

Multiscale Low-Frequency Circulation Modes in the Global Atmosphere

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Estrutura do Artigo

1. Introdução;
2. Dados e análise de procedimento;
3. Espacial e estrutura temporal;
 - a. Modo simétrico zonalmente;
 - b. Modo Interanual (IAM);
 - c. Oscilação Intrasazonal (ISO);
 - d. Modos Extratropicais no Hemisfério Norte;
 - i. Padrão do Pacífico / América Norte;
 - ii. Atlântico Norte / Padrão Eurásia;
 - e. Padrões Extratropicais do Hemisfério Sul;
4. Sazonalidade;
5. Análises do espectro singular (SSA);
6. Figuras da Fase-espço;
7. Síntese do espaço-físico;
8. Conclusão.



Introdução

Os padrões de circulação que ocorrem com intervalos da ordem de 10 dias são comumente referidos como variabilidade de baixa frequência/Low-frequency variability (LFV), pode ser dividido em:

1. Variabilidade Interanual (IAV)
2. Variabilidade Intrasazonal (ISV)

O IAV está ligado a padrões de teleconexões devem estar atribuídos ao aquecimento associado às anomalias de SST tropical durante o El Niño (ENSO) e ou anomalias SST extratropical. Horel and Wallace (1981), Livezey and Mo (1987), Lau and Nath (1990) sugerem ser importante manter a instabilidade barotrópica.

ISV apresentam oscilações de 30-60 dias (MJO) e mostra interação do calor latente, convergência de umidade de larga escala e evaporação da superfície.



Introdução

A circulação extratropical é importante para o forçamento da convecção tropical;

Os modos normais devem estar presentes nos trópicos e extratropicais separadamente e os padrões de teleconexões ocorrem em janelas de forma espacial e temporal seletivas;

Webster and Chang (1988) propôs que as alterações nos mecanismos de teleconexões enfatizam a importância do gradiente zonal tropical em determinadas regiões cuja influência pode emanar dos extratropicais e vice-versa;

Ferranti et al.(1990) e Lau and Shang (1992) mostram que os sinais extratropicais podem ser mais previsíveis quando tem influência forte da ISV tropical e vice-versa;



Introdução: Objetivo

Prover um melhor entendimento das variabilidades de baixa frequência sobre um grande *range* de escala espacial e temporal.



Dados e Procedimentos de análises

Dados de ventos em 200 mb

1. European Centre for Medium-Range Weather Forecasts (ECMWF);
2. 10 anos de dados (1980-89);
3. 4,5°x 7,5 latitude-longitude;

Outgoing longwave radiation (OLR)

1. National Oceanic and Atmospheric Administration (NOAA)
2. 10 anos de dados (1980-89);
3. pentadas de 5 dias



Dados e Procedimentos de análises

Foram realizados Rotate Empirical Orthogonal Function (REOF);

Estimou o grau de liberdade por meio de decorrelação

$$T = [1 + 2 \sum_{i=1}^N C_{xx}(i\Delta t)C_{yy}(i\Delta t)]\Delta t, \quad (1)$$

where Δt is the sampling time, N is the number of observations, and C is the autocorrelation function. The number of independent temporal samples for each grid is given by $n = N\Delta t/T$. An examination of the distri-

Foram realizados Empirical Orthogonal Function (EOF);

Estrutura espaciais e temporais: Modo zonalmente simétrico

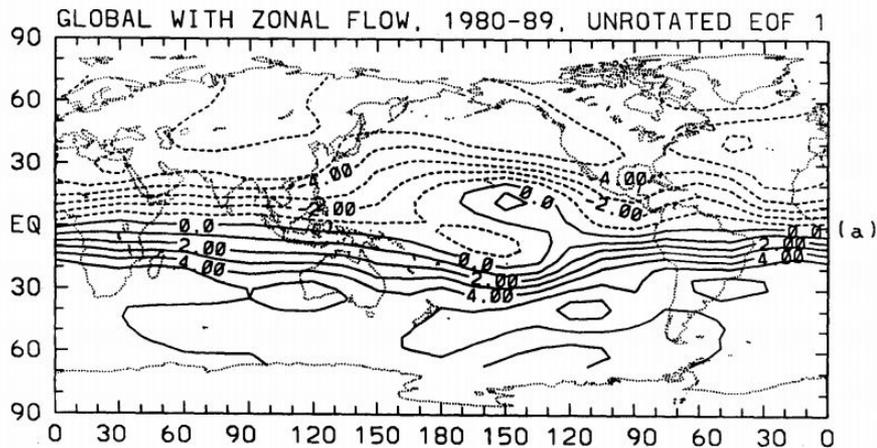


TABLE 1. Percentage variance distribution of eigenvectors before and after VARIMAX rotation.

