XMM-Newton Technical Note

XMM-CAL-TN-0206

RGS Diagnostic Trend Analysis Report - May 2015

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September 24, 2015

1 Introduction

The purpose of this note is to report on the evolution of several indicators derived from the RGS Diagnostic and Science data, with the aims of looking for eventual instrument degradation and necessary changes in the data corrections performed in the RGS scientific data reduction.

Running the RGS Diagnostic and Trend Analysis tools (see XMM-SOC-SW-TN-0012) we have collected and analysed data from the whole mission up to now. Evolution of instrument offsets "system peak") and bad pixels / columns have been under study.

2 Results of RGS Diagnostic and Trend Analysis

The RGS Diagnostics Tools are running over all collected diagnostic data through the monitoring procedures. They are started every night, looking for new PMSFITS data arrival. If data corresponding to a new orbit are present, they get analysed, the reduced data stored and some of the results published in the internal RGS monitoring web page [1].

2.1 System Peak evolution

Figure 1 shows the evolution of the system peak corresponding to the C nodes of all working CCDs in RGS1 in the whole XMM-Newton history. Although the evolution of the offsets is stable, in the last 120 revolutions analysed for this report a significant decrease can be observed in the node C of this instrument, while node D continues showing a stable trend (see figure 2). In average, the variation holds within a 3% range compared to the last CCF. There is no clear explanation for this issue nor it can be related to any environmental event such as solar flares. No operational hiccup or instrument misbehavior (eg: focal plane temperature or analog electronic chain variations) can be linked to it either. Nevertheless, no impact in the quality of the RGS science products has been noticed.

RGS2 offsets show also the expected stable trend, with no significant evolution, again with variations averaging within the 3% range compared to last CCF, as shown by Figs.5. We recall that there is only one node, C, used for reading out the whole of the RGS2 detector since revolution 1408, therefore this side of the CCD has not been updated since then.

Apart from the RGS1 node C issue, it is evident in all distributions that the evolution of the offset values became substantially smoother after evolution 532. In that revolution, the operating temperatures of the RGS were reduced from -80 C to -113 C degrees. A especially remarkable fact is that, while every medium-large to large solar flare produced a sensible change in the offset values during the first period, after cooling down the instruments these were fully insensitive to high radiation events, which continued to happen with approximately the same frequency within the same periods of the solar cycle. The increase of the solar activity, which reached a maximum in the cycle during the first third of 2014 does not seem to have affected the RGS CCDs.

[1] http://xmm.esac.esa.int/ xmmdoc/internal/int_cal_instr_supp/rgs/monitoring.php

