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NRL Report 8422

Atmospheric Transmission Measurements at White Sands Missile Range, August 1978

S. T. Hanley, J. A. Dowling, R. F. Horton, J. A. Curcio, C. O. Gott,
M. Woytko, and Ens. John Storvick, U.S.N.

Optical Radiation Branch
Optical Sciences Division

October 29, 1980

NAVAL RESEARCH LABORATORY
Washington, D.C.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER NRL Report 8422	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) ATMOSPHERIC TRANSMISSION MEASUREMENTS AT WHITE SANDS MISSILE RANGE, AUGUST 1978	5. TYPE OF REPORT & PERIOD COVERED Interim report on a continuing project.
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) S. T. Hanley, J. A. Dowling, R. F. Horton, J. A. Curcio, C. O. Gott, M. A. Woytko, and Ens. J. Storvick, USN	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Research Laboratory Washington, D.C. 20375	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Program Element No. 63754N, Project No. S0182-AA, Task No. 19625, Work Unit No. R0531.
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE October 29, 1980
	13. NUMBER OF PAGES 71
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Atmospheric transmission
Laser propagation
High-resolution
Fourier-transform spectroscopy

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

High-resolution atmospheric transmission measurements have been made at White Sands Missile Range, New Mexico. Wavelengths measured include 0.63 μm, 1.06 μm, 3–5 μm, and 8–14 μm. Meteorological variables including air temperature, dewpoint, wind speed and direction, solar radiation, and the atmospheric temperature structure parameter C_T were monitored during transmission measurements, at the endpoints of the propagation path. Stronger continuum absorptions at DF laser frequencies than expected and limiting effects of high winds and atmospheric turbulence were observed.

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S/N 0102-014-6601

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ATMOSPHERIC TRANSMISSION MEASUREMENTS AT WHITE SANDS MISSILE RANGE, AUGUST 1978

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INTRODUCTION

During August 1978 measurements were taken over a two-week period at White Sands Missile Range (WSMR), New Mexico. The Naval Research Laboratory's (NRL) Infrared Mobile Optical Radiation Laboratory (IMORL) was used to make high-resolution atmospheric transmission measurements over an elevated 6.4-km path in order to assess the effect of the atmosphere on laser transmission. The expected high turbulence at WSMR was a new parameter for the existing IMORL data base [1,2] and restricted operations to midmorning and late afternoon. Detailed surveys of the actual path used, providing beam elevation as well as local ground topography vs range, were carried out in support of this program. Meteorelogical parameters monitored at the endpoints of the path included air temperature, dewpoint, solar radiation, wind speed and direction, and the temperature structure parameter C_T. Laser extinction coefficient measurements were made to a precision of ± 0.008 km^{-1}* at HeNe, Nd-Yag, deuterium fluoride (DF), and CO_2 wavelengths. To achieve this precision for the highly transmissive DF wavelengths, a longer path was used than those chosen for previous IMORL operations. New dual-scatter-plate beam integrators were employed to reduce pointing errors at the receiver [3]. The turbulence-induced beam spread caused possible overfill of the 1.2-m (4-ft) receiver mirror and limited the path length to the 6.4 km used for successful operation during all but the periods of highest turbulence. Times of day and levels of turbulence for which this limitation became operative will be discussed in the section on laser extinctions.

Extinction measurements of the DF lines are in good agreement with predictions from sea level algorithms simply reduced in total pressure for most lines measured. The 2→1 P_5 DF line shows indications of an H_2O continuum dependence different from the model developed by the Army Atmospheric Sciences Laboratory, WSMR. This discrepancy is in the direction of smaller absorption coefficients for the 2→1 P_5 component of a multi-wavelength beam. The DF laser extinction measurements were used to calibrate Fourier Transform Spectrometer (FTS) data, providing absolute transmission spectra for the first time at the WSMR-MAR site. This information will be of substantial benefit to the future laser propagation programs at WSMR.

PLAN AND RATIONALE FOR THE WSMR EXPERIMENT

The technical objectives of this measurements program were threefold. A primary objective was to characterize the propagation environment at WSMR by measuring long path atmospheric extinction at several near- and mid-IR laser frequencies, together with local meteorological parameters. Second, this work was intended to provide basic experimental atmospheric transmission data at WSMR for systems analysis studies. Third, this measurement program was designed to acquire precise high-resolution atmospheric transmission spectra in-situ at WSMR.

Specific problem areas identified prior to the WSMR field measurements include the nature, composition, and effects of average atmospheric aerosol concentrations occurring in the inland desert

Manuscript submitted April 29, 1980.

*This error limit is larger than that reported for previous measurements with the IMORL [3] because of the high turbulence encountered at WSMR.

environment, anticipated new ranges of absolute humidity, and confirmation of the level and variability of HDO/H_2O abundance in the inland environment. Each of these atmospheric properties strongly affects the propagation of DF laser radiation in the atmosphere.

LASER EXTINCTIONS

The laser extinction procedures used at WSMR are described in References [1] and [4]. With use of the basic procedure of a chopped beam and phase-locked ratiometry, an experimental uncertainty of ± 0.008 km^{-1} was achieved in the measured extinction coefficients, with transmissions near 90% over the path. The required precision in the detector hardware was achieved through the use of tandem scatter-plate beam integrators having a deviation of less than 1% of detector–integrator efficiency over the entire 1.2-m (4-ft) collector pupil. This unique design was developed by R. F. Horton of NRL's Optical Radiation Branch [3]. Precision AC voltage regulators were added to the transmitter electronics to maintain uniform source temperatures and amplification characteristics of electronics under the sometimes harsh field environment. A magnetic tape data logger normally used for storage of meteorological parameters was expanded to include the laser extinction numbers from the ratiometer for improved temporal resolution in data analysis. For example, with the high turbulence frequently encountered at WSMR, the distribution of values from the ratiometer will have a larger than normal standard deviation and, if beam spreading nearly fills the 1.2-m receiving aperture, a skewness of the distribution appears that is easily recognized. This skewness flags a loss of validity of the laser extinction measurements and requires a new algorithm that selects an averaged ratio near the distribution edge away from the tail, depending on the degree of mirror fill.

Results of the long path DF extinction measurements are shown in Table 1. The calculated extinction coefficients are obtained from a line-by-line computer calculation commonly referred to as HITRAN, which uses a recent edition of the AFCRL line atlas [5], containing spectroscopic data for the seven principal IR molecular absorbers and their isotopes. All line wing contributions within a range of 25 cm^{-1} to either side of the wavenumber of interest are included in the calculation as contributions to the absorption coefficient. Midlatitude summer average values scaled to WSMR barometric pressure and air temperature are used for the amounts of all absorbers except H_2O, which is referenced to the measurement of actual dewpoint. A continuum contribution for N_2 and H_2O is included in the HITRAN calculations and is derived from the model used in LOWTRAN 3B [6]. No aerosol contribution is modeled in the numerical calculations, since all experimental conditions exceeded 80 km visibility, indicating a negligible aerosol component. A more detailed description of the visibility measurements will be given in a later section.

For help in assessing the correlations of the DF laser extinctions with atmospheric conditions, Table 2 contains a breakdown of individual contributions to the total molecular absorption coefficient from each molecular absorption component for a midlatitude summer atmosphere scaled to 33°C air temperature, 1172 Pa (8.8 torr) of water vapor, and 88×10^3 Pa (660 torr) total pressure. Absorption of the $2 \rightarrow IP_{10}$ (abbrv. $P_2 10$) line, for example, is dominated by the N_2O content of the atmosphere.

The variation of absorption coefficient for each of the DF lines with water vapor partial pressure is shown in Figs. 1 and 2. Included in the figures are previous sea level measurements and a plot of a polynomial algorithm [1] developed by Science Applications, Inc. (SAI). The recent measurements at WSMR are indicated by the W symbols, and the boxes and crosses represent data from Cape Canaveral, Florida, and Capistrano, California, respectively. The solid curve is a least squares fit to the Florida data, and the dashed curve is the polynomial calculation of SAI.

One notable result of the DF laser extinctions is the $P_2 5$ line, which indicates a different trend with water vapor than that expected, as shown in Fig. 2. Absorption of this line is dominated by HDO line and H_2O continuum absorptions, and any discrepancies in either species should also show up in some of the well-behaved lines observed, such as the $P_2 7$ which is also HDO-line dominated.

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Table 1 — DF Extinctions Measured over 6.4-km Path at WSMR and HITRAN Predictions for Corresponding Meteorological Conditions*

Date	Time (local)	Line ID	Line Position (cm^{-1})	Experimental Extinction Coefficient (km^{-1})	Calculated Absorption Coefficient (km^{-1})	Experimental −Calculated (km^{-1})
11 Aug 78	0900	$P_2 8$	2631.068	0.021	0.023	−0.002
11 Aug 78	0910	$P_1 8$	2717.539	0.120	0.107	+0.013
11 Aug 78	0912	$P_1 7$	2742.998	0.030	0.025	+0.005
11 Aug 78	0912	$P_1 6$	2767.968	0.069	0.063	+0.006
11 Aug 78	0915	$P_2 8$	2631.068	0.035	0.023	+0.012
11 Aug 78	0917	$P_2 10$	2580.097	0.092	0.060	+0.032
11 Aug 78	0919	$P_2 12$	2527.391	0.038	0.026	+0.012
11 Aug 78	0924	$P_2 8$	2631.068	0.031	0.023	+0.008
14 Aug 78	0952	$P_2 8$	2631.068	0.012	0.014	−0.002
14 Aug 78	0953	$P_2 7$	2655.863	0.041	0.038	+0.003
14 Aug 78	0954	$P_2 5$	2703.999	0.012	0.011	+0.001
14 Aug 78	0955	$P_1 8$	2717.539	0.078	0.057	+0.021
14 Aug 78	0957	$P_1 7$	2742.998	0.014	0.012	+0.002
14 Aug 78	0959	$P_1 6$	2767.968	0.034	0.033	+0.001
14 Aug 78	1001	$P_2 8$	2631.068	0.013	0.014	−0.001
14 Aug 78	1002	$P_2 10$	2580.097	0.059	0.052	+0.007
14 Aug 78	1002	$P_2 12$	2527.391	0.027	0.018	+0.009
14 Aug 78	1004	$P_2 8$	2631.068	0.014	0.014	0.000
15 Aug 78	0927	$P_2 8$	2631.068	0.009	0.011	−0.002
15 Aug 78	0929	$P_2 7$	2655.863	0.025	0.027	−0.002
15 Aug 78	0930	$P_2 5$	2703.999	0.017	0.008	+0.009
15 Aug 78	0934	$P_1 8$	2717.539	0.038	0.038	0.000
15 Aug 78	0936	$P_1 7$	2742.998	0.013	0.009	+0.004
15 Aug 78	0937	$P_1 6$	2767.968	0.026	0.024	+0.002
15 Aug 78	0939	$P_2 8$	2631.068	0.011	0.011	0.000
15 Aug 78	0940	$P_2 10$	2580.097	0.066	0.050	+0.016
15 Aug 78	0943	$P_2 12$	2527.391	0.030	0.016	+0.014
15 Aug 78	0946	$P_2 8$	2631.068	0.012	0.011	+0.001
19 Aug 78	0944	$P_2 8$	2631.068	0.019	0.022	−0.003
19 Aug 78	0945	$P_2 7$	2655.863	0.072	0.067	+0.005
19 Aug 78	0947	$P_2 5$	2703.999	0.023	0.020	+0.003
19 Aug 78	0948	$P_1 8$	2717.539	0.109	0.099	+0.010
19 Aug 78	0949	$P_1 7$	2742.998	0.023	0.023	0.000
19 Aug 78	0951	$P_1 6$	2767.968	0.047	0.058	−0.011
19 Aug 78	0952	$P_2 8$	2631.068	0.025	0.022	+0.003
19 Aug 78	0954	$P_2 10$	2580.097	0.072	0.059	+0.013
19 Aug 78	0956	$P_2 12$	2527.391	0.032	0.025	+0.007
19 Aug 78	0957	$P_2 8$	2631.068	0.021	0.022	−0.001

*See section on micrometeorology.

Table 2 — Contributions to Total Molecular Absorption Coefficient (km^{-1}) for DF Transitions of Interest for a Midlatitude Summer Atmosphere* Scaled to 33°C Air Temperature, 8.8 Torr H_2O, and 660 Torr Total Pressure Calculated Using HITRAN

Line ID	Total Molecular Absorption	H_2O Continuum	N_2 Continuum	HDO	CH_4	N_2O	H_2O	CO_2
2-1P12	0.019	0.009	0.009	0.000	0.001	0.000	0.000	0.000
2-1P10	0.054	0.008	0.002	0.002	0.000	0.041	0.000	0.001
2-1P8	0.017	0.008	0.001	0.002	0.003	0.000	0.003	0.000
2-1P7	0.050	0.008	0.001	0.039	0.002	0.000	0.000	0.000
2-1P5	0.014	0.010	0.000	0.004	0.000	0.000	0.000	0.000
1-OP8	0.076	0.010	0.001	0.065	0.000	0.000	0.000	0.000
1-OP7	0.016	0.011	0.000	0.003	0.002	0.000	0.000	0.000
1-OP6	0.042	0.012	0.000	0.025	0.005	0.000	0.000	0.000

*Contributions due to CO, O_3 and O_2 are not significant for the calculations represented in this table.

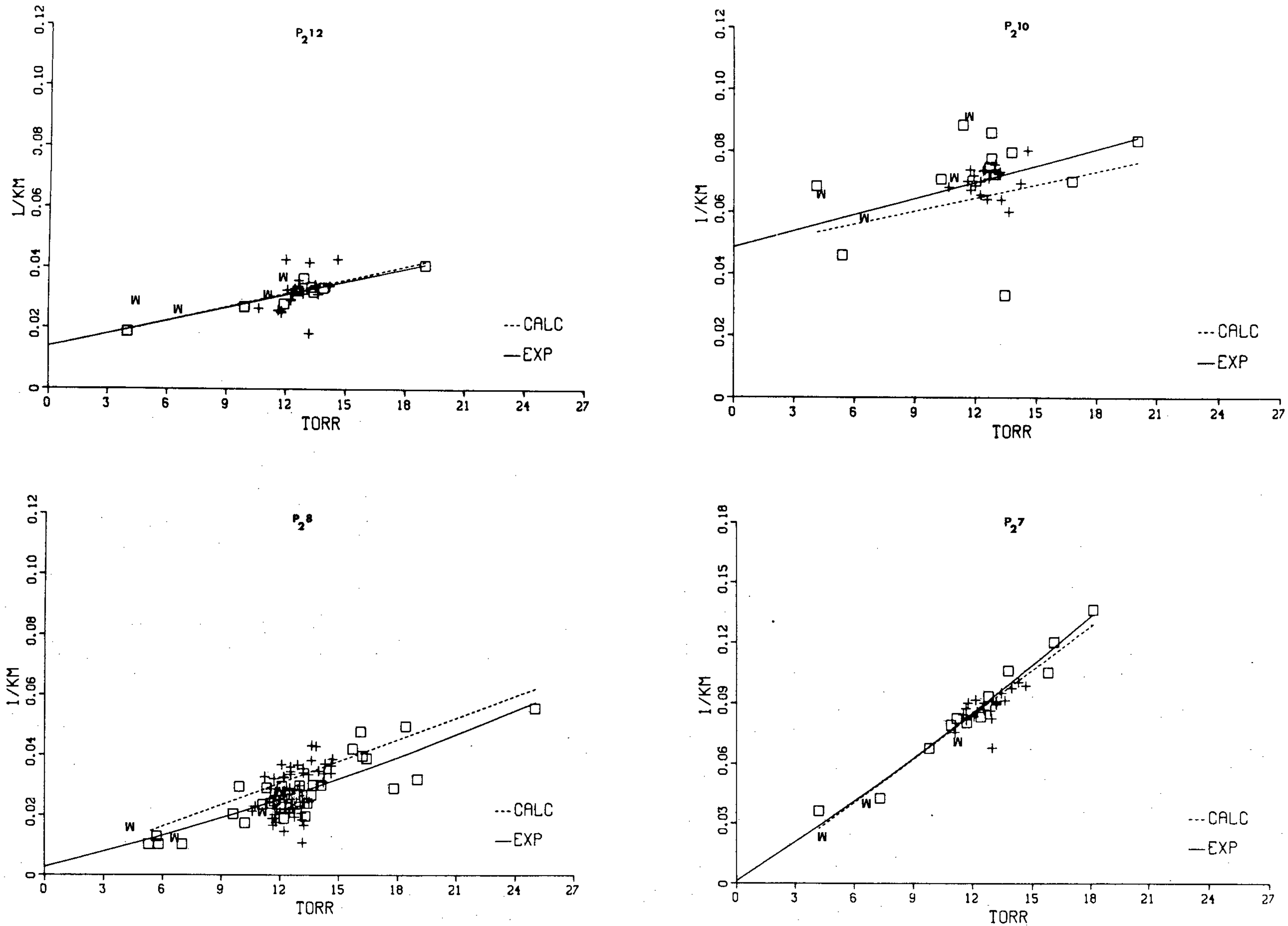

Fig. 1 — Measured DF molecular absorption coefficient dependence on water vapor partial pressure: □, Cape Canaveral Air Force Station Fla.; +, TRW Capistrano Test Site Calif.; W, WSMR, N. Mex.; ——, least squares fit to Flordia data; ------, SAI algorithm [1]

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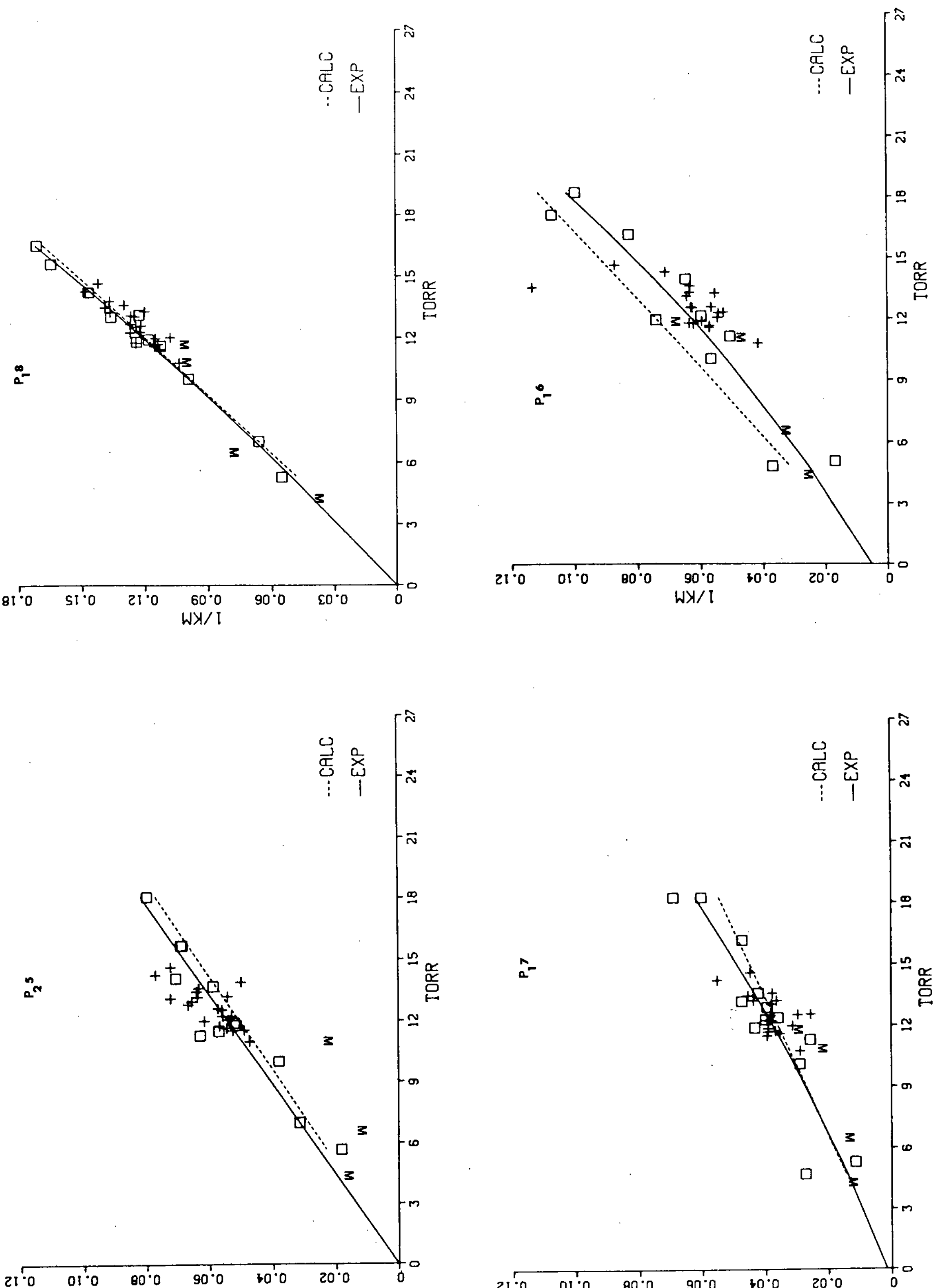

Fig. 2 — Measured DF molecular absorption coefficient dependence on water vapor partial pressure: □, Cape Canaveral Air Force Station, Fla.; +, TRW Capistrano Test Site Calif.; W, WSMR N. Mex.; ——, least squares fit to Flordia data; -----, SAI algorithm [1]

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The scatter of the P_210 line data in Fig. 1 exceeds the 0.008 km^{-1} uncertainty in the measurement and clearly indicates variations in the amount of the dominant absorbers for those atmospheric absorption lines that do not correlate with atmospheric H_2O. In this case it is the N_2O molecular component that comprises approximately 80% of the total absorption for the P_210 line (see Table 2). Inaccuracies in isolating the P_210 line from a neighboring DF line by the operator would tend to give a bimodal slope, depending on which of the two lines was present during measurement, but this is not indicated. The observed variation is present at both coastal measurement sites as well as the recent WSMR location. Software to obtain a ratio of the FTS spectra and numerical predictions will be generated to assess abundances of the IR absorbers along the path. A quantitative measure of the uncertainty caused by atmospheric variations and their influence on the measured absorption coefficient is given by the scatter of the data for the P_28 line shown in Fig. 1. The water-vapor concentration as integrated along the path will vary with the flux of air masses through the path and is only approximated by the two endpoint meteorological stations. Absorption of the P_28 line is dominated by H_2O line and H_2O continuum absorptions as shown in Table 2. Consequently, the uncertainties resulting from the use of the endpoint approximation to true-path-integrated H_2O result in a distribution of absolute humidities about the true value and contribute to the scatter seen in Fig. 1.

Within the limits of the scatter shown in Figs. 1 and 2, the molecular algorithms represented by the dashed lines accurately predict the water-vapor partial pressure dependence of DF laser molecular absorption near 30°C air temperature at WSMR.

Additional data were acquired in the 10-μm region with a CO_2 laser, and the results are shown in Table 3 along with HITRAN predictions for the observed atmospheric conditions. Agreement with predictions is generally not as good as that observed at DF wavelengths. With the exception of the R10-20* line, the differences between experiment and theory change with atmospheric conditions along the path. The precision of the CO_2 extinction experiment is equal to that of the DF results and certainly more than adequate to not give rise to the large discrepancies observed here. Hardware malfunctions of this order would be detected during zero path calibrations, where uncertainties are routinely in the third significant figure.

The R10-20 line absorption coefficient is consistently under that predicted for the observed atmospheric conditions. The dominant absorption process for this line, as shown in Table 4, is a strong H_2O line nearly coincident with the 975.931 cm^{-1} position of the R10-20 line. The H_2O line position is approximately 976.012 cm^{-1} and is apparently incorrectly identified in line position or line strength in the AFGL line atlas [5]. For example, were remeasurement to shift the H_2O line position by 0.05 cm^{-1}, agreement would be reached with the observed R10-20 extinction. If the line position is found to be correct, then the line strength must be significantly larger than previously believed. Figure 3 shows a HITRAN calculation using the existing AFGL line atlas behavior in the vicinity of the R10-20 line.

The large absorption effects at 10.6 μm that appear to vary with time are not modeled correctly by HITRAN. There is no direct correlation with water vapor, since better agreement and lower absorption coefficients were observed during the highest water-vapor conditions encountered, such as the 10 August measurement of 10.8-torr H_2O. Table 4 contains a breakdown of the molecular absorption mechanisms included in the theoretical predictions of HITRAN for conditions on 19 August. It is easy to see from Table 4 that our observations cannot be explained by increases in H_2O and CO_2 along the path, since all of the lines would be affected to some degree, and a characteristic shape for wavenumber dependence of the absorption would occur. Figures 4 through 7 show the comparison of experiment to theory for the range of water vapor conditions encountered. In all cases the upper trace at 975 cm^{-1} is the measured value. The effect seems to be broadband so as to affect neighboring lines but not so much so as to occur uniformly across the window. Absorption bands induced by airborne silicates are

*The notation R10-20 denotes the R_{10} line of the 001→100 CO_2 band; the same line in the 001→020 band would be denoted by R02-20, for example.

Table 3 — CO_2 Extinctions (km^{-1}) Measured over 6.4-km Path with HITRAN Predictions for Corresponding Meteorological Conditions*

Date	Time (local)	Line ID	Line Position (cm^{-1})	Experimental Extinction Coefficient (km^{-1})	Calculated Absorption Coefficient (km^{-1})	Experimental −Calculated (km^{-1})
10 Aug 78	1001	P10-20	944.195	0.198	0.208	−0.010
10 Aug 78	1004	P10-26	938.689	0.173	0.181	−0.008
10 Aug 78	1006	P10-30	934.895	0.166	0.168	−0.002
10 Aug 78	1008	P10-38	927.009	0.148	0.142	+0.006
10 Aug 78	1010	P10-14	949.480	0.197	0.203	−0.006
10 Aug 78	1016	R10-20	975.931	>1.	0.598	>0.4
10 Aug 78	1021	R10-28	980.914	0.522	0.166	+0.356
10 Aug 78	1024	P02-20	1046.854	0.509	0.208	+0.301
10 Aug 78	1028	R02-20	1078.591	0.238	0.207	+0.031
11 Aug 78	956	R02-38	1089.001	0.110	0.139	−0.029
11 Aug 78	958	R02-20	1078.591	0.211	0.231	−0.020
11 Aug 78	1000	P02-20	1046.854	0.459	0.233	+0.226
11 Aug 78	1005	R10-20	975.931	0.713	0.691	+0.022
11 Aug 78	1010	P10-20	944.195	0.585	0.242	+0.343
14 Aug 78	1028	P10-38	927.009	0.170	0.071	+0.099
14 Aug 78	1030	P10-20	944.195	0.770	0.148	+0.622
14 Aug 78	1035	R10-20	975.931	>1.	0.403	>0.6
14 Aug 78	1047	R02-38	1089.001	0.105	0.071	+0.034
15 Aug 78	1006	P10-20	944.195	0.577	0.121	+0.456
15 Aug 78	1008	P10-38	927.009	0.520	0.048	+0.472
15 Aug 78	1010	R10-20	975.931	0.715	0.281	+0.434
15 Aug 78	1014	R10-20	975.931	0.660	0.281	+0.379
15 Aug 78	1017	P02-20	1046.854	0.179	0.147	+0.032
15 Aug 78	1020	R02-20	1078.591	0.178	0.149	+0.029
15 Aug 78	1023	R02-38	1089.001	0.618	0.053	+0.565
17 Aug 78	1912	R02-38	1089.001	0.052	0.078	−0.026
17 Aug 78	1914	R02-20	1078.591	0.155	0.186	−0.031
17 Aug 78	1915	P02-20	1046.854	0.165	0.182	−0.017
17 Aug 78	1916	R10-20	975.931	>1.	0.456	>0.5
17 Aug 78	1920	P10-20	944.195	0.486	0.162	+0.324
17 Aug 78	1922	P10-38	927.009	0.602	0.079	+0.523
18 Aug 78	1007	P10-38	927.009	0.150	0.120	+0.030
18 Aug 78	1010	P10-20	944.195	0.642	0.197	+0.445
18 Aug 78	1014	R10-20	975.931	>1.	0.589	>0.4
18 Aug 78	1018	P02-20	1046.854	0.497	0.204	+0.293
18 Aug 78	1021	R02-20	1078.591	0.228	0.205	+0.023
18 Aug 78	1036	R02-38	1089.001	0.483	0.104	+0.379
19 Aug 78	1023	P10-20	944.195	0.128	0.219	−0.091
19 Aug 78	1024	P10-38	927.009	0.085	0.153	−0.068
19 Aug 78	1026	R10-20	975.931	>1.	0.633	>0.3
19 Aug 78	1029	P02-20	1046.854	0.502	0.217	+0.285
19 Aug 78	1032	R02-20	1078.591	0.222	0.216	+0.006
19 Aug 78	1033	R02-20	1078.591	0.219	0.216	+0.003
19 Aug 78	1036	R02-38	1089.001	0.130	0.123	+0.007

*The line identification notation used is as follows: P10-20 corresponds to the P_{20} line of the CO_2 00°1 → 10°0 vibrational band, P02-20 corresponds to the P_{20} line of the CO_2 00°1 → 02°0 vibrational band.

