Structure of regional climate variability in the Far-Eastern Seas

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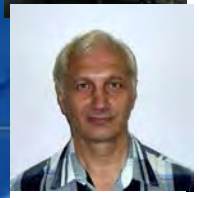

The main components of climate variability:

- regime shifts,
- trends,
- quasi-periodical oscillations,
- extreme events.

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Scheme of climate variability structure

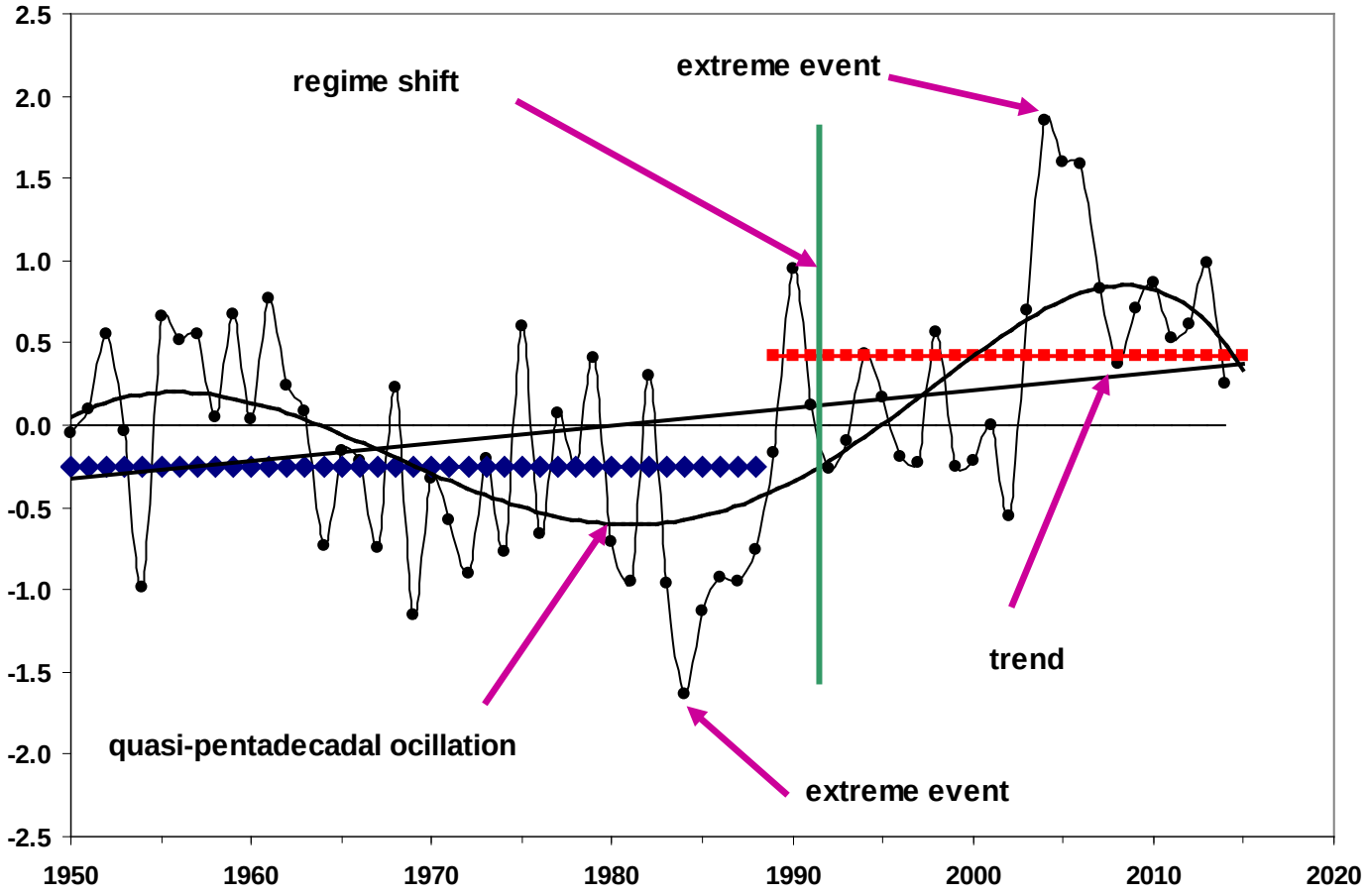
(*on example of autumn SST anomalies variation in the Japan/East Sea*):

