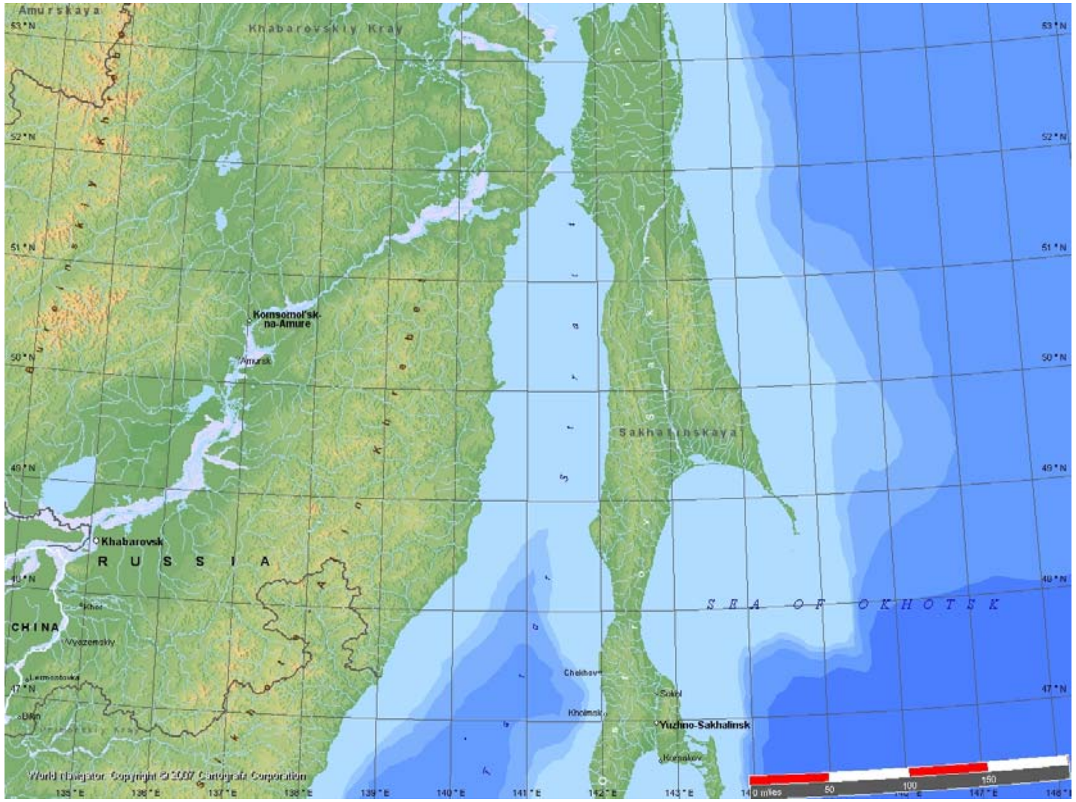
Features of climatic variability in the Tatar Strait (Japan/East Sea)

Elena I. Ustinova and Yury D. Sorokin

Pacific Fisheries Research Centre (TINRO-Centre)
690091 Shevchenko Alley, 4, Vladivostok, Russia
E-mail: eustinova@mail.ru



PICES-2014 (POC-Paper)

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 (10days-SST) 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

Historical and contemporary sources of regional data

Ice cover:

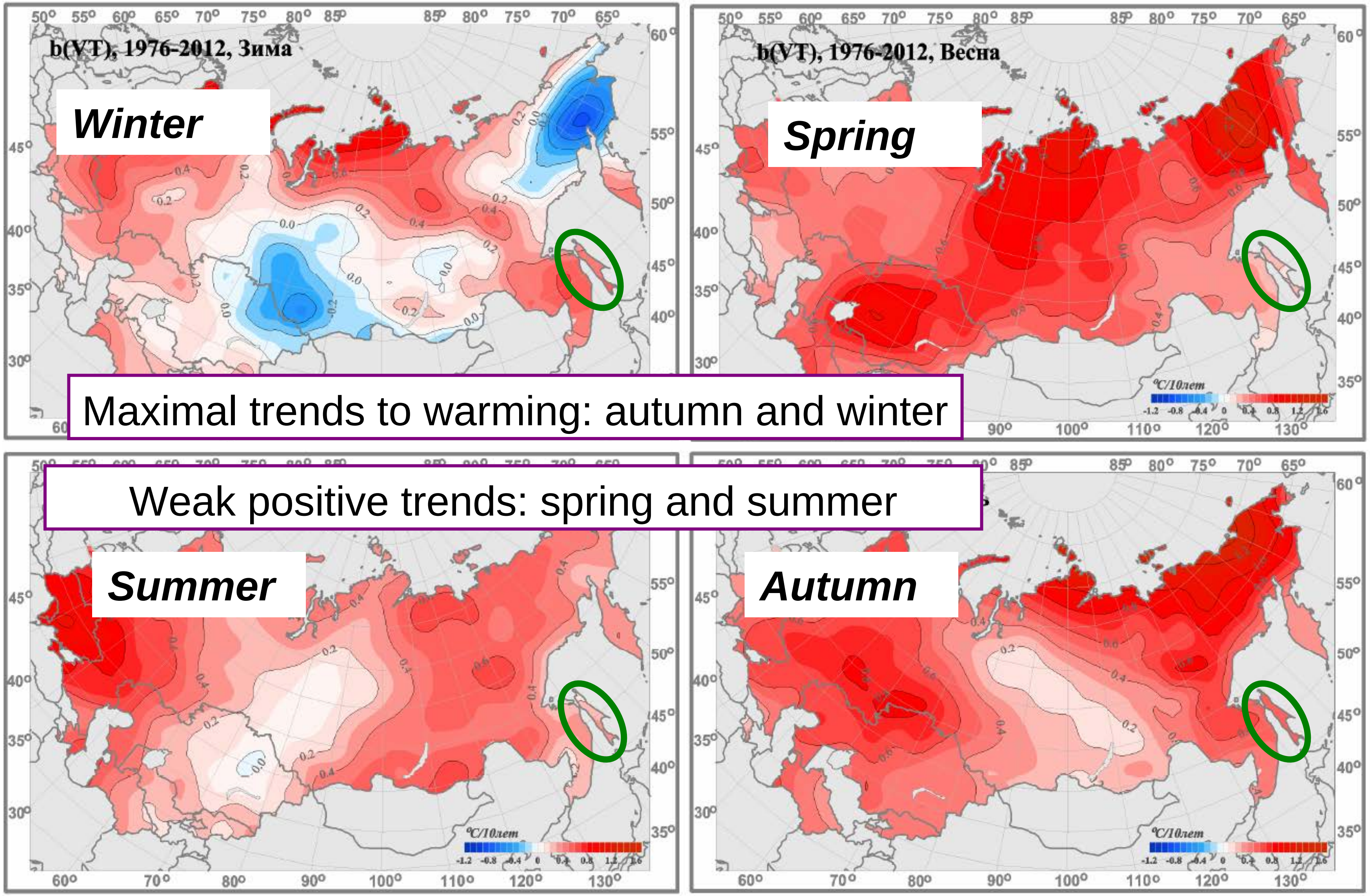
Regular ten-days aircraft observations conducted by Russian Hydrometeorological Service for 1960-1991.

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 (1998-2014).

