



UNIVERSIDADE FEDERAL DO RIO GRANDE - FURG



INSTITUTO DE
OCEANOGRAFIA
FURG

SUBMARINE GROUNDWATER DISCHARGE FOR THE COASTAL REGION IN SOUTHERN BRAZIL AND CONTINENTAL SHELF ADJACENT

Karina Kammer Attisano



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SUBMARINE GROUNDWATER
DISCHARGE FOR THE COASTAL
REGION IN SOUTHERN BRAZIL
AND CONTINENTAL SHELF
ADJACENT

A

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SUBMARINE GROUNDWATER
DISCHARGE FOR THE
COASTAL REGION IN
SOUTHERN BRAZIL

QUANTIFYING SGD TO THE
COASTAL REGION OF SOUTHERN
BRAZIL BY RADIUM ISOTOPES

COMPARISON BETWEEN
THE NORTH AND SOUTH
BARRIERS

POTENTIAL PRIMARY
PRODUCTION COMPARED
TO OTHER REGIONS

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SUBMARINE GROUNDWATER
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REGION IN SOUTHERN BRAZIL

B

SUBMARINE GROUNDWATER DISCHARGE
REVEALED BY RADIUM ISOTOPES (Ra-
223 AND Ra-224) NEAR A
PALEOCHANNEL ON THE SOUTHERN
BRAZILIAN CONTINENTAL SHELF

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Major water bodies in Rio Grande do Sul



Water bodies	~ Length (km)	~ Width (km)
Patos Lagoon	240	40 to 50
Mirim Lagoon	180	15 to 35
Mangueira Lagoon	110	5 to 9

Superficial connections

All these lagoons are connected.

Patos Lagoon



Mangureira Lagoon

Mirim Lagoon

Atlantic Ocean

Connection between



Mangureira Lagoon/Mirim Lagoon



Mirim Lagoon/Patos Lagoon



Patos Lagoon/Atlantic Ocean



Connection between Mangueira Lagoon and Mirim Lagoon

These are connected superficially by some wetlands

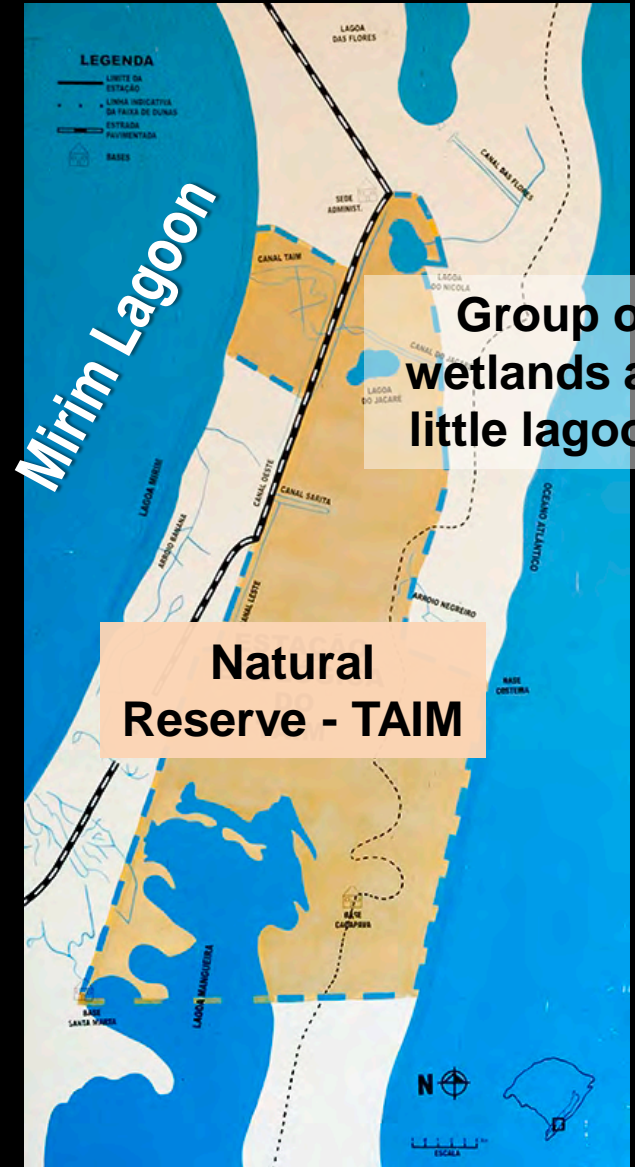
Patos Lagoon



Mirim Lagoon

Mangueira Lagoon

Atlantic Ocean



Group of wetlands and little lagoons

Natural Reserve - TAIM

Natural ecological reserve

The Taim Wetland Conflict



Despite of TAIM be a conversation and **ecological diversity area**, around TAIM there is a lot of rice plantation, which demands a lot of water during the whole growth period.

Depends on the level water:
The connection between Mangueira Lagoon and Mirim Lagoon could disappeared and affected the equilibrium of whole ecosystem.



Connection between Mirim Lagoon and Patos Lagoon



São Gonçalo Channel

São Gonçalo is a navigable channel
76 km long



In 1977 was built barrier to prevent the salinization of Mirim waters.

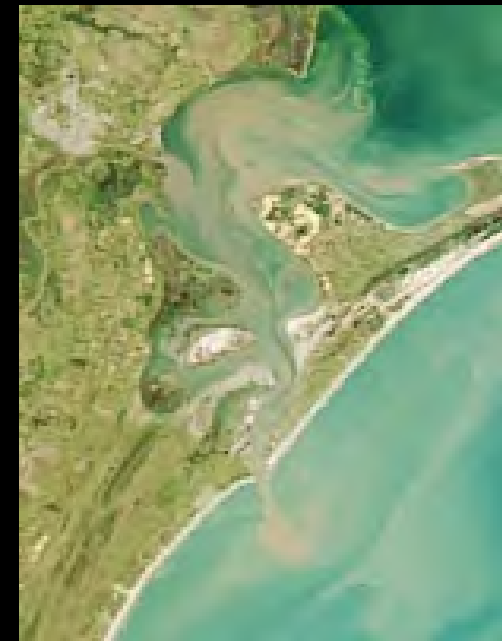


Connection between Patos Lagoon and Atlantic Ocean

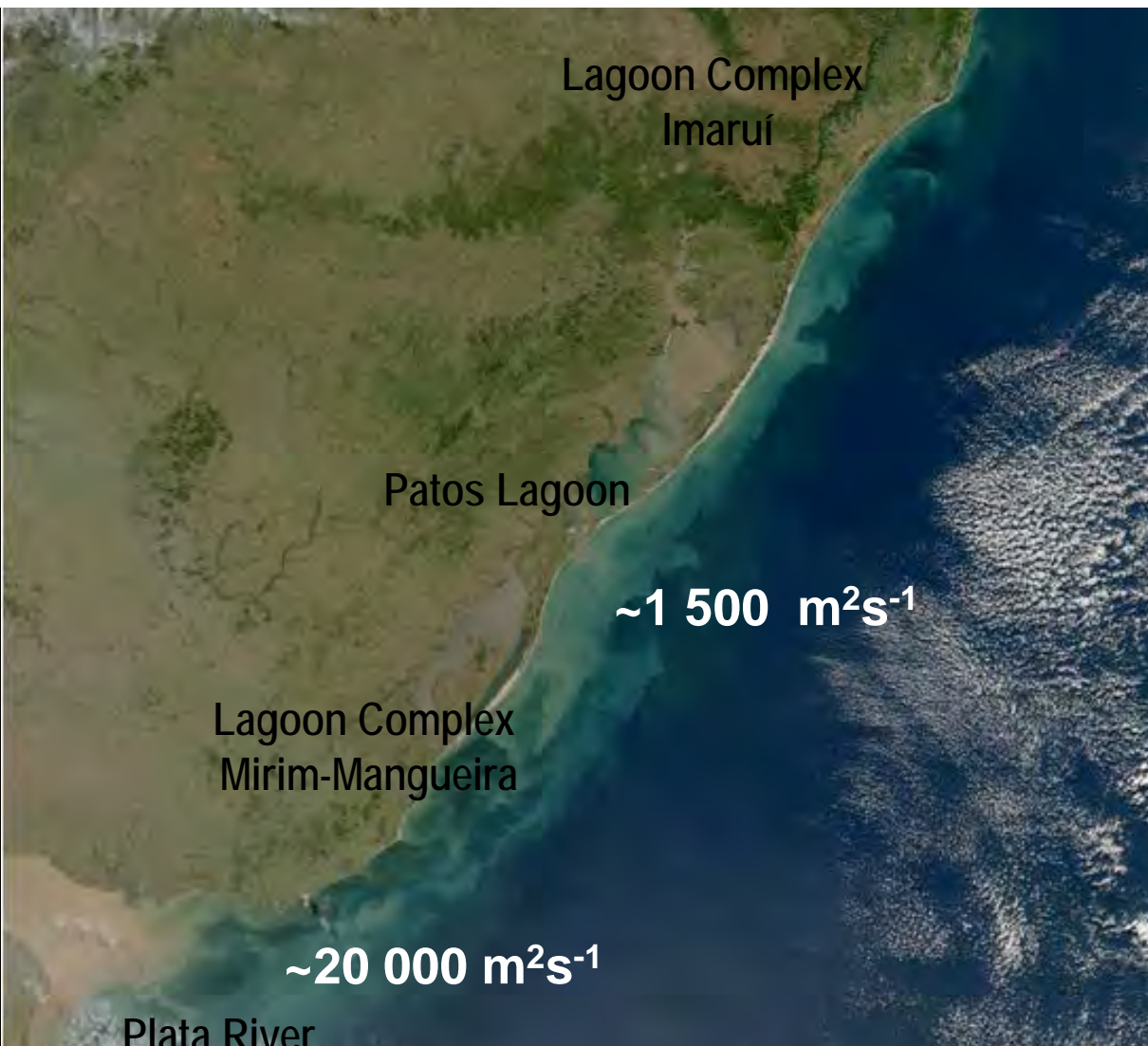


Patos Lagoon Estuary

- ❖ Biogeochemical process
- ❖ Acts as a nursery for a lot of species



Continental Discharge (Superficial)



The nutrient input in SCBS can be directly related to estuarine plumes.

The plumes are highly influenced by the wind, the rain, the local hydrodynamics and consequently to seasonality.

