The effects of the pointing jitter on SWS observations

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1. Correlation between pointing jitter and flux jumps

The correlation between ISO's pointing jitter and jumps in the flux of SWS observations were first studied with the source DO 24107, which was executed $\Delta y = -8.6$" and $\Delta z = 4.7$" off source because of an error in the input coordinates. Such a large discrepancy implies that the observation is carried out at a position where the beam profile is very steep. Therefore small oscillations of the pointing around the average position induce large variations of the measured flux. As a consequence of the study between flux jumps and pointing jitter it has become apparent that the pointing oscillations are delayed with respect to the flux ones. That is, the best correlation between them is found when 0.7 ± 0.07 seconds (depending on the AOT band) are subtracted from the IIPH UTK. This delay is not as yet completely understood. For more details see the note "Pointing jitter and SWS flux variation correlation".

In order to study the occurrence of these effects on other sources, the routine POINT_JITTER has been included in IA. Providing the AAR and the IIPH structures, the routine plots the relevant parameters and calculates the correlation between the flux and the evolution of dy and dz (oscillation in the Y and Z directions around the average pointing coordinates) for a certain wavelength range. In Figure 1 an example for the above mentioned source, DO 24107 is shown. In this particular case, down scan data for band 1D is plotted as a function of wavelength (top panel) and as a function of time (second panel). The average value of dz calculated during each ramp measurement is shown in the third panel, and the value of dz as derived from the IIPH file in the bottom panel. The vertical lines indicate the time when each ramp measurement starts. A shift of 14/24 seconds has been applied to the IIPH ITK to obtain a maximum correlation between flux and dz of -0.42 (-0.07 for dy). In this case the jitter in the Z direction is responsible for the flux jumps, which is in agreement with the available beam profile data of this band taking into account the pointing offset of the observation.

The correlation between flux and pointing jitter is obviously reduced by the presence of spectral features. In order to remove them, another observation of DO24107 with corrected coordinates was carried out in revolution 629. The corresponding AAR was divided by the "wrong-pointing" AAR to suppress the spectral features, so that the residual flux variations would be the directly related to the pointing jitter. The ratio of both observations is shown in Figure 2, where the improvement in the correlation with dz can be clearly seen (the correlation coefficient increases to -0.68).

