

# **List of all Science Requirements**

## **Introduction**

All science and instrument requirements put on OMI-EOS are listed according to the following rule: **SR w.x.y.z**, in which **SR** stands for Science Requirement and **wxyz** stand for respectively chapter (**w**), section (**x**), subsection (**y**) and number of the requirement (**z**) in the SRD.

## **Science requirements (SRD Chapter 3)**

### **List of priority ‘A’ products**

- SR 3.1.1 OMI shall retrieve the Earth radiance spectrum.*
- SR 3.1.2 OMI shall retrieve the solar irradiance spectrum.*
- SR 3.1.3 OMI shall retrieve the total ozone column (off-line).*
- SR 3.1.4 OMI shall retrieve the ozone profile (off-line).*
- SR 3.1.5 OMI shall retrieve the aerosol optical thickness.*
- SR 3.1.6 OMI shall retrieve the aerosol single scattering albedo.*
- SR 3.1.7 OMI shall retrieve the total NO<sub>2</sub> column.*
- SR 3.1.8 OMI shall retrieve the cloud-scattering pressure.*
- SR 3.1.9 OMI shall retrieve the cloud fraction.*
- SR 3.1.10 OMI shall retrieve the surface UV-B flux.*
- SR 3.1.11 OMI shall retrieve the total ozone column Near Real Time (NRT) product.*
- SR 3.1.12 OMI shall retrieve the ozone profile (NRT) product.*
- SR 3.1.13 OMI shall retrieve the total ozone column Very Fast Delivery (VFD) product.*
- SR 3.1.14 OMI shall retrieve surface UV-B flux (VFD) product.*

### **List of priority ‘B’ products**

- SR 3.1.15 OMI shall be able to retrieve the total SO<sub>2</sub> column.*
- SR 3.1.16 OMI shall be able to retrieve the total BrO column.*
- SR 3.1.17 OMI shall be able to retrieve the total OClO column.*
- SR 3.1.18 OMI shall be able to retrieve the total HCHO column.*
- SR 3.1.19 OMI shall be able to retrieve the surface reflectance.*
- SR 3.1.20 OMI shall be able to retrieve UV spectra.*
- SR 3.1.21 OMI shall be able to retrieve the ozone profile Very Fast Delivery (VFD) product.*
- SR 3.1.22 OMI shall be able to retrieve the total HCHO column (VFD) product.*
- SR 3.1.23 OMI shall be able to retrieve UV spectra (VFD) product.*

### **List of synergetic products**

- SR 3.1.24 OMI should be able to retrieve tropospheric O<sub>3</sub> columns by (among others) synergetic use of HIRDLS, TES, MLS and OMI data.*
- SR 3.1.25 OMI should be able to retrieve tropospheric NO<sub>2</sub> columns by (among others) synergetic use of HIRDLS, TES, MLS and OMI data.*

### **Cloud ground pixel size requirement**

- SR 3.2.4.1 Cloud information shall be retrieved on at least the same scale as the smallest ground pixel of any of the OMI data products (a spatial resolution of 20 ´ 20 km<sup>2</sup> will be sufficient).*

### **General Near Real Time (NRT) requirements**

- SR 3.2.7.1* Near Real Time (NRT) products shall be available within 3 hours after observation..
- SR 3.2.7.2* NRT products shall have the same ground pixel size as the off-line products.
- SR 3.2.7.3* NRT products shall have global coverage in one day.

### **General Very Fast Delivery (VFD) requirements**

- SR 3.2.8.1* The OMI data (gathered above Europe and Scandinavia) shall be downloaded to the FMI ground station at Sodankylä (Finland) on one pass per day.
- SR 3.2.8.2* Very Fast Delivery (VFD) products shall be available within 30 minutes after the reception of the data.

### **Global coverage requirements**

- SR 3.3.1* OMI shall be able to achieve global coverage in one day
- SR 3.3.2* Global coverage means that OMI shall be able to measure the UV/VIS spectrum reflected from every part on Earth within 24 hours, except for regions which are not illuminated by sunlight in 24 hours.
- SR 3.3.3* Global coverage shall be possible with the ground pixel sizes as specified in Table 3.1 (see **SR 3.4.2b - SR 3.4.23b**)
- SR 3.3.4* Global coverage shall be possible with a ground pixel sampling equal to the ground pixel sizes
- SR 3.3.5* For solar zenith angles between 85 and 90 degrees, the requirements in Table 3.1 for the ground pixel size for ozone, NO<sub>2</sub>, SO<sub>2</sub>, HCHO, aerosol, cloud products and the surface reflectance can be slightly relaxed to about 100 ´ 100 km<sup>2</sup>, in order to measure with sufficient S/N while maintaining the same accuracy.
- SR 3.3.6* For BrO and OClO the requirements in Table 3.1(see **SR 3.4.12** and **SR 3.4.13**) are applicable for all solar zenith angles.

### **Scientific Requirements for the OMI data products from table 3.1**

- SR 3.4.0* Summarise of Table 3.1:  
*The general product requirements are given in SR 3.1.1 - SR 3.3.6 and SR 4.0.1 (i.e. the priority requirements are given in SR 3.1.1 – SR 3.1.25; the coverage requirements are given in SR 3.2.7.3, SR 3.2.8.1 and in SR 3.3.1 – SR 3.3.6; the product availability requirements are given in SR 3.2.7.1, SR 3.2.8.2 and in SR 4.0.1).*  
*The product depended requirements are given in SR 3.4.1 – SR 3.4.23 (i.e. the accuracy, ground pixel size at nadir and vertical resolution requirements).*

### **Scientific Requirements (from table 3.1) for the off-line products**

- SR 3.4.1* The accuracy of the irradiance product shall be less than or equal to 2 %.
- SR 3.4.2a* The accuracy of the radiance product shall be less than or equal to 2 %.
- SR 3.4.2b* The ground pixel size at nadir of the radiance product shall be less or equal to 20 ´ 20 km<sup>2</sup>.
- SR 3.4.3a* The accuracy of the ozone column product shall be less than or equal to the largest of either 2 % or 4 DU
- SR 3.4.3b* The ground pixel size at nadir of the ozone column product shall be less or equal to 20 ´ 20 km<sup>2</sup>.
- SR 3.4.4a* The accuracy of the ozone profile product shall be less than or equal to 10 % in the stratosphere and less than or equal to 30 % in the troposphere.
- SR 3.4.4b* The ground pixel size at nadir of the ozone profile product shall be less or equal to 40 ´ 40 km<sup>2</sup>.
- SR 3.4.4c* The vertical resolution of the ozone profile product shall be about 5 km in stratosphere and less than or equal to 10 km in the troposphere over the vertical altitude range from 0 to 50 km.
- SR 3.4.5a* The accuracy of the aerosol optical thickness product shall be less than or equal to the largest of either 10 % or 0.08.