	Mode									
	1	2	3	4	5	6	7	8	9	10
EOF	8.96	4.56	3.83	3.38	2.94	2.82	2.71	2.47	2.38	2.26
REOF	7.37	4.61	3.51	3.17	3.14	2.90	2.87	2.84	2.77	2.76

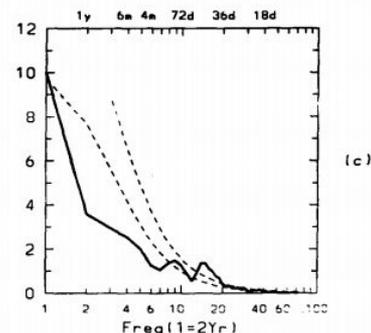
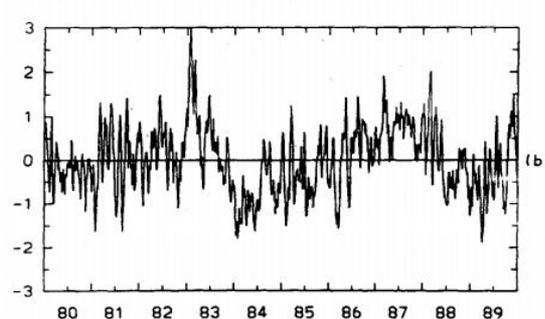


FIG. 1. (a) Spatial pattern of EOF1 (unrotated) for 200-mb streamfunction with zonal mean component included. Units are nondimensional. (b) Principal component of EOF1 (unrotated) for 200-mb streamfunction with zonal mean component included. Units are in $\text{m}^2 \text{s}^{-1}$ scaled by a factor of 1.4×10^8 . (c) Power spectrum of principal component of EOF1. Ordinate is spectral density in units of $\text{m}^4 \text{s}^{-2}$. The peak value is scaled to 10. Dotted lines represent the background red-noise spectrum and its 95% significant level.

Estrutura espaciais e temporais: Modo Interanual (IAM)

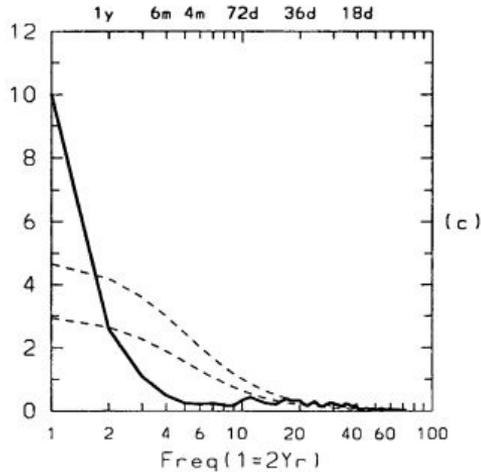
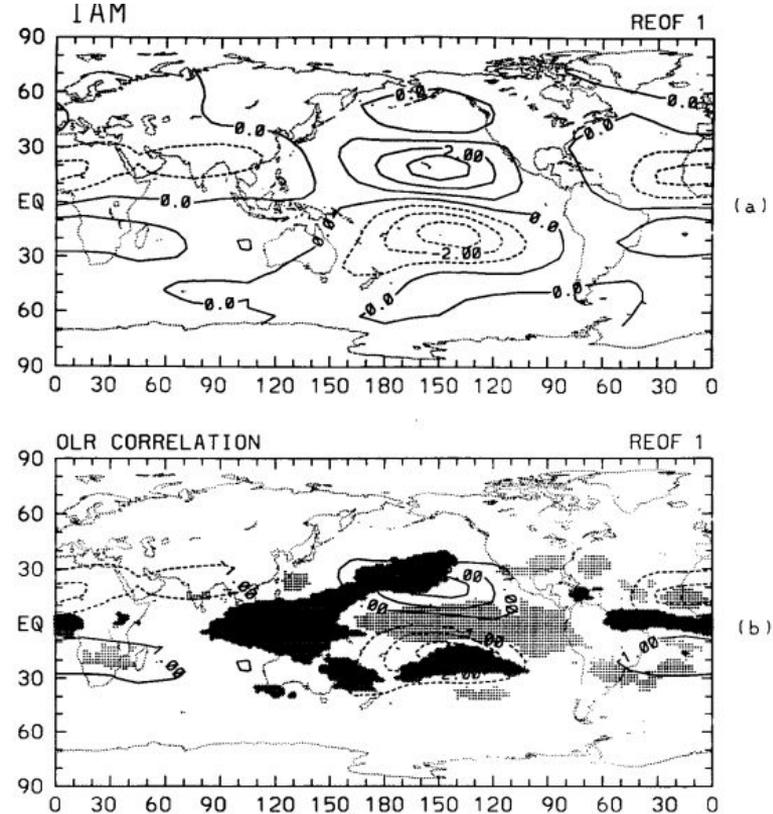


FIG. 2. (a) Spatial pattern of the first rotated EOF or IAM for the zonally asymmetric component of 200-mb streamfunction. (b) One-point correlation map of principal component of IAM with OLR between 30°N and 30°S. Only regions with correlation exceeding 95% significance level are shown. Heavy and light shading indicates positive and negative correlation, respectively. The contours show the main features of the streamfunction pattern. (c) Power spectrum of the principal component of IAM. Units as in Fig. 1c.