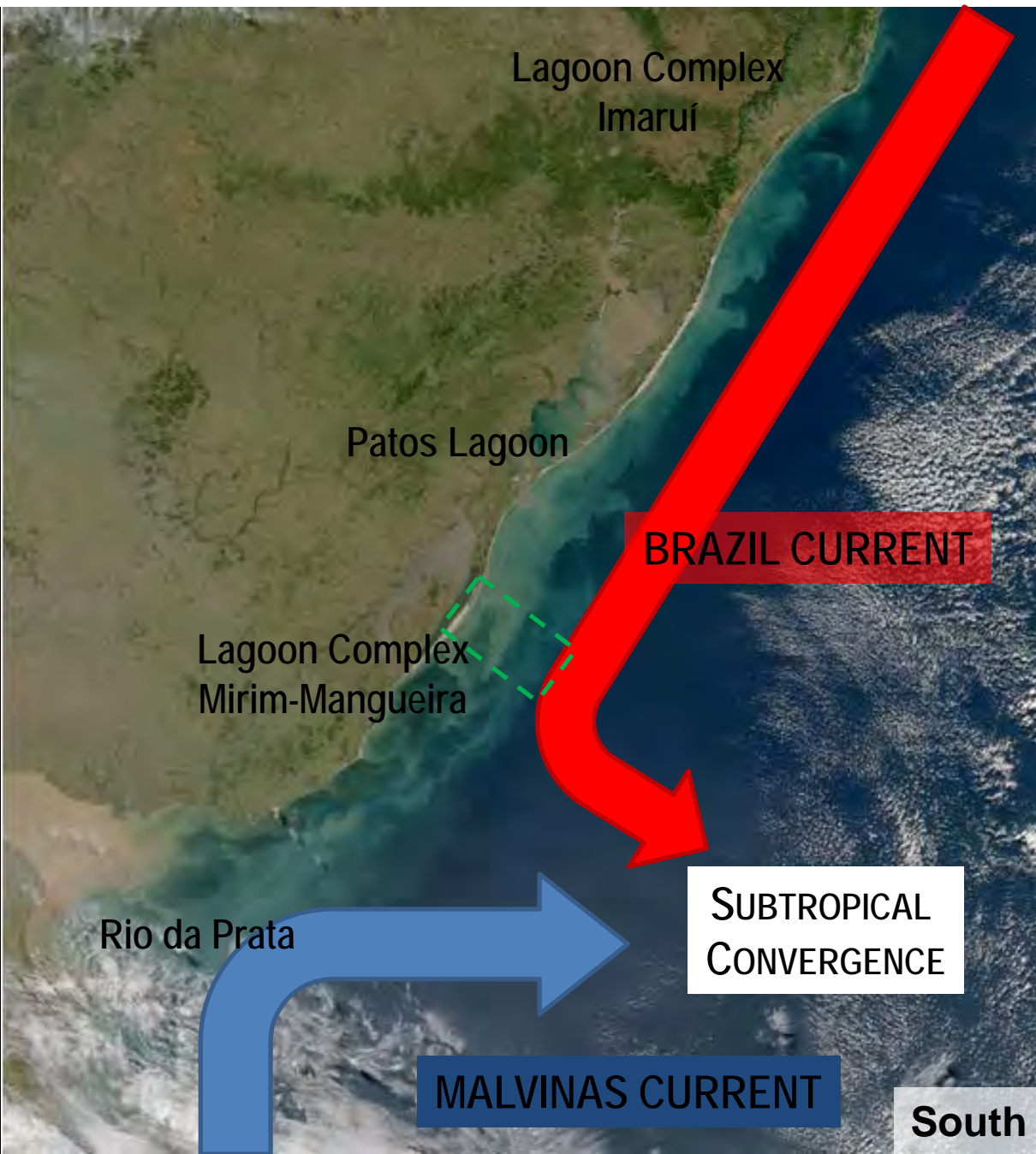
Autumn and Winter	Spring/Summer
Higher discharge	Lower discharge
Predominance of SW winds	Predominance of NE winds



Besides discharges from Patos Lagoon and Plata River, this region is strongly influenced by **oceanographic processes** that also help in high productivity of the region.



Water masses



The water masses that occurs on South Brazilian continental shelf is very important for the primary productivity of the region.

Southwest Atlantic Ocean comprises the region of the Subtropical Convergence, where a new water mass is formed.

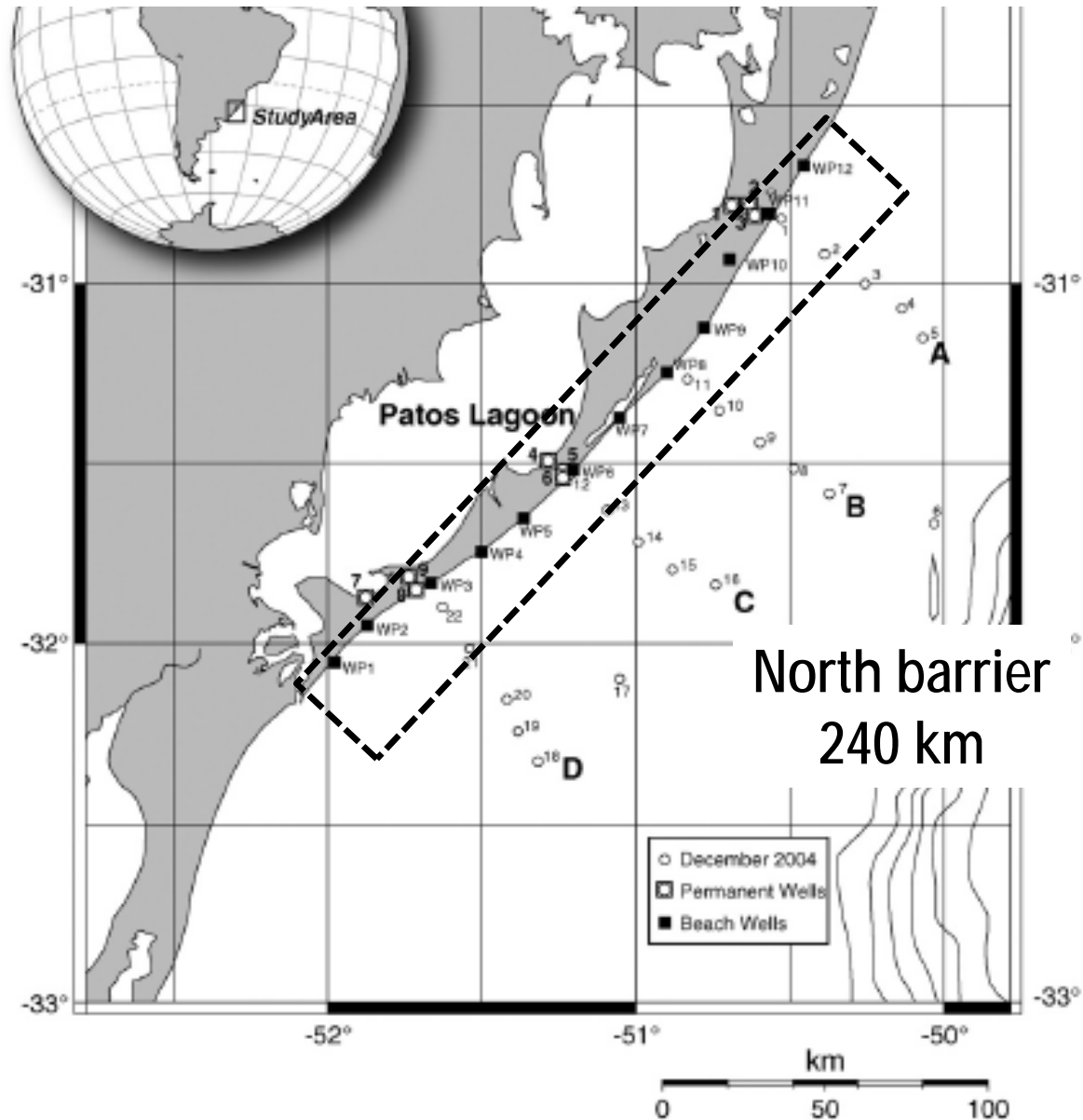


Albardão Lighthouse

Main factors associated with productivity coastal region in Southern Brazil and Continental Shelf adjacent

- ❖ Significant discharges;
- ❖ Oceanographic process;
- ❖ Submarine Groundwater Discharge ?

Submarine Groundwater Discharge has been detected and quantifying for the coastal region in Southern Brazil



These authors quantified the SGD and measured the contribution for a local productivity in terms of nutrients

(silicate, phosphate, nitrogenous and iron).



