Universidade Vigo
Applied Physics Dep.

# *Development and application of regionally specific chlorophyll a algorithms from MERIS data for the Galician (NW Spain) optically complex waters*

**Vagelis Spyrakos, Luis González & Jesús Torres**

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# Outline

1 → 2 → 3 → 4

- Background
- Development of regionally specific chlorophyll *a* algorithms
- Application of a regionally specific chlorophyll *a* algorithms during an upwelling cycle
- Conclusions

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# Motivations

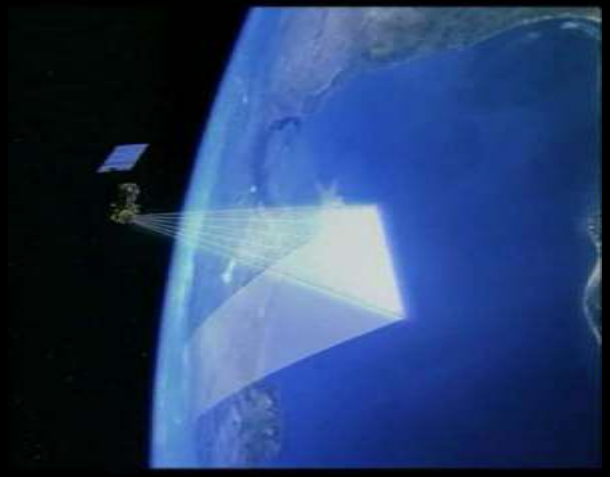
***¨A truly epidemic with little in common¨*** *Hallegraeff 1993*

## PSP



- nutrient overloading of the coastal waters
- reduction of grazers
- human-caused climate change
- improved monitoring methods

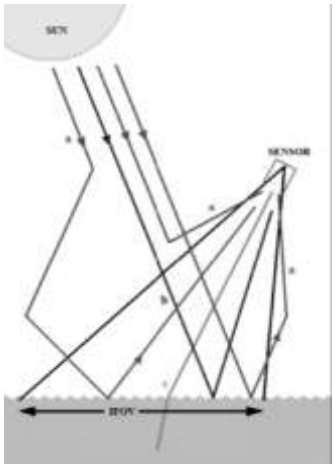
# Motivations



**Source:** European Space Agency

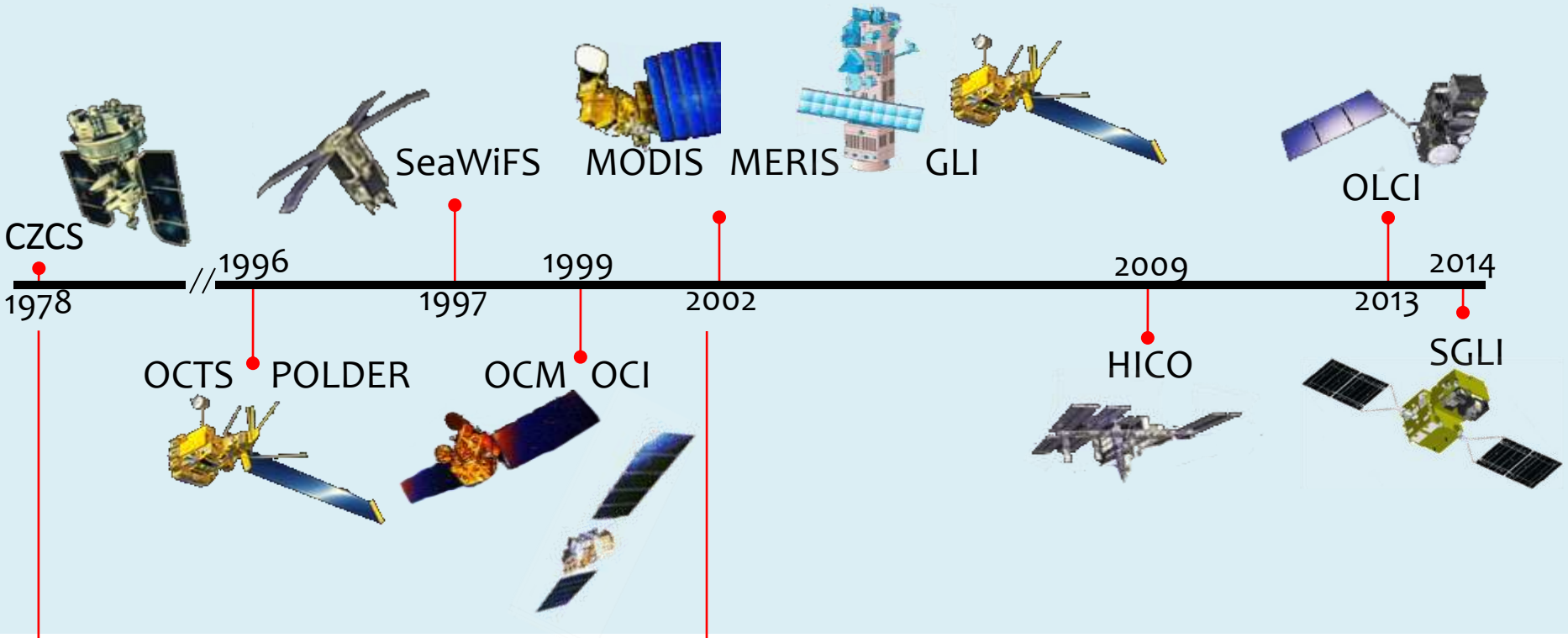
## Ocean colour

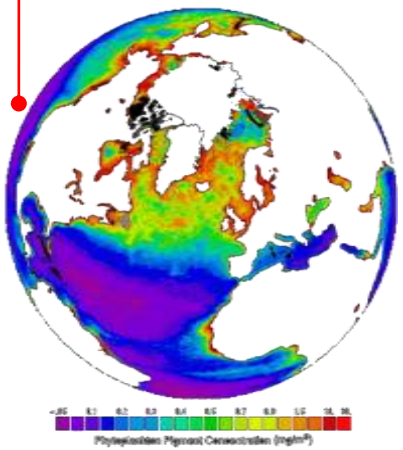
- loosely used to refer to the wavelength dependence of the water leaving radiances at the sea surface



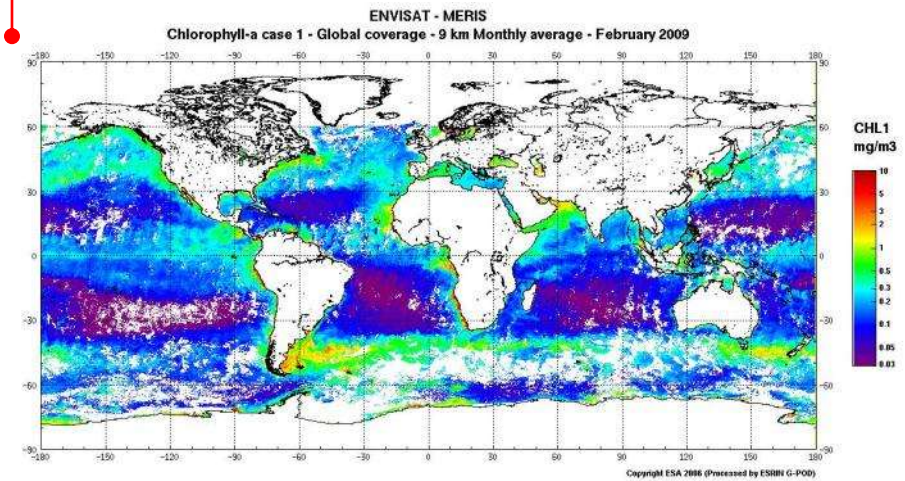

## Chl*a*

- most used ocean-colour derived product
- good estimation of phytoplankton biomass
- eutrophication status



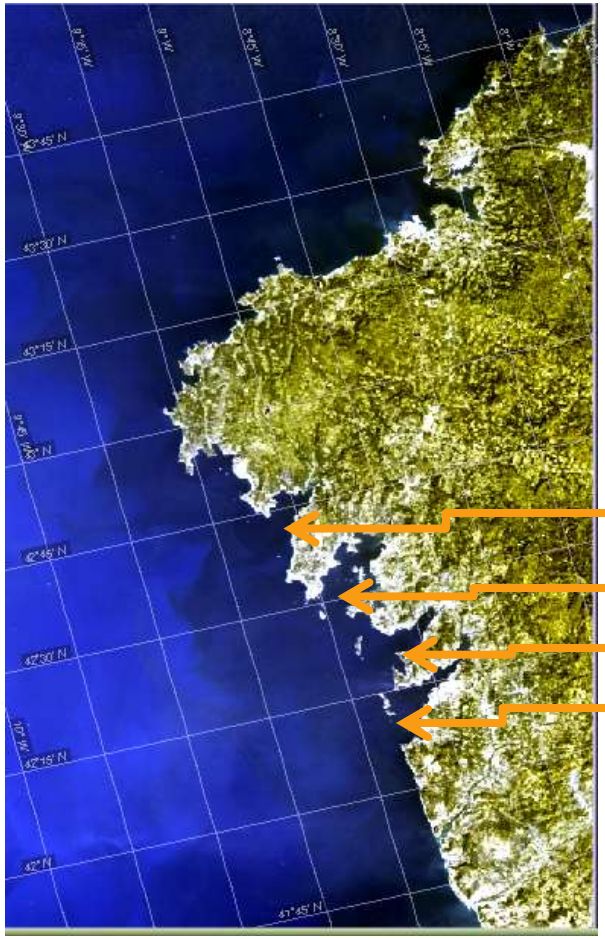
**Source:** NASA




**Source:** ESA

# Case study

## The Galician *rias*

- V-like coastal embayments
- more than 3200 suspended mussel rafts
- more than 240 $10^6$ kg of mussel per year

