# Allowable and critical risks of the Arctic development in terms of global climate change

**Y Bolsunovskaya[1], D Volodina, A Sentsov[3]**
[1,2] National Research Tomsk Polytechnic University, Tomsk, Russia
[3] National Research Tomsk State University, National Research Tomsk Polytechnic Russia Tomsk, Russia

**E-mail:** [1]ju_al@inbox.ru, [2]volodina.da2014@yandex.ru, [3]sentsov@tpu.ru

**Abstract**
The Arctic development is accompanied by different high risks which basically arise due to natural and technogenic factors. The changes in the Arctic cryosphere are commonly considered the most serious ones by the international scientific community. In our study we regard the changes in Arctic cryosphere as natural risks. Due to the fact that complex ice conditions, on the one hand, present the serious obstacle to Arctic resources development and, on the other hand, serve as indicator of alarming global climate change, the current research proposes the risk analysis based on the analytical model, with the risks being classified by their level of impact.

## 1. Introduction

The Arctic issues are becoming increasingly important in the current studies of global climate change. This is due to the fact that the Arctic region which is characterized by complex and rather specific climatic features (ice sheet) secures the balance of global climate system. As for the Arctic region itself, it should be noted that today it presents a vivid example of transforming climatic and environmental problems into economic and political ones. The growth of the Arctic geo-political importance on a worldwide scale due to Arctic shipping potential and the anticipated amount of hydrocarbons and strategic metals opens new avenues for economic activities both of the Arctic states and the states which do not border the Arctic region. The specific geographical and climatic conditions of the Arctic present a challenge to economic activity in the region. In fact, it is these conditions that restrain geophysical exploration of the Arctic continental shelf. Besides, they make higher demand on communications-infrastructure availability, sustainable development of social systems, staff resources trained specifically to work under Arctic conditions, and, most significantly, programs aimed at preserving and protecting the Arctic environment and unique eco-systems. Therefore, development of the Arctic resources is always accompanied by a great number of various risks.

Such a great concentration of risks in the Arctic region is due to different factors which can be conventionally divided into natural and technogenic ones. The natural factors involve geographical location of the region and harsh weather conditions, while technogenic factors imply the impact of hydrocarbon development activities. The combination of the above factors which constantly affect the Arctic ecosystems poses an enormous threat both to the Arctic region itself and the global climate system, in general.

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## 2. Materials and methods

The current research presents the complex analysis of the risks related to the Arctic region development. The effects of regional climate changes, their role in global climate system and relationships among the Arctic countries, including modernization of the already existing models of the Arctic region development were examined. Based on the analysis of natural, social, economic, and political uncertainties, four groups of the Arctic risks – natural, social and ecological, political, transport-related and technological – were distinguished. Each group includes the maximum number of risk-factors divided into catastrophic, critical, and allowed risks for definite areas. This was done to define the likely level of harm on a world-wide scale. The results of such a division are presented in a form of analytical model.

The allowable risks admit effective economic activity in the Arctic region, with risks being properly managed. The group of critical risks is characterized by high danger of potential losses which exceed the expected benefit. The group of catastrophic risks includes the risks which can lead to global irreparable damage (for example, environmental damage, etc.) or substantially affect geopolitical frames. The proposed model could serve as a basis to make strategic decisions on developing international Arctic projects.

### *2.1. Data sets*

Increasing interest in the Arctic region is basically conditioned by its geo-political importance, the Arctic region currently experiences surge in economic activity. Indeed, due to implementing up-to-date hydrocarbons production technologies, it has become possible to extract increasing amounts of oil and gas from hard-to-reach or highly complex reservoirs located in the traditional oil and gas regions. In addition, the shelf areas of the southern seas are also intensively developed. Thus, it can be stated that there is not great urgency in developing hydrocarbon resources of the Arctic region to address growing global demand for energy. Therefore, the crucial issue is what risks the countries are ready to bear in order to develop hard-to-reach Arctic resources. To address this issue, it is essential to reveal the risks related to the Arctic region development, define their possible adverse effects and estimate the anticipated damage. Arctic operations engender a variety of risks. Some risks can have a significant impact on the whole world, while others can be mitigated due to international, state and cooperative initiatives. The current study is based on the idea that any economic activity in the Arctic region is always accompanied by a number of risks. Among the scientists and experts there is no clear agreement on the classification of risks, their adverse impact and anticipated consequences. Besides, the present approaches to classify the risks do not fully describe the nature of the risks related both to the Arctic region itself and the Arctic states. The analysis of the research literature has revealed that the classification of the investment risks related to the Arctic region development is the most debated in the international practice.

