



Dataset Documentation
National Ground Segment (Nasjonalt bakkesegment - NBS)

Sentinel-2 Level 1C products in NetCDF/CF

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1 Introduction

In order to exploit the the MET Norway Scientific Information System (METSIS), the NBS has decided to make certain types of Sentinel satellite products available in NetCDF¹ format following the Climate and Forecast² (CF) convention, in addition to the original SAFE³ 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-2 Level 1C (L1C) products is described.

The Sentinel-2 satellites carries a MultiSpectral Instrument (MSI). The MSI samples 13 spectral bands from the Visible (VNIR) and Near Infra-Red (NIR) to the Short Wave Infra-Red (SWIR) in three categories of spatial resolutions: four bands at 10 metres, six bands at 20 metres and three bands at 60 metres. Read more about the specifications of the Sentinel-2 mission at sentinel.esa.int.

1.1 Scope

The scope of this document is to document the structure, content and outline of the NetCDF versions of the Sentinel-2 L1C products for the users.

1.2 Intended audience

The intended audience are the users of the NetCDF versions of the Sentinel-2 L1C products.

2 Product structure

The product file naming convention follows the same standard as the original top-level SAFE⁴ products folder name in addition to the raster band variable names. However, the product variables are not all equal. In the NetCDF products, all spectral bands are provided in the highest raster resolution i.e. 10m x 10m. For the spectral bands with lower original raster resolution, resampling has been applied using a nearest neighbor interpolation method preserving information when resampling to native resolution. In addition, view, sun and zenith angles are resampled to highest raster resolution (originally 500m x 500m) and all band masks originally provided in GML that contains information are rasterized like clouds, detector_footprint, nodata etc. Moreover, the .xml annotation files in SAFE are processed as character variables in NetCDF and can be printed/read as text string information.

¹ https://www.unidata.ucar.edu/software/netcdf/docs/netcdf_introduction.html

² <http://cfconventions.org/>

³ <http://earth.esa.int/SAFE/>

⁴ <https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi/naming-convention>

2.1 Variable types

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

Variable type	Type description
byte	8 bit integer
ubyte	8 bit unsigned integer
short	16 bit integer
ushort	16 bit unsigned 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. For instance, each spectral band have *units* = "1" according to the CF standard names⁵ table for *toa_bidirectional_reflectance*. For the spectral bands, we have also added the irradiance unit as *solar_irradiance_unit* = "W/m2/um". See an example below in section 3.2.

2.2 Overview of product content

Below is an overview of the content of a random Sentinel-2 L1C product. The format of the output is similar to what you obtain from a *ncdump -h* command.

Product: S2B_MSIL1C_*

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 ;

```

⁵ <http://cfconventions.org/Data/cf-standard-names/63/build/cf-standard-name-table.html>

```
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" ;
```