EVIDENCE FOR VOLCANIC SUPPORT OF IO'S JUPITER-FACING ATMOSPHERE FROM CONSTRAINTS ON POST-ECLIPSE ATMOSPHERIC CHANGES. J. R. Spencer[1], K. L. Jessup[1], C. C. C. Tsang[1], N. Cunningham[2], and K. Retherford[3], [1]Southwest Research Institute,1050 Walnut St. Suite 300, Boulder, CO 80302, spencer@boulder.swri.edu), [2]Nebraska Weslyan University, 5000 Saint Paul Avenue, Lincoln, NE 68504, [3]Southwest Research Institute, 6220 Culebra Rd., San Antonio, TX 78238.

Introduction: Io's tenuous SO_2-dominated atmosphere has been studied for many years via its emission and absorption features at UV, IR, and millimeter wavelengths [1]. A persistent unresolved question has been whether the atmosphere consists mostly of gas directly vented by the volcanos, or whether the bulk of the atmosphere is supported by vapor pressure equilibrium with the abundant SO_2 frost seen on the surface. The rate of decrease in abundance with increasing latitude at low latitudes on the anti-Jupiter side is consistent with sublimation support [2], and changes in auroral emission during and after eclipse by Jupiter have implied that the atmosphere collapses when Io cools down in eclipse, as expected for sublimation support [3, 4]. Also, it is difficult for the observed plumes to supply most of the atmosphere [5]. However the dawn-to-dusk persistence of the atmosphere as seen in Ly-alpha images, despite expected diurnal changes in frost temperature, is more consistent with volcanic support [6]. Monitoring of atmospheric density in the mid-infrared in the past decade reveals apparent seasonal changes on the anti-Jupiter hemisphere that are best explained by a combination of volcanic and sublimation components of comparable magnitude [7]. Recent observations at multiple wavelengths agree that atmospheric abundance is significantly higher on the anti-Jupiter hemisphere [2, 8, 9, 5].

Here we present new observations of the atmosphere on Io's Jupiter-facing hemisphere as Io emerges from Jupiter eclipse. Because surface frost is expected to cool significantly in Jupiter eclipse, and SO_2 vapor pressure is strongly temperature dependent, the sublimation component is expected to collapse in eclipse. Therefore changes in atmospheric abundance as sunlight returns to Io after an eclipse provides an important test of the importance of sublimation support.

Observations: We used the Cosmic Origins Spectrometer (COS) [10] on the Hubble Space Telescope (HST) to obtain UV spectra of Io during its emergence from Jupiter eclipse on December 5th and Dec. 19th 2011. Io was acquired just before eclipse egress in Dec. 5th, and 10 minutes after egress on December 19th. On both dates, spectra were obtained for nearly 2 hours, though with a time gap in the middle when the Earth passed between Hubble and Io.

The spectra covered the wavelength ranges 2100 – 2140 Å, 2200 – 2240 Å, and 2300 – 2340 Å with an original spectral resolution of 0.1 Å, though we binned the spectra to 3 Å resolution to improve SNR. The two shorter-wavelength bands show absorptions due to SO_2 in Io's atmosphere- here we focus on the 2100 – 2140 Å region which shows the strongest absorptions. Because the data were obtained in time-tag mode they can be binned to a range of temporal resolutions- here we bin the data to 10-minute resolution.

Results: Fig. 1 shows the 2100 – 2140 Å reflectance spectrum of Io as function of time after eclipse reappearance. A strong SO_2 absorption band at 2120 Å is visible in all spectra and has roughly constant depth with time.

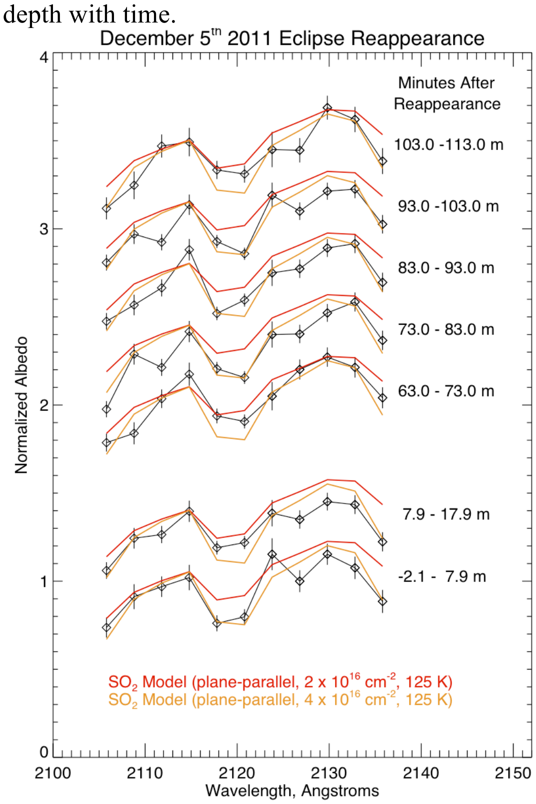

Figure 1 *Reflectance spectrum of Io vs. time after the Dec. 5 eclipse reappearance. Spectral reflectance is normalized, and successive spectra are offset vertically by 0.35 for clarity. The superposed models, which are identical for all spectra, are NOT fits to the data, and absolute abundances are preliminary. However, the models indicate that all spectra are consistent with an* SO_2 *abundance that varies only modestly with time after eclipse emergence. Dec. 19 results are similar.*

Models: Also shown on Fig. 1 are models of SO_2 absorption, using a simple plane-parallel model (uniform spatial distribution, no airmass effects). A linear variation in continuum brightness with wavelength is also included. Absolute abundances are preliminary due to the simplicity of the model, but it is clear that column abundance varies little, probably by less than a factor of two, from 5 minutes after eclipse emergence to nearly 2 hours later.

Interpretation: Fig. 2 shows that large variations in surface frost temperature and sublimation atmosphere column abundance are expected in the hours after Io emerges from eclipse, for a wide range of assumed frost thermal inertias.

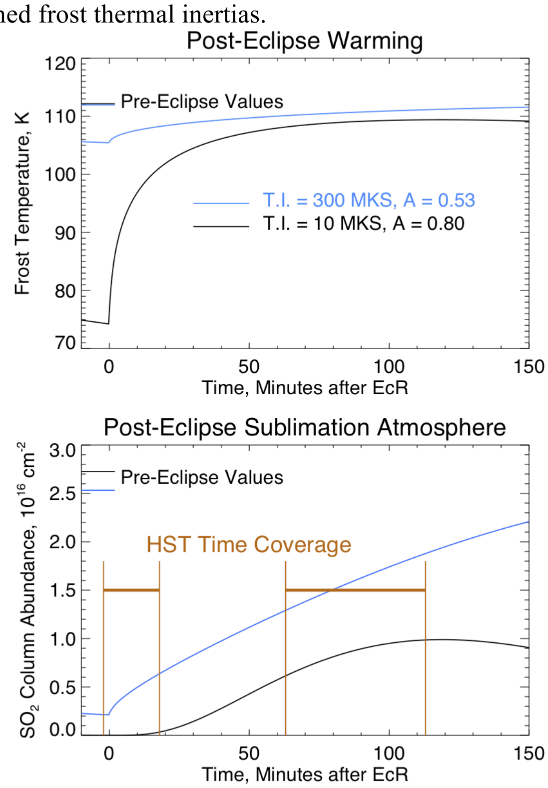

Figure 2 *Temperature, from a 1-D thermophysical model, and resulting equilibrium sublimation SO_2 column density over the period of our observations, for two very different assumptions about the frost thermal inertia (T.I.) and albedo (A), chosen to give similar pre-eclipse temperatures. Column densities are calculated on the assumption of instantaneous vapor pressure equilibrium with surface temperature- dynamic processes may result in a slower response.*

If the atmosphere on the Jupiter-facing hemisphere is dominantly sublimation-supported, as inferred from FUV auroral emission variations [3, 4], the fact that changes in SO_2 abundance on eclipse emergence (Fig. 1) are much smaller than expectations (Fig. 2) is very surprising. The simplest explanation is that most of the atmosphere observed by COS on this side of Io is supported by a process other than frost sublimation, and thus does not change significantly during or after eclipse. The most plausible alternate source of support is volcanic, so these data may indicate that the atmosphere on Io's Jupiter-facing hemisphere is dominantly volcanically supported. However, this result must be reconciled with previous indications that sublimation support dominates the atmosphere on this side of Io. Perhaps the apparent volcanic dominance is only temporary, due to a large eruption on this side of Io. New COS observations of changes in the FUV auroral emission after eclipse emergence, currently under way, and comparison of the inferred sunlit atmosphere with earlier observations, may clarify the situation.

References:

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