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Comprehensive Risk Prevention of "Ice Silk Road" Construction in the Context of Global Warming

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Abstract The Report of the 19th National Congress of the Communist Party of China has taken the Belt and Road Initiative and the implementation of the the Belt and Road Initiative as essential parts of China's economic construction and multi-faceted diplomatic layout. As an important navigation channel for the "21st Century Maritime Silk Road", the Arctic Route has unlimited development prospects in scientific research, transportation, resources, tourism, etc. Therefore, it is feasible to take this opportunity to adhere to the three policy concepts of respect, cooperation and mutual benefit, to deepen political, economic, trade and scientific and technological cooperation with the Arctic countries and interested countries. Starting from the joint creation of the "Ice Silk Road" between China and Russia, this paper analyzed the enormous challenges faced by traditional routes. The Arctic Route has the obvious advantages and the values of economy, politics, resources, shipping and scientific research. The development of Arctic Route faces threats and limitations of substrate data, development technologies, and extreme marine meteorological disasters. Therefore, this paper believes that the development and construction of the Arctic Route with the aid of meteorology should be fully integrated into the construction of Belt and Road Initiative, strengthen the research on the geographical and climatic environment of the Arctic Ocean, deepen the monitoring of climate services and climate change in the Arctic Ocean, and create a safe Arctic Route. Besides, it is necessary to vigorously enhance the international cooperation and exchanges in the research of the Arctic Ocean, and build a large-scale scientific research plan with the aid of the joint creation of "Ice Silk Road" by China and Russia. Besides, it is recommended to develop a variety of meteorological observation methods to enhance the early warning capability of disaster prevention and mitigation. In particular, it is recommended to vigorously develop the offshore meteorological observation capability of the "Ice Silk Road", and continuously meet the needs of meteorological services and disaster prevention and mitigation for the construction of Belt and Road Initiative. In addition, it is necessary to comprehensively build a Chinese meteorological polar discipline system to meet the future demands of the Arctic Route.

Key words Ice Silk Road, Arctic Route, Risk prevention, Climate changes, Countermeasures and recommendations

1 Introduction

On July 4, 2017, Chinese President Xi Jinping visited Russia. In a meeting with Russian Prime Minister, Medvedev, Xi urged the two countries to carry out the Northern Sea Route cooperation so as to realize an "Ice Silk Road". From brewing to introduction, the concept of "Ice Silk Road" experienced two years. In 2015, in the *Joint Communiqué of the 20th Meeting between the Chinese and Russian Prime Ministers*, the embryonic form of the "Ice Silk Road" has already appeared. The expression at that time was "strengthening the development and utilization of the Northern Sea Route and carrying out Arctic shipping research". In the *Joint Communiqué of the 21st Meeting between the China and Russia*, the expression changed to "research on the prospect of joint development of the transportation potential of the Northern Sea Route". By the Belt and Road Forum for International Cooperation held in May 2017, this framework had become become much clearer. Russian President Vladimir Putin hoped that China can use the Arctic Route to connect the Arctic Route with the

Belt and Road. The harsh environment caused by meteorological factors is the dominant factor limiting the development of the Arctic Route. According to its own technical advantages, the meteorological department has its unique advantages in assisting the development and construction of the Arctic Route^[1]. China is a "near-Arctic country" geographically. In order to gain more voice in the future Arctic affairs and protect its future practical interests, China must increase its participation in the Arctic^[2]. The Arctic Route consists of two passages, the Northwest Passage along the coast of Canada and the Northeast Passage along the Siberian coast. The Northwest Passage leads to the north of North America. There are too many bay islands and the water temperature is low, so it is not easy to get through. By comparison, the Northeast Passage starts from northern Europe and travels eastward through the Barents Sea, Kara Sea, Laptev Sea, Novosibirsk Sea and Chukchi Sea to the Bering Strait. It mainly passes through the north coast of Siberia. In addition to the North Atlantic Warm Current flowing deep into into the Arctic Ocean, the frozen sea area is relatively small, thus the possibility of navigation is very high^[3]. The passage Russia invited China to build jointly is the Northeast Passage, which greatly reduces the voyage compared with traditional routes. And in this paper, the Arctic Route refers to Northeast Passage.

