

# Influência da Maré Meteorológica no Nível do Mar

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Departamento de Ciências Atmosféricas

IAG-USP



# Agradecimentos

Ao IEAPM/CHM/MB pela iniciativa do OMARSAT  
desde 1995 e pelo convite

Aos ensinamentos que tive com:  
Almte Alberto dos Santos Franco  
Prof.Dr. Afranio Rubens de Mesquita  
Prof.Dr. Joseph Harari  
Dr. Carlos Augusto Sampaio França  
Prof.Dr. Eduardo Marone

# Nível do Mar

Projeto de pesquisas:

MARES E NÍVEL MÉDIO DO MAR NA COSTA DO BRASIL (NIVEMAR)

Responsável: Almte. Alberto dos Santos Franco

São Paulo, 15 de abril de 1985

ENTIDADES ENVOLVIDAS

Instituto Oceanográfico da Universidade de São Paulo (IOUSP)

Diretoria de Hidrografia e Navegação da Marinha do Brasil (DHN)

Instituto de Pesquisas Tecnológicas do Estado de São Paulo

S/A I.P.T.

VIII - EQUIPE DE PESQUISADORES E PESSOAL TÉCNICO-CIENTÍFICO

Responsável pelo projeto (e coordenador dos trabalhos no IPT-USP):  
Almte. Alberto dos Santos Franco

Coordenadores dos trabalhos no IOUSP:

Prof. Dr. Afrânio Rubens de Mesquita

Dr. Joseph Harari

Coordenadores dos trabalhos na DHN:

CC Domingos Sérgio Meirelles

CT Araken José da Silva Veloso

Prof. Marco Antonio de C

Colaborador:

Bel. Carlos Augusto de S



LOCAL	Lat.		Long.	
1 Santana	00° 0,2'S		51° 0,6'W	
2 Belém	01 30		48 30	
3 Itaqui (Maranhão)	02 36		44 18	
4 Luiz Correia (PI)	02 54		41 42	
5 Fortaleza	03 42		32 30	
6 Fern. de Noronha	03 48		32 24	
7 Natal	05 48		35 12	
8 Cabedelo	07 06		34 54	
9 Recife	08 02		34 54	
10 Maceió	09 36		35 42	
11 Itaparica	13 00		38 34	
12 Ilhéus	14 48		39 00	
13 Vitória	20 18		40 18	
14 Trindade	20 30		29 18	
15 Cabo Frio	23 00		42 00	
16 Ilha Fiscal	22 48		43 12	
17 Ubatuba	23 24		45 06	
18 Santos	23 54		46 24	
19 Cananéia	25 06		47 54	
20 Paranaguá	25 30		48 30	
21 S. Francisco do Sul	26 18		48 36	
22 Itajaí	26 54		48 42	
23 Imbituba	28 18		48 42	
24 Rio Grande	32 06		52 06	

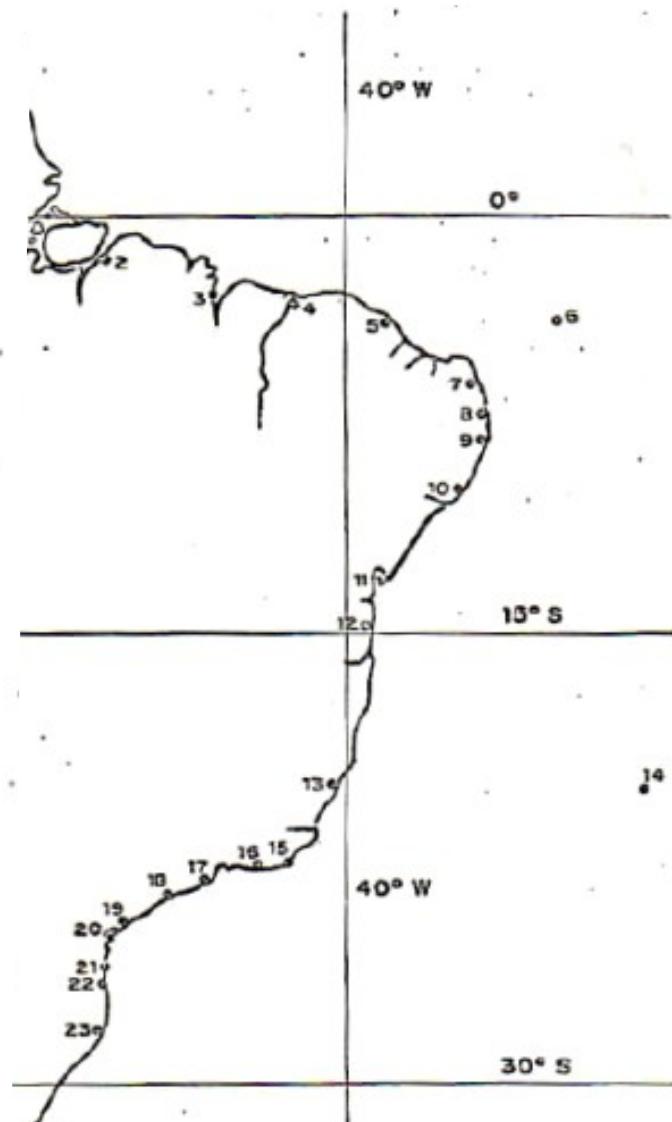


Figura 1 - Localização geográfica das 24 estações maregráficas permanentes prioritárias a corrigir os dados de maré.

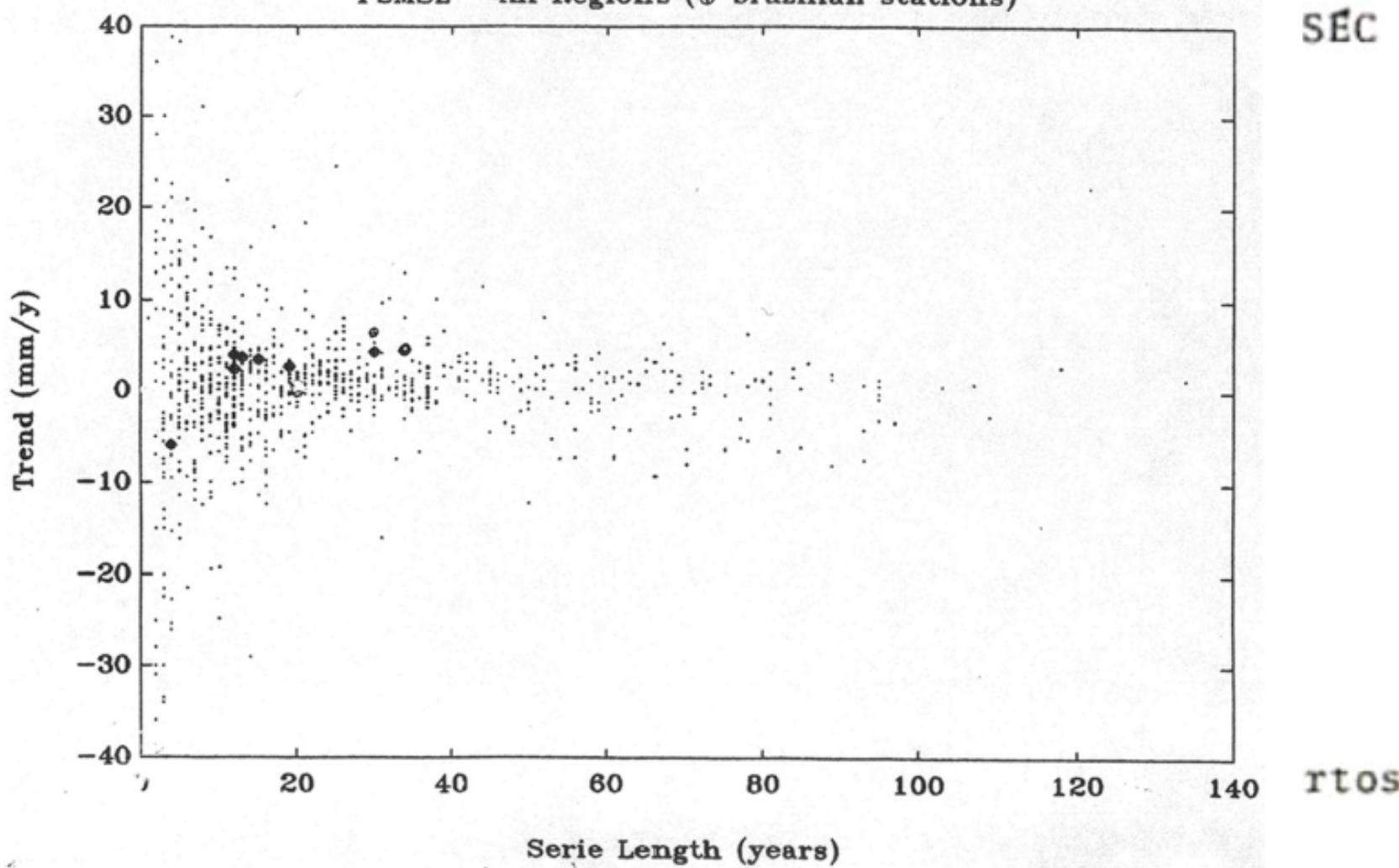
Tabela 1 - Localização das 24 estações maregráficas permanentes prioritárias a corrigir os dados de maré.

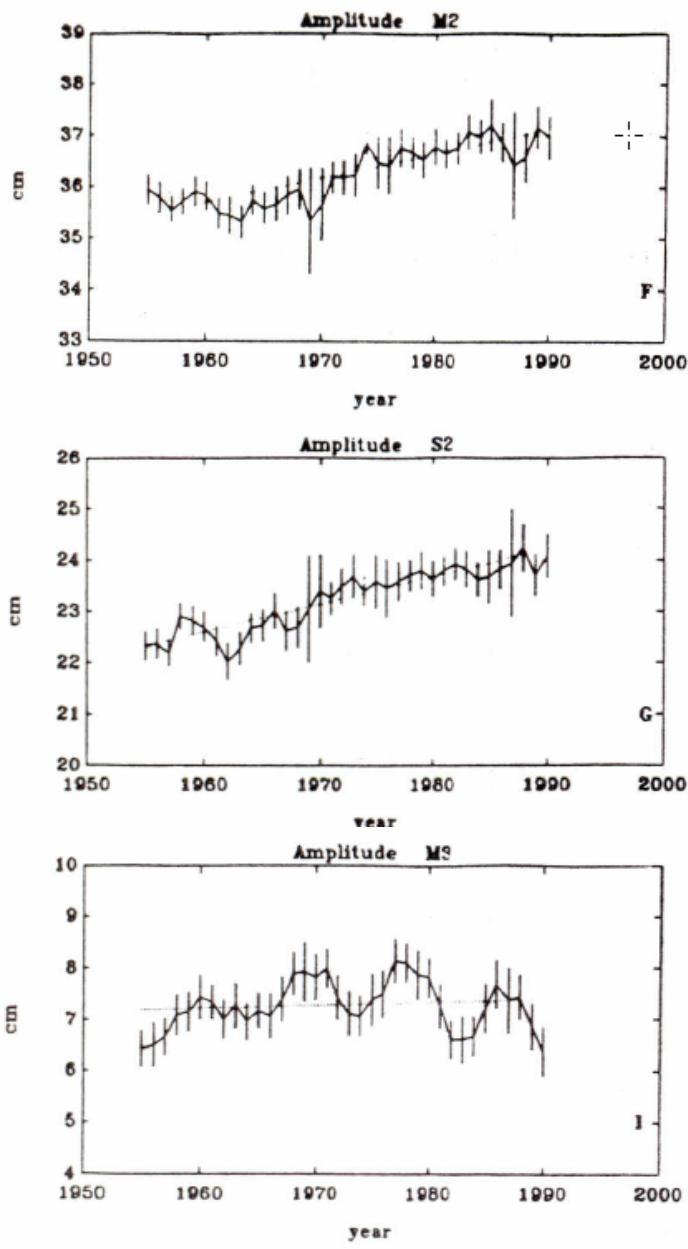
LOCAL

NO. ANOS DE TENDÊNCIA DO NÍVEL  
PSMSL - All Regions (⊕ brazilian stations)

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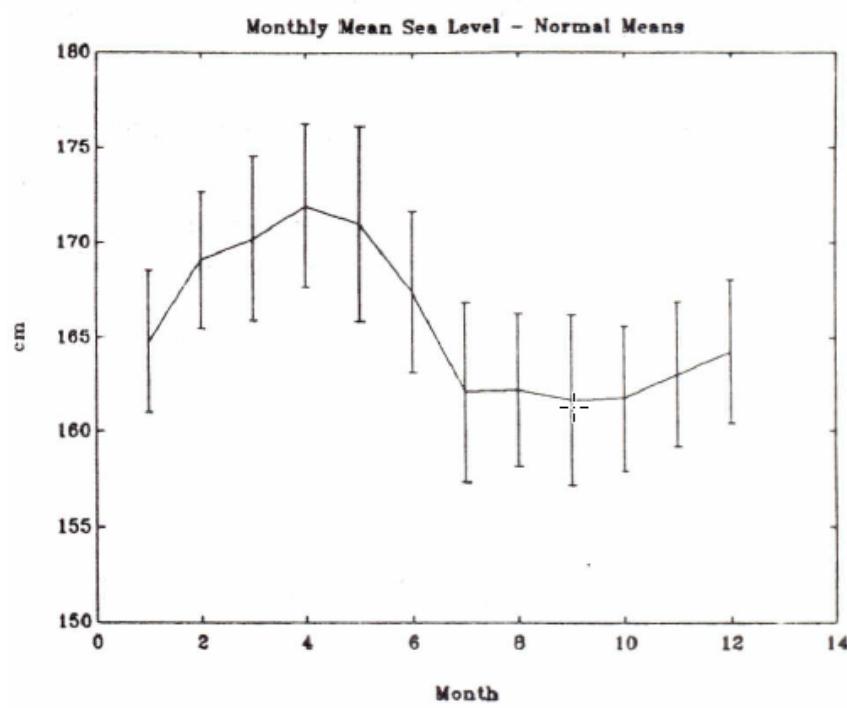
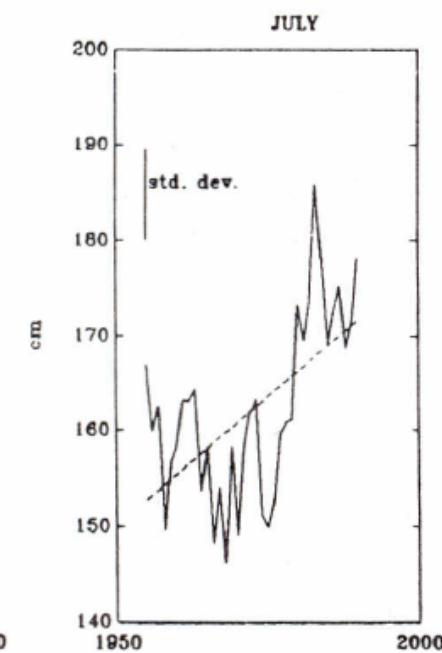
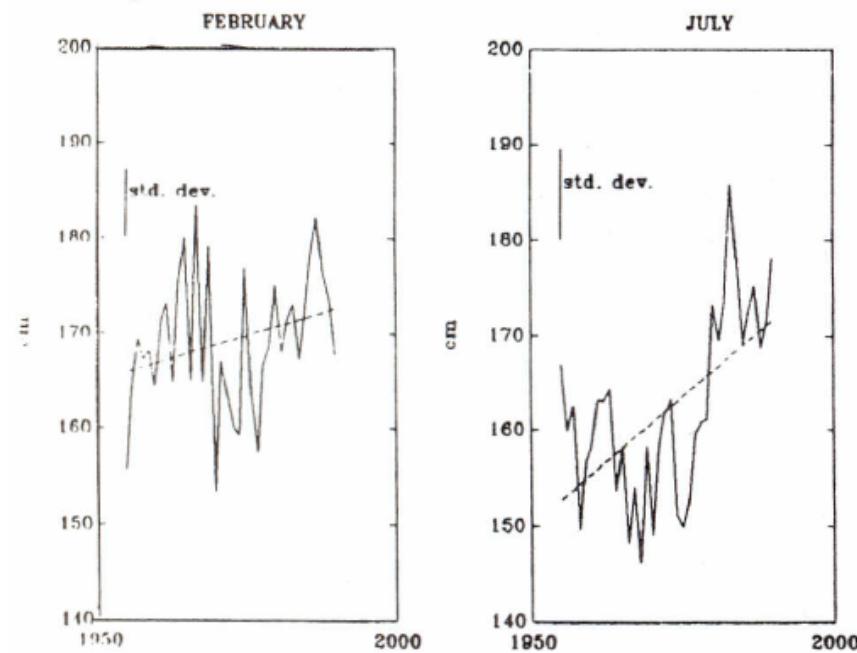
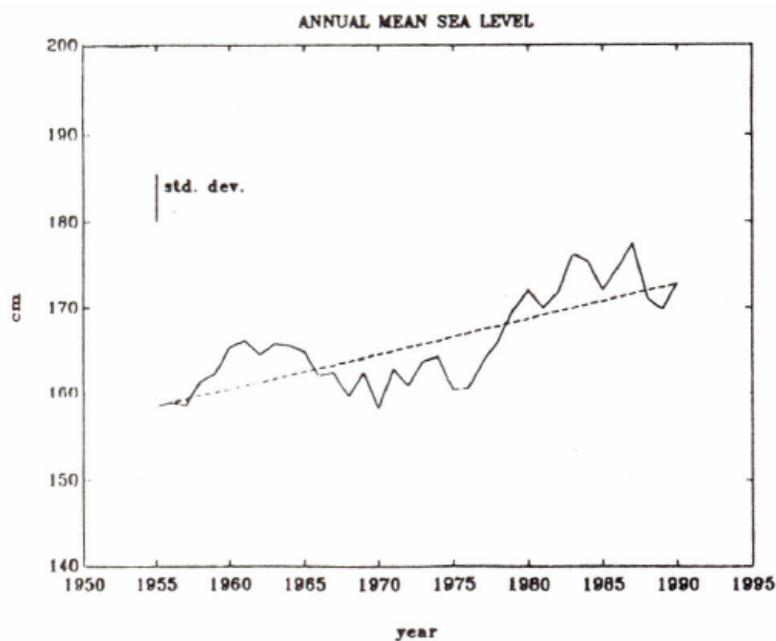




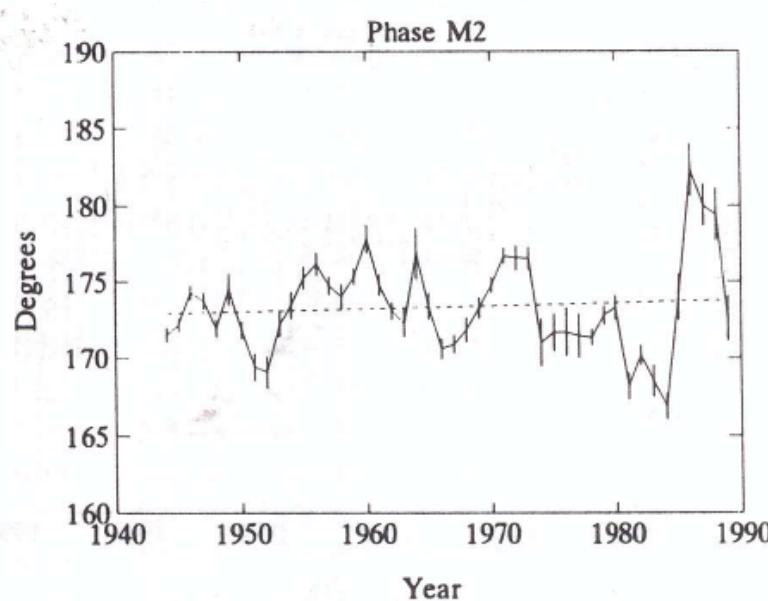
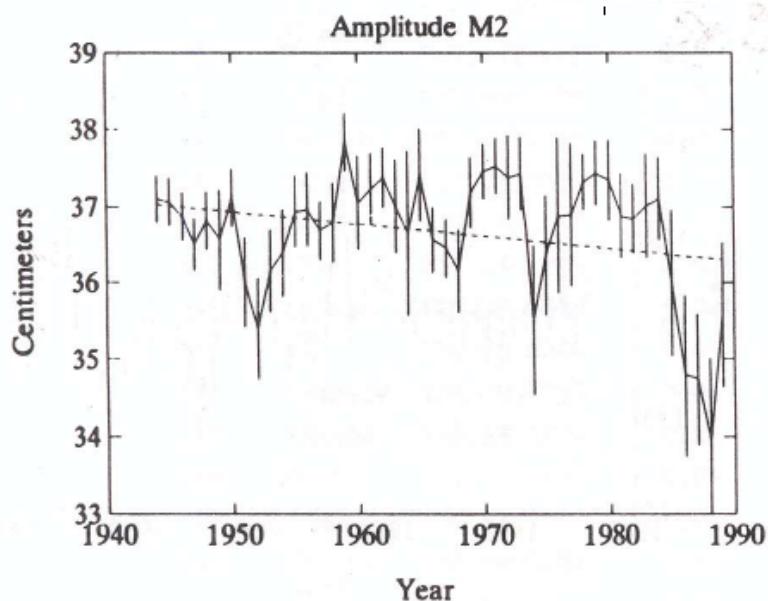
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oáio FRANÇA

