Analysis of the North and the Tropical Pacific SST Variability

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Objectives

The Pacific Ocean is a source of the climatic variability influencing the atmospheric processes not only at local, but also at global scales. The strongest signal is the El-Nino-South Oscillation (ENSO) representing the inter-annual variability in the tropics (Cane, 2005, Diaz and Markgraf, 2000, McPhaden, 2003). At the same time, in the mid and high latitudes there exists an inter-decadal signal, the so-called Pacific Decadal Oscillations (PDO) centered over the Pacific Ocean and North America (Biondi et al, 2001, Curchitser et al, 2005, Mantua, 2002, Stahl et al, 2006, Krishnan and Sugi, 2003, Montecinos et al, 2003, Salinger et al, 2001). This variability can be analyzed in the sea surface temperature patterns after some statistical processing. The data were adopted from the NCEP/NCAR SST reanalysis dataset. The domain chosen for the SST analysis was bounded by the rectangle [112.5E, 70.5W and 29.5S, 60.5N]. In the present paper, two methods are used. The first is a classical EOF analysis, which allows reconstructing the El-Nino and the La-Nina events by the first few EOF with a high enough accuracy. However, the periods between these events need a greater number of EOF for the reconstruction of the SST anomalies. The variability in the mid and high latitudes is also not separated precisely, because it is damped by a strong signal in the tropics. Therefore, for the separation of these signals including the PDO, the cluster method is used. The clusters were organized as well-correlated zones both in space and in time (Efimov et al, 1995, Xu and Wunsch, 2005). This allows us to classify the SST data in the total basin and make a classification of specific individual zones in the Pacific. The results obtained show that except a strong signal in the tropics, there exists a distinct signal in the Kuroshio Extension and in the subpolar gyre with the inter-decadal modulation which can be associated with the PDO.

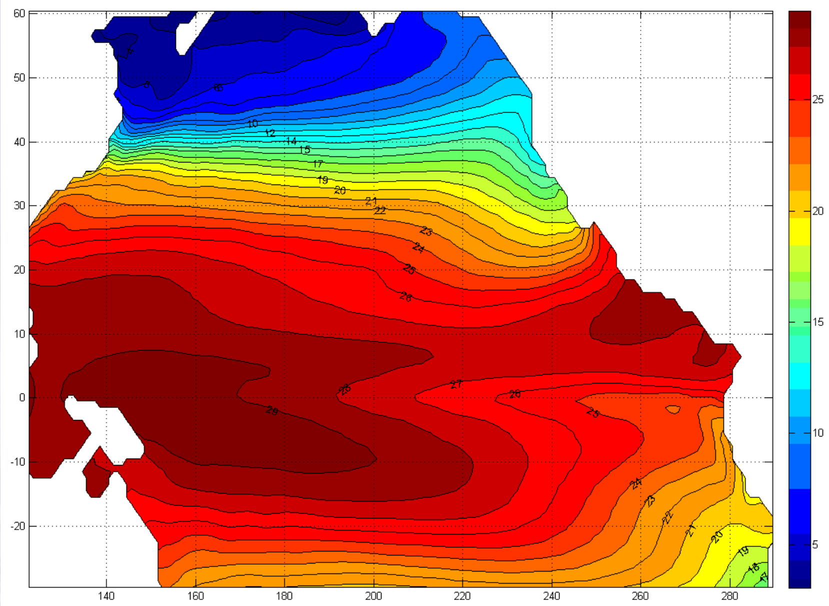


Fig. 1. The SST climatic state

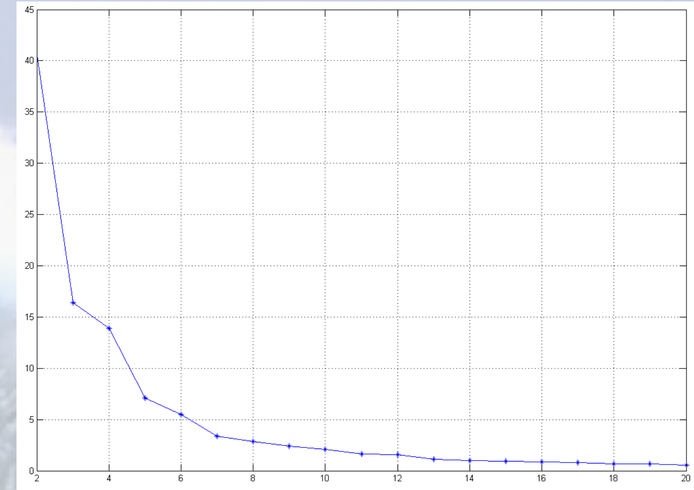


Fig. 1a. Eigen values for the numbers more then 2. The first number (seasonal variations) is 765.5

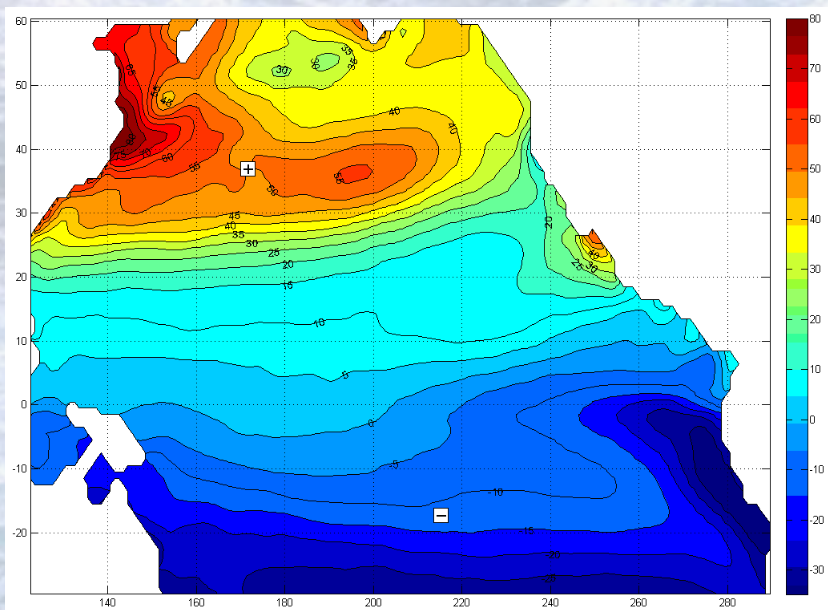


Fig. 2.The EOF-1 mode. The seasonal variations

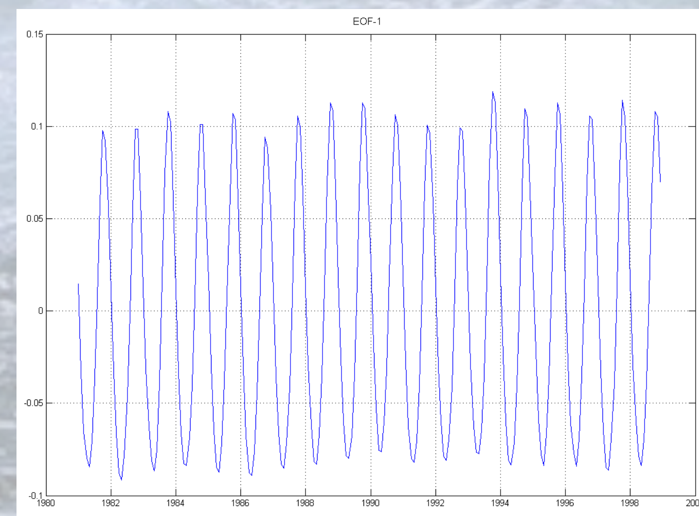


Fig. 2a. The temporal variations of the EOF-1 (minus climate)

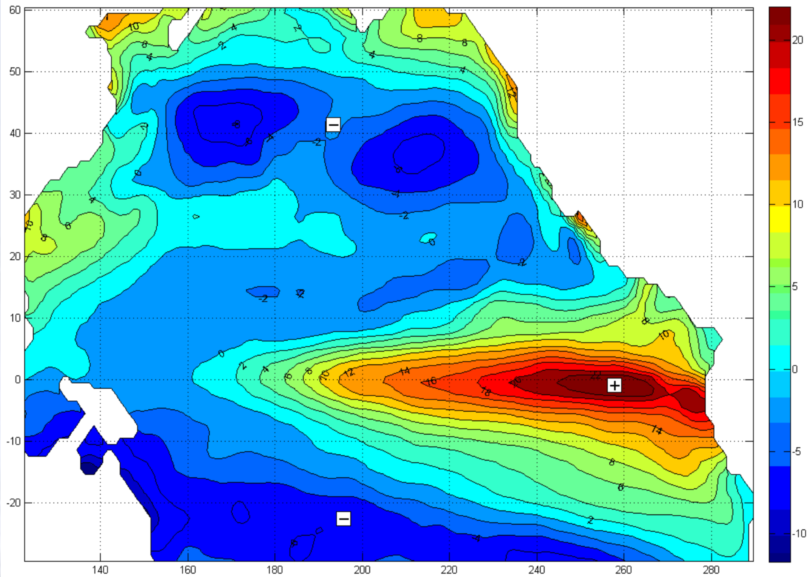


Fig. 3. The EOF-2 mode. Interannual variability (the El-Nino, La-Nina events)