*ria de Muros*

*ria de Arousa*

*ria de Pontevedra*

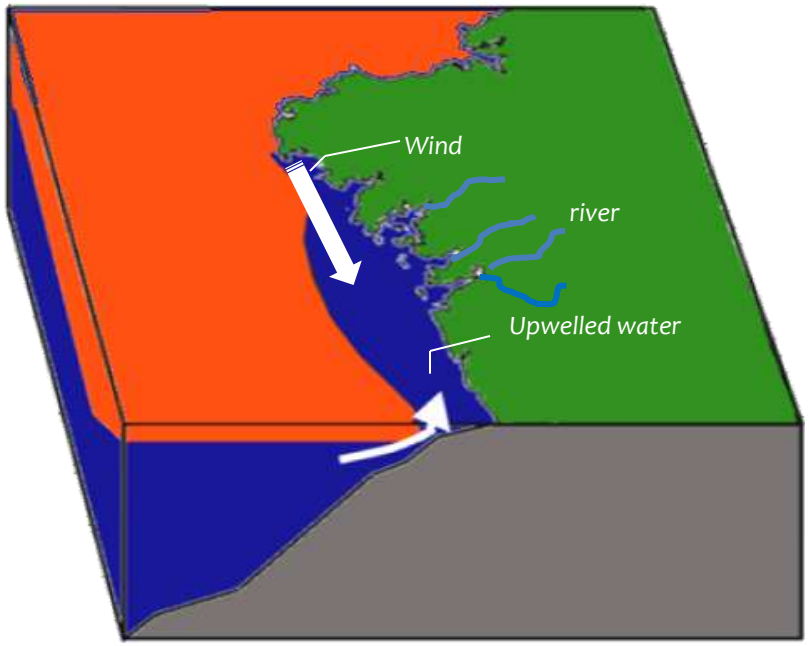
*ria de Vigo*

**Rias Baixas**

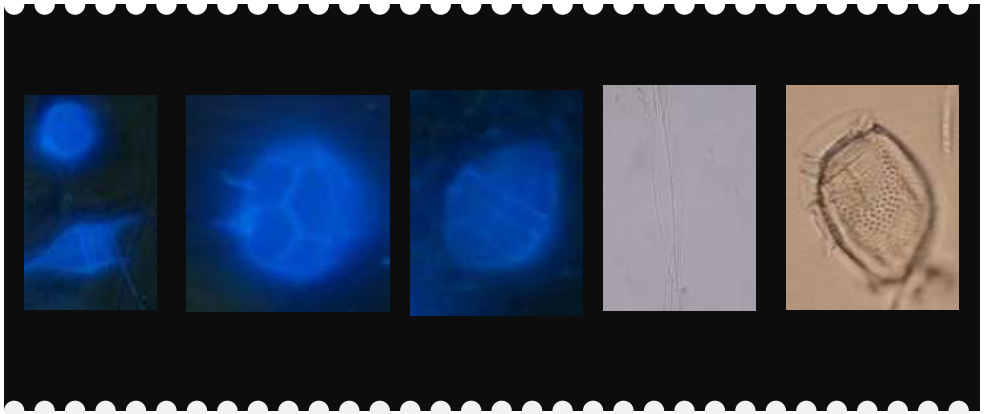
Case study

# The Galician *rias*

## Upwelling-freshwater inputs:

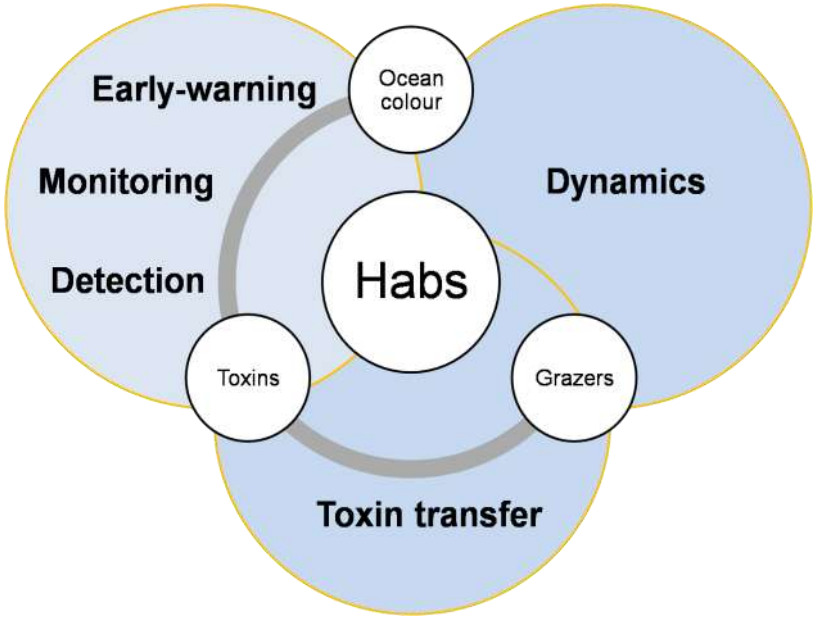


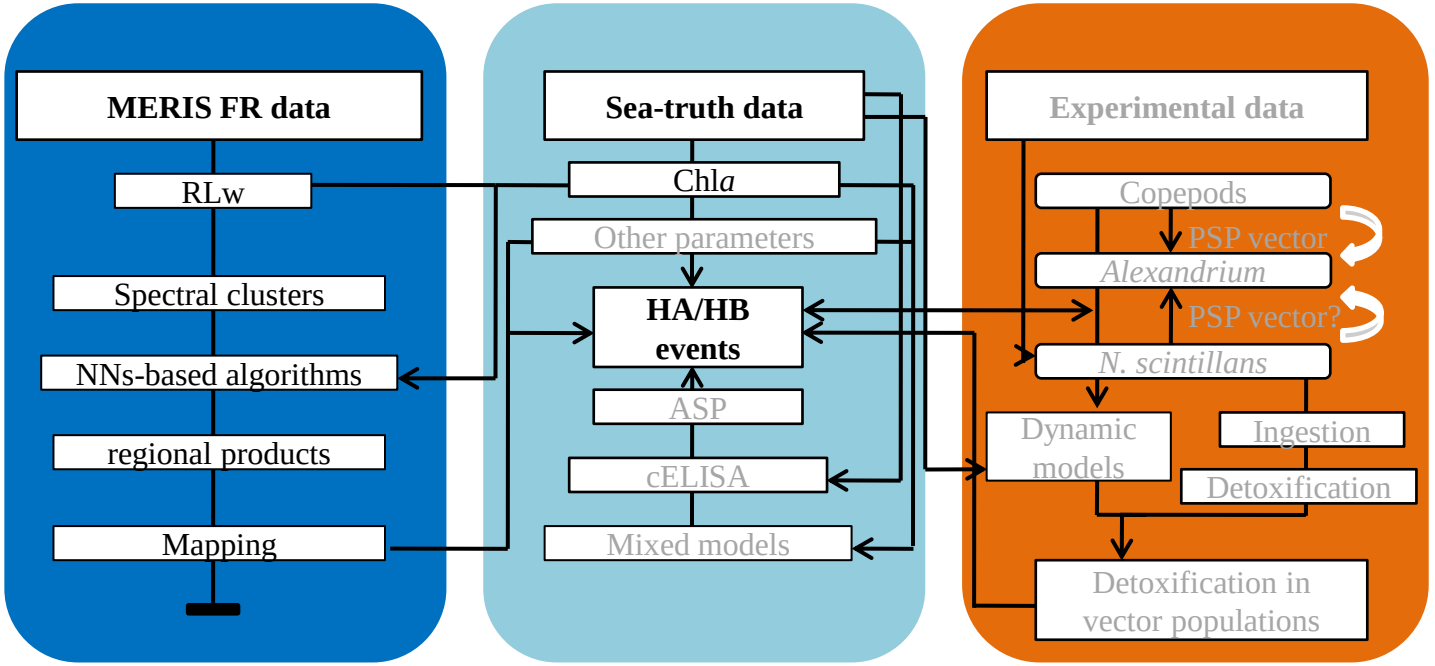

## Harmful algal events:



- *Pseudo-nitzschia* spp.
- *Dinophysis acuminata* and *D. acuta*
- *Gymnodynium catenatum*
- *Alexandrium minutum*
- *Noctiluca scintillans*
- *Ceratium furca*

# Harmful Algal Events — Towards multi-disciplinary approach



# Outline

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- Motivations and objectives
- Development of regionally specific chlorophyll *a* algorithms
- Application of a regionally specific chlorophyll *a* algorithms during an upwelling cycle
- Conclusions

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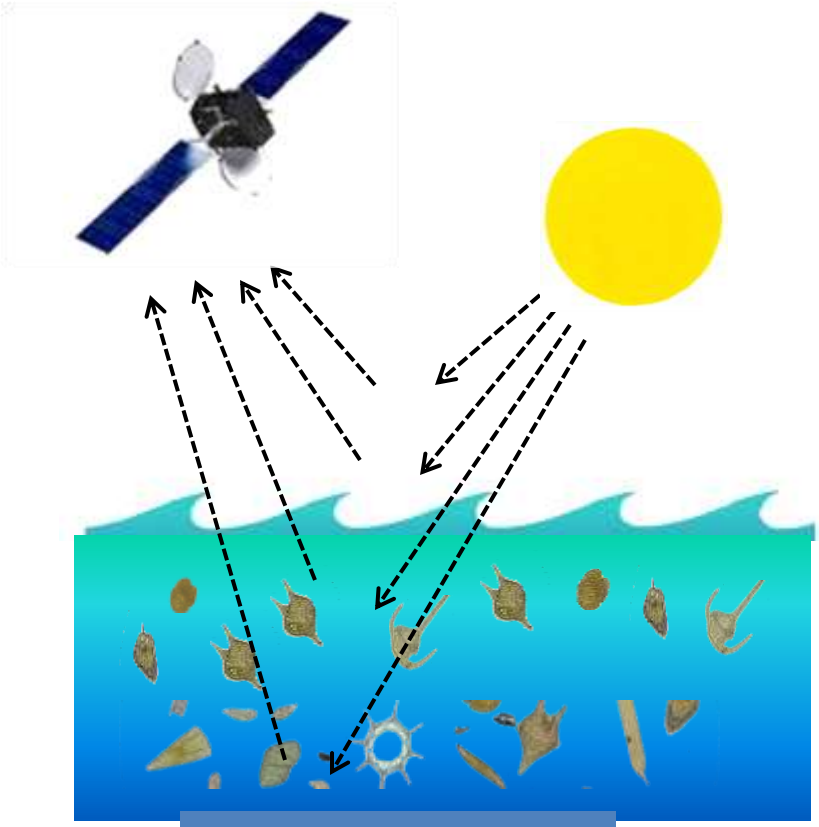
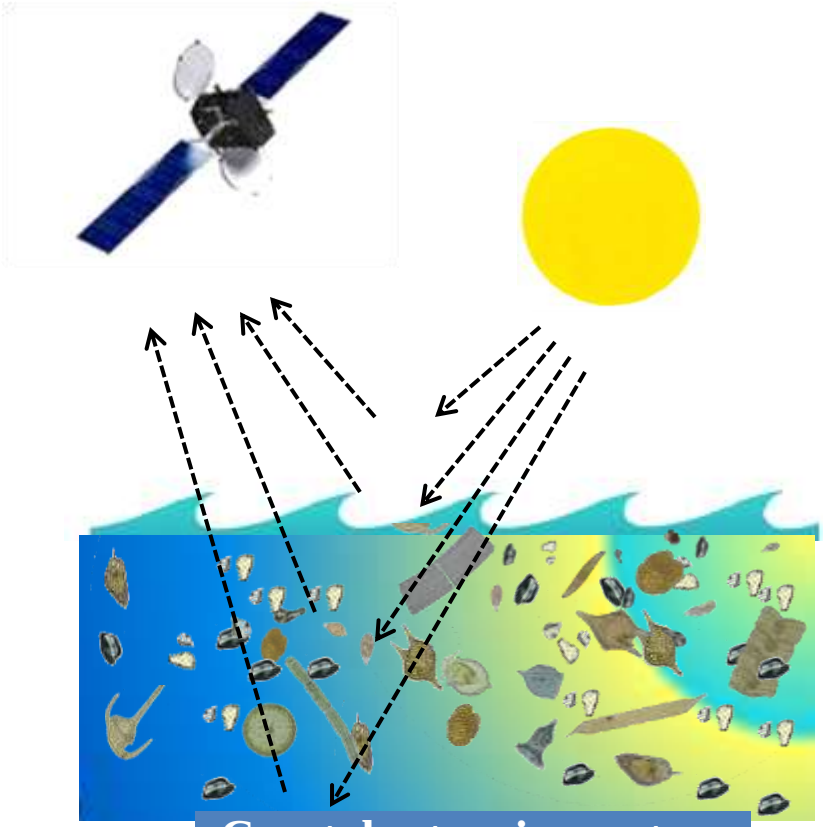
# Background

