

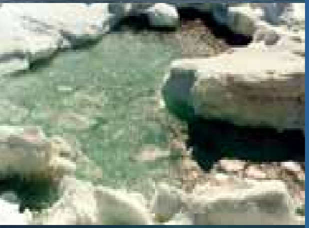


Statistical forecasting of ice cover in the Far-Eastern Seas

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PICES XVI *S9-4301*





INTRODUCTION

Sea ice conditions are always taken into account for fisheries forecasting of different terms ahead (from winter season to years) by TINRO – Centre in the Far Eastern region.

For the Far-Eastern Seas the ice cover is:

- one of the most important physical factors of the climate system

- important indicator of climate changes

- important indicator of environmental large-scale changes. The timing of the spring bloom, dynamics of zooplankton communities, seasonal fish migrations and other features of marine ecosystems are closely connected with variability of sea ice cover.

Sea ice extent is “natural filter” of high-frequency variability.

DATA SOURCES:

1. Time series of the ice cover in the Okhotsk Sea in March (annual maximum) for 1929-1956 collected by Kryndin (1964) from various visual observations (shipboard, aircraft, coastal).

2. Regular ten-days aircraft observations conducted by Russian Hydrometeorological Service: Okhotsk Sea for 1957-1991, Bering Sea and Japan Sea (Tatar Strait) for 1960-1991.

3. Satellite information obtained from Far-Eastern Regional Center, Khabarovsk (1992-1998) and from National Ice Center U.S.A (1999 - 2007) (http://www.natice.noaa.gov/pub/west_arctic)

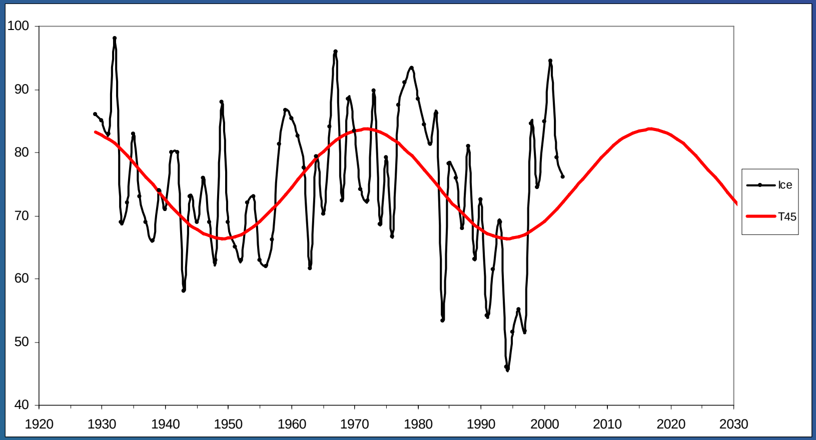
4. Ice charts of the Japanese Meteorological Agency for the Okhotsk Sea (1999-2007).

5. Repeatability of the types of atmospheric processes over the Far-Eastern Seas (by Glebova, 1999)

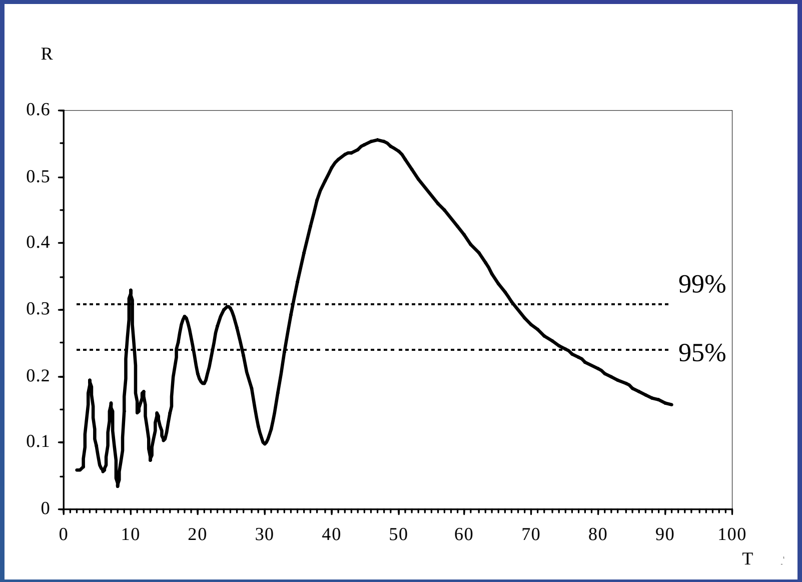
7. Time series of the 10-day mean SST and monthly mean analyzed SST from the Real Time Data Base, NEAR-GOOS (http://goos.kishou.go.jp/rrtdb).

8. Monthly mean air temperature and sea level pressure data of NCEP Reanalysis http://www.cdc.noaa.gov/cdc/data.ncep.reanalysis.derived.surface.html

Long-term forecasting



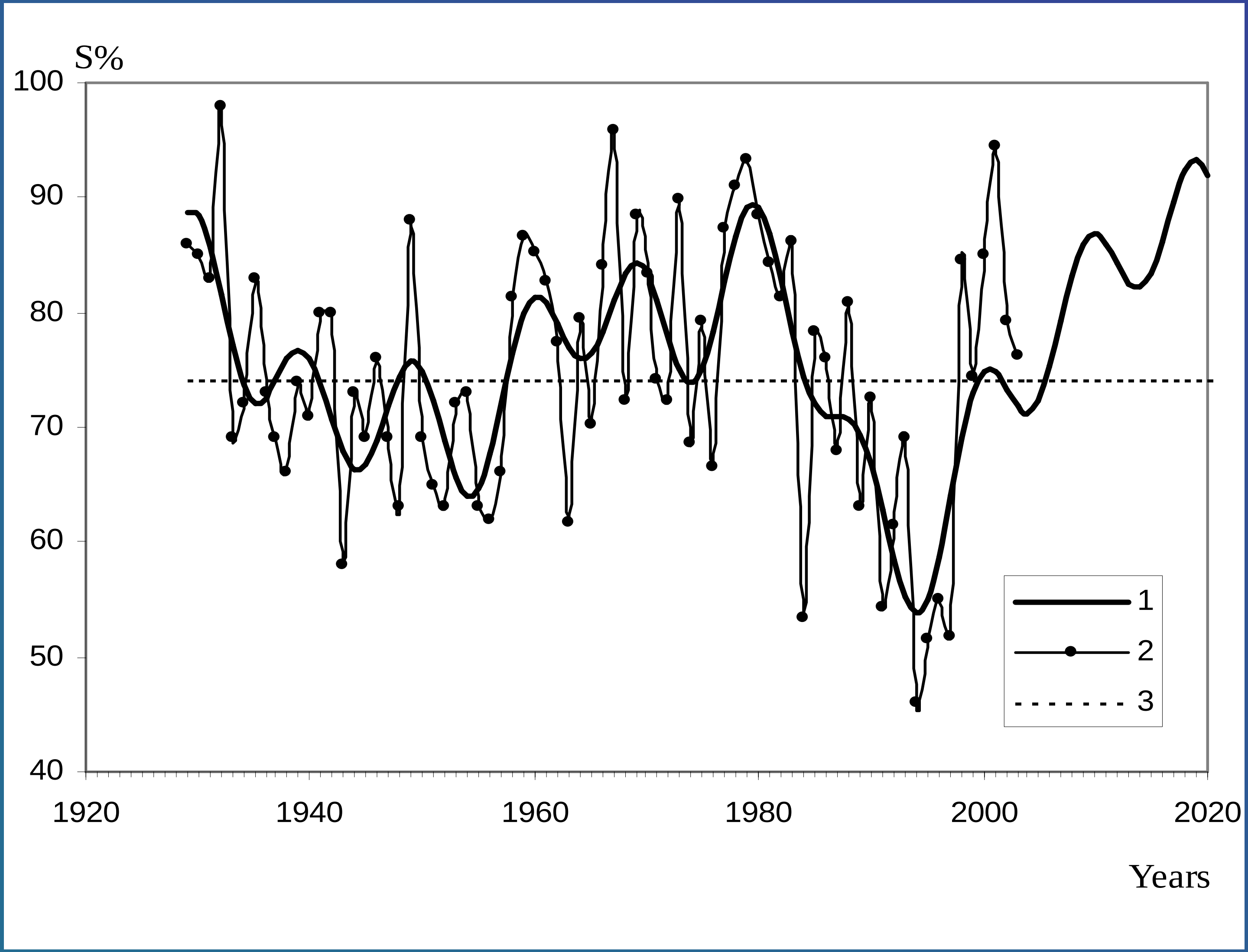
Interannual variations of the maximal ice cover in the Okhotsk Sea and harmonic oscillation with about 50-year period



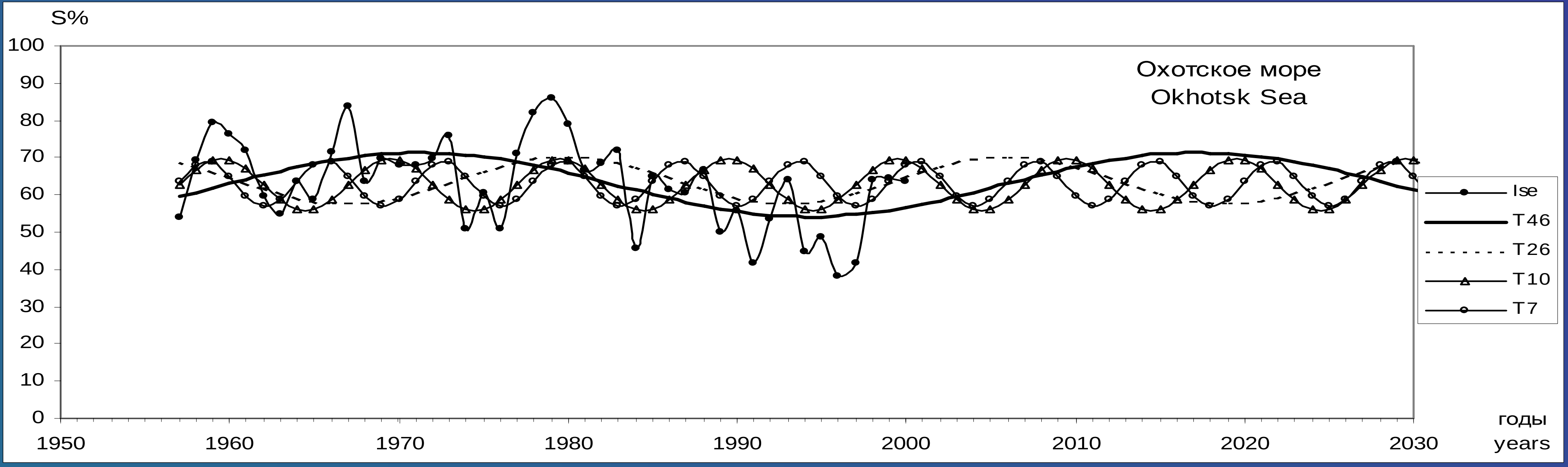
“Periodogram” of the maximal ice cover in the Okhotsk Sea