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2 Challenges faced by traditional routes and the strategic significance of Arctic Route development

2.1 Challenges faced by traditional routes and strengths of Arctic Route

2.1.1 Serious challenges faced by traditional routes. According to the traditional shipping routes, the trade between China and Europe must pass through the Straits of Malacca, the Indian Ocean and the Suez Canal to reach European ports. Once the tanker loads more than 210 000 t (the upper limit of the Suez Canal), it has to make a detour from the Cape of Good Hope in Africa, which is time-consuming and costly. Besides, the traditional shipping routes that China currently travels to Europe are mainly through Southeast Asia, South Asia, West Asia and North Africa. In these regions, the ethnic, religious and cultural issues are extremely complicated. Terrorism and extreme events occur frequently; pirates are rampant, there are many unstable factors, causing a great threat to shipping safety^[4].

2.1.2 Obvious strengths of Arctic Route compared with traditional routes. Once the Arctic Northeast Passage is formally opened, the voyage from China's coastal ports to the east coast of North America will be 2 000 – 3 500 nautical miles shorter than the traditional route from the Panama Canal; the ports in north of Shanghai to the western European, North Sea, Baltic Sea and other ports will be shorter than the traditional route by 25% – 55%, which will annually save 53.3 – 127.4 billion USD in international trade shipping costs. As the shortest route connecting East Asia, Eastern Europe and Westport areas, it can shorten one-third of the voyage compared with traditional routes. For example, from Dalian of China to Rotterdam of the Netherlands, the sailing time of the Northeast Passage of the Arctic is about 33 d, which is 12 – 15 d less than the traditional route through the Straits of Malacca and the Suez Canal. The shortened range means less cost of shipping and fuel consumption (Table 1). On the other hand, compared with the traditional routes, the countries along the "Ice Silk Road" are relatively simple, mainly the northern areas of Russia, and the unstable factors are relatively less. In addition, the special geographical environment of the Arctic Circle can prevent the risk factors such as pirates to a certain extent, and improve the navigation safety^[5].

Table 1 Comparison of voyage and consumption for three routes from Narvik of Norway to Qingdao of China

Voyage details	Through the Suez Canal	Through the Arctic Route	Through the Cape of Good Hope
Distance//nautical mile	11 800	6 800	15 075
Ship type	Panamax	Ice class Panamax	Panamax
Cargo capacity//t	68 000	68 000	68 000
Speed//knot	14.4	14.4	14.4
Fuel consumption//t/d	36.7	36.7	36.7
Fuel consumption per voyage//t	1 248	734	1 578

2.2 Strategic value of the Arctic Route

2.2.1 The Arctic Route can reduce the pressure of China's mari-

time transport and help promote the construction of the 21st Century Maritime Silk Road. In recent years, with the deep construction of the 21st Century Maritime Silk Road, China's marine economy has received considerable development, and China's shipping routes have also increased, but the existing routes are still unable to offset the growing pressure of maritime trade growth (Fig. 2). In the situation that the traditional routes are facing severe challenges, the development and construction of the Arctic Route will play an important role in alleviating the pressure on China's maritime transport. The smooth land transportation in the construction of the Belt and Road Initiative, together with the opening of the Arctic Route, has provided unprecedented convenience for China's economy and trade and cultural exchanges with Central and Western Asia and European countries. The Arctic Route will become the northernmost maritime passage to Europe in the Belt and Road Initiative, and will help promote the construction of the Belt and Road Initiative and incorporate it into the process of global economic integration^[6].