## Water composition for oceanic and coastal waters



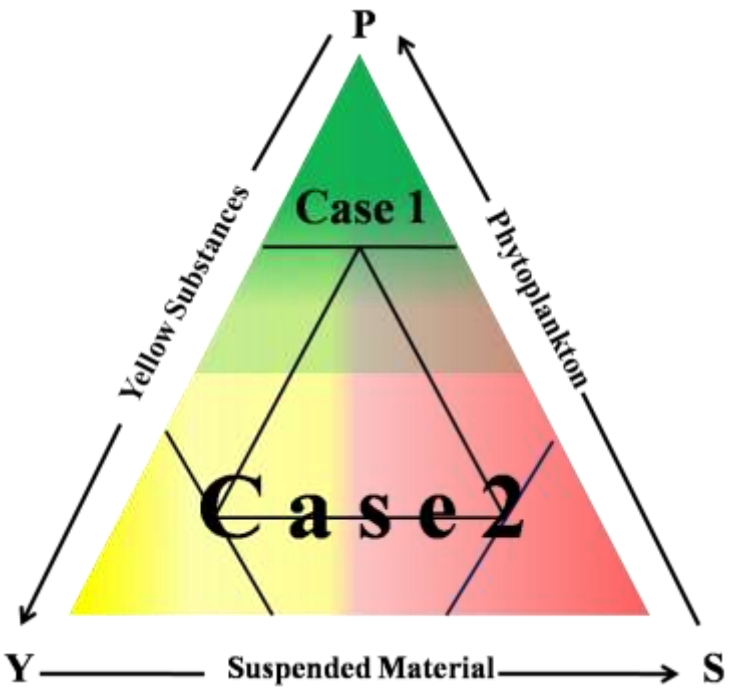
**Oceanic waters**
**CASE 1**
**phytoplankton**



**Coastal estuarine waters**
**CASE 2**
**Phytoplankton**
**CDOM**
**Suspended sediments**

# Background

## Methods for the remote sensing retrieval of Chl *a*




**Model – based methods**

**Neural network analysis**

**Empirical approaches**

# Motivation & Objectives

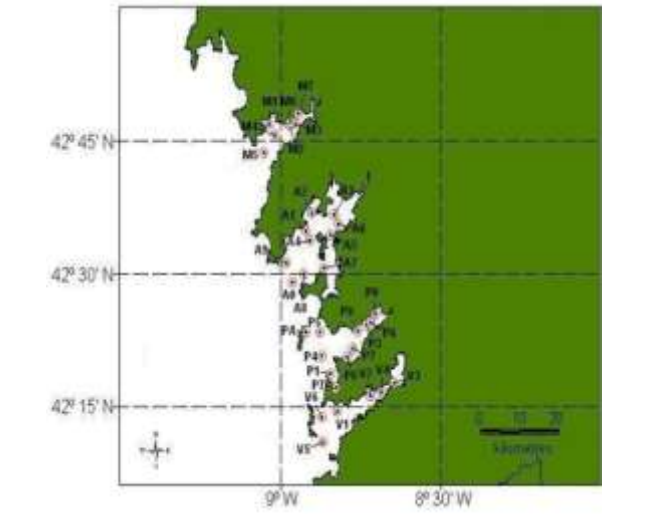
**Following** the widespread understanding that universally applicable water constituent retrieval algorithms from ocean colour sensors are currently not feasible in coastal waters

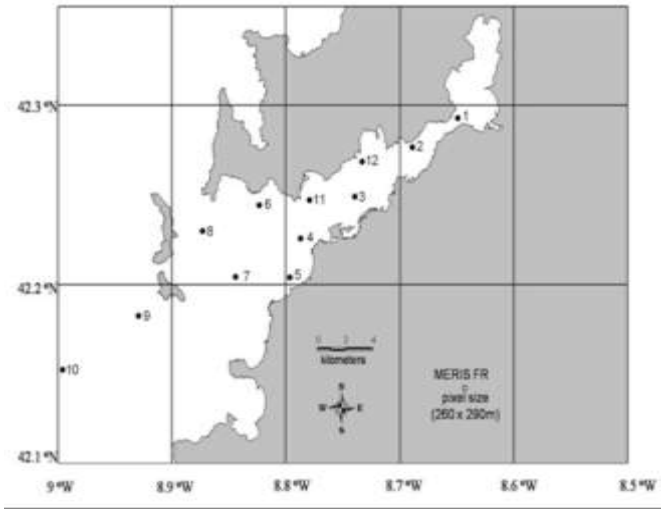
- develop and validate neural network-based chl*a* algorithms from MERIS FR data specific for the optically complex coastal waters of the Galician *rias*.

- test the performance of the algorithms in comparison to other which routinely used for MERIS data

# Methodology & Data

## The *in – situ* data set

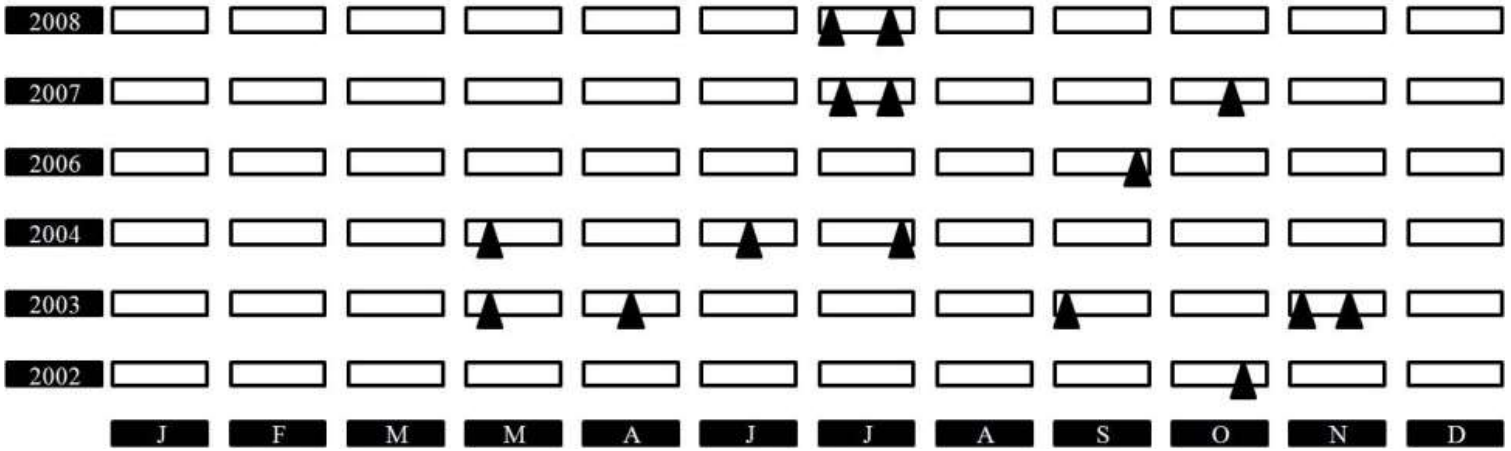


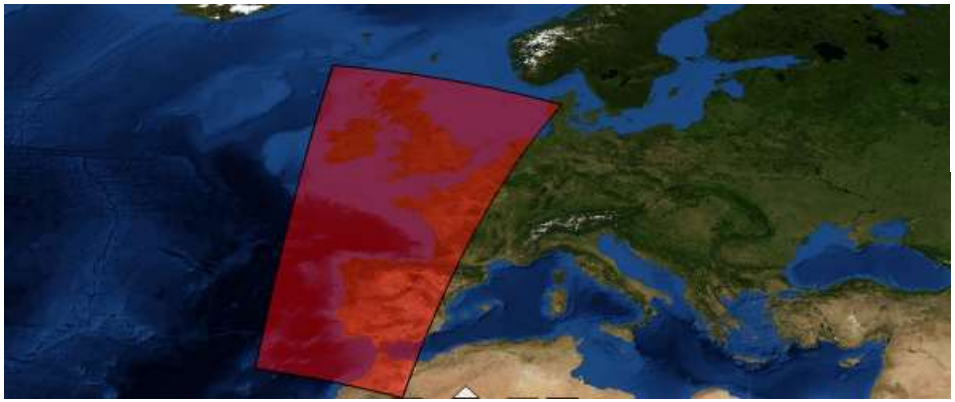

| Data set | Period | *Ria* | *n* | Range (mg m $^{-3}$) |
|---|---|---|---|---|
| INTECMAR monitoring programme | 2002-2004 | Muros y Noya (7), Arousa (10), Pontevedra (11), Vigo (6) | 181 | 0.13-7.94 |
| ECOSUMMER project | 2007-2008 | Vigo (12), Arousa (1) | 46 | 0.03-6.23 |

