

Challenges to Aviation in the Global Warming Context

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Abstract. Global warming has posed a variety of challenges to all sectors, and aviation is particularly affected. Over the past decades, the rapid growth in aviation has led to substantial increases in carbon emissions, with a significant impact on climate change. This paper aims to provide a comprehensive analysis of the current and future challenges of the global aviation industry. These challenges include safety problems arising from extreme weather events, the need for improved fuel efficiency and sustainable aviation fuels, changes in atmospheric conditions affecting flight paths, and increased operational costs. Furthermore, stringent environmental regulations and the necessity for advanced technological developments will also have a positive impact on the future of the aviation industry. This study discusses potential solutions, such as the development of cleaner energy sources, more efficient engines, and better aerodynamic designs, as well as the role of government policies and scientific advancements in mitigating these challenges. The aim is to provide practical and effective strategies to ensure the aviation industry can adapt and thrive in the context of global warming.

Keywords: Global warming, aviation, challenges.

1. Introduction

Global warming is a huge challenge humans face in twenty one century. It has had a great impact on a variety of fields and in different places in the past, present and future, including the aviation industry. The aviation industry has grown rapidly in the last decades in terms of flight kilometers, from 109 billion kilometers per year in 1960 to 8269 billion kilometers per year in 2018, which leads to an increment of a 6.8 factor in CO₂ emissions. This highlights the increasing influence of the aviation industry on the issue of climate change. Nowadays, global warming has become a serious issue caused by greenhouse gas emissions, and CO₂ plays a significant role [1]. The aviation industry, as a major contributor to the emission of greenhouse gases, is in an awkward position. It should not only reduce the damage to the environment and minimize the aggravation of global warming but also effectively face the challenges brought by global warming. Carbon emissions from aviation have a significant impact on global warming, with international aviation accounting for 1.3 percent of global anthropogenic carbon dioxide emissions [2]. Global warming brings challenges to the aviation industry from different aspects, including rising temperatures, altered weather etc. Many of these challenges have accompanied the industry from the past to the present and will continue. Addressing these challenges will require multiple efforts, and the aviation industry can achieve the goals by developing cleaner energy sources, more efficient engines, better aerodynamics, etc.

This paper aims to provide a comprehensive analysis of the challenges to aviation in the global warming context, discuss current challenges as well as projections of global warming trends and future challenges, and provide some practical and effective solutions.

2. The Impact and the Tendency of Global Warming

2.1. The Impact of Global Warming

Global warming is a major environmental problem facing the world at present, and its impact on all the industry is increasingly significant. As an important part of global transportation, aviation is also inevitably affected by the far-reaching effects of climate change. The impact of global warming

on the climate will greatly affect the aviation industry. Global warming has led to an increase in the frequency and intensity of extreme weather events. For example, extreme weather events such as heat waves, heavy rainfall, and hurricanes have become more common and intense. Scientists have found that global warming exacerbated Hurricane Katrina in 2005 and Hurricane Sandy in 2012, making them more destructive [3]. Since the late 19th century, global average temperatures have risen by about 1.1 degrees Celsius (2 degrees Fahrenheit). This change is largely due to human activities, such as burning fossil fuels and cutting down forests, which have led to an increase in greenhouse gas concentrations [3]. It has also led to an increase in the frequency and intensity of extreme heat events. Heat waves are becoming more frequent and intense, leading to more heat-related illnesses and deaths [4].

2.2. Future Global Warming Trend

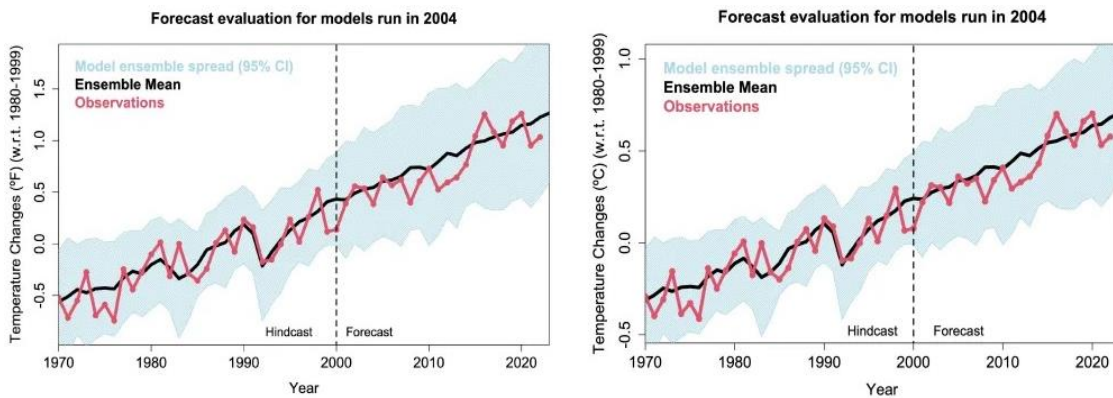


Figure 1. Forecast evaluation for models run in 2004 [5]

