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Climatology of selected dangerous weather phenomena at Cairo and Borg-Alarab airports

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ABSTRACT

Forecasting severe weather such as (fog, sand storms and dust storms) with the intensity and the duration has a significant increasing importance in the recent years where it affects directly on the aviation operations, particularly over big international airports. Ranked as the busiest airport in Africa, Cairo international airport is one of the affected airports by severe weather phenomena during the four seasons every year. The climatology of selected dangerous weather phenomena over Cairo and Borg-Alarab airports has been described by analyzing 18 years of aviation routine weather reports (METAR). The collected data showed that fog days at Cairo airport per year vary from 3 to 20 with an average of 10 days per year. Events are most frequently from September to march, with November and January being the most active months. The longest fog event experienced was on November 30th/ December 1st (14 hour) in 2010.Fog usually occurs between 0100 to 1000 local time with one case started at 1900 and another case ended at 1300.As for Borg Al-arab airport, fog days at Borg Al-arab airport per year vary from 8 to 34 with an average of 19 days per year. Events are most frequently from October to April, with February and January being the most active months respectively. The longest fog event experienced was on January 8th/9th (16.5 hour).in 2010.Fog usually occurs between 0100 to 1000 local time with one case started at 2030 and another 2 cases ended at 1300 local time. Statistical data for other phenomena such as (mist, haze, dust or sand storms) also have been analyzed in this study.

Keywords: Forecasting, weather, climatology, Borg-Alarab airports

1. Introduction

Weather is one of the most important factors affecting aircraft operations and safety. Dust/sand storms (DS and SS, respectively), fog (FG), and mist (BR) are common in different regions of the world which can impair visibility at or around the airport and sometimes cause serious disruption to flight schedules (WMO, 2007). It is impossible to avoid flight delays all the time. Climate change and meteorological conditions at the same time have a significant impact on the performance of aircraft at the airport, which in the end cannot be prevented (Oo and Oo, 2022).

In the current study, we focused on weather phenomena that frequently occur at two major airports in Egypt; Cairo International Airport and Borg Al-Arab International Airport.

Cairo International Airport is the principal international airport of Cairo, the largest airport in Egypt and ranked as the busiest airport in Africa (With 11.3 million passengers in 2021 according to Airports Council International (ACI)).Cairo airport is located in Heliopolis to the northeast of Cairo (fig.1).

Cairo is characterized by its hot and humid climate in summer, cold weather and few rainy days

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in winter and clear skies most of the year. The temperature ranges from 10°C to 35°C. Wind speed varies slightly at Cairo International Airport throughout the year, with the highest wind speed occurring from March to July, with the average wind speed exceeding 7.6 knots, while the quietest times of the year continue from July to March. June has the highest wind speed, with average wind speeds of 8.3 knots, while December is the quietest month with average wind speeds of 6.9 knots.

Borg Al-Arab airport is the international airport of Alexandria, the 2nd biggest city in Egypt. Borg Al-Arab airport is located about 40 km southwest of Alexandria (fig.1).

Borg Al-Arab is characterized by its hot and arid climate in summer, cold weather with shower rain in winter and clear skies most of the year. The temperature ranges from 8°C to 31°C. Wind speed varies slightly at Borg Al-Arab International Airport throughout the year, with the highest wind speed occurring from December to May, with the average wind speed exceeding 8.9 knots, while the quietest times of the year continue from May to December. February has the highest wind speed, with average wind speeds of 9.6 knots, while October is the quietest month with average wind speeds of 8.2 knots

Both airports experiences light to sever weather phenomena during the four seasons that affects the aviation operations such as (fog, mist, haze, dust, sand, and sand storm).

Fig. 1: Locations of Cairo and Borg Al-Arab international airports.

Definition of fog

Fog is one of several meteorological phenomena that seriously affect human activity in various ways, both negative (e.g. hazards to aviation as well as land and marine transportation) and positive (for water harvesting in arid regions; Ismail, 2007).

