



Dataset Documentation  
National Ground Segment (Nasjonalt bakkesegment - NBS)

# Sentinel-1 GRD IW and EW products in NetCDF/CF

Date	Comment	Responsible
2019-03-05	First draft.	Trygve Halsne

Corresponding author: Trygve Halsne ([t.halsne@met.no](mailto:t.halsne@met.no)).

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## 2 Introduction

In order to exploit the MET Norway Scientific Information System (METSIS), the NBS has decided to make certain types of Sentinel satellite products available in NetCDF<sup>1</sup> format following the Climate and Forecast<sup>2</sup> (CF) convention, in addition to the original SAFE<sup>3</sup> format. The background is benchmarked in support for an open data space allowing combination with other types of data sets like model data & in-situ observations, support for spatio-temporal subsetting and product aggregation and integration of services, among others. In this document, the structure of the Sentinel-1 Ground Range Detected (GRD) Interferometric Wide swath (IW) and Extra Wide swath (EW) mode products is described.

The Sentinel-1 satellites carries a Synthetic Aperture Radar (SAR) instrument. This is an active sensor which in this case illuminates the earth with an operating frequency of 5.405 GHz (C-band) with support of dual polarisation. The portion of the energy backscattered from the earth's surface forms the basis of the resulting radar image. The instrument can operate in four different acquisition modes i.e. IW, EW, stripmap and wave where IW and EW are the primary modes over land and ocean respectively. Read more about the specifications of the Sentinel-1 mission at [sentinel.esa.int](https://sentinel.esa.int).

### 2.1 Scope

The scope of this document is to document the structure, content and outline of the NetCDF versions of the Sentinel-1 GRD IW and EW products for the users.

### 2.2 Intended audience

The intended audience are the users of the NetCDF versions of the Sentinel-1 GRD IW and EW products.

## 3 Product structure

The product file naming convention follows the same standard as the original top-level SAFE<sup>4</sup> products folder name in addition to the raster band variable names. In addition to the measurements, several variables originally stored as annotation information in SAFE are added as raster layers like the calibration vectors, sub swath numbers and thermal noise matrices. The latter is generated according to the thermal denoising procedure developed by the Sentinel-1 Instrument Processing Facility<sup>5</sup> and the others according to the specifications

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<sup>1</sup> [https://www.unidata.ucar.edu/software/netcdf/docs/netcdf\\_introduction.html](https://www.unidata.ucar.edu/software/netcdf/docs/netcdf_introduction.html)

<sup>2</sup> <http://cfconventions.org/>

<sup>3</sup> <http://earth.esa.int/SAFE/>

<sup>4</sup> <https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar/naming-conventions>

<sup>5</sup> Riccardo, P.; Nuno, M. and Hajduch, G. (2017). *Thermal Denoising of Products Generated by the S-1 IPF*.

<https://sentinel.esa.int/documents/247904/2142675/Thermal-Denoising-of-Products-Generated-by-Sentinel-1-IPF>

within the SAFE product. Hence, subsetting and aggregation is supported for all these variables.

### 3.1 Variable types

The datatypes used in these NetCDF files are described in the following table:

Variable type	Type description
byte	8 bit integer
short	16 bit integer
int	32 bit integer
float	32 bit floating point
char	8 bit character

Table 1: Data types in NetCDF with description. The variable attribute *\_Unsigned* = "true" indicates that the unsigned version of the variable is used. E.g *ubyte* is in the range [0,255].

Each variable contains attributes describing the data like units and grid mapping. See examples below in section 3.2.

### 3.2 Overview of product content

Below is an overview of the content of a random Sentinel-1 product. The format of the output is similar to what you obtain from a *ncdump -h* command.

