Decadal atmosphere-ocean variations in the Pacific

Trenberth, K.E. & Hurrell, J.W. Climate Dynamics (1994) 9: 303.

1. INTRODUÇÃO

- ATMOSFERA: memória curta
- OCEANOS: enorme inércia térmica
- Interação oceano-atmosfera: variações climática

- Neste estudo: variações recentes na escala de tempo decadal envolvendo atmosfera e oceano no Pacífico norte + links com outras partes do globo

- Namias (1959, 1963, 1969): variações climáticas no Pacífico norte e teleconexões com a América do Norte
- Na época do estudo: evidências de mudança decadal na atmosfera e oceano na região do PN, começando ~1976

- Trenberth (1990): estudo das mudanças na circulação atmosférica na troposfera neste período
  - Associação com mudanças na tensão do vento em superfície e mudanças nas correntes

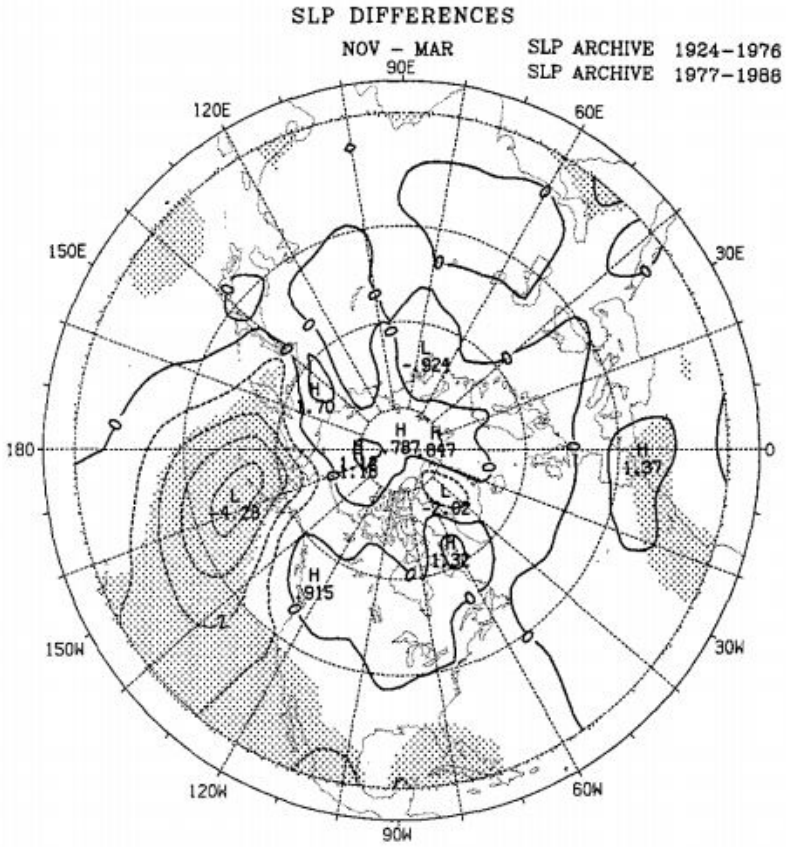
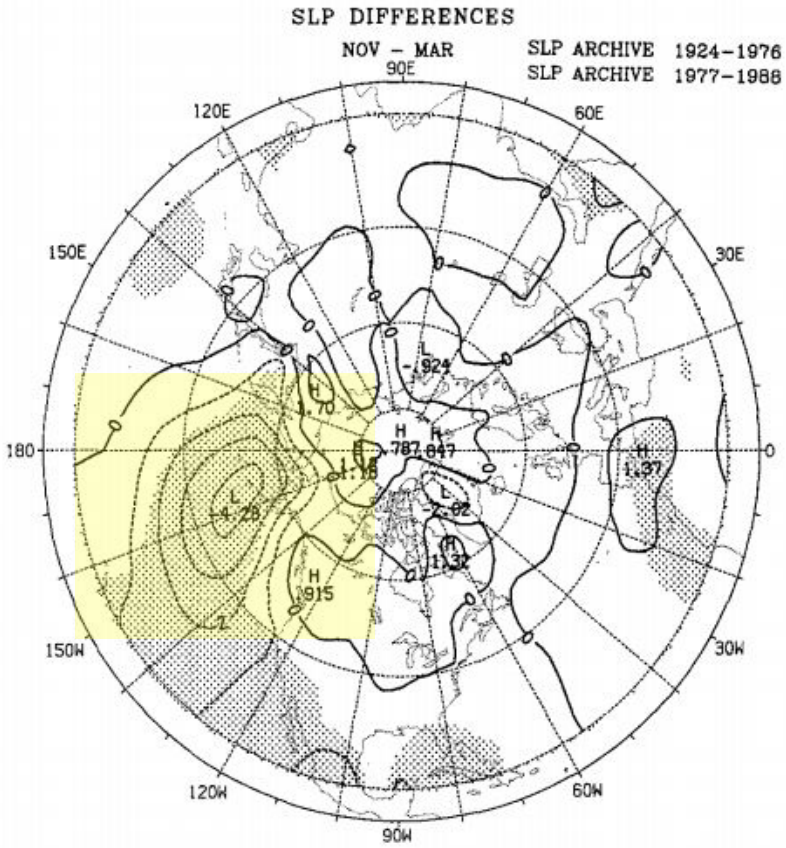


Fig. 1. The difference in mean sea level pressures from 1977 to 1988 for November through March versus 1924 to 1976 (mb). *Stippling* indicates statistical significance at 5%. From Trenberth (1990)



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Baixa das Aleutas mais intensa

- Mudanças:
  - *Storm tracks* (Rogers e Raphael 1992; Lau 1988)
  - Fluxos de calor latente e sensível (Cayan 1992)
  - Advecção de temperatura e umidade (Rogers e Raphael 1992)
  - Temperaturas ao longo da costa oeste dos EUA (Salmon 1992)
  - TSMs no Pacífico norte (Trenberth 1990)
  - Chuvas nas áreas costeiras(Cayan e Peterson 1989)
  - Gelo no mar de Bering (Manak e Mysak 1987)
  - Maior incidência de frentes nas planícies norte-americanas, afetando as culturas cítricas (Rogers e Rohli 1991; Downton e Miller 1993)
- Mudanças nos nutrientes das águas e mudanças nos padrões de migração dos peixes

- Trenberth (1990): série temporal até inverno de 1987-88

2. TENDÊNCIAS OBSERVADAS EM LARGA ESCALA NO PACÍFICO NORTE

- Associação entre as anomalias de TSM e a circulação atmosférica no Pacífico norte (Namias (1959, 1963, 1969), Namias et al. (1988), Davis (1976, 1978), Lanzante(1984), e Wallace et al. (1990))
- As mudanças na temp. da superfície vêm das mudanças de temperatura e advecção de umidade sobre os oceanos, por ventos anômalos e mudanças nos fluxos turbulentos verticais e horizontais

2.1. ÍNDICES DE CIRCULAÇÃO

- TSMs: padrão claro na modo dominante da EOF ⇔ modo preferencial de variabilidade no inverno do HN (similar ao padrão da PNA de Wallace e Gutzler em 1981)
  - PNA: 4 centros de sinais opostos
  - Índice PNA: média mensal de altura geopotencial em 500mb nos 4 centros
  - Útil mas não pesa corretamente os 4 centros; erro nos valores únicos
- Neste estudo: pressão ao nível do mar entre 30-65°N, 160° E-140°W ⇔ índice NP (north Pacific)
- Entre 1947-1991: correlação entre NP e PNA é -0.91
- NP: mostra o padrão PNA e mudanças na intensidade da baixa Aleutiana no inverno

2.2. ESCALA DE TEMPO DO ÍNDICE NP

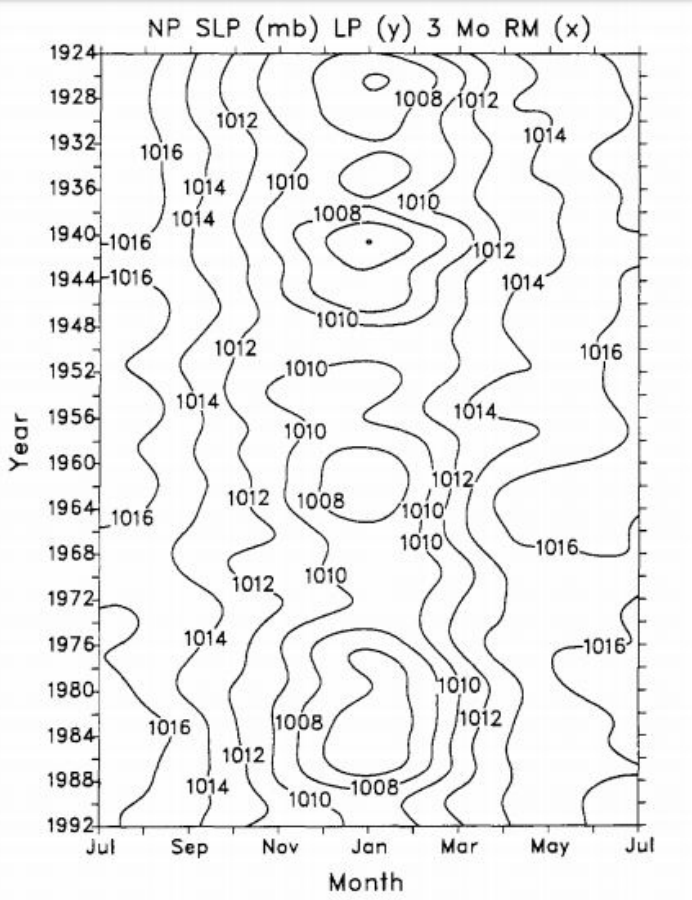
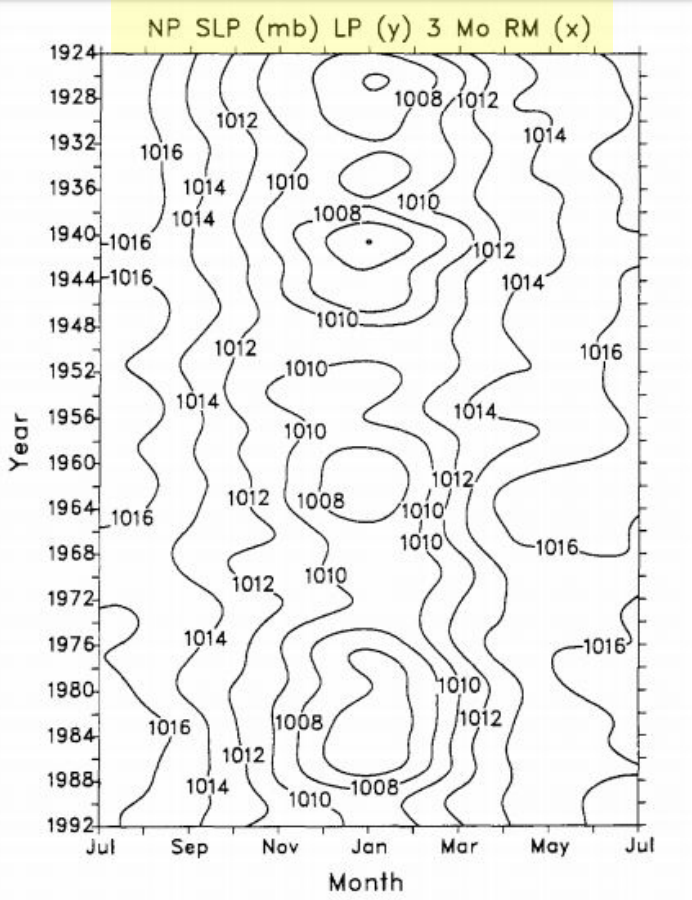


Fig. 2. Time series of NP, the mean north Pacific sea level pressures averaged over 30 to 65°N, 160°E to 140°W as a function of month and time. Shown is the total three-monthly mean values smoothed with a low pass filter with seven weights (1, 4, 8, 10, 8, 4, 1)/36 across years to emphasize the decadal time scales in mb



