Modern climate variability and increase of hazard in Altai Mountains

INTRO:
Climate change affects the world's mountain regions and may jeopardize the services provided by mountains. This is especially important for mountain regions located within the boundaries of several countries, for example, Altai Mountains that stretch over Mongolia, Russia, China and Kazakhstan. The Altai Mountains (85-92^{0}E and 48-52^{0}N) is a big region located in the Northern Asia, that is extended for more than 1200 km from the north to the south and can be divided into two areas: Russian Altai at north and Mongolian Altai at south. In this work we report the results of comparison of climate (both temperature and precipitation) trends in Russian and Mongolian Altai in 1979-2017.

DATA AND METHODS: For a diverse assessment of the reliability of climate changes in Altai Mountains, we used the initial data of meteorological stations located at altitudes of about 1000 meters or more, as well as reanalysis: NCEP-NCAR and ERA-Interim [https://climatedataguide.ucar.edu/data-type/atmospheric-reanalysis]. Only five meteorological stations are located at altitudes of about 1000 m and higher (Hovd 48.00° N, 91.4° E, 1400 m a.s.l.; Kara-Tureck 50.0°N, 86.4°E, 2600 m a.s.l.; Kosh-Agach 50.00°N, 88.4°E, 1760 m a.s.l.; Ulangom 49.9° N, 92.1° E, 939 m a.s.l.; Ulgii 48.9° N, 91.9° E, 1716 m a.s.l.; Ust-Coksa 50.30°N, 85.6°E, 978 m a.s.l.) and have a continuous series of observations [http://meteo.ru/english/data/; http://namem.gov.mn/eng/]. Climate change studies often analyze extreme climate events based on the use of so-called «extremes indices» [Zhang et al., 2011]. Table lists some specific indices, used in observational climate changes [IPCC, 2014].

For the Fifth Assessment Report (AR5) of IPCC, the scientific community has defined a set of four new scenarios. The CMIP5 simulations were performed with prescribed CO_2 concentrations reaching:421 ppm (RCP2.6),538 ppm (RCP4.5), 670 ppm (RCP6.0) and 936 ppm (RCP 8.5) by the year 2100. [https://www.ipcc.ch/; https://climexp.knmi.nl].

RESULTS: The temperature in Altai Mountains, in the period of 1979-2017, increased by both meteorological stations (trend +0.21^{0}C per decade) and NCEP/NCAR (trend +0.16^{0}C per decade) and ERA-Interim reanalysis (trend + 0.17^{0}C per decade). The results of the trends are consistent with trends calculated for 1896-2018 (trend + 0.18^{0}C per decade). However, the average temperatures for these reanalysis (NCEP/NCAR and ERA-Interim) and meteorological stations differ significantly due to the difference in data (primary data and reanalysis). Based on «step change point», it is shown that the most intense warming has been observed in the last 20 years (since 1997), both in Russian and Mongolian Altai with similar warmest years during this period.

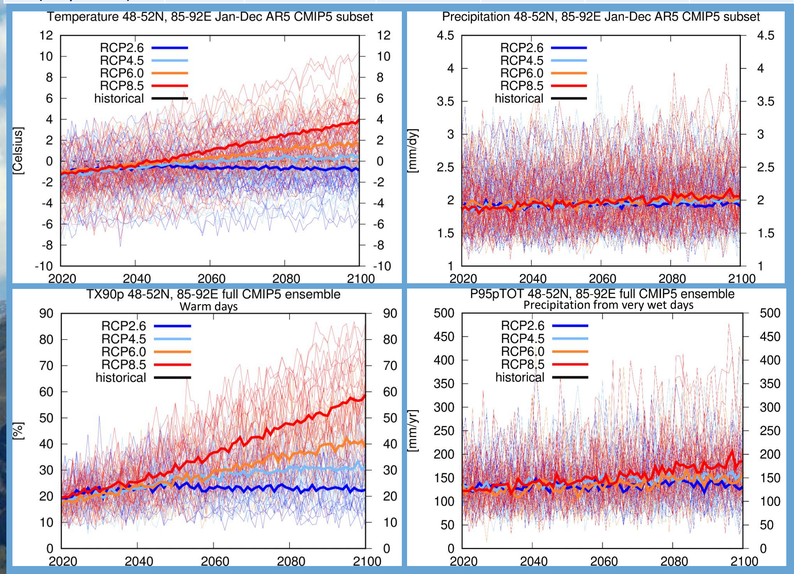
The precipitation in Altai Mountains is decreasing two times faster (trend -2.3 mm y^{-1} per decade) compared to Mongolian Altai, unlike Russian Altai. This trend is confirmed by the results of calculations for the ERA-Interim reanalysis (trend -2.3 mm yr^{-1} per decade). According to NCEP/NCAR reanalysis, the obtained trends give a positive position (trend +4.3 mm yr^{-1} per decade), in contrast to the trends obtained from two other sources (meteorological stations and ERA-Interim). Based on the "step change point", it was shown that the most dramatic decrease in precipitation, both in Russian and in Mongolian Altai, occurred in 2002.

The number of «Cold days» and «Cold nights» decreases, and the temperatures for these periods increase. All this happens against the background of an increase in the number of «Warm days» and «Warm nights» and an increase in their temperatures. At the same time, there are no uniform trends in changes for extreme indices of precipitation. It is important that during the years of maximum manifestation of some extreme climate indices in Altai Mountains, namely in Mongolian Altai (Hovd aimag), there were extreme climatic events that manifested themselves in catastrophic droughts and dzud.

In the Altai Mountains, by the end of the century, the temperature is projected to increase from 0.5^{0}C (RCP 2.6) to 5^{0}C (RCP 8.5), with no significant increase in precipitation (up to 0.2 mm for RCP 8.5), and the precipitation-evaporation rate will be the same. The temperature increase at RCP 8.5 to 5^{0}C will be by 2100 in Altai Mountains in the warmest daily and on warmest nights. But, the number of cold days and nights will decrease and the number of warm days and warm nights to 2100 for RCP 8.5 will increase by 40-45%. At the same time, the wettest day can increase by 5 mm/day at RCP 8.5 and daily intensity index will be an increase of almost 50 mm/year by 2100.

Photo: A. Litvinov

Period	Station	NCEP/NCAR	ERA-Interim	Station	NCEP/NCAR	ERA-Interim
Annual temperature (^{0}C)				Annual precipitation (mm)		
1979-2017 (all period)	+0.05	-4.02	-2.07	400	541	558
1979-1997/2002 (first period)	-0.27	-4.04	-2.27	420	537	585
1998/2003-2017 (second period)	+0.32	-3.63	-1.87	367	549	502
Trend(^{0}C per decade)				Trend(mm yr^{-1} per decade)		
1979-2017 (all period)	+0.21	+0.16	+0.17	-2.3	+4.3	-2.8



Natalia Malygina[1], Tatiana Barlyaeva[2], Otgonbayar Demberel[3]

[1]Institute for Water and Environmental Problems, Siberian Branch of the Russian Academy of Sciences (Russian Federation), [2]CITEUC, University of Coimbra, Almas de Freire, Sta. Clara, Coimbra, 3040-004 (Portugal), [3]Khovd State University (Mongolia)

natmgn@gmail.com

1 2 9 0 UNIVERSIDADE D COIMBRA