



**Surface Dust Flux Model
Design Document**



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1 Overview

1.1 Overview

This document describes the Surface Dust Flux modeling software package. The model uses forecasted surface winds to estimate the rate at which ground level dust is being produced from source areas within a mesoscale theater. Surface dust fluxes vary in desert regions from 10 –100 $\mu\text{gm}/\text{m}^2\text{-s}$ for small to moderate fluxes, and 500 to 2000 $\mu\text{gm}/\text{m}^2\text{-s}$ or more under dust storm conditions.

The model uses MM5 forecasted wind fields, soil moisture and estimated precipitation as input. Surface dust flux is calculated at each MM5 model grid location (~45 km intervals) in the mesoscale theater. The flux is calculated using forecasted 10 meter winds and the dust source database and model developed by Dr. Paul Ginoux at NASA GSFC/GIT.

The dust model can make forecasts for 2 MM5 mesoscale regions covering Northern Africa and the Middle East (T9z) and Southwest Asia (T4y). The surface dust fluxes are displayed as regional maps with color overlays showing dust fluxes in $\mu\text{gm}/\text{m}^2\text{-s}$. The user should note that this model does not forecast the transport of dust in the atmosphere. It only makes a prediction of the rate at which dust is generated at the surface.

1.2 Statement of purpose

The Surface Dust Flux model has been created as a forecasting and analysis tool to predict the rate at which surface dust is produced in desert regions. The model estimates the rate as a dust flux, calculated in $\mu\text{gm}/\text{m}^2\text{-s}$ from the surface. The model estimates surface fluxes for 4 particle sizes groups: 0.1 to 1.0 μm , 1.0-1.8 μm , 1.8-3.0 μm and 3.0 to 6 μm .

Features of the dust flux model are the inclusion of a new dust source model based on research work by Paul Ginoux and Mian Chin (*Ginoux et al. 2000, Chin et al. 2001*). The dust source model is unique in that it uses a global dust database based on terrain elevation data in desert regions to identify topographic depressions that are key dust source areas. The Ginoux dust source model included with this software package is based on the $1^\circ \times 1^\circ$ resolution reinterpolated to each MM5 mesoscale theater grid point at roughly $1/2^\circ$ intervals. The Ginoux source model has been verified and supplemented using satellite and ground observations. It is currently undergoing continuing research to generate a higher resolution 10kmx10km global model.

The surface dust fluxes are driven by the forecasted MM5 windfields at 10 meter heights. The dust flux is calculated based on a calculated wind threshold velocity, u_t for each particle diameter Φ_p . The threshold velocity is calculated using:

$$u_t = A \cdot \sqrt{(\rho_p - \rho_a) / \rho_a \cdot g \cdot \Phi_p} \cdot 1.2 + 0.2 \log_{10} w \quad \text{if } w < 0.5$$

$$\infty \quad \text{otherwise}$$

where g is the acceleration of gravity, ρ_p and ρ_a are the dust particle and air density respectively. The model can incorporate precipitation surface soil moisture to derive a soil wetness w , which varies from 0.01 to 1. If soil wetness values are included, dust fluxes are reduced in source areas as the soil wetness approaches 0.5. Above a soil wetness of 0.5, the dust flux is assumed to be zero where the wind threshold velocity becomes infinite. In desert regions under arid conditions, w varies from 0.01 to 0.1. If soil moisture and precipitation are not used in the Surface Dust Flux Model (SDFM), w is set to a default value of 0.1. Note that in the first version of DSFM, w is set to the default value for arid regions. The surface dust flux is calculated for each particle size class using:

$$F_p = C \cdot S \cdot s_p \cdot u_{10m}^2 (u_{10m} - u_t) \quad \text{if } u_{10m} > u_t$$

$$0 \quad \text{otherwise}$$

F_p is the surface dust flux in $\mu\text{g}/\text{m}^2\text{-s}$, C is a dimensional constant equal to $1 \mu\text{g} \text{ s}^2 \text{ m}^{-5}$, and S is the Ginoux dust source value at the MM5 grid point. The surface wind velocity is taken at 10 meters. Future versions of this model will use the surface friction velocity to calculate dust fluxes when available in MM5 data files.

1.3 Purpose of Document

The purpose of this document is to describe the architecture of the software and to list and identify the components of the software.

2 Product Architecture

2.1 Procedure Calling Hierarchy for the Surface Dust Flux Model Process

- 1.0 dust
 - 1.1 dust_common
 - 1.2 check_setup
 - 1.3 MMAPS_UI_Interface_Event

- 1.3.1 Surface_DustGUI
 - 1.3.1.1 stdcolor
 - 1.3.1.2 Plot_Theater
 - 1.3.1.2.1 stdcolor
 - 1.3.1.2.2 create_elev_map
 - 1.3.1.2.3 izoom
 - 1.3.1.2.3.1 lastplot
 - 1.3.1.2.3.2 imgunder
 - 1.3.1.2.3.2.1 maken
 - 1.3.1.2.3.3 nextplot
 - 1.3.1.2.4 map_segments
 - 1.3.1.2.4.1 map_getindex
 - 1.3.1.2.5 dist_scale
 - 1.3.1.3 mergecolors
- 1.3.2 MM5_mdfn_surfacextract72
 - 1.3.2.1 check_setup
- 1.4 make_movie

3 Object Descriptions

3.1 IDL Objects

3.1.1 SUBROUTINE check_setup

This subroutine checks if the setup file has been customized.

