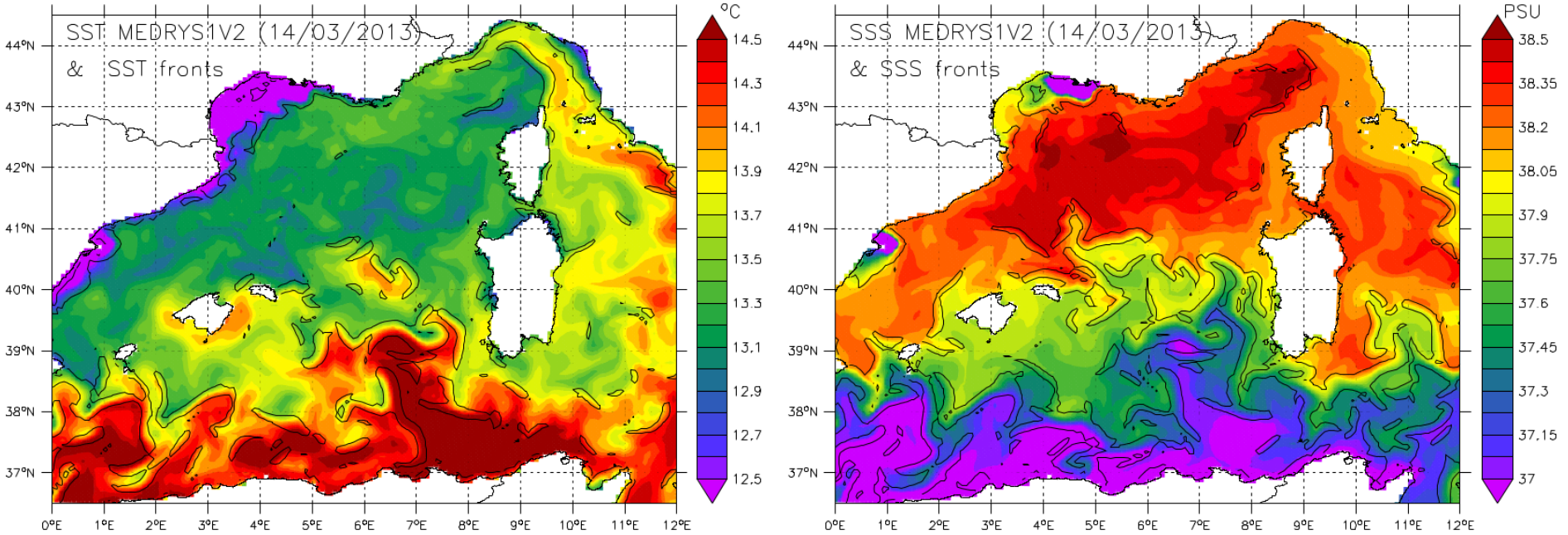
Étude et caractérisation du Front Nord-Baléares dans MEDRYS1V2



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Journées Scientifiques LEFE/GMMC 2019 - UTLN

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I. Le NBF, c'est quoi ?

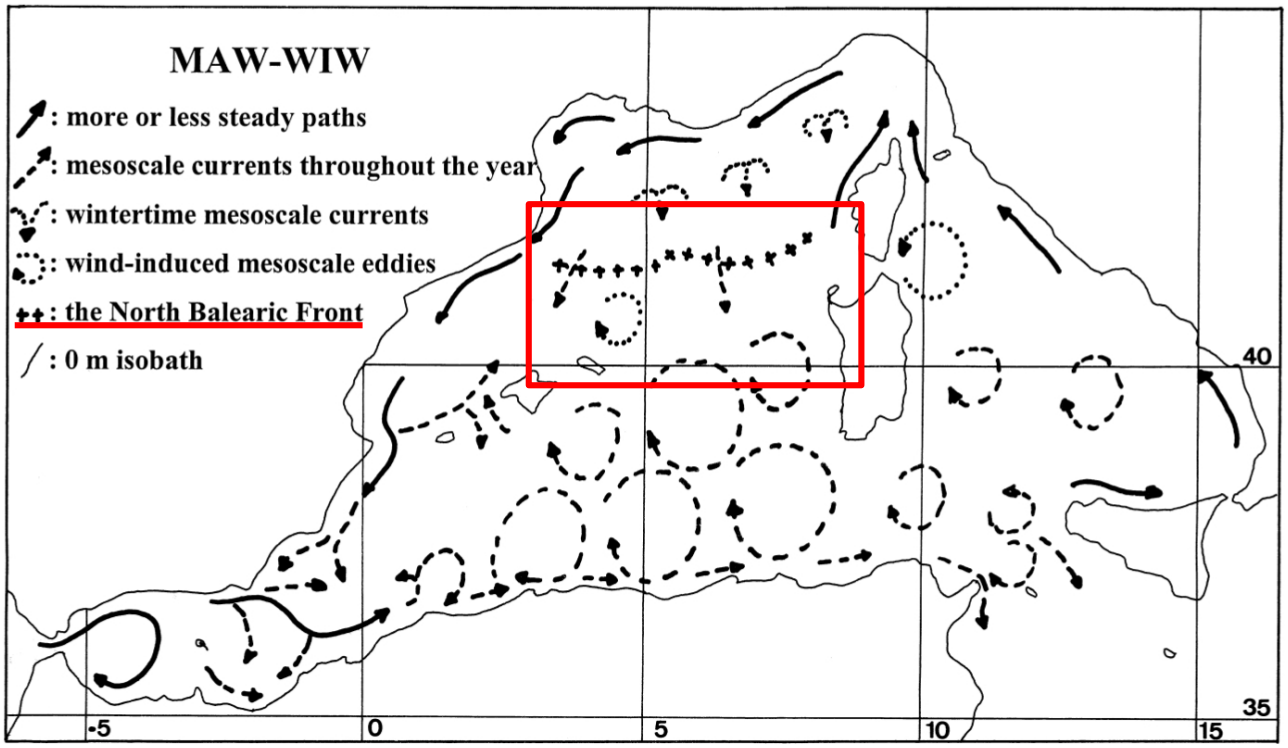
→ *Deschamps et al, 1984*
Première apparition du terme, le NBF est un « front thermique au Nord des îles Baléares »

→ *Millot, 1987*
« Le NBF est la limite Nord de réservoir de AW dans le bassin algérien »

→ *Lopez-Garcia et al, 1994*
« Le NBF est la continuation du front des Baléares (BF), à l'Est »

→ *Pascual et al, 2002*
Le BF est un front de salinité.
Le front des Pyrénées (PF) est un front de température.

→ *Mancho et al, 2007*
« Le NBF est une barrière Lagrangienne semi-permanente. »

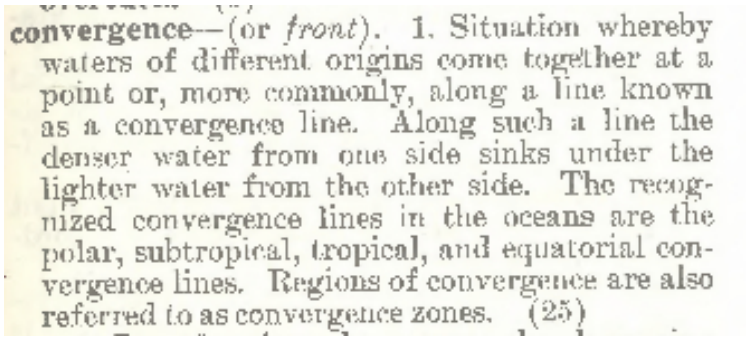


Circulation of the Modified Atlantic Water (MAW) and the Winter Intermediate Water (WIW) *(Millot, 1999)*

⇒ Qu'est ce qu'un front ?

I. Qu'est ce qu'un front ? Une zone frontale ?

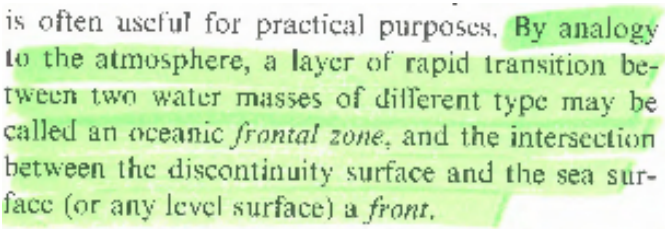
Situation d'affrontement (convergence) horizontale entre deux masses d'eaux



convergence—(or *front*). 1. Situation whereby waters of different origins come together at a point or, more commonly, along a line known as a convergence line. Along such a line the denser water from one side sinks under the lighter water from the other side. The recognized convergence lines in the oceans are the polar, subtropical, tropical, and equatorial convergence lines. Regions of convergence are also referred to as convergence zones. (25)

Glossary of Oceanographic Terms. U.S. Naval Oceanographic Office sp. Publ. #35 1966

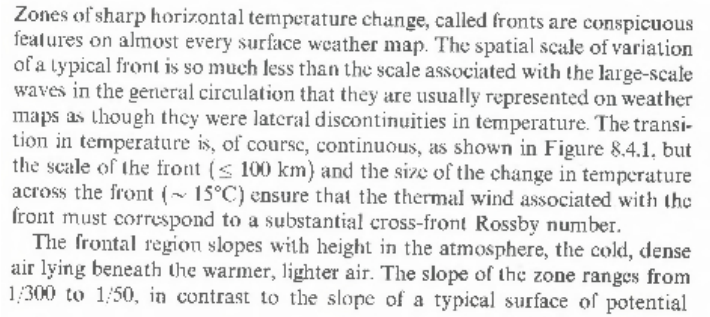
La zone frontale recouvre l'ensemble de la structure, le front est la signature de cette structure en surface.



is often useful for practical purposes. By analogy to the atmosphere, a layer of rapid transition between two water masses of different type may be called an oceanic *frontal zone*, and the intersection between the discontinuity surface and the sea surface (or any level surface) a *front*.

***Neumann and Pierson**. 1966. Principles of physical Oceanography. Prentice-Hall Inc. (Ed.), Englewood Cliffs, N. J. p164*

Les gradients des scalaires dans la zone frontales sont beaucoup plus forts que les gradients grande échelle ou synoptiques.



