Altitude Profiles of Infrared Radiance of O3 (9.6 μm) and CO2 (15 μm)

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ALTITUDE PROFILES OF INFRARED RADIANCE OF O_3(9.6 μm) AND CO_2(15 μm)

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Abstract. *The infrared spectrum of the upper atmospheric emissions between 7 and 23 μm has been measured with two spectrometers carried to high altitude by sounding rockets. Radiance profiles of O_3(9.6 μm) and CO_2(15 μm) radiations have been obtained to nearly 100 and 150 km, respectively.*

The emission spectrum of the upper atmospheric infrared emissions between 7 and 23 μm has been observed in the mesosphere and lower thermosphere by means of infrared spectrometers carried on sounding rockets. Two measurements were made in the auroral zone at the University of Alaska's Poker Flat Research Facility (65° N lat.) using Black Brant rockets. The first rocket (18.006-2) was launched at 0213 Alaska Standard Time (AST) (GMT-10 hrs) on 22 March 1973 and reached an apogee of 185 km. The second (18.006-4) was launched at 2007 ADT (GMT-9 hrs) on 13 February 1974 and reached 199 km. The dominant emission features observed on both flights, briefly reported herein, were observed at 9.6 and 15 μm, as expected.

The spectrometer has been described in detail elsewhere [*Wyatt*, 1971, 1974] and so only a brief summary of its salient features will be included here. The spectrometer used on each flight had a field of view of 9.6 x 10^{-4} sr which was held within 3° of the local vertical at altitudes above 65 km by an active attitude control system aboard the rocket payload which was separated from the rocket motor after burnout. The resolution of the spectrometer, which employed an Optical Coating Laboratory, Inc., circular-variable interference filter (CVF), ranged between 3 and 4 percent over the 6.75 to 23.2-μm free spectral range of the instrument. The noise equivalent spectral radiance (NESR) of the spectrometer at its wavelength of peak response (22 μm) was 1 x 10^{-11} watt $cm^{-2}sr^{-1}μm^{-1}$ (14 kilorayleighs/μm). The detector used was arsenic doped silicon operated at liquid helium temperature. The entire optical system of the spectrometer was cryogenically cooled, and its cover was not opened until nearly 90 km on ascent. Since the rocket payload was "backing down" on descent, measurements were possible down to 40 km on the first flight and about 65 km on the second flight. The scanning rate of the spectrometer was 2 scans/sec.

Zenith spectra at several altitudes obtained during rocket descent of the first flight are given in Figure 1. Salient upper atmospheric emission features are observed at 9.6 and 15 μm. The spectra are not corrected for the spectral response function of the instrument; however, the absolute spectral radiances at 9.6 and 15 μm are given on the left and right abscissa scales, respectively.

The emission at 9.6 μm is attributed to thermal and resonance emission from the ν_3 fundamental rotation-vibration band (1043 cm^{-1}) of gaseous ozone in its ground electronic state ($^1\Sigma$). The zenith peak spectral radiance of the 9.6-μm emission band observed as a function of altitude from the descent portion of the flights is shown in Figure 2. The overhead radiance value below 40 km logarithmically projects to the value previously observed by *Murcray et al.* [1972] from a balloon launched at nearby Ft. Wainwright. Since the ozone 9.6-μm radiation is optically thick, a detailed radiative transport computation must be accomplished in order to derive a volume emission rate profile. How-

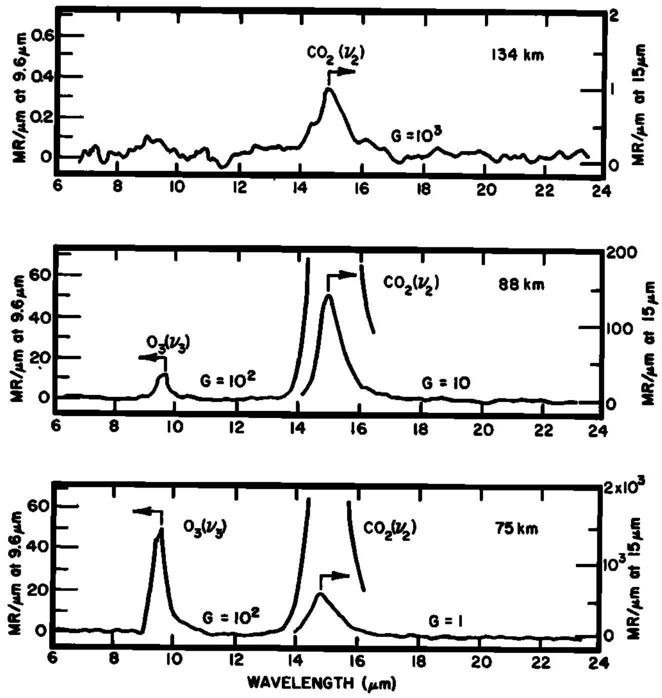

Figure 1. Zenith peak spectral radiance observed from rocket launched at Poker Flat, Alaska, on 22 March 1973 at 0213 hrs AST. The spectrometer resolving power was 30 and the relative gain G of the instrument scans are shown.

