

AO9106 - USING THE SISCAL IN SITU MEASUREMENTS FOR THE VALIDATION OF THE MERIS ALGAL PIGMENT INDICES I AND II

Frank Fell⁽¹⁾, Morten Brozek⁽²⁾, Barak Herut⁽³⁾, Torunn Johansen⁽⁴⁾

⁽¹⁾*Informus GmbH, Gustav-Meyer-Allee 25, D-13355 Berlin, Germany, fell@informus.de*

⁽²⁾*South Jutland County, Waste Water and Water Quality Section, DK-6270 Toender, Denmark, morten_brozek@sja.dk*

⁽³⁾*Israel Oceanographic and Limnological Research Ltd., IL-31080 Haifa, Israel, barak@ocean.org.il*

⁽⁴⁾*Norwegian University of Technology and Science, TBS, N-7491 Trondheim, Norway, torunn.johansen@ym.ntnu.no*

ABSTRACT

In the frame of the EC-funded project SISCAL, *in situ* campaigns have been executed in three coastal areas in the Baltic Sea, North-Eastern Atlantic, Eastern Mediterranean Sea and in a lake in North-Eastern Germany. The aim of these campaigns was to obtain measurements of the chlorophyll concentration, subsequently to be used for the validation of the corresponding MERIS data products. Between May and September 2002, *in situ* measurements have been performed concomitantly to eleven MERIS overpasses. As of December 2002, MERIS Level 2 ocean products could be made available for four of the eleven overpasses. At the specific *in situ* sampling sites, ocean products were available in two of these four MERIS data sets. On a pixel-by-pixel basis, two (six) match-ups are available for *Algal Pigment Index I (II)*. The following preliminary conclusions can be drawn from the SISCAL validation activities: 1) *Algal Pigment Index I* shows a higher dynamic range than does *Algal Pigment Index II* and reveals such more detailed dynamic structures in the ocean, 2) the *Algal Pigment Index II* values are systematically (three to seven times) larger than the *Algal Pigment Index I* values and appear to be overestimated, 3) the confidence flags PCD-15 and PCD-17 are raised over large areas where the need for these flags to be raised is not obvious from visual inspection.

1 INTRODUCTION

1.1 The SISCAL project

AO9106 has been undertaken in the frame of the pan-European project SISCAL (Satellite-based Information System on Coastal Areas and Lakes). This project is dedicated “... to develop facilities to provide end-users with customized and easy-to-use data for environmental monitoring of coastal areas and lakes in Near-Real-Time” [1]. The focus of SISCAL is set on the optimal integration of existing techniques. The main task will be to create a software system providing Near-Real-Time information on the aquatic environment (using space-borne instruments such as AVHRR, AATSR, MODIS or MERIS) and ancillary GIS-data. SISCAL data products will be tailored to individual customer needs, allowing them to exploit Earth Observation (EO) data without extensive in-house knowledge. This way, SISCAL aims at closing the gap between research institutes, satellite data providers and the actual end-users. Data and information exchange will entirely take place over the internet, from the acquisition of satellite raw data from the providers up to the dissemination of finalized data products to the end-users. The co-operation between the ten SISCAL partners, including four end-users representative of public authorities from local to national scale, aims at strengthening the operational use of EO data in the management of coastal areas and lakes.

1.2 SISCAL activities in the frame of the MAVT activities

The SISCAL project participates to the MERIS AATSR Validation Team (MAVT) activities through the Announcement of Opportunity AO9106. The goal of AO9106 is to contribute to the validation of the MERIS ocean products *Algal Pigment Index I* and *Algal Pigment Index II*. In order to provide ESA with a maximum of chlorophyll data for validation purposes, those SISCAL partners actually executing *in situ* measurements initially tried to adjust their sampling activities for the year 2002 with respect to the MERIS overpasses. However, since it often revealed difficult to reschedule *in situ* monitoring activities, especially for public end users who are subject to heavy organisational constraints, funds were made available within the SISCAL project to conduct specifically dedicated MERIS validation campaigns. The sampling strategy adopted was to use small, fast boats to be able to react quickly on favourable weather conditions.

Three of the four SISCAL partners conducting the *in situ* campaigns have participated to the first round of the of the pigment analysis ring test co-ordinated by NILU [2]. The aim of the ring test was to ensure a common quality standard for *in situ* data used for MERIS data product validation. One SISCAL partner, IOLR (Israel), could not receive the water samples on time because of unexpected difficulties regarding customs regulations. The evaluation of this first round shows that the results of the SISCAL laboratories do not differ significantly from the average of all participating labs. The four SISCAL partners doing *in situ* measurements are actually taking part to the second round of the pigment analysis ring test.

2 IN SITU CAMPAIGNS

2.1 Areas of interest

During spring and summer 2002, *in situ* campaigns were performed in coastal areas in Norway (Trondheim Fjord), Denmark (Flensburg Fjord) and Israel (Haifa Bay and Mediterranean coastline off Ashqelon). The geographical distribution of the SISCAL areas of interest is shown in Fig. 1. Since one of the objectives of SISCAL is to test the applicability of MERIS full resolution (FR) pigment products on the larger inland waters in the East-German Berlin-Brandenburg area, *in situ* sampling was also conducted in Lake Müggelsee which is the biggest lake of Berlin covering an area of about 8 km². However, these measurements are not used for the present validation exercise, since MERIS FR products could not be made available on time.



