Institut Pythéas
Observatoire des Sciences de l'Univers
Aix-Marseille Université

Étude du Front polaire aux alentours de Kerguelen à l'aide du modèle CROCO

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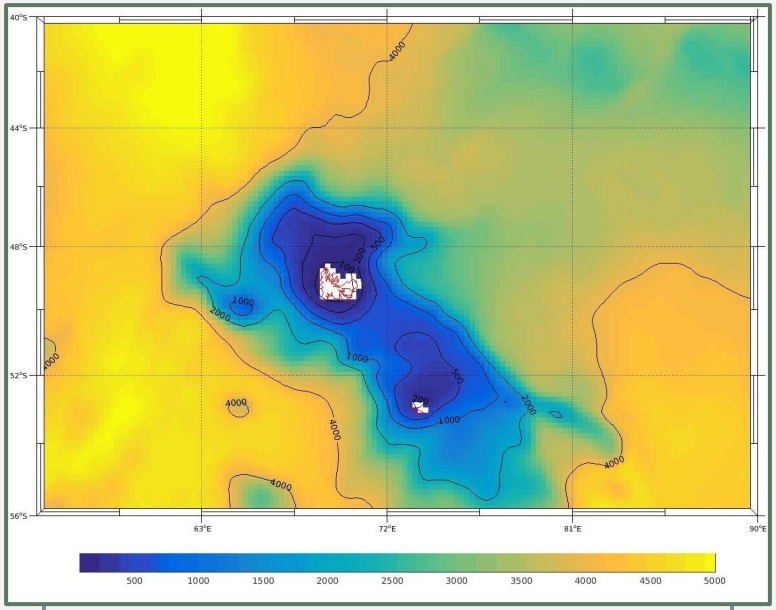
M1 Sciences de la mer

Parcours Océanographie Physique et Biogéochimique

UE : OPB 205
'*Modélisation 3D Océanique*'



Bathymétrie de la zone modélisée

Institut Méditerranéen d'Océanologie

Le Plateau de Kerguelen

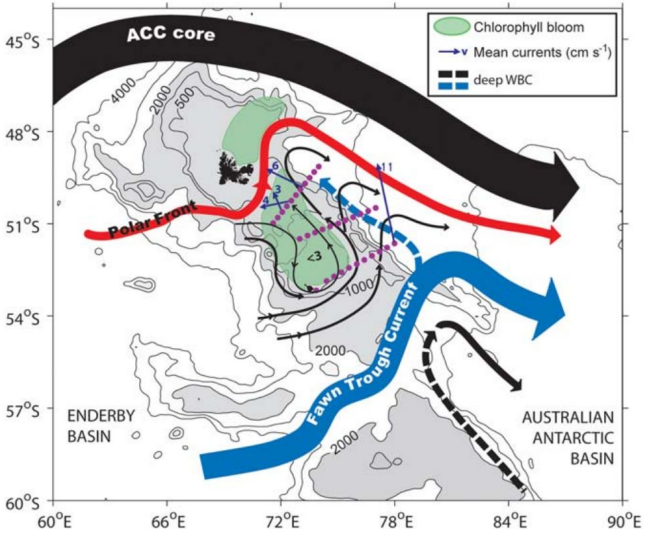


Fig.1: Schéma de circulation du CCA à travers le plateau.
[Park et al., 2014]

→ <u>Océan Austral</u>

- 70°E
- Obstacle quasi méridional
- HNLC

→ <u>Une région importante</u> :

- Apport de fer
- Intensification de production primaire

Le Front Polaire

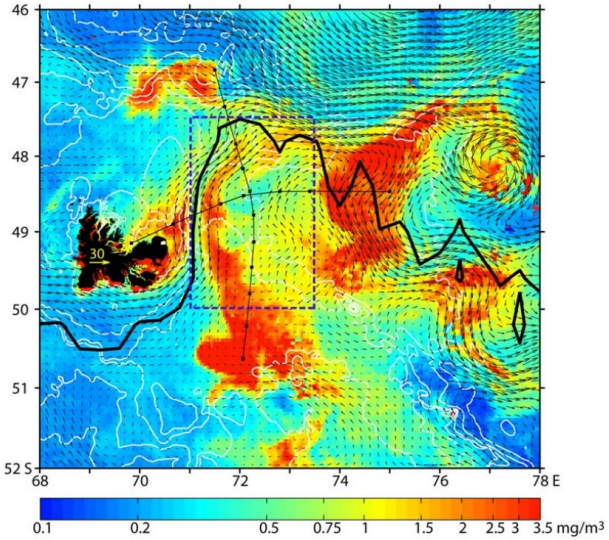
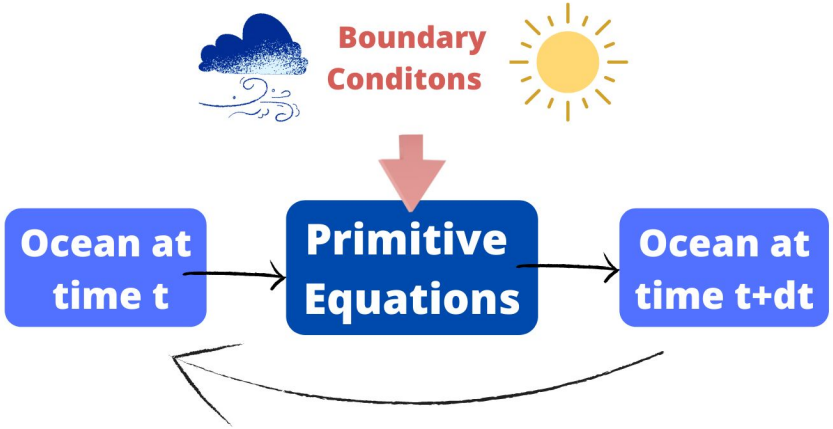


Fig.2: Image satellite composite de chlorophylle α (en mg/m3)
Champs de vitesse en surface moyens
[Park et al., 2014]

→ <u>Le Front Polaire</u>:

- Limite Nord de température ⩽2°C en subsurface
- Association avec une bande de courant du CCA

Le modèle CROCO



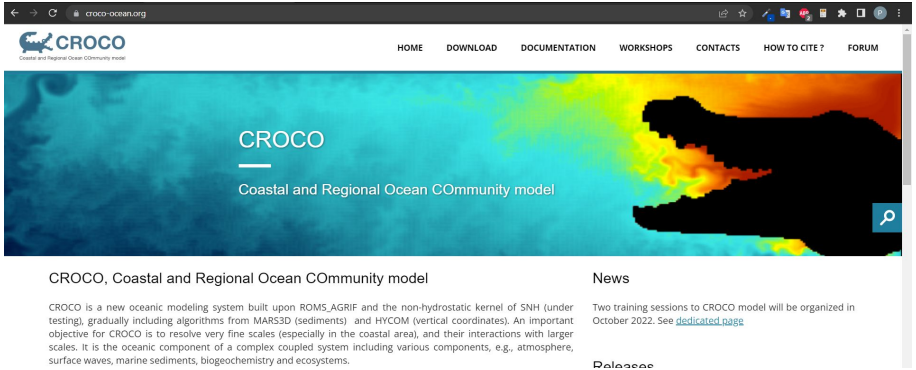


Fig.3: Principe d'un modèle numérique océanique

Le modèle CROCO

CROCO
Coastal and Regional Ocean COmmunity model

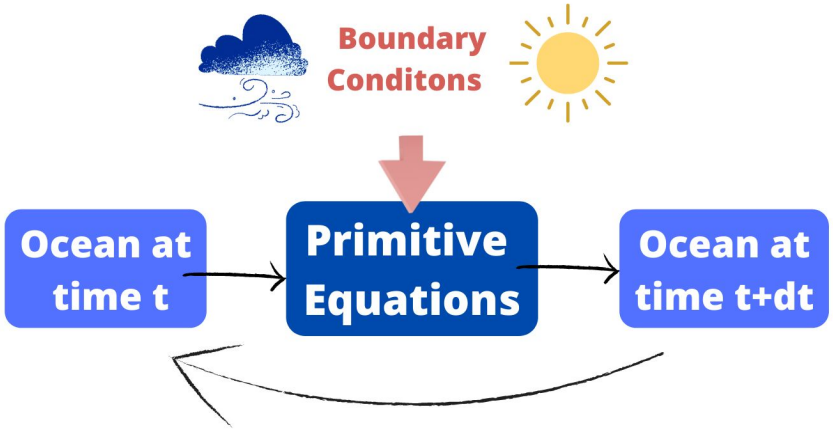


Fig.3: Principe d'un modèle numérique océanique

→ Conditions Initiales et de frontières :

