Southern African Large Telescope

Title: **HRS overscan and bias study**

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ABSTRACT

In this report I present some study of HRS biases and overscans. I studied 12536 HRS frames taken from the beginning of 2015 year, and calculated some simple overscan and bias characteristics for all of them. My results show that for both blue and red arm CCDs there is a jump in the overscan level between the first frame of any series and the rest of the frames. The largest jump is for the FIRST frame of the night. For that reason, if we would like to use overscan for HRS frames, we need to improve this situation and possibly update our low-level software to produce **dummy read-out** *at the beginning of any series of HRS frames.*

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1 Introduction

Understanding the overscan and biases of the High Resolution Spectrograph (HRS) is vital for the data reduction and for the planning of standard calibrations procedure. Currently, after practically a year of HRS work, with many science data and calibrations currently available in SALT database, it is possible to reanalyze all data in hands and check our understanding of HRS overscan and biases.

2 Data and Analysis

In this report I examined all available HRS spectral data to study HRS overscan and bias situation.

Small package of MIDAS programs was written, which were called from inside UNIX SHELL scripts:
1. At the very beginning MIDAS table was created with columns names taken from standard HRS FITS header descriptors.
2. Each observational night was checked for existence of HRS data and raw observational data were automatically copied to the temporary directory.
3. All important information was copied from each FITS header into MIDAS table in the format one table row for each existed file.
4. Overscan region statistic was calculated (mean and standard deviation) and results of this calculations were also written into the final table.
5. If current frame was BIAS frame, mean and standard deviation were calculated for the science frame (overscan region was NOT included) as well.

The output MIDAS table was calculated for each month of observation and all such tables were merged finally. The final output table was written to the disk as a FITS-table. The current version of this table consist of columns and their format as it shown in Table 1.

Table 1: The output table format

#	Column Name (1)	Units (2)	Format (3)	Type (4)	Comment (5)
1	:FILE		A25	C*25	FITS file name with raw data
2	:EXPTIME	sec	F6.1	R*4	Exposure time
3	:O_TIME	year	F16.10	R*8	Date of observation
4	:DATE_OBS		A8	C*8	Date of observation
5	:TIME_OBS		A12	C*12	UTC start of observation
6	:TIME_O	sec	F7.2	R*4	UTC start of observation
7	:OBJECT		A20	C*20	Object name
8	:PROPID		A15	C*15	SALT project ID
9	:DETNAM		A5	C*5	Detector Name
10	:OBSTYPE		A7	C*7	Observation type
11	:OBSMODE		A17	C*17	Observation mode
12	:FIFPORT		A4	C*4	FIF port selection
13	:AMPS		I2	I*1	Number of amplifiers used
14	:GAIN		A35	C*35	CCD gain (photons/ADU)
15	:ROSPEED		A14	C*14	CCD readout speed (Hz)
16	:CCDSUM		A4	C*4	On-chip binning
17	:CCDTEMP	K	F16.10	R*8	CCD temperature (degree)
18	:TEM_OB	K	F16.10	R*8	Optical bench temperature (K)
19	:TELAZ	deg	F16.10	R*8	Telescope azimuth
20	:TELALT	deg	F16.10	R*8	Telescope altitude
21	:OVER_LEV		F8.3	R*4	Mean level for overscan
22	:OVER_SIG		F6.3	R*4	Standard deviation for overscan
23	:BIAS_LEV		F8.3	R*4	Mean level for bias
24	:BIAS_SIG		F6.3	R*4	Standard deviation for bias
25	:BIAS_COR		F6.3	R*4	Mean level for bias corrected for overscan
26	:STATUS		A15	C*15	Calculated status

3 HRS Overscan. General picture.

3.1 HRS CCD for the Blue arm.

Before to analyze overscan and bias, we need just to look to the general overscan and bias shapes and levels for CCDs in both HRS arms. Figure 1 shows short summary for the blue arm HRS CCD. It shows one averaged row for the bias, averaged shape of overscan region ([1:26,1:4102] in IRAF style) and more detailed view for the averaged row in the area of overscan location.

