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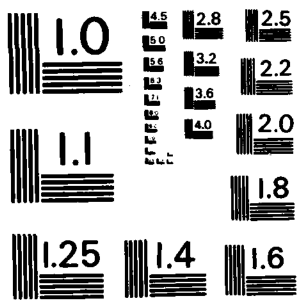

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NRL Memorandum Report 5168

Computed Survey Spectra of 2-5μ Atmospheric Absorption

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Applied Optics Branch
Optical Sciences Division

August 31, 1983

NAVAL RESEARCH LABORATORY
Washington, D.C.

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

Computed high resolution survey spectra of atmospheric absorption coefficient vs wavenumber are presented covering the wavelength region 2-5 μm. The 1980 AFGL atmospheric absorption parameter compilation was employed with a mid-latitude, sea-level atmospheric model.

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COMPUTED SURVEY SPECTRA OF 2-5μ ATMOSPHERIC ABSORPTION

This report presents computed spectra of atmospheric absorption in the 2-5 μm region. The spectra collected here followed from a request for detailed information on narrow transmission windows. The recent availability of tunable laser sources at 2-5 μm, including *F*-center lasers and downshifted Raman devices, has renewed interest in narrow atmospheric transmission windows.

The spectra in Figs. 3-77 present molecular absorption coefficient (km^{-1}) vs wavenumber (cm^{-1}), where $\nu(cm^{-1}) = 10^4 \times \lambda^{-1}(\mu m)$. Aerosol scattering and absorption are not considered here. The standard midlatitude-summer sea-level atmosphere is assumed, and described in Table 1. The water vapor standard isotopic ratio HDO/H_2O = 0.030% is assumed.

Table 1 — MidLatitude Summer Sea-Level
Atmospheric Parameters

Molecular	Pressure (torr)	Concentration (ppm)
H_2O	14.26	1.88×10^4
CO_2	0.251	330
O_3	2.3×10^{-5}	0.030
N_2O	2.1×10^{-4}	0.276
CO	5.7×10^{-5}	0.075
CH_4	1.2×10^{-3}	1.58
O_2	159.6	2.10×10^5
N_2	585.9	7.7×10^5

NOTE: Temperature = 22.9°C

The calculations were performed using our HITRAN code with the 1980 AFGL line compilation.[1,2] The plots were made on a Versatek plotter at 100 points per inch resolution. Since each plot is 40 cm^{-1} long across 7 inches, the effective wavenumber resolution is approximately 0.057 cm^{-1} per point. At sea level almost all absorption lines are pressure broadened to a HWHM greater than 0.05 cm^{-1}. The plot parameters were chosen to maximize the number of wavenumbers per plot panel, without undersampling the true spectrum. The user of these survey spectra is cautioned to pay attention to the vertical scale; each panel is self-scaling so some plots cover 2 decades where others cover as much as 6 decades of absorption coefficient.

The 1982 AFGL listing has recently been released,[3] but no significant changes have been made in the 2-5 μm region for the molecules considered here. Areas of uncertainty remain in the specific correction needed for the sub-Lorentz CO_2 lineshape,[4,5] and the Burch[6] vs White[7] 3.3-4.2 μm water continuum absorption model.

Table 2 — Spectral Plot Parameters

Lineshape: Lorentz with ± 20 cm^{-1} bound Self-to-Foreign Broadening: [1]		
	Ratio: γ_s/γ_F	Temperature Coefficient $\gamma \sim T^n$
H_2O	5.0	0.62
CO_2	1.3	0.58
O_3	1.0	0.50
N_2O	1.24	0.50
CO	1.02	0.50
CH_4	1.3	0.50
O_2	1.0	0.50

NOTE: Water Vapor Continuum 2350 – 2800 cm^{-1} [5,6]
Nitrogen continuum 2080 – 2740 cm^{-1} [5,8]
CO_2 sub-Lorentz lineshape [4]

The spectral plot parameters are summarized in Table 2. The two continuum absorption contributions are well documented in the literature. The line-by-line summation was carried out to ± 20 cm^{-1} from the plotted frequency. The correction to the CO_2 spectra to account for the sub-Lorentz line shape is described in Fig. 1 and Eq. (1) below:

$$k(\nu_0) = \chi(\nu - \nu_0)\, k_L(\nu_0) \tag{1}$$

where

$$k_L(\nu_0) = \frac{1}{\pi} \frac{\gamma S}{(\nu - \nu_0)^2 + \gamma^2}$$

and $\chi(\nu - \nu_0)$ is given in Fig. 1.

A broad-band transmittance plot for a 1 km path was produced using LOWTRAN-5b with the above atmosphere and no aerosols (9). This is given in Fig. 2 and is useful for a quick glance at the same region covered by the 75 high-resolution absorbance plots. The effective spectral resolution of Fig. 2 is 20 cm^{-1}.

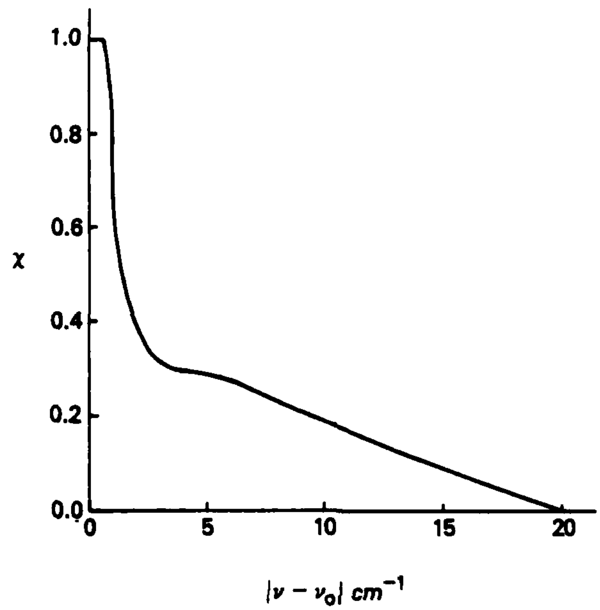

Fig. 1 — χ function in Eq. (1) used for CO_2 sub-Lorentz lineshape

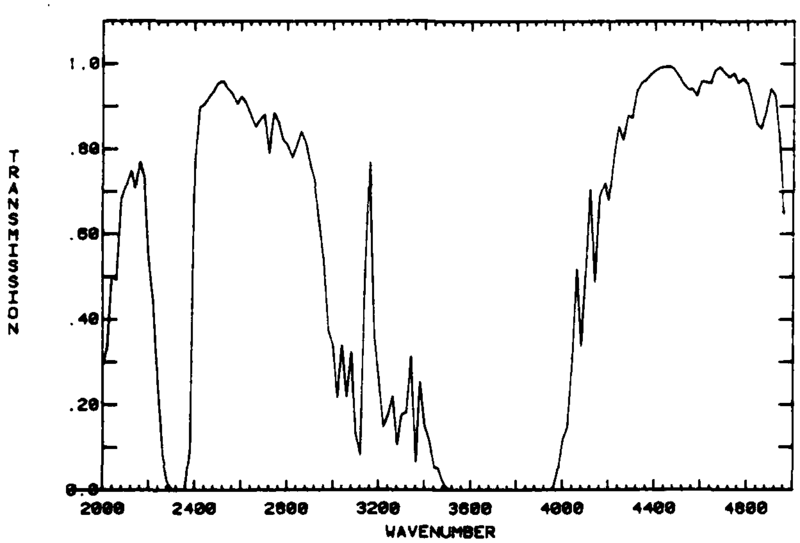

Fig. 2 — LOWTRAN-5 1 km mid-latitude summer sea-level transmittance 5-2 μm

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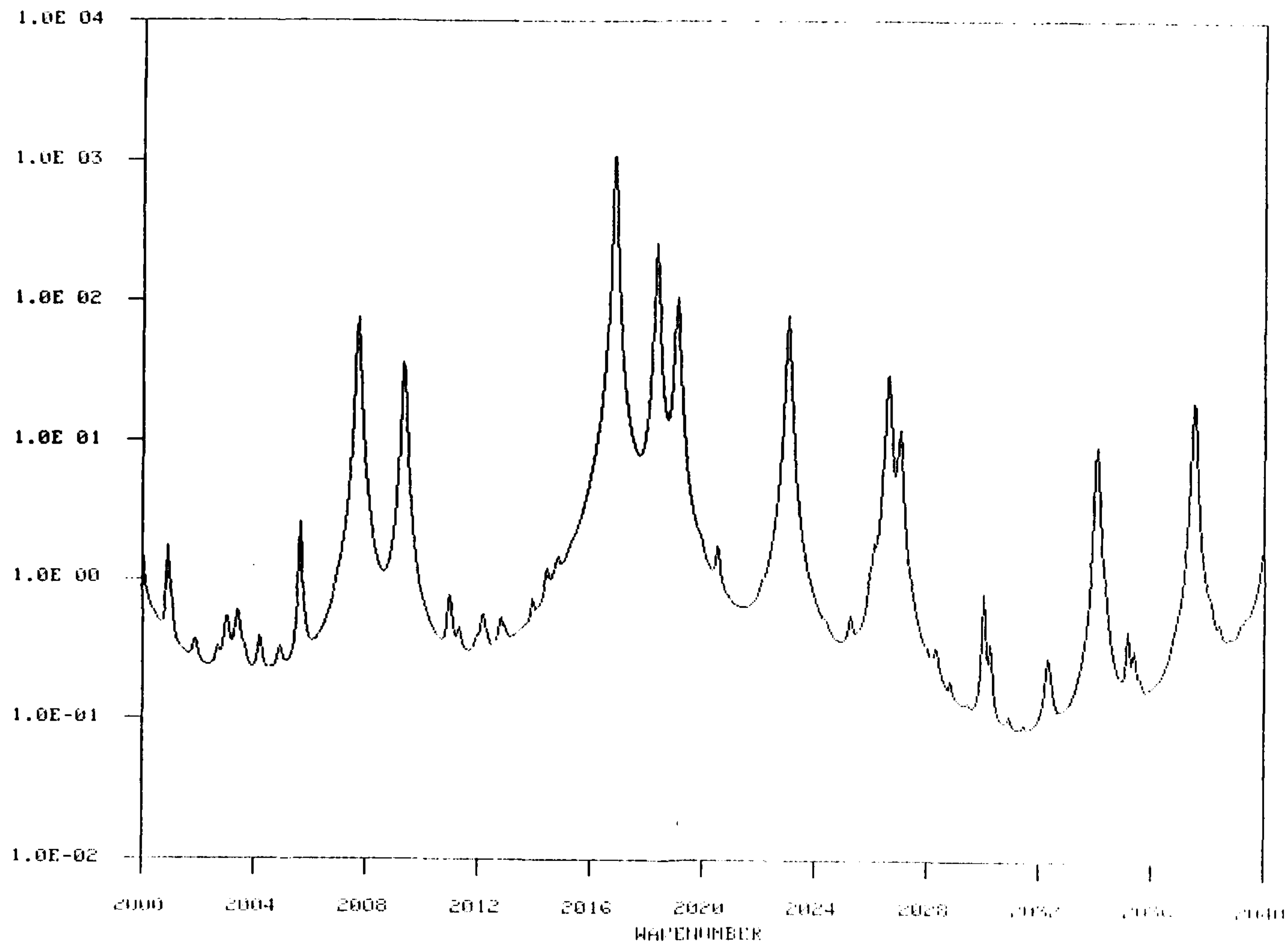

Fig. 3 — 2000-2040 cm^{-1} atmospheric absorption coefficient (km^{-1})

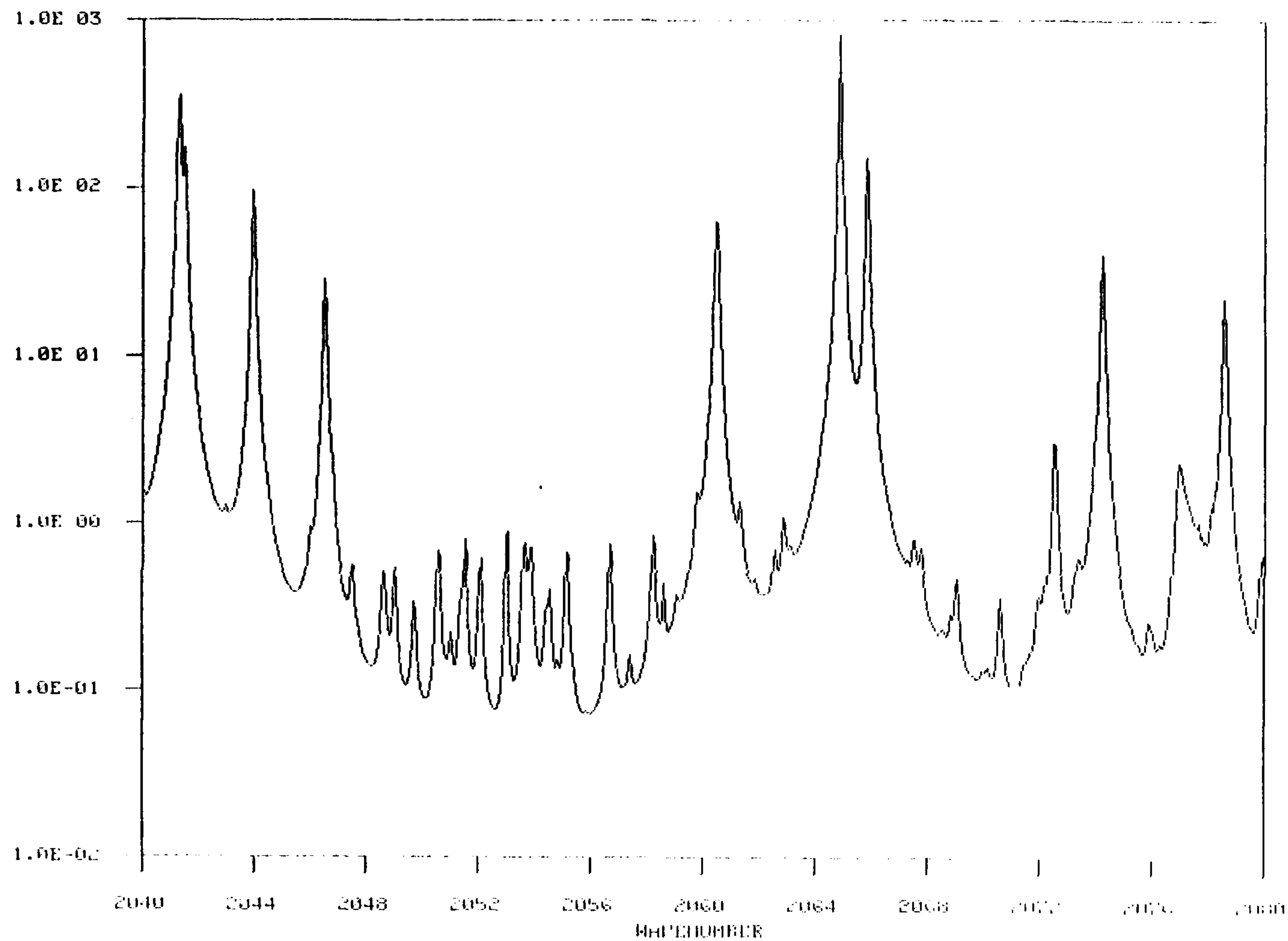

Fig. 4 — 2040-2080 cm^{-1} atmospheric absorption coefficient (km^{-1})

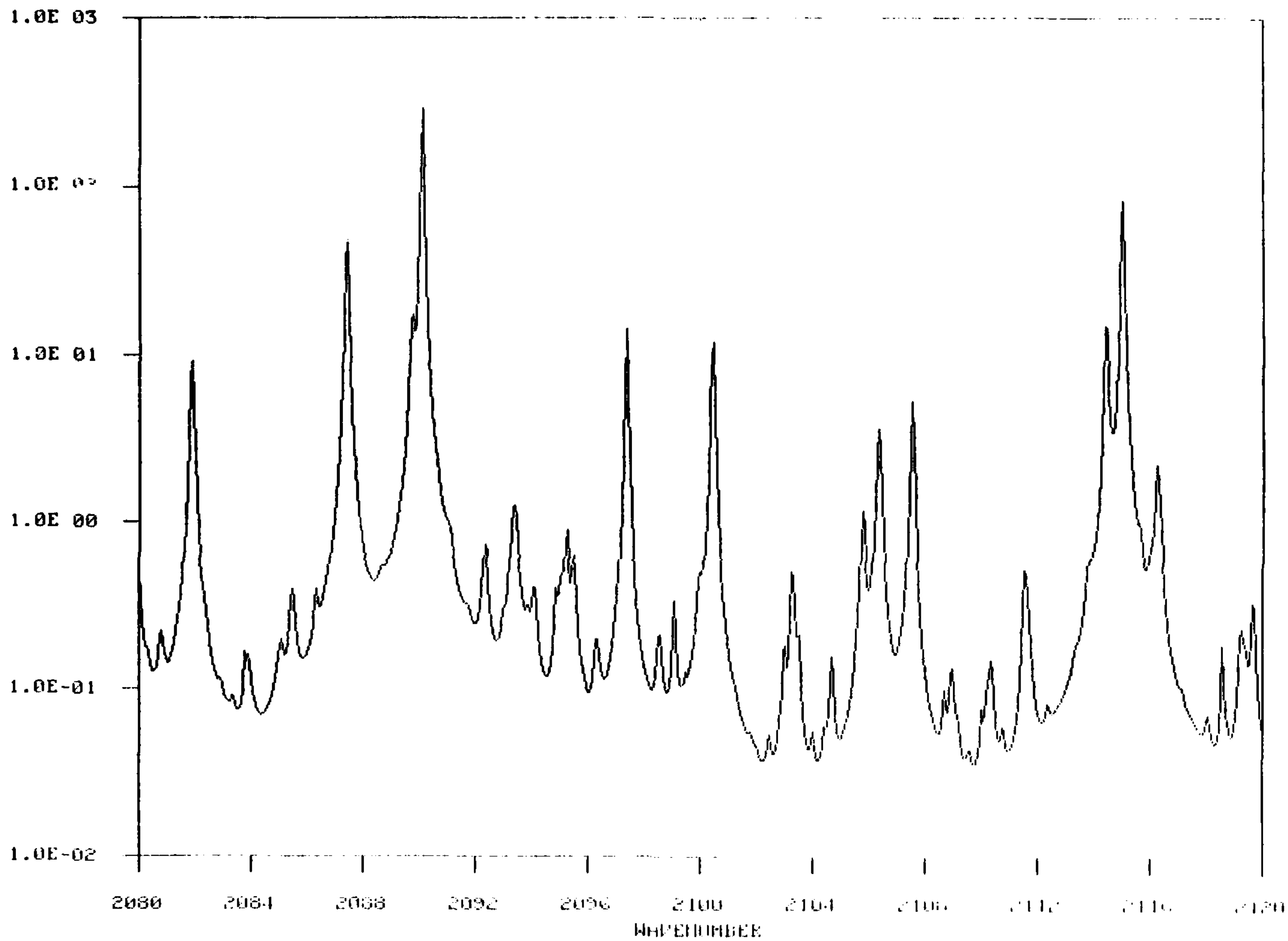

Fig. 5 — 2080-2120 cm^{-1} atmospheric absorption coefficient (km^{-1})

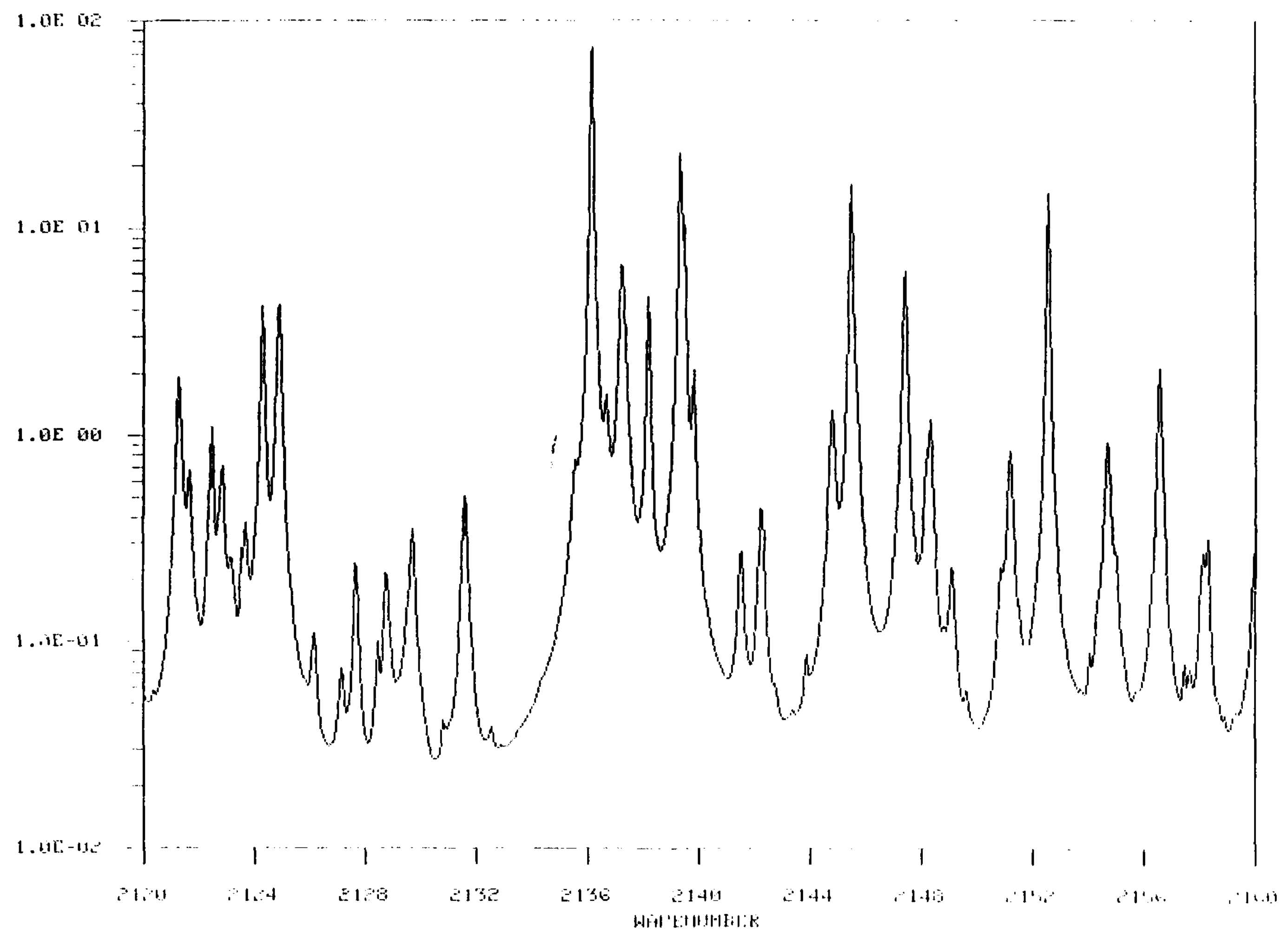

Fig. 6 — 2120-2160 cm^{-1} atmospheric absorption coefficient (km^{-1})

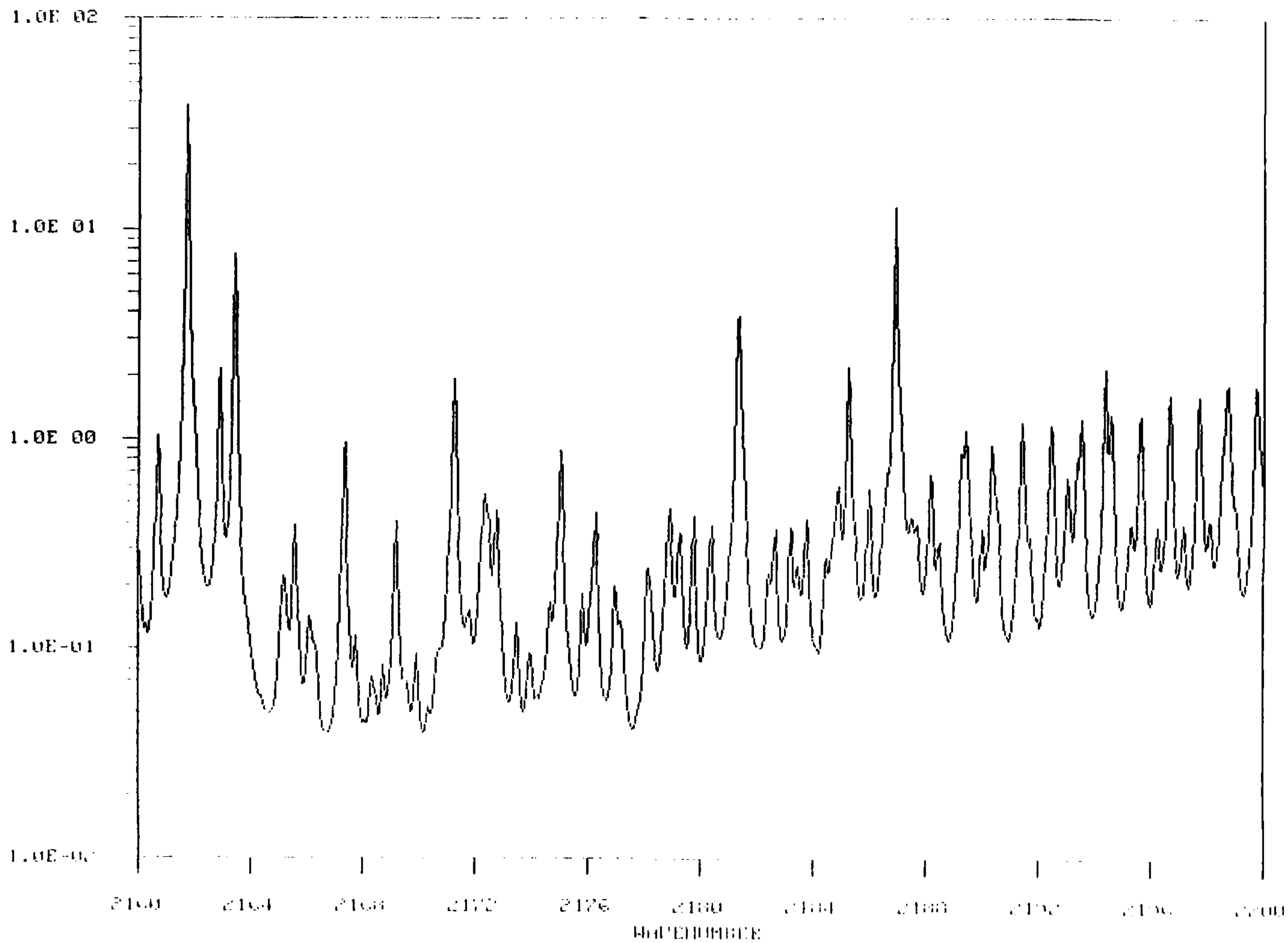

Fig. 7 — 2160-2200 cm^{-1} atmospheric absorption coefficient (km^{-1})

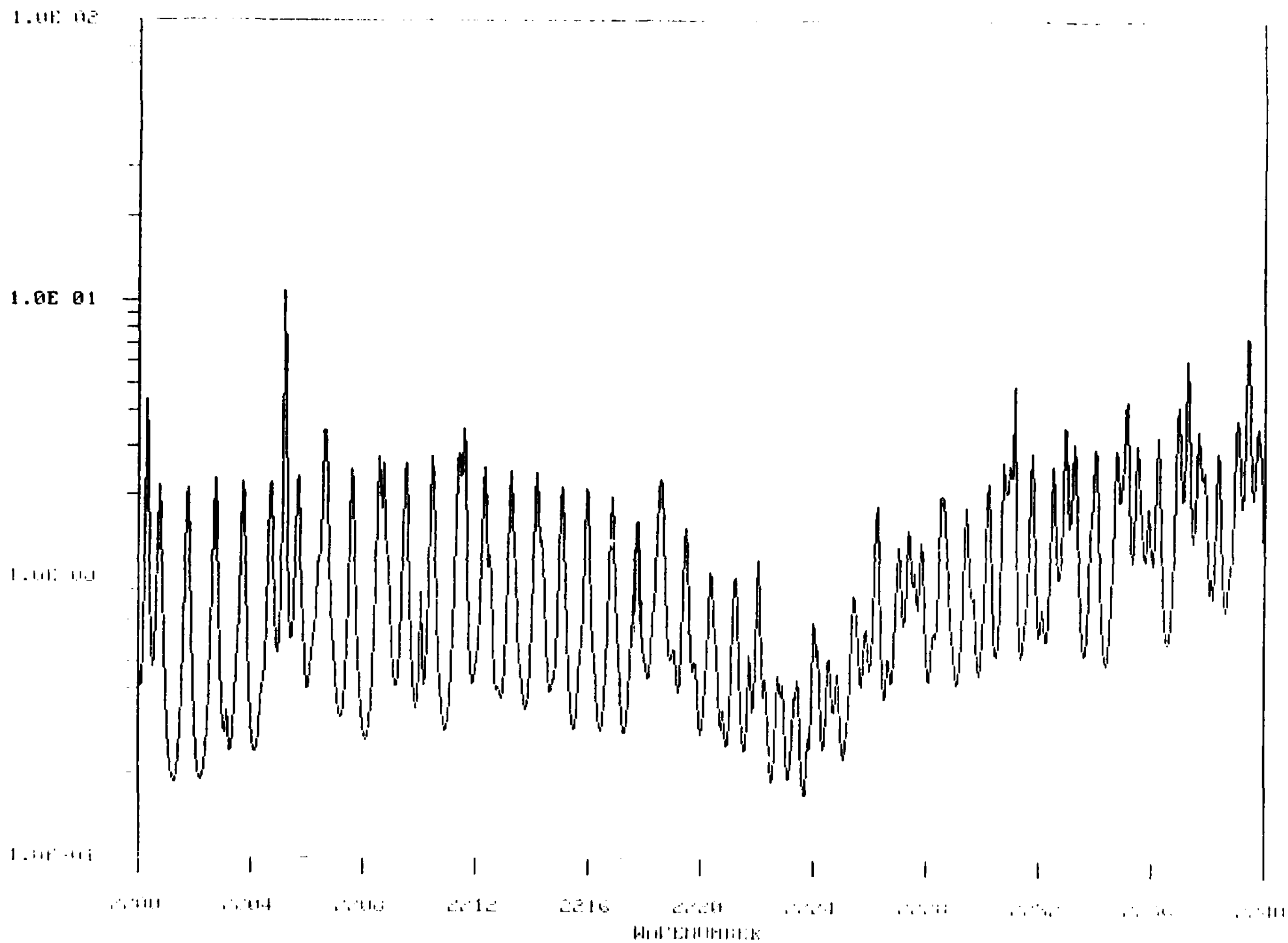

Fig. 8 — 2200-2240 cm^{-1} atmospheric absorption coefficient (km^{-1})

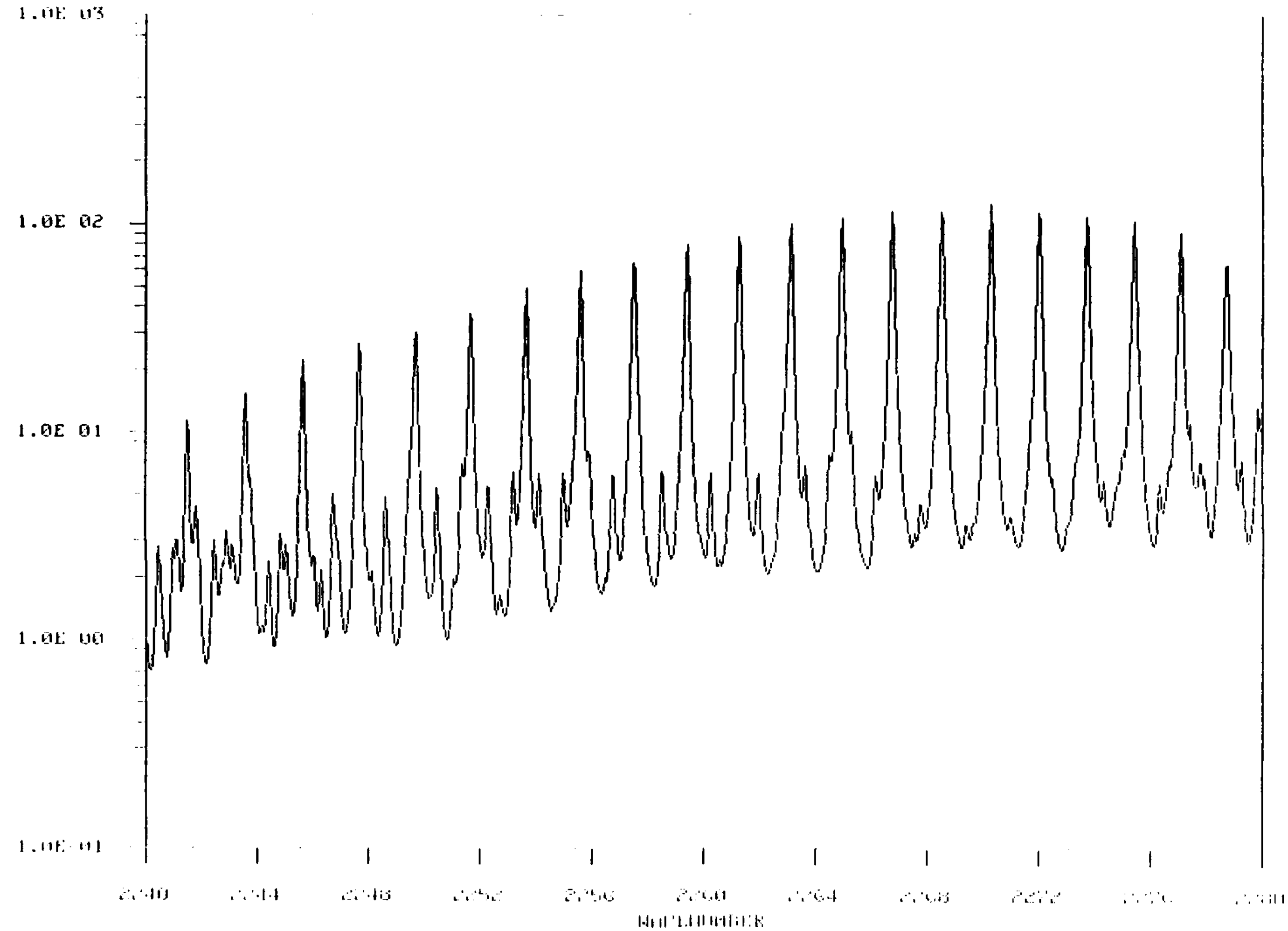

Fig. 9 — 2240-2280 cm^{-1} atmospheric absorption coefficient (km^{-1})

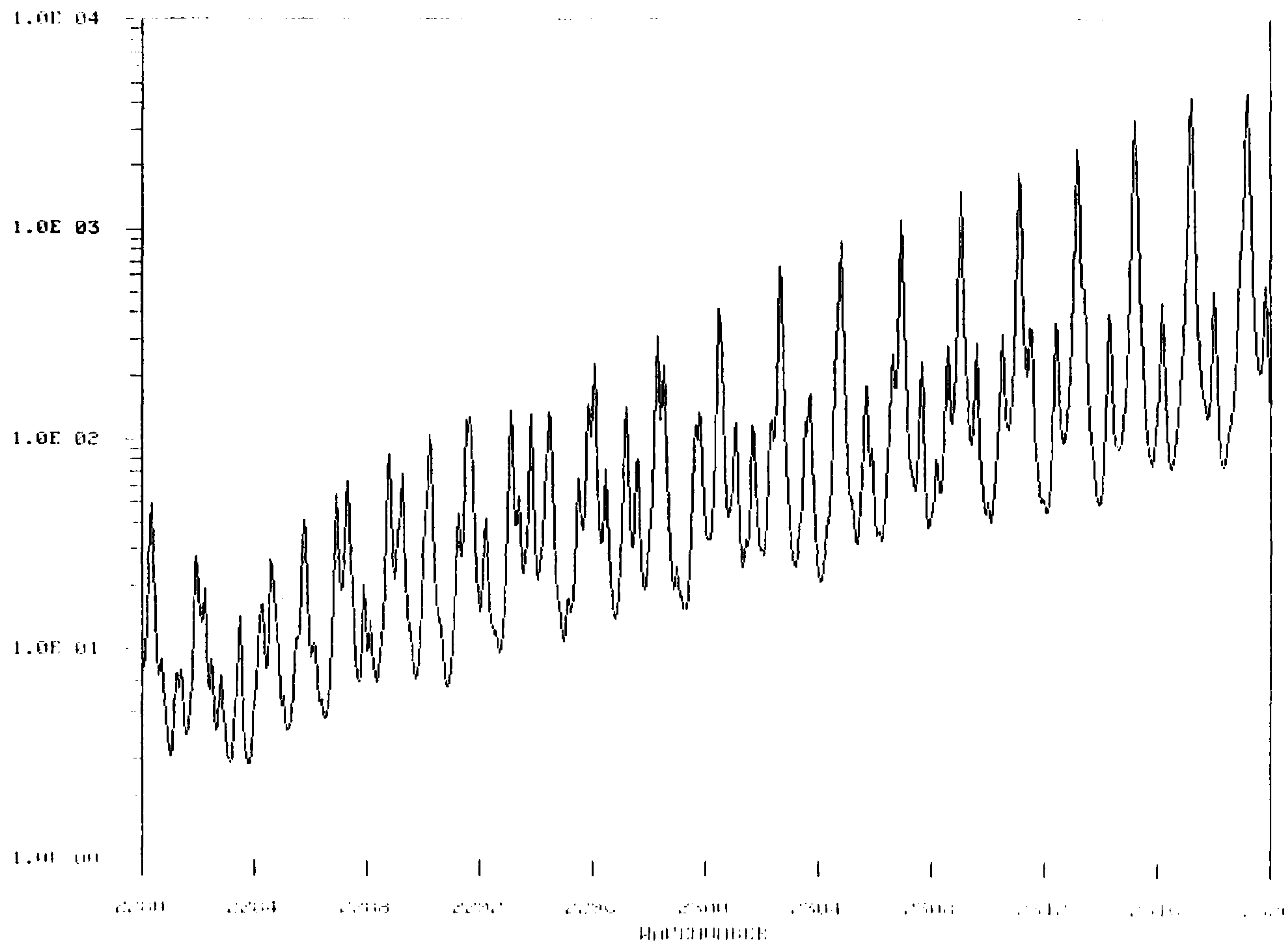

Fig. 10 — 2280-2320 cm^{-1} atmospheric absorption coefficient (km^{-1})

