SWS AOT-1 High Resolution Processing: Documentation

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Abstract

We present a complete set of 315 high resolution processed AOT-1 speed 3 and 4 spectra. The high resolution is achieved by splitting the integration ramp in several sub-slopes per reset interval. In addition we present a complete set of 439 AOT-1 speed 1 and 484 speed 2 spectra at normal resolution, but processed through an updated pipeline and defringed. All observations are provided in two versions, normal and defringed. A searchable catalog containing all observations with their average flux and noise per AOT-band is provided as well.

1 INTRODUCTION

1.1 SWS AOT-1

The SWS AOT-1 spectra cover the entire SWS spectral range (2.38 to 45 micron). This broad coverage could be achieved in a limited time using instrumental smoothing by moving the grating scanner over several scanner steps within one integration reset interval. There exist four different speeds for the AOT-1 spectra which are defined by their size and the number of scanner steps. Table 1 describes these speeds in terms of duration, reset interval, dwell time (time during which the grating does not move), scanner step size, number of updown scans and the degradation of the normal AOT-1 wrt. full grating resolution. More information on the AOT-1 observing mode can be found in the ISO handbook, volume V: SWS - The Short Wavelength Spectrometer.

1.2 PIPELINE PRODUCTS

The current AOT-1 products available in the ISO Data Archive (IDA) have been processed with the automatic data-analysis pipeline, i.e. Off-Line Processing (OLP) version 10.1. Each observation has three sets of data products; the ERD (Edited Raw Data), the SPD (Standard Processed Data) and the AAR (AutoAnalysis Results). In addition for some observations there exist the Survey Products, Icons and Postcards, and various Highly Processed Data Products (HPDP).

Speed	Duration [sec]	Reset [sec]	Dwell [readout]	Scanner [step size]	Resolution degradation
1	1200	1	3	4	3.2∼5.4
2	1900	2	3	2	3.5∼6
3	3600	2	3	1	2∼3
4	6500	2	6	1	1.3∼1.5

Table 1: Definition of the AOT-1 observing speeds by reset length, dwell time and the scanner step size. In the last column the degradation of the normal AOT-1 wrt. the full grating resolution is given. The degradation varies with detector band and with wavelength.

2 AOT-1 HPDP: SPEED 3 AND 4

This section describes the automatic processing which produces the high resolution AOT-1 speeds 3 and 4 products. All observations are reprocessed to the AAR using OSIA 4.0 the specific sequence of routines is listed in Appendix A. The calibration files remain the same as for OLP10.1 with the exception of CAL25 3A 060 which is an updated version of the band 3A relative spectral response function.

2.1 ERD to SPD

The pipeline uses the standard ISP_DSPD routine with the addition of the newly introduced keyword SUBSLOPE. This keyword defines the number of subslopes into which each second of the integration ramp is split. For speeds 3 and 4 the value is set to SUBSLOPE=1. This results into two sub-slopes per reset. The implementation of the sub-slope in the pipeline is described in Lahuis & Kester (2003). During the data reduction we encountered some problems in sub-routines used in the high resolution processing. These problems are briefly explained below. The routines in OSIA 4.0 are updated with the fix (see manual OSIA 4.0).

2.1.1 PULSESHAPE CORRECTION

In many observations there were some detectors that showed an improper splitting of the continuum after high resolution processing. Upon further investigation this problem was traced to an improper pulse shape application. The problem only appears when performing high resolution processing and is not deemed a significant problem for the existing OLP10.1 data products.

2.1.2 SUBSLOPE CORRECTION

In the high resolution sub-slope mode, the fitting of multiple slopes to the integration ramp could produce holes in the continuum around strong unresolved lines. This problem was traced back to the fact that the sub-slopes were not completely following the change in the integration ramp. The problem was resolved by processing with more sub-slopes and then combining slope fragments to make up the desired sub-slope. For the data processed here, each integration ramp was effectively divided into two slopes.

2.2 SPD to AAR

Several routines used for processing an SPD have been adapted in order to include the sub-slope configuration (see Appendix A). The user does not notice this, and processing an SPD to AAR uses the standard OSIA procedures in the following order. ANTIMEM reduces the memory effects. The dark current is subtracted for each band with the DARK routine. This routine uses DYNADARK for band 2 to correct for memory effects in this band. FLUXCON is used for the absolute flux calibration. The high resolution pipeline uses RESP INTER instead of the old RESPCAL to correct for the RSRF. The new correction will shift and smooth or enhance the RSRF before applying it to the data. This reduces the amplitude of the fringe residuals, and has been shown to give better results when applying FRINGES on the AAR. In addition an update of the RSRF for band 3A is used. RESP INTER uses by default RESPCAL for band 1,2 and 4 because these bands are not so sensitive to fringes. The velocity correction is done with VELCOR. After these steps, the AAR is produced with EXTRACT AAR.