Fog may be defined as a surface cloud sufficiently thick to reduce visibility to below 1000 m as a result of condensation in the atmosphere. (WMO, 2008). If the visibility is between 1000 and 5000m with high humidity, we have 'Mist' (ICAO, 2011; WMO, 2014), Fog is forecast to occur when the air temperature decreases to a 'crossover temperature' which is usually below the dew point (Baker *et al.*, 2002).

Many research projects have dealt with the mechanism and conditions associated with fog formation. Detailed studies by Tardif and Rasmussen (2007), Hansen *et al.* (2007) and Hyvarinen *et al.* (2007) suggest that climatological data can be used to help develop a better understanding of fog formation, as well as leading to improved forecasting methods and the organisation of better field programmes. Syed *et al.* (2012) investigated the climatology, inter-annual variability and trends in fog occurrence from 1976 to 2010 using observational data from 82 stations distributed over India and Pakistan.

Chen *et al.* (2006) used foggy days, mean temperature and relative humidity data from 602 stations in China for all month between 1961and 2003. The relationship between foggy days and temperature, as well as the possible reasons for fog formation, were analysed using regression, correlation and contrastive analysis methods. The results show that the higher (lower) the mean temperature and the lower (higher) the relative humidity, the less (more) likely fog formation becomes.

The relationship between fog and different weather conditions has also been studied over Cairo airport. Badawy (2014) used statistical methods to investigate the links between various meteorological parameters (relative humidity (RH), dew-point deficit ($T-T_d$), wind speed and wind direction) and fog formation. The study found that the following factors were conducive to fog formation at the study site:

- Relative humidity in excess of 75%.
- Dew-point deficit ($T-T_d$) of less than 5 deg C
- Wind speeds lower than 3m/s
- North-easterly, northerly or north-westerly wind direction.

Sayed and Morsy (2019) studied some possible mechanisms for fog formation over Borg Al Arab Airport in Egypt, in this study they found that fog usually occurs over Borg Al Arab airport in autumn and winter and the maximum occurrence of fog over Borg Al Arab airport occurs from October to March due to the abundant supply of moisture from the Mediterranean sea. It has been observed that the maximum daily and hourly frequency of fog occurs in November and December respectively due to the stability of the atmosphere (high pressure) and the presence of a large amount of moisture in the air column. The minimum frequency of fog occurrence was observed during summer, particularly in July, as a result of the extension of the Indian monsoon low over the whole of Egypt. All fog intensity types were observed most often between 0100h and 0700h LT (local time) (UTC+2Hr), with radiation fog dissipating after sunrise. Fog was not observed for more than 10h on any day. Fog occurs most frequently between 0400h and 0500h, but fog at this time was mostly moderate (Sayed and Morsy, 2019).

Dust and sand storms

Dust storms and sand storms are natural hazards that severely affect daily life for short and long time interval. Dust and sand storms are the consequence of the air turbulence, which spreads a large mass of dust and sand in the atmosphere and reduces the horizontal visibility to few hundreds of meters which affects directly on aviation as it affect aircraft engines and its performance. In aviation, such incidents lead to rerouting aircraft, flight delays and massive cancellation of scheduled flights as well as mechanical problems such as erosion and corrosion of aircraft engines (WMO, 2011).

Dust and sand events can reduce the visibility to below 5000m but not less than1000m while sand storm and dust storm can reduce the visibility below 1000m.

This work aims to identify the most weather phenomena that affect air traffic through statistical analysis of the phenomena of fog, mist, dust, sand and sand storms that occur in two Egyptian airports, namely Cairo International Airport and Borg Al-Arab Airport in Alexandria, using meteorological observations during the period 2000-2017.

2. Data and methodology

Routine Flight Weather Reports (METAR) has been the primary source for weather monitoring in the current work. METAR is a code that describes actual weather in detail, which includes wind speed and direction, associated weather phenomena, cloud types, horizontal visibility, air temperature, dew point temperature, and means sea level pressure.

The study period started on January 1, 2000, until December 31, 2017, every half hour for HECA, while for HEBA, data was available from January 1, 2004, until December 31, 2017 hourly. METAR data was downloaded from NOAA website: https://www7.ncdc.noaa.gov.

