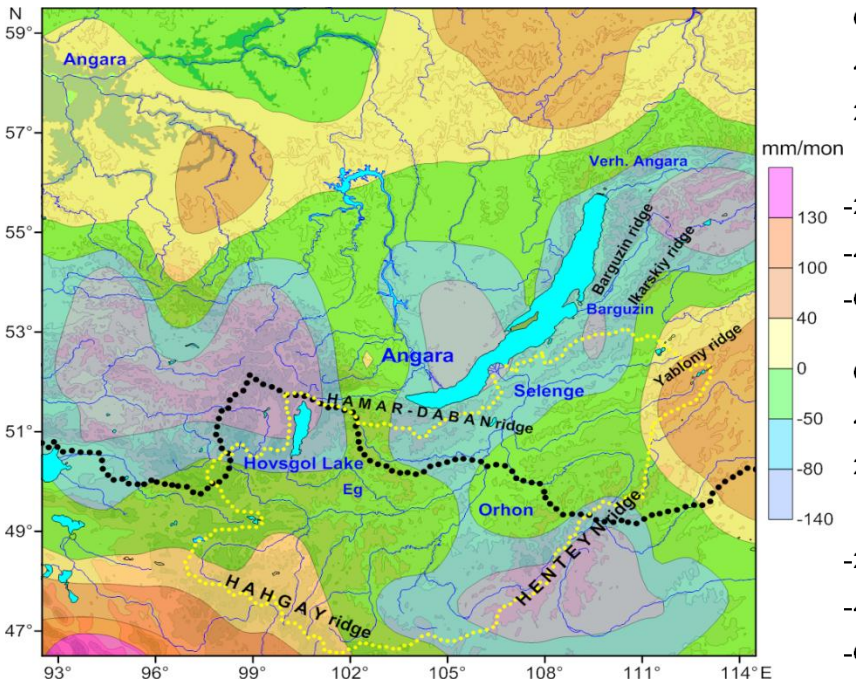
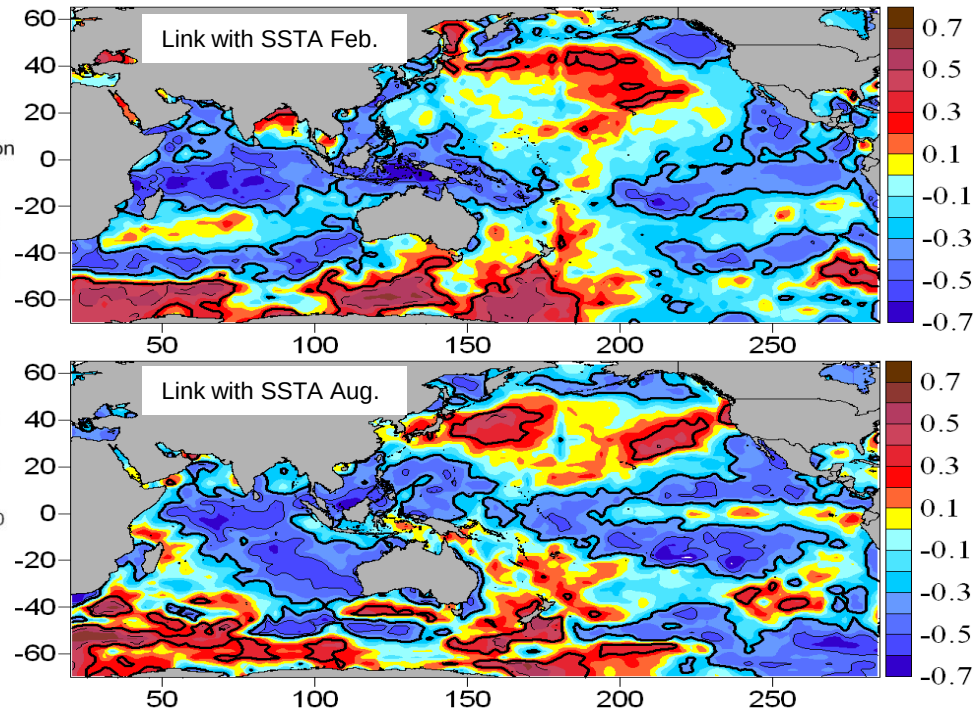
WINTER CLIMATIC ANOMALIES IN THE JAPAN, OKHOTSK SEAS, BAIKAL LAKE BASIN AND THEIR LINKAGES

Svetlana Shkorba *(1)*, **Elena Dmitrieva** *(1)*, **Vladimir Ponomarev** *(1)*, **Lubov Kuimova** *(2)*, **Vera Pustoshnova** *(1)*





(1) V.I.Il'ichev Pacific Oceanological Institute, FEB RAS, Vladivostok, Russia
(2) Limnological Institute, SB RAN, Irkutsk, Russia

Motivation

Interdecadal climate regime dynamics in the North Pacific Ocean: Theories, observations and ecosystem impacts (*Miller and Schneider, Progr. Oceanogr., vol. 47, 2000).*

A 50–70 year climatic oscillation over the North Pacific and North America (*Minobe, GRL, 24, 1997)*

. **Intra-secular changes in climate and sea ice area in the Eurasian Arctic Seas and their possible causes**. *(Gudkovich, Karklin, Frolov. 2005, Russian Meteorology and Hydrology, N 6, pp. 5–14, 2005)*

