MOVIMENTOS QUASE INERCIAIS NA CB REVELADOS POR DERIVADORES E DADOS DE VENTOS OFFSHORE

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MOVIMENTOS INERCIAIS: O QUE SÃO?

Heuristicamente: são emitidos pelo oceano quando perturbado de sua condição de equilíbrio (geostrofia).

A frequência teórica das oscilações inerciais (f_0), também chamada frequência inercial local, é dada por:

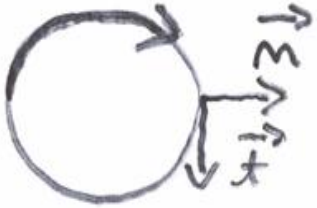
$$f_0 = 2\,\Omega \mid \sin\theta_0 \mid \qquad (1.1)$$

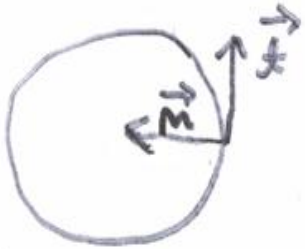
onde $\Omega = 7{,}29 \,.\, 10^{-5}\ \mathrm{s}^{-1}$ é a velocidade angular de rotação da Terra e θ_0 é a latitude local (positiva no hemisfério norte e negativa no hemisfério sul).

Equação do movimento
(coordenadas naturais)

$$\frac{V^2}{R} + fV = -g\frac{\partial h}{\partial M}^{\nearrow 0}$$

$$V\left(\frac{V}{R} + f\right) = 0 \Rightarrow V = -fR$$





$f > 0$, $R < 0$ { anticiclônico — H.N

$f < 0$, $R > 0$ { anti-ciclônico — H.S

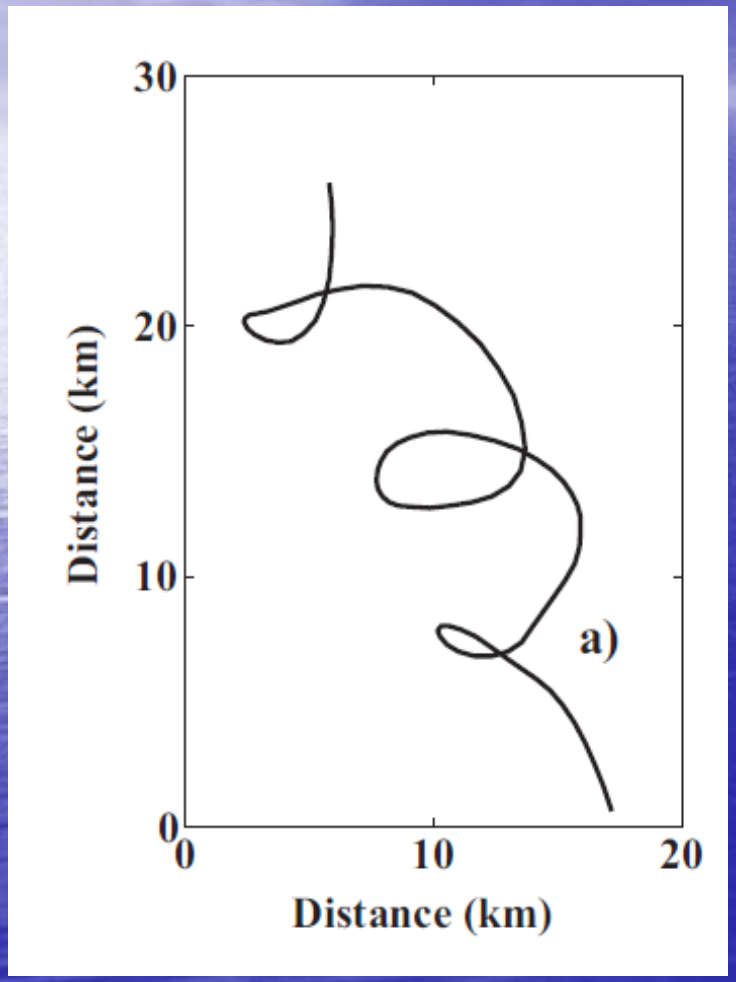
Período: $T_i = \frac{|2\pi R|}{|fR|} \Rightarrow T_i = \frac{2\pi}{|f|}$

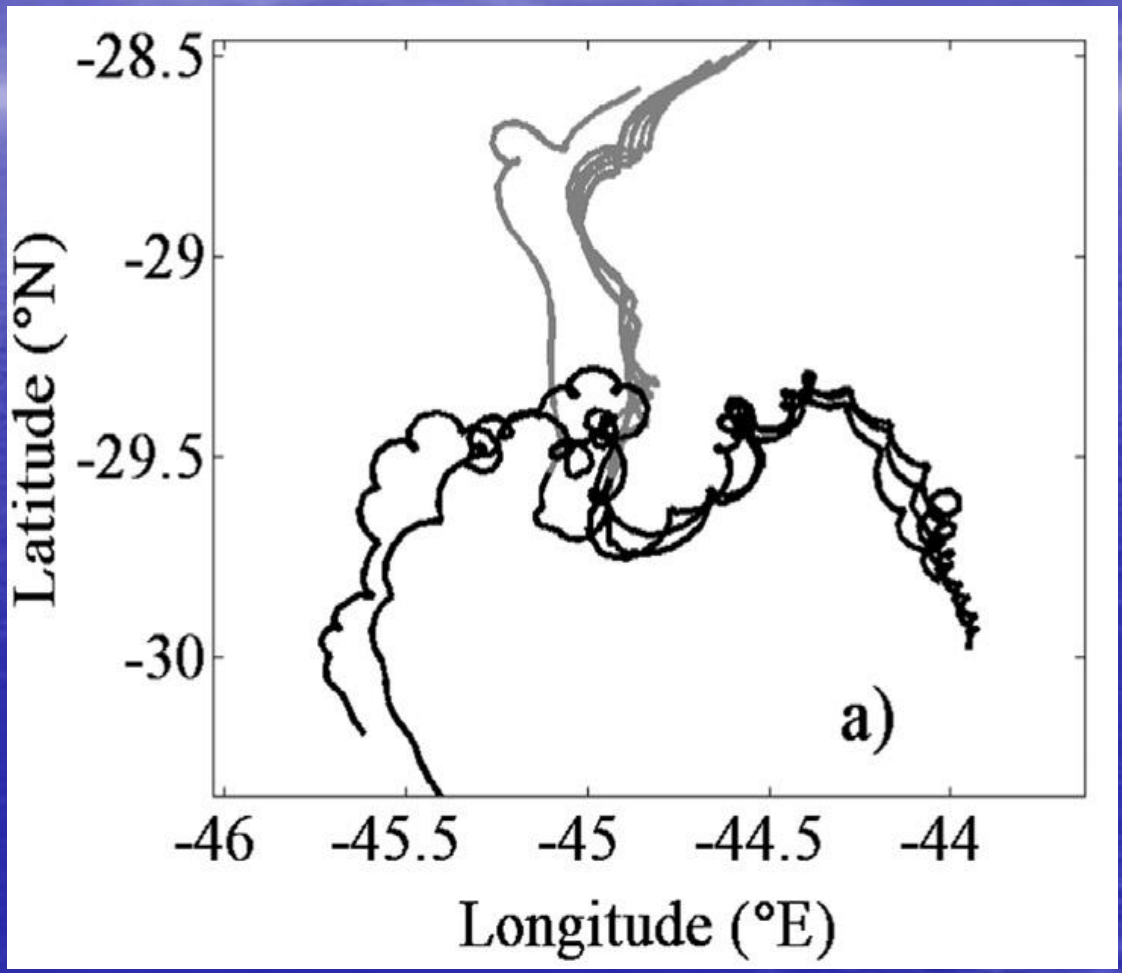
Movimentos inerciais: primeiras observações

Helland-Hansen & Ekman (1931)

Medidas correntométricas, a partir da segunda metade do século passado, possibilitou melhor compreensão do processo.

Maior capacidade de observação do processo





FONTE: Assireu et al. (2017)

Movimentos quase-inerciais (A partir do ano 2000):

$$f_{ef} = f_0 + \frac{\zeta}{2}$$

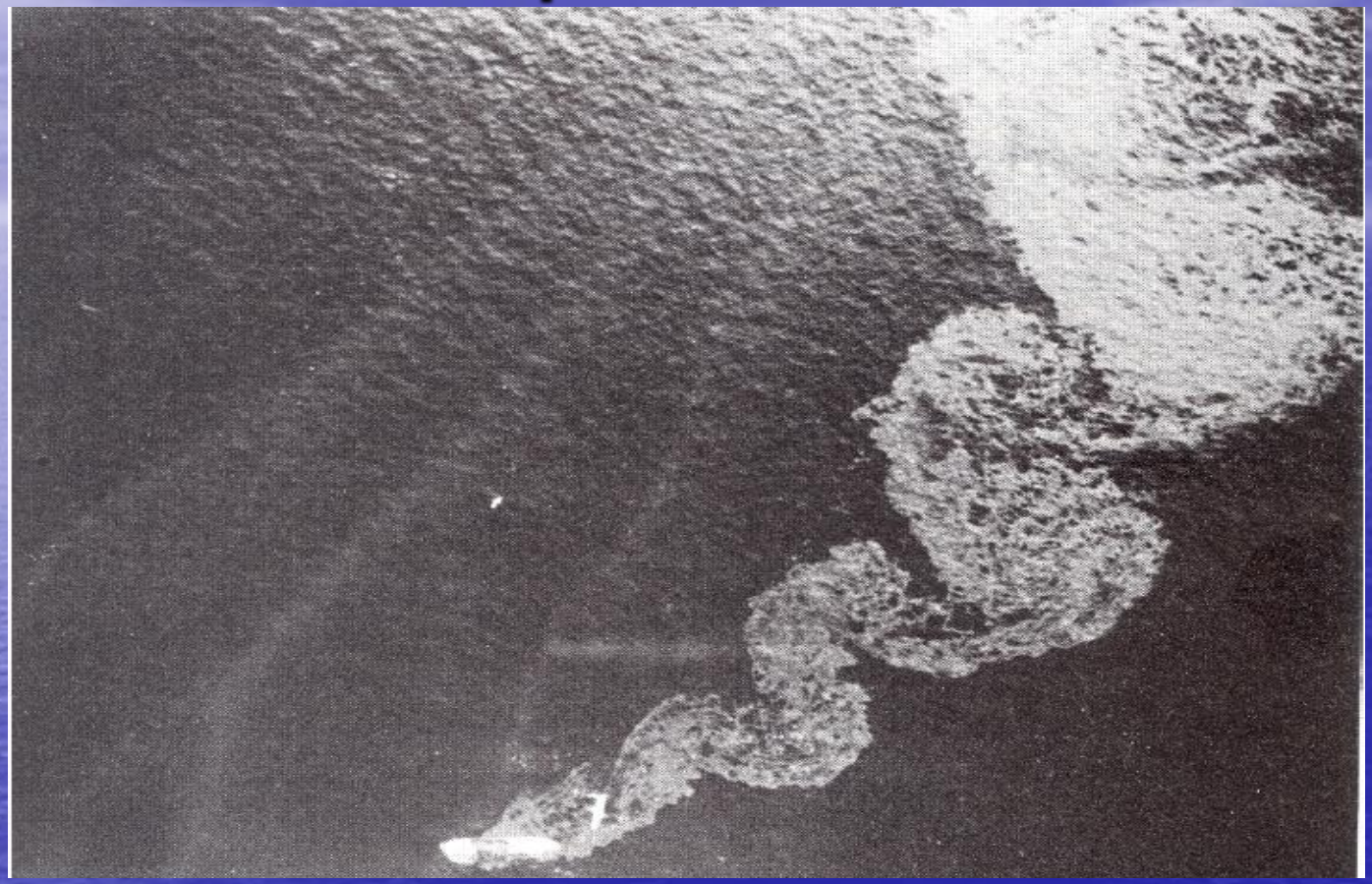
$$\zeta = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$$

