FOG NOWCASTING AND ITS INFLUENCE ON AVIATION OPERATIONS AT ENTEBBE INTERNATIONAL AIRPORT

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PRESENTATION OUT-LINE

- Introduction
- Definition
- Impact of fog on aviation
- Fog nowcasting methods
- Conclusion

Introduction

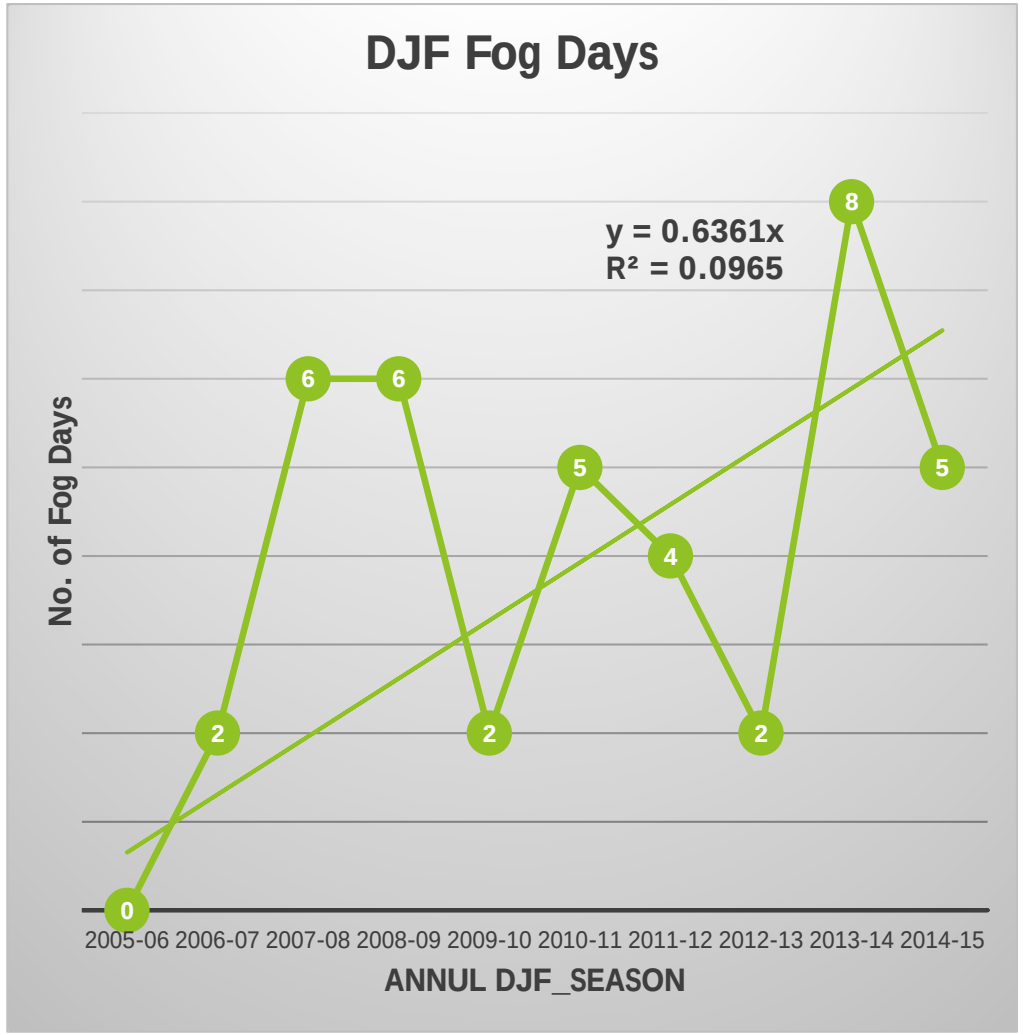
- Air transport in Uganda plays an increasingly important role in the import-export trade. As a land locked country, Uganda gains a lot from the civil aviation industry for economic and political survival since it guarantees access to the outside world. Of prime importance is the crucial role the sector plays in the promotion and sustenance of particularly high value, perishable goods like horticultural products and frozen fish. For instance, in 1998 fish exports accounted for 6550 tonnes representing 56% of the total exports followed by fresh produce at 24% (Kayabwe, 1999)

- The statistics show 1.34 million passengers used Entebbe airport in 2013, up from 1.23 million in 2012. The results further show 13,780 domestic passengers used the Airport in 2012, which number increased to 25,458 in 2013.
- Furthermore, 89,798 passengers landed in Entebbe before proceeding to other destinations in 2012 that increased to 94,583 in 2013.
  Exports increased from 22,131 tonnes in 2012 to 217,238 tonnes in 2013.

