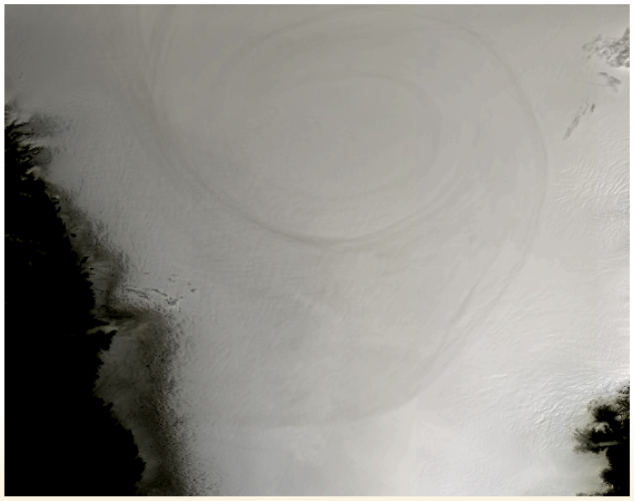

SEOM S3 for Snow / SICE

Release 2.0

Brockmann Consult GmbH

30 July 2021

Contents

List of Figures

List of Tables

1 Introduction

1.1 Project background

The SEOM Sentinel-3 for Science, Land Study 1: SNOW (referred as 'S3-SNOW' in the following) is "to develop, implement and validate algorithms for deriving several key snow parameters from Sentinel 3 optical satellite data, appropriate for addressing ESA's Cryosphere challenge C3 : "Seasonal snow, lake/river ice and land ice, their effect on the climate system, water resources, energy and carbon cycles: the representa<on of terrestrial cryosphere in land surface, atmosphere and climate models". See [1] for details.

As a successor of S3-SNOW, a new one-year project named SICE (Sentinel-3 snow and ice products) was established in 2019, with the particular goal to determine a dry/wet snow and clean/polluted bare ice spectral and broadband optical albedo 1 km daily product for land ice (glaciers, ice caps, ice sheet). Within SICE, both algorithms and corresponding data processors and software were updated and further improved. The relevant changes of the processors and software will be described in this updated version of the SUM.

1.2 Purpose and Scope

This document is the User Manual for the SNAP processors written in Java which have been developed in the frame of the S3-SNOW project and its successor SICE. Its purpose is to describe in detail how to obtain, install and operate these processors. Also, a comprehensive overview of the related data products (input as well as intermediate and final products) is provided.

The explicit structure of the document is as follows:

- Chapter 1 is this introduction.
- Chapter 2 gives an overview of the SNAP S3-SNOW and SICE processors.
- Chapter 3 describes all relevant S3-SNOW and SICE products.
- Chapter 4 explains how to get and install the processing software.
- Chapter 5 explains how to run the processing software.

1.3 References

1. Scientific Exploitation of Operational Missions (SEOM) Sentinel-3 for Science, Land Study 1: SNOW: Technical, Management/Administrative, Implementation, Financial and Contractual Proposal. Issue 1, Revision 1, 16 March 2016.
2. Kokhanovsky, A., Box, J.E., Lamare, M., Dumont, M., Picard, G., Danne, O., and C. Brockmann: Algorithm Theoretical Basis Document: Snow Properties Retrieval from Sentinel-3. Version 2.2, 8 November 2018.
3. Sentinel-3 OLCI User Guide, available at: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci
4. S3-SNOW Project Web Site, available at: http://seom.esa.int/page_project032.php
5. The Sentinel Application Platform (SNAP) Web Site, available at: http://step.esa.int/main/toolboxes/snap/

6. CoastColour Project Web Site, available at: http://www.coastcolour.org

7. OceanColour Project Web Site, available at: http://www.esa-oceancolour-cci.org

8. Bourg, L. (2009): MERIS Level 2 Detailed Processing Model. ACRI-ST, Document No. PO-TN-MEL-GS-0006, 15 July 2009.

9. Sentinel-3A Product Notice: OLCI Level-2 Ocean Colour, available at: https://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&dDocName=PDF_S3A_PN_OLCI_L2_REP&RevisionSelectionMethod=LatestReleased&Rendition=Web

10. Pre-operational Sentinel-3 snow and ice products (SICE) web site. available at: http://snow.geus.dk

11. Kokhanovsky, A., Lamare, M., Di Mauro, B., Picard, G., Arnaud, L., Dumont, M., Tuzet, F., Brockmann, C., and J.E. Box: On the reflectance spectroscopy of snow. The Cryosphere, 12, 2371-2382, 20 July 2018

1.4 Acronyms and Abbreviations

Acronym	Definition
ATBD	Algorithm Theoretical Basis Document
BB	broad-band
BC	Brockmann Consult
BEAM	Basic ERS & Envisat (A)ATSR and Meris Toolbox
BOA	Bottom-of-atmosphere
BOAR	Bottom-of-atmosphere reflectance
BRR	Bottom-of-atmosphere Rayleigh Reflectance
CCI	Climate Change Initiative
CLI	Command Line Interface
DEM	Digital Elevation Model
ESA	European Space Agency
GIMP	Greenland Ice Mapping Project
GPF	Graph Processing Framework
GUI	Graphical User Interface
IdePix	Identification of Pixels
JDK	Java Development Kit
MERIS	Medium Resolution Imaging Spectrometer
NBM	NetBeans Module
NDSI	Normalised Difference Snow Index
NetCDF	Network Common Data Form
OLCI	Ocean and Land Colour Instrument
PPA	Probability of Photon Absorption
SEOM	Scientific Exploitation of Operational Missions
SICE	Sentinel-3 Snow and Ice
SNAP	Sentinel Application Platform
SPP	Snow Properties Processor
SUM	Software User Manual
TOA	Top Of Atmosphere

2 The SNAP S3-SNOW Processors

2.1 Overview

The key goal of the S3-SNOW project and its successor SICE regarding software development, production and dissemination was to implement the proposed algorithms for several key snow parameters from Sentinel-3 OLCI data in free and easily accessible open source toolboxes, notably and foremost ESA's SNAP toolbox. During the implementation process, all processing software was distributed within the consortium in frequent cycles for the purpose of a comprehensive validation from an appropriate OLCI database containing products covering a variety of selected snow-covered areas. All SNAP S3-SNOW and SICE processors are available as SNAP plugins and can be run within SNAP on any supported platform (Windows, Linux, MacOS). The procedure for installation and operation is described in this chapter.

2.2 Theoretical Background

The motivation and theoretical background for the retrieval of key snow parameters is summarized in the S3-SNOW project proposal [1]. The underlying algorithms are described in detail in the corresponding project ATBD [2].

2.3 Processing Environment

As said, the S3-SNOW and SICE processors are available as SNAP plugins and can be run within SNAP on any supported platform (Windows, Linux, MacOS). The chapter *Software Installation* describes in more detail how to install the plugins in SNAP.

2.4 Processing Components

The SNAP S3-SNOW processing software consists of the following components and auxiliary datasets:

- *SNAP Sentinel-3 toolbox* (current version including latest updates is 7.0.2)
- *snap-slope* processor (comes with the SNAP Sentinel-3 toolbox)
- *s3tbx-olci-o2corr* processor (comes with the SNAP Sentinel-3 toolbox)
- lookup tables for OLCI O2 harmonisation (come with the SNAP Sentinel-3 toolbox)
- *s3tbx-snow* plugin (current version is 3.0)
- *idepix-core* plugin (current version is 7.0.1)
- *idepix-olci* plugin (current version is 7.0.1)
- GIMP Digital Elevation Model for Greenland

These components are described in more detail in the following subsections. Note that, compared to the previous version of this SUM, the software package looks a bit different due to the further SNAP evolution during 2019 towards current version 7.0.2. I.e., the O2 harmonisation processor (described in more detail later) is now an internal part of the Sentinel-3 toolbox, whereas the IdePix pixel classification modules are now provided as separate plugins.

2.4.1 The Sentinel Application Platform (SNAP)

A common architecture for all Sentinel Toolboxes has been jointly developed by Brockmann Consult, Array Systems Computing and C-S called the Sentinel Application Platform (SNAP).

The SNAP architecture is ideal for Earth Observation processing and analysis due to various technological innovations as well as approved concepts from the BEAM toolbox. Most of the software components listed above make use of various SNAP core capabilities.

A good starting point for much more detailed information is the SNAP homepage [4], and also the comprehensive help documentation integrated in the SNAP desktop application.

2.4.2 The SNAP Graph Processing Framework

One of the key components in SNAP is the Graph Processing Framework (GPF) for creating user-defined processing chains. All provided S3-SNOW processors make use of this framework.

Within SNAP, the term data processor refers to a software module which creates an output product from one or more input products configured by a set of processing parameters. The GPF framework was originally developed for the BEAM toolbox, the precursor of SNAP. Since the early days of BEAM, a number of data processors have been developed; some of them are standard modules while others are contributed by 3rd parties. All of these data processors have been developed using a dedicated processing framework which was already part of the first version of BEAM.

Based on the experience collected within a number of projects, the SNAP authors have developed what is now the SNAP Graph Processing Framework. The GPF provides all the features inherited from BEAM, but adds a number of new ones for developers and reduces the amount of source code to write while drastically improving its readability and maintainability.

Much more detailed information on the SNAP GPF is provided by the specific GPF help documentation integrated in the SNAP desktop application.

2.4.3 The OLCI Snow Properties Processor

The Snow Properties Processor (SPP) is the key component for the processing in S3-SNOW. The processor provides the implementation of the algorithms for the various snow properties of interest. These algorithms are also described in detail in [2].

As input, the processor requires an OLCI L1b product (original or being Rayleigh corrected in a preprocessing step). Optionally, an IdePix pixel classification product (see below) can be provided as additional input. The output is a set of snow properties of interest, defined by the user via processing parameters. This is described in detail in the chapter *How to use the S3-SNOW Processors*.

2.4.4 The OLCI SICE Snow Properties Processor

The SICE Snow Properties Processor (SICE SPP) is the most recent processor provided for the retrieval of snow properties. As it contains various improvements compared to the SPP, this processor is the recommended one for most users. However, the SPP is still a useful alternative for experienced users as it contains many user options to change specific algoritnm parameters as well as to generate additional bands in the final snow product. These underlying algorithms are described in detail in the latest version of [2].

As input, the SICE processor requires both an OLCI L1b product AND a corresponding Rayleigh corrected product from a preprocessing step. As for the SPP, an IdePix pixel classification product (see below) can be optionally provided as additional input. The output is again a set of snow properties of interest, described in detail in the chapter *How to use the S3-SNOW Processors*.

2.4.5 The IdePix OLCI Pixel Classification Processor

IdePix (Identification of Pixels) is a pixel classification tool which has been developed by BC originally for BEAM and has been used for a variety of projects. It was transferred to SNAP and is continuously being further developed.

Among the supported sensors is OLCI, which made IdePix the most appropriate candidate for cloud and snow identification in the S3-SNOW and SICE projects.

