NUMERICAL WEATHER MODELLING AND SATELLITE DATA ASSIMILATION FOR SIMULATION SEVERE DUST EVENTS OVER EGYPT

By

MOHAMED SAMIR MOHAMED KAMEL ELTAHAN

A Thesis submitted to the

Faculty of Engineering, Cairo University

In Partial Fulfillment of the

Requirements the Degree of

MASTER OF SCIENCE

In

AEROSPACE ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

GIZA, EGYPT

2019

NUMERICAL WEATHER MODELLING AND SATELLITE DATA ASSIMILATION FOR SIMULATION SEVERE DUST EVENTS OVER EGYPT

By

MOHAMED SAMIR MOHAMED KAMEL ELTAHAN

A Thesis submitted to the
Faculty Of Engineering, Cairo University
In Partial Fulfillment of the
Requirements The Degree of

MASTER OF SCIENCE
In
AEROSPACE ENGINEERING

Under Supervision of

Prof. Dr. Atef O.Sherif

……

Professor , Department Of Aerospace Engineering
Faculty Of Engineering , Cairo University

Prof. Dr. Mohammed Shokr

……..……..

Professor , Environmental and Climate Change Canada
, Toronto, Canada

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

GIZA, EGYPT

2019

NUMERICAL WEATHER MODELLING AND SATELLITE DATA ASSIMILATION FOR SIMULATION SEVERE DUST EVENTS OVER EGYPT

By

MOHAMED SAMIR MOHAMED KAMEL ELTAHAN

A Thesis submitted to the
Faculty of Engineering, Cairo University
In Partial Fulfillment of the
Requirements the Degree of

MASTER OF SCIENCE
In
AEROSPACE ENGINEERING

Approved by the Examination Committee

Prof. Dr. Atef O.Sherif , Thesis Main Advisor
……

Department of Aerospace Engineering, Faculty of Engineering, Cairo University

Prof. Dr. Dr Mohammed Shokr, Advisor
……
Environmental and Climate Change Canada**,** Toronto, Canada

Prof. Dr. Mohamed Madbouli Abdelrahman Internal Examiner
……

Department of Aerospace Engineering, Faculty of Engineering, Cairo University

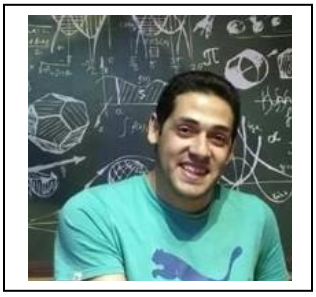
Associate Prof. Dr. Yunsoo, Choi , External Examiner
……

Department of Earth and Atmospheric Sciences, College of Natural Sciences and Mathematics, University of Houston

FACULTY OF ENGINEERING, CAIRO UNIVERSITY

GIZA, EGYPT

2019

Engineer's Name: Eng. Mohamed Samir Mohamed Kamel Eltahan
Date of Birth: 5/6/1989
Nationality: Egyptian
E-mail: Muhammedsamireltahan@gmail.com
Phone: +2-01005409552
Address: El Giza, Egypt

Registration Date: 1/3/2012
Awarding Date: 2019
Degree: Master of Science
Department: Aerospace Department

Supervisors:

1- Prof. Dr. Atef O.Sherif (Thesis Main Advisor)
2- Prof. Dr. Mohammed shokr (Advisor)

Examiners:

1- Prof. Dr. Dr.Atef O.Sherif (Thesis Main Advisor)
2- Pr of. Dr. Mohammed Shokr (Advisor)
3- Prof. Dr. Mohamed Madbouli Abdelrahman (Internal Examiner)
4- Associate Prof. Choi Yunsoo (External Examiner)

Title of Thesis:

NUMERICAL WEATHER MODELLING AND SATELLITE DATA ASSIMILATION FOR SIMULATION SEVERE DUST EVENTS OVER EGYPT

Key Words: Numerical Modelling, Data Assimilation, Satellite Data, Aerosols, Dust storms

Summary:

In this Thesis, Remote sensing AOD data from MODIS , MISR, OMI and SeaWiFS were investigated over the MENA domain and Egypt then Long Term , Spatial and Temporal High Resolution Survey of Atmospheric Aerosols over Egypt With MODIS 10 km resolution were studied as reference to capture the Severe Events over Egypt . two different dust severe events were selected to be simulated using Weather Research and Forecasting model coupled with Chemistry (WRF - Chem) . Testing Performance of different dust schemes in terms of optical properties were performed. Effect of different data assimilation methods (3DVar and 4Dvar) and changing domain setup on dust simulation were shown .Validation of the two simulations were against both satellite data from MODIS 10 Km spatial resolution and Ground observation from aerosol robotic network (AERONET) .

ACKNOWLEDGEMENT

In the name of God the Most Gracious the most Merciful

I would like to thank my family father Samir, mother Mervet and brother Mustafa for their continuous support to achieve and finish this research and work. Without their vital roles during the previous period, this work doesn't come to the light.

Many thanks to my beloved wife, Nour for her patience, support and giving me positive energy to continue and sacrificing life's comfort to establish very organized and smooth Environment.

I would like to express my deepest gratitude to my supervisor Professor Atef sherif. I consider him my mentor in the scientific axis of my life. he taught me new way of creative thinking. since, I was undergraduate student till now

At last I want to give my teacher Professor Mohammed shokr many thanks for continuous guidance, support and review during this research.

I would like to acknowledge Reda El-Gendy from National Authority for Remote Sensing and Space Sciences (NARSS) for his support in WRF-chem model. Also, I want to acknowledge Professor Jerome Fast from Pacific Northwest National Laboratory for his guidance in calculating Aerosol optical depth

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Mohamed Samir Eltahan Date: 5 December 2018

Signature:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

NOMEMCLATURE

g	Earth gravity
r	Radius
x	State vector
z	State vector
t	Time
u	Velocity component in x-direction
v	Velocity component in y-direction
w	Velocity component in z-direction
u_{*t}	Threshold velocity
x_b	Background field
$h(.)$	Mapping function
$n_N(v)$	Volume distribution function
w_D	Deposition Velocity
B	Background error covariance matrix
CO	Carbon monoxide
D	Deposition flux
F	External forces
H	Moisture correction
K	Empirical Tensor describing the 3D turbulent diffusion
NMVOC	Non-methane volatile organic compounds

P	pressure
Q	Flux
Q	Adiabatic heating term
R	Observation error covariance matrix / Gas Constant /
S	Source function representing the fraction of alluvium available for wind erosion
T	Temperature
V	Velocity vector
E	Emission flux of species
S_p	Fraction of each size class of dust in the emission
C_2	empirical constant for dust flux function of of GOCART-AFWA
B_0	background error statistics from generic BE data (CV3) or gen_be.
C_1	empirical constant for dust flux function of dust scheme GOCART
CH_4	Methane
CO_2	Carbon dioxide
c_p	specific heat at constant pressure
c_v	specific heat at constant volume
F_p	Emission of saltation flux
H(.)	Mapping function
J(.)	Cost function
Kx	turbulent diffusion in x direction
Ky	turbulent diffusion in y direction
Kz	turbulent diffusion in z direction