Aix*Marseille université
Institut PYTHEAS
Observatoire des Sciences de l'Univers
Aix*Marseille Université

Simulation de la dynamique et désintégration des courants dans le Passage de Drake avec le "Regional Ocean Modelling System (ROMS)"

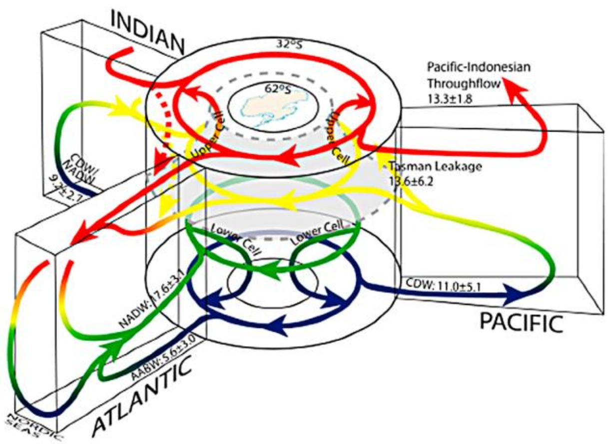
OPB205 - Modélisation de la circulation océanique
Master Océanographie 1er année, 2015 – 2016

Maximilian UNTERBERGER
Responsable de cours: Mr. A. DOGLIOLI

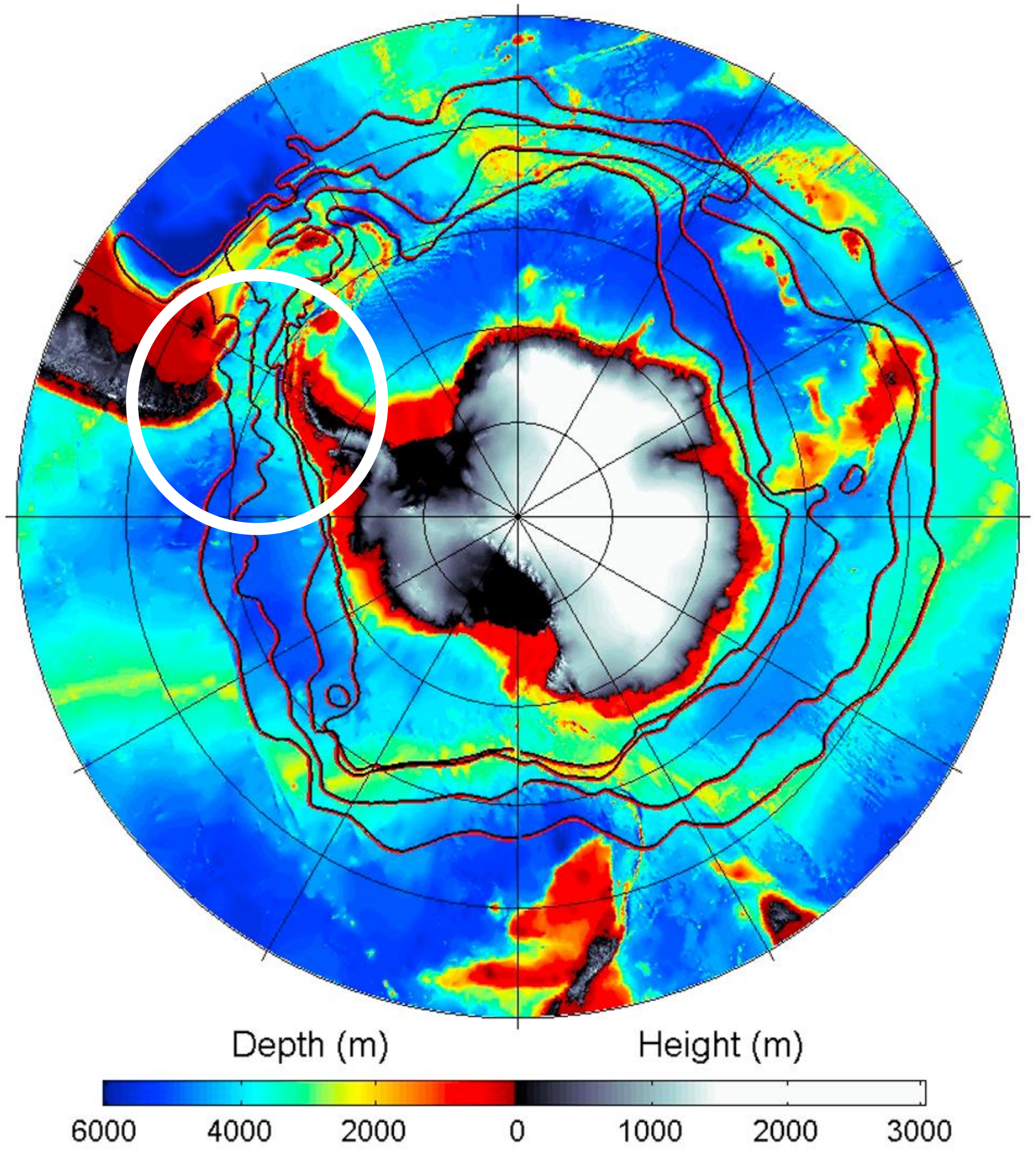
Passage de Drake

Facteurs essentiels:

