Ground-based Observations of the Spatial and Seasonal Distribution of Martian Water Vapor: The 1999 Pre-Opposition Period. E. S. Barker, McDonald Observatory, Univ. of Texas at Austin, RLM 15.308, Austin, TX 78713-1083, esb@astro.as.utexas.edu).

Introduction: Our long term coverage of the behavior of Martian water vapor at McDonald Observatory has continued into the 1999 Martian apparition. We obtained high resolution (R~225,000) spectra of the water vapor band at 8200Å between November 1998 and late March 1999 with scheduled observations in May, June and July of 1999. The abundance of Martian of water vapor has been monitored over 14 seasonal cycles since 1964 [1,2,3,6,8]. In recent years, this monitoring has been augmented by the Arizona group using similar techniques to the current CCD technology used at McDonald [4,5,7].

Both groups have added an additional procedure to our standard setup. We are now also routinely obtaining concurrent observations of the 8689Å CO_2 band to allow a correction for dust opacity in calculating the effective path length in the Martian atmosphere. These CO_2 spectra are obtained with the same 2DCoude cross-dispersed echelle spectrograph on the 2.7m telescope at McDonald observatory with a 2048x2048 Tektronics CCD (24μ pixels). The spatial scale along the 2DCoude slit was 0.13 arcseconds per pixel, resulting in seeing limited spatial resolution (~1.0-1.5 arcseconds). Guidance on the Martian disk was accomplished via a TV monitor with a RG-850 filter. For those periods when the Martian disk is larger than 8 arcseconds, we are using an interference filter to isolate the echelle orders corresponding to the CO_2 and H_2O absorptions.

Dataset: Table 1 summarizes the observations either carried out before or scheduled after opposition. The seasonal coverage in L_s concentrated on the northern spring summer season with samples at L_s = 56°, 68°, 83°, 91°, 111°, 116° before opposition and at scheduled time after opposition L_s = 147°, 158°, 166°, and 176°. Each of the spectra noted under the "slit" columns will yield 5-10 spatial samples along the spectrograph slit. The primary water vapor lines included in the region are: 8176.975, 8186.371, 8189.272, and 8197.704Å, but not all of these lines will have usable Martian counterparts due to Doppler shifts and blending with solar absorption lines. The slit was placed either in the N-S direction along the central meridian to study the latitudinal distribution or E-W to study the diurnal behavior of the Martian water vapor for the dates listed in Table 1.

Data reduction of the entire dataset is still in progress using the uniform reduction processes for ground-based observations which were agreed upon with Sprague, et al. at Mars Telescopic Observations (MTO) II in Tucson, October 1997.

TABLE 1: Martian Water Vapor Spectra

Date (UTC)	Slit N-S	Slit E-W	Ls °	Mars long °	Dia (")
1998 Nov 10	1	-	55.0	152-154	4.8
1998 Nov 11	4	-	55.5	88-163	4.8
1998 Nov 12	1	-	56.0	108-109	4.8
1998 Dec 8	2	-	67.3	136-146	5.4
1998 Dec 9	1	3	67.8	153-180	5.5
1999 Jan 12	4	-	82.6	176-200	6.8
1999 Jan 13	2	3	83.0	167-194	6.9
1999 Jan 30	1	-	90.6	45-48	7.9
1999 Jan 31	1	1	91.0	8-21	7.9
1999 Feb 1	2	1	91.4	357-21	8.0
1999 Mar 16	-	4	110.7	281-306	12.1
1998 Mar 17	2	7	111.1	227-283	12.2
1999 Mar 29	2	-	116.5	122-137	13.7
1999 May 30-31	tbo	tbo	147	tbo	14.4
1999 Jun 21-22	tbo	tbo	158	tbo	12.3
1999 Jul 6-9	tbo	tbo	166	tbo	11.0
1999 Jul 24-25	tbo	tbo	176	tbo	9.8

To improve the quality and intercomparability of our ground-based datasets, we are using common definitions of: (1) seeing disk width at the 10% level; (2) the location of sectors on the seeing disk and the conversion to a latitude and longitude for each sector; (3) the line strengths of water lines (HITRAN96); (4) the effective temperature from Mars GCM (Haberle, 1998, personal com.) at an altitude of 8km for each Martian latitude and longitude at a given L_s; (5) the same computer code to convert equivalent widths to vertical column abundances. Observations of several lines in

the 8689Å CO_2 band will allow us to separate the effects of dust/cloud opacity on the effective H_2O atmospheric path length.

