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# Dust Entrainment and Deposition (DEAD) model: User's Guide

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## 1 Introduction

This document describes the Dust Entrainment and Deposition model (DEAD). Complete information on DEAD (release note, source code, and an on-line version) from the [DEAD homepage](#). The reference article which describes the physics of DEAD version 1.x is [Zender \*et al.\* \[2003a\]](#). Numerous other articles use or refer to DEAD, including [Clarke \*et al.\* \[2001\]](#);

*Collins et al.* [2001]; *Rasch et al.* [2001]; *Collins et al.* [2002]; *Grini et al.* [2002]; *Mahowald et al.* [2002]; *Bian and Zender* [2003]; *Luo et al.* [2003b, a]; *Mahowald et al.* [2003]; *Mahowald and Luo* [2003]; *Luo et al.* [2003b]; *Zender et al.* [2003a, b]; *Grini and Zender* [2004]; *Okin et al.* [2003]. Many of these articles are available electronically from the [DEAD homepage](#).

## 1.1 Contributing

Obviously, this User's Guide is not finished. The most valuable help you can provide is feedback. Unless and until I am sure that users read this guide, I am unlikely to improve it much. **What is the most important missing information?**

The plan is to add these sections eventually:

1. Exact physics description
  - (a) Mobilization
  - (b) Dry deposition
  - (c) Wet deposition
2. Graphical output
3. FAQ: How do I ...

## 1.2 Command Line Arguments

Table 1 summarizes all of the command line arguments available to control the behavior of the Dust Entrainment and Deposition model (DEAD). DEAD is invoked at the command line by running the `aer` program.

Table 1: DEAD Command Line Switches<sup>12</sup>

Switch	Purpose	Default	Units
--foo_flg	Foo	true	Flag
--dbg_lvl	Debugging level	0	Index
--asp_rat_lps_df1	Ellipsoidal aspect ratio	1.0	Fraction
--drc_in	Input directory	./	String
--drc_out	Output directory	./	String
--fl_ext_dat	Name of netCDF file with external forcing data	""	String
--hgt_mdp	Midlayer height above surface	95.0	m
--oro	Orography: ocean=0.0, land=1.0, sea ice=2.0	1.0	Fraction
--prs_mdp	Environmental pressure	100825.0	Pa
--prs_ntf	Environmental surface pressure	prs_STP	Pa
--q_H2O_vpr	Specific humidity	cmd_ln_df1	kg kg <sup>-1</sup>
--sfc_typ	LSM surface type [0..28]	2	Index
--time_nbr	Number of timesteps to simulate	1	Number
--tpt_gnd	Ground temperature	300.0	K
--tpt_ice	Ice temperature	tpt_frz_pnt	K
--tpt_mdp	Environmental temperature	300.0	K
--tpt_soi	Soil temperature	297.0	K
--tpt_sst	Sea surface temperature	297.0	K
--wnd_mrd_mdp	Surface layer meridional wind speed	0.0	m s <sup>-1</sup>
--wnd_znl_mdp	Surface layer zonal wind speed	10.0	m s <sup>-1</sup>
--vai_dst	Vegetation area index (one-sided)	0.0	m <sup>2</sup> m <sup>-2</sup>

Table 2 summarizes the *fields* output by DEAD.

Table 2: DEAD Output Fields<sup>3</sup>

Name(s)	Purpose	Units
asp_rat_lps	Ellipsoidal aspect ratio	meter
cld_frc_cnv	Convective cloud fraction	fraction
cld_frc (CLOUD)	Cloud fraction	fraction
cld_vlm	Cloud volume	fraction
dmt_max	Maximum diameter in bin	meter
dmt_min	Minimum diameter in bin	meter
dmt_mjr	Major axis of ellipsoid	meter
dmt_mnr	Minor axis of ellipsoid	meter
dmt_naa	Number mean diameter analytic	meter
dmt_nma	Number median diameter analytic	meter
dmt_nmr	Number median diameter resolved	meter
dmt_nwr	Number weighted diameter resolved	meter
dmt_sma	Surface median diameter analytic	meter
dmt_smr	Surface area median diameter resolved	meter
dmt_swa	Surface area weighted mean diameter analytic	meter
dmt_swr	Surface area weighted diameter resolved	meter
dmt_vma_src	Mass median diameter of source distribution	meter
dmt_vma	Mass median diameter analytic	meter
dmt_vmr	Mass median diameter resolved	meter
dmt_vwa	Mass weighted mean diameter analytic	meter
dmt_vwr	Mass weighted diameter resolved	meter
dns_aer	Particle density	kilogram meter-3
dns_mdp	Midlayer density	kilogram meter-3
doy	Day of year [1.0..367.0)	day