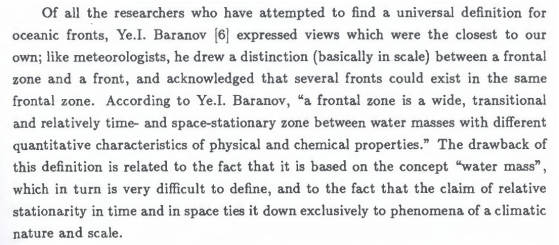
Zones of sharp horizontal temperature change, called fronts are conspicuous features on almost every surface weather map. The spatial scale of variation of a typical front is so much less than the scale associated with the large-scale waves in the general circulation that they are usually represented on weather maps as though they were lateral discontinuities in temperature. The transition in temperature is, of course, continuous, as shown in Figure 8.4.1, but the scale of the front ($\leq$ 100 km) and the size of the change in temperature across the front ($\sim$ 15°C) ensure that the thermal wind associated with the front must correspond to a substantial cross-front Rossby number.

The frontal region slopes with height in the atmosphere, the cold, dense air lying beneath the warmer, lighter air. The slope of the zone ranges from 1/300 to 1/50, in contrast to the slope of a typical surface of potential

***Pedlovsky J.**, 1979. Geophysical fluid Dynamics. Springer Verlag (Ed.), p569-570*

Une zone frontale est une zone large, transitoire et relativement stationnaire dans le temps et l'espace.

$$\nabla T_{instant} \geq 10 \times \nabla T_{climato} \qquad \nabla S_{instant} \geq 10 \times \nabla S_{climato}$$



Of all the researchers who have attempted to find a universal definition for oceanic fronts, Ye.I. Baranov [6] expressed views which were the closest to our own; like meteorologists, he drew a distinction (basically in scale) between a frontal zone and a front, and acknowledged that several fronts could exist in the same frontal zone. According to Ye.I. Baranov, "a frontal zone is a wide, transitional and relatively time- and space-stationary zone between water masses with different quantitative characteristics of physical and chemical properties." The drawback of this definition is related to the fact that it is based on the concept "water mass", which in turn is very difficult to define, and to the fact that the claim of relative stationarity in time and in space ties it down exclusively to phenomena of a climatic nature and scale.

***Fedorov K.N. 1986.** The Physical Nature and Structure of Oceanuc Fronts. Springer Verlag (Ed), p21*

I.II. Méthode et données

1. Gradient horizontal (T, S, σ_θ)

$$\nabla_{interface} SSX = \sqrt{(\nabla_i SSX)^2 + (\nabla_j SSX)^2}$$

2. Gradient climatologique latitudinal

$$\nabla_{clim} SSX = \frac{1}{N_i \cdot N_j} \sum_1^{N_i} \sum_1^{N_j} \nabla_{lat} \overline{SSX}$$

3. Normalisation

$${}_f R = \frac{\nabla_{interface} SSX}{\nabla_{clim} SSX}$$

4. Indice frontal binaire *(Fedorov, 1986)*

$${}_f R \geq 10 \rightarrow {}_f I = 1$$
$${}_f R < 10 \rightarrow {}_f I = 0$$

5. Moyenne temporelle des indices
⇒ Occurrence de fronts (%)

$${}_f O = \frac{1}{N} \sum_{t=1}^{N_t} {}_f I(t)$$

Données

→ Modélisation :

MEDRYS1V2 *(Hamon et al, 2016)*
NM-MED12 ~ 7km, 75 niveaux z
~ 21 ans (1992-2013)

→ Observations in situ :

3 gliders en été, automne
2012 et hiver 2013

→ Observations satellites :

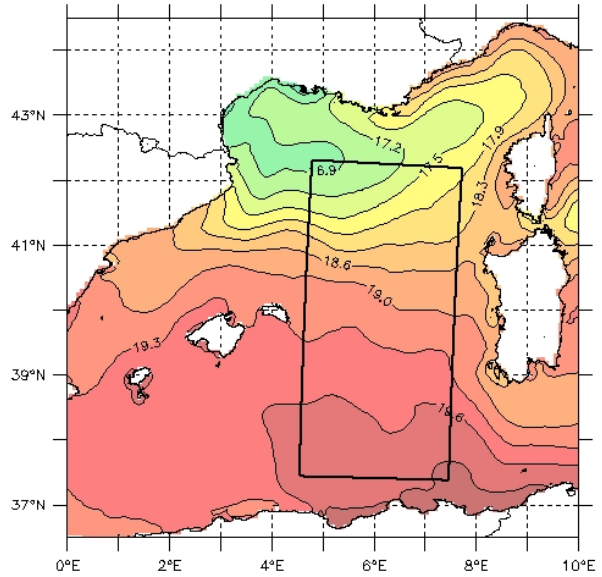
SST(~1km), 9 ans (2008-2017)
- *(Buongiorno et al, 2013)*
- SST(~5km), 35ans (1981-2017)
(Pisano et al, 2016)
- SLA(AVISO) +MDT
- *(Rio et al, 2014)*

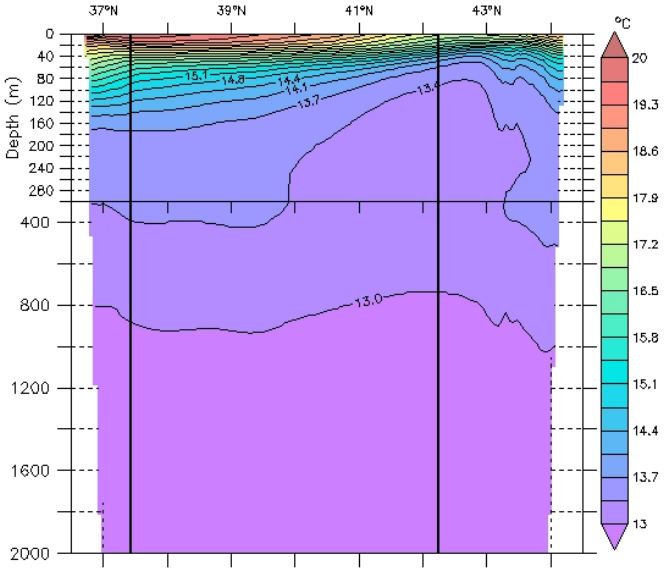
II. Définition du gradient climatologique

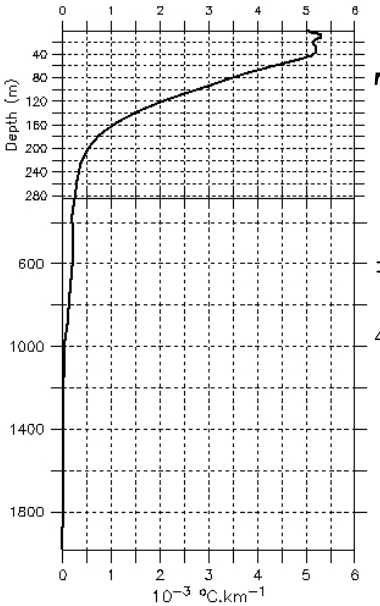
Champ moyen de surface
et domaine de normalisation

Coupe Nord-Sud
(moyenne de 4,5°E à 7,5°E)

Profil vertical de gradient horizontal
(moyenne entre 37,5°N et 42°N)

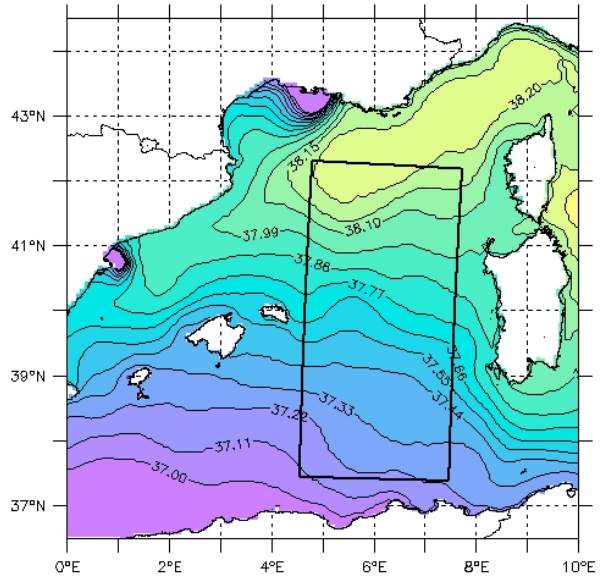


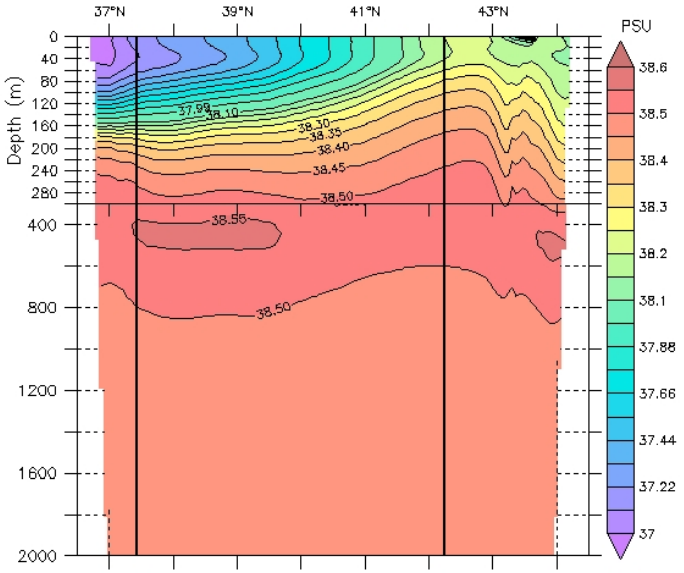


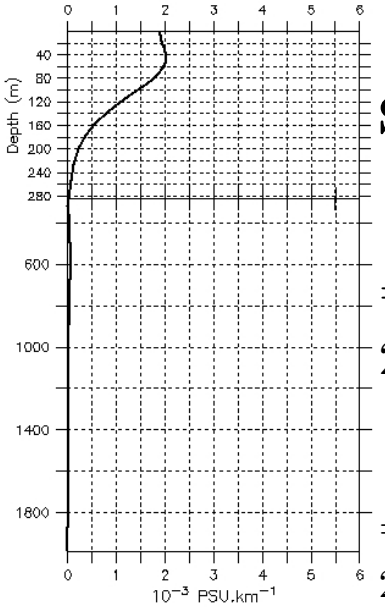


T (°C)

