VOYAGER IMAGES REVISITED: NEW VIEWS OF THE SATELLITES OF SATURN AND URANUS. P. J. Stooke[1], [1]Department of Geography, University of Western Ontario, London, Ontario, Canada N6A 5C2; pjstooke@julian.uwo.ca; www.uwo.ca/geog/faculty/stooke.htm

Introduction: Voyager images of Saturn and its moons are 20 years old, and images of the Uranian system are 15 years old. Although much was learned from them, more may still be done using recent image processing methods. Here I present results of a program of reprocessing of images of the icy satellites of these two planets. Highlights include the identification of features illuminated by planetshine on the northern hemisphere of Ariel, enigmatic markings on Enceladus and the identification of new features on Rhea and Umbriel. This program will result in new maps of the Saturnian satellites in time for Cassini's arrival.

Images and Processing: This study makes use of all available images from the PDS Ring Node archive. An interesting observation, which this program will rectify, is that the USGS maps of all these satellites do not make full use of the image sets. The large blank areas in the maps can be filled in most areas, often with images which show substantial detail when processed using new approaches.

Processing followed several typical steps, adapted as necessary for the individual images and sequences. For individual frames, details at all scales from the individual pixel to broad regional albedo variations were enhanced by processing the frames using high pass filters of various different sizes. Limb saturation effects created by filtering were suppressed by local adjustment or by replacing the artifact with an unprocessed patch. The differently filtered versions, and different contrast stretches of each, were combined to give composites which share the better qualities of each process. Multispectral sequences were merged using the super-resolution method to suppress noise further and increase visibility of fine detail. Reseau marks were removed by replacing the mark with a patch from another image. That these steps did not introduce large numbers of new artifacts is clearly demonstrated by the repeatability of features from image to image through the image sequences. The full set of processed images will be made available at:

http://www.ssc.uwo.ca/geography/spacemap/contents.htm

Results: Figure 1 shows two of the frames from the highest resolution sequence of Ariel, specially processed to show detail on the northern hemisphere (right) illuminated by planetshine. Uranus is overhead near bottom centre in this image. A bright ejecta crater with a darker floor and possible central peak are clearly seen near the sub-Uranus point. At top near the planetshine terminator, the sinuous graben complex Kachina Chasmata extends far into the northern hemisphere, possibly to the far limb. Additional details may be revealed by better noise removal. Unfortunately, few other Uranus satellite images show useful details in planetshine. Either the satellite is too far from the planet, and so more weakly illuminated, or the 'dark' side is seen only very obliquely in low phase angle views.

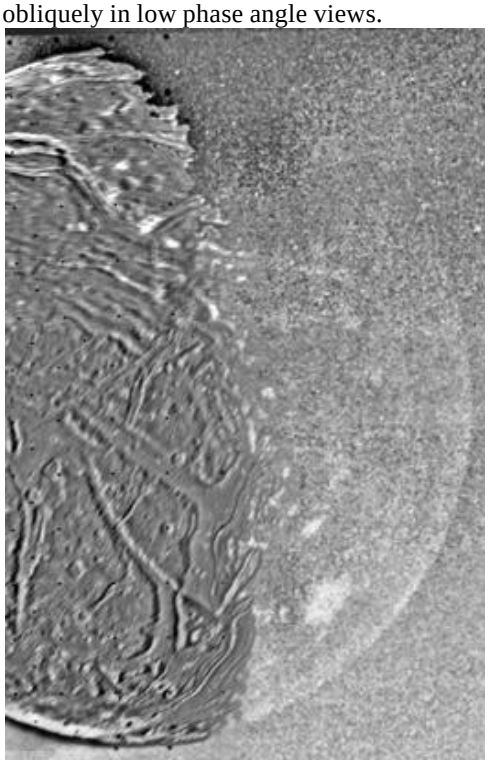

Figure 1. Ariel, mosaic of frames 2684537 and 2684539 from high resolution sequence showing features illuminated by planetshine. See text for discussion.

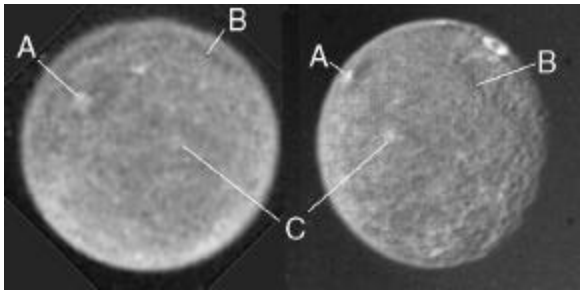

Figure 2. Umbriel: image composites from the 26797xx and 26825xx sequences. Corresponding points are lettered. A possible large basin surrounds A. See text for discussion.

Figure 2 shows Umbriel in the sequences before the highest resolution frames. The image at right was used in USGS mapping. In the left-hand image, at top left above the bright spot A, additional features can be seen, including a dark feature near the limb similar in form to feature B, a low albedo streak or possible degraded basin. In general, all Uranian satellites show additional features in low resolution views which are not shown on USGS maps.

