NLSRT Memo No. 52

MEMORANDUM February 17, 1989

TO: Paul Vanden Bout
FROM: Fred Schwab
SUBJECT: Analysis of radiosonde data from Huntington WV, Pittsburgh PA, and Albany NY

Analysis of these data has not been completed, but here is a summary of results I have obtained thus far. The data cover a sixteen-year period (1972–1987), generally with two radiosonde launches per day—at 0^h and 12^h UT. For the Millimeter Array study (Schwab and Hogg 1988), in which data covering the twenty-year period 1965–1984 were used, the pre-1972 data were found to be of poorer quality, so this time around I ordered only the more recent data. For the MMA study, Hogg and I used Liebe's early millimeter-wave propagation model (Liebe 1985) in order to infer zenith opacity from the radiosonde measurements; in January we decided to incorporate his extensively revised, more recent model (Liebe and Layton 1987) in our software. This decision has caused some (considerable) delay in cranking out the results.

For the numerical integrations of the atmospheric profiles I used a base height of 2750 feet above mean sea level (corresponding to Green Bank's elevation) for the Huntington and Pittsburgh data, and a height of 1030 feet MSL (corresponding to FCRAO's elevation) for the Albany data. Huntington and Pittsburgh each are approximately 140 miles from Green Bank—to the west and the north, respectively. Albany is approximately eighty miles west of FCRAO. In interpreting the radiosonde results one should bear in mind that mountains, as well as distance, separate the observatories from the radiosonde launch sites. In particular, Green Bank is leeward of high mountain ranges which may cause both condensation of water vapor into clouds and turbulence.

A plot of the daily median value of precipitable water vapor from each of the three sets of data is shown in Figure 1. The ordinate of each plot is precipitable H_2O vapor (PWV), measured in units of grams per square centimeter (1 g/cm^2 column density of water vapor equals 10 mm PWV). By 'daily median' I mean that the number that is plotted for a given day of the year is the median value of the (typically 32) values obtained for that day of the year.

Plots of the frequency distribution of 110 GHz opacities inferred from the radiosonde data are shown in Figure 2 for two sites, Pittsburgh and Albany. Pittsburgh (for an elevation of 2750 feet) is slightly favored over Albany (at 1030 feet) according to this interpretation of the data. Scatterplots of all the 110 GHz opacities are shown in Figure 3. Many of the extremely high opacities are due to our use of an *ad hoc* algorithm to infer the existence of clouds on the basis of high humidity measurements; when such a 'cloud' is detected, we include an opacity contribution due to droplets whose density we can only guess; this estimate is conservative, often leading to very high computed opacities. I have not yet, with Liebe's new propagation model, done the opacity calculations for the Huntington data.

References

Liebe, H. J. (1985), "An updated model for millimeter wave propagation in moist air", *Radio Science*, **20**, 1069–1089.

Liebe, H. J. and Layton, D. H. (1987), "Millimeter-wave properties of the atmosphere: laboratory studies and propagation modeling", NTIA Report 87-224, Institute for Telecommunication Sciences, National Telecommunications and Information Administration, U.S. Department of Commerce, Boulder, CO.

Schwab, F. R. and Hogg, D. E. (1988), "Millimeter-wave seeing inferred from radiosonde observations—preliminary results", Millimeter Array Memorandum No. 51, NRAO.

Fig. 1(a)

