Study of the flat-fielding of WFI data with ASTROWISE PART I

Ph. Héraudeau

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1 Quality control

To study the shape of the sky background of raw images and estimate the flatness of calibrated images, the median of all pixels were computed along each row and column. These "master_row" and "master_col" are plotted for raw science frames of individual nights and all calibrated science frames in the archive to date.

Frames were also divided in 25 squares to estimate the flatness of the sky background as follows:

$$flatness = (max(values) - min(values))/median(values) \tag{1}$$

where "values" represents the 25 values of the median computed in the squares. Bands of 200 pixels were rejected along the four sides of the CCDs in computing "values" as they can show very steep slopes toward the edges which will severely affect the statistics. Each of these squares represents about 340 rows ($[2100 - 2 * 200]/5$) and 740 columns ($[4100 - 2 * 200]/5$). Objects were detected and removed from the calibrated science frames using Sextractor.

2 Results

2.1 Raw science frames of individual nights

Figures 1 to 5 show the behaviour of master_row and master_col for the raw science frames taken during several individual nights and different filters. The master bias was computed as the median of several bias frames and has been removed. Note that no rescaling of the master bias has been performed (in particular the prescan and overscan regions were not used at all). The columns of all frames of individual nights have a similar behaviour, with a downward trend at the upper end of the CCD (large values along the y-axis). Differences reach up to 10% for the night 1999-06-12 in B-band (see Figure 1) while they remain below a few percents for the other nights and filters presented here. The night 1999-06-12 also shows, in B-band, 2 frames which depart from the behaviour of the other frames. These 2 frames have a very low background value. The lowest master_col at row 4000 has an exposure time of 1s and a background value of only 4 ADU.

The night 1999-06-13 in B-band (see Figure 2) shows little difference between the frames. Note however that the frames (only 10) have a similar background value, $\simeq 320$ ADU above the bias level.

2.2 Calibrated science frames

Figures 6 to 10 show master_row and master_col of CCD50 for all calibrated science frames available to date in the database for U, B, V, R and I. The umber of frames for each filter is indicated in the caption. One can first notice the presence of non-flat regions near the edges along rows and columns. These regions can be above or below the median of the frame (up to 15%) and extend as far as 500 pixels from the edges. Figures 11 to 15 show the histogrammes of the flatness of the sky background in percent for the calibrated science frames in U,B,V,R and I.The flatness was computed from the median of the 25 squares and the formula defined above. The number of calibrated frames in the archive often remains too small to obtain relevant statistics. In B (with 46 frames) the peak of the histogramme is at 1.5 % with a distribution of values up to 10%. In V (with 37 frames) the maximum of the histogramme is at 2% with secondary peaks at 8 and 10%.

I-band calibrated science frames show excellent results (see Figs. 10 and 15) as they have an additional step in the data reduction compared to the other bands, which is the subtraction of fringes. This step also probably removes the residual large scale structure in the sky background like a night flat would do for U, B, V and R allowing to achieve a flatness better than 1%.

3 Conclusions

- Quality control sometimes reveals very bad flat-fielding corrections (of the order of 10%) and has to be performed to detect such problems.

- The master bias removed here is flat and does not have neither the same level nor the shape of the prescan and overscan regions. The subtraction of a bias frame with the same intensity and shape of the prescan and overscan regions should decrease the differences between frames with different sky levels, if it is confirmed to be also the shape of the bias in the frame.

- The I-band calibrated science frames show the best result ($\leq 1\%$ for the flatness of the sky background). This is probably due to the additional correction, which removes the fringes but also corrects for residual large scale structure in the sky background.

- A night flat seems necessary to remove residual large scale variation in bands other than the I-band and enable us to reach the 1% level flatness.

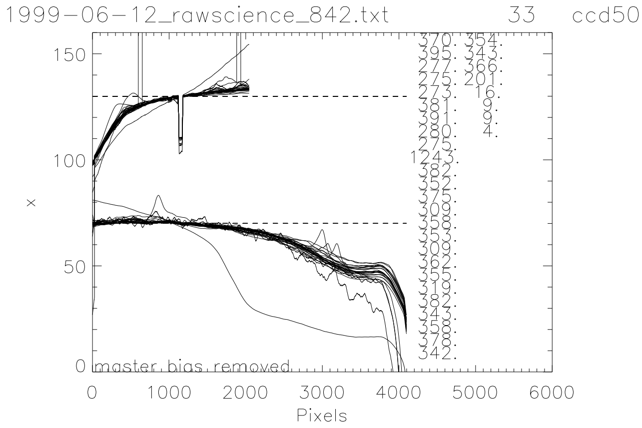

Figure 1: Master_row and master_col of CCD50 for the raw science frames of the night 1999-06-12 in B band. The master bias has been removed. Rows and columns are normalised to 100 but offset by 30 for rows, −30 for columns. The master_col shows 2 different behaviours (during this same night), which deviate by about 5 percent (33 frames are shown). The median value of the sky background of each frame after removing the bias is indicated in the right part of the graph. Median values can be read from top to bottom and left to write and are ordered according to the values of master_col at row number 4000 (20 frames are shown.