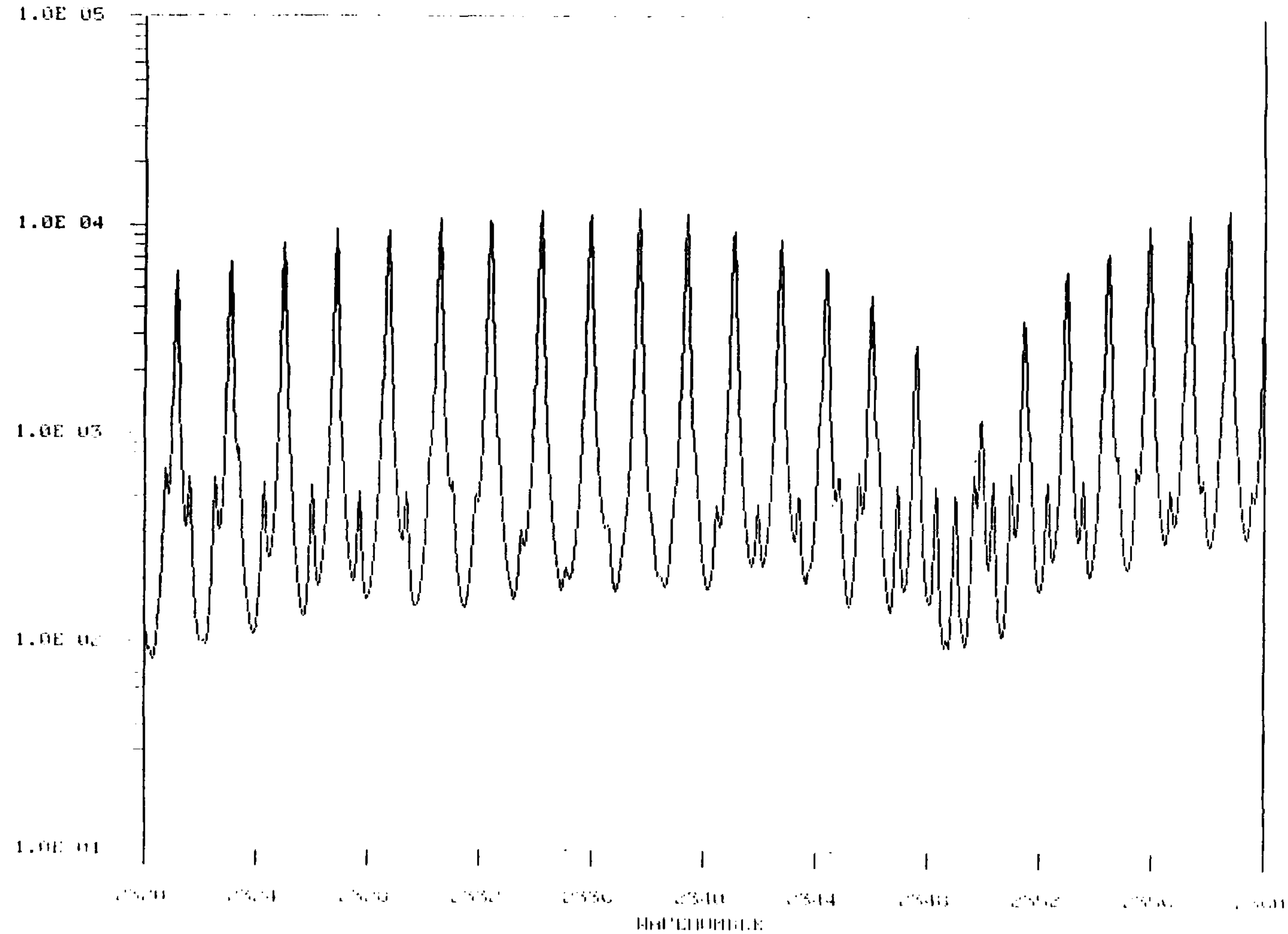

Fig. 11 — 2320-2360 cm^{-1} atmospheric absorption coefficient (km^{-1})

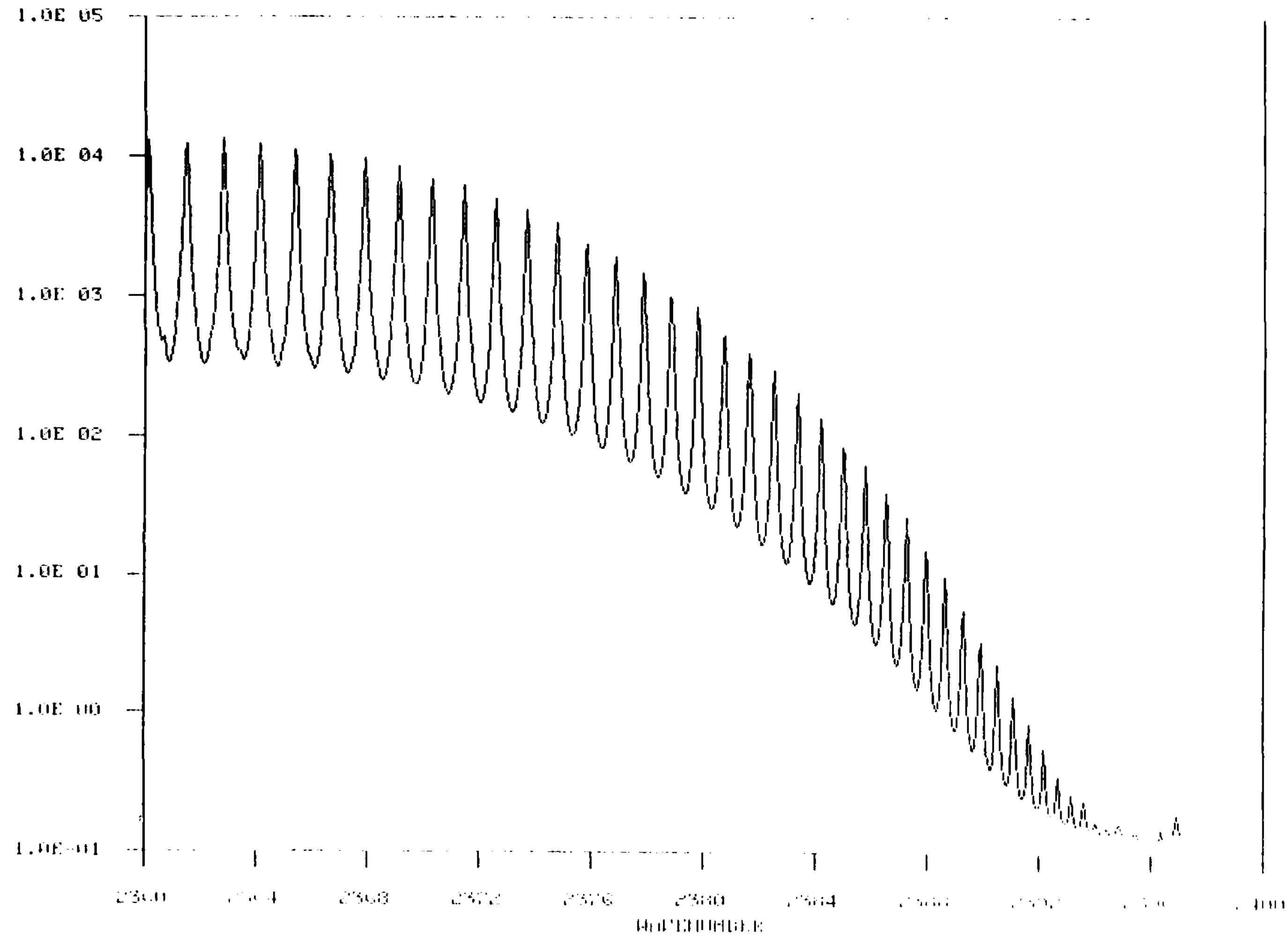

Fig. 12 — 2360-2400 cm^{-1} atmospheric absorption coefficient (km^{-1})

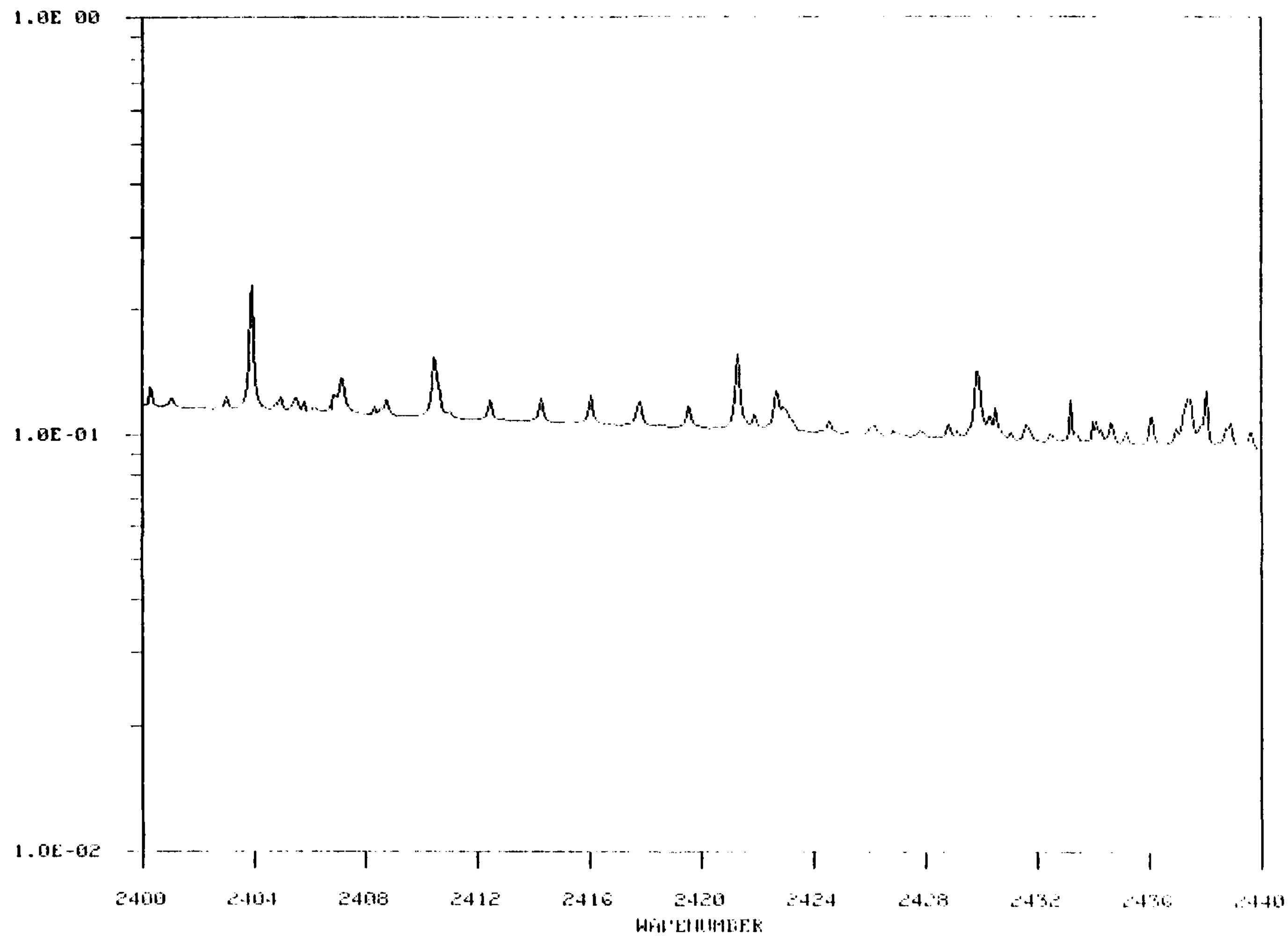

Fig. 13 — 2400-2440 cm^{-1} atmospheric absorption coefficient (km^{-1})

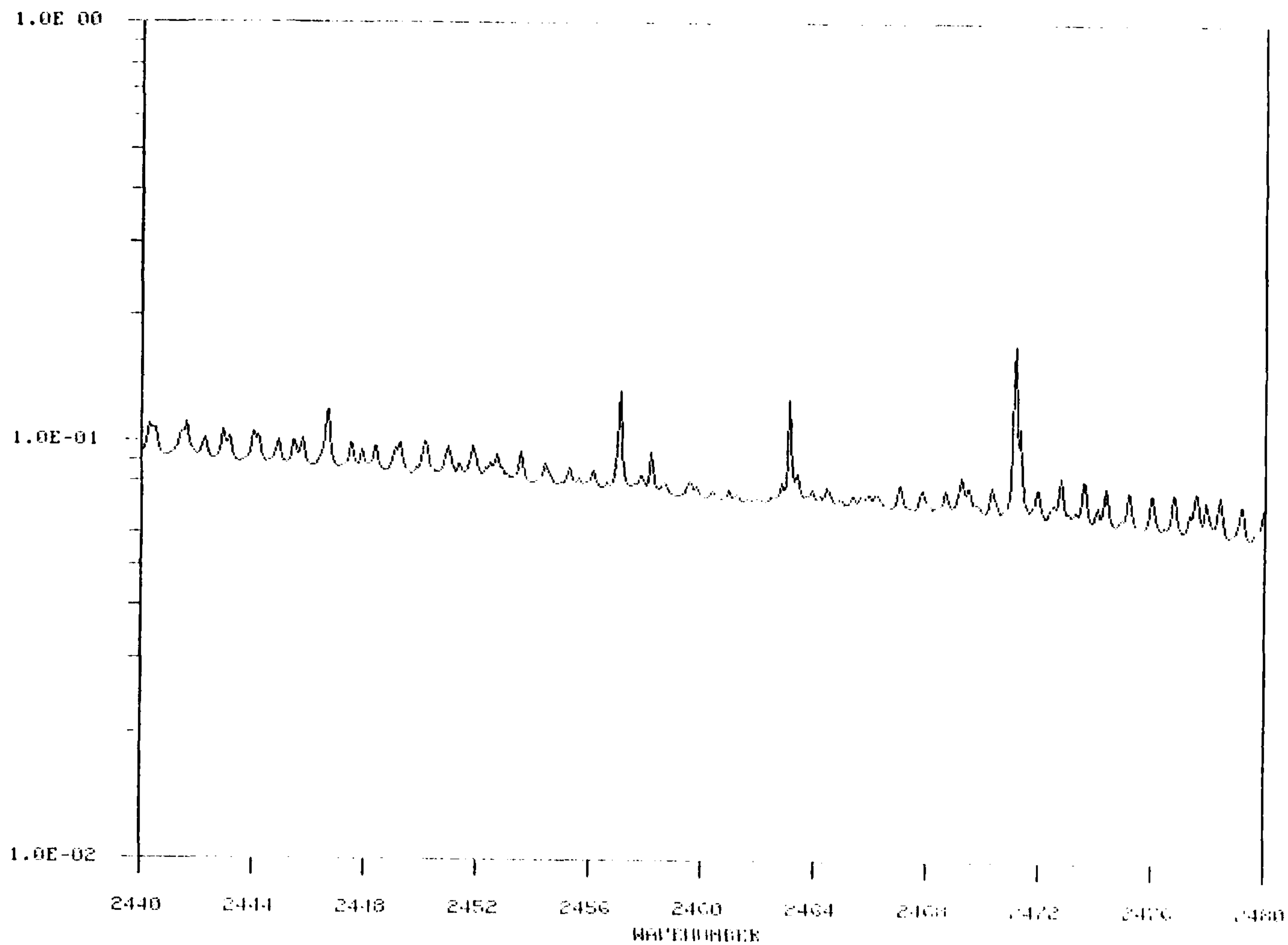

Fig. 14 — 2440-2480 cm^{-1} atmospheric absorption coefficient (km^{-1})

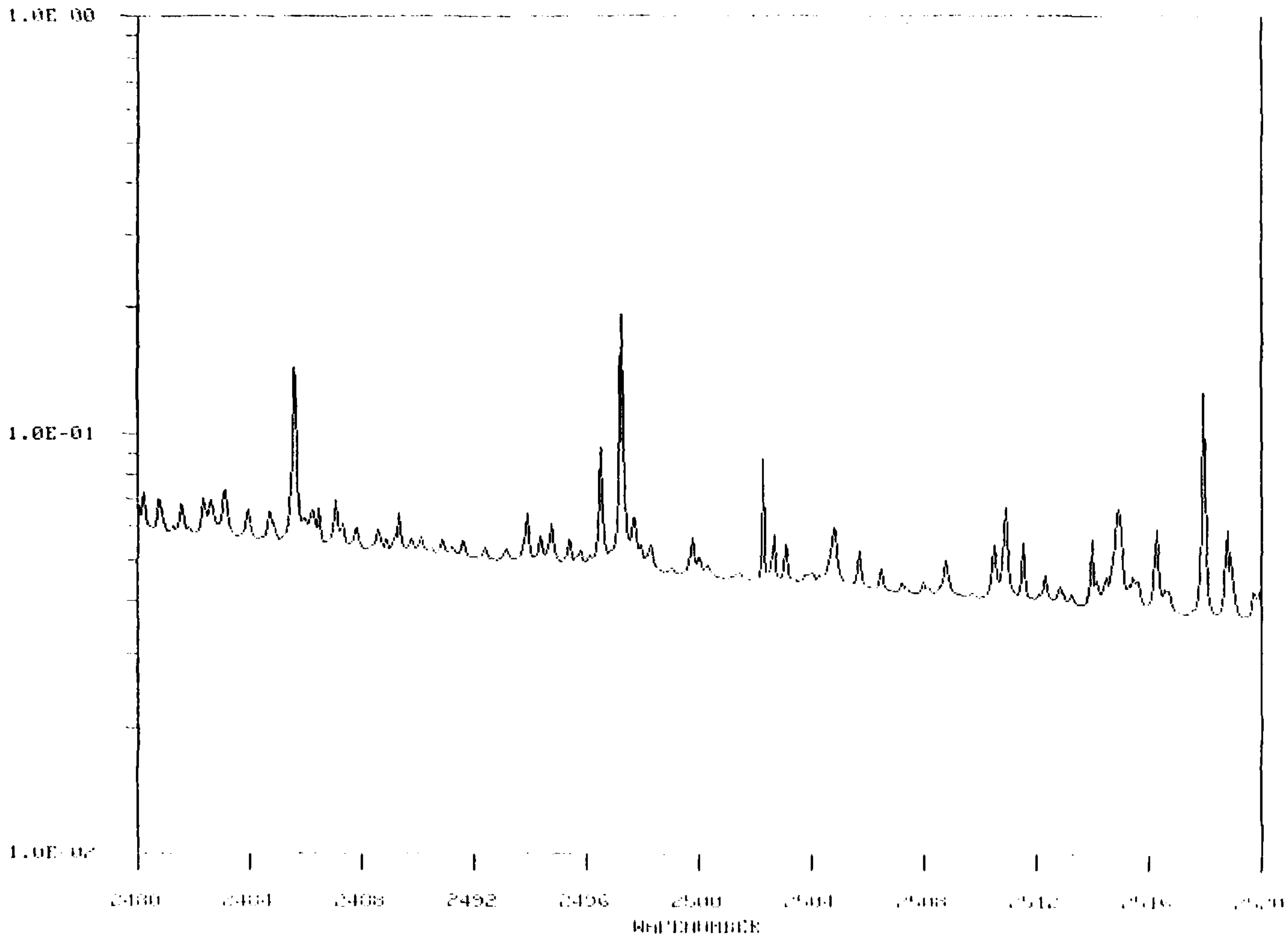

Fig. 15 — 2480-2520 cm^{-1} atmospheric absorption coefficient (km^{-1})

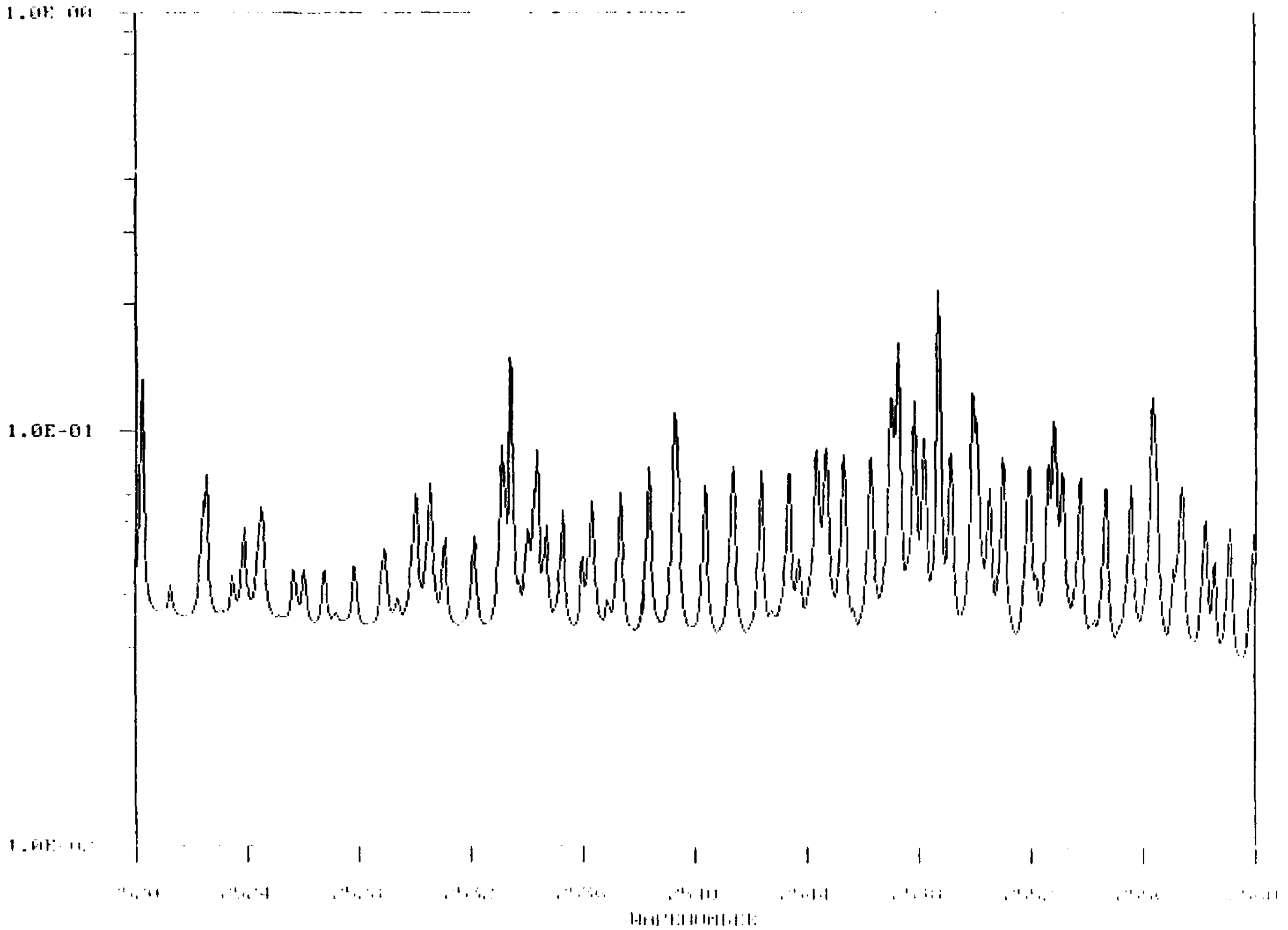

Fig. 16 — 2520-2560 cm^{-1} atmospheric absorption coefficient (km^{-1})

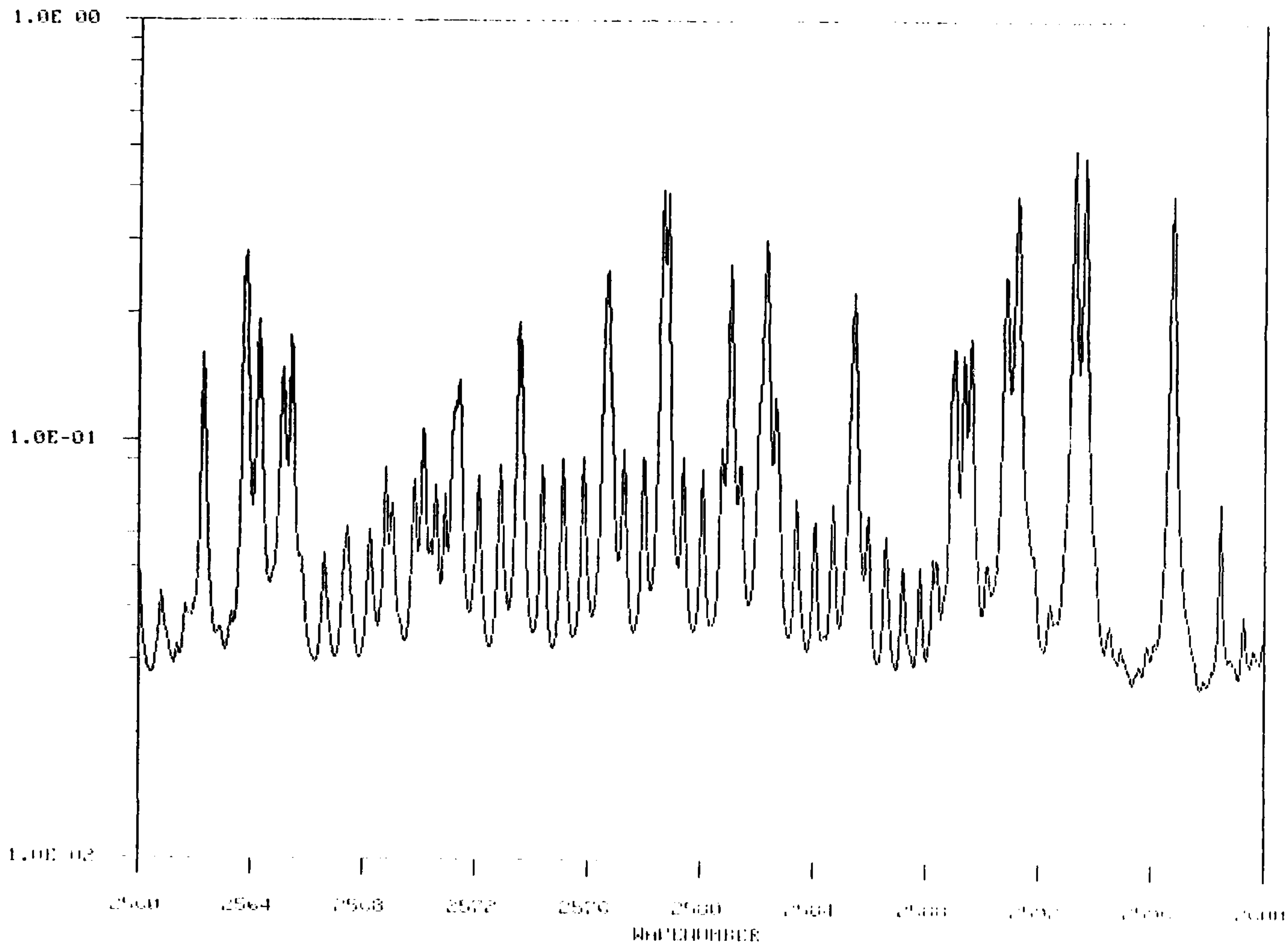

Fig. 17 — 2560-2600 cm^{-1} atmospheric absorption coefficient (km^{-1})

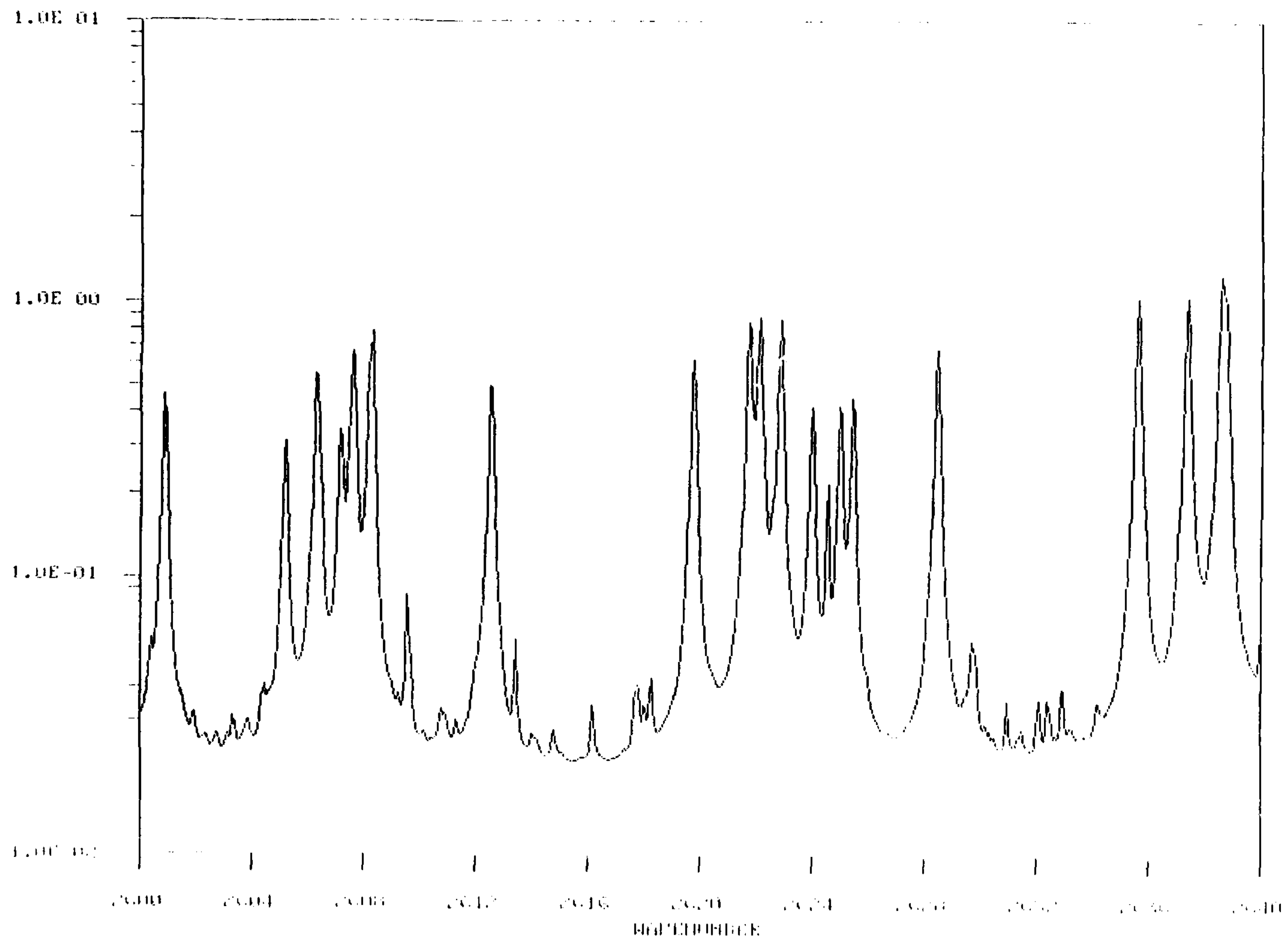

Fig. 18 — 2600-2640 cm^{-1} atmospheric absorption coefficient (km^{-1})

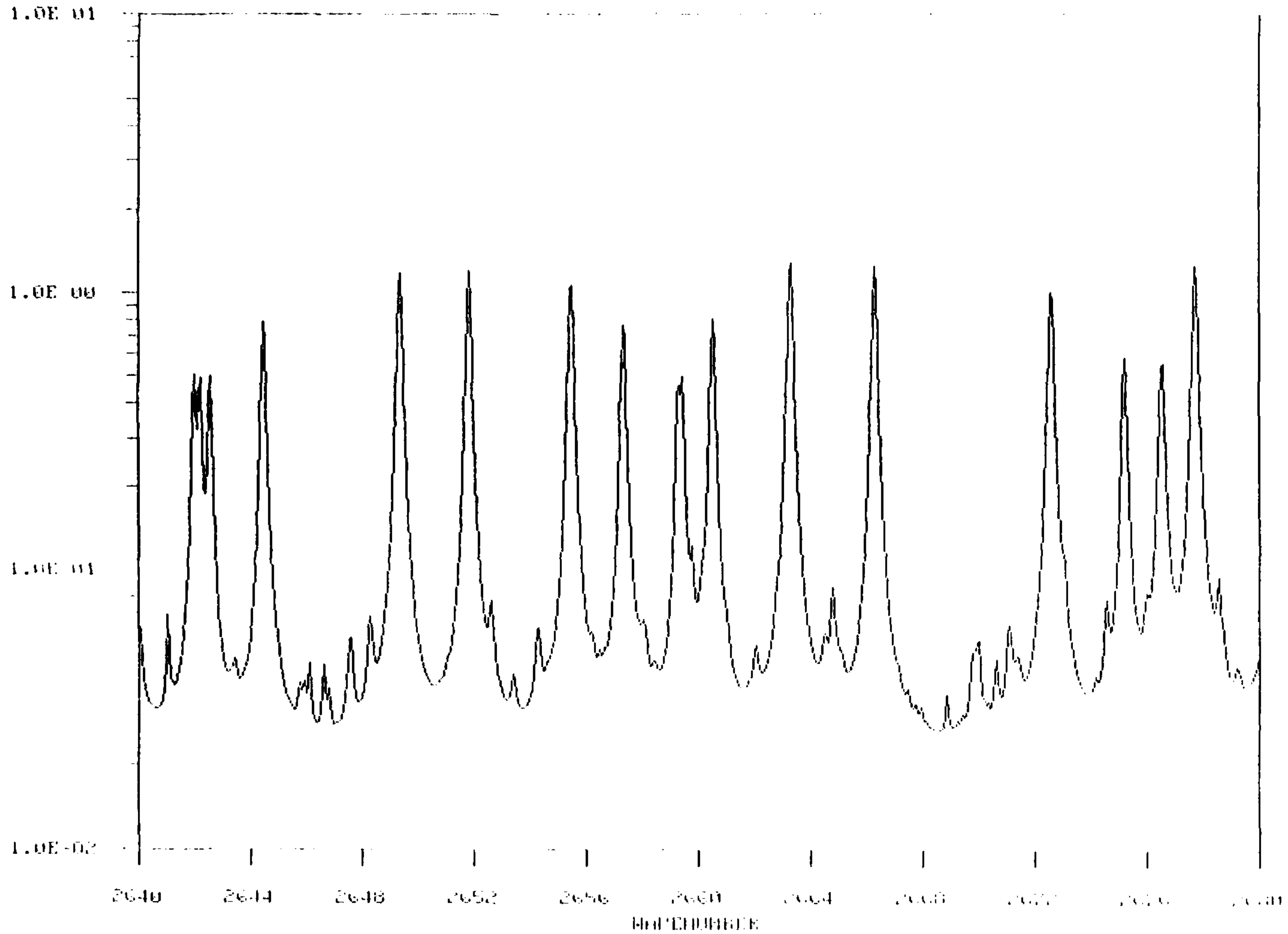

Fig. 19 — 2640-2680 cm^{-1} atmospheric absorption coefficient (km^{-1})

