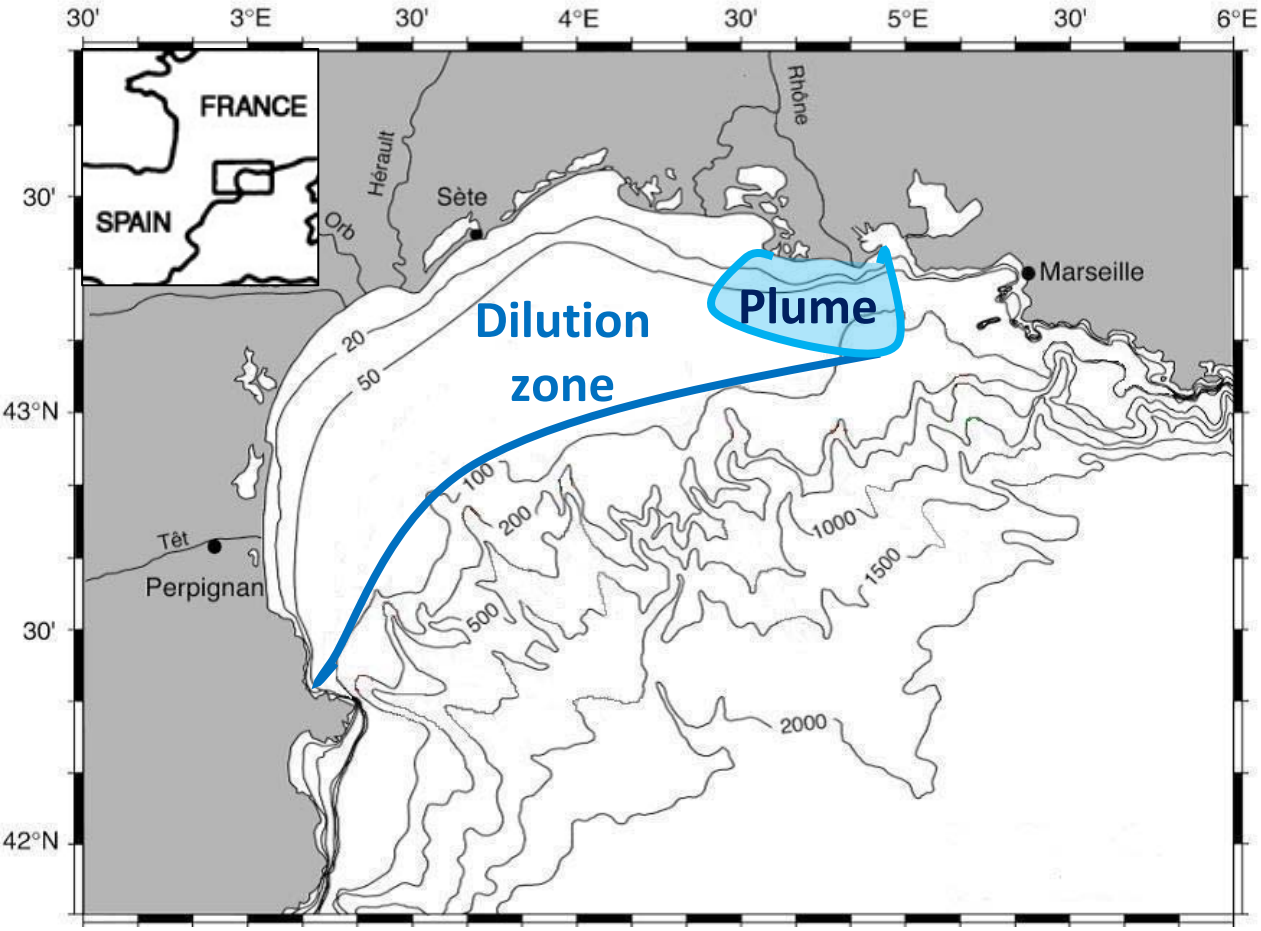
3D coupled physical-biogeochemical modelling in a coastal area: Study of Rhone River diluted water intrusion in Marseille's Bay

Fraysse M., Pairaud I.L., Faure V. and Pinazo C.

Projects : Massilia - MERMEX - GIRAC - PERSEUS

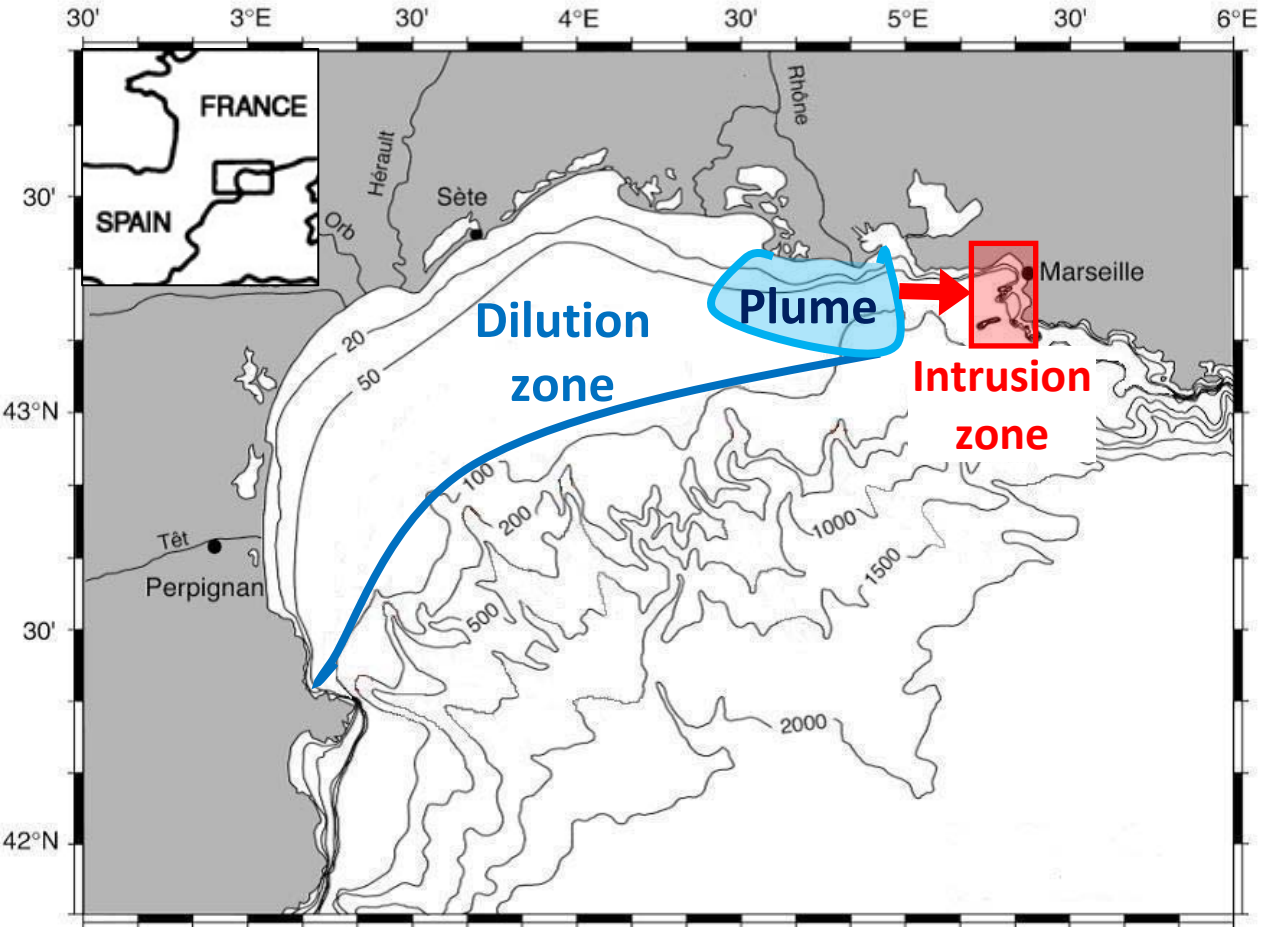
Study area : **Rhône - Marseille**



- Rhone River is the largest input of nutrients in Mediterranean Sea *(Sempere et al, 2000)*

