Study on the Ocean Colour Fluorescence Product

Detailed Processing Model

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1 Scope of the document

This document is the Detailed Processing Model (DPM) of the EUMETSAT Ocean Colour Fluorescence product (OC-Fluo) study. It represents a high level description of the processing of OLCI Level-1 TOA radiances and Level-2 water-leaving reflectances with the OC-Fluo algorithm.

2 Definitions

Table 1: List of Variables

Variable	descriptive Name	Unit
NBANDS	number of bands that are input (5)	
WVL	nominal center wavelength of OLCI band 8-12	nm
O	Offset	
S	Slope	
F	Fluorescence Peak Height	
A	Absorption Peak Depth	
l1_band_array	TOA radiance @ specific OLCI band	$mWm^{-2}sr^{-1}nm^{-1}$
l1_band_array_sc	smile corrected TOA radiance @ specific OLCI band	$mWm^{-2}sr^{-1}nm^{-1}$
l1_wvl_array	pixel center wavelength of specific OLCI band	nm
l1_lon	longitude of Level-1 pixel	degree
l1_lat	latitude of Level-1 pixel	degree
res_l1	result vector including O,S,A,F	$mWm^{-2}sr^{-1}nm^{-1}$
L-FPH	Fluorescence Peak Height based on TOA radiance	$mWm^{-2}sr^{-1}nm^{-1}$
L-APD	Absorption peak depth based on TOA radiance	$mWm^{-2}sr^{-1}nm^{-1}$
L-CHL	chlorophyll concentration based on L-FPH	mg/m^3
l2_band_array	water-leaving-reflectance @ specific OLCI band	-
l2_wvl_array	center wavelength of specific OLCI band	nm
l2_lon	longitude of Level-2 pixel	degree
l2_lat	latitude of Level-2 pixel	degree
res_l2	result vector including O,S,A,F	-
ρ_w-FPH	Fluorescence Peak Height based on water-leaving reflectance	-
ρ_w-APD	Absorption peak depth based on water-leaving reflectance	-
ρ_w-CHL	Chlorophyll concentration based on ρ_w-FPH	mg/m^3
land	land flag	boolean
invalid	invalid flag	boolean
ice	ice flag	boolean
cloud	cloud flag	boolean

The OC-Fluo algorithm is in it's core a matrix multiplication of the measurement vector and the derivative of the forward model to the state. I order to be efficient and fast this matrix multiplication is performed as an Einstein sum for the whole measurement vector at once. The Einstein sum is defined by:

$$(A \cdot B)_{ljk} = \sum_{i=1}^{n} A_{ijk} \cdot B_{il} = \text{einsum(ijk,il->ljk,A,B)} \tag{1}$$

The right_inverse of a matrix is defined by (mamul= matrix multiplication):

$$\text{right\_inverse(A)} = \text{mamul}(A^T, \text{inverse}(\text{mamul(A, A}^T))) \tag{2}$$

Offset, Slope, Absorption and Fluorescence are each defined as a function of wavelength:

$$\text{OFFSET} = 1. \tag{3}$$

$$\text{SLOPE} = \text{lambda wvl: (wvl-INI['MODEL']['SP'])/1000.} \tag{4}$$

$$\text{ABSORPTION} = \text{lambda wvl: -1*exp(-(wvl-INI['MODEL']['AC'])}^2\text{/INI['MODEL']['AW'])} \tag{5}$$

$$\text{FLUORESCENCE} = \text{lambda wvl: exp(-(wvl-INI['MODEL']['FC'])}^2\text{/INI['MODEL']['FW'])} \tag{6}$$

The K-matrix, also called Jacobian, with dimensions 4x5 is defined by:

$$\text{K[0,:]} = \text{OFFSET} \tag{7}$$

$$\text{K[1,:]} = \text{SLOPE(WVL)} \tag{8}$$

$$\text{K[2,:]} = \text{ABSORPTION(WVL)} \tag{9}$$

$$\text{K[3,:]} = \text{FLUORESCENCE(WVL)} \tag{10}$$

$$\text{KINV} = \text{right\_inverse(K)} \tag{11}$$

And finally the forward model for the measured spectrum:

$$\text{model=p[0]*OFFSET + p[1]*SLOPE(wvl) + p[2]*ABSORPTION(wvl) + p[3]*FLUORESCENCE(wvl)} \tag{12}$$

3 Processing

3.1 Processing of Level-1 data

1. Smile correction by performing retrieval, assuming nominal wavelength

$$\text{res\_l1\_smile} = \text{einsum(ijk,il->ljk,l1\_band\_array,KINV)} \tag{13}$$

2. Calculate radiance at nominal wavelength using ocfluo model

$$\text{delta} = \text{([l1\_wvl\_array[i,:,:] - WVL[i] for i in range(NBANDS)])} \tag{14}$$

$$\text{wvl\_matrix} = \text{np.zeros(l1\_wvl\_array.shape)} \tag{15}$$

$$\text{for i in range(NBANDS) :} \tag{16}$$

$$\text{wvl\_matrix[i,:,:]} = \text{WVL[i]} \tag{17}$$

$$\text{1\_band\_array\_sc} = \text{model(wvl\_matrix- delta,res\_l1\_smile)} \tag{18}$$

3. Do the processing on corrected

$$\text{res\_l1} = \text{einsum(ijk,il->ljk,l1\_band\_array\_sc,KINV)} \tag{19}$$

$$\text{L-FPH} = \text{res\_l1[3]} \tag{20}$$

$$\text{L-APD} = \text{res\_l1[2]} \tag{21}$$

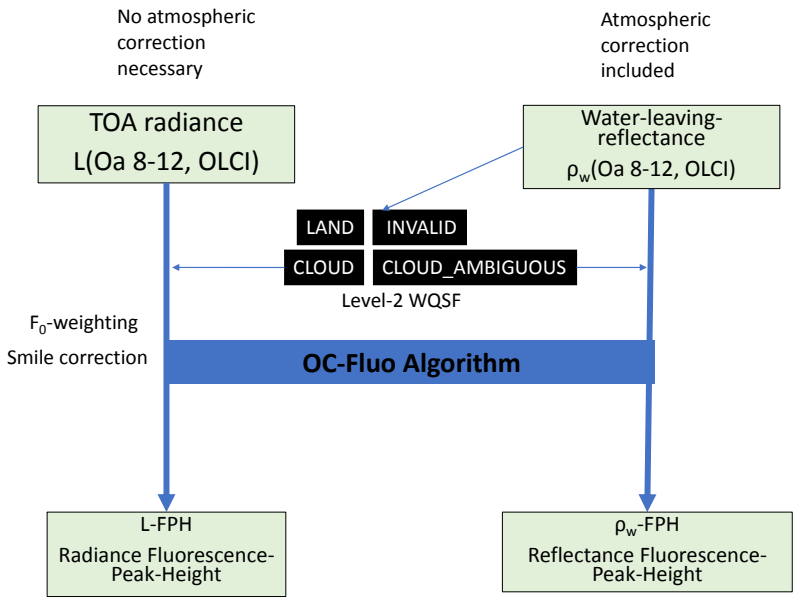

Figure 1: OC-Fluo processing

3.2 Processing of Level-2 data

$$\text{res\_l2} = \text{einsum(ijk,il->ljk,l2\_band\_array,KINV)} \tag{22}$$

$$\rho_w\text{-FPH} = \text{res\_l2}[3] \tag{23}$$

$$\rho_w\text{-APD} = \text{res\_l2}[2] \tag{24}$$