2.3 DEFRINGING

AOT-band 3 has the most fringing. The RSRF (CAL25s) should remove the fringes from the spectrum. However the calibration was created from a fully extended source in the laboratory before launch and will not fully match the fringes seen in flight. RESP INTER is a routine to help correct the differences seen in flight. RESP INTER removes the RSRF only for bands 3A, 3C, 3D, and 3E by shifting and scaling the calibrated RSRF. This results in better defined fringe residuals.

In addition, the RSRF for band 3A is updated to correct some standard fringe patterns seen within the band. This update to the calibration is available in OSIA 4.0.

The defringing is done using the routine FRINGES with the keyword CYSTEP set to 10. Setting the CYSTEP keyword to a lower value will not significantly affect the found fringe components, but will increase the processing time by a large amount.

We use an updated version of FRINGES which includes the keyword QUALITY. The routine then returns a float array containing quality information of the observation, i.e. average flux, mean flux, standard deviation, and number of points used for statistics. The statistics are calculated for the standard and the defringed data and are per detector per AOT-band.

An example of the necessity for defringing is given in Figure 2. This figure also shows the noise increase of the higher resolution data.

2.3.1 GENERAL NOISE INCREASE

The sub-slope implemented in the high resolution pipeline results in a higher spectral sampling. A drawback is that the integration ramp is split in half (for speeds 3 and 4 at SUBSLOPE=1) and therefore the integration time per data point is half the integration time per point at normal resolution. This results in an increase of the statistical noise by a factor of 1.4 (noise$\approx 1/\sqrt{t}$). Upgrades in the high resolution processing tend to improve the noise. Figure 1 shows as an example the noise increase distribution of the high resolution data wrt. the normal resolution data for band 3A. On average the noise increases by a small amount.

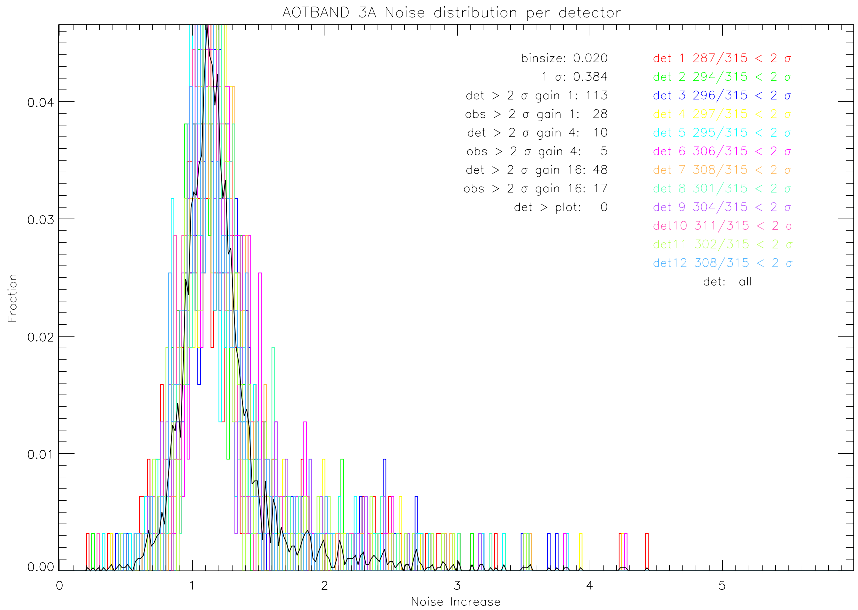

Figure 1: Noise increase distribution in band 3A. The x-axis is the ratio HPDP noise over old pipeline noise. The y-axis is the normalized fraction. The different colors represent detectors 25 to 36 of band 3A. The black line is the overall distribution.

2.3.2 LOW FLUX OBSERVATIONS

Figure 1 shows that there are observations which show a significant noise increase wrt. the low resolution data. This is visible in all bands. In general this noise increase is introduced in the sub-slope calculation for observations with low flux (i.e. around 0).

2.3.3 SHUTTER CLOSED

During the observations of TDTs 12200516 and 13501827 the shutter of the instrument was closed. These have been omitted from this product.