$\Rightarrow \nabla SST_{climato} = 4{,}8.10^{-3}$ °C/km





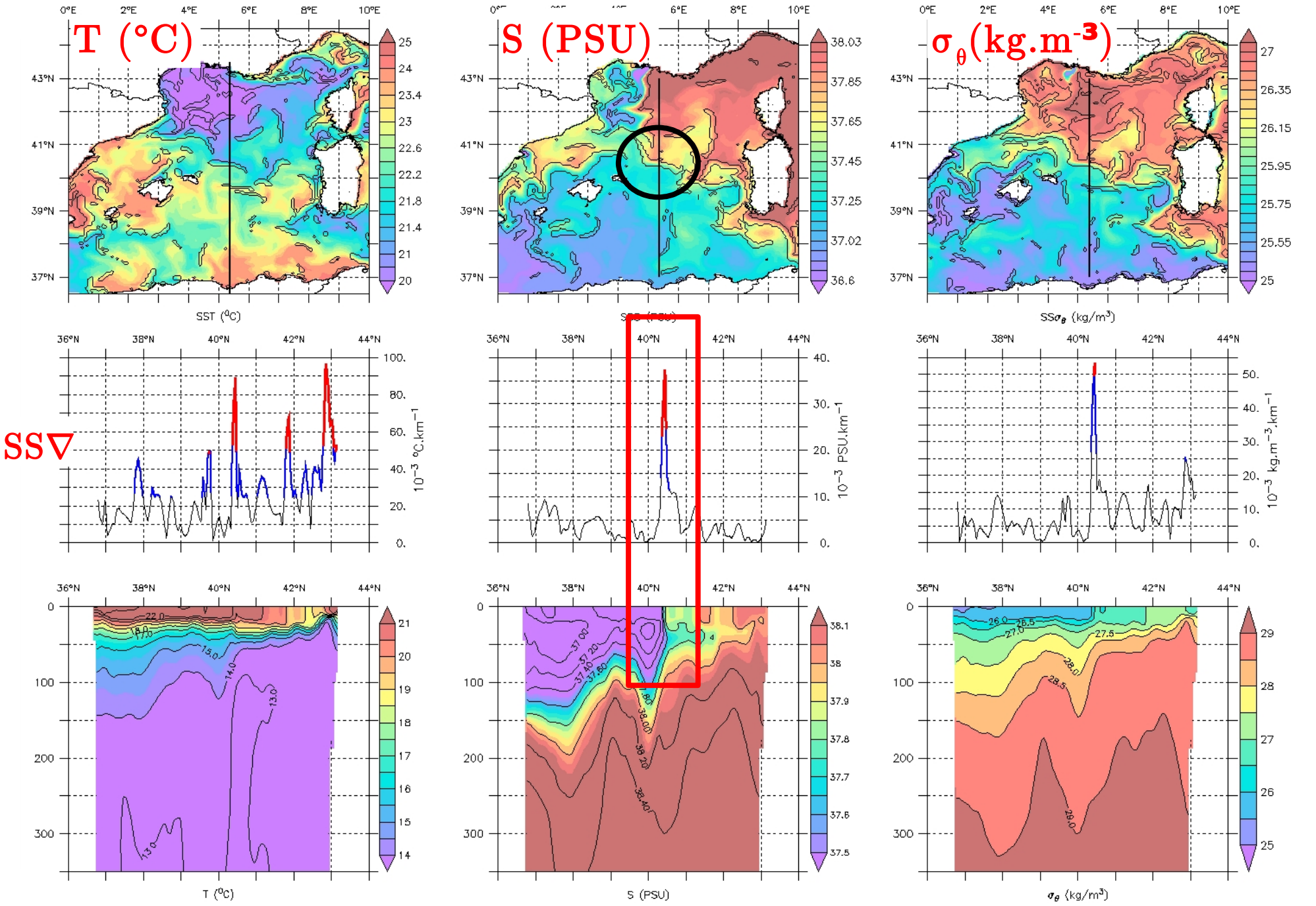


S (PSU)

$\Rightarrow \nabla SSS_{climato} = 2{,}25.10^{-3}$ PSU/km

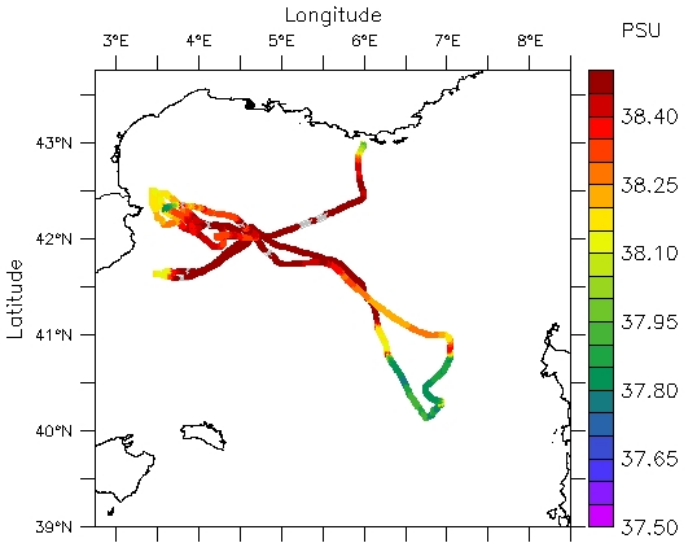
$\Rightarrow \nabla SS\sigma_{climato} = 2{,}8.10^{-3}$ kg.m^{-3}/km

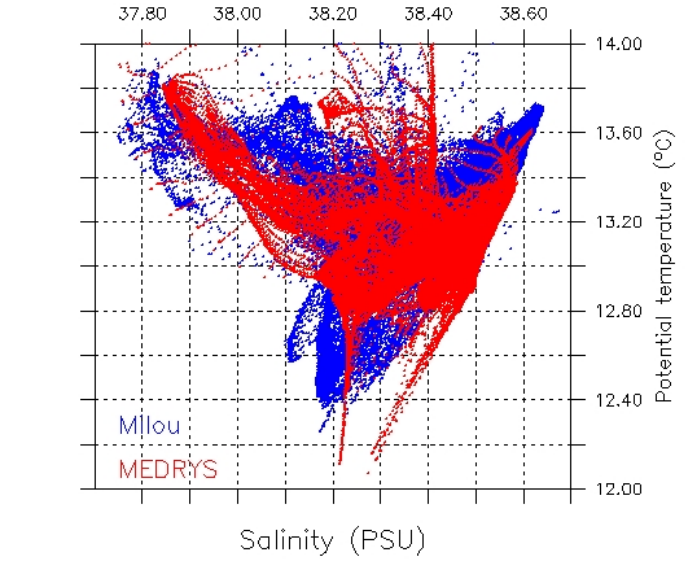
III. Résultats 1. Détection des indices frontaux

