ASID-v1

ASIP Sea Ice Dataset – version 1

User Manual

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The Danish Meteorological Institute
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Document version	Dataset version	Date	Change description	Responsible
1.0	1.0	17.06.2019	First version	Matilde Kreiner (PM), David Malmgren-Hansen, John Lavelle (ASIP team)
2.0	1.0	02.03.2020	Second version	Matilde Kreiner, David Malmgren-Hansen, and the ASIP team

Contents

Scope of the document

This user manual describes the content and format of the Sea ice data set produced by the ASIP project and made available to the public in March 2020.

The ASIP project

ASIP (Automated downstream Sea Ice Products) is a danish research and development project carried out in a collaboration between the Danish Meteorological Institute (DMI), the Technical University of Denmark (DTU) and Harnvig Arctic and Maritime, these partners together holding a wide expertise within active and passive microwave signature analysis, sea ice applications development and advanced computing methods. The ASIP project is funded by the Innovation Fund Denmark and partners. More information about the project can be found at www.asip.dk.

Synthetic Aperture Radar (SAR) satellite images are used extensively for producing sea ice charts in support for Arctic navigation. However, due to ambiguities in the relationship between SAR backscatter and ice conditions (different ice types and concentrations as well as different wind conditions over the ocean have the same backscatter signature) the process of producing ice charts is done by manual interpretation of the satellite data taking into account also the texture patterns of the ice in the SAR images. The process is labour-intensive and time consuming, and thus, the amount of ice charts that are produced on a given day is limited. Automatically generated high resolution sea ice maps have the potential to increase the use of satellite imagery in ice charting by providing more products and at shorter time delays between acquisition and product availability.The design of an automatic and robust sea ice classification scheme has been studied for many years. Recent approaches to this issue that use Convolutional Neural Networks (ie. image segmentation techniques) show promising results. The ASIP project uses this approach with the aim to partially or fully automate the generation of sea ice information from Copernicus Sentinel-1 SAR imagery. The ASIP sea ice data set has been produced so that it can be used for training of CNNs; it consists of Sentinel-1 imagery, AMSR2 microwave radiometer data and the corresponding ice charts that were manually produced by the ice analysts in the DMI Ice Service.

Ownership and copyright of the data set

The Sea ice data set has been produced under the responsibility of the Danish Meteorological Institute and the Technical University of Denmark. The ownership and copyrights of the data set belongs to the ASIP project. The dataset is distributed freely, but all those who use the data to publish their work are required to cite the **10.11583/DTU.11920416** and also consider if the following paper is relevant to cite:

A Convolutional Neural Network Architecture for Sentinel-1 and AMSR2 Data Fusion; David Malmgren-Hansen, Leif Toudal Pedersen, Allan Aasbjerg Nielsen, Matilde Brandt Kreiner, Roberto Saldo, Henning Skriver, John Lavelle, Jørgen Buus-Hinkler, and Klaus Harnvig; **[Submitted]**

Acknowledgement

The ASIP project acknowledges the European Commission and the European Space Agency for the use of Copernicus Sentinel-1 data and JAXA for the use of the AMSR2 data in the sea ice data set.

Acronyms and abbreviations

AMSR2	Advanced Microwave Scanning Radiometer 2
ASIP	Automated Sea Ice Products
CNN	Convolutional Neural Network
DMI	Danish Meteorological Institute
DTU	Technical University of Denmark
ESA	European Space Agency
EW	Extra Wide swath mode
GRDM	Ground Range Detected in Medium resolution
HH	Horizontal transmitting and Horizontal receiving polarization
HV	Horizontal transmitting and Vertical receiving polarization
netCDF	network Common Data Form
SAR	Synthetic Aperture Radar
SIC	Sea Ice Concentration
WMO	World Meteorological Organization

Data description

The "ASIP sea ice dataset – version1" includes 913 files in NetCDF format; the files contain a two channel dual polarised (HH and HV) Sentinel-1 image, auxiliary image parameters and the corresponding ice chart based on that Sentinel-1 image. The Sentinel-1 and ice chart variables are described in the chapters below. The other part of the files contain microwave radiometer measurements from the sensor AMSR2 on board the GCOM-W satellite operated by JAXA. Alongside the Sentinel-1 scene each netCDF file includes brightness temperatures from all frequencies and polarizations of AMSR2 in a grid matched with the Sentinel-1 scene.

The sea ice data set netCDF file name convention is adopted from the original Sentinel-1 files provided by the Copernicus data hubs in order to facilitate retrieving the original data if necessary.

Sentinel-1 files are available through the Copernicus Open Access Hub: https://scihub.copernicus.eu/. The file name convention is explained in the table below only for those indicators that are relevant for the use of the Sea ice data set. (A full description of the Sentinel-1 file naming convention can be found here: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar/naming-conventions).

Table 1- Sea ice data set file specifications.

File name convention	MMM_BB_TTTR_NNPP_YYYYMMDDTHHMMSS_ YYYYMMDDTHHMMSS _NNNNNN_NNNNNN_NNNN.NNNN.nc MMM – Sentinel-1 Mission identifier: "S1A" or "S1B" BB - Mode/Beam: "EW" for Extra Wide Swath Mode. TTTR - Product Type, Resolution Class: "GRDM" is a medium resolution product. PP - Polarisation: "DH" is dual HH+HV polarisation. YYYYMMDDTHHMMSS – the start and end date/time of the Sentinel-1 image, resp. Indicators with Ns are not relevant to this user manual.
Geographical coverage	
Variables Description	Ice chart ice concentration; Sentinel-1 image polarisations HH and HV; auxiliary Sentinel-1 image variables; AMSR2 regridded brightness temperatures (2x2 km grid)
Variable names	sar_incidenceangles; sar_primary; sar_secondary; icechart; sar_grid_line; sar_grid_sample; sar_grid_latitude; sar_grid_longitude; sar_grid_incidenceangle; sar_grid_height btemp_6.9h; btemp_6.9v; btemp_7.3h; btemp_7.3v; btemp_10.7h; btemp_10.7v; btemp_18.7h; btemp_18.7v; btemp_23.8h; btemp_23.8v; btemp_36.5h; btemp_36.5v; btemp_89.0ah; btemp_89.0bh; btemp_89.0av; btemp_89.0bv; btemp_89.0h; btemp_89.0v; lon; lat; sample; line; delay; delays; count
Time series	December 2014 – June 2017
Pixel Spacing	Sentinel-1: 40 m; AMSR2: 2km
Format	netCDF-4

