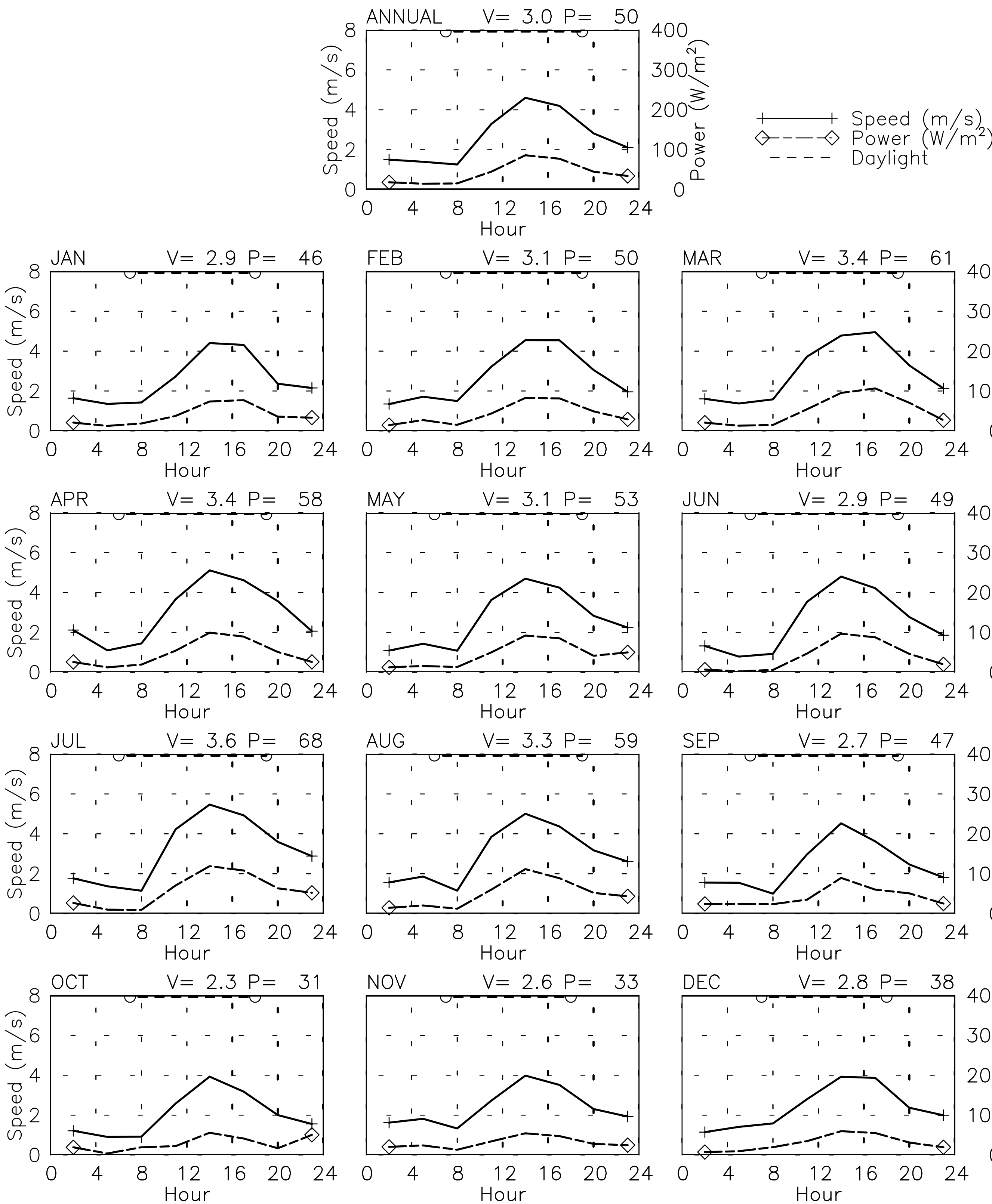
Fri May 14 16:12:58 1999

SPEED AND POWER BY HOUR

SABANA DE LA MAR DR – 784670

19° 03' N 69° 23' W – Elev 10m *LST=GMT –4 hours NT= –5

01/73–05/89 04/93–12/96



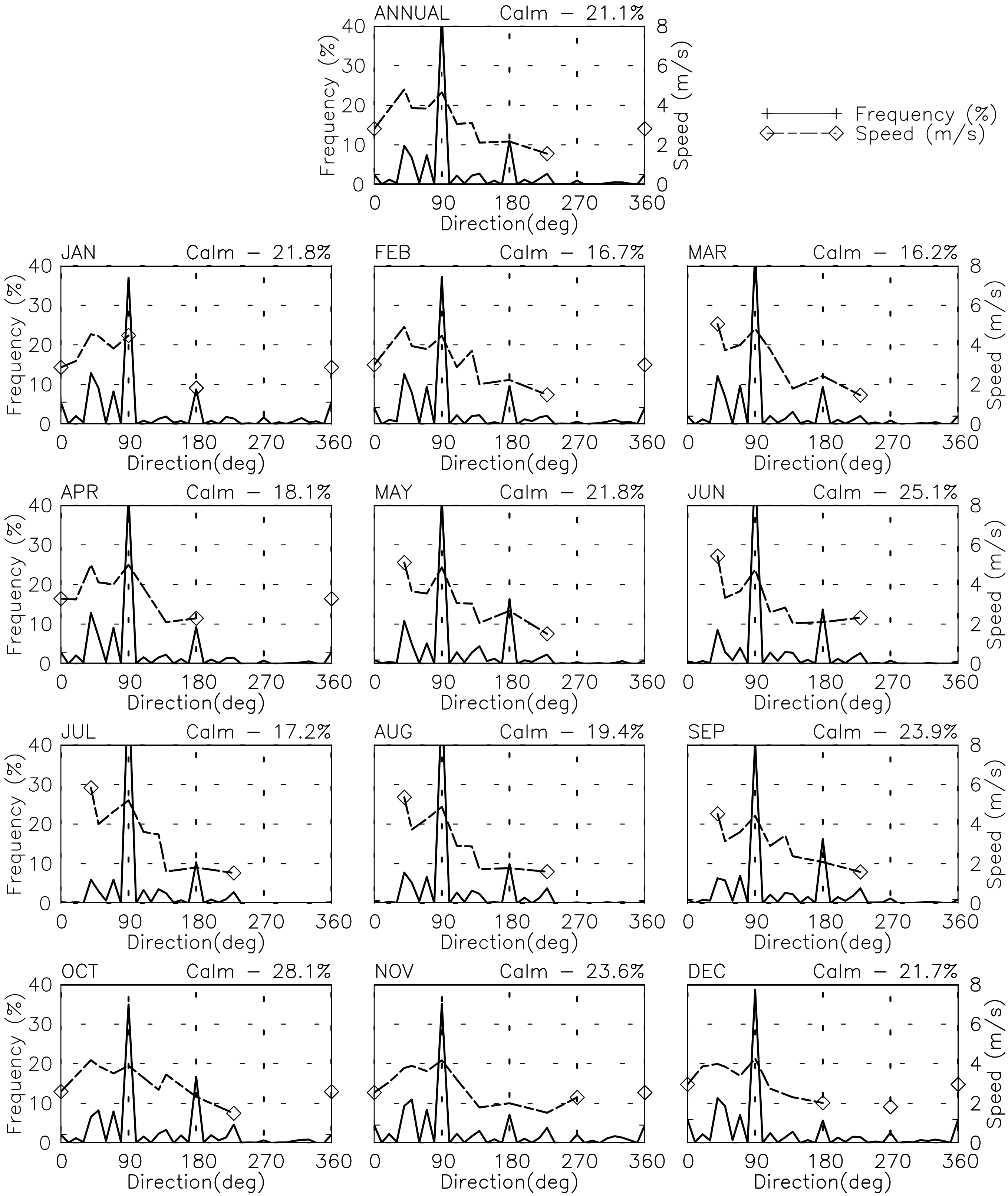
Fri May 14 16:12:59 1999

FREQUENCY AND SPEED BY DIRECTION

SABANA DE LA MAR DR – 784670

19° 03' N 69° 23' W – Elev 10m *LST=GMT –4 hours NT= –5

01/73–05/89 04/93–12/96



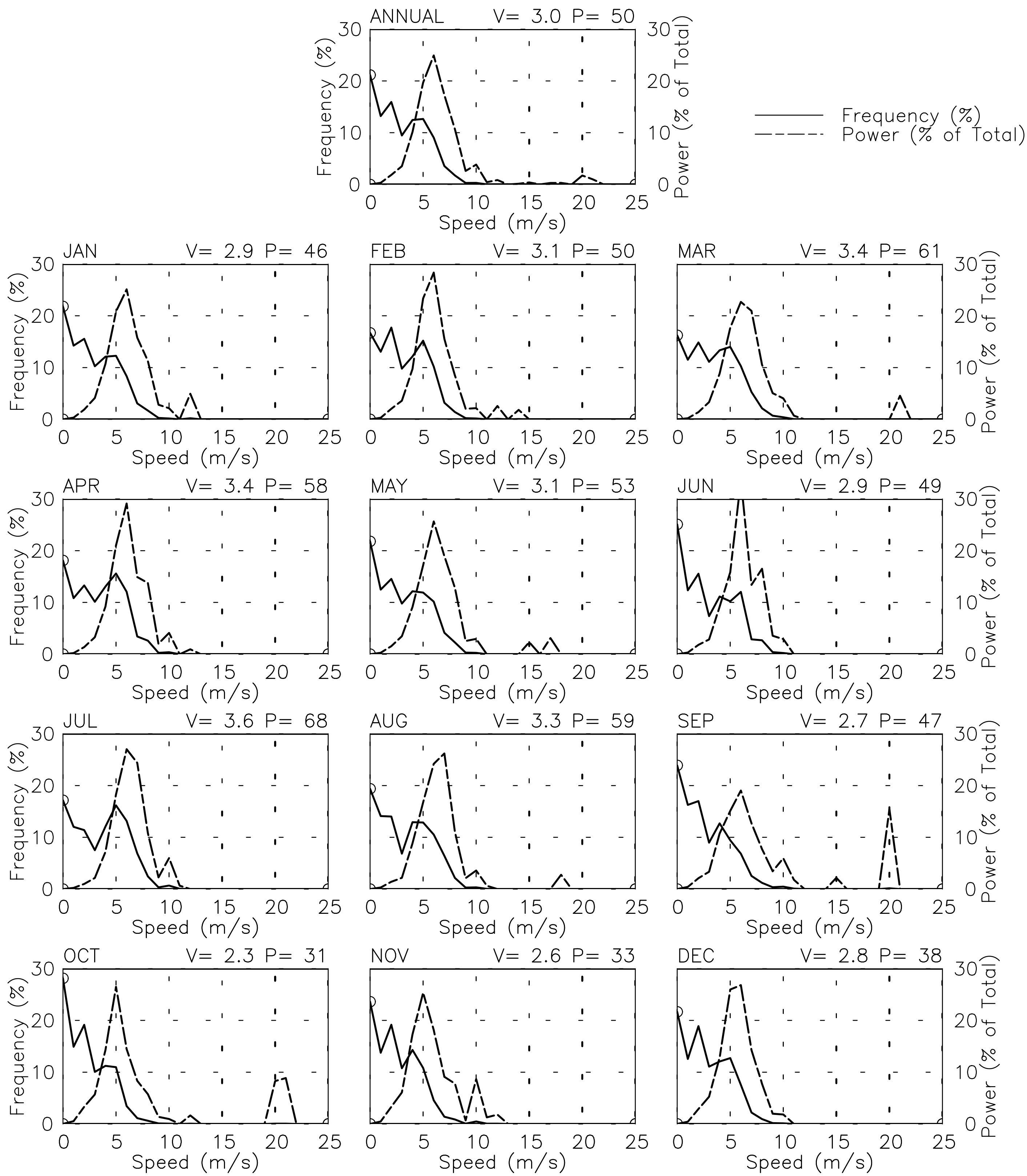
Fri May 14 16:13:04 1999

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

SABANA DE LA MAR DR – 784670

19° 03' N 69° 23' W – Elev 10m *LST=GMT –4 hours NT= –5

01/73–05/89 04/93–12/96



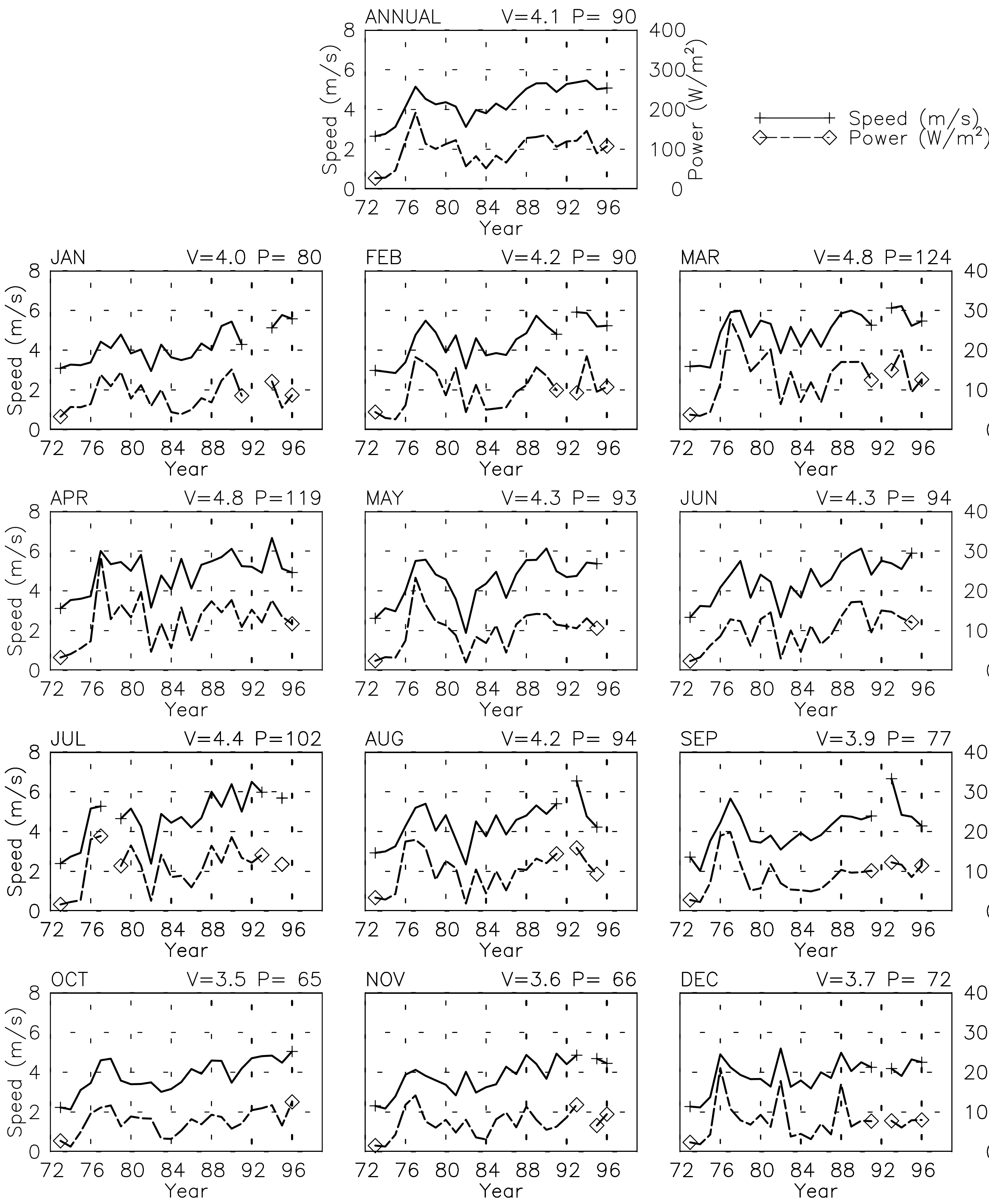
Fri May 14 16:13:09 1999

SPEED AND POWER BY YEAR

BARAHONA DR - 784820

18° 13' N 71° 06' W - Elev 26m *LST=GMT -4 hours NT= -5

01/73-12/96



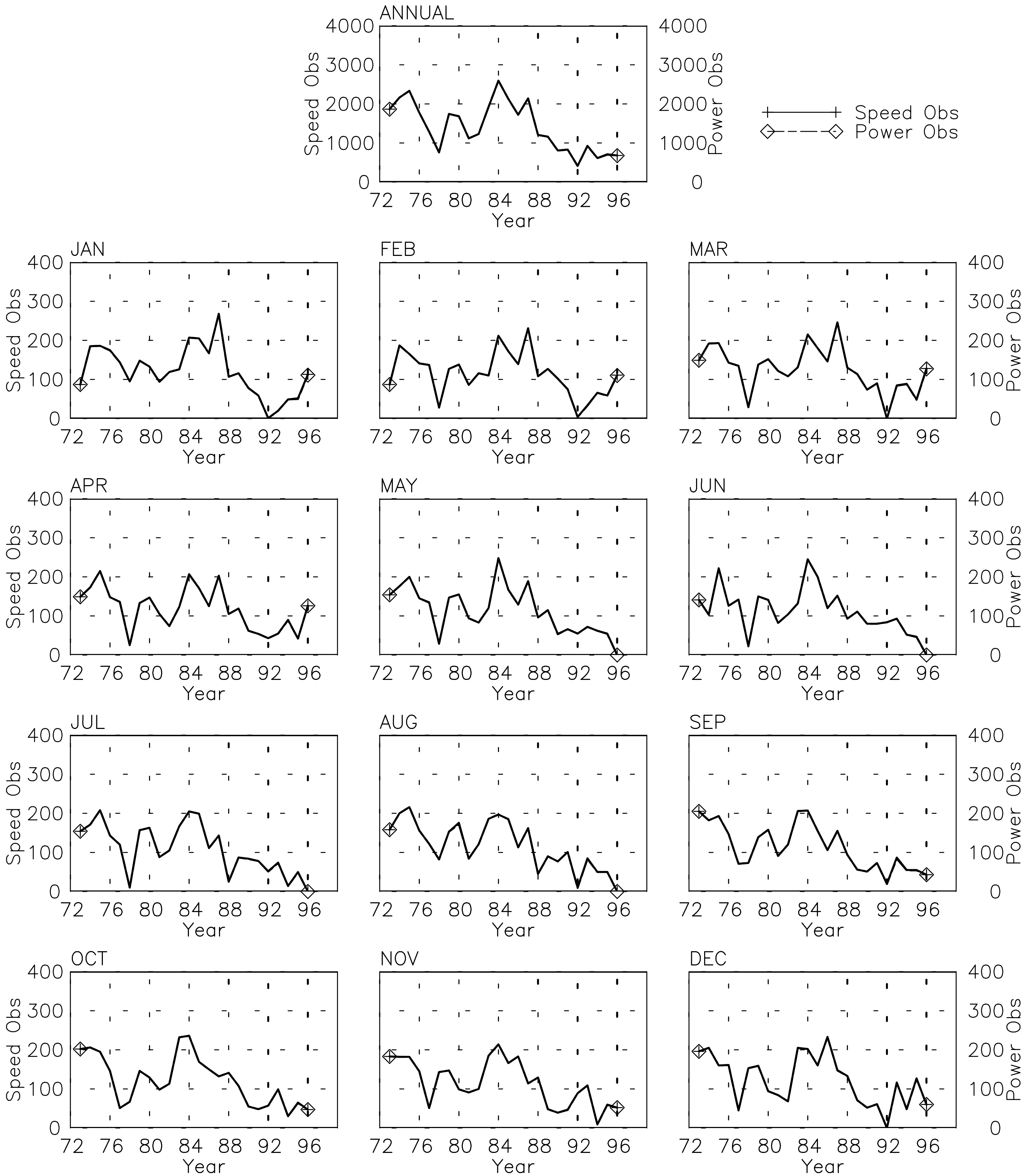
Fri May 14 16:13:54 1999

OBSERVATIONS BY YEAR

BARAHONA DR – 784820

18° 13' N 71° 06' W – Elev 26m *LST=GMT –4 hours NT= –5

01/73–12/96



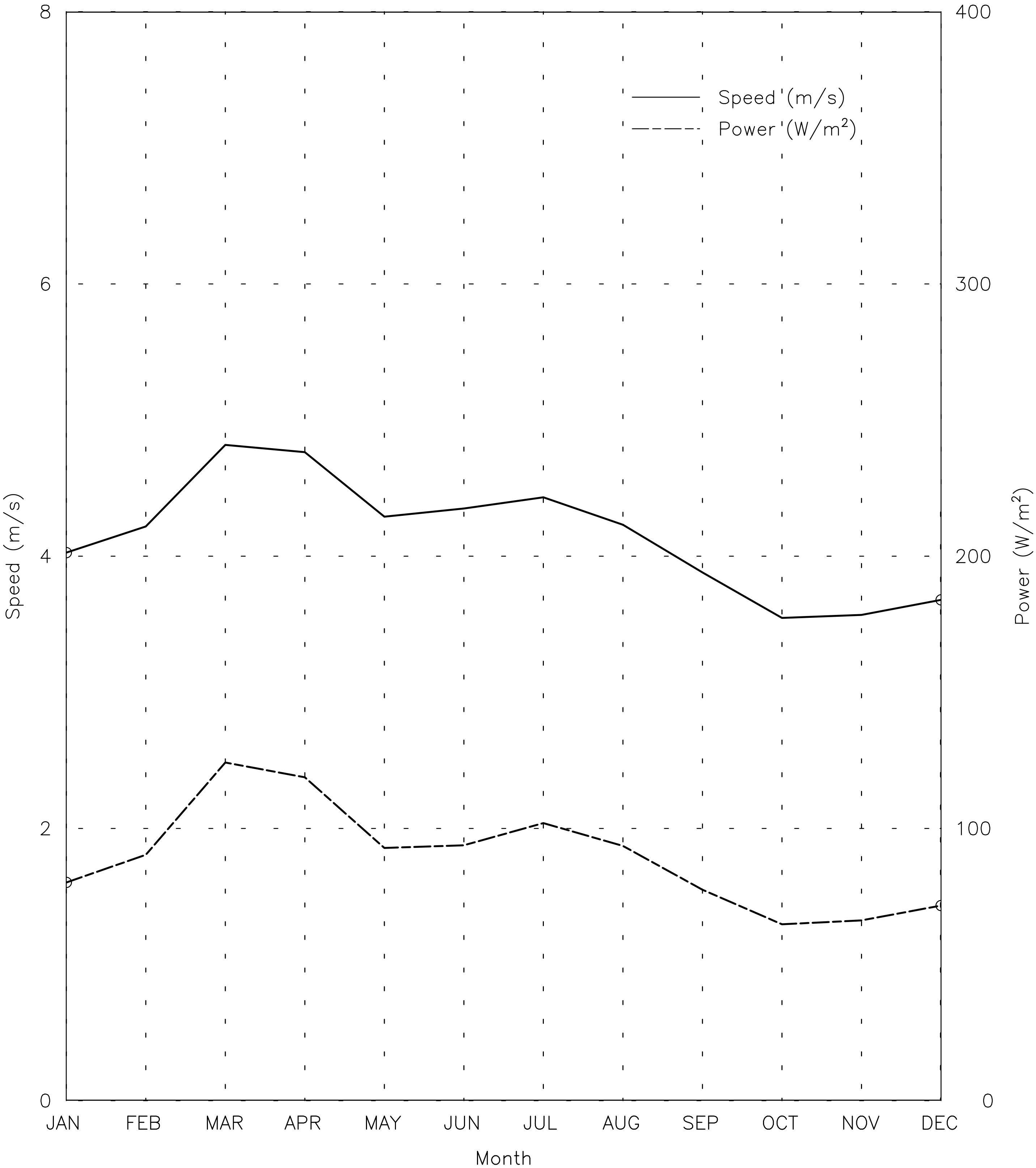
Fri May 14 16:14:00 1999

SPEED AND POWER BY MONTH

BARAHONA DR – 784820

18° 13' N 71° 06' W – Elev 26m *LST=GMT –4 hours NT= –5

