WRF3.8 FASDAS User's Guide – 07-20-2016

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The flux-adjusting surface data assimilation system (FASDAS) implemented into the Weather Research and Forecasting (WRF) model is a concise and effective method for constraining surface air temperature and moisture, as well as respective soil fields, in an attempt to better simulate planetary boundary layer processes and their impacts on precipitation and associated radiative processes. This method consists of a twofold approach: Surface layer air temperature and water vapor mixing ratio are nudged towards reanalysis fields utilizing the preexisting data assimilation system in the WRF model. Subsequently, the tendencies generated from the direct nudging approach are used to constrain the surface sensible and latent fluxes, thus ensuring thermodynamic consistency between the atmosphere and land surface. Currently, FASDAS works only with the YSU PBL and Noah LSM schemes. The steps required to activate FASDAS within the WRF code build upon those necessary to run boundary layer nudging and are as follows:

1) **Preparation of Analysis Data**
   a. Generation of the surface analysis fields for FASDAS requires the use of the OBSGRID utility. It is recommended that any user of FASDAS read Chapter 7 of the WRF User's Guide on compiling and running OBSGRID.
   b. A special version of OBSGRID for use with FASDAS has been created and is available from the WRF download website (http://www2.mmm.ucar.edu/wrf/users/download/get_sources.html#utilities).
      i.

WRF Utilities Downloads

read_wrf_nc	Updated February 13, 2009 This is a fix for *-tx* and *-vor*, when reading *U10* and *V10*. With this, all variables will be unstaggered when *-tx* is used.	Download read_wrf_nc
iowrf	Updated February 26, 2008 Fix: ratio in *-thin* option Addition: option *-t* for destaggering output	Download iowrf
wrf_interp	New since January 2015; updated June 25, 2015 This is an updated program to 'p_interp' and is recommended to use instead of p_interp	Download wrf_interp
p_interp	New since August 2010	Download p_interp
v_interp	Updated September 4, 2009 Major bug fix for *wrfbdy* interpolation	Download v_interp
OBSGRID	**OBSGRID for FASDAS** Updated April 8, 2016 Objective Analysis package. For details regarding this package, please see the online User's Guide or Chapter 7 of the WRF User's Guide	Download OBSGRID *If using the FASDAS option (new in V3.8), this special version of OBSGRID is required.
diffwrf	Download diffwrf	
MADIS2LITTLER	Updated June 12, 2014	Download MADIS2LITTLER

   c. To generate the `wrfsfdda_d<domain>` files necessary for FASDAS the user must have already prepared model input using the WRF Preprocessing System (WPS) for their given domains. It is highly recommended that the reanalysis data

used to generate met_em files in WPS be as close to the model domain resolution as possible in order to avoid errors from nudging to a non-representative state.

d. The user must provide surface observations for OBSGRID corresponding to each analysis time. These observation files can be either user-generated or downloaded and prepared following the steps in Chapter 7.

e. OBSGRID will generate the files necessary for free atmosphere and surface nudging simultaneously. The path to the observational data input files must be supplied to the obs_filename variable. Note: It is not necessary to include the <YYYY-MM-DD_HH> portion of the file names; OBSGRID will automatically take the correct dates from the observation data files in the obs_filename directory (assuming the files exist). Additionally, it is important to note that the OBSGRID radius_influence namelist variable may need adjusting based on domain resolution. The example below is for a 12-km grid:

   i. &record2
      grid_id = <domain number>
      obs_filename = path_to_obs/obs_filename(:<YYYY-MM-DD_HH>)

   ii. &record9
      oa_type = 'Cressman'
      radius_influence = 20,15,10,5
      mqd_minimum_num_obs = 30
      mqd_maximum_num_obs = 1000
      oa_min_switch = .TRUE.
      oa_max_switch = .TRUE./

f. The default radius of influence used to calculate the observation density weighting factor in the WRF model (rinblw) is rather large (250km). This parameter is used by the default OBSGRID program to calculate the distance from each grid cell to the nearest observation, information which is then used by WRF to calculate the observation weighting factor. This variable can be adjusted by the user in two ways. The first is to use the special version of the OBSGRID program released along with FASDAS that includes rinblw as a namelist variable (as shown in the example below). It is recommended to use a rinblw value of roughly 2Δx (the example below is for a 12-km grid). The second method would be to start with a default version of OBSGRID and manually change the rinblw value from the default 250.0 to the desired value in the ob_density subroutine contained within the qc0_module.F90 code prior to compiling OBSGRID. This requires replacing the 250.0 values in lines 60-63 and line 67 in qc0_module.F90 with the desired rinblw value and recompiling the OBSGRID code.

   i. &record4
      …
      max_p_extend_t = 1300
      max_p_extend_w = 1300
      rinblw = 24.0

```
/
```

g. If OBSGRID ran successfully, the `metoa_em` files necessary to generate WRF initial and boundary conditions files using the `real.exe` program and the `wrfsfdda_d<domain>` file necessary for FASDAS will be generated.

