Lower Tropospheric Wind Speed Statistics from Rawinsonde Observations at Albuquerque, New Mexico, Winslow, Arizona and Hilo, Hawaii

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Earlier on in the Millimeter Array project (MMA Memoranda Nos. 51 and 58), data from the U.S. Weather Service's archive of rawinsonde observations (temperature, pressure, and relative humidity) were used to estimate zenith-path atmospheric opacity at millimeter wavelengths in the general geographic locales of potential MMA sites. Wind speed and direction are also recorded in the archive. I was asked a few months ago whether I might be able to extract wind speed statistics from the data, around the altitude of the layer of turbulent water vapor, to aid in Mark Holdaway's phase stability simulation work. I was able to do so, and Mark's recent memorandum (MMA Memo. 68) makes use of those data, which here I present in detail.

Rawinsonde launches generally occur twice daily (at 0h and 12h UT) at each of the upper air observing stations. Wind velocity is inferred from tracking information provided by radar or radio direction finding devices. Data for each launch occur at altitude increments of typically several hundred meters. I analyzed twenty years of data (1965–1984) from Albuquerque, NM and Winslow, AZ, and twenty-six years (1965–1990) from Hilo, HI. I interpolated the data from each launch to estimate the wind speed at three altitude levels (3400, 4200, and 5000 m in the case of NM and AZ data; 4200, 5000, and 5800 m for HI).

Table 1 shows the monthly mean and median wind speeds at each site (for the middle altitude level). Figures 1, 2, and 3 are plots of the seasonal variation. Figures 4, 5, and 6 are histograms of the data, binned according to wind speed and month of the year.

The seasonal variation of the wind speed has, in each case, a maximum which occurs in winter and a minimum which occurs in summer. The seasonal variation above the two continental sites, both at about 35° N latitude, is much more pronounced than that over Hilo (~18° N lat). The median December wind speed at the middle altitude level over Albuquerque (15.5 m/s) is approximately twice that over Hilo (7.7 m/s). The winter maximum at Albuquerque is a bit larger than Winslow's, by about 2 to 2.5 m/s.

Finally, Figures 7 and 8 (from *Britannica*) show meteorologists' global picture of the wind speeds—specifically, contours of the average wind speed as a function of geographic latitude and of height in the atmosphere, for winter and summer season. Figure 7 shows the whole atmosphere (tropospheric, stratospheric, and mesospheric winds), while Figure 8 shows, in greater detail, only the tropospheric winds. My results are in excellent agreement with these figures (which I located just the other day). The figures show the peak winter time contours of the Northern Westerlies, in the lower troposphere, to be located very near the latitude of Albuquerque and Winslow. They also show Hawaii, in winter time, to be just inside the zone of the Northern Westerlies, and in summer to be just inside of the zone of the Tropical Easterlies; thus the average winds there are light during all seasons of the year.

I think that these data should suffice in providing sensible parameter values for Mark Holdaway's simulations. For site selection purposes, I believe that their only relevance would be in distinguishing a site in Hawaii from a site in the continental Southwest.

Table 1. Statistics of the Wind Speeds Measured at a Middle Altitude Level

Launch Site	Month	Mean (m/s)	Std. Dev. (m/s)	Median (m/s)	Median Dev.† (m/s)
Winslow, Arizona	1	13.4	7.0	12.6	4.6
(4200-m altitude;	2	12.4	6.5	11.3	4.3
1965–1984)	3	13.0	6.6	12.0	4.0
	4	11.9	6.7	10.6	4.2
	5	9.8	6.1	8.7	3.5
	6	8.5	5.0	7.8	3.0
	7	5.6	3.1	5.1	2.1
	8	5.9	3.3	5.4	2.4
	9	8.1	5.2	7.0	3.0
	10	10.1	6.4	8.8	3.8
	11	13.1	6.9	12.3	4.8
	12	13.9	7.7	13.0	5.4
Albuquerque, New Mexico	1	15.1	6.9	15.0	5.0
(4200-m altitude;	2	13.6	6.2	13.1	4.1
1965–1984)	3	14.0	5.9	13.1	3.7
	4	12.2	5.6	12.0	3.6
	5	10.0	5.0	9.6	3.2
	6	8.0	4.4	7.2	2.8
	7	5.1	2.7	4.8	1.8
	8	5.4	3.0	5.0	2.0
	9	7.9	4.5	7.2	2.9
	10	10.6	5.6	9.8	3.7
	11	14.3	7.0	13.9	5.1
	12	15.8	7.4	15.5	5.5
Hilo, Hawaii	1	9.8	5.8	8.9	3.6
(5000-m altitude;	2	10.3	6.3	9.1	4.1
1965–1990)	3	7.8	5.2	6.6	3.1
	4	6.5	4.2	5.6	2.5
	5	5.8	3.8	5.0	2.3
	6	5.7	3.3	5.0	2.0
	7	5.5	3.2	5.0	2.0
	8	4.7	2.7	4.0	1.8
	9	4.7	2.7	4.2	1.8
	10	5.5	3.2	5.0	2.2
	11	6.8	4.3	6.1	2.6
	12	8.8	5.6	7.7	3.3

†Median deviation here is defined as the median absolute deviation about the sample median.