Fig. 1: Areas of interest of the four SISCAL end users.

2.1.1 Flensburg Fjord

Flensburg Fjord is situated between Denmark and Germany. It is 68 km long and its width varies between 3-15 km. The surface area of the fjord covers 308 km². Its depth is on average 14.5 m, but varies much due to topographical discontinuities such as deep basins and shallow sills and grounds. The fjord is influenced by Baltic Sea water with salinity between approximately 17 and 22 PSU. It is surrounded by intensely used agricultural land and is as such subject to considerable nutrient inputs.

2.1.2 Trondheim Fjord

Trondheim Fjord is situated in the middle part of Norway. It is 126 km long, its width varies between 0.1 and 20 km and its surface area covers about 1400 km². Average and maximum depths are 165 m and 617 m, respectively. The fjord is both influenced by saline Atlantic water (~33 PSU), mainly in late winter, and by fresh water from six major rivers on the southeast side of the fjord (maximum total discharge of 6430 m³s⁻¹). In the course of the year, salinity and temperature in the surface layer (0-5 m) fluctuate from 5 to 34 PSU and from 2 to 20°C, respectively. In addition, the tidal current provides a constant exchange of the uppermost water masses in the fjord. Because of high spring and autumn fresh water runoff, the fjord water is rich in coloured dissolved organic matter (CDOM) and inorganic particles.

2.1.3 Haifa Bay

The eastern Mediterranean is a very oligotrophic sea with low levels of nutrients. This depletion is generated from the prevailing W-E anti-estuarine circulation with an inflow of nutrient-depleted surface waters from the Atlantic and a counterbalancing outflow of relatively nutrient-enriched Levantine intermediate and deep waters, its arid climate with little natural freshwater (nutrient-rich) run-off and its narrow continental shelf capable of only limited benthic-pelagic recycling of nutrients. This condition generates very low Chl *a* concentrations, having pronounced seasonal variations of 2-5 times higher levels during fall and winter (mean values of ~0.1 mg Chl *a* m⁻³) compared to summer (mean value of ~0.03 mg m⁻³) [3]. The depth distribution of Chl *a* concentration typically shows deep chlorophyll maximum (DCM) between 75 to 130 m, shifting downwards during summer.

2.2 *In situ* campaigns

At 15 occasions, measurements were performed at specific sites in the SISCAL areas of interest concomitantly (i.e. within ± 2h) to a MERIS overpass. *In situ* sampling and subsequent analysis followed as far as possible the protocols defined in [4] and references listed therein. Some sites have been visited more than once. A total of 53 stations (75 including Lake Müggelsee) have been sampled (see Table 1), in waters ranging from highly oligotrophic in Haifa Bay characterised by pigment concentrations down to 0.05 mg m⁻³ to eutrophic waters in the inner Flensburg Fjord characterised by pigment concentrations up to 8 mg m⁻³. The pigment concentrations observed in the shallow Lake Müggelsee are comparably low for this type of ecosystem, ranging between 2 and 15 mg m⁻³. They are included in Table 1 for the sake of completeness and for later assessment of the applicability of the MERIS ocean product algorithms on inland waters.

2.2.1 Flensburg Fjord

Two *in situ* campaigns were carried out in 2002 in Flensburg Fjord. During the campaign in June 2002, weather conditions were very unstable. Totally overcast skies varied with sunny spells within a few minutes. Wind speed was about 6 Bf on June 12 and 3-4 Bf on June 15. Due to the meteorological situation in the beginning of June 2002, relatively clear water from the open Baltic Sea was present both in the outer and in the middle Fjord. Chlorophyll concentrations were relatively low (≤ 3 mg Chl *a* m⁻³) and the mixed layer extended over the full euphotic zone. The meteorological conditions were more favourable during the campaign in August 2002. Sampling was performed using a rubber boat. Water samples were stored on board in cooling boxes at about 15°C. Subsequent chlorophyll analysis was performed according to the Danish national standard in an accredited external laboratory using a spectrophotometric method.

2.2.2 Trondheim Fjord

Three *in situ* campaigns were carried out in 2002 in Flensburg Fjord. The main sampling area for the campaigns in Trondheim Fjord has been Korsfjorden. No MERIS ocean products could be made available for the campaign in April 2002. During the campaign in May 2002, weather was partly cloudy with South-Easterly winds of 2-3 Bf. The surface water was highly influenced by riverine input of inorganic particles and CDOM. The water temperature ranged between 8°C and 12°C in the upper 5 m while the salinity fluctuated between 15 to 31 PSU. During the campaign in August

2002, there was morning haze and again South-Easterly winds of 2-3 Bf. The surface water was almost clear, the water temperature ranged between 15 and 20°C and the salinity fluctuated between 20 and 30 PSU. The speedboat “RV SISCAL” has been used as sampling platform. Each campaign was composed of approximately 10 stations. Salinity and temperature profiles were measured at each station. Water samples for determination of Chl *a* and phytoplankton composition were taken at 1 m depth using an aluminium rod with two 1.5 l bottles. The bottles were labelled and stored in darkness at ambient temperature on the boat for approximately 4 h. In the lab before filtration, the bottles were stored in darkness at 15°C. Chl *a* was determined using spectrophotometric analysis.