- Data set globaux

- *WOA2009*
- *Topo*
- *COADS5*

Le modèle CROCO

CROCO
Coastal and Regional Ocean COmmunity model

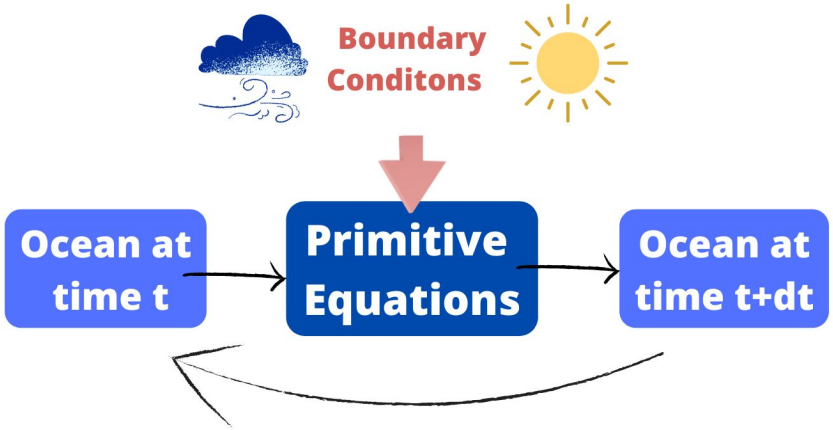


Fig.3: Principe d'un modèle numérique océanique

→ Équations primitives :

$$\begin{cases} \frac{\partial u}{\partial t} + \vec{V} \cdot \vec{\nabla} u = fv - \frac{1}{\rho_0}\frac{\partial P}{\partial x} + A_h \cdot \nabla_h^2 u + A_z \cdot \frac{\partial^2 u}{\partial z^2} \\ \frac{\partial v}{\partial t} + \vec{V} \cdot \vec{\nabla} v = -fu - \frac{1}{\rho_0}\frac{\partial P}{\partial y} + A_h \cdot \nabla_h^2 v + A_z \cdot \frac{\partial^2 v}{\partial z^2} \\ \frac{\partial P}{\partial z} + \rho g = 0 \end{cases}$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

$$\begin{cases} \frac{\partial T}{\partial t} + \vec{V} \cdot \vec{\nabla} T = K_h \nabla_h^2 T + K_v \frac{\partial^2 T}{\partial z^2} \\ \frac{\partial S}{\partial t} + \vec{V} \cdot \vec{\nabla} S = K_h \nabla_h^2 S + K_v \frac{\partial^2 S}{\partial z^2} \end{cases}$$

$$\rho = \rho(T, S, P)$$

Discrétisation horizontale

CROCO
Coastal and Regional Ocean COmmunity model

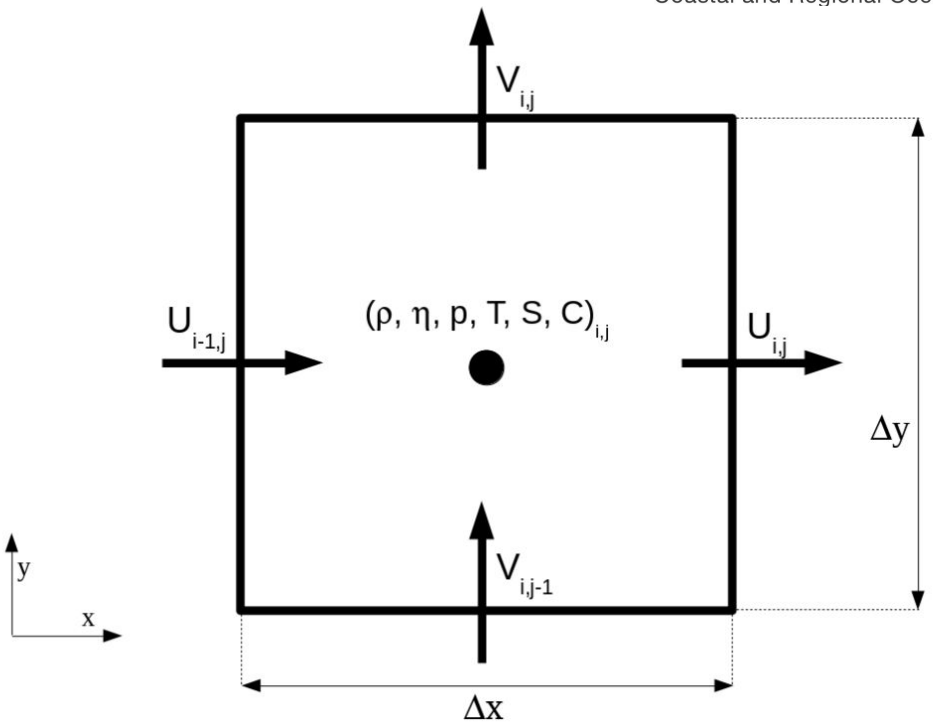


Fig.4: Grille Arakawa-C

Discrétisation vertical

CROCO
Coastal and Regional Ocean COmmunity model

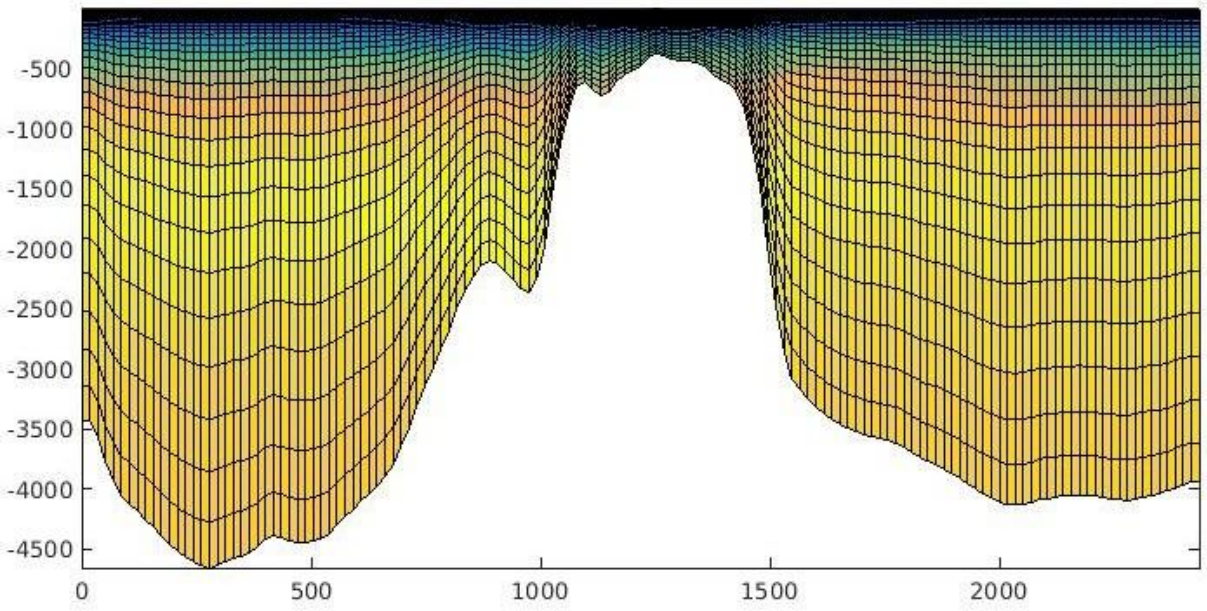


Fig.5: Modèle de ‘terrain following’ ou de coordonnées sigma

'Time-splitting'

