Considerations Regarding the Climate Change Induced Hazards on Airports in Romania – A Case Study of Timišoara International Airport

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Abstract. Climate change is regarded as a global scale process in which an increase of magnitude and intensity of severe weather events is observed, thus affecting both air travel as well as airport infrastructure. Although the COVID-19 crisis has a significant negative impact on air travel and thus on the further development of airport infrastructure, the demand for air travel will continue to rise as the crisis nears the end. The aim of this paper is to analyse and highlight the climate change associated hazards for the airport infrastructure as well as for the safety of passengers and goods in the Western part of Romania, mainly Traian Vuia International Airport from Timișoara. Throughout this analysis, aviation related severe weather events, such as thunderstorms, hail events, fog, icing, squalls, low level wind shear, snow falls and heavy precipitation, which affect airport infrastructure and thus air travel, are highlighted. By analysing meteorological parameters from the time scale 1980-2010 together with climate change scenarios, and thus developing weather hazard maps, a better perspective of area-related hazards and therefore customized mitigation measures and adaptation strategies are to be developed. The implementation of modern forecasting equipment such as dual polarization Terminal Doppler Weather Radar (TDWR) is thus necessary in order to prevent loss of human lives, to reduce financial losses and to protect the airport infrastructure and the aeronautical navigation and communication facilities. Long term changes in meteorological parameters include an increase in air temperature, an increase in speed for both horizontal and vertical wind shear during severe weather events, an increasing number of air mass thunderstorms and an increase of situations with limited visibility especially during the late autumn and early spring time.

1. Introduction

Timișoara International airport is located in the Western part of Romania, at around 11 km to the North-East of the city of Timișoara. It is one of the oldest airports in Romania, as it was inaugurated in the year 1935. The importance of this airport is given by the fact that it is an alternate airport for both Henri Coandă airport from Bucharest and Budapest Ferenc Liszt airport. Having a 3500-meter asphalt-paved runway and being equipped with state-of-the-art Approach Lighting System with Sequence Flashing Lights (ALSF – 2) and ICAO category III-A Instrument Landing System (ILS), the airport is capable of
handling even heavy aircrafts with total take off mass greater than 136 tonnes. Due to recent investments, the airport has now two new terminal buildings and the capacity has increased by 30% for both cargo and passengers. The airport is capable of operating both Visual Flight Rules (VFR) but also Instrument Flight Rules (IFR) flights. The reference point is located at 106 meters above sea level. Thus, the airport is included in the higher plains topoclimate [1]. The Western circulation is very powerful and brings humid air masses from the Southern part of Europe and dry air masses from the Northern African continent. During the winter, polar air masses are present in the area and may cause blizzards. The local climate is temperate-continental with humid influences. [2].

![Figure 1. Location of the National Weather Service weather station and Timisoara International Airport weather station](image)

Climate change, as a global process, affects all areas of activity. The study of climate change and its impact on civil aviation and airport infrastructure is gaining more importance due to the 2015 Paris Climate Change Agreement. Nowadays, the society faces many extreme climate events, which influence the infrastructure and the environment. Mitigating the effects of climate changes in aviation is one of the key objectives of the European Union. As such, multidisciplinary actions are to be developed and implemented in order to ensure a smooth climate change resilience plan. The demand for air travel reached a peak just before the COVID-19 crisis and then it started to decrease. Recently, due to the changes in travel restrictions, an increase of air travel is expected and the need for air travel is expected to reach the pre-COVID-19 peak in 2022.

2. Climatological analysis
In order to ensure the validity of the analysed data, the National Weather Service of Romania (Administrația Națională de Meteorologie) logs and records all the data which make up the climatological archive. The data, which is used for this study, originates from both the Banat-Crișana Regional Forecasting Centre as well as from Timișoara International Airport weather station.

The data presented from the National Weather Service of Romania was processed from the Climate of Romania [3]. An interpolation of the two data sets is needed because the available data stored by the
weather station from Timișoara airport dates back until 2005. The data was extracted from The Climate of Romania [3] and was integrated into SagaGIS software according to the current World Meteorological Organisation (WMO) recommendations. The location of the two weather stations is presented in figure 1. Note that the National Weather Service station is located within the city of Timișoara, in an industrial area and that the airport weather station is located outside the city, in the vicinity of the runway centreline extension, in open field. As such, small differences of 0.1° to 0.2°C due to heat island effect are to be observed. For the purpose of this study, such a difference is acceptable as long as the data is interpolated.

