Compact VIIRS SDR Product Format User Guide

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Document Change Record

Issue / Revision	*Date*	*DCN. No*	*Summary of Changes*
v1	24 October 2013		Initial version for review
v1A	12 December 2013		Added missing attributes in Table 4. Adjusted definition of expansion and alignment coefficients in Sections 8.10 and 8.11. Corrected name of `VIIRS-MOD-GEO_All` group from Compact VIIRS SDR.
v1B	4 April 2014		Adjusted definition of expansion and alignment coefficients in Section 8.5 . Corrected $-\sin(lat)$ to $-\sin(lon)$ in section 8.9.
v1C	21 August 2014		Added second paragraph in 10.14 and a new section 10.14.1 Determination of Offset and Scale Factors. Modified the use of Fill Values in section 7.1, step 6 and step 17. Table 33 updated to account for actual range of instrument data.
v1D	11 November 2014		Deleted section 1.6 Open Issues Corrected QF3_SCAN_SDR to QF3_SCAN_RDR in section 5.2 Corrected the dimension of Radiance and QF1_VIIRSMBANDSDR in Table 8 Included OriginalFilename attribute in new Table 7 and in Table 10. Added missing PadByte1 in Table 13, Step 29. Added Threshold value in Table 14, Step 7 and 8 Modified handling of scale and offset in Table 14 Step 12 and 14 Deleted redundant Step 8 in Table 16 Added missing QF2_SCAN_VIIRSSDRGEO in Table 16, Step 19. Improvements to the Radiance Representations and Conversions in section 10 Added section 11 Fill, Mode and Quality Flag Values. Improvements to section 12 Parameter Values Editorial changes throughout the document
v1F	07 July 2015		Updated for the Imagery Resolution Band channels

			and geolocation data
v1G	16 February 2016		Updated to include VIIRS Day Night Band handling and definitions, as well as introducing the concept of Tie Point Zone Groups. Correction of algorithm for creation and reconstruction of the Groups in the Data_Products group. Editorials and clarifications.
v1H	11 April 2016		Accepted changes from v1G.
v1I	25 January 2018		Updates to signature table. Release version for CVIIRS 2.0.x. Update to current state of EARS-VIIRS processing. Editorials and clarifications.
V1J			Add TD 14, CVIIRS Software User Manual to Reference Documents Remove sections 2 and 3 Reconstruct missing references in change log Typographical errors fixed

Table of Contents

List of Figures

List of Tables

1 INTRODUCTION

1.1 Purpose

During the implementation of the EUMETSAT provided VIIRS Regional Service (EARS-VIIRS, described in [RD-5]) a need was identified to develop a Compact VIIRS SDR Product Format (Level 1) to achieve a cost efficient distribution of the VIIRS data via EUMETCast, EUMETSAT's satellite based data distribution system.

This document specifies the Compact VIIRS SDR Product Format and how it relates to the Original VIIRS SDR Product Format developed as part of the Suomi-NPP and JPSS Programmes. It provides guidelines on how to construct the Compact product format from the Original product format and on how to reconstruct the Original product format from the Compact product format.

1.2 Scope

The document has been prepared as a product format specification, and as a guide for users and developers of tools for handling, visualising and processing the data from the VIIRS Regional Service.

The main use case is expected to be that VIIRS data distributed via EUMETCast in the Compact SDR format is converted back to the Original VIIRS SDR format for further processing and visualisation by the service users. However, it is also expected that tools will be developed for visualising and utilising the data directly from the Compact VIIRS SDR format without first reconstructing the Original VIIRS SDR format.

In combination with the relevant S-NPP/JPSS and HDF5 documentation this document provides sufficient level of detail for the development of tools capable of reading and writing the Compact VIIRS SDR format. Additionally, EUMETSAT provides software for converting between the two product formats, called CVIIRS. Further information about this software can be found in [RD-6].

1.3 Applicable Documents

[AD-1]	Joint Polar Satellite System (JPSS) Common Data Format Control Book - External Volume I - Overview	474-00001-01-B0200, August 23, 2016, 0200C
[AD-2]	Joint Polar Satellite System (JPSS) Common Data Format Control Book - External Volume III - SDR/TDR Formats	474-00001-03-B0124, October 02, 2014, 0124C
[AD-3]	Joint Polar Satellite System (JPSS) Common Data Format Control Book – External Volume V - Metadata	474-00001-05-B0124 October 02, 2014, 0124C

1.4 Reference Documents

[RD-1]	Compact VIIRS SDR - Representation of Observations	EUM/TSS/REP/13/710728 v1, 06/09/2015
[RD-2]	Joint Polar Satellite System (JPSS) Visible Infrared Imaging Radiometer Suite (VIIRS) Sensor Data Record (SDR) Geolocation Algorithm Theoretical Basis Document (ATBD)	E/RA-00004, December 18, 2013 Rev. A
[RD-3]	The HDF Group, Champaign, IL, USA. HDF5 User's Guide	Release 1.8.8.
[RD-4]	IEEE Standard for Floating-Point Arithmetic	IEEE Standard 754, 2008
[RD-5]	TD 14 - EUMETSAT Advanced Retransmission Service Technical Description	EUM/OPS/DOC/06/0467
[RD-6]	CVIIRS - Software User Manual	EUM/TSS/SUM/14/784457

1.5 Document Structure

Section 1	General information (this section).
Section 2	Provides an overview of both the Original and the Compact VIIRS SDR Product Format.
Section 3	Describes the detailed content of the Original VIIRS SDR Product Format with cross references to the Compact VIIRS SDR Product Format.
Section 4	Describes the detailed content of the Compact VIIRS SDR Product Format.
Section 5	Lists the steps required for generating the Compact VIIRS SDR from the Original VIIRS SDR.
Section 6	Lists the steps required for reconstructing the original VIIRS SDR from the Compact VIIRS SDR.
Section 7	Defines the Product file naming conventions.

Section 88 Details the mathematical algorithms required for generating and applying the geolocation data of the Compact VIIRS SDR.

Section 9 Provides Fill, Mode and Quality Flag Values.

Section 10 Provides typical parameters values for the mathematical algorithms.

2 OVERVIEW OF THE ORIGINAL AND THE COMPACT VIIRS SDR PRODUCT FORMAT

This section explains the VIIRS scanning geometry and provides an overview of the Original and the Compact VIIRS SDR Product format.

2.1 The VIIRS Scanning Geometry

2.1.1 M-Band and I-Band[1]

The VIIRS instrument has a wide swath of 3000 km and performs a scan every 1.786 s. Each scan contains 16 M-Band scan lines and 32 I-Band Scan lines. To ensure a more uniform pixel size across the swath, the VIIRS instrument performs a pixel aggregation in the scan direction. In the central 3:1 Aggregation Zone below the spacecraft three instrument pixels are aggregated to one pixel at the product level, in the intermediate 2:1 Aggregation Zone two instrument pixels are aggregated to one pixel at the product level, and in the outer 1:1 Aggregation Zone each instrument pixel results in one pixel at the product level. The result is 3200 pixels in the scan direction for the VIIRS M-bands and 6400 for the VIIRS I-Bands at the product level.

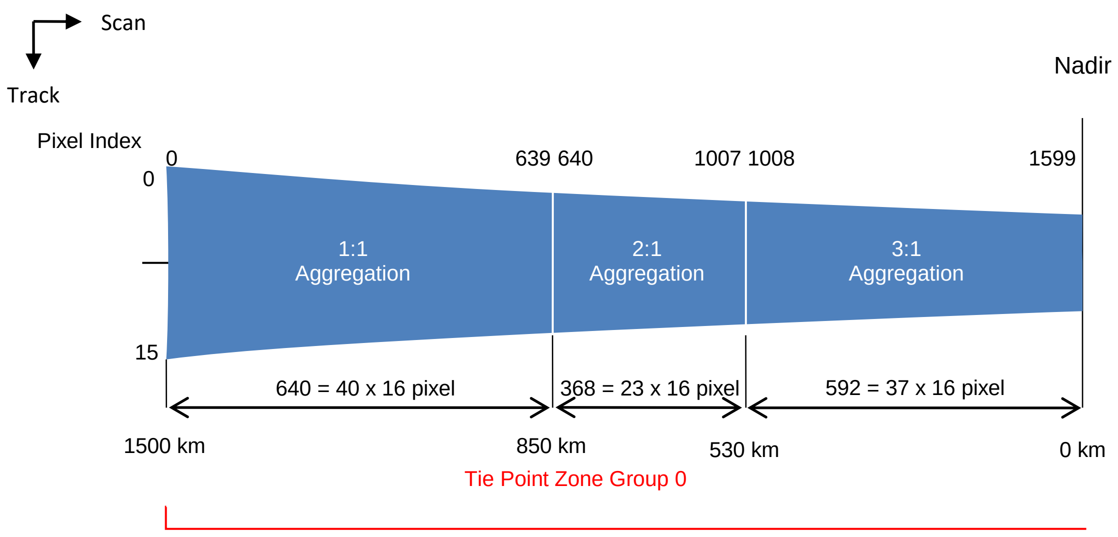

Figure 1 VIIRS M-Band scan and aggregation zone geometry shown for one half of a full scan. A full scan has 3200 pixels along scan and 16 pixels along track.

2.1.2 Day/Night Band (DNB)

While in the M-Band and I-Band data there are 3 aggregation zones on both left and right from nadir, in the DNB there are 32 aggregation zones on both sides of nadir.

The DNB has the same along-track extent on the Focal Plane Array (FPA) as all the other bands; however where the other bands have 16 or 32 along-track detectors the DNB has 672

[1] Please note, that in the following text, usually both M- and I-Band are mentioned, as the CVIIRS tool can handle both. For the time being, though, EUMETSAT disseminates the M-Band data only.

"sub-pixel" detectors. When scanning near nadir 16 pixels per frame are constructed on-board from an aggregation of 42 along-track sub-pixel detectors each. These 16 pixels coincide with the 16 ideal 'M' band pixels only at nadir. As the sensor scans away from nadir the number of sub-pixel detectors in the aggregation is reduced to eliminate the bow-tie effect and to keep the field of view on the ground very nearly constant at 0.742 km. This scheme involves a total of 32 different aggregation modes, each of which is used on both sides of nadir.

Table 1 shows how the DNB sub-pixel detectors are aggregated from nadir to end of scan:

Table 1 DNB Aggregation (Nadir to End-of-Scan)

Aggregation Mode from Nadir	Number of Sub-pixels per Pixel		Number of Pixels per Mode
	Track Direction	Scan Direction	
1	42	66	184
2	42	64	72
3	41	62	88
4	40	59	72
5	39	55	80
6	38	52	72
7	37	49	64
8	36	46	64
9	35	43	64
10	34	40	64
11	33	38	64
12	32	35	80
13	31	33	56
14	30	30	80
15	29	28	72
16	28	26	72
17	27	24	72
18	27	23	32
19	26	22	48
20	26	21	32
21	25	20	48
22	25	19	40
23	24	18	56
24	24	17	40
25	23	16	72
26	23	15	24
27	22	15	32
28	22	14	64
29	21	13	64
30	21	12	64
31	20	12	16
32	20	11	80
Total			**2032**

Note, that each scan of VIIRS Day/Night Band contains 4064x16 pixels where a scan of the VIIRS M-Band contains 3200x16 pixels.

Figure 2 illustrates where these 32 aggregation modes project to the ground this half of a scan. The S/C is assumed to be at its nominal 833km altitude and the orbit inclination is assumed to be zero degree, and the sub-spacecraft point is assumed to be at latitude/longitude (0, 0).

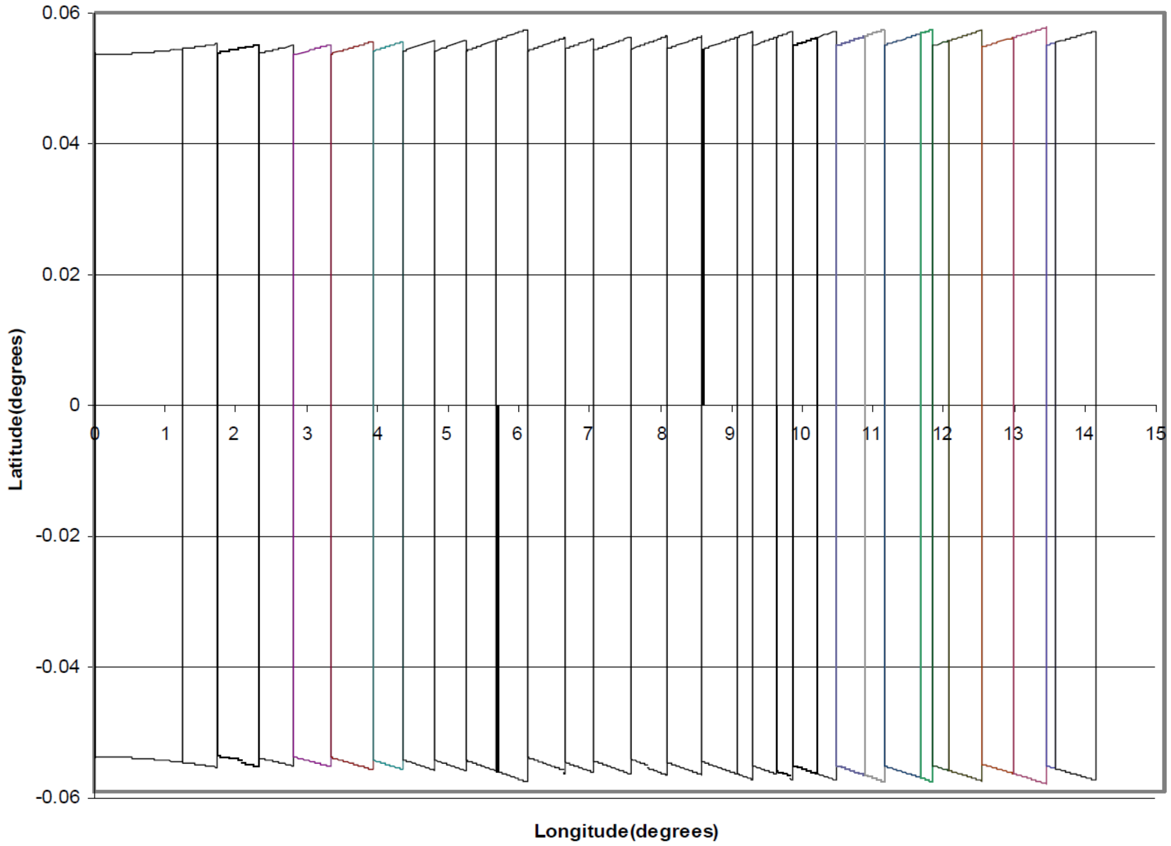

Figure 2 DNB Aggregation Zone Ground Coverage (Nadir to End-of-Scan)

2.2 The VIIRS SDR Granules

The VIIRS SDR product is organised in granules, each consisting of 48 VIIRS instrument scans in a single file. The granule boundaries and the granule (file) naming and numbering are accurately defined, i.e. granules generated by different processing centres are aligned and identically named.

For the VIIRS M-Band a granule with 48 instrument scans contains 768 lines along the track. Similarly for the VIIRS I-Band a granule with 48 instrument scans contains 1536 lines along the track.
For VIIRS DNB a granule contains as well 48 instrument scans with 768 lines along the track.

Please note that every so often, one granule contains only 47 instrument scans. This is to account for the necessary alignment of the scanning duration to the granule grid.

2.3 Geolocation Data in the Original VIIRS SDR Product

In the Original VIIRS SDR Product the geolocation data is provided in full for each pixel. It is organised in separate two-dimensional HDF5 datasets for each geolocation parameter as shown in Figure 3 for the example of the VIIRS M-Band.

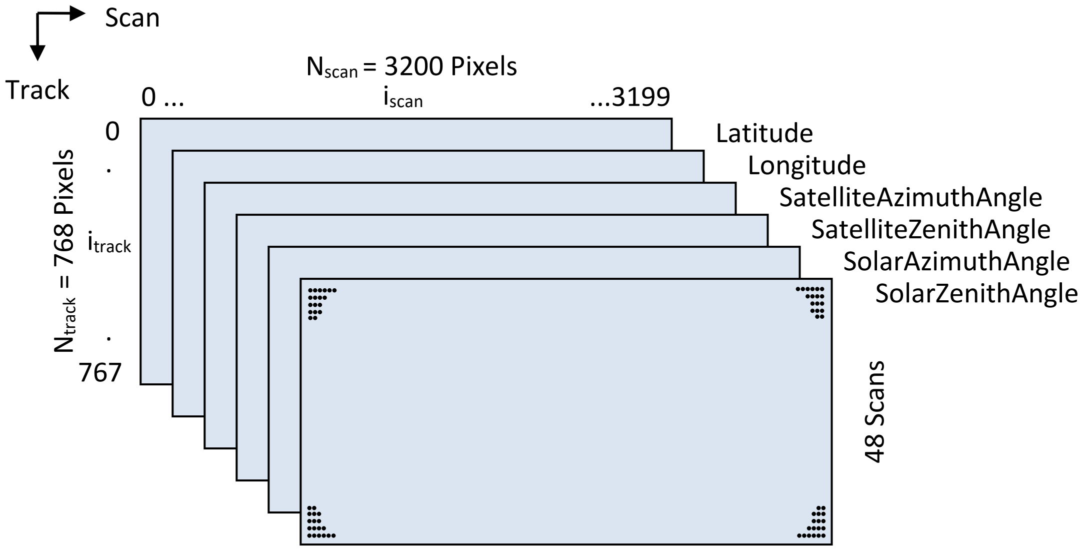

Figure 3 Layout of the Geolocation data in the original VIIRS SDR Product, based on the example of one granule of the VIIRS M-Band

2.4 Geolocation Data in the Compact VIIRS SDR Product

In the Compact VIIRS SDR format, geolocation data is stored only for the corner points, i.e. the Tie-Points, of each Tie-Point Zone. Interpolation functions are defined for re-constructing the geolocation data for all pixels within the Tie-Point Zone.

2.4.1 Tie-Point Zones

In the Compact VIIRS SDR Product the geolocation data and viewing angles are stored only at so-called Tie-Points, shown as point A, B, C and D in Figure 4 for a single Tie-Point Zone for the example of the M-Band. The Tie Point Zone has been defined to have a size of (16x16) M-Band pixels, (32x32) I-Band pixels and (variable x 16) DNB pixels. Interpolation functions are defined to interpolate the data to reconstruct the geolocation and viewing angles for each pixel. This is addressed in more detail in the subsequent sections of this document.

Note that the Tie-Points A, B, C and D shown in Figure 4 are located at the corners of the 16x16 M-Band pixel Tie-point Zone. Consequently the same Tie-Points can be used to reconstruct the full set of geolocation data for both the 16x16 M-Band pixels and the 32x32 I-Band pixels contained in the Tie-point Zone.

The process of generating the six parameters corresponding to the four Tie Point Zone corner points A, B, C and D uses exactly the same interpolation functions that a user would use to reconstruct the parameters at each pixel centre starting from the Tie Points. However, in this case the functions are set up to extrapolate the parameters from the centre of the four corner pixels to the four Tie Point Zone corner points A, B, C and D. This is also addressed in more detail in the subsequent sections of this document.

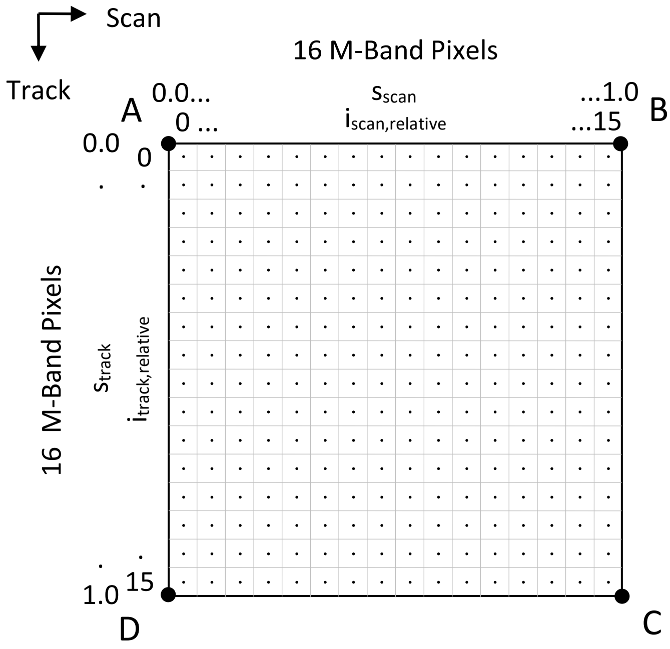

Figure 4 Tie Point Zone Layout. The Compact VIIRS SDR Product stores the six geolocation and angular parameters only in the four corner points A, B, C and D.

2.4.2 Tie-Point Zone Groups

Due to the irregularity of the DNB aggregation zones Tie-Point Zones need to be organized in Tie-Point Zone Groups.

A Tie-Point Zone Group is characterised by the following principles:

1. A Tie-Point Zone Group is a contiguous group - in both scan and track direction - of Tie-Point Zones, all with the same size (for example 16x16, 16x24 or 14x16 pixels in the scan and track direction respectively);
2. All neighbouring Tie-Point Zones within a Tie-Point Zone Group share their common corner Tie-Points, meaning that the geolocation data is stored only once for those shared Tie-Points;
3. Neighbouring Tie-Point Zones on the boundary between Tie-Point Zone Groups do not share Tie-Points, meaning that the geolocation data is stored separately for those Tie-Points;
4. A Tie-Point Zone Group may extend over multiple Aggregation Zones if the Aggregation Zones all share the same level of pixel aggregation in the track direction (for example Aggregation Zone A and B, but not Aggregation Zone B and C in Figure 5);

With this concept of Tie-Point Zone Groups and the listed principles, we can cover M-Band, I-Band and DNB. This covers both the logic and performance of the interpolation scheme as well as the storage logic for the geolocation data.

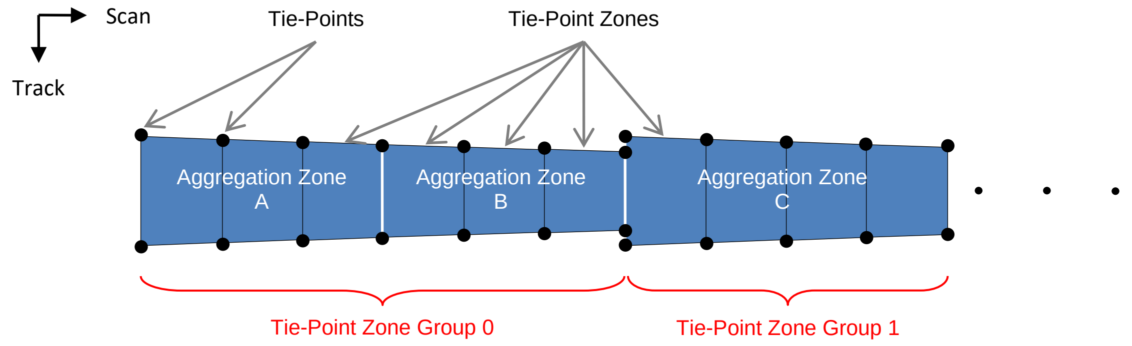

Figure 5 Example of Tie-Point Zone Groups.

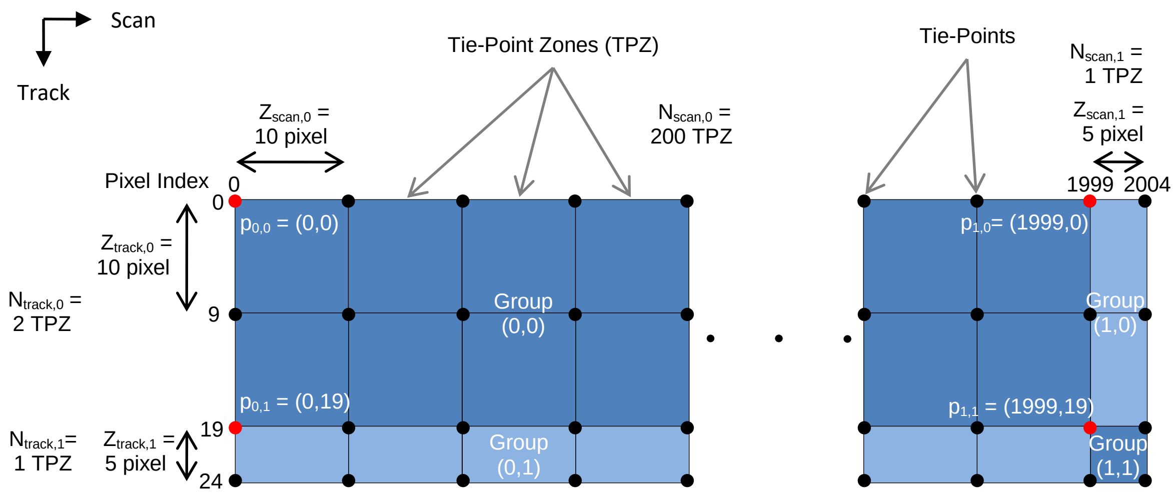

Figure 6 Example of an instrument scan of the size 2005x25 pixels divided in four Tie-Point Zone Groups with indices (i_{scan}, i_{track})= (0,0), (1,0), (0,1) and (1,1). Each group is characterised by the location (p_{scan} , p_{track}) of its upper left corner, the number of Tie-Point Zones in the group ($N_{zones, scan}$, $N_{zones, track}$) and the number of pixels in each Tie-Point Zone (Z_{scan}, Z_{track}).