Climate Change in Eurasian Arctic Shelf Seas: Centennial Ice Cover Observations," (*Frolov, Gudkovich, Karklin, Kovalev, Smolyanitsky, Springer Praxis Books Geophys. Sciences, Chichester, UK, p. 164, 2009)*

Regional peculiarities of the sea ice cover changes in the 20th – early 21st centuries and their causes, (*Frolov, Gudkovich, Karklin, Smolyanitsky. Ice and Snow. N.3, 91-98. 2011); (Gudkovich, Karklin, et al., 2008, 2009 (in Russian).*

Climate and hydrological processes in Lake Baikal in the 20th century, (*Shimaraev, Kuimova, Sinyukovich, Tsekhanovskii Russian Meteorology and Hydrology. N 3. C. 52-58, 2002)*

Comparison of ice conditions variability on Baykal Lake and the Arctic (*Kuimova, Sherstyankin Ice and Snow.105, pp. 140-144, 2008, in Russian).*

Climate change and the World's «Sacred Sea» – Lake Baikal, Siberia, *(Moore, Hampton, Izmest'eva et al. BioScience, vol. 59, N 5, pp. 405–417, 2009).*

Variability of ice conditions in the Russian Far Eastern Seas and their prediction, *(Plotnikov Dalnauka, Vladivostok, p. 172, 2002, in Russian).*

The main goal is

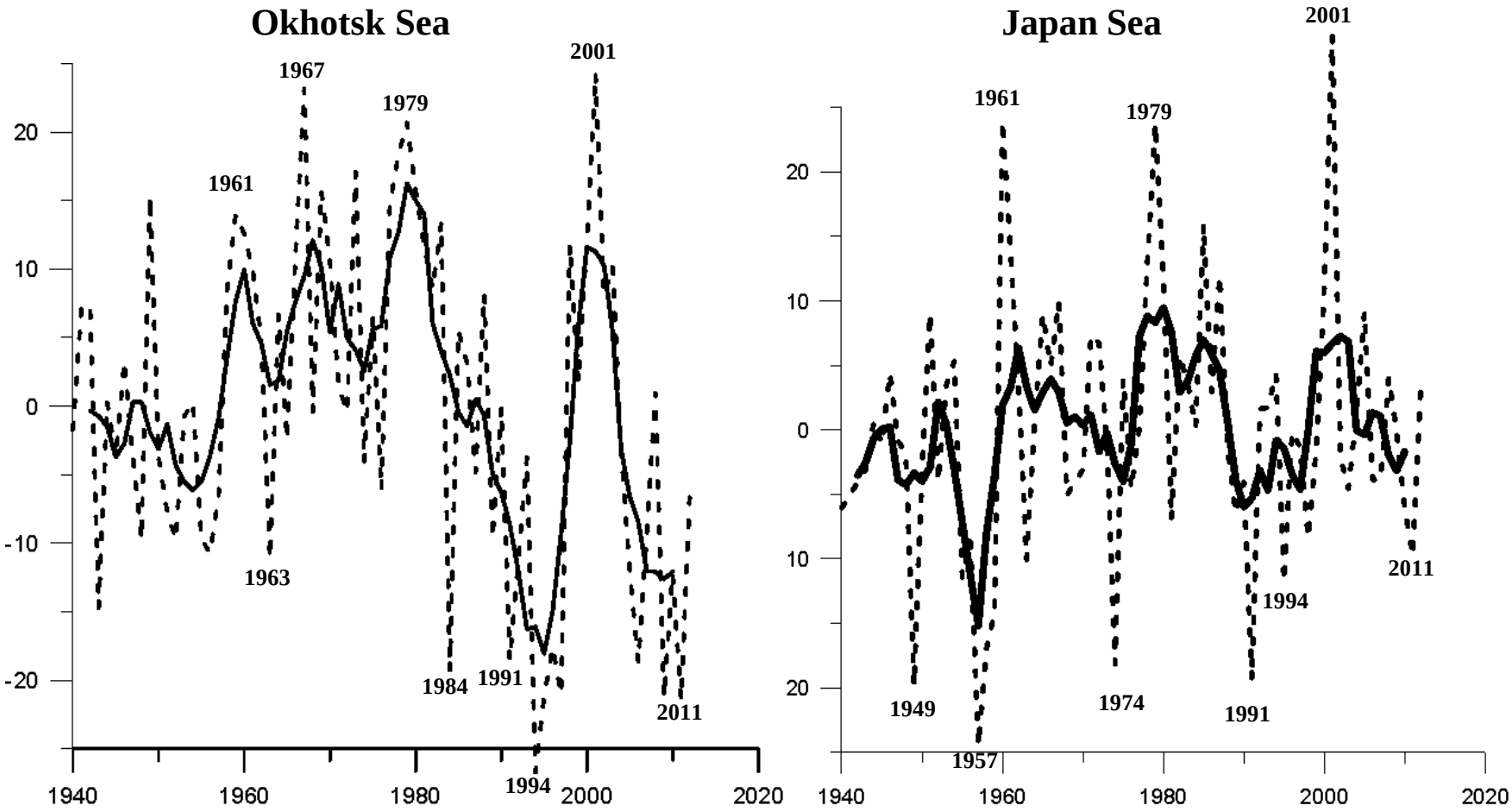
- **to reveal and compare regional features and linkages of interannual, interdecadal (20-30 years) and multidecadal (50-60 years) climatic oscillations in the Okhotsk, Japan Seas and Lake Baikal area in winter.**

The study is based on statistical analyses of the observation data.

