NLSRT Memo No. 64

Telescope Consultation

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NRAO
14.Juni.1989

GREEN BANK WIND DATA

1. History and Data

During the later part of our LFST study (Largest Feasible Steerable Telescope, John Findlay) we worked on the design of a 300-ft telescope, fully steerable, homologous deformations, with a small stable pointing-platform in the backup center, connected optically to the ground; and with small **flat** triangular surface plates. At this time, accurate surface panels would have been very expensive; also, there was not yet much interest in mm-waves. We thus went for 1.0 cm as the shortest wavelength during nights.

Green Bank was considered as its site. We needed wind data for the design specifications, which I collected from the records at the old 85-one and the 300-ft, first in 1961-64. These were taken from graphs recorded by 3-cup anemometers with about 5 sec time resolution. I used only the **maximum velocity of each hour**. Thus, a "gust factor" is already included in these data.

Later, I found a place in the Greenbriar valley, which looked better shielded (interference and wind). In 1967, we built a wind tower nearby, close to a dirt road. Our pointing system was supposed to eliminate the deformations of the whole azimuth and elevation structure, not only the thermal part, but also the steady part of the wind plus all gusts below the lowest dynamical mode of the telescope, about 3 sec. We thus needed the spectrum of **turbulence**, and measured with a hot-wire anemometer with 0.5 sec resolution, on many occasions from Sept.1967 to July 1968, at a hight of 115 ft above ground (1/2 telescope height). During the whole period we also recorded the maximum velocity of each hour with a 3 cup anemometer.

Results of the first measurments, 85-ft and 300-ft, were given in LFST Report 16, Dec.8, 1966. From the tower measurments, only the spectrum of turbulence was given in LFST Report 23, March 1, 1969. It was used to estimate the residual pointing error.

Later on, it seemed the 300-ft design would not get funded, and interests had also gone to shorter wavelengths. We started the design of a 65-m telescope for 3.5 mm wavelength (finally 25 m for 1.2 mm); we lost interest in Green Bank, and collected wind data from Mauna Kea, Mt. Whitney, Mt. Lemon, and the VLA site. Thus, maximum wind velocities from the tower did not make it into our reports, but I did keep my notes. The following is a summary of LFST Report 16 and my old notes.

2. Locations

During 1961-64, I had 28 months at the 85-ft, with 18,858 hours (92 % complete) and 12 months at the 300-ft with 6,378 hours (73 % complete). Using only the six months, from Feb.63 through July 63, where both data were fairly complete, we found not much difference for the averages of the hourly maxima, which where (2.0 ± 1.0) mph higher at the 85-ft.

But what counts are not averages but high winds. For a total of nine months, from all hours where both telescopes had data, we selected the hours within the two following velocity ranges, and we found

range	hours	$V_{85} - V_{300}$
15 - 25 mph	902	5.3 ± 0.3 mph
≥ 40	100	8.8 ± 2.1

(1)

The difference was even (12.0 ± 5.3) mph on the three days with maximum speeds above 50 mph.

During one winter, from December 1967 through April 1968, we measured both at the 85-ft (2681 hours) and the wind tower (2275 hours). Recording again the **maximum speed each hour**. Against our expectations (and very different from what I now remembered), higher winds were quite more frequent in the Greenbriar valley than at the 85-ft. See Fig.1. The result is:

The 300-ft was at the best of the three locations. (2)

3. Seasons

Regarding the maximum wind for observation at the shortest wavelengths, V_{ob}, we had agreed to use the third quartile of the cumulative distribution (25 % of time lost above). Quoting from LFST Reort 16, we found for the maximum each hour, for all data from November 1961 through February 1964 (reduced to an average of 85-ft and 300-ft):

summer, May - October, V_{ob} = 13.0 mph,
winter, November - April, V_{ob} = 19.6 mph. (3)

For a detailed comparison, see Fig.2, from wind tower data.

4. Time of Day

Here, I have data only at the wind tower, again maximum each hour, from September 1967 through July 1968 (5765 hours). Results:

day,	06:00 - 12:00,	V_{ob} = 16.3 mph,
	12:00 - 18:00	19.5
night,	18:00 - 24:00	14.5
	00:00 - 06:00	13.2

(4)

5. Maximum, for Observation at Shortest Wavelength

We got quite different speeds, regarding different seasons (3) and different times of day (4). Since this result can be used to some extent for scheduling, I suggest for our specifications:

$$V_{ob} = 15 \text{ mph (excluding only day-time in winter)} \qquad (5)$$

6. Maximum, for Survival Wind

The problem is extrapolation beyond measured speeds, up to some high speed V_{sv} beyond which the telescope may fail. We demanded

1 % chance of occurance within 30 years. (6)