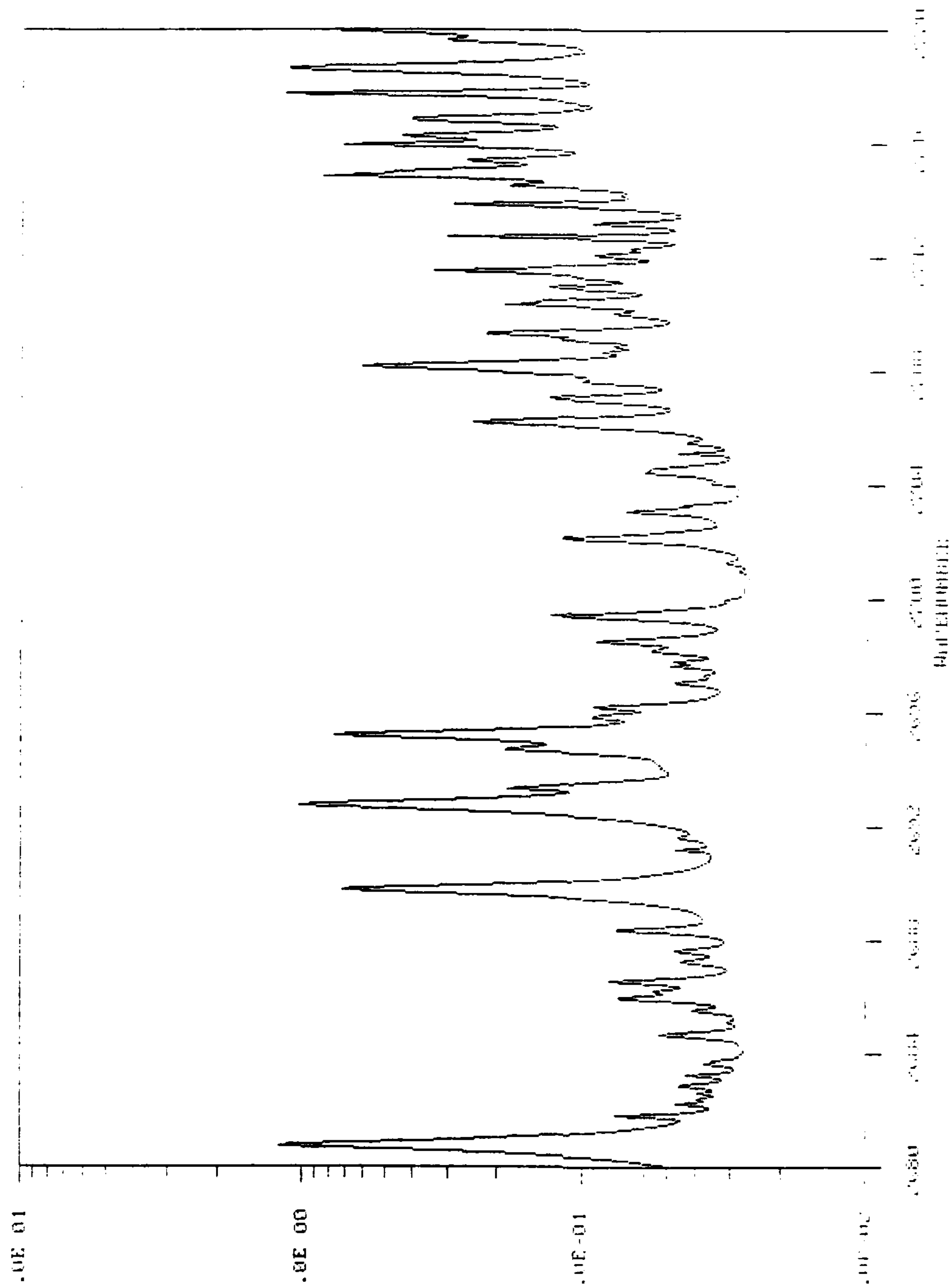

Fig. 20 — 2680-2720 cm^{-1} atmospheric absorption coefficient (km^{-1})

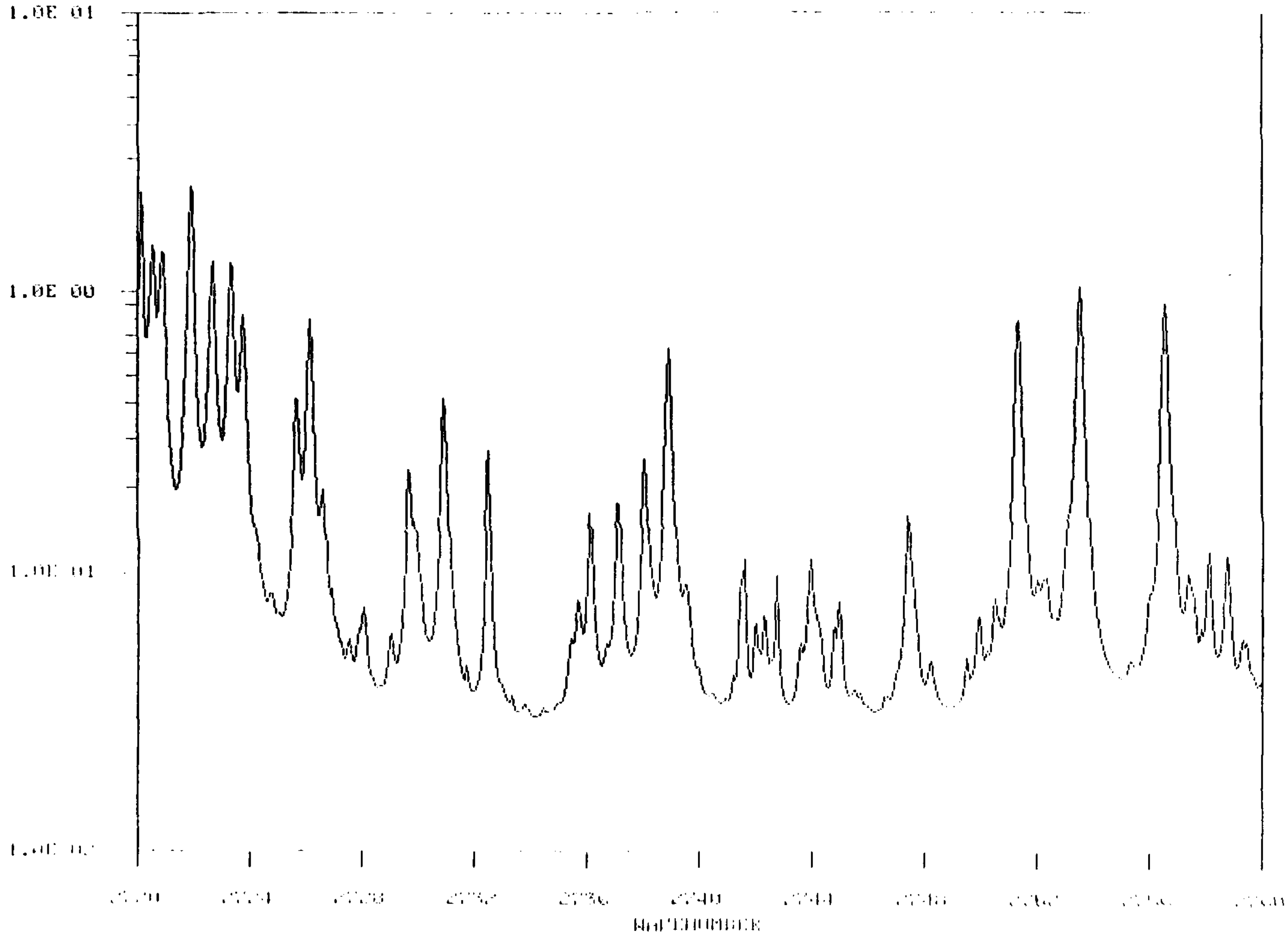

Fig. 21 — 2720-2760 cm^{-1} atmospheric absorption coefficient (km^{-1})

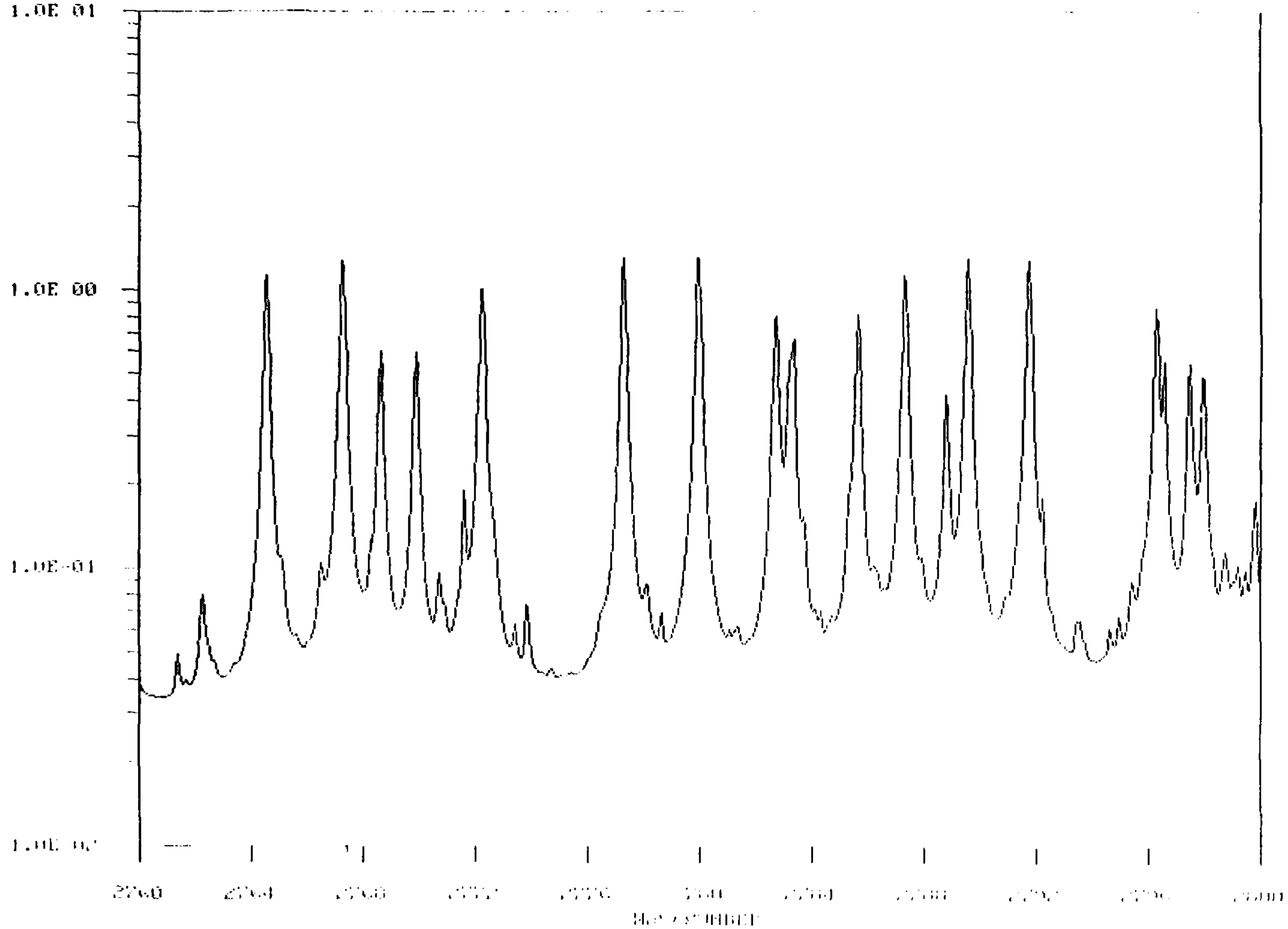

Fig. 22 — 2760-2800 cm^{-1} atmospheric absorption coefficient (km^{-1})

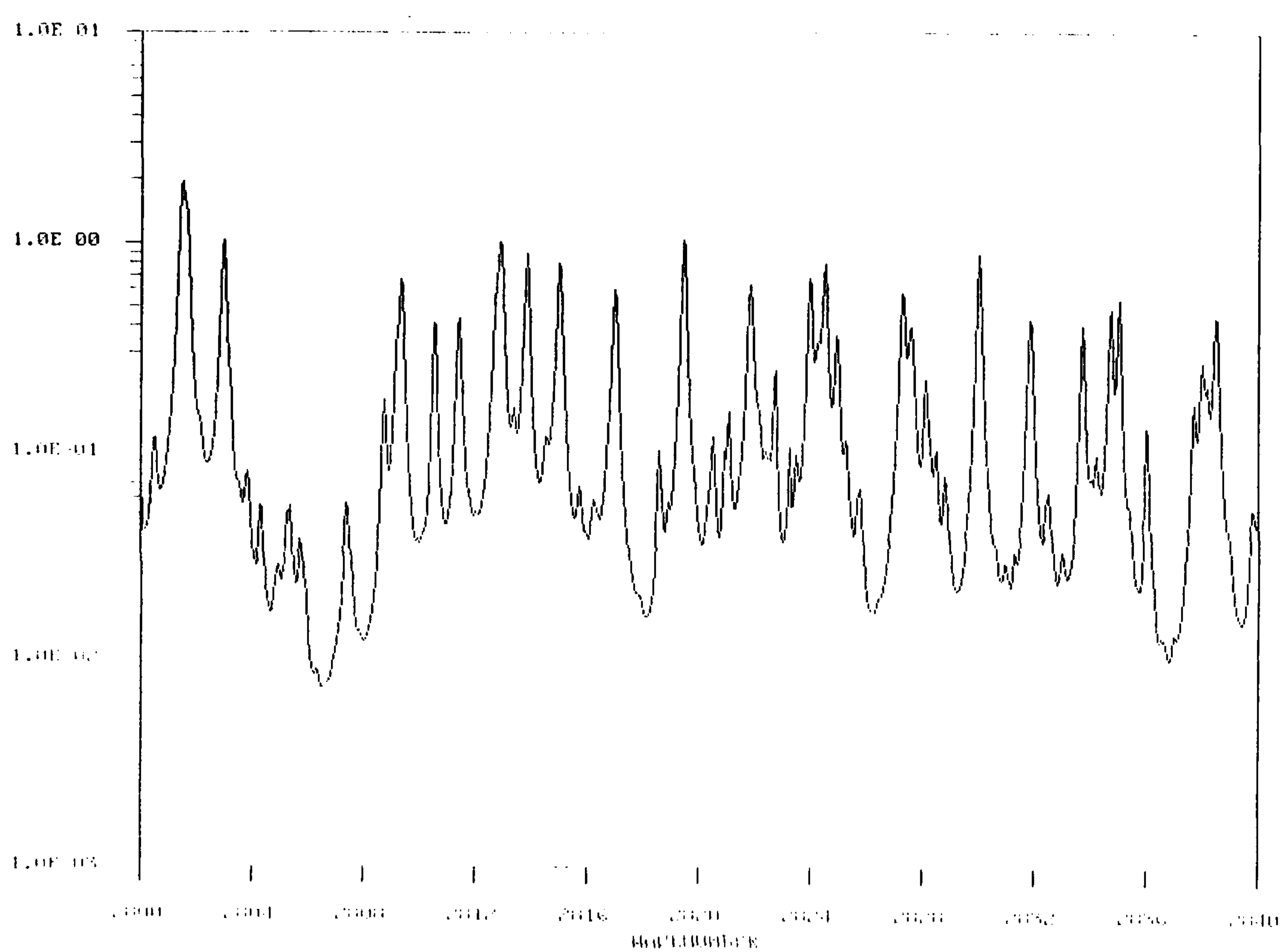

Fig. 23 — 2800-2840 cm^{-1} atmospheric absorption coefficient (km^{-1})

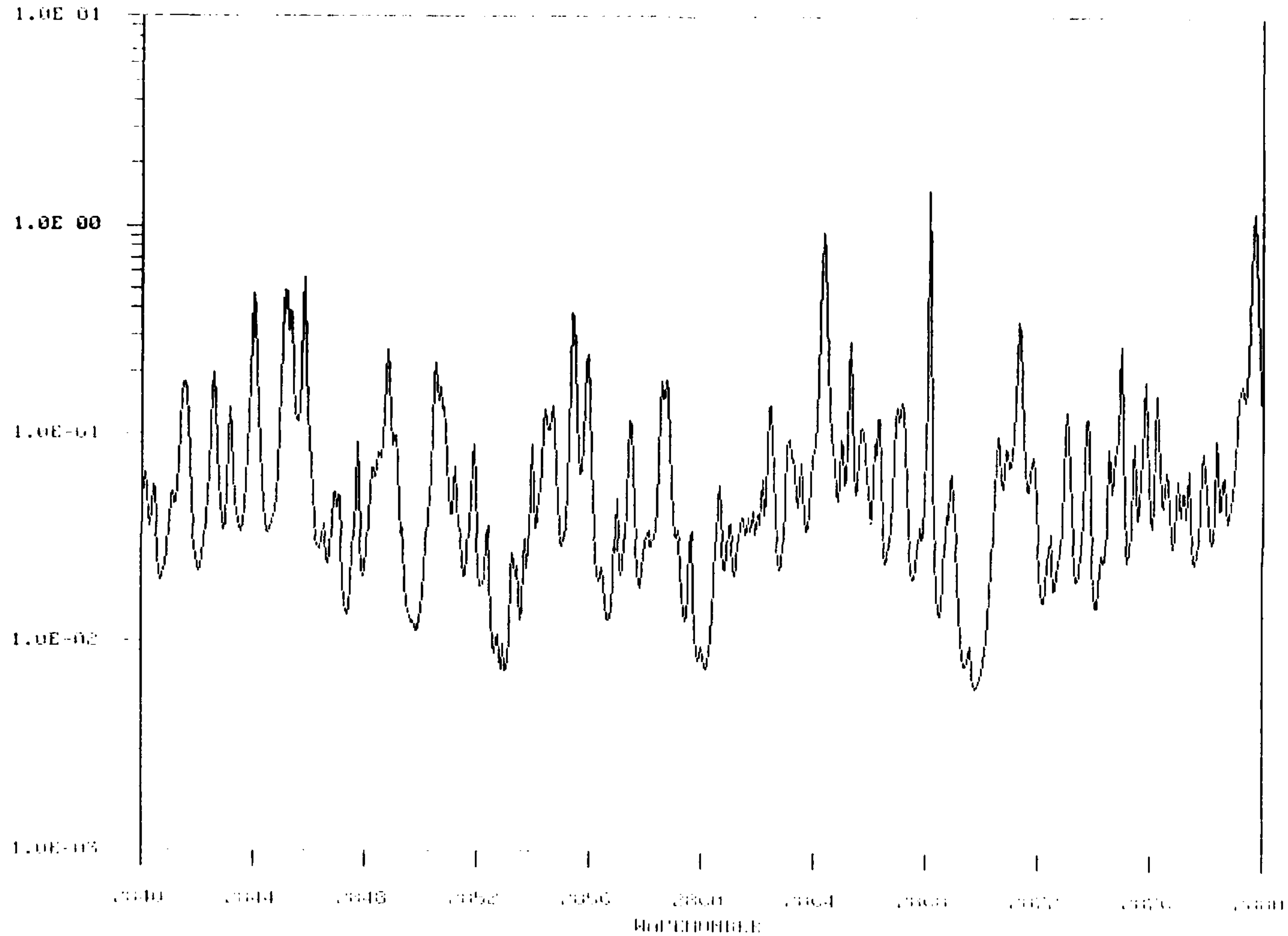

Fig. 24 — 2840-2880 cm^{-1} atmospheric absorption coefficient (km^{-1})

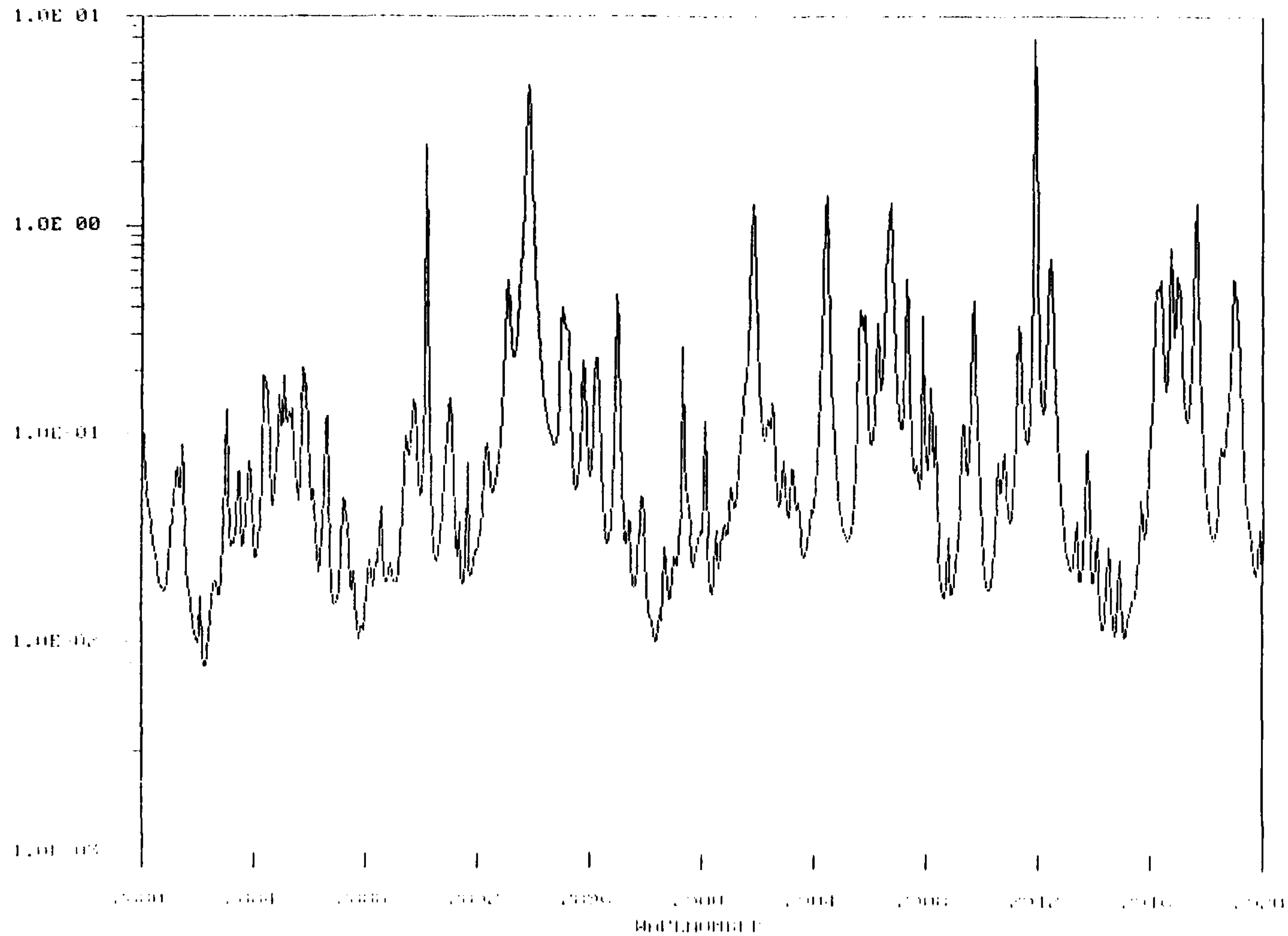

Fig. 25 — 2880-2920 cm^{-1} atmospheric absorption coefficient (km^{-1})

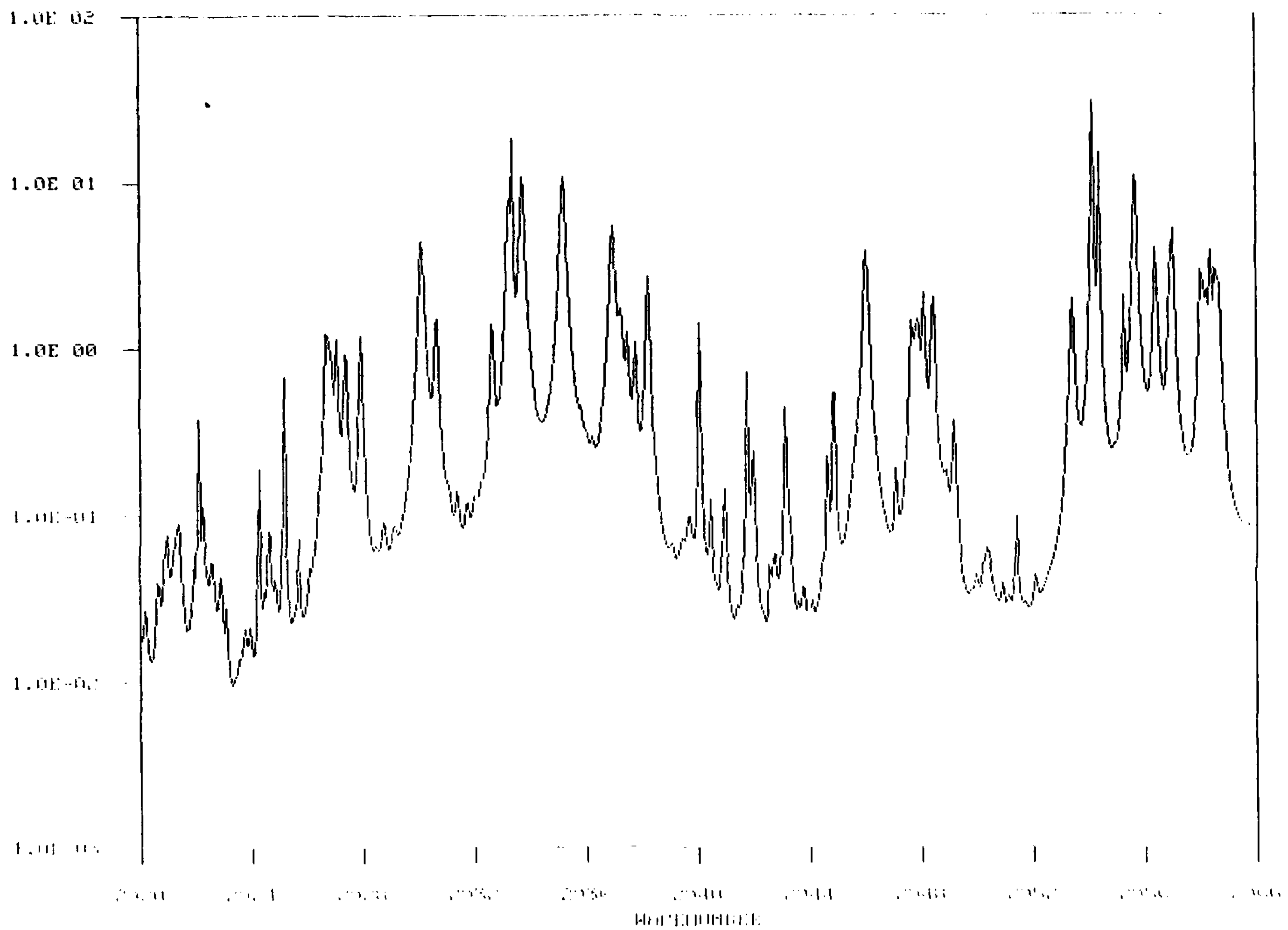

Fig. 26 — 2920-2960 cm^{-1} atmospheric absorption coefficient (km^{-1})

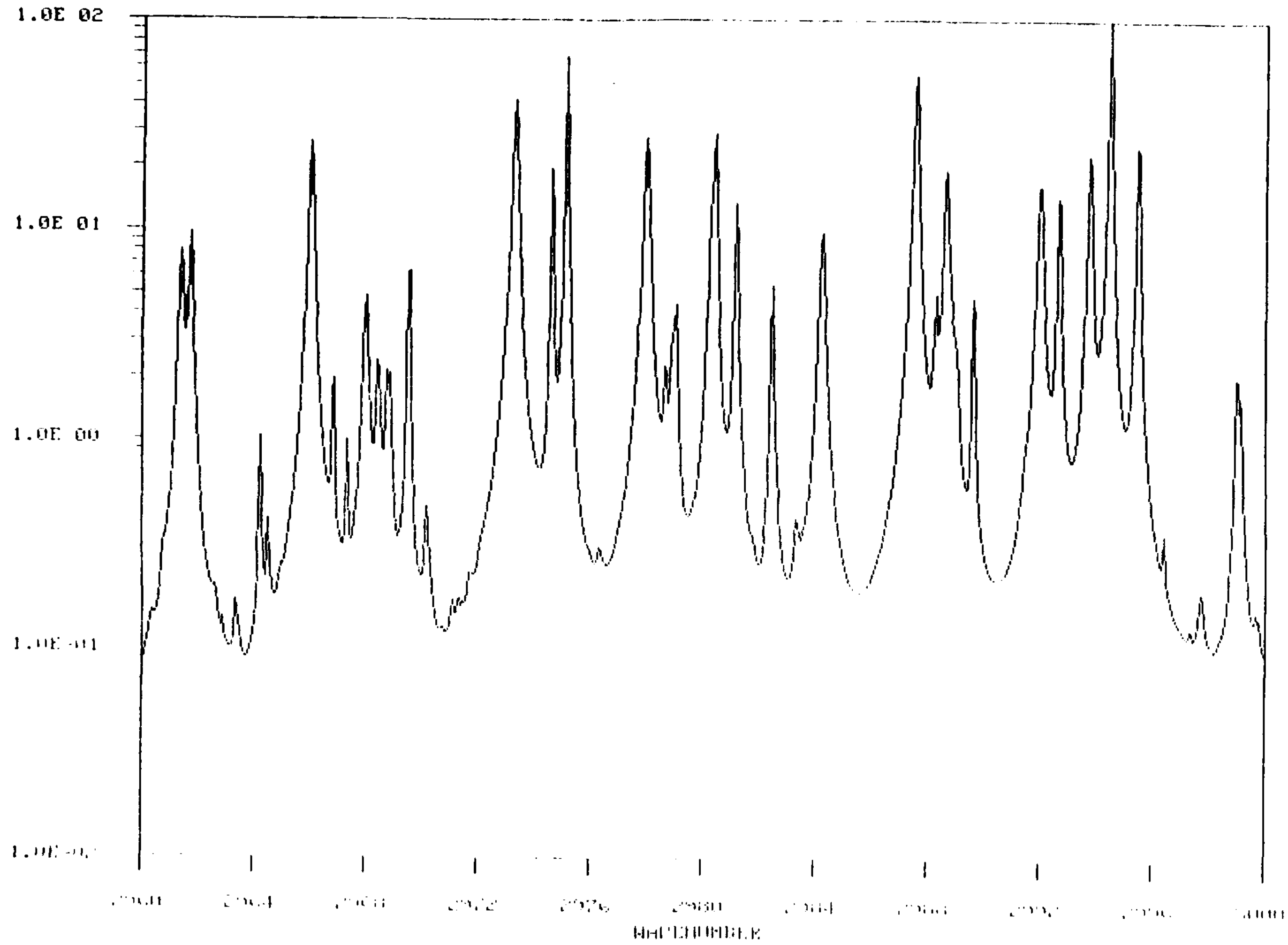

Fig. 27 — 2960-3000 cm^{-1} atmospheric absorption coefficient (km^{-1})

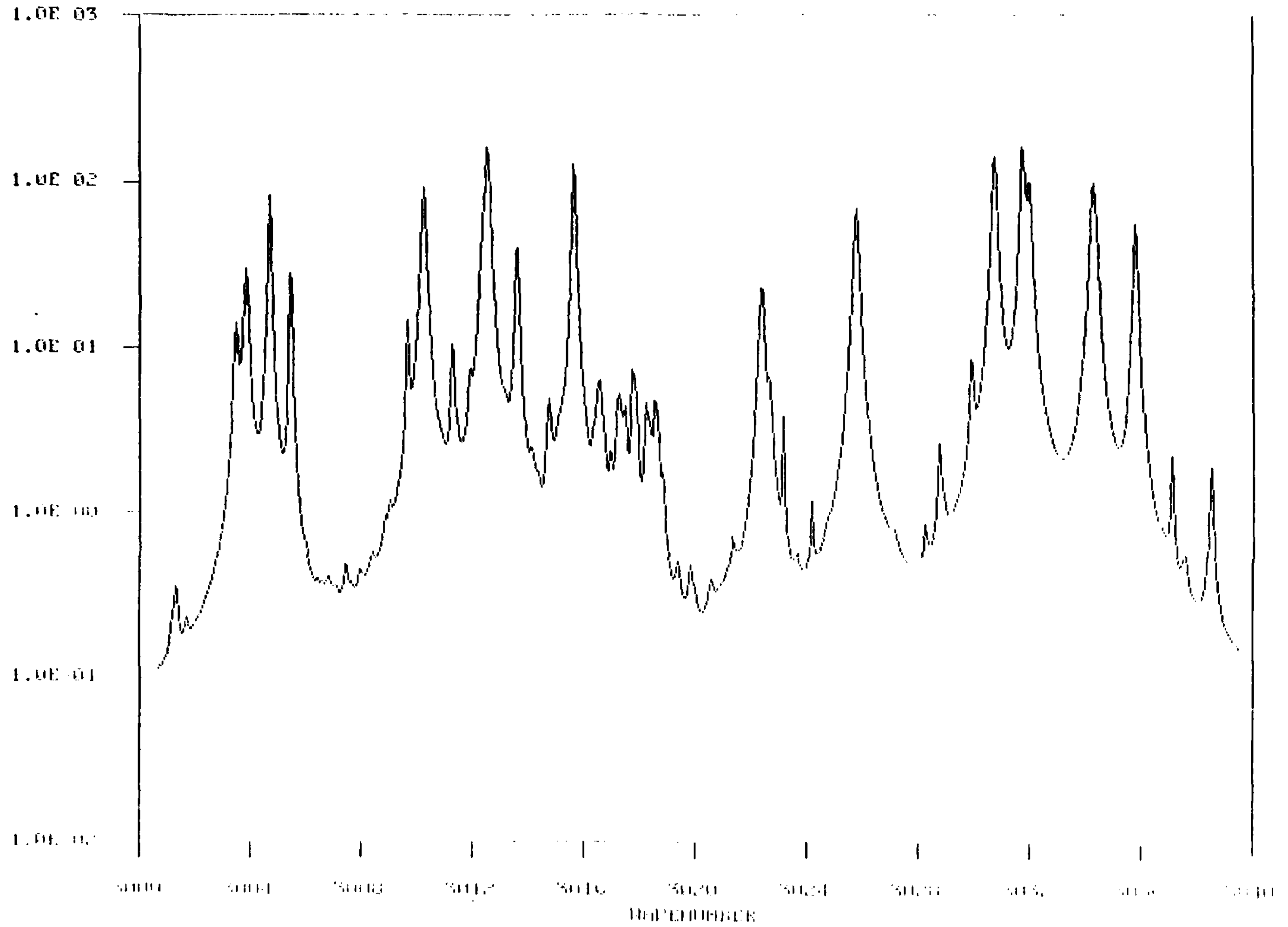

Fig. 28 — 3000-3040 cm^{-1} atmospheric absorption coefficient (km^{-1})

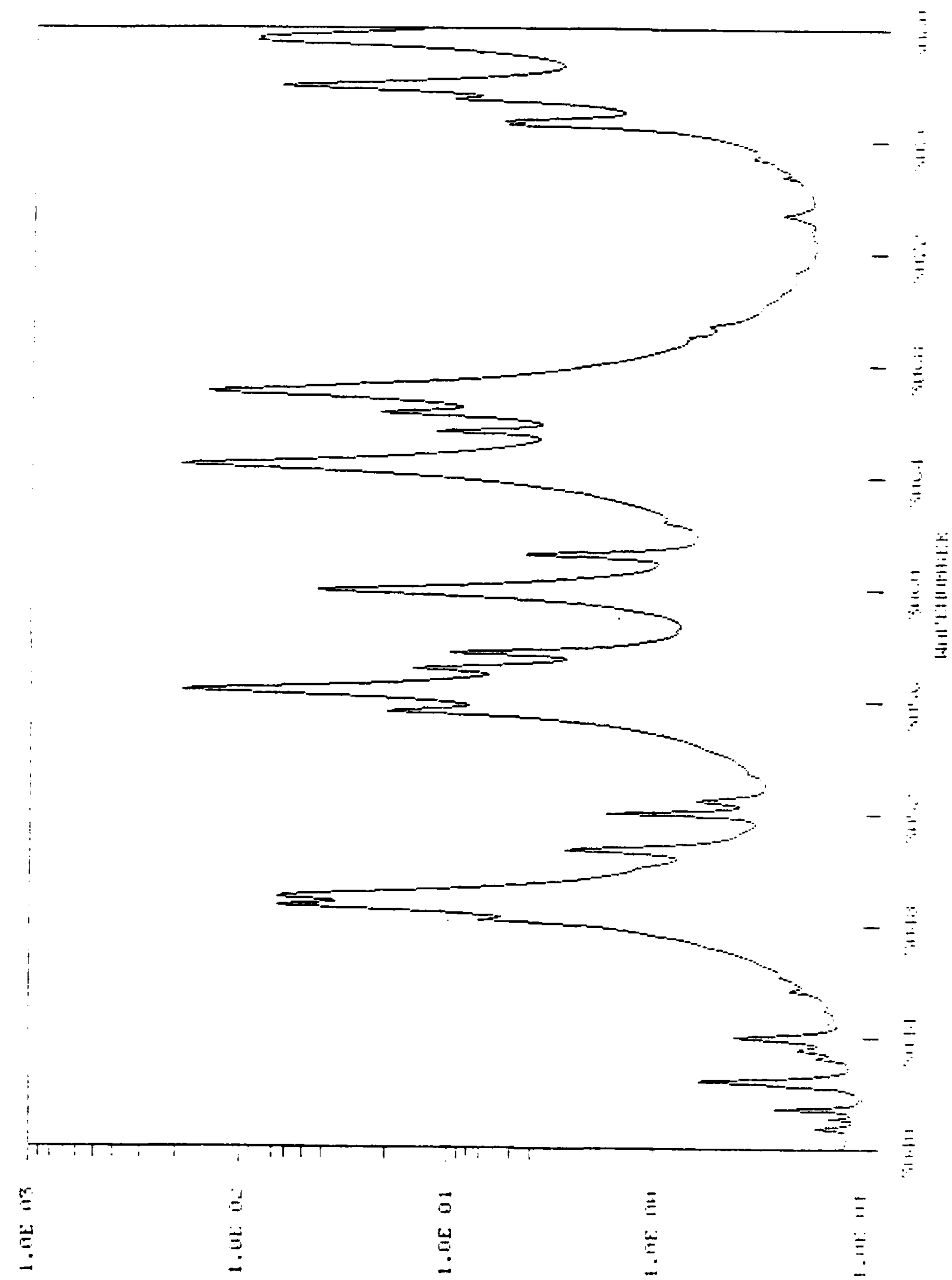

Fig. 29 — 3040-3080 cm^{-1} atmospheric absorption coefficient (km^{-1})