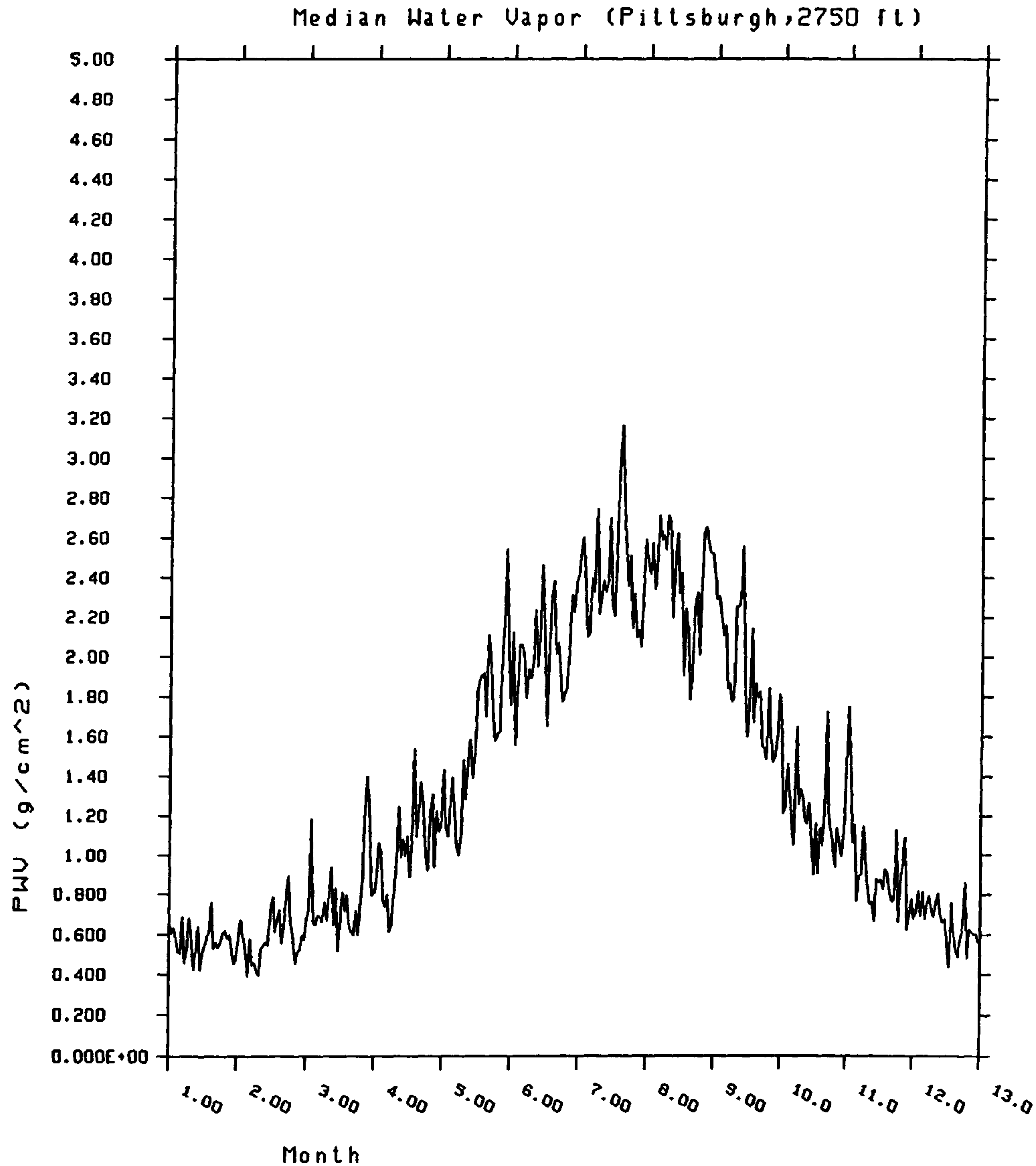