- **Courant Thermohaline**
- Courant Antarctique Circumpolaire (ACC) ~ 100 – 150 Sv
- Courant Péri Antarctique Côtier (PACC)
- Arrivée du Courant de Pacifique Est (Pacific Deep Water)



Michael P. Meredith et al., 2011



Michael P. Meredith et al., 2011

Présentation de l´Article de Comparaison

« **Deep boundary current disintegration in Drake Passage** »

J. Alexander Brearley et al. 2014

- **Désintégration d´un courant d´origine Pacifique Est**
  - **Transport des masses d´eau peu saline et chaude**
  - **Fraction de "l´eau profonde pacifique (PDW)"**
  - **~ 6 Sv**
- **Formation de tourbillons anticycloniques**
  - **Homogénéisation de l´eau de ACC**

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER

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Deep boundary current disintegration in Drake Passage

J. Alexander Brearley[1], Katy L. Sheen[1], Alberto C. Naveira Garabato[1], David A. Smeed[2], Kevin G. Speer[3], Andreas M. Thurnherr[4], Michael P. Meredith[5,6], and Stephanie Waterman[7]

[1]National Oceanography Centre, University of Southampton, Southampton, UK, [2]National Oceanography Centre, National Oceanography Centre, Southampton, UK, [3]Earth, Ocean and Atmospheric Science and Geophysical Fluid Dynamics Institute, Florida State University, Tallahassee, Florida, USA, [4]Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York, USA, [5]British Antarctic Survey, Cambridge, UK, [6]Scottish Association for Marine Science, Oban, UK, [7]Climate Change Research Centre and ARC Centre of Excellence for Climate System Science, University of New South Wales, Sydney, New South Wales, Australia

Key Points:
- Mid-depth eddies observed east of Drake Passage
- Eddies contain fresh Pacific Deep Water
- Eddies induce transport of water properties across the ACC

Correspondence to:
J. A. Brearley,
jab5@noc.soton.ac.uk

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Abstract The fate of a deep boundary current that originates in the Southeast Pacific and flows southward along the continental slope of South America is elucidated. The current transports poorly ventilated water of low salinity (a type of Pacific Deep Water, PDW), into Drake Passage. East of Drake Passage, the boundary current breaks into fresh anticyclonic eddies, nine examples of which were observed in mooring data from December 2009 to March 2012. The observed eddies appear to originate mainly from a topographic separation point close to 60°W, have typical diameters of 20–60 km and accompanying Rossby numbers of 0.1–0.3. These features are likely to be responsible for transporting PDW meridionally across the Antarctic Circumpolar Current, explaining the near homogenization of Circumpolar Deep Water properties downstream of Drake Passage. This mechanism of boundary current breakdown may constitute an important process in the Southern Ocean overturning circulation.

