Duty Cycle Analysis

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1 Introduction

On January 19 2010 the OMI IOT was called by the OC because the duration of the yellow limit warnings for CCD1 duty cycle was (much) longer than the persistency value of 32s. The yellow limit value at the time was 5%. The longest duration of the yellow limit warnings according to the OC analysis: 12:48:39 – 12:54:11 (5min 32s). This information is obtained from S-band TLM data (4 s between two TLM points). In section 2 the OMI IOT analysis of the situation and immediate actions taken are described.
Since launch the CCD duty cycles have been steadily decreasing from about 20-25% to about 6-9% (daily average). Eventually the duty cycle will become low enough for the OPB temperature to influence the CCD temperature. In section 3 the possibilities are described to increase the duty. In section 4 the conclusions are summarized.

2 Analysis of APID 1834 data of January 19 2010

The OMI IOT performed their analysis on APID 1834 data of January 19 2010 (X-band (2 seconds between two TLM points). The most important criterion for the OMI IOT is the stability of the OMI CCD temperatures. A script was run to check for periods for which the duty cycle value was lower than 5%, the yellow limit setting at the time, and that lasted longer than the persistency value of 32s. It found that that was the case on 10 occasions that day.

Figure **1** shows the CCD1 temperature (left) and the CCD1 duty cycle (right) as function of time. The red lines indicate the longest period for which the CCD duty cycle was below 5%. The CCD temperature is as stable as always, also during the extended period that the duty cycle was below 5%.
The period for which the duty cycle was below 5% is shorter than the period reported by the OC. This is true for all periods reported to be below 5% that lasted longer than 32s and is probably due to the differences between S-band and X-band TLM data: some single 6.27% TLM values in X-band data are not observed in S-band TLM data.

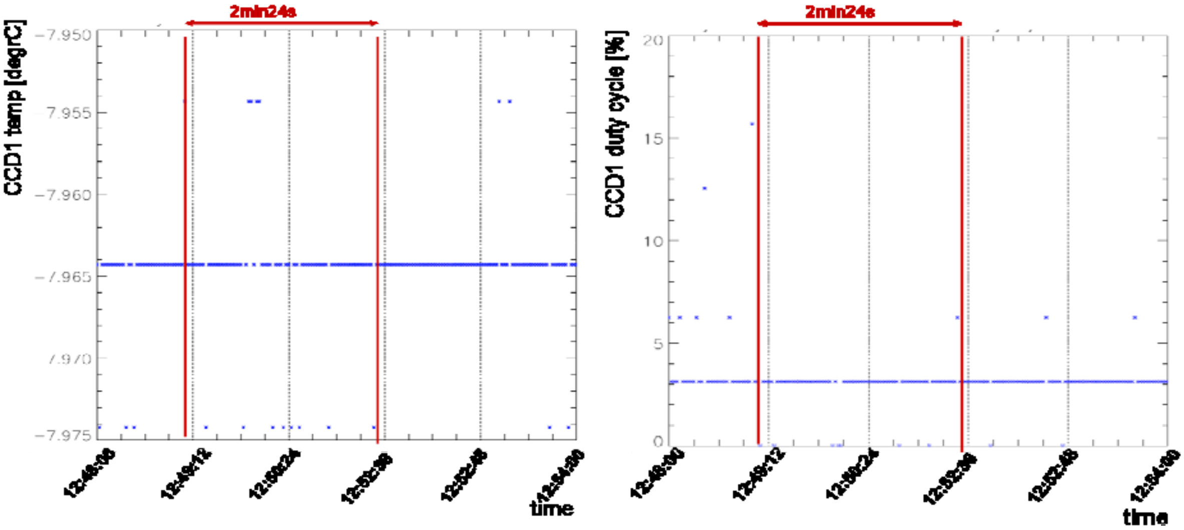

Figure 1. CCD1 temperature (left) and CCD1 duty cycle as function of time for January 19 2010 between 12:48:00 – 12:54:00. The red lines indicate a period for which the duty cycle remained below 5%.

