EUROPA: A NEW LOOK AT GALILEO UVS DATA. A. R. Hendrix[1] and R. E. Johnson[2], [1]Jet Propulsion Laboratory/California Institute of Technology, 4800 Oak Grove Dr., MS 230-250, Pasadena, CA, 91109 hendrix@jpl.nasa.gov, [2]University of Virginia, Thornton Hall B103, PO Box 400238, Charlottesville, VA 22904, rej@virginia.edu.

Introduction: Europa is unique among the icy galilean satellites, in that it is the one (with the exception of Io) that displays indications of recent or current surface activity. These indications include lineaments, triple bands, wedges, icebergs, as well as pits, spots and domes (e.g. [1], [2]). These regions of recent endogenic activity have been found to correlate with Galileo Near Infrared Mapping Spectrometer (NIMS) spectra in which the water ice absorption features at 1.5 and 2.0 μm are asymmetric [3]. There are two interpretations of NIMS Europa spectra and the asymmetric water ice bands that are measured. One interpretation is that the bands are produced by the presence of hydrated salts, such as $MgSO_4 \cdot 7H_2O$, derived from an internal ocean [3]. A second interpretation is that the spectral features are the result of the presence of sulfuric acid hydrate [4] that is being continuously produced and destroyed by radiolysis. More recent laboratory data show that fits to NIMS data are achieved for mixtures of sulfuric acid with sodium- and magnesium-bearing sulfate salts [5].

Disk-integrated UV observations of Europa from the International Ultraviolet Explorer (IUE) [6] and Hubble Space Telescope (HST) [7] show an absorption feature centered at 280 nm on the trailing hemisphere. The absorption feature has been presumed to be due to an exogenic activity such as implantation of sulfur ions [6] and has been successfully compared with a laboratory spectrum of SO_2 ice grown on H_2O ice; the feature is likely related to an S-O bond. Low-resolution disk-resolved UV observations from the Galileo Ultraviolet Spectrometer (UVS) [8] showed that the UV absorption feature decreases in strength with distance from the trailing hemisphere apex (270°W). Examples of two UV spectra of Europa are shown in Fig. 1.

We now present the highest spatial resolution observations from Galileo UVS. Early analysis of high-resolution Galileo UVS observations [9] showed a general correlation between the 280 nm absorption feature and the dark terrain on Europa's trailing hemisphere. We now investigate and quantify that correlation by mapping the band strength for all UVS observations across the surface, and comparing the strength of the 280 nm absorption feature across the surface with the strength of the NIMS-measured asymmetric water ice bands.

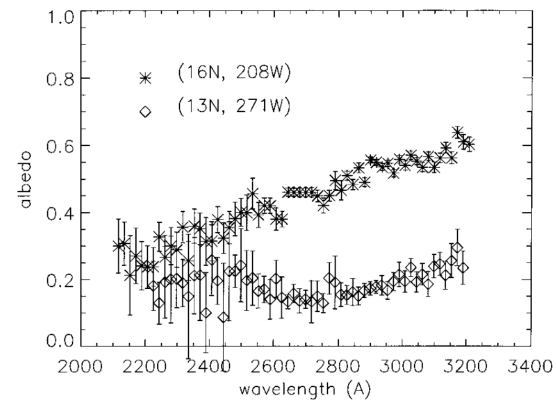

Fig. 1. Ultraviolet spectra for two disk-resolved regions on Europa, from the Galileo UVS [8]. At the apex of the trailing hemisphere (270° W), the 280 nm absorption band is prominent.

Observations: The Galileo UVS performed observations covering much of the surface of Europa, in the 210-320 nm range, at a variety of altitudes and observational geometry scenarios. The UVS instantaneous field-of-view (IFOV) was 0.1° x 0.4°, and the measurements we study here can generally be classified as low-resolution or high-resolution, made from distances of ~90,000 km or ~10,000 km, respectively.

Results: *Strength of UV band.* We quantify the strength of the 280 nm absorption feature in each reflectance spectrum by fitting the data with a straight line and dividing the spectrum by that straight line fit (to remove the overall red slope). The strength of the band is then the ratio of the signal strength at ~310 nm to the signal strength at ~280 nm.

For every observation, the band strength is plotted against location on the surface (longitude). An example is shown here in Fig. 2 (for a partial data set – more observations will be added). There is an overall correlation with longitude, with greater absorption strengths on the trailing hemisphere, as expected from previous disk-integrated observations [6][7] of the UV absorption band itself and from Voyager-era disk-resolved measurements of large-scale UV darkening in the broad-band UV filter [10] [11] [12]. However, the band strength – longitude correlation is by no means perfect, and we find that outlier points are identified with surface features that are visibly dark, such as chaos regions.

