



Article

ANALYSIS OF THE FOGGY DAYS AND ITS KEY MECHANISMS OVER THE YANGON FLIGHT REGION

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Abstract.

A preliminary study of the foggy day analysis at Yangon International Airport was carried out from the previous author's first study by using a statistical approach. This opens up a fresh line of inquiry and the opportunity to consider climatology from a different angle. Fog has occurred most frequently in the winter months of December and January. During the 19 years period from 2003 to 2021, we count 187038 occurrences of observation from Yangon International Airport using half-hourly METAR data. This information included 32966 instances of meteorological phenomena, including 379 incidences of mist and 7911 instances of foggy weather. The total number of days with fog varies from 23 to 91 per year, with the year 2014 having the most days with fog (91), and the year 2010 having the fewest days with fog (23). Winter has nearly six times the amount of fog days as summer and 1.5 times the amount of fog days as autumn. The most frequent time of day for fog was between 2300 and 01:00 UTC. Fog most usually occurs between 1800 and 2000 UTC following rains in the summer and early autumn. Data during the four to six hours prior to the commencement of the fog are subjected to classification criteria, 7610 of the 8289 fog events are only radiation and advection fog types. The first three months of the year have the highest incidence of radiation fog onset.

The greatest frequencies of radiation fog onset are in February (17 %) and March (18 %). Fog episodes in 19 years were observed to be accompanied by stratus clouds 53.3 percent of the time, with low clouds being absent in 46.7 percent of them. The departure of the beginning and dissipation from the sunrise and sunset, respectively, can be used to analyze the behavior of each form of fog. At Yangon International Airport, the conditions where the fog was most likely to form were those when the minimum temperature fell between 16 and 27 °C (liquid fog). The latest discovery raises a new topic and a new option for interpreting climatology from a new perspective and making considerable progress in the predictability study, according to a well-known physicist in another setting.

Keywords: Myanmar, Aviation Weather, VYYY, FOG and METAR.

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1. Introduction

The economy of wealthy nations like China, landlocked nations like Laos, and small island nation-states like Madagascar all rely heavily on the aviation sector. An essential element of long-term economic growth is the aviation sector. It also acts as a significant driver of other economic activity like as internal trade, military operations, and tourism. The aviation industry supported 65.5 million jobs globally and generated 704.4 billion dollars in direct gross benefits in 2019, according to the Air Transport Action Group. Aviation has a \$2.7 trillion global economic impact (including direct, indirect, induced, and tourism catalytic) and contributes 3.6 percent of global GDP in 2019 [1].

There is a long and distinguished connection between aviation and meteorology. Significant local weather shifts and severe weather patterns can be predicted by climatology. As a result, unless new solutions are found, the impact of weather on aviation is likely to increase over time. It is impossible to always prevent delays when flying. A considerable impact on aircraft performance at the airport is caused by concurrently changing climatic and meteorological circumstances, which ultimately cannot be avoided. Sometimes these delays are required to show that the safety of our customers comes first. As of, the weather is the only uncontrollable factor among the five forms of aviation delays [2]. As a result, departure delays caused by bad weather are virtually always unavoidable. It's critical to be prepared for departure delays for airfield operations to run properly, thus preparedness is necessary [3].

Even in bad weather on an aerodrome, air weather services do not have the authority or ability to close an airport [4]. Airport operators are the only authorities able to close an airport, and this would only be taken in extreme circumstances. The degree to which an aircraft's departure and arrival are visible (or RVR) is determined by the sophistication of ground equipment and the qualification of the flight crew [5]. A low visibility operation can reduce capacity at an airport both on the ground and in the air since fog can cause low visibility to restrict ground and air movements [6]. Today, as many aircraft are capable of landing and taking off in very low visibility, aircraft ground movement safety can sometimes be the ultimate capacity constraint. Although, low clouds, fog, and rain at or near an airport, can make visibility difficult, and can cause substantial delays in flight schedules. As a result, data on the spatial and temporal distribution and fluctuations of fog occurrence and convective rainfall is critical not only for understanding basic climate dynamics but also for societal uses such as airport operations and aircraft operations.

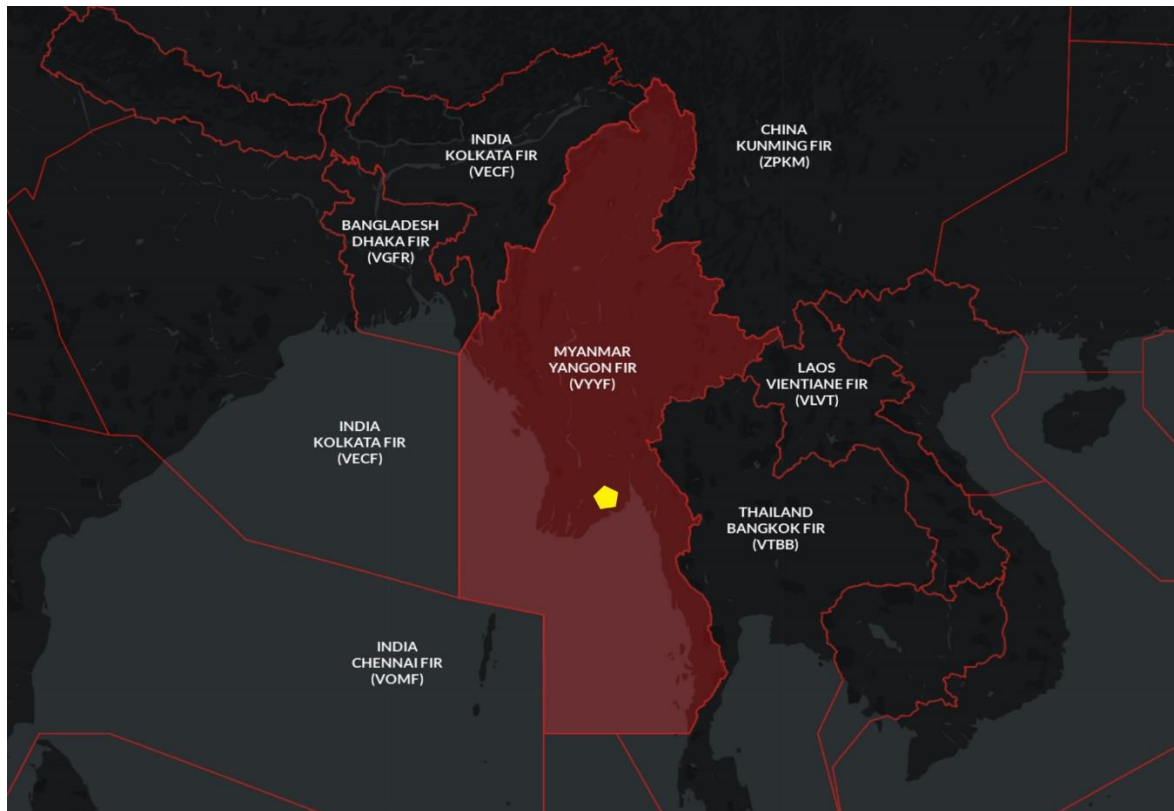


Figure 1. The red box indicates the Yangon International Airport Control's (YIAC) coverage region for the Flight Information Region (FIR) in the study area (Yellow Polygon) [7].

The Republic of the Union of Myanmar is one of the world's most beautiful visits to the country. It is bordered on the northeast by the People's Republic of China, the east by Laos, the southeast by Thailand, and the south by India [8]. The busiest airport in Myanmar is Yangon (RGN)/Yangon International Airport (VYYY), with flights to 56 destinations in 14 countries and catering to about six million passengers [9]. The primary research focus is Yangon International Airport (VYYY), and this work is the first to investigate the impact of aviation climatology over Yangon International Airport Figure 1. The airport is home to all ten Myanmar airlines as well as roughly 30 international airlines. In addition to the runway, there are two touchdown zones (TDZ) at an elevation of 33.6 meters (110 feet) [10]. The purpose of the studies has looked at the individual effects of foggy weather on regions. It is also intended not only for airport operations but also for a diverse group of users, including international and domestic civil airlines flying to and from Myanmar airports, pilots, airport operational and administrative services, and air navigation service providers. Besides the potential users mentioned above, this summary can also be used by specialists from other domains for scientific research.

2. Materials and Methods

The International Civil Aviation Organization (ICAO) and the World Meteorological Organization (WMO) have issued recommendations for the processing of climatologic data, which are followed in the creation of statistical data [11]. Count 187038 times of station observation data (thirty-minute METARs) from Yangon International Airport between 2003 and 2021. Data on accidents and flight delays are sourced from the ICAO Safety API Data Service and

the Aviation Safety Network (ASN). The aerodrome's data is supported by YIA Service Company Limited and MC-Jalux Airport Services Company Limited. The SGS international company has granted the Meteorological Service with a Quality Management ISO 9001:2015 Certificate.