01/73–12/96



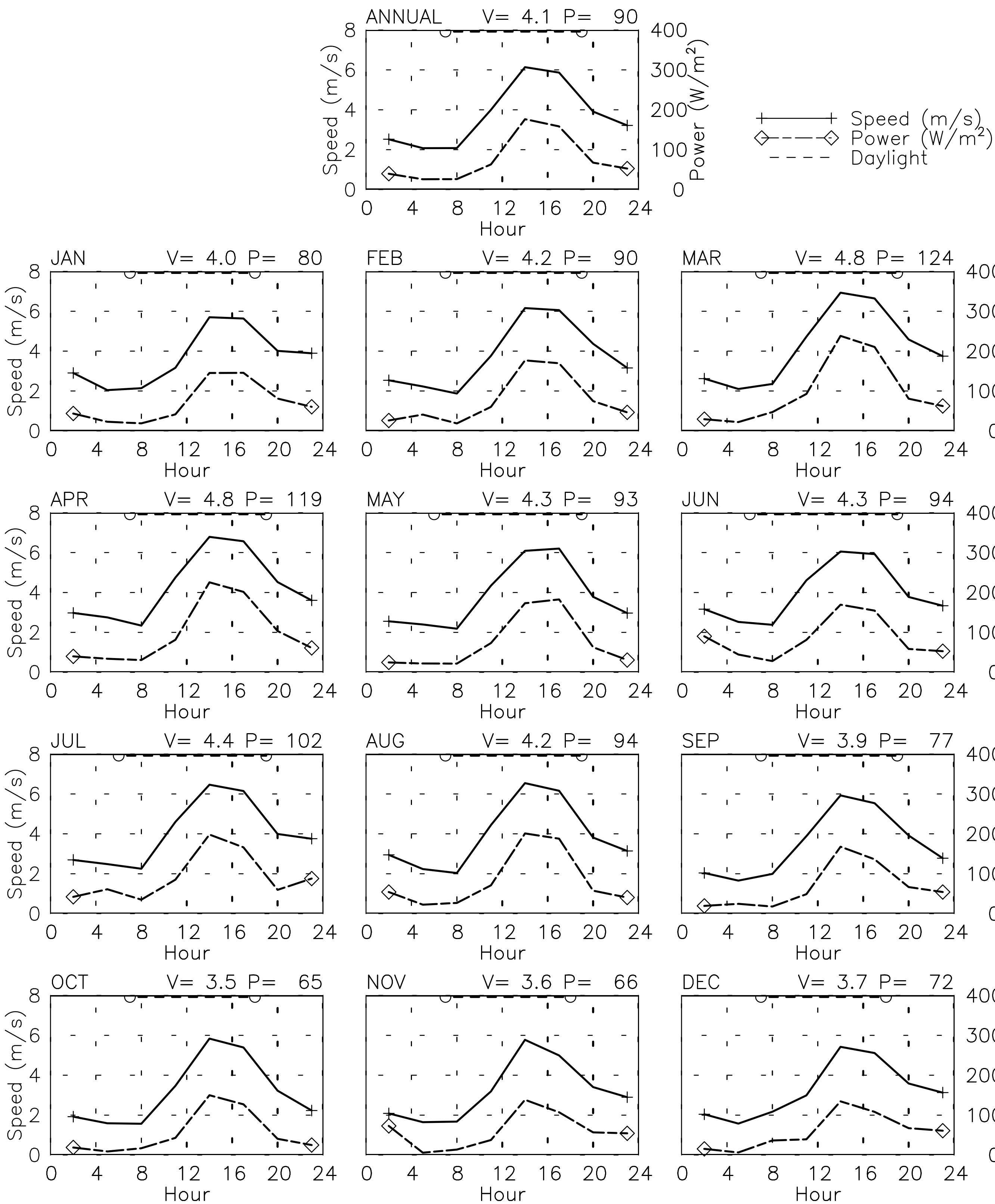
Fri May 14 16:14:03 1999

SPEED AND POWER BY HOUR

BARAHONA DR - 784820

18° 13' N 71° 06' W - Elev 26m *LST=GMT -4 hours NT= -5

01/73-12/96



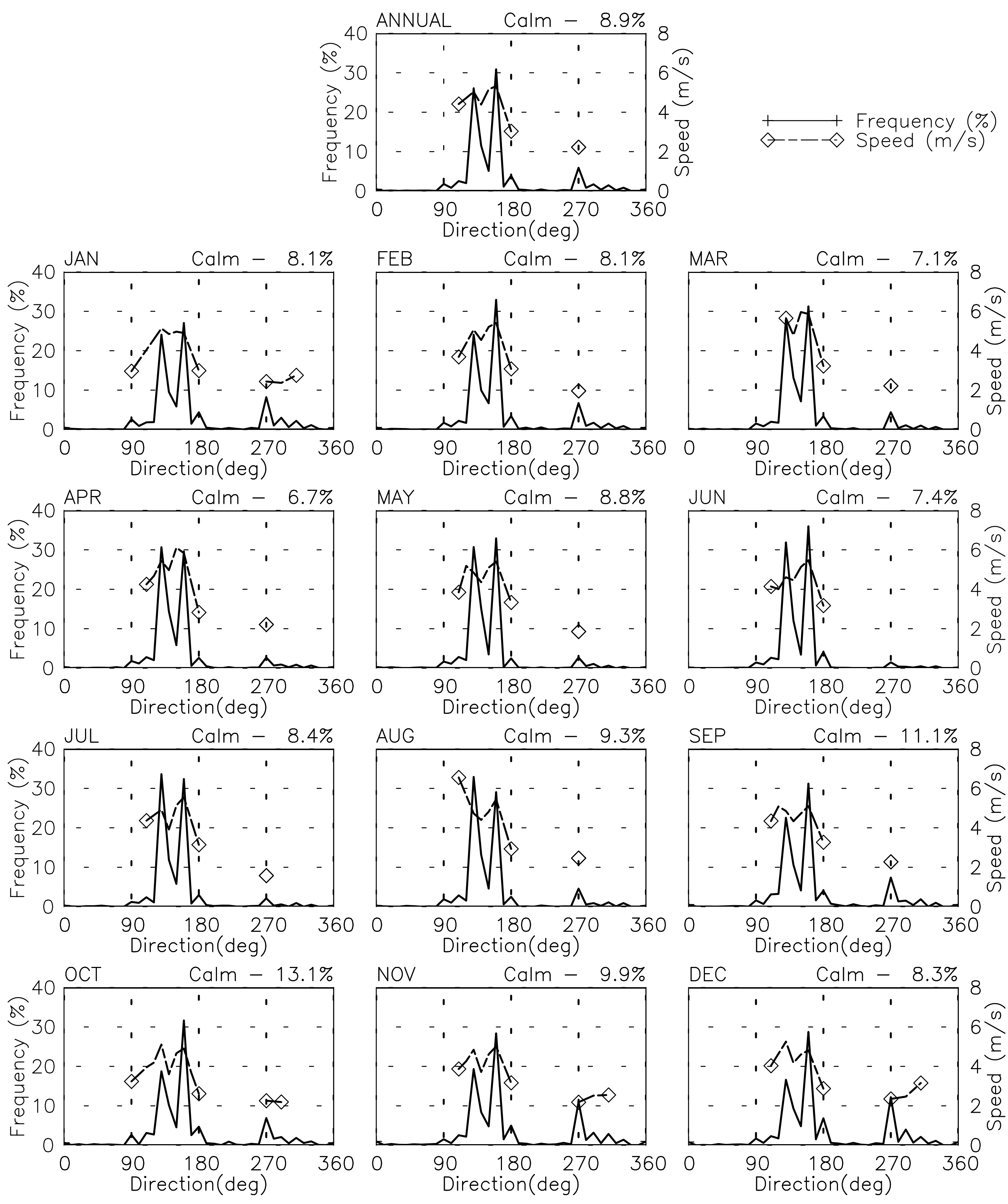
Fri May 14 16:14:05 1999

FREQUENCY AND SPEED BY DIRECTION

BARAHONA DR – 784820

18° 13' N 71° 06' W – Elev 26m *LST=GMT –4 hours NT= –5

01/73–12/96



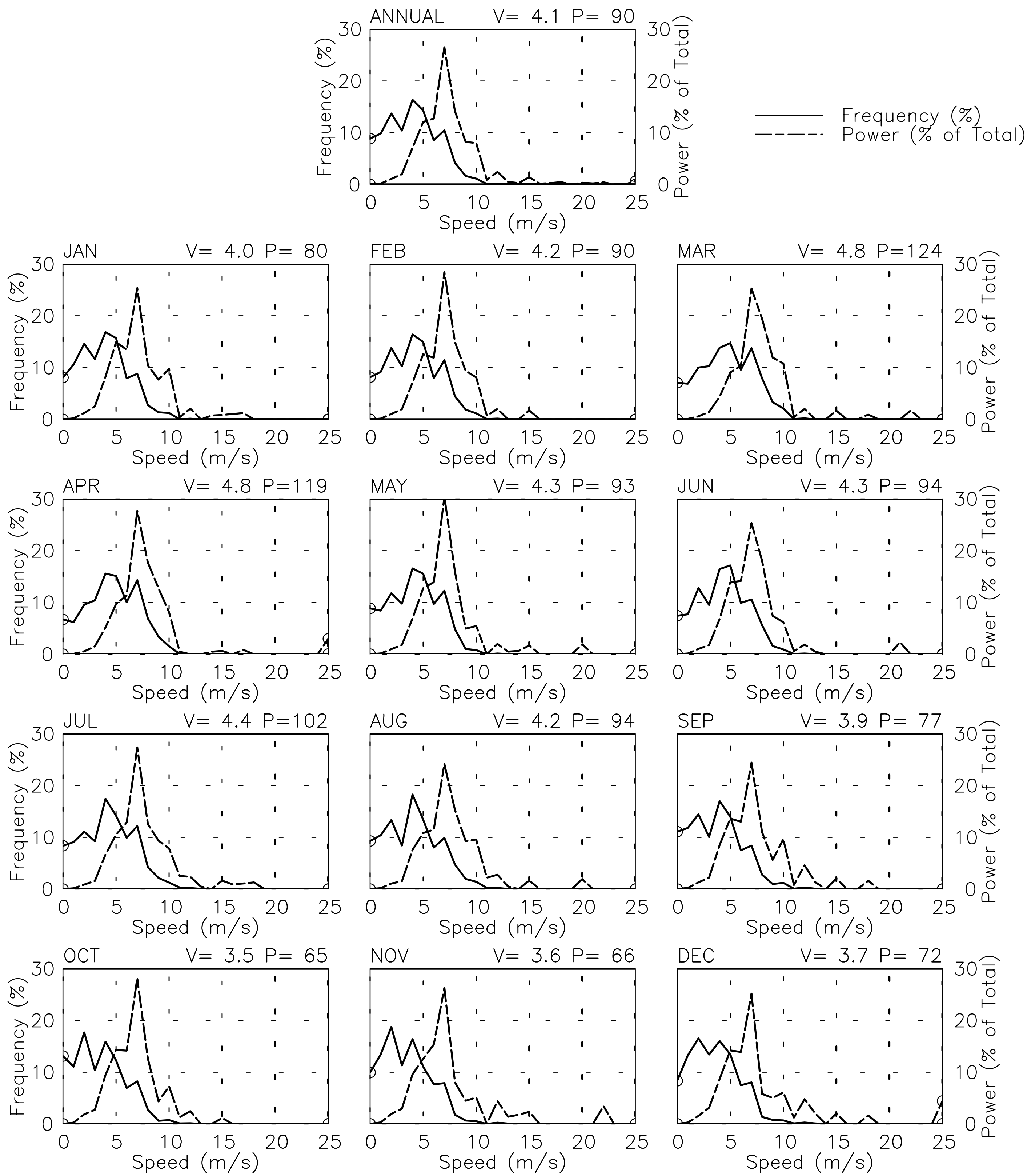
Fri May 14 16:14:09 1999

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

BARAHONA DR – 784820

18° 13' N 71° 06' W – Elev 26m *LST=GMT –4 hours NT= –5

01/73–12/96



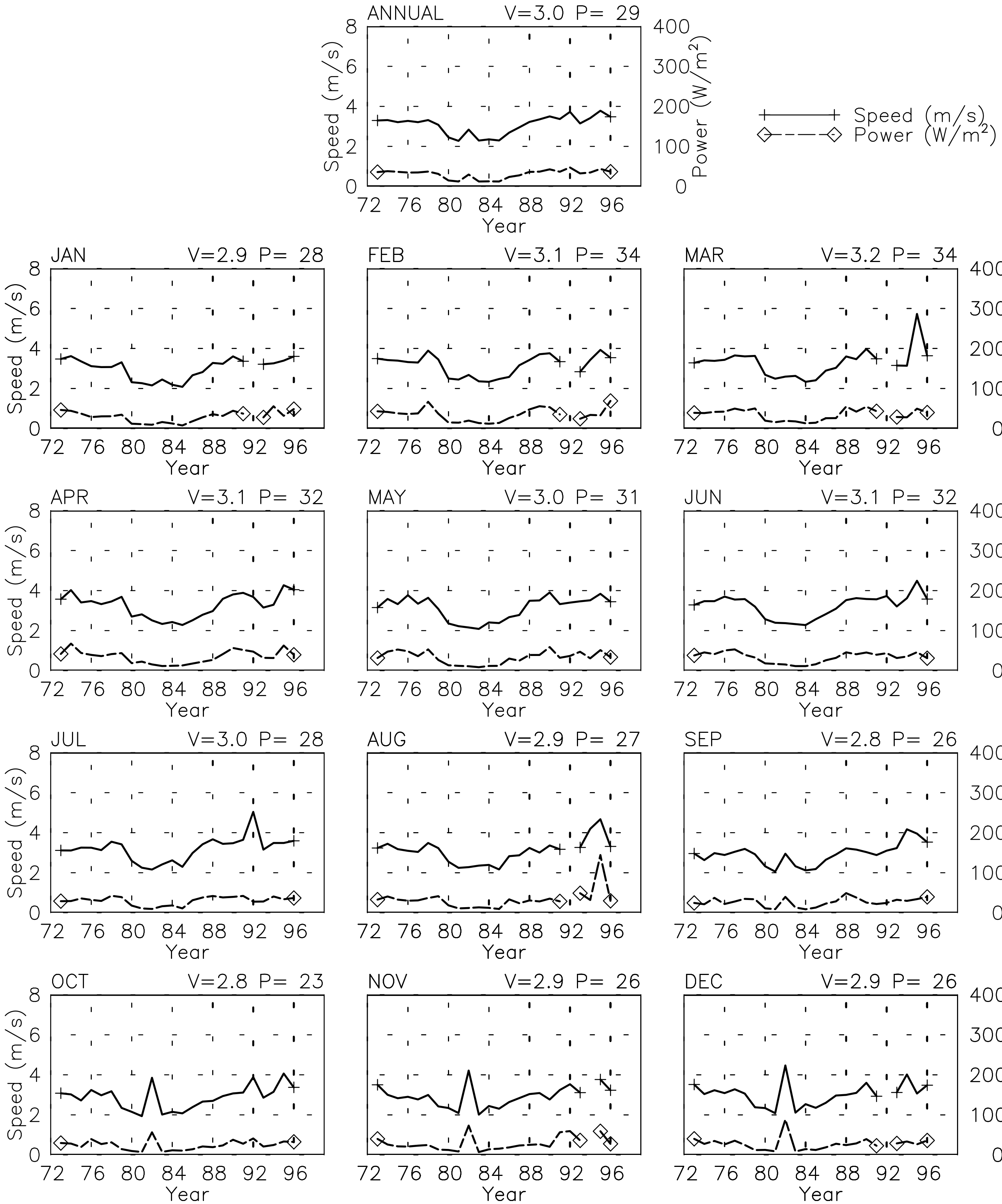
Fri May 14 16:14:14 1999

SPEED AND POWER BY YEAR

CAUCEDO/DE LAS AMER DR – 784850

18° 26' N 69° 40' W – Elev 18m *LST=GMT –4 hours NT= –5

01/73–12/96



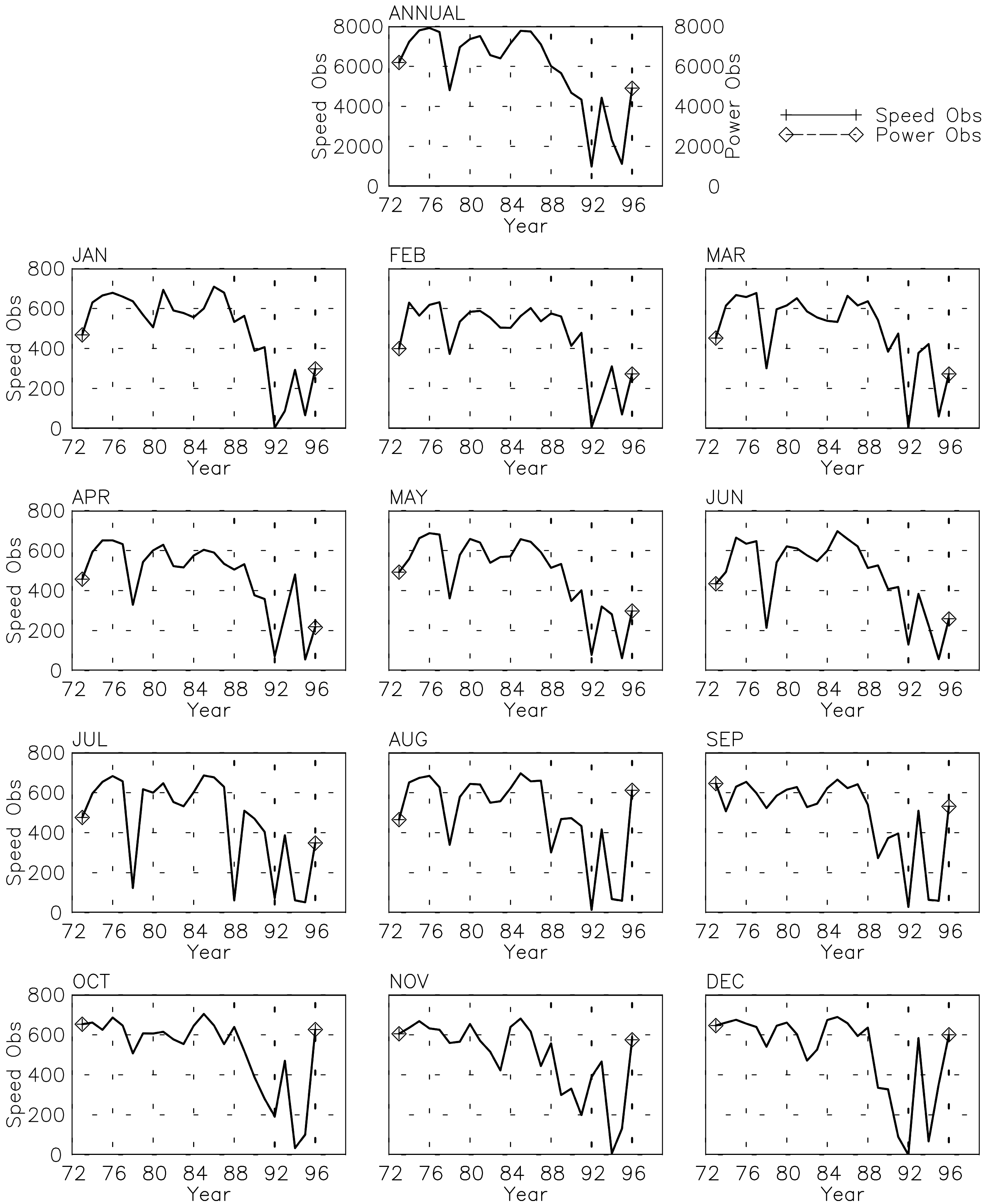
Fri May 14 16:14:46 1999

OBSERVATIONS BY YEAR

CAUCEDO/DE LAS AMER DR – 784850

18° 26' N 69° 40' W – Elev 18m *LST=GMT –4 hours NT= –5

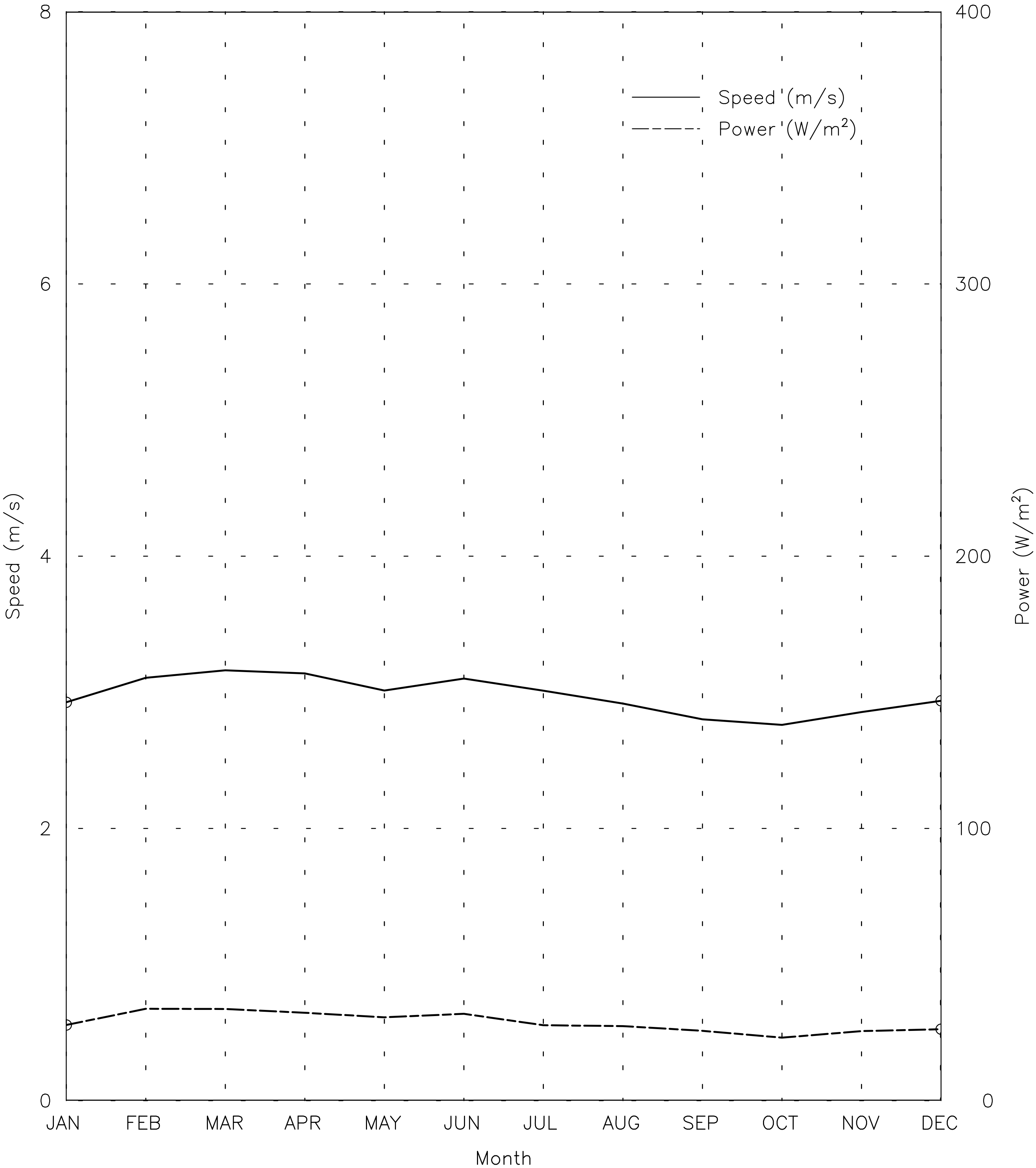
01/73–12/96



Fri May 14 16:14:51 1999

SPEED AND POWER BY MONTH

CAUCEDO/DE LAS AMER DR – 784850
18° 26' N   69° 40' W – Elev   18m *LST=GMT –4 hours   NT= –5
01/73–12/96



