SEASONAL OBSERVATIONS OF MARS

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ABSTRACT

IUE has detected the Hartley bands of ozone in the spectrum of Mars. Seasonal observations show a variation in the north consistent with the measurements of Mariner 9. New observations during Martian late fall in the south were made.

INTRODUCTION

Ozone was discovered on Mars by the ultraviolet spectrometer on board the Mariner 7 spacecraft (Barth and Hord, 1971), and was subsequently measured extensively from the Mariner 9 orbiter (Barth et al., 1973; Lane et al., 1973; Barth and Dick, 1974; Wehrbein, 1979). Those measurements demonstrated variations in both its vertical and global distribution. The total ozone amount was found to be a maximum during winter over the north pole but slowly decreased throughout the spring. In the south it was absent during the Martian midsummer season but appeared again in late summer. Daily variations were also observed and were occasionally associated with the presence of clouds. The general conclusion of these observations was that ozone is present when the Mars atmosphere is cold and dry. The photochemical theory of ozone, which considers the role of water vapor, supports this conclusion.

The Mariner measurements were restricted to northern winter-spring, and southern summer. In this report we describe a technique of using the IUE satellite to observe ozone on Mars, and present the results of a preliminary analysis on some of the data acquired.

TECHNIQUE

Ozone is detected by observing its absorption of sunlight in the wavelength region from 2100 to 2800 Å where the Hartley bands have a peak cross section of $1 \times 10^{-17} cm^2$. Because of its restricted global distribution on Mars, a successful detection with IUE depends on the ability to restrict the instrument's field of view to that region of the planet where ozone is present. As shown in Figure 1, the angular diameter of the planet as seen from earth has varied between 5 and 13.8 arc sec since April of 1979. The optimum observing time is at opposition when the 3 arc sec small aperture includes only about 5% of the bright disk. Ideally the small aperture would be placed over the winter pole where Mariner found ozone to be most abundant. However Figure 1 shows that the aspect of Mars also varies considerably, with the sub-Earth point moving between $\pm 25^{\circ}$ latitude. During the February opposition the northern hemisphere faced the Earth and provided the opportunity to observe the northern mid to late spring. Under these same conditions Mariner observed between 5 and 10 μ-atm. of ozone (1μ-atm. = 2.68 x 10^{-15} molecules cm^{-3}).

The drift rate of Mars with respect to the stars and its position were calculated in spacecraft-centered coordinates. Even though Mars had a maximum magnitude of -0.3 it was possible to track using the center-of-light lock after placing the planet in the large aperture. The pattern of scattered light in the Fine-Error-Sensor (FES) image was monitored to verify the tracking. During an observing session a pattern of five exposures were made as shown in Figure 2. Displacements were made in ecliptic coordinates by first slewing the spacecraft 4.5 arc sec in the desired direction from the center-of-light point and then moving directly to the small aperture. The orientation of Mars shown in Figure 2 is for March 15, 1980. In January, before the opposition, the terminator was to the west of the planet and its north pole was 10 deg closer to ecliptic north. Between January and April the phase angle varied between -30 and +30 deg.

Observations were made on September 25, 1979 and on January 23, March 15, and April 8, 1980 with exposure times varying from 9 to 75 sec. These exposures were made with the long wavelength camera in low resolution using both the large and small apertures. For the observations with the small aperture a 10 sec exposure gave good signal without saturation.

OBSERVATIONS

From the set of observations made in the pattern shown in Figure 2, the relative reflectance of the various regions of Mars was calculated as follows. The center-of-light observation from each session was taken to represent the equatorial region and was used as the standard spectrum. Each of the other four observations were divided by this spectrum and the ratio was normalized to unity in the 3000 Å region. The extracted net spectra computed by the IUE data processing operation were used.

Figures 3 and 4 show the relative reflectance spectra for the wavelength region from 2400 to 3000 Å. In each figure the ratio for the northern region is on the right and that for the southern region is on the left. The data were smoothed by an 11-point running average before the ratio was calculated. In all of the southern ratios and in the northern ratio for January, the smooth curve plotted over the data is the absorption spectrum of ozone normalized to the data.

