CALIBRATION ISSUES WITH DATA FROM THE ISO-SWS

G. C. Sloan[1], **K. E. Kraemer**[2], **and S. D. Price**[2]

[1]Boston College, Institute for Scientific Research, 140 Commonwealth Ave., Chestnut Hill, MA, 02467-3862, USA
[2]Air Force Research Laboratory, AFRL/VSB, 29 Randolph Road, Hanscom AFB, MA 01731-3010, USA

ABSTRACT

The calibration of data from the Short Wavelength spectrometer (SWS) has improved markedly since the end of the Infrared Space Observatory (ISO) mission. However, some problems remain in the most recently available pipeline data. These include: (1) variation in dark current during a scan; (2) artifacts in the data at wavelengths near abrupt changes in the responsivity correction; (3) proper identification and correction of glitches in the data and their effects on later stages of processing; (4) discontinuities in flux from one spectral segment to the next. We describe our efforts to evaluate and correct these problems.

Key words: ISO – SWS

1. INTRODUCTION

The star-type program (STARTYP) is a dedicated time experiment to create calibrated spectra of all sources observed in the full-scan (AOT01) mode of the SWS. The spectra are then to be ordered into an infrared spectral classification scheme.

Although considerable progress has been made on the calibration of the SWS spectra since the observing phase of ISO concluded in 1988 May, problems with the calibration remain the biggest challenge to the STARTYP analysis. We focus here on the problems that we have identified in the current publically available version of calibrated data created by the Off-Line Processing version 9.5 (OLP 9.5) and discuss the improvements which will be implemented in OLP 10.0 and how well these improvements mitigate these problems.

2. VARIATIONS IN DARK CURRENT

The dark current (DC) in bands 2 and 4 varies during a scan. The amplitude of this variation depends on the history of the flux seen by a given detector. This problem is inherent to the bulk extrinsic detectors used in these bands and has the added complication that the time constants of the variation are flux dependent (e.g. Zachor & Huppi 1981; Zachor et al. 1982). The blocked impurity band detectors used in band 3 do not suffer from this effect (Stetson et al. 1986 and references therein). If uncorrected, this memory effect results in significant differences between the spectra taken in the up and down scans. Proper correction for this effect would reproduce the known spectra of calibration stars and produce consistent spectra that are independent of scan direction.

OLP 10.0 will employ a new routine, *dynadark*, based on the Fouks-Schubert memory model (Fouks 2001), to estimate the dark current during a scan. This algorithm assumes that the detector has not been exposed to any sudden jumps in flux.

Fig. 1 illustrates the results from the current version of the *dynadark* routine. This procedure usually improves the data in Band 2C, but occasionally degrades the match between scan directions in Band 2A.

When detectors are exposed to a sudden large change in flux level (e.g. at the beginning of a scan of a bright source), they respond with a "hook" effect (see Sclar 1983 and Fouks 2001 for details). OLP 10.0 will not correct for this effect and, therefore, cannot remove the problem. The work-around solution is to rely more on the spectrum in the down scan. This scan follows the up scan and the detectors usually have more time to equilibrate to the flux levels in the spectrum.

Unfortunately, there is currently no version of *dynadark* applicable to Band 4. Kraemer et al. (2001) illustrate the seriousness of this problem in selected spectra.

3. ARTIFACTS FROM THE RSRF

The spectra are created by dividing the measured data by the relative spectral response function (RSRF) of the spectrometer. Some spectra show artifacts at wavelengths where the RSRF has a steep slope or strong features. The artifacts most likely result from a poor correction for the changes in the DC offset (Leech et al. 2001). The additive shift produced by a DC error would create an artifact from the multiplicative correction for RSRF. The *dynadark* improvement to the DC offset reduces the artifacts, as seen in Fig. 2.

