ALGORITHM THEORETICAL BASIS DOCUMENT

ATBD 2.14

WHITECAPS FLAG ALGORITHM

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1. Introduction

This chapter describes the algorithm used to prepare a mask to flag ocean pixels which are contaminated by whitecaps. This mask is an input to the atmosphere corrections algorithm (ATBD 2.7), and is made available in the MERIS Level 2 Product.

2. Algorithm Overview

The algorithm is performed at every tie point on or near the ocean in the MERIS data, and the resulting flag is applied to all the ocean pixels neighbouring a tie point. It uses external knowledge of the wind speed, to estimate the impact of whitecaps on the surface reflectance. The whitecaps flag is raised when the wind speed exceeds a threshold value (to be determined).

3. Algorithm Description

3.1. Theoretical description

3.1.1. Physics of the problem

The estimate of the whitecaps contribution to the ocean signal is based on two models:

1. a model describes the relative area of ocean covered with whitecaps (Monahan and O'Muircheartaigh) W, as a function of wind speed;
2. a model (Koepke) describes the reflectance of the whitecaps ρ_{wc} as a function of wind speed.

Neglecting Sun glint, the reflectance at ocean surface may be written

$$\rho'(\lambda)=\rho_{wc}(\lambda)+(1-\rho_{wc}(\lambda)).\rho(\lambda)$$

where ρ is the reflectance due to ocean back-scatter, that is the quantity of interest to ocean colour remote sensing.

Estimating ρ_{wc} from wind speed, and using worst case hypotheses about $\rho(\lambda)$ in the visible, it is possible to establish a threshold on wind speed. When the known wind exceeds

that threshold, at least one band in ocean colour is meaningfully polluted by whitecaps. The sensitivity of atmosphere corrections above ocean to whitecaps is studied in ATBD 2.7.

3.1.2. Mathematical description of the Algorithm

The modulus of the wind at 10m vector at each tie point over or near the ocean is computed and compared to a threshold. Above that threshold, the flag Whitecaps_f is raised for every ocean pixel in the neighbourhood of the tie point.

for each tie point :

$$W = \sqrt{W\_u^2 + W\_v^2}$$

if (W > WHITECAP_THR) then

whitecaps_f[j,f] = TRUE for all [j,f] surrounding the tie point

3.1.3. Parameter description

Symbol	Descriptive name	I/O	Origin
W_u, W_v	Wind vector components	i	Level 1b product tie point annotation
WHITECAP_THR	Threshold for whitecaps	i	
whitecaps_f[j,f]	Whitecaps flag for pixel j,f	o	

3.1.4. Error budget estimates

Wind uncertainty of 2 $m.s^{-1}$ (typical ECMWF accuracy) yields a relative uncertainty on whitecaps reflectance ρ_{wc} of ± 40% at 15 $m.s^{-1}$.

The W model is established for a sea surface temperature above 14°C; extrapolating it to colder seas may result in errors. No alternative model is available in that case.

3.2. Practical considerations

3.2.1. Calibration and Validation

The value of WHITECAP_THR should be established using simulation results. These simulations should take into account the uncertainty on the spectral reflectance of whitecaps.

3.2.2. Quality control and diagnostics

The PCD in the level 1 product header, indicating the quality of the available wind data, should be repeated in the level 2 product header to notify the likely error in the estimation of the pixels affected by whitecaps.

3.2.3 - Exception handling

N/A

3.2.4. Output Product

The output of the algorithm is a boolean flag for each pixel of the frame : Whitecap_f[j,f]. When true, that flag indicate that the pixel is (most likely) meaningfully affected by whitecaps.

4. Assumptions and Limitations

4.1. Assumptions

No further assumptions than mentioned in 3.1 above.

4.2. Limitations

This algorithm accepts as an established reference the models in reference. These models does not provide a complete description of whitecaps :

1. the W model is valid for a deep ocean where interaction with the sea bottom is negligible. In reality, waves break and whitecaps increase greatly when the sea bottom gets close to the surface;
2. the W model is valid for waters warmer than 14°C.

5. References

P. KOEPKE: Effective Reflectance of Oceanic Whitecaps, *Applied Optics* 23-11, pp1816-1824, 1984

E.C. MONAHAN and I. O'MUIRCHEARTAIGH, Optimal Power-law Description of Oceanic Whitecap Dependence on Wind Speed, *J. Phys. Ocean.* 10, p.2094, 1980

ATBD 2.14 — MERIS DATA PRODUCT SUMMARY SHEET

Product Name:	Whitecaps Flag Algorithm
Product Code:	WHITECAPS
Product Level:	2
Description of the product:	The product is a flag indicating the occurrence of whitecaps contamination

Product Parameters:

Coverage:	global
Packaging:	
Units:	no
Range:	
Sampling:	pixel by pixel
Resolution:	radiometric: N/A spatial: full
Accuracy:	
Geo-location Requirements:	yes
Format:	1 bits / sample
Appended Data:	
Frequency of generation:	1 product per orbit
Size of the Product:	

Additional Information:

Identification of bands used in algorithm:	none
Assumptions on MERIS input data:	none
Identification of ancillary and auxiliary data:	Wind speed
Assumptions on ancillary and auxiliary data:	at product tie points
Input from other ENVISAT instruments:	none