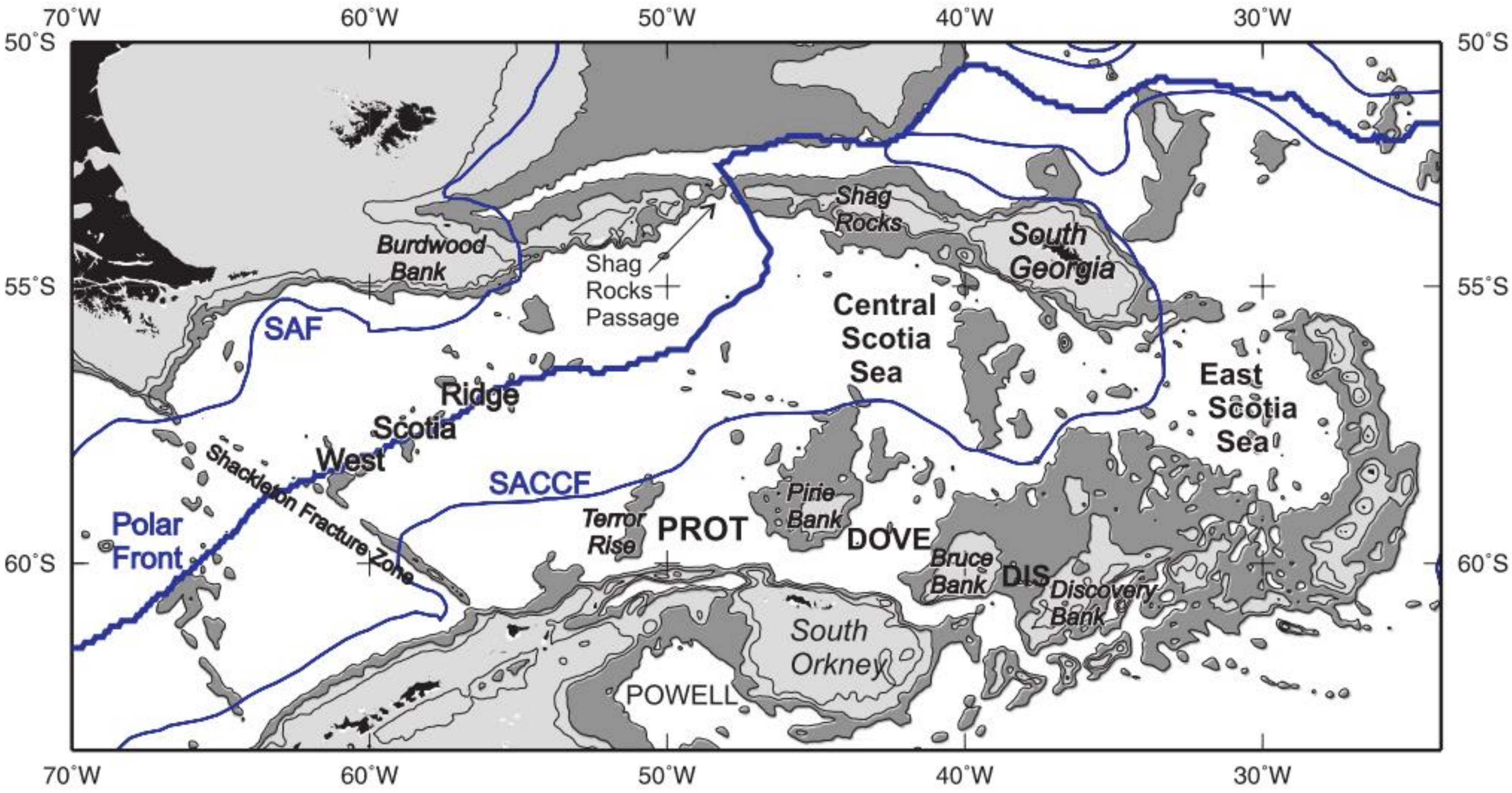
1. Introduction

The meridional overturning circulation (MOC) of the Southern Hemisphere oceans strongly influences the uptake of both heat and carbon from the atmosphere, and thus plays a fundamental role in global climate. A significant gap in our understanding of the Southern Ocean MOC pertains to the character and implications of the abrupt transition between the distinct dynamical regimes of the mid-depth ocean circulation to the north of and that within the Antarctic Circumpolar Current (ACC) [*Marshall and Speer*, 2012]. These intermediate waters must transit between topographically guided deep boundary currents and a strongly eddying, open channel environment as they enter the ACC, whereupon they form the Circumpolar Deep Water (CDW) that occupies much of the Southern Ocean. This process is particularly striking in Drake Passage, where topography is complex, circulation is intense, and the evolution of CDW properties along the ACC is dramatic [*Naveira Garabato et al.*, 2002].

One component of CDW originates in the South Pacific and is termed Pacific Deep Water (PDW). Analysis of a number of hydrographic sections [e.g., *Reid*, 1997; *Tsuchiya and Talley*, 1998] has shown that part of this poorly oxygenated water mass flows along the western and southern continental slopes of South America and enters the ACC in Drake Passage [*DeMets et al.*, 1990; *Tsuchiya and Talley*, 1998; *Faure and Speer*, 2012]. This deep boundary current is observed in Drake Passage, where it transports ~6 Sv (1 Sv = $1 \times 10^6\ m^3 s^{-1}$) of a variety of PDW that is cool, fresh, depleted in oxygen, and enriched in ^3He and Mn relative to CDW of the same density advected from the west by the ACC [*Well et al.*, 2003; *Sudre et al.*, 2011; *Middag et al.*, 2012]. This variety of PDW has been termed Southeast Pacific Deep Slope Water [*Well et al.*, 2003]. As it is advected through Drake Passage, its pronounced low oxygen concentration signature (< 150 µmol kg^{-1}) centered at 2000 m depth (Figures 1a and 1b) is gradually degraded and spread along isopycnals, such that by the time it reaches the SR1b repeat hydrography line 600 km farther east (Figure 1c), the oxygen minimum has crossed the Subantarctic Front (SAF). A similar distance farther downstream, over the Falkland Plateau, where the SAF and Polar Front (PF) move to the west of South Georgia, the oxygen minimum has virtually disappeared (Figure 1d; see also *Naveira Garabato et al.* [2007]). The ^3He fingerprint of the water mass is, nonetheless, traceable for thousands of kilometers along the ACC [*Well et al.*, 2003].

