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SCATSAT-1 Level 4 Data Products Format Document

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DOCUMENT CHANGE HISTORY

Version No.	Date	Changed section	Nature of change (A,M,D)*	Description
1.1	01/08/2017	2.2	M	Updated data decoding formulae
		3	M	Changed file names to reflect version number
		4	M	Updated xml outputs to with those generated with Ver. 1.1
		5	M	Updated browse images with those generated with Ver. 1.1

*: (A: Addition, M: Modification, D: Deletion)

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1.0 Introduction

The SCATSAT1 is an active Scatterometer designed to measure ocean surface wind velocity. The sensor transmits signals at regular interval and receives energy back scattered by the targets on the Earth. The DPGS generates Level 1B product from the sensor data. The Level 1B product carries back scattering coefficient (or sigma0) and other radiometric parameters along with geolocation information. The Level 4 products are generated from Level 1B products.

This document describes format of Level 4 products of SCATSAT1 (operational version 1.0). These are high resolution products and are generated using Scatterometer Image Reconstruction (or SIR) technique.

Currently, three parameters are given as a product: *sigma0, gamma0 and brightness temperature*. Depending on geo location extent, various categories of a product are defined. Depending on combinations of polarization/pass/look and temporal extent of data, various sub-categories of Level 4 products are defined. For a product (say, of sigma0, gamma0 or brightness temperature), the categories are described in Table 1 below:

Table 1 Categories of Level 4 Products

Category	Sub-category	Spatial Extent	
		Lat. Range	Lon. Range
India	VVDES, VVASC, VVBOTH, HHDES, HHASC, HHBOTH	[6:40]	[64:100]
Global	VVDES, VVASC, VVBOTH, HHDES, HHASC, HHBOTH	[-90:90]	[-180:180]
NorthPolar24	VVBOTH, HHBOTH	[60:90]	[-180:180]
NorthPolar72	VVDES, HHDES	[60:90]	[-180:180]
SouthPolar24	VVBOTH, HHBOTH	[-90:-50]	[-180:180]
SouthPolar72	VVASC, HHASC	[-90:-50]	[-180:180]

The products for all three parameters will be generated once daily using previous Level 1B data products. The product generation strategy is described in Table 2 below:

Table 2 Generation of Level 4 Products

Category	Product Generation for all sub-categories
India	Generated once every day using L1B products of last 48 hours, so 6 products per day per parameter
Global	Generated once every day using L1B products of last 48 hours, so 6 products per day per parameter
NorthPolar24	Generated once every day using L1B products of last 24 hours, so 2 products per day per parameter
NorthPolar72	Generated once every day using L1B products of last 72 hours, so 2 products per day per parameter
SouthPolar24	Generated once every day using L1B products of last 24 hours, so 2 products per day per parameter
SouthPolar72	Generated once every day using L1B products of last 72 hours, so 2 products per day per parameter

The Polar products will be having data for all the features such as land, ocean or ice. However, Global and India products will be having data for pure land only. The product format is GeoTIFF. The India Products and Global Products are defined in geographic lat-lon grid. The Polar products are defined in Polar Projection as specified by NPs.mpp and SPs.mpp of NSIDC (National Snow and Ice Data Centre) maps library. The EPSG codes for North and South polar projection defined by NPs.mpp and SPs.mpp are *3411* and *3412* respectively. The spatial resolution of INDIA products for all parameters is *0.02°*. The spatial resolution of GLOBAL sigma0 and gamma0 products is *0.02°*, whereas spatial resolution of GLOBAL brightness temperature product is *0.0625°*. The details are given in Table 3 below:

Table 3 Product parameters

Category	NumPixels	NumScans	Projection	Spatial Resolution
India	1800	1700	Geographic	*0.02°* per pixel
Global2	18000	9000	Geographic	*0.02°* per pixel
Global625	5760	2880	Geographic	*0.0625°* per pixel
NorthPolar24	3001	3001	Polar Projection	-
NorthPolar72	3001	3001	Polar Projection	-
SouthPolar24	4001	4001	Polar Projection	-
SouthPolar72	4001	4001	Polar Projection	-

2.0 Details of Product Format:

All products of Level 4 are supplied in GeoTIFF format. The brief introduction of the format is presented in section 2.1. Relevant information about Level 4 product is placed in next sub section.

2.1 Details of GeoTIFF:

Remote sensing and its applications use data in digital form. These datasets generally contain digital image along with other information which are further used for data interpretation and other applications. Different communities use these data for their required purpose. To make it convenient to the users, standards are required to store these datasets. Many image file formats like *GIF, PGM, BMP, JPEG* etc. are available globally. These formats have an image header with fixed fields containing information such as image dimensions, color space specification, etc.

