Ingestion, Camera Model, and Processing Software for JunoCam images based on USGS Astrogeology's Integrated Software for Imagers and Spectrometers (Version 3). M.P. Milazzo[1] J.W. Backer[1], J. Mapel[1], K. Berry[1], C.J. Hansen[2], [1]USGS Astrogeology, Flagstaff, AZ, USA (moses@usgs.gov), [2]Planetary Science Institute, Tucson, AZ, USA.

Introduction: JunoCam is a wide-angle camera designed and operated in a manner that allows collection of image data of Jupiter's polar regions uniquely defined by Juno's polar orbit [1]. JunoCam observations consist of a sequence of frames acquired as the instrument utilizes Juno's spin-stabilization to perform "push-framing" during flybys of Jupiter. Each frame can include up to three filters, and each observation can include many frames. There are four filters bonded to the detector's photoactive surface: "Methane" (880-900 nm, centered at 889 nm); "Red" (600-800 nm, centered at 698.9 nm); "Green" (500-600 nm, centered at 553.5 nm); "Blue (420-520 nm, centered at 480.1 nm) [c.f., 1].

The USGS Astrogeology's Integrated Software for Imagers and Spectrometers version 3 (ISIS3) is a suite of programs designed to provide research scientists with the capability of performing three main geometric functions: 1) Applying an accurate and precise instrument model to level 0 datasets so sensor data may be ingested into a common format [2]; 2) Ingesting and attaching appropriate NAIF SPICE or similar data that then allows geometric adjustments to be made to the data in order to account for actual viewing conditions and to allow mapping pixel locations to body surface locations in several coordinate systems [3]; 3) Photogrammetric corrections of large amounts of data from multiple instruments on multiple spacecraft—this is commonly referred to as "bundle adjustment" [4]. In addition to geometric corrections, ISIS3 includes the ability to process sensor data through radiometric and photometric models based on the above derived and corrected geometric information as well as models of radiometric and photometric behavior of the target body.

Ingestion of JunoCam data into ISIS3: The ISIS3 ingestion routine applicable to JunoCam is called *junocam2isis* and allows one of two separate ingestion functions: 1) FULLCCD=True allows one to import PDS-delivered JunoCam observations as a sequence of frame-sized images in which each filter's data is located as would be seen on the CCD at the time of that frame's acquisition (Fig. 1). This ingestion method is especially useful for understanding the relationships of concurrently-acquired filter data. 2) FULLCCD=False (default) instead ingests each filter framelet as a separate image. This ingestion method is needed to maintain SPICE information for each framelet so that precise geometric corrections and thus mosaics of each filter can be made as accurately as possible (Fig. 2).

Further processing enabled by ISIS3: Once the JunoCam data have been ingested into ISIS3 (generally with the FULLCCD parameter set to "False"), the individual framelets of a given filter can be easily map-projected and then mosaicked together to provide a set of full-observation color filters (Fig. 3). Those may then be stacked into a multi-color image. Due to potential pointing issues with the spacecraft, these mosaicked color images do not necessarily have perfect alignment between each framelet. ISIS3 can be used to do photogrammetric control of all of the framelets and thus enable improvements to both the overlapping of the framelets and to the observations's SPICE information. Once the data are bundle-adjusted, they may be used to com-

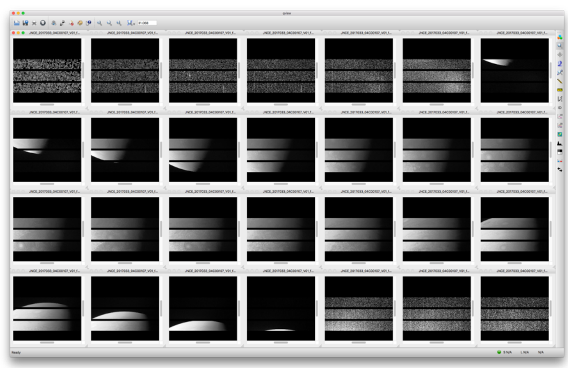

Figure 2. Sequence of 28 full-CCD frames acquired that make up the full observati on. Observation ID: JNCE_2017033_04C00107.

