UNIVERSITY OF NAIROBI

ASSESSING PRESSURE AND TEMPATURE FORECASTS IN THE TAKE-OFF DATA AT JOMO KENYATTA INTERNATIONAL AIRPORT

BY

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I45/11418/2018

A Research Report Submitted in Fulfillment of the Requirements for Award of the Post Graduate Diploma in Meteorology of the University of Nairobi

2019

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DECLARATION

I declare that this Research Report is my original work and has not been submitted elsewhere for examination, award of degree or publication. In cases where I have used other peoples' work, I have acknowledged and referenced in accordance with the University of Nairobi requirements

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DEDICATION

I dedicate this work to my family and colleagues.

ACKNOWLEDGEMENT

I would like to first take this opportunity to thank The Almighty God for giving the strength and good health to carry out this project.

Special thanks to my family for their support, encouragement and understanding.

I also wish to appreciate the efforts of my lecturers at the University of Nairobi, School of Physical Sciences, especially my supervisors Dr. Mutemi and Dr. Mutai for their guidance, advice and supervision when writing this research paper.

I also wish to extend my gratitude to my classmates Aliyare Mohammed Warsame and Akhenda Casper Adodi for their contribution, prowess in computer skills and constructive critiques.

ABSTRACT

This research sought to assess the accuracy of forecasts of pressure and temperature as two of the three Take-Off data parameters issued, against the data observed on hourly basis at JKIA.

The hypothesis for this study is 'Pressure and temperature forecasts in the Take-off data at JKIA meet the required International Civil Aviation Organization (ICAO) standards'

Data on the pressure and temperature forecasts was sourced from the Take-Off data while the data on observed pressures and temperature was sourced from the routine meteorological aerodrome weather reports (METARS) respectively. These datasets are generated at JKIA and archived at Kenya Meteorological Department Headquarters (KMD).

Data was subjected to various data analysis and statistical techniques. Hourly average pressure and temperature values were calculated and plotted to determine the temporal evolution of these parameters. Scatter plot was used to show the distribution of error while Root Mean Square Error was used to calculate the accuracy of the forecasts. Contingency tables were used to determine the skill scores which included: Percent Correct, Post Agreement, Bias, Critical Success Index, Heidke Skill, Probability of Detection and Reliability.

From the findings, the Hypothesis was tested and found to be true and the skill scores fell under the ICAO recommended practice and standards.

Discussions and interpretations were done and conclusions and recommendations put forth.

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LIST OF ABBREVIATIONS

Hpa	Hectopascals
ICAO	International Civil Aviation Organization
ITCZ	Inter Tropical Convergence Zone
JKIA	Jomo Kenyatta International Airport
KMD	Kenya Meteorological Department
Mb	millibars
METAR	Meteorological Aerodrome Report
NWP	Numerical Weather Prediction
QFE	Query Field Elevation
QNE	Query Nil Elevation
QNH	Query Nautical Height
SPECI	Special weather report
WAFCs	World Area Forecast Centers
WMO	World Meteorological Organization

1 CHAPTER ONE

1.0 Introduction

This project aims to assess the take-off data especially the pressure and temperature forecasts produced for Jomo Kenyatta International Airport (JKIA).

1.1 Background

Weather forecasting basically involves three key steps, namely:

- Observation and Analysis,
- Extrapolation to find the future state of the atmosphere and
- Prediction of particular variable.

Different methods are used in weather forecasting depending on:

- Amount of information available,
- The level of difficulty that the forecast situation presents and
- The experience of the forecaster.

Forecasting methods are divided into two main categories namely:

- Qualitative methods
- Quantitative methods

The qualitative methods used in weather forecasting at JKIA include:

- Persistence method which assumes that tomorrows will be the same as today's if the conditions at the time of forecasting are the same or there are minimal changes. This method works well where weather patterns evolve slowly and weather systems move slowly.
- Climatology which involves getting the mean weather statistics over many years to make a prognosis although this method rarely gives accurate hourly forecasts since the forecast values may vary from the mean.
- Trend method which involves the evaluation of how weather parameters are evolving and predicting their future values. This method works well for pressure and temperature

forecasts since these parameters exhibit a diurnal cycle. This method provides more accurate forecasts when weather causing systems are in a steady state, stationary or they are moving at the same speed in the same direction over a long period of time.

- Weather Charts which provide an overview of significant weather in the past 24 hours and a prognosis of the next 24 hours.
- Analogue method which involves evaluation of the present weather and identifying a time in the past that presented similar weather conditions. A forecast is then made assuming that the weather will behave in the same manner as in the past event. This method involves composite chart analysis where current plots are superimposed on previous plots to guide the forecaster in predicting future values.

The quantitative methods used include:

- Statistical method which involves developing empirical relationships between the predicted and the predictor using historical data.
- Dynamical method (Numerical Weather Prediction) which involves integration of time dependent equations of motion and state that governs the atmosphere to make forecasts of various atmospheric variables.
- Dynamical Statistical method which is a combination of the two above.