Brazil

Patos Lagoon

North Barrier
240 km

Mirim Lagoon

Mangueira Lagoon

South Barrier
220 km



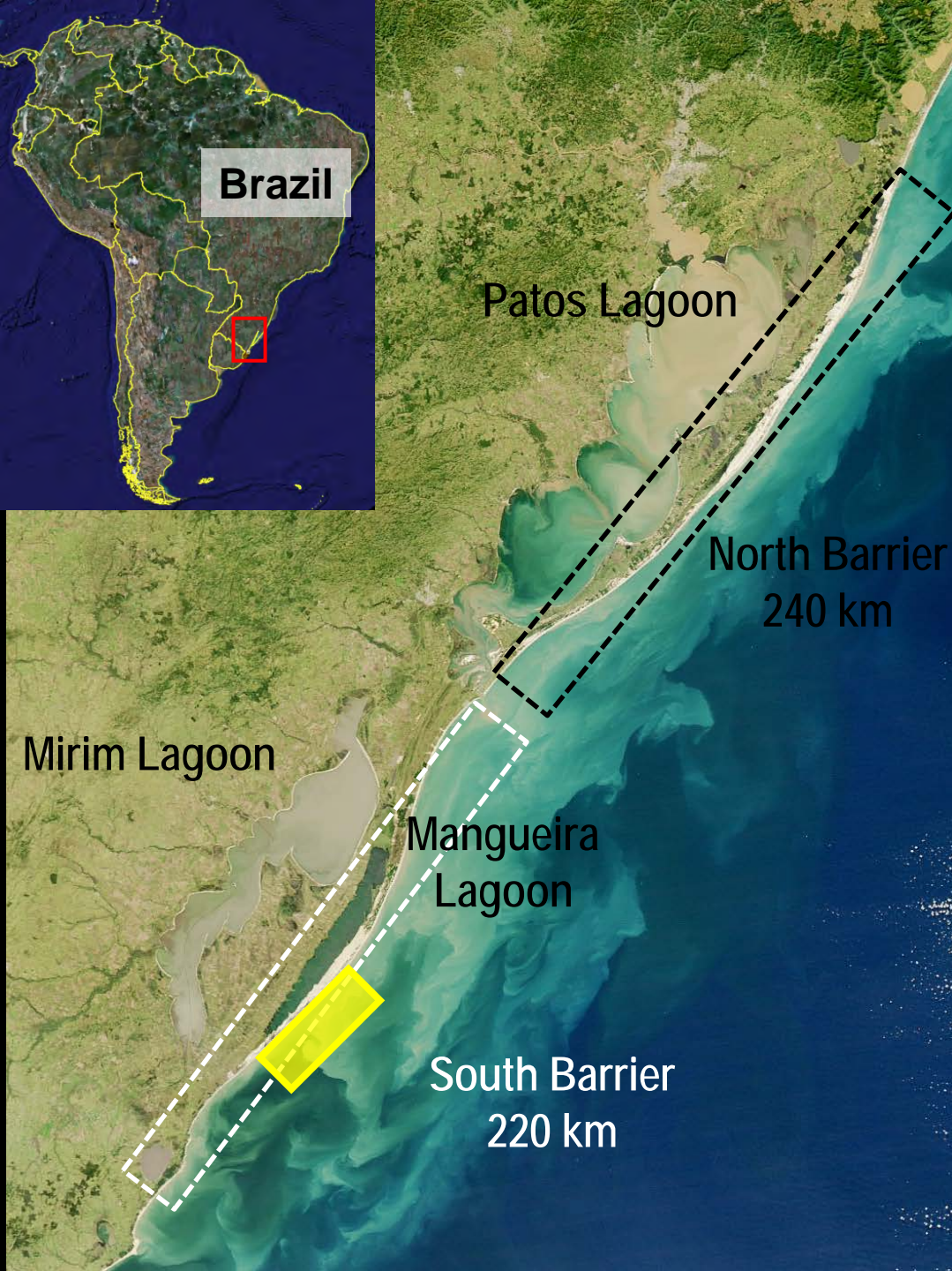
Windom *et al.* (2006)
Niencheski *et al.* (2007)

Despite of great geological similarity between the North and South barriers, we still had some doubts about the SGD behavior.

Once:
- On the south barrier Mangueira Lagoon is closer to the ocean;
- There is a zone where the sediments are more permeable (shell deposits).