CROCO
Coastal and Regional Ocean COmmunity model

$$\Delta t \leq \frac{1}{\sqrt{gH}} \sqrt{\left(\frac{1}{\Delta x^2} + \frac{1}{\Delta y^2}\right)}$$

Fig.5: Contrainte sur le pas de temps en mode externe

$$\boxed{\mathscr{C} = \frac{u \Delta t}{\Delta x} \leq 1}$$

Condition CFL

→ <u>Mode 'externe' :</u>

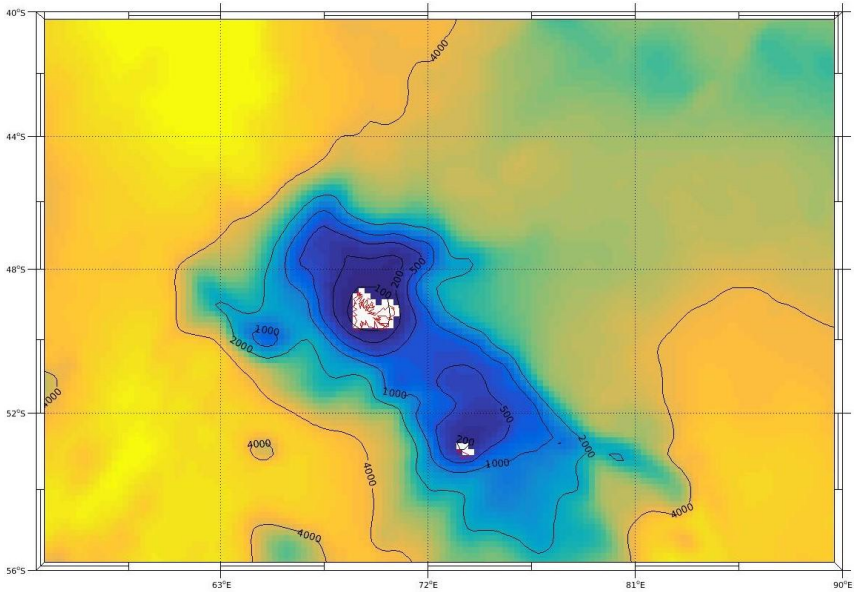
- DTE

→ <u>Mode 'interne' :</u>

- DTI
- NTDFAST

Configurations spatiales

Lat min	Lat max	Long min	Long max	LLm	MMm	Niveaux	Résolution
-56°N	-40°N	55°E	90°E	139	96	32	¼ °