Table 2 Parameters characterising the Tie-Point Zone Groups for the example of an instrument scan of the size 2005x25 pixels divided in four Tie-Point Zone Groups as shown in Figure 6.

Scan Direction						
TPZ Group Scan Index	Number of TPZs in Group Scan Direction	TPZ Size Scan Direction (pixels)	TPZ Group Location Scan Compact	TPZ Group Location Scan (pixel index)	TPZ Group Compact Size Scan Direction	TPZ Group Size Scan Direction (pixels)
$k_{group, scan}$	$N_{zones,scan}$	Z_{scan}	$p_{scan,compact}$	p_{scan}	$N_{scan} + 1$	$N_{scan} \cdot Z_{scan}$
0	200	10	0	0	201	2000
1	1	5	201	2000	2	5
				Total Size in Scan Direction	203	2005
2	Total number of TPZ Groups in Scan direction $N_{groups,scan}$					

Track Direction						
TPZ Group Track Index	Number of TPZs in Group Track Direction	TPZ Size Track Direction (pixels)	TPZ Group Location Track Compact	TPZ Group Location Track (pixel index)	TPZ Group Compact Size Track Direction	TPZ Group Size Track Direction (pixels)
$k_{group,track}$	$N_{zones,track}$	Z_{track}	$p_{track,compact}$	p_{track}	$N_{track} + 1$	$N_{track} \cdot Z_{track}$
0	2	10	0	0	3	20
1	1	5	3	20	2	5
				Total Size in Track Direction	5	25
2	Total number of TPZ Groups in Track direction $N_{groups,track}$					

For the VIIRS Day/Night Band the Aggregation Zones, based on Table 1 extracted from [RD-2], and the Tie-Point Group Zones are shown in Figure 7. Technically, it would have been possible to combine the two Aggregation Zones 32 and 31, 30 and 29, 28 and 27, and 26 and 25, respectively, into one Tie-Point Zone Group each. However, for the sake of simplicity, a one to one relationship between the VIIRS Day/Night Band Aggregation Zones and the Tie-Point Zone Groups is kept.

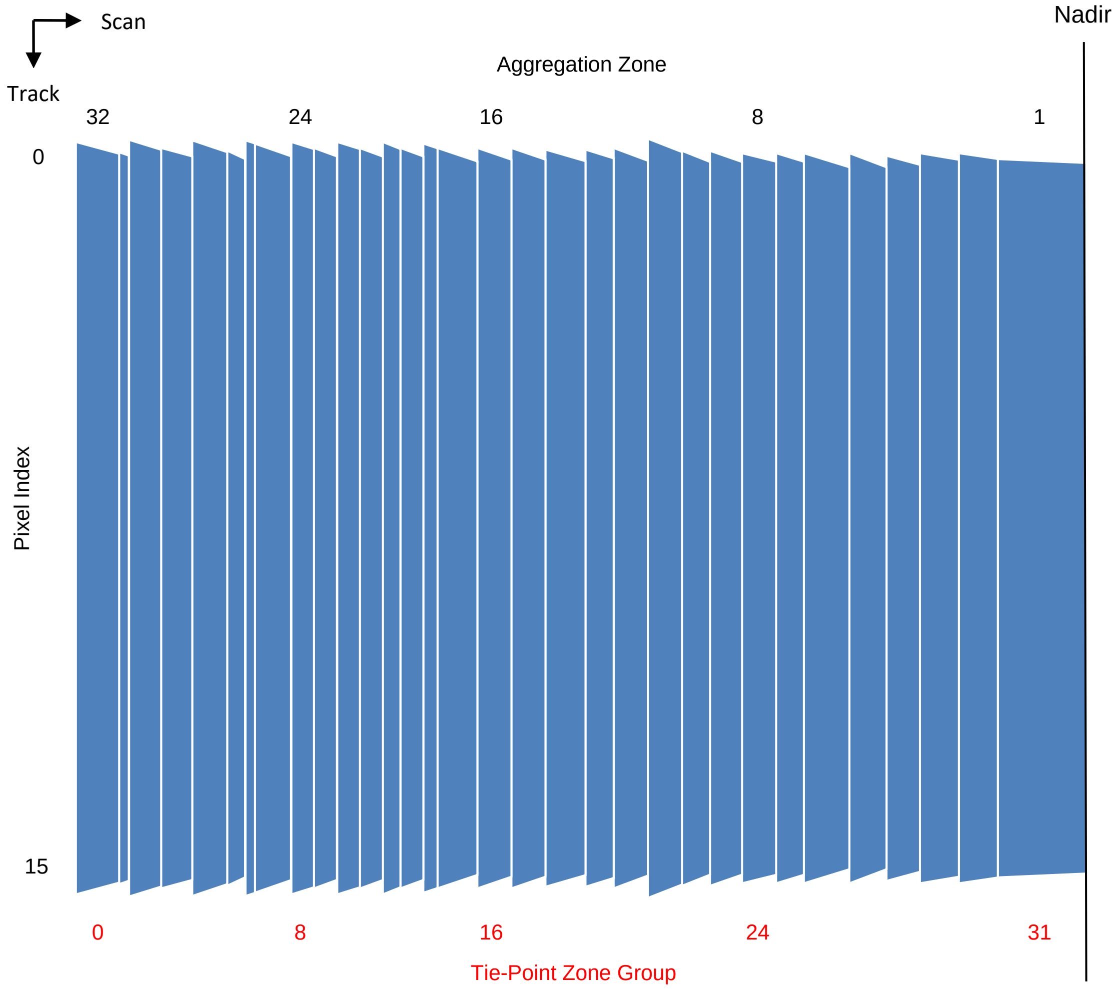

Figure 7 Aggregation Zones and Tie-Point Group Zones for the VIIRS Day/Night Band.

The detailed layout of the VIIRS Day/Night Band Tie-Point Zone Groups is given in Table 3 below. Note that the shaded part of the table is present in the HDF5 compact product file.

Table 3 Parameters characterising the proposed VIIRS Day/Night Band Tie-Point Zone Groups

Scan Direction							
TPZ Group Scan Index	Aggre-gation Mode from Nadir	Number of TPZs in Group Scan Direction	TPZ Size Scan Direction (pixels)	TPZ Group Location Scan Compact	TPZ Group Location Scan (pixel index)	TPZ Group Compact Size Scan Direction	TPZ Group Size Scan Direction (pixels)
$i_{group, scan}$	-	$N_{zones,scan}$	Z_{scan}	$p_{scan,compact}$	p_{scan}	$N_{scan} + 1$	$N_{scan} \cdot Z_{scan}$
0	32	5	16	0	0	6	80
1	31	1	16	6	80	2	16
2	30	4	16	8	96	5	64
3	29	4	16	13	160	5	64
4	28	4	16	18	224	5	64
5	27	2	16	23	288	3	32
6	26	1	24	26	320	2	24

7	25	3	24	28	344	4	72
8	24	2	20	32	416	3	40
9	23	4	14	35	456	5	56
10	22	2	20	40	512	3	40
11	21	3	16	43	552	4	48
12	20	2	16	47	600	3	32
13	19	3	16	50	632	4	48
14	18	2	16	54	680	3	32
15	17	3	24	57	712	4	72
16	16	3	24	61	784	4	72
17	15	3	24	65	856	4	72
18	14	5	16	69	928	6	80
19	13	4	14	75	1008	5	56
20	12	5	16	80	1064	6	80
21	11	4	16	86	1144	5	64
22	10	4	16	91	1208	5	64
23	9	4	16	96	1272	5	64
24	8	4	16	101	1336	5	64
25	7	4	16	106	1400	5	64
26	6	3	24	111	1464	4	72
27	5	5	16	115	1536	6	80
28	4	3	24	121	1616	4	72
29	3	4	22	125	1688	5	88
30	2	3	24	130	1776	4	72
31	1	23	8	134	1848	24	184
32	1	23	8	158	2032	24	184
33	2	3	24	182	2216	4	72
...	...	...	...	...	...	...	...
63	32	5	16	310	3984	6	80
Total Size in Scan Direction						316	4064
64	Total number of TPZ Groups in Scan direction $N_{groups,scan}$						

Track Direction						
TPZ Group Track Index	Number of TPZs in Group Track Direction	TPZ Size Track Direction (pixels)	TPZ Group Location Track Compact	TPZ Group Location Track (pixel index)	TPZ Group Compact Size Track Direction	TPZ Group Size Track Direction (pixels)
$i_{group,track}$	$N_{zones,track}$	Z_{track}	$p_{track,compact}$	p_{track}	$N_{track} + 1$	$N_{track} \cdot Z_{track}$
0	1	16	0	0	2	16
Total Size in Track Direction					2	16
1	Total number of TPZ Groups in Track direction $N_{groups,track}$					

For the VIIRS M- and I-Band geolocation there will be only one Tie Point Zone Group, each covering the full scan and containing 200 Tie-Point Zones, each of the size of 16x16 M-Band pixels or 32x32 I-Band pixels, covering a full VIIRS scan.

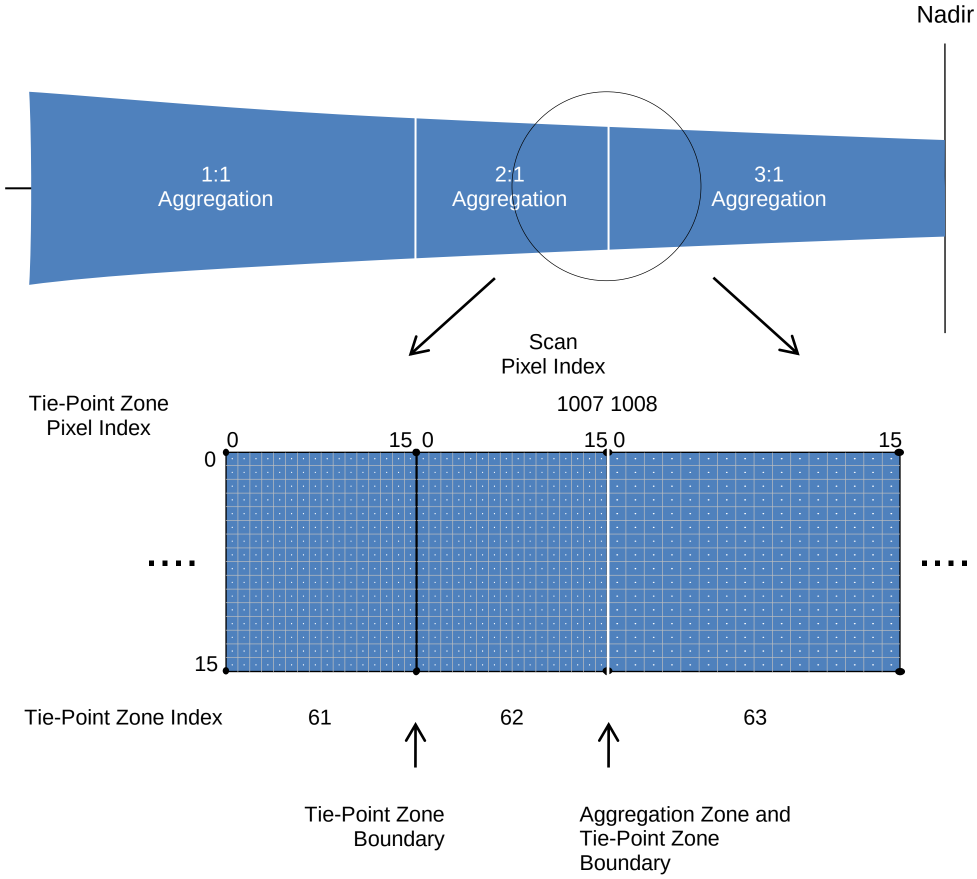

Figure 8 Aggregation Zone and Tie Point Zone Layout for M- and I-Band. The discontinuity in the pixel size at the Aggregation Zone boundary does not impact the interpolation within the Tie-Point Zones as the Aggregation Zone boundary coincides with a Tie-Point Zone boundary.

For the M-Band the detailed layout of the VIIRS M-Band Tie-Point Zone Groups is given in Table 4. Note that the shaded part of the table is intended for inclusion in the HDF5 compact product file.

Table 4 Parameters characterising the VIIRS M-Band Tie-Point Zone Groups

Scan Direction						
TPZ Group Scan Index	Number of TPZs in Group Scan Direction	TPZ Size Scan Direction (pixels)	TPZ Group Location Scan Compact	TPZ Group Location Scan (pixel index)	TPZ Group Compact Size Scan Direction	TPZ Group Size Scan Direction (pixels)
$i_{group, scan}$	N_{scan}	Z_{scan}	$p_{scan,compact}$	p_{scan}	$N_{scan} + 1$	$N_{scan} \cdot Z_{scan}$
0	200	16	0	0	201	3200
Total Size in Scan Direction					201	3200
1	Total number of TPZ Groups in Scan direction $N_{groups,scan}$					

Track Direction						
TPZ Group Track Index	Number of TPZs in Group Track Direction	TPZ Size Track Direction (pixels)	TPZ Group Location Track Compact	TPZ Group Location Track (pixel index)	TPZ Group Compact Size Track Direction	TPZ Group Size Track Direction (pixels)
$i_{group,track}$	N_{track}	Z_{track}	$p_{track,compact}$	p_{track}	$N_{track} + 1$	$N_{track} \cdot Z_{track}$
0	1	16	0	0	2	16
Total Size in Track Direction					2	16
1	Total number of TPZ Groups in Track direction $N_{groups,track}$					

The resulting layout of the parameters within the Compact VIIRS SDR Product Format for the M-Band is shown in Figure 9. Each parameter is stored in an HDF5 array of the size 96x201. This corresponds to 200 Tie Point Zones for each of the 48 scans.

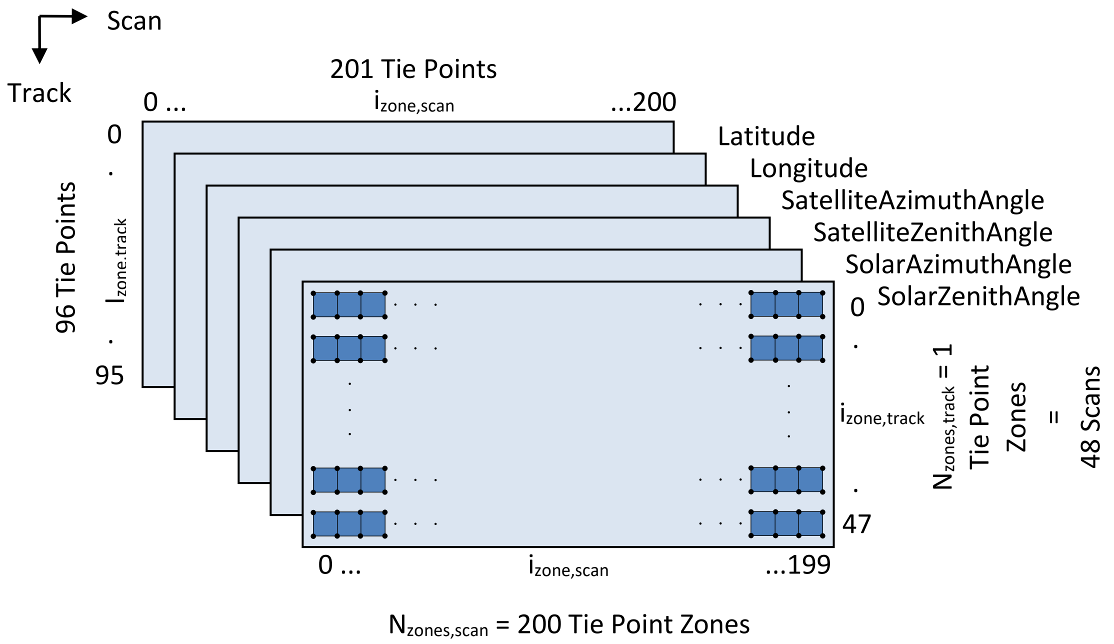

Figure 9 Geolocation and Angular parameter Layout in the Compact VIIRS SDR Product for the M- and I-Band.

Note that for neighbouring Tie Point Zones within one Tie Point Zone Group across the scan and track direction, the corner points are shared and the parameters are only stored once in the Compact VIIRS SDR Product. From comparing Figure 8 and Figure 9 it can be seen that the corner points B and C of the first Tie Point Zone in the Scan are identical to the corner points A and D respectively of the second Tie Point Zone. Corner points between individual scans are not shared since they are not identical due to the bow tie effect of the VIIRS scanning geometry.

From Figure 8 it can be seen that there is a discontinuity in the pixel size at the Aggregation Zone boundary. However, this does not impact the interpolation scheme as all Aggregation Zone boundaries coincide with a Tie-Point Zone boundary.

2.5 Observation Data in the Original and Compact VIIRS SDR Product

Common to the Original VIIRS SDR and the Compact VIIRS SDR is that all the observation data of a granule is stored in separate two dimensional HDF5 datasets for each channel and representation. The dataset size is 768x3200 for an M-Band channel and 1536x6400 for an I-Band Channel; for the DNB the dataset size is 768x4064.
The layout of the Compact VIIRS SDR product observations is shown in Figure 10 for M-Band, and in Figure 11 for DNB.

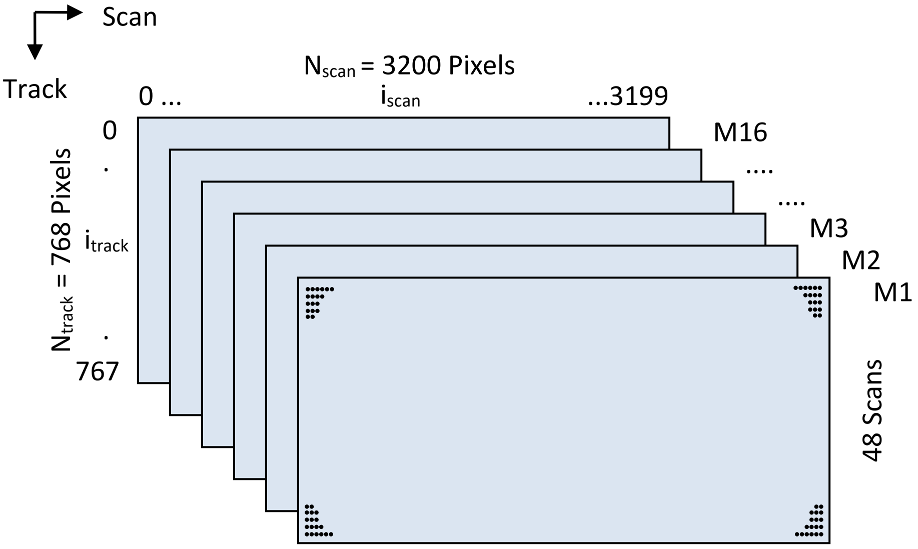

Figure 10 Layout of the Observation data in the Compact VIIRS SDR Product, based on the example of one granule of VIIRS M-Band data.

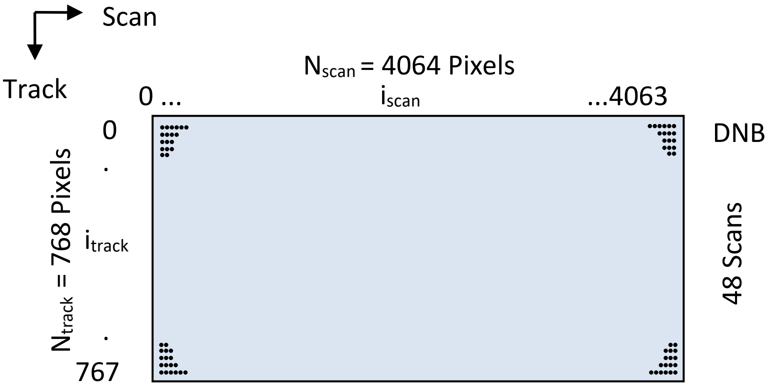

Figure 11 Layout of the Observation data in the Compact VIIRS SDR Product, based on the example of one granule of VIIRS Day/Night-Band data.

The main differences between the Observation data contained in the Original M-Band or I-Band VIIRS SDR and in the Compact M-Band or I-Band VIIRS SDR are, that where the Original M-Band or I-Band VIIRS SDR contains Radiances, Reflectances and Brightness Temperatures, the Compact M-Band or I-Band VIIRS SDR contains only Radiances, and that where the Original M-Band or I-Band VIIRS SDR makes use of both floating point and integers for storing the values, the Compact M-Band or I-Band VIIRS SDR only uses integers. This is shown in Table 5.

Please note, that due to the high dynamic range of the Day/Night Band, the representation of the radiances in the Compact DNB VIIRS SDR is through custom floating point numbers. More details on this are available in section 8.14.8.

Moreover, the Compact M-Band or I-Band VIIRS SDR uses a dual-scale representation for storing Radiance values as 16 bit unsigned integers. It is based on two offset and scale factor sets, one for low radiance values and one for high radiance values. The representation thereby matches the characteristics of the VIIRS dual gain channels and ensures a higher accuracy of the radiance values.

The Compact M-Band or I-Band VIIRS SDR contains supporting parameters for reconstructing both the Reflectances and Brightness Temperatures to an accuracy well within the instrument noise. A separate document is available demonstrating the performance of the reconstruction of the Reflectances and Brightness Temperatures ([RD-1]).

Table 5 Observation data in the Original and the Compact VIIRS SDR Product based on 32 bit floating point, 16 bit integer Single Scale and 16 bit integer Dual Scale.

Original VIIRS SDR				Compact VIIRS SDR	
Ch	Radiance	Reflectance	Bright.Tem.	Ch	Radiance
M1	16 bit uint	16 bit uint		M1	16 bit uint
M2	16 bit uint	16 bit uint		M2	16 bit uint
M3	32 bit float	16 bit uint		M3	16 bit uint
M4	32 bit float	16 bit uint		M4	16 bit uint
M5	32 bit float	16 bit uint		M5	16 bit uint
M6	16 bit uint	16 bit uint		M6	16 bit uint
M7	32 bit float	16 bit uint		M7	16 bit uint
M8	16 bit uint	16 bit uint		M8	16 bit uint
M9	16 bit uint	16 bit uint		M9	16 bit uint
M10	16 bit uint	16 bit uint		M10	16 bit uint
M11	16 bit uint	16 bit uint		M11	16 bit uint
M12	16 bit uint		16 bit uint	M12	16 bit uint
M13	32 bit float		32 bit float	M13	16 bit uint
M14	16 bit uint		16 bit uint	M14	16 bit uint
M15	16 bit uint		16 bit uint	M15	16 bit uint
M16	16 bit uint		16 bit uint	M16	16 bit uint
I1	16 bit uint	16 bit uint		I1	16 bit uint
I2	16 bit uint	16 bit uint		I2	16 bit uint
I3	16 bit uint	16 bit uint		I3	16 bit uint
I4	16 bit uint		16 bit uint	I4	16 bit uint
I5	16 bit uint		16 bit uint	I5	16 bit uint
DNB	32 bit float			DNB	n bit float

Single Gain Channel
Dual Gain Channel
Three Gain Channel
Single Scale Representation
Dual Scale Representation

2.6 HDF5 Files

The Original VIIRS SDR data product is separated in individual HDF5 files for each channel and for the geolocation data. The Compact VIIRS SDR combines all M-Band, I-Band or DNB data in one HDF5 file each[2] while maintaining the HDF5 group names consistent with the Original VIIRS SDR, see Figure 12, Figure 13, Figure 14 and Figure 15 below.

[2] Please note, that the Compact VIIRS SDR allows a variant where M-Band and I-Band data are present in one file.