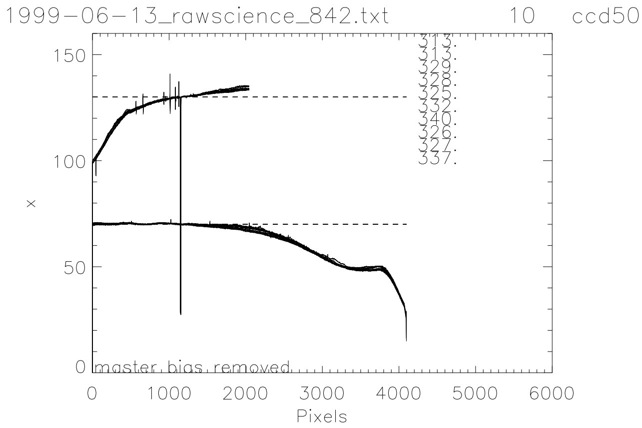

Figure 2: Same as figure 1 for the night 1999-06-13 and B-band (10 frames are shown).

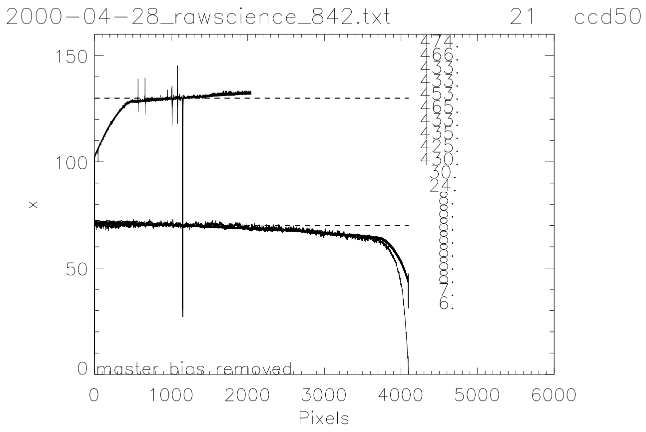

Figure 3: Same as figure 1 for the night 2000-04-28 and B-band (20 frames are shown).

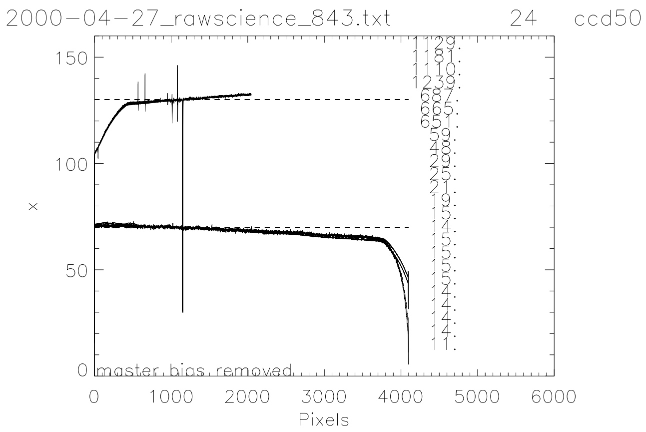

Figure 4: Same as figure 1 for the night 2000-04-27 and V-band (24 frames are shown).

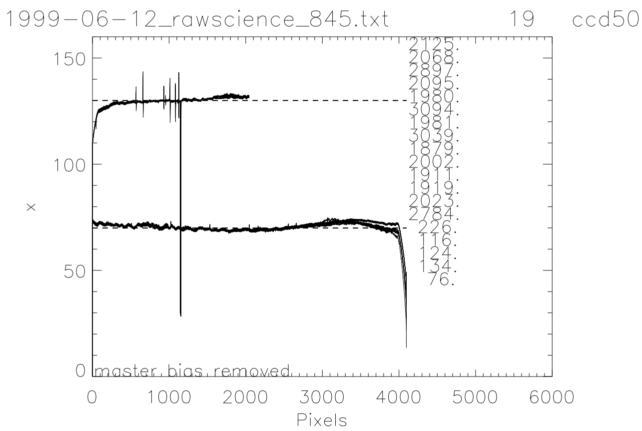

Figure 5: Same as figure 1 for the night 1999-06-12 and I-band (10 frames are shown).

