TOPOGRAPHY DRIVEN VARIATION IN ARGON ABUNDANCE AS MEASURED BY THE GRS ON MARS ODYSSEY.
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Introduction: Both Viking Landers (VLs) used gas chromatograph spectrometers to measure the composition of Mars' atmosphere [1, 2]. A single argon mixing ratio of 0.016 by volume was published for the northern summer at 48^{O} N latitude, 138^{O} E longitude by VL2 (the VL1 measurement was considered less reliable), and has been accepted as the standard value for the Mars atmosphere to date [3].

Other measurements of Ar in Mars' atmosphere have been made describing zonal average argon measurements as a function of 15° increments of latitude and 15° intervals of L_s [4] [5] by the Gamma Subsystem (GS) of the suite of three instruments comprising the Gamma Ray Spectrometer (GRS) on the 2001 Mars Odyssey spacecraft [6]. The Ar mixing ratio was observed to increase steadily from the VL2 measured mixing ratio (0.016 by volume, 0.0145 by mass) throughout autumn up to a mass mixing ratio value of nearly 0.06 ± 0.01 and then begin to decrease at the onset of winter to reach a minimum of 0.004 ± 0.003 by mid-spring. By summer, Ar abundance was at the level expected from the value measured by the VL2 mass spectrometer [3]. Argon was used as an atmospheric tracer and meridional mixing efficiencies in and out of the south-polar region were computed [4]. Mixing efficiency was found to be slow in autumn for the south polar region and an argon enhancement up to a factor of 6 over the VL2 value was a consequence. More rapid mixing out of the polar region in winter diminished the enhancement. In spring, when gaseous CO_2 sublimed off the southern polar cap, rapid dilution of Ar occurred lowering the mixing ratio. Also, increased equatorward atmospheric flow quickly depleted the south polar region of Ar to an amount below the VL2 value. Enhancement factors over the VL2 value for the northern polar region were about what is expected for the lower topography and shorter winter (factor of 3). However, the northern argon data show fluctuations on 15° and 30° increments of Ls. These rapid timescales for fluctuations in argon abundance are not seen in the south polar data. Details can be found in [4] and [5].

New analysis: We present measured Ar abundance at Mars for all seasons for three specially chosen longitude zones to explore the effects of topography on argon abundance in Mars' atmosphere. We use data from 8 June 2002 to 2 April 2005 summed from three longitude sectors chosen to search for the effects of topography on the seasonal and latitudinal behavior of Ar abundance. The longitude sectors are centered over Tharsis Montes (210° to 300° E), Hellas Basin (30° to 120° E), and a region where there are no large, uniques topographic structures (300° to 30° E). Data are binned in latitude by 30°: from 90° to 60°, 60° to 30°, and 30° to 0°, for both the N and S hemispheres.

Data set for this study. The Mars' atmospheric Ar data set is produced by deducing the amount of Ar in Mars' atmosphere within the footprint of the GS as it orbits Mars. The GS integrates γ-ray line emission at 1294 keV generated by the decay of ^{41}Ar created when a thermal neutron is captured by ^{40}Ar in Mars' atmosphere. The mapping orbit began 19 Feb. 2002 and continues to this day. The GS, on the 6-meter extended boom of the spacecraft, is at a nearly constant distance from the center of Mars and about 99% of the γ-ray signal comes from within a region defined by a 17^{O} half angle with vertex at the center of the planet. This geometry defines a footprint region approximately 2000 km in diameter. The actual footprint varies somewhat because atmospheric attenuation varies with the energy of γ-rays. The 1294 keV γ-ray line is generated in the atmosphere rather than in surface materials, and the footprint may not be the same as for γ-rays of comparable energy emanating from surface materials. However, the scale height of Mars' atmosphere is small (~ 10 km) compared to the altitude of the spacecraft (~400 km) so approximately the same footprint can be assumed.

Time periods are given in terms of areocentric longitude of Mars (L_s), where $L_s = 0^{O}$ is defined as the vernal equinox for the northern hemisphere. In this reference frame, the GRS began mapping at $L_s = 24.2^{O}$. Because data are binned in time to build meaningful statistics (a high signal-to-noise ratio), the first data point for Ar is $L_s = 27.2^{O}$. The total time span covered in this paper is $L_s = 24.2^{O}$, MY 1 to $L_s = 360^{O}$, MY 2. We refer to MY 1 as the first full Mars year of observation by the GS on Mars Odyssey, and MY 2 as the second.