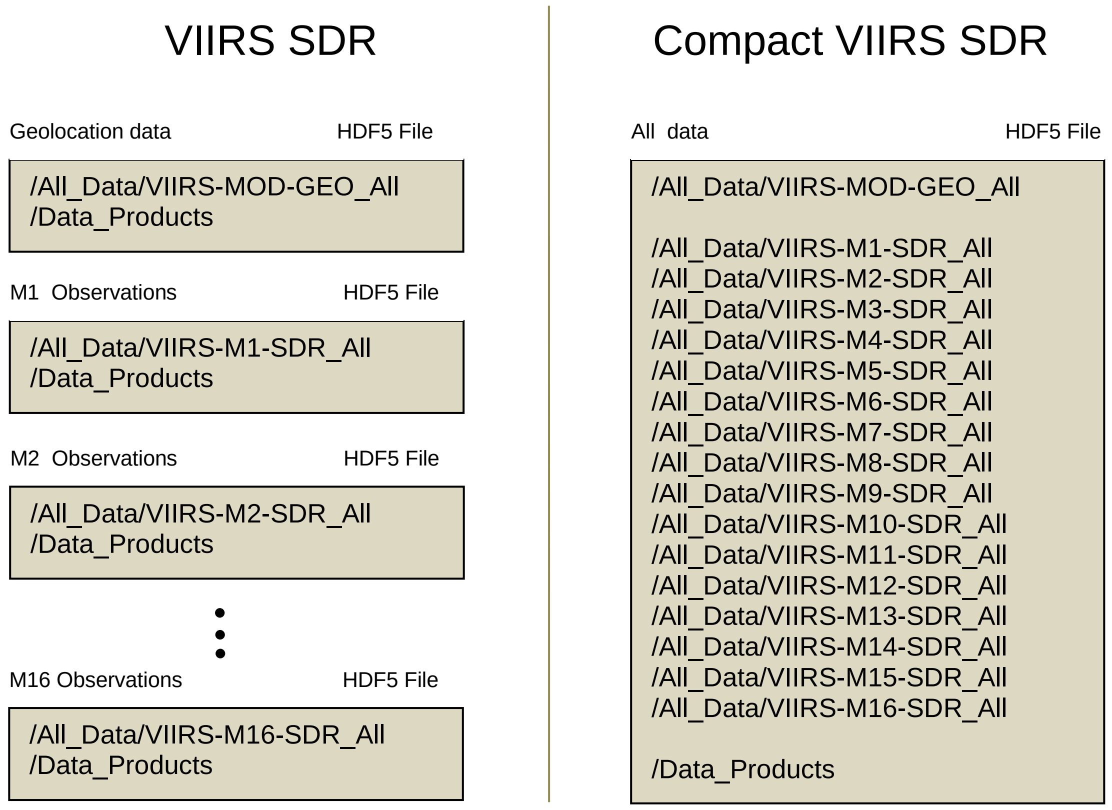

Figure 12 HDF5 file structure for the Original M-Band VIIRS SDR and the Compact M-Band VIIRS SDR.

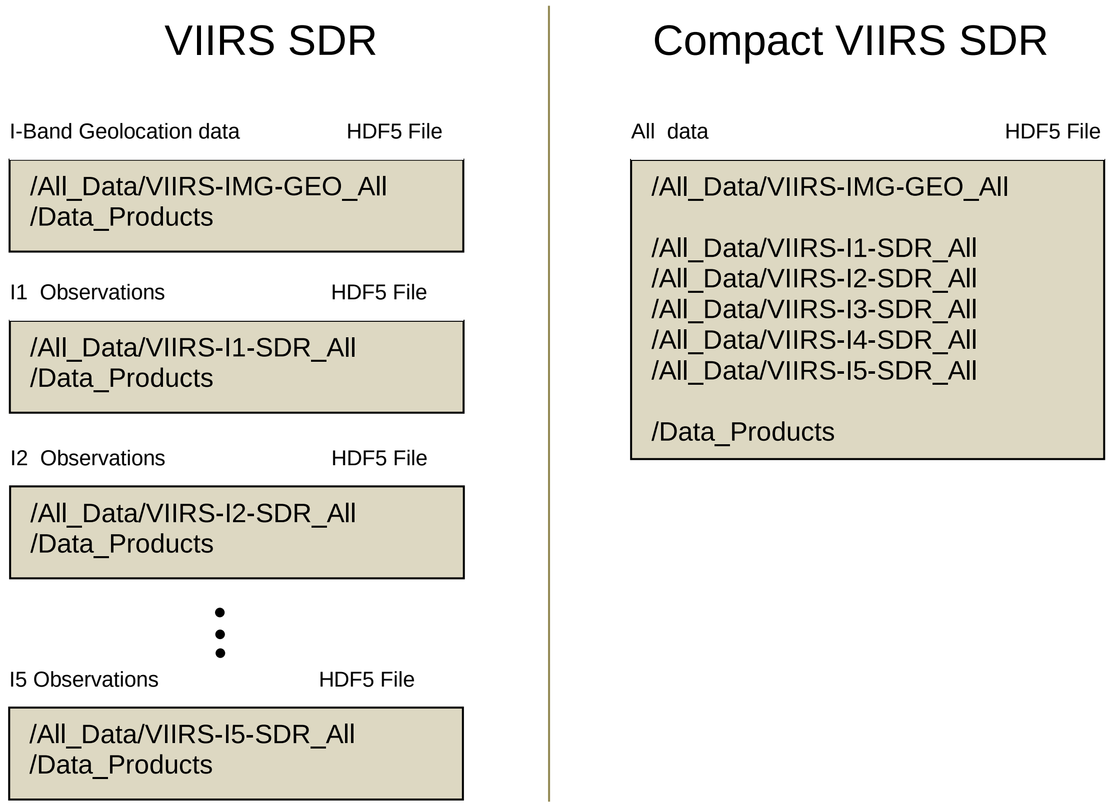

Figure 13 HDF5 file structure for the Original I-Band VIIRS SDR and the Compact I-Band VIIRS SDR.

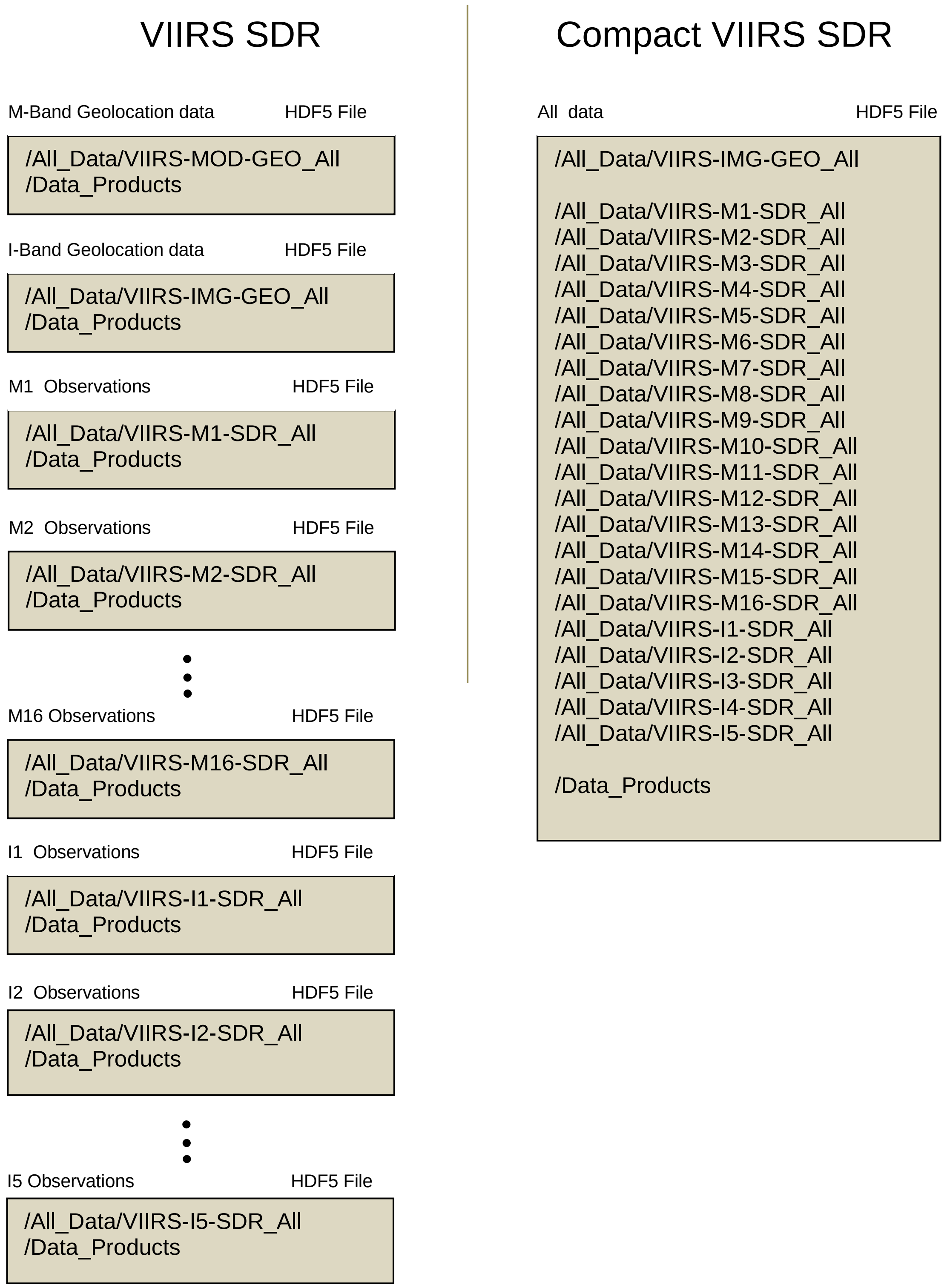

Figure 14 HDF5 file structure for the Original M- and I-Band VIIRS SDR and the Compact M- and I-Band VIIRS SDR.

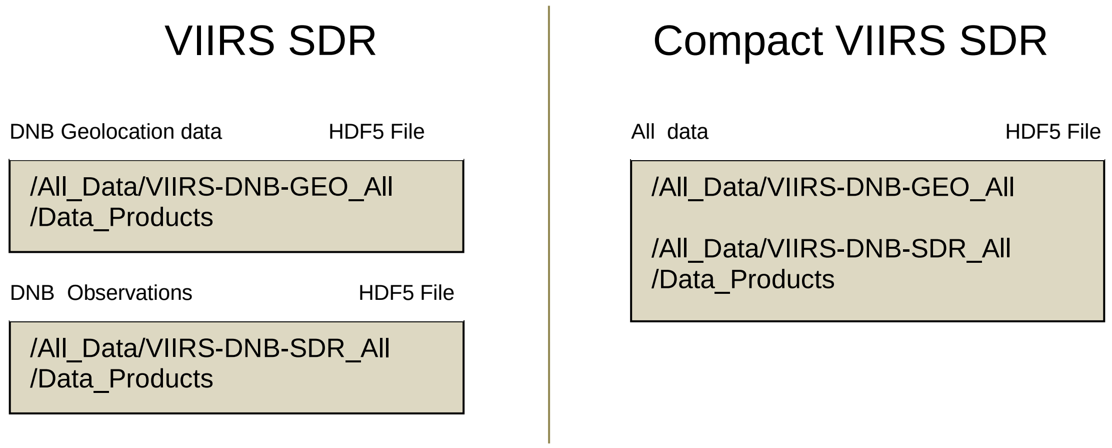

Figure 15 HDF5 file structure for the Original DNB VIIRS SDR and the Compact DNB VIIRS SDR.

3 CONTENT OF THE ORIGINAL VIIRS SDR

This section defines the groups and datasets of the Original VIIRS SDR product and indicates which of these are included in the Compact VIIRS SDR Product.
Please note, that the definition assumes that the Dataset Name, Description, etc., is the same for M-Band, I-Band and DNB, unless specifically highlighted.

3.1 Geolocation and Angular Data

Table 6 Geolocation Data in Original VIIRS SDR Product

Geolocation Data in Original VIIRS SDR Product HDF5 Datasets in Group **/All_Data/VIIRS-MOD-GEO_All**					Compact VIIRS SDR Product	
Dataset Name	Description	Data Type	Dim.	Units	Incl.	Comment/ Cross Reference
StartTime	Starting Time of each scan in IET (1/1/1958)	64 bit int	[48]	µs	✓	Included as is
MidTime	Mid-Time of each scan IET (1/1/1958)	64 bit int	[48]	µs	✓	Included as is
Latitude	Latitude of each pixel (positive North)	32 bit float	M: [768, 3200] I: [1536, 6400] DNB: [768, 4064]	degree	✓	Included at tie-points, interpolation scheme for all pixels
Longitude	Longitude of each pixel (positive East)	32 bit float		degree	✓	Included at tie-points, interpolation scheme for all pixels
Solar ZenithAngle	Zenith angle of sun at each pixel position	32 bit float		degree	✓	Included at tie-points, interpolation scheme for all pixels
Solar AzimuthAngle	Azimuth angle of sun (measured clockwise positive from North) at each pixel position	32 bit float		degree	✓	Included at tie-points, interpolation scheme for all pixels
Satellite ZenithAngle	Zenith angle to Satellite at each pixel position	32 bit float		degree	✓	Included at tie-points, interpolation scheme for all pixels
Satellite AzimuthAngle	Azimuth angle (measured clockwise positive from North) to Satellite at each	32 bit float		degree	✓	Included at tie-points, interpolation scheme for all pixels

Geolocation Data in Original VIIRS SDR Product HDF5 Datasets in Group **`/All_Data/VIIRS-MOD-GEO_All`**					Compact VIIRS SDR Product	
Dataset Name	Description	Data Type	Dim.	Units	Incl.	Comment/ Cross Reference
	pixel position					
Height	Ellipsoid-Geoid separation	32 bit float		meter	-	Currently not included, but under consideration
SatelliteRange	Line of sight distance from the ellipsoid intersection to the satellite	32 bit float		meter	-	Currently not included, but under consideration
SCPosition	Spacecraft position in ECR Coordinates (X, Y, Z) at the mid-time of scan	32 bit float	[48, 3]	meter	✓	Included as is
SCVelocity	Spacecraft velocity in ECR Coordinates (dx/dt, dy/dt, dz/dt) at the mid-time of scan	32 bit float	[48,3]	m/s	✓	Included as is
SCAttitude	Spacecraft attitude with respect to the Geodetic Reference Frame Coordinates (roll, pitch, yaw) at the midtime of scan	32 bit float	[48,3]	arc second	✓	Included as is
SCSolar ZenithAngle	The angle in the spacecraft reference frame from zenith vector (negative z-axis) to the solar vector	32 bit float	[48]	degree	✓	Included as is
SCSolar AzimuthAngle	The angle in the spacecraft reference frame from x-axis to	32 bit float	[48]	degree	✓	Included as is

Geolocation Data in Original VIIRS SDR Product HDF5 Datasets in Group **`/All_Data/VIIRS-MOD-GEO_All`**					Compact VIIRS SDR Product	
Dataset Name	Description	Data Type	Dim.	Units	Incl.	Comment/ Cross Reference
	the solar vector projected onto the spacecraft x-y plane, measured counterclockwise (observer looking toward zenith (negative z-axis))					
ModeScan	The VIIRS operational mode, reported at the scan level, see Table 27	8 bit uchar	[48]	unitless	✓	Included as is
ModeGran	The VIIRS operational mode, reported at the granule level, see Table 28	8 bit uchar	[1]	untiless	✓	Included as is
PadByte1	Pad byte	8 bit uchar	[3]	unitless	✓	Included as is
NumberOf Scans	Actual number of VIIRS scans that were used to create this granule	32 bit int	[1]	unitless	✓	Included as is
QF1_SCAN_ VIIRSSDR GEO	Scan-level quality flag, see Table 29.	8 bit uchar	[48]	unitless	✓	Included as is
QF2_SCAN_ VIIRSSDR GEO	Scan-level quality flag, see Table 30.	8 bit uchar	[48]	unitless	✓	Included as is
QF2_VIIRS SDRGEO	Pixel-level quality flag, see Table 31.	8 bit uchar	M: [768, 3200] I: [1536, 6400] DNB: [768, 4064]	unitless	-	Not considered relevant as geolocation data is based on interpolation scheme
Latitude_TC *DNB only*	Latitude of each pixel (positive North)), terrain corrected	32 bit float	[768, 4064]	degree	-	Currently not included, but under consideration

Geolocation Data in Original VIIRS SDR Product HDF5 Datasets in Group **`/All_Data/VIIRS-MOD-GEO_All`**					Compact VIIRS SDR Product	
Dataset Name	Description	Data Type	Dim.	Units	Incl.	Comment/ Cross Reference
Longitude_TC *DNB only*	Longitude of each pixel (positive East), terrain corrected	32 bit float	[768, 4064]	degree	-	Currently not included, but under consideration
Lunar ZenithAngle *DNB only*	Zenith angle of moon at each pixel position	32 bit float	[768, 4064]	degree	✓	Included at tie-points, interpolation scheme for all pixels
Lunar AzimuthAngle *DNB only*	Azimuth angle of moon (measured clockwise positive from North) at each pixel position	32 bit float	[768, 4064]	degree	✓	Included at tie-points, interpolation scheme for all pixels
Height_TC *DNB only*	Height over Ellipsoid	32 bit float	[768, 4064]	meter	-	Currently not included, but under consideration
Moon PhaseAngle *DNB only*	Angle between ray vector to moon from earth and ray vector of	32 bit float	[1]	degree	✓	Included as is
Moon IllumFraction *DNB only*	Fraction of the moon illuminated (expressed as percent)	32 bit float	[1]	percent	✓	Included as is
QF2_VIIRS SDRGEO_TC *DNB only*	Pixel-level quality flag, Table 32, terrain corrected	8 bit uchar	[768, 4064]	unitless	-	Not considered relevant as geolocation data is based on interpolation scheme

3.2 Observation Data in Original VIIRS SDR Product

Table 7 Observation Data in Original VIIRS SDR Product

Observation Data in Original VIIRS SDR Product HDF5 Datasets in Group `/All_Data/VIIRS-Ch-SDR_All`					Compact VIIRS SDR Product	
Dataset Name	Description	Data Type	Dim.	Units	Incl.	Comment/ Cross Reference
Radiance *M1-M16* *I1-I5* *DNB*	Calibrated Top of Atmosphere (TOA) Radiance for each VIIRS pixel, needs radiance scale and offset factors	*M1-M2, M6, M8-M12, M14-M16, I1-I5:* 16 bit uint *M3-M5, M7, M13, DNB:* 32 bit float	*M:* [768, 3200] *I:* [1536, 6400] *DNB:* [768, 4064]	*M, I:* W/(m2 sr μm) *DNB:* W/(cm² sr)	✓	Included as is M3-M5, M7, M13: Included as dual scale integer representation
Radiance factors *M1-M2, M6, M8-M12, M14-M16, I1-I5*	Radiance scale and offset: array[scale, offset]	32 bit float	[2]	unitless	✓	Included as attributes of the Radiance dataset
Reflectance *M1-M11,* *I1-I3*	Calibrated TOA Reflectance for each VIIRS pixel	16 bit uint	*M:* [768, 3200] *I:* [1536, 6400]	unitless	-	Not included, can be derived from the corresponding radiance
Reflectance Factors *M1-M11,* *I1-I3*	Reflectance scale and offset: array[scale, offset]	32 bit float	[2]	unitless	-	Not included, only meaningful with the reflectance
Brightness Temperature *M12-M16,* *I4-I5*	Calibrated TOA Brightness Temperature for each VIIRS pixel	*M12, M14-M16 ,* *I4-I5:* 16 bit uint *M13: 32 bit* float	*M:* [768, 3200] *I:* [1536, 6400]	K	-	Not included, can be derived from the corresponding radiances
Brightness Temperature Factors *M12, M14-M16,* *I4-I5*	Brightness Temperature scale and offset: array[scale, offset]	32 bit float	[2]	unitless	-	Not included, only meaningful with the brightness temperature

Observation Data in Original VIIRS SDR Product HDF5 Datasets in Group **/All_Data/VIIRS-Ch-SDR_All**					Compact VIIRS SDR Product	
Dataset Name	Description	Data Type	Dim.	Units	Incl.	Comment/ Cross Reference
ModeScan	The VIIRS operational mode, reported at the scan level, see Table 27.	8 bit uchar	[48]	unitless	-	Included as part of the geolocation data
ModeGran	The VIIRS operational mode, reported at the granule level, see Table 28.	8 bit uchar	[1]	unitless	-	Included as part of the geolocation data
PadByte1	Pad Byte	8 bit uchar	[3]	unitless	✓	Included as is
NumberOfScans	Actual number of VIIRS scans that were used to create this granule	8 bit uchar	[1]	unitless	-	Included as part of the geolocation data
NumberOfMissingPkts	Number of missing packets in scan	32 bit int	[48]	unitless	✓	Included as is
NumberOfBadChecksums	Number of packets with bad checksum in scan	32 bit int	[48]	unitless	✓	Included as is
NumberOfDiscardedPkts	Number of discarded packets in scan	32 bit int	[48]	unitless	✓	Included as is
QF1_VIIRS**MBANDSDR** *M1-M16*	Quality Flag for each pixel, see Table 32.	8 bit uchar	[768, 3200]	unitless	✓	Included as is
QF1_VIIRS**IBANDSDR** *I1-I5*	Quality Flag for each pixel, see Table 32.	8 bit uchar	[1536, 6400]	unitless	✓	Included as is
QF1_VIIRS**DNBSDR** *DNB*	Quality Flag for each pixel, see Table 32.	8 bit uchar	[768, 4064]	unitless	✓	Included as is
QF2_SCAN_SDR	Quality Flag for Scan (indicates general SDR information),	8 bit uchar	[48]	unitless	✓	Included as is

Observation Data in Original VIIRS SDR Product HDF5 Datasets in Group **`/All_Data/VIIRS-Ch-SDR_All`**					Compact VIIRS SDR Product	
Dataset Name	Description	Data Type	Dim.	Units	Incl.	Comment/ Cross Reference
	see Table 34.					
QF3_SCAN_RDR	Quality Flag for Scan (indicates general RDR information), see Table 34.	8 bit uchar	[48]	unitless	✓	Included as is
QF4_SCAN_SDR *M1-M16* *I1-I5*	Reduced Quality Indication, see Table 35.	8 bit uchar	[48]	unitless	✓	Included as is
QF5_GRAN_BAD_DETECTOR *M1-M16,* *I1-I5*	Quality Flag – Bad detector, see Table 36.	8 bit uchar	*M:* [16] *I:* [32]	unitless	✓	Included as is

3.3 Attributes of Geolocation and Observation data

Table 8 HDF5 Attributes of Root Group of Geolocation and Observation data

HDF5 Attributes of Root Group /					Compact VIIRS SDR Product	
Attribute Name	Description	Data Type	Dim.	Units	Incl.	Comment/ Cross Reference
Distributor	Designates the distributor of the data.	String	[1]	unitless	✓	Included as is
Mission_Name	The character string by which the mission is known.	String	[1]	unitless	✓	Included as is
N_Dataset_Source	The producer of the HDF5 files.	String	[1]	unitless	✓	Included as is
N_GEO_Ref *Contained in Observation data only*	Filename of the HDF5 file containing the related Geolocation information.	String	[1]	unitless	✓	Included as is
N_HDF_Creation_Date	The date that the HDF5 file was created. Expressed as **YYYYMMDD**. Paired with N_HDF_Creation_Time	String	[1]	unitless	✓	Included as is
N_HDF_Creation_Time	The time that the HDF5 file was created. Expressed as **HHMMSS.SSSSSSZ** Paired with N_HDF_Creation_Date.	String	[1]	unitless	✓	Included as is
Platform_Short_Name	An acronym, or shorter form of the platform name, used to identify the platform.	String	[1]	unitless	✓	Included as is

3.4 Metadata

The metadata is contained in the group `/All_Data/Data_Products` and it is included in full in the Compact VIIRS SDR product. The metadata is not described in further detail in this document, but is described in [AD-3].

4 CONTENT OF THE COMPACT VIIRS SDR

The HDF5 structure of the Compact VIIRS SDR is shown in Figure 14. Whenever possible and for reason of consistency, the original VIIRS SDR data set, attribute and group names have been maintained in the Compact VIIRS SDR. The HDF groups **`VIIRS-MOD-GEO_All`**, **`VIIRS-IMG-GEO_All`**, and **`VIIRS-DNB-GEO_All`** contain the geolocation information and the groups **`VIIRS-Ch-SDR_All`** contain the corresponding observations for channel *Ch*.

4.1 Geolocation and Angular Data

The groups **`/All_Data/VIIRS-MOD-GEO_All`**, **`/All_Data/VIIRS-IMG-GEO_All`** and **`/All_Data/VIIRS-DNB-GEO_All`** contain datasets needed for the calculation of the geolocation and viewing angles for each VIIRS pixel and are described in detail in Table 9 below. Additional channel specific datasets needed are included as attributes of the individual channel groups **`/All_Data/VIIRS-Ch-SDR_All`**, see Table 13.