In order to find a useful extrapolation, we used four most simple laws with **two parameters** each (without demanding normalization to 1.0 for the total), and checked how well they would fit the high speeds in four graphs. The two best-fitting laws are then used for extrapolation to limit (6). The data were again for an average of 85-ft and 300-ft locations, and the result was:

law used	best-fitting parameters	V_{sv}
$F(v) = \exp(-(v/A)^B)$	A = 12.8 mph, B = 1.46	90 mph
$F(v) = B^*\exp(-\frac{1}{2}(v/A)^2)$	A = 14.6 mph, B = 0.269	82 mph

(7)

I would like to add one more. If we assume that the velocity distribution in each dimension is independent and Gaussian, then the cumulative distribution of the absolute 2-dimensional speed is again a Gaussian, but to be correct, with only **one free parameter** if properly normalized:

$$F(v) = \exp(-\tfrac{1}{2}(v/A)^2). \qquad (8)$$

The best-fit at high velocities gives A = 13.0 mph, and the extrapolation to (6) is:

$$V_{sv} = 76 \text{ mph}. \qquad (9)$$

The measurments go only up to 65 mph, thus the extrapolation is uncertain. But (6) was a rather stringent demand, overdone a bit; and the 300-ft location, the best one, is better than the average used above, especially for high winds, see (1); also, gusts are already included in our data; finally, the highest gust ever mentioned was 74 mph (on an operator's log during the first years, at 85-1). Thus, using the highest value of (7) and (9) seems safe enough, and I suggest to use for our specifications:

$$V_{sv} = 90 \text{ mph}. \qquad (10)$$

Errata

1. The date on my last Memo should read: **June 9, 1989**
2. Page 5, second line after (5) should start: **angles as Δ L/L**