Air temperature trends, °C/10 years

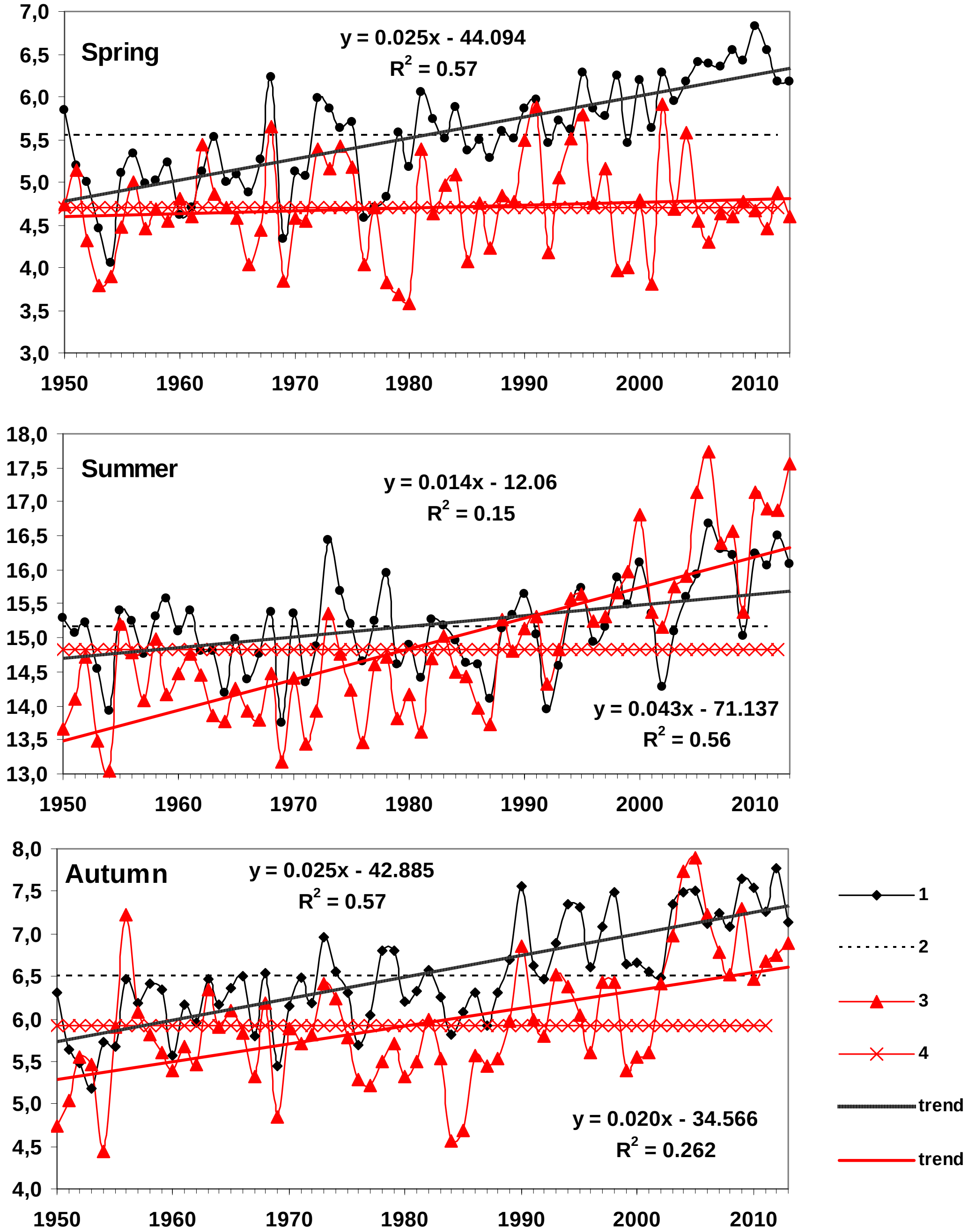
(Review of the state and tendencies of climate, 2012)



Maximal trends to warming: autumn and winter

Weak positive trends: spring and summer

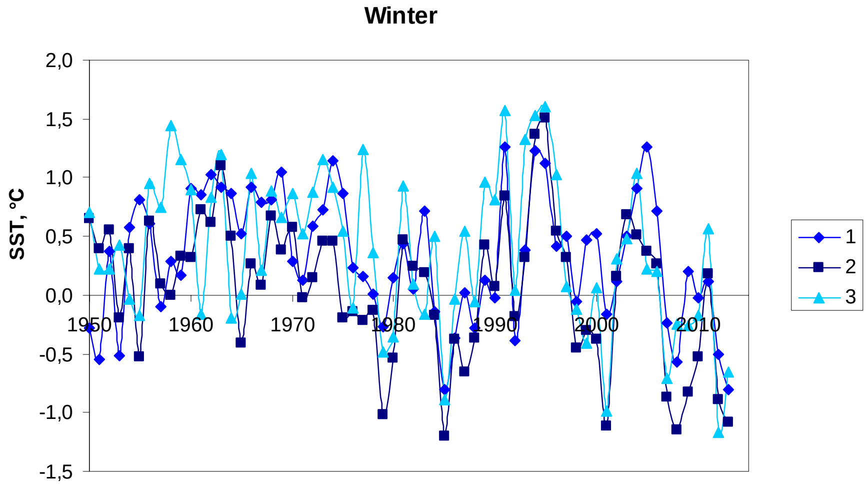
Seasonal SST anomalies

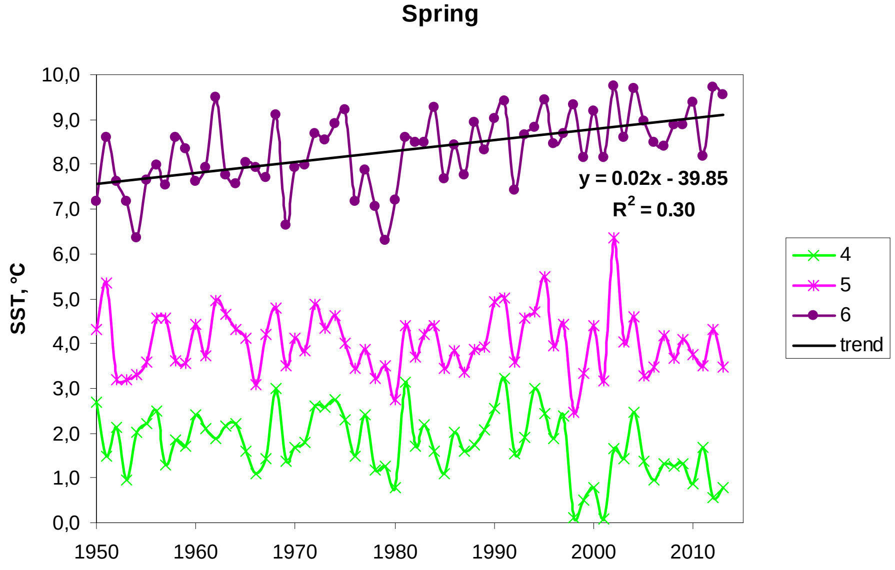


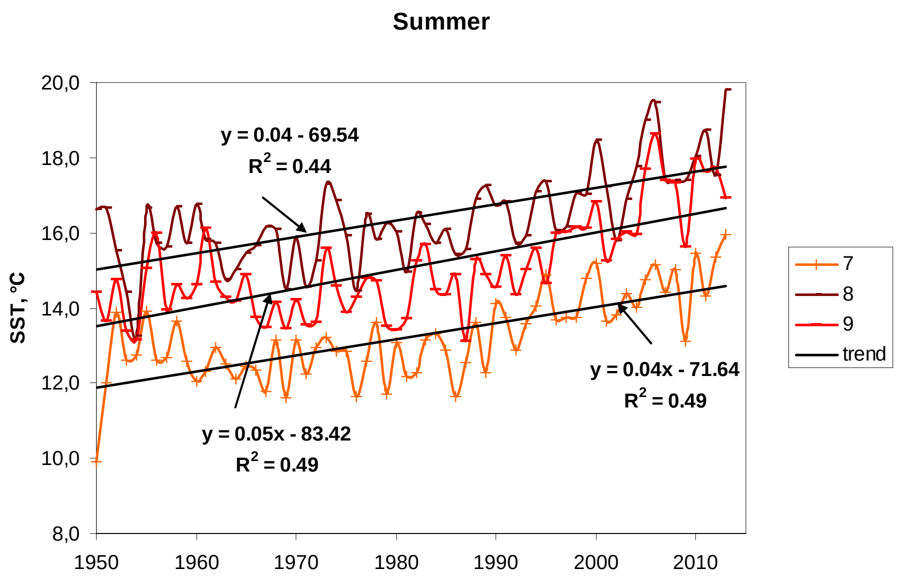
The main feature of the changes is warming of the surface layer (0.1-0.2 ° C per decade)