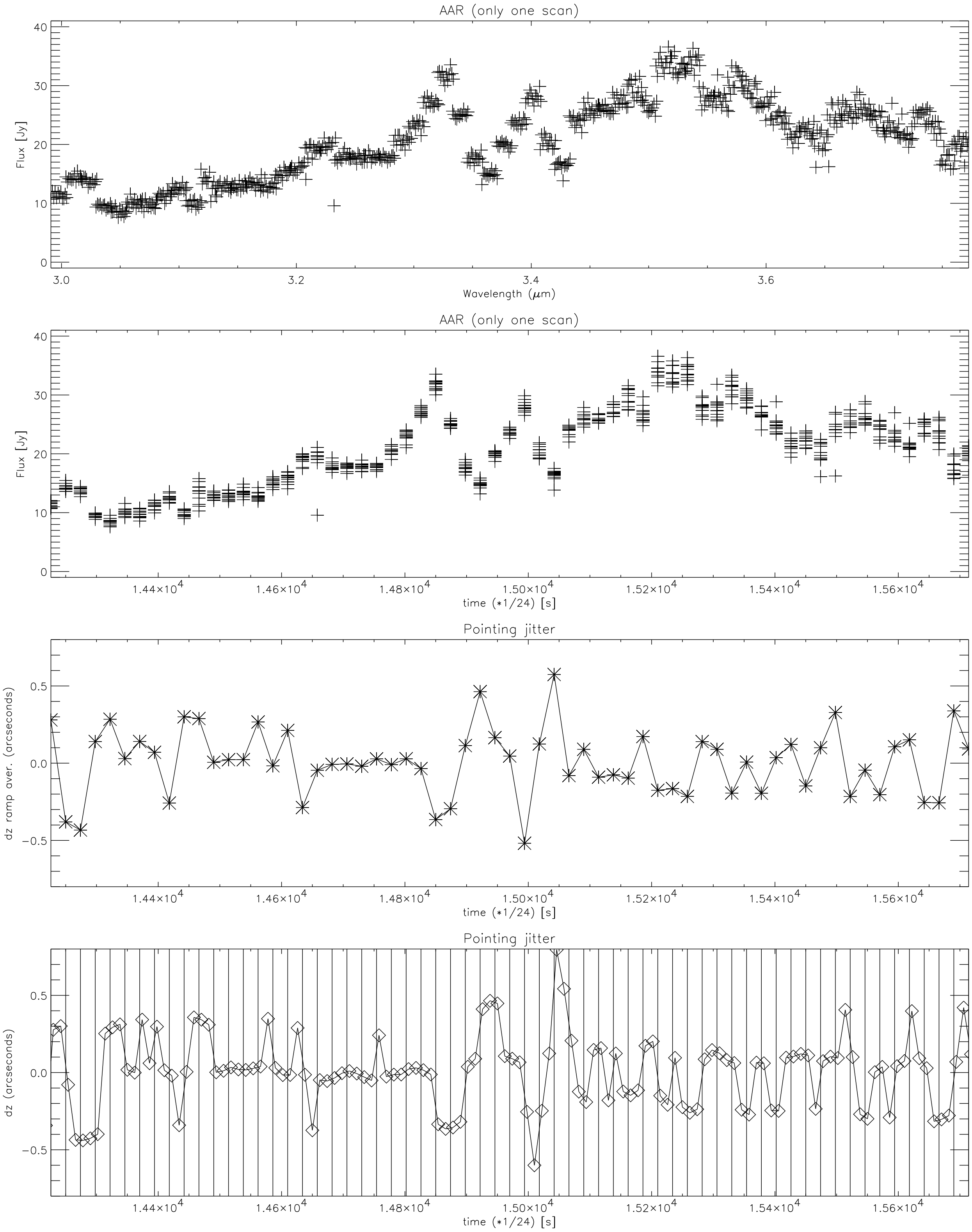

AAR (only one scan)
Flux [Jy]
Wavelength (μm)
AAR (only one scan)
Flux [Jy]
time (*1/24) [s]
Pointing jitter
dz ramp aver. (arcseconds)
time (*1/24) [s]
Pointing jitter
dz (arcseconds)
time (*1/24) [s]

Figure 1:

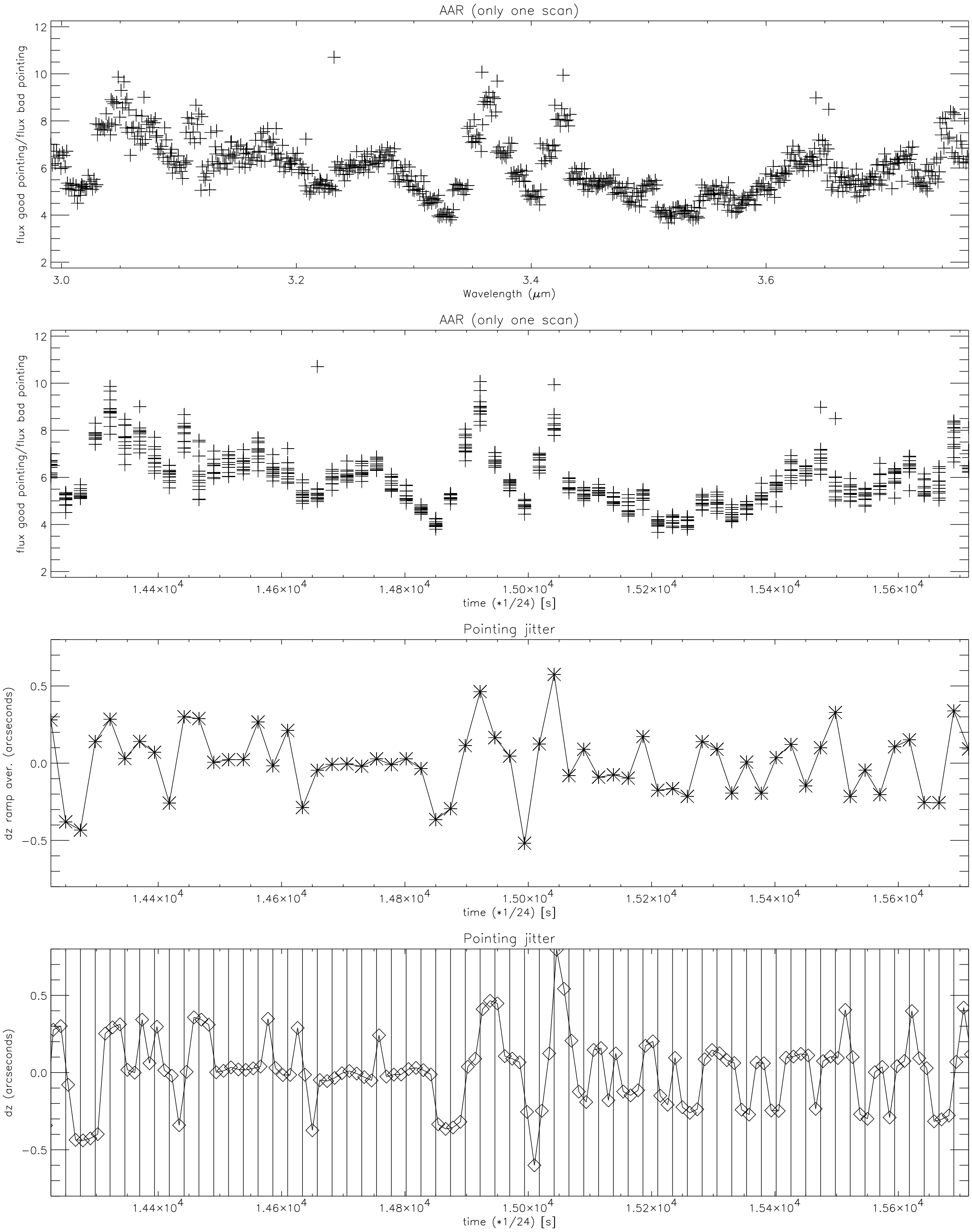

AAR (only one scan)
flux good pointing/flux bad pointing
Wavelength (μm)
AAR (only one scan)
flux good pointing/flux bad pointing
time (*1/24) [s]
Pointing jitter
dz ramp aver. (arcseconds)
time (*1/24) [s]
Pointing jitter
dz (arcseconds)
time (*1/24) [s]

Figure 2:

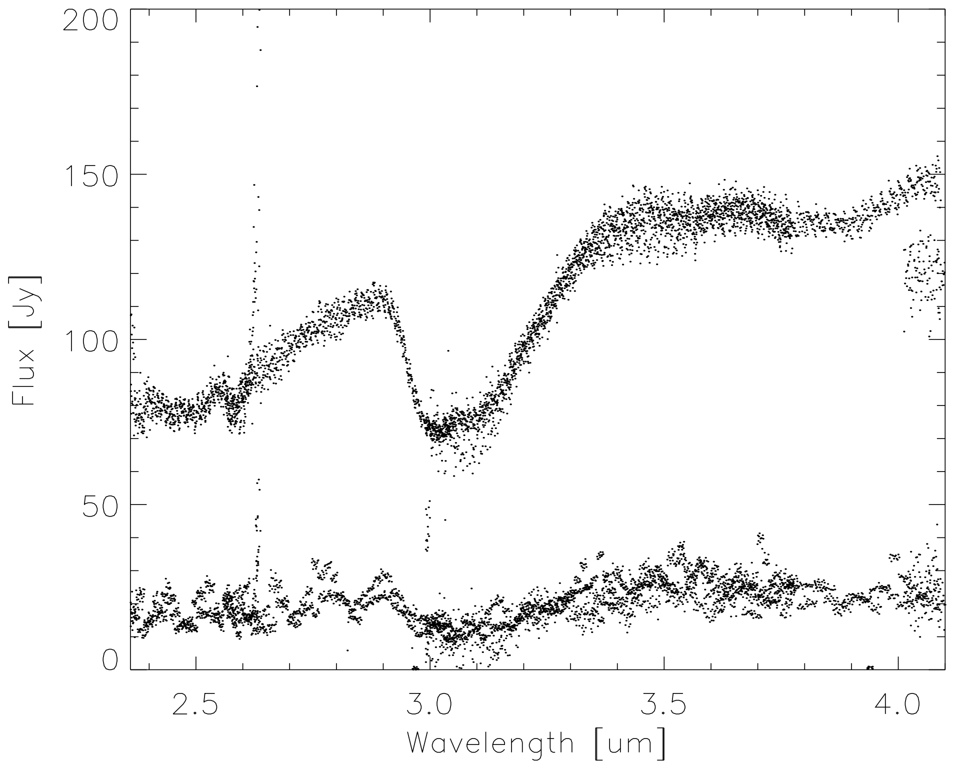


Figure 3:

2. Reconstruction of mispointed observations

The reconstruction of the flux in observations with large pointing offsets will only be possible after an accurate determination of the beam profile. However, in order to check the feasibility of this reconstruction, an attempt to reconstruct the mispointed DO24107 observation has been made, by using the correct DO24107 observation and the values of dz. Figure 3 displays band 1 spectra for both observations. As can be seen, the difference in the flux level is striking and the flux jumps appear only in the bad observation. The correction has been done in two steps:

1. Since, according to the available beam profiles, the offset in Y (-8.62") accounts for approximately 50% of the flux loss, the flux of the mispointed observation has been multiplied by this factor.