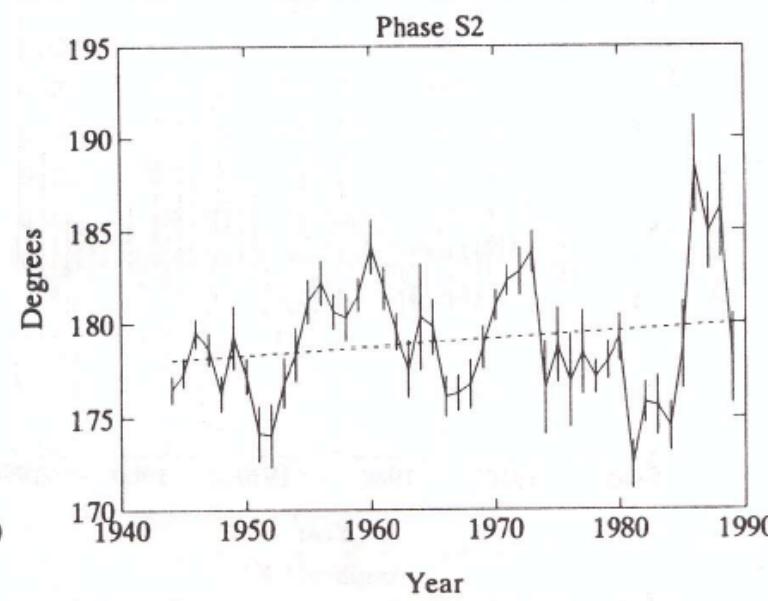
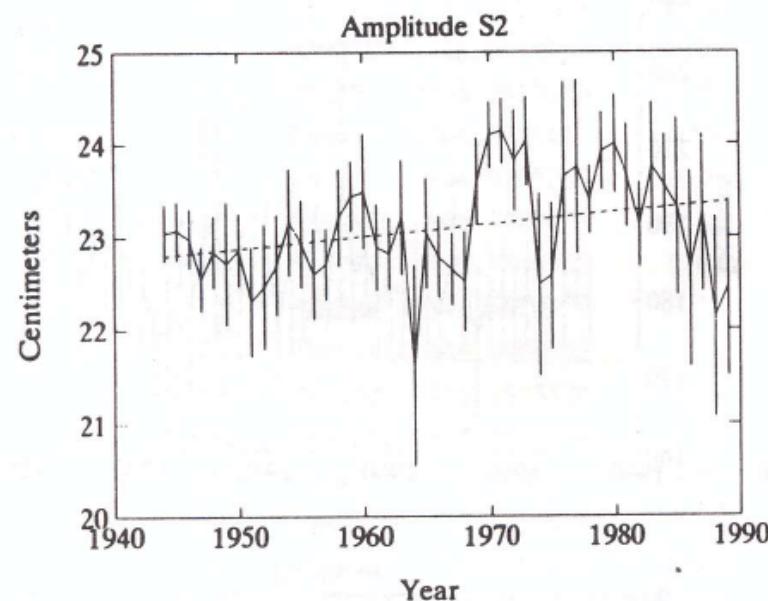
is of Cananéia  
riability of the  
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with a rate of  
ximately 4 cm  
series of each  
trends, which  
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as changes in



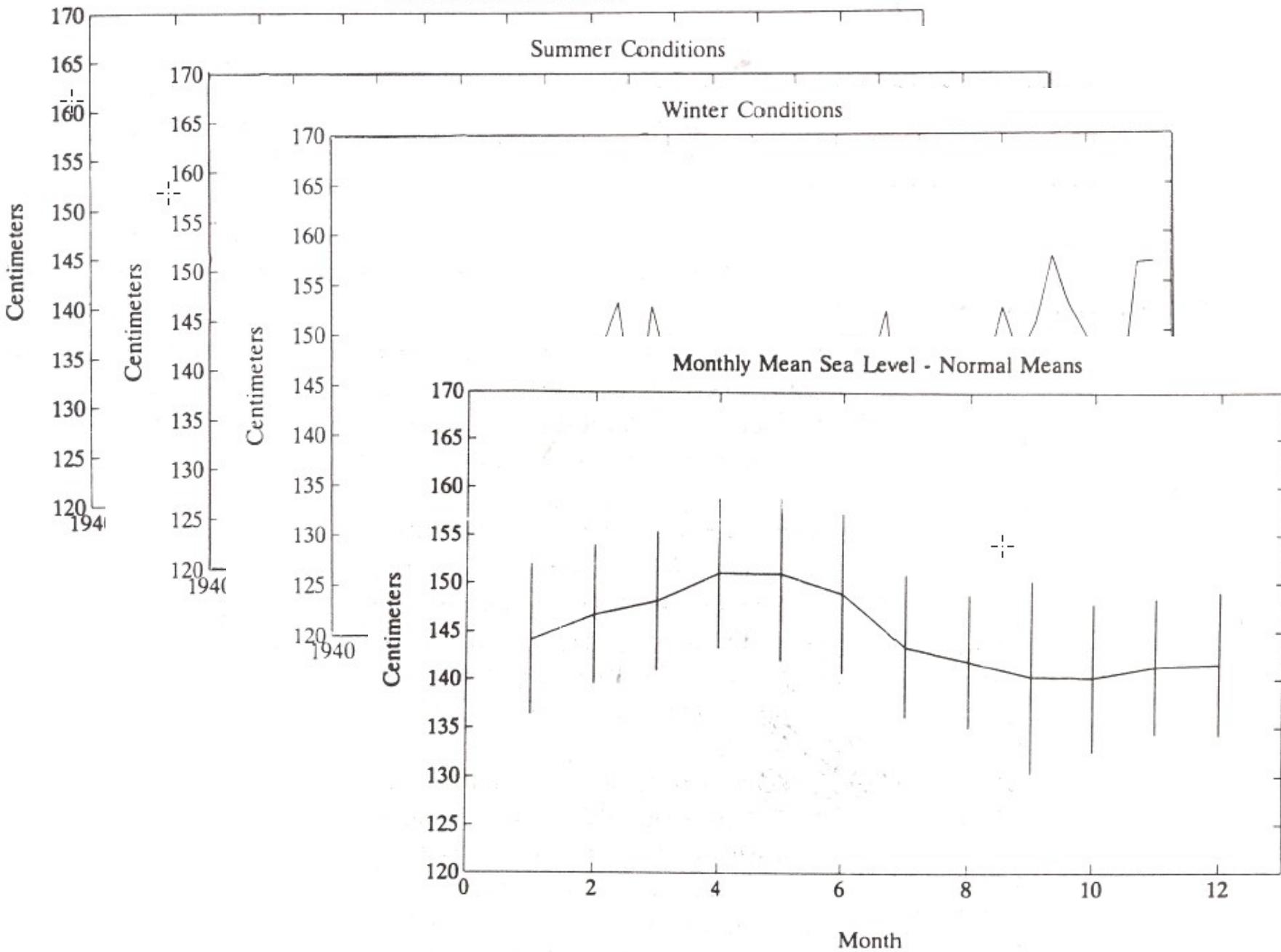
TI



the evolution of the tidal components and the mean sea level; these computations allowed to form the following time series: annual values of amplitudes and phases of



### Annual Mean Sea Level



# Permanent Service for Mean Sea Level (PSMSL)

## Global Sea Level Observing System (GLOSS)



### Afro America GLOSS news

ISSN 1983-0319



#### [GLOSS África](#)

Link para Informações sobre o GLOSS no continente africano

#### [GLOSS](#)

Global Sea Level Observing System

#### [GLOSS Chile](#)

Link para Informações sobre o GLOSS no Chile

#### **Apresentação:**

O Afro-America Gloss News é uma publicação que pretende estimular e difundir notícias referentes às atividades de instituições e pesquisadores das Ciências do Mar dedicados a estudos das variações do Nível do Mar. O alvo principal são as comunidades de fala Castelhana e Portuguesa da África e América, mas contribuições em outras línguas e outros Continentes são também bem vindas.

#### **Presentación:**

El Afro-America Gloss News es una publicación que pretende estimular y difundir noticias referentes a las actividades de instituciones e investigadores de Ciencias del Mar que trabajan con problemas relativos a variaciones del Nivel del Mar. Está dirigida principalmente a las comunidades de habla Castellana y Portuguesa de África y América, mas contribuciones relevantes y noticias en otras lenguas y de otras regiones son bienvenidas.

C357

Catálogo de Estações Maregráficas Brasileiras / Francisco J. Penido

Salles, Frederico C. Montenegro Bentes, José Antonio dos Santos (organizadores) - 1<sup>a</sup> ed. - Rio de Janeiro: FEMAR, 2000.

280 p.; tabelas

ISBN 85-85966-16-5

Apresentação: Almirante Fernando M.C. Freitas, Presidente da Fundação de Estudos do Mar - FEMAR.

I. Oceanografia. I. Salles, Francisco J. Penido, org. II. Bentes, Frederico C. Montenegro, org. III. Santos, José Antonio dos, org. IV. Fundação de Estudos do Mar.

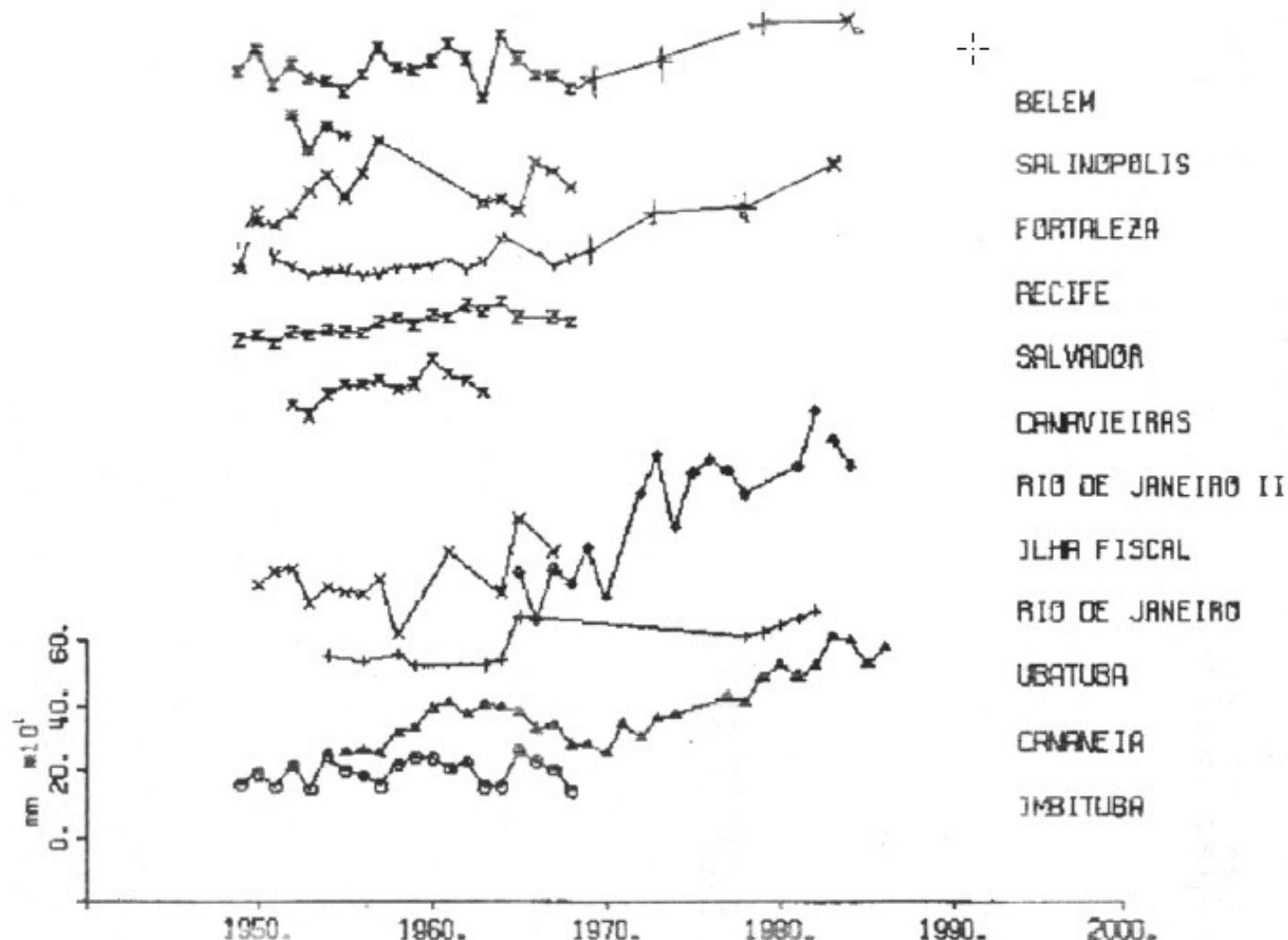
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2334	5.4					1928	1.2	1915	1.9	1906	1.2						2121	1.2		2017		
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1208	5.4	SAB	0645	1.5		SEG	0758	1.4	TER	0749	2.2	TER	0736	1.5	QUA	0650	2.2	SEX	0954	1.4	SAB	0858
1847	1.4					1258	5.3	1421	5.4	1358		FEMAR	1402	5.4	1311	4.9			1613	5.7		1508
						1911	1.6	2043	1.2	2039			2019	1.3	1945	2.0			2228	1.0		2132
0043	5.3	30	0126	5.1	15	0306	5.3					0251	5.3	30	0200	4.6	15	0449	5.8	30	0354	
0715	1.4	DOM	0743	1.8		TER	0911	1.4				0854	1.5	QUI	0821	2.3	SAB	1058	1.0	DOM	1006	
1326	5.3		1353	5.2			1541	5.6				1524	5.5	1430	4.8			1709	6.0		1624	
1958	1.4		2023	1.8		2158	1.1					2111	1.7	2106	2.0			2323	0.7		2236	
31	0230	4.9																0323	4.7			
SEG	0856	2.0																0941	2.1			
	1454	5.1																1551	4.9			

Nome da Estação :	CAETÉ - PA			
Localização :	Na Baía de Caeté – trapiche da cidade			
Organ. Responsável :	DHN			
Latitude :	00° 58,0' S		Longitude :	46° 42,6' W
Período Analisado :	28/05/83 a 28/06/83		Nº de Componentes :	78
Análise Harmônica :	Método Almirante Santos Franco			
Classificação :	Maré Semidiurna			
Estabelecimento do Porto: (HWF&C)	VII	H 22 min	Nível Médio (Zo):	275 cm acima do NR.
Médias das Preamares de Sizígia (MHWS) :		500 cm acima do NR.	Média das Preamares de Quadratura (MHWN) :	398 cm acima do NR
Média das Baixa-mares de Sizígia (MLWS) :		50 cm acima do NR.	Média das Baixa-mares de Quadratura (MLWN) :	152 cm acima do NR.

## CONSTANTES HARMÔNICAS SELECIONADAS

Componentes	Semi-amplitude (H) cm	Fase (g) graus (°)	Componentes	Semi-amplitude (H) cm	Fase (g) graus (°)
<b>As</b>	-	-	<b>MU<sub>2</sub></b>	7,8	330
<b>Ssa</b>	-	-	<b>N<sub>2</sub></b>	36,6	212
<b>Mm</b>	4,9	082	<b>NU<sub>2</sub></b>	7,0	212
<b>Mf</b>	-	-	<b>M<sub>2</sub></b>	173,8	211
<b>MTM</b>	2,7	320	<b>L<sub>2</sub></b>	14,0	164
<b>Msf</b>	8,3	279	<b>T<sub>2</sub></b>	3,0	246
<b>Q<sub>1</sub></b>	1,2	232	<b>S<sub>2</sub></b>	50,8	248
<b>O<sub>1</sub></b>	9,2	251	<b>K<sub>2</sub></b>	13,8	250
<b>M<sub>1</sub></b>	2,0	158	<b>MO<sub>3</sub></b>	2,5	038
<b>P<sub>1</sub></b>	2,6	265	<b>M<sub>3</sub></b>	2,3	338
<b>K<sub>1</sub></b>	7,7	266	<b>MK<sub>3</sub></b>	5,2	009
<b>J<sub>1</sub></b>	1,7	008	<b>MN<sub>4</sub></b>	11,0	346
<b>OO<sub>1</sub></b>	2,1	190	<b>M<sub>4</sub></b>	29,0	349
<b>MNS<sub>2</sub></b>	0,8	076	<b>SN<sub>4</sub></b>	6,8	227
<b>2N<sub>2</sub></b>	4,8	213	<b>MS<sub>4</sub></b>	15,3	024
<b>Referências de Nível:</b> RN-1 fixada na quina da casa do Sr. Lula. RN-2 implantad junto ao Mastro da Bandeira da escola local					



**Figure 2** – Brazilian sea level data for various ports. Annual means (mm). The series were separated in order to have them all in the same graph. Zero of the years axis has to be displaced and put in the starting year of each series in order to estimate its trend value (Mesquita & Harari, 2011).

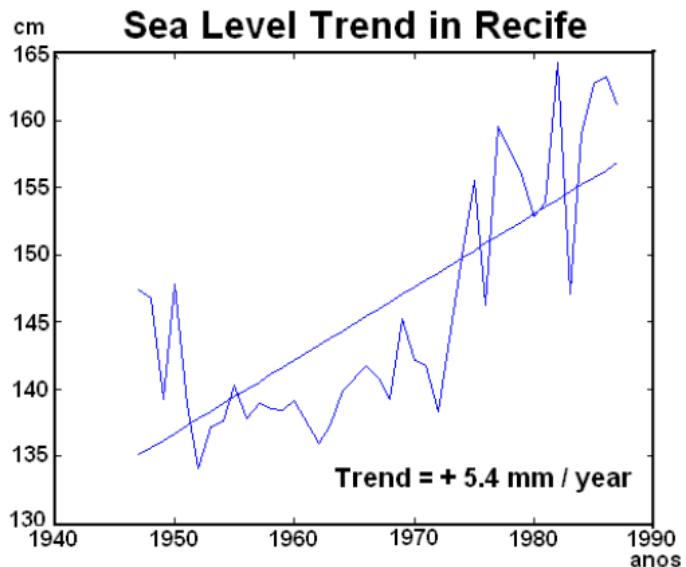


Figure 1 – Mean sea level in Recife.

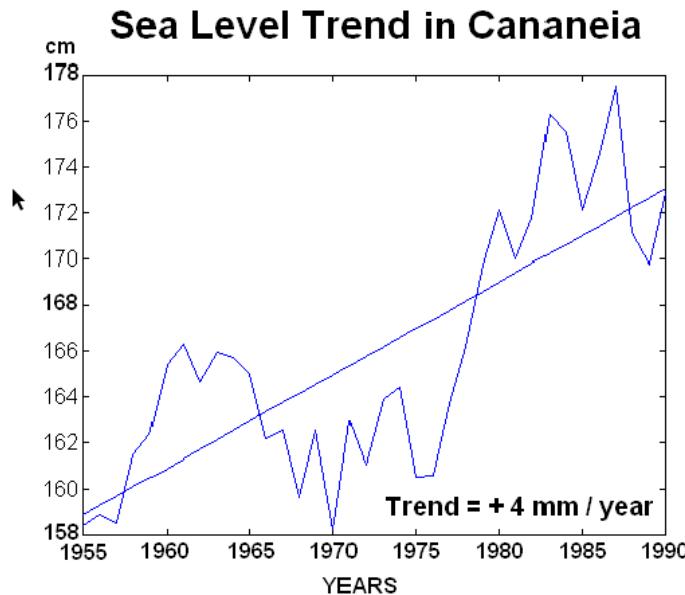


Figure 3 – Mean sea level in Cananeia.

3, Belém, Cananeia and Santos.

Phase	$S_2$ (°/decade)
10	2.600
90	1.000

(1954-1990)  
Santos  
(1944-1989)

around the world, the mean

**Keywords:** Brazilian coast,

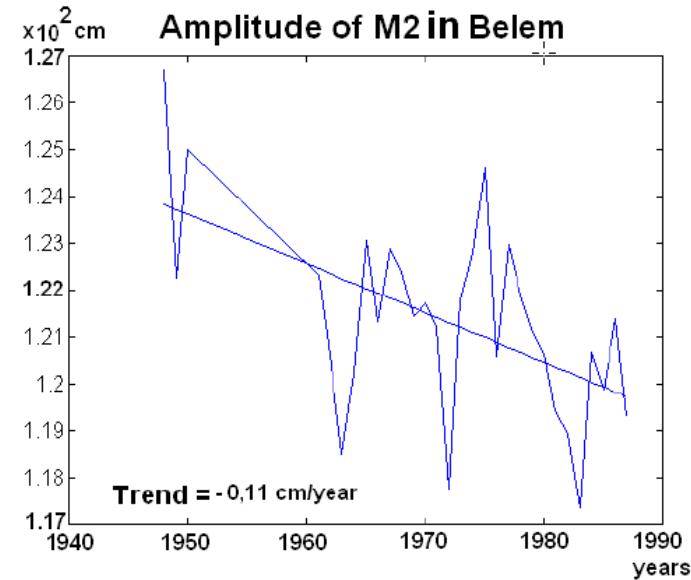


Figure 2 – Values of  $M_2$  amplitude in Belém, from the annual records analysis.