However, these formats have no facility to store information related to geo-location of image pixels. They also do not support storage of cartographic data. Due to these limitations, a new format is required to store image data along with image geometry as well as cartographic information along with ancillary information required for further processing. The new format has to be platform independent, flexible and extensible. The Tagged Image File Format (*TIFF*) is one of the popularly available image formats. It is platform independent extensible. Several third party solutions exist for recording

cartographic information using *TIFF* tags. The specifications for these tags (fields) are available in *TIFF-6.0* documents. These fields contain information ranging from the most primary, like image dimensions, over the most sophisticated information like copyright, up to so-called 'private tags' or 'custom tags' that can define to hold application-specific information. The *TIFF* specification defines a framework for an image header called '*IFD'* (Image File Directory) that is essentially a flexible set of specifically those tags that the *TIFF* writer software wishes to specify.

The *TIFF* file format can be used to store and digital satellite image data, scanned aerial photos, elevation models, scanned maps and the results of many types of geographic analysis. *TIFF* is the only full-featured format in the public domain, capable of supporting extension to include geographic metadata. *GeoTIFF* implements the geographic metadata formally, using compliant TIFF tags and structures. A *GeoTIFF* file actually contains geographic (or cartographic) data attached as tags within the *TIFF* file. The geographic data can then be used to position the image in the correct location and geometry on the screen of a geographic information display. *GeoTIFF* is a metadata format, which provides geographic information to associate with the image data. But the *TIFF* file structure allows both the metadata and the image data to be encoded into the same file. *GeoTIFF* makes use of a public tag structure which is platform interoperable between any and all *GeoTIFF*- readers.

The *GeoTIFF* format is supported by *TIFF – 6.0*. That is, the *GeoTIFF* images conform in every way to the *TIFF* formal specifications. The tags used for the "Geo" portion of the *TIFF* format conform to the acceptable and customary use of "private" or "registered" *TIFF* tags. The *GeoTIFF* tags and definitions are considered completely to the baseline and extended *TIFF* tag definitions currently supported in *TIFF-6* by Aldus Corp.

2.2 Details of Level 4 products:

A set of geographic parameters required to interpret the product for each category has been defined. This set is used for placing geographic information in GeoTIFF in form of tags (or keys). The sets for various categories of products are shown in Table 4 below:

Table 4 (a) Parameters of INDIA and GLOBAL products

Paramter	***Value for INDIA***	***Value for GLOBAL 0.02°***	***Value for GLOBAL 0.0625°***
OutputLineSpacing	0.02	0.02	0.0625
OutputPixelSpacing	0.02	0.02	0.0625
NoScans	1700	9000	2880
NoPixels	1800	18000	5760
ULLat	39.99	89.99	89.968750
ULLon	64.01	-179.99	-179.968750
URLat	39.99	89.99	89.968750

URLon	99.99	179.99	179.968750
LRLat	6.01	-89.99	-89.968750
LRLon	99.99	179.99	179.968750
LLLat	6.01	-89.99	-89.968750
LLLon	64.01	-179.99	-179.968750
SceneCenterLat	23.00	0.00	0.00
SceneCenterLon	82.00	180.00	180.00
EllipsoidSemiMajorAxis	6378137.0	6378137.0	6378137.0
EllipsoidSemiMinorAxis	6356752.3139897	6356752.3139897	6356752.3139897

Table 4 (b) Parameters of POLAR products

Parameter	***Value for NORTH POLAR***	***Value for SOUTH POLAR***
OutputLineSpacing	2216.453682	2257.350185
OutputPixelSpacing	2216.453682	2257.350185
NoScans	3001	4001
NoPixels	3001	4001
MapOriginLat	90.0	-90.0
MapOriginLon	-45.0	0.0
ULLat	48.457512	-35.429245
ULLon	179.999710	-44.989052
URLat	48.457512	-35.429245
URLon	90.002022	45.010746
LRLat	48.457512	-35.429245
LRLon	0.001852	135.010422
LLLat	48.457512	-35.429245
LLLon	-89.998314	-134.989563
ULMapX	-3323679.50	-4514076.50
ULMapY	3323713.25	4515802.00
URMapX	3323579.00	4515786.00
URMapY	3323813.50	4514092.50
LRMapX	3323803.75	4514118.00
LRMapY	-3323589.00	-4515760.50
LLMapX	-3323598.50	-4515761.50
LLMapY	-3323794.25	-4514117.00
SceneCenterLat	90.0	-90.0
SceneCenterLon	-45.0	0.0
StandardParallel1	70.0	-70.0
FalseEasting	0.0	0.0
FalseNorthing	0.0	0.0
EllipsoidSemiMajorAxis	6378273.0	6378273.0
EllipsoidSemiMinorAxis	6356889.4489106	6356889.4489106
EllipsoidEccentricity	0.081816153	0.081816153

The corner lat-lon and mapx-mapy values define in GeoTIFF refers to the value of centre of the corner pixel.