**Product: S1A\_EW\_GRDM\_1SDH\_\***

**dimensions:**

```
gcp_index = 483 ;
time = 1 ;
x = 10368 ;
y = 10704 ;
```

**variables:**

```
int time(time) ;
    time:long_name = "reference time of satellite image" ;
    time:units = "seconds since 1981-01-01 00:00:00" ;
    time:calendar = "gregorian" ;
float lat(y, x) ;
    lat:standard_name = "latitude" ;
    lat:units = "degrees_north" ;
    lat:long_name = "latitude" ;
    lat:_ChunkSizes = 974, 943 ;
float lon(y, x) ;
short Amplitude_HH(time, y, x) ;
    Amplitude_HH:long_name = "Amplitude HH-polarisation" ;
    Amplitude_HH:units = "1" ;
```

```

    Amplitude_HH:coordinates = "lat lon" ;
    Amplitude_HH:grid_mapping = "crsWGS84" ;
    Amplitude_HH:standard_name =
"surface_backwards_scattering_coefficient_of_radar_wave" ;
    Amplitude_HH:polarisation = "HH" ;
    Amplitude_HH:_FillValue = 0s ;
    Amplitude_HH:_Unsigned = "true" ;
    Amplitude_HH:_ChunkSizes = 1, 2676, 2592 ;
short Amplitude_HV(time, y, x) ;
int crsWGS84 ;
    crsWGS84:grid_mapping_name = "latitude_longitude" ;
    crsWGS84:semi_major_axis = "6378137" ;
    crsWGS84:inverse_flattening = "298.2572235604902" ;
float dn_HH(time, y, x) ;
    dn_HH:polarisation = "HH" ;
    dn_HH:coordinates = "lat lon" ;
    dn_HH:grid_mapping = "crsWGS84" ;
    dn_HH:units = "1" ;
    dn_HH:long_name = "dn_HH calibration table" ;
    dn_HH:_ChunkSizes = 1, 2141, 2074 ;
float sigmaNought_HH(time, y, x) ;
float gamma_HH(time, y, x) ;
float betaNought_HH(time, y, x) ;
float betaNought_HV(time, y, x) ;
float gamma_HV(time, y, x) ;
float dn_HV(time, y, x) ;
float sigmaNought_HV(time, y, x) ;
float noiseCorrectionMatrix_HH(time, y, x) ;
float noiseCorrectionMatrix_HV(time, y, x) ;
byte swathList(y, x) ;
    swathList:_Unsigned = "false" ;
    swathList:_FillValue = 0b ;
    swathList:long_name = "Subswath List" ;
    swathList:flag_values = 1b, 2b, 3b, 4b, 5b ;
    swathList:valid_range = 1b, 5b ;
    swathList:flag_meanings = "EW1 EW2 EW3 EW4 EW5" ;
    swathList:standard_name = "status_flag" ;
    swathList:units = "1" ;
    swathList:coordinates = "lat lon" ;
    swathList:grid_mapping = "crsWGS84" ;
    swathList:_ChunkSizes = 1784, 1728 ;
float GCP_incidenceAngle_HH(gcp_index) ;
    GCP_incidenceAngle_HH:units = "degrees" ;
    GCP_incidenceAngle_HH:long_name = "Incidence angle to grid point." ;
    GCP_incidenceAngle_HH:_ChunkSizes = 483 ;
float GCP_slantRangeTime_HV(gcp_index) ;
float GCP_azimuthTime_HV(gcp_index) ;
float GCP_pixel_HH(gcp_index) ;
float GCP_elevationAngle_HH(gcp_index) ;
float GCP_latitude_HH(gcp_index) ;
float GCP_height_HH(gcp_index) ;
float GCP_incidenceAngle_HV(gcp_index) ;
float GCP_longitude_HV(gcp_index) ;
float GCP_latitude_HV(gcp_index) ;
float GCP_height_HV(gcp_index) ;
float GCP_elevationAngle_HV(gcp_index) ;
float GCP_pixel_HV(gcp_index) ;
float GCP_azimuthTime_HH(gcp_index) ;
float GCP_line_HV(gcp_index) ;
float GCP_slantRangeTime_HH(gcp_index) ;
float GCP_line_HH(gcp_index) ;
byte s1Level1ProductSchema_HH ;

```

```
byte s1Level1ProductSchema_HV ;
byte orbitList_HH ;
byte swathMergeList_HH ;
byte coordinateConversionList_HH ;
byte swathMergeList_HV ;
byte coordinateConversionList_HV ;
```