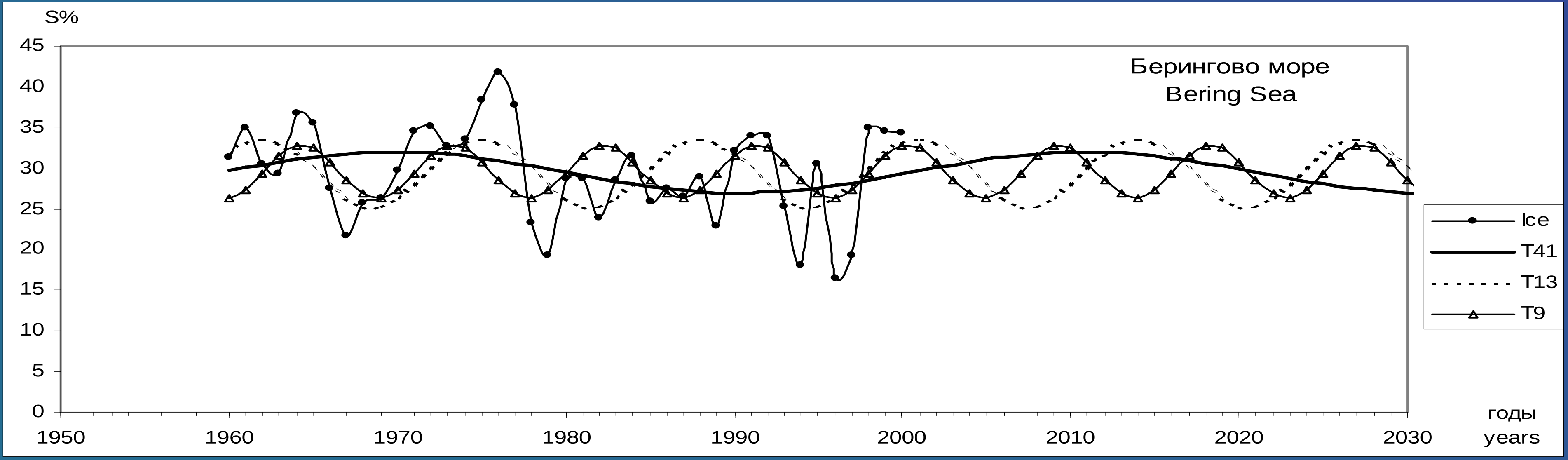
The spectral analysis of time series of the maximum annual ice cover showed that the basic contribution to the variance gave the scale about 50 years. Other important contributions were 10, 18 and 25 years oscillations. On the basis of these periodical components, the time series of the largest ice cover in the Okhotsk Sea may be approximated and extrapolated for the next decade. Although this method has a problem of reliability of the periods, it allows to reveal the periods comparable with length of data series and to fulfill rough long-range forecasts of time series. The periods with confidence level ≥95%. (significant contributions of ice cover variance) were used as independent variables for equations of multiple regression.

Approximation of ice cover variability by sum of long-term harmonics (1), year-to-year variation (2) and mean multi-year value of the maximal ice cover (3) in the Okhotsk Seas.

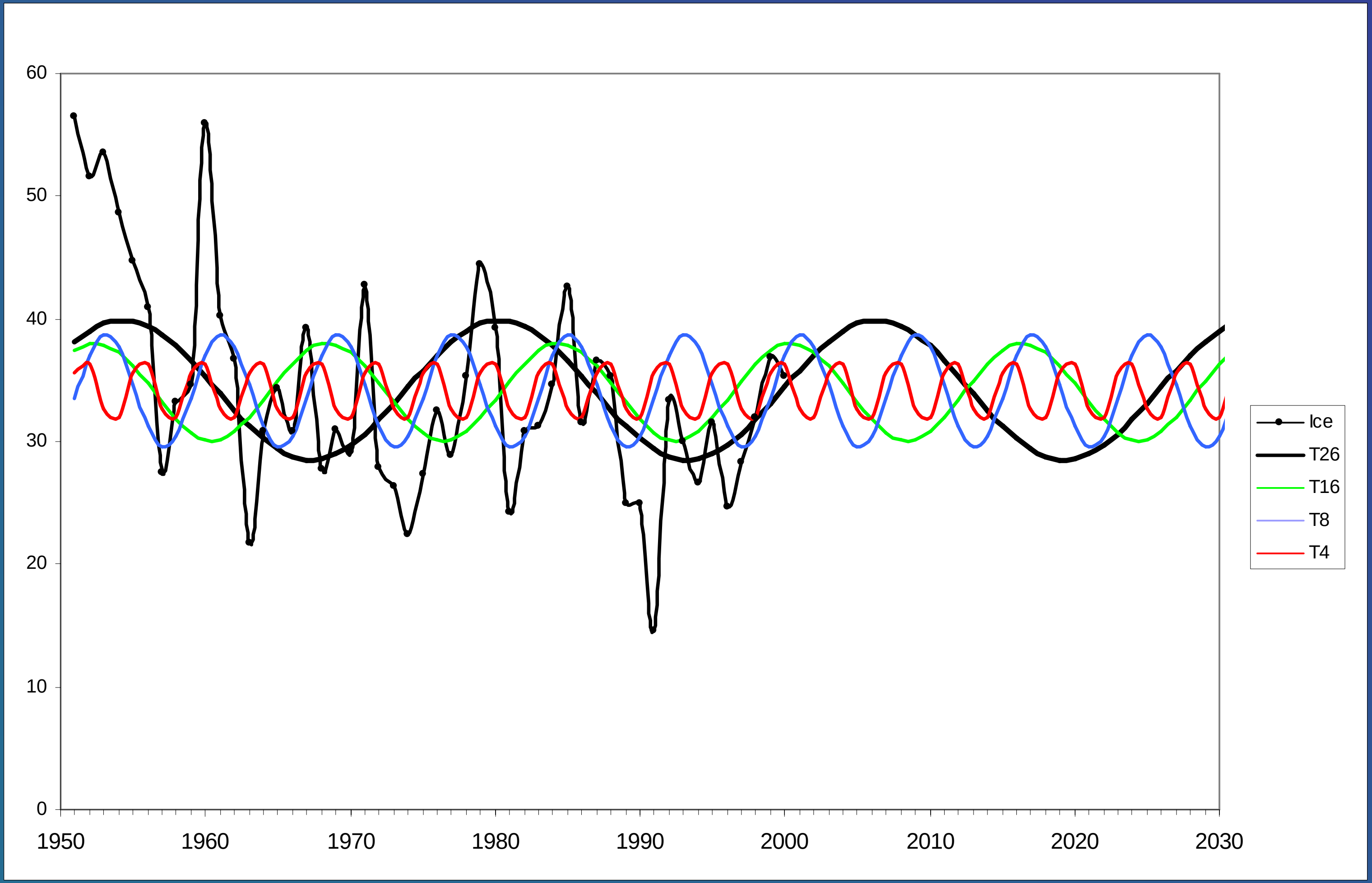


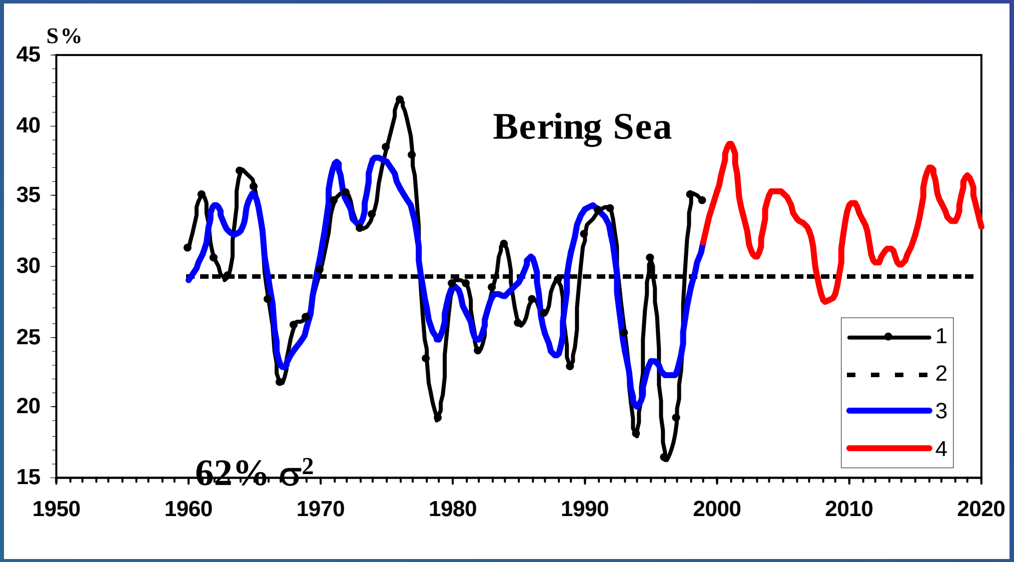
Long-term harmonics and interannual variations of the mean winter ice cover in the Okhotsk and Bering Sea

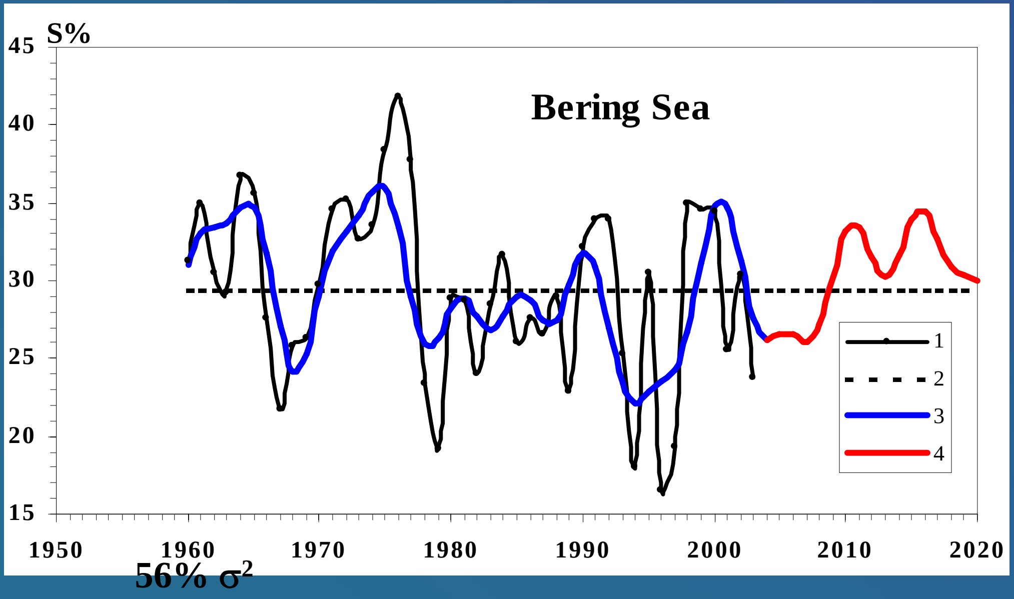




Long-term harmonics and interannual variations of the mean winter ice cover in the Tatar Strait