Estrutura espaciais e temporais: Oscilação Intrasazonal (ISO)

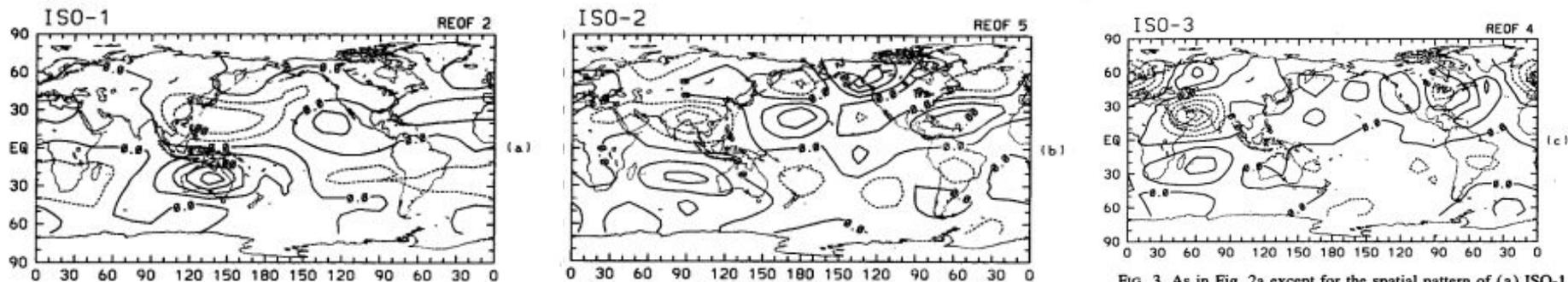


FIG. 3. As in Fig. 2a except for the spatial pattern of (a) ISO-1, (b) ISO-2, and (c) ISO-3. See text for nomenclature of the EOF erns.

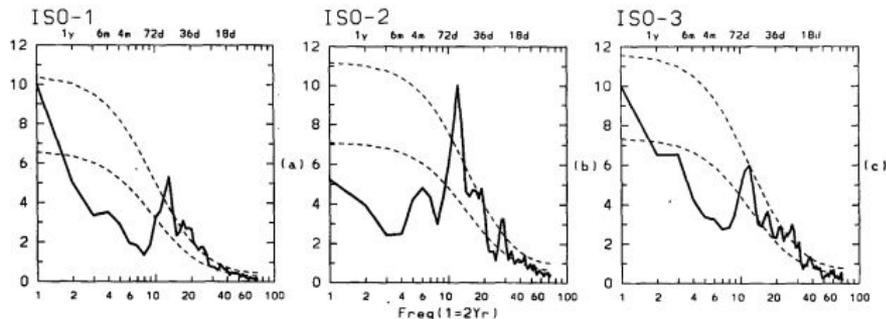


FIG. 4. As in Fig. 2c except for the power spectrum for (a) ISO-1, (b) ISO-2, and (c) ISO-3.

Estrutura espaciais e temporais: Oscilação Intrazonal (ISO)

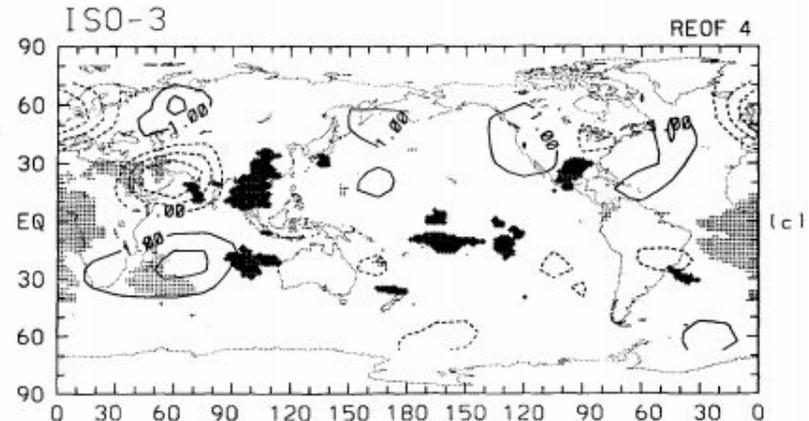
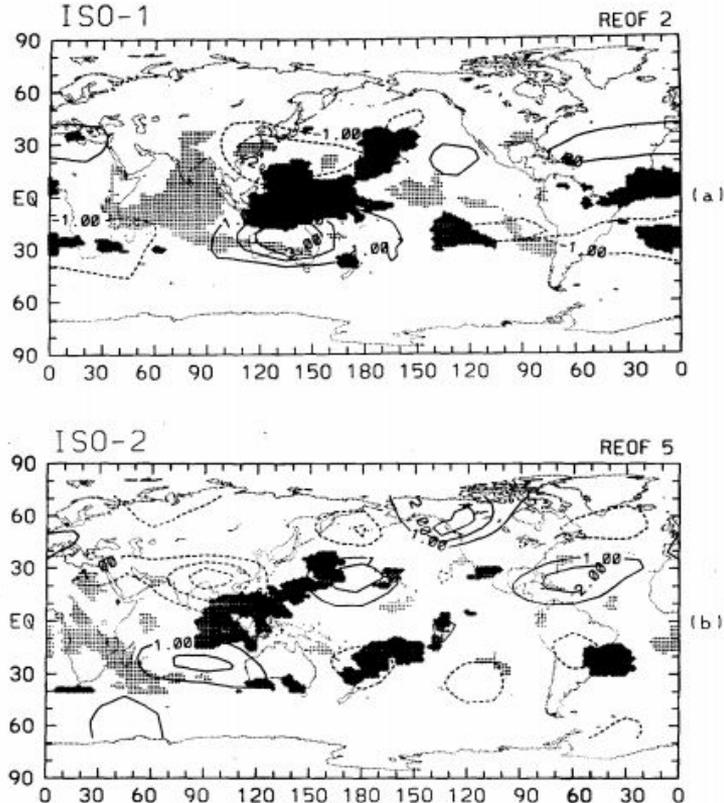