Sentinel-1 imagery

Sentinel-1 is the radar mission of the Copernicus Earth Observation programme of the European Union (EU). The Sentinel-1 mission comprises a constellation of two polar-orbiting satellites, Sentinel-1A and Sentinel-1B, sharing the same orbital plane and collecting C-band (4.5 cm wavelength) synthetic aperture radar (SAR) images. Radar images can be acquired regardless of the weather. The Sentinel-1 SAR has the advantage of operating at a wavelength not impeded by cloud cover or a lack of illumination, such as in polar darkness, and can acquire data over a site during day or night time under all weather conditions. Since the Arctic area is dominated by cloud cover and polar darkness in a large part of the year, the SAR instrument has for many years been valuable for Arctic monitoring applications such as sea ice charting.

The Sentinel-1 sensor transmit a radar signal towards the ground and the backscatter is the portion of the outgoing radar signal that the target on the Earth's surface redirects directly back towards the radar antenna. The usual notation for backscatter is the symbol sigma. It is a measure of the reflective strength of a radar target. The normalised measure of the radar return from a distributed target is called the backscatter coefficient, or sigma nought (Sigma0). Other portions of the incident radar signal will be reflected and/or scattered away from the radar or absorbed.

The Sentinel-1 mission includes operating in different imaging modes with different resolution (down to 5 m) and coverage (up to 400 km). It also provides dual polarisation capability in different polarisation combinations. The polarisation mode indicates the orientation of the electric field of the transmitted signal and can be either horizontal (H) or vertical (V). Similarly the received signal can have either polarisation. The combined polarisation of the transmitted and received radar signal are denoted as for example HV means horizontal polarisation for signal transmission, and vertical polarisation of the signal received by the radar antenna.

The mode and polarisation specifications of the Sentinel-1 images in the sea ice data set are those that are traditionally used for ice charting; Sentinel-1 Extra Wide Swath Mode (EW) Level-1 Ground Range Detected products in Medium resolution (GRDM) and in dual polarisation, HH and HV. These Sentinel-1 image products cover 400 x 400 square kilometers, have a resolution of ~90 m and a pixel spacing of 40 x 40 m. A Sentinel-1 image in EW mode consists of five sub-swaths. There are some radiometric variations between these sub-swaths, most evident in HV polarisation images. Correcting these differences is a complex task.

Detailed information about the Sentinel-1 sensor and data can be found at https://sentinel.esa.int/web/sentinel/missions/sentinel-1

The sea ice data set netCDF files contain the following Sentinel-1 data as 2D variables:

- "sar_primary" - Sentinel-1 image in HH polarisation
- "sar_secondary" - Sentinel-1 image in HV polarisation

The two variables give the backscatter coefficients, Sigma0 in dB. The backscatter values are packed from the range [-30:+10] into the range [-1:+1] (denoted ‘packed Sigma0 values’) to be better suited for ingestion in the CNNs. These two variables are the primary information in the data set together with the ice chart information. For the data set netcdf files all packed Sigma0 values are masked out where there is no ice chart information and replaced with _FillValue = NaNf. Examples of an individual Sentinel-1 scene HH (sar_primary) and HV (sar_secondary) images are shown in Figure 1 and Figure 2.

The incidence angle of the SAR sensor affects the amount of radar backscatter in the image cross-section and thus this variable is included in the netCDF to enable modelling of this radiometric variation:

- "sar_incidenceangle"

In addition, the netCDF files contain auxiliary information that describes the common grid of the ice chart and Sentinel-1 variables. This grid is adopted from the original Sentinel-1 image files provided by ESA. No geographic projection/rectification are performed to the data. The grid is given as a set of corresponding 21x21 line and sample coordinates and , 21x21 latitudes and longitudes. A final variable provides information on the geographical elevation of the grid above sea level. These five variables refer to the "sar_grid_points" that are ground control points and can be used for georeference of an image.

- "sar_grid_line"

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- "sar_grid_sample"
- "sar_grid_latitude"
- "sar_grid_longitude"
- "sar_grid_height"

An example of a netCDF file header and variable information is given in the last chapter of this document.

