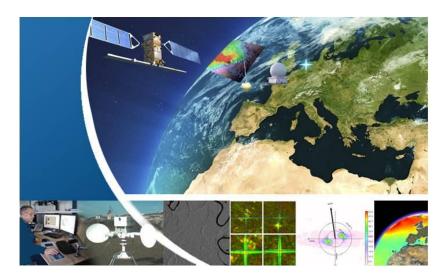


SAR-MPC

Sentinel-1 Level-2 Ocean Processor, Master ATBD



Reference: MPC-0583

Nomenclature: DI-MPC-LOP

Issue 1.1 -





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DI-MPC-LOP

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1 Introduction

1.1 Purpose of this document

The Sentinel-1 LOP (Level-2 Ocean Processor) is in charge of the generation of the Level-2 Ocean Products (OCN).

The OCN products are composed of three types of variables corresponding to:

- Wind measurement over ocean / Ocean Wind / OWI
- Swell measurement / Ocean Swell / OSW
- Surface Radial velocity measurement over Ocean / Radial Velocity / RVL

Each of those three types of variables are computed separately by dedicated processing module, scheduled by the Sentinel-1 LOP, performing at the end a wrapping of each variable in a unique OCN product.

The purpose of this document is to be an entry point of the Algorithm Baseline of the algorithms implemented in the LOP, either for each processing module, or as part of their scheduling.

1.2 Document organisation

This document is organised as follows:

- Chapter 1: this introduction
- Chapter 2: high level picture of the LOP processing and reference to the dedicated OSW/OWI/RVL ATBD
- Chapter 3: dedicated algorithms applied as part of the wrapping of the OCN products

1.3 Applicable and Reference Documents

1.3.1 Applicable Documents

None

1.3.2 Reference Documents

The following documents provide useful reference information associated with this document. These documents are to be used for information only. Changes to the date/revision number (if provided) do not make this document out of date. More recent versions of those documents may be available here: https://sentinel.esa.int/fi/web/sentinel/user-guides/sentinel-1-sar/document-library

ESA-IPF-ICD Generic IPF interface Specification, GMES-GSEG-EOPG-TN-09-0016, Issue 1, Revision 0, 24 septembre 2009

IPF-ADF Sentinel-1 IPF Auxiliary Product Specification, S1-RS-MDA-52-7443, DI-MPC-PB, SAR-MPC-0241, Issue 3, Revision 8, 17 decembre 2021

IPF-PS IPF Product Specification. S1-RS-MDA-52-7441-3-11. Version 3.11 issued on 18th February 2022.



OSW-ATBD Sentinel-1 Ocean Swell Wave Spectra (OSW) ATBD, Version 1.5, issued on 10 October 2022, NORCE.

OWI-ATBD Sentinel-1 Ocean Wind Fields (OWI) ATBD, DI-MPC-OWI, MPC-0469, Version 2.2, 10 October 2022, CLS

RVL-ATBD Sentinel-1 Doppler and Radial Velocity (RVL) ATBD, ISSN 1890-5226, MPC-0534, Version 1.5, issued on 30 Decembre 2021

1.4 Acronyms and Definition

EW Extra Wide Swath

IW Interferometric Wide Swath

ML Management Layer

OSW Ocean Swell

OWI Ocean Wind

RVL Radial Velocity

SM StripMAP

TOPS Terrain Observation Progressive Scan. For Sentinel-1, corresponds to the EW and IW acquisition modes



2 High-Level picture of the LOP

The level-2 (L2) ocean product (OCN) has been designed to deliver geophysical parameters related to the wind, waves and surface velocity to a large panel of end-users. The L2 OCN products are estimated from Sentinel-1 (S-1) Synthetic Aperture Radar (SAR) level-1 (L1) products.

A diagram of the L2 Ocean processing unit context is presented in Figure 2-1.

