ESA Climate Change Initiative CCI+

Product Specification Document

snow cci

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ESA STUDY CONTRACT REPORT

ESA CONTRACT NO:	Subject: ESA Climate Change Initiative CCI+ - SNOW		CONTRACTOR:
4000124098/18/I-NB	Product Specification Document		ENVEO
ESA CR ( )NO:	**STAR CODE:**	**NO OF VOLUMES:** 4 **THIS IS VOLUME NO:** 4	**CONTRACTOR'S REF:** Deliverable D1.2

Abstract:

The European Space Agency (ESA) Climate Change Initiative aims to generate high quality Essential Climate Variables (ECVs) derived from long-term satellite data records to meet the needs of climate research and monitoring activities. This document provides the product specifications for *snow_cci* ECVs (snow cover fraction – SCF; snow water equivalent – SWE). These specifications were derived from the user requirements obtained through engagement with users from across climate applications, including aspects of hydrology and meteorology. The *snow_cci* SCF product is derived from medium resolution optical data (0.05 and 0.01 degrees); the SWE product is derived from satellite passive microwave measurements (0.1 degrees) with input from weather station snow depth observations.

The work described in this report was done under ESA Contract. Responsibility for the contents resides in the author or organisation that prepared it.

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2.0	16 / 12 / 2019	Updated version	Derksen, C. et al.
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4.0	24 / 06 / 2022	Fourth version draft	Derksen, C. et al.
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1. INTRODUCTION

The European Space Agency (ESA) Climate Change Initiative aims to generate high quality Essential Climate Variables (ECVs) derived from long-term satellite data records to meet the needs of climate research and monitoring activities, including the detection of variability and trends, climate modelling, and aspects of hydrology and meteorology. This document provides the product specifications for *snow_cci* ECVs (snow cover fraction – SCF; snow water equivalent – SWE). These specifications were derived from the user requirements obtained through engagement with users from across climate applications (see the *snow_cci* User Requirements Document for more details). These products address the GCOS parameters snow extent and snow water equivalent (from which snow depth can be inferred using different approaches to estimate snow density).

1.1. Purpose and Scope

This document provides the product specifications for satellite-derived ECVs for fractional snow cover (SCF) and snow water equivalent (SWE). These specifications represent the initial implementation as closely aligned with the climate science user requirements as possible, given the characteristics of historical and currently available satellite data and the known performance of SCF and SWE algorithms. Both the user requirements and production specification documents are updated on an annual basis.

1.2. Document Structure

A general overview of the *snow_cci* SCF and SWE products is provided in Section 2. Detailed product specifications are provided for snow cover fraction (Section 2.1) and snow water equivalent (Section 2.2). Technical specifications on product format and dissemination are provided in Section 3.

1.3. Applicable and Reference Documents

[AD-1] Derksen, C., T. Nagler and G. Schwaizer (2022) ESA CCI+ Snow ECV: User Requirements Document version 4.0, April 2022.

[AD-2] Schwaizer, G., Luojus, K., Ossowska, J., Naegeli, K., Wunderle, S., Nagler, T., Metsämäki, S., Solberg, R. (2019) ESA CCI+ Snow ECV: Product Validation and Algorithm Selection Report, version 1.0, October 2019.

[AD-3] Notarnicola, C., Premier V., C. Marin, G. Schwaizer, T. Nagler, K. Luojus, C. Derksen, C. Mortimer, S. Wunderle, K. Naegeli (2021) ESA CCI+ Snow ECV: Product Validation and Intercomparison Report, version 3.0, December 2021.

[AD-4] Derksen, C., R. Essery, D. Gustafsson, G. Krinner, and P. de Rosnay (2021) ESA CCI+ Snow ECV: Climate Applications Report, version 3.0, December 2021.