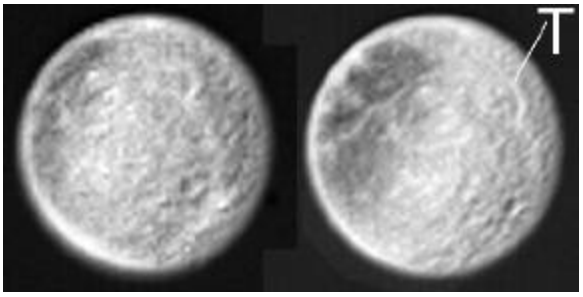

Figure 3. Rhea: Super-resolution composites of images from the 34870xx and 34877xx sequences. See text for details. T = Tirawa basin.

The Rhea images in Figure 3 show what super-resolution can reveal in Voyager images. The multispectral sequences can be combined to produce super-resolution composites with considerable noise reduction and some improvement in resolution, since regional color variations are very minor. The Tirawa basin (T) is seen here, together with a possible degraded impact basin, or tectonic corona-like structure, of similar size to its west (left). Cratered terrain is clearly resolved in the bright regions here, but is not seen as clearly in later, higher resolution images of the dark region at left. Most of the region shown here is blank on USGS maps.

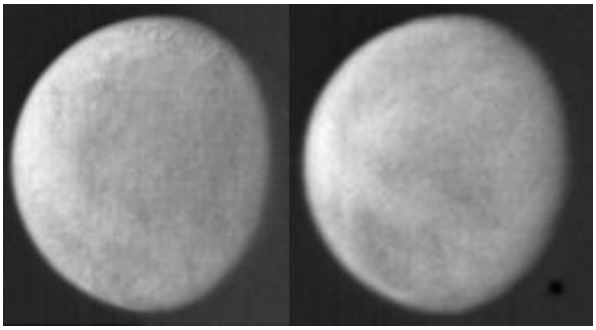

Figure 4. Enceladus: 43989xx and 43986xx image sequences showing subtle shading details.

The Voyager 1 views of Enceladus show complex albedo features near the south pole, including dark patches and bright streaks. These plus a longitude region near 90° are omitted from the USGS maps. In Figure 4, careful processing results reveal subtle shadings, including a linear east-west bright band just south of the equator which appears to be offset left-laterally, possibly more than once. Figure 5 combines all Voyager images in a global mosaic, revealing that the bright streaks near the south pole merge with very rugged terrain seen on the limb in the best Voyager 2 sequence. Figure 6 is a polar equidistant projection of the southern hemisphere, putting the polar albedo features in context. Maps such as these will be produced for all small and mid-sized bodies imaged by Voyager, and should be useful for Cassini image targeting.

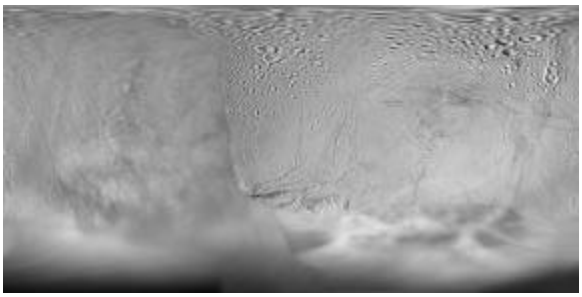

Figure 5. Global photomosaic of Enceladus from Voyager 1 and 2 images. Photometric information is lost in the processing, but details of markings and structures are enhanced. Zoom in for clearer view.

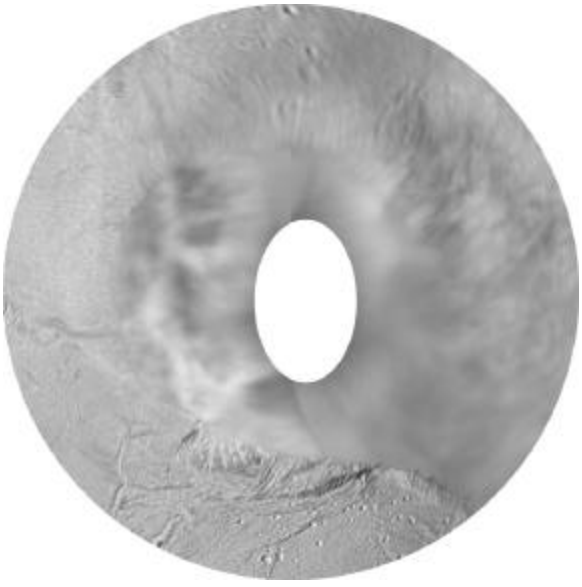

Figure 5. Southern hemisphere of Enceladus from the mosaic of Figure 4 (azimuthal equidistant projection). The central ellipse is the only region not imaged by Voyager. Zoom in for clearer view.