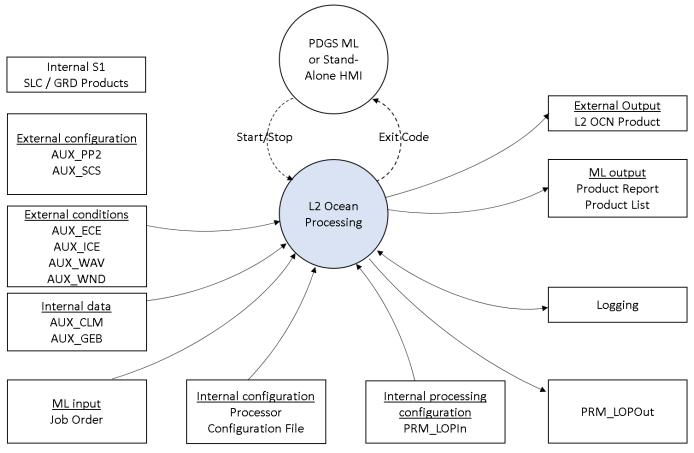


Figure 2-1 Sentinel-1 L2 Ocean Processing Context Diagram

This diagram the various boxes present the input and output by categories:

- The internal S1 SLC/GRD Products are specific products generated by the Level 1 part of the processor. They are not made available to end-user
- The external configuration, composed of AUX_PP2 (the external L2 processor configuration file) and the AUX_SCS (the simulated cross spectra). The formats of those files is exposed in [IPF-ADF]. The AUX_SCS is only used by the swell inversion process.
- The external conditions, composed of AUX_ECE (the antenna excitation coefficients, corresponding to error matrices either for V or H polarisation), the AUX_ICE (ice edge information), AUX_WAV (swell information), AUX_WND (wind information). The formats of those files is exposed in [IPF-ADF].
- The Internal data composed of AUX_CLM (Coastline) and AUX_GEB (Bathymetry / GEBCO data)
- The Management Layer (ML) input, composed of a Job Order. The format of the Job Order is described in the ESA Generic IPF ICD [ESA-IPF-ICD]
- The internal configuration of the LOP. This file provides the path to the product report/product list extension and the PRM_LOPIn path.



- The internal processing configuration. This file contains additional processing parameters, not supported in the external configuration. Those parameters are not expected to be changed during the mission duration.
- The PRM_LOPout is a generic output for the management layer
- The Logging, providing status of the execution process
- The Management Layer output, consisting in the product report and product list, as described in [ESA-IPF-ICD]
- The External Output, consisting in the Level 2 products, with a format described in the IPF product specification [IPF-PS]

The processor can be used in PDGS environment or in a stand-alone mode. In both cases, a job order is read by the processor to get all high-level information required for processing a particular product (e.g. names and directories of input L1 files, names and directories of auxiliary data files, directories of outputs files, etc...). Processing then starts from L1 products using the auxiliary data files provided (e.g. the L2 processor parameter file). During the processing, a log file is generated to monitor the status of each processing step. The final step of the processing is the creation of the product including writing of all the geophysical information into NetCDF files and a wrapping into a SAFE product.

2.1 OCN Product Organisation

Each L2 OCN product contains up to three geophysical components: the radial velocity (RVL), the ocean surface wind field (OWI) and the ocean swell spectra (OSW) components. These components are formatted into one output NetCDF file.

The detailed algorithm definition of each component is described in a dedicated document. Refer to [OSW-ATBD], [RVL-ATBD], [OWI-ATBD]

The output variables corresponding to each component are listed and defined in a dedicated document [IPF-PS]

For SM and WV modes, the L2 product contains all three components.

For TOPS mode, the product contains only the RVL and OWI components.