Originally, IdePix has been developed as an internal component of the SNAP Sentinel-3 toolbox. To increase flexibility, the sub-processors for the various sensors were recently extracted to make them available as separate plugins. One of these plugins is the IdePix Sentinel-3 OLCI processor which can now be used in its standard version as it has been further improved during 2019 and provides now all the needs for S3-SNOW and SICE, i.e. the distiction of cloud and snow/ice which now works reasonably well. (It is no longer necessary to use a 'special version' of Idepix OLCI, as described in previous SUM versions.)

The IdePix classification algorithm for Sentinel-3 OLCI is based on a neural network approach. A common neural net is used for both land and water pixels. As input for the neural net, the square roots of the OLCI TOA reflectances (obtained from an internal radiance-to-reflectance conversion) at all 21 wavelengths are used. As output, the neural net finally provides per pixel one of the properties 'cloud sure', 'cloud ambiguous', 'cloud' (which means sure OR ambiguous), or 'snow/ice'.

The pixel classification with IdePix is an optional processing step in S3-SNOW as well as in SICE (although recommended in most cases), applied on the same OLCI L1b products which are being considered for the snow properties retrieval.

2.4.6 The OLCI O2 Harmonisation Processor

The OLCI O2 harmonisation Processor provides a 'harmonisation' of O2 wavebands, which means a modification of the effective transmittances in O2A wavebands 13, 14 and 15 to their values which would be measured at their mean wavelengths and with nominal bandwidth. The corresponding algorithm was provided by R.Preusker (Spectral Earth, Berlin) and is described in detail in [2]. Among various outputs, the processor provides the rectified and desmiled transmission for OLCI waveband 13 (761.25nm) which is used by the IdePix classification for the detection of clouds over snow (previous subsection).

This processor has now become a part of the current Sentinel-3 toolbox, therefor it is no longer needed to install it from a separate plugin.

2.4.7 The SNAP Slope Processor

The Slope Processor provides pixelwise terrain slope and aspect angle from an arbitrary input product containing a band with terrain height (i.e. a DEM product). In addition, the variance of elevation over a 3x3 pixel window is provided. For S3-SNOW this processor is provided as utility tool, as slope and aspect are often useful information for the validation of snow properties.

2.4.8 The GIMP Digital Elevation Model for Greenland

A Digital Elevation Model for Greenland has been generated within the GIMP project. This product has been post-processed by BC and is provided in GeoTIFF format with a resolution of ~90m. As only layer in this product, the DEM altitude given in metres is provided. The altitude is e.g. used as input by the OLCI O2 Harmonisation Processor. The GIMP DEM product is illustrated in Figure 2.1.

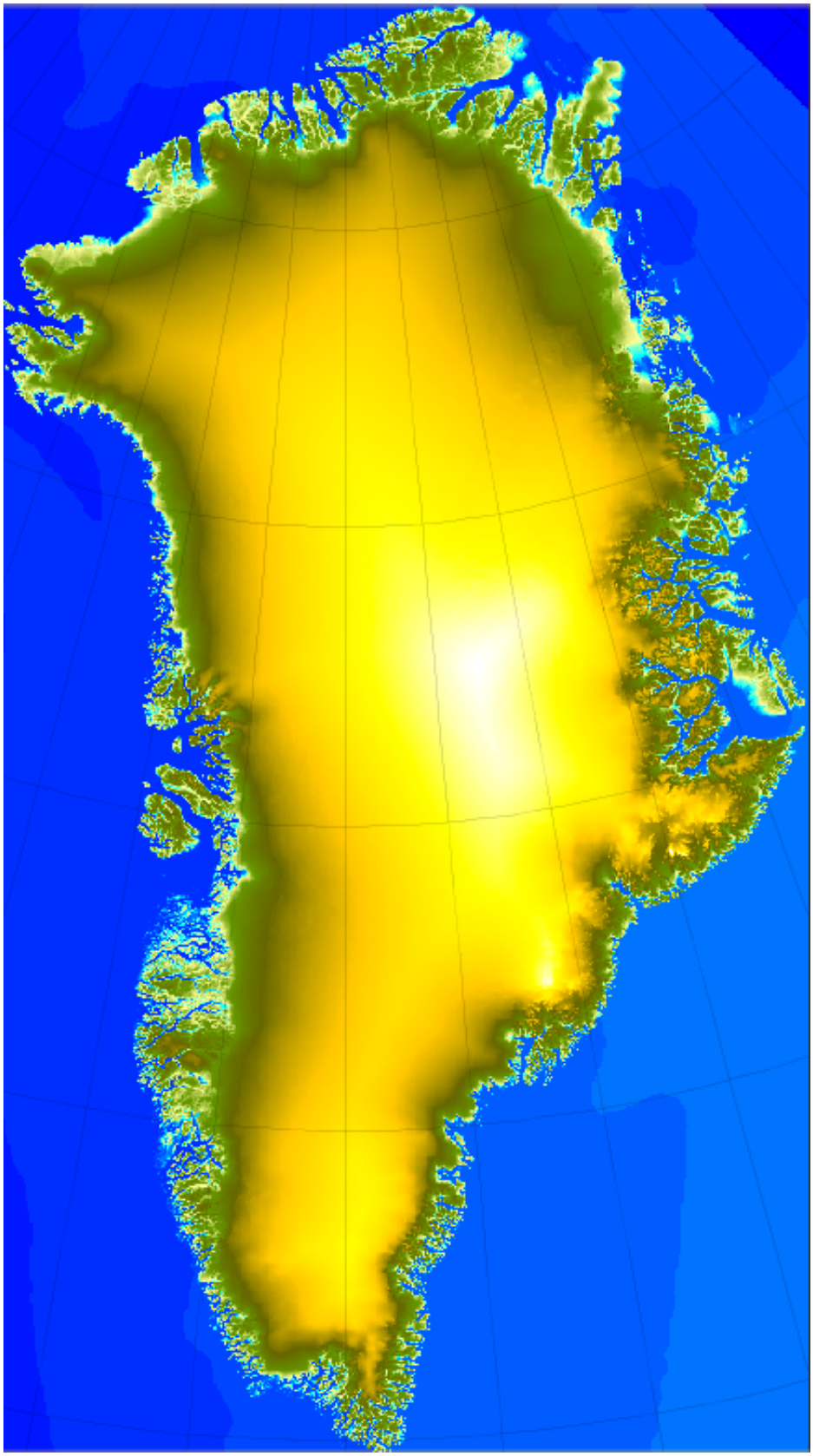

Figure 2.1: Illustration of the GIMP DEM for Greenland.

Using the SNAP Slope Processor, this product can be used as input to derive the corresponding slope and aspect.

2.4.9 Lookup Tables

Various lookup tables are used for the OLCI O2 harmonisation, which in return is part of the IdePix OLCI pixel classification, all described in more detail in [2]. These lookup tables are not provided separately, but as an internal part of the OLCI O2 Harmonisation processor.

2.5 Processing Flow

The overall processing flow and the interaction of the S3-SNOW components are illustrated in Figure 2.2.

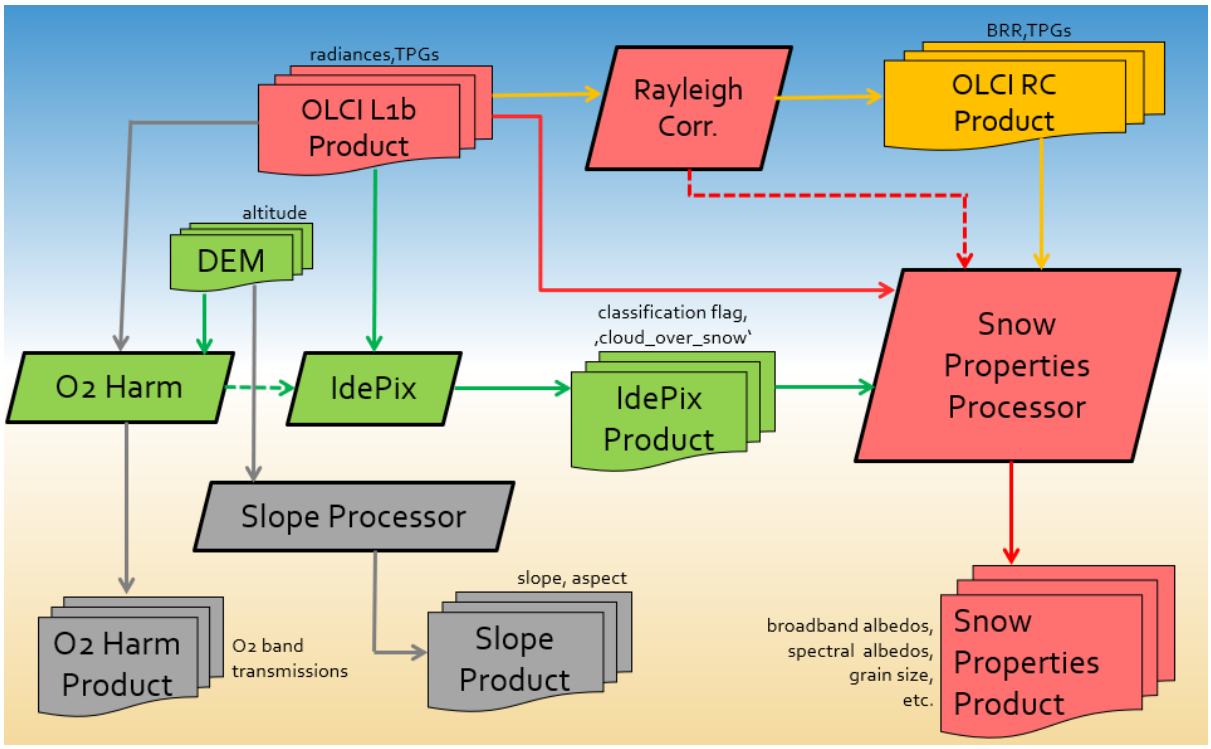

Figure 2.2: *Processing flow of the S3-SNOW processors. See text for details.*

The same is illustrated for SICE in Figure 2.3. The main difference to S3-SNOW is that the Rayleigh corrected product is needed as mandatory input for the SICE Snow properties processor, thus it needs to be generated in a pre-processing step.

