User Guide for GOES-R Imagery on the NOAAPort Satellite Broadcast Network

Version 0.3

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Table of Contents

List of Figures

List of Tables

1.0 PURPOSE

The first of the new GOES-R satellite series is scheduled for launch on October 14, 2016. The National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) will broadcast certain Geostationary Operational Environmental Satellites-R Series (GOES-R) imagery on the NOAAPort Satellite Broadcast Network (SBN). Users with NOAAPort receive equipment, within the broadcast footprint of the NOAAPort satellite, will be able to ingest and utilize this data. In addition, users who subscribe to third-party redistributors of NOAAPort SBN data may also have access to the data. This document describes the format of the GOES-R imagery that will be broadcast on the NOAAPort SBN. This document covers only the format of the NOAAPort SBN GOES-R imagery products. This document does not cover other GOES-R or non-GOES-R products on the NOAAPort SBN.

2.0 BACKGROUND

NOAA operates a constellation of GOES satellites to provide continuous weather imagery and monitoring of meteorological and space environment data for the protection of life and property across the United States. GOES satellites provide critical atmospheric, oceanic, climatic and space weather products supporting weather forecasting and warnings, climatologic analysis and prediction, ecosystems management, safe and efficient public and private transportation, and other national priorities. Today, two legacy GOES satellites are operational: GOES East at 75 degrees west and GOES West at 135 degrees west longitude. Together, these two satellites provide coverage for the eastern United States and most of the Atlantic Ocean, and the western United States and Pacific Ocean basin. In addition, an on-orbit spare is in storage at 105 degrees west longitude.

NOAA's current plans call for GOES-R to be initially positioned at 89.5 degrees west longitude, with GOES-R Post-Launch Tests (PLTs) conducted with the satellite in this position. GOES-R product activations will take place over a several-week or several-month period, beginning with the GRB activation currently scheduled for approximately January 2017. As described below, the activation of GOES-R imagery on the NOAAPort SBN is expected to take place within a few weeks after the GOES-R GRB activation. The above-mentioned PLTs will extend through at least the first half of 2017.

The longer-term plans for GOES-R (after September 2017) are less clear. The satellite might be placed into storage (on-orbit spares are typically stored near 105 degrees west longitude) or in the GOES East or West position (which, for GOES-R, will be either 75 degrees west or 137 degrees west longitude). As the GOES-R satellite transitions toward operations, information about it will be posted at the following NOAA web page:

http://www.ospo.noaa.gov/Operations/GOES/status.html

The primary GOES-R earth-pointing instrument is the Advanced Baseline Imager (ABI) that provides full disk, CONtinental United States (CONUS), and mesoscale imagery for weather monitoring, analysis, forecasting and warning. The GOES-R imagery planned for NOAAPort SBN dissemination is ABI imagery of a particular format, sometimes referred to Sectorized Cloud and Moisture Imagery (SCMI). The GOES-R Geostationary Lightning Mapper (GLM) is another important earth-pointing instrument that will provide lightning information. There are also the following non-earth-pointing GOES-R instruments: Extreme ultraviolet and Xray Irradiance Sensor (EXIS), Solar Ultraviolet Imager (SUVI), Space Environment In-Situ Suite (SEISS) and Magnetometer (MAG). Additionally, GOES-R provides a set of communications services (Unique Payload Services) in support of the Data Collection System (DCS), High-Rate Information Transmission/Emergency Managers Weather Information Network (HRIT/EMWIN), and Search-and-Rescue Satellite Aided Tracking (SARSAT). This document focuses on the GOES-R series SCMI products.

The NOAAPort SBN consists of approximately nine channels, including two channels that were expressly established in 2014 in anticipation for GOES-R imagery: the GOES West channel (ID=GRW, PID=107) and the GOES East channel (ID=GRE, PID=108). Prior to the activation of actual GOES-R imagery on the NOAAPort SBN, simulated GOES-R imagery will be broadcast on these channels (in variable test modes). As the future plans for GOES-R become clearer (in particular, with respect to its eventual position, east or west, as a future-operational GOES satellite), a decision will be made and publicized on the NOAAPort Users Page about the specific channel of the NOAAPort SBN that will be used for the dissemination of actual GOES-R SCMI in operations (i.e., either the NOAAPort SBN's GOES East or West channel).

Because of the criticality of GOES-R imagery to the NWS forecast process and to NOAA's partners, product-delivery timeliness was and is a major priority in engineering the data flow between GOES-R satellite and the NOAAPort SBN. Several data centers and networks will be involved in the GOES-R/SBN SCMI data flow— all of them redundant for high availability. NOAA's networks were upgraded to minimize the latency of SBN-broadcast GOES-R imagery (SCMI). It is currently estimated that end-to-end latency (i.e., GOES-R satellite to NOAAPort SBN downlink antenna) will be no more than 75 seconds for the larger GOES-R ABI sectors (e.g., full disk and CONUS) and no more than 45 seconds for the GOES-R ABI mesoscale imagery.

As later sections of this document describe, Network Common Data Form (netCDF4) was chosen as a data format for the GOES-R SCMI imagery on the SBN. Several data formats were considered, but netCDF4 was chosen because it is a self-describing, compressible, open standard that readily handles satellite imagery file types and has a considerable set of utility software and documentation. netCDF4 is also one of the NOAA standard formats for satellite imagery, and it is actively maintained by UCAR/Unidata. It allows the inclusion of Climate and Forecast metadata, incorporated into the SCMI files.

As mentioned earlier in this section, product-delivery timeliness has been a major consideration in the development of the GOES-R/NOAAPort SCMI data stream. While smaller SCMI scenes/sectors (e.g., mesoscale sectors) will be represented as a single netCDF4 file, imagery tiling (or "blocking") is employed for the non-mesoscale imagery. This tiling was implemented to help minimize product-delivery delays. With the tiling mechanism, each single-band larger sector (e.g., a full disk sector) will be broadcast across the NOAAPort SBN as a series of "tiles." Each tile will be a complete stand-alone netCDF4 file but, as described in the metadata sections of this document, metadata within each tile file can be used to associate the file with the other tile files from the same scene. User's receive systems can thus “stitch together” the tiles in order to reconstitute the full products (or could decode/display only a subset of the tiles, as desired). The metadata describing how to recompose original SCMI products with the tiles are described in section 4.2.

Like all products on the NOAAPort SBN, the GOES-R SCMI products will have WMO headers. The headers help superficially identify the products, and can be used by end-user systems to optionally ingest/retain or discard data, as needed. As with all other NOAAPort SBN products, the header should be stripped off in order to get to the native file format for decoding. These WMO headers are described in the next section. Section 4 deals with other SBN headers that encapsulate the WMO-headed netCDF4 SCMI products on the NOAAPort SBN. Section 5 addresses the SCMI metadata. Section 6 comments on expected data rates for the GOES-R SCMI across the SBN NOAAPort network.

3.0 WMO HEADER INFORMATION

As with the legacy NOAAPort-SBN GOES products, each GOES-R SCMI product disseminated across this network will include several headers. The inner-most header (essentially prefixed to the file during NOAAPort SBN transmission) will be a 25 byte World Meteorological Organization (WMO) header.