- trend,

- regime shift,

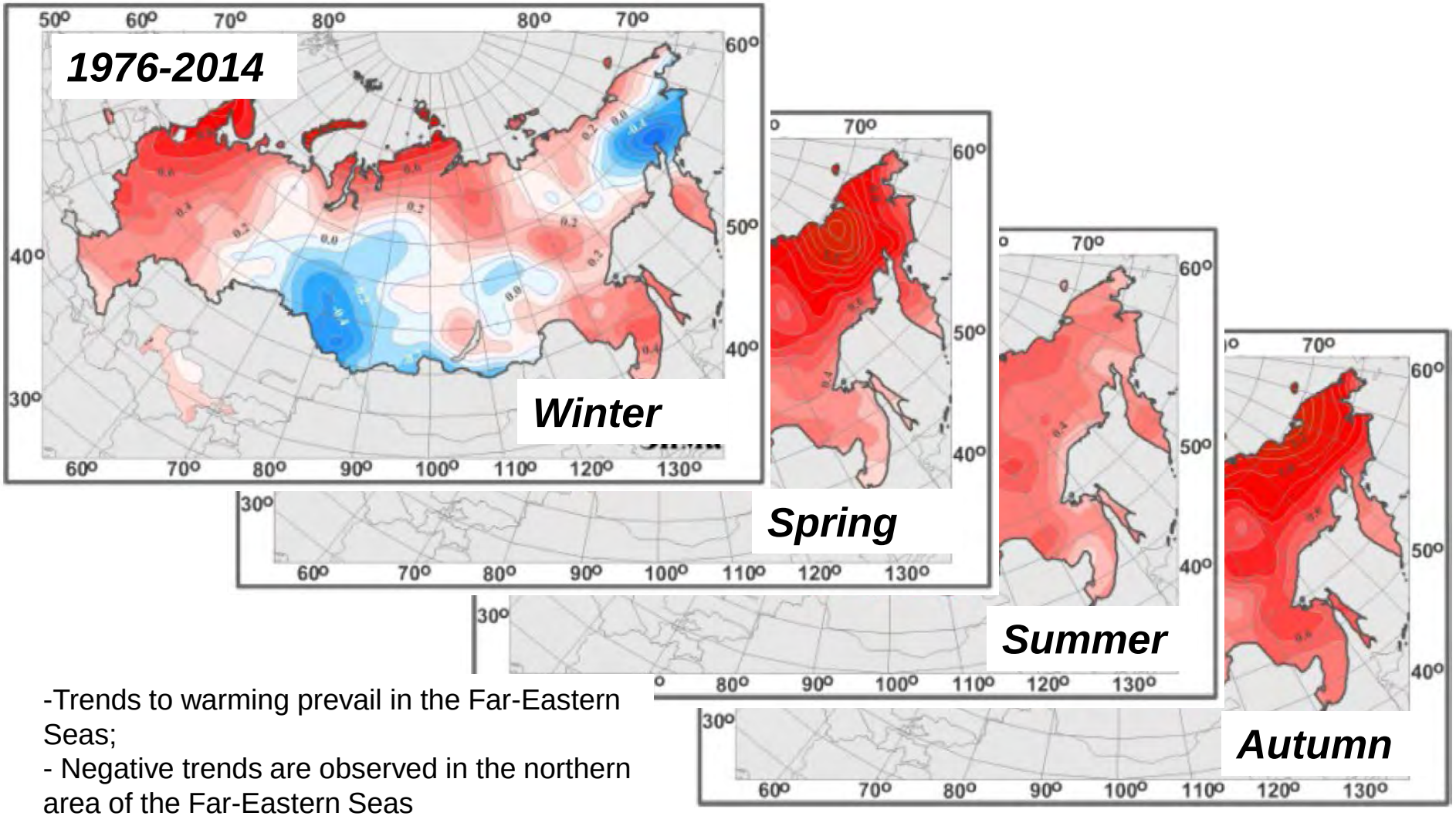
- quasi-periodical oscillation (here: pentadecadal oscillation),