We believe that identification of climate risks with investment ones is not quite appropriate due to the fact that such a classification is aimed at evaluating impact of risks only in terms of economic activity in the Arctic region. As a result, despite an increasing number of international initiatives launched to deal with environmental issues, the consequences of global climate changes, social and environmental protection problems are regarded as issues of secondary importance.

*2.2. Risk assessment during the Arctic development in the context of global climate change*

The basic components of the Arctic cryosphere, such as sea ice and permafrost, are among the most seriously affected by global and regional climate changes. Let us examine each component more closely.

The basic role of the sea ice in the Arctic is to preserve the heat balance between water body and bottom sediments. In summer, sea ice cover reduces the absorption of solar radiation by water surface. In winter, ice cover prevents heat exchange between deep water and surface layers [1]. In the coldest months, the ice extent is up to 16 mln. km$^2$ in the seas of the Northern Hemisphere. The thickness of the seasonal ice accounts for 2 m, while multiyear ice ranges from 3 to 6 m. The hummocks rise 5-9 m in the open sea and 20 m in the coastal area. In the Arctic seas, the shipping routes through fully consolidated ice with different degrees of compaction reduce by 10-25% in summer, in winter – by 20-40%. The increased ice-free period accelerates the processes of coastal erosion and degradation. In general, the process of ice cover transformation is of cyclic character: in different periods scientists note the stages of ice shrinkage or ice extension [2]. However, in accordance with the various forecasts, the Arctic sea ice will continue its rapid shrinkage [3, 4].

As National Snow and Ice Data Center [4] reported (figure 1), on September 11, the forth lowest Arctic sea ice extent in the satellite record for 2015 was 4.41 million square kilometers. After the date of the sea ice minimum, Arctic ice started increasing. The average Arctic ice sea extent for September 2015 was 4.63 million square kilometers, i.e. the lowest values in the satellite record. This is 1.87 million square kilometers below the 1981 to 2010 average extent; however, it is 1.01 square kilometers above the record low monthly average for September, 2012.

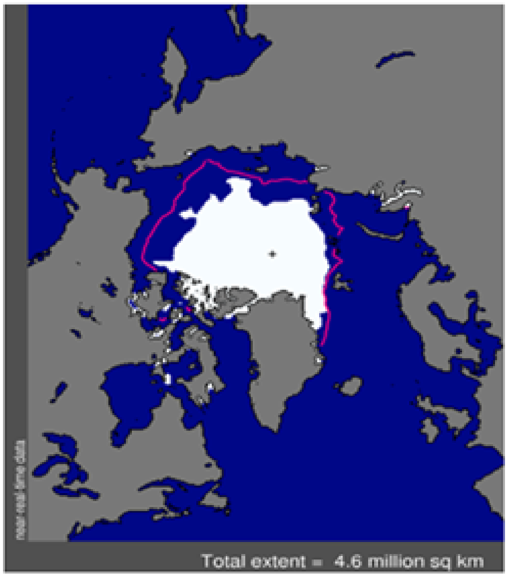


**Figure 1.** Satellite monitoring data on Arctic sea ice extent in September, 2015. The magenta line shows the average ice extent for the month in the 1981-2010 period [5].