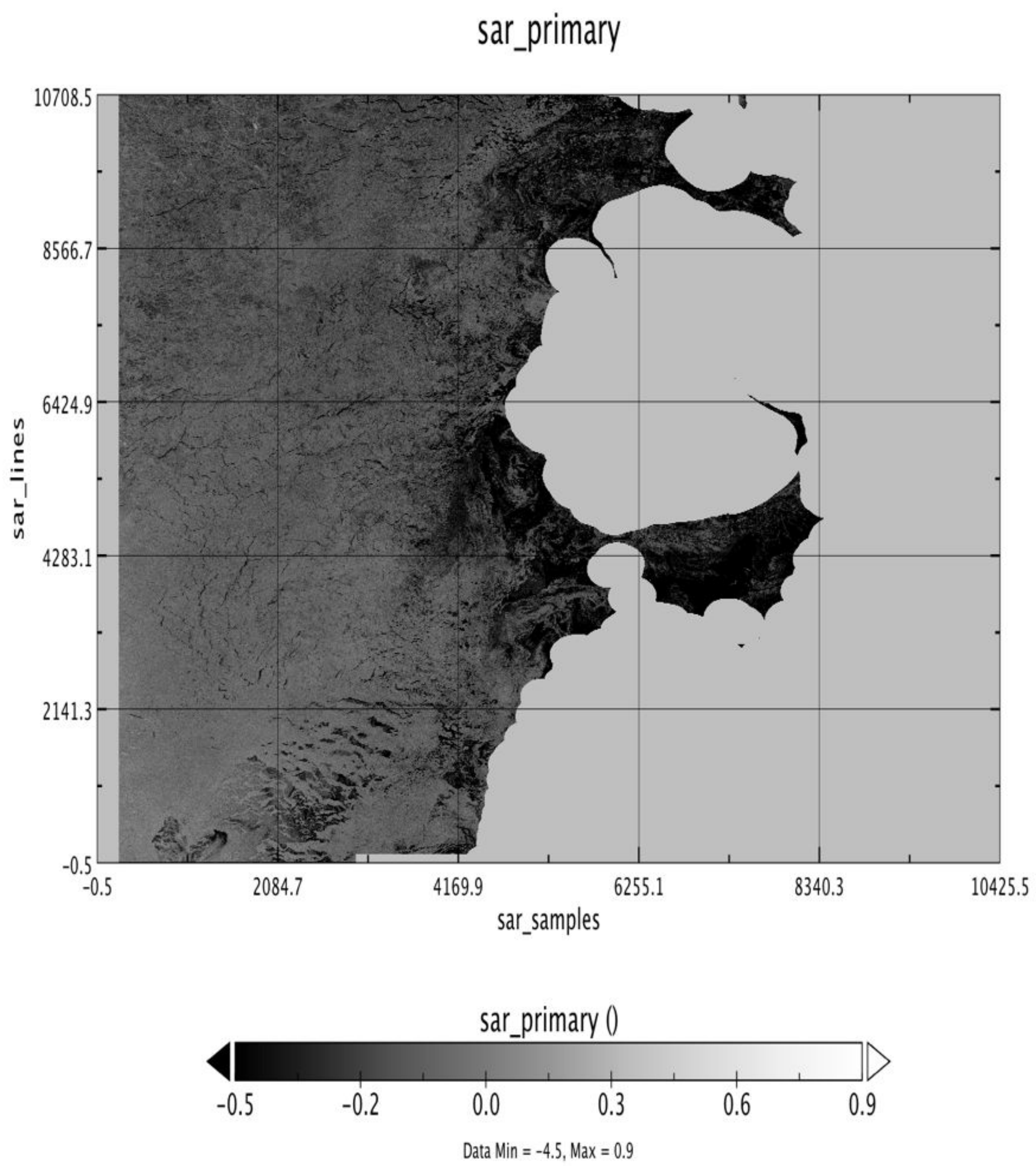

Figure 1 - Example of individual Sentinel-1 scene (HH polarisation channel) coverage corresponding to the icechart in Figure 3 and 4 (Filename: S1A_EW_GRDM_1SDH_20170109T205459_20170109T205604_014760_01807F_677B.SAFE.nc). Uniform grey area is a land buffer zone.

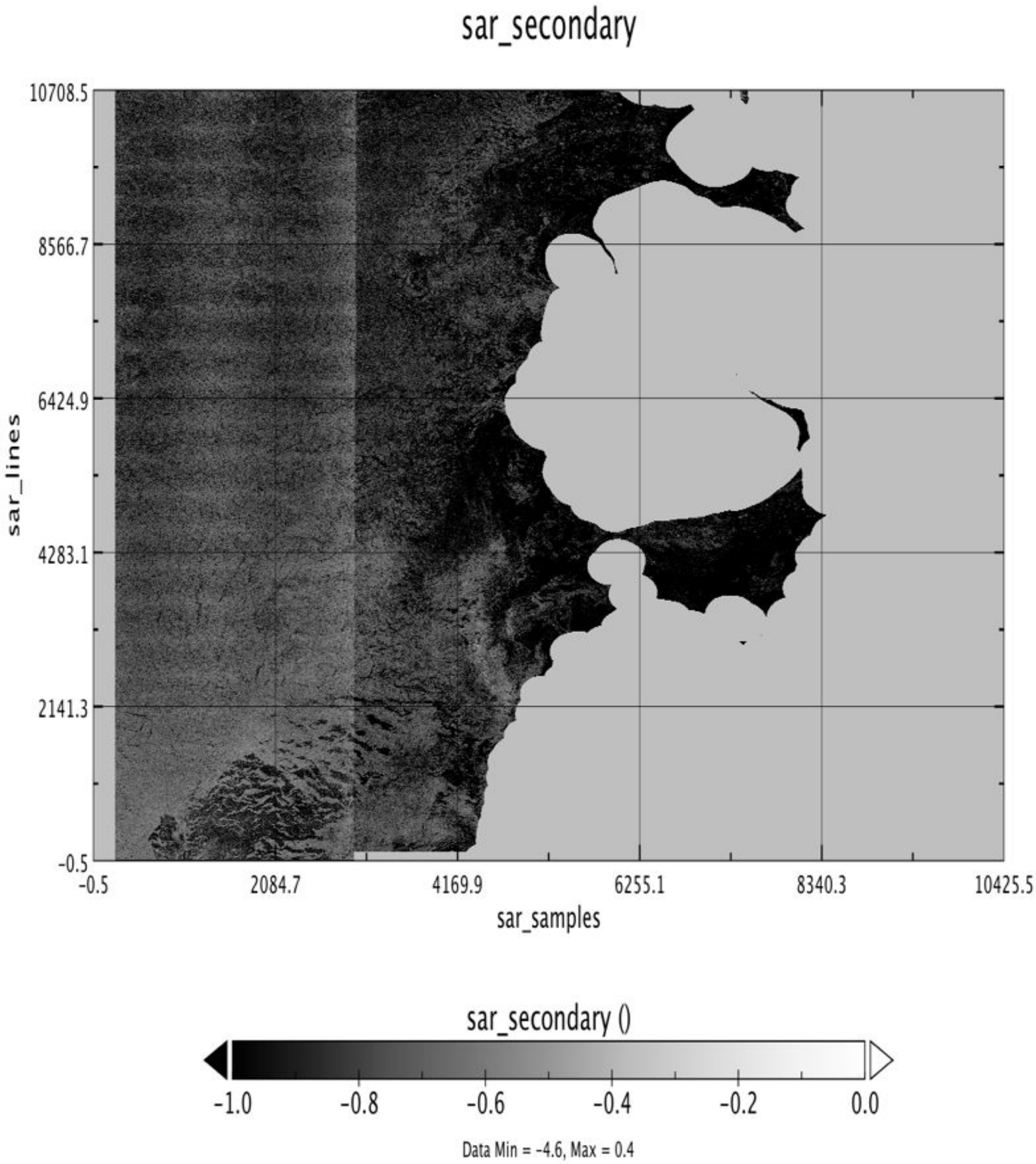

Figure 2 - Example of individual Sentinel-1 scene (HV polarisation channel) coverage corresponding to the ice chart in Figure 3 and 4 (Filename: S1A_EW_GRDM_1SDH_20170109T205459_20170109T205604_014760_01807F_677B.SAFE.nc). Uniform grey area is a land buffer zone.