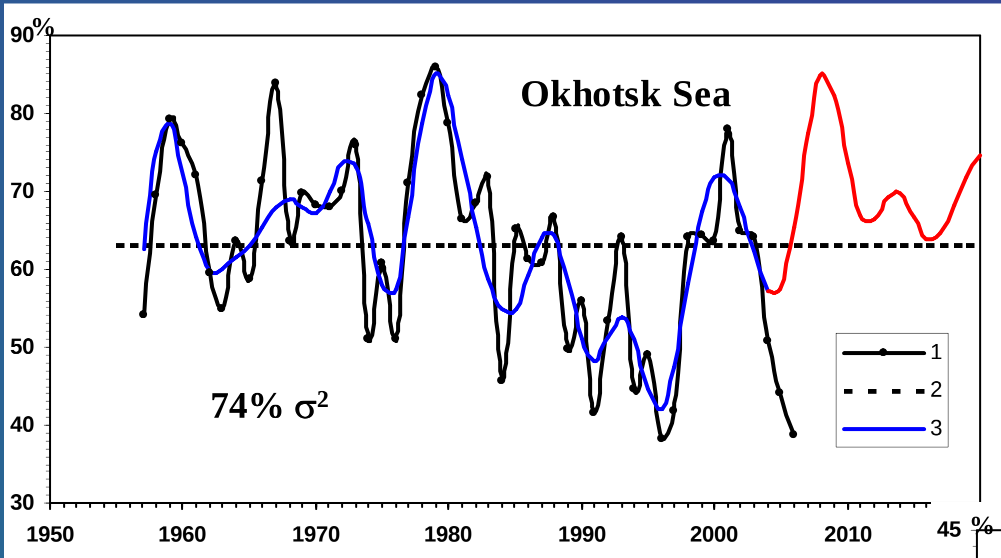






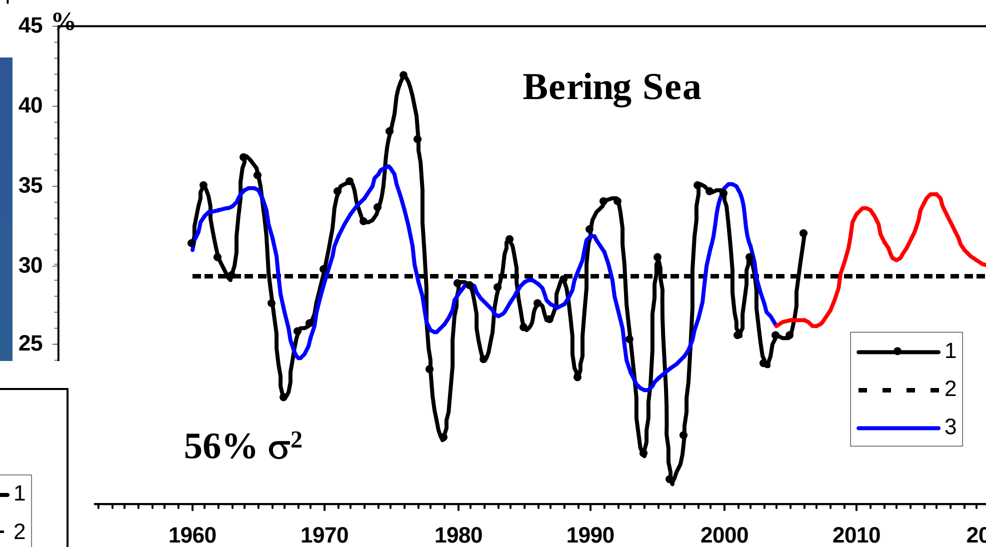
Mean winter (January – April) ice cover in Bering Sea (1), approximation of its variations by sum of harmonics (2) and mean multi-year value (3, 4).
A - the first calculations in 1999,
B – the recent calculations in 2003

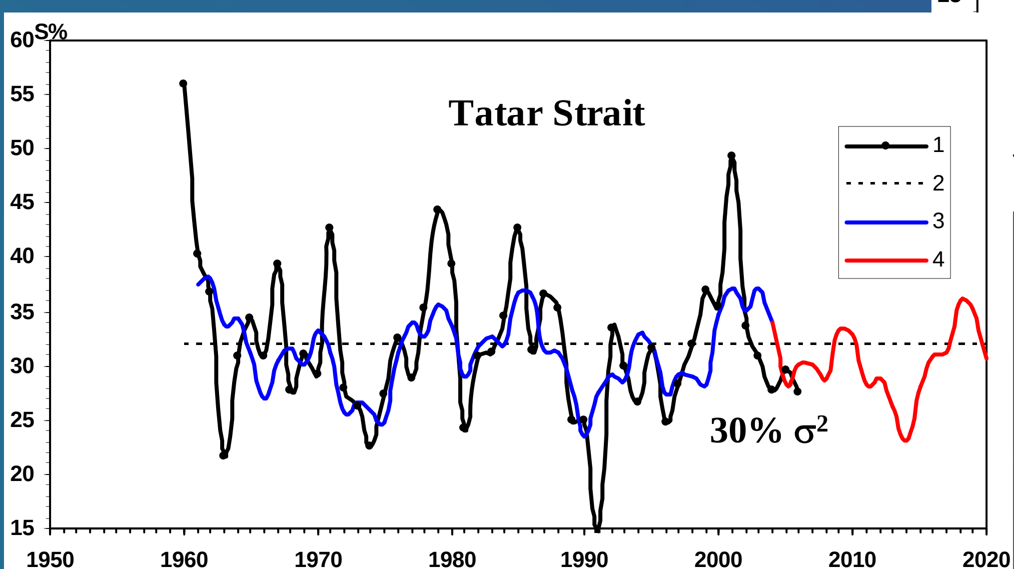
We made the first attempts to forecast a long-term ice cover variability in the Far-Eastern Seas in 1999. By comparison with these calculations, we found significant changes in the prognostic curve for mean winter ice cover in Bering Sea from 2003 to 2007. In this period, an increasing of ice cover was forecasted, but now decreasing.



Year-to-year changes of ice cover averaged for January – April (1), its mean values (2)