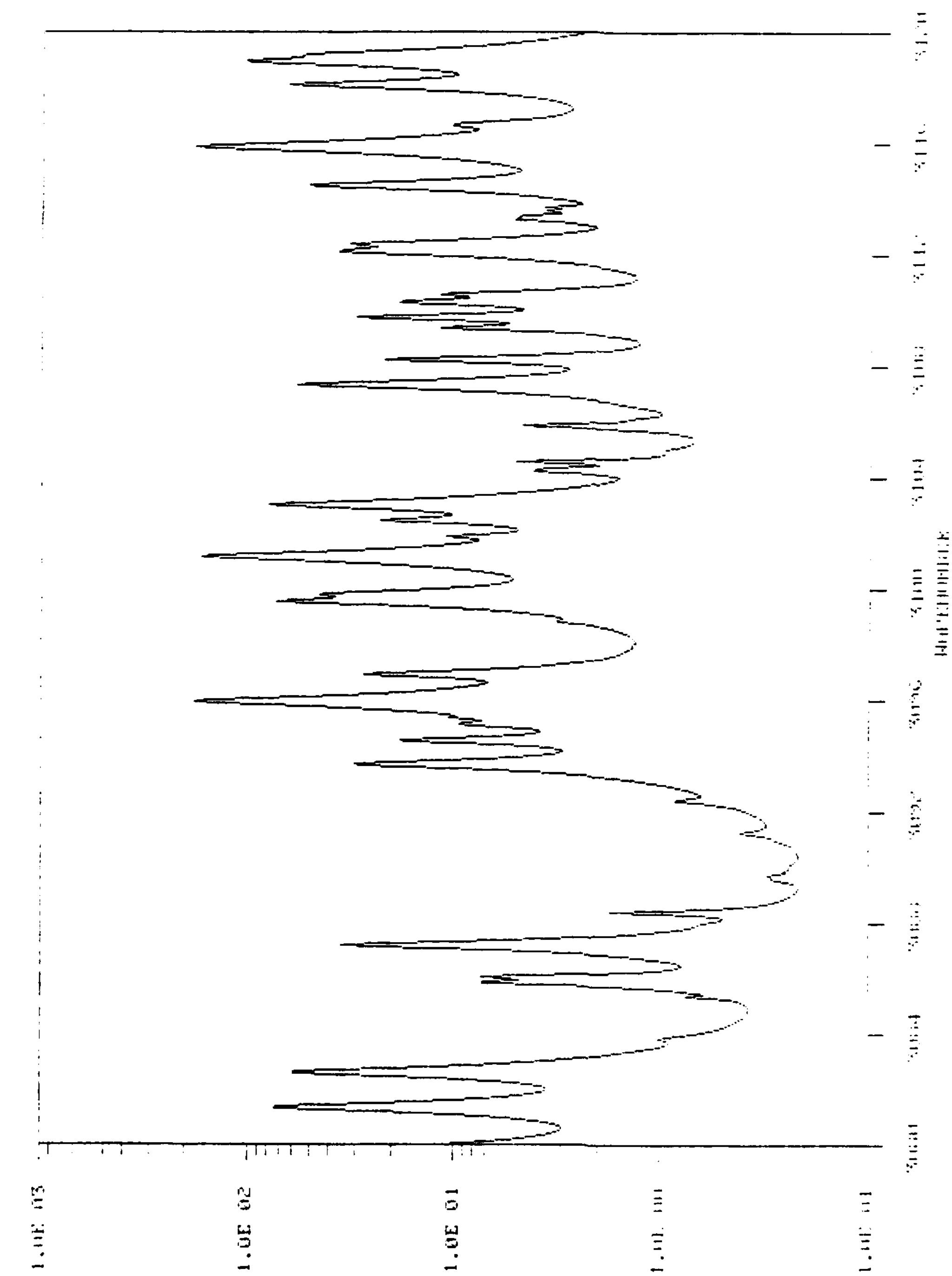

Fig. 30 — 3080-3120 cm^{-1} atmospheric absorption coefficient (km^{-1})

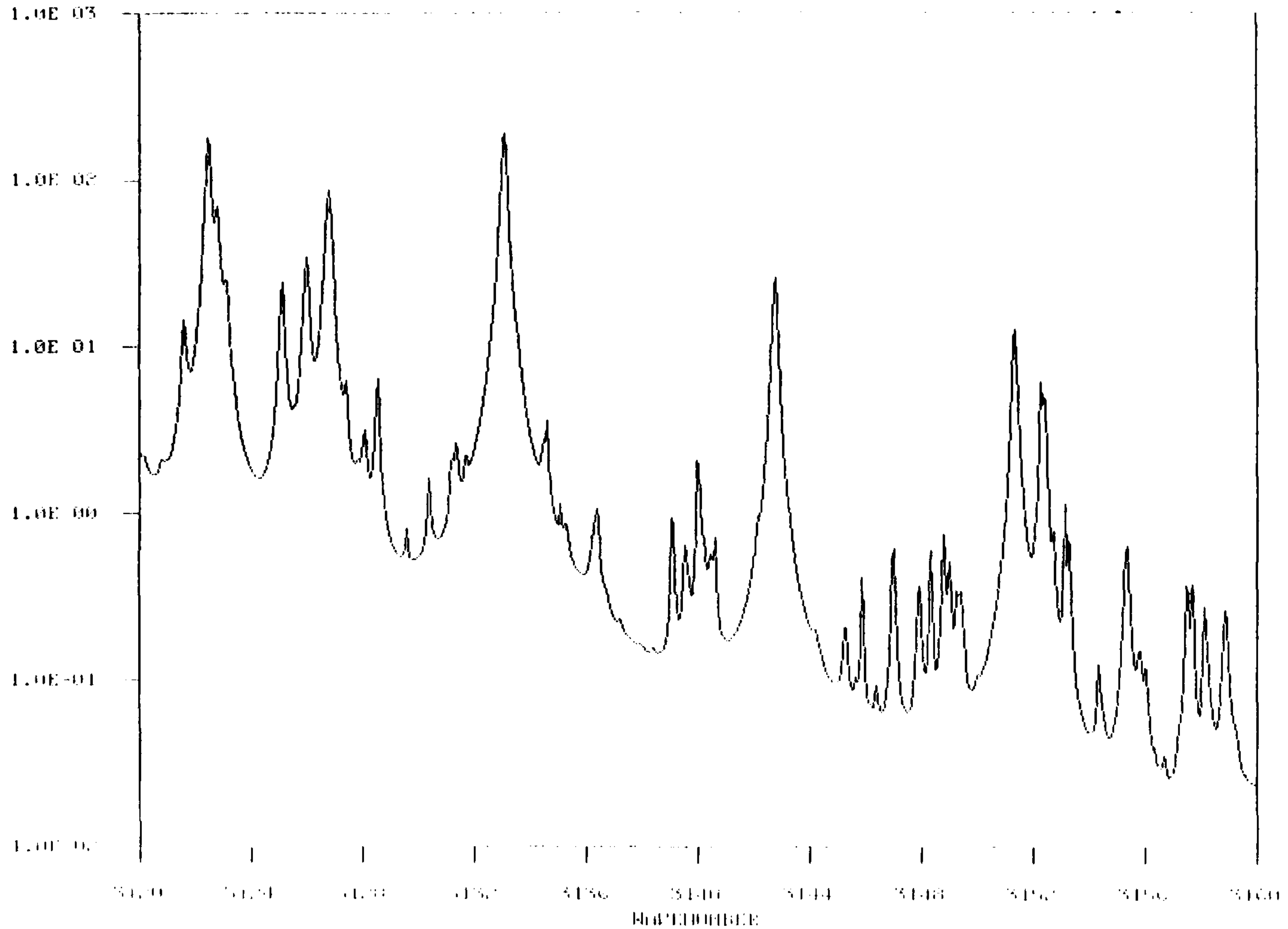

Fig. 31 — 3120-3160 cm^{-1} atmospheric absorption coefficient (km^{-1})

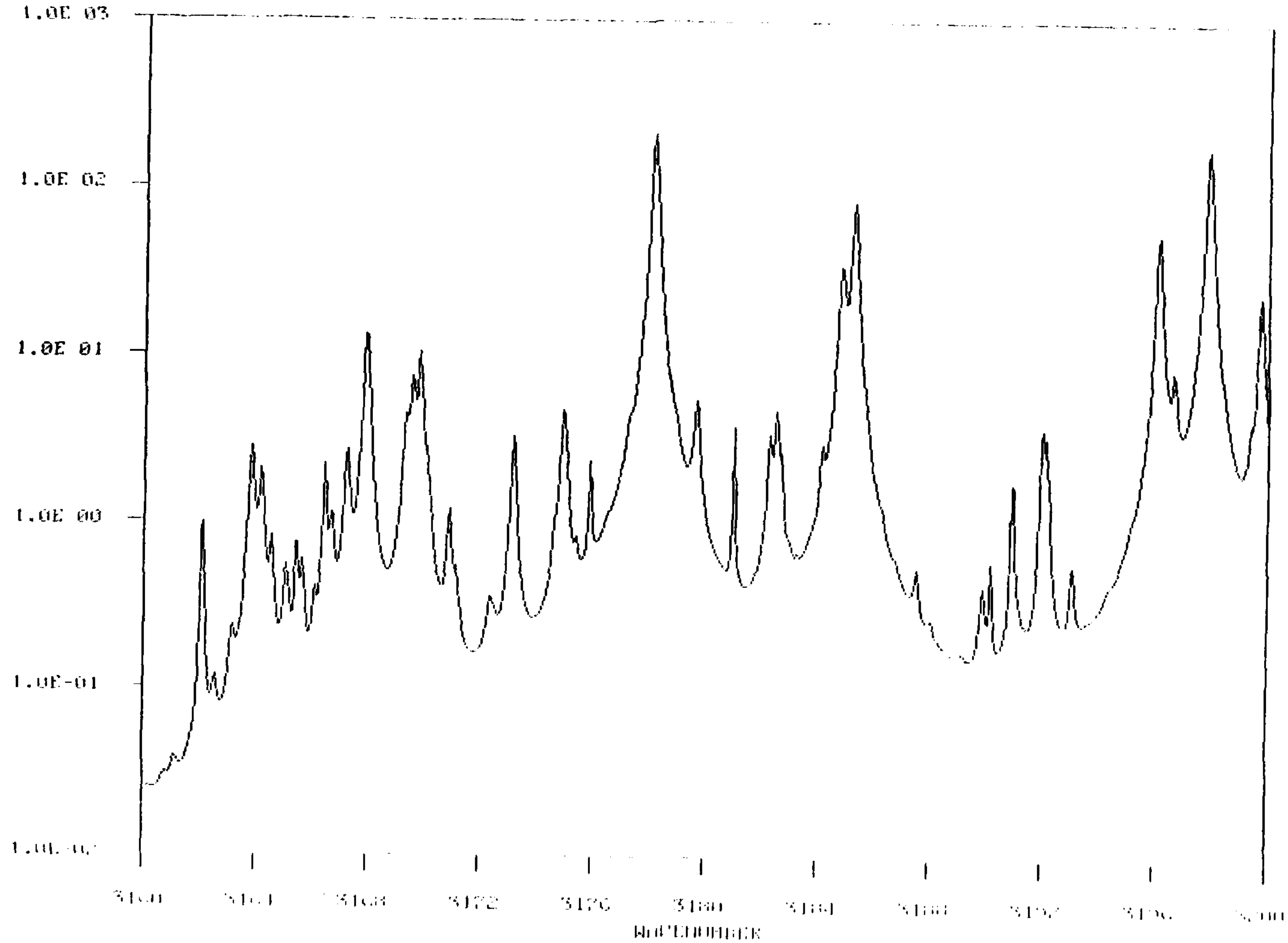

Fig. 32 — 3160-3200 cm^{-1} atmospheric absorption coefficient (km^{-1})

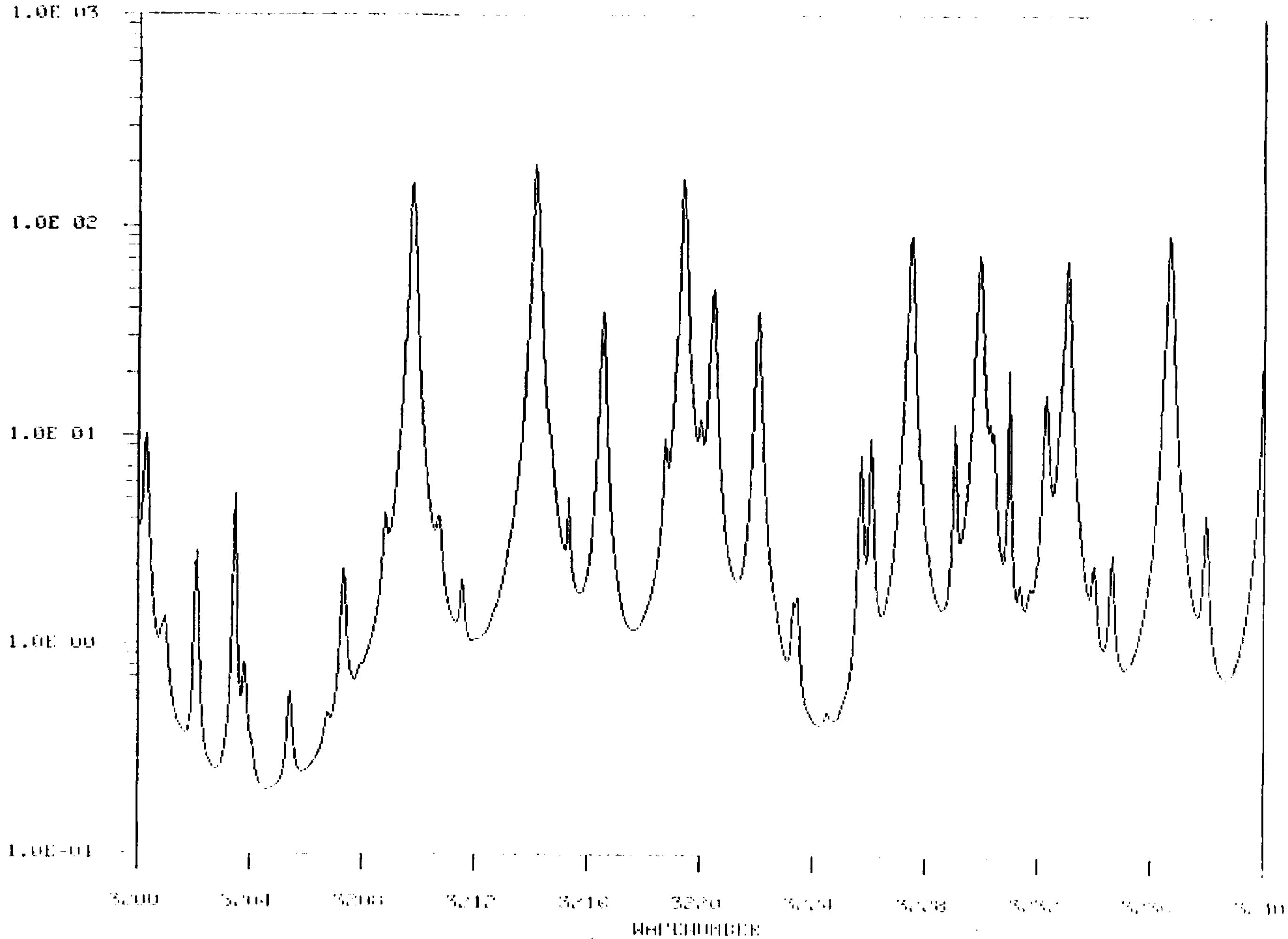

Fig. 33 — 3200-3240 cm^{-1} atmospheric absorption coefficient (km^{-1})

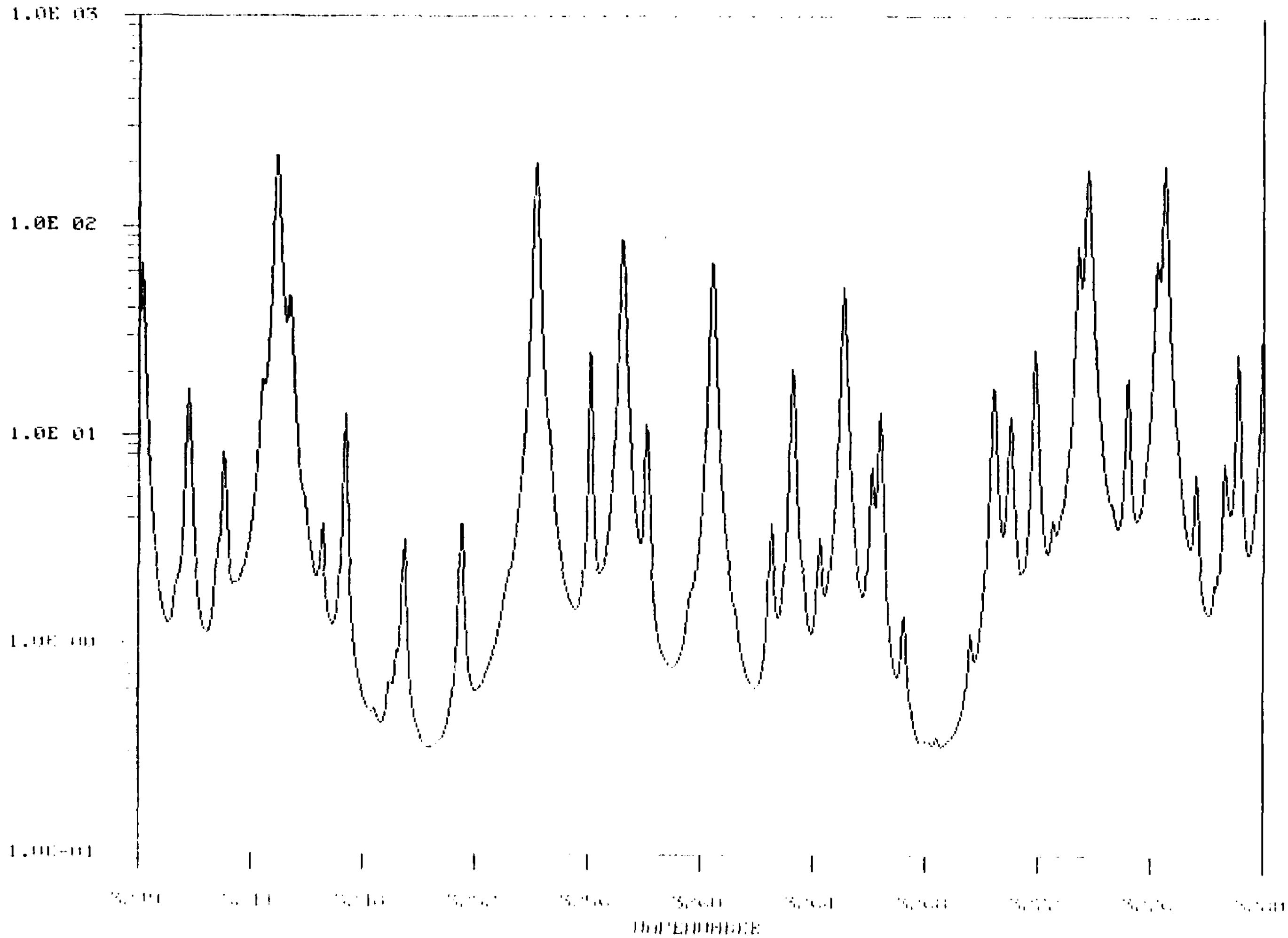

Fig. 34 — 3240-3280 cm^{-1} atmospheric absorption coefficient (km^{-1})

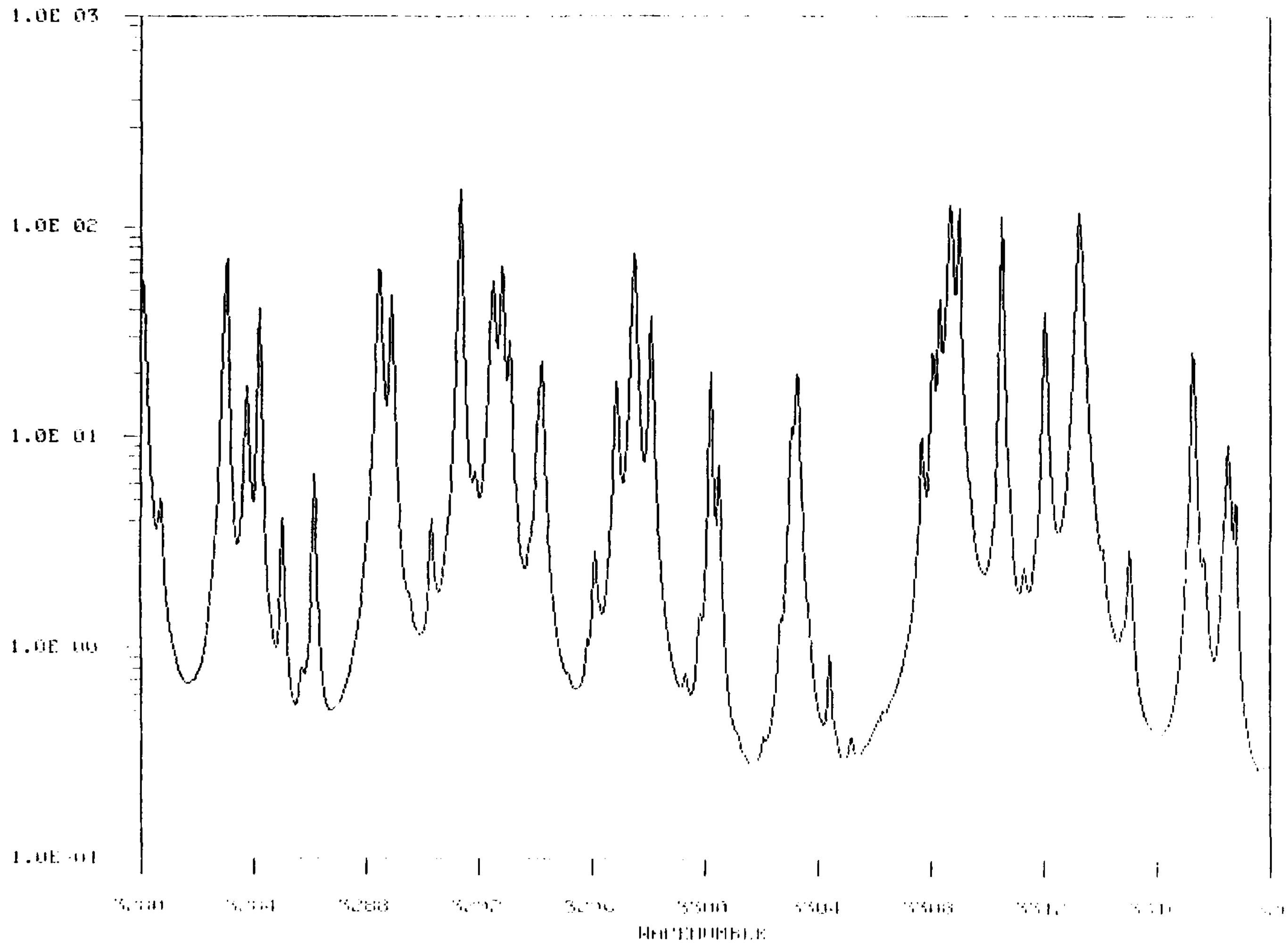

Fig. 35 — 3320-3280 cm^{-1} atmospheric absorption coefficient (km^{-1})

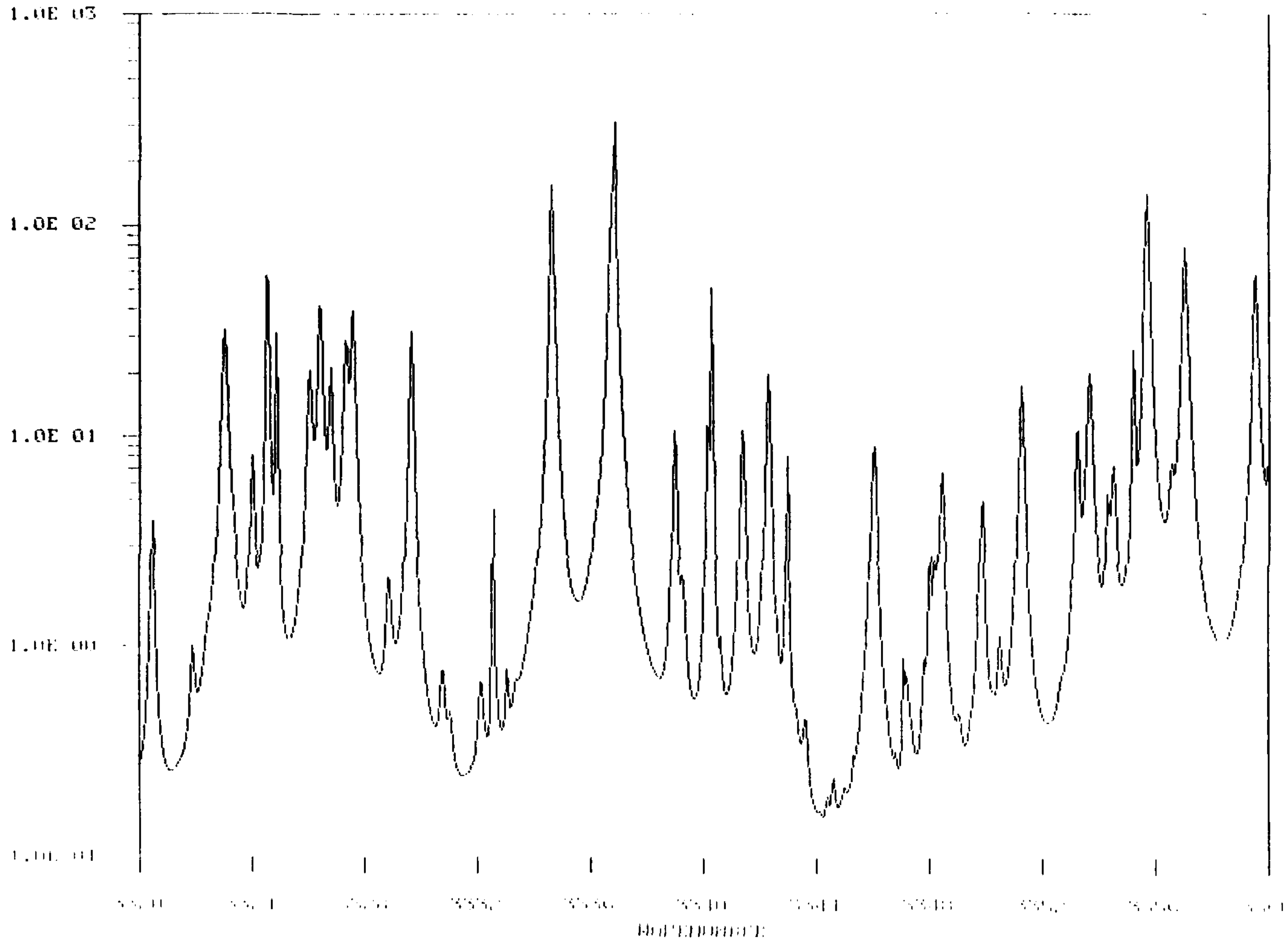

Fig. 36 — 3320-3360 cm^{-1} atmospheric absorption coefficient (km^{-1})

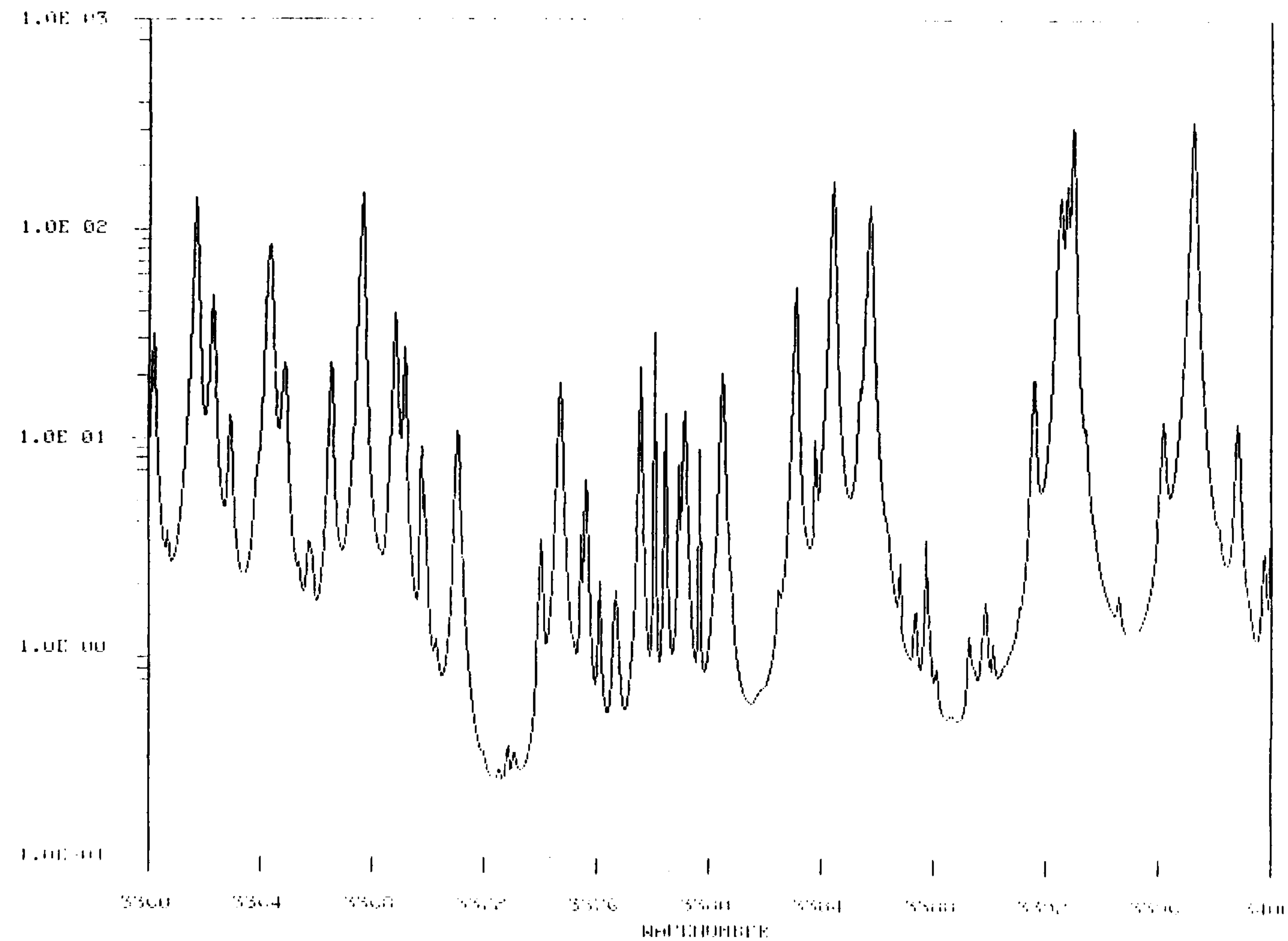

Fig. 37 — 3360-3400 cm^{-1} atmospheric absorption coefficient (km^{-1})

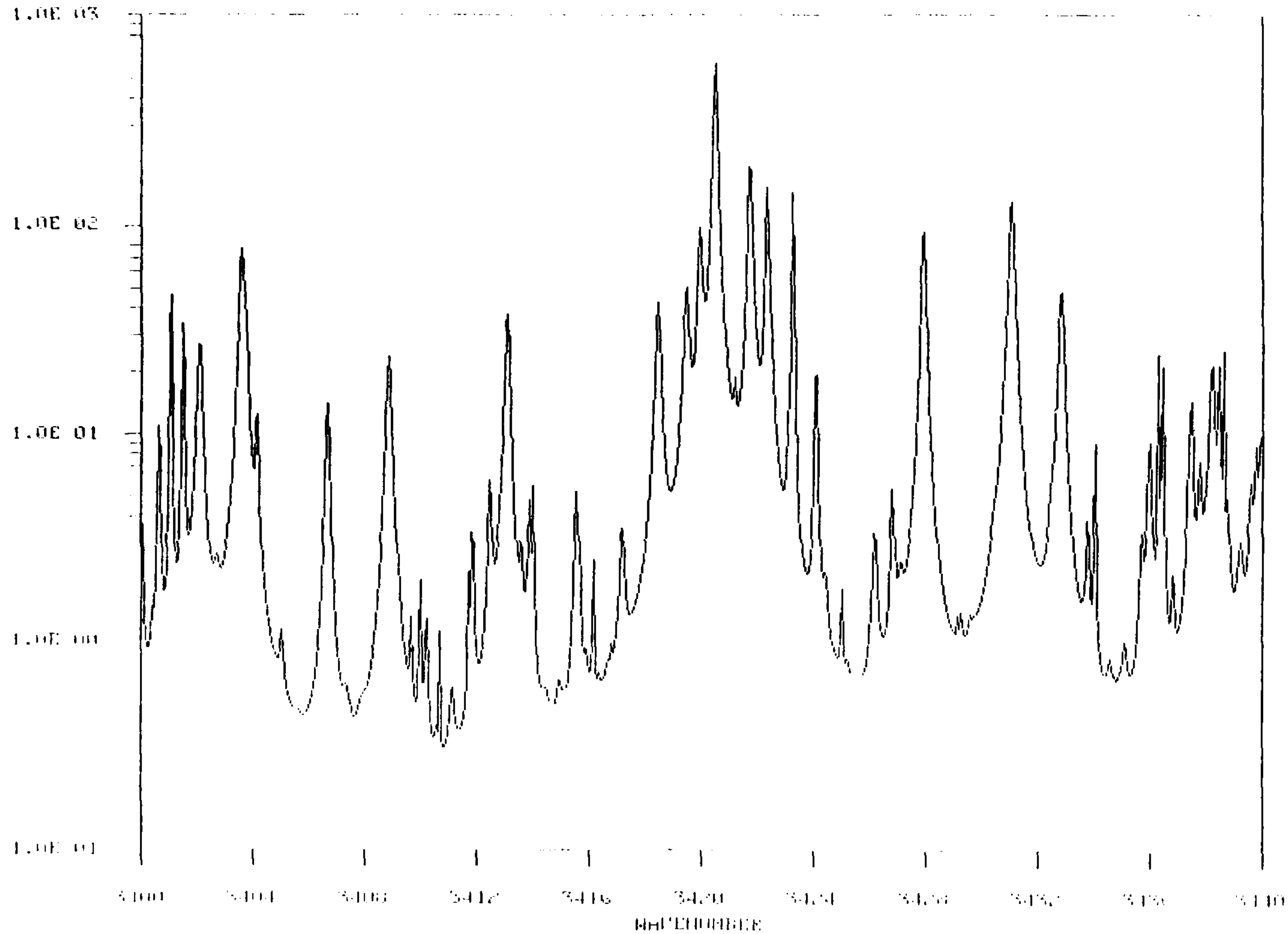

Fig. 38 — 3400-3440 cm^{-1} atmospheric absorption coefficient (km^{-1})

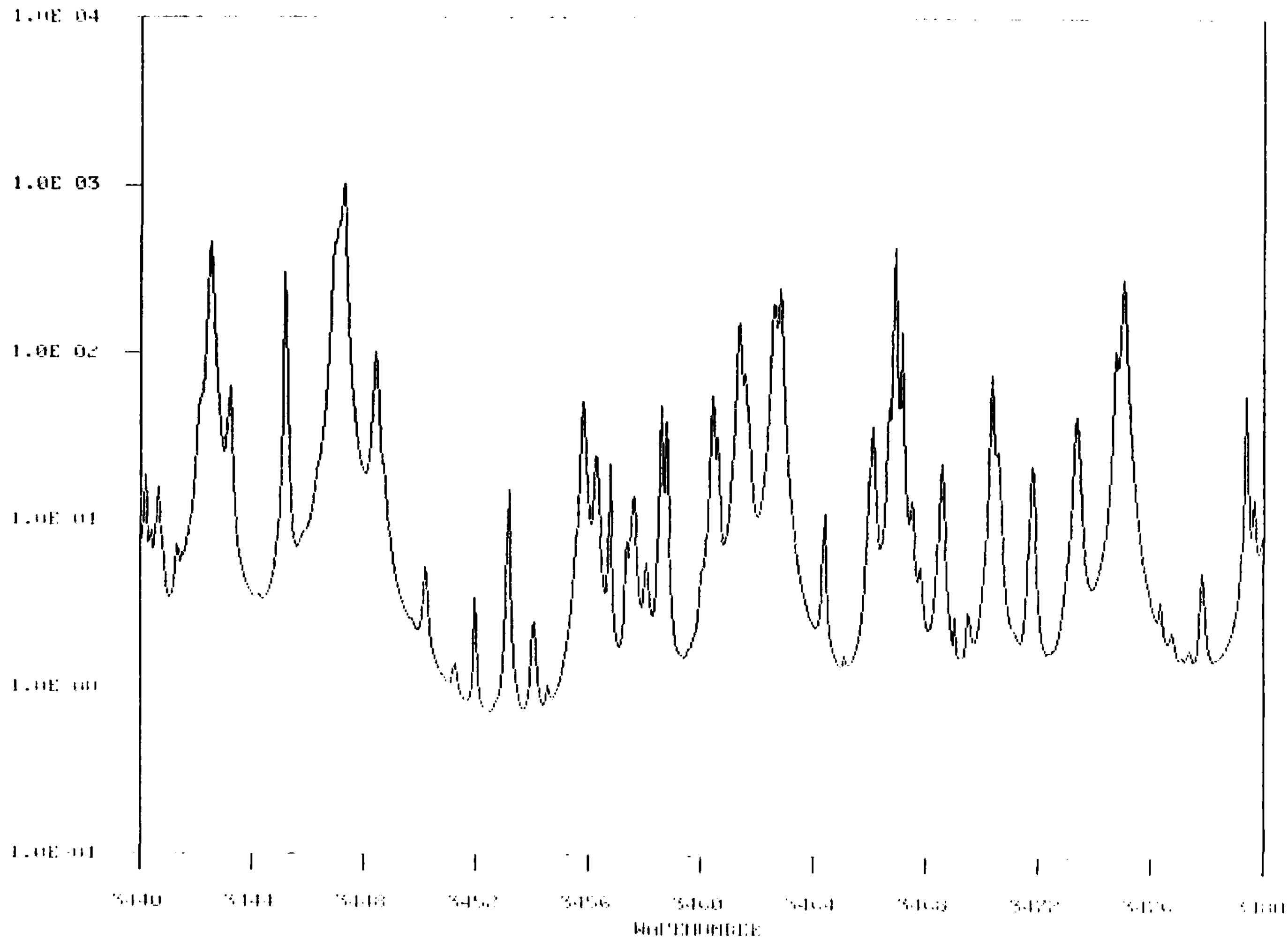

Fig. 39 — 3440-3480 cm^{-1} atmospheric absorption coefficient (km^{-1})