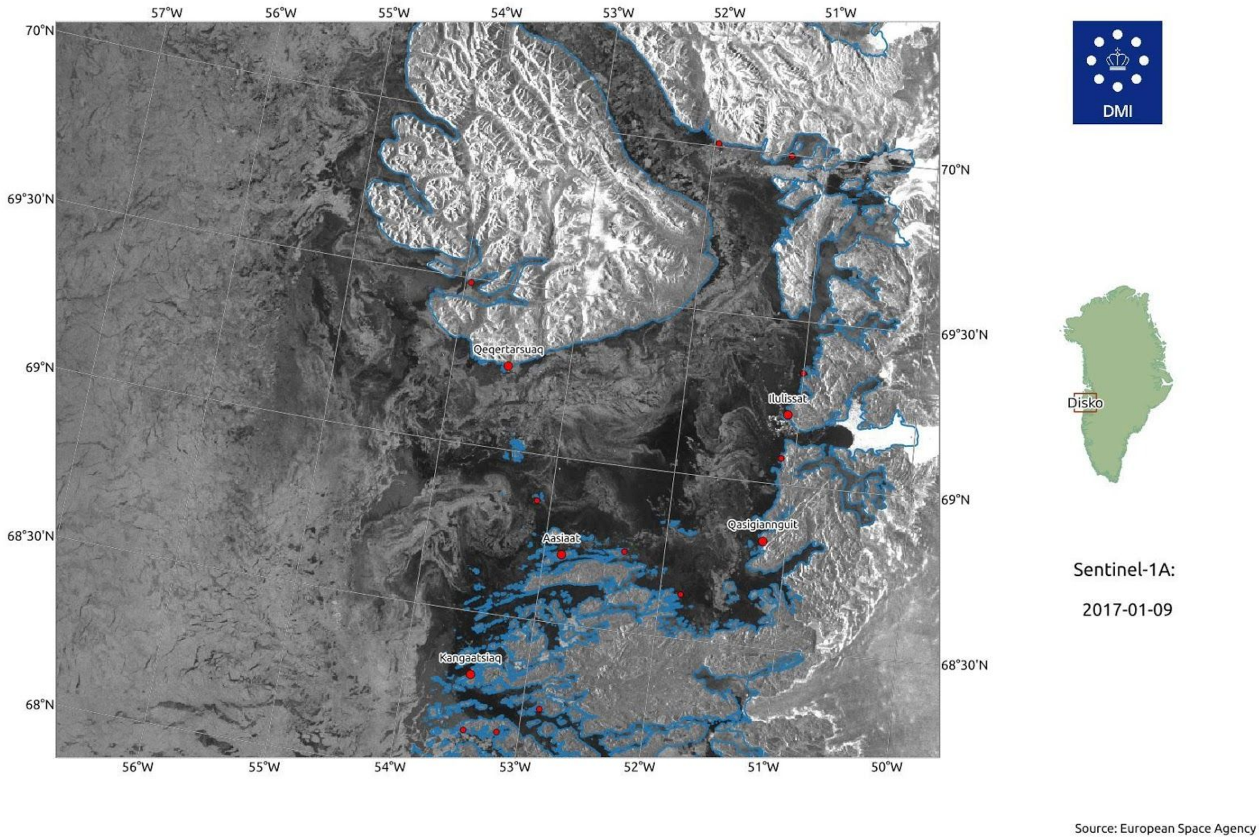

Figure 3 - Subsection of Sentinel-1A HH SAR scene with annotation and graticules. This is a section of the same Sentinel-1 scene as shown in Figure 1. This type of satellite image quick-looks can be found at http://ocean.dmi.dk/arctic/satimg.uk.php.

AMSR2 data

For each Sentinel-1 swath, a corresponding AMSR2 part of the netCDF file is produced, containing the AMSR2 brightness temperature pixels that are resampled to the subsampled Sentinel-1 pixels. The AMSR2 swaths are resampled to the coordinates of every 50th pixel (2km) of the Sentinel-1's swath, as to resample to every pixel would result in extremely oversampled AMSR2 swaths, due to AMSR2's much lower spatial resolution (see Table 2). The first pixel in an AMSR2 netCDF file has its center in the [x,y]=[25,25] position in the corresponding Sentinel-1 netCDF. Data in the AMSR2 netCDF files is brightness temperatures for each polarisation and frequency available from the AMSR2 sensor.

For each Sentinel-1 swath, the AMSR-2 netCDF files are produced by finding the AMSR-2 swaths which, in the seven-hour window preceding the timestamp of the Sentinel-1 swath, intersects with the Sentinel-1 swaths. Each of the AMSR-2 swaths, in this temporal window, is then resampled onto the subsampled Sentinel-1 pixel coordinates using Gaussian weighted interpolation, with the Python pyresample library. This results in a time series of resampled AMSR-2 swaths, some of which have missing pixel values, due to the Sentinel-1 and AMSR-2 swaths not overlapping. From this swath time series, the pixels without missing values and with the least time difference between with the Sentinel-1 swath and the AMSR-2 are selected across the time dimension. In some cases, this results in a mosaiced AMSR-2 file, where pixels are obtained from two or more swaths. A seven-hour window is sufficient to ensure that there are no missing values in this resampled AMSR-2 swath, provided that there were no AMSR-2 data outages.

The following AMSR2 related variables are are available in the netCDF provided per scene:

- btemp_FFP, brightness temperatures from instrument for frequencies FF = [6.9, 7.3, 10.7, 18.7, 23.8, 36.5, 89.0] and polarisations P = [v, h]
- lon
- lat
- sample
- line
- delay
- delays
- count

AMSR2 Channel Set					
Center Freq.	Band width	Pol.	Beam width	Ground res.	Sampling interval
GHz	MHz		degree	km	km
6.925/7.3	350	V/H	1.8	35 x 62	10
10.65	100		1.2	24 x 42	
18.7	200		0.65	14 x 22	
23.8	400		0.75	15 x 26	
36.5	1000		0.35	7 x 12	
89.0	3000		0.15	3 x 5	5

Table 2 - Specification of AMSR2 channels, sampling and spatial resolution. All AMSR2 data in the ASIP data files are resampled to a 2 km grid matching the 40 m grid of the Sentinel-1 SAR data.