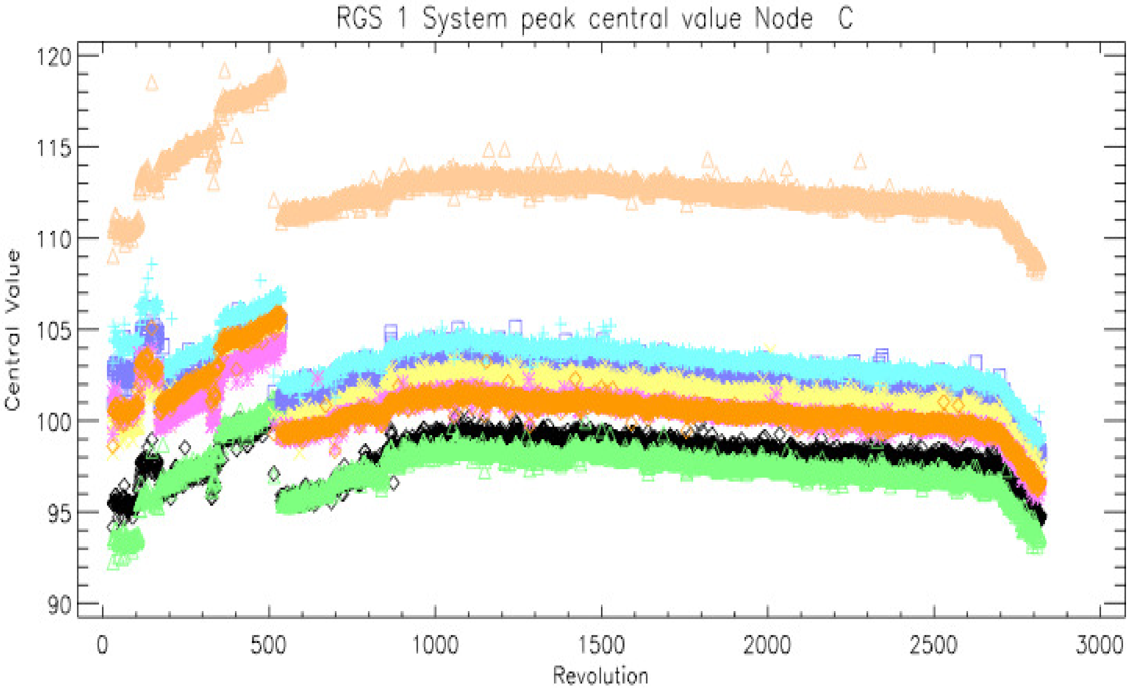

Figure 1: RGS1 - system peak evolution of node C data. Different colors represent the eight RGS1 working CCDs.

The default way of subtracting the offsets from the RGS scientific data consists in using the RGS Offset files derived from the averages of diagnostic images taken during three consecutive revolutions. This has the advantage of resolving the offsets per CCD pixel, and so to cover the variation of the offsets on a pixel by pixel basis. Nevertheless the possibility of subtracting a single offset value per CCD and node is also possible in the SAS (to be used for exceptional cases of lacking diagnostic derived offset files), with the corresponding values contained in the CCF RGS ADUCONV file. For this purpose, and in order to retain the capability of the data reduction software to handle RGS2 offset subtraction after the change to single node readout mode, an update of the ADUCONV files has been performed in the framework of this technical note. This new update consisted in changes in the value of the offset column in the aducoeff extension of the CCF files and resulted in the release of four new files (RGS2_ADUCONV_0025 -0026 -0027 -0028.CCF). The corresponding release note can be found under http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0327-1-0.pdf.

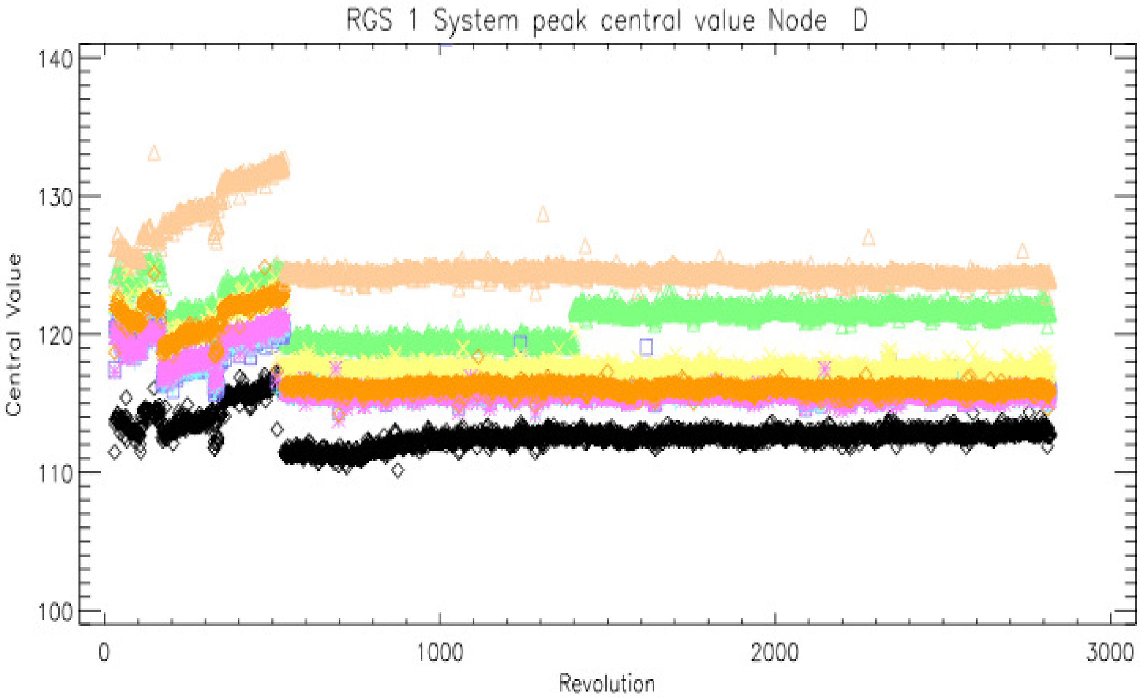

Figure 2: RGS1 - system peak evolution of node D data. Different colors represent the eight RGS1 working CCDs.