2.2.3 Haifa Bay

In the frame of SISCAL, two permanent stations located on the northern part of the Mediterranean coast of Israel (Haifa Bay area), approximately 5 km off shore, were visited in 4 cruises during July to September 2002. Additionally, data from a campaign carried out along the Mediterranean coast off Ashqelon could be made available to the project. In all cruises, the sea was relatively calm (wave height <0.8m), sky was clear or only partly cloudy and the visibility was above 10km. The cruises were performed with a rubber boat (Mark 3) from which *in-situ* measurements of salinity, temperature, dissolved oxygen, turbidity and pH were performed using the YSI 6000 probe. Surface water samples were collected using a 2.2 liter Wildco bottle or were directly filled into pre-cleaned bottles. The samples were used for the measurement of nutrients (nitrate, o-phosphate, silicic acid) and Chl *a*. Water samples for Chl *a* were filtered in the lab using glass fiber filters after pre-filtration through a 63 µm sieve, and the filters were frozen until analysis. Chl *a* was determined fluorometrically (TD 700, Turner Designs), after extraction in 90% acetone.

Table 1: *In situ* campaigns for MERIS validation purposes performed in the frame of the SISCAL project.

SISCAL Area	Date	Time (UTC)	Specific sites	Geographical coordinates	N stations	Secchi Median	CHL Range	CHL Median
Israel coastline	2002-07-31	07:05 – 07:50	Off Haifa Bay	32°49' – 32°52' N 34°53' – 34°54' E	2	16.0	0.12 – 0.17	0.15
Israel coastline	2002-08-06	06:20 – 07:35	Off Haifa Bay	32°49' – 32°52' N 34°53' – 34°54' E	2	26.0	0.05 – 0.07	0.06
Israel coastline	2002-08-25	09:10 – 11:28	Off Ashqelon	31°41' – 31°50' N 34°31' – 34°38' E	8	./.	0.17 – 0.61	0.24
Israel coastline	2002-09-04	07:10 – 07:50	Off Haifa Bay	32°49' – 32°52' N 34°53' – 34°54' E	2	28.5	0.08 – 0.14	0.11
Israel coastline	2002-09-10	05:30 – 06:25	Off Haifa Bay	32°49' – 32°52' N 34°53' – 34°54' E	2	25.0	0.11 – 0.24	0.18
SW Baltic Fjords	2002-06-12	07:50 – 11:10	Flensburg Fjord, outer	54°48' – 54°53' N 09°49' – 09°58' E	4	7.5	2 ± 1	1
SW Baltic Fjords	2002-06-15	07:50 – 11:15	Flensburg Fjord, outer	54°48' – 54°55' N 09°46' – 10°07' E	3	6.5	1 ± 1	1
SW Baltic Fjords	2002-08-14	08:55 – 11:10	Flensburg Fjord, outer	54°47' – 54°53' N 09°49' – 10°07' E	5	8.8	1 – 3	2
SW Baltic Fjords	2002-08-15	08:10 – 08:20	Flensburg Fjord, inner	54°50' – 54°51' N 09°28' – 09°29' E	1	(3.5)	(8)	8
SW Baltic Fjords	2002-08-15	08:40 – 09:10	Flensburg Fjord, middle	54°49' – 54°51' N 09°38' – 09°45' E	2	7.0	2-3	2
SW Baltic Fjords	2002-08-15	09:20 – 10:20	Flensburg Fjord, outer	54°47' – 54°49' N 09°50' – 10°06' E	3	9.5	1 ± 1	1
Norwegian Fjords	2002-05-30	08:35 – 10:27	Trondheim Fjord	63°23' – 63°24' N 09°59' – 10°04' E	9	./.	1.4 – 2.3	1.8
Norwegian Fjords	2002-08-08	08:25 – 11:00	Trondheim Fjord	63°36' – 63°41' N 09°53' – 10°06' E	10	./.	1.6 – 2.2	1.9
North German Lakes	2002-06-16	07:00 – 09:25	Müggelsee	52°25' – 52°27' N 13°37' – 13°41' E	13	2,8	9 – 15	12
North German Lakes	2002-07-17	07:00 – 08:25	Müggelsee	52°25' – 52°27' N 13°37' – 13°41' E	9	1,4	2 – 15	7

3 VALIDATION OF ALGAL PIGMENT INDEX I AND II

3.1 Availability of MERIS data

In situ measurements took mostly place at distances between 1 and 15 km off shore. As the SISCAL areas of interest are located in potentially highly dynamic areas (e.g. strong nutrient gradients in Flensborg Fjord, fresh water influx in Trondheim Fjord, pollution events in Haifa Bay, ...), it would have been of great interest to use MERIS FR ocean products for validation purposes. Unfortunately, such data could not be made available until December 2002. Instead, four reduced resolution (RR) ocean products were available (Table 2).

Table 2: Availability of MERIS ocean products corresponding to the SISCAL *in situ* measurements as of December 2, 2002.