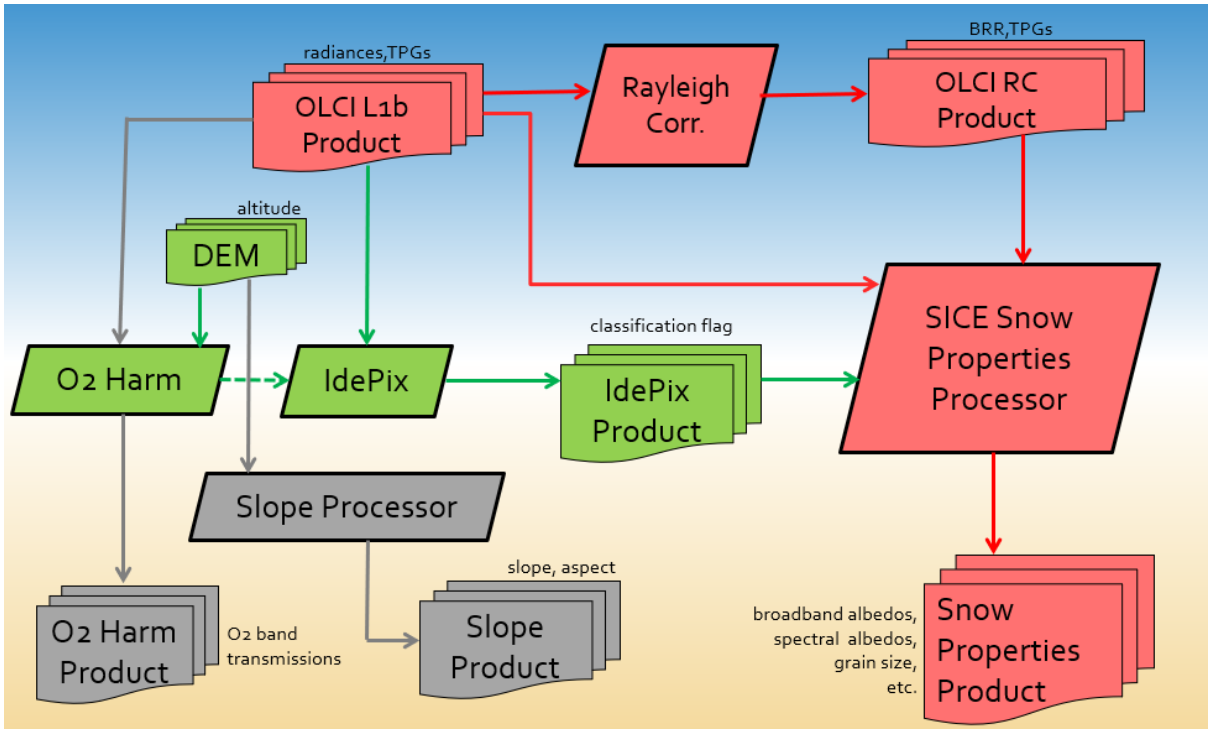

Figure 2.3: *Processing flow for SICE. See text for details.*

The colour and arrow schemes in the diagrams have the following meaning:

- **red** : The standard processing flow for snow properties retrieval. The red boxes indicate the mandatory input products and processing modules: An OLCI L1b radiances product is used as input product for the SPP. If not provided as pre-processed product, BRRs are computed from an internal call of the SNAP Rayleigh Correction Processor, which in return are used for the retrieval of the various snow properties. In opposite to SPP, SICE needs the BRR product as mandatory input from pre-processing.
- **orange** : Alternative processing flow in SPP for snow properties retrieval: An OLCI BRR product is used as input product for the SPP. This BRR product has been computed independently in a preprocessing step, directly using the Rayleigh Correction Processor.
- **green** : Optional processing, i.e. cloud classification: An OLCI L1b radiances product is used as input product for the IdePix Pixel Classification Processor. The IdePix output product can then be used as optional second input product for the SPP or SICE. Internally, IdePix calls the O2 Harmonisation Processor to obtain the O2 waveband transmissions being used to generate the improved cloud classification band 'cloud_over_snow'. An optional DEM product can be used as input for the O2 Harmonisation Processor. If no DEM is specified by the user, the altitude band from the Olci L1b product is used.
- **grey** : Additional processing options, not directly used in the snow properties retrieval. I.e., O2 harmonisation and slope/aspect computation, as outlined above.
- **solid arrows** : indicate input/output to/from a processing module
- **dashed arrows** : indicate internal calls of one processing module into another

3 The S3-SNOW Products

3.1 Overview

This section will give an overview of all input, intermediate, optional and final products used and generated by the SNAP S3-SNOW and SICE processors introduced in the previous chapter.

3.2 Input Products

3.2.1 OLCI L1b TOA Radiance Product

Both reduced and full resolution OLCI L1b TOA radiance products can be used as input data. Tables 3.1 to 3.4 give an overview of OLCI L1b bands, tie point grids and L1b flag coding, respectively. A more detailed description of the OLCI standard L1b product is given in [3]. (Note that in SNAP terminology, the term 'bands' does not only refer to 'spectral bands' (i.e., 1-21 for OLCI), but for all raster data quantities read or written by SNAP.)

Table 3.1: *OLCI bands in L1b product*

Name in product	Unit	Type	Description
Oa<nn>_radiance; n=01,..,21	mW/(m^2*sr*nm)	float32	TOA radiance in band <nn>
lambda0_band_<nn>; n=01,..,21	nm	float32	Central wavelength in band <nn>
FWHM_band_<nn>; n=01,..,21	nm	float32	Bandwidth in band <nn>
solar_flux_band_<nn>; n=01,..,21	mW/(m^2*nm)	float32	Solar flux in band <nn>
quality_flags	dl (flag band)	int32	L1b quality flags
altitude	m	float32	Altitude
latitude	degrees	float32	Latitude
longitude	degrees	float32	Longitude
frame_offset	dl	float32	Resampling frame offset
detector_index	dl	float32	Detector index

Table 3.2: *OLCI instrument channels.*

Channel	Wavelength (nm)
1	400.0
2	412.5
3	442.5
4	490
5	510
6	560
7	620
8	665
9	673.75
10	681.25
11	708.75
12	753.75
13	761.25
14	764.375
15	767.5
16	778.75
17	865
18	885
19	900
20	940
21	1020

Table 3.3: OLCI tie point grids in L1b product.

Name in product	Unit	Type	Description
TP_latitude	deg	float32	Latitude of the tie points
TP_longitude	deg	float32	Longitude of the tie points
SZA	deg	float32	Sun zenith angle
SAA	deg	float32	Sun azimuth angle
OZA	deg	float32	View zenith angle
OAA	deg	float32	View azimuth angle
horizontal_wind_vector_1	m/s	float32	Zonal wind component
horizontal_wind_vector_2	m/s	float32	Meridional wind component
total_columnar_water_vapour	kg/m^2	float32	Total column of water vapour
sea_level_pressure	hPa	float32	Mean sea level pressure
ozone	kg/m^2	float32	Total ozone
humidity	%	float32	Relative humidity

Table 3.4: OLCI L1b flag coding.

Bit	Flag	Description
0-20	saturated_Oa<21-nn>	Band <nn> is saturated
21	dubious	Pixel is cosmetic
22	sun_glint_risk	Pixel has been duplicated
23	duplicated	Pixel has glint risk
24	cosmetic	Pixel is suspect
25	invalid	Pixel is over land,
26	straylight_risk	Pixel is bright
27	bright	Pixel is part of a coastline
28	tidal_region	Pixel is suspect
29	fresh_inland_water	Pixel is over land
30	coastline	Pixel is bright
31	land	Pixel is part of a coastline

3.2.2 OLCI L1b Bottom-of-Rayleigh Reflectances (BRR) Product

As outlined in the previous chapter, the S3-SNOW Snow Properties Processor also accepts BRR[1] products as an alternative to the OCLI L1b radiance products, whereas the SICE processor needs them as mandatory input in addition to the L1b products. These BRR[1] products must have been generated in a pre-processing step using the SNAP Rayleigh Correction Processor. This processor can be accessed from the SNAP Desktop application as shown in Figure 3.1.

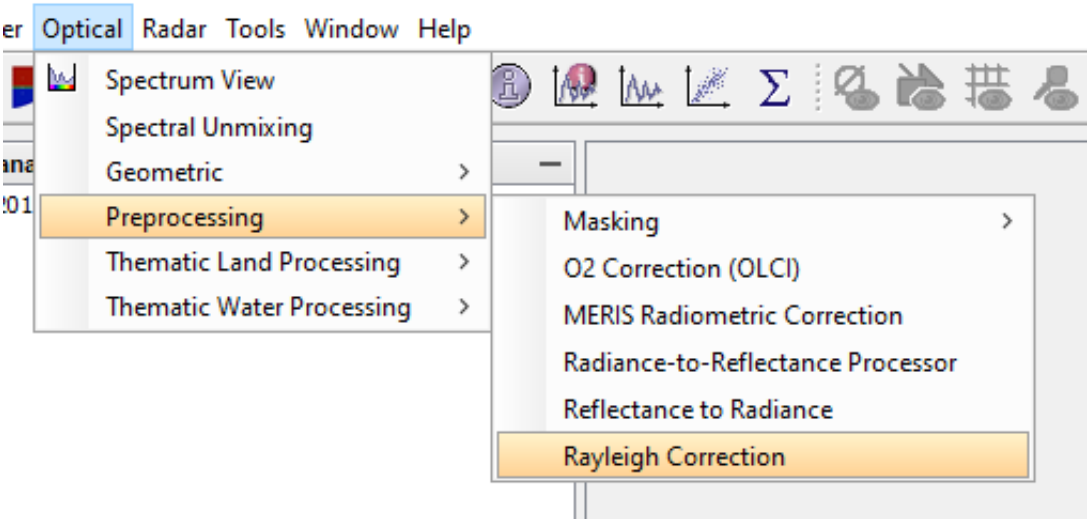

Figure 3.1: *Access to Rayleigh Correction Processor in SNAP Desktop.*

The Rayleigh Correction Processor is a SNAP build-in component. For a detailed description see the corresponding SNAP help documentation. For BRR products to be used with the Snow Properties Processor, BRR for spectral bands 1, 6, 17 and 21 (400nm, 560, 865 and 1020nm) must be generated, and in addition the BRRs for all other spectral bands of interest. For the SICE processor, bands 10 and 11 (681 and 708nm) are also mandatory in addition to bands 1, 6, 17 and 21. In the example shown in

[1] Physically, the term 'BRR' used in the Rayleigh Correction Processor should better be called 'BOAR' (Bottom-of-atmosphere reflectance). The BOAR is derived from Top-of-atmosphere reflectance by correction for molecular scattering and absorption.

Figure 3.2, the parameter settings to generate BRR in bands 1, 6, 17 and 21, and in addition bands 9 and 10, are shown.