- Marseilles Bay is mainly oligotrophic

Study area : **Rhône - Marseille**



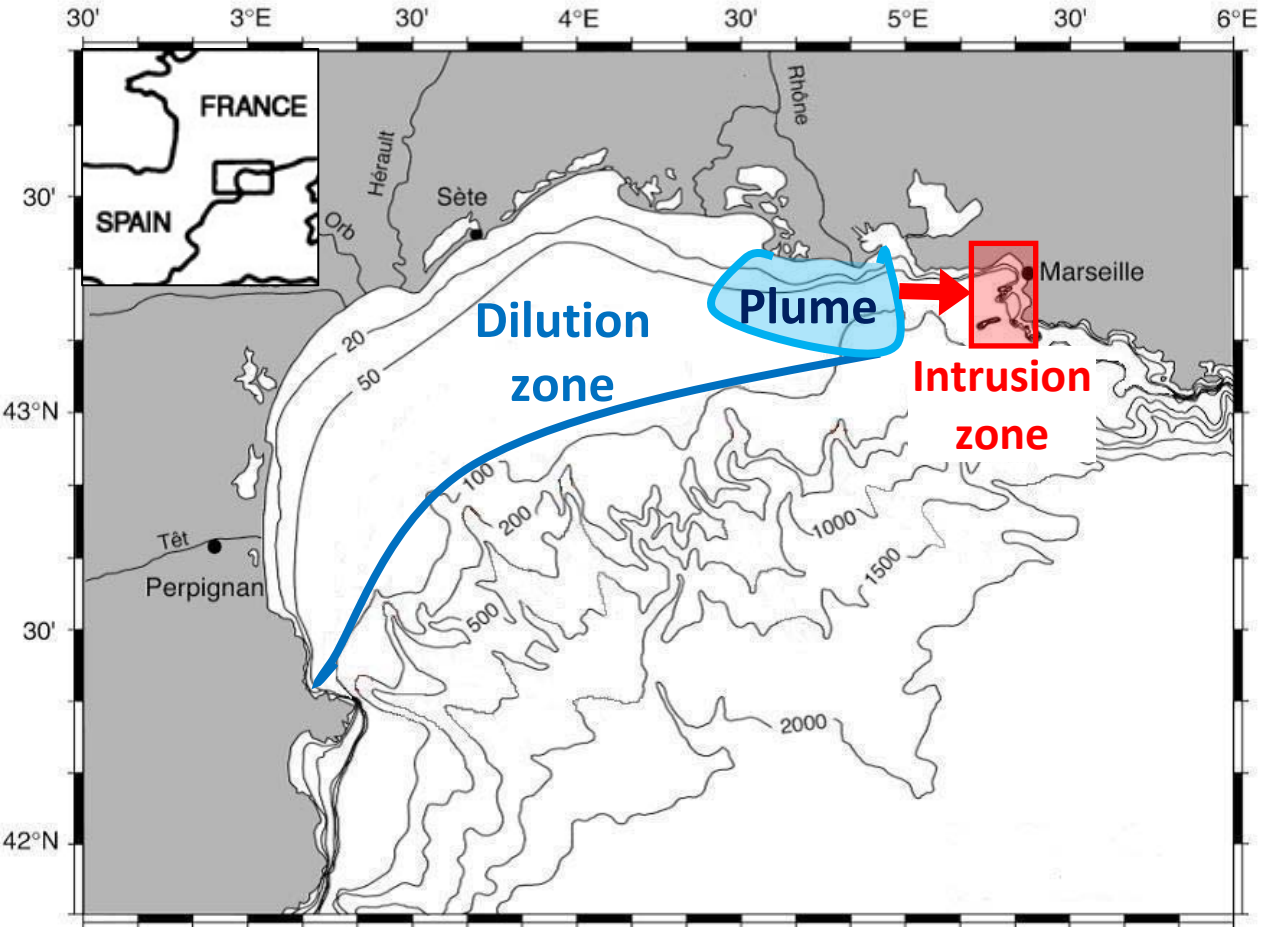
Intrusion in literature :

Gatti et al, 2008

Para et al, 2010

Pairaud et al, 2011

Study area : **Rhône - Marseille**

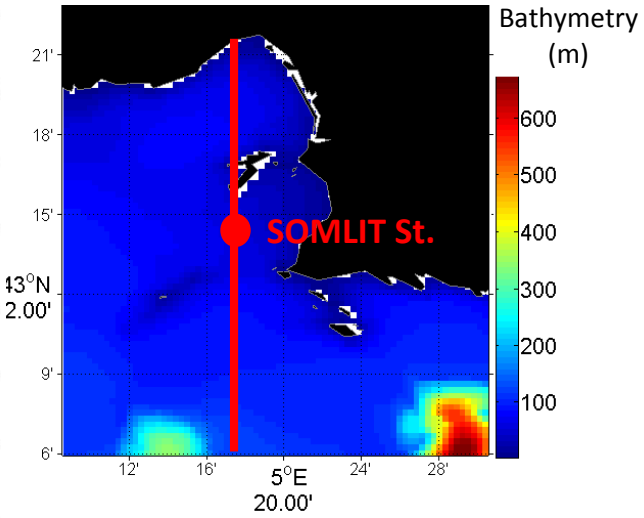


Intrusion in literature :

Gatti et al, 2008

Para et al, 2010

Pairaud et al, 2011



Intrusion if waters from Rhone River with a **salinity < 37,8** are located eastward of the **5°E 17’30 ’’**.

Main issue:
What are the impacts of Rhone River diluted water on the Marseilles Bay coastal zone ?

Outline:

- Model
  - MARS3D-ECO3M coupled model presentation
  - Model skills assessment
- Characterization of intrusion events
- Generation processes
- Conclusion

Coupled model

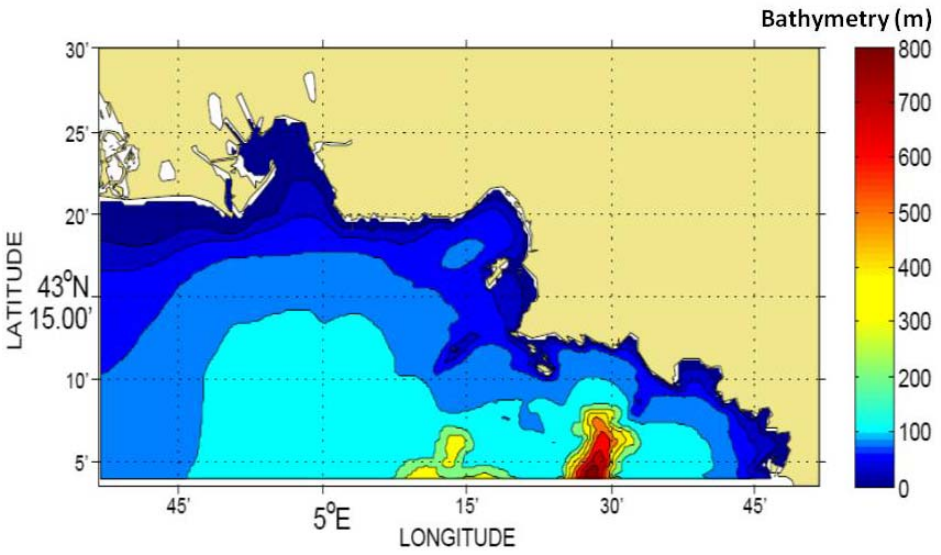
Hydrodynamical model
(MARS3D , IFREMER)

RHOMA configuration

Finite differences, hydrostatic and Boussinesq approximation, free surface elevation

Resolution
Dx~400m; dz=30 sigma levels
Inputs :
Lateral forcing : MENOR (dx~1200m)
Rivers : Rhone daily outflow
Atmospheric forcing : MM5

→ **Validated in JMS by Pairaud et al (2011)**



Coupled model

Hydrodynamical model
(MARS3D , IFREMER)

RHOMA configuration

Finite differences, hydrostatic and Boussinesq approximation, free surface elevation