- extreme events



Trends

Air temperature trends, °C/decade

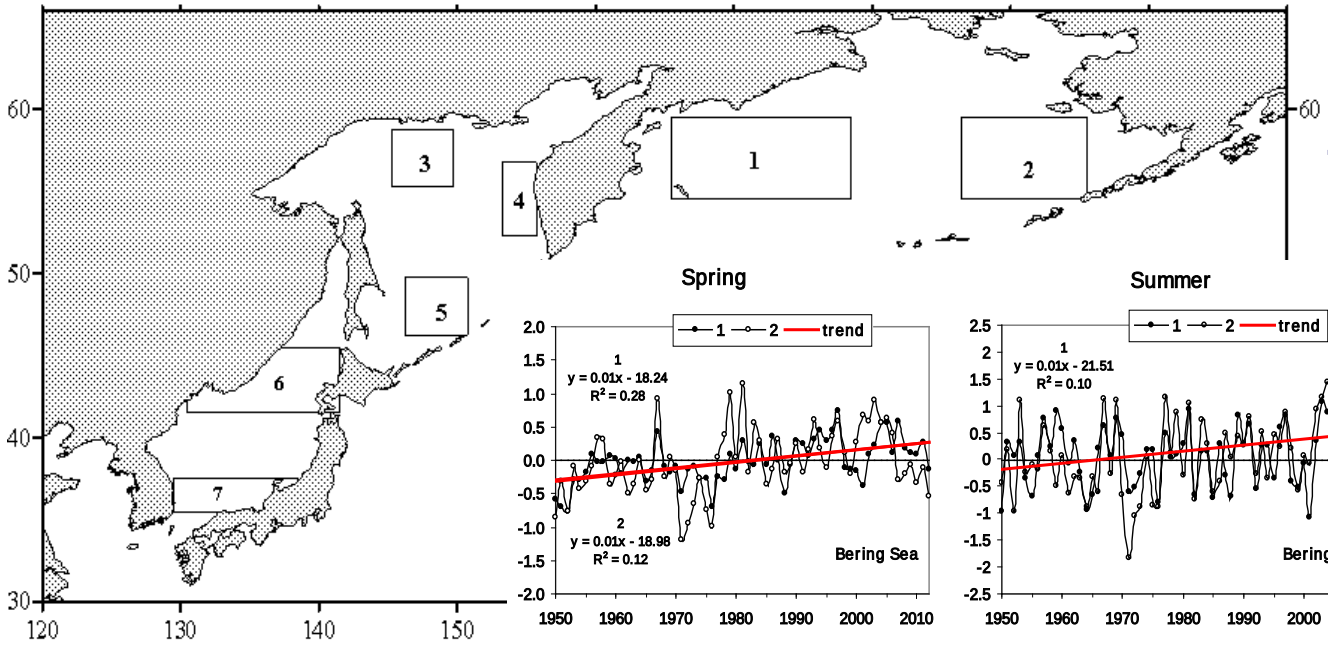


-Trends to warming prevail in the Far-Eastern Seas;

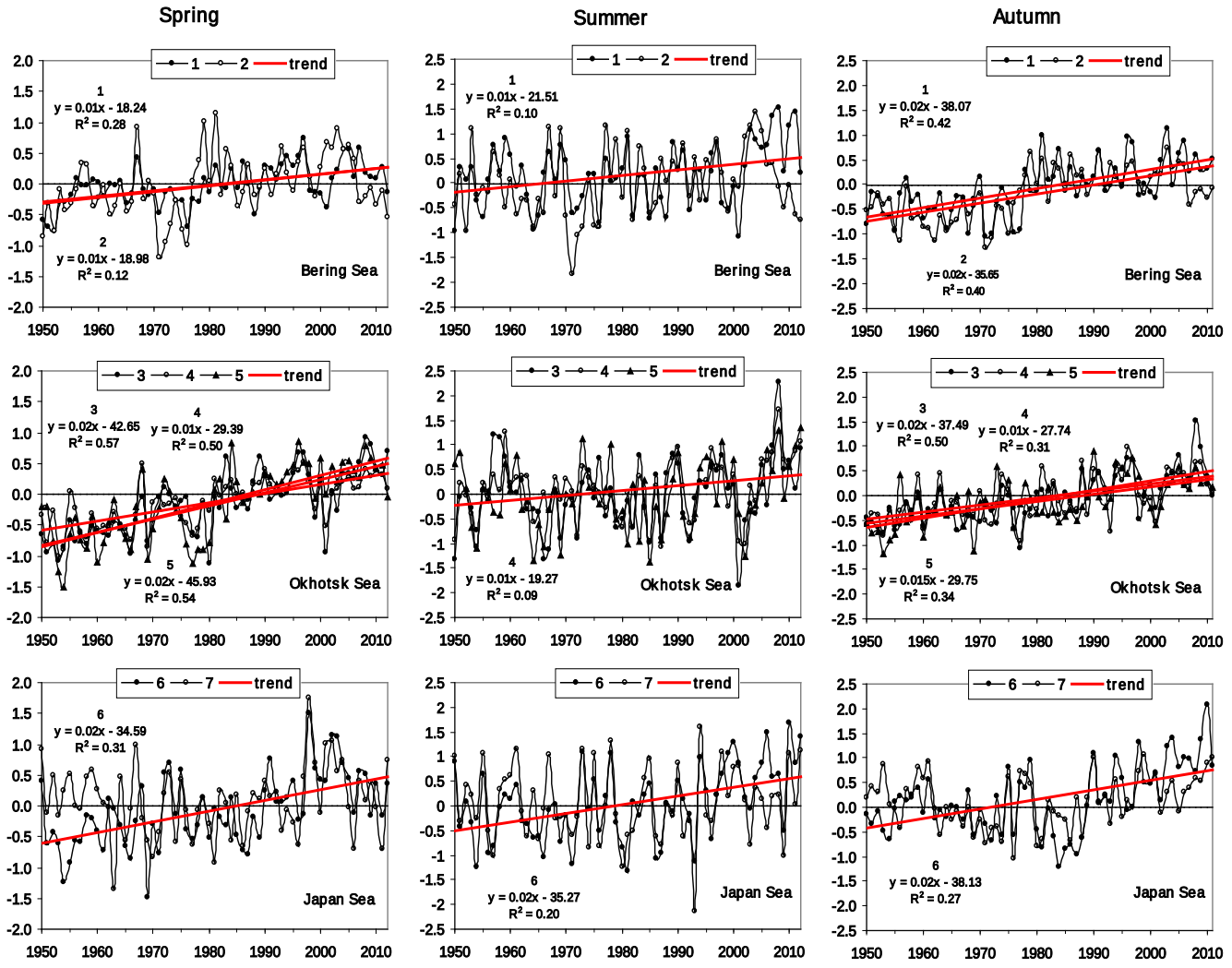
- Negative trends are observed in the northern area of the Far-Eastern Seas

- Difference between summer and winter air temperatures (index of continentality) becomes lower in the Japan/East Sea only