Frequency is a measure of the number of occurrences of a particular score in a given set of data [12]. The climatological is the examination of each month and season to determine the mean proportion of occurrences of meteorological factors in the study area. The frequency of the weather element is divided by the total number of observation times and then multiplied by 100% to get the percentage [13].

$$\text{Frequency Percentage} = \frac{\text{Frequencies of element}}{\text{Total of Observation Times}} * 100$$

There are several statistical relationships for perceiving the relationships between two variables which are expressed in both linear and non-linear equations. The correlation coefficient is the most important statistic for explaining the relationship between variables. This index shows the degree and direction of correlation between a variable and its environment. The following equation is used to determine the Pearson correlation coefficient (r) value:

$$r = \frac{n(\sum xy) - (\sum X)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2] [n \sum y^2 - (\sum y)^2]}}$$

Fog Types Classification

Horizontal vision may improve above 1000 meters, resulting in fleeting gaps in the presence of fog. It is necessary to submit a SPECI report when the visibility improvement takes more than 10 minutes. Despite the minutes between fog occurrences, the basic mechanism that favored the creation of the first occurrence is essentially the same. However, when accompanied by a quick visibility drop below 1000 m, the deteriorating state is instantly reported. A fog event is defined in this sense as a collection of clearly characterized fog sequences separated by under two hours. The algorithm was modified from the event concept put forth by Tardif & Rasmussen, (2007) [14], with the only requirement being that the fog events be separated by at least two hours.

Table 1- Main mechanism that causes fog to form

Fog Types	Precondition	Primary Mechanisms	References
Precipitation (PREC)	Precipitation at onset or hour prior.	Evaporation of precipitation from surface.	Baars et al., 2001 Tardif & Rasmussen, 2007 [14, 15]
Advection (ADV)	Wind speed above 1.5 m/s, low clouds below 200 m in hour prior to onset or clear sky.	Advection of temperature or moisture and condensation over a cold surface.	Tardif & Rasmussen, 2007 [14]
Cloud-base lowering (CBL)	Low clouds in hour prior to onset with gradual decreasing of base height.	Radiative cooling of the stratus clouds top leading to cooled subsidence followed by water vapor condensation due to sub-layer turbulent mixing.	Tardif & Rasmussen, 2007 [14] Gultepe et al., 2007 Dupont et al., 2012 [16, 17]
Radiation (RAD)	Wind speed bellow 1.5 m/s, clear sky or low clouds in hour prior to onset and cooling in hour leading to onset or onset in the cooler period, between hour prior to sunset and before sunrise.	Surface radiative cooling due to upward heat flux and turbulent mixing.	Duynkerke, 1991 [18] Tardif & Rasmussen, 2007 [14] Haeffelin et al., 2013 [19]
Evaporation (EVP)	Clear sky or onset one hour after sunrise followed by the rise of dewpoint greater than rise of temperature	Increasing rate in surface evaporation due to early morning warming after sunrise followed by condensation into cold air and turbulent mixing.	Tardif and Rasmussen (2007) [14]

In general, wind acts as a dynamic driver while temperature and moisture act as the thermodynamic qualities that cause fog to form. The half-hourly observational sampling limits any deep examination of the behavior of the properties into the mechanisms favoring the creation of fog and, consequently, a correct categorization, even when exceptional observations are interposed. However, research conducted in the New York City area by Tardif & Rasmussen (2007) [14] found five distinct types of fog, including advection fog (ADV), cloud-based lowering fog (CBL), evaporation fog (EVAP), precipitation fog (PREC), and radiation fog (RAD). The main mechanism that causes fog to form is brought on by preconditioning features obtained five hours before onset, as shown in Table 1.

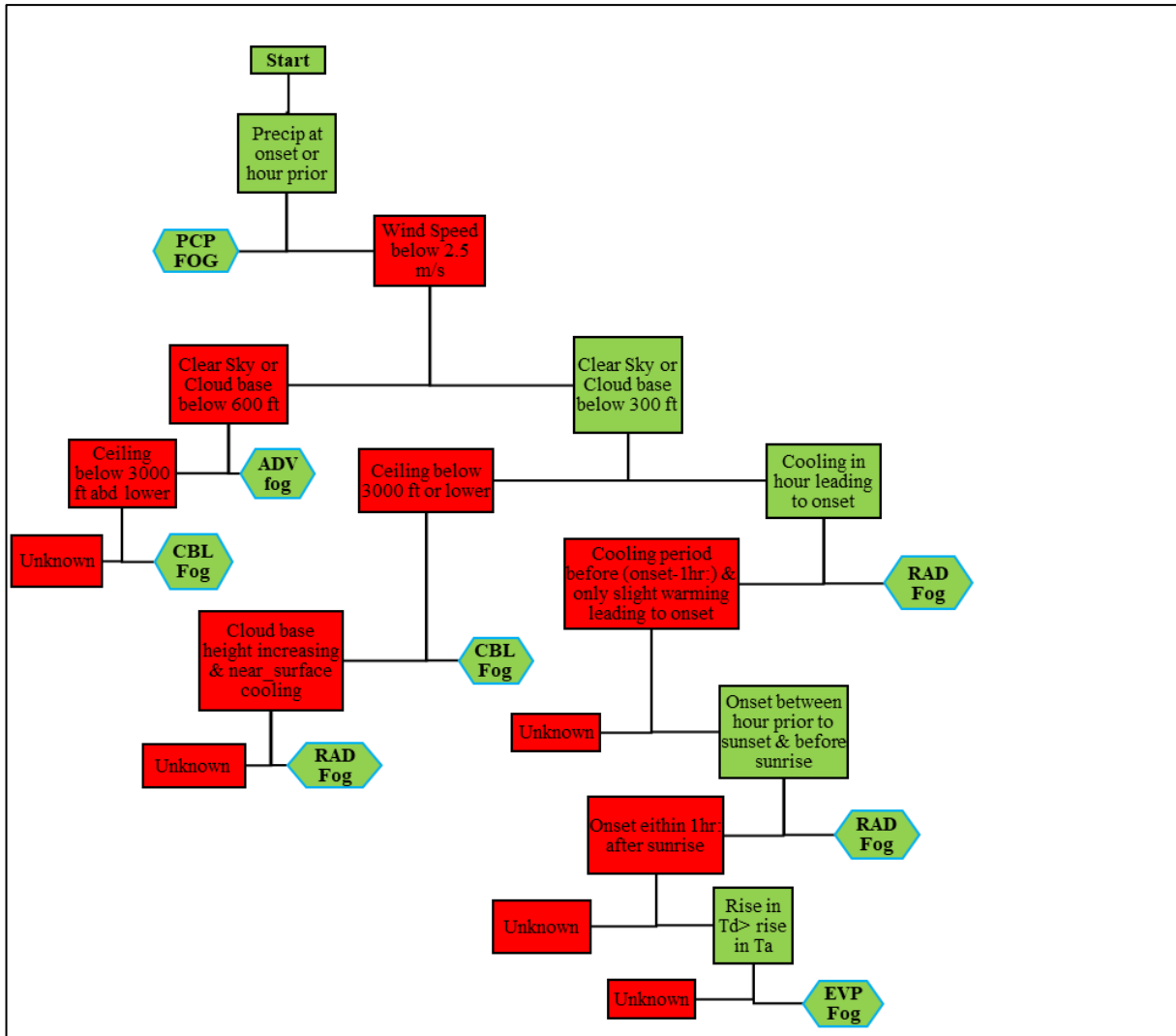


Figure 2: Flowchart for the type of fog classification [14].

The precondition fluctuations in temperature, humidity, wind, and cloudiness from the prior time were examined in the current investigation, and each instance of fog was categorized into one of the fog categories. The fog is categorized as an unknown type if the physical reasoning does not match any particular fog kind (UNK). The categorization approach is shown in the flow chart in Figure 2.

3. Results and Discussion

We count 187038 occurrences of observation from Yangon International Airport using half-hourly METAR data. This data contained 32966 instances of meteorological phenomena, including 379 Mist conditions and 7911 Foggy weather conditions. The percentage of each weather phenomenon that happens, including thunderstorms, is shown in distinct hues for each weather phenomenon. The maximum frequencies in February are mist (BR) 1.1%, haze (HZ) 21.3%, and fog (FG) 24%. Maximum Thunderstorm Rain (TSRA) of 27.6% occurred in July during 2003–2021 with Drizzle (DZ) of 15.5%, and Rain (RA) of 6.49% (Figure 3).

We determined which features of Yangon International Airport had a significant impact on operations after looking at a variety of factors. The following accident case study section also demonstrates how weather, specifically TSRA and FG, can influence aviation crashes. As a result, we identified two meteorological events (TSRA and FG) that were very likely to cause plane accidents or operational delays.