3. Results and discussion

3.1. Fog climatology

Fog days over Borg Al-Arab airport exceeded those over Cairo international airport (253 fog days over Borg Al-Arab from 2004 to 2017 versus 174 fog days over Cairo international from 2000 to 2017). Fog events over Cairo international airport were most frequently from September to march,

With January and November being the most active months. The longest fog event experienced over Cairo international airport was 14 hours on November 30th/ December 1st in 2010.

For Borg Al-Arab international airport, Fog events were most frequently from October to April, with February and January being the most active months respectively. Table 1: Represents the duration of all weather phenomena events and its repetition over Cairo international airport and Borg Al-Arab international airport. Fig. 2 shows the monthly fog days at both Cairo International Airport and Borg Al-Arab International Airport. The longest fog event experienced over Borg Al-Arab international airport was 16.5 hours on January8th/ January 9th in 2010. Fog lasted for 1 hour on 42.5% of fog days over Cairo international airport, while the most repetitive duration over Borg Al-Arab international airport was 2 hours on 22.5% of fog days.

3.2. Mist climatology

Mist was the most experienced phenomenon over Cairo international airport and Borg Al-Arab international airport, with more than 53% of the phenomena over Cairo international airport and more than 54% of the phenomena over Borg Al-Arab international airport. Mist events over Cairo International Airport occurred most frequently from June to January, with October as the most active month. Fig. 3.

The longest mist event experienced over Cairo international airport was 31 hours on January12nd/ January 13rd in 2002.

At Borg Al-Arab international airport, mist events occurred most frequently from November to May, with February and March being the most active months respectively. Fig.3

The longest mist event experienced over Borg Al-Arab international airport was 25 hours on October 18th and October 19th in 2009.

Mist lasted for 1 hour on 21% of mist days over Cairo international airport, while the most repetitive duration over Borg Al-Arab international airport was also 1 hour on 39% of mist days. Table 1

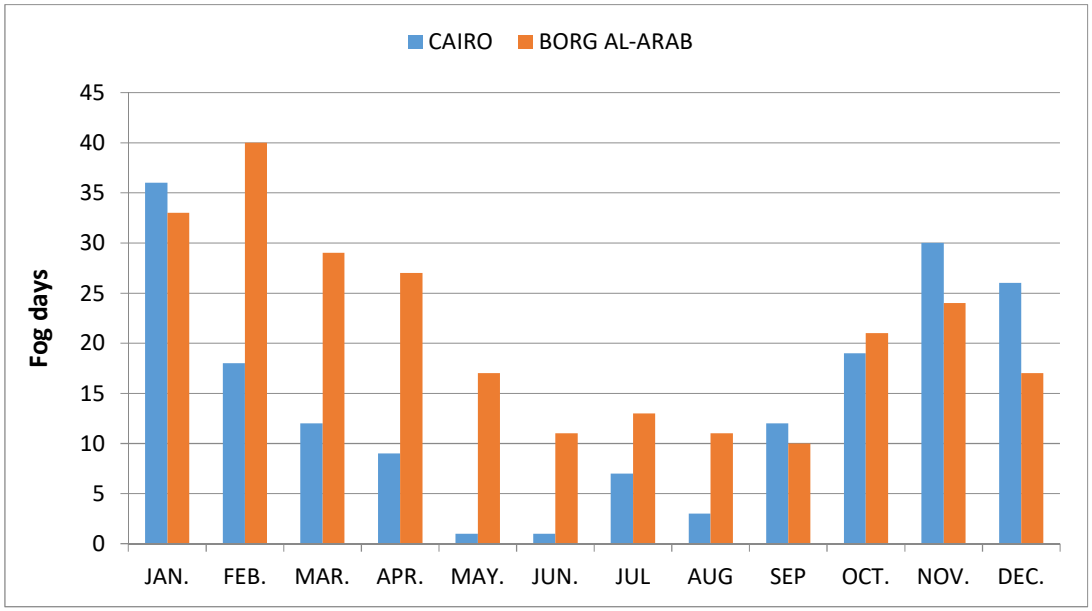

Fig. 2: Monthly fog days at Cairo international airport and Borg Al-Arab international airport