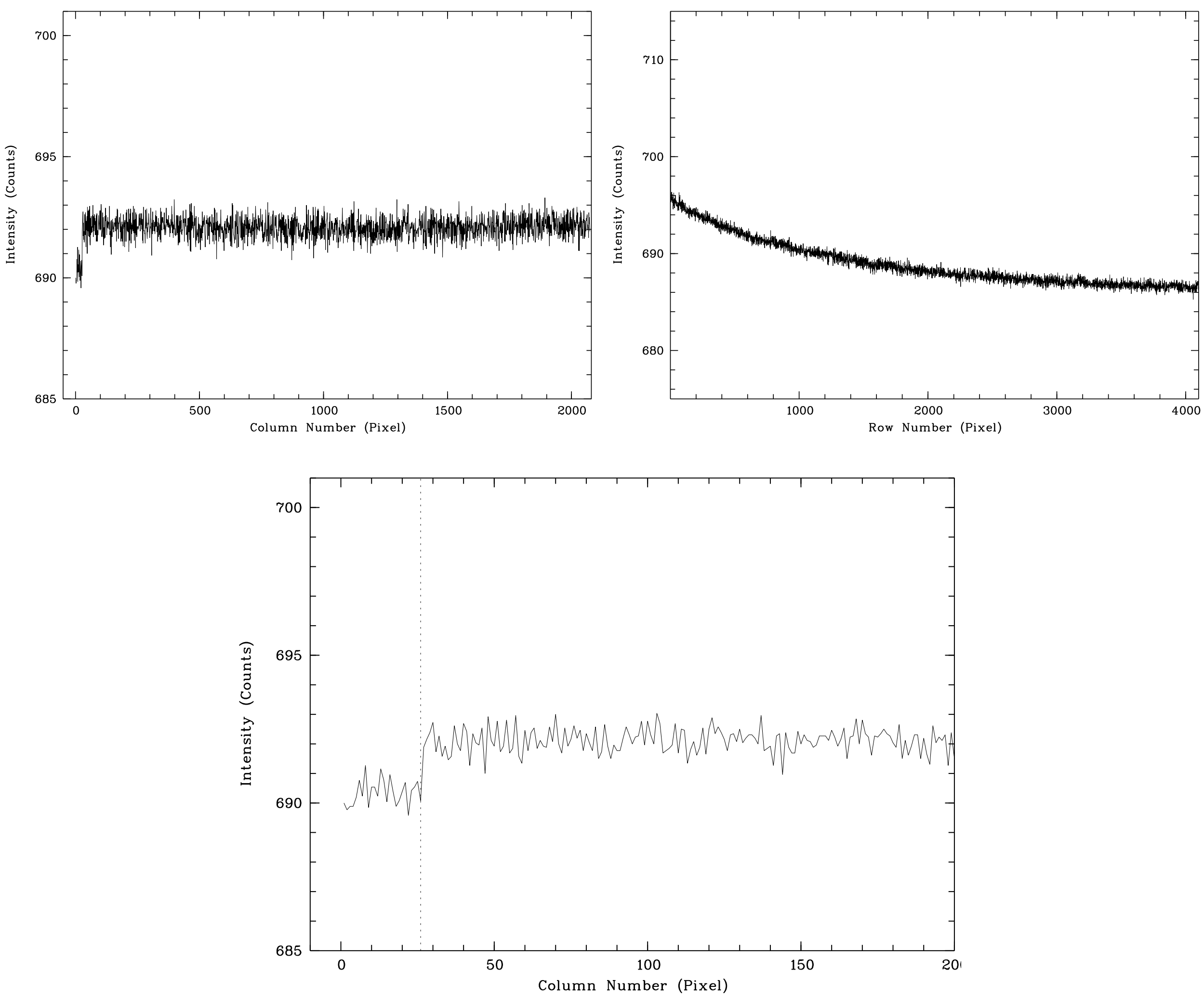


Figure 1: Bias frame for the blue arm CCD: **The left-up** panel shows the result of averaging for 26 rows. **The right-up** panel shows the result of averaging for overscan region (26 columns). **The bottom** panel is the same as the left-up, but shows only first 200 pixels. The overscan region location is shown with vertical dotted line.

3.2 HRS CCD for the Red arm.

Figure 2 shows short summary for the red arm HRS CCD. It shows one averaged row for the bias, averaged shape of overscan region ([1:26,1:4102] in IRAF style) and more detailed view for the averaged row in the area of overscan location.

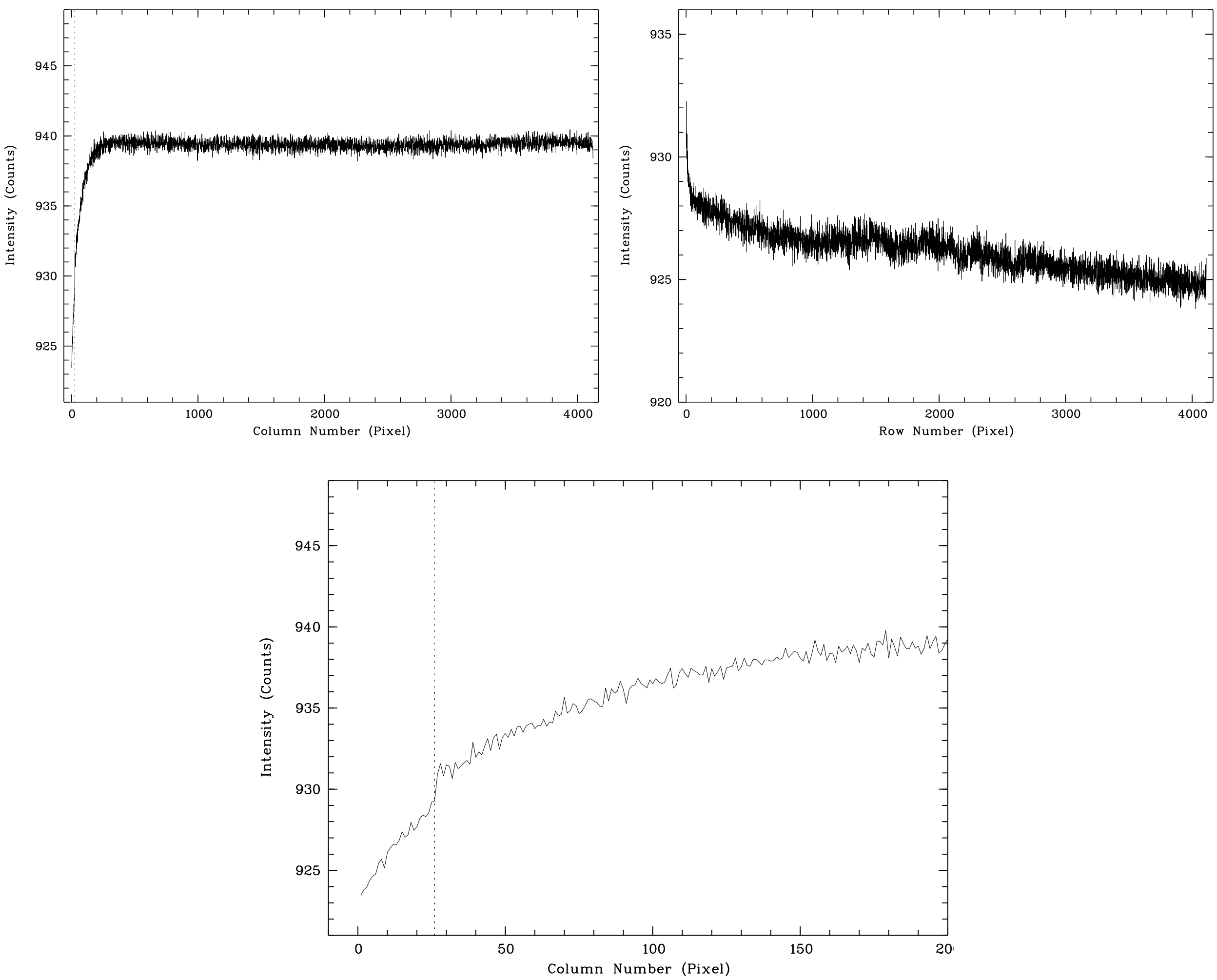


Figure 2: Bias frame for the red arm CCD: **The left-up** panel shows the result of averaging for 26 rows. **The right-up** panel shows the result of averaging for overscan region (26 columns). **The bottom** panel is the same as the left-up, but shows only first 200 pixels. The overscan region location is shown with vertical dotted line.

4 Historical note

During the 2014-2 semester (end of 2014 till April of 2015 year) both HRS CCDs were used in slightly different modes compare to 2015-1 and current 2015-2 semesters. Different modes (number of amplifiers and read-out speed) resulted different levels of overscan and bias. For that reason, my analysis was done only for data taken from 2015 May, 1st even all available data were used for the calculations.