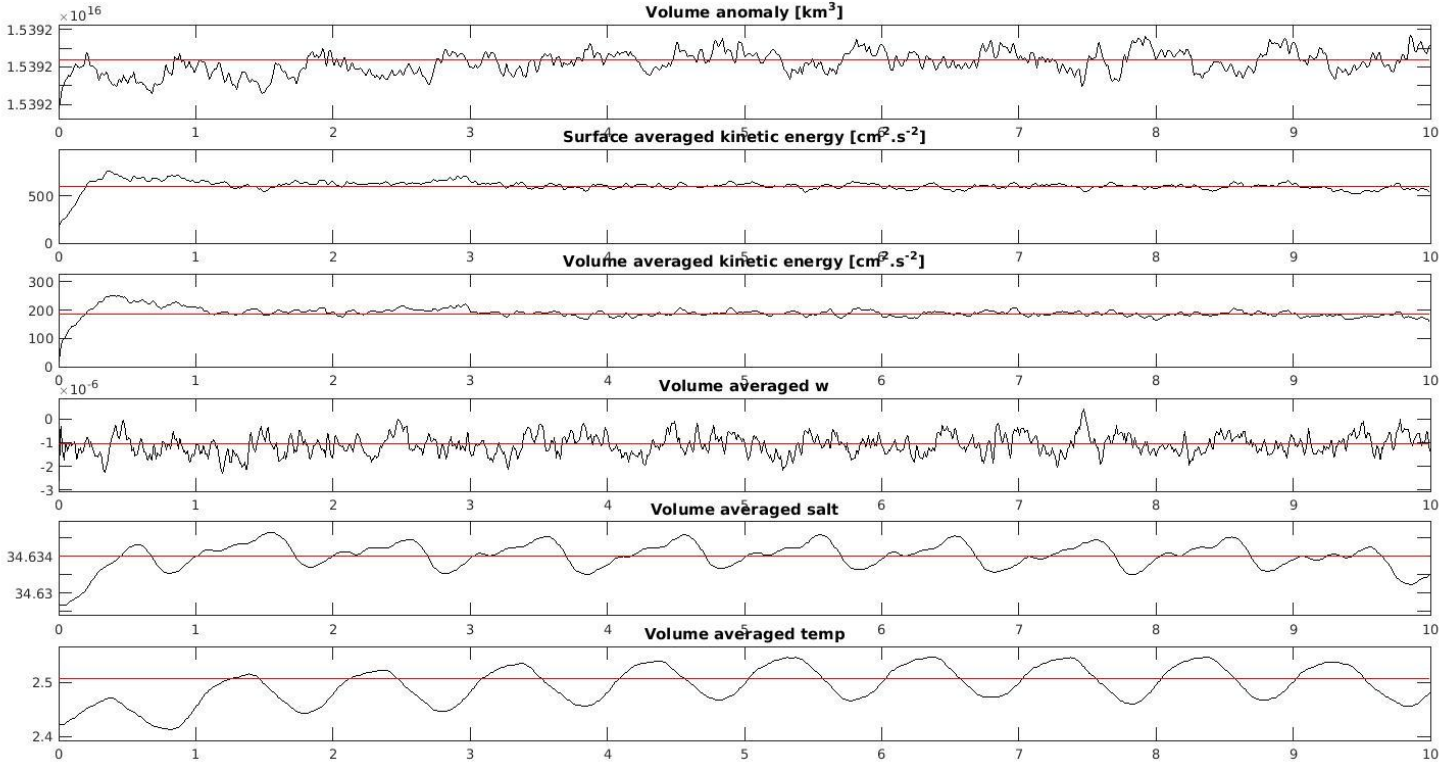


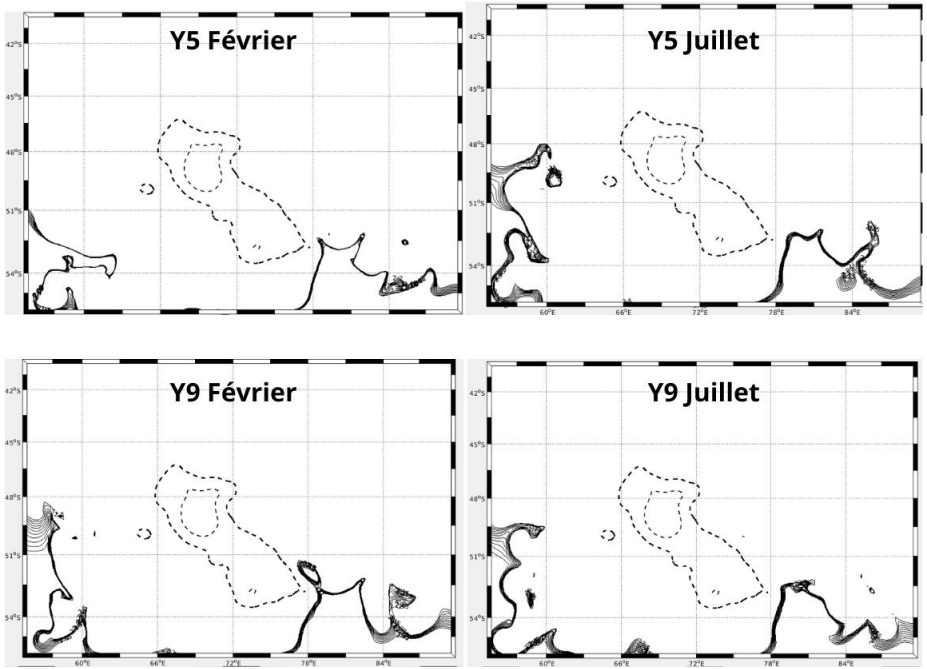
Configurations temporelles

Lat min	Lat max	Long min	Long max	LLm	MMm	Niveaux	Résolution
-56°N	-40°N	55°E	90°E	139	96	32	¼ °

Durée	NTIMES	NDTFAST	DTE	DTI	AVG
10 ans	1800	60	24sec	1440sec	3 jours

Diagnostics





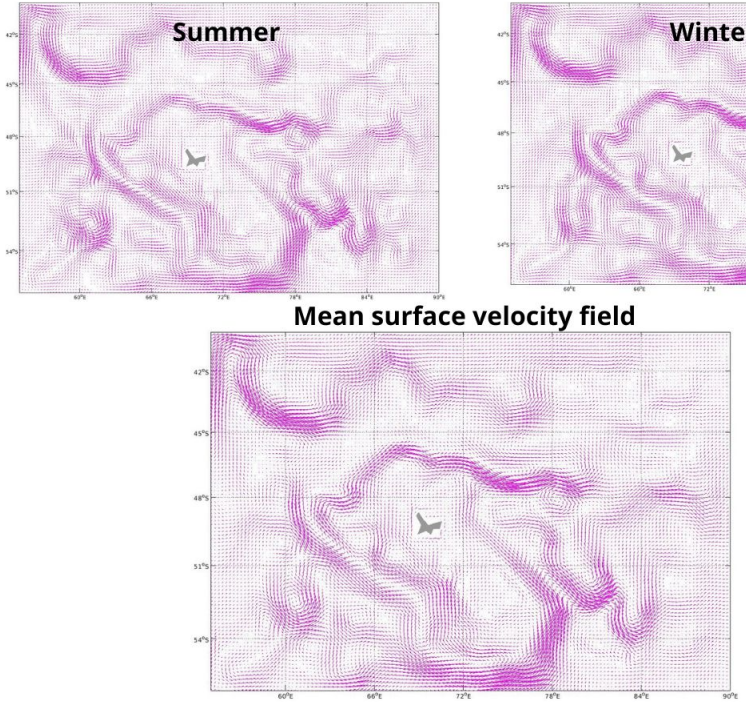
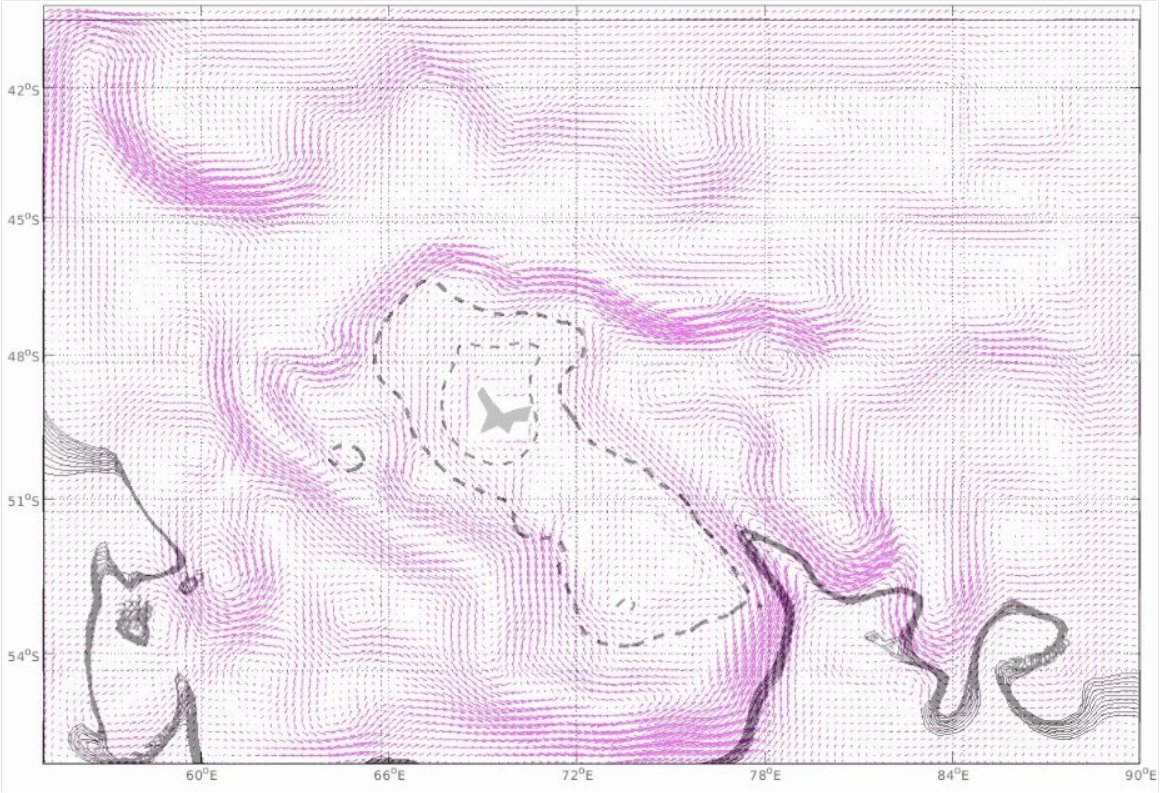


Fig.6: Variations interannuelles et saisonnières des sorties du modèle (Front Polaire, Champs de vitesses de surface moyens)