The SCMI WMO Headers will be as follows, where the WMO header template or format is represented as follows:

$T_1T_2A_1A_2$ii CCCC YYGGgg bbb<cr><cr><lf>

where,

T_1 = T

T_2 = I

A_1 = R for large-scale (non-mesoscale) sectors; = S for mesoscale sectors

A_2 The use of the fourth character of the WMO header (A_2) is different depending upon the value of A1.

Where A_1=R, for large-scale (non-mesoscale) sectors, A_2 corresponds to geographical sectors as follows:

= A for the Alaska Regional sector (PID 107, see Figure 1, next page)
= E for the East CONUS sector (PID 108, see Figure 2)
= H for the Hawaii Regional sector (PID 107, see Figure 2)
= P for the Puerto Rico Regional sector (PID 108, see Figure 2)
= S for the East Full Disk (PID 108)
= T for the West Full Disk (PID 107)
= W for the West CONUS sector (PID 107, see Figure 2)

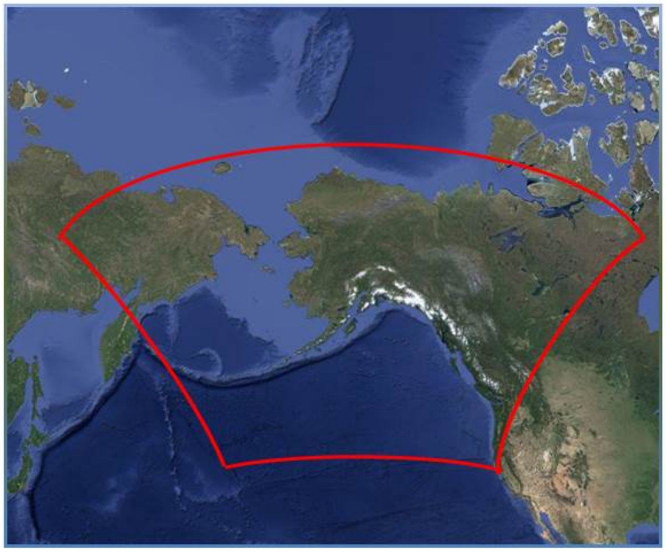
Where A_1=S, for mesoscale sectors, A_2 values corresponds to geographical latitude/longitude areas as follows (PIDs 107 and 108, see Figure 3):

= A for 45°N ≤ Lat. < 60°N and 120°W < Long. ≤ 135°W
= B for 45°N ≤ Lat. < 60°N and 105°W < Long. ≤ 120°W
= C for 45°N ≤ Lat. < 60°N and 90°W < Long. ≤ 105°W

= D for 45°N ≤ Lat. < 60°N and 75°W < Long. ≤ 90°W
= E for 45°N ≤ Lat. < 60°N and 60°W < Long. ≤ 75°W
= F for 30°N ≤ Lat. < 45°N and 120°W < Long. ≤ 135°W
= G for 30°N ≤ Lat. < 45°N and 105°W < Long. ≤ 120°W
= H for 30°N ≤ Lat. < 45°N and 90°W < Long. ≤ 105°W
= I for 30°N ≤ Lat. < 45°N and 75°W < Long. ≤ 90°W
= J for 30°N ≤ Lat. < 45°N and 60°W < Long. ≤ 75°W
= K for 15°N ≤ Lat. < 30°N and 120°W < Long. ≤ 135°W
= L for 15°N ≤ Lat. < 30°N and 105°W < Long. ≤ 120°W
= M for 15°N ≤ Lat. < 30°N and 90°W < Long. ≤ 105°W
= N for 15°N ≤ Lat. < 30°N and 75°W < Long. ≤ 90°W
= O for 15°N ≤ Lat. < 30°N and 60°W < Long. ≤ 75°W
= P for 0°N ≤ Lat. < 15°N and 90°W < Long. ≤ 135°W
= Q for 0°N ≤ Lat. < 15°N and 60°W < Long. ≤ 90°W
= R for 45°N ≤ Lat. < 90°N and 135°W < Long. ≤ 180°W
= S for 0°N ≤ Lat. < 45°N and 135°W < Long. ≤ 180°W
= T for 60°N ≤ Lat. < 90°N and 90°E < Long. ≤ 135°W
= U for 0°N ≤ Lat. < 60°N and 90°E < Long. ≤ 60°W
= V for 0°N ≤ Lat. < 90°N and 180°W < Long. ≤ 90°E
= W and X are reserved for future use
= Y for 90°S ≤ Lat. < 0°S and 105°W < Long. ≤ 90°E
= Z for 90°S ≤ Lat. < 0°S and 90°E < Long. ≤ 105°W

Preliminary Geographical Regions
for GOES-R ABI Large-Scale Sectors on NOAAPort/SBN

Sector Identification Character for WMO Header A_2 Character



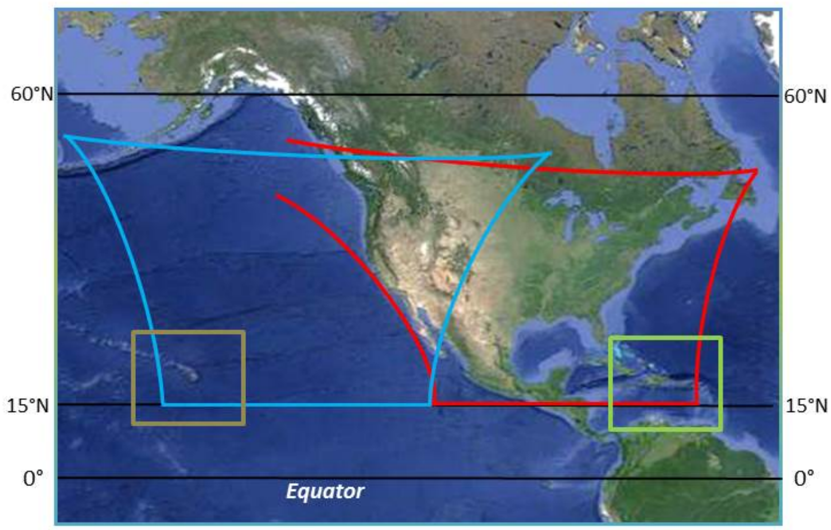
Sector Name	WMO Hdr A_2	Corner Coordinates			
		Lower Left	Lower Right	Upper Right	Upper Left
Alaska Regional Sector	A	42.0N 176.0W	42.0N 124.0W	64.0N 94.0W	64.0N 154.0E
West Full Disk*	T	Centered at Satellite Subpoint, Nominally 0°N 137°W			
East Full Disk*	S	Centered at Satellite Subpoint, Nominally 0°N 75°W			

** Sectors not shown.*

Figure 1: Preliminary Geographical Regions for GOES-R ABI Large-Scale Sectors on NOAAPort/SBN

Preliminary Geographical Regions
for GOES-R ABI Large-Scale Sectors on NOAAPort/SBN