DEFINITION

- Fog is a surface based cloud composed of either water droplets or ice crystals. Fog is the most frequent cause of surface visibility below 3 miles, and is one of the most common and persistent weather hazards encountered in aviation. The rapidity with which fog can form makes it especially hazardous. It is not unusual for visibility to drop from VFR to less than a mile in a few minutes (FAA, 2002).
- Low visibility meteorological conditions, such as fog, are not necessarily considered extreme weather conditions, such as those encountered in storms, but their effects on society can be just as significant (Gultepe *et al.* 2009).

DJF seasonal fog variation



According to the above figure, an increasing trend has been drawn from the available dataset for fog days.

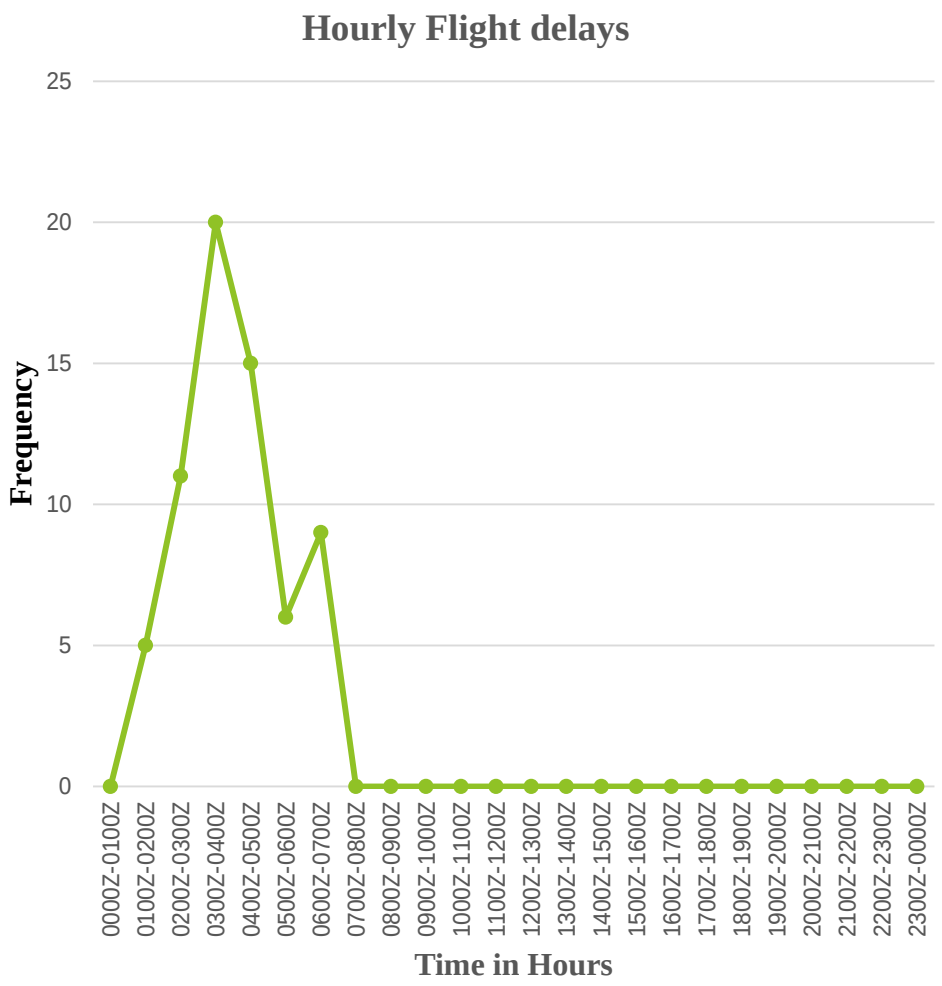
This trend has weak significance due to a discrepancy brought about by a very low value that is zero (0) and a high value of 8. The modal frequency was 2 fog days for 2006/07, 2009/10 and 2012/13 DJF seasons.