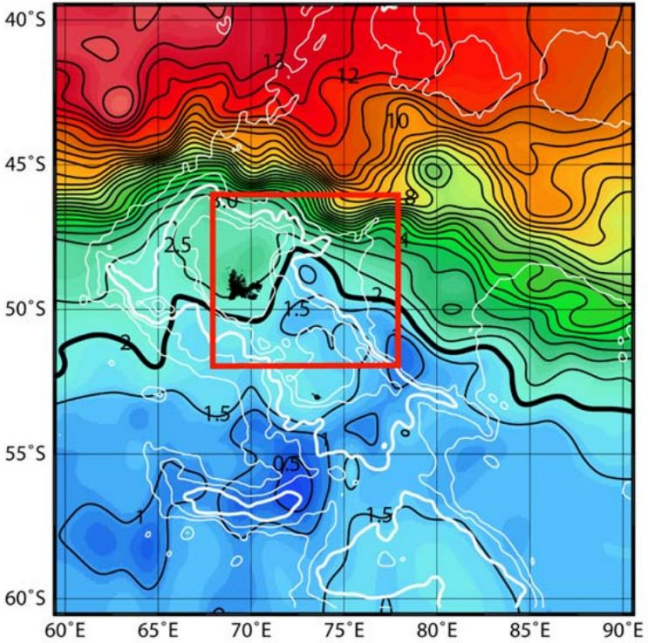
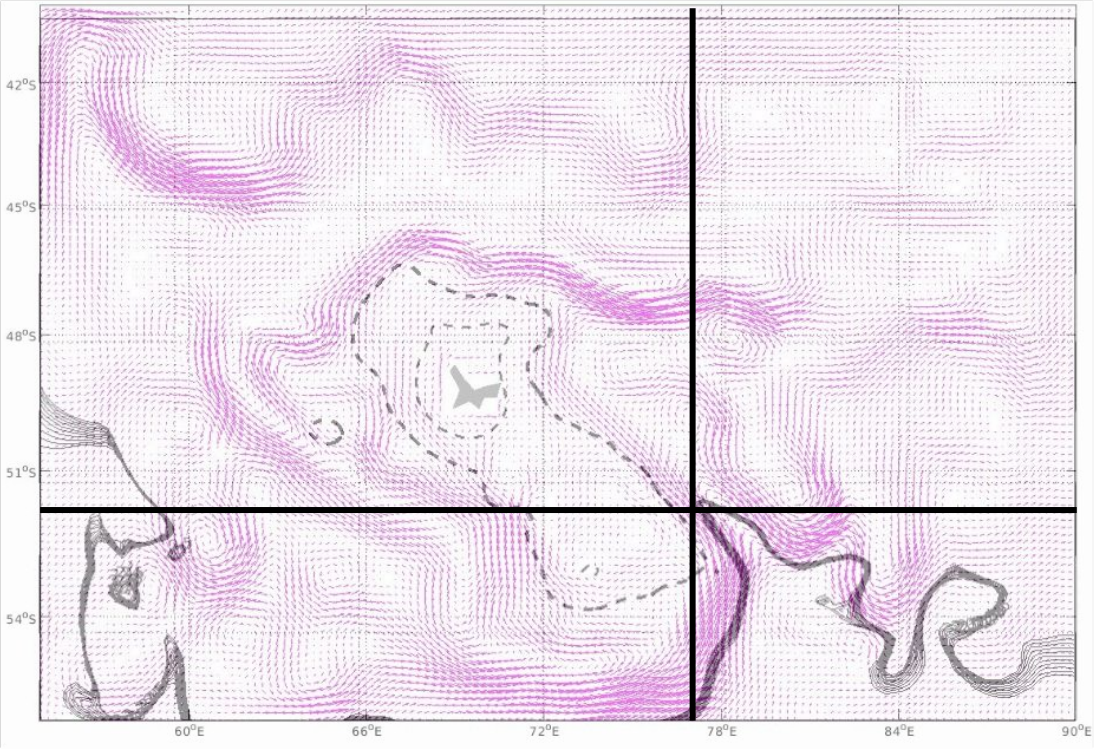
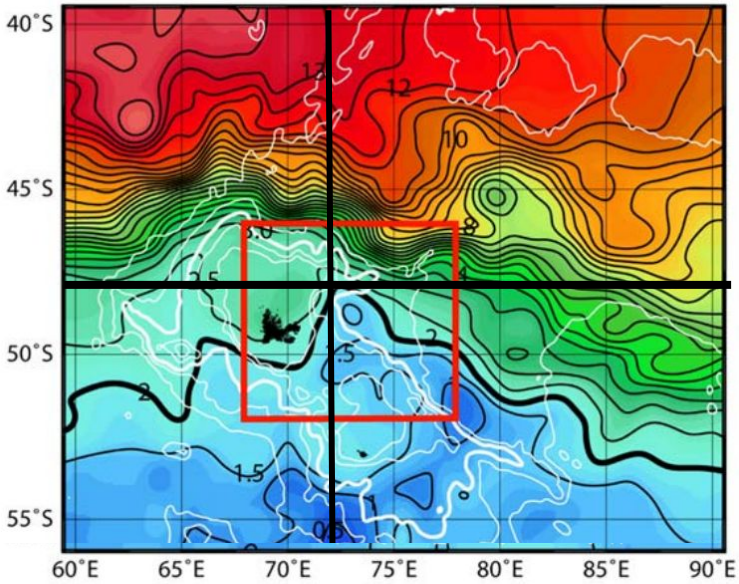
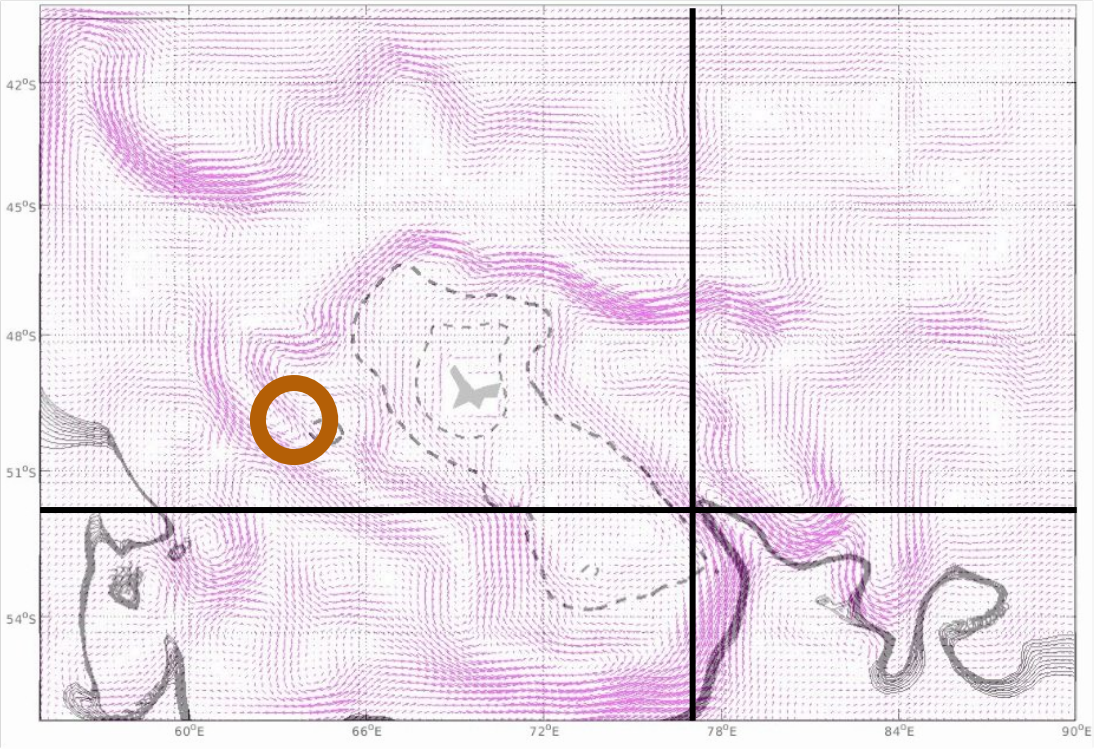
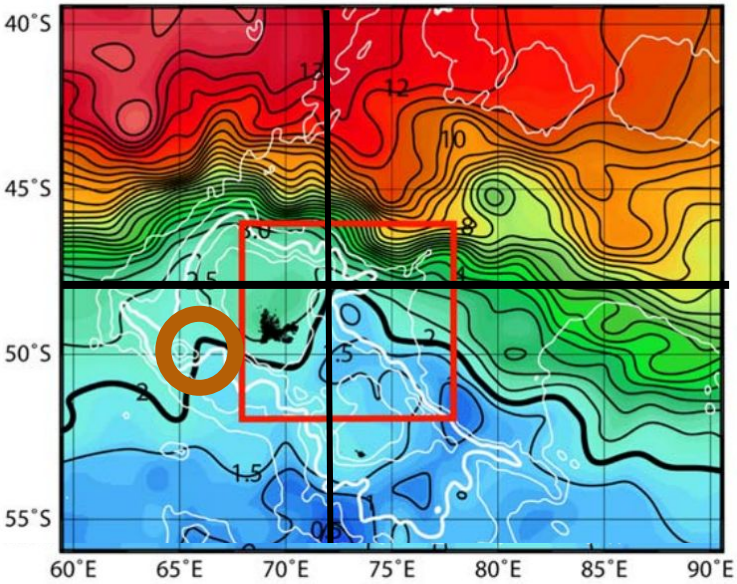