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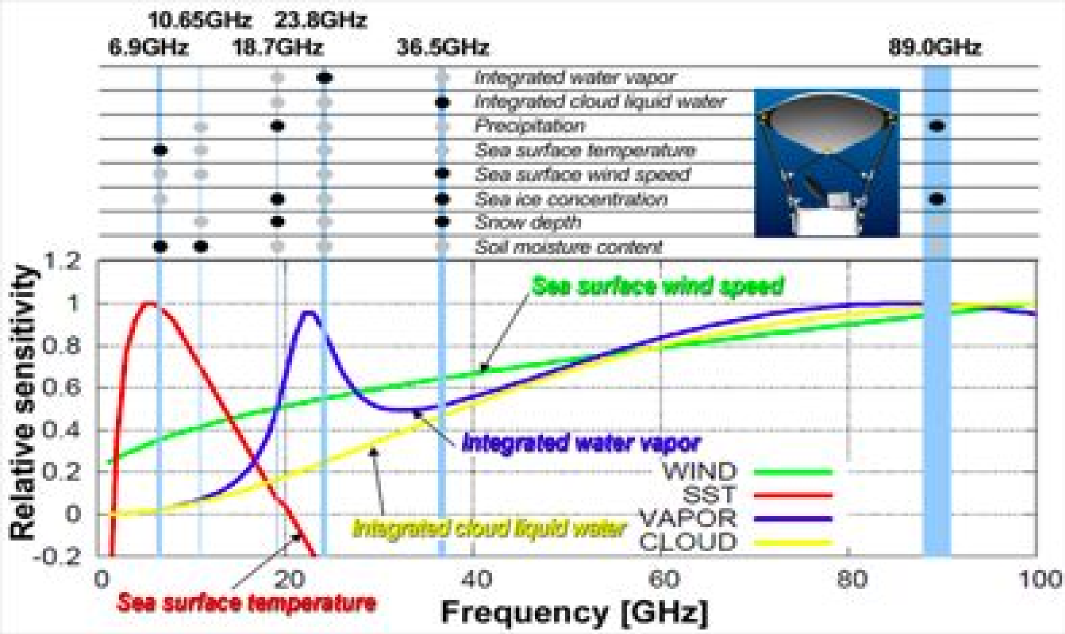

Figure 4 - Overview of AMSR2 channels and their relative sensitivities to a number of ocean and atmosphere variables.

Ice Charts

Manual ice charting from multi-sensor satellite data analysis has for many years been the method applied at the National Ice Centers around the world for producing sea ice information for marine safety. The ice charts used in the ASIP Sea ice data set are from the ice chart archive of the operational sea ice service at the Danish Meteorological Institute (DMI). DMI produces sea ice concentration charts for the waters around Greenland. The DMI Ice Analysts primarily use Copernicus Sentinel-1 SAR imagery, due to the radar sensor high resolution and capability to see through clouds and in polar darkness. The Sentinel-1 imagery used for ice charting is primarily in Extra Wide Swath (EW) mode and dual polarization (HH+HV). Auxiliary satellite imagery is used when available, to support the analysis of the SAR imagery, e.g. optical imagery, thermal-infrared and passive microwave radiometer data.

The ice chart coverage and frequency depends on season, ship routes and data availability. Normally one ice chart is produced on the basis of one Sentinel-1 image and the individual scenes/ice charts cover a subset of the DMI ice charting area around Greenland. The ice charts are thus snapshot interpretations of the ice conditions at the time of the Sentinel-1 image acquisition.

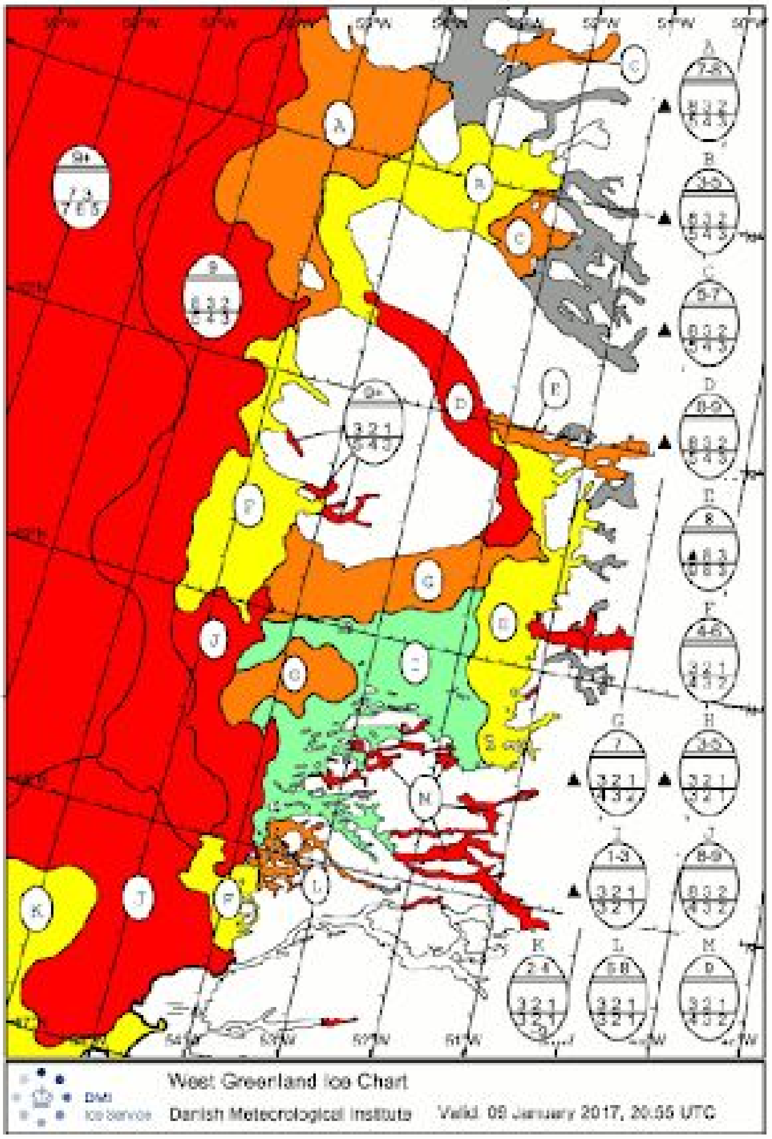

Figure 5 - Example of Regional Ice Chart of central West Greenland produced by the Greenland Ice Service at the Danish Meteorological Institute (DMI).