Resolution
Dx~400m; dz=30 sigma levels
Inputs :
Lateral forcing : MENOR (dx~1200m)
Rivers : Rhone daily outflow
Atmospheric forcing : MM5 (resolution)

→ **Validated in IMS by Pairaud et al (2011)**

Coupled model

Hydrodynamical model
(MARS3D , IFREMER)

RHOMA configuration

Finite differences, hydrostatic and Boussinesq approximation, free surface elevation

Resolution
Dx~400m; dz=30 sigma levels
Inputs :
Lateral forcing : MENOR (dx~1200m)
Rivers : Rhône daily outflow
Atmospheric forcing : MM5

→ **Validated in JMS by Pairaud et al (2011)**

Biogeochimical model
(ECO3M-MASSILIA, MIO)

Initial biogeochemical model:

Pinazo et al. (1996),

Faure et al. (2010a)

Characteristics :

- C, N and P
- 17 states variables
- Variable stoichiometry

Coupled model

Hydrodynamical model
(MARS3D , IFREMER)

RHOMA configuration

Finite differences, hydrostatic and Boussinesq approximation, free surface elevation

Resolution

Dx~400m; dz=30 sigma levels

Inputs :

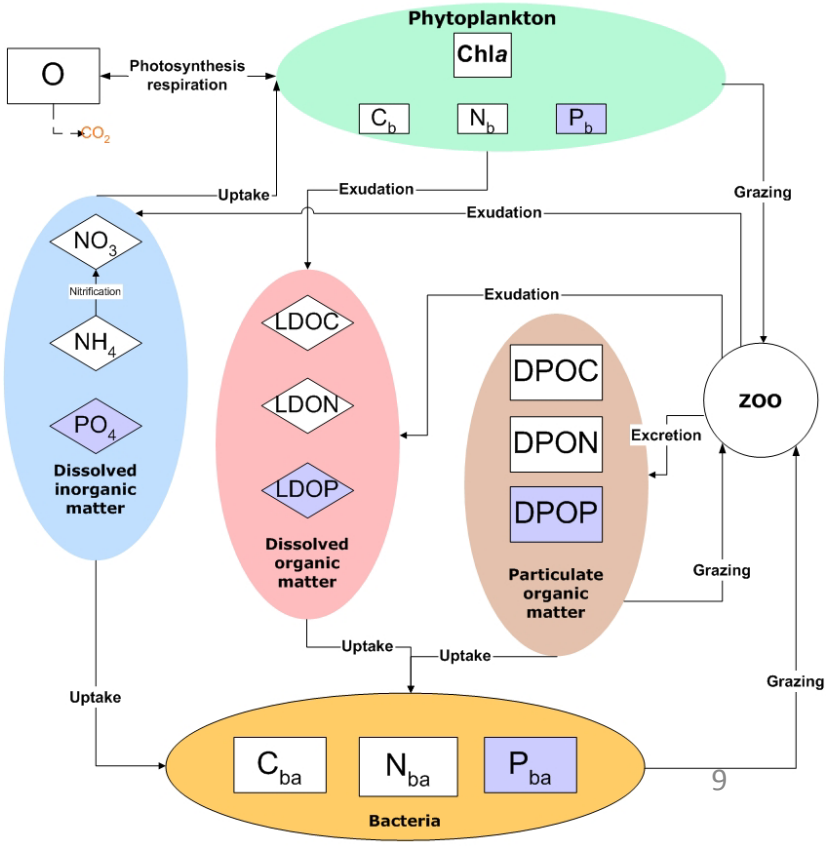
Lateral forcing : MENOR (dx~1200m)

Rivers : Rhone daily outflow

Atmospheric forcing : MM5

→ **Validated in JMS by Pairaud et al (2011)**

Biogeochimical model
(ECO3M-MASSILIA, MIO)



Coupled model

Hydrodynamical model
(MARS3D , IFREMER)

Biogeochimical model
(ECO3M-MASSILIA, MIO)

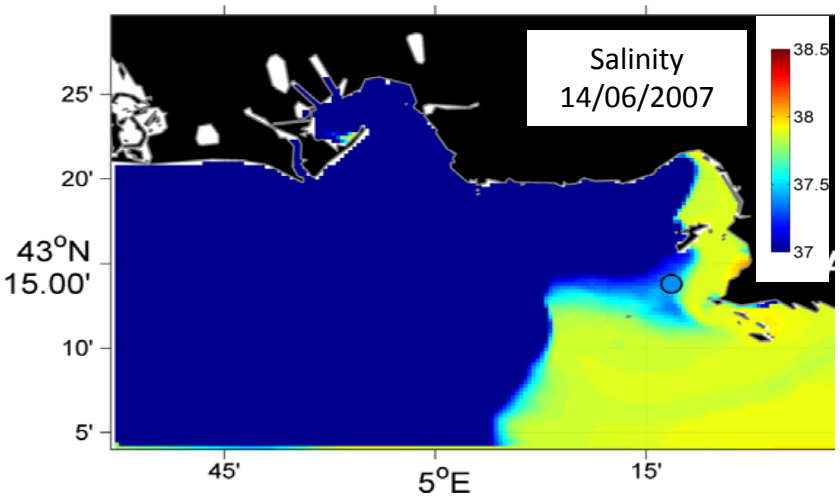
$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} + w\frac{\partial C}{\partial z} = \frac{\partial}{\partial x}\left(K_x \frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_y \frac{\partial C}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_z \frac{\partial C}{\partial z}\right) + Tend$$

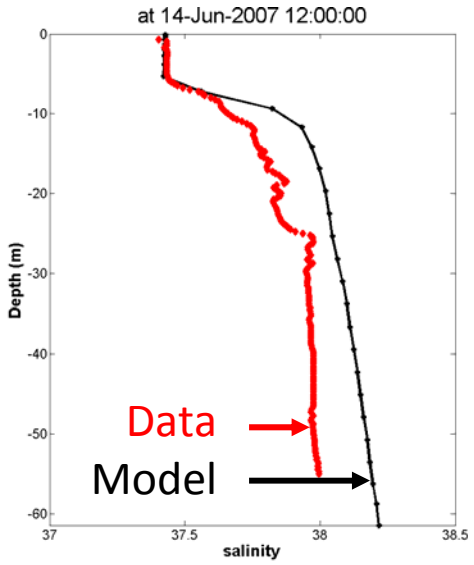
C : Tracer concentration

Tend = sources - sinks : tendency term calculated by the biogeochemical model

Model skills assessments at the Somlit station

Qualitative comparisons :

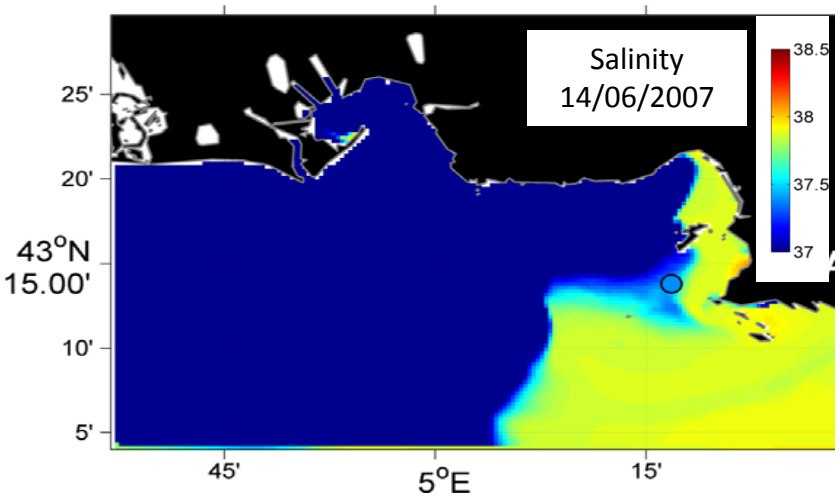


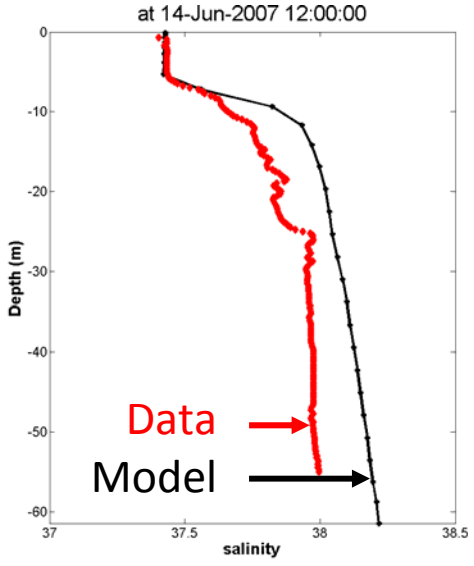


Quantitative comparisons :