Observation data

- **Hadley Sea Surface Temperature (SST) (1870-2015) ,**
- **surface net heat fluxes, air temperature (SAT), and atmospheric pressure (SLP) from NCEP NCAR reanalysis (1948-2015),**
- **Ice Extent in the Okhotsk / Japan Seas (1948-2015/13),**
- **Ice Thickness (1946-2012) and winter ice duration (in days) in the Lake Baikal (1900-2012)**
- **Arctic Oscillation (AO), Pacific Decadal Oscillation (PDO), Multidecadal Atlantic Oscillation (AMO) Indexes (1900-2015)**

Anomalies of Ice Extent (%) in the Okhotsk and Japan Seas in February from 1940 to 2012



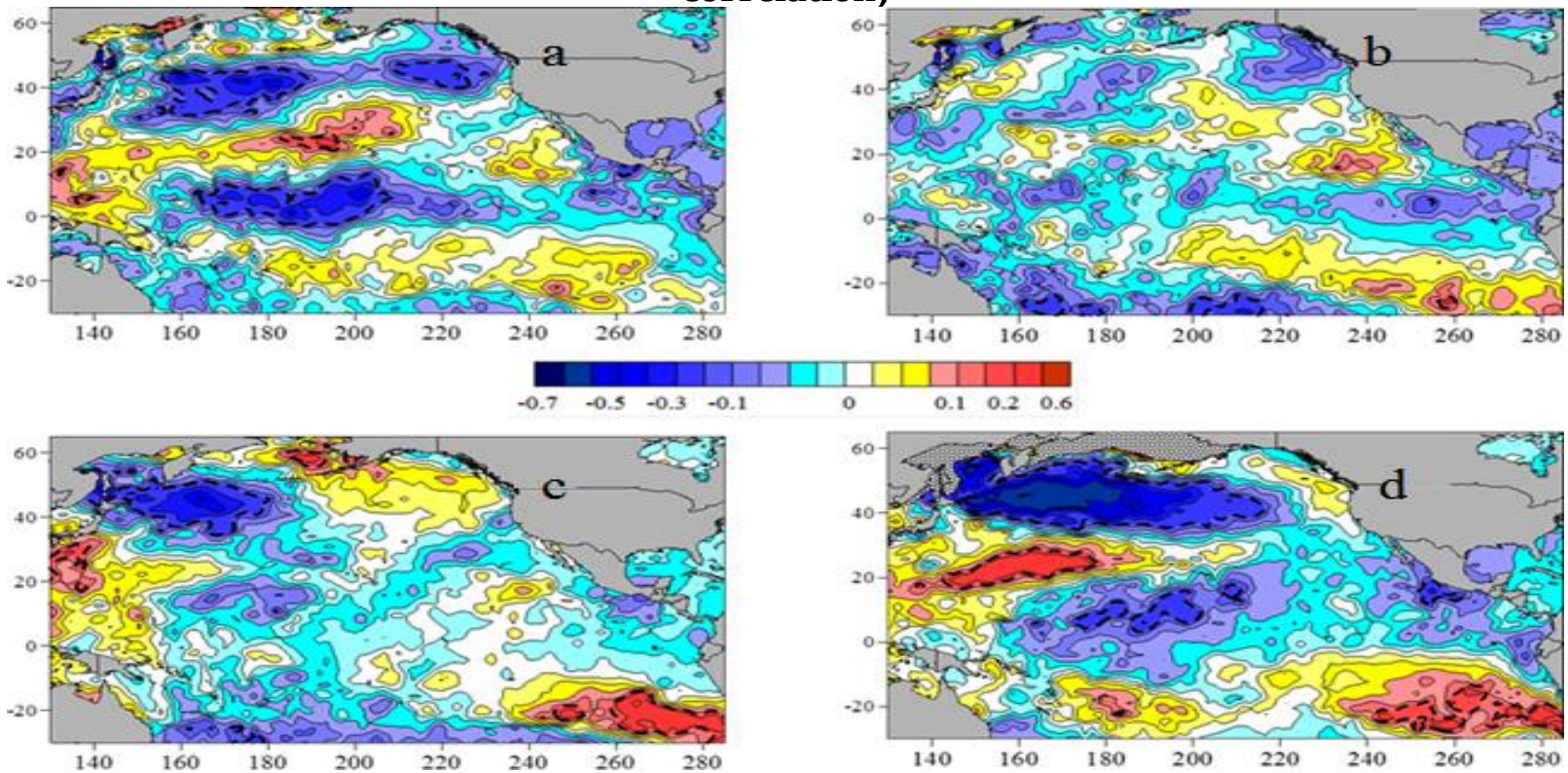
(1) - - - - Original monthly mean time series (2) _____ 5-years running mean monthly time series

The interannual (1) (period 3-7 years) and interdecadal (2) oscillations (period 18-20 years) prevail in the Okhotsk and Japan Sea Ice Extent.