2.2.2 The Arctic Route has unique scientific value in global climate change. The Arctic Ocean through which the Arctic Route passes is an important object in global climate change research. The Arctic Ocean connects the "three continents" and the "two oceans". It is the world's highest latitude ocean, most of the Arctic Ocean is covered by snow and ice all year round, and the geographical environment is very harsh (Fig. 3). Besides, the Arctic Ocean is not only one of the most sensitive areas for response to global climate change, but also plays an important role in regulating global atmospheric and ocean circulation changes, so it can be said it is a driver of global change. As an important cold source of the global hot and cold cycle, the seasonal alternation of the Arctic Ocean sea ice and the exchange of water with the North Pacific and the North Atlantic are important driving forces of global climate change^[7]. In geographic position, the Arctic Ocean as a high latitude region that penetrates the Atlantic and Pacific waterways, its geological tectonic evolution history plays an important role in the evolution and heat distribution of the global ocean circulation. At present, China's research on this region is still not systematic and sufficient. The lack of knowledge and understanding of the role of global climate change in this region seriously threatens the safety construction of the "Ice Silk Road". Therefore, it is urgent to make a comprehensive systematic and scientific evaluation of this region.

2.2.3 The Arctic Route has important geoeconomic, political, technological and strategic positions. At present, China's ocean routes are constantly expanding, but the routes to Europe are limited and face various costs and security issues. In this situation, the development and construction of the Arctic Route will undoubtedly alleviate this limitation, reduce costs, increase the transportation efficiency, and evade certain security issues. Now, the major powers in the world are concentrated in the northern hemisphere, and the North Pole is the shortest strategic commanding height from all major countries. Through developing and utilizing the Arctic route, China will have a new passage to the distant sea, which will weaken the restriction of island chain. Most of the countries in the Arctic are technological powers. They have tech-

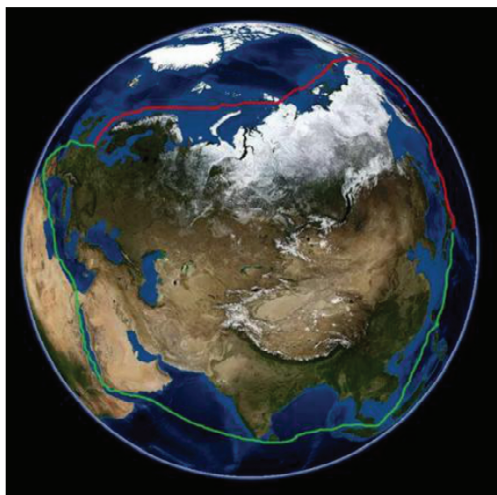


Fig. 1 Schematic diagram for the Arctic Northeast Passage (red) and the traditional routes (green)



Fig. 2 Distribution of China's major ocean routes

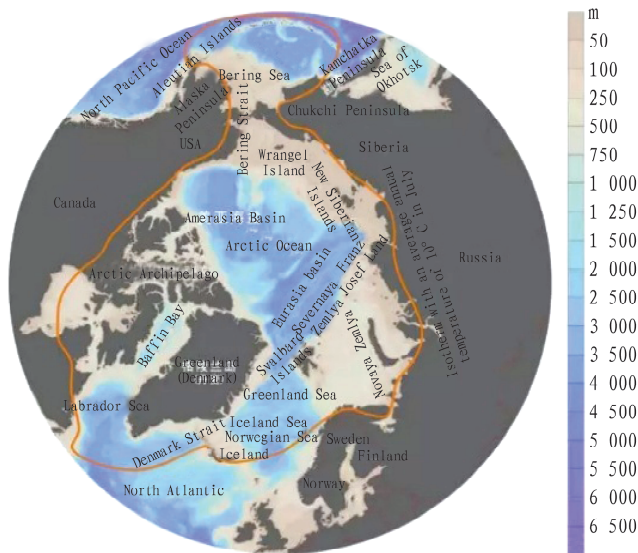


Fig. 3 Geographical location and seabed topography of the Arctic
 Note: The red and yellow lines separately represent the isotherms of the ocean and land average temperatures of 10°C in July.

Arctic Route is increasing. It will become the shortest route connecting Northeast Asia and Western Europe and linking the east and west coasts of North America. It is necessary for China to connect the construction of the Belt and Road Initiative with the Eurasian Economic Union, and strive to promote the project of the Primorye International Transport Corridor and other projects to jointly develop and utilize the Arctic Route. Connecting the Arctic Route and the construction of the Belt and Road Initiative will help to jointly promote the economic belt crossing the Arctic Circle, accordingly connecting the three economic centers: North America, East Asia and Western Europe. The Arctic Route will compete fiercely with the Suez Canal and the Panama Canal, and the opening of the Northern route will connect North America, Russia, Western Europe and East Asia to form the Arctic Economic Circle^[8]. Once the development of the Northeast Passage and the interconnection of the Arctic Economic Circle are realized, it will bring huge economic value, political value and strategic value to the expansion of China's global development space in the next 30 to 50 years.