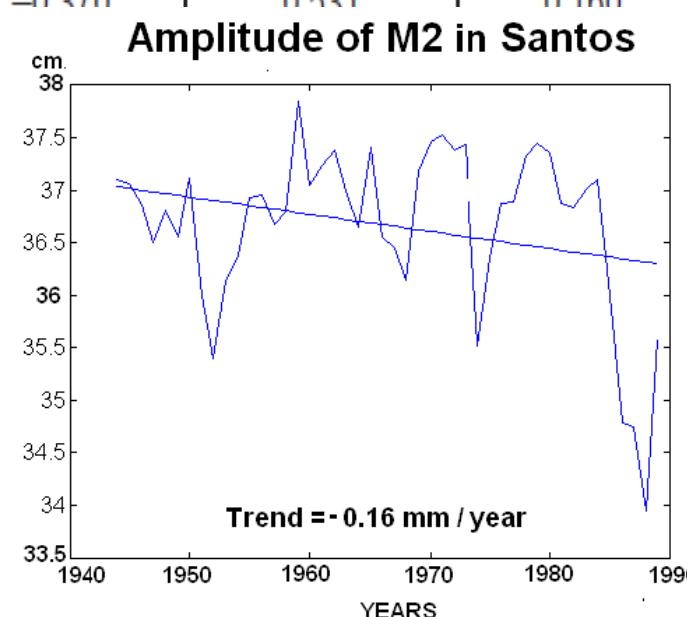


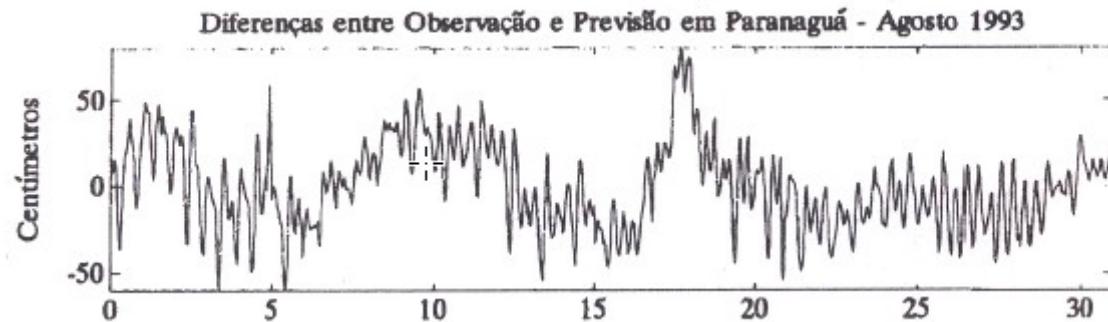
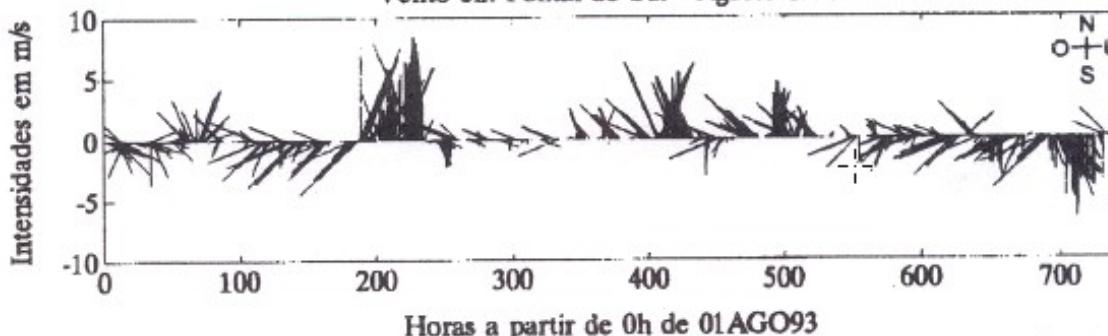
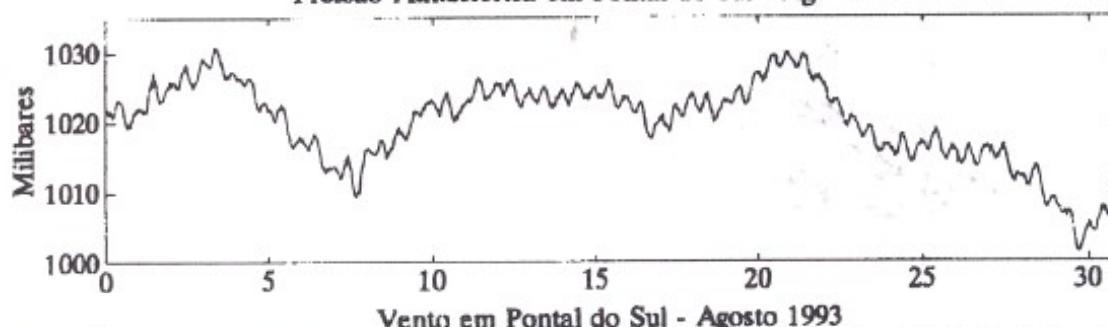
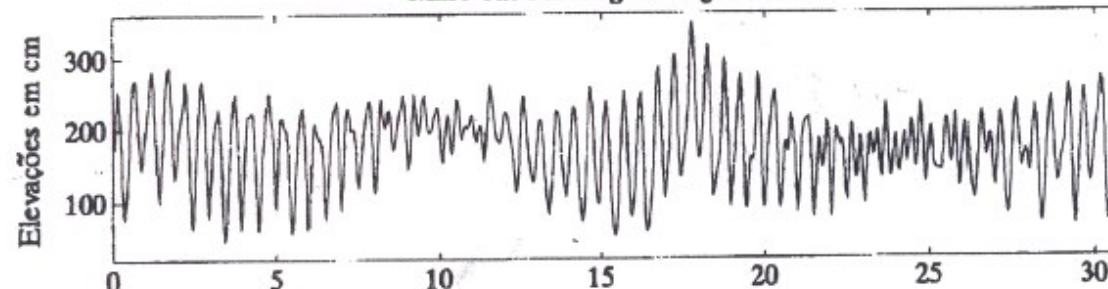
Figure 4 – Values of  $M_2$  amplitude in Santos, from the annual records analysis.

# Influência meteorológica no nível do mar

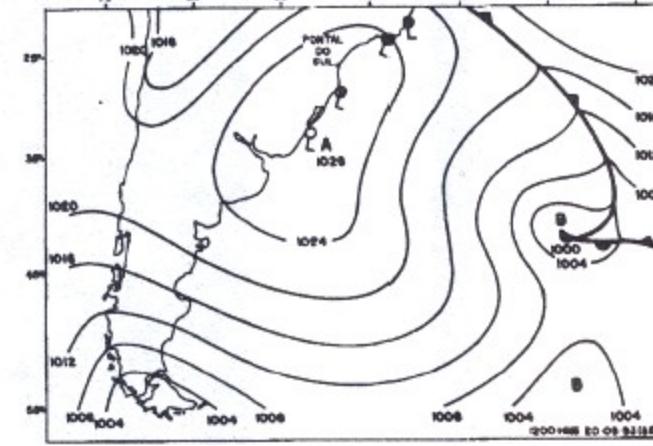
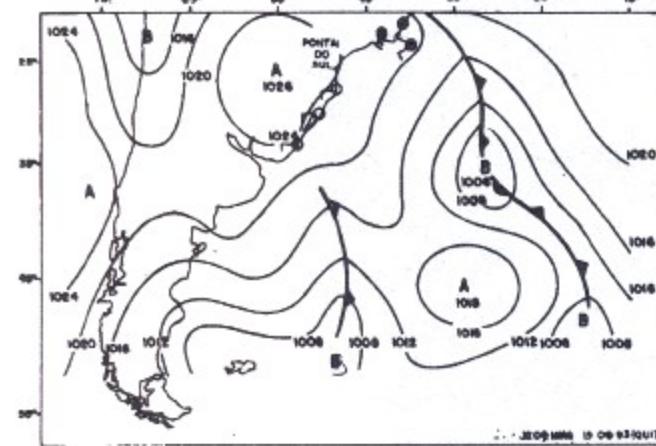
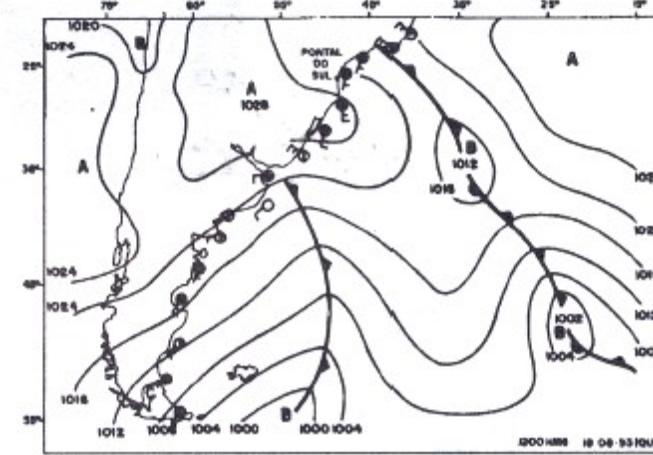
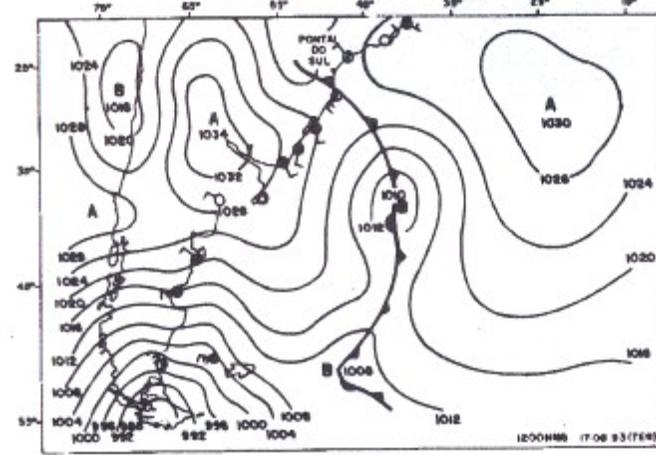
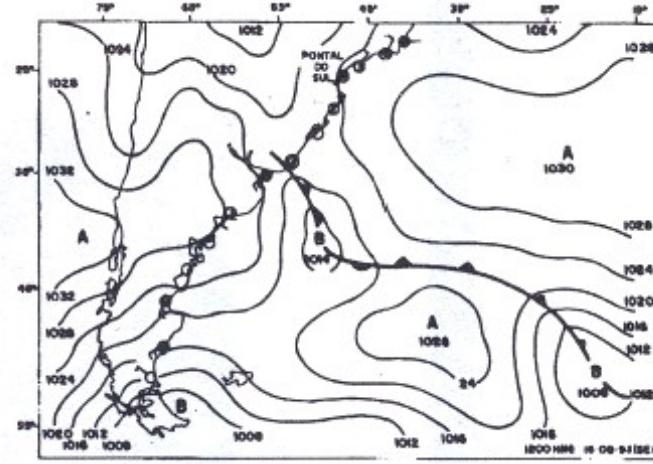
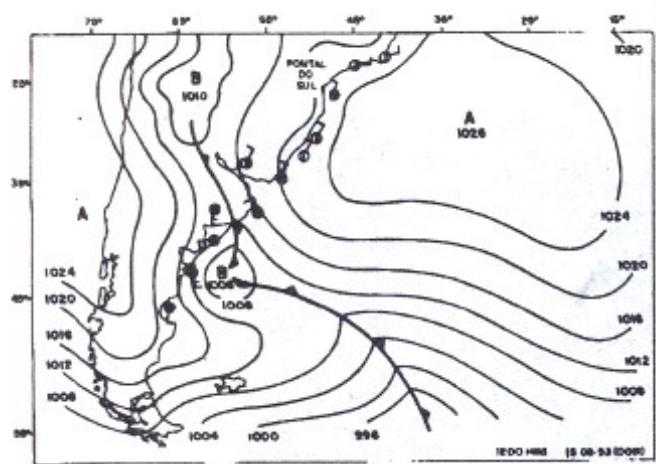
Maré em Paranaguá - Agosto 1993

**MARÉS I  
PAI**

**ESTADO DO  
SUL - 1993**

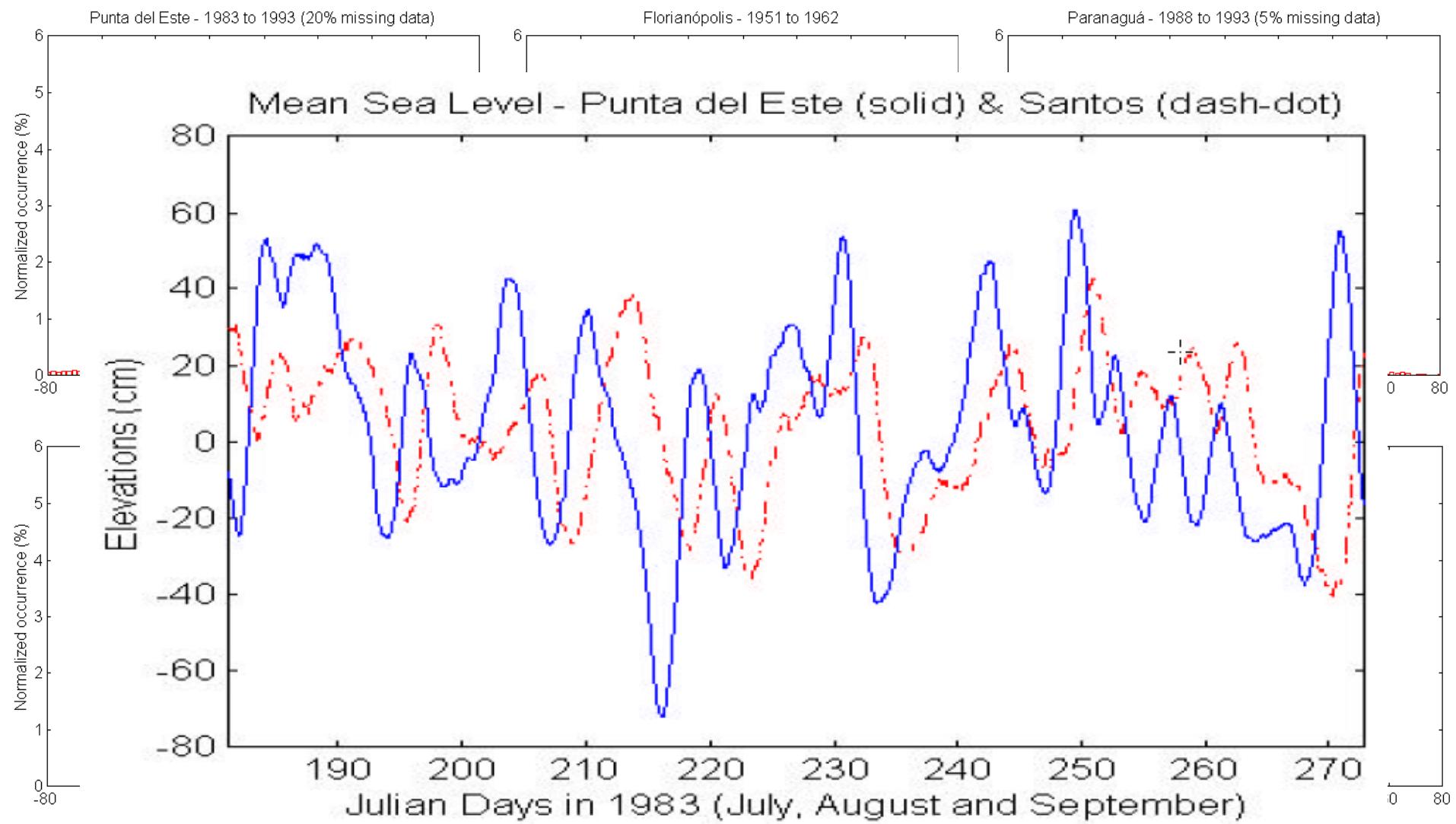


ar  
do MARONE\*  
de CAMARGO\*



Meteoromarinha  
15 a 20 de Agosto  
1993

CAMARGO, R., HARARI, J. & CARUZZO, A. 1999 Basic Statistics of Storm Surges over the South-Western Atlantic Ocean. Afro-America GLOSS News



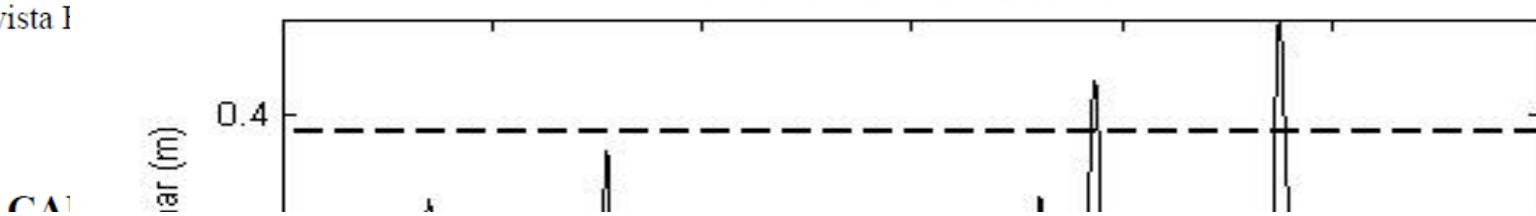
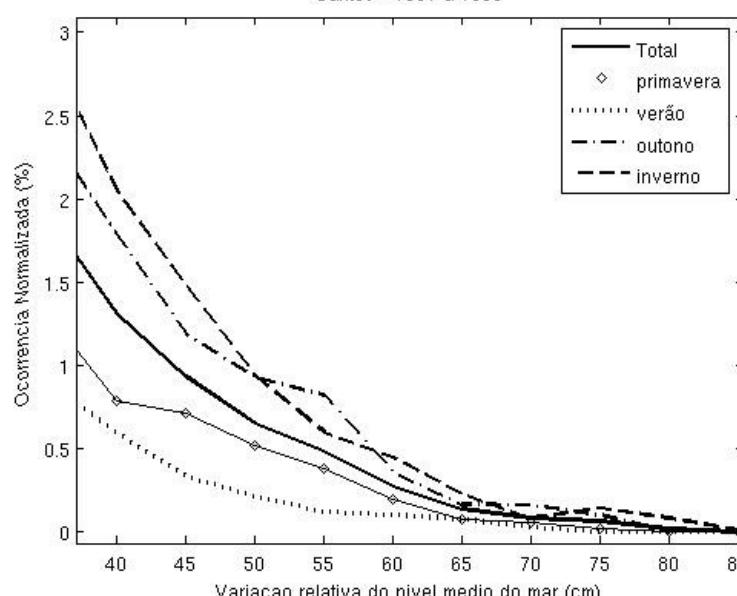
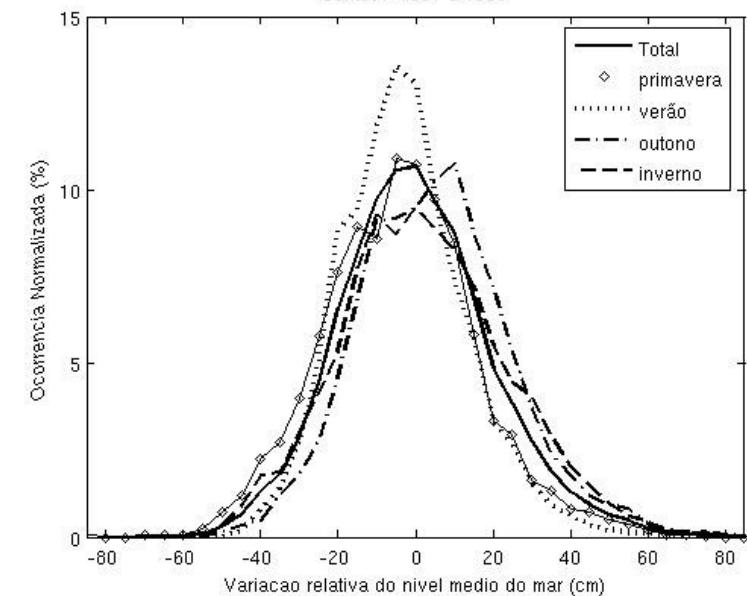


Tabela 1 – Quantificação dos eventos superiores a +2 desvios padrão, considerando a série filtrada de valores diários de elevação do nível do mar.