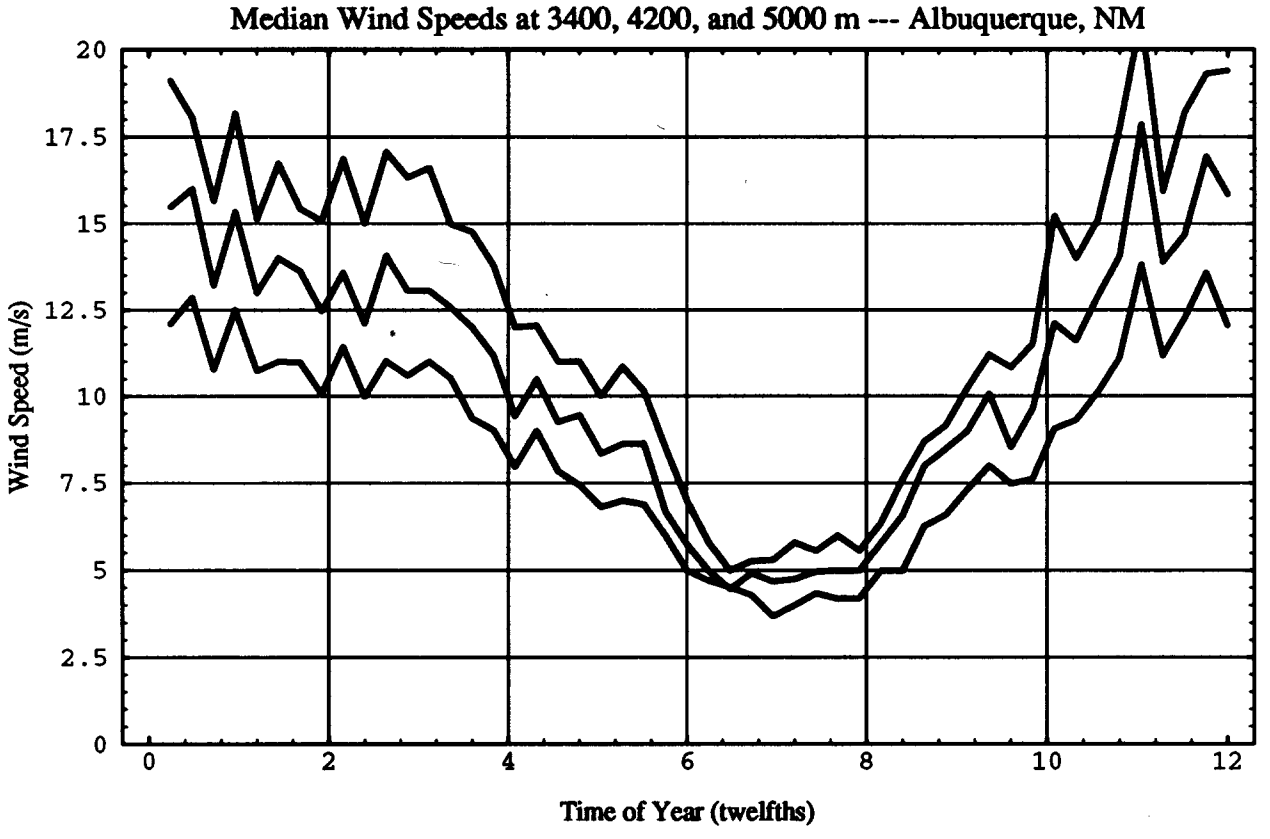

Figure 1. Wind speeds (1965–1984) measured over Albuquerque, New Mexico, at selected altitudes. The measurements obtained over the twenty year period were grouped into fifty seasonal time bins. The median wind speed within each bin is shown in this plot. *(Upper Curve)* 5000 m altitude; *(Middle Curve)* 4200 m; *(Lower Curve)* 3400 m.