Model skills assessments at the Somlit station

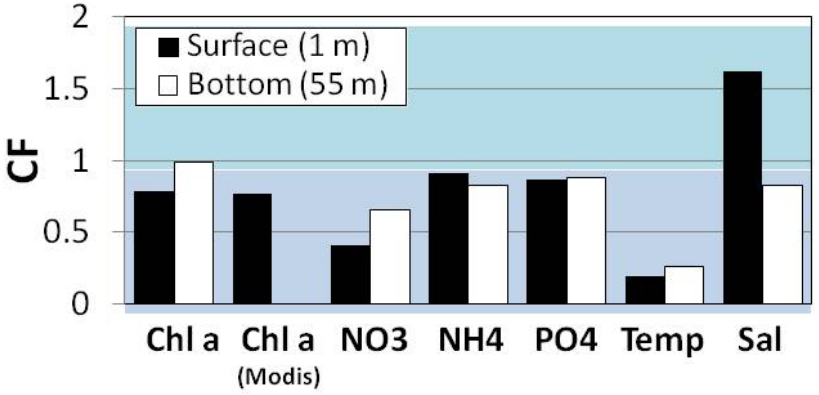
Qualitative comparisons :

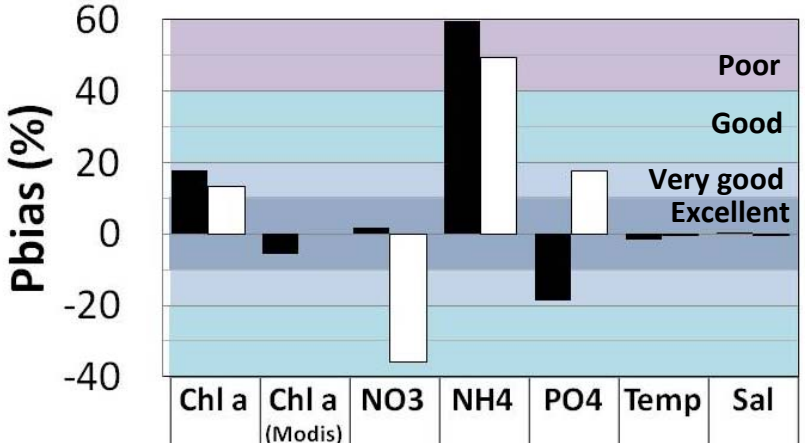




Quantitative comparisons :

$$CF = \frac{1}{N}\sum_{n=1}^{N}\frac{|D_n - M_n|}{\sigma_D}$$

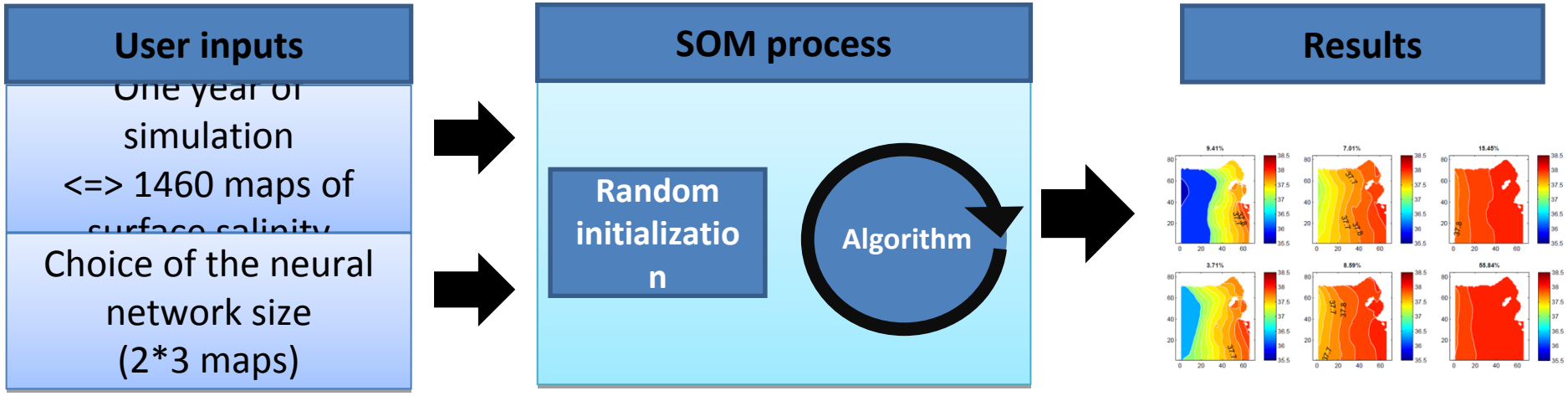




Allen et al (2007), Radach and Moll (2006)
Marechal (2004)

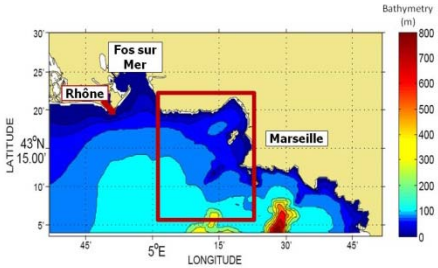
Self Organizing Maps (SOM):

- → neural network
- → effective tool of nonlinear clustering, pattern recognition and feature extraction.
- → SOM Toolbox 2.0 - *Copyright (C) 1999 by Esa Alhoniemi,Johan Himberg, Jukka Parviainen and Juha Vesanto*

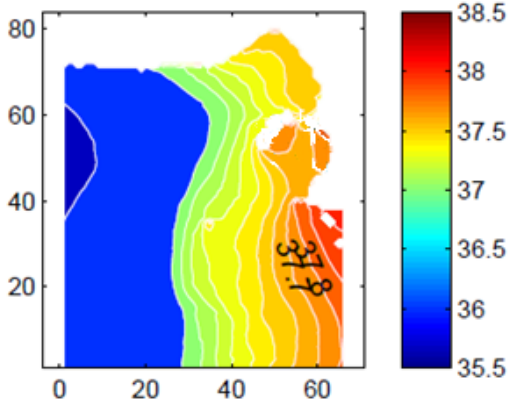


SOM of surface salinity Bay of Marseille - Year 2008

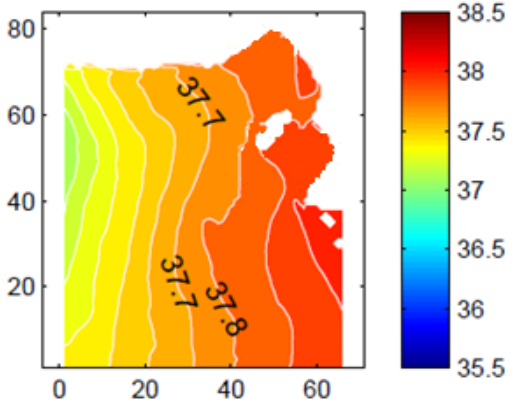
→ **Intrusion of Rhone diluted water in Marseille's Bay**
≈ 13% year