Sector Identification Character for WMO Header A_2 Character



Sector Name	WMO Hdr A_2	Corner Coordinates			
		Lower Left	Lower Right	Upper Right	Upper Left
Hawaii Regional Sector	H	9.3N 167.3W	9.3N 145.9W	28.1N 145.9W	28.1N 167.3W
West CONUS Sector	W	15.0N 160.0W	15.0N 113.0W	53.0N 90.0W	54.0N 173.0W
East CONUS Sector	E	15.0N 113.0W	15.0N 64.0W	52.0N 52.0W	Space View
Puerto Rico Sector	P	9.0N 77.0W	9.0N 58.6W	26.4N 58.6W	26.4N 77.0W

Notes

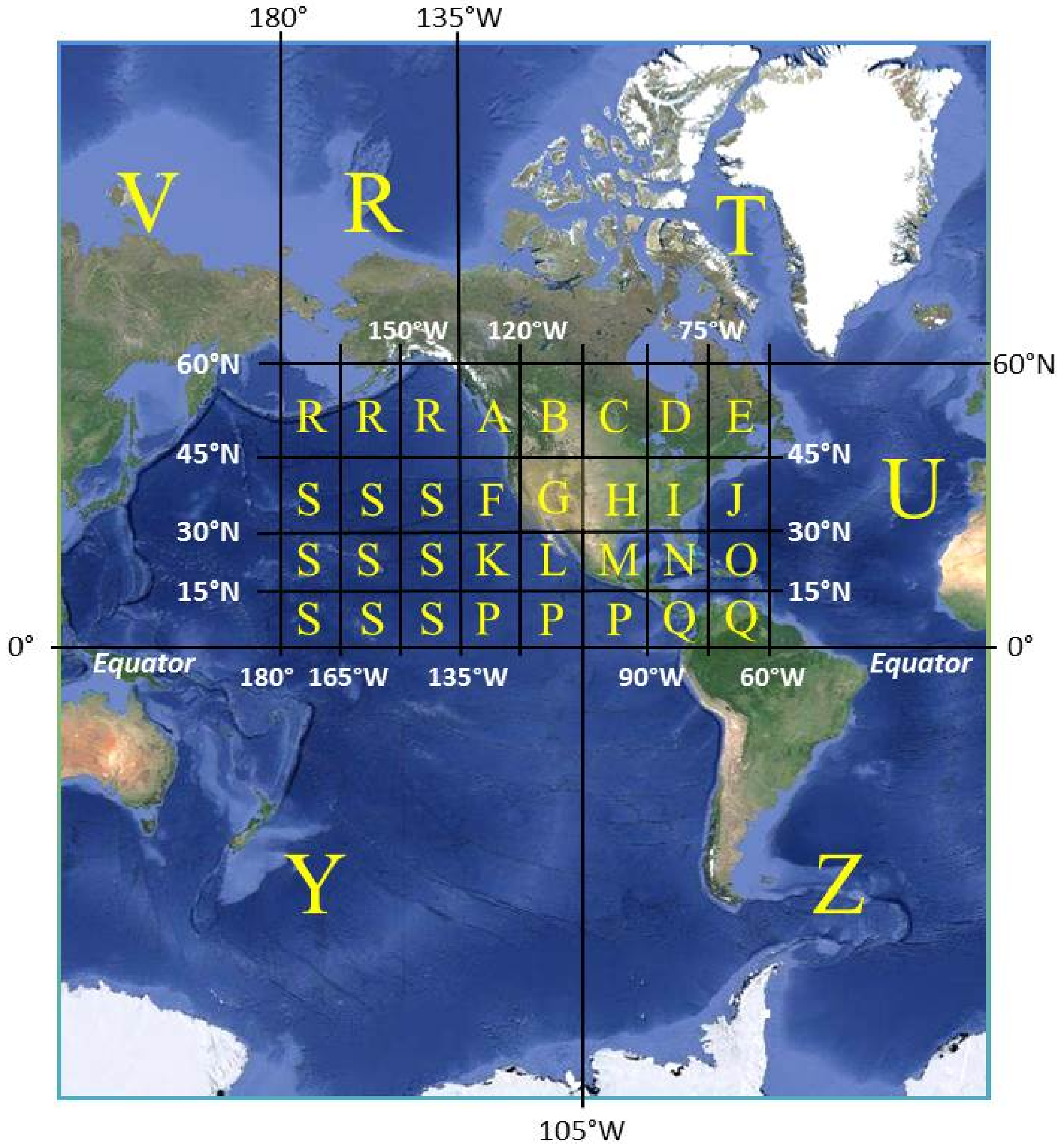
1. NWS will be further evaluating the set of GOES-R imagery sectors and the dimensions of the sectors that will be included in the SBN suite. Thus, the sectors and corner points tabulated above may change.

2. For sectors above (i.e., non-mesoscale sectors), the geographical sector determines A_2 (the fourth character in the WMO Header: $T_1T_2A_1A_2ii$ CCCC).

Figure 2: Preliminary Geographical Regions for GOES-R ABI Large-Scale Sectors on NOAAPort/SBN

Geographical Regions
for GOES-R ABI Mesoscale Sectors on NOAAPort/SBN

Sector Identification Character for WMO Header A_2 Character



Center latitude/longitude of center point of netCDF4 tile file determines A_2 (the fourth character in WMO Header: $T_1T_2A_1A_2$ii CCCC).

Figure 3: Geographical Regions for GOES-R ABI Mesoscale Sectors on NOAAPort/SBN

Continuing with the WMO header, the fifth and six characters correspond to the ABI band (or channel). Thus, the "ii" in the TTAAii WMO header will range from 01 (for ABI channel 1) through 16 (for ABI channel 16).

With the first field of the WMO header ($T_1T_2A_1A_2$ii) addressed above, we can move on to the CCCC field. As a reminder, here's the header template again:

$T_1T_2A_1A_2$ii CCCC YYGGgg bbb<cr><cr><lf>

For the GOES-R SCMI, the CCCC field will always be KNES.

For the GOES-R SCMI, the YY in the YYGGgg field will always correspond to the day of the month (01-31). The GGgg field will always correspond to the hour (GG) and minute (gg) of the scene or sector, in UTC. GGgg thus can range from 0000 to 2359.

For the GOES-R SCMI, the bbb field will be used to identify the various tiles of a scene or sector whose headers might be otherwise be identical: PAA, PAB, PAC, …, PAZ, PBA, PBB, etc.

The above-described WMO headers are affixed to the front of the SCMI netCDF4 files. The SBN also has a product framing/header protocol, something of an outer wrapper, described in the next section.

4.0 GOES-R PRODUCT CODES AND IDS

This section describes the values of specific NOAAPort SBN frame/headers attached to the GOES-R SCMI. These product codes and IDs are described at http://www.nws.noaa.gov/noaaport/html/transprt.shtml.