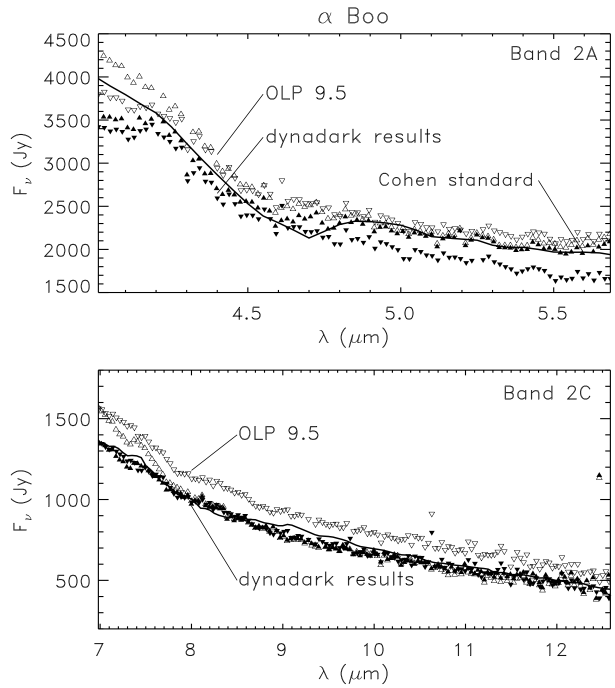

Figure 1. A comparison of OLP 9.5 data for α Boo (open triangles) to new results using dynadark *(filled triangles) and the standard spectrum for this source (solid line, Cohen et al. 1995). Triangles pointing up denote the up scan; those pointing down are for the down scan. While* dynadark *improves Band 2C, its effect on Band 2A is not as good.*

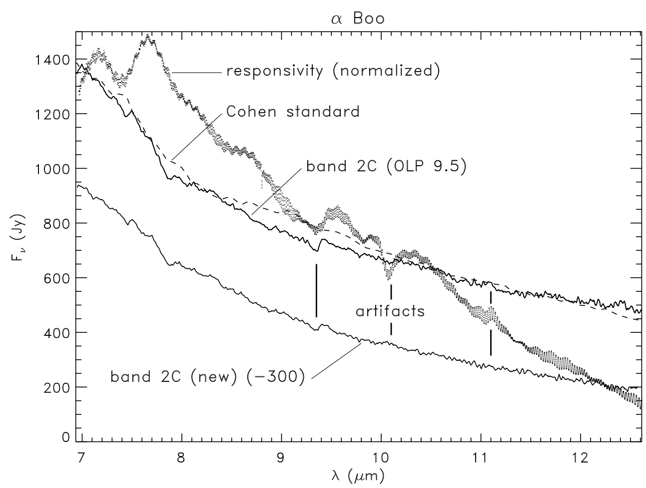

Figure 2. Responsivity artifacts in the data (solid lines). The new curve from OLP 10.0 is offset down by 300 Jy, and it illustrates how the dynadark *routine improves the DC correction and thus reduces the impact of the artifacts. For comparison, the Cohen spectrum is plotted as a dashed line.*

4. FLAGGING OF BAD DATA

The algorithm in OLP 9.5 that flags bad data produced by radiation hits is imperfect. Narrow atomic lines are sometimes flagged, which leads to an irrecoverable flux miscalibration for the lines. Fig. 3 illustrates these effects. The new pipeline processing has an improved flagging algorithm that produces fewer erroneously flagged atomic lines (Lahuis et al. 2001). Generally, even when lines are flagged, the presence of other atomic lines will alert the user to the possibility that these are real features.

Radiation hits often produce spikes followed by long tails, especially in Band 4. While the spike may be flagged, the tail often is not. Removing the tails would improve the quality of Band 4 significantly, and we are working on an algorithm to do so.

It is straightforward to implement a spike-rejection filter that can catch many of the other remaining spikes, and we are also developing techniques to automatically search for and flag these in all spectral segments. However, care must be taken. Apparent spikes appearing in all detectors at a given wavelength and in both scan directions are most likely real.

5. SEGMENT-TO-SEGMENT NORMALIZATION

This problem is often referred to as "stitching." Despite efforts to calibrate the flux of each spectral segment in the standard pipeline, discontinuities usually exist at the boundaries between each of the 12 spectral segments. This problem is likely to be the most significant difficulty in producing complete spectra over the full wavelength range of the SWS after all the updates to OLP 10.0 are implemented.

This problem most likely results from errors in satellite pointing (Shipman et al. 2001). Since the point spread function (PSF) is comparable in angular size to the aperture, a slight offset from the center of the aperture will result in truncation of the PSF. Unfortunately, the SWS calibration measurements are also affected by this problem so the apparent errors in the scientific data can be below or above true values, as Fig. 4 shows.