The absolute maximum of Ice Extent was observed in the severe winter of 2001 both in the Japan and Okhotsk Seas.

Extremely high positive anomalies in 1961, 1967, 1979, while extremely low ice extent was observed in 1994, 2011, 2015 in Okhotsk Sea, in 1957, 1974, 1991, 2011, 2015 in Japan Sea.

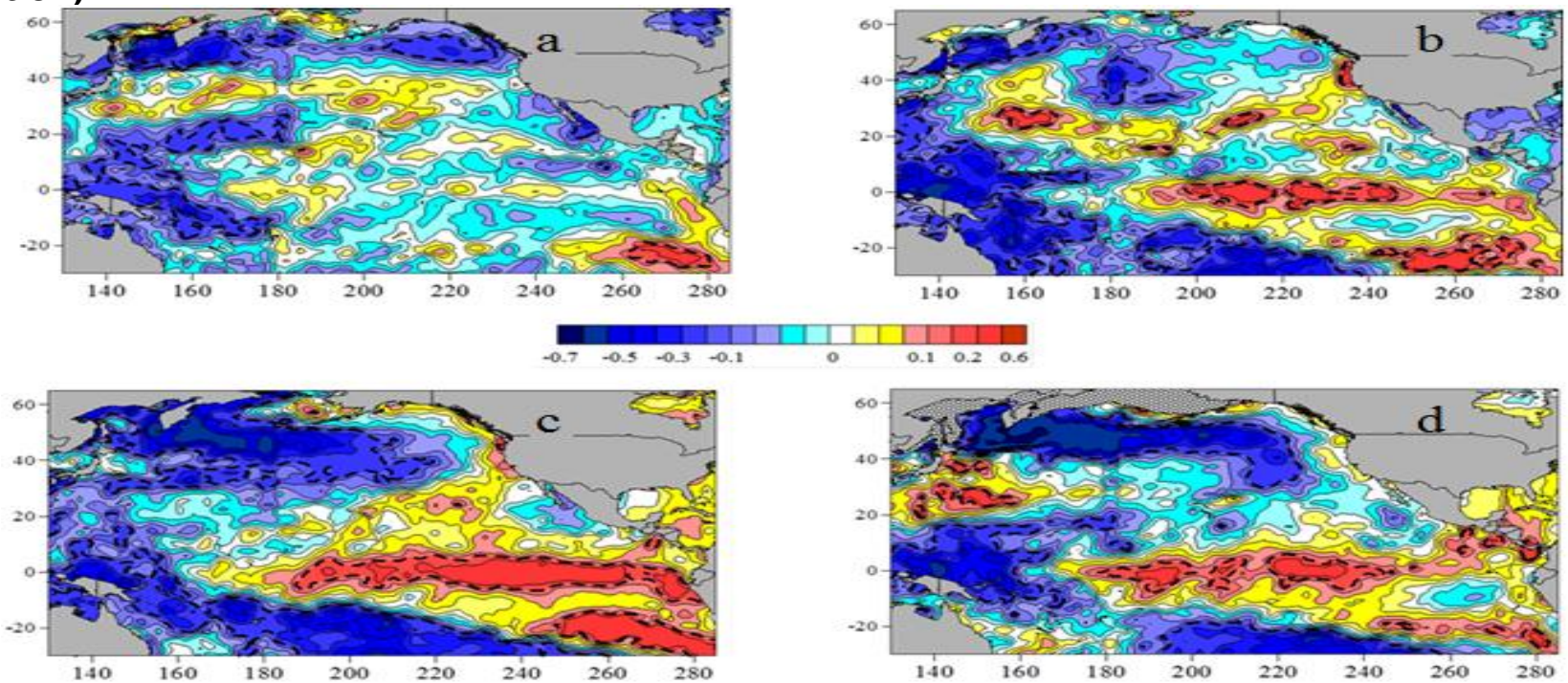
Correlation coefficient between unsmoothed time series of the Japan Sea Ice Extent (1949-2012) in February and Pacific Hadley SST anomalies north of 30 S in May (a), August (b), November (c) of previous year, as well as, in February (d) of the current year (red is positive, blue is negative correlation)



Dashed curve limits 95% confidence level of correlations coefficient

Rise/decrease of the Ice Extent in the Okhotsk, Japan (East) Seas is accompanied by winter SST decrease/rise in central extratropic and subarctic North Pacific with maximal correlation coefficient (0.8) in western subarctic region adjacent to the Okhotsk Sea (d, next slide d). Japan Sea Ice Extent positive/negative anomaly is accompanied by SST decrease/rise in central tropical Pacific (d).