- SR 3.4.5b** *The ground pixel size at nadir of the aerosol optical thickness product shall be less or equal to  $20 \times 20$  km<sup>2</sup>.*
- SR 3.4.6a** *The accuracy of the aerosol single scattering albedo product shall be less than or equal to 0.1.*
- SR 3.4.6b** *The ground pixel size at nadir of the aerosol single scattering albedo product shall be less or equal to  $20 \times 20$  km<sup>2</sup>.*
- SR 3.4.7a** *The accuracy of the NO<sub>2</sub> product shall be less than or equal to the largest of either 10 % or  $10^{14}$  cm<sup>-2</sup> in unpolluted areas and less than or equal to 20 % in polluted areas.*
- SR 3.4.7b** *The ground pixel size at nadir of the NO<sub>2</sub> product shall be less or equal to  $40 \times 40$  km<sup>2</sup>.*
- SR 3.4.8a** *The accuracy of the cloud scattering pressure product shall be less than or equal to 100 hPa.*
- SR 3.4.8b** *The ground pixel size at nadir of the cloud scattering pressure product shall be less or equal to  $20 \times 20$  km<sup>2</sup>.*
- SR 3.4.9a** *The accuracy of the cloud fraction product shall be less than or equal to 0.1.*
- SR 3.4.9b** *The ground pixel size at nadir of the cloud fraction product shall be less or equal to  $20 \times 20$  km<sup>2</sup>.*
- SR 3.4.10a** *The accuracy of the surface UV-B flux product shall be less than or equal to 4 %.*
- SR 3.4.10b** *The ground pixel size at nadir of the surface UV-B flux product shall be less or equal to  $20 \times 20$  km<sup>2</sup>.*
- SR 3.4.11a** *The accuracy of the SO<sub>2</sub> column product shall be less than or equal to the largest of either 20 % or 0.4 DU.*
- SR 3.4.11b** *The ground pixel size at nadir of the SO<sub>2</sub> column product shall be less or equal to  $40 \times 40$  km<sup>2</sup>.*
- SR 3.4.12a** *The accuracy of the BrO column product shall be less than or equal to the largest of either 10 % or  $10^{13}$  cm<sup>-2</sup>.*
- SR 3.4.12b** *The ground pixel size at nadir of the BrO column product shall be less or equal to  $40 \times 40$  km<sup>2</sup>.*
- SR 3.4.13a** *The accuracy of the OClO column product shall be less than or equal to the largest of either 20 % or  $10^{15}$  cm<sup>-2</sup>.*
- SR 3.4.13b** *The ground pixel size at nadir of the OClO column product shall be less or equal to  $40 \times 40$  km<sup>2</sup>.*
- SR 3.4.14a** *The accuracy of the HCHO column product shall be less than or equal to the largest of either 20 % or  $10^{15}$  cm<sup>-2</sup>.*
- SR 3.4.14b** *The ground pixel size at nadir of the HCHO column product shall be less or equal to  $40 \times 40$  km<sup>2</sup>.*
- SR 3.4.15a** *The accuracy of the surface reflectance product shall be less than or equal to the largest of either 5 % or 0.01.*
- SR 3.4.15b** *The ground pixel size at nadir of the surface reflectance product shall be less or equal to  $20 \times 20$  km<sup>2</sup>.*
- SR 3.4.16a** *The accuracy of the UV spectra product shall be less than or equal to 10-20 % (depending on wavelength).*
- SR 3.4.16b** *The ground pixel size at nadir of the UV spectra product shall be less or equal to  $20 \times 20$  km<sup>2</sup>.*

**Scientific Requirements (from table 3.1) for the Near Real Time (NRT) products**

- SR 3.4.17a** *The accuracy of the ozone column NRT product shall be less than or equal to the largest of either 5 % or 10 DU.*
- SR 3.4.17b** *The ground pixel size at nadir of the ozone column NRT product shall be less or equal to  $20 \times 20$  km<sup>2</sup>.*
- SR 3.4.18a** *The accuracy of the ozone profile product NRT shall be less than or equal to 10 % in the stratosphere.*
- SR 3.4.18b** *The ground pixel size at nadir of the ozone profile NRT product shall be less or equal to  $40 \times 40$  km<sup>2</sup>.*
- SR 3.4.18c** *The vertical resolution of the ozone profile NRT product shall be about 5 km in stratosphere over the vertical altitude range from 10 to 50 km.*

**Scientific Requirements (from table 3.1) for the Very Fast Delivery (VFD) products**

- SR 3.4.19a** *The accuracy of the ozone column VFD product shall be less than or equal to the largest of either 5 % or 10 DU.*

- SR 3.4.19b** *The ground pixel size at nadir of the ozone column VFD product shall be less or equal to  $20 \times 20 \text{ km}^2$ .*
- SR 3.4.20a** *The accuracy of the surface UV-B flux VFD product shall be less than or equal to 10 %.*
- SR 3.4.20b** *The ground pixel size at nadir of the surface UV-B flux VFD product shall be less or equal to  $20 \times 20 \text{ km}^2$ .*
- SR 3.4.21a** *The accuracy of the ozone profile product VFD shall be less than or equal to 10 % in the stratosphere.*
- SR 3.4.21b** *The ground pixel size at nadir of the ozone profile VFD product shall be less or equal to  $40 \times 40 \text{ km}^2$ .*
- SR 3.4.21c** *The vertical resolution of the ozone profile VFD product shall be about 5 km in stratosphere and less than or equal to 10 km in the troposphere over the vertical altitude range from 10 to 50 km.*
- SR 3.4.22a** *The accuracy of the HCHO column VFD product shall be less than or equal to the largest of either 20 % or  $10^{15} \text{ cm}^{-2}$ .*
- SR 3.4.22b** *The ground pixel size at nadir of the HCHO column VFD product shall be less or equal to  $40 \times 40 \text{ km}^2$ .*
- SR 3.4.23a** *The accuracy of the UV spectra VFD product shall be less than or equal to 10-20 % (depending on wavelength).*
- SR 3.4.23b** *The ground pixel size at nadir of the UV spectra VFD product shall be less or equal to  $20 \times 20 \text{ km}^2$ .*

**Table 3.1 Overview of the scientific requirements for the priority ‘A’ and ‘B’ OMI data products.**

In column 2, priorities are listed for each product (in the context of the OMI mission objectives): Priority A indicates highest (at launch availability) priority, priority B is assigned to desired (post launch availability) products. All products are level 2 products, except the (ir)radiances which are level 1b products. Each product has a global coverage of one day, except for the Very Fast Delivery (VFD) products. Product delivery requirements are for Near Real Time (NRT) products less than 3 hours after observation and less than 30 minutes after the data receipt for the VFD products, for other products less than two days after observation. The accuracy is defined in the introduction of section 3.2. With column is meant the vertical column. (T) stands for “in the troposphere”, (S) stands for “in the stratosphere”. 1 DU  $\equiv$  2.687 10<sup>16</sup> mol./cm<sup>2</sup>.

Data product	Priority status	Accuracy of observations <sup>1)</sup>	Ground pixel size at nadir (km × km)	Vertical resolution (km)	Remarks
Irradiances <sup>2), 3)</sup>	A	≤ 2 %	N/A	N/A	
Radiances <sup>2)</sup>	A	≤ 2 %	≤ 20 × 20	N/A	
Ozone column	A	≤ 2 % / 4 DU	≤ 20 × 20	N/A	
Ozone profile	A	≤ 30 % (T) ≤ 10 % (S)	≤ 40 × 40	≤ 10 km (T) ≥ 5 km (S)	Vertical range is 0-50 km
Aerosol optical thickness	A	≤ 10 % / 0.08	≤ 20 × 20	N/A	At 400 nm
Aerosol single scattering albedo	A	0.1	≤ 20 × 20	N/A	
NO <sub>2</sub> column <sup>4)</sup>	A	≤ 10 % / 10 <sup>14</sup> mol. cm <sup>-2</sup>	≤ 40 × 40	N/A	
Cloud scattering pressure	A <sup>5)</sup>	≤ 100 hPa	≤ 20 × 20	N/A	
Cloud fraction	A <sup>5)</sup>	≤ 0.1	≤ 20 × 20	N/A	
Surface UV-B flux	A	≤ 4%	≤ 20 × 20	N/A	
SO <sub>2</sub> column	B	≤ 20 % / 0.4 DU	≤ 40 × 40	N/A	Pollution, volcanic
BrO column	B	≤ 10 % / 10 <sup>13</sup> mol. cm <sup>-2</sup>	≤ 40 × 40	N/A	
OCIO column	B	≤ 20 % / 10 <sup>13</sup> mol. cm <sup>-2</sup>	≤ 40 × 40	N/A	Polar vortex
HCHO column	B	≤ 20 % / 10 <sup>15</sup> mol cm <sup>-2</sup>	≤ 40 × 40	N/A	Pollution
Surface reflectance	B	≤ 5 % / 0.01	≤ 20 × 20	N/A	
UV spectra	B	≤ 10-20 %	≤ 20 × 20	N/A	Accuracy is wavelength dependent
<b>Near Real Time Products</b>					
Ozone column	A	≤ 5 % / 10 DU	≤ 20 × 20	N/A	
Ozone profile	A	≤ 10 % (S)	≤ 40 × 40	≥ 5 km (S)	Vertical range is 10-50 km
<b>Very Fast Delivery Products</b>					
Ozone column	A	≤ 5 % / 10 DU	≤ 20 × 20	N/A	Over Northern Europe
Surface UV-B flux	A	≤ 10 %	≤ 20 × 20	N/A	Over Northern Europe
Ozone profile	B	≈ 10 % (S)	≤ 40 × 40	≥ 5 km (S)	Vertical range is 10-50 km Over Northern Europe
HCHO column	B	≤ 20 % / 10 <sup>15</sup> mol. cm <sup>-2</sup>	≤ 40 × 40	N/A	Over Northern Europe
UV spectra	B	≤ 10-20 %	≤ 20 × 20	N/A	Over Northern Europe Accuracy is wavelength dependent

Note 1) The valid requirement on accuracy will be the largest of the given percentile or absolute number.