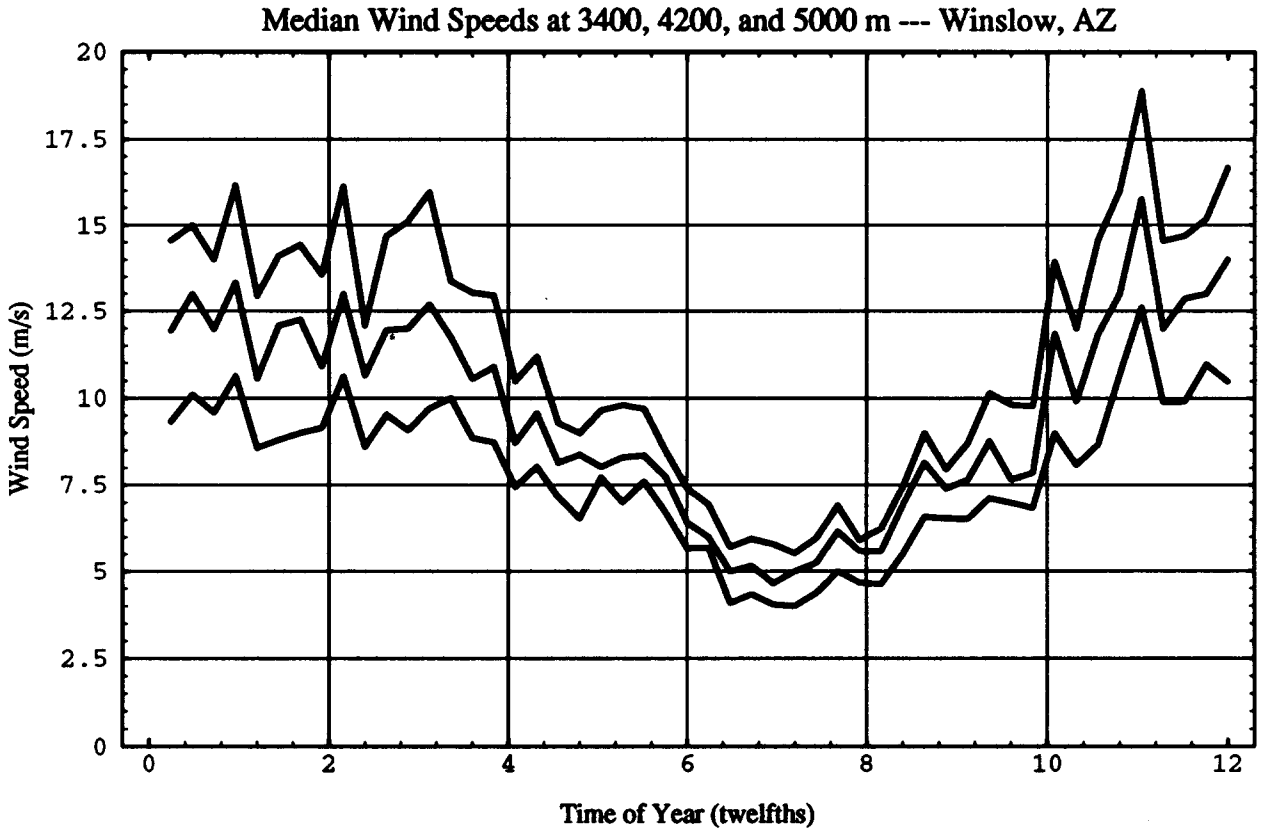

Figure 2. Wind speeds (1965–1984) measured over Winslow, Arizona, at selected altitudes. The measurements obtained over the twenty year period were grouped into fifty seasonal time bins. The median wind speed within each bin is shown in this plot. *(Upper Curve)* 5000 m altitude; *(Middle Curve)* 4200 m; *(Lower Curve)* 3400 m.