-Latitude crítica

-Ressonância brisa x movimentos inerciais

-Interação entre diferentes escalas

Importância



Espiral de óleo na costa leste dos EUA. A forma sinuosa evidencia oscilações inerciais sobrepostas à deriva. FONTE: Apel (1987)

Importância

-Metade da energia cinética do oceano é associada a faixa inercial (Alford et al. 2012).

-Substancial fração da energia quase-inercial é transferida desde a camada de mistura até 800m de profundidade (Alford et al. 2012).

- Correntes geradas pelo vento foram entre 8 e 12 vezes mais intensas próximas a latitude crítica na costa oeste dos EUA (Kim & Crawford, 2014).

-Correspondentes flutuações das isotermas pode chegar a 60 m com propagação de fase ~ 140 m/dia (Mihanovic et al. 2016)

Continental Shelf Research 145 (2017) 1–12

Contents lists available at ScienceDirect

Continental Shelf Research

journal homepage: www.elsevier.com/locate/csr

Research papers

Near-inertial motions in the Brazil Current at 24°S-36°S: Observations by satellite tracked drifters

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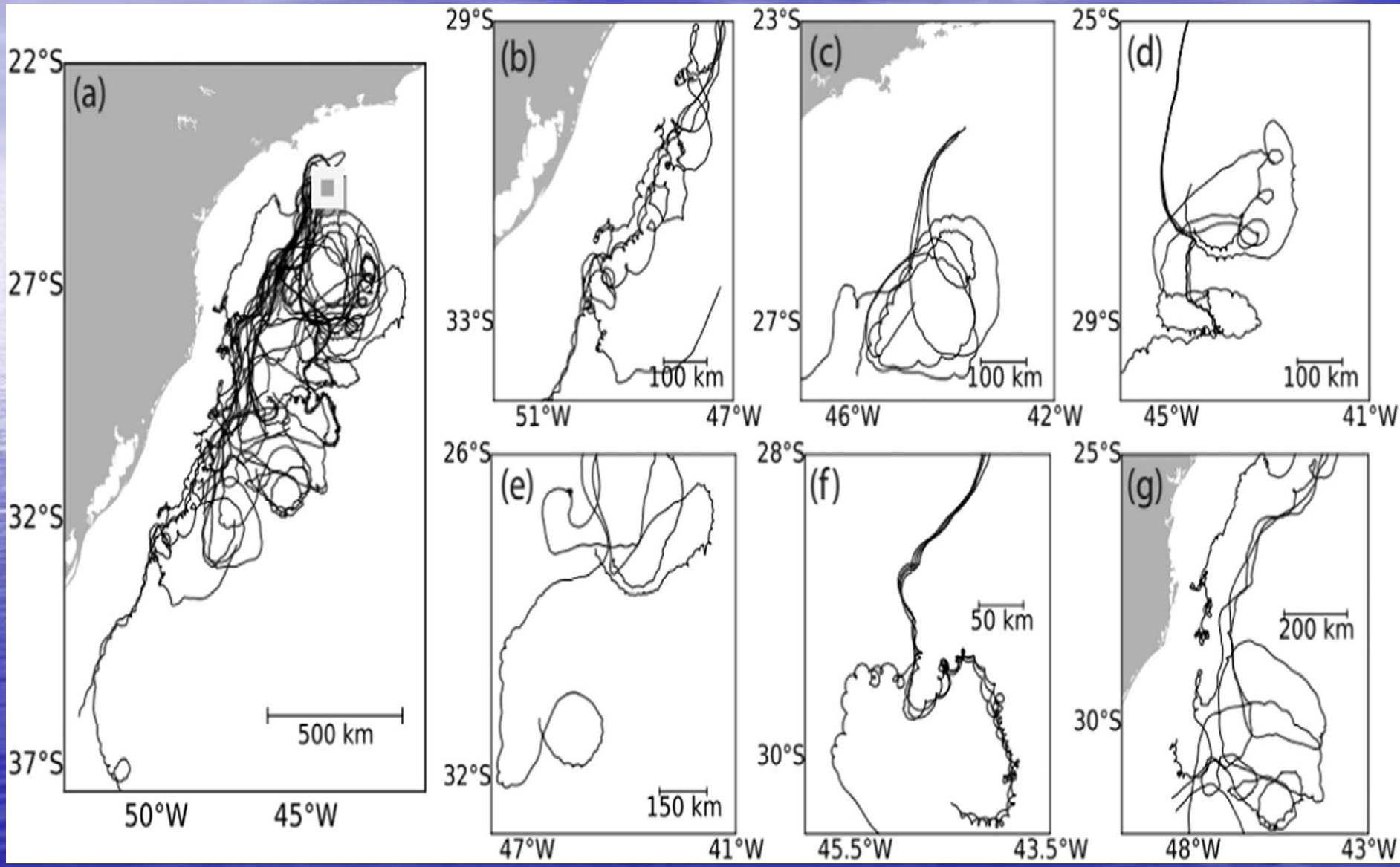
ARTICLE INFO

Keywords:
Near-inertial currents
Brazil Current
Drifters
Submesoscale flow

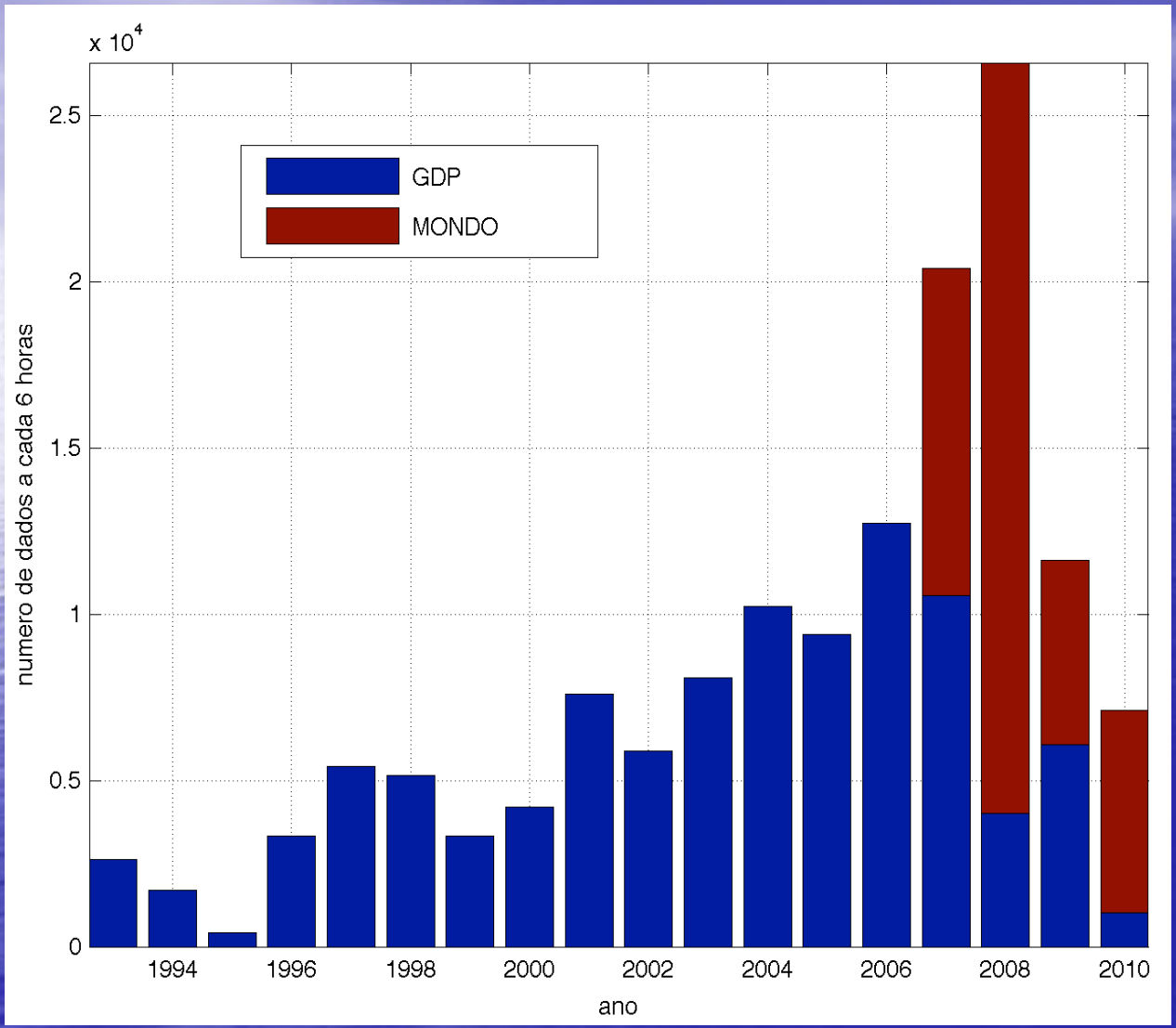
ABSTRACT

Increased spatial and temporal resolution of recent observations and modeling have pointed out the importance of small scale structures (in the range of 1–50 km) for the mixing processes in the ocean. Based on high-frequency drifter measurements, we show here that the near-inertial currents (NICs) can contribute significantly to the surface kinetic energy in the Brazil Current (BC) region and, therefore, should be properly taken into account in the studies of transport and mixing processes. To characterize these submesoscale features, we examine the current response to the wind forcing in the Brazilian ocean margin between 24°S and