**global attributes:**

```
:title = "Sentinel-1 GRD data" ;
:netcdf4_version_id = "4.4.0" ;
:file_creation_date = "2019-02-27T10:39:51Z" ;
:PRODUCT_TYPE = "GRD" ;
:ACQUISITION_STOP_TIME = "2019-02-27T05:34:44.817591" ;
:ORBIT_NUMBER = "26111" ;
:BEAM_MODE = "EW" ;
:SWATH = "EW" ;
:ProductTimelinessCategory = "Fast-24h" ;
:keywords = "[Earth Science, Spectral/Engineering, RADAR, RADAR
backscatter], [Earth Science, Spectral/Engineering, RADAR, RADAR imagery], [Earth Science,
Spectral/Engineering, Microwave, Microwave Imagery]" ;
:summary = "Sentinel-1 C-band SAR GRD product." ;
:FACILITY_IDENTIFIER = "Copernicus S1 Core Ground Segment - UPA" ;
:polarisation = "HHV" ;
:SENSOR_IDENTIFIER = "SAR" ;
:MODE = "EW" ;
:PIXEL_SPACING = "4.000000e+01" ;
:BEAM_SWATH = "EW" ;
:SATELLITE_IDENTIFIER = "SENTINEL-1" ;
:keywords_vocabulary = "GCMD Science Keywords" ;
:ACQUISITION_START_TIME = "2019-02-27T05:33:40.536934" ;
:institution = "Norwegian Meteorological Institute" ;
:ORBIT_DIRECTION = "DESCENDING" ;
:LINE_SPACING = "4.000000e+01" ;
:Conventions = "CF-1.6" ;
:MISSION_ID = "S1A" ;
:history = "2019-02-27T10:39:51Z. Converted from SAFE to NetCDF by NBS
team." ;
```

**Product: S2B\_MSIL1C\_20180415T094029\_N0206\_R036\_T35VLJ\_20180415T114141**

**dimensions:**

```
time = 1 ;
x = 10980 ;
y = 10980 ;
dimension_rgb = 3 ;
dimension_INSPIRE_Metadata = 18848 ;
dimension_Format_OLQC_Report_Datastrip1_InformationData = 22480 ;
dimension_S2_Level_1C_Product_Metadata = 44503 ;
dimension_Format_OLQC_Report_Tile1_InformationData = 24375 ;
dimension_General_OLQC_Report_Datastrip1_InformationData = 7587 ;
dimension_Radiometric_OLQC_Report_Datastrip1_InformationData = 6256 ;
dimension_General_OLQC_Report_Tile1_InformationData = 2986 ;
dimension_S2_Level_1C_Datastrip1_Metadata = 14584245 ;
dimension_Sensor_OLQC_Report_Tile1_InformationData = 4806 ;
dimension_Geometric_OLQC_Report_Datastrip1_InformationData = 8412 ;
dimension_Sensor_OLQC_Report_Datastrip1_InformationData = 4708 ;
dimension_S2_Level_1C_Tile1_Metadata = 192379 ;
dimension_Geometric_OLQC_Report_Tile1_InformationData = 5668 ;
```

```
dimension_SAFE_structure = 7622 ;
```