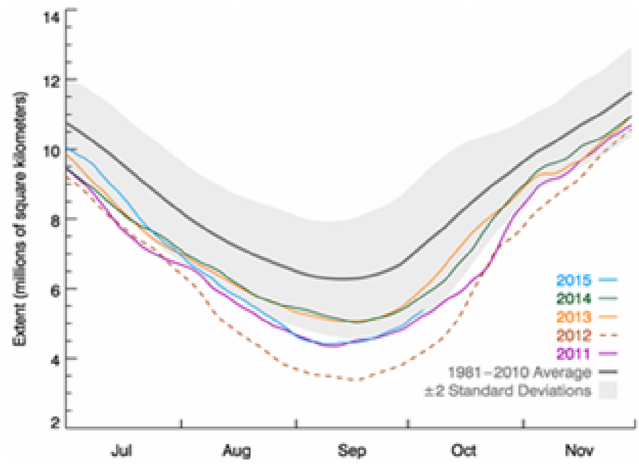


**Figure 2.** Arctic Sea Ice Extent (Area of ocean with at least 15% sea ice). The graph presents Arctic sea ice extent for 5 October, 2015 compared to daily ice extent data for the 2011 to 2014. The grey area around the grey line (1981-2010) shows two standard data deviation ranges [5].

The findings indicate that despite the seasonal increase (September, 2015) Arctic sea ice extent does not reach the 1981-2010 average for that month. Thus, Arctic sea ice extent changes in the cyclic manner. However, on a global scale, it continues melting. This trend is illustrated in (figure 2) which shows data deviation from the 1981 to 2010 for four previous years.

Thawing or degradation of permafrost and associated release of carbon dioxide ($CO_2$) and methane ($CH_4$) present another significant concern. Permafrost degradation is termed as uneven melting of ground ice leading to ground surface subsidence (thermokarst). Unlike other cryosphere components which are subjected to direct climate change impact, permafrost is protected by the surface organic layer. Therefore, it can be affected only if this insulating organic surface layer is completely destroyed. Thus, it can be stated that the most serious damage is basically caused by technogenic activities, while climate changes serve as accelerating agents. However, the intensity and duration of greenhouse gas emission in the Arctic region, as well as the impact of such gases on climate change have not been completely studied yet [6]. The urgency and importance of the above issues contributed to launching a number of international initiatives aimed at monitoring climate change in the Arctic region and forecasting the changes in the global climate system based on modeling principle (AMAP, IPCC, CAFF, etc.).

Methane is considered a more potent greenhouse gas whose impact on the environment is more than several times higher than $CO_2$. Despite the fact that the amount of methane release into the atmosphere is much lower than that of carbon dioxide, its heat-trapping ability is 25 times higher. Thus, methane contributes substantially to global climate change in the near term (10-15 years). Therefore, quantitative estimates of methane emission in various Arctic regions, on land and sea, constitute a great part of international research [6, 7, 8]. Based on Global Methane Initiative [9] data, methane emissions from oil and natural gas systems for 2010 accounted for 20% of global anthropogenic methane emissions. These emissions are projected to grow approximately by 35% by 2020. Oil and gas emissions are expected to increase the projected amount of emitted methane by 3% annually. Therefore, it can be stated that the effects of oil and gas activities in the Arctic region can be rather crucial and catastrophic. Thus, the specific natural and climatic conditions of the Arctic region pose significant limitations to the resource development perspectives in this region. It is impossible to completely eliminate natural risks which consequences are hard to predict. In addition, it is rather difficult to address these risks.

Oil and gas activity causes substantial environmental damage to the Arctic region, as a whole. The most dangerous and hard-to-eliminate consequences of such an activity are oil and chemical spills that accompany any hydrocarbon field development including drilling operations and oil and gas transportation. The most harmful effect of such accidental spills is a constant degradation of Arctic sea ecosystems. Such adverse effects of anthropogenic activities are examples of ecological risks [10]. The basic danger related to ecological risks is due to the fact that they produce combined impact on the whole region, thus, reducing efficiency of risk mitigation plans. Therefore, high environmental safety of the Arctic region is a key factor of its sustainable development.

