

# GENERATION OF GRIDDED OCEAN COLOR PRODUCTS FROM MERIS: AN EFFICIENT PROCESSING CHAIN

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## ABSTRACT

Online services provide several Ocean Color datasets for the exploitation of Remote Sensing (RS) applied to marine and coastal areas. Despite the large number of services and data available, end users often require full resolution gridded products at regional scale.

In order to provide a higher resolution datasets better suitable for coastal areas analysis and management, an efficient processing chain was developed to generate full resolution Ocean Color (OC) gridded geophysical products from MEdium Resolution Imaging Spectrometer (MERIS) L1b data, using open source tools and software and parallel processing. It makes use of standard MEGS® (MERIS Ground Segment development platform) processor for geophysical parameters estimation from MERIS full resolution data (300 m spatial resolution).

The processing chain has been successfully applied to a test area in northern Adriatic Sea, results of processed data and customization of the processing chain are discussed.

## 1. INTRODUCTION

The MEdium Resolution Imaging Spectrometer (MERIS) sensor operated on the ESA (European Space Agency) satellite Envisat (Environmental Satellite) from 2002 to 2012, was designed to investigate different domains: land (vegetation), ocean and coast (Ocean Color and biology), atmosphere (clouds and precipitation). Its unique spatial and spectral resolutions provided measurements of unprecedented quality for coastal zone management and research. The forthcoming Sentinel 3 satellite will be equipped with the Ocean and Land Colour Instrument (OLCI), based on MERIS sensor technology that will ensure consistency of new measurement with the MERIS ones.

While online services (e.g. CoastColour [1], MyOcean, OceanColor [2]) provide Ocean Color datasets for marine and coastal applications at moderate resolution, requirements for full resolution gridded products and specific cases investigation in coastal areas are not currently met. Moreover, the available processing chain still need

improvement in geophysical parameters estimation, cloud identification and processing performance due to the significant amount of data.

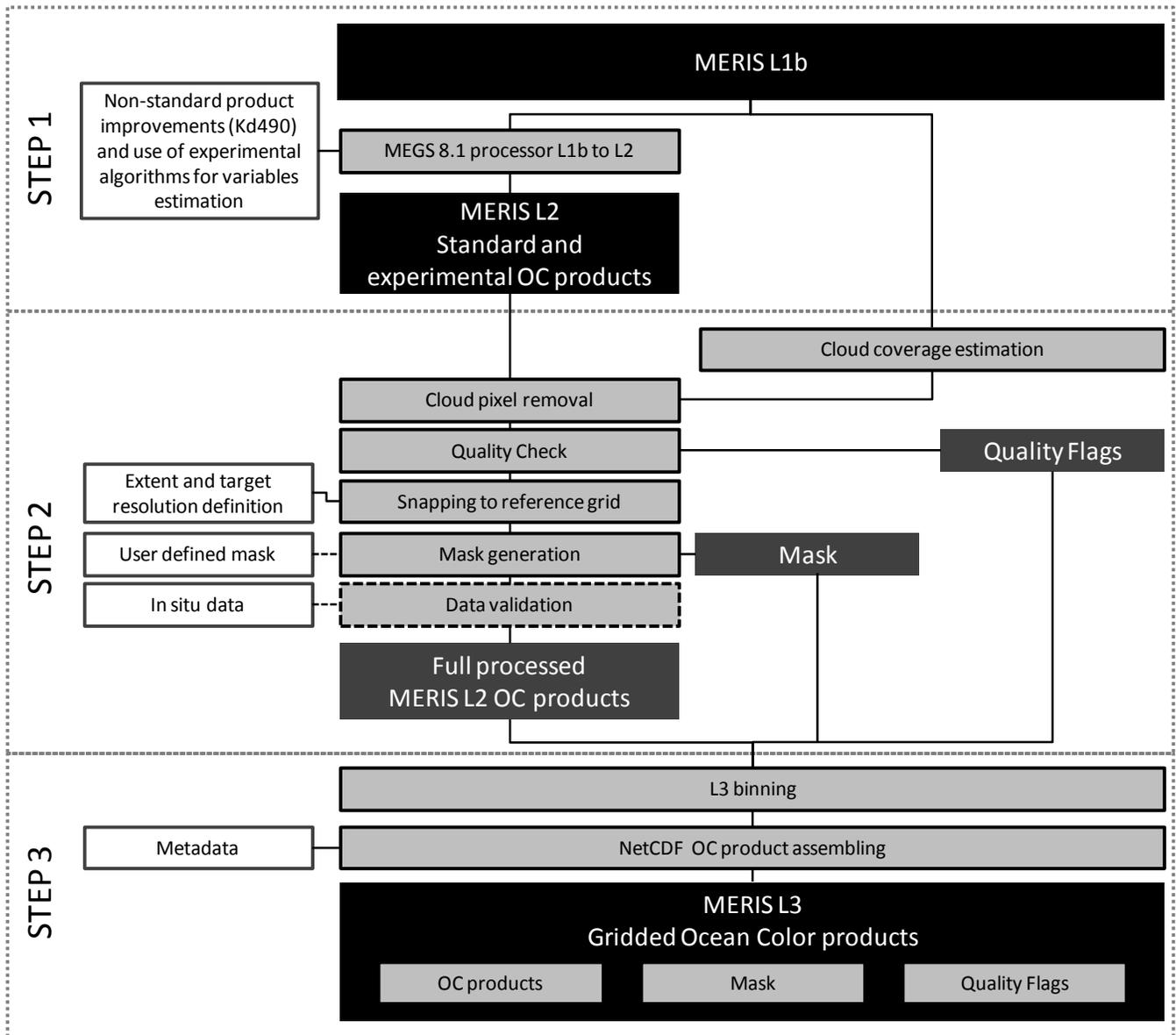
In late December 2013 ESA announced free distribution and full access to the Envisat MERIS Level 1 Full Resolution Full Swath data (MER\_FRS\_1P) for research purposes, retrievable through the MERIS MERCI system.