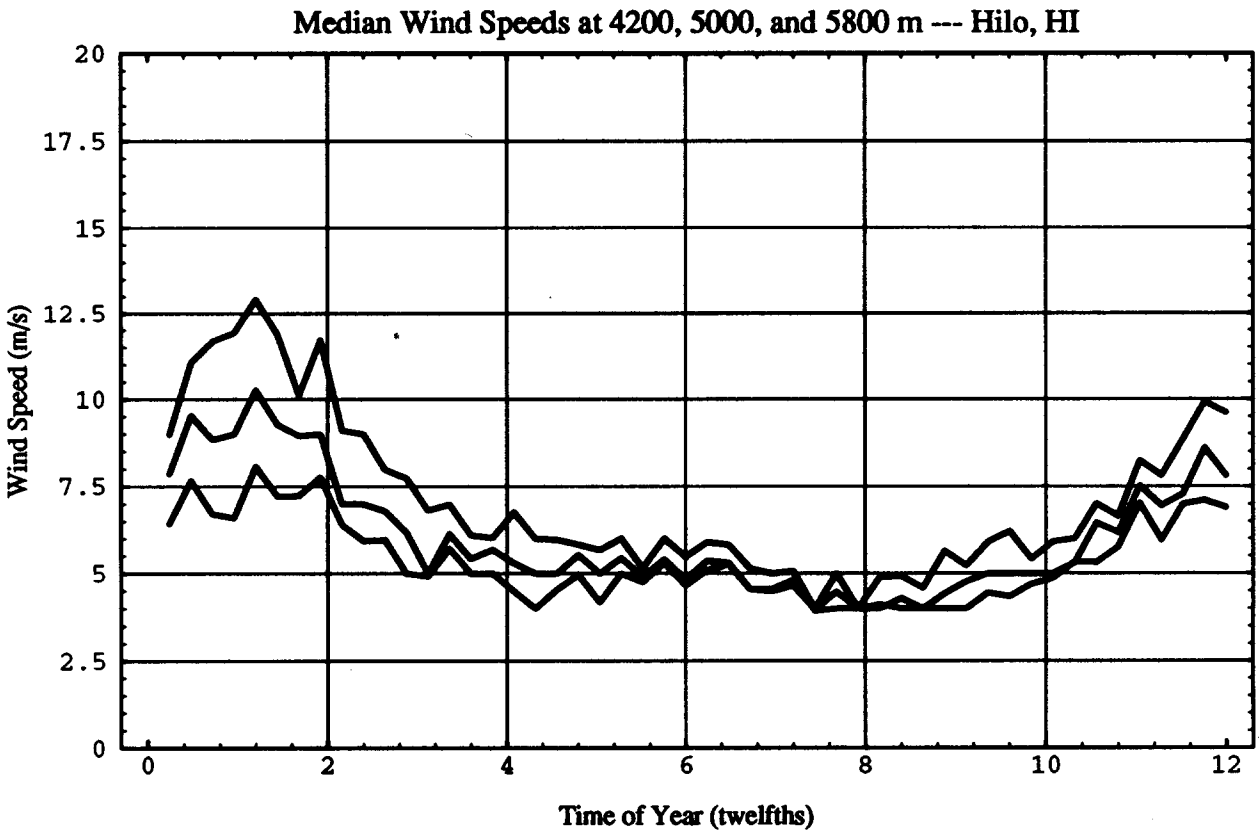

Figure 3. Wind speeds (1965–1990) measured over Hilo, Hawaii, at selected altitudes. The measurements obtained over the twenty-six year period were grouped into fifty seasonal time bins. The median wind speed within each bin is shown in this plot. *(Upper Curve)* 5800 m altitude; *(Middle Curve)* 5000 m; *(Lower Curve)* 4200 m.