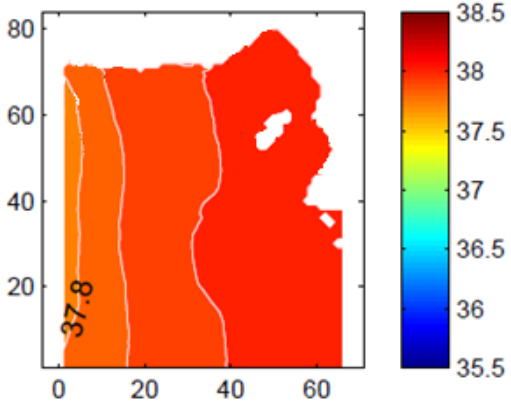
9.41 %



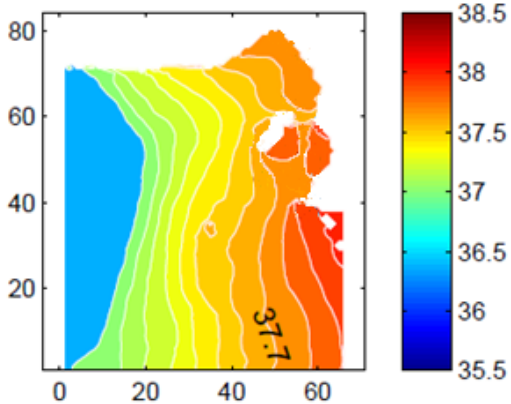
7.01 %



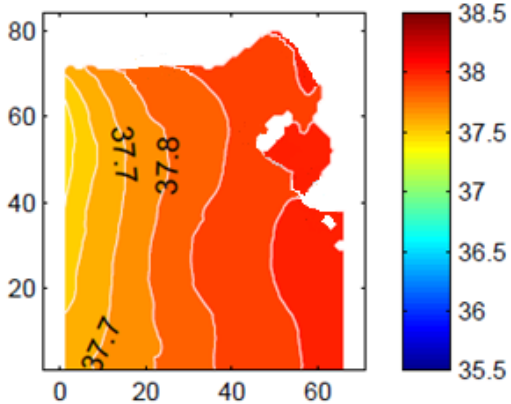
15.45 %



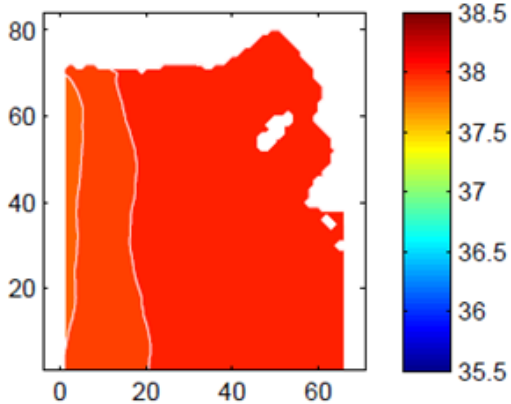
3.71 %



8.59 %



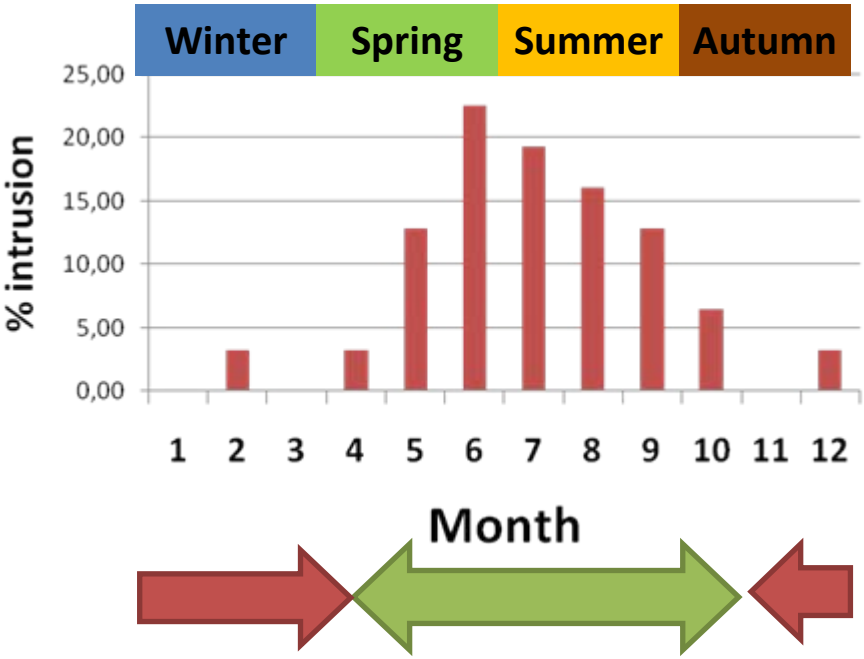
55.84 %



Characteristics of Rhone River intrusion

General physics characteristics	
Studied period	2007 - 2010
Frequency	~ 8 /year
Seasonality	yes
Vertical extension	5-30 m

Intrusion seasonality :

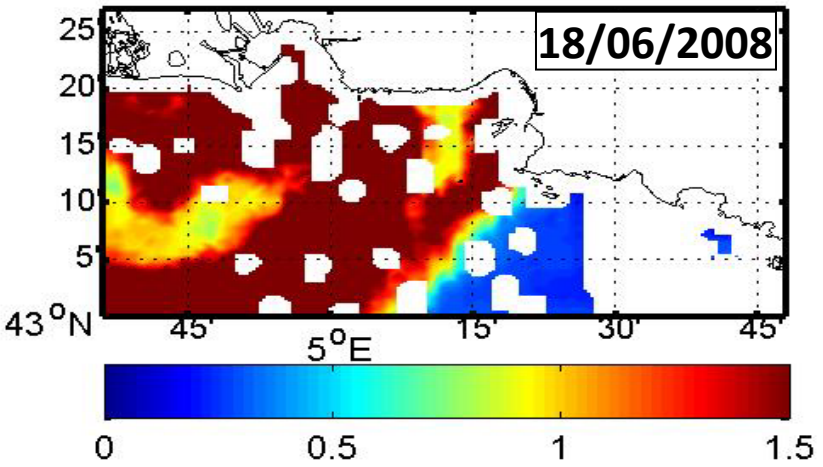


Characteristics of Rhone River intrusion

General physics characteristics	
Studied period	2007 - 2010
Frequency	~ 8 /year
Seasonality	yes
Vertical extension	5-30 m
Biogeochemical characteristics	
Studied period	2007-2008
Chl a	↗
NO3	↗
NH4	↗
PO4	↗
Organic matter	↗

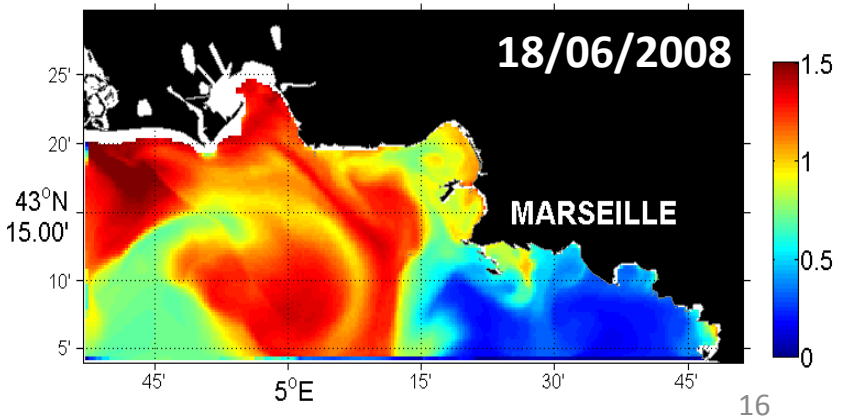
Chlorophyll (µg.L^{-1})

MODIS Ocean color data- OC5



Chlorophyll (µg.L^{-1})

(model results mean between surface and 10m)