1.4. Acronyms

AATSR	Advanced Along-Track Scanning Radiometer
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
CCI	Climate Change Initiative
CMUG	Climate Modelling User Group
CRDP	Climate Record Data Product
CRG	Climate Research Group
ECV	Essential Climate Variable
MODIS	Moderate resolution Imaging Spectrometer
NDSI	Normalized Difference Snow Index
RMSE	Root Mean Square Error
SCDA	Simple Cloud Detection Algorithm
SCE	Snow Cover Extent
SCF	Snow Cover Fraction
SCFG	Snow Cover Fraction on Ground
SCFV	Snow Cover Fraction Viewable
SLSTR	Sea and Land Surface Temperature Radiometer
SMMR	Scanning Multichannel Microwave Radiometer
SSM/I	Special Sensor Microwave/Imager
SWE	Snow Water Equivalent

2. *SNOW_CCI* ECV PRODUCTS OVERVIEW

Overviews of the Phase 1 *snow_cci* products with anticipated changes for Phase 2 are provided in Table 2.1 (snow cover fraction) and Table 2.2 (snow water equivalent). The input data are summarized in Table 2.3. The majority of climate user requirements were met by the version 1 products; enhancements for future versions will address some of the outstanding user requirements (see [AD-1] for more details on planned product development). Algorithm selection was initially based on the results of inter-comparison and validation exercises performed as part of the ESA Satellite Snow product inter-comparison and Evaluation Exercise (SnowPEx). Algorithm refinements are developed as part of the *snow_cci* product development cycle. Additional details specific to the SCF and SWE products are provided in Sections 2.1 and 2.2.

Table 2.1: Baseline SCF product specifications for *snow_cci* Phase 1 and 2.

	Snow Extent		
Parameter	Fractional snow extent [%]		
Description	Viewable Snow (SCFV); Snow on Ground (SCFG) (SCFV and SCFG are the same in non-forested areas)		
Spatial Coverage	Global (without Antarctica and Greenland ice sheet)		
EO Data	Optical imagery		
File Format	NetCDF		
	***snow_cci* CRDPv1**	**snow_cci CRDPv2**	**snow_cci CRDPv3**
Release Date	December 2020	January 2022	November 2023
Algorithm Heritage	NDSI+SCAmod (5 km) Adapted SCAmod (1 km)	NDSI+SCAmod (5 km) Adapted SCAmod (1 km)	NDSI+SCAmod (5 km) Adapted SCAmod (1 km)
Spatial Resolution	0.05 deg (ca. 5 km) 0.01 deg (ca 1 km)	0.05 deg (ca. 5 km) 0.01 deg (ca 1 km)	0.05 deg (ca. 5 km) 0.01 deg (ca 1 km)
Period	1982 – 2019 (5 km; AVHRR) 2000 – 2019 (1 km; MODIS)	1982 – 2018 (5 km; AVHRR) 2000 – 2020 (1 km; MODIS) 1995 - 2012 (1 km, ATSR-2/AATSR)	1979 – 2022 (5 km; AVHRR) 2000 – 2022 (1km; MODIS) 2020 – 2022 (1 km; SLSTR)
Frequency	Daily	Daily	Daily
Map Projection	Geographic Grid (Lat/Lon)	Geographic Grid (Lat/Lon)	Geographic Grid (Lat/Lon)
Cloud Masking	Cloud CCI v3.0 (5 km) SCDAv2.0 (1 km)	Cloud CCI v3.0 (5 km) SCDAv2.0 (1 km)	CLARA-A3 (5 km) TBD (1 km)
Cloud Gap Filling	None	None	Addressed via temporal aggregation
Temporal Aggregation	None	None	Weekly/Monthly
Spatial Aggregation	None	None	None
Uncertainty	Per-pixel unbiased RMSE	Per-pixel unbiased RMSE	Per-pixel unbiased RMSE
Accuracy Target	10-20% unbiased RMSE	10-20% unbiased RMSE	10-20% unbiased RMSE

Table 2.2 Baseline SWE product specifications for *snow_cci* Phase 1 and 2.

	Snow Water Equivalent		
Parameter	Snow mass		
Description	Snow depth converted to SWE via density		
Spatial Coverage	NH non-mountain areas (without Greenland)		
EO Data	Passive microwave brightness temperatures		
File Format	Net CDF		
	***snow_cci* CRDPv1**	**snow_cci CRDPv2**	**snow_cci CRDPv3**
Release Date	March 2020	November 2021	August 2023
Algorithm Heritage	GlobSnow v3	snow_cci CRDPv1	snow_cci CRDPv2
Spatial Resolution	0.25 deg	0.1 deg	0.1 deg
Period	1979 - 2018	1979-2020	1979-2022
Frequency	Daily	Daily	Daily
Map Projection	Geographic Grid (Lat/Lon)	Geographic Grid (Lat/Lon)	Geographic Grid (Lat/Lon)
Snow Density	Static	Dynamic	Dynamic
Snow Extent Mask	Passive Microwave	Passive Microwave/JAXA	Passive Microwave/JAXA
Temporal Aggregation	None	None	Monthly
Spatial Aggregation	None	None	None
Bias Correction			Monthly data, February – May following Pulliainen et al., 2020
Uncertainty	Per-pixel unbiased RMSE	Per-pixel unbiased RMSE	Per-pixel unbiased RMSE
Accuracy Target	20-30% unbiased RMSE	20-30% unbiased RMSE	20-30% unbiased RMSE

Table 2.3: Input data time series processing plan.