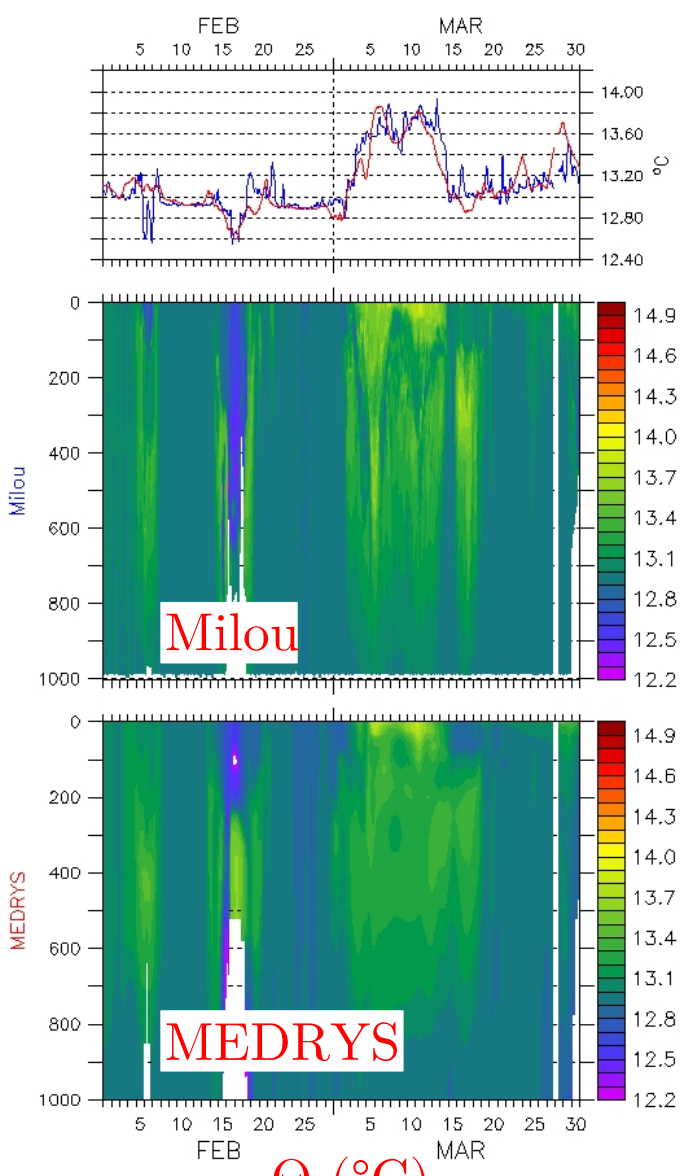


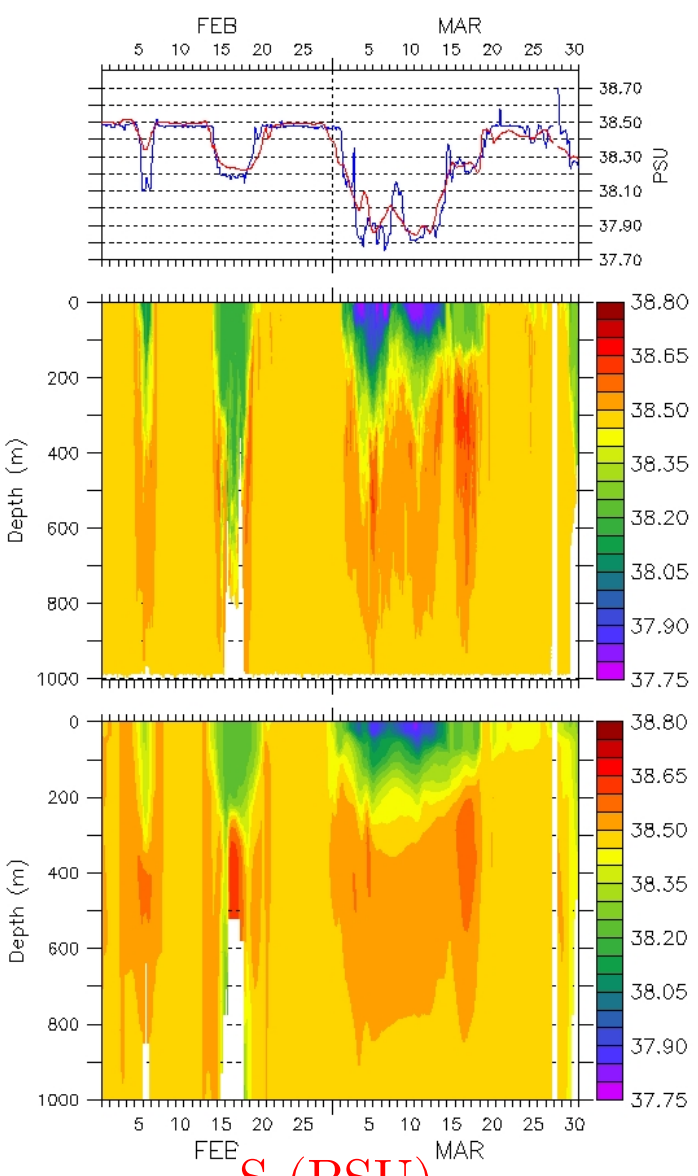
T, S et σ_Θ le 06/07/1993, et à 5,4°E avec $_F I>5$ $_F I>10$ pour les gradients instantannés

III. Résultats 1. Glider virtuel et interface frontale









Glider Milou de ASICSMED (hiver 2013) et glider virtuel dans MEDRYS

III. Résultats 2. Occurrence de fronts saisonnières (%)

Notion de **Zones Frontales**
(Fedorov, 1983) ⇒ **NBFZ**

Stats de fronts de SST
Saturation avec seuil 5
⇒ rapport frontal 10

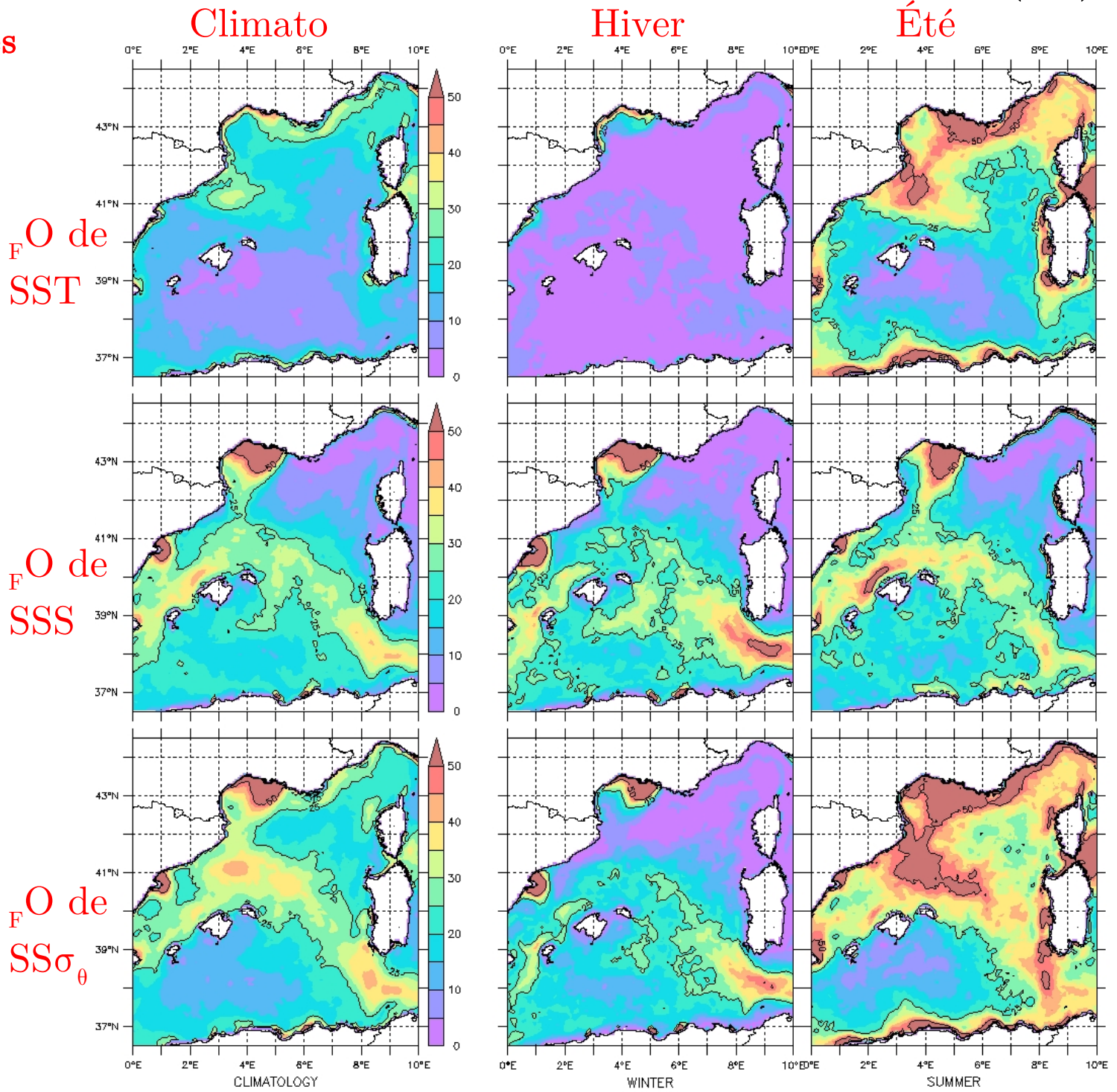
* Forte variabilité saisonnière
* Apparition du PF, du NC et des upwellings

Stats de fronts de SSS
Peu d'infos avec seuil 10
⇒ rapport frontal 5

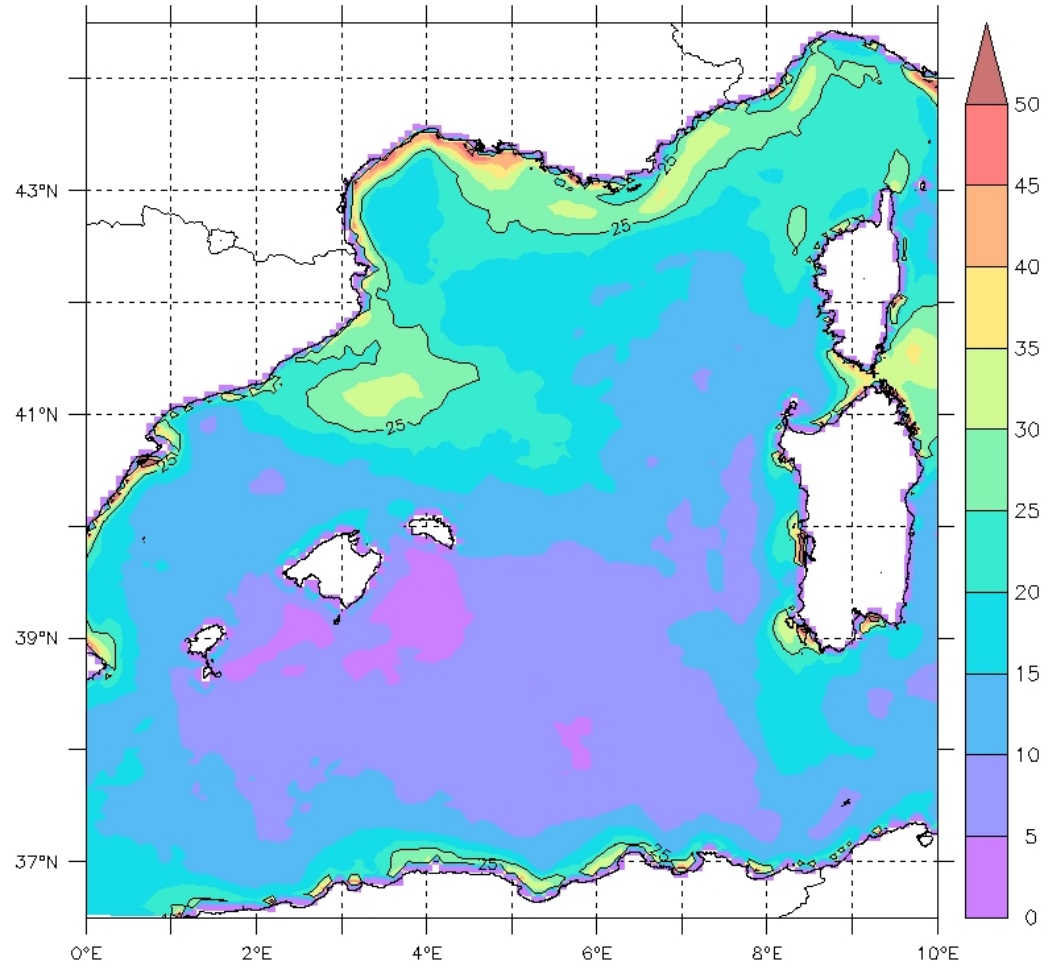
* Faible variabilité saisonnière
* Apparition des panaches Fluviaux et de la NBFZ

