NESTING IN WRF

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What is a nest?

- A *finer-resolution* domain used during a model run
- Covers a portion of the parent domain, and is fully surrounded by the parent domain
- Driven along its lateral boundaries by the parent domain
- Enables running at a higher-resolution without:
  - Uniformly high-resolution over a large domain – VERY expensive
  - High resolution for a very small domain, with mismatched time and spatial lateral boundary conditions

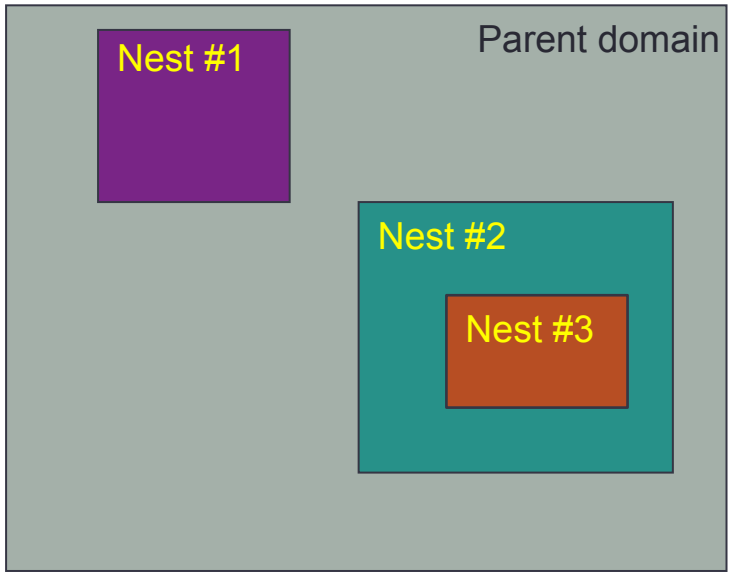
Types of Nesting

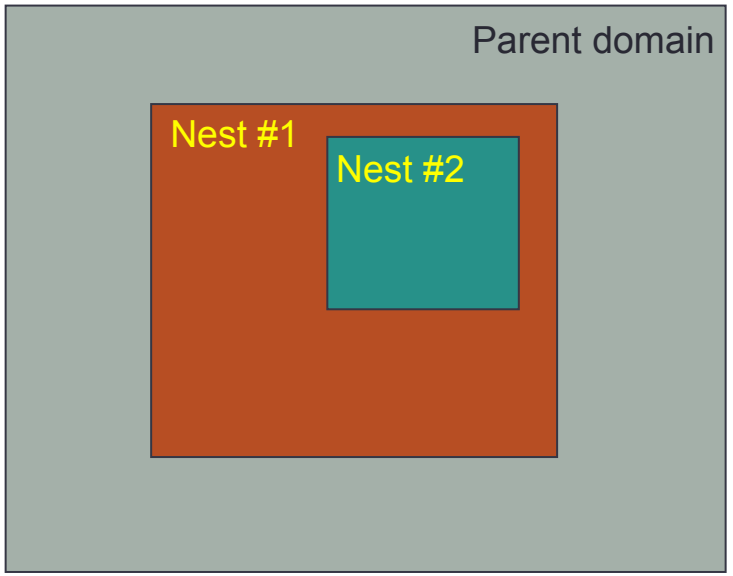
- Using a single input file (met_em.d0*)
  - Only met_em.d0* files for the first time period is used (for nests)
  - All fields are interpolated from the coarse grid
  - Only recommended if using a flat surface (e.g., ocean)
- Using multiple input files
  - Each domain contains full input data files for every time period
- One-way/two-way nesting
  - Determined by the namelist parameter “feedback”
  - feedback = 0 (turned off/one-way) ; feedback = 1 (turned on/two-way)
- Specified move
  - Build WRF with “2=preset moves”
  - Originally used as a testing facility – do not use
- Automatic move
  - Build WRF with “3=vortex following”’
  - Ideal for cyclone tracking

When Should I Use Nests?