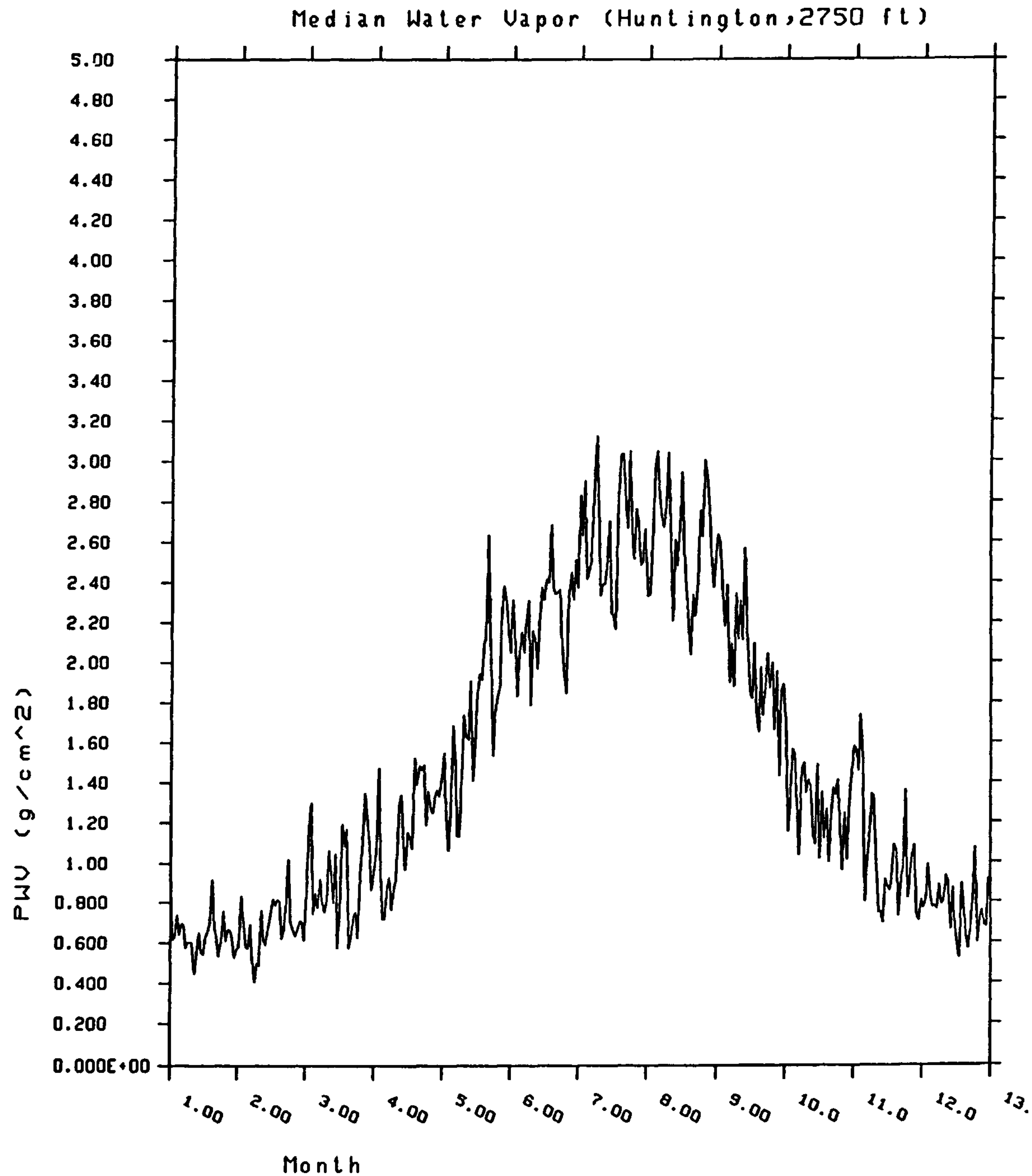