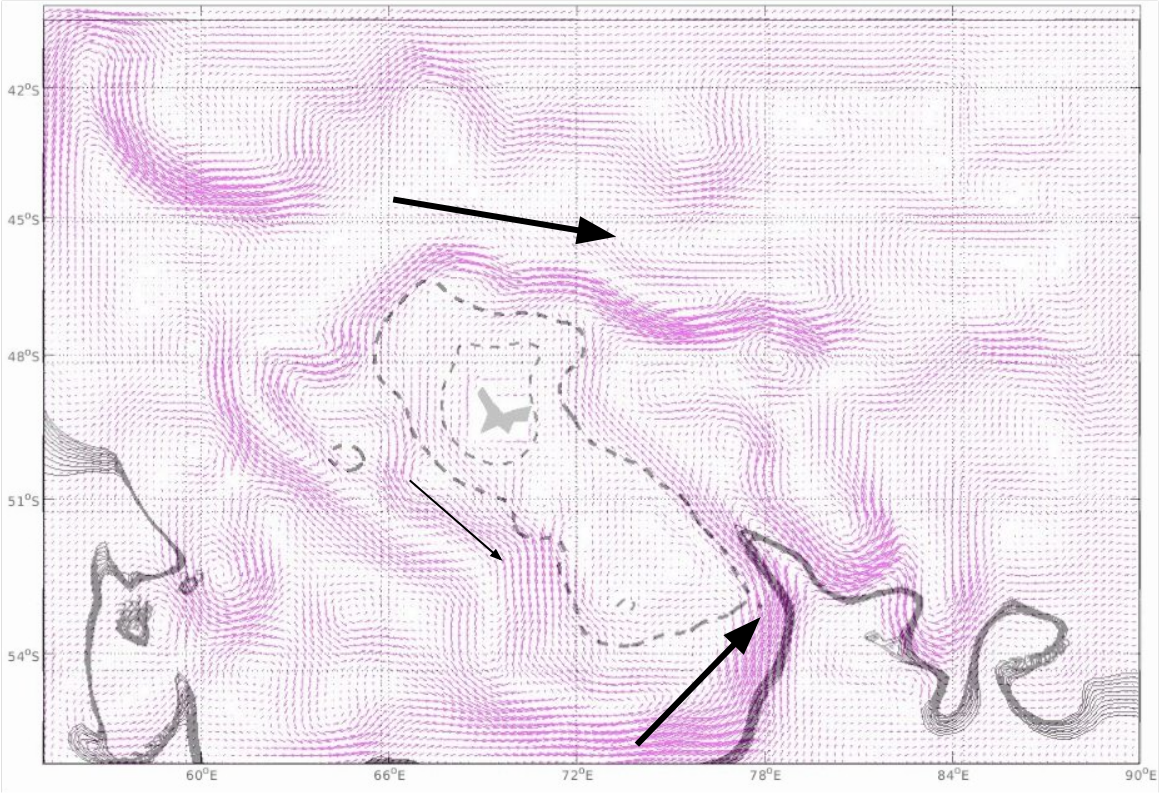
Fig.7: Position du front polaire et température de subsurface (200m) [Park et al., 2014]

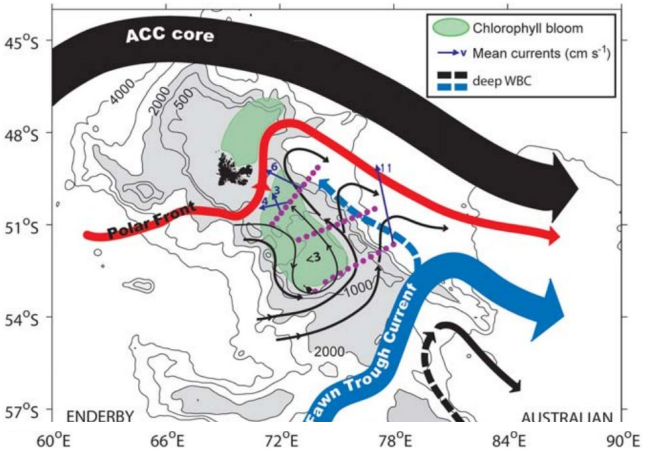

42°S
45°S
48°S
51°S
54°S
60°E
66°E
72°E
78°E
84°E
90°E


40°S
45°S
50°S
55°S
60°E
65°E
70°E
75°E
80°E
85°E
90°E


42°S
45°S
48°S
51°S
54°S
60°E
66°E
72°E
78°E
84°E
90°E


40°S
45°S
50°S
55°S
60°E
65°E
70°E
75°E
80°E
85°E
90°E


42°S
45°S
48°S
51°S
54°S
60°E
66°E
72°E
78°E
84°E
90°E


ACC core
Chlorophyll bloom
Mean currents (cm s-1)
deep WBC
Polar Front
Trough Current
4000
2000
500
1000
2000
45°S
48°S
51°S
54°S
57°S
ENDERBY
AUSTRALIAN
60°E
66°E
72°E
78°E
84°E
90°E