2. The correction for dz has been applied on the dy-corrected AAR. A beam profile has been self-derived by studying the dependence of the "Flux good pointing/flux bad pointing" ratio with respect to dz. The result is shown in Figure 4 for two bands. As expected, the correlation is very good and a polynomial can be easily fitted through the points, providing the functional dependence of $dz/Flux\_ratio$ on dz. In this way, for each given dz, a correction can be applied to the measured flux value. Figure 5 displays band-1 spectrum of the observation on-source (in black) and the corrected spectrum (in grey).

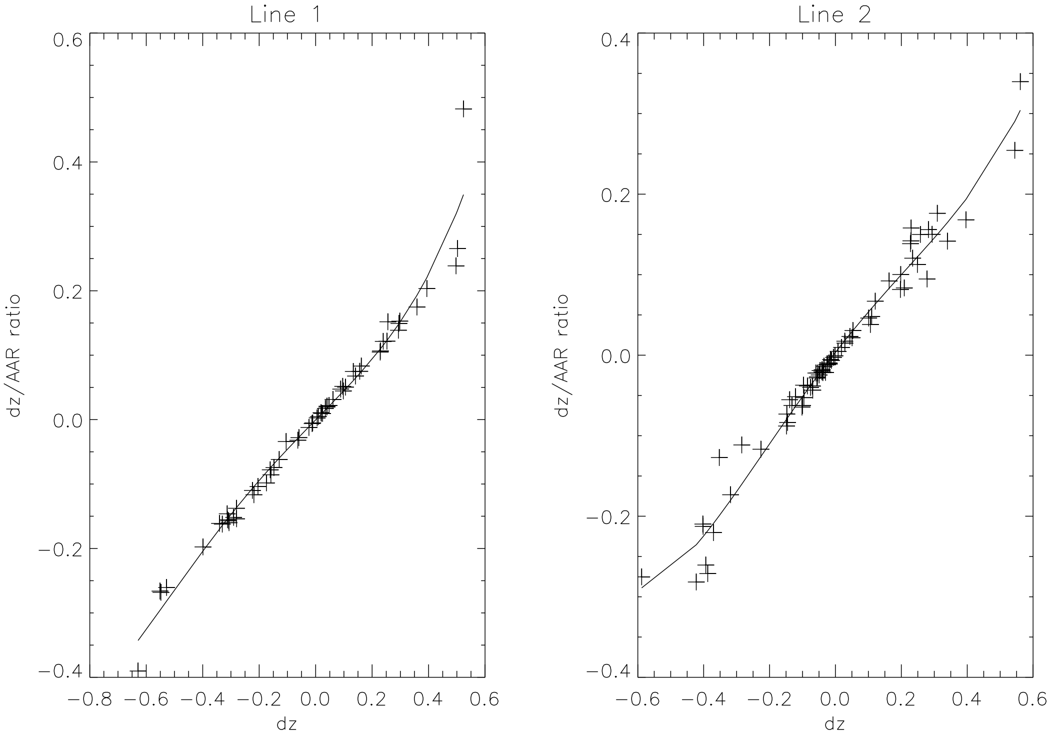


Figure 4:

Although with a higher noise, most of the spectral features have been reconstructed. This result is promising and shows how bad observations can be significantly improved.

3. Correlation between noise and pointing jitter

In observations in which the pointing offset is less than 4", it is still possible that the pointing jitter contributes significantly to the noise. This noise component would appear as a variation of the flux correlated in all detectors as a function of time. Although other components of the total noise could mask this correlation to the point that it would not be noticeable, it is important to check its presence so that it may be used to reduce the noise in the observation once the beam profiles are accurately known. The correlation between pointing jitter and noise is analyzed for a given observation by the routine POINT_NOISE, which has been inserted in IA. An example is displayed in Figure 6, corresponding to the observation of S Per carried out in revolution 433, which was executed with a pointing offset of $\Delta y = 3.06$" and $\Delta z = 0.15$". The two upper panels show respectively the evolution of the flux as a function of wavelength and time for the down scan data in band 1E. Note the pattern of the flux in the top panel due to the fact that for slight mispointings the detectors are not uniformly illuminated. The third panel from top to bottom displays the residual of the flux calculated as the difference between the median of the flux in four resolution elements and the flux measured at each instant. In this way many spectral features are removed and the variations of the residual are related to the pointing oscillations. However, care should be taken with narrow spectral features, since they may stay and blur the