**variables:**

```
int time(time) ;
float lat(y, x) ;
float lon(y, x) ;
int x(x) ;
int y(y) ;
ushort B1(time, y, x) ;
    B1:_FillValue = 0US ;
    B1:units = "1" ;
    B1:coordinates = "lat lon" ;
    B1:grid_mapping = "UTM_projection" ;
    B1:standard_name = "toa_bidirectional_reflectance" ;
    B1:long_name = "Reflectance in band B1" ;
    B1:bandwidth = "20" ;
    B1:bandwidth_unit = "nm" ;
    B1:wavelength = "443" ;
    B1:wavelength_unit = "nm" ;
    B1:solar_irradiance = "1874.3" ;
    B1:solar_irradiance_unit = "W/m2/um" ;
    B1:_Unsigned = "true" ;
ushort B4(time, y, x) ;
ushort B3(time, y, x) ;
ushort B2(time, y, x) ;
ushort B8(time, y, x) ;
ushort B5(time, y, x) ;
ushort B6(time, y, x) ;
ushort B7(time, y, x) ;
ushort B8A(time, y, x) ;
ushort B11(time, y, x) ;
ushort B12(time, y, x) ;
ushort B9(time, y, x) ;
ushort B10(time, y, x) ;
ubyte TCI(dimension_rgb, y, x) ;
    TCI:long_name = "TCI RGB from B4, B3 and B2" ;
int UTM_projection ;
byte MSK_DETFOO_B8A(time, y, x) ;
    MSK_DETFOO_B8A:_FillValue = -1b ;
    MSK_DETFOO_B8A:long_name = "MSK_DETFOO_B8A mask 10m resolution" ;
    MSK_DETFOO_B8A:comment = "Rasterized vector information." ;
    MSK_DETFOO_B8A:coordinates = "lat lon" ;
    MSK_DETFOO_B8A:grid_mapping = "UTM_projection" ;
    MSK_DETFOO_B8A:flag_values = 1b, 2b ;
    MSK_DETFOO_B8A:flag_meanings = "detector_footprint_B8A_02_1
detector_footprint_B8A_01_0" ;
byte MSK_DETFOO_B07(time, y, x) ;
byte MSK_DETFOO_B01(time, y, x) ;
byte MSK_DETFOO_B11(time, y, x) ;
byte MSK_DETFOO_B10(time, y, x) ;
byte MSK_DETFOO_B12(time, y, x) ;
byte MSK_DETFOO_B06(time, y, x) ;
byte MSK_DETFOO_B04(time, y, x) ;
byte MSK_DETFOO_B08(time, y, x) ;
byte MSK_DETFOO_B09(time, y, x) ;
byte MSK_DETFOO_B05(time, y, x) ;
byte MSK_DETFOO_B02(time, y, x) ;
byte MSK_DETFOO_B03(time, y, x) ;
float view_azimuth_B8A(time, y, x) ;
    view_azimuth_B8A:_FillValue = 9.96921e+36f ;
    view_azimuth_B8A:units = "degree" ;
    view_azimuth_B8A:long_name = "Viewing incidence azimuth angle" ;
```

```

view_azimuth_B8A:coordinates = "lat lon" ;
view_azimuth_B8A:grid_mapping = "UTM_projection" ;
view_azimuth_B8A:comment = "1 to 1 with original 22x22 resolution" ;
float view_zenith_B2(time, y, x) ;
float view_azimuth_B12(time, y, x) ;
float view_azimuth_B10(time, y, x) ;
float view_azimuth_B11(time, y, x) ;
float view_zenith_B11(time, y, x) ;
float view_zenith_B10(time, y, x) ;
float view_zenith_B12(time, y, x) ;
float sun_azimuth(time, y, x) ;
float view_azimuth_B1(time, y, x) ;
float view_azimuth_B2(time, y, x) ;
float view_azimuth_B3(time, y, x) ;
float view_azimuth_B4(time, y, x) ;
float view_azimuth_B5(time, y, x) ;
float view_azimuth_B6(time, y, x) ;
float view_azimuth_B7(time, y, x) ;
float view_azimuth_B8(time, y, x) ;
float view_azimuth_B9(time, y, x) ;
float view_zenith_B8A(time, y, x) ;
float view_zenith_B1(time, y, x) ;
float view_zenith_B3(time, y, x) ;
float sun_zenith(time, y, x) ;
float view_zenith_B5(time, y, x) ;
float view_zenith_B4(time, y, x) ;
float view_zenith_B7(time, y, x) ;
float view_zenith_B6(time, y, x) ;
float view_zenith_B9(time, y, x) ;
float view_zenith_B8(time, y, x) ;
char INSPIRE_Metadata(dimension_INSPIRE_Metadata) ;
INSPIRE_Metadata:long_name = "SAFE xml file: INSPIRE_Metadata" ;
INSPIRE_Metadata:comment = "Original SAFE xml file added as character
values." ;
char
Format_OLQC_Report_Datastrip1_InformationData(dimension_Format_OLQC_Report_Datastrip1_Infor
mationData) ;
char S2_Level_1C_Product_Metadata(dimension_S2_Level_1C_Product_Metadata) ;
char
Format_OLQC_Report_Tile1_InformationData(dimension_Format_OLQC_Report_Tile1_InformationData
) ;
char
General_OLQC_Report_Datastrip1_InformationData(dimension_General_OLQC_Report_Datastrip1_Inf
ormationData) ;
char
Radiometric_OLQC_Report_Datastrip1_InformationData(dimension_Radiometric_OLQC_Report_Datast
rip1_InformationData) ;
char
General_OLQC_Report_Tile1_InformationData(dimension_General_OLQC_Report_Tile1_InformationDa
ta) ;
char S2_Level_1C_Datastrip1_Metadata(dimension_S2_Level_1C_Datastrip1_Metadata) ;
char
Sensor_OLQC_Report_Tile1_InformationData(dimension_Sensor_OLQC_Report_Tile1_InformationData
) ;
char
Geometric_OLQC_Report_Datastrip1_InformationData(dimension_Geometric_OLQC_Report_Datastrip1
_InformationData) ;
char
Sensor_OLQC_Report_Datastrip1_InformationData(dimension_Sensor_OLQC_Report_Datastrip1_Infor
mationData) ;
char S2_Level_1C_Tile1_Metadata(dimension_S2_Level_1C_Tile1_Metadata) ;
S2_Level_1C_Tile1_Metadata:long_name = "SAFE xml file: char

