Preliminary MERIS-Validation Results for the Baltic Sea

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ABSTRACT

Validation of MERIS data was performed for Case-2 waters of the Baltic Sea. The area of investigation was focussed on the western part including open sea and discharge areas of the Oder river in the Pomeranian Bight. These activities included an overview about the variation ranges of the different MERIS products, methodical investigations, as well as qualitative and quantitative validations. Preliminary results are presented, because of the limited number of available match-ups and delivered MERIS level-2 products. The results induce that the validation has to be continued and further activities should be focussed on the identification of absorbing Case-2 waters and the atmospheric correction.

1. INTRODUCTION

The aim of this investigation was the validation of MERIS level 2 Products of the ESA-ENVISAT satellite according to the MERIS Validation Protocols for the Case-2 waters of the Baltic Sea [1]. The water of the enclosed and tide-less Baltic Sea is characterised in the central basins by relatively low concentrations of suspended matter, a high background level of yellow substances due to the drainage of swamp areas and a chlorophyll concentration depending on the seasonal phytoplankton development with blooms in spring and summer. In the discharge areas of large rivers the composition of suspended water constituents depends strongly on the wind mixing in the inner lagoons which most of the rivers cross before entering the Baltic. An example is the Pomeranian Bight in the southern Baltic Sea which was included in the validation campaigns to cover a wide range of variations in the composition and concentration of optically active water constituents. The description of the variation ranges in the constituents partly comprises the inner coastal waters.

2. AREA OF INVESTIGATION, CRUISES AND MEASURING VARIABLES

Three types of ship campaigns were conducted to validate the MERIS level 2 products. For MERIS validation purposes 3 different cruises with r.v. "Prof. Penck" were organised in May, June and August 2002, focussed on the western Baltic Sea including the Pomeranian Bight to cover a wide range in the concentrations of optically active water constituents. The measurements were performed at the German continental shelf to reduce logistic problems and travel time and mainly concentrated on the satellite overpasses to get match-ups defined within a special time interval before and after the satellite passing time. To extend the time of possible match-ups monitoring cruises of the IOW, responsible for the German Baltic Sea Monitoring Programme, were included in the validation. Due to the reduced number of cloud-free conditions during the validation campaigns operational cruises were planned for weather conditions that met the validation requirements. These measurements were performed at a small research cutter "Palaemon" just in front of the coast of Warnemünde. Fig. 1A gives an overview about the monitoring stations measured during MERIS overpasses in the central Baltic Sea. Fig. 1b shows a detailed map of the western Baltic Sea with all match-up stations. The details of all possible match-up stations are summarized in Tab. 1 together with

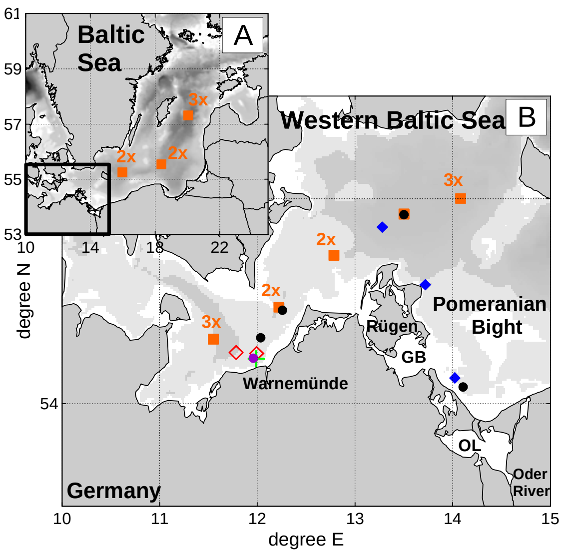

Fig. 1. Map of the validation sites of the Baltic Sea including the stations of different kinds of cruises

indications on received level-2 products. From the possible 29 match-ups we received only 13 level-2 products.

Tab. 1: Performed stations during overpasses, possible match-ups during the different cruises, delivered MERIS data and important information to the data quality.

Cruise/	station	Lat/°N	Lon/°E	abs.	rel.	L2	station	clouds
Date				orbit	orbit		in image	
Monitoring								
27.03.02	12	54.32	11.55	377	8			
29.03.02	113	54.93	13.50	405	36			
04.04.02	271	57.32	20.05	491	437			
07.04.02	12	54.32	11.55	534	480			
05.05.02	213	55.25	15.98	935	380	x	yes	Yes
08.05.02	271	57.32	20.05	978	423	x	yes	No
09.05.02	259	55.55	18.40	992	437			
10.05.02	113	54.93	13.50	1006	451	x	no	X
11.05.02	12	54.32	11.55	1021	466	x	yes	No
11.05.02	30	54.72	12.78	1021	466	x	yes	No
11.05.02	46	54.47	12.22	1021	466	x	yes	No
27.07.02	30	54.72	12.78	2123	65			
27.07.02	46	54.47	12.22	2123	65			
27.07.02	113	54.93	13.50	2123	65			
28.07.02	213	55.25	15.98	2137	79	x	yes	No
29.07.02	109	55.00	14.08	2152	94	x	no	X
30.07.02	259	55.55	18.40	2166	108			
31.07.02	271	57.32	20.05	2180	122	x	yes	No
Meris05								
14.05.02	046A	54.45	12.26	1064	8			
15.05.02	113	54.92	13.50	1078	22			
16.05.02	997	54.08	14.11	1092	36			
17.05.02	42	54.32	12.04	1107	51	x	yes	No
Meris06								
11.06.02	10	54.25	11.78	1465	409			
14.06.02	Reede	54.24	11.99	1508	452			
Meris08								
14.08.02	011A	54.58	13.72	2381	323	x	yes	No
15.08.02	989	54.13	14.02	2395	337			
16.08.02	114	54.86	13.28	2409	351	x	yes	No
Meris								
21.08.02	War	54.22	11.99	2481	423	x	yes	No
Meris								
03.09.02	War	54.22	11.96	2667	108			