Fig. 1 is a forecast of the temperature change the National Aeronautics and Space Administration (NASA) ran in 2004 by its model. The blue area in the line chart is the range of the predicted value, the black line is the mean value of the prediction, and the red line is the actual observed value. The line chart shows that the predicted value of NASA’s model is very consistent with the actual observation to some extent. Some of this model is still being used in the subsequent predictions in order to confirm the accuracy of the prediction, for example:

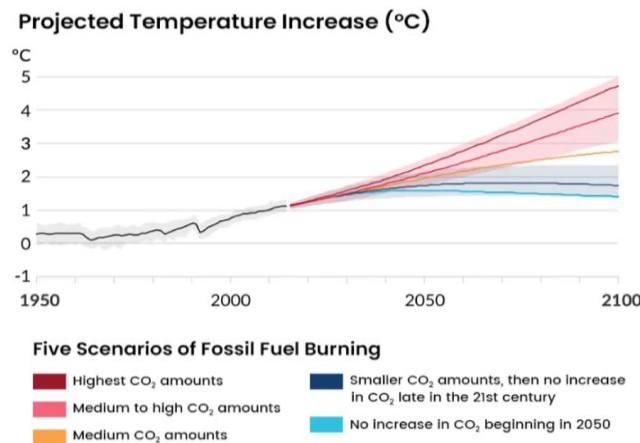


Figure 2. Projected temperature increase [6]

Fig. 2 is a prediction released in 2021 by the Intergovernmental Panel on Climate Change (IPCC). The predicted value of the temperature increase shows five different possibilities due to the different amounts of carbon dioxide. The prediction shows that the larger amount of carbon dioxide will lead to a more significant increase in the temperature. Moreover, according to the IPCC’s report released in 2021, the human-caused rise in greenhouse gases has increased the frequency and intensity of extreme weather events.

3. The Challenges the Aviation Industry Faces Now

3.1. Safety

Due to the extreme weather events caused by global warming, aviation accidents occur frequently, the safety of the aviation industry is greatly affected, and the probability of flight delay increases rapidly. According to the National Department of Transportation Safety, weather-related accidents account for 23 percent of all aviation accidents, costing more than 3 billion dollars a year in losses, flight delays and additional operations. Extreme weather caused by climate warming will produce turbulence, ice, lightning, hail and other disastrous weather on the flight route, making aviation flight obstacles increase and even make the aircraft lose control, causing structural damage and eventually leading to flight accidents. For example, thunderstorms caused by extreme weather will increase the pressure on both sides of the fuselage or wings by 5% to 20%, which will damage the horizontal momentum of the aircraft and create certain safety problems [7].

3.2. Fuel Efficiency and Carbon Management

Another big challenge the aviation industry faces now from global warming is to reduce carbon emissions and improve fuel efficiency. The aviation industry accounts for about 2.5% of global carbon emissions, so measures must be taken to improve fuel efficiency and promote sustainable aviation fuels (SAF). However, developing and disseminating SAF faces technical and economic challenges. The production of efficient fuels requires large amounts of biomass and renewable electricity, and the acquisition and utilization of these resources are not yet mature. So fuel efficiency and carbon management are a great challenge the aviation industry faces now [8].

3.3. Changes in Air Currents and Flight Paths

Climate change caused by global warming has led to changes in atmospheric circulation patterns and increased the risk of turbulence in high-altitude flights. This not only affects the comfort and safety of flights but also increases fuel consumption and operating costs. Research has shown that transatlantic flight times and fuel consumption will increase significantly due to climate change [9].

3.4. Cost

Rising temperatures and extreme weather events caused by global warming have increased operating costs for airlines. For example, higher temperatures reduce air density and will affect the lift and fuel efficiency of aircraft, requiring longer runways and more fuel. This not only increases fuel costs but also affects flight times and flight scheduling. In addition, extreme weather events such as storms increase the risk of flight delays and cancellations, further raising operating costs [9]. At the same time, in order to meet the government's low-carbon policies, companies and enterprises need to buy and use more advanced and environmentally friendly fuels and engines, which usually require more expensive prices and will increase the cost of enterprises to a certain extent.