Brazil



Patos Lagoon

North Barrier
240 km

Mirim Lagoon

Mangueira
Lagoon

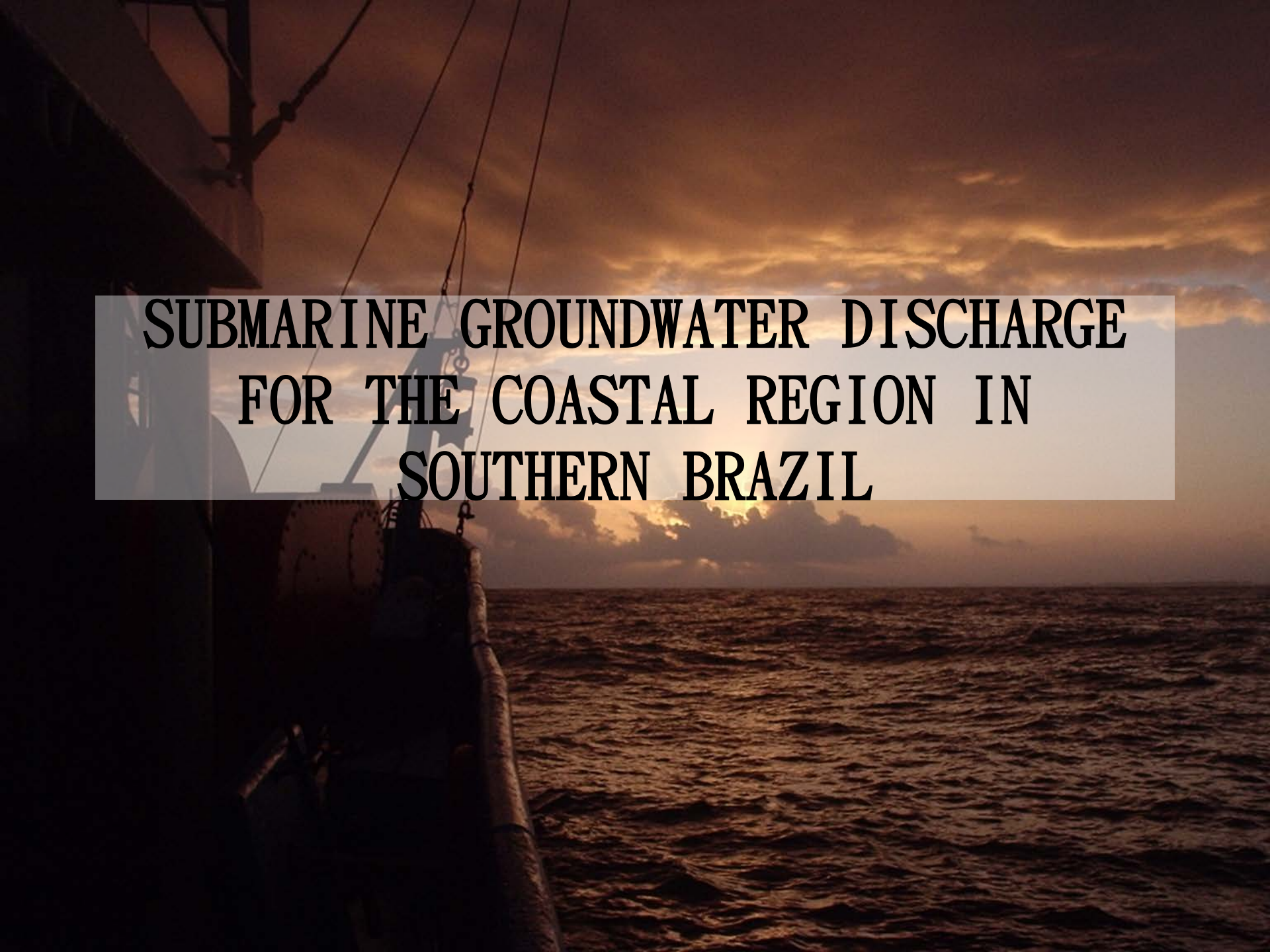
South Barrier
220 km



Concheiros

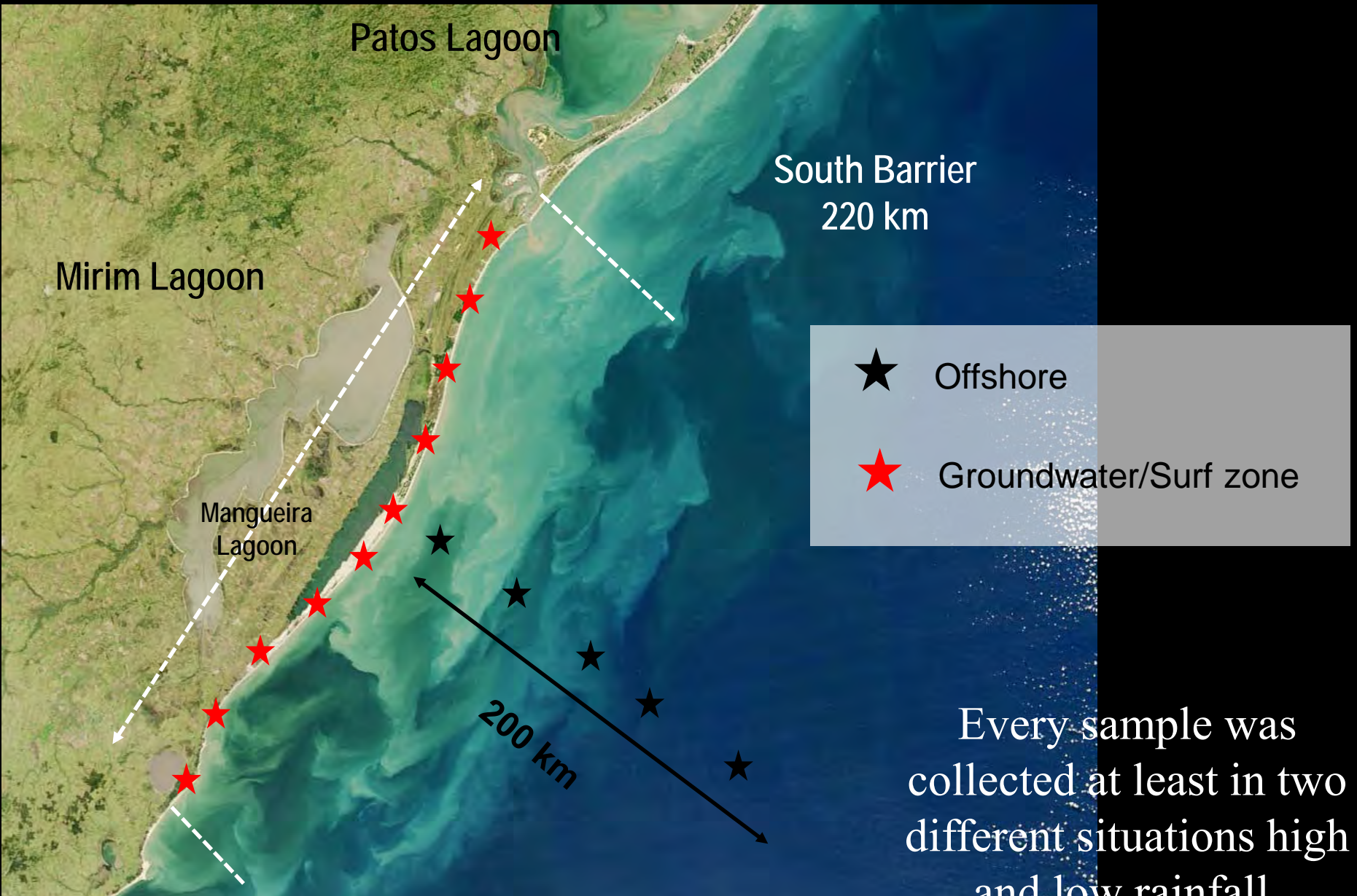


André Colling

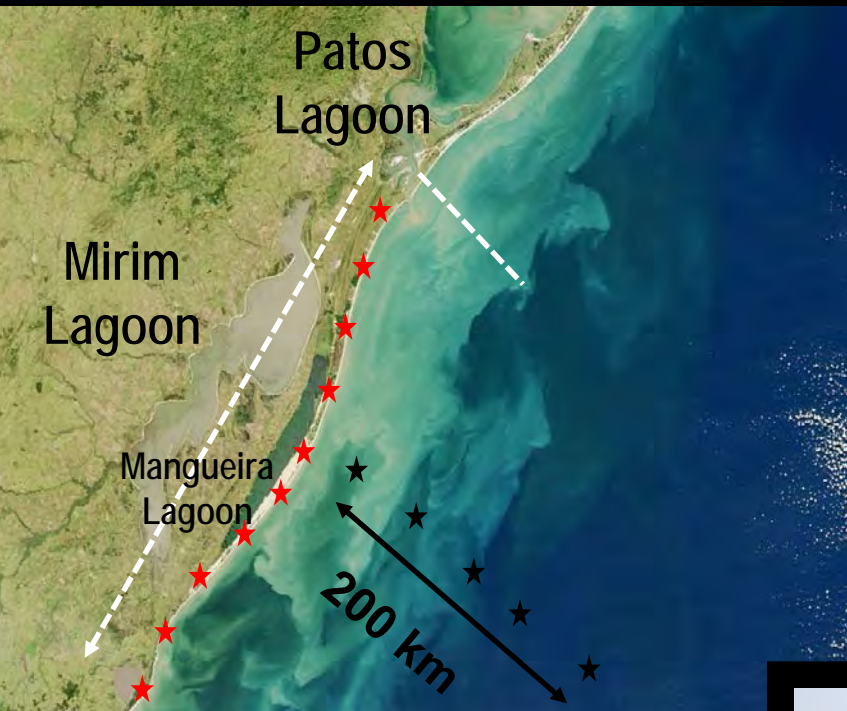
A photograph of a sunset over the ocean, taken from the deck of a ship. The sky is filled with orange and yellow clouds, and the sea is dark with small waves. The ship's rigging and a vertical pipe are visible in the foreground on the left side.

**SUBMARINE GROUNDWATER DISCHARGE
FOR THE COASTAL REGION IN
SOUTHERN BRAZIL**

Sampling grid

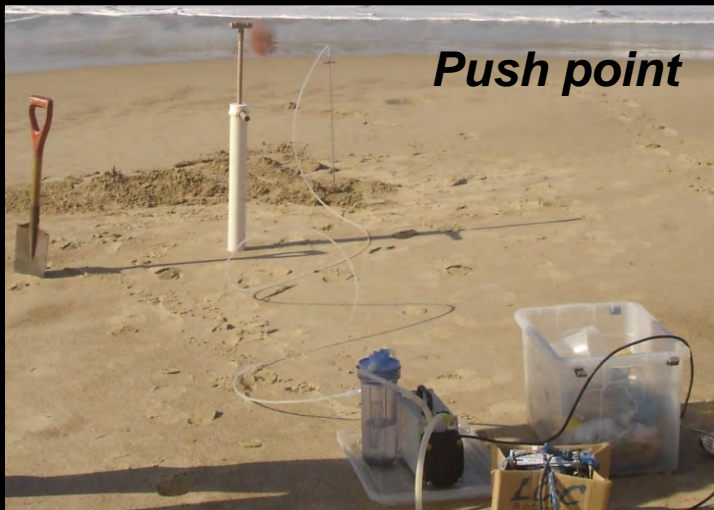


Field and laboratory methods



Groundwater/Surf zone

Sampling grid for groundwater were spaced at 20 km intervals on the 220 km of coastal.



May/08



Sep/08



July/09

Field and laboratory methods

★ offshore transect – across from the *Albardão* Lighthouse



Sampling was collected from the
**Oceanographic Research Vessel
Atlântico Sul – FURG,**

Winter (August) 2005
Summer (February) 2007.

We used a water sample system
with a CTD device.



Field and laboratory methods



Nutrients samples
were also collected



Field and laboratory methods



Samples for radium isotopes were carried out in subsurface waters.

The radium samples were measured by the **RaDeCC** – Delayed Coincidence Counter – following Moore & Arnold's recommendations (1996).

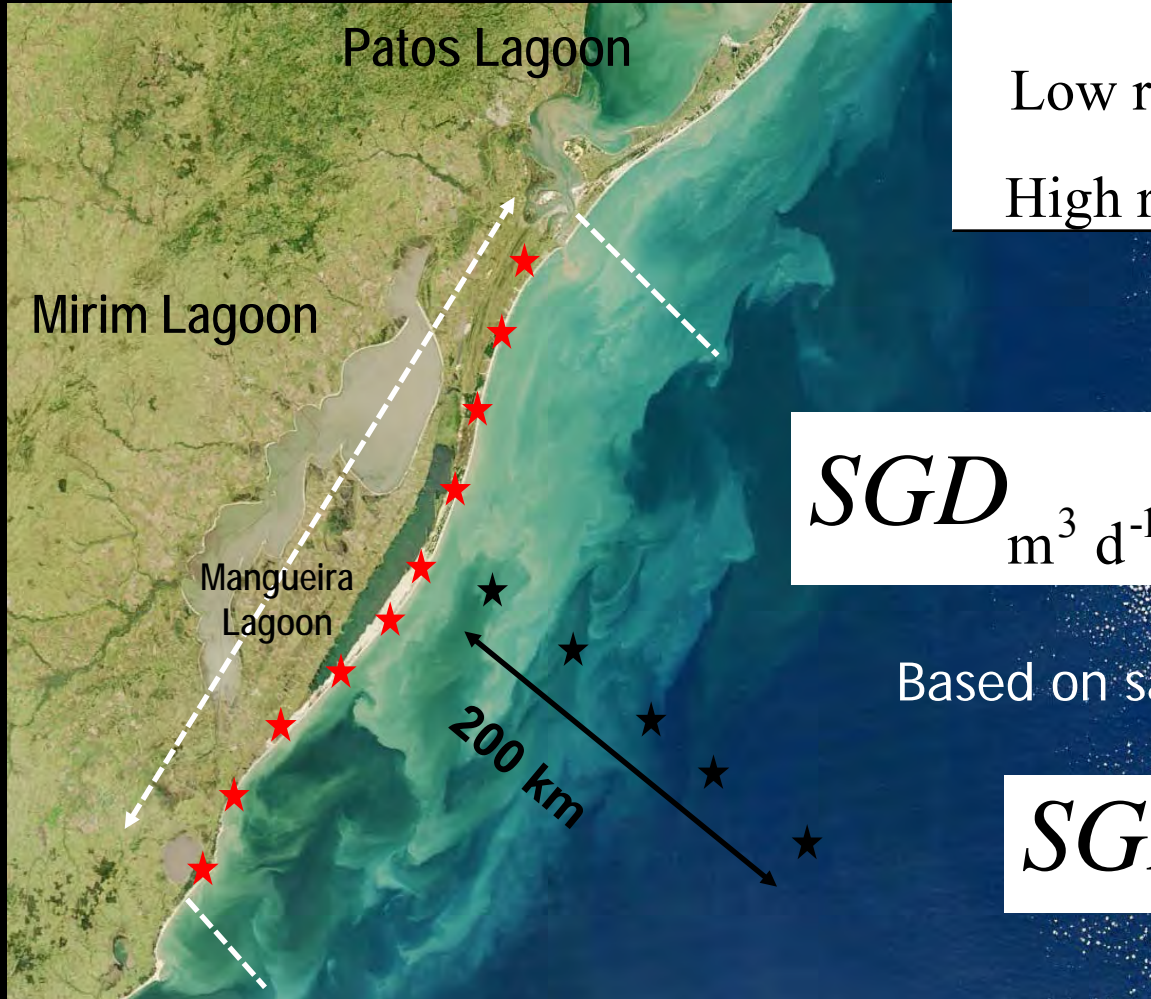


Measurements of ^{226}Ra : **RAD-7** (Peterson *et al.*, 2008).



Results and Discussion

We estimate the SGD for low and high rainfall.



cm.d⁻¹

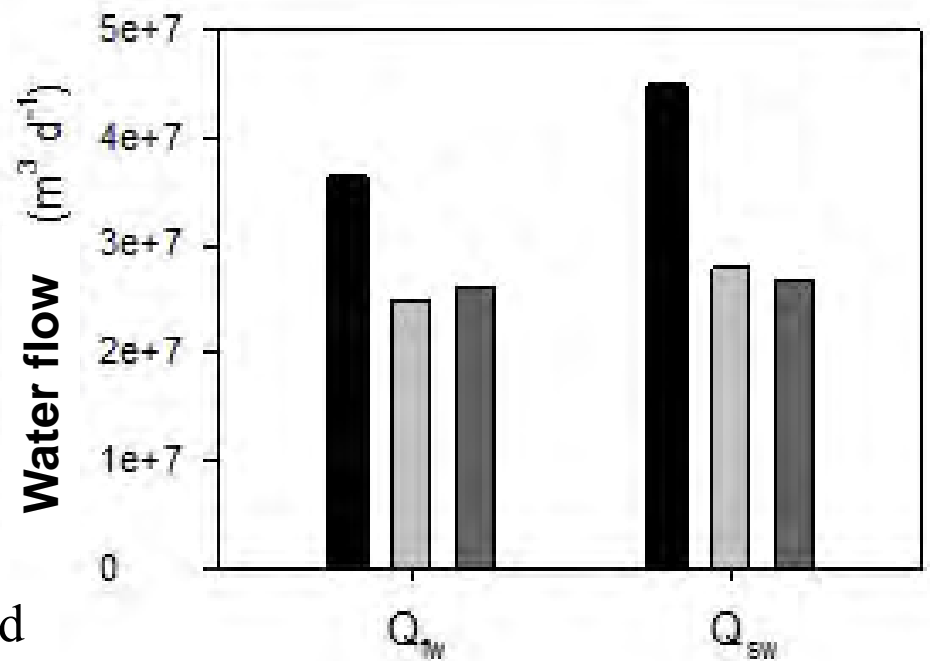
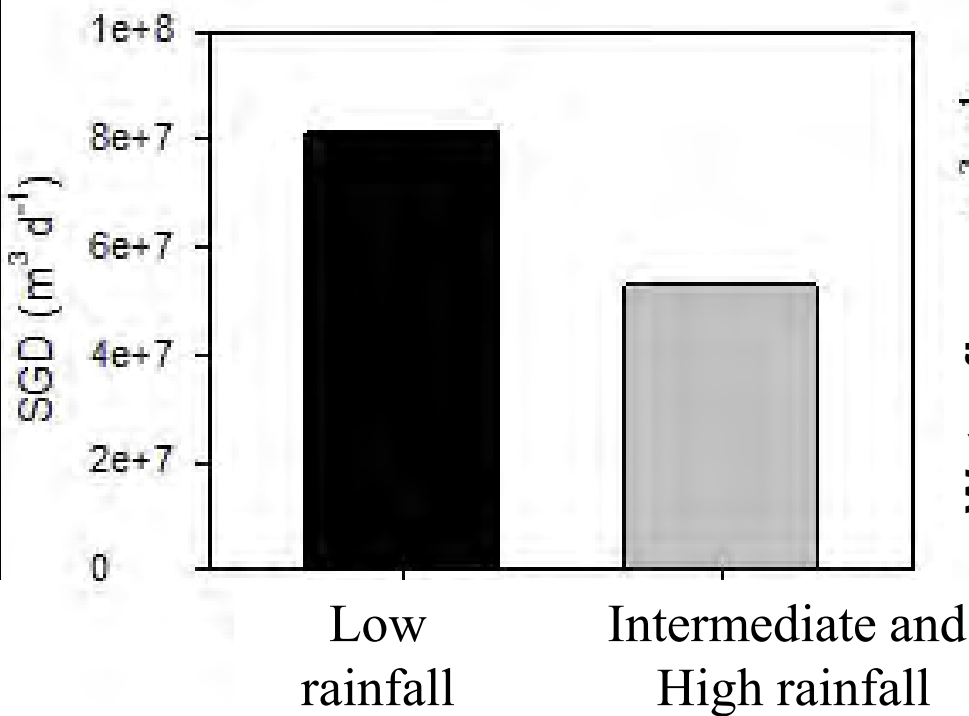
Low rainfall **3.7 ± 2.7**