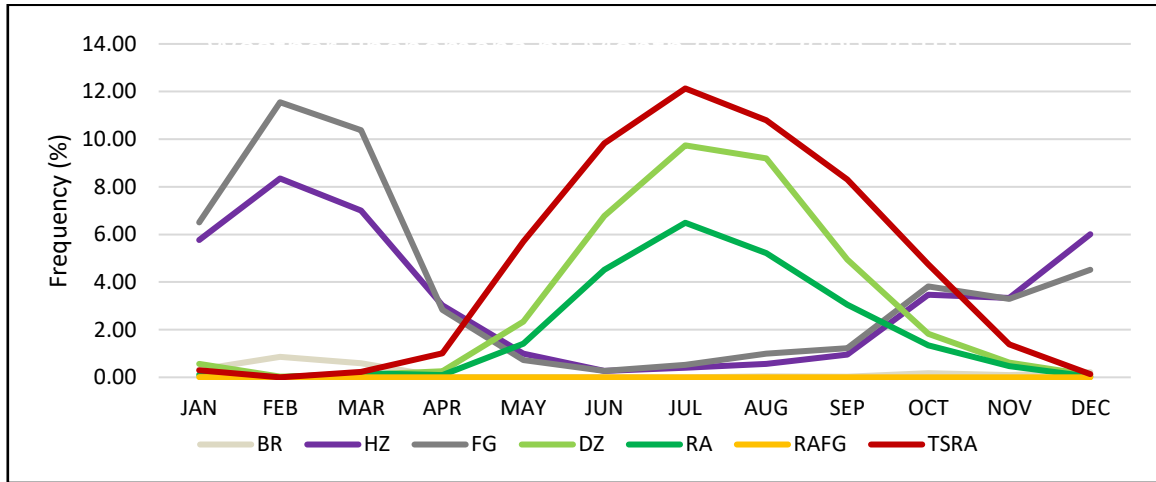


Figure 3. Climatology of Monthly Frequencies (%) of weather phenomena (2009-2019) [2]

The three seasons in Myanmar are the Summer or Hot weather season (March - Mid May), Rainy or Southwest monsoon season (Mid May - October), and Northeast monsoon season on the other hand Winter (November - February) as to Myanmar Climate Report 2017 [20]. FG and BR have been reported not only during the winter (DJF) seasons but also during the first month of the summer season (March), which extends to April in some years. As a result of Figure 3, maximum FG and BR conditions have been present for at least 7 months at Yangon International Airport.

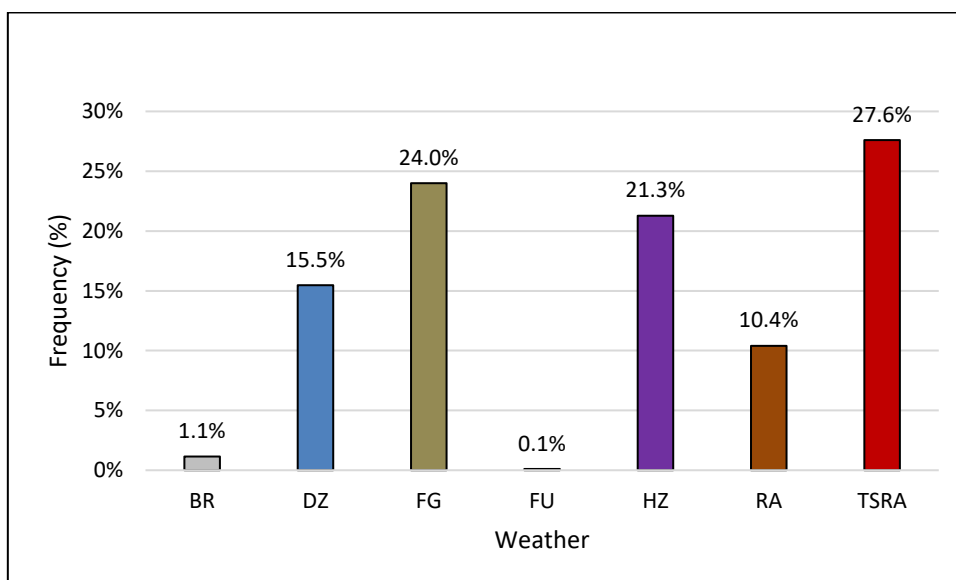


Figure 1. Frequency (%) of weather occurrences by phenomenon (2003-2021)

FG is the high-impact weather phenomenon at Yangon International Airport as Figure 4. FG had a greater influence on airport operations because the factors have a significant impact on not only aircraft operations but also airfield operations. Thus, the following evaluations of FG conditions are carried out in great depth as a continuation of the previous study [2].

To maintain airspace effectiveness and safety, it is essential to look at flight delays and their causes [21]. Weather conditions can create major delays in air travel, resulting in the cancellation or postponement of hundreds or thousands of flights, affecting the itineraries and budgets of millions of people [22]. More than that, bad weather conditions may lead to flight accidents. A comprehensive study was conducted on Yangon International Airport using climatology data and the aircraft delay index to identify the particular meteorological elements that cause flight delays and cancellations by month. At Yangon International Airport, the relationship between flight delays and bad weather is mostly relative, as the delay index created by Airports INFO Statistics demonstrates (Figure 5). Weather delays can happen directly or indirectly. Bad weather at the airport may have a direct effect, while bad weather along the flight path may have an indirect effect by making a flight arrive later. After categorizing the delay causes, we found the weather-related delay index is high. The Delay Index represents the percentage of delayed flights (take-offs) [23]. For example, the delay index would be 50% if there are 10 flights on a given day and 5 of them are delayed. We discovered that, between 2019 and 2021, May is the month with the lowest monthly delay index, and July, August, and March have the highest monthly delay indexes. (Figure 5).

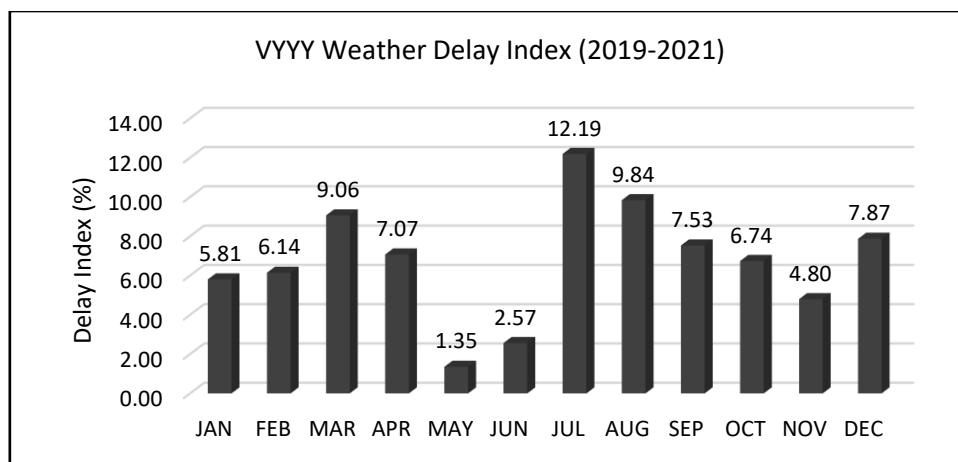


Figure 5. Weather Delay Index for Yangon International Airport (2019-2021) [2]

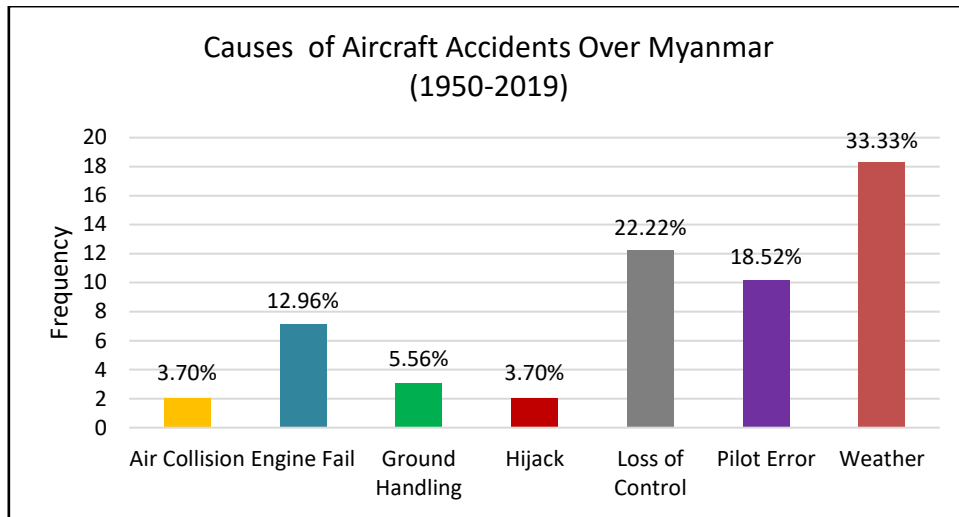


Figure 6. Aircraft accidents over Myanmar: their causes (1950-2019)

It is quite rare for an accident to be explained by one single cause. Almost every catastrophe is the result of a series of circumstances, and most accident reports distinguish between the main cause and multiple contributory elements. The following Figure 6 shows the distribution of the main causes identified in an aircraft accident. The main root cause is weather-related accidents. Also, some loss of control accidents may be unfortunate factors that can result in aviation accidents.