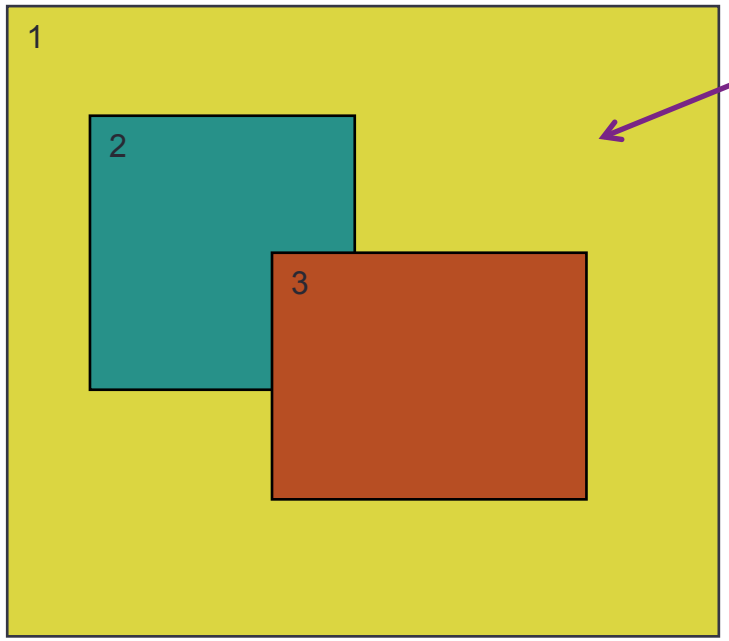
- Input data resolution is too coarse
- Would like to simulate localized convection, topography, and/or landuse-forced phenomena, etc.
- Would like to provide better boundary conditions for the area of interest
  - BC's for external sources are typically 3-6 hours
- Sufficient computing resources are not available