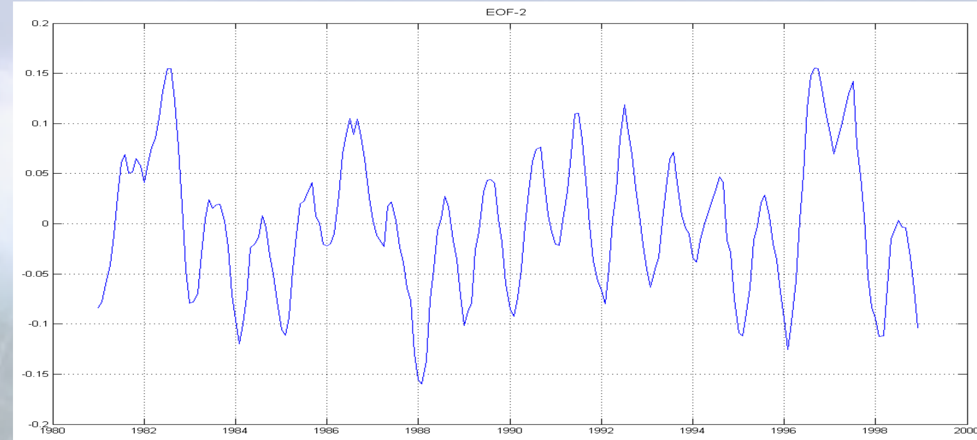


Fig. 3a. The temporal variations of the EOF-2. The positive values of the curve correspond to the El-Nino event, the negative ones - to the La-Nina event (see the sign of mode 2)

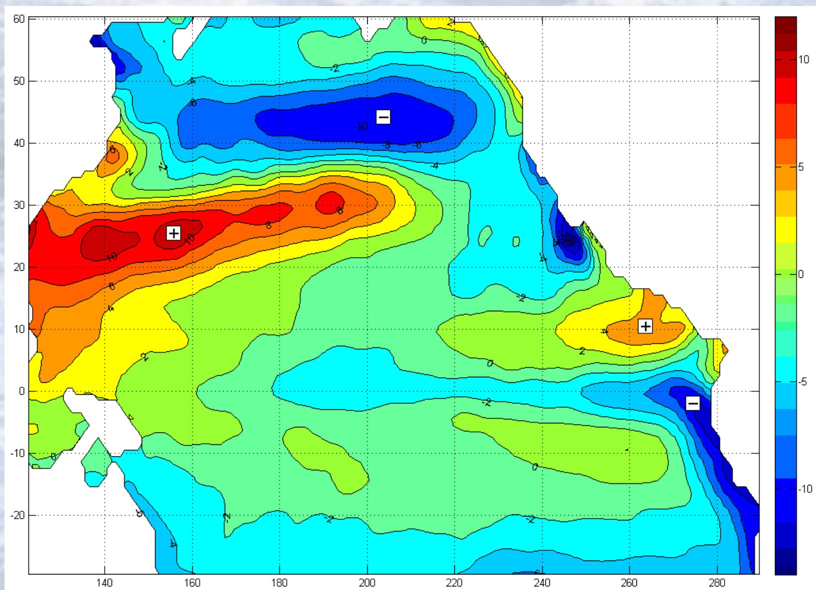


Fig. 4. The EOF-3 mode. The variability in the subtropical, subpolar zones

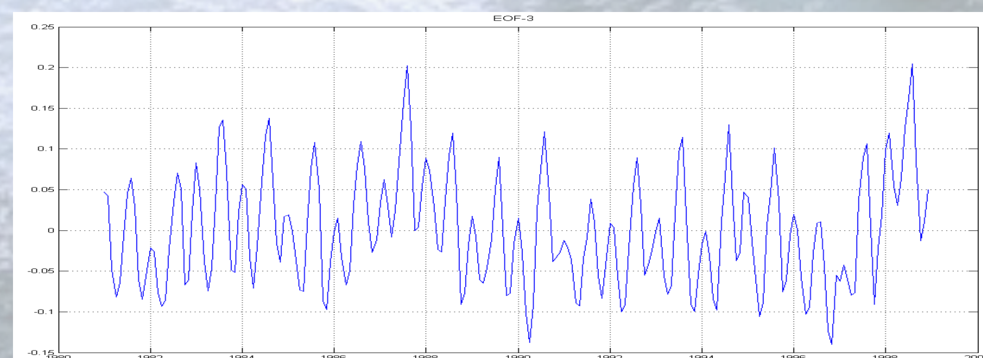


Fig. 4a. The temporal variations of the EOF-3

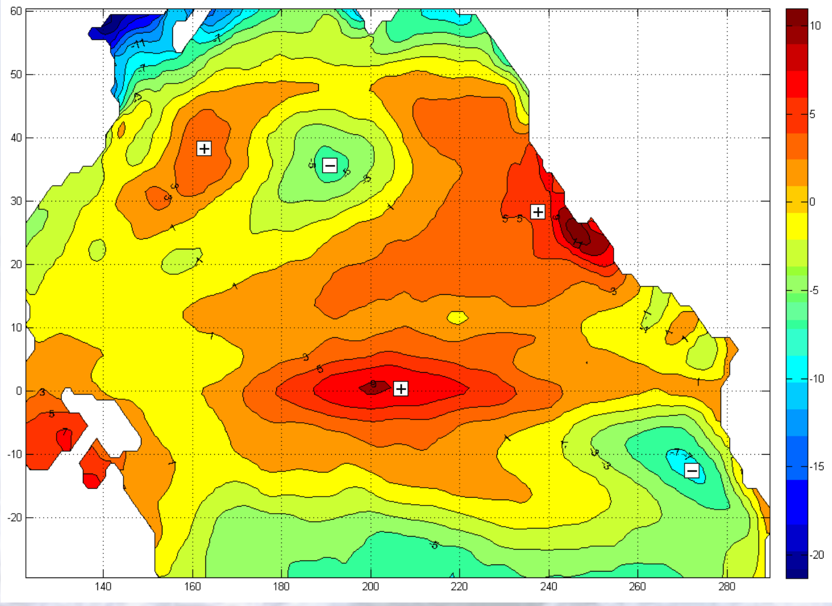


Fig. 5. The EOF-4 mode. The variability in the central tropical, subtropical zones

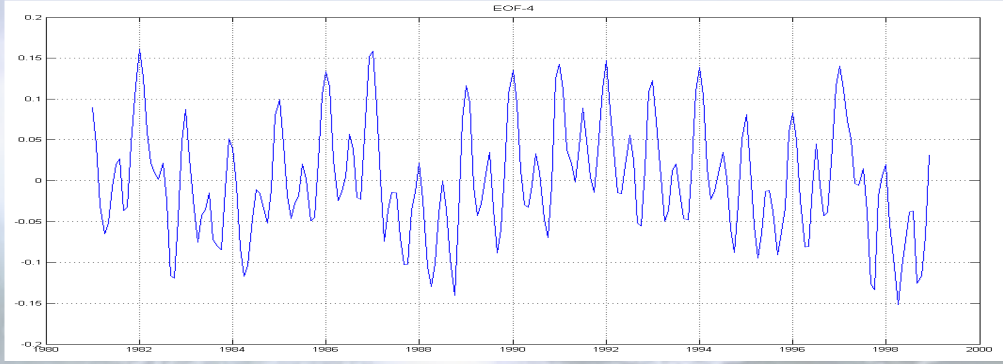


Fig. 5a. The temporal variations of the EOF-4

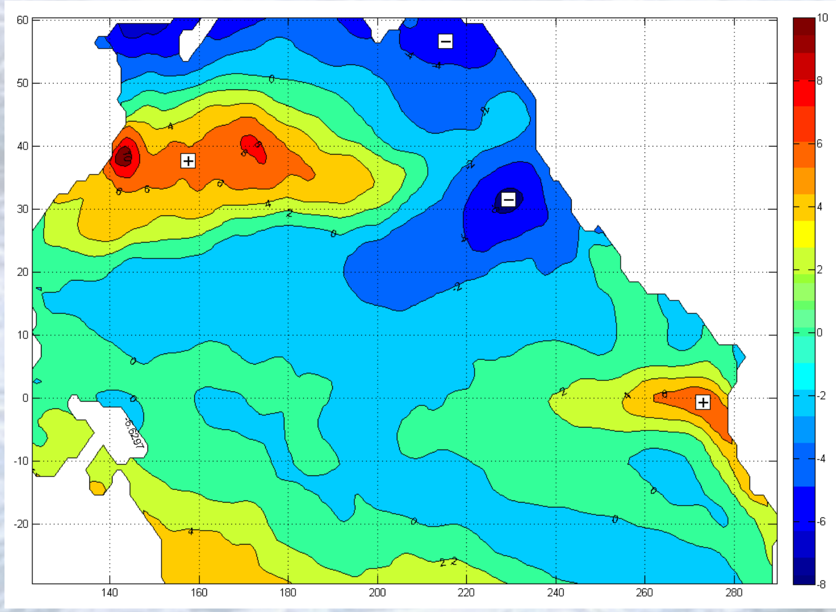


Fig. 6. The EOF-5 mode. The variability in the Kuroshio Extension, subtropical, subpolar zones

