OZONE DECLINE AND ITS EFFECT ON NIGHT AIRGLOW INTENSITY OF OH (8,3) BAND

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Abstract. The paper presents the effect of O_3 depletion on OH (8,3) band. It is shown that Bates–Nicolet theory for the excitation of OH band is predominant excitation process. Calculations based on chemical kinetics show that the intensity of OH (8,3) band will also be effected due to the depletion of O_3 concentration. O_3 is depleted everywhere specially at Antarctica. Intensity of OH (8,3) band is calculated theoretically for Halley Bay (76° S, 27° W), British Antarctic survey station during the period 1973 to 1984.

1. Introduction

The self-luminescence of the upper atmosphere is called airglow. OH (8,3) band is one of the important emissions during day, night and twilight. It is shown that Bates-Nicolet mechanism for the excitation of OH is predominant than Breig mechanism. It is concluded that O_3 plays an important role for the emission of OH (8,3) band. Thus intensity of OH (8,3) band will also be affected with the depletion of O_3 concentration. Farman *et al.* (1985), Sahai *et al.* (1987) and other investigators throughout the world have already reported the depletion of O_3 layer at Antarctica. The volume emission rate of OH (8,3) band at Halley Bay is calculated for normal period and intensity of OH (8,3) band is calculated from the volume emission rate curve. Following this process, the intensity of OH (8,3) band for other years are also calculated. It is also mentioned in a previous article by Midya and Midya (1993) that OH band intensity should be affected with the depletion of O_3 concentration.

2. Results and Conclusion

The main excitation mechanism of OH emission are as follows:

(a) Bates–Nicolet Mechanism (1950)

$$O + O_2 + M \xrightarrow{K_1} O_3 + M$$

$$O_3 + H \xrightarrow{K_2} O_2 + OH^*$$

$$OH^* \longrightarrow OH + h\nu$$

(b) Breig Mechanism (1970)

$$H + M + O_2 \xrightarrow{K_3} HO_2 + M$$

TABLE I

Comparison of different reaction rates at temperatures 250° K

Number densities (cm^{-3}) at 90 km of					Volume emission rates of $n(OH^*)$ as given by (cm^{-3} sec^{-1})	
$n(O_3)$ $\times 10^{-7}$	$n(H)$ $\times 10^{-8}$	$n(O_2)$ $\times 10^{-13}$	$n(N_2)$ $\times 10^{-13}$	$n(O)$ $\times 10^{-11}$	Bates–Nicolet mechanism	Breig mechanism
11	2.3	1.48	5.57	2.45	6×10^5	8.9×10^4

TABLE II

Volume emission rates of OH (8,3) band at different heights for normal period

Altitude (km)	Number density		Volume emission rates (cm^{-3} sec^{-1})		Intensities	
	$n(O_3)$ $\times 10^{-8}$	$n(H)$ $\times 10^{-8}$	^{Q}OH $\times 10^{-4}$	^{Q}OH (8,3) $\times 10^{-3}$	I_{OH} (MR)	$I_{OH(8,3)}$ (MR)
75	3.2	0.51	38.7	11.46		
76	2.8	2.1	130	38.48		
77	2.5	3.7	210	62.20		
78	2.1	5.4	260	76.90		
79	1.8	7.0	300	90		
80	1.4	8.6	285	80		
81	1.3	8.3	260	76	15	0.4
82	1.2	7.9	220	65		
83	1.16	7.6	200	59.2		
84	1.08	7.2	180	53		
85	1	6.9	160	47		
86	1.02	5.9	142	42		
87	1.04	5.1	126	37		
88	1.06	4.1	103	30.48		
89	1.08	3.2	82	24.29		
90	1.1	2.3	60	17.76		

$^{Q}OH\ (8,3) = A_{8,3}\ {}^{Q}OH$

$A_{8,3}$ = Einstein transition probability = 0.0296 sec^{-1} (Takahashi *et al.*, 1981).

$$HO_2 + O \xrightarrow{K_4} OH^* + O_2$$

$$OH^* \rightarrow OH + h\nu$$

TABLE III

Calculated OH (8,3) night airglow intensity during the period 1973 to 1984 for Halley Bay (76° S, 27° W)

Year	$n(O_3)$ in D.U.	% of O_3 depletion from mean	Concentration of O_3 at peak emission height (79 km) $\times 10^{-8}$	Peak volume emission rate	Calculated intensity of OH (8,3) band (MR)
1973	290	14.85	2.07	0.103	0.52
1974	300	18.81	2.14	0.107	0.54
1975	310	22.77	2.21	0.111	0.56
1976	280	10.89	1.99	0.099	0,49
1977	255	0.99	1.82	0.091	0.46
1978	280	10.89	1.99	0.099	0.49
1979	260	2.97	1.85	0.093	0.46
1980	245	−2.97	1.75	0.086	0.43
1981	230	−8.91	1.64	0.082	0.41
1982	205	−18.81	1.46	0.073	0.37
1983	190	−24.75	1.35	0.068	0.34
1984	185	−26.73	1.32	0.066	0.33

$K_1 = 1.5 \times 10^{-34} \exp(445/T)$ $\mathrm{Cm^6\,s^{-1}}$ (Stuhl and Niki, 1971).