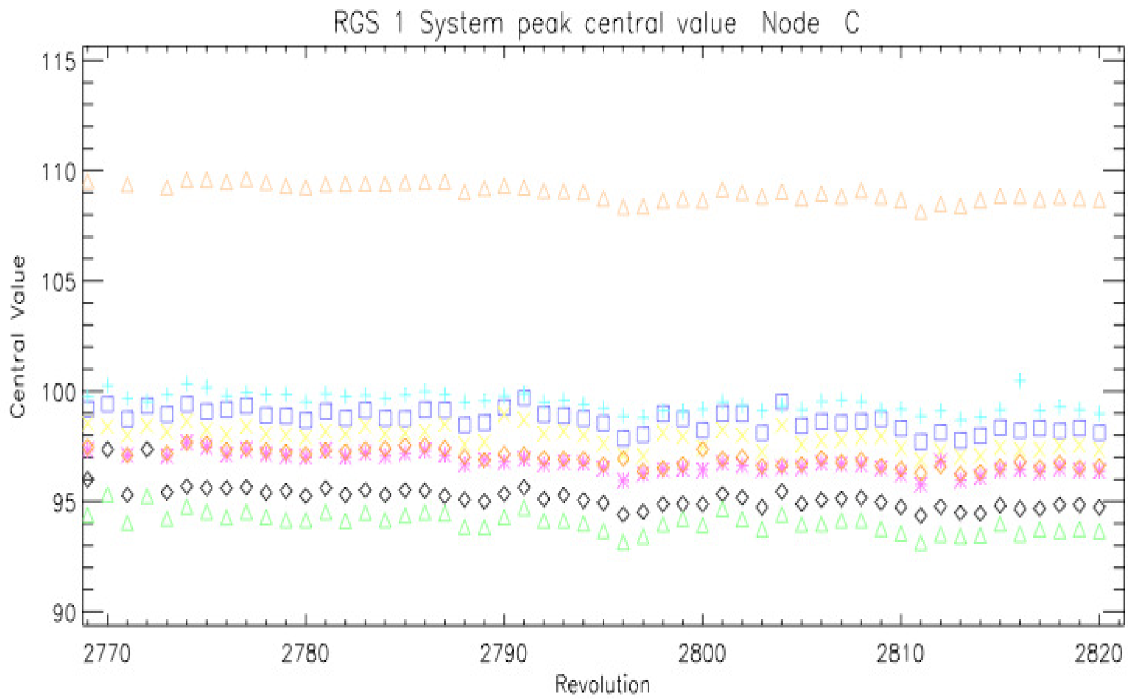

Figure 3: RGS1 - system peak evolution of node C data in the revolutions range [2770-2820].