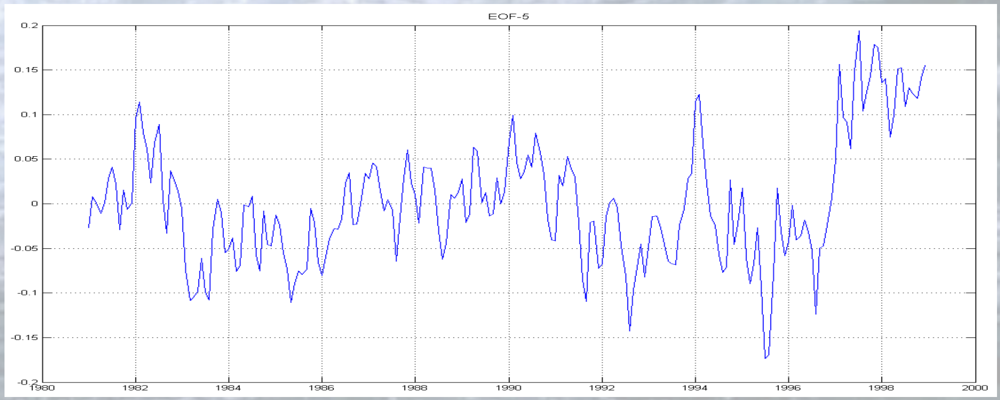


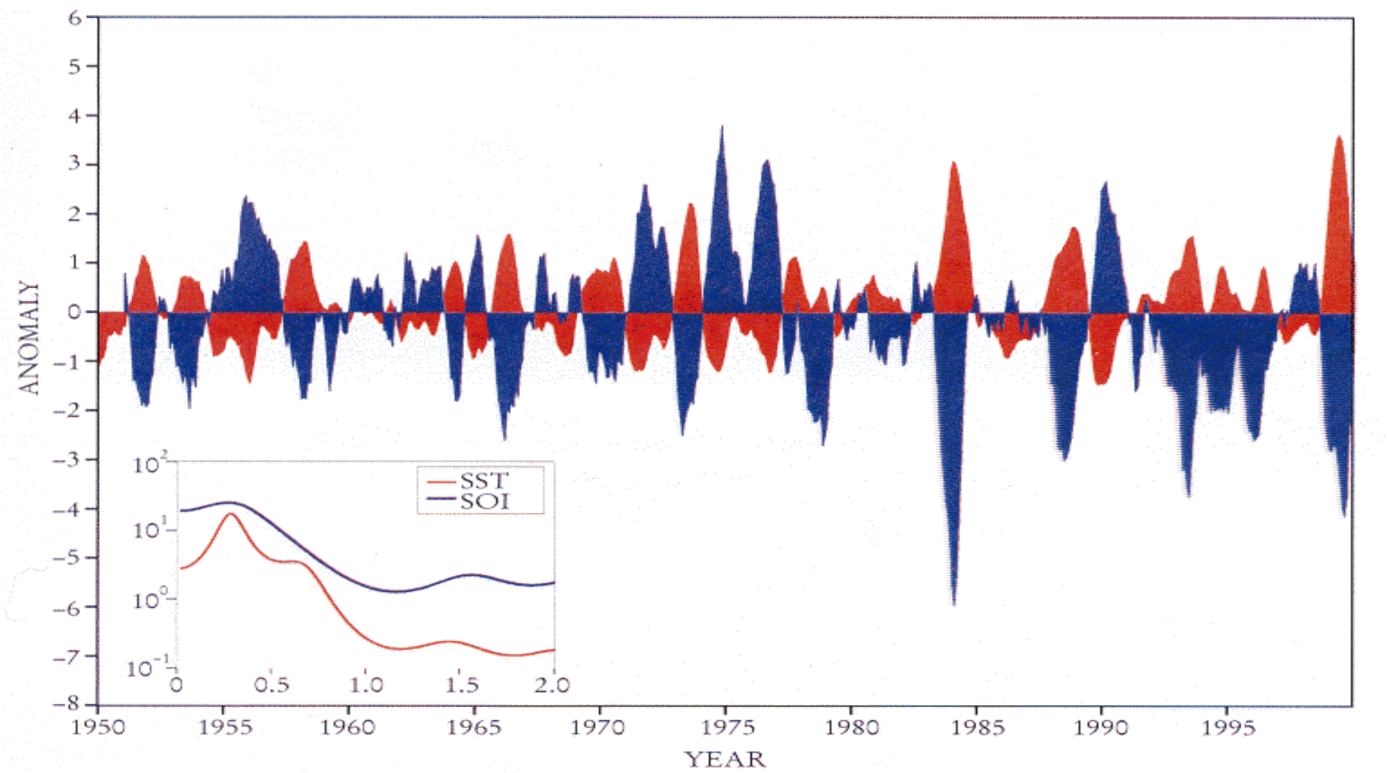
Fig. 6a. The temporal variability of the EOF-5

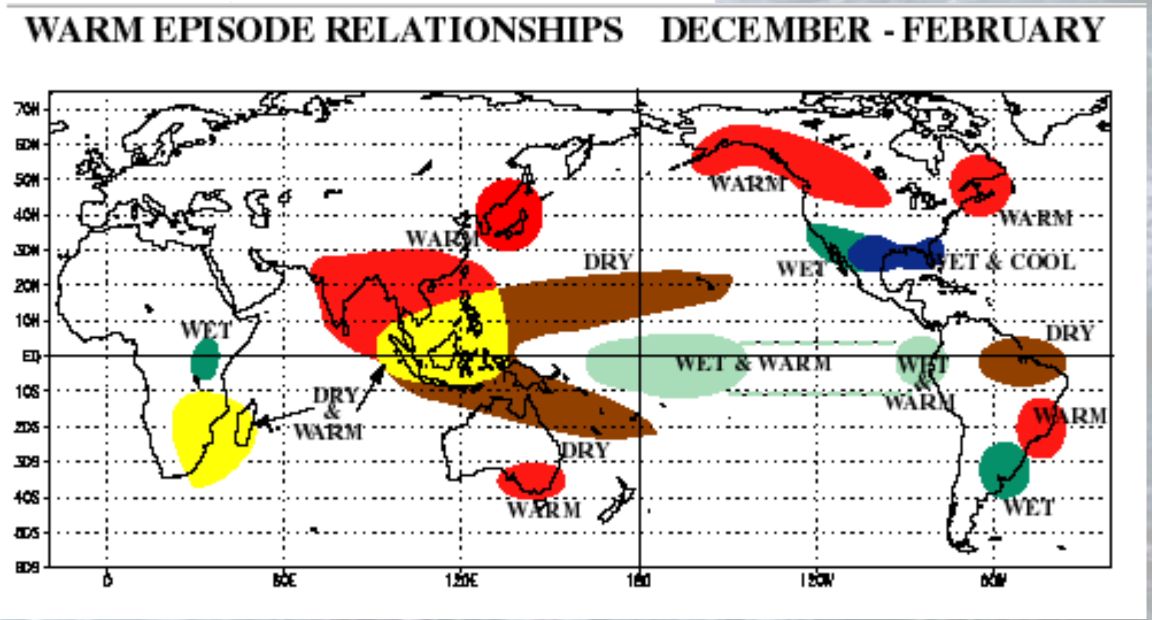
Table 1. The Eigen vales of the five first EOF modes

Mode No	Eigen function value	% of Variance	Remarks
1	765.5	0.89	The mode describes the seasonal variations. The spatial and the temporal variations are presented in Figs. 2, 2a.
2	40.8	0.047	The mode describes the interannual variability in the Eastern tropics (the El-Nino and the La-Nina events). The spatial and the temporal variations are presented in Fig. 3, 3a.
3	16.4	0.019	The mode describes the variability in the subtropical, subpolar zones. (Figs. 4, 4a).
4	13.9	0.016	The mode describes the variations in the central tropical and subtropical zones (Figs. 5, 5a).
5	7.1	0.008	The mode represent the variations in the Kuroshio Extension region and the Eastern subtropical subpolar zones (Fig. 6, 6a).