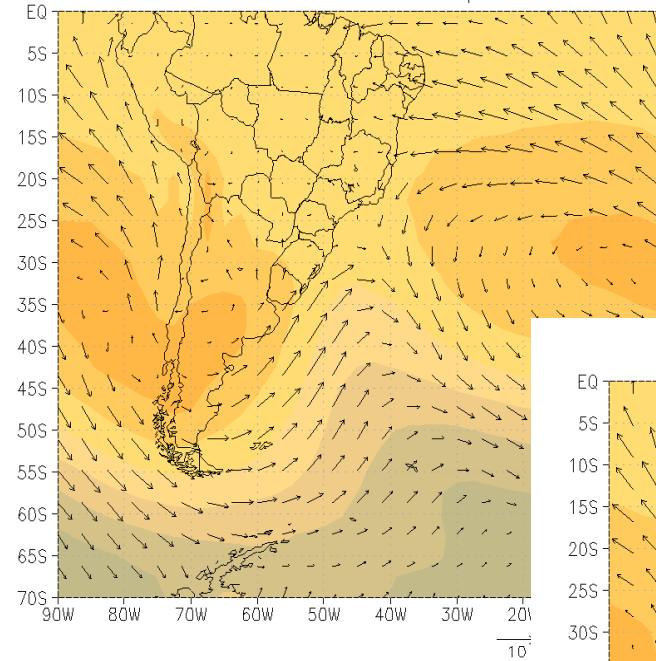
Acima de +2 d.p.	Primavera	Verão	Outono	Inverno	Total
1951 - 1960	16	12	48	28	104
1961 - 1970	13	16	49	41	119
1971 - 1980	19	26	53	36	134

Santos - 1951 a 1990

Santos - 1951 a 1990



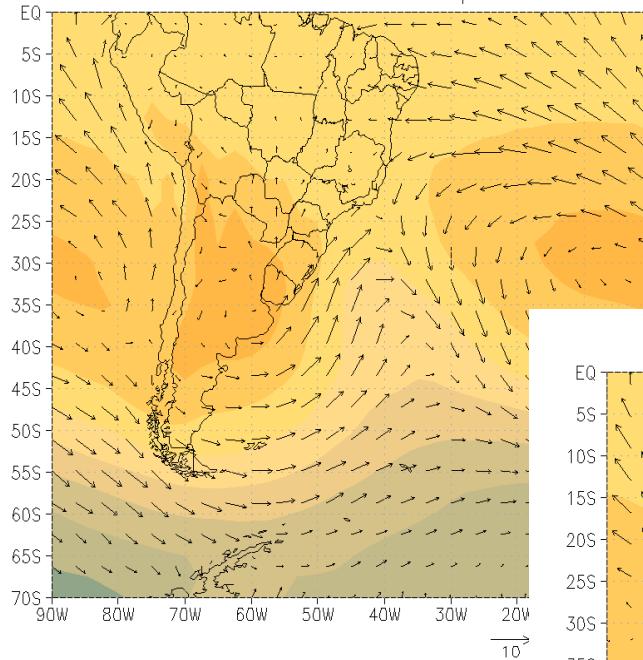
Pressao e Vento em Superficie



2 dias antes

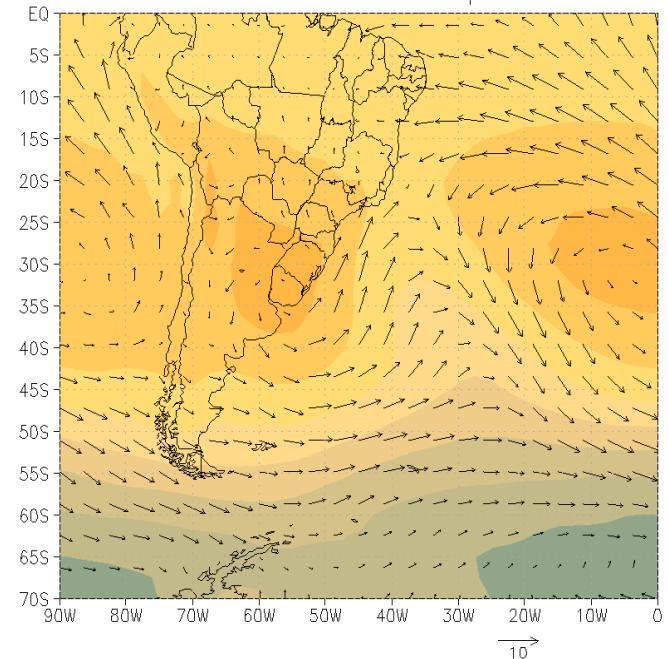
Eventos positivos > 3 std

Pressao e Vento em Superficie

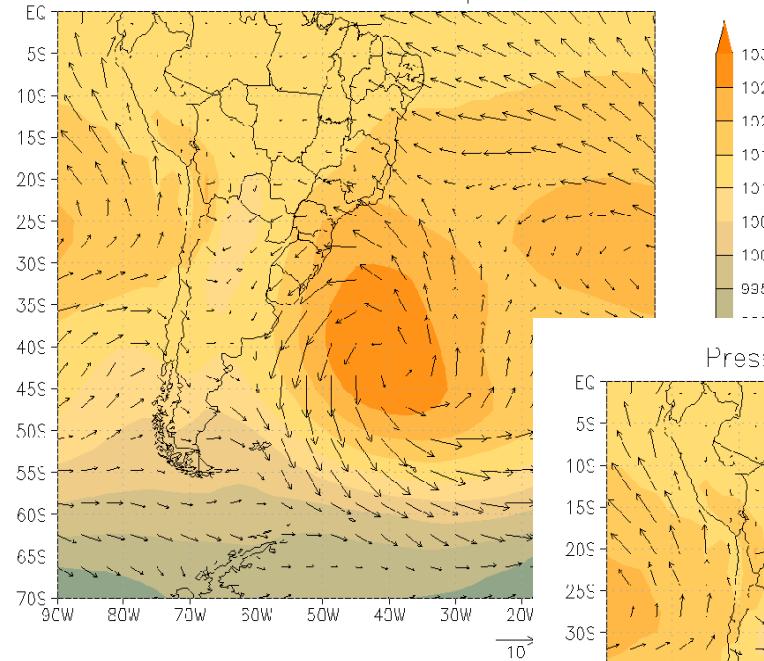


1 dia antes

Pressao e Vento em Superficie



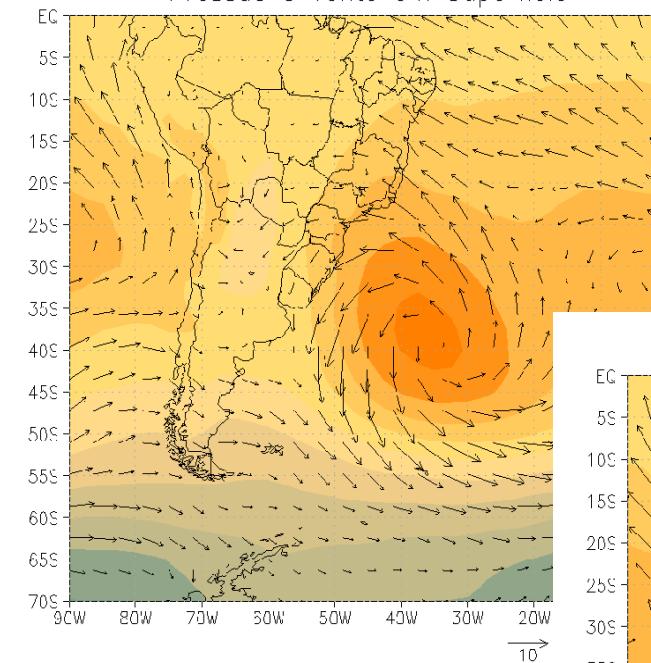
Pressão e Vento em Superfície



2 dias antes

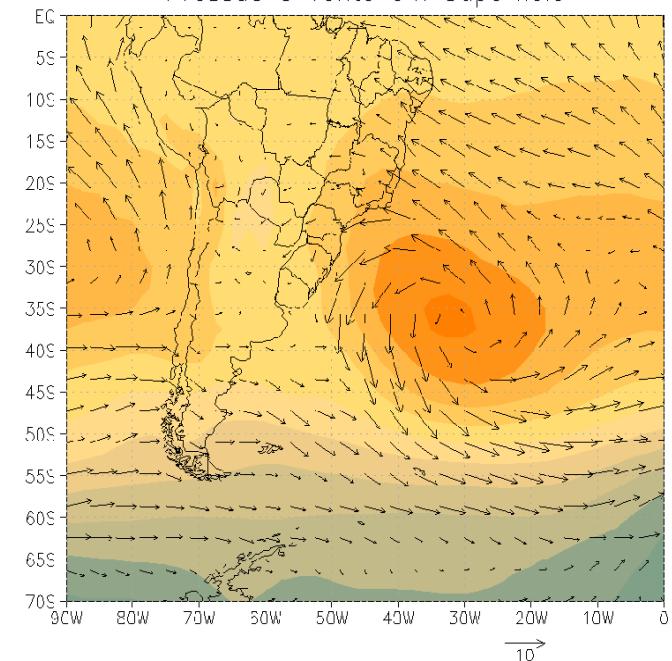
Eventos negativos < -3 std

Pressão e Vento em Superfície



1 dia antes

Pressão e Vento em Superfície



# MODELAGEM NUMÉRICA

Quatro simulações para combinar diferentes forçantes

Ventos e Fluxos (sal e calor) (sempre considerados)

Marés (com e sem)

Pressão ao Nível do Mar (com e sem)

Experimento 1: vento, fluxos, maré e pressão

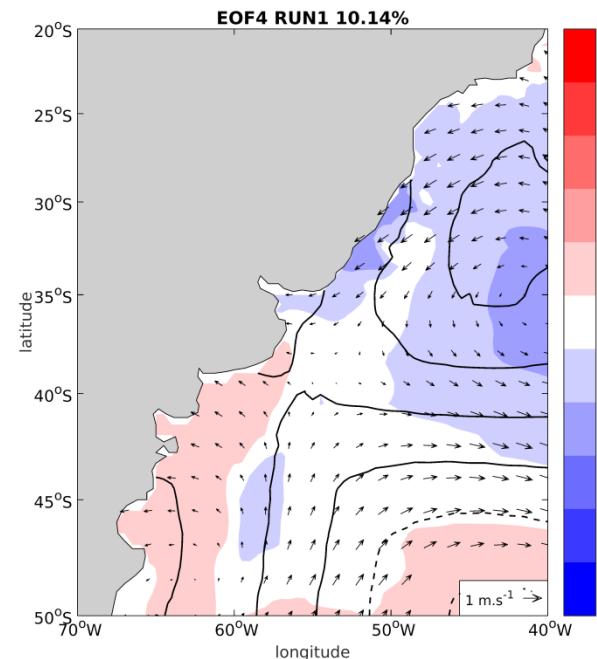
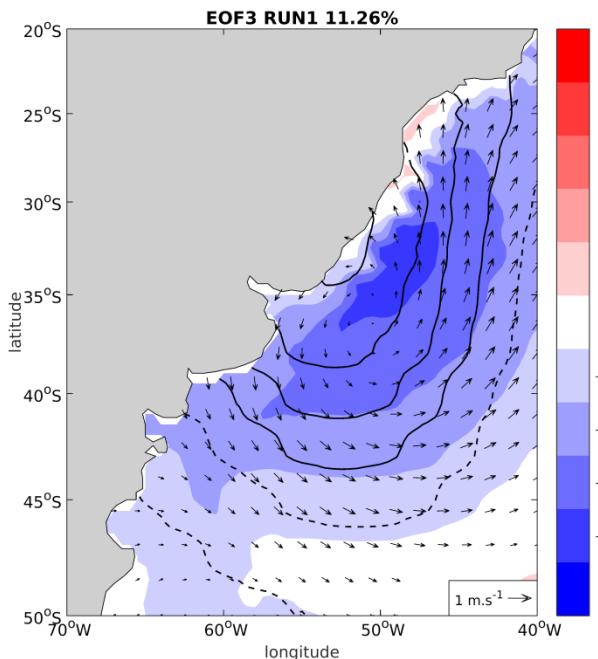
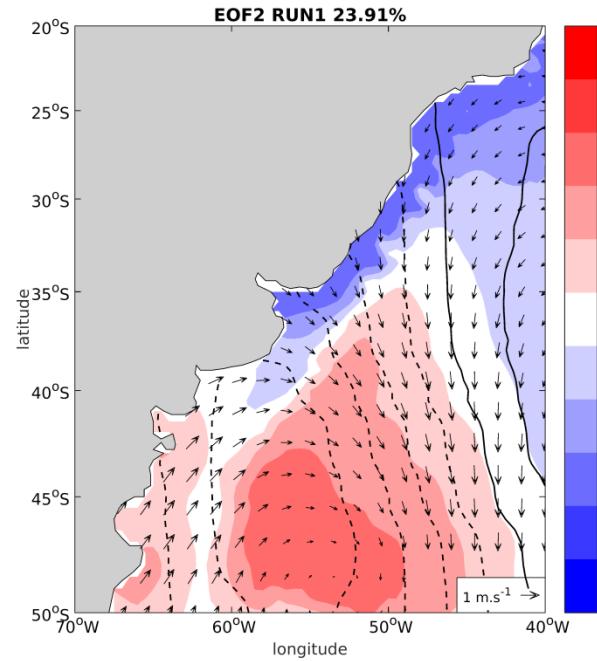
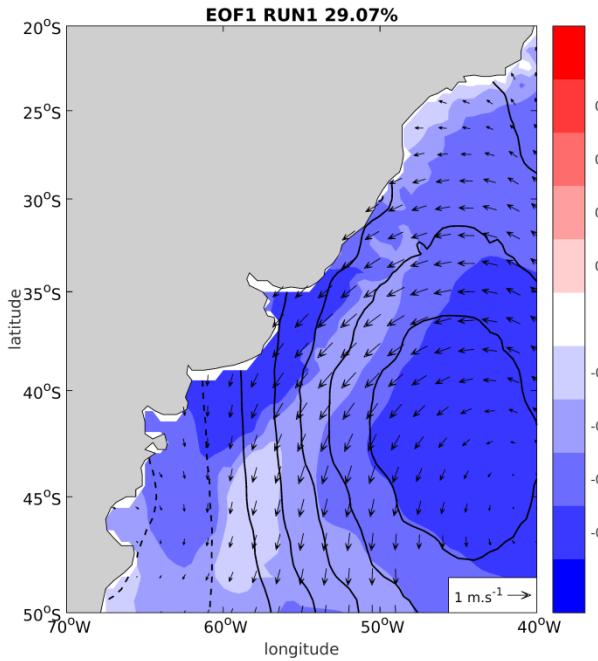
Experimento 2: vento, fluxos e maré

Experimento 3: vento, fluxos e pressão

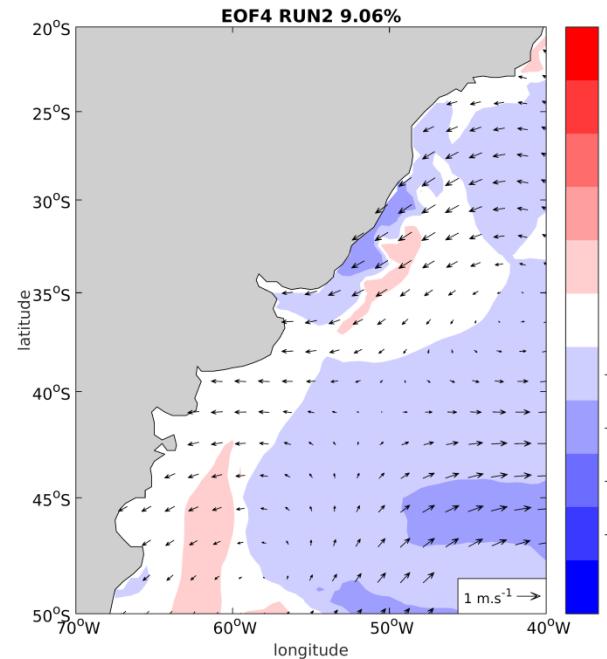
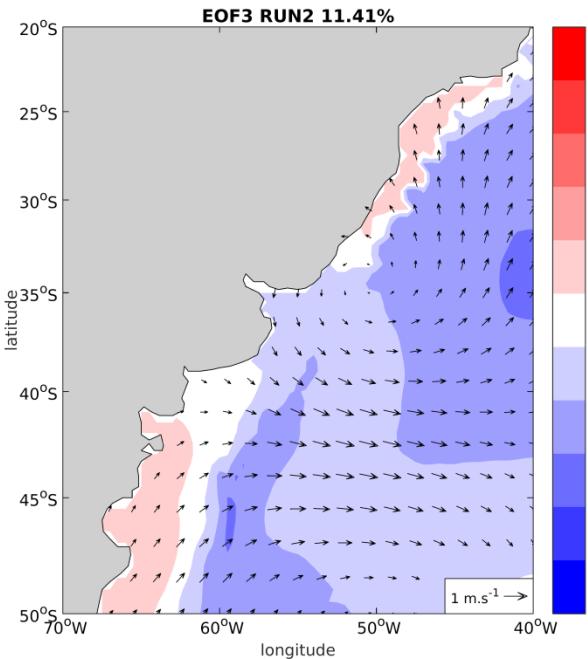
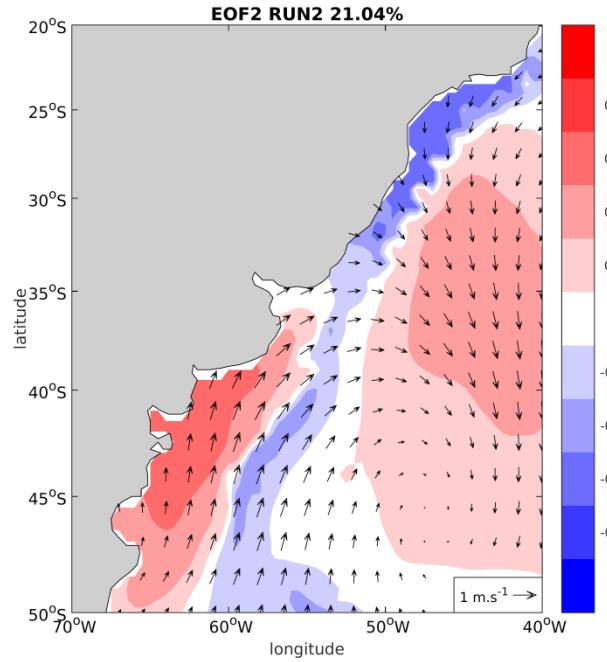
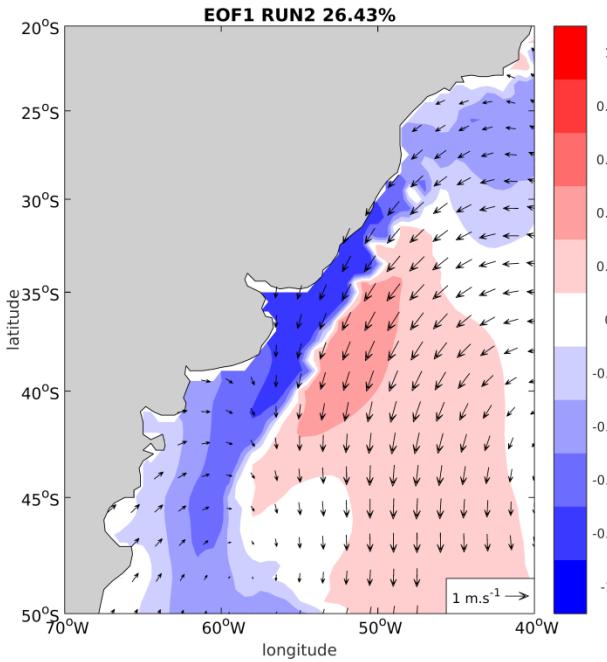
Experimento 4: vento e fluxos

# ASPECTOS DE GERAÇÃO

EXP1

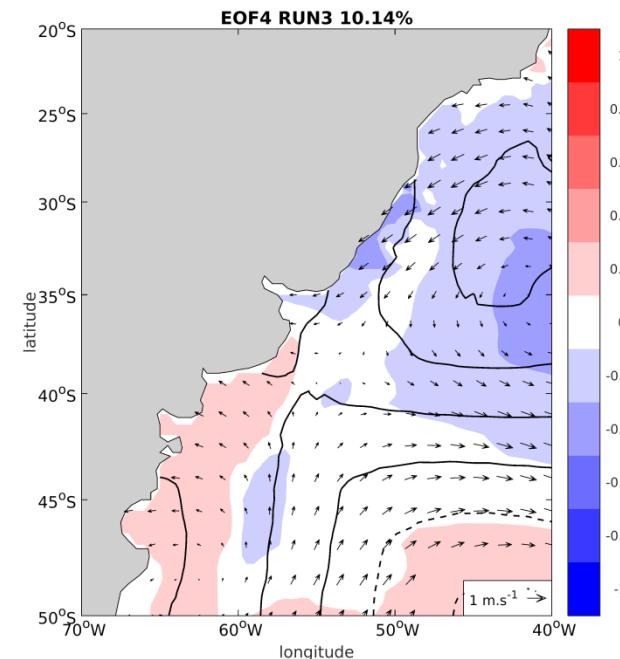
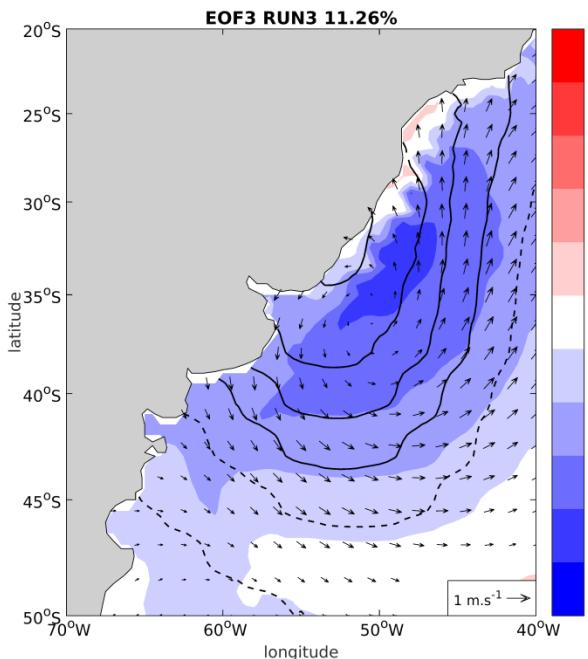
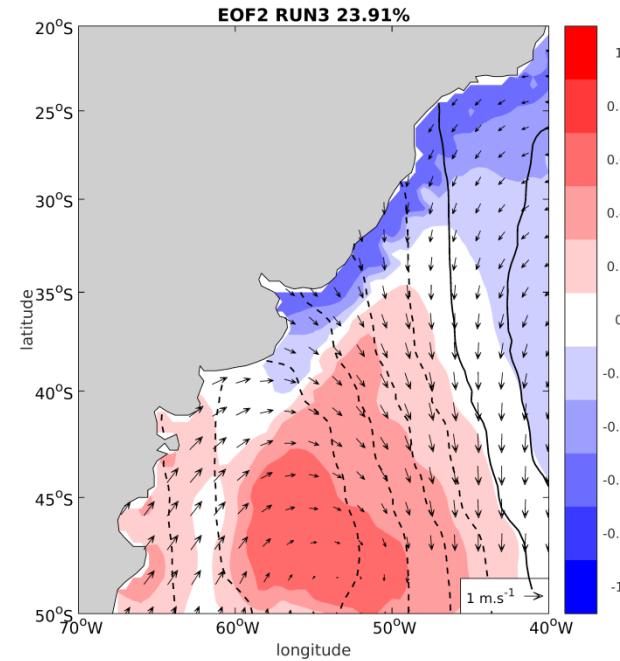
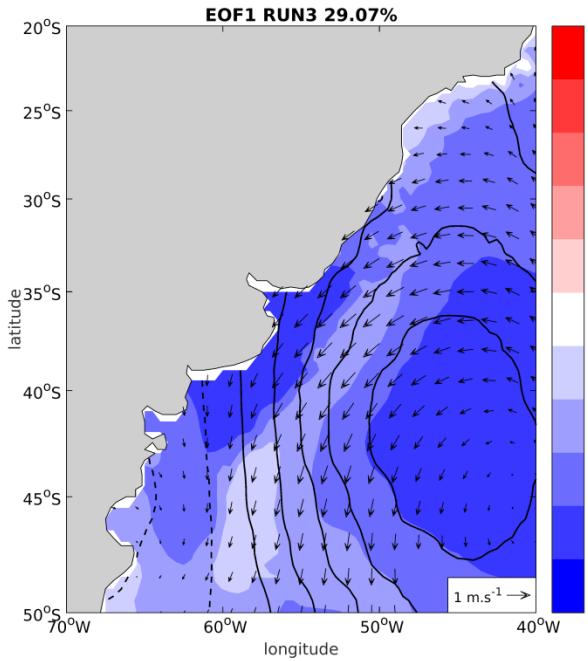