The data part of the product carries the parameter values in range defined by minimum and maximum defined in Table 5 below. Any value out of this range is clipped (to lower or upper bound of range) appropriately. The image pixels are coded as unsigned short integer using slope and offset. The slope and offset are mentioned in the corresponding xml file. The BT value can be obtained from unsigned short integer value as shown by equation 1. The sigma0 or gamma0 value can be obtained from unsigned integer value as shown by equations 2 to 7. Basically, LSB of sigma0 or gamma0 product carries the sign of parameter in linear scale. Rest of the bits carry sigma0/gamma0 value in dB.

For BT:

*BT_value_in_degK = unsigned_short_int_value*slope + offset* *(1)*

For sigma0 and gamma0:

intermediate_value = unsigned_short_int_value AND (0xFFFE) *(2)*

sign_bit = unsigned_short_int_value AND (0x0001) *(3)*

*para_value_in_dB = intermediate_value*slope + offset* *(4)*

sign_value = -1 if sign_bit = 1 *(5)*

sign_value = 1 if sign_bit = 0 *(6)*

*para_value_in_linear_scale = sign_value*10.0^(para_value_in_dB/10.0)* *(7)*

The absence of parameter is denoted by coded value of *65535*. So, value of parameter should be computed only if coded value is not equal to 65535.

Table 5 Slope and Offset for products

Product Parameter	Slope	Offset	Minimum	Maximum	Physical unit
Sigma0	0.001	-50.0	-50.0	15.0	dB
Brightness Temperature	0.01	0.0	0.0	640.0	deg. K
Gamma0	0.001	-50.0	-50.0	15.0	dB

3.0 File Naming Convention

The naming convention is designed to convey necessary information about the product. The products formed using multiple days of data has start day as well as end day information. The products generated using single day of data has the corresponding day in the file name. The file name also conveys parameter, category and sub-category of the product. The convention is described below:

- For NorthPolar24 and SouthPolar24 products:

S1L4PL_yyyyddd_AAA_CC_V_R.tif

- For India, NorthPolar72, SouthPolar72 and Global products:

S1L4PL_yyyyddd_yyyyddd _AAA_CC_V_R.tif

where

S1 = product of SCATSAT1
L4 = product of level 4
P = S/B/G for product of sigma0/brightness temperature/gamma0
L = H/V for HH/VV polarization
yyyyddd = Acquisition start and end date in year and Julian day.
AAA =ASC/DES/BTH corresponding to ascending/descending/both passes
CC = IN/NP/SP/GL2/GL625 for INDIA/NPOLAR/SPOLAR/GLOBAL category

V = Version number of L1B product used as input (e.g., v1.1.2)
R = Version of L4 product generation algorithm (e.g., 1.1)

Following table shows example file names for all categories of sigma0 products having end date of 28th September 2016. For 24 hrs products, the start and end acquisition time are start and end acquisition time of first and last revolution of Julian day mentioned by the filename. For a product spanning more than 24 hrs, start acquisition time is acquisition start time of first revolution of first Julian day and end acquisition time is acquisition end time of last revolution of second Julian day.

Table 6 Naming convention of products

Category	FileName
INDIA	S1L4SH_2016271_2016272_ASC_IN_v1.1.2_1.1.tif
	S1L4SH_2016271_2016272_BTH_IN_v1.1.2_1.1.tif
	S1L4SH_2016271_2016272_DES_IN_v1.1.2_1.1.tif
	S1L4SV_2016271_2016272_ASC_IN_v1.1.2_1.1.tif
	S1L4SV_2016271_2016272_BTH_IN_v1.1.2_1.1.tif
	S1L4SV_2016271_2016272_DES_IN_v1.1.2_1.1.tif
GLOBAL2	S1L4SH_2016271_2016272_ASC_GL2_v1.1.2_1.1.tif
	S1L4SH_2016271_2016272_BTH_GL2_v1.1.2_1.1.tif
	S1L4SH_2016271_2016272_DES_GL2_v1.1.2_1.1.tif
	S1L4SV_2016271_2016272_ASC_GL2_v1.1.2_1.1.tif
	S1L4SV_2016271_2016272_BTH_GL2_v1.1.2_1.1.tif
	S1L4SV_2016271_2016272_DES_GL2_v1.1.2_1.1.tif
NPOLAR24	S1L4SH_2016272_BTH_NP_v1.1.2_1.1.tif
	S1L4SV_2016272_BTH_NP_v1.1.2_1.1.tif
NPOLAR72	S1L4SH_2016271_2016272_DES_NP_v1.1.2_1.1.tif
	S1L4SV_2016271_2016272_DES_NP_v1.1.2_1.1.tif
SPOLAR24	S1L4SH_2016272_BTH_SP_v1.1.2_1.1.tif
	S1L4SV_2016272_BTH_SP_v1.1.2_1.1.tif
SPOLAR72	S1L4SH_2016271_2016272_ASC_SP_v1.1.2_1.1.tif
	S1L4SV_2016271_2016272_ASC_SP_v1.1.2_1.1.tif