Fig. 5. As in Fig. 2b except for the one-point correlation maps of OLR with (a) ISO-1, (b) ISO-2, and (c) ISO-3.

Estruturas espaciais e temporais: Modos Extratropicais do Hemisfério Norte - PNA

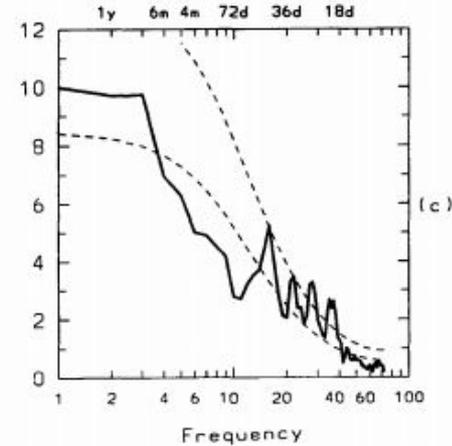
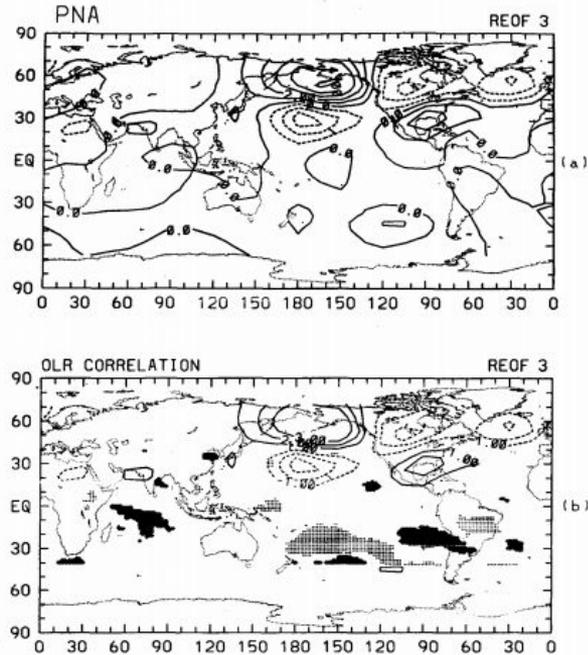


FIG. 6. As in Fig. 2 except for (a) the PNA (REOF-3), (b) the OLR correlation with the PNA, and (c) the power spectrum of the PNA.

Estrutura espaciais e temporais: Modos Extratropicais do Hemisfério Norte - NAE

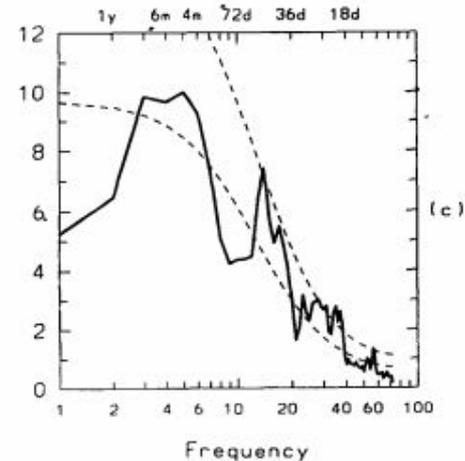
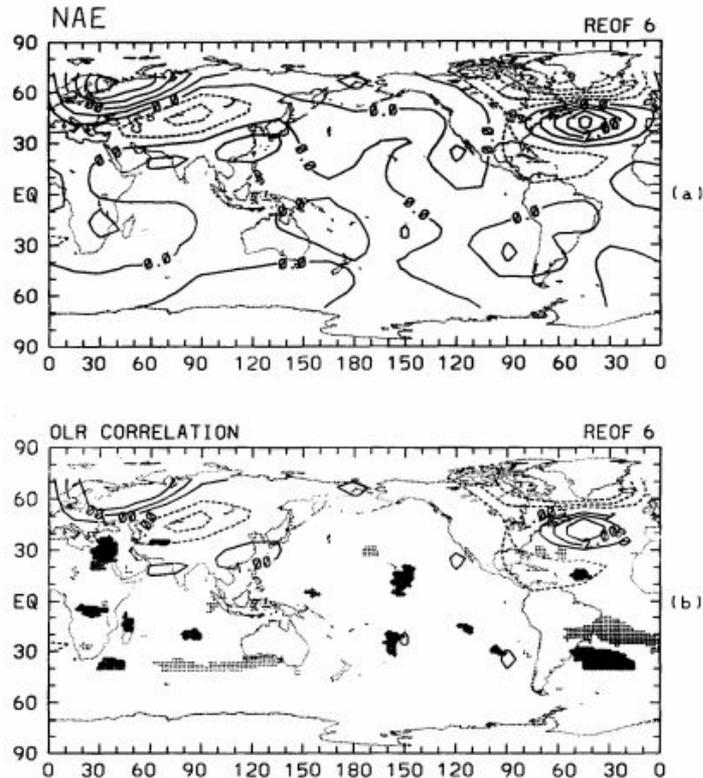