Nests that are OK



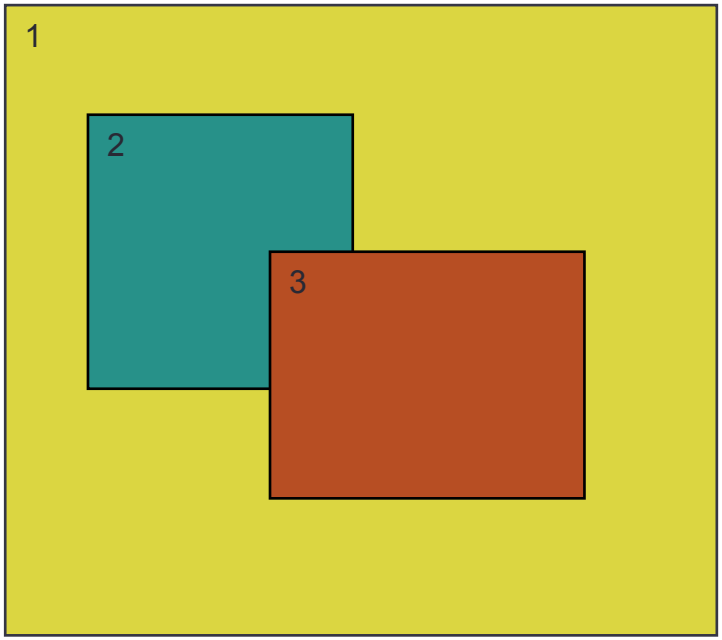


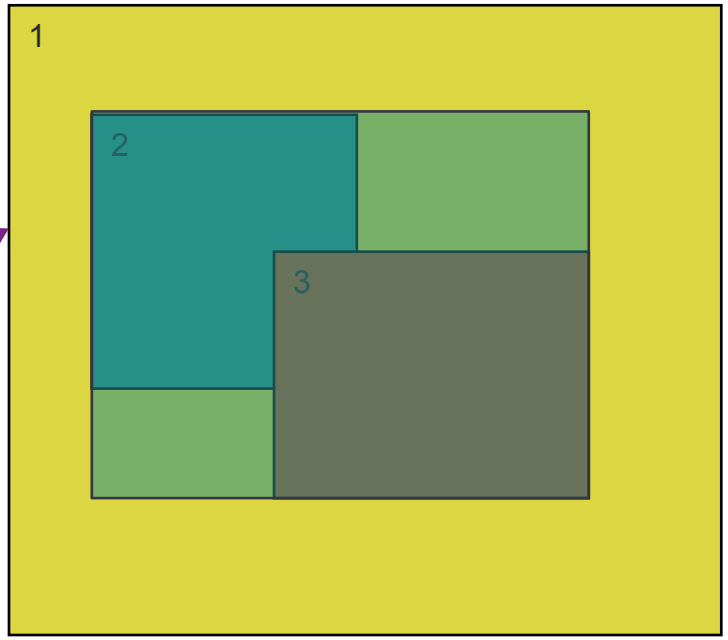
Nests that are NOT OK



Child domains *may not* have overlapping points in the parent domain (1-way nesting excluded).