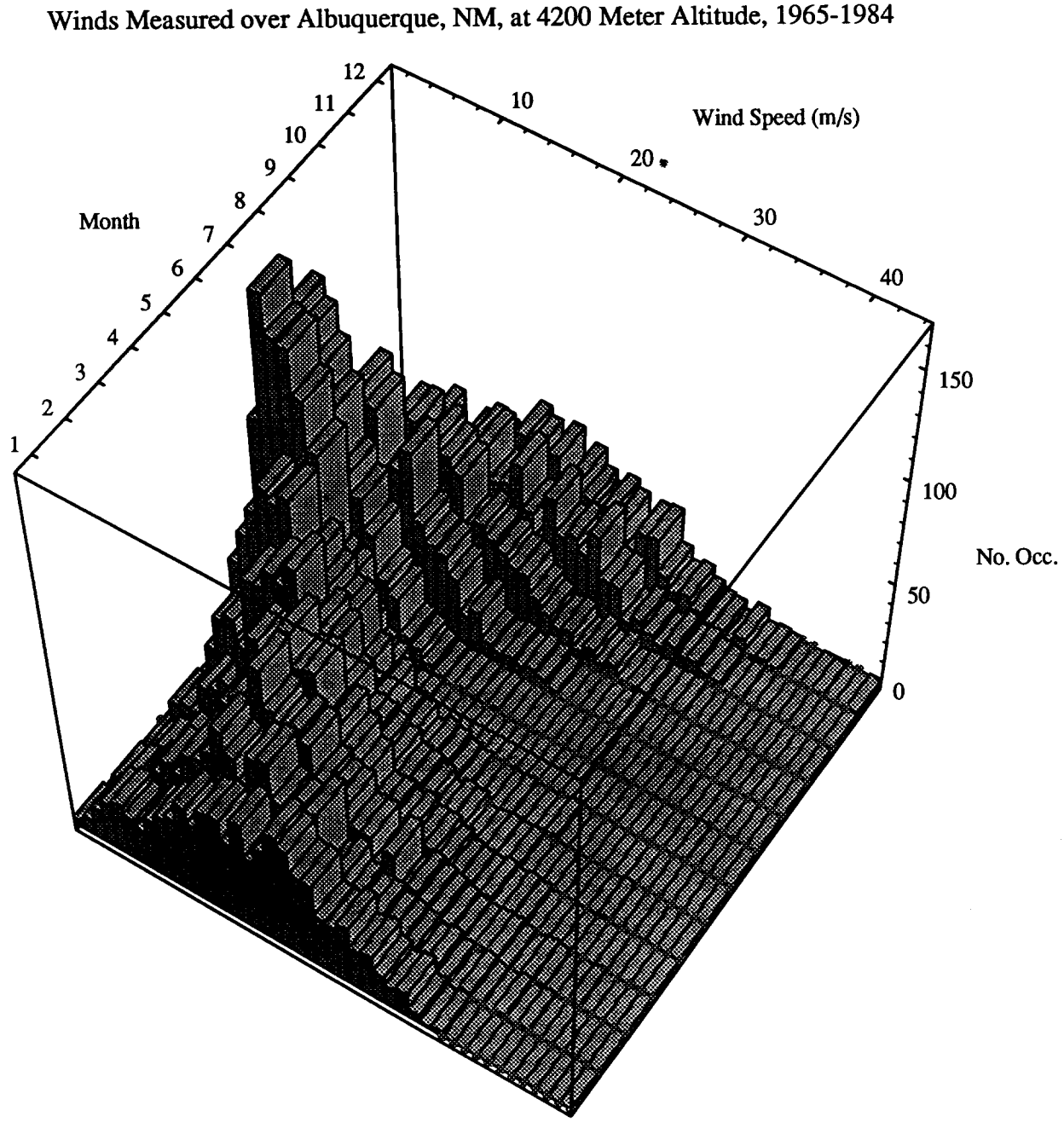

Figure 4. Monthly histograms of the wind speeds measured at a middle altitude level (4200 m) above Albuquerque, New Mexico, during the twenty year period 1965–1984.