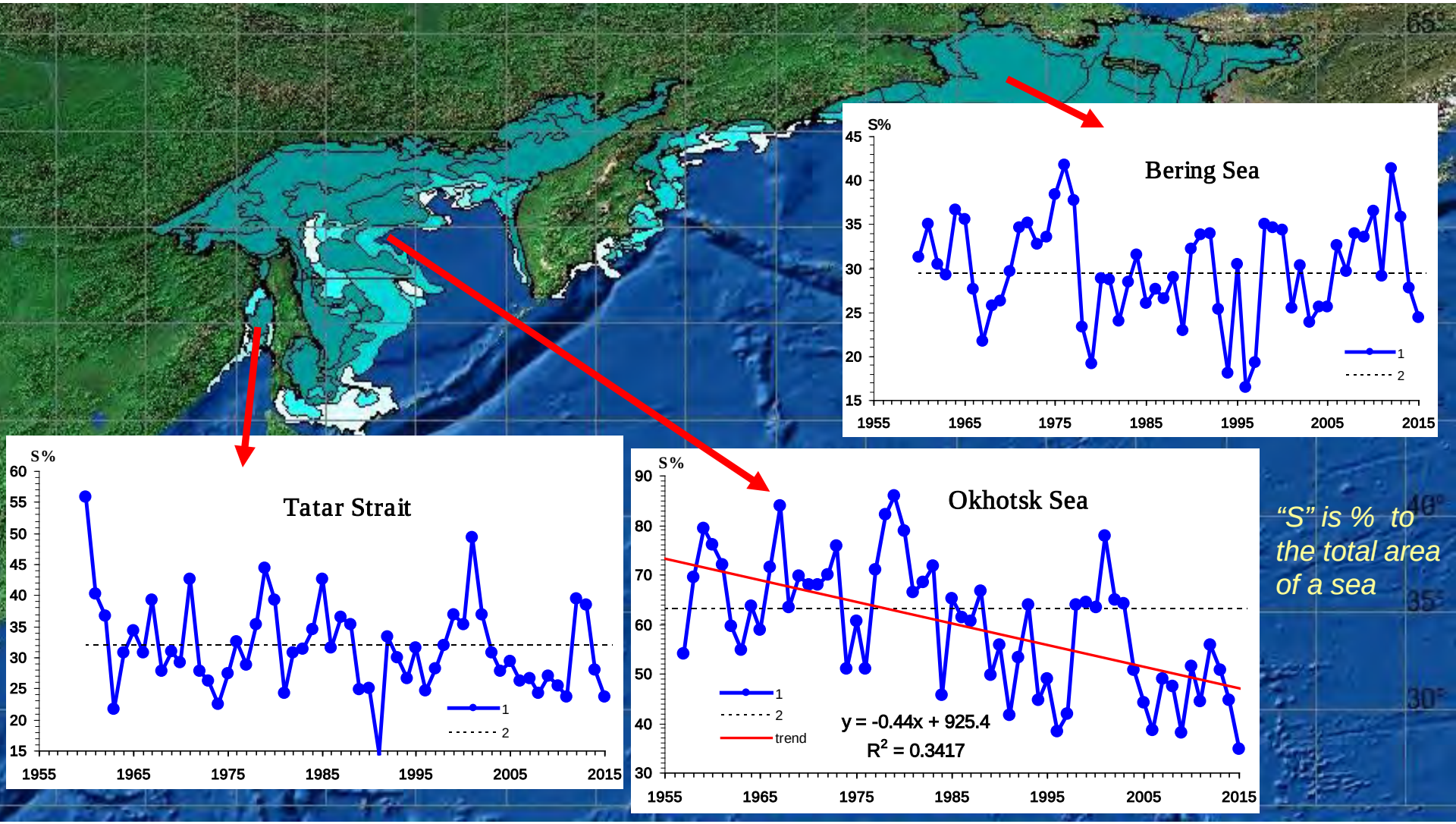
SST trends in selected areas of the Far-Eastern Seas



SST increases in 0.1-0.2 grad/decade everywhere



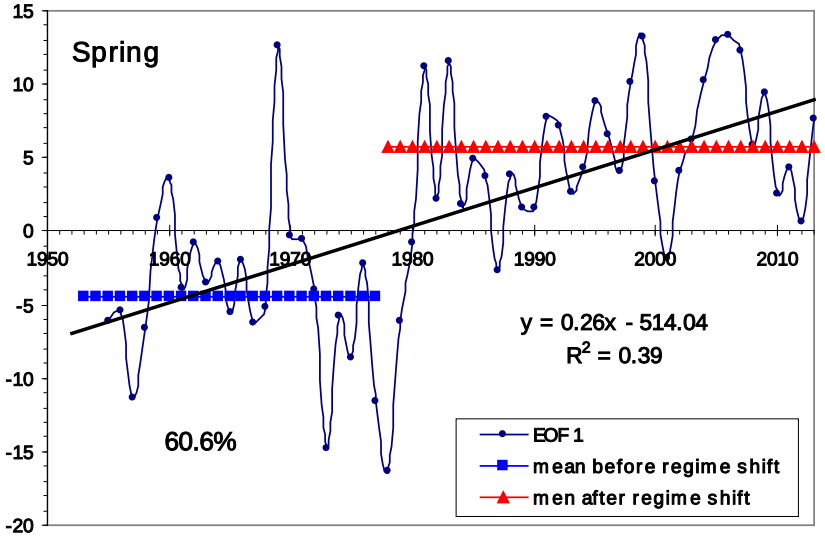
Year-to-year changes of the mean winter ice cover.
Negative trend is statistically significant for the Okhotsk Sea only (red line)