No.	Date	Specific sites	Time <i>in situ</i> (UTC)	MERIS overpass (UTC)	MERIS L0 ?	MERIS L2 ?	CHL 1 / CHL 2 product available?
1	2002-07-31	Haifa Bay	07:05 – 07:50	07:53	Y	Y	Y / Y
2	2002-08-06	Haifa Bay	06:20 – 07:35	08:04	N		
3	2002-08-25	coast off Ashqelon	09:10 – 11:28	08:07	N		
4	2002-09-04	Haifa Bay	07:10 – 07:50	07:53	N		
5	2002-09-10	Haifa Bay	05:30 – 06:25	08:04	N		
6	2002-06-12	Flensborg Fjord, outer	07:50 – 11:10	10:06	Y	Y	N / Y
7	2002-06-15	Flensborg Fjord, outer	07:50 – 11:15	10:11	Y	Y	N / N
8	2002-08-14	Flensborg Fjord, outer	08:55 – 11:10	10:26	Y	Ø	
9	2002-08-15	Flensborg Fjord, inner	08:10 – 08:20	09:54	N		
9	2002-08-15	Flensborg Fjord, middle	08:40 – 09:10	09:54	N		
9	2002-08-15	Flensborg Fjord, outer	09:20 – 10:20	09:54	N		
10	2002-05-30	Trondheim Fjord	08:35 – 10:27	10:12	Y	Y	N / N
11	2002-08-08	Trondheim Fjord	08:25 – 11:00	10:13	Y	N	
12	2002-06-16	Müggelsee	07:00 – 09:25	09:41	N		
13	2002-07-17	Müggelsee	07:00 – 08:25	10:07	?	?	

3.2 Trondheim Fjord, May 30, 2002

MERIS image: MER_RR_2PNACR20020530_101218_0000090X000_00237_01293_0000.NI_Trondheim_fjord

No match-up has been achieved for May 30, 2002 in Trondheim Fjord (Fig. 2). Cloud free areas are located over the Atlantic Ocean North of 65° latitude and over large parts of the Baltic Sea (the latter not shown on Fig. 2). Two rectangular regions of interest have been defined over these areas in order to compare the MERIS products *Algal Pigment Index I* and *II*. In both areas, *Algal Pigment Index II* gives three to four times higher results than *Algal Pigment Index I*. *API I* shows more detailed dynamical structures than *API II*. However, less pixels are flagged out for *API II* than for *API I*.

Table 3: Comparison of *Algal Pigment Index I* and *II* for two regions of interest (see green rectangles in Fig. 2) in the Northern Atlantic and in the Baltic Sea, South-East of the Åland Islands (not shown in Fig. 2). The values in columns 4-5 specify arithmetic mean and range for *API I* and *II* (average ± std. dev.).

Left-Right	Up-Down	N Pixels	<i>API I</i>	<i>API II</i>
North Atlantic				
[800, 1100]	[1, 20]	6020	1.22 [0.82, 1.79]	4.70 [2.39, 9.23]
Gulf of Bothnia, SE of Åland Islands				
[50, 100]	[450, 500]	2601	1.66 [1.14, 2.42]	4.79 [4.01, 5.71]

3.3 Flensburg Fjord, June 12, 2002

MERIS image: MER_RR__2PNACR20020612_100617_00000090X000_00423_01479_0000.NI_Flensburg_fjord

On a pixel-by-pixel basis, four match ups have been achieved for *API II* on June 12, 2002 in Flensburg Fjord (Fig. 3). Confidence flags PCD-15, PCD-17 and PCD-19 are raised over the area of interest. Compared to the *in situ* measurements, *API II* seems to underestimate the pigment concentration by a factor of three to four. Since the chlorophyll distribution was very homogeneous in outer Flensburg Fjord during the June campaign, the mean value within a 7 by 7 area centered around selected target pixels was calculated for both *API I* and *API II*. In this case, the concentration range provided by *API II* agrees rather well with the *in situ* data, while the *API I* results are significantly underestimated.

Table 4: Match-up of June 12, 2002 in Flensburg Fjord. The values in columns 3-5 specify mean, range (min/max for the *Chl-a in situ* data, average \pm std. dev. for *API I* and *II*) and number of samples.

Left-Right	Up-Down	<i>Chl in situ</i>	<i>API I</i>	<i>API II</i>
Pixel by pixel match ups				
604	249	2 \pm 1, [./], N=1	./	0.58
603	252	2 \pm 1, [./], N=1	./	0.47
600	255	2 \pm 1, [./], N=1	./	0.44
594	252	2 \pm 1, [./], N=1	./	0.47
Pixels within 7 by 7 area around target pixel				
603	252	2, [1, 3], N=3	0.19, [0.10, 0.33], N=9	1.2, [0.48, 3.0], N=18
594	252	2 \pm 1, [./], N=1	0.26, [0.16, 0.42], N=4	1.1, [0.46, 2.8], N=12

3.4 Flensburg Fjord, June 15, 2002

MERIS image: MER_RR__2PNACR20020615_101157_00000090X000_00466_01522_0000.NI_Flensburg_fjord

No match-up has been achieved for June 15, 2002 in Flensburg Fjord. Cloud free areas are located over the German Bight and the area around the island of Rügen (Fig. 4). Two rectangular regions of interest have been defined over these areas in order to compare the MERIS products *Algal Pigment Index I* and *II*. In both areas, *Algal Pigment Index II* values are four to five times higher than *Algal Pigment Index I* values.

Table 5: Comparison of *Algal Pigment Index I* and *II* for two regions of interest (see green rectangles in Fig. 4) in the German Bight and in the Baltic Sea. The values in columns 4-5 specify arithmetic mean and range for *API I* and *II* (average \pm std. dev.).

