Sea Ice Climate Change Initiative: Phase 2

Sea Ice Concentration (SIC) Round Robin Data Package

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1 Introduction

1.1 Purpose and Scope

This document describes the Round Robin datasets (RRDP) for the Sea Ice Concentration Essential Climate Variables products to be produced in ESA's Climate Change Initiative.

The RRDP is a set of comma separated ASCII files which contain reference sea ice concentrations and co-located satellite TBs extracted from the SMMR, SSMI and AMSR-E swath datasets to be used to produce the final ECV product.

The dataset should be easy to use by reading the files line by line, calculate SIC from the given TBs and compare with the given reference SIC.

1.2 Document Structure

The document includes the RRDP description for Sea Ice Concentration, including information about how the dataset was generated and the choices made.

1.3 Document Status

More background information on the validation procedures can be found in the PVP document (Product Validation Plan).

1.4 Applicable Documents

The following table lists the Applicable Documents that have a direct impact on the contents of this document.

Acronym	Title	Reference	Issue
AD-1	Sea Ice ECV Project Management Plan	ESA-CCI_SICCI_PMP_D6.1_v1.1	1.1
AD-2	Sea Ice ECV Product Validation Plan	ESA-CCI_SICCI_PVP	
AD-3	Sea Ice ECV Data Access and Requirements Document	ESA-CCI_SICCI_DARD	

Table 1-1: Applicable Documents

1.5 Applicable Standards

Acronym	Title	Reference	Issue

Table 1-2: Applicable Standards

1.6 Acronyms and Abbreviations

Acronym	Meaning
ACDD	Attribute Convention for Dataset Discovery
AMSR-E	Advanced Microwave Scanning Radiometer aboard EOS
AO	Announcement of Opportunity
ASAR	Advanced Synthetic Aperture Radar (on ENVISAT)
ASCII	American Standard Code for Information Interchange
ASIRAS	Airborne Synthetic Aperture and Interferometric Radar Altimeter System
ATBD	Algorithm Theoretical Basis Document
CF	Climate and Forecasting
CM-SAF	Climate Monitoring Satellite Application Facility
DMSP	Defence Meteorological Satellite Program
DWD	Deutscher Wetterdienst
EASE	Equal Area Scalable Earth-Grid
ECV	Essential Climate Variable
Envisat	Environmental Satellite
EO	Earth Observation
ERS	European Remote Sensing Satellite
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FB	Freeboard
FCDR	Fundamental Climate Data Record
FOC	Free of Charge
FOV	Field-of-View
FTP	File Transfer Protocol
GB	GigaByte
GCOM	Global Change Observation Mission
GHRSST	Group for High Resolution Sea Surface Temperature
H	Horizontal polarization
H+V	Horizontal and vertical polarization
IDL	Interactive Data Language
ISF	Ice Surface Fraction
Matlab	Matrix Laboratory
MB	MegaByte
MIZ	Marginal ice zone
MODIS	Moderate Resolution Imaging Spectroradiometer
MPF	Melt Pond Fraction
n.a.	Not applicable
NetCDF	Network Common Data Format
NH	Northern hemisphere
NSIDC	National Snow and Ice Data Center
OIB	Operation Ice Bridge

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Acronym	Meaning
OSI-SAF	Ocean and Sea Ice Satellite Application Facility
OWF	Open Water Fraction
PDGS	Payload Data Ground System
PI	Principal Investigator
PMR	Passive Microwave Radiometry
PMW	Passive Microwave
PRF	Pulse Repetition Frequency
RA	Radar altimeter
RADAR	Radio Detection and Ranging
RTM	Radiative Transfer Model
SAR	Synthetic Aperture Radar
SIC	Sea Ice Concentration
SIRAL	SAR/Interferometric Radar Altimeter
SIT	Sea Ice Thickness
SH	Southern hemisphere
SMMR	Scanning Multichannel Microwave Radiometer
SMOS	Soil Moisture and Ocean Salinity
SSM/I	Special Sensor Microwave / Imager
SSMIS	Special Sensor Microwave / Imager+Sounder
TB	TeraByte
TBD	To be defined
TM	Thematic Mapper
ULS	Upward Looking Sonar
URD	User Requirements Document
URL	Uniform Resource Locator
V	Vertical polarization

Table 1-3: Acronyms

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2 Round Robin Data Package (RRDP) (SIC)

The purpose of the RRDP is to collect a reference dataset of brightness temperatures (TBs) and validated sea ice concentrations as well as relevant auxiliary information that allow evaluation of sea ice concentration algorithms and understanding of the error contributions from different sources of errors.