Results. There do appear to be differences between the longitudinal sectors with respect to the seasonal argon abundance, as shown in Fig. 1 which is an illustrative example of the variation of argon abundance as a function of latitude for southern autumn (northern spring) for two Mars years. The top panel is for a longitude sector of 90° centered on Hellas Basin. The middle panel is for a 90° longitude sector with no special topographic high or low except the normal dichotomy between the southern highlands and northern lowlands. The bottom panel is a 90° longitude sector centered over the Tharsis Montes. Data for 2 Mars years are shown for each panel (longitude sector). Year to year differences and similarities are also obvious. A quantitative comparison of Fig. 1

cannot be made directly because the data have not been corrected for atmospheric absorption.

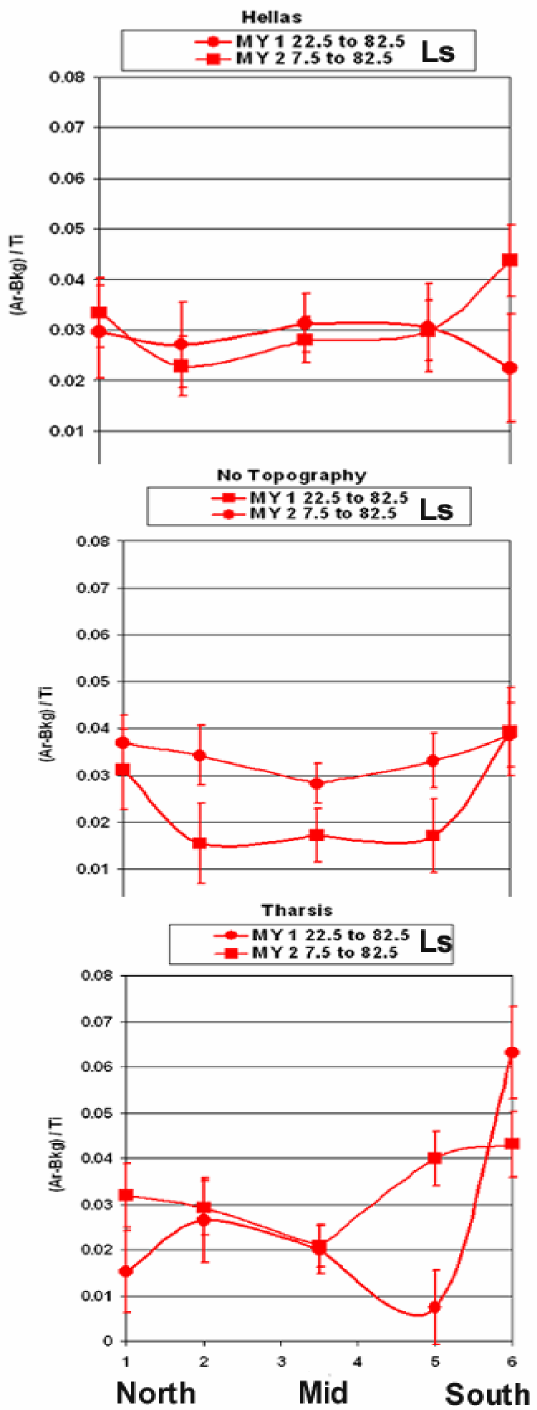

Fig 1. Atmospheric argon measurements for three 90° longitudinal sectors for the southern autumn (northern spring) season are shown above. Argon data are averaged from $L_s = 0°$ to 90° and are binned 30° in latitude with the exception of the Mid bin which is the average of 2 30° bins (30°S to 30°N). One σ error bars are shown. Data are obtained by the GRS on Mars Odyssey.

Seasonal fluctuations in the local atmospheric pressure affect the signal as observed by the GS. The seasonal effects of thermal neutron production have been removed by taking the ratio of argon signal to that of titanium which has the same origin of neutron capture. The background has been estimated using data from elements known to be in the GS cannister itself.

We expect to have these data and those from the other seasons corrected for atmospheric absorption and ready for presentation during the conference in July, 2007.

Future studies using GRS argon measurements: We hope that the analysis of our MY 2 data along with the results presented earlier [4,5] and these separate longitude studies will help to elucidate meridional atmospheric circulation on Mars to the level that is useful for better tuning the vector wind fields in the NASA ARC GCM [7]. A series of simulations of the argon enhancements expected in Mars' atmosphere as computed by the NASA ARC GCM, failed to reproduce the magnitude of the enhancements observed [8].

References: [1] Biemann K. et al. (1976), [2] Owen T. and Biemann K. (1976). [3] Owen T. et al. (1977) [4] Sprague A. L. et al. (2003), [5] Sprague A. L. et al. (2007) [6] Boynton W. V. et al. (2004), [7] Haberle R. M. et al. (1993), [8] Nelli S. et al. (2007).

Acknowledgments: We acknowledge the contributions of the entire GRS team and Bob Haberle for providing the NASA ARC MGCM output 2002.17 for analysis purposes. Funding for this analysis is provided by NASA contract 1228726.