ATMOSPHERIC MODELING OF THE MARTIAN POLAR REGIONS: ONE MARS YEAR OF CRISM EPF OBSERVATIONS OF THE SOUTH POLE. A.J. Brown[1] and M. J. Wolff[2] [1]SETI Institute, 515 N. Whisman Rd Mountain View, CA 94043, abrown@seti.org, [2]Space Science Institute (18970 Cavendish Rd, Brookfield, WI, 53045). Author website: http://abrown.seti.org

Introduction: CRISM has observed the planet Mars for a full Mars year, here we continue the work reported in [1] to document the opacity of the atmosphere in the polar regions for Martian Years 28/29.

Previous planetwide surveys of atmospheric opacity have generally omitted the areas poleward of 65 degrees due to the variability of the polar opacity and the presence of optically thick polar hood clouds during winter [2-4] although see [5] for observations of global dust storms using MOC.

CRISM has the ability to take 'gimballed' observations of the surface as it passes over a target, thus creating what is termed an Emission Phase Function 'EPF' measurement (Figure 1) [6]. We report here on our initial investigations of the EPF polar observations and our attempts to model dust and ices suspended in the atmosphere and soil and ice covered surface.

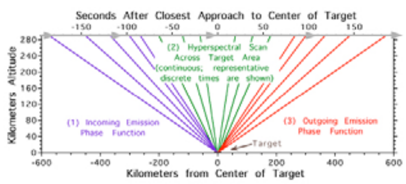

Figure 1. Schematic of a CRISM EPF observation.

Table 1 shows all the CRISM EPF observations poleward of 55°S. Prior to L_s=152, the sun had not yet risen sufficiently high over the south polar region. CRISM is limited to daytime observations and MRO is in a ~250km circular orbit that crosses the equator south to north at 1500 local Mars standard time.

Method: We are using the DISORT [7] algorithm to generate a Mars model atmosphere column at one wavlength (0.696 μm) for each observation. We iteratively adjust three parameters (surface albedo, dust and ice opacity) in order to achieve a close fit at five points spread across the EPF (two points in the wings and one central point). The surface albedo is assumed to be lambertian (scatters equally in all directions).

We have decided to use a four stream model, since this is suggested by Liou [8] to yield an accuracy of within 1% for 'typical phase functions', compared to a two stream model which introduces errors of the order of 3-10%. 16 streams is considered to give 'close agreement' to reality but at this stage is time prohibitive.

Earth DOY 2007	MY/L_s	*EPF*	*FRT*	*HRL*	*HRS*
06_352-5	28/[152-159)	8			
006-016	[160-168)	9			
016-033	[168-176)	3		3	1
033-044	[176-183)	10	6	3	4
044-059	[183-192)	20	17	1	6
059-073	[192-200)	8	20	1	5
073-086	[200-208)	2	14		1
086-101	[208-217)	25	27		24
101-115	[217-225)	*17*	*29*	11	12
115-116	[225-234)		4	1	
132-142	[234-243)		36		3
142-156	[243-252)	27	*42*	*5*	8
156-171	[252-261)	3	37	7	2
171-185	[261-270)	*12*	48	4	1
185-198	[270-278)	124	30	2	2
199-212	[278-286)	*43*	30		
213-225	[286-295)	*49*	*137*	1	6
227-240	[295-303)	22	*111*	2	2
241-255	[303-312)		*111*	4	
255-268	[312-320)	*16*	66	3	4
269-282	[320-328)		*34*	16	4
283-296	[328-335)		*49*	5	13
297-311	[335-343)		18	8	4
311-348*	[343-002)				
348-004*	29/[002-012)		61	1	2
004-033*	[012-026)		43	3	
033-074*	[026-044)		39	3	2
TOTAL	*n=1599*	399	1009	84	107

Table 1. Totals of CRISM observations relevant to this study. Counts in italics indicate some missing geometries. Each line corresponds to the two week MRO planning cycle. DOY column gaps are when CRISM collected no data at the south pole.
* Indicates non 14-day time periods

Model Assumptions: We use phase functions for water ice 'Type 1' (non-aphelion ice cloud) with 64 moments [9] and dust particle phase function with 64 moments derived in [10] and recommended by [11]. The dust and ice particles are assumed spherical, with a gamma particle size distribution:

$$n(r) = r^{(1-3v_{eff})/v_{eff}} \exp\left(-\frac{r}{R_{eff} v_{eff}}\right)$$

For dust: R_{eff}=1.5 microns, v_{eff}=0.4, ice: R_{eff}=2.0 microns, v_{eff}=0.1. Dust optical constants were from [12] and water ice optical constants were from [13]. The single scattering albedo for each atmospheric layer can then be derived.

We use an elevation corrected scheme for rayleigh molecular scattering:

$$\tau_{Rayleigh} = 1.56e^{-25} e_{scale} \sigma \left(\frac{0.305}{\lambda} \right)^4$$

where σ is the column density in cm^{-2} and e_{scale} is an elevation scaling factor based on a 10km scale height [14]. We have used the MOLA heights in the center of each observation to scale the atmospheric surface pressure and assumed no barometric pressure changes with height.