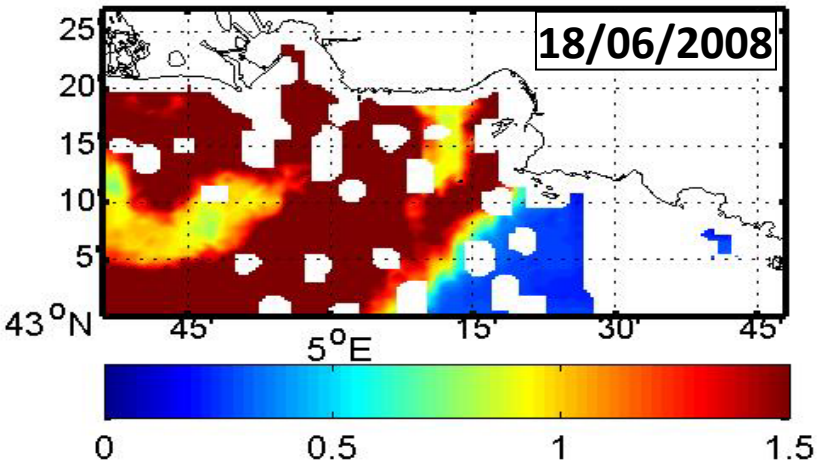


Characteristics of Rhone River intrusion

General physics characteristics	
Studied period	2007 - 2010
Frequency	~ 8 /year
Seasonality	yes
Vertical extension	5-30 m
Biogeochemical characteristics	
Studied period	2007-2008
Chl a	↗
NO3	↗
NH4	↗
PO4	↗
Organic matter	↗

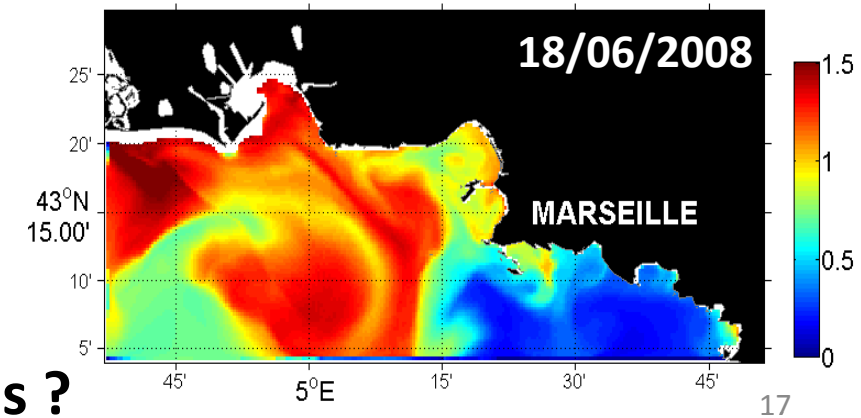
Chlorophyll (µg.L^{-1})

MODIS Ocean color data- OC5



Chlorophyll (µg.L^{-1})

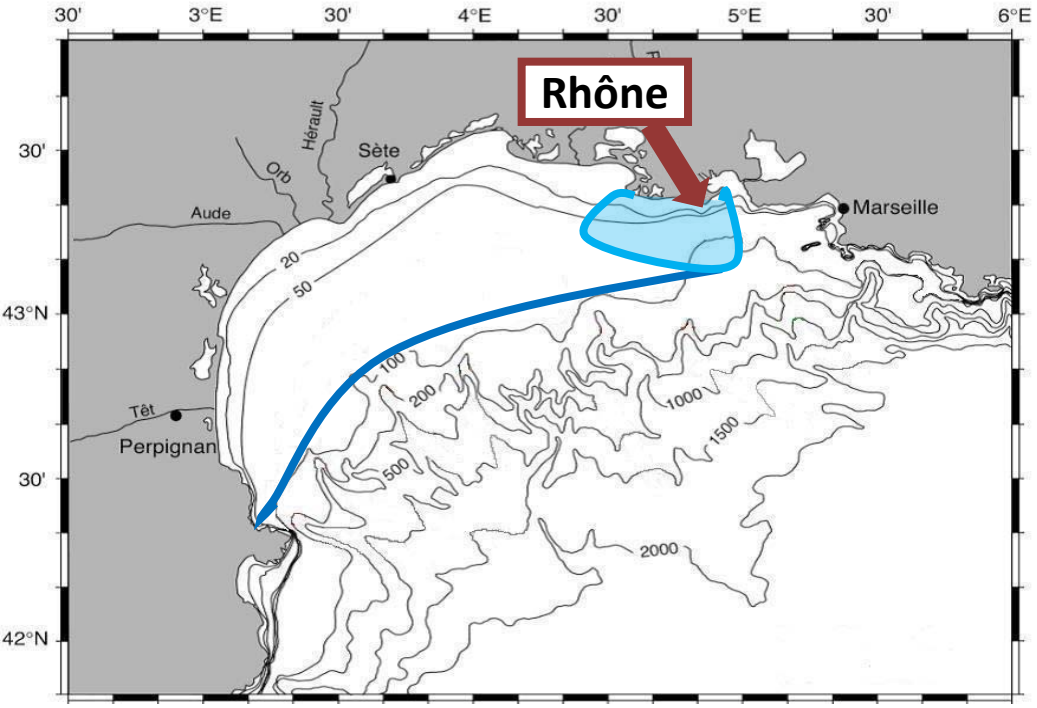
(model results mean between surface and 10m)



→ **What are the generation processes ?**

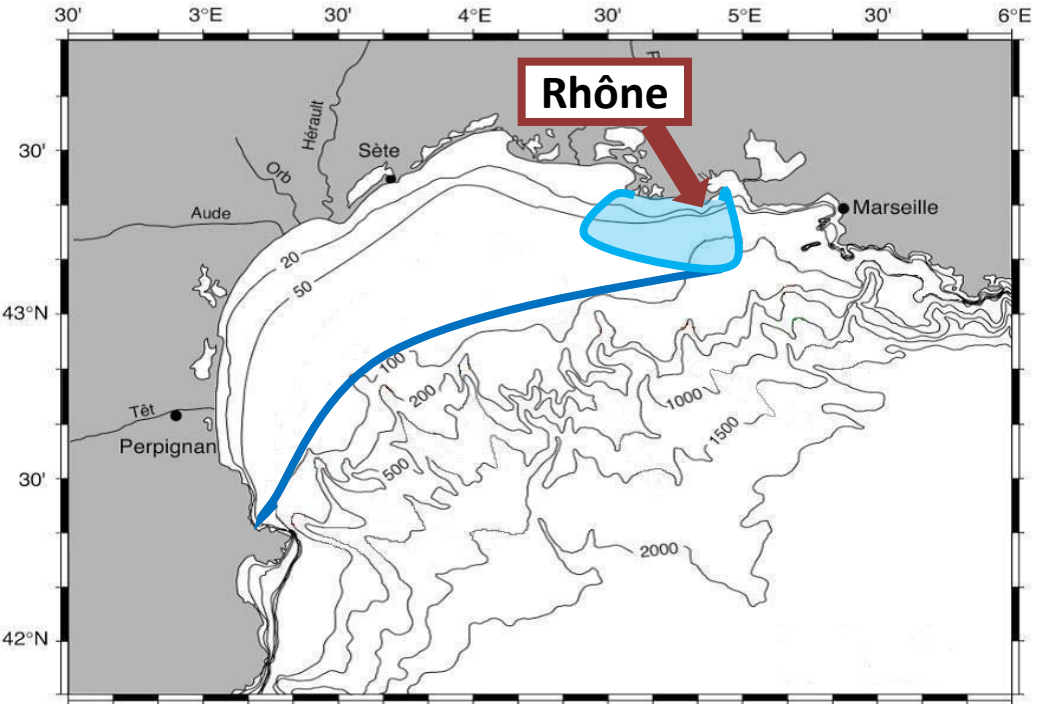
Hypothesis of intrusion generation processes

→ **Rhone river outflow** (75 % intrusion when outflow< 1700 m3)



Hypothesis of intrusion generation processes

→ **Rhone river outflow** (75 % intrusion when outflow< 1700 m3)
→ **Summer vertical stratification**
→ **Wind conditions**