Dados


(a)
22°S
27°S
32°S
37°S
50°W
45°W
500 km
(b)
29°S
33°S
51°W
47°W
100 km
(c)
23°S
27°S
46°W
42°W
100 km
(d)
25°S
29°S
45°W
41°W
100 km
(e)
26°S
32°S
47°W
41°W
150 km
(f)
28°S
30°S
45.5°W
43.5°W
50 km
(g)
25°S
30°S
48°W
43°W
200 km

DADOS

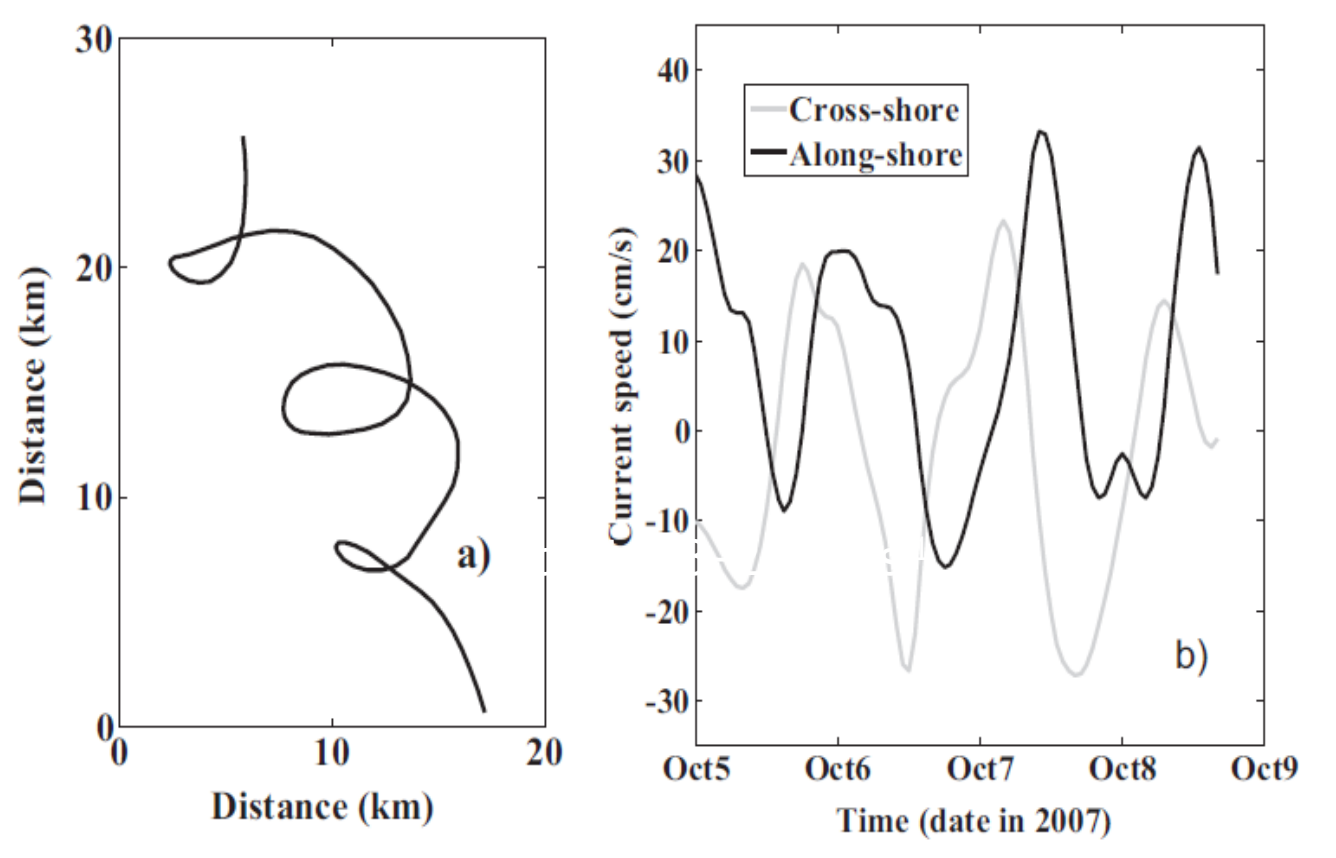


Global Drifter Program (GDP
http://www.aoml.noaa.gov/phod/dac)

Projetos MONDO
http://prooceano.com.br/mondo

FONTE: Cerrone (2010)

Resultados - Descrição

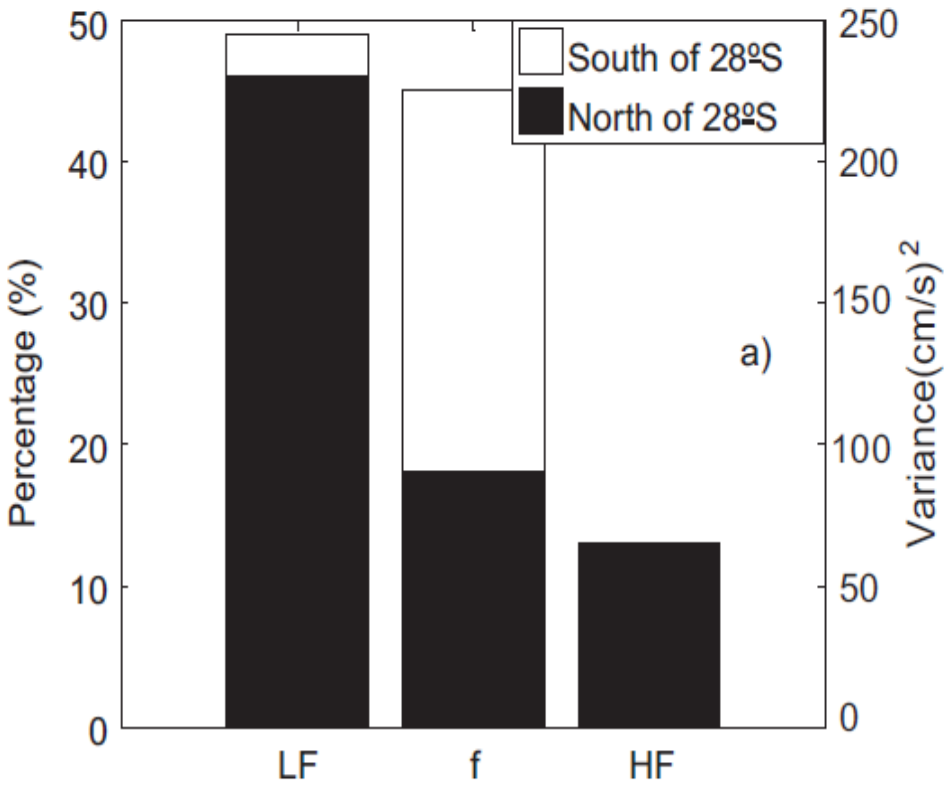


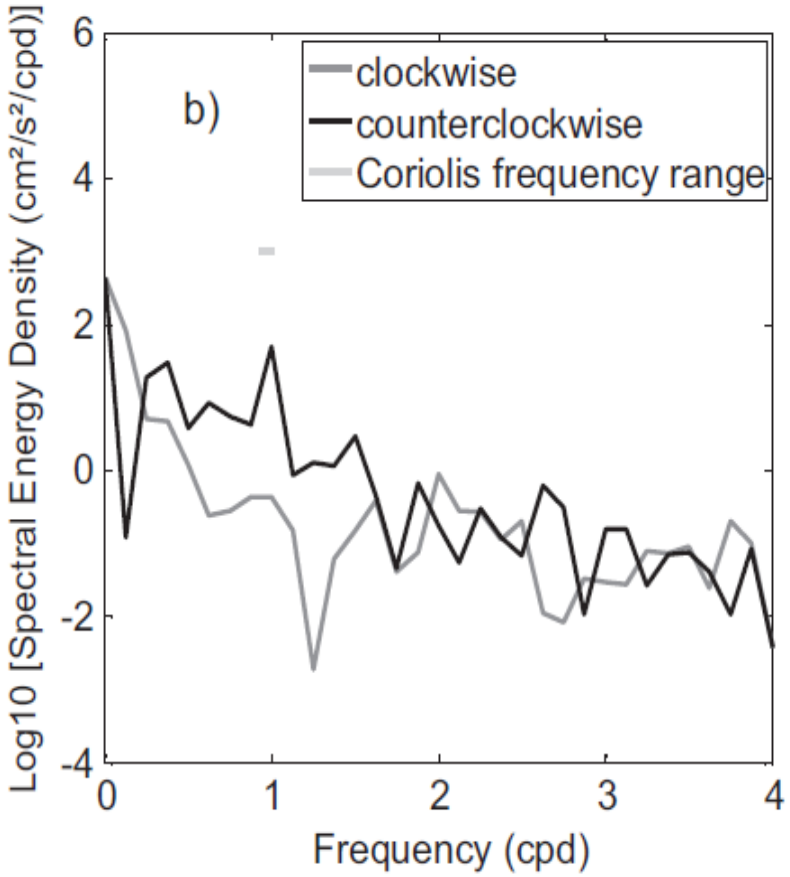
L ~ 3 km, U ~ 10 cm/s e f ~ 10-5 s-1 Ro = U/fL,

Ro = O(1)