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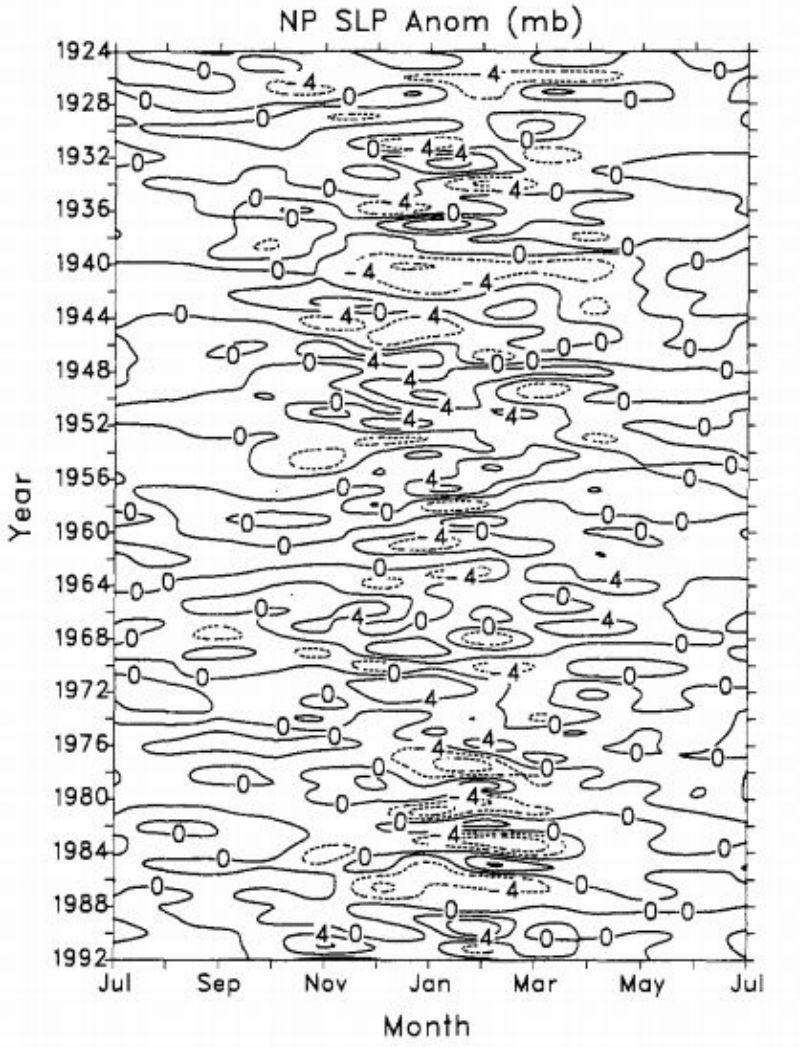
NP para todos os meses; média 3 meses (1924 - 1992)



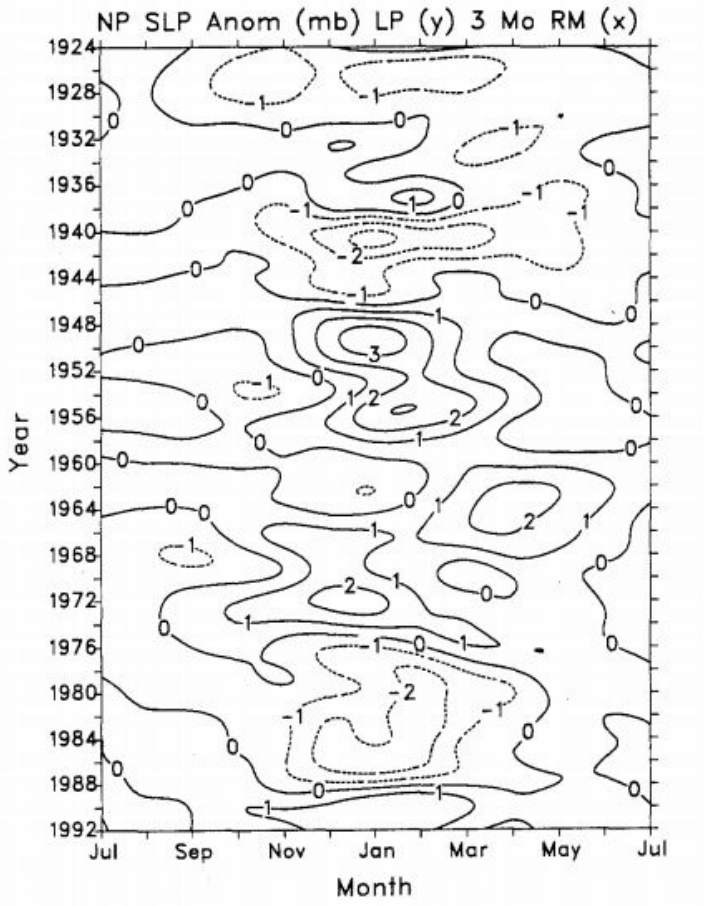
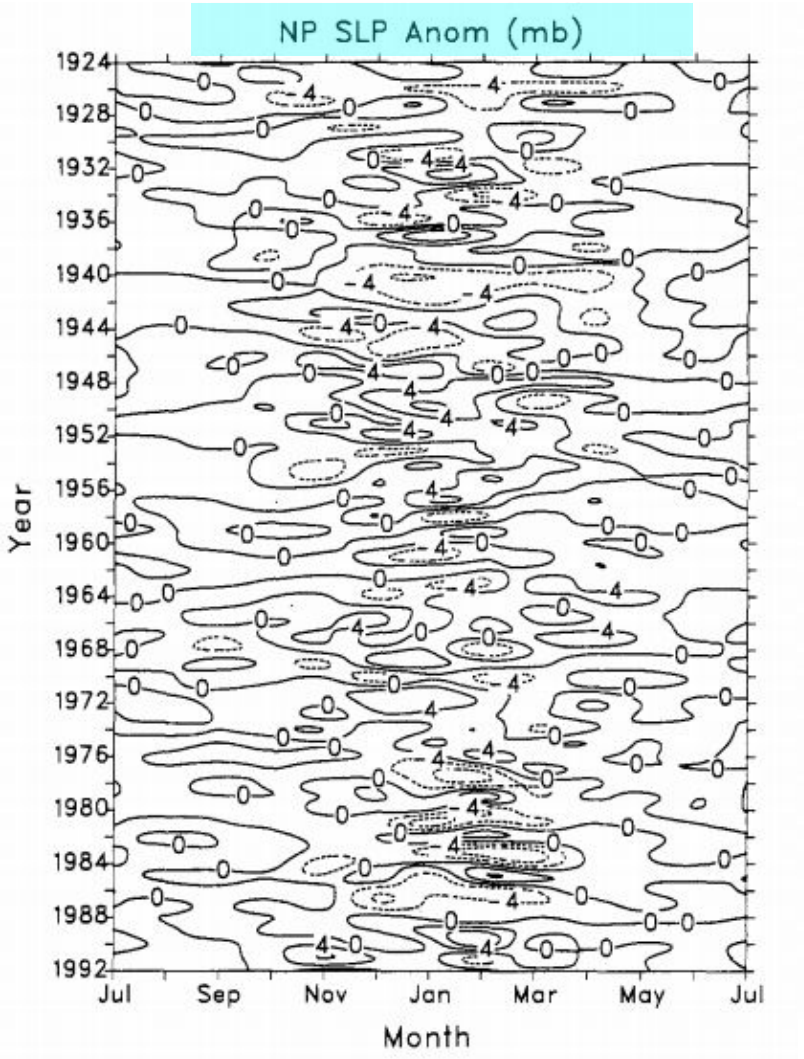
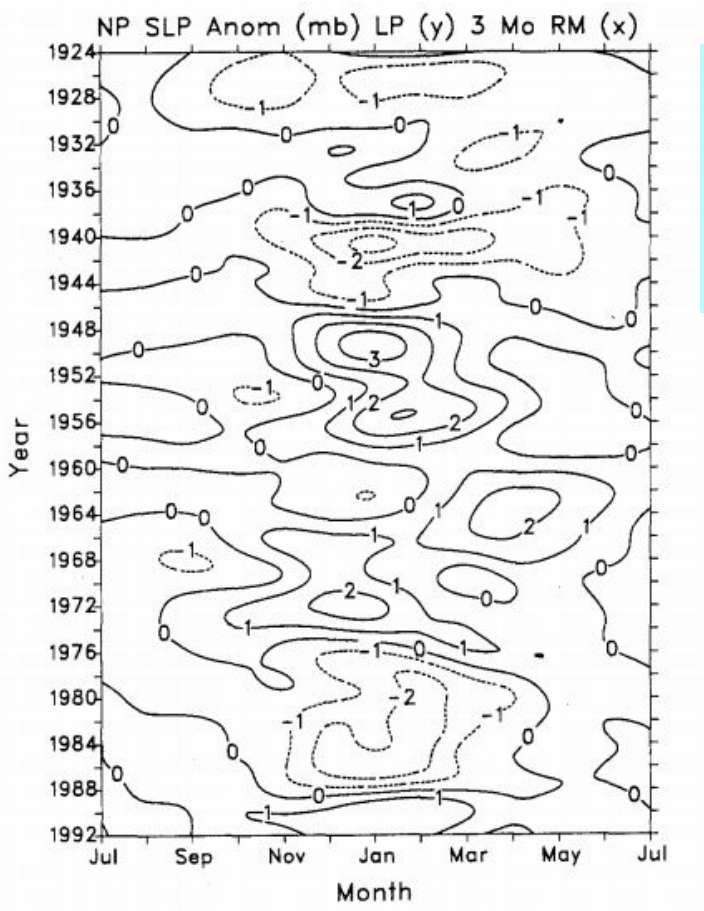


Fig. 3. As in Fig. 2 but *top* monthly mean anomalies in mb, and *bottom* seasonal (three month) mean anomalies smoothed with the low pass filter in mb





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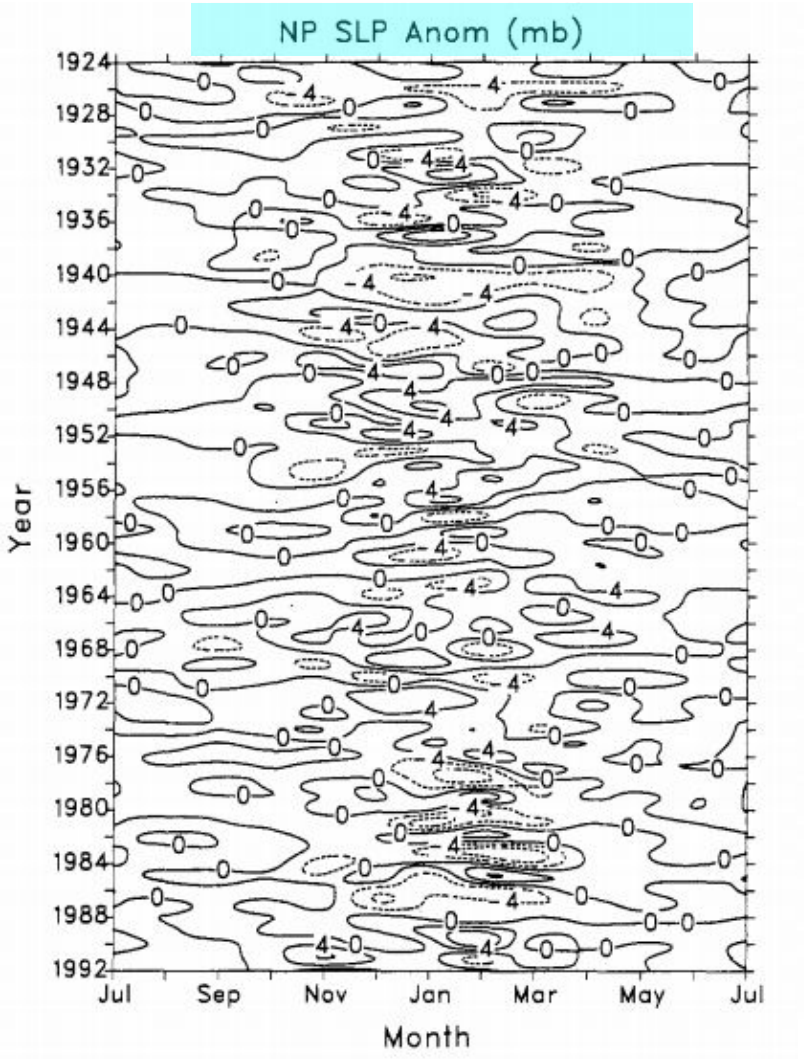
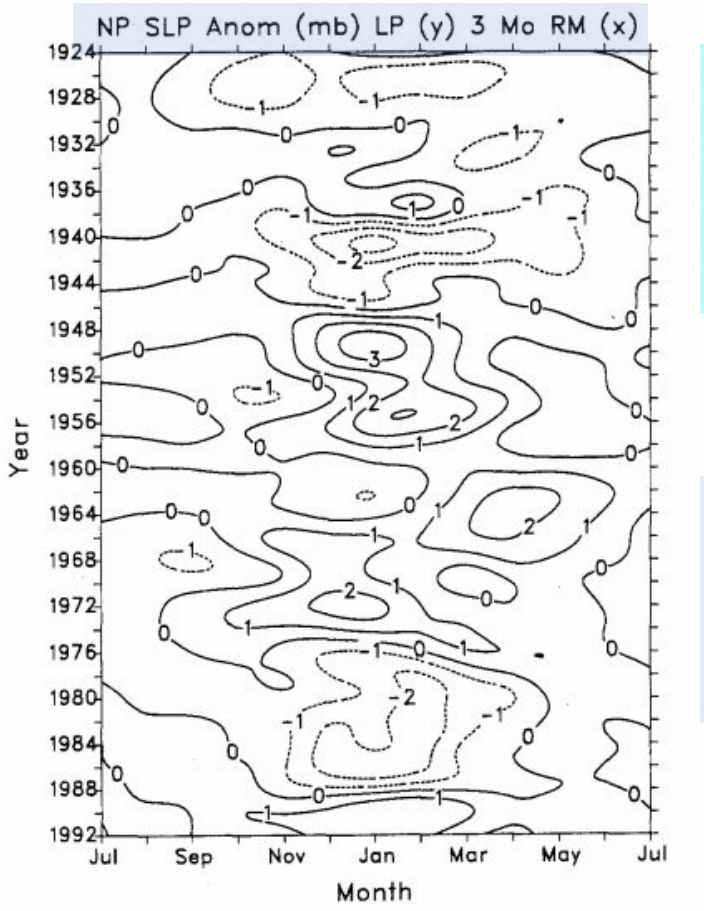
Valores mensais (sem ciclo anual médio); muito ruído