Another challenge that impedes sustainable development of the Arctic region is significant social risks. In the Arctic region, social consequences of climate changes and anthropogenic impact are more notable due to the fact that it is place for indigenous peoples to live. Such factors as landscape continuity, maintenance of the traditional biodiversity of the Arctic region are obligatory conditions for indigenous peoples' well-being. However, the rapid warming trend and consequences of industrial activity in this region significantly reduce the possibility of on-time adaptation of local communities to ongoing changes threatening their traditional lifestyle. Besides, there is a growing risk for the health of northern peoples: increase in morbidity and mortality resulting from anomalous high/low temperatures, increased accidents of injury and mortality caused by unpredictable weather conditions (storms, floods, etc.), growing number of infectious, parasitic diseases and cancer, acute and chronic illnesses, reproductive dysfunction [11, 12].

Efficient and safe development of Arctic resources is also complicated by transport-related and technological problems. Oil and gas activity in the Arctic region inevitably involves the use of stationary drilling and production platforms, ice-class vessels designed for ice navigation, exploration, and rescue operations under harsh Arctic weather conditions. куport infrastructure that would meet international navigating requirements is also of great importance. Due to projected increase in cargo flows on the Northern Sea Route, it is of great importance to find the ways to reduce the discussed transport-related and technological risks. Here Russia's Arctic strategies are of great value as the Northern Sea Route is the historically formed national single transport communication of the Russian Federation in the Arctic. To guarantee cargo flow security on the Northern Sea Route, it is necessary to use up-to-date engineering facilities and provide highly developed infrastructure in Russian Arctic. However, currently these conditions are not sufficiently fulfilled. In comparison with other polar countries, Russia is characterized by insufficient level of infrastructure development in the northern regions. Therefore, the problems related to the applied technologies and infrastructure should be considered in a wider arena including political background [13] and political risks [14] of the Arctic region. Today, there is no well-developed international Arctic law. The legal status of the Arctic seas is defined by the principles and norms of the international law, precisely by 1958 Geneva Conventions on the Law of the Sea and UN Convention on the Law of the Sea which do not capture many legal aspects of the Arctic issues. There is no unique approach to define the Arctic borders as a geographical region with strict division into political and administrative regions of the Arctic countries and clear mapping of areas of their responsibility. Such an uncertainty stipulates geopolitical competition to claim the right to natural resources found in the Arctic and control of Northern Sea routes. Therefore, the system of international cooperation in the Arctic region is actually twofold. On the one hand, competition among the Arctic nations seeking to assert their influence in the region is getting tougher; on the other hand, no Arctic country appears to have sufficient scientific and technological capacities to implement Arctic resources development projects alone [14].

The international Arctic cooperation has achieved such a scale that it can be carried out on the following bases: bilateral cooperation, multilateral cooperation, and large scale cooperation (including all Arctic countries, as well as a number of non-Arctic nations). It is assumed that such a cooperation could be affective not only for participants, but for the Arctic region, as a whole. In accordance with Oran R. Young [15], improvement of the current Arctic governance systems and development of new ones with due regard to the newly emerged risks are the ultimate priority of the Arctic international cooperation. The focus of the non-Arctic countries has definitely shifted from pure research activity to the intent to exploit Arctic strategic potential, which makes a perspective trend in the Arctic international cooperation. However, there is a potential for international conflicts. The list of non-Arctic countries and the procedure to gain the observer status in the Arctic Council unveil the unseen links between the Arctic and non-Arctic countries. In addition, membership of the Arctic and non-Arctic countries in various international organizations (EU, NATO) can influence their relationships.

## 3. Results and Discussion

The basic findings of the current research are as follows: relationships of the Arctic countries, as well as the Arctic region itself, are intensively transforming. Due to interacting forces of climate change, globalization, social and economic trends, there is an urgent need to modernize the already existing models of the Arctic region development. The Arctic sustainable development is directly dependent on natural, social, economic, and political uncertainties which contribute to new risks. Based on our estimates and specific geographical and climatic conditions of the Arctic, we assume that uncertainties can emerge within any activity related to the Arctic development. The analysis of ongoing transformations allows us to define four basic groups of Arctic risks which could cause negative effects on a world-wide scale. To predict the likely level of harm, each group of Arctic risks is presented in the form of analytical model, with the risks being divided into catastrophic, critical, and allowable (figure 3). The model demonstrates that catastrophic and critical risks are predominant in each group of Arctic risks. This proves the fact that Arctic resources are impossible to develop by one country.

