

MESSENGER MASCS UVVS Processing Updates – PDS 16
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CDR Processing Updates

Grating shift correction

A grating drive anomaly occurred three times during the course of the MESSENGER mission in which the UVVS grating drive jumped a fringe pattern: once during the first flyby (Jan 14, 2008) and twice during the orbital phase (March 30-April 23, 2012 and Sept. 5-Nov. 22, 2013). This caused all data taken after the jump to be shifted by 5 grating steps relative to the expected position, which in turn caused an incorrect registration in wavelength. Each time the anomaly occurred, re-initializing of the UVVS via the startup procedure re-centered the grating and corrected the shift. However all spectral data taken during the anomaly were affected.

Figure 1 illustrates the anomaly. Figure 1a shows a typical measured sodium (Na) spectral scan. To isolate the exosphere emission component in the scan, the dark counts and any solar background must be estimated and removed from the measurement. The solar background is estimated by fitting a reference solar spectrum to the wings of the spectral scan while maintaining the core-to-wing ratio of the Fraunhofer absorption line. Figure 1b shows a Na scan suffering from the grating drive anomaly. The difference between the scans is apparent in the longer wing on one side of the emission and the absence of the wing on the other side; the lack of one solar wing makes removal of the solar spectrum more complicated. Together with the shift of the spectral line away from the scan center, these issues result in a processing failure when the standard data pipeline is used.

The CDR processing code was updated to correct the Ca, Mg and Na data products during these time periods. We shifted the wavelength registration so that the spectral line(s) were at the correct wavelength(s). This caused the spectral scan to be truncated by 5 wavelength steps on the long wavelength side of the scan, which unfortunately cuts off the long-wavelength wing normally used to fit a solar spectrum. For dayside data, where the solar continuum is subtracted, we modified the existing code to ensure a proper solar fit and subtraction, but because part of the wavelength scan is truncated, a good solar fit was not always possible. The truncated data are set to zero in the CDRs during the aforementioned time ranges. Other data taken during this time period (excluding Ca, Na, Mg) have not been corrected; this includes all data in the MUV and FUV channels.

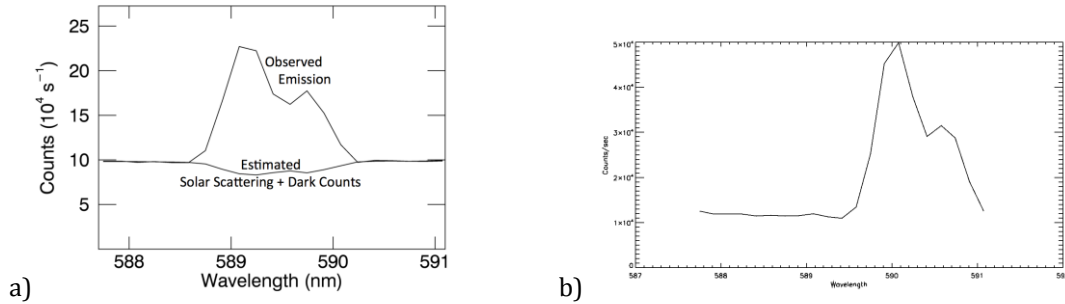


Figure 1: a) Example of a UVVS spectrum of sodium D_1 and D_2 emission in observed counts/sec. The estimated solar scattering and dark count backgrounds are used to isolate the exospheric emission. b) Example of a sodium spectral scan affected by grating drive anomaly. The range of measured wavelengths has shifted by 5 grating steps, which cannot be accommodated by the existing CDR pipeline.