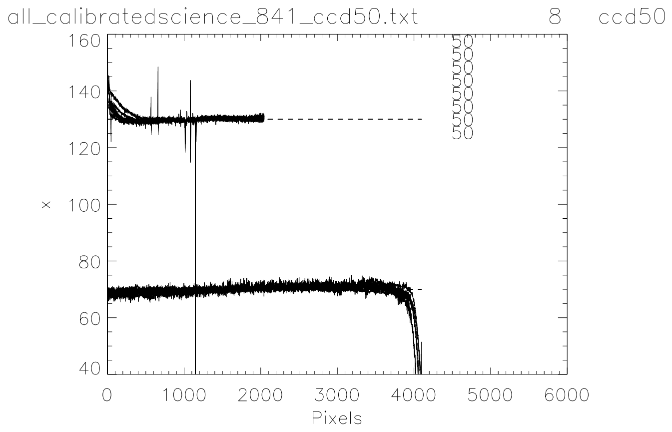

Figure 6: Master_row and master_col of CCD50 for calibrated science frames in U-band. Rows and columns are normalised to 100 but offset by 30 for rows, −30 for columns (8 frames are shown.

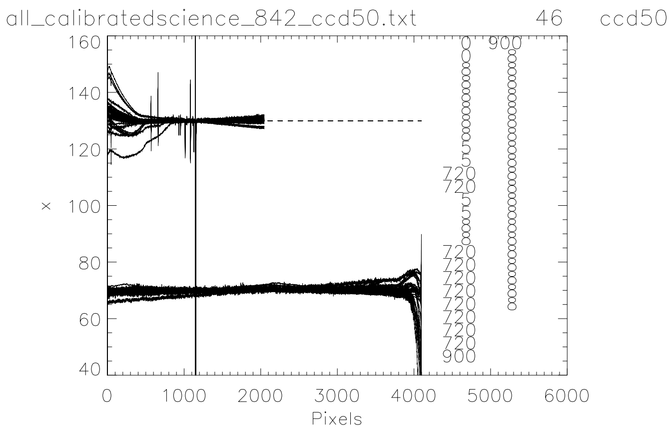

Figure 7: Master_row and master_col of CCD50 for calibrated science frames in B-band. Rows and columns are normalised to 100 but offset by 30 for rows, −30 for columns (46 frames are shown).

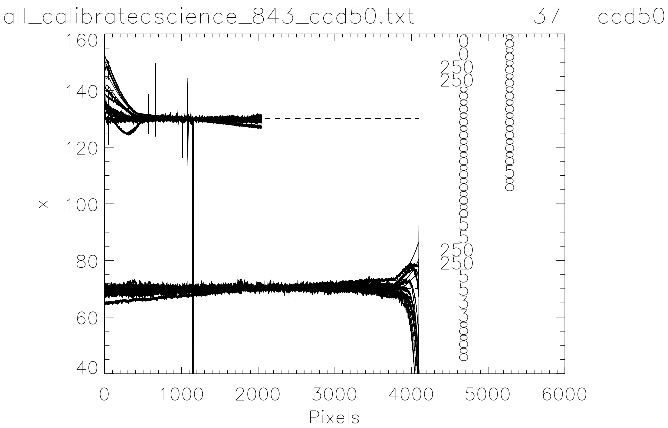

Figure 8: Master_row and master_col of CCD50 for calibrated science frames in V-band. Rows and columns are normalised to 100 but offset by 30 for rows, −30 for columns (37 frames are shown).

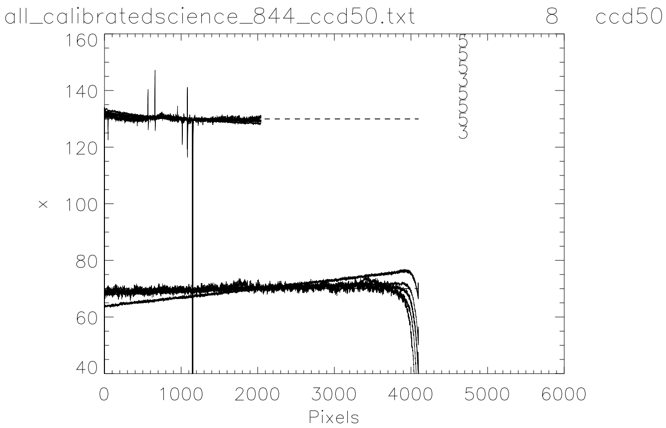

Figure 9: Master_row and master_col of CCD50 for calibrated science frames in R-band. Rows and columns are normalised to 100 but offset by 30 for rows, −30 for columns (8 frames are shown).