Product	*Phase 1*	*Phase-2*
SCF	AVHRR/2 (1982-2007) AVHRR/3 (1998-2020) ATSR-2 (1995-2003) AATSR (2002-2013) MODIS (2000-2020) SLSTR (2016-2020) Merged AVHRR (1982-2020) Merged ATSR-2, AATSR & SLSTR (1995-2020) Merged Terra and Aqua MODIS (2000-2020) Merged all missions (1982-2020)	AVHRR/1 (1979-1985) AVHRR/2 (1992-2007) AVHRR/3 (1998-2022) MODIS (2000-2022) SLSTR (2020-2022) Merged AVHRR (1982-2022) Merged all missions (1982-2022)
SWE	SMMR (1979-1987) SSM/I, SSMIS (1987-2020) Merged all missions (1979-2020)	SMMR (1979-1987) SSM/I, SSMIS (1987-2022) Merged all missions (1979-2022)

2.1. Snow Cover Fraction Product Specification

The *snow_cci* SCF product is derived from medium resolution optical data (see Table 2.3). The product contains two separate variables: (i) the snow cover at the surface in open areas and on top of vegetation cover such as forest canopies (called 'viewable snow') and (ii) snow extent on ground for open land (same as 'viewable snow') and corrected for masking by trees in forested areas (called 'snow on ground'). The fractional snow cover per resolution cell of the sensor is provided as a percentage.

In Phase 1, two baseline algorithms were selected for the development of SCF products version 1 [AD-2]: an NDSI based method developed for MODIS which provides viewable snow (Salomonson and Appel, 2006), and the SCAmod algorithm with heritage to the ESA GlobSnow project which provides both viewable snow and snow on ground in forested areas, described in Metsämäki et al. (2015). The algorithms were selected because they ranked highly within SnowPEx. The SCAmod algorithm is further developed within snow_cci, which will continue in Phase 2. Additionally, the development of a multi-spectral unmixing algorithm for the SCF retrieval from MODIS and SLSTR data is planned for Phase 2. The SCF retrieval process has 4 modules: pre-processing of satellite data, cloud screening, pre-classification of snow free areas, and SCF estimation.

Module 1: conversion to top-of-atmosphere values and the rectification of the data to the lat/lon grid

Module 2: application of sensor specific cloud screening algorithms and the use of available cloud products generated by other projects (e.g. *cloud_cci*)

Module 3: apply a multi-spectral decision tree (exploiting NDSI, thermal bands, visible bands) with spatially and temporally variable thresholds to mask areas where snow is very unlikely, including water areas.

Module 4: retrieve SCF using the two algorithms to provide viewable snow and snow on ground by correcting for the masking of canopy layer, and per-pixel uncertainty estimates for SCF estimated via the propagation of uncertainties in the various retrieval components.

2.1.1. Thematic Information

The SCF product provides the fraction of a pixel covered by snow given in percent. The products include two consistent layers providing fractional snow as it is seen from space (viewable snow) and fractional snow on ground, which applies a model to correct for the masking effect of the canopy layer (primarily forest). This correction uses auxiliary data on the density and optical transmissivity of the forest layer (note that in non-vegetated areas these two values are the same). Figure 2.1 uses tower-based photographs to illustrate the thematic difference between viewable snow and snow on ground. In the left photo, the canopy and ground surface are both snow covered. When extrapolated over a pixel, these conditions result in viewable snow close to 100%. In the right photo, there is no snow in the canopy, but snow is present on the ground. The viewable snow is therefore lower compared to the other example, but the snow on ground is similar.

Fractional snow extent is calculated only for cloud free land areas, open water areas (inland and oceans) as well as glaciers and ice sheets are masked using a common land mask.