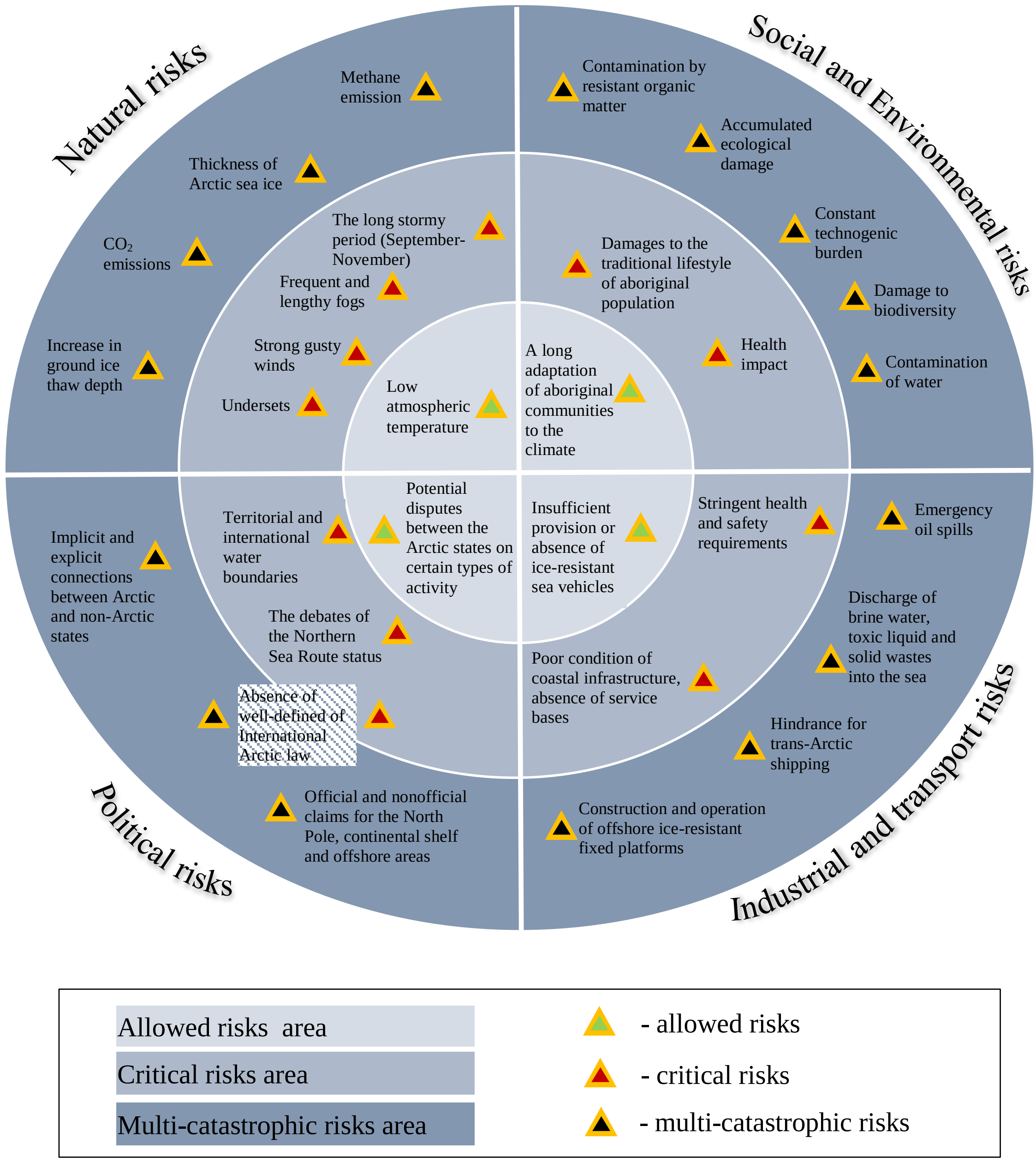


**Figure 3.** Analytical model of Arctic risks breakdown by the areas of possible harm (Author's edition)

## 4. Conclusion

Today, it is difficult to predict the dynamics of global climate changes. In addition, it is difficult to define the impact of the Arctic climate changes on the global climate. However, the tremendous expansion of economic activity in the Arctic region involves a growing number of new risks which should be consistently analyzed with regard to natural factors. There is little doubt that the specific geographical and climatic conditions of the Arctic contributed to the shift of non-Arctic countries' interests from research level to the intent to participate in Arctic resource development and control of the Northern Sea routes. This proves the fact that it is of particular importance to establish the partnership among all participants involved in economic activity in the Arctic, to achieve the balance between efficient use and economic feasibility of Arctic resources development. Besides, it can be required to enhance the dialogue with non-Arctic countries in order to foster mutually beneficial cooperation.

## References

[1] Olerskiy V A 2014 Razvitie transportnoy sistemy Arkticheskoy zony RF: Processing of IV International Forum «the Arctic: present and future» 15-18
[2] Rosgidromet. Russian Federal Service for Hydrometeorology and Environmental Monitoring. URL: http://www.meteorf.ru
[3] Lindsay R and Schweiger A 2015 Arctic sea ice thickness loss determined using subsurface, aircraft, and satellite observations *The Cryosphere* No. **9** 269-283
[4] 2015 Melt season in review. National Snow and Ice Data Center: Advancing knowledge of Earth's frozen regions. URL: http://nsidc.org/arcticseaicenews/