During the validation cruises measurements were performed according to the MERIS validations protocols [1] to validate the MERIS level-2 products. Vertical profiles of the downward irradiance and upward radiance including surface reference were measured using a Satlantic profiling system to calculate the water leaving reflectance RHO_W. Water samples were taken using a rosette sampler during CTD casts of a Seabird system in three recommended depth (0m, 1/2 Secchi depth, 1 Secchi depth). From the water samples the following quantities were determined according to the validation products: chlorophyll-a concentration using HPLC (ALGAL_2), concentration of total suspended particulate material (TSM), the absorption of yellow substances YS, the absorption of particles AP and the bleached particle absorption BPA. The resulting validation level 2 product is YSBPA the sum of the absorption of YS and BPA at 442 nm. The absorption was measured using a Perkin Elmer Lambda-2 spectralphotometer and TSM was determined using the gravimetric method. The HPLC (High Pressure Liquid Chromatography) measurements were performed in the department of Biology of the IOW. In the frame of the HELCOM Baltic Sea Monitoring Programme the standard method for the determination of the chlorophyll-a is based on *in vivo* fluorescence. Therefore, HPLC and fluorometric measured chlorophyll-a concentrations were compared during the validation cruises which is included in the methodical accompanying investigations to retrieve a relationship between both measuring quantities. For a qualitative validation of MERIS products selected scenes of NOAA derived SST and SeaWiFS chlorophyll-a were taken into consideration.

3. MATCH-UPS

The measurement of water constituents, and inherent and apparent optical properties were performed close to the ENVISAT overpasses in order to get a match-up data set and to validate the MERIS level 2 products. Most of the data were submitted to the NILU database, where the IOW was strongly involved in the preparation of metadata guidelines and development of validation protocols including the compilation of metadata and data example files of all validation products. An overview about all possible match-ups during the three types of ship campaigns (planned and operational validation cruises and monitoring cruises) described above is given in Tab. 1. Overall 29 possible match-ups were performed. From these dates 13 Level1B/Level2-MERIS-Files were obtained from Brockmann Consult. Additional 16 date sets are possible and will be delivered beginning of 2003. From the 13 existing match-ups four were during the validation cruises including measurements of HPLC, YSBPA, TSM, RHO_W (only 3). 9 match-ups were performed during the monitoring cruises with only chlorophyll-a fluorometric measurements. From these 13 overpasses one was cloudy and at 2 days the measured stations were not covered by the path. Therefore, 8 MERIS scenes were analysed in detail. Table 2 gives an overview about the flags. Only 3 correspond to the optimal match-up conditions (no glint, no clouds, low wind), one from the validation and two from the monitoring cruises.

Tab. 2: MERIS flags of the 10 match-ups. Station 990 (measured on 15.08.02) was included in the analysis of the match-up on 21.08.02 as the only Case-2 flagged area.

Date	08.05.02	11.05.02	11.05.02	11.05.02	28.07.02	31.07.02	17.05.02	14.08.02	16.08.02	21.08.02	21.08.02
in-situ station/flag	271	12	30	46	213	271	42	011A	114	WAR	990
LAND	false	false	false	false	false	false	false	false	false	false	false
CLOUD	false	false	false	false	false	false	false	false	false	false	false
WATER	true	true	true	true	true	true	true	true	true	true	true
PCD_1_13	false	false	true	false	false	false	true	false	true	false	false
PCD_14	false	false	false	false	false	false	false	false	false	false	false
PCD_15	false	false	true	false	false	false	true	false	true	false	true
PCD_16	true	true	true	true	true	true	true	true	true	true	true
PCD_17	true	true	true	true	true	true	true	true	true	true	true
PCD_18	true	false	false	false	false	true	true	false	true	true	false
PCD_19	false	false	true	false	false	false	true	false	true	false	false
COASTLINE	false	false	false	false	false	false	false	false	false	false	false
COSMETIC	false	false	false	false	false	false	false	false	false	false	false
SUSPECT	true	true	true	true	false	false	true	false	false	false	false
ABSOA_CONT	true	true	true	true	true	true	true	false	false	true	false
ABSOA_DUST	false	false	false	false	false	false	false	false	true	false	true
CASE2_S	false	false	false	false	false	false	false	false	false	false	true
CASE2_ANOM	false	false	false	false	false	false	false	false	false	false	false
CASE2_Y	false	false	false	false	false	false	false	false	false	false	false
ICE_HAZE	false	false	false	false	false	false	false	false	false	false	false
MEDIUM_GLINT	true	true	true	true	false	false	true	true	false	true	true
DDV	false	false	false	false	false	false	false	false	false	false	false
HIGH_GLINT	false	false	false	false	false	false	true	false	false	false	false
P_CONFIDENCE	false	false	false	false	false	false	false	false	false	false	false
LOW_PRESSURE	true	false	false	false	true	false	true	true	true	false	false