Although the actual periods of time that the CCD1 duty cycle remains below 5% is not as long as the OC reported, it is (much) longer than the persistency value of 32s that was in the database at the time.
Since the criterion for OMI IOT is the stability of the CCD temperatures and the CCD temperatures remain stable even when the duty cycle is as low as 3.14% for a prolonged period of time the OMI IOT requested the yellow limit warning to be put at 2% (which catches only the zero percent duty cycle values) and the persistency to 1 minute. This was done on February 18 2009.

3 Measures to increase the duty cycle

Since start of the mission the OPB2 temperature daily average has increased by about 1 K, see Figure 3, caused by contamination of the cooler. The CCD temperatures are actively adjusted to a set value. As a result the CCD1 duty cycle daily average has decreased by about 12% as can be seen in Figure 4. In Figure 2 the CCD1 temperature daily average is plotted since the start of the mission. The fact that the CCD temperature does change and doesn’t remain completely stable is due to the fact that P controls, which approach asymptotically a set value, have been used instead of PID controls, which oscillate quickly to a set value.
It is expected that when the duty cycle is 0% (daily average) the CCD temperature will start to follow the OPB temperature and will no longer be stable. When the duty cycle continues to decrease at the present rate, it is expected to reach this point somewhere in the year of 2012. When the CCD temperature will start to follow the OPB temperature the duty cycle should be increased. This can be accomplished by:

1. increasing the CCD temperature (change the CCD temperature setpoint)
2. decreasing the OPB temperature (change OPB power)

A change of CCD temperature will result in an increase of dark current and RTS behaviour. The TDOPF/GDPS are capable to correct dark current for CCD temperature changes. A change in OPB temperature, however, could cause changes in the radiometric calibration. The fact that the heater mats are wired separately from each other could lead to gradients in the OPB temperature when a different heater setting is used with possible optical consequences. Therefore, it is not desirable to change the OPB power/temperature. Our calibration scientist suggests the CCD temperature setpoint should be increased by 0.5 – 1.0 K.
The change of the CCD (or OPB) temperature is a simple command that has also been used several times in the past during the LEO phase.