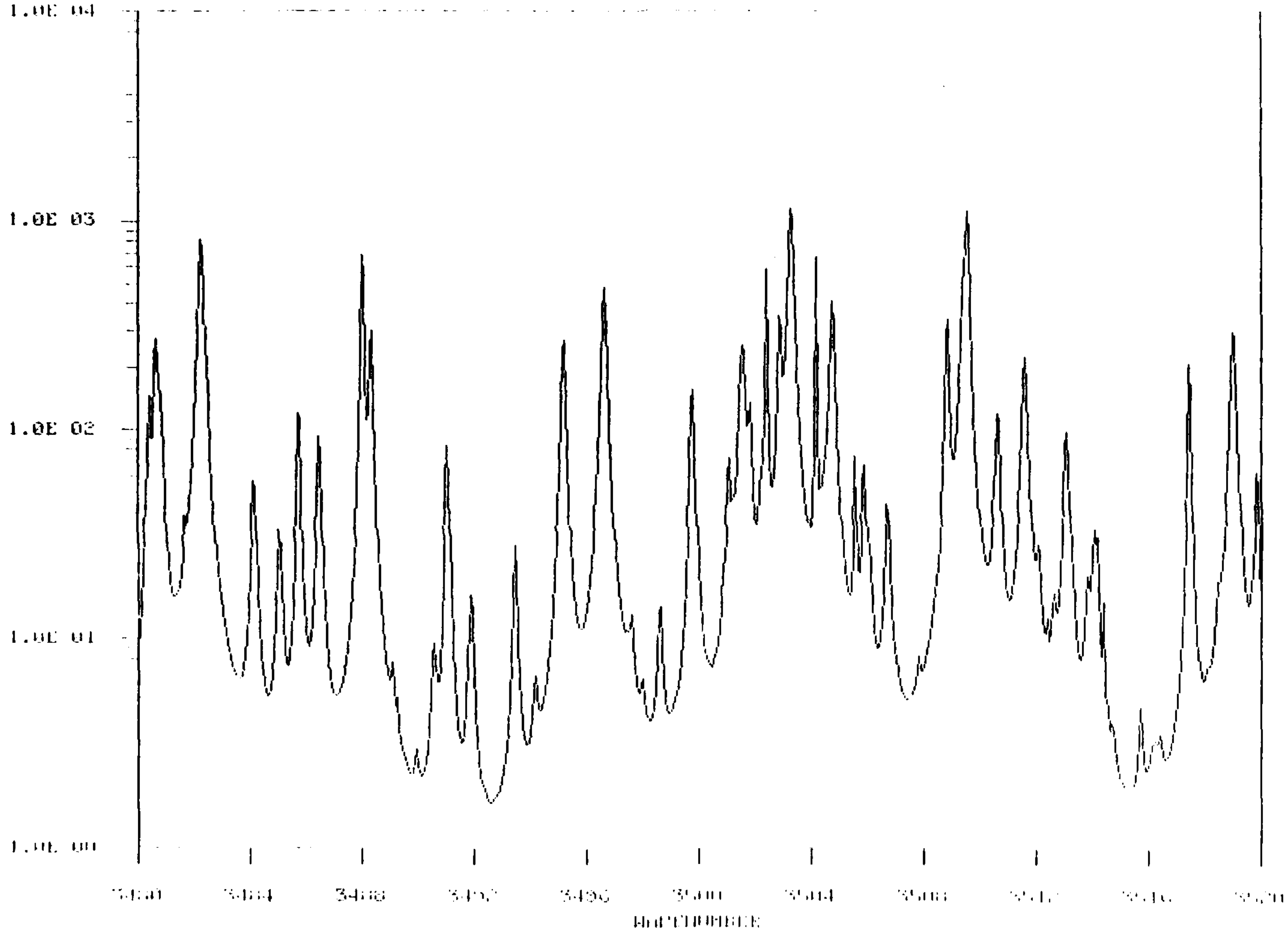

Fig. 40 — 3480-3520 cm^{-1} atmospheric absorption coefficient (km^{-1})

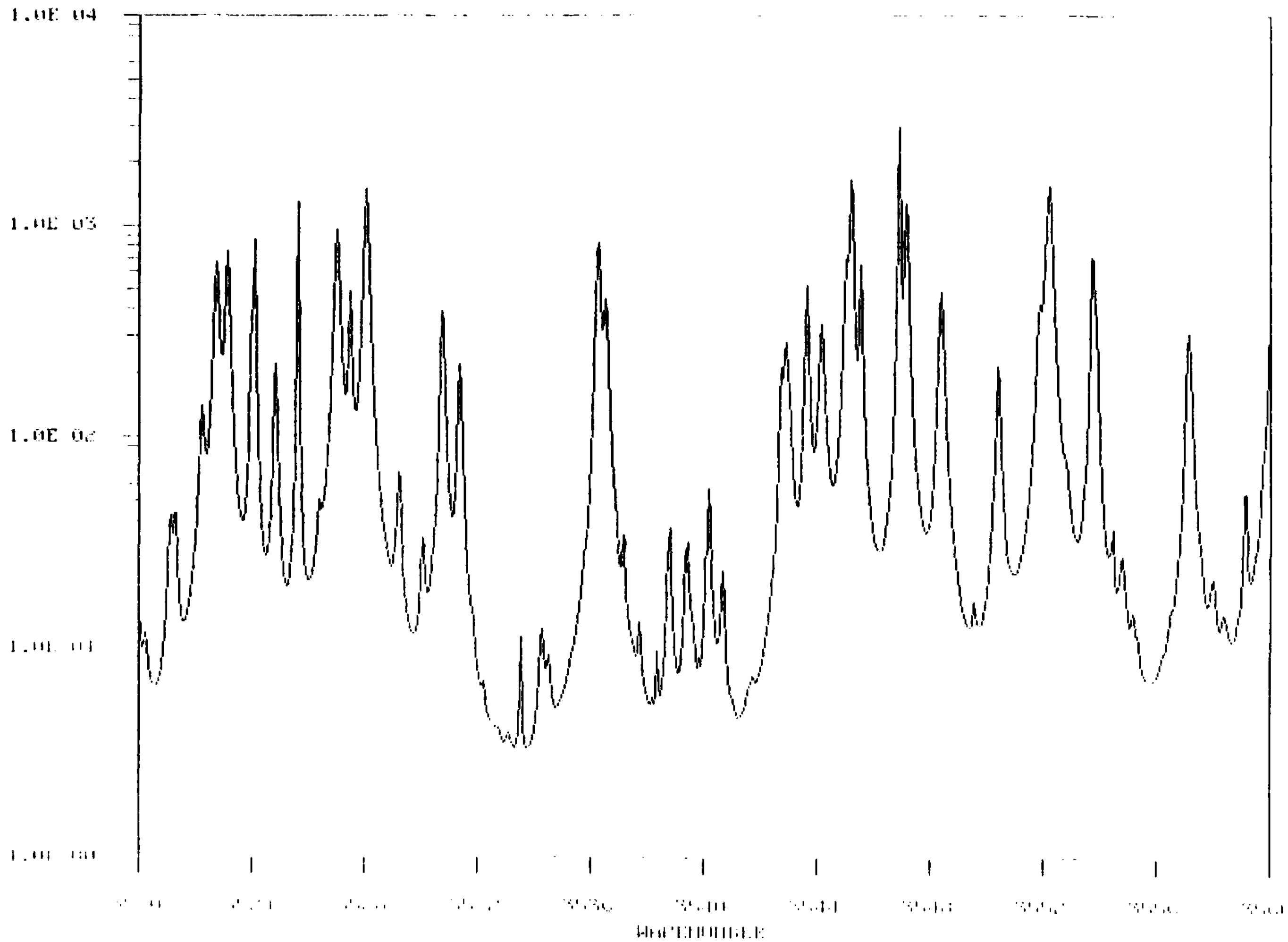

Fig. 41 — 3520-3560 cm^{-1} atmospheric absorption coefficient (km^{-1})

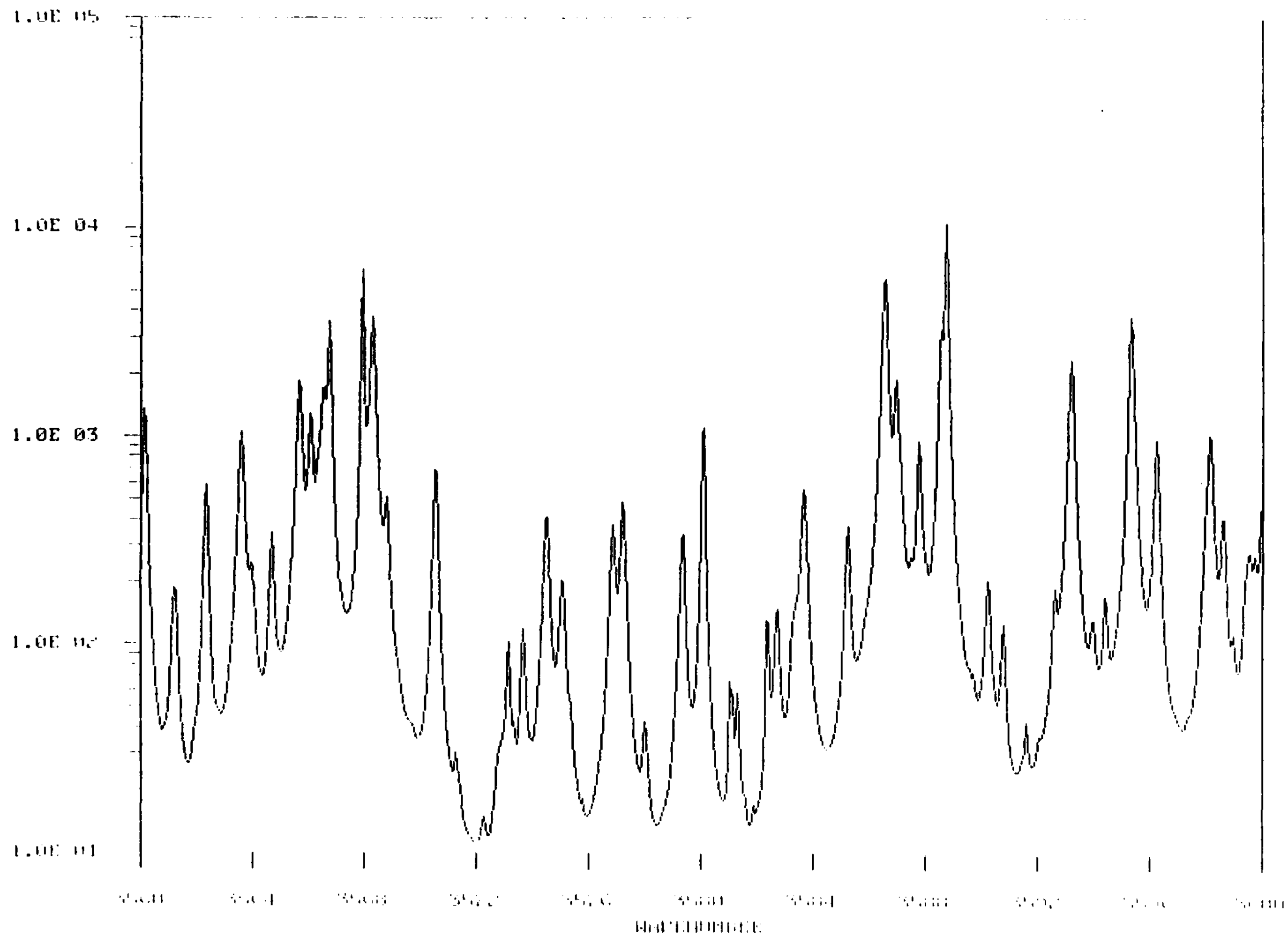

Fig. 42 — 3560-3600 cm^{-1} atmospheric absorption coefficient (km^{-1})

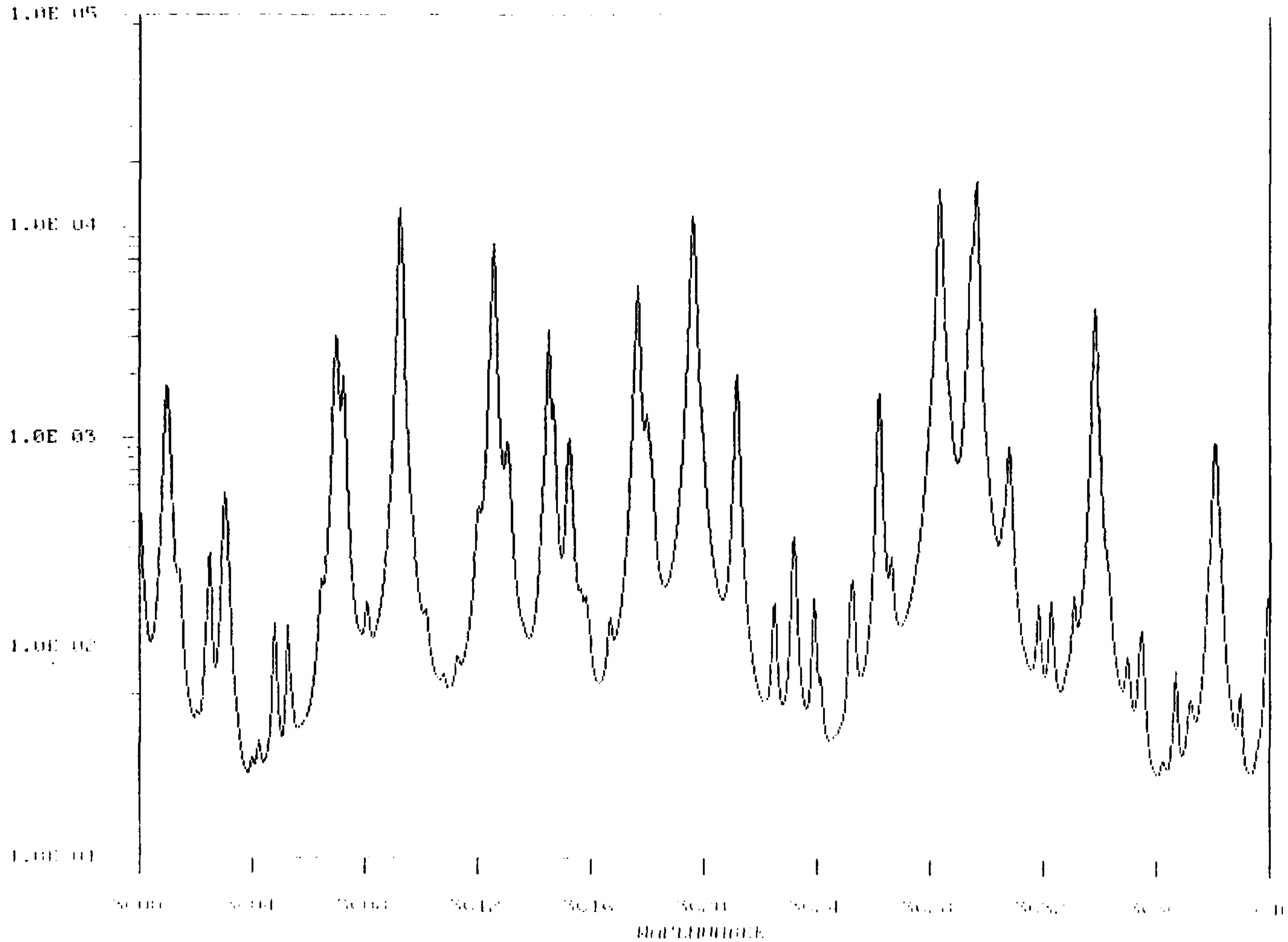

Fig. 43 — 3600-3640 cm^{-1} atmospheric absorption coefficient (km^{-1})

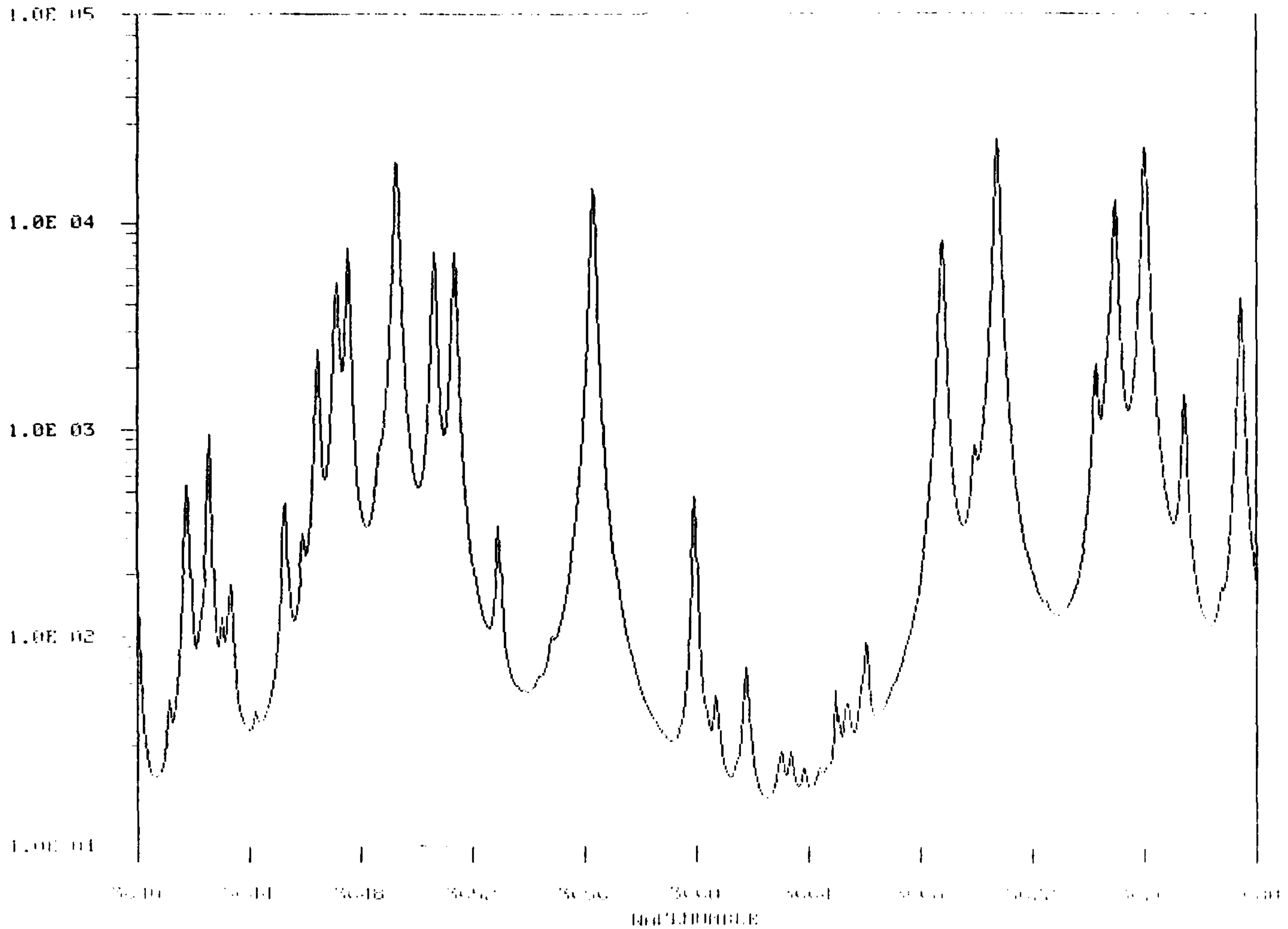

Fig. 44 — 3640-3680 cm^{-1} atmospheric absorption coefficient (km^{-1})

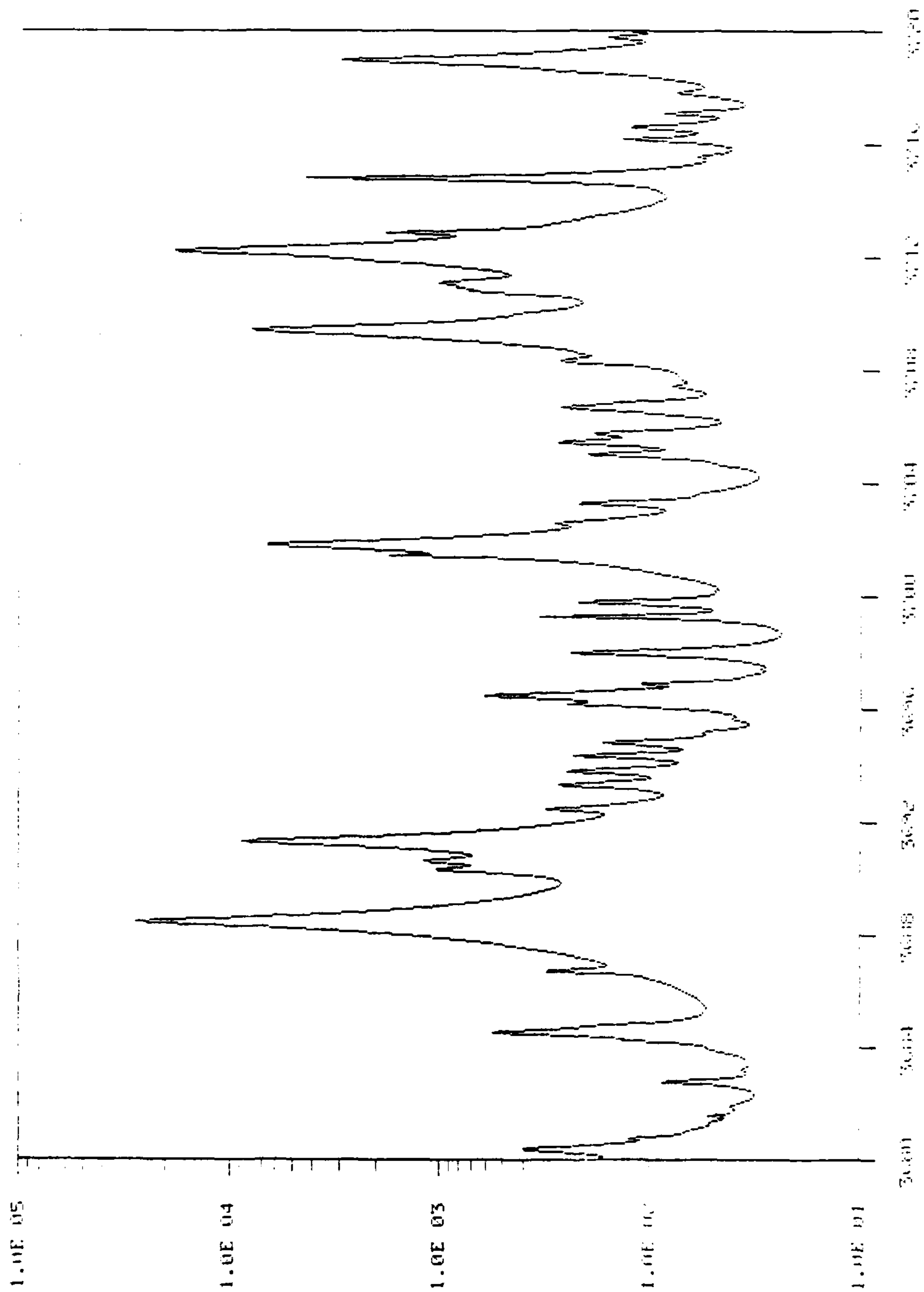

Fig. 45 — 3680-3720 cm^{-1} atmospheric absorption coefficient (km^{-1})

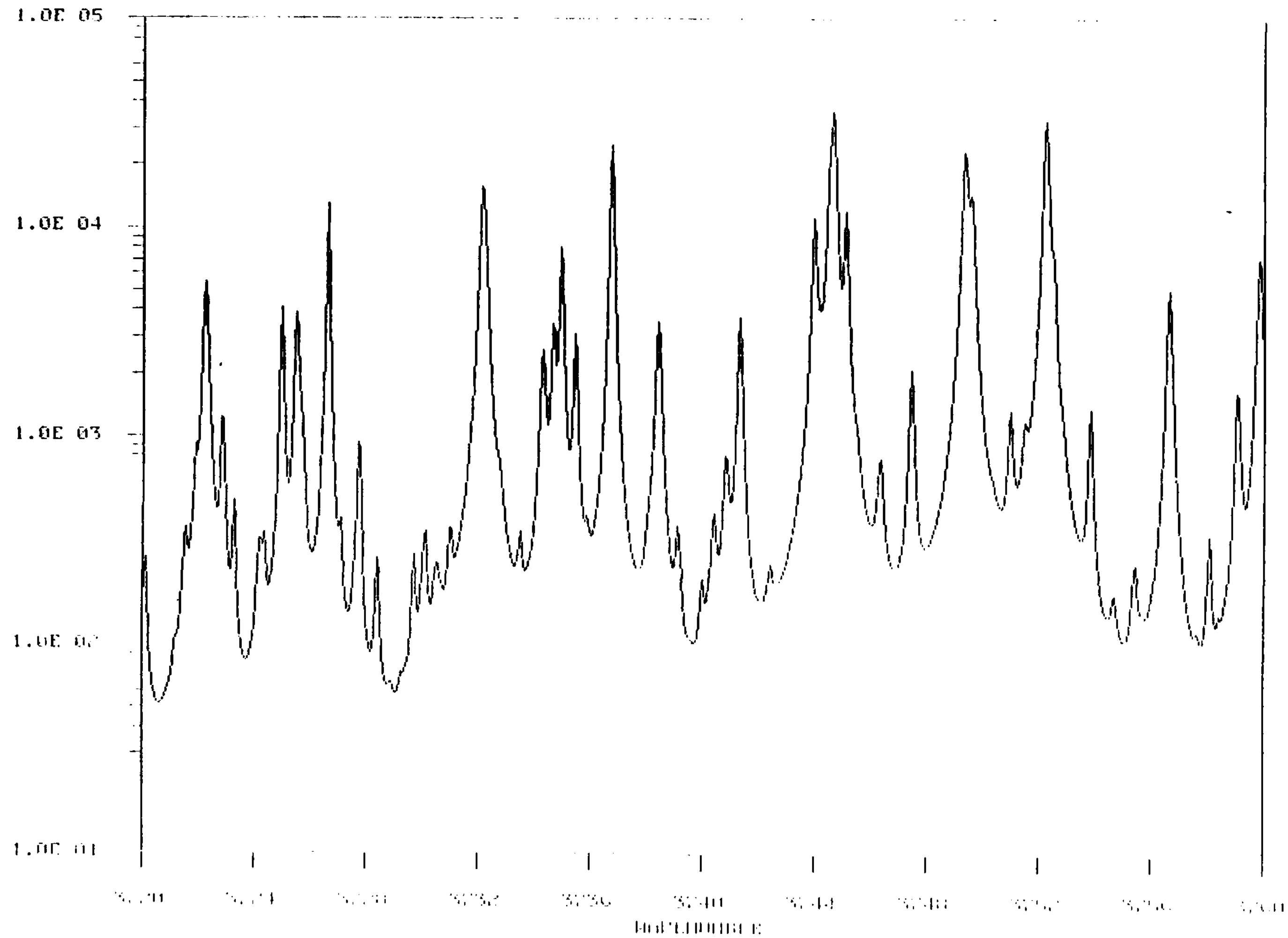

Fig. 46 — 3720-3760 cm^{-1} atmospheric absorption coefficient (km^{-1})

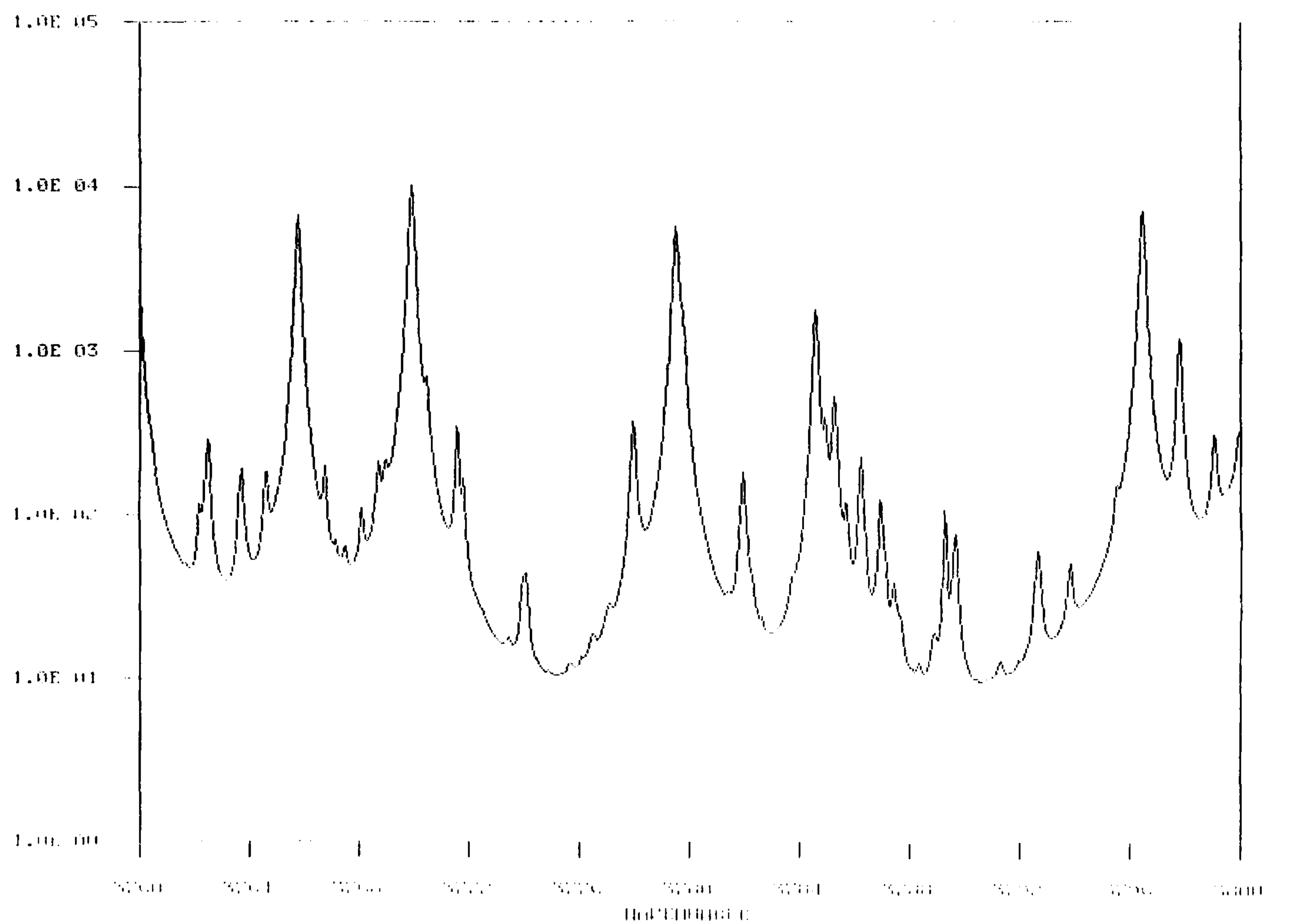

Fig. 47 — 3760-3800 cm^{-1} atmospheric absorption coefficient (km^{-1})

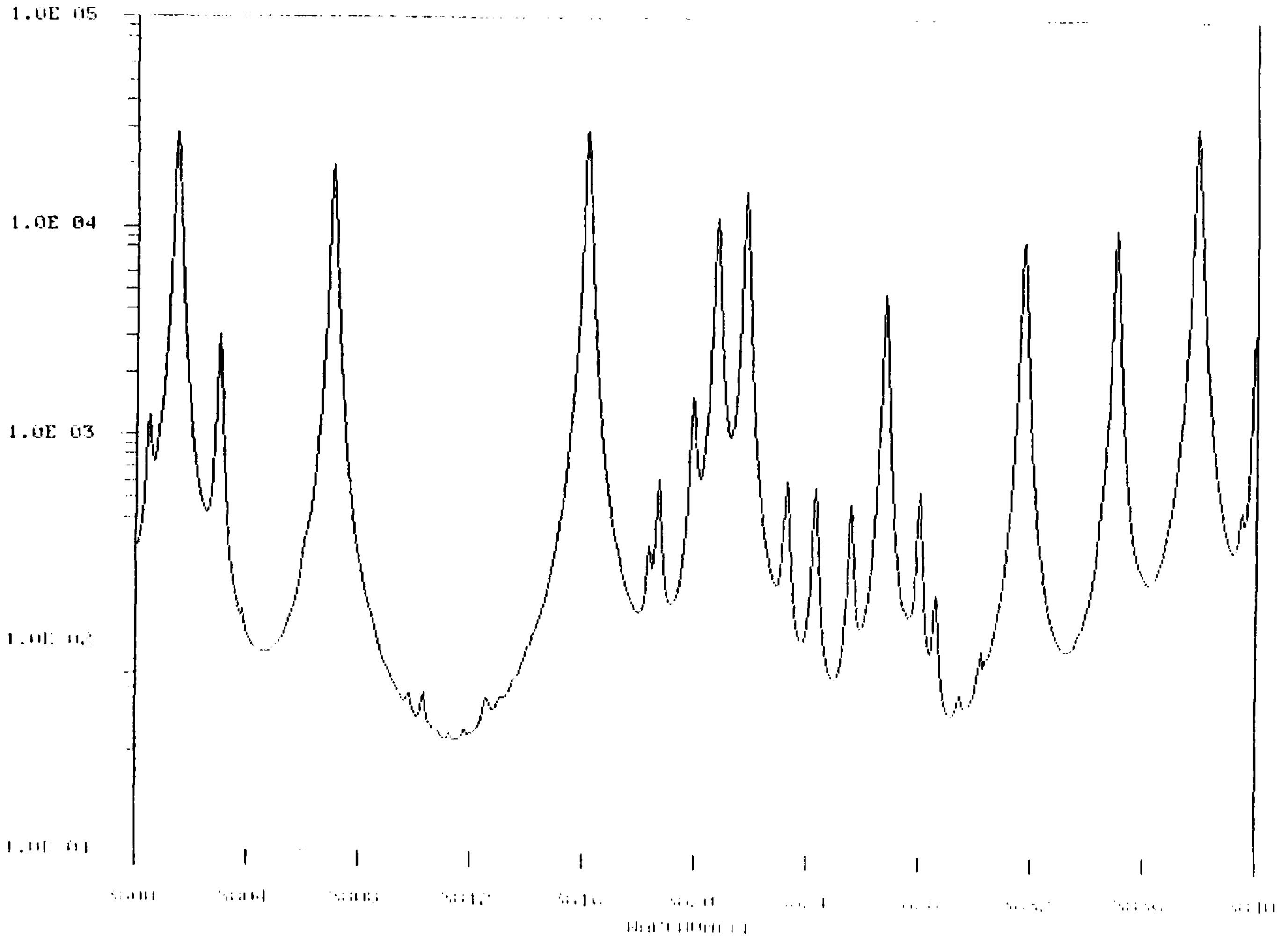

Fig. 48 — 3800-3840 cm^{-1} atmospheric absorption coefficient (km^{-1})