4. VARIABILITY OF LEVEL 2 PRODUCTS IN THE BALTIC SEA

For qualitative validation it is important to get an idea about the possible variability of the level-2 variables in a distinct region. The Baltic Sea is optically a particular area due to the dominant absorbing properties. Therefore, the water colour in terms of spectral reflectance is characterised by a strong slope in the short wavelength range and a maximum between 520nm and 580nm. The calculated water leaving reflectance for all match-up stations are comprised in Fig. 2. The lowest curve was measured at the station 113 in the central Arkona Sea representing the clearest water of all measurements with low concentrations of water constituents and the highest transparency (Secchi-depth = 9m). Higher particle scattering increases the reflectances in the entire spectral range and higher yellow substance absorption increases the slope in the short wavelength range, particularly, in river mouth areas. In general, the spectral shape of the reflectances in the entire Baltic Sea is characterised by this slope decreasing to the short wavelength range due to the level of yellow substances and their exponential increasing spectral absorption in this range.

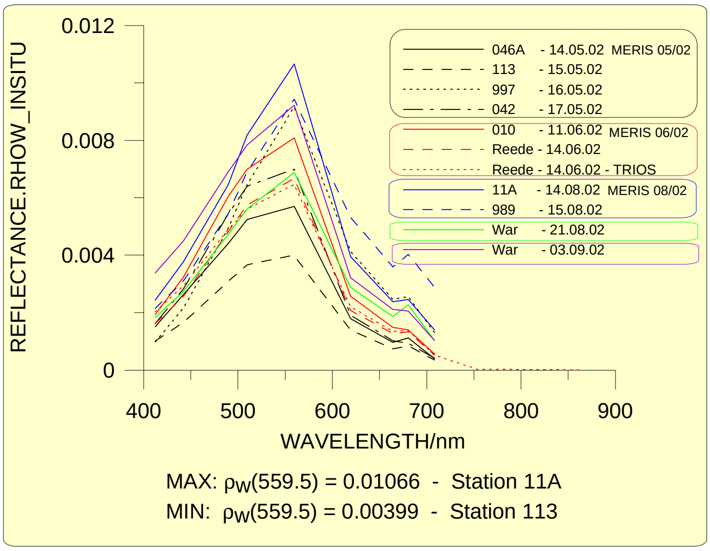

Fig. 2. In situ water-leaving reflectance of different regions in the western Baltic Sea

The variation range of chlorophyll-a, TSM, YS and Secchi depth in the Oder lagoon, Greifswald Bay (GB), Pomeranian Bight (PB) and Western Baltic including Arkona Sea are given in Tab. 3.

Tab. 3: Variation range of chlorophyll-a, TSM, YS and Secchi depth in the Oder lagoon, Greifswald Bay (GB), Pomeranian Bight (PB) and Western Baltic including Arkona Sea

	Oder lagoon	GB	PB	Western Baltic
Chl_a / mg/m³		3-20 (36)	0.5-18 (48)	0.3-9
TSM / mg/dm³		4-32	1-14(20)	1-6 (10)
YS (442nm) / m^{-1}	1-2.2	0.5-1.3	0.2-0.9	0.2-0.5
Secchi depth / m	0.2-0.4	0.3-3	2-5.5	5.5-9

The variability of the concentration of water constituents in the western Baltic Sea depends strongly on the influence of coastal discharge and phytoplankton blooms [4, 5, 6]. The single extreme values in brackets are due to such special cases as from Oder and Peene river plumes or bloom of cyanobacteria. Special phenomena for the tide-less Baltic Sea