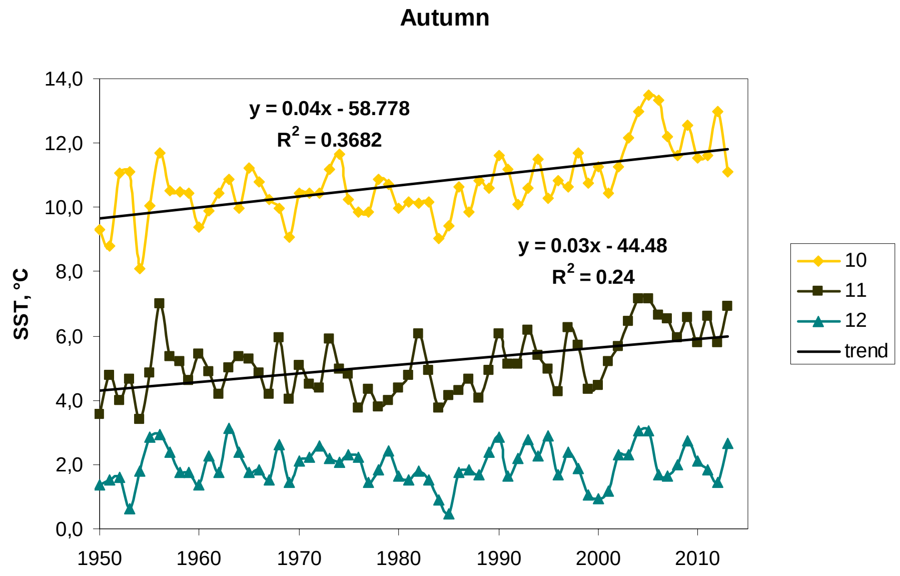
Red – 10 days SST
Black – COBE SST

Monthly SST


Winter
2,0
1,5
1,0
0,5
0,0
-0,5
-1,0
-1,5
SST, °C
1950
1960
1970
1980
1990
2000
2010
1
2
3

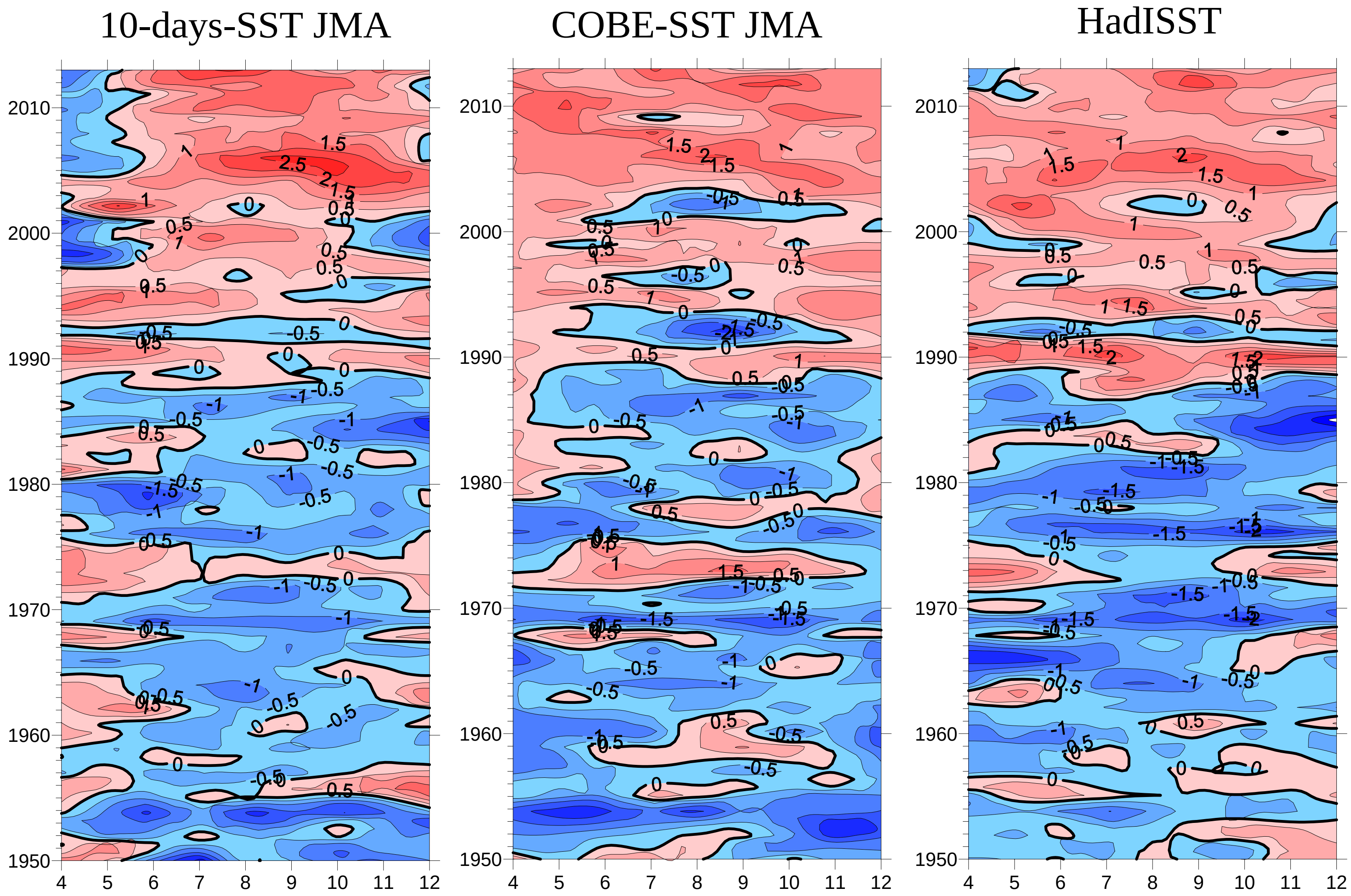

Spring
10,0
9,0
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
SST, °C
1950
1960
1970
1980
1990
2000
2010
y = 0.02x - 39.85
R2 = 0.30
4
5
6
trend


Summer
20,0
18,0
16,0
14,0
12,0
10,0
8,0
SST, °C
1950
1960
1970
1980
1990
2000
2010
y = 0.04 - 69.54
R2 = 0.44
y = 0.05x - 83.42
R2 = 0.49
y = 0.04x - 71.64
R2 = 0.49
7
8
9
trend

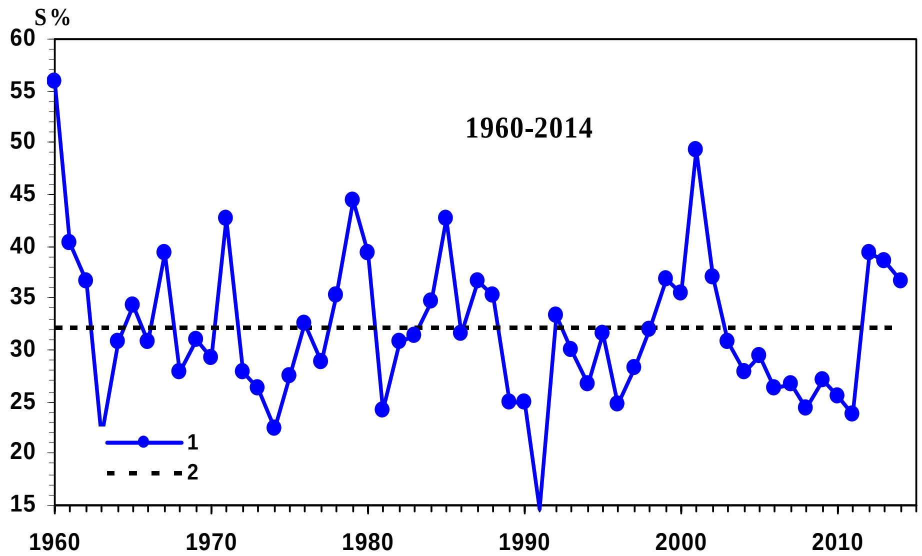

Autumn
14,0
12,0
10,0
8,0
6,0
4,0
2,0
0,0
SST, °C
1950
1960
1970
1980
1990
2000
2010
y = 0.04x - 58.778
R2 = 0.3682
y = 0.03x - 44.48
R2 = 0.24
10
11
12
trend