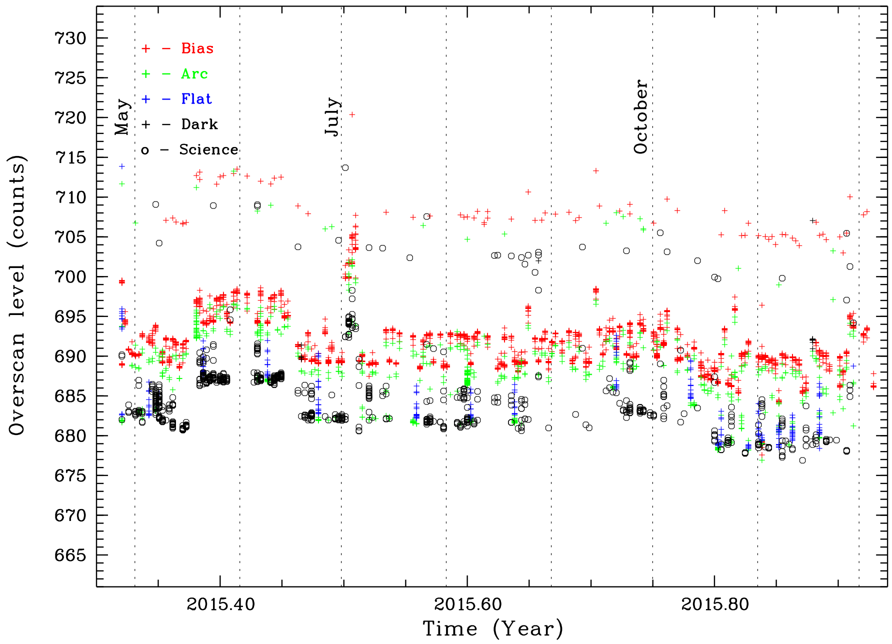
5 HRS overscan and bias long-term stability

5.1 The blue arm CCD

The long-term trends for average overscan and bias levels for the blue arm HRS CCD as well as long-term trends for overscan and bias standard deviations and CCD temperature dependence are shown in Figures 3, 4 and 5. The result of correction of the average bias level for overscan is shown in Figure 5.

Some primary notes is possible to formulate immediately after shortly looking of these figures:

- There is small long-term negative trend of the average overscan level from ∼690 counts to ∼685 counts during last half of the year.
- There is the same pattern in overscan levels for frames of different types: usually one frame has much higher level compare to others.
- There are two systematic jumps for the overscan level for all types of frames: (1) during May-June and (2) at the beginning of July.
- There are happen some sudden jumps in overscan levels for one day only.
- It looks to me that ANY additional signal drops overscan down somehow since practically all Arc, Flat and Science frames have average level of overscan LOWER compare to the overscan level from bias frames. **Possibly it is proportional either to signal level or exposure time and has to be checked additionally**.
- The difference between bias and other frames is also visible in the standard deviations picture, where all biases are higher compare to all others frames types.
- The similar pattern is visible for the temperature.
- For the most of bias frames correction for the overscan level produces very stable result with standard deviation $\sigma = 0.25$ counts only.
- I belive that problems at the end of November are related to the additional light. **Such problems could be EASILY recognized with simple analysis of bias levels.**



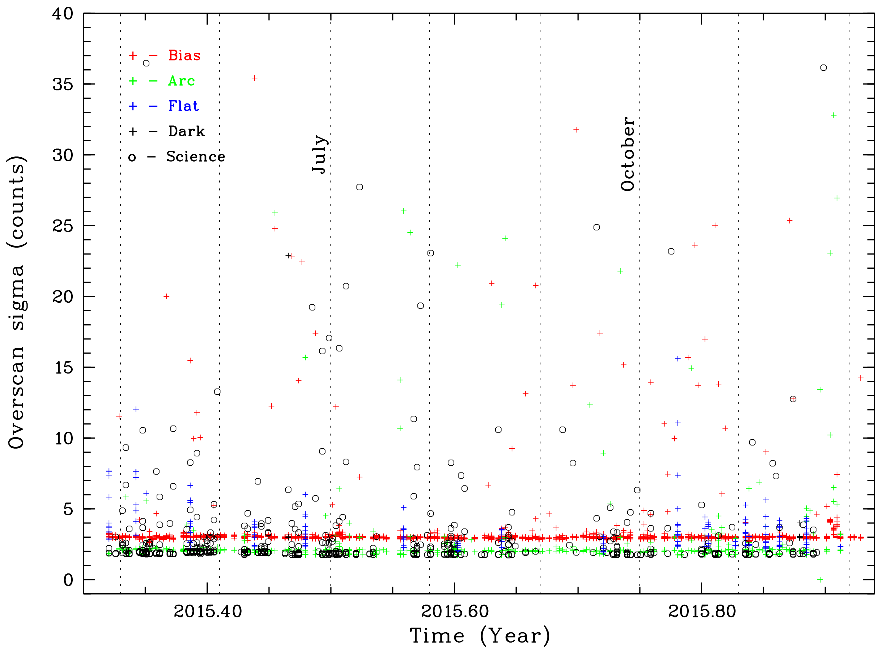


Figure 3: Overscan average level and standard deviation for overscan for the blue arm CCD and slow read-out speed (400 kHz) and one amplifier only. It is shown for the period of time, when this read-out speed and number of amplifiers started to be used massively – from the 2015 May, 1st. **Top:** Overscan level for bias frames is shown with red crosses, for Arc frames with green crosses, for Flats with blue crosses, for Darks with black crosses and for Science frames with black circles. **Bottom:** Standard deviation for the overscan region.