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Table 4 — Contributions to Total Molecular Absorption Coefficient (km^{-1}) of a Midlatitude Summer Atmosphere Scaled to 25.8°C Air Temperature, 10.8 Torr H_2O and 660 Torr Total Pressure for CO_2 Laser Lines of Interest*

Line ID	Total Molecular Absorption	H_2O Continuum	CO_2	H_2O	O_3
P10-38	0.153	0.125	0.026	0.002	0.000
P10-20	0.219	0.118	0.093	0.008	0.000
R10-20	0.633	0.106	0.099	0.428	0.000
P02-20	0.217	0.089	0.118	0.001	0.009
R02-20	0.216	0.084	0.0128	0.004	0.000
R02-38	0.123	0.083	0.036	0.003	0.000

*Contributions due to CH_4, N_2O, HDO, CO, and O_2 are not significant for the calculations represented in this table.

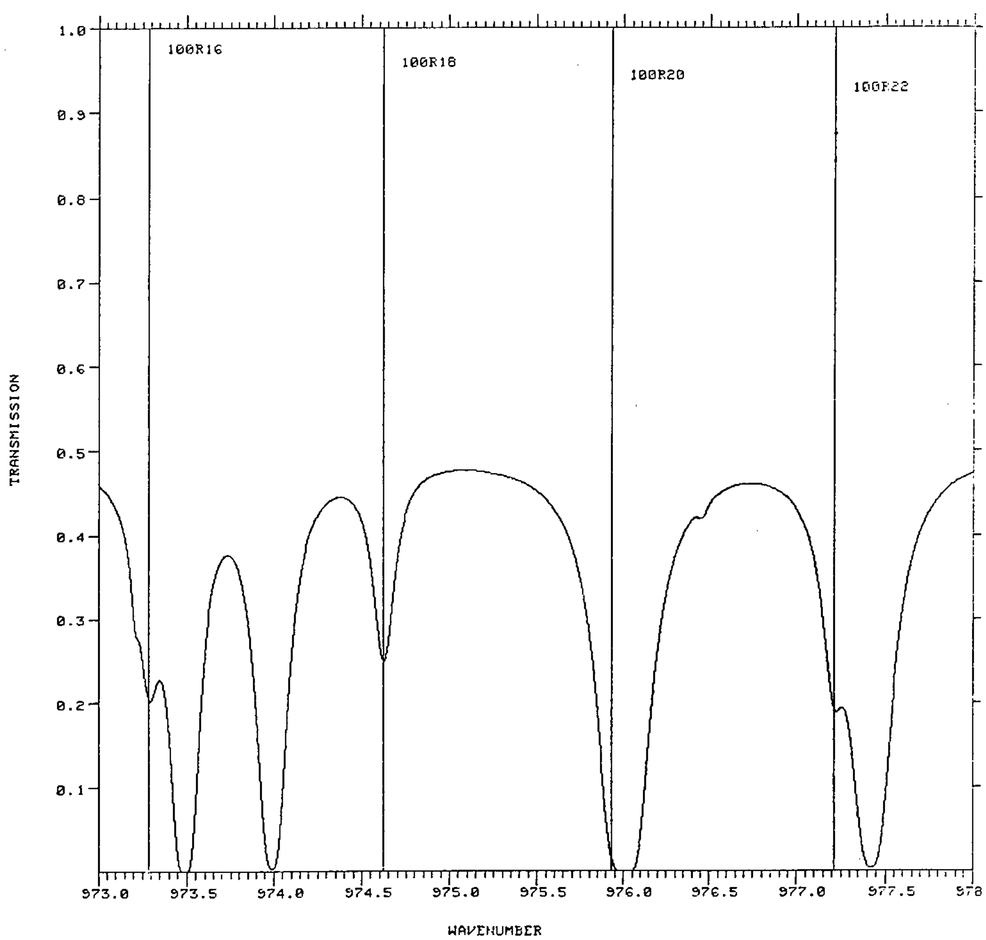

Fig. 3 — HITRAN transmission prediction over 6.4-km path in vicinity of R10-20 CO_2 line for midlatitude summer atmosphre scaled to 25.8°C air temperature, 1440 Pa (10.8 torr) H_2O, and 88 × 10^3 Pa (660 torr) total pressure

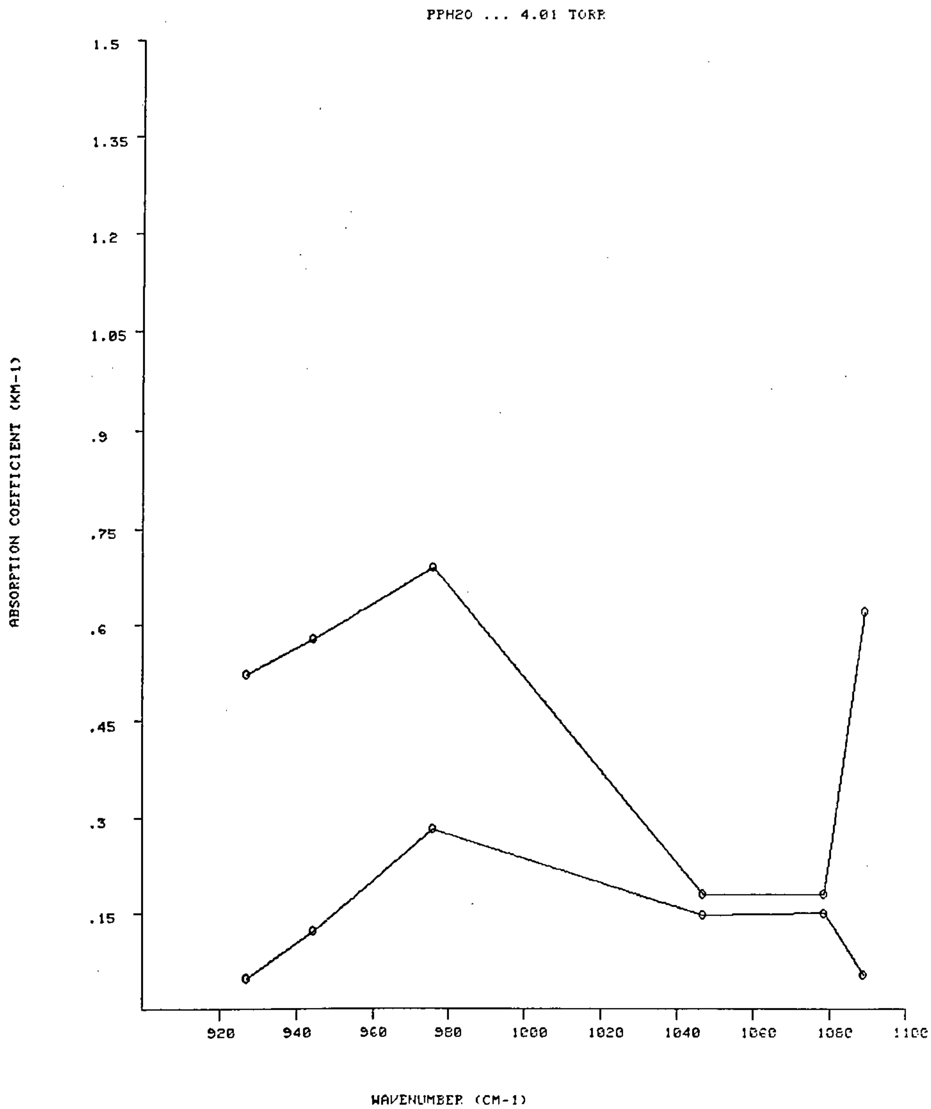

Fig. 4 — Top trace at 975 cm^{-1} is measured CO_2 absorption coefficient over 6.4-km path. Bottom trace at 975 cm^{-1} HITRAN is the prediction for 534 Pa (4.01 torr) H_2O.

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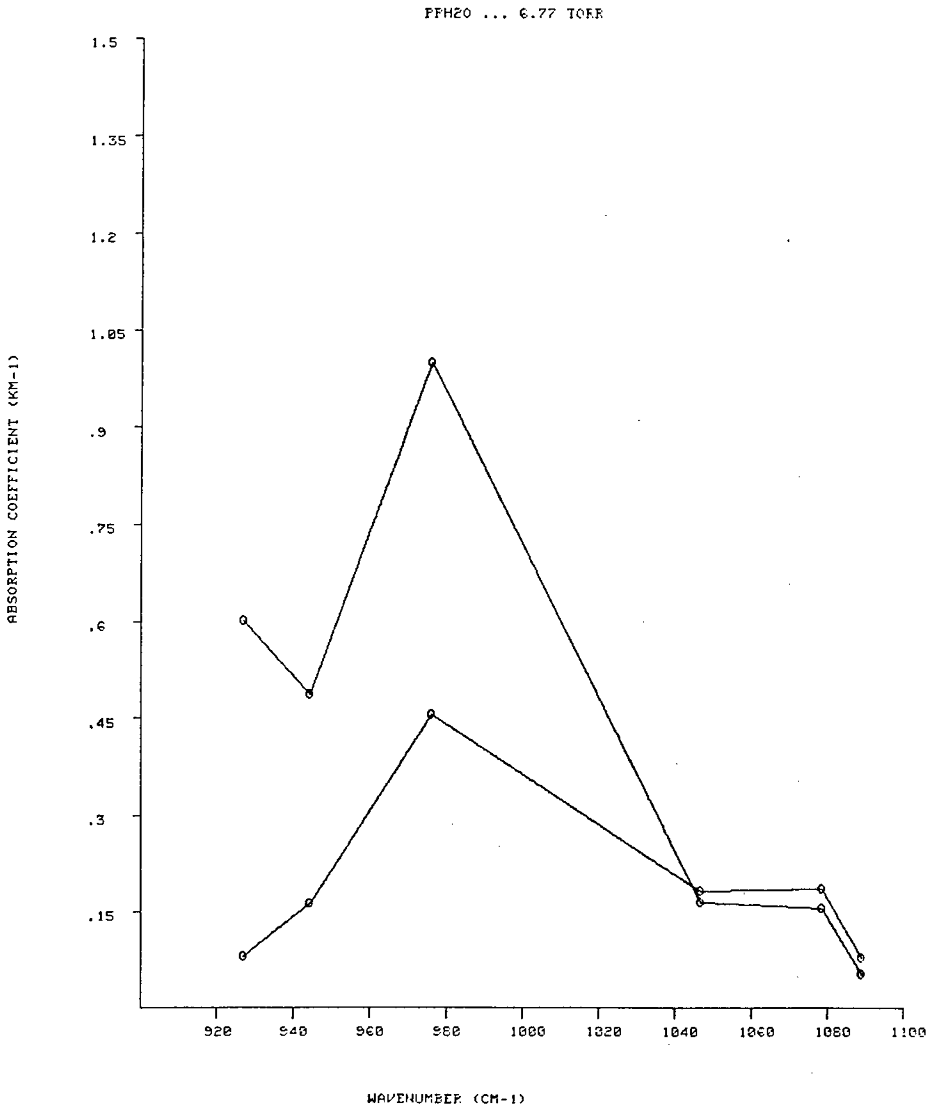

Fig. 5 — Top trace at 975 cm^{-1} is measured absorption coefficient over 6.4-km path. Bottom trace at 975 cm^{-1} is the HITRAN prediction for 903 Pa (6.77 torr) H_2O.

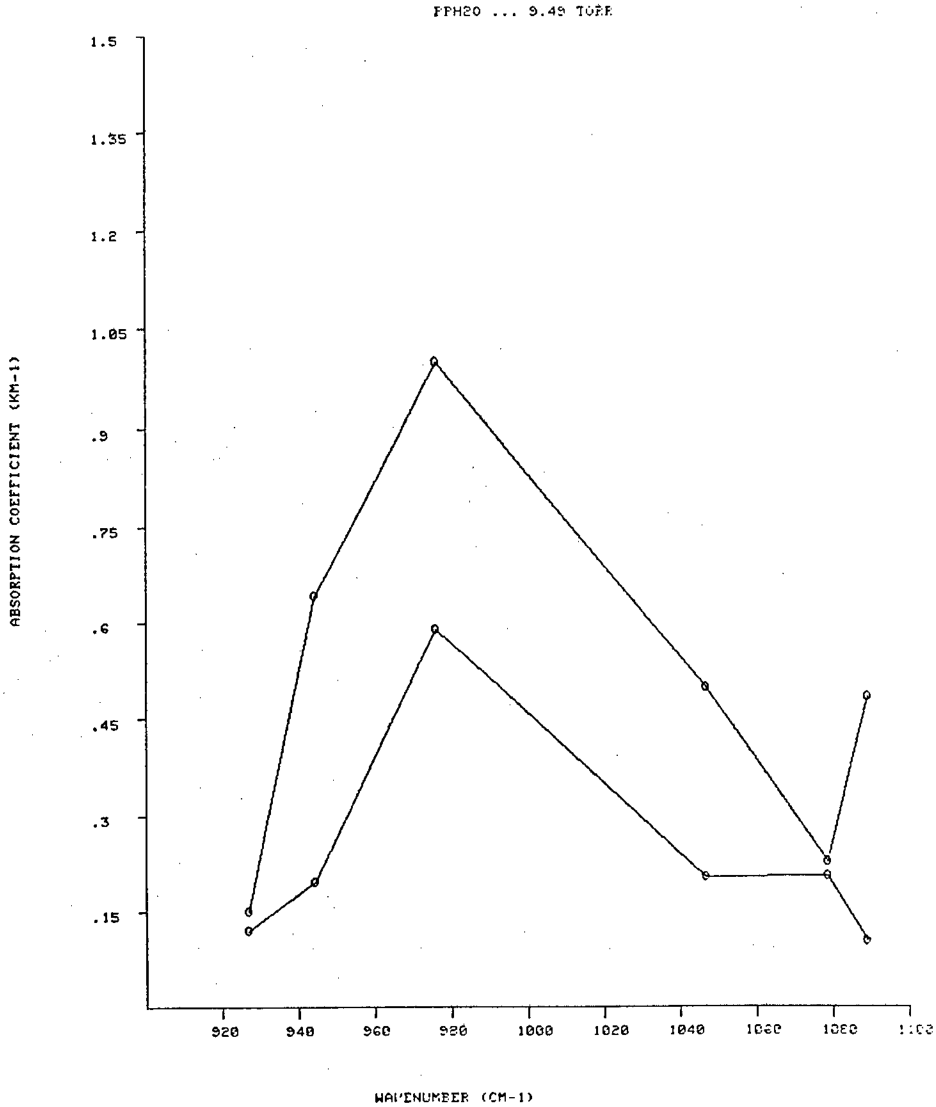

Fig. 6 — Top trace at 975 cm^{-1} is measured absorption coefficient over 6.4-km path. Bottom trace at 975 cm^{-1} is the HITRAN prediction for 1265 Pa (9.49 torr) H_2O.

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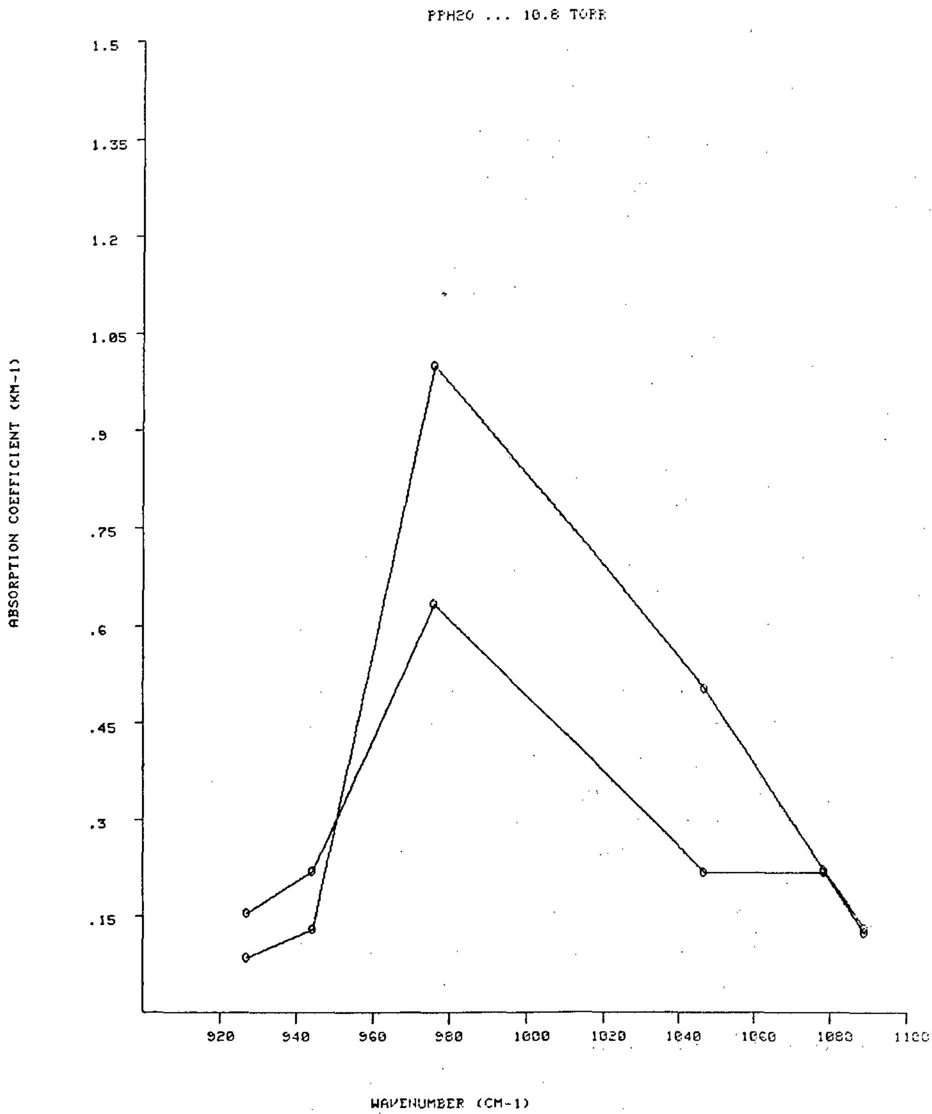

Fig. 7 — Top trace at 975 cm^{-1} is measured absorption coefficient over 6.4-km path. Bottom trace at 975 cm^{-1} HITRAN is the prediction for 1440 Pa (10.8 torr) H_2O.

known to coincide with the observed absorptions, but the amount of absorption is higher than that to be expected from airborne silicates. Wind speed and direction are recorded in the section of this report on micrometeorology and may be used to study correlation with this strong absorption mechanism.

FOURIER TRANSFORM SPECTROSCOPY

A scanning Michelson interferometer with 16-cm retardation capability was used to measure relative atmospheric transmission from 2 to 6 μm and from 3 to 14 μm, with two separate detector—beamsplitter combinations. For 3 to 14 μm, the HgCdTe detector and KBr beamsplitter produce a lower signal-to-noise ratio and are more sensitive to background radiance levels than the 2- to 6-μm InSb detector and CaF_2 beamsplitter combination. The advantage of the extended 3- to 14-μm wavelength coverage would be more apparent at lower noise levels; this would be achievable with a matched detector—preamplifier combination and a smaller detector chip (noise equivalent power for a detector scales directly with chip area). Currently, the 8- to 14-μm window fast Fourier transform (FFT) data are presented at low resolution for inclusion in this report. Software is being developed to average noisy spectra and improve the transform process, which will result in higher resolution data in the 8- to 14-μm region.

Representative spectra for the InSb spectral region are shown in Figs. 8 through 11 for conditions of 1172 Pa (8.8 torr) H_2O and 33°C air temperature. The stronger absorption lines in general appear narrower than those obtained in earlier atmospheric measurements [7]. Figures 12 through 16 are HITRAN predictions for the same atmospheric conditions that have been convolved with a 0.08 cm^{-1} $(\sin x)/x$ instrument function to match more closely the data presented in Figs. 8 through 11. In the 5-μm region, we observe stronger continuum absorption features than those currently predicted by HITRAN. Close scrutiny of features reveals minor differences between theory and experiment such as the window between 2020 cm^{-1} and 2040 cm^{-1}. The AFGL line atlas should be adjusted to match the structure of the peak of transmission and relative intensities of peaks observed in this spectral region important for CO laser propagation. As previously observed [8], in sea level coastal measurements, the 4.3-μm CO_2 band edge near 2400 cm^{-1} is more rounded than the HITRAN predictions (Fig. 14). This indicates that a different absorption line wing profile is required for the strong CO_2 absorption lines in this region than the Lorentz shape normally used, or else that a greater N_2 continuum absorption exists than is currently modeled in the 4.2-μm region. The relative strengths of the two HDO lines and the one H_2O line at 2730 cm^{-1} (Fig. 9) indicate only slightly less than the 0.03% abundance ratio for HDO expected relative to H_2O. Most spectral features are in fairly good agreement with HITRAN predictions in the DF region, as indicated by the DF laser extinction results presented earlier in this report.

High dispersion HITRAN plots for the 1172 Pa (8.8 torr) water-vapor conditions of the spectra shown above are plotted near several DF lines in Figs. 17 and 18. The N_2O dominance of the P_210 line as well as the H_2O and CH_4 dominance of the P_28 are indicated in Fig. 17.

Representative FTS plots for the 8- to 14-μm region are shown in Fig. 19 for data taken on 17 August 1978. The upper panel in Fig. 19 shows a spectrum resulting from a 200-scan average taken during a 30-min period centered around 1830, and the lower trace is again a 200-scan average taken during a 30-min period centered around 2030. These data correspond to 1.4 cm^{-1} resolution but can be processed with improved resolution as software is upgraded. During these measurements, the air temperature was 31°C and the water vapor was 1065 Pa (8.0 torr) at the endpoints of the 6.4-km path.

In general it is observed that there is greater continuum absorption in the 12- to 14-μm region than predicted, but otherwise spectral features appear quite similar to the HITRAN calculations convolved with a 1.4 cm^{-1} $(\sin x)/x$ instrument function shown in Figs. 20 and 21.