CALLING SEQUENCE:

check_setup,tmp

Where :

tmp = string to hold setup information

3.1.2 SUBROUTINE create_elev_map

This subroutine gets the dted level0 data from NIMA maps. Some NIMA map regions are not well patched and will display with line disjoints along 1 by 1 degree patch borders.

CALLING SEQUENCE:

create_elev_map,wholemap,latmin,latmax,lonmin,lonmax

Where :

wholemap = returned array of elevations

latmin	=	latitude of southern edge
latmax	=	latitude of northern edge
lonmin	=	longitude of western edge
lonmax	=	longitude of eastern edge

3.1.3 SUBROUTINE dist_scale

This subroutine displays a distance scale on an image.

CALLING SEQUENCE:

dist_scale,X0,Y0,length=len,height=ht,scale=sc,title=ttl,size=sz,help=hlp,
color=clr,background=bclr,thick=thk

Where:

X0,Y0	=	pixel coordinates of the center of scale
scale	=	number of units per pixels
length	=	length of scale in units given in scale
height	=	height of scale in units given in scale
title	=	scale title text
size	=	text size
color	=	color of scale
background	=	background color
thick	=	scale thickness

3.1.4 SUBROUTINE dust

This routine displays the graphical user interface for Surface_Dust.pro

CALLING SEQUENCE:

dust

There are no arguments passed.

3.1.5 SUBROUTINE imgunder

This routine displays the image in the same area as last plot.

CALLING SEQUENCE:

imgunder,z,interp=interp,center=center,xfrac=xfrac,yfrac=yfrac,help=hlp

Where:

z	=	scaled byte image to display
interp	=	causes bilinear interpolation to be used
xfrac	=	fraction of image to use in x

3.1.6 **yfrac** = fraction of image to us in y
SUBROUTINE izoom

This subroutine zooms an image and displays with labeled axes.

CALLING SEQUENCE:

Call izoom,x,y,z

Where:

x = 1-d array of x coordinates for every column in z
y = 1-d array of y coordinates for every column in z
z = 2-d byte scaled image array

3.1.7 **SUBROUTINE lastplot**

This subroutine backup !p.multi to last plot position.

CALLING SEQUENCE:

Call lastplot

There are no arguments passed.

3.1.7 **SUBROUTINE maken**

This routine makes an array of N values, linear between two given limits.

CALLING SEQUENCE:

Call x=maken(first,last,num)

Where:

first = array of starts values
last = array pf end values
num = number of values from first to last

3.1.8 **SUBROUTINE make_movie**

This routine creates a .res movie file from the user generated GIF images.

CALLING SEQUENCE:

Call make_move,name

Where:

name = name of the.res movie file

3.1.9 SUBROUTINE map_getindex

This subroutine is used to read in the index file for each map data file. On successful completion, error is set to 0.

CALLING SEQUENCE:

Call `ndx=map_getindex(fndx,error)`

Where

fndx = the index file for the map data file
error = error status holder

3.1.10 SUBROUTINE map_segments

This subroutine outputs a segment file.

CALLING SEQUENCE:

Call `mag_segments,fnames,name,hires,bounds,zvalue,polyfill=poly`

Where:

fnames = [lowresname,hiresname]
name = description for error message
hires = 0 for low res, 1 for hi res
zvalue = z value for 3D
bounds = lat/lon bound
polyfill = 0 for lines, 1 for polyfill

3.1.11 SUBROUTINE mergecolors

This routine overlays second image onto another image.

CALLING SEQUENCE:

Call `merge_colors,aa,bb,r,g,b,ncolors,imout,rout,gout,bout,frame,mpegID`

Where:

aa = input byte image to be colored
bb = input byte image with colors
r = red (3 byte arrays with color table)
g = green (3 byte arrays with color table)
b = blue (3 byte arrays with color table)
ncolors = number of colors in merged image
imout = output byte image
rout = red (color table needed to display output image)
gout = green (color table needed to display output image)
bout = blue (color table needed to display output image)

frame = not used
mpegID = not used

3.1.12 SUBROUTINE nextplot

This routine updates !p.multi to next plot position.

CALLING SEQUENCE:

Call nextplot

Where:

There are no arguments passed

3.1.13 SUBROUTINE Plot_Theater

This subroutine makes the Topographic Map for the given theater.

