CALLISTO AND GANYMEDE: NEW RESULTS FROM THE GALILEO UVS. Amanda. R. Hendrix[1] and Robert E. Johnson[2], , [1]Jet Propulsion Laboratory/California Institute of Technology, 4800 Oak Grove Dr., MS 230-250, Pasadena, CA, 91109, arh@jpl.nasa.gov, [2]University of Virginia, Thornton Hall B103, PO Box 400238, Charlottesville, VA 22904, rej@virginia.edu.

Introduction: Ganymede and Callisto are both unique icy moons and together present an interesting case for comparisons of the effects of exogenic processes on icy moons as measured through UV spectroscopy. Callisto is darker and more heavily cratered than Ganymede and Europa, and plays a significant part in the understanding of icy moon evolution [1]. Although the radiation environment of Callisto is not negligible, it is farther from Jupiter and evidently outside the region of intense plasma bombardment [2]. In the case of Europa, the surface is highly influenced by the energetic particles trapped in Jupiter's magnetosphere, whereas at Ganymede such bombardment occurs primarily at its poles with much of the low latitude region effectively shielded from particle bombardment by its magnetic field.

We investigate the effects of exogenic processes on Ganymede and Callisto by analyzing Galileo Ultraviolet Spectrometer (UVS) data to determine the spatial distribution of the UV absorption features. Ultraviolet wavelengths sense the topmost layers of the surface, and are therefore very sensitive to exogenic effects. A thorough analysis of Galileo UVS data can lead to a determination of the abundances and distribution of radiation products such as H_2O_2, O_3 and SO_2. Important connections with the external environment have been obtained for bands associated with O_3 on Ganymede [3]. A previous investigation of Galileo UVS observations of Callisto [4] suggested variations in absorption bands across the surface. These studies were all performed before the Galileo mission was complete and therefore with incomplete data sets. Therefore, we now use the full UVS data set to determine the distribution and band depths of various features and then associate these when possible with abundances of radiation products, for these two very different icy moons.

Observations: The Galileo UVS was built at the University of Colorado's Laboratory for Atmospheric and Space Physics and is described by [5]. The observations discussed here were performed using the F-channel of the UVS, which covers the 161.6-321.3 nm wavelength range. The observations were performed in "full-scan" mode, where the grating was stepped over the 528 channels covering the wavelength range in 4.33 sec, with 0.006 sec integration time at each channel. The UVS instantaneous field-of-view (IFOV) was 0.1°x0.4°, and Ganymede and Callisto measurements are generally be classified as low-resolution (or global-resolution) and high-resolution, made from distances of ~200,000 km and ~20,000 km, respectively. During the Galileo mission (1996-2000), the UVS performed observations covering most of the surface of Callisto, focusing on the leading hemisphere. Primary targets were the regions surrounding the Asgard impact basin on the anti-jovian/leading quadrant (central latitude/longitude of approximately 30°N/140°W), and the Valhalla impact basin on the jovian/leading quadrant (central latitude/longitude of approximately 5°N/55°W). Observations of Callisto's south polar region were also made . Ganymede observations focused on the leading and anti-jovian hemispheres, between latitudes 50°S and 50°N, with isolated observations at other locations such as very high southern and northern latitudes.

Analysis: For every observation in the UVS database, we applied the same reduction and analysis technique, as follows. Each spectrum, a total of 14 grating scans (60.67 sec total integration), was converted to a reflectance spectrum by subtracting background, applying calibration and dividing by the solar spectrum. The solar spectrum was measured by the Solar-Stellar Irradiance Comparison Experiment (SOLSTICE) [6] and was double boxcar smoothed to match the UVS resolution. The background signal primarily includes system radiation signal and is wavelength-independent. The background level is determined by averaging the signal at the lowest wavelengths, where reflected sunlight does not contribute to the measured signal.

The Galileo UVS instrument was calibrated in terms of what would be observed from an extended source, in units of 10^6 ph/cm^2-sec-4πstr-Å. The calibrated measurements are brightness = $4\pi I$. Because the SOLSTICE-measured solar spectrum is πF, the reflectance is given as $r=I/4F$, where the solar spectrum is corrected for the Sun-Jupiter distance.

To look for trends in spectral shapes across the surfaces of Callisto and Ganymede, we have taken the approach of fitting portions of each spectrum with a straight line to determine the spectral slopes in the 280-320 nm and 220-240 nm wavelength ranges. In determining slopes, we remove brightness variations due to phase angle variations by first normalizing each spectrum to unity at 255 nm. We use only spectra of adequate signal-to-noise ratio (SNR > 5 at 280 nm).