El-Nino – Southern Oscillation (ENSO)

Index ENSO


ANOMALY
YEAR
SST
SOI


WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY
WARM
WARM
WARM
DRY
WET
WET & COOL
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DRY
DRY & WARM
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DRY
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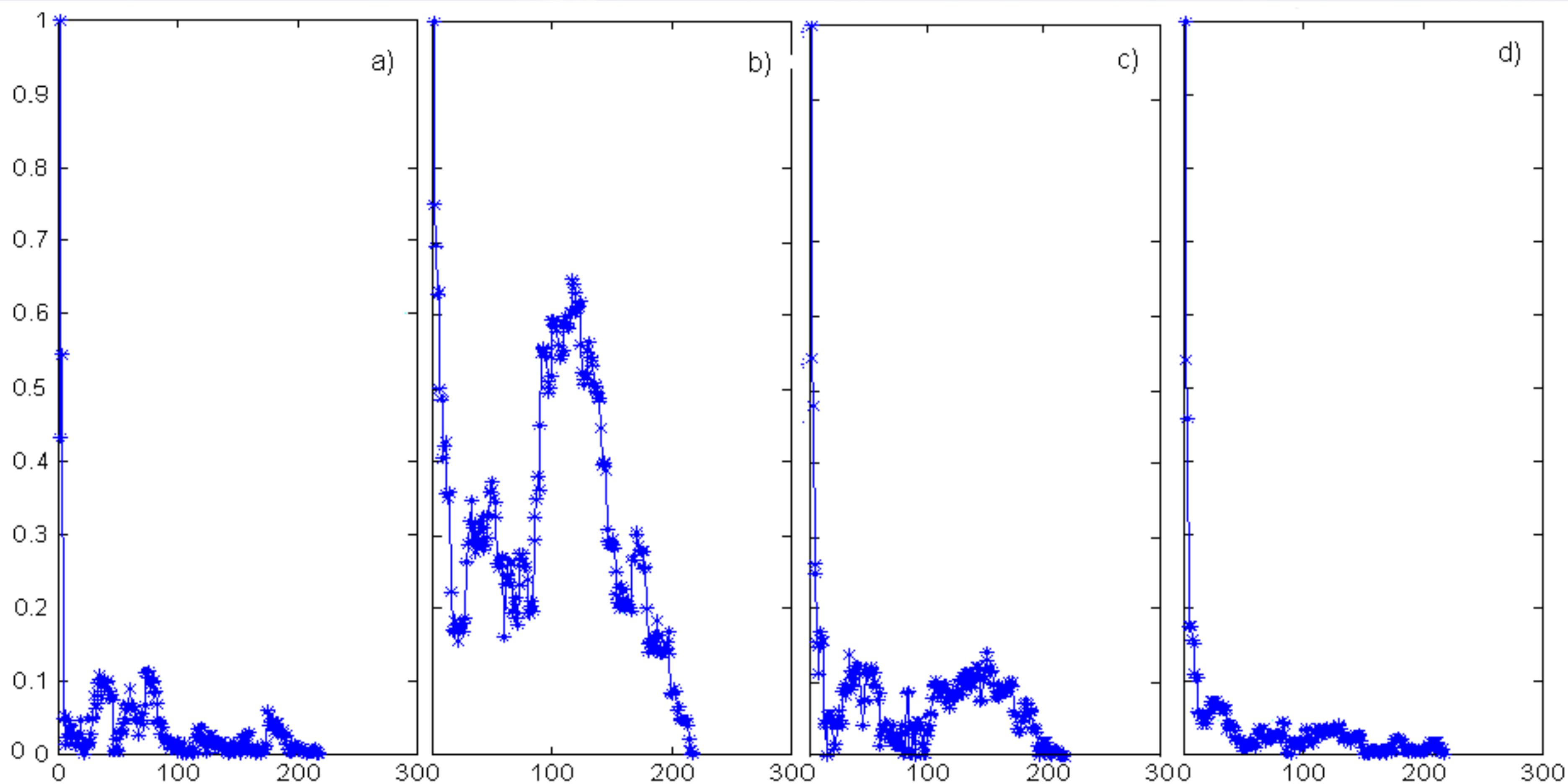
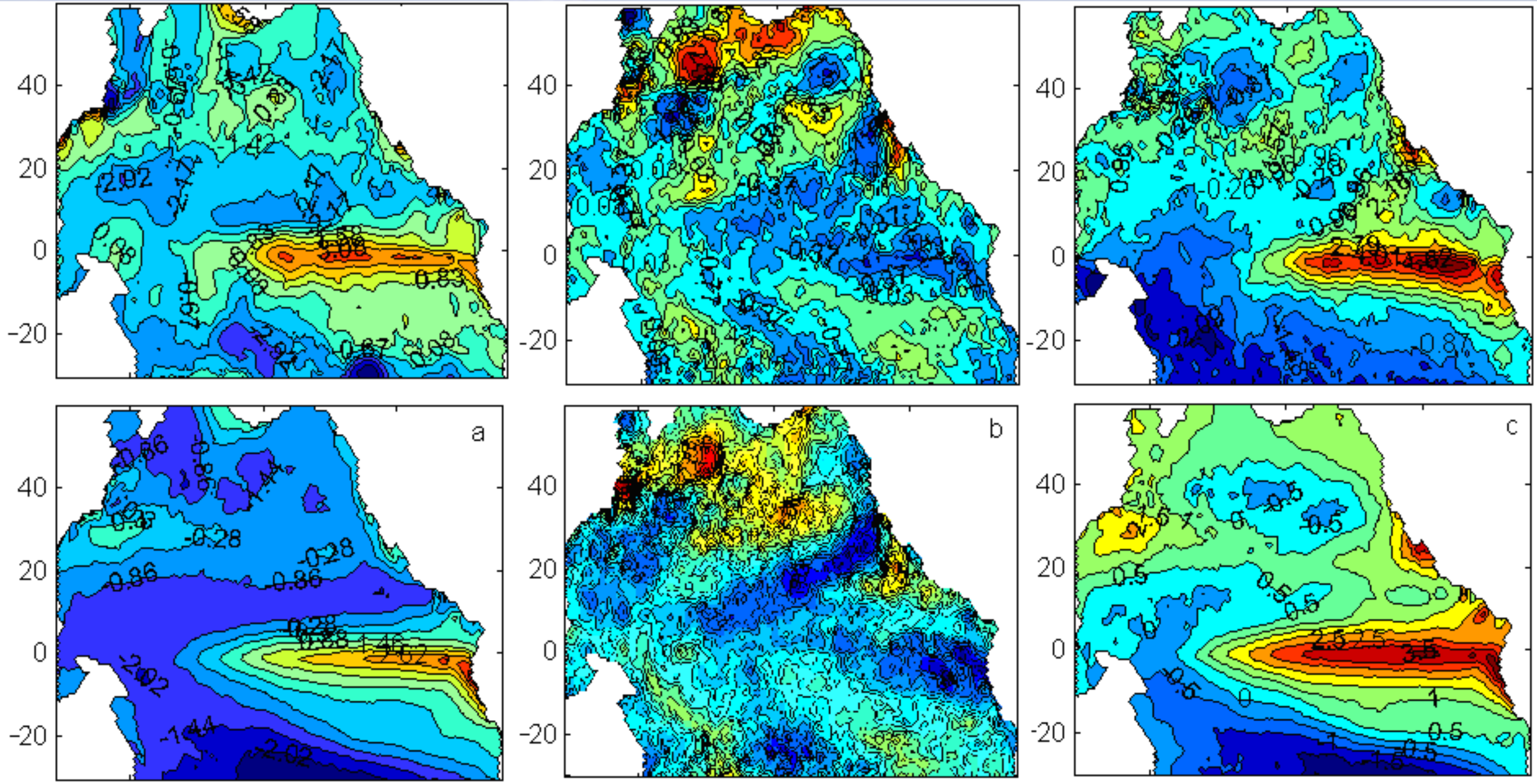


The share of the EOF harmonics to the SST anomaly field in different periods:
a) - December 1982, b) – September 1984, c) – July 1988, d) – November 1997



The reconstruction of the SST anomaly field by the EOF harmonics in different periods:

a) El-Nino – December, 1982 (4 harmonics),

b) Intermediate period –September, 1984 (150 harmonics),

c) El-Nino — November, 1997 (4 harmonics).