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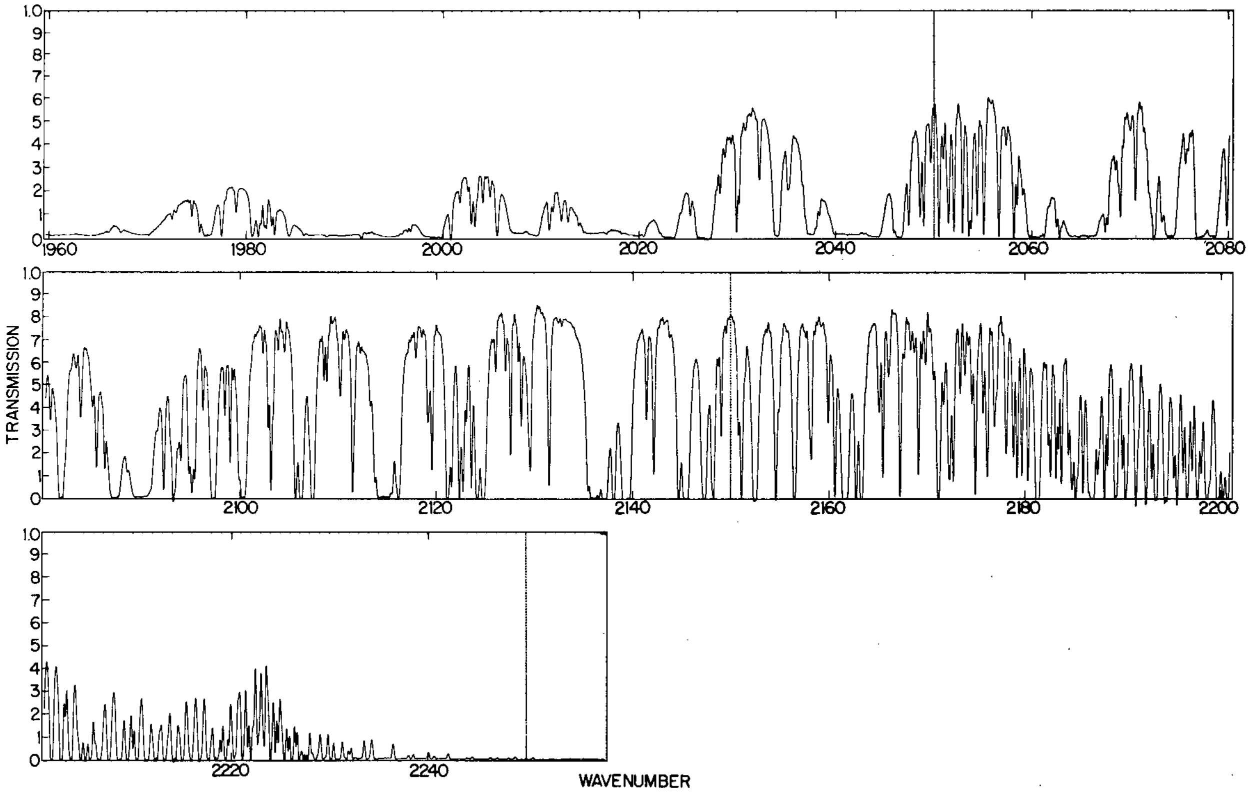

Fig. 8 — Measured atmospheric transmission over 6.4-km path for 1173 Pa (8.8 torr) H_2O and 33°C air temperature in the 3- to 5-μm region

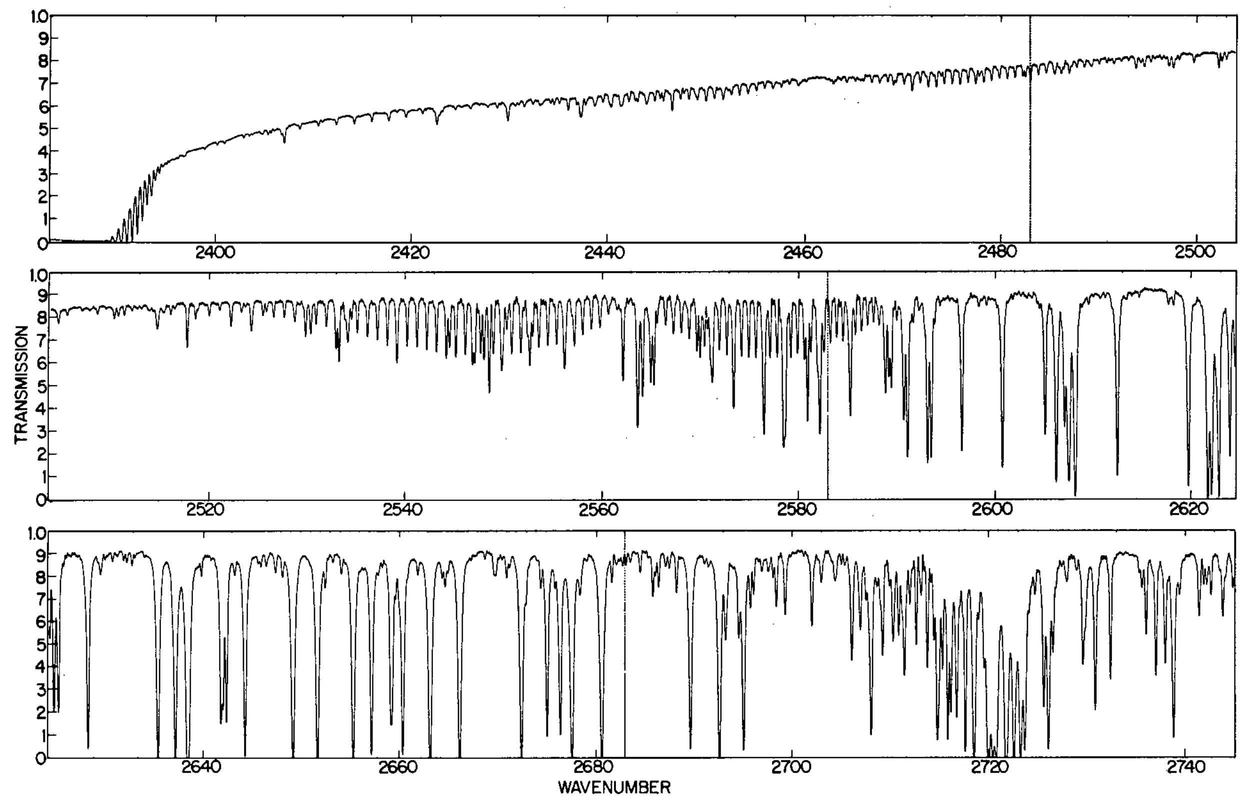

Fig. 9 — Measured atmospheric transmission over 6.4-km path for 1173 Pa (8.8 torr) H_2O and 33°C air temperature in the 3- to 5-μm region

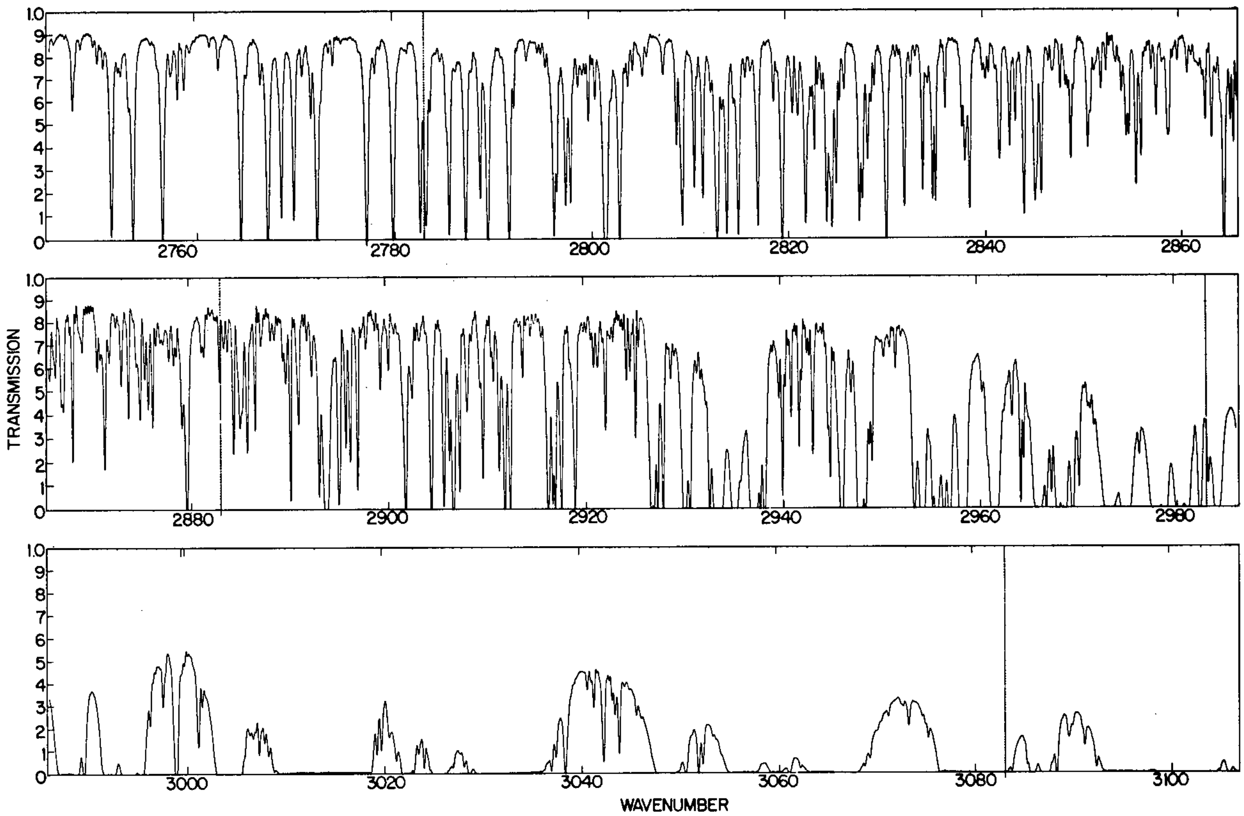

Fig. 10 — Measured atmospheric transmission over 6.4-km path for 1173 Pa (8.8 torr) H_2O and 33°C air temperature in the 3- to 5-μm region

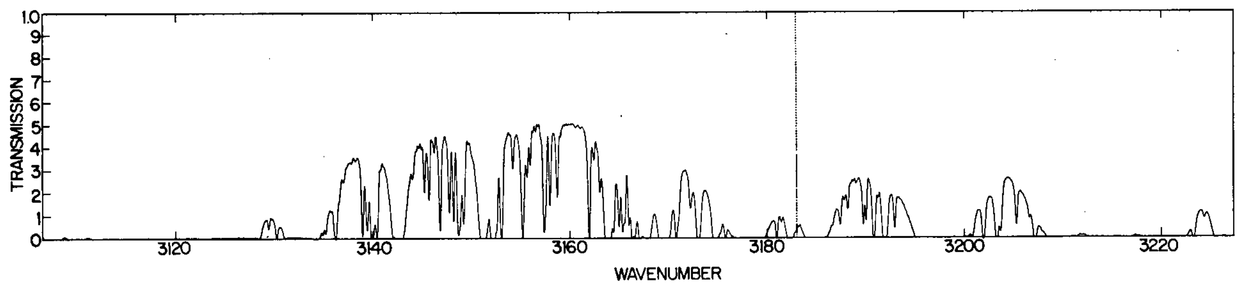

Fig. 11 — Measured atmospheric transmission over 6.4-km path for 1173 Pa (8.8 torr) H_2O and 33°C air temperature in the 3- to 5-μm region

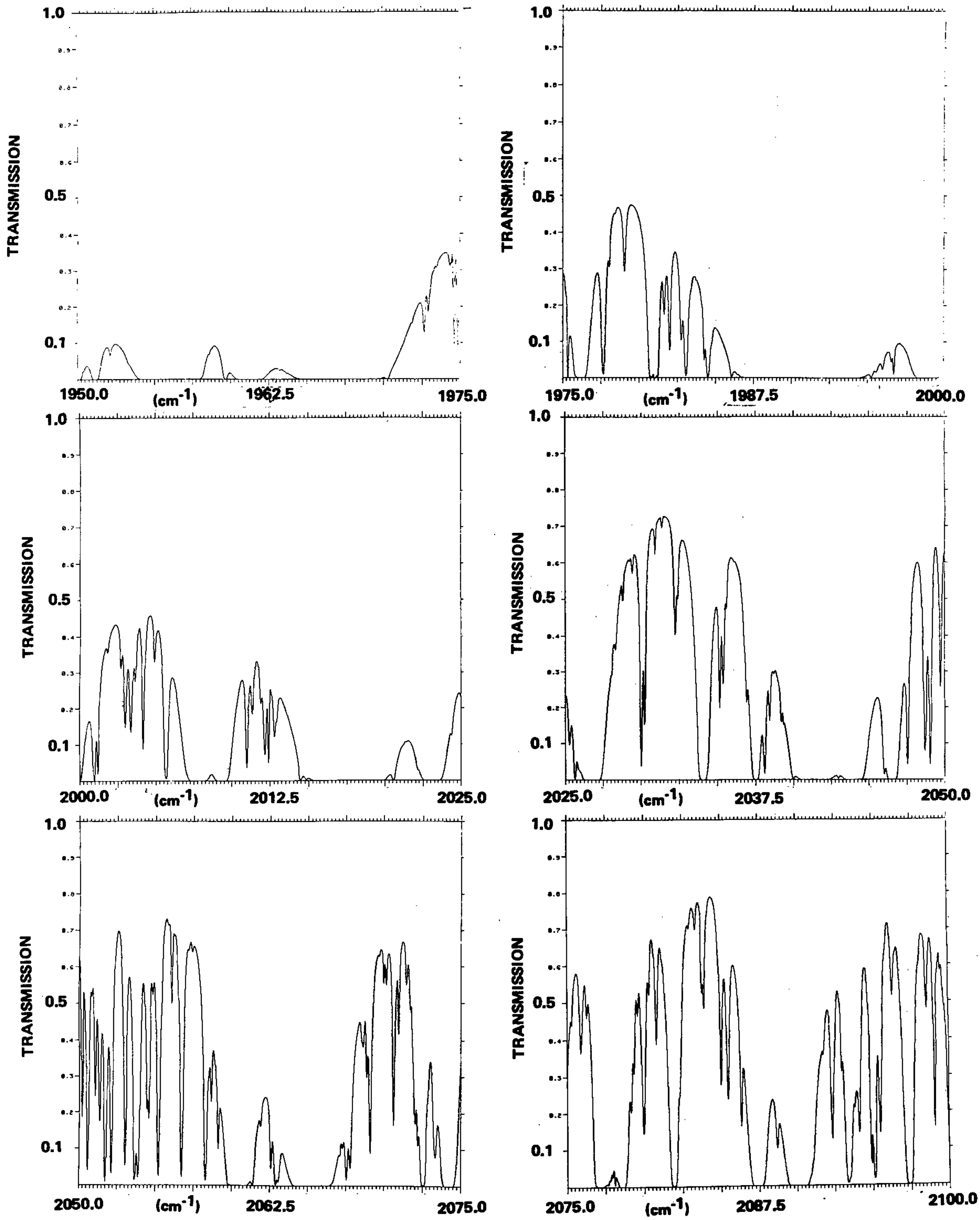

Fig. 12 — HITRAN predictions for atmospheric transmission over 6.4-km path with midlatitude summer conditions scaled to 1173 Pa (8.8 torr) H_2O, 33°C air temperature, and 88 × 10^3 Pa (660 torr) total pressure

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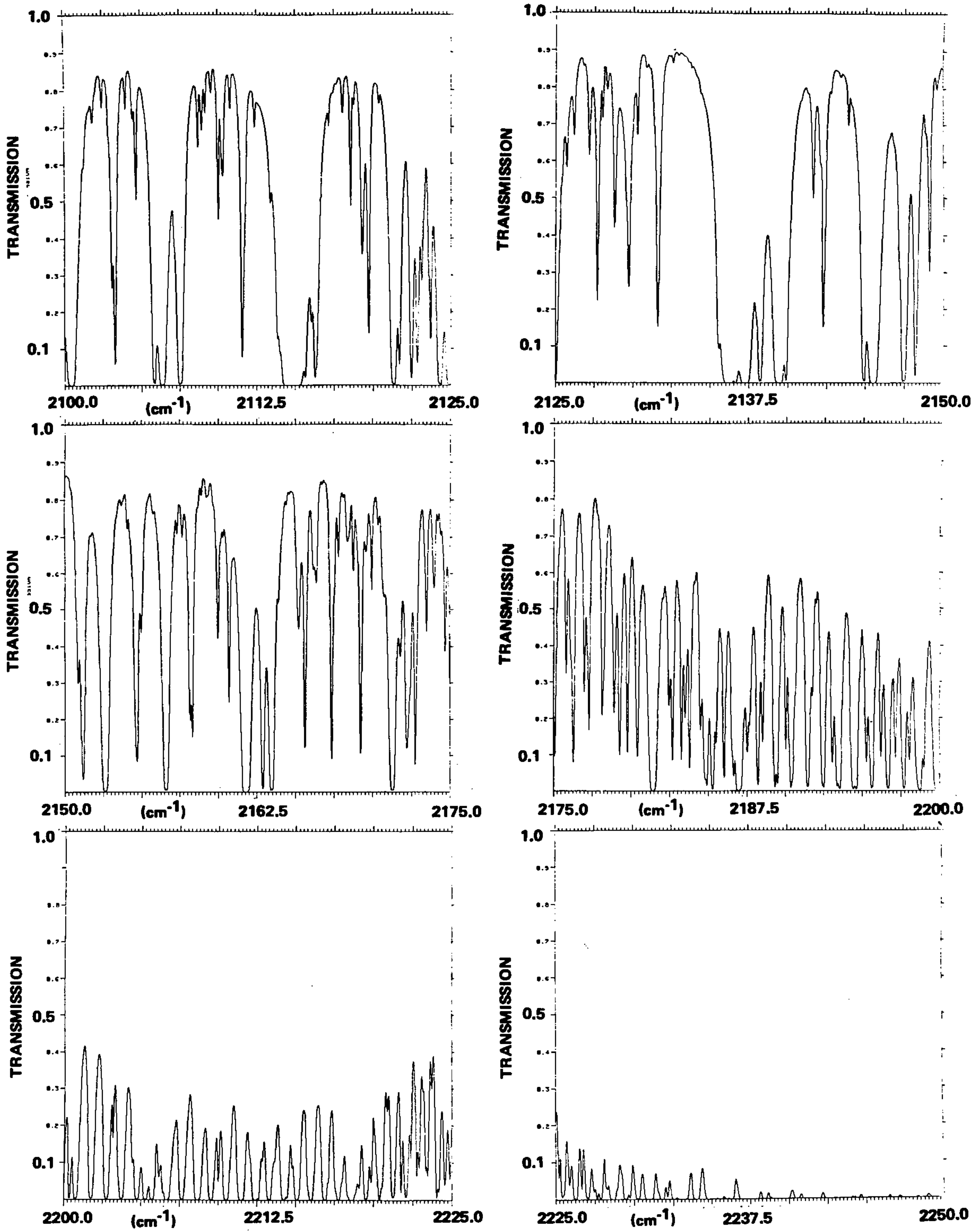

Fig. 13 — HITRAN predictions for atmospheric transmission over 6.4-km path with midlatitude summer conditions scaled to 1173 Pa (8.8 torr) H_2O, 33°C air temperature, and 88 × 10^3 Pa (660 torr) total pressure

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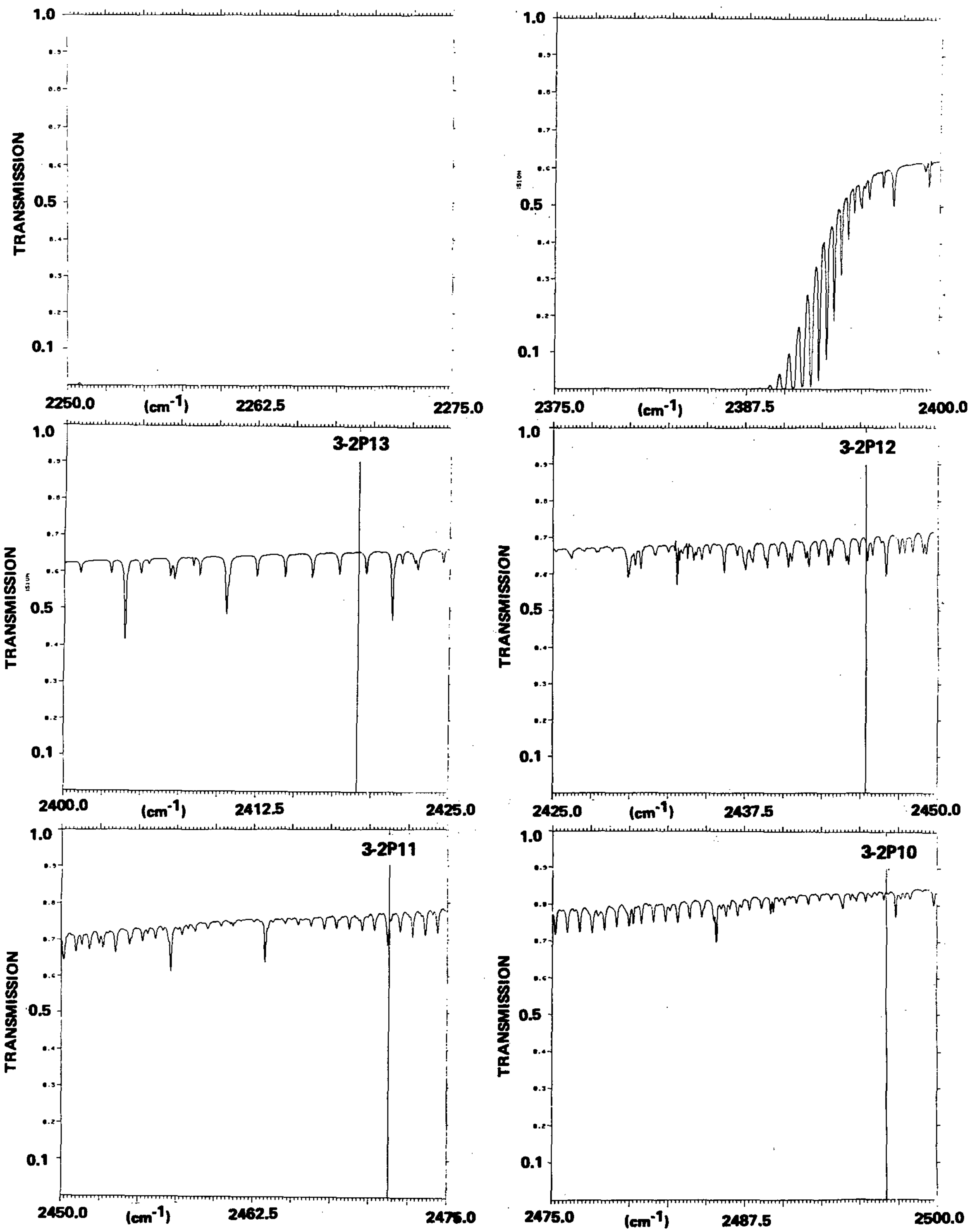

Fig. 14 — HITRAN predictions for atmospheric transmission over 6.4-km path with midlatitude summer conditions scaled to 1173 Pa (8.8 torr) H_2O, 33°C air temperature, and 88×10^3 Pa (660 torr) total pressure

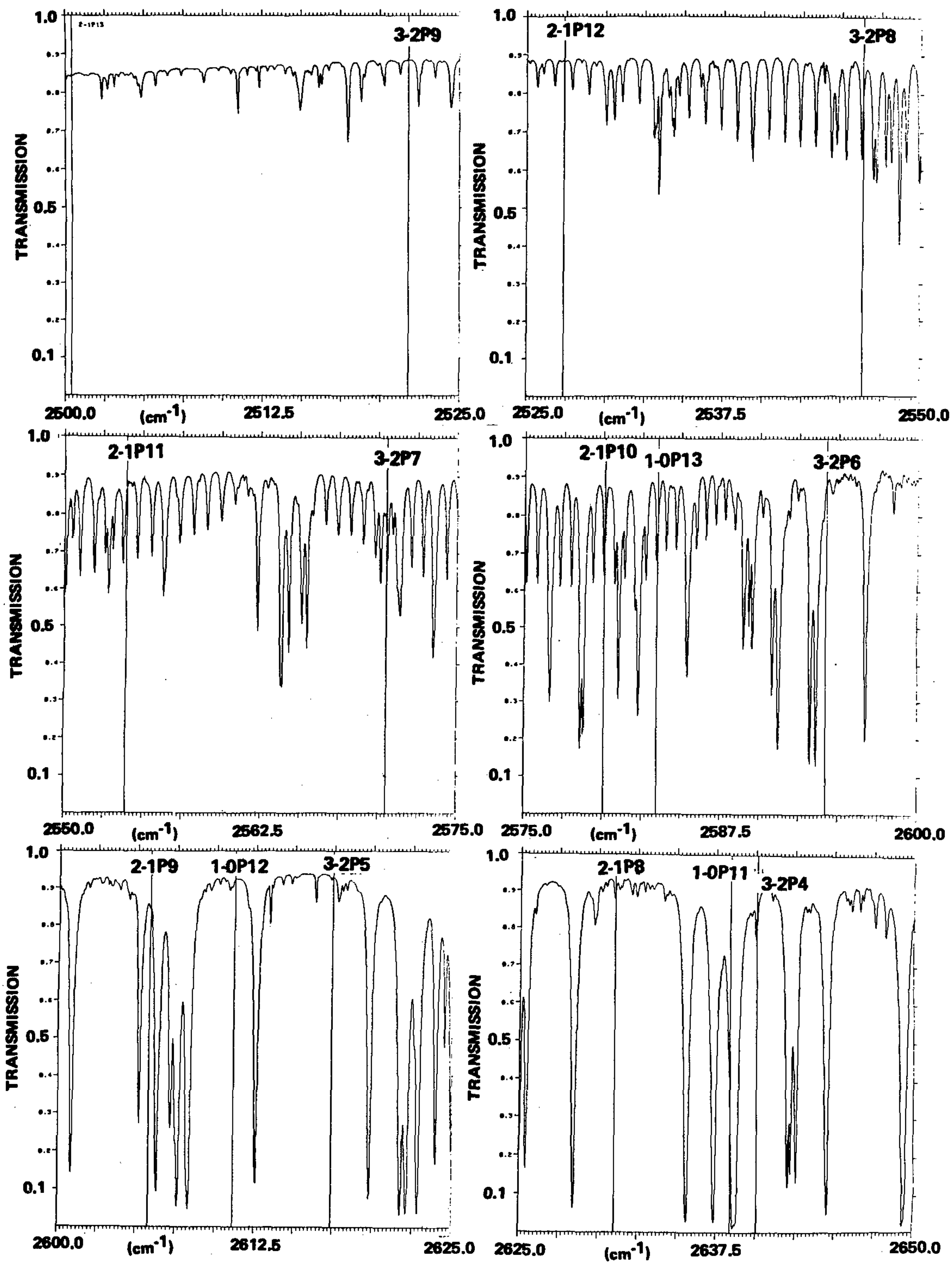

Fig. 15 — HITRAN predictions for atmospheric transmission over 6.4-km path with midlatitude summer conditions scaled to 1173 Pa (8.8 torr) H_2O, 33°C air temperature, and 88 × 10^3 Pa (660 torr) total pressure

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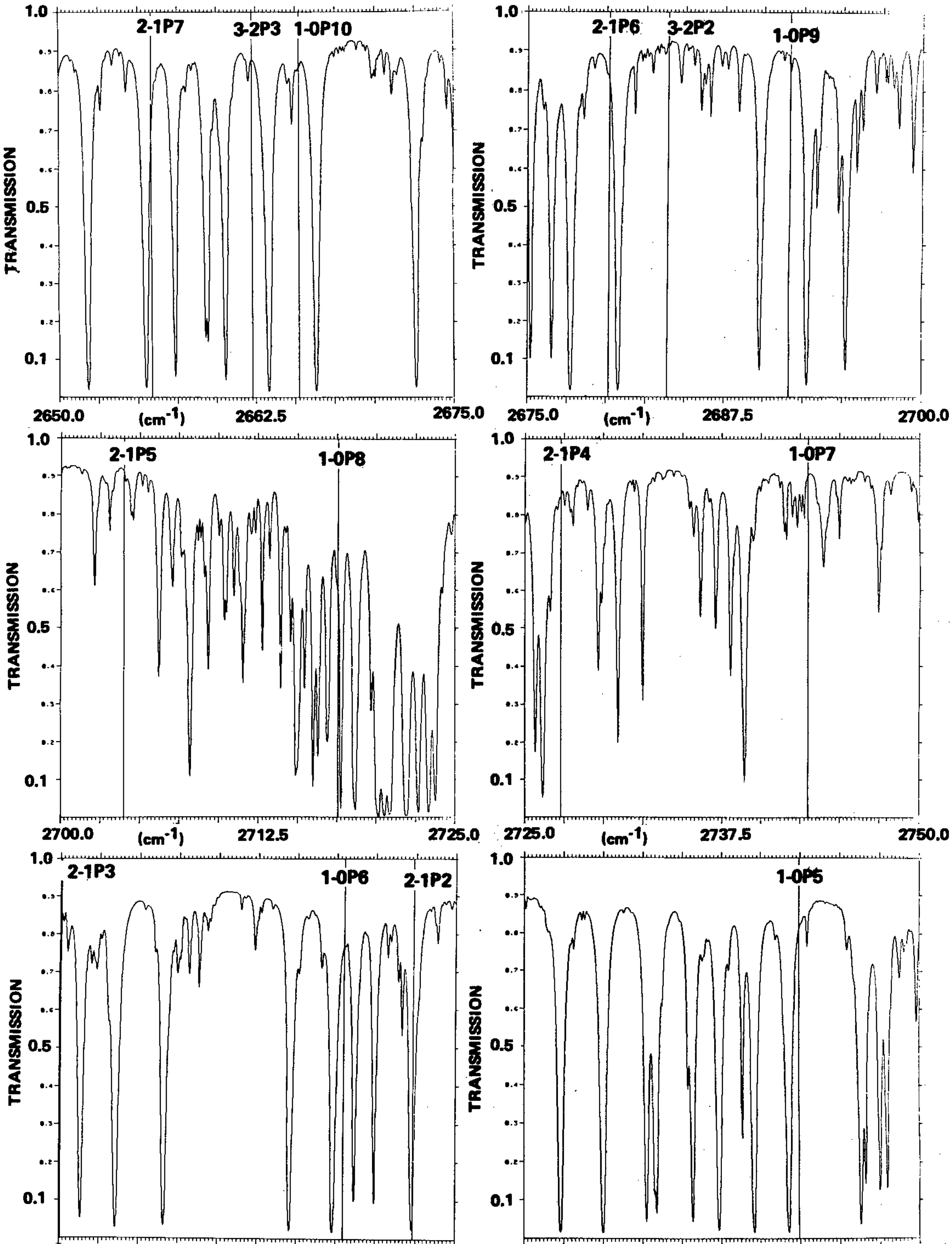