Figure 2.1: Tower-based forest canopy photos showing viewable snow that is very similar to snow on ground (left) and viewable snow that is less than snow on ground (right). Photos courtesy of Paul Bartlett (ECCC).

2.1.2. Uncertainty Characterisation for SCF

The estimate of the pixel-level statistical accuracy for SCF considers observation noise, uncertainty in two-way forest canopy transmissivity, snow reflectance variability, forest canopy reflectance variability, and snow-free ground reflectance variability. The observation noise includes the effect of the inaccuracy of the instrument, as well as effects of other variables such as the atmospheric attenuation. The per-pixel uncertainty, expressed as unbiased RMSE, is provided for each day.

Uncertainties which cannot be specified on a pixel level are also identified and attached to the products in the associated metadata.

Systematic error is derived from validation of the daily SCF data set using high resolution optical imagery and reference snow measurements. Users can consult the annual Product Validation and Intercomparison Report for accuracy results.

2.1.3. Spatial Resolution and Coverage

The *snow_cci* SCF product covers global non-ice covered land areas, excluding permanent inland open water bodies (lakes, rivers; see Figure 2.2). For Greenland, coastal (non-ice sheet) areas are included. Coastal non-ice covered areas of Antarctica and islands in the southern ocean are not included in the CRDP versions 1 and 2, but may be considered for future versions. Permanent ice and open water areas are treated as static masks. Two time series of SCF will be processed, with the spatial resolution dependent on the input optical imagery: 0.05 deg. from 1982 (based on AVHRR) and 0.01 deg. from 2000 (based on AATSR, MODIS, and SLSTR). No spatial aggregation of the products is done for CRDP version 1 and 2, but a strategy will be developed to meet the aggregation needs of the CMUG. Spatial aggregation of SCF is non-trivial because of the influence of variable cloud cover within aggregation windows.

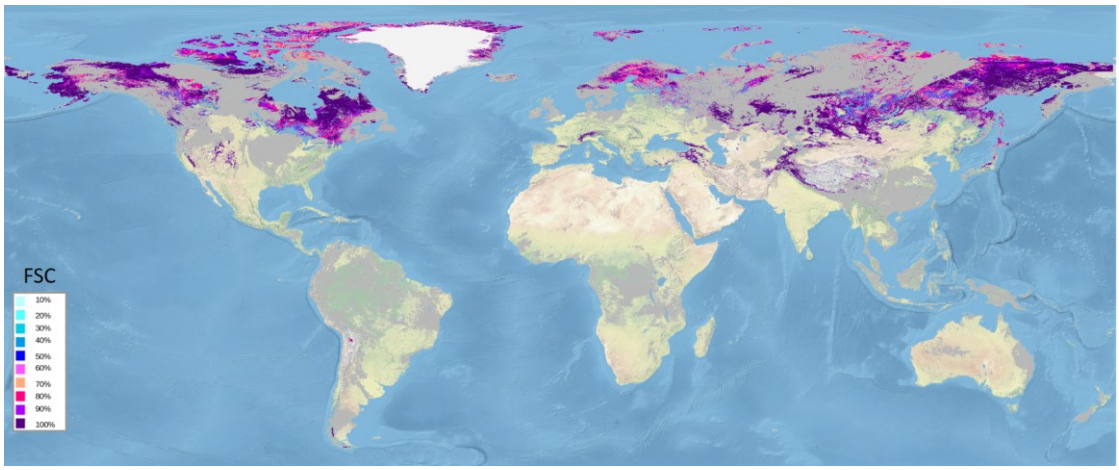

Figure 2.2: Example daily SCF map derived from SLSTR data.

2.1.4. Temporal Characteristics

The *snow_cci* SCF products (CRDPv2) extend from 1982 to 2018 (AVHRR) and 2000 to 2020 (MODIS). SCF is produced at daily temporal resolution with cloud cover flagged. During Phase 1, the *cloud_cci* cloud mask was applied to the AVHRR-2/-3 GAC based SCF products. In Phase 2, this will be replaced with the CLARA-A3 cloud mask from the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF). For all other sensors, the Simple Cloud Detection Algorithm, version 2.0 (SCDA v2.0) (Metsämäki et al., 2015) was selected as the baseline cloud screening method. During Phase 2, this approach will continue to be adapted as needed for different sensors. User demand for temporal aggregation was low, but options for weekly or monthly products will be further investigated for future product versions. The SCF product will be updated annually, following the CCI cyclical processing strategy.