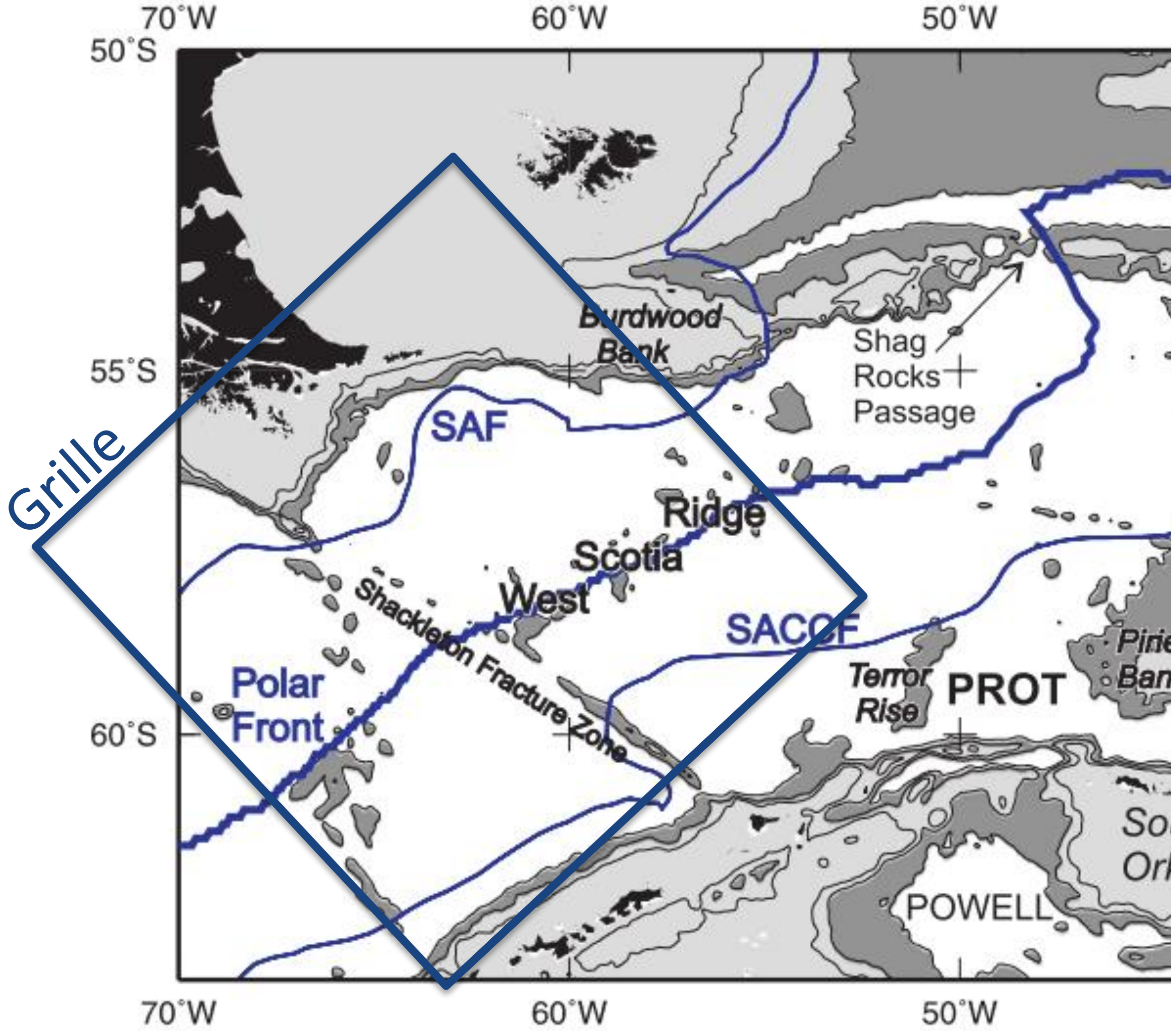
Mécanismes importants pour le Courant Thermohaline ?

Zone d´Etude et Bathymétrie



Roy Livermoore et al., 2007

Zone d´Etude et Implémentation du Model



Roy Livermoore et al., 2007

Grid parameters	Model
Longitude min.	-74°W
Longitude max.	-62°W
Latitude min.	-61°S
Latitude max.	-53°S
Number of vertical levels	32
Grid dimensions LLm/MMm	94/73
Grid resolution	12 km
Resolution	1/5
Open borders	all

Time parameters		
time of model simulation	-	10 years
Number of loops 3D	NTIMES	3600
Time steps	Dt	720 seconds
Number of loops 2D / (3D loops)	NTDFAST	60 seconds