Weather forecasting is categorized into four ranges as follows:

i) Short range forecasting which is further subdivided into:
   - Now-casting which is a forecast of between 0-2 hours.
   - Very short range weather forecasting which is a forecast of up to 12 hours.
   - Short range weather forecasting which is a forecast of between 12-72 hours.

ii) Medium range forecasting which is further subdivided into:
   - Medium range weather forecasting which is a forecast of between 3-10 days.
   - Extended medium range weather forecasting which is a forecast of between11-30 days.

iii) Long range forecasting which is a forecast of between 31 days to 2 years.

iv) Climatology forecasting which is a forecast beyond 2 years.

Take-off Data is a three hour forecast of the expected meteorological parameters on the runway from the hour an observation is made. It is categorized under short range forecasts and more specifically; Now-casting. It consists of wind (both direction and magnitude), air temperature and pressure. The forecast for the airport covers a radius of 5 nautical miles which is equivalent to 8 kilometers. Pressure is further divided into three namely: QNH, QNE and QFE. Pressure and temperature determine air density. Low temperatures and high pressures are good for aircraft performance during take-off and landing. Observed pressures and temperatures are plotted hourly and their graphs drawn diurnally. Hourly temperatures and pressures vary depending on the shortwave down-welling radiation mainly from the sun during the day and long-wave upwelling radiation during the night. The atmosphere being an open environment, pressure and temperature have an inverse proportionality relation, thus an increase in temperature results in a decrease in pressure and vice versa. Pressure forecasts are done for QNH while QNE and QFE are derived from QNH. Temperature forecasts are done for air temperature or dry bulb and dew point are calculated thereafter. Therefore for the purpose of this study, QNH and dry bulb values only will be used. Seasonal Pressure variations at JKIA are influenced by the position of the ITCZ (thus low pressures are experienced when the ITCZ is over our region which coincides with the onset of long rains and short rains period while high pressures are observed when the sun is overhead the tropics). It is also influenced by the strength and orientation St. Helena and Mascarene high pressure cells in the Southern belt and Azores and Arabian ridge (from Siberian high) in the North. It is also influenced by the East African Ridge which is an extension either Mascarene or St. Helena depending on which of them is stronger.

A Forecast is a statement of expected meteorological conditions over a specified area or portion of airspace for a specified time or period.

A meteorological observation is an evaluation of one or more meteorological elements.

Data verification is a process of confirming one types in what was intended to ascertain that no mistake is done during data entry. Validation on the other hand is the process of ensuring that the input data meets the data requirements of the system to avoid data errors.

Forecast verification are the procedures of assessing the quality of a forecast.

1.2 Statement of the Problem

Pressure and temperature affects aircrafts performance in a significant way. They both determine the quantity of payload and the distance the aircraft will have to cover on the runway to gain lift during takeoff or coming to a stop during landing. Take-off data is used for flight planning and with inaccurate forecasts, the airline is forced to offload or add more load at the hour of take-off thus inconveniencing the airline operators in terms of time wastage, delays, economic losses or accidents. Overloading may result in cases of overshooting the runway before gaining lift.

Take-off data is also used as landing forecasts and inaccurate forecasts might also result in overshooting the runway or crash landing before reaching the runway.

1.3 Hypotheses

The null hypothesis H_0, is 'Pressure and temperature forecast in the Take-off data at JKIA do not meet the ICAO standards'

The alternate hypothesis H_1, is 'Pressure and temperature forecasts in the Take-off data at JKIA meet ICAO standards'

1.4 Objectives

The main objective of this study is to assess the pressure and temperature forecast in the take-off data for JKIA.

Specific Objectives

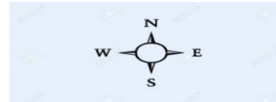
I. To determine temporal evolution of temperature and pressure at JKIA.
II. To evaluate the accuracy of pressure and temperature forecasts at JKIA.
III. To determine the skill of forecasts at JKIA with an insight into the attributes of verification.

