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Row 36-39 Anomaly Report

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1 Anomaly Description

1.1 Summary

On May 11th 2008 a new row anomaly was found. The row anomaly is observed for cross-track scenes 37-44 (0-based). The row anomaly has four distinct effects on the OMI radiance spectra: blockage effect, solar radiation, wavelength shift and Earth radiance from outside the nominal field of view.
The row anomaly is only observed in earth radiance measurements. It is not observed in sun or WLS measurements. Also the row anomaly changes during the orbit. It is therefore assumed that the cause of the row anomaly is outside the instrument, but it is unclear what is causing it.
The row anomaly changes over time. Efforts are under way to provide corrections for the four row anomaly effects.

1.2 Background

A row anomaly is an anomaly which affects the quality of the level 1B radiance data at all wavelengths for a particular viewing direction of OMI. This corresponds to a row on the CCD detectors, and hence the term 'Row Anomaly'. The OMI row anomaly is dynamic, it changes over time. The row anomaly affects the quality of the Level 1B radiance data and consequently the Level 2 data products.

Since June 25th of 2007 the cross-track positions 53-54 (0-based) are affected by the row anomaly. The anomaly comprises a decrease in the radiance signal, with secondary effects.

Since May 11th of 2008 the cross-track positions 37-42 (0-based) are affected towards the northern end of the OMI orbit. The anomaly comprises a decrease or increase in the radiance signal depending on position in orbit, again with secondary effects.

The row anomalies have four distinct effects on the OMI radiance spectra:

1. Blockage effect

   This is a decrease in the radiance level for several viewing directions. It is currently assumed that this is caused by a partial blocking of the OMI nadir port. The blocking object is assumed to be opaque. This is effectively a multiplicative error on the radiances with a factor smaller than unity.

2. Solar radiation

   This is an increase in the radiance level for the northern part of the orbit. This type of anomaly occurs when the part of OMI containing the nadir port is directly illuminated by the sun. This is assumed to be caused by reflection of sunlight into the nadir port via the blocking object (outside of OMI). This is an additive error on the radiances.

   This increase in the radiance level is not observed for the first anomaly in rows 53-54 (0-based).

3. Wavelength shift

   The blocking object causes an inhomogeneous illumination of the spectral slit in OMI. This causes a change in the slit function, shifting the center of weight away from the nominal center. This causes light of a specific wavelength to hit the detector in a slightly different location than expected with a fully illuminated entrance slit.

4. Earth radiance from outside nominal field of view

   Light reflected by the earth from outside the nominal field of view is coupled into the nadir port. This light is collected over a large area, giving an additive error on the radiances, with a term which is not constant.

1.3 Investigation

For the new row anomaly the following facts have been observed:

1) The row anomaly is observed for rows 36-39 in UV1 in the level-0 data (0-based). This corresponds to rows 18-21 in the level-1b data (also 0-based). The maximum signal increase is observed in rows 37 and 38 (level-0) and rows 19-20 (level-1b).
2) The row anomaly is observed for rows 41-44 in UV2 and VIS in the level-0 data (0-based). This corresponds to rows 38-41 in the level-1b data (also 0-based). The maximum signal decrease is observed in row 43 (level-0) and row 40 (level-1b).
3) The rows affected by the anomaly in UV1, UV2 and VIS correspond to the same viewing direction.
4) The row anomaly is observed as a strong signal increase in UV1. The signal increase can be as much as a factor 5-10 as compared to the normal earth radiance signals.
5) The row anomaly is observed in UV2 and VIS initially as a signal decrease and towards the eclipse close to the North Pole as a signal increase (when the OMI instrument views a dark earth while the spacecraft is still illuminated by sun light). The observed signal increase in UV2 and VIS is by far not as strong as the one in UV1.
6) The row anomaly appears rather instantly each orbit in the northern hemisphere and persists until the satellite enters the eclipse side of the orbit close to the North Pole. The southern hemisphere measurements are not affected by the May 2008 row anomaly. This pattern repeats itself every orbit.
7) The row anomaly starts exactly 14 minutes before the "highest point" in the orbit. The highest point in the orbit is defined as the point for which the elevation angle in the sun measurements equals 0 degrees.
8) The row anomaly starts at about nTimes = 1140 in the level-1b data products.
9) The row anomaly starts each orbit when the instrument is within the "tropical" setting range and persists also into the mid-latitude and arctic settings of the instrument. The row anomaly is not correlated to these tropical, mid-latitude and arctic settings of the instrument.
10) The row anomaly is only observed in earth radiance measurements. It is not observed in sun or WLS measurements.
11) The row anomaly suddenly increased in magnitude on 11 May 2008 at about 10.30 GMT. This corresponds to orbit 20331. A second increase was observed on 16 May 2008 in orbit 20410.
12) The row anomaly is also visible (but weaker in intensity) before 11 May 2008. For example it is also visible on 8 May 2008, but it may be present even earlier. The exact date of the start of the anomaly is not known, but it is probably end of April / beginning of May 2008.
13) The row anomaly is not visible in the beginning of March 2008.
14) The row anomaly causes ADC saturation in UV1, which is in turn visible in the pixel ADC overflow counter.
15) The row anomaly is observed in level-0 data and in level-1b data, as well as in some of the level- 2 data.