Foggy Days Analysis

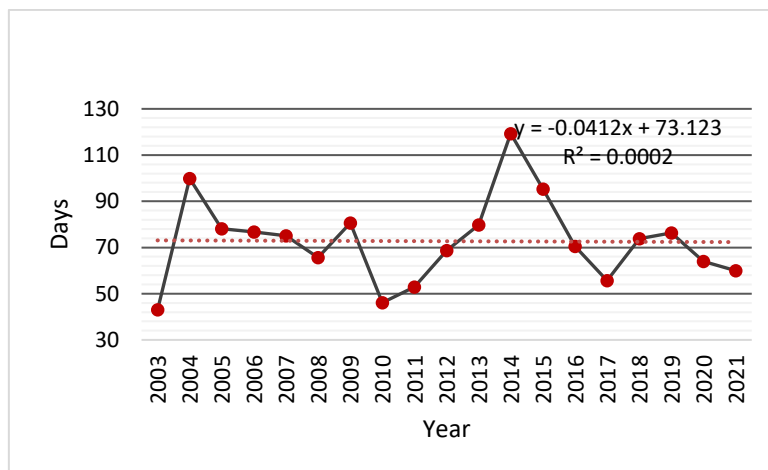


Figure 7. Total annual number of days with fog at Yangon International Airport for the period 2003 to 2021 with a linear trend. The dotted orange line is obtained by linear regression.

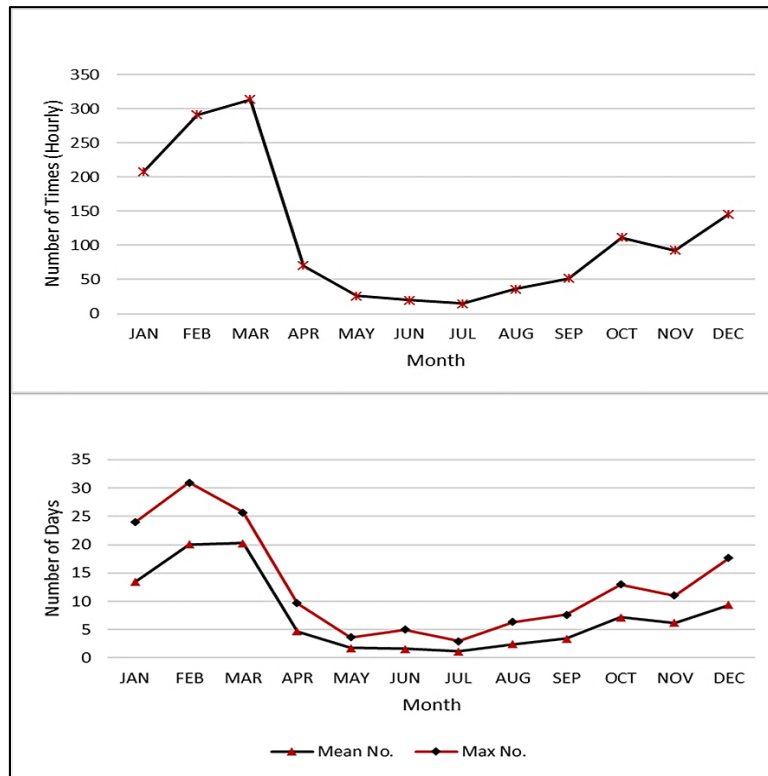


Figure 8. Top, the total number of days with fog per month; bottom, the red line-absolute monthly maximum number of days with fog per month; the black line-meaning the number of days with fog per month. Analysis was made for Yangon International Airport during 2003-2021.

Over the period from 2003 to 2021, the total number of days with fog ranges from 23 to 91 per year. As can be seen in Figure 7, Total annual number of days with fog at Yangon International Airport for the period 2003 to 2021 with a linear trend. The dotted orange line is obtained by linear regression., the maximum number of fog days was in the year 2014, which was 91 days, and the minimum in 2010 which was 23 days. Here, we ignore the year 2003 as the minimum for lack of observation data.

The temporal distribution of fog-event numbers indicates that events occur mostly in winter months (DJF) and far exceed the number of fog days in the spring (MAM) and the beginning of autumn (SON) (Figure 8). Winter has nearly six times the amount of fog days as summer and 1.5 times the amount of fog days as autumn. In winter specifically (December, January, and February (DJF)), there were 644 days with fog, whilst in summer (June, July, and August (JJA)), and autumn (September, October, and November (SON)), there were 71 and 256 days with fog, respectively.

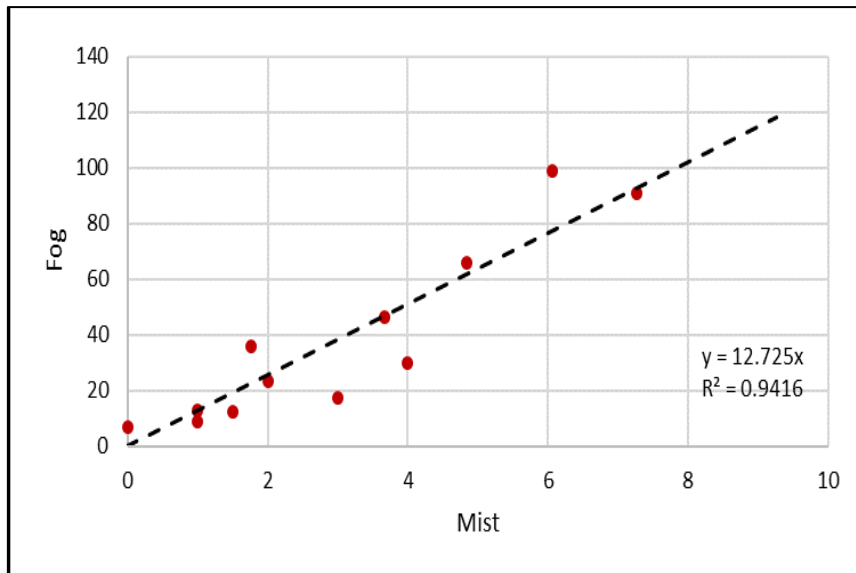


Figure 9: The monthly correlation between Mist vs. fog, per month, for the period 2003-2021 between the number of days with fog and mist at Yangon International Airport. The dotted line is obtained by linear regression. R is the correlation coefficient.

Inspecting the relationship between monthly occurrences of mist ($1,000\text{ m} \leq \text{visibility} \leq 2,000\text{ m}$) and fog for the period from 2003 to 2021, a very high correlation ($R=0.92$) between the two was found (Figure 9). Fog and mist have a robust, positive, and linear association. Accordance to (Quan et al., 2011) [24], the occurrence of mist/haze and fog was influenced by weather conditions, such as static stable weather conditions and abundant vapors (for fog). In addition, the aerosol concentration might also be a factor that influences the number of fog days. As can be expected, for long nights in winter, fog occurred most frequently in the early morning and more frequently than in summer (Figure 10). The majority of fog events begin in the early morning and last until the end of the night. During the winter (DJF), from January 2003 to December 2021 (18 years), fog occurred between 2200 and 0200 UTC and most commonly between 2300 and 0100 UTC. In summer and early autumn, fog occurred most frequently between 1800 and 2000 UTC; after rainfall. Winter and early spring fog frequencies are almost four times greater than summer and spring fog frequencies. We looked at if there was a statistical relationship between subsequent fog incidents over the course of the 19-year period from 2003 to 2021.

The two primary mechanisms of fog generation are used to categorize the fog events that are described in this article. Thus, advection and radiation fog are the two categories into which events are divided. Following the classification criterion for these two fog types that are proposed by (Tardif & Rasmussen, 2007) [14], we examined data for 19 years (2003–2021). The distinction between advection and radiation fog was defined (e.g., whilst with radiation fog, the observed wind speed at the surface is below 2.5 m s^{-1} (calm or weak wind conditions), the advection fog is associated with moderate winds—greater than 2.5 m s^{-1}). Classification criterion is applied to data for a period of 4 to 6 h before fog onset. During this period, among the 8289 fog events, 7610 times were analyzed and the above-mentioned fog types were selected. Those events that did not fulfil any of the criteria were not classified. The monthly distribution

of radiation and advection fog onset in the form of frequency, along with the times of sunset–sunrise (which are related to the radiative cooling potential), is presented in Figure 11. Results show that radiation and advection fog are the most prevailing types in autumn, winter, and early springtime (the monthly sum of the frequencies of these two types from October to March is approximately 80 %). Radiation fog is more frequent than advection fog for virtually the whole year.