4.0 Information in xml files

Corresponding to each GeoTIFF product, one xml file and one browse image are also generated. The file naming will be same as product except the extension. The xml file carries metadata of the product such as geographical and temporal extent of product, product generation time and version, quality of product, etc. Sample xml files for different categories of products having end date of 2nd May 2017 are shown below:

Sample xml for INDIA VV DES sigma0 product:

```
<xml version="1.0">
<DATA_FILENAME>S1L4SV_2017121_2017122_DES_IN_v1.1.2_1.1.tif</DATA_FILENAME>
<DATA_FILESIZE>6139298</DATA_FILESIZE>
<ACQUISITION_START_TIME>01-05-2017 00:14:15</ACQUISITION_START_TIME>
<ACQUISITION_END_TIME>03-05-2017 00:18:52</ACQUISITION_END_TIME>
<NORTH_LAT>40.0</NORTH_LAT>
<SOUTH_LAT>6.0</SOUTH_LAT>
<WEST_LONG>64.0</WEST_LONG>
<EAST_LONG>100.0</EAST_LONG>
<L4SOFTWARE_VERSION>1.1</L4SOFTWARE_VERSION>
<START_ORBIT>03143_03144_SN</START_ORBIT>
<END_ORBIT>03172_03173_SN</END_ORBIT>
<NUM_REV>5</NUM_REV>
<DATA_SCALE>0.001</DATA_SCALE>
<DATA_OFFSET>-50.0</DATA_OFFSET>
<PROD_CREATION_DATE>24-07-2017:03:55:37</PROD_CREATION_DATE>
<QC>2</QC>
</xml>
```

Sample xml for NPOLAR24 HH BTH sigma0 product:

```
<xml version="1.0">
<DATA_FILENAME>S1L4SH_2017122_BTH_NP_v1.1.2_1.1.tif</DATA_FILENAME>
<DATA_FILESIZE>18041708</DATA_FILESIZE>
<ACQUISITION_START_TIME>02-05-2017 00:22:48</ACQUISITION_START_TIME>
<ACQUISITION_END_TIME>03-05-2017 00:18:52</ACQUISITION_END_TIME>
<NORTH_LAT>60.0</NORTH_LAT>
<SOUTH_LAT>90.0</SOUTH_LAT>
<WEST_LONG>-180.0</WEST_LONG>
<EAST_LONG>180.0</EAST_LONG>
<L4SOFTWARE_VERSION>1.1</L4SOFTWARE_VERSION>
<START_ORBIT>03158_03159_SN</START_ORBIT>
<END_ORBIT>03172_03173_SN</END_ORBIT>
<NUM_REV>29</NUM_REV>
<DATA_SCALE>0.001</DATA_SCALE>
<DATA_OFFSET>-50.0</DATA_OFFSET>
<PROD_CREATION_DATE>24-07-2017:01:57:46</PROD_CREATION_DATE>
<QC>2</QC>
</xml>
```

Sample xml for SPOLAR24 HH BTH sigma0 product:

```
<xml version="1.0">
<DATA_FILENAME>S1L4SH_2017122_BTH_SP_v1.1.2_1.1.tif</DATA_FILENAME>
<DATA_FILESIZE>32053708</DATA_FILESIZE>
<ACQUISITION_START_TIME>02-05-2017 00:22:48</ACQUISITION_START_TIME>
<ACQUISITION_END_TIME>03-05-2017 00:18:52</ACQUISITION_END_TIME>
<NORTH_LAT>-90.0</NORTH_LAT>
<SOUTH_LAT>-50.0</SOUTH_LAT>
<WEST_LONG>-180.0</WEST_LONG>
<EAST_LONG>180.0</EAST_LONG>
<L4SOFTWARE_VERSION>1.1</L4SOFTWARE_VERSION>
<START_ORBIT>03158_03159_SN</START_ORBIT>
<END_ORBIT>03172_03173_SN</END_ORBIT>
<NUM_REV>29</NUM_REV>
<DATA_SCALE>0.001</DATA_SCALE>
<DATA_OFFSET>-50.0</DATA_OFFSET>
<PROD_CREATION_DATE>24-07-2017:01:18:25</PROD_CREATION_DATE>
<QC>2</QC>
</xml>
```

Sample xml for NPOLAR72 VV DES sigma0 product:

<xml version="1.0">
<DATA_FILENAME>S1L4SV_2017120_2017122_DES_NP_v1.1.2_1.1.tif</DATA_FILENAME>
<DATA_FILESIZE>18041708</DATA_FILESIZE>
<ACQUISITION_START_TIME>30-04-2017 00:21:18</ACQUISITION_START_TIME>
<ACQUISITION_END_TIME>03-05-2017 00:18:52</ACQUISITION_END_TIME>
<NORTH_LAT>60.0</NORTH_LAT>
<SOUTH_LAT>90.0</SOUTH_LAT>
<WEST_LONG>-180.0</WEST_LONG>
<EAST_LONG>180.0</EAST_LONG>
<L4SOFTWARE_VERSION>1.1</L4SOFTWARE_VERSION>
<START_ORBIT>03129_03130_SN</START_ORBIT>
<END_ORBIT>03172_03173_SN</END_ORBIT>
<NUM_REV>43</NUM_REV>
<DATA_SCALE>0.001</DATA_SCALE>
<DATA_OFFSET>-50.0</DATA_OFFSET>
<PROD_CREATION_DATE>24-07-2017:01:30:24</PROD_CREATION_DATE>
<QC>1</QC>
</xml>