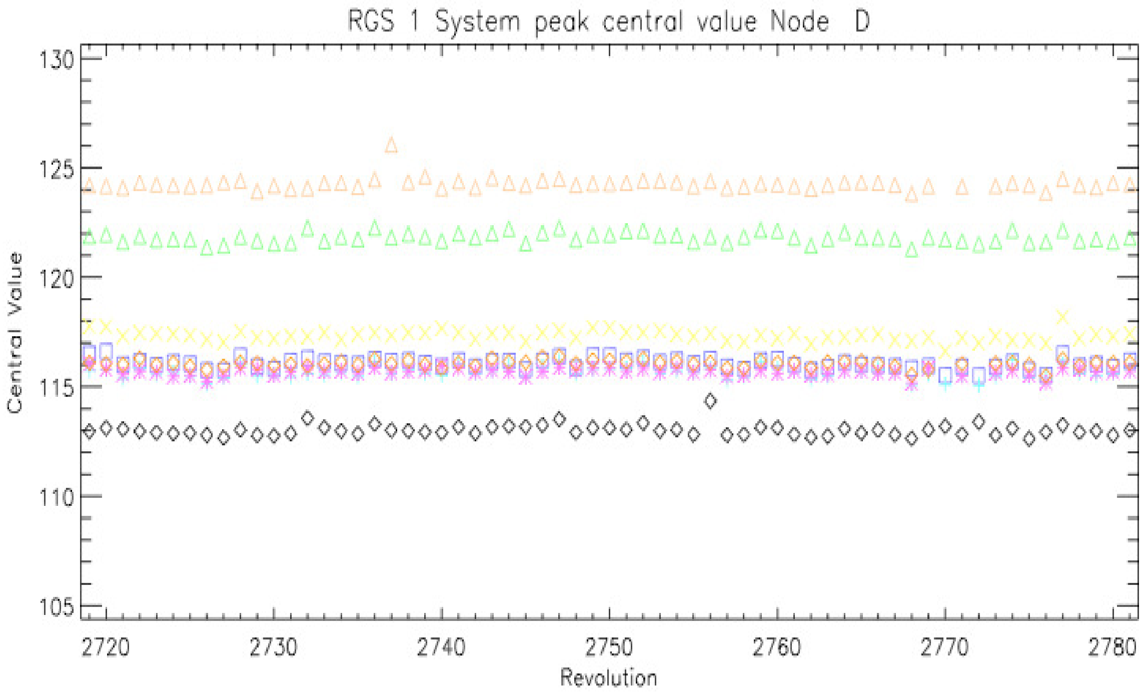

Figure 4: RGS1 - system peak evolution of node D data in the revolutions range [2770-2820].

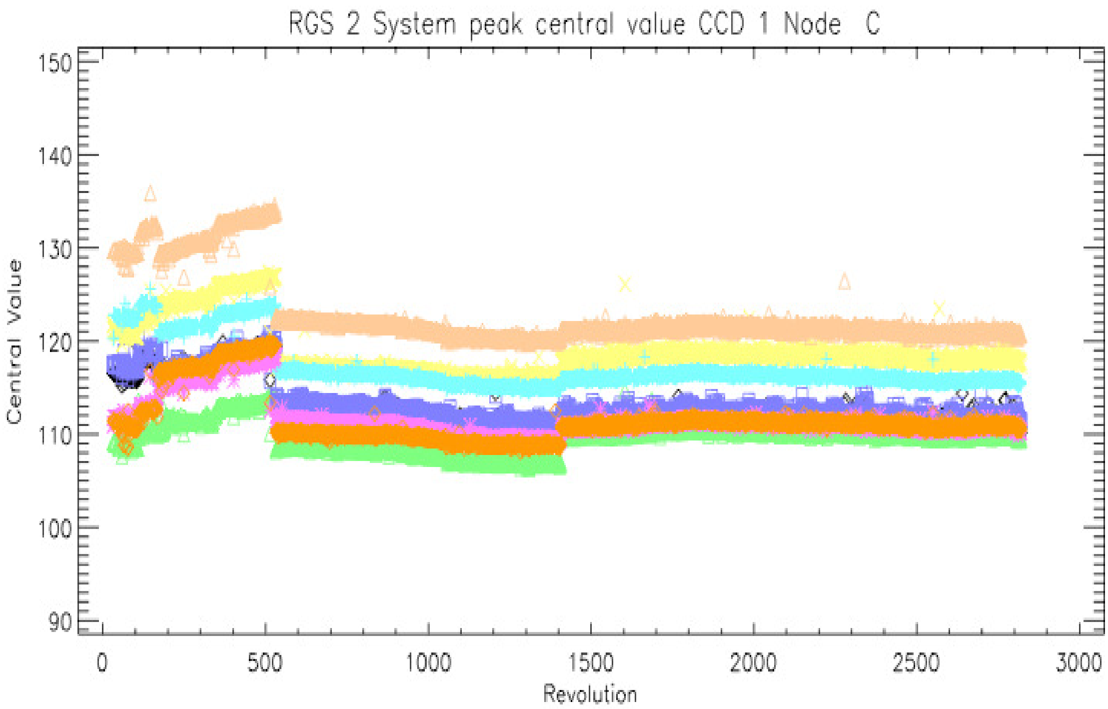

Figure 5: RGS2 - system peak evolution of node C - whole mission.