Category ID	Category Name
8	NetCDF Image

Table 1: GOES-R Product-Specific Category IDs

Type ID	Type Name
9	GOES-R West
10	GOES-R East

Table 2: GOES-R Product-Specific IDs

GOES-R Product code	GOES-R Product Name
1	ABI Band 1
2	ABI Band 2
3	ABI Band 3
4	ABI Band 4
5	ABI Band 5
6	ABI Band 6
7	ABI Band 7
8	ABI Band 8
9	ABI Band 9
10	ABI Band 10
11	ABI Band 11
12	ABI Band 12
13	ABI Band 13
14	ABI Band 14
15	ABI Band 15
16	ABI Band 16

Table 3: GOES-R Product Codes

Region ID	Region Name
1	East Full Disk
2	West Full Disk
3	East CONUS
4	West CONUS
5	Alaska Regional
6	Hawaii Regional
7	Puerto Rico Regional
8	Mesoscale

Table 4: GOES-R Region IDs

Channel	ID	Multicast Address	Port	PID
GOES-R West (GRW)	12	224.0.1.9	1209	107
GOES-R East (GRE)	13	224.0.1.10	1210	108

Table 5: GOES-R Product SBN Channel Information

5.0 METADATA

5.1 Sectorized CMI Tile-file Data Element Description

Each SCMI tile-file is a self-contained, NetCDF4 file. Each SCMI tile-file can be used individually or re-assembled at the user endpoint to be part of a larger imagery product. The position of each tile-file within the larger end-product can be determined using an indicator (i.e. tile_row_offset and tile_column_offset) which is included in the metadata for each tile-file. The default size for the image in each NetCDF4 tile-file is 1024 by 1024 pixels, though this size is configurable by NOAA and it could potentially range from 256 to 2048 pixels. The number of tile-files making up a single product has a maximum value of 999 tile-files. All tile-files are produced regardless of available source pixels unless the entire product (collection of tiles) is missing. If data in a particular source pixel is missing, it will also be coded as missing in the affected tile. The data quality value flags (Good, Conditionally Usable, Out of Range, No Value) are used to determine which pixels are bad and/or missing. Only those pixels with corresponding data quality flags marked “Good” or “Conditionally Usable” are then used in the necessary imagery data computations performed by the GOES-R Ground System that produces the SCMI files. Pixels with data quality flags marked as “Out of Range” or “No Value” are not used. Additionally, the dimensions of tile-files whose boundary extends past the right or bottom edge of the full CMI end-product are sized such that the pixels outside the full product size are not included. Thus these edge tile-files may be smaller than the selected size.

The SCMI included in each tile-file will be defined as a two dimensional array of unsigned, scaled integer values (expressed as a 3 dimensional array with the first dimension “t” equal to 1). If the bit depth is 8, the Imagery Data variable is stored using a NC_BYTE data type (8-bit signed integer), otherwise it is stored using a NC_SHORT data type (16-bit signed integer). These data types are used to conform to the NetCDF classic data model but the contents of the data are unsigned 8 and 16 bit values and should be treated as such. The dimensions will be the number of rows and columns of the portion of the product contained in the tile-file. The base data type for these unsigned, scaled integer values will be values ranging from 0 to 4095 (for all bands but band 7) and range in values from 0 to 16383 for band 7. The bit-depth of the products for CMI is 8 -12 bits for all the bands, with the exception of band 7, which is 8-14 bits. The scaled integers for bands 1-6 represent reflectance factor. The scaled integers for bands 7-16 represent brightness temperature. Offset and Scale factor values (contained in metadata) can be used to convert the scaled integers to science data values (reflectance factor or brightness temperature). Image pixels in the NetCDF data variable start in the northwest corner and proceed eastward through the rest of the most northern row. Then, the same sequence occurs for the second most northern row, and so on. Additionally, for image pixel size, the resolution is always at the map origin which is nadir for ABI Fixed Grid projection and where the tangent plane touches the earth for Polar Stereographic, Lambert Conformal, and Mercator projections.

The baseline configuration used to determine the fill values for this interface is designed such that the input fill value (65535) maps to zero in all cases independent of output bit depth. Using this approach means that a true value of zero cannot be distinguished from the fill value (which is also zero). Other input values are calculated using linear scaling such that 1 to “max input value” (12bit =4095, 14 bit= 16383) maps to 1 to “max output value” (12bit=4095, 11bit=2047, 10bit=1023 etc). Advantages of this configuration include: 1) if display software does not support special handling of fill values, the fill value will display as black, 2) both scale_factor and add_offset remain unchanged if no bit depth reduction (same as non-sectorized data). Disadvantages of this configuration includes: 1) an input value of zero cannot be distinguished from a fill value of 0, and 2) add_offset is changed if bit depth reduction is enabled. Figure 4: Fill Value Baseline Configuration shows sample fill values for various combinations of bit depth, scale factor and add offset values.

	Input	AWIPS Product scale_factor and add_offset Values									
Bit Depth	12	12		11		10		9		8	
scale_factor	1.00	1.000000		2.000489		4.002933		8.013699		16.058824	
add_offset	0.00	0.000000		-0.500244		-1.501466		-3.506849		-7.529412	
		AWIPS Product Values									
	Value	AWIPS	Science	AWIPS	Science	AWIPS	Science	AWIPS	Science	AWIPS	Science
	Fill Value	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
	0	0	0.0000	0	-0.5002	0	-1.5015	0	-3.5068	0	-7.5294
	1	1	1.0000	1	1.5002	1	2.5015	1	4.5068	1	8.5294
	2	2	2.0000	1	1.5002	1	2.5015	1	4.5068	1	8.5294
	3	3	3.0000	2	3.5007	1	2.5015	1	4.5068	1	8.5294
	4	4	4.0000	2	3.5007	1	2.5015	1	4.5068	1	8.5294
	5	5	5.0000	3	5.5012	2	6.5044	1	4.5068	1	8.5294
	14	14	14.0000	7	13.5032	4	14.5103	2	12.5205	1	8.5294
	15	15	15.0000	8	15.5037	4	14.5103	2	12.5205	1	8.5294
	16	16	16.0000	8	15.5037	4	14.5103	2	12.5205	1	8.5294
	17	17	17.0000	9	17.5042	5	18.5132	3	20.5342	2	24.5882
	18	18	18.0000	9	17.5042	5	18.5132	3	20.5342	2	24.5882
	2046	2046	2046.0000	1023	2045.9995	512	2048.0000	256	2048.0000	128	2048.0000
	2047	2047	2047.0000	1024	2048.0000	512	2048.0000	256	2048.0000	128	2048.0000
	2048	2048	2048.0000	1024	2048.0000	512	2048.0000	256	2048.0000	128	2048.0000
	2049	2049	2049.0000	1024	2048.0000	512	2048.0000	256	2048.0000	128	2048.0000
	2050	2050	2050.0000	1025	2050.0005	512	2048.0000	256	2048.0000	128	2048.0000
	4078	4078	4078.0000	2039	4078.4958	1019	4077.4868	509	4075.4658	254	4071.4118
	4079	4079	4079.0000	2039	4078.4958	1019	4077.4868	509	4075.4658	254	4071.4118
	4087	4087	4087.0000	2043	4086.4978	1021	4085.4927	510	4083.4795	255	4087.4706
	4088	4088	4088.0000	2044	4088.4983	1022	4089.4956	511	4091.4932	255	4087.4706
	4089	4089	4089.0000	2044	4088.4983	1022	4089.4956	511	4091.4932	255	4087.4706
	4090	4090	4090.0000	2045	4090.4988	1022	4089.4956	511	4091.4932	255	4087.4706
	4091	4091	4091.0000	2045	4090.4988	1022	4089.4956	511	4091.4932	255	4087.4706
	4092	4092	4092.0000	2046	4092.4993	1023	4093.4985	511	4091.4932	255	4087.4706
	4093	4093	4093.0000	2046	4092.4993	1023	4093.4985	511	4091.4932	255	4087.4706
	4094	4094	4094.0000	2047	4094.4998	1023	4093.4985	511	4091.4932	255	4087.4706
	4095	4095	4095.0000	2047	4094.4998	1023	4093.4985	511	4091.4932	255	4087.4706