Sample xml for SPOLAR72 VV ASC sigma0 product:

<xml version="1.0">
<DATA_FILENAME>S1L4SV_2017120_2017122_ASC_SP_v1.1.2_1.1.tif</DATA_FILENAME>
<DATA_FILESIZE>32053708</DATA_FILESIZE>
<ACQUISITION_START_TIME>30-04-2017 00:21:18</ACQUISITION_START_TIME>
<ACQUISITION_END_TIME>03-05-2017 00:18:52</ACQUISITION_END_TIME>
<NORTH_LAT>-90.0</NORTH_LAT>
<SOUTH_LAT>-50.0</SOUTH_LAT>
<WEST_LONG>-180.0</WEST_LONG>
<EAST_LONG>180.0</EAST_LONG>
<L4SOFTWARE_VERSION>1.1</L4SOFTWARE_VERSION>
<START_ORBIT>03129_03130_SN</START_ORBIT>
<END_ORBIT>03172_03173_SN</END_ORBIT>
<NUM_REV>44</NUM_REV>
<DATA_SCALE>0.001</DATA_SCALE>
<DATA_OFFSET>-50.0</DATA_OFFSET>
<PROD_CREATION_DATE>24-07-2017:05:12:33</PROD_CREATION_DATE>
<QC>1</QC>
</xml>

Sample xml for GLOBAL625 HH BTH BT product:

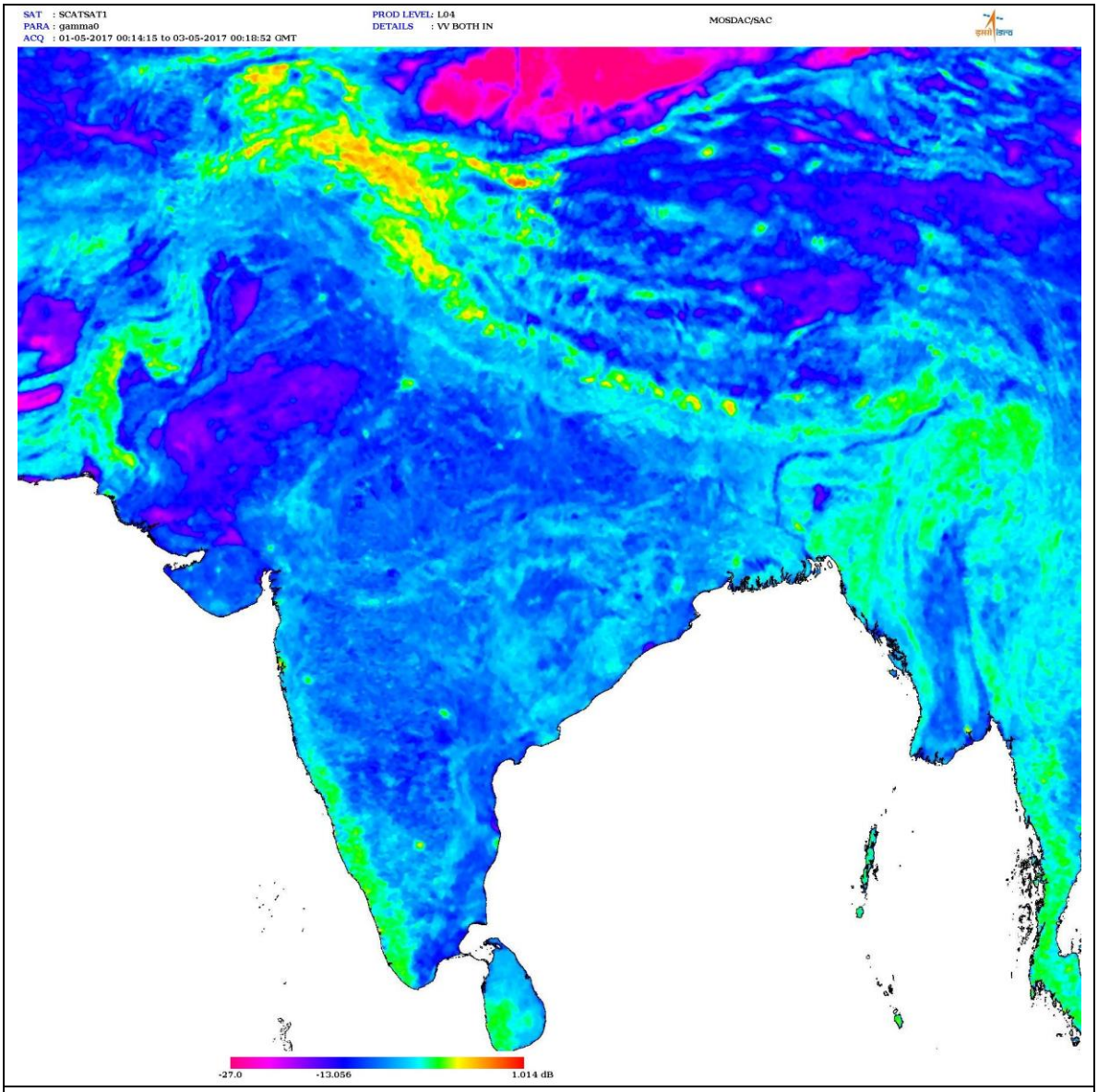
<xml version="1.0">
<DATA_FILENAME>S1L4BH_2017121_2017122_BTH_GL625_v1.1.2_1.1.tif</DATA_FILENAME>
<DATA_FILESIZE>33206338</DATA_FILESIZE>
<ACQUISITION_START_TIME>01-05-2017 00:14:15</ACQUISITION_START_TIME>
<ACQUISITION_END_TIME>03-05-2017 00:18:52</ACQUISITION_END_TIME>
<NORTH_LAT>-90.0</NORTH_LAT>
<SOUTH_LAT>90.0</SOUTH_LAT>
<WEST_LONG>-180.0</WEST_LONG>
<EAST_LONG>180.0</EAST_LONG>
<L4SOFTWARE_VERSION>1.1</L4SOFTWARE_VERSION>
<START_ORBIT>03143_03144_SN</START_ORBIT>
<END_ORBIT>03172_03173_SN</END_ORBIT>
<NUM_REV>59</NUM_REV>
<DATA_SCALE>0.01</DATA_SCALE>
<DATA_OFFSET>0.0</DATA_OFFSET>
<PROD_CREATION_DATE>26-07-2017:05:26:42</PROD_CREATION_DATE>
<QC>2</QC>
</xml>