# Methodology & Data

## MERIS data set



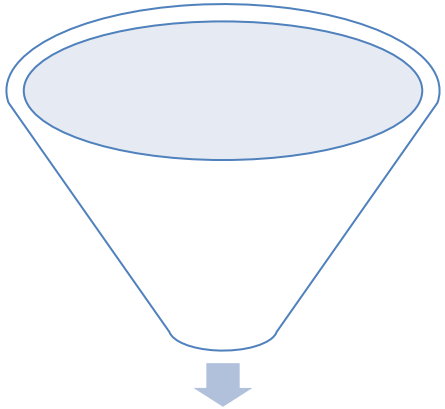

**15 MERIS (FR) images**
**15 match-ups**
**227 chla data match-up**

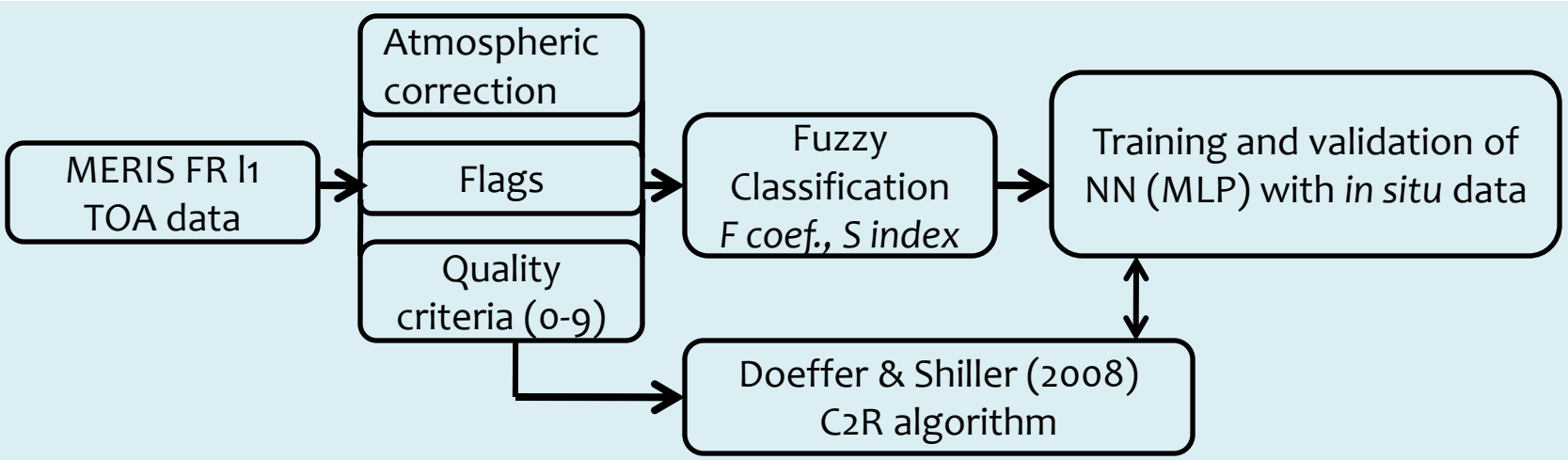


**AO 623 project**
**ENVISAT**

# Methodology & Data

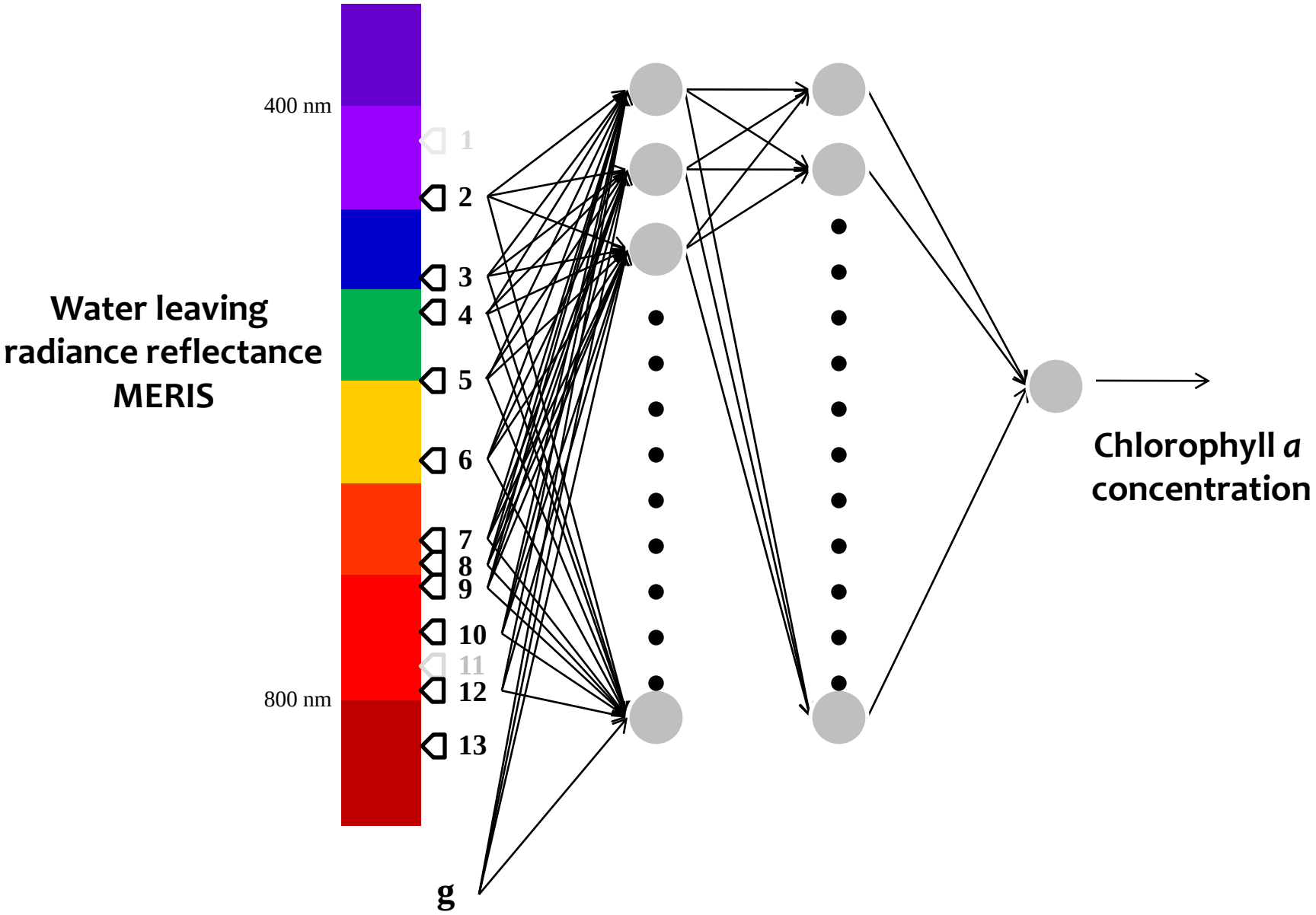
## Data process





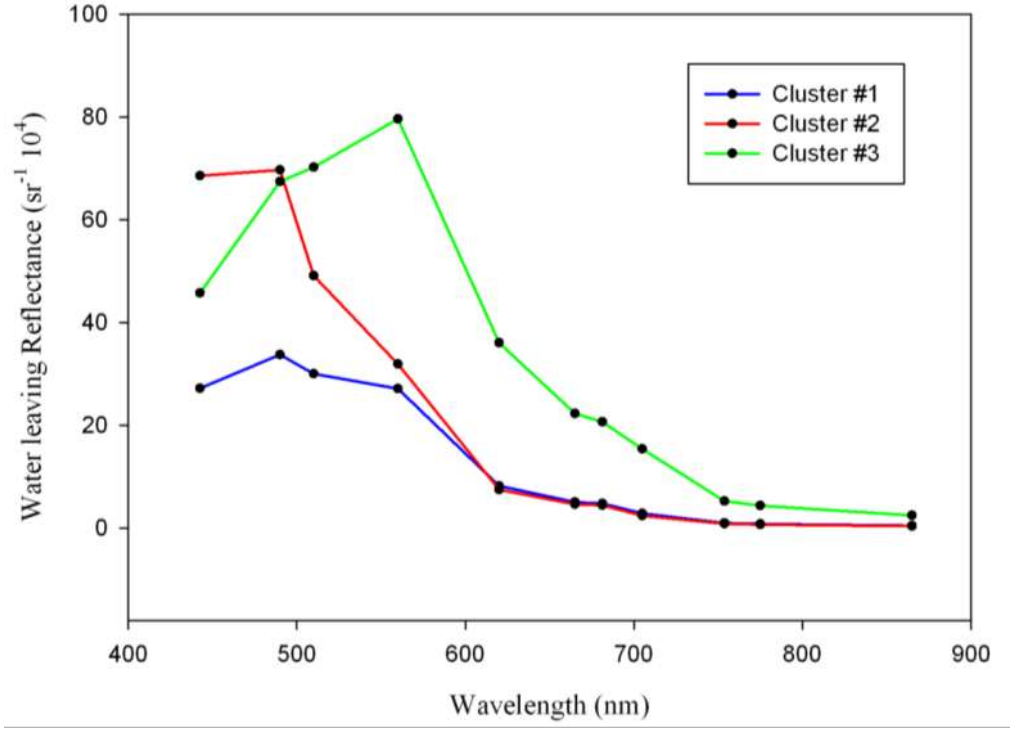
# Methodology & Data

## The MLP ANN Model



# RESULTS

## FCM

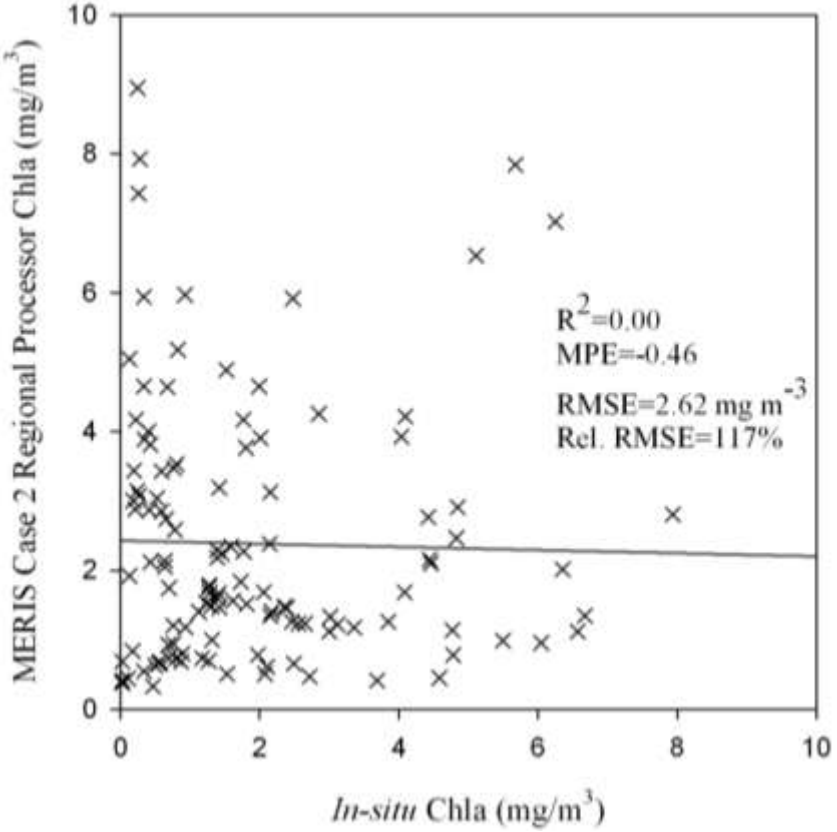



- Cluster#1 → Chl*a* range: 0-7.9 mg m$^{-3}$, n=119
- Cluster#2 → Chl*a* range: 0.2-3 mg m$^{-3}$ /blue waters, n=23
- Cluster#3 → Chl*a* range: 0.3-1.5 mg m$^{-3}$ /atmospheric aerosol, n=8