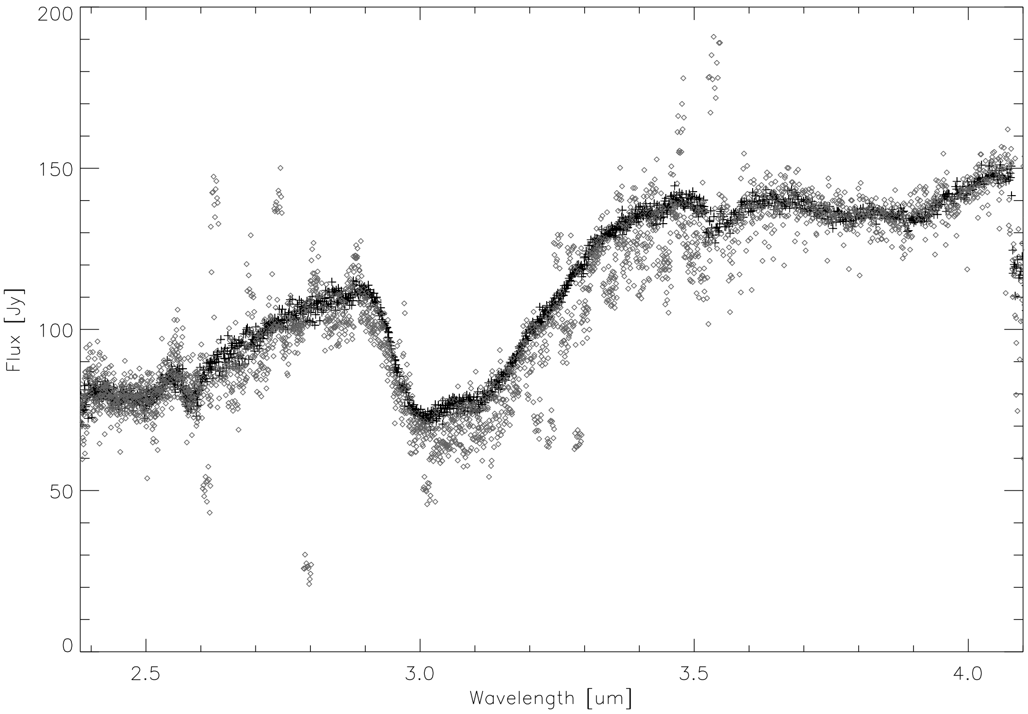


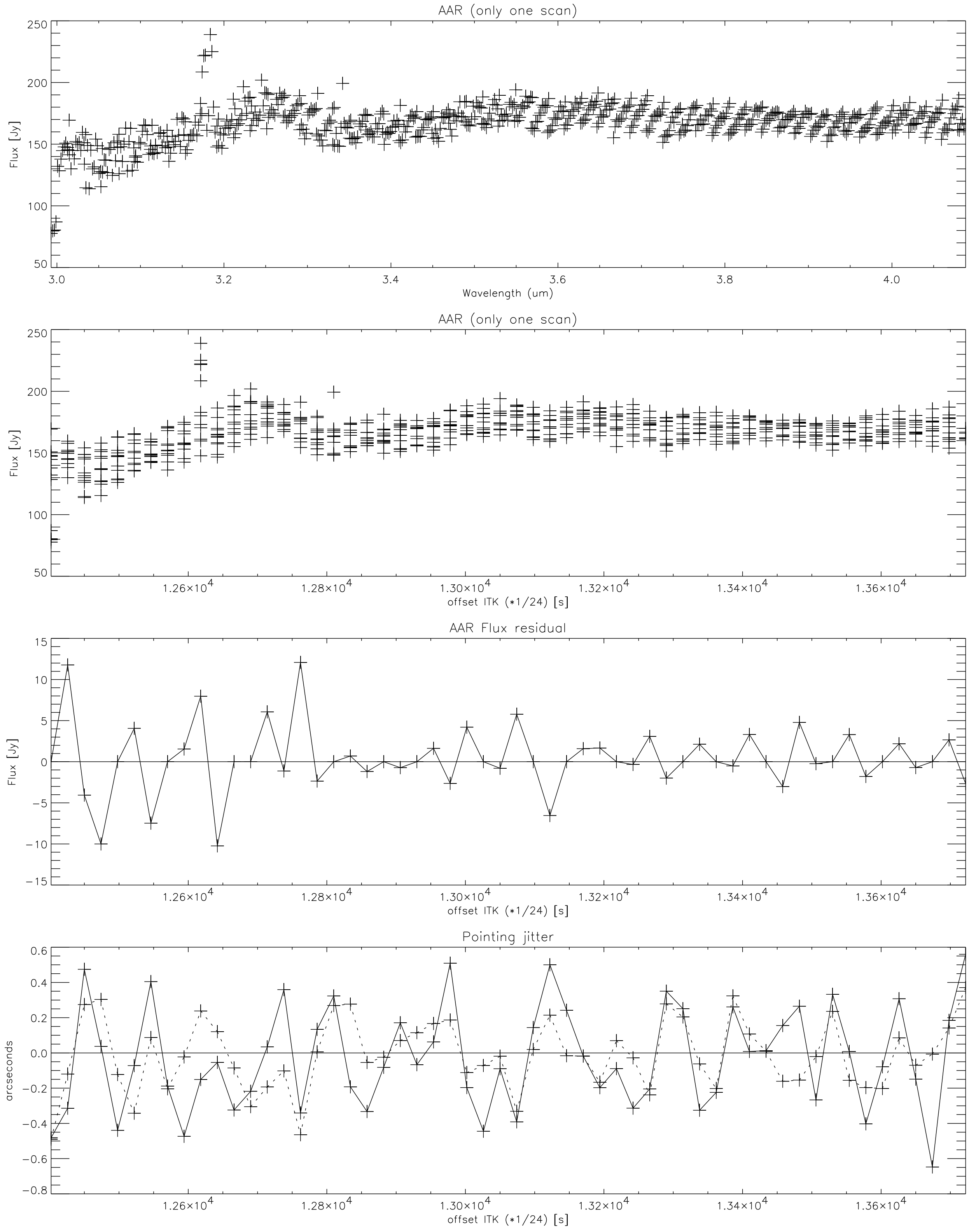
Figure 5:

correlation. The bottom panel shows the pointing jitter in the Y direction (dotted line) and in the Z direction (solid line). The correlation coefficients found in this case are -0.44 for dy and -0.35 for dz. The high value of the correlation for dz, taking into account the small pointing offset in this direction, may be due to the fact that it follows very closely the evolution of dy and not to an intrinsic dependence. In Figure 7 the same is displayed for band 3A. Here the correlation coefficients are -0.22 for dy and -0.47 for dz, that is, the influence in the noise of the pointing jitter in the Z-direction is more important than in the Y-direction in spite of the smaller pointing offset. This is related to two facts. First the beam profile in this band is much broader in the Y direction and, second, beam profile data indicate that there is a misalignment of band 3, implying that the distance to the maximum of the beam profile would be greater than the 0.63" given by the offset.

Future work should therefore be focused on reducing the pointing jitter related noise in observations with pointing offsets $< 4"$, through the application of the beam profile data.