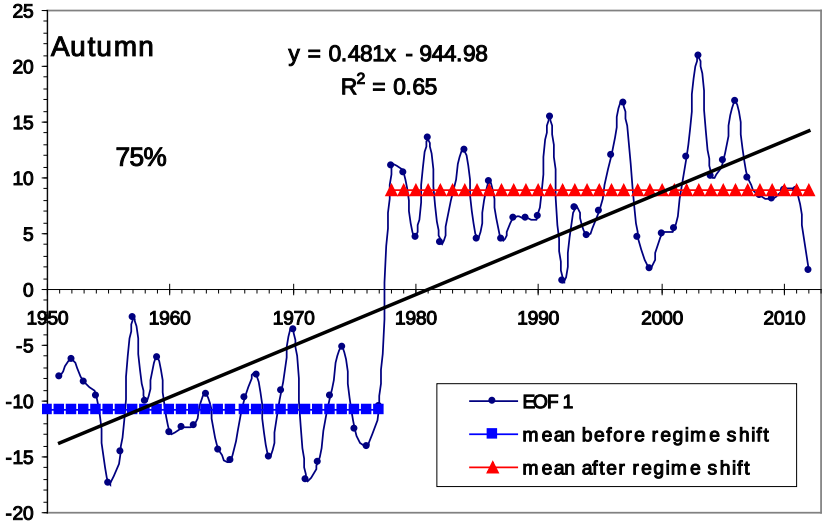


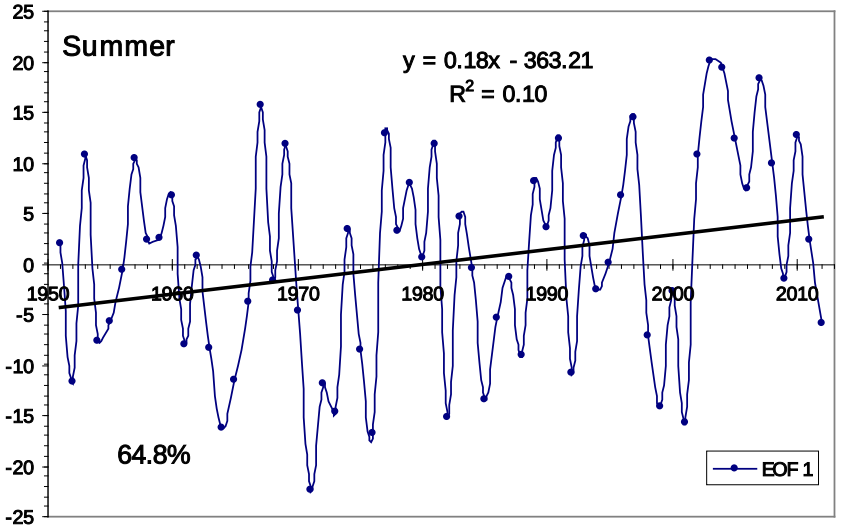
Trend to warming is accompanied by significant decreasing trend of the sea ice cover in the Okhotsk Sea only (4,4% per decade). Reduction of the mean winter ice cover in the Bering Sea and the Tatar Strait is not statistically significant for the period 1960-2015