For the SM and TOPS modes, the information related to each component is estimated onto a specific grid cell (ground range) whose properties are chosen to optimize the inversion schemes. Therefore, the SM mode output NetCDF file has three components and the TOPS mode output NetCDF file has two components, each set having its own resolution. In addition, the most pertinent geophysical parameters from RVL and OSW components are interpolated onto the OWI grid to present a set of variables defined at the same resolution. The default value for the resolution of this common grid is 1 km for SM and TOPS modes. The set of variables from RVL and OSW interpolated onto the OWI grid is listed in section 3.3.2. RVL and OSW are estimated from an internal L1 SLC product. OWI is estimated from an internal L1 GRD product.

For WV mode, there is no grid. In this case, the resolution of the components is simply the size of the imagette: 20 km. The three components are estimated from internal L1 SLC products.



2.2 Generic Processing Workflow

The three components (OWI, OSW, RVL) are estimated independently, and the results are then merged into one NetCDF file (for SM and TOPS modes) or multiple NetCDF file (for WV).

This means that for a given acquired SAR scene, the following steps are applied independently by each component:

- Access and calibration of the appropriate internal L1 product
- Estimation of the variables corresponding to each component
- Generation of intermediate NetCDF file(s) containing the result for each component.

The intermediate NetCDF files are then merged, with a rational which is different depending on the acquisition mode. The differences with respect to acquisition mode are exposed in following sections.

2.3 Processing Workflow for WV mode

For WV mode, the input product is an IPF internal SLC product composed of multiple imagettes.

The processing workflow for WV is presented in following figure.



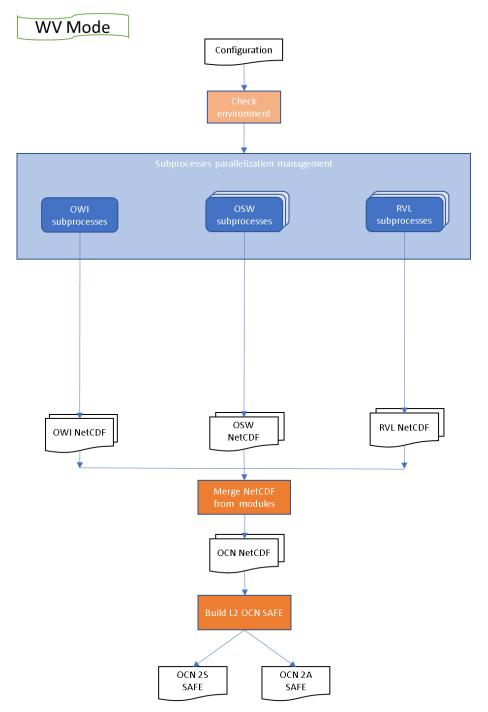


Figure 2: LOP Workflow for WV mode (blue parts are described in OWI/OSW/RVL ATBD, orange part are described in this document)

The LOP first checks the environment and configuration and schedules the launch of multiple processes in charge of the three components.

Multiple OWI, OSW and RVL process are launched in parallel. Each process in in charge of the processing of a given number of imagettes. The number of processes activated for each component is configurable through the internel LOP.cfg configuration file. Each process is generating a single NetCDF for each imagette, containing the corresponding variables. The Algorithm Theoretical Baseline of those processes are described in [OWI-ATBD], [OSW-ATBD], [RVL-ATBD].

For each imagette, the NetCDF files corresponding to the three components are then merged. The output is a series of NetCDF files, corresponding to each imagette and containing the three sets of variables. This specific process is described in section 3.3.

This series of NetCDF is then packed into a proper L2 OCN SAFE format. This specific process is further described in section 3.4



2.4 Processing Workflow for SM mode

For SM mode, the input product is both an IPF internal SLC product and an IPF internal GRD product.

The processing workflow for SM modes is presented in following figure.