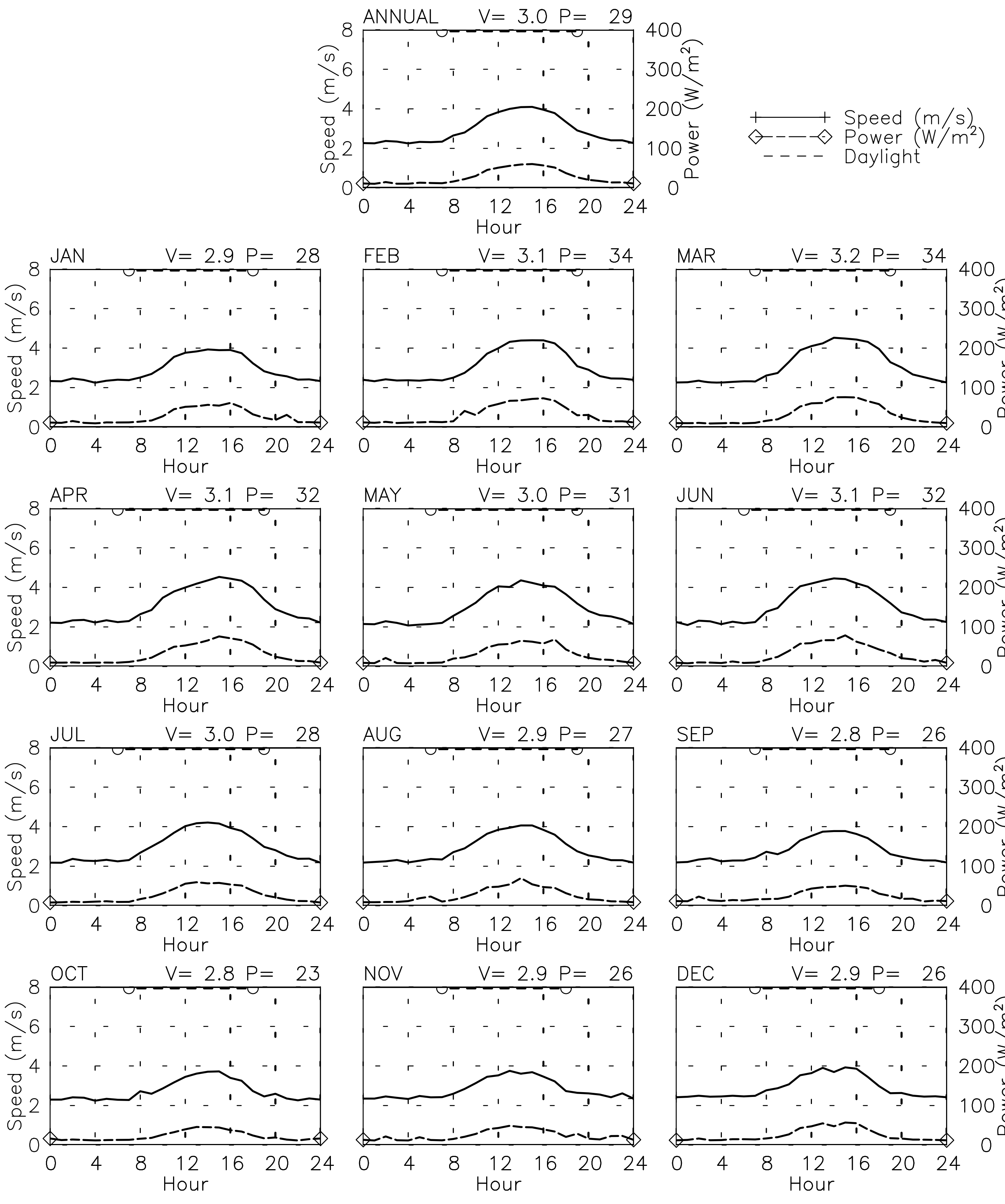
Fri May 14 16:14:54 1999

SPEED AND POWER BY HOUR

CAUCEDO/DE LAS AMER DR – 784850

18° 26' N 69° 40' W – Elev 18m *LST=GMT –4 hours NT= –5

01/73–12/96



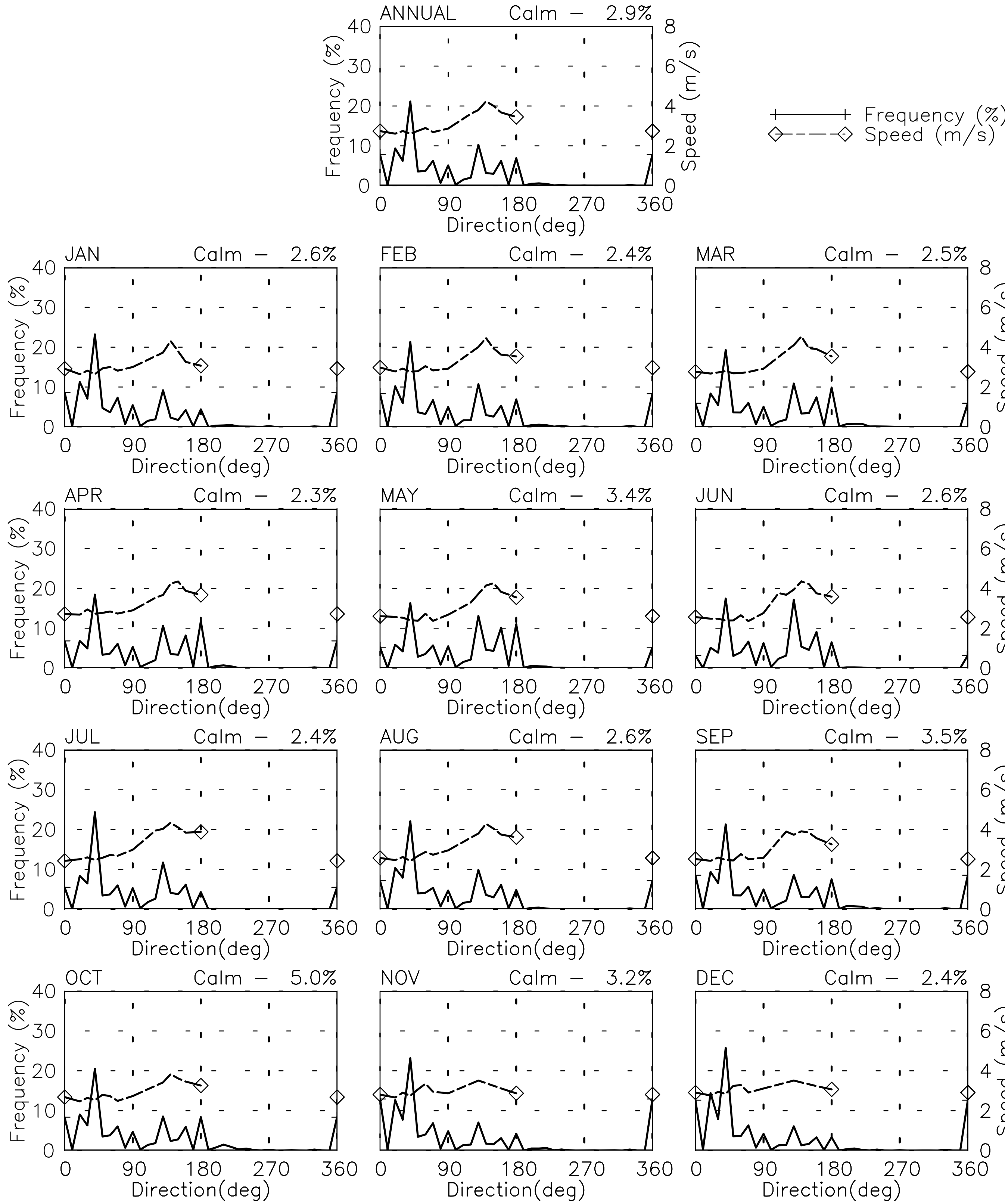
Fri May 14 16:14:56 1999

FREQUENCY AND SPEED BY DIRECTION

CAUCEDO/DE LAS AMER DR – 784850

18° 26' N   69° 40' W – Elev   18m *LST=GMT –4 hours   NT= –5

01/73–12/96



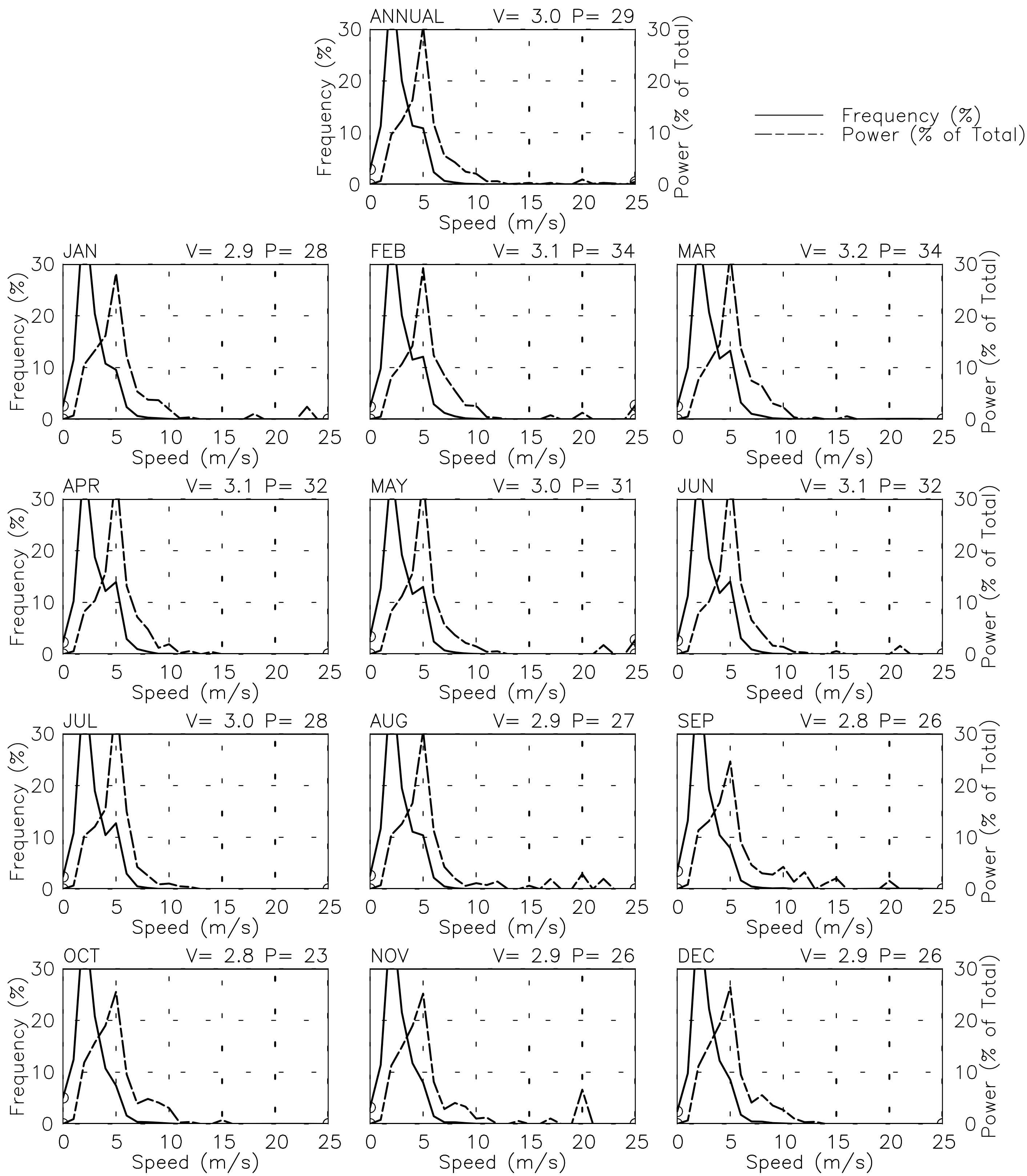
Fri May 14 16:15:01 1999

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

CAUCEDO/DE LAS AMER DR - 784850

18° 26' N 69° 40' W - Elev 18m *LST=GMT -4 hours NT= -5

01/73-12/96



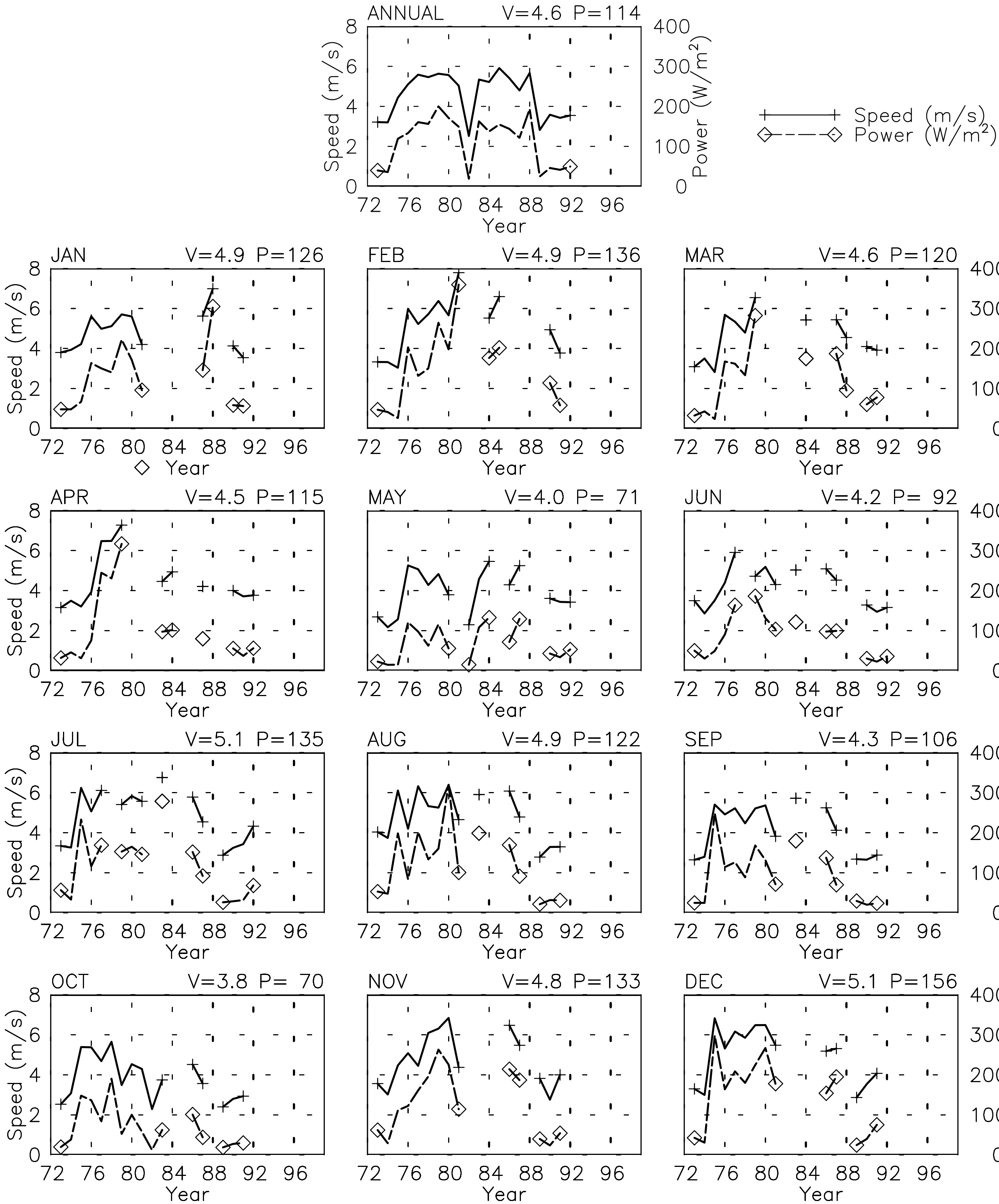
Fri May 14 16:15:06 1999

SPEED AND POWER BY YEAR

CABO ENGANO DR – 784780

18° 37' N 69° 19' W – Elev 2m *LST=GMT –4 hours NT= –5

01/73–08/93 07/95–11/96



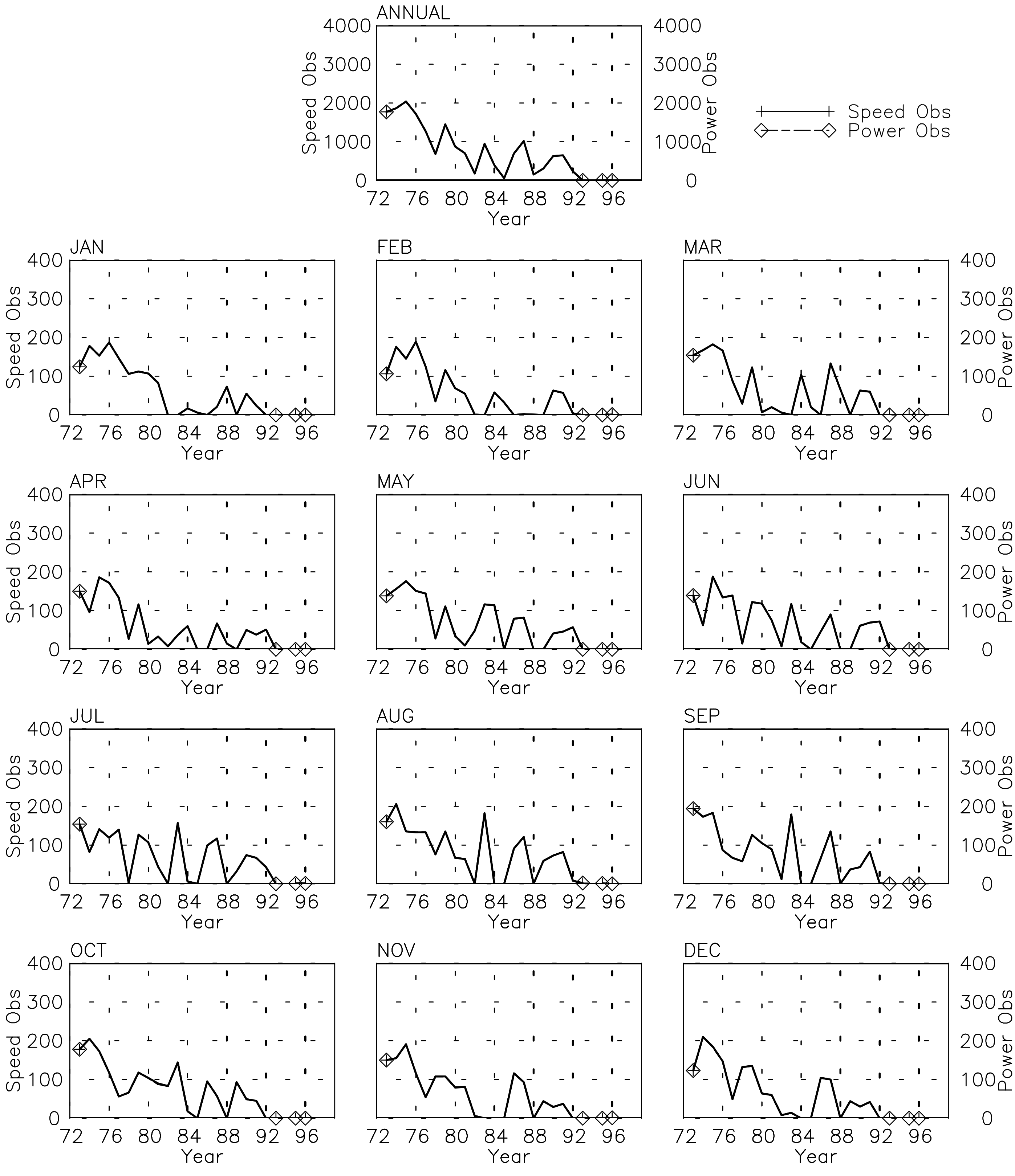
Fri May 14 16:13:18 1999

OBSERVATIONS BY YEAR

CABO ENGANO DR – 784780

18° 37' N 69° 19' W – Elev 2m *LST=GMT –4 hours NT= –5

01/73–08/93 07/95–11/96



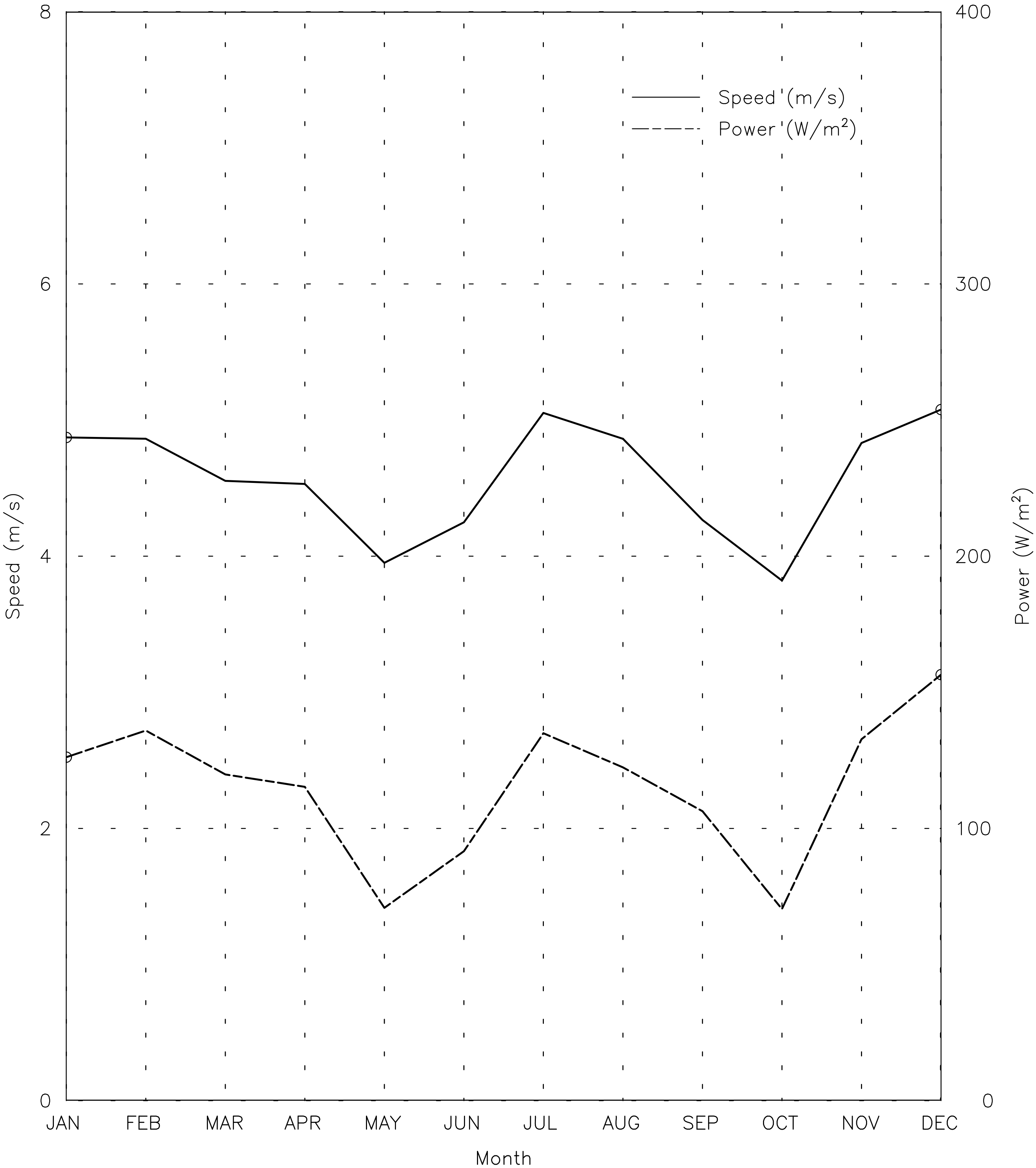
Fri May 14 16:13:25 1999

SPEED AND POWER BY MONTH

CABO ENGANO DR – 784780

18° 37' N 69° 19' W – Elev 2m *LST=GMT –4 hours NT= –5

01/73–08/93 07/95–11/96



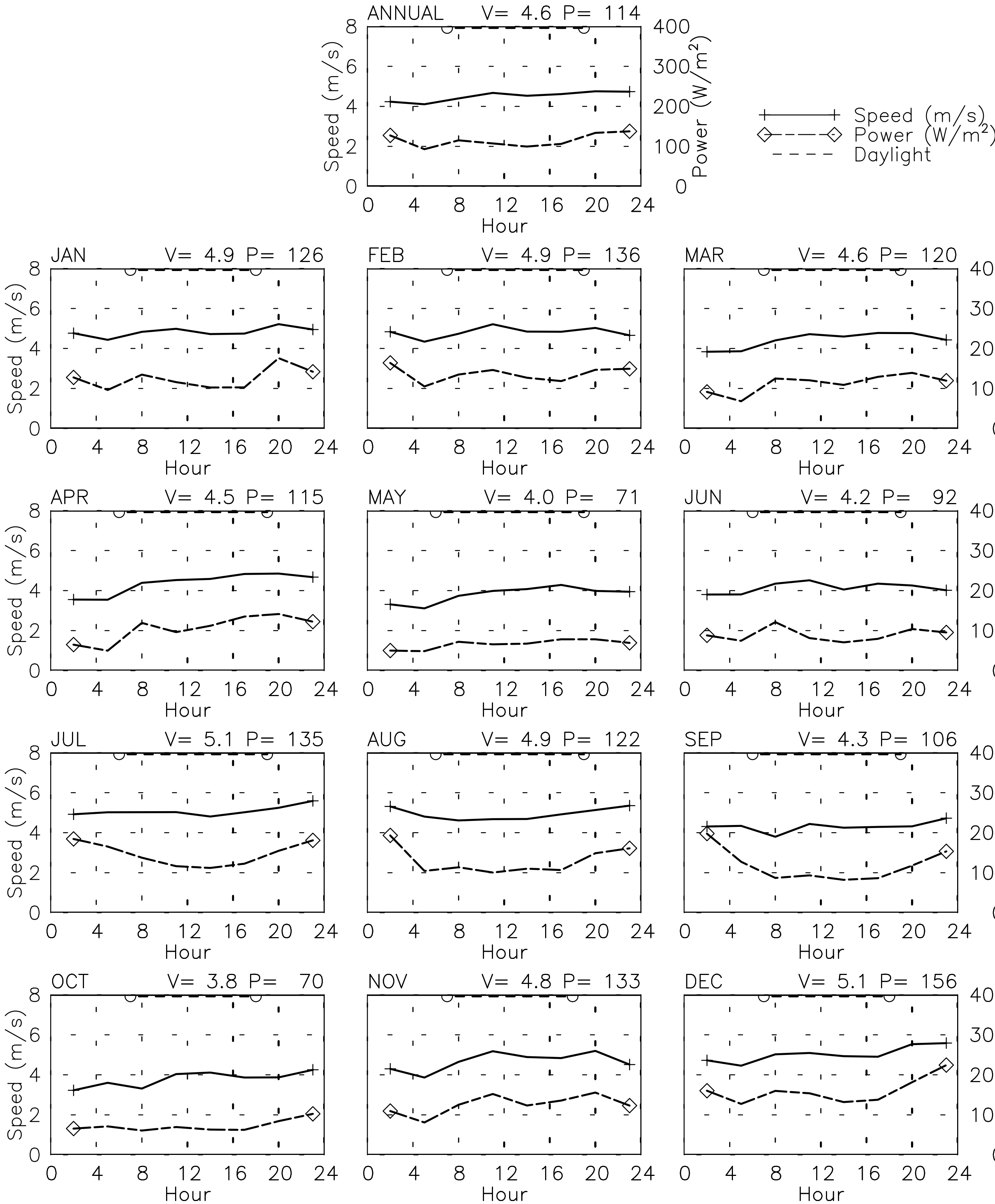
Fri May 14 16:13:30 1999

SPEED AND POWER BY HOUR

CABO ENGANO DR – 784780

18° 37' N 69° 19' W – Elev 2m *LST=GMT –4 hours NT= –5

01/73–08/93 07/95–11/96



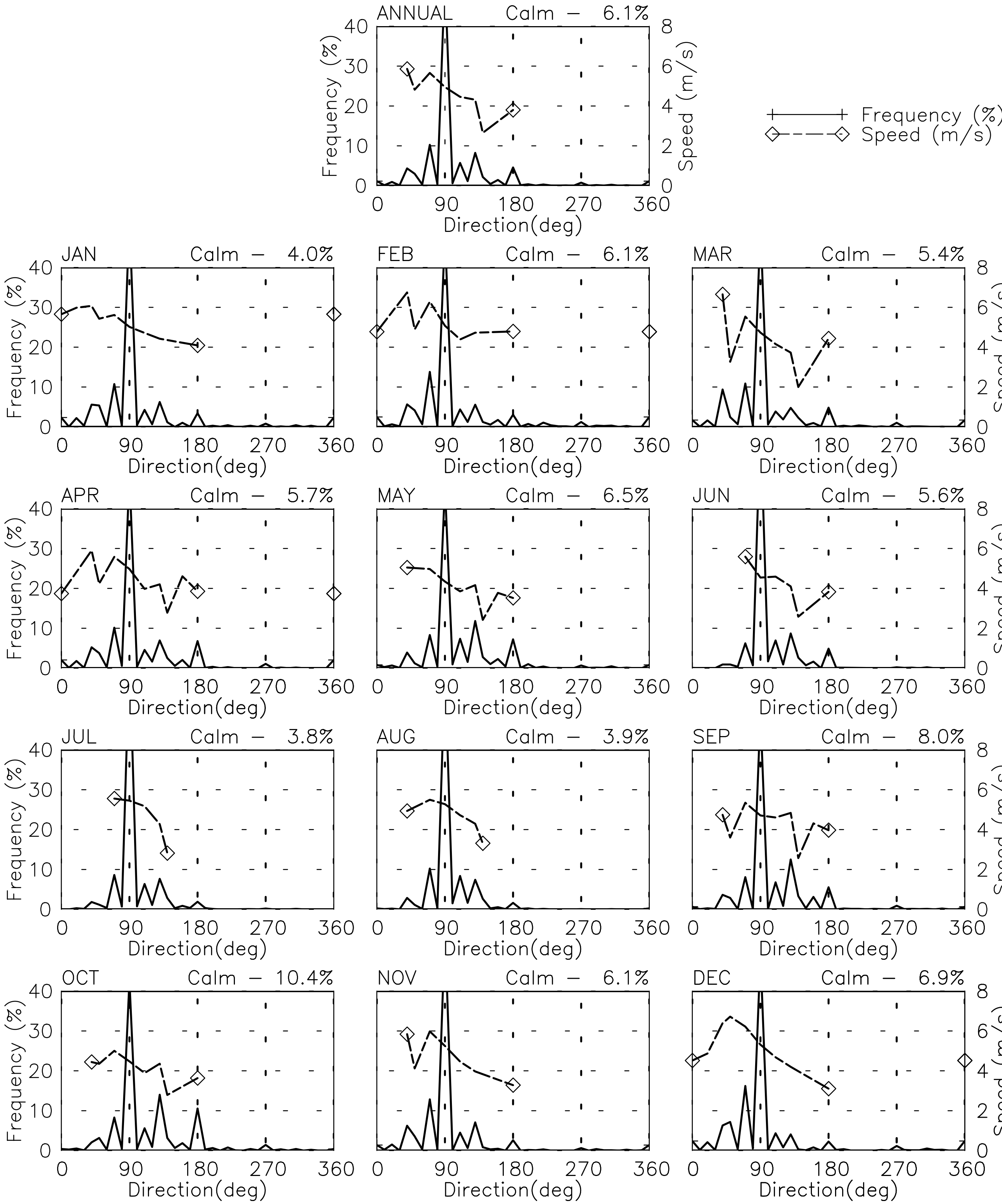
Fri May 14 16:13:32 1999

FREQUENCY AND SPEED BY DIRECTION

CABO ENGANO DR – 784780

18° 37' N 69° 19' W – Elev 2m *LST=GMT –4 hours NT= –5

01/73–08/93 07/95–11/96