3 AOT-1 HPDP: SPEEDS 1 and 2

The processing of the AOT-1 speed 1 and 2 is done with the same routines as used for the high resolution processing. The only difference is that the ISP_DSPD runs in default (which is SUBSLOPE=0). This means the processing differs from the old pipeline by the pulse-shape correction, RESP_INTER for band 3 and an updated RSRF for band 3A. In addition there is again a defringed version, and the statistical information for each observation is in the catalog.

3.1 DEFRINGING of SPEEDS 1 and 2

For the processing of Speeds 1 and 2, we had to be a little careful with stability of the routines. RESP INTER requires rather good signal or high sampling throughout band 3 to operate properly. Since this was not uniformly the case for all speeds 1 and 2, we used the standard RSRF correction routine of RESPCAL.

Also, for the noise determination, we obtained more stable results by turning the routine ANTIMEM off (again only for Speeds 1 and 2). ANTIMEM simply masks the first dark current samples in a dark current measurement. This has the biggest effect in band 3 which masked the first 3 points (reducing the number of dark current samples greatly). By turning ANTIMEM off, we retain more dark current points but also possible include unknown states of the dark current shutter (i.e. shutter could still be closing during the first sample).

3.1.1 FAILED DEFRINGING

For observations 37801819 and 71101311 the defringing failed for AOT band 3E. These are AOT1 speed 2 observations and FRINGES was unable to collect enough usable data points for each detector to calculate a proper continuum level. The other bands successfully completed FRINGES.

3.2 QUALITY INFORMATION

We attempt to assess the quality of our processing based on the noise measured within each AOT band for each detector. This is possible with the FRINGES routine. Spectral fragments such as an AOT band, can have significant spectral structure in terms of slopes and/or features. It is necessary to remove broad features when removing fringes in the spectral fragment. This also provides an opportunity to measure the noise on the spectrum. Without spectral features, the noise can be directly calculated as the standard deviation of the difference of the data and the smoothed continuum.

We calculated the noise on the original data as well as the newly processed AAR data. Noise calculated in this manner is likely an over estimation since it will have a strong contribution from the noise at the AOT band edges, where the sensitivity is low relative to the center of the band. Furthermore, since individual detectors may be offset from each other, the noise is more properly calculated for each detector individually.

However, in the flux-noise catalog, we list per AOT band an average flux (average over the continuum) and the combined RMS of all twelve detectors in the band. The average calculated in this way only gives a rough indication of the flux level but still useful to be able to select observations based on brightness in a particular AOT band (or combination thereof).

NOTE: We must emphasize that the noise and flux values listed in the catalog are measures of two different things and cannot be combined. In other words, the catalog is NOT suitable as low resolution broad band data.

4 END PRODUCT

4.1 FILENAME CONVENTION

The high resolution HPDP speed 3 and 4 are available in two versions. The following file convention is used.
swha*tdt*.fits : high resolution processed AAR (speed 3/4)
swhf*tdt*.fits : high resolution processed defringed AAR (speed 3/4)

The HPDP speed 1 and 2 are also available in two versions. A similar convention is used but only indicates that the non-defringed product has been processed with the OSIA 4.0 pipeline as described in this document.
swha*tdt*.fits : reprocessed AAR (speed 1/2)
swhf*tdt*.fits : reprocessed and defringed AAR (speed 1/2)

5 CATALOG

We present a catalog of spectral noise and average band flux. The catalog lists 1237 AOT1s by TDT number, the ISO name the spectral noise and average continuum flux per AOT band. There is also a set of flags telling if the defringing was successful, whether the data are processed in high resolution mode, and a coded noise increase and the AOT band with the highest noise increase.

Appendices

A Scripts

The routines given here can be used to reprocess the AOT-1s. They are implemented and fully upgraded in OSIA v4.0. The manual explains the changes made.

High resolution processing speed 3 and 4:	**ISP_DSPD,SUBSLOPE=1** **ANTIMEM** **DARK** **FLUXCON** **RESP_INTER** **VELCOR** **EXTRACT_AAR** **FRINGES,CYSTEP=10,QUALITY=quality**
Speed 1 and 2 processing:	**ISP_DSPD** **ANTIMEM** **DARK** **FLUXCON** **RESPCAL** **VELCOR** **EXTRACT_AAR** **FRINGES,CYSTEP=10,QUALITY=quality**

B FRINGES

To examine the fringes that have been removed from a specific defringed observation, follow the procedures described here in OSIA 4.0.