Its the principal international airport of Uganda. It is near the town of Entebbe, on the shores of Lake Victoria, and about 41 km (25 mi), by road, southwest of the central business district of Kampala, the capital of Uganda and its largest city. The coordinates of the airport are 00°02'41"N, 032°26'35"E (Latitude: 0.044721; 32.443055), elevated at 3782 feet above sea level, the airport is part of a peninsular bordering Africa's biggest fresh-water-lake, Victoria.

There are two runways namely; runway 12/30 (2,408 metres) and runway 17/35 (3,658m). However, only runway 17/35 is operational because it has the Instrument Landing System (ILS).

FOG IMPACT ON AVIATION OPERATIONS

Hourly aircraft delays analysis



From the analysis a total of 66 flights were delayed due to poor visibility, with mean average of 3 flights per hour in 24 hours a day.
The maximum number of flights delayed in a single hour was discovered to be 20 flights at 0300Z and 0400Z (0600AM and 0700AM).
Since fog development at EIA was discovered to be in morning hours it is evident that there were no flights delays in the afternoon hours due fog.
The modal frequency is zero flights, this is attributed to very short lived period of fog existence of radiative fog.

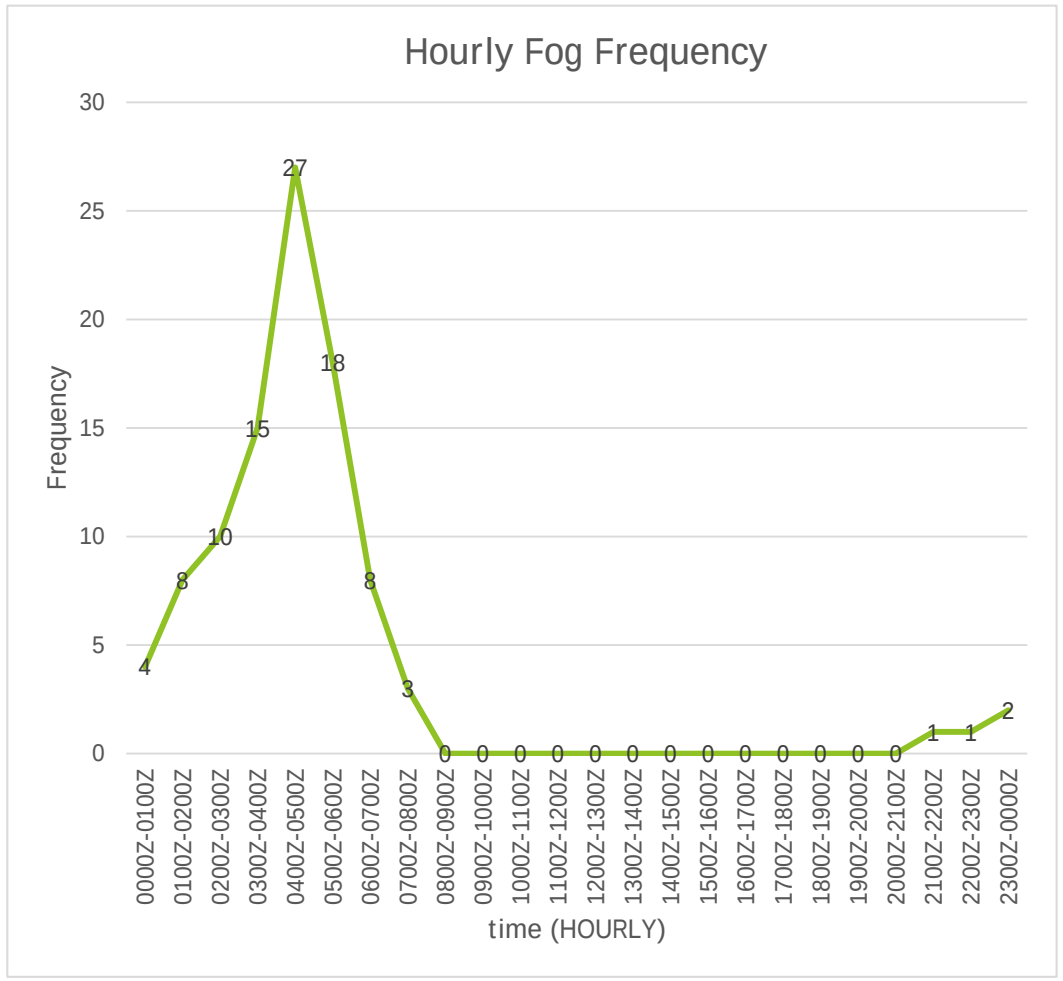
Correlation Analysis Between Hourly Fog and Hourly Flight Delays