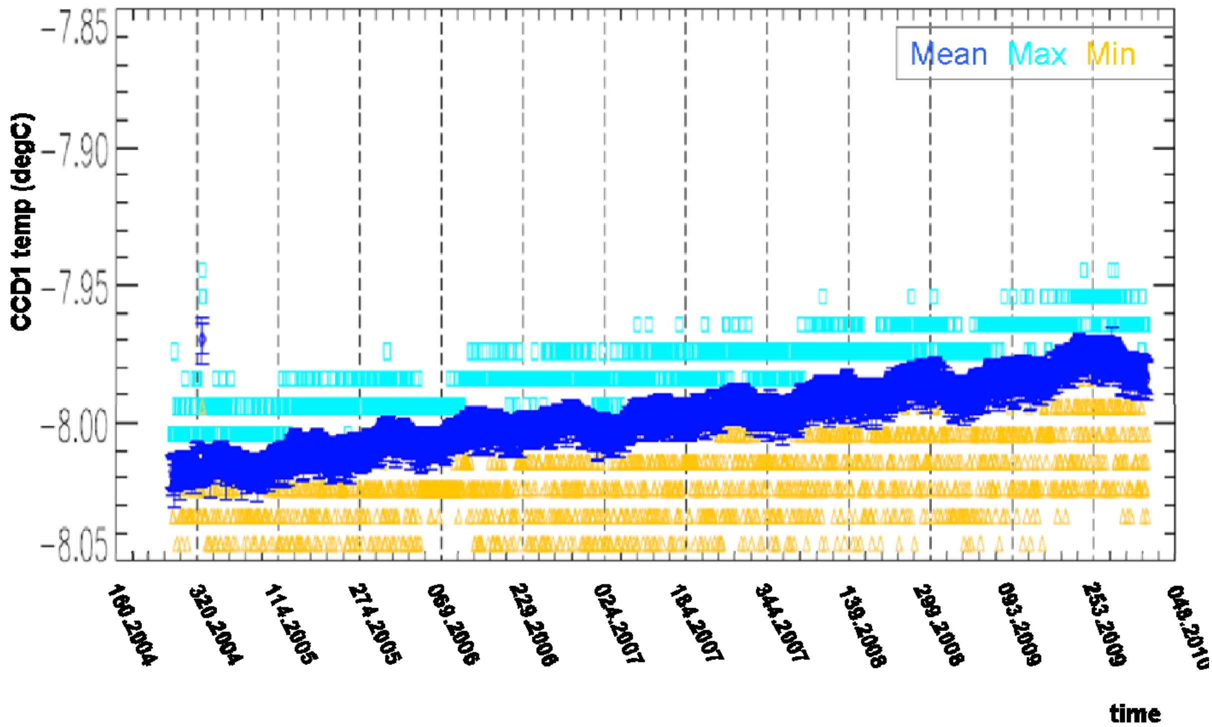

Figure 2. The daily mean CCD1 temperature since start of the mission.

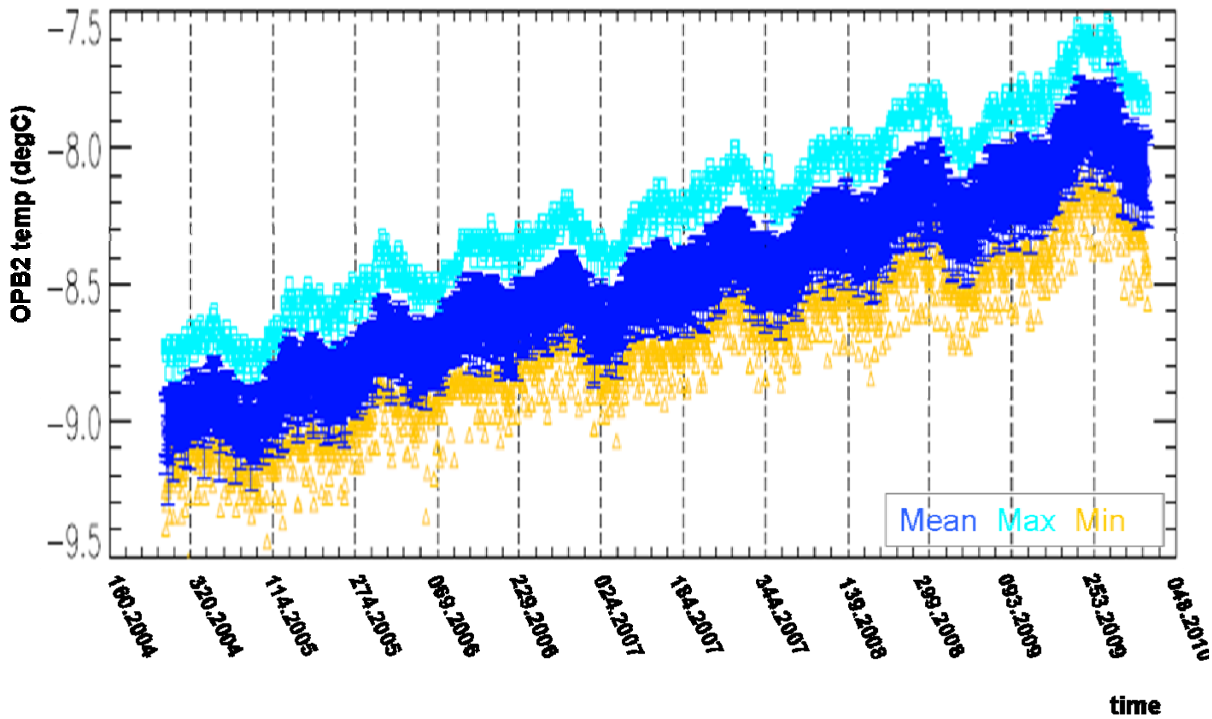

Figure 3. The daily mean OPB2 temperature since start of the mission.