A formal solution to this problem does not yet exist. A work-around is to apply multiplicative normalizations to segments to reduce the discontinuities at their boundaries.

Unfortunately, there is no current algorithm to cope with a possible consequence of this problem: changes in the shape of the spectrum *within* a spectral segment. As an example, Band 2C runs from 7 to 12 μm, so the width of the PSF will nearly double from the blue to the red end of the spectrum. If some fraction of the flux from a source is truncated by the aperture due to a pointing problem, this fraction will increase with wavelength.

6. CONCLUSION

The new version of the pipeline processing due to be released this year should solve many of the problems described here. In particular, OLP 10.0 should significantly reduce the errors produced by floating dark currents, which in turn will also reduce artifacts from the RSRF. It should

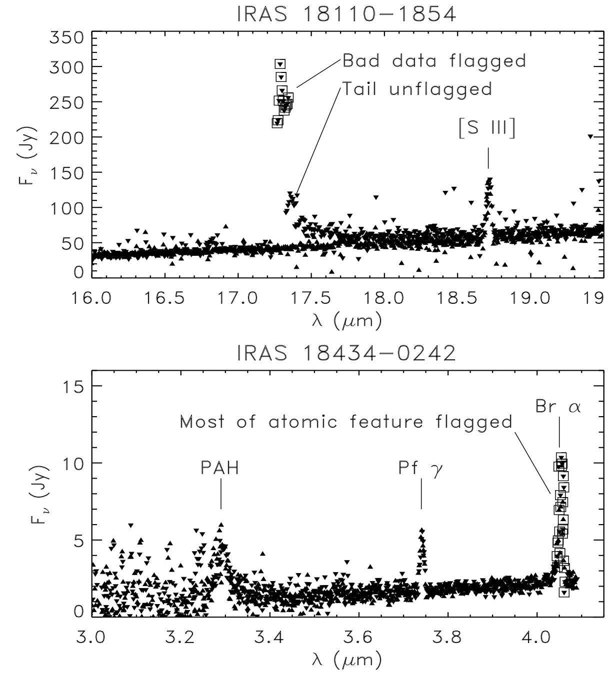

Figure 3. Glitches and flags in two sources with atomic lines in spectra from OLP 9.5. Triangles denote scan directions as in Fig. 1. In the upper panel, a strong radiation hit is flagged, but its tail is not. In the lower panel, the Brackett α line has been flagged as a radiation hit. In OLP 10.0, fewer atomic lines will be flagged as hits (Lahuis et al. 2001).

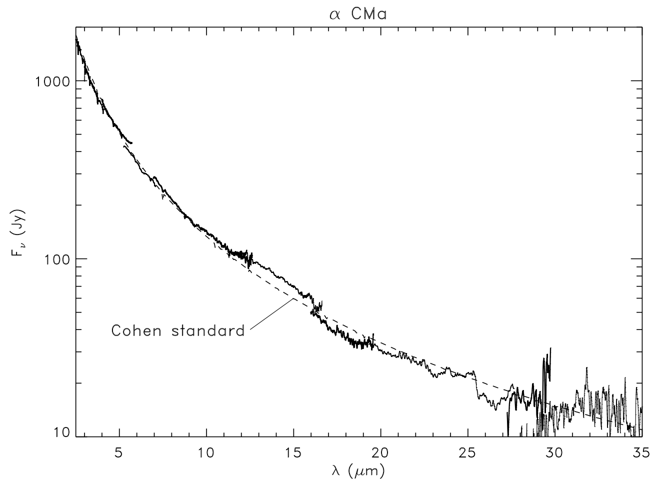

Figure 4. The spectrum of α CMa (solid lines) compared with the standard spectrum for this source (dashed line; Cohen et al. 1992) Alternating bands are plotted with thin and thick solid lines. The discontinuities between spectral segments are a serious problem.

also reduce the number of atomic lines flagged erroneously as radiation hits.

Anticipated improvements after the release of OLP 10.0 should provide even better corrections to the floating dark current, and we are implementing post-pipeline algorithms to flag many of the spikes and tails.

The most significant unsolved problem involves stitching spectral segments to each other. The simple expedient of using regions of overlap to multiplicatively normalize one spectral segment to its neighbor will not correct for distortions to the shape of the spectrum within a segment which would result from partial obscuration of the object by the aperture edges.

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