Diagnostique de la Simulation

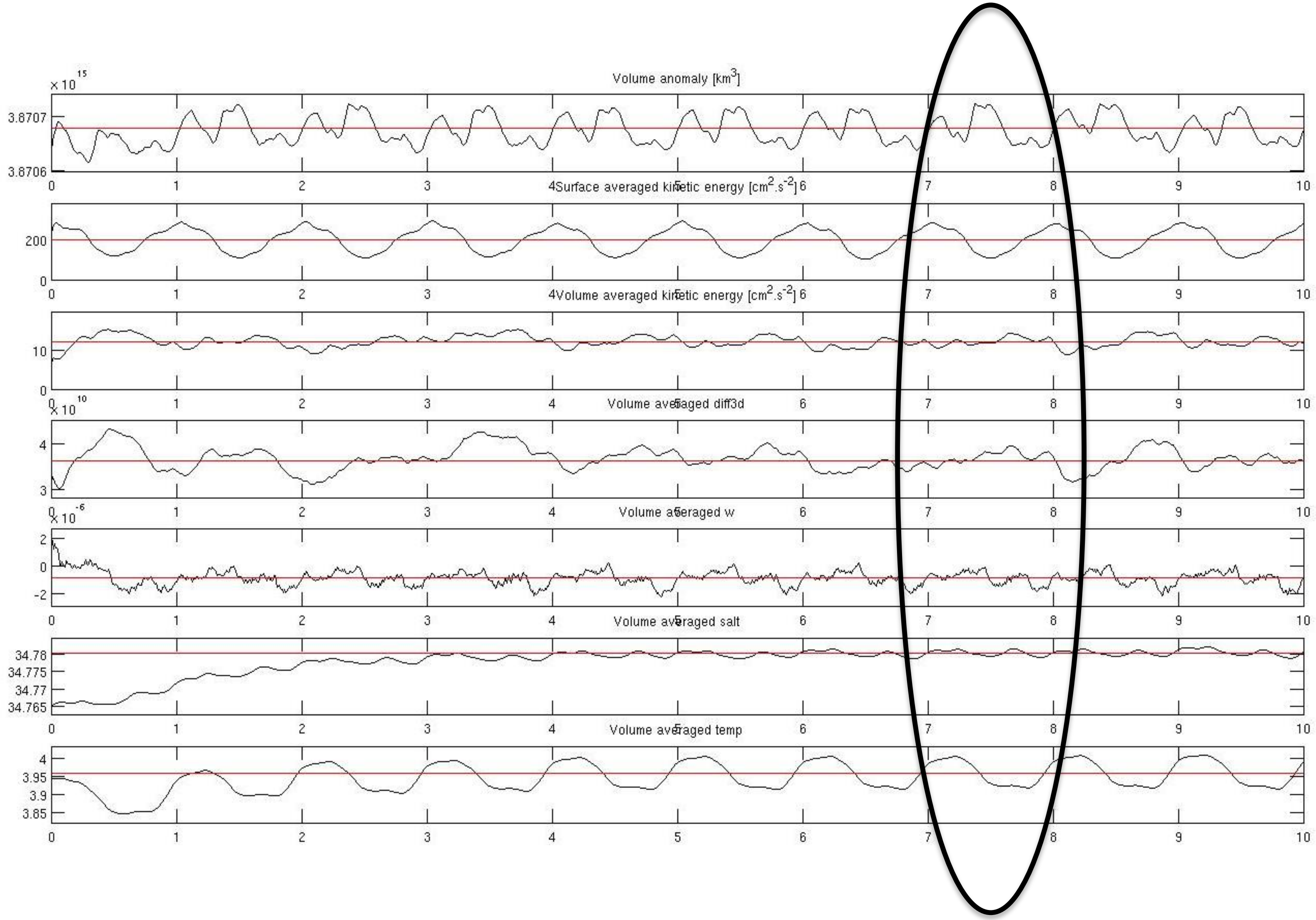
- **8eme année la plus stable**

➡ **Les résultats de l´année 8 sont sélectionnés**

- **Changements saisonnier pas significatifs**

➡ **Choix des résultats du 1er mars**

- **Profondeurs: Surface, 1000 m et 2000 m**



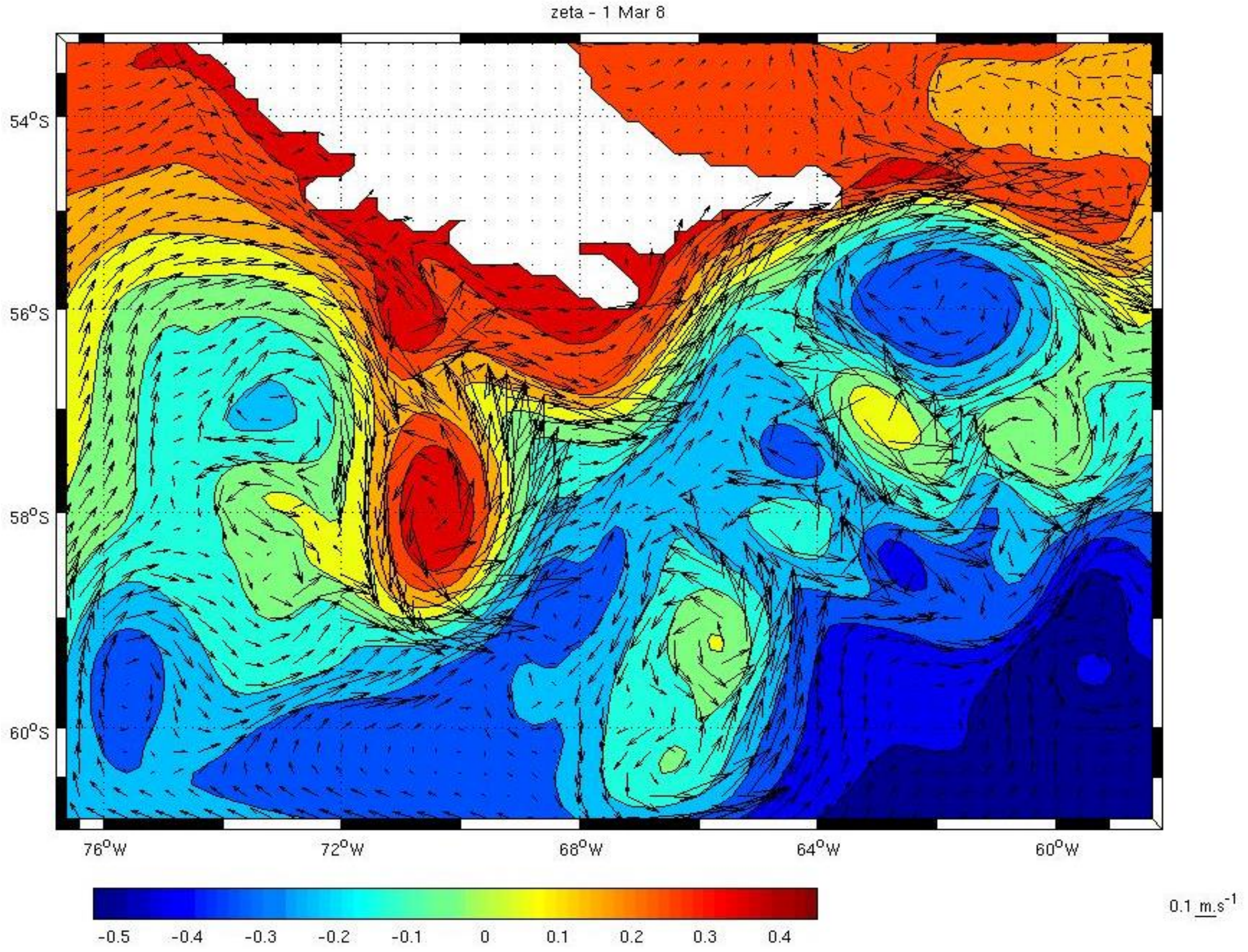
Courants et Elévation

- **Courants observables:**
  - **de Pacific Est**
  - **de ACC**
  - **PACC**

- **Formation des tourbillons:**
  - **Anticycloniques**
  - **Un seul cyclonique**

