



Cairo University

**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**

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Title of Thesis:

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**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 ) .

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# **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

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## NOMENCLATURE

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$g$	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
$K_x$	turbulent diffusion in x direction
$K_y$	turbulent diffusion in y direction
$K_z$	turbulent diffusion in z direction