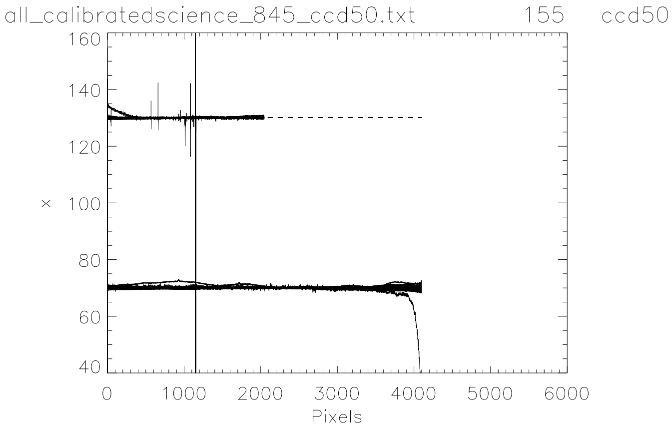

Figure 10: Master_row and master_col of CCD50 for calibrated science frames in I-band. Rows and columns are normalised to 100 but offset by 30 for rows, -30 for columns (155 frames are shown).

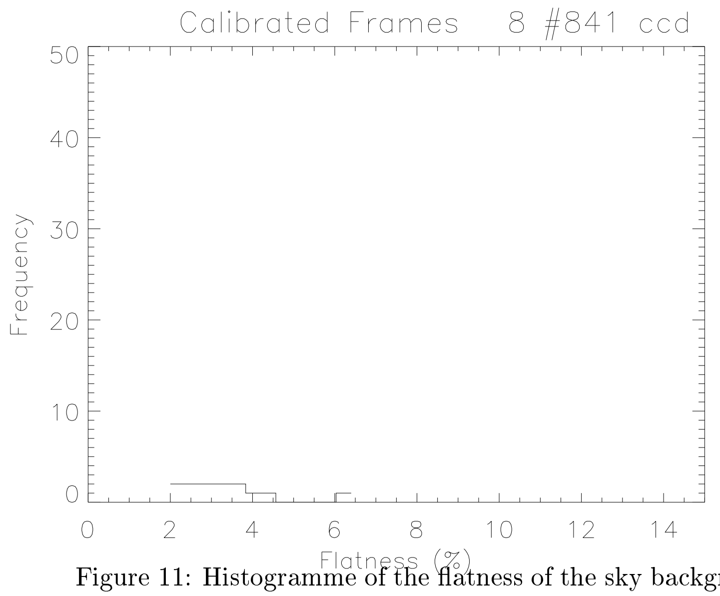

Figure 11: Histogramme of the flatness of the sky background in percent for the calibrated science frames in U (8 frames were used).

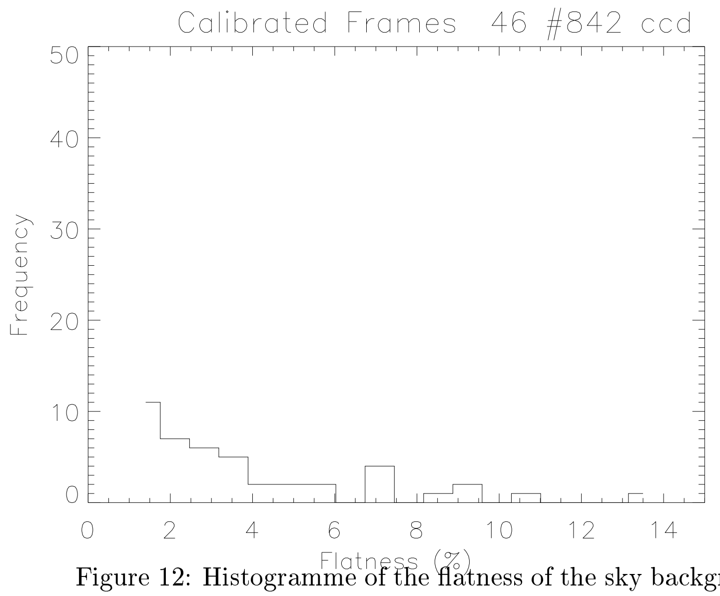

Figure 12: Histogramme of the flatness of the sky background in percent for the calibrated science frames in B (46 frames were used).