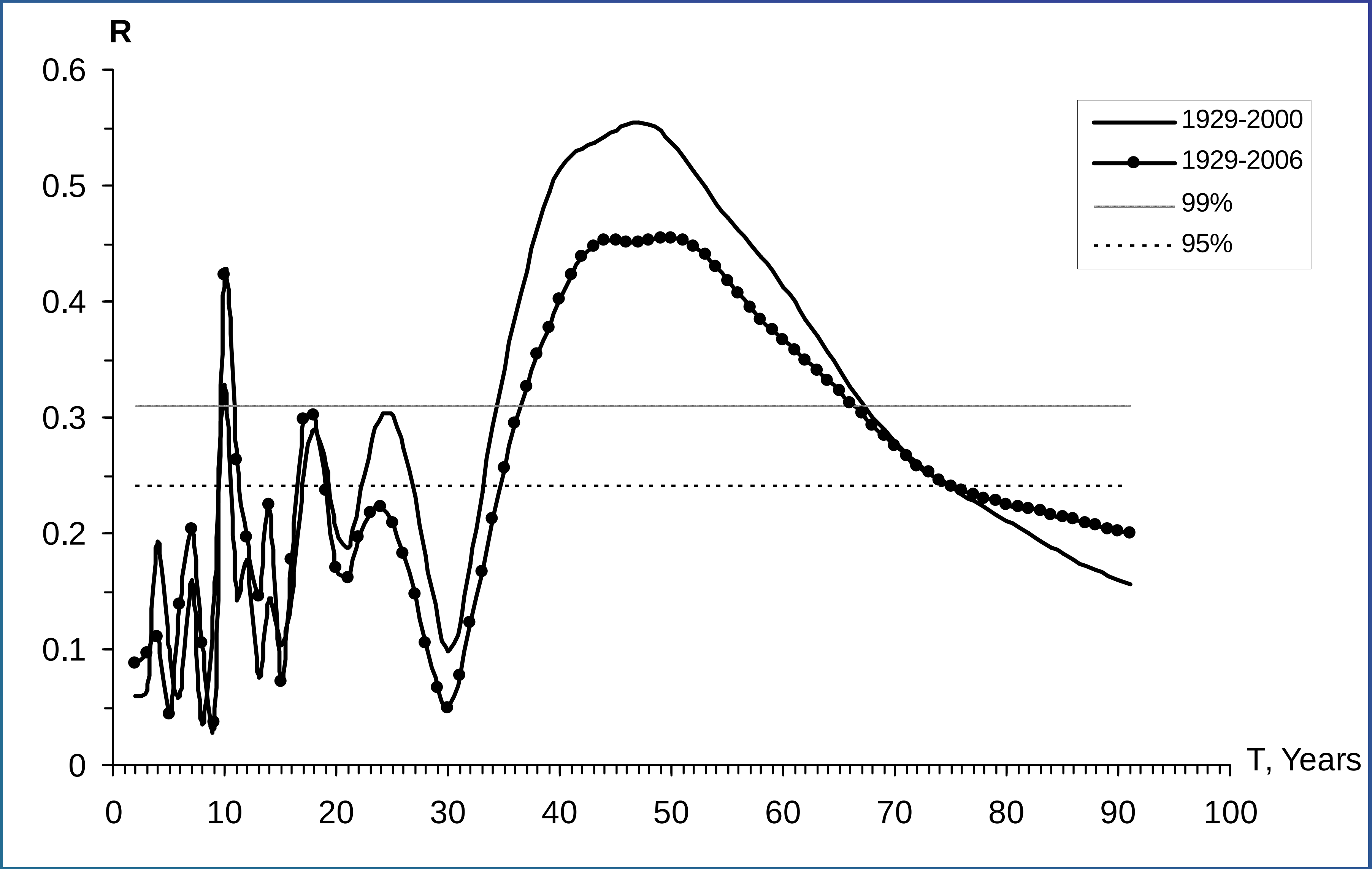
Version 2004



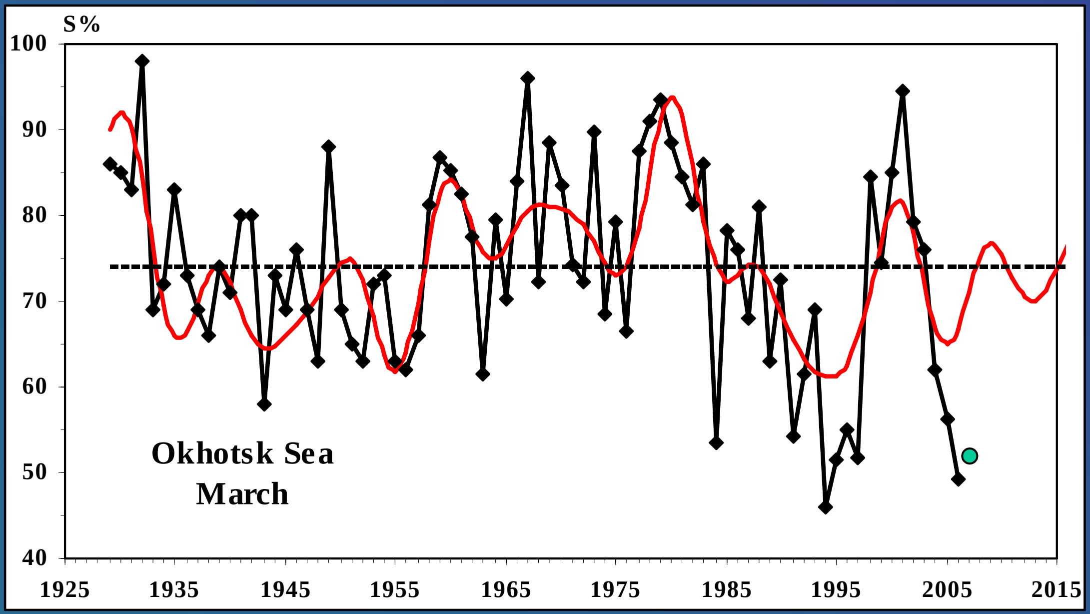


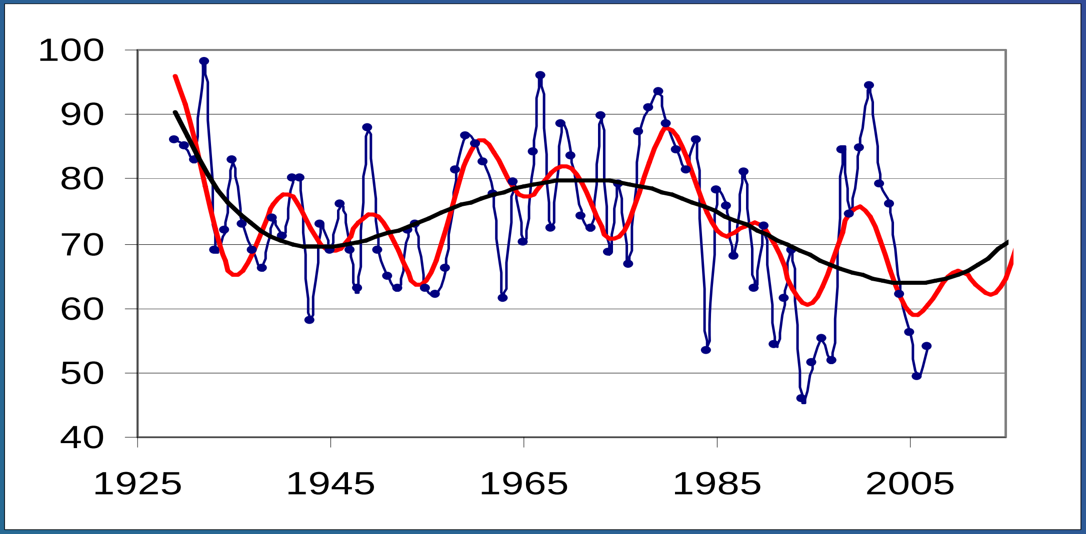
and its approximation and extrapolation by sum of harmonics (3, 4)

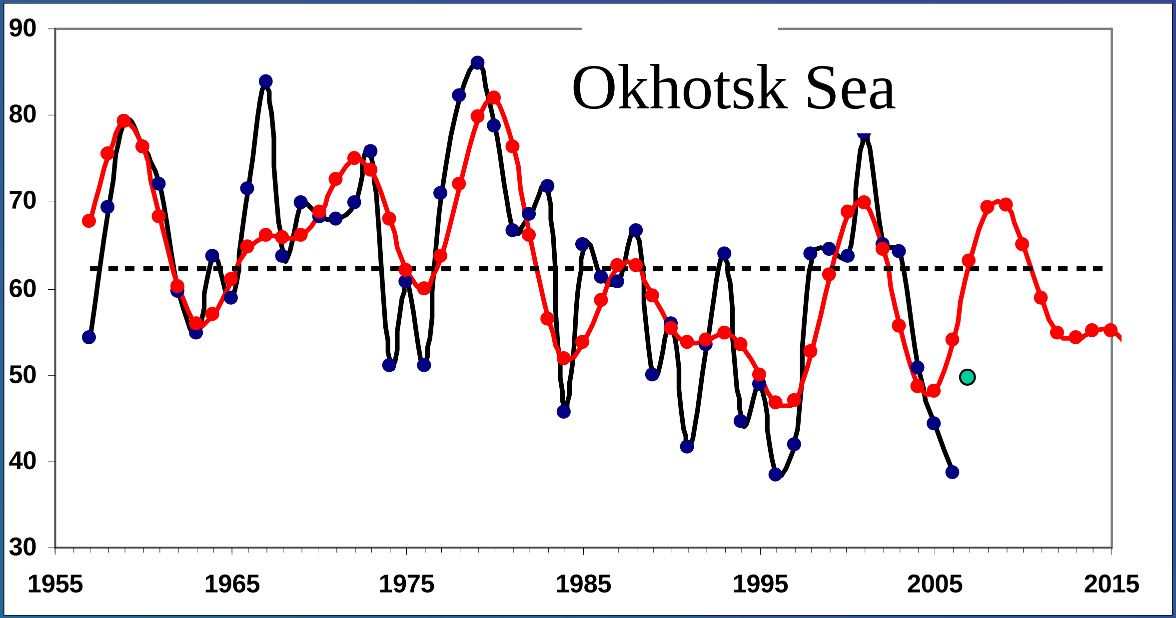
"Periodogram" of the maximal ice cover in the Okhotsk Sea

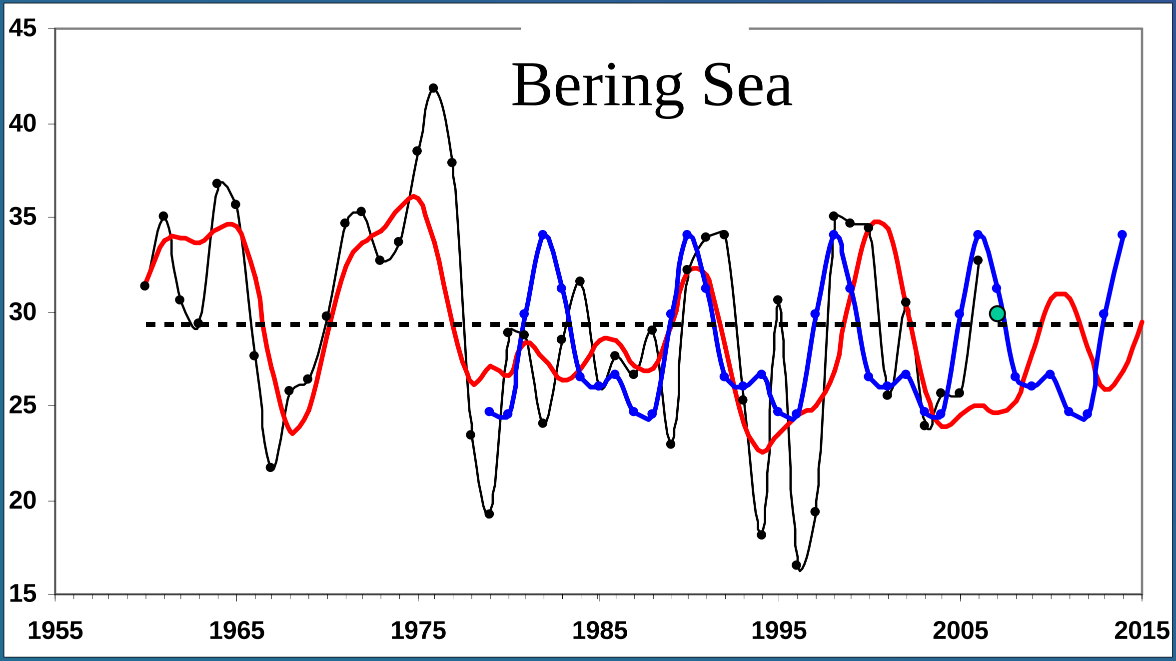


Approximation of ice cover variability by sum of long-term harmonic components, year-to-year variation and mean value of the maximal ice cover in the Okhotsk Sea : long time series