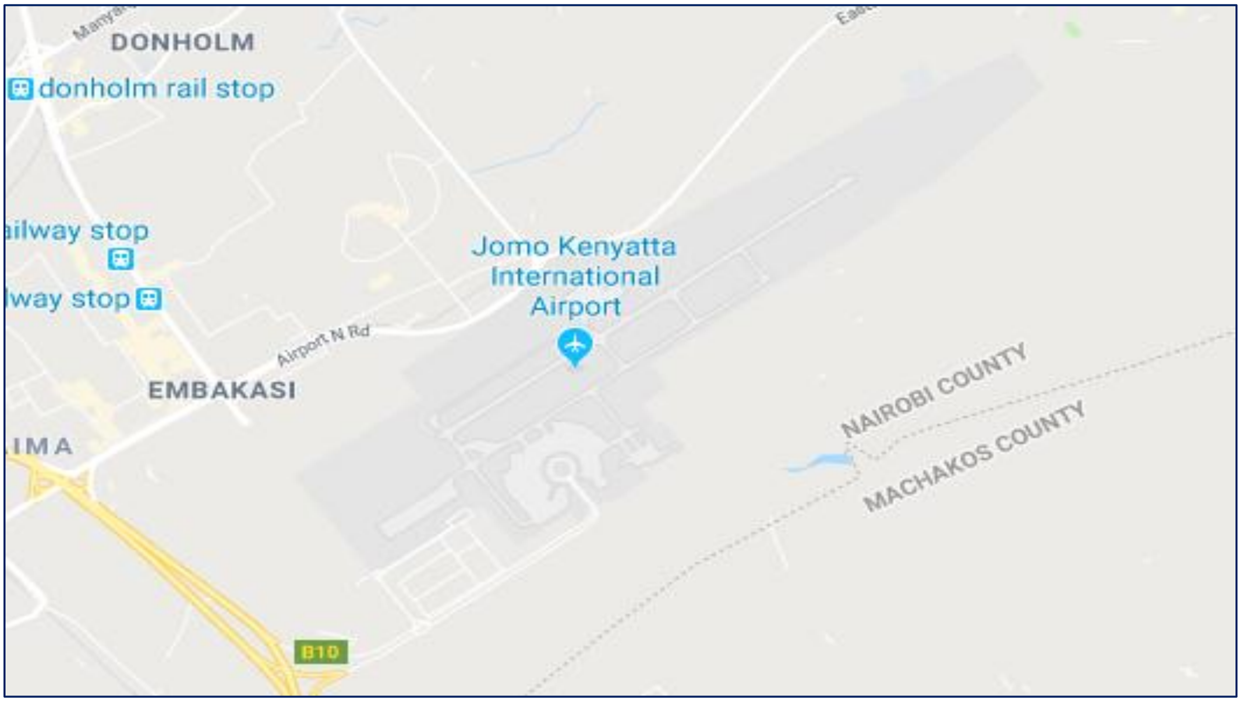
1.5 Area of Study

The study was done at JKIA in Nairobi, Kenya. JKIA is the busiest airport in Kenya and the larger East and Central African region and it is a Category I airport. It is located on Latitude 01° 19' S and Longitude 36° 55'E. Its elevation is 1624m or 5,329ft. Its standard pressure level is 840mb and the runway is 4117m. Boiling point is 94.647 ºC.

Figure 1: Map of JKIA.

MAP OF JKIA





1.6 Justification and Significance

Assessment of forecasts is key because it informs us of the accuracy of the forecasts issued and the need for improvement on the same. JKIA, having been elevated to Category I status implies that much more is required in terms of service delivery. Consequently, Meteorological services being essential to the aviation industry, its products need to be of good quality.

The demand for air transport is on the rise thus there is much need to assess the accuracy of forecasts issued at JKIA. Some of the indicators of growth in aviation industry include: formation of regional blocks like EA community, more countries are opening up their airspaces for bilateral and multilateral socio-economic activities, Africa is also being seen as the next frontier in economic development with many multinational companies opening up businesses in Africa, there is also marked improvement in the tourism sector. Therefore safety of the aviation industry is paramount and this calls for tough decisions based on the available meteorological information for proper planning.

2 CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter reviews previous studies that have been done in the field of forecast assessment and verification.

According to the International Standards and Recommended Practices in Annex 3 to the Convention on International Civil Aviation, the operationally desirable accuracy of forecasts for pressure value (QNH) is ±1 hpa or mb and the minimum percentage of cases within range is 90%. Air temperature has the same values, that's ±1 °c and minimum percentage of cases within range is 90%.

(Murphy, 1993), distinguished what makes a forecast good into the following three types:

Consistency - the extent to which the forecast corresponds to the forecaster's best evaluation about the situation, depending on the available information

Quality - the extent to which the forecast corresponds to what really occurred

Value - the extent to which the forecast guides a planner to make some incremental economic and/or other benefit.

Murphy came up with nine aspects which he called "attributes" that resulted to the quality of a forecast. They were:

Bias which is the correspondence between the averages of forecast and averages of observation.

Association which is the magnitude of the linear relationship between the forecasts and observations.

Accuracy which is the degree of agreement between the forecasts and observations. The difference between the observations and the forecasts is the error. The lesser the errors, the better the accuracy and vice versa.

Skill which is the relative degree of accuracy of the forecast as compared to reference forecast. Generally, the reference forecast could be unskilled forecast like random chance, persistence or climatology. Skill may imply betterment in accuracy levels due to purely the easiness of the forecast methods. Skill considers whether the accuracy levels of forecasts are good just because the weather is easier to forecast.

Reliability which is the mean agreement between the observations and forecasts. Suppose the forecasts were taken together, then generally bias and reliability are the same. Suppose the forecasts were stratified into different categories or ranges, then the reliability can be equated to conditional bias, meaning each category will have a different value.

Resolution which is the ability of the forecast to categorize the group of events into subgroups with different frequency distributions. Which implies that the distribution of outcomes when "A" was forecast will not be similar to the distribution of outcomes when "B" is forecast. Although the forecasts could be in accurate, the forecast system is said to have resolution if it is able to distinguish one type of outcome from another.

Sharpness which is the ability and/or frequency of the forecast to forecast extreme values. A forecast that is based on climatology lacks sharpness. Sharpness relies on the forecast only, and similarly for resolution, a forecast can have sharpness although it's wrong but its reliability will be poor.

Discrimination which is the ability of the forecast to discriminate among observations, meaning there can be higher forecast frequency for an event every time that event happens.

Uncertainty which implies the difficulty in making predictions when there is variability in observations. More uncertainties in observations results in more difficulties to forecast.