1.4 Comparison May 2008 and September 2007 row anomalies

The row anomalies from September 2007 and May 2008 have some similarities, but also some distinct differences. These similarities and differences are discussed in this section.
The anomalies are similar in the following respects:

1) Both row anomalies show a decrease in signal in UV2 and VIS when the earth radiance signal is relatively large and an increase in signal when the earth radiance signal is rather low at the north pole, just prior to the eclipse.
2) Both row anomalies suddenly increase in intensity for reasons unknown to us. Upon further inspection it seems that before these moments something is already visible at a smaller intensity.
3) Both row anomalies occur at a relatively small number of rows in UV2 and VIS: 1-2 rows for the September 2007 anomaly and 4 rows for the May 2008 anomaly.

The anomalies differ in the following respects:

1) The September 2007 anomaly is observed for the complete illuminated part of the orbit, whereas the May 2008 anomaly is only observed in the northern hemisphere starting 12 minutes and 40 seconds before the elevation=0 degrees point in the orbit. The signal increase in UV2 and VIS is only observed just prior to the eclipse for the September 2007 anomaly, it is not observed just after the eclipse at the South Pole.

2) The September 2007 anomaly is not observed in UV1, whereas the May 2008 anomaly shows a strong signal increase in UV1 (sun light).

1.5 Analysis of the row anomaly origin

Question: Can the origin of any of the row anomalies be electronic / detector?
Answer: This seems unlikely for the following reasons:

- The anomalies affect more than a single (binned) row.
- The anomalies affect more than a single unbinned row on the detectors.
- The anomalies affect different rows in UV1, UV2 and VIS that correspond optically.
- The May 2008 anomaly only appears suddenly on the northern hemisphere. The anomaly is not observed for other parts of the orbit.
- The anomalies are observed for different instrument settings (ICIDs), i.e. different exposure times and electronic gain settings.
- The anomalies are not observed in dark (or other) measurements that have the same instrument settings as the earth radiance measurements for which the effect is observed.

So the anomaly seems to have an optical origin.

Question: Are the anomalies originating from inside the instrument or from outside the instrument?
Answer: The fact that the observed behaviour is different for UV1 on one hand and UV2 and VIS on the other hand seems to suggest that the origin of the row anomalies lies within the OMI instrument.
On the other hand, the fact that the row anomaly from May 2008 is strongly dependent on orbit position is a strong indication that the origin lies outside the OMI instrument.

As the earth radiance signals become smaller the signal decrease becomes a signal increase originating from weak reflections of sun light from the obstructions. As soon as the spacecraft enters the eclipse part of the orbit the anomalies disappear. The fact that the anomaly is not observed in irradiance or calibration measurements, but only for earth radiance measurements suggests that the problem originates from either the primary mirror or a source outside the instrument. The solar radiation effect and the changes of the effects throughout the orbit can not be explained by a defect on the primary mirror.
This leaves a blockage of some sort somewhere outside the instrument.
If the blockage reflects sun light into the nadir port the effect will be first observed in UV1, because UV1 has the largest footprint (VIS the smallest). This is the case for the May 2008 anomaly. If the blockage merely blocks earth light (does not reflect sun light into the nadir port) the effect is not observed clearly in UV1, because UV1 is less sensitive to blockage (as compared to UV2 and VIS) as a result of the larger footprint. This is the case for the first (September 2007) anomaly.

2 Causes and Contributing Factors

2.1 Root cause conclusion

A very tentative explanation is that some of the MLI close to the nadir and solar ports has moved partly in the field of view of the nadir port. Unfortunately not all features of the row anomaly can be explained in this way and therefore we must conclude that at present the cause of the row anomaly is not known / understood.

3 Impact

All data, L0, L1B and L2, are affected by the row anomaly. Some products can be affected more than others by the row anomaly and also not all products suffer from all row anomaly effects. OMI does no longer achieve daily coverage. Large part of the OMI data is still unaffected and the row anomaly has no consequences for the Nominal operations baseline.

4 Proposed anomaly solutions

There is no solution for the row anomaly. The OMI IOT developed a special row anomaly measurement that runs as part of the Operations baseline once a week and an orbit-type activity with extended arctic measurements to monitor all the row anomaly effects. The OMI team develops a way to flag the row anomaly rows and develops correction algorithms.

5 Resolution

None. The OMI team works on flagging of the row anomaly rows in L1B data and on correction algorithms. This work is still ongoing.

For the latest status on the row anomaly and the work to flag the affected groundpixels in the L1b data and also to correct the affected radiances, see the OMI webpage: www.knmi.nl/omi/research/product/rowanomaly-background.php