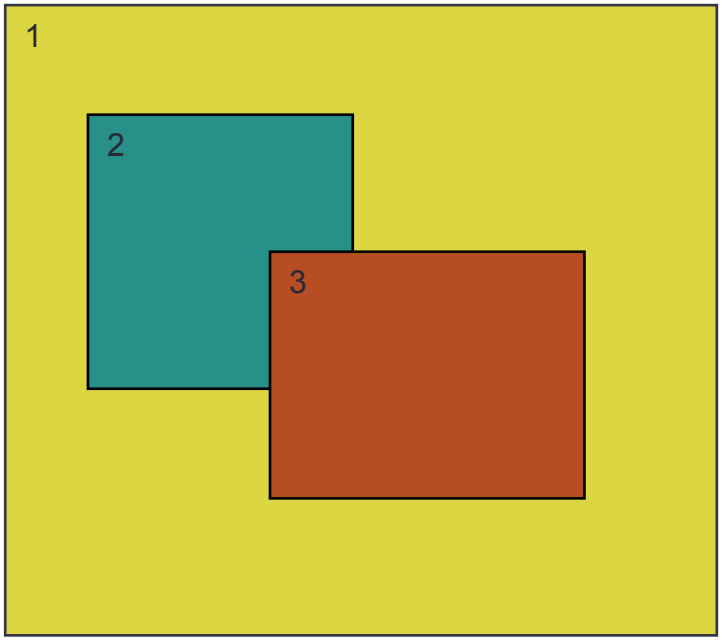
Nests that are NOT OK

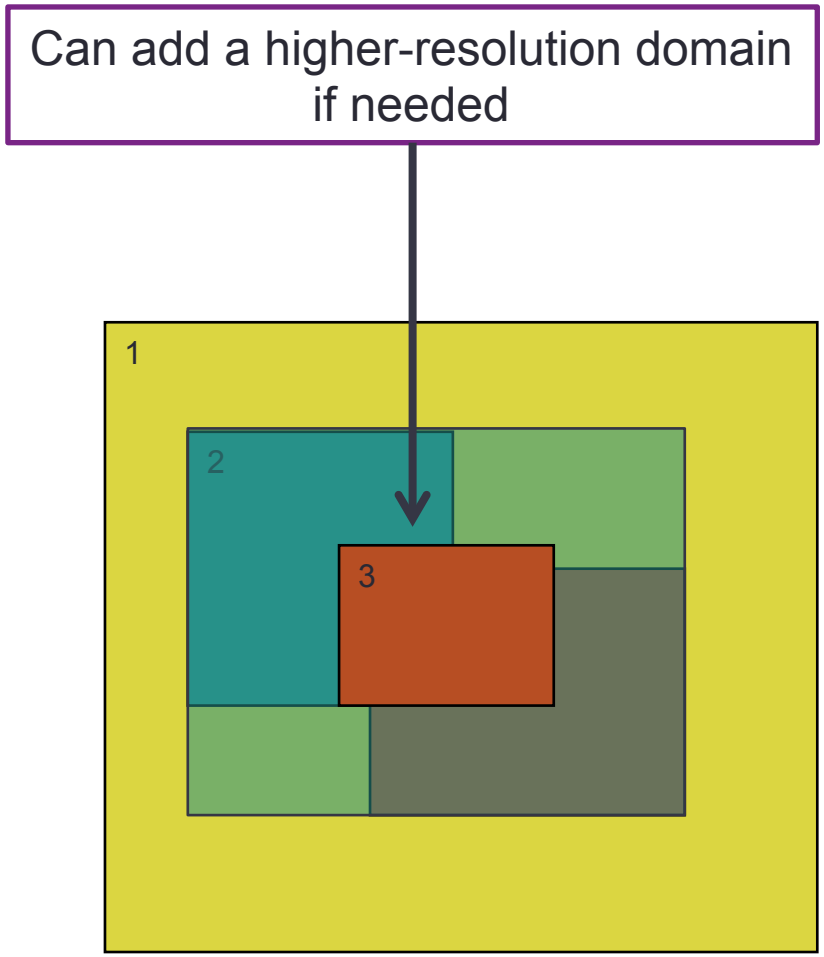




It's best to combine domains to create 1 large fine-resolution nested domain

Nests that are NOT OK

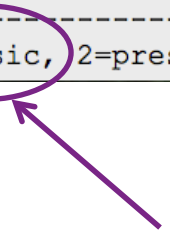




Nesting Set-up and Run

Compiling for Nesting

```
------------------------------------------------------------------------
Please select from among the following Darwin ARCH options:

  1. (serial)   2. (smpar)   3. (dmpar)   4. (dm+sm)   PGI (pgf90/pgcc)
  5. (serial)   6. (smpar)   7. (dmpar)   8. (dm+sm)   INTEL (ifort/icc)
  9. (serial)  10. (smpar)  11. (dmpar)  12. (dm+sm)   INTEL (ifort/clang)
 13. (serial)               14. (dmpar)                GNU (g95/gcc)
 15. (serial)  16. (smpar)  17. (dmpar)  18. (dm+sm)   GNU (gfortran/gcc)
 19. (serial)  20. (smpar)  21. (dmpar)  22. (dm+sm)   GNU (gfortran/clang)
 23. (serial)               24. (dmpar)                IBM (xlf90_r/cc)
 25. (serial)  26. (smpar)  27. (dmpar)  28. (dm+sm)   PGI (pgf90/pgcc): -f90=pgf90

Enter selection [1-28] : 9
------------------------------------------------------------------------
Compile for nesting? (0=no nesting, 1=basic, 2=preset moves, 3=vortex following) [default 0]:
```

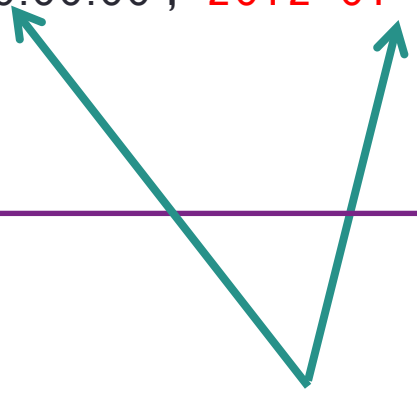


Compile with nesting option (1=basic)

namelist.*wps* set-up: *&share*

To edit the namelist.wps file, make sure you are in the WPS/ directory

```
&share
   wrf_core = 'ARW',
   max_dom = 2,
   start_date = '2012-01-27_00:00:00',' 2012-01-27_00:00:00'
   end_date = '2012-01-28_00:00:00',' 2012-01-28_00:00:00'
   interval_seconds = 21600
   io_form_geogrid = 2,
/
```



Make sure to edit start/end dates for both domains!