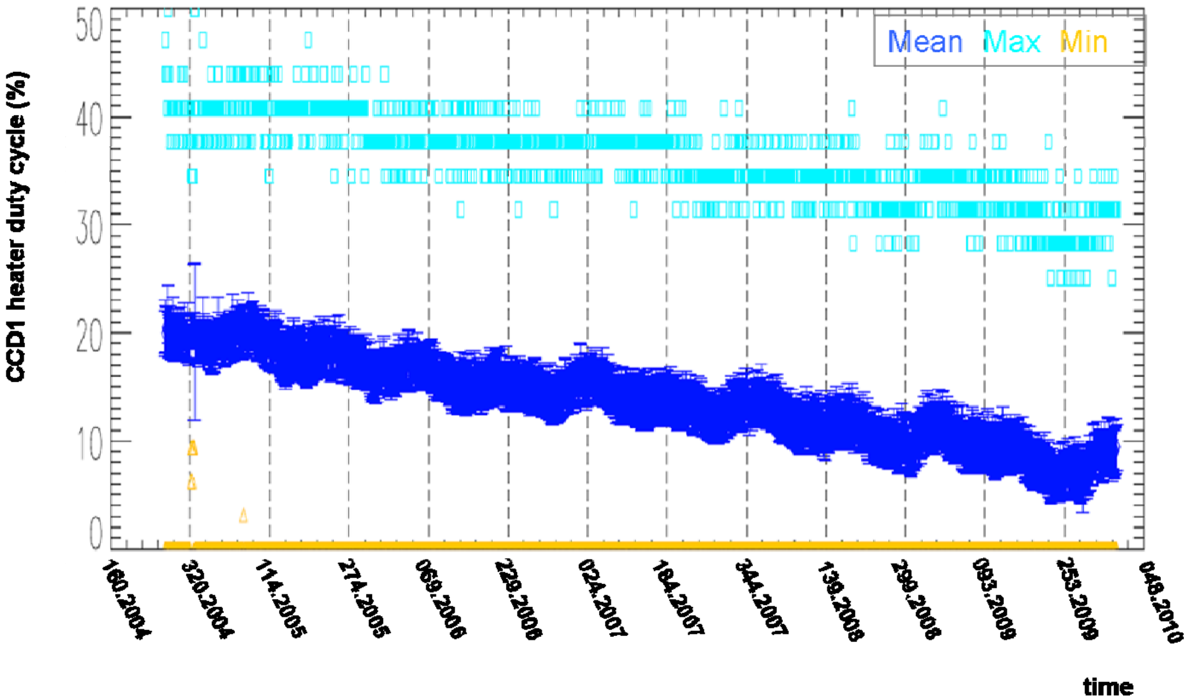

Figure 4. The daily mean ccd1 duty cycle value since start of the mission.

Figure 5 shows the CCD temperatures as function of OPB power. Although the CCD setpoint does not change there is a change in CCD temperature of about 0.017 degrees per Watt. Figure 6 shows that the duty cycles will change by about 5% per Watt change of the OPB power. Figure 7 shows a change of the OPB temperatures of about 0.46 degrees per Watt change of the OPB power. Decreasing the OPB power would result in an increase in CCD duty cycle of 10%. The OPB temperature will increase by almost 1 degrees and the CCD temperature will decrease by almost 0.034 degrees.

Unfortunately we don't have these parameters as function of CCD temperature settings since there was not enough data during the LEO phase where only the CCD temperature setpoint changed or a long enough stable period could be found. So we don't know what effect a change in CCD temperature setpoint has on the OPB temperatures. But it is estimated to be minimal.