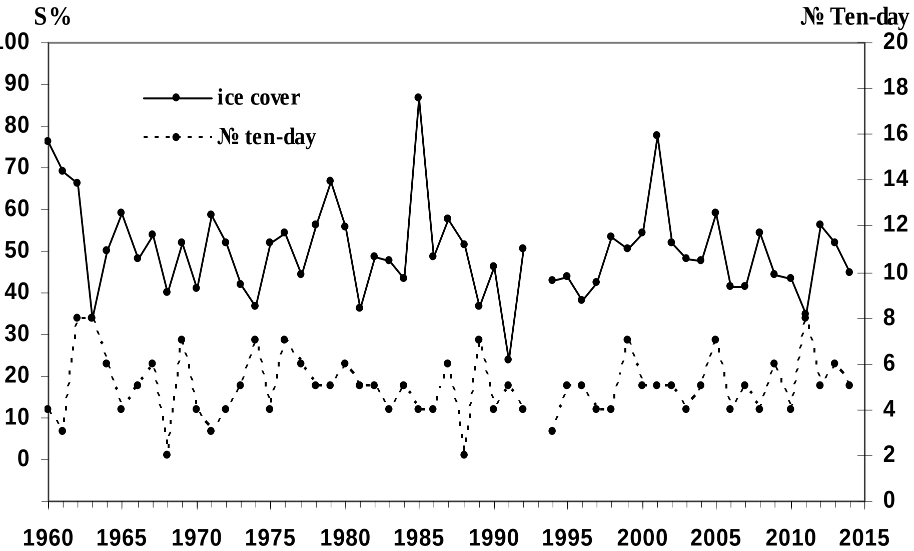
Variability of SST anomalies in the Tatar Strait

Positive (negative) anomalies in red (blue) color correspond to warm (cold) conditions. Time series are standardized.



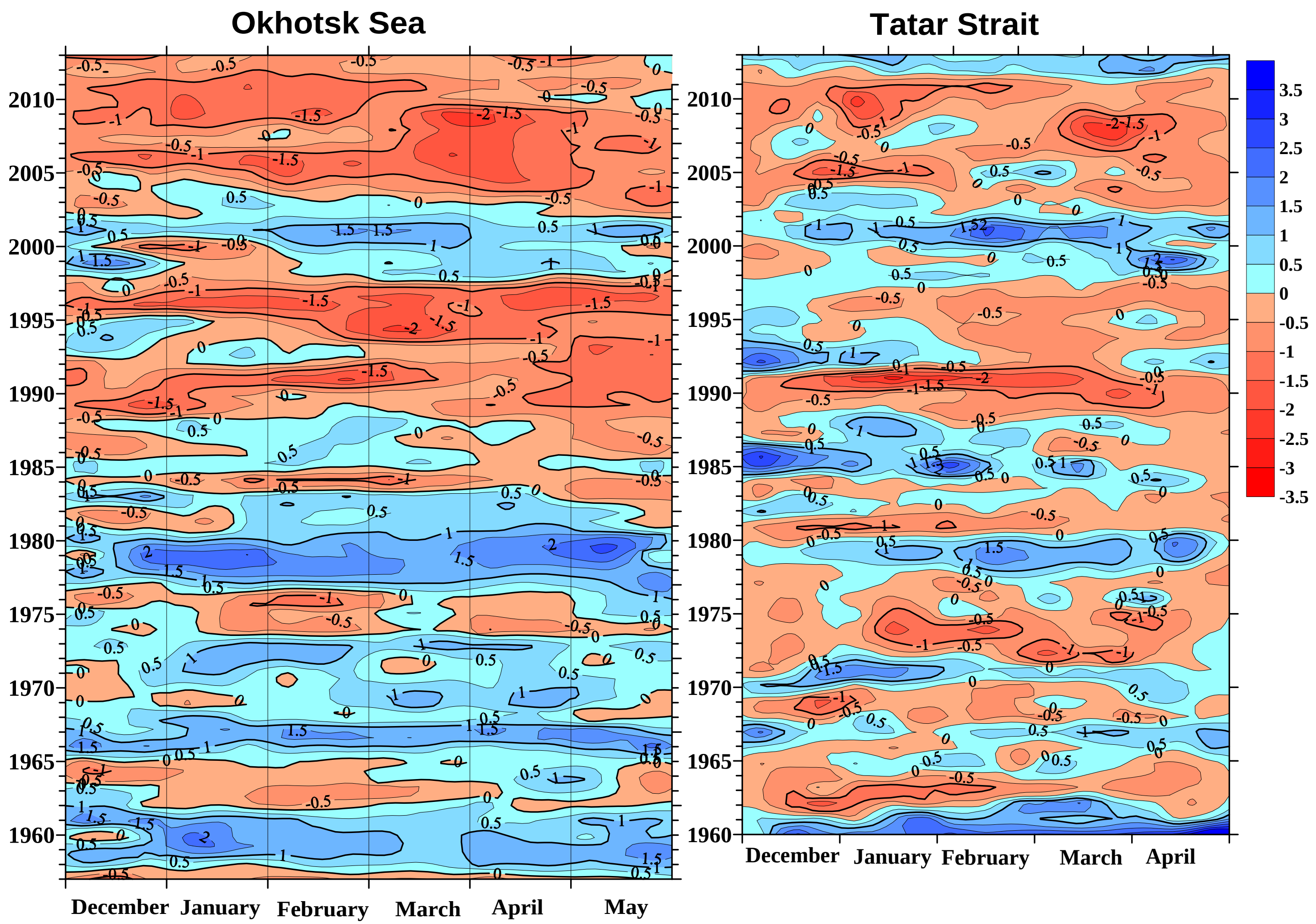
Left: **Mean winter (January – April) ice cover (1) in the Tatar Strait and mean multi-year value (2).**
Right: **Annual maximum ice cover (S, %) and its terms (number of ten-day from the beginning of the year)**
(updated from Ustinova et al., 2008)





February is the month when sea ice of the Japan Sea reaches its maximum extent. The fast increase of an ice cover is marked in December, and intensive melting occurs in March. To the middle of April ice remains in the northern part of the Tatar Strait (Yakunin, 2003). The maximum variances of monthly averaged ice extent in the Tatar Strait is marked in February and March, and minimum in April. The amplitude of year-to-year oscillations achieved 50% in February. Reduction of mean winter (annual maximum) ice extent in the Tatar Strait is not statistically significant during the period 1960-2014