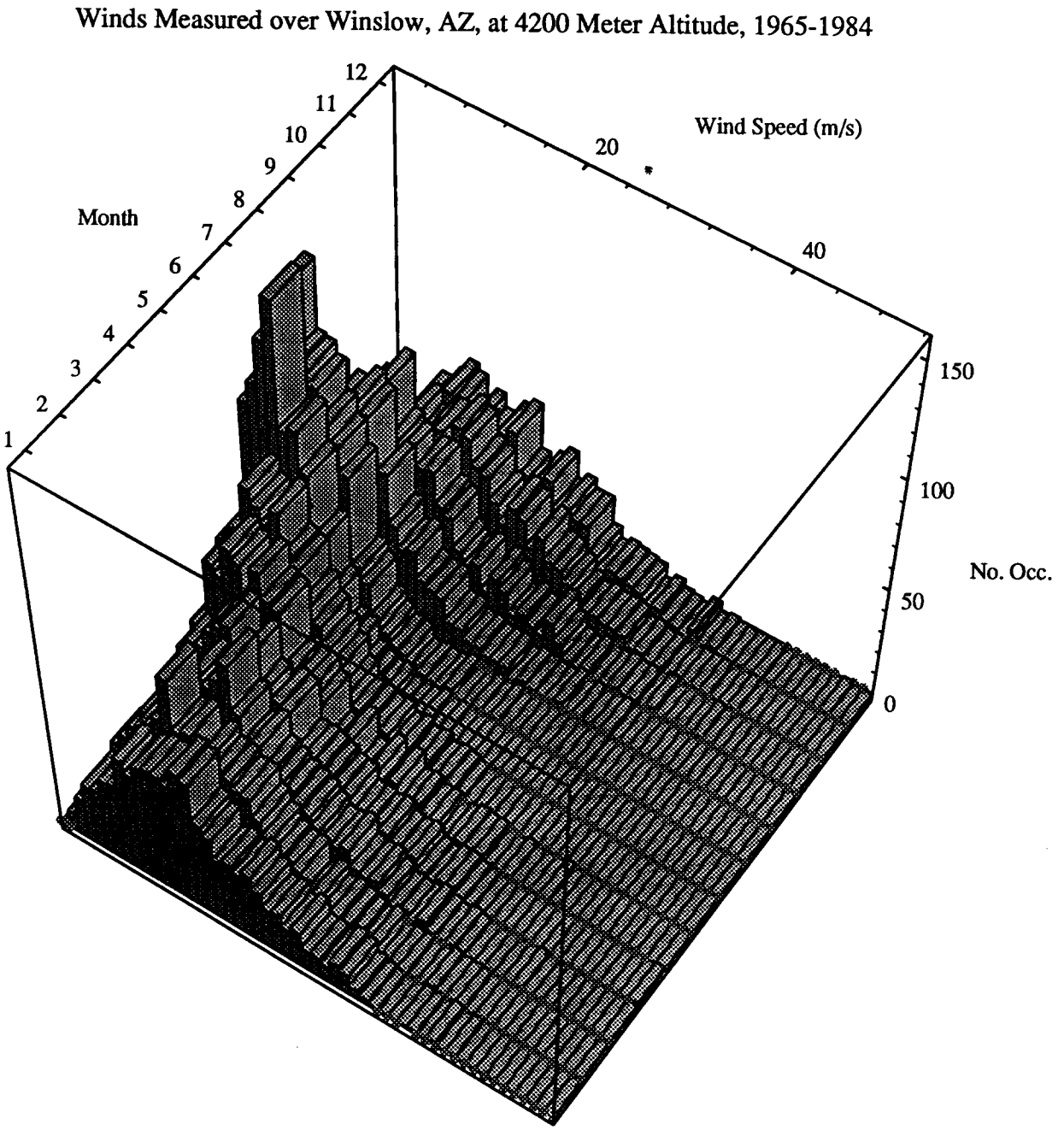

Figure 5. Monthly histograms of the wind speeds measured at a middle altitude level (4200 m) above Winslow, Arizona, during the twenty year period 1965–1984.