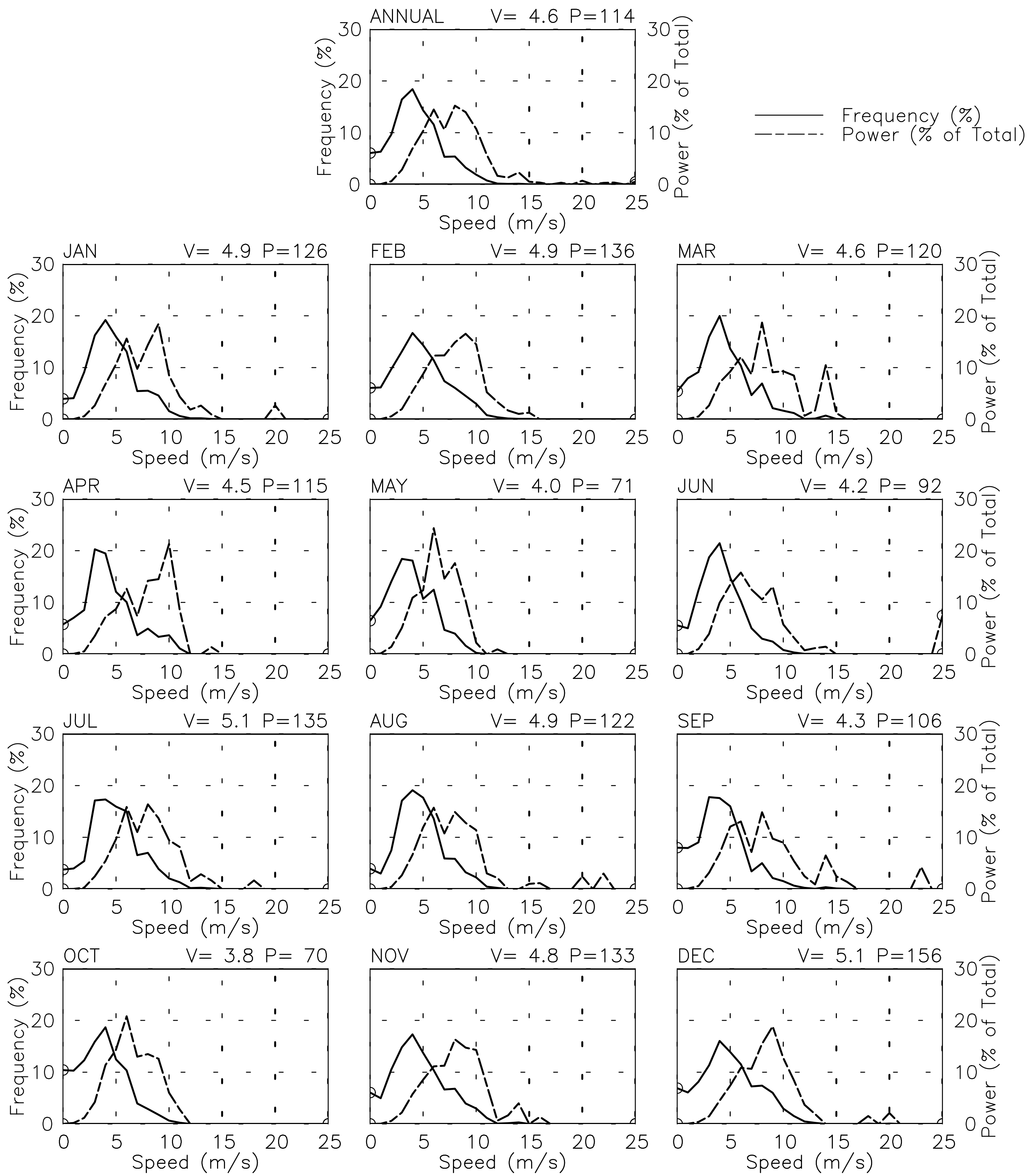
Fri May 14 16:13:36 1999

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

CABO ENGANO DR – 784780

18° 37' N 69° 19' W – Elev 2m *LST=GMT –4 hours NT= –5

01/73–08/93 07/95–11/96



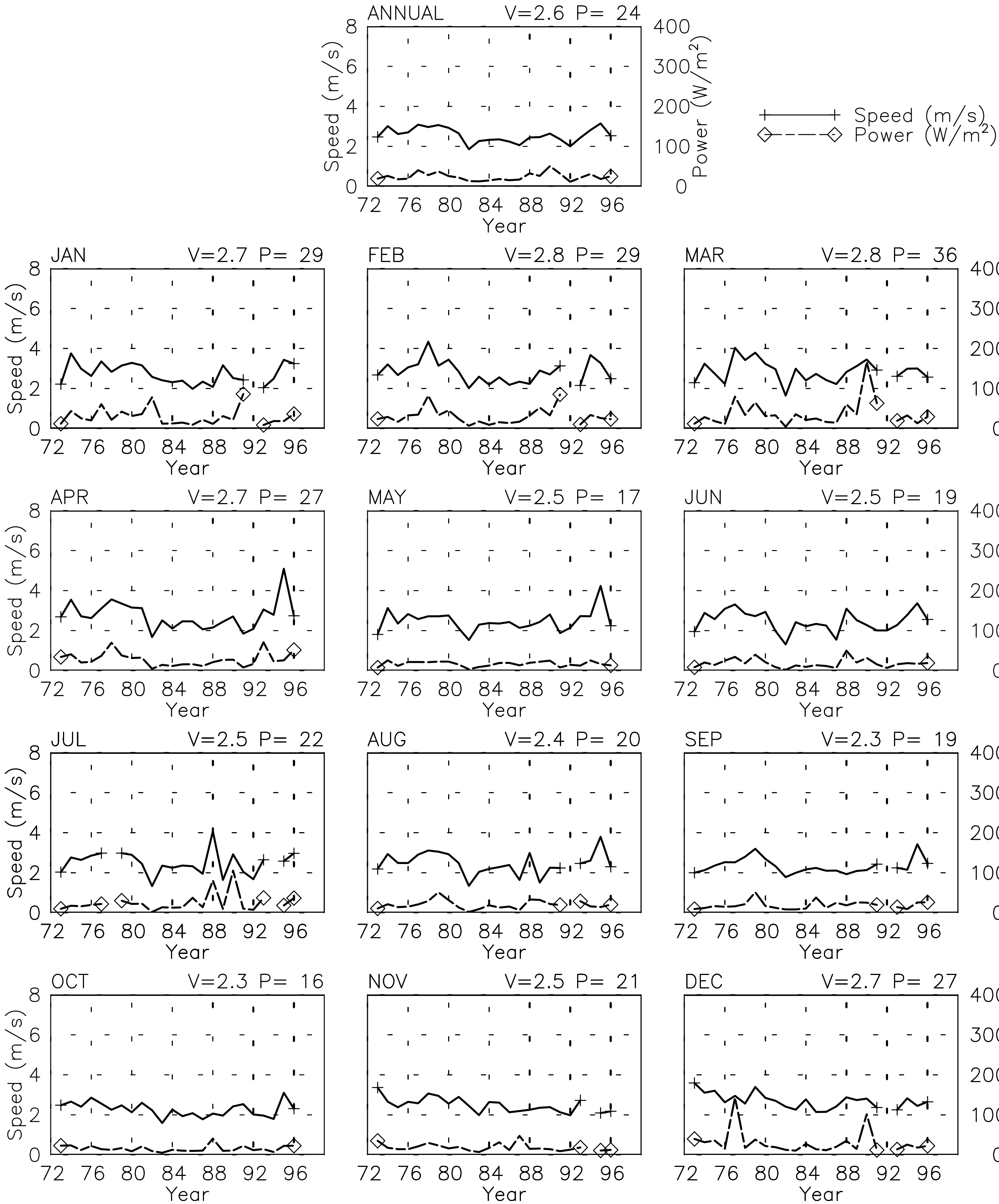
Fri May 14 16:13:40 1999

SPEED AND POWER BY YEAR

SANTO DOMINGO DR – 784860

18° 26' N 69° 53' W – Elev 14m *LST=GMT –4 hours NT= –5

01/73–12/96



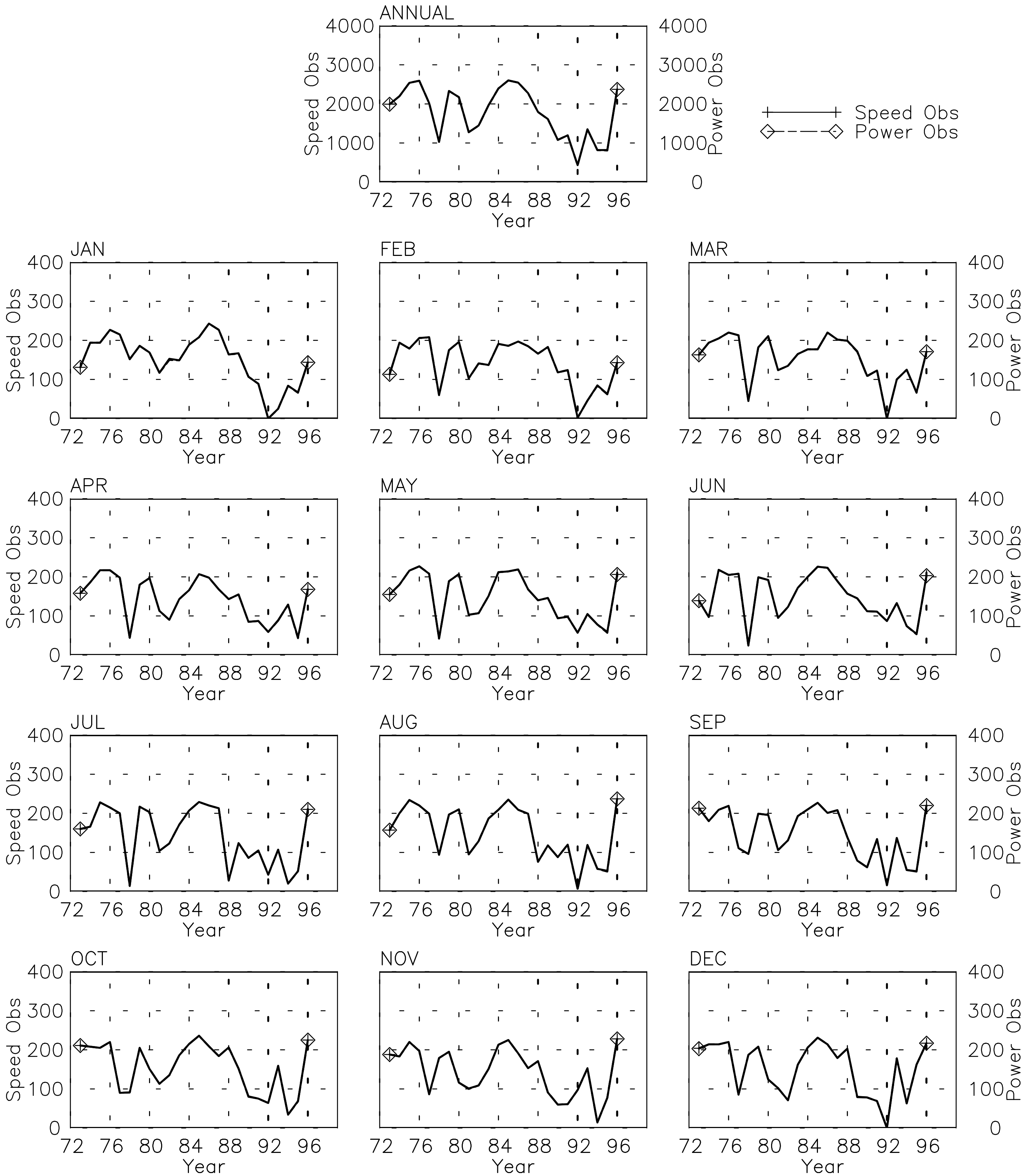
Fri May 14 16:00:53 1999

OBSERVATIONS BY YEAR

SANTO DOMINGO DR – 784860

18° 26' N 69° 53' W – Elev 14m *LST=GMT –4 hours NT= –5

01/73–12/96



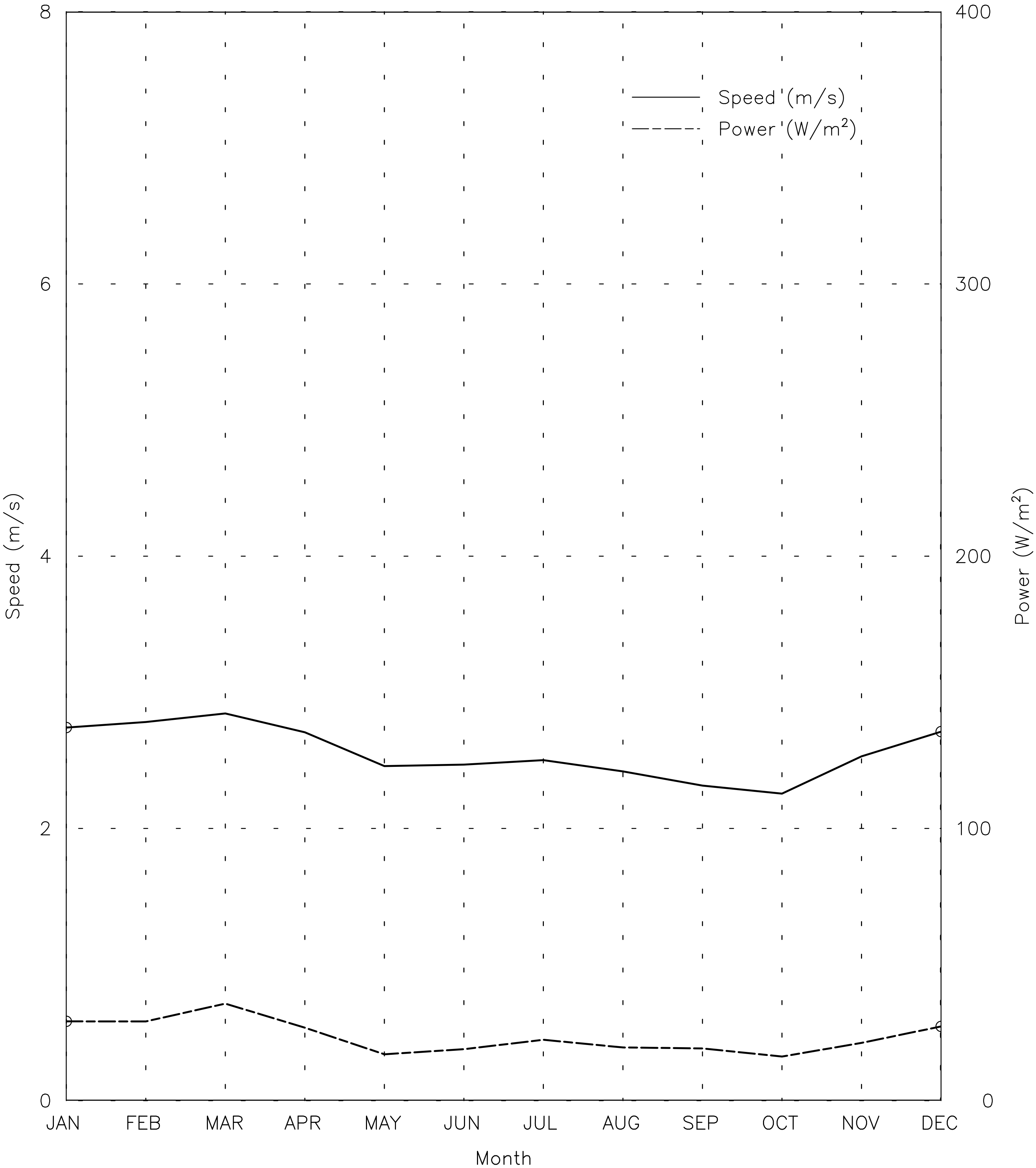
Fri May 14 16:00:58 1999

SPEED AND POWER BY MONTH

SANTO DOMINGO DR – 784860

18° 26' N 69° 53' W – Elev 14m *LST=GMT –4 hours NT= –5

01/73–12/96



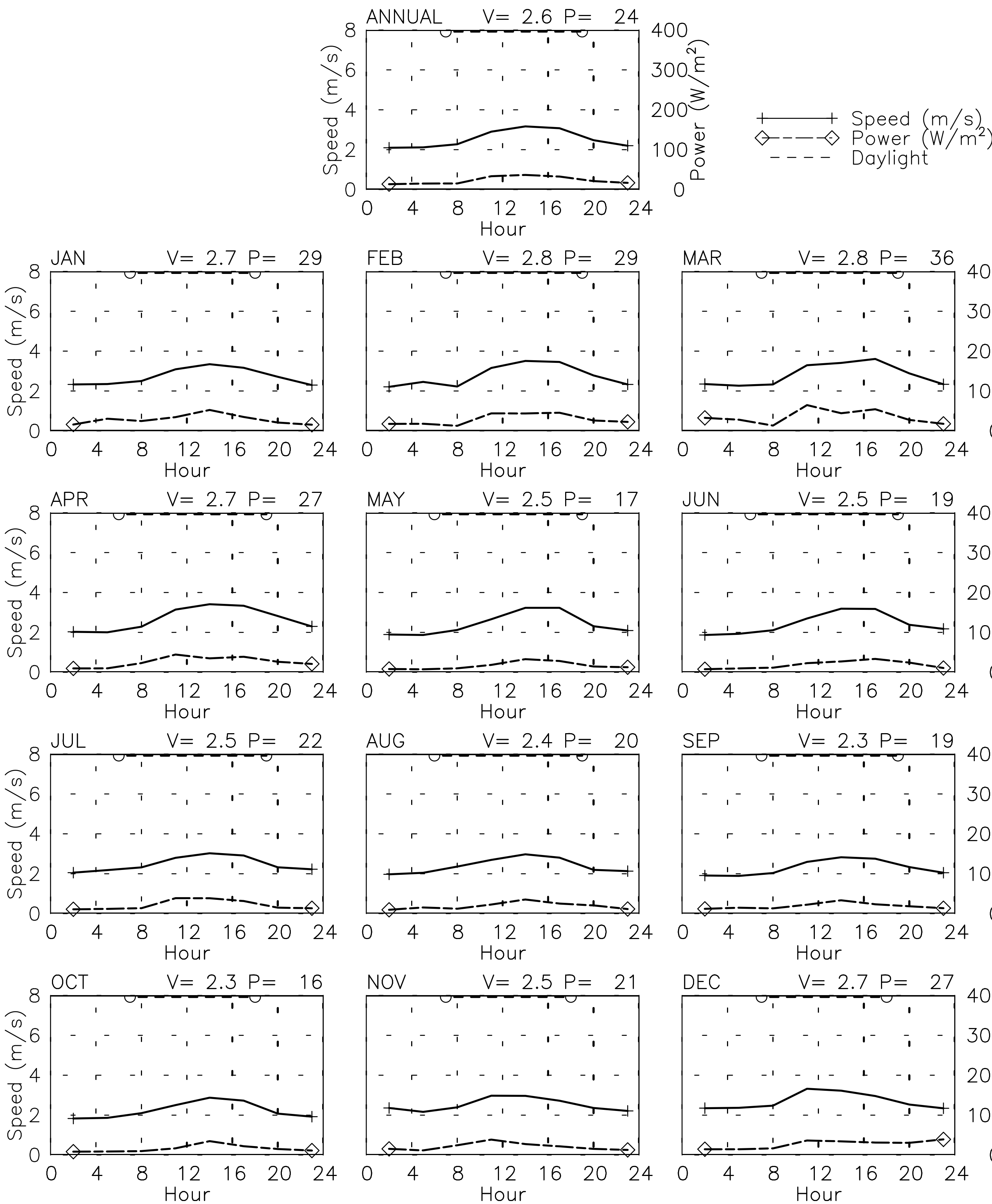
Fri May 14 16:01:01 1999

SPEED AND POWER BY HOUR

SANTO DOMINGO DR – 784860

18° 26' N 69° 53' W – Elev 14m *LST=GMT –4 hours NT= –5

01/73–12/96



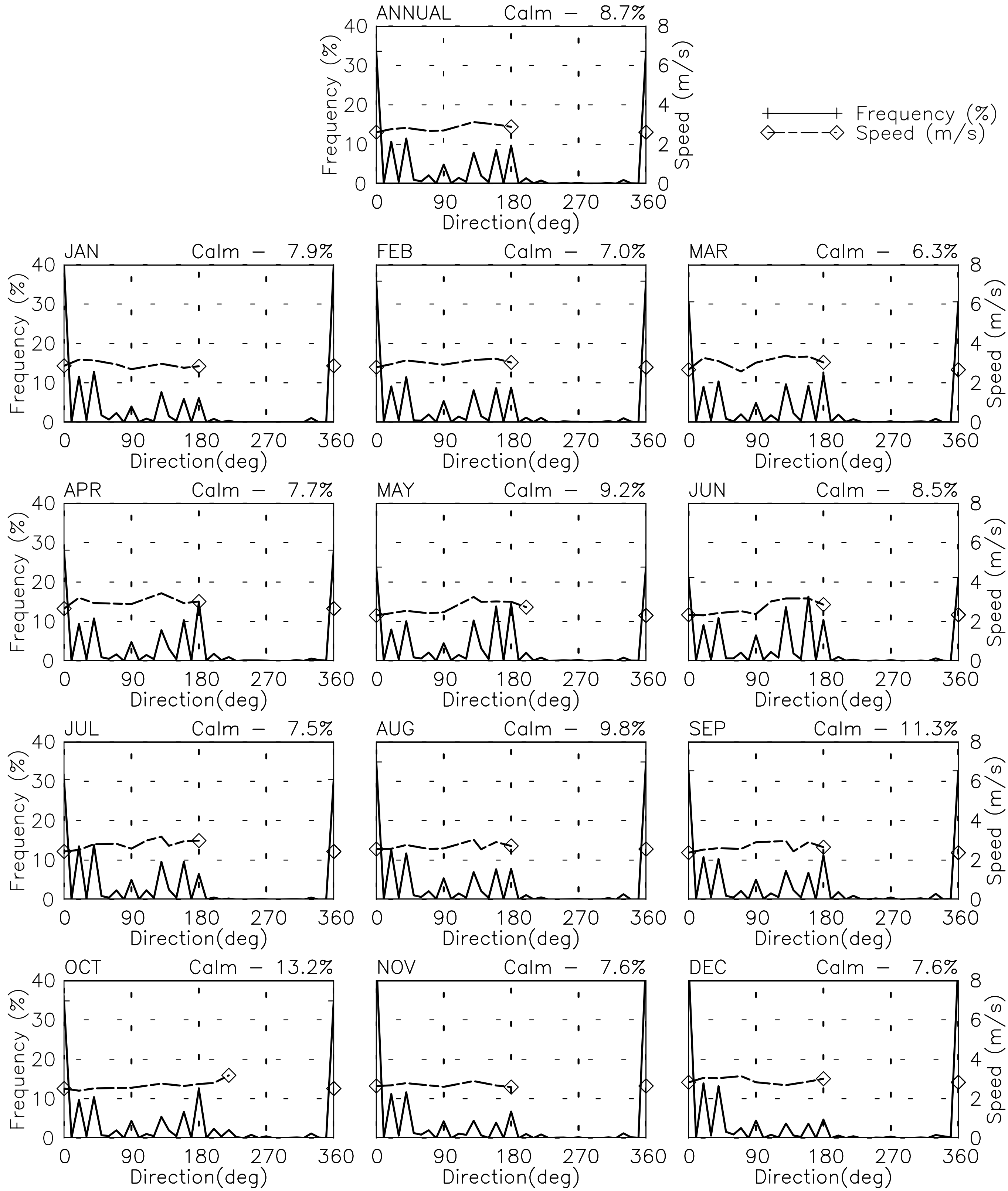
Fri May 14 16:01:03 1999

FREQUENCY AND SPEED BY DIRECTION

SANTO DOMINGO DR - 784860

18° 26' N 69° 53' W - Elev 14m *LST=GMT -4 hours NT= -5

01/73-12/96



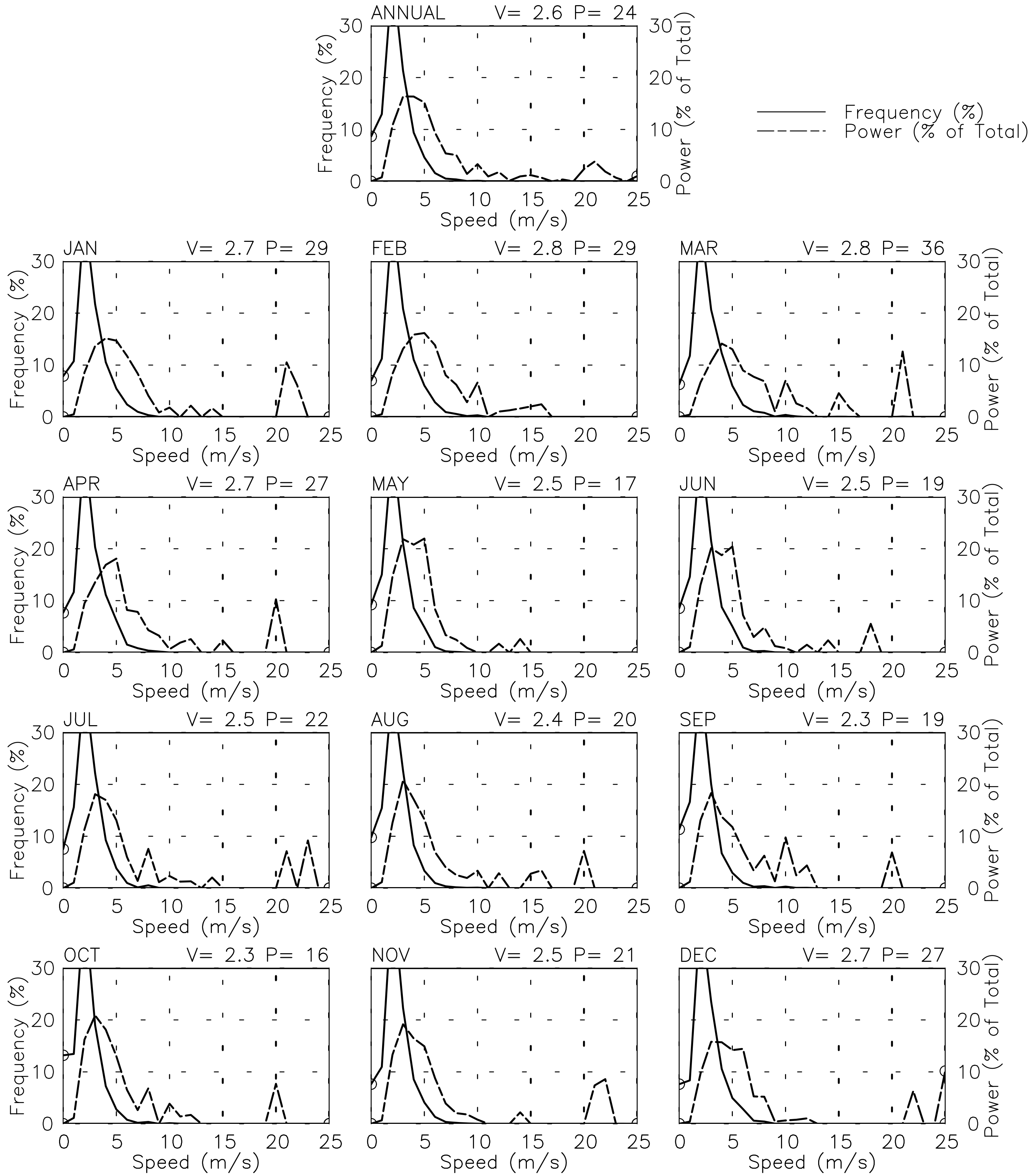
Fri May 14 16:01:08 1999

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

SANTO DOMINGO DR - 784860

18° 26' N 69° 53' W - Elev 14m *LST=GMT -4 hours NT= -5

01/73-12/96



Fri May 14 16:01:13 1999

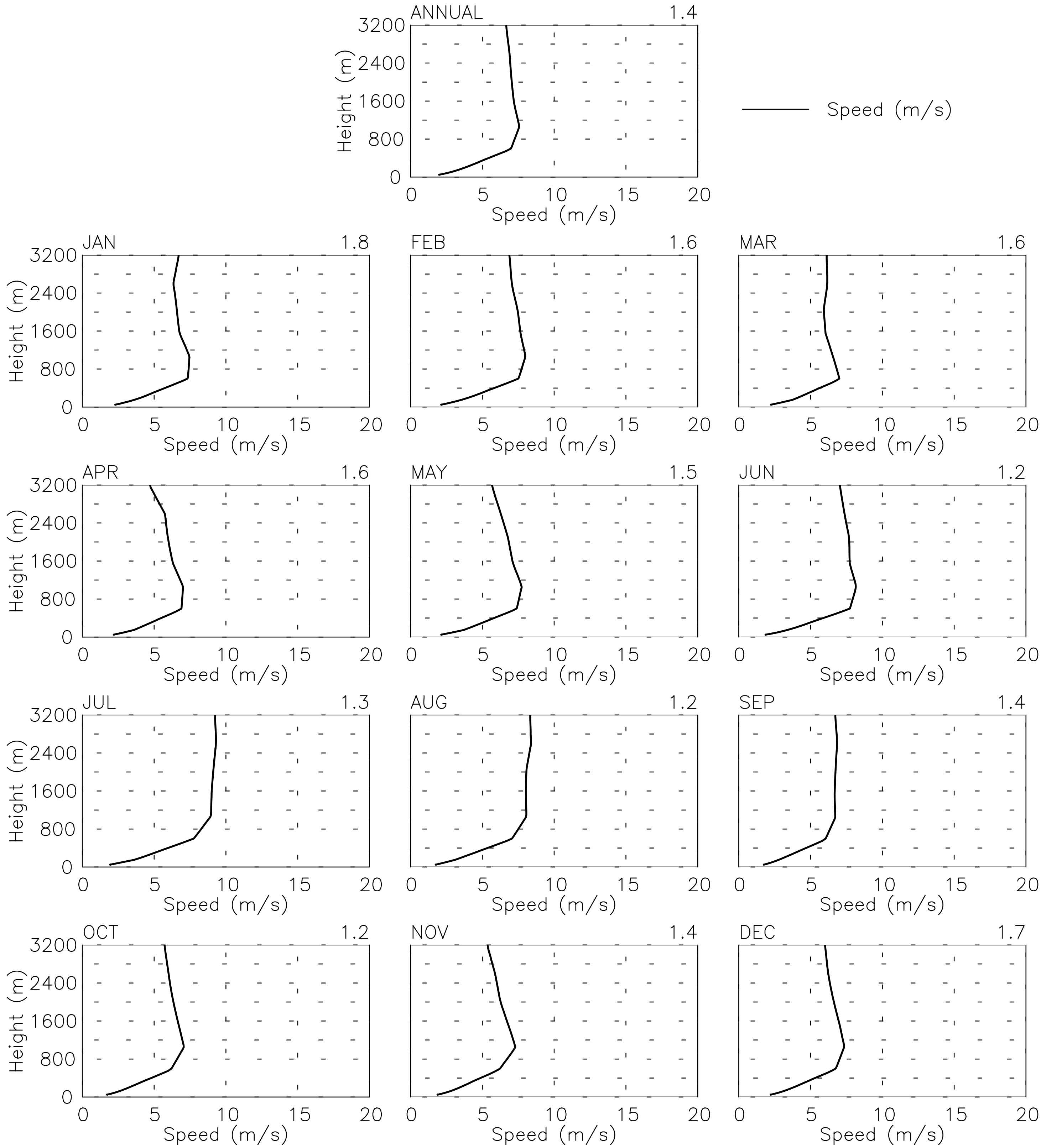
Appendix C

Upper-Air Stations - Data Summaries

Sabana de la Mar
Santo Domingo
Grand Turk (1957-70)
Grand Turk (1973-78)
San Juan
St. Maarten