Over the years, accuracy and skill has been given greater significance over the other attributes in terms of forecast verification. The other attributes have been given much importance when determining the value of the forecast.

Quality and quantity of the data are of greater significance in validity of verification results. The higher quality and quantity of verification data the more the verification results can be trusted. It is advisable to have some error bounds on the verification results and have considerations for:

(a) uncommon events with typically small sample sizes,

(b) data with lots of variability, and

(c) cases where one wants to determine the statistical significance of a forecast product from the other.

Seaman et al. (1996), Wilks (2011, ch.5), Hamill (1999), and Kane and Brown (2000) came up with different methods of determining the confidence intervals for verification scores. These included analytic method, approximate, or bootstrapping methods which depended on the score.

Mwebesa (1979) indicated that an aircraft operates in an environment where weather has a crucial effect which determine the length of runway required for safe landing and takeoff. Flight planning is based on the temperature forecasts which affects engine performance. They perform well under low temperatures and their efficiency reduces with increasing temperatures.

Almazan (1992) found that 41% of aircraft delays in 1990 were related to weather with 17% being avoidable if decisions were made on more accurate forecast information, unnecessary flight scheduling and route changes which could have time and fuel.

3 CHAPTER THREE:

3.0 DATA AND METHODOLOGY

This chapter discusses the data and the methods that were used to achieve the main and specific objectives mentioned in section 1.4

3.1 DATA

The data that was used in this research is secondary data that was collected from the METARS and the Take-off Data at Jomo Kenyatta International Airport Meteorological Office.

METAR is routine weather report observed at hourly or half-hourly intervals. It is an evaluation of the meteorological elements observed at an airport at a specific time.

Take-off Data is a three hour forecast of the expected meteorological parameters on the runway from the hour an observation is made.

The data was collected over a period of one year, that is, 2018.

3.2 DATA QUALITY CONTROL

With the implementation of Quality Management Systems as a requirement by WMO and ICAO standards, all meteorological aviation weather providers ensure that data undergo quality control and validation before transmission storage.

3.3 METHODOLOGY

This section presents the various methods that were used to determine the temporal variability of pressure and temperature, accuracy of the forecasts and their skill scores.

3.3.1 Method of determining temporal evolution of pressure and temperature

To determine the temporal evolution of pressure and temperature, hourly averages were calculated and time series curve plotted.

3.3.2 Method of determining the accuracy

To assess the accuracy for both pressure and temperature forecasts, Scatter Plot was used to show how the forecasted and observed values correlated with a near straight line indicating a strong correlation. Then Root Mean Squared Error (RMSE) method was used to determine the accuracy of the forecasts where the smaller the value showed the better accuracy levels and vice versa.

The formula for RMSE used is given below:

$$\mathbf{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(F_i - O_i)^2}{N}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 1.}$$

Where: F_i is the Forecasted value.

O_i is the corresponding Observed value.

N is the total number of Forecasts/Observations.

3.3.3 Method of determining the Skill of Forecast

Data for both the pressure and temperature values were sorted in ascending order and divided into three categories of Below Normal, Near Normal and Above Normal.

To determine the skill of forecast, 3X3 contingency tables was used and its attributes such as: Percentage Correct, Probability of Detection, Post Agreement, Heidke Skill Score, Bias, and Reliability were calculated.

Table 1: A sample of a 3X3 Contingency Table

		Forecasting Category			
		Below	Normal	Above	Totals
Observation Category	Below	A_{11}	A_{12}	A_{13}	J
	Normal	A_{21}	A_{22}	A_{23}	K
	Above	A_{31}	A_{32}	A_{33}	L
	Totals	M	N	O	T

The Associated skill scores were calculated as follows:

Percentage Correct (PC)

PC is the percentage of all the forecasts that matched with the observed values divided by the total forecasts/observations. The forecast values that had errors of +/-1 were considered as correct since they fall under the desirable accuracy.

PC $= \frac{(A_{11}+A_{22}+A_{33})\times 100}{T}$………………………………………….……………... Equation (2)

Post Agreement (PA)

PA is the number of correctly forecasted values divided by the number of all forecasts for every category.

PA $= \frac{A_{11}}{M}, \frac{A_{22}}{N}, \frac{A_{33}}{O}$……………………………………….…………………….….. Equation (3)

(for each category)

Probability of Detection (POD)

POD is the number correctly forecasted values divided by the number observed values in every category. It measures the capability to forecast correctly a specific category. POD is also referred to as the Hit Rate for cases of severe weather assessment.

POD $= \frac{A_{11}}{J}, \frac{A_{22}}{K}, \frac{A_{33}}{L}$………………………………………………………..……… Equation (4)

(for each category)

Bias

Bias is the total number of forecasted values divided by the total number observed values for each category. Bias measures the ability to predict values at the same frequency as those in the sample without considering the forecast accuracy.

Bias = $\frac{M}{J}, \frac{N}{K}, \frac{O}{L}$ …………………………………………………………….…… Equation (5)

(for each category)

Where: Bias equals 1 implies no bias.

Bias is greater than 1 implies over forecasting.

Bias is less than 1 implies under forecasting.