Fig. 16 — HITRAN predictions for atmospheric transmission over 6.4-km path with midlatitude summer conditions scaled to 1173 Pa (8.8 torr) H_2O, 33°C air temperature, and 88×10^3 Pa (660 torr) total pressure

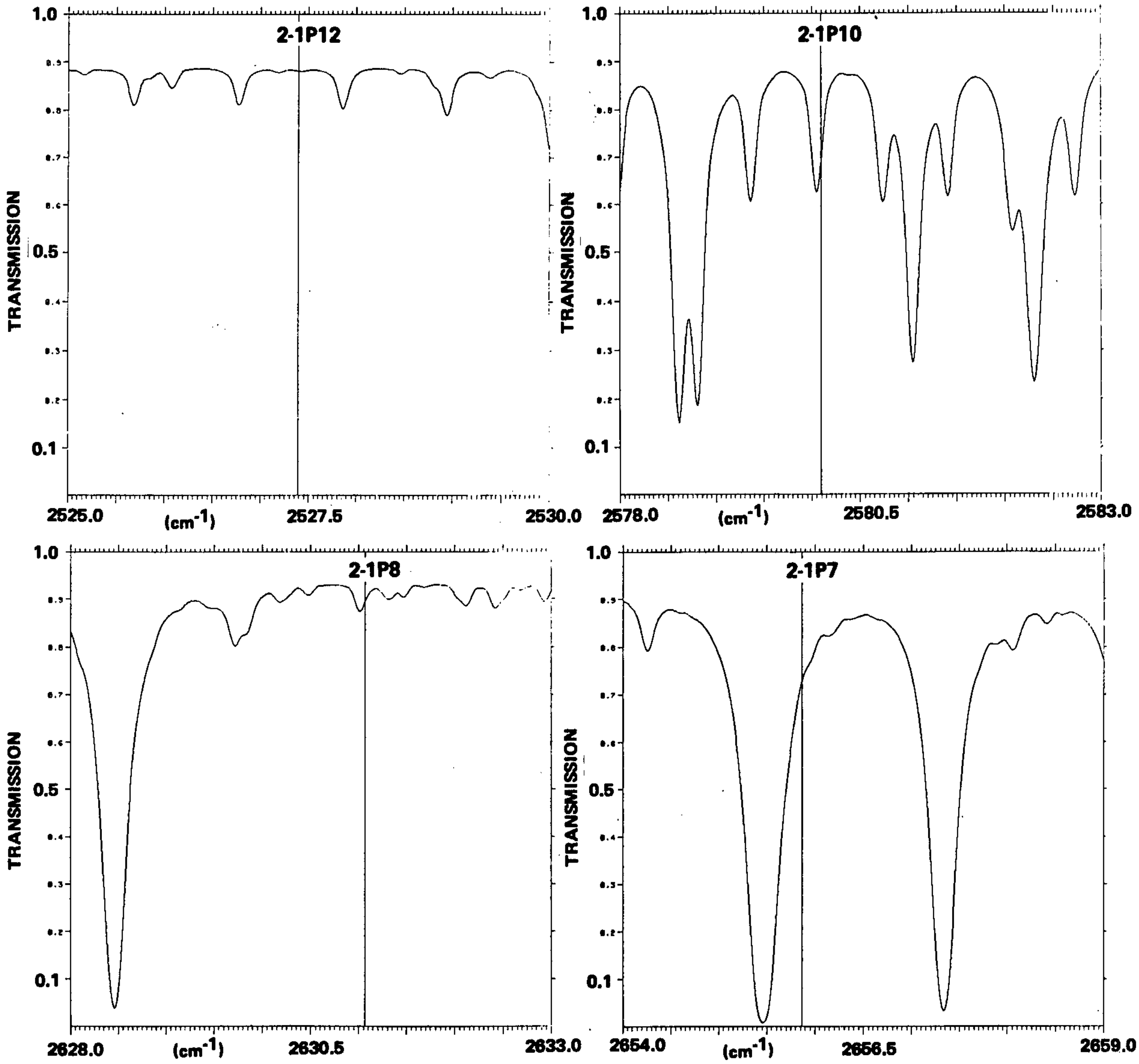

Fig. 17 — High-dispersion HITRAN plots for 1173 Pa (8.8 Torr) H_2O, 33°C air temperature, and 88×10^3 Pa (660 torr) total pressure for each DF line of interest

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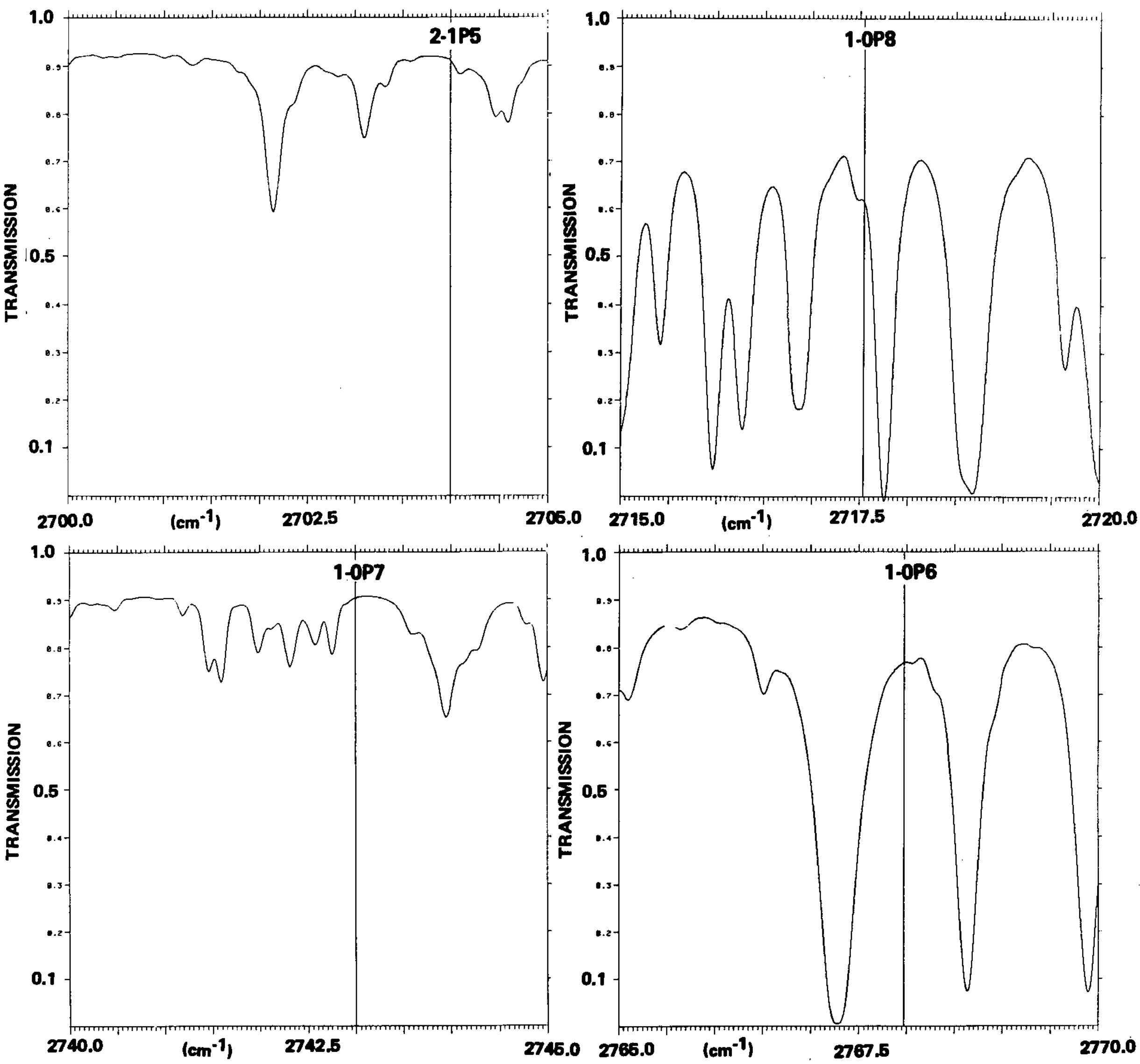

Fig. 18 — High dispersion HITRAN plots for 1173 Pa (8.8 Torr) H_2O, 33°C air temperature, and 88×10^3 Pa (660 torr) total pressure for each DF line of interest

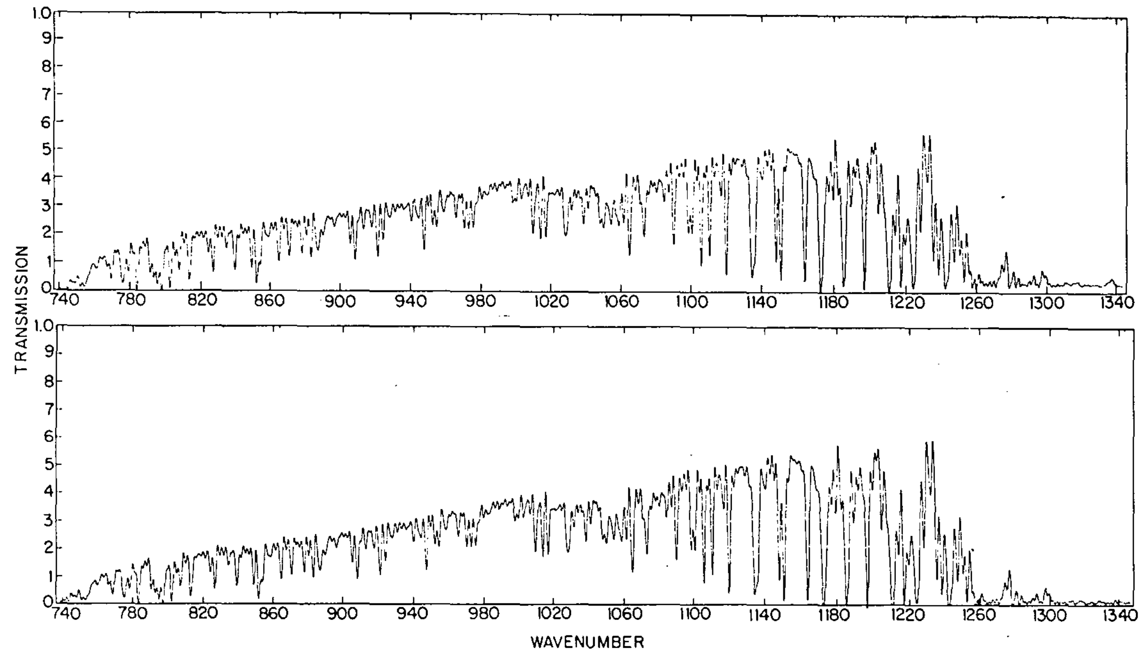

Fig. 19 —Measured atmospheric transmission over 6.4-km path for 1067 Pa (8.0 torr) H_2O and 31°C air temperature in the 8- to 14-μm region. Upper panel measurement centered at 1830 on 17 August 1978; lower panel measurement centered at 2030 on the same day.

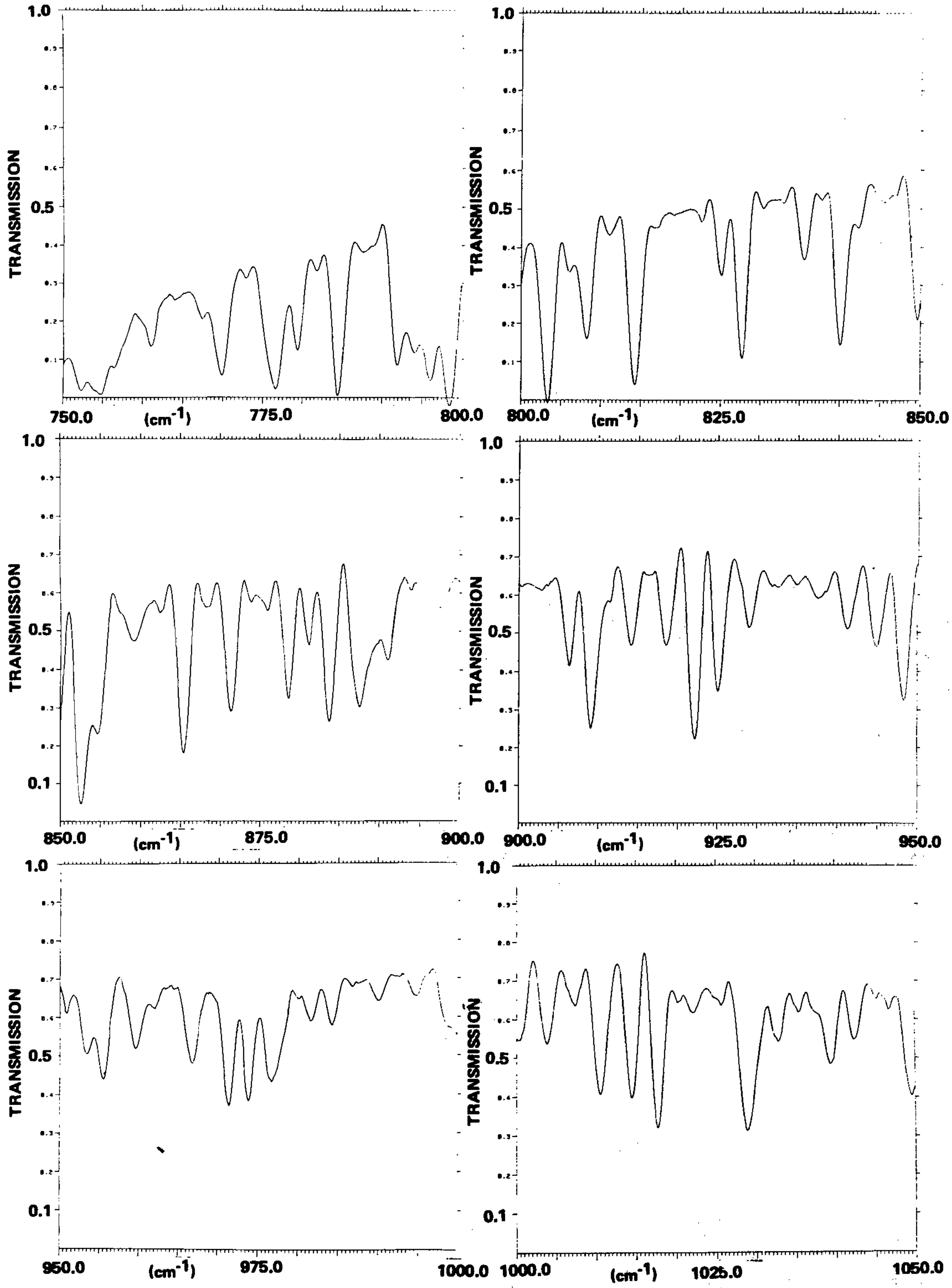

Fig. 20 — HITRAN predictions for atmospheric transmission over 6.4-km path with midlatitude summer conditions scaled to 1067 Pa (8.0 torr) H_2O, 31°C air temperature, with a 1.4 cm^{-1} $(\sin x)/x$ instrument function convolution

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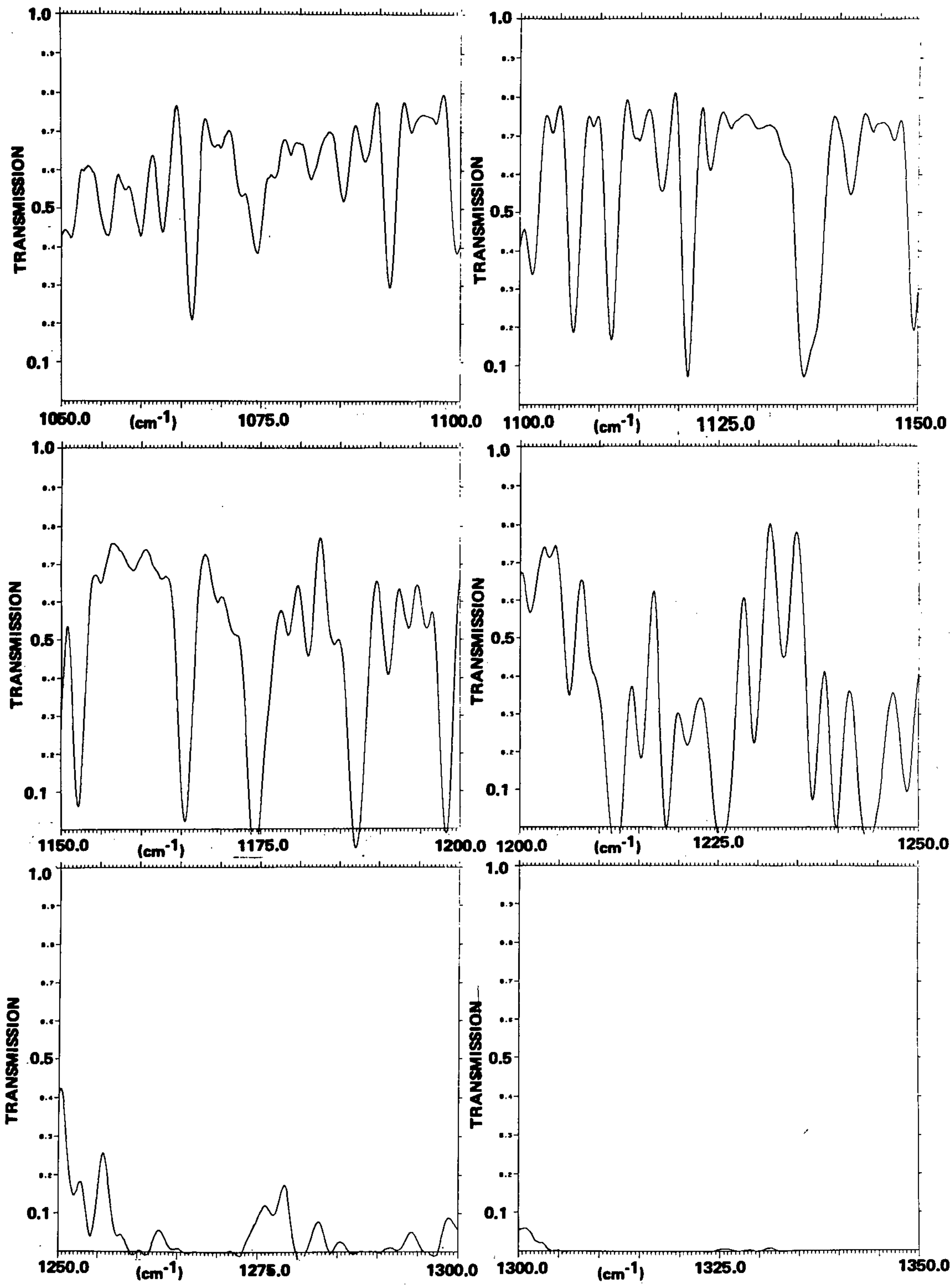

Fig. 21 — HITRAN predictions for atmospheric transmission over 6.4-km path with midlatitude summer conditions scaled to 1067 Pa (8.0 torr) H_2O, 31°C air temperature, with a 1.4 cm^{-1} $(\sin x)/x$ instrument function convolution

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PATH SELECTION

Selection of a suitable path for these measurements was subject to several constraints. A major goal was to maintain beam elevation some distance above ground cover. The elevated beam height minimizes sensitivity of results to strong vertical gradients of turbulence and aerosols. Funding limited the size of the earthen berms which could be built for this experiment, and range restrictions ruled out all but a few locations for beam placement. The transmitter position was built at a test site near a location called ARKY. An additional 6.1 m (20 ft) were added to existing high ground in this area, with the top surface bladed flat and compacted. Earthen ramps were constructed and overall dimensions were designed to enable zero path calibrations to be carried out on top of the mound without disturbing transmitter alignment. It was necessary to locate the receiver at 4 to 7 km distance and preferably to utilize existing high ground to obtain maximum effectiveness of existing monies. Range Control at WSMR ruled out the first two receiver sites chosen, but finally relented and agreed to the use of the receiver site at a location called PAT, a distance of 6.4 km from the transmitter as shown in Fig. 22. This 6.4-km path provides a good compromise between the long path needed for precise absorption coefficient measurements and the need for limiting path length so as not to allow turbulence beam spreading to overfill the 1.2-m receiver mirror.

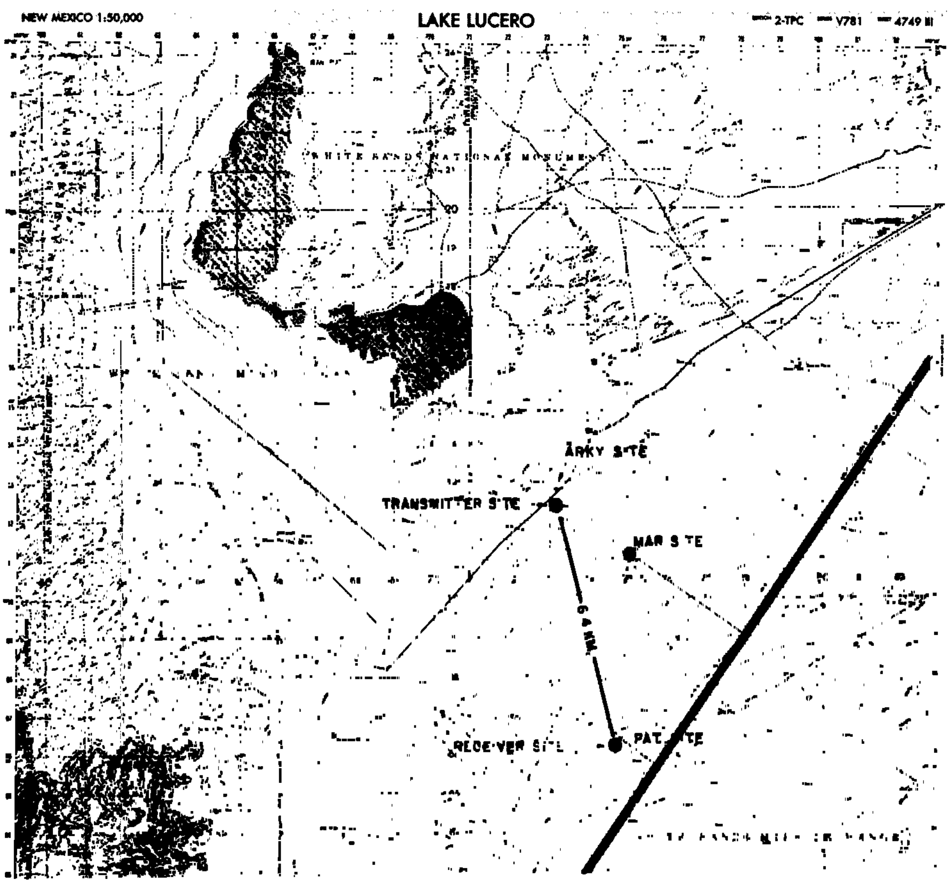

Fig. 22 — Location of the 6.4-km path used for the WSMR extinction measurements of August 1978

Figures 23 and 24 show a detailed survey of the entire 6.4-km path. The zero distance position or receiver site is PAT and the path extends NNW to the transmitter position at a mound built near ARKY. The mounds for the transmitter and receiver sites are evident in the survey data and provide an elevated beam path (indicated by the top trace).

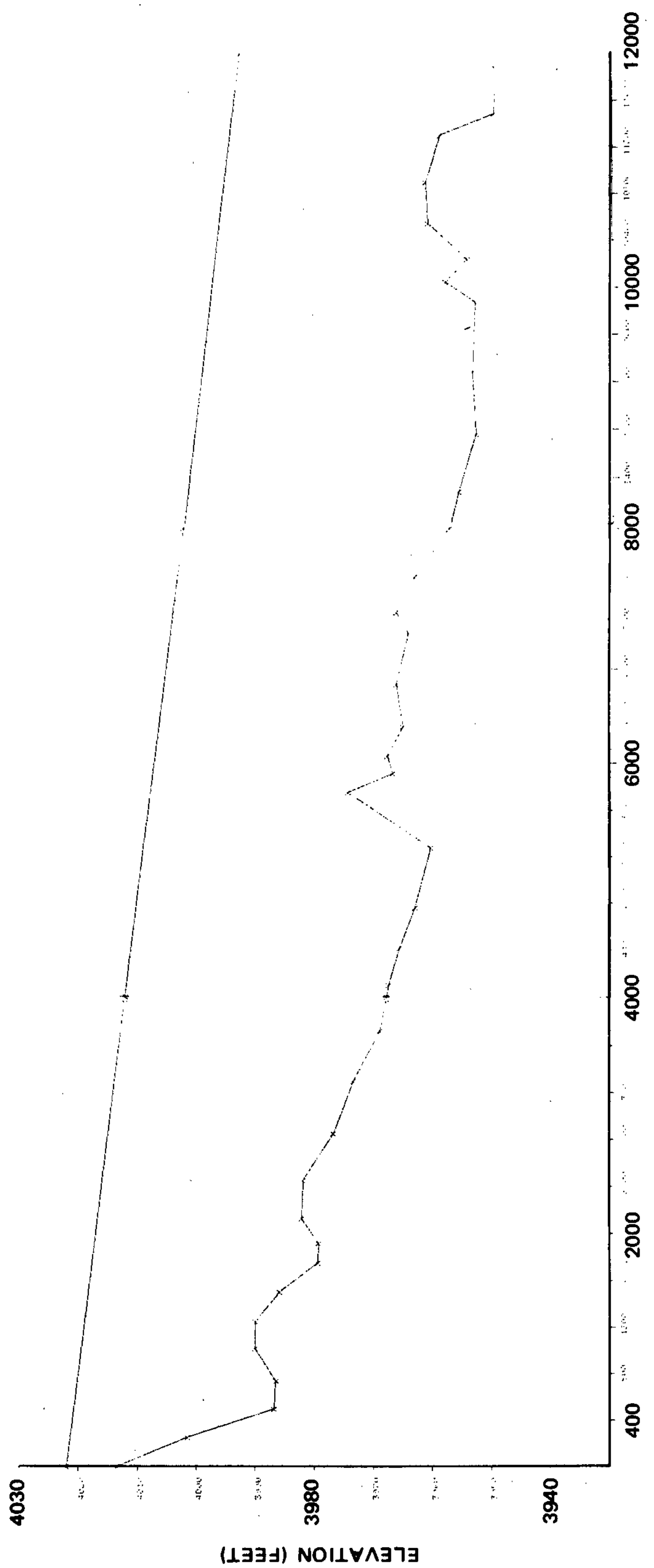

Fig. 23 — Survey of 6.4-km measurement path, including beam elevation and ground topography

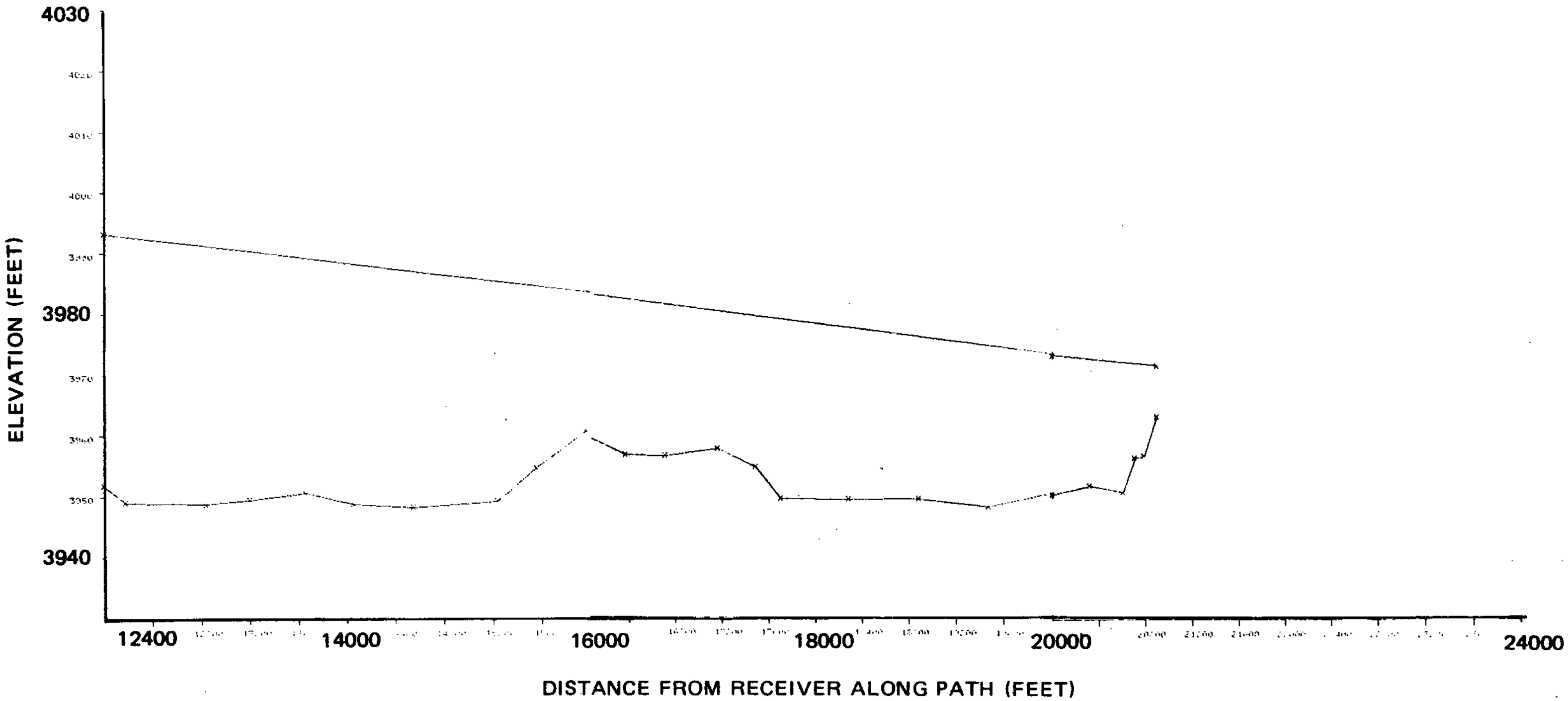

Fig. 24 — Survey of 6.4-km path used for measurement, including beam elevation and ground topography (continued)

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MICROMETEOROLOGICAL DATA

Appendix A contains all of the micrometeorological data obtained in support of the WSMR extinction experiment. The data are presented in a tabular format of 10-min averages suitable for correlating with specific events. The tabular data are followed by plots of the atmospheric index structure constant C_N^2, windspeed, and solar radiation vs time to show more clearly trends in these parameters. For example, one notes the strong correlation of C_N^2 and windspeed with blockage of solar radiation near 1500 on August 11. The afternoon "window" or quiet period of turbulence does not occur until 1930 in August and is approximately 45 min in halfwidth as shown on the 17 August plot.