VERTICAL WIND SPEED PROFILE BY HEIGHT

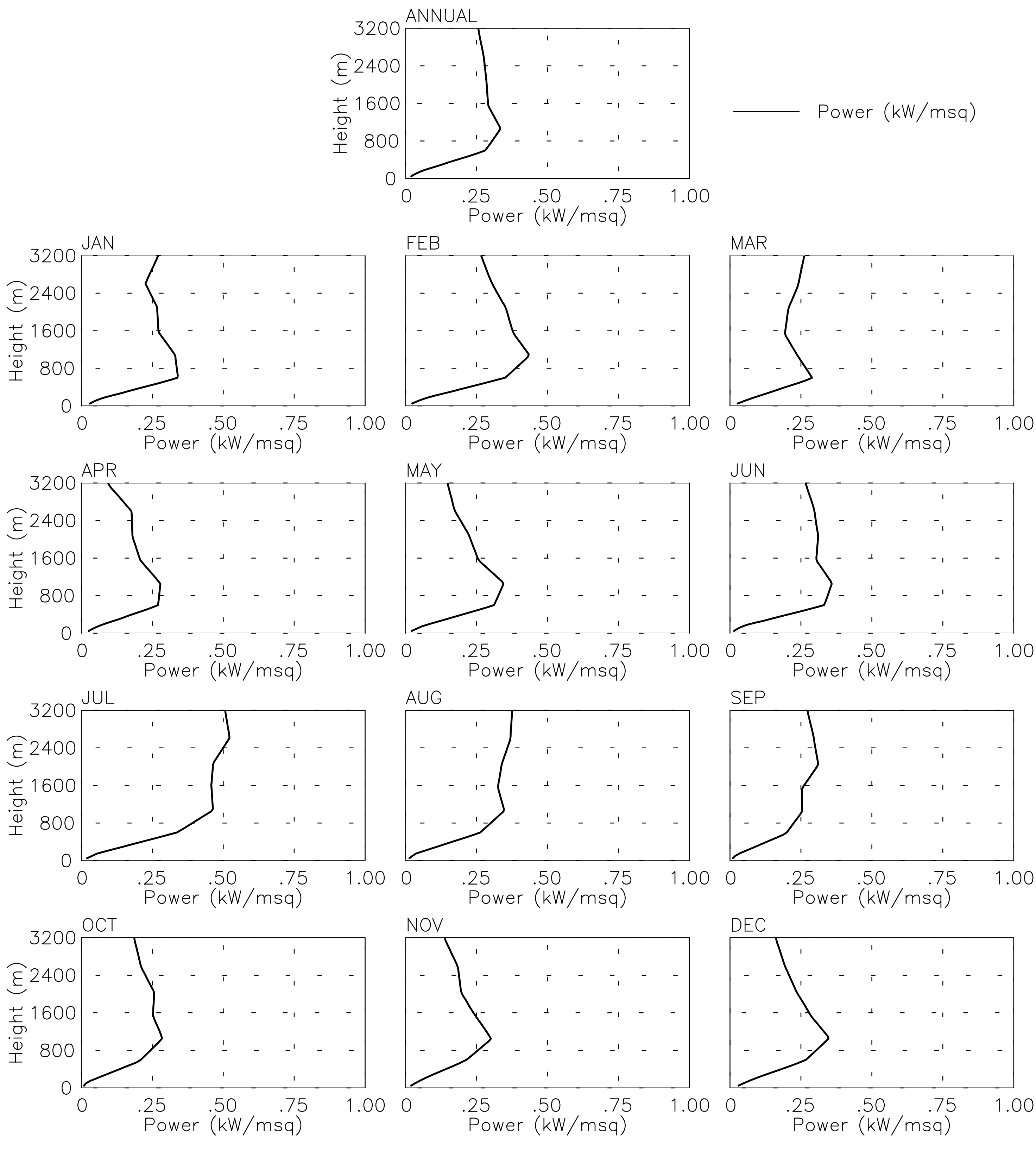
Sabana De La Mar – 78467 – 1200 LST
19° 03' N 69° 23' W – Elev 11m
06/57–08/62



Thu Aug 16 09:48:56 2001

VERTICAL WIND POWER PROFILE BY HEIGHT

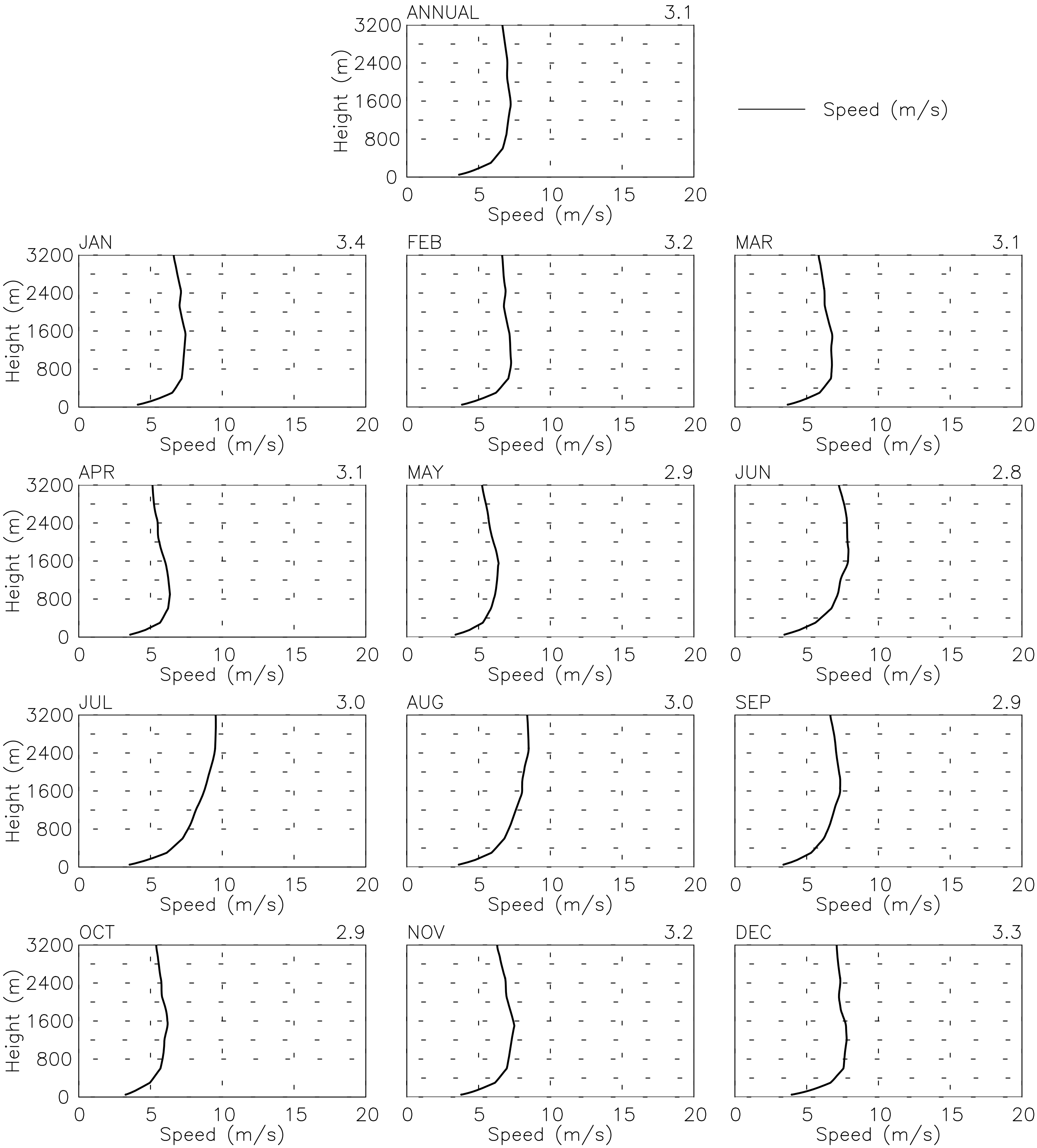
Sabana de la Mar – 78467 – 1200 LST
19° 03' N 69° 23' W – Elev 10m
06/57–08/62



Fri May 14 16:54:20 1999

VERTICAL WIND SPEED PROFILE BY HEIGHT

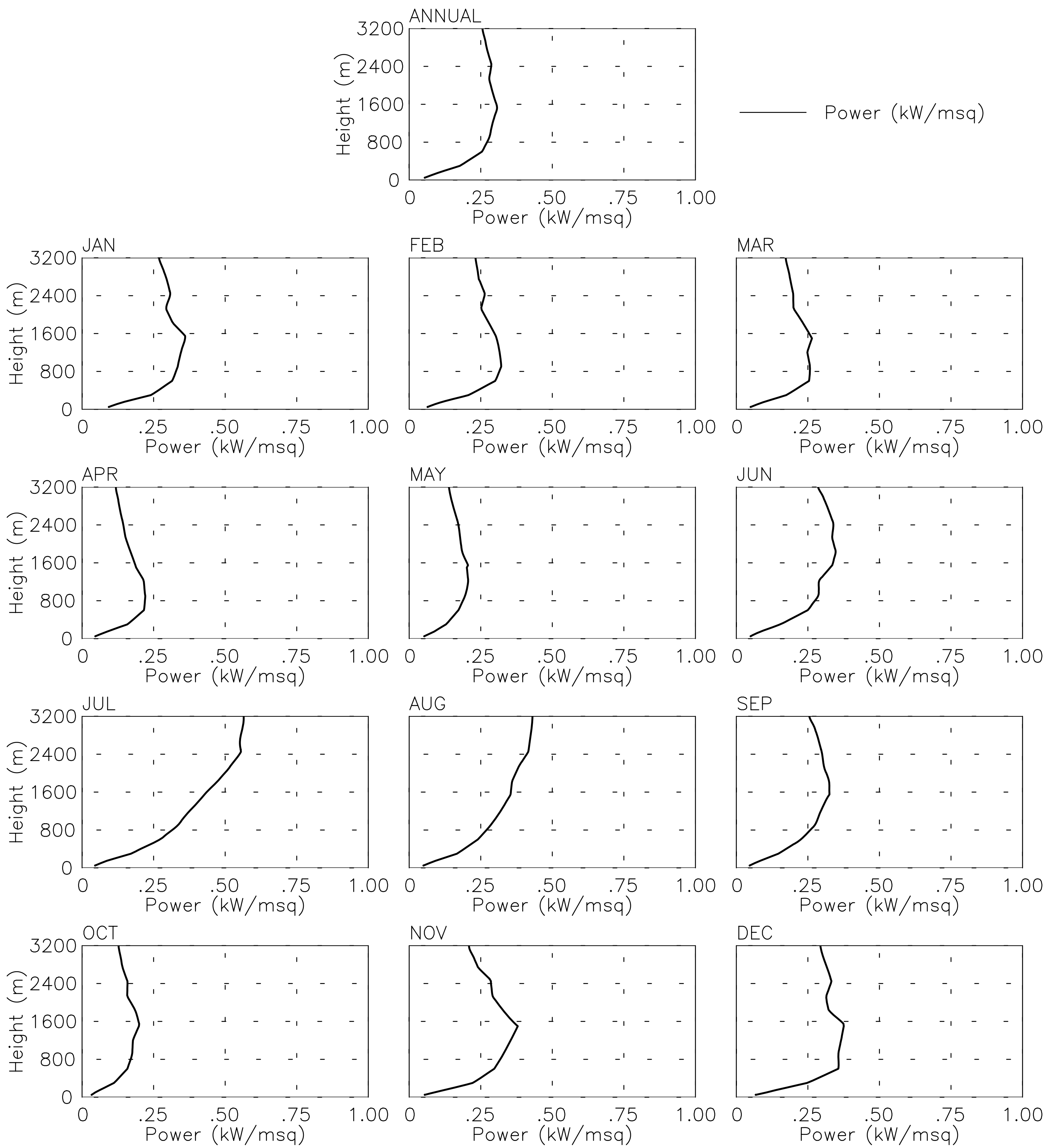
Santo Domingo – 78486 – 0800 LST
18° 28' N 69° 53' W – Elev 14m
01/73–03/97



Thu Aug 16 10:30:37 2001

VERTICAL WIND POWER PROFILE BY HEIGHT

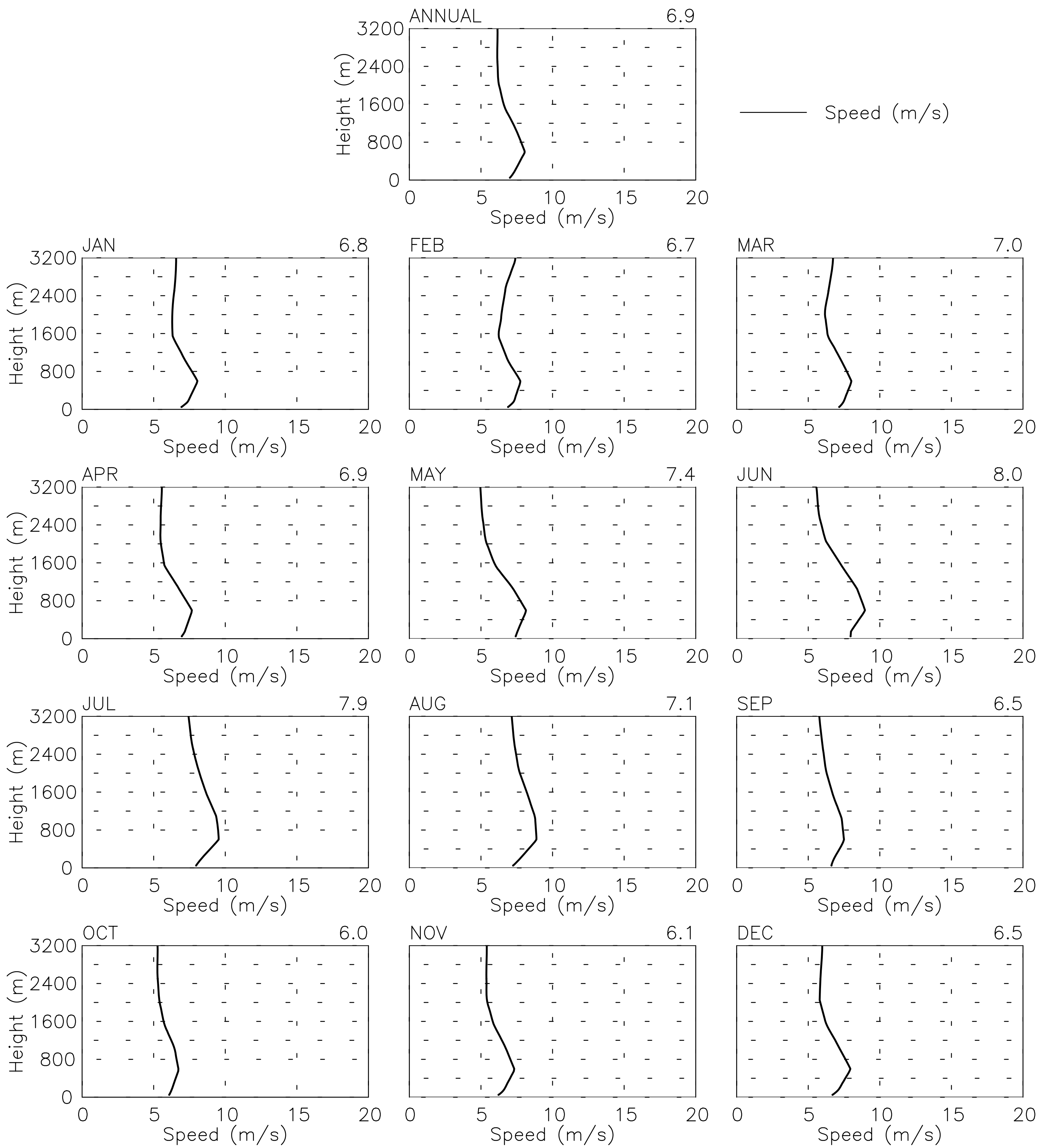
Santo Domingo – 78486 – 0800 LST
18° 28' N 69° 53' W – Elev 14m
01/73–03/97



Fri May 14 16:45:46 1999

VERTICAL WIND SPEED PROFILE BY HEIGHT

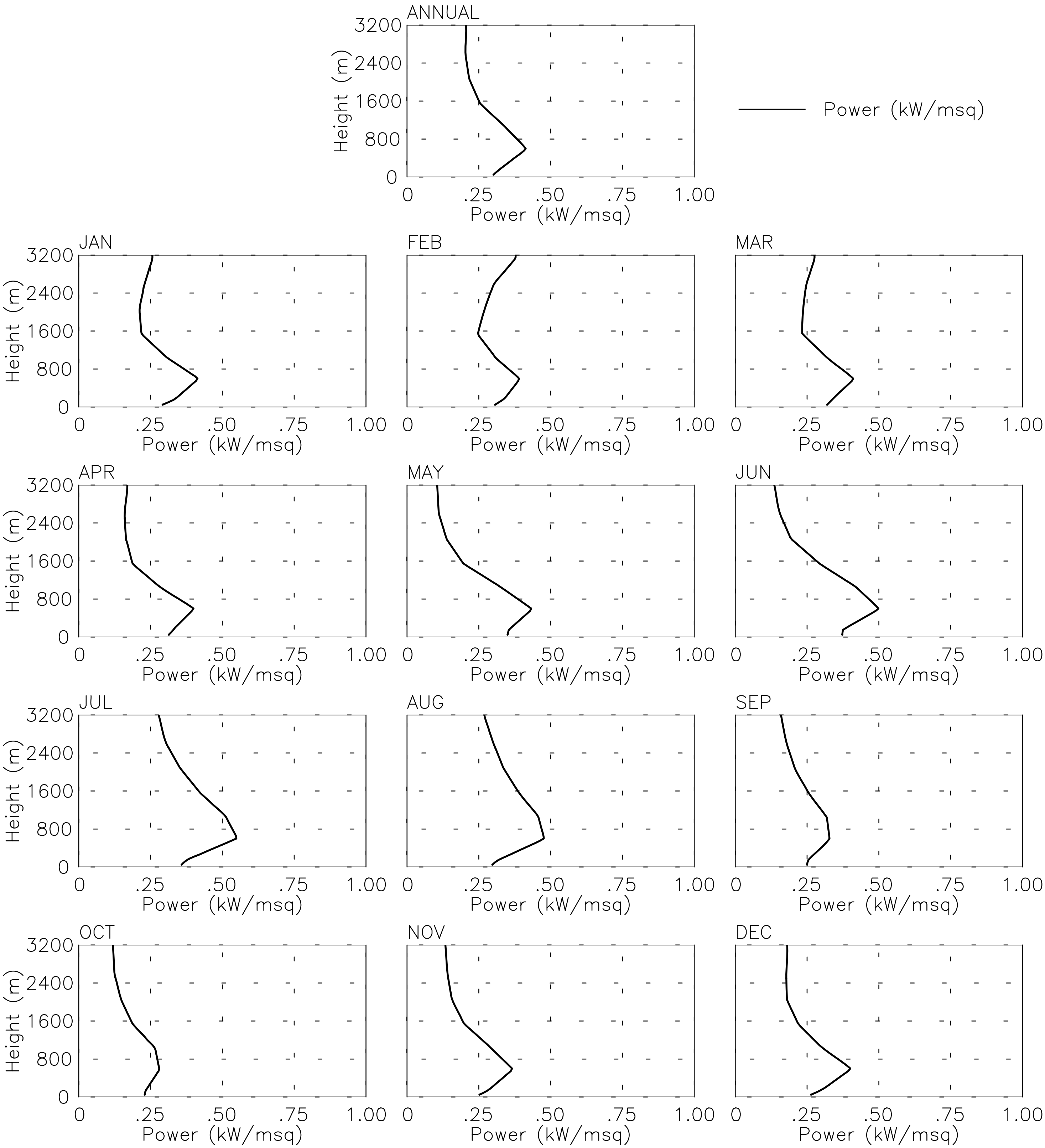
Grand Turk – 78118 – 1200 LST
21° 27' N 71° 09' W – Elev 8m
06/57–05/70



Thu Aug 16 09:59:58 2001

VERTICAL WIND POWER PROFILE BY HEIGHT

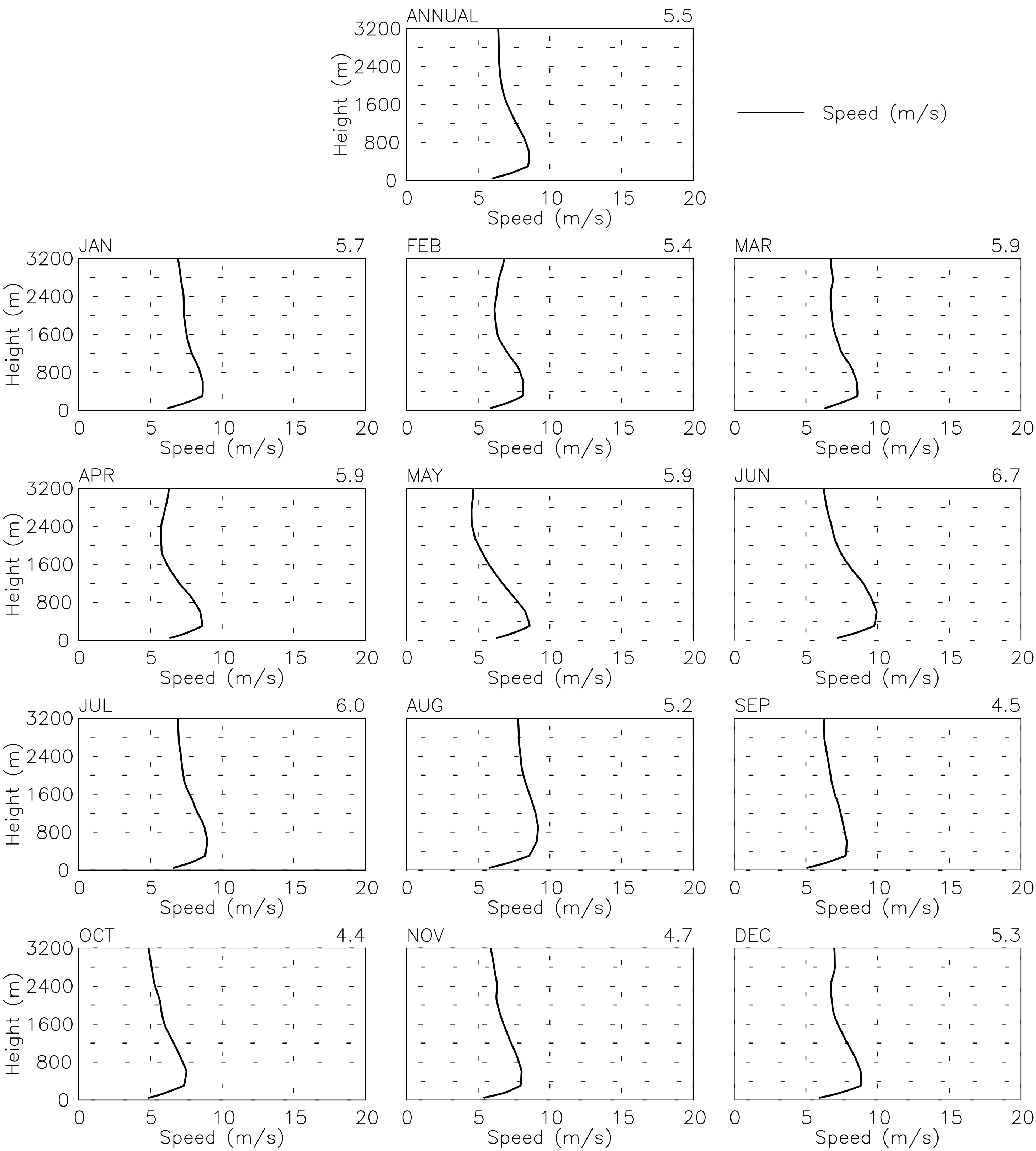
Grand Turk – 78118 – 1200 LST
21° 27' N 71° 09' W – Elev 8m
06/57–05/70



Fri May 14 16:53:16 1999

VERTICAL WIND SPEED PROFILE BY HEIGHT

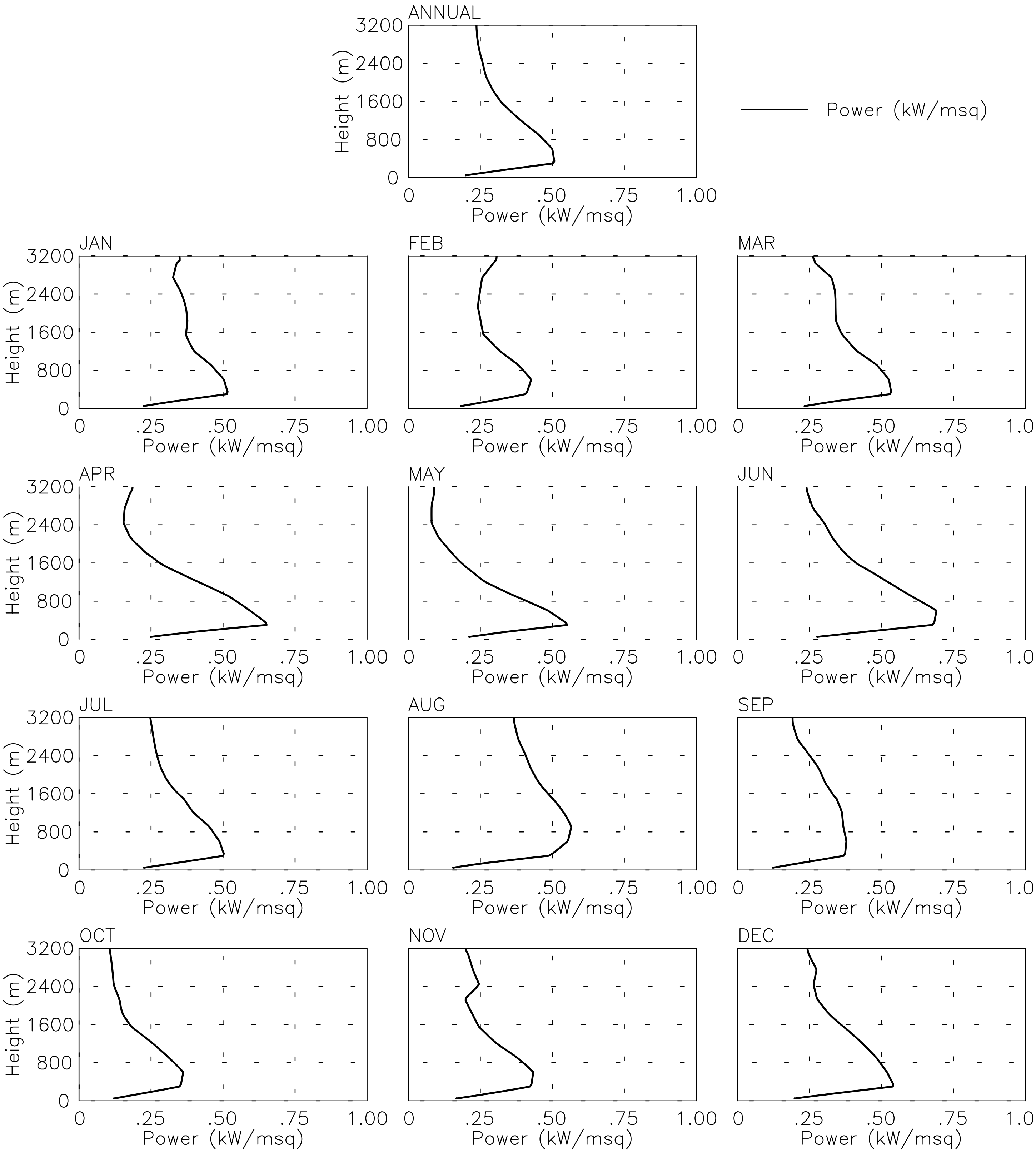
Grand Turk - 78118 - 0700 LST
21° 27' N 71° 09' W - Elev 8m
01/73-12/81 03/83-06/83 03/87-12/87