2.2 Evolution of Hot Columns and Hot Pixels

We have analysed both diagnostic and science data for finding out the evolution of hot columns and pixels. The analysis methods have been discussed in former reports (see XMM-CCF-REL-226[2]). Actually the diagnostic data does not show any increase of hot columns in the last 3 years. There are 2 persistent hot columns, one in each RGS (RGS1-CCD1-D38 and RGS2-CCD9-C94), as well as the hot spots, reported in the same CCF release note. The diagnostic bad pixel maps in Fig.6 show the 2014 collected data corresponding to RGS1 CCD1.

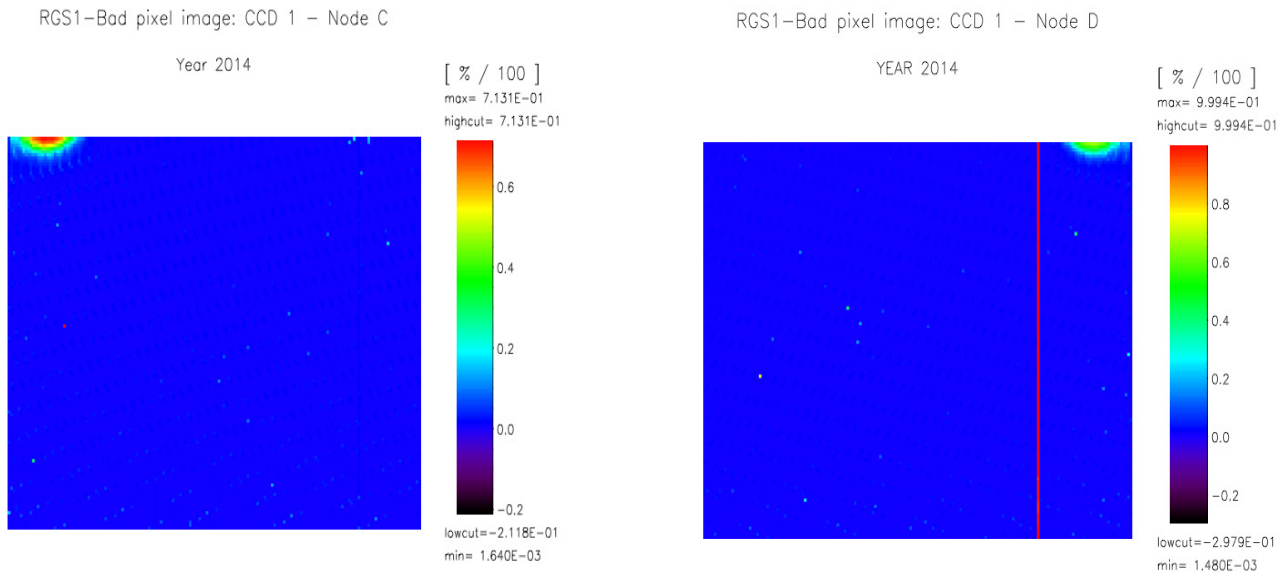

Figure 6: RGS1 - CCD1 C and D bad pixel maps showing the two "hot spots" and the only hot column found in RGS1 in the diagnostic data (column 38 on the D side) corresponding to 2014.

The analysis of the science data is based on the SAS task "rgsbadpix". We monitor yearly the number of columns and pixels found to be "hot" by the task, without using the otherwise default parameter "withadvisory=true", which would be excluding the advisory hot columns and segments present in the valid BADPIX CCF file. In this way we can detect unstable columns, which become hot in certain periods and irregularly. Seen on the long term there is a large level of stability in the number of hot stuff found. Plotting the number of columns found hot $B_c = N_c^{bad}/N_c^{total}$ in more than 25% ($B_c > 0.25$) of the observations analysed (Fig.7), we see clearly that the number of hot stuff is extremely stable for the RGS2 instrument since after the operational temperature has been reduced in 2002. The data corresponding to RGS1 is more variable, with a relative peak in 2009, an increase in 2012 and 2013 and a small reduction in 2014.