➡ **Les tourbillons correspondent avec ceux de l´article**

Elévation



Température et Salinité

- **L´arrivée des masses d´eau:**
  - **PDW**
    - Chaude et peu saline
  - **ACC**
    - Froide et saline
  - **PACC**
    - Froide et saline au fond

- **Formation des tourbillons:**
  - **Anticycloniques**
    - Eau chaude et peu saline

➡ **PDW**

  - **Cyclonique**
    - Eau froid et peu saline

➡ **L´eau de ACC et PACC**

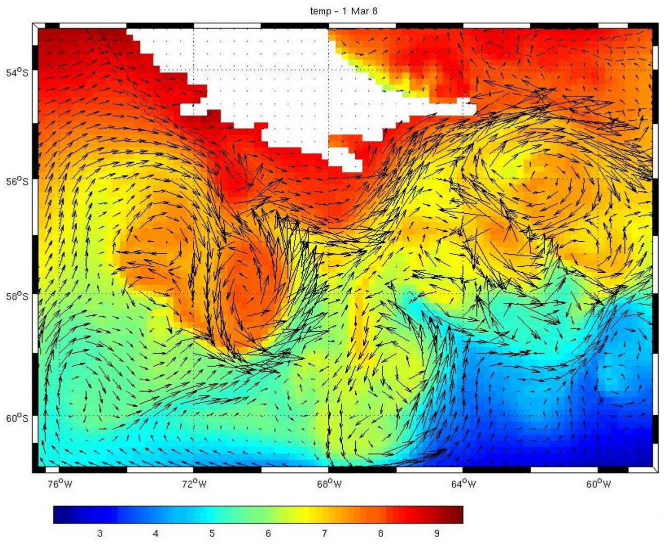
Homogénéisation de ACC dans le Passage de Drake