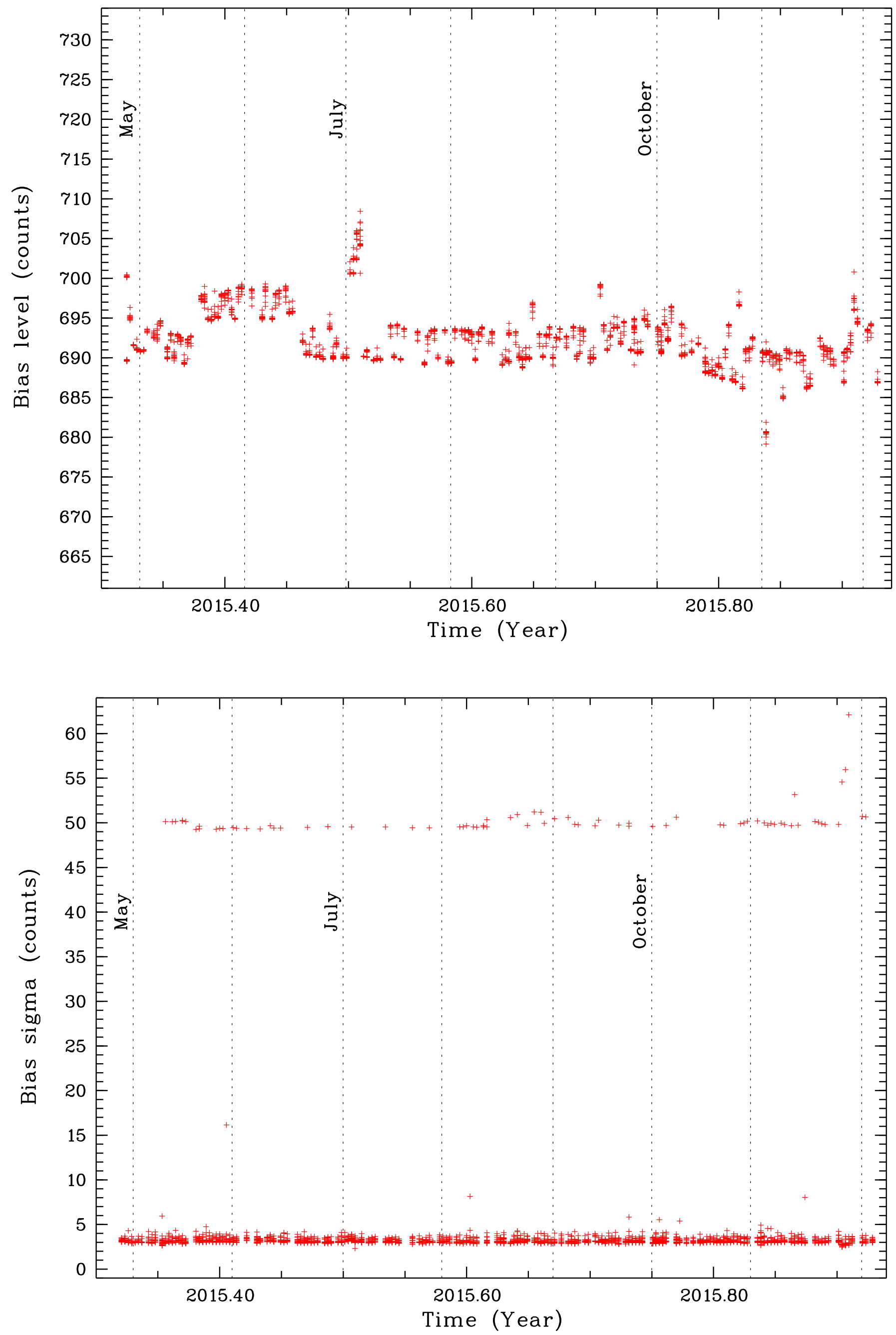


Figure 4: Bias average level (top) and standard deviation for Bias frames (bottom) for the blue arm CCD and slow read-out speed (400 kHz) and one amplifier only. Symbols are the same as in the previous figures.

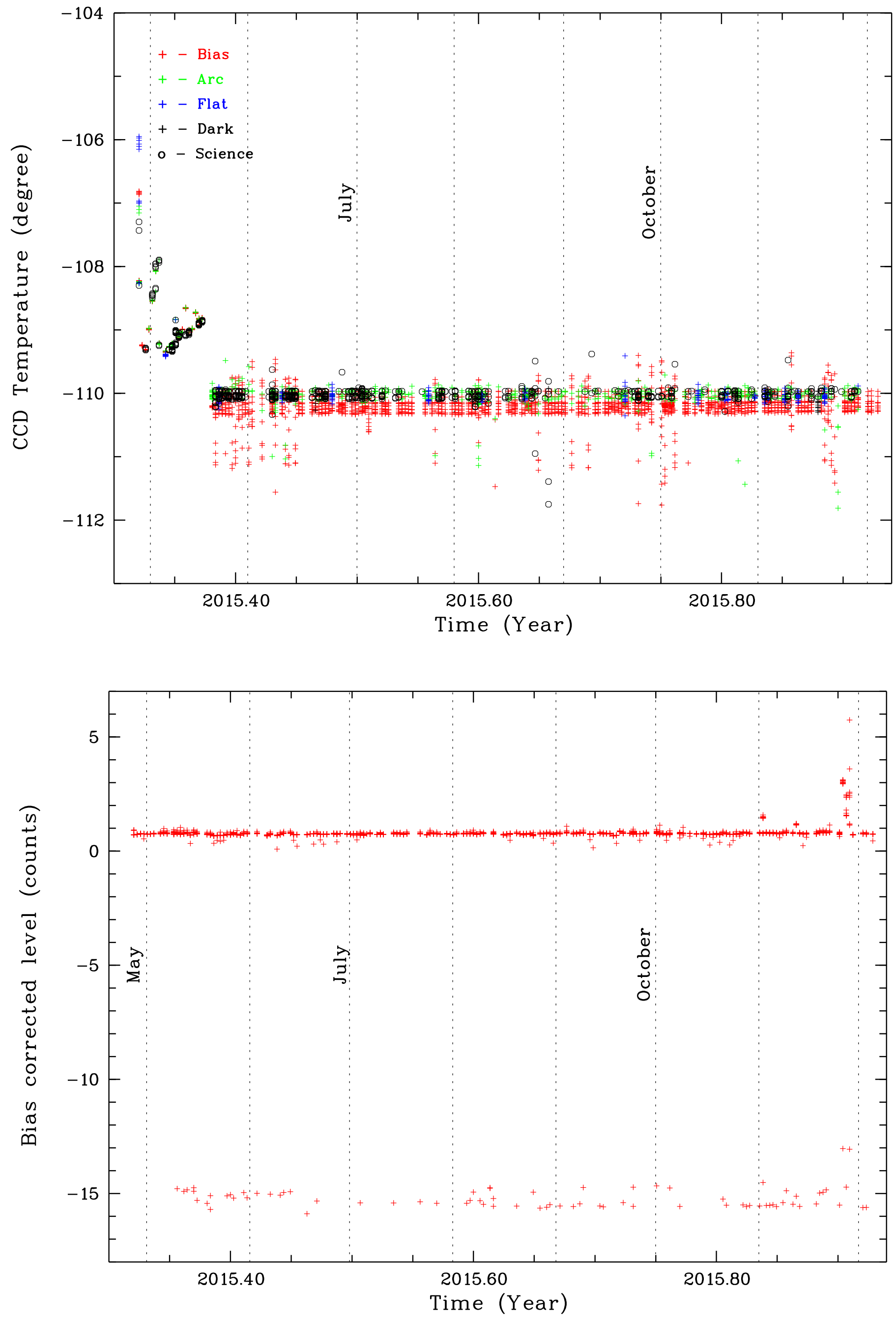


Figure 5: Temperature of the CCD (top) and Bias average level corrected for overscan (bottom) for the blue arm CCD and slow read-out speed (400 kHz) and one amplifier only. Symbols are the same as in the previous figures.

