# Studying climate change in Siberia based on climatic indices assessment

*T. Shulgina [1,2] (stm@scert.ru ), V. Bogomolov[1,2], E.Genina[1], E. Gordov [1,2], K. Nikitchuk[1], I. Okladnikov [1,2], A. Titov[1,2]*
*[1] Institute of Monitoring of Climatic and Ecological Systems SB RAS, Tomsk, Russia (http://www.imces.ru )*
*[2] Siberian Center for Environmental Research and Training, Tomsk, Russia (http://scert.ru )*

Nowadays substantial progress has been achieved in studying climatic changes. However, standard set of meteorological and climatic characteristics, used for climate change assessment on global scale, is not sufficient for assessment of regional manifestations of climate changes. To study peculiarities of climate behavior in the selected region, it is necessary to enlarge the set of indicators and to improve spatial resolution. The most practically important are the data on change of extreme values of meteorological elements and not just on change of their average values.
This report is devoted to studying climate change in Siberia based on analysis of climate change indices characterizing behavior of thermal conditions in the region considered. The indices used for calculation have been developed by CC1/CLIVAR working group (http://cccma.seos.uvic.ca/ETCCDMI/indices.shtml) and approved by Expert Group on detection, monitoring and climate change indices at WMO Climatology Commission. Initial data are data from JMA/CRIEPI JRA Reanalysis on air temperature over period from 1979 till 2001 with resolution of 1.125°×1.251°, as well as observation data at weather stations (Global Synoptic Climatology Network). Using the data available we determined spatial behavior of climatic characteristics on Siberian territory for the first half of 20th century, when there was no anthropogenic impact, and for the second half of that century, when such an impact become sufficient. Comparative analysis was made for behavior of thermal conditions.

**Purpose**
To study surface air temperature behavior using data of meteorological models and instrumented observations obtained at weather stations' network on the Siberian territory by means of analysis of a set of climatic indicators.

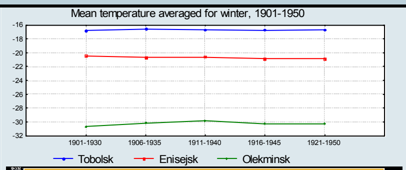
**Initial data**
▪Diurnal observation data on surface air temperature obtained at three Siberian stations (Global Synoptic Climatology Network) over the period 1901-1950;
▪JMA/CRIEPI JRA Reanalysis data at 2-m altitude with a spatial resolution of 1.125°×1.125° over the period 1979-2006 were used.

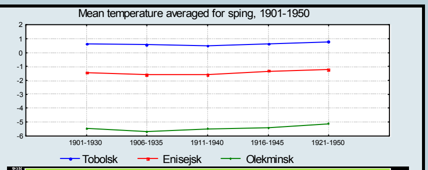
**Surface temperature indicators:**
1.Monthly mean temperatures averaged over 30 years with the 5-year step over the period 1901-1950 (from observation data);
2.Seasonally mean temperatures averaged over the period 1979-2006 (JMA/CRIEPI JRA Reanalysis data);
3.Monthly maximum and minimum surface air temperatures (observation and JMA/CRIEPI JRA Reanalysis data);
4.Climatic indices "Number of frost days" and "Number of summer days" provided by CCl/CLIVAR/JCOMM Expert Team (ET) on Climate Change Detection and Indices over the period 1979-2006 (JMA/CRIEPI JRA data ).

***Dynamics of monthly mean temperature changes***

At the first stage of the study observation data over the period from 1901-1950 was analyzed, when the first 30 years were taken as the basic period. Temperature changes in the first half of the 20th century is formed mostly due to winter and spring seasons and to a lesser degree due to autumn season. There are no sufficient temperature changes at the territory of Siberia over the 1901–1950 years: Tobolsk station (West Siberia) – temperature changes of 0.007 °C/10 years in winter, 0.013 °C/10 years in spring; Enisejsk and Olekminsk stations (East Siberia) temperature changes of 0.02 °C/10 years in winter, 0.023 °C/10 years in spring.

Calculation of a linear trend in seasonal mean temperatures based on JMA/CRIEPI JRA data over the period from 1979 through 2006 are presented on the Fig.1 and Fig.2.
Warming rates are quite high (more that 0.2 °C/10 years), while in separate regions (mostly at the territory of East Siberia) they can reach value of 0.5 °C/10 years. The only exception is West Siberia territory, where some cooling is observed.



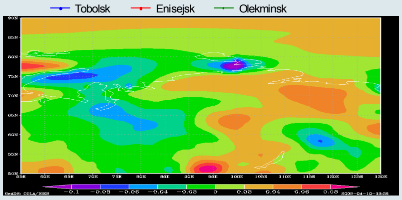



Fig.1. Linear trend of mean temperature for winter, 1979-2002

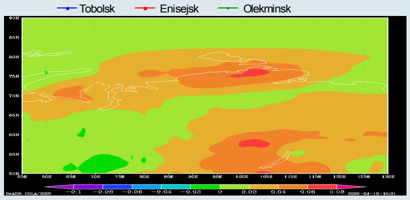
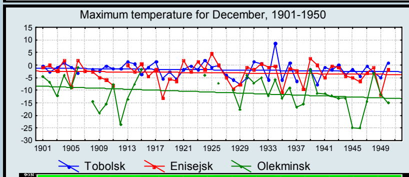
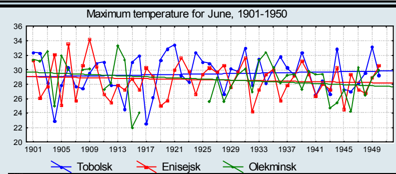