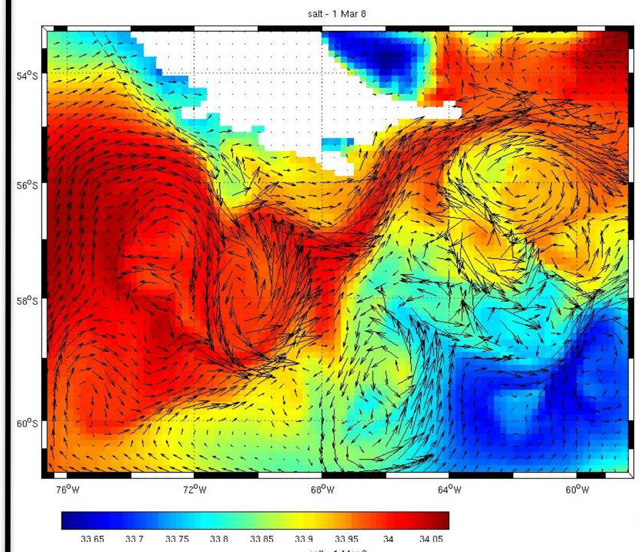
➡ **Correspondance avec l´article**

Température

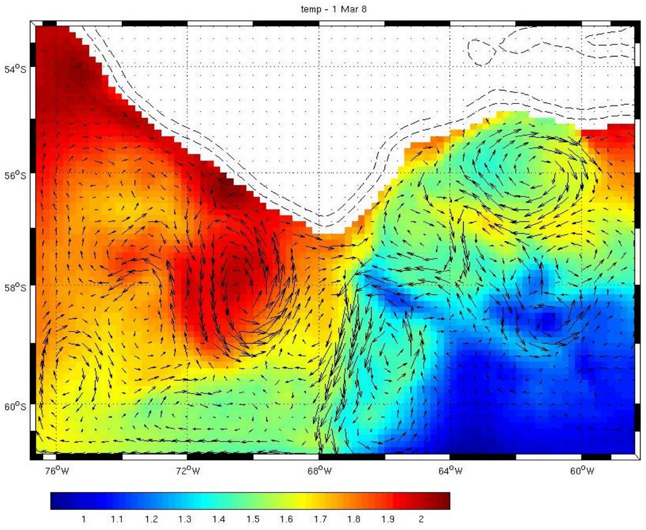
Salinité

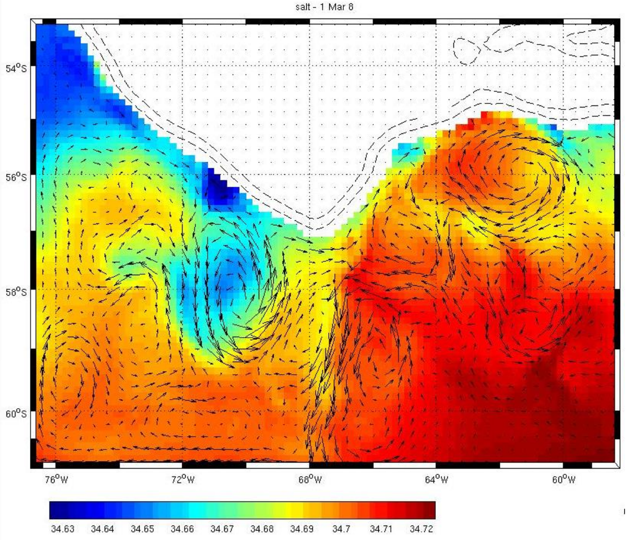
Surface:





Profondeur 2000 m:





Tourbillons

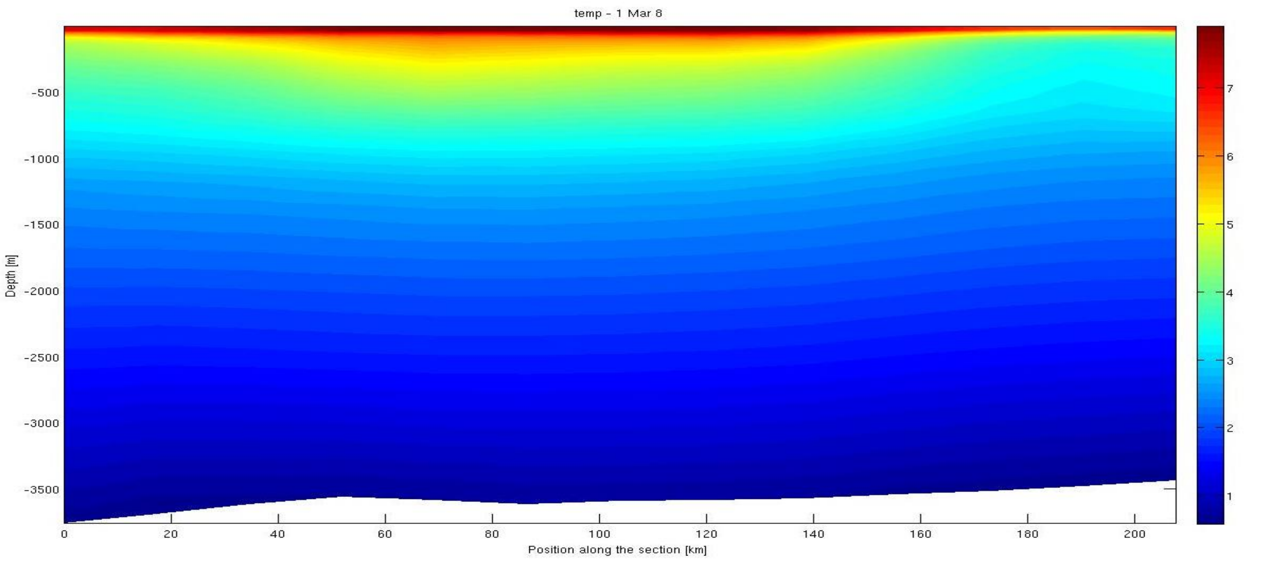
Coupe vertical:

- **Température**
  - **Max. en milieu**

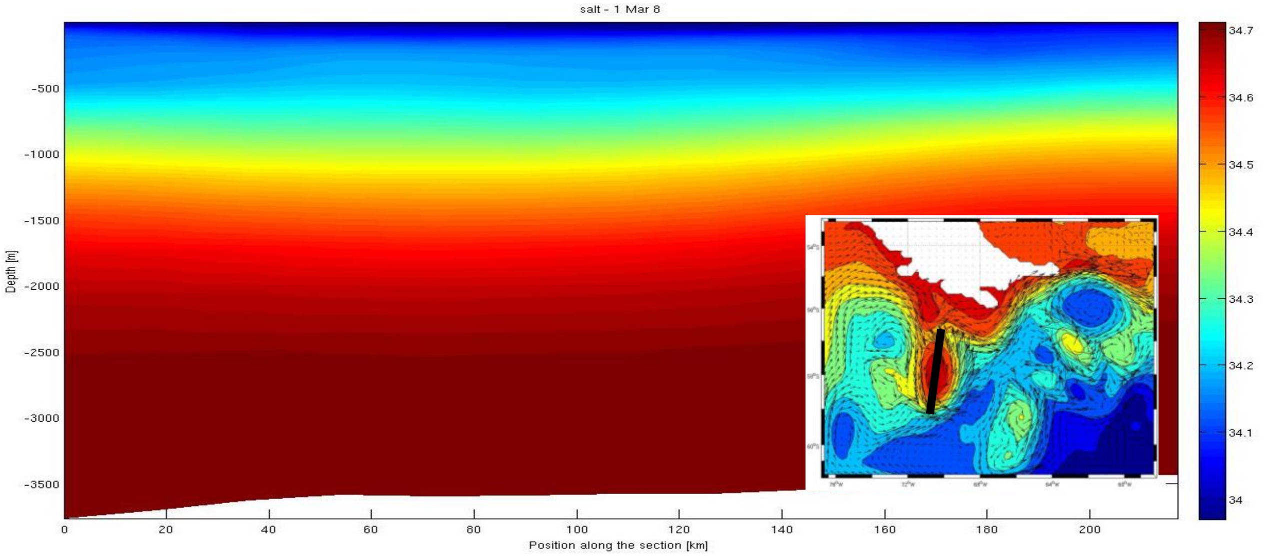
- **Salinité**
  - **Min. en milieu**

➡ **Indication de l´origine de PDW**
Correspondance avec l´article

Température:



Salinité:



Conclusion

- **Les résultats de la simulation avec ROMS correspondent bien à la réalité**
  - Les courants essentiel apparaissent
  - Tourbillons bien détaillés

- **Résultats en forte corrélation avec l´article de J.Alexander Brearley et al.**

- **Désintégration du courant de Pacific Est**
  - Circulation, salinité et température indiquent le courant

- **Tourbillons**
  - Direction, salinité et température indiquent le PDW dans les tourbillons

- **Homogénéisation**
  - Mélange dans le passage très important par la désintégration les tourbillons

La désintégration de PDW influence le Courant Thermohaline dans le passage de Drake

➡ Impulsion de la désintégration sur le Courant Thermohaline très probable

Merci pour votre attention

Questions?