5.1.1 Effect of the first frame

Many effects, which are shown in the previous section could be explained in terms of "the first frame effect". First view into Figures 6 and 7 make obvious that the overscan level for the first frame of the night has usually much higher level and this effect does not depend on the frame type. The first frame in any series also has slightly (or considerably) higher level of the overscan.

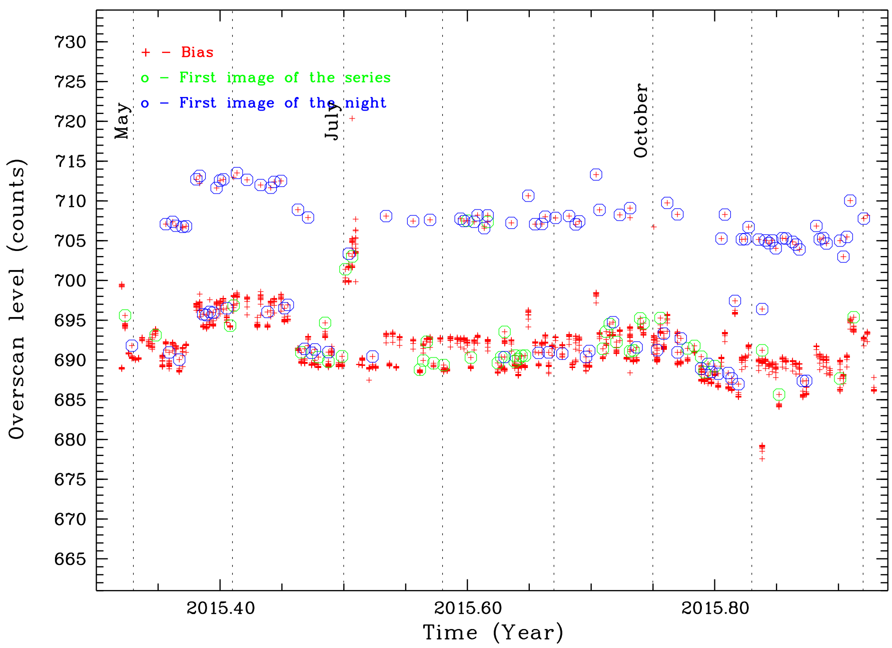
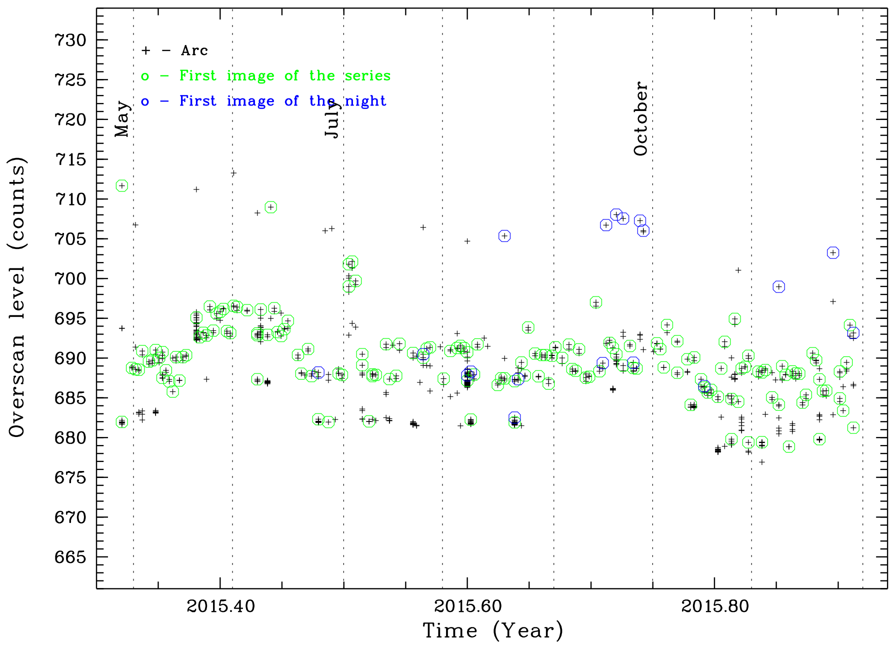


Figure 6: Overscan average level for bias frames depending on their number in series for the blue arm CCD and slow read-out speed (400 kHz) and one amplifier only.