Starting from MERIS L1b we present an efficient processing chain that generates full resolution Ocean Color L3 geophysical products. The proposed processing chain is intended to satisfy the following needs: i) processing of MERIS L1b at Full Resolution (300m spatial resolution), ii) improvements of cloud pixel identification, where the geophysical parameters estimation is uncertain due to cloud effects, ii) use of parallel processing techniques for fast generation of product datasets, iii) processing of reduced spatial subset, to decrease memory allocation and processing time. The processing chain was successfully used to create a multitemporal dataset of OC products in northern Adriatic Sea, for environmental analysis purpose.

## 2. PROCESSING CHAIN

The processing chain workflow is showed in Figure 1, and can be divided in three steps: 1) the generation of L2 standard and experimental OC products, 2) generation of fully processed L2 OC products, 3) creation of L3 gridded OC products.

The processing chain makes use of standard MEGS® 8.1 processor [3], implemented in ODESA software, to generate L2 geophysical products from MERIS L1b data. In the first step the standard processor performs an atmospheric correction procedure to convert radiance data to normalized water leaving reflectances, and then estimates geophysical parameters using experimental algorithms. The algorithms are calibrated and validated for both Case1 and Case 2 waters, use centralized database of merged in situ optical measurements collected worldwide during the full Envisat mission [4]. A standard processor was implemented also for the algorithms for Kd490 estimation (diffuse attenuation coefficients of downwelling irradiance at 490 nm) [5], that is



**Figure 1:** Workflow used in the processing chain, describing generated products (black), intermediate products (dark grey), processing operations (grey) and user defined parameters (white).

not included in MERIS L2 standard products. Implemented experimental algorithms are Neural Network for the estimation of parameters in Case 2 waters and TSM (Total Suspended Matter) with bright pixel method that can be selected by user for the estimation of OC products. The second and third steps of the processing chain were developed using GDAL tools, NetCDF libraries and BEAM software through Bash scripting running in parallel mode.

Since clouds heavily hamper optical RS data, most of processing algorithms perform cloud detection, in order to remove pixel covered by clouds. Clouds have four special radiative properties that enable their detection: 1) color, 2) brightness, 3) elevation 4) temperature [6].