# ASPECTOS DE GERAÇÃO EXP2

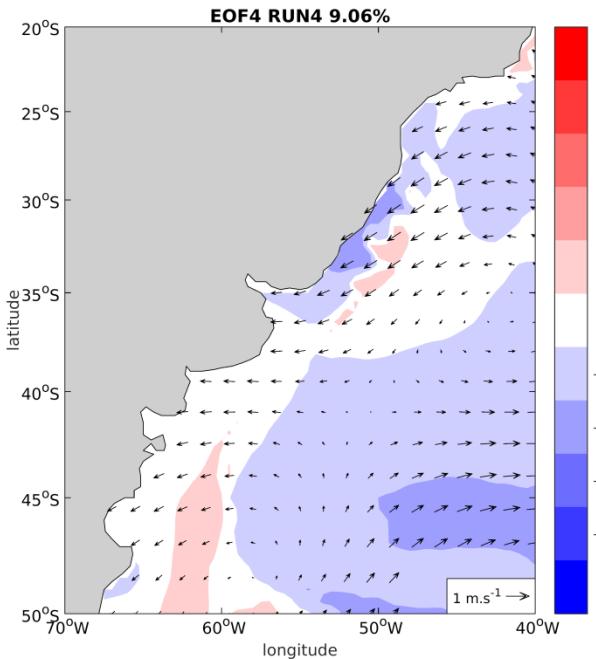
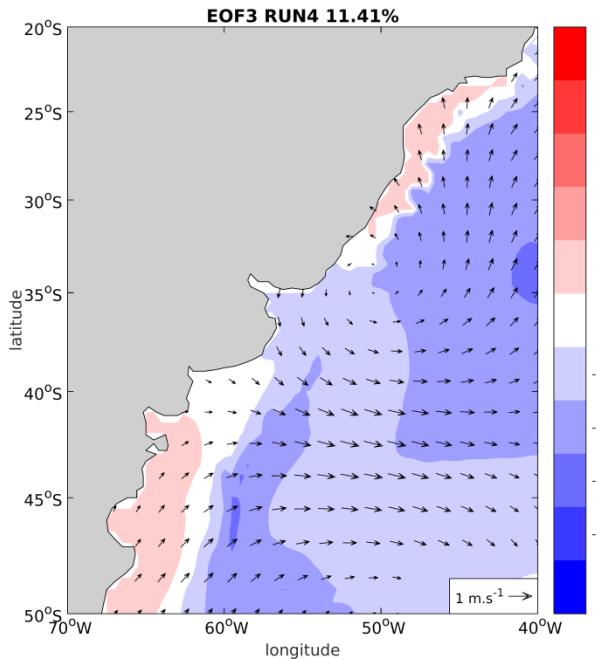
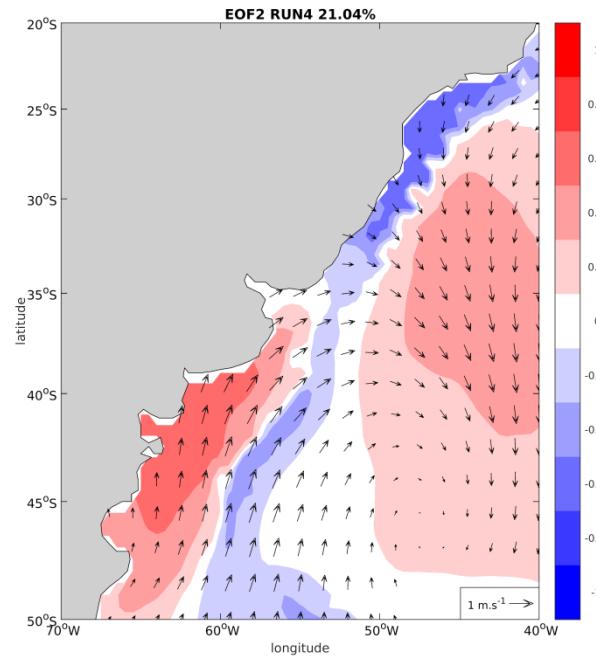
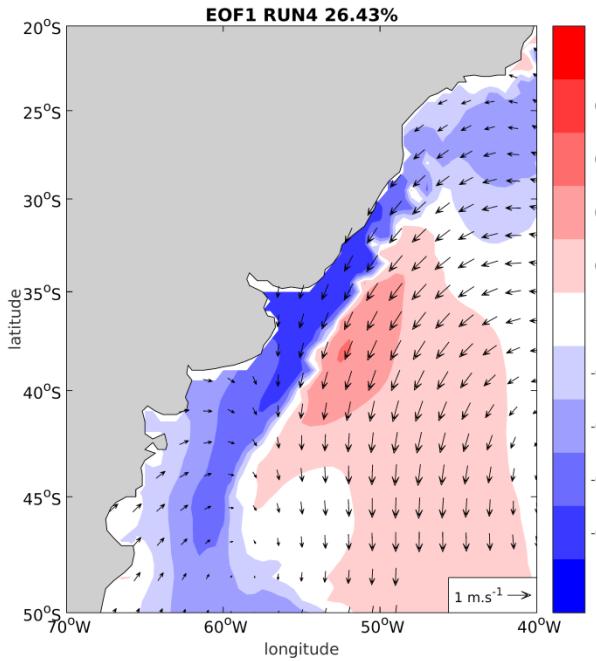


# ASPECTOS DE GERAÇÃO

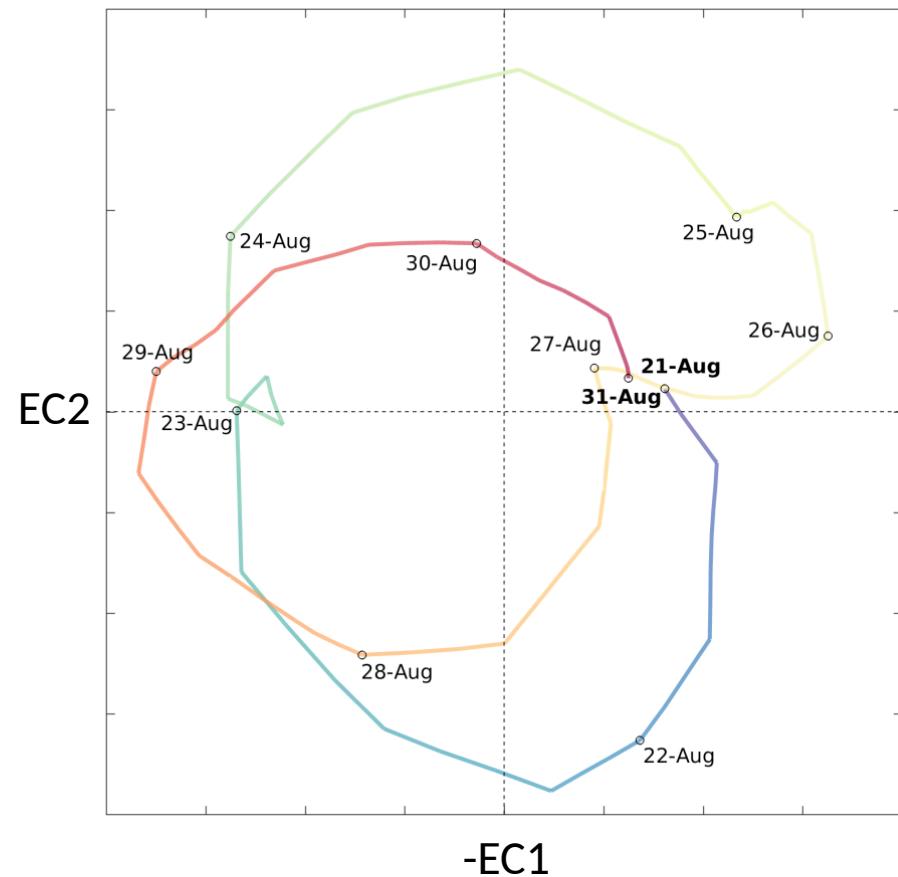
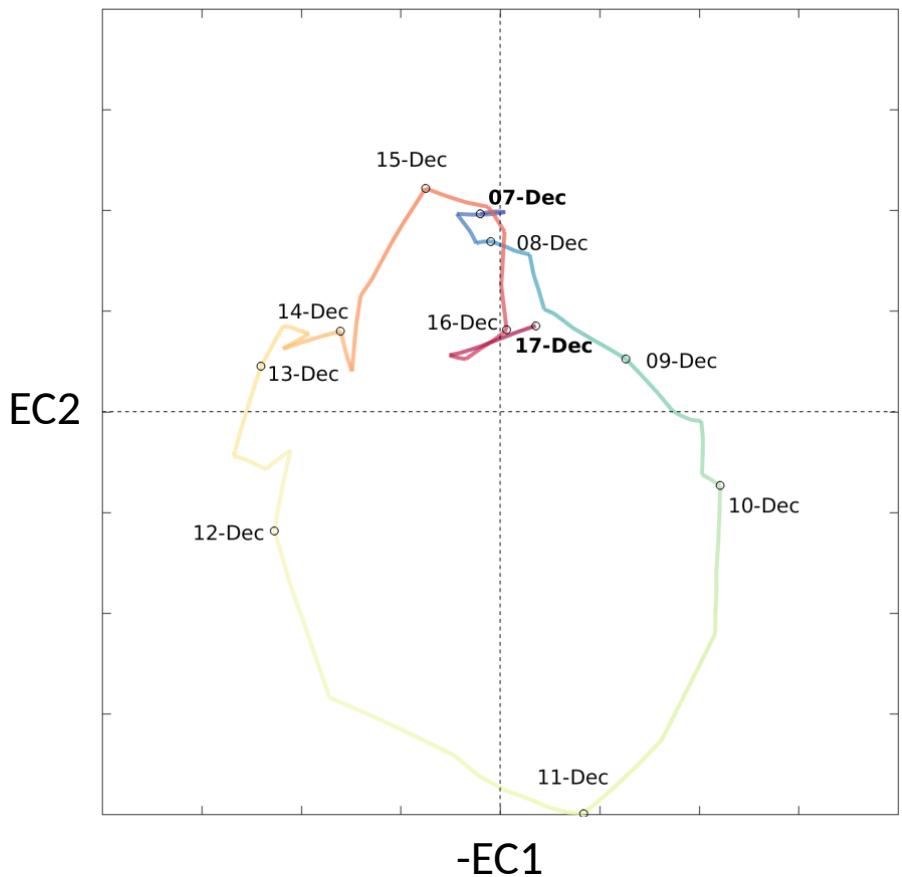
EXP3



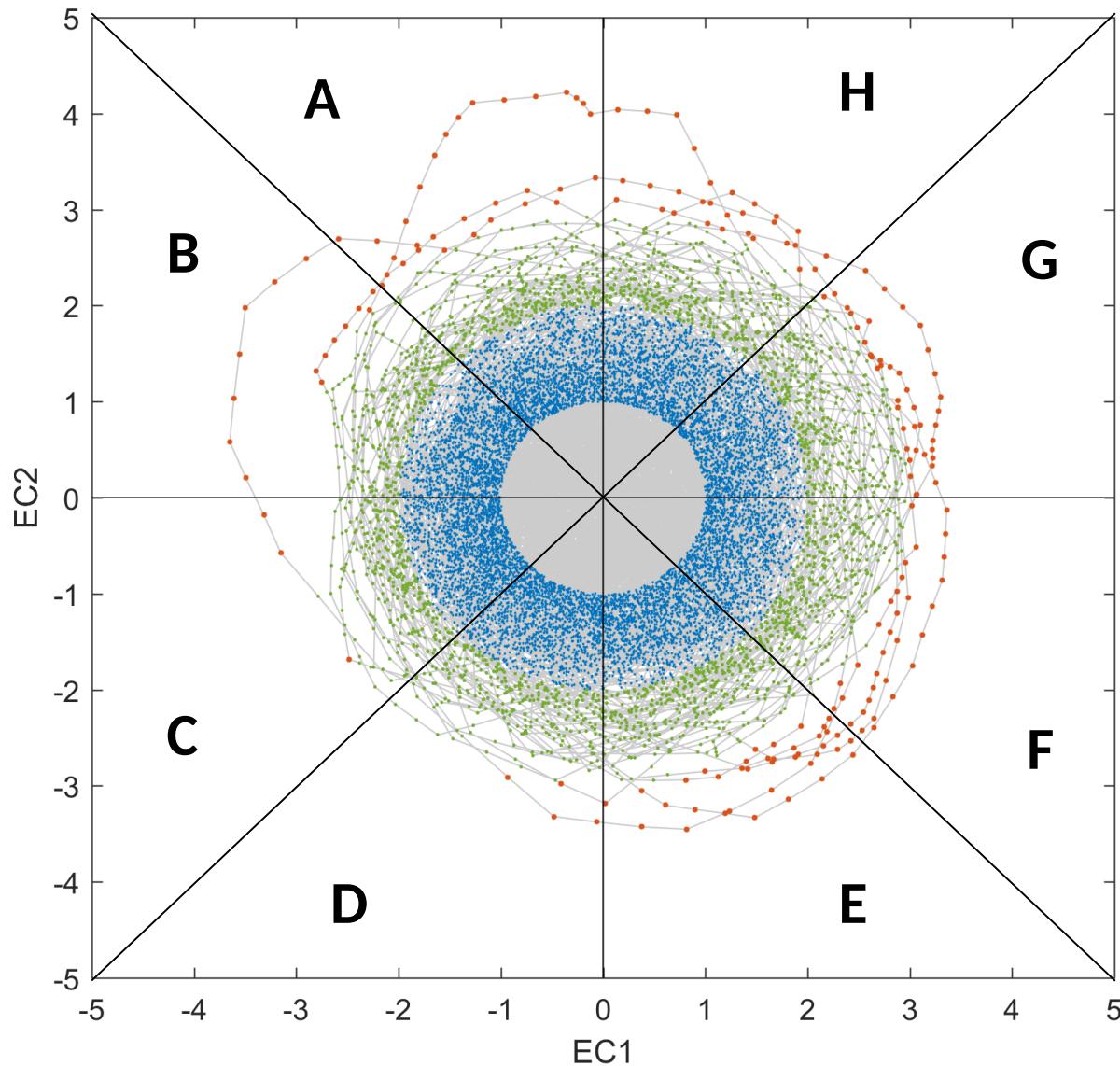
# ASPECTOS DE GERAÇÃO EXP4



# EVOLUÇÃO DOS MODOS

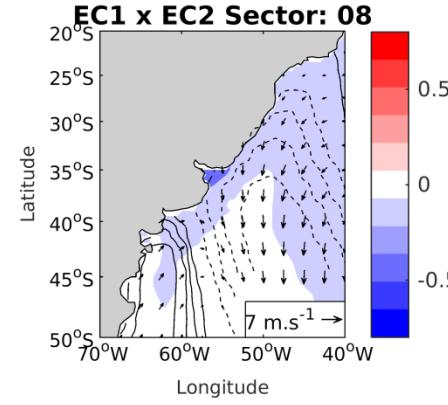
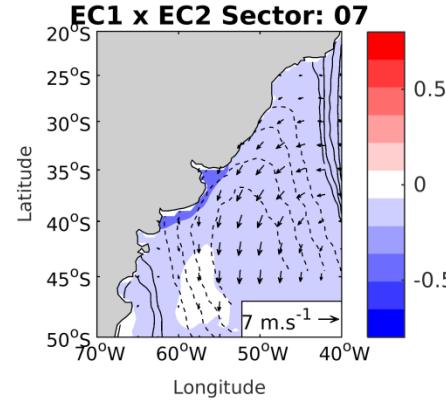
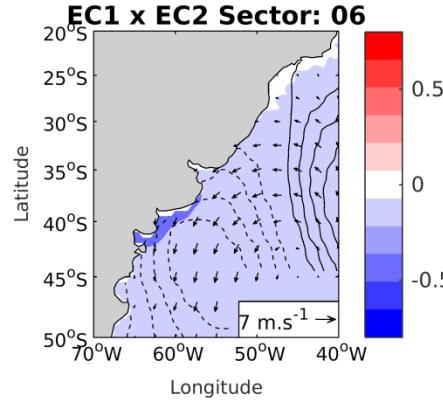
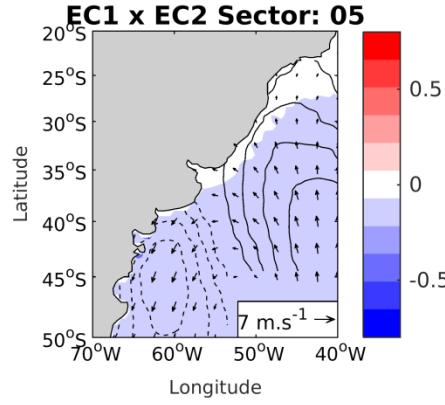
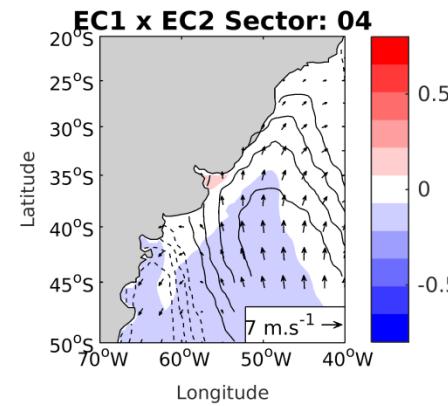
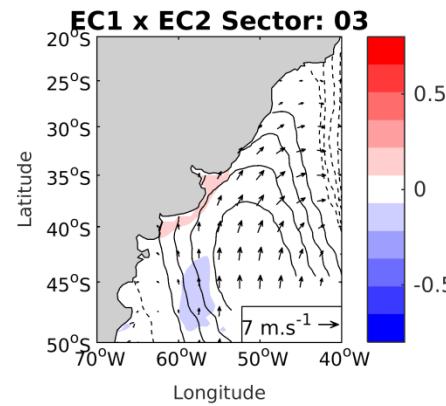
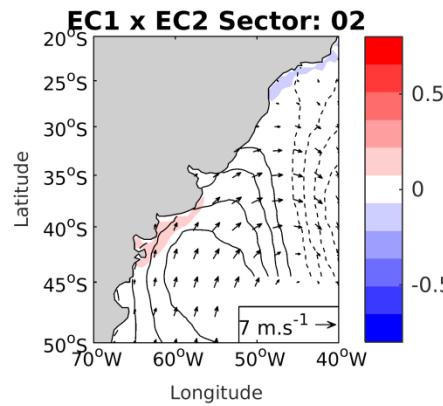
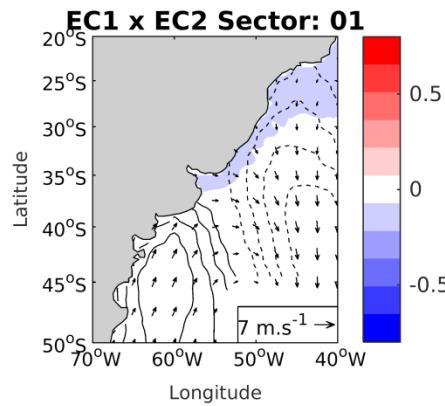