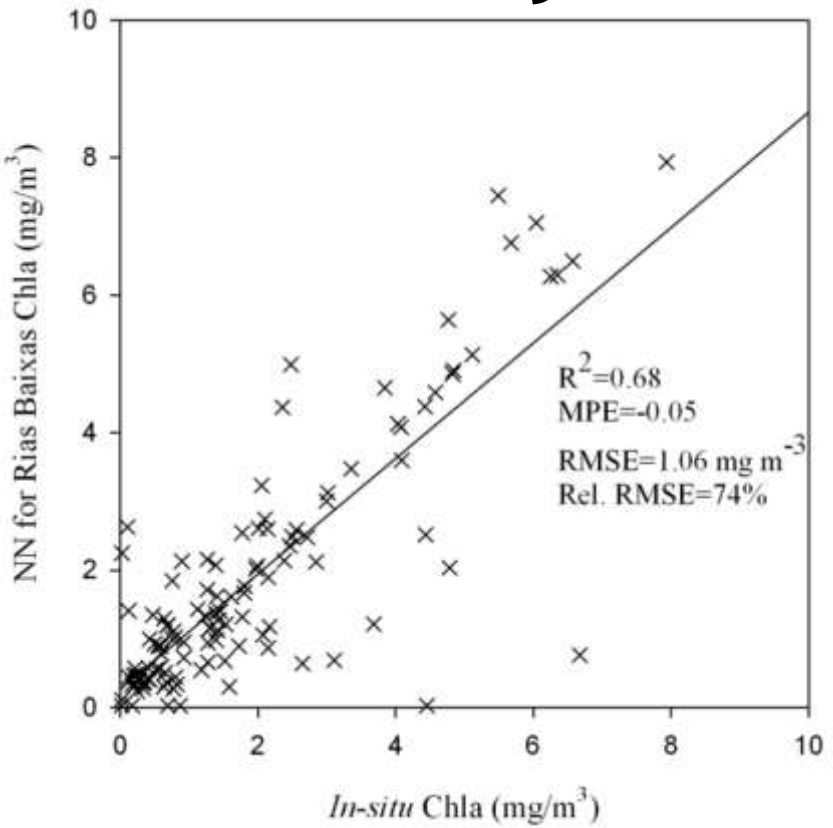
# RESULTS

## Evaluation of model derived chl*a* data

### C2R




### NNRB#3



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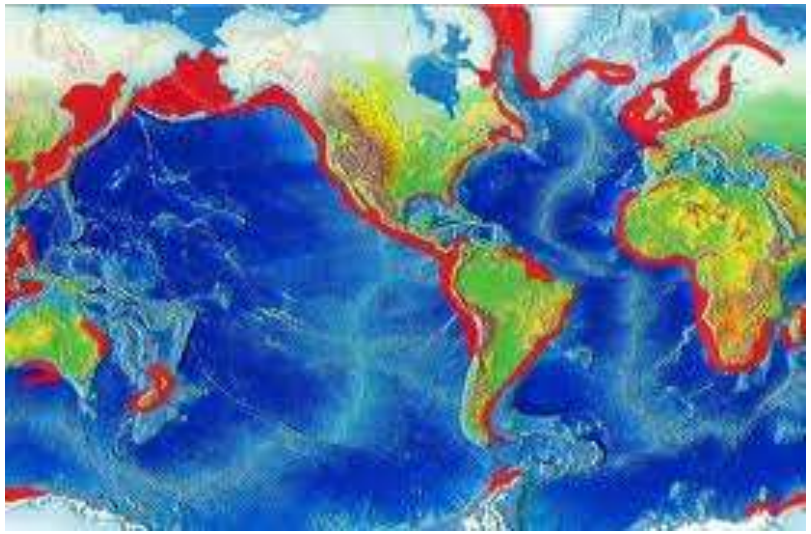
# Background

## Coastal upwelling areas:

- 1% of the ocean surface but they support 50% of the worlds fisheries



- Remote sensing tools are not always totally accurate in **local areas** and highly dynamic systems such upwelling regimes

## Galician coast:

- Previous ocean colour studies by satellite sensors (CZCS, SeaWiFS, MODIS) in the study area are consider problematic

# Motivation & Objectives

**Given** the considerable interest for accurate chlorophyll *a* mapping in the optically complex waters of the study area

- apply regionally specific chl*a* algorithms to MERIS (FR) images during an upwelling cycle
- test the potential of these algorithms to map the spatial extent of possible algal blooms caused by coastal upwelling

# Methodology & Data

## *In-situ* data

**Two Campaigns in 2008**

- chl*a*
- total suspended material
- Secchi disk depth

## Oceanographic and meteorological data

**Seawatch buoy**

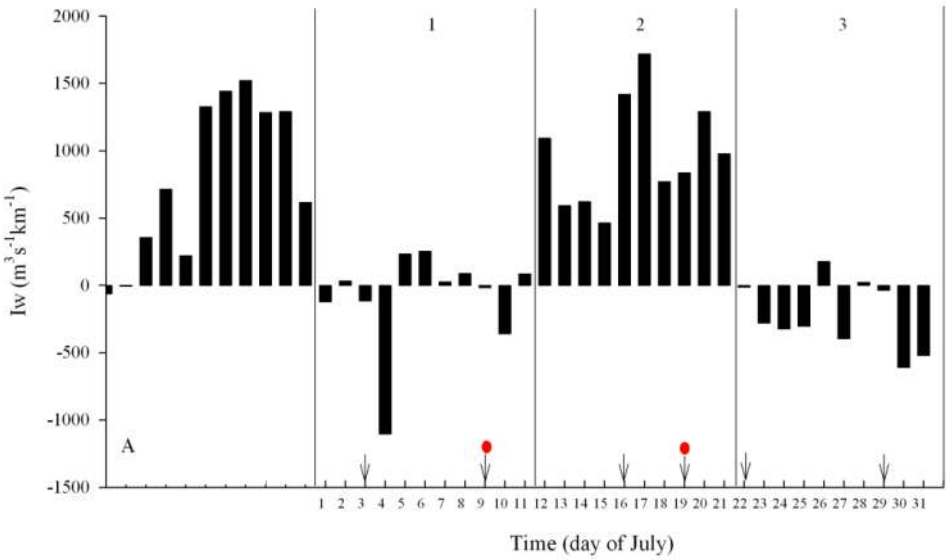
- wind speed → Upwelling index
- wind direction → Upwelling index
- currents
- water temperature