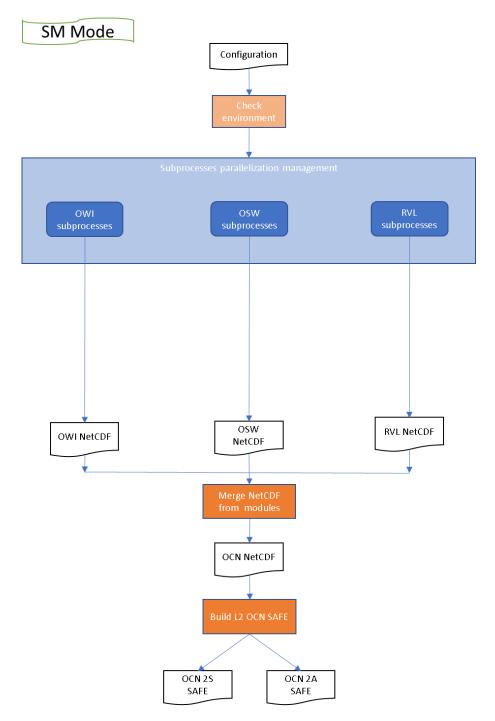


Figure 3: LOP Workflow for SM mode mode (blue parts are described in OWI/OSW/RVL ATBD, orange part are described in this document)

The LOP first checks the environment and configuration and schedules the launch of multiple processes in charge of the three components.

One single process of each OWI, OSW and RVL are launched in parallel. Each process is generating a single NetCDF, thus in total three NetCDF files, each containing the variables of the corresponding components. The Algorithm Theoretical Baseline of those processes are described in [OWI-ATBD], [OSW-ATBD], [RVL-ATBD].

The NetCDF files corresponding the three components are then merged. The output is a single NetCDF file, corresponding to the image product and containing the three sets of variables. This specific process is described in section 3.3.

The NetCDF is then packed into a proper L2 OCN SAFE format. This specific process is further described in section 3.4



2.5 Processing Workflow for TOPS modes (EW and IW)

For TOPS modes (EW and IW), the input product is both an IPF internal SLC product and an IPF internal GRD product.

The processing workflow TOPS modes is presented in following figure.

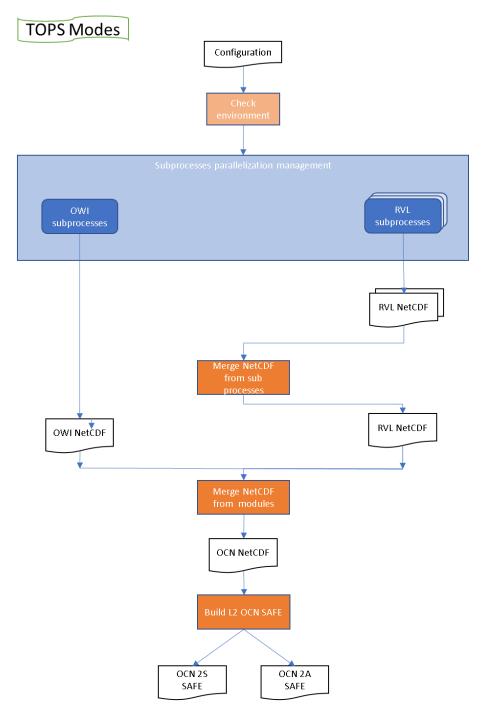


Figure 4: LOP Workflow for TOPS mode (blue parts are described in OWI/OSW/RVL ATBD, orange part are described in this document)

The LOP first checks the environment and configuration and schedules the launch of multiple processes in charge of the three components.

One single process of each OWI, RVL are launched in parallel. The OSW process is not launched (as not applicable to TOPS mode). The OWI process is generating a single NetCDF file. The RVL process is generating a set of NetCDF files, each corresponding to a given subswath in the the TOPS product. Then 3 NetCDF are generated for the IW mode and 5 for the EW mode. The Algorithm Theoretical Baseline of those processes are described in [OWI-ATBD], [RVL-ATBD].

The NetCDF files for RVL are then merged into a single NetCDF. This specific process is described in section 3.2

The NetCDF files of OWI and RVL are then merged. The output is a single NetCDF file containing the three sets of variables, however the OSW variables are only provided with fill values. This specific process is described in section 3.3.