A closer analysis reveals that the variation is mainly due to the number of columns found hot under the "hot spots" of RGS1 CCD1 on the C side, which was found augmenting with time in the last years. In order to see the evolution in the last years we can compute the variation of the "hotness" in the columns found hot more than 25% of the time (ie. with $B_i > 0.25$) commonly in successive years. This number, defined for the last two years as ($R_c = \Sigma(B_i^{2014}/B_i^{2013})/n = 1.09 \pm 0.16$) is slightly increasing. Fig. 8 show the RGS1 CCD1 C side bad pixel maps extracted

[2] http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0226-1-0.ps.gz

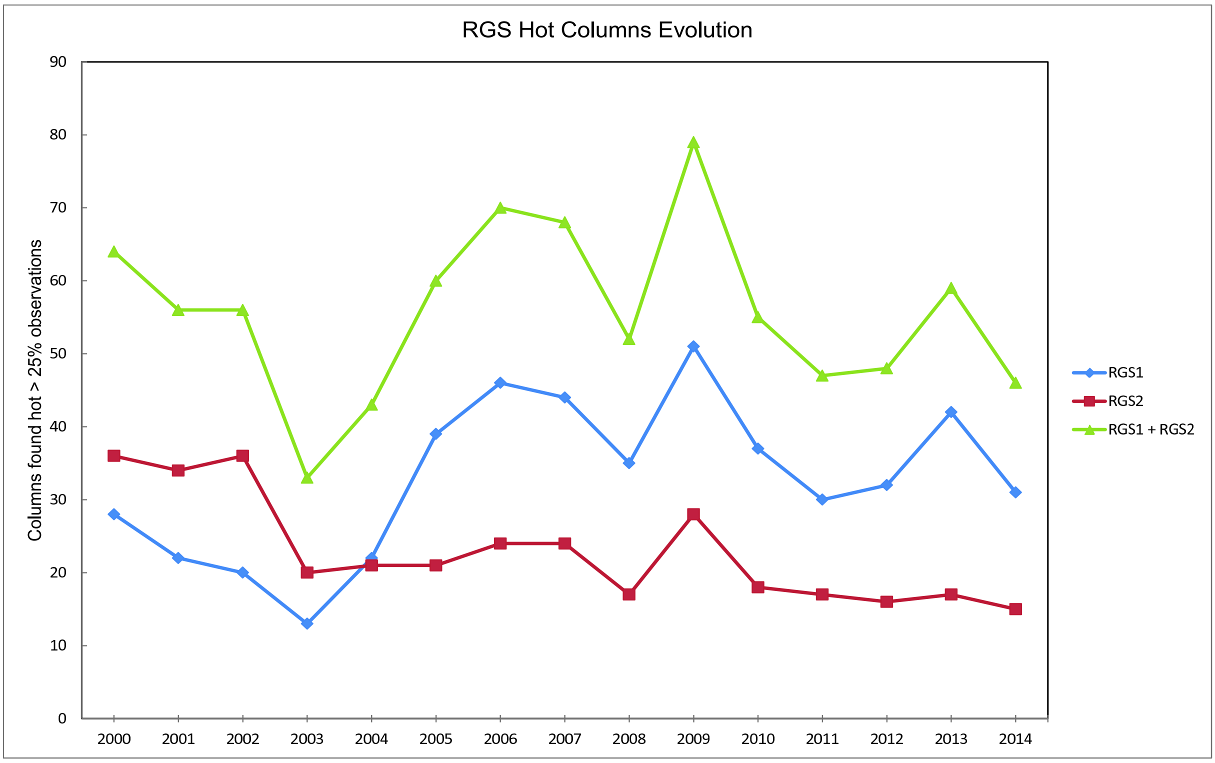

Figure 7: Number of hot columns found hot in more than 25% of the observations

from the science data corresponding to the years 2013 and 2014. Such behavior is not (yet?) seen in the D side data, despite the presence also there of a masked "hot spot" (the masks are uploaded as hot segments, so no science data telemetry for those regions since 2008). It has to be said that the variation of hot columns under the masked spot is affecting the lowest end of the low energy tail detectable by RGS, with a very low efficiency, therefore the actual incidence on science is fully marginal. However, taking into account that the lower end of the "hot spot" is now clearly visible even below the masked region, we propose to extend the mask doubling the number of pixels masked out per column from 8 to 16. A database update has been prepared, which is expected to take place first end of this year. It should be followed by the issue of a corresponding new CCF BADPIX file for RGS1.