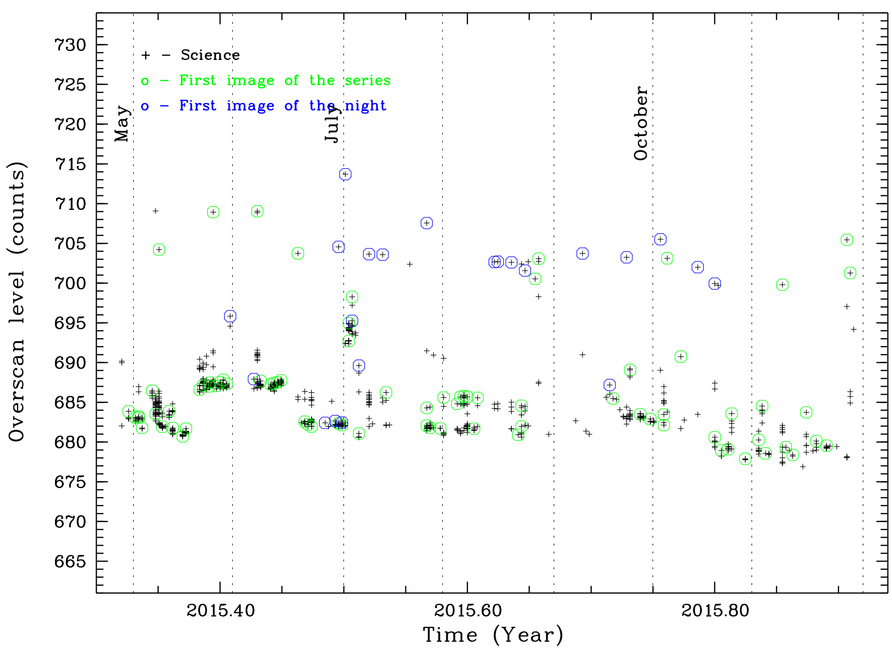


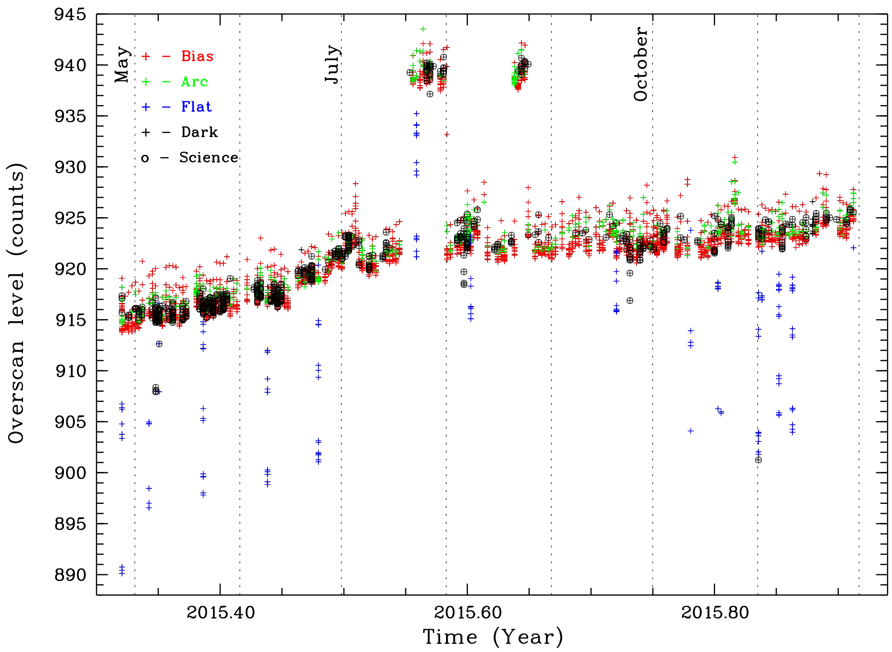
Figure 7: Overscan average level for arc frames (top) and science frames (bottom) depending on their number in series for the blue arm CCD and slow read-out speed (400 kHz) and one amplifier only.

5.2 The red arm CCD

The long-term trends for average overscan and bias levels for the red arm HRS CCD as well as long-term trends for overscan and bias standard deviations and CCD temperature dependence are shown in Figures 8, 9 and 10. The result of correction of the average bias level for overscan is shown in Figure 10.

Some primary notes is possible to formulate immediately after shortly looking of these figures:

- There is long-term positive trend of the average overscan level from ∼915 counts to ∼925 counts during last half of the year.
- There are two systematic jumps for the overscan level for all types of frames: (1) at the end of July and (2) during August.
- The average overscan level for all Flat frames is located systematically lower and the standard deviation is systematically higher.
- The average overscan level for Bias, Arcs and Science frames is about the same during the night.
- The average overscan level for each set of Bias frames usually has a spread where one or two Bias frames have it higher compare to others.
- There is a pattern for the temperature, where Bias frames were observed with slightly lower temperature.
- For the most of Bias frames correction for the overscan level produces very stable result with standard deviation $\sigma = 0.25$ counts only. Small trend of the corrected level is visible there.



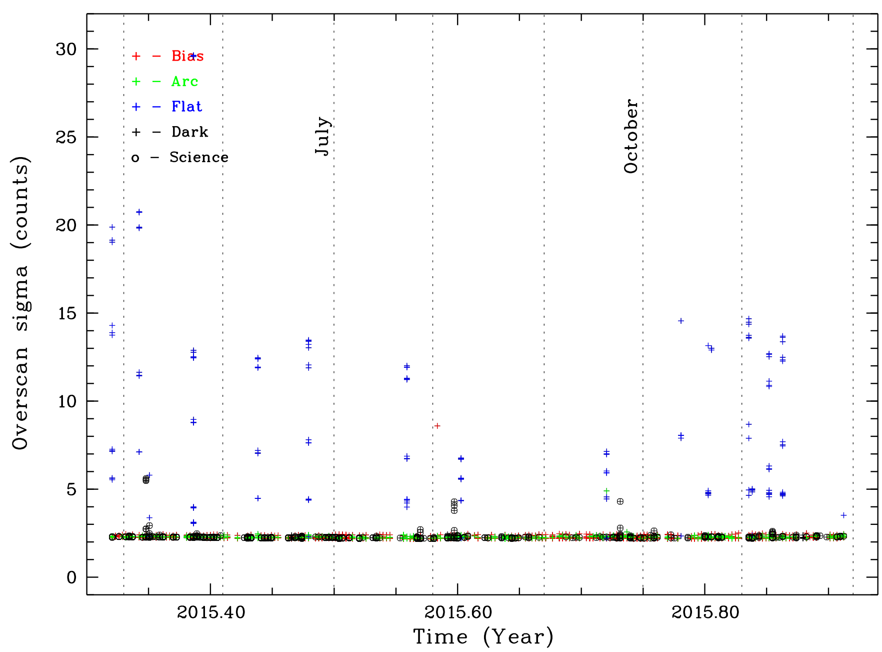
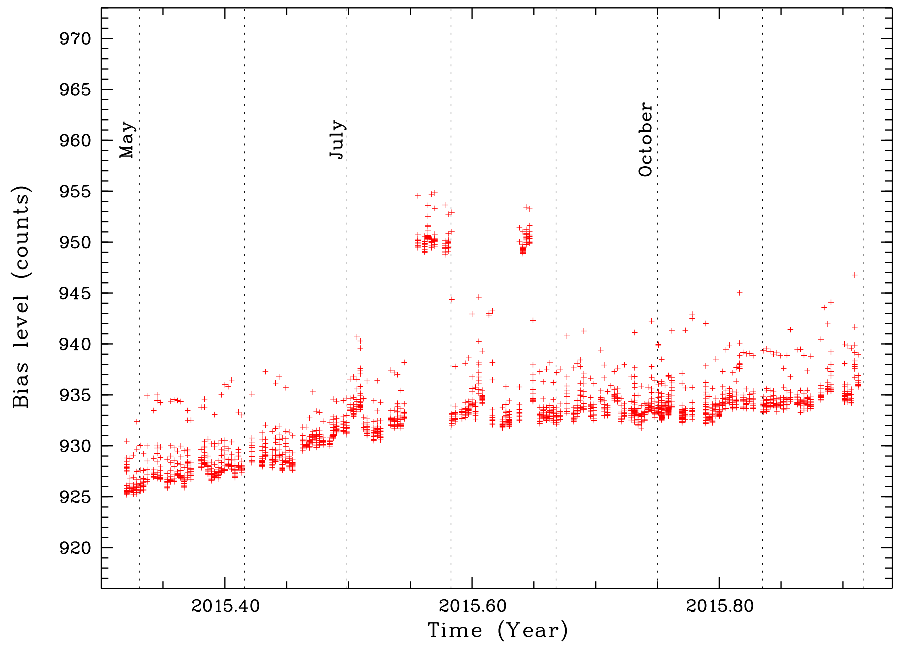


Figure 8: Overscan average level and standard deviation for overscan for the red arm CCD and slow read-out speed (400 kHz) and one amplifier only. It is shown for the period of time, when this read-out speed started to be used massively: from the 2015 May, 1st. **Top:** Overscan level for different types of frames. Symbols are the same as in the previous figures for the blue arm CCD. **Bottom:** Standard deviation for the overscan region.