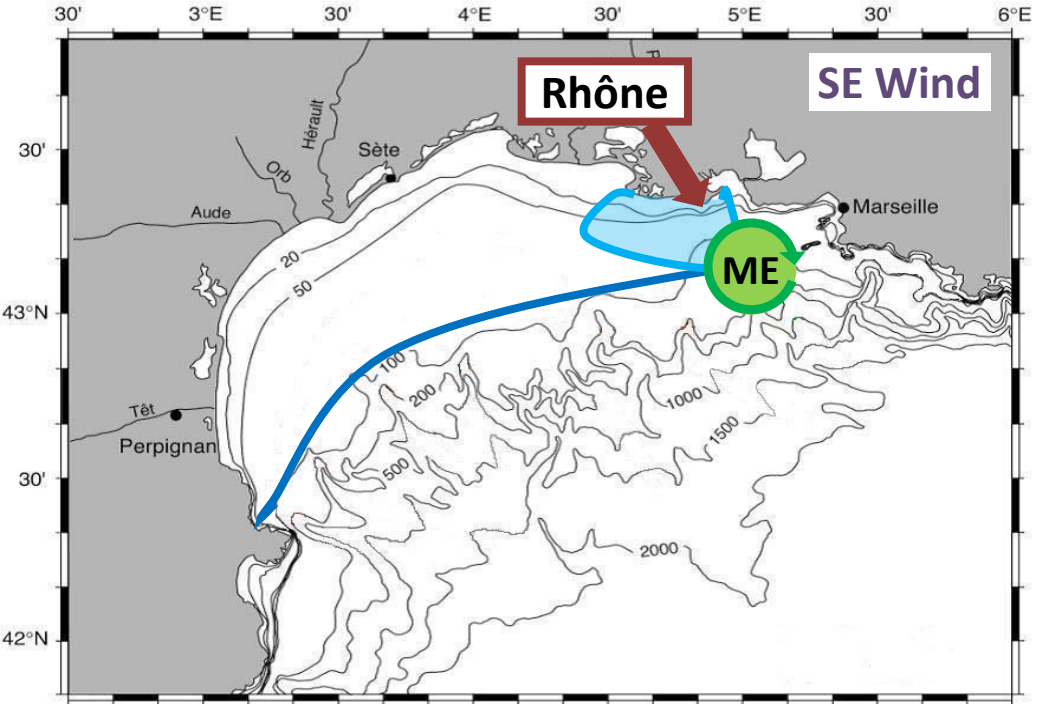
Hypothesis of intrusion generation processes

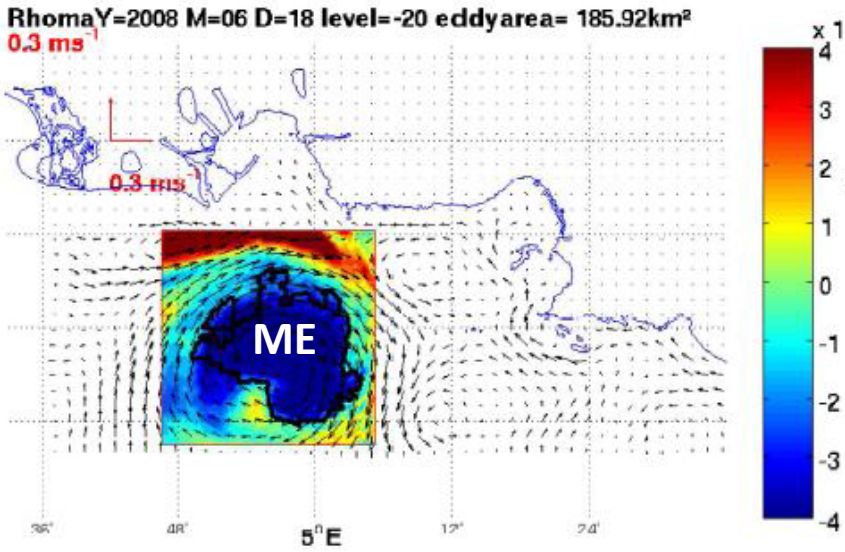
→ **Rhone river outflow** (75 % intrusion when outflow< 1700 m3)

→ **Summer vertical stratification**

→ **Wind conditions**

→ **Anticyclonic Marseille Eddy (ME)** – Schaeffer et al (2011)





Boiron et al, 2011- WATERS tool

http://www.com.univ-mrs.fr/~doglioli/waters.htm

Conclusion :

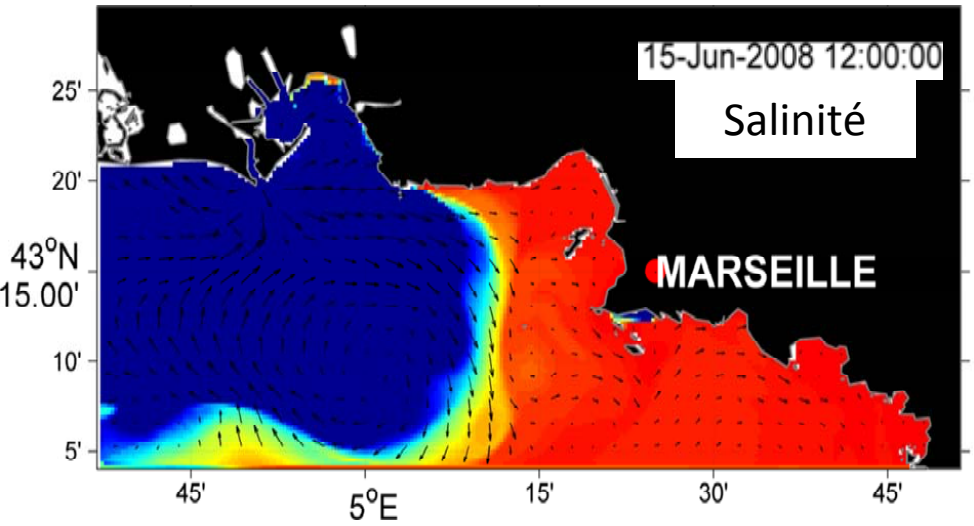
- Intrusion induced an increase of the biological production in the surface layer.
- Intrusion of Rhone River is a non negligible process at the Bay of Marseille scale.
- Our coupled model is a good tool to investigate the impact of the physical forcings over biogeochemistry

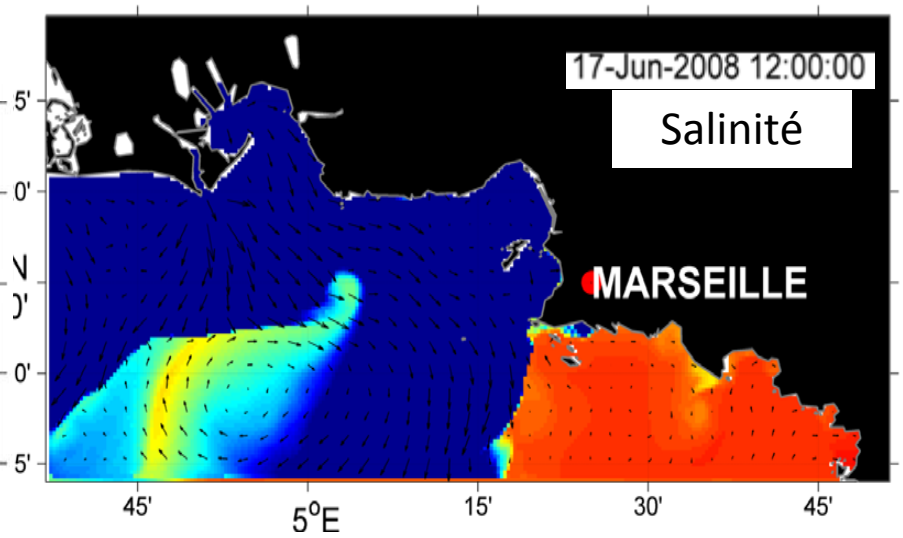
Perspectives :

- Perform a sensitivity analysis to explore generation processes of intrusion event
- Quantify the associated input of matter in the Bay of Marseille

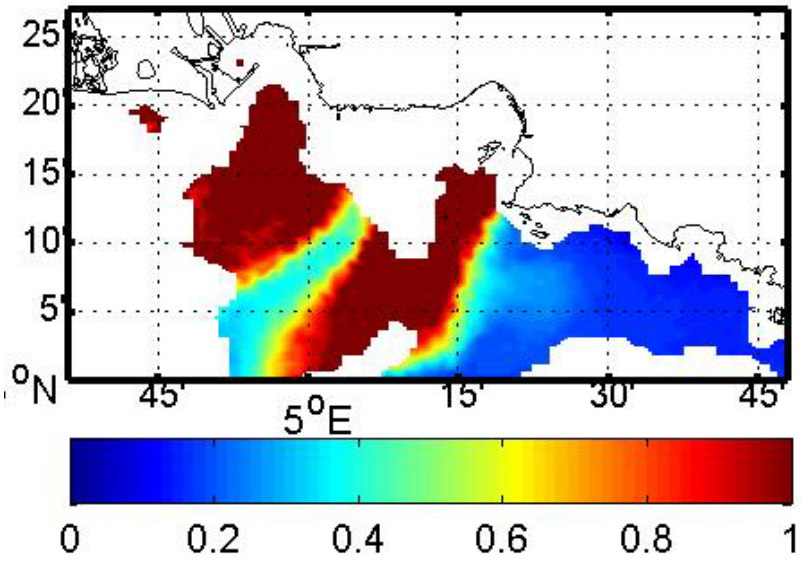

Thank you for
your attention!