The micrometeorological towers used for these measurements contained air temperature and dewpoint sensors manufactured by EG&G, a windspeed and direction sensor built by Young Devices, Inc., and sensors to monitor the atmospheric temperature structure constant C_T, solar radiation, and barometric pressure. All tower sensors were sampled at 3-s intervals and were then averaged to provide the 10-min data presented here. Care was taken to locate the towers at beam elevation and upwind of the equipment structures for the predominant wind directions.

Figures A1—A16 contain plots of C_N^2 ($m^{-2/3}$), solar radiation (W/m^2), and windspeed (m/s) monitored at the transmitter and receiver meteorological stations during the experiment.

VISIBILITY MEASUREMENTS

Visibility was determined by the contrast method developed by Koschmieder [9-11] in 1942. Here visibility is defined as the distance from an object that produces a threshold contrast between the object and the background. In these experiments, the target was a shadowed mountainside (Elephant Mountain) 33 km away, and the background was the sky immediately above the mountain.

The contrast formula is

$$\frac{B_X - B_H}{B_H} = e^{-\alpha X} = T_X \text{ (contrast transmittance)},$$

where B_X and B_H are the radiances of the cone of air in front of the target at distance X and the horizon, respectively. Attenuation coefficient α in the visible region can generally be attributed to aerosol scattering. However, in high visibility conditions the molecular component is a significant factor and must be considered in determinations of aerosol effects.

For visibility determination we define γ as the threshold contrast where the target is minimally visible and R as the range at that contrast. For our work we let $\gamma = 0.02$ at a wavelength of 0.55 μm, so that

$$\frac{B_R - B_H}{B_H} = e^{-\alpha R} = 0.02,$$

or visibility = $3.92/\alpha$. An optical pyrometer is a convenient instrument to use for the determination of B_R and B_H. With a programmable hand calculator, a visibility observation can be made in about 1 min. Table 5 summarizes the visibility measurements made during the experiment.

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Table 5 — Visibilities Measured by Optical Constrast Method

Date	Time	σ (km^{-1})	Visibility (km)
3 Aug 78	0900	0.026	148.
4 Aug 78	1200	0.038	103.
5 Aug 78	0930	0.048	81.
	1155	0.039	100.
8 Aug 78	0810	0.038	103.
	1000	0.046	85.
	1300	0.041	95.
10 Aug 78	0830	0.034	117.
	0955	0.036	108.
11 Aug 78	0805	0.039	101.
	0915	0.035	113.
	1005	0.033	118
	1115	0.033	118
	1215	0.036	110
14 Aug 78	0925	0.028	141
	1055	0.028	140
15 Aug 78	0925	0.024	163
	1037	0.025	158
16 Aug 78	0845	0.037	105
	0930	0.036	110
17 Aug 78	1930	0.0137	285
18 Aug 78	0830	0.038	105
19 Aug 78	0950	0.026	149
21 Aug 78	0845	0.026	150
	1025	0.027	147
22 Aug 78	0842	0.029	137
	1030	0.030	131
23 Aug 78	0830	0.027	145

CONCLUSIONS

DF laser extinction was measured for the first time at the inland WSMR location. Extinction did not have a significant aerosol contribution at DF wavelengths during the observation period in August 1978. High winds carrying large aerosols encountered during setup could limit the operation of precision optical systems because of both extinction and damage to external optics. High winds (> 10 m/s) do not occur regularly during August but may affect operations during other months. DF laser absorption coefficients agreed well with previous coastal measurements once aerosol effects were removed. Predictions of DF laser transmission using HITRAN calculations and a Burch [12] water-vapor continuum for the conditions at WSMR show less absorption on the average ($\sim$0.006 km^{-1}) than the experimentally measured values but this small difference is not particularly significant when compared to the experimental uncertainty in the measured extinction values.

ACKNOWLEDGMENTS

The authors wish to thank LCDR Michelle Hughes of Naval Sea Systems Command, PMS-405, for help in support of this project. The technical support provided by the Navy HEL office at WSMR, Frank Tidball of Sachs Freeman Associates, and Claude Acton of NRL's Optical Sciences Division was invaluable and is gratefully appreciated. Many thanks are due Mrs. J. Pinkney and Mrs. R. Reithmeyer for their dedicated typing of this manuscript.

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Appendix A

METEOROLOGICAL DATA

During the experiment, meteorological measurements were obtained with two measurement systems, each located at opposite ends of the 6.4-km propagation path. The data are presented here for each measurement site and for each day, tabulated in 10-min averages, followed by plots of solar radiation, windspeed, and C_N^2 vs measurement time. The units of each measured quantity are given in the appropriate column headings, except for C_N^2, which is given in units of $m^{-2/3}$.

Figures A1—A16 contain plots of solar radiation, windspeed, and C_N^2 monitored at the transmitter and reciever meterological stations.

NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

7 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR* (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
920	23.2	0.35	48.5	895.2	0.74	2.6	107.	1.97E-14
930	23.4	0.31	47.7	895.1	0.78	2.7	148.	1.66E-14
940	23.9	0.35	46.6	895.0	0.83	2.2	123.	1.69E-14
950	24.3	0.29	45.3	895.1	0.87	2.2	127.	1.99E-14
1000	24.9	0.23	43.4	895.1	0.91	1.3	97.	2.33E-14
1010	25.3	0.17	42.0	895.1	0.96	1.8	100.	2.82E-14
1020	25.7	0.06	40.6	895.0	0.99	1.2	173.	3.84E-14
1030	26.9	0.13	38.0	895.0	1.03	1.6	69.	1.14E-13
1040	26.5	9.93	38.1	895.0	1.07	1.0	139.	8.71E-14
1050	26.8	0.02	37.9	895.0	1.10	1.6	127.	3.42E-14
1100	26.7	9.80	37.3	895.0	1.13	1.8	97.	2.60E-14
1110	28.0	9.68	34.1	894.8	1.16	1.5	98.	8.37E-14
1120	28.2	9.61	33.6	894.8	1.19	1.2	72.	8.42E-14
1130	28.7	9.61	32.5	894.8	1.21	1.8	112.	8.18E-14
1140	28.3	9.56	33.2	894.7	1.24	1.9	92.	4.74E-14
1150	28.7	9.49	32.1	894.7	1.26	1.4	187.	7.57E-14
1200	28.8	9.32	31.4	894.5	1.28	2.5	147.	5.12E-14
1210	29.0	9.28	30.9	894.4	1.29	2.6	203.	6.80E-14
1220	29.3	9.19	30.1	894.3	1.31	1.3	207.	9.20E-14
1230	29.5	9.19	29.7	894.3	1.32	1.3	222.	7.10E-14
1240	29.8	9.11	29.0	894.0	1.32	1.9	174.	8.81E-14
1250	30.4	9.12	28.1	893.8	1.33	1.5	229.	1.36E-13
1300	30.1	9.17	28.6	893.7	1.34	2.4	143.	5.30E-14
1310	30.3	8.94	27.6	893.5	1.34	2.4	168.	6.08E-14
1320	30.5	8.85	27.0	893.5	1.34	2.7	146.	6.36E-14
1330	30.7	8.74	26.4	893.4	1.34	2.0	156.	5.38E-14
1340	31.1	8.68	25.6	893.2	1.34	2.0	187.	6.54E-14
1350	32.0	8.47	23.8	893.2	1.32	2.0	127.	9.21E-14
1400	31.3	8.18	23.9	893.0	1.32	2.6	175.	4.75E-14
1410	31.8	8.08	23.0	892.9	1.30	1.7	69.	7.93E-14
1420	32.3	7.90	21.9	892.7	1.29	2.2	110.	8.70E-14
1430	32.3	7.50	20.7	892.6	1.28	2.1	201.	8.78E-14
1440	33.0	7.70	20.5	892.4	1.26	2.0	235.	8.98E-14
1450	32.9	7.84	20.9	892.2	1.24	3.8	182.	1.16E-13
1500	32.8	7.62	20.6	892.1	1.22	4.0	168.	7.41E-14
1510	32.4	7.57	20.8	892.0	1.19	2.9	152.	6.02E-14
1520	33.4	7.55	19.6	891.8	1.17	2.7	152.	8.16E-14
1530	32.9	7.43	19.9	891.5	1.14	2.0	196.	3.23E-14
1540	33.2	7.36	19.4	891.4	1.11	2.8	203.	
1550	33.1	7.34	19.4	891.2	1.08	5.4	149.	

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NRL-IMØRL TRANSMITTER

WSMR MICRØMETEØRØLØGICAL DATA

7 AUGUST 1978

TIME	AT (DEG)	PPH2Ø (TØRR)	RH (%)	BP (MBAR)	SR* (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
1600	32.8	7.37	19.8	891.1	1.04	3.0	130.	
1610	33.4	7.37	19.2	891.0	1.01	2.9	208.	
1620	33.5	7.29	18.9	890.9	0.97	4.5	163.	
1630	32.9	7.24	19.3	890.9	0.93	2.7	138.	

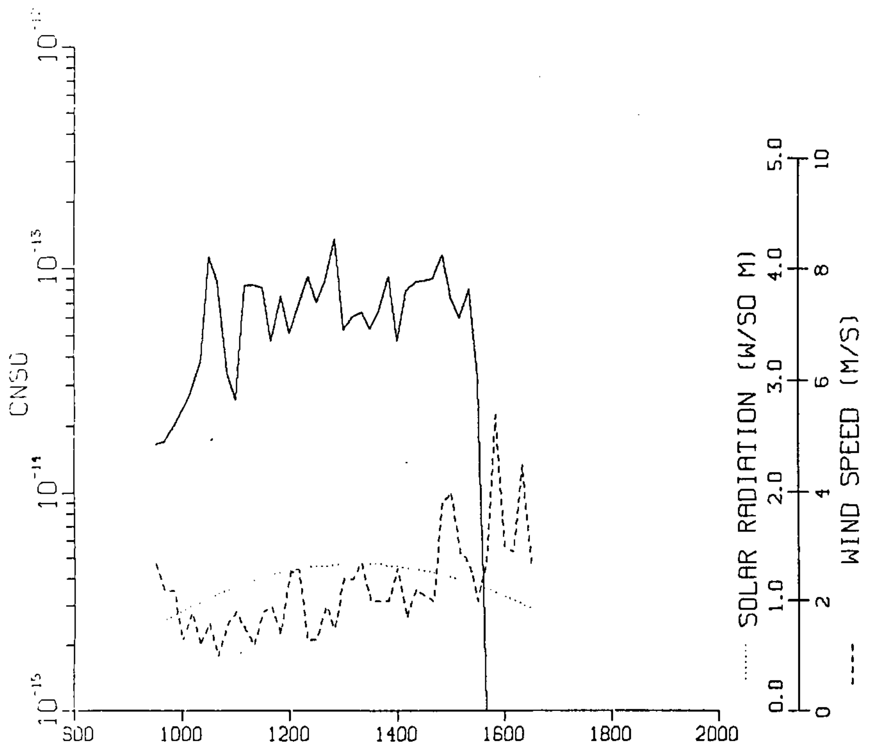

Fig. A-1 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 7 August 1978

NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

8 AUGUST 1978

TIME	AT	PPH2O	RH	BP	SR	WS	WD	CNSQ
	(DEG)	(TORR)	(%)	(MBAR)	(W/SQ M)	(M/S)	(DEG)	
910	20.7	2.15	66.5	894.5	0.32	3.1	323.	7.26E-15
920	20.9	2.19	65.8	894.5	0.39	3.0	322.	1.02E-14
930	21.3	2.34	65.2	894.5	0.42	2.9	323.	1.29E-14
940	21.4	2.18	63.6	894.5	0.47	3.2	324.	1.13E-14
950	21.7	2.30	63.2	894.5	0.55	2.8	318.	1.45E-14
1000	22.0	2.40	62.4	894.5	0.63	2.7	318.	1.09E-14
1010	22.4	2.65	62.5	894.5	0.45	2.9	324.	1.75E-14
1020	22.7	2.28	59.3	894.5	0.88	2.7	322.	1.48E-14
1030	23.5	2.25	56.3	894.5	1.07	2.4	316.	2.76E-14
1040	23.9	1.87	53.4	894.5	0.86	2.5	323.	2.30E-14
1050	24.3	1.60	50.8	894.5	0.89	2.1	241.	2.59E-14
1100	24.5	1.27	48.9	894.5	0.76	2.4	281.	1.61E-14
1110	25.2	1.29	46.9	894.5	0.82	0.9	174.	8.01E-14
1120	25.3	0.84	44.7	894.5	0.90	1.1	156.	3.50E-14
1130	25.3	0.97	45.5	894.5	0.92	1.2	208.	2.14E-14
1140	25.6	1.30	46.0	894.4	1.12	1.8	228.	5.87E-14
1150	25.7	1.38	45.8	894.1	1.10	2.1	215.	4.91E-14
1200	26.1	1.41	45.0	894.1	1.33	2.1	219.	5.46E-14
1210	26.2	1.33	44.4	894.1	1.27	1.8	201.	4.14E-14
1220	26.5	1.42	43.9	894.0	1.20	1.5	180.	5.23E-14
1230	26.9	1.48	43.3	893.9	1.16	1.8	175.	6.95E-14
1240	26.8	1.34	42.9	893.8	1.21	2.2	176.	4.82E-14
1250	27.5	1.43	41.4	893.7	1.21	1.8	221.	9.43E-14
1300	27.4	1.31	41.2	893.4	1.28	2.0	226.	7.86E-14
1310	27.9	1.22	39.8	893.2	1.26	1.3	250.	1.02E-13
1320	27.8	0.97	39.2	893.2	1.22	2.0	132.	1.19E-13
1330	28.2	0.58	36.9	893.0	1.21	1.9	256.	8.72E-14
1340	28.4	0.41	35.9	892.9	1.25	1.2	256.	8.46E-14
1350	29.2	0.54	34.6	892.7	1.25	1.1	195.	9.54E-14
1400	29.3	0.42	34.2	892.6	1.26	1.6	175.	8.67E-14
1410	29.5	0.44	33.8	892.4	1.25	1.4	272.	1.07E-13
1420	30.1	0.33	32.4	892.2	1.24	1.8	124.	1.04E-13
1430	30.0	0.69	33.6	891.9	1.26	2.6	78.	7.02E-14
1440	29.2	0.76	35.5	891.9	0.28	2.2	112.	2.76E-14

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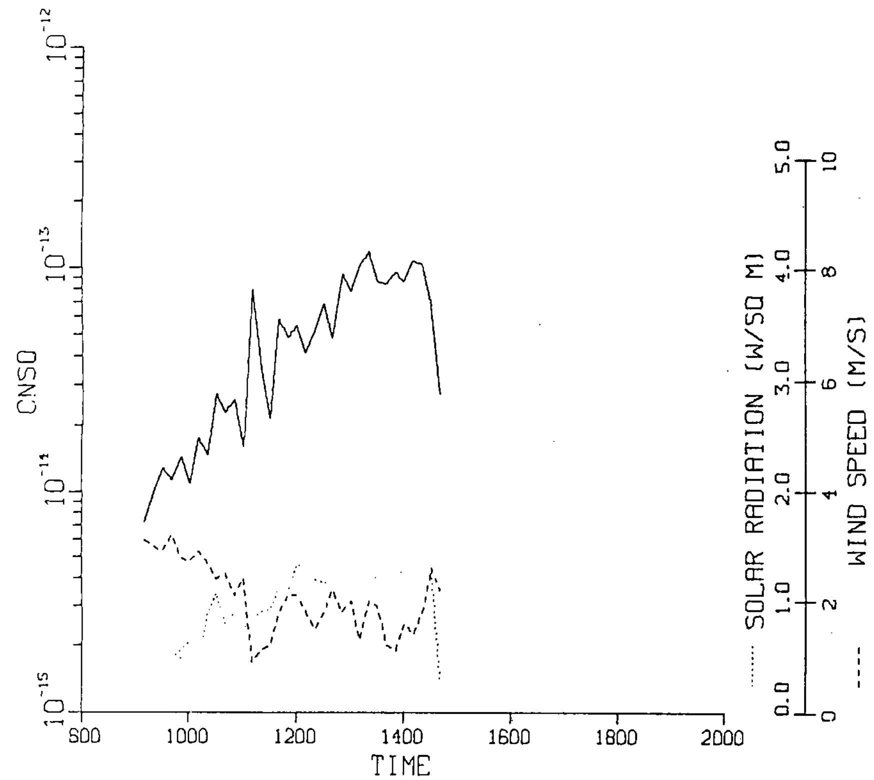

Fig. A-2 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 8 August 1978

NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

10 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
900	21.0	1.22	60.1	893.7	0.59	3.0	318.	1.80E-14
910	21.5	1.13	58.0	893.7	0.63	2.6	302.	1.40E-14
920	22.2	0.97	54.5	893.7	0.68	2.4	258.	1.76E-14
930	22.9	1.04	52.8	893.7	0.72	2.4	300.	2.63E-14
940	23.3	0.83	50.5	893.7	0.76	2.4	309.	1.88E-14
950	23.8	0.74	48.4	893.7	0.80	2.2	226.	2.76E-14
1000	24.4	0.73	46.8	893.7	0.84	2.3	299.	3.58E-14
1010	24.8	0.33	44.1	893.7	0.88	1.6	171.	3.21E-14
1020	25.2	0.05	41.8	893.8	0.91	1.1	127.	6.27E-14
1030	25.4	0.08	41.5	893.8	0.93	1.6	199.	3.92E-14
1040	25.5	0.13	41.3	893.8	0.96	1.8	202.	4.79E-14
1050	26.2	0.27	40.3	893.7	1.00	1.2	268.	5.55E-14
1100	26.5	0.34	39.8	893.7	1.03	1.4	106.	8.92E-14
1110	27.0	0.22	38.3	893.6	1.06	1.1	80.	1.14E-13
1120	26.9	0.14	38.2	893.5	1.10	1.4	262.	5.94E-14
1130	27.2	0.01	36.9	893.5	1.13	1.6	221.	7.97E-14
1140	27.7	9.75	34.9	893.4	1.16	1.9	259.	9.47E-14
1150	28.2	9.68	33.7	893.2	1.18	1.5	238.	9.35E-14
1200	28.6	9.46	32.2	893.1	1.20	1.9	280.	9.98E-14
1210	28.5	9.20	31.6	893.0	1.25	1.8	178.	7.92E-14
1220	28.7	9.19	31.1	892.8	1.27	1.4	131.	9.37E-14
1230	29.2	9.01	29.6	892.7	1.28	2.0	98.	1.07E-13
1240	29.9	8.95	28.4	892.6	1.24	3.0	86.	1.16E-13
1250	28.7	8.39	28.4	892.2	1.02	2.0	98.	5.65E-14
1300	29.0	8.23	27.3	892.2	1.31	2.0	208.	8.16E-14
1310	29.6	8.34	26.8	892.0	1.30	2.6	243.	8.30E-14
1320	29.9	8.38	26.5	891.7	1.29	1.7	246.	1.09E-13
1330	29.8	8.31	26.5	891.6	1.30	2.8	174.	1.02E-13
1340	29.7	8.22	26.3	891.4	1.30	2.7	196.	9.20E-14
1350	29.9	8.06	25.5	891.3	1.30	2.2	250.	1.14E-13
1400	29.9	7.92	25.0	891.2	1.29	1.6	148.	5.53E-14
1410	30.1	7.45	23.2	891.0	1.22	3.2	110.	7.29E-14
1420	30.2	7.39	22.9	890.9	1.24	2.6	110.	6.30E-14
1430	30.1	7.42	23.2	890.7	1.24	2.4	267.	5.18E-14
1440	30.9	7.44	22.2	890.5	1.21	3.0	250.	8.35E-14
1450	30.6	7.34	22.3	890.2	1.20	3.2	169.	5.93E-14
1500	31.0	7.22	21.4	890.1	1.19	3.3	211.	1.08E-13
1510	31.1	7.13	21.1	890.0	1.17	2.1	214.	6.94E-14
1520	31.3	7.12	20.9	889.9	1.14	2.0	213.	9.84E-14
1530	31.7	7.59	21.7	889.8	1.11	1.5	185.	7.78E-14

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NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

10 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR* (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
1540	31.8	6.97	19.8	889.5	1.07	2.2	70.	6.04E-14
1550	31.4	6.90	20.1	889.3	1.05	1.9	155.	6.45E-14
1600	31.4	6.83	19.8	889.3	1.06	1.6	170.	5.30E-14
1610	32.2	6.78	18.9	889.2	0.98	3.1	119.	6.97E-14
1620	31.4	6.71	19.6	889.0	0.92	3.3	153.	4.22E-14
1630	31.7	6.80	19.4	888.7	0.89	2.0	205.	4.43E-14
1640	31.8	6.82	19.5	888.6	0.86	4.0	144.	4.55E-14
1650	31.6	6.84	19.7	888.6	0.80	3.3	147.	4.29E-14
1700	31.5	6.79	19.7	888.6	0.75	2.6	166.	3.05E-14

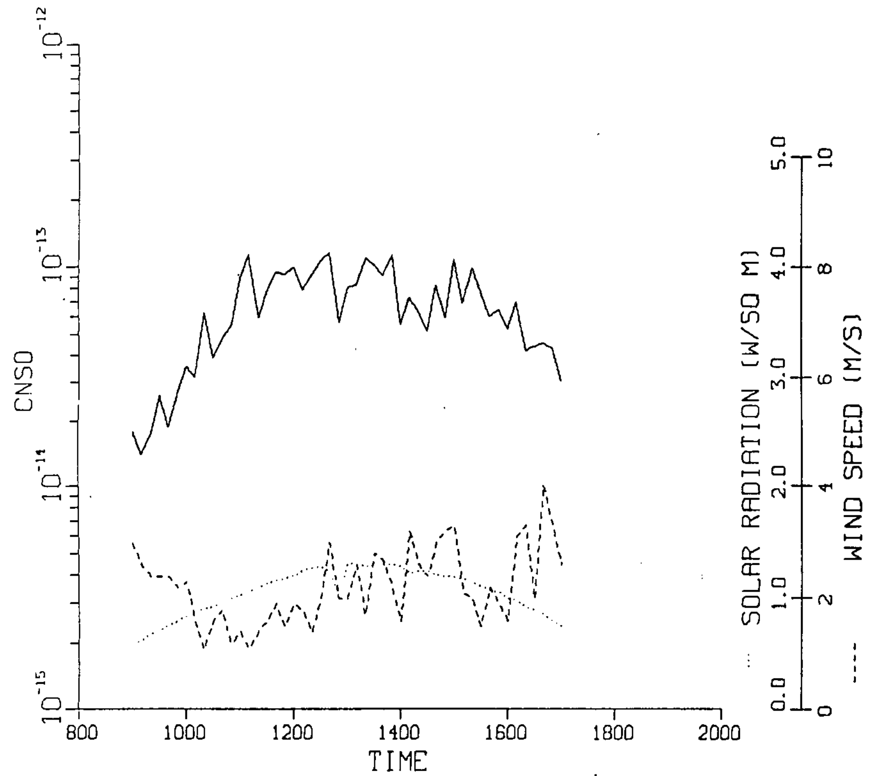

Fig. A-3 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 10 August 1978

NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

11 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR' (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
830	22.2	1.56	57.5	890.7	0.45	3.9	158.	1.06E-14
840	22.4	1.53	56.5	890.7	0.50	3.5	160.	1.04E-14
850	22.9	1.52	54.8	890.8	0.55	4.0	169.	1.75E-14
900	23.2	1.60	54.4	890.9	0.60	3.9	174.	2.25E-14
910	23.3	1.63	54.3	890.9	0.64	3.2	164.	1.88E-14
920	23.8	1.74	53.1	890.9	0.69	3.4	175.	2.95E-14
930	24.3	1.79	51.7	890.9	0.74	3.3	175.	3.54E-14
940	24.4	1.78	51.3	890.9	0.78	3.7	175.	3.11E-14
950	24.7	1.80	50.4	891.1	0.81	2.8	170.	3.68E-14
1000	25.1	1.83	49.5	891.1	0.85	2.9	164.	4.04E-14
1010	25.3	1.83	48.8	891.1	0.89	3.1	155.	3.70E-14
1020	25.9	1.83	47.1	891.1	0.92	2.6	163.	5.22E-14
1030	26.3	1.87	46.3	891.0	0.95	3.3	151.	4.36E-14
1040	27.0	1.87	44.5	891.0	0.98	3.4	123.	7.21E-14
1050	26.9	1.70	43.9	890.9	1.02	2.9	139.	4.29E-14
1100	27.4	1.51	42.0	890.7	1.05	2.2	163.	5.78E-14
1110	27.5	1.05	40.2	890.4	1.08	3.4	114.	5.42E-14
1120	27.9	1.41	40.6	890.7	1.11	1.5		3.72E-14
1130	28.7	1.39	38.7	890.7	1.14	1.6		5.96E-14
1140	29.5	1.13	36.0	890.6	1.17	1.9		1.18E-13
1150	29.3	0.84	35.5	890.6	1.19	0.9		4.49E-14
1200	29.7	0.97	35.1	890.6	1.21	1.6		5.86E-14
1210	30.3	0.87	33.6	890.4	1.23	1.1		1.29E-13
1220	30.4	0.47	32.2	890.3	1.25	2.0		5.97E-14
1230	31.1	0.59	31.3	890.2	1.26	1.3		1.71E-13
1240	31.3	0.36	30.2	890.1	1.27	3.0		1.35E-13
1250	31.1	9.96	29.5	890.1	1.29	2.1		1.22E-13
1300	31.5	9.72	28.1	890.0	1.30	0.8		1.04E-13
1310	31.9	9.75	27.6	890.0	1.31	0.9		1.29E-13
1320	32.4	9.39	25.9	889.9	1.21	1.2		9.93E-14
1330	32.2	9.12	25.3	889.6	0.86	1.4		5.73E-14
1340	32.9	9.25	24.8	889.6	1.36	0.8		2.31E-13
1350	32.8	9.26	24.9	889.6	1.41	1.4		1.18E-13
1400	33.3	8.81	23.1	889.4	1.42	1.1		1.26E-13
1410	33.4	8.39	21.9	889.3	1.39	1.8	18.	1.01E-13
1420	33.5	8.38	21.7	889.1	1.33	1.8	18.	9.34E-14
1430	32.7	8.44	22.8	889.1	1.30	1.8	18.	4.74E-14
1440	33.7	8.44	21.6	888.8	1.29	1.8	18.	
1450	33.7		0.0	0.0				
1500	33.1	8.18	21.6	888.6	1.24	1.8	18.	6.24E-14

