OMI Small Pixel Data

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1 Introduction

1.1 Purpose of the document

In this document we present some information for Level 2 product developers about OMI small pixel data. Small pixels are ground pixels that have the same spatial resolution in the across-track direction as the standard OMI ground pixels. In the flight-direction small pixels (may) provide a higher spatial resolution than standard ground pixels. Small pixel data are contained in separate entries in the Level 1B data products.

1.2 Contents of the document

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2 Measurement principle of OMI

OMI can be imagined as a two-dimensional CCD that orbits the Earth (see Figure 1). Each CCD row contains the spectrum of an across-track viewing angle. Each CCD column corresponds to a specific wavelength. The across-track field-of-view, that is perpendicular to the flight-direction, is usually called the *swath*[1]. In the same way the direction perpendicular to the flight-direction is called the swath-direction.

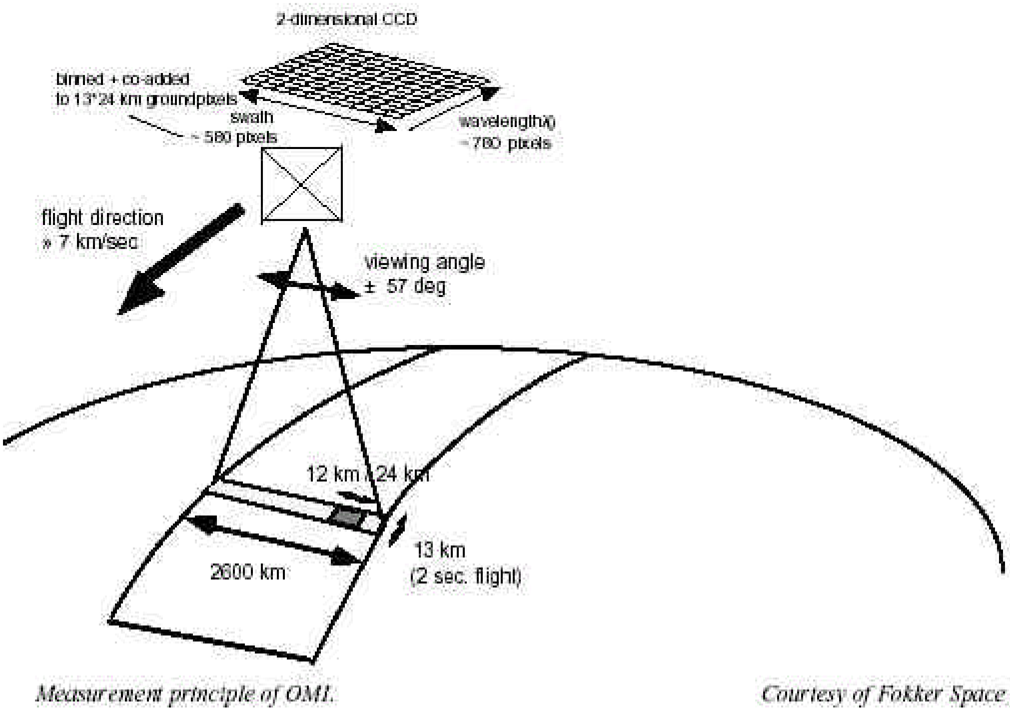


Figure 1

[1]Note that in this document *swath* is used to indicate the wide field-of-view of OMI and not the HDF-EOS data structure.

Each measurement of OMI results in an image that is contained in the downlink telemetry stream of OMI. There are basically three parameters that determine the properties of an image: 1) the Master Clock Period or MCP, 2) the exposure time $t_{\exp}$ and 3) the binning factor N_{bin}.

Each measurement of OMI lasts one Master Clock Period so OMI generates one image per MCP. The Master Clock Period is programmable and for radiance measurements of the Earth the Master Clock Period is set to 2 seconds ($MCP = 2$ seconds).
Because the CCD can become saturated for strong signals, OMI actually performs a number of short exposures during a Master Clock Period. Each of these exposures lasts one exposure time $t_{\exp}$. All exposures that fall within one Master Clock Period are digitally co-added so that in the end only one image is generated per Master Clock Period. There is, however, one exception: the so-called small pixels. On each of the OMI CCD's there is one column of pixels, the small pixels, that are not digitally co-added but down-linked separately. This implies that 'normal' pixels have an effective exposure time of one MCP while small pixels have an exposure time $t_{\exp}$.

An important operational constrained of OMI is that the exposure time $t_{\exp}$ has to fit an integral times into the Master Clock Period. As explained above, this integral number has to be equal to the number of digital co-additions performed during one Master Clock Period: N_{coad}. The operational constrained can then be written as: $MCP = N_{coad} \times t_{\exp}$. Note that the number of digital co-additions N_{coad} equals the number of small pixel columns because it also equals the number of times a CCD is read out during one Master Clock Period.