Despite the fact that MEGS® processor has the ability to

detect clouds, “cloud” flag is not detecting all cloud pixels. For this reason, cloud probability processor [6] implemented in BEAM software was also used to retrieve cloud coverage probability for each pixel from MERIS L1b data. The algorithm yields a probability value for each pixel between 0 and 1, indicating whether it can be flagged as “cloud” and removed from the dataset from further analysis.

Optical RS data can also be affected by sun glint, white scatterers, bright pixels, adjacency. The processing chain also performs quality check for each pixel of the image, in order to supply additional information on pixel quality and estimation accuracy of the OC products. Quality Flags are generated from L1b and L2 flags (invalid reflectances, high sun zenith angle, bright pixel atmospheric correction

activated, anomalous scattering, high glint, medium glint, adjacency effect, ice haze, land), in order to resume pixel information in the following classes: not valid, land, low accuracy, pixel quality (very good, medium, poor). Quality Flags generation is intended to be useful for further data analysis, e.g. for the generation of weights in data modeling. To reduce the volume of data to be processed, a reference grid is generated from user definition of spatial extent and resolution of the target OC products, and used to snap generated L2 OC products. User can also define a mask to further reduce the dataset to the Area Of Interest. After the dataset is successfully subsetted, a mask layer is generated to identify invalid and valid pixels, in which parameters estimation is successfully performed.

Accuracy of the geophysical parameters estimation can be done at this part of the processing chain, for single pixel location where in situ data are available. Third part of the processing chain is the binning process, a procedure used to combine temporal and/or spatial cluster of pixels to fixed L3 grid, and was applied to OC products, masks and Quality Flags. The final dataset was combined with metadata and assembled in NetCDF (Network Common Data Form) format, which is a self described data format largely used for Earth Observation products and ocean modeling datasets. All the information related to the generated gridded OC products are stored in global and variable attributes within the NetCDF file.

### 3. RESULTS

The processing chain was used to process a large dataset (10 years of MERIS data, about 800 images) at regional scale in a test area in northern Adriatic Sea. Cloud probability threshold value was set to 0.35, allowing the removal of pixel where cloud were not detected by standard MEGS® processor. Spatial subsetting and parallel processing allowed faster generation of the following OC products: Case 2 Chlorophyll, Colored Dissolved Organic Matter (CDOM),

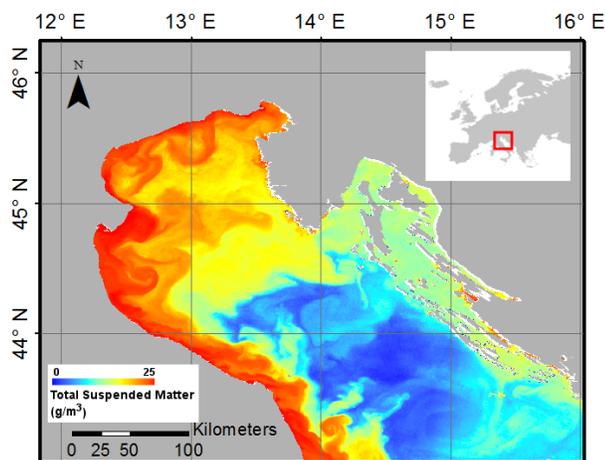


Figure 2: TSM map of MERIS acquired on 02/08/2010.

Total Suspended Matter (TSM), estimated using MEGS® processor algorithms [3], and Kd490, using OceanColor algorithm [2].

Map in Figure 2 shows an example of TSM product generated from MERIS image acquired on 02/08/2010 for the northern Adriatic Sea. Full resolution products, in which spatial features at lower scales become visible, allow improvements in spatial pattern identification as a main validation input for data assimilation in different ocean modeling. Multitemporal analysis of RS time series make use of dataset with fixed L3 grid, with the aim of facilitating the analysis for both spatial and temporal dimensions.

### 4. CONCLUSION

An efficient processing chain to generate L3 gridded Ocean Color products was developed for the MERIS sensor. The processing chain makes use of open source tools and software and parallel processing techniques, allowing user customization of algorithms and spatial information. The results obtained on a test site in northern Adriatic Sea show the fast generation capability of large datasets and the potentiality of temporal analysis and environmental applications from the generated OC products.

### 5. ACKNOWLEDGEMENTS

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