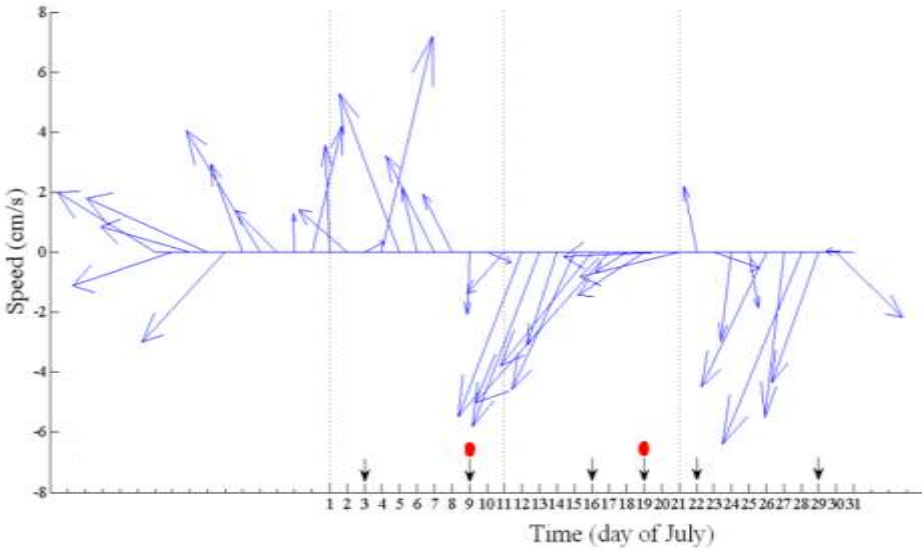
## Satellite data

- MODIS
- MERIS FR → NNRB
- MERIS FR → C2R

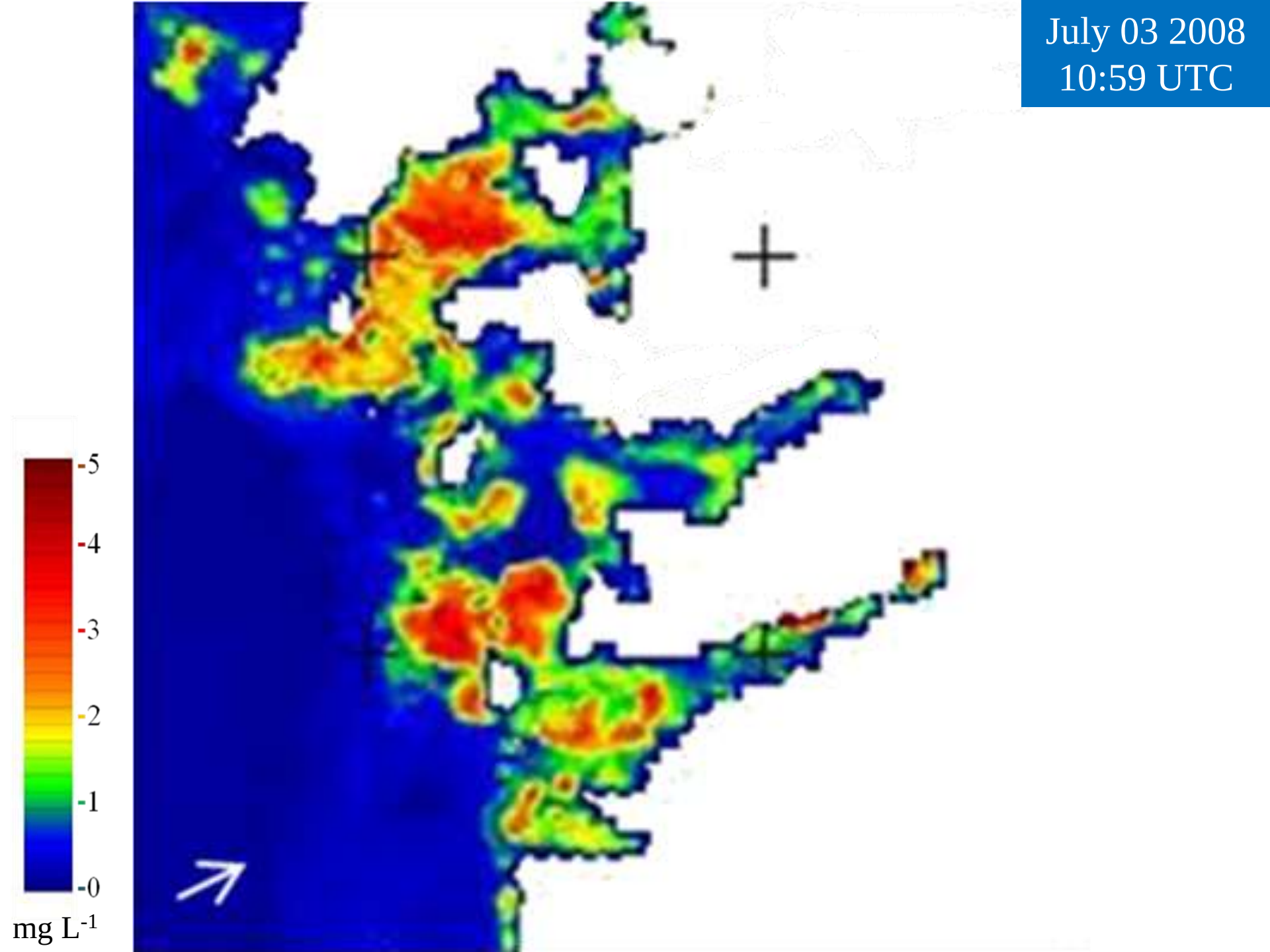
# RESULTS

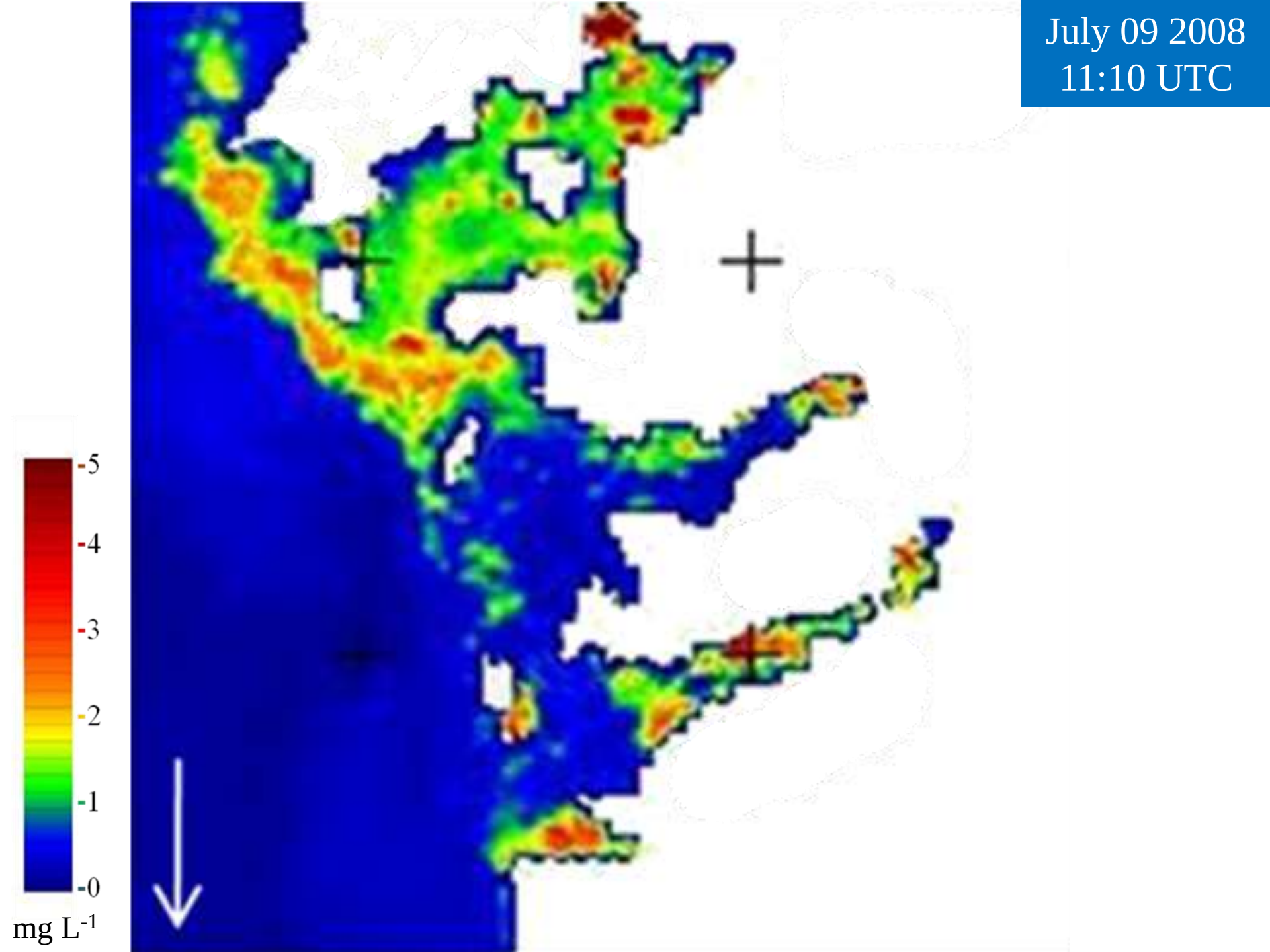
## Upwelling cycle July 2008

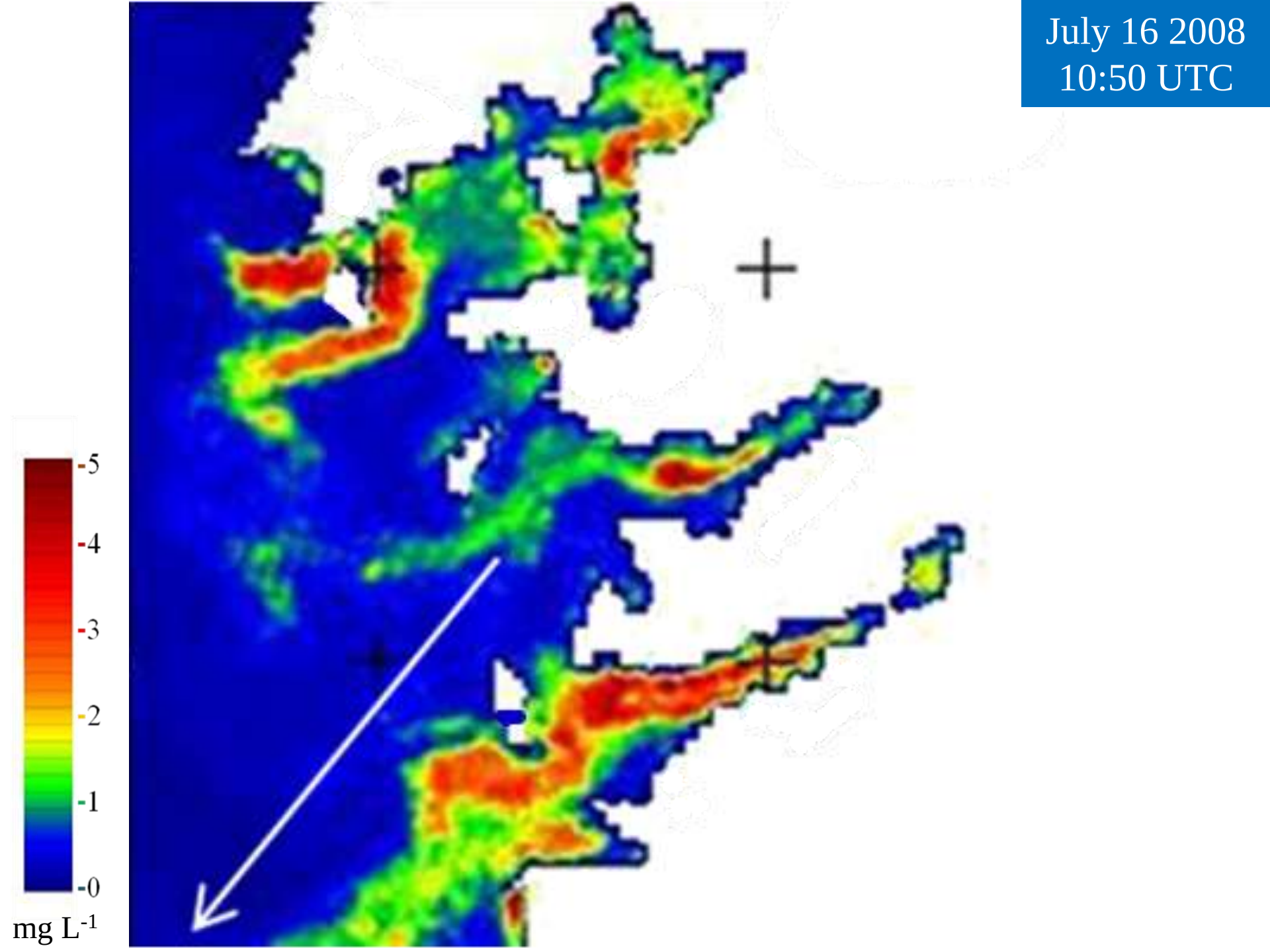


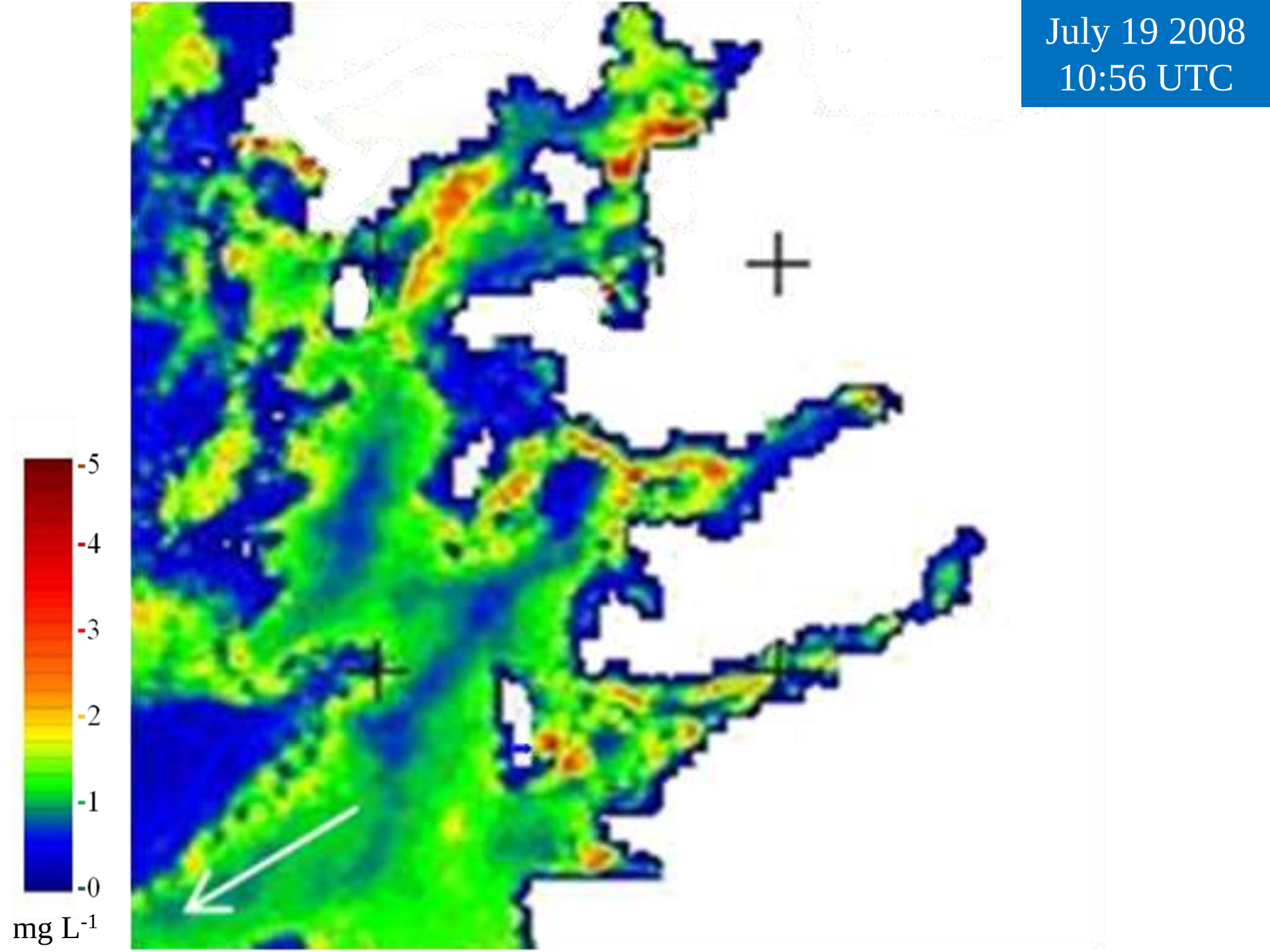



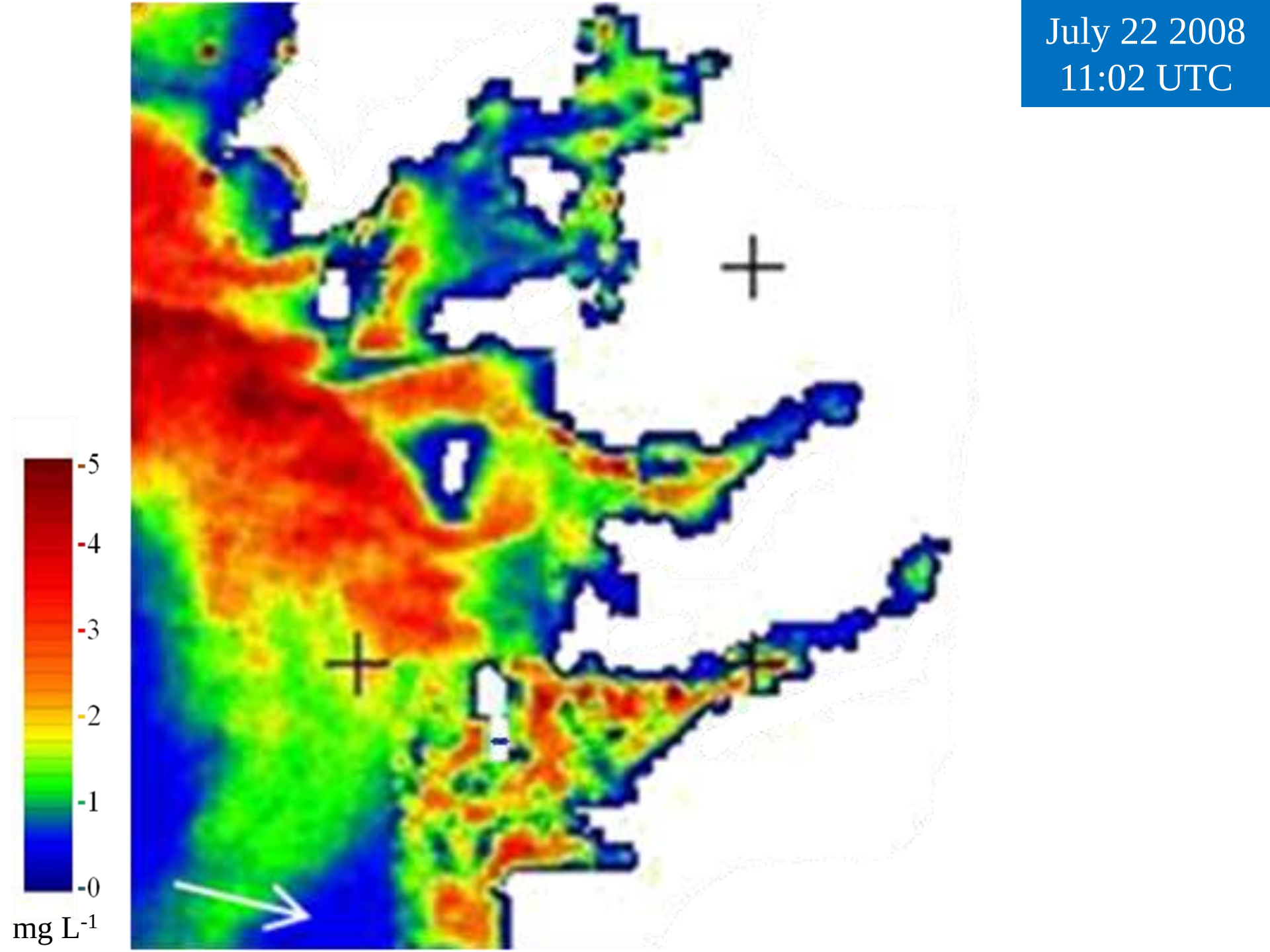

| State | Date | Dominant atmospheric and oceanographic conditions off Rias Baixas |
|---|---|---|
| 1 | 1-10 July | changing direction winds (Iw=-108) after a period of favourable upwelling winds, mostly northward surface flow |