Correlation coefficient between unsmoothed time series of the Okhotsk Sea Ice Extent (1949-2012) in February and Pacific Hadley SST anomalies north of 30 S in May (a), August (b), November (c) of previous year, as well as, in February (d) of the current year (red is positive, blue is negative correlation)



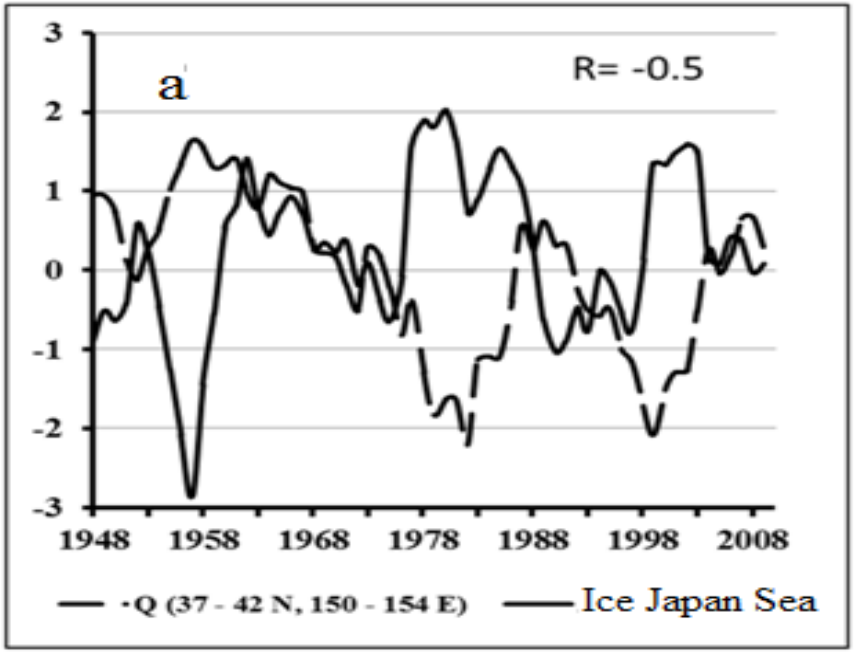
Dashed curve limits 95% confidence level of correlations coefficient

The Okhotsk Sea Ice Extent positive anomaly is accompanied by SST decrease in western tropical Pacific and western-central subtropical Pacific area of Southern Hemisphere (d, south of 30 S) as well as SST rise in the equatorial El Nino area (NINO3, NINO 3-4) and eastern tropical and subtropical Pacific area of Southern Hemisphere.

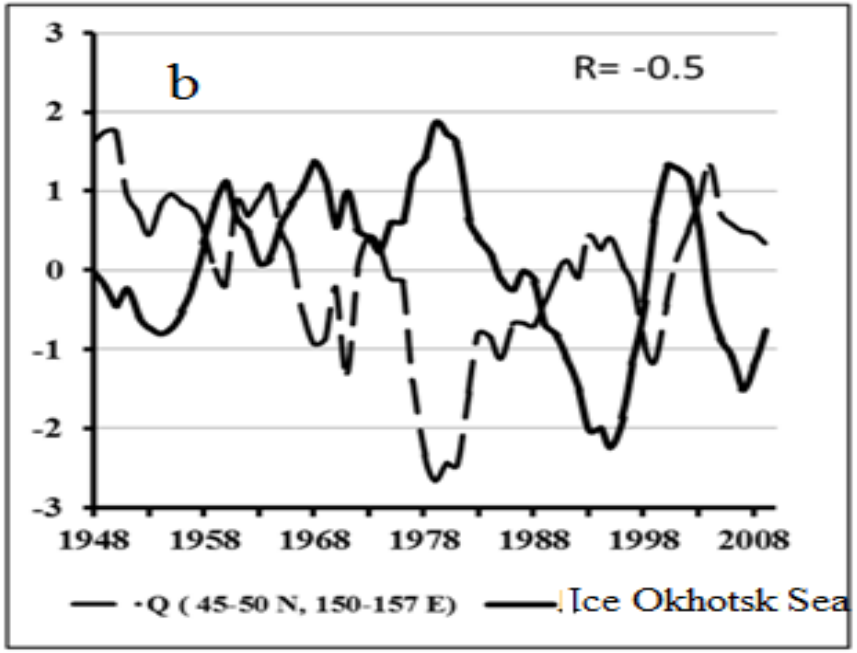
Before cold winter in the Okhotsk Seas negative SST anomaly observed in the North East (a,b, May, August) and central (b, August) subarctic and subtropics North Pacific.

It is very important for prediction of the extreme cold or warm winters.

5- years running mean time series (1948 - 2012) of normalized anomalies of Ice Extent (IE) in the Japan (a) and Okhotsk (b) Seas in February (solid curve) and net heat flux Q from the ocean to the atmosphere (negative values) in winter averaged within the areas (37-42 N, 150-154 E) of the Northwest Pacific with significant negative correlation between Q and IE