Critical Success Index (CSI) or Threat Score

This is a fraction between the number of correct forecasts and the total number of times the event was forecasted or observed. CSI=1 means a perfect forecast.

CSI = $\frac{A_{11}}{M+J-A_{11}}, \frac{A_{22}}{N+K-A_{22}}, \frac{A_{33}}{O+L-A_{33}}$…………..……………………..……..… Equation (6)

(for each category)

Heidke Skill Score (HSS)

HSS shows how good a model is compared to climatology. The higher the value of HSS the better the forecast while a negative value shows the forecast is worse than climatology.

HSS = $\frac{(A_{11}+A_{22}+A_{33})-\frac{JM+KN+LO}{T}}{T-\frac{(JM+KN+LO)}{T}}$………………………….………….……... Equation (7)

Reliability

When the averages of the differences between observed values and forecasted values are calculated, a positive value indicates over forecasting of the observed values while a negative value indicates under forecasting of the observed values.

Reliability $=\frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)$……………………………………………………….. Equation (8)

Hanssen-Kuiper Score (HK)

HK gives a measure of the accuracy both for events and non-events and it ranges from minus one to one. A score of less than zero shows the model is unable to produce a significant forecast. HK=1 means a perfect forecast.

HK$=\frac{Hits}{Hits+Misses}-\frac{False\ Alarms}{False\ Alarms+Correct\ Negatives}$………………..…………………..……Equation (9)

4 CHAPTER FOUR:

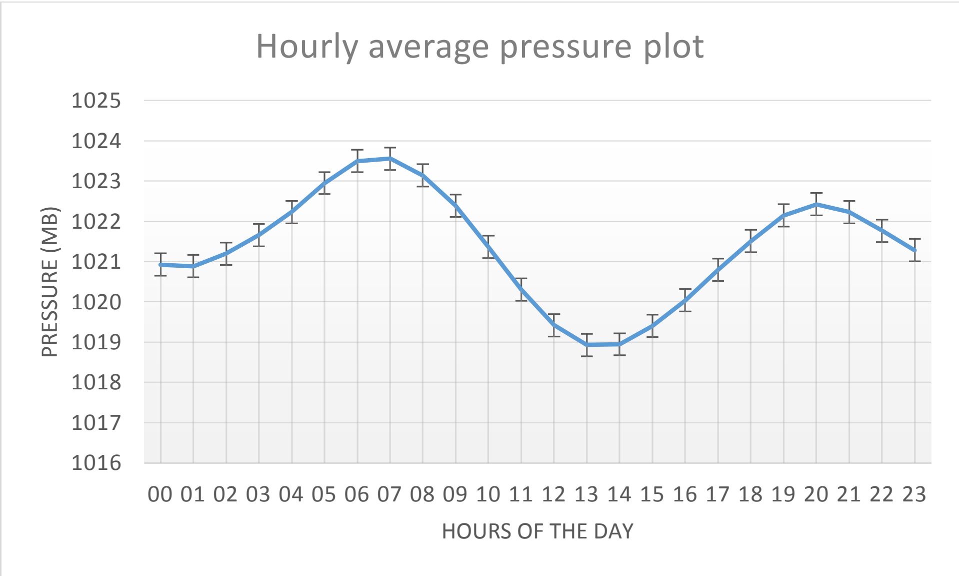
4.0 RESULTS AND DISCUSSIONS

This Chapter presents the findings from the research and discussions.

4.0 Results for Temporal evolution for Pressure and Temperature.

Mean hourly evolution for pressure was determined as shown in Fig. 2 below:

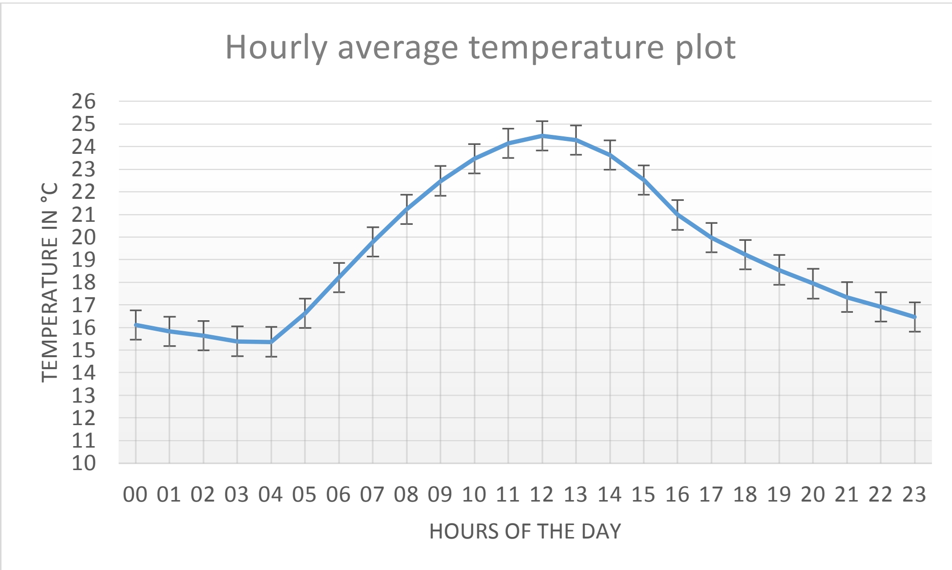
Fig. 2: Hourly average pressure plot.