The lat-lon given in xml files shows the lat-lon coverage of the product. The start and end orbit number conveys the start and end revolution number used for product generation.

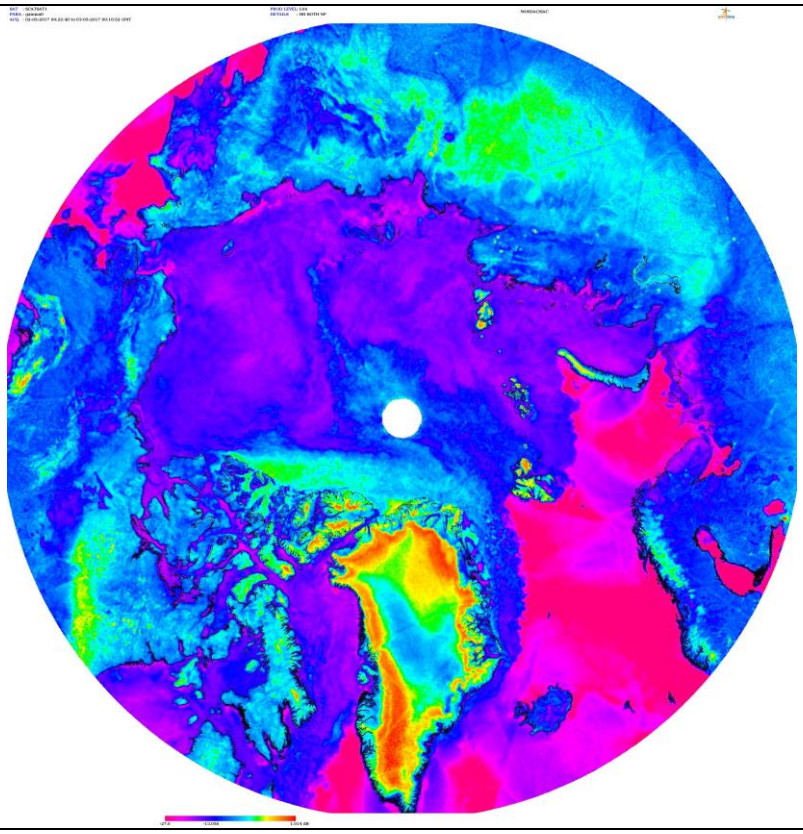
The NUM_REV entry indicates actual number of revolutions available for generation for product. Similar information is conveyed in the quality parameter. The QC will have value of 0/1/2 depending on quality being poor/partially good/good respectively. The DATA_SCALE and DATA_OFFSET indicate the scale and offset values (as specified in section 2) used for generating particular product.