Left-Right	Up-Down	N Pixels	<i>API I</i>	<i>API II</i>
German Bight				
[590, 620]	[350, 370]	651	1.40 [0.97, 2.03]	5.47 [3.91, 7.64]
Baltic Sea off Fischland				
[351, 365]	[250, 260]	165	1.25 [0.96, 1.63]	6.53 [5.04, 8.47]

3.5 Haifa Bay, July 31, 2002

MERIS image: MER_RR__2PNACR20020731_075159_00000090X000_00121_02179_0000.NI_Israel

Two match ups on a pixel-by-pixel basis have been achieved for *API I* and *II* on July 31, 2002 in the Eastern Mediterranean off Haifa (Fig. 5). MDS flags 15 and 19 are raised over the area of interest. Both *API I* and *API II* give similar results but seem to overestimate the chlorophyll concentration measured *in situ* by a factor of five to seven. Also when considering all pixels within a 7 by 7 area, the observed tendency for overestimation of the MERIS products as compared to the *in situ* measurements remains unchanged. As is the case for the North Atlantic scene, *API I* shows much more dynamical structures than does *API II*. In the very oligotrophic areas outside the coastal areas, *API I* seems

to provide reasonable values, whereas *API II* provides unrealistically high chlorophyll values. An artefact visible in both the *API I* and *II* products is extending Northward from the Nile estuary.

Table 6: Match-up of July 31, 2002 in Haifa Bay. The values in columns 3-5 specify mean, range (min/max for the Chl-*a in situ* data, average \pm std. dev. for *API I* and *II*) and number of samples.

Left-Right	Up-Down	<i>Chl in situ</i>	<i>API I</i>	<i>API II</i>
Pixel by pixel match ups				
786	190	[0.15, 0.17], N=2	0.81	1.11
787	188	[0.12, 0.15], N=2	0.81	1.11
Pixels within 7 by 7 area around target pixel				
786	190	0.15, [0.12, 0.17], N=4	0.82, [0.57, 1.2], N=49	0.84, [0.56, 1.2], N=49

4 CONCLUSIONS

The flexible approach chosen for the *in situ* campaigns has proven successful. Between April 2002 and September 2002, a total of 53 stations were visited concomitantly to 11 MERIS overpasses. As of December 2002, MERIS Level 0 reduced resolution data could be made available for six, and MERIS Level 2 ocean products for four of these 11 overpasses.

On two occasions, the sampling areas were not cloud covered such that direct match-ups on a pixel-by-pixel basis could be performed using the SISCAL *in situ* measurements, once in Flensburg Fjord, once in the Eastern Mediterranean Sea off Haifa Bay. Both areas are located close to the coast, partly in CDOM rich waters (Flensburg Fjord). The validation results differ systematically between the two scenes:

- in the Flensburg Fjord area, *Algal Pigment Index I* is significantly underestimated, while *Algal Pigment Index II* gives results comparable to the *in situ* measurements,
- regarding the area off Haifa, both *Algal Pigment Index I* and *Algal Pigment Index II* give similar results; however, both significantly overestimate the measured pigment concentration.

In both areas, confidence flags PCD-15 and PCD-19 are raised, for Flensburg Fjord also PCD-16 and PCD-17. The need for the flags to be raised is not always apparent from visual inspection of the images.

When averaging over larger areas in the Northern Atlantic, Baltic Sea and German Bight, *Algal Pigment Index II* gives three to seven times higher pigment concentrations than *Algal Pigment Index I*. According to the local SISCAL experts, *Algal Pigment Index I* values for these areas appear to be more "typical" for the respective area and season than *Algal Pigment Index II* values. Besides, *Algal Pigment Index II* appears to be more sensitive to noise and therefore does not resolve the marine dynamical features as does *Algal Pigment Index I*. Less pixels are flagged out for *Algal Pigment Index II*, especially in coastal zones.

Further work is required to confirm these results and to identify the reasons for the observed differences between *Algal Pigment Index I* and *Algal Pigment Index II* as well as for the discrepancies between MERIS products and the corresponding *in situ* measurements.

5 REFERENCES

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MER_RR_2PNACR20020530_101218_0000090X000_00237_01293_0000.N1_Trondheim_fjord