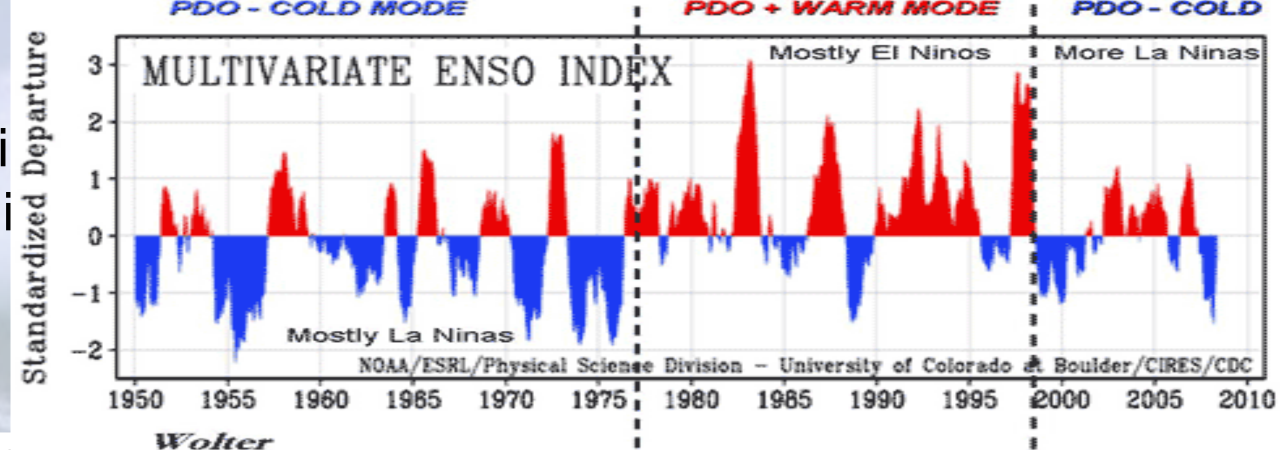
The upper panels is the NCEP/NCAR reanalysis data.

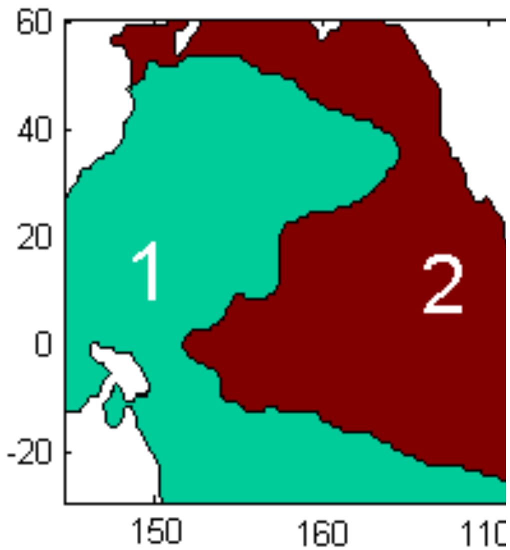
Cluster analysis of SST for the period 1948-2002 (V.Efimov et al.,1995)

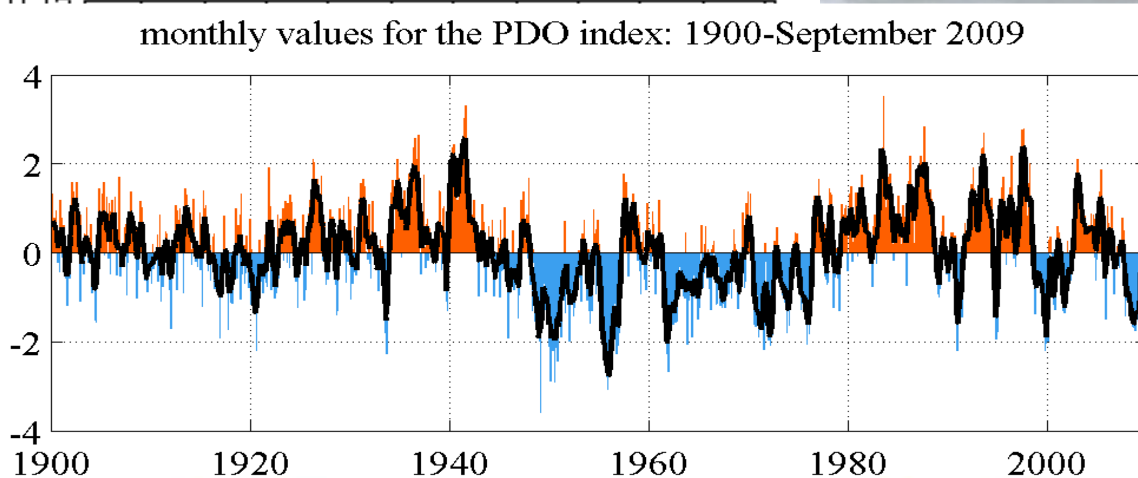
Cluster analysis is a method of combining of the data by the criterion correlation between the spatial points or the time points. Cluster analysis method allows one to solve the problems:

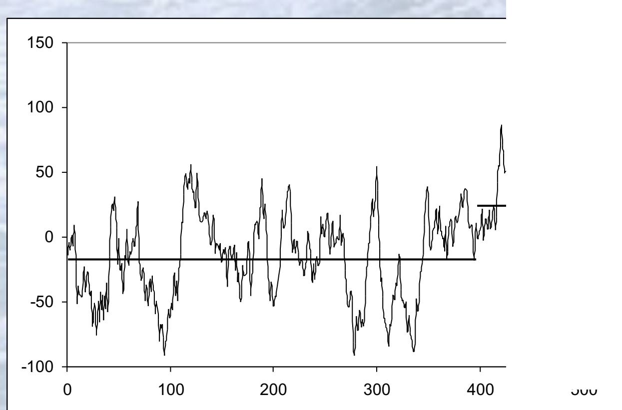
- To classify the objects with taking into account the main features of the objects;
- To check some hypothesis about occurrence of some structure in the aggregate of the objects;
- Construction of the new classification for the poor investigated events, when it is necessary to establish the relations in the aggregate and to introduce some structure into it.

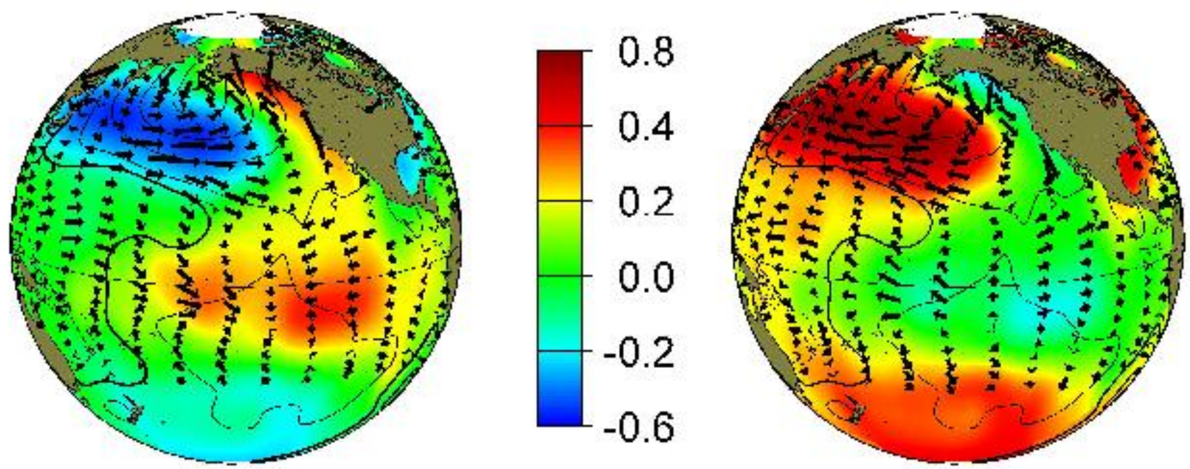
Pacific Decadal Oscillati
Pacific climatic state whi
Siberia