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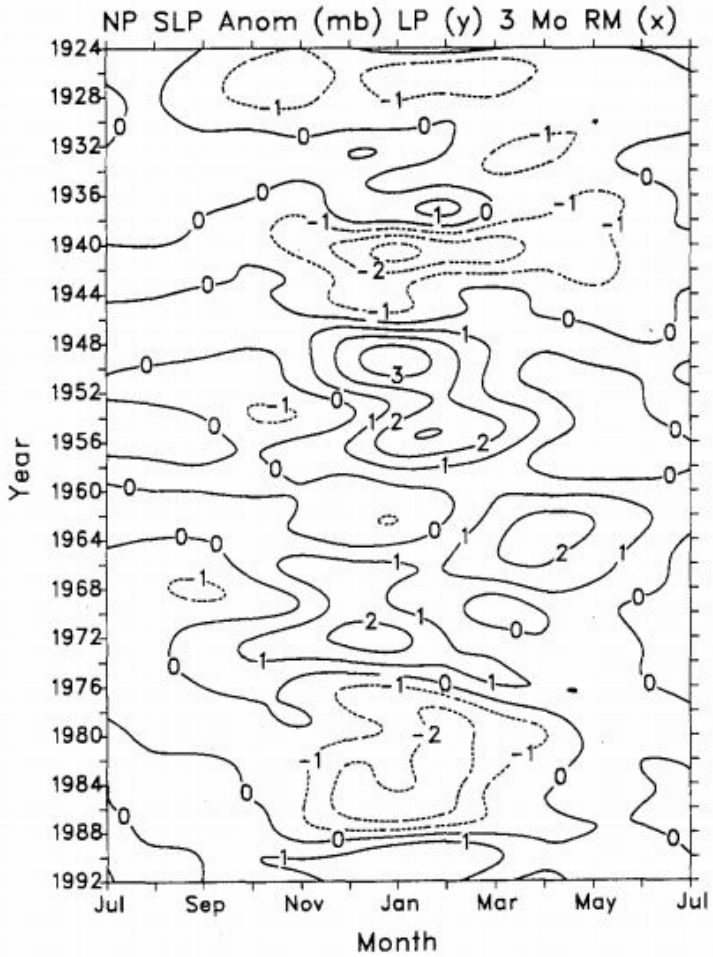
Valores mensais (sem ciclo anual médio); muito ruído

Versão suavizada da Fig. 2; anomalias mais persistentes



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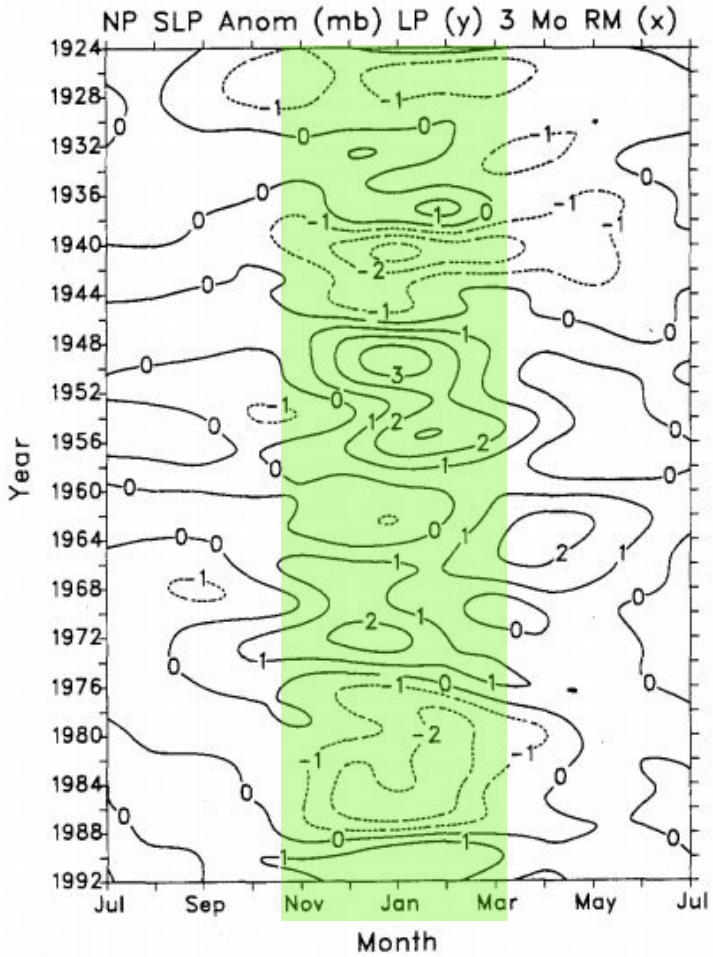

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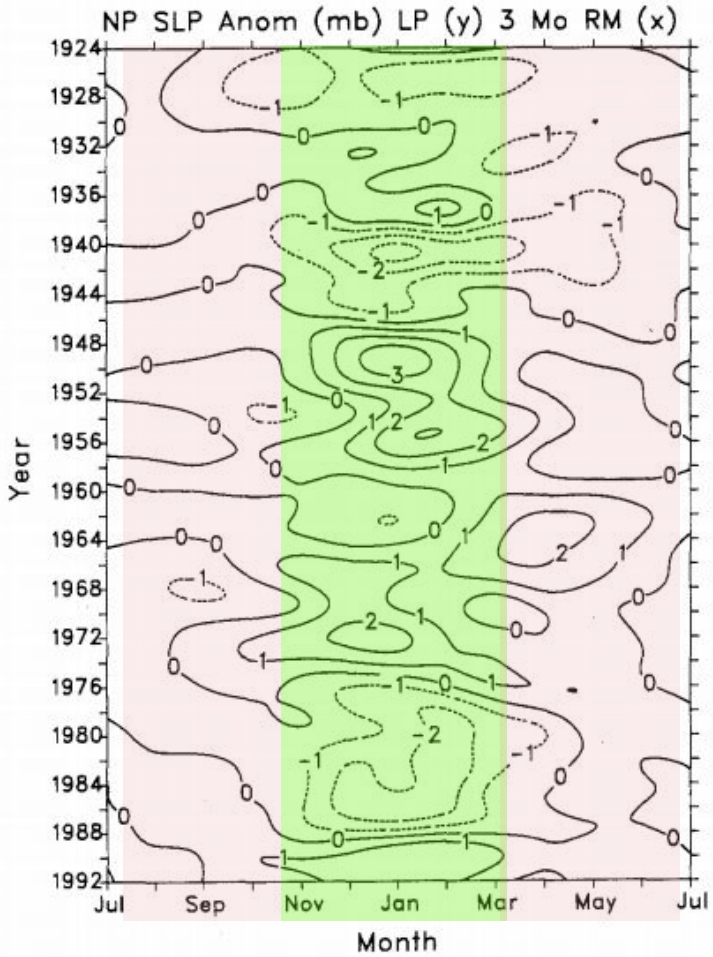
Nov a Mar: inverno; baixas pressões no Pacífico

Período com maior variabilidade



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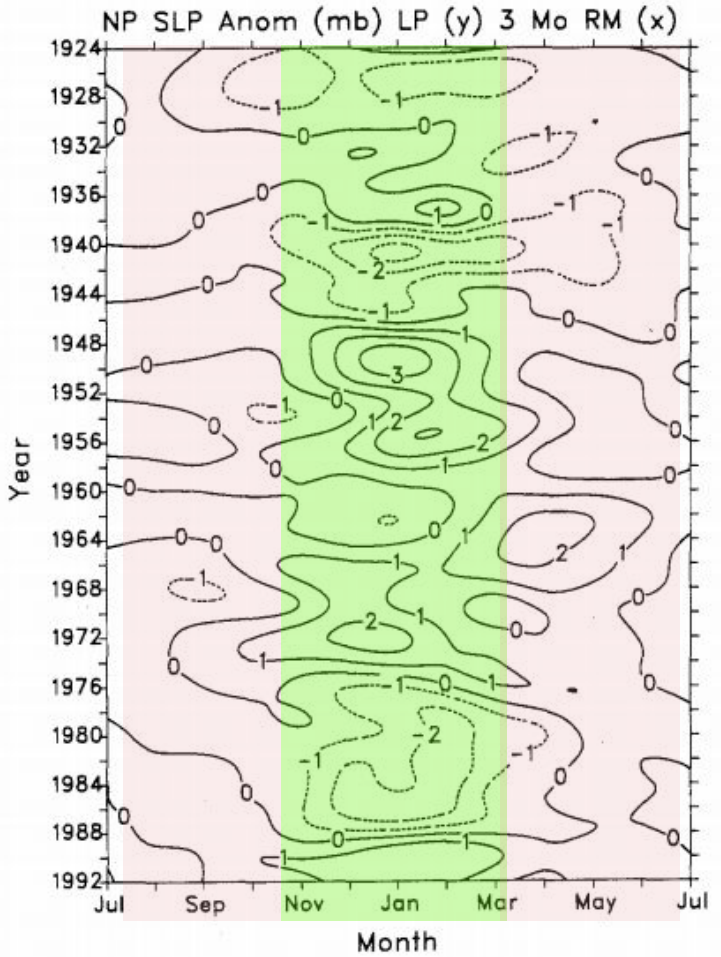
Nov a Mar: inverno; baixas pressões no Pacífico

Período com maior variabilidade

Resto do ano: domínio do anticiclone subtropical



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Nov a Mar: inverno; baixas pressões no Pacífico

Período com maior variabilidade

Resto do ano: domínio do anticiclone subtropical

Variações mensais num mesmo inverno vêm dos transientes, que ficam mal representados em dados mensais