	Hourly Fog	Hourly Flight Delays
Hourly Fog	1	
Hourly Flight Delays	0.854184418	1

- The correlation (0.9) from the analysis is very high and positive implying that the higher the frequency fog hour the higher the frequency of hourly flight delays.

Fog nowcasting methods

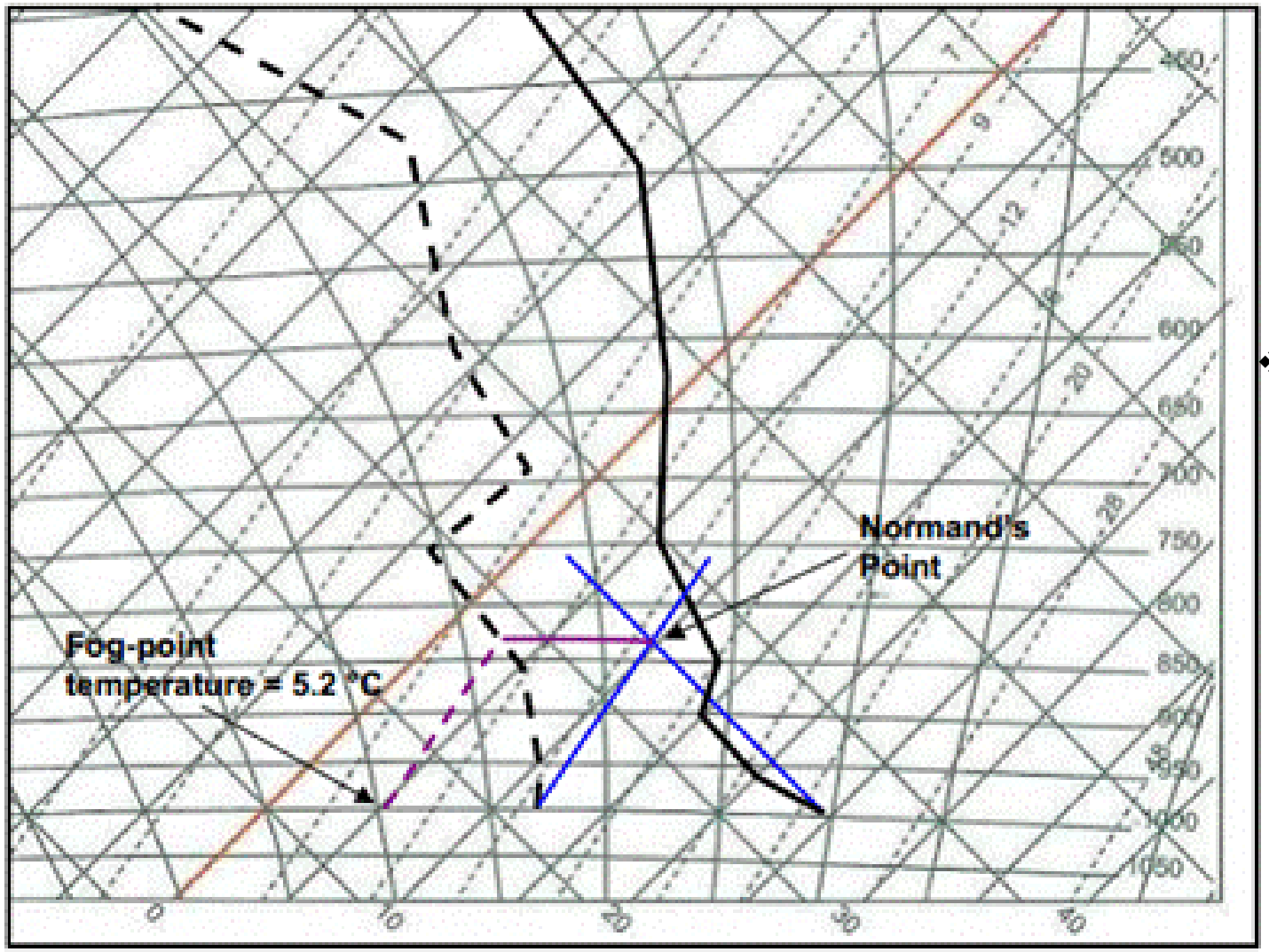
FOG FORMATION DURING DJF SEASON



From the hourly fog variation analysis it was discovered that early morning hours starting from 2100Z- 2200Z (0000AM-0100Z local time) exhibit the hours of fog occurrence, all the afternoon hours hardly had fog because solar radiation dissipates fog, therefore radiation fog is the type of fog experienced at EIA. The following figures 5 provides a statistical summary of hourly fog variation analysis.