Variability of ice coverage anomalies in the Tatar Strait and Okhotsk Sea

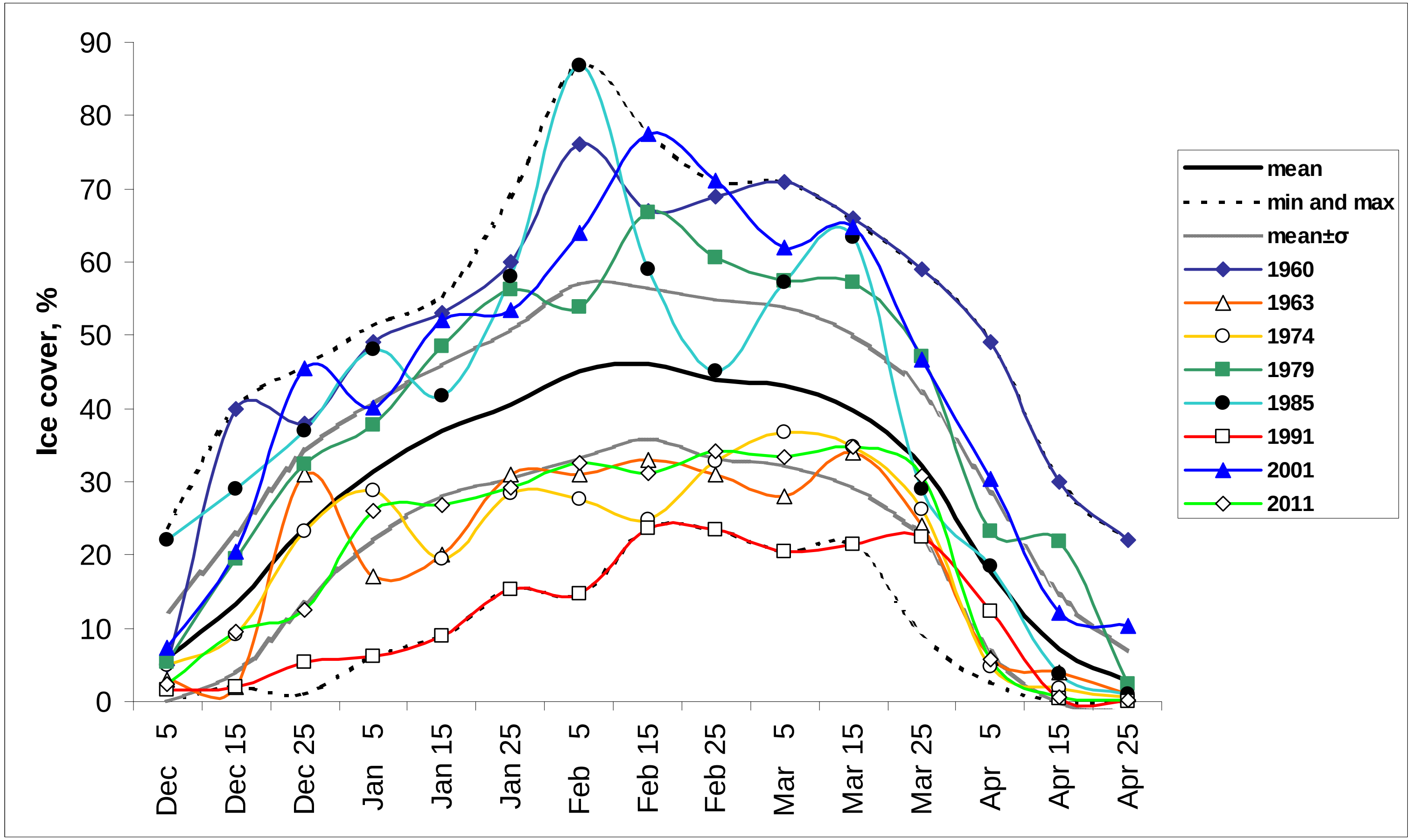


Positive (negative) ice coverage anomalies in blue (red) color correspond to cold (warm) conditions.

Time series are standardized.

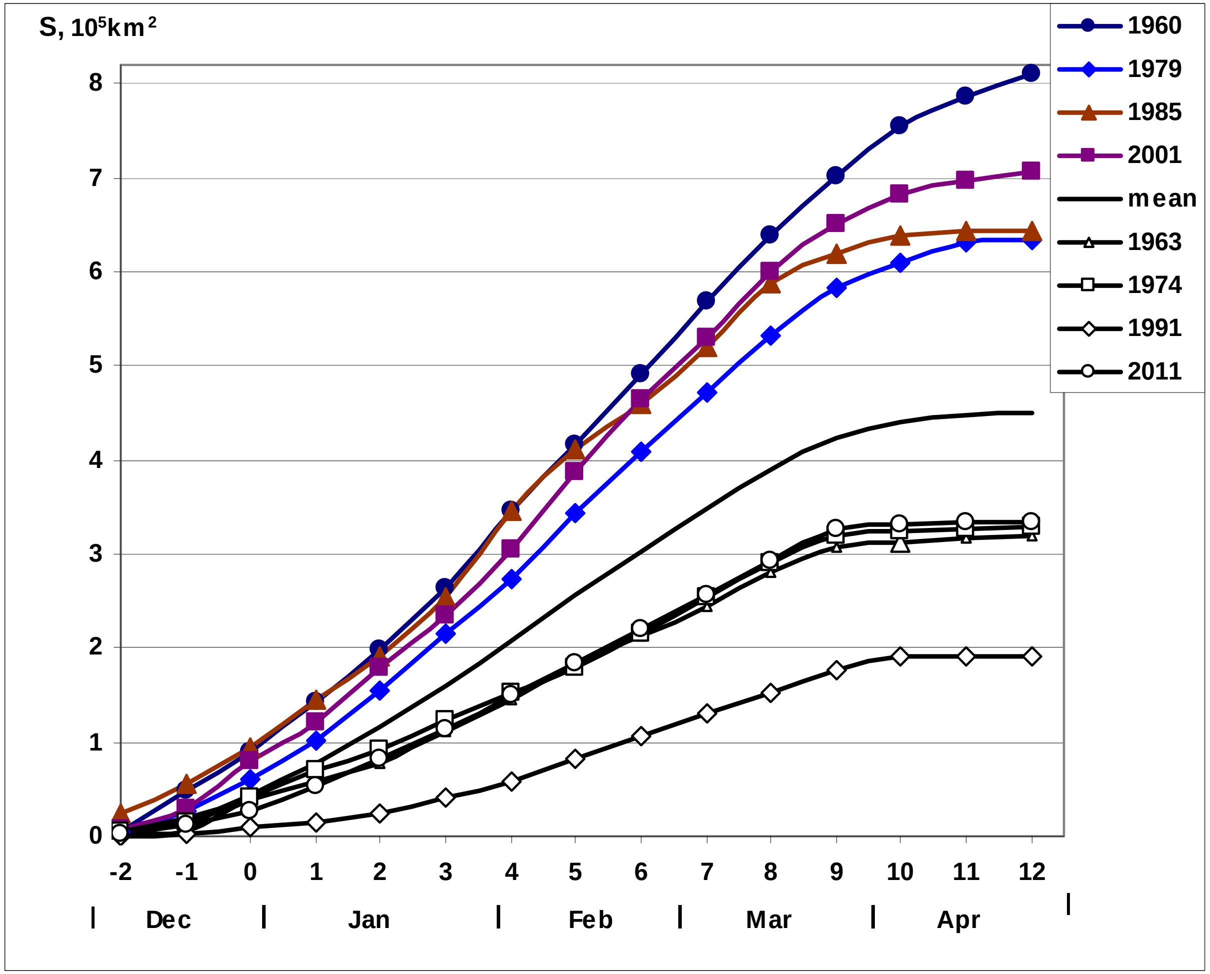
During the period 2004-2011 predominance of warm conditions is evident. In spite of the fact that winter ice extent in the Tatar Strait is closely connected with ice in the Okhotsk Sea, during several periods the synchronism can be broken, especially in 1980s.
The maximum positive correlation between ice extent in the Tatar Strait and Okhotsk Sea is in January, minimum in December. The most significant reduction of the mean winter ice extent occurred in the Okhotsk Sea, while in the Tatar Strait a negative trend isn't statistically significant.