# ASPECTOS DE PROPAGAÇÃO



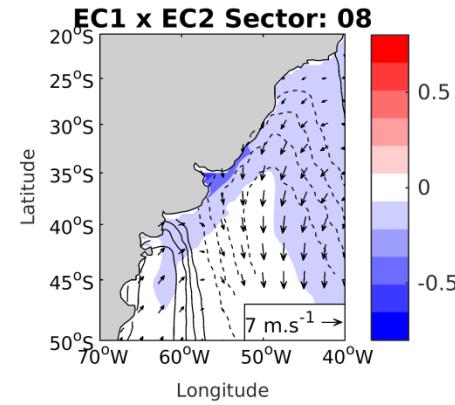
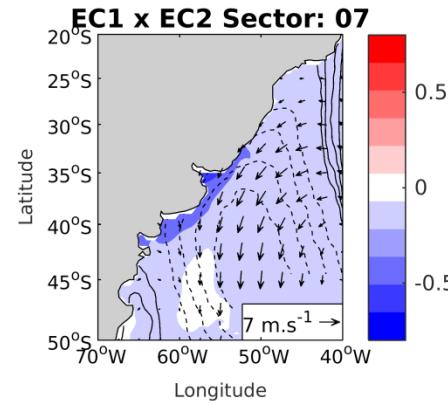
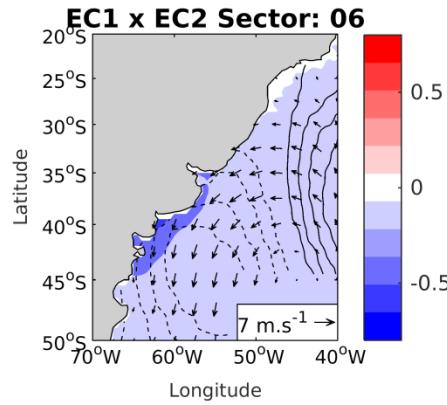
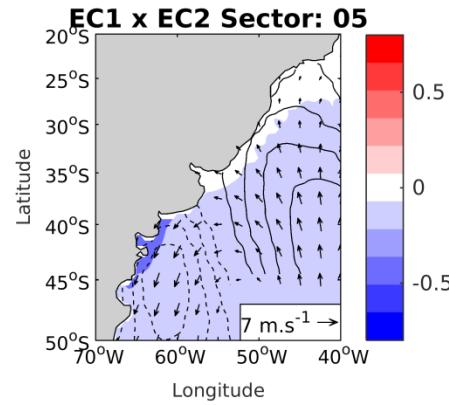
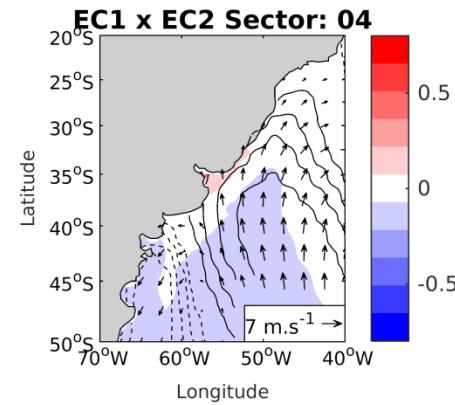
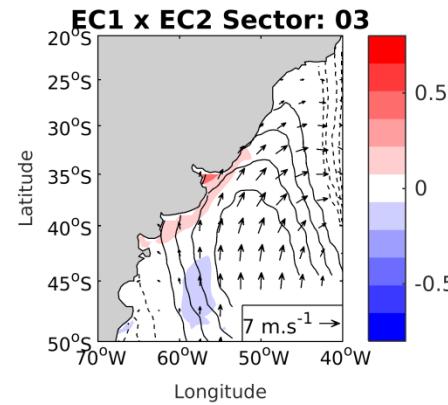
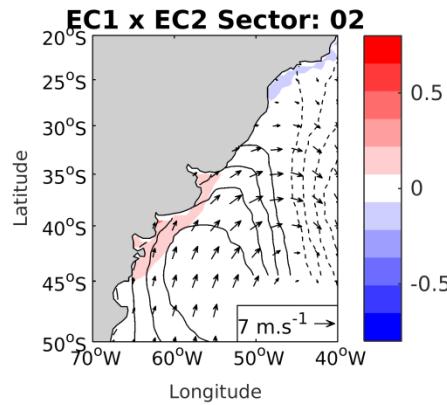
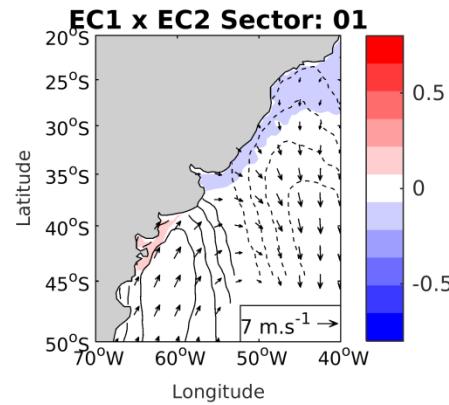
# COMPOSITES EXP1 TODOS OS PONTOS

Eta+Wind Composites - RUN1



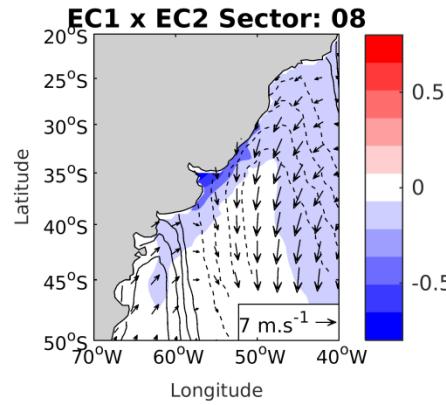
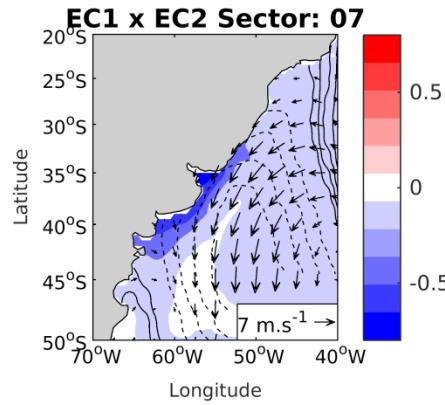
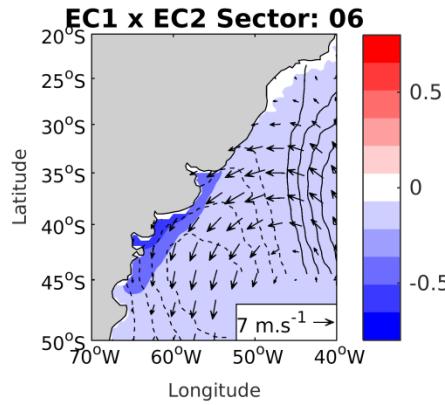
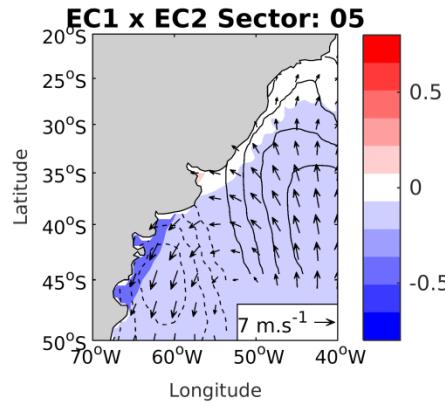
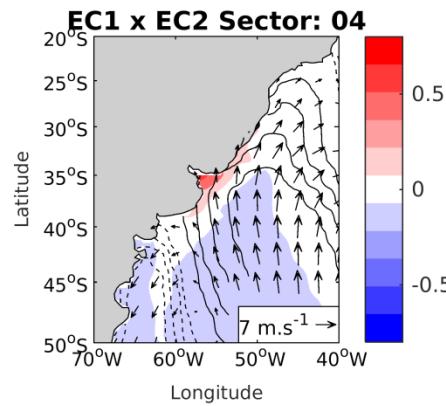
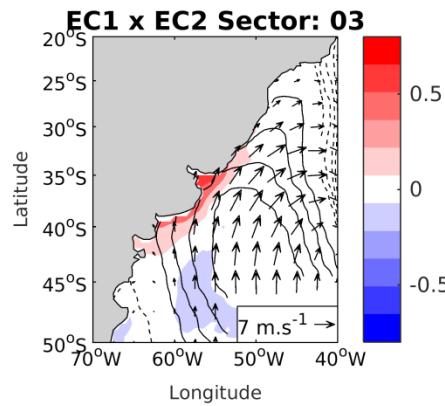
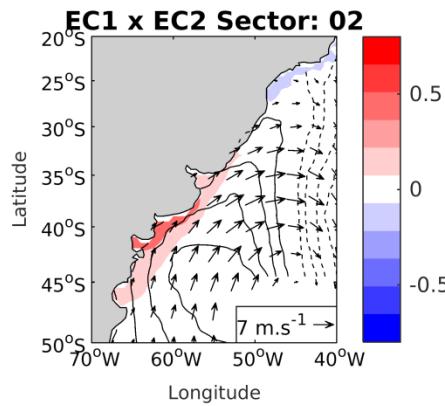
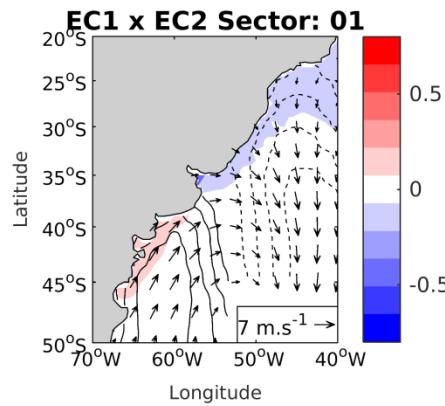
# COMPOSITES EXP1 1std

Eta+Wind Composites - RUN1



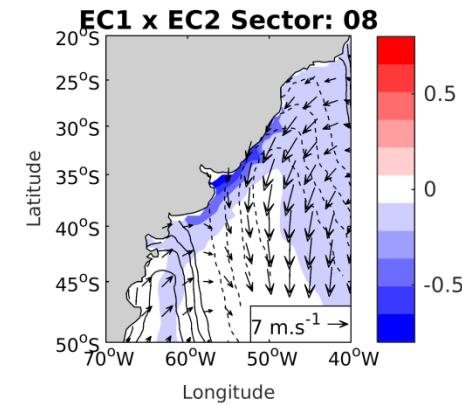
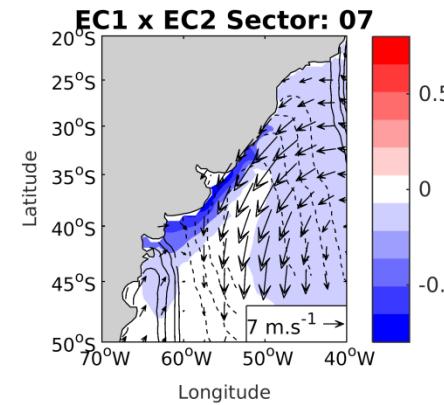
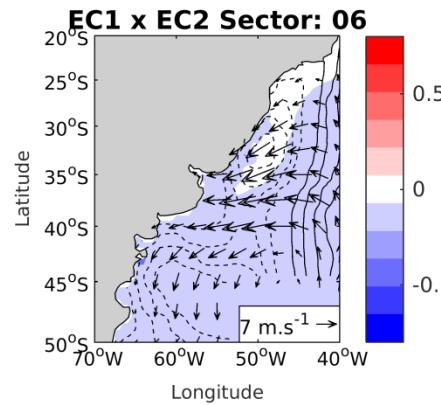
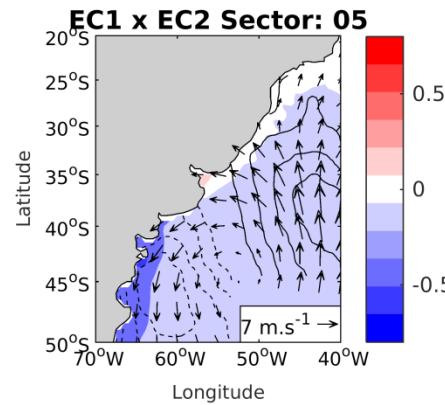
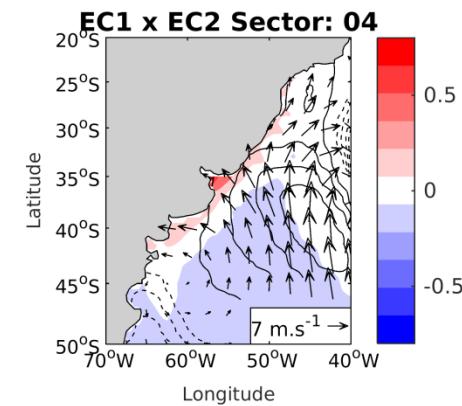
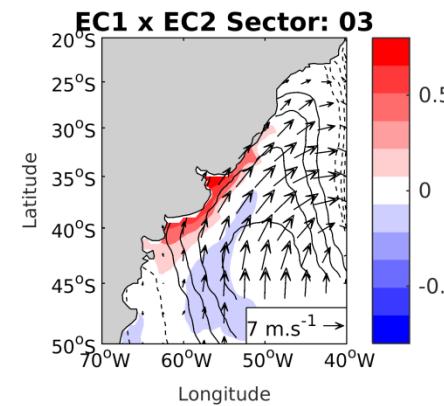
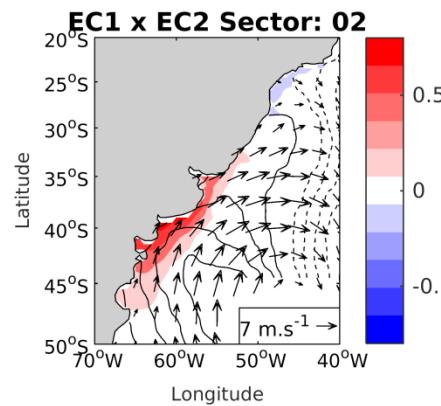
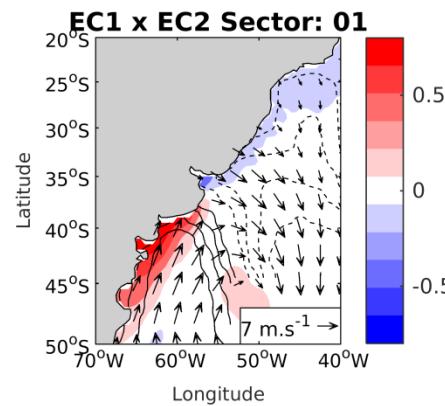
# COMPOSITES EXP1 2std

Eta+Wind Composites - RUN1



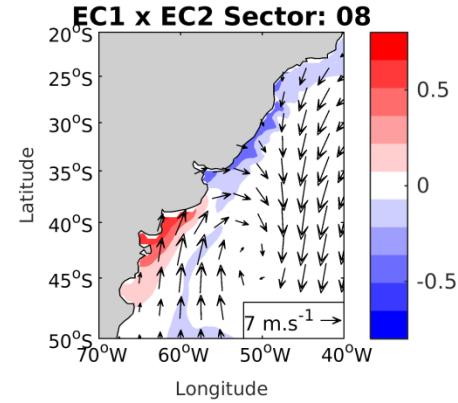
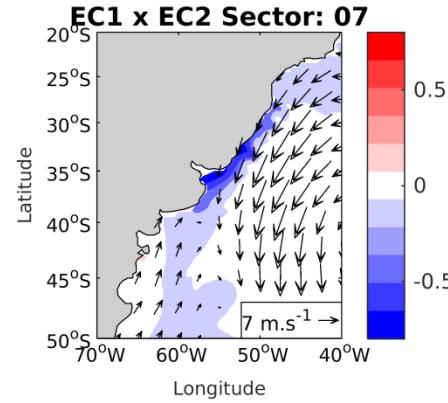
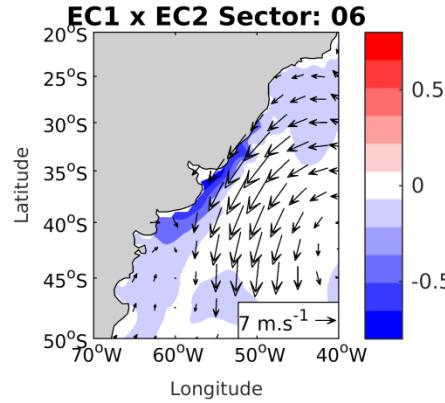
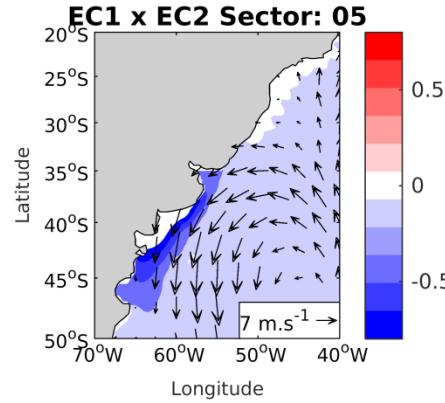
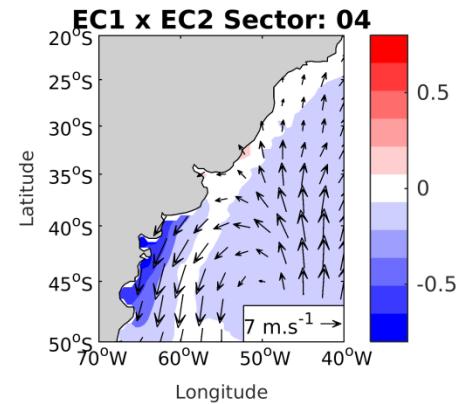
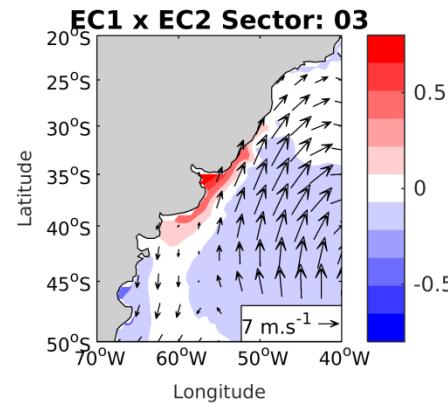
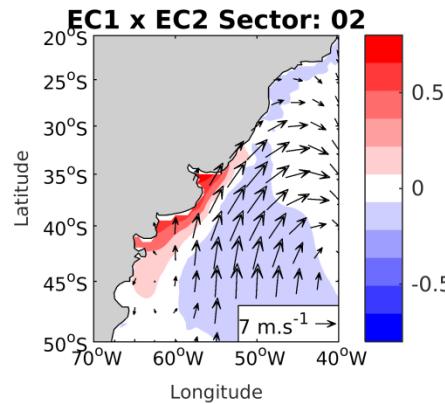
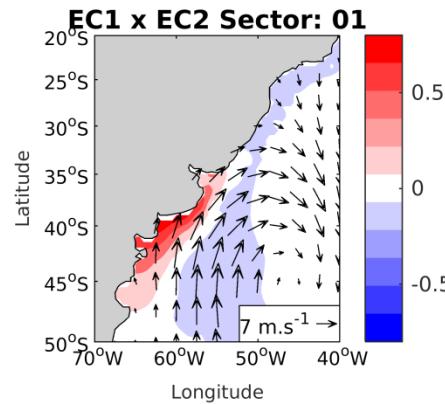
# COMPOSITES EXP1 3std