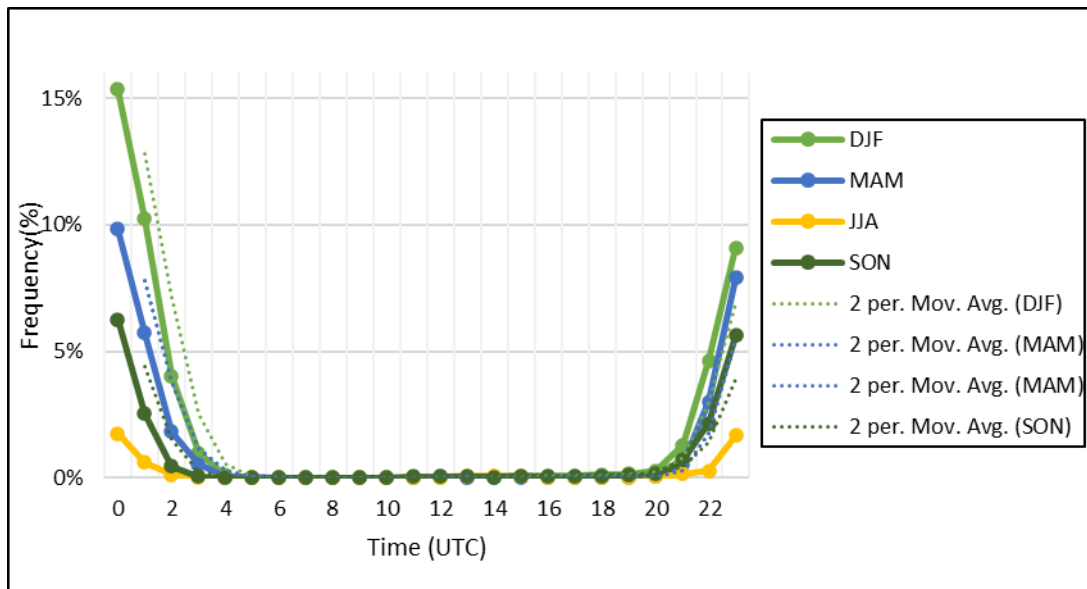


Figure 10: Diurnal frequency of fog onset at Yangon International Airport for the period 2003 to 2021, for four seasons (see legend), dashed line; the 2-month moving average, solid line.

The frequency of radiation fog onset is the highest for the first 3-month period of the year. This is not surprisingly, given what we know in that period, there is a maximum surface cooling along with the clear skies above and light winds situation—mean monthly relative humidity during this period is over 80 %, based on climatological data. In addition, monthly trends in radiation fog onset are positive for the periods of October to March. The months of September through December and January through March see an increase in the monthly frequency of advection fog onset. The greatest frequencies of radiation fog onset are in February (17 %) and March (18 %) Figure 11. That is in agreement with the physical processes of radiation fog by Mason, (1981) [25] due to the climatology parameter values of each month.

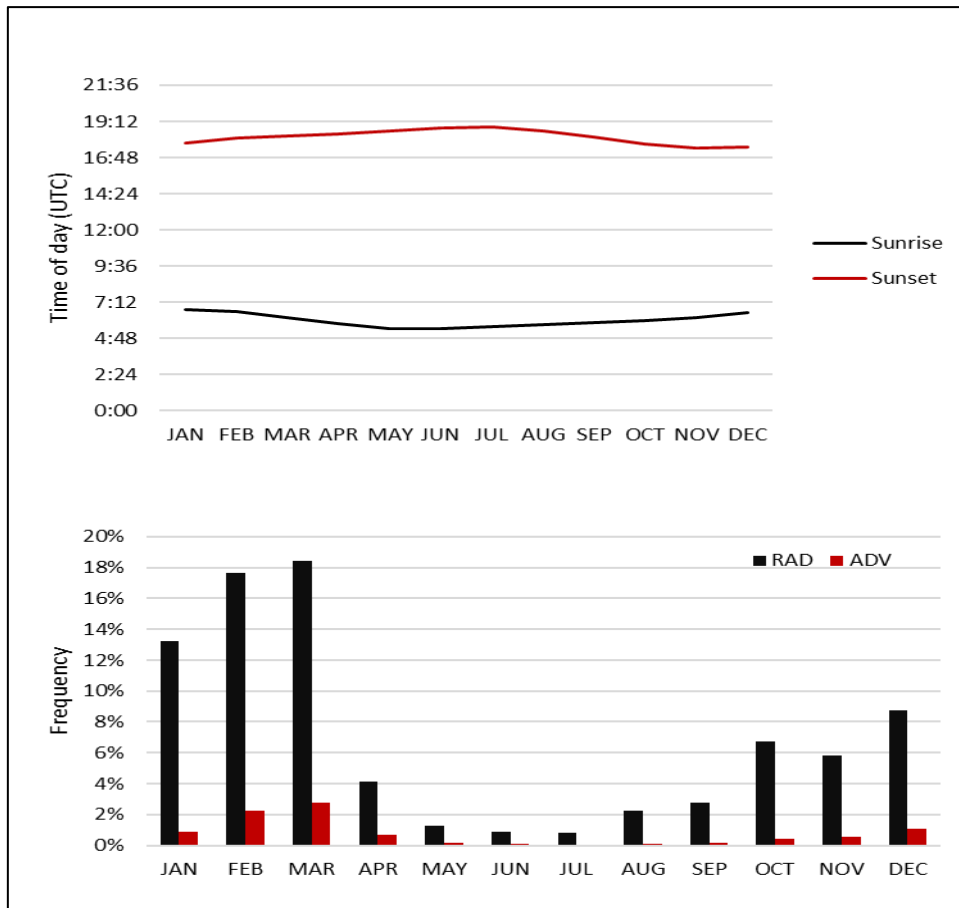


Figure 11: Top, UTC times of sunrise (black line) and sunset (red line). Bottom, monthly frequency (in percent) of the onset of advective (red bars) and radiation (black bars) fog, for Yangon International Airport. Type classification was made following (Tardif & Rasmussen, 2007). The data cover the period from 2003 to 2021.

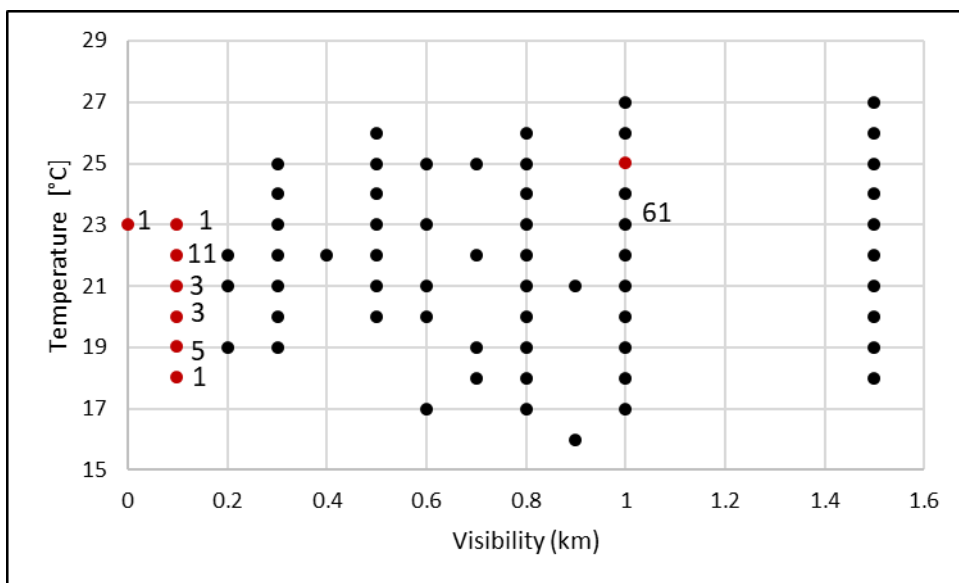


Figure 12: Visibility thresholds (in kilometers) and number of fog events as a function of average temperature, T2m (in degrees).

A 19-year analysis of fog episodes indicated that 53.3 percent of them occurred in the presence of stratus clouds while 46.7 percent of them did not have low clouds. Moreover, the average air temperature in the presence of fog was 22 °C; the highest number of fogs occurred in conditions with air temperatures ranging from 19 to 25 °C (Figure 12). Following the (Petterssen, 1956) [26] classification, all onset were liquid fogs. Because 100 % of fogs occurred at a temperature above -10 °C at VYYY due to the above results. The average temperature difference between air and soil (T_{2m}-T_{7cm}) was 1.6±0.3 °C (Figure 13)

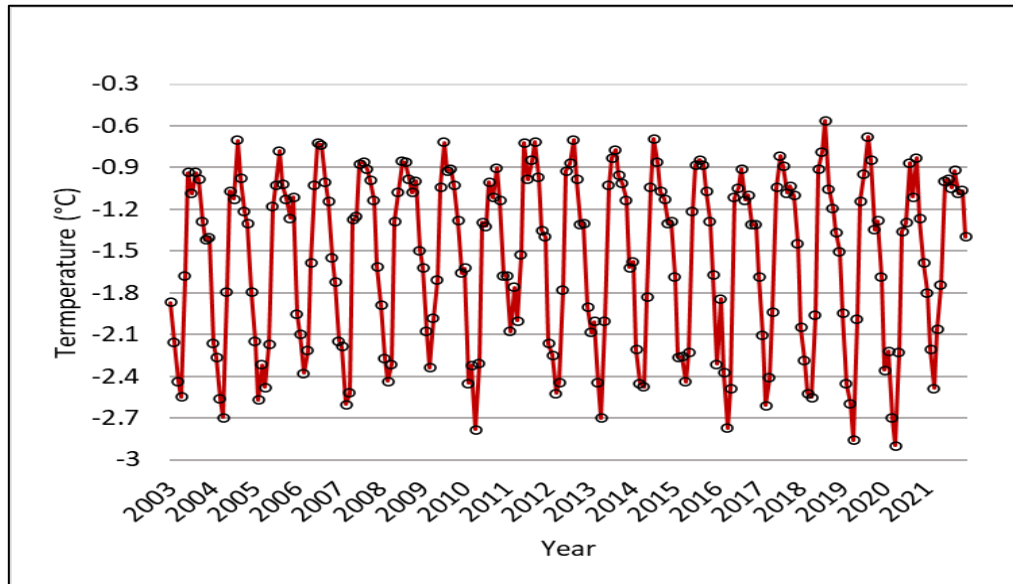


Figure 13: Air-soil temperature differences, T_{air}-T_{7cm} (in degrees Celsius); during fog events at 0000 UTC at Yangon International Airport during the period 2003–2021.