Note 2) The requirements for radiance and irradiance follow from Chapter 4.

Note 3) Irradiance is not a separate data product.

Note 4) The required accuracy for the NO<sub>2</sub> column is about 10% in unpolluted areas, but about 20% in polluted areas.

Note 5) Cloud scattering pressure and cloud fraction are also needed for the retrieval of other products by OMI and other instruments.

## **Algorithm requirements (SRD Chapter 4)**

### **General algorithm requirements**

#### **Product availability requirements**

*SR 4.0.1 The off-line level 2 products shall be available less than two days after observation.*

#### **Geographical Coverage and Resolution**

*SR 4.2.1.1 The Level 1b radiance data shall have daily global coverage.*

*SR 4.2.1.2 The ground pixel size of the Level 1b data shall be  $20 \times 20 \text{ km}^2$  at nadir, or smaller.*

*SR 4.2.1.3 For the wavelengths below 310 nm, the ground pixel size of the Level 1b data shall be  $40 \times 40 \text{ km}^2$  at nadir, or smaller.*

*SR 4.2.1.4 In the Level 1b product, the geolocation of the pixels shall be given, with an accuracy of  $1/10^{\text{th}}$  of the ground pixel size.*

*SR 4.2.1.5 For at least one wavelength, the Level 1b data shall be obtained with a higher spatial sampling than for the nominal pixels.*

#### **Spectral Range**

*SR 4.2.2.1 The total spectral range shall at least cover the range between 270 and 500 nm.*

#### **Spectral Resolution and Sampling**

*SR 4.2.3.1 The spectral resolution and sampling shall be as listed in Table 5.1 (SR 5.1.1.9 – SR 5.1.1.15).*

#### **Spectral Knowledge**

*SR 4.2.4.1 The required spectral knowledge of the radiance and irradiance spectra shall be better than  $1/100^{\text{th}}$  of a CCD-pixel above 300 nm and better than  $1/50^{\text{th}}$  of a CCD-pixel below 300 nm for ozone profile retrieval.*

#### **Spectral Stability**

*SR 4.2.5.1 The required spectral stability for Earth and solar measurements is at least  $1/20^{\text{th}}$  of a CCD-pixel.*

#### **Radiometric Accuracy**

*SR 4.2.7.1 The overall requirement for the radiometric accuracy of the reflectivity is 1%.*

#### **Level 1b Product Content**

*SR 4.2.8.2 All Level 1b product content requirements, specified in the latest version of the “OMI Level 1b data format”, shall be applicable.*

#### **Level 1b Product Availability**

*SR 4.2.9.1 The level 1b data shall be accessible within 24 hours after arrival of the OMI level 0 at the processing site.*

*SR 4.2.9.2 A preliminary version of the Level 1b data has to be available within 2½ hours after observation to derive the NRT products.*

*SR 4.2.9.3 All other Level 1b product availability requirements, specified in the latest version of RS-OMIE-0000-NIVR-007 “The Netherlands and Finnish data requirements in the operational phase of OMI”, shall be applicable.*

**Viewing angles: knowledge & precision**

- SR 4.2.10.1** *The required accuracy knowledge for the Solar Zenith angle is 0.08°.*  
**SR 4.2.10.2** *The required accuracy knowledge for the viewing zenith angle 0.08°.*  
**SR 4.2.10.3** *The required accuracy knowledge for the relative azimuth angle 0.05°.*

**Level 1b Requirements from table 4.1**

**SR 4.3.0** *Summarise of Table 4.1:*

*The general requirements on the Level 1b product are given in **SR 4.2.1.1 – SR 4.2.10.3**. (i.e. the geographical coverage and resolution requirements are given in **SR 4.2.1.1 – SR 4.2.1.5**; the spectral (range, resolution, sampling, knowledge and stability) requirements are given in **SR 4.2.2.1 – SR 4.2.5.1**; the requirement on the overall radiometric accuracy of the reflectivity is given in **SR 4.2.7.1**; the Level 1b product contents and availability requirements are given in **SR 4.2.8.1, SR 4.2.8.2 and SR 4.2.9.1 – SR 4.2.9.3**; the knowledge and precision requirements on the viewing angles are specified in **SR 4.2.10.1 – SR 4.2.10.3**).*

*The product depended requirements on the Level 1b product are given in **SR 4.3.1 – SR 4.3.21** (i.e. the spectral range, spectral knowledge, radiometric accuracy of the reflectivity and radiometric precision requirements).*

**Level 1b Requirements (from table 4.1) for the off-line products**

- SR 4.3.1a-1** *The available spectral range for the ozone column DOAS product shall be at least 320 – 340 nm.*  
**SR 4.3.1a-2** *The available spectral range for the ozone column TOMS product shall be at least 310 – 380 nm.*  
**SR 4.3.1b-1** *The spectral knowledge of the ozone column DOAS product shall be at least 1/100<sup>th</sup> CCD-pixel.*  
**SR 4.3.1b-2** *The spectral knowledge of the ozone column TOMS product shall be at least 1/3<sup>rd</sup> CCD-pixel.*  
**SR 4.3.1c-1** *The radiometric accuracy of the ozone column DOAS product shall be at least 3%.*  
**SR 4.3.1c-2** *The radiometric accuracy of the ozone column TOMS product shall be at least 1%.*  
**SR 4.3.1d-1** *The radiometric precision (S/N) of the ozone column DOAS product shall be at least 250 (for ground pixel size of 20 ´ 20 km<sup>2</sup>).*  
**SR 4.3.1d-2** *The radiometric precision (S/N) of the ozone column TOMS product shall be at least 300 (for ground pixel size of 20 ´ 20 km<sup>2</sup>).*  
**SR 4.3.2a** *The available spectral range for the ozone profile product shall be at least 270 – 340 nm.*  
**SR 4.3.2b** *The spectral knowledge of the ozone profile product shall be at least 1/50<sup>th</sup> CCD-pixel.*  
**SR 4.3.2c** *The radiometric accuracy of the ozone profile product shall be at least 1%.*  
**SR 4.3.2d** *The radiometric precision (S/N) of the ozone profile product shall be at least 100 below 310 nm (for ground pixel size of 40 ´ 40 km<sup>2</sup>).*  
**SR 4.3.3a** *The available spectral range for the aerosol optical thickness product shall be at least 340 – 500 nm.*  
**SR 4.3.3c** *The radiometric accuracy of the aerosol optical thickness product shall be at least 1%.*  
**SR 4.3.3d** *The radiometric precision (S/N) of the aerosol optical thickness product shall be at least 500 (for ground pixel size of 20 ´ 20 km<sup>2</sup>).*  
**SR 4.3.4a** *The available spectral range for the aerosol single scattering albedo product shall be at least 340 – 500 nm.*  
**SR 4.3.4c** *The radiometric accuracy of the aerosol single scattering albedo product shall be at least 1%.*  
**SR 4.3.4d** *The radiometric precision (S/N) of the aerosol single scattering albedo product shall be at least 500 (for ground pixel size of 20 ´ 20 km<sup>2</sup>).*  
**SR 4.3.5a** *The available spectral range for the NO<sub>2</sub> column product shall be at least 425 – 450 nm.*  
**SR 4.3.5b** *The spectral knowledge of the NO<sub>2</sub> column product shall be at least 1/50<sup>th</sup> CCD-pixel.*