Winter ice covered area of the Tatar Strait in "extreme years" (cold and warm) in comparing with mean long-term (± standard deviation σ) and extreme low and high values for the period 1960-2014



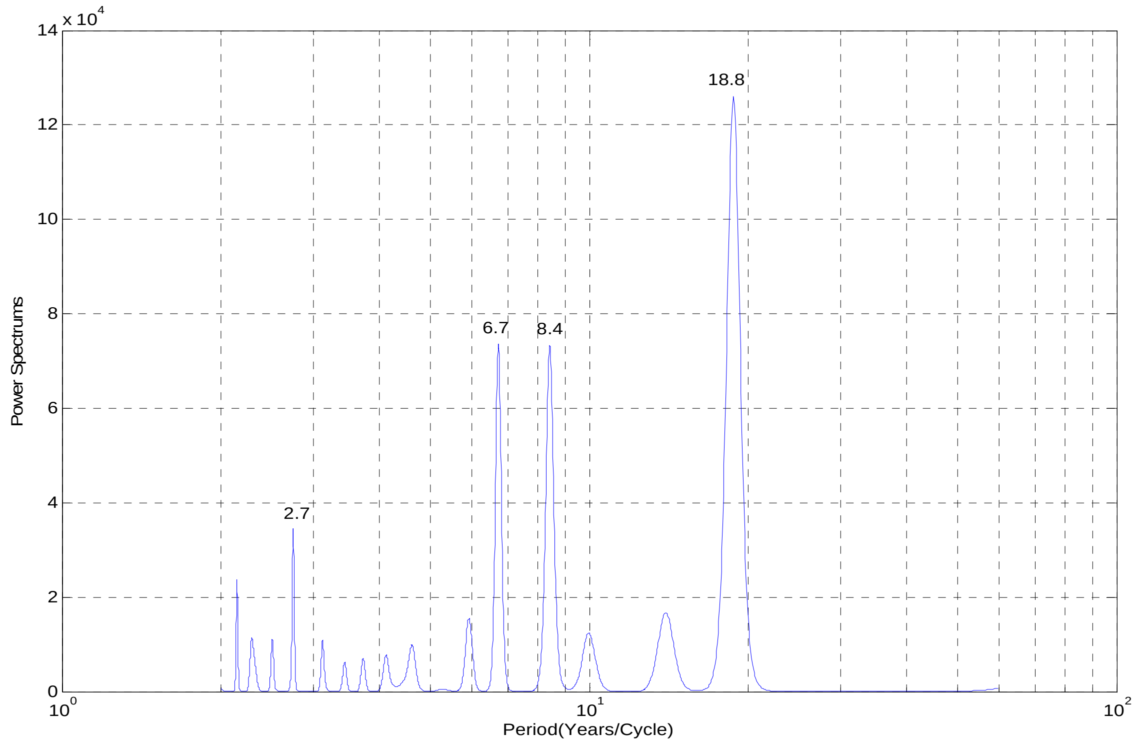
As a rule, the large anomalies remain during all ice season, but intraseasonal inhomogeneity of the anomalies is marked in several years (for example, in 1963, 1985). In severe years with extensive sea ice, the rates of ice cover seasonal increase and melting were higher than the 1960-2011 average

Accumulation curves of sea ice cover in the Tatar Strait from December to April in “extreme years” (cold and warm) and mean long-term value



The extreme warm years were characterized by very slow increase of ice. The rate of ice cover seasonal increase from December to January is reduced after 1998 with local maximum of the rate.

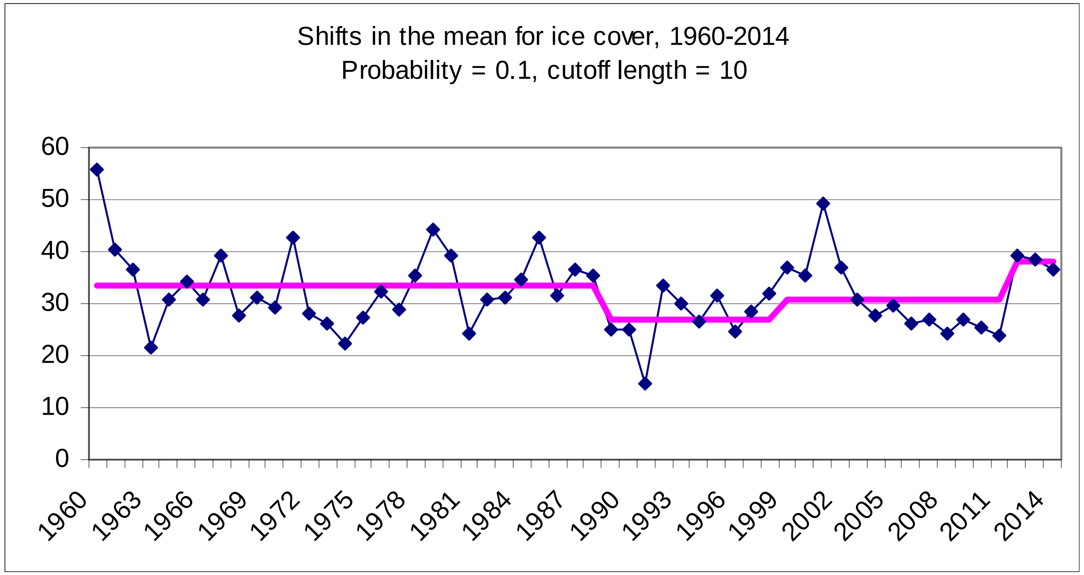
Power spectrums of ice cover in the Tatar Strait

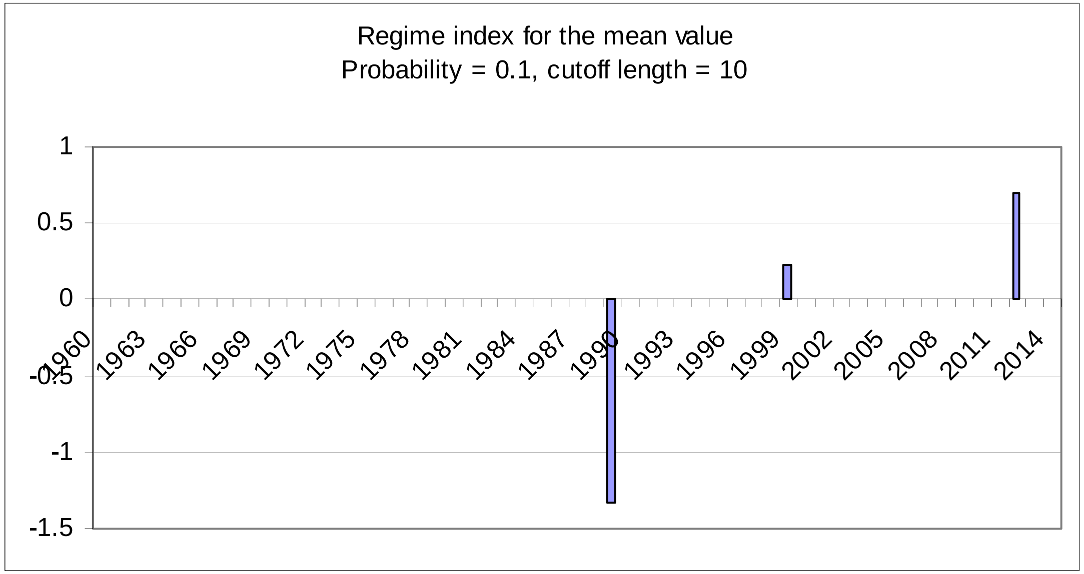


The periodical components in total variance are represented weakly in the Tatar Strait. Its contribution to interannual variability is 30 % only. For the period 1960-2011, the basic contribution to a variance is formed by 18.6 and 8 years oscillations. In the last 12 years, the redistribution of variance on frequencies towards high frequencies has occurred: from 22- years scale to 18.6 (from “solar” cycle to “lunar”) and from quasidecadal scale to 7-8 years. The contribution of 2-4 years fluctuations has decreased, but the "noise" component has increased.