Regime shifts

Regime shift *vs* trend

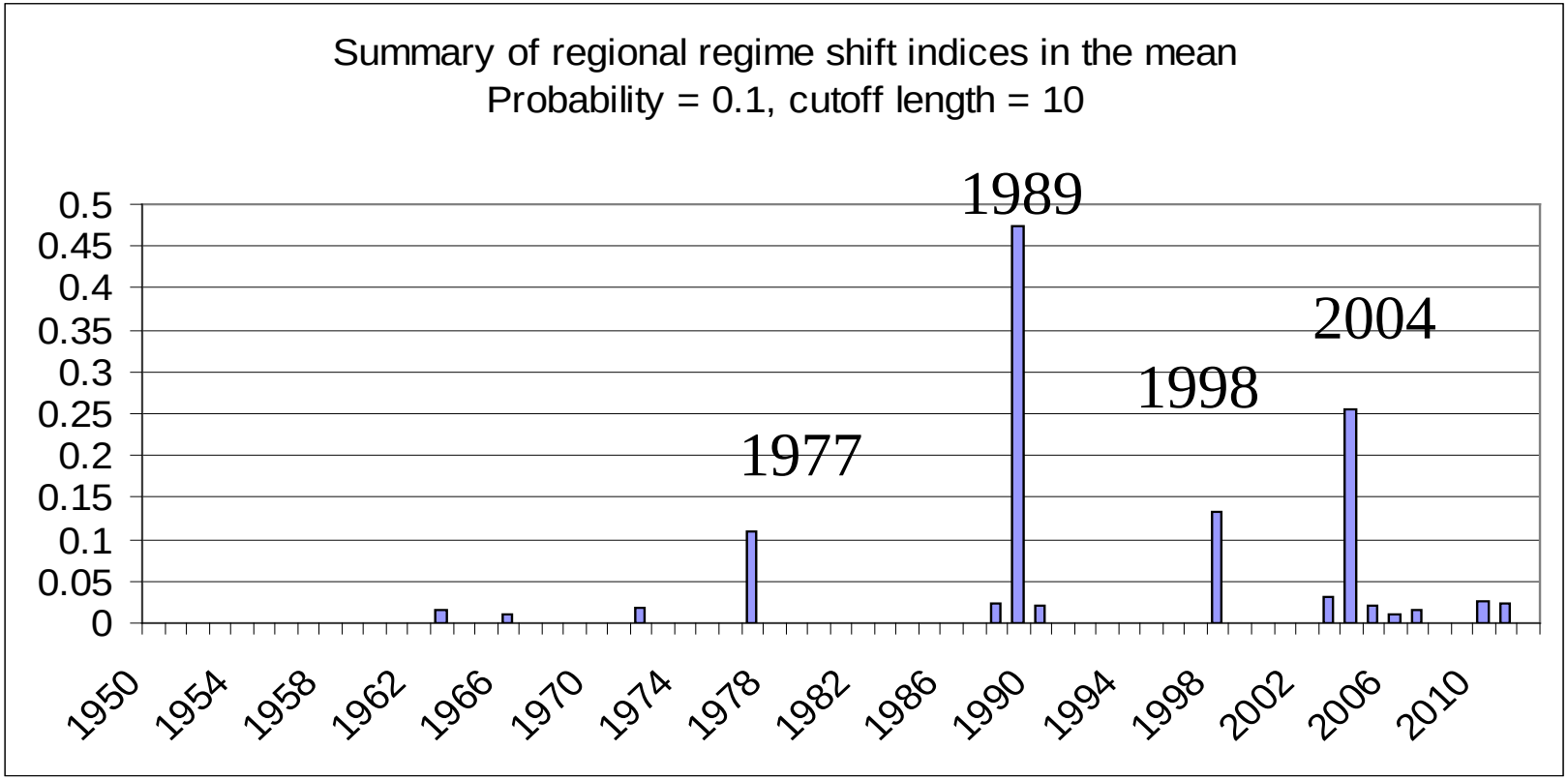






EOF-1 for SST time series in the Bering Sea, by seasons.
Regime shift of the 1877/78 is detected on the background of the trend to warming.

Rodionov (2004) Regime Shift Index (RSI) for thermal variables in the Far-Eastern Seas

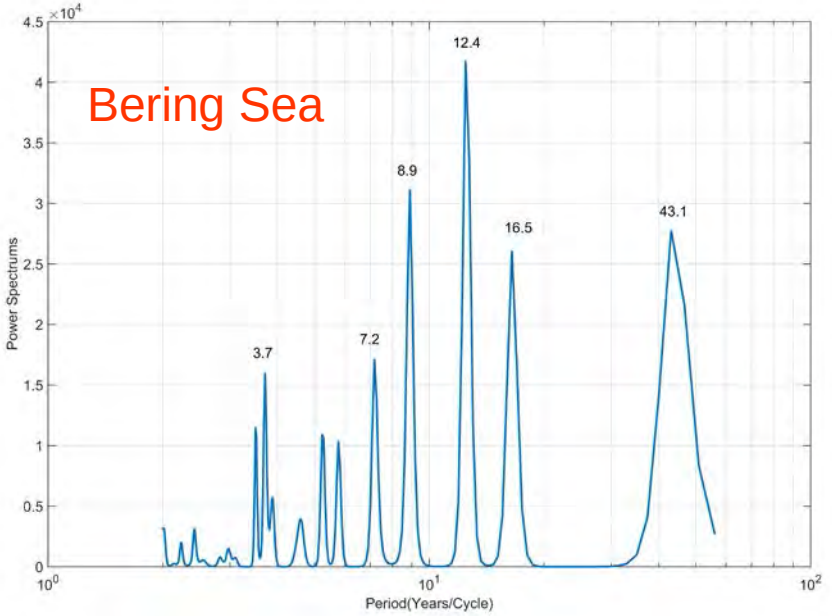


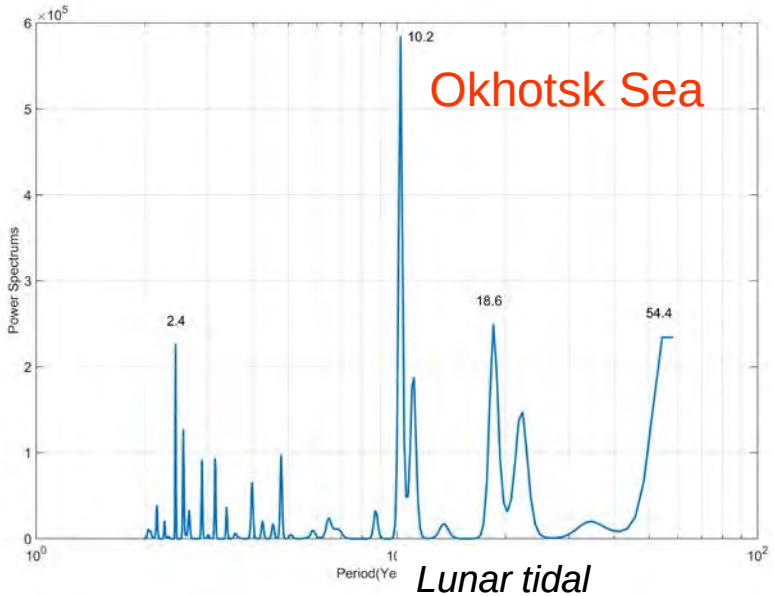
Strong regime shifts are different for different regions:
- shift of the 1977/78 (to warming) was observed mainly in the Bering Sea
- shift of the 1988/89 (to warming, the strongest) was observed mainly in the Japan/East Sea
- shift of the 2004/2007 (to cooling) was observed mainly in the Bering Sea

