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Mars atmospheric water vapor abundance: 1991–1999, emphasis 1998–1999

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Abstract

Our ground-based measurements of martian atmospheric water vapor, made throughout $L_S = 34°$ to 249°, 24 September 1998 to 23 November 1999, during Mars year 24 (MY 24), show changes in Mars' humidity on hourly, daily, and seasonal timescales. We made concomitant measurement of nearby CO_2 bands, and when possible, results were corrected for aerosol extinction using aerosol optical depths derived from our own CO_2 analysis. Where there is spatial and temporal overlap, similar results are obtained for water vapor abundances and aerosol opacities as those observed from the Thermal Emission Spectrometer on Mars Global Surveyor. In addition some further discussion of our published earlier water vapor measurements (1991–1995) is included. Six results from this data set are: (1) the measured aerosol opacity in Mars atmosphere was variable but not greater than $\tau = 1$, with almost no clear atmosphere being observed, (2) measurements made with the slit crossing many hours of local time on Mars' Earth-facing disk show a diurnal pattern with highest abundances at mid-day and low abundance in very early morning and late afternoon for some but not all measurements, (3) water vapor abundance is patchy on hourly and daily time scales but follows the usual seasonal trends seen by instrumentation on the Mars Atmospheric Water Detector on the Viking Orbiters and by the Thermal Emission Spectrometer on Mars Global Surveyor, (4) there is a slight longitudinal correlation with the ground-ice observed by the Gamma Ray Spectrometer on Mars Odyssey, (5) there is evidence of the Low Southern Latitude Summer Minimum in our water vapor measurements but our data set for southern summer is limited, and (6) MY 24 appears to be wetter than MY 22 and MY 23.

Keywords: Mars, atmosphere; Abundances, atmospheres; Spectroscopy

1. Introduction

This is the fifth in a series of papers describing the results of ground-based spectroscopic measurements of martian atmospheric water vapor made from 1991 to 1999 (MY 20–MY 24). Sprague et al. (1996, referred to as PI) published results from 1991 to 1995. Hunten et al. (2000, PII) detail methods to correct measurements at high air mass along the limb of the planet (which also often includes the terminator) for the substantial dust and aerosol opacity, and describe the tendency for water vapor abundances to be higher around noon than in early morning or late evening. Sprague et al. (2001, PIII) gave results for a selected high northern latitude data set. Sprague et al. (2003, PIV) published the water vapor abundances for 1996–1997 (MY 23), including special measurements of the Pathfinder landing site taken at the same time that in situ measurements were made with the Imager for Mars Pathfinder (IMP) instrument. They also document several measurements that exhibit higher water abundance around noon than over early morning and late afternoon values. In this paper we publish new water-vapor abundances from ground-based observations made during 1998–1999 (MY 24) and make detailed comparisons to water vapor abundances derived from Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES) for the same period. Aerosol measurements used in the correction of our water vapor abundances are compared with those resulting from the TES analysis for similar time periods. We also compare the atmospheric water vapor distribution with the map of surface water equivalent hydrogen as measured by the Gamma Ray Spectrometer (GRS) on Mars Odyssey orbiter.

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2. Observations

Ground-based measurements were made at the 1.5 m Catalina Observatory near Tucson, AZ with the high resolving power échelle spectrograph (Hunten et al., 1991). Table 1 gives dates and times for all observations of both CO_2 and H_2O. All observations were made in the same fashion as those of PI, PII, PIII, and PIV. Our observing strategy and techniques for measuring water vapor are described in PI. The associated CO_2 spectral observations and analysis necessary to make correc-

Table 1
Water vapor measurements 1998 and 1999: observing details

Obs. No.	Date	Frame No.	Slit location	UT start	L_s (°)	Sub-solar long. (W)/lat. (°/°)	Sub-Earth long. (W)/lat. (°/°)	Phase angle (°)	Diam. (arcsec)
	1998								
1	24 September	14	E/W-cen	11:48	34	180/14	157/22	23	4.1
2		16	E/W-cen	12:00		183/14	161/22		
3		17	N/S-cen	12:13		186/14	164/22		
4		18	N/S-cen	12:24		189/14	167/22		
5	5 October	25	N/S-cen	11:15	39	68/16	43/23	25	4.2
6		26	N/S-cen	11:27		71/16	46/23		
7		27	E/W-cen	11:46		75/16	50/23		
8		28	E/W-cen	11:52		77/16	52/23		
9		29	N/S-cen	12:08		81/16	56/23		
10		30	N/S-cen	2:20		83/16	58/23		
11	29 October	31	E/W-n	11:45	49	206/19	176/25	29	4.6
12		32	E/W-cen	11:58		209/19	179/25		
13		33	E/W-s	12:11		213/19	182/25		
14		34	N/S-cen	12:25		216/19	186/25		
15	5 November	23	N/S-cen	11:54	53	141/20	110/25	30	4.7
16		24	N/S-e	12:04		144/20	112/25		
17		25	E/W-cen	12:18		147/20	116/25		
18		27	E/W-s	12:31		150/20	119/25		
19		28	E/W-n	12:41		153/20	121/25		
20	6 November	33	E/W-s	11:50	53	131/20	99/25	30	4.7
21		34	E/W-n	12:00		133/20	102/25		
22		35	E/W-cen	12:09		136/20	104/25		
23		36	N/S-cen	12:24		139/20	107/25		
24	17 November	27	N/S-cen	11:58	58	28/21	354/25	31	4.9
25		28	N/S-cen	12:10		31/21	357/25		
26		29	E/W-cen	12:25		34/21	1/25		
27		30	E/W-s	12:39		38/21	4/25		
28		31	E/W-n	12:49		40/21	7/25		
29	30 November	22	E/W-cen	11:20	64	254/23	219/25	33	5.2
30		23	E/W-s	11:32		257/23	222/25		
31		24	E/W-n	11:43		260/23	224/25		
32		25	N/S-cen	11:58		264/23	228/25		
33		26	N/S-w	12:10		267/23	231/25		
34		27	N/S-e	12:21		269/23	233/25		
35	1 December	13	N/S-cen	11:42	64	250/23	214/25	33	5.2
36	17 December	24	E/W-cen	11:13	71	90/24	52/24	35	5.7
37		25	E/W-cen	11:29		94/24	56/24		
38		26	E/W-cen	11:45		98/24	60/24		
39		27	E/W-cen	12:04		103/24	65/24		
40	31 December	23	E/W-cen	11:47	77	325/25	286/22	36	6.3
41		24	N/S-cen	12:13		331/25	292/22		
42		27	E/W-cen	12:39		337/25	298/22		
43		28	E/W-n	12:55		341/25	302/22		
	1999								
44	16 January	22	N/S-cen	12:08	84	177/25	138/20	36	7
45		23	N/S-e	12:26		181/25	142/20		
46		24	E/W-cen	12:47		186/25	147/20		
47	17 January	23	N/S-cen	11:03	85	151/25	112/20	36	7.1
48		24	N/S-e	11:22		156/25	117/20		
49		25	E/W-cen	11:41		161/25	121/20		

(*continued on next page*)