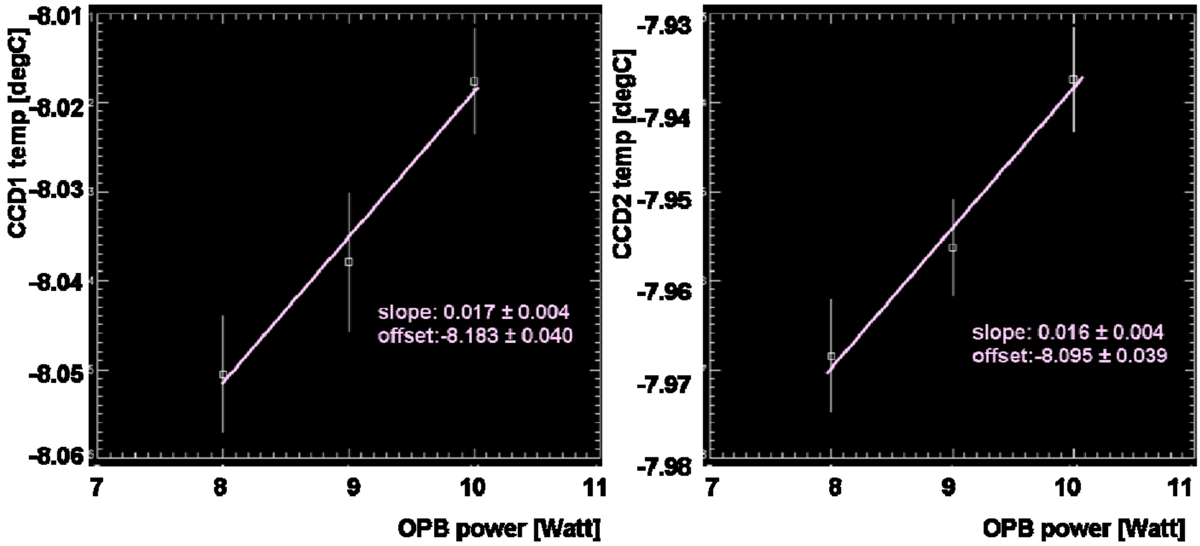

Figure 5. CCD1 temperature (left) and CCD2 temperature (right) as function of OPB power.

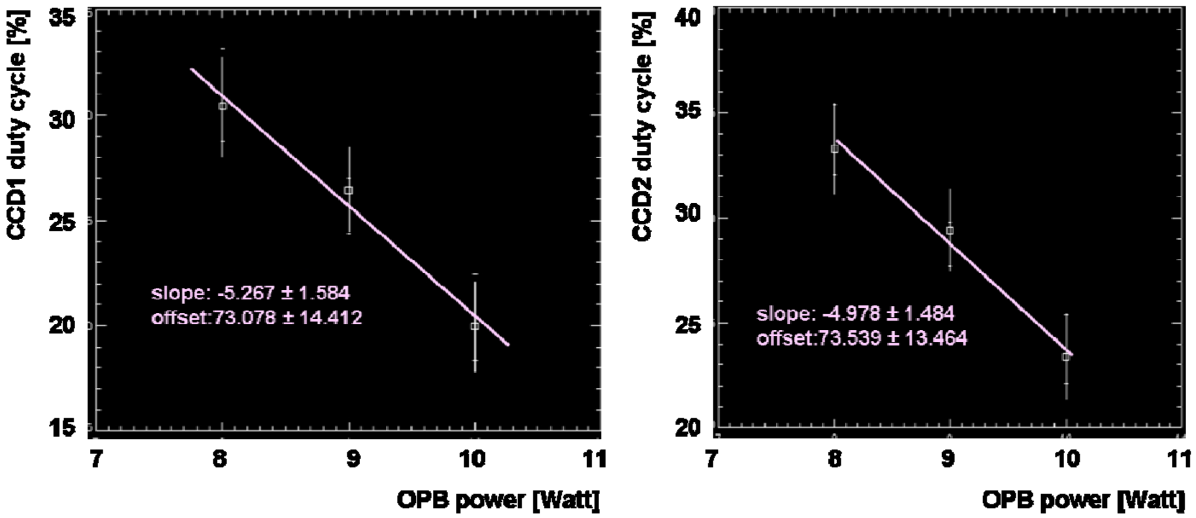

Figure 6. CCD1 duty cycle (left) and CCD2 duty cycle (right) as function of OPB power.