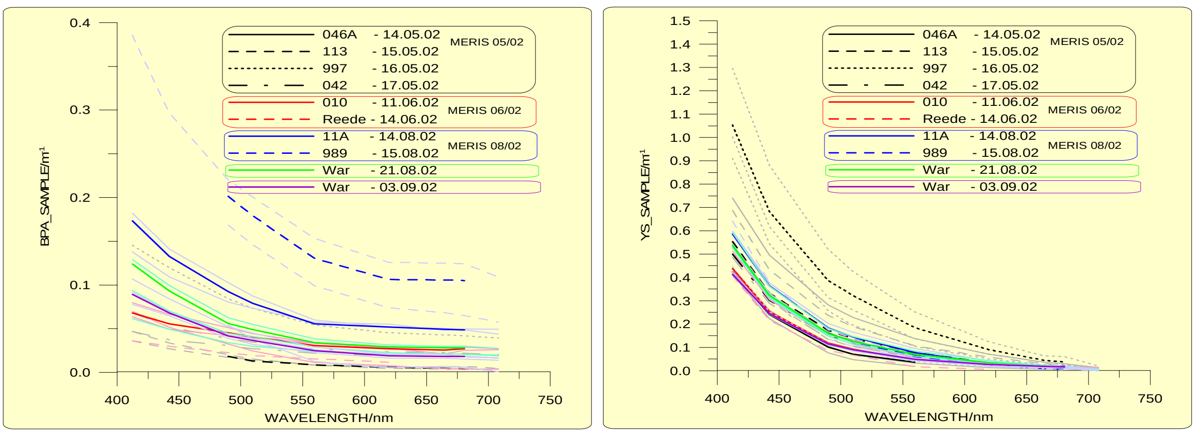

Fig. 3. Comparison between BPA(λ) and YS(λ) for the MERIS channels at the match-up stations (mean values bold) in different depth (light)

are the background value of the absorption of yellow substances of about 0.2 m^{-1} and the relatively low concentration of TSM in the open sea and outside intense plankton blooms.
In Tab. 3, there are only presented variation ranges of the absorption of yellow substances. The MERIS level-2 product is the sum (YSBPA) of the absorption of dissolved organic substances (yellow substances, YS) and of detritus in terms of the bleached particle absorption (BPA), both measured at 442nm. Therefore, the measurements of spectral absorption of these variables performed during the validation campaigns are shown in Fig. 3.
YS varied between 0.2 and 0.9 m^{-1} and BPA between 0.03 and 0.3m^{-1}. That means that BPA contributes to the total YSBPA by about 15% in the clear open Baltic Sea and up to 25% in coastal discharge waters. The background value for YSBPA is slightly higher for the open western Baltic Sea than the value derived from the measured YS in Tab. 3.

5. METHODICAL INVESTIGATIONS

Methodical investigations were implemented in order to check different methods and to have relationships for including different methods in semi-quantitative validation of MERIS level-2 products. To raise the number of match-up data sets chlorophyll measurements obtained during the monitoring cruises of the IOW should be included. For the HELCOM Monitoring Programme of the Baltic Sea the recommended methods for the determination of chlorophyll concentration are based on in vivo fluorometry and spectrophotometry. In the biological group of the IOW the in vivo fluorometric method is used. During the validation campaigns samples were taken for the determination of the concentration of chlorophyll-a a using HPLC and the in vivo fluorometric method. The results in Fig. 4 show a very good correlation between both methods, that the fluorometric data can be transformed into HPLC values for the validation of the measuring periods in May and August 2002.

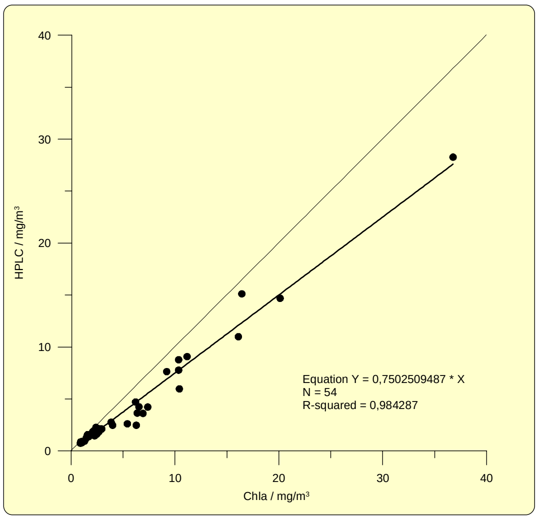

Fig. 4. Relationship HPLC – chlorophyll-a (in vivo fluorometric)

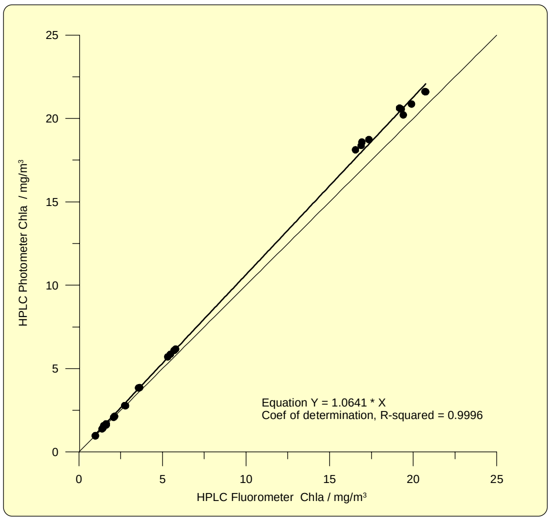

Fig. 5. Comparison between HPLC derived chlorophyll a using internal spectro-photometric and fluorometric method.