Thomas et al. (2008) = escoamento de sub-mesoescala

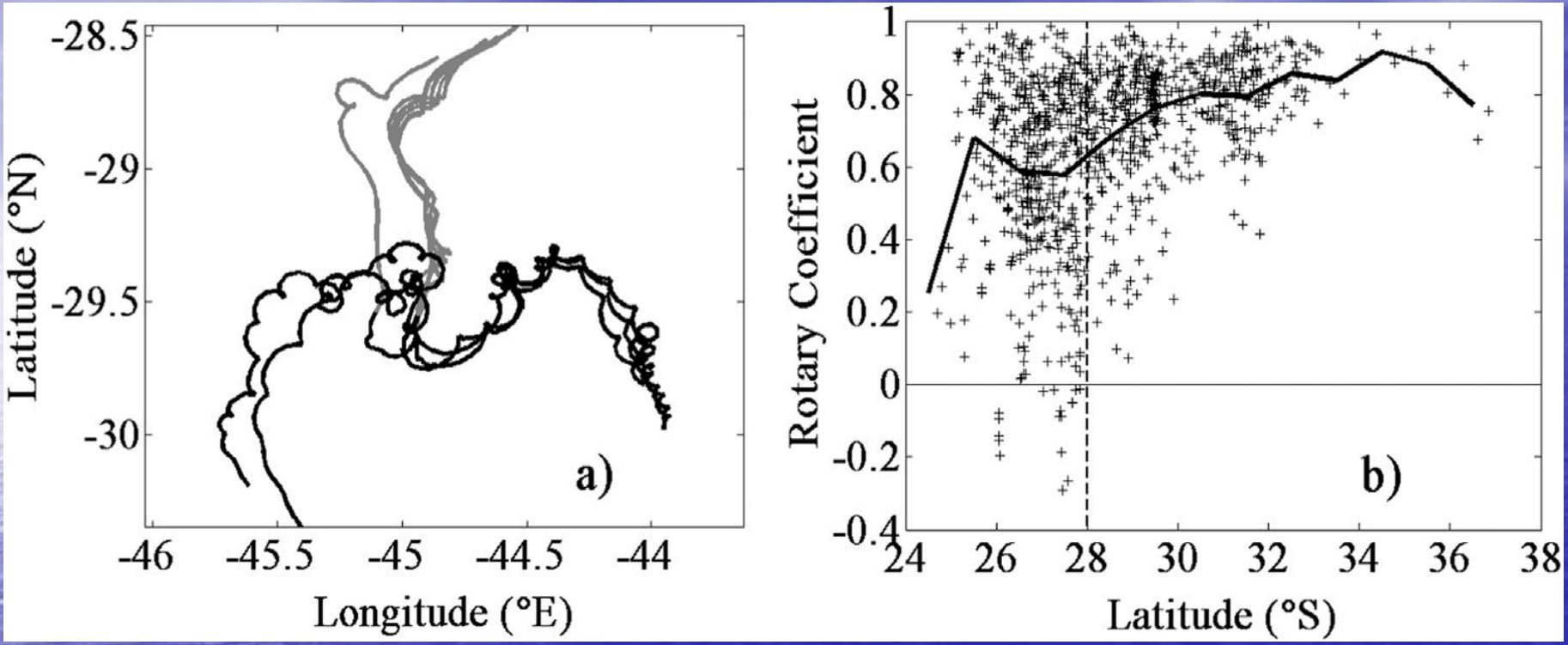
Resultados - Descrição





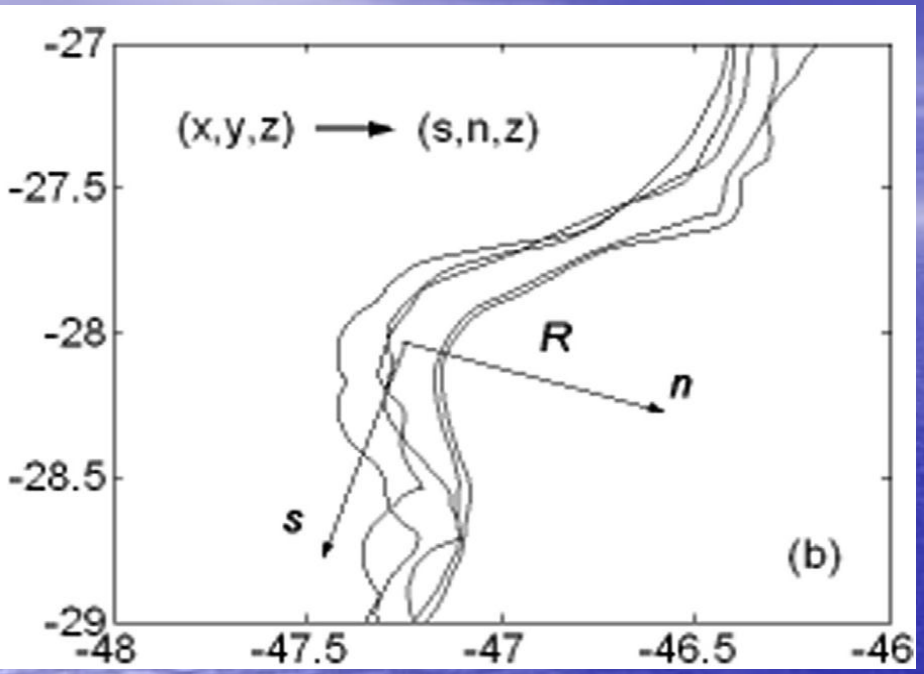
LF: sub-inercial; f: inercial; HF: supra-inercial

Resultados – Variação latitudinal



Coeficiente rotacional: positivo (negativo) para Movimentos anti-horários (horário) e igual a zero (unitário) para oscilações lineares (circularmente polarizado)

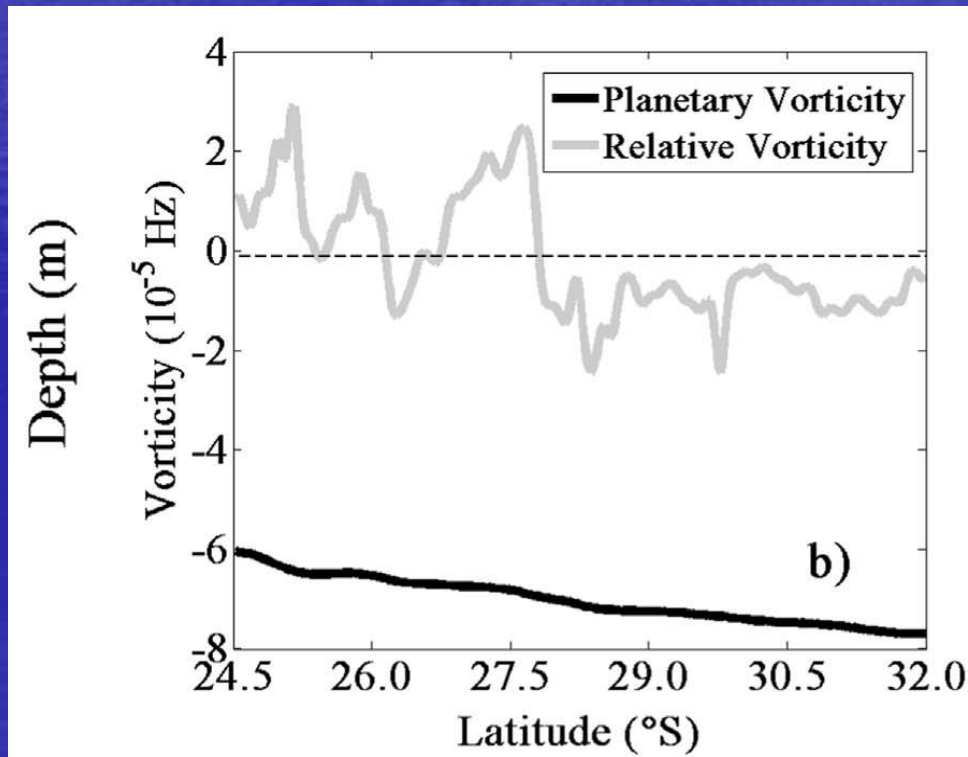
Resultados – Contribuição de ζ



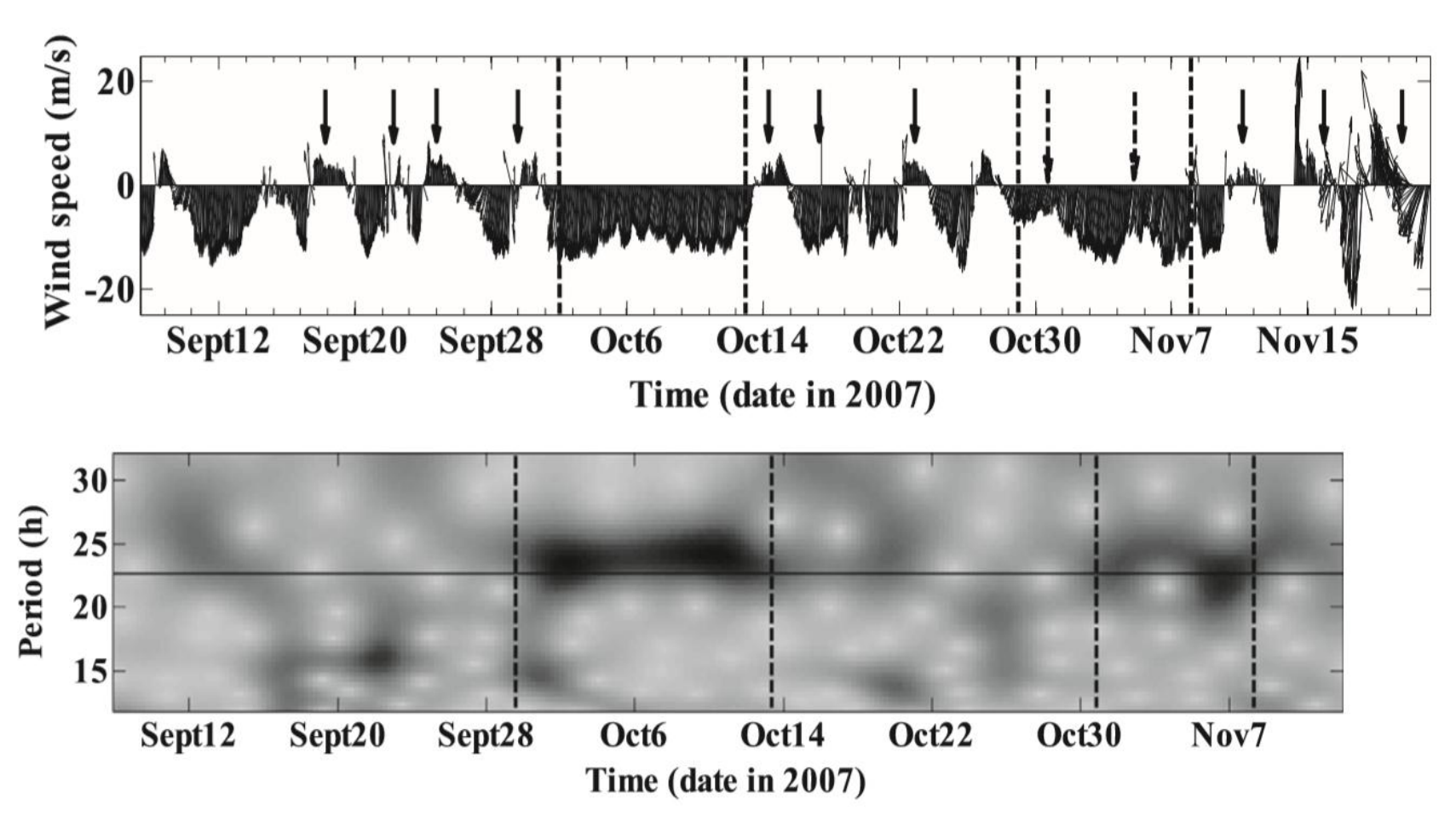
$$\zeta = \frac{V}{R} - \frac{\partial V}{\partial n}$$