[5] Tayushchaya krasota. Izmeneniya klimata i ego posledstviya 2009 Heinrich Böll Foundation, Russian Regional Ecological Center
[6] Schuur E A G et al 2015 Climate change and the permafrost carbon feedback *Nature* vol 520 (7546) 171–179
[7] Natali S M et al 2015 Permafrost thaw and soil moisture drive CO2 and CH4 release from upland tundra *Journal of Geophys. Res.* vol **120** (3) 525-537
[8] Fisher R E et al 2011 Arctic methane sources: Isotopic evidence for atmospheric inputs *Geophys. Res. Lett.* vol **38** L21803
[9] Global Methane Emissions and Mitigation Opportunities 2011 Global Methane Initiative. URL: https://www.globalmethane.org/documents/analysis_fs_en.pdf
[10] Bolsunovskaya Y and Bolsunovskaya L 2015 Ecological risk analysis as a key factor in environmental safety system development in the Arctic region of the Russian Federation *IOP Conf. Ser.: Earth and Environ. Sci.* vol **24** 012003
[11] Revich B et al 2008 Climate Change Impact on Public Health in the Russian Arctic. The United Nations Office in Russia Arctic Initiative. URL: http://www.unrussia.ru/sites/default/files/doc/Arctic-eng.pdf
[12] Dudley J P, Hoberg E P, Jenkins E J and Parkinson A J 2015 Climate Change in the North American Arctic: A One Health Perspective *EcoHealth* vol **12** (2) online first articles
[13] Sentsov A, Bolsunovskaya Y and Bolsunovskaya L 2014 Effective Planning of the Future of the Arctic *IOP Conf. Ser.: Earth and Environ. Sci.* vol **21** 012014
[14] Bolsunovskaya Y, Boyarko G and Bolsunovskaya L 2014 Political risks of hydrocarbon deposit development in the Arctic seas of the Russian Federation *IOP Conf. Ser.: Earth and Environ. Sci.* vol **21** 012046
[15] Young Or 2012 Arctic tipping points: governance in turbulent times *Ambio* vol **41**(1) 75-84