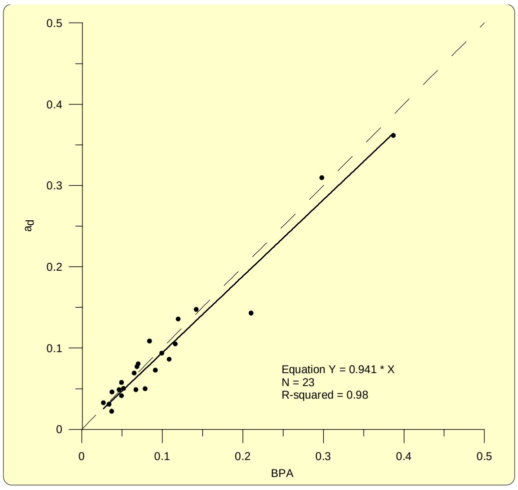

Fig. 6. Comparison between detritus absorption and bleached particle absorption

In the HPLC inter-comparison exercise strong differences occurred between different laboratories that is certainly due to the complicated method and the different methodical details using in the labs. In the IOW HPLC device 2 different measurements (fluorometric and spectrophotometric) can be achieved that allow to calculated the chlorophyll-a concentration. Because the participating labs differed in this manner both methods were compared for the second inter-comparison. The results in Fig. 5 show a very good agreement.
The determination of non-pigment particle absorption using the bleaching technique (BPA) is the recommended method for

validation. In previous studies the detritus absorption (a_d) was calculated from the particle absorption according to [2, 3]. Fig. 6 shows the comparison between a_d and BPA for the measurements during the validation campaigns. For a great number of stations, there is a good agreement, even though the methods are rather different.

6. QUALITATIVE ANALYSES OF LEVEL 2 PRODUCTS

The distribution pattern of MERIS derived water constituents are compared with NOAA-AVHRR derived sea surface temperature maps (SST) and SeaWiFS chlorophyll-a for the best example of the western Baltic Sea on 21 August 2002 (Fig. 7).

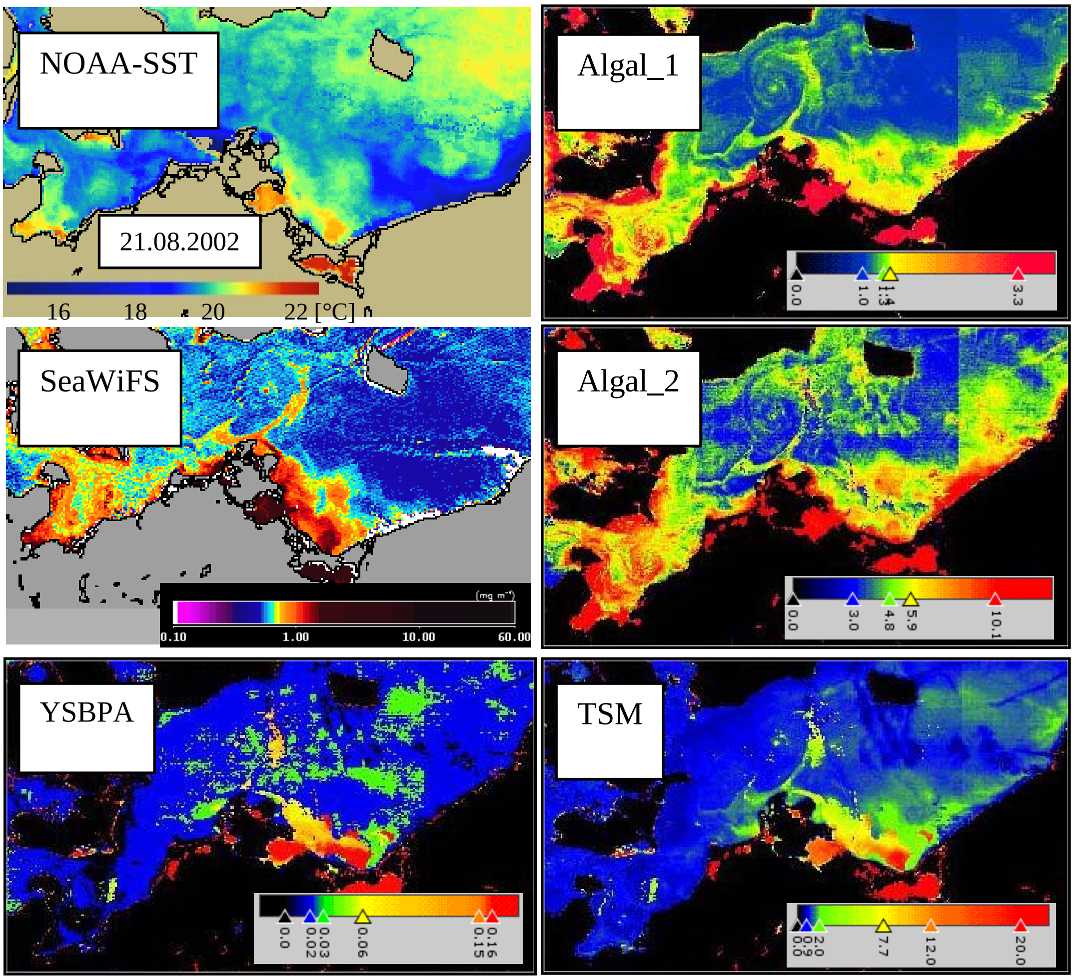

Fig. 7. Comparison between NOAA_AVHRR derived SST, SeaWiFS chlorophyll and MERIS derived water constituents on 21 August 2002