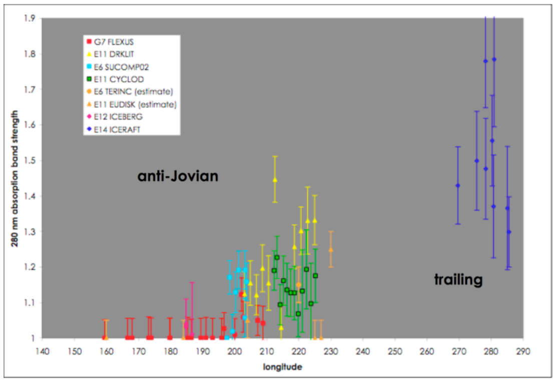

Fig. 2. UVS-measured 280 nm band strength vs. longitude on Europa. Different colors designate different observation sets. The band strength increases toward the trailing hemisphere (as expected). The correlation is not perfect and we find that surface features (such as dark linea and chaos regions) also influence the strength of the absorption band. This plot does not include all UVS observations; more data will be analyzed and presented.

Correlation with NIMS spectral feature. The strength of the NIMS-measured asymmetric water ice bands has been interpreted in terms of abundance of sulfuric acid. We can compare the band strength of the 280 nm feature with the NIMS-measured hydrate abundance for observations when both UVS and NIMS were taking data. For a subset of these observations results are shown in Fig. 3. We find that there is a much better correlation between UV band strength and hydrate abundance than with longitude – suggesting that an internal, endogenic process is also at play in the production of the UV band, and that it is not only due to an exogenic process.

What is the 280 nm absorber? We investigate the spectral shapes of salts such as epsomite ($MgSO_4$•$7H_2O$) and bloedite ($Na_2Mg(SO_4)_2$•$7H_2O$) in the UV, which have been proposed to be responsible for the NIMS asymmetric water ice bands (e.g., [3]). Though laboratory data are lacking, the salts for which we have reflectance data (from the USGS spectral library) do not appear to exhibit any sort of absorption at 280 nm.

As previously suggested, sulfur dioxide displays an absorption at 280 nm, as does the reflectance spectrum of sulfur dioxide ice grown on water ice [13]. It is likely that implantation of S^+ (and subsequent chemistry with H_2O) provides the large-scale pattern of UV darkening; local concentrations of the SO_2 appear superimposed on this large scale configuration, generally correlated with dark terrains. This suggests a local source of SO_2 and/or a heating mechanism (such as diapirism) that could create a concentrated lag deposit.

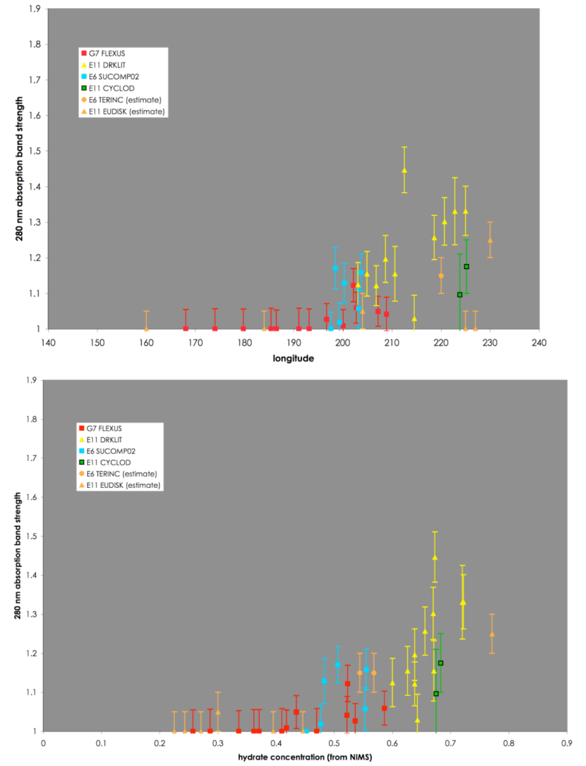

Fig. 3. (Upper) This subset of the UVS observations (those observations for which simultaneous NIMS observations were also obtained) shows the relationship between UV band strength with longitude. (Lower) For the same subset of data, a better correlation is obtained when comparing UV band strength with NIMS-measured hydrate concentration.

References: [1] Pappalardo, R. T. et al. (1999). [2] Greeley, R. et al, (2004). [3] McCord, T. B. et al. (1999). [4] Carlson, R. W. et al. (1999). [5] Orlando, T. et al. (2005). [6] Lane, A. L. et al. (1981). [7] Noll, K. S. et al. (1995). [8] Hendrix, A. R. et al. (1998). [9] Hendrix, A. R. et al. (2000). [10] Nelson, M. L. et al. (1986). [11] Johnson, T. V. et al. (1983). [12] McEwen, A. (1986). [13] Sack, N. et al. (1992).