The choice for a MCP of 2 seconds is derived from the science requirement that the size of a groundpixel in the flight-direction shall be ~13 km. Combining the intrinsic field-of-view of OMI in the flight-direction with the groundspeed of the AURA spacecraft shows that a MCP of 2 seconds results in the required size of the ground pixel.
The exposure time will be adjusted to the orbital phase of OMI. When there is less light longer exposure times will be used while for strong signals shorter exposure times will be used. For a Master Clock Period of 2 seconds the following combinations are allowed:

Exposure time $t_{\exp}$ (s)	**Number of co-additions N_{coad}**
0.4	5
0.5	4
1	2
2	1

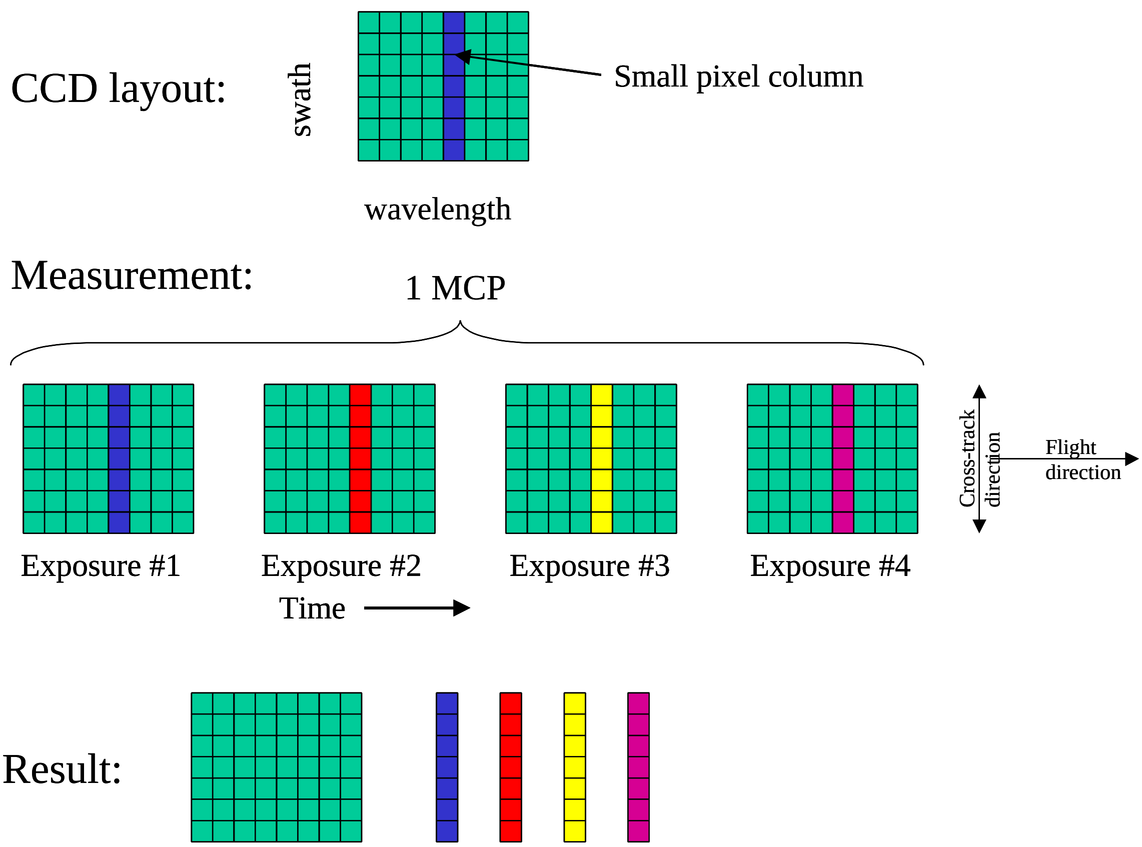
It is important to keep in mind the in the swath-direction small pixels have identical sizes as standard pixels[2]. Only in the flight-direction they provide a higher resolution than standard pixels by an amount set by N_{coad}.
It must be anticipated that N_{coad} varies along the orbit because $t_{\exp}$ varies along the orbit. Therefore also the number of small pixels will vary along the orbit.