- Meteorological parameters considered for fog nowcasting at EIA in the analysis approach are ambient temperature, relative humidity (RH), and wind speed. Hence these are closely scrutinized for model validation based on the observational data of Entebbe Airport.

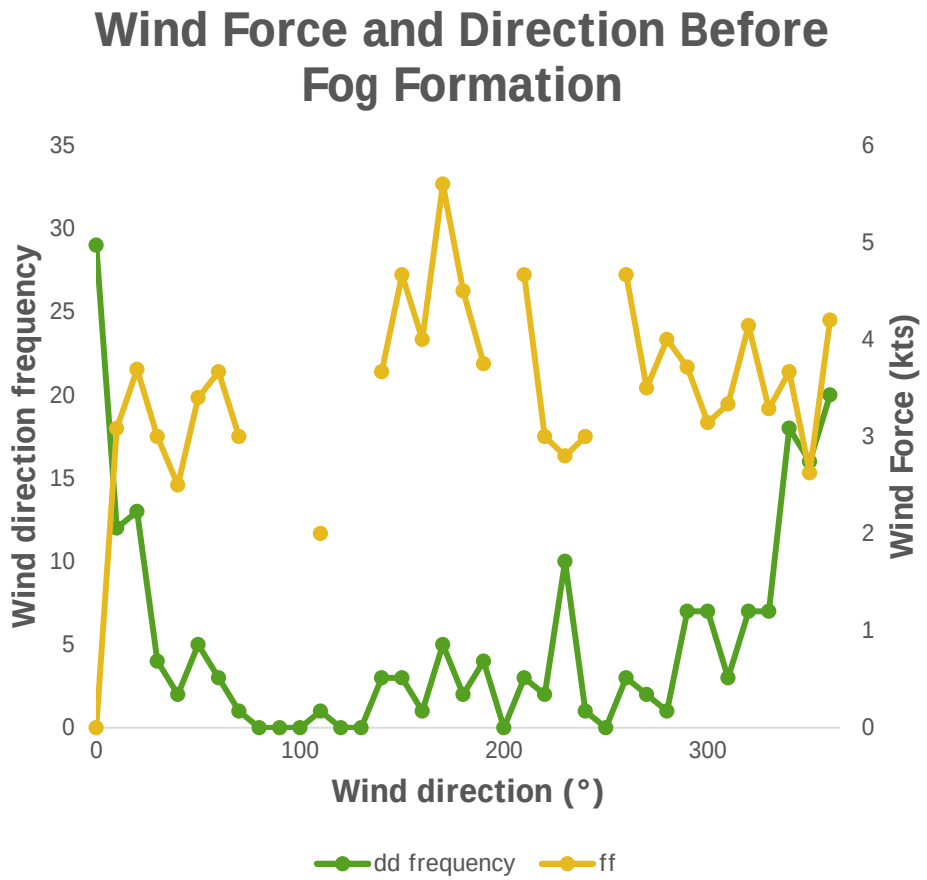
Sounding - Tephigram



- We use the tephigram to forecast the temperature at which radiation fog could form for a given airmass.
- Other aspects come into play, such as wind strengths, doud cover and moisture content of the air, but temperature is one of the key factors in radiation fog formation.