The database consists of TB data measured by:

- AMSR-2
- AMSR-E,

The format of the RRDP is a set of data files in simple ASCII comma separated format with a number of columns containing:

- Reference ice/snow data (time, position, source, reference data, including total ice concentration, snow parameters (if known), ice type, ice thickness etc. if available);
- Associated environmental parameters (atmosphere from ECMWF reanalysis closest 3h forecast in some datasets (DARD: ID 2.01)). *http://old.ecmwf.int/publications/manuals/d/gribapi/param/filter=grib1/order=paramId/order_type=asc/p=1/table=128/*
- AMSR brightness temperature data (time, sensor, dataset-ID, TBs);
- ASCAT scatterometer data from IFREMER CERSAT
- SMOS TB and (PD/AD) data (Not available in v 1.0)

6 sets of reference data have been used

- Data from Ice Mass Balance Buoys *http://imb.erdc.dren.mil/buoysum.htm, Perovich, D., J. Richter-Menge, B. Elder, T. Arbetter, K. Claffey, and C. Polashenski, Observing and understanding climate change: Monitoring the mass balance, motion, and thickness of Arctic sea ice, http://imb.erdc.dren.mil , 2013.*
- Snow/Ice data from NASA's Operation Ice Bridge (OIB)
- High latitude areas of no ice (identified in ice charts) (SIC0)
- High latitude areas of high ice concentration (~100%) identified from convergence in SAR ice drift data. (SIC1)
- MODIS melt pond fraction dataset from University of Hamburg
- SMOS thin ice thickness dataset from University of Bremen (not available in v1.0)

2.1 Validation database from SAR, VIS/IR, IMB and OIB data

For the validation and algorithm selection a Round Robin Data Package (aka a "match-up data base") has been created following the specifications given in the validation protocol. The RRDP is hereby made available for users in the sea ice and passive microwave science community. The RRDP consists of data based on:

- Data from areas of ~100% ice from quantification of convergence areas in ENVISAT ASAR, RADARSAT and Sentinel-1 ice drift data (DTU/DMI). Use convergence from ASAR ice drift in high concentration ice areas, central Arctic as detection of 100% ice.

- Data from high latitude areas of 0% ice concentration identified from ice charts, climatology and classified satellite images (DARD: ID 2.02) such as SAR discrimination between water and ice (DARD: ID 2.10);

- High quality validation dataset of large areas of ca. 100% thin ice (areas in the order of 100x100km) with ice thickness estimated from SMOS data (DARD: 2.19)

- Validation data set of daily melt-season ice concentration and melt-pond cover fraction derived from MODIS imagery (2009-06-01 to 2009-08-31) (DARD: ID 2.08 and 2.09);

- Time series of data along CRREL IMB buoy trajectories with reference ice- and snow thickness data as well as temperature profiles in the ice/snow.

- Data along Operation Ice Bridge fright tracks with reference ice thickness and snow thickness.

All data are collocated with available AMSR data (brightness temperatures), ERA Interim data and ASCAT data.

We have developed the necessary collocation processing system (See chapter 3) based on satellite effective fields of view.

2.2 Collocation methods (SIC)

For the algorithm selection procedure a simpler version of the collocation has been applied for time constraint reasons. Since we only use data from larger areas of homogenous ice conditions, we will average a number of satellite footprints in order to secure approximately the same resolution in all relevant channels. The target resolution for AMSR-E data is that of the 6.9 GHz channels (using the resolution matched AMSR-E dataset from NSIDC (Ashcroft & Wentz, 2013), whereas for SMMR and SSMI we averaged all footprints within a 25km radius of the desired center location. All microwave radiometer data are extracted from swath TB datasets.

The collocation processing system takes high quality/high resolution ice concentration data from data producers and calculates weighted averages of TBs corresponding to the target resolutions.

2.3 Methods for deriving independent ice concentrations

2.3.1 ASAR convergence method (SIC=100%)

The main method for identifying areas of 100% ice is based on the PolarView / MyOcean ice drift dataset from ENVISAT ASAR. This dataset is processed to find areas of ~100x100 km² with convergence in the ice drift pattern between two consecutive days. During winter this will correspond to areas of total ice cover (assuming that we start on day 1 with near 100% ice). Eventual openings will after 1 day of convergence be either frozen or removed due to ridging/rafting. Since the areas are of the order of 100 km x 100 km we subsequently find corresponding PMR data at similar resolution (see section 2.2) at all channels and where the resulting resolution cell is completely inside the 100x100 km² convergence area.