[2] Background information: the ground pixel size in the swath-direction is determined by the binning factor N_{bin}. The intrinsic field-of-view of an OMI pixel in the swath-direction is 3 km. To arrive at the required sizes of ground pixels in the swath-direction N_{bin} CCD rows are binned together in the Readout Register of the CCD. This is done for all pixels, so also for small pixels! For the Global product $N_{bin} = 8$ resulting in a ground pixel dimension in the swath direction of 8×3= 24 km. For Spectral and Spatial Zoom products $N_{bin} = 4$ resulting in a ground pixel size in the swath direction of 4×3= 12 km.

Note that when OMI goes into the Spectral or Spatial Zoom-mode, the size of the small pixels in the swath-direction is halved with respect to the Global mode. In the Spatial Zoom-mode also the full swath size is halved to 57 degrees. In the Spectral Zoom-mode the full swath of 114 degrees is available.

3 An example

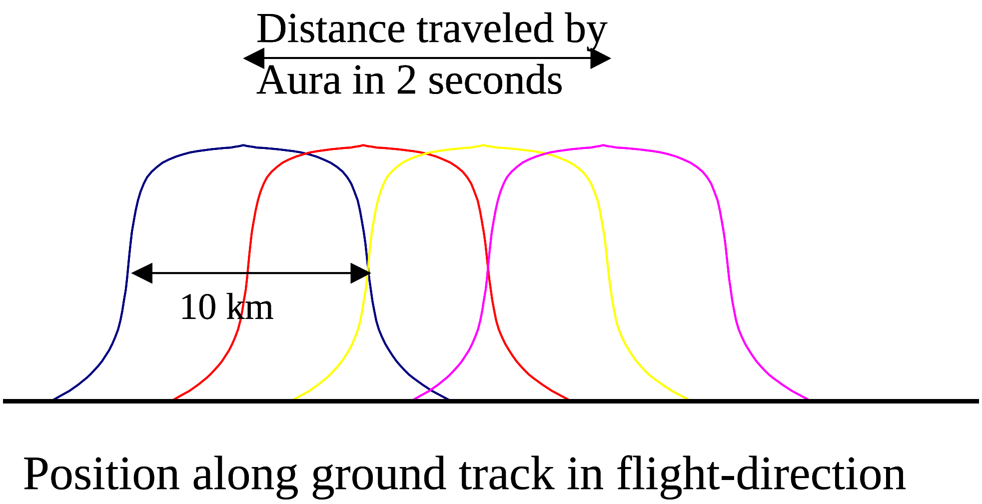
The Figure below shows what happens for $MCP = 2$, $t_{\exp} = 0.5$ and $N_{coad} = 4$. The top of the figure shows the CCD lay out: the columns correspond to wavelength and the rows to viewing direction in the swath. The dark blue column indicates the small pixel column.



The middle of the figure shows the measurement: four consecutive exposures are performed, each at a different time. The four exposures are, on-board, digitally co-added but the four measured small pixel columns (dark blue, red, yellow, purple) are kept apart. The Level 0-1B processor combines the four small pixel columns and generates a complete image for one MCP but also outputs the four measured small pixel columns separately in the Level 1B product. The result is show at the bottom of the figure. The process of row binning is not shown in the figure. It occurs automatically when each of the four exposures is read out. In this example the number of co-additions is four but it can equally be five, two or one. The number of small pixel columns will vary accordingly.

4 Properties of small pixels

Small pixels have sizes in the swath-direction that are equal to the sizes of the standard ground pixels. In the flight-direction small pixels have a slightly smaller size than standard ground pixels but only to a limited extend. L2 algorithm developers should keep in mind that the small pixels corresponding to a specific across-track viewing direction are not completely independent. The intrinsic field-of-view of OMI in the flight direction is about 0.8 degrees or 10 km. To be more specific: the sensitivity of OMI in the flight-direction is a flat-topped Gaussian with a Full Width at Half Maximum of 0.8 degrees (10 km on-ground). The groundspeed of the AURA spacecraft is about 7 km/s. This implies that small pixel (columns) that are 0.4, 0.5 or even 1 second apart still contain information from the same scene. This is shown in the figure below for the example given in Section 3.



The curves indicate the sensitivity of OMI in the flight-direction. The figure shows that only the information contained in the first small pixel (dark blue) and in the last small pixel (purple) is truly independent. When a different number of co-additions is used this changes of course.

The small pixel wavelengths that have been selected are 342.5 nm in the UV-2 channel and 388 nm in the VIS channel. These wavelengths should not be interpreted too strictly. OMI has a so-called spectral smile that results in a small variation of the wavelength along a CCD column. Typically between the nadir viewing angle and the edge of the swath the wavelength variation is about 3.3 nm in UV-2 and 0.5 nm in VIS. These are typical values based on ambient spectral calibration but under operational conditions this will not change considerably. In the Level 1B product the exact wavelength of each small pixel is given (SmallPixelWavelength).