GRS MEASUREMENTS OF MARS' ATMOSPHERIC ARGON: EFFECTS OF UPDATED MARS MODEL ATMOSPHERES ON CONCENTRATION COMPUTATIONS. A. L. Sprague[1], W. V. Boynton[1], A. Colaprete[2], D. M. Janes[1], A.E. Metzger[3], K.E. Kerry[1], F. Forget[4], R. Starr[5], R. M. Haberle[2], [1]Lunar and Planetary Laboratory, Tucson, AZ, 85745, (sprague@lpl.arizona.edu) [2]NASA Ames Research Center, Moffett Field, Mountain View, CA 94035-1000 (Anthony.Colaprete-1@nasa.gov), [3]Jet Propulsion Laboratory, Pasadena, CA, 91109, [4]Institut Pierre Simon Laplace Laboratoire de Météorologie Dynamique, UMR 8539 Université Paris 6, BP 99, 4 place Jussieu, 75252 Paris, France, [5]Department of Physics, Catholic University of America, Washington, DC.

Introduction: The Gamma Subsystem (GS) component of the Gamma Ray Spectrometer (GRS) on Mars Odyssey has been measuring the abundance of atmospheric argon (Ar) since 8 June 2002. Previous results [1, 2] have found the GS Ar measurements and subsequent analysis to provide an ideal tracer for Mars' atmospheric circulation. Here we present seasonal Ar column abundance and distribution around Mars since the start of measurements to 28 July 2007--nearly three full Mars years. Specifically, we discuss the ability of current Global Circulation Models (GCMs) to adequately portray observed seasonal Ar distributions.

Current GCM models fail to predict seasonal Ar concentrations: One area in which the GS Ar data have profoundly influenced Mars atmospheric modeling is by revealing inadequacies in the world's most prestigious GCMs to accurately predict seasonal meridional transport. Forget [3] attempted to reproduce the GS Ar results with the LMD-AOPP-IAA GCM and discovered that it predicted Ar to be distributed in the lower atmosphere in patchy regions. In addition, the model predicted more polar Ar in northern winter than in southern winter--exactly the opposite of GS measurements. Nelli [4] and collaborators made a detailed study of the NASA ARC GCM by extensively modeling Ar transport in an experiment in which major parameters (e. g. elipticity, albedo, topography, emissivity) were tested to determine their influence on Ar seasonal concentration. The best models underestimated the Ar concentration by a factor of 2 at both polar regions. However, results did have the correct sense of enhancement--predicting more in southern winter than in northern winter. The GFDL-Caltech GCM, now called Mars WRF GCM [5], is under critique and modification. Following revisions to the Mars WRF [6], qualitative similarity to the GS Ar data set was achieved in that the model predicted the largest enhancement in southern winter with a lesser enhancement in northern winter. However, magnitudes of maximum enrichment in the models are lower than those observed by the GS. Altering the vertical Ar distribution controlled, to some degree, near-surface transport and off-cap circulation and resulted in further enhancement of non-condensable tracers in the winter pole. The addition of an extra buoyancy term in the dynamics is underway. A step forward came with improvement of the NASA ARC GCM [7] by including new microphysical parameters as well as convection from condensation available potential energy (CAPE) [8]. After the addition of strong upward convection to the NASA ARC MGCM, the computed mass and distribution of non-condensable gasses increased for southern winter at southern high latitudes. The transport of non-condensables was improved with predicted distribution and abundances (Ar concentration 4.7%) closer to but still less than that observed by the GS (maximum Ar concentration 9%).

GS Argon Measurements, Three Mars Years: Interesting inter-annual differences in Ar abundance have been observed and are shown for two latitude bins in Figs. 1 and 2.

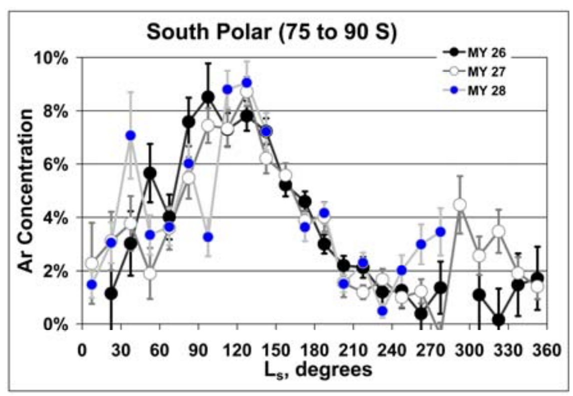

Fig.1. Ar concentrations (%) for zonally averaged latitude sector from 75 to 90 degrees S are shown for nearly three consecutive Mars years (year numbering convention by [9]).

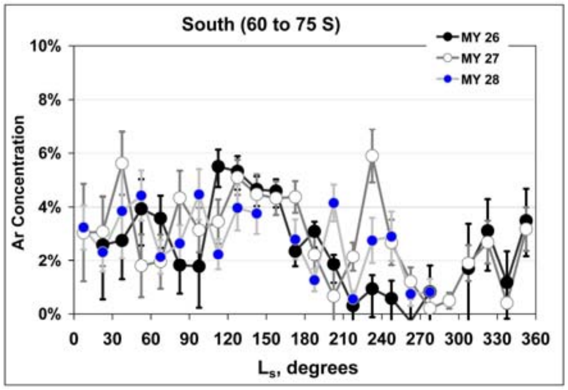

Fig. 2. Ar concentrations (%) for zonally averaged latitude sector from 60 to 75 degrees S are shown for nearly three consecutive Mars years (year numbering convention by [9]). The year-to-year difference during southern spring (L_s 210 to 250 degrees) is a target of future modeling.