Eta+Wind Composites - RUN1



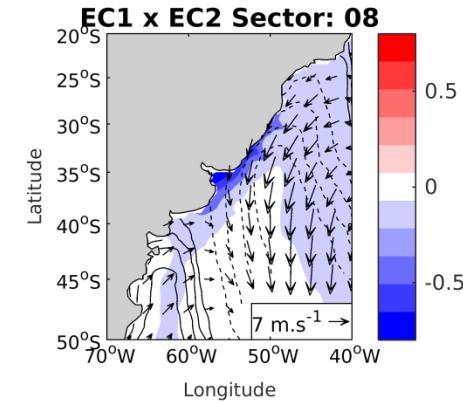
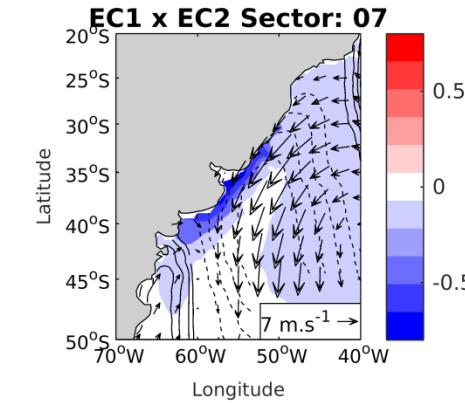
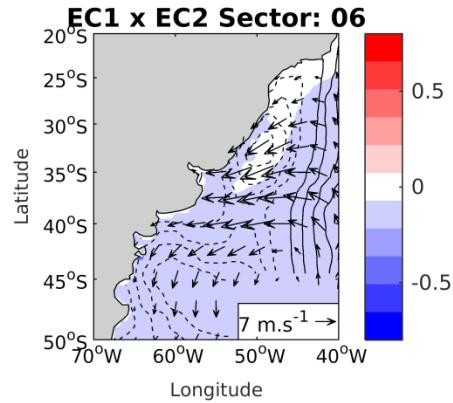
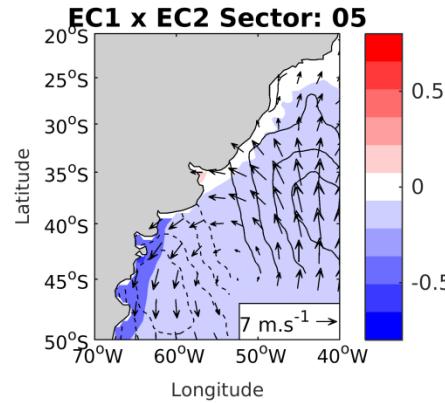
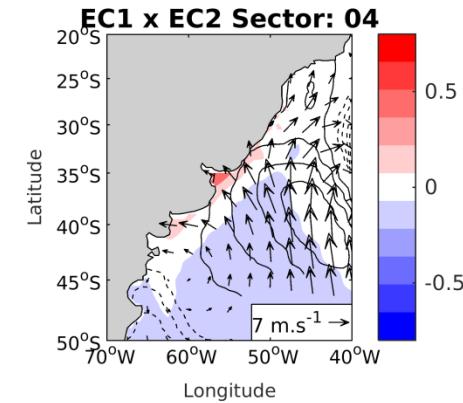
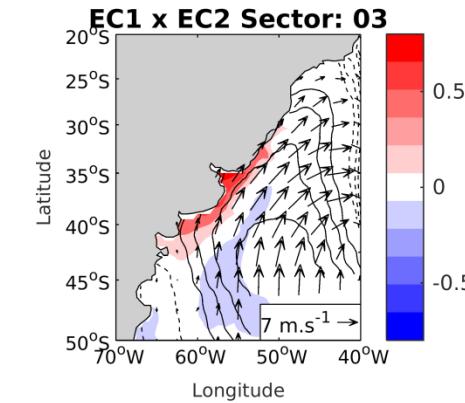
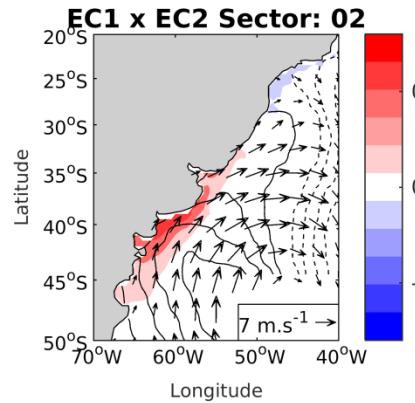
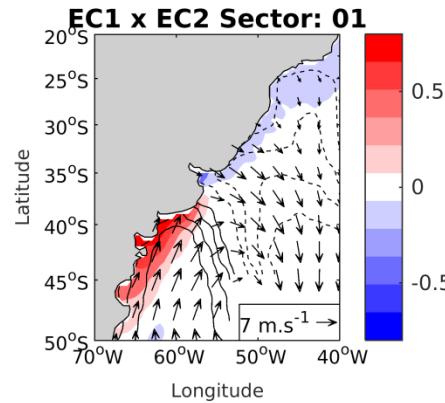
# COMPOSITES EXP2 3std

Eta+Wind Composites - RUN2



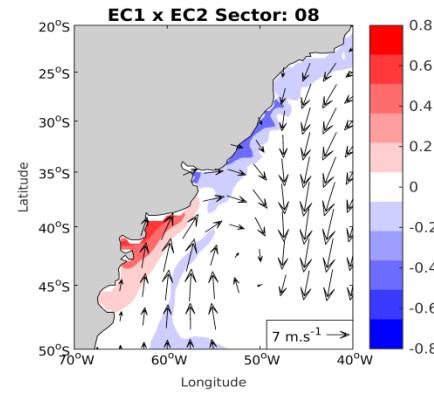
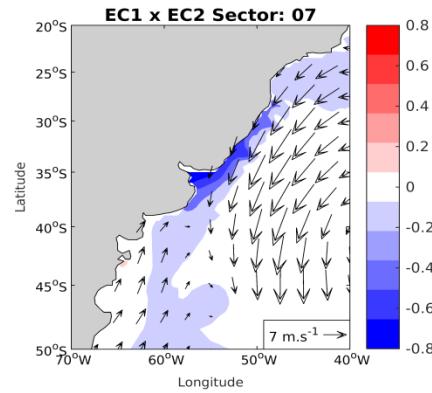
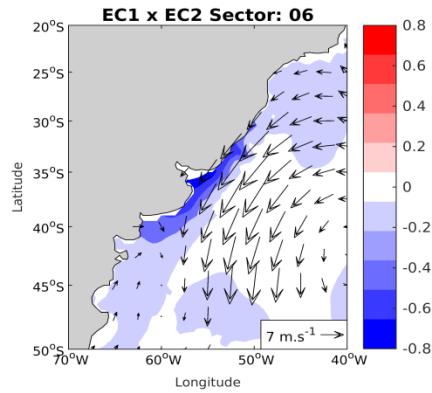
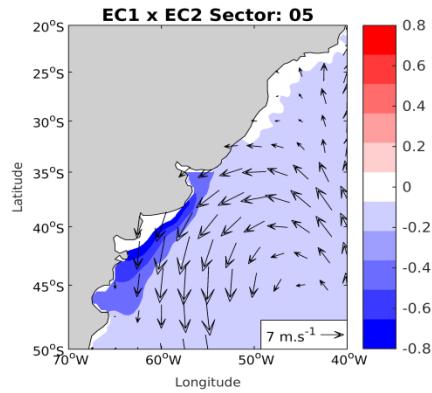
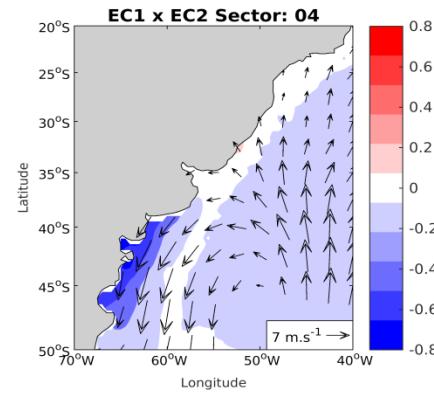
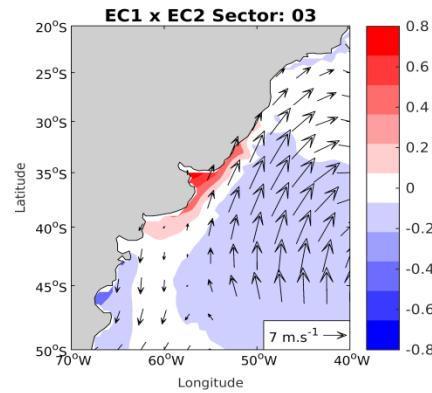
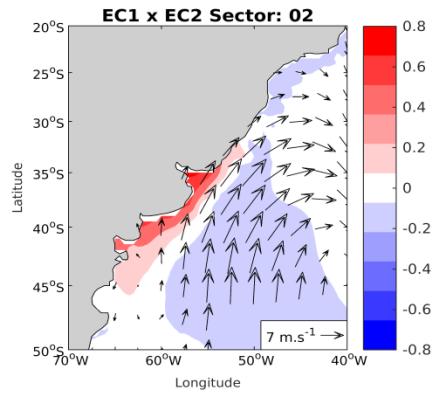
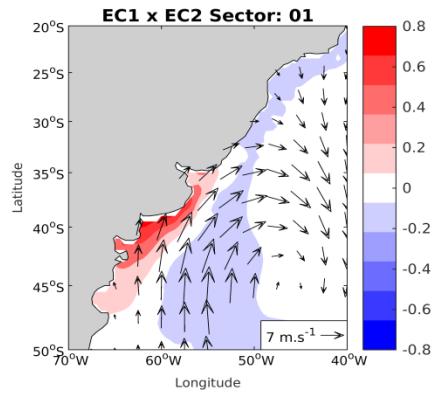
# COMPOSITES EXP3 3std