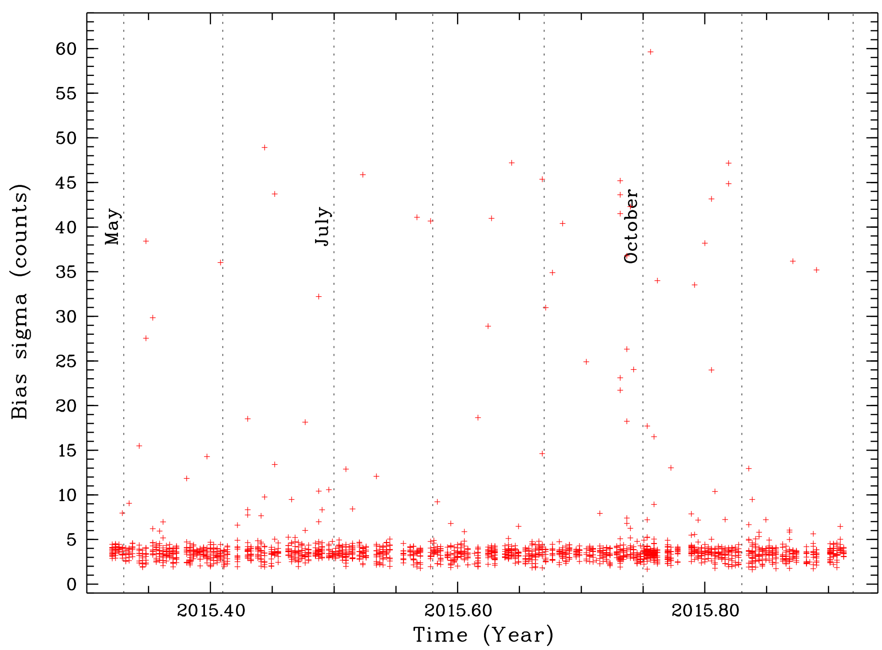


Figure 9: Bias average level (top) and standard deviation for Bias frames (bottom) for the red arm CCD and slow read-out speed (400 kHz) and one amplifier only. Symbols are the same as in the previous figures.

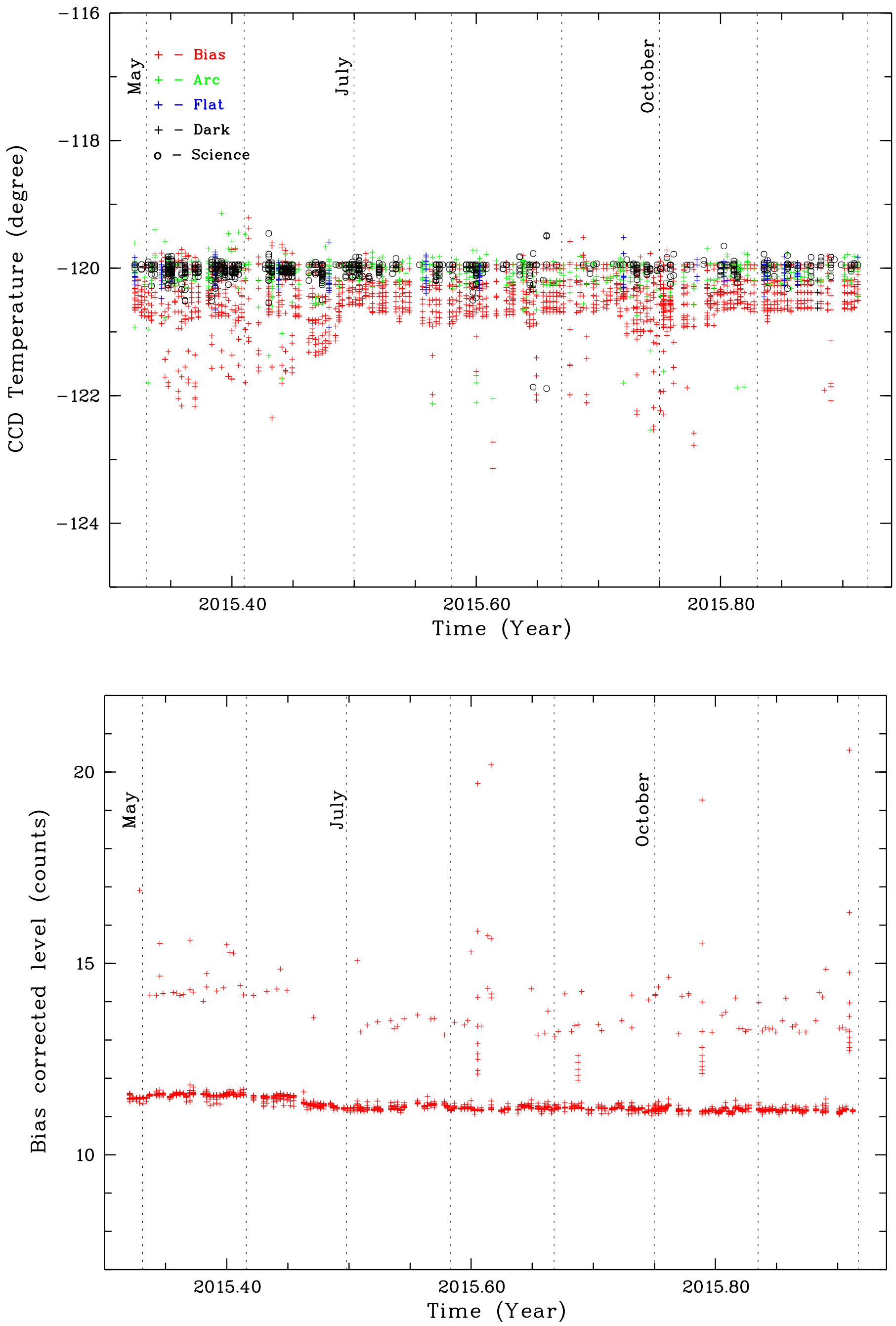


Figure 10: Temperature of the CCD (top) and Bias average level corrected for overscan (bottom) for the red arm CCD and slow read-out speed (400 kHz) and one amplifier only. Symbols are the same as in the previous figures.

5.2.1 Effect of the first frame

Some effects, which are shown in the previous section could be explained in terms of "the first frame effect". First view into Figures 11 and 12 make obvious that the overscan level for the first Bias frame of the night has usually much higher level, but it is not totally true for Science and Arc frames. The first frame in any series also has slightly (or considerably) higher level of the overscan for Bias frames, but this tendency is not so obvious for Science and Arc frames.