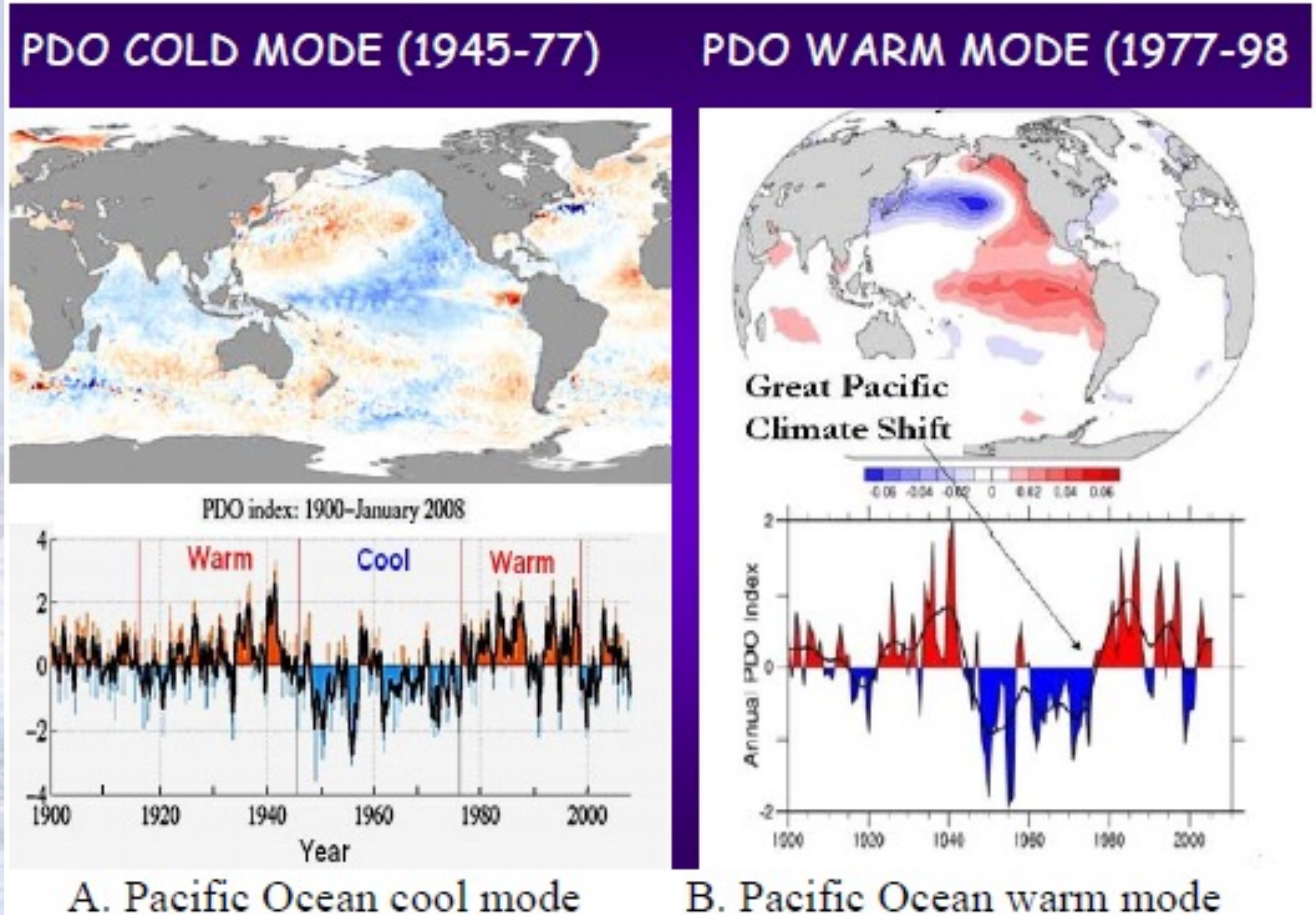






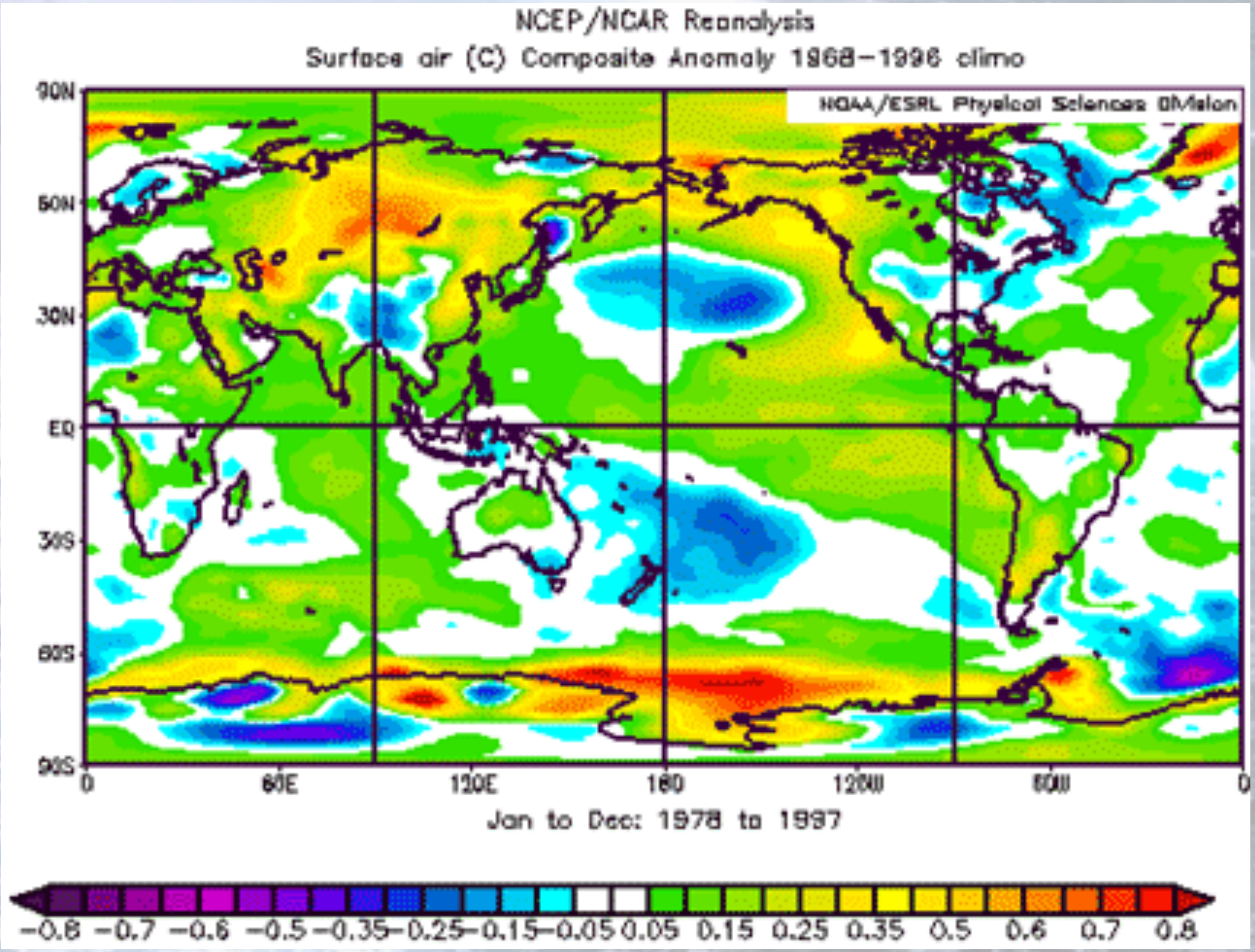


Pacific Decadal Oscillations (PDO)