The NetCDF is then packed into a proper L2 OCN SAFE format. This specific process is further described in section 3.4



3 Specific algorithms applied during OCN product wrapping

3.1 Check the environment and sub process management

Input:

Internal Level 1 product (SLC and /or GRD product)

Objective:

This part of the LOP is solely in charge of launching the OWI/OSW/RVL processes in parallel.

Depending on the acquisition mode considered part or all of those sub processes are launched. For instance, for TOPS mode, the OSW process is never launched.

The number of components launched in parallel depends on the component and of the acquisition mode. This is configured through the LOP.cfg internal configuration file.

The following tables present the rationale of the OWI/OSW/RVL parallel execution for the various acquisition mode.

Table 1: configuration of parallel processing for WV mode - internal configuration

WV Mode (composed of multiple imagettes)		
Component	Output	Number of instances
OSW	One NetCDF per WV imagette	Configurable, each instance in charge of a set of imagettes within the WV product
OWI	One NetCDF per WV imagette	Configurable, each instance in charge of a set of imagettes within the WV product
RVL	One NetCDF per WV imagette	Configurable, each instance in charge of a set of imagettes within the WV product

Table 2: configuration of parallel processing for SM mode - internal configuration

SM Mode		
Component	Output	Number of instances
OSW	One NetCDF per input product	1
OWI	One NetCDF per input product	1
RVL	One NetCDF per input product	1

Table 3: configuration of parallel processing for TOPS modes (EW or IW) - internal configuration

TOPS Mode (EW or IW)	



Component	Output	Number of instances
OSW	None	0
OWI	One NetCDF per input product	1
RVL	One NetCDF per subswath	3 or 5

Output:

Set of internal NetCDF for each component that were run (OWI/OSW/RVL) and when applicable for each imagette and/or each subswath.

If for some reason, one of the OWI/OSW/RVL process is failing, the corresponding NetCDF is not generated.

3.2 Merge NetCDF from Sub processes (applicable for TOPS mode)

Input:

Set of NetCDF generated by RVL component, each of them corresponding to a specific sub swath.

Objective:

The objective is to merge all internal NetCDF from a given component into a single NetCDF. This applies only to the components for which multiple process are launched in parallel and a merging into a single NetCDF is required. In practice, this applies only to the output of the RVL component for the TOPS modes.

The RVL process cannot directly generate this merged process as the RVL variables are provided for each sub swath, with a size that is computed as part of the process. The dimensions of the merged RVL variables cannot thus be inferred before running the RVL process and the merging must be performed separately.

The input NetCDFs contain 2 dimensional variables with dimensions corresponding to range and azimuth grid position. Each NetCDF corresponds to a specific sub swath.

The output NetCDF contains 3 dimensional variables with dimensions corresponding to sub swath identifier, range and azimuth positions.

Output

Single NetCDF containing the RVL variables for all sub swath.

3.3 Build L2 NetCDF

Input:

Set of internal merged NetCDF, corresponding to OWI/OSW/RVL components.

Objective

The objectives are the following:

- Merge the variables of the three components into a compact NetCDF (One per WV imagette, or one per product for other modes). Refer to 3.3.1
- Resample some variables from one component to the grid of another component. Refer to section 3.3.2



 Apply normalization of some variable from one component with information provided from another component. Refer to section 3.3.3

Output

For WV mode: one NetCDF for each imagette containing the variables of the three components

For SM mode: one NetCDF containing the variables of the three components

For TOPS mode: one NetCDF containing the variables of the two components (OWI and RVL)

3.3.1 Merging of variables

This step corresponds to the concatenation of variables from the two or three available components into a single NetCDF file. The merger annotates also the status of each subtasks (OWI/RVL/OSW) as global NetCDF attribute rvlStatus, oswStatus, owiStatus.

When one input NetCDF file is missing due to failure of the upstream processing (one of the OSW/OWI/OSW component or the NetCDF merging from sub processes), the corresponding variables are provided with fill dimensions (dimension 1) and fill values.