From Fig. 2 above, it shows that on average there is a diurnal cycle with two crests and two troughs where the highest pressures are observed at 0400UTC or 0700Hrs and the lowest at 1000UTC or 1300Hrs. This is so because the atmosphere is coldest at 0400UTC and hottest at 1000UTC and since the atmosphere is an open environment, there is an inverse relationship between temperature and pressure.

Mean hourly evolution for temperature was determined as shown in Fig. 3 below:

Fig. 3: Hourly average temperature plot.



From Fig. 3 above, it shows that on average there is a diurnal cycle with highest temperatures of the day were observed at 1200UTC or 1500Hrs local time with the lowest being observed at 0400UTC or 0700Hrs. The lowest temperatures observed at 0400UTC can be attributed to the fact that earth surface and atmosphere losses heat all night till daybreak while the highest temperatures at 1200UTC is due to solar insolation and the fact that by this time, the earth surface has heated enough and is also emitting radiations into the atmosphere.

4.1 Results for Accuracy of the forecasts.

The Scatter Plot for Pressure is as shown in Figure 4 below:

Fig. 4: Pressure scatter plot.

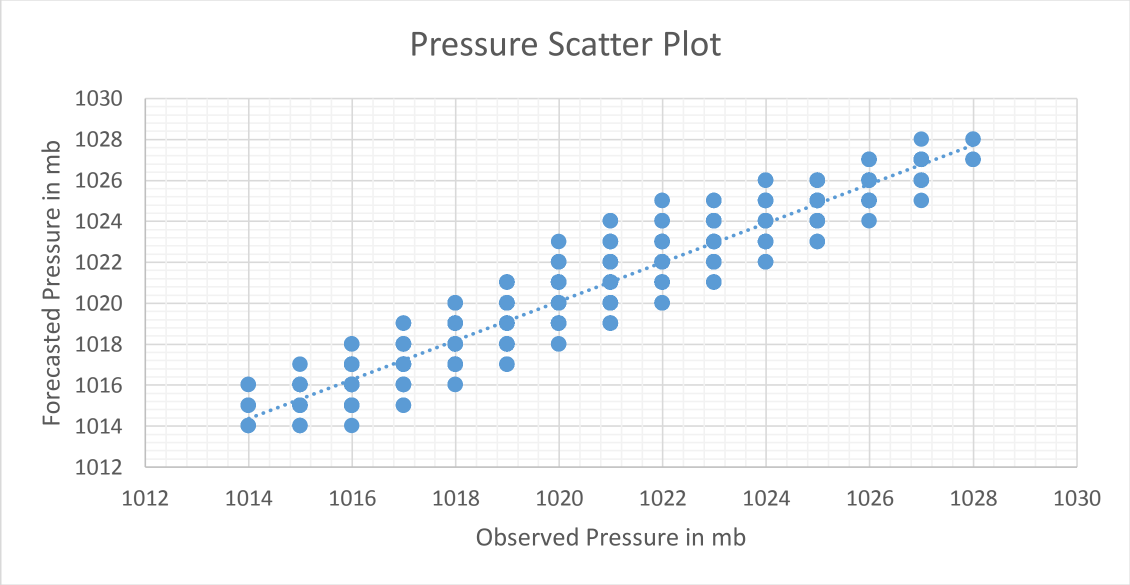


Fig. 4 above shows the distribution of errors falling on a near straight line which indicates that there was a strong correlation between the forecasted and observed pressure values.

The Scatter Plot for Temperature is as shown in Figure 5 below:

Fig. 5: Temperature scatter plot.