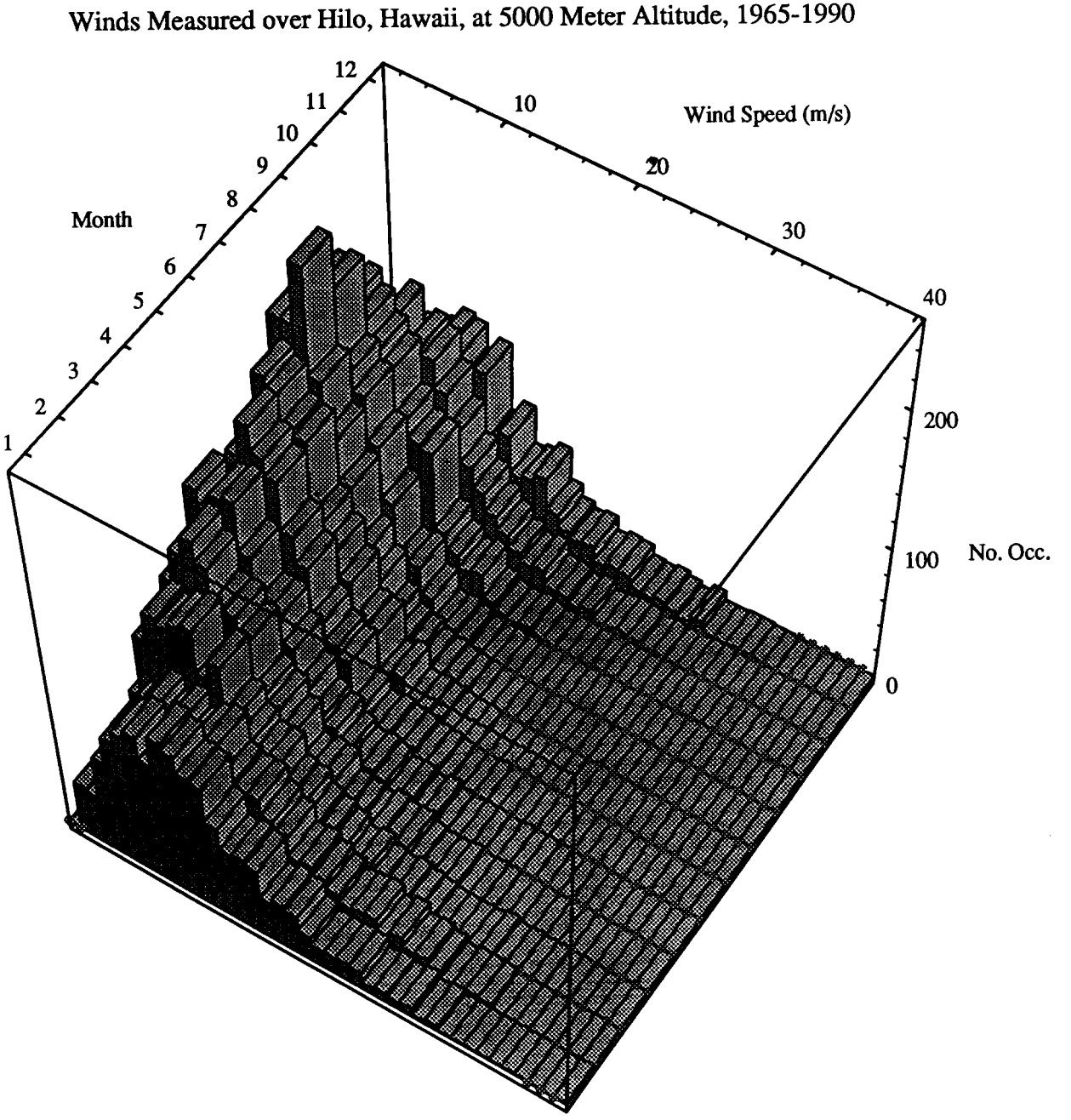

Figure 6. Monthly histograms of the wind speeds measured at a middle altitude level (5000 m) above Hilo, Hawaii, during the twenty-six year period 1965–1990.

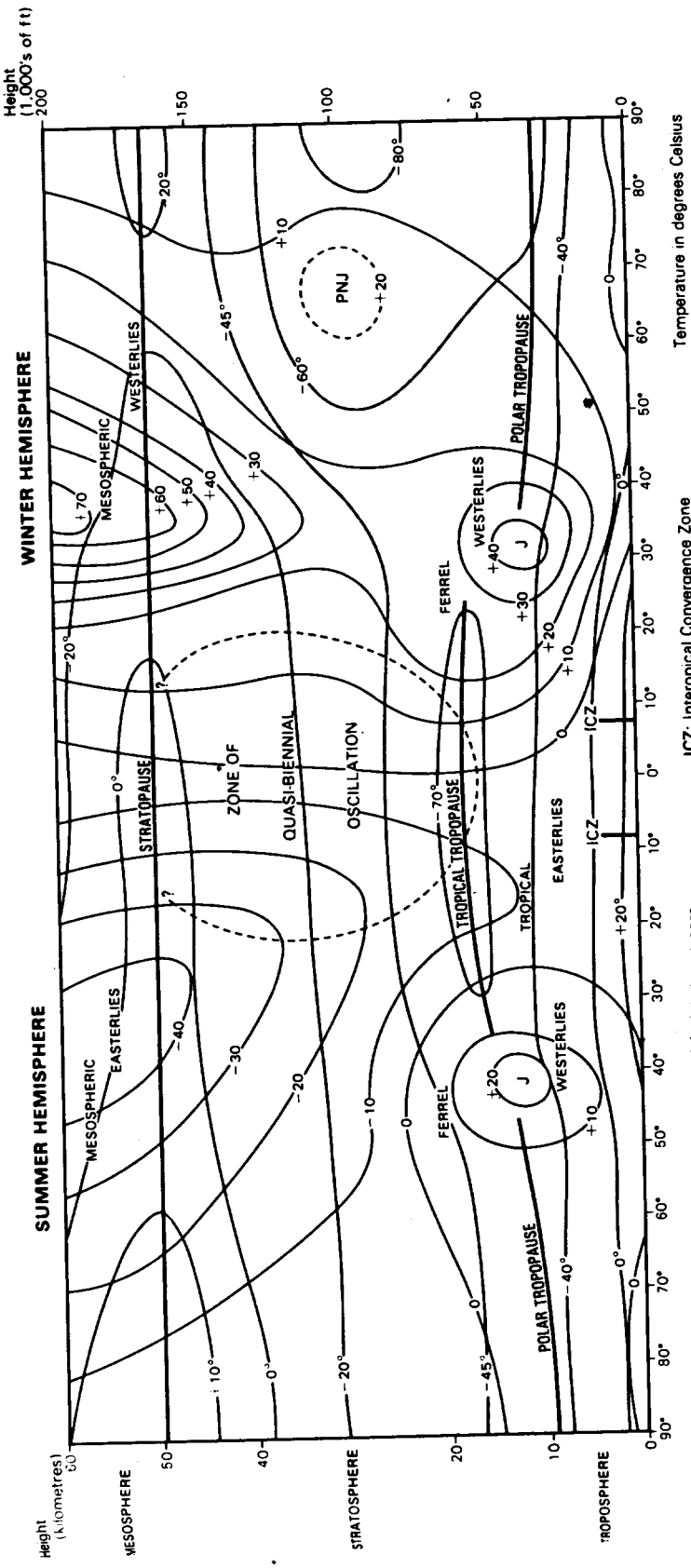

Figure 1: Meridional cross section of the atmosphere to a height of 60 kilometres (about 200,000 feet) in summer and winter hemispheres, showing seasonal changes. Numerical values for wind are in units of metres per second (one metre per second approximately equals two knots) and are typical of the Northern Hemisphere, but the structure is much the same in the Southern Hemisphere. Positive and negative signs indicate winds of opposite directional sense (see text).
By courtesy of World Meteorological Organization

Figure 7. Zonal wind systems of the earth's atmosphere, showing average wind speeds. (Source: *Encyclopædia Britannica*).