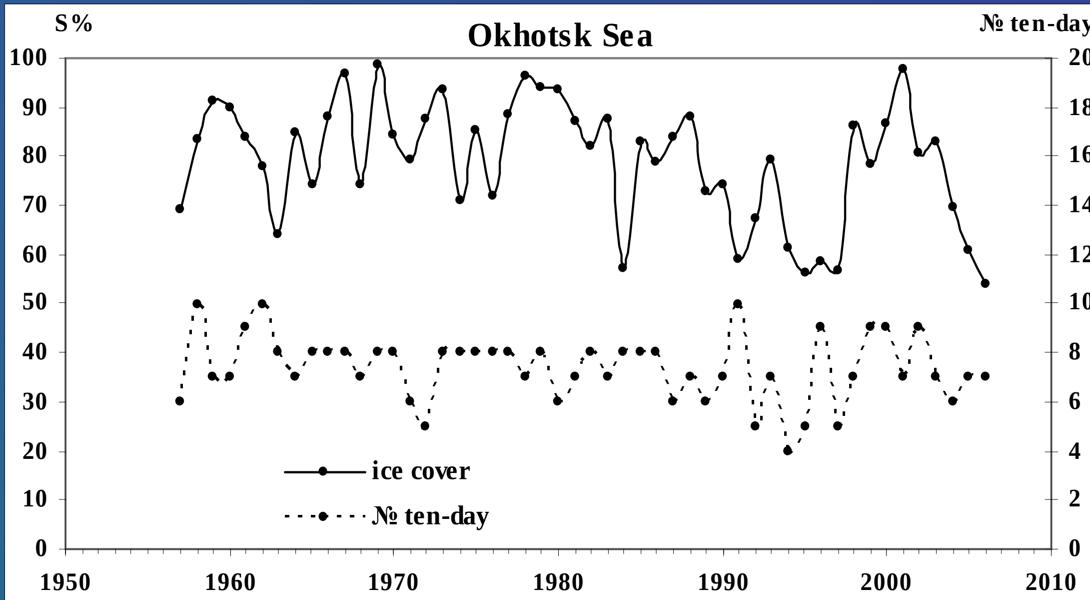


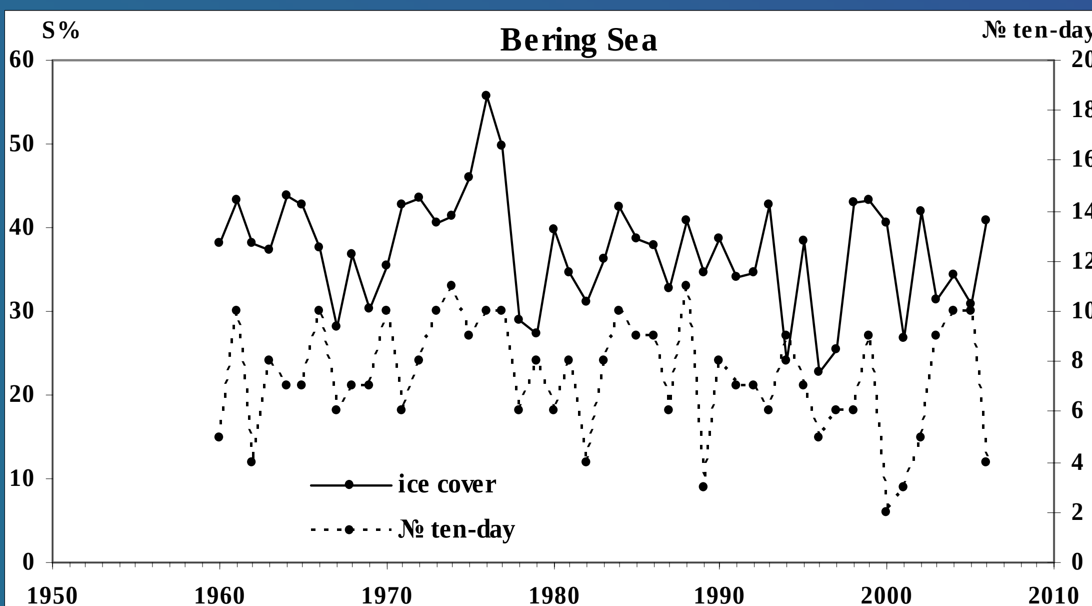


Version 2006

Year-to-year changes of ice cover averaged for January – April

and its approximation and extrapolation by sum of harmonic components (red and blue)