(Methodology by Vilnis Liepins, 1997)

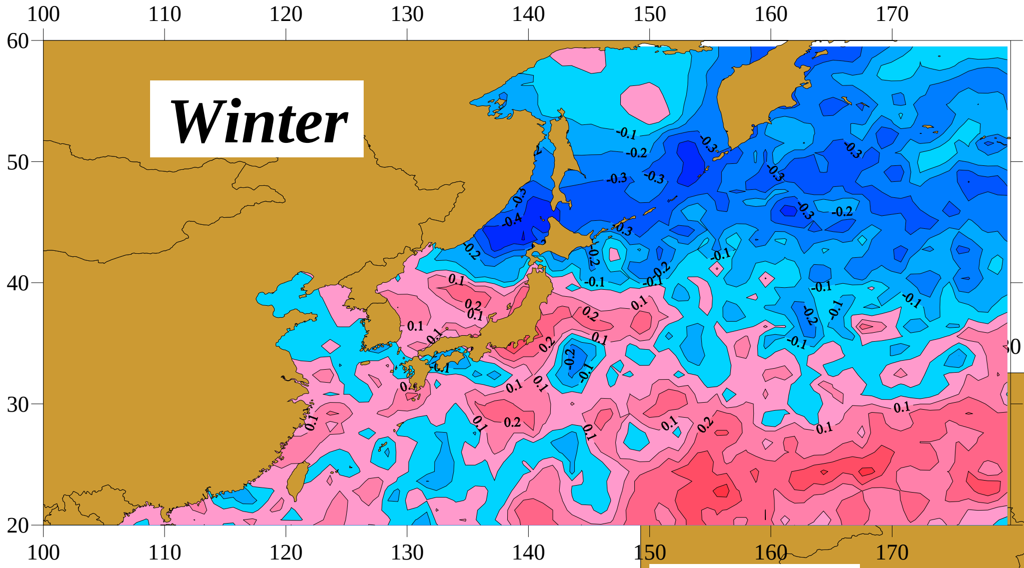
Shifts in ” ice variable”

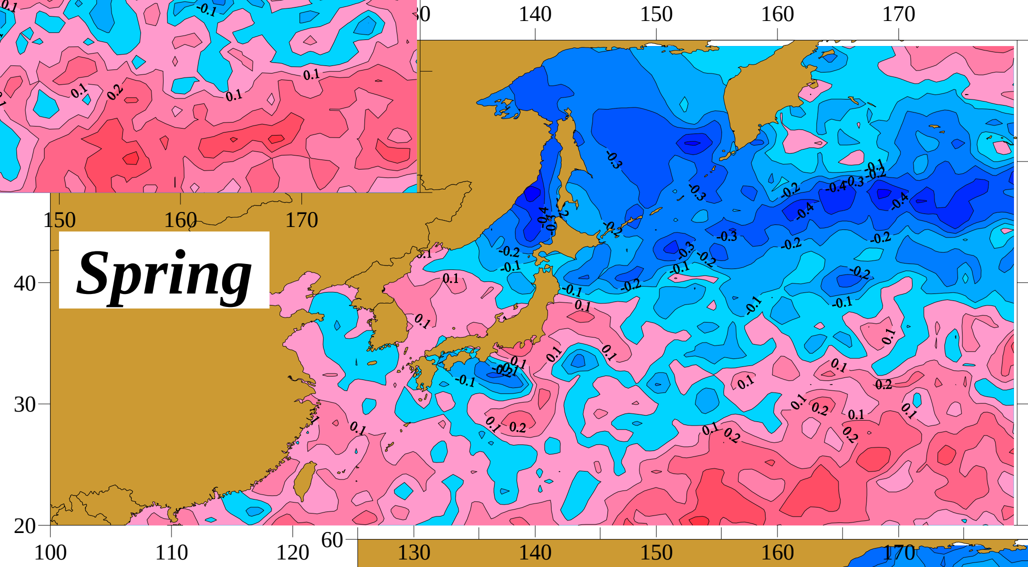


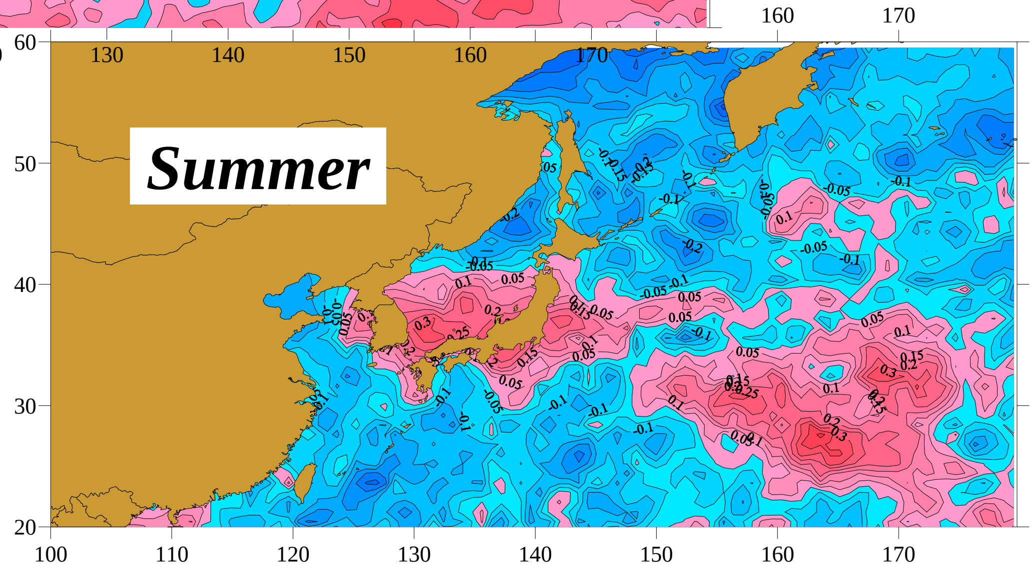


The shift of 1989 is strongest for the Tatar Strait

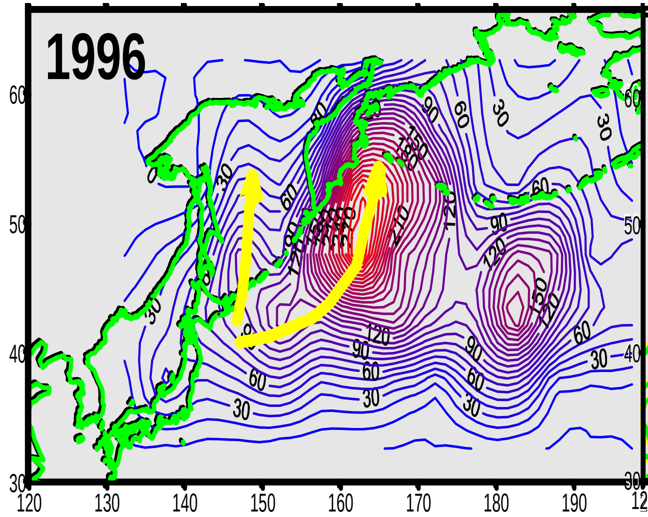
Correlation between mean winter ice cover and SST