5.0 Visualization through browse products

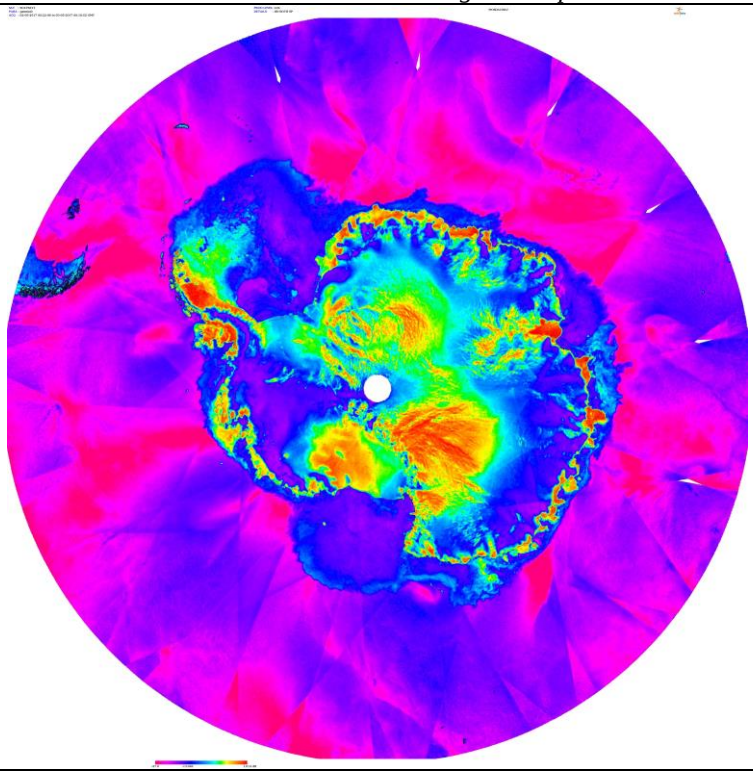
The browse products are generated for each tif product. These jpg images are intended to help user visualize the quality of product before using it. The range chosen for browse product is subset of range specified by section 2. The browse product range has been reduced for better visualization.