Eta+Wind Composites - RUN3

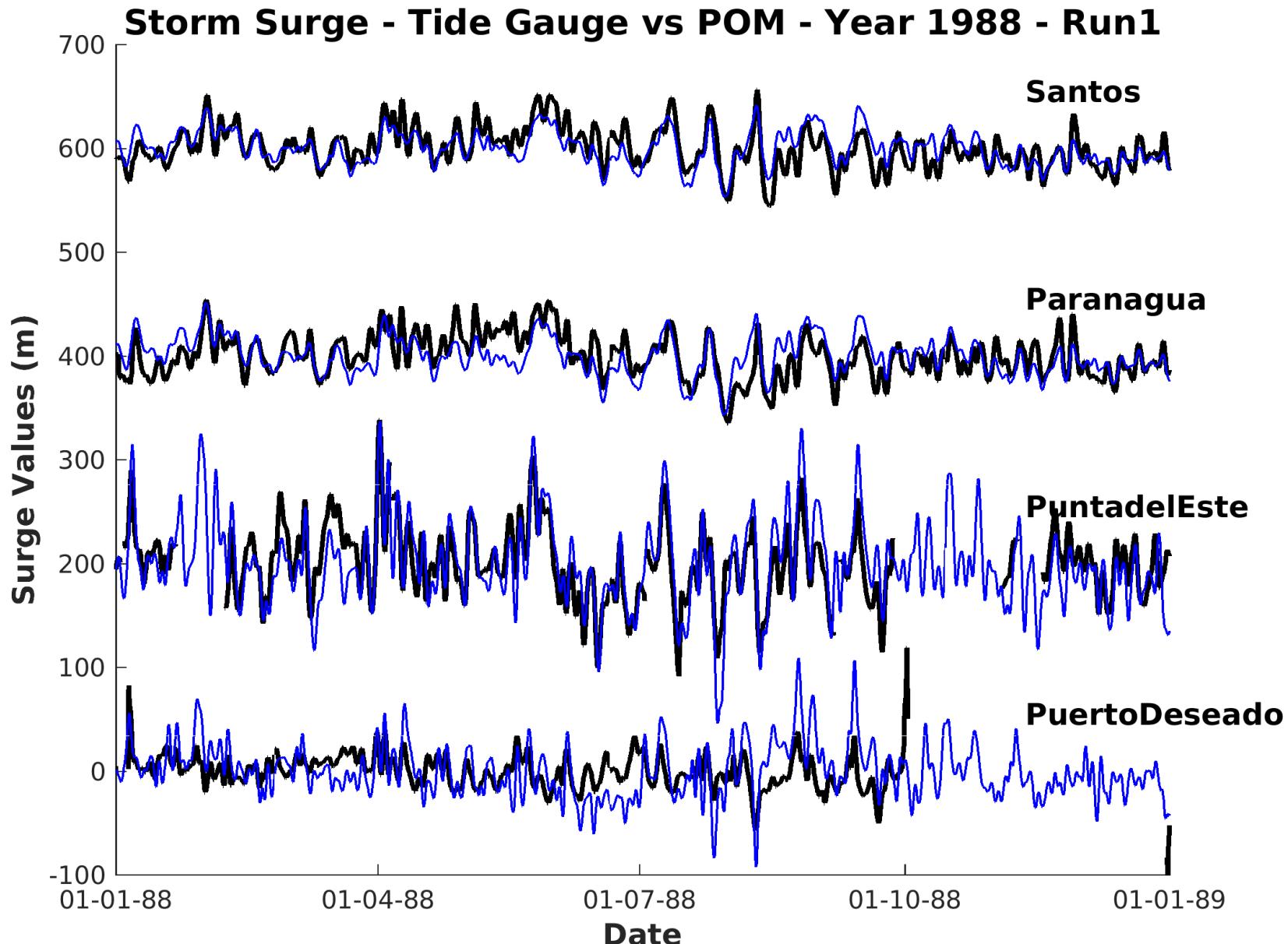


# COMPOSITES EXP4 3std

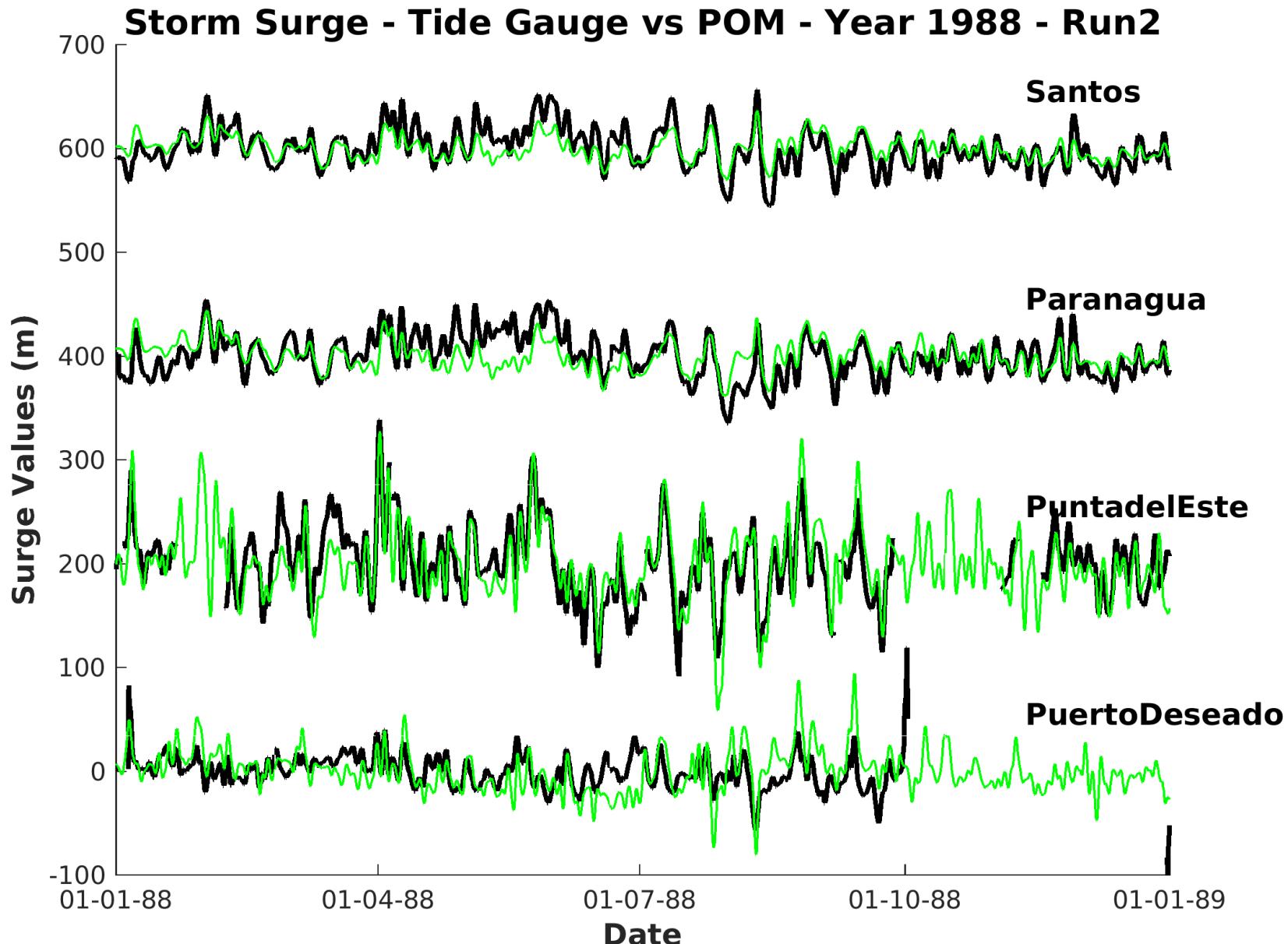
Eta+Wind Composites - RUN4



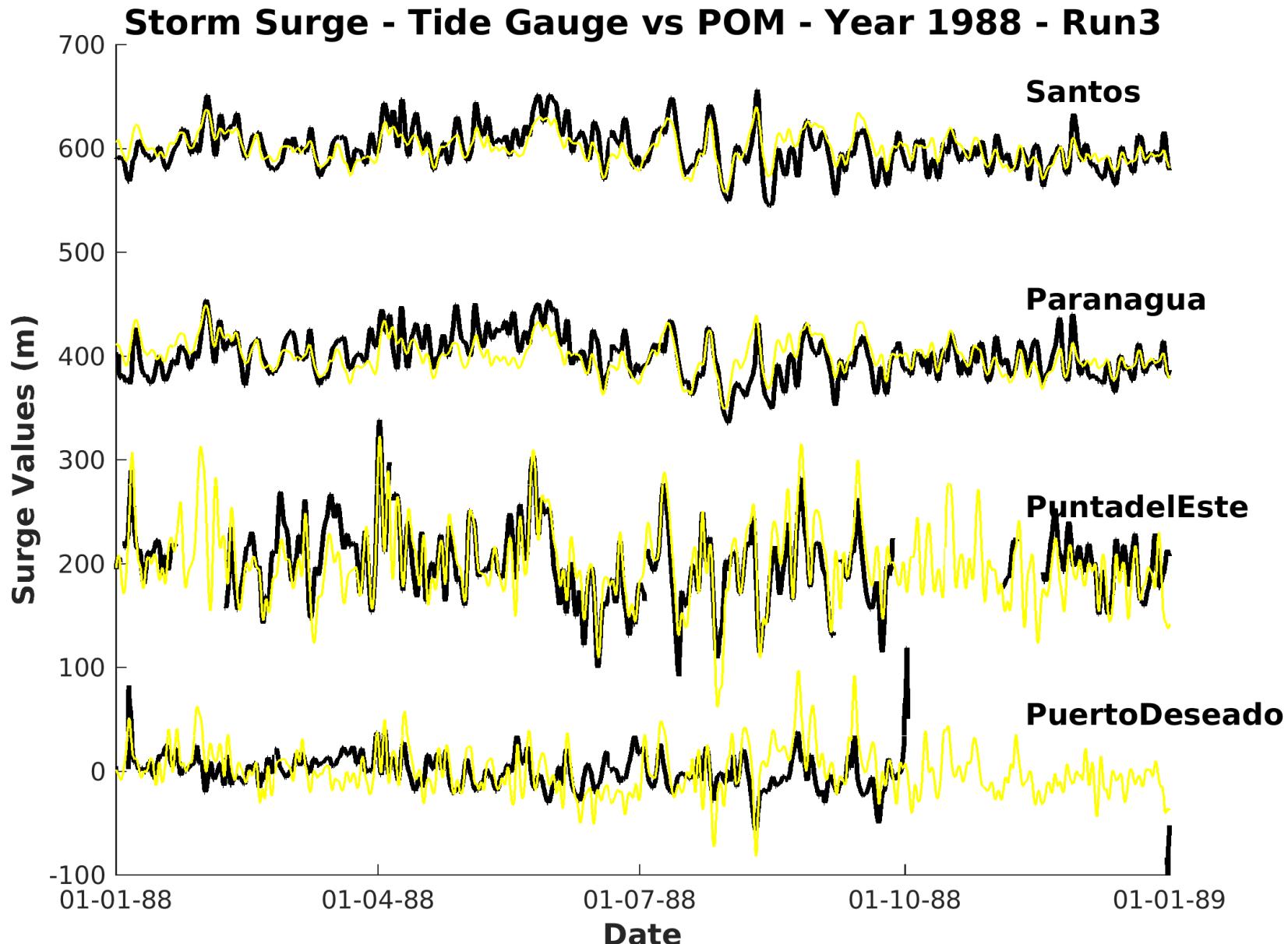
# SEPARAÇÃO DE FATORES



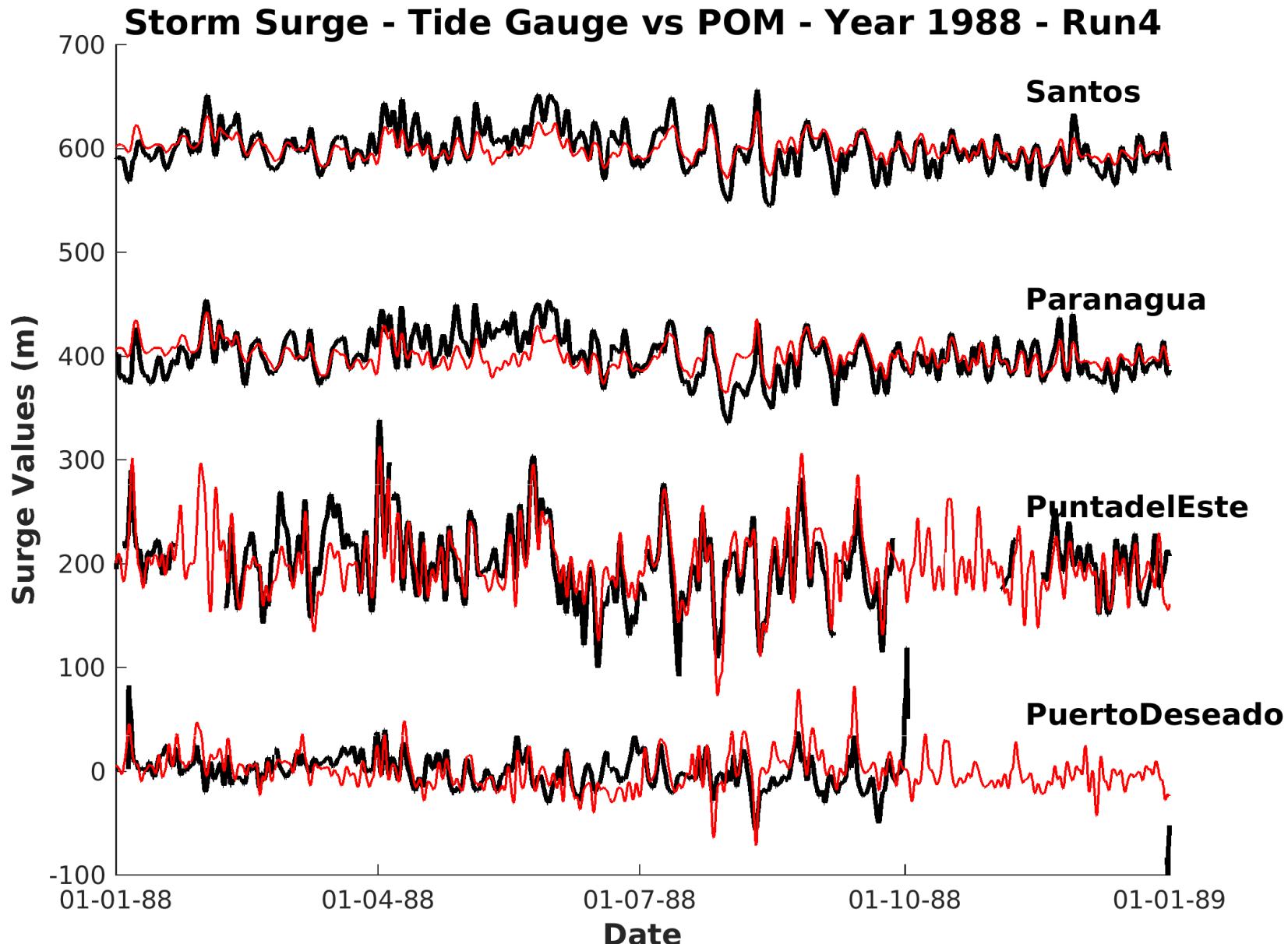
# SEPARAÇÃO DE FATORES



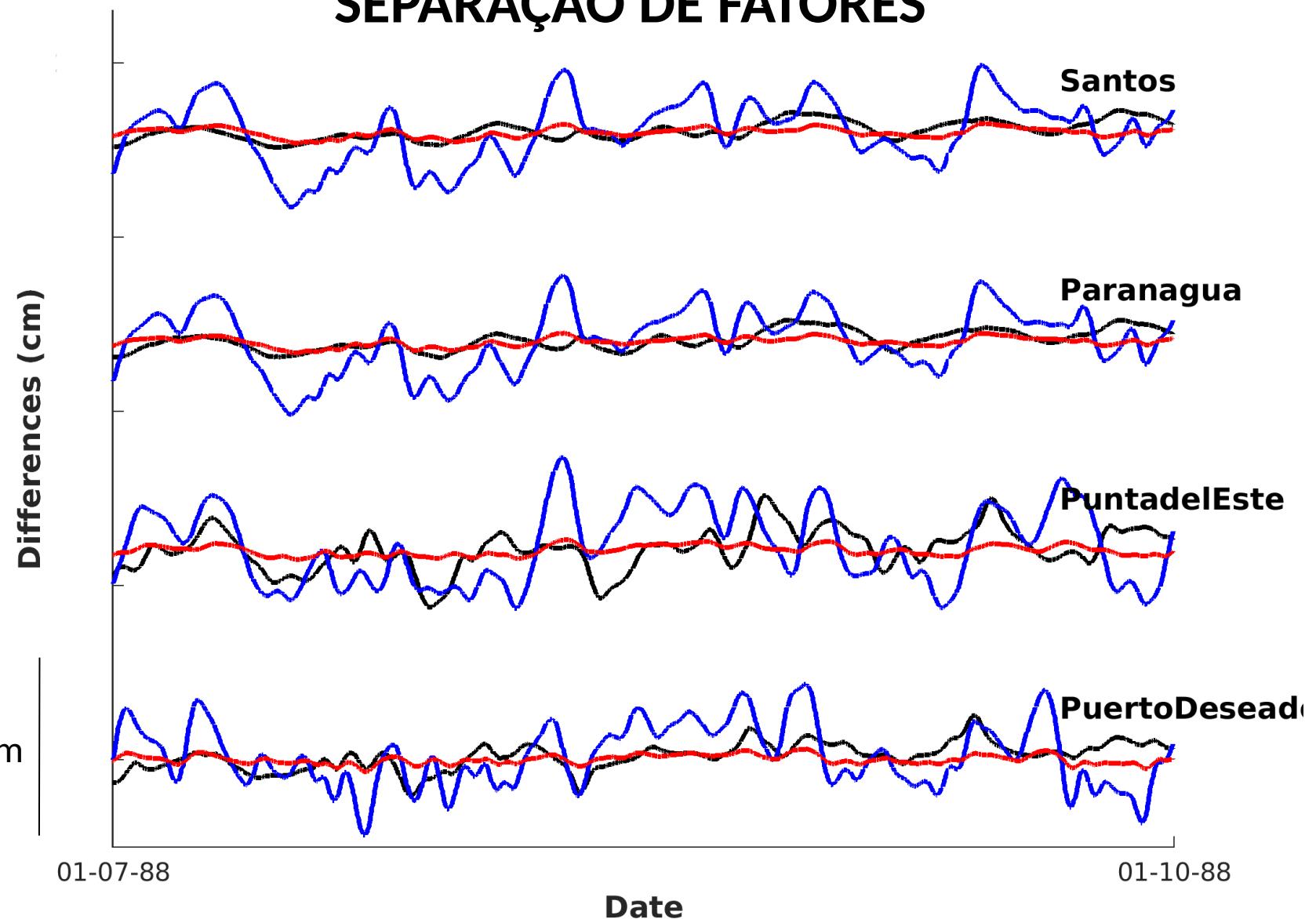
# SEPARAÇÃO DE FATORES



# SEPARAÇÃO DE FATORES



# SEPARAÇÃO DE FATORES

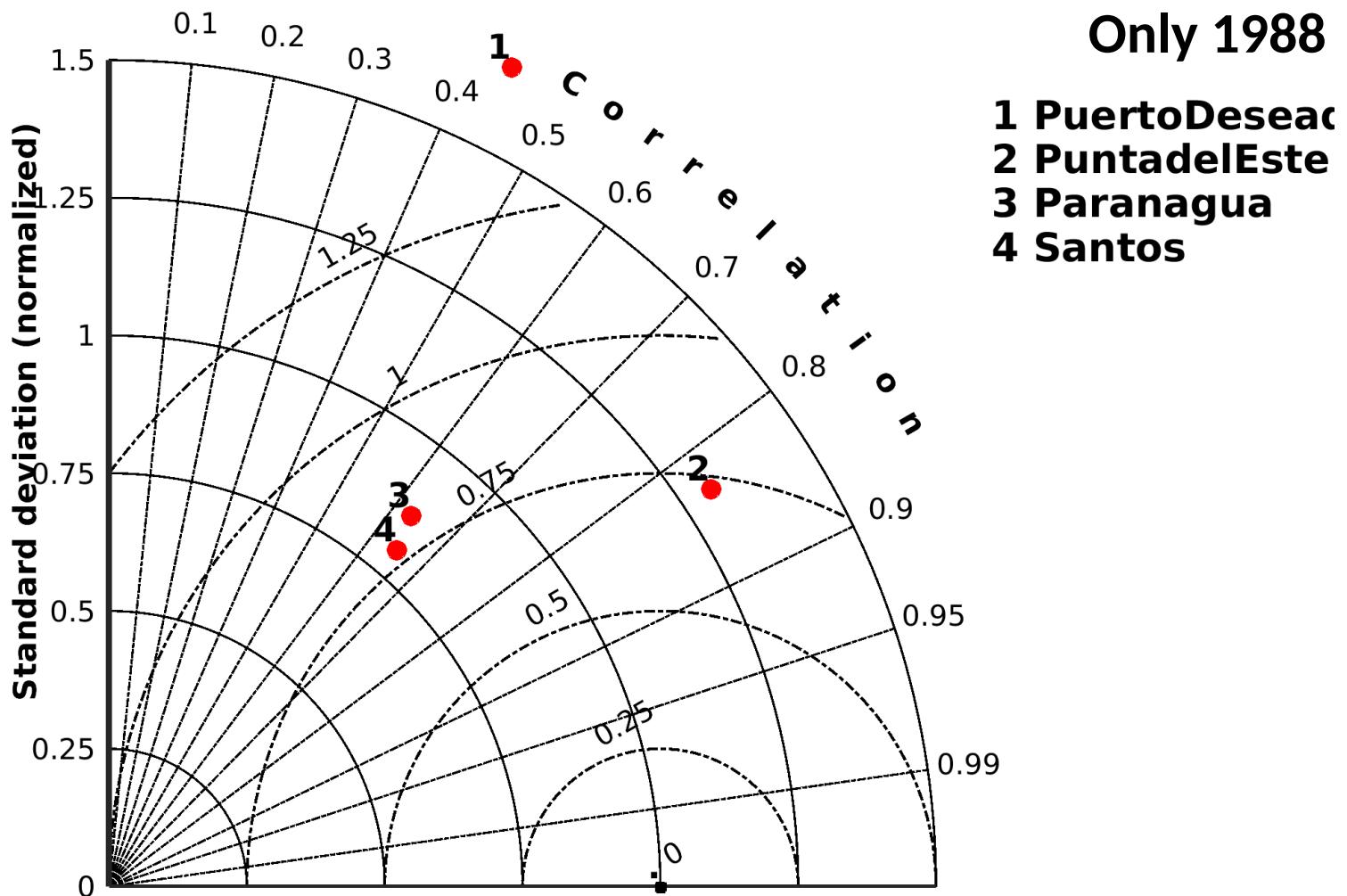


Tide effect

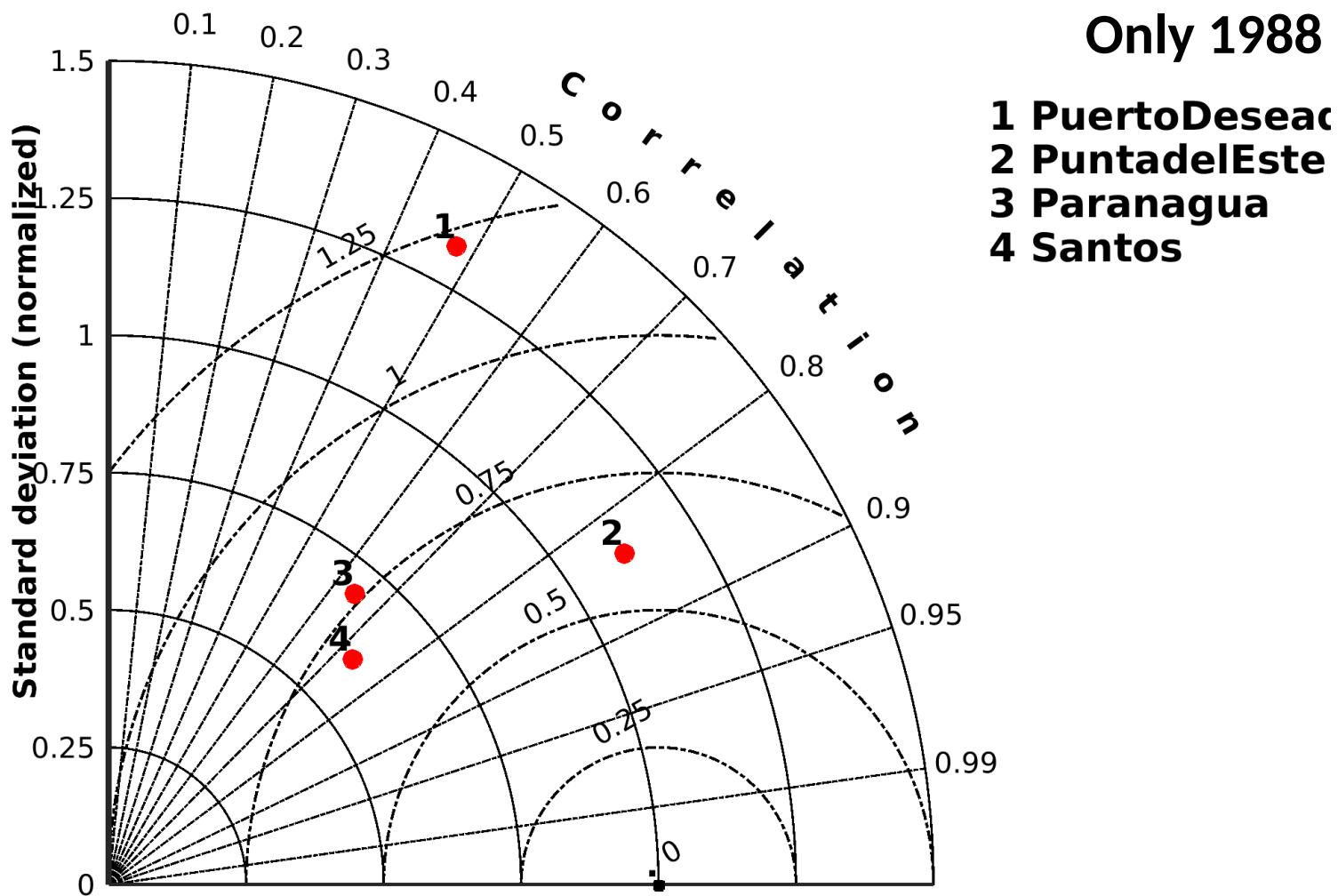
SLP effect

Non linear effect Tide/SLP

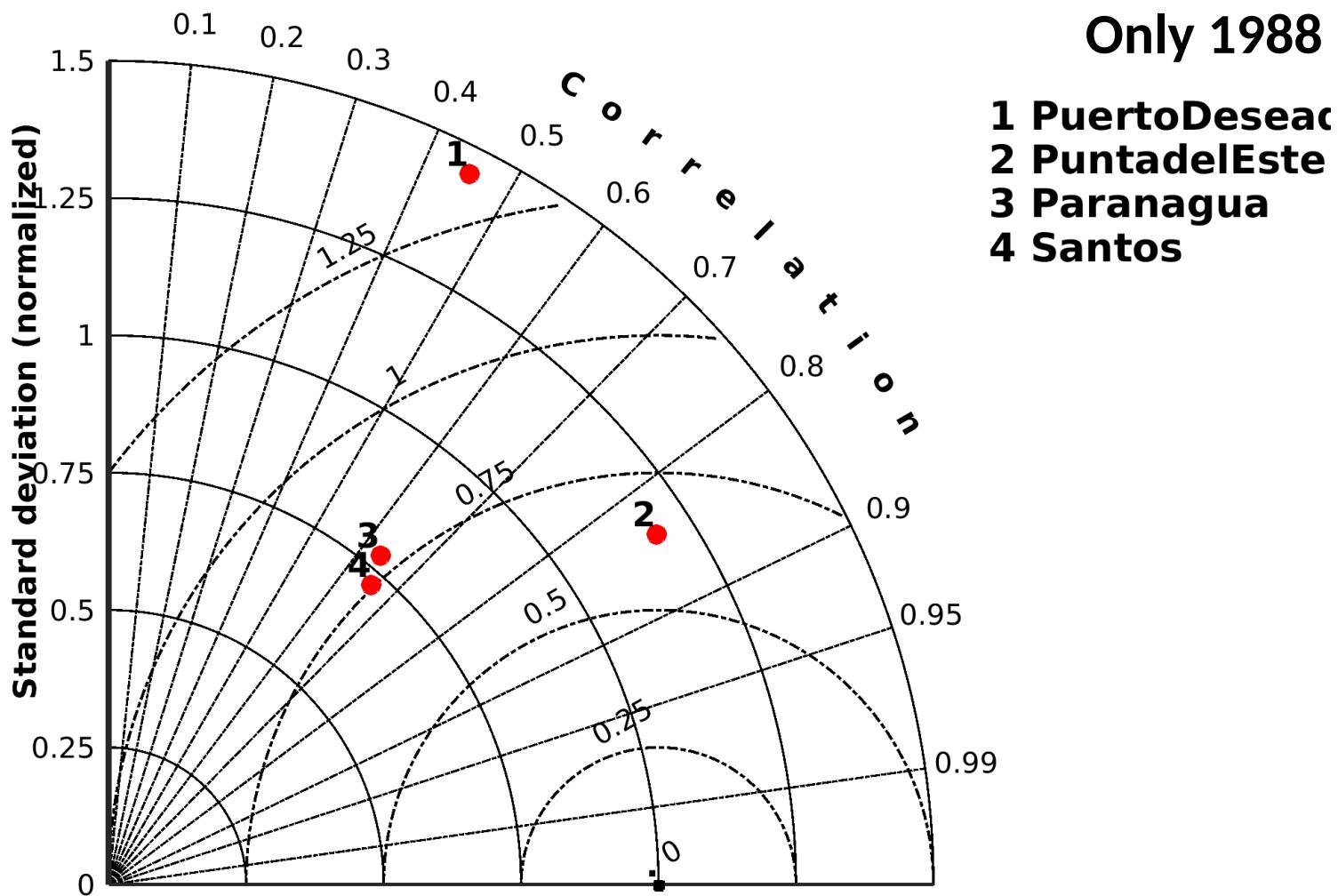
## Storm Surge - Tide Gauge vs POMrun1



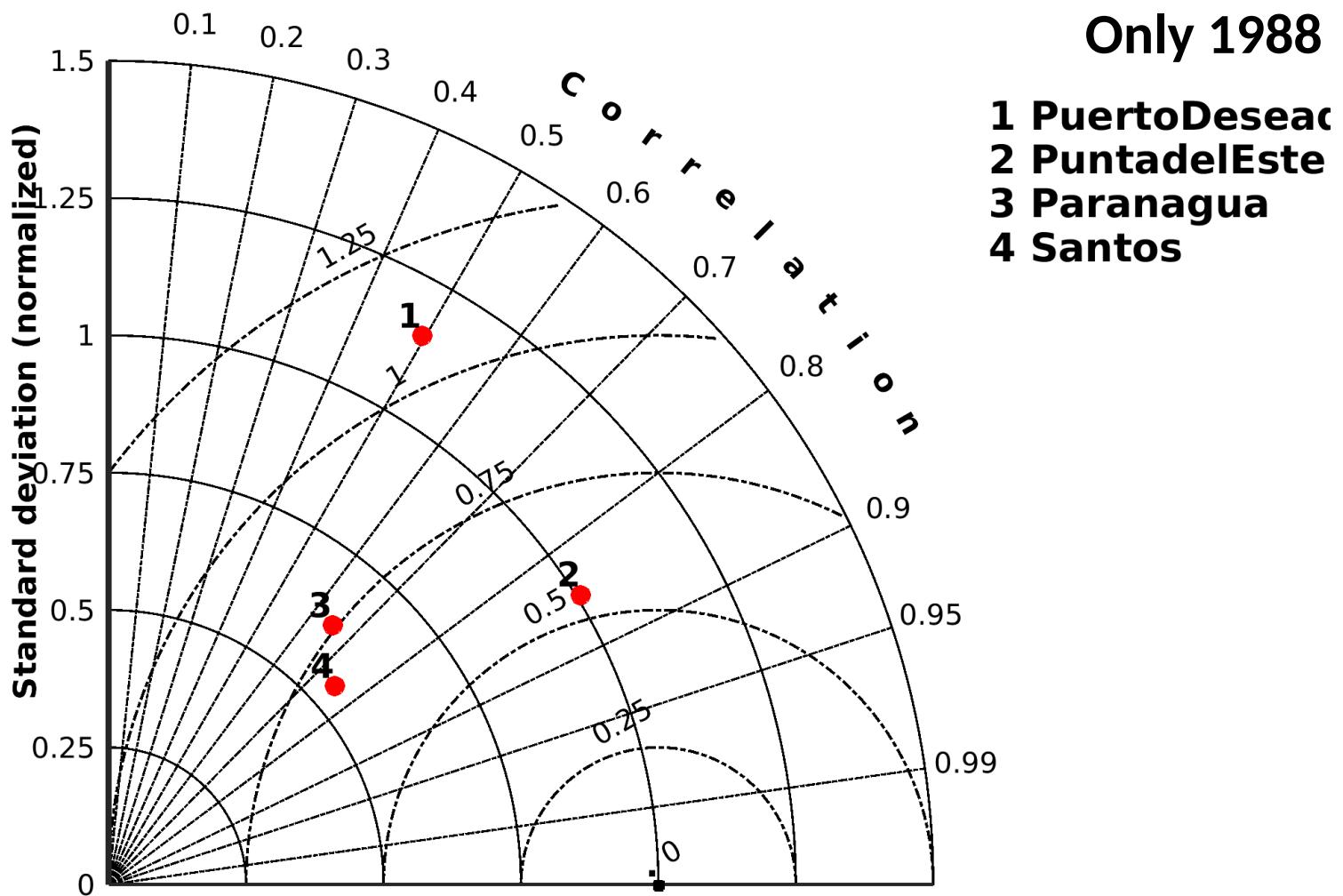
# Storm Surge - Tide Gauge vs POMrun2



# Storm Surge - Tide Gauge vs POMrun3



## Storm Surge - Tide Gauge vs POMrun4



Obrigado pela atenção!

[ricamarg@usp.br](mailto:ricamarg@usp.br)