During easterly winds upwelling of cold water occurred along the Polish and parts of the German coasts. In the region of the upwelling along the Polish coast, where in the SeaWiFS chlorophyll map clouds and atmospheric effects are seen, the MERIS level-1 data contain also atmospheric feature like dust. Therefore, it is surprising that TSM and YSBPA reflect the upwelling very well with low concentration. In contrast to this findings, ALGAL_1 and ALGAL_2 show very high concentrations. If the upwelling water is originated from below the halocline of the Bornholm Sea high nutrient concentration could induce the bloom. The TSM shows higher concentrations outside the most active upwelling. In this upwelling cell the spectral reflectances have the typical slope of the Baltic in the short wavelength range. In other areas as in the open sea parts it is not the case, different spectral shapes were found as presented in Fig. 8.
The Oder river water propagated along the German coast into the Arkona Sea characterised by higher temperature and chlorophyll, and the plume is well indicated by YSBPA and TSM. Differences were found in the patterns of MERIS

and SeaWiFS derived chlorophyll-a and other constituents which indicates the good separation of water constituent by the neuronal networks for MERIS and the influence of yellow substance absorption and scattering of suspended matter in the channels of the SeaWiFS chlorophyll algorithm. Since no actual in situ data were collected on 21 August in the Pomeranian Bight it is impossible to validate that in detail, but in the in situ data the chlorophyll-a and TSM correlate rather good with different slopes depending on the ratio between inorganic and organic suspended matter.
Furthermore, in Fig. 7 eddy like structures are seen in the Arkona Sea and Mecklenburg Bight much more pronounced in MERIS Algal products than in SeaWiFS and in the other variables.
The advantage of the MERIS product separation was also visible in a scene on 28 July 2002, where a cyanobacteria bloom developed north-west of Rügen island. High concentrations were found in SeaWiFS chlorophyll, MERIS algal products and TSM, but not in YSBPA. In the Oder lagoon the data evaluation procedure calculate very high concentrations of ALGAL_1 (up to 1000 mg/m^{-3}) out of the range of natural conditions. An upper limit should be introduced for all constituents.

7. QUANTITATIVE ANALYSES OF MATCH-UPS

7.1 Water leaving reflectances

Comparisons between MERIS and in-situ derived water-leaving reflectance are shown in Figs. 8 A-D. For all monitoring stations only the remote sensing derived reflectances are summarised in Fig. 9, because in-situ radiation measurements were not performed. The in-situ water-leaving reflectances were determined at the validation cruises using Satlantic instruments during MERIS over-passes according to MERIS validation protocols. Three vertical profiles of upward radiance were measured at each station simultaneously with the downward irradiance just above the water surface to eliminate effects of misregistration by software analyses. The water-leaving reflectance RHO_W as a validation quantity was calculated from the water-leaving radiance obtained from a logarithm fit of the profiles of upward radiance in the top water layer and from the mean downward irradiance values above the water surface. The corresponding MERIS values were determined by averaging 3 x 3 pixel around the in-situ station.
The MERIS derived spectra depend strongly on the conditions and the selected parameters in the data evaluation procedure which are indicated in the flags (compare Tab. 2). One of the worst MERIS spectrum (Fig. 8A) was obtained if the algorithm detects high sun glint. The MERIS reflectance is to high especially in the blue part of the visible spectrum. During medium glint the reflectance spectra are better in the red wavelength range but always to high in the blue part resulting in underestimation of absorption of yellow substances in the Baltic Sea (see Fig. 8B). No in-situ water-leaving reflectance was determined at the over-flight on 16 August 2002 and therefore one typical in-situ spectrum of the western Baltic Sea is shown in Fig. 8C. This is the best result with a good agreement in the spectral shape showing the typical slope in the blue spectral range for the Baltic Sea due to the background value of yellow substances if no sun glint affects the sensor. There are always still discrepancies in the red wavelength range and in the first MERIS band (412.5nm).

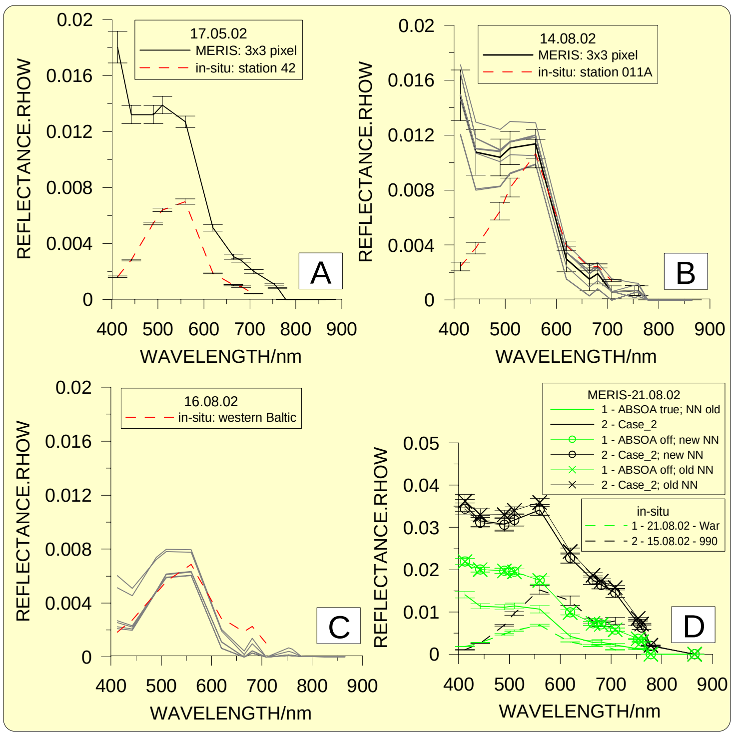

Fig. 8. Comparison between MERIS derived and measured water leaving reflectances of different overpasses: (a) 17 May 2002, (b) 14 August 2002, (c) 16 August 2002, (d) 21 August