In the following, the method derived and the methods used for the identification of nominal 100% sea ice is described.

It should be noticed that this method only provides reliable 100% data in winter, so the summer data should be used with care, since biases may exist.

2.3.1.1 AOI (Area Of Interest) cell grid description

The extent of the geographical areas of interest covers for the northern hemisphere 55N to 90N, and for the southern hemisphere 55S to 80S as only sea ice is relevant.

To facilitate the identification of nominal 100% ice a special AOI grid has been devised.

The sea covered areas are divided into round AOI grid cells each with a diameter of 100km and evenly spaced with approximately 50% overlap and at least 50km from land. The 50km distance is chosen to ensure that the antenna footprint of any available passive microwave measurement sample with a centre position inside an AOI cell does not cover any land.

2.3.1.2 Identification of nominal 100%

To identify locations with nominal 100% ice cover, the transport of ice is examined directly in the form of the DTU MyOcean SAR based sea ice drift product.

It is assumed that an observed area which conforms to specific set of criteria with respect to area changes indicates 100% ice cover. The observed area must decrease slightly from day to day, as area increase indicates leads and large decreases indicate too little ice. A basic assumption is that during winter, eventual openings in the ice on day 1 will either close due to the convergence, or refreeze due to the cold weather. During Summer the latter part of this assumption does not

hold, so the Summer data cannot be assumed to represent close to 100% ice.

Furthermore the observations must cover the AOI cell well.

The requirements set up as follows

2.3.1.3 Compression zone identification

All drift observations for a given day are ordered in groups of 4 neighbors and the area change calculated using a free 3rd party tool called Planimeter available from http://geographiclib.sourceforge.net/ in the package GeographicLib.

The area-change observations from a period of 48hrs are then sorted into the AOI grid, so that one AOI cell keeps track of all available area observations that fall within its boundaries.

During this process the area observations are flagged at either 'good' or 'bad' depending on their characteristics.

For a single drift observation to be considered 'good' the area change must lie within certain limits, these have been loosely chosen to be 90%-103%, to account for the round-off uncertainty associated with the 300m resolution of the SAR data on which the sea ice drift product is based.

For an AOI cell full of observations to enter the RRDP, it must contain 40 or more 'good' cells.

2.3.2 No ice near ice boundary (SIC=0%)

From icecharts we identify the limit of all ice and select areas in the order of 100 km away from the ice edge in the open water region. These areas provide the open water test data, and collocation with PMR data is done in the same manner as above for the 100% ice areas.

Table 2.1 Location and valid period for open water data points

Northern hemisphere		Southern hemisphere	
January and February	**August and September**	**January, February,March, April**	**August, September, October,November**
58N 52W	65N 56W	64S 80W	60S 80W
63.5N 35W	63.5N 35W	63S 170W	58S 170W
70N 0E	70N 0E	59S 90E	55S 90E
73N 30E	75N 40E	64S 10E	50S 10W
55N 180	70N 170W	58.5S 20W	

Figure 1. Location of areas for SIC=0 validation. Green are summer points, blue are winter points and cyan are points used all year.

Figure 2. Location of SIC=0 areas for the Southern Hemisphere. Green are Austral Summer locations and blue are Austral Winter locations.

2.3.3 Thin ice collocation

ESA's L-band microwave radiometer sensor SMOS is intended to observe soil moisture and ocean salinity (name). Because of its long wavelength the observations are also suitable to retrieve the thickness of thin sea ice data (up to approximately 50 cm depending on salinity and temperature of the sea ice). Two algorithms have been suggested, one based on intensity and incidence angles below 40° (Kaleschke et al. 2012; Tian-Kunze et al., 2014), and one based on simultaneously using both intensity and polarization difference at incidence angles above 40° (Huntemann et al., 2014). Here, the latter procedure is applied to observations of the Arctic in the period of October to December 2010, the first Arctic freezing season which was observed by SMOS.