Juin 2008

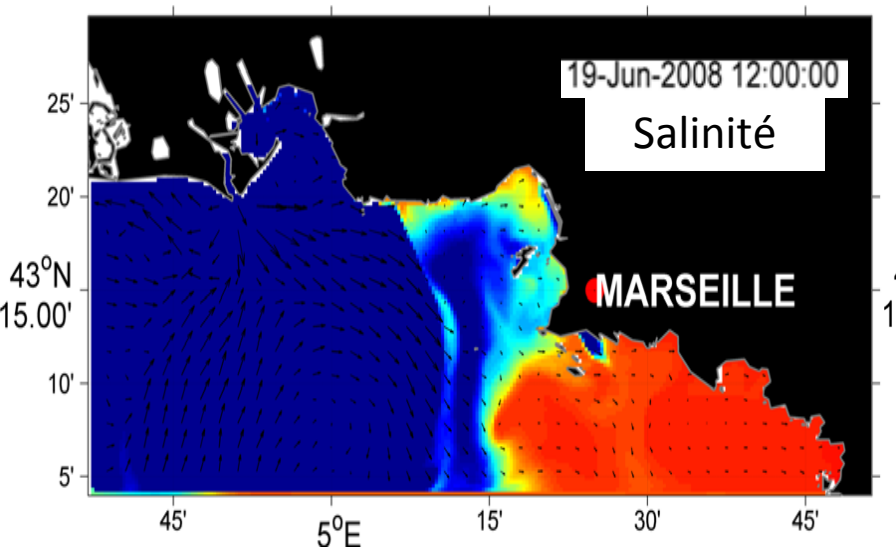


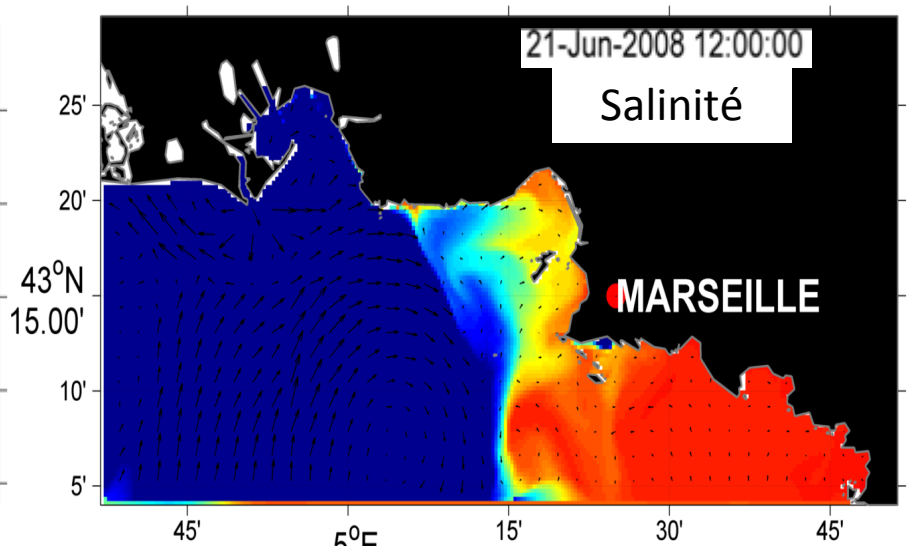


Chlorophylle MODIS OC5 17/6/2008

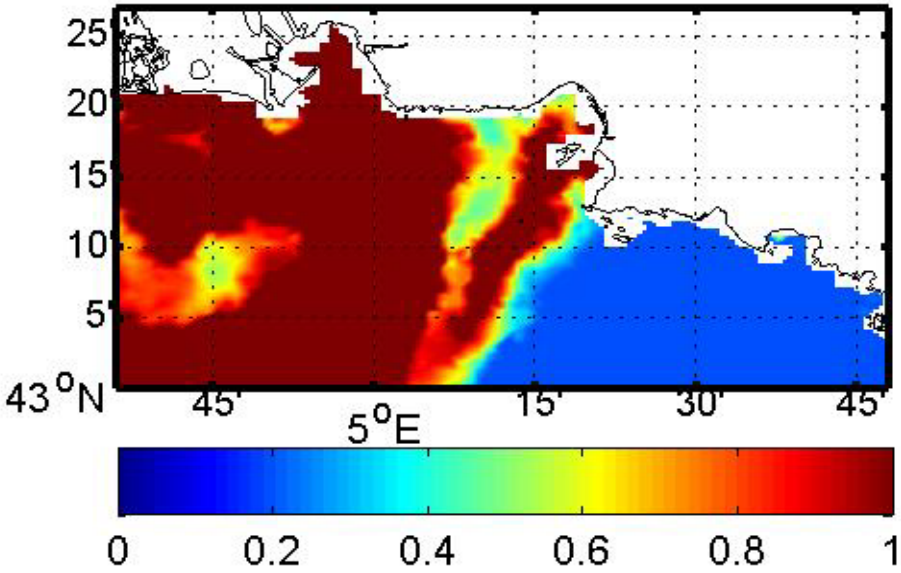


Juin 2008

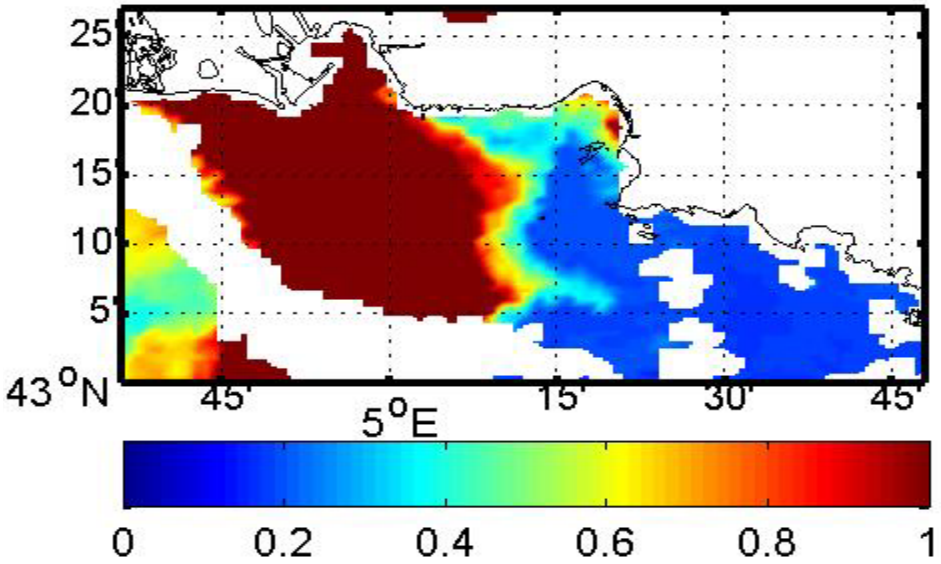




Chlorophylle MERIS OC5 19/6/2008



Chlorophylle MERIS OC5 21/6/2008



Octobre 2008