The latest available Sentinel-1 image along with other information and satellite images are inputs to a detailed manual interpretation and mapping procedure which is mostly based on the texture of the ice in the SAR images and is carried out by a skilled (experienced and trained) ice analysts who draws the ice chart in an ArcGIS production system. An ice chart consists of manually drawn polygons of fairly homogenous ice conditions given as a concentration of ice inside the polygon from 0-100%, where 100% ice is total ice covered ocean and 0% ice means open water. The estimates of ice concentration in the charts are based on the subjective judgement of the analyst and ice charts have no associated uncertainty. Analysts pay particular attention to regions near the ice edge because the characteristics and extent of ice in the marginal ice zone are important for operations taking place within or near that region Thus, ice charts are considered more accurate and detailed at the ice edge. Conversely, analysts generally do not characterize the inner ice zone with as much attention to detail, because most of the time there is no supported navigation there. It is important to notice that the relative accuracy and level of analysis detail varies. Studies of the differences between ice charts from different Ice Centres covering the same geographical region shows relatively large (up to 20%) discrepancies in ice concentrations standard deviation of the differences especially at intermediate concentrations.

The 913 ice charts in the Sea ice data set cover an area in Greenland between 58°N - 83°N and cover all seasons except late summer/early Fall, in the period from December 2014 until June 2017.

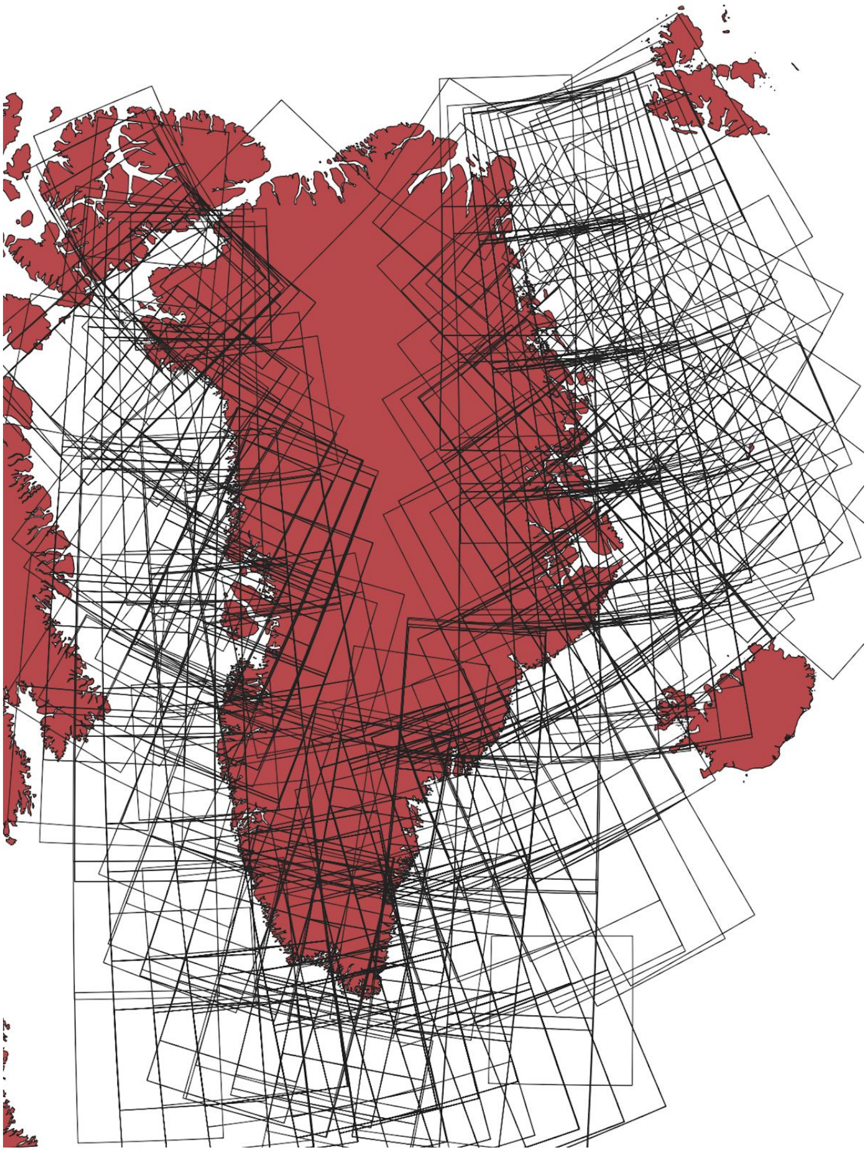

Figure 6 - Overview of the locations of the 913 Sentinel-1 SAR scenes corresponding to Regional Ice Charts produced by the Greenland Ice Service at the Danish Meteorological Institute (DMI).

Pdf versions of the original ice charts can be found in the ice chart archive at the DMI homepage:
http://ocean.dmi.dk/arctic/icecharts_gl_centralwest.uk.php

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The ice charts follow the World Meteorological Organization (WMO) code for sea ice, where the ice concentration classes are defined by concentration intervals, spanning over 10 to 30% such as ‘50-60% ice’ or ‘40-70% ice’. When converting the original ice chart format into the sea ice data set netCDF format, these concentration intervals are converted to fixed concentration values (50-60% becomes 55% and 40-70% also becomes 55%) in the gridded product described by the 2D “icechart” variable:

- Sea ice concentration from 0-100% ("icechart")

The range between the concentration values are 5% (eg. 0%, 5%, 10%, 15%,…, up to 100%). Not all concentration values are represented in a given ice chart.