Arthur (1965)

FIE = $f + \zeta/2$



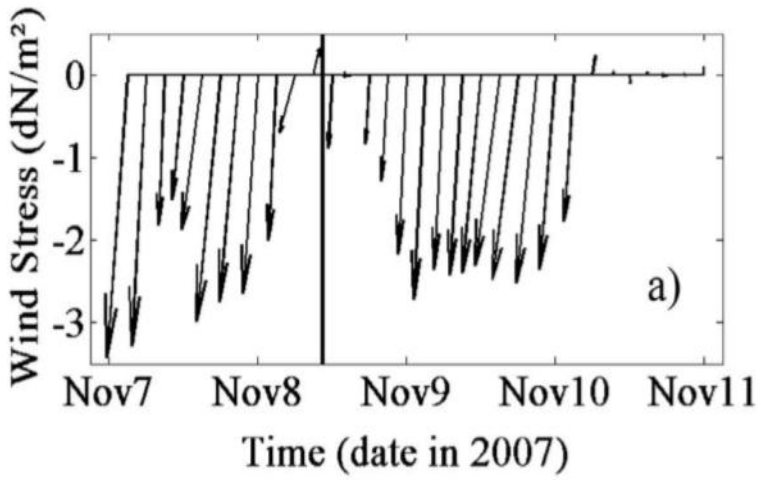
Resultados – Forçantes meteorológicas

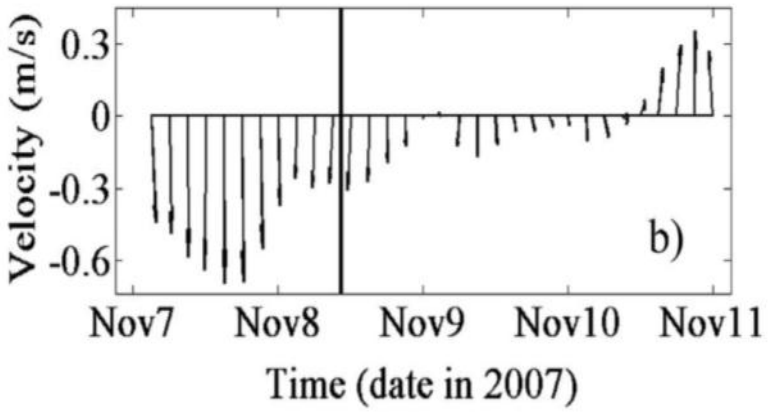


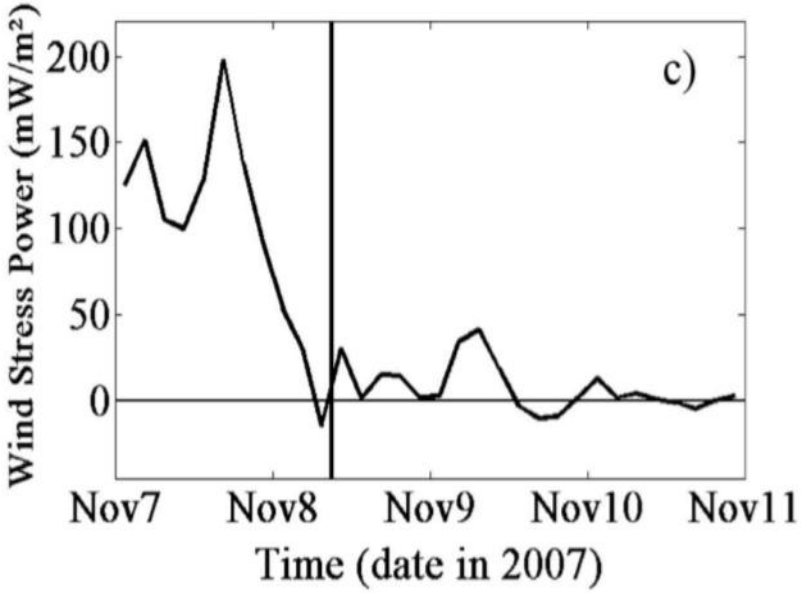
Setas contínuas: frente fria

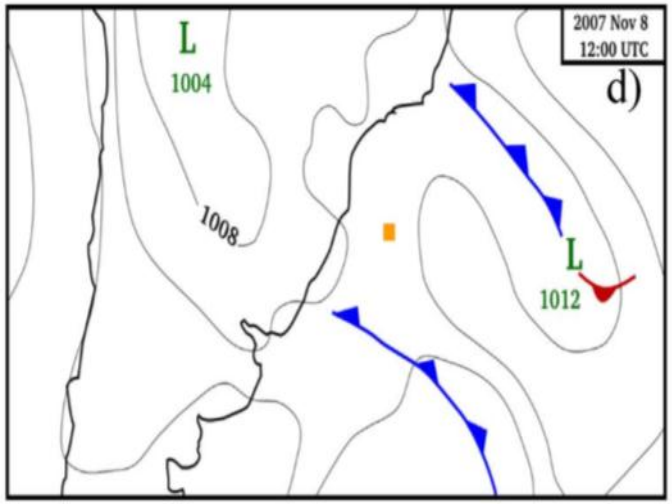
Setas tracejadas: frente fria sem inversão do vento