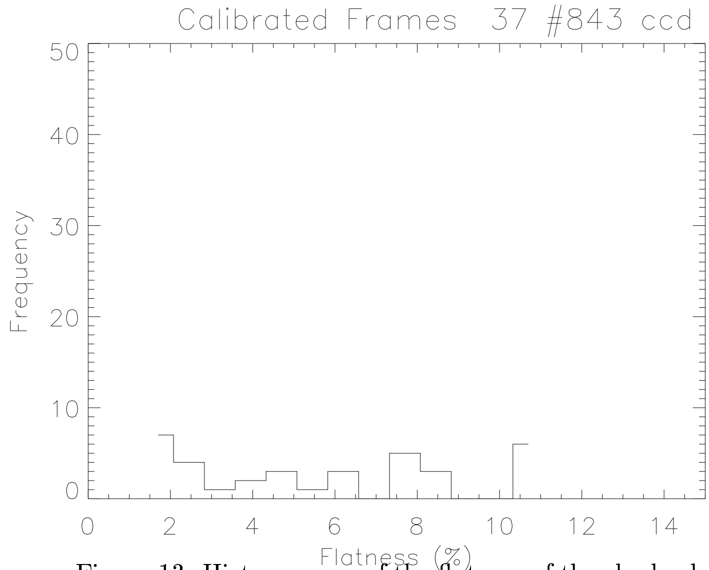

Figure 13: Histogramme of the flatness of the sky background in percent for the calibrated science frames in V (37 frames were used).

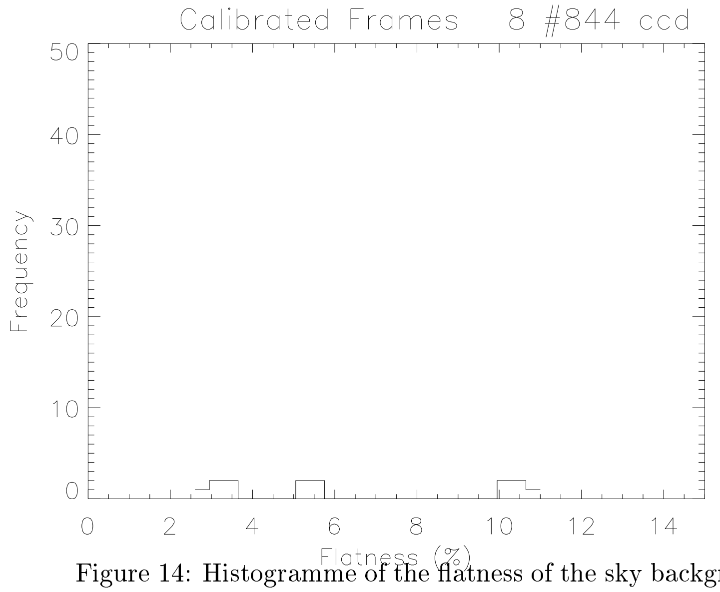

Figure 14: Histogramme of the flatness of the sky background in percent for the calibrated science frames in R (8 frames were used).

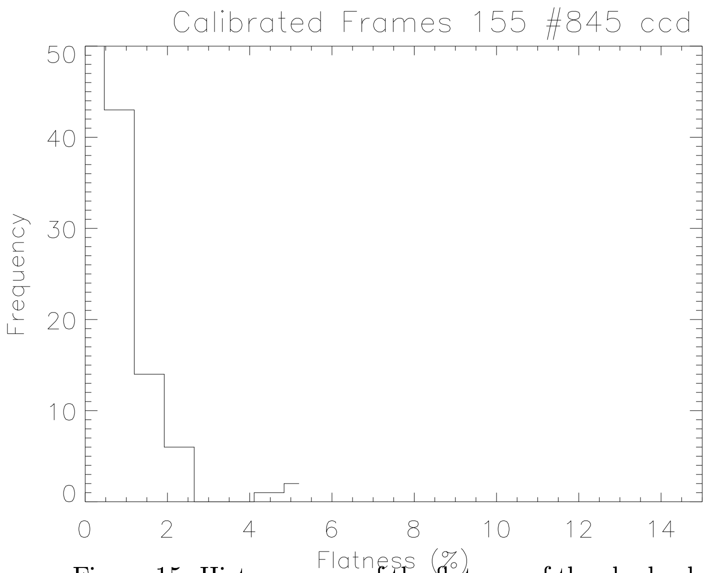

Figure 15: Histogramme of the flatness of the sky background in percent for the calibrated science frames in I (155 frames were used).