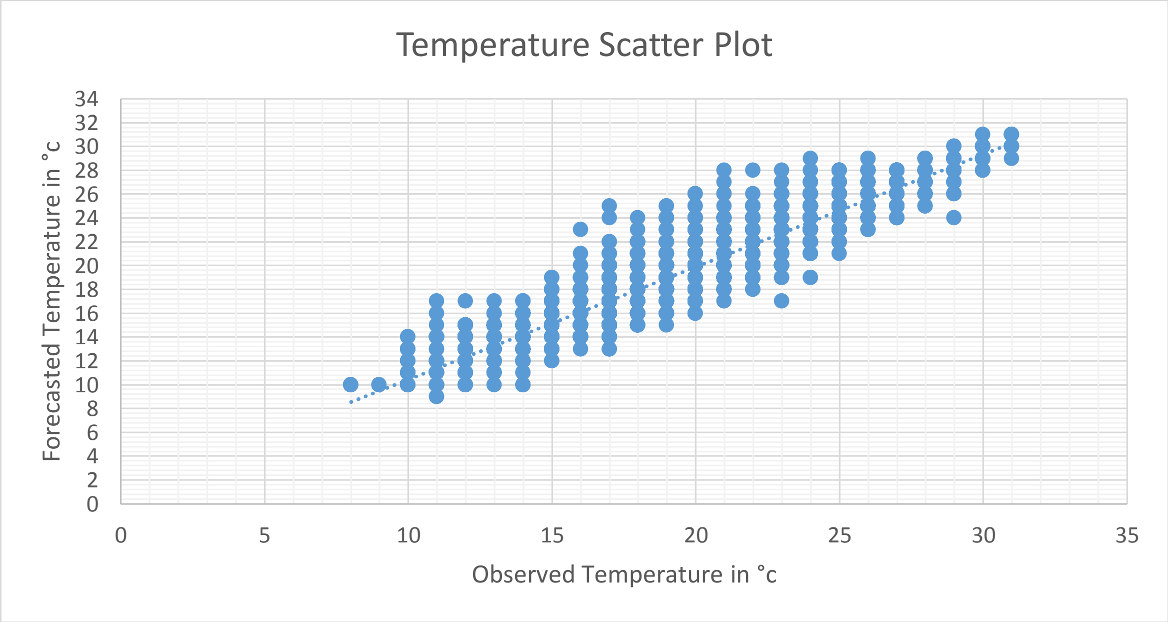


Fig. 5 above shows the distribution of errors falling on a near straight line which indicates that there was a strong correlation between the forecasted and observed temperature values.

The RMSE for Pressure was **0.355207074** which is a low value thus indicating the accuracy levels are high.

The RMSE for Temperature was **1.000912825** which is a low value thus indicating the accuracy levels are high.

The results show that there is more accuracy in forecasting Pressure than Temperature although both scores good.

4.2 Results for the Skill Scores

The table below shows the Contingency table used to calculate the various skill scores for Pressure.

Table 2: Contingency table for pressure.

		OBSERVED PRESSURE			
		BELOW	NORMAL	ABOVE	TOTAL
FORECASTED PRESSURE	BELOW	816	145	0	961
	NORMAL	149	5742	222	6113
	ABOVE	0	241	1445	1686
	TOTAL	965	6128	1667	8760

The results for various skill scores are as follows:

Table 3: Skill score values for pressure from the contingency table.

SKILL SCORE	SKILL SCORE VALUE		
	BELOW NORMAL	NEAR NORMAL	ABOVE NORMAL
PA	0.849116	0.93931	0.857058
POD	0.845596	0.93701	0.866827
BIAS	0.995855	0.997552	1.011398
CSI	0.393253	0.45474	0.404196
HK	0.826994	0.796053	0.832849

Table 4: Other skill score values.

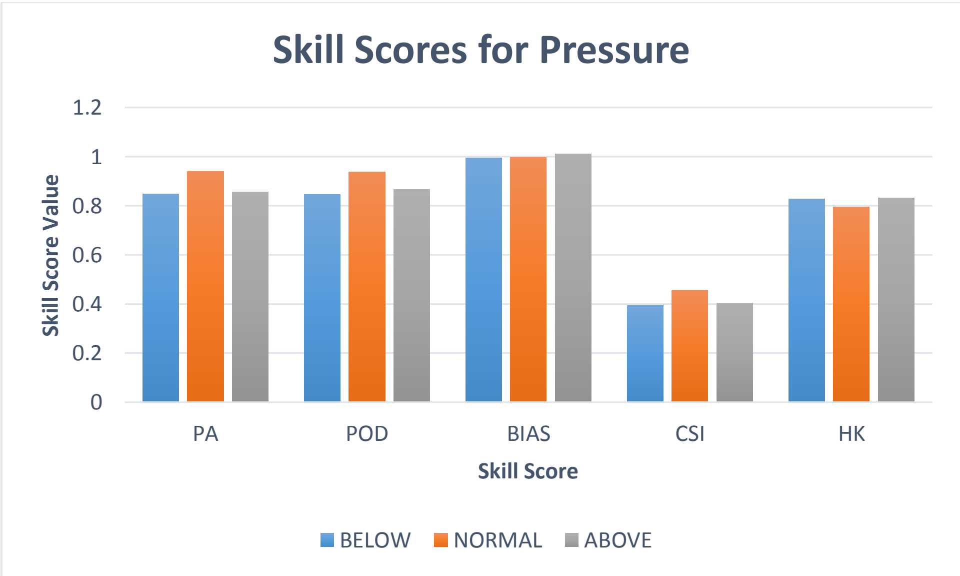
SKILL SCORE	SKILL SCORE VALUE
P.C	0.913584
HSS	0.813408
RELIABILITY	0.028425

From Table 4 above:

PC was at 0.913 which is above 90%

Reliability had a positive value of 0.028 which indicates that there were slight cases of over forecasting.

Figure 6.Skill score plot for pressure.



From Fig 6. Above, it was found that:

For PA, the values were almost the same at averagely 0.9 with the category for Normal being slightly higher.

For POD, the values were almost the same at averagely 0.9 with the category for Normal being slightly higher which indicates that the ability to forecast was generally good in each category.

For BIAS, the values were almost the same at averagely 1.0 with the category for Normal being slightly higher which indicates that there were negligible cases of under forecasting and/or over forecasting.

For CSI, the values were almost the same at averagely 0.4 with the category for Normal being slightly higher.

For HK, they values were almost the same at averagely 0.8 with the category for Normal being slightly lower.

The table below shows the Contingency table used to calculate the various skill scores for Temperature.