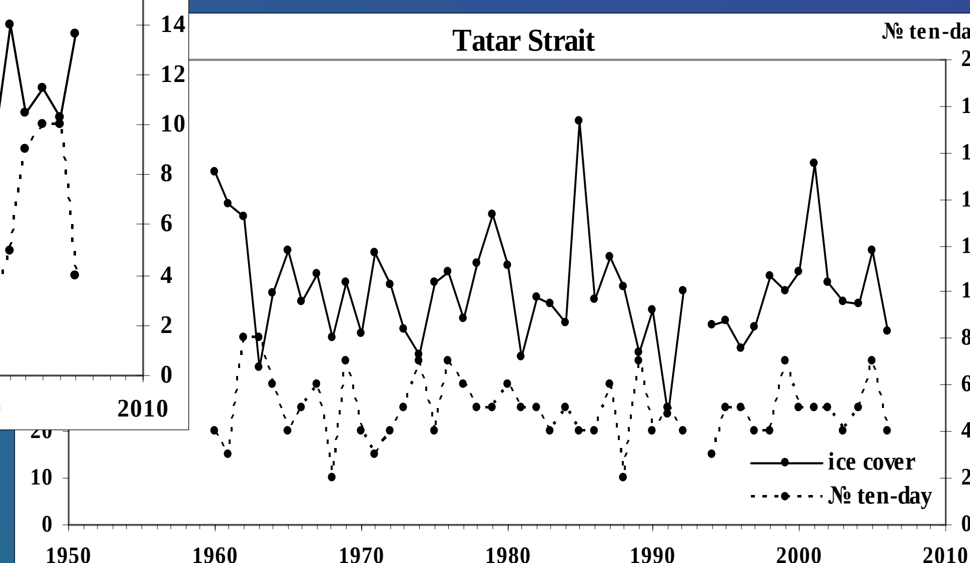




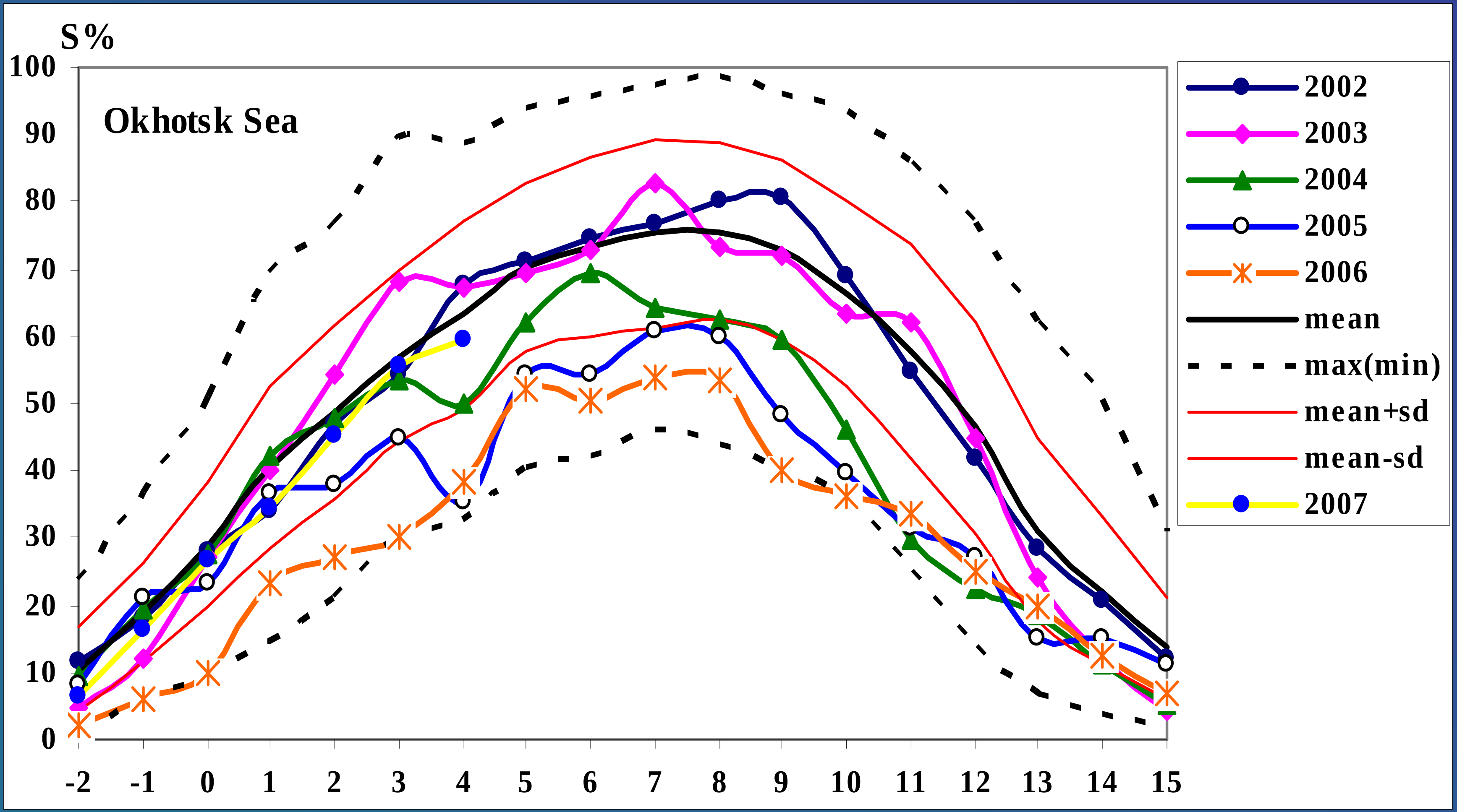
Annual maximum ice cover

in the Okhotsk Sea, Bering Sea and Tatar Strait

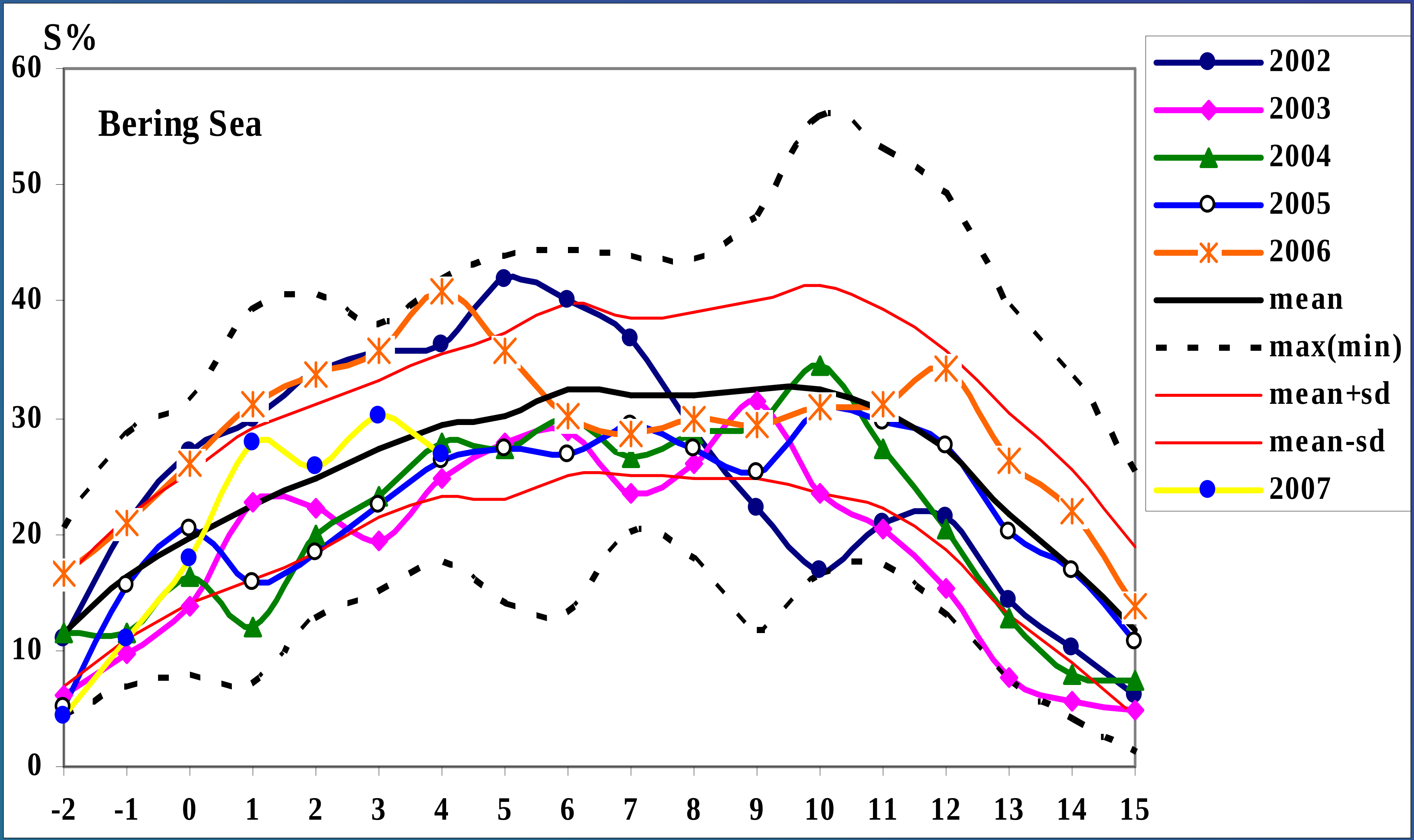
and its timing



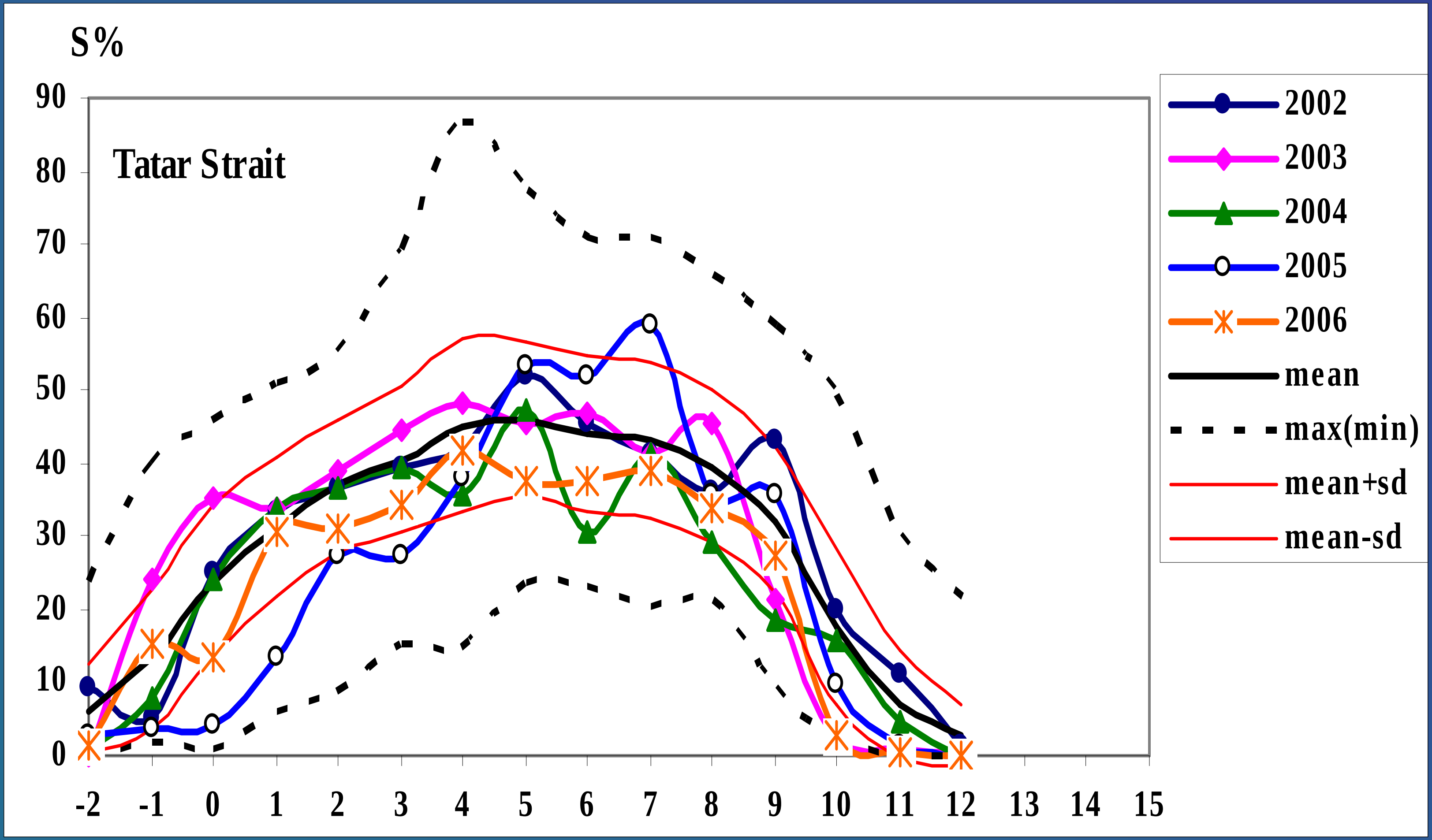
Winter ice covered area of the Okhotsk Sea in 2002-2006 in comparing with mean (± standard deviations) and extreme low and high values for the period 1957-2006



Winter ice covered area of the Bering Sea in 2002-2006 in comparing with mean (± standard deviations) and extreme low and high values for the period 1957-2006



Winter ice covered area of the Tatar Strait in 2002-2006 in comparing with mean (± standard deviations) and extreme low and high values for the period 1957-2006



Seasonal forecasting

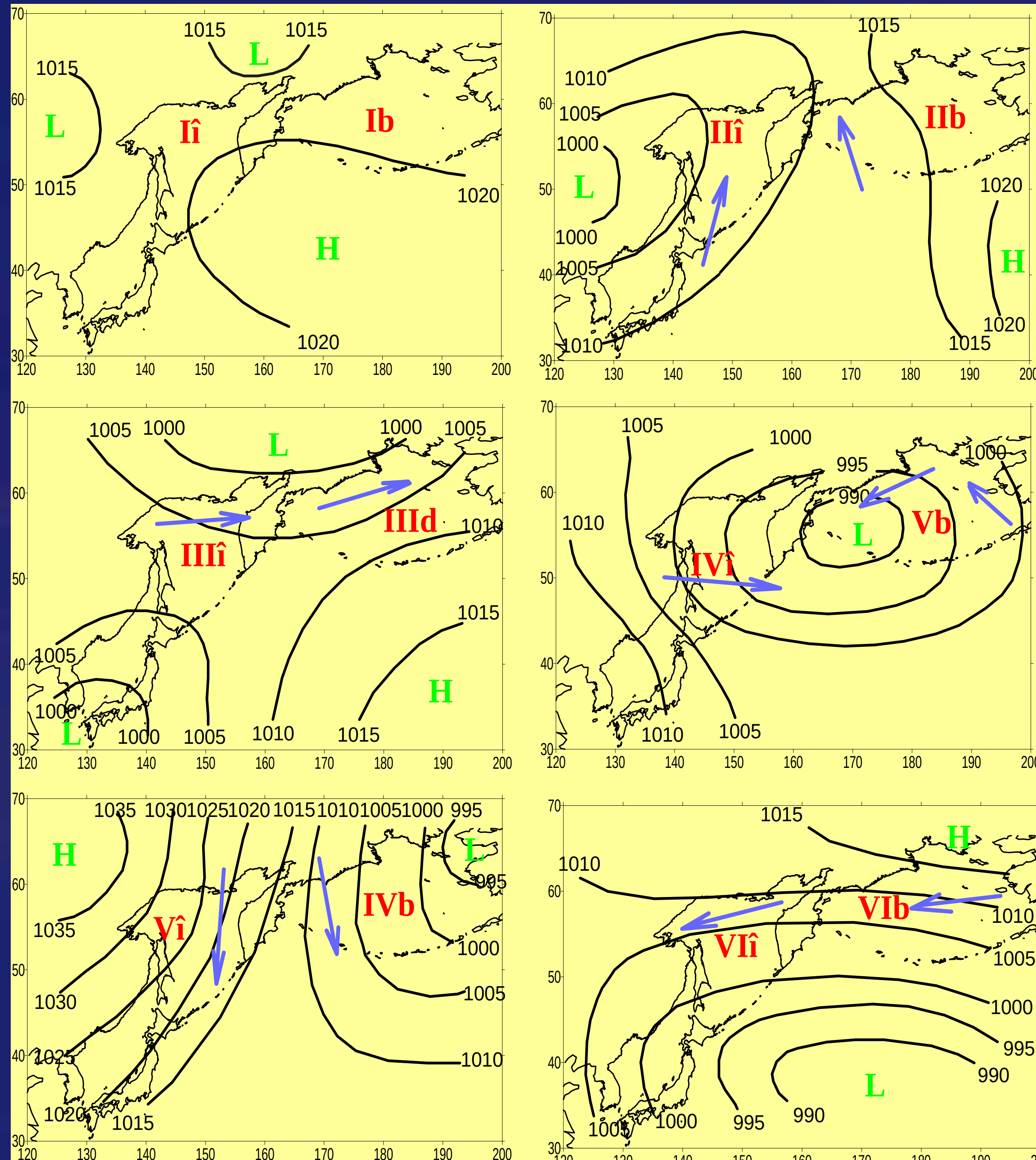
for next winter:

with autumn conditions

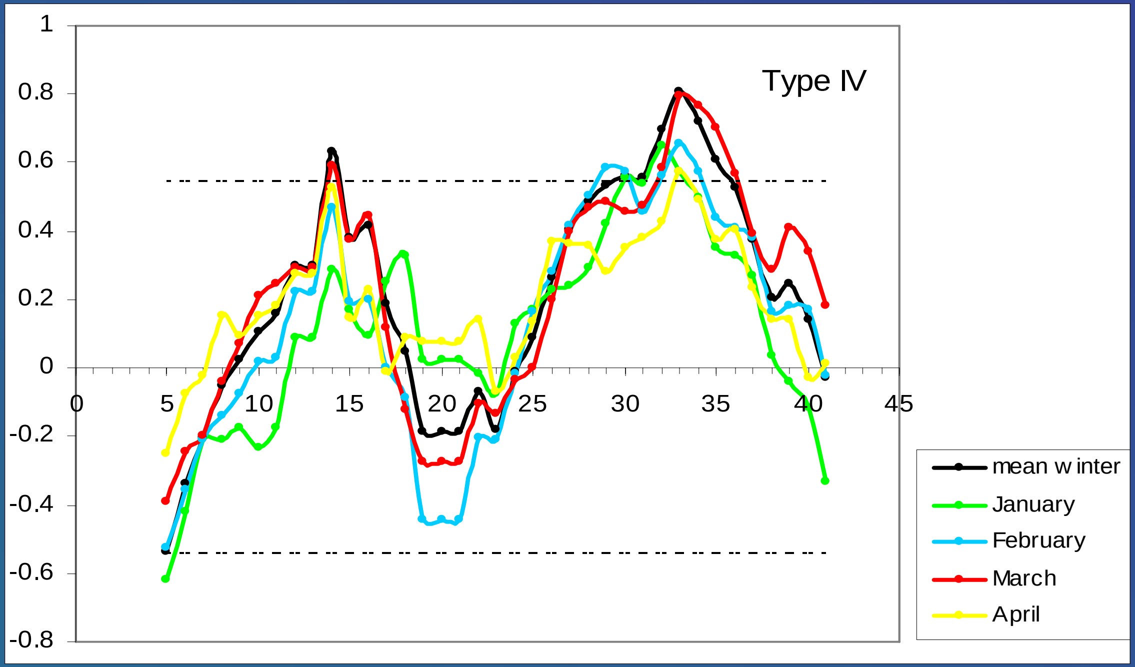
Indices for regional scales:

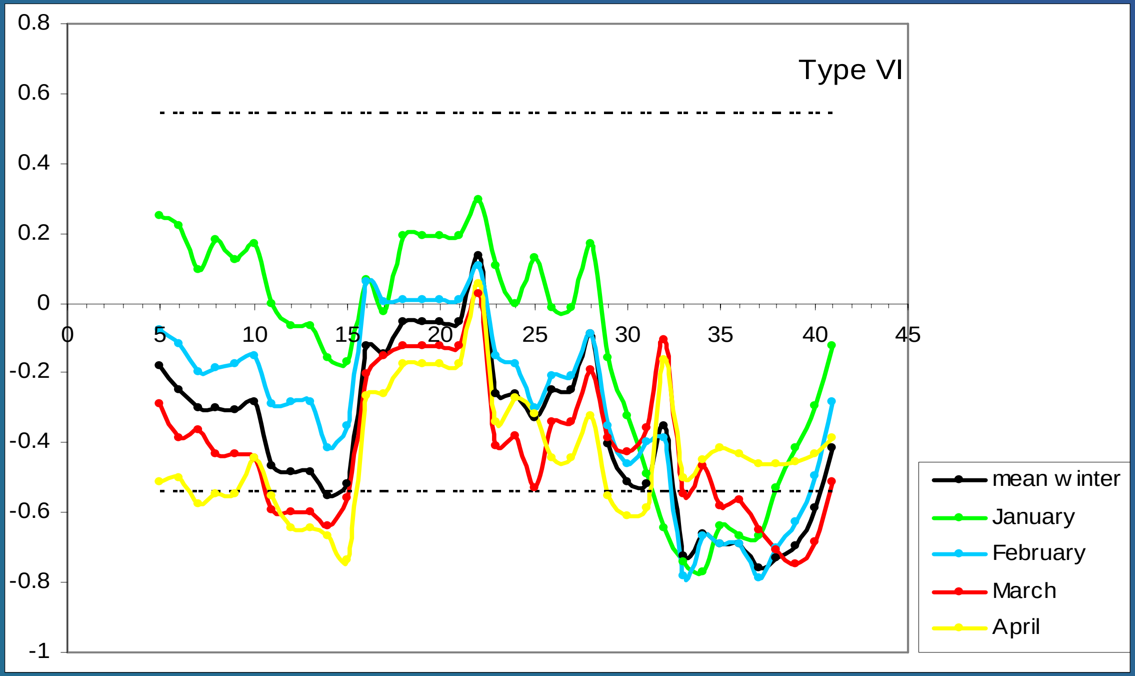
Types of atmospheric processes over the Okhotsk and Bering Seas

(after Glebova, 1999; 2001)

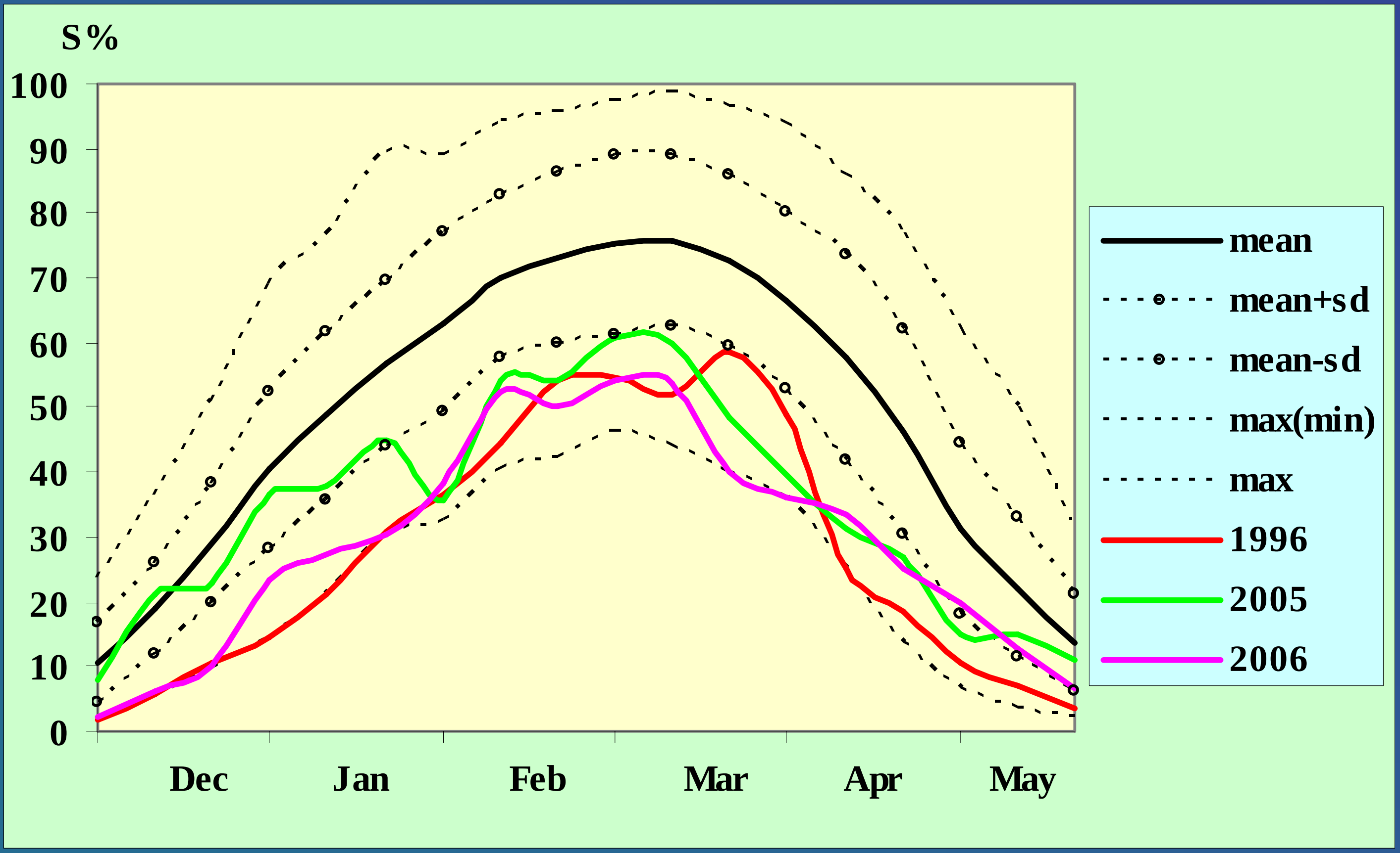


Correlations between regional atmospheric indices (by Glebova's) and ice extent on the Okhotsk Sea

