MODELS OF HELIOSPHERIC LYMAN-ALPHA IN SUPPORT OF LRO LAMP. W. R. Pryor[1], W. K. Tobiska[1], K. D. Retherford[2], C. Grava[2], A. Egan[2], T. K. Greathouse[2], G. R. Gladstone[2]. [1]Space Environment Technologies, Pacific Palisades, CA, USA, email: wayne.pryor@centralaz.edu, [2]Southwest Research Institute, San Antonio, TX, USA.

Introduction: Lyman-alpha models [1] are used to find the night-side illumination of the Moon from heliospheric hydrogen scattering sunlight in support of Lunar Reconnaissance Orbiter (LRO) Lyman-Alpha Mapping Project (LAMP) studies of the lunar Lyman-alpha albedo [2]. Our models use measurements of the solar Lyman-alpha flux from the LASP Lyman-alpha composite database [3] to estimate the solar illumination in different directions from the Sun.

Models: The major loss process for slow interstellar wind hydrogen in the heliosphere capable of scattering solar Lyman-alpha photons is charge-exchange with solar wind protons. The hydrogen atom lifetime against charge-exchange in the ecliptic, t(latitude=0), is estimated from solar wind mass flux measurements from the National Space Science Data Center (NSSDC). To estimate the solar latitude variation in the hydrogen atom lifetime t, we use a 1-parameter model with an asymmetry parameter A:

$$t(\text{latitude})=t(\text{latitude}=0)/(1-A\sin^2(\text{latitude}))$$

If A=0, the lifetime is the same at all latitudes; if A=0.5, the lifetime of hydrogen atoms over the solar poles is twice the lifetime at the solar equator. A secondary loss process, solar EUV photoionization of hydrogen, is included using photoionization rates from the Solar Irradiance Program (SIP) [4,5].

Previously, we produced models for 2008-present using A=0.5 and compared the models to all-sky heliospheric Lyman-alpha maps produced by the Solar and Heliospheric Observatory (SOHO) Solar Wind ANistropy (SWAN) experiment [6]. In early years of the LRO mission, the data/model ratio was declining in time, suggesting SWAN instrumental degradation with time. Therefore, we used the model directly, without scaling the model to the SWAN data.

In recent years, the data/model ratio using the A=0.5 value has recovered to nearly its initial value, suggesting a solar cycle variation instead of significant SWAN degradation. To explore this, we ran a set of models for 2008-2019 with A=0.0, 0.1, 0.2, 0.3, 0.4, 0.5, and 0.6. For each year, we found the best-fitting model from this set. For 2008, 2011, and 2015-2019 the best-fitting model was A=0.4, appropriate for solar minimum conditions with enhanced solar wind mass flux near the ecliptic plane. For 2009 and 2010 A=0.5 was the best-fitting model. For 2012, 2013, and 2014, near solar maximum, the best-fitting models were A=0.3, 0.2, and 0.2, respectively, consistent with more isotropic solar wind at solar maximum.

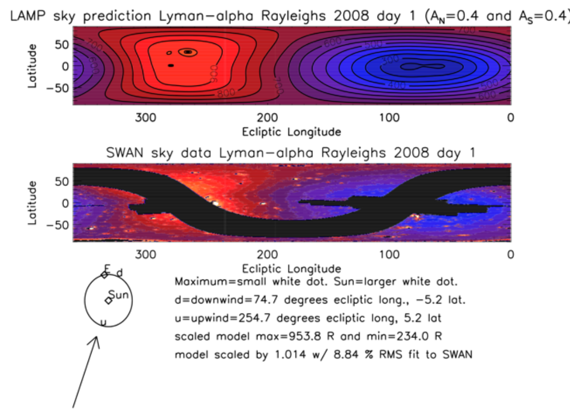

Figure 1. Sample SWAN all-sky Lyman-alpha map for Jan 1, 2008 (bottom) and corresponding best fit model, with A=0.4 in both hemispheres (top).

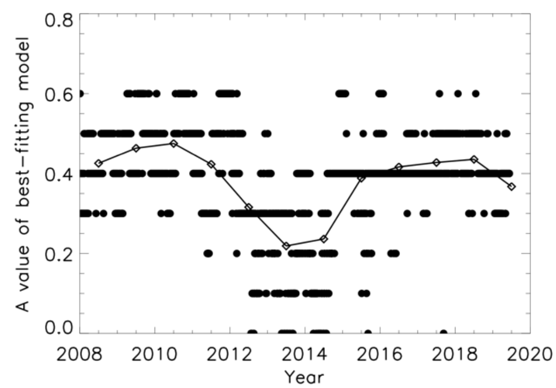

Figure 2 Best-fitting model to the SWAN data from the set of 7 models. Each dot is the daily best-fitting model; each diamond is the annually averaged best-fitting model.

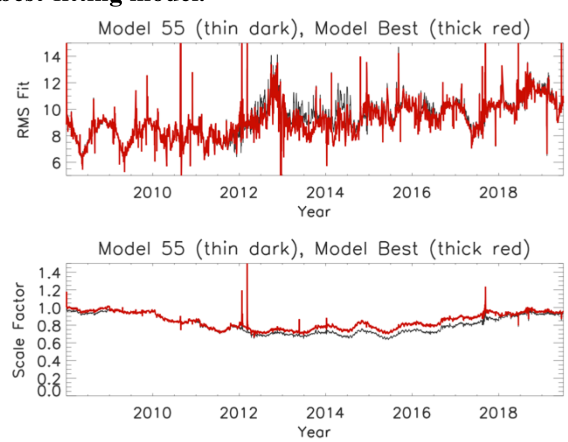

Figure 3 RMS % fit (top) and data/model (bottom) for the previously used A=0.5 model and the model formed from the best-fitting model for each year.

Conclusions: By using the best-fitting model for each year, the SWAN data/model ratio for the mission is closer to a straight line, with somewhat improved RMS fits. There is still an unexplained data/model variation that tracks the solar cycle at the ~20% level. We will now use the best-fitting model for each year, and scale each model to the data, using the scale factors stored in an IDL save file with each year of the best-fitting model. The new model will be used to estimate the lunar dark side Lyman-alpha illumination in the LAMP mapping pipeline. Future work will compare lunar Lyman-alpha albedo maps made by the two models and cross-compare with several LAMP sky-viewing Lyman-alpha observations as well.

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References: [1] Pryor, W.R. et al. (2013) in *Cross-calibration of past and present far UV spectra of solar system objects and the heliosphere,* 163-176, Springer. [2] Gladstone, G. R. et al. (2010) *Sp. Sci. Rev., 150*, 161-181. [3] Woods, T. et al. (2000) *JGR*, 105, 27,195-27,215. [4] Tobiska, W. K. et al. (2000) *J. Atm. Solar Terr. Phys.,* 62, 1233-1250. [5] Tobiska, W. K. and Bouwer, S. D. (2006) *Adv. Space Res*., 37, 347-358. [6] Bertaux, J. L. (1995) *Solar Physics*, 162, 403-439.