Table 9 HDF5 Datasets in Group /All_Data/VIIRS-MOD-GEO_All, /All_Data/VIIRS-IMG-GEO_All and /All_Data/VIIRS-DNB-GEO_All

HDF5 Datasets in Group /All_Data/VIIRS-MOD-GEO_All, /All_Data/VIIRS-IMG-GEO_All and /All_Data/VIIRS-DNB-GEO_All					
Dataset Name	Description	Data Type	Dimension	Units	Symbol in Document
NumberOfTiePointZoneGroupsTrack	Number of Tie Point Zones Groups in the Track direction	32 bit int	[1]	unitless (groups)	$N_{groups,track}$
NumberOfTiePointZoneGroupsScan	Number of Tie Point Zones Groups in the Scan direction	32 bit int	[1]	unitless (groups)	$N_{groups,scan}$
TiePointZoneGroupLocationTrackCompact	Start of the Tie Point Zone Group in the Track direction	32 bit int	$[N_{groups,track}]$	unitless (pixel index)	$P_{track,compact}$
TiePointZoneGroupLocationScanCompact	Start of the Tie Point Zone Group in the Scan direction	32 bit int	$[N_{groups,scan}]$	unitless (pixel index)	$P_{scan,compact}$
NumberOfTiePointZonesTrack	Number of Tie Point Zones in the Track direction	32 bit int	$[N_{groups,track}]$	unitless (zones)	$N_{zones,track}$
NumberOfTiePointZonesScan	Number of Tie Point Zones in the Scan direction	32 bit int	$[N_{groups,scan}]$	unitless (zones)	$N_{zones,scan}$

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HDF5 Datasets in Group /All_Data/VIIRS-MOD-GEO_All, /All_Data/VIIRS-IMG-GEO_All and /All_Data/VIIRS-DNB-GEO_All					Symbol in Docu-ment
Dataset Name	Description	Data Type	Dimension	Units	
Latitude	Latitude of each Tie Point (positive North)	32 bit float	$[48 * \sum N_{groups,track} (N_{zones,track} + 1), \sum N_{groups,scan} (N_{zones,scan} + 1)]$	degree	lat
Longitude	Longitude of each Tie Point (positive East)	32 bit float	$[48 * \sum N_{groups,track} \cdot (N_{zones,track} + 1), \sum N_{groups,scan} (N_{zones,scan} + 1)]$	degree	lon
SolarZenithAngle	Zenith angle of sun at each Tie Point position	32 bit float	$[48 * \sum N_{groups,track} \cdot (N_{zones,track} + 1), \sum N_{groups,scan} (N_{zones,scan} + 1)]$	degree	zen
SolarAzimuthAngle	Azimuth angle of sun (measured clockwise positive from North) at each Tie Point position	32 bit float	$[48 * \sum N_{groups,track} \cdot (N_{zones,track} + 1), \sum N_{groups,scan} (N_{zones,scan} + 1)]$	degree	azi
SatelliteZenithAngle	Zenith angle to Satellite at each Tie Point position	32 bit float	$[48 * \sum N_{groups,track} \cdot (N_{zones,track} + 1), \sum N_{groups,scan} (N_{zones,scan} + 1)]$	degree	zen
SatelliteAzimuthAngle	Azimuth angle (measured clockwise positive from North) to Satellite at each Tie Point position	32 bit float	$[48 * \sum N_{groups,track} \cdot (N_{zones,track} + 1), \sum N_{groups,scan} (N_{zones,scan} + 1)]$	degree	azi
ExpansionCoefficient	Correction coefficient accounting for the variation in Pixel size along the Scan direction each	32 bit float	$[\sum N_{groups,scan} N_{zones,scan}]$	unitless	$c_{expansion}$
AlignmentCoefficient	Correction coefficient accounting for the Pixels not being linearly aligned along the track direction	32 bit float	$[\sum N_{groups,scan} N_{zones,scan}]$	unitless	$c_{alignment}$
QF1_SCAN_VIIRSSD	Scan level quality flag,	8 bit	[48]	unitless	

HDF5 Datasets in Group /All_Data/VIIRS-MOD-GEO_All, /All_Data/VIIRS-IMG-GEO_All and /All_Data/VIIRS-DNB-GEO_All					Symbol in Document
Dataset Name	Description	Data Type	Dimension	Units	
RGEO	see Table 29. ***Table 30 QF2_SCAN_VIIRSSDRGEO Quality Flag Values.***	uchar			
QF2_SCAN_VIIRSSDRGEO	Scan level quality flag, see Table 30. Table 31 QF2_VIIRSSDRGEO Quality Flag Values.	8 bit uchar	[48]	unitless	
SCVelocity	Spacecraft position in ECR Coordinates (X, Y, Z) at the mid-time of scan	32 bit float	[48, 3]	meter	
SCPosition	Spacecraft velocity in ECR Coordinates (dx/dt, dy/dt, dz/dt) at the mid-time of scan	32 bit float	[48, 3]	m/s	
SCAttitude	Spacecraft attitude with respect to the Geodetic Reference Frame Coordinates (roll, picth, yaw) at the midtime of scan	32 bit float	[48, 3]	arc second	
StartTime	Starting of each scan in IET (1/1/1958)	64 bit int	[48]	micro sec	
MidTime	Mid-Time of each scan IET (1/1/1958)	64 bit int	[48]	micro sec	
PadByte1	Pad Byte	8 bit uchar	[3]	unitless	
SCSolar ZenithAngle	The angle from the normal vector of the Solar Diffuser surface (z-axis of the solar diffuser frame) to the solar vector	32 bit float	[48]	degree	
SCSolar AzimuthAngle	The angle from the Solar Diffuser reference frame x-axis to the	32 bit float	[48]	degree	

HDF5 Datasets in Group `/All_Data/VIIRS-MOD-GEO_All`, `/All_Data/VIIRS-IMG-GEO_All` and `/All_Data/VIIRS-DNB-GEO_All`					Symbol in Document
Dataset Name	Description	Data Type	Dimension	Units	
	projection of the solar vector onto the solar diffuser surface (x-y plane), measured counterclockwise (observer looking toward the SD surface)				
LunarZenithAngle *DNB only*	Zenith angle of moon at each pixel position (present only for DNB)	32 bit float	[48* $\sum N_{groups,track}$ ·($N_{zones,track}$ + 1), $\sum N_{groups,scan}$ ($N_{zones,scan}$ + 1)]	degree	zen
LunarAzimuthAngle *DNB only*	Azimuth angle of moon (measured clockwise positive from North) at each pixel position (present only for DNB)	32 bit float	[48* $\sum N_{groups,track}$ ($N_{zones,track}$ + 1), $\sum N_{groups,scan}$ ($N_{zones,scan}$ + 1)]	degree	azi
MoonIllumFraction *DNB only*	(present only for DNB)	32 bit float	[1]	degree	
MoonPhaseAngle *DNB only*	(present only for DNB)	32 bit float	[1]	percent	

4.1.1 Attributes of the Geolocation and Angular Data Group

The **`VIIRS-MOD-GEO_All`**, **`VIIRS-IMG-GEO_All`**, **`and`** **`VIIRS-DNB-GEO_All`** groups have the following attributes.

Table 10 HDF5 Attributes of Group /All_Data/VIIRS-MOD-GEO_All, /All_Data/VIIRS-IMG-GEO_All, and /All_Data/VIIRS-DNB-GEO_All

HDF5 Attributes of Group `/All_Data/VIIRS-MOD-GEO_All, /All_Data/VIIRS-IMG-GEO_All, and /All_Data/VIIRS-DNB-GEO_All`					Symbol in Docu-ment
Attribute Name	Description	Data Type	Dim.	Units	
Original Filename	The filename of the original VIIRS SDR file containing the Geolocation and Angular Data	String	[1]	unitless	-

4.2 Observation Data

The group **`VIIRS-Ch-SDR_All`** contains the M Band, I-Band and Day/Night-Band channel information. Each group contains the information related to one channel and all the **`VIIRS-Ch-SDR_All`** groups have the same structure in the Compact VIIRS SDR Product Format with the exception of the **`QF1_VIIRSMBANDSDR`** dataset whose name changes to **`QF1_VIIRSIBANDSDR`** for the I-Band channels and to **`QF1_VIIRSDNBSDR`** for the DNB.

Below is the list of datasets contained in this group. The attributes of the dataset **`Radiances`** contained in the group are described in section 4.2.1. The attributes of the group itself are described in section 4.2.2.

Table 11 HDF5 Datasets in Group /All_Data/VIIRS-Ch-SDR_All

HDF5 Datasets in Group `/All_Data/VIIRS-Ch-SDR_All`					Symbol in Docu-ment
Dataset Name	Description	Data Type	Dim.	Units	
Radiance *M1-M16,* *I1-I5* *DNB*	Integer representation of Calibrated Top of Atmosphere (TOA) Radiance for each VIIRS pixel	*M, I:* 16 bit uint *DNB:* 32 bit float	*M:* [768, 3200] *I:* [1536, 6400] *DNB:* [768, 4064]	*M, I:* W/(m² sr µm) *DNB:* W/(cm² sr)	C
QF1_VIIRS**MBA**	Quality Flag for each pixel,	8 bit	[768, 3200]	unitless	-

HDF5 Datasets in Group /All_Data/VIIRS-Ch-SDR_All					Symbol in Docu-ment
Dataset Name	Description	Data Type	Dim.	Units	
N**DSDR** *M1-M16*	see Table 32	uchar			
QF1_VIIRS**IBAN DSDR** *I1-I5*	Quality Flag for each pixel, see Table 32	8 bit uchar	[1536, 6400]	unitless	-
QF1_VIIRS**DNBS**DR *DNB*	Quality Flag for each pixel, see Table 32	8 bit uchar	[768, 4064]	unitless	-
QF2_SCAN_SDR	Quality Flag for Scan (indicates general SDR information), see Table 34 QF3_SCAN_RDR Quality Flag Values.	8 bit uchar	[48]	unitless	-
QF3_SCAN_RDR	Quality Flag for Scan (indicates general RDR information), see Table 34	8 bit uchar	[48]	unitless	-
QF4_SCAN_SDR *M1-M16,* *I1-I5*	Reduced Quality Indication, see Table 35	8 bit uchar	*M:* [768] *I:* [1536]	unitless	-
QF5_GRAN_BAD DETECTOR *M1-M16,* *I1-I5*	Quality Flag – Bad detector, see Table 36	8 bit uchar	*M:* [16] *I:* [32]	unitless	-
PadByte1	Pad Byte	8 bit uchar	[3]	unitless	-
NumberOfMissing Pkts	Number of missing packets in scan	32 bit int	[48]	unitless	-
NumberOfBadChe cksums	Number of packets with bad checksum in scan	32 bit int	[48]	unitless	-
NumberOfDiscard edPkts	Number of discarded packets in scan	32 bit int	[48]	unitless	-

4.2.1 Attributes of the Radiance Dataset for M-Band, I-Band and Day/Night-Band

Each Radiance dataset for M-Band, I-Band and Day/Night-Band has the following attributes:

Table 12 HDF5 Attributes of Dataset /All_Data/VIIRS-Ch-SDR_All/Radiance.

HDF5 Attributes of Dataset /All_Data/VIIRS-Ch-SDR_All/Radiance					Symbol in Document
Attribute Name	Description	Data Type	Dim.	Units	
RadianceOffset High *M1-M16, I1-I5*	Offset for calculating Radiance L from its integer representation C for $C>C_{treshold}$	32 bit float	[1]	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	a_{high}
RadianceScale High *M1-M16, I1-I5*	Scale factor for calculating Radiance L from its integer representation C for $C>C_{treshold}$	32 bit float	[1]	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	b_{high}
RadianceOffset Low *M1-M16, I1-I5*	Offset for calculating Radiance L from its integer representation C for $C\leq C_{treshold}$	32 bit float	[1]	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	a_{low}
RadianceScale Low *M1-M16, I1-I5*	Scale factor for calculating Radiance L from its integer representation C for $C\leq C_{treshold}$	32 bit float	[1]	$W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$	b_{low}
Threshold *M1-M16, I1-I5*	Integer threshold for selection of the High or Low Offset and Scale pair	16 bit uint	[1]	unitless	$C_{treshold}$
EquivalentWidth *M1-M11, I1-I3*	Equivalent width. Needed for the calculation of the Reflectance	32 bit float	[1]	μm	A_{vis}
IntegratedSolar Irradiance *M1-M11, I1-I3*	Band-integrated solar irradiance. Needed for the calculation of the Reflectance	32 bit float	[1]	$W\ m^{-2}$	B_{vis}
EarthSun Distance Normalised *M1-M11, I1-I3*	Relation between the mean and the actual Earth-Sun distance. Needed for the calculation of the Reflectance	32 bit float	[1]	unitless	d_{se}
CentralWave Length *M12-M16, I4, I5*	Central wavelength. Needed for the calculation of the Brightness Temperature	32 bit float	[1]	m	λ_C
BandCorrection	Band Correction	32 bit	[1]	unitless	A_{ir}

HDF5 Attributes of Dataset /All_Data/VIIRS-Ch-SDR_All/Radiance					Symbol in Document
Attribute Name	Description	Data Type	Dim.	Units	
CoefficientA *M12-M16, I4, I5*	Coefficient A. Needed for the calculation of the Brightness Temperature	float			
BandCorrection CoefficientB *M12-M16, I4, I5*	Band Correction Coefficient B. Needed for the calculation of the Brightness Temperature	32 bit float	[1]	K	B_{ir}

4.2.2 Attributes of the Observation Data Group

Each `VIIRS-Ch-SDR_All` group has the following attributes.

Table 13 HDF5 Attributes of Group /All_Data/VIIRS-Ch-SDR_All.

HDF5 Attributes of Group /All_Data/VIIRS-Ch-SDR_All					Symbol in Document
Attribute Name	Description	Data Type	Dim.	Units	
TiePointZoneGroupLocationTrack	Start of the Tie Point Zone Group in the track direction	32 bit int	$[N_{groups, track}]$	unitless	P_{track}
TiePointZoneGroupLocationScan	Start of the Tie Point Zone Group in the scan direction	32 bit int	$[N_{groups, scan}]$	unitless	P_{scan}
TiePointZone SizeTrack	Size of the Tie Point Zone in the Track direction	32 bit int	$[N_{groups, track}]$	pixels	Z_{track}
TiePointZone SizeScan	Size of the Tie Point Zone in the Scan direction	32 bit int	$[N_{groups, scan}]$	pixels	Z_{scan}
PixelOffsetTrack	Offset in Track direction of Pixel [0,0] centre relative to Tie Point A	32 bit float	[1]	pixels	$p_{offset, track}$
PixelOffsetScan	Offset in Scan direction of Pixel [0,0] centre relative to Tie Point A	32 bit float	[1]	pixels	$p_{offset, scan}$
Original Reflectance Offset *M1-M11, I1-I3*	Offset used in the Original VIIRS SDR Product for representing the Radiance as an integer	32 bit float	[1]	unitless	$a_{reflectance}$
Original ReflectanceScale *M1-M11,*	Scale factor used in the Original VIIRS SDR Product for representing the radiance as an integer	32 bit float	[1]	unitless	$b_{reflectance}$

HDF5 Attributes of Group `/All_Data/VIIRS-Ch-SDR_All`					Symbol in Document
Attribute Name	Description	Data Type	Dim.	Units	
I1-I3					
Original Brightness Temperature Offset *M12, M14-M16, I4, I5*	Offset used in the Original VIIRS SDR Product for representing the Radiance as an integer	32 bit float	[1]	K	a_{bt}
Original Brightness Temperature Scale *M12, M14-M16, I4, I5*	Scale factor used in the Original VIIRS SDR Product for representing the radiance as an integer	32 bit float	[1]	K	b_{bt}
Original Filename	The filename of the original VIIRS SDR file containing the data of this channel	String	[1]	unitless	1

4.3 All_Data

The group /**`All_Data`** contains datasets related to the VIIRS instrument. These datasets are applicable to both geolocation and observation data and are described in detail in Table 14 below.

Table 14 HDF5 Datasets in Group /All_Data

HDF5 Datasets in Group `/All_Data`					Symbol in Document
Dataset Name	Description	Data Type	Dim.	Units	
NumberOfScans	Actual number of VIIRS scans that were used to create this granule	32 bit integer	[1]	unitless	N_{scan}
ModeScan	The VIIRS operational mode, reported at the granule level	8 bit uchar	[48]	unitless	-
ModeGran	The VIIRS operational mode, reported at the granule level	8 bit uchar	[1]	unitless	-

4.4 Attributes of the Root Group

The root group / has the flowing attributes

Table 15 HDF5 Attributes of Root Group /

HDF5 Attributes of Root Group /					Symbol in Document
Attribute Name	Description	Data Type	Dim.	Units	
CVIIRS_Version	SW Version of the CVIIRS tool which created this compact SDR	String	[1]	unitless	
Compact_VIIRS_SDR_Version	Version of the format of the compact SDR contained in this file	String	[1]	unitless	
Distributor	Designates the distributor of the data.	String	[1]	unitless	-
Mission_Name	The character string by which the mission is known.	String	[1]	unitless	-
N_Dataset_Source	The producer of the HDF5 files.	String	[1]	unitless	-
N_GEO_Ref	Filename of the HDF5 file containing the related Geolocation information.	String	[1]	unitless	-
N_HDF_Creation_Date	The date that the HDF5 file was created. Expressed as **YYYYMMDD**. Paired with N_HDF_Creation_Time	String	[1]	unitless	-
N_HDF_Creation_Time	The time that the HDF5 file was created Expressed as **HHMMSS.SSSSSSZ** Paired with N_HDF_Creation_Date.	String	[1]	unitless	-
Platform_Short_Name	An acronym, or shorter form of the platform name, used to identify the platform.	String	[1]	unitless	-
Satellite_Id_Filename	The Satellite ID used for the filename	String	[1]	unitless	-

4.5 Metadata

The metadata is contained in the group **/All_Data/Data_Products** of the Original VIIRS SDR product and it is included in full in the Compact VIIRS SDR product. The metadata is not described in further detail in this document, but is described in [AD-3].

5 STEPS FOR GENERATING THE COMPACT VIIRS SDR FROM THE ORIGINAL VIIRS SDR

5.1 Generating the Geolocation and Angular Data

Table 16 below lists the steps required for generating the geolocation data of the Compact VIIRS SDR Product from the Original VIIRS SDR Product. Each step contains a short description as well as references to sections of this document giving more detailed instructions.

Please note that for the generation of the simplified Tie Point Zone schema with just one Tie Point Zone Group (M-Band, I-Band), the following values shall be used:

`NumberOfTiePointZoneGroupsTrack` = 1,
`NumberOfTiePointZoneGroupsScan` = 1,
`TiePointZoneGroupLocationTrackCompact` = 0,
`TiePointZoneGroupLocationScanCompact` = 0,
`TiePointZoneGroupLocationTrack` = 0,
`TiePointZoneGroupLocationScan` = 0.

Each Scan in the VIIRS SDR corresponds here to one entry in the Tie Point Zone Groups Track directory. That is, for a standard VIIRS SDR granule with 768 pixels along track, i.e. 48 scans, the algorithm described below needs to be repeated 48 times, i.e. for each scan.

Table 16 Steps for generating the geolocation data of the Compact VIIRS SDR Product

Step	Description	References
1	Create the target group `/All_Data/VIIRS-MOD-GEO_All` (or `/All_Data/VIIRS-IMG-GEO_All` or `/All_Data/VIIRS-DNB-GEO_All`) in the Compact VIIRS SDR HDF5 file.	HDF5 definitions www.hdf5.org
2	Access the source group `/All_Data/VIIRS-MOD-GEO_All` (or `/All_Data/VIIRS-IMG-GEO_All` or `/All_Data/VIIRS-DNB-GEO_All`) in the Original VIIRS SDR HDF5 geolocation file.	
3	From the source group read the `Latitude, Longitude, SatelliteAzimuthAngle, SatelliteZenithAngle, SolarAzimuthAngle, andSolarZenithAngle`, and for DNB also the `LunarAzimuthAngle` and `LunarZenithAngle` data sets in full.	Section 3.1
4	Iterate over all Tie Point Zone Groups and perform Steps 5-17 below. The Tie Point Zone Groups are defined via the scanning properties of the instrument; e.g., for DNB they are defined according to the aggregation zones, see Table 3.	
5	Iterate over all Tie Point Zones in the Tie Point Zone Group and perform the Steps 6-17 for each Tie Point Zone.	Tie Point Zones Section 2.4.1
6	Extract from the data read from file in Step 3, the data for the Pixels	Indices

Step	Description	References
	with relative indices (0,0), (0, Z_{scan} -1), (Z_{track} -1, 0) and (Z_{track} -1, Z_{scan} -1) and use it as the temporary Tie Points A', B', C' and D' respectively of the Tie Point Zone.	Section 8.1
7	If any of the dataset values associated with the temporary Tie Points A', B', C' and D' are a floating point Fill Value as defined in Table 25, then set all values of the final Tie Points A, B, C and D of the Tie Point Zone to the floating point Fill Value. If different Fill Values are present, use the one with the smallest absolute value. Else perform Steps 8-17.	Fill Values Section 9.1
8	For each of the temporary Tie Points A', B', C' and D' Calculate from the Longitude and Latitude the Position Unit Vector.	Calculation Section 8.7.1
9	For each of the temporary Tie Points A', B', C' and D' calculate from the `SatelliteAzimuthAngle` and `SatelliteZenithAngle` the Satellite Unit Vector and transform the vector from the Pixel Centred Frame to the Earth Centred Frame.	Calculation Section 8.8.1 Transformation, section 8.9.1
10	For each of the temporary Tie Points A', B', C' and D' calculate from the `SolarAzimuthAngle` and `SolarZenithAngle` the Solar Unit Vector and transform the vector from the Pixel Centred Frame to the Earth Centred Frame.	Calculation Section 8.8.1 Transformation, section 8.9.1
11	Only for DNB: For each of the temporary Tie Points A', B', C' and D' calculate from the `LunarAzimuthAngle` and `LunarZenithAngle` the Lunar Unit Vector and transform the vector from the Pixel Centred Frame to the Earth Centred Frame.	Calculation Section 8.8.1 Transformation, section 8.9.1
12	Calculate the Pixel Expansion Correction coefficient $c_{expansion}$ based on temporary Tie Points A', B', C' and D'.	Section 8.10
13	Calculate the Pixel Alignment Correction coefficient $c_{alignment}$ based on temporary Tie Points A', B', C' and D'.	Section 8.11
14	Iterate over the four final Tie Points A, B, C and D of the Tie Point Zone and perform Steps 15-17 for each Tie Point.	
15	Based on the temporary Tie Points, calculate the extrapolation parameters s_{track} and s_{scan} for the Tie Point.	Section 8.13
16	Based on the temporary Tie Points, calculate the corrected interpolation parameters α_{track} and α_{scan} for the Tie Point.	Section 8.5
17	Based on the temporary Tie Points, use the Vector Extrapolation to calculate the Position Unit Vector, Satellite Unit Vector and Solar Unit Vector for the Tie Point.	Extrapolation, section 8.12.1
18	Iterate over all Tie Point Zone Groups.	Section 2.4.2
19	Iterate over all Tie Point Zones within the Tie Point Zone Group. If the Tie Point Zone has a neighbour Tie Point Zone in the scan direction,	Tie Point Zones

Step	Description	References
	perform Step 20. This step forces the Tie Points that are shared between Tie Point Zones to be identical by using the midpoints of the calculated values.	Section2.4.1
20	For each of the vectors Position Vector, Satellite Vector and Solar Vector, and Lunar Vector for DNB, calculate the midpoint between the Vector for the Tie Point B of this Tie Point Zone and Tie Point A of the neighbour Tie Point Zone, and replace the Vector of both Tie Points with the result. If one of the two input vectors contains Fill Values as defined in Table 26, then use the vector without Fill Values as the result. If both vectors contain Fill Values, then set the result to the one with the smallest absolute value. Repeat the above for the Tie Point C of this Tie Point Zone and Tie Point D of the neighbour Tie Point Zone.	Midpoint Section 8.12.2 Fill Values Section 9.1
21	Iterate over all Tie Point Zone Groups and perform Steps 22-30 for each Tie Point Zone Group.	Section 2.4.2
22	Iterate over all Tie Point Zones within the Tie Point Zone Group and perform the Steps 23-29 for each Tie Point Zone.	Tie Point Zones Section 2.4.1
23	Iterate over the four final Tie Points A, B, C and D of the Tie Point Zone and perform Steps 24-26 for each Tie Point.	
24	If the Position Vector contains Fill Values as defined in Table 26, then set the Latitude and Longitude for the Tie Point to the Fill Value. Else covert the Position Vector for the Tie Point to the longitude and latitude representation. The result of this step is the Latitude and Longitude for the Tie Point.	Fill Values Section 9.1 Conversion, section 8.7.2
25	If the Satellite Vector contains Fill Values as defined in Table 26, then set the `SatelliteAzimuthAngle` and `SatelliteZenithAngle` for the Tie Point to the Fill Value. Else transform Satellite Vector for the Tie Point from the Earth Centred Frame to the Pixel Centred Frame and convert the result back to azimuth and zenith angle representation. The result of this step is the `SatelliteAzimuthAngle` and `SatelliteZenithAngle` for the Tie Point.	Fill Values Section 9.1 Transformation, section 8.9.2 Conversion, section 8.8.2
26	If the Solar Vector contains Fill Values as defined in Table 26, then set the `SolarAzimuthAngle` and `SolarZenithAngle` for the Tie Point to the Fill Value. Transform the Solar Vector for the Tie Point from the Earth Centred Frame to the Pixel Centred Frame and convert the result back to azimuth and zenith angle representation. The result of this step is the `SolarAzimuthAngle` and	Fill Values Section 9.1 Transformation, section 8.9.2 Conversion, section 8.8.2

Step	Description	References
	SolarZenithAngle for the Tie Point.	
27	If the Lunar Vector contains Fill Values as defined in Table 26, then set the LunarAzimuthAngle and LunarZenithAngle for the Tie Point to the Fill Value. Transform the Lunar Vector for the Tie Point from the Earth Centred Frame to the Pixel Centred Frame and convert the result back to azimuth and zenith angle representation. The result of this step is the LunarAzimuthAngle and LunarZenithAngle for the Tie Point.	Fill Values Section 9.1 Transformation, section 8.9.2 Conversion, section 8.8.2
28	If any of the values associated with the final Tie Points A, B, C and D contains Fill Values as defined in Table 26, then set $c_{expansion}$ to zero. Else, recalculate the Pixel Expansion Correction coefficient $c_{expansion}$ now based on the final Tie Points A, B, C and D.	Section 8.10
29	If any of the values associated with the final Tie Points A, B, C and D contains Fill Values as defined in Table 26, then set $c_{alignment}$ to zero. Recalculate the Pixel Alignment Correction coefficient $c_{alignment}$ now based on the final Tie Points A, B, C and D.	Section 8.11
30	Add to the target HDF5 file the size of the Tie Point Zone, Z_{track} and Z_{scan}, and the Pixel Offset $p_{offset,track}$, $p_{offset,scan}$, P_{track} and P_{scan} corresponding to TiePointZoneSizeTrack, TiePointZoneSizeScan, PixelOffsetTrack, PixelOffsetScan, TiePointZoneGroupLocationTrack and TiePointZoneGroupLocationScan as HDF5 attributes of each observation group /All_Data/VIIRS-Ch-SDR_ALL contained in the product.	Section 4.2.2
31	Add to the target HDF5 file the number of Tie Point Zones $N_{zones,track}$ and $N_{zones,scan}$ corresponding to NumberOfTiePointZonesTrack, NumberOfTiePointZonesScan, and number of Tie Point Zone Groups $N_{groups,track}$ and $N_{groups,scan}$ corresponding to NumberOfTiePoinZoneGroupsTrack and NumberOfTiePointZoneGroupsScan within the HDF5 data object /All_Data/VIIRS-MOD-GEO_All (or /All_Data/VIIRS-IMG-GEO_All or /All_Data/VIIRS-DNB-GEO_All).	Section 4.1
32	Add to the target HDF5 file correction coefficients $c_{expansion}$ and $c_{alignment}$, corresponding to ExpansionCoefficient, AlignmentCoefficient, within the HDF5 data object /All_Data/VIIRS-MOD-GEO_All (or /All_Data/VIIRS-IMG-GEO_All or /All_Data/VIIRS-DNB-GEO_All).	Section 4.1
33	Add, for all Tie Points, the calculated Latitude, Longitude, SatelliteAzimuthAngle, SatelliteZenithAngle, SolarAzimuthAngle, and SolarZenithAngle, and LunarAzimuthAngle and LunarZenithAngle for DNB, values to the target HDF5 file in the data object /All_Data/VIIRS-MOD-GEO_All (or /All_Data/VIIRS-IMG-GEO_All or	Section 4.1 Index relations Section 8.3

Step	Description	References
	/All_Data/VIIRS-DNB-GEO_All).	
34	From the source group copy the datasets StartTime, MidTime, SCPosition, SCVelocity, SCAttitude, PadByte1, QF1_SCAN_VIIRSSDRGEO and QF2_SCAN_VIIRSSDRGEO, and for DNB as well MoonIllumFraction and MoonPhaseAngle, to the target group.	Section 3.1 Section 4.1
35	From the source group copy the datasets ModeScan, ModeGran and NumberOfScans to the target group /All_Data	Section 3.1 Section 4.3

5.2 Generating the Observation Data

Table 17 below lists the steps required for generating the observation data of the Compact VIIRS SDR Product from the Original VIIRS SDR Product. Each step contains a short description as well as references to sections of this document giving more detailed instructions.