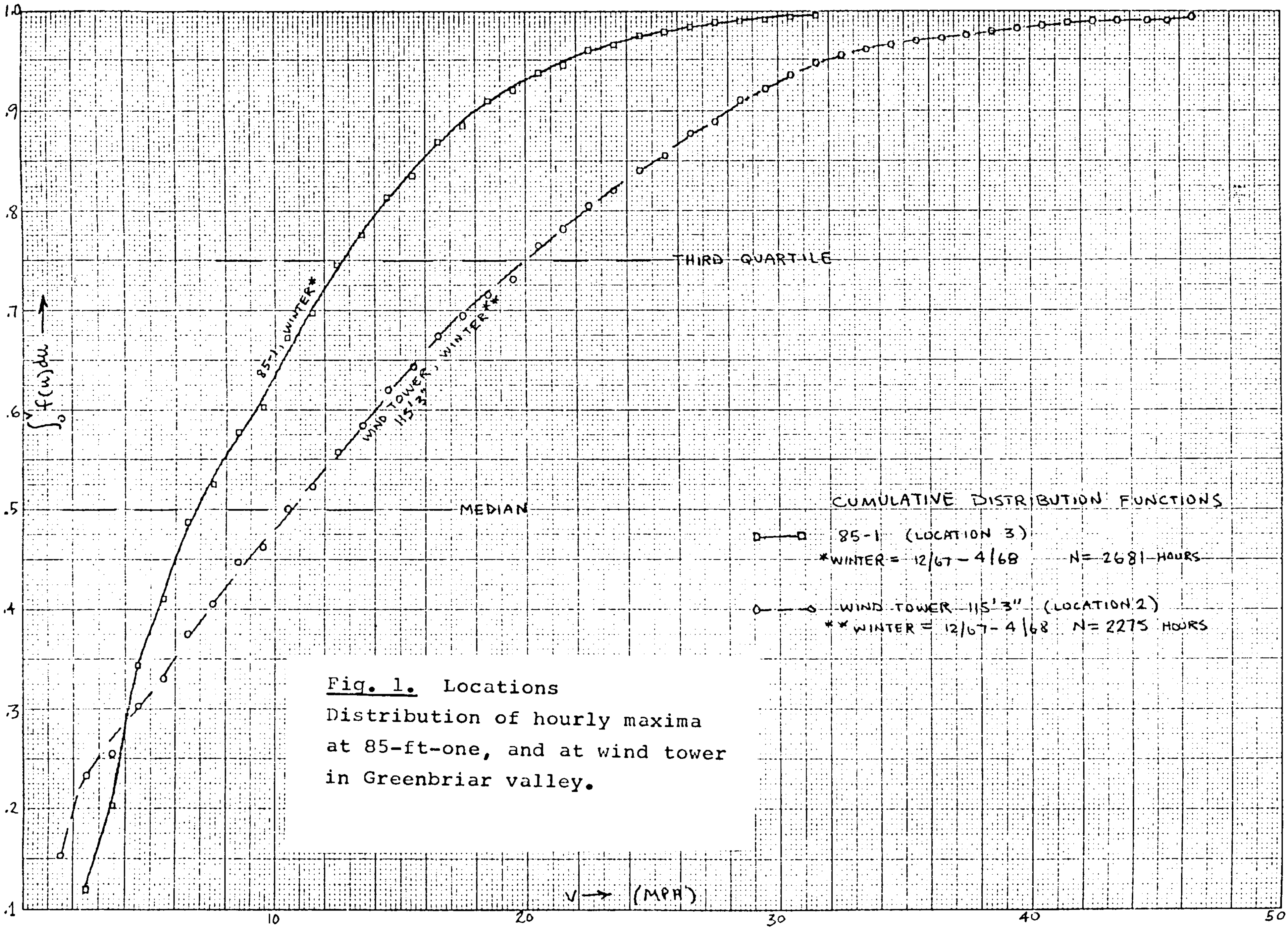

Fig. 1. Locations
Distribution of hourly maxima at 85-ft-one, and at wind tower in Greenbriar valley.

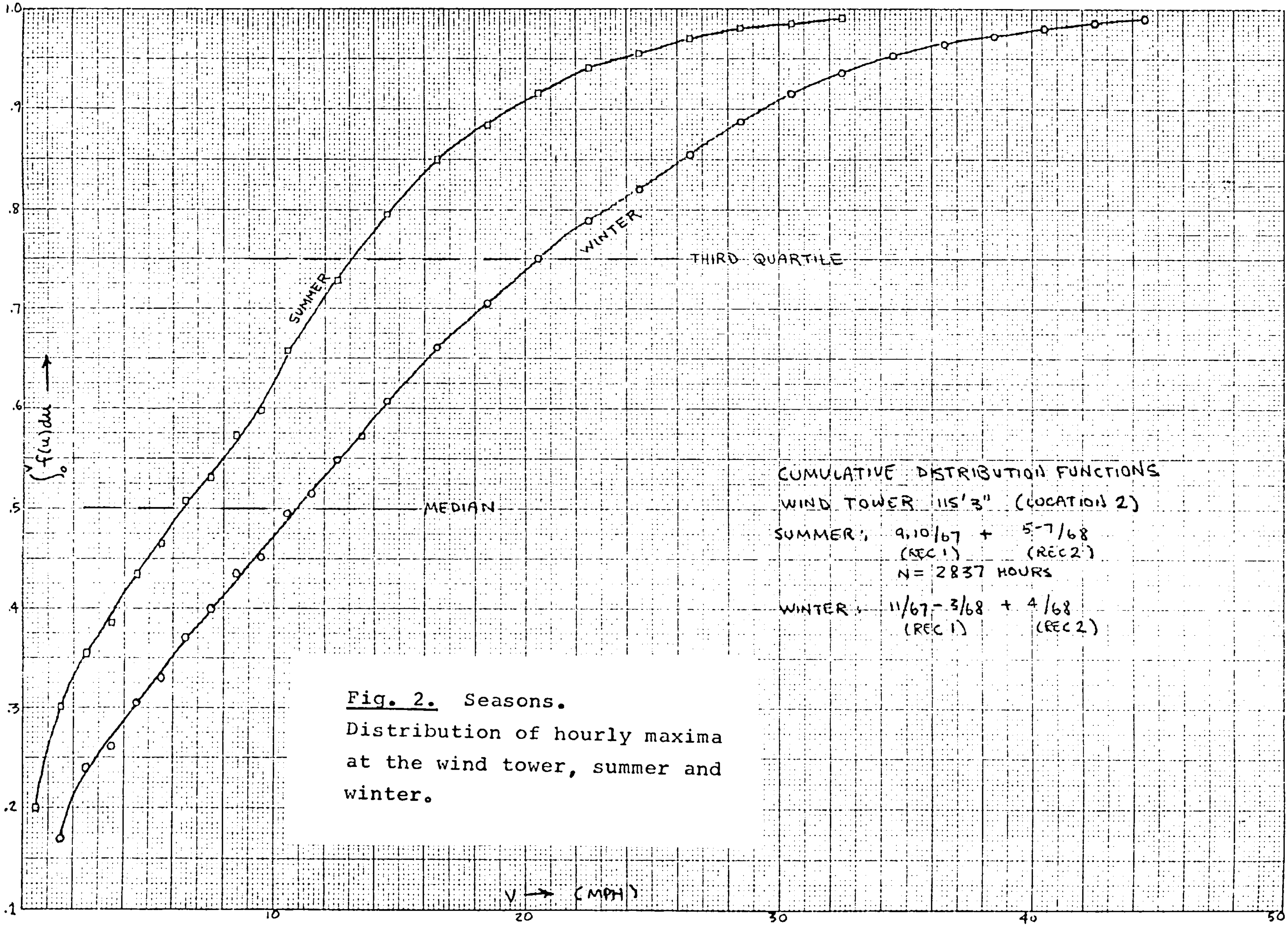

Fig. 2. Seasons. Distribution of hourly maxima at the wind tower, summer and winter.