- SR 4.3.5c** *The radiometric accuracy of the NO<sub>2</sub> column product shall be at least 3%.*
- SR 4.3.5d** *The radiometric precision (S/N) of the NO<sub>2</sub> column product shall be at least 5800 (for ground pixel size of 40 ´ 40 km<sup>2</sup>).*
- SR 4.3.6a-1** *The available spectral range for the cloud top pressure product shall be at least 390 – 400 nm*
- SR 4.3.6a-2** *Also available for the cloud top pressure product shall be the spectral range of at least 470 – 485 nm.*
- SR 4.3.6b** *The spectral knowledge of the cloud top pressure product shall be at least 1/100<sup>th</sup> CCD-pixel.*
- SR 4.3.6c** *The radiometric accuracy of the cloud scattering pressure product shall be at least 3%.*
- SR 4.3.6d-2** *The radiometric precision (S/N) of the cloud top pressure product shall be at least 1600 in the spectral range of at least 470 – 480 nm (for ground pixel size of 20 ´ 20 km<sup>2</sup>).*
- SR 4.3.7a** *The available spectral range for the cloud fraction product shall be at least 320 – 500 nm.*
- SR 4.3.7c** *The radiometric accuracy of the cloud fraction product shall be at least 1%.*
- SR 4.3.8** *The surface UV-B product requires the fulfilment of the requirements on the ozone column (SR 4.3.1), cloud cover (SR 4.3.7) and aerosol (SR 4.3.3 and SR 4.3.4) products.*
- SR 4.3.9a** *The available spectral range for the SO<sub>2</sub> column product shall be at least 300 – 300 nm.*
- SR 4.3.9b** *The spectral knowledge of the SO<sub>2</sub> column product shall be at least 1/100<sup>th</sup> CCD-pixel.*
- SR 4.3.9c** *The radiometric accuracy of the SO<sub>2</sub> column product shall be at least 3%.*
- SR 4.3.9d** *The radiometric precision (S/N) of the SO<sub>2</sub> column product shall be at least 400 (for ground pixel size of 40 ´ 40 km<sup>2</sup>).*
- SR 4.3.10a** *The available spectral range for the BrO column product shall be at least 344 – 360 nm.*
- SR 4.3.10b** *The spectral knowledge of the BrO column product shall be at least 1/50<sup>th</sup> CCD-pixel.*
- SR 4.3.10c** *The radiometric accuracy of the BrO column product shall be at least 3%.*
- SR 4.3.10d** *The radiometric precision (S/N) of the BrO column product shall be at least 2500 (for ground pixel size of 40 ´ 40 km<sup>2</sup>).*
- SR 4.3.11a** *The available spectral range for the OCIO column product shall be at least 355 – 385 nm.*
- SR 4.3.11b** *The spectral knowledge of the OCIO column product shall be at least 1/100<sup>th</sup> CCD-pixel.*
- SR 4.3.11c** *The radiometric accuracy of the OCIO column product shall be at least 3%.*
- SR 4.3.11d** *The radiometric precision (S/N) of the OCIO column product shall be at least 1500 (for ground pixel size of 40 ´ 40 km<sup>2</sup>).*
- SR 4.3.12a** *The available spectral range for the HCHO column product shall be at least 335 – 360 nm.*
- SR 4.3.12b** *The spectral knowledge of the HCHO column product shall be at least 1/100<sup>th</sup> CCD-pixel.*
- SR 4.3.12c** *The radiometric accuracy of the HCHO column product shall be at least 3%.*
- SR 4.3.12d** *The radiometric precision (S/N) of the HCHO column product shall be at least 3200 (for ground pixel size of 40 ´ 40 km<sup>2</sup>).*
- SR 4.3.13a** *The available spectral range for the surface reflectance product shall be at least 320 – 500 nm.*
- SR 4.3.13c** *The radiometric accuracy of the surface reflectance product shall be at least 1%.*
- SR 4.3.13d** *The radiometric precision (S/N) of the surface reflectance product shall be at least 100 (for ground pixel size of 20 ´ 20 km<sup>2</sup>).*
- SR 4.3.14** *The UV spectra product requires the fulfilment of the requirements on the ozone column (SR 4.3.1), cloud cover (SR 4.3.7) and aerosol (SR 4.3.3 and SR 4.3.4).*

**Level 1b Requirements (from table 4.1) for the Near Real Time (NRT) products**

- SR 4.3.15a** *The available spectral range for the ozone column NRT product shall be at least 320 – 340 nm.*
- SR 4.3.15b** *The spectral knowledge of the ozone column NRT product shall be at least 1/50<sup>th</sup> CCD-pixel.*
- SR 4.3.15c** *The radiometric accuracy of the ozone column NRT product shall be at least 3%.*
- SR 4.3.15d** *The radiometric precision (S/N) of the ozone column NRT product shall be at least 100 (for ground pixel size of 20 ´ 20 km<sup>2</sup>).*
- SR 4.3.16a** *The available spectral range for the ozone profile NRT product shall be at least 270 – 340 nm.*

- SR 4.3.16b** *The spectral knowledge of the ozone profile NRT product shall be at least 1/50<sup>th</sup> CCD-pixel.*
- SR 4.3.16c** *The radiometric accuracy of the ozone profile NRT product shall be at least 1%.*
- SR 4.3.16d** *The radiometric precision (S/N) of the ozone profile NRT product shall be at least 100 below 310 nm (for ground pixel size of 40 ´ 40 km<sup>2</sup>).*

**Level 1b Requirements (from table 4.1) for the Very Fast Delivery (VFD) products**

- SR 4.3.17a** *The available spectral range for the ozone column VFD product shall be at least 320 – 340 nm.*
- SR 4.3.17b** *The spectral knowledge of the ozone column VFD product shall be at least 1/50<sup>th</sup> CCD-pixel.*
- SR 4.3.17c** *The radiometric accuracy of the ozone column VFD product shall be at least 3%.*
- SR 4.3.17d** *The radiometric precision (S/N) of the ozone column VFD product shall be at least 100 (for ground pixel size of 20 ´ 20 km<sup>2</sup>).*
- SR 4.3.18** *The surface UV-B VFD product requires the fulfilment of the requirements on the ozone column VFD product (SR 4.3.17).*
- SR 4.3.19a** *The available spectral range for the ozone profile VFD product shall be at least 270 – 340 nm.*
- SR 4.3.19b** *The spectral knowledge of the ozone profile VFD product shall be at least 1/50<sup>th</sup> CCD-pixel.*
- SR 4.3.19c** *The radiometric accuracy of the ozone profile VFD product shall be at least 1%.*
- SR 4.3.19d** *The radiometric precision (S/N) of the ozone profile VFD product shall be at least 100 below 310 nm (for ground pixel size of 40 ´ 40 km<sup>2</sup>).*
- SR 4.3.20** *The UV spectra product requires the fulfilment of the requirements on the ozone column VFD product (SR 4.3.17).*
- SR 4.3.21a** *The available spectral range for the HCHO VFD column product shall be at least 335 – 360 nm.*
- SR 4.3.21b** *The spectral knowledge of the HCHO VFD column product shall be at least 1/100<sup>th</sup> CCD-pixel.*
- SR 4.3.21c** *The radiometric accuracy of the HCHO VFD column product shall be at least 3%.*
- SR 4.3.21d** *The radiometric precision (S/N) of the HCHO VFD column product shall be at least 3200 (for ground pixel size of 40 ´ 40 km<sup>2</sup>).*

**Auxiliary and Ancillary Data Requirements**

- SR 4.4.1** *All requirements, specified in the latest version of “Auxiliary and Ancillary data requirements document for OMI-EOS”, shall be applicable.*