Thu Aug 16 10:28:58 2001

VERTICAL WIND POWER PROFILE BY HEIGHT

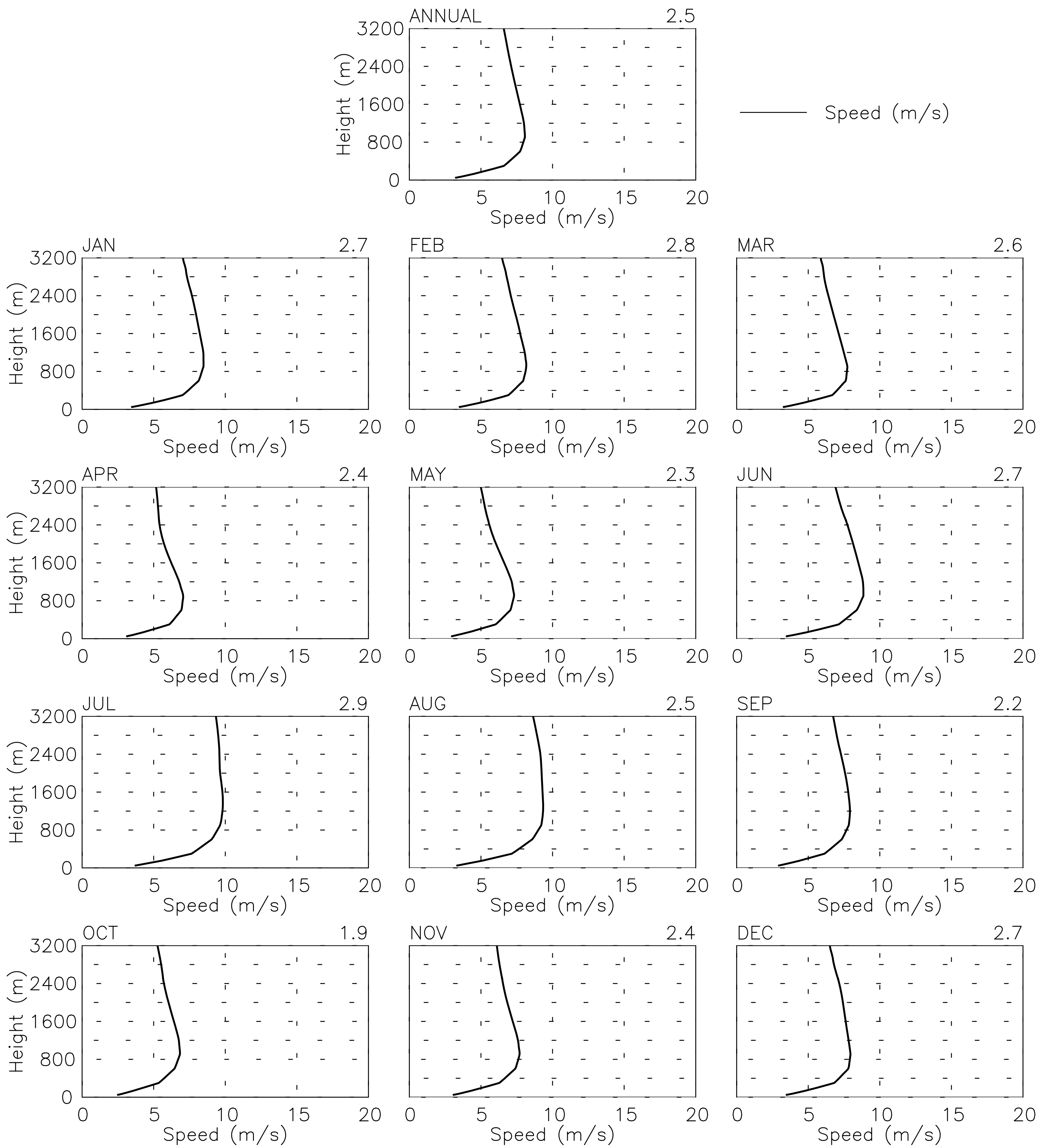
Grand Turk – 78118 – 0700 LST
21° 27' N   71° 09' W – Elev   8m
01/73–12/78



Fri May 14 16:42:29 1999

VERTICAL WIND SPEED PROFILE BY HEIGHT

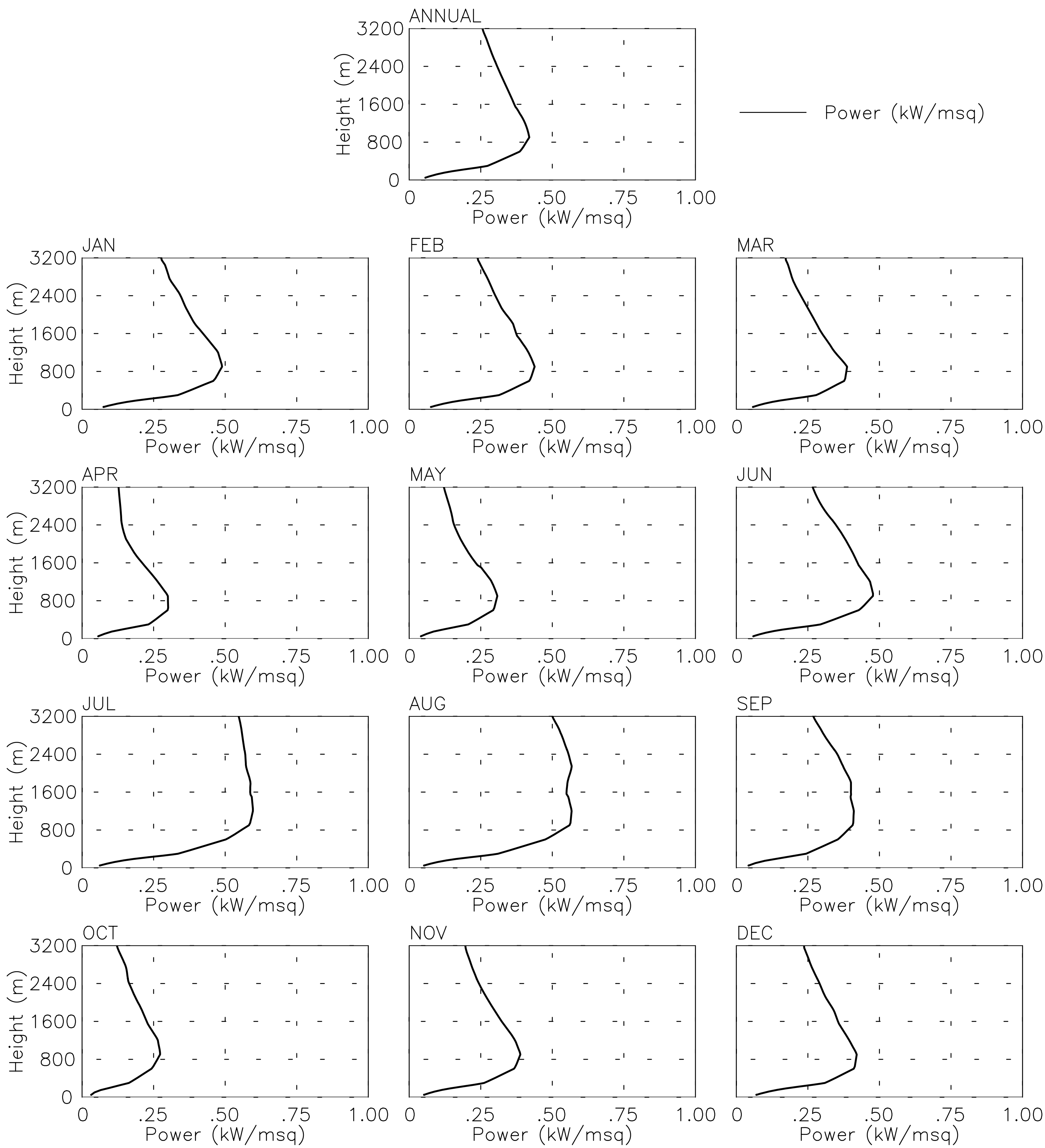
San Juan – 78526 – 0800 LST
18° 26' N 66° 00' W – Elev 3m
12/72–03/97



Thu Aug 16 10:34:06 2001

VERTICAL WIND POWER PROFILE BY HEIGHT

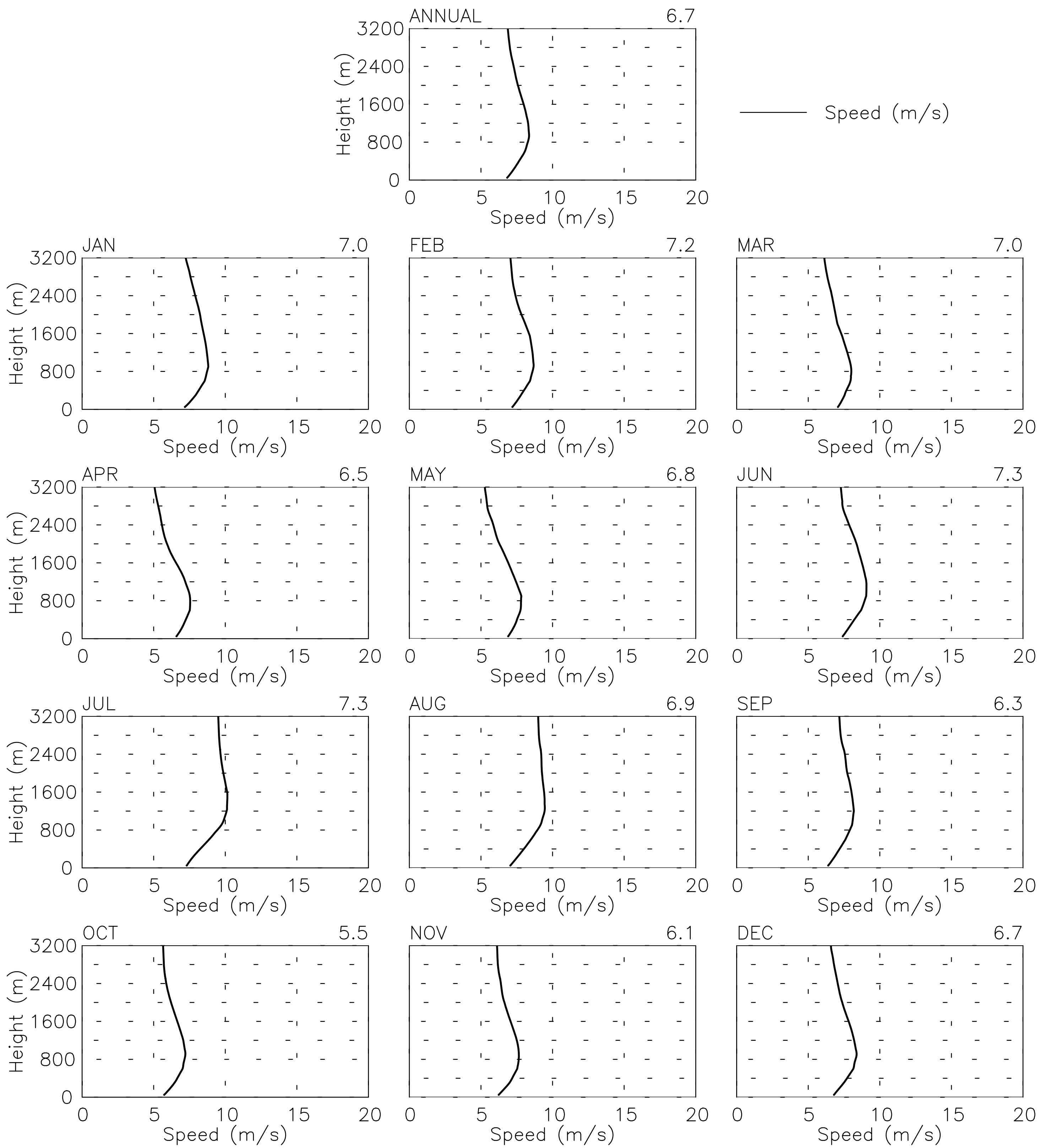
San Juan – 78526 – 0800 LST
18° 26' N   66° 00' W – Elev   3m
12/72–03/97



Fri May 14 16:49:38 1999

VERTICAL WIND SPEED PROFILE BY HEIGHT

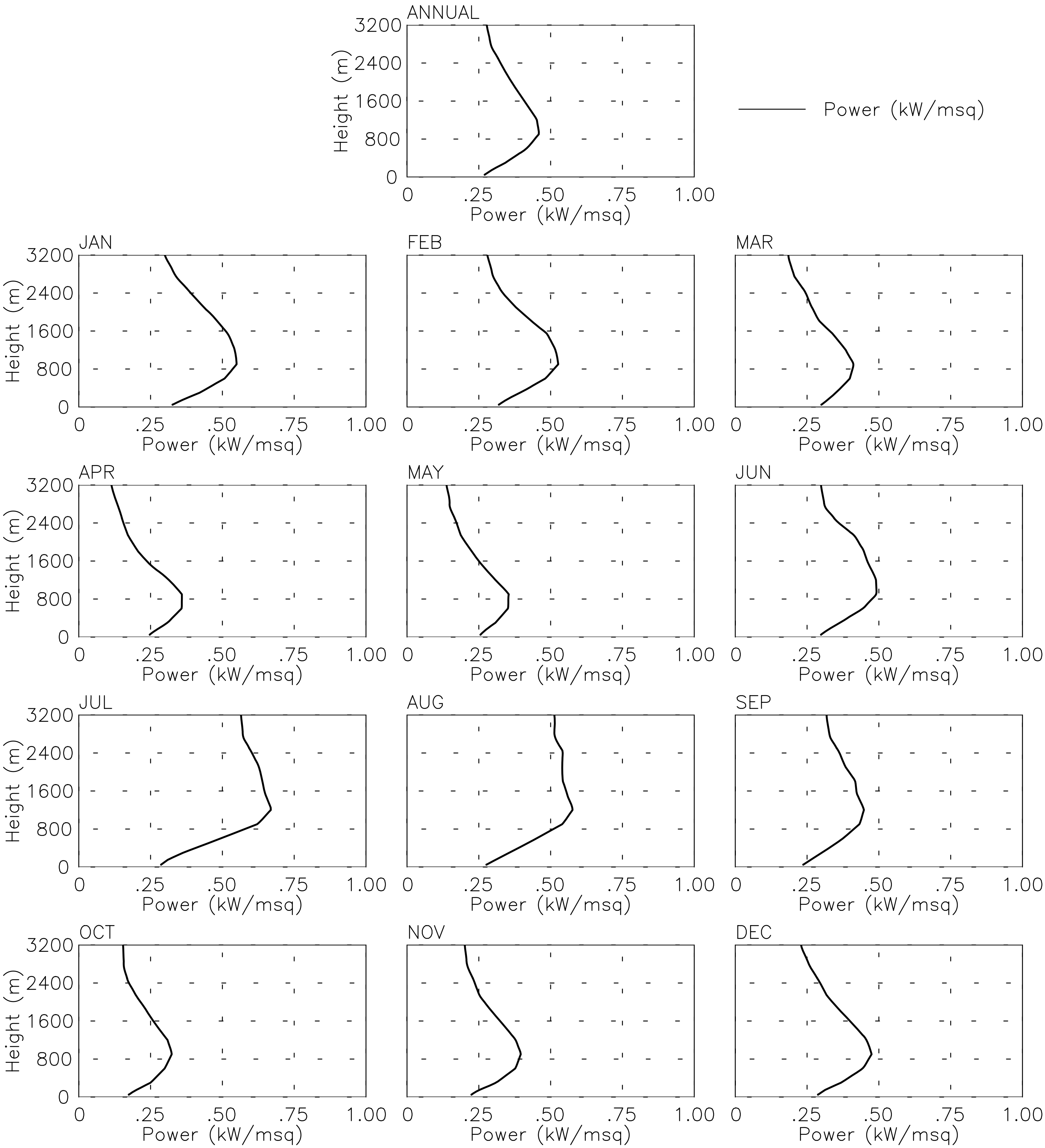
St. Maarten – 78866 – 0800 LST
18° 03' N 63° 07' W – Elev 3m
01/73–03/97



Thu Aug 16 10:35:37 2001

VERTICAL WIND POWER PROFILE BY HEIGHT

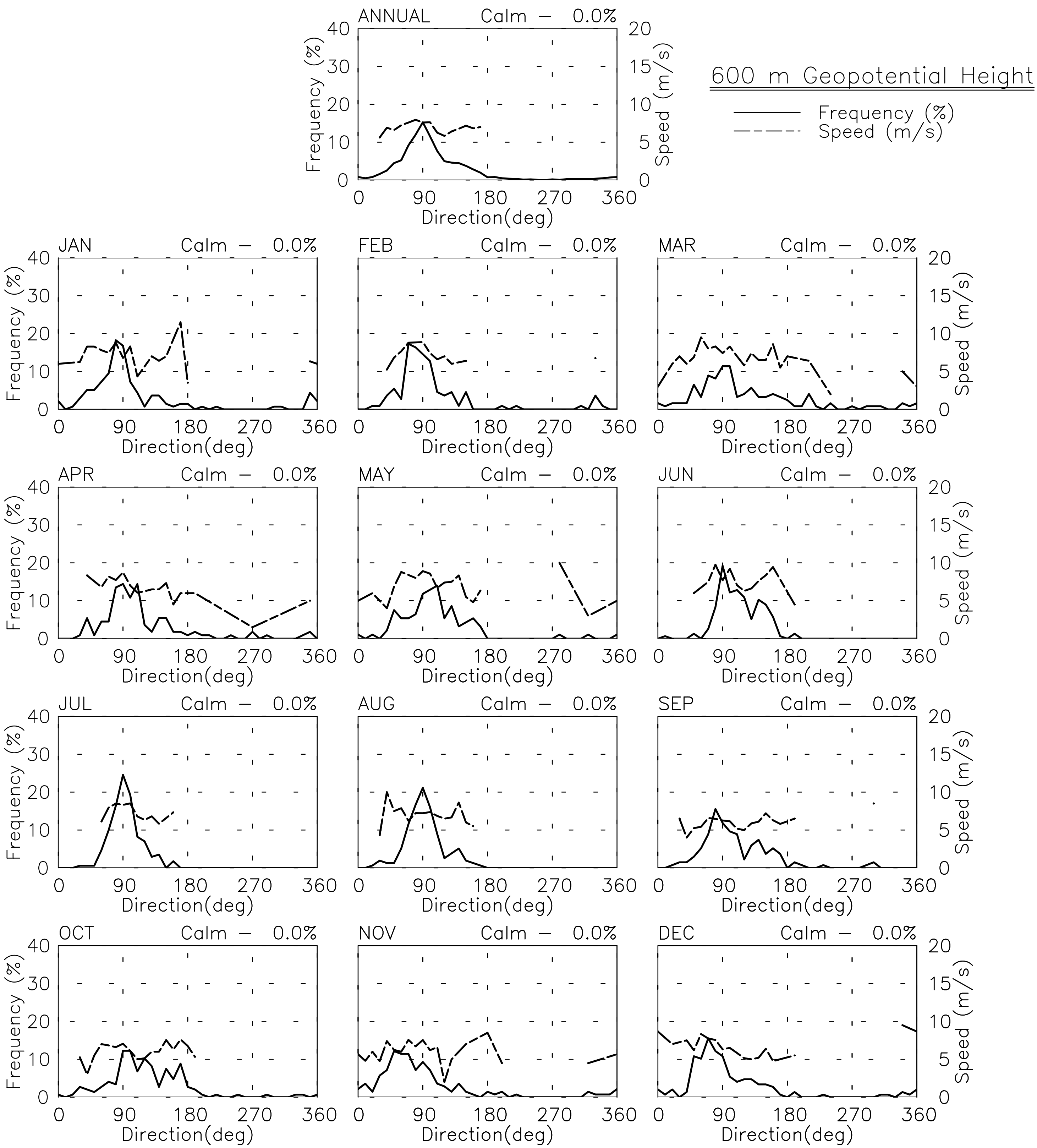
St. Maarten – 78866 – 0800 LST
18° 03' N 63° 07' W – Elev 3m
01/73–03/97