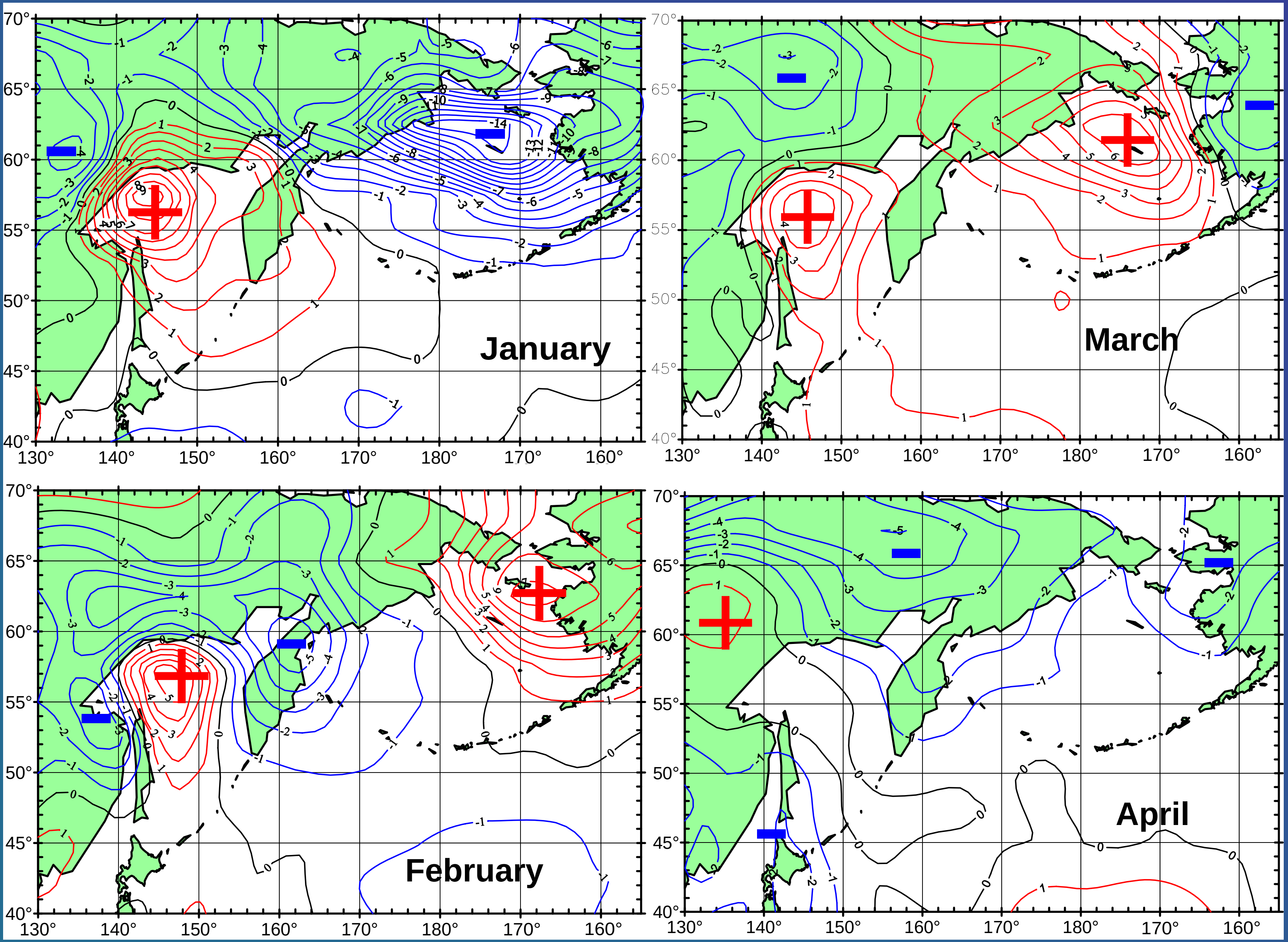




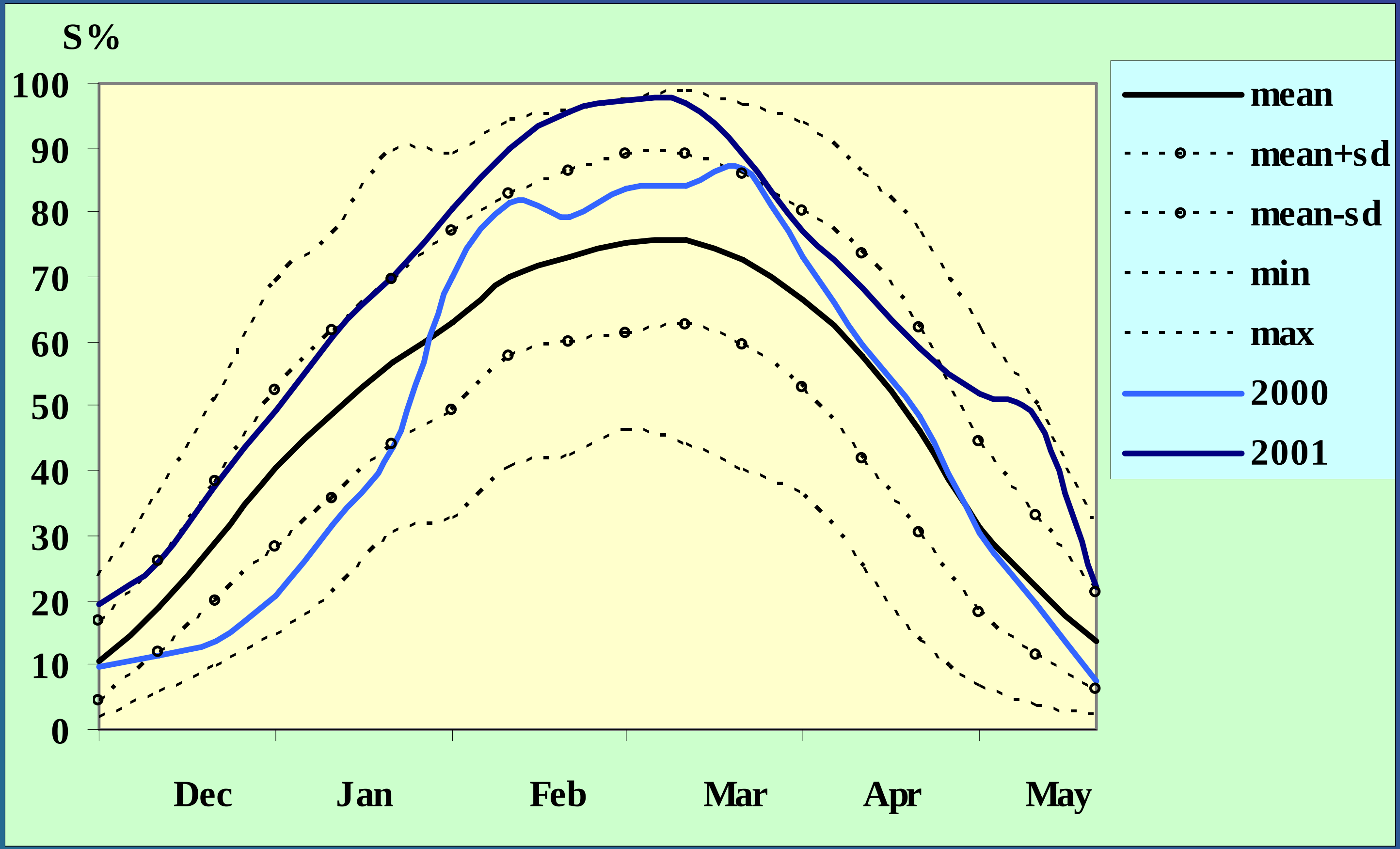
Winter ice covered area of the Okhotsk Sea in 1996, 2005, 2006 (lowered ice coverage) in comparing with mean long-term (± standard deviations) and extreme low and high values for the period 1957-2006



Air temperature anomalies in 2006:

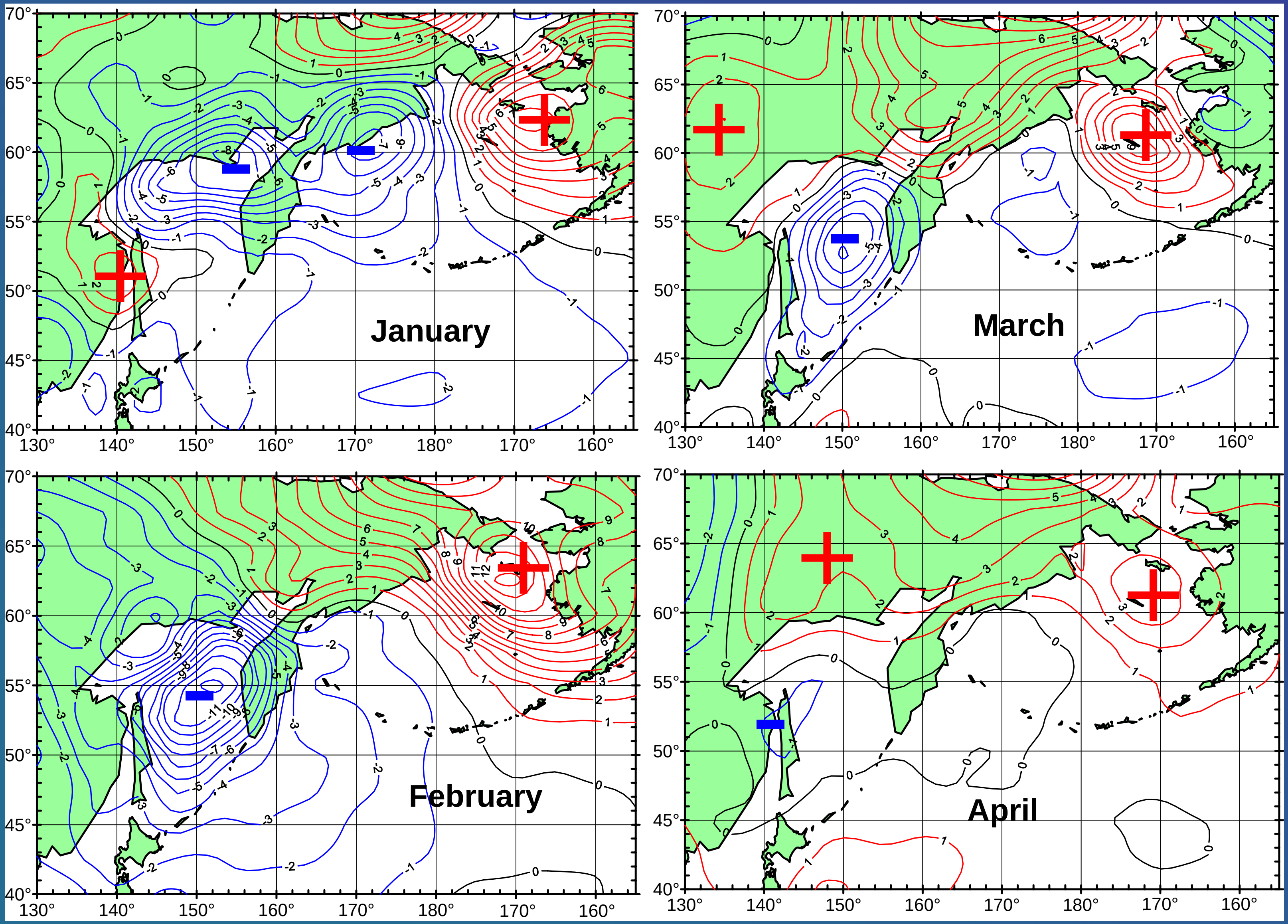


Winter ice covered area of the Okhotsk Sea in 2000-2001 (increase of ice coverage) in comparing with mean long-term (± standard deviations) and extreme low and high values for the period 1957-2006



The formation of strong winter atmospheric anomalies over Far-Eastern region causes the fast response in large ice cover anomalies. In the winter 2000 and 2001 (with high ice cover in the Okhotsk Sea) lag period was only 10-20 days.

Air temperature anomalies in 2001:



CONCLUSIONS

- “Stability” of the statistical “scenarios” of ice cover long-term variability: 3-4 years for the Bering Sea and 5-6 years for the Okhotsk Sea. Contribution of quasi-harmonic components to interannual variability is from 30 % for the Tatar Strait to 74 % for the Okhotsk Sea.
- In the Okhotsk Sea repeatability of extreme situations has increased last 12 years.
- In Bering Sea the similar unidirectional tendency is absent.
- For the time series from 1929 to 2007 the contribution of the quasi-pentadecadal and 25-years components had decreased relatively, but the contribution 10- years scale had increased.
- During recent “extreme” years (2001 and 2006) for the Okhotsk Sea, anomalies of the ice cover of Bering Sea were in opposite phase with the Okhotsk Sea. The atmospheric thermal condition in these areas was antiphase in this years, too.
- For the predictions of change in the ice regime over short time scales (month and season) atmospheric characteristics are used. In this case the errors of the forecast are connected with extreme events. The formation of strong winter atmospheric anomalies over Far-Eastern region causes the fast response in large ice cover anomalies.

Thank you for attention!