Figure 4: Fill Value Baseline Configuration

The NOAAPort SBN will disseminate NetCDF4 formatted products compatible with NetCDF's internal data compression capability using zlib. Compression using zlib can be either set to "on" or "off" uniformly for all products. In order to read NetCDF4 formatted products created using this feature, the receiving system must ensure its NetCDF4 reader supports zlib decompression. The expansion of the compressed files is automatic and transparent to the end user provided a compatible NetCDF4 reader is used.

5.2 Sectorized CMI Tile-file Metadata

The global metadata attributes defined for Sectorized CMI tile-files are shown in Table 5: Sectorized CMI Metadata Global Attributes below. Because Sectorized CMI products are delivered as a series of tile-files which together make up a full product, the metadata provided for each Sectorized CMI tile-file is a mixture of tile-file and full product metadata attributes. The mixture of metadata attributes listed below allow a tile-file to be viewed independently as well as provide enough information to rebuild a product file from its corresponding tile-files as desired by the NWS. Applicable NetCDF metadata attributes listed below follow the Climate and Forecasting (CF) Convention Version 1.6. CF Convention Version

1.6 is used to promote the data processing and sharing of NetCDF files across NOAA and its partner communities. There will be no ISO Series-level metadata for these products as they are not intended for long term archive.

Global Attributes			
Metadata Attribute	**Description**	**Type/Value**	**CF Convention**
title	A global attribute that is a character array providing a succinct description of what is in the dataset.	Type: NC_CHAR Value: Varying	Y
ICD_version	The version number of the ICD used to create the metadata.	Type: NC_CHAR Value: ICD filename	N
Conventions	Which version of the CF conventions was used.	Type: NC_CHAR Value: CF-1.6	Y
production_location	Where the data comes from (WCDAS or RBU).	Type: NC_CHAR Value: "WCDAS" or "RBU"	N
product_name	Product name The product name is represented by this portion of the data short name **xxxx-rrr-Bnn-MnCnn**. The full product name can be inferred from the data short name fields in the file naming convention.	Type: NC_CHAR Value: Varying	N
channel_id	ABI sensing channel	Type: NC_INT Values: 1-16	N
central_wavelength	ABI sensing channel central wavelength	Type: NC_FLOAT Value: 0.47 to 13.3	N
satellite_id	Satellite Serial Number	Type: NC_CHAR Value: GOES-16 or GOES-17	N

Global Attributes			
Metadata Attribute	**Description**	**Type/Value**	**CF Convention**
abi_mode	What ABI mode the instrument is operating in at the time data is collected.	Type: NC_INT Value: 3 or 4	N
source_scene	ABI Scene from which the sectorized product was generated	Type: NC_CHAR Value: “Full Disk” “CONUS” “Mesoscale-1” “Mesoscale-2”	N
product_center_latitude	Center latitude of full product (signed decimal degrees)	Type: NC_DOUBLE Value: -90 to 90	N
product_center_longitude	Center longitude of full product (signed decimal degrees)	Type: NC_DOUBLE Value: -180 to 180	N
periodicity	The delivery rate of the product. This value must be a multiple of the refresh rate, where the refresh rate = ABI Mode/Scene cycle (either 5 or 15 minutes) depending on the Mode/Scene combination being discussed.)	Type: NC_FLOAT Value: Multiple of the ABI Mode/Scene cycle time. Configurable.	N
projection	The map projection used.	Type: NC_CHAR Value: “Mercator” “Lambert Conformal” “Polar Stereographic” “Fixed_Grid”	N

Global Attributes			
Metadata Attribute	**Description**	**Type/Value**	**CF Convention**
bit_depth	Bits used to define a pixel.	Type: NC_INT Value: 8/9/10/11/12/13/14	N
source_spatial_resolution	The collected size at the nadir point of the satellite.	Type: NC_FLOAT Value: 0.5, 1.0 or 2.0km	N
request_spatial_resolution	The resolution used in the creation of the sectorized CMI product which was asked for via the product configuration.	Type: NC_FLOAT Value: Between 0.5km and 28km	N
start_date_time	The start date / time that the satellite began capturing the scene. The start/date time will be the same for all products cut from the same scene.	YYYYDDDhhmmss where: YYYY = Year DDD = Day of Year hh = hour of day mm = minutes of day ss = seconds of day	N
number_product_tiles	The number of tile-files of imagery that get transmitted as a sectorized product.	Type: NC_INT Value: 1-999 (integer number)	N
tile_center_latitude	Center latitude of tile-file (signed decimal degrees)*	Type: NC_DOUBLE Value: -90 to 90	N
tile_center_longitude	Center longitude of tile-file (signed decimal degrees)*	Type: NC_DOUBLE Value: -180 to 180	N
product_tile_width	The width of an individual tile of imagery	Type: NC_INT Width: integer (256 to 2048)	N
product_tile_height	The height of an individual tile of imagery	Type: NC_INT Height: integer (256 to 2048)	N

Global Attributes			
Metadata Attribute	**Description**	**Type/Value**	**CF Convention**
product_rows	Number of points in the product along the y-axis.	Type: NC_INT Values: 1 to 32000	N
product_columns	Number of points in the product along the x-axis.	Type: NC_INT Values: 1 to 32000	N
pixel_x_size	Distance between pixel centers in x direction (along a row) once the projection calculations are complete.	Type: NC_DOUBLE Values: 0.5km to 28km	N
pixel_y_size	Distance between pixel centers in y direction (along a column) once the projection calculations are complete. The mathematical equations used to calculate the various projections can be found in the PSDF SE-11 Appendix A.	Type: NC_DOUBLE Values: 0.5km to 28km	N
tile_row_offset	Row location of tile-file's upper left (0,0) pixel in full product image.	Type: NC_INT Value: 0 to n-1 Where n equals the number of product_rows	N

Global Attributes			
Metadata Attribute	**Description**	**Type/Value**	**CF Convention**
tile_column_offset	Column location of tile-file's upper left (0,0) pixel in full product image.	Type: NC_INT Value: 0 to n-1 Where n equals the number of product_columns.	N
satellite_latitude	ABI grid based satellite position used by L1b processing.	Decimal Degrees (NC_DOUBLE) Value: 0	N
satellite_longitude	ABI grid based satellite position used by L1b processing.	Decimal Degrees (NC_DOUBLE) Value: -180 to 180	N
satellite_altitude	ABI grid based satellite altitude used by L1b processing.	Meters (NC_DOUBLE) Value: 35786023	N

Table 6: Sectorized CMI Metadata Global Attributes

In the case of full disk native projection, it is possible for the center of the tile to be off the disk and thus not have a latitude/longitude value. In this case, the value will be left blank.