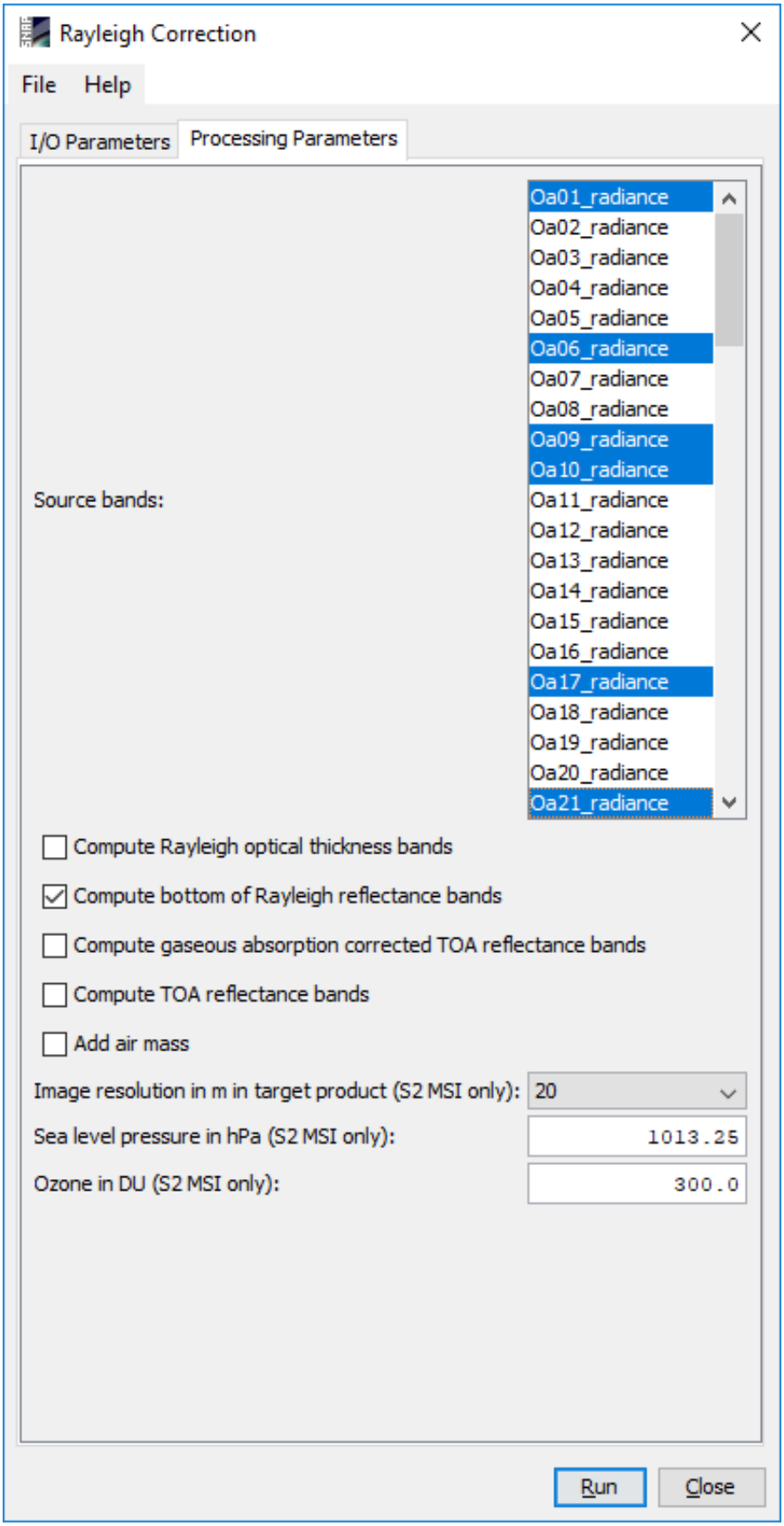

Figure 3.2: *Rayleigh Correction: parameters for the generation of BRR in spectral bands 1, 5, 17 and 21, and in addition in spectral bands 9 and 10.*

The bands in the resulting BRR product are listed in Table 3.5.

Table 3.5: Bands in BRR product

Name in product	Unit	Type	Description
rBRR_01	dl	float32	Bottom-of-Rayleigh reflectance for band 1 (400nm)
rBRR_05	dl	float32	Bottom-of-Rayleigh reflectance for band 5 (510nm)
rBRR_08	dl	float32	Bottom-of-Rayleigh reflectance for band 8 (665nm)
rBRR_09	dl	float32	Bottom-of-Rayleigh reflectance for band 9 (673nm)
rBRR_17	dl	float32	Bottom-of-Rayleigh reflectance for band 17 (865nm)
rBRR_21	dl	float32	Bottom-of-Rayleigh reflectance for band 21 (1020nm)
rBRR_<nn>	dl	float32	Bottom-of-Rayleigh reflectance in band <nn> (optional)
quality_flags	dl	int32	L1b quality flags

3.3 Intermediate and Optional Products

3.3.1 SNAP IdePix Classification Product

The IdePix classification product is the result of the pixel classification performed on the OLCI L1b product. In return, the IdePix product can be used as optional input for Snow Properties Processor. The IdePix OLCI classification product generated with default user options containing the flag bands listed in Table 3.6. Optionally, more bands can be written to the classification product, as described in more detail in the IdePix processor help documentation. However, the S3-SNOW and SICE just need the pixel classification band.

Table 3.6: Bands in IdePix pixel classification product

Name in product	Unit	Type	Description
pixel_classif_flags	dl	int16	Standard IdePix classification flag band
quality_flags	dl	int32	L1b quality flags

The IdePix OLCI classification flag coding is given in Table 3.7.

Table 3.7: Bands in IdePix pixel classification product

Bit	Flag	Description
0	IDEPIX_INVALID	Pixel is invalid
1	IDEPIX_CLOUD	Pixel is either ‘cloud sure’ or ‘cloud ambiguous’
2	IDEPIX_CLOUD_AMBIGUOUS	Semi-transparent clouds, or detection is uncertain
3	IDEPIX_CLOUD_SURE	Fully opaque clouds with full confidence of detection
4	IDEPIX_CLOUD_BUFFER	A buffer of N pixels (user option) around a cloud
5	IDEPIX_CLOUD_SHADOW	Pixel is affected by a cloud shadow
6	IDEPIX_SNOW_ICE	Snow or ice pixel
7	IDEPIX_BRIGHT	Pixel is bright
8	IDEPIX_WHITE	Pixel is white
9	IDEPIX_COASTLINE	Pixel is part of a coastline
10	IDEPIX_LAND	Land pixel

3.3.2 O2 Harmonisation Product

The O2 harmonisation step is done as part of the IdePix pixel classification. The results of this step are used by IdePix internally, and no separate products are written in the S3-SNOW processing flow. However, as the O2 harmonisation is also available as a standalone SNAP plugin with a separate target product, its default contents are listed in Table 3.8 for completeness.

Table 3.8: Bands in O2 Harmonisation target product

Name in product	Unit	Type	Description
trans_13	dl	float32	Rectified and desmiled transmission for band 13
press_13	hPa	float32	Pressure for band 13 neglecting scattering
surface_13	dl	float32	Rectified transmission for band 13
radiance_13	mW/(m^2*sr*nm)	float32	TOA radiance in band 13

3.3.3 Slope Product

A slope product is the output of the SNAP Slope Processor introduced in chapter *The SNAP S3-SNOW Processors*. As mentioned, this is an optional product which is not directly used in the S3-SNOW processing flow. For completeness, its contents are listed in Table 3.9.

Table 3.9: Bands in Slope Processor target product

Name in product	Unit	Type	Description
slope	degrees	float32	Terrain slope
aspect	degrees	float32	Aspect angle in [0, 360] deg
elevation_variance	degrees	float32	Variance of elevation over 3x3 pixel window
<altitude_band>	m	float32	Altitude band from input product (optional)

3.4 Final Snow Properties Product

The S3-SNOW and SICE final products contain various snow properties, depending on the processing parameters specified by the user. The maximum number of bands which can be generated with the S3-SNOW processor is given in Table 3.10. For more detailed explanations of the physical meaning of the parameters, see [2].

Table 3.10: Bands in final S3-SNOW snow properties product

Name in product	Unit	Type	Description
albedo_bb_spherical_vis	dl	float32	Spherical albedo in BB visible range
albedo_bb_spherical_nir	dl	float32	Spherical albedo in BB near infrared range
albedo_bb_spherical_sw	dl	float32	Spherical albedo in Bb shortwave range
albedo_bb_planar_vis	dl	float32	Planar albedo in BB visible range
albedo_bb_planar_nir	dl	float32	Planar albedo in BB near infrared range
albedo_bb_planar_sw	dl	float32	Planar albedo in BB shortwave range
albedo_spectral_spherical_<nn>	dl	float32	Spectral spherical albedo in band <nn>
albedo_spectral_planar_<nn>	dl	float32	Spectral planar albedo in band <nn>
rBRR_<nn>	dl	float32	BRR in band <nn> (max. 21 bands)
ppa_spectral_<nn>	dl	float32	PPA in band <nn> (max. 21 bands)
grain_diameter	mm	float32	Snow grain diameter
snow_specific_area	m^2/kg	float32	Snow specific surface area
ndbi	dl	float32	Bare ice indicator
pollution_mask	dl	float32	Pollution mask
f	1/mm	float32	Snow impurity absorption coefficient
l	mm	float32	Effective absorption length
m	dl	float32	Absorption Angstrom parameter
r_0	dl	float32	Reflectance of nonabsorbing snow layer
f_rel_err	dl	float32	Relative error of parameter f
l_rel_err	dl	float32	Relative error of parameter l
m_rel_err	dl	float32	Relative error of parameter m
r_0_rel_err	dl	float32	Relative error of parameter r_0
ndsi	dl	float32	NDSI
ndsi_mask	dl	float32	NDSI mask for snow identification
quality_flags	dl	int16	L1b quality flags
pixel_classif_flags	dl	int16	Pixel classification flags (see Table 3.7)

The maximum number of bands which can be generated with the SICE processor is given in Table 3.11. Again, for more detailed explanations of the physical meaning of the parameters, see [2].

Table 3.11: *Bands in final SICE snow properties product*

Name in product	Unit	Type	Description
albedo_bb_spherical_vis	dl	float32	Spherical albedo in BB visible range
albedo_bb_spherical_nir	dl	float32	Spherical albedo in BB near infrared range
albedo_bb_spherical_sw	dl	float32	Spherical albedo in BB shortwave range
albedo_bb_planar_vis	dl	float32	Planar albedo in BB visible range
albedo_bb_planar_nir	dl	float32	Planar albedo in BB near infrared range
albedo_bb_planar_sw	dl	float32	Planar albedo in BB shortwave range
albedo_spectral_spherical_<nn>	dl	float32	Spectral spherical albedo in band <nn>
albedo_spectral_planar_<nn>	dl	float32	Spectral planar albedo in band <nn>
grain_diameter	mm	float32	Snow grain diameter
snow_specific_area	m^2/kg	float32	Snow specific surface area
scattering_angle	dl	float32	Scattering angle.
concentration_of_pollutants	dl	float32	Concentration of pollutants
ndbi	dl	float32	NDBI ratio.
ndsi	dl	float32	NDSI ratio.
sice_pollution_type_flags	dl	int16	SICE pollution type flags.
sice_ground_type_flags	dl	int16	SICE ground type flags.
quality_flags	dl	int16	L1b quality flags
pixel_classif_flags	dl	int16	Pixel classification flags

4 Software Installation

4.1 Overview

This chapter describes the overall S3-SNOW software installation procedure.

4.2 Usage Requirements

4.2.1 General Requirements

The S3-SNOW and SICE processors require SNAP in the latest release version (v7.0.0), which is available for all platforms (Windows, Linux, MacOS) from the SNAP website (step.esa.int).

4.2.2 Operating System

The S3-SNOW software can be run on any operating system which is suppported by SNAP (Windows, Linux, MacOS).

4.2.3 Hardware Requirements

The S3-SNOW / SICE processing system is a complex piece of software. Although the algorithms for the snow properties retrieval are mostly relatively simple, the effort for data input/output is fairly high in case of full resolution OLCI products. Therefore, up-to-date and sufficiently powerful and dimensioned hardware is strongly recommended for reliable and convenient processing.