All these shifts are less significant for the Okhotsk Sea that looks like intermediate position of the Okhotsk Sea on the boundary between two variation systems

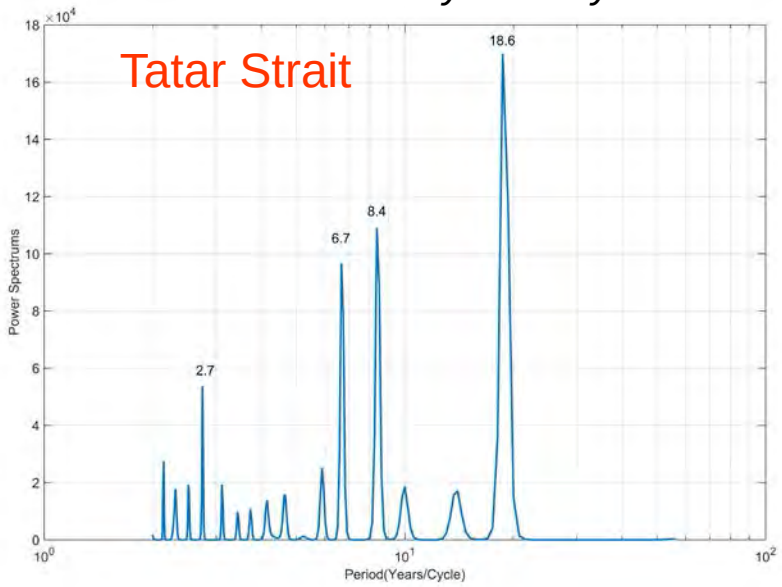
Quasi-periodical components

Power spectrums of ice cover in the Far-Eastern Seas





Lunar tidal cycle18.6 yr



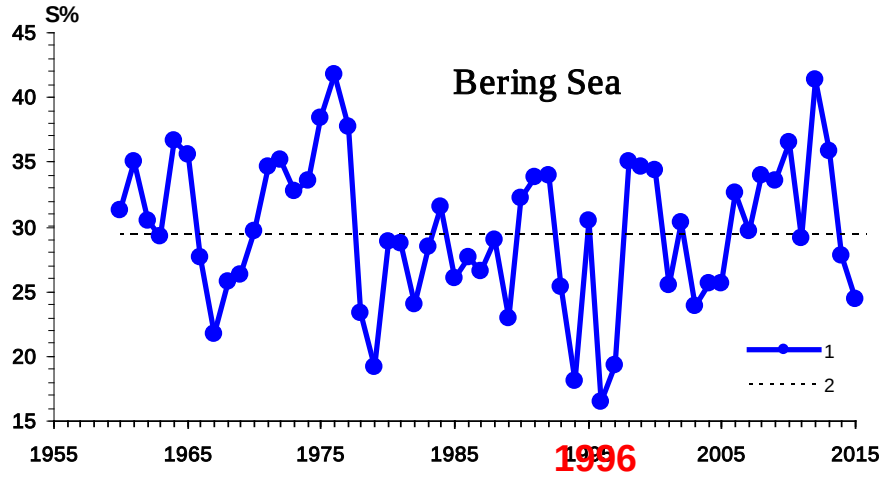
Basic contribution to the variance give the cycles with the following periods:

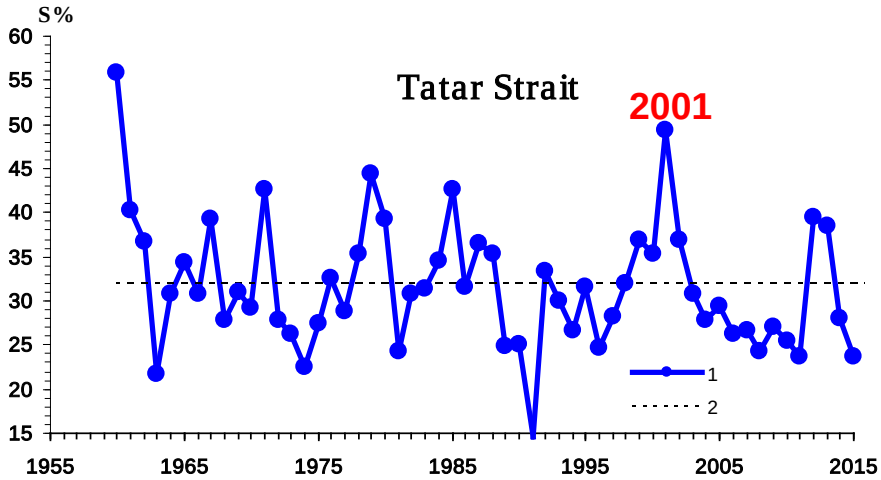
- about 50 years in the Okhotsk and Bering Seas (the hemisphere-scale oscillation in atmosphere)
- 18,6 years in the Okhotsk and Japan/East Sea (long-term variation of lunar tide)
- 10 years in the Okhotsk and Bering Seas (regional-scale atmosphere-ocean oscillation).