Table 17 Steps for generating the observation data of the Compact VIIRS SDR Product

Step	Description	References
1	Iterate over the VIIRS channels *Ch* = M1-M16, I1-I5 or DNB and perform the Steps 2-21 for each channel.	
2	Create the target group /All_Data/VIIRS-Ch-SDR_All in the Compact VIIRS SDR HDF5 file.	
3	Access the source group /All_Data/VIIRS-Ch-SDR_All in the Original VIIRS SDR HDF5 file for *Ch*.	
4	From the source group copy the applicable datasets QF1_VIIRSMBANDSDR (or QF1_VIIRSIBANDSDR or QF1_VIIRSDNBSDR), QF2_SCAN_SDR, QF3_SCAN_RDR, QF4_SCAN_SDR (M- and I-Band only), QF5_GRAN_BADDETECTOR (M- and I-Band only), PadByte1, NumberOfMissingPkts, NumberOfBadChecksums and NumberOfDiscardedPkts to the target group.	Section 3.2 Section 4.2
5	If *Ch* is one of the channels M1, M2, M6, M8-M12, M14-M16, I1-I5 then perform Steps 6-8.	
6	Copy the 16 bit uint source group dataset Radiance to the target group.	Section 3.2 Section 4.2 Section 8.14.2

Step	Description	References
7	Add the scale contained in the source group dataset `RadianceFactors` twice to the dataset `Radiance` in the target group as the attributes b_{low} and b_{high}, i.e. `RadianceScaleLow`, `RadianceScaleHigh`. Add the offset contained in the source group dataset `RadianceFactors` twice to the dataset `Radiance` in the target group as the attributes a_{low} and a_{high}, i.e. `RadianceOffsetLow`, `RadianceOffsetHigh`.	Section 3.2 Section 4.2.1 Section 8.14.2
8	Set the value of dataset `Threshold` in the target group to zero.	Section 4.2.1 Section 8.14.2
10	If *Ch* is one of the channels M3-M5, M7, M13 then perform Steps 11-14.	
11	Read the 32 bit floating point source group dataset `Radiance`	Section 3.2
12	Compute the values of a_{low}, b_{low}, a_{high}, b_{high} and the threshold $L_{threshold}$ from the parameters defined in Table 41. Convert each 32 bit floating point value in the `Radiance` dataset to a 16 bit uint using the dual-scale representation.	Section 8.14.1 Section 8.14.7
13	Write the 16 bit uint dataset `Radiance` to the target group.	Section 4.2
14	Add a_{low}, b_{low}, a_{high}, b_{high} and $C_{threshold}$ corresponding to `RadianceOffsetLow`, `RadianceScaleLow`, `RadianceOffsetHigh`, `RadianceScaleHigh` and `Treshold` as attributes to the dataset `Radiance` in the target group.	Section 4.2.1
15	If *Ch* is one of the channels M1-M11, I1-I3 then perform Steps 16-18.	
16	Lookup A_{vis} and B_{vis} for the channel *Ch* in Table 39 and add them as the attributes `EquivalentWidth` and `IntegratedSolarIrradiance` of the dataset `Radiance` in the target group.	Section 4.2.1 Section 9.2
17	Calculate the normalised Earth-Sun distance d_{se} and add it as the attribute `EarthSunDistanceNormalised` of the dataset `Radiance` in the target group	Section 4.2.1 Section 8.15
18	Add the offset and scale contained in the source group dataset `ReflectanceFactors` as the attributes `OriginalReflectanceOffset` and `OriginalReflectanceScale` to the target group.	Section 3.2 Section 4.2.2
19	If *Ch* is one of the channels M12-M16, I4-I5 then perform Steps 20-21.	
20	Lookup λ_C , A_{ir} and B_{ir} for the channel *Ch* in Table 40 and add them	Section 4.2.1

Step	Description	References
	as the attributes CentralWaveLength, BandCorrectionCoefficientA, and BandCorrectionCoefficientB of the dataset Radiance in the target group.	Section 9.2
21	Add the offset and scale contained in the source group dataset BrightnessTemperatureFactors as the attributes OriginalBrightnessTemperatureOffset and OriginalBrightnessTemperatureScale of the target group.	Section 3.2 Section 4.2.2
22	If *Ch* is DNB then perform Steps 23-25	
23	Calculate N-bit Floating point parameters as described in section 8.14.8 and create custom datatype based on Float32.	Section 8.14.8
24	Copy Radiance data into dataset Radiance with datatype as created in Step 23.	
25	Set N-Bit Filter for HDF5 Dataset	

5.3 Generating the Metadata

The table below lists the steps required for generating the metadata of the Compact VIIRS SDR Product from the Original VIIRS SDR Product.

Table 18 Steps for generating the metadata of the Compact VIIRS SDR Product

Step	Description	References
1	Create Group **/Data_Products**	
2	For each Group m_All in /All_Data create Group m under /Data_Products	
3	For each Group /Data_Products/m create Dataset m_Aggr and m_Gran_0	
4	For each Dataset n under /All_Data/m_All create Dataset references to n in Dataset /Data_Products/m/m_Aggr and Dataset Region reference in Dataset /Data_Products/m/m_Gran_0	
5	For each Group Data_Products/m copy the attributes of the original Product to the compact product	
6	For each Dataset under Data_Products/m copy the attributes of the original Product to the compact product	

6 STEPS FOR RECONSTRUCTING THE ORIGINAL VIIRS SDR FROM THE COMPACT VIIRS SDR

6.1 Reconstructing the Geolocation and Angular Data

Table 19 below lists the steps required for reconstructing the geolocation data for each Pixel starting from the Tie Point based information contained in the Compact VIIRS SDR Product. Each step contains a short description as well as references to sections of this document giving more detailed instructions.

Please note that for the re-generation with the simplified Tie Point Zone schema with just one Tie Point Zone Group (M-Band, I-Band), the following values shall be used, if those are not available in the Compact VIIRS SDR format. This is true for Compact VIIRS SDR products created with a CVIIRS version <1.0.0:

`NumberOfTiePointZoneGroupsTrack` = 1,
`NumberOfTiePointZoneGroupsScan` = 1,
`TiePointZoneGroupLocationTrackCompact` = 0,
`TiePointZoneGroupLocationScanCompact` = 0,
`TiePointZoneGroupLocationTrack` = 0,
`TiePointZoneGroupLocationScan` = 0.

Each Scan in the VIIRS SDR corresponds here to one entry in the Tie Point Zone Groups Track directory. That is, for a standard VIIRS SDR granule with 768 pixels along track, i.e. 48 scans, the algorithm described below needs to be repeated 48 times, i.e. for each scan.

Table 19 Steps for reconstructing geolocation data of the Original VIIRS SDR Product

Step	Description	References
1	From the Compact VIIRS SDR HDF5 file read the following attributes of any of the groups `/All_Data/VIIRS-Ch-SDR_ALL` `TiePointZoneSizeTrack`, `TiePointZoneSizeScan`, `PixelOffsetTrack`, `PixelOffsetScan`, `TiePointZoneGroupLocationTrack` and `TiePointZoneGroupLocationScan`.	HDF5 definitions www.hdf5.org Section 4.2.2
2	Create the target group `/All_Data/VIIRS-MOD-GEO_All` (or `/All_Data/VIIRS-IMG-GEO_All` or `/All_Data/VIIRS-DNB-GEO_All`) in the Original VIIRS SDR HDF5 geolocation file.	
3	Access the source group `/All_Data/VIIRS-MOD-GEO_All` (or `/All_Data/VIIRS-IMG-GEO_All` or `/All_Data/VIIRS-DNB-GEO_All`) in the Compact VIIRS SDR HDF5 file.	
4	From the source group read the datasets `NumberOfTiePointZonesTrack`, `NumberOfTiePointZonesScan`, `NumberOfTiePoinZoneGroupsTrack`, `NumberOfTiePointZoneGroupsScan`,	Section 4.1

Step	Description	References
	`TiePointZoneGroupLocationTrackCompact`, `TiePointZoneGroupLocationScanCompact`, `ExpansionCoefficient`, `AlignmentCoefficient`, `Latitude`, `Longitude`, `SatelliteAzimuthAngle`, `SatelliteZenithAngle`, `SolarAzimuthAngle`, `SolarZenithAngle`, and for DNB as well `LunarAzimuthAngle` and `LunarZenithAngle`, in full.	
5	If any of the dataset values associated with the temporary Tie Points A', B', C' and D' are a floating point Fill Value as defined in Table 25, then set all values of the final Tie Points A, B, C and D of the Tie Point Zone to the floating point Fill Value. If different Fill Values are present, use the one with the largest absolute value. Else perform Steps 6-18.	Fill Values Section 9.1
6	Iterate over all Tie Point Zone Groups and determine the start of the Tie Point Zones in this group by using the values read from `TiePointZoneGroupLocationTrackCompact` and `TiePointZoneGroupLocationScanCompact`, as well as `TiePointZoneGroupLocationTrack` and `TiePointZoneGroupLocationTrack`, respectively.	
7	Iterate over all Tie Point Zones within the Tie Point Zone Group and perform the Steps 8-18 for each Tie Point Zone. Use `NumberOfTiePoinZoneGroupsTrack` and `NumberOfTiePointZoneGroupsScan` to determine the number of Tie Point Zones in this Tie Point Zone Group.	Tie Point Zones Section 2.4
8	Associate the data read from file in Step 1-4 with the corresponding Tie Points A, B, C and D of the Tie Point Zone using the index relations.	Index relations Section 8.3
9	If the Tie Point Zone, defined by the positions of its four Tie Points A, B, C and D, crosses the Datum Line or lies within the polar regions, then calculate from the Longitude and Latitude the Position Unit Vector for each of the Tie Points A, B, C and D. Otherwise do nothing.	Condition, section 8.6.1 Calculation Section 8.7.1
10	If, for Tie Points A, B, C and D, the range of the `SatelliteAzimuthAngle` values is large or the points are close to one of the Poles or the `SatelliteZenithAngle` is small, then, for each of the Tie Points A, B, C and D, calculate from the `SatelliteAzimuthAngle` and `SatelliteZenithAngle` the Satellite Unit Vector and transform the vector from the Pixel Centred Frame to the Earth Centred Frame. See section 10.6.2 for the definition of "large", "small" and "close to". Otherwise do nothing.	Condition, section 8.6.2 Calculation Section 8.8.1 Transformation, section 8.9.1
11	If, for Tie Points A, B, C and D, the range of the `SolarAzimuthAngle` values is large or the points are close to one of the Poles or the `SolarZenithAngle` is small, then, for each of the Tie Points A, B, C and D, calculate from the	Condition, section 8.6.3 Calculation

Step	Description	References
	SolarAzimuthAngle and SolarZenithAngle the Solar Unit Vector and transform the vector from the Pixel Centred Frame to the Earth Centred Frame. See section 8.6.3 for the definition of “large”, “small” and “close to”. Otherwise do nothing.	Section 8.8.1 Transformation, section 8.9.1
12	Only for DNB: If, for Tie Points A, B, C and D, the range of the LunarAzimuthAngle values is large or the points are close to one of the Poles or the LunarZenithAngle is small, then, for each of the Tie Points A, B, C and D, calculate from the LunarAzimuthAngle and LunarZenithAngle the Lunar Unit Vector and transform the vector from the Pixel Centred Frame to the Earth Centred Frame. See section 8.6.3 for the definition of “large”, “small” and “close to”. Otherwise do nothing.	Condition, section 8.6.3 Calculation Section 8.8.1 Transformation, section 8.9.1
13	Iterate over all Pixels within the Tie Point Zone and perform Steps 14-18 for each Pixel.	
14	Calculate the interpolation parameters s_{track} and s_{scan} for the pixel.	Section 8.4
15	Calculate the corrected interpolation parameters α_{track} and α_{scan} for the pixel.	Section 8.5
16	If the Position Unit Vectors were calculated in Step 9, use the Vector Interpolation to calculate the Position Unit Vector for the Pixel and convert the result back to the longitude and latitude representation. Otherwise, interpolate directly in longitude and latitude. The result of this step is the Latitude and Longitude for the Pixel.	Interpolation, section 8.12.1 Conversion, section 8.7.2 Interpolation, section 8.12.3
17	If the Satellite Unit Vectors were calculated in Step 10, use the Vector Interpolation to calculate the Satellite Unit Vector for the Pixel, transform the vector from the Earth Centred Frame to Pixel Centred Frame and convert the result back to azimuth and zenith angle representation. Otherwise, interpolate directly in azimuth and zenith angle. The result of this step is the SatelliteAzimuthAngle and SatelliteZenithAngle for the Pixel.	Interpolation, section 8.12.1 Transformation, section 8.9.2 Conversion, section 8.8.2 Interpolation, section 8.12.4
18	If the Solar Unit Vectors were calculated in Step 11, use the Vector Interpolation to calculate the Solar Unit Vector for the Pixel, transform the vector from the Earth Centred to Pixel Centred Frame and covert the result back to azimuth and	Interpolation, section 8.12.1 Transformation,

Step	Description	References
	zenith angle representation. Otherwise, interpolate directly in azimuth and zenith angle. The result of this step is the `SolarAzimuthAngle` and `SolarZenithAngle` for the Pixel.	section 8.9.2 Conversion, section 8.8.2 Interpolation, section 8.12.4
19	Only for DNB: If the Lunar Unit Vectors were calculated in Step 12, use the Vector Interpolation to calculate the Lunar Unit Vector for the Pixel, transform the vector from the Earth Centred to Pixel Centred Frame and covert the result back to azimuth and zenith angle representation. Otherwise, interpolate directly in azimuth and zenith angle. The result of this step is the `LunarAzimuthAngle` and `LunarZenithAngle` for the Pixel.	Interpolation, section 8.12.1 Transformation, section 8.9.2 Conversion, section 8.8.2 Interpolation, section 8.12.4
20	Write, for all Pixels, the calculated `Latitude`, `Longitude`, `SatelliteAzimuthAngle`, `SatelliteZenithAngle`, `SolarAzimuthAngle`, and `SolarZenithAngle`, and for DNB the `LunarAzimuthAngle` and `LunarZenithAngle`, values to the target group.	Section 3.1
21	From the source group copy the datasets `StartTime`, `MidTime`, `SCPosition`, `SCVelocity`, `SCAttitude`, `PadByte1`, `QF1_SCAN_VIIRSSDRGEO` and `QF2_SCAN_VIIRSSDRGEO`, and for DNB as well `MoonIllumFraction` and `MoonPhaseAngle`, to the target group.	Section 4.1 Section 3.1
22	From the source group `/All_Data` copy the datasets `NumberOfScans`, `ModeScan` and `ModeGran` to the target group.	Section 4.3 Section 3.1

6.2 Reconstructing the Observation Data

Table 20 below lists the steps required for generating the observation data of the Original VIIRS SDR Product from the Compact VIIRS SDR Product. Each step contains a short description as well as references to sections of this document giving more detailed instructions.

Table 20 Steps for reconstructing the observation data of the Original VIIRS SDR Product

Step	Description	References
1	Iterate over the VIIRS channels *Ch* = M1-M16, I1-I5 or DNB and perform the Steps 2-23 for each channel.	
2	Access the source group `/All_Data/VIIRS-Ch-SDR_All` in the Compact VIIRS SDR HDF5 file.	
3	Read the target group attribute `OriginalFilename` and create a new Original VIIRS SDR HDF5 file for channel *Ch*.	Section 4.2.2
4	Create the target group `/All_Data/VIIRS-Ch-SDR_All` in the Original VIIRS SDR HDF5 file.	
5	From the source group copy the datasets `QF1_VIIRSMBANDSDR` (or `QF1_VIIRSIBANDSDR` or `QF1_VIIRSDNBSDR`), `QF2_SCAN_SDR`, `QF3_SCAN_RDR`, `QF4_SCAN_SDR` (only M- and I-Band), `QF5_GRAN_BADDETECTOR` (only M- and I-Band), `PadByte1`, `NumberOfMissingPkts`, `NumberOfBadChecksums` and `NumberOfDiscardedPkts` to the target group.	Section 3.2 Section 4.2
6	From the source group `/All_Data` copy the datasets `NumberOfScans` , `ModeScan` and `ModeGran` to the target group.	Section 4.3 Section 3.2
7	Read the source group Radiance dataset attributes `RadianceOffsetLow`, `RadianceScaleLow`, `RadianceOffsetHigh`, `RadianceScaleHigh` and `Threshold` corresponding to a_{low}, b_{low}, a_{high}, b_{high} and $C_{threshold}$.	Section 4.2.1
8	If *Ch* is one of the channels M1, M2, M6, M8-M12, M14-M16, I1-I5 then perform Steps 9-10.	
9	Copy the 16 bit uint source group dataset `Radiance` to the target group.	Section 3.2 Section 4.2
10	Add b_{low} and a_{low} as scale and offset respectively to the target group dataset `RadianceFactors`.	Section 4.2.1 Section 3.2
11	Read the 16 bit uint source group dataset `Radiance`.	Section 0
12	If *Ch* is one of the channels M3-M5, M7, M13 then perform Step 13.	Section 3.2 Section 8.14.6
13	Convert each 16 bit uint value in the `Radiance` dataset to a 32 bit floating point using the dual-scale representation conversion and write the 32 bit floating point dataset Radiance to the target group.	Section 8.14.6
14	If *Ch* is one of the channels M1-M11, I1-I3 then perform Steps 15-18.	

Step	Description	References
15	Read the source group Radiance dataset attributes EquivalentWidth, IntegratedSolarIrradiance and EarthSunDistanceNormalised corresponding to A_{vis}, B_{visand} and $d_{se.}$	Section 4.2.1
16	For each value in the 32 bit floating point dataset Radiance find the corresponding /All_Data/VIIRS-MOD-GEO_All/SolarZenithAngle for the pixel and calculate the Reflectance.	Section 8.15
17	Read the source group attributes OriginalReflectanceOffset and OriginalReflectanceScale corresponding to $a_{reflectance}$ and $b_{reflectance}$ and write them to the target group dataset ReflectanceFactors.	Section 4.2.2 Section 3.2
18	For each Reflectance value, calculate the integer representation based on $a_{reflectance}$ and $b_{reflectance}$ and write it to the target group Reflectance dataset	Section 8.17 Section 3.2
19	If *Ch* is one of the channels M12-M16, I4, I5 then perform Steps 19-21.	
20	Read the source group Radiance dataset attributes CentralWaveLength, BandCorrectionCoefficientA, and BandCorrectionCoefficientB corresponding to λ_C , A_{ir} and B_{ir}	Section 4.2.1
21	Read the source group attributes OriginalBrightnessTemperatureOffset and OriginalBrightnessTemperatureScale corresponding to a_{bt} and b_{bt} and write them to the target group dataset BrightnessTemperatureFactors.	Section 4.2.2 Section 3.2
22	For each value in the 32 bit floating point dataset Radiance calculate the BrightnessTemperature.	Section 8.16
23	If *Ch* is one of the channels M12, M14-M16, I4-I5 then convert the Brightness Temperatures to the integer representation based on a_{bt} and b_{bt} and write it to the target group BrightnessTemperature dataset	Section 8.18 Section 3.2
24	If *Ch* is the channel M13 then write the Brightness Temperatures to the target group BrightnessTemperature dataset	Section 3.2
25	If *Ch* is the channel DNB then copy the Radiance dataset to the target group with datatype of Float32.	

6.3 Reconstructing the Metadata

Table 21 below lists the steps required for reconstructing the metadata of the Original VIIRS SDR Product from the Compact VIIRS SDR Product

Table 21 Steps for reconstructing the metadata of the Original VIIRS SDR Product

Step	Description	References
1	Create Group `/Data_Products`	
2	For each Group `m_All` in `/All_Data` create Group `m` under `/Data_Products`	
3	For each Group `/Data_Products/m` create Dataset `m_Aggr` and `m_Gran_0`	
4	For each Dataset `n` under `/All_Data/m_All` create Dataset references to `n` in Dataset `/Data_Products/m/m_Aggr` and Dataset Region reference in Dataset `/Data_Products/m/m_Gran_0`	
5	For each Group `Data_Products/m` copy the attributes of the original Product to the compact product	
6	For each Dataset under `Data_Products/m` copy the attributes of the original Product to the compact product	

7 FILE NAMING CONVENTION

The file naming convention for the Compact VIIRS SDR follows the convention for the Original VIIRS SDR as defined in [AD-1] section 3.4.1. The structure is shown in

Figure 16 below.

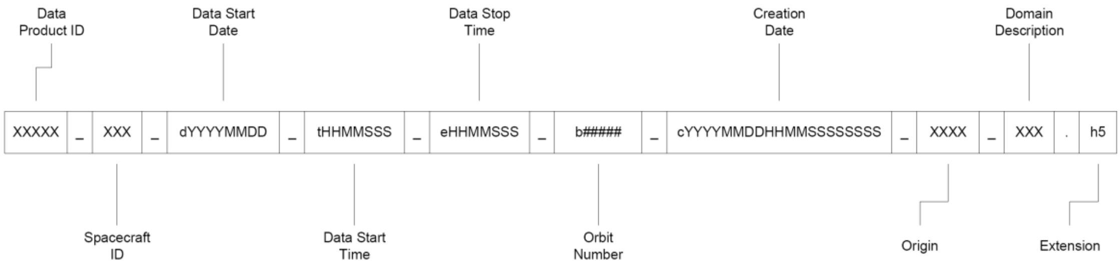

Figure 16 File Name Structure

The Spacecraft ID for S-NPP is **`npp`** and for JPSS-1/NOAA20 **`j01`**.