All processing is based on SMOS L1C version 3.46 data. These data are organized in Discrete Global Grid (DGG) cells of 9 km spacing in an Icosahedral Snyder Equal Area projection with aperture 4 and resolution 9 (ISEA 4H9). The grid cells have a size of about 15x15 km². Observations closer than 50 km to land have been excluded. All SMOS snapshots containing one or more pixels with brightness temperature higher than 300 K are considered RFI contaminated and excluded.

Initially, regions of homogeneous thin sea ice have been visually identified using ENVISAT ASAR data. Large areas (~50 km radius) of fairly homogenous high concentration ice is identified in the SAR data and date and center locations are recorded for subsequent SMOS ice thickness co-location and co-location with AMSR TBs.

The mere SMOS ice thickness retrieval is organized in four steps:

1. convert observations of the four Stokes components from the instrument reference frame to the surface reference frame,
2. averaging of all observations of one day within one DGG and incidence angle range of 40° to 50°
3. retrieval of ice thickness based on intensity of polarization difference values
4. interpolate results to polar stereographic projection of 12.5 km (NSIDC grid).

The SMOS thin ice algorithm is developed for the Arctic so only northern hemisphere data is included.

2.3.4 Summer melt collocation

Gridded independent SIC estimates from MODIS has been colocated with the coincident melt pond cover fraction (DARD: ID 2.08 and 2.09) and TB data from the relevant PMR instruments (AMSR-E).

Reflectances measured by bands 1, 3, and 4 of the MODIS sensor and provided by NASA as MODIS Surface Reflectance 8-Day L3 Global 500m SIN Grid V005" - product (MOD09A1) and "MODIS Surface Reflectance daily L2G Global 500 m and 1 km" - product (MOD09GA) are projected onto a polar-stereographic grid with 500 m grid resolution, applying land, cloud and other flags provided with the original MODIS product. The analysis is limited to tiles covering the Arctic Ocean, i.e. north of 60°N. A spectral un-mixing process is applied together with an artificial neural network to classify the reflectances of each grid cell into the three surface classes: open water, melt ponds, and snow / ice. For the final melt pond fraction product, surface class distributions are interpolated onto a 12.5 km grid resolution polar-stereographic grid; resulting netCDF files contain melt pond fraction (MPF), number of valid (non-flagged) 500 m grid cells per 12.5 km grid cell (N), standard deviation of MPF according to N (MPF-SD), and the open water fraction (OWF). This is the standard product which is available as 8-day composite via ICDC (http://icdc.zmaw.de) and which has been retrieved as 1-day product specifically for SICCI.

The RRDP requires high quality, high ice concentration data at 100 km grid resolution. For the RRDP product, a 100 km x 100 km grid product based on the average values of 8x8 12.5 km grid cells is computed for MPF, MPF-SD, and OWF. For this only those 12.5 km grid cells are used where the MODIS SIC, which is 100% minus OWF, is above 90% and where the cloud fraction is below 5%. It is further ensured that only grid cells are used which are in at least 100 km distance to the coast. For the colocation of the 100km x 100km MPF product with PMW data all AMSR-E passes during the day are included (with a max distance to the center of the 100x100 km MODIS MPF grid cell area of 5 km).

2.3.5 CRREL Ice Mass Balance Buoy data

Time series of data along IMB buoy trajectories have been compiled. These data include snow/ice thickness and snow/ice temperature profile data. Data have been interpolated to every 6 hours in order to have continuous 6 hourly NWP accumulated fields.

2.3.6 Operation Ice Bridge (OIB) data

Since 2009 NASA's Operation Ice Bridge has collected ice and snow thickness data in the Arctic during annual flight campaigns (March-May). The data are especially valuable in this context since they contain snow thickness information from the snow radar. Original OIB data are averaged into 50 Km sections for better overlap/co-location with AMSR TB data.

2.3.6.1 Original Operation Ice Bridge (OIB) data

2.3.6.1.1 /IDCSI4_001 - version 4 downloaded from NSIDC mid October 2015

data and documentation:

http://nsidc.org/data/docs/daac/icebridge/idcsi4/index.html

Period: 2009 - 2013

2.3.6.1.2 /Original_data_ql (quick look) - downloaded from NSIDC mid November 2015

https://nsidc.org/data/docs/daac/icebridge/evaluation_products/sea-ice-freeboard-snowdepth-thickness-quicklook-index.html

This folder contains also /Documentation for more details about the QL data.

Period: 2014 - 2015

2.3.6.2 Averaged Operation Ice Bridge (OIB) data

The averaged values are obtained from original OIB tracks and are averages and STDs of all the points per each segment of 50km length.