Resultados – Mecanismos geradores

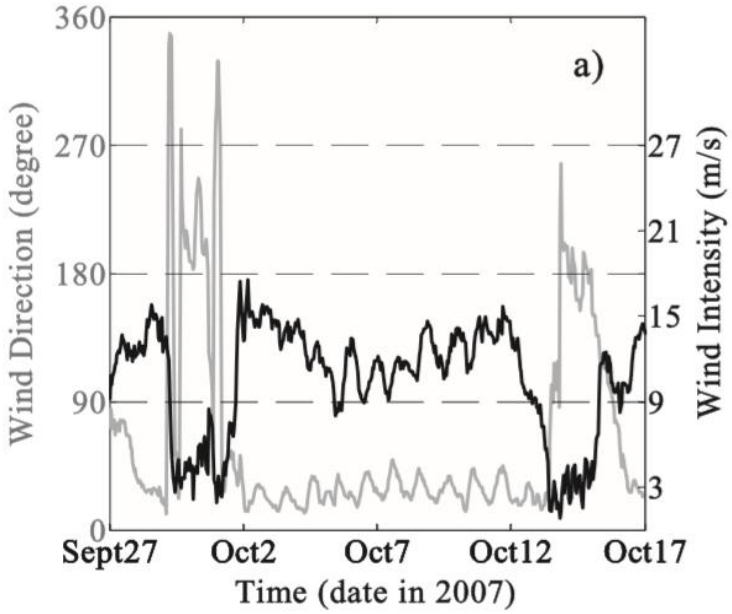


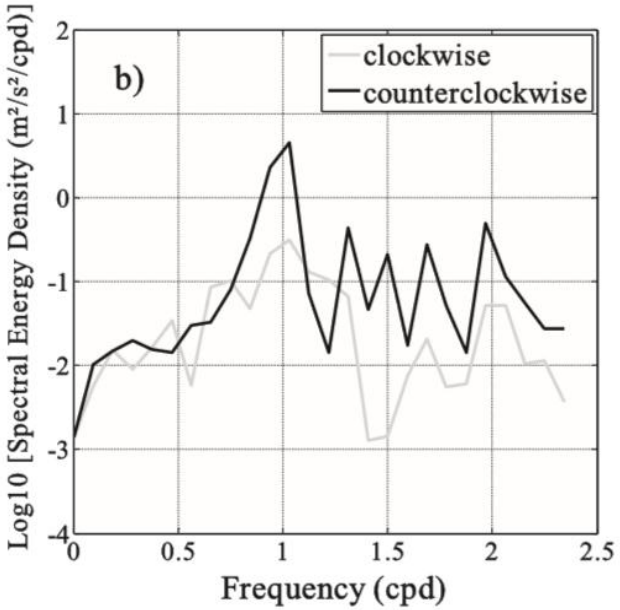


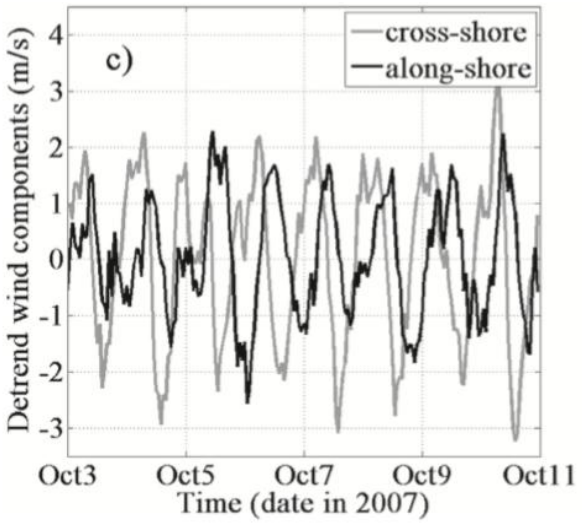


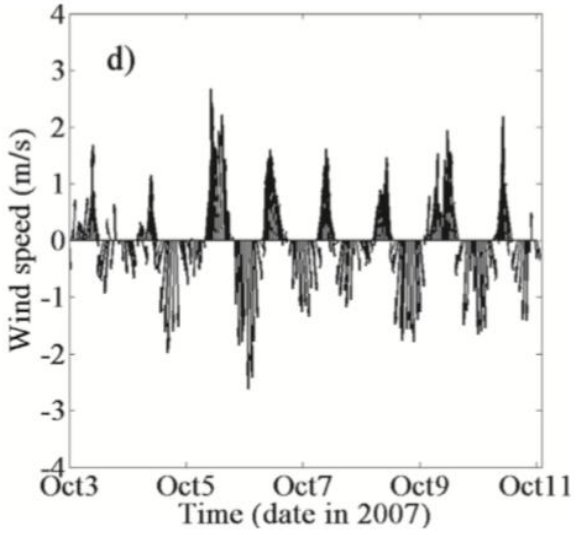


Resultados – brisa

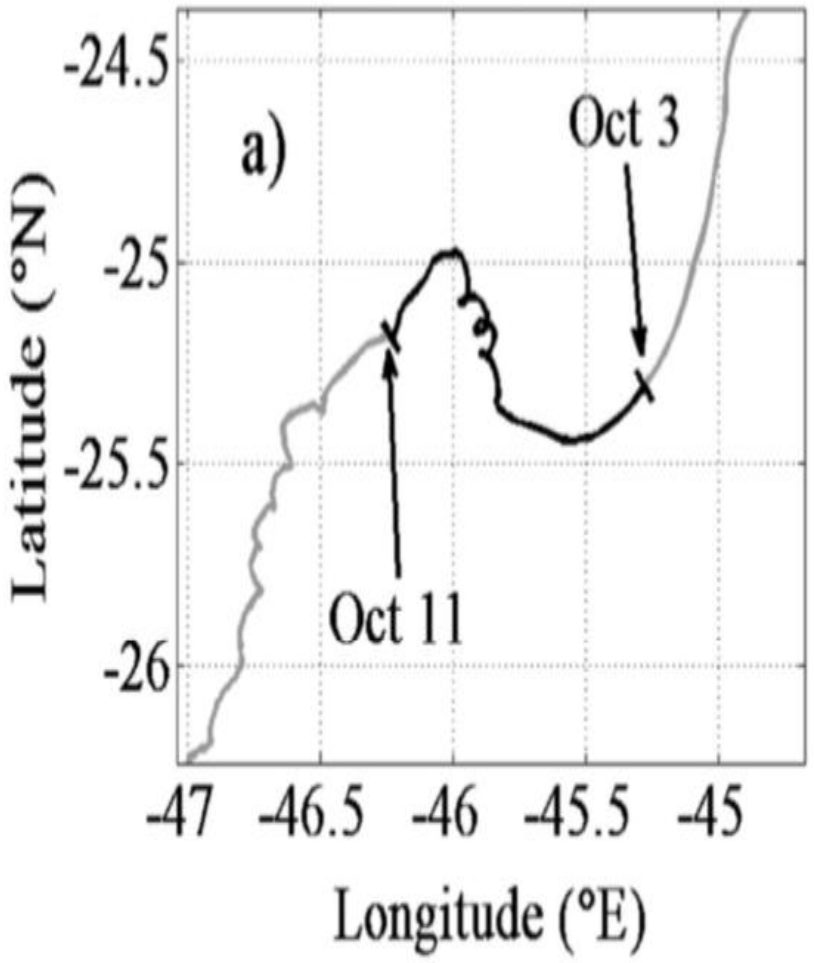


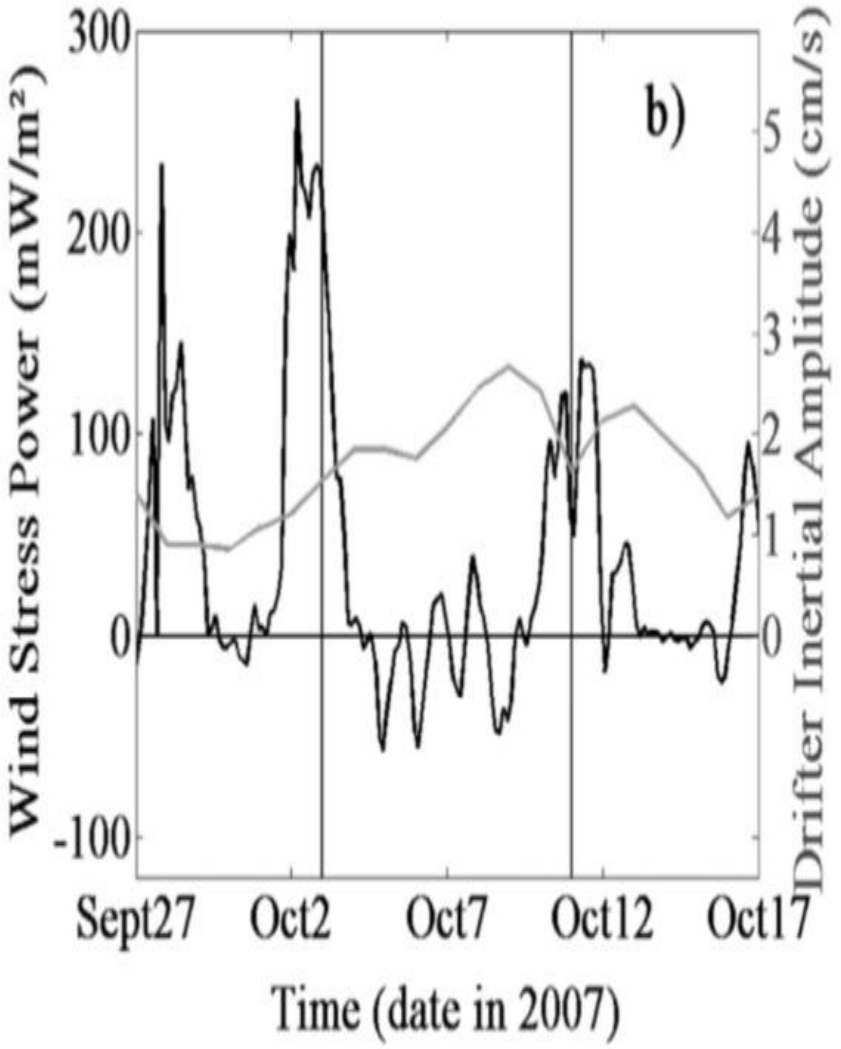






Resultados – brisa

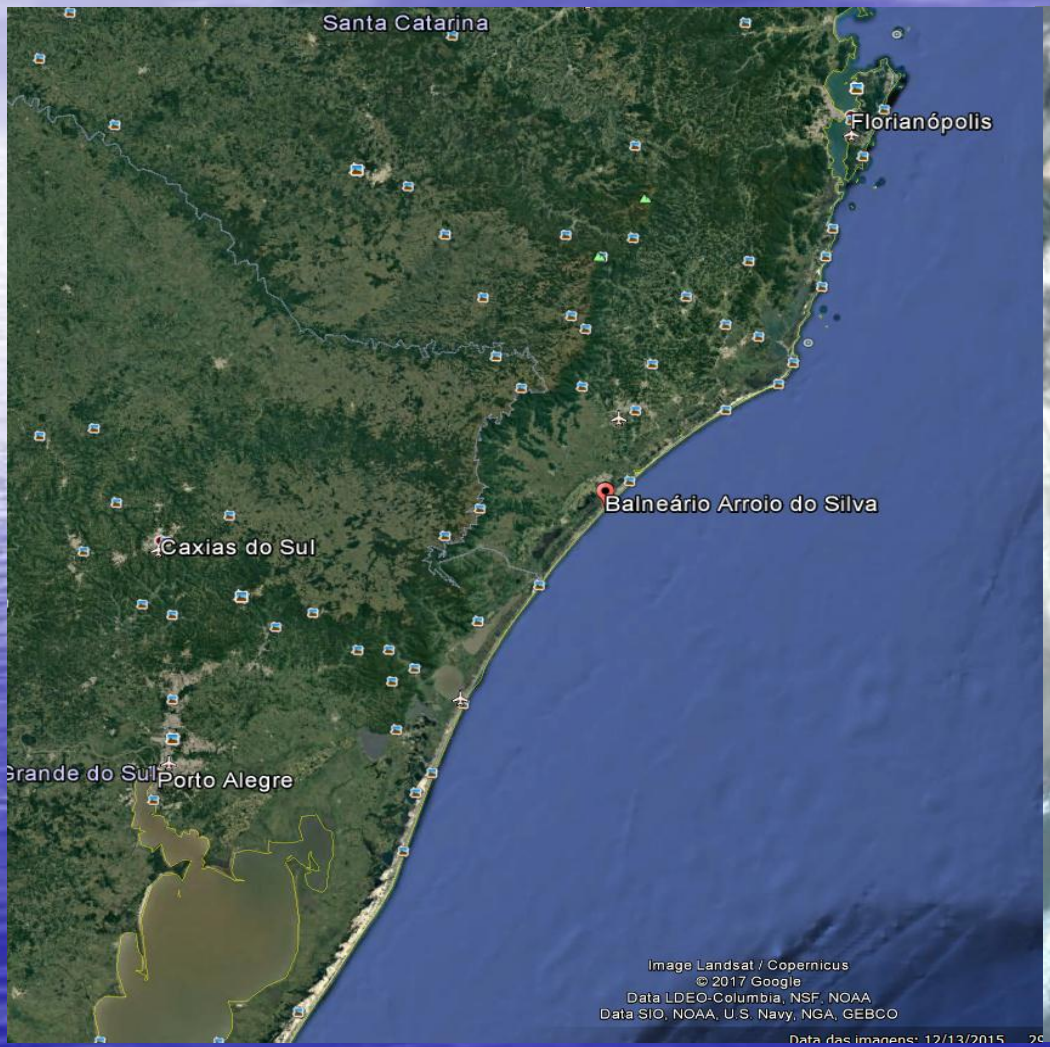




Conclusões e sugestões

- Frente fria e brisa são as principais motivadoras
- Predomínio de MQI a sul de 28°S
- ζ ciclônico (negativa) desloca a FIE em direção a frequência diurna → possibilidade de ressonância
- Revisitar estimativas de EKE → não levaram em conta contribuição da sub-mesoescala
- Avaliar implicações para a estrutura vertical e conhecer melhor a estrutura da brisa

