Absorption bands in the Galileo Near Infrared Mapping Spectrometer (NIMS) infrared reflectance spectra, attributed to the presence of CO$_2$ and SO$_2$ on the surface of Callisto, have been analyzed and mapped in greater detail than previously reported [1], resulting in confirmation and extension of previous results as well as new knowledge. The CO$_2$ concentration on the trailing hemisphere has a longitudinal distribution consistent with a modified sinusoidal centered on the equator near 270° longitude (Figure 1). On the leading hemisphere, the only large-scale pattern in the CO$_2$ distribution is a deficiency in the polar regions. In many cases, visibly bright and ice-rich impact craters have high CO$_2$ concentrations within or near them, but the CO$_2$ often appears to be associated more with dark material near or in the craters (Figure 2). The apparently sinusoidal pattern of the trailing side CO$_2$ distribution suggests that exogenic effects related to Jupiter's corotating magnetic field are involved. Elevated CO$_2$ concentrations associated with ice-rich impact craters on the leading and trailing hemispheres suggest impact processes may also affect the distribution of CO$_2$ on the surface of Callisto. The presence of a single band shape and band minimum wavelength position in all data sets for the CO$_2$ absorption implies the physical state of CO$_2$ is similar over the surface of Callisto.

The distribution of SO$_2$ on the surface is less well defined due to characteristically shallower band depths, but it appears generally mottled, with some areas of high concentrations correlated with ice-rich impact craters (Figure 2). Large-scale patterns include the depletion of SO$_2$ in the polar regions; and a depletion of SO$_2$ on the trailing side relative to the leading side. The center of the SO$_2$ band is determined to be between 4.01 and 4.02 µm, which is broader than originally reported and closer to the SO$_2$ gas absorption band near 4.00 µm than the solid SO$_2$ absorption band at 4.07 µm. There is no evidence for a Jovian hemisphere enrichment, suggesting neutral ion implantation is not a significant source for SO$_2$ on the surface. The SO$_2$ depletion on the trailing hemisphere is consistent with previous IUE, HST, and UVS findings and suggests that S$^+$ trapped in the Jovian magnetosphere does not contribute significantly to the SO$_2$ on Callisto. There is no apparent sinusoidal nature to the distribution of SO$_2$ on either hemisphere of Callisto. The differences in the distributions of CO$_2$ and SO$_2$ imply that different mechanisms of emplacement or modification dominate.


Figure 1. A scatter plot of CO$_2$ abundance vs. longitude for the E14GLOBAL and C20GLOBAL observations of the trailing hemisphere. The center of the trailing hemisphere is delineated with a vertical dashed line, and the profile of a sinusoidal distribution with a maximum at 0.29 is plotted as a solid line. Note the general correlation of CO$_2$ abundance with the sinusoidal profile.
Figure 2. False topography derived from the 1.48 µm band depths are colored with CO$_2$ banddepth information for the C3ARINGS and C3ASGARD observations. This displaying technique relates CO$_2$ and water-ice distribution. The highest concentrations of CO$_2$ are consistently related to areas of very high water-ice concentrations (associated with bright impact craters), but not confined to ice-rich pixels. The dark-floored crater in the C3ARINGS observation contains the highest CO$_2$ levels for that observation. Note the effect of spatial resolution on band depths: the ice-rich pixels with the deepest 1.48 µm absorption bands within C3ARINGS are poorly resolved in C3ASGARD.

Figure 3. The (a) 1.48 µm (b) and SO$_2$ band depth maps from the C9VALHAL observation (~40 km/pixel). In this 90° phase angle observation, the limb is over Valhalla Basin and the terminator is off the image to the right. Generally shallow SO$_2$ band-depths (< 10% of the continuum) are typical, but SO$_2$ is enriched adjacent at two large impacts and depleted in a large area northeast of the center of Valhalla Basin (red 'x'). Low signal levels result in uncertain SO$_2$ banddepth estimates near the terminator.