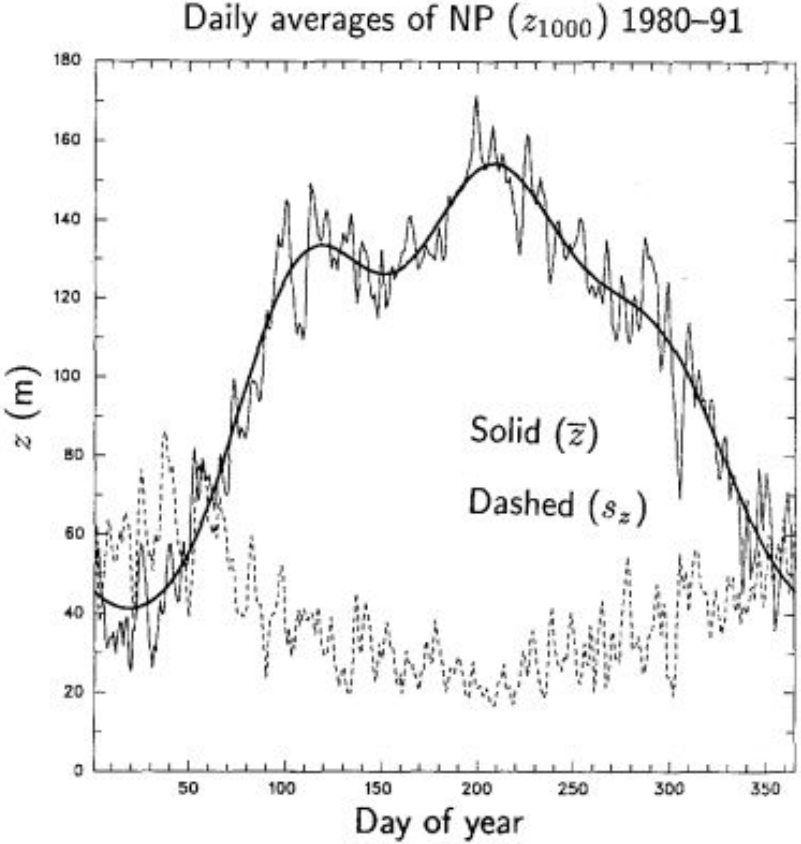
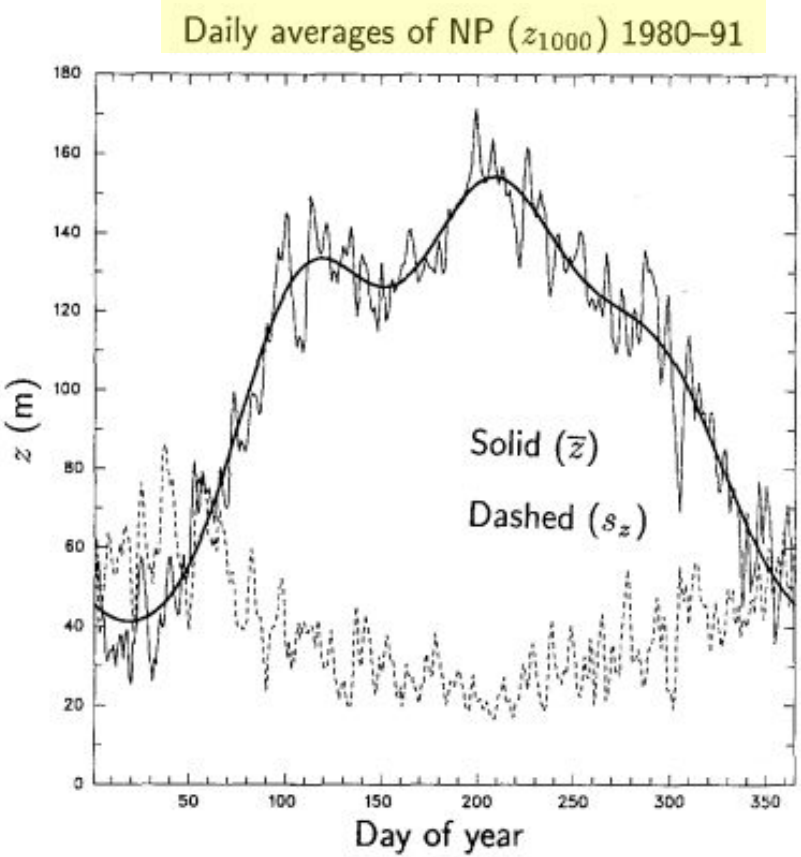


Fig. 4. Daily averages (*thin solid*) and standard deviations (*dashed*) of the NP index in the form of the 1000 mb height as a function of day of the year. Averages are over the twelve years 1980 to 1991. The *heavy solid curve* shows the fit of the first four harmonics to the mean annual cycle



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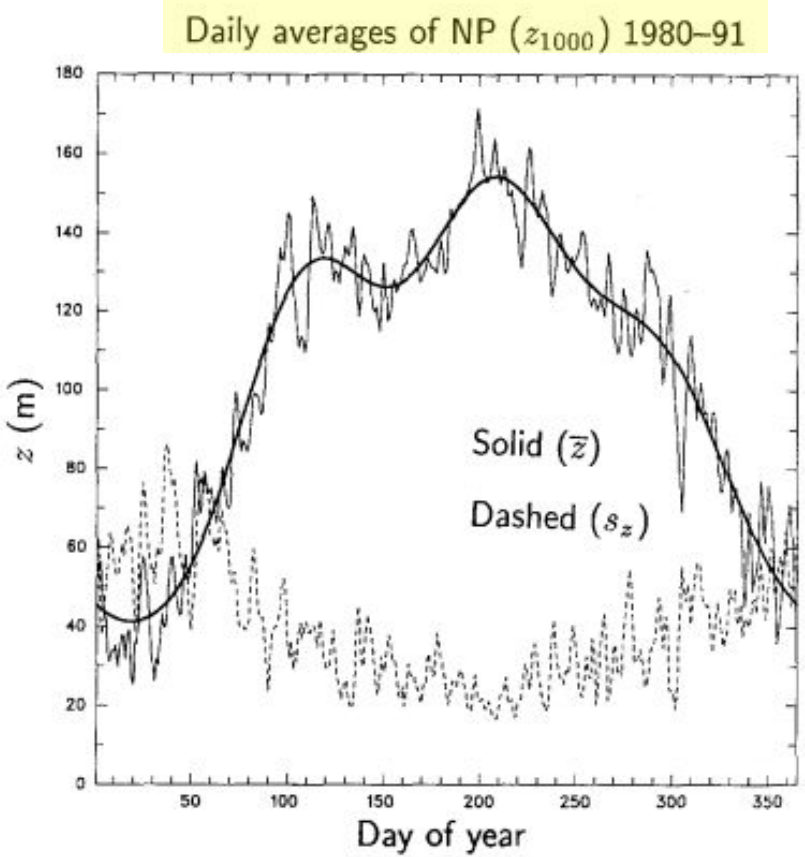
Dados diários de altura geopotencial em 1000mb, do ECMWF 1980-1991



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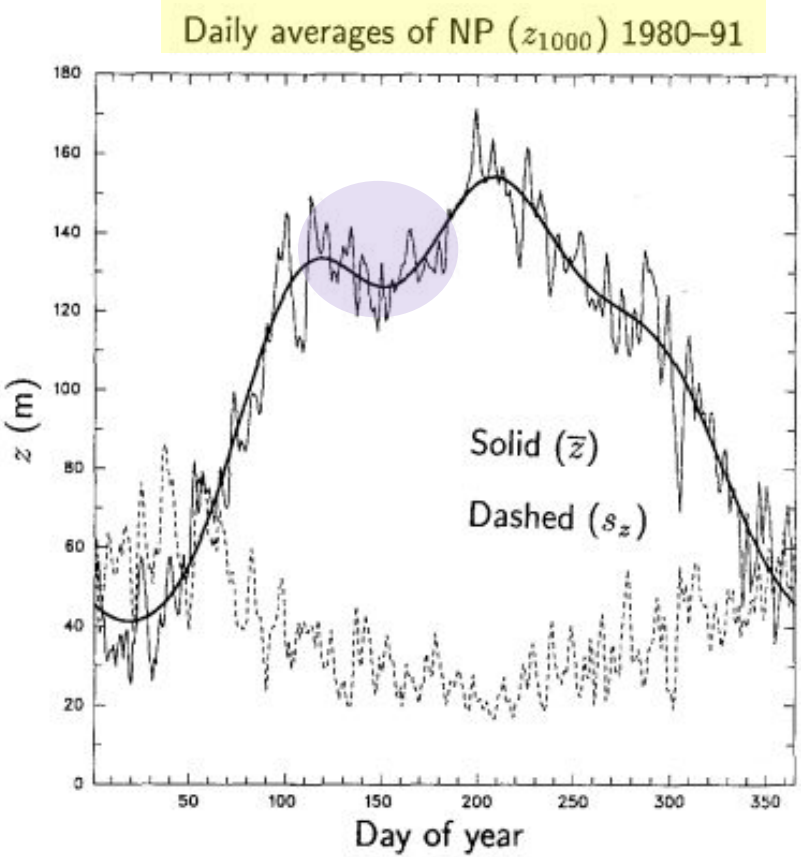
Menores valores de NP no inverno e maior variabilidade de NOV a MAR



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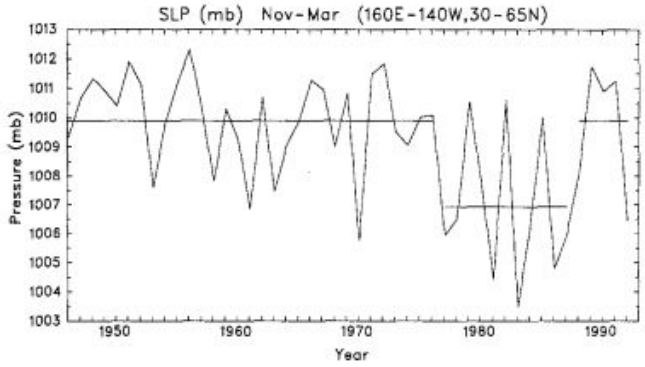

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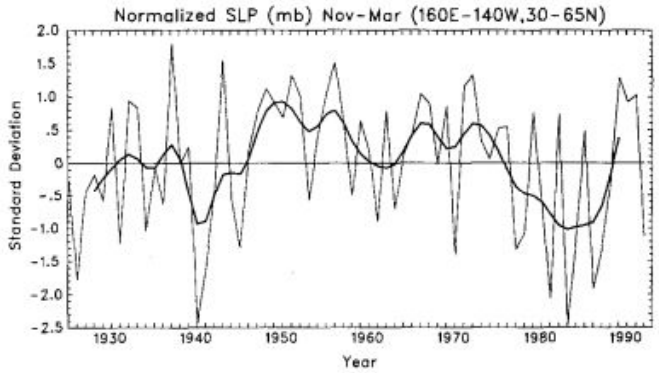
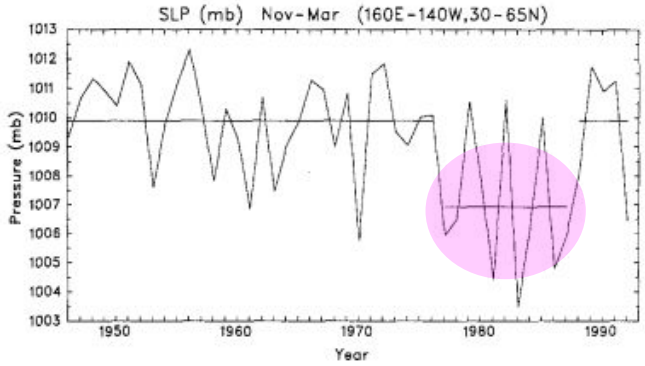


Fig. 7. Time series of mean north Pacific sea level pressures for November through March, as in Fig. 3, but beginning in 1925 and smoothed with the low pass filter



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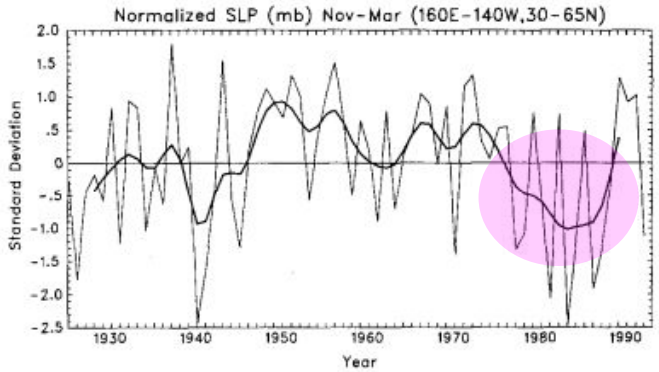

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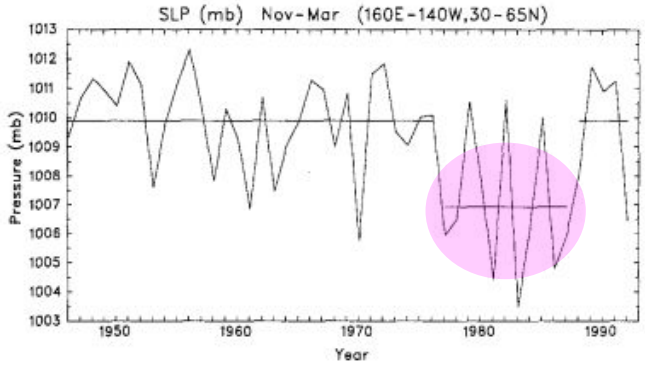
1976 - 1988



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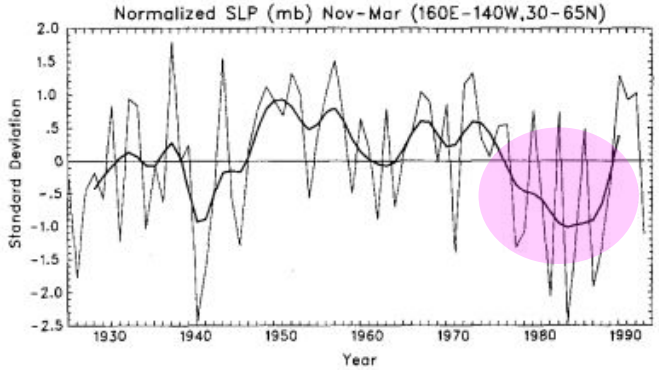