In Fig. 8D a test of different settings in the algorithm is shown to get better results for the reflectance in the Baltic Sea and a comparison of Case-1- to Case-2- atmospheric correction (CASE2_S flag – false or true). The in-situ reflectance was determined during the MERIS over-flight in area 1 on 21 August 2002, but only in-situ spectra from 15 August were available of the Oder river mouth in area 2. The MERIS reflectance is always to high in both areas for all runs of different algorithms but much higher if Case-2- atmospheric correction is used as in area 2. There are no better results for new neuronal network (NN) approach in comparison to the standard NN. The MERIS derived spectrum is increased in area 1 if ABSOA_CONT is set off (old and new NN) meaning the maritime model is used for atmospheric correction. Hence, a under-correction of the atmospheric signal occurred. ABSOA_CONT is always off in area 2 (Case-2) and only small variations in the MERIS reflectance curves appeared due to different NN.

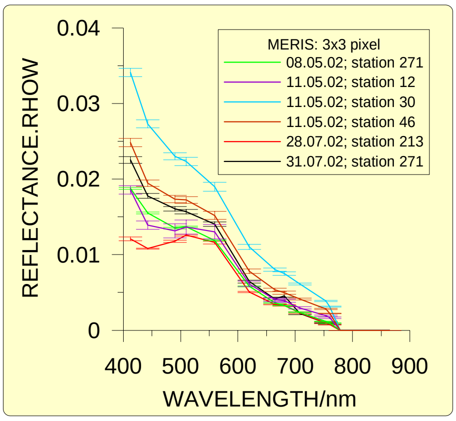

Fig. 9. MERIS derived reflectances at different monitoring stations

From the MERIS derived spectral reflectances of all IOW monitoring stations in Fig. 9 only the spectrum from 28 July 2002 shows the typical slope for the Baltic Sea in the short wavelength range except the first MERIS band (compare Fig. 2). There is no glint affecting the sensor like the good MERIS spectrum in Fig. 8C.

All results show that the quality of the derived reflectance strongly depends on different parts of the data evaluation procedure like atmospheric correction in Case-2 waters taking into account different types of aerosols, detection and correction of sun glint and of sediment- and absorptions-dominated water. The best MERIS water-leaving reflectances are obtained if no sun glint affects the sensor and no Case-2 atmospheric correction is used. But these conditions not always provide satisfied reflectances (see 31 July 2002 in Fig. 9). Therefore, the sun glint correction, Case-2 water identification and atmospheric correction should be checked and improved to get better reflectance values in the Baltic Sea especially in the blue part of the visible spectrum. Furthermore, the MERIS band 1 deviates from mean reflectance curves of the Baltic Sea and should be verified.

7.2 <u>Water constituents</u>

The in-situ concentrations of chlorophyll-a and suspended matter (TSM) as well as the absorption of yellow substance at 442nm (YSBPA) were determined according to the validation protocols [1]. Almost all derived in-situ values are weighted averages of measurements in the surface layer, half and one secchi depth. The recommended HPLC-method for the derivation of chlorophyll-a concentration was only used for the stations of MERIS validation cruises in May, June, August and September 2002. The standard method for the others IOW monitoring stations is the in-vivo fluorometric method. It is possible to transform these values to HPLC concentrations using the relationship in Fig. 4. The corresponding MERIS derived water constituents were also determined by averaging 3 x 3 pixel around the in-situ station.