Table 1: Weather phenomena duration and repetition

Duration	Fog No. of events		Mist No. of events		Sand No. of events		Sand storm No. of events	
Hr.	C.I.A	B.A.I.A.	C.I.A	B.A.I.A.	C.I.A	B.A.I.A.	C.I.A	B.A.I.A.
0.5	-	-	107	-	107	-	-	-
1	74	52	559	354	198	34	20	12
2	33	58	514	244	112	22	5	4
2.5	-	-	1	-	-	-	-	1
3	24	50	398	116	56	14	1	7
3.5	-	-	-	-	-	-	1	-
4	13	27	318	72	39	11	4	6
4.5	-	1	-	-	-	1	-	-
5	14	18	213	43	29	16	2	1
5.5	-	-	-	-	-	-	1	-
6	3	14	180	18	16	12	1	2
6.5	-	-	-	-	-	-	1	-
7	5	8	123	19	12	10	-	1
8	4	7	83	13	10	6	-	3
9	1	6	61	7	8	6	-	-
10	1	6	41	6	7	7	-	-
11	-	2	20	2	7	3	-	-
12	-	2	18	-	2	2	-	-
13	-	-	13	1	6	-	-	-
14	1	1	5	1	5	1	1	2
15	-	-	4	-	3	4	-	-
16	-	-	-	1	-	1	-	-
16.5	-	1	-	-	-	-	-	-
17	-	-	-	-	1	-	-	-
18	-	-	-	-	1	1	-	1
19	-	-	2	-	-	-	-	-
20	-	-	-	-	1	-	1	-
21	-	-	-	-	1	-	-	-
22	-	-	1	-	-	-	-	-
23	-	-	-	-	2	-	-	-
25	-	-	-	1	-	-	-	-
28	-	-	-	-	-	1	-	-
31	-	-	1	-	1	-	-	-
33	-	-	-	-	1	-	-	-
35	-	-	-	-	1	-	-	-
44	-	-	-	-	-	1	-	-

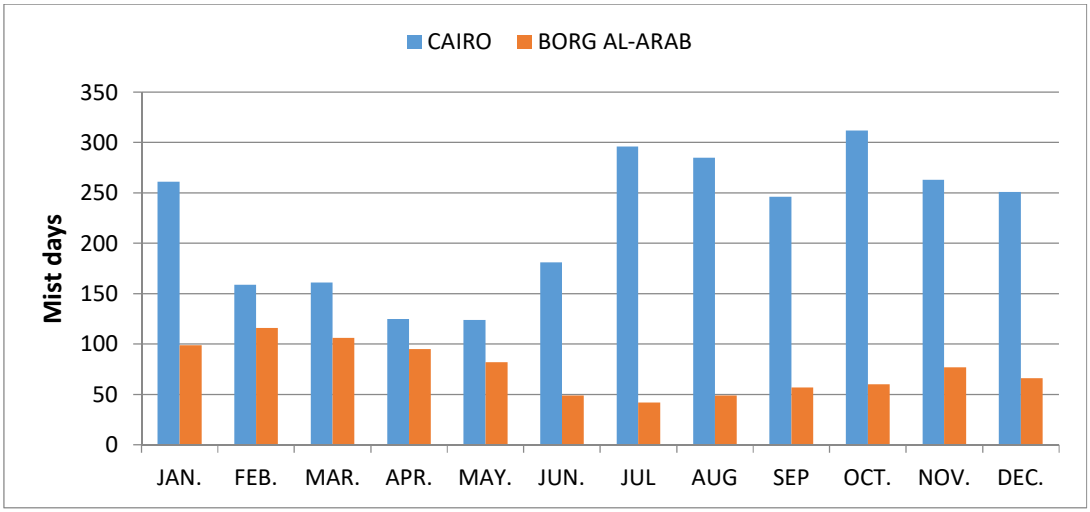

Fig. 3: Monthly mist days at Cairo international airport and Borg Al-Arab international airport

3.3. Sand climatology

One of the most experienced phenomena at both Cairo international airport and Borg Al-Arab airport is the Sand events took place in more than 10% of weather phenomena over Cairo international airport and more than 17% of weather phenomena over Borg Al-Arab international airport.