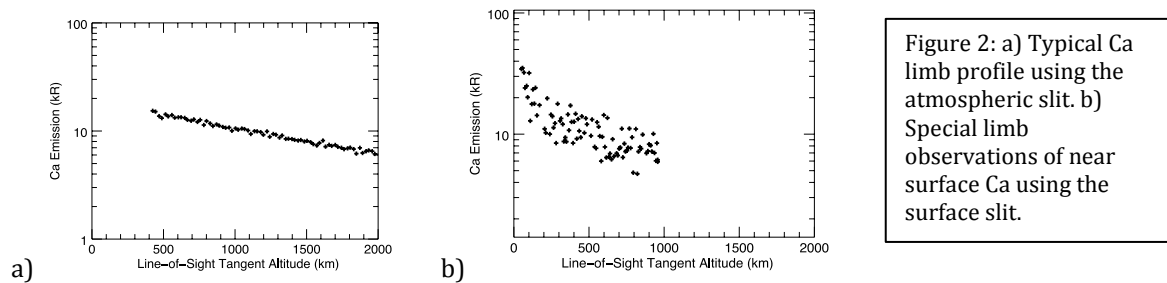
Dayside potassium processing update

Due to thermal effects, there is a small (less than a single grating step) wavelength shift in each spectral scan. This causes a slight change in the shape of the Fraunhofer features and solar continuum. These small shifts in wavelength can have a big impact on the retrieved radiance values because an improper fit and removal of the solar background could cause some wavelengths in the resulting spectrum to have very high or very low (negative) values due to the offset. To fine tune the retrieval process we implemented code to fit an assortment of convolved solar continuum spectra that are slightly shifted in wavelength. The code finds the spectrum with the best fitting coefficients and uses it in the retrieval process. The enhanced retrieval process was implemented for both Ca and Mg in PDS delivery 15. It was applied to the potassium CDR data for PDS delivery 16. Because the Na signal is so strong compared to the solar scattering signal, this correction did not need to be applied to the Na data.

DDR Processing Updates

Dayside Ca surface-slit averaging

Dayside UVVS limb scans of calcium were observed with a systematic cadence throughout the MESSENGER orbital phase. Typically, a set of altitude profiles was obtained every third orbit at seven evenly spaced local times beginning at 6 am and ending near 6 pm. The altitude range probed per profile varied between 50 km-2500 km and 50 km-1000 km with a sampling resolution of 150-200 km using the large “atmospheric slit” of the UVVS (see Figure 2a). However, owing to solar light scattered from the dayside surface, Ca measurements obtained below 400 km altitude with the atmospheric slit are saturated and are not usable. To probe this important region of the exosphere, special observation sequences were designed to use the smaller “surface slit” of the UVVS, which reduced the solar scattering by a factor of 20 and enabled unsaturated observations of Ca near the surface with much higher spatial resolution (see Figure 2b).



Using the smaller surface slit allowed fewer photons to reach the instrument detector, thus avoiding saturation of the Ca observations near the surface. However, although these observations are now usable, they are extremely noisy. To make these observations more useful to researchers, we post-processed these data by doing a running 4-point smooth over adjacent points. The raw spectral scans were averaged before solar continuum subtraction and calibration. We only averaged dayside data and used points that were adjacent with similar observing geometry, such as found in the dayside limb scans and limb opportunities observation types. The averaged data replaced the dayside limb data where a surface slit was used in the PDS 15 and earlier Ca DDRs. The corresponding geometry variables were also replaced with averaged values, whereas the time variables correspond to the first data point of the 4 averaged points. The original un-averaged data are still stored in the CDRs in the event the unaveraged data are desired.

Instrument scattering correction for dayside Mg observations

At certain viewing geometries scattered light reflecting off one of the UVVS instrument components entered the detector housing and contaminated the measured spectra by artificially raising the baseline background signal (See Figure 3). This additional background was discovered to significantly impact the measured

Mg emission, and routine observations were employed to track and characterize this anomaly from its discovery in March 2013 to the end of the mission in March 2015. A correction algorithm has been developed and tested and is now incorporated, but all data from PDS delivery 15 and earlier were affected. Without this correction, the dayside Mg data in the PDS would be unreliable, particularly at the lower altitudes.

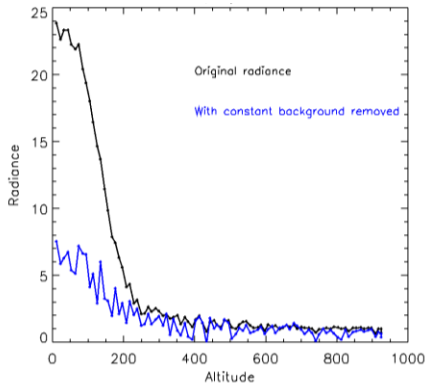


Figure 3: Example Mg dayside emission profiles with and without the background correction. The black line represents the measured Mg emission profile without a correction and is representative of data currently in the PDS. The blue line is the same profile with the correction applied. The reported Mg radiances in the PDS are in error by as much as a factor of 5 at the lowest altitudes.

The Mg correction was formulated by analyzing the routine observations of the background signal. It was determined that the anomalous background signal varied by altitude, true anomaly and local time. A lookup table was designed to correct the Mg dayside limb scans based on these three variables. We incorporated the correction into the DDR code to correct only the Mg dayside limb scans taken between March 2013-March 2015. All other Mg observations taken on the dayside have not been corrected and are not included in the Mg DDRs. None of the CDR dayside Mg data have been corrected as it was determined that the DDRs are the best calibrated set of Mg data to work with.