7.1 Original VIIRS SDR File Naming Convention

Examples of file names for the M-Band VIIRS SDR observation files are:

SVM01_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_noaa_ops.h5
SVM02_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_noaa_ops.h5
.
.
SVM16_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_noaa_ops.h5

and the corresponding geolocation file:

GMODO_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_noaa_ops.h5

Examples of file names for the I-Band VIIRS SDR observation files are:

SVI01_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_noaa_ops.h5
SVI02_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_noaa_ops.h5
.
.
SVI05_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_noaa_ops.h5

and the corresponding geolocation file:

GIMGO_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_noaa_ops.h5

Examples of file names for the Day/Night-Band VIIRS SDR observation files are:

SVDNB_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_noaa_ops.h5

and the corresponding geolocation file:

GDNBO_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_noaa_ops.h5

7.2 Compact VIIRS SDR File Naming Convention

In the file name convention for the Compact VIIRS SDR the Data Product ID is defined as SV[M | I | IM | DNB]C, where S stands for SDR, V for VIIRS, M for M-Band, I for I-Band, IM for M- and I-Band, DNB for Day/Night-Band, and C for Compact.

The 'I' and 'M' indicate, respectively, the presence of the I- and/or M-band channels inside the aggregation, as well as the respective geolocation data, i.e. GMODO and/or GIMGO.
The allowed combinations are:

- M – only M-band channels and the M-band geolocation data are present.
- I – only I-band channels and the I-band geolocation data are present.
- IM – both the I- and the M-band channels and geolocation data are present.

Example file names:

SVMC_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_eum_ops.h5
SVIC_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_eum_ops.h5
SVIMC_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_eum_ops.h5
SVDNBC_npp_d20030125_t0847056_e0848301_b00015_c20090513182937523620_eum_ops.h5

8 MATHEMATICAL ALGORITHMS

This section details the mathematical algorithms required for generating and applying the geolocation data of the Compact VIIRS SDR Product. The individual sections are referenced in the steps defined in sections 5 and 6.

8.1 Relative and Absolute Pixel Indices

Within the Tie Point Zone a pixel is given relative indices ($i_{track,relative,}$, $i_{scan,relative}$) starting at (0,0) at the Tie Point A and counting up to (Z_{track} -1, Z_{scan} -1) at Tie Point C, where Z_{track} and Z_{scan} are the size of the Tie Point Zone along the track and scan directions respectively. In the case of the VIIRS M-band, ($i_{track,relative,}$, $i_{scan,relative}$) runs from (0,0) through (15,15) as shown in Figure 4. For the DNB it runs from (0,0) through (7,15), (13,15), (15,15), (19,15), (21,15) or (23,15) depending on the Tie Point Zone Group; see details in Figure 7 and Table 37.

Similarly, within the granule a pixel is given absolute indices ($i_{track,}$, i_{scan}) starting at (0,0) and counting up to (N_{track} -1, N_{scan} -1), where N_{track} and N_{scan} are the size of the Granule along the track and scan directions respectively. In the case of the VIIRS M-band, (i_{track}, i_{scan}) runs from (0,0) through (767, 3199), for I-Band up to (767, 6399) and for DNB (767, 4063).

For the simplified case of M- and I-Band, as the Tie Point Zones are all the same size across the full VIIRS swath, the conversions from absolute to relative pixel indices

$$i_{relative,track} = remainder\left(\frac{i_{track}}{Z_{track}}\right)$$
$$i_{relative,scan} = remainder\left(\frac{i_{scan}}{Z_{scan}}\right)$$

as well as the conversion from relative to absolute pixel indices

$$i_{track} = i_{zone,track} \cdot Z_{track} + i_{relative,track}$$

$$i_{scan} = i_{zone,scan} \cdot Z_{scan} + i_{relative,scan}$$

are simple. Here ($i_{zone,track}$, $i_{zone,scan}$) are the indices of the Tie Point Zone within the Granule as shown in Figure 9.

For the general case (Day/Night-Band, applicable as well to M- and I-Band) the Tie Point Zone sizes vary through the Tie Point Zone Groups. Thus, the formulas to be used need to consider the index of the start of a Tie Point Zone Group. Those are stored in the Datasets or Attributes of the Compact VIIRS SDR: TiePointZoneGroupLocationTrack ($P_{track}[j]$), TiePointZoneGroupLocationScan($P_{scan}[j]$), TiePointZoneGroupLocationTrackCompact ($P_{track,compact}[j]$), TiePointZoneGroupLocationScanCompact ($P_{scan,compact}[j]$).

For any given Tie Point Zone Group ***j***:

Conversion from absolute to relative pixel indices:

$$i_{relative,track} = remainder\left(\frac{i_{track} - P_{track}[j]}{Z_{track}[j]}\right)$$
$$i_{relative,scan} = remainder\left(\frac{i_{scan} - P_{scan}[j]}{Z_{scan}[j]}\right)$$

Conversion from relative to absolute pixel indices:

$$i_{track} = i_{zone,track} \cdot Z_{track}[j] + i_{relative,track} + P_{track}[j]$$

$$i_{scan} = i_{zone,scan} \cdot Z_{scan}[j] + i_{relative,scan} + P_{scan}[j]$$

In the Compact VIIRS SDR Product the size of the Tie Point Zone Z_{track} and Z_{scan} as well as the Start of the Tie Point Zone Groups P_{track} and P_{scan} are stored as attributes of each contained observation group, see section 4.2.2.

8.2 Tie Point Zone Indices

For the simplified case of M- and I-Band the Tie Point Zone indices ($i_{zone,track}$, $i_{zone,scan}$) can be calculated from the absolute pixel indices ($i_{track,}$, i_{scan}) as

$$i_{zone,track} = integer\left(\frac{i_{track}}{Z_{track}}\right)$$

$$i_{zone,scan} = integer\left(\frac{i_{scan}}{Z_{scan}}\right)$$

In the case of the VIIRS M-band, ($i_{zone,track,}$, $i_{zone,scan}$) runs from (0, 0) through (47, 199) corresponding to a full Granule.

For the general case (Day/Night-Band, applicable as well to M- and I-Band) the Tie Point Zone indices ($i_{zone,track}$, $i_{zone,scan}$) can be calculated from the absolute pixel indices ($i_{track,}$, i_{scan}) for each Tie Point Zone Group ***j*** as

$$i_{zone,track} = \sum_{n=1}^{j-1} N_{zones,track} + integer\left(\frac{i_{track} - p_{track}[j]}{Z_{track}[j]}\right)$$

$$i_{zone,scan} = \sum_{n=1}^{j-1} N_{zones,scan} + integer\left(\frac{i_{scan} - p_{scan}[j]}{Z_{scan}[j]}\right)$$

8.3 HDF5 Data Array Indices

For all cases (the simplified case of M- and I-Band, as well as the general case (Day/Night-Band, applicable as well to M- and I-Band)) the Tie Point Zone indices ($i_{zone,track}$, $i_{zone,scan}$) are used for calculating the location of geolocation and angular parameters within the HDF5 data array. For each of the Tie Points A, B, C and D the array indices are

$$(i_A, j_A)_{HDF5} = (2 \cdot i_{zone,track}, i_{zone,scan})$$

$$(i_B, j_B)_{HDF5} = (2 \cdot i_{zone,track}, i_{zone,scan} + 1)$$

$$(i_C, j_C)_{HDF5} = (2 \cdot i_{zone,track} + 1, i_{zone,scan} + 1)$$

$$(i_D, j_D)_{HDF5} = (2 \cdot i_{zone,track} + 1, i_{zone,scan})$$

8.4 Interpolation Parameters and Pixel Offset

Where the pixel indices are integer numbers, the interpolation parameters s_{track} and s_{scan} are real numbers varying as a function of the relative pixel indices

$$s_{track}(i_{relative,track}) = \frac{p_{offset,track} + i_{relative,track}}{Z_{track}}$$

$$s_{scan}(i_{relative,scan}) = \frac{p_{offset,scan} + i_{relative,scan}}{Z_{scan}}$$

Here the Pixel Offsets ($p_{offset,track}$, $p_{offset,scan}$) indicate the offsets of the corner pixel centre with respect to its nearest Tie Point A as shown in Figure 17, where the corner pixel is the one with local indices (0,0) within its Tie Point Zone. The Pixel Offset is measured in units of pixels and in the case of the VIIRS instrument, the Pixel Offset is (0.5, 0.5) for all bands and channels.

In the Compact VIIRS SDR Product the Pixel Offset ($p_{offset,track}$, $p_{offset,scan}$) is stored as attributes of each contained observation group, see section 4.2.2.

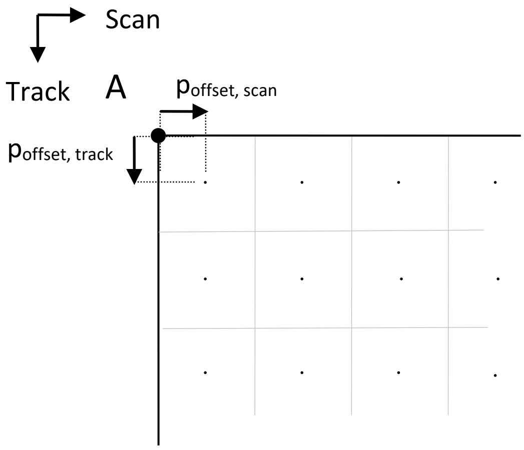

Figure 17 Definition of the Pixel Offset

8.5 Scanning Geometry Corrections

Two geometrical corrections are applied to the Interpolation Parameters s_{track} and s_{scan} introduced in section 8.4, resulting in the Corrected Interpolation Parameters α_{track} and α_{scan}

$$\alpha_{scan} = s_{scan} + s_{scan}(1 - s_{scan})c_{\text{expansion}} + s_{track}(1 - s_{track})c_{\text{alignment}}$$

$$\alpha_{track} = s_{track}$$

Both corrections are approximated as second order polynomials in s_{track} and s_{scan}. The corrections depend on the coefficients $c_{expansion}$ and $c_{alignment}$ that can be considered constant for each Tie Point Zone.

The first correction, expressed by the coefficient $c_{expansion}$, accounts for the variation in Pixel size across each Tie Point Zone and is described in further detail in section 8.10.

The second correction, expressed by the coefficient $c_{alignment}$, accounts for the Pixels not being linearly aligned along the track direction and is described in further detail in section 8.11.

In the Compact VIIRS SDR Product the geometrical correction coefficients $c_{expansion}$ and $c_{alignment}$ are included once for each Tie Point Zone scan index $i_{zone,scan}$, corresponding to a total of $N_{zones,scan}$ of each coefficient, see section 4.1. These coefficient values can be applied for all scans contained in the granule.

8.6 Interpolation Conditions

Within a given Tie Point Zone, the conditions defined in this section determine if the Vector Interpolation method must be applied for the Pixel Position, Satellite Direction and Solar Direction respectively, to ensure numerical accuracy.

The Vector Interpolation method is generally applicable and always provides the best possible accuracy. However, for reasons of computational speed, it is recommended to use the simpler direct interpolation methods whenever possible.

The indices A, B, C and D used in the expressions refer to the four Tie Points of the Tie Point Zone.

8.6.1 Pixel Position Interpolation Condition

For the Pixel Position, Vector Interpolation must be applied if the Tie Point Zone crosses the Datum Line

$$\max(lon_A, lon_B, lon_C, lon_D) - min(lon_A, lon_B, lon_C, lon_D) > 90°$$

or if the Tie Point Zone lies within the Polar regions

$$\max(|lat_A|, |lat_B|, |lat_C|, |lat|_D) > \; lat_{position\ limit}$$

where a typical value of the limit is $lat_{position\ limit} = 60°$.

Otherwise, the longitude and latitude can be interpolated directly.

8.6.2 Satellite Direction Interpolation Condition

For the Satellite Direction, Vector Interpolation must be applied if the range of the Satellite Azimuth Angle is large

$$\max(azi_A, azi_B, azi_C, azi_D) - \; min(azi_A, azi_B, azi_C, azi_D) > azi_{satellite\ limit}$$

where a typical value of the limit is $azi_{satellite\ limit} = 5°$,
or if the Satellite Zenith Angle is small

$$\min(zen_A, zen_B, zen_C, zen_D) < \; zen_{satellite\ limit}$$

where a typical value of the limit is $zen_{satellite\ limit} = 10°$,
or if the Tie Point Zone is close to one of the Poles

$$\max(|lat_A|, |lat_B|, |lat_C|, |lat|_D) > \; lat_{satellite\ limit}$$

where a typical value of the limit is $lat_{satellite\ limit} = 80°$.

Otherwise, the azimuth and zenith angles can be interpolated directly.

8.6.3 Solar Direction Interpolation Condition

For the Solar Direction, Vector Interpolation must be applied if the range of the Solar Azimuth Angle is large

$$\max(azi_A, azi_B, azi_C, azi_D) - \; min(azi_A, azi_B, azi_C, azi_D) > azi_{solar\ limit}$$

where a typical value of the limit is $azi_{solar\ limit} = 5°$,
or if the Solar Zenith Angle is small

$$\min(zen_A, zen_B, zen_C, zen_D) < \; zen_{solar\ limit}$$

where a typical value of the limit is $zen_{solar\ limit} = 10°$,
or if the Tie Point Zone is close to one of the Poles

$$\max(|lat_A|, |lat_B|, |lat_C|, |lat|_D) > \; lat_{solar\ limit}$$

where a typical value of the limit is $lat_{solar\ limit} = 80°$.

Otherwise, the azimuth and zenith angles can be interpolated directly.

8.6.4 Lunar Direction Interpolation Condition

For the Lunar Direction, Vector Interpolation must be applied if the range of the Lunar Azimuth Angle is large

$$\max(azi_A, azi_B, azi_C, azi_D) - min(azi_A, azi_B, azi_C, azi_D) > azi_{lunar\ limit}$$

where a typical value of the limit is $azi_{lunar\ limit} = 5°$,
or if the Lunar Zenith Angle is small

$$\min(zen_A, zen_B, zen_C, zen_D) < zen_{lunar\ limit}$$

where a typical value of the limit is $zen_{lunar\ limit} = 10°$,
or if the Tie Point Zone is close to one of the Poles

$$\max(|lat_A|, |lat_B|, |lat_C|, |lat|_D) > lat_{lunar\ limit}$$

where a typical value of the limit is $lat_{lunar\ limit} = 80°$.

Otherwise, the azimuth and zenith angles can be interpolated directly.

8.7 Position Conversions

In the interpolation scheme a position can either be represented as longitude and latitude or as a vector pointing from the centre of the Earth towards the position. The advantage of using the vector for interpolation is that it provides the same good accuracy for all longitudes and latitudes. However, it is computationally more demanding.

Note that, for the purpose of interpolation within a Tie Point Zone, it is sufficiently accurate to assume a spherical Earth.

8.7.1 Longitude, Latitude to Unit Vector

The conversion from longitude and latitude to a Position Unit Vector is

$$x = \cos(lat)\cos(lon)$$
$$y = \cos(lat)\sin(lon)$$
$$z = \sin(lat)$$

8.7.2 Vector to Longitude, Latitude

The conversion from Position Vector to longitude and latitude is

$$lon = \tan^{-1}\left(\frac{y}{x}\right)$$

$$lat = \tan^{-1}\left(\frac{z}{\sqrt{x^2 + y^2}}\right)$$

For correct computation of $\tan^{-1}(y/x)$ use the dual argument function atan2(y,x) provided in most programming languages.

8.8 Direction Conversions

In the interpolation scheme a direction can either be represented as azimuth and zenith angle or as a vector.

8.8.1 Azimuth Angle, Zenith Angle to Unit Vector

The conversion from azimuth and zenith angles to a Direction Unit Vector is

$$x = \sin(zen)\sin(azi)$$
$$y = \sin(zen)\cos(azi)$$
$$z = \cos(zen)$$

8.8.2 Vector to Azimuth Angle, Zenith Angle

The conversion from a Direction Vector to azimuth and zenith angles is

$$azi = \tan^{-1}\left(\frac{x}{y}\right)$$

$$zen = \frac{\pi}{2} - \tan^{-1}\left(\frac{z}{\sqrt{x^2 + y^2}}\right)$$

For correct computation of $\tan^{-1}(y/x)$ use the dual argument function atan2(y,x) provided in most programming languages.

8.9 Reference Frame Transformations

Two reference frames are being used in the interpolation scheme.

In the Pixel Centred reference frame the x-axis points to the East, the y-axis to the North and the z-axis to the Zenith. Generally the azimuth and zenith angles are expressed in the Pixel Centred reference frame.

In the Earth Centred reference frame the z-axis points to the North, the x-axis to the 0° longitude and the y-axis completes the system.

Vector interpolation are performed in the Earth Centred reference frame to ensure that the interpolated coordinate values all refer to the same reference frame.

The transformation between the Earth Centred reference frame and the Pixel Centred reference frame can be expressed using the orthogonal transformation matrix

$$M = \begin{pmatrix} m_{0,0} & m_{0,1} & m_{0,2} \\ m_{1,0} & m_{1,1} & m_{1,2} \\ m_{2,0} & m_{2,1} & m_{2,2} \end{pmatrix} = \begin{pmatrix} -\sin(lon) & \cos(lon) & 0 \\ -\sin(lat)\cos(lon) & -\sin(lat)\sin(lon) & \cos(lat) \\ \cos(lat)\cos(lon) & \cos(lat)\sin(lon) & \sin(lat) \end{pmatrix}$$

8.9.1 Pixel Centred to Earth Centred

A vector expressed in the Pixel Centred reference frame (PC) can be transformed to the Earth Centred (EC) reference frame using

$$\begin{aligned} x_{EC} &= m_{0,0}x_{PC} + m_{0,1}y_{PC} + m_{0,2}z_{PC} \\ y_{EC} &= m_{1,0}x_{PC} + m_{1,1}y_{PC} + m_{1,2}z_{PC} \\ z_{EC} &= m_{2,0}x_{PC} + m_{2,1}y_{PC} + m_{2,2}z_{PC} \end{aligned}$$

8.9.2 Earth Centred to Pixel Centred

A vector expressed in the Earth Centred (EC) reference frame can be transformed to the Pixel Centred reference frame (PC) using

$$\begin{aligned} x_{PC} &= m_{0,0}x_{EC} + m_{1,0}y_{EC} + m_{2,0}z_{EC} \\ y_{PC} &= m_{0,1}x_{EC} + m_{1,1}y_{EC} + m_{2,1}z_{EC} \\ z_{PC} &= m_{0,2}x_{EC} + m_{1,2}y_{EC} + m_{2,2}z_{EC} \end{aligned}$$

8.10 Pixel Expansion Correction

For the VIIRS M-Band and I-Band, pixels are sampled at constant increments in the instrument scanning angle φ, see Figure 18. Consequently the on-ground pixel size increases towards the edge of the swath. This means that the pixel centres are not linearly distributed along the scan direction within a Tie Point Zone.

To characterise this effect the coefficient $c_{\text{expansion}}$ is introduced. It expresses the pixel centre shift, normalised against the scan direction size of the Tie Point Zone, for a Pixel at the midpoint of the Tie Point Zone. The actual correction is a function of s_{scan} and can be approximated as a second order polynomial

$$s_{scan}(1 - s_{scan})c_{\text{expansion}}$$

where s_{scan} varies from 0.0 to 1.0 across the Tie Point Zone.

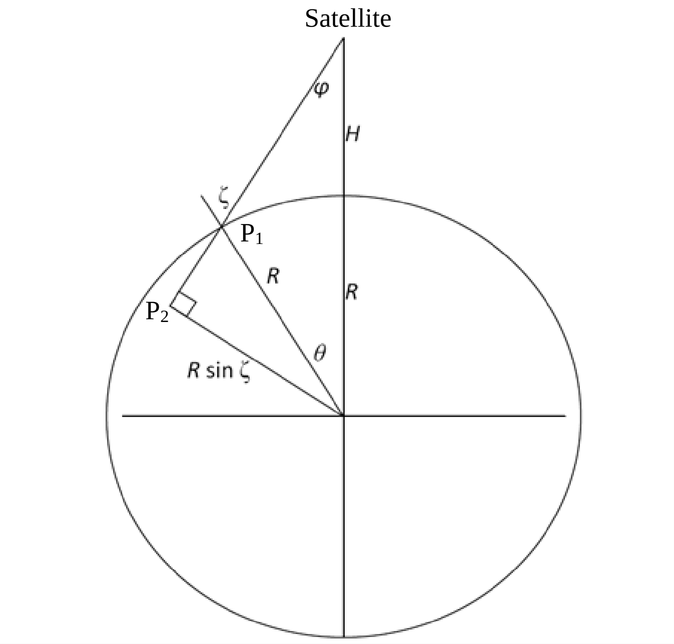

Figure 18 View along the track direction of the VIIRS scanning geometry

The Satellite Zenith Angles at Tie Point A and B are written ζ_A and ζ_B respectively.

The corresponding scan angles can be computed from

$$\varphi_A = sin^{-1}\left(\frac{\mathrm{R}\cdot\sin(\zeta_A)}{R+H}\right)$$

$$\varphi_B = sin^{-1}\left(\frac{\mathrm{R}\cdot\sin(\zeta_B)}{R+H}\right)$$

where the mean Earth radius R = 6371 km and the mean orbital height H = 824 km are sufficiently accurate as a basis for the calculation of the geometrical correction considered in this section.

The corresponding values of θ are

$$\theta_A = \zeta_A - \varphi_A$$

$$\theta_B = \zeta_B - \varphi_B$$

At the scan midpoint

$$\varphi = \frac{\varphi_A + \varphi_B}{2}$$

$$\zeta = sin^{-1}\left(\frac{(\mathrm{R}+\mathrm{H})\cdot\sin(\varphi)}{R}\right)$$

$$\theta = \zeta - \varphi$$

For use in the quadratic approximation of the pixel size variation across the Tie Point Zone, the following correction factor is defined

$$c_{\text{expansion}} = 4 \cdot \frac{\frac{\theta_A + \theta_B}{2} - \theta}{\theta_A - \theta_B}$$

8.11 Pixel Alignment Correction

The VIIRS instrument scans 16 M-Band lines and 32 I-Band lines during one instrument scan. At the sub-satellite point the 16 or 32 pixels are linearly aligned along the track direction. However, away from the sub-satellite point, the pixels are located along a curved arc formed by the intersection of the along track scan plane and the Earth surface.

To characterise this effect the coefficient $c_{\text{alignment}}$ is introduced. It expresses the pixel centre shift in the scan direction, normalised against the size of the Tie Point Zone, for a Pixel at the midpoint of the Tie Point Zone. The actual correction is a function of s_{track} and can be approximated as a second order polynomial

$$s_{track}(1 - s_{track})c_{\text{alignment}}$$

where s_{track} varies from 0.0 to 1.0 across the Tie Point Zone.

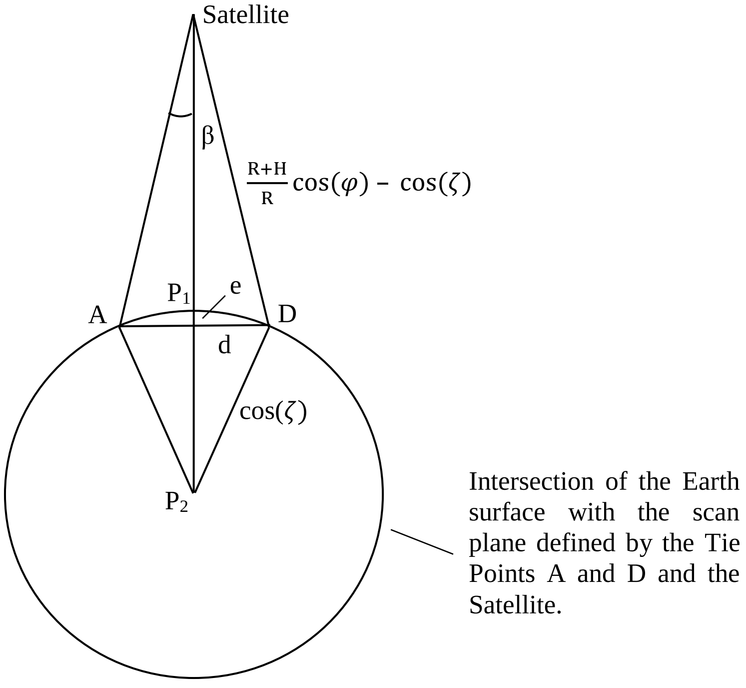

Figure 19 View of the VIIRS scanning geometry in a plane perpendicular to the track direction and containing the line through P_1, P_2 and the satellite introduced in Figure 18.

An overview of the geometry is given in Figure 19. A and D are two Tie Points, the distance d is half the scan width and can be found from

$$d = \left(\frac{R+H}{R}\cos(\varphi) - cos(\zeta)\right)\sin\left(\frac{\beta}{2}\right)$$

where an approximate value of $\sin\left(\frac{\beta}{2}\right) \approx \frac{11.9\ \text{km}}{2\cdot 824\ \text{km}}$ found from the VIIRS scan width at the sub-satellite point and the mean orbit height is sufficiently accurate for the purpose of this correction.

In the plane considered in Figure 19, the correction e can be expressed as

$$e = cos(\zeta) - \sqrt{cos^2(\zeta) - d^2}$$

which must be projected to the horizontal plane and normalised against the scan direction size of the Tie Point Zone to give

$$c_{\text{alignment}} = 4 \cdot \frac{e \cdot \sin(\zeta)}{\theta_A - \theta_B}$$

8.12 Interpolation/Extrapolation

The indices A, B, C and D used in the expressions refer to the four Tie Points of the Tie Point Zone.