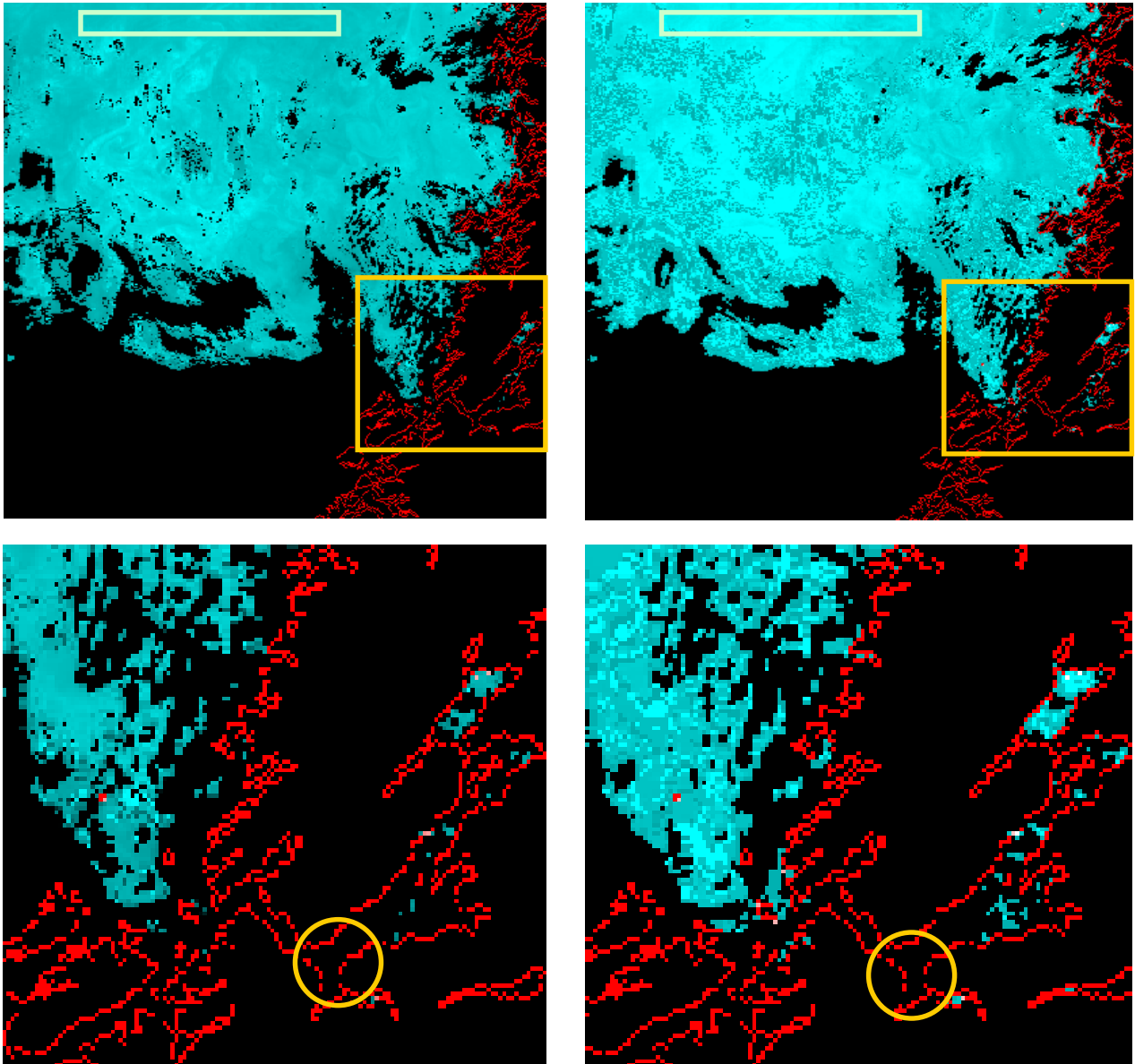


Fig. 2: Algal Pigment Index I (left column) and II (right column) derived from MERIS scene MER_RR_2PNACR20020530_101218_0000090X000_00237_01293_0000.N1_Trondheim_fjord, covering the North-East Atlantic and the Northern Baltic Sea (not shown in this Fig.). The orange circle indicates the area where concomitant *in situ* measurements have been performed.