Variables:

- lat
- lon
- snow_depth_mean, m
- snow_depth_std, m
- sea_ice_thickness_mean, m
- sea_ice_thickness_std, m
- pcnt_ow_mean, %
- pcnt_ow_std, %

- pcnt_thin_ice_mean, %
- pcnt_thin_ice_std, %
- pcnt_grey_ice_mean, %
- pcnt_grey_ice_std, %
- surface_roughness_mean (mean used temporarily, however it is probably not physically meaningful).
- surface_roughness_std
- num_per_segment - number of measurements per segment
- delta_mean - mean distance between measurements within the segment, m
- delta_gt_0_5 - number of distances larger than 500 m

2.3.6.3 Closeness to land

The measurements close to land are assigned NaN values (in addition to original NaNs from OIB for whatever reasons they were NaN). This was done as follows: if (lat, lon)-location falls into a grid cell that is within the range of two 25km-grid-cells from the coastline, the location is considered to be too close to land (gives approximately 50km distance). The coastline used is the one on the NSIDCs polar stereographic 25km-grid. In such cases lat,lon will be non-NaN values, while all the rest is NaN.

Figure 3. Operation IceBridge flight tracks Northern Hemisphere (left) and Southern Hemisphere (right)

3 Data sources and versions

3.1.1 AMSR-E data source and version

The AMSR-E Level-2A product (AE_L2A) contains brightness temperatures available at a variety of resolutions that correspond to the footprint sizes of the observations. Each swath is packaged with associated geolocation fields.

The AMSR-E Level-2A product (AE_L2A) contains brightness temperatures at 6.9 GHz, 10.7 GHz, 18.7 GHz, 23.8 GHz, 36.5 GHz, and 89.0 GHz. Data are resampled to be spatially consistent, and therefore are available at a variety of resolutions that correspond to the footprint sizes of the observations such as 56 km, 38 km, 24 km, 21 km, 12 km, and 5.4 km, respectively. Each swath is packaged with associated geolocation fields. Data are stored in Hierarchical Data Format - Earth Observing System (HDF-EOS) format and are available from 19 June 2002 to the present via FTP.

Ashcroft, P. and F. J. Wentz. 2013. *AMSR-E/Aqua L2A Global Swath Spatially-Resampled Brightness Temperatures, Version 3*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: http://dx.doi.org/10.5067/AMSR-E/AE_L2A.003.

http://nsidc.org/data/AE_L2A/versions/3

3.1.2 AMSR-2 data source and version

L1R AMSR-2 data from JAXA:

AMSR2 geophysical parameters are calculated by combining multiple AMSR2 frequencies and polarizations. In that case, there is no consistency with latitude and longitude of same observation point because of different footprint size. AMSR2 provides product call L1R that resamples the L1B product using pre-calculated resampling coefficients to adjust data for lower frequency resolutions.

The center latitude and longitude of data is adjusted to the 89 GHz A channel receiver data.

Resampling converts the brightness temperature at a higher resolution frequency to a brightness temperature at a lower resolution frequency. Resampling data based on 6.9, 10.7, 23.8, 36.5GHz footprint size is created. 6 GHz and 7 GHz data sets have the same spatial resolution; therefore, a shared set of resampling data is created. 18 GHz and 23 GHz data sets have almost the same resolution, but 23 GHz resolution is slightly lower; therefore, one set of resampling data is created matching the 23 GHz resolution. Table 6 shows L1R data and frequencies selected for resampling.

Table 6. L1R data and frequencies selected for resampling

Footprint	6G (H/V) 243 points	7G (H/V) 243 points	10G (H/V) 243 points	18G (H/V) 243 points	23G (H/V) 243 points	36G (H/V) 243 points	89G (H/V) 243 points	89G A-horn (H/V) 486 points	89G B-horn (H/V) 486 points
6GHz	☆	○	○	○	○	○	○		
10GHz			☆	○	○	○	○		
23GHz				○	☆	○	○		
36GHz						☆	○		
89GHz								△	△

○ indicate resampling data undergo spatial resolution conversion and processing for center latitude and longitude alignment.
☆ indicate resampling data only undergo processing for center latitude and longitude alignment.
△ indicate original observational data (same as L1B).
* 18 GHz and 23 GHz data sets have almost the same resolution, but 23 GHz resolution is slightly lower; therefore, one set of resampling data is created matching the 23 GHz resolution.