**Level 0-1b processing requirements**

- SR 4.5.1** *All requirements as specified in the latest version of RS-OMIE-7000-FS-186 “User Requirements Document for the OMI Level 0 to 1b Data Processor”, shall be applicable.*



**Table 4.1 Overview of the Level 1b product requirements for the priority ‘A’ and ‘B’ OMI data products.**

Data product	Spectral Range [nm]	Ground pixel size [km × km]	Spectral knowledge [CCD pixel]	Radiometric accuracy <sup>1)</sup> [%]	Radiometric precision <sup>2)</sup> [S/N]
Ozone column					
? DOAS	320 – 340	20 × 20	0.01	≤ 3	≥ 250
? TOMS	310 – 380	20 × 20	0.33	≤ 1	≥ 300
Ozone profile	270 – 340	40 × 40	0.02	≤ 1	$\lambda < 310$ ≥ 100
Aerosol optical thickness	340 – 500	20 × 20	not critical	≤ 1	≥ 500
Aerosol single scattering albedo	340 – 500	20 × 20	not critical	≤ 1	≥ 500
NO <sub>2</sub> column	425 – 450	40 × 40	0.02	≤ 3	≥ 5800
Cloud scattering pressure	390 – 400	20 × 20	0.01	≤ 3	not critical
	470 – 485	20 × 20	0.01	≤ 3	≥ 1600 <sup>3)</sup>
Cloud fraction	320 – 500	20 × 20	not critical	≤ 1	not critical
Surface UV-B	280 – 400	20 × 20	not critical	not critical	not critical
SO <sub>2</sub> column	300 – 330	40 × 40	0.01	≤ 3	≥ 400
BrO column	344 – 360	40 × 40	0.02	≤ 3	≥ 2500
OCIO column	355 – 385	40 × 40	0.01	≤ 3	≥ 1500
HCHO column	335 – 360	40 × 40	0.01	≤ 3	≥ 3200
Surface reflectance	320 – 500	20 × 20	not critical	≤ 1	≥ 100
UV spectra	280 – 400	20 × 20	not critical	not critical	not critical
<b><i>Near Real Time Products</i></b>					
Ozone column	320 – 340	20 × 20	0.02	≤ 3	≥ 100
Ozone profile	270 – 340	40 × 40	0.02	≤ 1	$\lambda < 310$ ≥ 100
<b><i>Very Fast Delivery Products</i></b>					
Ozone column	320 – 340	20 × 20	0.02	≤ 3	≥ 100
Surface UV-B flux	280 – 400	20 × 20	not critical	not critical	not critical
Ozone profile	270 – 340	40 × 40	0.02	≤ 1	$\lambda < 310$ ≥ 100
UV spectra	280 – 400	20 × 20	not critical	not critical	not critical
HCHO column	335 – 360	40 × 40	0.01	≤ 3	≥ 3200

Note 1) The radiometric accuracy defined here refers to the reflectivity (i.e. ratio of the Earth radiance and the solar irradiance)

Note 2) S/N requirements are valid for the given ground pixels size in column 3 (i.e. the same ground pixel sizes as in Table 3.1)

Note 3) The most stringent requirement on radiometric precision is given by the method using the 477 nm O<sub>2</sub>-O<sub>2</sub> collision complex.

Note 4) A requirement noted as not critical means that other products demand stronger requirements for the Level 1b product.

## **Instrument requirements (SRD Chapter 5)**

### **Overall characteristics**

- SR 5.0.1** *The OMI instrument shall be built such that it is possible to retrieve the products as listed in Table 3.1 (SR 3.4.0) with the noted accuracies, spatial resolutions etc., using the algorithms as summarised in Chapter 4 (SR 4.3.0).*
- SR 5.0.2** *OMI shall measure the Earth radiance and the solar irradiance spectra.*
- SR 5.0.3** *OMI shall not have a scan mirror.*
- SR 5.0.4** *OMI shall not be sensitive to polarisation.*  
*Note: this is quantified with the requirement on rest-polarisation and similar structures in the signal, SR 5.0.10 and with SR 5.2.2.8.*
- SR 5.0.5** *OMI shall be designed and operated in a way that prevents etalon effect.*
- SR 5.0.6** *OMI ground pixel shall be smaller than  $20 \times 20 \text{ km}^2$ .*
- SR 5.0.7** *OMI shall have a field-of-view that provides cross-track global coverage at all latitudes of the atmosphere in one day from the EOS-Aura spacecraft orbit.*
- SR 5.0.8** *OMI shall not suffer from spatial aliasing.*
- SR 5.0.9** *The OMI Duty Cycle shall be 100% (continuous operation) in flight.*
- SR 5.0.10** *In general, the instrument sensitivity to polarisation shall not be more than 0.5% for fully polarised incident light, for all polarisation directions, over the Full Performance Range.*  
*This means that fully polarised and unpolarised light should give the same instrumental response within 0.5% over the entire spectral range.*
- SR 5.0.11** *Optics, detectors and electronics of OMI shall have sufficient reliability (including radiation hardness) for the expected 5-year lifetime of EOS-Aura.*
- SR 5.0.12** *OMI shall provide images of atmospheric radiance and the solar irradiance of visible wavelengths.*
- SR 5.0.13** *OMI shall provide images of atmospheric radiance and the solar irradiance of ultra-violet wavelengths.*
- SR 5.0.14** *OMI shall view in nadir direction, with a field-of-view in swath direction, which is perpendicular to the spacecraft's flight direction, and a field-of-view in flight direction.*
- SR 5.0.15** *OMI shall use a polarisation scrambler to scramble the polarisation of the incoming atmospheric radiance.*
- SR 5.0.16** *OMI shall convert radiance to spectrum.*
- SR 5.0.17** *OMI shall convert photons to ADC counts.*
- SR 5.0.17-note** *The spacecraft will send the ADC counts to ground.*
- SR 5.0.18** *The OMI Ground Data Processor shall process the data (i.e. ADC counts) to level 1b products.*

### **Spectral properties**

- SR 5.1.1.1** *OMI shall be a nadir viewing imaging spectrometer with full performance range 270-500 nm.*
- SR 5.1.1.2** *OMI shall have an ultraviolet (UV) channel with full performance range 270-365 nm.*
- SR 5.1.1.3** *OMI shall have a visible (VIS) channel with full performance range 365-500 nm.*
- SR 5.1.1.4** *The 50 % sensitivity point of both channels shall be 365 nm.*
- SR 5.1.1.5** *The total overlap of the UV and VIS channels shall be the range 350-380 nm.*
- SR 5.1.1.6** *The UV channel shall be split into two parts, UV-1 and UV-2, with full performance ranges 270-310 nm and 310-365 nm, respectively.*
- SR 5.1.1.7** *The 50 % sensitivity point of both UV channels shall be 310 nm.*
- SR 5.1.1.8** *The total overlap of the UV-1 and UV-2 channels shall be the range 306-314 nm.*
- SR 5.1.1.9** *The spectral resolution of the UV-1 channel shall equal or better than 0.64 nm.*
- SR 5.1.1.10** *The spectral resolution of the UV-2 channel shall equal or better than 0.45 nm.*
- SR 5.1.1.11** *The spectral resolution of the VIS channel shall equal or better than 0.63 nm.*

- SR 5.1.1.12** *The spectral sampling of the UV-1 channel shall equal or better than 0.32 nm while keeping a sampling ratio equal or larger than 2.*
- SR 5.1.1.13** *The spectral sampling of the UV-2 channel shall equal or better than 0.15 nm while keeping a sampling ratio equal or larger than 3.*
- SR 5.1.1.15** *The spectral sampling of the VIS channel shall equal or better than 0.21 nm while keeping a sampling ratio equal or larger than 3.*
- SR 5.1.1.16** *The total range, full performance range, spectral resolution, and spectral sampling distance of OMI shall be as specified in Table 5.1. (Summarise of SR 5.1.1.1 up to SR 5.1.1.15).*