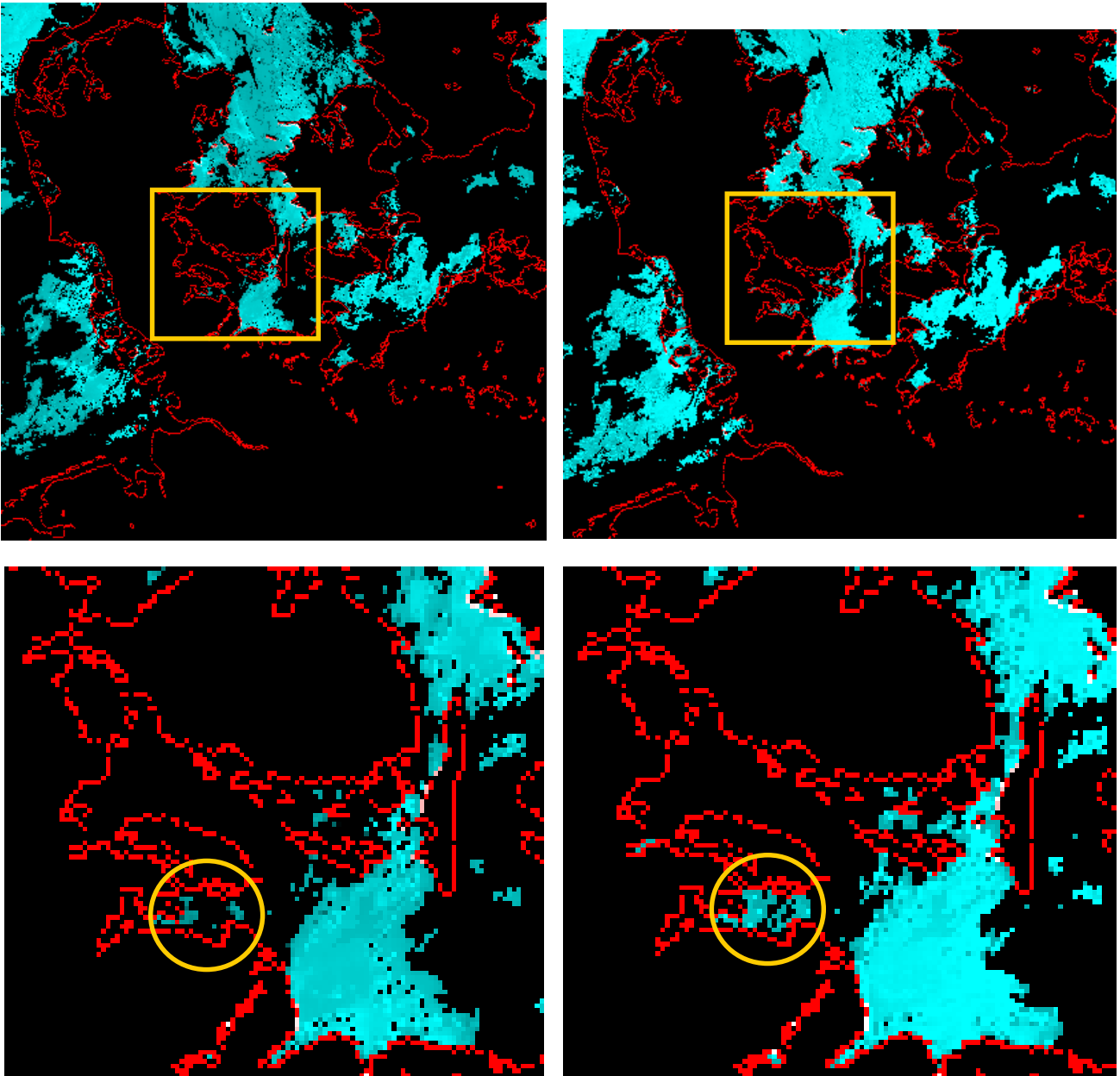


Fig. 3: Algal Pigment Index I (left column) and II (right column) derived from MERIS scene MER_RR_2PNACR20020612_100617_00000090X000_00423_01479_0000.N1_Flensburg_fjord, covering the German Bight and the South-Western Baltic Sea. The orange circle indicates the area where concomitant *in situ* measurements have been performed.