FIG. 7. (a) As in Fig. 2a except for the NAE (REOF-6). (b) Same as in Fig. 2b except for the OLR correlation with the NAE. (c) The power spectrum of the NAE.

Sazonalidad

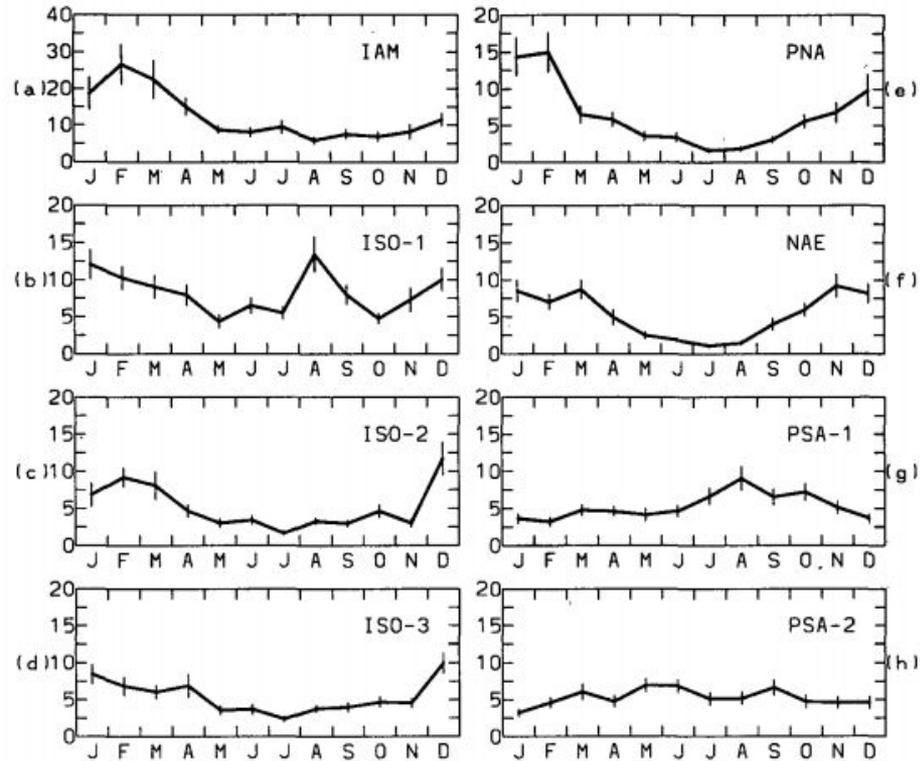


Fig. 9. Root-mean-square amplitude of the principal modes as a function of the calendar months. Vertical bars indicate the standard error of the mean. Units are in $\text{m}^4 \text{s}^{-2}$ scaled by a factor of 4×10^{14} .

Análise de espectro Singular (SSA)

TABLE 2. Percentage variance explained by each eigenfrequency for the principal multiscale modes.

	SSA-PC							
	1	2	3	4	5	6	7	8
IAM	49.0	12.4	4.2	3.8	1.3	1.3	1.25	1.2
ISO-1	13.9	5.6	4.9	4.9	3.6	3.3	3.3	3.2
ISO-2	5.8	5.7	4.0	3.5	3.4	3.3	3.3	3.2
ISO-3	9.5	4.6	4.5	4.2	4.1	3.9	3.8	3.0
PNA	6.7	5.8	5.6	4.4	3.9	3.8	3.0	3.0
NEA	5.3	5.2	5.2	4.9	3.8	3.8	3.3	3.2
PSA-1	4.0	3.8	3.7	3.7	3.3	3.1	2.8	2.8
PSA-2	3.6	3.6	3.2	2.8	2.7	2.6	2.6	2.5

Análise de espectro Singular (SSA)