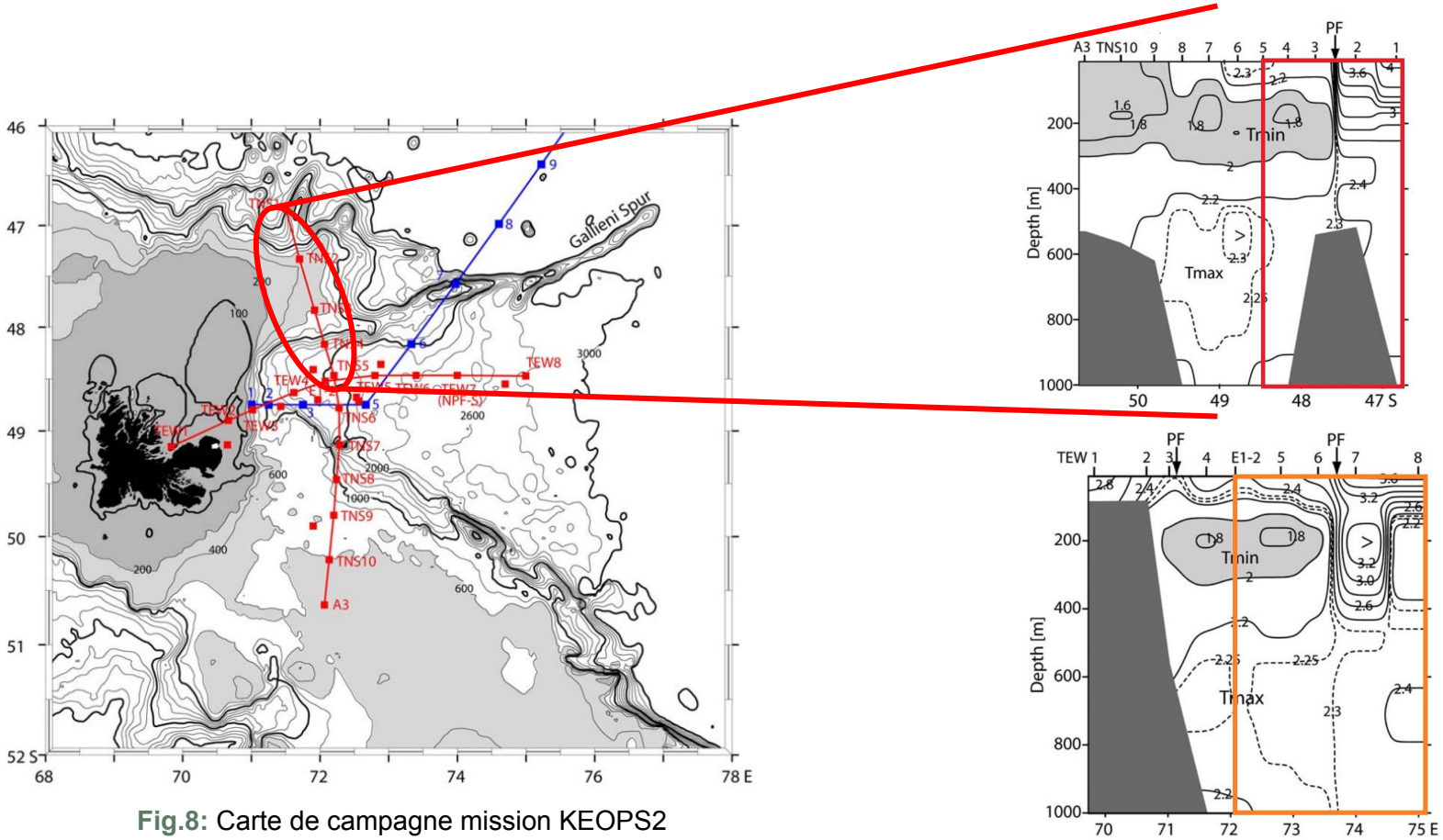
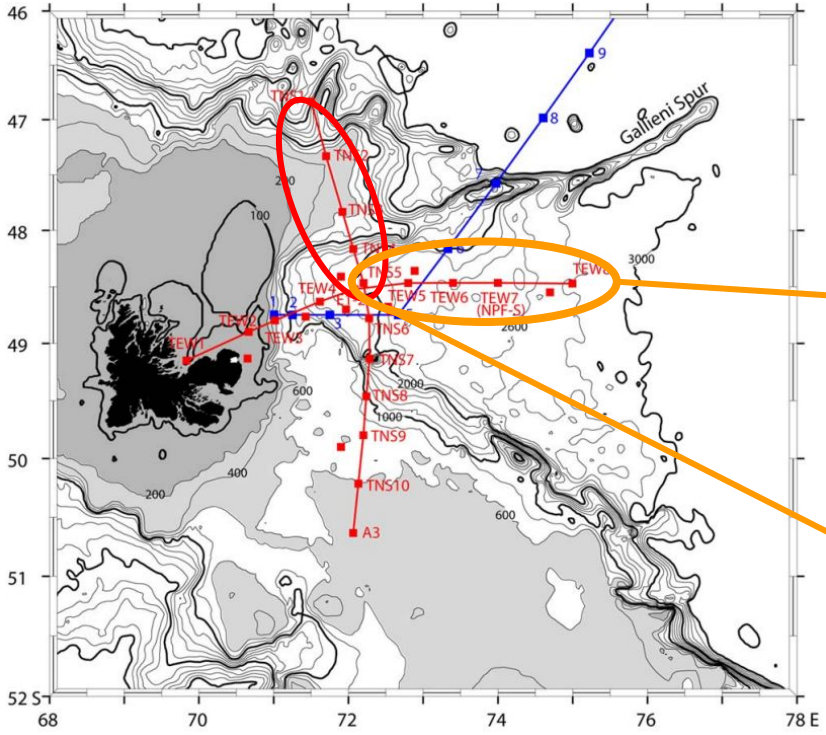
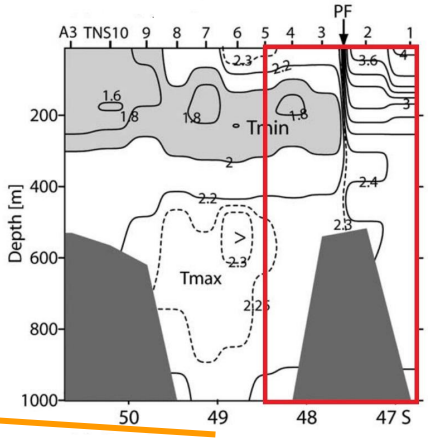
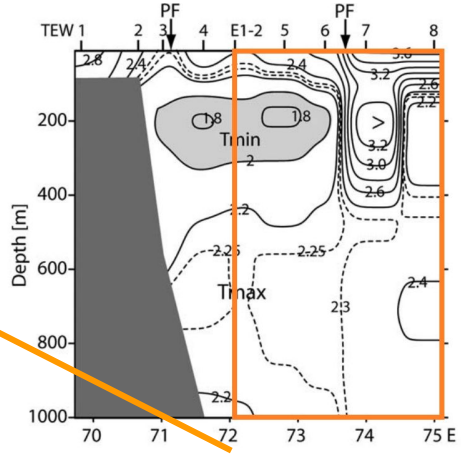


Fig.8: Carte de campagne mission KEOPS2
Sections verticales de température
[Park et al., 2014]