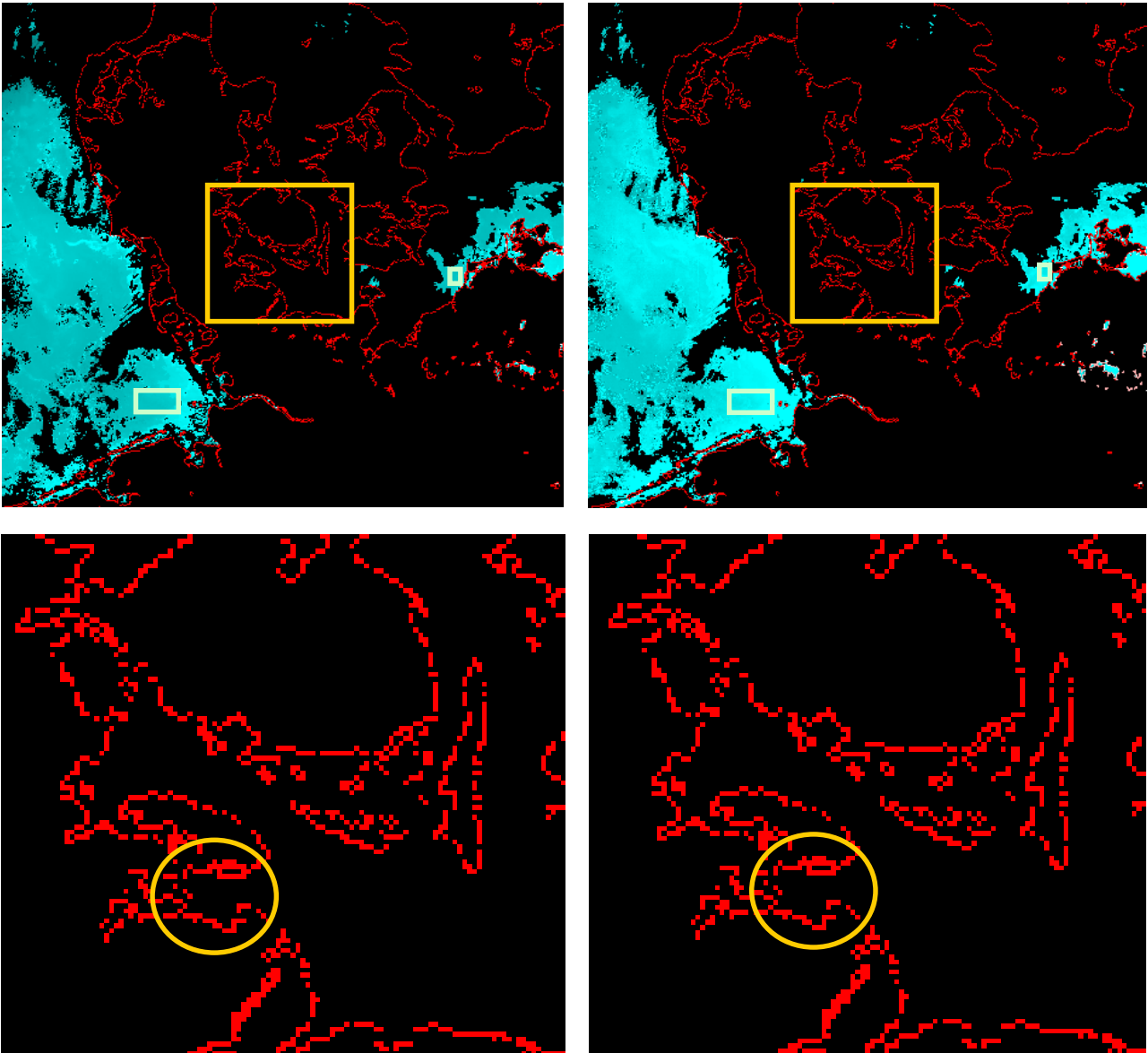


Fig. 4: *Algal Pigment Index I* (left column) and *II* (right column) derived from MERIS scene MER_RR_2PNACR20020615_101157_00000090X000_00466_01522_0000.N1_Flensburg_fjord, covering the German Bight and the South-Western Baltic Sea. The orange circle indicates the area where concomitant *in situ* measurements have been performed.

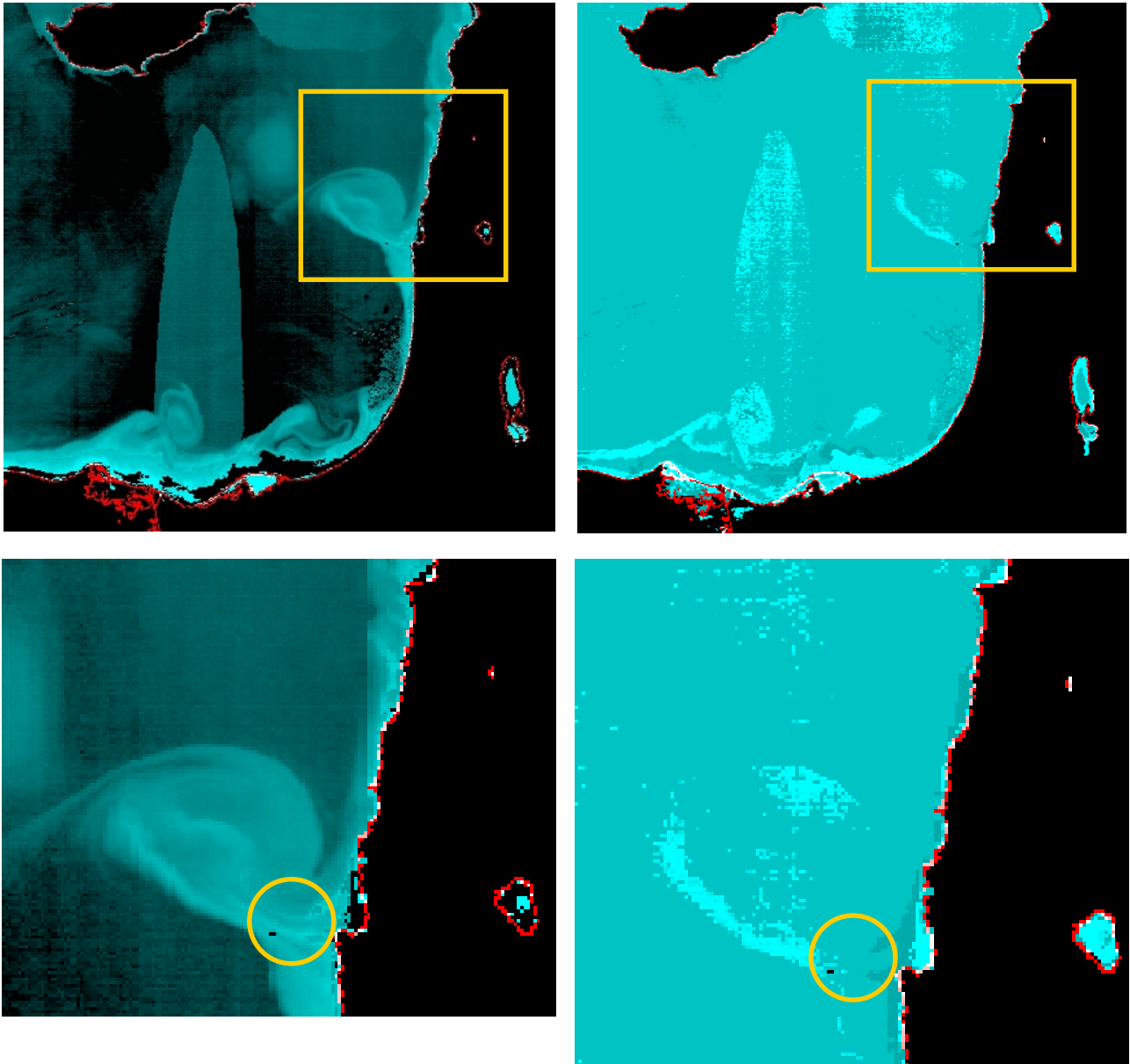


Fig. 5: Algal Pigment Index I (left column) and II (right column) derived from MERIS scene MER_RR_2PNACR20020731_075159_00000090X000_00121_02179_0000.N1_Israel, covering the Eastern Mediterranean. The orange circle indicates the area where concomitant *in situ* measurements have been performed.