8.12.1 Vector Interpolation/Extrapolation

Within a Tie Point Zone, a vector can be interpolated based on the Tie Points A, B, C and D as well as the corrected interpolation parameters α_{track} and α_{scan} for the pixel

$$\begin{pmatrix} x_1 \\ y_1 \\ z_1 \end{pmatrix} = (1 - \alpha_{scan})\begin{pmatrix} x_A \\ y_A \\ z_A \end{pmatrix} + \alpha_{scan}\begin{pmatrix} x_B \\ y_B \\ z_B \end{pmatrix}$$

$$\begin{pmatrix} x_2 \\ y_2 \\ z_2 \end{pmatrix} = (1 - \alpha_{scan})\begin{pmatrix} x_D \\ y_D \\ z_D \end{pmatrix} + \alpha_{scan}\begin{pmatrix} x_C \\ y_C \\ z_C \end{pmatrix}$$

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = (1 - \alpha_{track})\begin{pmatrix} x_1 \\ y_1 \\ z_1 \end{pmatrix} + \alpha_{track}\begin{pmatrix} x_2 \\ y_2 \\ z_2 \end{pmatrix}$$

8.12.2 Direction Vector and Position Vector Midpoint

The midpoint between two direction vectors can be calculated using

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = 0.5 \begin{pmatrix} x_1 \\ y_1 \\ z_1 \end{pmatrix} + 0.5 \begin{pmatrix} x_2 \\ y_2 \\ z_2 \end{pmatrix}$$

8.12.3 Longitude, Latitude Interpolation/Extrapolation

Within a Tie Point Zone, a latitude and longitude can be interpolated based on the Tie Points A, B, C and D as well as the corrected interpolation parameters α_{track} and α_{scan} for the pixel

$$\begin{pmatrix} lat_1 \\ lon_1 \end{pmatrix} = (1 - \alpha_{scan}) \begin{pmatrix} lat_A \\ lon_A \end{pmatrix} + \alpha_{scan} \begin{pmatrix} lat_B \\ lon_B \end{pmatrix}$$

$$\begin{pmatrix} lat_2 \\ lon_2 \end{pmatrix} = (1 - \alpha_{scan}) \begin{pmatrix} lat_D \\ lon_D \end{pmatrix} + \alpha_{scan} \begin{pmatrix} lat_C \\ lon_C \end{pmatrix}$$

$$\begin{pmatrix} lat \\ lon \end{pmatrix} = (1 - \alpha_{track}) \begin{pmatrix} lat_1 \\ lon_1 \end{pmatrix} + \alpha_{track} \begin{pmatrix} lat_2 \\ lon_2 \end{pmatrix}$$

8.12.4 Azimuth, Zenith Angle Interpolation/Extrapolation

Within a Tie Point Zone, azimuth and zenith angles can be interpolated based on the Tie Points A, B, C and D as well as the corrected interpolation parameters α_{track} and α_{scan} for the pixel

$$\begin{pmatrix} azi_1 \\ zen_1 \end{pmatrix} = (1 - \alpha_{scan}) \begin{pmatrix} azi_A \\ zen_A \end{pmatrix} + \alpha_{scan} \begin{pmatrix} azi_B \\ zen_B \end{pmatrix}$$

$$\begin{pmatrix} azi_2 \\ zen_2 \end{pmatrix} = (1 - \alpha_{scan}) \begin{pmatrix} azi_D \\ zen_D \end{pmatrix} + \alpha_{scan} \begin{pmatrix} azi_C \\ zen_C \end{pmatrix}$$

$$\begin{pmatrix} azi \\ zen \end{pmatrix} = (1 - \alpha_{track}) \begin{pmatrix} azi_1 \\ zen_1 \end{pmatrix} + \alpha_{track} \begin{pmatrix} azi_2 \\ zen_2 \end{pmatrix}$$

8.13 Extrapolation of Parameters for Tie Points

When the Tie Points are derived from the geolocation data of the original VIIRS SDR Product the following parameters s_{track} and s_{scan} support the extrapolation of the geolocation data from the centres of the four Tie Point Zone corner Pixels to the Tie Points A, B, C and D.

$$s_{A,track} = \frac{-p_{offset,track}}{z_{track}-1} \qquad s_{A,scan} = \frac{-p_{offset,scan}}{z_{scan}-1}$$

$$s_{B,track} = \frac{-p_{offset,track}}{z_{track}-1} \qquad s_{B,scan} = \frac{z_{scan} - p_{offset,scan}}{z_{scan}-1}$$

$$s_{C,track} = \frac{z_{track} - p_{offset,track}}{z_{track} - 1} \qquad s_{C,scan} = \frac{z_{scan} - p_{offset,scan}}{z_{scan} - 1}$$

$$s_{D,track} = \frac{z_{track} - p_{offset,track}}{z_{track} - 1} \qquad s_{D,scan} = \frac{-p_{offset,scan}}{z_{scan} - 1}$$

8.14 Radiance Representations and Conversions

In the original VIIRS SDR product radiance values are either represented using the single-scale integers or floating point values. In the Compact VIIRS SDR product all radiance values are represented using the dual-scale integer representation. See also section 2.5.

The floating point representation is based on storing the radiances directly as 32 bit floating point values.

The single-scale integer representation is based storing radiances as 16 bit unsigned integers with an associated single set of offset and scale factor a/b.

The dual-scale representation is based on storing radiance values as 16 bit unsigned integers with two associated offset and scale factor sets, one for low radiance values and one for high radiance values. The representation thereby matches the characteristics of the VIIRS dual gain channels and ensures a higher accuracy of the radiance values than possible with a single scale representation. The two offset and scale factor sets a_{low}/b_{low} and a_{high}/b_{high} as well as the integer threshold $C_{threshold}$ determining the set to be used when converting from the integer to the float representation are included in the Compact VIIRS SDR, see Table 12. The calculation of the two offset and scale factor sets a_{low}/b_{low} and a_{high}/b_{high} are described in section 8.14.1 below.

Conversions between any of these representations, as shown in Figure 20, are described in sections 8.14.2 through 8.14.7.

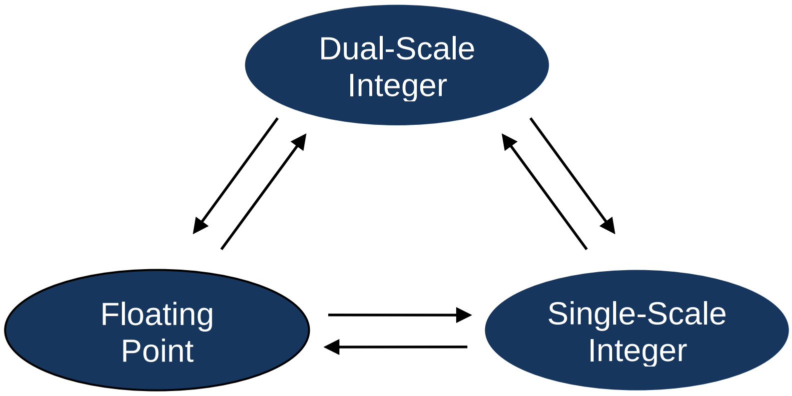

Figure** 20 **Radiance Representation Conversions

8.14.1 Determination of Dual-Scale Offset and Scale Factors

The floating point radiance values L_{min} and L_{max} define the range of radiance values covered by the dual scale representation. The corresponding range of integer values available for the dual scale representation is defined by the integers C_{min} and C_{max}. The threshold $L_{threshold}$ determines if floating point radiance will be assigned to the low or to the high part of the dual gain representation. Finally $C_{threshold}$ defines the range of integers assigned to the low and to the high part of the dual gain representation.

The two offset and scale factor sets a_{low}/b_{low} and a_{high}/b_{high} are determined as follows, cf. as well Figure 21 ,

$$b_{low} = \frac{L_{threshold} - L_{min}}{C_{threshold} - C_{min}}, \qquad a_{low} = L_{min} - b_{low} * C_{min}$$

$$b_{high} = \frac{L_{max} - L_{threshold}}{C_{max} - C_{threshold}}, \qquad a_{high} = L_{threshold} - b_{high} * C_{threshold}$$

Typical values for the offsets a_{low} and a_{high}, the scale factors b_{low} and b_{high} as well as C_{min}, $C_{threshold}$, C_{max}, L_{min}, $L_{threshold}$ and L_{max} are given in sections 10.4 and 10.5.

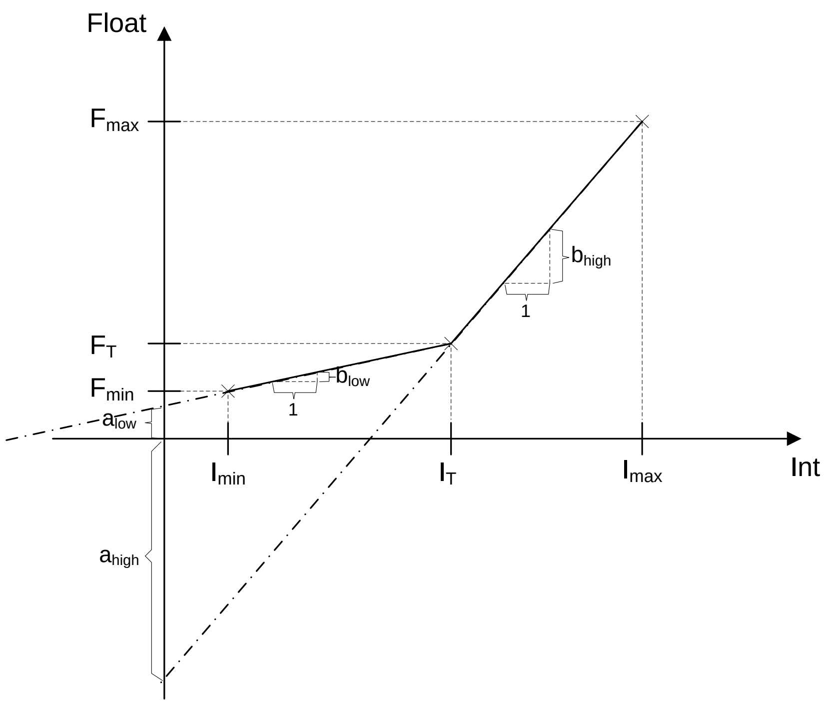

Figure 21 Determination of the Dual-Scale Offset and Scale Factors

8.14.2 Single-Scale to Dual-Scale Radiance Conversion

For a radiance stored as a single-scale integer $C_{Single-Scale}$, the conversion to a dual-scale integer $C_{Dual-Scale}$ is simple:

$$C_{Dual-Scale} = C_{Single-Scale}$$
$$a_{low} = a_{high} = a_{Single-Scale}$$
$$b_{low} = b_{high} = b_{Single-Scale}$$
$$C_{Threshold} = 0$$

8.14.3 Dual-Scale to Single-Scale Radiance Conversion

For a dual-scale integer $C_{Dual-Scale}$ that was originally created form a single-scale integer, the conversion back to a single-scale integer $C_{Single-Scale}$, is simple:

$$C_{Single-Scale} = C_{Dual-Scale}$$
$$a = a_{low}$$
$$b = b_{low}$$

8.14.4 Single-Scale to Floating Point Radiance Conversion

If the single-scale integer radiance value *C* matches one of the integer Fill Values defined in Table 25, then set L to the corresponding floating point Fill Value.

Else calculate the floating point radiance value as follows:

$$L = a + b \cdot C$$

8.14.5 Floating Point to Single-Scale Radiance Conversion

If floating point radiance L matches one of the floating point Fill Values defined in Table 25, then set *C* to the corresponding integer Fill Value.

Else calculate the integer radiance value as follows:

$$C = nint\left\{\frac{L - a}{b}\right\}$$

If the computed integer *C* is outside the range $0 \leq C \leq 65527$, then set *C* to the Fill Value SOUB_UINT16_FILL defined in Table 25, indicating that the scaling is out of bounds.

8.14.6 Dual-Scale to Floating Point Radiance Conversion

If the integer radiance value *C* matches one of the integer Fill Values defined in Table 25, then set L to the corresponding floating point Fill Value.

Else, depending on the value of the integer representation *C*, calculate the floating point radiance value as follows

$$L = a_{low} + b_{low} \cdot C \qquad 0 \leq C \leq C_{threshold}$$

$$L = a_{high} + b_{high} \cdot C \qquad C_{threshold} < C \leq 65527$$

8.14.7 Floating Point to Dual-Scale Radiance Conversion

The threshold to be used when converting from floating point radiance to the integer representation can be calculate as

$$L_{threshold} = a_{low} + b_{low} \cdot C_{threshold}$$

If floating point radiance L matches one of the floating point Fill Values defined in Table 25, then set *C* to the corresponding integer Fill Value.

Else, depending on the value of the floating point radiance *L*, then calculate the integer radiance value as follows:

$$C = nint\left\{\frac{L - a_{low}}{b_{low}}\right\} \qquad L \leq L_{thres}$$

$$C = nint\left\{\frac{L - a_{high}}{b_{high}}\right\} \qquad L > L_{thres}$$

If the computed integer *C* is outside the range $0 \leq C \leq 65527$, then set *C* to the Fill Value SOUB_UINT16_FILL defined in Table 25, indicating that the scaling is out of bounds.

8.14.8 Floating Point to Custom Floating Point Radiance Conversion

HDF5 has a set of predefined data types, amongst others 32 bit Floating Point numbers (IEEE). HDF5, however, allows as well defining user-defined floating point numbers with bit-lengths which are not a multiple of 16. This feature allows customizing data types to the actual needs. See [RD-3] for more details.

8.14.8.1 Floating Point Numbers

The IEEE 754 [RD-4] standard defines the encoding of floating point numbers, e.g. with 32 bits length as follows (Figure 22):

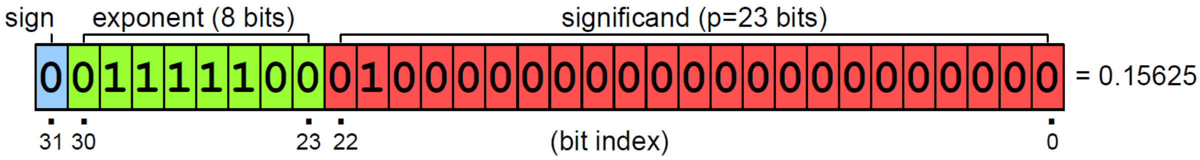

Figure 22 Encoding layout of IEEE 754 32 bit floating point numbers, precision 24 bits

HDF5 allows, following the standard encodings defined in IEEE 754, to define variable bit-length floating point numbers, e.g. 17 bits (Figure 23):

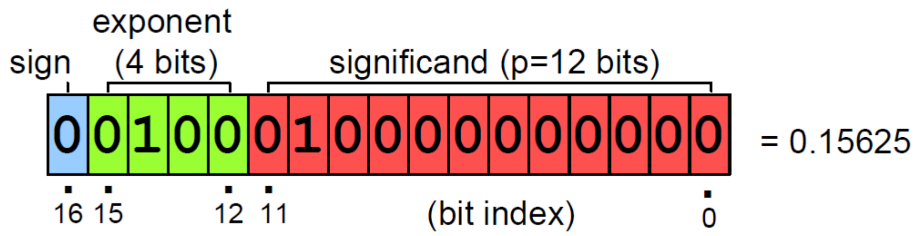

Figure 23 Encoding layout of N-bit (17) bit floating point numbers, example, precision 13 bits

All parameters needed to define the N-bit floating point number in HDF5 need to be set by the defining user: sign-position, exponent-size, -position and -bias, significand-size and -position.

8.14.8.2 Determining the needed exponent size automatically

The exponent size can be determined automatically and optimally based on the data represented in the data array.

The number of normalized floating-point numbers in a system F (*B*, *P*, *L*, *U*) (where *B* is the base of the system, *P* is the precision of the system to *P* numbers, *L* is the smallest exponent representable in the system, and *U* is the largest exponent used in the system) is [RD-5]:

$$\mathbf{2(B-1)(B^{P-1})(U-L+1)+1} \qquad \textbf{(1)}$$

There is a smallest positive normalized floating-point number, Underflow level = $\boldsymbol{UFL = B^L}$ which has a 1 as the leading digit and 0 for the remaining digits of the significand, and the smallest possible value for the exponent.

There is a largest floating-point number, Overflow level = $\boldsymbol{OFL = (1 - B^{-P})(B^{U+1})}$ which has $\boldsymbol{B-1}$ as the value for each digit of the significand and the largest possible value for the exponent.

Given Range of values $[|\boldsymbol{a}|; |\boldsymbol{b}|]$; $\boldsymbol{a}$ is the smallest number to be represented, $\boldsymbol{b}$ the largest; $\boldsymbol{B}$ = ***2*** (binary representation).
$\boldsymbol{L}$ and $\boldsymbol{U}$ to be determined based on given $[|\boldsymbol{a}|; |\boldsymbol{b}|]$.

$$\boldsymbol{UFL = 2^L = a;\;\; L = \log_2(a)} \qquad \textbf{(2)}$$

$$\boldsymbol{OFL = (1 - 2^{-P}) * (2^{U+1}) = b;\;\; U = \log_2\left(\frac{b}{1-2^{-P}}\right) - 1} \qquad \textbf{(3)}$$

<u>Determine exponent-bias:</u>
The exponent bias is used to give the maximum possible range in the exponent, it can be used to shifts the exponent by the minimum exponent.
<u>Example:</u>
[1.0E-9; 1.6E-2] shall be represented optimally. Using (2) and (3) we get L=-29.897 and U=-6.943.
Thus, a range of exponents from -30 to -6, i.e. 25 different exponents, is needed. Additionally, two special meaning exponents are required by IEEE 754. The 27 exponents needed can be encoded with 5 bits. The exponent bias used here is -31.

8.14.8.3 Determining the needed significand size

In contrast to the exponent size the significand size cannot be automatically determined; it needs to be given based on the numerical accuracy required.
For example, the VIIRS Day and Night Band (DNB) senses the data on-board with a resolution of 12 bit (low gain state) to 14 bit (high gain state) and specifies a calibration uncertainty between 5% (one half of maximum radiance for low gain state) and 100% (minimum radiance for high gain state). The dynamic range of the panchromatic DNB is 3.0E-9 Watt cm-2 sr-1 to at least 2.0E-2 Watt cm-2 sr-1, divided roughly equally over the 3 gain stages. Each gain state covers approx. a range of 300 numbers, encoded in 12 to 14 bits. The minimum resolution is thus ~0.018.
The maximum relative spacing (epsilon) for a given significand is $2^{-Precision}$,
e.g. 6 bits: epsilon = 2^{-6} = 0.015625, maximum error = +/- 2^{-7} = +/-0.0078125
8 bits: epsilon = 2^{-8} = 0.00390625, maximum error = +/- 2^{-9} = +/-0.001953125
For the mentioned example, a significand of 8 bits can thus be used without losing information.

8.14.8.4 Applying Custom Floating Point Numbers

The radiance data set is read into a 32-bit floating point array. The optimum exponent size is determined by applying formulas (2) and (3) to the detected range of values (min, max of absolute values) within the data array. A user specific data type is created following the examples given in the HDF5 User's Guide [RD-3]. When the data is written to disk, the new data type applying the N-Bit filter is used.

8.14.8.4.1 Radiance float coefficients for Day-Night Band

Custom floating points with a dynamically determined exponent size based on the min and max of the data present in the dataset is applied only if aggregations of 1 granule are processed. For any aggregation with more than one granule, custom Floating Points Numbers with a fixed size of 8 bits exponents and an exponent bias of 127 are used.

8.14.8.5 Fill Values

For Floating Point numbers in the Radiance dataset, the Fill Values in the VIIRS SDR formats are defined according to [AD-2] and are in the range of -999.2 to -999.9.
With the standard 32 bit Floating Point numbers, those Fill Value numbers can be properly encoded. However, with the tailored Floating Point numbers used for the Radiance dataset in the Observation data, due to the shorter mantissa size (8 bits instead of 23 bits), those fill values cannot be encoded properly anymore.
Thus, the Compact VIIRS SDR for the DNB stores the Fill Values as different numbers, Table 22.

Table 22 Fill Values mapping between Original VIIRS DNB SDR and Compact VIIRS DNB SDR for Radiance Dataset

Fill Values used for the Radiance dataset in the Original VIIRS DNB SDR, F_O	Fill Values used for the Radiance dataset in the Compact VIIRS DNB SDR, F_C
-999.9	-99
-999.8	-98
-999.7	-97
-999.6	-96
-999.5	-95
-999.4	-94
-999.3	-93
-999.2	-92

The following formulas can be used to convert the Fill Values between the Original and the Compact VIIRS DNB SDR for the Radiance Dataset:
$F_C = F_O * 10 + 9900$
$F_O = (F_C - 9900)/10$

8.15 Visible channels Radiance to Reflection conversion

In the original VIIRS SDR, both, radiances and the associated reflectances are stored. The reflectances for all 11 visible channels are represented by 16-bit integer counts. The reflectance conversion is performed with a slope value that can in principle be channel dependent, but is the same for all channels.

If the radiance value L matches one of the floating point Fill Values defined in Table 25, then set r to this floating point Fill Value.

If the solar zenith angle Θ_{sol} is greater or equal than π/2, then set the value of r to the Fill Value NA_FLOAT32_FILL defined in Table 25.

Else, convert the radiance value *L* to a reflectance value *r* the using the following formula

$$r = \frac{\pi\, L}{cos(\Theta_{sol})} \frac{\int \Phi(\lambda) d\lambda}{\int \Phi(\lambda) E_{sun}(\lambda) d\lambda} \; d_{se}^2 = \frac{\pi\, L}{cos(\Theta_{sol})} \frac{A_{vis}}{B_{vis}} \; d_{se}^2$$

where λ is the channel wavelength, $\Phi(\lambda)$ the response function and $E_{sun}(\lambda)$ *the* Spectral solar irradiance (W m^{-2} μm^{-1}).
If the resulting r is greater than the Fill Value NA_FLOAT32_FILL defined in Table 25, or if the calculation of *r* otherwise fails, then set the value of *r* to the Fill Value ERR_FLOAT32_.
.

The parameters required for the actual calculation of the reflectance are:

Table 23 Parameters used fir Reflectance calculation

	Description	Reference
Θ_{sol}	Actual solar zenith angle (rad)	Included in Compact VIIRS SDR at tie-points, see section 4.1. Interpolation required for reconstructing value for each pixel, see section 6.1.
A_{vis}	Equivalent width (µm)	Included in the Compact VIIRS SDR, see section 4.2.1. Typical values are provided in Table 38.
B_{vis}	Band-integrated solar irradiance (W m^{-2})	
d_{se}	Relation between the mean and the actual Earth-Sun distance (Unitless)	Included in the Compact VIIRS SDR, see section 4.2.1. Given the Julian Day D_{Jul} of the Year (0-366), the actual value of d_{se} is $d_{se} = 1 - 0.01673 \cdot cos\left[0.9856\,(D_{Jul} - 4)\,{}^{\pi}/_{180}\right]$

8.16 Infrared channels Radiance to Brightness Temperature conversion

Once calibrated Earth view radiances *L* have been computed, the calculation of the equivalent blackbody temperature, henceforth referred to as brightness temperature *T*, will be performed by a single equation:

$$T = \left[\frac{hc}{k\,\lambda_c \ln\left(1 + \frac{2hc^2}{\lambda_c^5\,L_{ir}}\right)}\right] \cdot A_{ir} + B_{ir}$$

where L must be given in W/(m2 sr m) and not in W/(m2 sr µm). If the calculation of *T* fails, then set the value of *T* to the Fill Value ERR_FLOAT32_FILL defined in Table 25.

The parameters required for the actual calculation of the brightness temperature are:

Table 24 Parameters used fir Brightness Temperature calculation

	Description	Reference
λ_c	Central wavelength (m)	Included in the Compact VIIRS SDR, see section 4.2.1. Typical values are provided in Table 40, in section 10.3.
A_{ir}	Band Correction Coefficient (Unitless)	
B_{ir}	Band Correction Coefficient (K)	
c	Speed of Light (m s^{-1})	299792458 m s^{-1}
h	Planck constant (m^2 kg s^{-1})	6.6260755 10^{-34} m^2 kg s^{-1}

k	Boltzmann constant (m^2 kg s^{-2} K^{-1})	1.380658 10^{-23} m^2 kg s^{-2} K^{-1}

8.17 Reflectance Conversion from Floating Point to Integer

When reconstructing the Original VIIRS SDR product from the Compact VIIRS SDR product, the floating point reflectance L must be converted to the integer reflectance value C.

If L matches one of the floating point Fill Values defined in Table 25, then set *r* to the corresponding integer Fill Value.

Else, the integer value is calculated as follows:

$$r = nint\left\{\frac{L - a_{reflectance}}{b_{reflectance}}\right\}$$

where the offset $a_{refelctance}$ and the scale factor $b_{reflectance}$ used in the Original SDR are included in the Compact SDR, section 4.2.1.

If the calculation of *r* fails, then set the value of *r* to the Fill Value ERR_UINT16_FILL defined in Table 25.

If the computed integer *r* is outside the range $0 \leq C \leq 65527$, then set *r* to the Fill Value SOUB_UINT16_FILL defined in Table 25, indicating that the scaling is out of bounds.