namelist.*wps* set-up: *&geogrid*

```
&geogrid

 parent_id         =   1,      1,
 parent_grid_ratio =   1,      3,
 i_parent_start    =   1,     20,
 j_parent_start    =   1,     17,

 e_we              =  220,   181,
 e_sn              =  175,   181,
 geog_data_res     = '5m',  '2m',


 dx                = 15000,
 dy                = 15000,
 map_proj     = 'lambert',
 ref_lat      = 37.0,
 ref_lon      = -97.0,
 truelat1     = 45.0,
 truelat2     = 30.0,
 stand_lon    = -97.0,
 geog_data_path = '/data/static/geog/'
/
```

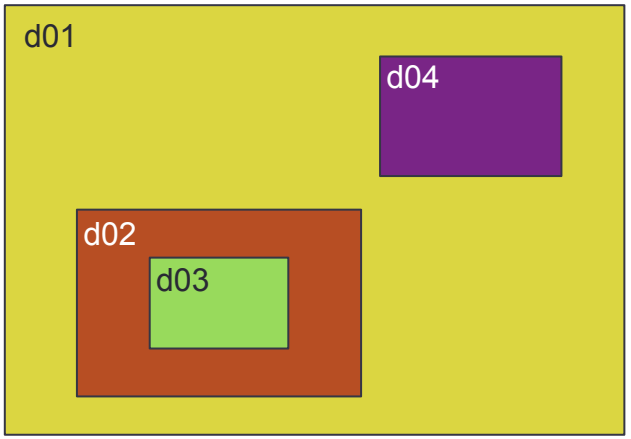
Used for nesting purposes?
- What is the grid ratio for each nest?
- Where is it located inside its parent?

Domain sizes: How many grid points Does the domain have? What is the grid spacing?

namelist.*wps* set-up: *&geogrid*

```
&geogrid

 parent_id         =   1,      1,
 parent_grid_ratio =   1,      3,
 i_parent_start    =   1,     20,
 j_parent_start    =   1,     17,

 e_we              =  220,   181,
 e_sn              =  175,   181,
 geog_data_res     = '5m',  '2m',


 dx                = 15000,
 dy                = 15000,
 map_proj     = 'lambert',
 ref_lat      = 37.0,
 ref_lon      = -97.0,
 truelat1     = 45.0,
 truelat2     = 30.0,
 stand_lon    = -97.0,
 geog_data_path = '/data/static/geog/'
/
```

parent_id:
The domain # of the nest's parent



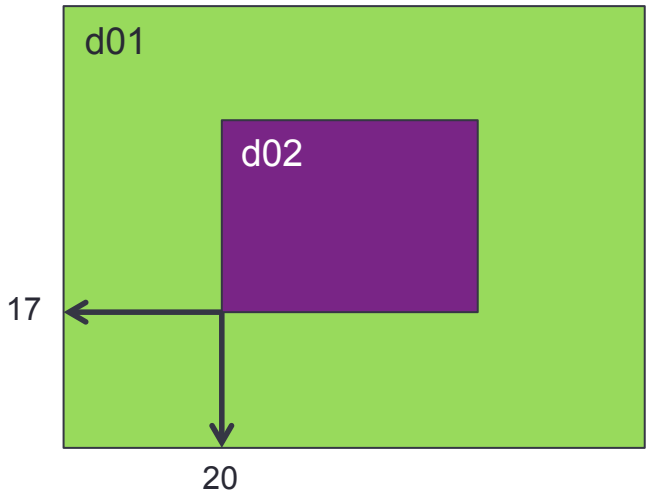
parent_id = 1, 1, 2, 1

namelist.*wps* set-up: *&geogrid*

```
&geogrid

 parent_id         =   1,      1,
 parent_grid_ratio =   1,      3,
 i_parent_start    =   1,     20,
 j_parent_start    =   1,     17,

 e_we              =  220,    181,
 e_sn              =  175,    181,
 geog_data_res     = '5m',    '2m',


 dx                = 15000,
 dy                = 15000,
 map_proj     = 'lambert',
 ref_lat      = 37.0,
 ref_lon      = -97.0,
 truelat1     = 45.0,
 truelat2     = 30.0,
 stand_lon    = -97.0,
 geog_data_path = '/data/static/geog/'
/
```

