Meris Reflectance and Algal-2 validation at the North Sea

Steef W.M. Peters

IVM, De Boelelaan 1087, 1081 HV Amsterdam, Netherlands (steef.peters at ivm.vu.nl)

Abstract

In this paper spectral reflectances as measured by MERIS in Dutch coastal waters together with observations of Chlorophyll-a (as the algal2 product) are validated. In order to evaluate the effects of the upgrade of MERIS processing from MEGS7.0 to MEGS7.4 match-up stations of 2003 were revisited. To validate the performance of the algal2 product, it was compared to Dutch monitoring network measurements (MWTL) in a number of time series for 2003. The results of both validation exercises were ambiguous. The spectral reflectance match-up dataset was too small. The algal2 validation using time series showed improvements in spring but also a deterioration of the quality of the Chlorophyll-a estimations in summer.

Introduction

The Medium Resolution Imaging Spectrometer Instrument (MERIS) is part of the payload of the ENVISAT environmental satellite that was launched by the European Space Agency in March 2002. The MERIS instrument is dedicated to measurements of sea colour in the oceans and in coastal areas, thus providing measurements of chlorophyll pigment concentration, suspended sediment concentrations and yellow substance absorption over the marine/coastal domain. The upgrade of the MERIS standard processor from MEGS7.0 to MEGS7.4 with simultaneous upgrades of the MERIS neural network processor require an update of the validation of the measured reflectance and the standard products. In this paper some of the MERIS reflectance measurements are validated by revisiting the IVM 2003 reflectance match-ups. Also the algal-2 pigment index (Chlorophyll-a or Chl-a) is validated using 2003 Chl-a observations at monitoring locations of the standard Dutch MWTL network.

It is important to realize that validation of MERIS products such as Algal2 serves a number of purposes of which we mention:

- To approve of MERIS standard products and to identify further improvements
- To build up Confidence in the MERIS products at end-users
- To avoid false alarms for operational applications such as HAB-alerts, which is an actual requirement for MARCOAST services.
- Support monitoring quality requirements (OSPAR etc.)

Materials and Methods

A description of the cruises that IVM participated on to collect field match-up data can be found in [1]. Here a short overview is presented.

In 2003, one cruise was made with the Ms. Mitra from 22-25 April 2003 as part of the 'Tox*alg' project, funded and carried out by the North Sea Directorate. From 7 – 18 July 2003, IVM participated on a cruise in the western part of the central North Sea during the ICES coordinated international hydro-acoustic survey for herring that was commissioned and carried out by the Netherlands Institute for Fisheries Research (RIVO). Thumbnails of the three research vessels are provided in Fig.1.

![Ms. Mitra](image1.png)

Ms. Mitra
North Sea Directorate

![Ms. Tridens](image2.png)

Ms. Tridens
RIVO

Figure 1. Research vessels, from left to right, the Ms. Mitra, commissioned by the North Sea Directorate and the Tridens, commissioned by the Netherlands institute for fisheries research.

At each station a water sample was taken with a rosette sampler at 1 m depth or with a hydrographical bucket, simultaneously with a surface reflectance measurement with a PhotoResearch PR650 spectroradiometer. Immediately after sampling additional parameters were recorded, including wind speed and direction, time (UTC) and geographic position in UTM 31U or lat/lon WGS94 projection, relative humidity (if available), surface pressure, sky coverage, wave height, Secchi Disk depth, and any other observations that seemed relevant. Digital photos of sky and water coverage were also taken. Reflectance was measured at least three times in quick succession (typically within 3 minutes) to reduce effects of changing water masses and illumination conditions. Preferable measurement position on the ship is on the bow, to minimize surface wave effects and shading and/or reflectance from the ship's superstructure. Relevant protocol descriptions and references can be found in [1] and [3].

For the validation of algal2, in this paper use was made of Chlorophyll-a data from the Monitoring Programme of the National Water Systems (MWTL). This network consists of 17 sampling stations that are biweekly visited in summer and monthly in winter. The data is available since 1975. Chlorophyll-a is determined by the spectrophotometric technique. In figure 3 the location of the monitoring stations is indicated by the red dots.