Sand events over Cairo international airport occurred most frequently from December to May, with January as the most active month. Fig.4

The longest sand event experienced over Cairo international airport was 35 hours on January 18th and January 19th of 2016.

At Borg Al-Arab international airport, sand events occurred most frequently from December to May, with March as the most active month. Fig.4

The longest sand event experienced over Borg Al-Arab international airport was 44 hours, starting on February 24th and ending on February 26th in 2006.

Sand lasted for 1 hour in 31% of sand days over Cairo international airport, while the most repetitive duration over Borg Al-Arab international airport was also 1 hour with 22% of sand days. Table 1.

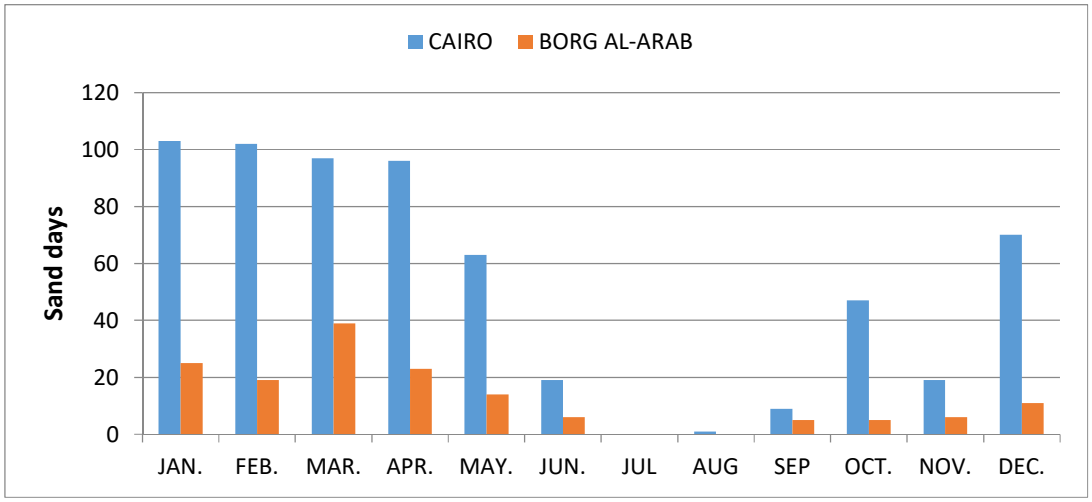

Fig. 4: Monthly sand days at Cairo international airport and Borg Al-Arab international airport

3.4. Sand storm climatology

Sandstorms are one of the most severe weather phenomena that can reduce the visibility to less than 1000 m. Sand storm events over Cairo international airport occurred most frequently from December to May, with February as the most active month Fig. 5.

The longest sand storm event experienced over Cairo international airport was 20 hours on March 18th, 2003. At Borg Al-Arab international airport, sand storm events occurred most frequently from December to May, with March as the most active month Fig. 5.

The longest sand storm event experienced over Borg Al-Arab international airport was 18 hours started on Febreuary10th/ Febreuary11st in 2015. Sand storms lasted for 1 hour on 52% of sand storm days over Cairo international airport, while the most repetitive duration over Borg Al-Arab international airport was also 1 hour on 30% of sand storm days Table 1.