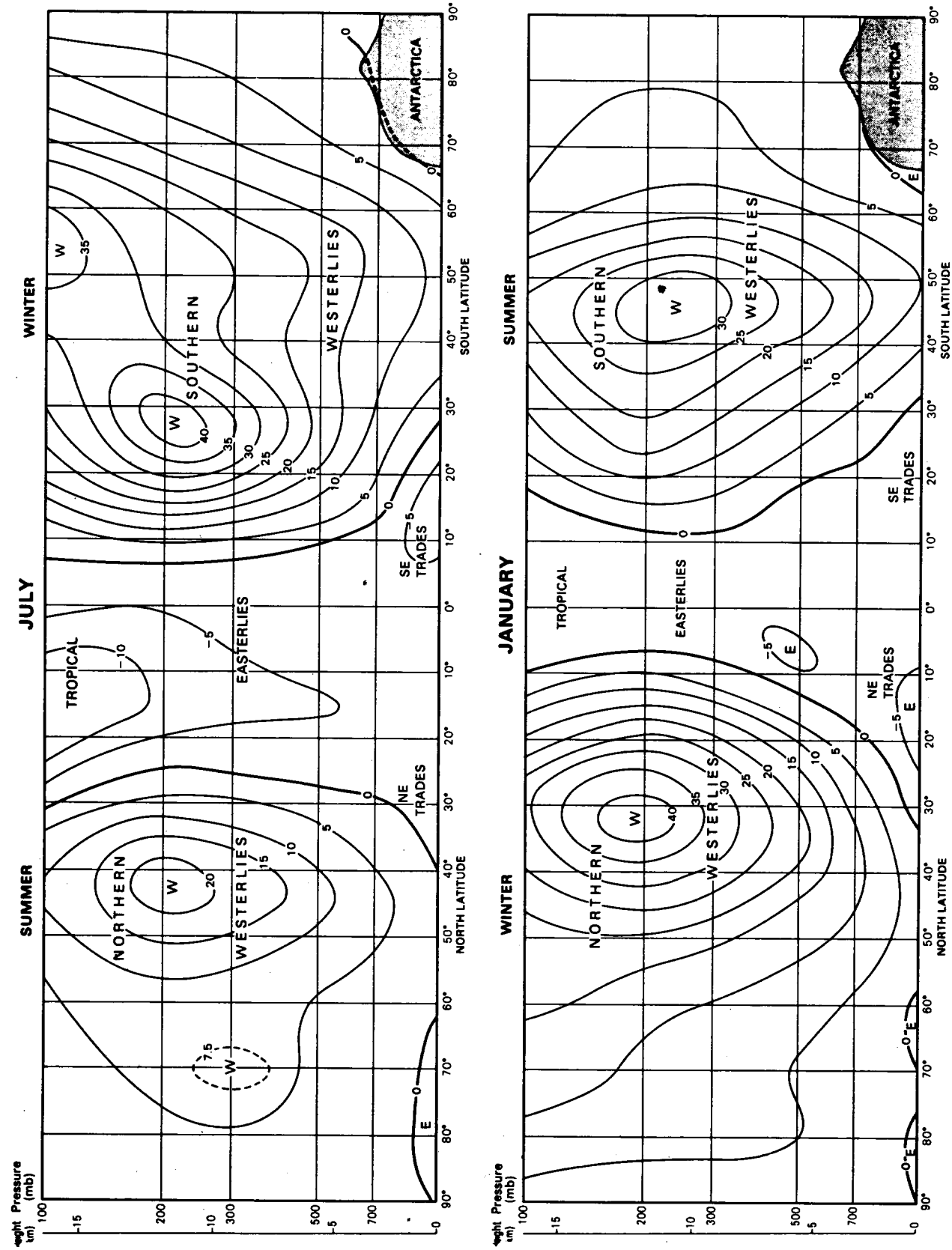

Figure 5: Detailed cross section (arranged longitudinally) through zonal wind systems of the troposphere from sea-level surface to about 18 kilometres (about 50,000 feet). Lines of constant wind speed (isotachs) into or out of the plane of the cross section (*i.e.*, west is positive, east is negative) are shown for January and July.

From H.L. Crutcher, R.L. Jenne, H. van Loon, and J.J. Taljaard, *Climate of the Upper Air*, part 1, *Southern Hemisphere*, NAVAIR 50-1C-55; U.S. Naval Weather Service Command

Figure 8. Zonal wind systems of the troposphere showing average wind speeds for the months of January and July. (Source: *Encyclopædia Britannica*).