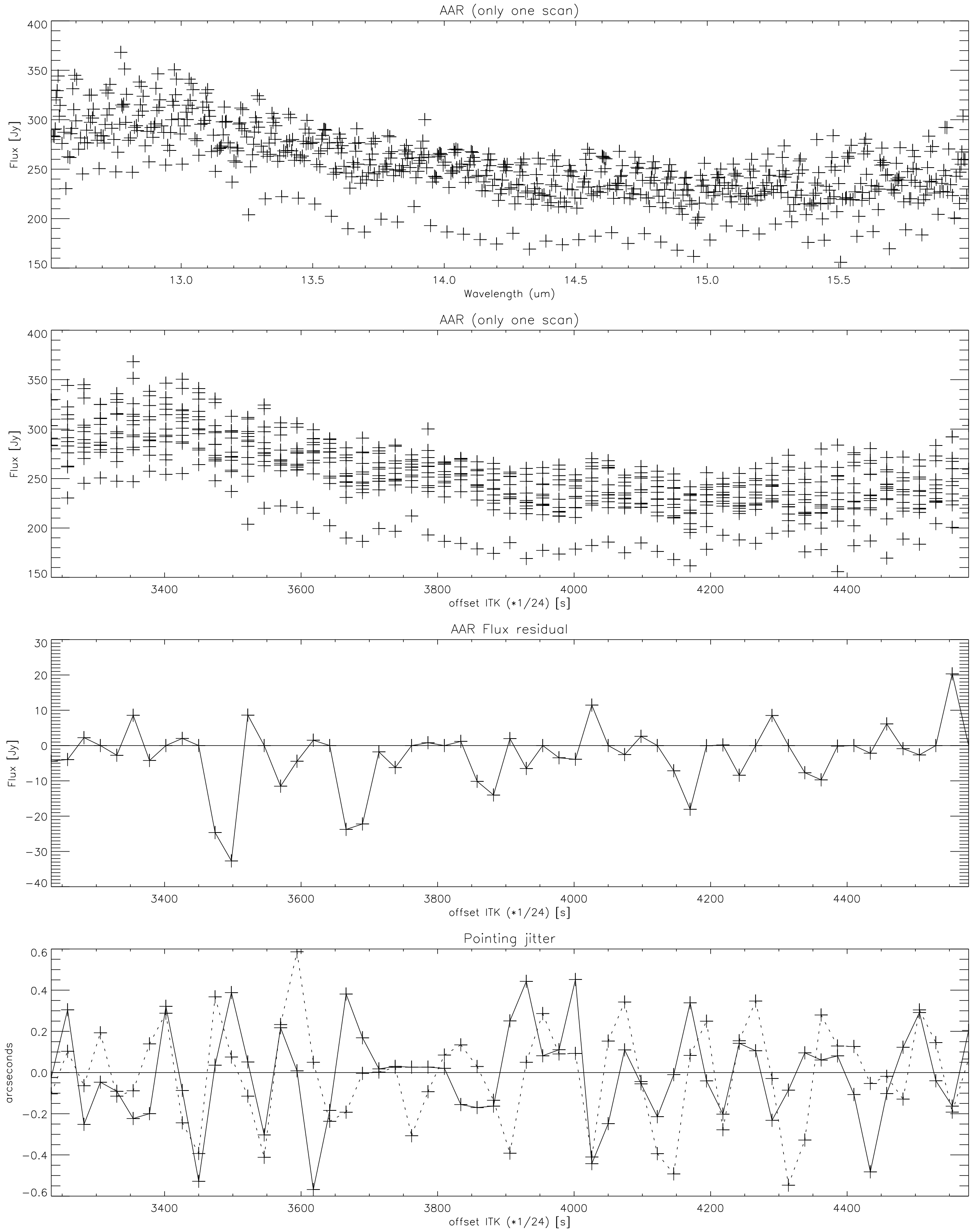
4. Up-down scans discrepancies and pointing jitter

Another consequence of the pointing jitter is that up and down scan data, since taken at different times, show discrepancies that may be determinant in the identification of small spectral features. The IA routine POINT_UP_DOWN provides a tool to check if up-down discrepancies are related to the pointing jitter. Figure 8 shows the results for the same source as studied in the previous



AAR (only one scan)
Flux [Jy]
Wavelength (um)
AAR (only one scan)
Flux [Jy]
offset ITK (*1/24) [s]
AAR Flux residual
Flux [Jy]
offset ITK (*1/24) [s]
Pointing jitter
arcseconds
offset ITK (*1/24) [s]

Figure 6:



AAR (only one scan)
Flux [Jy]
Wavelength (um)
AAR (only one scan)
Flux [Jy]
offset ITK (*1/24) [s]
AAR Flux residual
Flux [Jy]
offset ITK (*1/24) [s]
Pointing jitter
arcseconds
offset ITK (*1/24) [s]

Figure 7:

section, S Per. From top to bottom, the first panel displays the up and down scan data in band 1D (dotted and solid lines, respectively), which are rather different for some wavelength intervals. In the second and third panels the same data are plotted as a function of time; in the fourth panel, the ratio between down and up scan data for each instant is shown and in the fifth panel the corresponding differences in the evolution of dy ("down scan" dy - "up scan" dy) are displayed (a shift of 16/24 seconds has been applied to the IIPH ITK). The correlation coefficient between the data in panels four and five is -0.78, which is rather significant taking into account that there are other sources of noise. As a consequence, when a spectral feature can only be identified in one of the scans, the behaviour of the pointing jitter should be checked in order to assess the reliability of the identification. The good correlation found between pointing jitter and up and down discrepancies opens the possibility to correct for this effect through the application of the beam profile data.