Table 5: Contingency table for temperature.

		OBSERVED TEMPERATURES			
		BELOW	NORMAL	ABOVE	TOTAL
FORECASTED TEMPERATURES	BELOW	843	256	0	1099
	NORMAL	212	5731	240	6183
	ABOVE	0	205	1273	1478
	TOTAL	1055	6192	1513	8760

The results for various skill scores are as follows:

Table 6: Skill score values for temperature from the contingency table.

SKILL SCORE	SKILL SCORE VALUE		
	BELOW NORMAL	NEAR NORMAL	ABOVE NORMAL
PA	0.767061	0.926896	0.861299
POD	0.799052	0.925549	0.841375
BIAS	1.041706	0.998547	0.976867
CSI	0.356298	0.446479	0.393996
HK	0.765827	0.749537	0.813087

Table 7: Other skill scores.

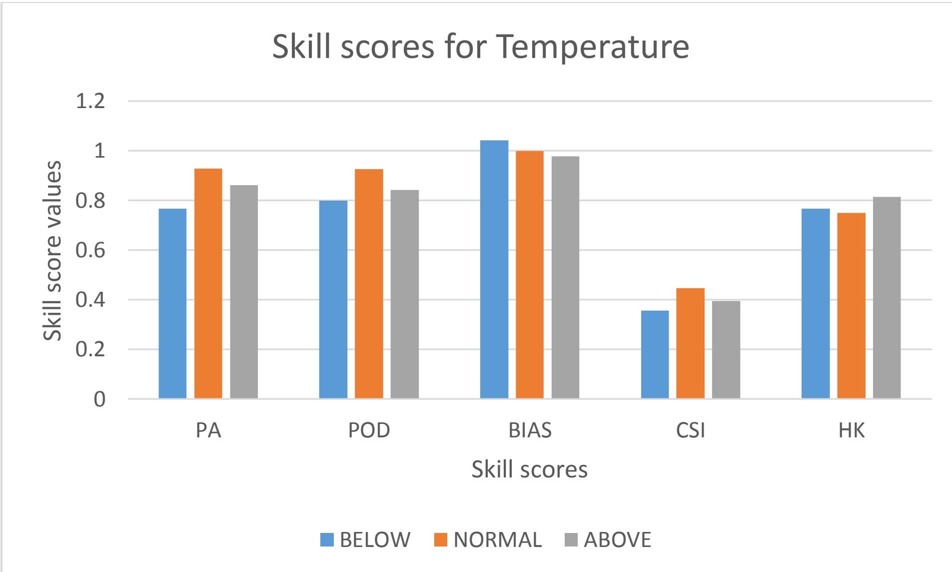
SKILL SCORE	SKILL SCORE VALUE
P.C	0.895776
HSS	0.771859
RELIABILITY	-0.08755

From Table 7 above:

PC was at 0.896 which is almost 90%

Reliability had a negative value of -0.0876 which indicates that there were slight cases of under forecasting.

Figure 7: Skill score plot for temperature.



From Fig 7. Above, it was found that:

For PA, the values were almost the same at averagely 0.9 with the category for Normal being slightly higher.

For POD, the values were almost the same at averagely 0.9 with the category for Normal being slightly higher.

For BIAS, the values were almost the same at averagely 1.0 with the category for Below being slightly higher followed by Normal and Above respectively

For CSI, the values were almost the same at averagely 0.4 with the category for Normal being slightly higher.

For HK, they values were almost the same at averagely 0.8 with the category for Normal being slightly lower.

5 CHAPTER FIVE

5.0 CONCLUSSIONS AND RECOMMENDATION

5.1 Conclusions:

The accuracy levels for both the pressure and temperature forecasts at JKIA were found to be above the threshold of 90% set by ICAO standards thus the alternate Hypothesis H_1 holds.

All the skill score recorded the recommended high values which is an indication of good forecasting skills.

The forecasts for pressure had more accuracy levels as compared to temperature forecast. This can be attributed to the fact that pressure changes occur gradually as compared to temperature which could be erratic.

The high accuracy levels and skill score values can be attributed to the fact that Take Off forecasts are short range forecasts (Nowcasting) which limits growth of error as compared to long range forecasts.

The three categories of Below, Normal and Above didn’t have much differences in terms error distribution and skill scores. This is because Take-off data is forecasted continuously and with the use trend method and analogue method the slight variations can occur in any of the categories.

Drastic drop in forecasted temperatures were observed during afternoon storms mainly during the long and short rainy seasons where temperatures dropped even by up to 5-7°C within an hour from the predicted values.

5.2 Recommendations:

Due to the airport’s proximity to the Equator and since weather forecasting within the tropics has more challenges as compared to the mid-latitudes and extra tropics, I recommend that JKIA develops its own customized forecasting models since the ones being used are subscribed to expensively and might not be capturing real factors affecting JKIA weather.

Most models have low resolutions making it harder to make forecasts for smaller areas. I recommend that their resolutions be improved to enhance better forecasting.

The NWP products from World area forecasts centers (WAFS) are issued and amended at intervals of 6 hours, that is, 00, 06, 12 and 18UTC. I recommend that they could be issued on hourly basis to improve Take-off forecasts which are done hourly.

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