LIDAR - Balneário Arroio do Silva-SC - ~29°S



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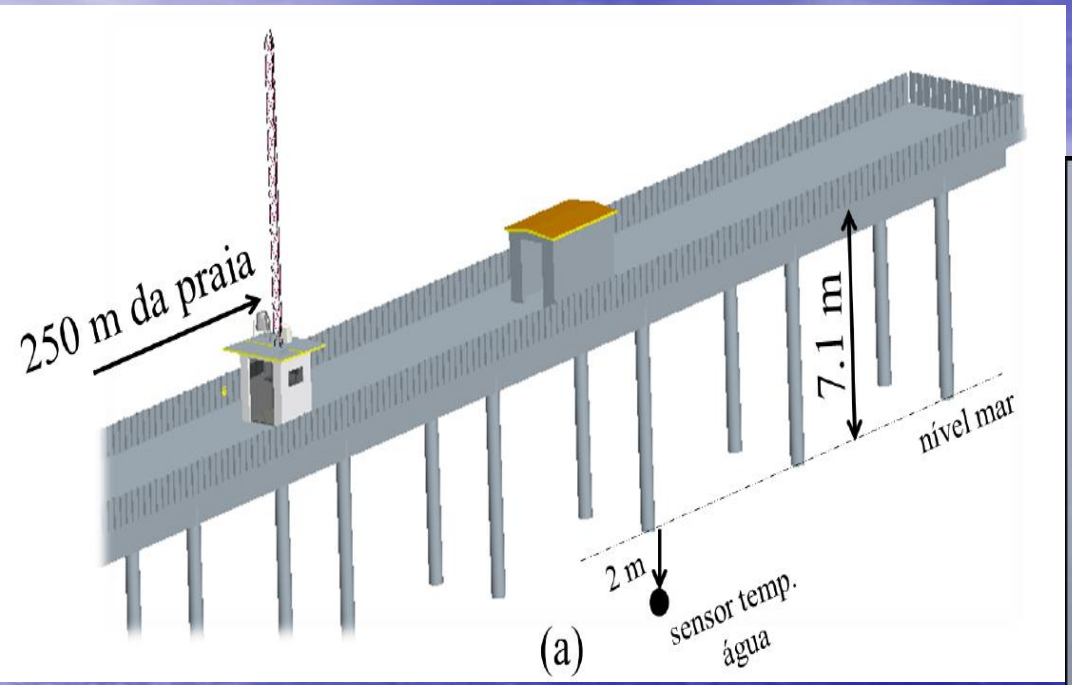
BOOA



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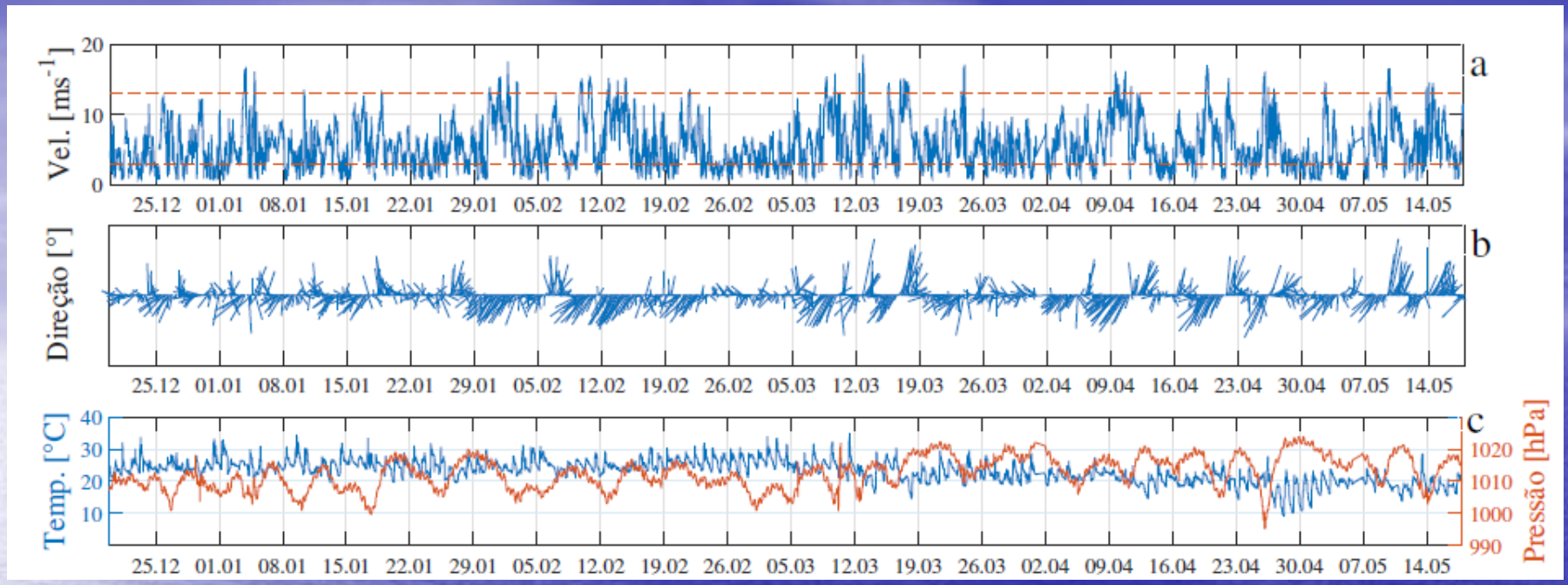
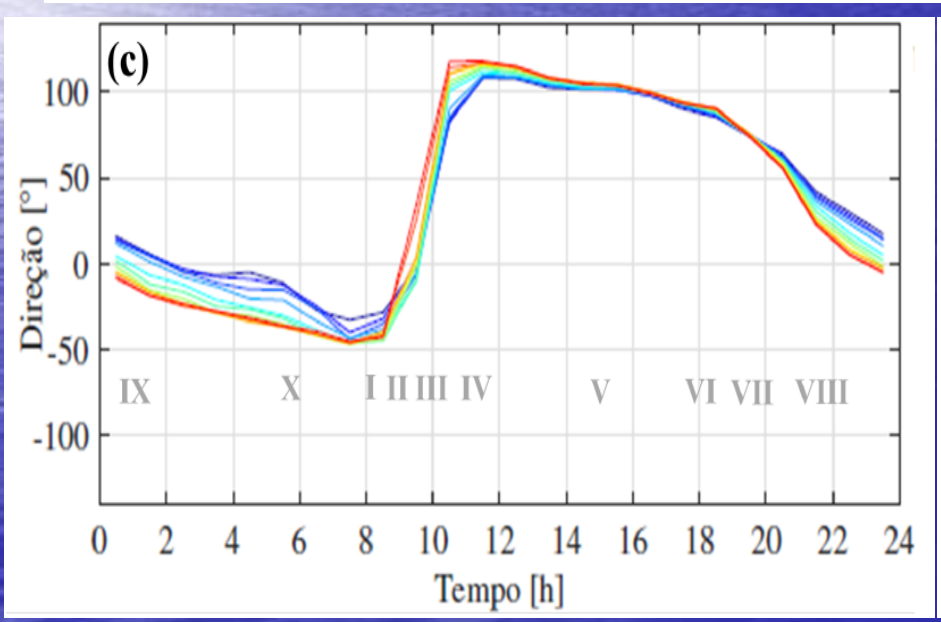
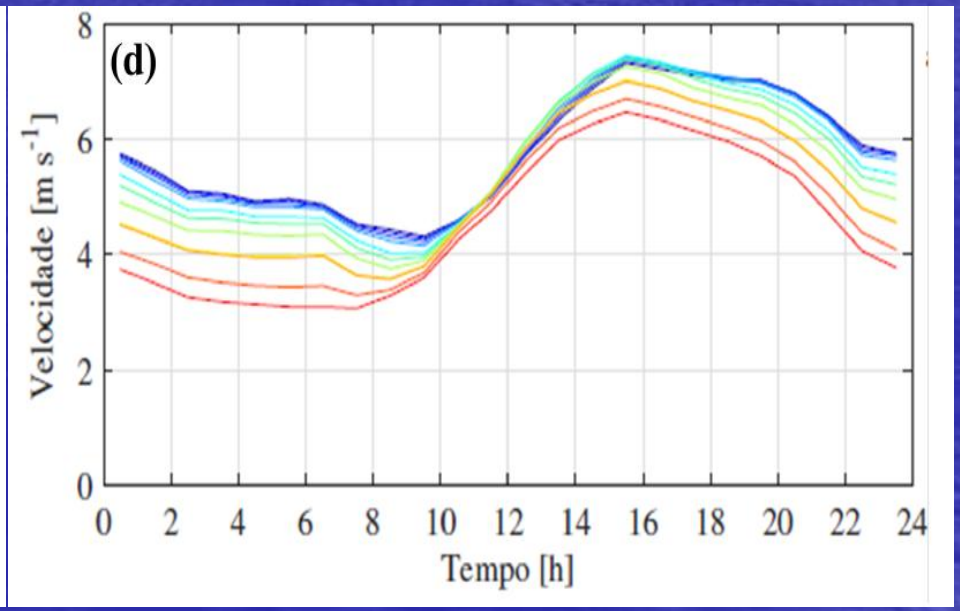
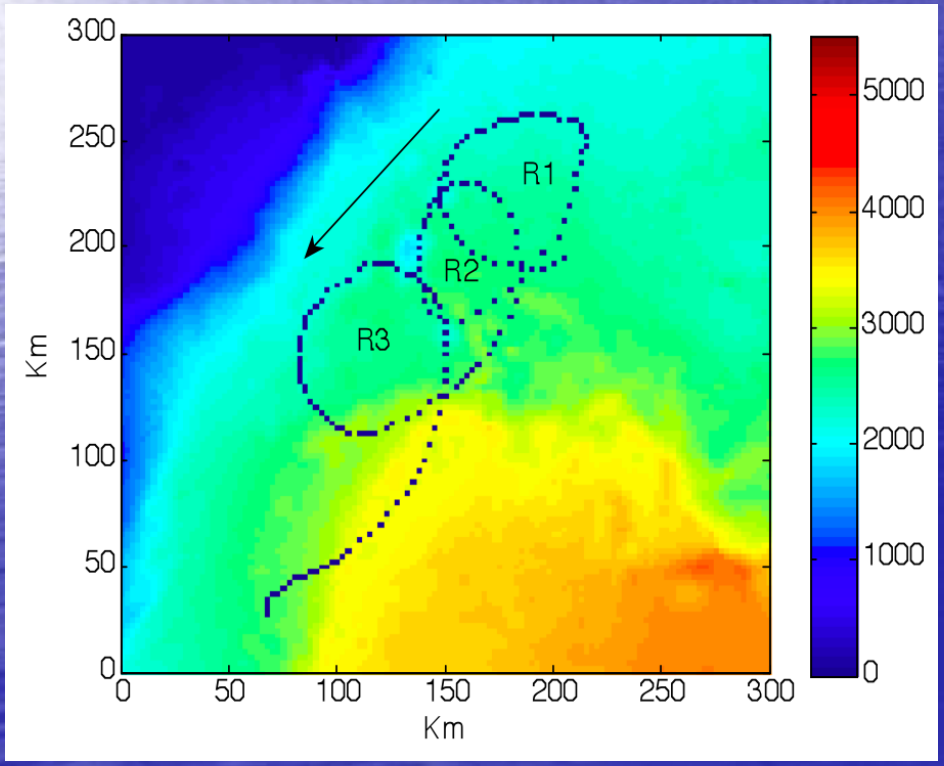


