

A Brief Description of New Dust Source Functions in NU-WRF version 7

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Table of Contents

1. Overview	2
2. How to Run	3
2.1 WPS.....	3
2.2 WRFV3.....	3
References	4

1. Overview

In the current GOCART dust model of WRF/chem and NASA Unified-WRF (NU-WRF), only a static dust source function (static) in 0.25° resolution (Ginoux et al., 2001; Chin et al., 2002) is available. Although the seasonality and inter-annual variation of semi-arid dust sources are omitted in the static dust source function (static), it is found that the dynamic nature of surface bareness needs to be considered for dust sources especially over semi-arid sources (Kim et al., 2013).

The NU-WRF version 7 has incorporated three new dust sources of (1) a satellite observation based dust source function derived from a climatology of MODIS Deep Blue aerosol optical depth in 0.1° resolution (mdb) (Ginoux et al., 2012), (2) a dynamic dust source function using climatology of MODIS GVF data in 30 sec resolution (dyn_climo), and (3) a dynamic dust source function using near real time MODIS NDVI in 1 km resolution (dyn). While land surface bareness (L) and topographic depression (S) are combined in static and mdb methods for dust emission calculation (Eq. 1), they are explicitly calculated and treated in the high-resolution dynamic dust source function methods in dyn_climo and dyn. Four dust source functions are summarized in Table 1. Note that new source functions works with GOCART options only in the current version of NU-WRF.

$$F(r) = C L S s(r) u_{10m}^2 (u_{10m} - u_t(r, w)) \quad (1)$$

when $u_{10m} > u_t$, otherwise $F(r) = 0$

C : Constant ($1 \times 10^{-9} \text{ kg s}^2 \text{ m}^{-5}$)

L : Land surface bareness (Time)

S : Topographic depression

$s(r)$: Fraction of particle size class (0.1-1, 1-1.8, 1.8-3, 3-6, 6-10 μm)

u_{10m} : Wind speed at 10m

u_t : Threshold wind

w : soil moisture

Table 1. Summary of dust source functions.

Name	Region	Resolution	Time	L and S	Input Variables	Source
static	Global	0.25°	Constant	Combined	EROD_STATIC	Ginoux et al. (2001)
mdb	Global	0.1°	Seasonal	Combined	EROD_MDB_SAND EROD_MDB_SILT EROD_MDB_CLAY	Ginoux et al. (2012)
dyn_climo	Global	30 sec	Monthly	Separated	BARENESS_DYN_CLIMO TOPODEP	New
dyn	US	1 km	Daily (2010~)	Separated	BARE_DYN TOPODEP	New

2. How to Run

Both WPS and WRFV3 are affected by new dust source functions as described in this section. Also ‘./WRFV3/Registry/registry.chem’ file is modified for input/output variables. This section assumes a user is already familiar with WRF/Chem (<http://ruc.noaa.gov/wrf/WG11/Welcome.html>). For more detail about WRF/Chem, we refer WRF/Chem User Guide (http://ruc.noaa.gov/wrf/WG11/Users_guide.pdf).

2.1 WPS

Several new input fields are introduced in “GEOGRID.TBL.ARW_CHEM_NUWRF” and “METGRID.TBL.ARW” for new dust source functions. The following steps need to be done to use the new dust source functions.

1. Make sure a symbolic link GEOGRID.TBL with GEOGRID.TBL.ARW_CHEM_NUWRF in ./WPS/geogrid/

```
> ln -s GEOGRID.TBL.ARW_CHEM_NUWRF GEOGRID.TBL
```

2. Make sure a symbolic link METGRID.TBL with METGRID.TBL.ARW in ./WPS/metgrid/

```
> ln -s METGRID.TBL.ARW METGRID.TBL
```

3. Add or modify the following options in “namelist.wps” before running WPS with dynamic dust source function options.

```
&geogrid  
geog_data_res = 'modis_fpar+30s', 'modis_fpar+30s', 'modis_fpar+30s'
```

```
&metgrid  
fg_name = 'FILE', 'BARE_DYN'
```

2.2 WRFV3

Current and new dust source functions are handled in namelist.input. The existing dust source function ‘erod’ is renamed as ‘static’. Four options of **erod_option** are ‘static’, ‘mdb’, ‘dyn_climo’, and ‘dyn’. The chemistry option (chem_opt=300) is for simple GOCART aerosol.

```
&chem  
erod_option = 'dyn',  
chem_opt = 300,
```

References

- Chin, M., et al. (2002), Tropospheric aerosol optical thickness from the GOCART model and comparisons with satellite and Sun photometer measurements, *J. Atmos. Sci.*, 59, 461–483.
- Ginoux, P., et al. (2001), Sources and distributions of dust aerosols simulated with the GOCART model, *J. Geophys. Res.*, 106(D17), 20,255–20,273.
- Ginoux, P., J. M. Prospero, T. E. Gill, N. C. Hsu, and M. Zhao (2012), Global-scale attribution of anthropogenic and natural dust sources and their emission rates based on MODIS Deep Blue aerosol products, *Rev. Geophys.*, 50, RG3005, doi:10.1029/2012RG000388.
- Kim, D., M. Chin, H. Bian, Q. Tan, M. Brown, T. Zheng, R. You, T. Diehl, P. Ginoux, T. Kucsera (2013), The Effect of the Dynamic Surface Bareness on Dust Source Function, Emission, and Distribution, *J. Geophys. Res.*, doi:10.1029/2012JD017907.