**Table 5.1: Required spectral range and resolution of OMI.**  
“Resolution” means the FWHM of the slit function.

Channel	Total range	Full performance range	Resolution in nm	Resolution in pixels	Sampling distance
UV-1	270 - 314 nm	270 - 310 nm	≤ 0.64 nm	≥ 2	≤ 0.32 nm
UV-2	306 - 380 nm	310 - 365 nm	≤ 0.45 nm	≥ 3	≤ 0.15 nm
VIS	350 - 500 nm	365 - 500 nm	≤ 0.63 nm	≥ 3	≤ 0.21 nm

**Spatial properties and observation modes**

- SR 5.1.2.1** *The UV and VIS channels of OMI shall have a CCD as detector, where the spectrum is imaged in one direction and the swath is imaged in the other direction.*
- SR 5.1.2.2** *OMI shall have a swath of 2600 km wide or larger to achieve daily global coverage.*
- SR 5.1.2.3** *OMI shall have contiguous coverage of the Earth both along and across satellite ground track.*
- SR 5.1.2.4** *The instantaneous spatial resolution of OMI shall be 10 ´ 10 km<sup>2</sup> or smaller at the sub-satellite point.*
- SR 5.1.2.5** *The instantaneous spatial resolution of OMI shall be 10 ´ 10 km<sup>2</sup> or smaller at the sub-satellite point.*
- SR 5.1.2.6** *The spatial angles seen by the OMI pixel shall be constant over the swath.*
- SR 5.1.2.7** *The swath width and sub-satellite ground pixel size of OMI shall be as specified in Table 5.2, for the global mode, the spectral zoom-in mode, and the spatial zoom-in mode.*

**Table 5.2 Required swath width and sub-satellite ground pixel of OMI for the three different observation modes.**

Observation mode	Spectral range	Swath width*	Ground pixel size (along x across track)	Application
Global mode				
UV-1	270 - 310 nm	2600 km	13 × 48 km <sup>2</sup>	global observation of all products
UV-2 & VIS	310 - 500 nm	2600 km	13 × 24 km <sup>2</sup>	
Spatial zoom-in mode				
UV-1	270 - 310 nm	2600 km	13 × 24 km <sup>2</sup>	regional studies of all products
UV-2 & VIS	310 - 500 nm	≥ 725 km	13 × 12 km <sup>2</sup>	
Spectral zoom-in mode				
UV	At least 306 - 364 nm	2600 km	13 × 12 km <sup>2</sup>	global observation of some products
VIS	At least 350 - 432 nm	2600 km	13 × 12 km <sup>2</sup>	

\* and symmetric around sub-satellite track

- SR 5.1.2.8** *A sub-pixel read-out capability shall exist for one wavelength in the UV channel and one wavelength in the VIS channel of OMI, which is achieved by not co-adding the CCD-images for all three observation modes.*
- SR 5.1.2.9** *It shall be possible to choose the wavelengths for sub-pixel data flexible.*
- SR 5.1.2.10** *The latitude and longitude of the centre of each ground pixel shall be known with an accuracy better than  $1/10^{\text{th}}$  of the size of the ground pixel of the global, spatial and spectral zoom in modes (either in an angular unit or in a distance unit on the Earth's surface).*

#### **Detector requirements**

- SR 5.1.3.1** *At the edges of the CCD, dark current and straylight shall be measured on every exposure.*
- SR 5.1.3.2** *Frame transfer smear shall be measured for every exposure.*
- SR 5.1.3.3** *The spectrum of each viewing direction (i.e. one CCD row) shall be spectrally calibrated separately.*
- SR 5.1.3.4** *Gain switching in the preamplifier shall be used to improve S/N in the UV channel.*
- SR 5.1.3.5** *There shall be 4 different gains per CCD detector.*
- SR 5.1.3.6** *The order of gains shall be programmable in flight.*
- SR 5.1.3.7** *The wavelength at which the gain is switched shall be programmable in flight.*
- SR 5.1.3.8** *Gain switching shall be such that the range between minimum and maximal radiance permits an optimal use of the full dynamical range of the 12 bits ADC converter.*
- SR 5.1.3.9** *The alignment of the slit of OMI with the CCD shall be accurate within 0.4 CCD pixel. This means that in each spectral channel (UV 1, UV 2 and VIS) each CCD row shall contain the spectrum belonging to one viewing direction, within an accuracy of 0.4 CCD pixel in the swath direction.*
- SR 5.1.3.10** *The co-alignment of the UV-2 and VIS channels shall be within 1 CCD pixel in the swath direction.*
- SR 5.1.3.11** *The co-alignment of the UV-1 and UV-2 channels shall be within 1 CCD pixel in the swath direction.*
- SR 5.1.3.12** *Optical distortion leading to different spectral definition as a function of the viewing angle, like the curved swath image, shall not influence the required spectral range over the entire CCD, according to Table 5.1 (SR 5.1.1.16).*
- SR 5.1.3.13** *The curved swath image shall not influence the required spectral resolution and sampling distance over the entire CCD, according to Table 5.1 (SR 5.1.1.16), to within a margin of 10 % around these values.*
- SR 5.1.3.14** *Spectral lines imaged onto the columns of the CCD for both channels shall be aligned with an accuracy of 0.1 CCD pixel.*
- SR 5.1.3.15** *CCD exposure times shall be possible between 0.1 s and 6 s.*
- SR 5.1.3.16** *OMI shall be able to do long exposures between 6 and 768 s.*
- SR 5.1.3.17** *The nominal exposure time shall be 0.4 s.*
- SR 5.1.3.18** *The exposure time shall be programmable during flight.*
- SR 5.1.3.19** *Read-out time shall not influence data acquisition in the image area of the CCD.*
- SR 5.1.3.20** *Co-adding of images shall be possible, with co-addition period between 2 s and 6 s.*
- SR 5.1.3.21** *The co-addition period shall be programmable during flight.*
- SR 5.1.3.22** *Binning of pixels (in the swath direction) shall be possible.*
- SR 5.1.3.23** *Binning factors between 1 and 15 shall be possible.*
- SR 5.1.3.24** *The binning factor shall be programmable during flight.*
- SR 5.1.3.25** *It shall be possible to operate the UV and VIS channels independently (so that different exposure time, co-addition period, read-out time and binning factors are possible).*
- SR 5.1.3.26** *The CCD detectors shall not have more than 100 bad or dead pixels.*
- SR 5.1.3.27** *Bad/dead pixels shall not influence the retrieval accuracy of any of the OMI data products listed in Table 3.1.*
- SR 5.1.3.28** *There shall be no bad or dead pixels in the read-out register.*

**SR 5.1.3.29** *The instrument shall be operated in such a way that no ice forms on the CCD or on any other optical component in the OMI-instrument.*

**SR 5.1.3.30** *All channels (UV and VIS) shall start their exposures simultaneously when equal read-out disciplines are used.*