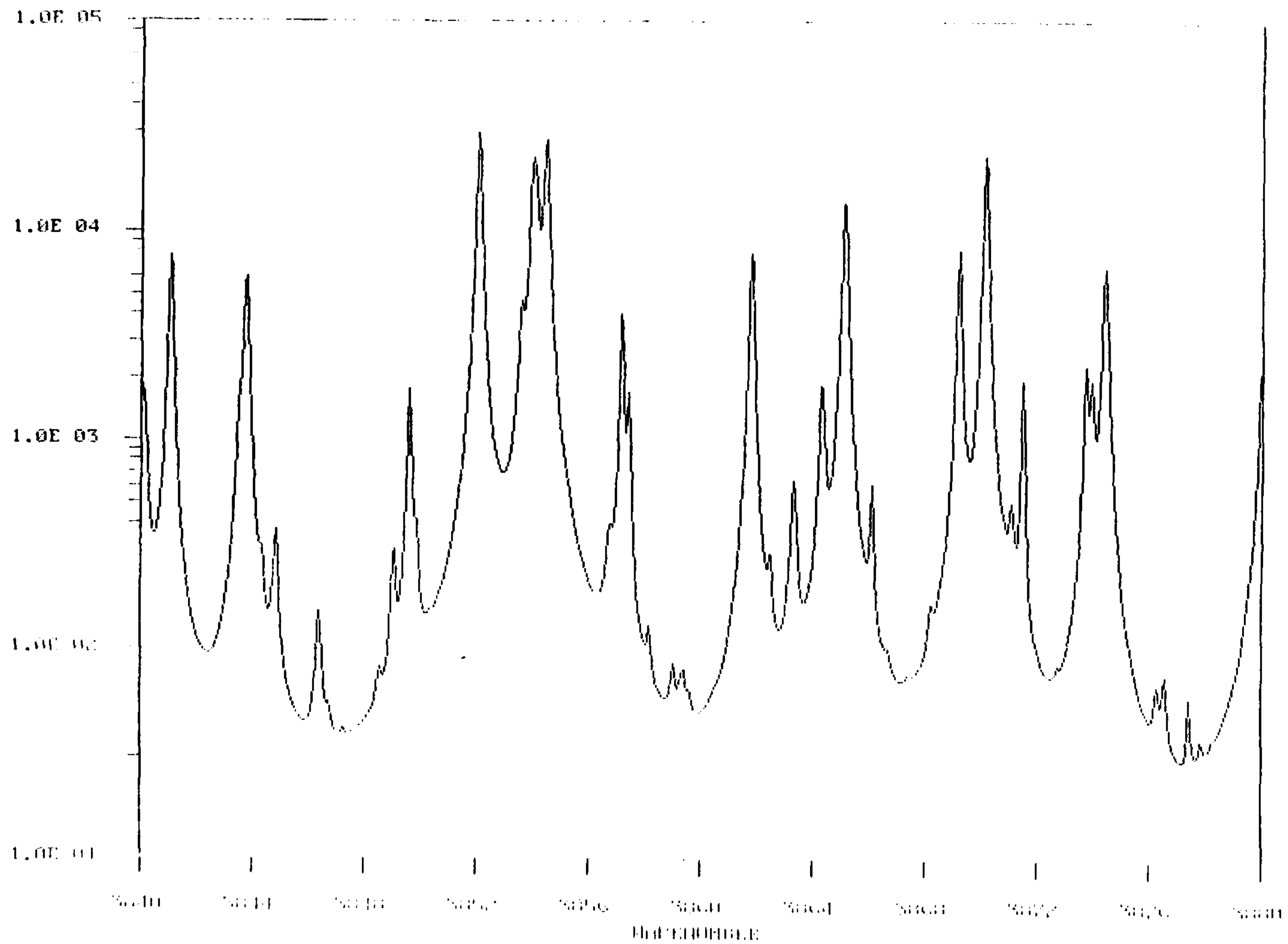

Fig. 49 — 3840-3880 cm^{-1} atmospheric absorption coefficient (km^{-1})

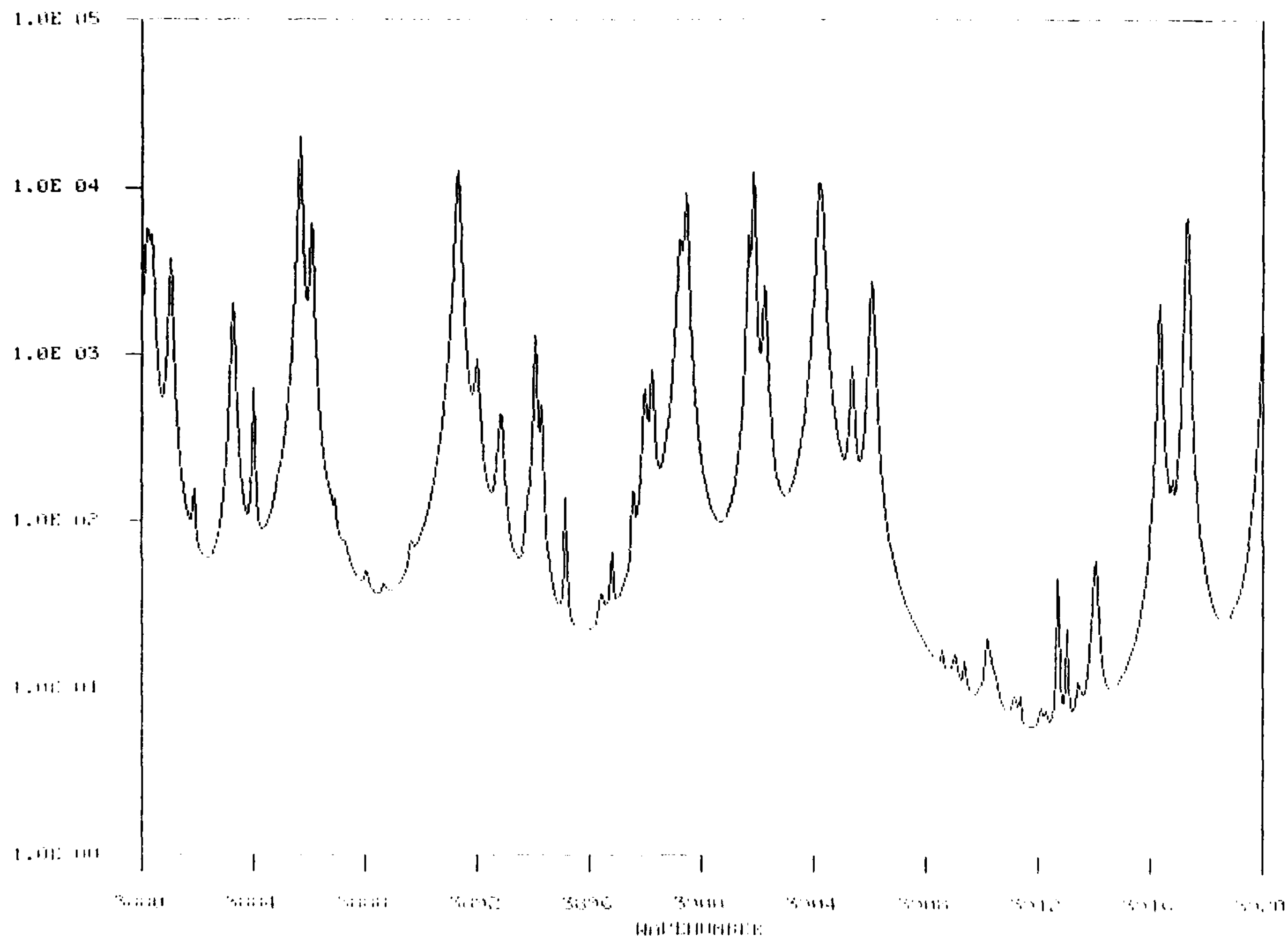

Fig. 50 — 3880-3920 cm^{-1} atmospheric absorption coefficient (km^{-1})

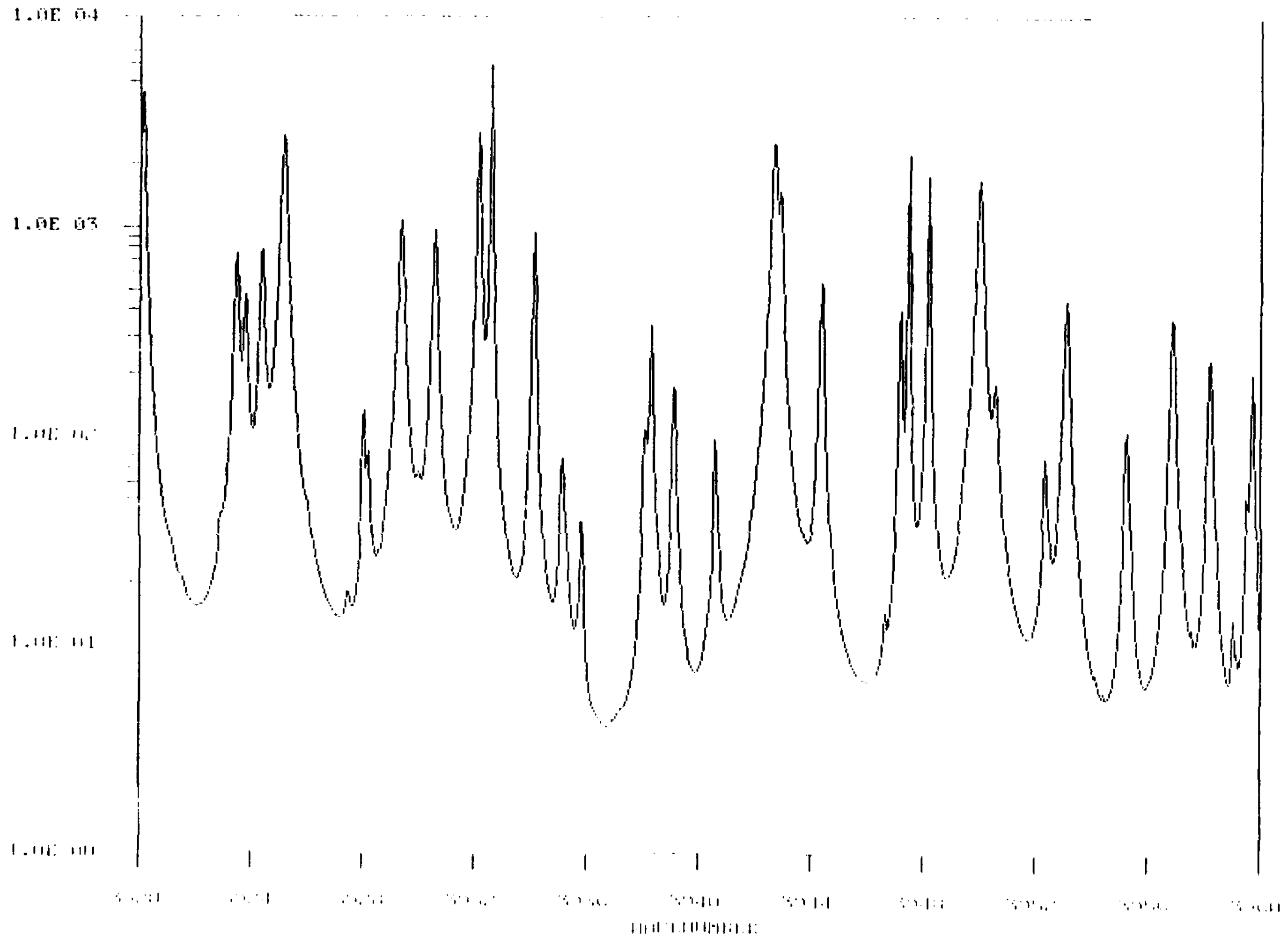

Fig. 51 — 3920-3960 cm^{-1} atmospheric absorption coefficient (km^{-1})

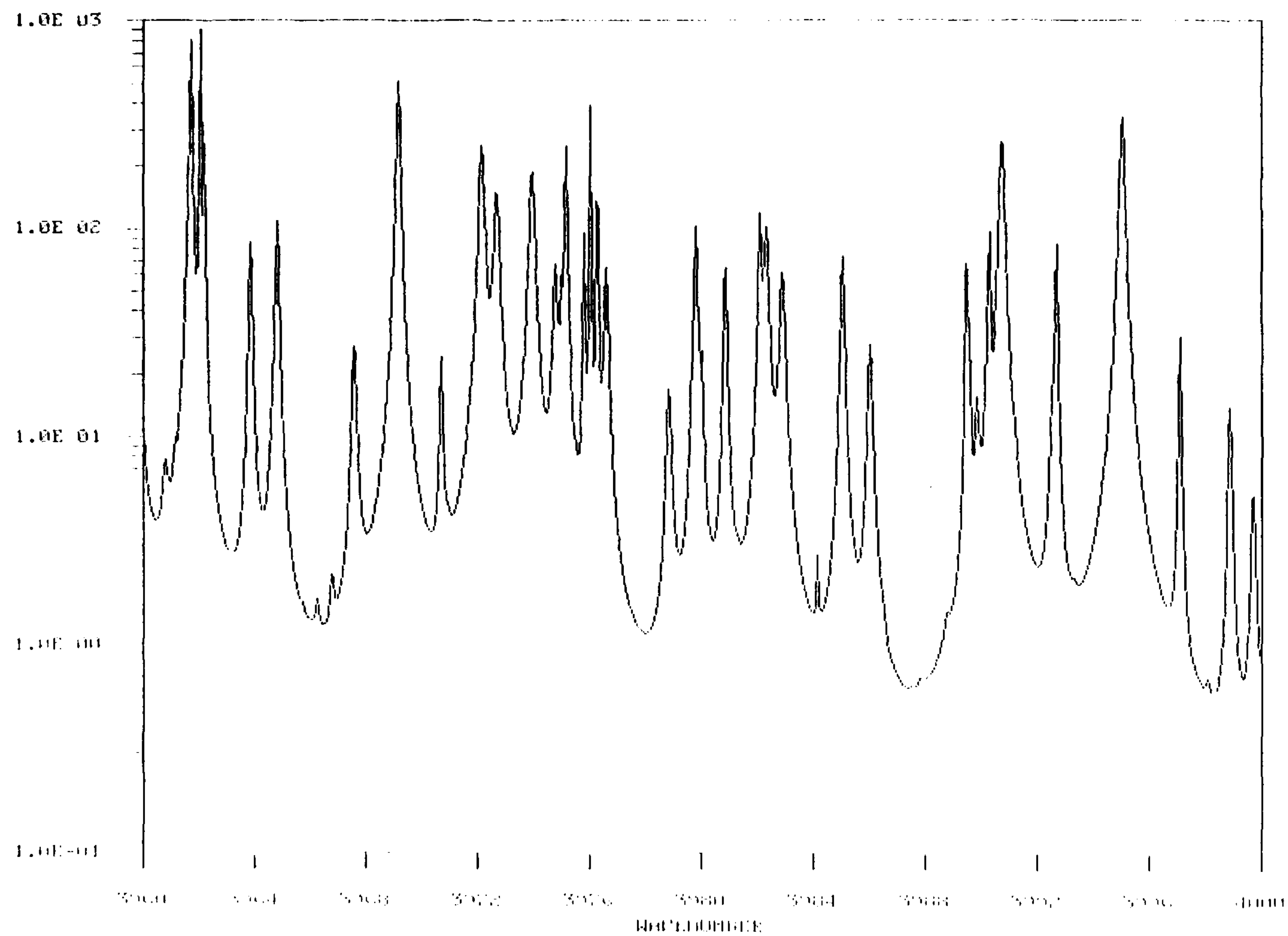

Fig. 52 — 3960-4000 cm^{-1} atmospheric absorption coefficient (km^{-1})

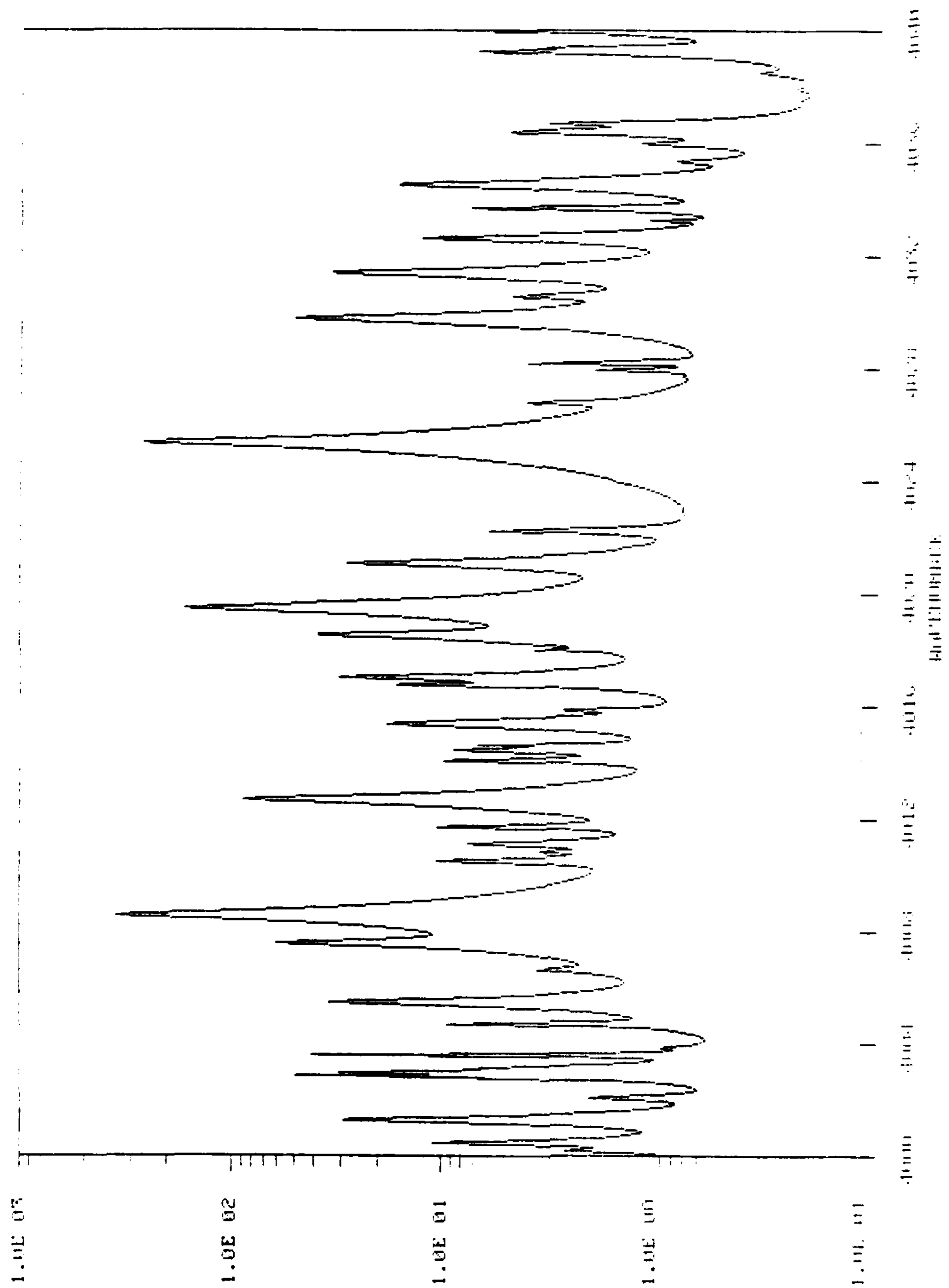

Fig. 53 — 4000-4040 cm^{-1} atmospheric absorption coefficient (km^{-1})

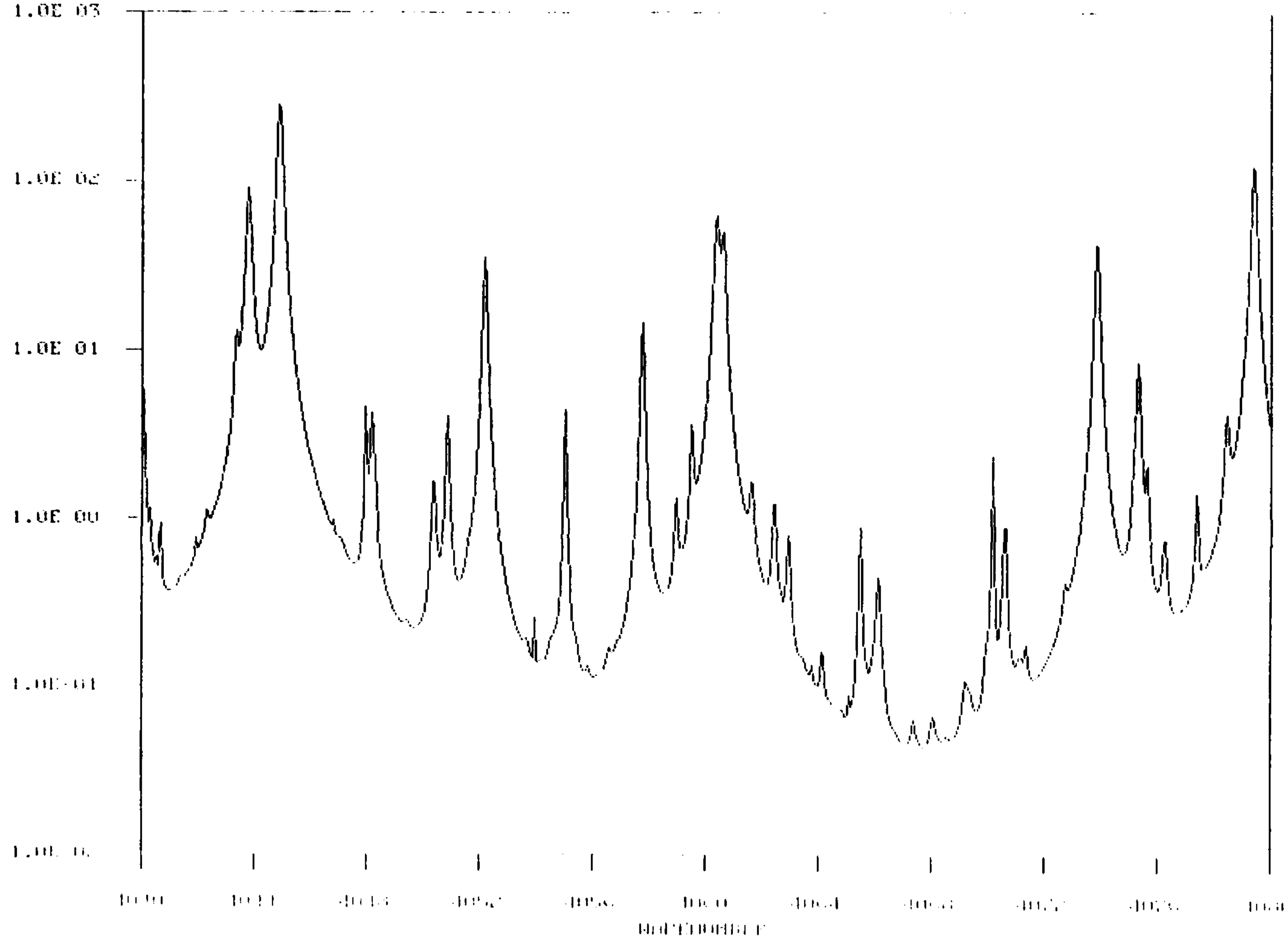

Fig. 54 — 4040-4080 cm^{-1} atmospheric absorption coefficient (km^{-1})

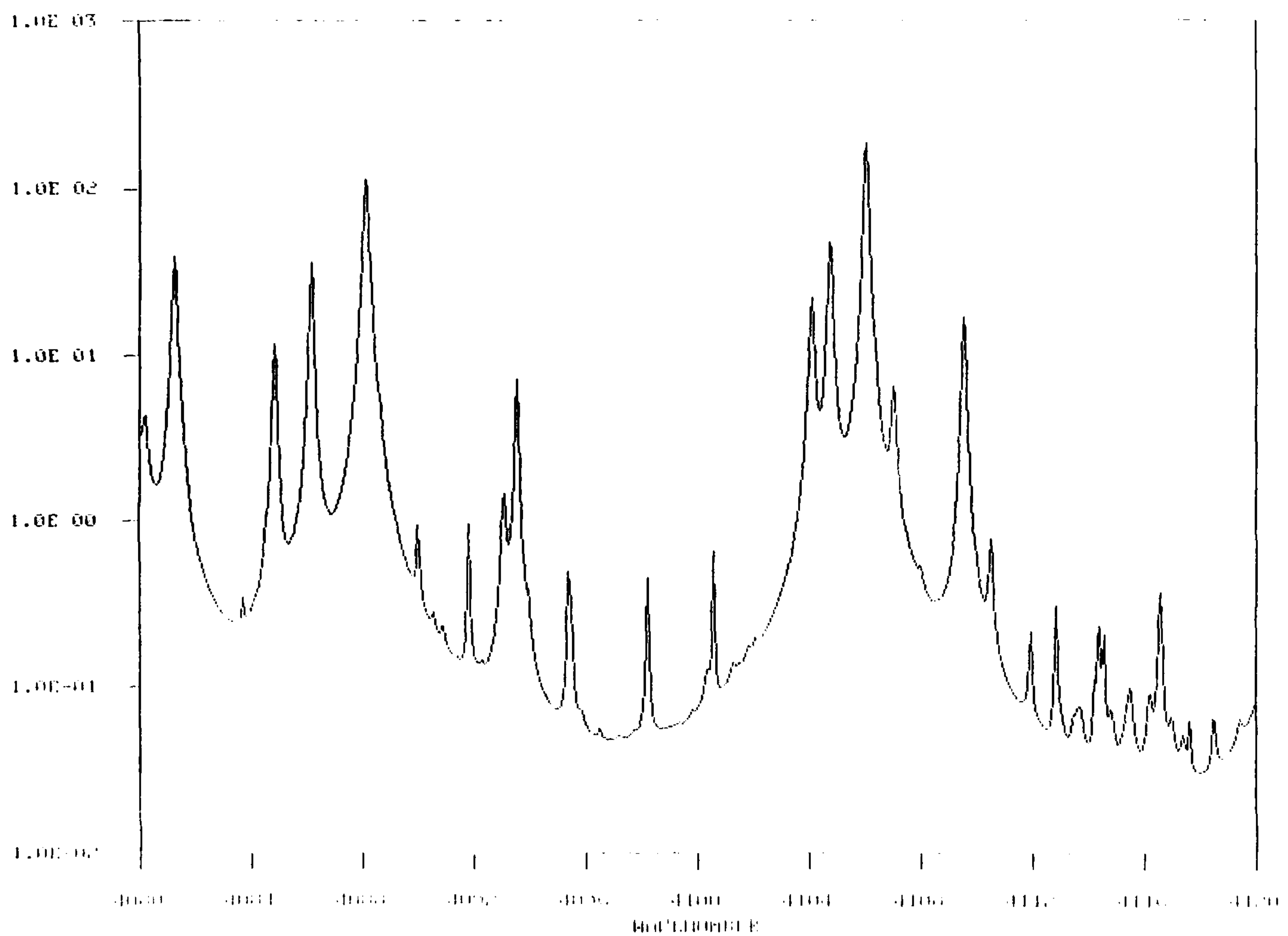

Fig. 55 — 4080-4120 cm^{-1} atmospheric absorption coefficient (km^{-1})

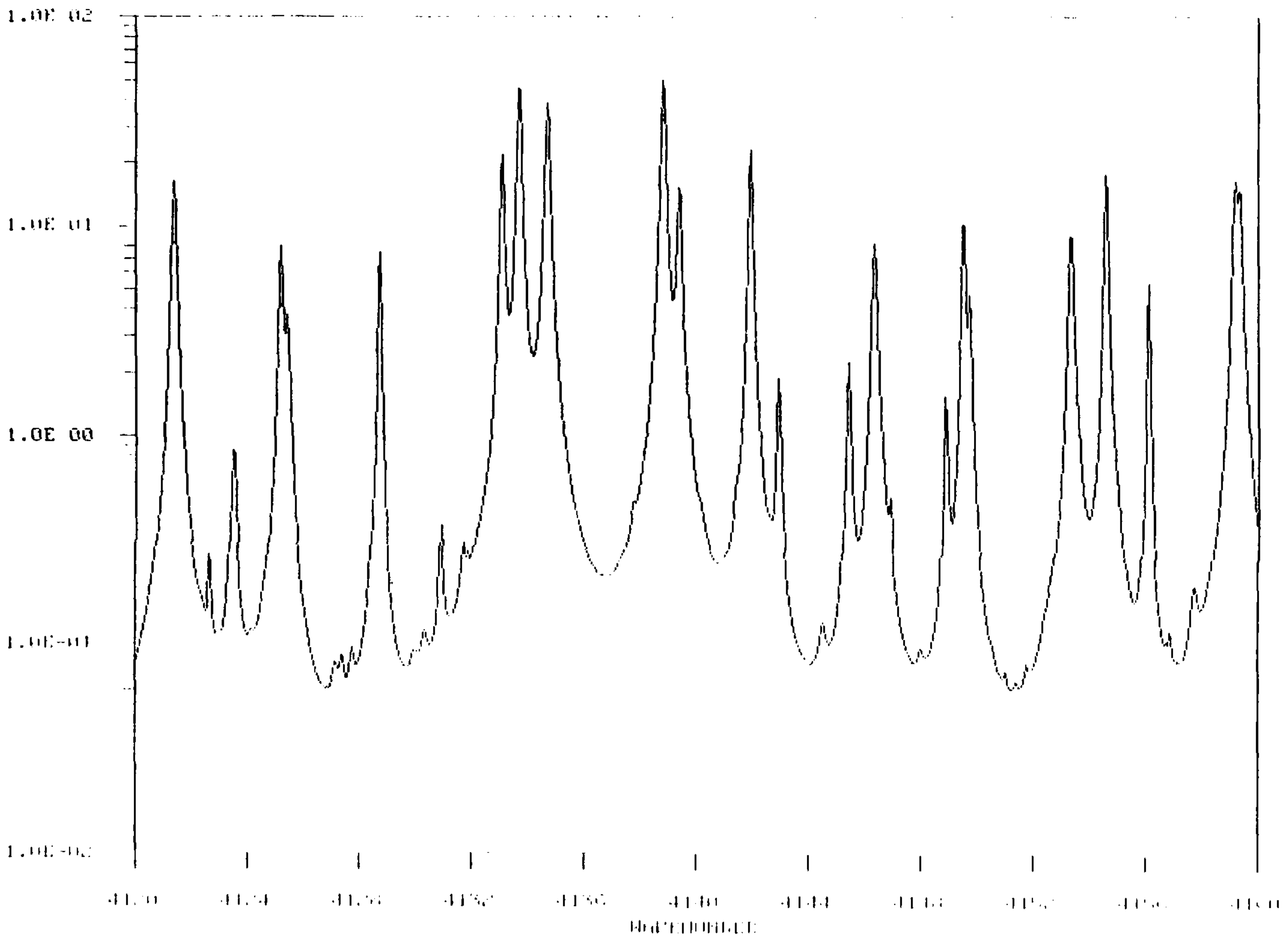

Fig. 56 — 4120-4160 cm^{-1} atmospheric absorption coefficient (km^{-1})

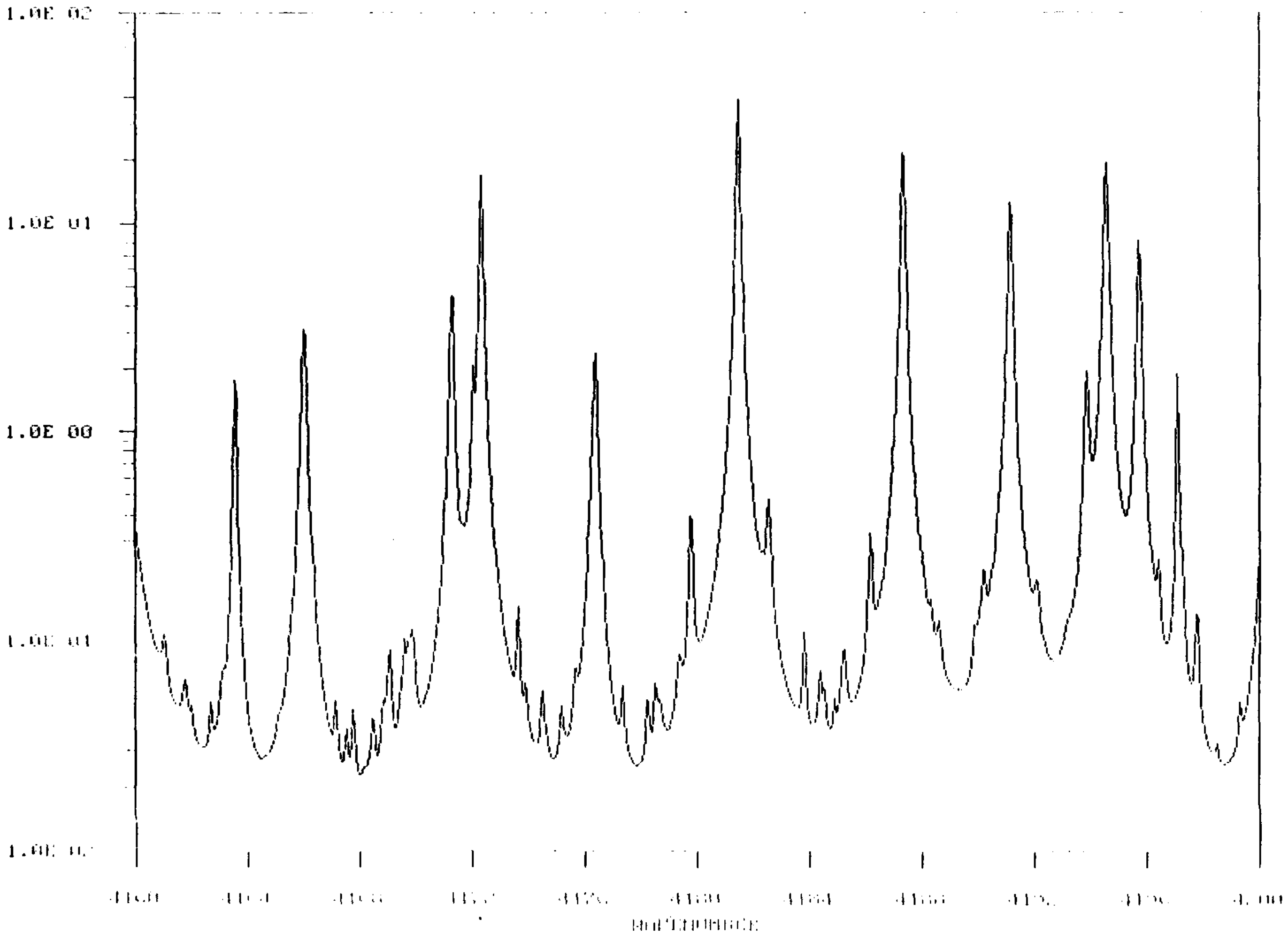

Fig. 57 — 4160-4200 cm^{-1} atmospheric absorption coefficient (km^{-1})

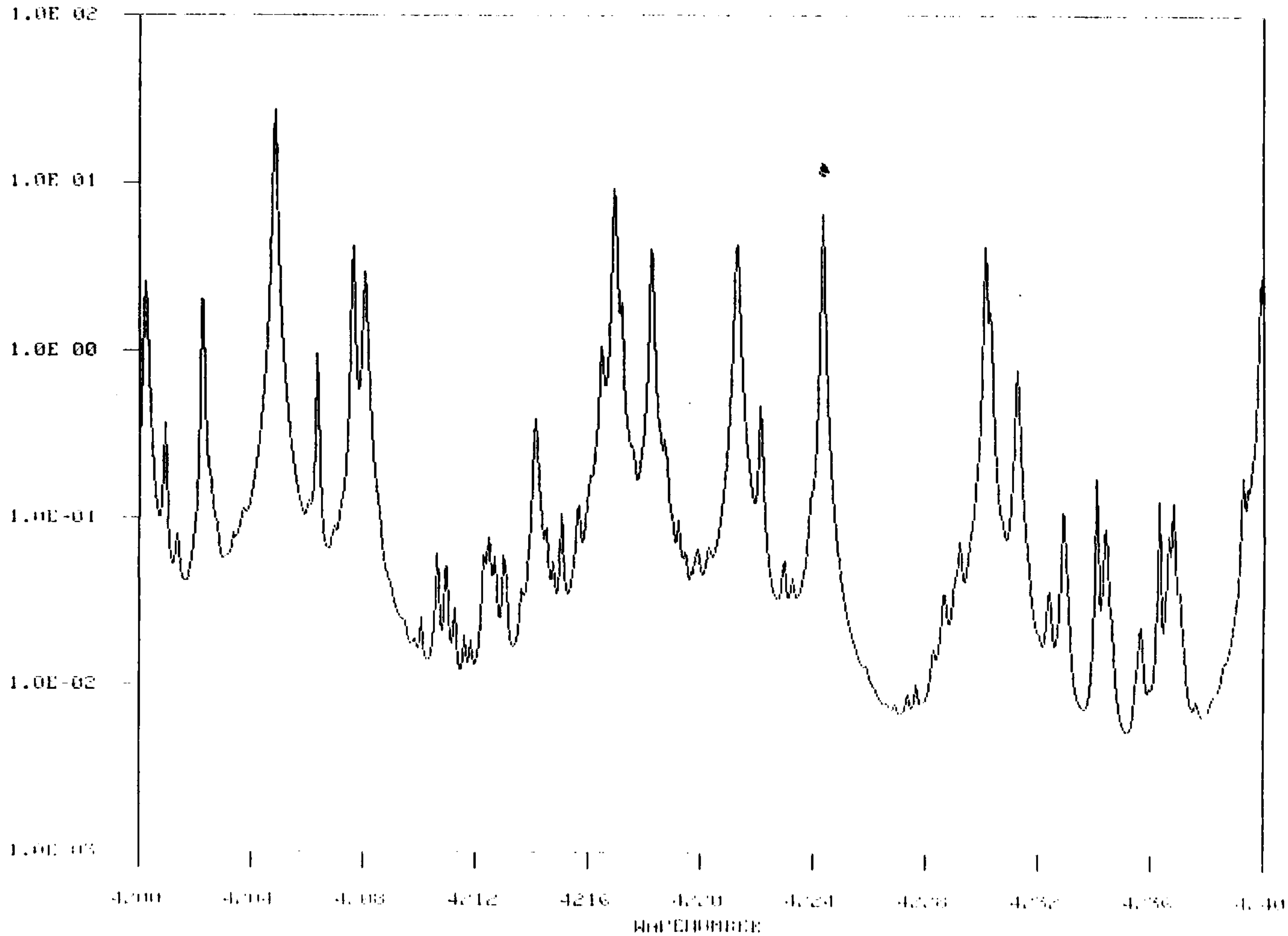

Fig. 58 — 4200-4240 cm^{-1} atmospheric absorption coefficient (km^{-1})