If the computed integer *r* is in the range $-100 \leq r < 0$, then set $r=0$ in order to handle values that fall below zero by a small amount.

8.18 Brightness Temperature Conversion from Floating Point to Integer

When reconstructing the Original VIIRS SDR product from the Compact VIIRS SDR product, the floating point brightness temperature *L* must be converted to the integer brightness temperature value *T*.

If *L* matches one of the floating point Fill Values defined in Table 25, then set *T* to the corresponding integer Fill Value.

Else, the integer value is calculated as follows:

$$T = nint\left\{\frac{L - a_{bt}}{b_{bt}}\right\}$$

where the offset a_{bt} and the scale factor b_{bt} used in the Original SDR are included in the Compact SDR, section 4.2.1.

If the calculation of T fails, then set the value of T to the Fill Value ERR_UINT16_FILL defined in Table 25.

If the computed integer T is outside the range $0 \leq C \leq 65527$, then set T to the Fill Value SOUB_UINT16_FILL defined in Table 25, indicating that the scaling is out of bounds.

9 FILL, MODE AND QUALITY FLAG VALUES

9.1 VIIRS Pixel Level Fill Values

A summary of the Pixel Level Fill Values relevant to the Compact VIIRS SDR product format is provided in Table 25, below. For a full definition of Fill Values see section 3.5.6 of [AD-1] in combination with section 2.16 of [AD-2].

Table 25 Summary of the Pixel Level Fill Values relevant to the Compact VIIRS SDR product format.

Pixel Level	Definition	Values	
Algorithm Exclusions	The pixel/cell was not computed because it is not applicable to this situation (i.e., NA is the correct answer)	NA_FLOAT32_FILL	-999.9
		NA_UINT16_FILL	65535
Missing at Time of Processing	C3S provided a fill value, the S/C did not provide the value, or AP missing	MISS_FLOAT32_FILL	-999.8
		MISS_UINT16_FILL	65534
Onboard Pixel Trim	The VIIRS pixel was trimmed on the S/C (e.g., overlap omitted)	ONBOARD_PT_FLOAT32_FILL	-999.7
		ONBOARD_PT_UINT16_FILL	65533
On-ground Pixel Trim	The VIIRS pixel was trimmed during processing (i.e., we intentionally chose not to process the pixel)	ONGROUND_PT_FLOAT32_FILL	-999.6
		ONGROUND_PT_UINT16_FILL	65532
Cannot Calculate	The algorithm could not compute the pixel/cell because of a software or hardware problem (e.g., could not converge to a solution)	ERR_FLOAT32_FILL	-999.5
		ERR_UINT16_FILL	65531
Ellipsoid Intersection Failed	The observation does not intersect the earth's surface This is an indication of a calibration manoeuvre.	ELINT_FLOAT32_FILL	-999.4
		ELINT_UINT16_FILL	65530
Value Does Not Exist	The data was not available - it is not missing, nor is any attempt made to calculate the data	VDNE_FLOAT32_FILL	-999.3
		VDNE_UINT16_FILL	65529
Scaling Out Of Bounds	The scaled data was out of bounds of the data type	SOUB_FLOAT32_FILL	-999.2
		SOUB_UINT16_FILL	65528

9.2 Other VIIRS Fill Values

A summary of the other VIIRS Fill Values relevant to the Compact VIIRS SDR product format is provided in Table 26, below. For a full definition of Fill Values see section 3.5.6 of [AD-1] in combination with section 2.16 of [AD-2].

Table 26 Summary of the other VIIRS Fill Values relevant to the Compact VIIRS SDR product format.

Data set	Definition	Values	
NumberOfMissingPkts	Number of missing packets in scan	MISS_INT32_FILL	-998
		VDNE_INT32_FILL	-993
NumberOfBadChecksums	Number of packets with bad checksums in scan	MISS_INT32_FILL	-998
		VDNE_INT32_FILL	-993
NumberOfDiscardedPkts	Number of discarded packets in scan	MISS_INT32_FILL	-998
		VDNE_INT32_FILL	-993

9.3 VIIRS Mode Values

A summary of the Mode Values relevant to the Compact VIIRS SDR product format is provided in the tables below. For a full definition of Mode Values see section 2.16 of [AD-2].

Table 27 ModeScan Values.

Description	Datum Offset	Data Type	Legend Entries	
The VIIRS operational mode, reported at the scan level	0	8 bits	Name	Value
			Night	0
			Day	1
			Fill Values	
			MISS_UINT8_FILL	254
			ERR_UINT8_FILL	251
			VDNE_UINT8_FILL	249

Table 28 ModeGran Values.

Description	Datum Offset	Data Type	Legend Entries	
The VIIRS operational mode, reported at the granule level	0	8 bits	Name	Value
			Night	0
			Day	1
			Mixed	2
			Fill Values	
			MISS_UINT8_FILL	254
			ERR_UINT8_FILL	251
			VDNE_UINT8_FILL	249

9.4 VIIRS Quality Flag Values

A summary of the Quality Flag Values relevant to the Compact VIIRS SDR product format is provided in the tables below. For a full definition of Quality Flag Values see section 2.16 of [AD-2].

Table 29 QF1_SCAN_VIIRSSDRGEO Quality Flag Values.

Description	Datum Offset	Data Type	Legend Entries	
Attitude and Ephemeris availability status	0	2 bits	Name	Value
			Nominal - E&A data available	0
			Missing Data <= Small Gap	1
			Small Gap < Missing Data < Granule Boundary	2
			Missing Data >= Granule Boundary	3
HAM/RTA Encoder Flag - Indicates the quality of the HAM and RTA encoder timestamps	2	2 bits	Name	Value
			Good Data	0
			Bad Data - either HAM, RTA, or both are bad for the entire scan	1
			Degraded Data - either HAM, RTA, or both are corrupted within the scan	2
			Missing Data - Missing encoder data for the scan	3
Within South Atlantic Anomaly	4	1 bit	Name	Value
			False	0
			True	1
Solar Eclipse during Earth view scan	5	1 bit	Name	Value
			False	0
			True	1
Spare	6	1 bit	Name	Value
Half Angle Mirror side	7	1 bit	Name	Value
			Mirror Side A	0
			Mirror Side B	1

Table 30 QF2_SCAN_VIIRSSDRGEO Quality Flag Values.

Description	Datum Offset	Data Type	Legend Entries	
Scan Controller Electronics (SCE) Side	0	2 bits	Name	Value
			Both sides off	0
			Side A on	1
			Side B on	2
			Invalid side [This state should not occur]	3

Spare	2	6 bits	Name	Value

Table 31 QF2_VIIRSSDRGEO Quality Flag Values.

Description	Datum Offset	Data Type	Legend Entries	
Invalid Input Data (Indicates that any of the Spacecraft Ephemeris or Attitude Data is Invalid or the encoder data is invalid).	0	1 bit	Name	Value
			False	0
			True	1
Bad Pointing (Indicates that the sensor LOS does not intersect the geoid or is near the limb based upon sensor zenith angle.)	1	1 bit	Name	Value
			False	0
			True	1
Bad Terrain (Indicates that the algorithm could not obtain a valid terrain value)	2	1 bit	Name	Value
			False	0
			True	1
Invalid Solar Angles:	3	1 bit	Name	Value
			False	0
			True	1
Spare	4	4 bit	Name	Value

Table 32 QF1_VIIRSMBANDSDR, QF1_VIIRSIBANDSDR and QF1_VIIRSDNBSDR Quality Flag Values.

Description	Datum Offset	Data Type	Legend Entries	
Quality - Indicates calibration quality due to bad space view offsets, OBC view offsets, etc or use of a previous calibration view:	0	2 bits	Name	Value
			Good	0
			Poor	1
			No Calibration	2
Saturated Pixel - Indicates the level of pixel saturation:	2	2 bits	Name	Value
			None Saturated	0
			Some Saturated	1
			All Saturated	2
Missing Data - Data required for calibration processing is not available for processing:	4	2 bits	Name	Value
			All data present	0
			EV RDR data missing	1
			Cal data (SV, CV, SD, etc.) missing	2
			Thermistor data missing	3
Out of Range - Calibrated	6	2 bits	Name	Value

pixel value outside of LUT threshold limits:			All data within range	0
			Radiance out of range	1
			Reflectance or EBBT out of range	2
			Both Radiance and Reflectance or EBBT out of range	3

Table 33 QF2_SCAN_SDR Quality Flag Values.

Description	Datum Offset	Data Type	Legend Entries	
Half Angle Mirror Side	0	1 bit	Name	Value
			Side A on	0
			Side B on	1
The Moon has corrupted the space view	1	1 bit	Name	Value
			False	0
			True	1
Spare	2	6 bits	Name	Value

Table 34 QF3_SCAN_RDR Quality Flag Values.

Description	Datum Offset	Data Type	Legend Entries	
Checksum failed for zone 1	0	1 bit	Name	Value
			False	0
			True	1
Checksum failed for zone 2	1	1 bit	Name	Value
			False	0
			True	1
Checksum failed for zone 3	2	1 bit	Name	Value
			False	0
			True	1
Checksum failed for zone 4	3	1 bit	Name	Value
			False	0
			True	1
Checksum failed for zone 5	4	1 bit	Name	Value
			False	0
			True	1
Checksum failed for zone 6	5	1 bit	Name	Value
			False	0
			True	1
Scan data is not Present (No valid Data)	6	1 bit	Name	Value
			False	0

			True	1
Spare	7	1 bit	Name	Value

Table 35 QF4_SCAN_SDR Quality Flag Values.

Description	Datum Offset	Data Type	Legend Entries	
Quality for this scan-line is reduced. The value is determined by the combined number of steps required to find a replacement for thermistor or calibration source data	0	un-signed 8 bit	Name	Value
			False	0
			True	>1

Table 36 QF5_GRAN_BAD_DETECTOR Quality Flag Values.

Description	Datum Offset	Data Type	Legend Entries	
Bad Detector - M-Band	0	1 bit	Name	Value
			False	0
			True	1
Spare	1	7 bits	Name	Value

10 PARAMETER VALUES

10.1 Tie Point Zone Parameter Values

The tie point zone parameters listed in Table 37 below are contained within the Compact VIIRS SDR, see Table 9 and Table 13, and their values are VIIRS specific constants.

When generating a Compact VIIRS SDR Product it shall be populated with the tie point zone parameters values listed in the Table 37 below.

When reading a Compact VIIRS SDR Product or reconstructing an original VIIRS SDR Product from a Compact VIIRS SDR Product, the tie point zone parameters shall be read from the Compact VIIRS SDR Product itself.

Table 37 Tie point zone parameter values

Dataset/Attribute Name	Type (DS=Dataset of VIIRS-*Band*-GEO_All, A=Attribute of VIIRS-*Ch*-*SDR_All*)	Description	Symbol	Value		
				M-Band	I-Band	DNB
NumberOfTiePointZoneGroupsTrack	DS	Number of Tie Point Zone Groups in the Track direction	$N_{groups,track}$	1	1	1
NumberOfTiePointZoneGroupsScan	DS	Number of Tie Point Zone Groups in the Scan direction	$N_{groups,scan}$	1	1	64
NumberOfTiePointZonesTrack	DS	Number of Tie Point Zones in the Track direction	$N_{zones,track}$	1	1	1
NumberOfTiePointZonesScan	DS	Number of Tie Point Zones in the Scan direction	$N_{zones,scan}$	200	200	5, 1, 4, 4, 4, 2, 1, 3, 2, 4, 2, 3, 2, 3, 2, 3, 3, 3, 5, 4, 5, 4, 4, 4, 4, 4, 3, 5, 3, 4, 3, 23, 23, 3, 4, 3, 5, 3, 4, 4, 4, 4, 4, 5, 4, 5, 3, 3, 3, 2, 3, 2, 3, 2, 4, 2, 3, 1, 2, 4, 4, 4, 1, 5
TiePointZoneSizeTrack	A	Size of the Tie Point Zone in the Track direction	Z_{track}	16	32	16
TiePointZoneSizeScan	A	Size of the Tie Point Zone in the Scan direction	Z_{scan}	16	32	16, 16, 16, 16, 16, 16, 24, 24, 20, 14, 20, 16, 16, 16, 16, 24, 24, 24, 16, 14, 16, 16, 16, 16, 16, 16, 24, 16, 24, 22, 24, 8, 8, 24, 22, 24, 16, 24, 16, 16, 16, 16, 16, 16, 14, 16, 24, 24, 24, 16, 16, 16, 16, 20, 14, 20, 24, 24, 16, 16, 16, 16, 16, 16
PixelOffsetTrack	A	Offset in Track direction of Pixel [0,0] centre relative to Tie Point A	$p_{offset, track}$	0.5	0.5	0.5
PixelOffsetScan	A	Offset in Scan direction of Pixel	$p_{offset, scan}$	0.5	0.5	0.5

Dataset/Attribute Name	Type (DS=Dataset of VIIRS-*Band*-GEO_All, A=Attribute of VIIRS-*Ch*-*SDR_All*)	Description	Symbol	Value		
				M-Band	I-Band	DNB
		[0,0] centre relative to Tie Point A				
TiePointZone GroupLocation TrackCompact	DS	Location in the compact data set of the corner of each Tie Point Zone Group in the Track Direction	$P_{track,compact}$	0	0	0
TiePointZone GroupLocation ScanCompact	DS	Location in the compact data set of the corner of each Tie Point Zone Group in the Scan Direction	$P_{scan,compact}$	0	0	0, 6, 8, 13, 18, 23, 26, 28, 32, 35, 40, 43, 47, 50, 54, 57, 61, 65, 69, 75, 80, 86, 91, 96, 101, 106, 111, 115, 121, 125, 130, 134, 158, 182, 186, 191, 195, 201, 205, 210, 215, 220, 225, 230, 236, 241, 247, 251, 255, 259, 262, 266, 269, 273, 276, 281, 284, 288, 290, 293, 298, 303, 308, 310
TiePointZone GroupLocation Track	A	Location in the expanded data set of the corner of each Tie Point Zone Group in the Track Direction	P_{track}	0	0	0
TiePointZone GroupLocation Scan	A	Location in the expanded data set of the corner of each Tie Point Zone Group in the Scan Direction	P_{scan}	0	0	0, 80, 96, 160, 224, 288, 320, 344, 416, 456, 512, 552, 600, 632, 680, 712, 784, 856, 928, 1008, 1064, 1144, 1208, 1272, 1336, 1400, 1464, 1536, 1616, 1688, 1776, 1848, 2032, 2216, 2288, 2376, 2448, 2528, 2600, 2664, 2728, 2792, 2856, 2920, 3000, 3056, 3136, 3208, 3280, 3352, 3384, 3432, 3464, 3512, 3552, 3608, 3648, 3720, 3744, 3776, 3840,

Dataset/Attribute Name	Type (DS=Dataset of VIIRS-*Band*-GEO_All, A=Attribute of VIIRS-*Ch*-*SDR_All*)	Description	Symbol	Value		
				M-Band	I-Band	DNB
						3904, 3968, 3984

10.2 Typical Reflectance Parameter Values

The reflectance parameters listed in Table 38 below are contained within the Compact VIIRS SDR, see Table 12, and are required for the conversion from radiance to reflectance. The values in the table are typical values provided for information and the optimal values for operational use may differ, e.g. in response to changed instrument characteristics or settings.

When generating a Compact VIIRS SDR Product it shall be populated with the appropriate operational reflectance parameters values, see also Table 17, Step 16.

When reading a Compact VIIRS SDR Product or reconstructing an original VIIRS SDR Product from a Compact VIIRS SDR Product, the reflectance parameters shall be read from the Compact VIIRS SDR Product itself, see Table 20, Step 15.

Table 38 Equivalent width and band-integrated solar irradiance for the 11 VIIRS visible M-Band channels

VIIRS Channel	EquivalentWidth A_{vis} µm	IntegratedSolarIrradiance B_{vis} W m^{-2}
M1	0.1979783550E-01	33.83940249
M2	0.1430752221E-01	26.66728877
M3	0.1900157705E-01	37.98883065
M4	0.2093922533E-01	39.14834573
M5	0.1996985823E-01	30.56515889
M6	0.1459505595E-01	18.69858623
M7	0.3869968280E-01	37.24469424
M8	0.2712116949E-01	12.38904874
M9	0.1500406861E-01	5.398250081
M10	0.5875030532E-01	14.41161119
M11	0.4669837281E-01	3.506045974
I1	0.080	130.4500003
I2	0.039	37.57360035
I3	0.060	14.73727253

10.3 Typical Brightness Temperature Parameter Values

The brightness temperature parameters listed in the table below are contained within the Compact VIIRS SDR, see Table 12, and are required for the conversion from radiance to brightness temperature. The values in the table are typical values provided for information and the optimal values for operational use may differ, e.g. in response to changed instrument characteristics or settings.

When generating a Compact VIIRS SDR Product it shall be populated with the appropriate operational brightness temperature parameters values, see also Table 17, Step 20.

When reading a Compact VIIRS SDR Product or reconstructing an original VIIRS SDR Product from a Compact VIIRS SDR Product, the brightness temperature parameters shall be read from the Compact VIIRS SDR Product itself, see Table 20, Step 20.

Table 39 Coefficients used for the central wavelengths and the band corrections to convert Earth view radiances to brightness temperatures

VIIRS Channel	CentralWaveLength λ_c m	BandCorrection CoefficientA A_{ir} Unitless	BandCorrection CoefficientB B_{ir} K
M12	3.692118094E-6	1.000869385	-0.637890868
M13	4.063950468E-6	1.000524131	-0.338046119
M14	8.574690139E-6	1.000666830	-0.201236951
M15	10.68610341E-6	1.004393762	-1.049491534
M16	11.81466532E-6	1.003041012	-0.649809876
I4	3.740000E-6	1.003471	-1.923757
I5	11.450000E-6	1.003843	-0.655337

10.4 Typical Radiance Range Values

In the original VIIRS SDR product format radiances are stored using a 32 bit floating point representation for the channels M3, M4, M5, M7 and M13. In order to convert these floating point radiances into the dual gain representation used in the Compact VIIRS SDR, the appropriate offsets a_{low} and a_{high} and scale factors b_{low} and b_{high} are required. These can be computed as described in section 8.14.1 using the radiance range values provided in the table below. The values in the table are typical values provided for information and the optimal values for operational use may differ, e.g. in response to changed instrument characteristics or settings.

The floating point radiance values L_{min} and L_{max} define the range of radiance values covered by the dual scale representation. The corresponding range of integer values available for the dual scale representation is defined by the integers C_{min} and C_{max}. The threshold $L_{threshold}$ determines if floating point radiance will be assigned to the low or to the high part of the dual gain representation. Finally $C_{threshold}$ defines the range of integers assigned to the low and to the high part of the dual gain representation. See section 8.14 for further details.

When generating a Compact VIIRS SDR Product it shall be populated with the appropriate operational offsets a_{low} and a_{high}, scale factors b_{low} and b_{high} and threshold $C_{threshold}$ values, see also Table 17, Step 14.

When reading a Compact VIIRS SDR Product or reconstructing an original VIIRS SDR Product from a Compact VIIRS SDR Product, the offsets a_{low} and a_{high}, scale factors b_{low} and b_{high} and threshold $C_{threshold}$ parameters values shall be read from the Compact VIIRS SDR Product itself, see also Table 20 Step 7.

Table 40 Typical Radiance Range Values for M3, M4, M5, M7 and M13.

Channel	C_{min} Minimum Integer Radiance -	$C_{threshold}$ Threshold Integer Radiance -	C_{max} Maximum Integer Radiance -	L_{min} Minimum Floating Point Radiance W m^{-2} sr^{-1} µm^{-1}	$L_{threshold}$ Minimum Floating Point Radiance W m^{-2} sr^{-1} µm^{-1}	L_{max} Maximum Floating Point Radiance W m^{-2} sr^{-1} µm^{-1}
M3	1	32767	65527	-0.250	107.000	900.000
M4	1	32767	65527	-0.200	78.000	850.000
M5	1	32767	65527	-0.200	59.000	830.000
M7	1	32767	65527	-0.100	29.000	460.000
M13	1	32767	65527	-0.020	3.537	660.000

10.5 Typical Radiance Representation Conversion Parameter Values

For information Table 41 provides a summary of offset and scale factors with corresponding integer and floating point ranges and thresholds for the dual gain representation of the Compact VIIRS SDR format.

For the channels M3, M4, M5, M7 and M13 the range and threshold values are taken from Table 40 and the corresponding offset and scale factors are computed from these according to the formulas in section 8.14.1.

For the remaining channels, the offset and scale factors have been extracted from operational original VIIRS SDR products and the corresponding range and threshold values are computed from these according to the formulas in section 8.14.

Table 41 Offset and scale factors with corresponding integer and floating point ranges and thresholds for the dual gain representation of the Compact VIIRS SDR format.

Channel	a_{low} Radiance Offset Low (W m^{-2} sr^{-1} µm^{-1})	b_{low} Radiance Scale Low (W m^{-2} sr^{-1} µm^{-1})	a_{high} Radiance Offset High (W m^{-2} sr^{-1} µm^{-1})	b_{high} Radiance Scale High (W m^{-2} sr^{-1} µm^{-1})	C_{min} Minimum Integer Radiance (-)	$C_{threshold}$ Threshold Integer Radiance (-)	C_{max} Maximum Integer Radiance (-)	L_{min} Minimum Floating Point Radiance (W m^{-2} sr^{-1} µm^{-1})	$L_{threshold}$ Minimum Floating Point Radiance (W m^{-2} sr^{-1} µm^{-1})	L_{max} Maximum Floating Point Radiance (W m^{-2} sr^{-1} µm^{-1})
M1	-0.210000	0.01126574	-0.210000	0.01126574	0	0	65527	-0.210	-0.210	738.000
M2	-0.200000	0.01258413	-0.200000	0.01258413	0	0	65527	-0.200	-0.200	824.400
M3	-0.253273	0.00327321	-686.169444	0.02420635	1	32767	65527	-0.250	107.000	900.000
M4	-0.202387	0.00238662	-694.164957	0.02356532	1	32767	65527	-0.200	78.000	850.000
M5	-0.201807	0.00180675	-712.164744	0.02353480	1	32767	65527	-0.200	59.000	830.000
M6	-0.090000	0.00091703	-0.090000	0.00091703	0	0	65527	-0.090	-0.090	60.000
M7	-0.100888	0.00088812	-402.092094	0.01315629	1	32767	65527	-0.100	29.000	460.000
M8	-0.140000	0.00302196	-0.140000	0.00302196	0	0	65527	-0.140	-0.140	197.880
M9	-0.090000	0.00141331	-0.090000	0.00141331	0	0	65527	-0.090	-0.090	92.520
M10	-0.040000	0.00130450	-0.040000	0.00130450	0	0	65527	-0.040	-0.040	85.440
M11	-0.020000	0.00058266	-0.020000	0.00058266	0	0	65527	-0.020	-0.020	38.160
M12	0.000000	0.00005173	0.000000	0.00005173	0	0	65527	0.000	0.000	3.390
M13	-0.020109	0.00010856	-653.066270	0.02003855	1	32767	65527	-0.020	3.537	660.000
M14	-0.030000	0.00032155	-0.030000	0.00032155	0	0	65527	-0.030	-0.030	21.040
M15	-0.020000	0.00031315	-0.020000	0.00031315	0	0	65527	-0.020	-0.020	20.500
M16	-0.020000	0.00026554	-0.020000	0.00026554	0	0	65527	-0.020	-0.020	17.380
I1	-0.410000	0.01315504	-0.410000	0.01315504	0	0	65527	-0.410	-0.410	861.600
I2	-0.240000	0.00639492	-0.240000	0.00639492	0	0	65527	-0.240	-0.240	418.800
I3	-0.210000	0.00133090	-0.210000	0.00133090	0	0	65527	-0.210	-0.210	87.000
I4	-0.010000	0.00005524	-0.010000	0.00005524	0	0	65527	-0.010	-0.010	3.610

I5	-0.080000	0.00028340	-0.080000	0.00028340	0	0	65527	-0.080	-0.080	18.490

APPENDIX A: *Abbreviations*

AD	Applicable Document
ATBD	Algorithmic Theoretical Baseline Document
CADU	Channel Access Data Unit
CCSDS	Consultative Committee for Space Data Systems
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CSPP	Community Satellite Processing Package
CVIIRS	EUMETSAT tool for compacting and expanding VIIRS data
DNB	Day and Night Band
DS	Dataset
EARS	EUMETSAT Advanced Retransmission Service
EUMETCast	EUMETSAT's DVB S2 satellite broadcasting system
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FPA	Focal Plane Array
GTS	Global Telecommunication System
HAM	Half Angle Mirror
HDF	Hierarchical Data Format
ID	Identifier
JPSS	Joint Polar Satellite System
LUT	Lookup Table
NA	Not Available
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NPP	(Suomi) National Polar-orbiting Partnership
PDF	Portable Data Format
PPN	Product Processing Node
RD	Reference Document
RDR	Raw Data Record
RT-STPS	Real-time Software Telemetry Processing System
SCE	Scan Controller Electronics
SDR	Sensor Data Record
TC	Terrain Corrected
TOA	Top of Atmosphere
TPZ	Tie Point Zone
VIIRS	Visible Infrared Imager Radiometer Suite