ENVIRONMENT CHANGES IN THE EURASIAN ARCTIC

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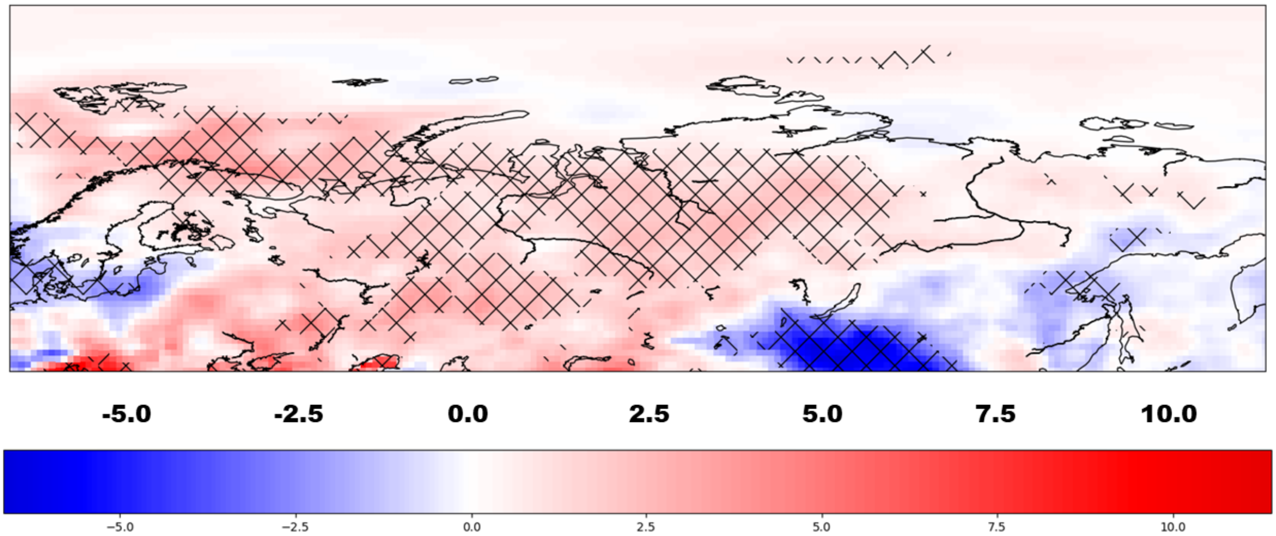
Environment changes in the Eurasian Arctic are among the largest during the past century. Surface air temperature increases are most pronounced in spring and winter. In the winter season we observe the largest interannual temperature variability and in spring the warming is accompanied by a regional-wide increase in Convective Available Potential Energy (CAPE) in the atmosphere (see attached Figure). In other seasons, there is a steady temperature increase by 1 to 2°C per century. The cold season temperature increases play a relatively low direct role in the Arctic environmental changes. However, in the cold season, the Arctic temperatures controls the temperature difference between the tropics and the high latitudes. This difference has already significantly declined and impacted the strength of the westerlies and the heat transport from the North Atlantic Ocean into the continental extratropics. This decline, among others, results in higher winter variability over Northern Eurasia, including the strengthening of the winter blocking events. More and more frequently in the last winters, we observe destructions in the circumpolar atmospheric vortex that generally prevents the cold Arctic air masses to enter the lower latitudes. This may affect the entire cold season weather over the Northern Extratropics as we used to know. Average annual and summer rates of warming are 1.6°C and 1.2°C per 100 years respectively. During the last 60 years these rates have nearly doubled. The summer temperatures in the Eurasian Arctic began their rise only about 30 years ago and since 2005 their values in each year remained among the highest in the instrumental record. This summer warming plays a critical role in environmental changes in the Arctic. It controls the vegetation season onset and ecological zone shifts, the demolition of the multi-annual sea ice, and the permafrost thawing. The last factor impacts the well-being of man-made infrastructure in the Arctic. Vegetation season onset and ecological zone shifts have been observed across the entire Northern Eurasia. In warming and drying climates during the 21 century simulated by 2.6 and RCP 8.5 scenarios of the 20 GCMs ensemble of CMIP5, the northern zono-biomes (tundra, forest-tundra, northern woodlands) neighboring the Arctic were predicted to decrease and shift northwards while forest-steppe, steppe, and drylands were predicted to extend over Eurasia. In the end of each warm season in the Arctic, the extent of the Arctic sea ice is steadily declining at about 13.5% per decade since the time of establishment of the circumpolar satellite sea ice monitoring in 1979. Furthermore, the structure of the sea ice is changing leaving a lesser amount of multi-annual ice and making the sea ice cap thinner. For the Arctic as whole, melt onset and ice opening are getting earlier at a rate of over 5 days per decade, making it more transparent to the solar radiation and upward heat fluxes from the ocean. The permafrost warming rates in Northern Eurasia are among the highest documented globally. Permafrost degradation negatively affects well-being on communities upon it and has severe economic consequences. Recent study estimated that under RCP 8.5 scenario more than 50% of all residential housing and 20% of critical infrastructure will be severely affected by permafrost degradation by mid-21 century. The cost of mitigation due to permafrost degradation is likely to exceed 100 billion USD.

Keywords: Eurasian Arctic, regional climatic change, impact on infrastructure due to environment changes, environmental changes

Spring (MAM) Convective Available Potential Energy Trends (1979-2018)



⟐ ERA interim reanalyses; CAPE trends (J kg^{-1} $decade^{-1}$); regions with statistically significant at the 0.05 level CAPE trends are hatched.