L1R stores resampling data of 6, 10, 23, 36GHz resolution, and original 89GHz data. L1R data marked by ☆ in Table 6 does not coincident with L1B data of same frequencies and polarizations, because processing for center latitude and longitude alignment is applied.

3.1.3 ERA Interim data source and version

http://apps.ecmwf.int/datasets/data/interim-full-daily/levtype=sfc/

http://old.ecmwf.int/publications/manuals/d/gribapi/param/filter=grib1/order=paramId/order_type=asc/p=1/table=128/

3.1.4 OIB data cource and version

http://nsidc.org/data/docs/daac/icebridge/idcsi4/index.html

3.1.5 CRREL IMB data source and version

http://imb.erdc.dren.mil/buoysum.htm

3.1.6 MODIS MPF data source and version

Special 1-day MODIS melt pond fraction dataset derived following the method described in Rösel et al,

4 SIC RRDP data format

We have produced a set of simple to use comma separated flat ASCII files. Each line records comma separated information for a unique (validation data, collocated PM) pair. The latitude, longitude, time, source/institution, reference SIC value are part of the information recorded.

Files consists of 4 sections

1. The reference data section (location, time, reference data)
2. The NWP data section with data from ERA Interim
3. The AMSR data section with colocated AMSR data
4. The ASCAT data section with colocated ASCAT data

Finally a unique data identifier is added in the last column.

Below we present a detailed description of the data columns in each type of RRDP files.

The following sections describe the content of these datasections.

The reference data sections differ between types of reference data, whereas the satellite data sections and NWP sections are always the same.

4.1 100% SIC reference data files

Reference data section (SIC1)	
latitude	Reference latitude
longitude	Reference Longitude
time	Reference time
identification	Reference ID (COMPRESSIONCELLS_DTU)
SIC	Reference sea ice concentration (1)

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4.2 0% SIC reference data

The following tables contain information about the columns in each type of RRDP files.
Each line of each file contains a reference part and an observation part.
All values/IDs are separated by commas ","

Reference data section (SIC0)	
latitude	Reference latitude
longitude	Reference Longitude
time	Reference time
identification	Reference ID (ICECHART_DMI)
SIC	Reference sea ice concentration (0)

4.3 IMB data files

The following is a list of columns in the IMB reference datafiles

Reference data section (CRREL IMB)	
latitude	Reference latitude
longitude	Reference longitude
time	Buoy/reference time - Interpolated to 6h
identification	Buoy ID (e.g. BUOY_CRREL_2012B)
timedifference(sec)	Time difference (always 0)
Date	Buoy/reference time
Latitude (degrees)	Buoy latitude
Longitude (degrees)	Buoy longitude
Quality (+/- km)	Location quality (GPS)
Air Temp (C)	Air temperature ©
Air Pressure (mb)	Air pressure (mb)
Snow Surface Position (m)	Snow surface position (m)
Ice Thickness(m)	Ice thickness (m)
Ice Surface Position (m)	Ice surface position (m)
Ice Bottom Position(m)	Ice bottom position (m)
T1 (C)	Buoy IMB temperature (C)
T2 (C)	Buoy IMB temperature (C)
T3 (C)	Buoy IMB temperature (C)
T4 (C)	Buoy IMB temperature (C)
T5 (C)	Buoy IMB temperature (C)
T6 (C)	Buoy IMB temperature (C)
T7 (C)	Buoy IMB temperature (C)
T8 (C)	Buoy IMB temperature (C)
T9 (C)	Buoy IMB temperature (C)
T10 (C)	Buoy IMB temperature (C)
T11 (C)	Buoy IMB temperature (C)
T12 (C)	Buoy IMB temperature (C)
T13 (C)	Buoy IMB temperature (C)
T14 (C)	Buoy IMB temperature (C)
T15 (C)	Buoy IMB temperature (C)

4.4 OIB data files

The following table contains a list of the Operation Ice Bridge reference data columns.