2.2. Snow Water Equivalent Product Specifications

2.2.1. Thematic Information

The ESA GlobSnow SWE retrieval approach (described in Takala et al. 2011) was successfully adapted to produce the Snow CCI CRDPv1 (see Figure 2.3). Subsequent enhancements for the SWE CRDPv2 included the adoption of a recalibrated and reprocessed satellite passive microwave dataset with improved grid spacing (12.5 km) and the integration of spatially and temporally dynamic snow density described in Luojus et al. (2021). Benchmarking of developmental versions of the Snow CCI SWE algorithm is described in Mortimer et al. (2022). The retrieval methodology combines satellite passive microwave measurements with ground based synoptic weather station observations via Bayesian non-linear iterative assimilation. A background snow depth field from re-gridded surface snow depth observations and a passive microwave emission model are required components of the retrieval scheme.

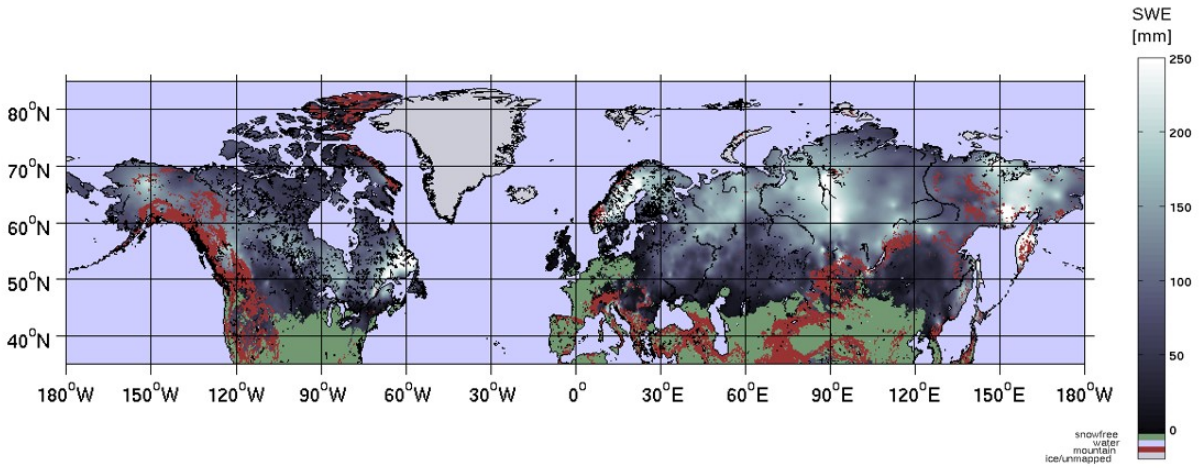

Figure 2.3: Example daily SWE map derived from SSM/I data.

2.2.2. Uncertainty Characterization for SWE

Statistical error is determined through an adaptive dynamic error propagation approach (Pulliainen, 2006; Takala et al. 2011) which considers uncertainty in the weather station observed snow depth, uncertainty of the (forward) modelling of space-borne observed brightness temperature, and the estimated sensitivity of brightness temperature to SWE. This information is provided daily as unbiased RMSE on a per-grid cell basis. Determination of systematic error (bias) is achieved through validation of the daily product using independent reference snow course measurements from Russia, Finland, and Canada. Users can consult the annual Product Validation and Intercomparison Report for accuracy results.

A source of uncertainty with respect to the SWE ECV is the impact of variable weather station input data on time series continuity. SWE retrievals were produced from two synoptic snow depth input data sets: stations which pass the initial consistency and QC check but may vary over time (as employed in GlobSnow v2.1 and Snow CCI v1), versus a reduced but consistent set of weather station inputs. This developmental version was evaluated (Mortimer et al., 2022) and ultimately the pre-existing QC check was determined to be sufficient.