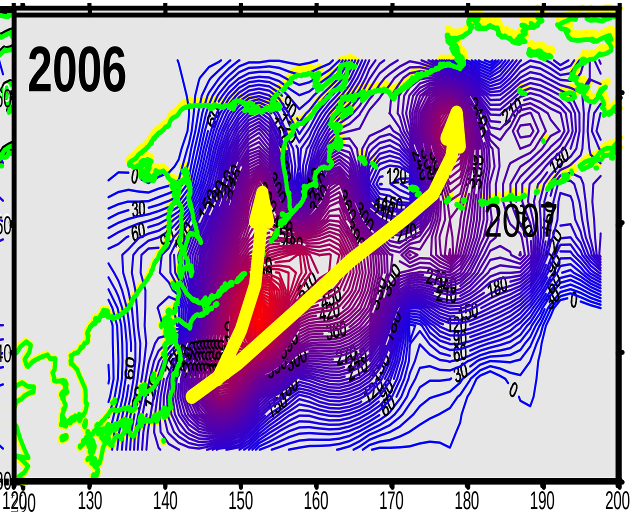


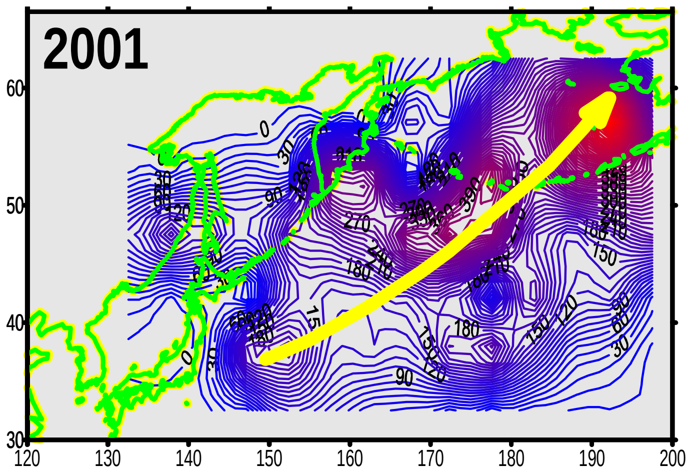




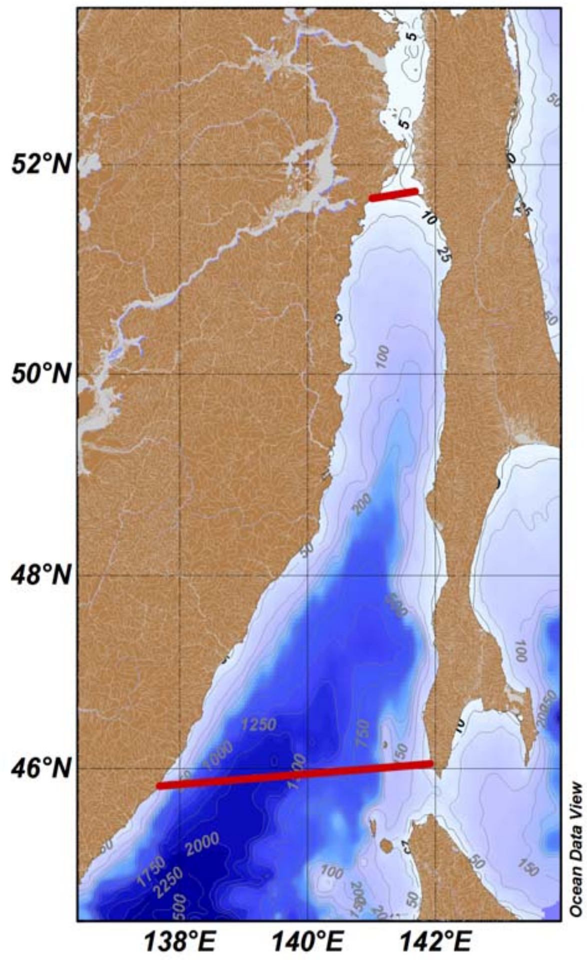
Storm tracks (by Glebova, 2012)



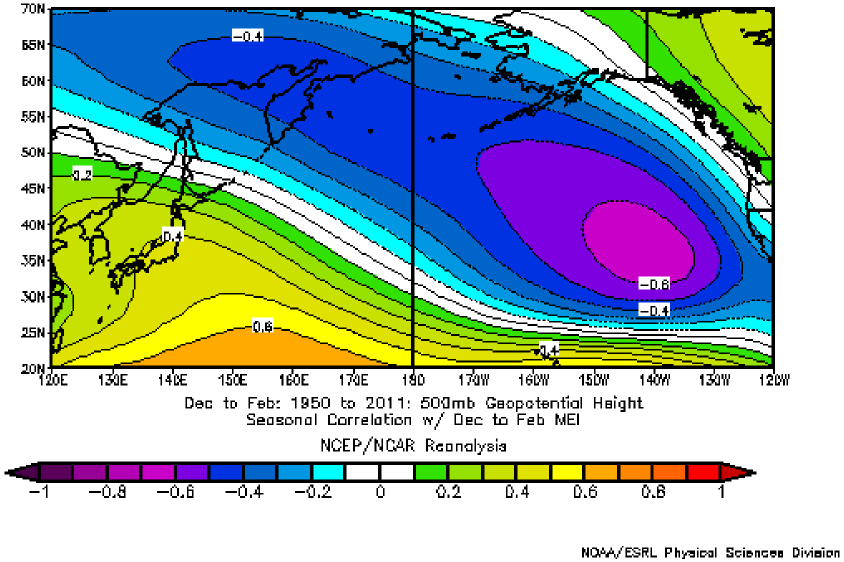


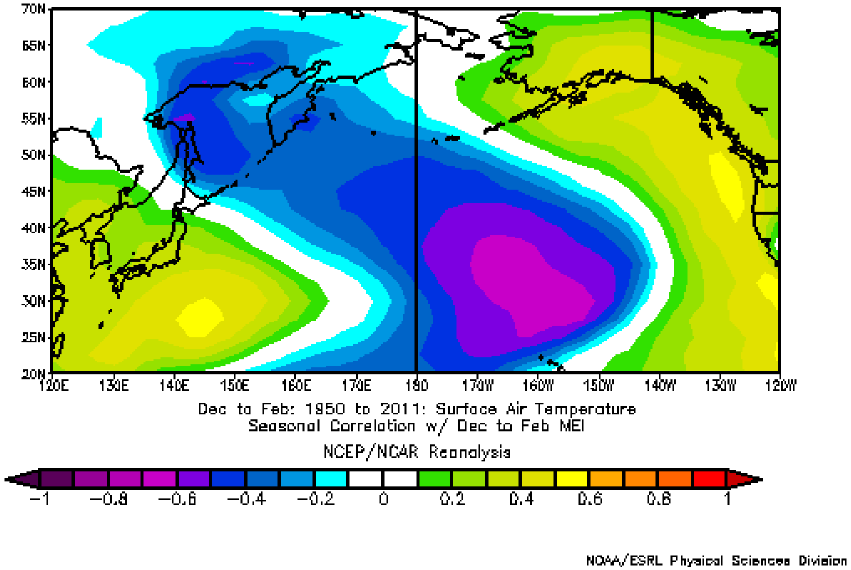


In the Tatar Strait ice cover variability are more connected with regional and local processes of synoptic scale. The extreme warm and cold winters were characterized by strong atmospheric anomalies, with changes in the paths of the storms.



Relationships with large-scale climatic processes: El Nino





The linkages between large-scale climatic processes and regional ice conditions in the Tatar Strait are different for various temporal and spatial scales. Correlation between ice cover and the majority of large-scale climatic indices is not high. Victoria SST pattern is more representative for the Tatar Strait than PDO. Winter monsoon index (macro-scale pressure gradient between the Siberian High and Aleutian Low) are important factor for the Tatar Strait.

http://www.esrl.noaa.gov/psd/data/correlation/

Conclusions

The main feature of the changes is warming of the surface layer in June-October (0.2-0.5° C per decade with a maximum in September).

Reduction of mean winter ice extent in the Tatar Strait is not statistically significant during the period 1960-2014. Among “ice months” the maximal reduction of the ice extent occurred in March and April.

Contribution of the periodical components in total variance is 30% (for ice) or 26% (for SST).

The formation of strong winter atmospheric anomalies over the Japan/East Sea and adjacent regions causes the very fast response in large ice cover anomalies. The extreme warm and cold winters were characterized by strong atmospheric anomalies, with changes in the paths of the storms. There are integrated impacts of cyclones on the thermal variability.

Correlation between regional thermal parameters and the majority of large-scale climatic indices is not high. Changes in the sign correlation between some large-scale climate indices (e.g., AO, ENSO, etc.) and regional climatic parameters occur over the Tatar Strait. The Victoria SST pattern is more representative for the Strait than the PDO. The winter monsoon index is an important factor here. Among well-known large-scale climate regime shifts, the shift of 1988/89 is strongest for the Tatar Strait.