As discussed in [1, 2] eddy mixing in and out of the polar regions is likely strongly influenced by wave activity and the seasonal sublimation cycle. Localized phenomena may be important. Differences in southern spring (L_s 210 to 250 degrees) Ar concentrations are striking and indicate changes in meridional transport from year to year.

Argon Differences Among Four Longitude Sectors: Colaprete [9] and others have noticed in highly resolved modeling that Hellas basin drives certain meteorological phenomena. We wished to explore the effect of extreme topography on the actual distribution of Ar and its seasonal changes.

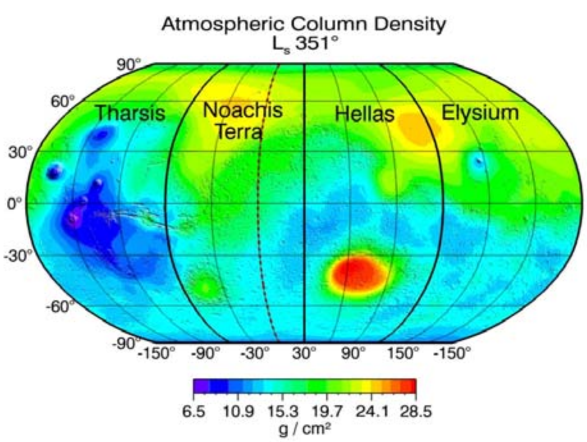

Fig. 3. Atmospheric column abundances are shown as a proxy for topography to illustrate the topographic differences among regions chosen for our new Ar study.

To this end, we rebinned the GS Ar data in four different topographic sectors, each 90 degrees of longitude in width and extending from pole to pole in latitude bins of 30 degrees. The sectors were chosen to coincide with distinct topographic features that might drive differences in meridional mixing or seasonal differences in Ar abundance. The topographic differences among the four sectors are shown in Fig. 3 where atmospheric column abundance in g/cm^2 serves as a proxy for surface altitude and topography.

Using the same calibration and techniques of [1, 2] we have computed the column abundances and enhancement factors of Ar in the four different topographic sectors (see Fig. 4). To maintain an adequate signal-to-noise ratio, we binned data in 30 degree latitude sectors rather than in the 15 degree latitude sectors of our previous work. Besides the differences shown in Fig. 4 for the southern most latitudes, interesting differences among topographic sectors are seen between 30 to 60 degrees S and at some northern latitudes. Also, Ar abundance increases and decreases on short time scales (15 degrees of L_s) occur and may be significant.

For the results shown in Fig. 4, we have used the same model atmosphere (NASA ARC MGCM 2002.17) used in our previous work. When the new models are available, Figs. 1, 2, and 4 will be revised.

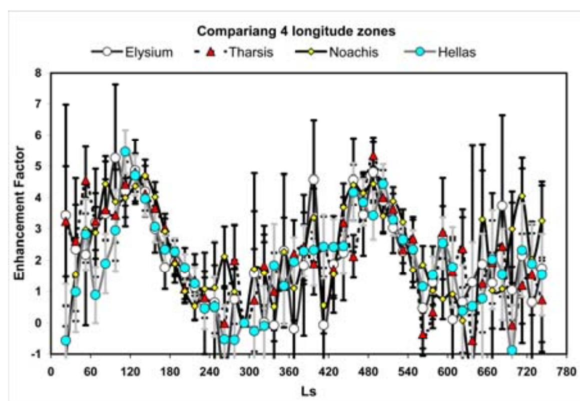

Fig. 4. Ar enhancement factors (VL2 measurement of 0.045 mass mixing ratio equals an enhancement factor of 1) for two Mars years and 60 to 90 degrees S latitude are shown. Data have been analyzed using the NASA ARC MGCM 2002.17 atmospheric model. Some differences are seen among topographic sectors but are not clearly significant.

New Analysis: We anticipate a reanalysis of all Ar data using model atmospheres from the newly upgraded NASA ARC MGCM [8] and a recent version of the LMD MGCM [11] which will be discussed at the workshop. Our analysis relies on CO_2 column abundances as a function of latitude, longitude (with correct average topography), and season in 15 degree increments of L_s. As described in detail in [2], we create a standard reference atmosphere in the same geographic and seasonal bins as the GS Ar data. The comparison atmosphere has Ar homogeneously mixed in the VL2 concentration of 0.0145 by mass. It is by comparison to this reference atmosphere that our enhancement factors are computed. It is not obvious that the use of new reference models generated from upgraded MGCMs will make a difference to our Ar computations. This is what we shall test before the Third International Workshop on The Mars Atmosphere: Modeling and Observations to be held in Williamsburg, VA in November, 2008. Our results and discussion of these tests will be presented.

References:

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