2.2.4 Areas along the Arctic Route are rich in natural resources and tourism resources. The Arctic is rich in resources, and is a potential blood transfusion bank for China's future economic development. Crude oil reserves in the Arctic are roughly equivalent to 1/4 of the world's confirmed crude oil reserves; natural gas reserves are about 45% of the world's natural gas reserves; the total reserves of coal resources are about 1 trillion t or more; the bottom of permanently frozen soil and the continental shelf of the Arctic Ocean contain abundant flammable ice resources. Apart from the fossil fuels, the Arctic is also abundant in fisheries and forest resources and mineral resources such as nickel, lead, zinc, copper, cobalt, gold, silver, diamond, asbestos and rare elements. At present, Russia's national income in the Arctic region accounts for 11% of Russia's gross national income, and the Arctic nickel and cobalt mining accounts for 90% of Russia's total national mining. Russia's invitation to China to participate in the development of the Arctic Route is helpful for alleviating some of the domestic resource pressure, and the resources development process will help Chinese enterprises and technologies to go out^[9]. In addition, the Arctic tourism is also a main field of China's peaceful use of the Arctic. The polar scenery of the Arctic Ocean and its coastal areas, as well as its rich plant resources and beautiful scenery, make it an excellent tourist destination.

3 Difficulties and prospects in the development and construction of the Arctic Route through promotion of meteorology

3.1 Difficulties in the development and construction of the Arctic Route

3.1.1 The lack of substrate data on the Arctic Ocean in a harsh geographical environment limits the construction of the "Ice Silk Road". China's marine scientific survey and research on the Arctic Ocean started late. Since 1999, China's Snow Dragon (Xue Long in Chinese) polar scientific research ship has entered the Arctic Ocean for scientific research eight times and obtained a

nologies needed for high-altitude areas, which are worth learning. With the acceleration of global warming, the melting rate of the Arctic ice layer is accelerating, and the navigation time of the

large amount of valuable sample information and data, laying a solid foundation for studying the Arctic Ocean and its role in global change. However, due to severe weather conditions and geographical restriction, the previous work was concentrated on the Canadian Basin and the Chukchi Sea. In previous international research projects, such as the Integrated Ocean Drilling Program (IODP), China also participated but only played a minor role. It should be pointed out that due to the extensive area of continental shelf of the Arctic Ocean, its shelf area accounts for 40% of the entire Arctic Ocean area, more than half of which is in Russia. Russia is the earliest and largest developer and investor in the "Arctic Eight Countries". Therefore, China urgently needs to strengthen cooperation with Russia in the Arctic Ocean, so as to provide scientific and technological support for the construction of the "Ice Silk Road".

3.1.2 Cold weather conditions bring the Arctic Route with problems of short navigation period and development technology. Compared with traditional routes, the Arctic Route greatly shortens the voyage. However, in areas along the "Ice Silk Road", the temperature remains between minus 40°C and minus 20°C all the year round, and the sea has been iced for many years, and the ice can melt only two or three months in a year. From the perspective of commercial shipping, this is obviously not enough. The lack of accurate and reliable navigation data, in addition to large area of ice floes, icebergs, poses a huge challenge to ships sailing in the ocean. The harsh natural environment brings various problems to the infrastructure of the Arctic Route. Compared with the traditional routes, its development cost is higher and it requires stronger technical support^[10]. There are few replenishment points along the Northeast Passage and the infrastructure is obviously lagging behind. To develop this route, it is obviously necessary to invest huge amount of funds and extensive technologies. Due to the long-term lack of development, there is considerable room for improvement in the business environment along the route, such as the high "navigation fee" currently implemented by Russia for the Arctic Route.