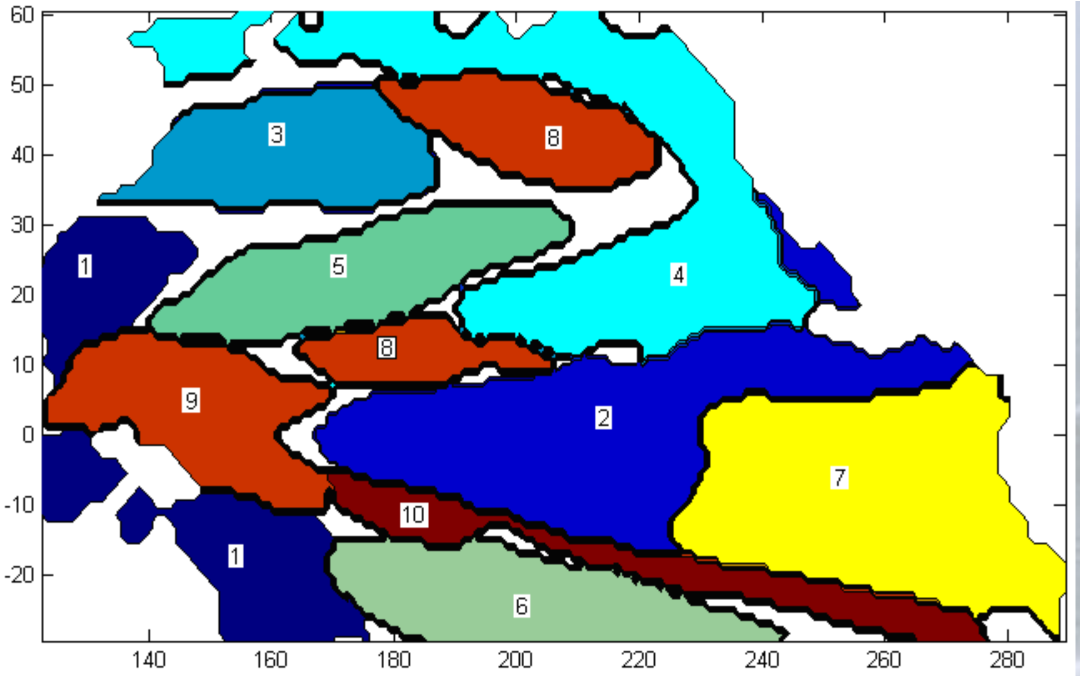


In 1945, the PDO (Pacific Decadal Oscillation) switched from its warm mode to its cool mode and global climate cooled from then until 1977, despite the sudden soaring of CO2 emissions. In 1977, the PDO switched back from its cool mode to its warm mode, initiating what is regarded as Cglobal warmingT from 1977 to 1998). (from NASA imagery and PDO data)

Temperature anomalies during warm phase PDO (1978 -1997)

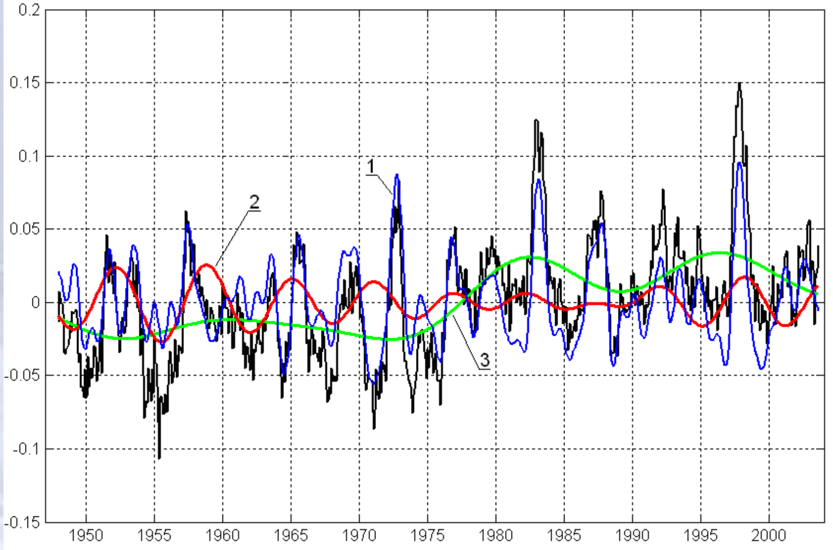


Distribution of ten classes of spatial classification

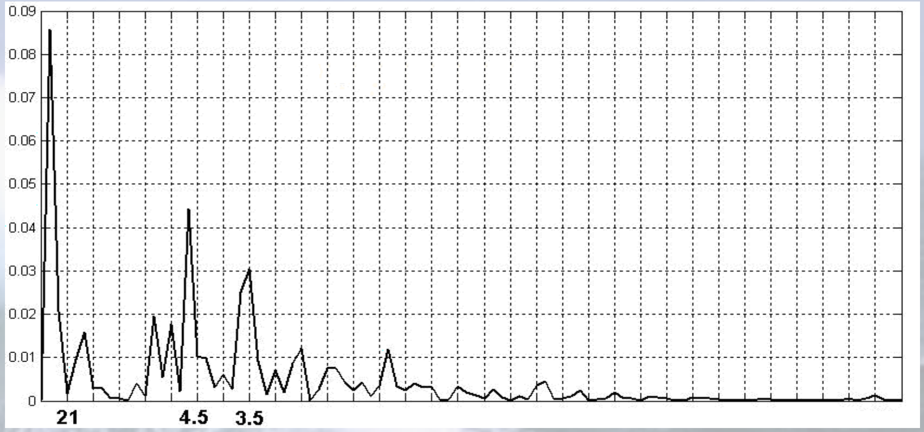


Inter correlation between te centers of classes

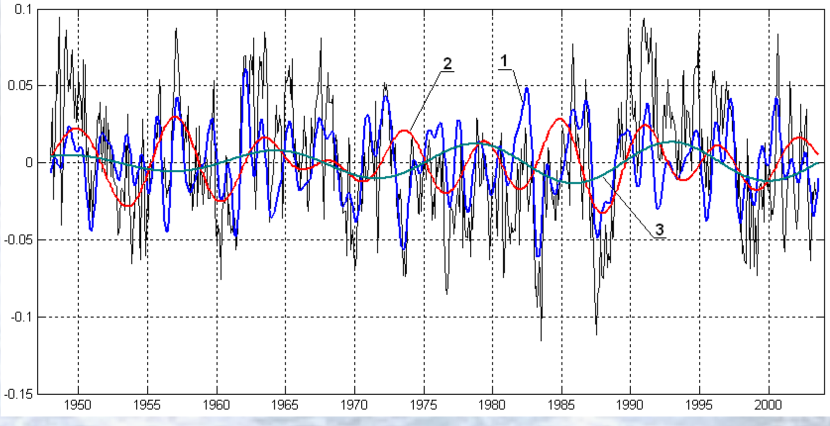
R(i,j)	1	2	3	4	5	6	7	8	9	10
1	1.000	-0.006	0.150	0.029	0.189	0.358	0.106	-0.302	0.399	0.157
2		1.000	-0.218	0.482	-0.395	-0.465	0.795	-0.011	-0.259	0.419
3			1.000	-0.222	-0.005	0.248	-0.326	0.307	0.188	-0.057
4				1.000	-0.107	-0.126	0.414	0.109	0.116	0.363
5					1.000	0.373	-0.254	-0.039	0.168	-0.008
6						1.000	-0.342	-0.007	0.388	0.255
7							1.000	-0.152	-0.053	0.401
8								1.000	0.026	0.044
9									1.000	0.249
10										1.000



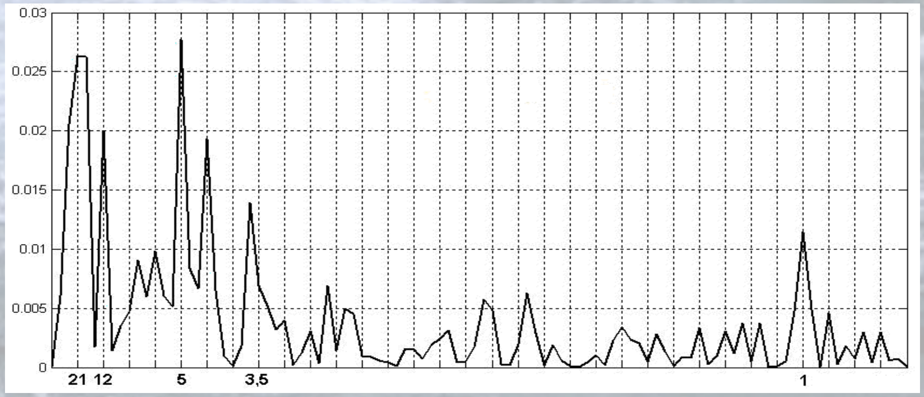
Temporal behavior of the center of the class 7 (tropical zone) and the results of the Fourier widow analysis with the following window intervals: the curve number 1 – from 1 to 5 years, number 2 – from 5 to 10 years, number 3 – from 10 years and more



The spectrum of the temporal behavior of the center of the class 7 (tropical zone). By the abscises axis the periods in the years are marked. The main peaks correspond to the harmonics with 3,5 and 5 years periods