Median Water Vapor (Pittsburgh,2750 ft)
5.00
4.80
4.60
4.40
4.20
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.800
0.600
0.400
0.200
0.000E+00
PWV (g/cm^2)
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.0
11.0
12.0
13.0
Month

Fig. 1(b)



Median Water Vapor (Huntington,2750 ft)
5.00
4.80
4.60
4.40
4.20
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.800
0.600
0.400
0.200
0.000E+00
PWV (g/cm^2)
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.0
11.0
12.0
13.0
Month

Fig. 1(c)

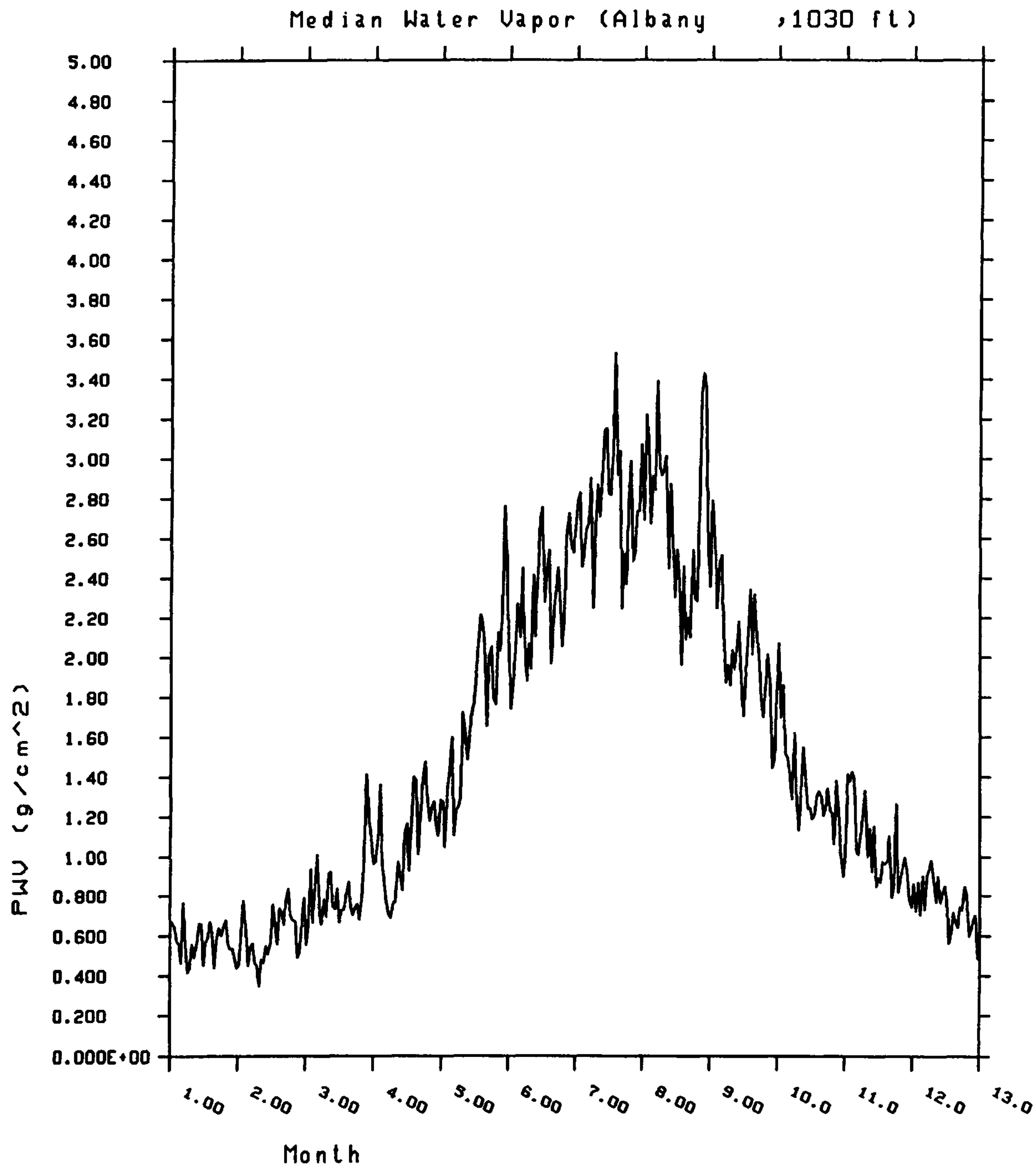

Median Water Vapor (Albany ,1030 ft)
5.00
4.80
4.60
4.40
4.20
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.800
0.600
0.400
0.200
0.000E+00
PWV (g/cm^2)
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.0
11.0
12.0
13.0
Month

Fig. 2(a)