2.2.3. Spatial Resolution and Coverage

The 0.25° resolution SWE dataset derived from passive microwave measurements (SMMR, SSM/I, and SSMIS) for CRDPv1 was updated to a reprocessed and recalibrated dataset for CRPDv2. This allowed an improved grid spacing to 0.1° and had the further benefit of improved radiometric homogeneity through time (see Mortimer et al., 2022). Because of known limitations in alpine areas, a complex terrain mask is applied based on the sub-grid variability in elevation determined from a high resolution digital elevation model. A new DEM was produced for *snow_cci*, (for consistent use within SCF and SWE processing chains and validation activities) based on a new 90 m resolution TanDEM-X DEM gap-filled with SRTM V4.1 and ASTER GDEM V003 and resampled to 0.01 / 0.05 / 0.25 deg. grids. A high

resolution (~500m) SWE product for mountain areas is under investigation as part of a snow_cci option project during Phase 2. All land ice and large lakes are masked; retrievals are not produced for coastal regions of Greenland.

At present, there are no plans to extend the SWE product to the southern hemisphere because very little snow covered land occurs outside of the alpine mask. This may change depending on the outcome of the research and development activities within the option project.

2.2.4. Temporal Characteristics

SWE over the full northern hemisphere domain is produced at a daily time step. The product update frequency is annual, following the CCI cyclical processing strategy.

3. PRODUCT FORMAT AND DISSEMINATION

3.1. File Contents

3.1.1. Global Attributes

A full summary of global attribute fields for *snow_cci* was developed alongside the version 1 products, with updates as required for subsequent versions. Table 3.1 provides a working list of global attributes with some content definitions.

Table 3.1: Summary of global attribute fields.

Global Attribute	*Content*
title	ESA CCI snow product level L3C daily
institution	
source	
history	
references	http://snow-cci.enveo.at/
tracking_id	
Conventions	CF-1.9
product_version	3.0
format_version	CCI Data Standards v2.3, 2021
summary	
keywords	snow cover / snow water equivalent, sensor, platform
id	filename.nc
naming authority	
keywords_vocabulary	NASA Global Change Master Directory (GCMD) Science Keywords
cdm_data_type	Swath
comment	
date_created	
creator_name	
creator_url	
creator_email	
project	Climate Change Initiative - European Space Agency
geospatial_lat_min	-90
geospatial_lat_max	90
geospatial_lon_min	-180
geospatial_lon_max	180
geospatial_vertical_min	0

Global Attribute	*Content*
geospatial_vertical_max	0
geospatial_lon_resolution	0.01, 0.05, 0.10, 0.25
geospatial_lat_resolution	0.01, 0.05, 0.10, 0.25
geospatial_lat_units	degrees_north
geospatial_lon_units	degrees_east
time_coverage_start	
time_coverage_end	
time_coverage_duration	P1D
time_coverage_resolution	P1D
standard_name_vocabulary	NetCDF Climate and Forecast (CF) Metadata Convention version 1.9
license	ESA CCI Data Policy: free and open access
platform	
sensor	
spatial_resolution	0.01, 0.05, 0.10 0.25 degree
key_variables	snow_cover_fraction, snow_water_equivalent

For final products provided in netCDF format, the per-file metadata is summarized in Table 3.2. The defined grid sizes in lat/lon (WGS84 map projection) are:

- 0.25 deg. (CRDPv1 SWE product)
- 0.10 deg. (CRDPv2 SWE product)
- 0.05 deg. (AVHRR based SCE products)
- 0.01 deg. (MODIS and SLSTR based SCE products)
- 0.00025 deg. (Landsat based SCE products used for validation)

3.1.2. Variable Attributes

Per-product metadata is summarized in Table 3.2. Variable attributes for the *snow_cci* products, including uncertainty information and data quality flags were developed alongside the version 1 products. Metadata will be updated in subsequent versions of the PSD as required.

Table 3.2: Summary of product metadata.

Product	Variable	Description
SCF[G|V]	lat	Latitude at the upper left corner of each pixel [deg]
	lon	Longitude at the upper left corner of each pixel [deg]
	scf[g|v]	Snow Cover Fraction, Snow on ground / Viewable Snow
	spatial_ref	Coordinate reference system definition
	scf[g|v]_unc	Snow Cover Fraction uncertainty layer, unbiased RMSE
	time	Time information [UTC]
SWE	lat	WGS84 latitude coordinates, centre of pixel [deg]
	lon	WGS84 latitude coordinates, centre of pixel [deg]
	spatial_ref	Coordinate reference system definition
	swe	Snow water equivalent [mm]
	swe_std	Statistical standard deviation of SWE estimate [mm]
	time	Time information [UTC]

3.2. Product Characteristics and Data Access

Snow_cci products are provided in a latitude/longitude geographic grid. Data are 8-bit for SCF and 16-bit for SWE, with daily files in netCDF format. Individual netCDF files will be produced for each day and will include snow cover fraction or snow water equivalent, grid-cell level uncertainty estimates produced from the retrieval processing, and any relevant data flags. Data access is via the CCI data portal. Quicklook images are produced as part of each product processing line.