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NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

11 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR* (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
1510	33.5	8.18	21.1	888.6	1.20	1.9	19.	6.93E-14
1520	34.2	8.29	20.6	888.5	1.18	1.9	19.	1.10E-13
1530	33.5	8.19	21.2	888.4	1.19	1.9	19.	7.75E-14
1540	33.6	8.37	21.6	888.6	1.13	2.1	21.	1.09E-13
1550	33.5	8.13	21.1	888.1	1.06	1.9	19.	5.88E-14

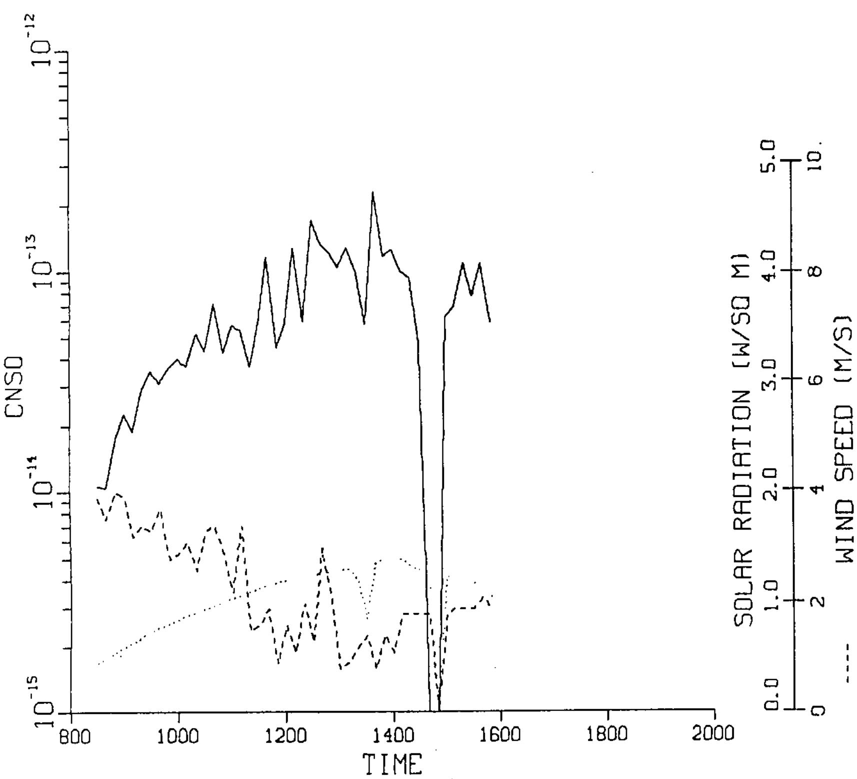

Fig. A-4 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 11 August 1978

NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

14 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR* (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
840	25.8	9.00	36.0	890.9	0.50	1.4	340.	5.78E-15
850	26.5	8.95	34.5	890.9	0.55	1.3	311.	1.37E-14
900	27.1	8.89	33.0	890.9	0.59	1.0	243.	6.67E-14
910	27.5	8.80	31.9	890.9	0.65	1.6	129.	1.76E-14
920	28.0	8.72	30.8	890.9	0.71	2.5	208.	3.04E-14
930	28.5	8.65	29.6	890.9	0.76	3.4	311.	3.42E-14
940	28.8	8.58	29.0	890.9	0.83	3.2	332.	3.05E-14
950	29.1	8.43	28.0	890.8	0.78	3.3	178.	3.36E-14
1000	29.4	8.40	27.4	890.7	0.69	3.4	316.	2.78E-14
1010	29.5	8.40	27.2	890.7	0.99	3.5	255.	3.54E-14
1020	29.8	8.46	26.9	890.7	0.87	3.8	312.	4.39E-14
1030	30.0	8.43	26.5	890.7	1.02	3.6	276.	4.49E-14
1040	30.1	8.43	26.4	890.7	0.83	3.2	293.	4.28E-14
1050	30.2	8.38	26.1	890.7	0.88	2.5	283.	3.61E-14
1100	30.5	8.34	25.5	890.7	1.05	3.1	265.	3.95E-14
1110	30.9	8.29	24.8	890.7	1.13	3.1	135.	5.79E-14

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NRL-IMØRL RECIEVER

WSMR MICRØMETEØRØLØGICAL DATA

14 AUGUST 1978

TIME	AT (DEG)	PPH2Ø (TØRR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
950	29.4	4.79	15.6		1.08	0.8	143.	
940	28.7	5.23	17.7		1.02	1.6	171.	
1000	29.8	4.65	14.8		1.13	1.1	182.	
1010	30.7	4.21	12.7		1.18	0.7	236.	
1020	30.9	4.03	12.0		1.22	0.9	225.	
1030	31.7	3.83	11.0		1.27	0.9	121.	
1040	31.7	3.82	10.9		1.32	1.1	141.	
1050	31.8	3.78	10.8		1.35	1.4	209.	
1100	32.0	3.84	10.8		1.38	1.5	202.	
1110	32.6	3.90	10.6		1.42	1.2	143.	
1120	32.4	4.09	11.2		1.46	1.5	87.	
1130	32.8	4.42	11.9		1.48	1.6	150.	
1140	32.8	4.50	12.1		1.51	2.0	249.	
1150	33.2	4.62	12.2		1.53	1.8	117.	
1200	32.9	4.94	13.2		1.55	1.9	64.	
1210	33.2	4.75	12.5		1.58	1.6	150.	
1220	33.7	4.74	12.2		1.59	2.2	157.	
1230	34.5	4.99	12.3		1.60	3.8	261.	
1240	34.3	5.03	12.5		1.60	2.2	200.	
1250	35.2	5.43	12.8		1.63	6.0	248.	
1300	34.7	5.29	12.9		1.63	2.8	183.	
1310	35.9	5.43	12.4		1.62	5.5	274.	
1320	35.4	5.89	13.8		1.62	6.9	241.	
1330	35.0	5.74	13.7		1.63	3.2	252.	
1340	35.4	5.71	13.4		1.56	4.5	244.	
1350	35.6	5.97	13.8		1.62	6.6	243.	
1400	35.8	5.87	13.5		1.61	5.8	241.	
1410	35.6	5.93	13.7		1.66	5.8	208.	
1420	36.1	5.99	13.5		1.64	7.0	216.	
1430	36.2	6.35	14.2		1.63	5.5	210.	
1440	35.8	6.25	14.3		1.59	5.5	228.	
1450	35.6	6.08	14.1		1.47	4.3	273.	
1500	36.2	6.06	13.6		1.63	6.9	232.	
1510	36.1	6.06	13.7		1.59	6.7	211.	
1520	35.9	6.04	13.8		1.17	5.3	204.	
1530	35.8	6.12	14.0		1.39	5.4	182.	
1540	36.1	6.23	14.0		1.04	5.6	233.	
1550	35.3	6.30	14.8		0.58	6.2	235.	
1600	35.4	6.40	15.0		1.05	5.5	249.	
1610	35.7	6.43	14.8		0.78	5.6	252.	

NRL-IMØRL RECIEVER

WSMR MICRØMETEØRØLØGICAL DATA

14 AUGUST 1978

TIME	AT (DEG)	PPH2Ø (TØRR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
1620	36.4	6.59	14.6		1.37	7.0	233.	
1630	36.4	6.62	14.7		1.28	6.8	232.	
1640	36.2	6.45	14.5		1.22	7.1	224.	
1650	35.9	6.42	14.6		0.83	6.5	236.	
1700	36.1	6.39	14.4		1.09	5.9	213.	
1710	36.2	6.38	14.3		1.05	6.2	231.	
1720	36.2	6.37	14.3		1.01	7.2	215.	
1730	36.1	6.29	14.2		0.95	7.5	238.	
1740	35.9	6.37	14.5		0.90	5.0	246.	
1750	36.0	6.32	14.3		0.84	6.4	228.	
1800	35.6	6.32	14.6		0.78	5.3	226.	
1810	35.7	6.22	14.3		0.73	6.9	216.	
1820	35.7	6.22	14.3		0.68	6.9	220.	
1830	35.4	6.19	14.4		0.63	6.6	213.	
1840	35.2	6.21	14.7		0.57	6.5	220.	
1850	35.2	6.18	14.6		0.51	5.7	219.	
1900	34.7	6.16	15.0		0.38	5.6	237.	
1910	34.5	6.14	15.1		0.37	6.4	219.	
1920	34.1	6.13	15.3		0.35	6.0	217.	
1930	34.0	6.11	15.4		0.33	5.8	219.	
1940	33.7	6.05	15.5		0.30	6.2	218.	
1950	33.3	5.99	15.7		0.29	5.6	216.	
2000	32.7	5.95	16.1		0.28	5.0	215.	
2010	32.0	5.92	16.6		0.28	4.4	216.	
2020	31.5	5.88	17.0		0.29	4.0	222.	
2030	31.0	5.82	17.3		0.29	3.9	217.	
2040	30.8	5.71	17.1		0.29	4.0	214.	
2050	30.3	5.74	17.7		0.29	3.6	223.	
2100	30.2	5.83	18.1		0.20	3.8	220.	
2110	30.1	5.88	18.3		0.20	3.7	240.	
2120	30.4	5.03	18.2		0.30	3.5	244.	

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NRL-IMØRL TRANSMITTER

WSMR MICRØMETEØRØLØGICAL DATA

15 AUGUST 1978

TIME	AT (DEG)	PPH2Ø (TØRR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
840	22.1	4.25	21.2	891.9	0.54	6.3	335.	9.12E-15
850	22.4	4.32	21.2	891.9	0.58	5.2	347.	1.02E-14
900	23.1	4.38	20.6	892.0	0.64	5.4	347.	1.31E-14
910	23.9	4.37	19.7	892.1	0.69	5.6	345.	1.54E-14
920	24.8	4.36	18.6	892.2	0.74	5.0	343.	1.39E-14
930	25.7	4.27	17.3	892.2	0.78	5.4	336.	1.54E-14
940	26.3	4.22	16.5	892.2	0.82	5.3	332.	1.64E-14
950	26.9	4.16	15.7	892.2	0.86	4.8	333.	1.86E-14
1000	27.4	4.09	15.0	892.2	0.90	4.7	340.	3.33E-14
1010	27.7	4.05	14.5	892.2	0.93	4.1	342.	3.27E-14
1020	28.3	4.03	13.9	892.3	0.97	4.0	333.	4.63E-14
1030	28.6	3.87	13.2	892.4	1.00	3.9	313.	3.68E-14
1040	28.7	4.12	14.0	892.4	1.03	3.0	314.	4.36E-14
1050	29.3	4.24	13.9	892.4	1.06	2.7	271.	4.33E-14
1100	29.7	4.30	13.7	892.4	1.10	2.8	312.	6.41E-14
1110	30.0	4.37	13.8	892.4	1.13	2.1	243.	4.77E-14
1120	30.2	4.44	13.8	892.4	1.17	2.7	174.	4.26E-14
1130	30.5	4.54	13.9	892.4	1.20	2.0	257.	5.91E-14
1140	30.7	4.66	14.1	892.4	1.23	2.5	196.	6.83E-14
1150	30.9	4.73	14.2	892.4	1.25	2.9	124.	6.11E-14
1200	31.1	4.78	14.1	892.2	1.26	2.6	188.	6.44E-14
1210	31.4	4.88	14.2	892.1	1.28	2.8	103.	5.93E-14
1220	31.7	4.88	13.9	891.9	1.28	2.2	74.	6.85E-14
1230	32.1	4.86	13.6	891.9	1.31	2.2	242.	7.29E-14
1240	31.9	4.88	13.8	891.7	1.33	2.4	101.	3.98E-14
1250	32.8	4.90	13.2	891.6	1.34	1.5	144.	7.62E-14
1300	33.1	4.86	12.9	891.5	1.34	1.8	220.	1.07E-13
1310	32.7	4.92	13.3	891.4	1.34	2.1	116.	3.68E-14
1320	33.2	4.92	13.0	891.2	1.35	2.4	160.	6.72E-14
1330	33.2	4.94	13.0	891.2	1.35	2.9	174.	5.86E-14
1340	33.6	4.90	12.7	891.1	1.35	1.9	2 7.	6.97E-14
1350	33.6	4.92	12.7	891.0	1.33	1.9	242.	7.39E-14
1400	34.4	5.23	12.9	890.9	1.32	3.2	178.	1.05E-13
1410	34.6	5.49	13.4	890.7	1.31	3.1	222.	1.02E-13
1420	35.1	5.59	13.3	890.6	1.31	3.6	187.	1.20E-13
1430	34.7	5.70	13.9	890.6	1.32	3.0	202.	6.86E-14
1440	35.4	5.88	13.8	890.4	1.27	3.9	201.	1.34E-13
1450	35.1	5.91	14.1	890.2	1.24	3.1	184.	7.25E-14
1500	35.7	6.56	15.1	890.0	1.23	6.3	254.	1.25E-13
1510	35.3	6.36	15.0	889.9	1.20	3.6	266.	1.02E-13

NRL-IMJRL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

15 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
1520	35.7	6.44	14.8	889.9	1.17	5.5	239.	1.39E-13
1530	35.8	6.26	14.3	889.9	1.14	4.1	244.	1.25E-13
1540	35.8	6.14	14.1	889.7	1.11	4.6	249.	1.08E-13
1550	36.0	6.06	13.7	889.6	1.08	5.1	253.	9.76E-14
1600	35.9	6.03	13.8	889.6	1.04	5.3	251.	1.05E-13
1610	35.7	6.02	13.8	889.6	1.00	4.2	245.	9.87E-14
1620	35.8	5.97	13.7	889.5	0.97	3.2	232.	9.26E-14

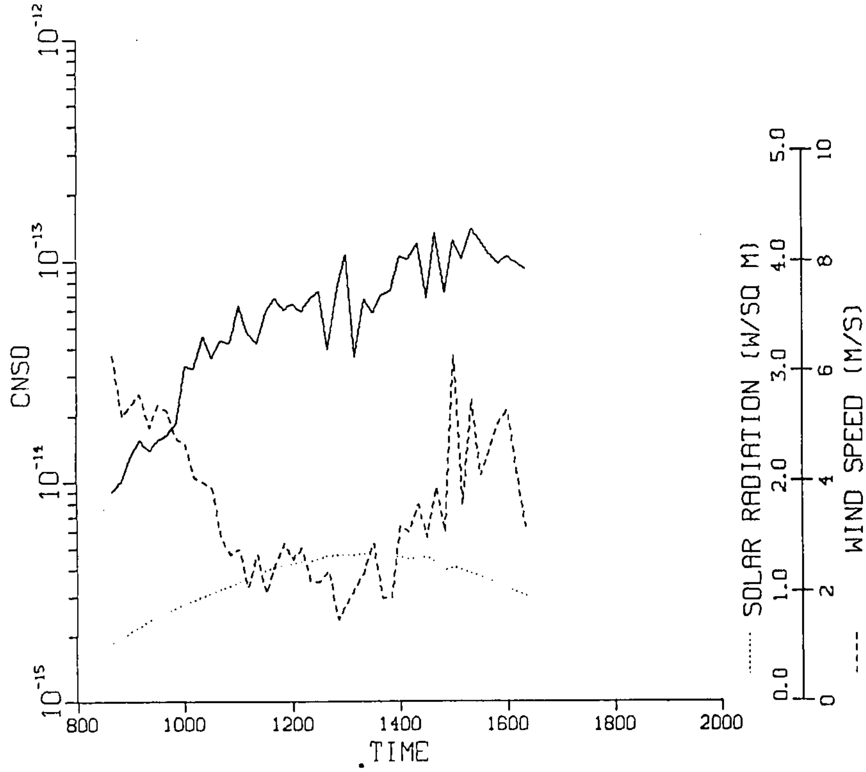

Fig. A-5 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 15 August 1978

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NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

16 AUGUST 1978

TIME	AT	PPH2O	RH	BP	SR	WS	WD	CNSQ
	(DEG)	(TORR)	(%)	(MBAR)	(W/SQ M)	(M/S)	(DEG)	
2000	33.4	6.22	16.2	888.3	0.00	4.0	236.	5.03E-15
2010	33.2	6.15	16.2	888.3	0.00	4.4	232.	8.11E-15
2020	32.8	6.10	16.5	888.3	0.00	4.0	231.	8.97E-15
2030	32.6	6.09	16.5	888.4	0.00	4.3	233.	9.06E-15
2040	32.3	6.09	16.8	888.4	0.00	3.9	235.	1.25E-14
2050	32.0	6.09	17.2	888.4	0.00	3.7	233.	1.55E-14
2100	31.1	6.07	17.9	888.6	0.00	3.2	241.	1.99E-14
2110	31.1	6.10	18.1	888.6	0.00	3.6	239.	2.15E-14
2120	30.8	6.14	18.4	888.6	0.00	3.6	246.	2.22E-14

NRL-IMØRL TRANSMITTER

WSMR MICRØMETEØRØLØGICAL DATA

17 AUGUST 1978

TIME	AT (DEG)	PPH2Ø (TØRR)	RH (%)	BP (MBAR)	SR* (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
1120	33.8	7.35	18.7	891.2	1.16	5.2	268.	1.58E-14
1130	34.0	7.14	18.1	891.1	1.19	4.2	248.	1.73E-14
1140	33.9	7.29	18.5	891.1	1.22	4.0	278.	8.65E-14
1150	34.5	7.47	18.4	890.9	1.24	6.7	263.	1.02E-13
1200	34.2	7.49	18.7	890.9	1.26	6.1	292.	8.99E-14
1210	34.5	7.52	18.5	890.8	1.28	6.2	277.	1.15E-13
1220	34.4	7.52	18.5	890.6	1.30	6.6	284.	1.12E-13
1230	34.7	7.48	18.2	890.6	1.31	6.6	272.	1.05E-13
1240	34.4	7.36	18.1	890.5	1.32	6.4	288.	1.21E-13
1250	34.6	7.34	17.9	890.4	1.33	5.2	284.	1.03E-13
1300	34.6	7.31	17.8	890.2	1.33	6.8	270.	1.02E-13
1310	35.3	7.38	17.4	890.1	1.33	7.2	263.	1.26E-13
1320	35.3	7.39	17.4	890.1	1.33	6.3	267.	1.22E-13
1330	35.4	7.54	17.6	889.9	1.34	6.0	260.	1.54E-13
1340	34.9	7.50	18.0	889.9	1.33	4.1	212.	9.46E-14
1350	35.5	7.46	17.3	889.6	1.28	6.0	231.	1.23E-13
1400	36.1	7.28	16.4	889.3	1.31	7.5	278.	1.09E-13
1410	35.7	7.26	16.7	889.3	1.30	6.2	263.	1.13E-13
1420	35.6	7.38	17.1	889.1	1.30	4.5	259.	1.11E-13
1430	36.2	7.36	16.5	888.9	1.27	6.8	260.	1.35E-13
1440	36.1	7.27	16.3	888.8	1.26	7.7	267.	1.09E-13
1450	36.1	7.33	16.5	888.6	1.18	6.8	264.	1.02E-13
1500	36.8	7.35	16.0	888.3	1.20	8.0	256.	1.32E-13
1510	36.8	7.07	15.3	888.3	1.27	8.1	263.	1.06E-13
1520	37.2	6.98	14.8	888.2	1.08	7.4	251.	1.16E-13
1530	36.6	7.11	15.6	888.1	1.21	5.2	238.	1.10E-13
1540	37.1	7.02	15.0	888.0	1.21	6.7	248.	1.37E-13
1550	37.0	7.01	15.1	887.8	1.16	6.8	224.	1.19E-13
1600	37.7	6.99	14.5	887.7	1.13	6.9	240.	1.20E-13
1610	36.8	7.00	15.2	887.8	0.82	6.8	256.	6.95E-14
1620	36.6	7.06	15.5	887.8	1.05	7.2	281.	8.37E-14
1630	36.8	7.09	15.4	887.7	0.89	7.9	276.	7.93E-14
1640	36.7	7.08	15.4	887.6	0.81	8.3	260.	7.05E-14
1650	36.2	7.05	15.8	887.5	0.61	8.9	288.	3.88E-14
1700	36.6	7.13	15.6	887.4	0.75	7.4	262.	4.86E-14
1710	36.5	7.16	15.8	887.3	0.71	7.8	270.	4.60E-14
1720	36.3	7.06	15.7	887.3	0.71	7.5	272.	4.66E-14
1730	36.5	7.05	15.5	887.3	0.66	8.4	268.	4.13E-14
1740	36.1	7.04	15.8	887.3	0.58	7.3	253.	3.69E-14
1750	36.4	7.01	15.6	887.3	0.57	6.6	281.	2.98E-14

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NRL-IMØRL TRANSMITTER

WSMR MICRØMETEØRØLØGICAL DATA

17 AUGUST 1978

TIME	AT (DEG)	PPH2Ø (TØRR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
1800	35.8	7.00	16.0	887.3	0.34	7.4	284.	1.55E-14
1810	35.9	7.05	16.0	887.3	0.44	7.4	262.	1.77E-14
1820	35.7	7.06	16.2	887.3	0.38	7.9	268.	1.53E-14
1830	35.4	7.16	16.7	887.3	0.34	6.7	290.	1.13E-14
1840	35.3	7.07	16.6	887.3	0.29	8.0	279.	6.60E-15
1850	35.2	6.87	16.3	887.2	0.24	8.4	292.	3.46E-15
1900	34.9	6.80	16.4	887.3	0.17	7.1	290.	1.40E-15
1910	34.7	6.87	16.7	887.4	0.14	6.2	287.	5.10E-16
1920	34.4	7.01	17.3	887.4	0.10	6.8	282.	9.47E-17
1930	34.0	7.26	18.3	887.5	0.04	6.4	275.	6.69E-16
1940	33.6	7.33	18.9	887.6	0.01	5.2	270.	2.67E-15
1950	33.2	7.50	19.7	887.6	0.01	5.7	278.	3.11E-15
2000	32.8	7.61	20.5	887.8	0.00	4.5	279.	4.70E-15
2010	33.0	7.73	20.6	887.8	0.00	5.5	291.	4.97E-15
2020	32.6	7.71	20.9	887.8	0.00	4.6	275.	6.21E-15
2030	31.3	7.71	22.5	887.8	0.00	5.5	270.	6.35E-15
2040	32.3	7.71	21.4	888.0	0.00	4.3	265.	6.67E-15
2050	31.6	7.71	22.1	888.1	0.00	3.9	254.	1.00E-14

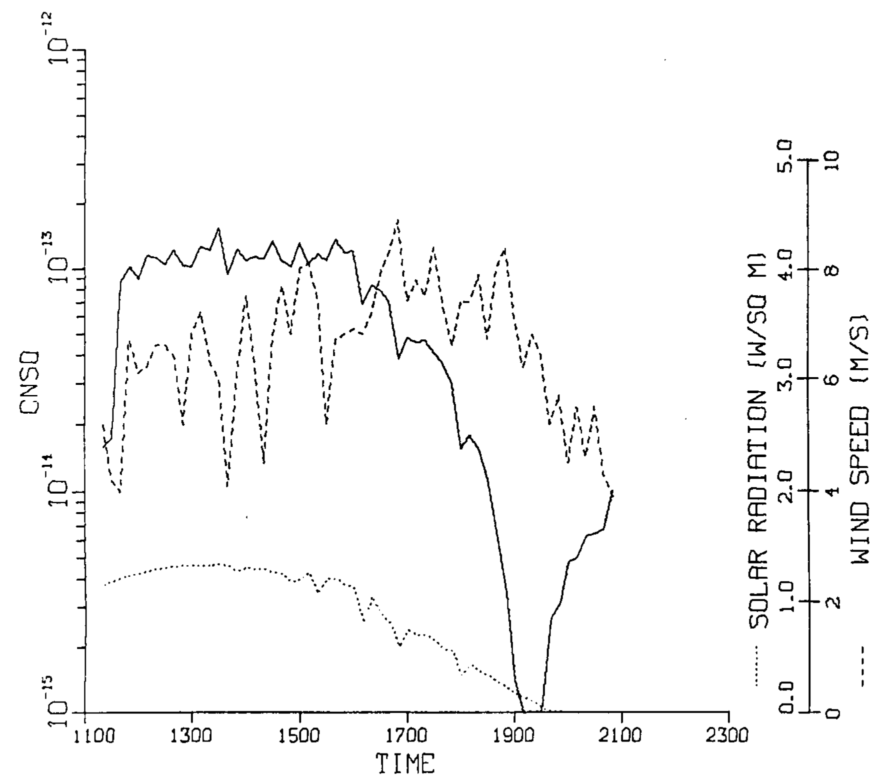

Fig. A-6 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 17 August 1978

NRL-IMPRL RECIEVER

WSMR MICROMETEOROLOGICAL DATA

17 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
1020	30.9	6.41	19.2		0.99	1.3	110.	
1030	31.5	6.56	19.3		1.06	2.4	215.	
1040	31.8	6.68	19.0		1.14	3.6	233.	
1050	31.4	6.57	19.1		1.21	1.9	203.	
1100	31.9	6.66	18.9		1.27	1.8	280.	
1110	32.2	6.64	18.5		1.31	3.0	215.	
1120	32.2	6.55	18.2		1.37	1.5	265.	
1130	32.5	6.64	18.1		1.40	3.4	175.	
1140	33.1	6.77	17.9		1.44	1.9	192.	
1150	33.1	6.71	17.8		1.47	4.1	187.	
1200	32.9	6.58	17.6		1.50	3.4	183.	
1210	33.1	6.83	18.0		1.52	3.5	201.	
1220	34.0	7.09	17.9		1.55	6.3	260.	
1230	33.7	7.20	18.4		1.56	6.6	270.	
1240	34.2	7.15	17.9		1.56	5.9	266.	
1250	34.4	7.17	17.7		1.57	6.1	242.	
1300	34.2	6.98	17.4		1.58	6.8	244.	
1310	34.1	7.08	17.7		1.58	6.5	259.	
1320	34.3	7.08	17.5		1.58	6.1	234.	
1330	34.7	7.02	17.1		1.58	6.9	221.	
1340	34.8	7.23	17.4		1.58	6.7	240.	
1350	34.7	7.23	17.5		1.57	5.9	240.	
1400	34.9	7.01	16.8		1.57	7.5	221.	
1410	35.3	6.99	16.5		1.56	6.3	224.	
1420	35.1	6.89	16.4		1.55	6.8	250.	
1430	35.4	6.91	16.1		1.53	5.1	250.	
1440	35.5	7.04	16.4		1.51	6.9	227.	
1450	35.5	7.09	16.5		1.53	6.2	238.	
1500	36.2	7.01	15.7		1.45	7.2	258.	
1510	35.3	6.83	16.1		1.10	6.9	254.	
1520	36.0	6.50	14.7		1.43	8.1	277.	
1530	35.4	6.58	15.4		1.34	6.5	267.	
1540	36.0	6.79	15.4		1.31	8.8	268.	
1550	36.0	6.91	15.7		1.35	7.3	272.	
1600	36.1	6.78	15.3		1.24	8.4	268.	
1610	36.2	6.91	15.5		1.36	9.4	251.	1.28E-13
1620	35.8	6.91	15.8		1.28	9.5	251.	2.83E-13
1630	35.9	6.85	15.6		1.12	8.0	268.	1.73E-13
1640	36.2	6.84	15.3		1.12	9.5	273.	1.70E-13
1650	35.7	6.77	15.6		0.94	8.5	260.	1.25E-13