Fig.2. Linear trend of mean temperature for summer, 1979-2002



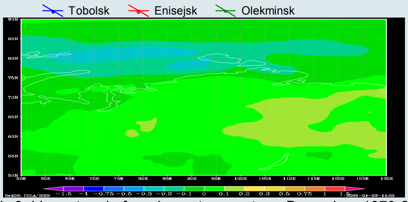



Fig.3. Linear trend of maximum temperature, December, 1979-2006

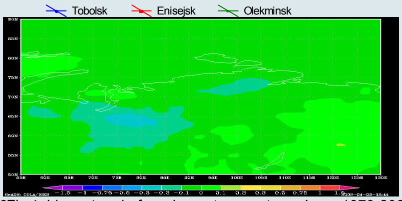


Fig.4. Linear trend of maximum temperature, June, 1979-2006

***Analysis of extreme temperature behavior (maximum temperature)***

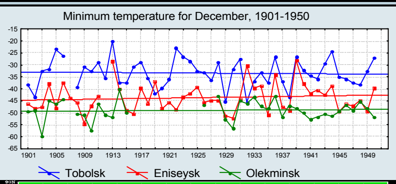
Calculations, made on the data of weather stations located on the Siberian territory over the period 1901-1950, give negative trends both for winter and summer months. The most significant decrease of maximum temperatures is observed on the East Siberia territory (data of Olekminsk weather station), which is -0.9°C/10 years for December (-0.4 °C/10 years for winter season) and -0.4°C/10 years for June (-0.25°C/10 years for summer season).

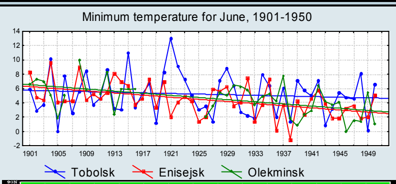
Calculations, made on JMA/CRIEPI JRA data over the period from 1979 through 2006, show that significant warming is observed mostly in winter. As seen from Fig. 3, maximum temperature tends to increase at all territory under study. Vast warming spots are observed, first of all, at the territory of East Siberia, where trend value exceeds 0.2 °C every year, which is significantly exceeds warming rate in the first half of 20th century. As seen from the map presented, temperature increase over Arctic ocean is several times smaller that one over the continent. At the same time, negative trends are dominated in summer season at large territory of Siberia (Fig. 4).

***Analysis of extreme temperature behavior (minimum temperature)***

Trend obtained for winter indicate temperature increase in East Siberia (0.3 °C/10 years). While at the territory of West Siberia weak negative trend (-0.2 °C/10 years) is observed. Results obtained for summer season show that cooling took place at the territory of Siberia in the first half of 20th century.

Similar results obtained when analyzing late period based on JMA/CRIEPI JRA data.



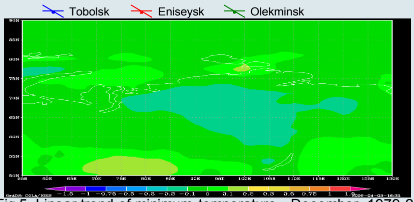



Fig.5. Linear trend of minimum temperature , December, 1979-2006

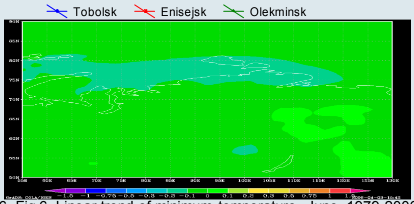


Fig.6. Linear trend of minimum temperature, June, 1979-2006

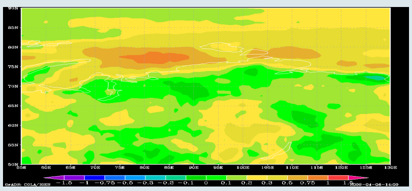


Fig.7. "Number of frost days" index, 1979-2006

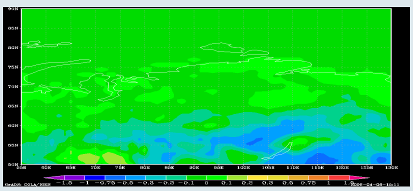


Fig.8. "Number of summer days" index, 1979-2006

***Number on frost and summer days indices***

Calculation of number of frost days (annual count of days when daily mean temperature < 0°C) and number of summer days (annual count of days when daily maximum temperature > 25°C) were made on the basic of JMA/CRIEPI JRA data over the period 1979-2006.
Significant inhomogeneity of temperature change in Siberia has been related. Temperature increase smaller in warm season then in cold one. Areas where warming is observed alternate with areas where cooling is significant. Increase of frost days is observed in the north of West and East Siberia, as well as at the Arctic ocean.

**Conclusions:** Fields of long-term trends have inhomogeneous structure. Regions with maximum warming rates are located mostly in East Siberia. Spatial distribution of seasonally mean temperature changes is specific for seasons. Winter and spring seasons made the main contribution to climate warming. In general, changes are within -0.5ºC to +0.5ºC every 10 years.
**Plans:** To retrieve meteorological parameters' fields by interpolation methods based on weather stations' data with the aim to get fields with the higher-resolution grids. To increase number of stations under consideration and enlarge time interval.

**Acknowledgement**
This work is partially supported by SB RAS Integrated Projects Nos. 50 and 66. The JMA/CRIEPI JRA Reanalysis datasets used for this study are provided from the cooperative research project of the JRA long-term reanalysis by the Japan Meteorological Agency (JMA) and the Central Research Institute of Electric Power Industry (CRIEPI).