On the basis of this analysis, we conclude that these observations have detected ozone in the Mars atmosphere. The observations of the northern region in January and March occurred when the Martian seasons were mid and late spring respectively. They show a positive detection in midspring and the absence of ozone in late spring. This is the same behavior observed by Mariner 9 over the north pole. The observations of the southern region are for Martian mid to late fall. These IUE observations contain new information since Mariner 9 did not observe the south during those seasons.

REFERENCES

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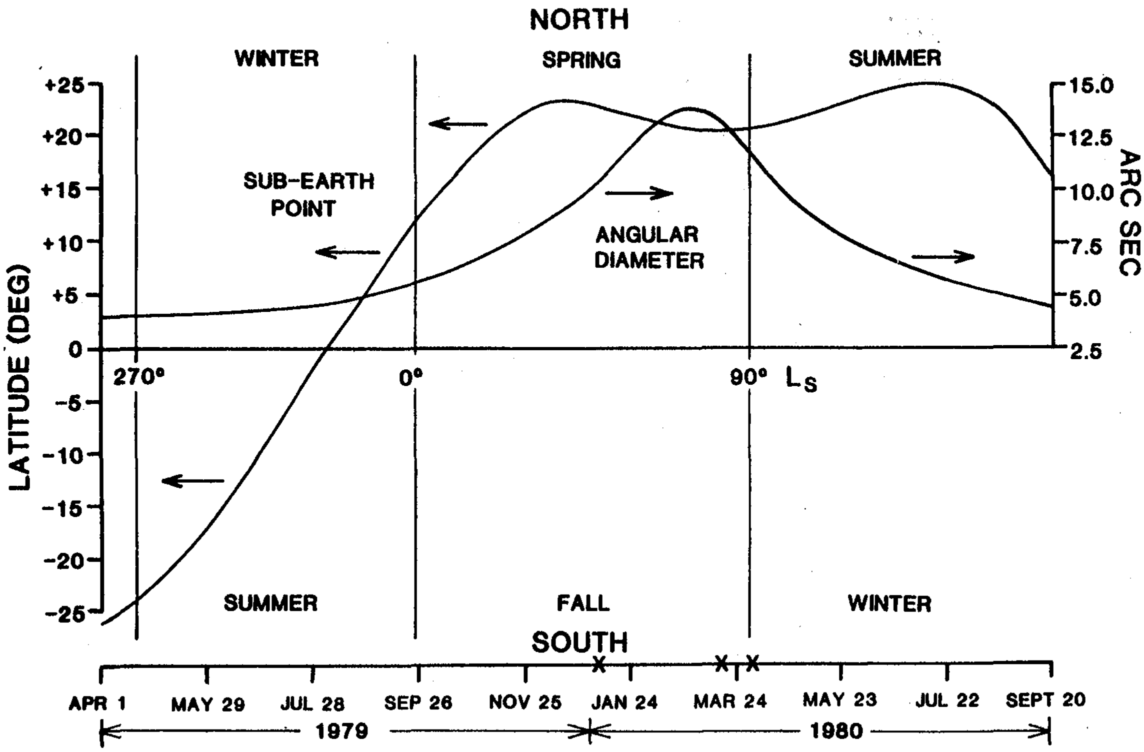
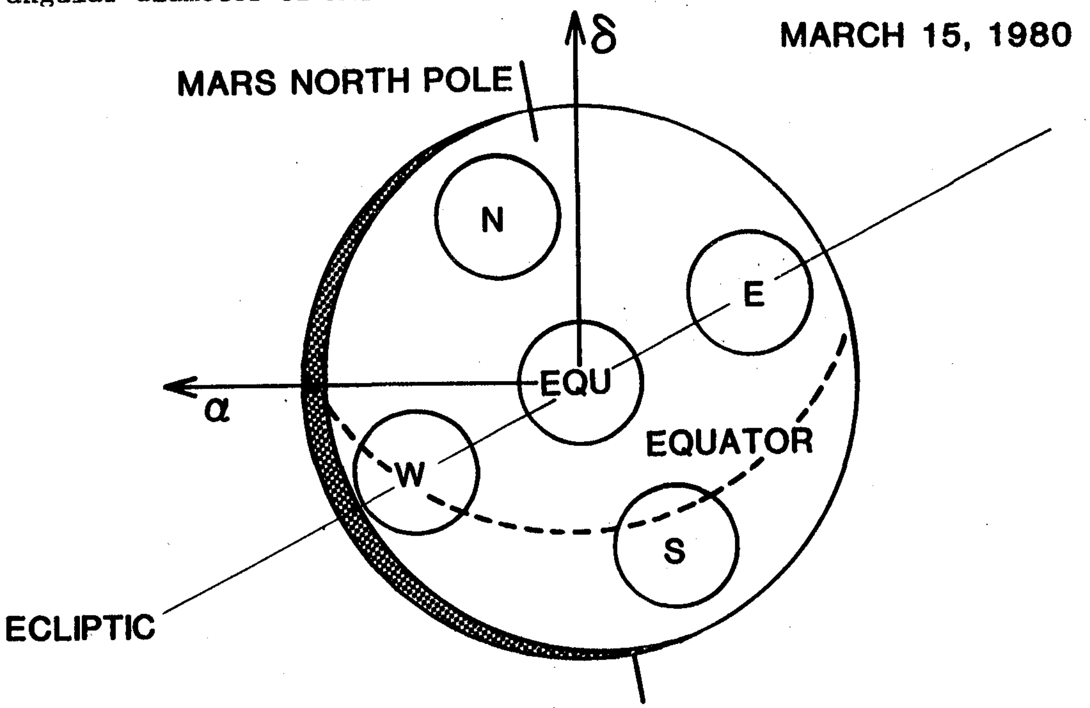
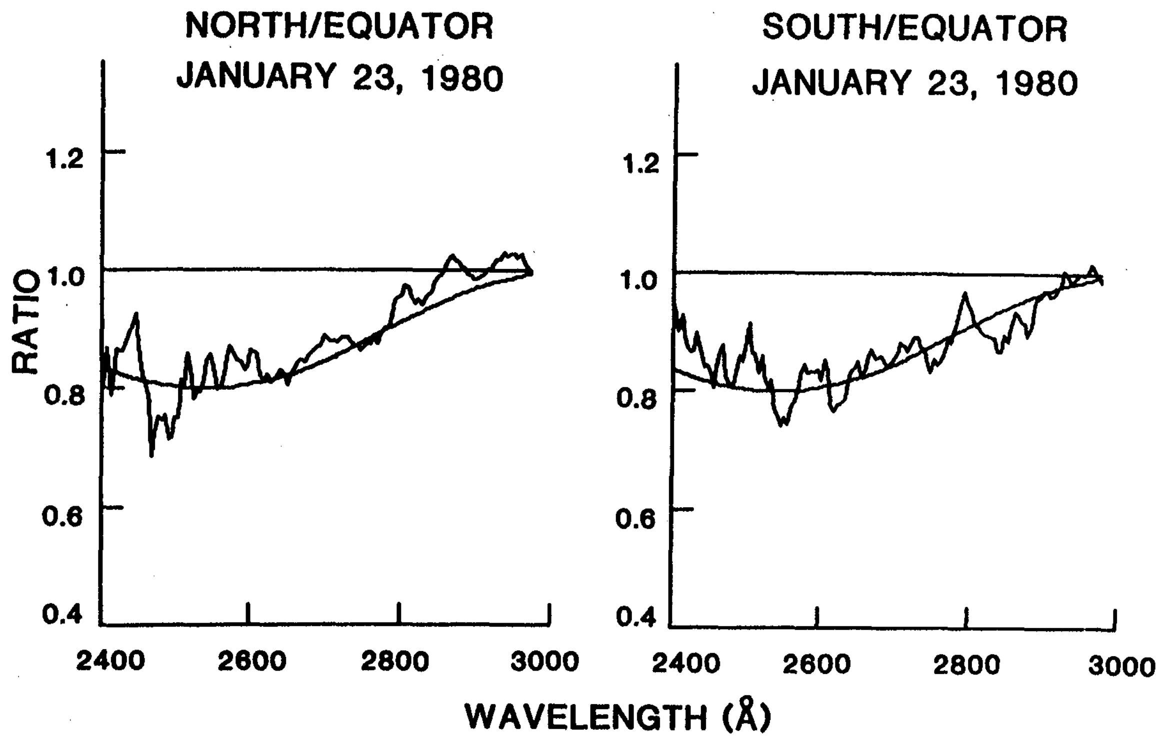