Reference data section (OIB)	
latitude	Reference latitude
longitude	Reference Longitude
time	Reference time
identification	Reference ID (OIB_50KM_NERSC)
sd_mean	Snow depth average
sd_std	Snow depth st dev
sit_mean	Sea Ice Thickness average
sit_std	Sea Ice Thickness st dev
pcnt_ow_mean	% open water in 50 Km section
pcnt_ow_std	St dev of % open water in 50 Km section
pcnt_thin_ice_mean	% thin ice in 50 Km section
pcnt_thin_ice_std	St dev of % thin ice in 50 Km section
pcnt_grey_ice_mean	% grey ice in 50 Km section
pcnt_grey_ice_std	St dev of % grey ice in 50 Km section
surface_roughness_mean	Surface roughness (average)
surface_roughness_std	
num_per_segment	Number of datapoints in 50 Km segment
delta_mean	
delta_gt_0_5	

4.5 MODIS Melt Pond Fraction data files

Reference data section (OIB)	
latitude	Reference latitude
longitude	Reference Longitude
time	Reference time
reference-id	Reference ID (OIB_50KM_NERSC)
MPF[%]	MODIS melt pond fraction in 100 Km diameter area
MPF_STDDEV[%]	stdev of MODIS melt pond fraction in 100 Km diameter area
MPF_grid_cell_STDDEV[%]	
numcells	Number of used 12.5 Km cells
SIC[%]	Average MODIS Sea Ice Concentration (%) in 100 Km diameter area
SIC_grid_cell_STDDEV[%]	St dev of MODIS Sea Ice Concentration (500 m cells)
NUMCELLS	Number of used 12.5 Km
AVGnum_clear-sky_500m_pixels	Average number of clear sky 500m pixels
cloud_fraction_[%]	Cloud fraction (%)

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4.6 Thin ice data derived from SMOS - (Not included in v1.0)

The following table lists the variables included in the reference section of the SMOS thin ice datafiles

	Each line contains a reference part and an observation part as comma separated values: **Reference part:**
1	latitude [degrees]
2	longitude [degrees]
3	time (UTC)
4	reference ID (sensor/method and producer ex ICECHART_DMI)
5	nominal seaice concentration (SIC)
6	SMOS based 'thinice' ice thickness [m]
7	std of SMOS based 'thinice' ice thickness
	Observation part: // Further more the University of Bremen (UB) SMOS Thinice files contains ice thickness (less than 1 meter) and thinice std. Please contact: rs@space.dtu.dk for more information

4.7 The NWP section

The following table lists the variables in the NWP section of each RRDP file

ERA Interim section	# ERA: v20150911 noval gapfill
latitude	ERA Interim Latitude
longitude	ERA Interim Longitude
time	ERA Interim time
reference-id	NWP_ECMWF
upstreamfile	Name of ERA Interim file (Internal)
msl	Mean sea level pressure (hPa)
u10	Wind speed 10 m (u component) (m/s)
v10	Wind speed 10 m (v component) (m/s)
ws	Wind speed (m/s)
t2m	2 m air temperature (K)
skt	Skin temperature (K)
istl1	Ice temperature layer 1 (0-7 cm)
istl2	Ice temperature layer 2 (7-28 cm)
istl3	Ice temperature layer 3 (28-100 cm)
istl4	Ice temperature layer 4 (100-150 cm)
sst	Sea surface temperature
d2m	2 m dew point temperature
tcwv	Total columnar water vapour (kg/m2)
tclw	Total columnar liquid water (kg/m2)
tciw	Total columnar ice water (kg/m2)
ssrd	Surface solar radiation downwards (J/m2) (accumulated 6h)
strd	Surface thermal radiation downwards (J/m2) (accumulated 6h)
e	Evaporation (m of water equivalent) (Accumulated 6h)
tp	Total precipitation (m) (Accumulated 6h)
sf	Snow fall (m of water equivalent) (accumulated 6h)
fal	Forecast albedo (0-1)
ci	ERA Interim Ice Concentration

4.8 The AMSR data section

This section is the same for AMSR-E and AMSR2 datafiles. In the ASMR-E files the 7.3GHz columns are filled with noval.

AMSR section	AMSRX: v201602 noval gapfill nearest 1.5h/5km + timediff parameter
latitude	AMSR Latitude
longitude	AMSR Longitude
time	AMSR time
identification	AMSR ID
6.9GHzH	AMSR channel TB (K)
6.9GHzV	AMSR channel TB (K)
7.3GHzH	AMSR channel TB (K)
7.3GHzV	AMSR channel TB (K)
10.7GHzH	AMSR channel TB (K)
10.7GHzV	AMSR channel TB (K)
18.7GHzH	AMSR channel TB (K)
18.7GHzV	AMSR channel TB (K)
23.8GHzH	AMSR channel TB (K)
23.8GHzV	AMSR channel TB (K)
36.5GHzH	AMSR channel TB (K)
36.5GHzV	AMSR channel TB (K)
89.0GHzH	AMSR channel TB (K)
89.0GHzV	AMSR channel TB (K)
Earth Incidence	Earth Incidence angle
Earth Azimuth	Earth azimuth angle
scanpos	Scanpos
upstreamfile	Name of AMSR file
timediff	Time difference between reference time and AMSR time