Read the standard and defringed AAR
aar=READ_FAAR(swha*tdt***.fits)**
aarf=READ_FAAR(swhf*tdt***.fits)**

Extract fringe patterns
aarfringes=aar
aarfringes.data.flux=aar.data.flux/aarf.data.flux

Plot fringes for a specific band
plotaar,aarfringes,band='*aot_band***'**

C FAILED OBSERVATIONS

There was a small set of observations which failed the DSPD processing. These were 13501827,12200516,12501616,12601620,40201614,14801733,70301713, 87700502, 87702501. These are all indicated in the IDA as having some major failure. There are also 6 which we list as failing FRINGES in one AOTBAND: 37801819, 71101311, 25601404, ,63103501, 07200272, 30101147. Some of these observations failed FRINGES because there was no data for a given aperture while others failed because the noise increase was too high (greater than a factor of 5).

The Observers SWS Interactive Analysis (OSIA) software package is distributed by the SWS consortium and is available at: `http://www.iso.vilspa.esa.es/ ==> ISO Data Analysis Software ==> OSIA`

References

Lahuis, F., & Kester D. 2002, *SWS AOT-1 High Resolution Processing*, February 2003 (see ISO documentation under `http://www.iso.vilspa.esa.es`)

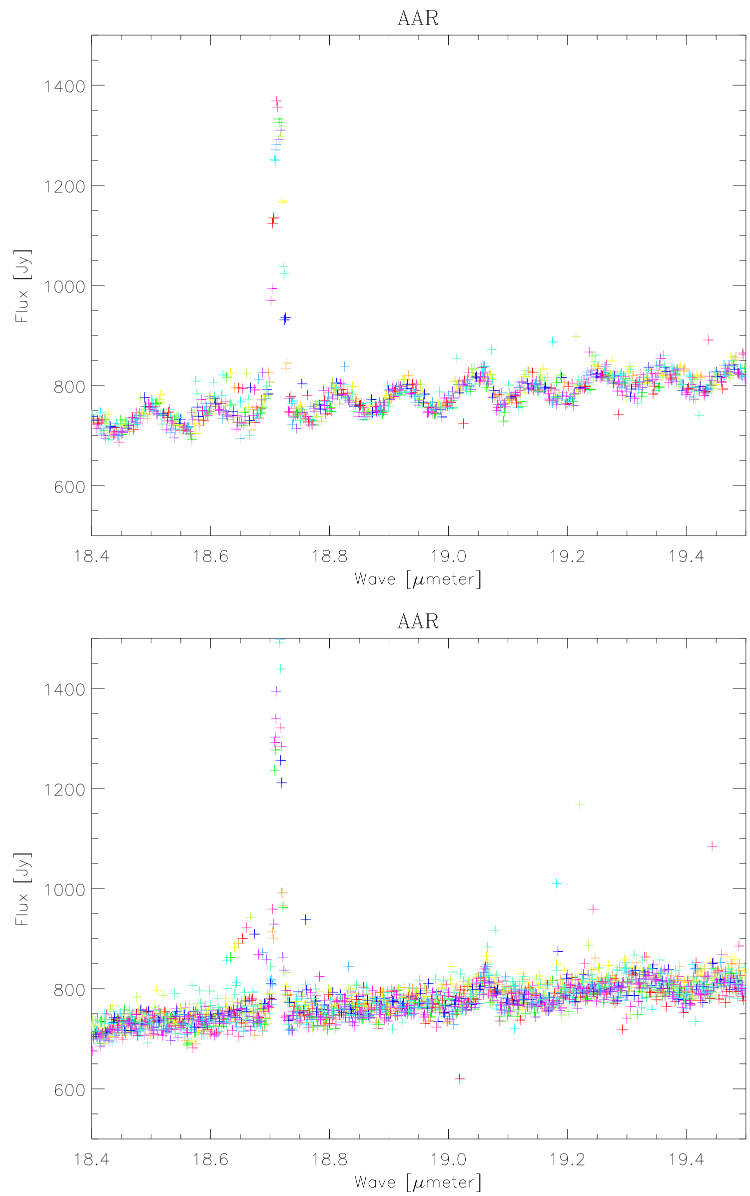

Figure 2: These figures show the utility of FRINGES. The top figure is the OLP10.1 AAR for a spectral fragment in AOTBAND 3C. The SIII forbidden line is quite evident. What is not so clear is the HI 8-7 line at 19.06 μm. This line is clearly seen in the high resolution and defringed product.