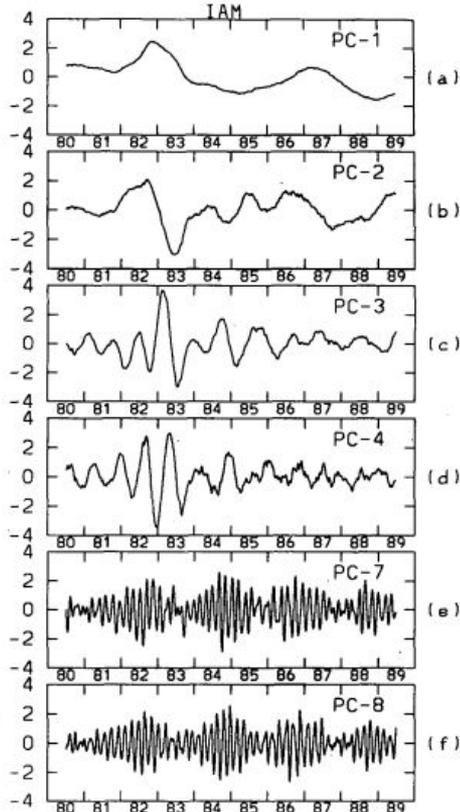


FIG. 10. Selected principal components (PC) of the IAM from singular spectrum analysis. Only the first few PCs or paired PCs indicating quasi-periodic oscillations are shown. Units are normalized by individual standard deviation.

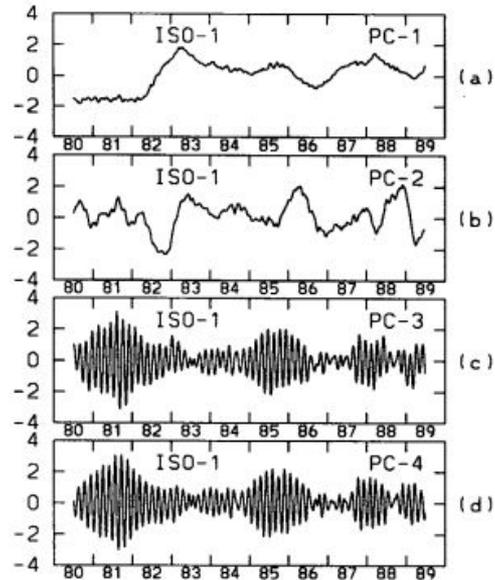


FIG. 11. As in Fig. 10 except for selected PCs of the ISO-1 modes indicating low-frequency background variation (PC1 and PC2) and quasi-periodic oscillations (PC3 and PC4).

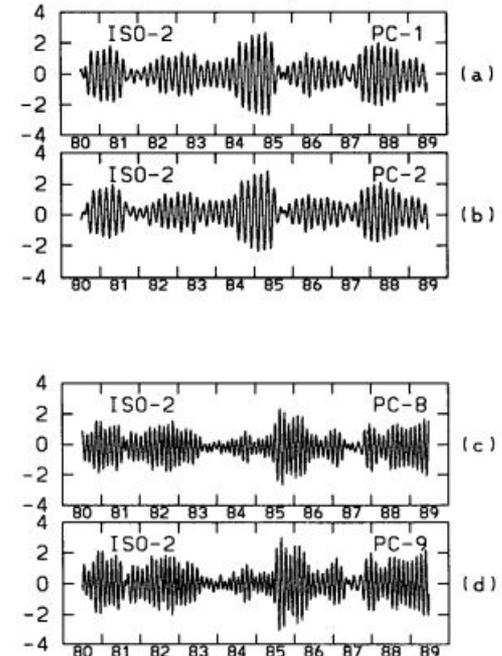


FIG. 12. As in Fig. 10 except for selected PCs of ISO-2 showing amplitude modulation of the 50–60 day oscillation (PC1 and PC2) and the 30–40 day oscillation (PC8 and PC9).

Figuras de Fase e Espaço

TABLE 3. Summary of the fundamental time scales and eigenfrequencies obtained from SSA and spectral analysis for each principal circulation mode. The ▼ indicates the dominant periodicities.

Modes	Period							
	>2 yr	Seasonal modulation	180–240	90–120	50–60 (days)	40–50	30–40	20–30
IAM	▼	X	X		X			
ISO-1	X	X			▼		X	
ISO-2		X			▼		X	X
ISO-3	X	X			▼		X	X
PNA		X	X		▼	X	X	X
NAE		X			▼		X	X
PSA-1				▼		▼	X	X
PSA-2				▼		▼	X	X