4.9 The ASCAT section

This section contains ASCAT data from IFREMER CERSAT

ASCAT section	ASCAT: v20160329 static grid fix
latitude	ASCAT latitude
longitude	ASCAT longitude
time	ASCAT time
reference-id	ASCAT_CERSAT_IFREMER
upstreamfile	Name of ASCAT file
sigma_40	ASCAT backscatter (dB)
sigma_40_mask	ASCAT backscatter (dB) - masked
nb_samples	Number of ASCAT samples
warning	ASCAT flag
std	Standard deviation of ASCAT data

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4.10 The data identifier section

At the end of each dataline you find a unique data identifier.

Data identifier section	ID number unique to this RRDP version in last field
RRDP_ID	Unique data id

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5 Access the RRDP datafiles

The RRDP files are accessible from

http://www.seaice.dk/ecv2/rrdb-v1.0/SICCI-RRDP-V1.0.zip

Table lists Northern hemisphere RRDP files in SICCI2 RRDP v1.0

# records	# Bytes	Filename
3697	2539152	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DMISIC0-2012-N.text
7196	4942965	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DMISIC0-2013-N.text
7266	4991055	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DMISIC0-2014-N.text
4736	3252945	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DMISIC0-2015-N.text
385	269236	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DTUSIC1-2013-N.text
905	633756	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DTUSIC1-2014-N.text
201	140252	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DTUSIC1-2015-N.text
791	731675	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2011M-N.text
351	324185	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2012B-N.text
408	376967	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2012D-N.text
511	472854	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2012G-N.text
596	551649	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2012H-N.text
520	480847	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2012I-N.text
660	610319	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2012J-N.text
652	603561	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2012L-N.text
922	853026	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2013B-N.text
471	435540	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2013H-N.text
972	899231	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-IMBCRREL2014E-N.text
3710	2614785	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2002-N.text
6650	4687485	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2003-N.text
6560	4624035	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2004-N.text
6588	4643775	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2005-N.text
6578	4636725	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2007-N.text
6553	4619100	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2008-N.text
6562	4625445	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2010-N.text
5159	3636330	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2011-N.text
339	243014	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DTUSIC1-2007-N.text
1240	890833	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DTUSIC1-2008-N.text
1475	1059798	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DTUSIC1-2009-N.text
1088	781545	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DTUSIC1-2010-N.text
1120	804553	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DTUSIC1-2011-N.text
1082	1020622	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-IMBCRREL2006B-N.text
458	431437	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-IMBCRREL2009A-N.text
702	662507	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-IMBCRREL2009F-N.text
704	664051	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-IMBCRREL2011C-N.text
20	17979	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-IMBCRREL2011M-N.text
13589	10739509	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-MODIS_MELTPOND_UHAM.text
101417	**63773234**	**Total**

Table lists Southern hemisphere RRDP files in SICCI2 RRDP v1.0

# records	# Bytes	Filename
1245	854628	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DMISIC0-2012-S.text
4030	2767923	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DMISIC0-2013-S.text
4116	2827005	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DMISIC0-2014-S.text
3170	2177103	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DMISIC0-2015-S.text
322	225073	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DTUSIC1-2013-S.text
157	109408	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DTUSIC1-2014-S.text
50	34401	SICCI-RRDP-ASCAT-vs-AMSR2-vs-ERA-vs-DTUSIC1-2015-S.text
1444	1017255	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2002-S.text
3933	2772000	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2003-S.text
3951	2784690	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2004-S.text
3838	2705025	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2007-S.text
3785	2667660	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2010-S.text
3206	2259465	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DMISIC0-2011-S.text
331	237262	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DTUSIC1-2007-S.text
357	255956	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DTUSIC1-2008-S.text
443	317790	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DTUSIC1-2009-S.text
989	710364	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DTUSIC1-2010-S.text
278	199155	SICCI-RRDP-ASCAT-vs-AMSR-vs-ERA-vs-DTUSIC1-2011-S.text
35645	24922163	total

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