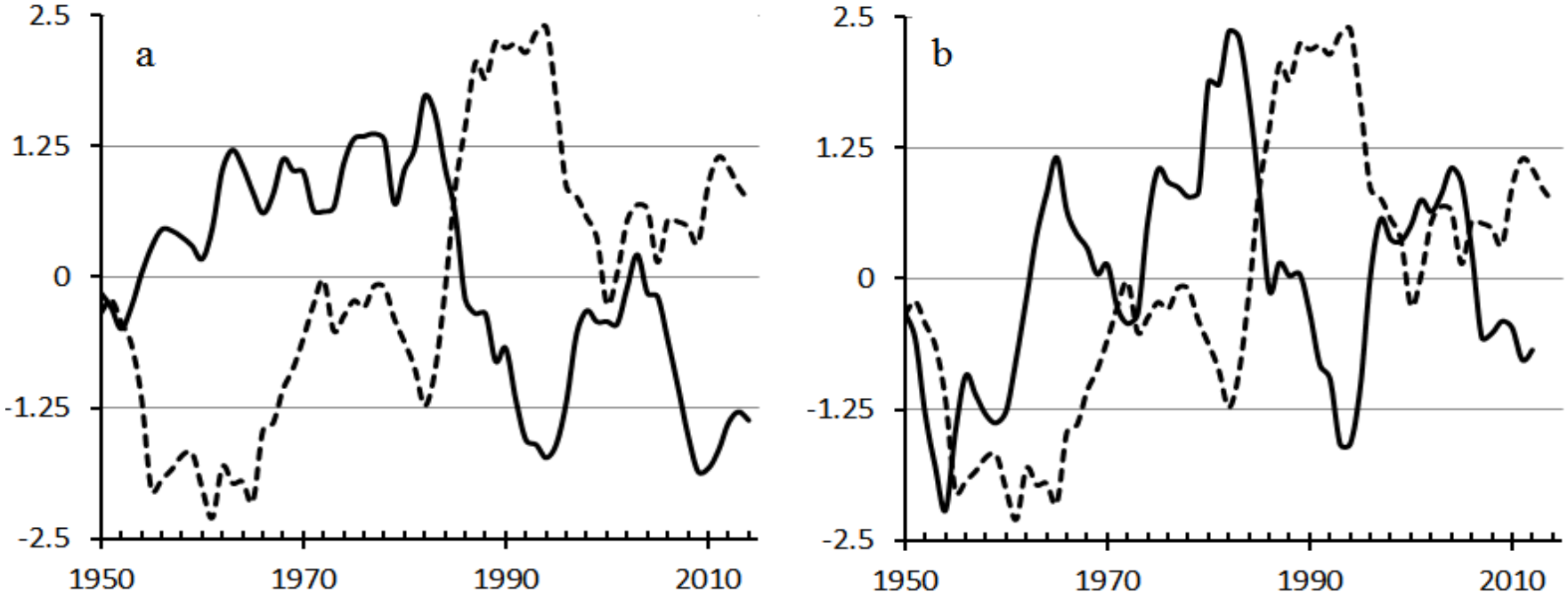
a) Japan Sea



b) Okhotsk Sea

Rise of the net heat flux from the ocean to the atmosphere (absolute values of negative Q increases) in the Northwest Pacific in winter accompanies rise of the Ice Extent in both Japan and Okhotsk Seas due to intensification of the winter monsoon in the North East Asia in both interannual and interdecadal time scales.

Time series of 11-year running mean normalized anomaly of the Ice Extent (solid curve) in the Okhotsk (1950 - 2014) (a) and Japan (1950 - 2012) (b) Seas in February and annual mean AO Indices.



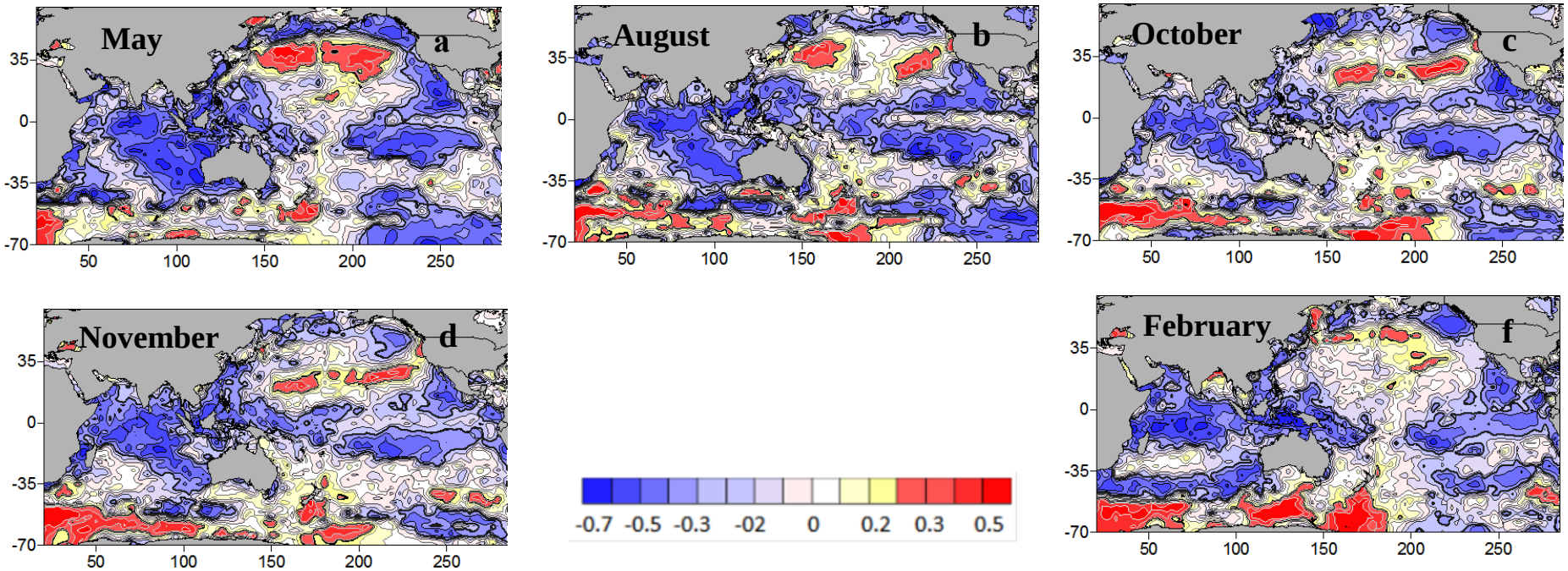
a) Okhotsk Sea

b) Japan Sea

Relationship between Arctic Oscillation Indices (AOI) and Ice Extent in the Japan, Okhotsk Seas is also clear seen on the interdecadal – multidecadal time scales with periods about 24-28 and 50-60 years.