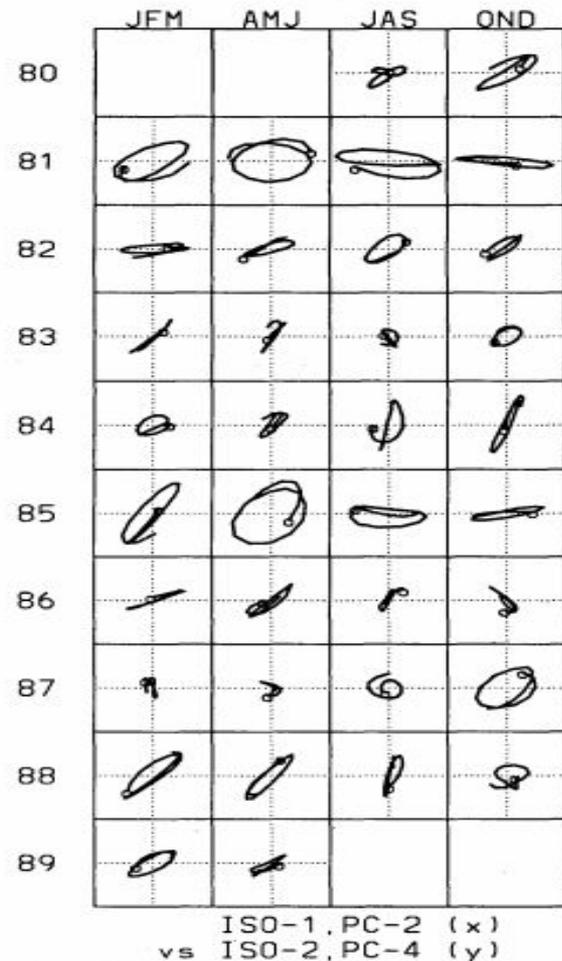


FIG. 16. Phase space portrait of climate state vector projected on to the ISO-1 and ISO-2 for the entire data period indicating the interannual variability of the phase coherence between the two major modes.

Figuras de Fase e Espaço

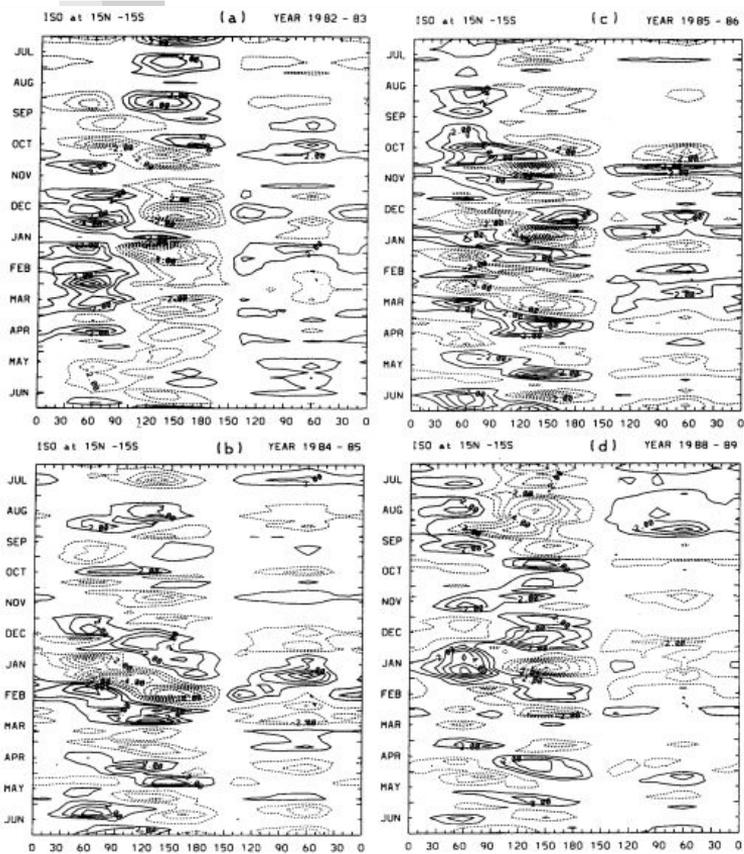


FIG. 18. Time-longitude section showing the propagation and stationary characteristics of the main feature of the intraseasonal oscillation based on the reconstruction of the ISO family of modes for (a) 1982-83, (b) 1983-84, (c) 1984-85, and (d) 1988-89. Units are in $10^{10} \text{ m}^2 \text{ s}^{-1}$.