Figure 2. Mean multiannual temperature for Timisoara International Airport for the timescale 1980 - 2010 (processed from the Climate of Romania and Timisoara Airport weather station archive)

The air temperatures in the western part of Romania are mainly influenced by western regional and local circulation. The cold air originates from cold air advections from the polar circulation. Due to the terrain, the mean multiannual temperature values as seen in figure 2 range between 11.2° and 11.4° C.

Extreme temperatures may cause the disruption of the operational flow for both inbound and outbound traffic. Positive extreme temperatures may lead to payload reduction in order to fulfil the safety margins necessary for the take-off procedure. The terminal buildings are equipped with high-capacity ventilation systems. Extreme temperatures may lead to the overcharging of the ventilation system of the terminal building and further on to uncontrolled fire in the terminal building.

Negative extreme temperatures may cause delays because of the de-icing procedures, which are needed in order fulfil safety requirements. Both ventilation as well as surveillance equipment are affected by negative extreme temperatures and thus operational flow is being disrupted.

Some aircraft types are not suitable to operate in low or high temperature environments, as such extreme temperatures do not only affect air traffic and airport infrastructure, but also airline operations and local economy.
Figure 3. Temperature extremes (minimum and maximum) recorded at Timisoara International airport weather station during the time scale 1980 – 2010

According to the data presented in figure 3, the hot season starts on the 23rd of April and lasts until the 7th of October. The cold season starts on the 11th of December and lasts for around two months, until the 10th of February. The peak of the hot season is between the 7th of July and the 16th of August, when the daily maximum mean temperature reaches +32°C. The lowest temperature which was measured during the time scale 1980 – 2010 occurred on the 8th of December 2012, when a temperature of –23°C was recorded. The highest temperature for the time scale 1980 -2010 was +41°C and was recorded on the 24th of July 2007.

Figure 4. January mean temperature for Timisoara International Airport for the timescale 1980 - 2010 (processed from the Climate of Romania and Timisoara Airport weather station archive)
Due to the warm advections, which originate from Northern Africa, the winter months are mild and the mean temperature in January is negative, with values ranging from -0.1°C to -0.3°C as seen in figure 4.

![Wind direction](image)

**Figure 5.** Wind direction for Timisoara International Airport for the timescale 1980 – 2010

The wind direction is mostly from the Eastern part (18%), followed by the Northern part (8%), Eastern-South-Eastern part (7.1%). The rarest direction from which wind blows is the South-Western direction (1.9%). Wind also originates from variable directions (13.4%) and around 6% of the cases the wind is calm, so that the wind speed is less than 0.5 ms\(^{-1}\).

2.1. Climate change induced severe weather events

Severe weather events, also known as extreme weather events, are those meteorological phenomena which may cause important damage for both population and infrastructure, in which a partial or total disruption of operational flow occurs. Climate change implies a change in frequency and magnitude of severe weather events. Studies [2] have shown that both airports and airplanes are vulnerable to such events, especially to hail-producing thunderstorms. Other risks which arise in this case are the low-level windshear, severe turbulence, high risk of icing and the appearance of microburst phenomena.

Microbursts are strong, concentrated downdrafts, which originate from convective clouds and whose extension is not larger than 4 km over the surface [4]. The biggest risk arises when an airplane is taking off during a microburst because of the vertical and horizontal shears which occur. The airplane sensors may record erroneous readings and report a false speed indication to the pilots. This may lead to early rotation and eventually, if the shear is strong enough, to aerodynamic stall and crash. After the crash of Delta Air Lines flight 191, wind speed monitoring using Weather Surveillance Radar has been implemented [5].