4.3 Contents of the S3-SNOW / SICE Processing Software Bundle

The S3-SNOW / SICE processing software consists of the following components:

- *s3tbx-snow-3.0.nbm*: nbm plugin file
- *snap-slope-1.0.nbm*: nbm plugin file
- GIMP Digital Elevation Model for Greenland: GeoTIFF auxiliary file

Processors for Rayleigh correction and for IdePix pixel classification are included in the SNAP software. The Rayleigh correction processor is installed automatically as part of the SNAP installation, the IdePix processor for OLCI needs to be installed from the plugin manager in SNAP Desktop (described in more detail below).

4.4 How to get the Software

The S3-SNOW processing software bundle can be obtained from the S3-SNOW ftp site hosted at BC. As web browsers have dropped the support for FTP, it is suggested to use an FTP Client, like FileZilla or WinSCP. Use the following configuration:

- SFTP @ Port 22; FTP @ Port 21
- ftp.brockmann-consult.de
- username: s3snow

- password: $3Sn0W@bc
- subdirectory: software/s3snow_sice

4.5 Installation Steps

4.5.1 Installation of the SNAP Software

Download SNAP (Unix version) from the SNAP web site [4] and follow the information and instructions for installation given there.

4.5.2 Installation of the S3-SNOW Processor modules

Once SNAP has been installed, the installation of all NBM plugin files needs to be done from the 'Plugins' toolwindow in the SNAP Desktop application. This is illustrated in the figure sequence Figure 4.1 to Figure 4.4.

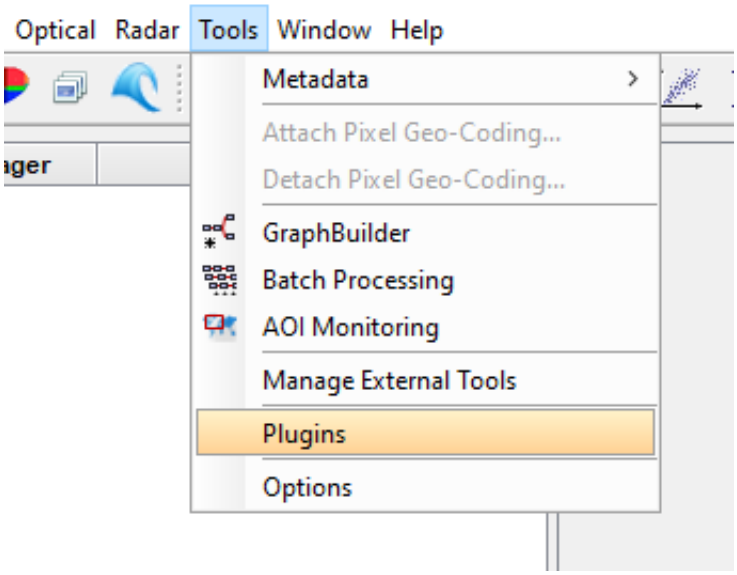

Figure 4.1: *The SNAP menu entry for installation of plugins.*

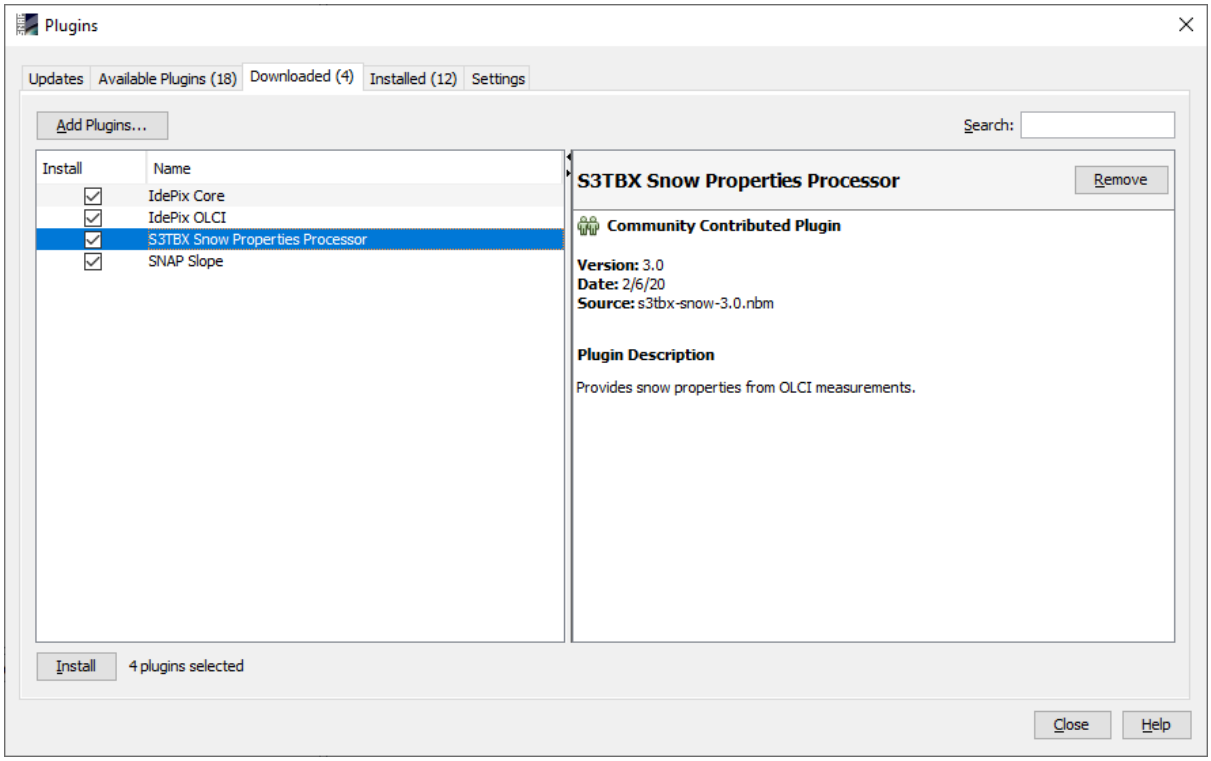

Figure 4.2: *Selection of plugins to be installed. (Note that the IdePix OLCI plugin is shipped with SNAP and is listed under 'Available Plugins', whereas the plugin for S3-SNOW / SICE needs to be accessed through the 'Download' tab from the local disk after download from S3-SNOW ftp site. Also note that the 'IdePix core' plugin needs to be installed in addition to the 'IdePix OLCI'.)*

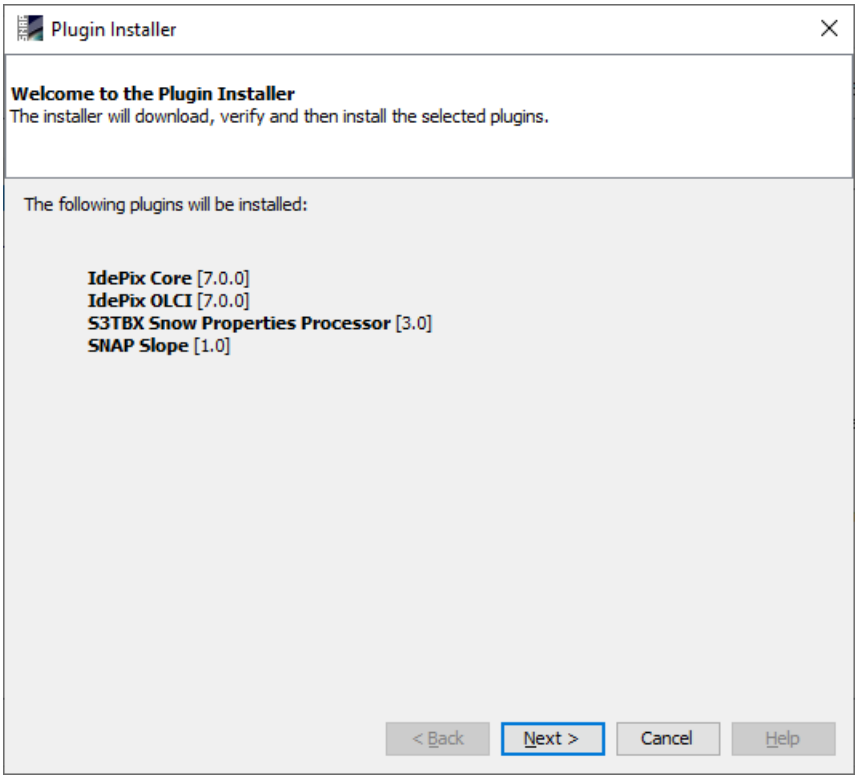

Figure 4.3: *Confirmation of selected plugins (step 1 of 4).*

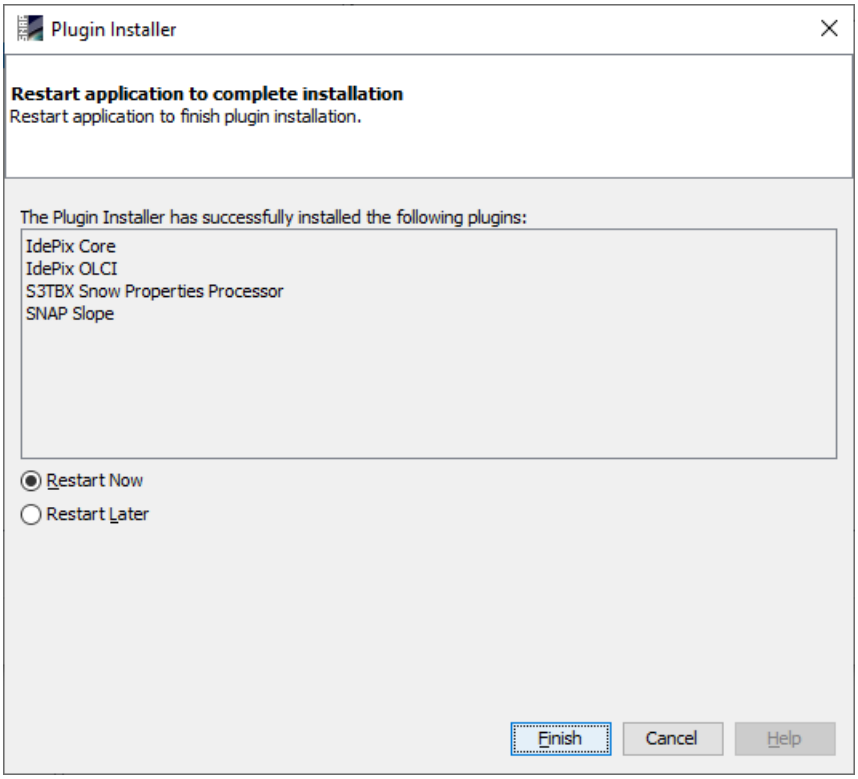

Figure 4.4: *Final confirmation for restart after selection of plugins.*

After restart of SNAP, the installed processors will be available from their dedicated menu entries. This will be shown in more detail in the next chapter.

5 How to use the S3-SNOW Processors

5.1 Test of the Installation

If all plugins described in chapter *Software Installation* were installed successfully in SNAP, the modules should be visible in their dedicated menus as shown in the figure sequence Figure 5.1 to Figure 5.4.