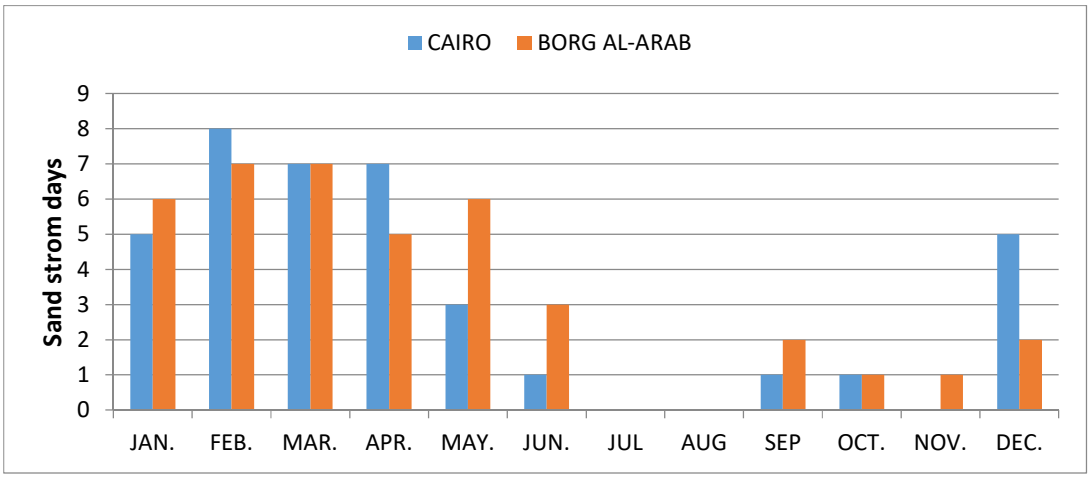

Fig. 5: monthly sand storm days at Cairo international airport and Borg Al-Arab international airport

3.5. Meteorological climatology.

Among all the weather phenomena that happened during the study period at both airports (Cairo International Airport and Borg Al-Arab International Airport), mist (BR) comes in first place with the highest percentage (53.8% of all weather phenomena at Cairo International Airport and 54.4% at Borg Al-Arab International Airport). Due to its location, Borg Al-Arab International Airport had more fog days than Cairo International Airport, with a percentage of 22.1%, while it was 2.8% at Cairo International Airport. Figure 6 shows the weather phenomena and their percentages over Cairo International Airport. Due to the urban activity at Cairo International Airport, haze (HZ) was the 2nd most frequented weather phenomenon over Cairo International Airport with a percentage of 30.3%. Sand (SA) comes in the 3rd place with a percentage of 10.6%, while fog (FG) comes in the 4th place with a percentage of 2.8%, and in the end comes dust (DU) and sandstorms (SS) with a percentage of 1.8 and 0.6%, respectively. These percentages were different over Borg Al-Arab International Airport. Figure 7, where mist (BR) and fog (FG) were dominating the weather phenomena with the highest percentage of occurrence (54.4 and 22.1% respectively). Sand and sandstorms took place in 17.2 and 4.1% respectively of all weather phenomena over Borg Al-Arab International Airport. At the end, haze (HZ) and dust (DU) had the least percentage of all weather phenomena, with percentages of 1.5 and 0.5% of all weather phenomena.