High rainfall **2.4 ± 1.7**

$$SGD_{m^3 d^{-1}} = cm.d^{-1} * Area$$

Based on salt balance

$$SGD = Q_{fw} + Q_{sw}$$

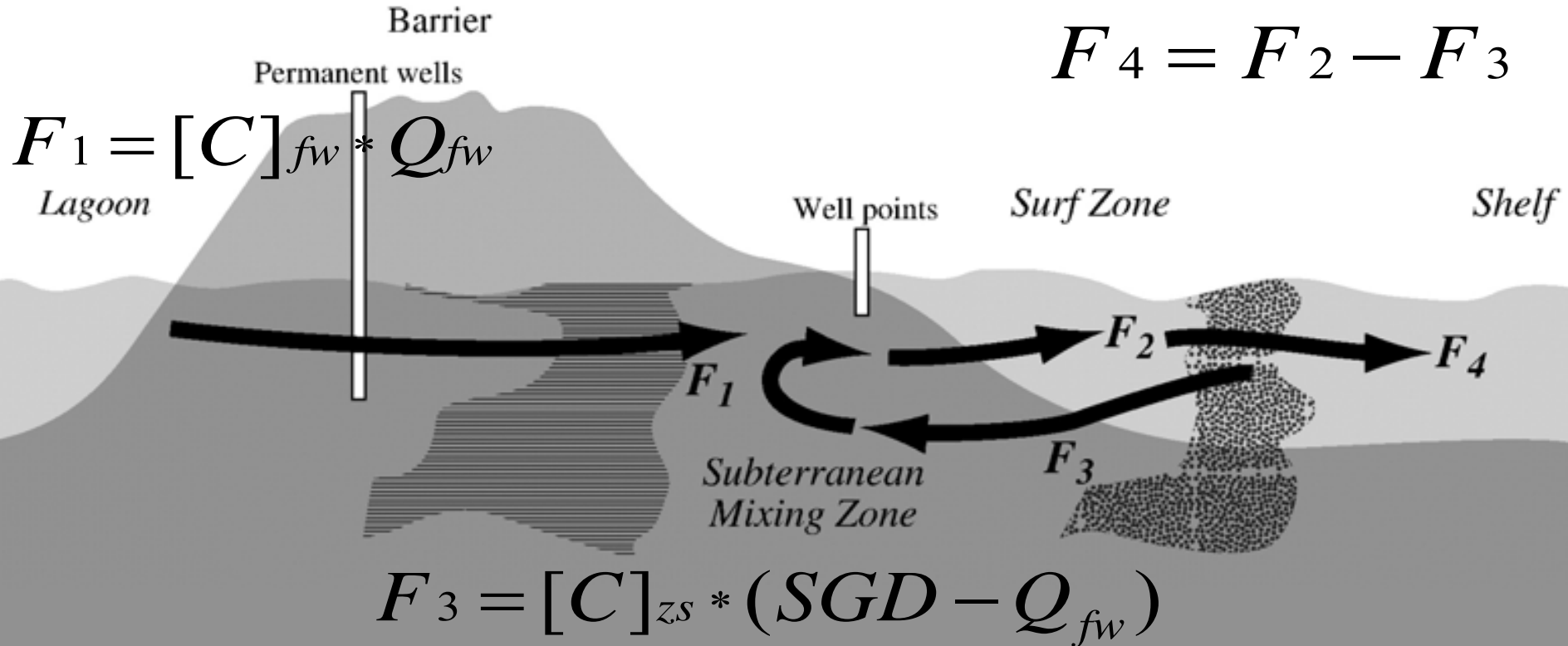


		Precipitation <i>mm</i>	Evaporation <i>mm</i>	P-E	
■	May/08	0,89	3,31	-2,41	Low rainfall
■	Sep/08	2,76	2,72	0,04	High rainfall
■	July/09	1,28	2,75	-1,47	Intermediate rainfall

SGD and nutrients

$$F_2 = [C]_{bgw} * SGD$$

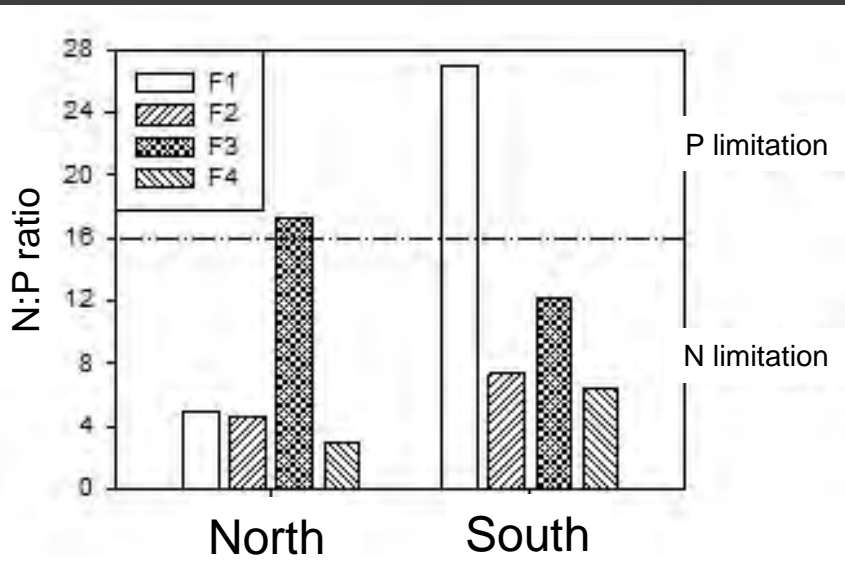
$$F_4 = F_2 - F_3$$



Niencheski *et al.* (2007)

Fluxes associated with nutrient concentration = The flux of nutrients in these directions.

Potential primary production supported by SGD



Despite the fluctuations of N:P ratio

There is a nitrogen limitation on F2, for both barrier.

Using the molar Redfield ratio,
106 C:16 N

Redfield (1963)

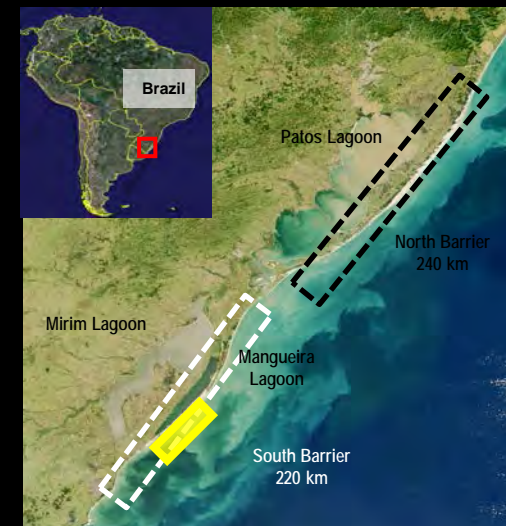
Potential primary production supported by SGD

North Barrier

2981 gC m²year⁻¹

South Barrier

2780 gC m²year⁻¹



Both barriers shows a potencial production higher than what has been documented.

Productive potencial from SGD

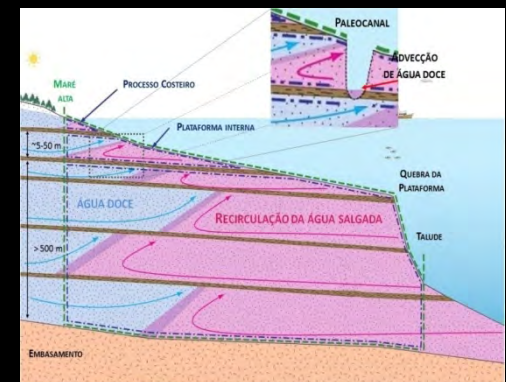
Local	DIN	PID	P. Potencial		
	$10^5 \text{ mol } d^{-1}$		<i>N:P</i>	$g \text{ C } m^{-2} \text{ ano}^{-1}$	
North Barrier - Rio Grande do Sul, BR	24	5,2	4,7	2931	Niencheski <i>et al.</i> (2007)
South Barrier - Rio Grande do Sul, BR	21	2,86	7,4	2780	Present Study
South Caroline, USA	0,33	0,02	19,4	422	Krest <i>et al.</i> (2000)
Yellow Sea, KP	6	0,20	30	149	Waska & Kim (2011)
Pangasinan, PH	0,04	0,002	22	93	Senal <i>et al.</i> (2011)

The potential primary production supported by SGD from coastal southern Brazil is 7 times higher than South Carolina and 32 times higher than Philipppines.