General Results: During the 1998-99 pre-opposition period, normal amounts of Martian water vapor were observed with increasing amounts towards higher northern latitudes (15-25μ at 50-75°N). Most of N-S samples showed just barely detectable (~2μ=internal error) amounts at southern latitudes. Measurements made to investigate the diurnal change in atmospheric water vapor at different Martian latitudes, showed maxima ~1-2 hours after local noon and much lower abundances above the morning terminator regions. Both of these general behaviors (see Figures 1 and 2 for samples) were seen in the 1996-97 apparition datasets obtained by McDonald [6,8] and Arizona groups [7]. The low abundances seen in our datasets at the morning and evening terminators are partially due to the large geometric airmass factors which correspond to the observed locations on the disk of Mars. These airmass values need to be corrected for the presence of clouds or dust over the terminator regions which will reduce the masking of the water vapor at lower altitudes.

The 1997 and 1999 McDonald observational datasets will allow direct comparison of abundances at different Martian seasons seen exactly one Martian year apart (at L_s = 67°, 83° and with scheduled observations at 165°, 181°). The 1999 dataset includes observations during the seasonal period during which Viking detected its peak water vapor abundances (~60-100μ) near the northern polar cap at L_s = 110-120°. These comparisons will be presented at the conference.

Pathfinder Abundances: Measurements were made on July 5 and 6, 1997 UT (Sols 1 and 2) over the Martian disk including the Pathfinder site (Figure 3). Our [8] early afternoon, Pathfinder site abundances (11.6±1.0μ) are smaller than those obtained by [7] on July 12 by several μ for yet as undetermined reasons. But, our afternoon abundances are generally consistent with the in-situ Pathfinder measurement of 8μ [9] made later in the Martian afternoon and season.

References: [1] Barker, E. et al. (1970) *Science 170*, 1308-1310. [2] Barker, E. (1976) *Icarus 28*, 247-268. [3] Jakosky, B. and Barker, E. (1984) *Icarus 57*, 322-334. [4] Rizk B. et al. (1988) *Icarus 90*, 205-213. [5] Sprague, A. et al. (1996) *JGR 101*, 23229-23241. [6] Barker, E. (1997) *LPI Technical Report* #97-03, 6-7. [7] Sprague, A. et al. (1997), *ibid.* 30-32. [8] Barker, E. (1998) *BAAS 30*, 1032. [9] Lemmon, M. et al. (1997) *LPI Technical Report* #97-03, 22-23.

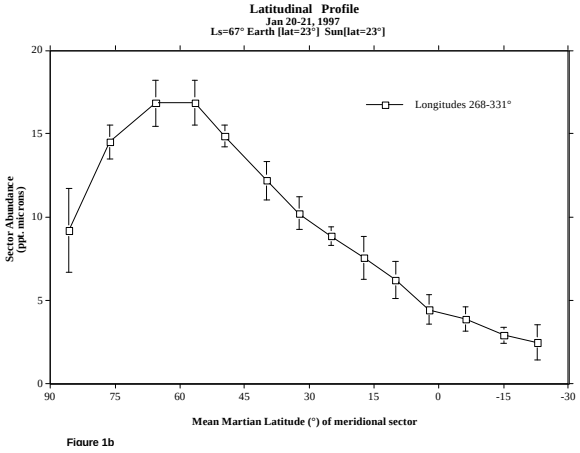

Figure 1: Sample latitudinal profile, 1997 dataset

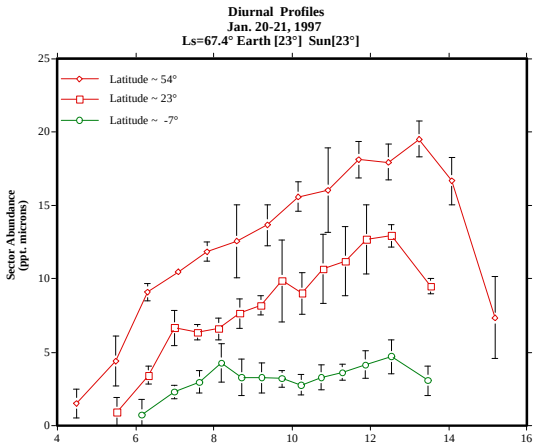

Figure 2: Sample diurnal profile from 1997 dataset.

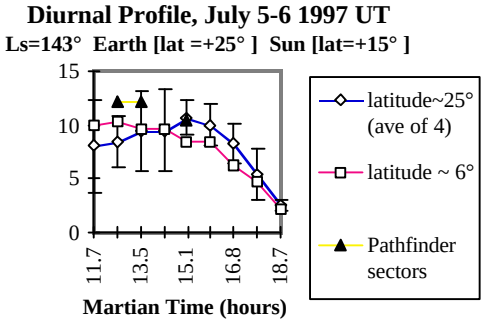

Figure 3. The diurnal profiles encompassing the Pathfinder site (+19.5°N). Observations of the actual site were contained in Pathfinder sectors ( ).