Fri May 14 16:51:28 1999

FREQUENCY & SPEED BY DIRECTION

Sabana de la Mar – 78467 – 1200 LST
19° 03' N 69° 23' W – Elev 10m
06/57–08/62



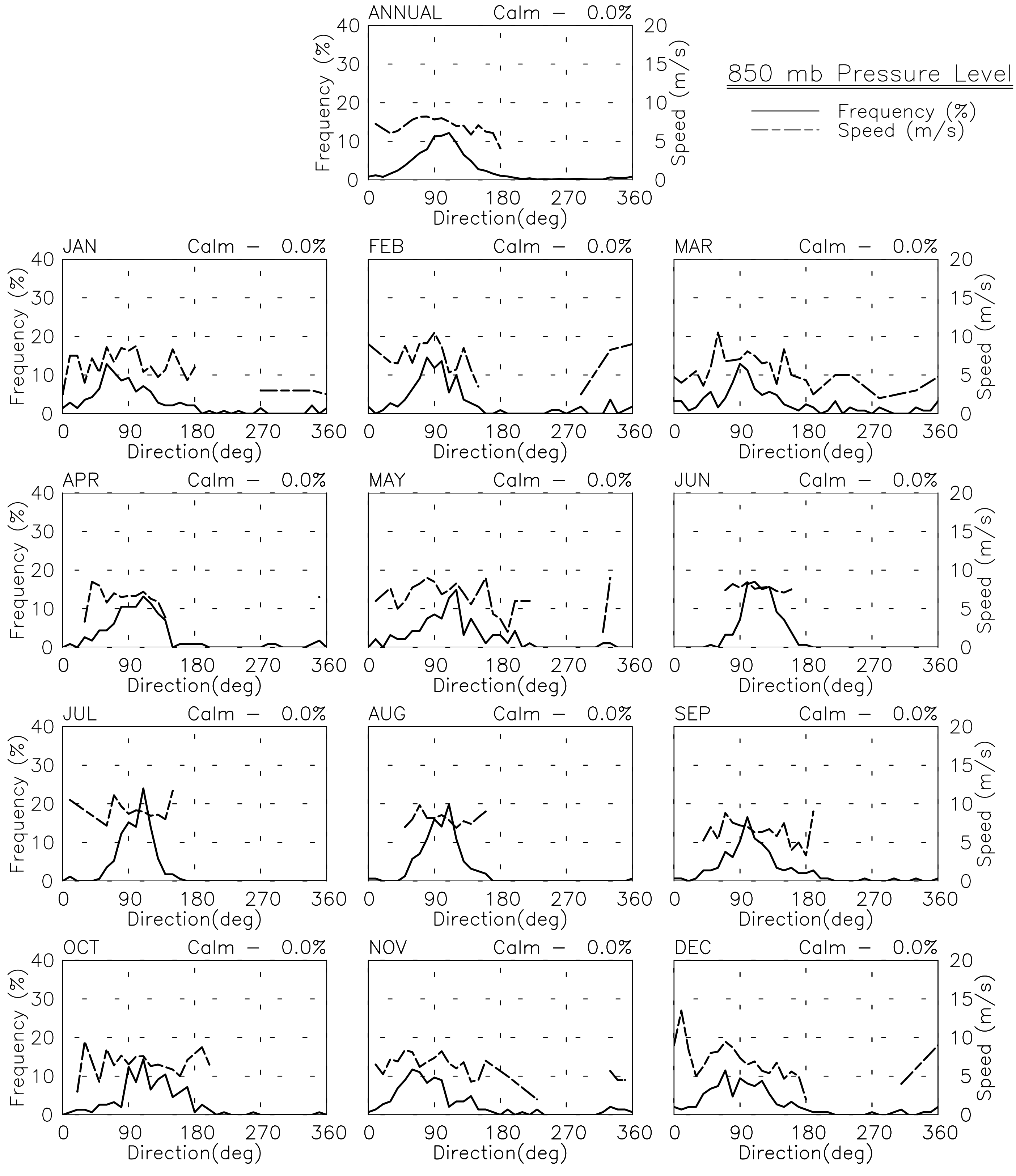
Fri May 14 16:54:35 1999

FREQUENCY & SPEED BY DIRECTION

Sabana de la Mar – 78467 – 1200 LST

19° 03' N 69° 23' W – Elev 10m

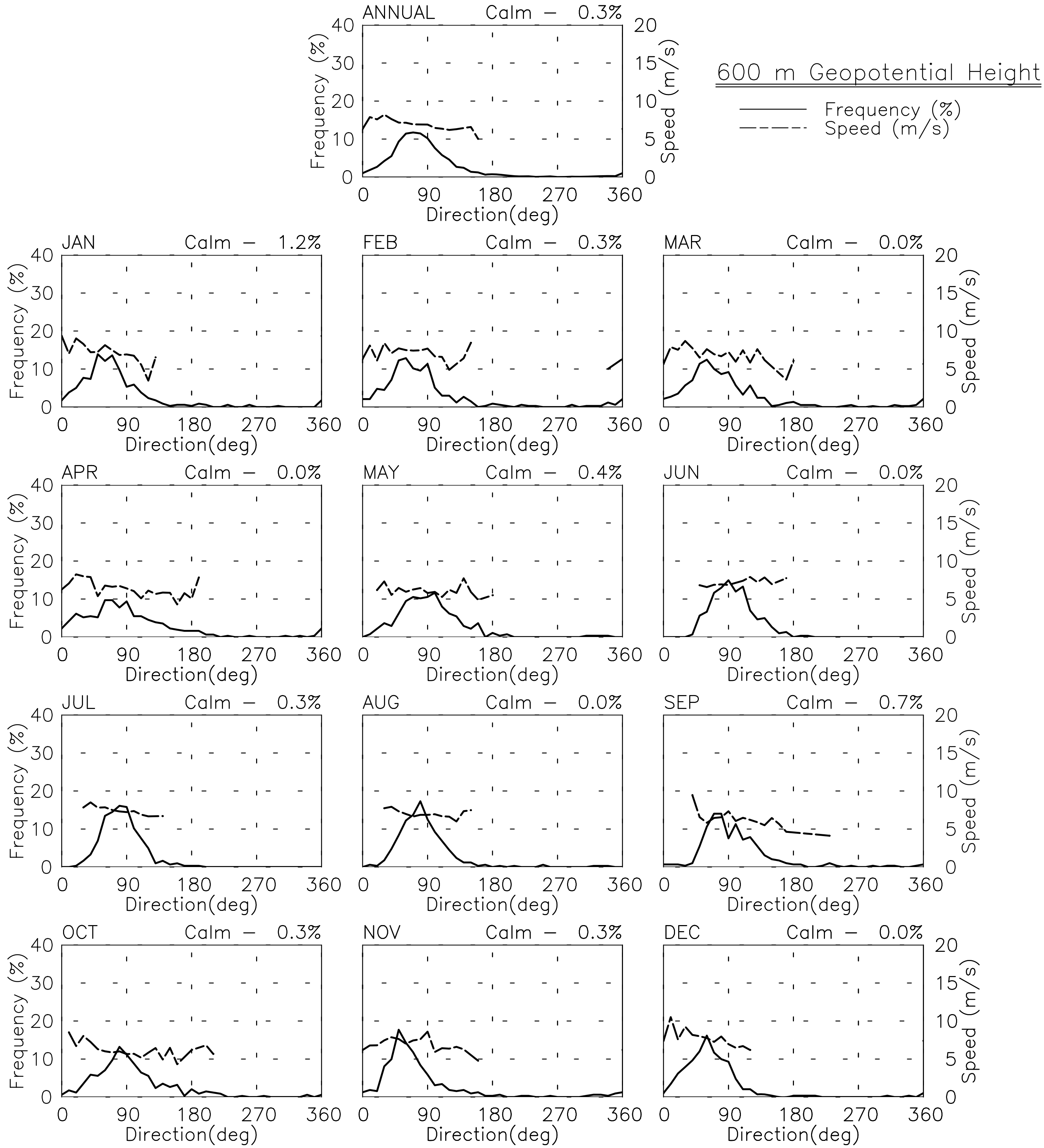
06/57–08/62



Fri May 14 16:54:26 1999

FREQUENCY & SPEED BY DIRECTION

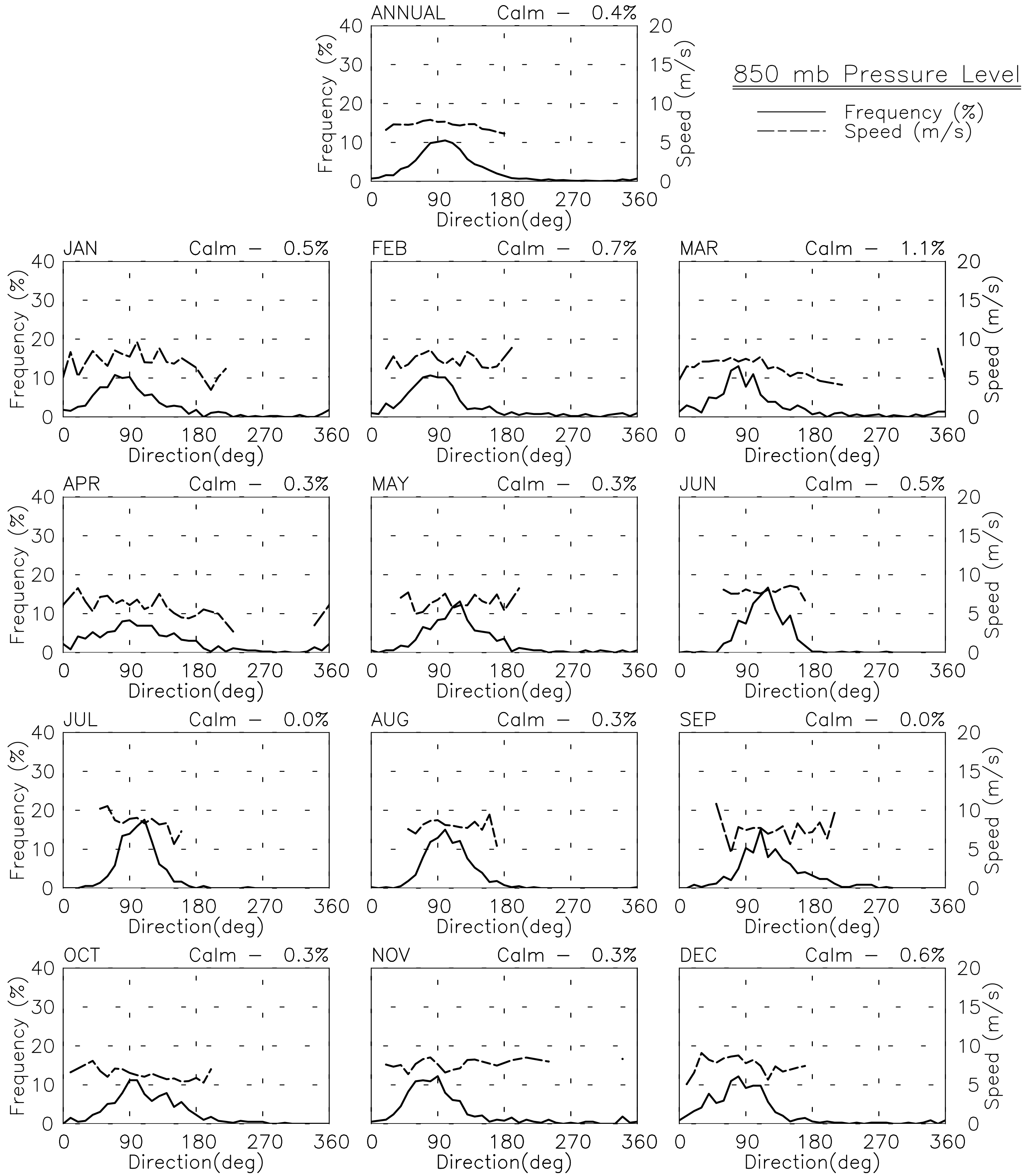
Santo Domingo – 78486 – 0800 LST
18° 28' N   69° 53' W – Elev   14m
01/73–03/97



Fri May 14 16:46:00 1999

FREQUENCY & SPEED BY DIRECTION

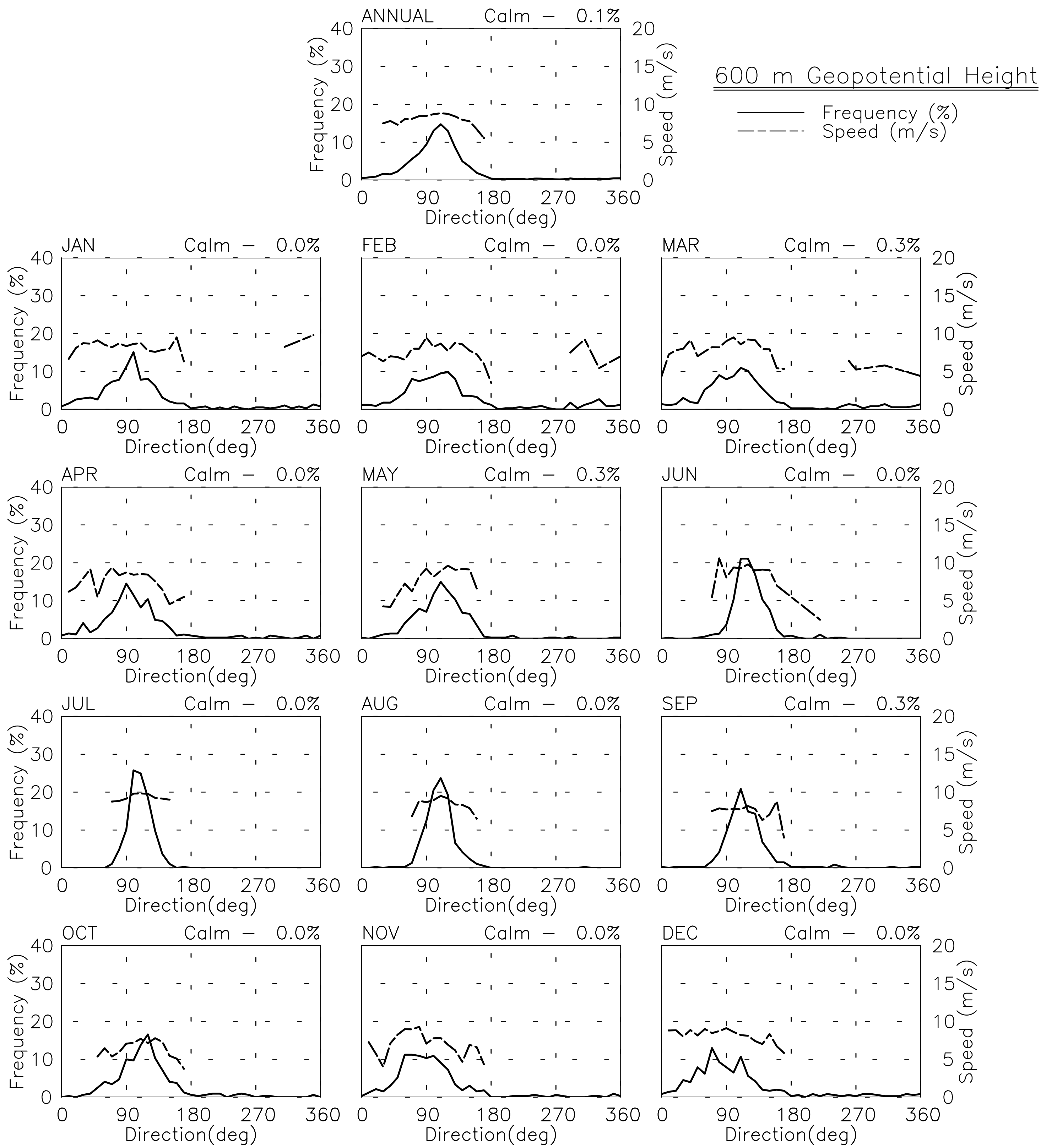
Santo Domingo - 78486 - 0800 LST
18° 28' N 69° 53' W - Elev 14m
01/73-03/97



Fri May 14 16:45:51 1999

FREQUENCY & SPEED BY DIRECTION

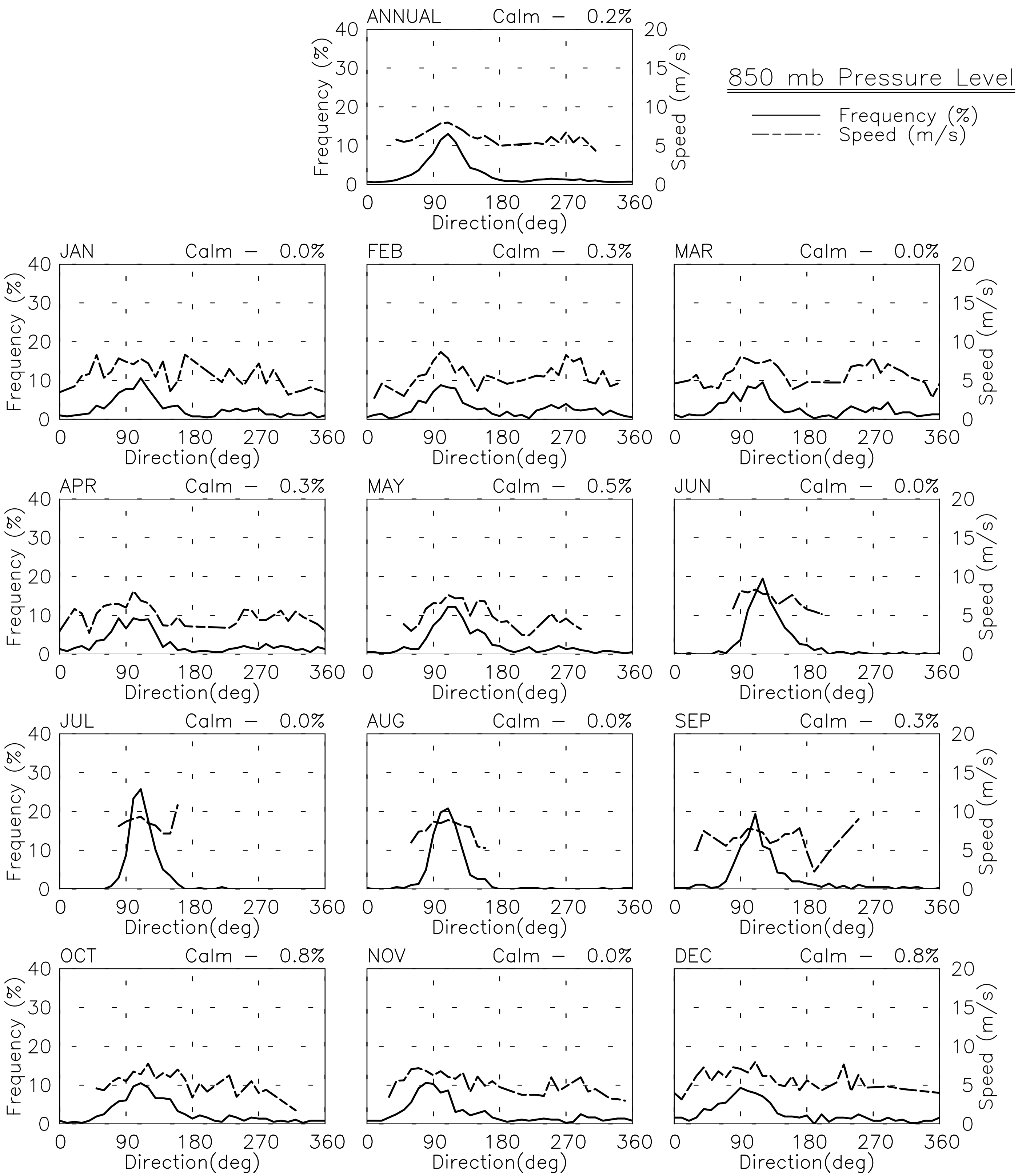
Grand Turk – 78118 – 1200 LST
21° 27' N 71° 09' W – Elev 8m
06/57–05/70



Fri May 14 16:53:31 1999

FREQUENCY & SPEED BY DIRECTION

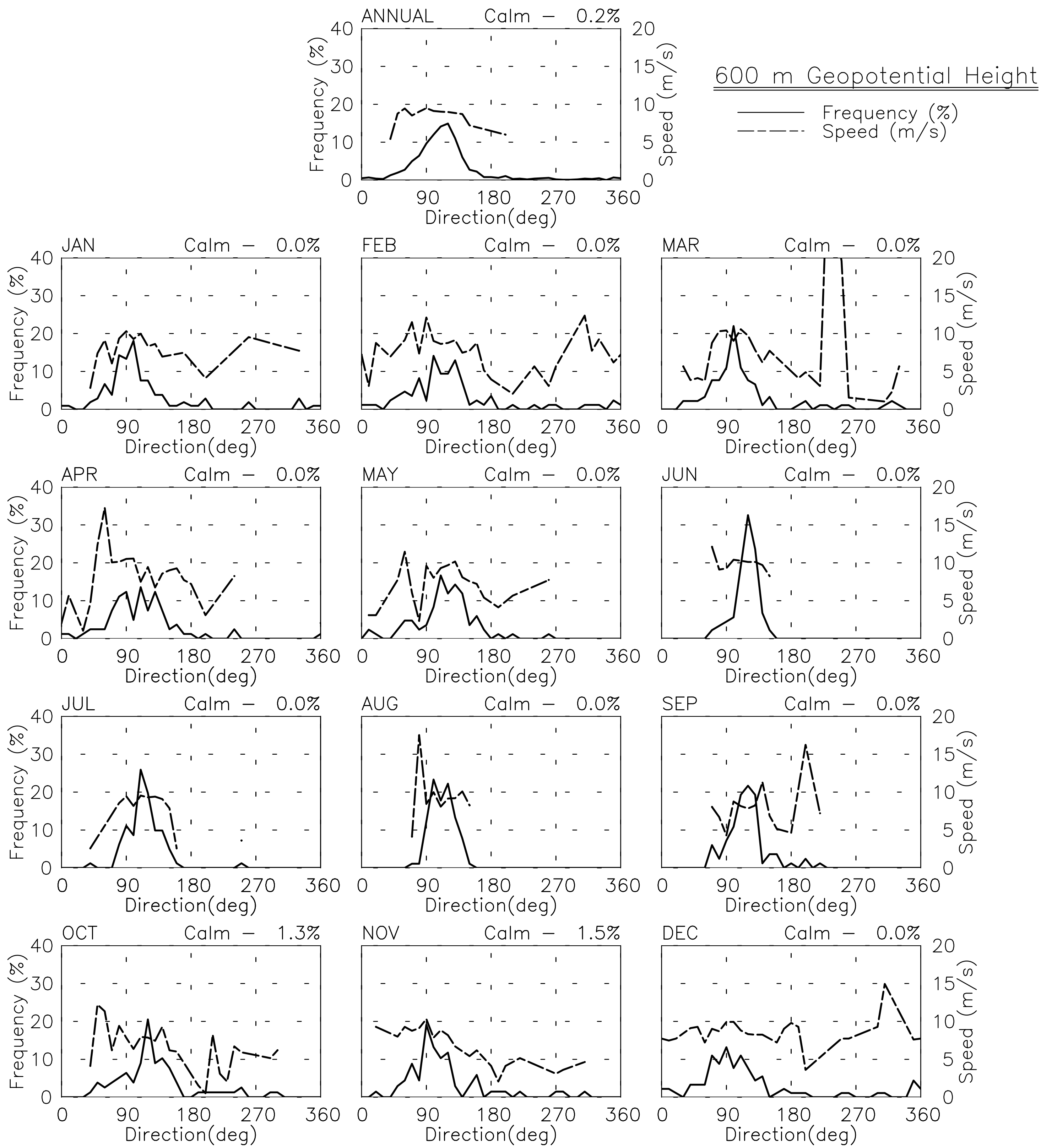
Grand Turk – 78118 – 1200 LST
21° 27' N 71° 09' W – Elev 8m
06/57–05/70



Fri May 14 16:53:22 1999

FREQUENCY & SPEED BY DIRECTION

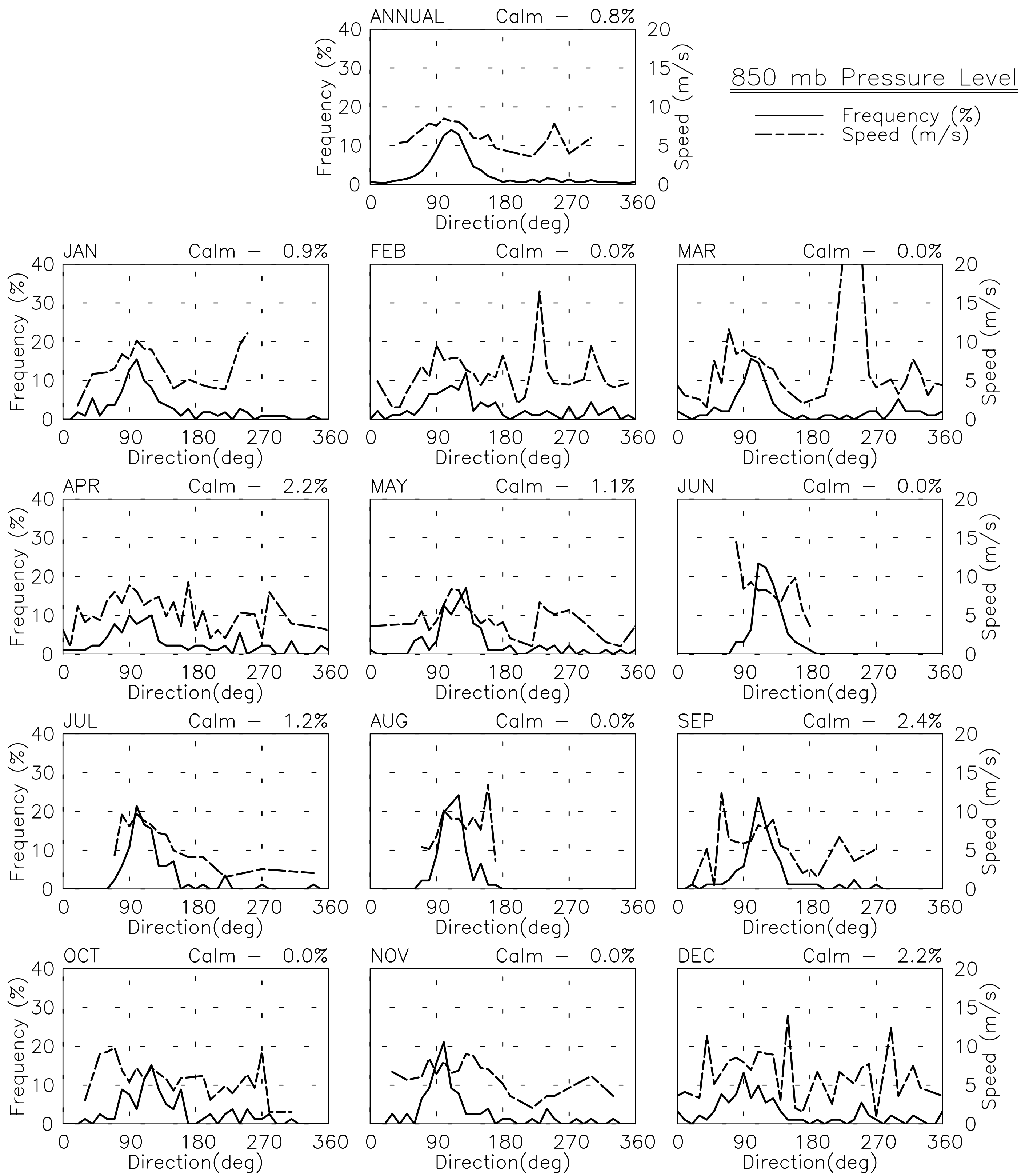
Grand Turk – 78118 – 0700 LST
21° 27' N 71° 09' W – Elev 8m
01/73–12/78



Fri May 14 16:42:35 1999

FREQUENCY & SPEED BY DIRECTION

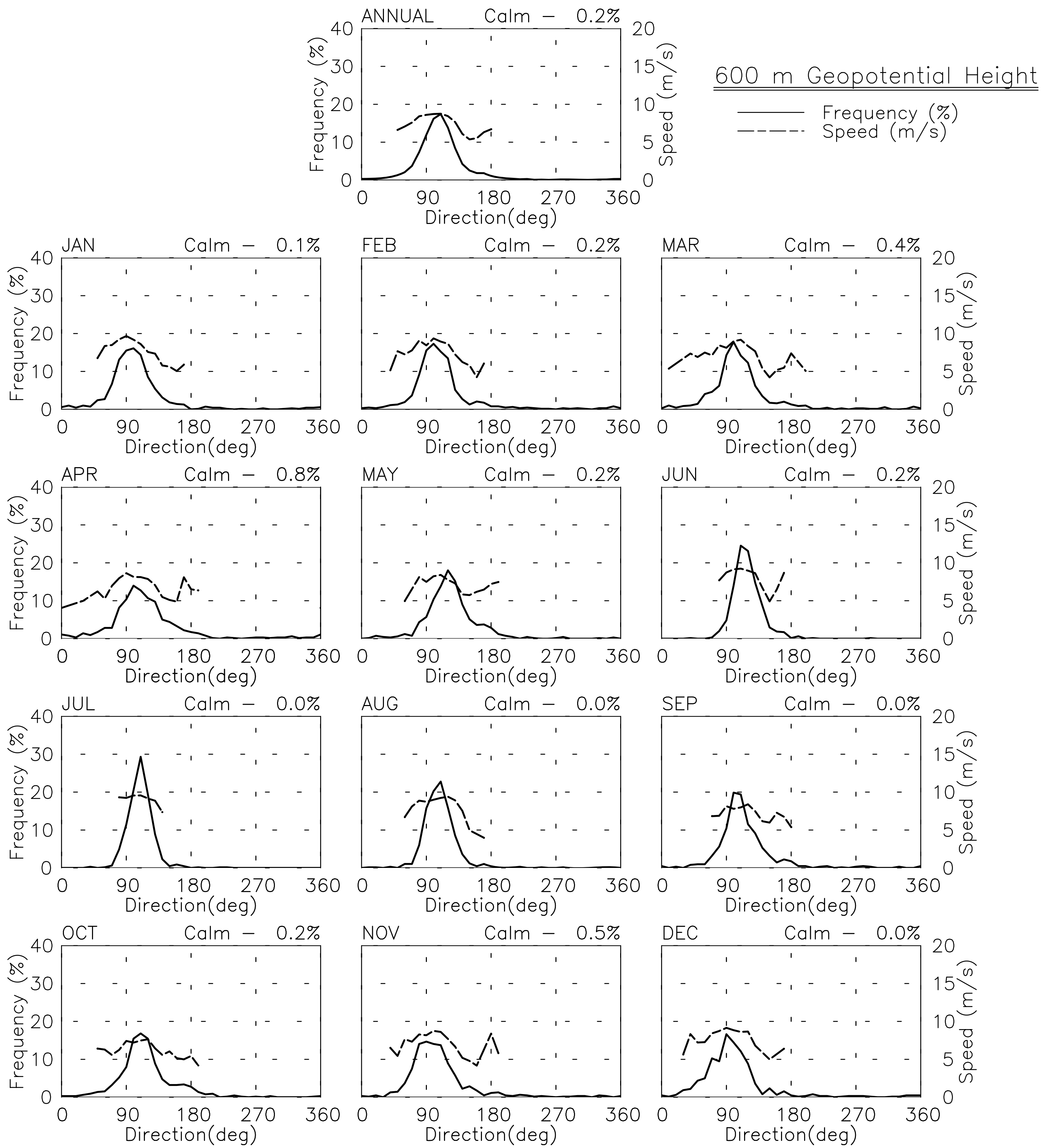
Grand Turk – 78118 – 0700 LST
21° 27' N 71° 09' W – Elev 8m
01/73–12/78