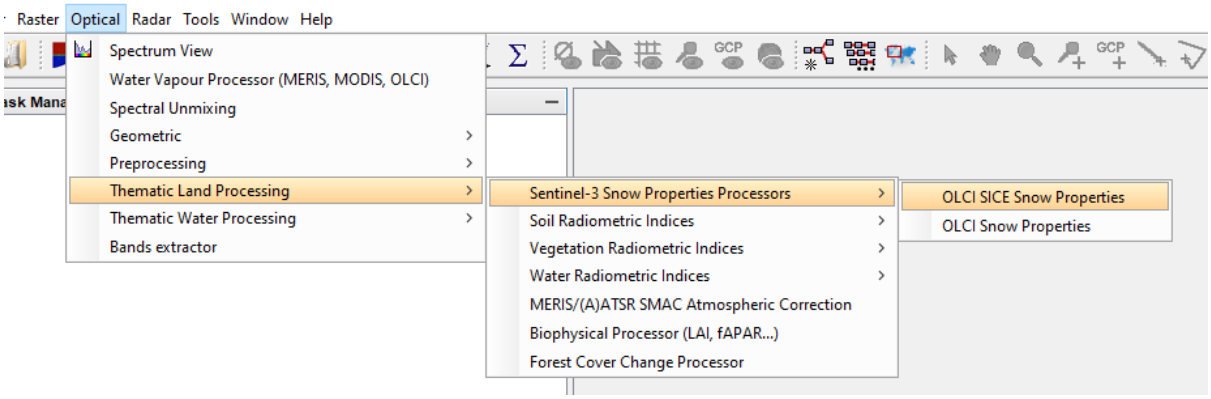

Figure 5.1: *The SNAP menu entries for the S3-SNOW and SICE Snow Properties Processors.*

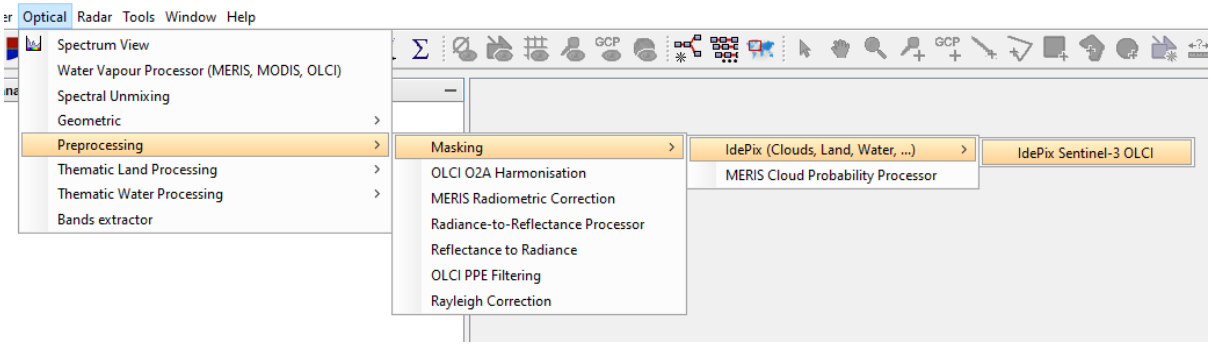

Figure 5.2: *The SNAP menu entry for the IdePix Pixel Classification Processor.*

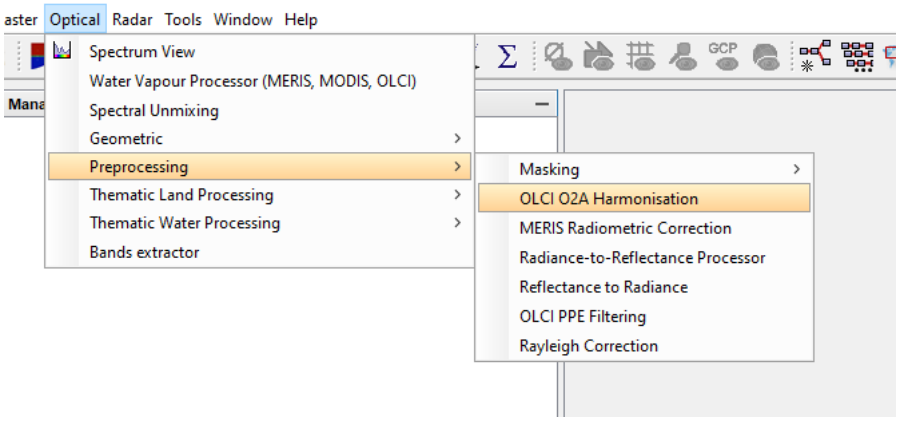

Figure 5.3: *The SNAP menu entry for the O2 Harmonisation Processor.*

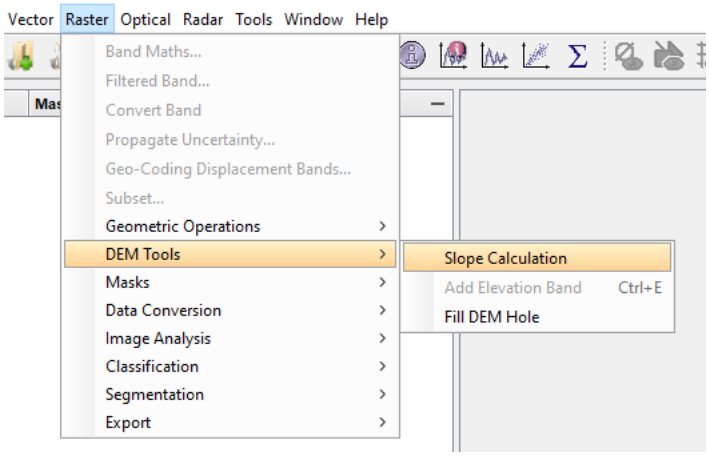

Figure 5.4: *The SNAP menu entry for the Slope Processor.*

5.2 Test Products

The S3-SNOW project delivery D2.4 'Task 2 Data Base' contains a variety of suitable Sentinel-3 OLCI L1b products which can be used for initial tests of the functionalities of the single processors as well as for the whole processing flow. These products can also be obtained from the S3-SNOW ftp site hosted at BC with the following configuration:

- FTP, Port 21
- ftp.brockmann-consult.de
- username: s3snow
- password: $3Sn0W@bc
- subdirectories: data/<region> (Dome-C, French Alps, Greenland, Morteratsch)

5.3 The SICE Snow Properties Processor

5.3.1 GUI Elements

When the OLCI SICE Snow Properties Processor is called from its menu entry, the processor GUI is displayed. It contains two tabs 'I/O Parameters' and 'Processing Parameters', as shown in (Figure 5.5).

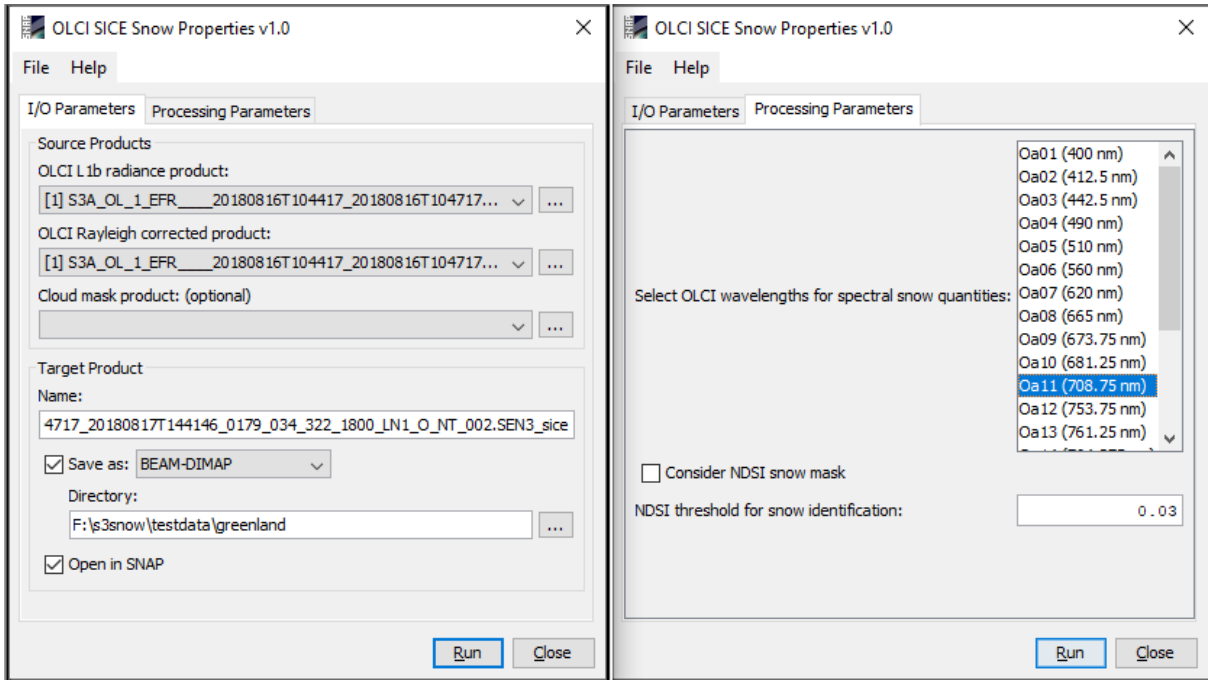

Figure 5.5: The SICE Snow Properties Processor: I/O and processing parameters tabs.

5.3.2 Help Documentation

From the main menu bar of the processor dialog window, an 'About' dialog showing general information on the processor can also be displayed (Figure 5.6).

Figure 5.6: The SNAP Snow Properties Processor: 'About' dialog window.

Also from the main menu bar of the processor dialog window, the SNAP specific help documentation for this processor can be invoked (Figure 5.11, Figure 5.8). This documentation contains some general information, a description of the underlying algorithms (i.e. dedicated references), a description of the processor I/O interface, a description of the processing parameters, and a description how to run the processor from the command line.

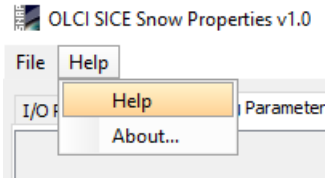

Figure 5.7: The SICE Snow Properties Processor: Accessing the SNAP desktop help documentation.