Table 2: (continued)

Name(s)	Purpose	Units
dst_slt_flux_rat_ttl	Ratio of vertical dust flux to streamwise mass flux	meter-1
flx_LW_dwn_sfc	Longwave downwelling flux at surface	watt meter-2
flx_SW_abs_sfc	Solar flux absorbed by ground	watt meter-2
flx_mss_dry_sfc_ttl (DSTSFDRY)	Total surface flux due to dry deposition	kilogram meter-2 second-1
flx_mss_dry_sfc (DSTSF01)	Surface flux due to dry deposition	kilogram meter-2 second-1
flx_mss_grv_sfc_ttl	Total surface flux due to gravitational settling	kilogram meter-2 second-1
flx_mss_grv_sfc	Surface flux due to gravitational settling	kilogram meter-2 second-1
flx_mss_hrz_slt_ttl	Vertically integrated streamwise mass flux	kilogram meter-1 second-1
flx_mss_pcp_sfc_ttl (DSTSFPCP)	Total dust reaching surface in precipitation	kilogram meter-2 second-1
flx_mss_pcp_sfc (DSTSF01)	Dust reaching surface in precipitation	kilogram meter-2 second-1
flx_mss_trb_sfc_ttl (DSTSFTRB)	Total surface flux due to turbulent mix-out	kilogram meter-2 second-1
flx_mss_trb_sfc (DSTSF01)	Surface flux due to turbulent mix-out	kilogram meter-2 second-1
flx_mss_vrt_dst_ttl (DSTSFMBL)	Total vertical mass flux of dust	kilogram meter-2 second-1
flx_mss_vrt_dst (DSTSF01)	Vertical mass flux of dust	kilogram meter-2 second-1
frc_thr_ncr_drg	Threshold friction velocity increase from roughness	fraction
frc_thr_ncr_wtr (FRC_WET)	Threshold friction velocity increase from moisture	fraction
frc_trc_trn_cnv_ptn	Interstitial tracer fraction	fraction
gsd_anl_src	Geometric standard deviation of source distribution	fraction
gsd_anl	Geometric standard deviation	fraction
gwc_sfc (GWC_SFC)	Gravimetric water content	kilogram kilogram-1
hgt_mdp	Midlayer height above surface	meter

Table 2: (continued)

Name(s)	Purpose	Units
hgt_zpd_mb1	Zero plane displacement height (mobilization)	meter
hgt_zpd_dps	Zero plane displacement height (deposition)	meter
lat_dgr	Latitude	degrees north
lat_rdn	Latitude	radians north
lat	Latitude	radians north
levp	Interface pressure	Pascal
lev	Midlayer pressure	Pascal
lnd_frc_dry	Dry land fraction	fraction
lnd_frc_mb1 (LND_MBL)	Bare ground fraction	fraction
lon	Longitude	degrees east
mb1_bsn_fct (BSN_FCT)	Erodibility factor	fraction
mcdat	Current date in YYMMDD format	day
mcsec	Seconds past current date at 0Z	second
mno_lng_mb1	Monin-Obukhov length (mobilization)	meter
mno_lng_dps	Monin-Obukhov length (deposition)	meter
mpc_dst_tt1 (DSTMPC)	Total column mass path of dust	kilogram meter-2
mpc_dst (DSTMPC01)	Column mass path of dust	kilogram meter-2
mpl_air	Air mass path in layer	kilogram meter-2
mss_cnc_dst	Mass concentration of dust	kilogram meter-3
mss_frc_CaCO3	Mass fraction CaCO3	fraction
mss_frc_cly	Mass fraction clay	fraction
mss_frc_slt	Mass fraction silt	fraction
mss_frc_snd	Mass fraction sand	fraction
mss_frc_src	Mass fraction of source distribution	fraction

Table 2: (continued)