2) Activating and Running FASDAS in WRF

a. To use FASDAS, the `wrfsfdda_d<domain>` file must be copied to the run directory and the `wrfinput_d<domain>`, `wrfbdy_d<domain>`, and `wrffdda_d<domain>` files must be generated from the `real.exe` program. Free atmosphere nudging files must be prepared and used in conjunction with FASDAS or the WRF model will generate a namelist error. Note that mixed layer or PBL nudging is not allowed when using FASDAS to nudge the surface layer.

b. FASDAS can be activated in WRF by setting the `grid_sfdda` namelist variable in the `&fdda` section of the WRF namelist to 2 (see Registry file). Variable fasdas will be set to 1 when `grid_sfdda` = 2, otherwise it will be set to zero (This is done in share/module_check_a_mundo.F). See below:

i.
```
&fdda
…
fgdtzero                            = 0,
grid_sfdda                          = 2,
if_no_pbl_nudging_uv                = 1
if_no_pbl_nudging_t                 = 1
if_no_pbl_nudging_q                 = 1
if_no_pbl_nudging_ph                = 1
…
```

c. All other surface nudging variables in the namelist need to be set, as well, including: setting `sgfdda_end_h` to the simulation length in hours and setting `sgfdda_interval_m` to the interval between observation inputs (usually 180 minutes). The accuracy of the `sgfdda_end_h` variable is critically important because the simulation will terminate if the `sgfdda_end_h` occurs before the simulation ends and ramping is not set.

i.
```
&fdda
…
io_form_gfdda               = 2,
sgfdda_inname               ="wrfsfdda_d<domain>",
sgfdda_end_h                = <simulation length hours>,
sgfdda_interval_m           = 180,
io_form_sgfdda              = 2,
…
```

d. In the event that the `wrfsfdda_d<domain>` file does not cover the entire simulation period as specified in the namelist, `if_ramping` must be set to 1 and `dtramp_min` must be set to 60.0 in the namelist. This will slowly ramp the nudging down following the last analysis time. This option should only be used if FASDAS is used for forecast simulations or if no observational data is available

for the simulation period. However, we strongly suggest generating a `wrfsfdda_d<domain>` file that covers the full simulation period.

i.
```
&fdda
…
 if_ramping                          = 1,
 dtramp_min                          = 60.0,
…
io_form_gfdda              = 2,
sgfdda_inname              ="wrfsfdda_d<domain>",
sgfdda_end_h               = <analysis length hours>,
sgfdda_interval_m          = 180,
io_form_sgfdda             = 2,
…
```

e. In the `&fdda` section of the namelist, the user must also supply the nudging coefficients `gt_sfc` and `gq_sfc` for temperature and water vapor nudging, respectively. The current recommended values are 8.3×10^{-4} s^{-1}, which correspond to an adjustment time period of about 20 minutes. There is a stability factor (`stabFac`) adjustment on line 1146 of the FASDAS-modified `module_fdda_psufddagd.F` code that reduces the nudging by a factor of 1/3 to represent an adjustment period of 1 hour when the boundary layer is stable. However, this parameter can be adjusted based on the user's needs. The nudging coefficient for the *u* and *v* wind components, `guv_sfc`, should be set to zero, for now. The `rinblw` parameter should also be set in this section of the namelist. Unlike previous WRF versions, `rinblw` is now adjustable for each WRF domain.

i.
```
&fdda
…
guv_sfc                            = 0.0
gt_sfc                             = 8.3E-4,
gq_sfc                             = 8.3E-4,
rinblw                             = 24.0,
…
```

f. As mentioned earlier, both FASDAS and mixed layer (PBL) nudging cannot be activated simultaneously. When grid_sfdda = 2, fasdas variable is set to 1, then the nudging will only occur in the surface layer. When grid_sfdda = 1 (no FASDAS nudging), fasdas variable is set to zero.

3) Full Example of WRF FDDA namelist for FASDAS on 12-km Grid

```
&fdda
 grid_fdda                          = 1,
 gfdda_inname                       = "wrffdda_d<domain>",
 gfdda_end_h                        = 176040,
 gfdda_interval_m                   = 360,
 fgdt                               = 0,
 fgdtzero                           = 0,
 if_no_pbl_nudging_uv               = 1,
 if_no_pbl_nudging_t                = 1,
 if_no_pbl_nudging_q                = 1,
```

```
if_no_pbl_nudging_ph                = 1,
if_zfac_uv                          = 0,
 k_zfac_uv                          = 17,
if_zfac_t                           = 0,
 k_zfac_t                           = 17,
if_zfac_q                           = 0,
 k_zfac_q                           = 17,
if_zfac_ph                          = 0,
 k_zfac_ph                          = 17,
dk_zfac_uv                          = 2,
dk_zfac_t                           = 2,
dk_zfac_ph                          = 2,
guv                                 = 5.0E-5,
gt                                  = 5.0E-5,
gq                                  = 5.0E-6,
gph                                 = 0.0,
xwavenum                            = 2,
ywavenum                            = 2,
if_ramping                          = 0,
dtramp_min                          = 60.0,
io_form_gfdda                       = 2,
grid_sfdda                          = 2,
sgfdda_inname                       = "wrfsfdda_d<domain>",
sgfdda_end_h                        = 176040,
sgfdda_interval_m                   = 180,
io_form_sgfdda                      = 2,
pxlsm_soil_nudge                    = 0,
guv_sfc                             = 0.0,
gt_sfc                              = 8.3E-4,
gq_sfc                              = 8.3E-4,
rinblw                              = 24.0,
obs_nudge_opt                       = 0,
max_obs                             = 1500000,
fdda_start                          = 0.0,
fdda_end                            = 10562400,
obs_nudge_wind                      = 1,
obs_coef_wind                       = 4.e-4,
obs_nudge_temp                      = 1,
obs_coef_temp                       = 4.e-4,
obs_nudge_mois                      = 1,
obs_coef_mois                       = 4.e-4,
obs_nudge_pstr                      = 0,
obs_coef_pstr                       = 0.0,
obs_rinxy                           = 40.0,
obs_rinsig                          = 0.1,
obs_twindo                          = 0.6666667,
obs_npfi                            = 10,
obs_ionf                            = 1,
obs_idynin                          = 0,
obs_dtramp                          = 40.0,
obs_ipf_in4dob                      = .true.,
obs_ipf_errob                       = .true.,
```

```
obs_ipf_nudob                       = .true.,
obs_ipf_init                        = .true.,
/
```