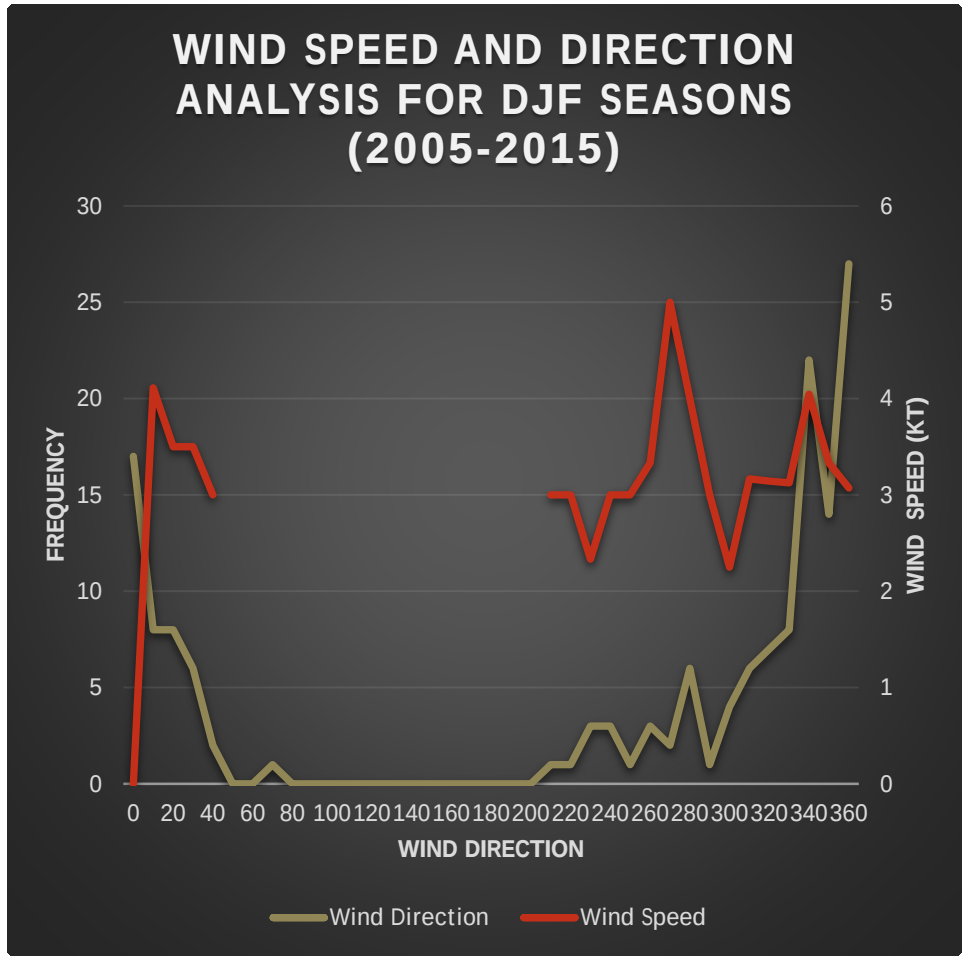
WIND ANALYSIS

- **Wind direction analysis before development**



Calm (00000KT) winds have dominated the wind direction 6 hours before fog formation with a frequency of 29 times for the considered DJF season 2005-2015.
This has been followed by 360° with a frequency of 19 times, 340° appearing 18 times and then by 350° appearing 16 times, therefore the considered period was dominated by calms and northerly winds.
The southerly winds ranged from 3 to 5 (140°to 210°) whereas the northerly winds ranged between 3 and 29 wind directions ranging between 300° to 30°. Therefore northerly winds from inland dominate the winds that prevail 6 hours before fog formation. EIA topography is a valley with northern parts gradually sloping into this valley. These northerly winds into the airport valley contributes to the creation of a temperature gradient which is a key contributing factor to the formation of radiation fog, that is experienced at EIA.

Wind analysis during fog events



Wind speed during fog events

Wind speed analysis has been effectuated to determine wind speed thresholds any given during fog event, statistical summaries from wind speed analysis has been given in the table below;

The total analyzed dataset for wind speed had 22 records with the highest wind speed being 5kts and the minimum of 0kts therefore ranging between 0 to 5kts ($0 \leq FF \geq 5$).