parent_grid_ratio:
recommended ratios are 3:1 or 5:1

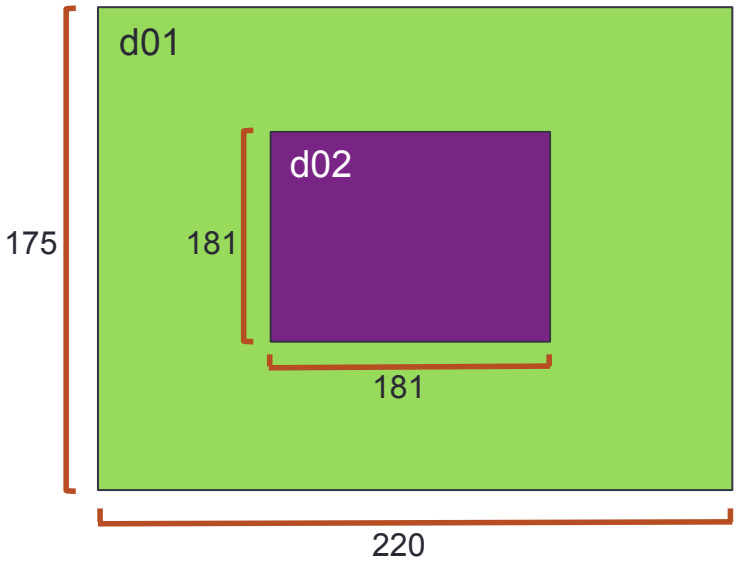
i/j_parent_start:



namelist.*wps* set-up: *&geogrid*

```
&geogrid

 parent_id             =   1,      1,
 parent_grid_ratio     =   1,      3,
 i_parent_start        =   1,     20,
 j_parent_start        =   1,     17,

 e_we                  =  220,   181,
 e_sn                  =  175,   181,
 geog_data_res         =  '5m',  '2m',


 dx                    = 15000,
 dy                    = 15000,
 map_proj     = 'lambert',
 ref_lat      = 37.0,
 ref_lon      = -97.0,
 truelat1     = 45.0,
 truelat2     = 30.0,
 stand_lon    = -97.0,
 geog_data_path = '/data/static/geog/'
/
```

e_we and e_sn:
Each domain's full west-east and south-north dimensions (grid spaces)



Notes:

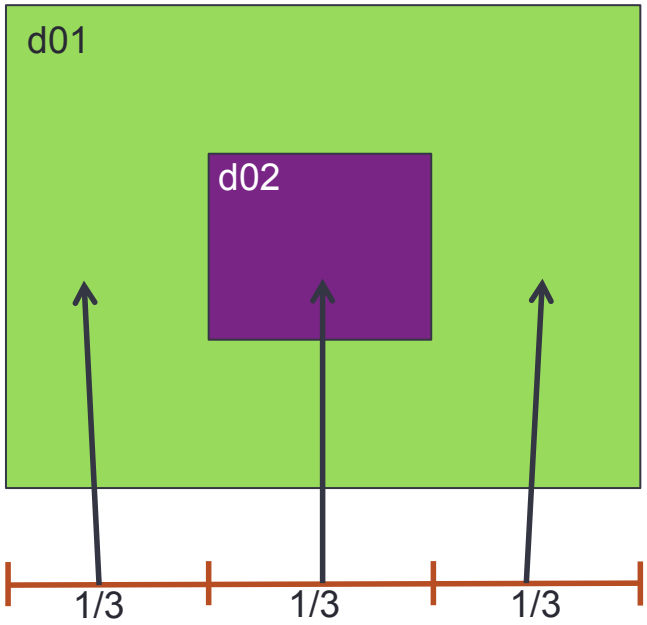
- Domains should be no smaller than about 100x100
- Avoid placing any boundaries over high terrain