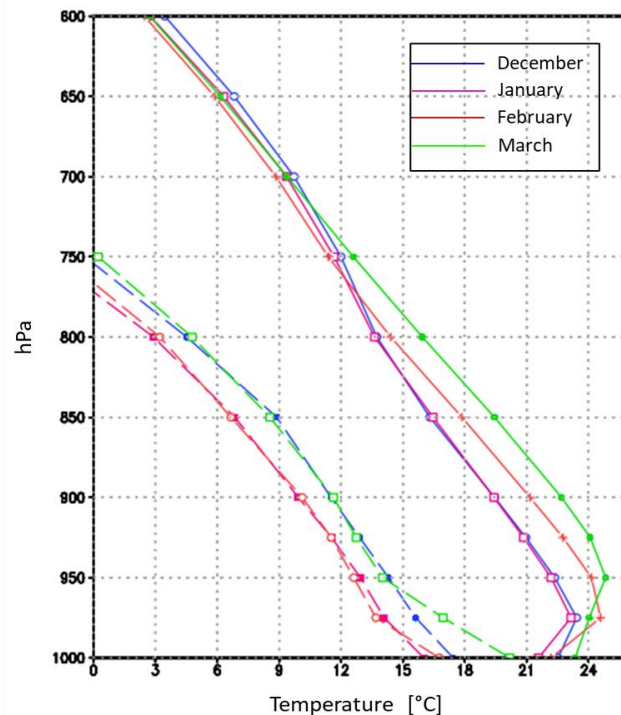


Figure 14 - Monthly summarised average vertical profiles of temperature (solid lines) and dew-point temperature (dashed lines) in the surface layer for Yangon International Airport at 2300-0100 UTC during the fogs occurred in the winter (December–March) for the period 2003 to 2021

Inversion layers have an impact on microclimates, and among other things, may help understand the climatological aspects of fog. To calculate the surface-based inversion height and strength, pressure level data related to the cases with fog events at 0000 UTC during the winter and early spring (from December to March) for the 19 years is considered. Data showed that surface-temperature inversions were present with practically all fog episodes (90%) that occurred at 0000 UTC. Monthly, temperature profiles are summarized. Climatological monthly vertical temperature and dew-point profile from the surface layer (up to 600 mb level) are shown in Figure 14. January and February have the highest inversion value and March has the highest inversion depths that, when averaged over many fog events, are about 300 to 600 m thick with 1–2.5 °C temperature differences from the base to the top of the inversion. In terms of inversion strength in the presence of fogs, January and February show the highest temperature increase (about 1.0 °C/300 m), and December has the shallowest inversion layer (~300 m deep). The temperature inversions in DJF are comparable to one another in strength (~1 °C/300 m). Additionally, March has the warmest fogs, 2° warmer than DJF.

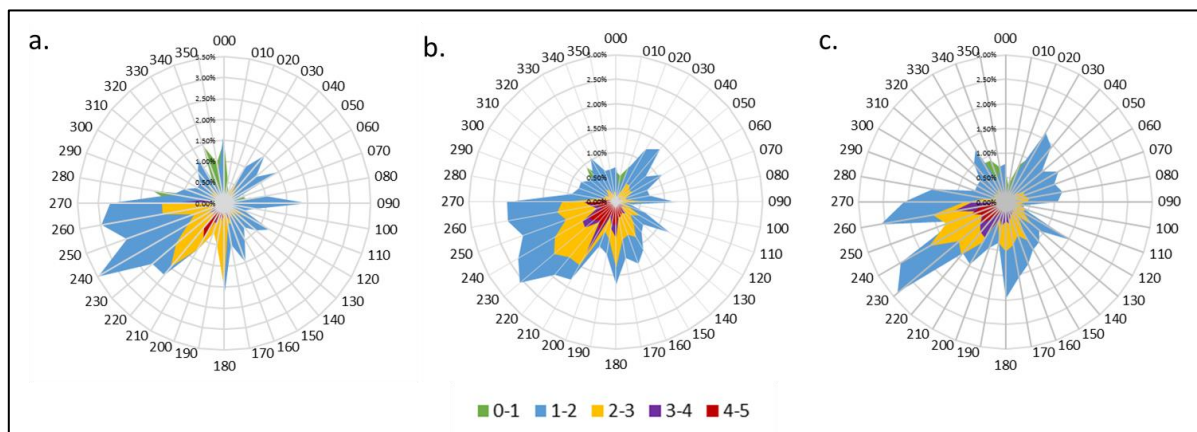


Figure 15: Wind rose for three stages of DJFM Fog events (a) Before 1-hour onset, (b) During Fog, and (c) Dissipation during 2003-2021

The wind roses shown in Figure 15 combine the wind direction with the velocity of foggy days in December, January, February, and March, which indicates that fog is strongly constrained by local circulation. One hour before fog onset most frequency of wind comes from west and east with low intensity (below 2 m/s) Figure 15a. But during and after fog events, wind intensity is increasing with no direction change Figure 15b and c. Fog occurrence is also analyzed considering the synoptic characteristics concerning main meteorological forms development. The selected case is 1st and 2nd March 2004; overnight, the fog began forming on 2nd March 2004 within a region of higher pressure and lasted for 48 hours. The surface pressure and temperature weather map over South East Asia (SEA) before and during the fog formation (from 0000 UTC 1st March 2004 (non-fog day) to 1200 UTC 2nd March 2004 (fog day)) are shown in Figure 16. The synoptic situation over SEA on 1st March 2004 at 0000 UTC is characterized by a deep steady state anticyclone located over the north Bay of Bengal (BoB), and a powerful stationary cyclone over the north of Myanmar, Tibetan, and China high-pressure system which extends by a ridge even to the east of Myanmar. Similar patterns are found each time with significant surface temperature change.

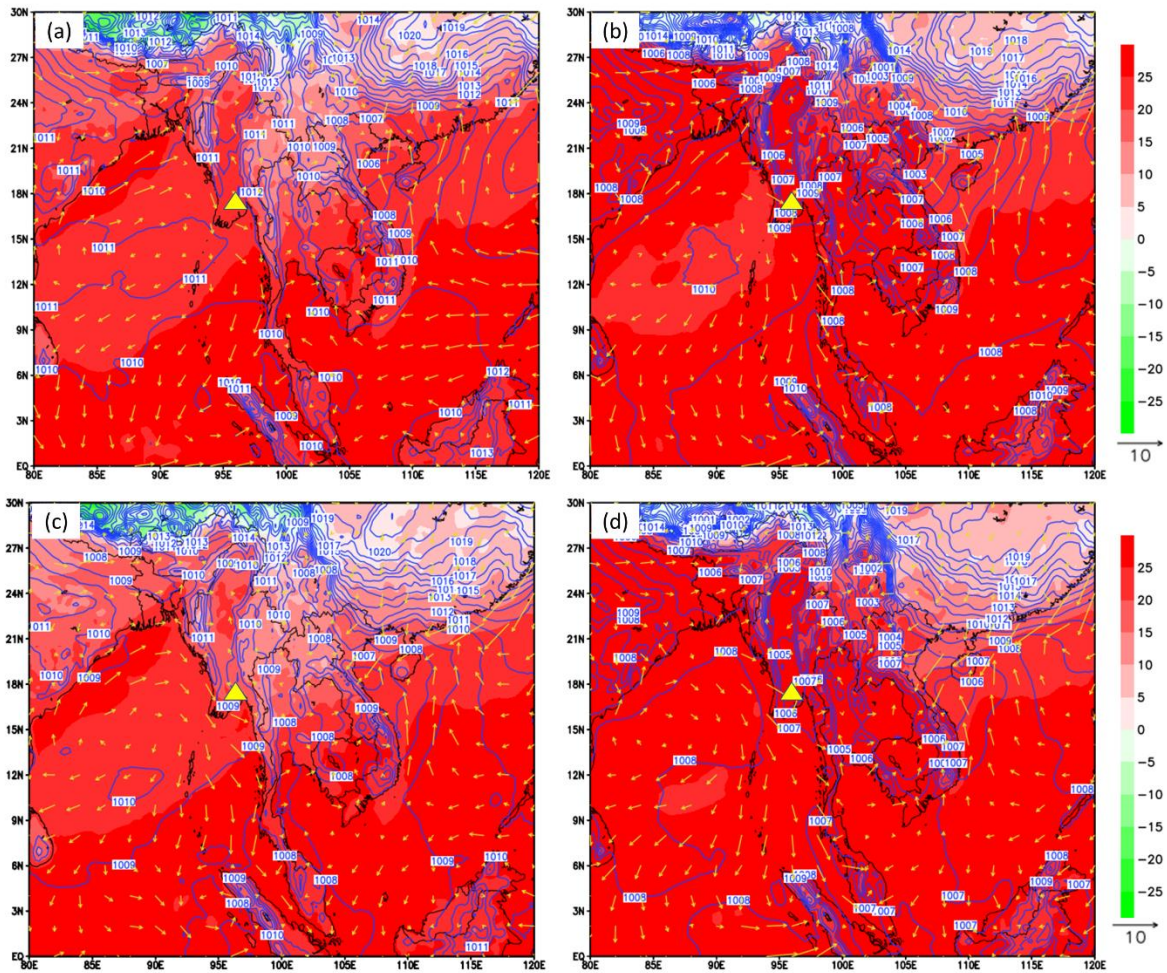


Figure 16 - Four 12-h successive surface analyses of surface temperature (in °C; shading) and mean sea-level pressure (contours) over South East Asia Region, from 0000 UTC 1st March 2004 (top panel) to 1200 UTC 2nd March 2004 (bottom). The isobar contour interval is 1 hPa. The isotherm shading interval is 5-degree Celsius. Yangon International Airport's location is indicated with a yellow triangle.