3.1.3 The development of the Arctic Route faces the risk of extreme meteorological marine disasters. The Arctic Route mainly passes through high latitudes and high cold areas. Extreme winds, polar invasion, blizzards, sea ice, sea ice floes and icebergs have varying degrees of impact on the safe operation of the Arctic Route. The port infrastructure along the Arctic Route faces severe threats from extreme cold weather. Besides, in the context of global warming, the thermal expansion and contraction of infrastructure and the freezing and thawing of soil during temperature changes have a serious impact on port construction along the Arctic Route, and severely test infrastructure technologies and materials, such as crack due to insufficient spatial extension, consequently leading to serious damage. In addition, in the context of global warming, the Arctic ecological environment is fluctuating in an unstable direction, which also tests the safety development of the Arctic Route.

3.2 Strengths and prospects of the "Ice Silk Road" through promotion of meteorology

3.2.1 The experience of successful cooperation between China

and Russia is helpful for building the "Ice Silk Road". China and Russia have had successful cooperation experience in the Arctic Circle. For example, the Russian Yamal LNG project once received no attention because no one believed that it could advance under such extreme polar conditions. However, in 2013, PetroChina entered and held 20% of the shares. From then on, annually 4 million t of liquefied gas has been shipped to the Chinese market. In Yamal LNG project base in Russia, there has built various infrastructures: a material terminal with a capacity of 14 million TPY, two LNG and condensate process terminals with an annual transportation capacity of 170 – 80 million t, airport, school, technical school, and hospital have also landed^[11]. The advance of the LNG project has undoubtedly accumulated valuable experience for the Sino-Russian meteorological department to promote the construction of the "Ice Silk Road".

3.2.2 The Sino-Russian meteorological assistance in "Ice Silk Road" construction has complementary advantages. In recent years, Russia's domestic economic development is sluggish, and it faces economic sanctions from both the EU and the United States. Merely relying on its conditions, its development is time-consuming and requires great efforts. Since the Belt and Road Initiative was proposed in 2013, China has received support from most countries in the world. The Belt and Road Initiative is an important means of building a global community of destiny. The "Ice Silk Road" will undoubtedly bring excellent opportunities for Sino-Russian cooperation. Russia has the location and technological advantages in construction of the "Ice Silk Road", while China has capital and policy advantages. Besides, Russia has certain experience in infrastructure construction under the Arctic cold weather conditions. Sino-Russian cooperation will help China learn from the experience and promote the construction of the Arctic Route.

3.2.3 Meteorological assistance in the development of Arctic Route has great strategic prospects for China's development. The "Ice Silk Road" mainly passes through the northern part of Russia. Russia is rich in resources and is the world's richest natural gas resource reserve; the natural gas resources within the Arctic Circle are more abundant. As estimated by the US Geological Survey, the undiscovered, technically recoverable reserves of conventional oil, natural gas, and natural gas condensate may be 412 billion barrels of oil equivalent (BOE). By contrast, the problem of insufficient resource reserves in China is serious. China is the world's largest energy importer. The proven reserves of oil in China are 2.4 trillion t, accounting for about 1% of global reserves, the proven reserves of natural gas are 3.1 trillion cm³, accounting for only 1.7% of global reserves. China's energy system will still be highly dependent on foreign countries. Taking oil as an example, the International Atomic Energy Agency (IAEA) predicts that China's foreign dependence on oil will reach 68% in 2020. Once the Arctic Northeast Passage is opened, the Arctic region will become another important energy source and energy export destination (Table 2), and China will undoubtedly stay ahead of the curve. With the deterioration of the global warming, the commercial value of Arctic Route will continue to increase in the future. The assistance of Sino-Russian meteorological department in the integration of the space, land, air and sea in the Arctic

Route will help to achieve safe construction of the Arctic Route. Some studies have predicted that by 2020, the navigation time of the Arctic Ocean may be extended to six months, and by 2030, the Arctic Ocean will be open to traffic throughout the year. This will vigorously activate the status and trade of coastal ports in northern China, and inject new vitality and provide new impetus to

the economic development of China's coastal areas. The Arctic Route is also a new route apart from the two links of the East and West lines in the construction of the Belt and Road Initiative. It will accelerate the integration process between the East and the West in the Asia-Europe continent and open up a "new route" between China and the world.