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Sections verticales de température
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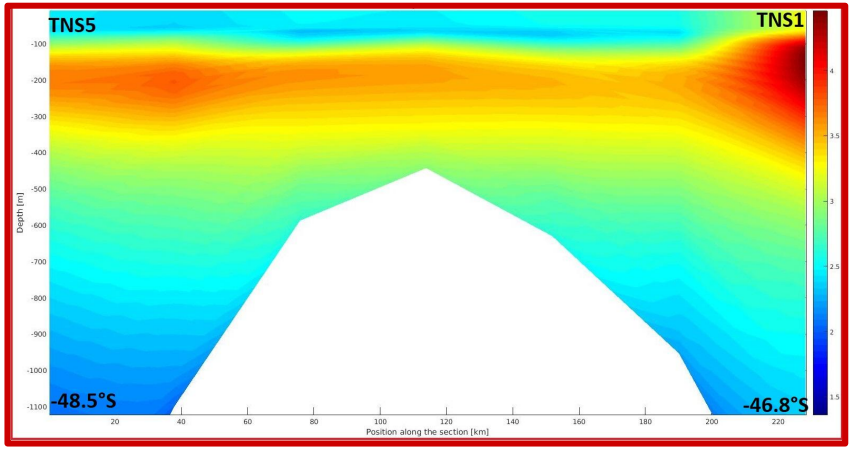
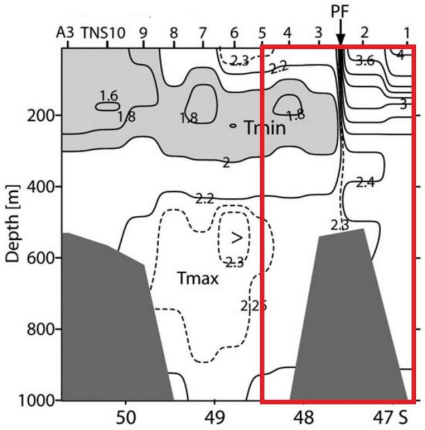
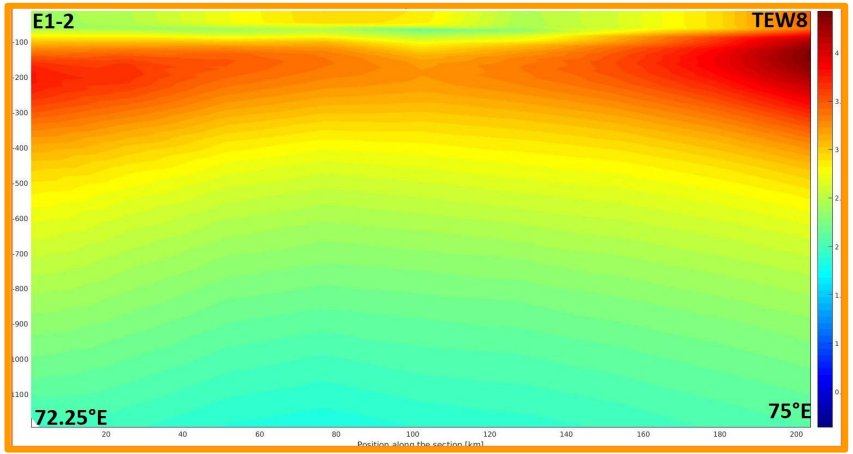
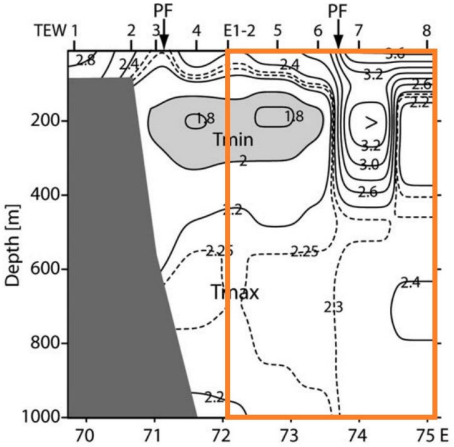
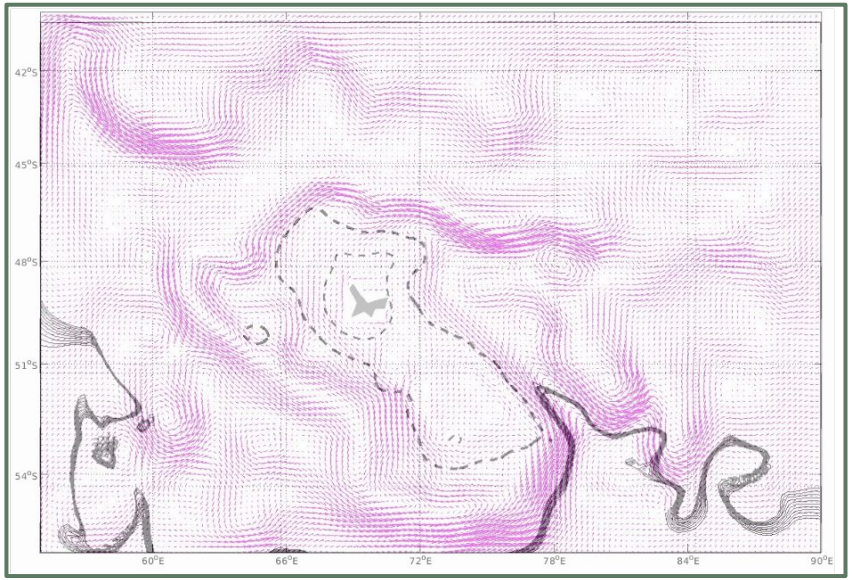

TNS5
TNS1
-48.5°S
-46.8°S
Depth [m]
Position along the section [km]

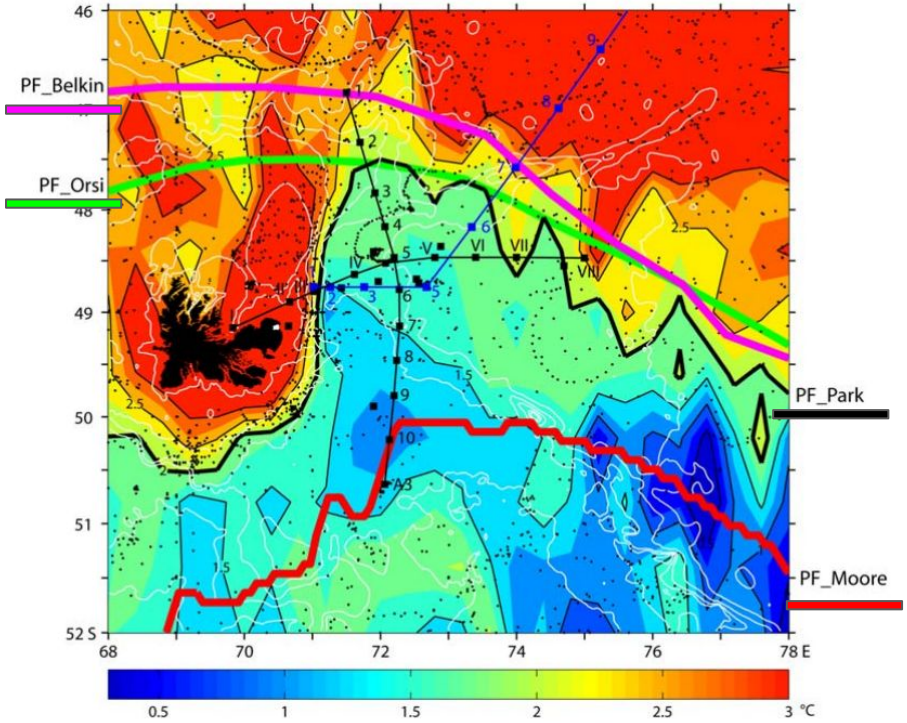

PF
A3 TNS10 9 8 7 6 5 4 3 2 1
Tmin
Tmax
Depth [m]
50 49 48 47 S


E1-2
TEW8
72.25°E
75°E
Position along the section [km]


PF
PF
TEW 1 2 3 4 E1-2 5 6 7 8
Tmin
Tmax
Depth [m]
70 71 72 73 74 75 E



- Peu de variations des années ‘types’ simulées
- Représentation fidèle du CCA
- Dérive Sud-Est du front polaire



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- Représentation fidèle du CCA
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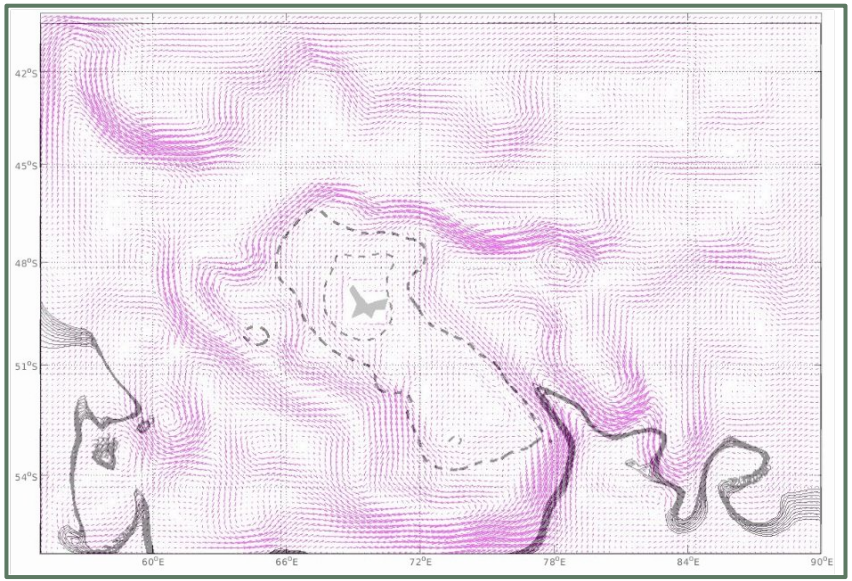
- <u>Hypothèses :</u>
  - Conditions initiales
  - Subdivision du front polaire [M.Fieux, 2010]



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- <u>Hypothèses :</u>
  - Conditions initiales
  - Subdivision du front polaire [M.Fieux, 2010]
- <u>En plus :</u>
  - Fermeture de la turbulence
  - Couplage biogéochimie
  - Nouvelles conditions initiales

Bibliographie & Ressources

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