CALLING SEQUENCE:

Call Plot_Theater, thnum, bounds, map_window, MM, DD, YY, HH

Where:

thnum = theater number
bounds = [lonmin, latmin, lonmax, latmax]
map_window = returned map window index
MM = month for map label
DD = day for map label
YY = year for map label
HH = MM5 hour for map label

3.1.14 SUBROUTINE stdcolor

This subroutine assigns the 256 elements into the !d.n_colors minus the number of labels colors.

CALLING SEQUENCE:

Stdcolor, color, show=show

Where:

color = returned structure with color indices
show = display color table as a 16x16 array of colors on the screen

4 External Interfaces

4.1 Data

Input Data

The Surface Dust Flux Model Process shall ingest MM5 data. The data format is described in the following reference:

C. H. Dey. GRIB, Edition 1, NCEP Central Operations, National Weather Service, NOAA, U.S. Dept. of Commerce, Office Note 388, 1998.

4.2 Operating System Services

The UNIX routines of the Surface Dust Flux Model application will execute under Solaris 2.7 or Solaris 2.8 operation system on a SUN Workstation. The software will be developed for use on a SUN Ultra 60 UNIX platform.

4.3 Output

When the Surface Dust Flux Model process is executed it outputs Mesoscale maps overlaid with the dust surface flux in $\mu\text{g}/\text{m}^2\text{-s}$. Appendix C contains an example of the final Surface Dust Flux Model output file. This image can be saved as a GIF file. The user can also generate a .res movie file from multiple GIF images.

4.4 Other Software Programs or Libraries

The UNIX software was developed under Solaris version 2.7. IDL version 5.4 should be present on the UNIX target system. The following IDL libraries are installed with the Surface Dust Flux Model software:

Library	Description
dust_lib	Library containing IDL routines used in the surface flux model.
mm5_lib	Library containing IDL routines used to extract and look at MM5 data.
idluser	Library containing APL developed IDL utility routines.

A Acronyms and Abbreviations

Acronym	Definition
AACGM	Attitude Adjusted Corrected Geomagnetic
AFCCC	Air Force Combat Climatology Center
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
AFSCN	Air Force Satellite Control Network
AFSPACECOM	Air Force Space Command
AFSWC	Air Force Space Weather Center
AFWA	Air Force Weather Agency
AFWIN	Air Force Weather Information Network
AF/XOW	Air Force Director of Weather
APL	Applied Physics Laboratory of Johns Hopkins University
ASCII	American Standard Code for Information Interchange
ASPAM	Atmospheric Slant Path Analysis Model
AVHRR	Advanced Very High Resolution Radiometer
AVN	Aviation Model
AVO	Alaska Volcano Observatory
BATS	Biosphere-Atmosphere Transfer Scheme
CLASS	Canadian Land Surface Scheme
COE	Common Operating Environment
DII	Defense Information Infrastructure
DMSP	Defense Meteorological Satellite Program
ECMWF	European Center for Medium-Range Weather Forecasts
FNMOC	Fleet Numerical Meteorology and Oceanography Center
FSL	Forecast Systems Laboratory
FTP	File Transfer Protocol
GI	Geophysical Institute
GIF	Graphic Interchange Format
GIT	Georgia Institute of Technology
GMT	Generic Mapping Tools
GOLD	Geophysical On-Line Data
GRIB	Gridded Binary
GSFC	Goddard Space Flight Center
HLBL	High Latitude Boundary Layer
IDL	Interactive Data Language
IMF	Interplanetary Magnetic Field
JHU	Johns Hopkins University
LAN	Local Area Network
LAPS	Local Analysis and Prediction System

LSM	Land Surface Model
MM5	Fifth Generation Mesoscale Model
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
netCDF	Network Common Data Form
NGDC	National Geophysical Data Center
NGM	Nested Grid Forecast Model
NOGAPS	Navy Operational Global Atmospheric Prediction System
NWP	Numerical Weather Prediction
OWS	Operational Weather Squadron
PACE	Polar Anglo-American Conjugate Experiment
PBL	Planetary Boundary Layer
PCA	Polar Cap Absorption
PFRR	Poker Flat Research Range
SABER	Sounding of the Atmosphere using Broadband Emission Radiometry
SD	Space Department of the Applied Physics Laboratory
SDP	Software Development Plan
SEC	Space Environment Center
SEE	Solar EUV Experiment
SEON	Solar Electro-optical Observing Network
SFOC	Spaceflight Operations Center
STP	Solar Terrestrial Physics
SWOC	Space Weather Operations Center (Offutt)
SWXS	Space Weather Squadron
Tcl	Tool Command Language
Tk	Toolkit
Tix	Tk Interface Extension
UAF	University of Alaska, Fairbanks
UCAR	University Corporation for Atmospheric Research
UPOS	University Partnering for Operational Support
WDC	World Data Center
WF	Weather Flight
WMO	World Meteorological Organization
XDR	External Data Representation

B Source Code

C SURFACE DUST FLUX MODEL OUTPUT