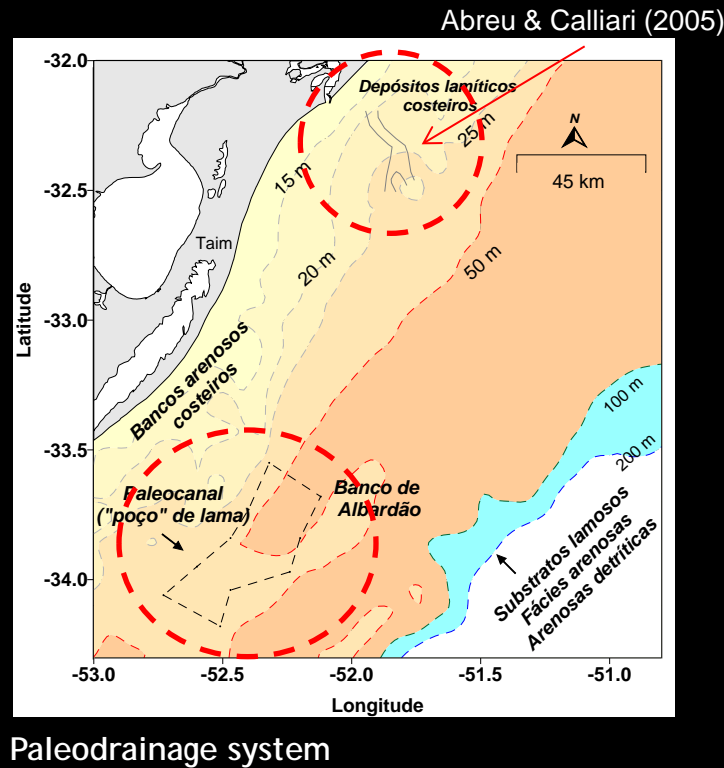
However ...

We know that SGD is not restricted coastal areas

Bratton (2010) suggested that SGD could happen in other scales.



There is a lot of evidence of **paleodrainage systems** in Southern Brazil Continental Shelf, promoted by events of transgression and regression.



We suggested that these paleodrainage systems may thus be a preferential pathway for SGD and consequently nutrients, metals...

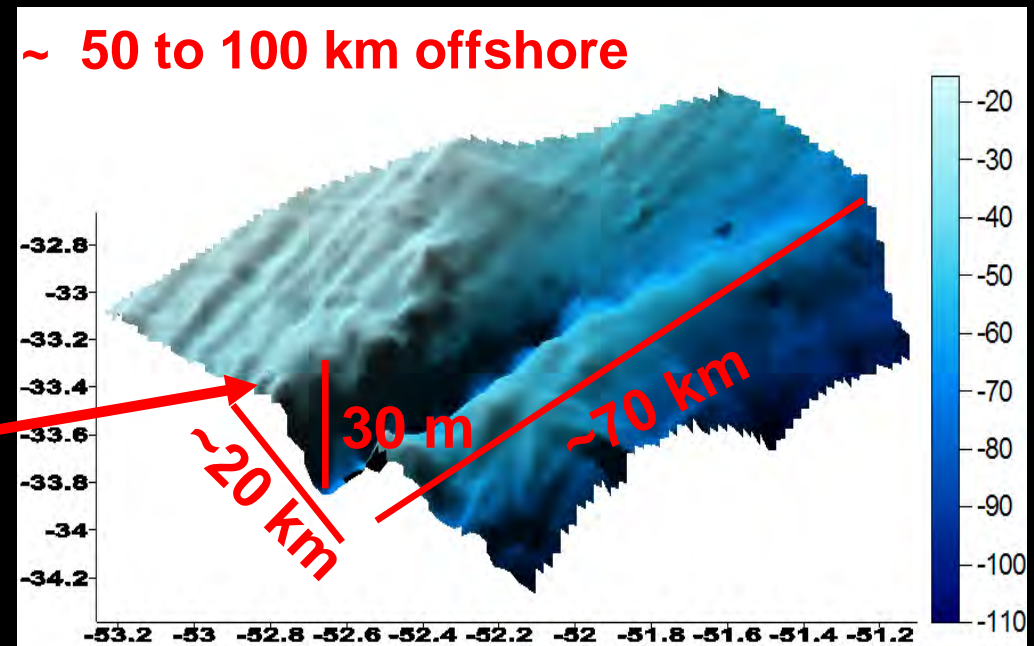
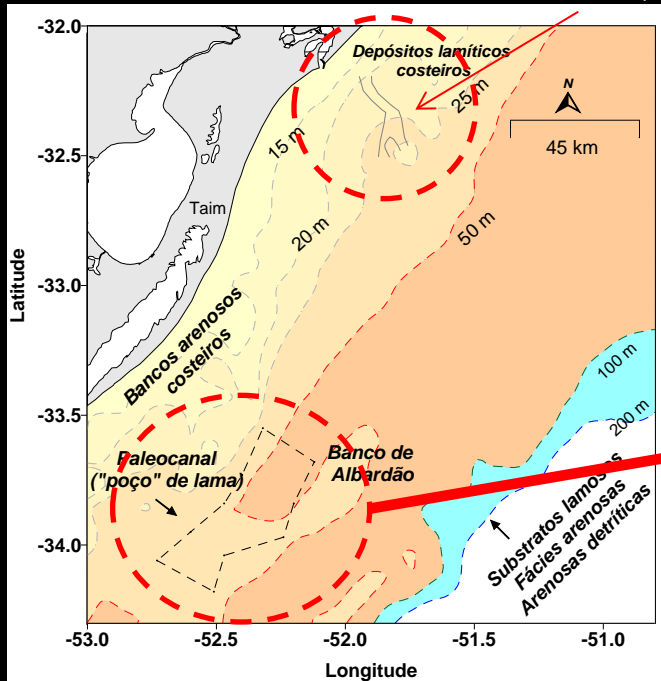


Some of these systems have been identified and others are in the process of identification.

Laboratory of Geology-FURG

There is one paleochannel already identified and mapped: Albardão Paleochannel

Abreu & Calliari (2005)



Campos et al. (2009)

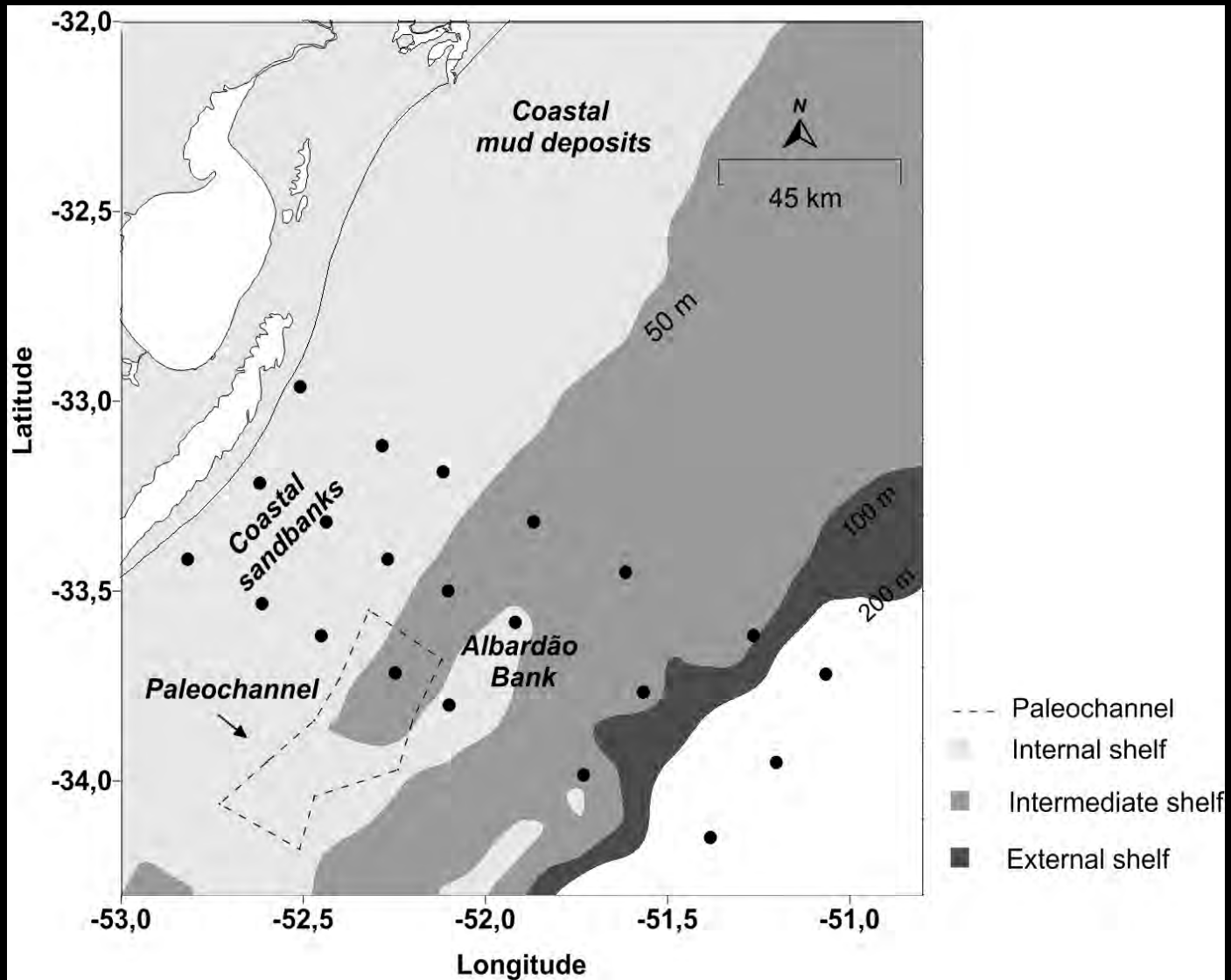
Sistemas de paleodrenagem na PCSB.

Major depression on Southern Brazilian Continental Shelf

A photograph of a sunset over the ocean. The sun is low on the horizon, partially obscured by dark, heavy clouds. The sky is a mix of deep blue and golden yellow. The water in the foreground is dark blue with white-capped waves. A blue railing is visible in the bottom right corner.

Aiming to explore SGD on the Southern Brazilian Continental Shelf,
we defined a sampling grid...