For TOPS mode, no OSW input NetCDF is provided as the OSW process is not activated. OSW variables are provided with fill dimensions and fill values as a placeholder for future evolutions. In that case, the global attribute oswStatus is "missing".

3.3.2 Resampling of variables

Some output variables from RVL and OSW are resampled on the OWI grid. This is the case for RvIRadVel which is regridded as owiRadVel and oswHs, oswDirmet, oswWI respectively as owiHs, owiDirmet, owiWI. The idea of this process is to provide all the geophysical output of a product in a common collocated grid.

This process is performed on all the modes for RvlRadVel, except in case of processing failure, as RVL and OWI processes are active for all the modes. In the case of TOPS, rvlRadVel (provided as a mosaic piece by beam) is stitched on the OWI grid product.

For OSW parameters (oswHs, oswDirmet, oswWI), the process is active only for SM, OSW not being activated on TOPS mode and giving only one dimension parameter for owiHs, owiDirmet, owiWI in the case of WV mode.

3.3.3 Normalisation of variable

Both the RVL and OWI components perform a computation of a NRCS over the product under processing. However, each component applies a different denoising and signal filtering methodology, thus achieving different values of NRCS as annotated in the intermediate NetCDF files. To obtain comparable measurements of NRCS in the final product, the rvINRCS variable is normalised/rescaled considering the owiNRCS variable. This normalisation is performed as an extra step at the top of OWI and RVL processing.



The following figure is illustrating the observed differences without normalisation.

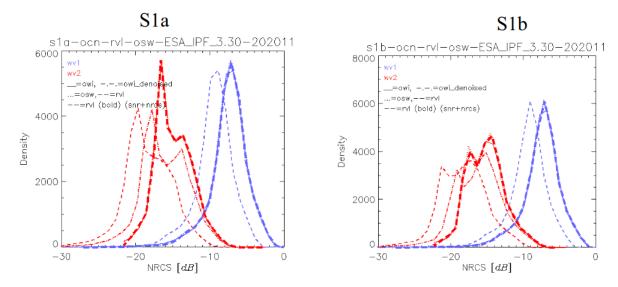


Figure 5: Comparison of OWI/ OSW/RVL NRCS before rescaling for WV1 and WV2

To compensate for this a normalisation/rescaling is performed as follows.

The rvINRCS value is computed from the SL2 input product considering a specific filtering of the spectra described in [RVL-ATBD]. The corresponding value is an output of the RVL process available in the corresponding intermediate NetCDF file.

The owiDenoisedNRCS is computed from GR2 input product considering the denoising vector. The computation is described in [OWI-ATBD]. The corresponding value is an output of the OWI process available ien the corresponding intermediate NetCDF file.

A scaling factor gamma between the $\underline{\text{mean}}$ denoised NRCS sigma_nought and the $\underline{\text{mean}}$ rvlNRCS, sigma_rvl is computed

$$\gamma = \frac{\sigma_o}{\sigma_{rvl}}$$
where $\sigma_{rvl} = \text{cocnStr.vars.rvlNRCS.value}(x,y)>$

The rvINRCS is rescaled using this scaling factor:

When this specific processing is applied, a specific "scaled" attribute of the rvINRCS variable is present and set to "yes"

3.4 SAFE wrapping

The SAFE wrapping corresponds to the packaging of the set of output NetCDF into a proper SAFE product format.

Two output OCN SAFE products are generated:

- OCN Standard product corresponding to nominal product delivered to end-users



 OCN Annotation product: engineering product only containing the metadata of the internal Level 1 product considered as input of the LOP processor. This OCN annotation is not delivered to endusers.

During this step:

- The manifest of the product is build based on the product specification of OCN products
- The support and preview directory of the product are filled
- The name of the SAFE product is computed using the proper Sentinel-1 mission name, acquisition mode, acquisition period, datatake number, orbit number and CRC according to product specification.



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