Also clear in the comparison of both maps is the presence of a very often recognized hot column (column 146), which had been marked as advisory hot column in RGS1_BADPIX_0031, valid from 1/1/06 to 8/4/07. We set a threshold of $N_{BC} = N_{HOT} \div N_{TOTAL} > 95\%$ in the science data for declaring a column (advisory) hot. This column went in 2007 clearly below the threshold for being considered hot, but became increasingly recognized as hot in the years 2012 (with $N_{BC} = 90\%$) and 2013 (with $N_{BC} = 97\%$), staying over 95% in 2014. It has been added to the advisory hot columns in the latest BADPIX CCF (RGS1_BADPIX_0033.CCF), with a start validity of 01/01/2013. On the RGS2 data we see that the so far advisory hot columns 33 and 159 of CCD1 C side, for the fifth consecutive year both stay under the threshold, even decreasing with N_{BC} to 92% and 91% respectively in 2014. Therefore, a new CCF should be issued with validity date 01/01/2010, which does not mark anymore those two columns as "advisory hot".

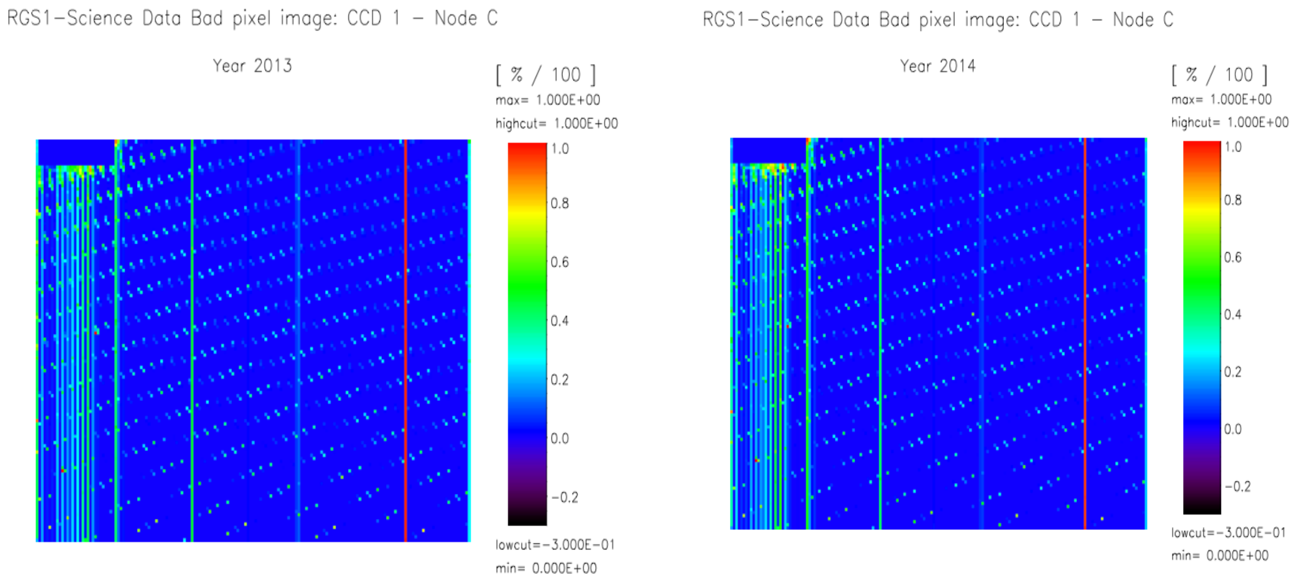

Figure 8: RGS1 - CCD1 C science bad pixel maps corresponding to data from 2013 on the left and 2014 on the right.