**Radiometric Accuracy: Random errors (required signal-to-noise)**

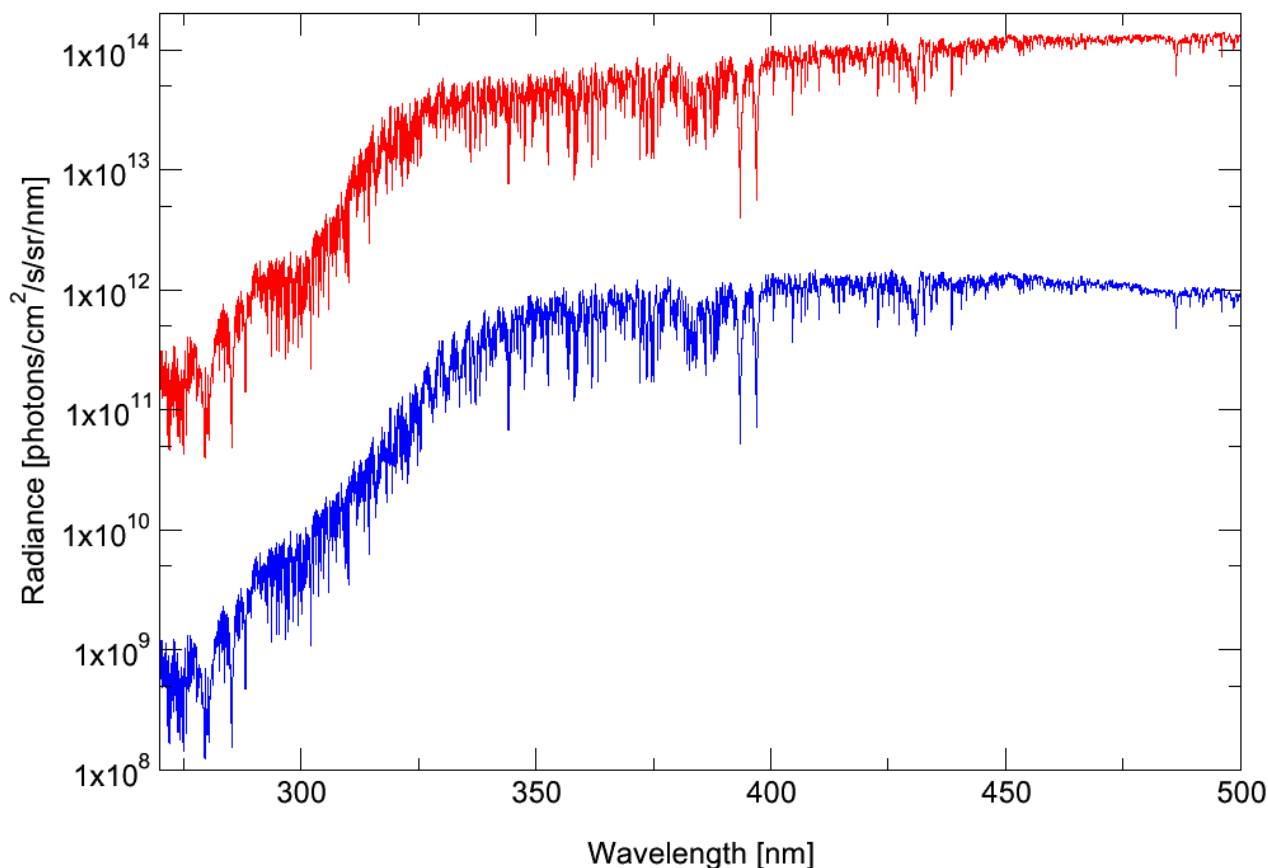
**SR 5.2.1.1** *The S/N ratio's for the Earth radiance measurements as tabulated in Table 5.3 shall be reached for the minimum radiance levels as shown in Figure 5.2.*

**SR 5.2.1.2** *The OMI instrument shall not saturate for the maximum Earth radiance levels as defined in Figure 5.2*

**Table 5.3** **Required scaled signal-to-noise levels for different wavelength ranges.**

The values in this table are derived from the values in Table 4.1. by re-scaling for the ground pixel sizes given in this table.

Wavelength range	Critical trace gas	Scaled S/N (global mode)	Scaled S/N (spatial zoom-in mode)
270 – 310 nm	O <sub>3</sub> profile	60 (13 × 48 km <sup>2</sup> )	45 (13 × 24 km <sup>2</sup> )
310 – 335 nm	O <sub>3</sub> column	265 (13 × 24 km <sup>2</sup> )	190 (13 × 12 km <sup>2</sup> )
335 – 365 nm	HCHO	1450 (13 × 24 km <sup>2</sup> )	1050 (13 × 12 km <sup>2</sup> )
365 – 420 nm	OCIO	700 (13 × 24 km <sup>2</sup> )	470 (13 × 12 km <sup>2</sup> )
420 – 450 nm	NO <sub>2</sub>	2600 (13 × 24 km <sup>2</sup> )	1850 (13 × 12 km <sup>2</sup> )
450 – 500 nm	O <sub>2</sub> – O <sub>2</sub>	1400 (13 × 24 km <sup>2</sup> )	1000 (13 × 12 km <sup>2</sup> )



**Fig. 5.2** *Overall minimum and maximum radiances to be observed by OMI, as derived from simulations for different scenario's as described in Annex XII.*

- SR 5.2.1.3** *Solar irradiance measurements, through the calibration port of OMI, shall have S/N ratios of at least 1000, independent of season.*
- SR 5.2.1.4** *During solar irradiance measurements OMI shall not saturate, independent of season.*
- SR 5.2.1.5** *The OMI Instrument shall not be damaged by high Earth radiances (red line in Figure 5.2) or solar irradiances entering the telescope and/or caused by:*
- the sun glint effect*
  - lasers used for the alignment (less than 20 mW)*
  - the sun*

#### **Radiometric Accuracy: Systematic errors**

- SR 5.2.2.1** *Requirements SR 5.2.2.4 – SR 5.3.3 shall be met for all swath angles, wavelengths, positions in orbit and seasons.*
- SR 5.2.2.2** *The calibration lamp used for the absolute radiometric calibration (see SR 5.2.2.4) shall be a NIST calibrated 1000 W FEL lamp and shall be NIST traceable.*
- SR 5.2.2.3** *The NIST calibrated 1000 W FEL lamp shall be calibrated within a 2 % (2 $\sigma$  error) accuracy over the total spectral range of OMI (270 nm – 500 nm).*
- SR 5.2.2.4** *The absolute radiometric accuracy of the atmospheric radiance and the solar irradiance spectra shall be known to within  $\pm$ 2%, excluding the calibration lamp error.*
- SR 5.2.2.5** *The error in the absolute reflectivity (defined as the radiance divided by the irradiance) shall be = 1.0 % for any (collimated to 0.5 degree circular, i.e. Solar like) position in the irradiance Field-Of-View.*
- SR 5.2.2.6** *The effect of multiplicative factors on the absolute reflectivity shall be less than 1% of the true signal after correction at all wavelengths and swath angles.*
- SR 5.2.2.7** *The effect of additive factors on the absolute reflectivity shall be less than 1% of the true signal after correction at all wavelengths and swath angles.*
- SR 5.2.2.8** *The effect of spectral structures similar to absorption structures caused by the instrument and/or its calibration in the reflectivity spectra shall be less than  $10^{-4}$  at all wavelengths and swath angles.*
- SR 5.2.2.9** *The non-linearity on the reflectivity after correction shall be less than 0.2%.*  
*Note: Here non-linearity is defined as is the maximum excursion relative to linear behaviour (= Definition 5.2.2.3), so  $|I_{measured} - I_{true}| < 0.002 I_{true}$ . Moreover the linearity requirement applies for all illuminations between expected minimum radiance (and irradiance) and pixel full well.*  
*In case the noise-floor in the measured S/N for the relevant ground pixel size is larger than the non-linearity itself, this requirement can be relaxed and applies to the dynamic range above twice the noise floor.*

#### **Spectral stability and spectral knowledge**

- SR 5.3.1** *The wavelength scale of the Earth radiance and solar irradiance spectra shall be in vacuum wavelengths.*
- SR 5.3.2** *The spectral knowledge of the radiance and irradiance spectra shall be better than 1/100<sup>th</sup> of a CCD-pixel above 300 nm and better than 1/50<sup>th</sup> of a CCD-pixel below 300 nm.*
- SR 5.3.3** *The thermal and mechanical spectral stability of the instrument shall be better than 1/20<sup>th</sup> of a CCD-pixel.*

#### **OMI On-Ground and Preflight Calibration Requirements**

- SR 5.4.1** *A PI period is needed to measure atmospheric spectra with the Flight Model, and to measure trace gas absorption spectra of, for example, ozone and NO<sub>2</sub>.*