Minimum of Ice Extent accompanies maximum of the annual mean AOI, when colder air circulates basically across the Arctic region.

Correlation between 3 years running mean time series (from 1948 to 2012) *of Ice Thickness in the Lake Baykal* in February and SST anomalies in the Pacific, Indian and Southern Oceans in May (a), August (b), October (c), November (d) of previous year and February (f) of recent year

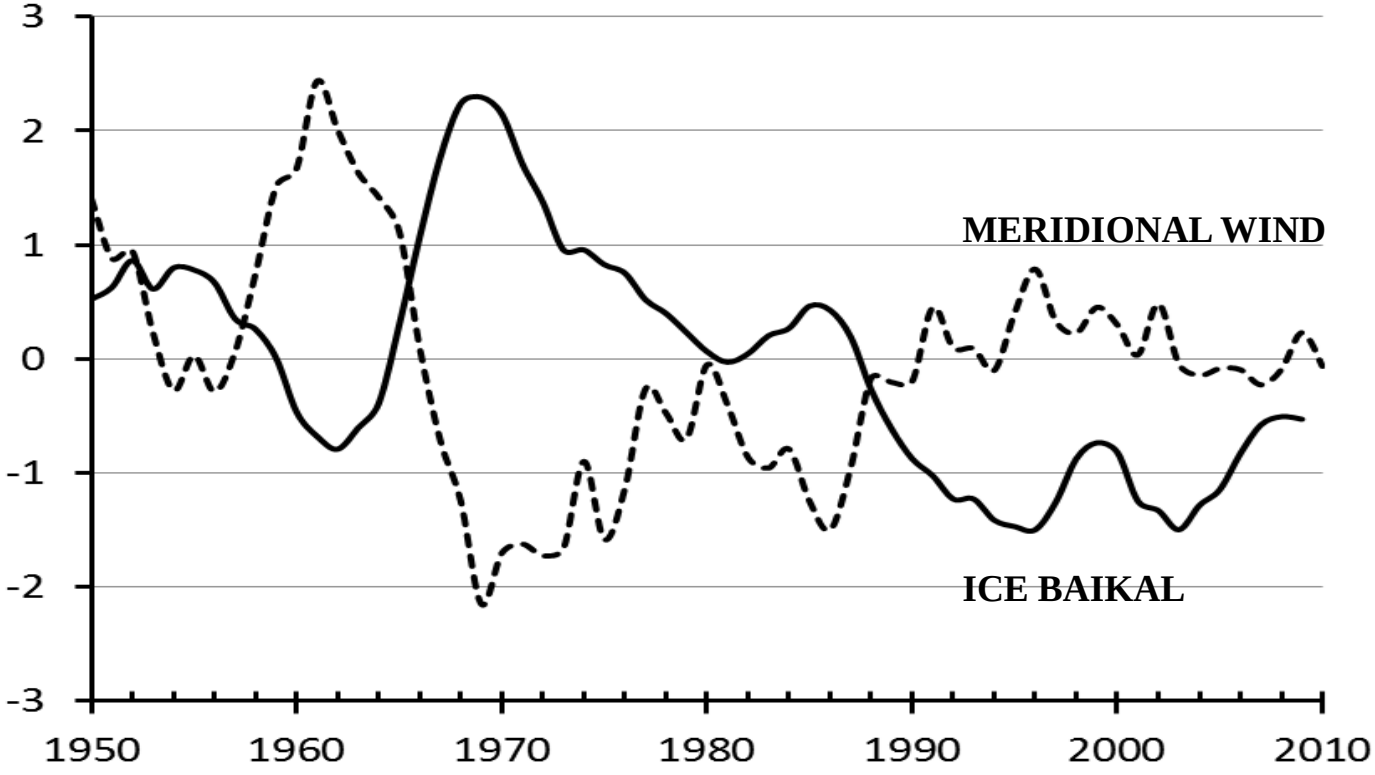


Ice Thickness in the Lake Baykal has significant negative correlation with SSTA in the Indian Ocean, Eastern Subarctic and tropical Pacific Ocean with various lag.

Ice Thickness rises when the SST decreases .

Positive correlation is found in mid-latitude North Pacific (25 - 45 N) and western area of the Southern Ocean.