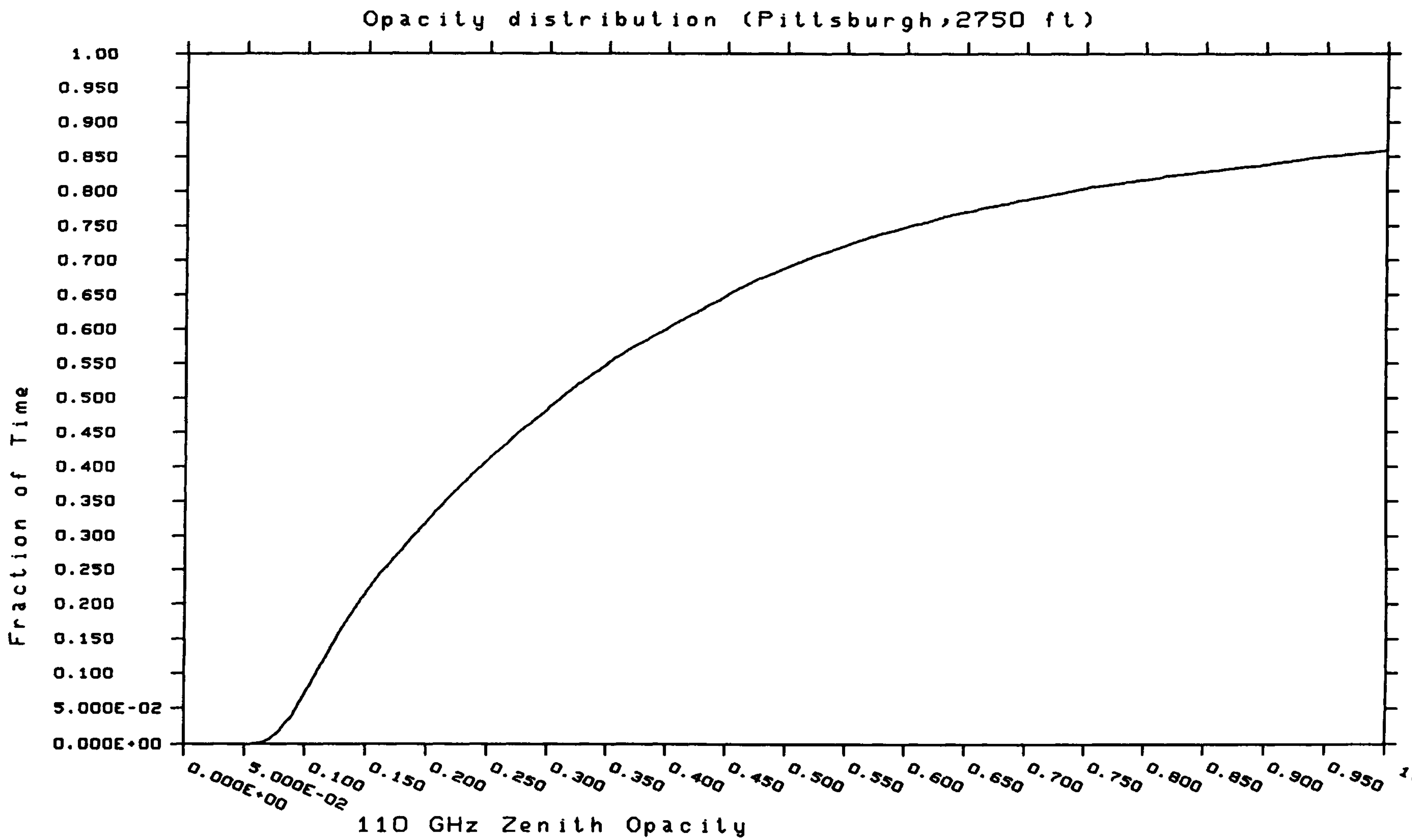

Opacity distribution (Pittsburgh,2750 ft)
Fraction of Time
1.00
0.950
0.900
0.850
0.800
0.750
0.700
0.650
0.600
0.550
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
5.000E-02
0.000E+00
0.000E+00
5.000E-02
0.100
0.150
0.200
0.250
0.300
0.350
0.400
0.450
0.500
0.550
0.600
0.650
0.700
0.750
0.800
0.850
0.900
0.950
1.
110 GHz Zenith Opacity

Fig. 2(6)