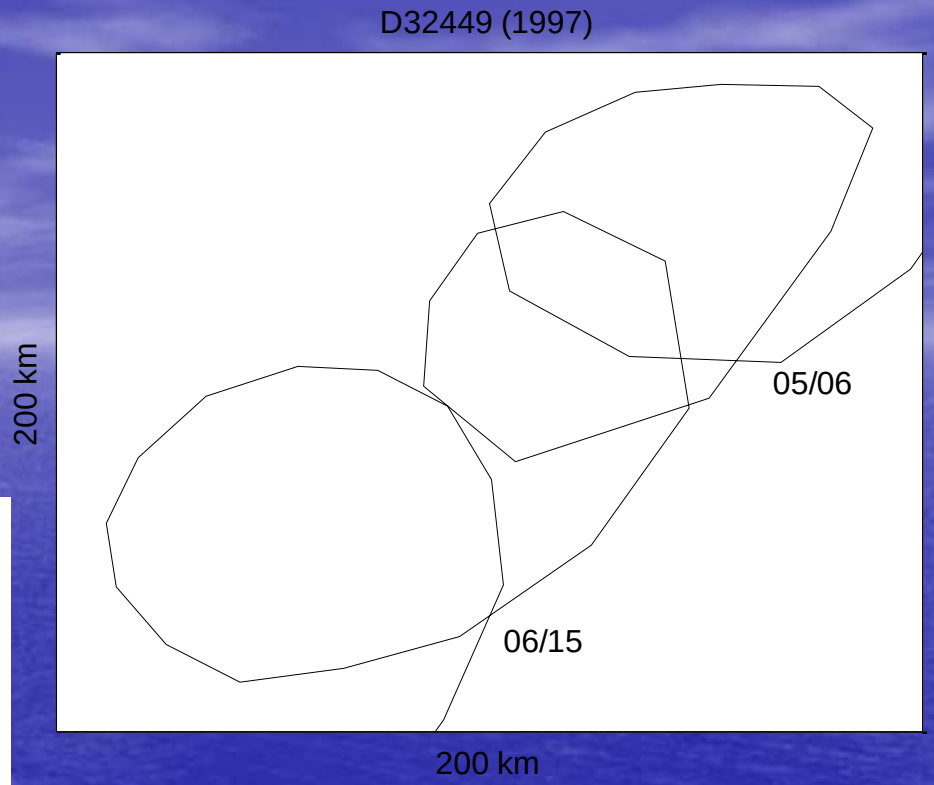




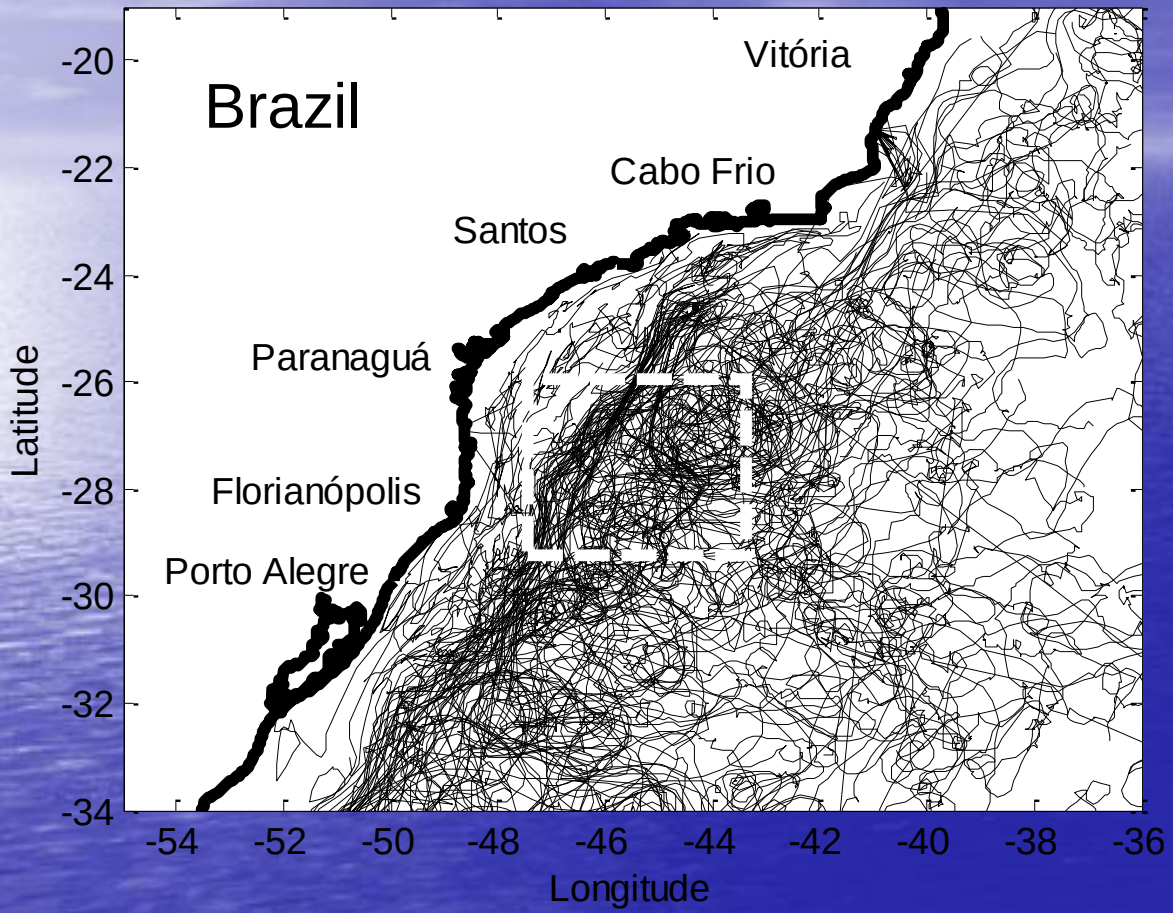
Fonte: Nassif e Pimenta (2017)

Origem da vorticidade negativa



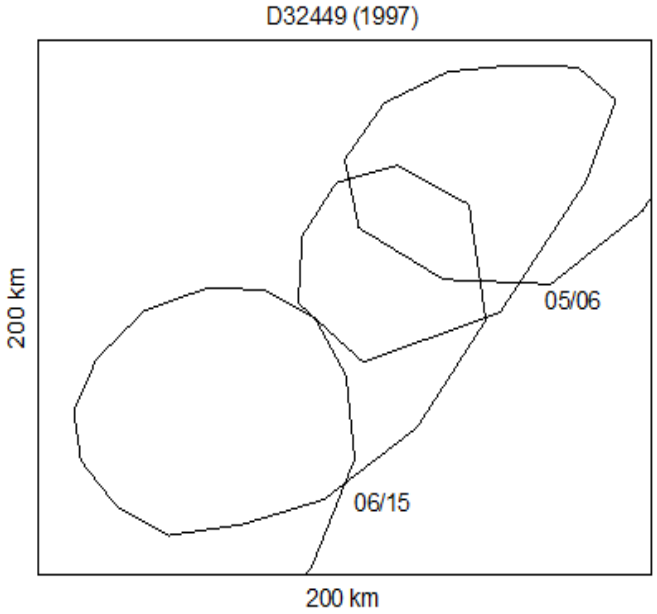


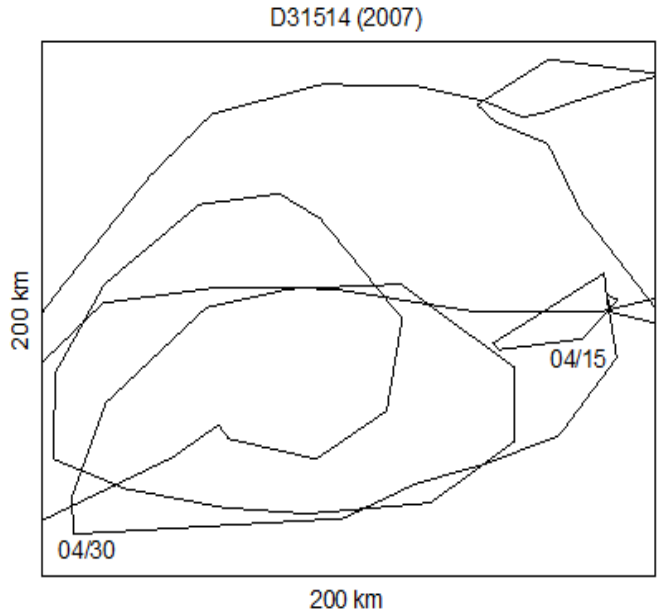
Vórtice quase-estacionário?

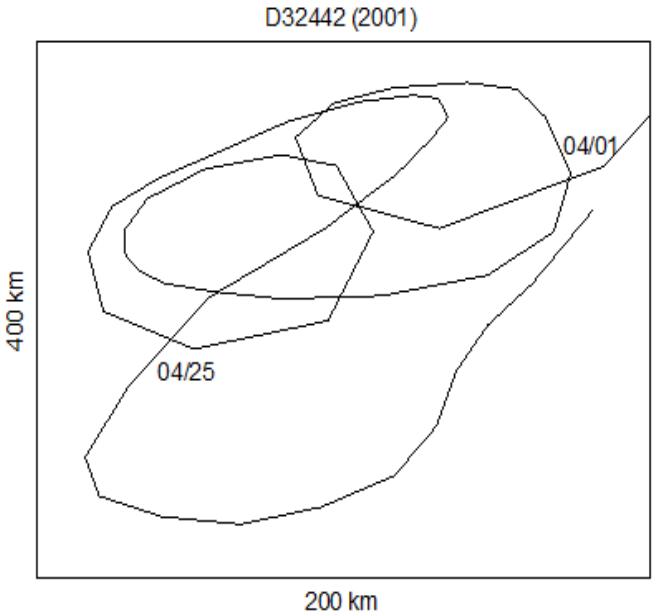


114 derivadores (1993-2009).


D3180 (1993)
03/13
04/11
200 km
130 km


D32449 (1997)
05/06
06/15
200 km
200 km


D31514 (2007)
04/15
04/30
200 km
200 km


D32442 (2001)
04/01
04/25
400 km
200 km

Obrigado pela atenção!!!