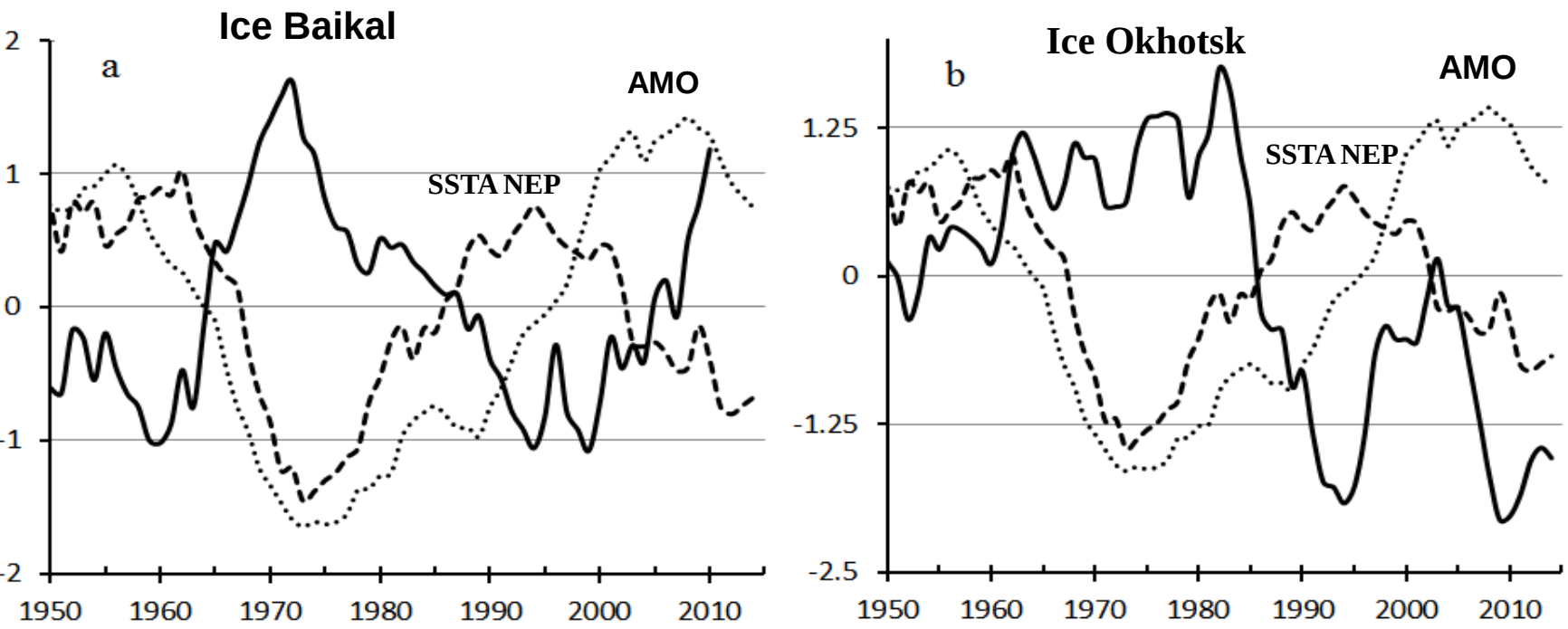
Normalized anomalies of 5-years running mean time series (1950 - 2012) of the *Ice Thickness (solid curve) in the Lake Baykal* and meridional wind component (dashed curve) over the lake basin and adjacent area



An increase in the south wind, reduction of the north wind result in reduction in ice thickness and winter ice duration in the Lake Baykal.

There is similar relationship between anomalies of the Ice Extent in the Japan, Okhotsk Seas and northern, north western winds intensity, that is related to climate regime change after rapid shift. manifested in previous presentation.

Normalized anomalies of 11-years running mean time series of Ice Thickness (IT) in the Lake Baykal (solid curve) (1950 - 2012) (a), Okhotsk Sea (1950 – 2014) (b), annual mean SST anomalies (dashed curve) in the Northeast Pacific (NEP, 40-60 N; 160-145 W) and Atlantic Multidecadal Oscillation (AMO) Indices (dot curve)



On the multidecadal time scale the warming in the Northeast Pacific accompany winter warming in the Lake Baykal area. Correlation coefficient between IT and SSTA in the NE Pacific is -0.8.

Correlation coefficient between Baikal IT and AMO is -0.5 due to the AMO has same phase with SST before late 70s , while after late 70s the AMO is leading in recent climate change in the North Pacific and South Siberia.

Conclusion

- **Winter anomalies in South Siberia on both interannual and interdecadal time scales have best positive correlation with similar anomalies in the Indian Ocean, Eastern Subarctic and South Tropical Pacific.**

- **The interdecadal climate oscillations (20-30 years period) in the Okhotsk, Japan Seas are usually in inversed phase with similar scale oscillations in both South Siberia and Northeast Pacific.**

- **Alternation of the cold/warm decadal anomalies in different longitude zones of the North Asian Pacific is accompanied by alternation of anomalies in north/south winds.**

Multidecadal Oscillation

- **The multidecadal oscillation with period 50-60 years in South Siberia accompanies similar scale oscillation in Arctic, Pacific, Indian and Atlantic Oceans, being a global scale phenomena related to the climate regime change.**

- **The Atlantic Multidecadal Oscillation (AMO) had same phase with Multidecadal Oscillation in the North Asia Pacific Region before late 70s., while change in AMO is leading on the multidecadal time scale after climate regime shift in late 70s.**