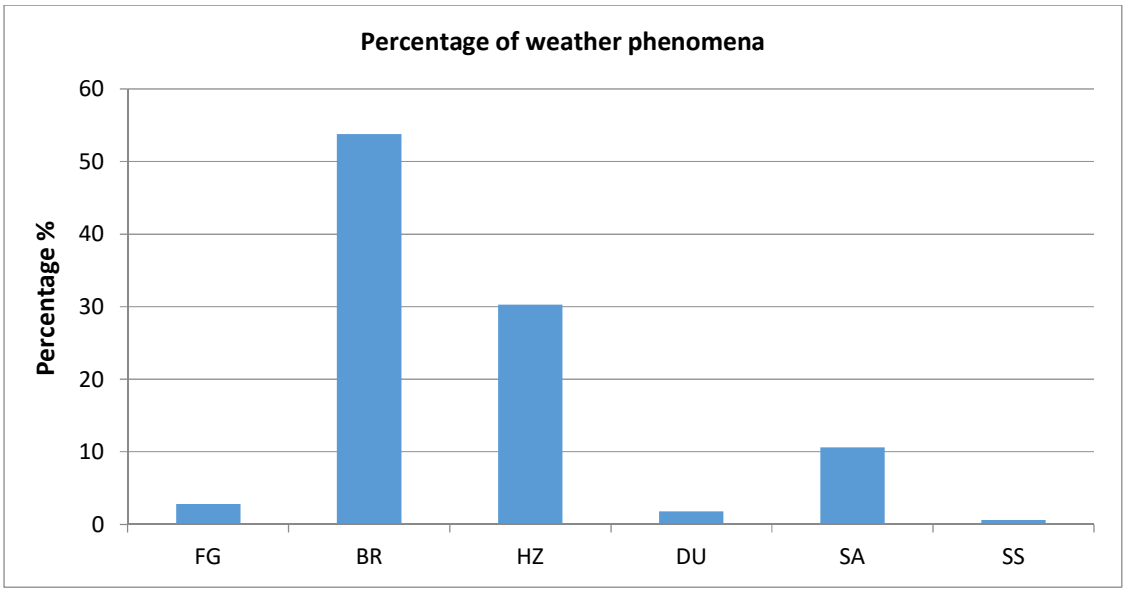

Fig. 6: Percentage of weather phenomena over Cairo International Airport

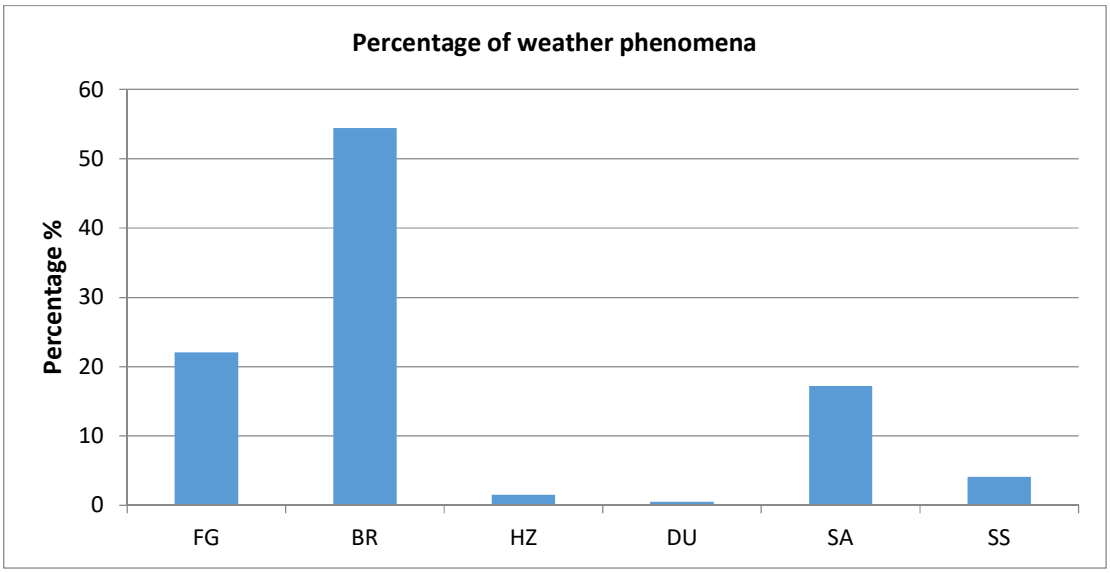

Fig. 7: Percentage of weather phenomena over Borg Al-Arab International Airport

Conclusion

In this article, different severe weather phenomena over one of the busiest airports in Africa have been studied. The results of annual record analysis showed that mist was the most experienced weather phenomenon over both Cairo international airport and Borg Al-Arab international airport. Mist (BR) was the most common weather phenomenon over both airports, with the highest percentage of occurrence. And as a result of the urban activity near Cairo International Airport, haze (HZ) had the 2nd highest percentage at Cairo International Airport, while the location of Borg Al-Arab International Airport was a major factor for more foggy days. Sand events (SA) were common at both airports and took 3rd place in terms of percentage of occurrence.

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