Fri May 14 16:42:32 1999

FREQUENCY & SPEED BY DIRECTION

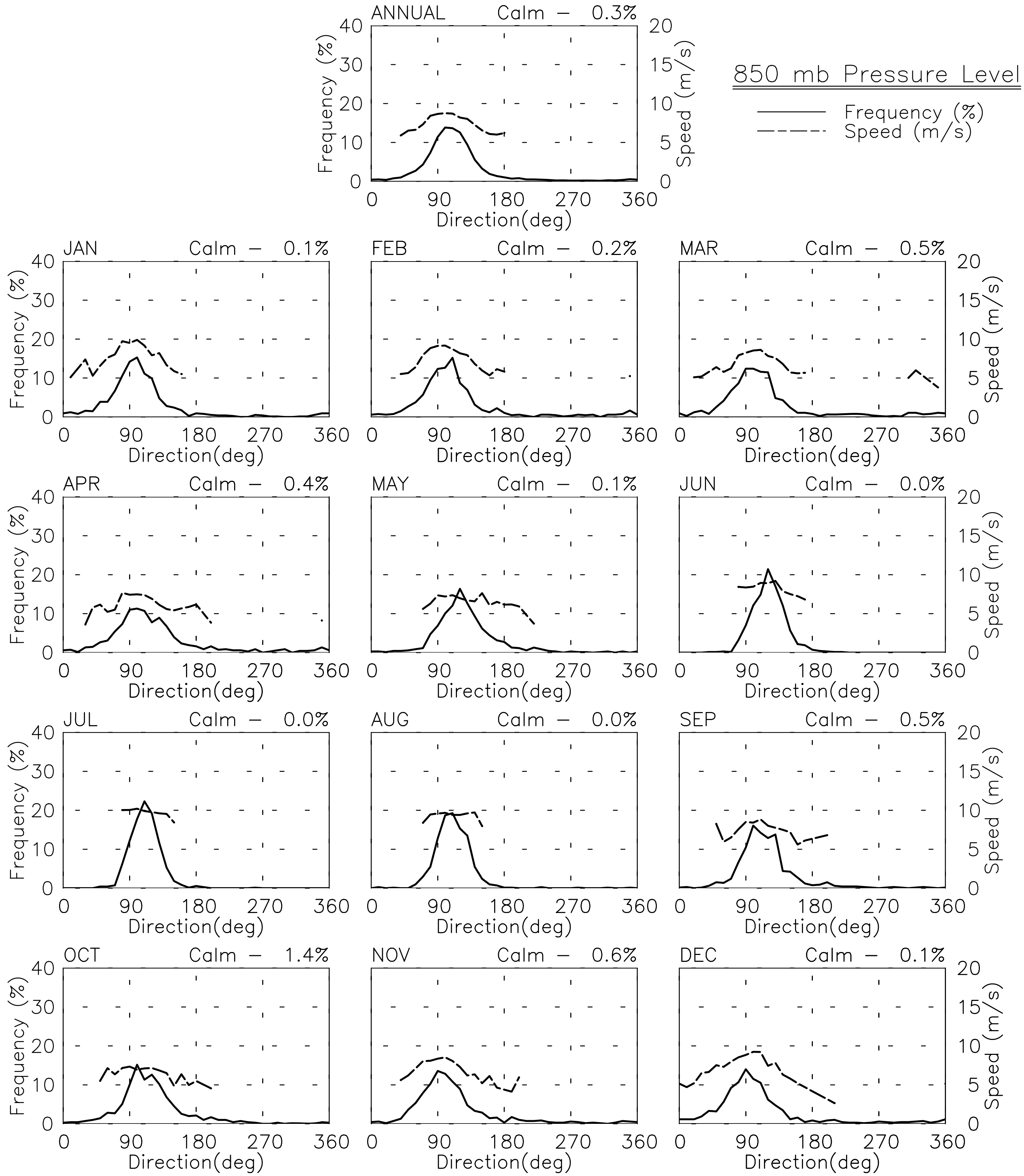
San Juan – 78526 – 0800 LST
18° 26' N 66° 00' W – Elev 3m
12/72–03/97



Fri May 14 16:49:51 1999

FREQUENCY & SPEED BY DIRECTION

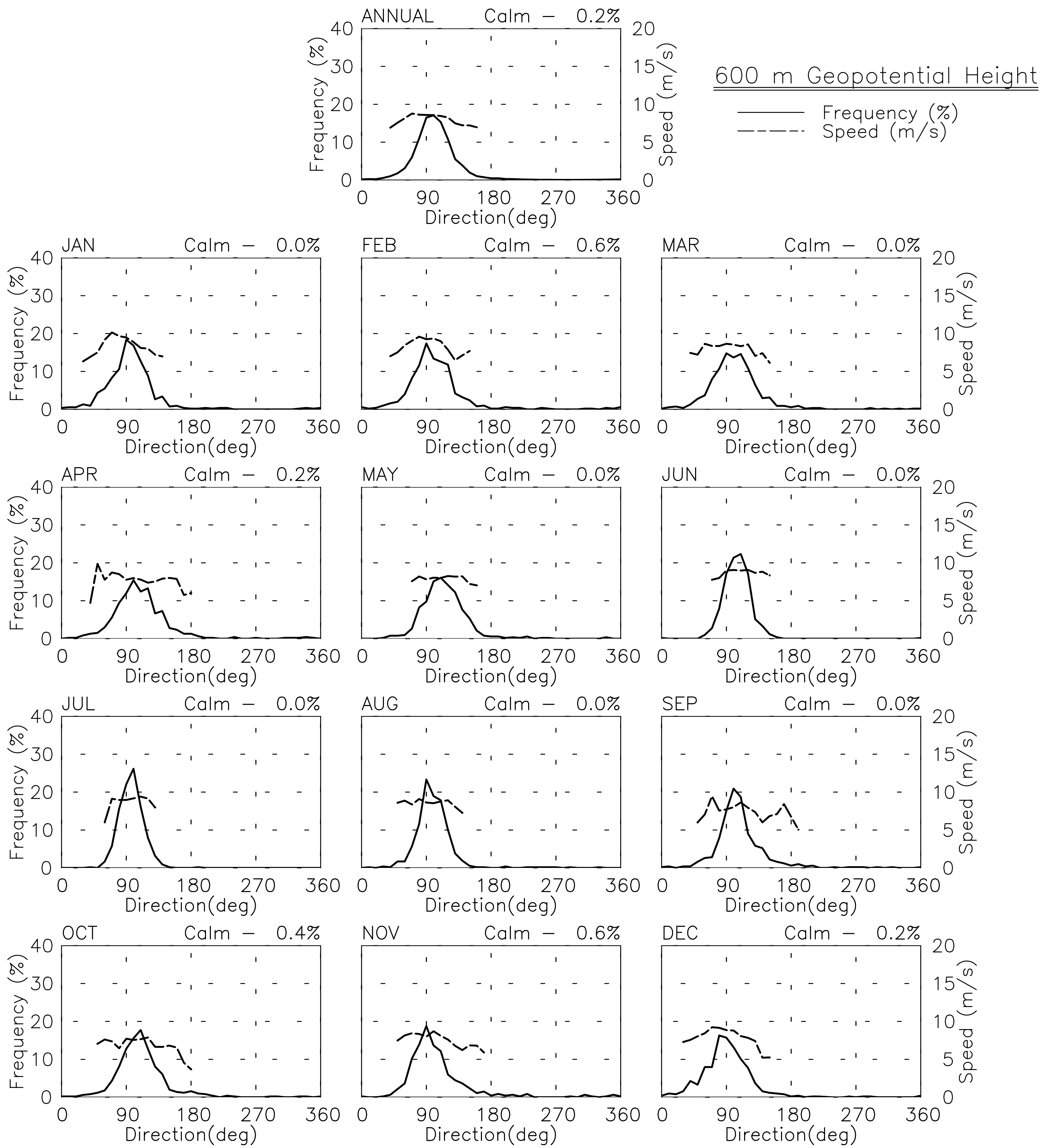
San Juan – 78526 – 0800 LST
18° 26' N 66° 00' W – Elev 3m
12/72–03/97



Fri May 14 16:49:43 1999

FREQUENCY & SPEED BY DIRECTION

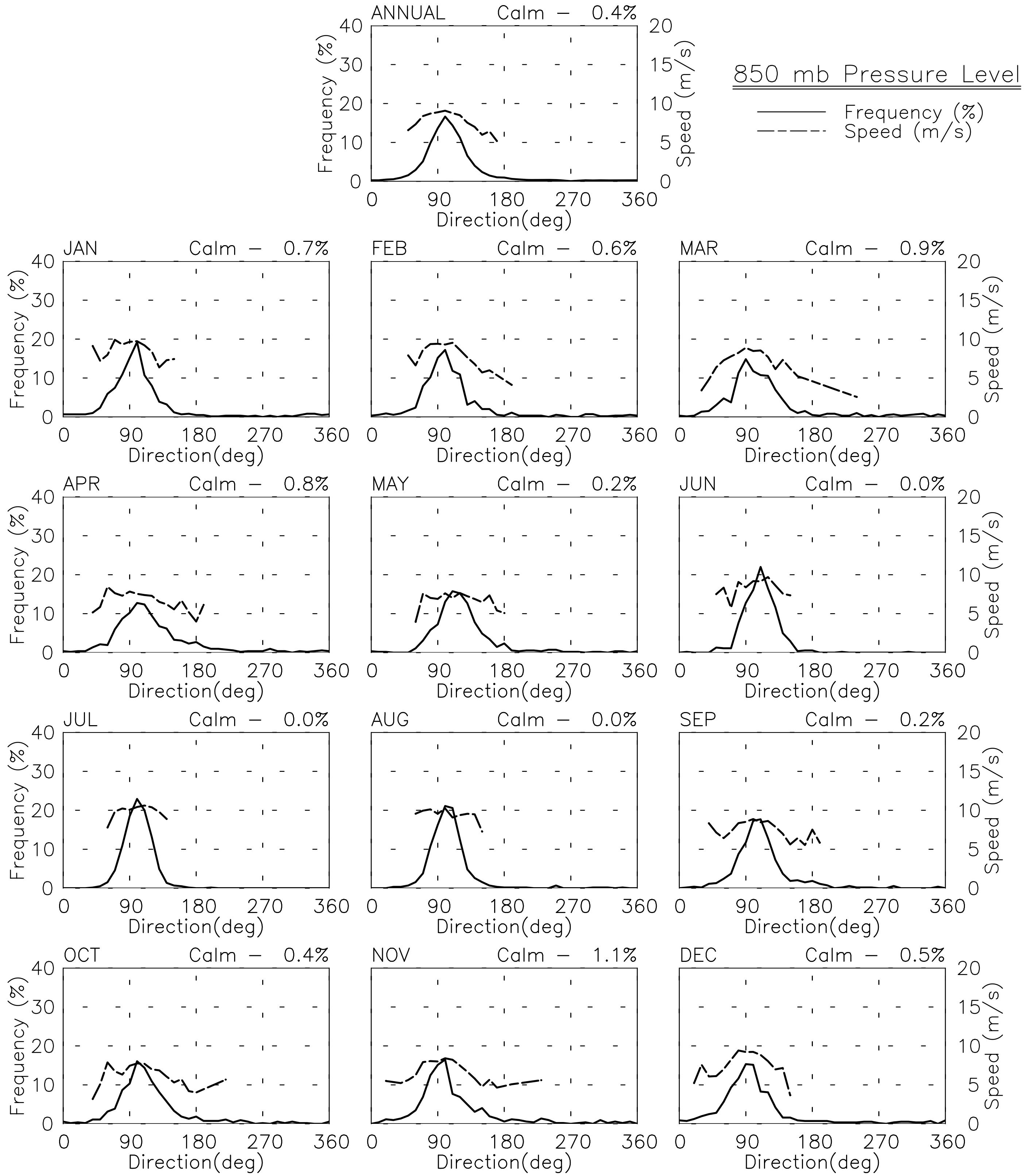
St. Maarten – 78866 – 0800 LST
18° 03' N 63° 07' W – Elev 3m
01/73–03/97



Fri May 14 16:51:35 1999

FREQUENCY & SPEED BY DIRECTION

St. Maarten – 78866 – 0800 LST
18° 03' N   63° 07' W – Elev   3m
01/73–03/97

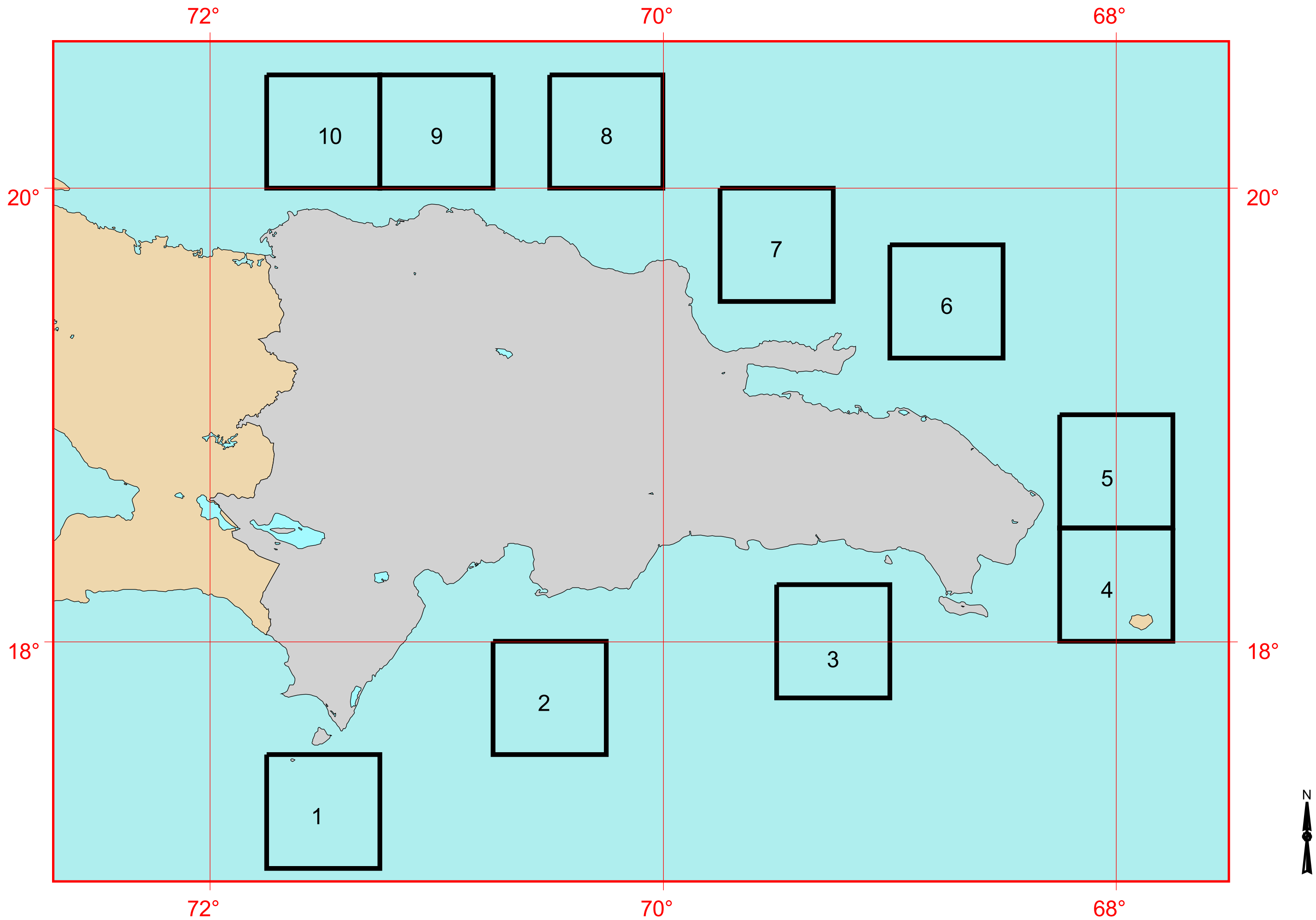


Fri May 14 16:51:31 1999

Appendix D

Satellite Ocean Wind Data – Summaries for Selected Regions

Dominican Republic - Region Location Map,
Satellite-Based Ocean Wind Data, Valid for 10 m Height

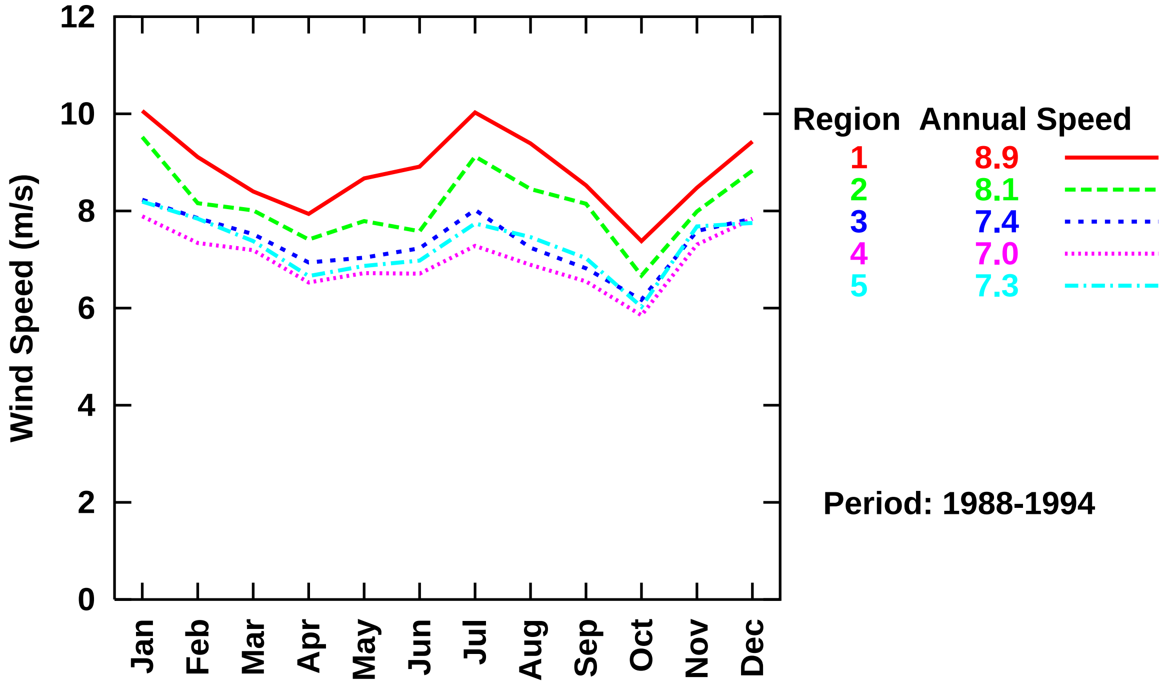


US Dept. of Energy - National
Renewable Energy Laboratory

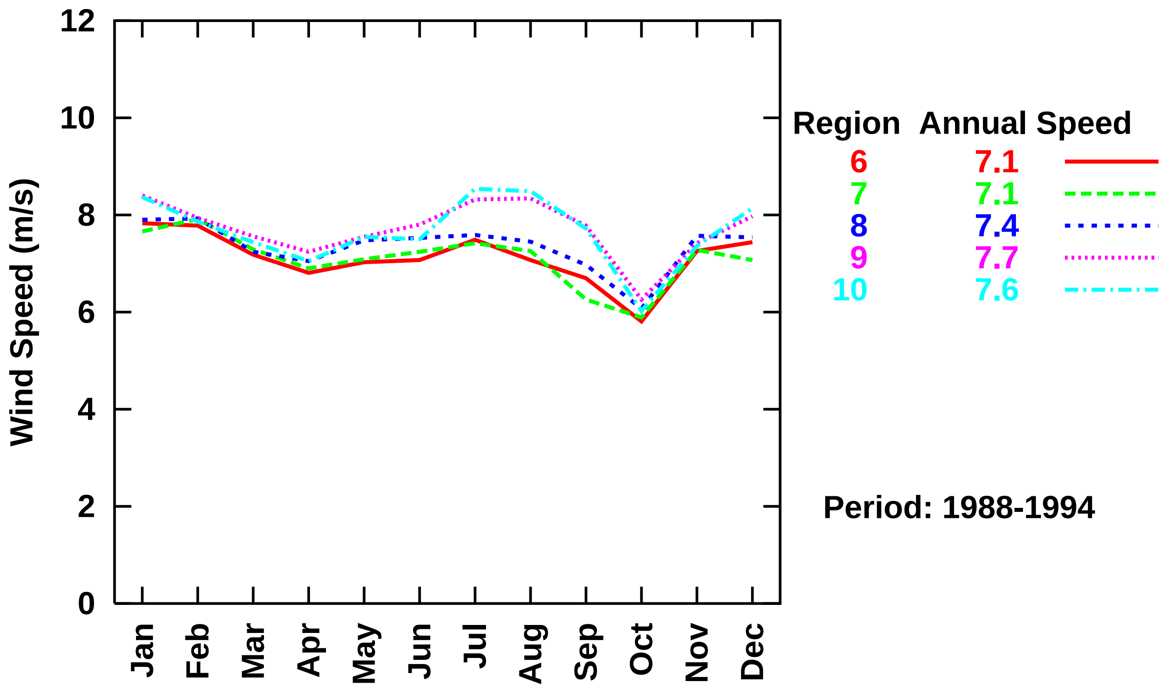
NREL Contacts:
Dennis Elliott (303) 384-6935
Marc Schwartz (303) 384-6936

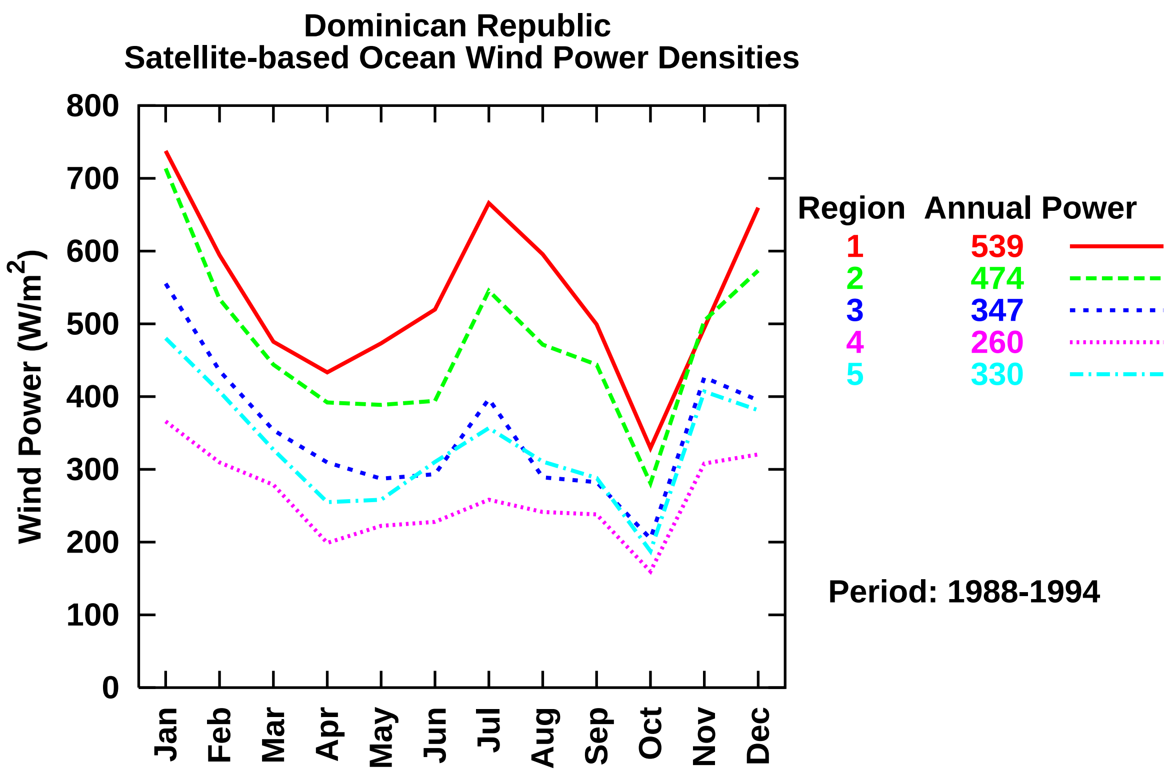
DM Heimiller 27-APR-1999 1.1

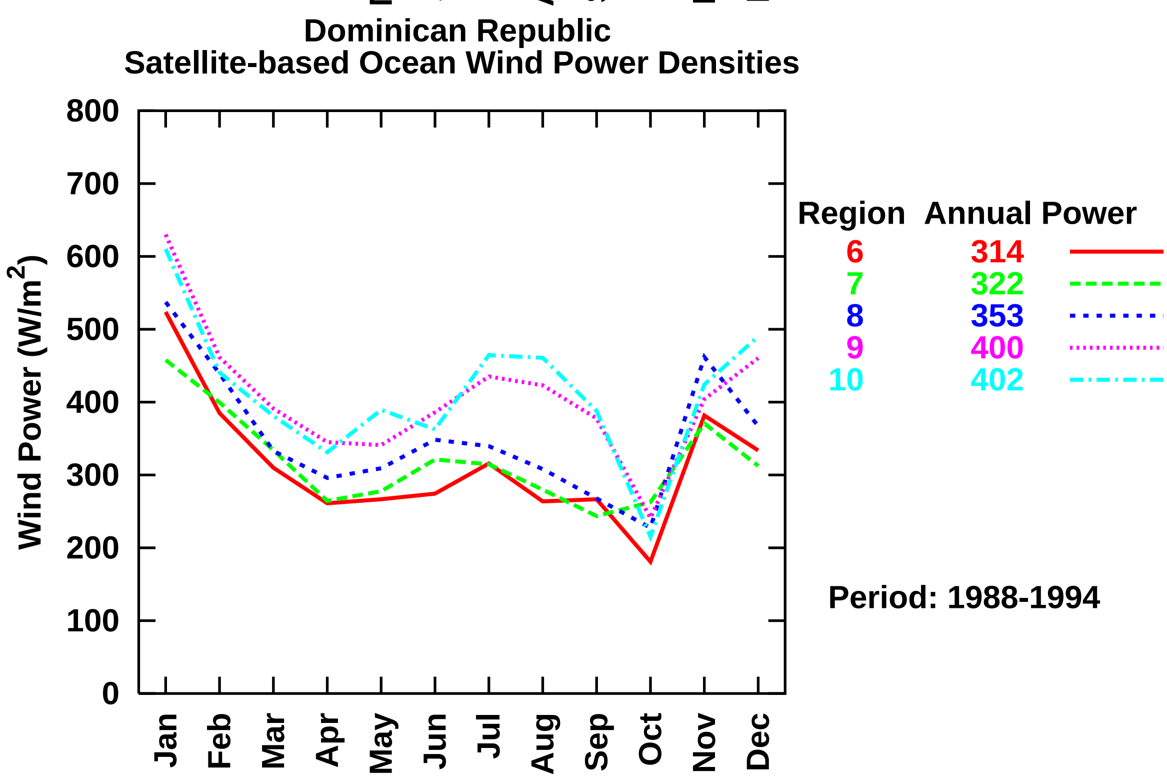
Dominican Republic
Satellite-based Ocean Wind Speeds



Dominican Republic
Satellite-based Ocean Wind Speeds




Dominican Republic
Satellite-based Ocean Wind Power Densities
Wind Power (W/m^2)
0
100
200
300
400
500
600
700
800
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Region Annual Power
1 539
2 474
3 347
4 260
5 330
Period: 1988-1994


Dominican Republic
Satellite-based Ocean Wind Power Densities
Wind Power (W/m^2)
0
100
200
300
400
500
600
700
800
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Region Annual Power
6 314
7 322
8 353
9 400
10 402
Period: 1988-1994

REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 2001	Technical Report

4. TITLE AND SUBTITLE
Wind Energy Resource Atlas of the Dominican Republic

5. FUNDING NUMBERS
WER11050
DO059999

6. AUTHOR(S)
Elliott, D., Schwartz, M., George, R., Haymes, S., Heimiller, D., Scott, G.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NREL/TP-500-27602

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
The Wind Energy Resource Atlas of the Dominican Republic identifies the wind characteristics and the distribution of the wind resource in this country. This major project is the first of its kind undertaken for the Dominican Republic. The information contained in the atlas is necessary to facilitate the use of wind energy technologies, both for utility-scale power generation and off-grid wind energy applications. A computerized wind mapping system developed by NREL generated detailed wind resource maps for the entire country. This technique uses Geographic Information Systems (GIS) to produce high-resolution (1-square kilometer) annual average wind resource maps.

14. SUBJECT TERMS
Wind energy resource atlas; Dominican Republic; maps; Geographic Information Systems

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

Prepared for
U.S. Department of Energy

U.S. Agency for International Development

Winrock International

U.S. National Rural Electric Cooperative Association

Prepared by
National Renewable Energy Laboratory
1617 Cole Boulevard • Golden, Colorado 80401-3393
A national laboratory of the U.S. Department of Energy
Managed by Midwest Research Institute • Battelle • Bechtel
for the U.S. Department of Energy under Contract No. DE-AC36-98-GO10337
NREL/TP-500-27602 • October 2001