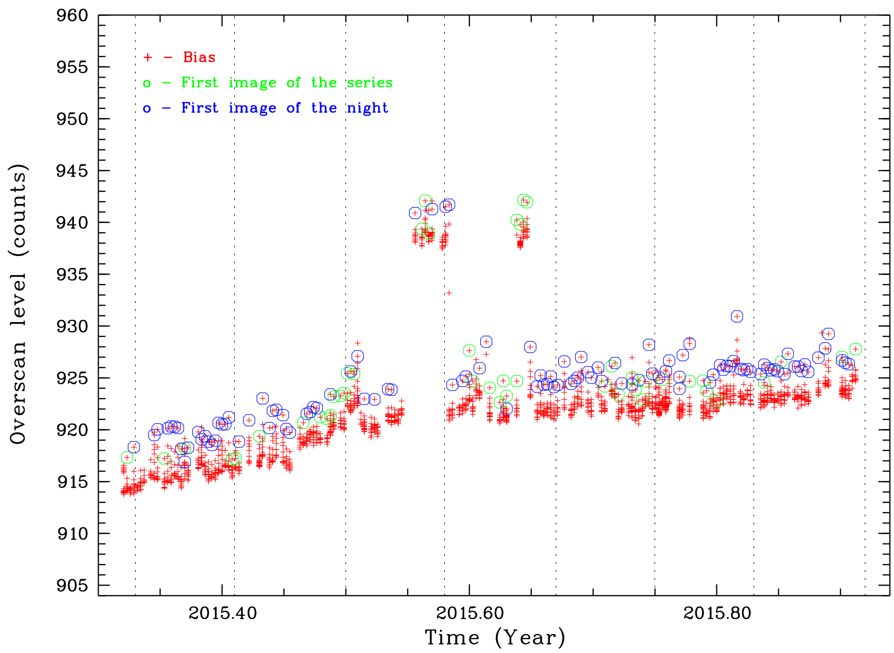
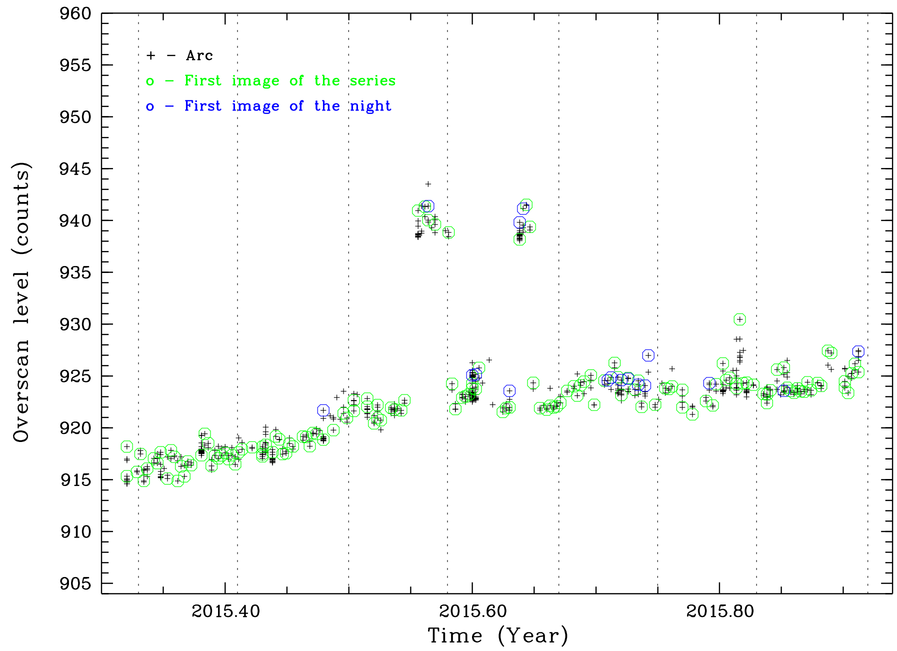


Figure 11: Overscan average level for bias frames depending on their number in series for the blue arm CCD and slow read-out speed (400 kHz) and one amplifier only.



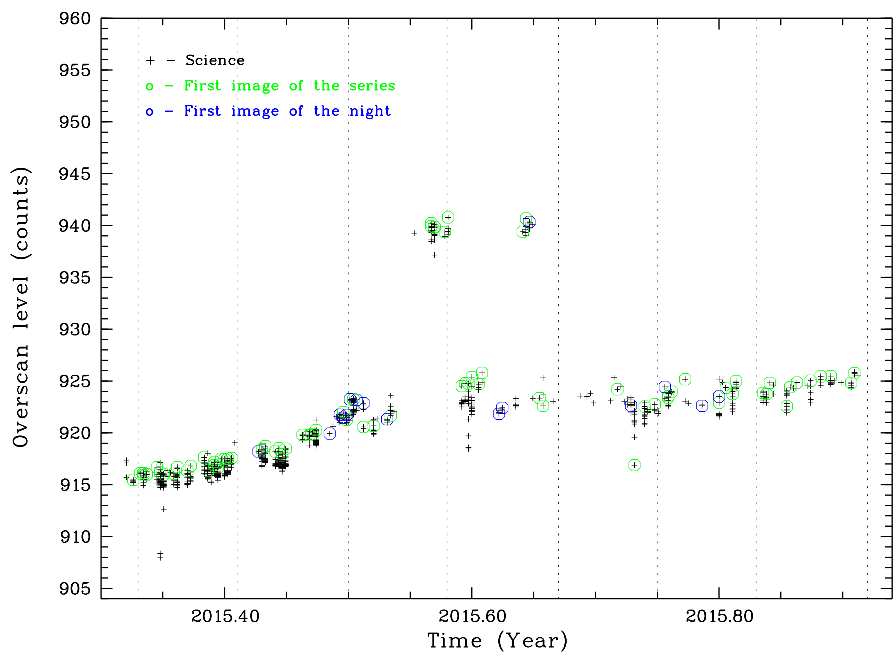


Figure 12: Overscan average level for arc frames (top) and science frames (bottom) depending on their number in series for the blue arm CCD and slow read-out speed (400 kHz) and one amplifier only.

6 Summary and recommendations

In this report I studied different aspects of HRS overscan for CCDs from both blue and red arms.

My results show that for both blue and red arm CCDs there is a jump in the overscan level between the first frame of any series and the rest of the frames. The largest jump is for the FIRST frame of the night. This situation is obvious for ALL frame types for the blue arm CCD and for Bias frames for the red arm CCD. For that reason, if we would like to use overscan for HRS frames, we need to improve this situation and possibly update our low-level software to produce **dummy read-out** at the beginning of any series of HRS frames.