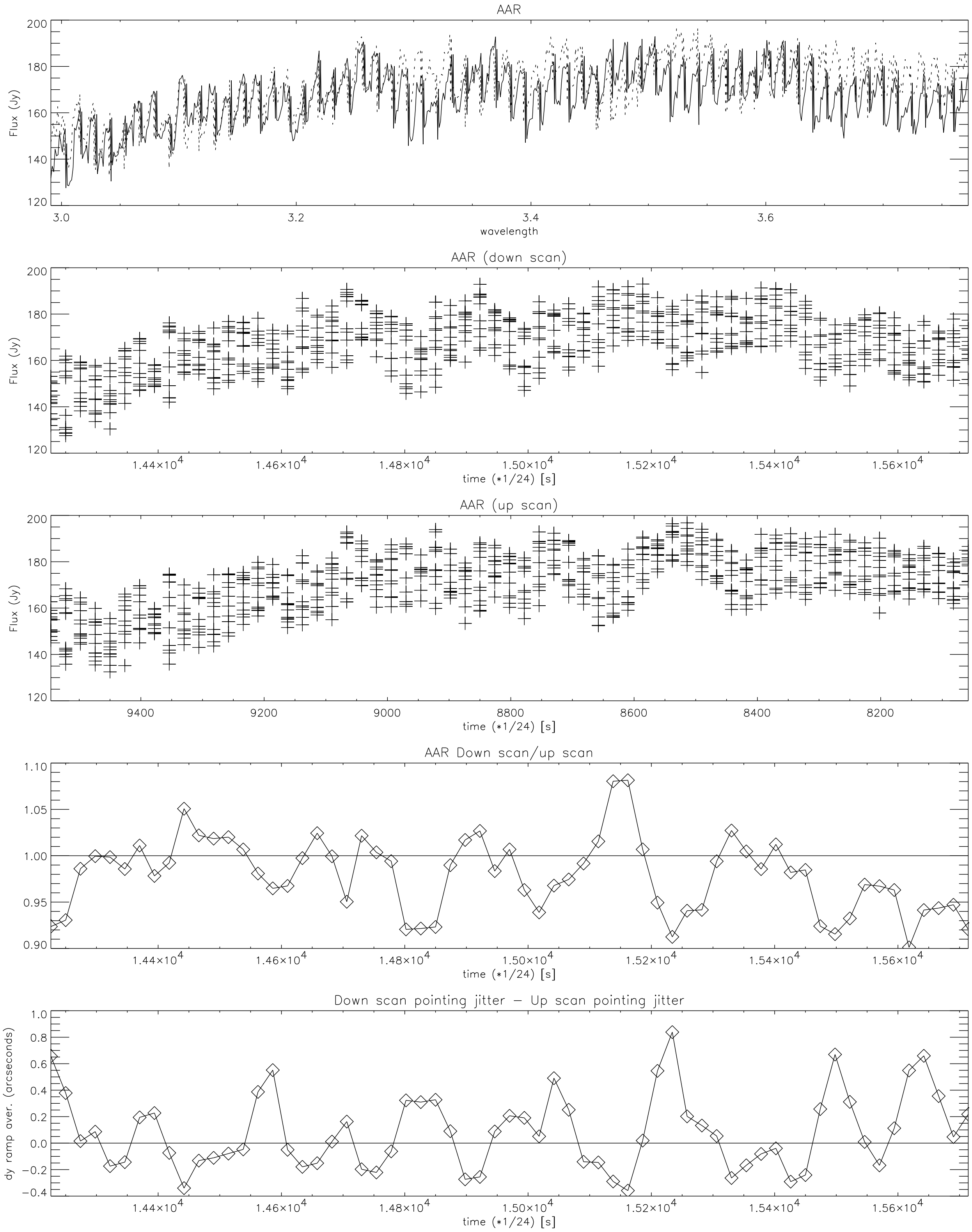

AAR
Flux (Jy)
wavelength
AAR (down scan)
Flux (Jy)
time (*1/24) [s]
AAR (up scan)
Flux (Jy)
time (*1/24) [s]
AAR Down scan/up scan
time (*1/24) [s]
Down scan pointing jitter – Up scan pointing jitter
dy ramp aver. (arcseconds)
time (*1/24) [s]

Figure 8: