THE INFRARED DISTRIBUTION ON SO_2 FROST ON IO: THE EFFECT OF THERMAL EMISSION ON THE ESTIMATION OF FROST ABUNDANCES. D. L. Blaney[1], M. S. Hanner[1], R. Russell[2], D. Lynch[2], and J. Hackwell[2], 1. Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., MS 183-501, Pasadena, CA 91109, 2. Aerospace Corp., Los Angeles Ca.

A persistent problem with the distribution of SO_2 frost on Io has been the lack of agreement between the infrared abundance and distribution (4.08 μm band depth [1]) and the uv/visible distribution [2,3,4]. In the past, the flux from thermal emission of volcanic regions at 4 μm has been considered to be negligible when compared with the solar insolation. This assumption was reasonable because solar radiation does dominate the observed radiance, and the spectra have lacked longer wavelength data (i.e. 4.5 - 20 μm) needed to quantify the volcanic thermal emission. Howell et al. [1] presented a mapped SO_2 line depth as a function of the longitude of the sub-earth point (see figure 1a). This distribution followed similar trends in the uv/visible frost distribution [2,4] with the highest abundances of frost located in the leading hemisphere (0°-180° West Longitude) and lower SO_2 abundances on the trailing hemisphere (180°-360° W). Loki is located at 309° W longitude for reference. The spectra in Howell et al. show almost a factor of 2 difference in the band strength between the leading hemisphere and the trailing hemisphere. However, the abundance of SO_2 derived in the infrared has always been greater than those derived from the visible and uv [1,2,3,4].

We collected data February 7 and 8, 1993 UT using the Aerospace Corp. liquid-He-cooled spectrograph (known as BASS). The instrument covered the wavelength region 3-13 μm and all spectral elements were observed simultaneously [5,6]. With these spectra, we decided to investigate the effect of thermal emission on SO_2 frost band depths at 4 μm. Figure 1b shows the SO_2 line depth, measured using the ratio of the values at 3.47 μm (continuum) and at 4.08 μm (band minim) without the thermal emission modeled. The infrared distribution is sharply different from the Howell et al. observations of roughly a decade earlier and with visible and uv measurements. *The leading and trailing hemispheres have roughly equal amounts of SO_2 frost.* Our next step was to see if accurate modeling of the thermal emission could reconcile these observations. We used the model of Veeder et al. [7] for the 1993 apparition which was collected 1 month after these observations. Emission levels at 8.7 μm agreed within 2% so we extended the Veeder et al. model to the shorter wavelengths. Figure 1c shows the SO_2 frost distribution with the thermal emission removed. While the shape of the spectral distribution remains the same as in 1 b, the SO_2 line depth has increased, *indicating that there is even more SO_2 frost than calculations without removing thermal emission would indicate*. These 1993 observations were collected during a period of relatively low volcanic activity, especially on the trailing hemisphere at Loki. It is possible to reconcile these measurements with the various Howell et al. observations if the measurements presented in Howell el al were collected during a period of higher thermal emission than in 1993. The scatter between 270° and 360° W longitude in Howell's original data (around Loki's longitude) could be additional evidence for the importance of thermal emission in determining infrared SO_2 frost abundance. The Howell et al. measurements have no long wavelength (8-12 μm) data collected contemporaneously so no statements can be made on levels of volcanic activity directly. Therefore this remains a plausible, but unprovable explanation. The reconciliation of the different IR observations, however, only acerbates the discrepancy between the IR SO_2 frost abundances and the uv/visible abundances (i.e. there is now even more SO_2 frost than the uv and visible observations would indicate).

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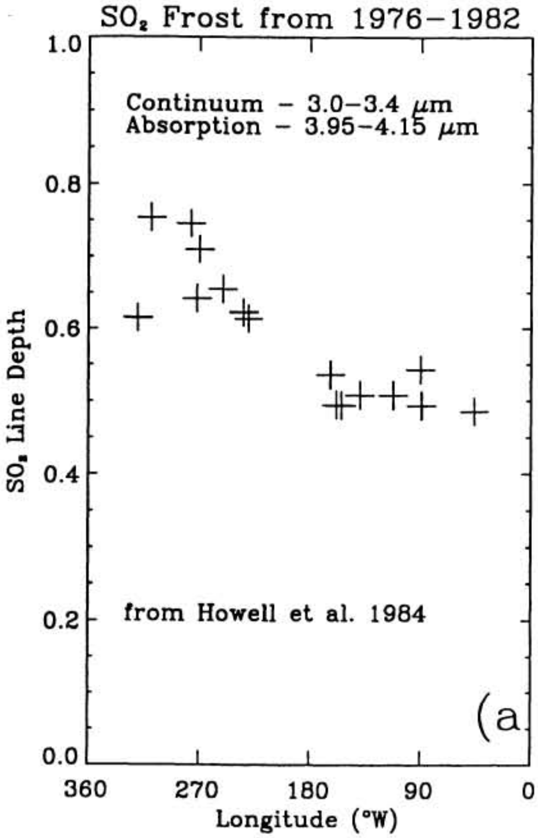