namelist.*wps* set-up: *&geogrid*

```
&geogrid

 parent_id             =   1,        1,
 parent_grid_ratio     =   1,        3,
 i_parent_start        =   1,       20,
 j_parent_start        =   1,       17,

 e_we                  =  220,     181,
 e_sn                  =  175,     181,
 geog_data_res         =  '5m',    '2m',


 dx                    = 15000,
 dy                    = 15000,
 map_proj     = 'lambert',
 ref_lat      = 37.0,
 ref_lon      = -97.0,
 truelat1     = 45.0,
 truelat2     = 30.0,
 stand_lon    = -97.0,
 geog_data_path = '/data/static/geog/'
/
```

Mimimum distance between nest boundary and parent boundary:

- 4 grid cells
- need MUCH larger buffer zone



Good practice to have ~1/3 of coarse-grid surrounding each side of nest

namelist.*wps* set-up: *&geogrid*

```
&geogrid

 parent_id         =   1,      1,
 parent_grid_ratio =   1,      3,
 i_parent_start    =   1,     20,
 j_parent_start    =   1,     17,

 e_we              =  220,   181,
 e_sn              =  175,   181,
 geog_data_res     = '5m',  '2m',


 dx                = 15000,
 dy                = 15000,
 map_proj     = 'lambert',
 ref_lat      = 37.0,
 ref_lon      = -97.0,
 truelat1     = 45.0,
 truelat2     = 30.0,
 stand_lon    = -97.0,
 geog_data_path = '/data/static/geog/'
/
```

Dx and dy:
Only need the coarse domain Resolution. geogrid calculates the nest resolution(s) using “parent_grid_ratio”

***Note:**
No changes need to be made to the &ungrib and &metgrid namelists for Nesting purposes

namelist.*input* set-up: *&time_control*

```
&time_control
 run_days                            = 0,
 run_hours                           = 24,
 run_minutes                         = 0,
 run_seconds                          = 0,
 start_year                          = 2000,   2000,   2000,
 start_month                         = 01,     01,     01,
 start_day                           = 24,     24,     24,
 start_hour                          = 12,     12,     12,
 start_minute                        = 00,     00,     00,
 start_second                        = 00,     00,     00,
 end_year                            = 2000,   2000,   2000,
 end_month                           = 01,     01,     01,
 end_day                             = 25,     25,     25,
 end_hour                            = 12,     12,     12,
 end_minute                          = 00,     00,     00,
 end_second                          = 00,     00,     00,
 interval_seconds                    = 21600
 input_from_file                     = .true.,.true.,  .true.
 history_interval                    = 360,    60,     60
 frames_per_outfile                  = 1000,   1,      1
 restart                             =  .false
 restart_interval                    = 180
 io_form_history                     = 2
 io_form_restart                     = 2
```

** To edit the namelist.input file, make sure you are in the *WRFV3/test/em_real/* (or *WRFV3/run/*) directory

start/end date/times:
These values typically will be the same for all domains

history_interval:
May choose to have a smaller output time for nests

frames_per_outfile:
May choose to have all history outputs in 1 file, or in multiple files

namelist.*input* set-up: *&domains*

```
&domains
 time_step                  = 180,
 time_step_fract_num        = 0,
 time_step_fract_den        = 1,
 max_dom                    = 2,
 e_we                       = 74,    112,   94,
 e_sn                       = 61,    97,    91,
 e_vert                     = 30,    30,    30,
 p_top_requested            = 5000,
 num_metgrid_levels         = 27,
 num_metgrid_soil_levels    = 4,
 dx                         = 30000, 10000,  3333.33,
 dy                         = 30000, 10000,  3333.33,
 grid_id                    = 1,     2,     3,
 parent_id                  = 0,     1,     2,
 i_parent_start             = 1,     31,    30,
 j_parent_start             = 1,     17,    30,
 parent_grid_ratio          = 1,     3,     3,
 parent_time_step_ratio     = 1,     3,     3,
 feedback                   = 1,
 smooth_option              = 0
 /
```

max_dom:
Activate nests - # of domains to run
VERY IMPORTANT!