Table 6: Sectorized CMI Metadata Attributes for Imagery Data discusses the Sectorized CMI Imagery Data variable metadata attributes. The Imagery Data variable is a variable containing the science data values as scaled integers. If the bit depth is 8, the Imagery Data variable is stored using a NC_BYTE data type (8-bit signed integer), otherwise it is stored using a NC_SHORT data type (16-bit signed integer). These data types are used to maintain the NetCDF classic data model but the contents of the data are unsigned 8 and 16 bit values and should be treated as such.

Imagery DataVariable Variable "Sectorized_CMI" Attributes			
Metadata Attribute	**Description**	**Value**	**CF Convention (Y/N)**

Imagery DataVariable Variable “Sectorized_CMI” Attributes			
Metadata Attribute	**Description**	**Value**	**CF Convention (Y/N)**
standard_name	A standard name that references a description of a variable's content in the standard name table. Because there is no standard name in the CF convention for Reflectance Factor, toa_bidirectional_reflectance is believed to be the CF convention equivalent.	Type: NC_CHAR Channels 1-6 Value: “toa_bidirectional_reflectance” Channels 7-16 Value: “brightness_temperature”	Y
units	These units are applied to the values after the offset and scale factor have been applied.	Type: NC_CHAR Channels 1-6 Value: “1” Channels 7-16 Value: “kelvin” Note: A value of 1 is used to indicate Unitless per the CF Convention.	Y
grid_mapping	Identifies a variable that contains the projection parameter values (as attributes as defined in the CF Conventions)	Type: NC_CHAR Value: “lambert_projection” “mercator_projection” “polar_projection” “fixedgrid_projection”	Y
add_offset	To determine the science data value, this number is to be added to the data after it is read and scaled by the scale_factor.	Type: NC_FLOAT Value: Varying	Y
scale_factor	To determine the science data value, the data are multiplied by this factor after the data are read.	Type: NC_FLOAT Value: Varying	Y
_FillValue	A value used to represent missing or undefined data.	Type: same as variable type Value: 0	Y
valid_min	A scalar specifying the minimum valid value for this variable.	Type: NC_INT Value: 0	Y

Imagery DataVariable Variable "Sectorized_CMI" Attributes			
Metadata Attribute	**Description**	**Value**	**CF Convention (Y/N)**
valid_max	A scalar specifying the maximum valid value for this variable.	Type: NC_INT Value: Varying	Y

Table 7: Sectorized CMI Metadata Attributes for Imagery Data

Table 7: Sectorized CMI Projection Coordinate X Variable Metadata Attributes and Table 8: Sectorized CMI Projection Coordinate Y Variable Metadata Attributes describe the X and Y Projection Coordinate Variable metadata attributes. The Projection X-Coordinate variable and Projection Y-Coordinate variable are dimensioned by the number of tile columns and number of tile rows, respectively and are stored using a NC_SHORT data type. The variable coordinates are used to locate the position of the image pixels in the projected system. Before scaling_factor and add_offset are applied, the values in the variables represent the position of the column (Projection X-Coordinate) and row (Projection Y-Coordinate) in the full product image. After scale_factor and add_offset are applied, the values in the variables specify the x and y projected system coordinates of the corresponding columns and rows in the imagery data variable (discussed in Table 2 above). The scale_factor and add_offset values are identical for all tile-files within a single product. This allows the NetCDF x-axis and y-axis coordinate variables to be concatenated together to build a larger product file.

Projection X-Coordinate Variable Variable "x" Attributes			
Metadata Attribute	**Definition**	**Value**	**CF Convention (Y/N)**
standard_name	A standard name that references a description of a variable's content in the standard name table.	Type: NC_CHAR Value: "projection_x_coordinate"	Y
units	These units are applied to the values after the offset and scale factor have been applied.	Type: NC_CHAR Value: microradian (fixed grid) meters (all others)	Y
scale_factor	The data are to be multiplied by this factor after the data are read by an application.	Type: NC_DOUBLE Value: Varying	Y
add_offset	This number is to be added to the data after it is read by an application. If both scale_factor and add_offset attributes are present, the data are first scaled before the offset is added.	Type: NC_DOUBLE Value: Varying	Y

Table 8: Sectorized CMI Projection Coordinate X Variable Metadata Attributes

Projection Y-Coordinate Variable Variable "y" Attributes			
Metadata Attribute	**Definition**	**Value**	**CF Convention (Y/N)**
standard_name	A standard name that references a description of a variable's content in the standard name table.	Type: NC_CHAR Value: "projection_y_coordinate"	Y
units	These units are applied to the values after the offset and scale factor have been applied.	Type: NC_CHAR Value: micro ian (fixed grid) meters (all others)	Y
scale_factor	The data are to be multiplied by this factor after the data are read by an application.	Type: NC_DOUBLE Value: Varying	Y
add_offset	This number is to be added to the data after it is read by an application. If both scale_factor and add_offset attributes are present, the data are first scaled before the offset is added.	Type: NC_DOUBLE Value: Varying	Y

Table 9: Sectorized CMI Projection Coordinate Y Variable Metadata Attributes

The projection variables group the attributes which define the projection parameters. There is no data associated with these variables except for the metadata attributes. Projection parameters are mutually exclusive; only one projection will appear in each tile-file. Table 9: Sectorized CMI Lambert Conformal Projection Variable Metadata Attributes below describes the metadata attributes exclusive to Lambert Conformal map projections. Table 10: Sectorized CMI Mercator Projection Variable Metadata Attributes, Table 11: Sectorized CMI Polar Stereographic Projection Variable Metadata Attributes and Table 12: Sectorized CMI Fixed Grid Variable Metadata Attributes describes the metadata attributes exclusive to the Mercator map projection, Polar Stereographic map projection, and Fixed Grid respectively.