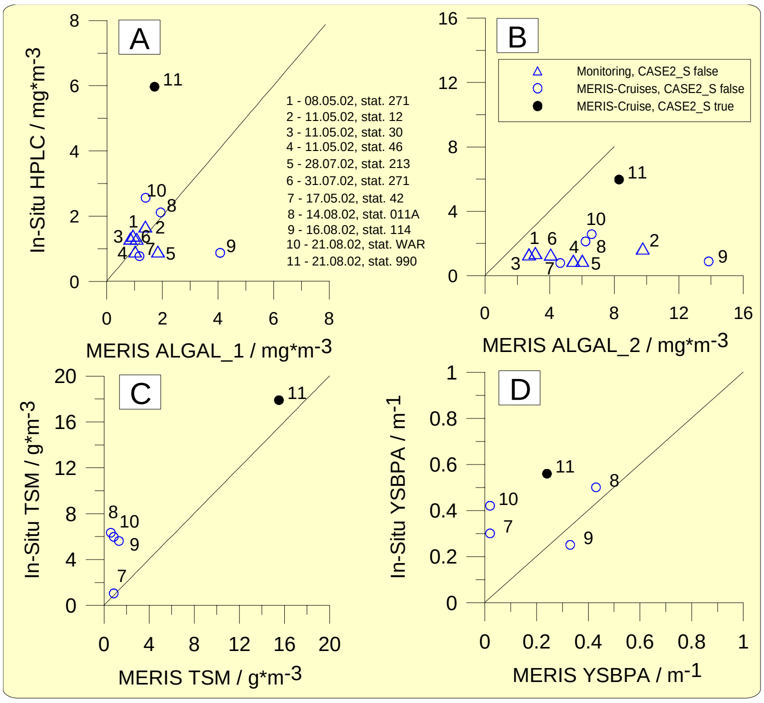

Fig. 10. Comparison between MERIS derived water constituents and in situ measurements: (A) HPLC – MERIS Algal_1, (B) HPLC - MERIS Algal_2, (C) TSM, (D) YSBPA

The comparison between in-situ derived chlorophyll-a and MERIS determined ALGAL_1 and ALGAL_2 indices is shown in Figs. 10A and B. The ALGAL_1 index fit better the in-situ values as the ALGAL_2 index which should be vice versa in the Baltic Sea. There is a good agreement of ALGAL_1 index for low concentrations and for Case-1-

atmospheric correction (CASE2_S flag - false) but ALGAL_2 index is always to high. The ALGAL_1 index is to low and the ALGAL_2 index is near the in-situ concentration if Case-2- atmospheric correction (CASE2_S flag – true) is used as at station 990 in the Oder river plume.
In Figs. 10C and D are shown the TSM- and YSBPA results for only 5 stations, because there are no in-situ data available at the monitoring stations. The MERIS TSM values are mostly to low for Case-1- atmospheric correction and near the in-situ values for Case-2- atmospheric correction. The YSPBA values derived from MERIS are mostly to low.
The best reflectance spectra were found at 28 July and 16 August if no sun glint affects the sensor. This is no guarantee to get good concentrations from the NN. The ALGAL indices are to high at both dates. The TSM concentration is to low and the YSBPA value is near the in-situ determined absorption.
The number of match-ups was to low for a final appreciation of the MERIS level 2 products and therefore, the missing level-2 data should be included.

8. SUMMARY AND CONCLUSIONS

The MERIS- level-2 product validation activities included methodical investigations to typical concentration ranges, selected variables, qualitative and quantitative validation.
In the tide-less open Baltic Sea the concentrations of optically active water constituents and their composition depends mainly on phytoplankton development. A typical optical property is a background value of yellow substance absorption of 0.2 m^{-1}. In river discharge areas the different constituents are only partly correlated.
Good correlation were found for different methods for the determination of selected validation variables, between ad and BPA, between chlorophyll-a measured by HPLC and fluorometric methods, between HPLC-Chlorophyll-a using internal fluorometric and spectrophotometric measuring devices.
The water constituents derived from MERIS reduced resolution data describe very detailed horizontal patterns in comparison to SeaWiFS data. The level-2 product evaluation procedure on the basis of neuronal networks deliver partly independent water constituents but the values fit mostly not the variation range.
For the quantitative validation of MERIS level-2 products 10 match-up data sets were performed, but only 3 represented recommended validation conditions as no clouds and no glint.
The agreements between measured and MERIS derived water-leaving reflectances is different depending on the conditions, very good for no glints, no Case-2, no ABSOA_CONT (Marine Aerosols), good for medium glint only at wavelength $\lambda > 550$nm, which is not sufficient in Case-2 waters.
The validation of MERIS derived water constituents shows very different results. If no Case-2 waters is identified Algal_1 showed good agreement for low values and Algal_2 was to high. In identified Case-2 water Algal_1 was to low and Algal_2 to high. Best chlorophyll results were found for ABSOA_CONT=off and new NN. The MERIS band 1 deviates from mean reflectance curves of the Baltic Sea. YSBPA was mostly to low and out of the variation range in open waters. TSM was partly to low, in Case-2 identified waters ok.
For a detailed validation the number of match-ups was not sufficient. The results have clearly shown that the algorithm do not identify Case-2 waters and use a absorbing continental atmosphere due to the high absorption of yellow substances and the low particle scattering in the open waters. That means, a better identification and atmospheric correction for YS influenced Case-2 waters as in the Baltic Sea is needed.

9. RECOMMENDATION

The validation has to be continued for all match-up stations and over-passes in 2002, that require the delivery of all MERIS scenes.
A further development of a better identification and atmospheric correction for YS influenced Case-2 waters is required.
Reprocessing of the best validation data sets.
The MERIS band 1 extremely deviates from the shape of the mean Baltic reflectance and has to be improved.
The exploitation of MERIS advantages requires the delivery of Full-Resolution-MERIS-Data, that enables to exclude patchiness in the validation.

10. ACKNOWLEDGEMENT

The authors thank J. P. Huot and Brockmann Consult, ESA and IOW for supporting these investigations and I. Topp (IOW) for HPLC measurements.

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