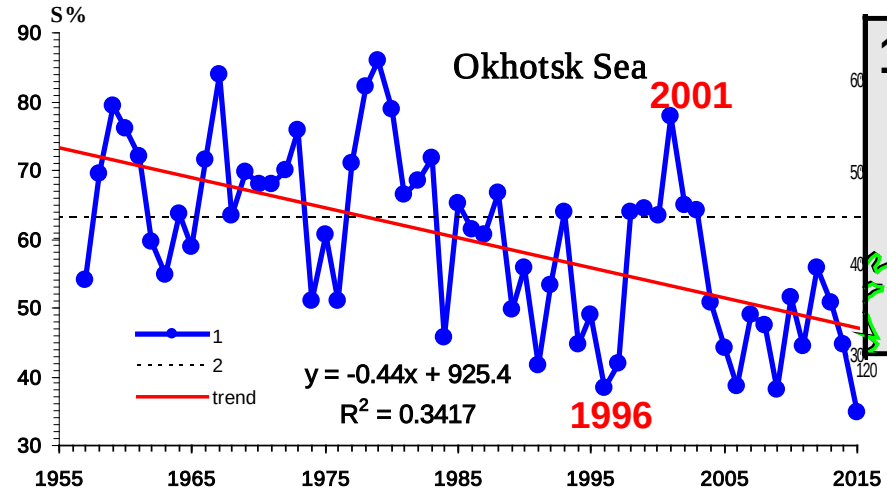
There are no strong common cycles between the Bering and Japan/East Seas, but periodic variability in the Okhotsk Sea has common features with both these seas.

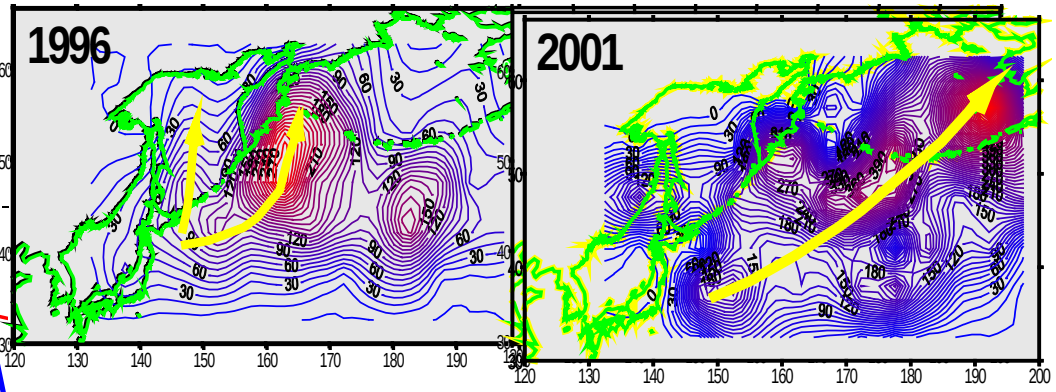
Extreme events

Year-to-year changes of the mean winter ice cover in the Far-Eastern Seas. Extreme events are labeled by years









Index of cyclonicity and the main tracks of cyclons in "warm" winter of 1996 and "cold" winter of 2001

Extreme events in the Far-Eastern Seas emerge usually under influence of anomalous shifting of cyclone tracks.

Sometimes the extreme events appear simultaneously in the Japan/East and Okhotsk Seas or in the Bering and Okhotsk Seas but never in all seas together.

Summary

The only feature of variability is common for the all Far-Eastern Seas – it is a positive trend of SST.

Two different variation systems are supposed within the Far-Eastern Seas: the northern one controlled by oceanic processes (driven mainly by the Aleutian Low activity) and the southern one controlled by continental processes.

Marine ecosystems of the Far-Eastern Seas are more vulnerable to the regime shifts and extreme events because of limited adaptive capacity of living organisms to high rates of change.

Questions

Historical and contemporary sources of regional data

Air temperature:

Monthly mean air temperature data at coastal meteorological stations published by Russian Hydrometeorological Agency (as monthly and annual reports and climatic directories).

Monthly mean air temperature data at the meteorological stations data from NASA GISS (http://www.giss.nasa.gov/data/update/gistemp)

SST:

Time series of the monthly mean SST (COBE-SST) and 10-day mean from 1950 to latest month for 1 degree square of the Pacific Ocean from the Real Time Data Base, NEAR-GOOS http://goos.kishou.go.jp/rrtdb

Time series of the monthly mean SST (HadISST) for 1 degree square from the Hadley Centre (Rayner et al., 2003) http://www.metoffice.gov.uk/hadobs/hadisst

Ice cover:

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).

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.

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

Ice charts of the Japanese Meteorological Agency for the Okhotsk Sea (1998-2015).