```



```
Geometric_OLQC_Report_Tile1_InformationData(dimension_Geometric_OLQC_Report_Tile1_InformationData) ;
char SAFE_structure(dimension_SAFE_structure) ;
```

**global attributes:**

```
:title = "Sentinel-2 L1C data" ;
:netcdf4_version_id = "4.4.0" ;
:file_creation_date = "2019-02-28T08:03:19Z" ;
:DATATAKE_1_SPACECRAFT_NAME = "Sentinel-2B" ;
:PRODUCT_START_TIME = "2018-04-15T09:40:29.027Z" ;
:PRODUCT_TYPE = "S2MS1C" ;
:relativeOrbitNumber = "36" ;
:QUANTIFICATION_VALUE = "10000" ;
:DATATAKE_1_SENSING_ORBIT_DIRECTION = "DESCENDING" ;
:PRODUCT_URI =
"S2B_MS1C_20180415T094029_N0206_R036_T35VLJ_20180415T114141.SAFE" ;
:keywords = "[Earth Science, Atmosphere, Atmospheric radiation,
Reflectance]" ;
:SPECIAL_VALUE_NODATA = "0" ;
:REFLECTANCE_CONVERSION_U = "0.995949104445435" ;
:DATATAKE_1_ID = "GS2B_20180415T094029_005782_N02.06" ;
:institution = "Norwegian Meteorological Institute" ;
:source = "surface observation" ;
:FOOTPRINT = "POLYGON((24.58237248680248 61.22098863844452,
24.600994107944487 61.250025908275454, 24.69370935926566 61.393412988942906,
24.787369891455835 61.53672830877798, 24.881914351776647 61.67993617381577,
24.976787249505463 61.82317825581031, 25.072661388554447 61.96637109188654,
25.16970514616204 62.10950545054046, 25.24568135473475 62.22053183537065, 25.26515555084272
62.220923807248376, 25.319687679163653 61.23569362676834, 24.58237248680248
61.22098863844452))" ;
:PROCESSING_BASELINE = "02.06" ;
:keywords_vocabulary = "GCMD Science Keywords" ;
:DEGRADED Anc_DATA_PERCENTAGE = "0.0" ;
:orbitNumber = "005782" ;
:SPECIAL_VALUE_SATURATED = "65535" ;
:GENERATION_TIME = "2018-04-15T11:41:41.000000Z" ;
:PREVIEW_GEO_INFO = "Not applicable" ;
:PROCESSING_LEVEL = "Level-1C" ;
:summary = "Sentinel-2 Multi-Spectral Instrument Level-1C product." ;
:DATATAKE_1_DATATAKE_TYPE = "INS-NOBS" ;
:Conventions = "CF-1.6" ;
:DATATAKE_1_DATATAKE_SENSING_START = "2018-04-15T09:40:29.027Z" ;
:DEGRADED_MSI_DATA_PERCENTAGE = "0" ;
:history = "2019-02-28T08:03:19Z. Converted from SAFE to NetCDF by NBS
team." ;
:CLOUD_COVERAGE_ASSESSMENT = "0.1002" ;
:PRODUCT_STOP_TIME = "2018-04-15T09:40:29.027Z" ;
:PREVIEW_IMAGE_URL = "Not applicable" ;
```