For the purpose of validation use was made of a data-set of all MERIS MEGS7.4 images of 2003 covering the Dutch territorial waters. This dataset was kindly provided by ACRI to IVM in the framework of the ESA-GSE MARCOAST project. In order to evaluate the effect of the changes from MEGS7.0 to MEGS7.4 some MEGS7.0 2003 images were used that were originally provided by Brockmann Consult to the REVAMP project [2].

Because of the relative low number of matchup-spectra the available ones were evaluated as separate cases without applying any statistics. Algal2 was validated as time series at MWTL monitoring stations locations. Without applying further statistics the time series were inspected for potential under and over-estimations of Chlorophyll-a.

**Validation of Reflectance Spectra**

At 6 matchup locations a comparison was made between the in-situ spectrum and the MERIS spectrum at MEGS7.0 and MEGS7.4 as illustrated in Fig 2.a – 2.f
Figure 2.a and 2.b: Spectral observations along the Noordwijk transect. These are relatively close to the coast. The spectrum is influenced by relatively high concentrations of TSM, CDOM and Chlorophyll-a.
Figure 2.c, 2.d, 2.e and 2.f: matchup spectral observations on the Tridens cruise. These observations are all in open North Sea water. The spectrum is influenced by relatively low concentrations of Chlorophyll-a only.
Analyzing the coastal water spectra of the Mitra cruise it seems that MEGS7.4 processing causes lower values in the blue-green spectral range. When looking at open water spectra (the TRIDENS series) it is evident that there are very few changes between MEGS7.0 and MEGS7.4. Because there is a variety of differences in again the blue-green spectral range between in-situ observations and the MERIS reflectance it is not clear how to interpret the match-up results. (NB: Matchup spectra were used only if the PCD_1_13 flag was not raised).

Validation of the Algal-2 pigment index

![Fig 3: Shows for several locations the time series of Chlorophyll-a from 3 sources: 1) MWTL in-situ observations; 2) MERIS MEGS7.0Algal2 and 3) MERIS MEGS7.4 algal2. The locations are: Goeree6 as an example of a location where threshold exceedence should be measured accurately because of...](image-url)
potential HAB threat. The Noordwijk and Walcheren rai show typical examples of the gradients found in Dutch coastal waters with high Chlorophyll-a values close to the coast and low (almost case-1 water) values at larger distances from the coast. As an example of extreme open North Sea water the Terschelling 235 station is included. Red Circles indicate underestimation, green circles indicate overestimation. (NB: all presented MERIS algal2 values were extracted for pixels where the PCD_1_13 flag was not raised).

In figure 3 a number of examples of 2003 time series of Chlorophyll-a are shown (winter months were excluded). In all plots the spring peak is clearly visible. In a number of these cases MEGS7.4 results are above MWTL values. In summer, a lot of stations feature Chlorophyll-a underestimation, whereby the underestimation in MEGS7.4 results seems to be more severe than in the MEGS7.0 results. At the stations close to the coast (Walcheren2 and Noordwijk2) there is up to 50% underestimation in summer. Just after the spring peak both locations show a pronounced and probably unrealistic dip (towards zero) in the Chlorophyll-a values.

In general it seems that MEGS7.0 Chlorophyll-a values are a bit higher and closer to the MWTL values in summer and it is not easy to issue a quantitative statement on the quality of the improvements between the two processing versions.

Conclusions

In this paper results have been presented on the validation of MERIS MEGS7.4 spectral observations and the algal2 product in Dutch coastal waters. There are quite some differences between the in-situ and the satellite reflectance measurements that cannot be interpreted in a unique way because of the small dataset. The algal2 product was compared to MWTL Chlorophyll-a measurements at a number of locations. It is difficult to quantify if MEGS7.4 algal2 is an improvement above MEGS7.0 algal2. In spring MEGS7.4 gives higher estimates than MEGS7.0, but sometimes overestimations are observed. In summer MEGS7.4 algal2 is in general too low and lower than MEGS7.0 algal2.

Recommendations

For reflectance validation our recommendation is to compile a larger dataset of spectral observations in this type of waters. The algal2 validation should be extended to other years. To understand the spring-summer hysteresis with respect to the MWTL observations the specific phytoplankton absorption used in the neural net should probably be evaluated against algal species occurrence.

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Literature