$K_2 = 1.5 \times 10^{-12}\sqrt{T}$ $\mathrm{Cm^3\,s^{-1}}$ (Nicolet, 1970).

$K_3 = 3.3 \times 10^{-33} \exp(800/T)$ $\mathrm{Cm^6\,s^{-1}}$ (Gattinger, 1971).

$K_4 = 1.5 \times 10^{-12}\sqrt{T}$ $\mathrm{Cm^3\,s^{-1}}$ (Gattinger, 1971).

Neglecting the quenching terms, the rate of production of n(OH)* according to Bates–Nicolet theory

$$n(OH)^* = K_2 n(O_3)\, n(H) \qquad (1)$$

Again according to Breig theory

$$n(HO_2) = K_3 n(H) n(M) n(O_2)$$

$$\therefore n(OH^*) = K_4 n(HO_2) n(O)$$

$$= K_3 K_4 n(H) n(O_2) n(M) n(O) \qquad (2)$$

The volume emission rate of $n(OH^*)$ is calculated and the results are given in Table I. The concentration of $n(O)$, $n(O_2)$ and $n(N_2)$ are taken from Jacchia (1977), $n(O_3)$ and $n(H)$ are taken from Krassovsky (1971).

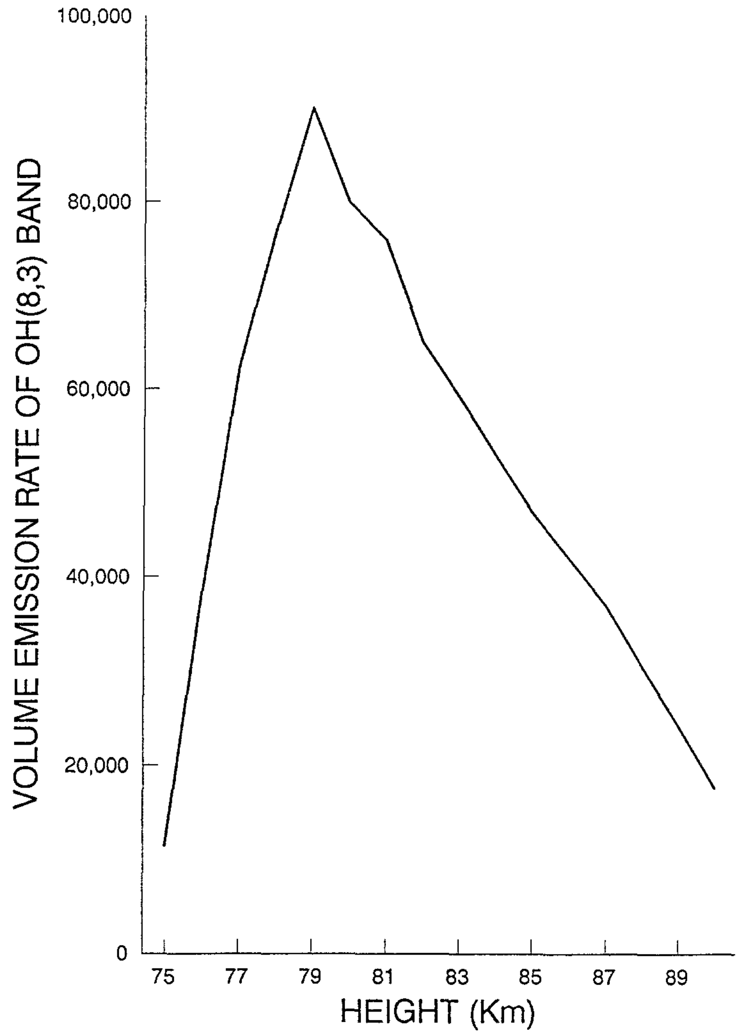

Fig. 1. Volume emission rate of OH (8,3) band at night for normal period.

From Table I it is clear that the volume emission rate as given by Bates–Nicolet mechanism is greater than Breig mechanism. Thus one can conclude that O_3 plays an important role for the emission of OH (8,3) band and OH (8,3) band will also be depleted with the depletion of O_3 concentration. Farman *et al.* (1985), Sahai *et al.* (1987) and other investigators reported depletion of O_3 concentration at Antarctica. Farman *et al.* (1985) observed dramatic decrease of O_3 concentration at Halley Bay specially for the month of October during 1973 to 1984. In this paper the intensity variation of OH (8,3) band during the above mentioned period for the station Halley Bay is presented. Concentration of O_3 for the station Halley Bay is used to calculate OH (8,3) band emission.