| 2 | 11-21 July | strong north winds (Iw=900), southward transport |
| 3 | 22-31 July | mainly south blowing winds (Iw=-230), southward surface flow |

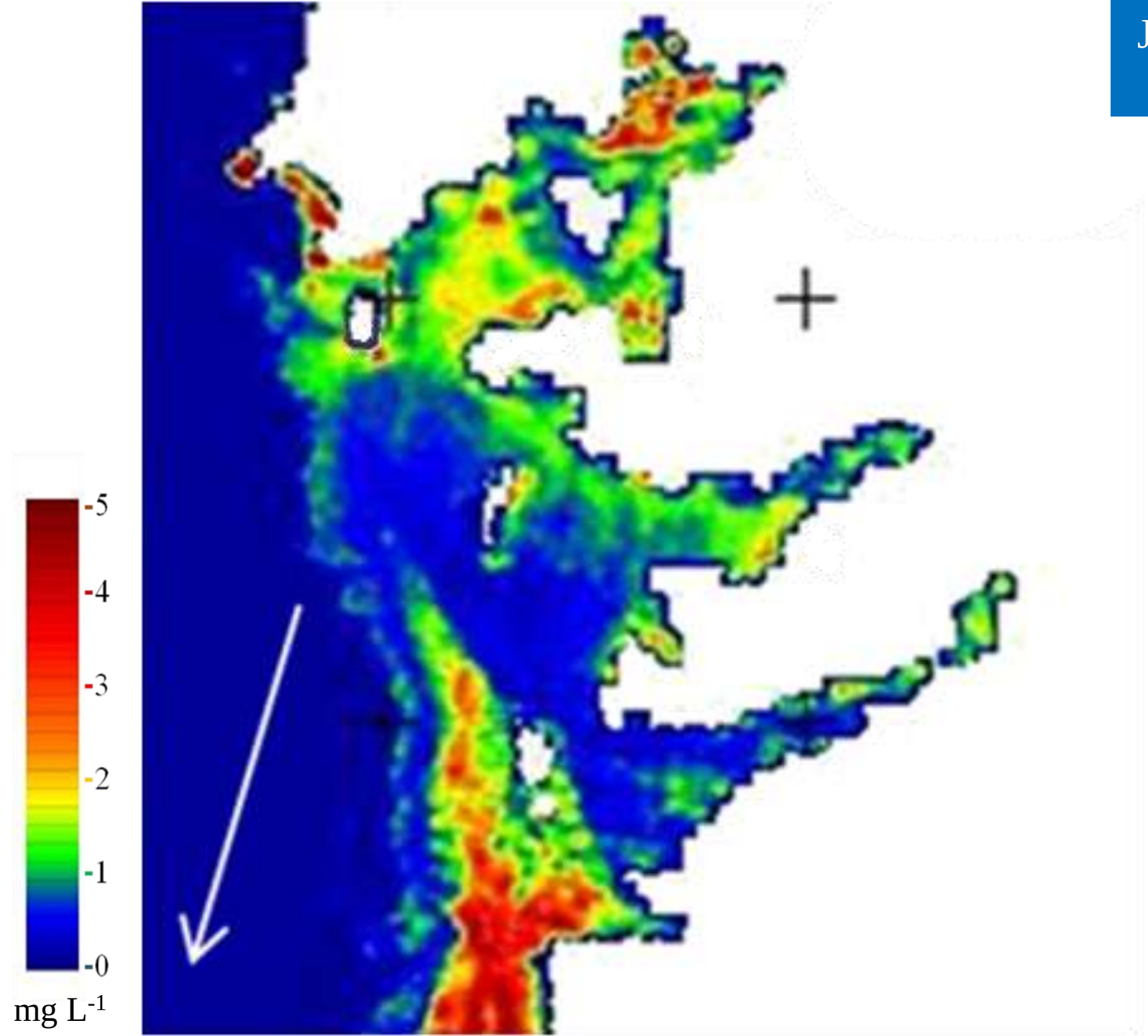

July 03 2008
10:59 UTC
5
4
3
2
1
0
mg L-1

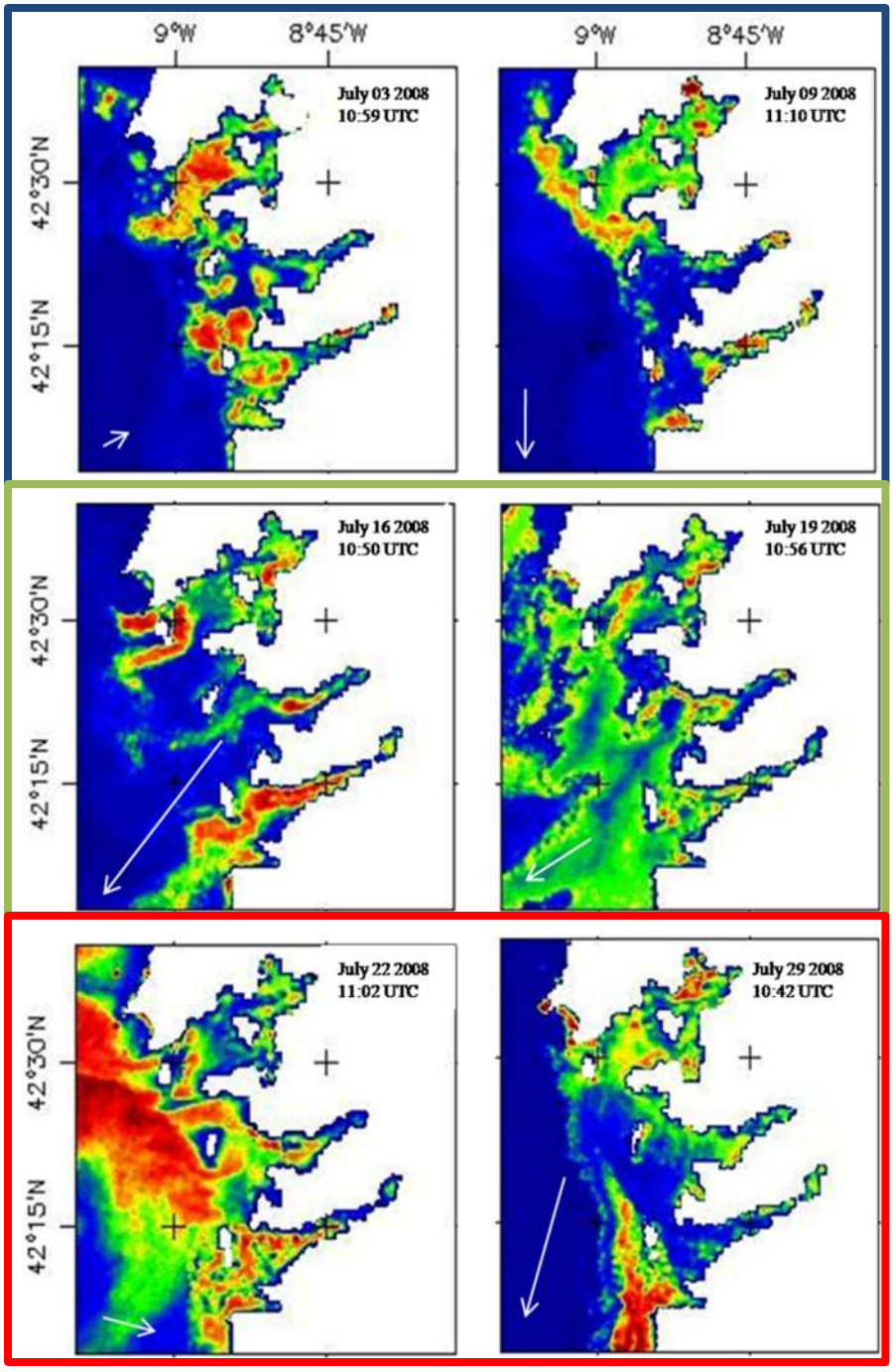

July 09 2008
11:10 UTC
-5
-4
-3
-2
-1
-0
mg L-1


July 16 2008
10:50 UTC
5
4
3
2
1
0
mg L-1


July 19 2008
10:56 UTC
-5
-4
-3
-2
-1
-0
mg L-1


July 22 2008
11:02 UTC
5
4
3
2
1
0
mg L-1


July 29 2008
10:42 UTC
5
4
3
2
1
0
mg L-1




# State 1

- several high chl*a* patches
- phytoplankton biomass principally confined in the *rias*