Stats de fronts de SSσ
Peu d'infos avec le seuil 10
⇒ rapport frontal 5

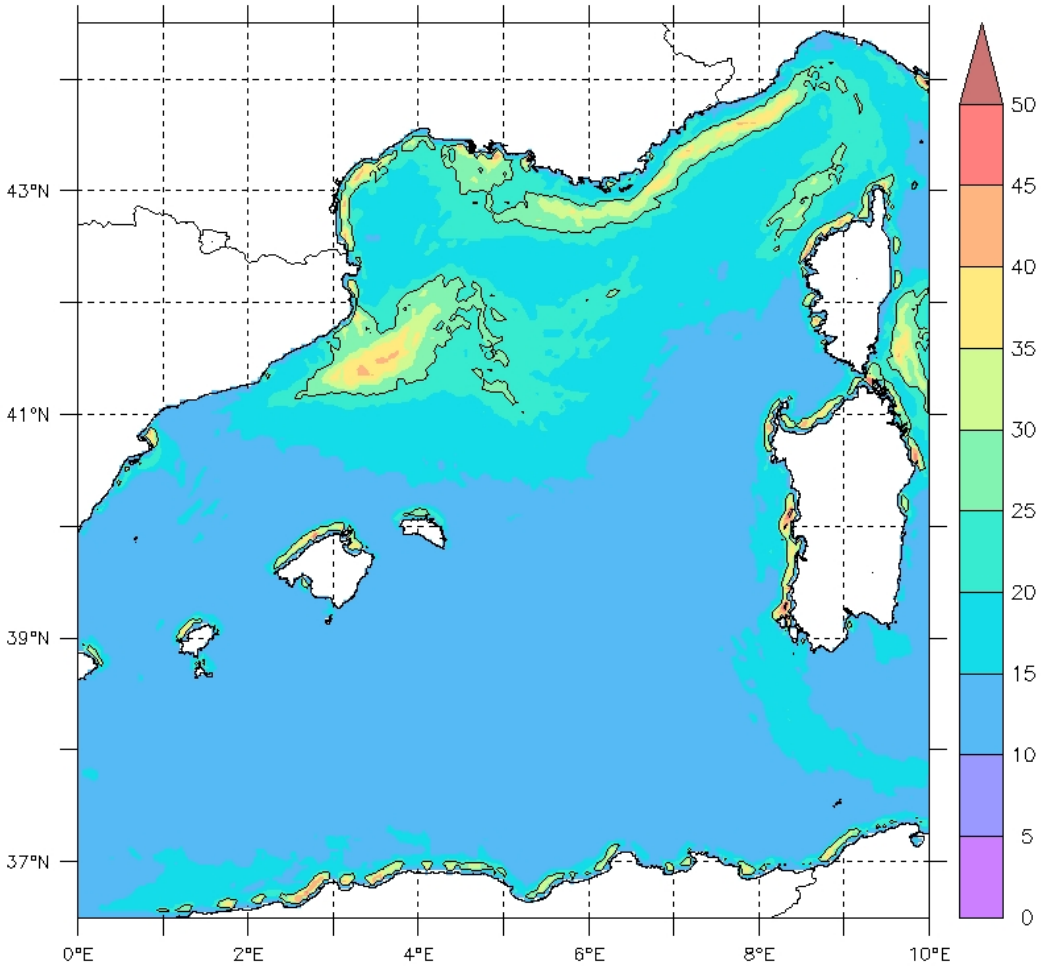
* Combinaison des variabilités Ssσ précédentes
* Apparition du front du WCC



III. Résultats 2. Zones frontales et obs satellites



$_{F}$O de SST MEDRYS (%)

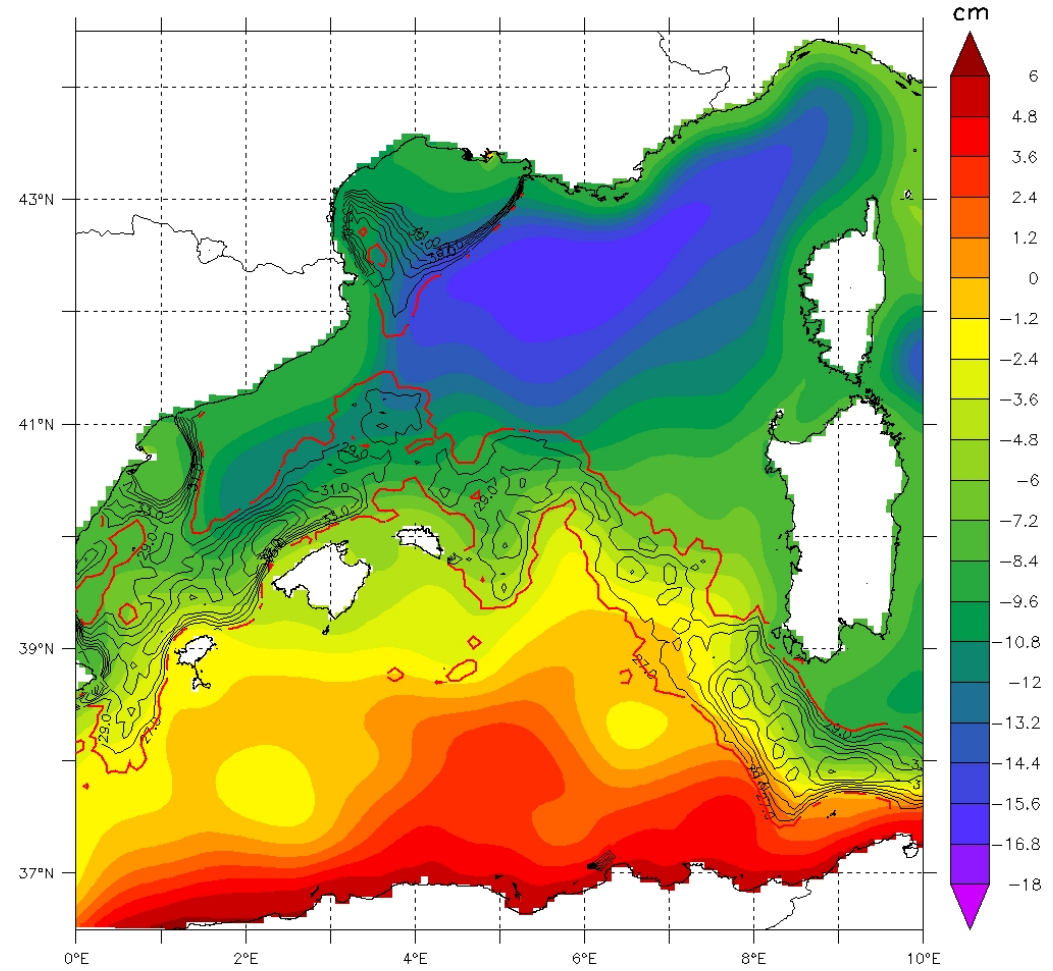


$_{F}$O de SST satellite (%+11)

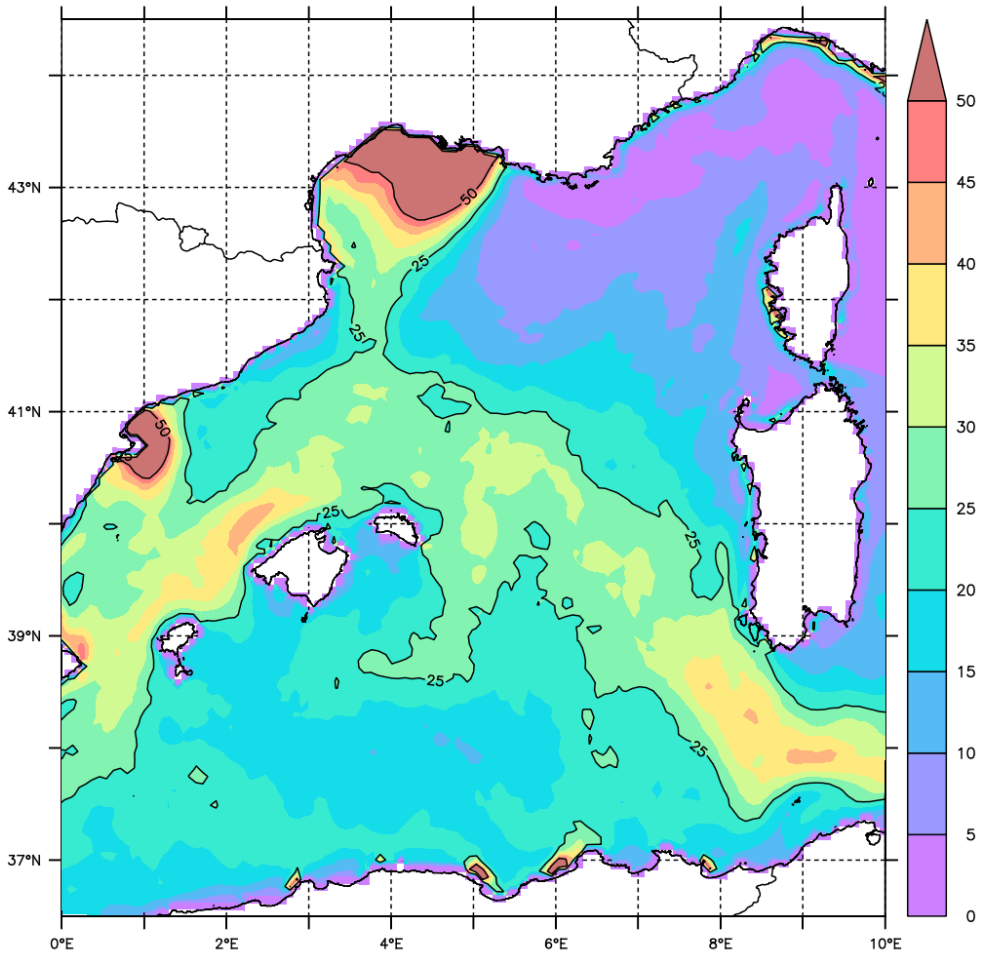
Occurrences Frontales de SST observées par satellite :

- ~11% inférieures au modèle → biais dû à l'interpolation L4
- Bonne concordance des zones frontales de température (PF, NC)

III. Résultats 2. Zones frontales et SSH



MSSH & $_{F}O$ de SSS (>27%)



$_{F}O$ de SSS climato (%)

Zones frontales de SSS et pente de SSH

⇒ Bon accord entre les AW et la haute SSH
et entre la zone frontale de SSS et la pente de SSH (~ -5cm)