- SR 5.4.2** *The accuracy of the effective spectral slitfunction of the instrument shall be 1 % of the peak value of the effective spectral slitfunction over the whole spectral range and for all swath-angles and for all relevant measurements modes (nadir and sun diffuser).*
- SR 5.4.3** *There shall be a Development Model with at least a complete UV-channel. This DM and its measurements shall be available for us in PFM design and the PFM calibration and characterisation measurements.*
- SR 5.4.4** *Straylight shall be characterised for all spatial and spectral dimensions.*
- SR 5.4.5** *In all measurement modes (measurement and calibration) the instrument response for all sources outside 2 times the IFOV (centred to the IFOV) shall not exceed 1 % of the response for the radiance from inside the IFOV.*
- SR 5.4.6** *Straylight determined for the minimum radiance spectrum as shown in Figure 5.2 (blue line) shall be less than 10 % before correction and 0.5 % after correction at all wavelengths and swath angles.*
- SR 5.4.7** *The signal from dark current shall not exceed 20% of the useful minimal signal as shown in Figure 5.2 (blue line) before correction and 0.5 % after correction at all wavelengths and swath angles.*
- SR 5.4.8** *All other requirements, specified in the latest version “OMI On-Ground Calibration and Characterisation Requirement Document”, shall be applicable.*

### **In-flight calibration facilities**

#### **Solar calibration**

- SR 5.5.1** *The solar calibration shall be used for the absolute radiometric calibration of OMI during flight. Therefore the sun shall be observed at least once each day via a solar port and a diffuser plate.*
- SR 5.5.2** *The long-term degradation of the nominally used reflection diffuser shall be monitored by using an identical reflection diffuser that is typically used once per month.*
- SR 5.5.3** *In addition, it shall be possible to use the transmission diffuser (which is used for the white light source (WLS)) as a reflection diffuser.*
- SR 5.5.4** *In order to correct for spectral effects of the reflection diffuser plate a third reflection diffuser of a different material shall be used.*
- SR 5.5.5** *The solar calibration port shall be large enough to observe the total sun in the field-of-view and the useful calibration time shall be about 1 minute.*
- SR 5.5.6** *When closed, the solar calibration port shall be light tight.*

#### **White light source calibration**

- SR 5.5.7** *There shall be a calibration white light source (WLS) in the instrument. This WLS is used for relative radiometric calibration of the instrument optical path after the primary mirror, plus detectors and for pixel-to-pixel characterisation purposes.*
- SR 5.5.8** *The spectrum of the WLS shall be continuous, well characterised and stable.*

#### **Smooth field light source**

- SR 5.5.9** *There shall be a smooth field light source in front of each detector CCD in the wavelength range that can be measured with the CCD, preferably in the wavelength range measured by the channel in question. This means that the UV1, UV2 and VIS channel all preferably shall have a different smooth field light source.*

#### **Dark current signal measurements**

- SR 5.5.10** *The dark current of all CCD pixels shall be measured and characterised during the dark side and the illuminated side of the orbit, in order to characterise temperature variation of the dark current.*
- SR 5.5.11** *Dark current measurements with multiple exposure times of all CCD pixels shall be performed to separate the electronics offset, dark current and noise in order to correct for dark current and electronic off-set in the on-ground software (and characterise the S/N in the measured signal).*

**Straylight measurements**

*SR 5.5.12 The straylight shall be measured for each image using dedicated CCD rows and shall be corrected for in on-ground software. This correction shall be based on the dedicated CCD row straylight measurements and the on-ground straylight calibration.*

**Detector Smear**

*SR 5.5.13 Detector smear shall be measured using dedicated CCD rows and shall be corrected for in on-ground software.*

*SR 5.5.14 The OMI in-flight telemetry shall include data which enables on-ground software correction for multiplicative and additive factors as defined in definitions 5.2.2.1 and 5.2.2.2 above.*

*SR 5.5.15 All other requirements, specified in the latest version “OMI In-flight Calibration Requirements Document”, shall be applicable.*

## **Validation requirements (SRD Chapter 6)**

### **Validation strategy**

- SR 6.1.2.1 The validation shall continue throughout the OMI lifetime.*
- SR 6.1.2.2 Validation is envisaged to consist of three phases, each having a distinct goal. Firstly, the commissioning phase, which aims to provide a quick-look first validation; secondly, the core phase, to ensure a thorough validation of all data products; and finally, a long-term validation, establishing the stability of the instrument which is important for its ability to measure trends.*
- SR 6.1.2.3 The validation strategy is to rely on measurements based on validated techniques. Preferably, several independent measurement techniques shall be used, at a large number of representative locations and conditions.*
- SR 6.1.2.4 Validation campaigns shall be co-ordinated with other instruments on EOS-Aura.*
- SR 6.1.2.5 New instrumentation shall be considered to provide an intercomparison rather than a validation.*
- SR 6.1.2.6 To validate OMI data, participation in scientific validation projects, e.g., the NASA-NRA for Aura-validation, shall be encouraged.*
- SR 6.1.2.7 Experience gained during the validation of GOME and SCIAMACHY shall be exploited.*
- SR 6.1.2.8 Validation tools which shall be needed are: software for data processing, coincidence predictor, correlative and Aura data database, cataloguing tools, data assimilation tools, auxiliary data.*
- SR 6.1.2.9 Validation workshops shall be held regularly throughout the OMI lifetime.*

### **Commissioning phase**

- SR 6.2.1.1 In the commissioning phase absolute irradiance and absolute radiance shall be validate and a preliminary validation of the main level 2 data products shall be provided.*
- SR 6.2.1.2 In the commissioning phase, one satellite instrument (with global coverage) and one or two groundbased instruments shall be used as correlative instruments.*
- SR 6.2.1.3 The commissioning phase shall take place after instrument functional tests, and lasts about three months.*

### **Core phase**

- SR 6.2.2.1 In the core phase, all products shall be validated thoroughly in order to determine their accuracy.*
- SR 6.2.2.2 Data from existing instruments (ground-based and satellite instruments) as well as from dedicated campaigns shall be needed.*
- SR 6.2.2.3 Campaigns shall be incorporated within the EOS-Aura framework.*
- SR 6.2.2.4 Existing campaigns, outside the scope of EOS-Aura validation, shall also to be exploited.*
- SR 6.2.2.5 During the core phase, data measured by different independent instruments shall be used.*
- SR 6.2.2.6 Data measured within existing networks of instruments shall be exploited, since these are well-validated and often very stable.*
- SR 6.2.2.7 Data from satellite instruments and data-assimilation techniques shall also be included and are essential for obtaining global coverage.*
- SR 6.2.2.8 The core phase starts after the commissioning phase and ends when all data products have been validated. It shall span at least one year, to achieve seasonal coverage.*
- SR 6.2.2.9 Campaigns shall not start earlier than 1 year after launch.*
- SR 6.2.2.10 During the core phase, EOS-Aura as well as correlative data shall be available for all validation participants, through (an) easily available database(s).*
- SR 6.2.2.11 If data are reprocessed (e.g., based on the validation results), they shall be validated again, using the already available correlative data.*

**Long-term phase**

- SR 6.2.3.1** *The long-term phase starts after the core phase and last during the complete lifetime of the instrument. In the long-term phase, all available data shall be used.*
- SR 6.2.3.2** *In the long-term phase, long-term changes in the accuracies of the products, e.g., due to instrument degradation, shall be detected and newly developed or advanced OMI data products shall be validated.*
- SR 6.2.3.3** *In the long-term phase, a regular, optimised repetition of the essential elements of the core validation phase is necessary.*

**Validation rehearsal**

- SR 6.2.4.1** *A validation rehearsal shall be planned before launch.*
- SR 6.2.4.2** *The main goals of a validation rehearsal are to provide a check on the data flow and accessibility of the database(s), and to test the validation tools.*
- SR 6.2.4.3** *All other requirements, specified in the latest versions of the “OMI Validation Requirements Document”, the “OMI Validation Handbook” and the “EOS-Aura Validation Plan” shall be applicable.*

**Availability of validation data sources/campaigns**

- SR 6.3.1** *Correlative measurements of (tropospheric) columns of NO<sub>2</sub> shall be supplied, either through the NASA-NRA for Aura-validation or through other sources of funding.*