Starting with a Martian atmosphere with 39 2km high layers from 1-79km (with a base layer of 1km and a top layer of 100km), with 10km scale height (Table 2) we interpolate 15 layers at 50, 40, 35, 30, 25, 20, 17, 14, 11, 9, 7, 4, 2, 1, 0.00145 and 0 km. We use MOLA heights from the CRISM DDR files to scale the atmospheric column. Dust is restricted to heights of 0-80km, water ice clouds are restricted to 25-80km. We use standard corrk files (produced by M. Smith) for CO_2, (95.3%) molecules (we currently omit seasonally variable CO, H_2O and CH_4) and a typical ozone column at perihelion (L_s=240) varying from 2.45×10^{-7} (at 6.96mbar) to 7.8×10^{-5}% at 0.02mbar. We do not treat thermal radiation from the surface or within the atmosphere (this has minimal effects at ~0.7 μm).

Results: The τ_d results for CRISM EPF data from Mars Year 28/29 (2006-2008) are shown in Figure 2. Employing a moving window (n=128) average (red line) we see a background value of τ_d~0-3-0.5, which rises to a peak background of τ_d=1.4 during the MY28 L_s=270-310 dust event. The average τ_d during the dust event rises quickly to a peak value from L_s=270-280, and slowly returns to background levels from L_s=280-320. Several other dust opacity excursions are also apparent, at the start of the spring recession and a small but noticeable peak from L_s=240-260.

Conclusions: We have derived estimates of surface albedo (Figure 3) and atmospheric dust (Figure 2) and ice opacities for the first Mars year of CRISM operations (MY28-29), which included a large dust event at L_s=260-270. The results for this period are consistent with background dust opacities of τ_d=0.3-0.5 for the south polar region, with average excursions to 1.4 during the MY28 dust event. Future work will cover north polar FRT observations and next year of operations.

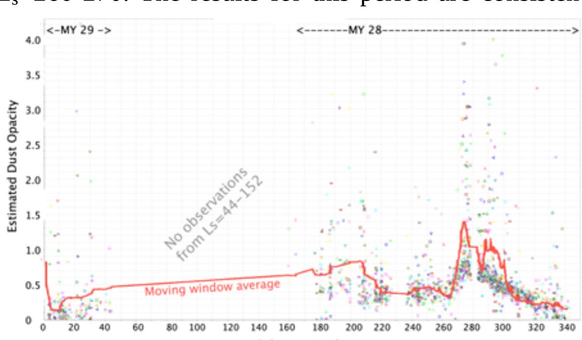

Figure 2. τ_d estimates for CRISM EPF observations over the south pole (poleward of 55°S) for MY28/29.

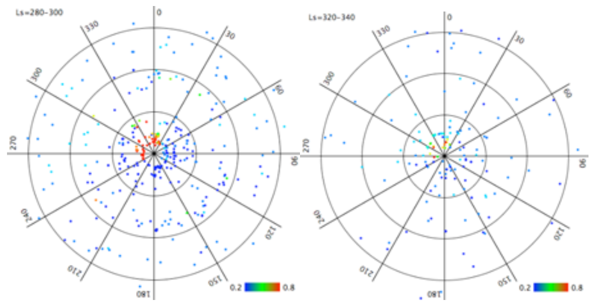

Figure 3. Surface albedo estimates for CRISM EPF observations covering L_s=280-300 and L_s=320-340.

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References: [1] Brown, A. et al. (2008) *LPSC XXIX* #2140 [2] Martin, T.Z. (1986) *Icarus* 66 2-21 [3] Colburn, D.S. et al. (1989) *Icarus* 79 159-189 [4] Smith, M.D. (2004) *Icarus* 167 148-165 [5] Cantor, B. (2001) *JGR* 106, 23653-23687 [6] Murchie, S. et al. (2007) *JGR* 112 [7] Stamnes, K. et al. (1988) *AO* 27, 2502 [8] Liou, K.-N. (1973) JAS 30, 1303-1326 [9] Clancy et al. (2003) *JGR* doi:10.1029/2003JE002058 [10] Tomasko et al. (1999) *JGR* 8987-9008 [11] Wolff, M. et al. (2007) *7th Mars*, #3121. [12] Wolff, M. et al. (2008) *3rd Mars Atmos. Wksp*, #9125 [13] Pollack, J.B. et al. (1979) *JGR* 84 2929-2945 [14] Warren, S.G. (1984) *AO* 23, 1206-1225

Layer height (km)	*Pres. (mbar)*	*Layer height (km)*	*Pres. (mbar)*
0.0	6.799	41.0	1.362e-01
1.0	6.288	43.0	1.089e-01
4.0	4.950	45.0	8.686e-02
7.0	3.869	47.0	6.915e-02
9.0	3.269	49.0	5.496e-02
11.0	2.752	51.0	4.364e-02
13.0	2.309	53.0	3.462e-02
15.0	1.929	55.0	2.745e-02
17.0	1.605	57.0	2.175e-02
19.0	1.331	59.0	1.723e-02
21.0	1.099	61.0	1.365e-02
23.0	9.042e-01	63.0	1.081e-02
25.0	7.414e-01	65.0	8.559e-03
27.0	6.059e-01	67.0	6.779e-03
29.0	4.937e-01	69.0	5.369e-03
31.0	4.011e-01	71.0	4.253e-03
33.0	3.249e-01	73.0	3.370e-03
35.0	2.625e-01	75.0	2. 670e-03
37.0	2.115e-01	77.0	2.116e-03
39.0	1.700e-01	79.0	1.678e-03
		179.0	1.678e-10

Table 2. Model Martian atmospheric layers. These are scaled for each observation according to elevation of the terrain. Pressure inversions or large variations with height are not treated. We interpolate 15 layers from this profile at 50, 40, 35, 30, 25, 20, 17, 14, 11, 9, 7, 4, 2, 1, 0.00145 and 0km.