The ice concentrations are not always homogeneously distributed inside the drawn polygons down to the scale of the gridding, so whereas the average concentrations of the polygons are considered correct for the polygon, each individual 40x40 m grid cell may deviate substantially from this average value.

Due to the relatively poor quality of the Greenland coastline used in the ice charting software (with offset and missing islands) sea ice concentrations within a land-mask bufferzone of 10 km are removed and replaced by NaN in the "icechart" variable.

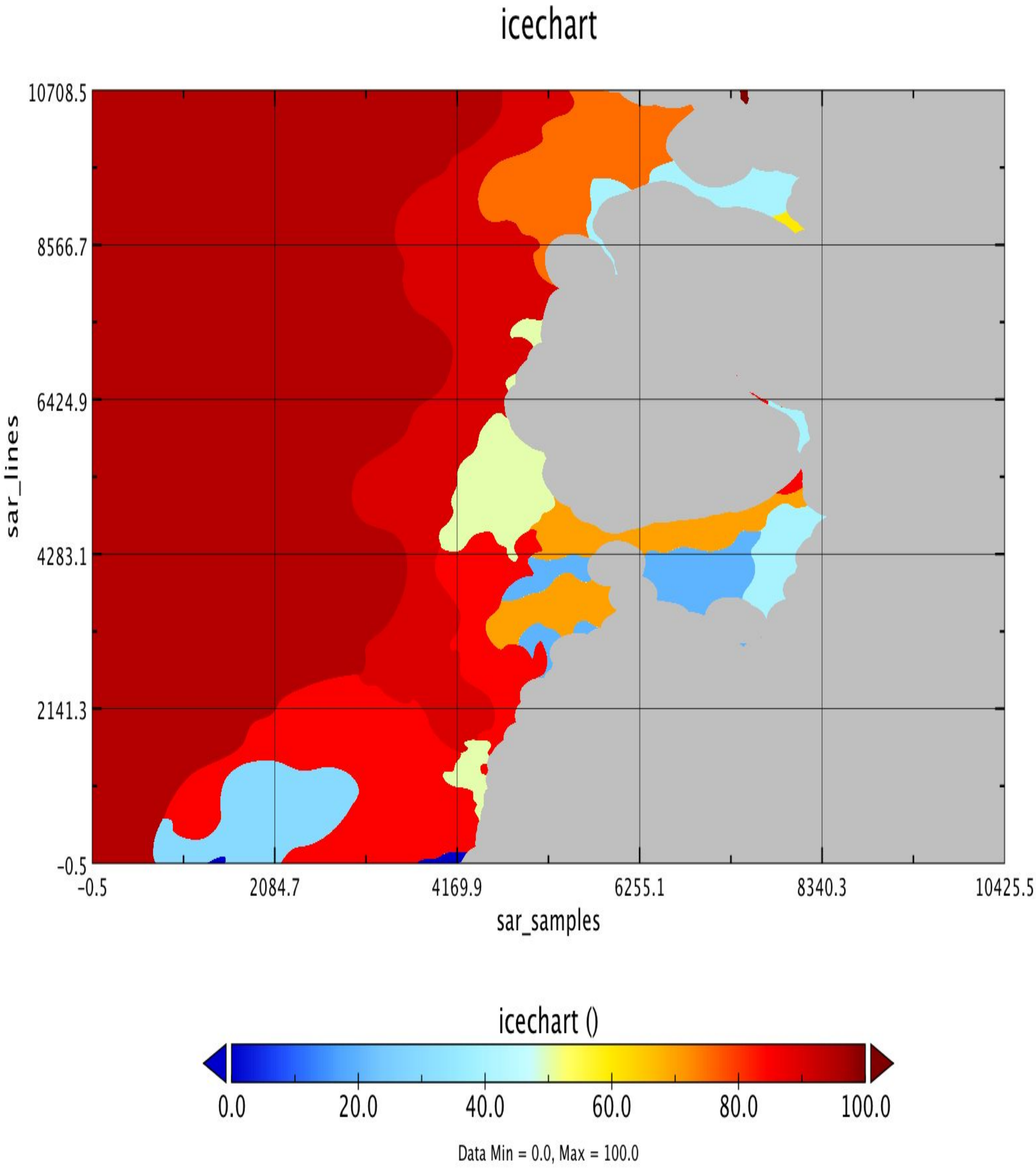

Figure 7 - Example of individual ''ice chart'' variable (Filename: S1A_EW_GRDM_1SDH_20170109T205459_20170109T205604_014760_01807F_677B.SAFE.nc). This is a section of the same ice chart shown in Figure 3, with a different colour scheme. Uniform grey area is a land buffer zone.