Sampling grid

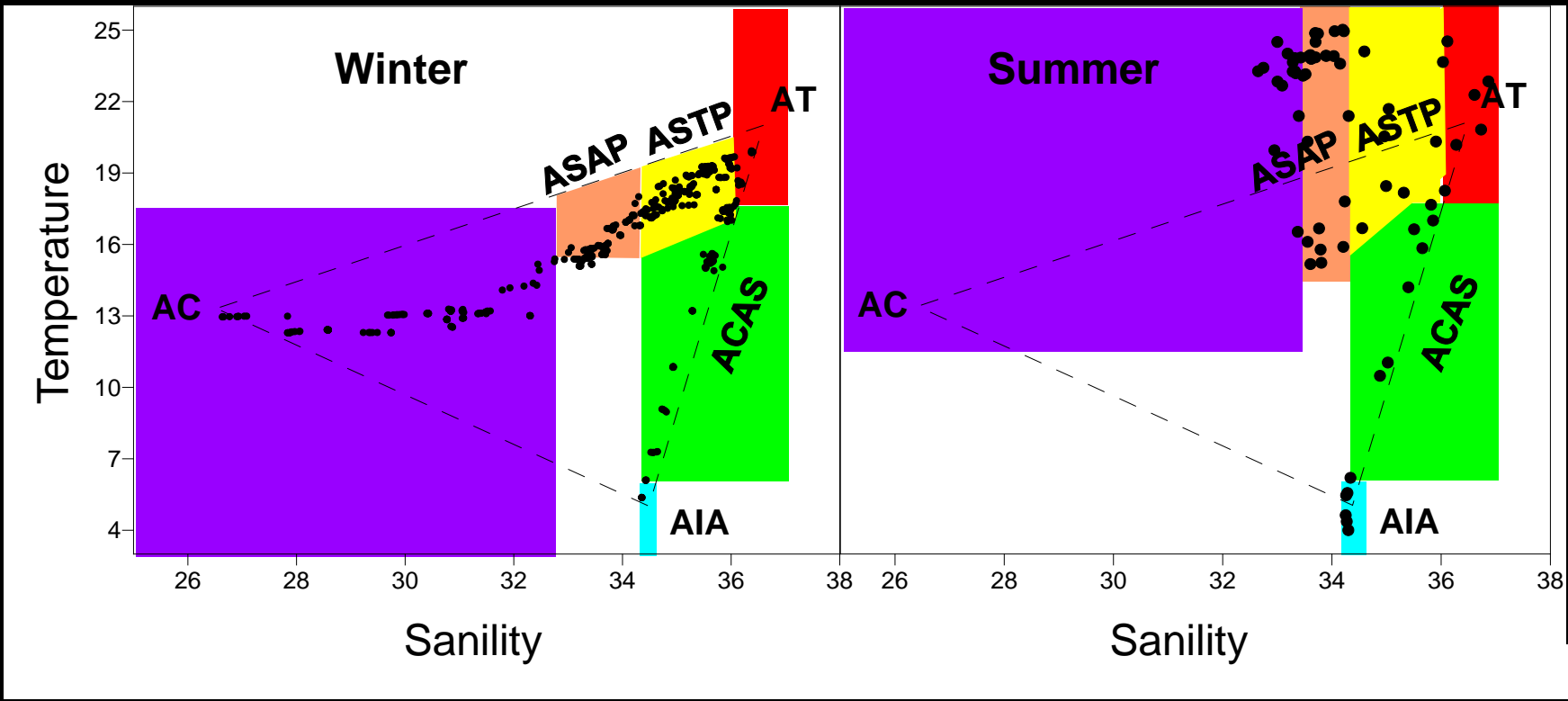


Field and laboratory methods



physical data, nutrients and radium isotopes

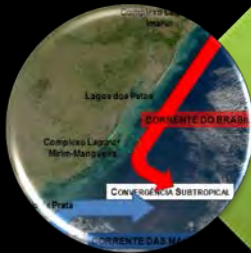
We identified six different water masses based on Temperature and Salinity (Möller Jr. *et al.*, 2008). This approach allowed the identification of the classic T-S diagrams recommended by Sverdrup *et al.* (1942) and Miranda; Castro Filho (1979).



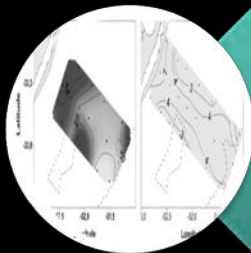
TS diagram for the Albardão region (a) winter and (b) summer

- Coastal Water (CW);
 Subantarctic Shelf Water (SASW);
 Subtropical Shelf Water (STSW);
- Tropical Water (TW);
 South Atlantic Central Water (SACW) and
 Antarctic Intermediate Water (AIW).