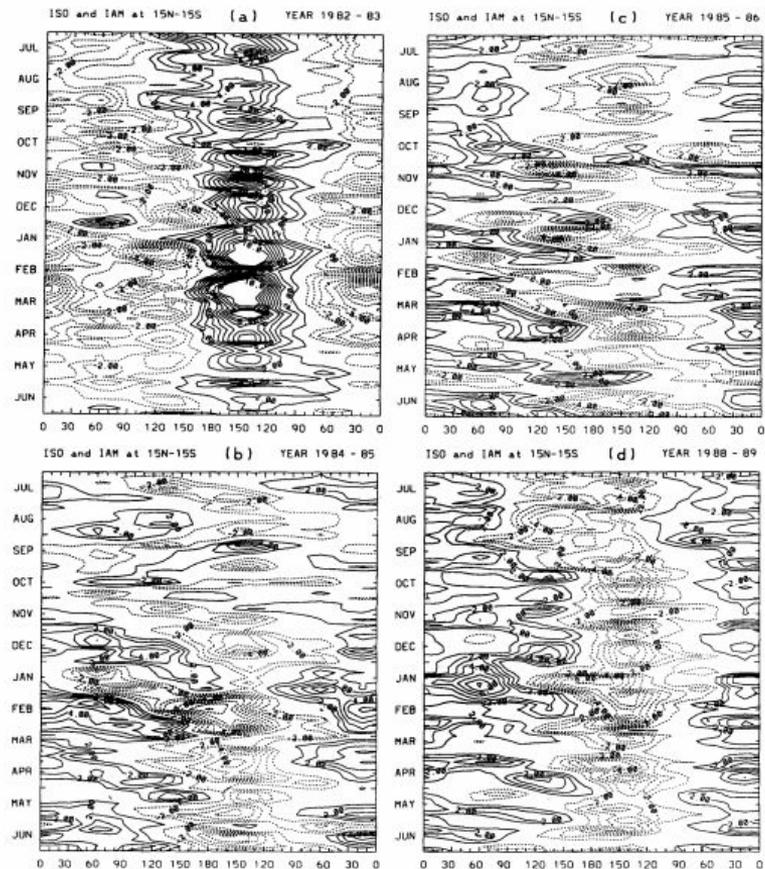


FIG. 19. As in Fig. 18 except for the reconstruction based on the ISO modes and the IAM.

Figuras de Fase e Espaço: Variância

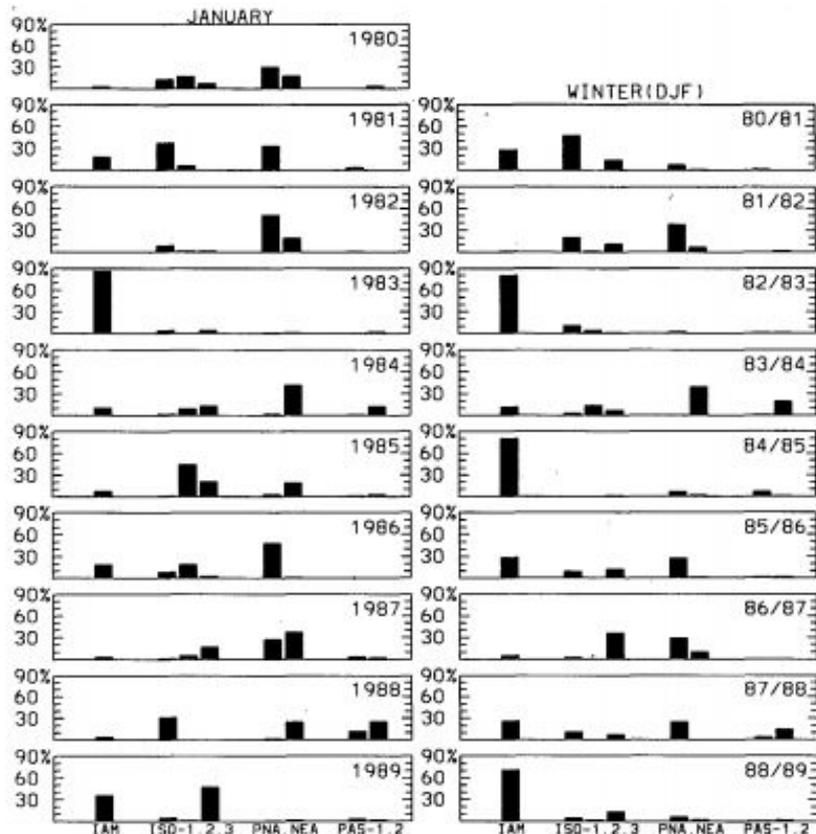


FIG. 22. Fractional variance relative to the first ten REOFs contributed by the different multiscale modes discussed in the text for the January anomalies (left panel) and the seasonal anomalies (right panel) for all years.

Conclusão

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1. Foram encontrados robustos modos de circulação de multiescala na atmosfera global em escalas de 10 dias ou mais;
 2. A inclusão da média zonal mostrava uma super rotação do fluxo, cuja variabilidade é dominada pelo ENSO e oscilações intrasazonais;
 3. Modos zonais assimétricos obtidos:
 - a. Modo Interanual (IAM): pode ser identificado em larga escala dos níveis superiores montando pares anticiclônicos e um dipolo de calor sobre o leste e oeste do Pacífico. Mostra oscilações de 30 a 60 dias;
 - b. Modo Tropical Intrasazonal (ISO): apresenta simetria em um ciclone duplo montado no Equador, similar ao IAM. Retrata em conjunto o complexo movimento da MJO do Oceano Índico;
 - c. Oscilação Extratropical Intrasazonal:
 - i. Hemisfério Norte Extratropical: PNA e NAE são caracterizados pela presença distinta de picos de frequência múltiplos no tempo da escala intrasazonal. Marca sazonalidade e pequenas alterações na circulação durante o inverno. Esses modos são independentes das forçantes tropicais
 - ii. Hemisfério Sul Extratropical: apresenta espaço e fase coerentes entre os modos sugeridos de propagação do trem de ondas para o leste extratropical. Independem da forçante tropical.



Obrigada a todos!