File format description

Programs such as Ncview and Panoply can be used to open and visualize the file content. Below is an example of a netCDF file header:

```
netcdf
file:/S1A_EW_GRDM_1SDH_20141218T212008_20141218T212108_003779_00482D_A417.SAFE.nc
{
  dimensions:
    sar_lines = 9996;
    sar_samples = 10486;
    sar_grid_points = 441;
    sample = 211;
    line = 200;
    delay = 4;
  variables:
    float sar_incidenceangles(sar_samples=10486);
      :description = "Incidence angles halfway through";
      :_ChunkSizes = 10486U; // uint

    float sar_primary(sar_lines=9996, sar_samples=10486);
      :min = -1.2496731f; // float
      :max = 0.5404822f; // float
      :polarisation = "HH";
      :upstream_id =
"S1A_EW_GRDM_1SDH_20141218T212008_20141218T212108_003779_00482D_A417.SAFE";
      :description = "Sigma0 in dB -30:+10 packed -1:+1";
      :_FillValue = NaNf; // float
      :_ChunkSizes = 999U, 1048U; // uint

    float sar_secondary(sar_lines=9996, sar_samples=10486);
      :min = -1.5328219f; // float
      :max = 0.28788656f; // float
      :polarisation = "HV";
      :upstream_id =
"S1A_EW_GRDM_1SDH_20141218T212008_20141218T212108_003779_00482D_A417.SAFE";
      :description = "Sigma0 in dB -30:+10 packed -1:+1";
      :_FillValue = NaNf; // float
      :_ChunkSizes = 999U, 1048U; // uint

    ubyte icechart(sar_lines=9996, sar_samples=10486);
      :_FillValue = 255UB; // ubyte
      :upstream_id =
"s1a-ew-grd-hh-20141218t212008-20141218t212108-003779-00482d-001_icechart_20141218
2120_cb.tiff";
      :description = "icechart from DMI";
      :_ChunkSizes = 1999U, 2097U; // uint
```

```
double sar_grid_line(sar_grid_points=441);
  :_ChunkSizes = 441U; // uint

double sar_grid_sample(sar_grid_points=441);
  :_ChunkSizes = 441U; // uint

double sar_grid_latitude(sar_grid_points=441);
  :_ChunkSizes = 441U; // uint

double sar_grid_longitude(sar_grid_points=441);
  :_ChunkSizes = 441U; // uint

double sar_grid_incidenceangle(sar_grid_points=441);
  :_ChunkSizes = 441U; // uint

double sar_grid_height(sar_grid_points=441);
  :_ChunkSizes = 441U; // uint

double btemp_6.9h(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
  :long_name = "Brightness temperature for the 6.9 GHz H channel";
  :unit = "K";
  :coordinates = "delays lon lat";

double btemp_6.9v(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
  :coordinates = "delays lon lat";

double btemp_7.3h(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
  :coordinates = "delays lon lat";

double btemp_7.3v(line=200, sample=211);
  :coordinates = "delays lon lat";
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long

double btemp_10.7h(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
  :coordinates = "delays lon lat";

double btemp_10.7v(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
```

```
  :coordinates = "delays lon lat";

double btemp_18.7h(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
  :coordinates = "delays lon lat";

double btemp_18.7v(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
  :coordinates = "delays lon lat";

double btemp_23.8h(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
  :coordinates = "delays lon lat";

double btemp_23.8v(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
  :coordinates = "delays lon lat";

double btemp_36.5h(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
  :coordinates = "delays lon lat";

double btemp_36.5v(line=200, sample=211);
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long
  :coordinates = "delays lon lat";

double btemp_89.0ah(line=200, sample=211);
  :coordinates = "delays lon lat";
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long

double btemp_89.0bh(line=200, sample=211);
  :coordinates = "delays lon lat";
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long

double btemp_89.0av(line=200, sample=211);
  :coordinates = "delays lon lat";
  :_FillValue = NaN; // double
  :least_significant_digit = 2L; // long

double btemp_89.0bv(line=200, sample=211);
```

```
    :coordinates = "delays lon lat";
    :_FillValue = NaN; // double
    :least_significant_digit = 2L; // long

  double btemp_89.0h(line=200, sample=211);
    :coordinates = "delays lon lat";
    :_FillValue = NaN; // double
    :least_significant_digit = 2L; // long

  double btemp_89.0v(line=200, sample=211);
    :_FillValue = NaN; // double
    :least_significant_digit = 2L; // long
    :coordinates = "delays lon lat";

  double lon(line=200, sample=211);
    :comment = "corresponds the longitude at the centre of the pixel";
    :units = "degrees_east";
    :long_name = "longitude";
    :_FillValue = NaN; // double
    :least_significant_digit = 6L; // long
    :standard_name = "longitude";

  double lat(line=200, sample=211);
    :comment = "corresponds the latitude at the centre of the pixel";
    :units = "degrees_north";
    :_FillValue = NaN; // double
    :least_significant_digit = 6L; // long
    :standard_name = "latitude";
    :long_name = "latitude";

  int sample(sample=211);
    :y_coordinate = "Sentinel swath sample number";

  int line(line=200);
    :x_coordinate = "Sentinel swath line number";

  long delay(delay=4);

  double delays(line=200, sample=211);
    :_FillValue = NaN; // double
    :long_name = "Time between the Sentinel and AMSR-2 acquisitions";
    :unit = "s";

  long count(delay=4);
    :long_name = "The number of pixels with a given delay";

// global attributes:
:aoi_coverage_pct = 93; // int
```

```
  :aoi_upperleft_line = 1; // int
  :aoi_upperleft_sample = 103; // int
  :aoi_lowerright_line = 9996; // int
  :aoi_lowerright_sample = 10486; // int
  :version = "version 2018.04.11 without noise correction";
}
```

Example python script to read a datafile

Python code that reads NetCDF file content and convert one 2D layers (sar_primary) to Geotiff format using the included GCPs:

```
from osgeo import gdal, ogr, osr
import netCDF4, os, numpy

in_nc_filename =
'S1B_EW_GRDM_1SDH_20170502T183535_20170502T183635_005423_00981A_BEAD.SAFE.nc'
out_gtiff_filename = '20170502T183535_20170502T183635_sea_ice_predictions.tif'

ncf = netCDF4.Dataset(in_nc_filename)

lines = numpy.array(ncf.variables.get('sar_grid_line'))
samps = numpy.array(ncf.variables.get('sar_grid_sample'))
lats = numpy.array(ncf.variables.get('sar_grid_latitude'))
lons = numpy.array(ncf.variables.get('sar_grid_longitude'))
hgts = numpy.array(ncf.variables.get('sar_grid_height'))

arr_to_put_in_gtiff = numpy.array(ncf.variables.get('sar_primary'))
arr_to_put_in_gtiff = numpy.nan_to_num(arr_to_put_in_gtiff)
rows, cols = arr_to_put_in_gtiff.shape

spr_gcp = osr.SpatialReference()
spr_gcp.ImportFromEPSG(4326)
gcps=()
for i in range(len(lines)):
    x, y, z, pix, lin = lons[i],lats[i],hgts[i],samps[i],lines[i]
    gcps = gcps + (gdal.GCP(x, y, z, pix, lin, '', str(i)),)

# NOTE: gdal.GDT_Float32 must be changed to gdal.GDT_"something_else" if output is
another type
gtiff = gdal.GetDriverByName('GTiff').Create(out_gtiff_filename, cols, rows, 1,
gdal.GDT_Float32)
gtiff.GetRasterBand(1).WriteArray(arr_to_put_in_gtiff)
gtiff.SetGCPs(gcps, spr_gcp.ExportToWkt())
gtiff = None
```

References

Sentinel-1 User guide: https://sentinel.esa.int/web/sentinel/missions/sentinel-1