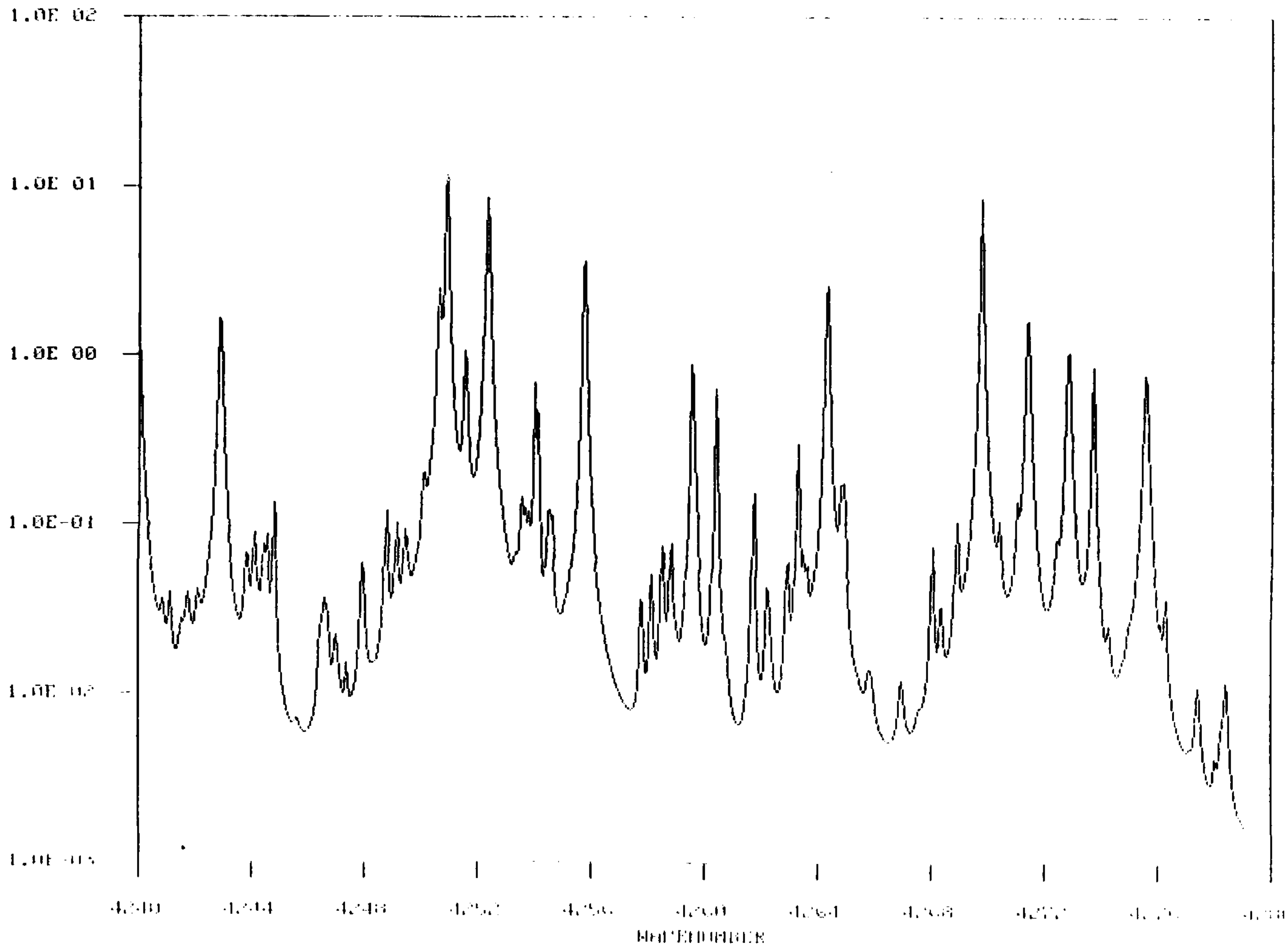

Fig. 59 — 4240-4280 cm^{-1} atmospheric absorption coefficient (km^{-1})

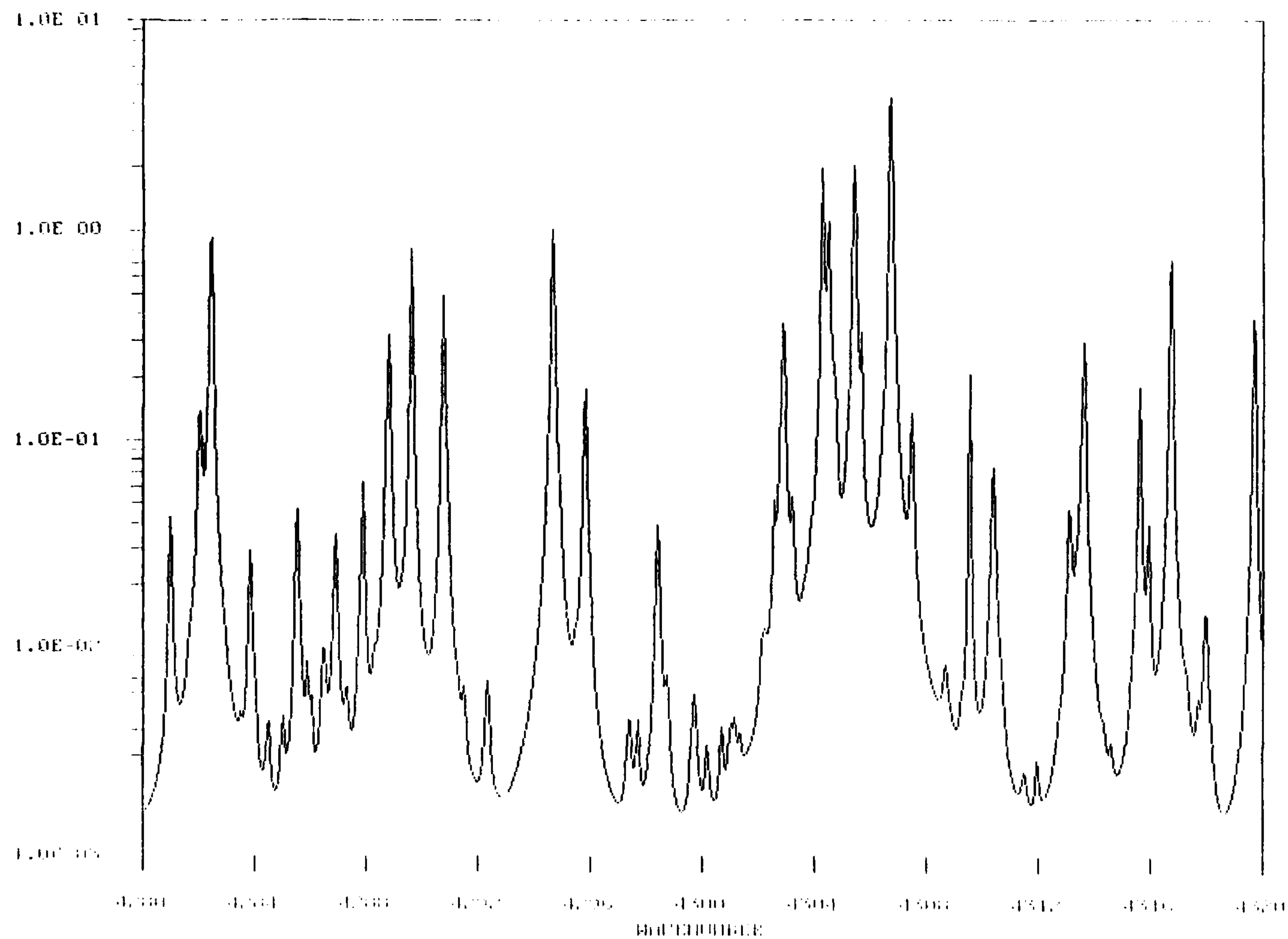

Fig. 60 — 4280-4320 cm^{-1} atmospheric absorption coefficient (km^{-1})

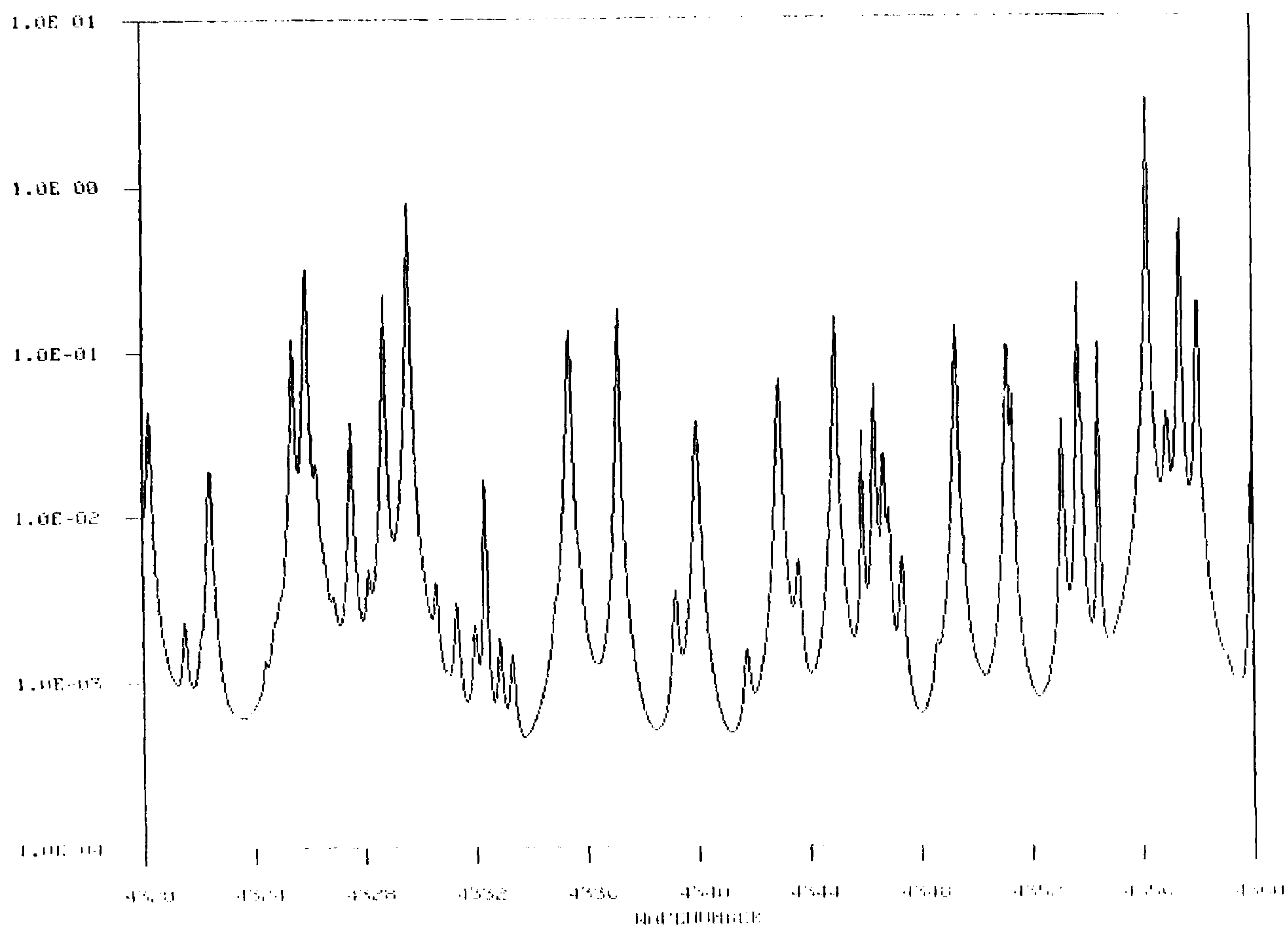

Fig. 61 — 4320-4360 cm^{-1} atmospheric absorption coefficient (km^{-1})

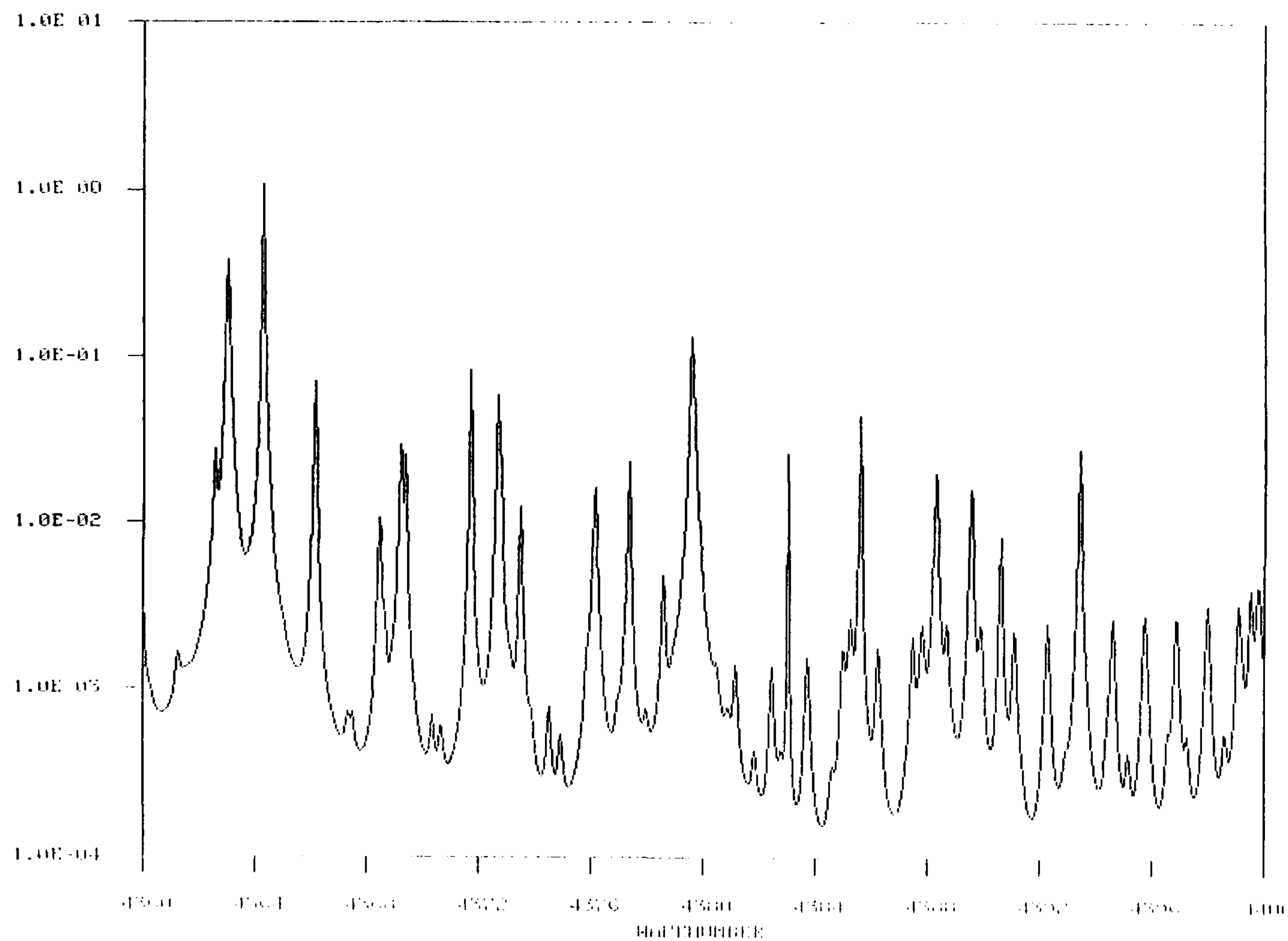

Fig. 62 — 4360-4400 cm^{-1} atmospheric absorption coefficient (km^{-1})

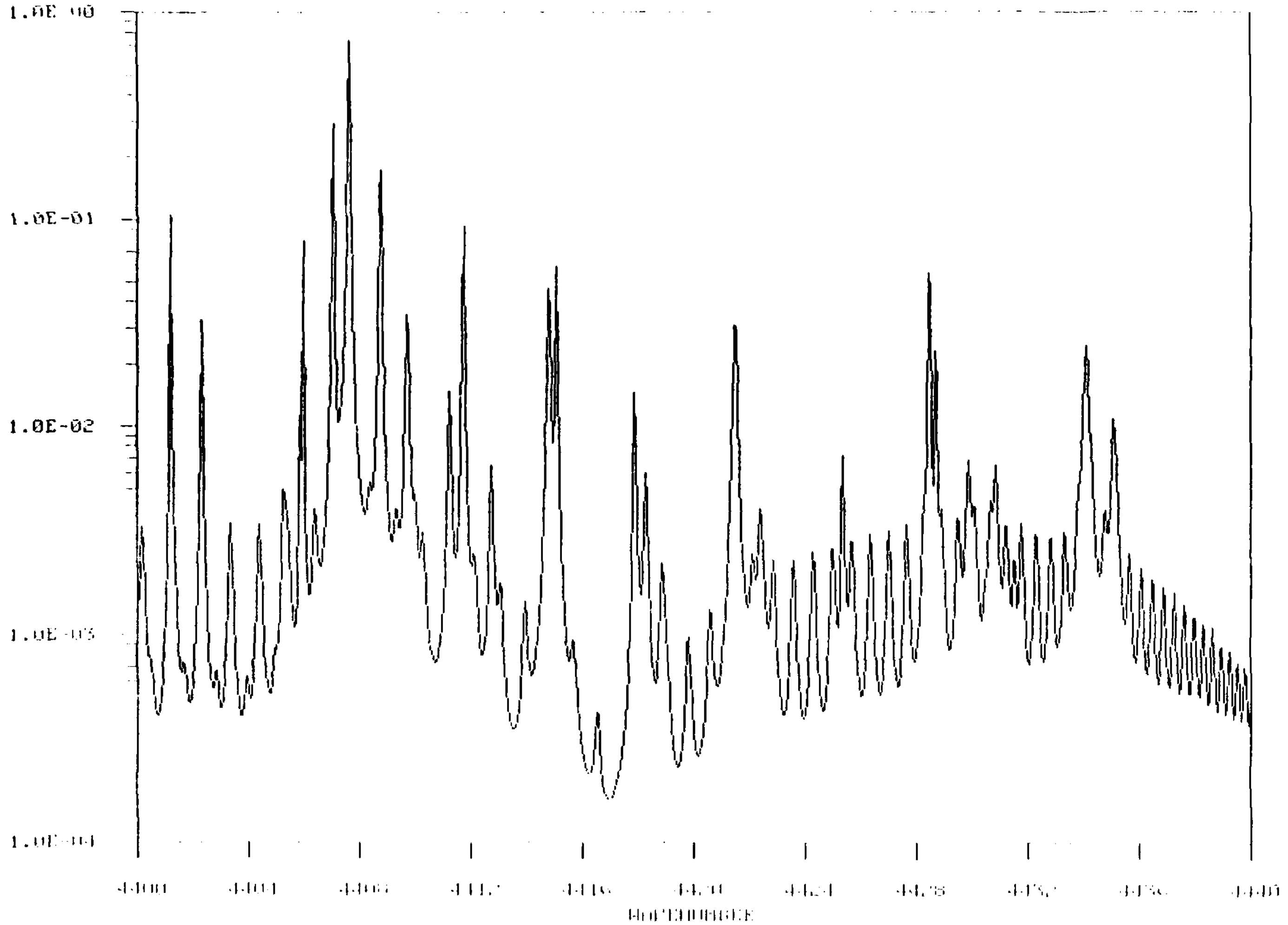

Fig. 63 — 4400-4440 cm^{-1} atmospheric absorption coefficient (km^{-1})

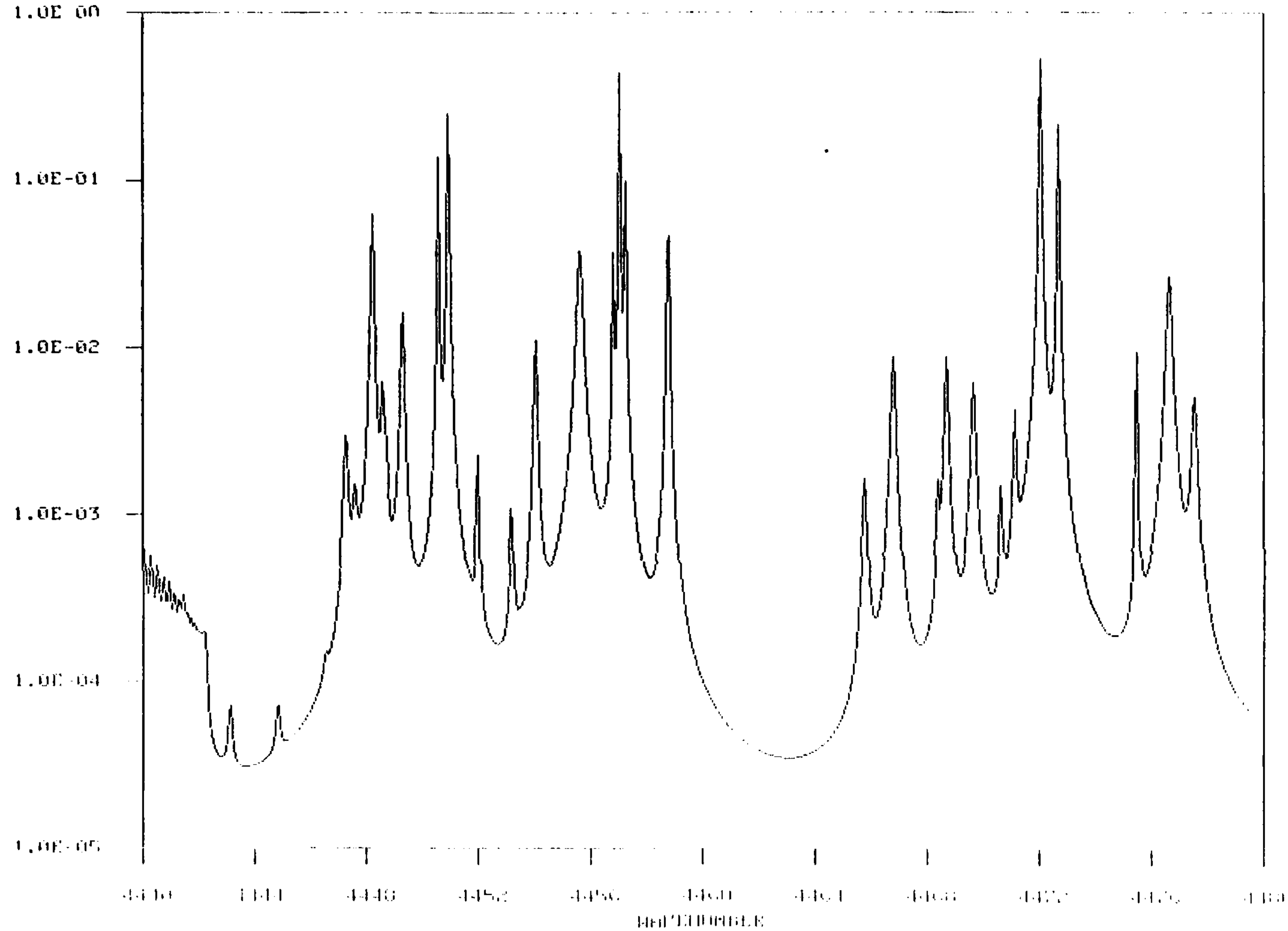

Fig. 64 — 4440-4480 cm^{-1} atmospheric absorption coefficient (km^{-1})

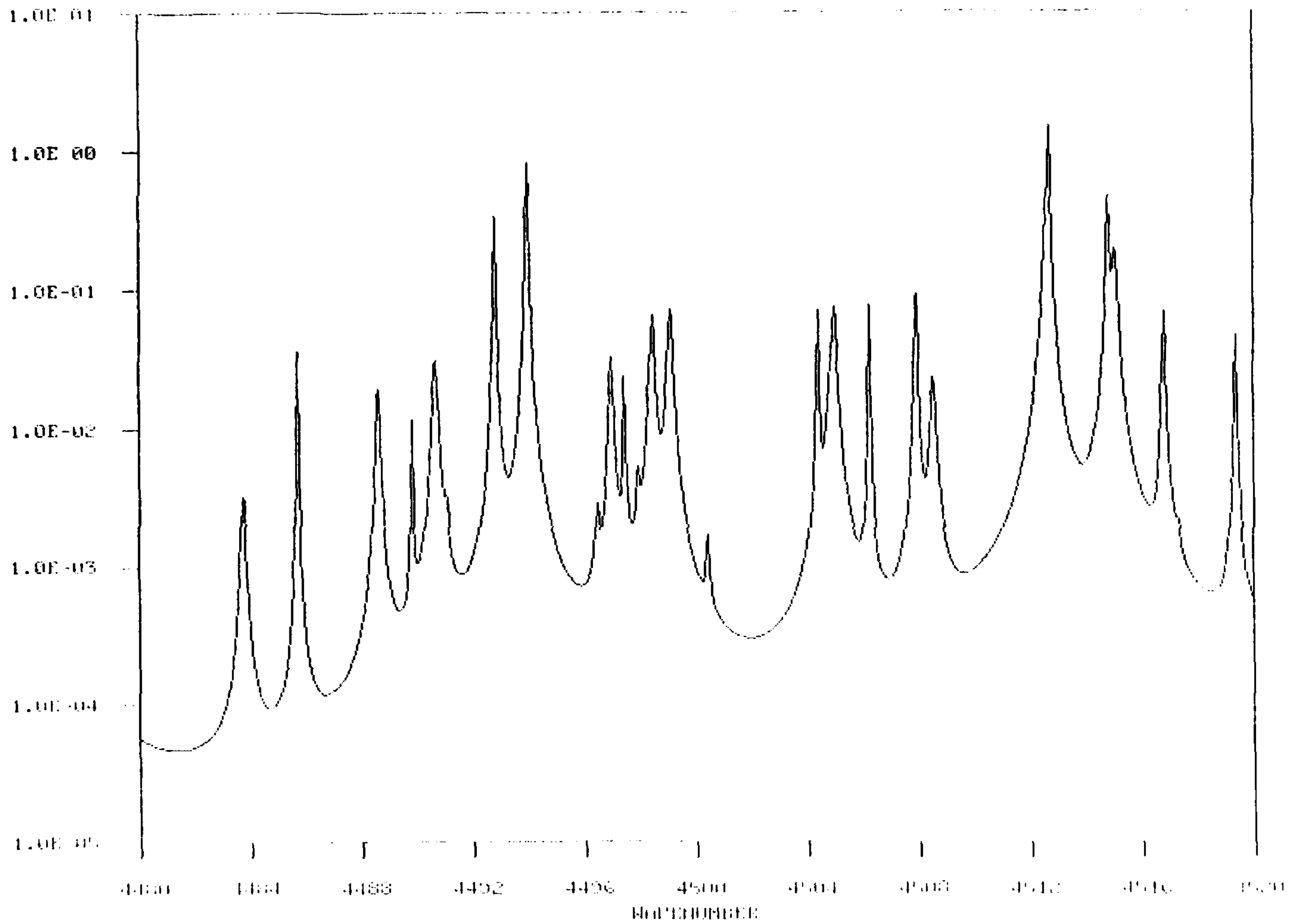

Fig. 65 — 4480-4520 cm^{-1} atmospheric absorption coefficient (km^{-1})

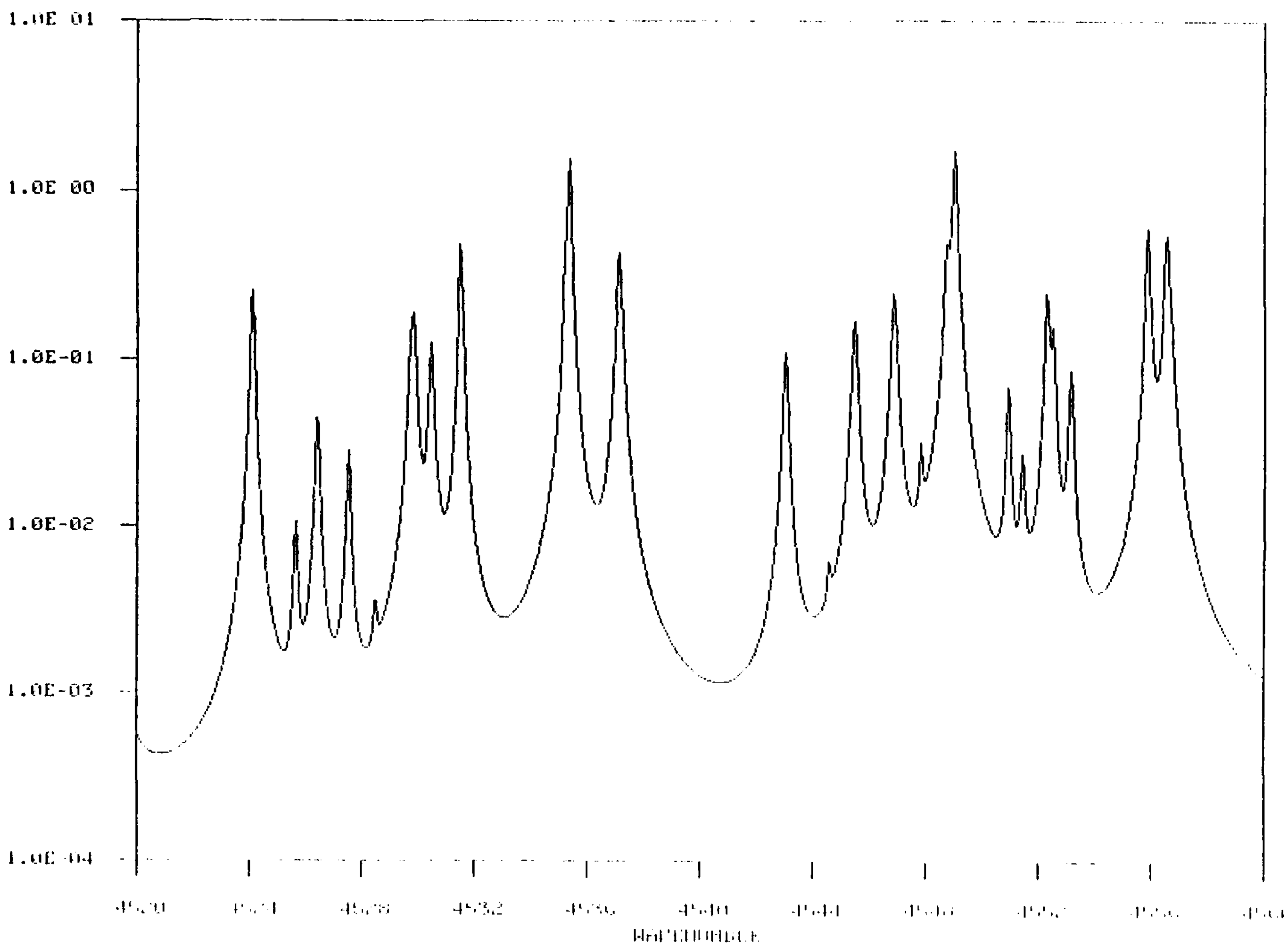

Fig. 66 — 4520-4560 cm^{-1} atmospheric absorption coefficient (km^{-1})

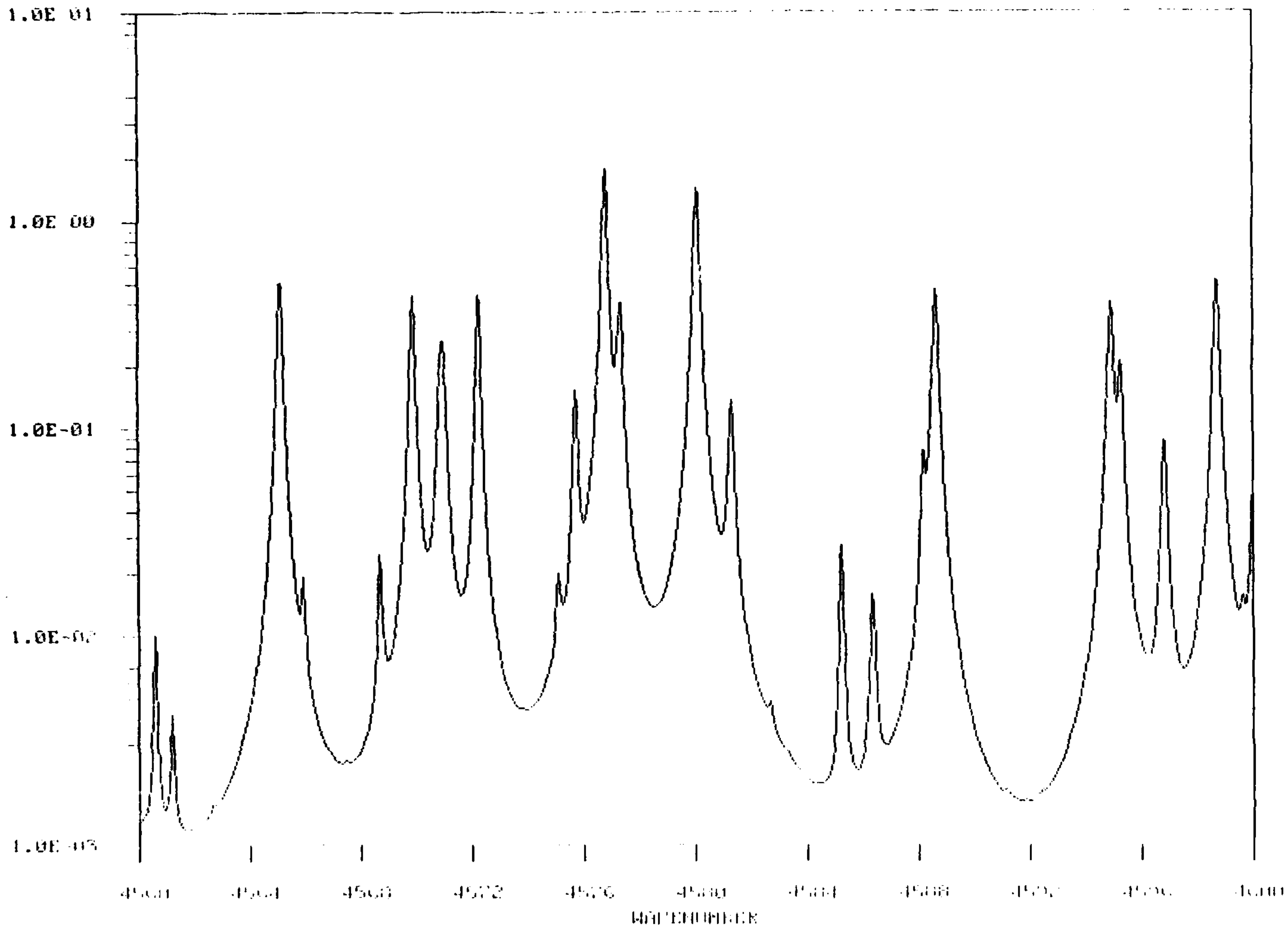

Fig. 67 — 4560-4600 cm^{-1} atmospheric absorption coefficient (km^{-1})