Callisto Results: All of the reflectance spectra increase in brightness with wavelength over the 200-320 nm range (i.e., they are spectrally red). At high southern latitudes, the spectra tend to be spectrally blue (or "roll over") >280 nm – suggesting the shoulder of an absorption feature with a band center ~350 nm (Fig. 1). At lower latitudes, in both the Asgard and Valhalla regions, such a spectral shape is not seen. We find that the Asgard region is spectrally red at wavelengths >280 nm while the spectra of the Valhalla region are spectrally flat at wavelengths >280 nm. The lower latitudes are generally darker and largely spectrally redder than the high southern latitude region. This suggests that an absorber is present at high latitudes, which is weathered away by charged particle or UV bombardment at low latitudes. We suggest that the high latitude absorption feature could be due to an organic species. A carbon cycle may be occurring on Callisto, with CO_2, carbonates and carbon sub-oxides are principal end-products. The overall dark grey visible appearance of Callisto is consistent with laboratory measurements of carbonization of organics through radiation.

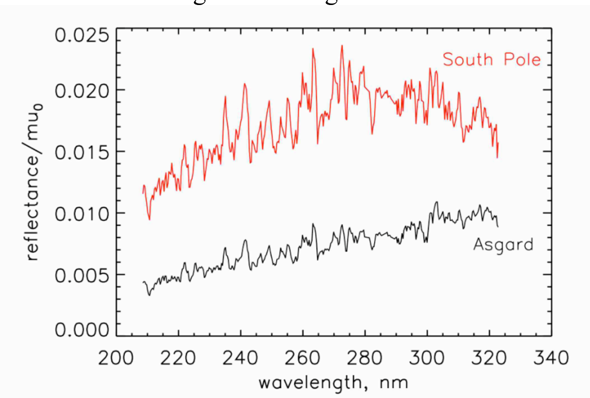

Fig. 1. Galileo UVS reflectance spectra of two regions on Callisto – the low latitude Asgard region and the high south pole region. The south pole region is brighter and the spectrum appears to show the shoulder of an absorption band, which may be the result of an organic species. Both regions were observed at a phase angle of ~40°.

Iogenic material reaching Callisto as a neutral wind has been proposed to explain an absorption feature detected on Callisto's leading jovian-facing hemisphere. The UV absorption feature resembles the 280 nm absorption feature seen on Europa [7][8]. We investigate the extent of this absorption feature as measured by the Galileo UVS.

Preliminary Ganymede Results: Ganymede presents a much more complicated situation than Callisto, with more spectral variation in the UV across the surface; this is consistent with Ganymede's visibly more heterogeneous surface compared with Callisto. Sample Ganymede reflectance spectra are shown in Fig. 2; sources of spectral variations will be explored.

Investigating the spectral slopes in the 220-240 nm and 280-320 nm regions, we find that steeper/redder long-wavelength slopes are present at higher latitudes, consistent with earlier results of concentrations of an ozone-like absorber at high latitudes [3]. We investigate how the spectral variations are related to terrain type (e.g., old dark terrain vs the younger bright regions), as well as magnetic region (i.e., regions of open and closed field lines). We investigate sources of compositional variations that contribute to spectral differences across the surface.

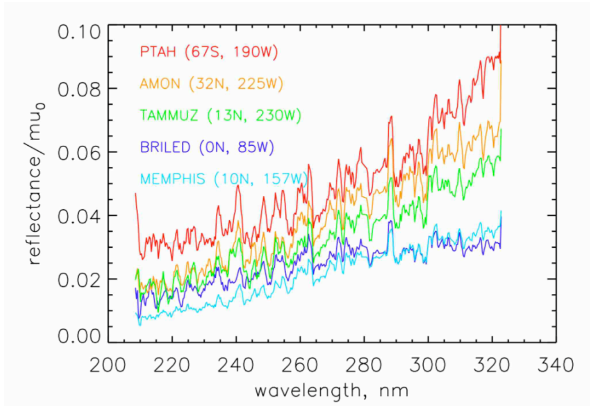

Fig. 2. Galileo UVS reflectance spectra of several regions on Ganymede, all at similar phase angles (~25°). The spectral shape varies widely across the surface, indicating compostional variations.

References: [1] Moore J. M. et al. (2004) in Jupiter: The Planet, Satellites and Magnetosphere [2] Johnson R. E. et al. (2004) in Jupiter: The Planet, Satellites and Magnetosphere [3] Hendrix et al. (1999) *J. Geophys. Res.*, *104*, 14169-14178 [4] Hendrix et al. (1998) *Lunar Planet. Sci., XXIX* #1865 [5] Hord C. W. et al. (1992) *Space Sci. Rev., 60,* 503-530 [6] Rottman G. J. et al. (1993) *J. Geophys. Res., 98,* 10667-10677 [7] Lane A. L. and Domingue D. L. (1997) *Geophys. Res. Lett., 24*, 1143-1146 [8] Noll K. S. et al. (1997) *Geophys. Res. Lett., 24*, 1139-1142.