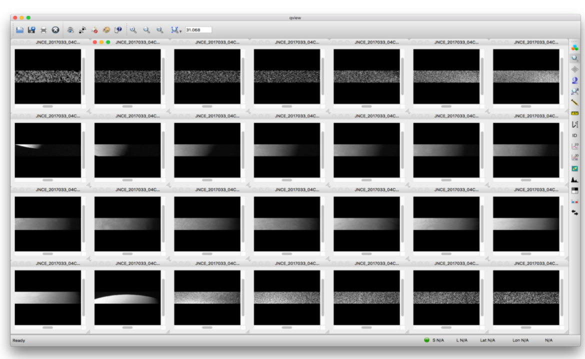

Figure 1. A sequence of 28 framelets of just the green filter from a full JunoCam observation acquired during Juno's fourth orbit of Jupiter. Observation ID: JNCE_2017033_04C00107.

pare against other data acquired by JunoCam or previous imaging systems such as the imaging systems onboard Voyager, Galileo, and Cassini

Complications: At the date of abstract submission, the camera model and SPICE ingestion is producing a consistent offset between where SPICE and/or, the ISIS3 implementation of the camera model suggest the target is and where the target appears in the images (Fig.

Figure 3. Full observation color mosaic produced in ISIS3. This mosaic is created assuming the delivered SPICE files are correct, this means geometric corrections have been performed, but no photogrammetric control has been ap-

4). At present, this is expected to be a timing issue because the offset seems to consistently increase with time as more frames are acquired during any given observation as opposed to a random offset in SPICE's suggestion of where the instrument is pointed and where it's truly pointed. We expect to have corrected this timing issue by the time we deliver our Poster to this conference.

Additional Work: Obviously, first we must reconcile the difference between where the ISIS3 and SPICE combination suggest the target should be with where it appears in the images. We might also add additional functionality including a simple flatfield and radiometric correction procedure. Finally, we are hoping to develop a processing pipeline and intend to include the JunoCam data into the PILOT user interface to data served by the USGS Imaging and Cartography node of the PDS [5].

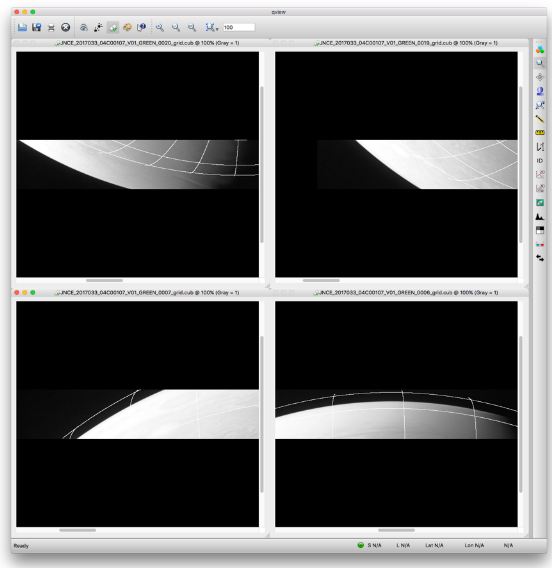

Figure 4. Comparison of Jupiter in a given framelet and where ISIS3+SPICE currently suggest Jupiter should be (shown as latitude and longitude gridlines). This offset is being investigated and an update will be reported at the conference. Observation ID: JNCE_2017033_04C00107

References: [1] Hansen, C. J. et al. (2014) Space Sci Rev., 213:475-506. [2] Gaddis, L. et al. (1997) *LPSC XXVII* Abstract #1226 [3] Becker, K. (2013) *LPSC XLIV,* abstract #2829. [4] Edmundson, K. et al., (2012), Remote Sensing and Spatial Information Sciences, Volume I-4. [5] Hare, T.M. et al., (2014), *LPSC XLV*, abstract #2487.