Name(s)	Purpose	Units
mss_frc_trn_dst_src	Fraction of transported dust mass at source	fraction
nbdate	Simulation start date in YMMDD format	day
nbr_spc_rsl	Specific number concentration resolved	number kilogram-1
nbsec	Simulation start second relative to nbdate	second
ndcur	Current day number of simulation	day
nscur	Seconds relative to ndcur	second
nstep	Timestep	index
odxc_dst_ttl (DSTODXC)	Total column dust optical depth	fraction
odxc_dst (DSTODX01)	Column dust optical depth	fraction
oro (ORO)	Orography: ocean=0.0, land=1.0, sea ice=2.0	fraction
ovr_src_snk_frc	Overlap of src dist. i with sink bin j	fraction
ovr_src_snk_mss_ttl	Total transported mass fraction of dust flux	fraction
ovr_src_snk_mss	Mass overlap of src dist. i with sink bin j	fraction
pcp_flx_sfc (PRECT)	Total precipitation reaching surface	kilogram meter-2 second-1
prs_dlt	Pressure thickness	pascal
prs_mdp	Midlayer pressure	pascal
prs_ntf	Interface pressure	pascal
q_H20_cnd2pcp_tnd	Condensed H2O to precipitation tendency	kilogram kilogram-1 second-1
q_H20_cnd_pcp	H2O precipitation mixing ratio	kilogram kilogram-1
q_H20_cnd_tnd	Net H2O condensate formation tendency	kilogram kilogram-1 second-1
q_H20_cnd	Condensed H2O mixing ratio	kilogram kilogram-1
q_H20_pcp2vpr_tnd	H2O precipitation to vapor tendency	kilogram kilogram-1 second-1
q_H20_pcp_lqd	Rain water mixing ratio	kilogram kilogram-1



Table 2: (continued)

Name(s)	Purpose	Units
q_H2O_vpr2pcp_cnv_tnd	H2O vapor to convective precipitation tendency	kilogram kilogram-1 second-1
q_H2O_vpr (Q)	Water vapor mixing ratio	kilogram kilogram-1
q_dst_tnd_dry_tt1 (DSTSSDRY)	Total dust tendency due to settling and turbulence	kilogram kilogram-1 second-1
q_dst_tnd_dry (DSTSSD01)	Dust tendency due to settling and turbulence	kilogram kilogram-1 second-1
q_dst_tnd_evp_tt1 (DSTSSEVP)	Total evaporation tendency	kilogram kilogram-1 second-1
q_dst_tnd_evp (DSTSSE01)	Evaporation tendency	kilogram kilogram-1 second-1
q_dst_tnd_nc1	Nucleation scavenging tendency	kilogram kilogram-1 second-1
q_dst_tnd_pcp_tt1 (DSTSSPCP)	Total scavenging tendency	kilogram kilogram-1 second-1
q_dst_tnd_pcp (DSTSSP01)	Scavenging tendency	kilogram kilogram-1 second-1
q_dst_tnd_wet	Wet deposition (evaporation minus scavenging) tendency	kilogram kilogram-1 second-1
q_dst_tt1 (DSTQ)	Total dust mixing ratio	kilogram kilogram-1
q_dst (DSTQ01)	Dust mixing ratio	kilogram kilogram-1
rgh_mmn_mb1	Roughness length momentum (mobilization)	meter
rgh_mmn_dps	Roughness length momentum (deposition)	meter
rss_aer	Aerodynamic resistance	second meter-1
rss_lmn	Laminar resistance	second meter-1
rss_trb	Resistance for turbulent deposition	second meter-1
rxrc_HNO3_gas_dst_vmr	Mean rate of HNO3 removal by dust	molecule molecule-1 second-1
rxrc_HNO3_dst	Pseudo first order rate coefficient for HNO3	second-1
rxrc_HO2_dst	Pseudo first order rate coefficient for HO2	second-1
rxrc_N2O5_dst	Pseudo first order rate coefficient for N2O5	second-1
rxrc_O3_dst	Pseudo first order rate coefficient for O3	second-1

Table 2: (continued)

