Climatic Change as a Driver of Economic Development: an Example from Angara–Yenisey Siberia

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Abstract. Climate change and its impact on economic development is an important, but still understudied issue. This paper is aimed to fill in this gap in relation to the Angara–Yenisey macroeconomic region. It contributes to the literature in several dimensions. First, an overview of research on the climate impact on various sectors of the Russian economy is given. Second, we showed the main trends and factors in the dynamics of economic development in Russia over the past 20 years. And at last, the comparison of the average annual temperature and the gross regional product growth rates was conducted for the four regions of the Angara–Yenisey Siberia. It was concluded that there is no sufficient evidence that regional economies are significantly dependent on temperature fluctuations. Nevertheless, there is still space for further research.

1. Introduction
In recent years, the climate agenda has been increasingly discussed, both in academia and political discourse. Under the influence of the global warming trend, the environment is undergoing significant changes, e.g., permafrost thawing and increased frequency of extreme events, such as hurricanes, heat waves and droughts, forest fires, floods, and so on [1]. Such events have a significant effect on biodiversity and local populations by affecting their habitat [2].

Additionally, climate change has multilateral effects on resource-intensive economic sectors such as agriculture, forestry, fishery, energy, etc. [3–5]. It is also evidently a factor of economic growth, especially in regions of intensive natural resource use [6].

However, there are certain gaps in the field of climate change economics [7]. For Russia, this topic is still rather novel and understudied. This paper is one of the first attempts to analyze the impact of climate change on economic development levels through a simple comparative analysis of the dynamics of ambient air temperature and economic growth rates.

2. Literature review
While the overall impact of global warming on Russian economic development is poorly studied, there are few studies on the impact on individual economic sectors that should be carefully discussed. Fruitful results have been obtained on the economic consequences of climate change for the Russian forestry sector [8].

Among the most significant future changes, Torzhkov et al. named changes in the species composition of forests and average annual timber growth due to an increase in the vegetation period...
It was found that the average annual temperature increase might lead to the replacement of coniferous species by deciduous forests and raise the monetary estimates of the Russian forest fund. However, logging season duration in Siberian boreal forests decreases as the global temperature slowly grows up [10]. Convincing evidence of a reduction in the length of the logging season in the retrospective period of 1966–2018 is obtained for the top Russian logging regions, Krasnoyarsk Krai and Irkutsk Oblast, which might be a significant threat for logging companies in these regions.

The increasing trend of the frequency and affected area of the forest fires is extensively studied by the Space Research Institute, Russian Academy of Sciences using the remote sensing instruments [11]. In the last decade, there has been a significant increase in the number of forest fire outbreaks in the hard-to-reach northern Russian territories [12].

Russian permafrost territories are mostly affected by climate change because of their simultaneous large resource endowment and lack of infrastructure. Streletskiy et al found that the negative impact of permafrost degradation will impose additional economic stress on buildings, structures and infrastructure of northern lands [13]. In addition, indigenous population might also suffer from those changes, which is an incentive for the authorities to intensify the communication process between researchers, local communities, and decision-makers [2].

On the contrary, the agricultural sector seemed to not suffer significantly from the future climatic changes. There is some evidence that for Russia, the decline in crop production in some territories will be compensated by its growth in other areas [14].

Low-carbon development pathways in Russia are also a hot topic. The economic growth rates in Russia are crucially dependent on fossil fuels extraction. The scenarios of implementing the Paris Agreement and contributing to the global decarbonization trend for the Russian energy sector are much discussed in the literature [15,16].

3. Methods and data
Our study deals with the dynamics of Russian economic development with special emphasis on several Siberian territories. Angara–Yenisey macroeconomic region is an ensemble of four Siberian regions combined on the basis of the river-basin approach [17]. The idea of positioning these regions as a single space is popular among the local policy makers to promote the economic interests of these regions. Angara–Yenisey Siberia includes Krasnoyarsk Krai, Irkutsk Oblast, Tyva Republic, and the Republic of Khakassia.

The key hypothesis of our research is that climatic change affects the economic development trend in the studied regions. The average annual temperature was obtained by calculating the mean value between average January and average July temperatures. This approach might be not the most accurate, but it is convenient in terms of data availability and reflects the main climatic trend. Temperature statistics was obtained from Russian Statistical Yearbook, published by the Federal State Statistics Service of Russia (Rosstat) [18].

We use the index of the physical volume of gross regional product (GRP) to proxy-measure the level of economic development on the territory [19]. The problems of Russian data in terms of its availability, consistency and integrity are widely discussed in literature [20,21]. Due to the scarcity of data, the obtained time series are short containing only 18 yearly observations (2002–2019).

4. Results and discussion
We compare the temperature growth rates with the GRP growth rates during 2002–2019 for the four Angara–Yenisey territories (figure 1). For the whole macroeconomic region, the temperature growth rates are rather similar and mostly shows slight fluctuations less than 1%. The highest volatility shows the temperature in the Krasnoyarsk region, which is generally explained by the large length of the region from north to south. All regions reflect the increase of the average annual temperature in 2007, which was the warmest year in Russia during last 150 years [22] and the Earth’s second warmest year in a century [23].
Figure 1. Comparison of the average annual temperature and GDP growth rates for the Angara–Yenisey macroeconomic region.

The GRP dynamics of the Angara–Yenisey Siberia is more controversial. Russia experienced the highest rate of economic growth in the early 2000s until the global financial crisis of 2008–2009. However, the most significant driver of this growth was a beneficial oil price. At the same time, the Angara–Yenisey macroeconomic region does not have sufficient resources to provide a significant contribution to oil production. Besides, the Vankor oil source field production in the Krasnoyarsk Krai was launched only in 2009.

Only the Irkutsk Oblast shows a significant growth in GRP in the early 2000s. Nevertheless, the entire macro-region experienced the effects of the world crisis in 2008–2009, which was reflected in a decline in production and personal income.

The Russian economy gradually recovered until production peaked in 2012. The Tyva Republic reflects this trend to a lesser extent, since it is one of the poorest and most depressed regions, heavily...
dependent on federal budget support. Since 2013, the Russian economy began to stagnate, and this trend crucially intensified due to the devaluation of the ruble in 2014. Since that time, there has been no recovery, the growth rate of the economy remains low, and personal income in real terms continues to fall. This pattern is true for the Angara–Yenisey Siberia, as well as for the entire Russian Federation.

For the above-mentioned reasons, climate change has not become a significant factor influencing economic development of the Angara–Yenisey macroeconomic region. Despite significant reserves of forest resources and crop areas, the agriculture and forestry sector does not make a significant contribution to the GRP of the regions under consideration. In the Tyva Republic, there is the slight similarity of temperature and GRP trends. This can be explained by a slightly higher share of agriculture in the structure of GRP (5% in 2019 [19]) in comparison with other regions, as well as low rates of economic growth in general.

The main drivers of economic growth in the Angara–Yenisey Siberia are mining and industry, which have not yet experienced significant changes from global warming. At the same time, economic stagnation is primarily due to global and all-Russian economic and political trends and is not related to climate change. However, given the limitations of the methodology used, an important direction for further study could be econometric modeling of the impact of climate change on economic growth, highlighting the sectors of the economy most dependent on temperature fluctuations, including forestry, fishery, energy and agriculture.

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