III. Résultats 3. NBF et convection dans le GdL

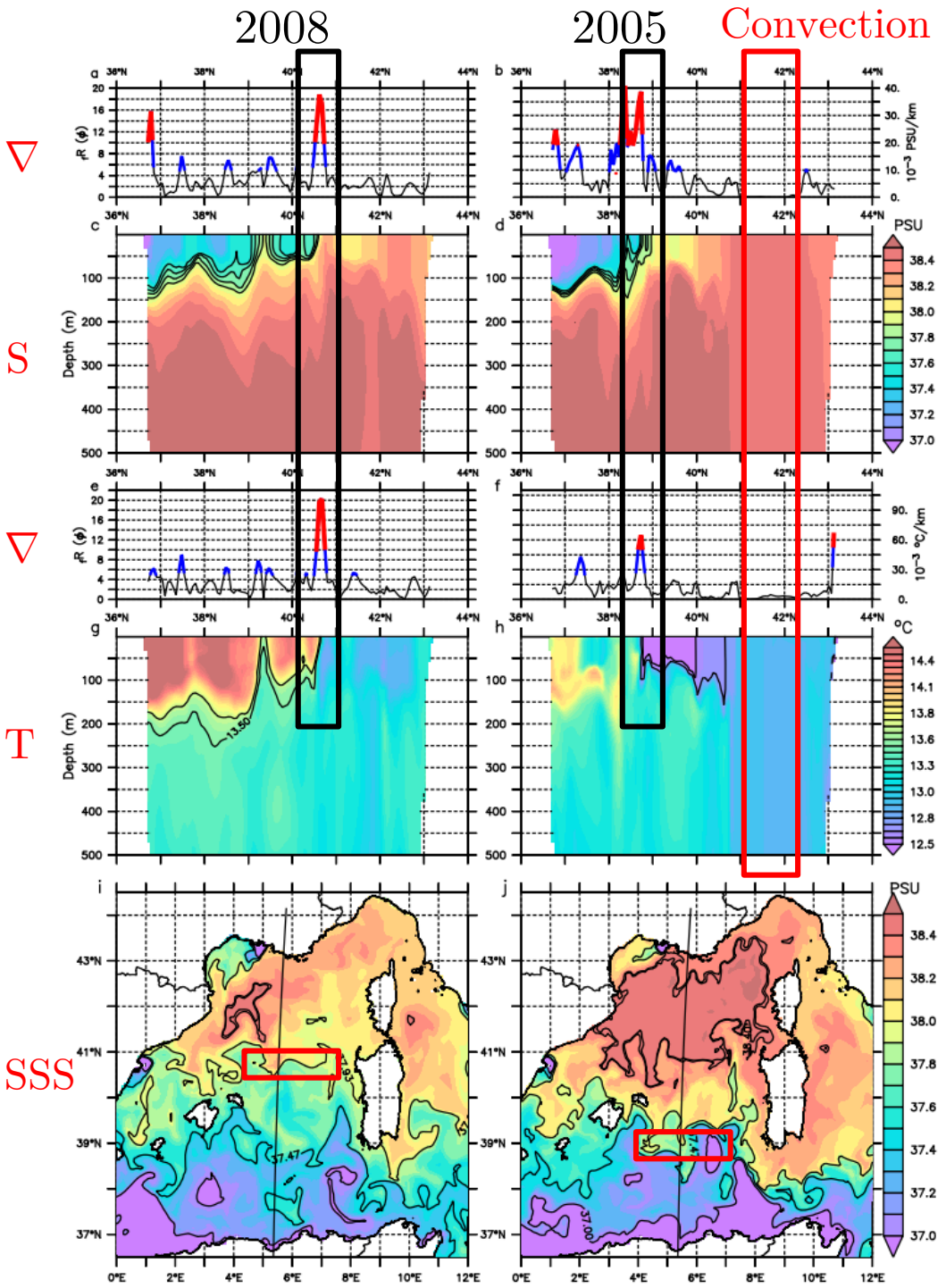
Deux épisodes différents :

avec convection (10/03/05)
sans convection (10/03/08)
dans le Golf du Lion

2005, NBF vers 39°N
Colonne d'eau de convection
2008, NBF vers 40.5°N
Pas de convection

Ici, deux épisodes extrêmes.

⇒ Forte variabilité interannuelle
⇒ différence de position :
~1,5°N ou ~170km

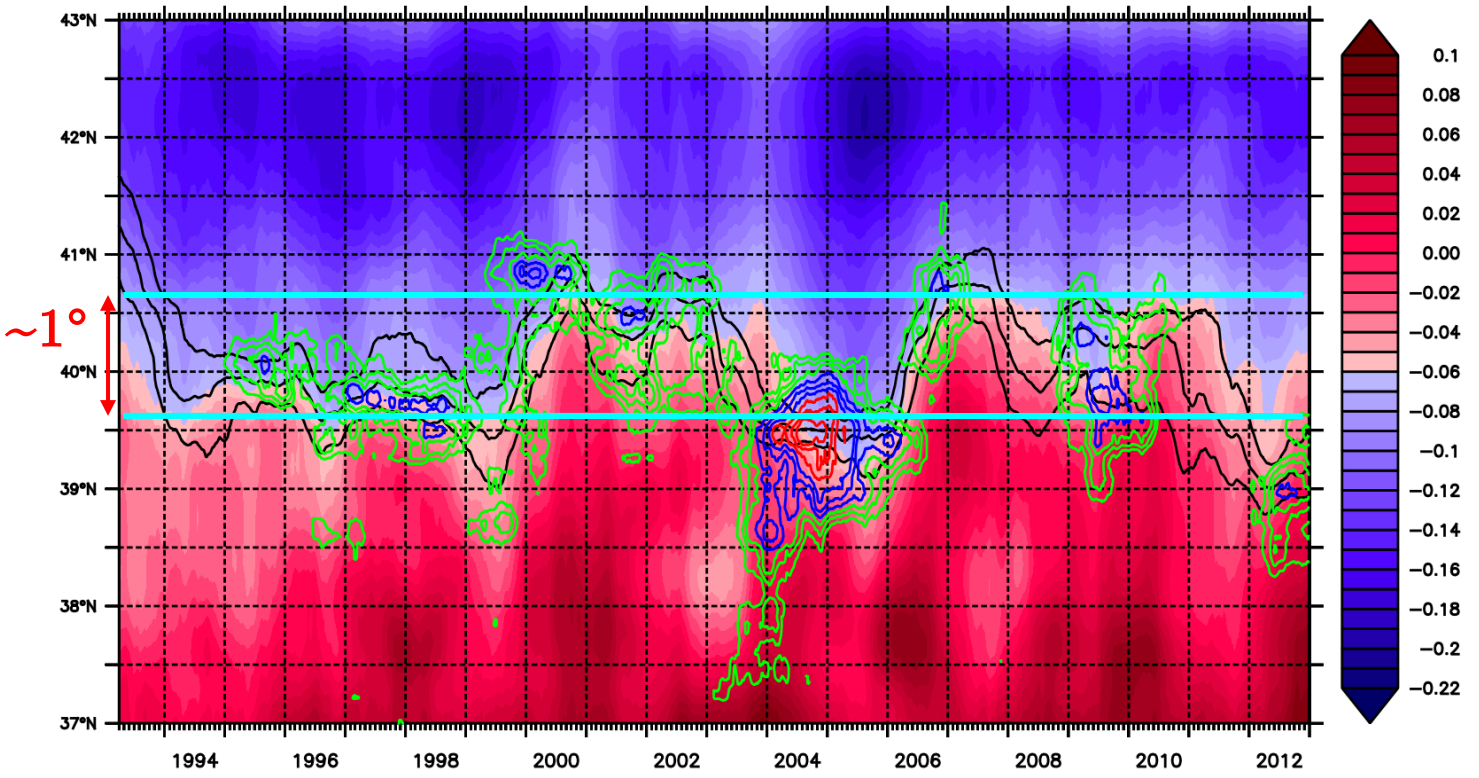


III. Résultats 3. Occurrences et convection

Moyennes interannuelles
et longitudinales de :

→ SSH (en cm, bleu-rouge)
→ isolignes de SSS en noir
(37.6, 37.7 et 37,8 PSU)
→ Occurrences frontales de SSS
(de 30% 45% 50%)

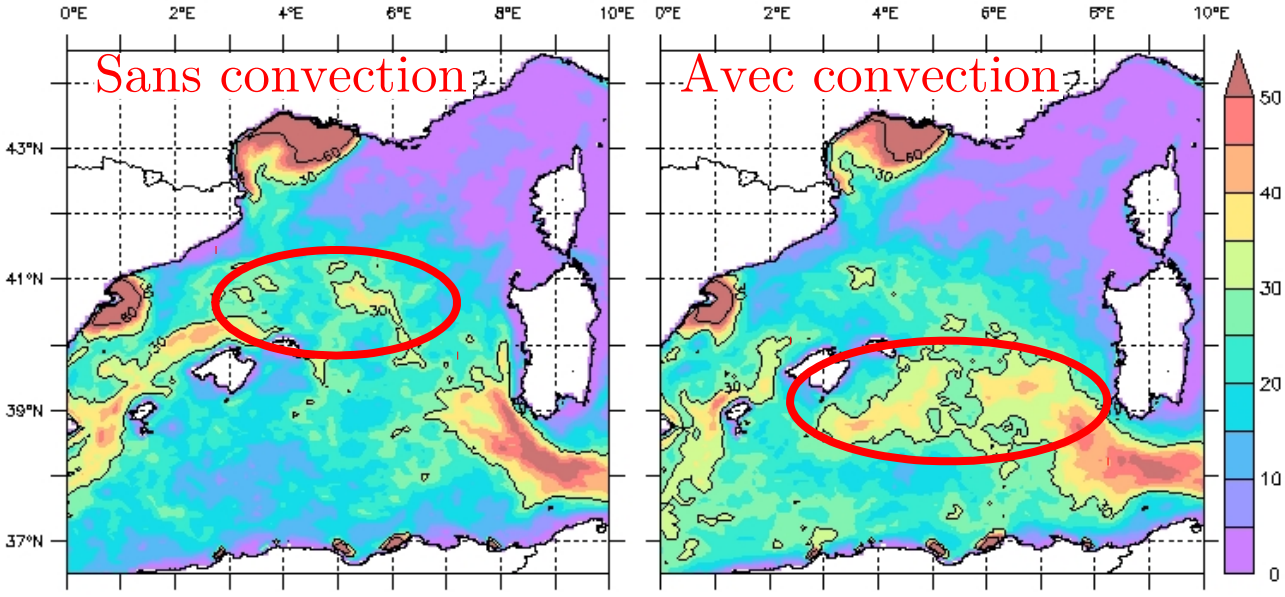
Déplacement au Sud, au Nord
ou stagnation de la NBFZ.