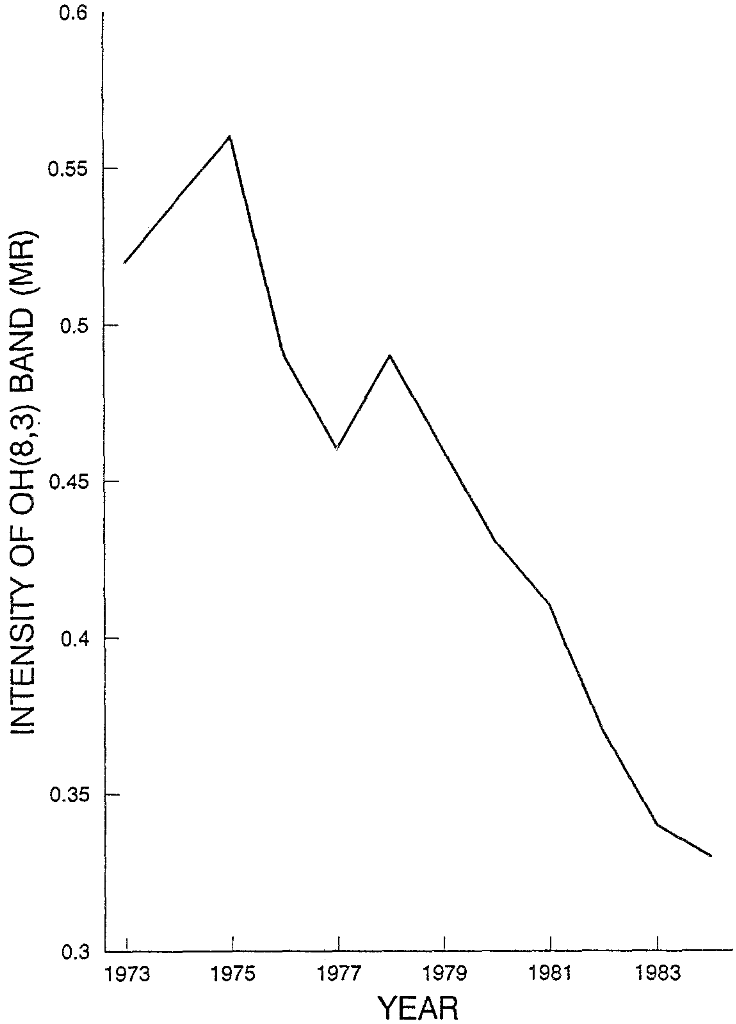

Fig. 2. Variation of OH (8,3) band intensity calculated theoretically for the station Halley Bay during the period 1973 to 1984.

The volume emission rate of OH (8,3) band is calculated (Table II) from the expression of n(OH*) as given by Bates–Nicolet mechanism (Equation (1)) for normal period. The variation is shown in Figure 1. The intensity is calculated from the volume emission rate curve by the following formula

$$I = \frac{1}{2} \times \text{peak emission rate} \times \text{layer thickness}.$$

The intensity of OH (8,3) band is calculated for normal period and it is 0.4 MR which fairly agrees with the accepted value. Following this process, the intensity OH (8,3) band for different years are calculated theoretically for the station Halley Bay (Table III) and the variation is shown in Figure 2

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References

Bates, D. R. and Nicolet, M.: 1950, *J. Geophys.* **55**, 301.
Breig, E. L.: 1970, *Plant Space Sci.* (GB) **18**, 1271.
Farman, J. C., Gardener, B. C., and Shanklin, J. D.: 1985, *Nature* **315**, 207.
Gattinger, R. L.: 1971, 'The Radiating Atmosphere', B. M. McCormac (ed.), D. Reidel Pub. Co., Dordrecht, p. 51.
Jacchia, L. G.: 1977, SAO Special Report No. 375, Smithsonian Institution Astrophysical Observatory, Cambridge, Massachusetts.
Midya, S. K. and Midya, D.: 1993, *Earth, Moon and Planets* **61**, 175.
Nicolet, M.: 1970, *Ann. Geophys* **26**, 531.
Sahai, Y., Kane, R. P., and Teixeira, N. R.: 1987, *Revista Brasileira de Geofisica* **5**, 49.
Stuhl, F. and Niki, H. J.: 1971, *Chem. Phys.* **55**, 3943.
Takahashi, H., Sahai, Y., Clemesha, B. R., Simonich, D. M., Batista, P. P., and Teixeira, N. R.: 1981, *Revista Brasileira de Fisica* **11**, 727.
Krassovsky, V. I.: 1971, *Ann Geophys.* **27**, 211.