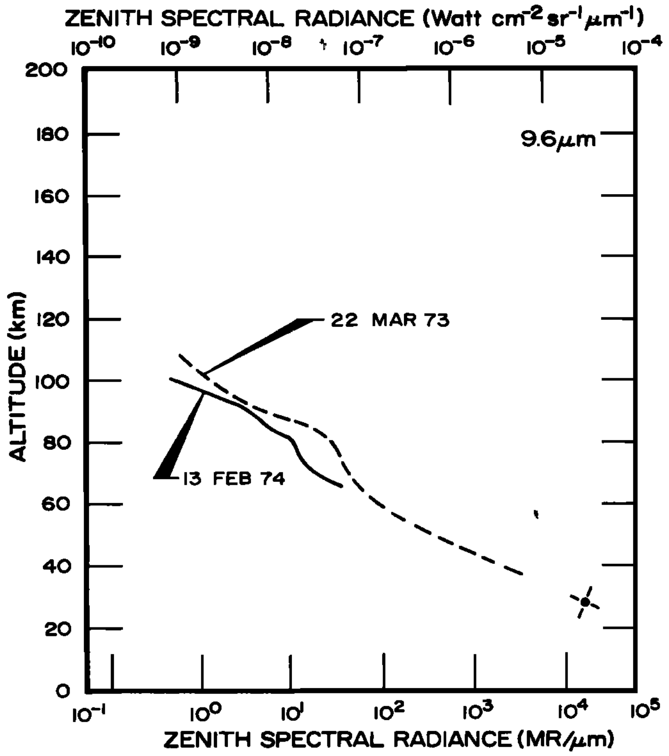

Figure 2. Zenith peak spectral radiance at 9.6 μm measured from rockets launched at Poker Flat, Alaska, on (a) 22 March 1973 at 0213 hrs AST and (b) 13 February 1974 at 2007 hrs ADT. (The cross gives the value from the *Murcray et al.* [1972] balloon measurement of 15 September 1971.)

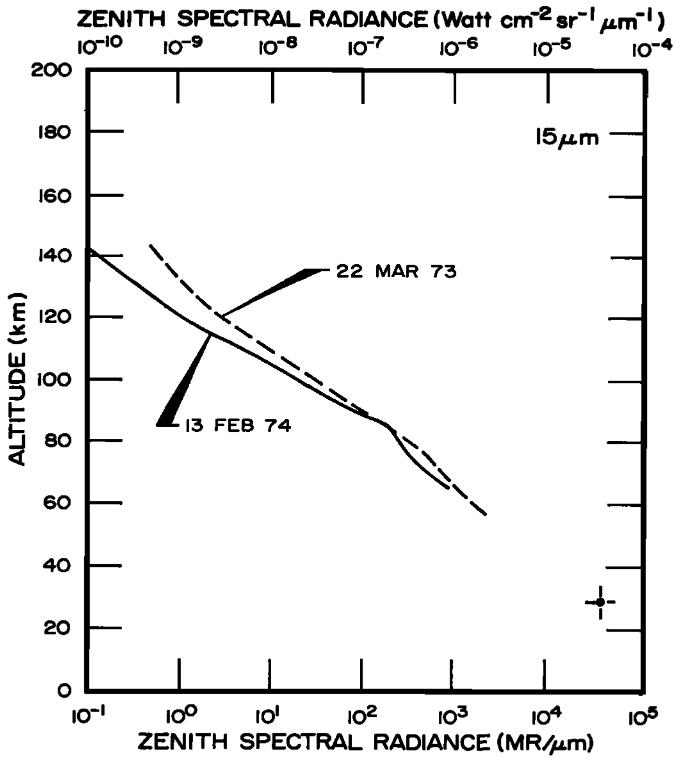

Figure 3. Zenith peak spectral radiance at 15 μm measured from rockets launched at Poker Flat, Alaska, on (a) 22 March 1973 at 0213 hrs AST and (b) 13 February 1974 at 2007 hrs ADT. (The cross gives the value from the *Murcray et al.* [1972] balloon measurement of 15 September 1971.)

ever, the slope of the radiance profile indicates the existence of a secondary ozone layer at about 86 km, well above the main ozone layer which would be below the lowest altitude of measurement (40 km). Apparently, this observation is the first reported wherein this upper ozone layer has been seen in infrared emission. It has previously been observed by solar ultraviolet absorption [*Miller* and *Ryder* , 1973].

The emission at 15 μm, which persists to an altitude of about 150 km, is thermal emission from the ν_2 infrared fundamental bands of carbon dioxide (667.3 cm^{-1}) in the ground electronic state ($^1\Sigma_g^+$). The zenith peak spectral radiance altitude profiles of the 15-μm band observed on each flight are shown in Figure 3. A computation of volume emission rate profiles requires a detailed radiative transfer analysis since CO_2 is optically thick at the lower altitudes. Analyses of this and the other infrared emission features observed in these experiments are being made by us and our co-workers and will be reported at a future date. Also being studied is the possible association of the observed emissions with auroral activity.

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