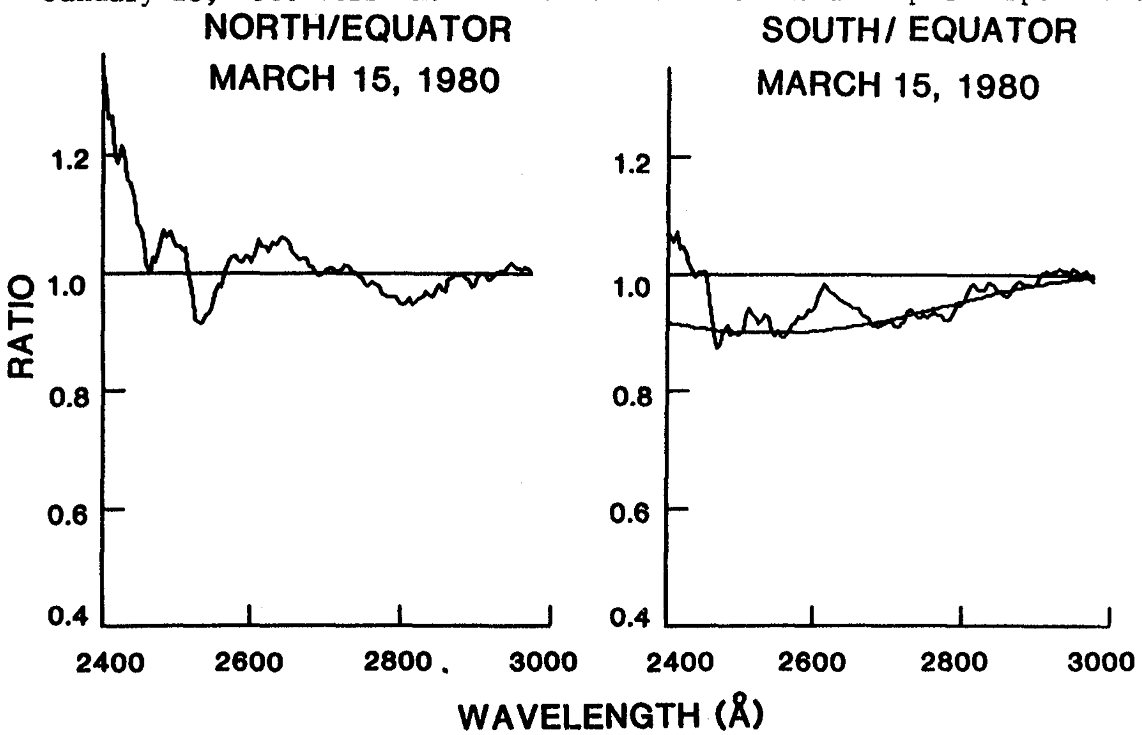
1. Variation of the latitude of the sub-Earth point on Mars with Martian season from April of 1979 through September of 1980. The apparent angular diameter of Mars is also shown.



2. Aspect of Mars as viewed from Earth on March 15, 1980. Small circles indicate locations of small aperture for each of five exposures.



3. Ratio of north and south observations to equatorial observation for January 23, 1980 session. Smooth curve is ozone absorption spectrum.



4. Ratio of north and south observations to equatorial observations for March 15, 1980 session. Smooth curve is ozone absorption spectrum.