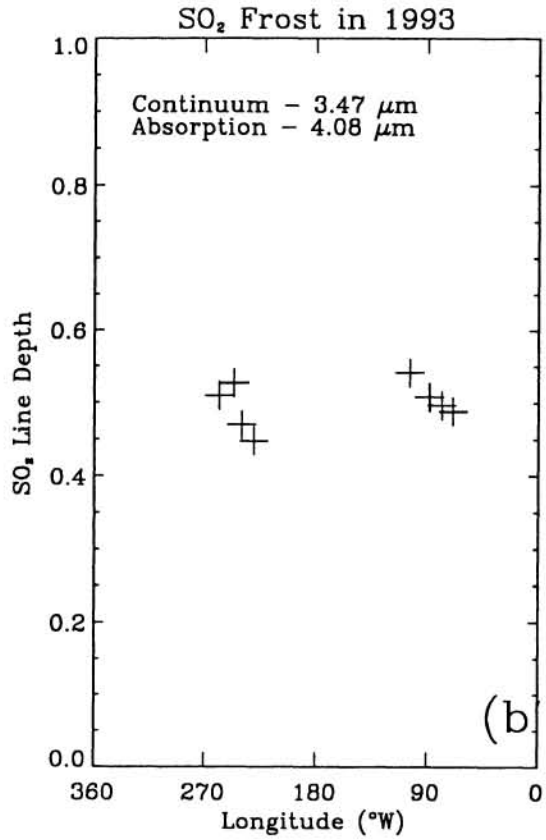

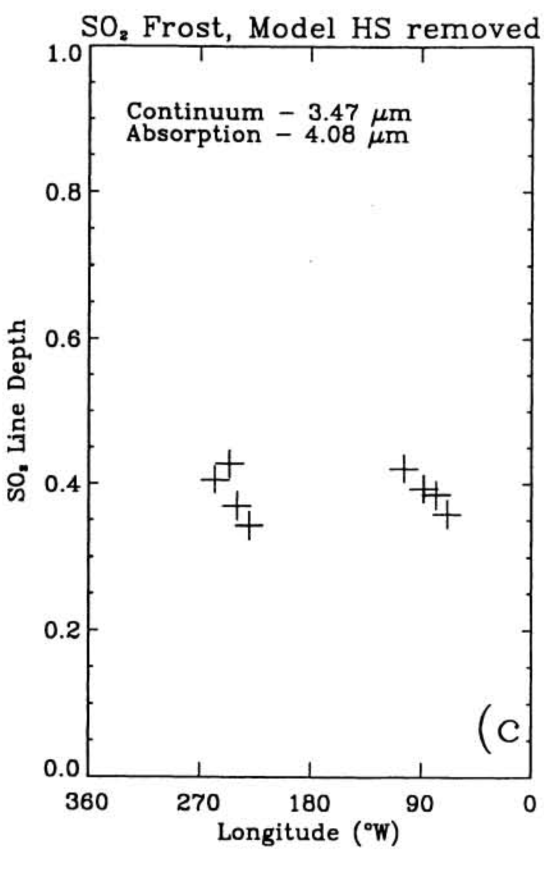

Figure 1. The distribution of SO_2 frost as a function of the longitude of the central meridian of the sub-earth point. a) Shows the frost distribution from Howell et al [1]. The spectra these line depths calculations are based on include thermal emission from volcanic regions as well as reflected sunlight. b) The SO_2 frost distribution from the 1993 BASS spectra. The line depth calculations are based on spectra which have reflected sunlight and thermal emission. Notice that unlike the Howell et al distribution, there is roughly the same amount of SO_2 frost on the leading and trailing hemisphere. c) The SO_2 frost distribution with the thermal emission from volcanic hotspots (HS) removed. The explicit removal of thermal emission acts to deepen the SO_2 line depth, implying greater SO_2 frost abundances (average depth in 1b 0.50, compared to 0.39 in 1c-- a greater than 20% change)

References:[1] Howell et al., Icarus, 57, 82, 1984. [2]. Nelson et al, Science, 210,784-786,1980. [3]. Nash et al., Geophys. Res. Lett. 7, 665-668, 1980. [4]. McEwen et al., Icarus, 75, 450-478, 1988. [5] Warren D. W. and Hackwell J. A., SPIE, 1155, 314, 1989. [6] Hackwell et al., Proc. SPIE Conf. 1235 on Instrumentation in Astronomy VII, 1990. [7] Veeder et al., J Geophys. Res.,99, 17,095-17,162, 1994.