Table 2 Distribution of energy resources in the Arctic

Oil area	Crude oil 1 billion barrels	Natural gas 1 000 billion m ³	LNG 1 billion barrels	Total//1 billion barrels of oil equivalent
West Sibirica Basin	3.66	651.50	20.33	132.57
Arctic Alaska	29.96	221.40	5.90	72.77
East Barents Basin	7.41	317.56	1.42	61.76
Eastern Greenland Rift Basin	8.90	86.18	8.12	31.39
Yenisei-Khatanga Basin	5.58	99.96	2.68	24.92
Amerasia Basin	9.72	56.89	0.54	19.75
Western Greenland-Eastern Canada	7.27	51.82	1.15	17.06

4 Policy recommendations

4.1 Fully integrating into the construction of Belt and Road Initiative, strengthening the research on the geographical and climatic environment of the Arctic Ocean, deepening the monitoring of climate services and climate change in the Arctic Ocean, and creating a safe Arctic Route

As an important foundation and carrier of the "Northern Branch of the 21st Century Maritime Silk Road" and the "Ice Silk Road", the strategic position of the Arctic Ocean has become increasingly prominent and has attracted worldwide attention. With the global warming, the degradation trend of Arctic sea ice is obvious, the Arctic Ocean waterway is also expected to achieve summer navigation in recent years. This is not only favorable for the development of the rich oil and mineral resources of the Arctic Ocean, but also will profoundly affect the future world shipping and trade pattern. Therefore, comprehensively promoting the construction of Belt and Road Initiative and strengthening the research on geographical and climatic environment of the Arctic Ocean will have great scientific support and practical significance for systematic understanding of the geographical environment and climate change characteristics of the Arctic Ocean, and deepening the meteorological services of the Arctic Route.

4.2 Vigorously enhancing the international cooperation and exchanges in the research of the Arctic Ocean, and building a large-scale scientific research plan with the aid of the joint creation of "Ice Silk Road" by China and Russia

On the basis of the previous works, it is recommended to vigorously strengthen the international cooperation in Northern Ocean Climate Monitoring and Disaster Prevention and Reduction, and then launch a large-scale international research plan for the Arctic Ocean to promote the role of the Arctic Ocean in climate change, the response of the Arctic Route to climate change, and the scientific research of the prevention and mitigation of Arctic Route.

4.3 Developing a variety of meteorological observation methods to enhance the early warning capability of disaster prevention and mitigation

It is recommended to further improve and develop a variety of meteorological observation methods, such

as satellite monitoring, high-performance UAV observation, sounding observation, ground sounding, island weather station, ship automatic station, marine meteorological buoy station, marine detection base, port monitoring, GNSS/MET station, marine meteorological disaster emergency boats, *etc.*, to form a network-wide, multi-party integrated sea, land, air, and weather integrated whole-process observation system.

4.4 Vigorously developing the offshore meteorological observation capability of the "Ice Silk Road", and continuously meeting the needs of meteorological services and disaster prevention and mitigation for the construction of Belt and Road Initiative

With the continuous advancement of the construction of the Belt and Road Initiative, the offshore meteorological observation capability can not meet the needs of the construction of the "21st Century Maritime Silk Road". On the whole, 90% of China's foreign trade cargo transportation volume relies on maritime transportation, building the offshore meteorological observation methods is primarily to develop maritime shipping. In particular, it is mainly to develop meteorological observation methods near the oceanic waterway of China, and serves the construction of the Belt and Road Initiative.

4.5 Comprehensively building a Chinese meteorological polar discipline system to meet the future demands of the Arctic Route

Since 1984, China has carried out an exploration of the Antarctic. However, from a geographical point of view, the Arctic is closer to China and has greater significance for the development of China. Thus, It deserves more attention. In Russia, the Arctic and Arctic scientific research is a professional discipline, and the discipline development has a history of more than hundreds of years, from college to research institute, there is a complete set of discipline mechanism. To establish a complete Arctic meteorological education and meteorological research mechanism in China, there is no basis. However, it is possible to consider cooperation with Russia and learn from Russia's experience to improve the relevant mechanisms, which will be of great benefit to China's future participation in the Arctic development.

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