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1976 - 1988

Variabilidade interanual

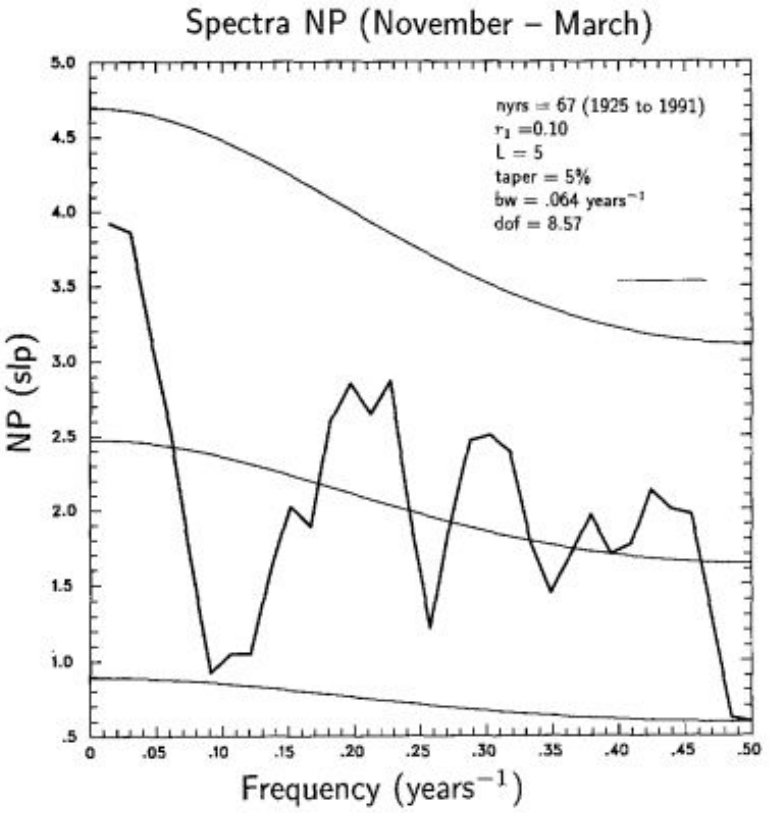
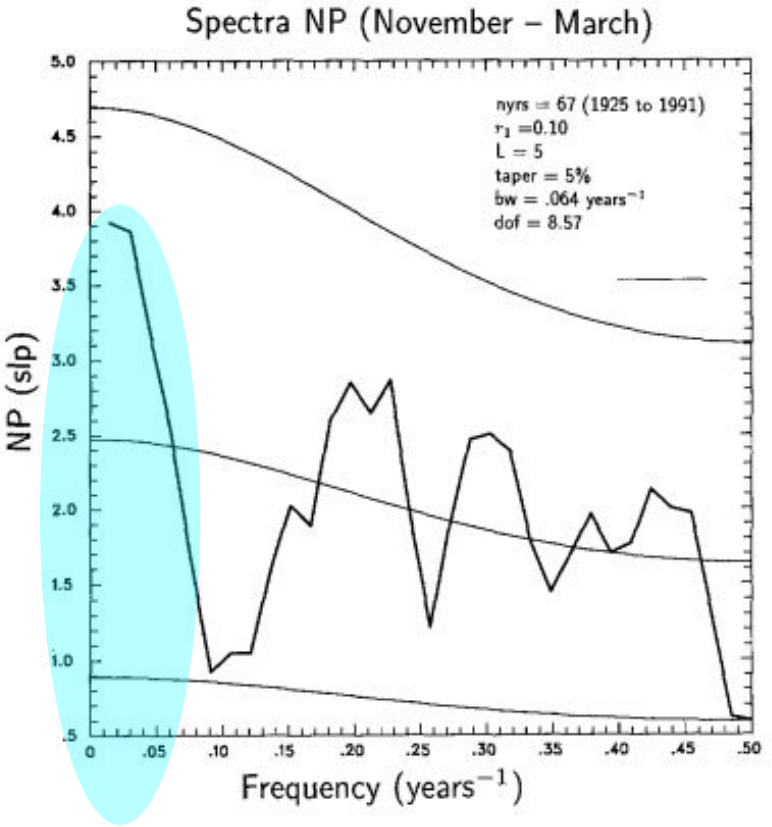


Fig. 8. Power spectrum of the NP index for November through March averages for the 67 years from 1924–25 to 1990–91. A taper of 5% of the values at each end was applied and the spectral estimates were averaged over 5 values. Also shown is the corresponding red noise spectrum with the same lag one autocorrelation coefficient (0.91) and the 5 and 95% confidence limits



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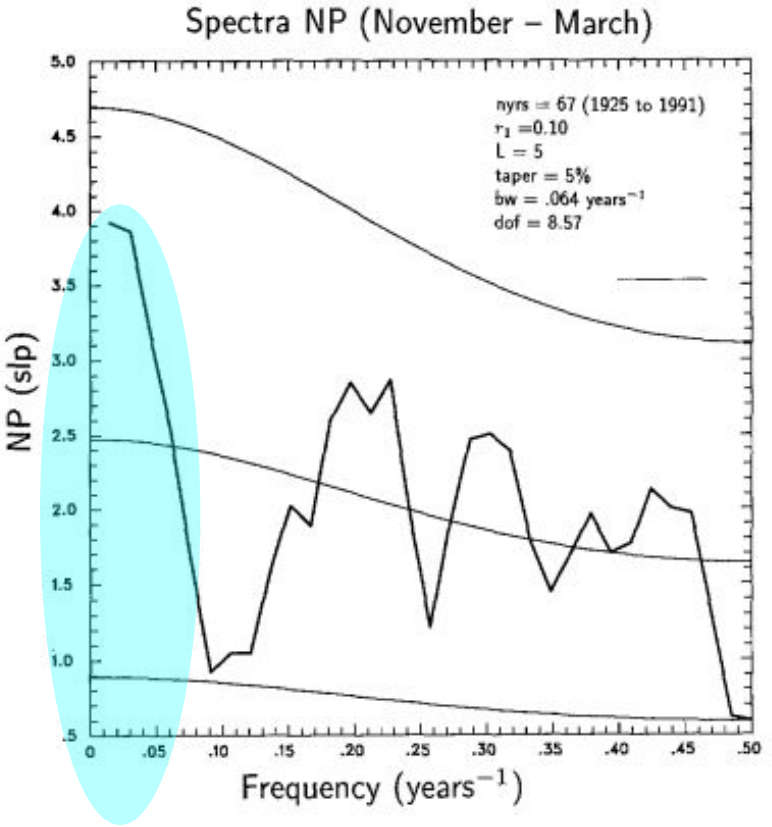
Interdecadal



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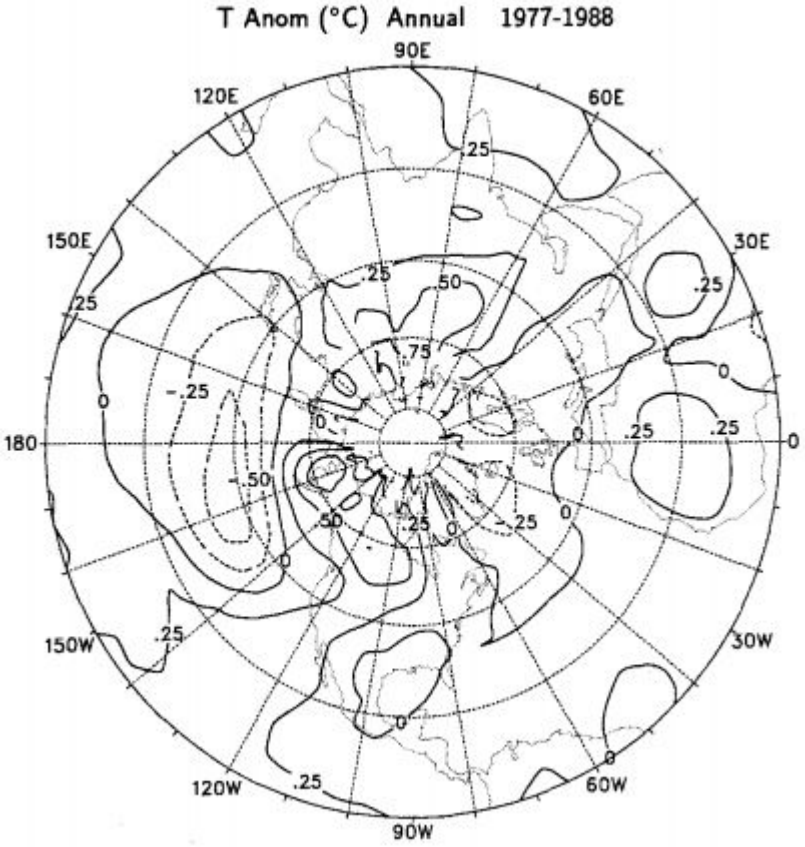
Interdecadal

ENSO

2.3. RELAÇÕES OBSERVADAS



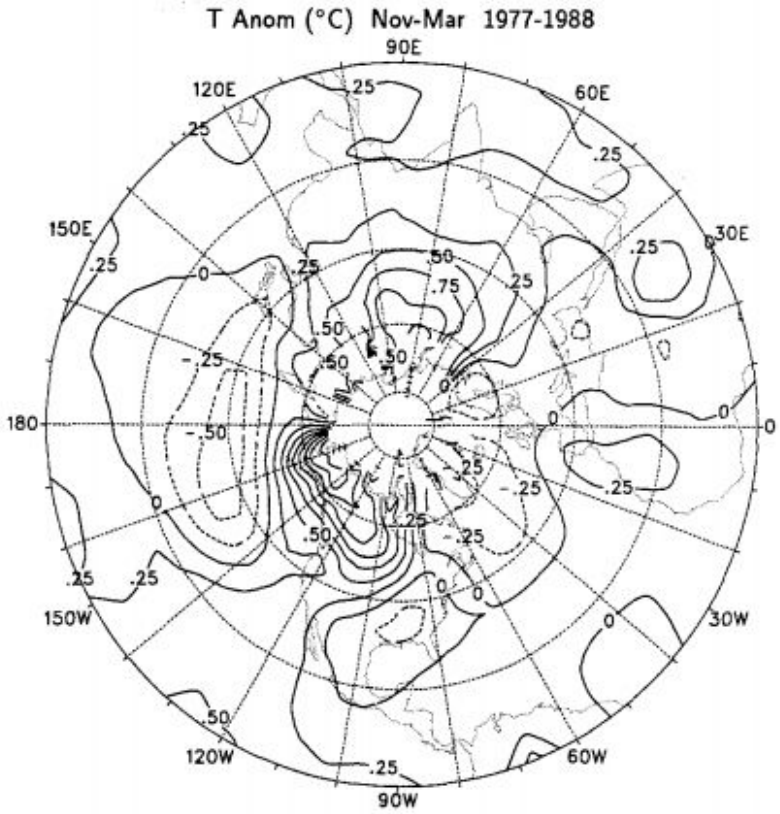
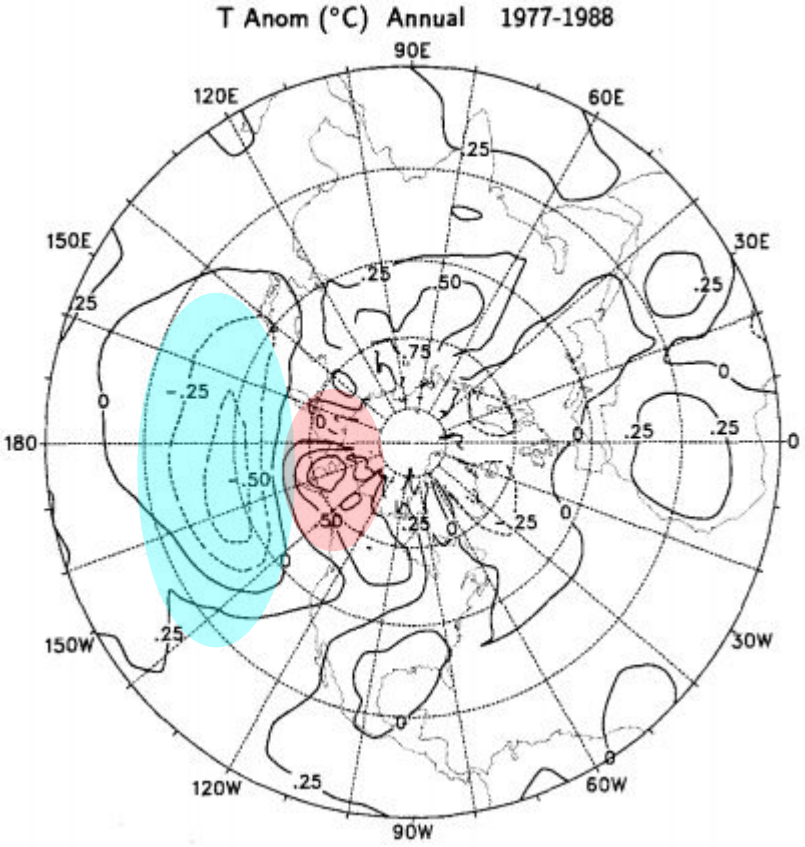
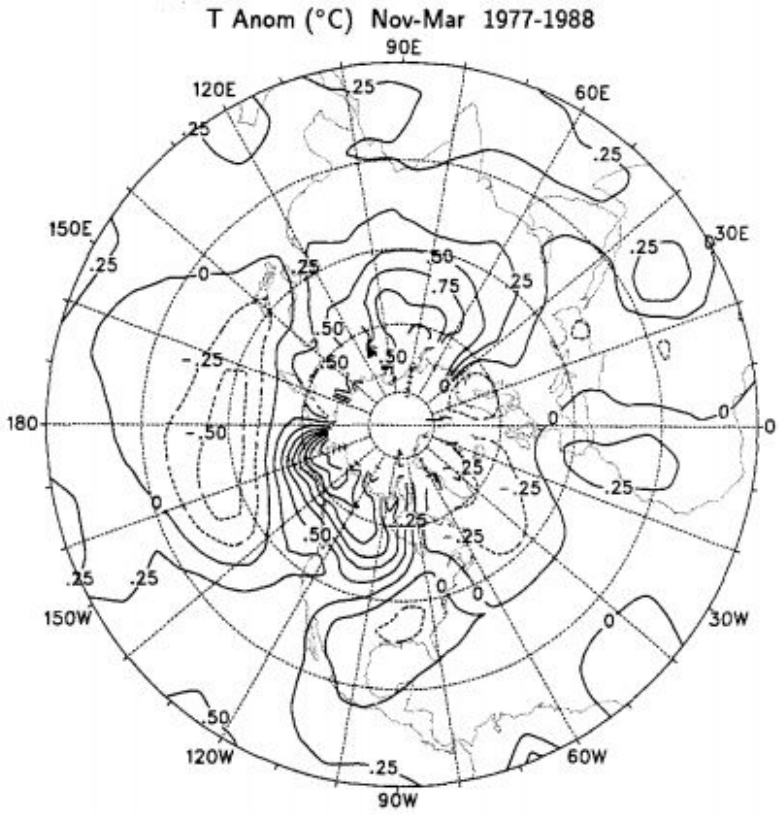