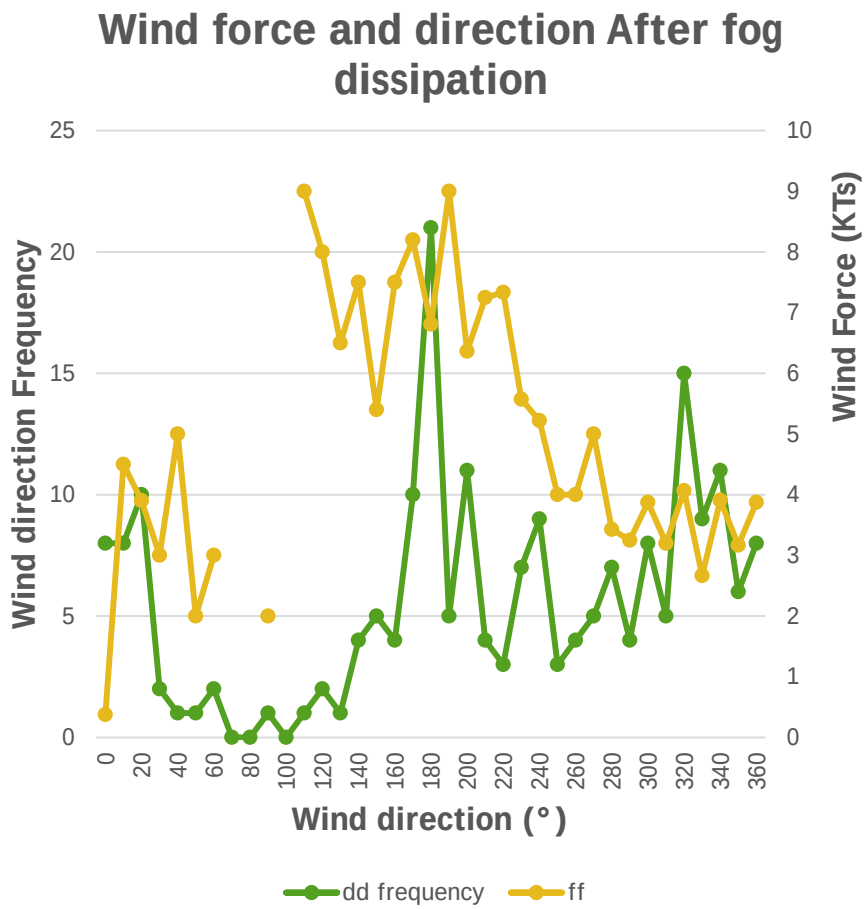
The mean speed during fog existence is 3Kts with a maximum of 5Kts and minimum being 0kts (calm wind).

Wind direction during fog events

The calm and northerly winds continue to dominate during fog existence, 360° dominating followed by 340°and then by calm winds with 26, 22 and 17 times frequencies respectively.

There's hardly no winds from the 80° to 200° sector therefore there is no winds blowing from the lake during fog existence because it is lake Victoria dominating the southern frontiers of EIA.

Wind speed and Direction Analysis after fog dissipation



Wind speed after fog dissipation

The strongest wind speeds were found to be 9 knots from 110° and 190° and the minimum being 0 knots also referred to as calm winds but with a frequency of 8 in the entire DJF seasonal analysis.

The total wind force was found to be 168 Knots with mean wind speed of 5 Knots just strong enough to dissipate the fog and the modal wind speed has been found to be 3 Knots.

Wind direction during fog dissipation

From figure 10 the dominant wind direction was 180° which is a southerly wind hence there a probability that there is influence of Lake Victoria winds in fog dissipation followed by 320° which is North North East Wind.

RECOMMENDATION

- Need for capacity building of UNMA forecasters in advanced modern fog forecasting techniques.
- UNMA need to cooperate with other countries that have already constituted Fog Nowcasting systems for better forecast.
- Due to limited resources, this study has not been carried out to its optimum capacity level whereby dynamical fog model development for EIA is the next level, incorporating in factors like LWC and Nd.

THANK YOU FOR YOUR ATTENTION
ANY PARTNERSHIP TO ENHANCE THIS WORK IS WELCOME