Moyennes des occurrences de fronts de SSS pour les hivers sans convection (gauche) et avec convection (droite)

14 hivers avec convection et 8 sans *(Somot et al, 2016)*

Déplacement de la NBFZ d'environ 100km au Sud par hiver convectif



IV. Discussion

NBF et PF
→ PF : ∇ **SST** ∼ 50m
→ BF & NBF : ∇ S ∼ **200m**

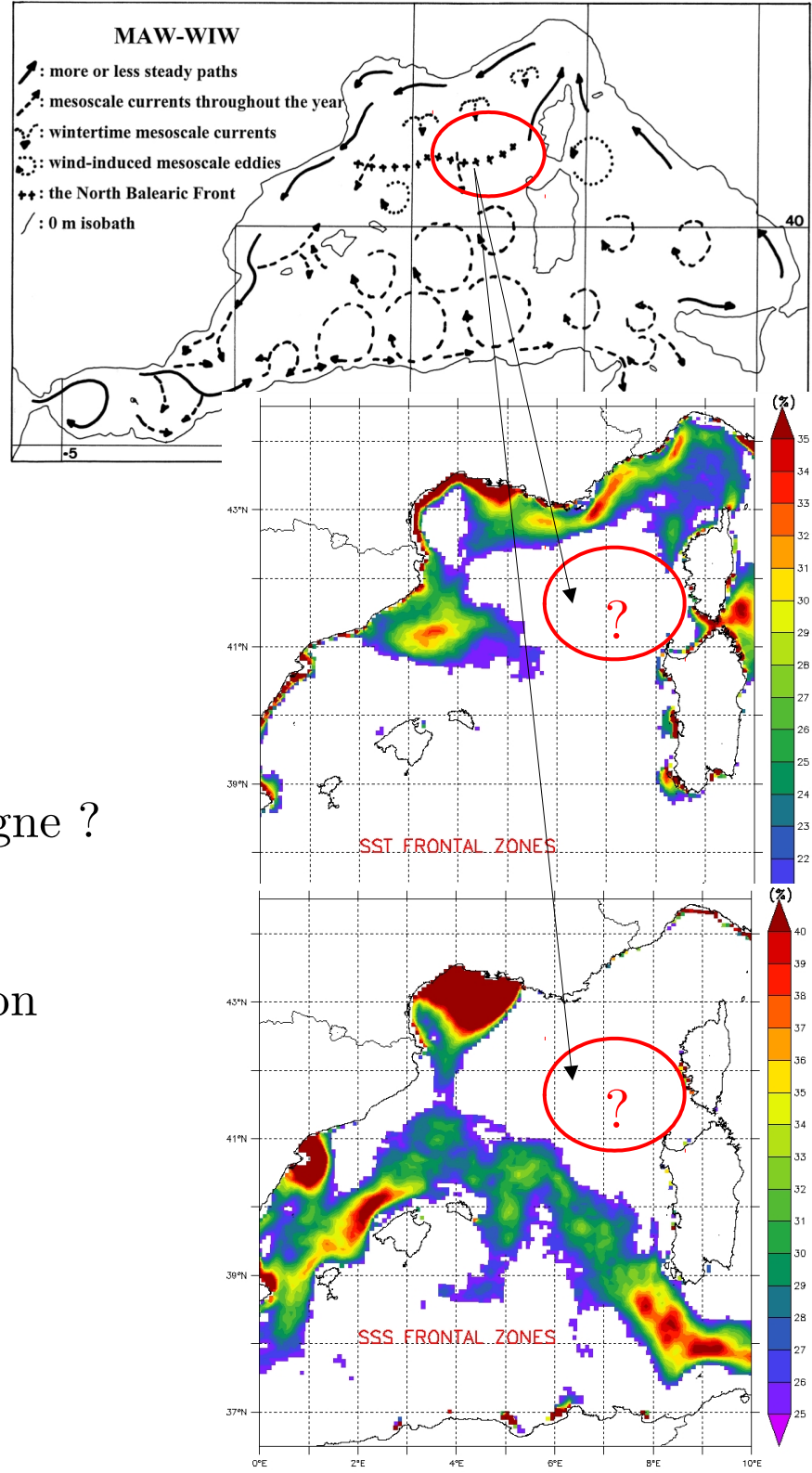
Variabilités :
→ journalière : vent, tourbillons
→ saisonnière : FZ de SST
→ interannuelle : FZ de SSS, convection

« North BFZ » alors que vers le Sud de la Sardaigne ?

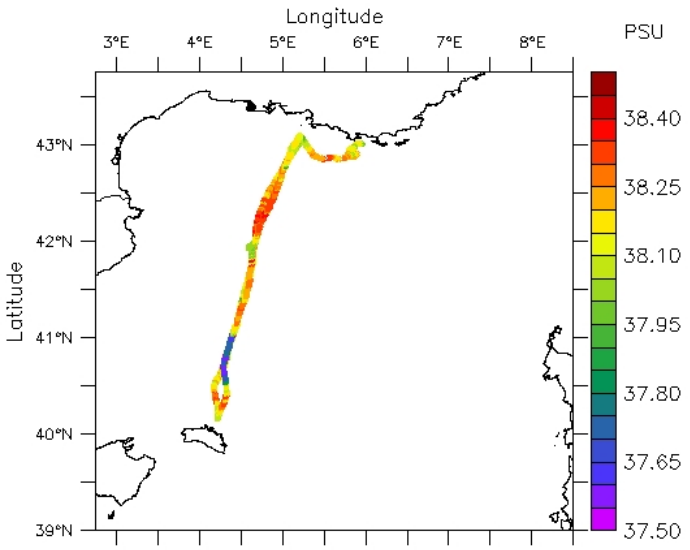
→ Occurrence max du NBF : 5.5°E – 40.5°N
→ Déplacement de 1° vers le Sud lors la convection

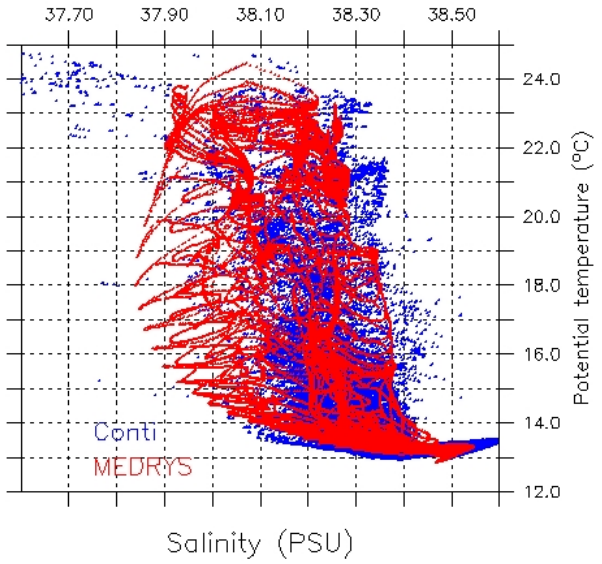
Fermeture de la gyre Nord ?
Zone frontale du Sud-Ouest de la Sardaigne ?

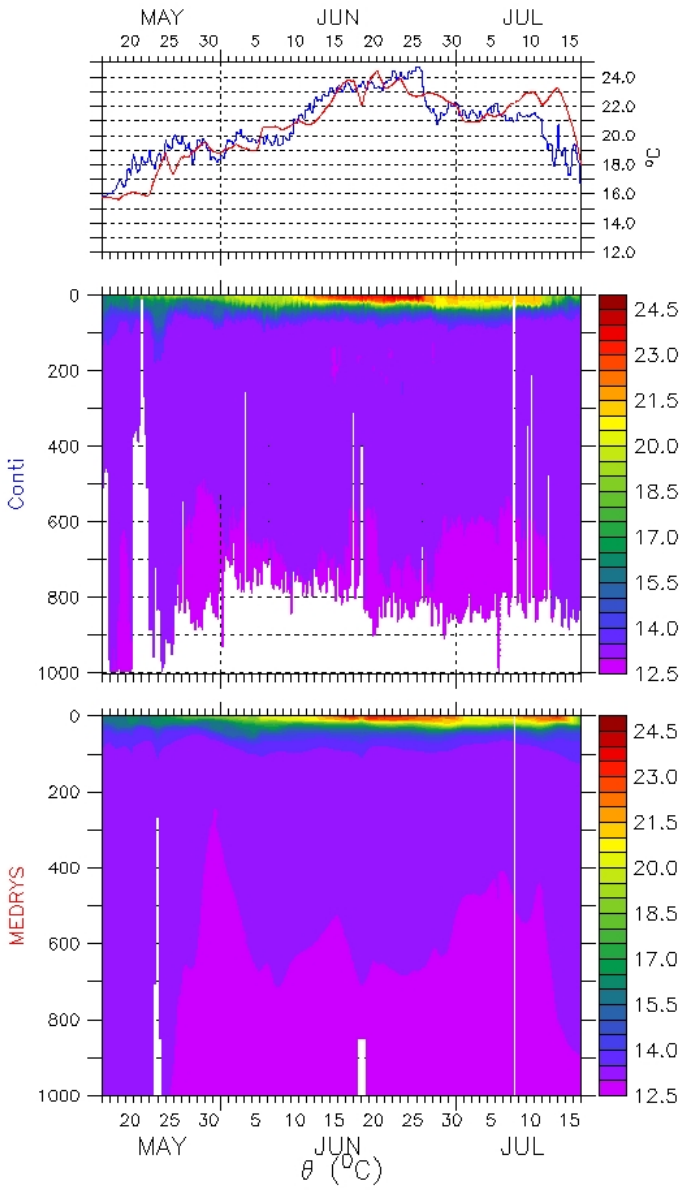
Merci pour votre attention !