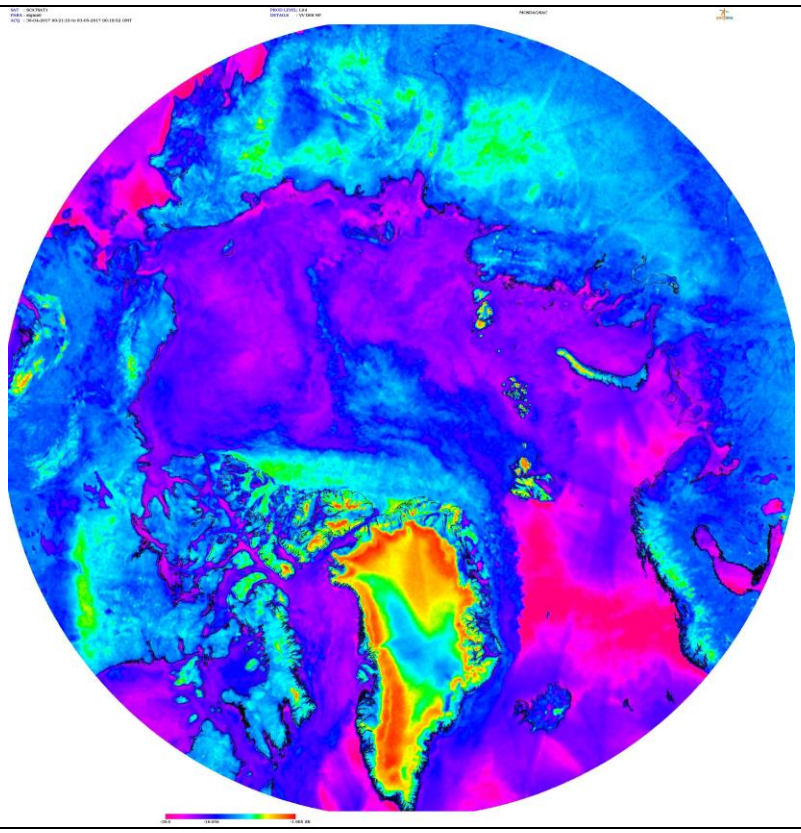
India VV BOTH gamma0 Product



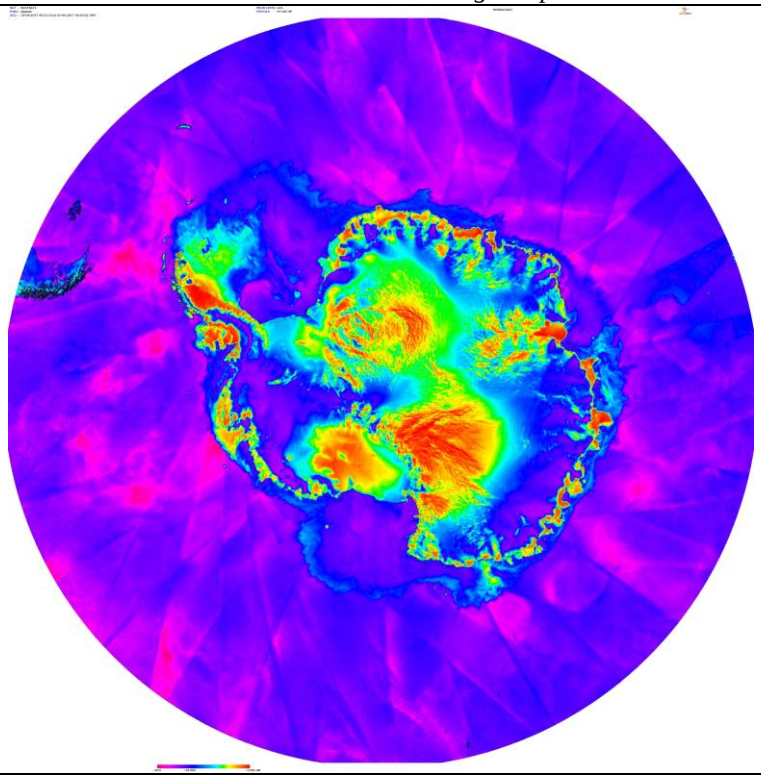
NorthPolar 24hours HH BOTH gamma0 product



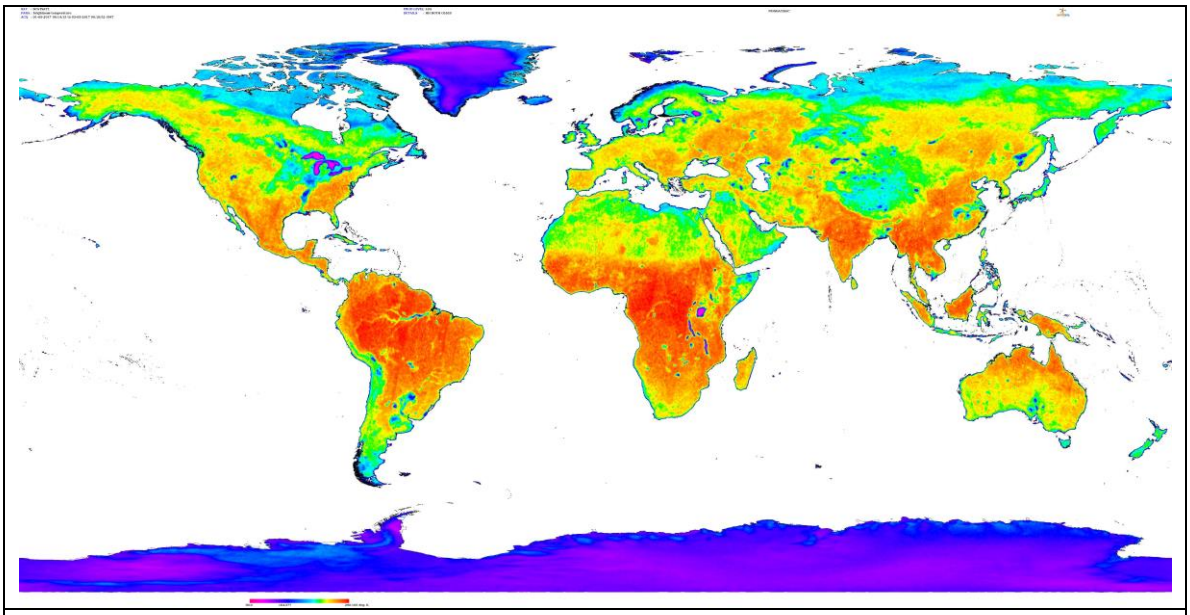
SouthPolar 24hours HH BOTH gamma0 product



NorthPolar 72hours VV DES sigma0 product



SouthPolar 72hours VV ASC sigma0 product



Global 0.0625° HH BOTH BT product

6.0 Product Generation and Dissemination

The SCATSAT1 Level 4 data products are generated at MOSDAC using Level 1B data products. The Data Product Generation System is installed at MOSDAC. The DPGS regularly fetches L1B products and invokes product generation software for all kinds of Level 4 products. After generation of products, the DPGS uploads product files on MOSDAC site.

The products are disseminated from the MOSDAC site (www.mosdac.gov.in). Along with the products in GeoTIFF format, browse jpeg images and xml metadata files are made available to the users. The users can search the products based on information in xml files and view the product using browse images.

7.0 Abbreviations

NSIDC	National Snow and Ice Data Centre
EPSG	European Petroleum Survey Group
MOSDAC	Meteorological & Oceanographic Satellite Data Archival Centre
xml	Extensible Markup Language
SIR	Scatterometer Image Reconstruction
TIFF	Tagged Image File Format
DPGS	Data Product Generation System

8.0 Related Documents

Specifications and Formats for SCATSAT-1 Scatterometer Data Products
SC1/DP/SPFDOC/1.0/APR2017