UNCLASSIFIED

NRL-IMORL RECIEVER

WSMR MICROMETEOROLOGICAL DATA

17 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
1700	35.3	6.76	15.9		0.68	8.9	268.	5.76E-14
1710	35.0	6.78	16.2		0.71	8.2	252.	3.93E-14
1720	35.2	6.73	15.9		0.99	8.1	248.	8.48E-14
1730	35.0	6.72	16.0		0.76	8.0	261.	4.66E-14
1740	35.3	6.76	15.9		0.89	6.4	256.	7.55E-14
1750	35.2	6.67	15.7		0.84	9.8	263.	5.72E-14
1800	35.2	6.46	15.3		0.79	7.0	266.	4.73E-14
1810	35.0	6.65	15.9		0.74	8.1	245.	3.66E-14
1820	34.9	6.70	16.1		0.69	8.1	257.	2.91E-14
1830	34.9	6.72	16.1		0.64	7.6	246.	2.46E-14
1840	34.9	6.46	15.5		0.59	7.1	251.	1.81E-14
1850	34.6	6.49	15.8		0.54	6.0	253.	1.16E-14
1900	34.4	6.43	15.9		0.49	6.8	254.	4.94E-15
1910	34.2	6.43	16.0		0.45	6.2	257.	1.10E-15
1920	33.9	6.53	16.5		0.40	5.4	258.	2.10E-16
1930	33.5	6.54	17.0		0.34	4.6	251.	1.74E-15
1940	33.1	6.58	17.4		0.33	5.2	241.	6.46E-15
1950	32.7	6.88	18.6		0.32	5.0	256.	9.21E-15
2000	32.2	7.08	19.6		0.32	4.3	261.	1.08E-14
2010	31.7	7.04	20.1		0.32	3.6	252.	1.91E-14
2020	31.7	6.94	19.8		0.32	4.6	257.	1.78E-14
2030	31.7	7.35	21.1		0.32	4.3	266.	1.74E-14
2040	31.6	7.48	21.5		0.32	4.8	261.	2.03E-14
2050	31.6	7.58	21.8		0.32	5.4	253.	1.81E-14
2100	31.6	7.34	21.2		0.32	5.7	256.	2.05E-14
2120	31.2	7.53	22.1		0.32	5.6	254.	2.35E-14
2130	31.1	7.43	22.0		0.32	5.8	254.	1.98E-14
2140	31.0	7.34	21.9		0.32	6.0	258.	2.45E-14
2150	31.0	7.55	22.5		0.32	5.6	259.	2.28E-14
2200	30.7	7.60	23.0		0.32	5.6	253.	2.20E-14
2210	30.1	7.86	24.5		0.32	4.8	249.	2.69E-14
2220	30.1	8.03	25.1		0.31	5.0	250.	2.49E-14
2230	29.7	8.16	26.0		0.31	4.9	256.	2.28E-14
2240	29.5	8.20	26.5		0.31	4.7	260.	2.58E-14
2250	29.9	8.58	27.2		0.30	6.1	268.	2.02E-14
2300	29.9	8.61	27.3		0.30	6.2	269.	1.80E-14
2310	29.8	8.47	27.0		0.30	6.0	266.	1.91E-14
2320	29.5	8.45	27.3		0.29	4.8	266.	1.70E-14
2330	28.8	8.60	28.9		0.29	3.8	248.	2.37E-14
2340	28.7	8.92	30.2		0.29	4.8	252.	2.33E-14

NRL-IMØRL RECIEVER

WSMR MICRØMETEØRØLØGICAL DATA

17 AUGUST 1978

TIME	AT	PPH2Ø	RH	BP	SR	WS	WD	CNSQ
	(DEG)	(TØRR)	(%)	(MBAR)	(W/SQ M)	(M/S)	(DEG)	
2350	28.5	8.81	30.1		0.28	4.6	243.	2.46E-14

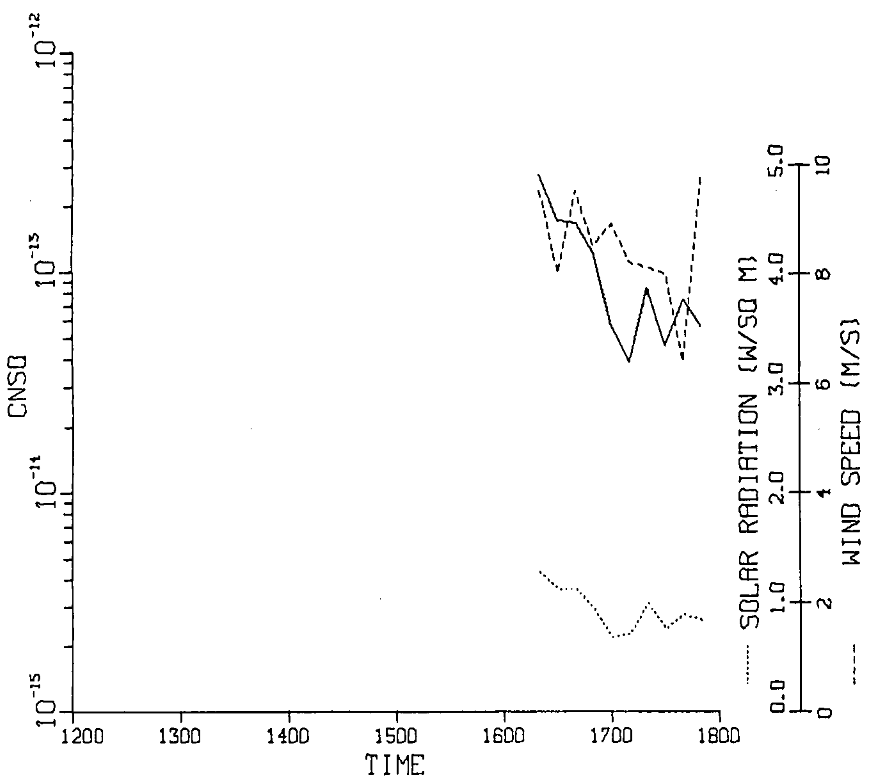

Fig. A-7 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 17 August 1978 (1610 to 1800 h)

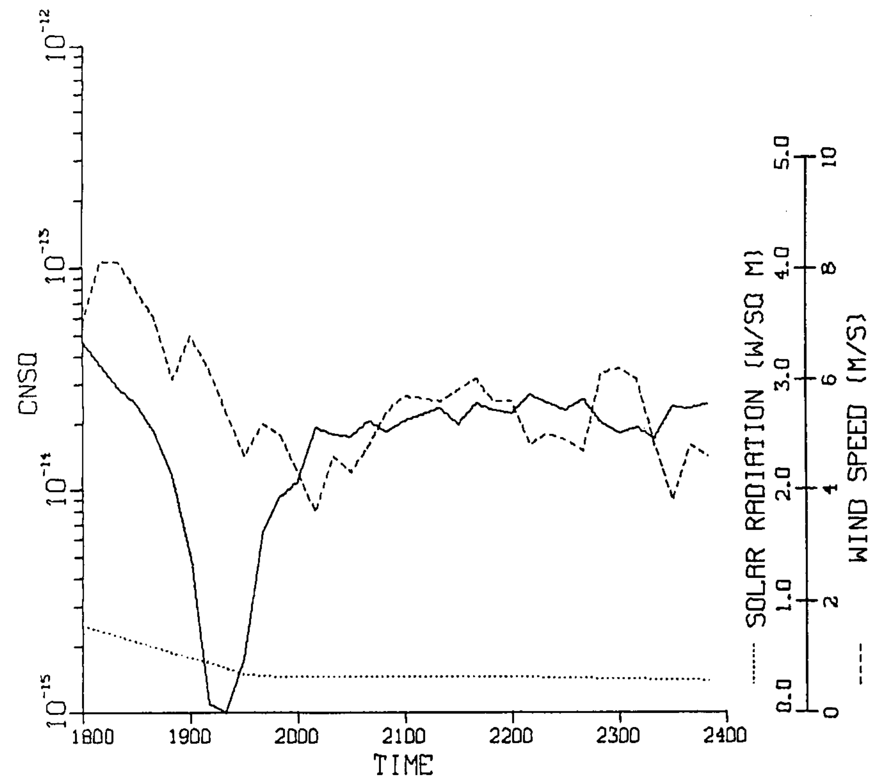

Fig. A-8 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 17 August 1978 (1800 to 2350 h)

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NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

18 AUGUST 1978

TIME	AT	PPH2O	RH	BP	SR	WS	WD	CNSQ
	(DEG)	(TORR)	(%)	(MBAR)	(W/SQ M)	(M/S)	(DEG)	
930	30.2	9.64	30.1	891.4	0.76	3.3	321.	1.21E-14
940	30.1	9.66	30.2	891.4	0.80	2.8	319.	1.20E-14
950	30.4	9.68	29.8	891.3	0.83	2.3	210.	1.48E-14
1000	30.8	9.69	29.1	891.2	0.87	2.9	197.	1.45E-14
1010	30.7	9.68	29.3	891.2	0.90	2.5	236.	1.47E-14
1020	30.9	9.70	29.1	891.2	0.94	2.5	137.	2.07E-14
1030	31.3	9.74	28.5	891.3	0.97	2.4	152.	3.90E-14

UNCLASSIFIED

NRL-IMORL RECIEVER

WSMR MICROMETEORLOGICAL DATA

18 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
0	28.0	8.64	30.4		0.28	3.9	235.	3.35E-14
10	27.8	8.48	30.3		0.28	3.2	239.	3.82E-14
20	27.9	8.49	30.1		0.28	3.8	261.	4.34E-14
30	28.1	8.31	29.2		0.27	4.3	278.	2.31E-14
40	27.9	5.22	18.4		0.27	4.4	280.	2.21E-14
50	27.7	8.25	29.7		0.27	4.0	295.	2.87E-14
100	27.7	8.93	32.0		0.27	4.3	294.	2.06E-14
110	27.2	8.89	32.9		0.27	3.2	296.	2.54E-14
120	26.5	9.13	35.3		0.27	2.3	284.	2.39E-14
130	26.1	9.12	36.0		0.26	2.2	282.	2.23E-14
140	25.5	8.89	36.2		0.26	0.6	248.	7.65E-15
150	26.1	9.19	36.2		0.26	0.7	194.	8.06E-15
200	25.9	9.17	36.6		0.26	1.1	94.	2.77E-14
210	26.3	9.15	35.6		0.26	1.0	221.	9.40E-15
220	26.0	9.39	37.3		0.26	1.0	263.	5.24E-15
230	25.6	9.27	37.7		0.26	3.6	259.	3.63E-14
240	26.7	9.11	34.6		0.28	6.5	279.	2.93E-14
250	27.0	8.96	33.5		0.25	6.8	274.	2.40E-14
300	27.2	9.15	33.9		0.25	7.0	267.	2.28E-14
310	27.0	9.49	35.5		0.25	6.8	268.	1.78E-14
320	26.8	9.46	35.8		0.25	6.1	269.	2.14E-14
330	26.4	9.49	36.8		0.25	5.5	264.	2.02E-14
340	26.0	9.57	37.9		0.25	4.4	272.	1.81E-14
350	26.0	9.61	38.1		0.25	4.3	274.	1.75E-14
400	25.9	9.79	39.1		0.25	4.3	269.	1.95E-14
410	25.5	9.76	39.5		0.25	3.4	253.	2.73E-14
420	24.2	9.54	42.2		0.25	1.7	204.	1.82E-14
430	23.9	9.44	42.5		0.25	2.2	190.	5.65E-14
440	24.4	9.48	41.3		0.25	2.5	182.	7.17E-14
450	24.5	9.52	41.4		0.25	1.6	146.	3.22E-14
500	24.7	9.48	40.6		0.25	0.6	220.	6.97E-15
510	25.1	9.63	40.3		0.24	1.3	265.	7.87E-15
520	25.7	9.38	37.8		0.24	2.7	278.	2.67E-14
530	25.4	9.52	39.1		0.24	3.4	263.	4.26E-14
540	25.5	9.71	39.8		0.24	3.2	273.	3.13E-14
550	25.6	9.59	38.9		0.24	3.0	267.	3.86E-14
600	22.4	9.24	45.6		0.24	2.0	125.	1.54E-14
610	21.1	8.79	46.7		0.24	2.0	102.	1.46E-14
620	21.5	8.88	46.3		0.24	1.5	63.	8.72E-15
630	23.0	9.25	44.0		0.24	1.1	109.	9.86E-15

NRL-IMORL RECIEVER

WSMR MICROMETEOROLOGICAL DATA

18 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
640	21.6	9.28	47.9		0.25	1.5	129.	7.50E-14
650	22.9	9.46	45.1		0.27	1.3	99.	1.31E-14
700	23.6	9.51	43.6		0.30	1.1	119.	4.42E-14
710	24.3	9.63	42.2		0.33	0.7	63.	8.30E-16
720	22.6	9.34	45.4		0.37	1.5	40.	9.06E-15
730	23.7	9.38	42.7		0.41	1.4	67.	1.52E-14
740	23.2	9.17	42.9		0.46	3.3	59.	7.51E-15
750	23.9	9.26	41.7		0.50	2.9	61.	1.46E-14
800	24.8	9.39	40.2		0.56	2.9	50.	1.05E-14
810	25.7	9.51	38.4		0.61	1.7	84.	8.31E-15
820	27.3	9.90	36.3		0.66	1.8	132.	6.75E-15
830	28.3	9.95	34.5		0.71	3.1	326.	9.49E-15
840	28.3	9.89	34.2		0.77	2.7	271.	1.23E-14
850	28.6	9.84	33.5		0.83	1.9	316.	1.36E-14
900	28.9	9.62	32.2		0.88	2.0	318.	2.43E-14
910	29.0	9.30	31.0		0.94	2.3	305.	2.68E-14
920	29.3	9.07	29.7		0.99	2.4	301.	4.07E-14
930	29.6	8.99	28.9		1.04	2.9	317.	6.42E-14
940	29.9	9.22	29.2		1.09	3.0	316.	7.76E-14
950	30.3	9.23	28.6		1.14	2.1	284.	5.93E-14
1000	30.3	9.21	28.5		1.18	2.3	249.	1.02E-13
1010	30.1	9.39	29.3		1.22	2.7	230.	6.69E-14
1020	30.5	9.37	28.6		1.26	2.2	242.	7.87E-14
1030	31.0	9.39	28.0		1.29	2.1	202.	1.21E-13
1040	30.4	9.22	28.3		1.34	2.9	136.	9.02E-14
1050	31.0	9.40	27.9		1.38	1.8	143.	7.26E-14
1110	31.9	9.33	26.4		1.28	2.8	104.	1.69E-13
1120	32.3	9.41	26.1		1.51	2.0	181.	1.73E-13
1130	32.4	8.03	22.1		1.57	2.4	250.	2.80E-13
1140	31.7	9.24	26.4		1.64	1.8	227.	1.32E-13
1150	31.6	9.25	26.7		1.59	1.4	230.	5.21E-14
1200	32.0	9.23	26.0		1.15	1.8	245.	9.20E-14
1210	32.3	8.92	24.6		1.65	2.2	77.	1.65E-13
1220	32.9	9.10	24.4		1.16	2.4	177.	1.43E-13
1230	33.2	8.78	23.1		1.46	1.9	221.	2.02E-13
1240	33.0	8.25	21.9		0.84	5.2	286.	2.25E-13
1250	32.3	8.60	23.7		0.67	3.5	294.	6.59E-14
1300	32.3	8.55	23.7		0.64	3.6	255.	3.55E-14
1310	32.7	8.47	22.9		1.15	1.2	215.	5.48E-14
1320	33.7	8.57	22.0		1.77	5.5	274.	2.43E-13

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NRL-IMORL RECIEVER

WSMR MICROMETEOROLOGICAL DATA

18 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
1330	33.4	8.29	21.5		1.05	5.4	281.	2.06E-13
1340	33.3	8.63	22.6		1.71	4.6	258.	1.96E-13
1350	33.6	8.83	22.9		1.72	3.1	244.	2.48E-13
1400	33.7	9.03	23.1		1.71	5.4	228.	3.97E-13
1410	33.6	9.08	23.4		1.38	3.1	177.	1.97E-13
1420	34.5	8.96	22.0		1.72	5.0	218.	3.96E-13
1430	34.6	8.60	21.0		1.73	7.2	208.	5.97E-13
1440	33.8	8.97	22.8		1.58	4.5	214.	2.70E-13
1450	34.1	8.95	22.4		1.03	3.0	245.	1.75E-13
1500	34.1	8.84	22.1		1.53	3.4	218.	2.50E-13
1510	34.4	8.99	22.2		1.67	3.8	225.	2.80E-13
1520	35.0	8.50	20.3		1.61	5.9	229.	4.60E-13
1530	34.9	8.53	20.5		1.60	5.3	247.	3.67E-13
1540	34.9	8.19	19.7		1.05	5.8	246.	2.78E-13
1550	34.6	8.49	20.7		0.98	6.1	229.	2.11E-13
1600	35.0	8.24	19.6		1.45	5.2	248.	2.97E-13
1610	34.5	8.05	19.7		0.72	5.2	246.	1.04E-13
1620	35.0	8.09	19.4		1.31	7.4	242.	2.64E-13
1630	34.7	8.46	20.5		0.75	6.8	271.	1.15E-13
1640	34.9	8.25	19.8		1.06	7.4	276.	1.72E-13
1650	34.7	8.02	19.4		1.11	5.2	289.	1.68E-13
1700	34.2	8.31	20.7		0.76	3.3	260.	8.63E-14
1710	34.1	8.51	21.3		0.57	5.3	272.	4.37E-14
1720	33.9	8.28	21.0		0.45	3.6	297.	2.47E-14
1730	33.0	7.45	19.9		0.43	5.6	329.	1.86E-14
1740	31.9	9.65	27.3		0.40	6.4	331.	2.13E-14
1750	29.6	0.66	34.3		0.38	7.8	320.	9.86E-14
1800	30.3	0.35	32.1		0.37	3.9	277.	3.67E-14
1812	28.4	1.01	38.0		0.36	6.2	296.	2.79E-14
1822	28.0	1.13	39.2		0.38	6.4	280.	2.82E-14
1832	28.5	1.65	39.9		0.46	4.9	264.	4.64E-15
1842	29.1	1.12	36.9		0.45	3.4	247.	1.58E-15
1852	29.5	0.59	34.3		0.42	3.2	226.	1.76E-15
1902	29.2	0.31	34.0		0.40	8.4	234.	1.89E-15
1912	29.2	0.03	33.0		0.39	7.4	224.	1.31E-15
1922	29.3	9.86	32.3		0.35	5.7	217.	1.19E-16
1932	29.3	9.45	30.9		0.32	6.3	221.	1.21E-16
1942	29.5	9.13	29.5		0.30	5.9	227.	5.46E-16
1952	29.6	8.94	28.8		0.29	4.2	237.	1.70E-15
2002	29.6	8.83	28.4		0.28	3.9	226.	1.74E-15

NRL-IMORL RECIEVER

WSMR MICROMETEOROLOGICAL DATA

18 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	DP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
2012	29.4	8.87	28.9		0.28	3.0	179.	1.64E-15
2022	28.7	9.27	31.3		0.28	3.2	96.	1.09E-15
2032	27.6	0.69	38.6		0.23	5.4	72.	1.99E-15
2042	27.3	1.36	41.8		0.27	6.1	73.	4.64E-16
2052	27.2	1.14	41.1		0.27	4.6	65.	1.47E-15
2102	27.2	1.08	41.0		0.27	4.1	67.	1.06E-15
2112	26.6	1.64	44.6		0.27	4.1	74.	3.50E-16
2122	26.0	1.81	46.9		0.27	5.2	61.	3.38E-16
2150	25.1	2.06	50.4		0.26	3.5	71.	3.30E-15
2200	24.9	1.89	50.2		0.26	3.5	65.	5.72E-15
2210	24.7	2.02	51.4		0.26	2.6	70.	3.30E-15
2220	24.4	2.16	52.9		0.26	1.3	80.	1.48E-15
2230	24.2	1.79	51.9		0.26	1.3	186.	4.17E-15
2240	24.4	1.86	51.7		0.26	2.1	57.	1.09E-14
2250	23.5	1.98	55.0		0.26	2.1	36.	8.39E-15
2300	23.2	2.12	57.0		0.26	1.1	74.	5.82E-15
2310	22.8	1.66	56.9		0.26	1.8	221.	9.02E-15
2320	23.1	1.30	53.3		0.26	2.0	200.	8.03E-15
2330	23.0	1.63	55.3		0.26	2.5	190.	1.30E-14
2340	23.1	1.83	55.9		0.25	2.2	206.	2.66E-14
2350	23.2	1.73	55.9		0.25	2.1	197.	2.65E-14

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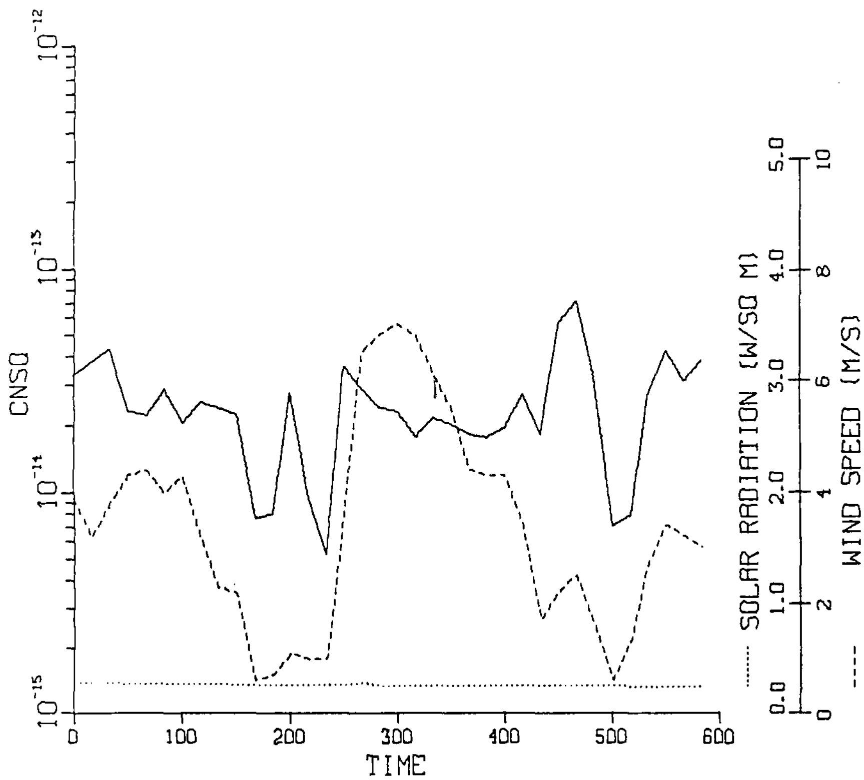

Fig. A-9 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 18 August 1978 (0000 to 0600 h)

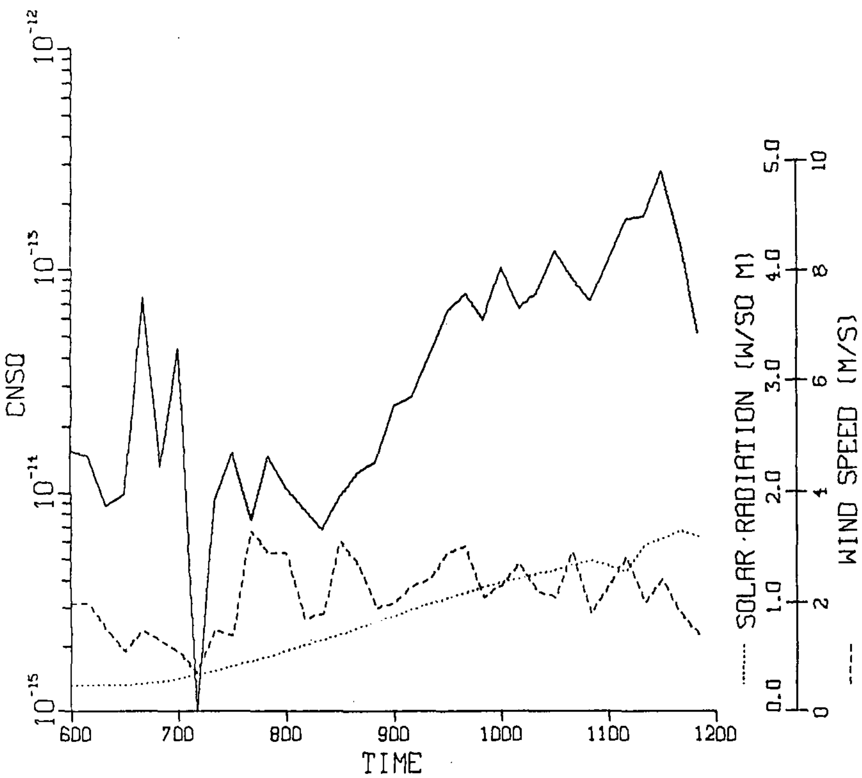

Fig. A-10 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 18 August 1978 (0600 to 1200 h)