Fig. 9. Twelve year (1977–1988) average surface temperature or sea surface temperature anomalies as departures from the 1951–1980 mean. *Contours* every 0.25°C. Shown are the annual mean anomalies and the anomalies for the 5 winter months (November to March). Negative values are *dashed*





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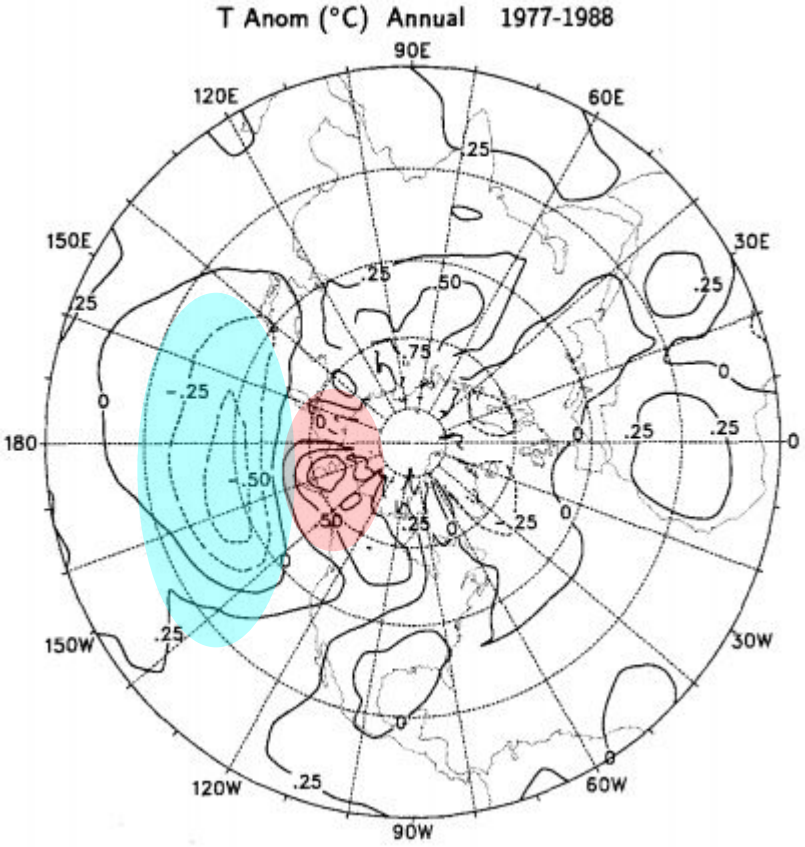

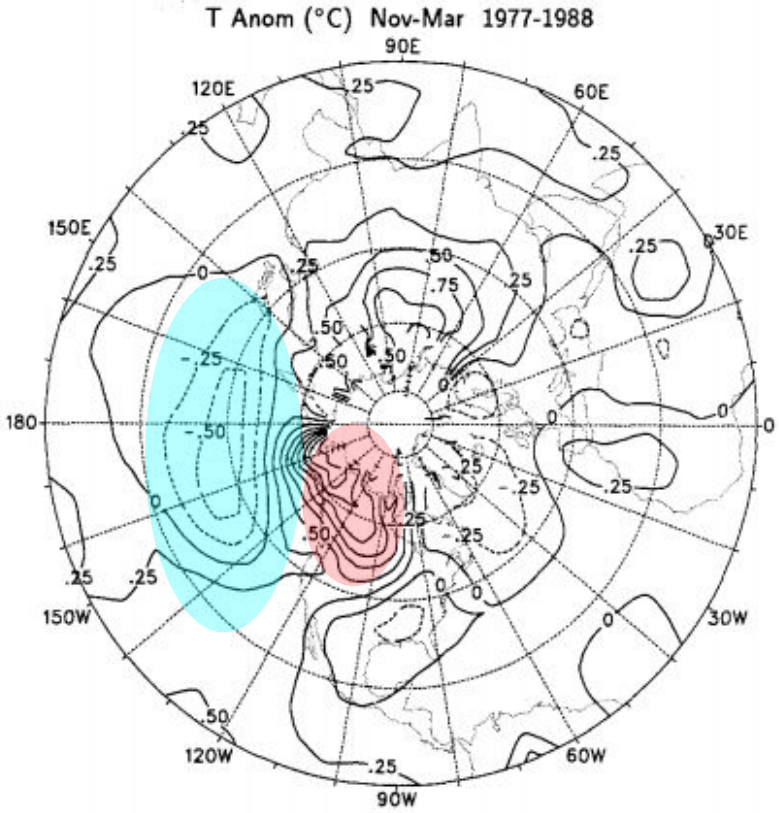

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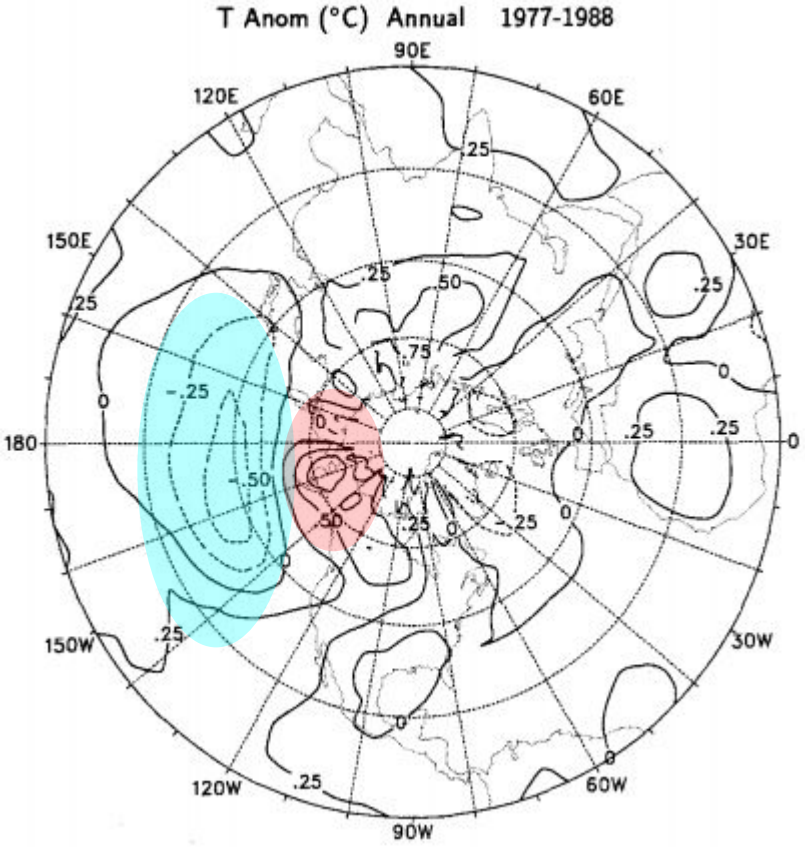

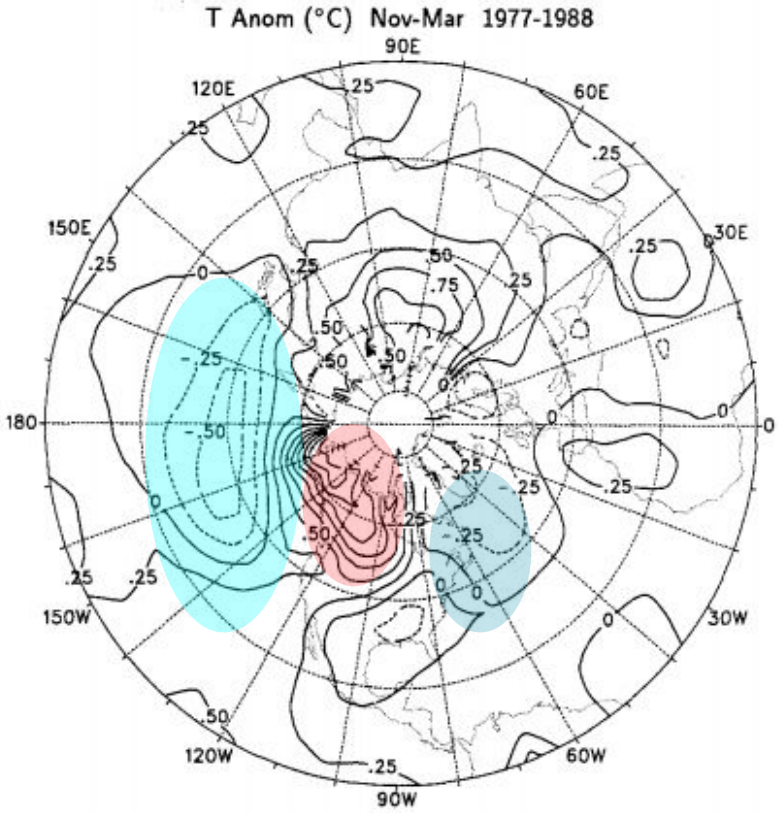

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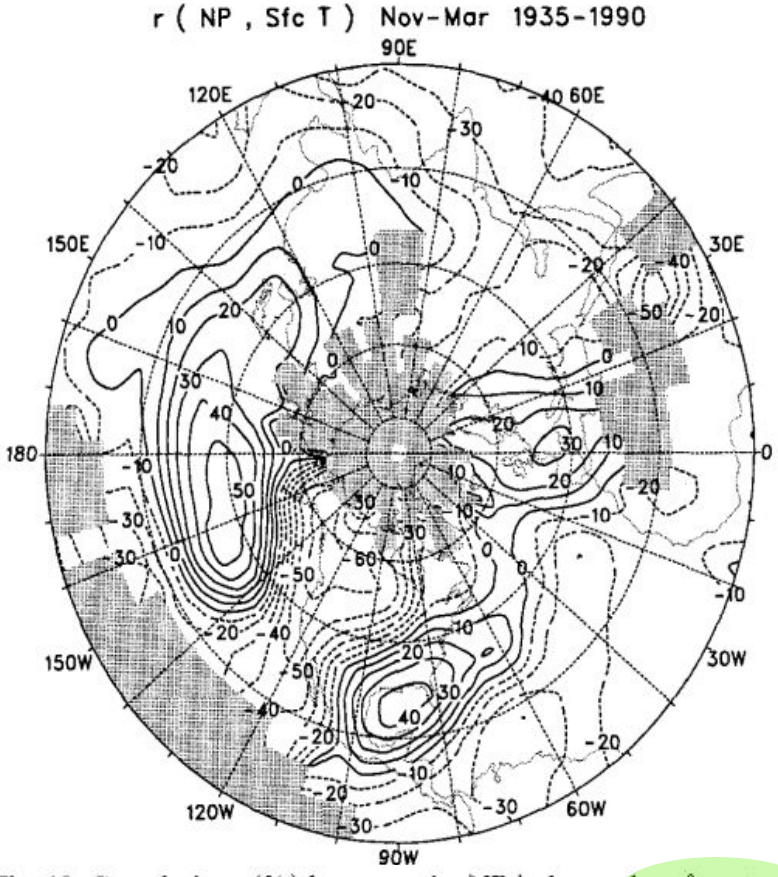