4. Key Future Challenges

4.1. Government and Policy

Governments and international organizations will implement stringent environmental regulations and policies, such as restrictions for aircraft emissions, requirements on aircraft fuel, etc., to drive the aviation industry towards greener practices.

4.2. Companies and Enterprises

In order to respond to government requirements and reduce environmental pollution, enterprises and companies need to develop more sustainable and clean engines that consume less energy and are more efficient, as well as more aerodynamic design optimization.

4.3. Technique

While these improvements in the hardware may be effective, these optimizations are actually just in advance, and there will be some difficulties in actual operation. Take clean fuels as an example: one way to process fuel is Waste-to-Fuel (WTF) Technology. WTF technology uses pyrolysis or classification to convert municipal solid waste or industrial waste into syngas. During this process, there are some challenges in dealing with the complex composition of waste materials and ensuring complete reactions.

4.4. Cost

Extensive use of composite materials to reduce weight on aircraft such as the Boeing 787 and Airbus A350. The Boeing 787 uses about 50% composite materials, with its fuselage and wings predominantly made of carbon fiber composites. This results in a weight reduction of about 20%. The empty weight of the Boeing 787-8 is approximately 119 tons, which is about 13 tons lighter than similarly sized traditional aluminum aircraft.

However, there is another element that is important to the enterprise is the cost. Composite materials, particularly carbon fiber reinforced plastic (CFRP) used in the Boeing 787, are significantly more expensive than traditional aluminum alloys. On average, the cost of carbon fiber materials is about \$25-30 per kilogram, while aluminum typically costs around \$2-3 per kilogram [10, 11]. At present, the cost of these technological improvements is very high, so it is also a challenge for companies to balance costs and emissions.

5. Suggestion and Solution

To address the multifaceted challenges posed by global warming, the aviation industry needs to do innovative research in a variety of ways, such as from sustainable aviation fuels to efficient and environmentally friendly engines or hybrid aircraft engines. At the same time, the participation of the government is also very important. The government can introduce relevant policies, such as attracting more funds to invest in relevant enterprises, cutting taxes on them and reducing enterprise costs, so as to support relevant companies and enterprises, encourage them to carry out continuous innovation and research, and attract new enterprises to join, in order to produce better solutions as soon as possible.

From the perspective of airline operations, scientific and reasonable business decisions are also an important way to reduce carbon emissions. For example, routes that are grounded due to low passenger load factor can be said to reduce the number of flights, use small aircraft, flight consolidation and other ways without affecting their service quality. At the same time, fuel consumption can be reduced through the introduction of new aircraft with low fuel consumption and the direct elimination or leasing of older aircraft with high fuel consumption. In addition, giving full play to synergies in the process of operation and management is also an effective strategy for airlines to reduce fuel consumption and carbon emissions [12].

6. Conclusion

This paper provides a comprehensive analysis of the impacts of global warming on the aviation industry, highlighting challenges such as safety problems, the problems faced when improving fuel efficiency and controlling carbon emissions, changes in flight paths and atmospheric conditions, and increased operational costs. Global warming has led to more frequent and more serious extreme weather events, increasing the risk of aviation accidents and affecting the safety of flights. As a major contributor to carbon emissions, the aviation industry must improve fuel and engine efficiency and promote sustainable aviation fuels in the face of significant technical and economic challenges.

The research also provides many practical solutions, including developing cleaner energy sources, more efficient engines, and better aerodynamics. The paper highlights the importance of government

policies and scientific advances in supporting industry innovation and mitigating the effects of climate change. However, this paper also has certain limitations, such as regional and temporal differences in the impact of global warming, as well as problems due to rapid changes in technological and economic conditions and uneven development in different regions.

Future studies should further explore the specific impacts of regional climate change on aviation and assess the potential of new sustainable fuels. Setting more stringent global environmental standards by the government. By strengthening international cross-disciplinary cooperation and through continuous innovation and policy support, the aviation industry can adapt and thrive in a warming world.

In conclusion, while global warming presents significant challenges to aviation, it also provides opportunities for innovation and sustainability. With scientific research and effective policy support, the aviation industry is expected to achieve greener and more sustainable growth in the future.

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