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Predicting the development of weather phenomena that influence aviation at Abu Dhabi International Airport

by

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SUMMARY

Predicting the development of weather phenomena that influence aviation at Abu Dhabi International Airport

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Keywords: Abu Dhabi, United Arab Emirates, Shamal, Nashi, fog, sand storm, dust storm, thunderstorm, rain trough, tropical depression, land and sea breezes.

The United Arab Emirates is a new country that has had little time to accumulate a scientific heritage. Meteorologically researched and documented weather material for forecasters is virtually non-existent and that available is fragmented and anecdotal.

The thesis tackles this problem by identifying weather phenomena significant to aviation in the Emirates and particularly at Abu Dhabi International Airport (ADIA). Mechanisms responsible for their development are described and applicable forecasting rules and principles are derived. Surface and upper air observation data at ADIA from 1983 to 2002 were analysed to identify the weather phenomena, their associated weather systems and for statistical analyses. When relevant, observation data at Al Ain was also used. Post-processed numerical weather prediction Global Forecast Service Eta model data are used and when and where possible radar and satellite imagery. A secondary aim is to provide information of the general seasonal climate. This was achieved by means of a literature study of the dominating weather systems and the presentation of surface and upper air mean circulation charts.

Fog is the most important weather phenomenon and serious disrupter of aviation at ADIA throughout the year. It does not occur during Shamal conditions, but fog can form well inland on the edge of the Empty Quarter at the Liwa Oasis when the Shamal wind becomes light. Contrary to local belief, fog is unlikely to occur on two, or more, consecutive nights. The Shamal can last for several days and disrupt helicopter flights to the oil rigs, while anabatic and katabatic effects often make it gustier and stronger inland at Al Ain than ADIA. While dust storms occur in strong southerly winds off the desert, the Shamal can bring dust from further afield from the north as can the previously unreported Nashi wind. The sea breeze can extend about 150 km inland to Al Ain and the Liwa Oasis. Thunderstorms associated with winter upper air troughs from the west, are the main producers of rain, while occasional thunderstorms off the Hajar Mountains in the east bring some rain in summer. Tropical depressions are a rare event.

SAMEVATTING

Voorspelling van die ontwikkeling van weerverskynsels wat lugvaart by die Abu Dhabi Internasionale Lughawe beinvloed

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Die Verenigde Arabiese Emirate (VAE) is ‘n nuwe land min tyd gehad om ‘n wentenskaplike erfnis op te bou. Weerkundige navorsing sowel as die dokumentasie van weervoorspelling-tegnieke en kennis bestaan amper nie en dit wat wel bestaan is, is gefragmenteer en in is hoofsaaklik anekdoties (van aard).

In hierdie theses word die problem aangespreek deur die identifisering van belangrike weer-verskynsels asook die gepaardgaande weerstelsels wat ‘n invloed het op lugvaart in die Emirate en veral by Abu Dhabi Internasionale Lughawe. Die meganismes verantwoordelik vir hul ontwikkeling word beskryf sowel as die reëls en beginsels toepaslik vir die voorspelling van hierdie weerstelsels. Weerkundige waarneemings, te Abu Dhabi en wat oor twintig jaar (1983 tot 2002) strek, oppervlak asook bolug, was nagevors om hierdie weer-verskynsels en die weerstelsels wat hulle veroorsaak te identifiseer. Hierdie data is ook vir statistiese doeleindes aangewend. Waar van toepassing was die oppervlak waarnemings te Al Ain ook benut. Data afkomstig van die Numeriese Globale Voorspellingsdiens Eta Model was ook gebruik, wanneer en waar moontlik, asook radar en satelietbeelde. ’n Tweede doel van die projek was die opstel van ’n algemene klimatolgie vir die Emirate. Dit is bereik deur ‘n literatuurstudie van die dominante weerstelsels en aangevul deur die opstel (voorsiening) van oppervlak en bolug gemiddelde sirkulasiekaarte.

Die voorkoms van mis is die heel belangrikste weerverskynsel en het ’n ernstige en nadelige invloed op lugvaart by die Abu Dhabi Internastionale Lughawe. Mis kom nie voor gedurende Shamal toestande nie, maar dit kan vorm in die binneland veral in die omgewing van die Liwa Oase wanneer die Shamal wind swak word. In stryd met plaaslike (opvatting) mening, is die voorkoms van mis onwaarskynlik op twee of meer opeenvolgende aande. Die Shamal kan vir etlike dae lank duur en helikopter vlugte na die oliebore ontwrig. Anabatise en katabatise effekte maak dit dikwels meer turbulent and sterker in die binneland by Al Ain. Sandstorms kom voor wanneer ‘n sterk suidelike wind uit die woestyn waai. Die Shamal kan ook stof van ver in die noorde bring en so ook die Nashi wind wat nog nie vantevore beskrywe was nie.. Die seebries kan so ver as 150 km die binneland indring en word waargeneem by Al Ain en die Liwa Oase. Donderstorms, geassosieer met winter bolug troë vanuit die weste, is die belangrikste bron van reën, maar in die somer kom reën af en toe voor uit donderstorms wat ontstaan oor die die Hajarbege in die ooste. Tropiese laagdrukstelsels (tropiese werwelstorms) kom baie selde voor.

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DECLARATION

I, Michael Pierre de Villiers, declare that the thesis, which I hereby submit for the degree Doctor of Philosophy at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

SIGNATURE: ……

DATE: ……

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LIST OF SYMBOLS

°	Degree.
°C	Degrees Celsius, previously Centigrade.
θ_e	Wet-bulb potential temperature.
≥	Equal to, or greater than.
>	Greater than.
≤	Equal to, or less than.
<	Less than.
ω	Vertical motion in the pressure coordinate system.

LIST OF ABBREVIATIONS

ADIA	Abu Dhabi International Airport.
AGL	Above ground level.
AMS	American Meteorological Society.
AVN	Aviation NWP model product.
BLDU	Blowing dust.
BR	Mist.
CAPE	Convective available potential energy.
CAT	ILS category level.
DALR	Dry adiabatic lapse rate.
dBZ	Radar reflectivity unit. The reflectivity is related to the number of drops per unit volume and the 6^{th} power of their diameter. Rainfall rate can be determined using an empirical formula called the Z-R relationship.
DU	Dust.
ECMWF	European centre for medium range weather forecasting.
FG	Fog.
ft	Feet
GFS	Global Forecast Service.
gpm	geopotential metres.
GRADS	A type of NWP model post-processing product
hPa	Air pressure in hectoPascals. Previously millibar(s) was used.
HZ	Haze.
ICAO	International Civil Aviation Organization.
ILS	Instrument landing system.
KT	Knots.
m	Metres.
ms^{-1}	Metres per second
MSL	Mean sea level.
NWP	Numerical weather prediction.
NWS	National Weather Service (USA).
PCRGIDDS	Personal Computer based Gridded Interactive Display and Diagnostic System.
PPI	Plan position indicator.
RVR	Runway visual range.
SALR	Saturated adiabatic lapse rate.
SAWS	South African Weather Service, formally the South African Weather Bureau.
UAE	United Arab Emirates.
UK	United Kingdom.

UKMO	United Kingdom Meteorological Office.
UTC	Universal Time Corrected. The same as Greenwich Mean Time (GMT).
VCFG	Fog in the vicinity.
WAFS	World area forecast system.
WBPT	Wet bulb potential temperature.
WMO	World Meteorological Organization.