Hail is a form of solid precipitation which originates from inside a Cumulonimbus cloud. If in the mid-level regions of a thunderstorm, the area where the temperature is between 0°C and –40°C, a strong updraft of more than 20 ms\(^{-1}\) occurs together with the presence of condensation nuclei, this may cause the solidification of supercooled water droplets and the subsequent formation of hail. This solid precipitation produces important damages for both airport infrastructure as well as for airplanes on ground or in flight.
The mean annual number of hail events at Timisoara airport is around 1.4. Hail was reported together with convective activity and strong atmospheric instability. The air traffic flow was generally not disrupted, as the hail events occurred mainly during the afternoon. Usually during the night and during the afternoon the majority of flights are on route. Hail mainly occurs due to orographic lift in the Western part of Romania [6]. Cloud seeding equipment and procedures are currently installed and are operational, as such the number of hail events at Timisoara airport might decrease in time.
Glazed frost is a critical weather hazard for aviation. It forms when a warm front is aloft over a cold surface and produces precipitation. Because of the temperature amplitude, the water droplets freeze and create a clear ice-like effect. Glazed frost is dangerous for all airport operations, but especially for aircrafts. This ice causes fast structural icing and may lead to loss of control, decrease in stability and in lift.

Timișoara airport experiences around 2.4 glazed frost events every year. De-icing and anti-icing equipment is to be set on stand-by for such events because of the limited effect of the de-icing and of the anti-icing fluids in time.

3. Results and discussions

Taking into account the current climate change scenarios stated in the 5th Intergovernmental Panel for Climate Change (IPCC) report, an increase in mean global temperature is expected in the next 10 – 15 years. Authors suggest that an increase of 0.6°C of the temperature is enough to cause damage to certain airport infrastructures, such as radio navigation equipment and a heavier load on ventilation systems [7]. As such, the decrease in precipitation may cause prolonged droughts, which may impact the water resource for Timișoara airport. Climate change induced weather hazards do have an impact on aviation and on its associated infrastructure. The identified risks are in connection to both airport infrastructure, but also operational aspects. As such, the decrease in mean monthly but also mean annual amount of precipitation may lead to a lack of water for operational use. The increase in frequency and intensity of precipitation, due to convective weather, may lead to perturbations of the operational flow because of the flooding which may occur. The increase of the number of days with fog is also another factor which will affect air traffic flow.

With regard to the airport infrastructure, any heat waves or cold spell will put pressure on the ventilation system, but also on water supply for both operational as well as non-operational use. The increase of the wind speed, especially during severe weather events, may cause damage to both operational flows, as well as to the airport infrastructure. Runway Visual Range sensors (RVR), meteorological equipment and radio navigation aids may be damaged and the repairs will disturb the operational flow of air traffic.

In order to cope with the climate change induced weather hazards, adaptation strategies and mitigation measures are to be researched and implemented. The installation of Terminal Doppler Weather Radar (TDWR) will help airport meteorologists to issue better warnings with regard to the severe weather events with immediate occurrence. Thunderstorm associated aviation related hazards such as hail, low-level wind shear and heavy precipitation may thus be forecasted and aircrafts are to be placed either in a holding pattern or re-routed towards alternate airports. Another aviation related hazard is the occurrence of glazed frost. It is formed during the winter when a warm front approaches a cold area. This meteorological phenomenon causes delays and imposes high risks upon airport infrastructure. Stockpiling the adequate de-icing and anti-icing fluids will limit the delays and will assure a continuous operational flow.

4. Conclusions

Aviation is one of the most important economic factors in everyday life. Although the COVID-19 crisis has produced huge losses in aviation, expectations are high that this economy will resume is growth by the summer of 2022. Climate change and climate change induced weather hazards are a serious threat in the development of this industry.

By improving the weather forecasts using state of the art technology such as dual polarization Terminal Doppler Weather Radar (TDWR) and computer-generated weather forecasts, many of the severe weather events can be avoided. Cloud seeding, especially in the airport terminal area, is important and offers another safety benefit for both airport infrastructure but also for airliners. By designing a
water treatment plant for the airport, water can be reused much faster for both operational but also for general use.

While conventional Weather Surveillance Radar (WSR) equipment only measures electromagnetic oscillations in one plane, a dual-polarization WSR measures these quantities in both horizontal and vertical planes and thus can compare and contrast the two measurements. This yields valuable information on particle shape, size and orientation. The main advantages of dual-polarization WSR especially as TDWR are the accurate discrimination of precipitation types, better measurement of rainfall and identification of hailstones.

The costs for such equipment are high, but the benefits of implementing mitigation measures and adaptation strategies are far better for the future development of the airport infrastructure and for the safety of aviation.

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