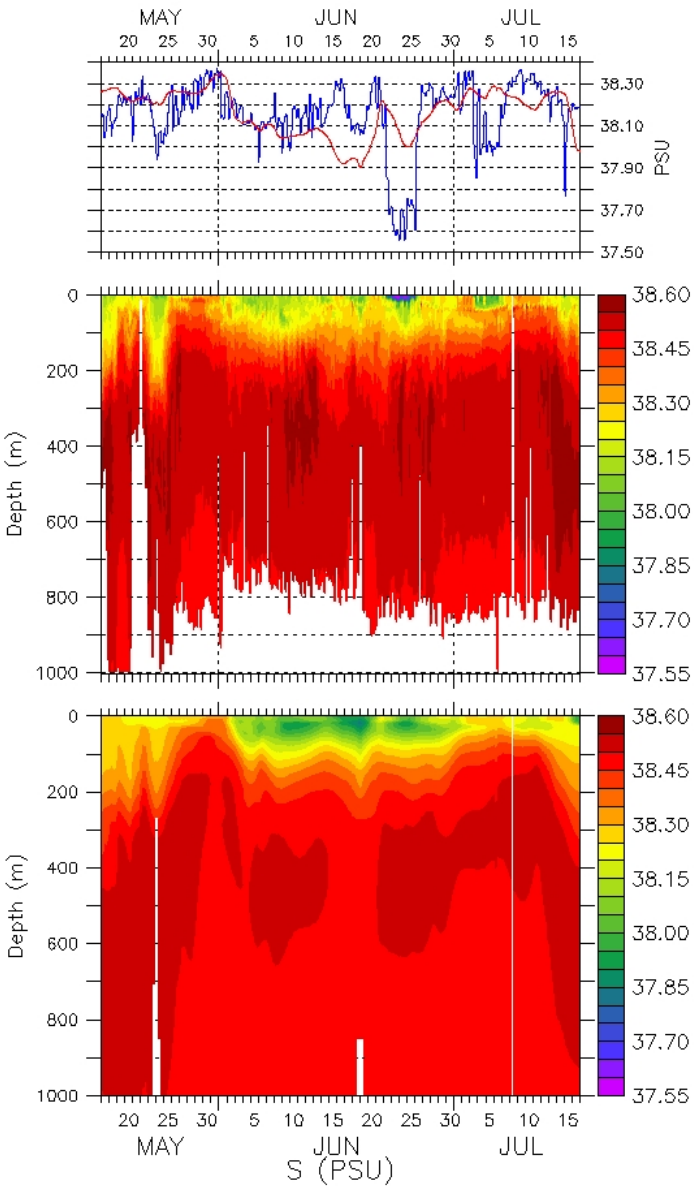


Annexe 1 : Glider 1



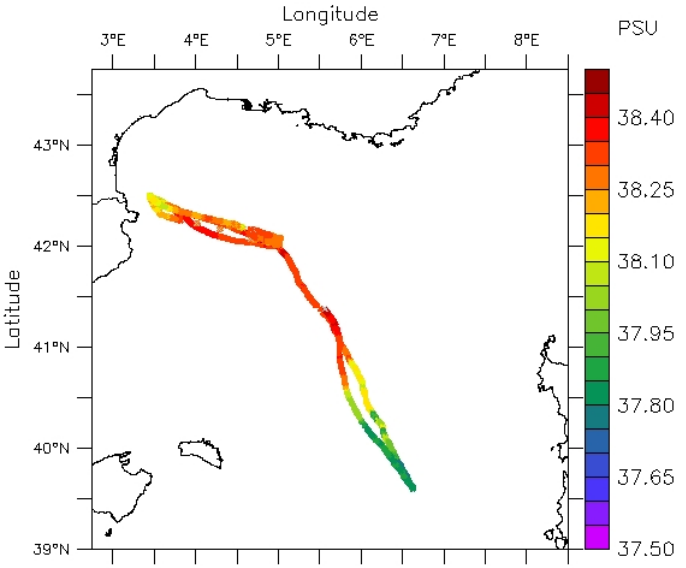


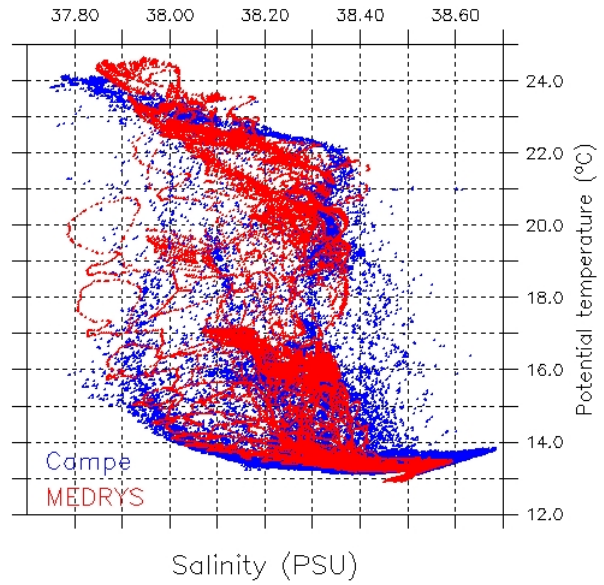


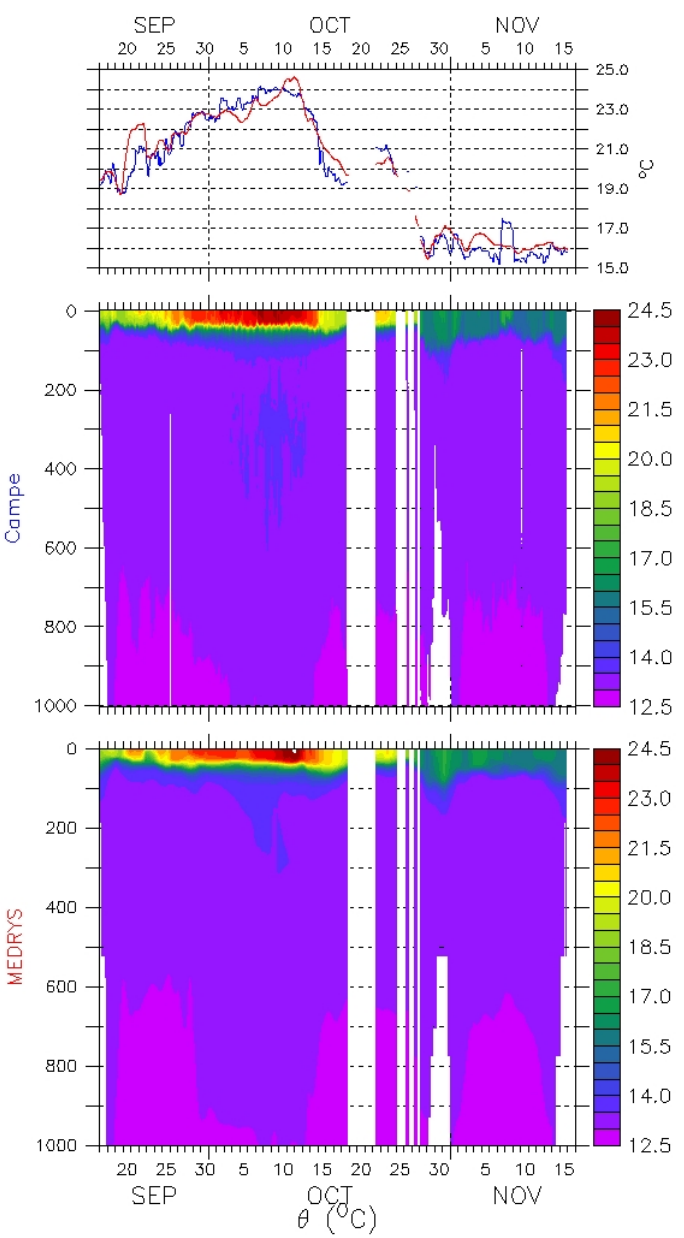


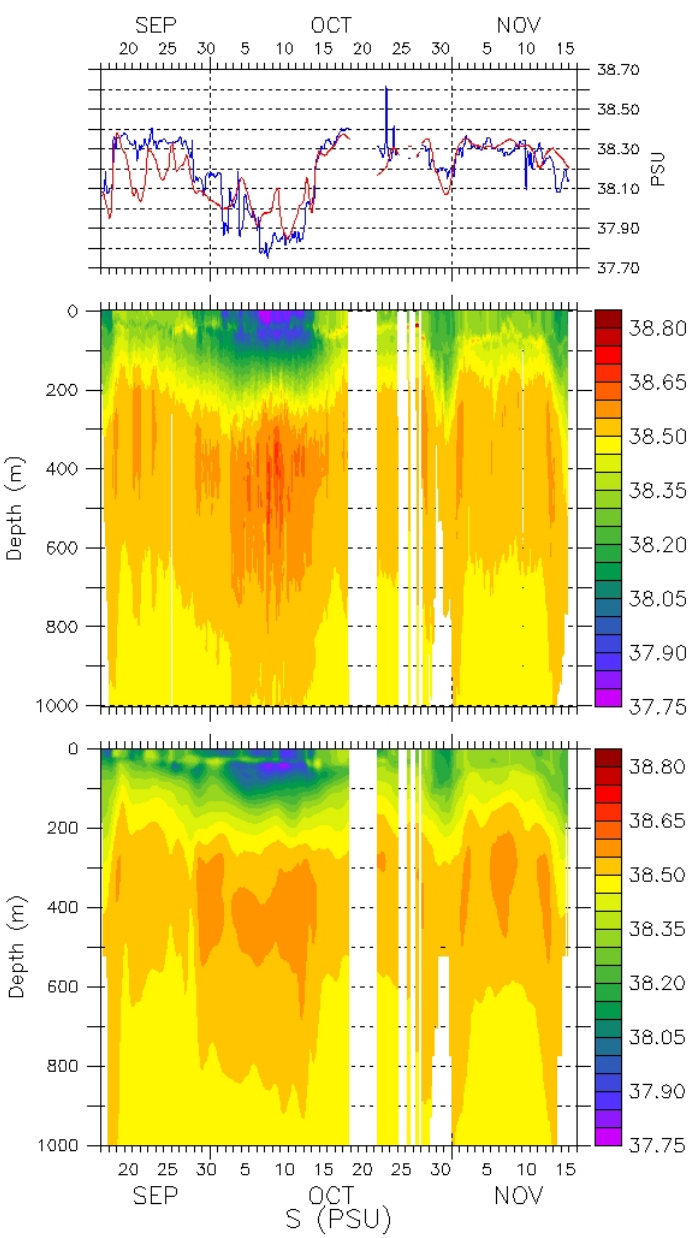
Glider Conti de MOOSE (été 2012) et glider virtuel dans MEDRYS1V2

Annexe 2 : Glider 2









Glider Campe de MISTRALS (automne 2012) et glider virtuel dans MEDRYS