e_we and e_sn:
should match namelist.wps values

e_vert:
All columns must have the same value

dx/dy:
must set values for each domain.
make sure values correspond with "parent_grid_ratio"
- for fractional grid resolutions, use at least 2 decimal places

namelist.*input* set-up: *&domains*

```
&domains
.....
grid_id                  = 1,    2,    3,
parent_id                = 0,    1,    2,
i_parent_start           = 1,   31,   30,
j_parent_start           = 1,   17,   30,
parent_grid_ratio        = 1,    3,    3,
parent_time_step_ratio   = 1,    3,    3,
feedback                 = 1,
smooth_option            = 0
/
```

All must be set to the same values used in namelist.wps

feedback:
Whether a nest will overwrite parent results (2-way nesting; =1), To turn off, =0

namelist.*input* set-up: *&physics*

- You must use the same physics options for all domains for all schemes
  - Exception: cumulus_scheme (cu_physics) may need to be turned off for a nest that has a grid distance of only a few kilometers

- Use same values for physics calling frequency parameters
  - radt: radiation time step
  - cudt: cumulus scheme time step

Where do I start?

- Always start with a *namelist* template provided in the WRFV3/test/em_real (or WRFV3/run/) directory

- Use documents/websites to guide your namelist modifications
  - WRFV3/run/*README.namelist*
  - Users' Guide, Chapter 5
    - http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_V3.8/users_guide_chap5.htm
  - Namelist Best Practice web pages:
    - WPS: http://www2.mmm.ucar.edu/wrf/users/namelist_best_prac_wps.html
    - WRFV3: http://www2.mmm.ucar.edu/wrf/users/namelist_best_prac_wrf.html

- Not all namelists are functions of domains. If in doubt:
  - Check WRFV3/Registry/*Registry.EM_COMMON* or *registry.io_boilerplate* (grep for parameter names)
  - Check WRFV3/run/*README.namelist* (grep for parameter names)
  - Rule of thumb: If default namelist only has 1 column, don't add values for other columns!

Steps to run

- WPS: Identical to single domain run:
  1) Make sure you are in the WPS/ directory
  2) Make necessary changes to the namelist.wps file
  3) Run geogrid.exe, ungrib.exe, and metgrid.exe

```
./geogrid.exe
./ungrib.exe
./metgrid.exe
```

- WRFV3: Identical to single domain run:
  1) Make sure you are in the *WRFV3/test/em_real* (or *WRFV3/run/) directory*
  2) Move or link WPS output files (*met_em.d0**) to your running directory

```
ln -sf ../../../WPS/met_em* .
```

  3) Edit *namelist.input* file for the appropriate grid and times of the case
  4) Run initialization program: *`mpirun -np n ./real.exe`*
     - "n": number of processors used
  5) Run model executable: *`mpirun -np n ./wrf.exe`*

Successful *real.exe* Run

- If *real.exe* was successful, you should see this at the end of your rsl.error.0000 file:
  - `tail rsl.error.0000`
  - SUCCESS COMPLETE REAL_EM INIT

- You should have these files in your running directory:
  - wrfbdy_d01 :
    - time level data at model's start time (includes all domains)
  - wrfinput_d01, wrfinput_d02, ….
    - time_level data at the lateral boundary for all times
    - 1 file per domain

Successful *wrf.exe* Run

- If *wrf.exe* was successful, you should see this at the end of your rsl.error.0000 file:
  - `tail rsl.error.0000`
  - SUCCESS COMPLETE WRF

- You should have these files in your running directory:
  - wrfout_d01_2005-08-28_00:00:00
  - wrfout_d02_2005-08-28_00:00:00
    - One for each domain, for each history time (depending on how you set 'frames_per_outfile')
  - wrfrst_d01_2005-08-28_00:00:00
  - wrfrst_d02_2005-08-28_00:00:00
    - If "restart_interval" is smaller than integration time

Questions?