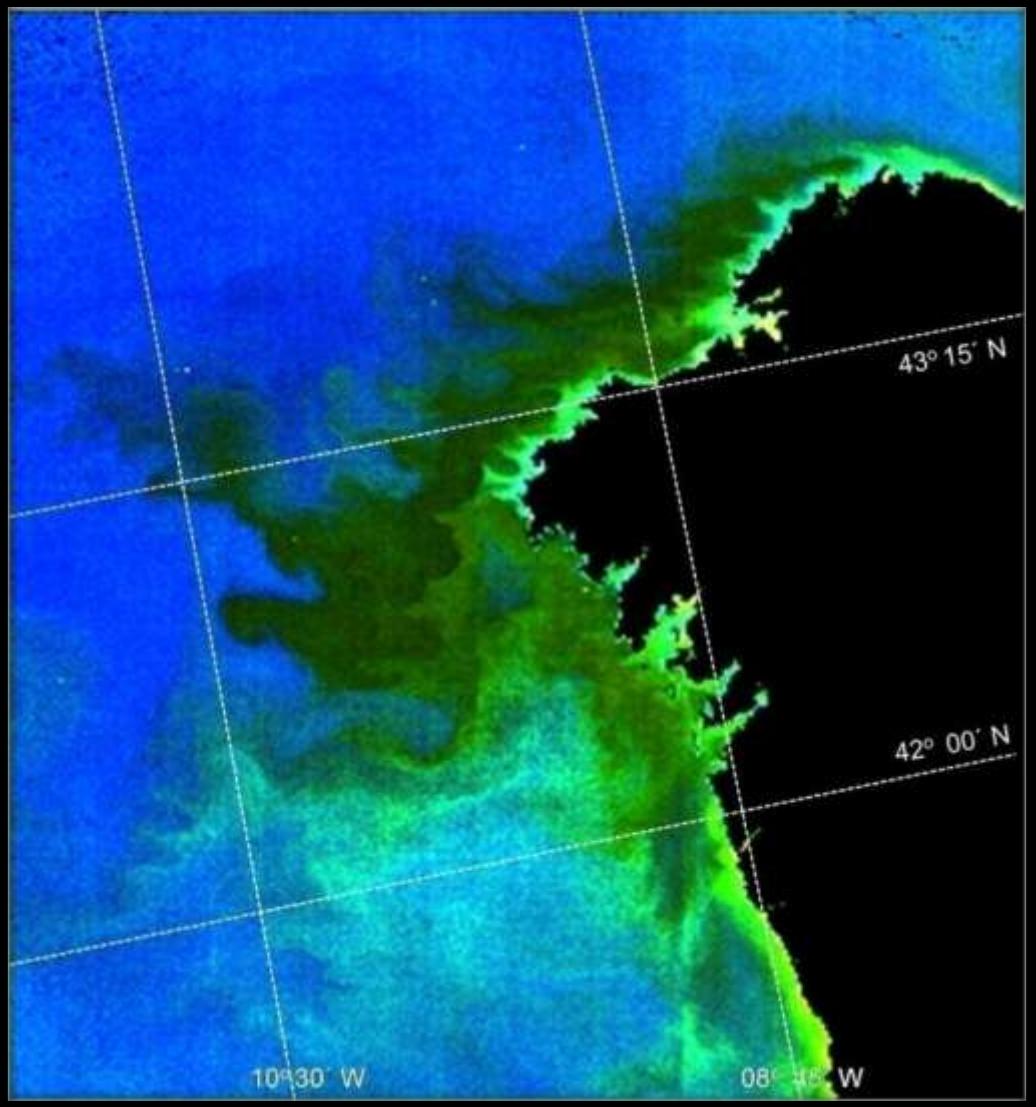
# State 2

- primary results of the upwelling favourable winds
- positive estuarine circulation

# State 3

- high chl*a* concentration originated from the offshore area
- the remains of the high biomass filament appeared in the southern part

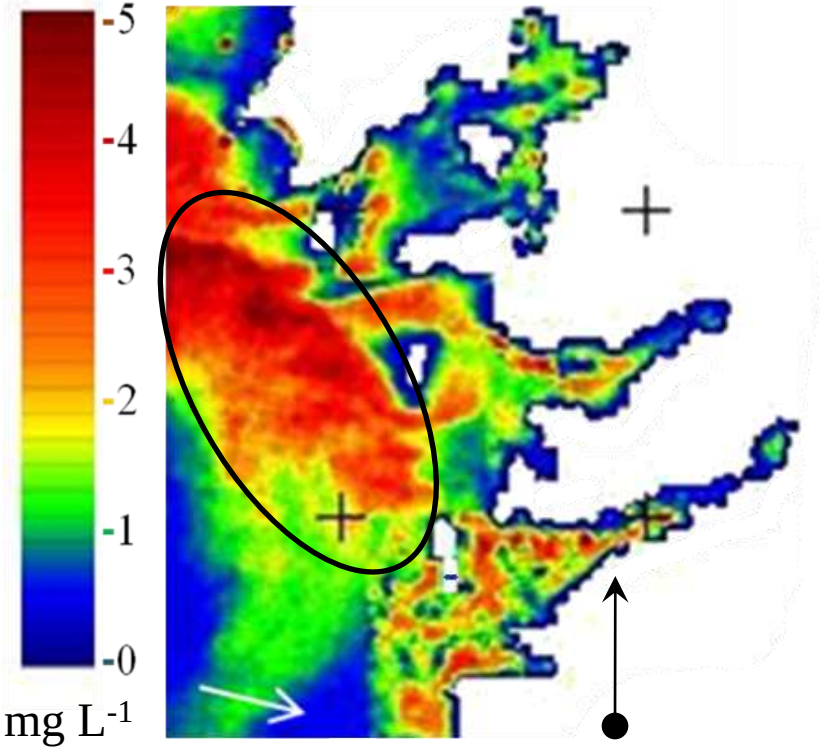
July 22 2008



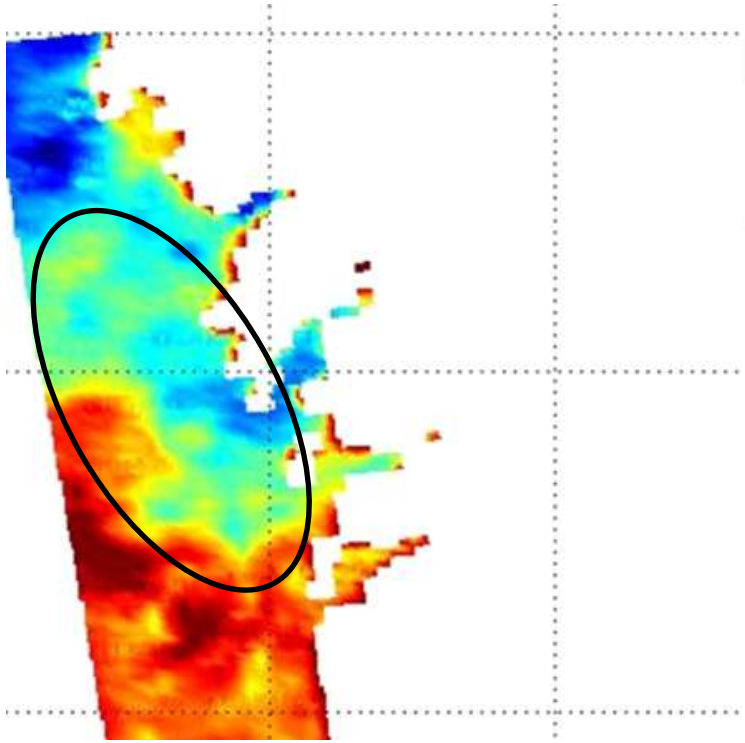
# RESULTS

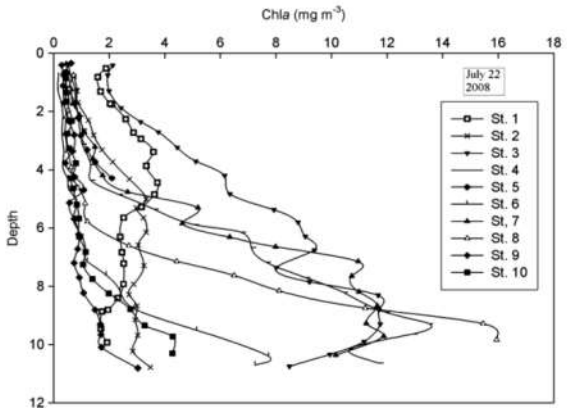
## A HB event

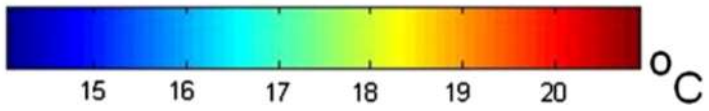
### MERIS FR NNRB chl*a*- July 22 2008 11:01




### MODIS SST- July 22 2008 14:10





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# CONCLUSIONS

1. A set of chl*a* algorithms was developed from MERIS FR data specifically for the optically complex waters of the Galician *rias* and the adjacent area. These algorithms performed better than C2R, which is routinely used for MERIS images in Case 2 waters. The algorithm proposed here as adequate for chl*a* mapping is the NNRB#3. Its scope is defined by the FCM results and the chl*a* concentrations.

2. The application of an algorithm specially developed for the study area provided for the first time, to our knowledge, surface chl*a* mapping of the *rias Baixas*.

3. The present study allows more detailed examination of the chl*a* distribution and detection of high biomass "patches" in the area during a summer upwelling cycle due to the finer spatial resolution and precise atmospheric correction offered by MERIS and the application of the local specific algorithms. This can be of great help in the chl*a* monitoring in any coastal upwelling area providing high-quality near real-time ch*a* maps and showing possible and actual harmful algal events.

# References:


- E. Spyrakos, L. González Vilas, J. Torres Palenzuela & E. D. Barton, 2011: Remote sensing chlorophyll a mapping of optically waters (rías Baixas, NW Spain): Application of a regionally specific chlorophyll *a* algorithm for MERIS full resolution data during an upwelling cycle. *Remote Sensing of Environment*
- L. González Vilas, E. Spyrakos & J. Torres Palenzuela, 2011: Neural network estimation of chlorophyll a from MERIS full resolution data for the coastal waters of Galician rias (NW Spain). *Remote Sensing of Environment*
- E. Spyrakos, E. Garet, Á. González-Fernández & J. Torres Palenzuela 2011: Remote sensing, in situ monitoring and environmental perspectives of toxic *Pseudo-nitzschia* events in the surface waters of two Galician *rias* (NW Spain). *Harmful Algae*
- E. Spyrakos, T. Santos-Diniz, G. Martinez-Ingesias, J. Torres Palenzuela & G. J. Pierce, 2011: Marine mammal distribution in Galician waters in relation to environmental parameters. *Hydrobiologia*
- E. Spyrakos, M. Frangópulos, A. Barreiro & C. Guisande, 2012: Modelling PST transfer and accumulation in two planktonic grazers. *Harmful Algae*
- M. Frangópulos, E. Spyrakos & C. Guisande, 2011: Ingestion rates of the heterotrophic dinoflagellate Noctiluca scintillans fed on the toxic dinoflagellate Alexandrium minutum (Halim). *Harmful Algae*


# Thank you for your attention!

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