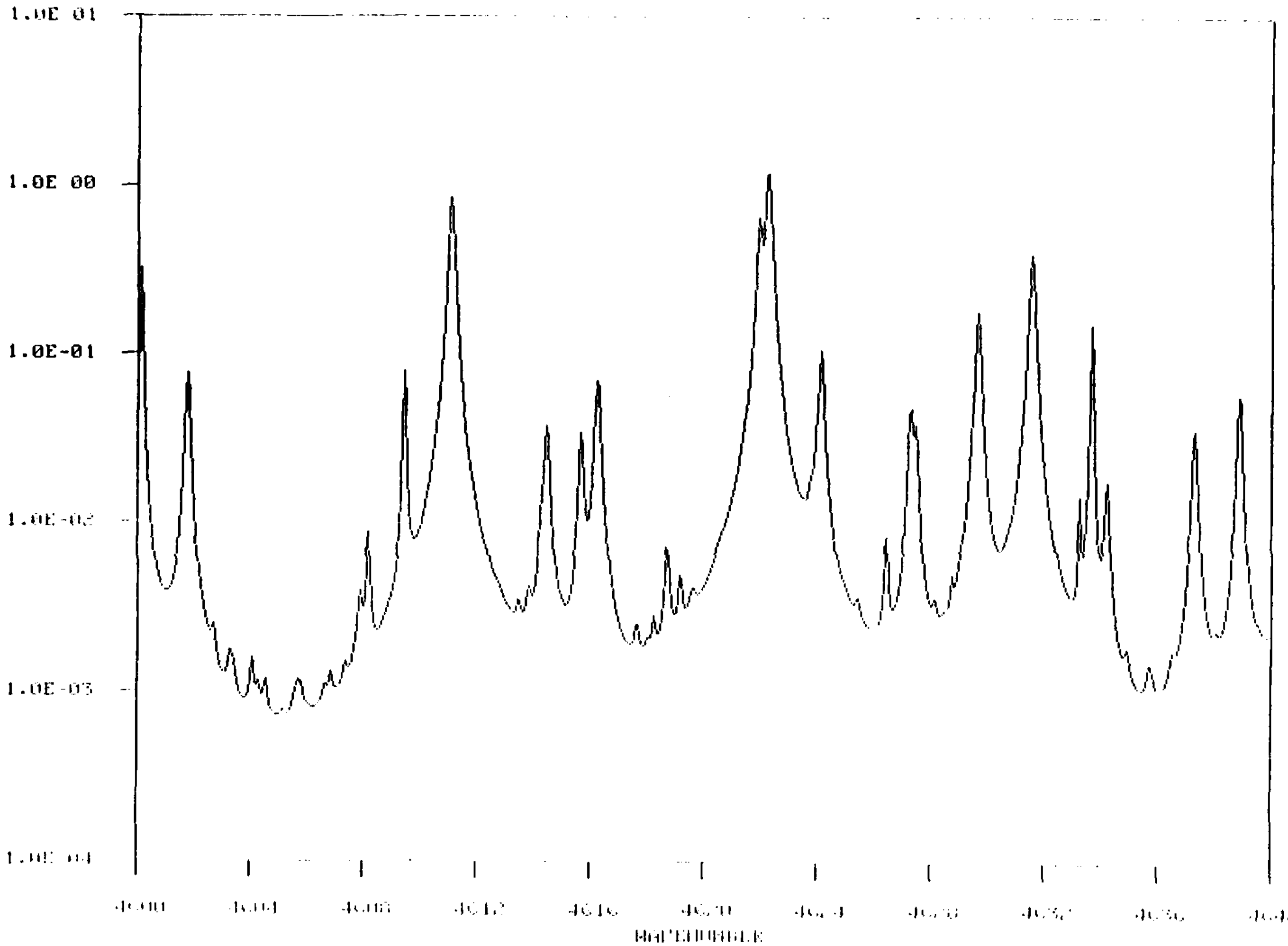

Fig. 68 — 4600-4640 cm^{-1} atmospheric absorption coefficient (km^{-1})

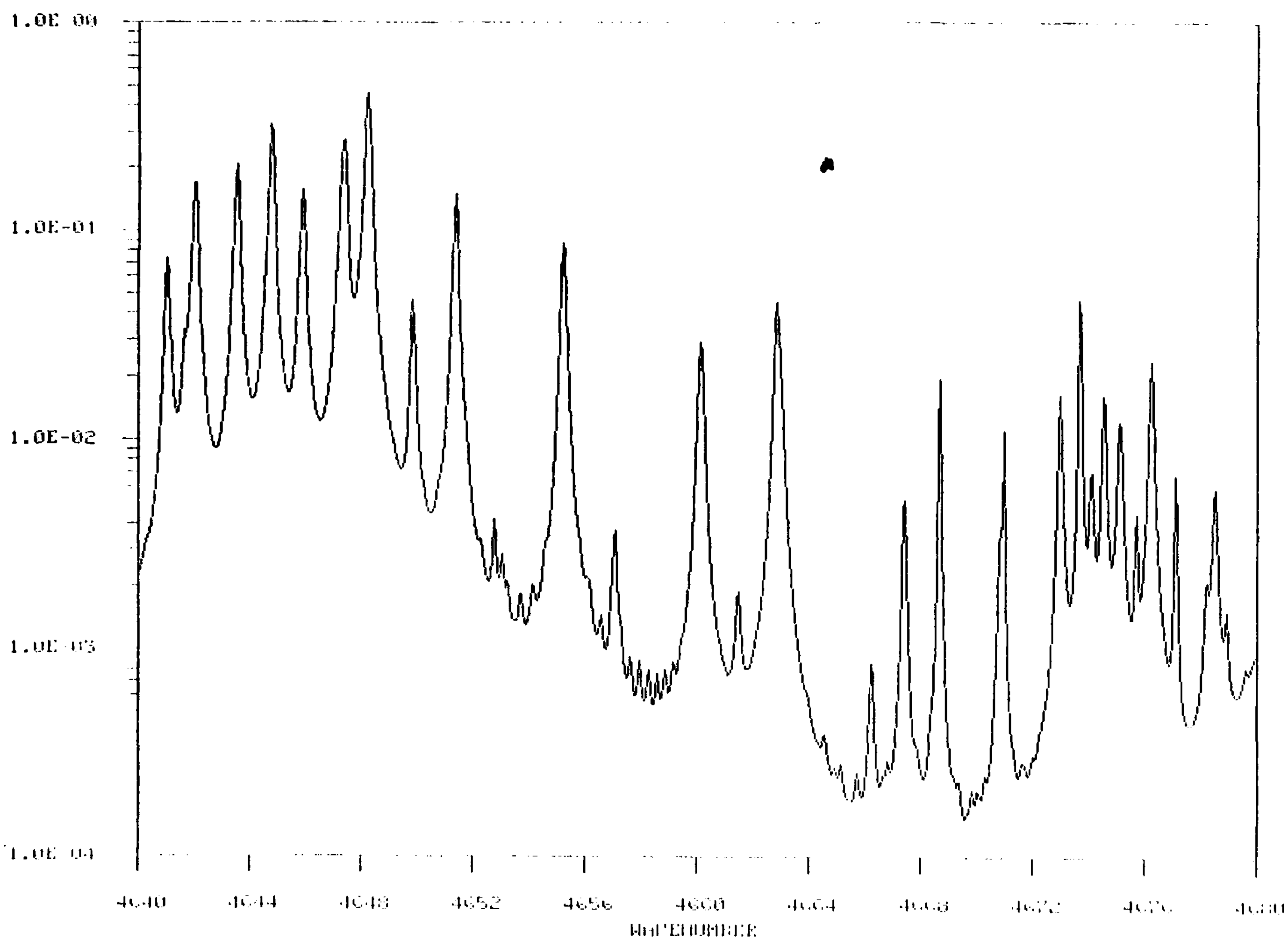

Fig. 69 — 4640-4680 cm^{-1} atmospheric absorption coefficient (km^{-1})

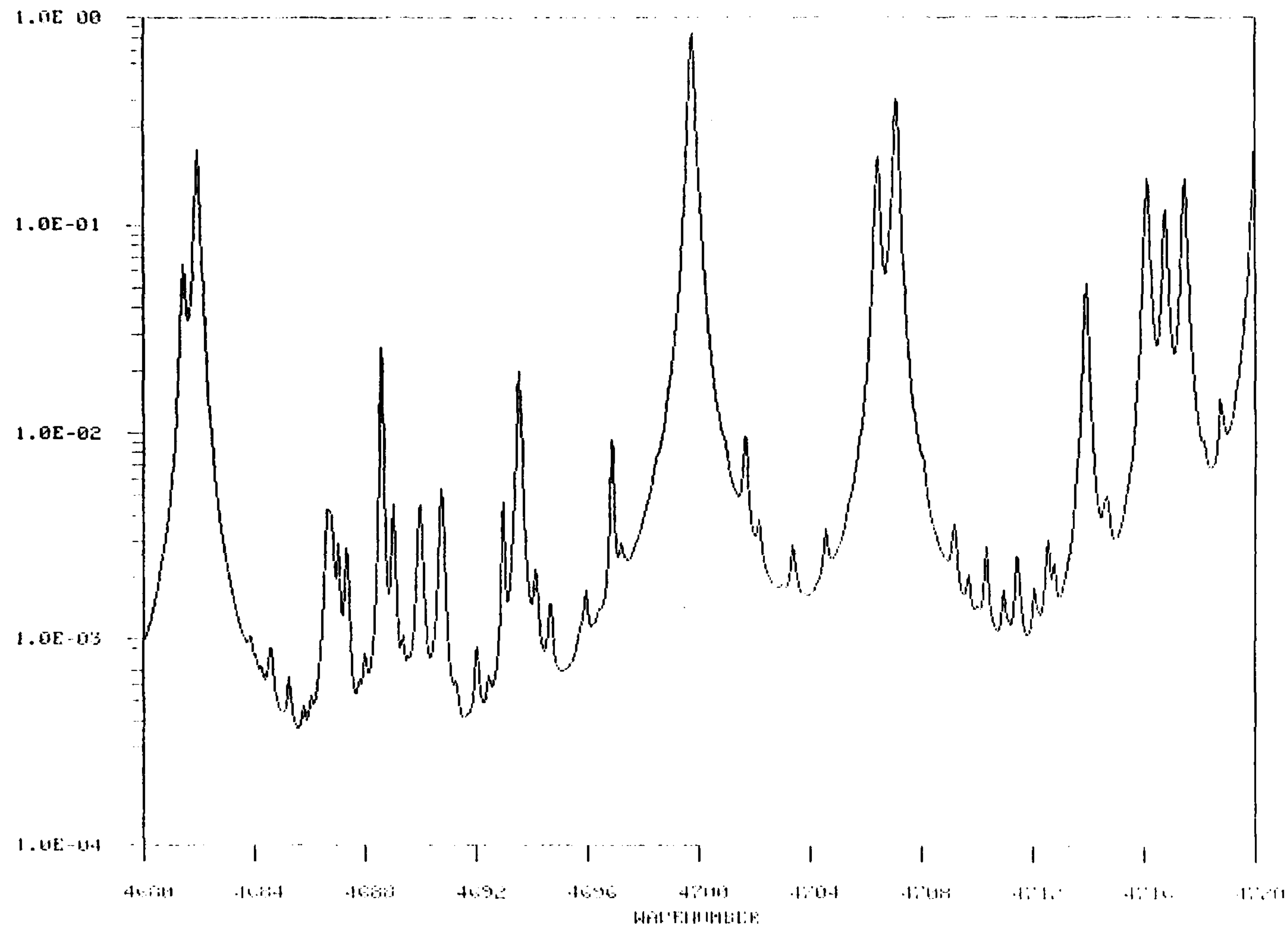

Fig. 70 — 4680-4720 cm^{-1} atmospheric absorption coefficient (km^{-1})

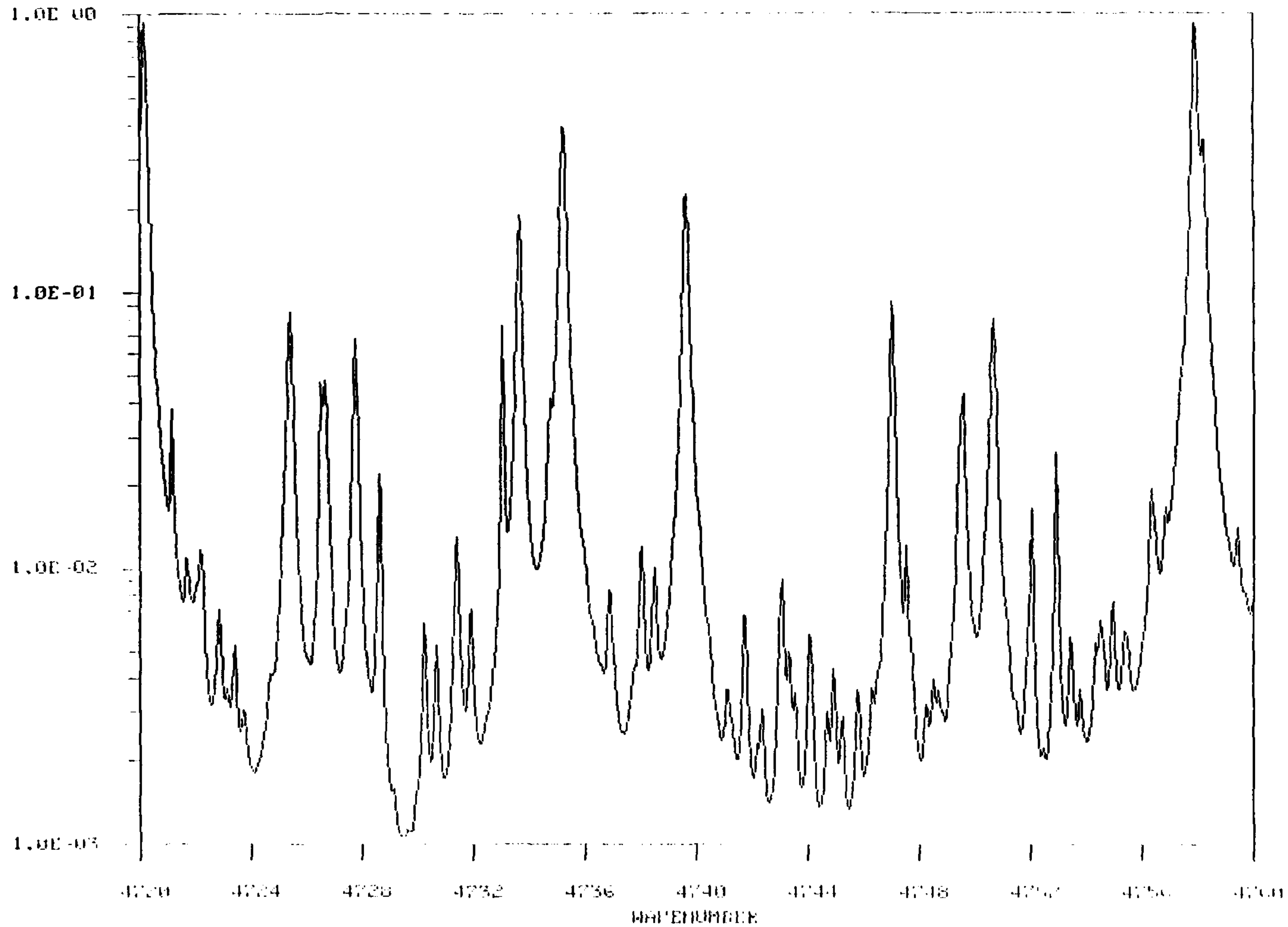

Fig. 71 — 4720-4760 cm^{-1} atmospheric absorption coefficient (km^{-1})

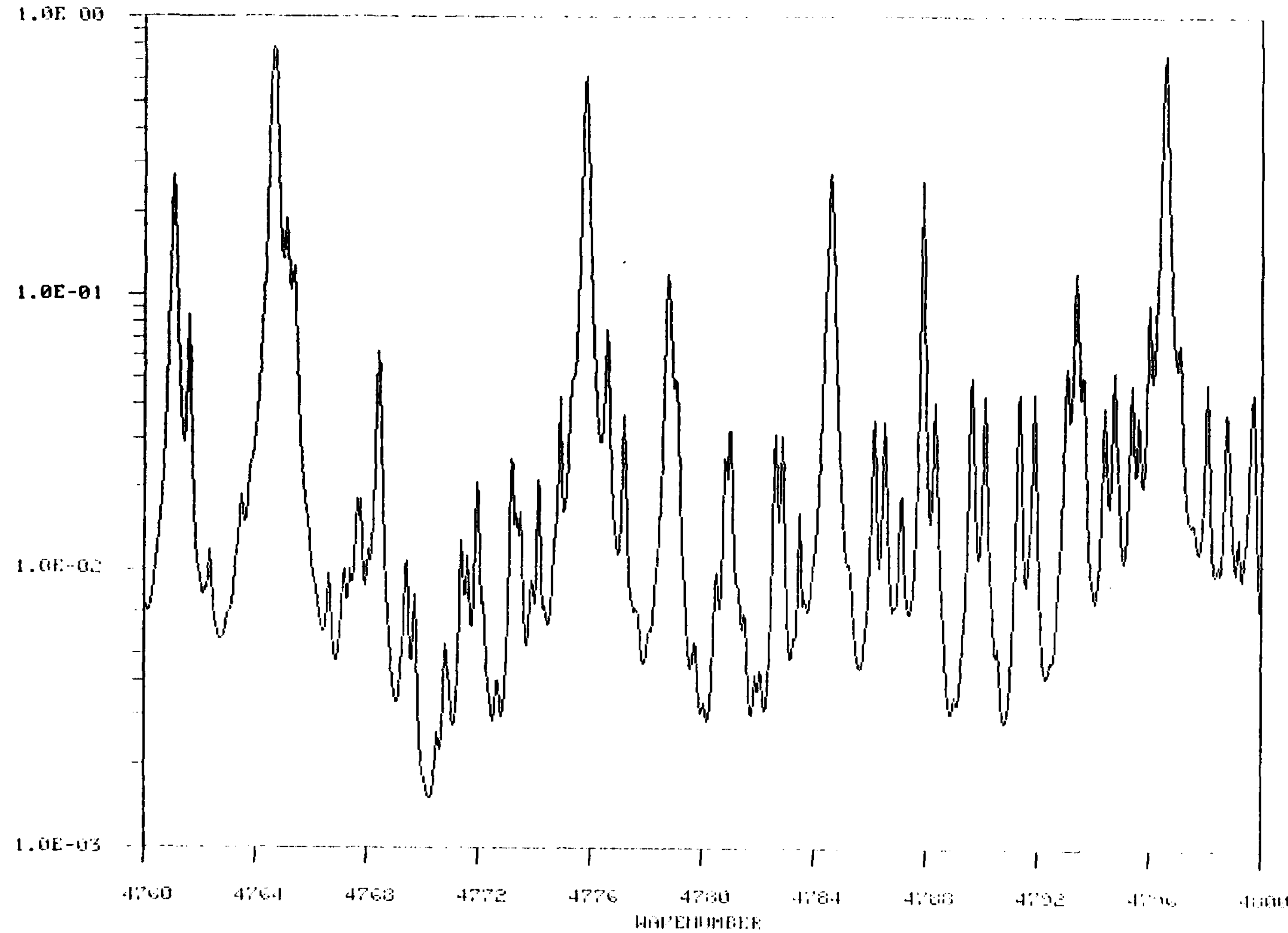

Fig. 72 — 4760-4800 cm^{-1} atmospheric absorption coefficient (km^{-1})

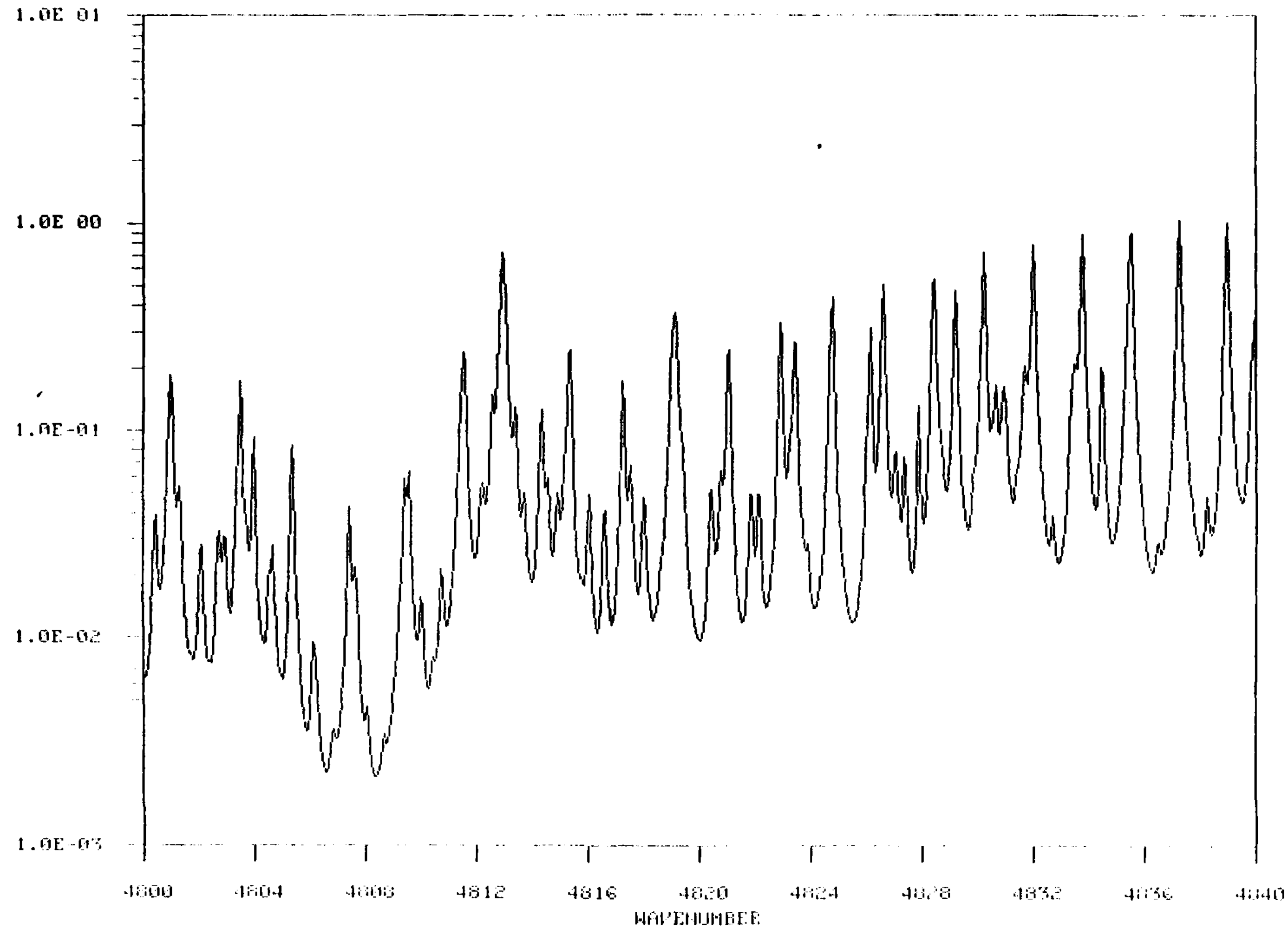

Fig. 73 — 4800-4840 cm^{-1} atmospheric absorption coefficient (km^{-1})

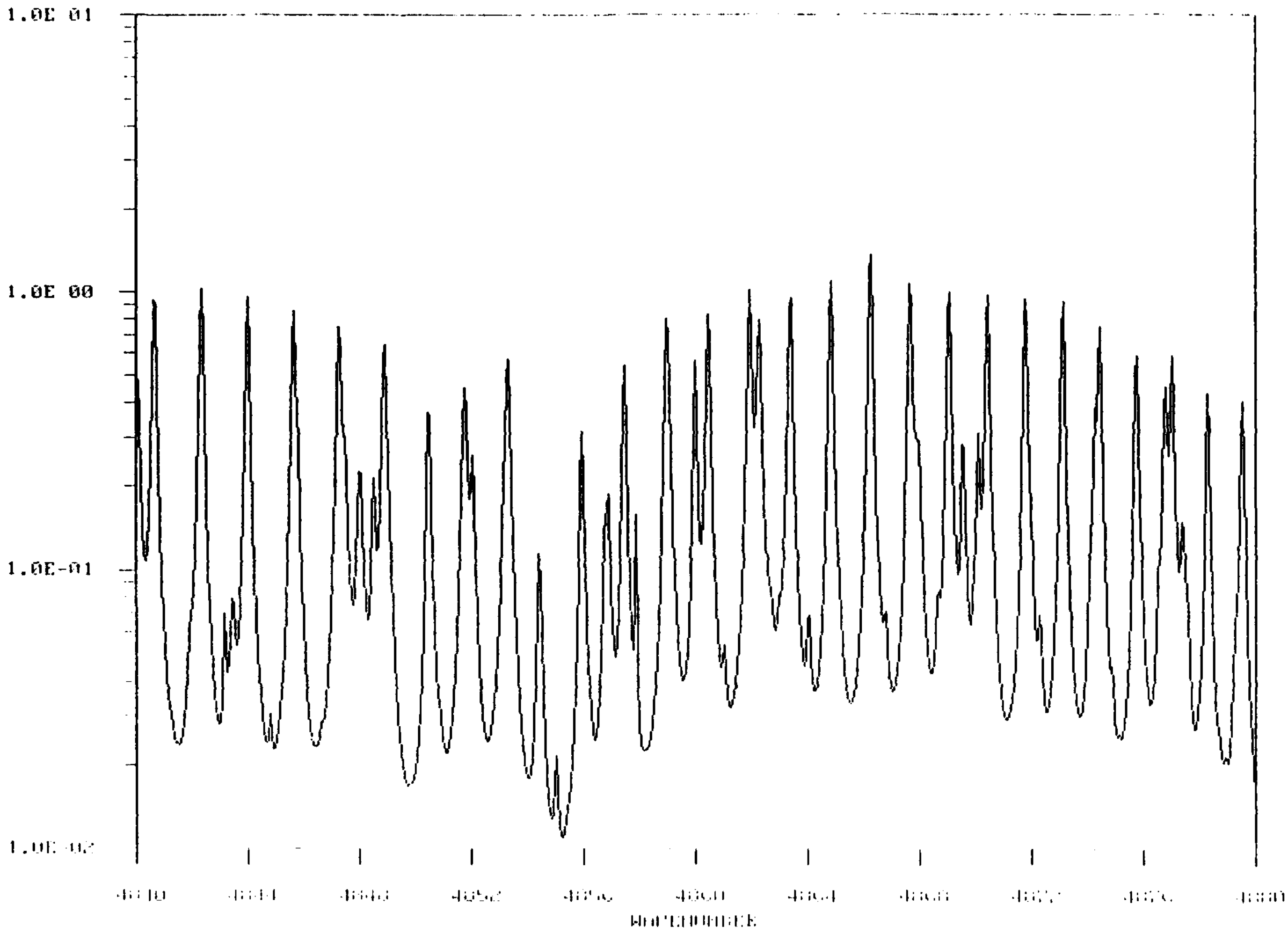

Fig. 74 — 4840-4880 cm^{-1} atmospheric absorption coefficient (km^{-1})

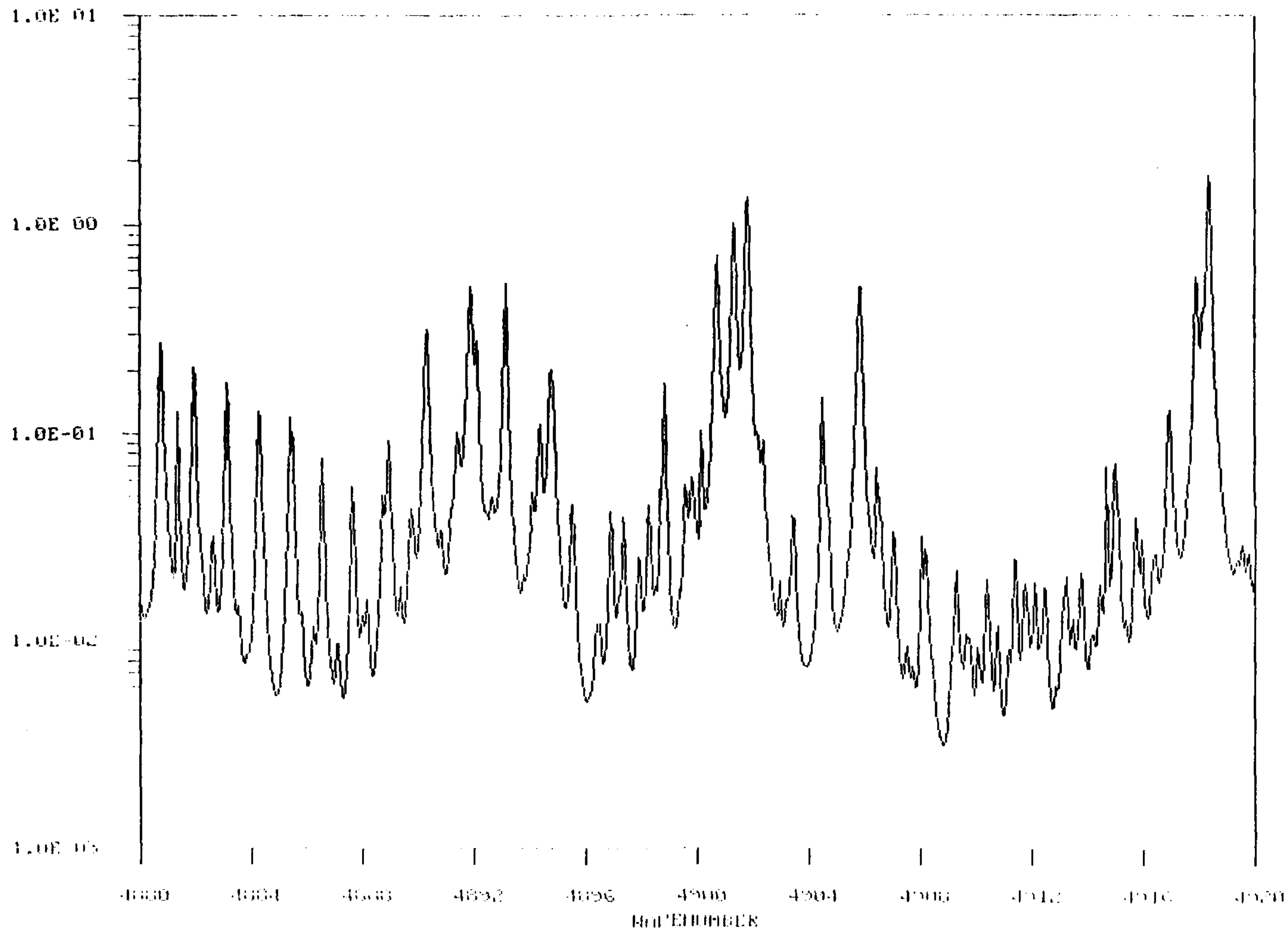

Fig. 75 — 4880-4920 cm^{-1} atmospheric absorption coefficient (km^{-1})

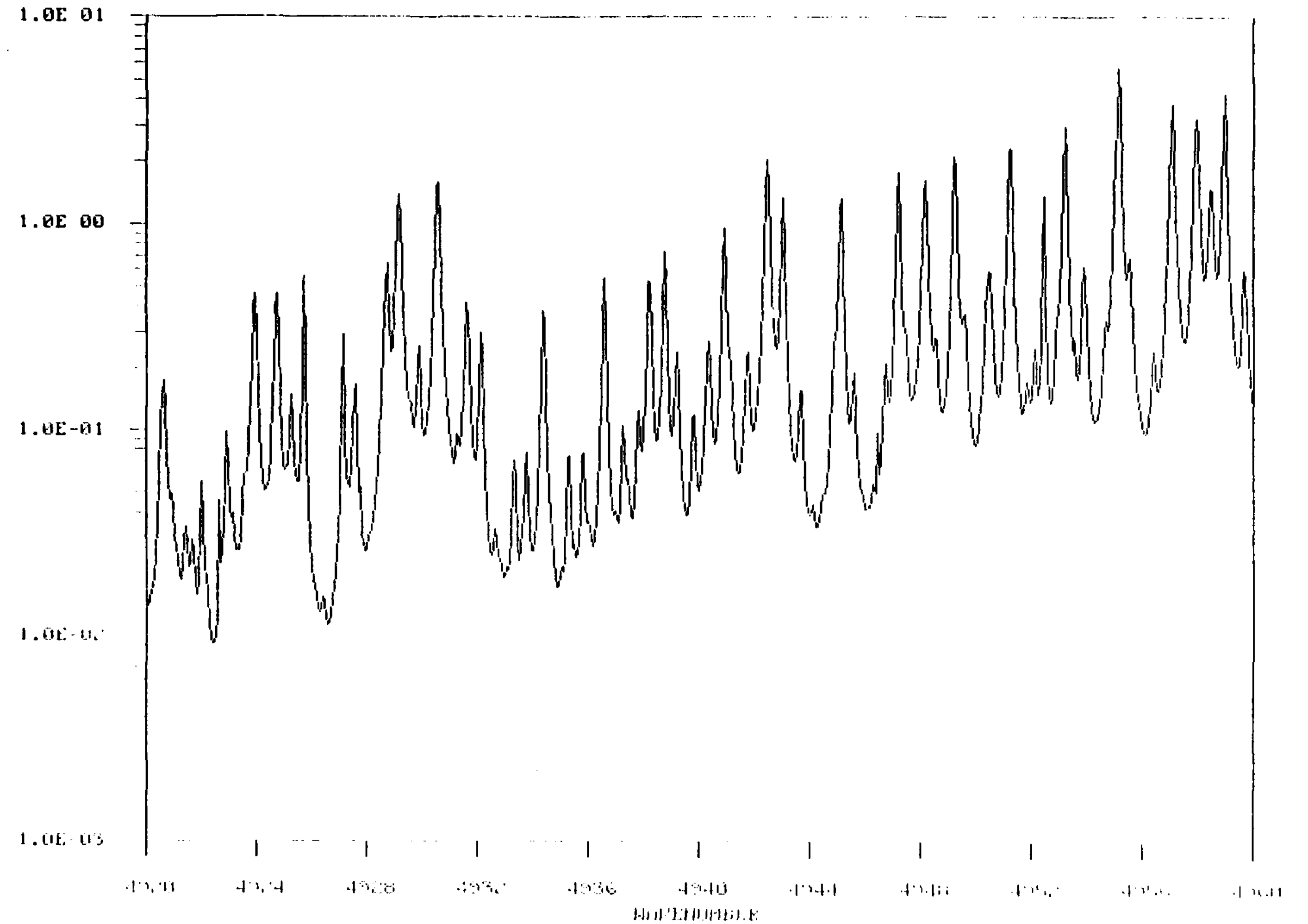

Fig. 76 — 4920-4960 cm^{-1} atmospheric absorption coefficient (km^{-1})

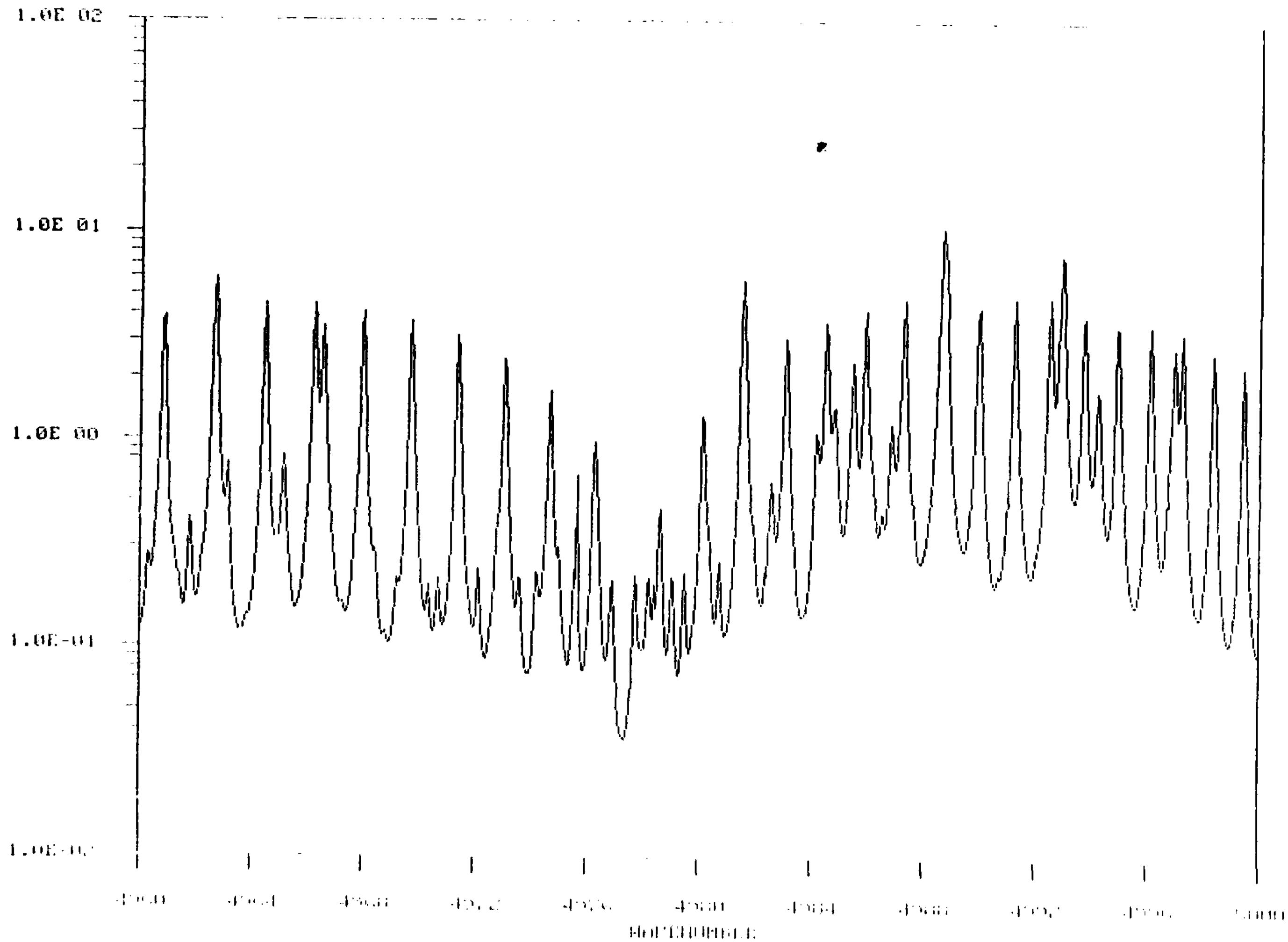

Fig. 77 — 4960-5000 cm^{-1} atmospheric absorption coefficient (km^{-1})

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