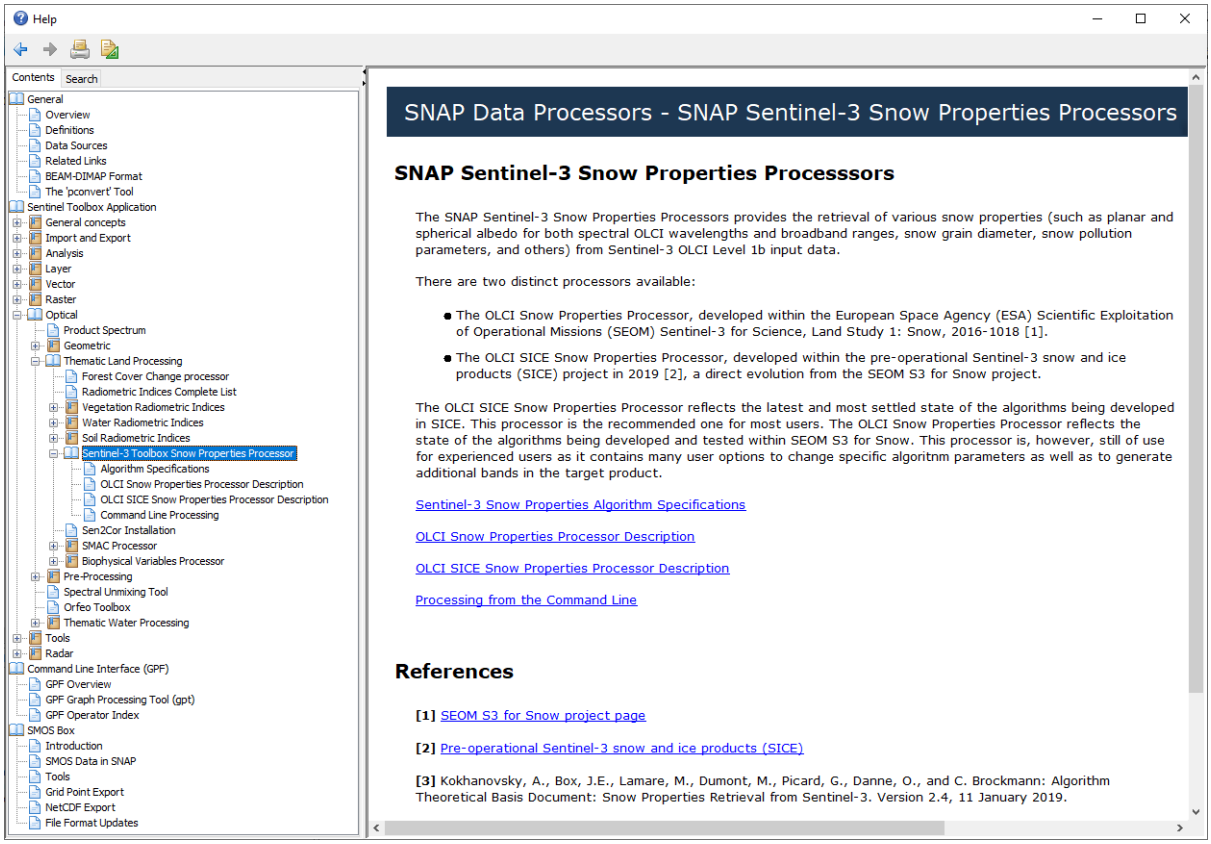

Figure 5.8: The SICE Snow Properties Processor: Start page of the help documentation.

5.4 The S3-SNOW Snow Properties Processor

5.4.1 GUI Elements

When the S3-SNOW Snow Properties Processor is called from its menu entry, the processor GUI is displayed. It contains two tabs 'I/O Parameters' and 'Processing Parameters', shown for SICE in (Figure 5.9).

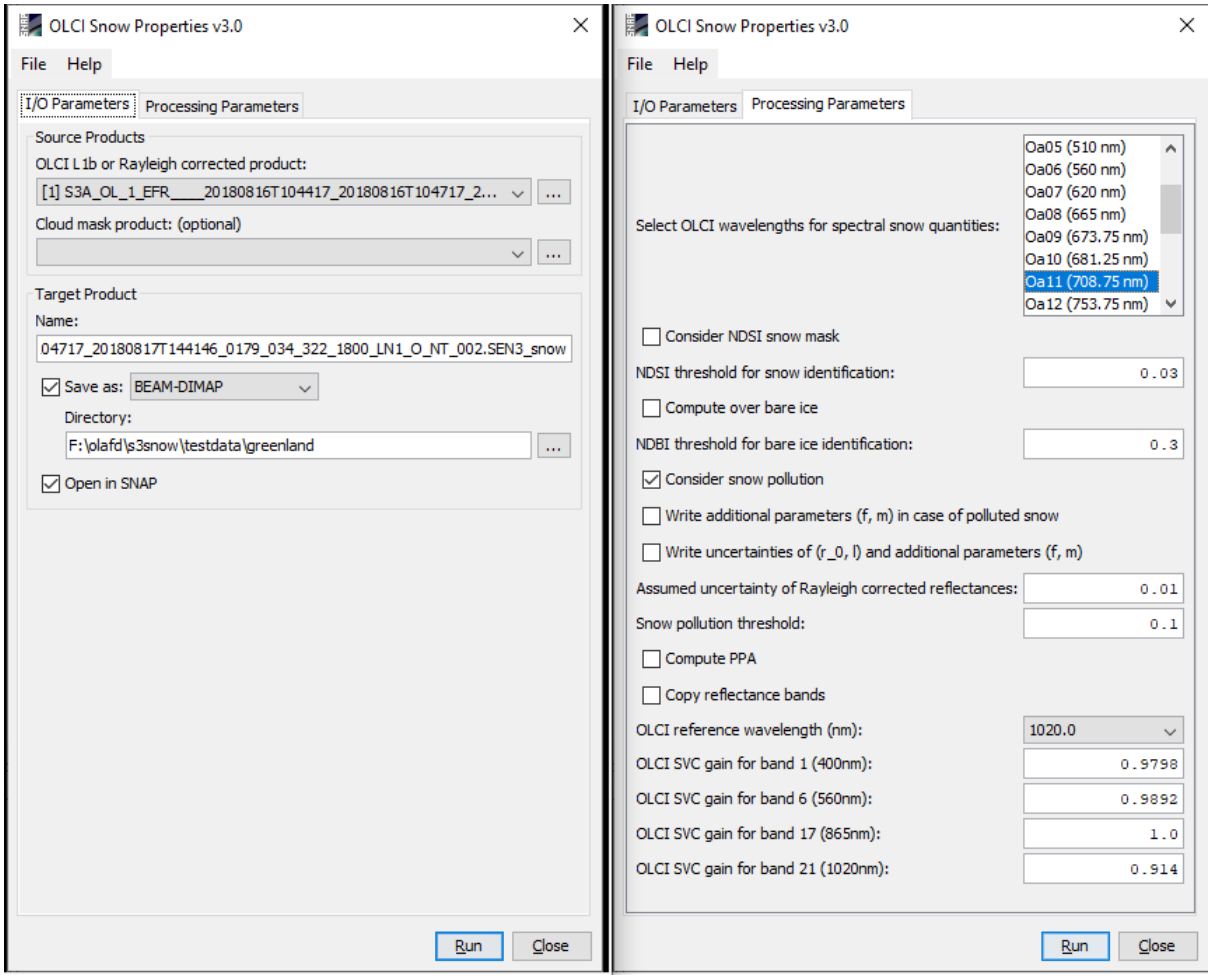

Figure 5.9: The S3-SNOW Snow Properties Processor: I/O and processing parameters tabs.

5.4.2 Help Documentation

From the main menu bar of the processor dialog window, an 'About' dialog showing general information on the processor can also be displayed (Figure 5.10).

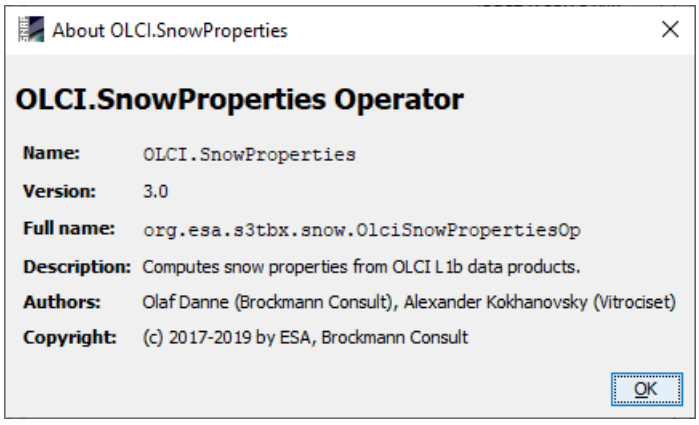

Figure 5.10: The SNAP Snow Properties Processor: 'About' dialog window.

Also from the main menu bar of the processor dialog window, the SNAP specific help documentation

for this processor can be invoked (Figure 5.11, Figure 5.8). This help documentation entry is the same as for the SICE processor.

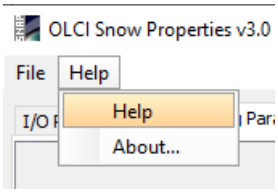

Figure 5.11: *The S3-SNOW Snow Properties Processor: Accessing the SNAP desktop help documentation.*

5.5 The IdePix OLCI Pixel Classification Processor

5.5.1 GUI Elements

When the IdePix OLCI Pixel Classification is called from its menu entry, the processor GUI is displayed. As all other processors provided for S3-SNOW, it contains two tabs 'I/O Parameters' and 'Processing Parameters' (Figure 5.12).

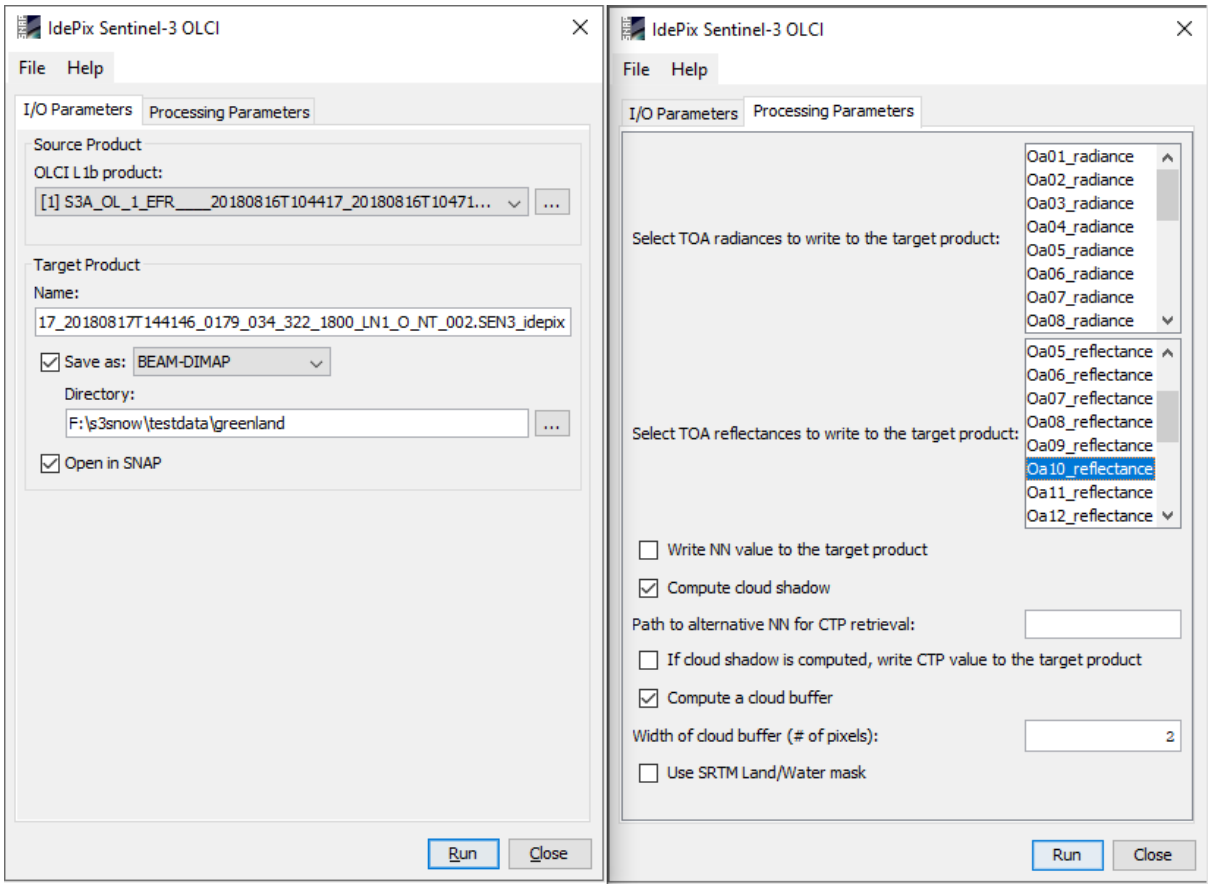

Figure 5.12: *The IdePix OLCI Pixel Classification Processor: I/O and processing parameters tabs.*

5.5.2 Help Documentation

From the main menu bar of the processor dialog window, an ‘About’ dialog showing general information on the processor can be displayed (Figure 5.10).