Lambert Conformal Variable "lambert_projection" Attributes			
Metadata Attribute	**Definition**	**Value**	**CF Convention (Y/N)**
grid_mapping_name	Name used to identify the grid mapping	Type: NC_CHAR Value: "lambert_conformal_conic"	Y
standard_parallel	Specifies the line, or lines, of latitude at which the developable map projection cone touches the reference sphere or elipsoid used to represent the Earth.	Type: NC_DOUBLE Value: Varying	Y
longitude_of_central_meridian	The line of longitude at the center of a map projection generally used as the basis for constructing the projection	Type: NC_DOUBLE Value: -180 to 180	Y
latitude_of_projection_origin	The latitude chosen as the origin of rectangular coordinates for a map projection	Type: NC_DOUBLE Value: -90 to 90	Y
false_easting	The value added to all abscissa values in the rectangular coordinates for a map projection. This value frequently is assigned to eliminate negative values.	Type: NC_DOUBLE Value: 0 This field is part of the CF Convention so it has been included. For GOES-R, the value will always be 0 because we will not need to have a positive projection coordinate system.	Y

Lambert Conformal Variable "lambert_projection" Attributes			
Metadata Attribute	**Definition**	**Value**	**CF Convention (Y/N)**
false_northing	The value added to all ordinate values in the rectangular coordinates for a map projection. This value frequently is assigned to eliminate negative values.	Type: NC_DOUBLE Value: 0 This field is part of the CF Convention so it has been included. For GOES-R, the value will always be 0 because we will not need to have a positive projection coordinate system.	Y
semi_major	The semi-major axis of the projection system.	Type: NC_DOUBLE Value: 6371200 m	Y
semi_minor	The semi-minor axis of the projection system.	Type: NC_DOUBLE Value: 6371200 m	Y

Table 10: Sectorized CMI Lambert Conformal Projection Variable Metadata Attributes

Mercator Variable "mercator_projection" Attributes			
Metadata Item	**Definition**	**Value**	**CF Convention (Y/N)**
grid_mapping_name	Name used to identify the grid mapping	Type: NC_CHAR Value: "mercator"	Y
standard_parallel	Specifies the line, or lines, of latitude at which the developable map projection cylinder touches the reference sphere or elipsoid used to represent the Earth.	Type: NC_DOUBLE Value: Varying	Y

Mercator Variable “mercator_projection” Attributes			
Metadata Item	**Definition**	**Value**	**CF Convention (Y/N)**
longitude_of_projection_origin	The longitude chosen as the origin of rectangular coordinates for a map projection.	Type: NC_DOUBLE Value: -180 to 180	Y
false_easting	The value added to all abscissa values in the rectangular coordinates for a map projection. This value frequently is assigned to eliminate negative values.	Type: NC_DOUBLE Value: 0 This field is part of the CF Convention so it has been included. For GOES-R, the value will always be 0 because we will not need to have a positive projection coordinate system.	Y
false_northing	The value added to all ordinate values in the rectangular coordinates for a map projection. This value frequently is assigned to eliminate negative values.	Type: NC_DOUBLE Value: 0 This field is part of the CF Convention so it has been included. For GOES-R, the value will always be 0 because we will not need to have a positive projection coordinate system.	Y
semi_major	The semi-major axis of the projection system.	Type: NC_DOUBLE Value: 6371200 m	Y
semi_minor	The semi-minor axis of the projection system.	Type: NC_DOUBLE Value: 6371200 m	Y

Table 11: Sectorized CMI Mercator Projection Variable Metadata Attributes

Polar Stereographic Variable “polar_projection” Attributes			
Metadata Item	**Definition**	**Value**	**CF Convention (Y/N)**

Polar Stereographic Variable "polar_projection" Attributes			
Metadata Item	**Definition**	**Value**	**CF Convention (Y/N)**
grid_mapping_name	Name used to identify the grid mapping	Type: NC_CHAR Value: "polar_stereographic"	Y
standard_parallel	Specifies the line, or lines, of latitude at which the developable map projection plane touches the reference sphere or elipsoid used to represent the Earth.	Type: NC_DOUBLE Value: Varying	Y
straight_vertical_longitude_from_pole	The longitude to be oriented straight up from the North or South Pole.	Type: NC_DOUBLE Value: -180 to 180	Y
latitude_of_projection_origin	The latitude chosen as the origin of rectangular coordinates for a map projection.	Type: NC_DOUBLE Value: -90 to 90	Y
false_easting	The value added to all abscissa values in the rectangular coordinates for a map projection. This value frequently is assigned to eliminate negative values.	Type: NC_DOUBLE Value: 0 This field is part of the CF Convention so it has been included. For GOES-R, the value will always be 0 because we will not need to have a positive projection coordinate system.	Y

Polar Stereographic Variable "polar_projection" Attributes			
Metadata Item	**Definition**	**Value**	**CF Convention (Y/N)**
false_northing	The value added to all ordinate values in the rectangular coordinates for a map projection. This value frequently is assigned to eliminate negative values.	Type: NC_DOUBLE Value: 0 This field is part of the CF Convention so it has been included. For GOES-R, the value will always be 0 because we will not need to have a positive projection coordinate system.	Y
semi_major	The semi-major axis of the projection system.	Type: NC_DOUBLE Value: 6371200 m	Y
semi_minor	The semi-minor axis of the projection system.	Type: NC_DOUBLE Value: 6371200 m	Y

Table 12: Sectorized CMI Polar Stereographic Projection Variable Metadata Attributes

Un-Projected (Fixed Grid) Variable "fixedgrid_projection" Attributes			
Metadata Item	**Definition**	**Value**	**CF Convention (Y/N)**
grid_mapping_name	Name used to identify the grid mapping	Type: NC_CHAR Value: "geostationary"	Y
latitude_of_projection_origin	The latitude chosen as the origin of rectangular coordinates for a map projection.	Type: NC_DOUBLE Value: 0	Y

Un-Projected (Fixed Grid) Variable "fixedgrid_projection" Attributes			
Metadata Item	**Definition**	**Value**	**CF Convention (Y/N)**
longitude_of_projection_origin	The longitude chosen as the origin of rectangular coordinates for a map projection.	Type: NC_DOUBLE Value: -180 to 180	Y
semi_major	The semi-major axis of the projection system (WGS-84).	Type: NC_DOUBLE Value: 6378137 m	Y
semi_minor	The semi-minor axis of the projection system (WGS-84).	Type: NC_DOUBLE Value: 6356732.31414 m	Y
perspective_point_height	Records the height in meters of the satellite perspective point above the ellipsoid.	Type: NC_DOUBLE Value: 35786023 m	Y
sweep_angle_axis	The axis across which the sensor sweeps as it collects data	Type: NC_CHAR Value: "x"	Y

Table 13: Sectorized CMI Fixed Grid Variable Metadata Attributes

6.0 EXPECTED DATA VOLUMES AND DATA RATES

The peak NOAAPort SBN data rates for each GOES-R series satellite is not expected to exceed 25 Mbits/second. NWS plans to send (across the SBN) environmental data products from no more than two GOES-R series satellites at any given time. GOES-S will be added during its test period, after its launch (scheduled for 2017).

7.0 CONTACT INFORMATION

For further information about the GOES-R SCMI on the NOAAPort SBN, please visit the users' page (link below) or email nws.noaaport.support@noaa.gov.

http://www.nws.noaa.gov/noaaport/html/noaaport.shtml

APPENDIX A

A.1 DESCRIPTION OF CMI

The GOES-R ABI SCMI product is a so-called Key Performance Parameter— one of critical importance to NOAA and its partners both in terms of its usefulness and the time criticality. The products are netCDF4 , with the main parameter being reflectance factor for ABI bands 1 through 6 and brightness temperature for ABI bands 7 through 16. The Top of Atmosphere (TOA) radiances measured by the ABI are converted to reflectance factor and brightness temperature for visualization, analysis, greatly contributing to the weather analysis/forecasting/warning processes. Reflectance factor and brightness temperature are representative physical attributes of the observed systems (i.e., land, oceans, atmosphere) as opposed to radiance, which is measured at the satellite.