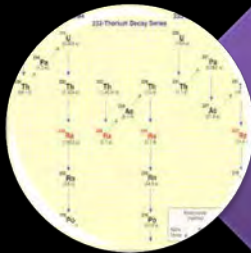
RESULTS AND DISCUSSION



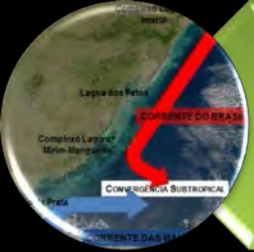
WATER MASSES



NUTRIENTS

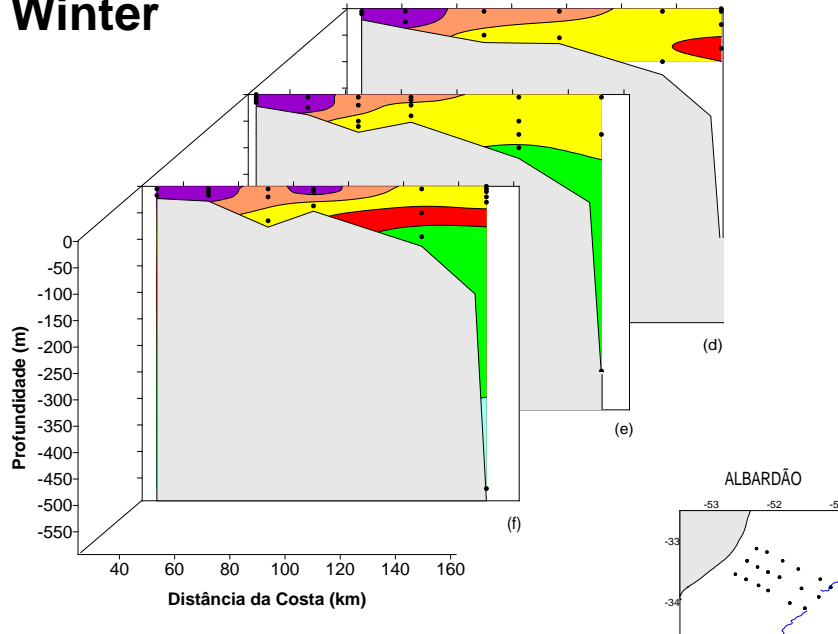


RADIUM ISOTOPES

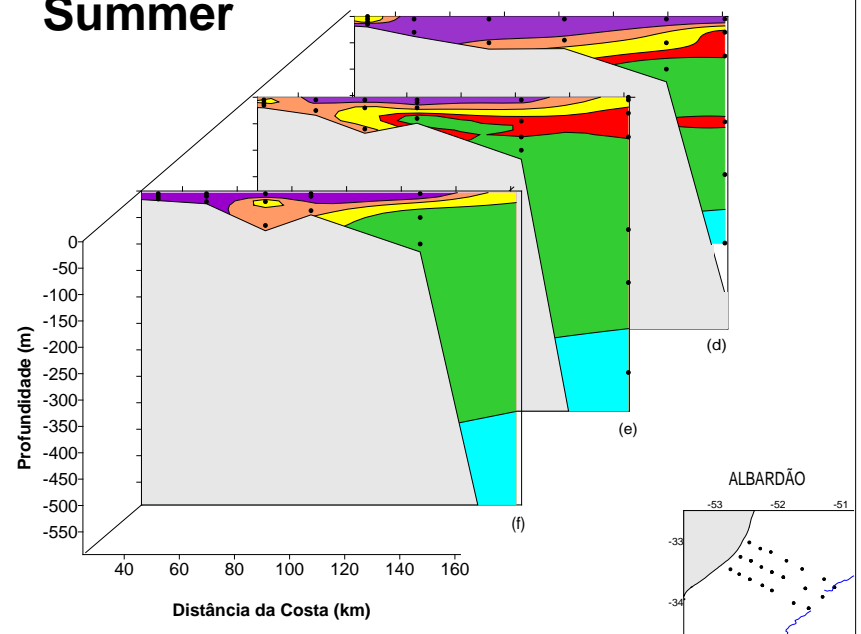


WATER MASSES

Winter



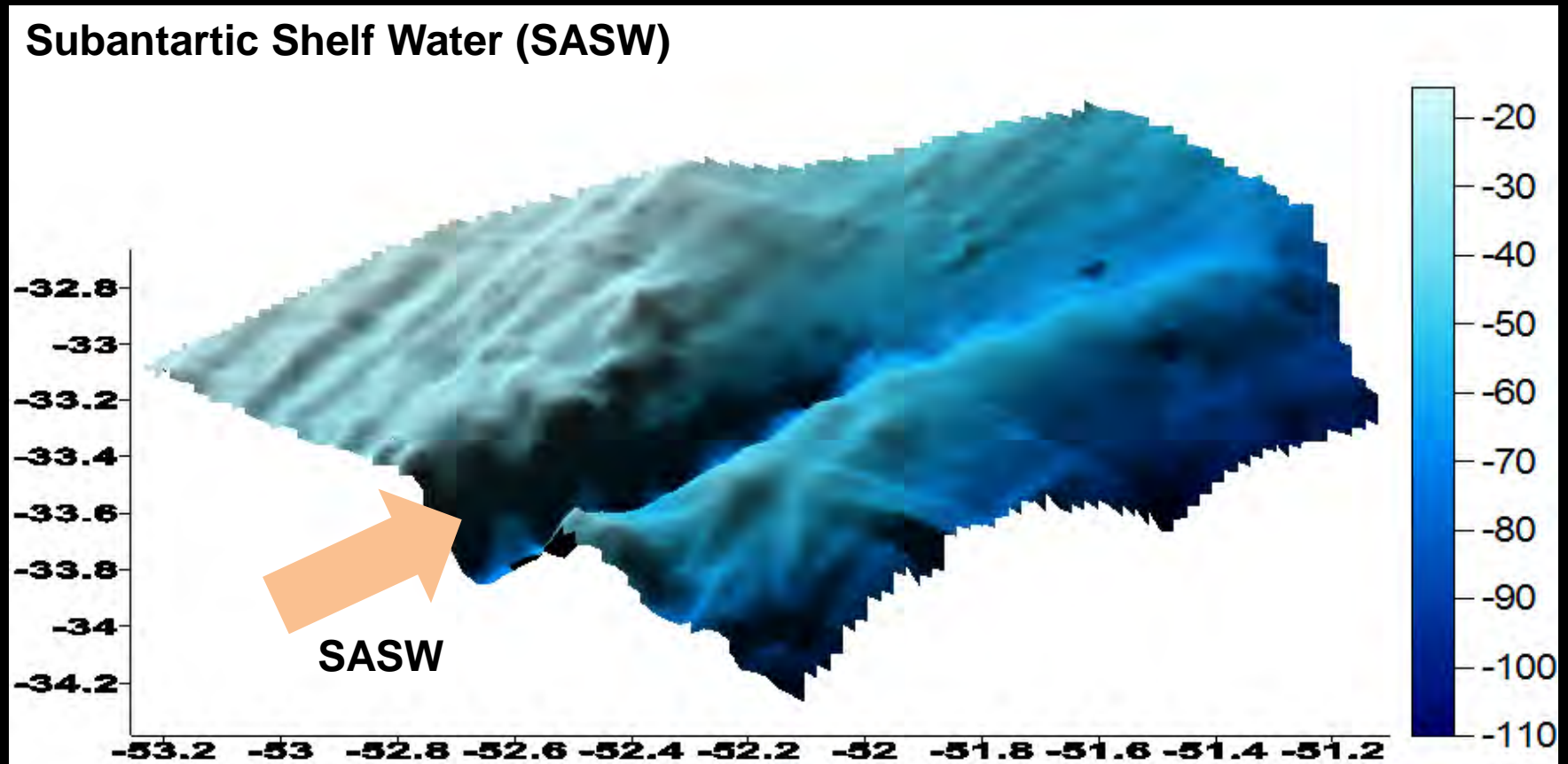
Summer



Vertical distribution of water masses in the Albardão region in (A) winter and (B) summer

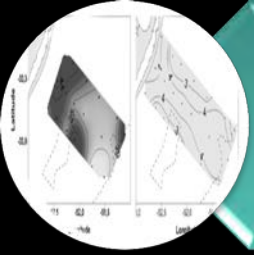
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Intrusion of SASW through the Albardão Paleochannel may cause the advection of continental groundwater by the mechanism of convection.



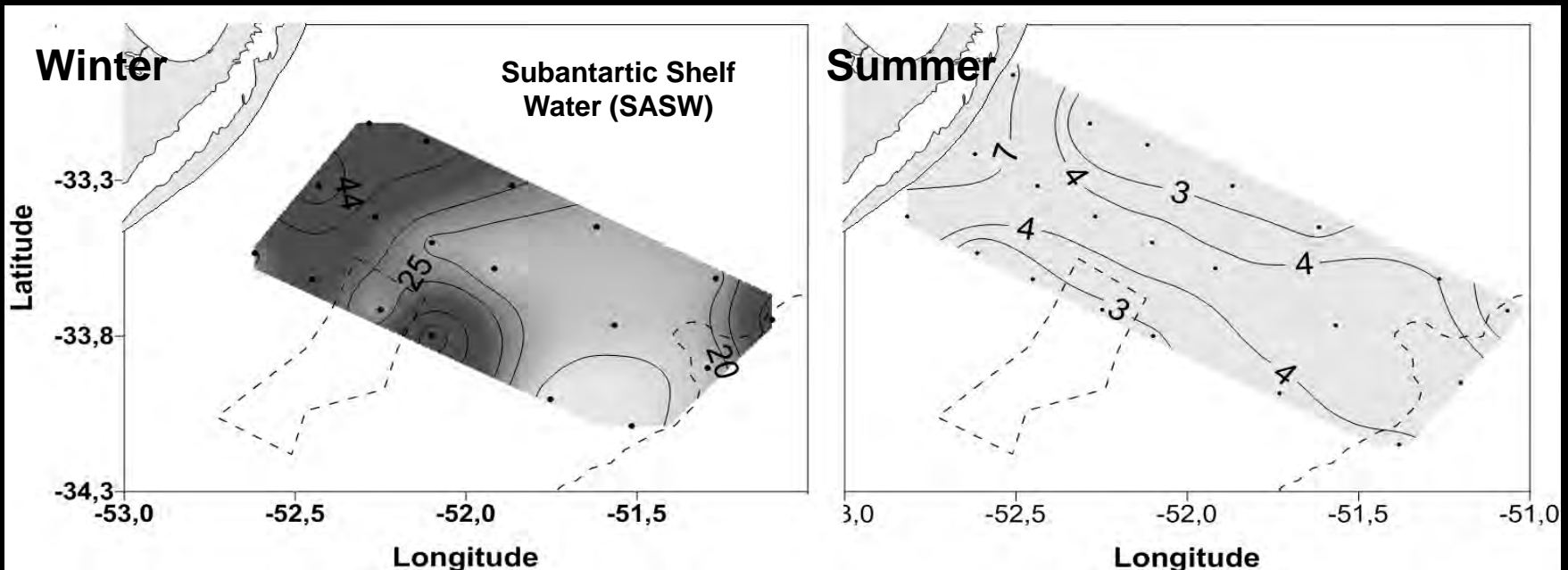
Campos et al. (2009)

The intrusion of cold and denser SASW into the paleochannel may lead to density inversion at the sediment-water interface and may potentially release the radium and nutrients to the water column.



NUTRIENTS

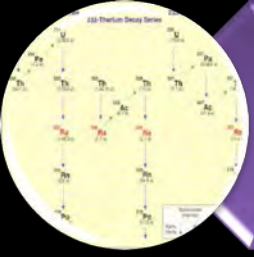
Silicate is a good continental water tracer



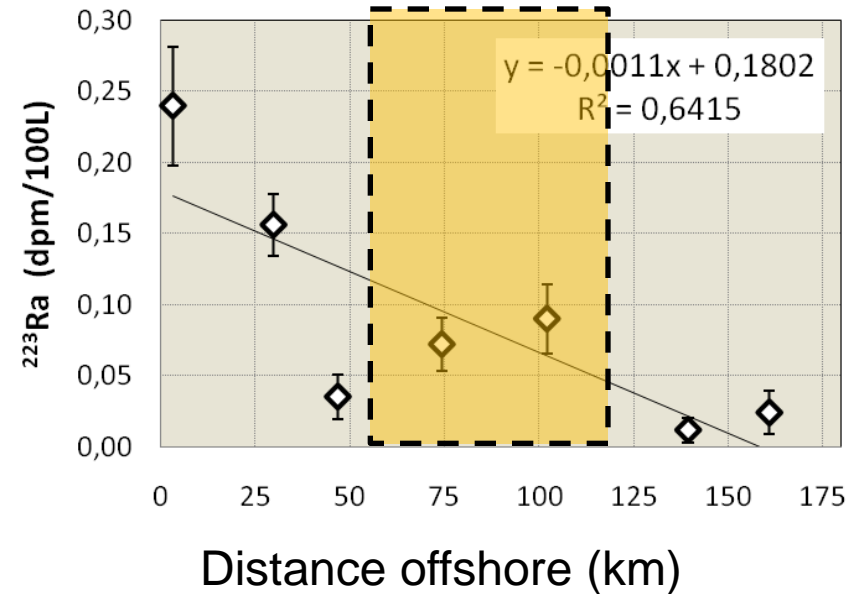
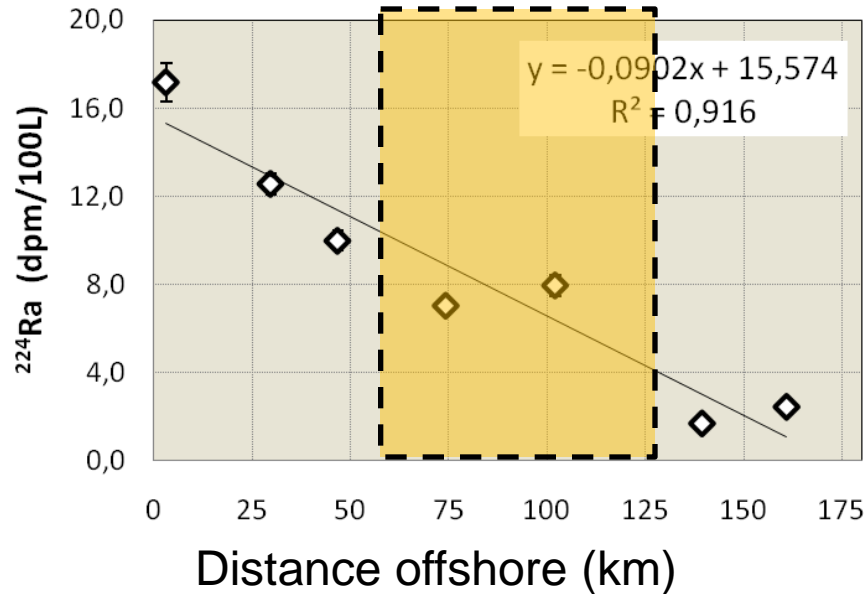
Distribution of silicate ($\mu\text{mol L}^{-1}$) along the transects offshore in (a) winter and (b) summer.

Winter: the volume of SASW is larger, the silicate was enriched near peleochannel.

This could provides evidence for the advection of continental groundwater.



RADIUM ISOTOPES



The distribution of short-lived radium isotopes (^{224}Ra and ^{223}Ra) showed an enrichment of isotopes nearshore and again at 50-100 km offshore (coast coincides with the location of the depression in the Algardão Paleochannel).

Thus, according with our hypothesis the paleochannel is a preferred pathway for groundwater or porewater, once radium isotopes is another excellent tracer of this process.

Summary

- ❖ **There is a great potential primary production supported by SGD in southern Brazil coast;**
- ❖ Based on water masses; dissolved nutrients and radium isotopes Albardão Paleochannel could be a pathway for SGD;
- ❖ Radium isotopes in vertical profiles in Albardão Paleochannel is necessary to obtain additional information from SGD;
- ❖ The others paleodrainage system must be mapped and investigated.

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A photograph of a boat's wake in the ocean under a clear blue sky. The water is dark blue with white foam from the wake. The sky is a uniform light blue.

*Thank you
for your time and attention!*

karina.attisano@furg.br