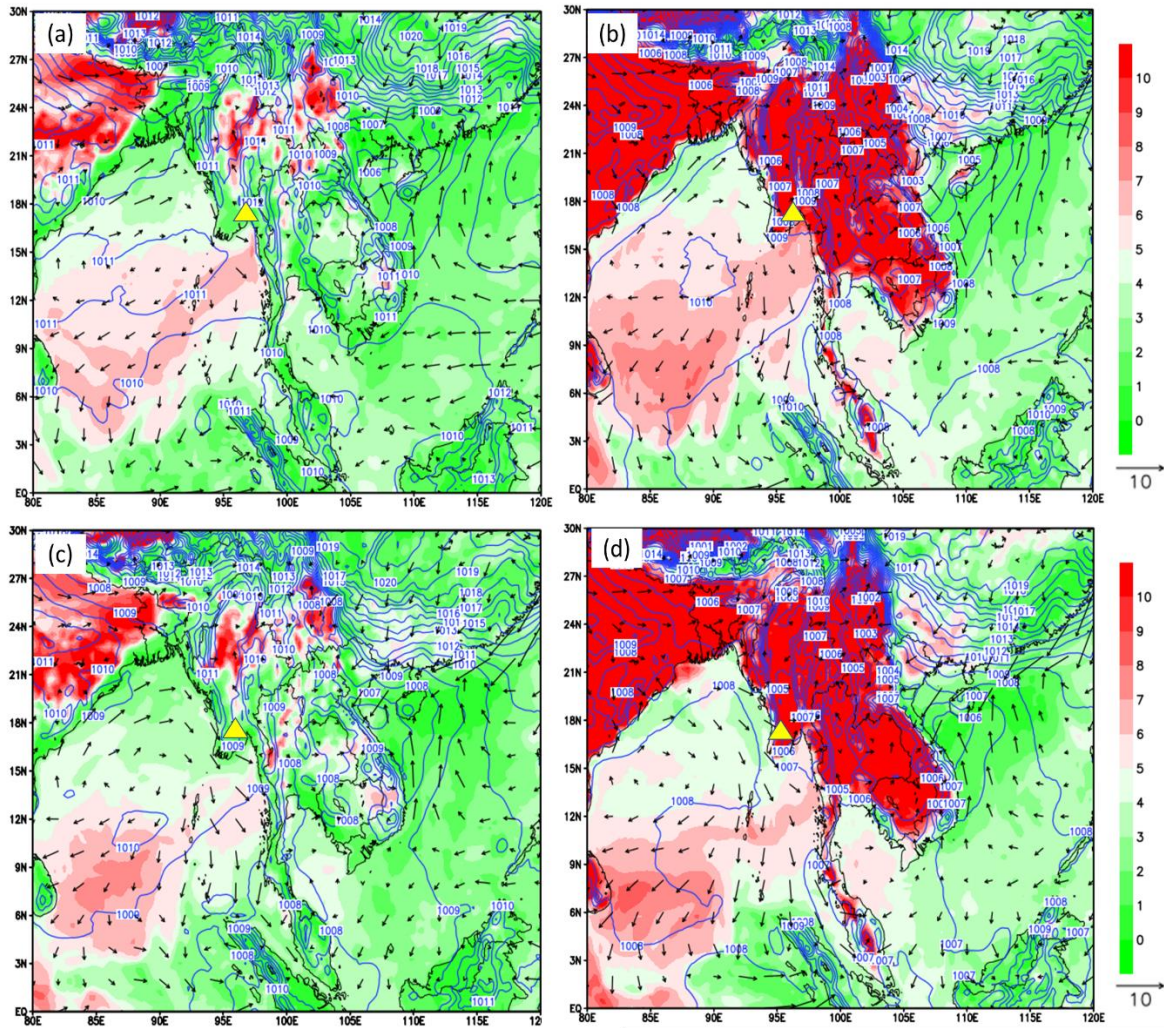


Figure 17: Four 12-h successive surface analyses of dew point depression (T_a-T_d) (in $^{\circ}\text{C}$; shading) and mean sea-level pressure (contours) over South East Asia Region, from 0000 UTC 1st March 2004 (top panel) to 1200 UTC 2nd October 2004 (bottom). The isobar contour interval is 1 hPa. The isotherm shading interval is 5-degree Celsius. Yangon International Airport's location is indicated with a yellow triangle.

The fog can form because of a high-pressure system that brings calm weather and a clear sky. The significant change of spatial dew point depression (T_a-T_d) over SEA is also displayed in Figure 17. The difference between two temperature value lower than 2°C during the Fog event and the dissipating stage show more than 2°C . Fog is most likely to occur when the dew-point depression is 2° or lower and the wind is 2.5 m s^{-1} or less by the definition by Duynkerke, (1991), Tardif & Rasmussen, (2007) and Haeffelin et al., (2013) [14, 18, 19]. The fog occurred after a couple of south-south-easterly wind days. The winds were weak, below 2 m s^{-1} , at first but by the time the mist and then fog occurred the winds became light and veered to the west and southwest at the surface whilst an anticyclone over eastern BoB slowly became weaker Figure 16. During the foggy day, 2nd March 2004, The mean temperature largely remained stable and matched the Yangon Airport average temperature during fog events, 21°C (Figure 12 and Figure 18). The influence of solar heating is obvious, and this fog lasted for only a few hours after sunrise, so it can be classified as a radiation fog (Figure 11 and Figure 18).

In addition to the previous results, observed meteorological parameters are plotted to represent the behavior of each fog type at both airports. Based on a visual examination of the variations in the meteorological factors, one event of each type of fog was chosen for each site as proof of the main process. The selected criteria were the seasonal occurrence at each location, the weather type associated with the day of occurrence and the fog event must be consistent in terms of intensity (reduction in visibility below 1000 meters) and persistence (greater than two hours in duration). Figure 19 allows a detailed analysis of these fog cases, concerning the temperature, the dewpoint, the soil temperature, the wind speed, and evaporation with the significant values changing with time between fog day (2nd March 2004) and non-fog day (1st March 2004).

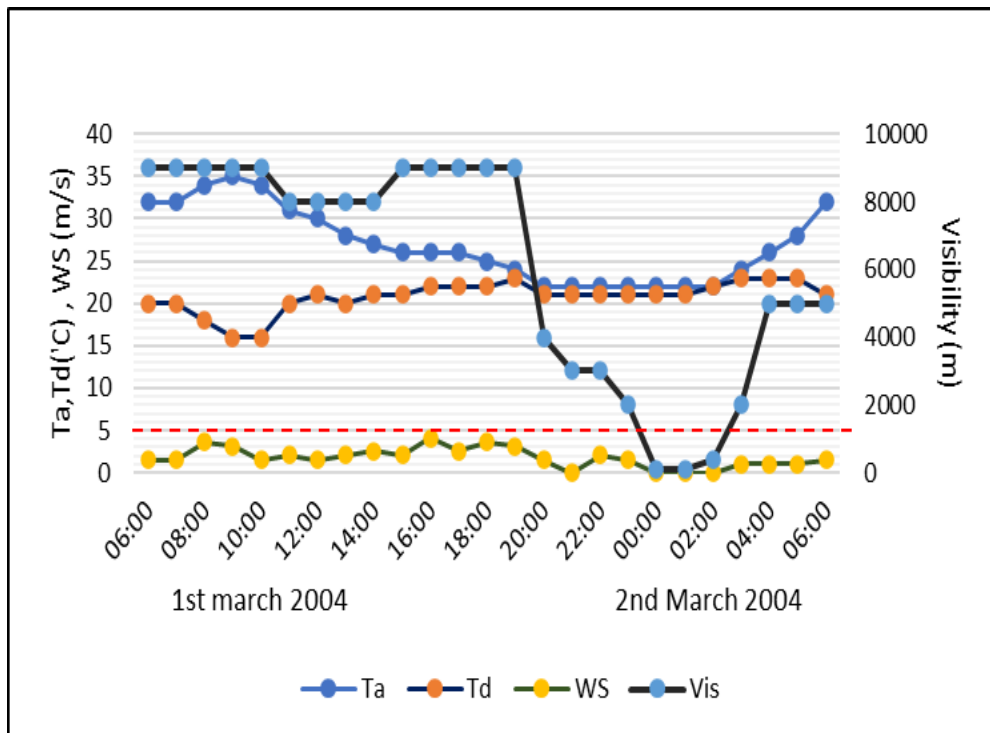


Figure 18: Mean temperature (Ta (in degrees Celsius)), dew-point (Td (in degrees Celsius)), wind intensity (WS) (in meters per second; left vertical axis) and visibility (Vis) (in meters; right vertical axis) as a function of time (UTC) on 1st and 2nd March 2004. The dotted red line denotes the isoline of 1,000-m visibility