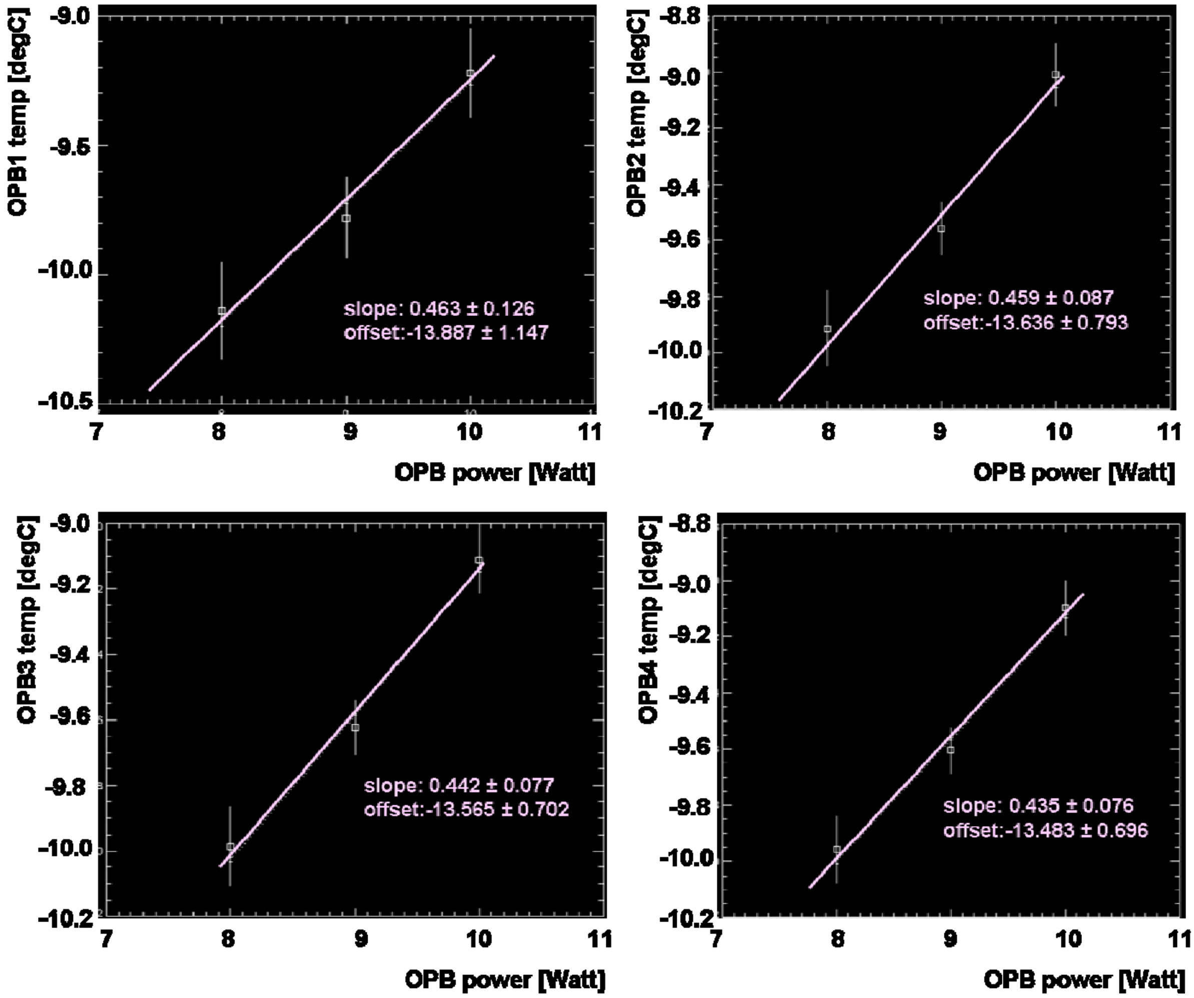

Figure 7. OPB1 temperature (top left), OPB2 temperature (top right), OPB3 temperature (bottom left) and OPB4 temperature (bottom right) as function of OPB power.

4 Conclusions

- On January 19 2010 the OMI IOT was called by the OC because the duration of the yellow limit warnings for CCD1 duty cycle was (much) longer than the persistency value of 32s.
- APID 1834 engineering data of January 19 2010 has been analyzed
- The ccd1 and ccd2 temperatures remain stable even when the duty cycle is low for an extended period of time.
- The period that the CCD1 duty cycle remained below the yellow limit value was not as long as reported by the OC which is probably due to the differences between X-band and S-band data.
- On February 18 2009 the duty cycle yellow limit was put to 2% and the persistency value to 1 minute. The OMI IOT continues to monitor the situation.
- It is expected that when the daily average of the duty cycle will reach 0% the CCD temperature will (partly) start to follow the OPB temperature and will no longer be stable.
- When this point is reached the duty cycle should be increased.
- From calibration point of view it is better to change the CCD temperature than to change the OPB temperature.
- the CCD temperature set point should be changed by 0.5 – 1.0 K

- To increase the CCD temperature a single command needs to be issued. This command has been issued successfully several times in the past during the LEO phase of the mission.