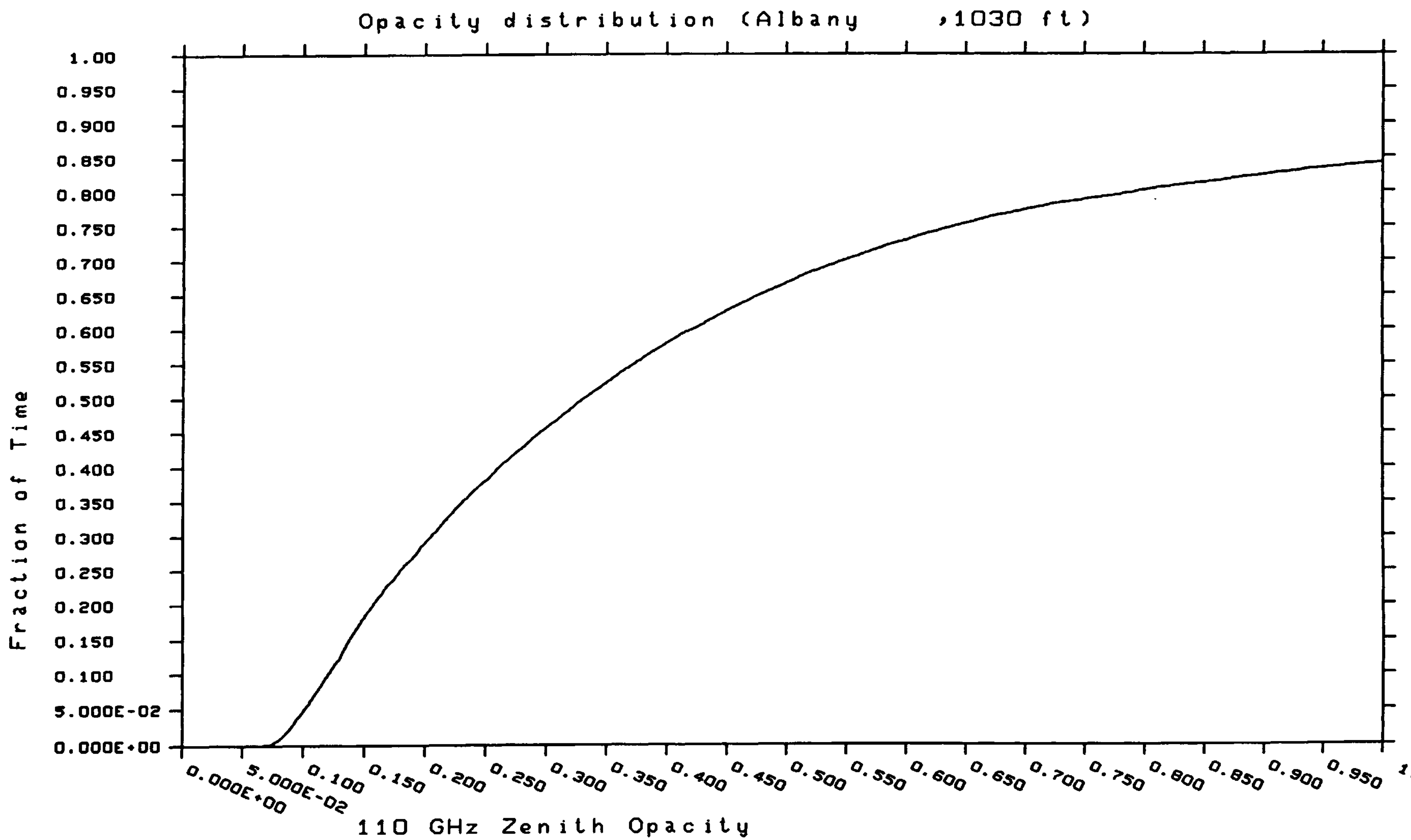
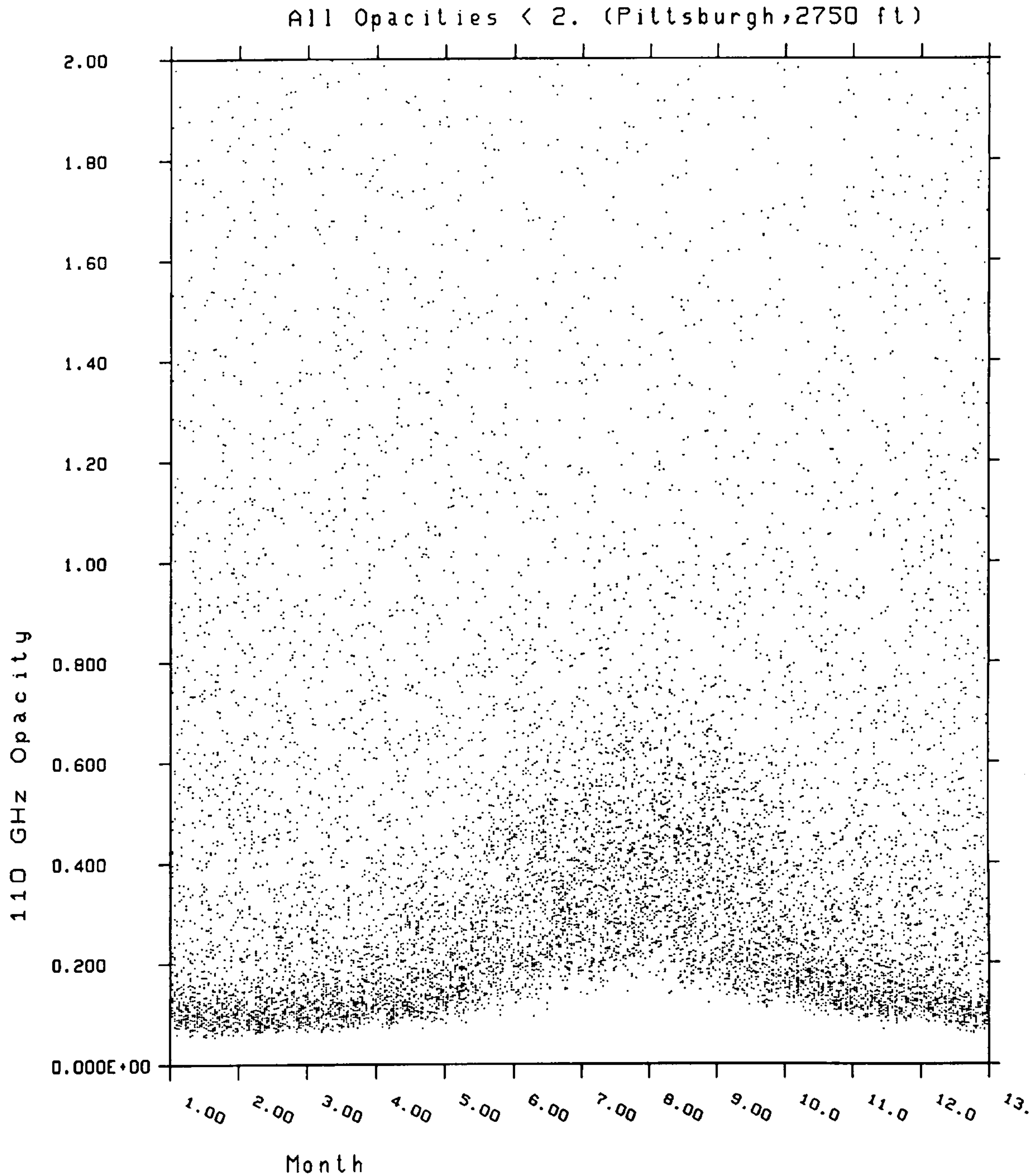
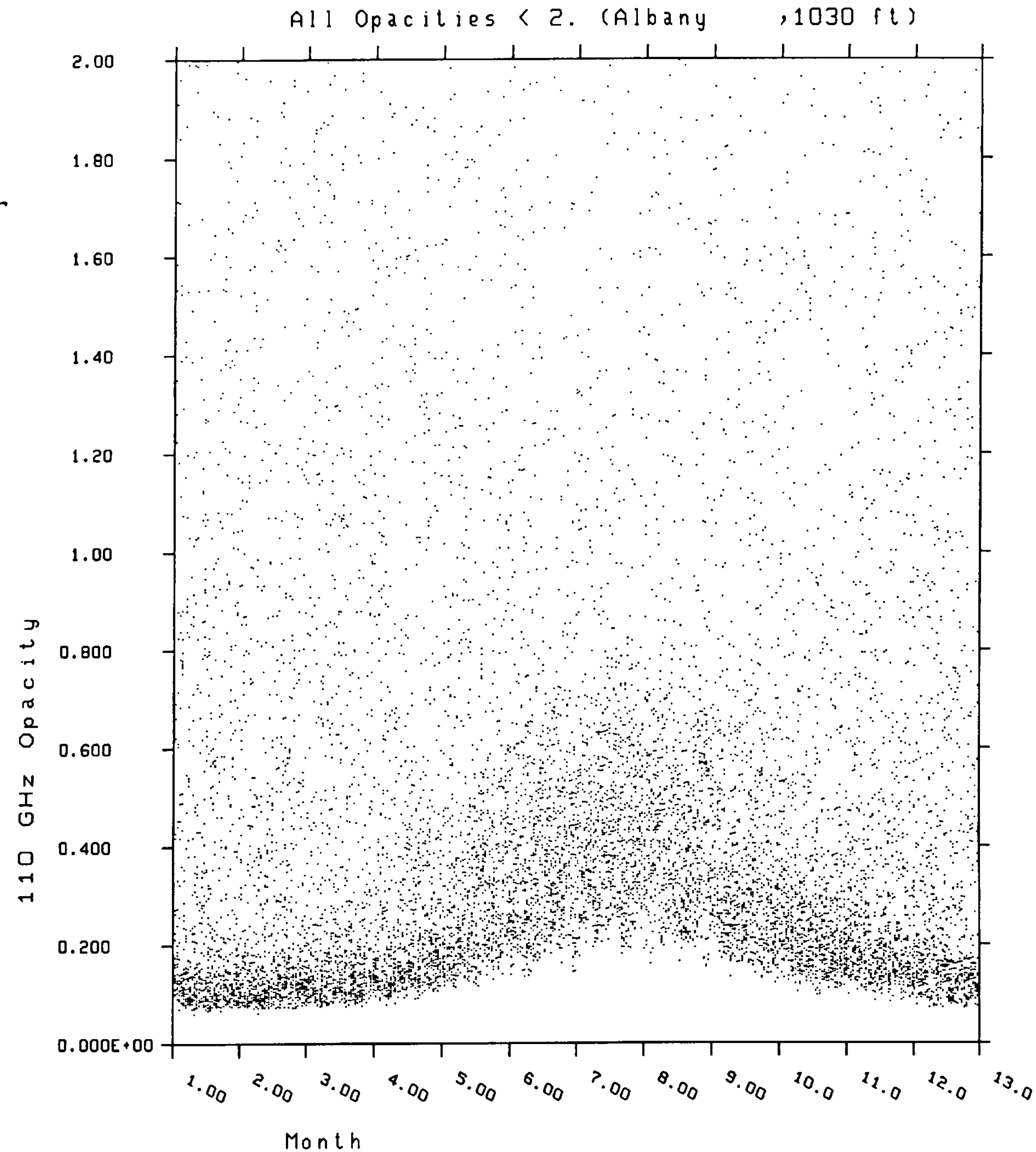

Opacity distribution (Albany ,1030 ft)
1.00
0.950
0.900
0.850
0.800
0.750
0.700
0.650
0.600
0.550
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
5.000E-02
0.000E+00
Fraction of Time
0.000E+00
5.000E-02
0.100
0.150
0.200
0.250
0.300
0.350
0.400
0.450
0.500
0.550
0.600
0.650
0.700
0.750
0.800
0.850
0.900
0.950
1.
110 GHz Zenith Opacity

Fig. 3(a)



All Opacities < 2. (Pittsburgh,2750 ft)
2.00
1.80
1.60
1.40
1.20
1.00
0.800
0.600
0.400
0.200
0.000E+00
110 GHz Opacity
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.0
11.0
12.0
13.0
Month

Fig. 3(b)


All Opacities < 2. (Albany ,1030 ft)
2.00
1.80
1.60
1.40
1.20
1.00
0.800
0.600
0.400
0.200
0.000E+00
110 GHz Opacity
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.0
11.0
12.0
13.0
Month