The Sectorized CMI product is created by taking a subset of a larger CMI Product. For instance, a sectorized CMI product can be created by taking a subset of a Full Disk CMI Product (sectorizing is sometimes referred to as subsetting). This subset could be a pre-defined region (e.g., a portion of the full disk). It is anticipated that the pre-defined regions will rarely change. However, the NOAAPort SBN stream exists primarily to service NWS forecast offices, so occasional changes to the GOES-R SCMI sectors are likely in response to evolving NWS office requirements.

As described earlier in this document, each product is delivered as a set of one or more independent NetCDF4 files each containing the data for a rectangular region of the full product. The rectangular regions (tiles) are non-overlapping and combining the full set of tile-files is required to create a full product. The number of rows and columns in each tile-file is determined by the Product Tile-file size specified in the product configuration except for tiles which extend beyond the image range (i.e. whose last rows or columns extend beyond the rows and/or columns of the full product). In that case, the tile-file will only contain the number of rows and/or columns that overlap the full product range. If any of the data required for the product is missing or not available, the fill/missing value is used. If all the data is missing for a tile-file, a tile-file filled with the fill/missing value will be disseminated. This is expected to be a rare/anomalous event. If the GOES-R Ground Segment receives *any* data for a scheduled end product, then all tile-files for that product will be broadcast across the SBN (even if data was not received for some tile-files).

SCMI Theoretical Basis

The NOAA NESDIS Center for Satellite Applications and Research *GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Cloud and Moisture Imagery Product (CMIP)* describes in detail the procedures for developing and using the algorithms designed for the capture of ABI CMI data and was used as supplemental information in the development of the NOAAPort SBN data stream. Refer to the link below for more details:

Title of Document: GOES-R_ABI_ATBD_Imagery_v2.0.doc

URL: http://www.goes-r.gov/products/ATBDs/baseline/Imagery_v2.0_no_color.pdf

Sectorized CMI Data Values

Data values will be stored as scaled integers. If a bit depth of 8 is specified, the data will be stored using the NetCDF 8-bit integer data type. All other bit depths will use a NetCDF 16-bit integer data type.

If the specified bit depth is not the same as the source data, a linear mapping will be used to convert the source data to the specified bit depth and the scale_factor attribute will be adjusted accordingly. The linear mapping will be defined so as to preserve the uniqueness of the missing/bad data value. (Zero will map to zero and no non-zero value will be mapped to zero.) In addition, if the maximum value in the source data represents a special value, the linear mapping will be defined so as preserve that uniqueness. (The maximum value at the source bit depth will be mapped to the maximum value at the product bit depth and no other source value will be mapped to the maximum product bit depth value.)

When spatial re-sampling of the data to approximately the same resolution as the source data or finer is required for generating an SCMI product, bilinear interpolation (a distance weighted average of the surrounding values) will be used to compute the product values. Missing/bad source values will not be used in the computation. If 50% or more of the source values are missing/bad, the missing/bad value (0) will be used for the value.

When spatial re-sampling to a significantly coarser resolution is required for generating an SCMI product, an average of the values covering the area represented by the product value will be used. Missing/bad values will not be used in the computation. If 50% or more of the source values are missing/bad, the missing/bad value will be used for the value.

SCMI Expected Periodicity

Sectorized CMI output products are generated at 5-minute intervals for CONUS, 15-minute intervals for Full Disk and 30-second intervals for Mesoscale in ABI mode 3. Full Disk is produced at 5-minute intervals in ABI mode 4. Please see Appendix A for additional information.

SCMI Source Data Inputs

The sectorized CMI algorithm uses ABI imagery data, which comes from lesser-processed (closer to raw) “Level 1b” Full Disk, CONUS or Mesoscale GOES-R products. But further processing is done in the creation of the SCMI products, as this document describes. Thus, SCMI is sometimes referred to as a “Level 2” or “Level 2+” product, to reflect the additional processing and information contained within the SCMI files. An individual sectorized CMI end product can come from a Full Disk, CONUS or Mesoscale scene, depending on its configuration.

SCMI Mesoscale Projection Computation

Mesoscale projection parameters will be computed from the center point of the Mesoscale Scene. The latitude of the scene center will be used to select the projection. Each latitude range will have an associated projection that should be used for Mesoscale Scenes whose center falls in that latitude range. The latitude range is a configurable parameter that may be changed through configuration management.

Unless Fixed Grid is used, it is expected that Mercator will be used for near equator latitudes, Lambert Conformal for mid-latitudes, and Polar Stereographic for high latitudes. The projection parameters will be computed from the scene center latitude and longitude and the pixel size of the center source pixel.

Computed Mesoscale Product Projection Information

Spatial Resolution: The minimum of the scene center pixel height and width in the ABI grid space height or width times the Spatial Resolution Scaling Factor value.

Image Corners/Image Size: Computed from the geographic location of the ABI Mesoscale Scene corners such that the projected product contains all the pixels in the Mesoscale scene. If a Mesoscale scene corner falls off or very near the ABI disk edge, a point inside the disk edge will be used in the computation.

- Projection: Selected based on the scene center latitude.
- Mercator Computed Parameters
  - Scaling Latitude: Latitude of scene center
- Lambert Conformal Computed Parameters
  - Tangent Latitude/Scaling Latitude: Latitude of scene center
  - Reference Longitude: Longitude of scene center
- Polar Stereographic Computed Parameters
  - Reference Longitude: Longitude of scene center
  - Scaling Latitude: Latitude of scene center
- Fixed Grid/Satellite View Computed Parameters
  - None

SCMI Mesoscale Spatial Resolution Computation Explanation

The base spatial resolution (as explained above) is computed based on the size of the ABI grid pixel at the center of the Mesoscale. This value will vary across the ABI grid. The pixels directly below the satellite (at the nadir position) will have the nominal 0.5, 1.0, and 2.0 km pixel sizes. Pixels toward the edge of the disk will cover more ground space since each sensor of the ABI sensor grid is able to see more of the surface of the earth.

Using the base spatial resolution gives a Mesoscale product that is close to the size (in pixels) of the Mesoscale scene (1000x1000 for the 1 km channels). Using the Spatial Resolution Scaling Factor configuration parameter allows the size and resolution of the sectorized product to be adjusted. If a Mesoscale Spatial Resolution Scaling Factor of 1.0 is used the base for a 1 km band sectorized Mesoscale product, the base spatial resolution will be used and the resulting product have a size slightly larger than the 1000x1000 size of the Mesoscale scene. If the center of that Mesoscale scene is the satellite nadir position, the sectorized product will have a spatial resolution of 1 km. Using a scale factor of 2.0 on the same Mesoscale Scene gives a sectorized Mesoscale product that is slightly larger than 500x500 and for a Mesoscale scene centered at nadir, a the spatial resolution of 2.0 km.