Name(s)	Purpose	Units
rxrc_S02_dst	Pseudo first order rate coefficient for SO2	second-1
scv_cff_mss_avg_pcp_nrm_cnv	Mass mean scavenging coefficient, precipitation normalized, convective	meter <sup>2</sup> kilogram-1
scv_cff_mss_avg_pcp_nrm_str	Mass mean scavenging coefficient, precipitation normalized, stratiform	meter <sup>2</sup> kilogram-1
sfc_spc_rsl	Specific surface area resolved	meter <sup>2</sup> kilogram-1
sfc_typ	LSM surface type (0..28)	index
shm_nbr	Schmidt number	fraction
snw_frc	Fraction of surface covered by snow	fraction
snw_hgt_lqd	Equivalent liquid water snow depth	meter
spc_xsx_ncl_scv	Specific cross section for nucleation scavenging	meter <sup>2</sup> kilogram-1
stk_nbr	Stokes number	fraction
sz_grd	Size grid interfaces	meter
sz_src	Mass median diameter of source distribution	meter
sz	Nominal size bin center	meter
time	Days since simulation start	day
tm_adj	Adjustment timestep (CCM: $2\Delta t$ , MATCH: $\Delta t$ )	second
tpt_gnd (TPT_GND)	Ground temperature	kelvin
tpt_mdp (T)	Midlayer temperature	kelvin
tpt_ptn	Potential temperature	kelvin
tpt_sfc (TS)	Surface temperature	kelvin
tpt_soi (TS1)	Soil temperature	kelvin
tpt_vrt	Virtual temperature	kelvin

Table 2: (continued)

Name(s)	Purpose	Units
upt_cff_H2O2_dst	Uptake coefficient for H2O2 to dust	fraction
upt_cff_HNO3_dst	Uptake coefficient for HNO3 to dust	fraction
upt_cff_HO2_dst	Uptake coefficient for HO2 to dust	fraction
upt_cff_N2O5_dst	Uptake coefficient for N2O5 to dust	fraction
upt_cff_NO3_dst	Uptake coefficient for NO3 to dust	fraction
upt_cff_O3_dst	Uptake coefficient for O3 to dust	fraction
upt_cff_OH_dst	Uptake coefficient for OH to dust	fraction
upt_cff_SO2_dst	Uptake coefficient for SO2 to dust	fraction
vai_dst (VAI_DST)	Vegetation area index, one-sided	meter <sup>2</sup> meter <sup>-2</sup>
vlc_dry	Total dry deposition velocity	meter second <sup>-1</sup>
vlc_grv	Gravitational settling velocity	meter second <sup>-1</sup>
vlc_trb	Turbulent deposition velocity	meter second <sup>-1</sup>
vln_spc_rsl	Specific volume resolved	meter <sup>3</sup> kilogram <sup>-1</sup>
vmr_HNO3_gas	Gaseous HNO3 volume mixing ratio	molecule molecule <sup>-1</sup>
vmr_HO2_gas	Gaseous HO2 volume mixing ratio	molecule molecule <sup>-1</sup>
vmr_N2O5_gas	Gaseous N2O5 volume mixing ratio	molecule molecule <sup>-1</sup>
vmr_NO3_aer	Particulate NO3 volume mixing ratio	molecule molecule <sup>-1</sup>
vmr_O3_gas	Gaseous O3 volume mixing ratio	molecule molecule <sup>-1</sup>
vmr_SO2_gas	Gaseous SO2 volume mixing ratio	molecule molecule <sup>-1</sup>
vmr_SO4_aer	Particulate SO4 volume mixing ratio	molecule molecule <sup>-1</sup>
vwc_sfc (VWC_SFC)	Volumetric water content	meter <sup>3</sup> meter <sup>-3</sup>
wnd_frc_slt (WND_FRCS)	Saltating friction velocity	meter second <sup>-1</sup>
wnd_frc_thr_slt (WND_FRCT)	Threshold friction velocity for saltation	meter second <sup>-1</sup>
wnd_frc_mb1 (WND_FRC)	Friction velocity (mobilization)	meter second <sup>-1</sup>

Table 2: (continued)

Name(s)	Purpose	Units
wnd_frc_dps	Friction velocity (deposition)	meter second-1
wnd_mdp	Surface layer mean wind speed	meter second-1
wnd_mrd_mdp	Meridional wind component	meter second-1
wnd_rfr_thr_slt (WND_RFRT)	Threshold 10 m wind speed for saltation	meter second-1
wnd_rfr_mb1 (WND_RFR)	Wind speed at reference height (mobilization)	meter second-1
wnd_rfr_dps	Wind speed at reference height (deposition)	meter second-1
wnd_rfr	Wind speed at reference height	meter second-1
wnd_znl_mdp	Zonal wind component	meter second-1

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