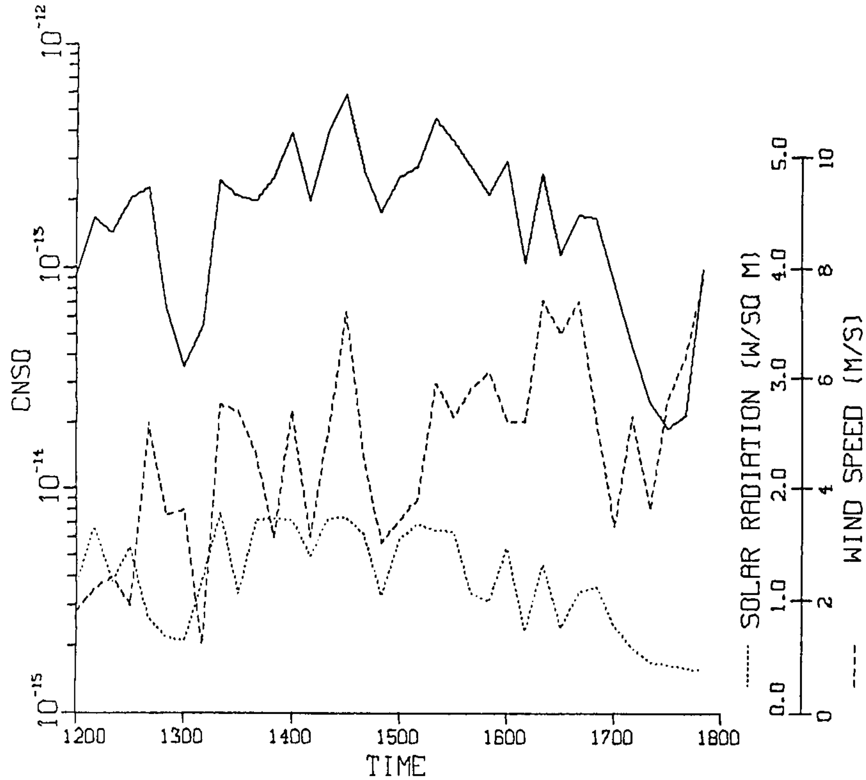

Fig. A-11 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 18 August 1978 (1200 to 1800 h)

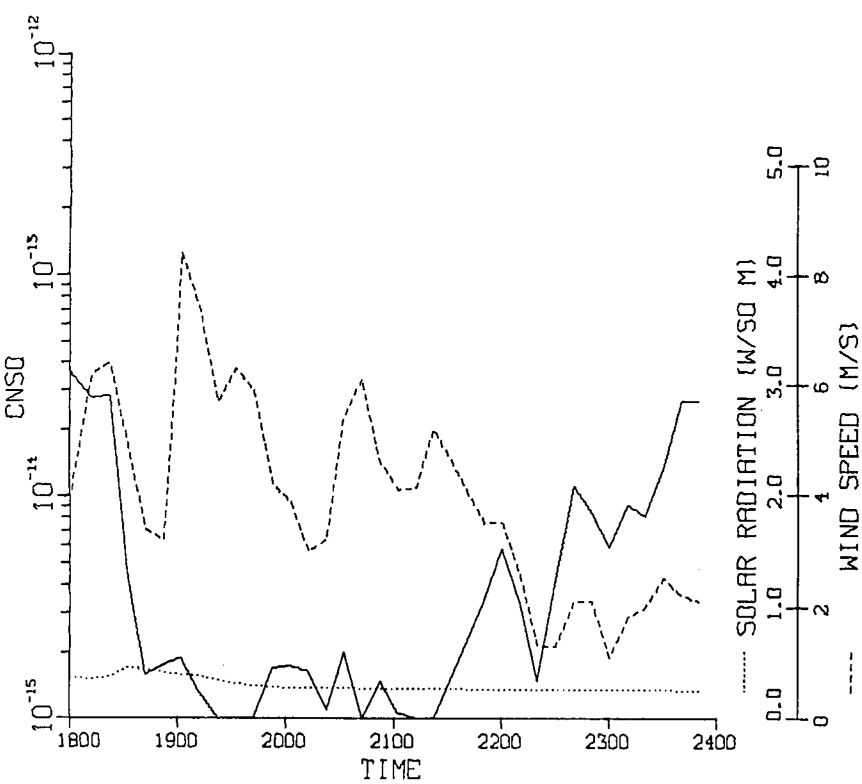

Fig. A-12 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 18 August 1978 (1800 to 2400 h)

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NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

19 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR* (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
840	21.7	1.73	60.3	894.2	0.29	1.2	266.	7.63E-15
850	22.4	1.62	57.1	894.2	0.38	0.7	71.	4.29E-14
900	22.9	1.45	54.4	894.2	0.42	0.6	154.	7.75E-14
910	23.3	1.34	52.8	894.2	0.40	0.8	159.	1.15E-14
920	23.6	1.39	52.1	894.4	0.41	0.8	232.	4.01E-14
930	24.1	1.42	50.6	894.5	0.76	1.0	206.	4.13E-14
950	12.2	5.89	55.5	885.5	0.35	2.5	185.	5.73E-14
1000	24.4	1.26	49.0	894.5	0.42	0.6	184.	1.18E-14
1010	25.0	1.19	47.2	894.5	0.45	0.8	184.	1.16E-14
1020	25.0	1.17	46.9	894.5	0.62	1.7	148.	7.03E-15
1030	25.6	1.09	45.0	894.7	0.98	1.8	177.	2.74E-14
1040	26.0	1.21	44.3	894.7	1.00	2.3	169.	3.76E-14

NRL-IMØRL RECIEVER

WSMR MICRØMETEØRØLØGICAL DATA

19 AUGUST 1978

TIME	AT (DEG)	PPH2Ø (TØRR)	RH (%)	BP (MBAR)	SR* (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
0	23.0	1.58	54.9		0.25	2.0	185.	2.59E-14
10	23.3	1.60	54.0		0.25	1.4	223.	1.05E-14
20	23.1	1.40	53.9		0.25	1.5	242.	6.21E-15
30	21.9	1.56	58.5		0.25	2.3	268.	1.68E-14
40	21.8	1.56	59.1		0.25	2.0	258.	9.86E-15
50	21.5	1.33	58.9		0.25	2.6	239.	3.06E-14
100	21.7	0.64	54.6		0.25	3.0	252.	3.12E-14
110	22.3	0.84	53.7		0.24	2.1	250.	2.03E-14
120	22.5	0.78	52.8		0.24	1.1	239.	6.78E-15
130	20.9	1.69	63.0		0.24	1.4	24.	1.24E-14
140	21.7	1.77	60.4		0.24	0.8	219.	1.70E-15
150	23.4	1.03	51.2		0.24	0.9	315.	1.99E-15
200	23.5	1.32	52.1		0.24	1.0	264.	4.07E-15
210	24.1	0.97	48.8		0.24	0.6	265.	3.69E-15
220	22.8	1.19	53.6		0.24	0.9	228.	1.85E-14
230	22.5	1.26	55.0		0.23	0.8	159.	6.86E-15
240	20.8	1.71	63.7		0.23	1.7	98.	1.66E-14
250	20.7	1.79	64.3		0.23	3.3	120.	8.10E-15
300	21.1	1.18	59.6		0.23	3.4	136.	9.96E-15
310	21.1	1.02	58.8		0.23	2.4	138.	9.22E-15
320	21.0	0.90	58.6		0.23	1.8	123.	9.22E-15
330	20.8	0.85	58.8		0.23	1.3	132.	4.20E-15
340	20.4	0.83	60.2		0.23	1.4	167.	1.23E-14
350	20.5	0.49	58.0		0.23	0.4	121.	2.86E-15
400	19.2	0.89	65.3		0.23	1.7	37.	1.67E-14
410	19.3	1.11	66.3		0.23	1.2	62.	4.20E-15
420	20.2	1.16	62.9		0.23	1.0	103.	1.67E-15
430	19.1	0.98	66.2		0.23	1.8	68.	4.16E-15
440	19.7	1.02	64.0		0.23	1.2	89.	7.92E-15
450	18.8	1.13	68.3		0.23	1.4	91.	2.24E-14
500	18.0	1.00	71.3		0.23	1.9	54.	2.89E-14
510	18.2	0.99	70.3		0.23	2.4	88.	3.63E-14
520	18.4	0.86	68.7		0.22	2.4	87.	2.94E-14
530	18.2	0.95	70.0		0.22	2.5	83.	2.08E-14
540	18.2	0.98	70.2		0.22	2.4	78.	1.30E-14
550	18.5	0.76	67.4		0.22	3.5	100.	2.68E-14
600	18.8	0.56	65.1		0.22	2.4	86.	3.01E-14
610	18.8	0.44	64.3		0.22	1.2	86.	1.03E-14
620	19.1	0.54	63.5		0.22	0.7	168.	9.87E-15
630	18.2	0.70	68.2		0.22	1.1	276.	1.91E-15

UNCLASSIFIED

NRL-IMORL RECIEVER

WSMR MICROMETEOROLOGICAL DATA

19 AUGUST 1978

TIME	AT (DEG)	PPH20 (TORR)	RH (%)	BP (MBAR)	SR (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
640	17.8	0.65	69.6		0.22	0.7	151.	2.19E-15
650	18.1	0.54	67.9		0.23	1.8	66.	6.57E-15
700	18.4	0.47	66.2		0.24	2.5	67.	1.15E-14
710	18.3	0.65	67.8		0.25	2.4	64.	1.09E-14
720	18.5	0.90	68.5		0.27	2.0	53.	7.26E-15
730	19.0	0.88	66.3		0.30	1.1	59.	6.08E-15
740	19.5	0.73	63.0		0.31	0.4	111.	4.75E-15
750	19.6	0.88	63.7		0.34	0.3	144.	2.81E-15
800	19.7	0.92	63.6		0.40	0.9	241.	1.53E-15
810	19.9	1.18	64.4		0.49	1.0	289.	1.60E-15
820	20.2	1.34	64.1		0.45	0.8	293.	3.16E-15
830	20.8	1.27	61.2		0.47	0.5	308.	3.49E-15
840	21.3	1.34	59.7		0.51	0.6	326.	5.99E-15
850	21.5	1.48	59.6		0.52	0.9	239.	4.96E-15
900	22.1	1.23	56.5		0.51	0.4	136.	8.19E-15
910	22.6	0.86	52.7		0.55	0.6	230.	7.23E-15
920	23.0	0.70	50.7		0.60	0.7	207.	8.12E-15
930	23.5	0.77	49.7		0.59	1.2	233.	1.31E-14
940	23.5	0.74	49.3		0.54	1.7	229.	9.86E-15
950	23.9	0.66	48.0		0.80	2.0	226.	2.02E-14
1000	24.5	0.27	44.6		0.70	1.8	227.	3.70E-14
1010	24.7	0.61	45.5		0.70	1.9	207.	2.12E-14
1020	25.5	0.43	42.5		1.18	1.6	175.	7.86E-14
1030	26.1	0.51	41.5		1.27	2.1	161.	1.28E-13
1040	26.4	0.40	40.3		1.30	2.5	163.	1.38E-13
1050	27.1	0.50	39.0		1.34	2.4	148.	1.76E-13
1100	27.4	0.48	38.2		1.39	2.9	150.	2.57E-13
1110	27.8	9.94	35.4		1.41	3.1	157.	2.96E-13
1130	28.1	0.85	38.0		1.47	2.6	109.	1.89E-13
1140	28.9	0.24	34.3		1.51	4.8	118.	3.13E-13
1150	29.3	0.20	33.5		1.53	5.2	137.	3.09E-13
1200	29.3	0.12	33.1		1.56	5.6	118.	3.84E-13
1210	29.4	0.06	32.7		1.57	4.7	137.	3.28E-13
1220	30.1	9.94	31.1		1.59	4.4	141.	3.65E-13
1230	30.1	9.81	30.6		1.63	5.4	145.	3.77E-13
1240	29.6	0.01	32.2		1.27	5.0	136.	2.29E-13
1250	30.2	0.22	31.9		1.48	4.4	132.	2.32E-13
1300	30.4	9.73	29.9		1.63	5.0	132.	4.07E-13
1310	30.2	0.38	32.2		1.36	5.4	138.	2.58E-13
1320	30.4	0.42	32.1		1.46	3.6	121.	2.70E-13

NRL-IMØEL RECIEVER

WSMR MICRØMETEØRØLØGICAL DATA

19 AUGUST 1978

TIME	AT	PPH2Ø	RH	SP	SR	WS	WD	CNSQ
	(DEG)	(TØRR)	(%)	(MBAR)	(W/SQ M)	(M/S)	(DEG)	
1330	30.3	0.43	32.3		1.51	5.2	106.	2.54E-13
1340	30.7	0.37	31.4		1.38	6.5	113.	3.56E-13
1350	30.4	0.51	32.4		1.05	4.6	130.	1.56E-13
1400	30.7	0.45	31.6		1.01	5.2	116.	2.05E-13
1410	30.8	0.45	31.4		0.78	5.4	135.	1.44E-13
1420	30.7	0.70	32.3		0.98	7.0	130.	1.25E-13
1430	31.0	0.54	31.4		0.89	7.0	148.	1.11E-13
1440	31.0	9.79	29.1		0.96	5.7	148.	1.09E-13

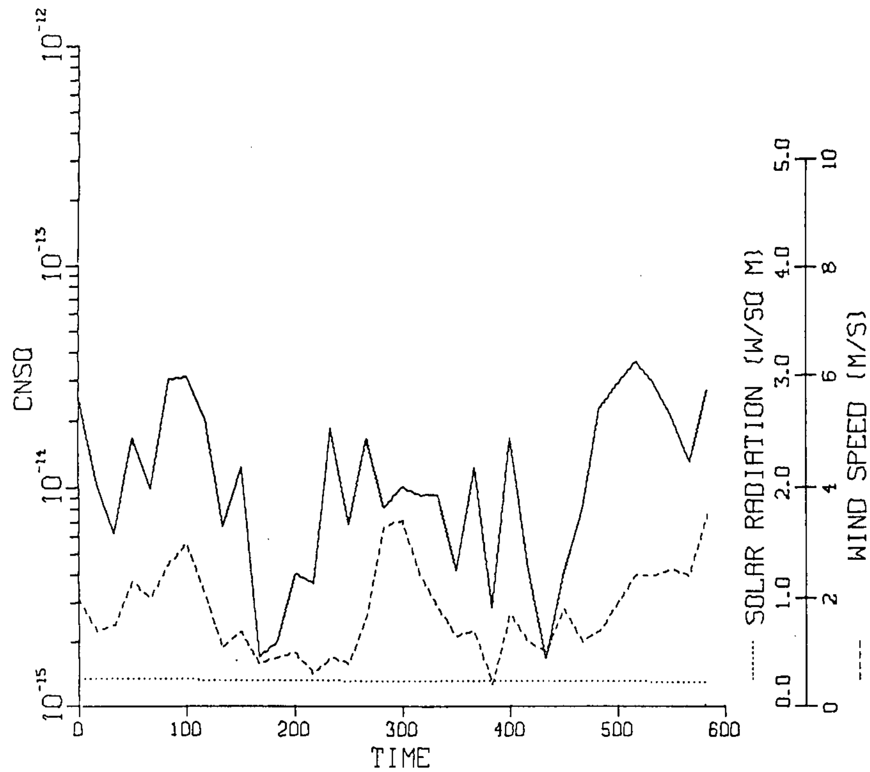

Fig. A-13 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 19 August 1978 (0000 to 0600 h)

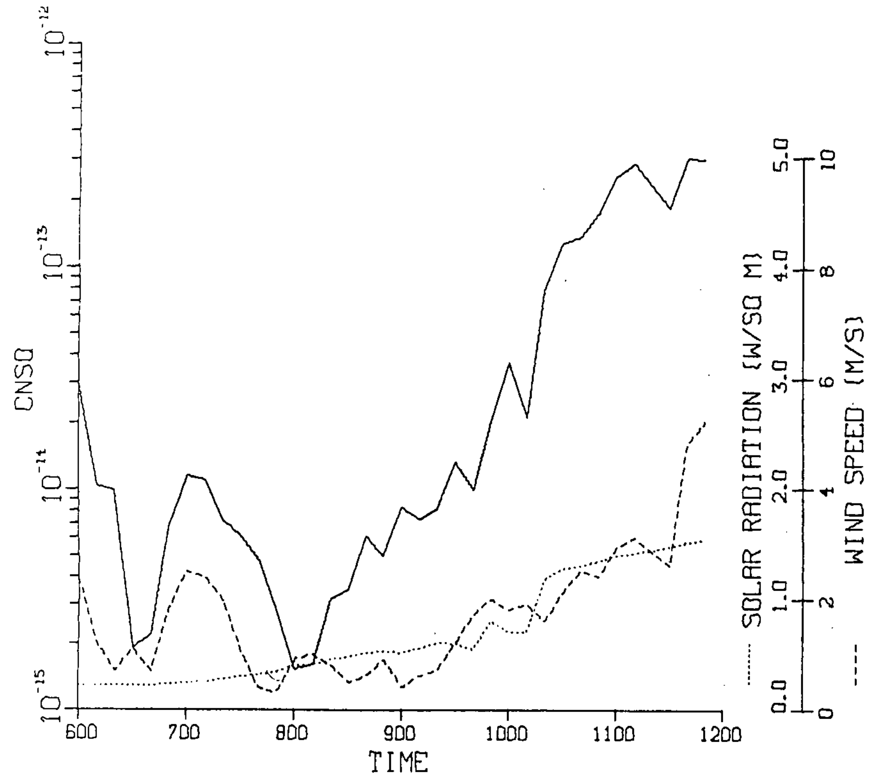

Fig. A-14 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 19 August 1978 (0600 to 1200 h)

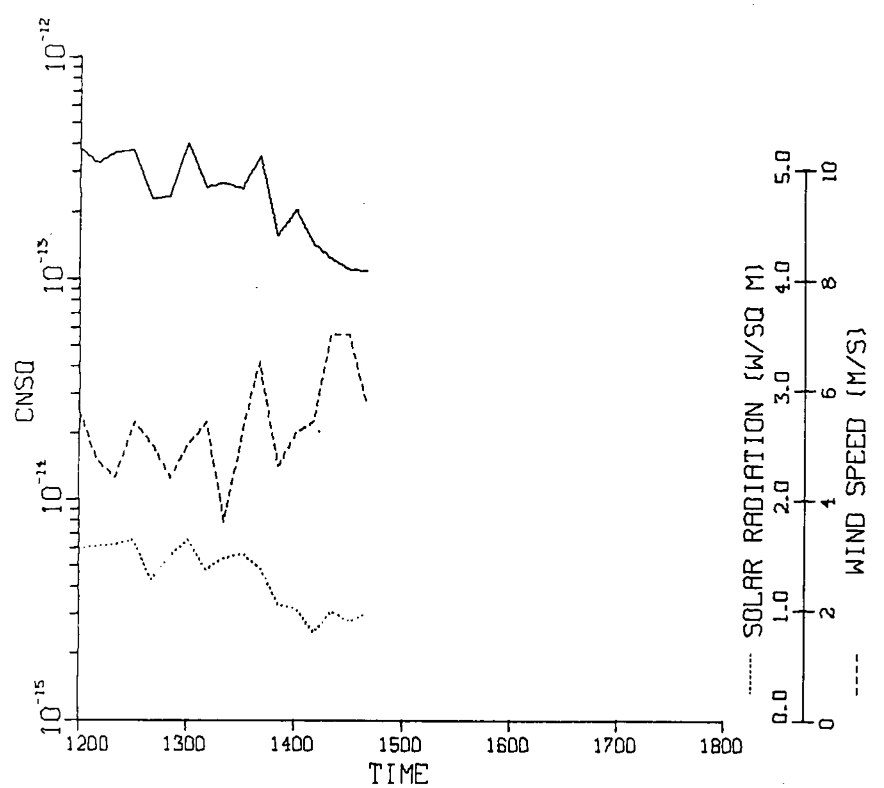

Fig. A-15 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 19 August 1978 (1200 to 1440 h)

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NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

21 AUGUST 1978

TIME	AT (DEG)	PPH2O (TORR)	RH (%)	BP (MBAR)	SR* (W/SQ M)	WS (M/S)	WD (DEG)	CNSQ
850	20.6	4.87	81.7	895.8	0.49	1.3	312.	4.31E-15
900	21.6	4.79	76.6	895.8	0.52	0.9	253.	1.15E-14
910	22.2	4.52	72.3	895.8	0.57	1.6	334.	7.13E-15
920	22.9	9.11	91.0	895.8	0.62	1.6	286.	9.64E-15
930	23.6	6.784	42.6	895.8	0.66	1.2	239.	1.47E-14
940	23.6	4.15	64.6	895.8	0.71	1.6	307.	9.73E-15
950	23.5	4.44	66.3	895.9	0.75	1.6	312.	1.00E-14
1000	23.9	4.36	64.6	896.0	0.79	1.3	286.	1.30E-14
1010	24.3	4.31	62.9	896.0	0.82	1.1	304.	1.32E-14
1020	24.8	3.82	58.7	896.0	0.86	1.0	253.	1.71E-14
1030	25.3	3.25	54.9	896.0	0.90	1.1	133.	3.20E-14
1040	25.6	3.67	55.6	896.0	0.94	1.1	148.	3.32E-14
1050	26.0	3.75	54.6	896.0	0.97	1.1	199.	3.97E-14
1100	25.8	3.35	53.4	896.0	1.00	1.4	231.	1.93E-14

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NRL-IMORL TRANSMITTER

WSMR MICROMETEOROLOGICAL DATA

22 AUGUST 1978

TIME	AT	PPH2O	RH	BP	SR*	WS	WD	CNSQ
	(DEG)	(TORR)	(%)	(MBAR)	(W/SQ M)	(M/S)	(DEG)	
850	23.7	2.93	58.8	892.9	0.45	3.2	36.	4.65E-15
900	24.0	2.82	57.3	892.9	0.35	3.6	53.	3.57E-15
910	24.4	2.60	54.9	892.9	0.35	3.2	183.	2.87E-15
920	24.9	2.67	53.6	892.9	0.73	3.2	178.	8.68E-15
930	25.1	2.96	54.3	892.9	0.51	2.1	59.	1.71E-14
940	25.0	2.86	54.0	892.9	0.60	1.4	97.	1.15E-14
950	25.4	2.58	51.6	892.9	0.84	0.8	121.	1.17E-14
1000	25.8	2.38	49.8	892.9	0.79	1.7	85.	2.30E-14
1010	26.1	2.27	48.4	892.9	0.95	2.4	195.	2.65E-14
1020	22.9	0.14	48.5	890.8	0.77	3.1	177.	3.66E-14
1030	26.2	1.02	43.2	892.9	0.88	2.0	241.	1.39E-14
1040	26.5	1.22	43.2	892.9	0.77	2.1	295.	1.58E-14
1050	26.6	1.13	42.5	892.9	1.10	2.0	164.	2.42E-14
1100	26.9	1.39	42.7	892.8	1.07	2.2	211.	2.37E-14
1110	27.3	1.24	41.3	892.7	1.11	0.9	5.	4.30E-14
1120	27.5	1.12	40.4	892.7	1.16	1.0	6.	3.02E-14
1130	27.7	1.10	39.8	892.7	1.18	1.1	98.	4.18E-14
1140	27.7	0.77	38.7	892.7	0.89	2.2	329.	2.30E-14
1150	27.9	0.86	38.5	892.7	0.95	1.1	260.	3.81E-14
1200	28.4	1.37	39.2	892.7	0.91	1.1	238.	9.25E-14
1210	28.3	1.26	39.0	892.7	0.83	2.1	298.	3.32E-14
1220	28.6	1.16	38.0	892.7	1.31	1.0	269.	6.27E-14
1230	29.0	1.06	36.8	892.5	1.29	1.5	279.	1.06E-13
1240	29.4	1.19	36.5	892.4	1.25	1.1	81.	1.05E-13
1250	29.3	0.73	35.1	892.2	1.05	0.9	217.	9.62E-14
1300	29.8	0.90	34.7	892.2	1.23	1.2	209.	7.41E-14
1310	30.5	0.58	32.4	892.0	1.28	1.1	263.	7.66E-14
1320	30.3	0.49	32.5	891.7	1.28	1.8	205.	5.52E-14
1330	30.3	0.36	32.0	891.6	1.28	2.1	210.	4.77E-14
1340	30.3	0.37	32.0	891.4	1.28	1.5	257.	5.11E-14
1350	30.7	0.46	31.6	891.4	1.27	1.4	222.	7.67E-14
1400	31.2	0.23	30.0	891.4	1.28	2.5	224.	1.02E-13
1410	31.3	0.21	29.9	891.2	1.29	3.3	265.	8.56E-14
1420	31.1	0.01	29.5	891.1	1.26	2.9	275.	8.77E-14
1430	31.9	0.31	29.1	891.0	1.24	3.2	229.	1.08E-13
1440	31.1	0.28	30.3	891.1	1.18	3.3	276.	1.00E-13
1450	31.5	0.28	29.7	890.9	0.97	2.5	191.	6.19E-14

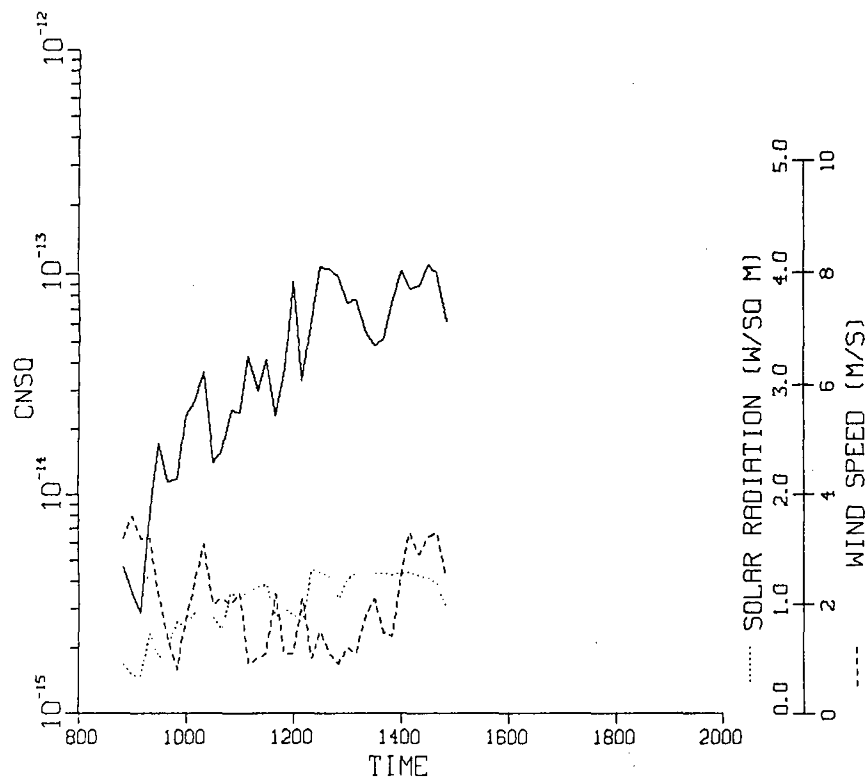

Fig. A-16 — Solar radiation, windspeed, and C_N^2 at the optical transmitter meteorological station on 22 August 1978