3.3. Filename Conventions

Filename convention is based on the CCI Data Standards document:

<Indicative Date>-ESACCI-<Processing Level>_<CCI Project>-<Data Type>-
<Product String>[-<Additional Segregator>][-v<GDS version>]-fv<File version>.nc

Definitions of the filename components are:

- Indicative Date: YYYYMMDD
- Processing Level: L3C for daily SCF and SWE version 3 products
- CCI Project: ‘SNOW’
- Data Type:
    - SWE (snow water equivalent);
    - SCFV (viewable snow);
    - SCFG (snow on ground).

- Product String: Identifies the source satellite data for each product:
  - For SCF, this can be:
    - AVHRR_MERGED (data spanning 1982-2022);
    - MODIS_TERRA (data spanning 2000-2022);
    - SLSTR_MERGED (data spanning 2020-2022).
  - For SWE, it is:
    - SMMR-NIMBUS7 (1979 through May 1987);
    - SSMI-DMSP (October 1987-December 1991);
    - SSMIS-DMSP (January 1992-2022).
- File version: unique identifier increasing with each dataset instance

Note that the 'Additional Segregator' and 'GDS version' are not used as part of the *snow_cci* file names.

3.4. Digital Coding of SCF and SWE

Layer Name	SCFG / SCFV
Description	This layer provides the fraction of snow cover in each grid cell as a percentage
Data type	8 bit unsigned integer

Code range	Class
0-100	Mapped snow cover fraction in percent Note: 0 = snow free; 100 = fully snow covered
205	Clouds (incl. cloud shadow) Note: snow retrieval not possible due to masking of earth surface
206	(Polar) Night but satellite data available, but large solar zenith angle does not allow classification
210	Water
211	Sea (**might be added in future product version**)
212	Lake/River (**might be added in future product version**)
215	Glaciers, ice caps, ice sheets
252	ERROR Code: Retrieval / Classification failed
253	ERROR Code: Input data error (e.g. bad pixels, etc)
254	ERROR code: No satellite acquisition
255	Not Valid Pixel
All other values	Not used

Layer Name	SCFG_UNC / SCFV_UNC (uncertainty layer, unbiased RMSE per pixel)
Description	This layer provides the uncertainty of the fraction of snow cover in each grid cell (unbiased RMSE)
Data type	8 bit unsigned integer

Code range	Class
0-100	RMSE unbiased of snow cover fraction, in per cent Note: 0 = pixel identified as snow free in the pre-classification module; 1 - 100 = unbiased RMSE per pixel considered for SCF retrieval
205	Clouds (incl. cloud shadow) Note: snow retrieval not possible due masking of earth surface
206	(Polar) Night but satellite data available, but large solar zenith angle does not allow classification
210	Water
211	Sea (**might be added in future product version**)
212	Lake/River (**might be added in future product version**)
215	Glaciers, ice caps, ice sheets
252	ERROR Code: Retrieval / Classification failed
253	ERROR Code: Input data error (e.g. bad pixels, etc)
254	ERROR Code: No satellite data value
255	Not Valid Pixel
All other values	Not used

Layer Name	SWE
Description	This layer provides the SWE in mm
Data type	16-bit signed integer

Code range	Class
0	Bare ground (SWE = 0 mm)
1-500	SWE [mm]
-1	Masked: land areas on Southern Hemisphere, no SWE data available
-10	Masked: water (oceans, or water fraction > 50%)
-20	Masked: mountain
-30	Masked: Glaciers / permanent ice
All other values	Not used

Layer Name	SWE_STD (statistical standard deviation of estimate)
Description	This layer provides the uncertainty of the SWE retrieval in each grid cell (unbiased RMSE)
Data type	16-bit signed integer

Code range	Class
0	Bare ground (SWE = 0 mm)
1-250	SWE_STD [mm]
-1	Masked: land areas on Southern Hemisphere, no SWE data available
-10	Masked: water (oceans, or water fraction > 50%)
-20	Masked: mountain
-30	Masked: Glaciers / permanent ice
All other values	Not used

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