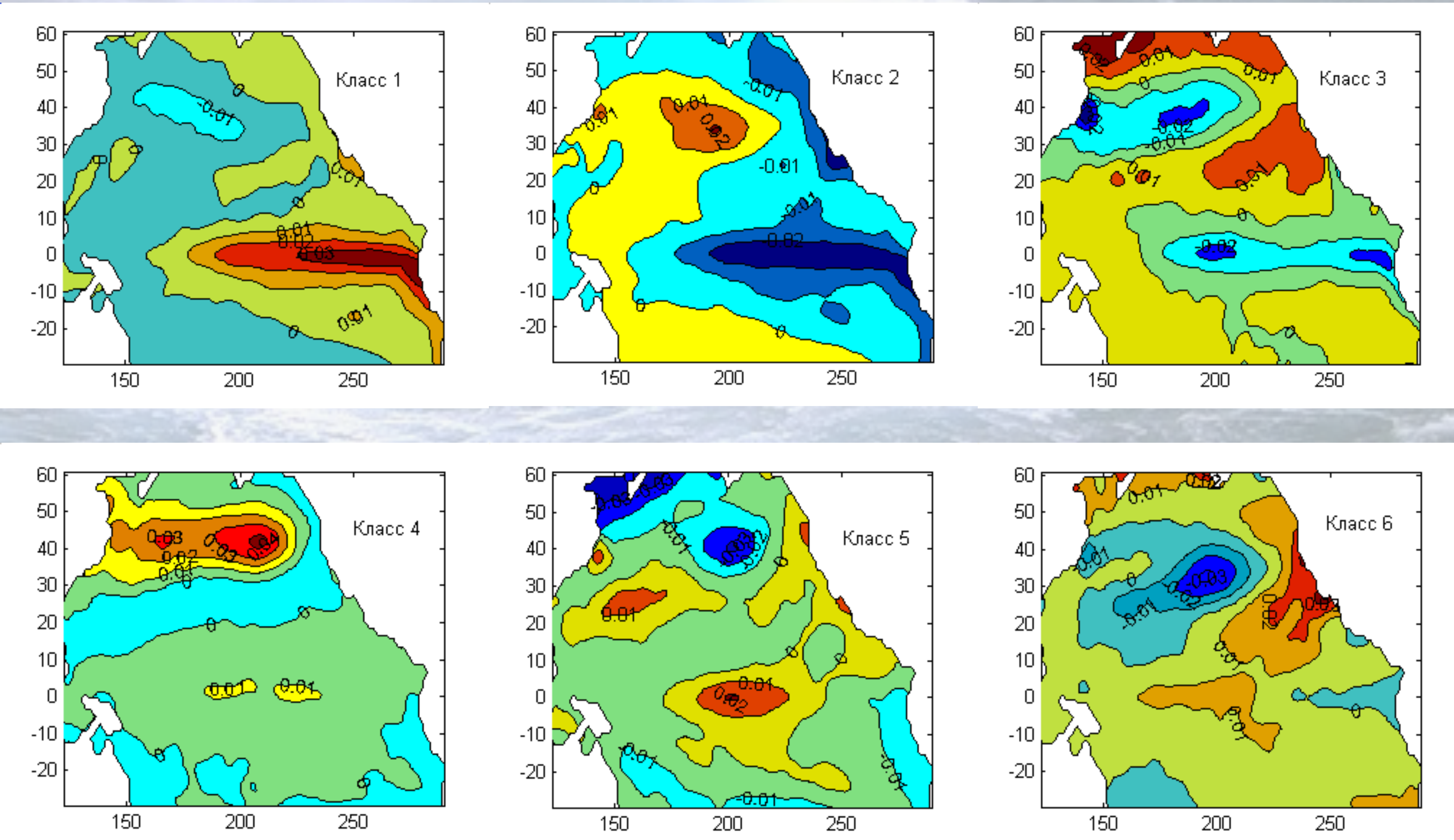


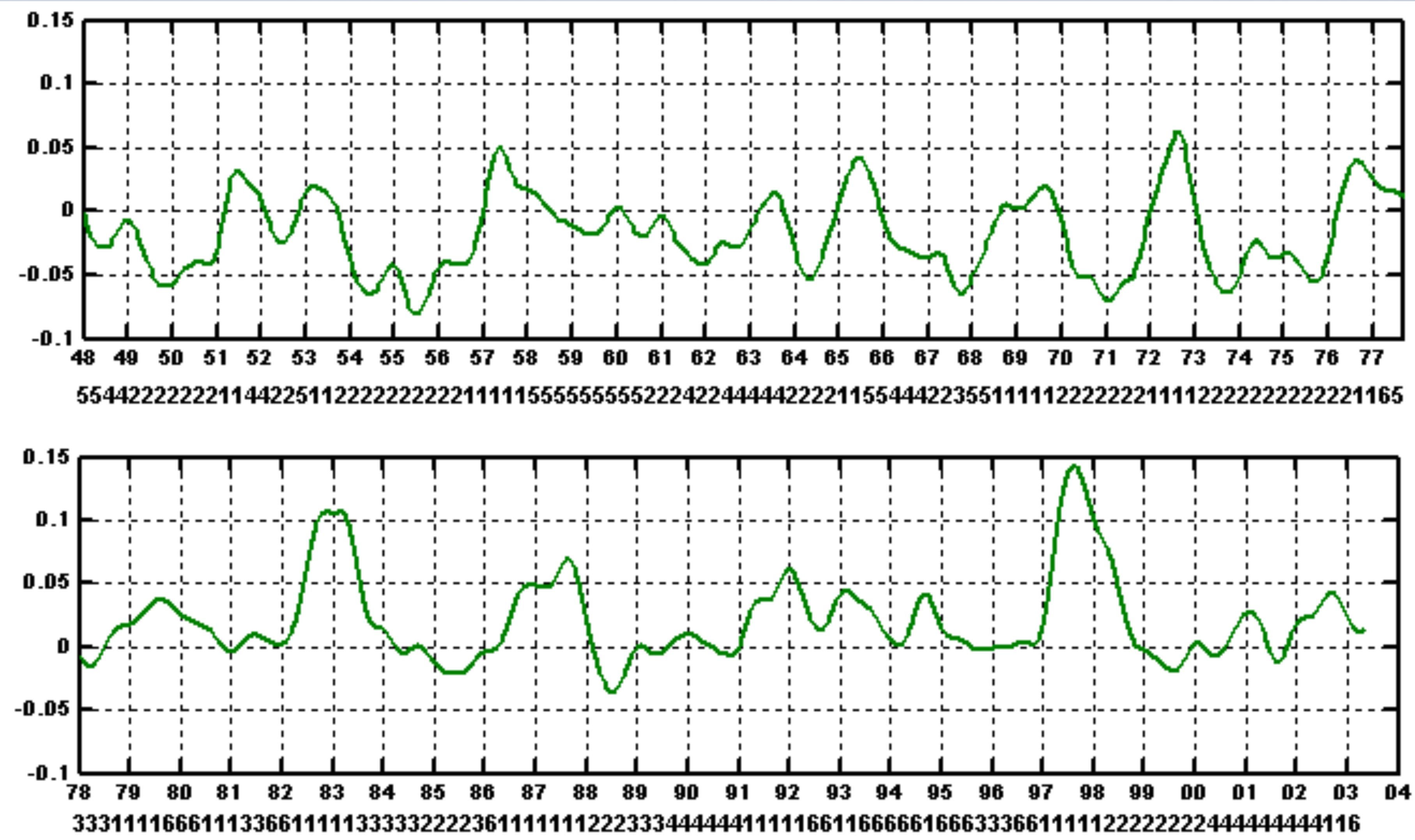
Temporal behavior of the center of the class 3 (Kuroshio Extension region) and the results of the Fourier widow analysis with the following window intervals: the curve number 1 – from1 to 5 years, number 2 – from 5 to 10 years, number 3 – from 10 years and more



The spectrum of the temporal behavior of the center of the class 3 (Kuroshio Extension). By the abscises axis the periods in the years is presented. The main peaks correspond to the harmonics with 3,5, 5 and 12,5 years periods

Six classes of the temporal classification





Temporal behavior of the center of the class 7 obtained in the spatial classification with the indication below the diagram the number of temporal class dominating in each period

Discussion

• The EOF analysis of the reanalysis data enables us to separate the strongest interannual SST signal in the Pacific tropics and to reconstruct it with a few first harmonics. The periods between the El-Nino and the La-Nina events need a greater number of harmonics for reconstruction of the anomalies. This indicates to the fact that the anomalies periods of the extreme events in the tropics are governed by the first two harmonics and more complicated processes form the anomalies in the intermediate periods. The PDO variability in the subtropics and in the subpolar regions is damped by a stronger tropical signal.

• The spatial-temporal cluster analysis allows us to separate typical structures in the SST variability, to indicate the variability in the subtropical and the subpolar regions and to establish the relations between these regions. It also allows us to indicate a marked signal of the inter-decadal variability in the subpolar-subtropical zones which may be attributed to the PDO signal.


Thank you for attention!