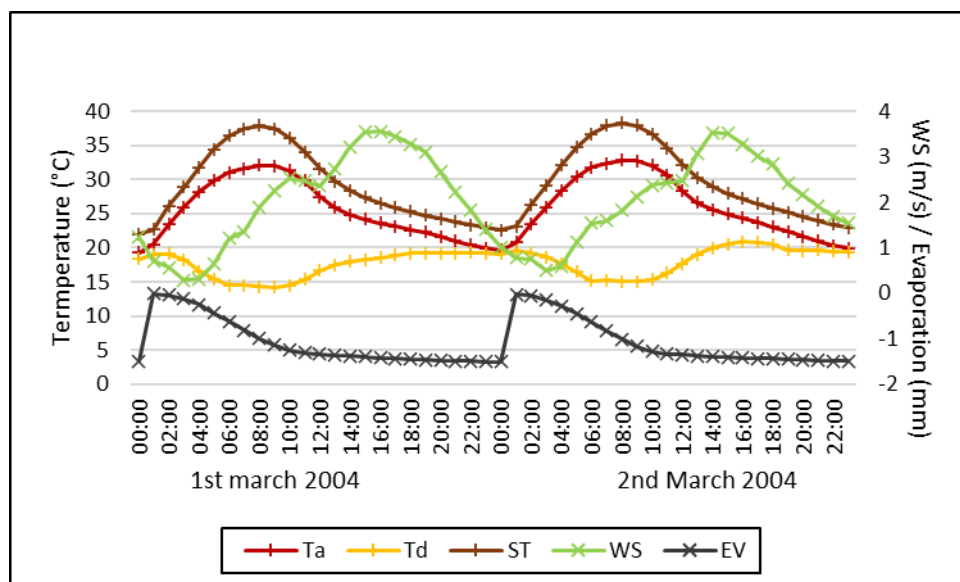


Figure 19 - Mean temperature (Ta (in degrees Celsius; right vertical axis)), dew-point (Td (in degrees Celsius; right vertical axis)), soil temperature ((St (in degrees Celsius; right vertical axis)), wind intensity (WS) (in meters per second; left vertical axis) and evaporation (EV) (in meters; left vertical axis) as a function of time (UTC) on 1st and 2nd March 2004. The fog event occurred from 23:00 to 0100 UTC on 2nd March.

The deviation of each fog type's beginning and dissipation from dawn and sunset, respectively, as well as its duration, horizontal visibility, and strength, can all be used to analyze its behavior (minimum visibility). In summary, the outcomes are as anticipated: fog requires weak winds, both synoptic and local, as seen in anticyclonic weather, as well as moist air over the estuary or coastal region and sustained cooling, as at night.

4. Conclusions

Before-Flight-Briefing without weather discussion will lead to your flight as a blindfold beyond your vision”
 Hlaing Myint (Flight Captain, Air Thankwin, Myanmar)

The airliner's daily path is chosen to benefit from weather or atmospheric conditions (e.g., jet stream tailwind to improve fuel efficiency). In addition, every pilot and aircrew need to know what weather situation has occurred on their route of flight. Pilots should gather all the necessary information regarding the nature of the flight before to each flight. This includes a weather briefing the pilot has gotten from a reliable weather source, the Internet, or a weather forecasting expert.

Yangon International Airport's fog climatology is the subject of this study, which is the first attempt to analyze it comprehensively. This was accomplished by the objective statistical study of climatic factors. This study has two objectives.

Firstly, the study links fog development to conditions in the lower troposphere and is in general agreement with many previous research conclusions about fog-forming conditions but for different locations [14, 16, 27-29]. Secondly, based on the application of the previously described complicated fog criterion, the study proposes a new way to evaluate the likelihood of fog occurrence. Phenomena compatible with fog occurrences at the airport are identified, and probabilities of fog occurrences under different atmospheric conditions are quantified.

In this study, we can learn about the climatology of Yangon International Airport, which is a vital resource for the country's economic gateway. Weather forecasters or specialists can get a lot of important and useful information for weather forecasters or specialists, such as analyzing what weather situation is the most important or best time for flight operations. A fog or misty weather phenomenon is most common in the wintertime. After examining numerous characteristics of Yangon International Airport, we identified two meteorological occurrences (TSRA and fog) that were extremely likely to result in plane crashes or operational delays. The aforementioned findings show that, following the widely accepted definition of fog, the frequency of fog at the airport is relatively high. The number of winter fog days was almost six times greater than in summer and 1.5 times greater than in autumn. The outcome suggests that the frequency of fog and mist at this airport is correlated linearly. Furthermore, fog events were categorized into two types, using criteria that were based on primary physical mechanisms responsible for fog formation. In both radiation and advection conditions, low visibility is frequently observed. Fog occurrences were most likely when the dew-point depression is 2° or lower, and the wind is 2.5 m s^{-1} or less. According to a diurnal and seasonal analysis, low visibility was most prevalent during late nights and early mornings. That suggests that radiation fog at Yangon International Airport is very common, and the fog occurrence is mainly due to radiative cooling, particularly in autumn morning hours. The increase in fog frequency observed at the airport is clear. Could this also be an effect of the rise in the level of air pollution in the nearby urban area? To explore this possibility, a more detailed study would be required than the one attempted in this paper, as the effect should be observable over a much wider area.

An analysis similar to this would be useful for determining the nature of fog dissipation at the airport. One could argue that the minimum temperature range between 16 and 27°C (liquid fog) was the one that was most conducive to the occurrence of fog. This probability is in agreement with the probability of fog occurrence in the presence of a stratus cloud, calculated from the observations (52 %). Finally, the present finding has another implication for forecasters. In order to get a realistic prediction of Yangon International Airport, other variables must be studied and the model must be simulated. This discovery raises a new question and offers a new possibility for approaching climatology from a new perspective and making progress in predictability studies, according to a well-known physicist.

Data Availability

Source Data

- Meteorological statistical data (METAR) based on the recommendations of the International Civil Aviation Organization (ICAO) and the World Meteorological Organization (WMO) is obtained from the Department of Meteorology and Hydrology (DMH, Myanmar) and the University of Wyoming. <http://weather.uwyo.edu/surface/meteorogram/seasia.shtml>. And these can be obtained freely.

- Flight delay and accident data are obtained from Aviation Safety Network (ASN) Aviation Safety Network > (aviation-safety.net) and ICAO safety API Data Service (icao.int) . These also can download freely.
- Historical Himawari-8 satellite images which developed by Japan Meteorological Agency can be obtained from JAXA Himawari Monitor (P-Tree System) freely.
- Aerodrome's Flight delay data are supported by YIA Service Company Limited and MC-Jalux Airport Services Company Limited and hence cannot be freely distributed. Requests for access to these data should be made to the <https://yangonairport.aero/index.php/en/>.
- The SST Niño 3.4 indexes (area-averaged SSTA over 150W - 90W, 5S - -5N) data are taken from the website of the National Centre for Atmospheric Research (US), Climate data Store and it can be obtained freely from Nino SST Indices (Nino 1+2, 3, 3.4, 4; ONI and TNI) | NCAR - Climate Data Guide (ucar.edu).
- And CAPE Index value, K-Index, and Bay of Bengal SST data are taken from ERA-5 reanalysis data from ECMWF <https://cds.climate.copernicus.eu/cdsapp#!/home?tab=overview>.
- Above Datasets are now freely available from 1950 to the present by registration at ECMWF.

Software availability

Open Grads (OpenGrADS - Home), Climate data operator (<https://code.mpimet.mpg.de/>) and IBM SPSS are mainly used for this study. Among these first two are open-source applications for everyone.

Conflicts of Interest

I declared that there is no potential conflict of interest with any of the following statements.

- For any component of the submitted work, the author received no cash or services from a third party (government, commercial, private foundation, etc). (Including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc).
- The author is not affiliated with any entity that has a direct or indirect financial interest in the manuscript's subject matter.
- The author was involved in the following aspects of the project: (a) idea and design, or data analysis and interpretation; (b) authoring the article or critically reviewing it for essential intellectual content, and (c) approval of the final version.
- This work has not been submitted to and is not currently being reviewed by any other journal or publishing venue.
- The author has no patents that are broadly relevant to the work, whether proposed, pending, or issued.
- The author received no payment or services from a third party for any aspect of the submitted work (government, commercial, private foundation, etc). (Including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc).

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