Fig. 10. Correlations (%) between the NP index and surface temperatures for 1935 to 1990 and corresponding departure pattern corresponding to a unit standard deviation of NP. Negative values are *dashed*. The 5% significance level is 0.27. *Shaded areas* indicate insufficient data

PNA

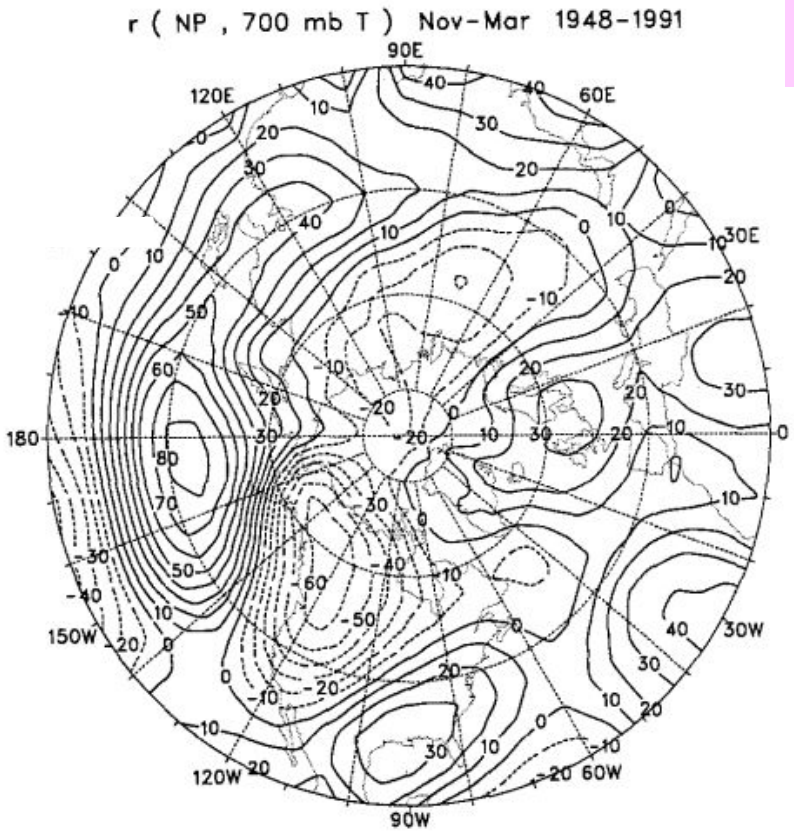


Fig. 11. Correlations (%) between the NP index in Fig. 6 and 700 mb temperatures. Negative values are *dashed.* The 5% significance level is 0.30. 20% of the variance is accounted for by the correlations over the 140°E to 60°W, 30–65°N region

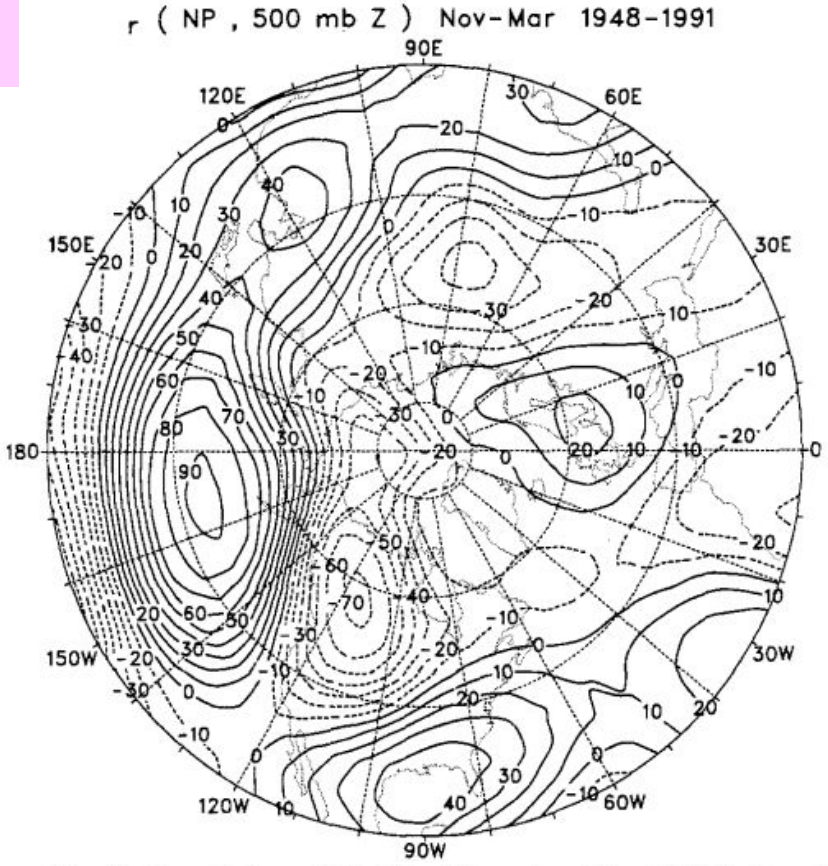
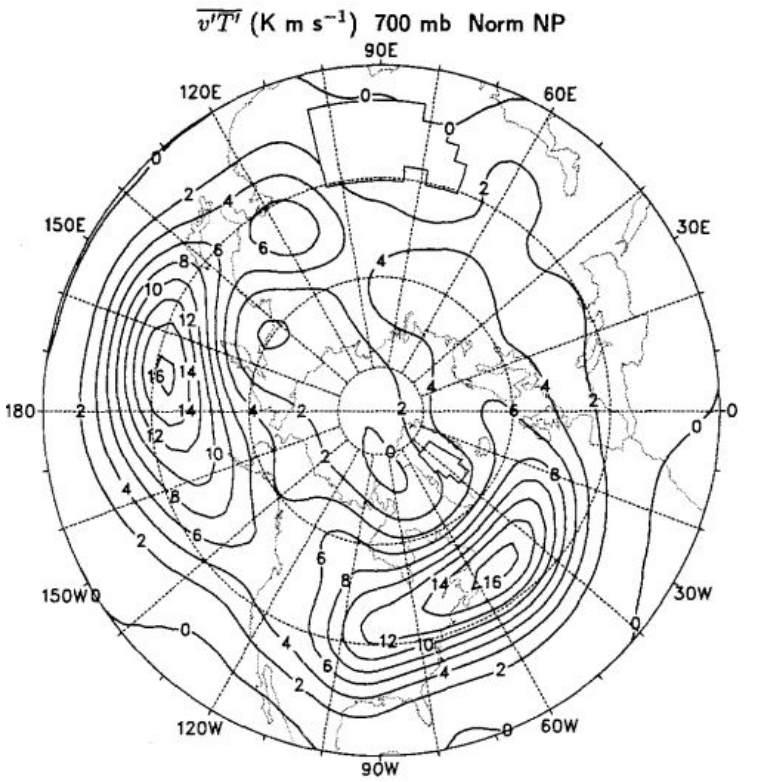


Fig. 12. Correlations (%) of the November–March NP index with 500 mb heights for 1948 to 1991 and corresponding departure pattern corresponding to a unit standard deviation of NP. Negative values are *dashed.* 26% of the variance is accounted for by the correlations over the 140°E to 60°W, 30–65°N region

3. MUDANÇAS NOS *STORM TRACKS* E SEUS EFEITOS NO FLUXO MÉDIO

- Dados bons após 1979



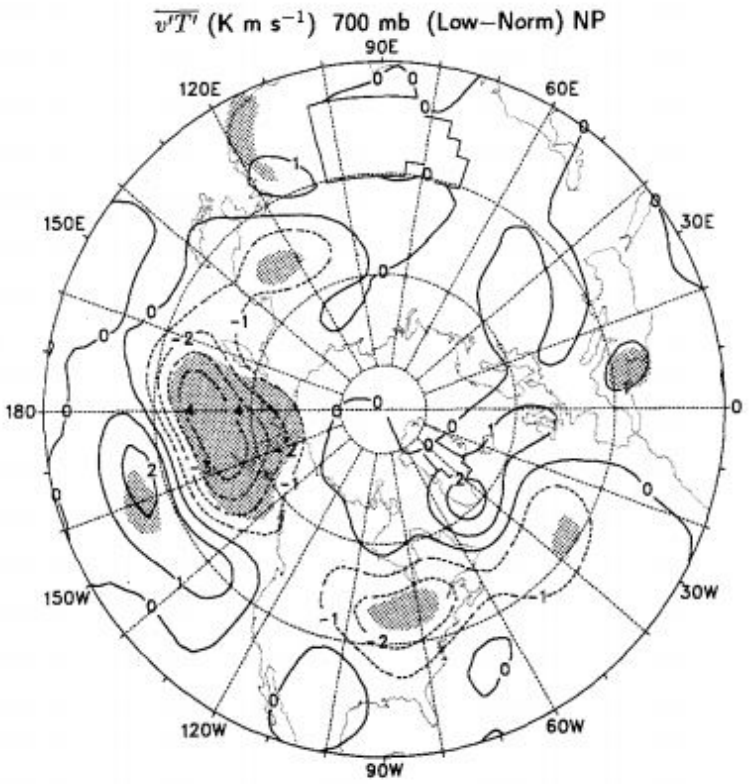
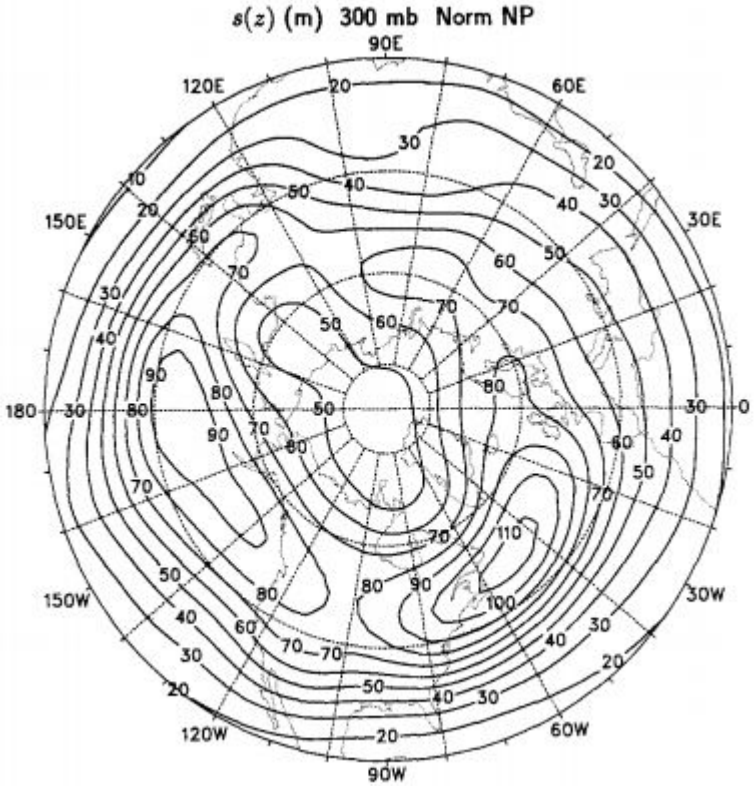