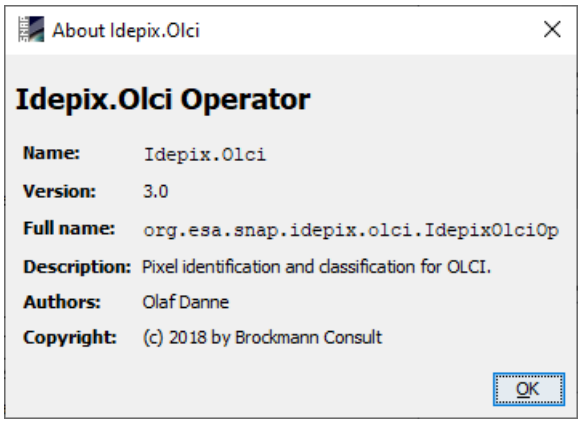

Figure 5.13: *The IdePix OLCI Pixel Classification Processor: ‘About’ dialog window.*

As for all other processors provided for S3-SNOW / SICE, the SNAP specific help documentation for this processor can be invoked from the main menu bar of the processor dialog window. Again, this documentation contains some general information, a description of the underlying algorithms (i.e. dedicated references), a description of the processor I/O interface, a description of the processing parameters, and a description how to run the processor from the command line (Figure 5.14).

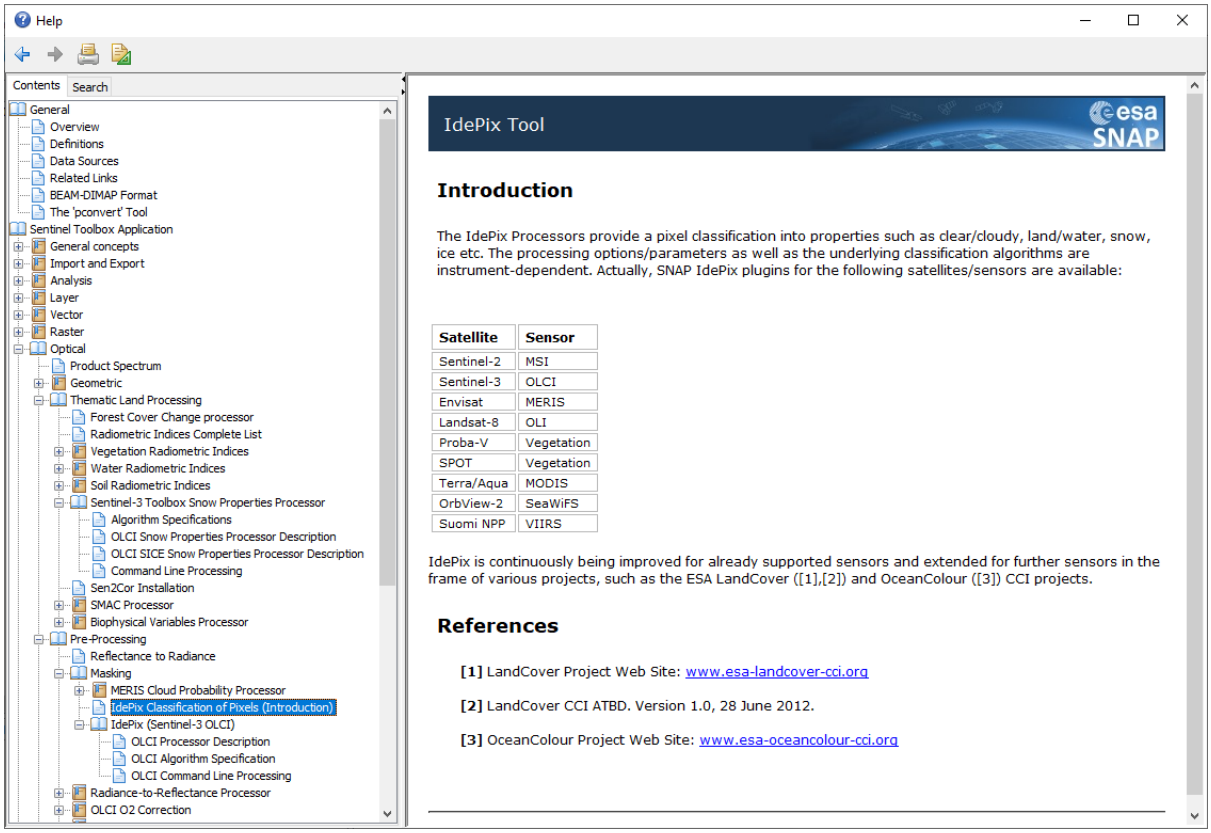

Figure 5.14: *The IdePix OLCI Pixel Classification Processor: Start page of the help documentation.*

5.6 The OLCI O2 Harmonisation Processor

5.6.1 GUI Elements

When the OLCI O2 Harmonisation is called from its menu entry, the processor GUI is displayed. Again, this processor contains two tabs 'I/O Parameters' and 'Processing Parameters' (Figure 5.15).

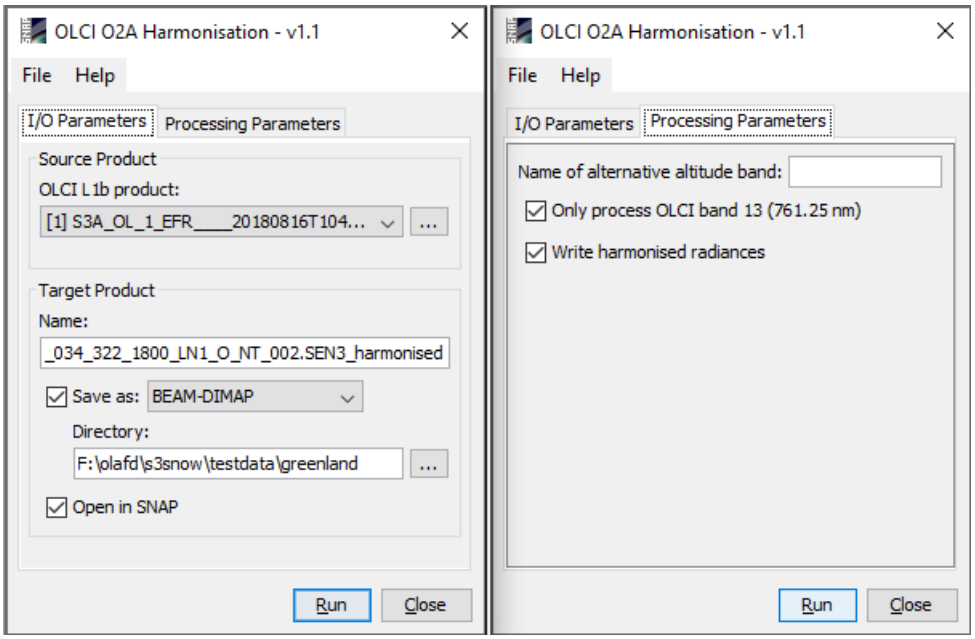

Figure 5.15: *The OLCI O2 Harmonisation Processor: I/O and processing parameters tabs.*

5.6.2 Help Documentation

The 'About' information and help documentation can be accessed through the 'Help' menu in the same way as for all other processors provided for S3-SNOW / SICE.

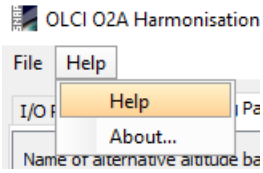

Figure 5.16: *The OLCI O2 Harmonisation Processor: Entry to help documentation.*

5.7 The SNAP Slope Processor

5.7.1 GUI Elements

When the Slope Processor is called from its menu entry, the processor GUI is displayed. Again, this processor contains two tabs 'I/O Parameters' and 'Processing Parameters' (Figure 5.17).

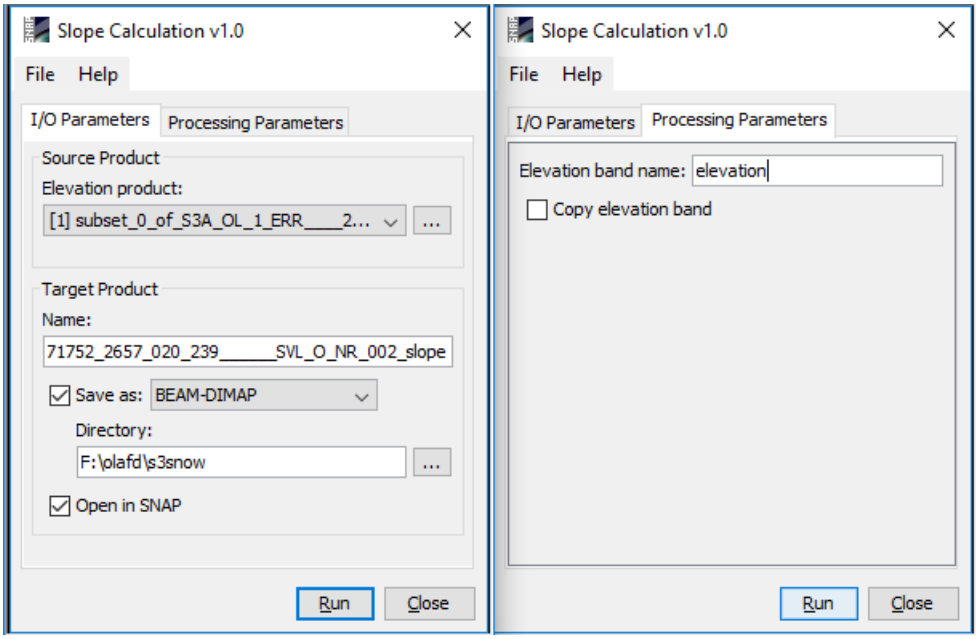

Figure 5.17: The SNAP Slope Processor: I/O and processing parameters tabs.

5.7.2 Help Documentation

The 'About' information and help documentation can be accessed through the 'Help' menu in the same way as for all other processors provided for S3-SNOW / SICE.

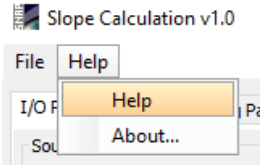

Figure 5.18: The Slope Processor: Entry to help documentation.