Fig. 13. Mean storm tracks for normal NP years and the anomalies, low – normal NP values, as revealed by the 700 mb transient eddy heat flux $\overline{v'T'}$ bandpassed to include 2 to 8 day period fluctuations, K m s^{-1}. Negative values are *dashed* and results are smoothed to T21 resolution. Values significantly different from zero at the 5% level using a t test are *stippled* on the *lower panel*

Mudança para sul na atividade convectiva; redução na América do Norte



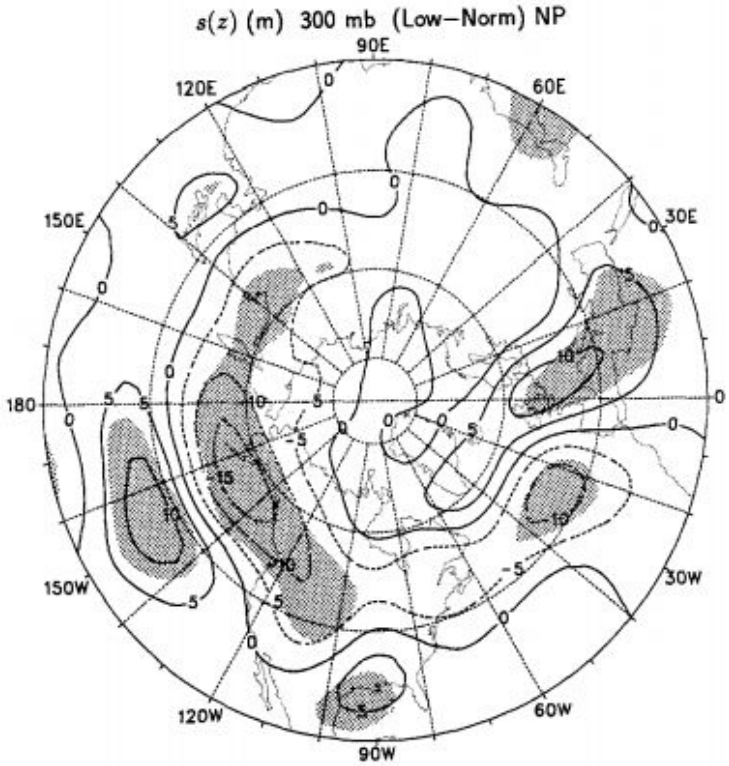


Fig. 14. Mean storm tracks for normal NP years and the anomalies, low – normal NP values, as revealed by the 300 mb root mean square transient geopotential height $s(z)$ bandpassed to include 2 to 8 day period fluctuations, m. Negative values are *dashed* and results are smoothed to T21 resolution. Values significantly different from zero at the 5% level using a t test are *stippled* on the *lower panel*

Mudança para sul dos *storm tracks*;

- Mudanças nos *storm tracks*: possibilidade de que os fluxos de calor, umidade e momento associados a eles tenham ajudado a manter as anomalias na circulação média

4. CAUSAS DAS MUDANÇAS NO PACÍFICO NORTE

- Influência das anomalias de TSM nos extratrópicos
- Mudanças nos transportes de fluxos pelos eddies
- Efeitos do aquecimento atmosférico podem não ser locais

5. RELAÇÕES COM O PACÍFICO TROPICAL

- 1976-77 a 1987-88: 3 eventos de El Niño, sem eventos compensadores de La Niña
  - Pacífico: anomalias positivas de TSM
  - Índice negativo da Oscilação Sul

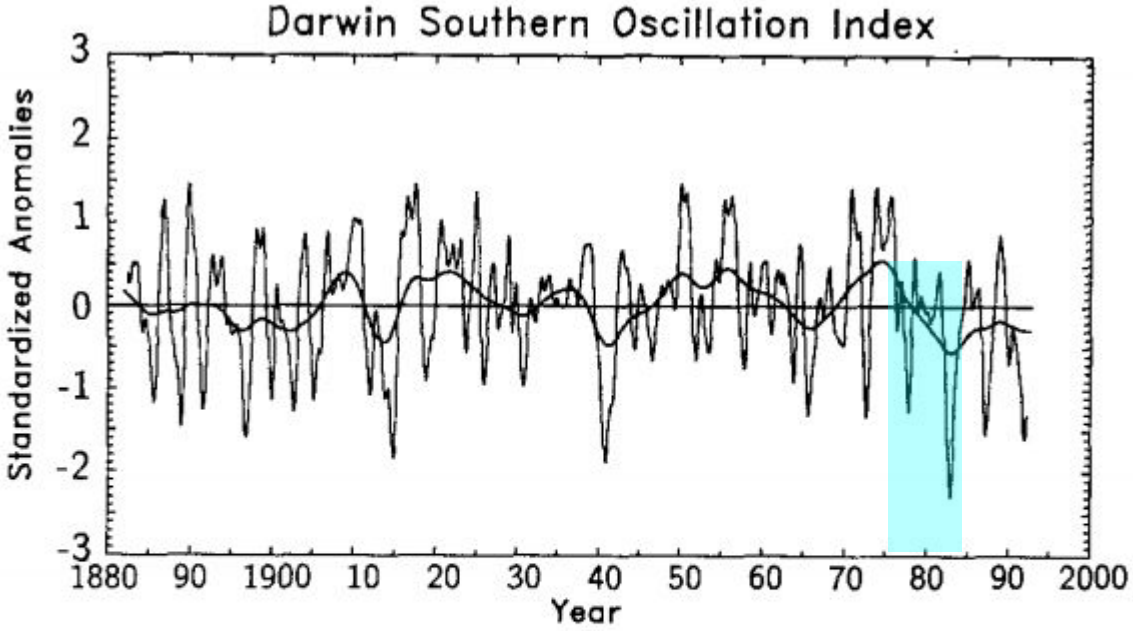


Fig. 17. Time series of the normalized Southern Oscillation Index (minus Darwin sea level pressure anomalies) monthly, filtered with an 11 term low pass filter designed to remove fluctuations less than a year (Trenberth 1984) and with a low pass spline filter that removes periods less than 10 years

- Baixa Aleutiana mais intensa: teleconexão El Niño

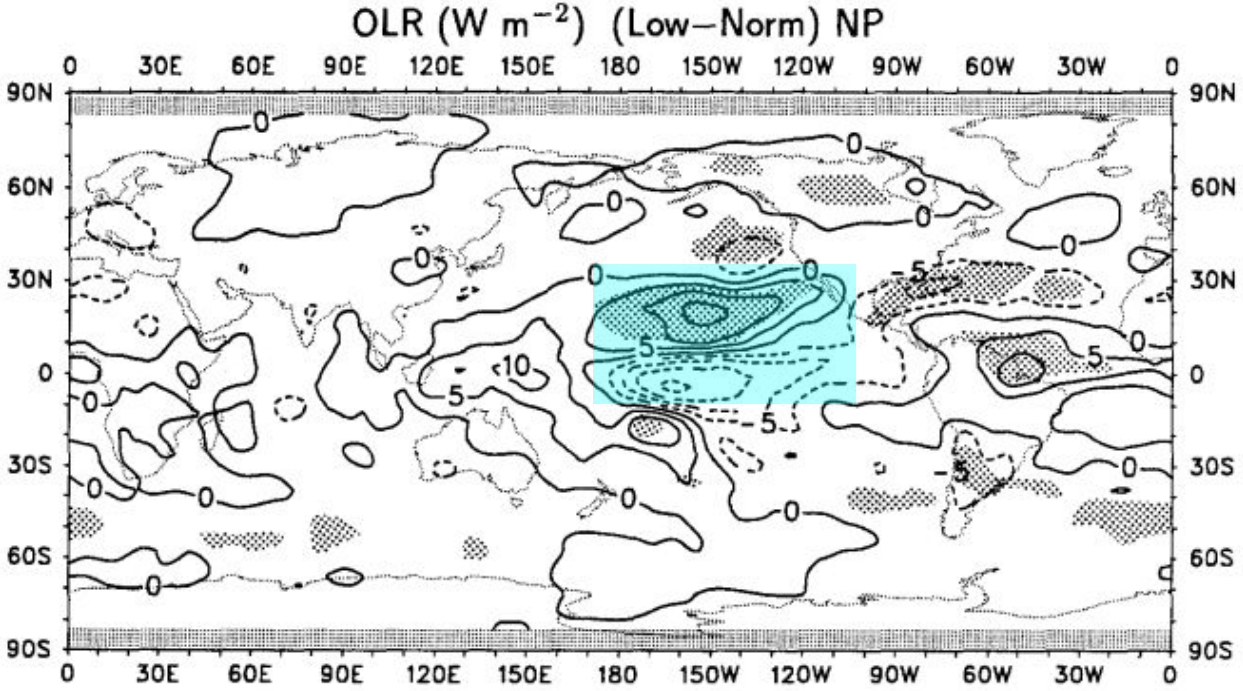


Fig. 18. Mean OLR composite anomalies for low – normal NP values in W m^{-2}. Negative values are *dashed*. The regions where values depart from zero at the 5% level of statistical significance using a *t* test are *stippled* (except at very high latitudes where the data are missing)

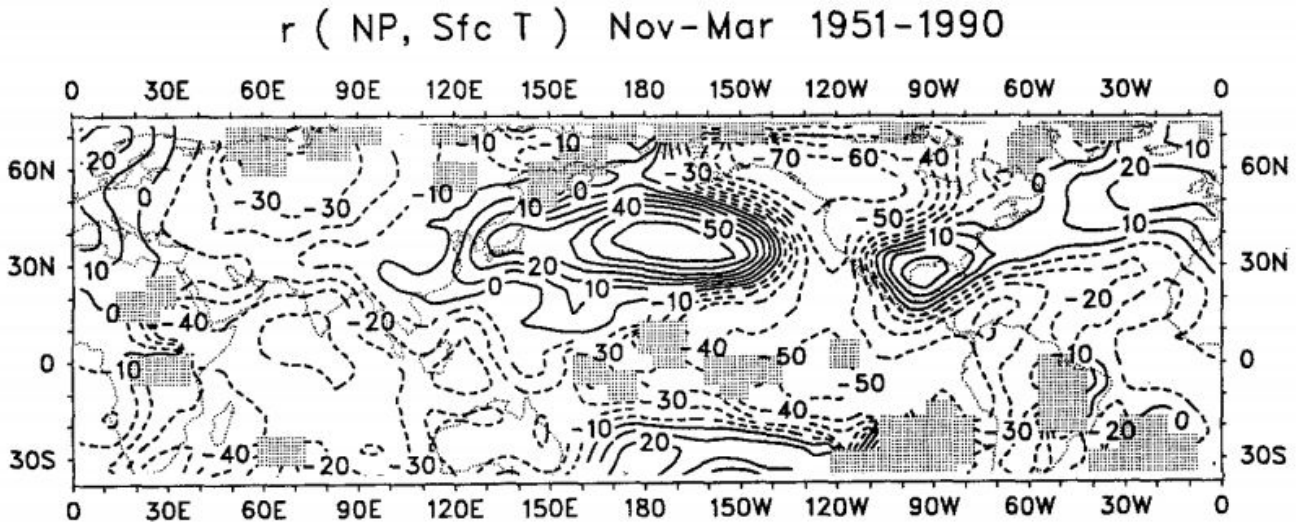


Fig. 19. Correlations (%) of the five month mean November–March NP index with surface temperatures at zero lag for 1951–1990. Negative values are *dashed* and areas of insufficient data (see appendix) are *stippled*

Table 1. Correlations (%) between the NP November–March index and indices of SST for the Niño 1+2, 3, and 4 regions and the SOI

Index Lead	Niño 1+2	Niño 3	Niño 4	Niño 3+4	SOI
+6	−39	−47	−46	−47	44
+4	−44	−49	−50	−51	46
+2	−48	−50	−49	−51	50
0	−44	−51	−45	−51	52
−2	−30	−44	−34	−43	47
−4	−18	−34	−25	−31	39
−6	−12	−15	−23	−19	16

All values are 5 month means. The period for the SOI and Niño 1+2 regions is 1935 to 1990 inclusive so that the one-tailed 1% significance level is 0.32. For the other Niño regions the period is 1951 to 1990 and the 1% significance level is 0.38. Maximum values are underlined. The lead is by the Niño SST or SOI index in months

Áreas maiores: maiores valores de correlação

6. DISCUSSÕES E CONCLUSÕES

- Baixa Aleutiana mais intensa começou no inverno de 1976-77 e foi acompanhada por mudanças de temperatura na superfície e troposfera
- Mudanças no Pacífico ⇔ mudanças na América do Norte
- Precursores nos trópicos
- Escalas de tempo mais curtas: atmosfera guia o oceano, mudanças nas TSM ocorrem 1-2 meses depois (mudanças nos fluxos de calor latente e sensível com a mistura e entranhamento no oceano)