WRF Nesting: Set Up and Run

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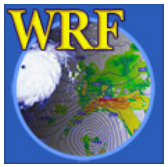
Outline

- General comments
- Nest namelist options
- Running WRF with nests
  - NMM case: one-way, two-way nesting
  - ARW case: two-way nesting
  - ARW moving nest
  - ARW one-way nesting
- Summary



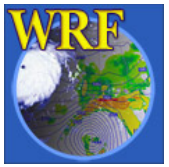
Before You Run ..

- Make sure you have selected basic nest compile options and appropriate executables are created in **`WRFV3/main/`** directory:

  For ARW:
  - **`real.exe`**
  - **`wrf.exe`**
  - **`ndown.exe`**
  - **`tc.exe`**

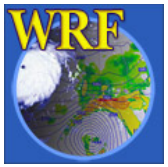
  For NMM:
  - **`real_nmm.exe`**
  - **`wrf.exe`**

- If you are running a real-data case, be sure that files for *nest* domains from WPS are generated:
  - **`met_em.d01.<date>`**, **`met_em.d0*.<date>`**
  - **`met_nmm.d01.<date>`**, **`geo_nmm_nest.l0*.nc`** for NMM



Steps to Run (same as before)

1. cd to *run/* or one of the *test case* directories
2. Link or copy WPS output files to the directory for real-data cases
3. Edit *namelist.input* file for the appropriate grid and times of the case
4. Run initialization program (*real.exe*, or *real_nmm.exe*) as in the single domain case
5. Run model executable, *wrf.exe*

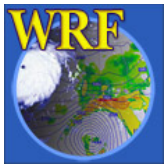


All in the namelist…

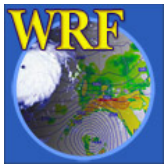
- Nearly all controls for a nested run can be achieved by editing the namelist file.
- Look at nest specific namelist options

Important to note:

- Key variable: **`max_dom`** must be set to >= 2
- Need to pay attention to multi-column namelists



Nest namelist Options

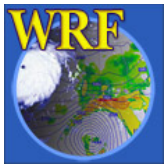


&time_control

```
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
```

First column: domain 1 option

These control the start and end times of the nests. They can be different from the parent domain, but must fit in the time window of the parent domain

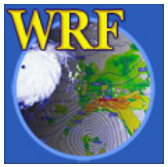


&time_control

```
interval_seconds     = 21600
history_interval     = 180,  60,   60,
frame_per_outfile    = 1000, 1000, 1000,
restart_interval     = 360,
```

History output may be split into multiple files

- History files are written one for each domain
- History intervals may be different for different domains
- restart files are also written one per domain



&time_control

Nest input option: ARW only

```
input_from_file  = .true., .true., .true.,
fine_input_stream   = 0, 2, 2,
```

Specify what fields to use in nest input: they can be all (0), or data specified in I/O stream 2 in Regsitry (2).
Limited use: if a nest starts at a later time, or have an updated analysis only on domain 1.

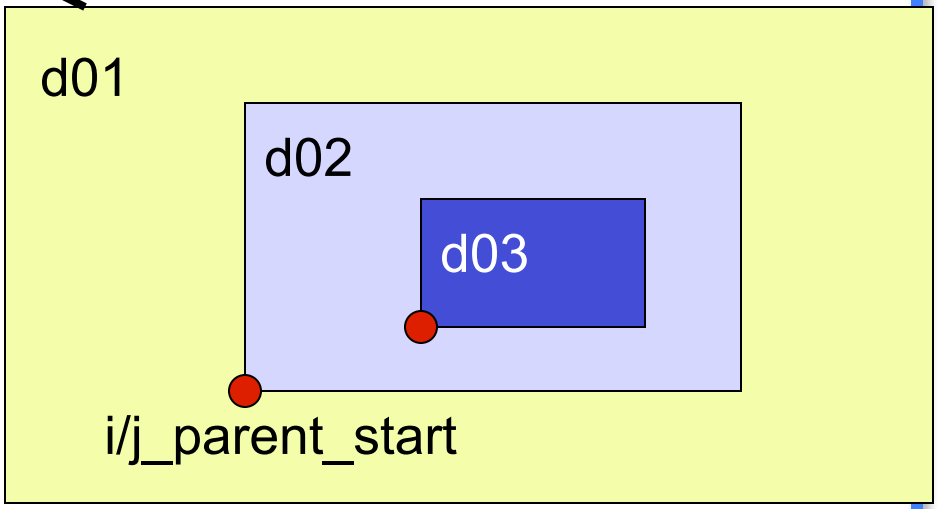
Whether to produce in *real.exe* and use nest wrfinput files in *wrf.exe*. This is usually the case for real-data runs. For idealized nest runs, set it to .false. .

&domains

```
max_dom   = 3,
e_we      = 74, 112,94,
e_sn      = 61, 97, 91,
e_vert    = 28, 28, 28,
grid_id         = 1,  2,  3,
parent_id       = 0,  1,  2,
i_parent_start = 0, 31, 30,
j_parent_start = 0, 17, 30,
```

Activate nests: no. of domains to run

Dimensions of all domains; same as in WPS.



Make sure the nest domain parameters match those defined in WPS

&domains

ARW

```
dx = 30000., 10000., 3333.33,
dy = 30000., 10000., 3333.33,
parent_grid_ratio = 1, 3, 3,
parent_time_step_ratio = 1,3,3,
```

For fractional grid distance, use at least 2 decimal places

All 4 variables must be specified. *Grid ratio* can be any integer, and *time step ratio* can be different from grid ratio. Grid distance is in meters, even for lat/lon map projection.

NMM

```
dx = 0.096290,
dy = 0.096011,
parent_grid_ratio = 1,
parent_time_step_ratio = 1,
```

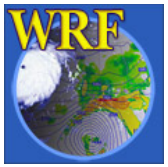
Values in nest columns are ignored. Everything is defined by 1:3 ratio in the model.

&domains

```
feedback        = 1,
smooth_option = 2,
```

When feedback is on, this option can be selected to smooth the area in the parent domain where the nest is. Valid values are 0,1,2.

Whether a nest will overwrite parent domain results. Setting feedback=0 ➔ 'one-way' nesting in a concurrent run.



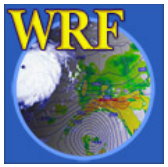
&bdy_control

```
spec_bdy_width = 5,  (1 for NMM)
spec_zone      = 1,  (ARW only)
relax_zone     = 4,  (ARW only)
specified      = .T.,.F.,.F.,
nested         = .F.,.T.,.T.,
```

Boundary condition option for domain 1.

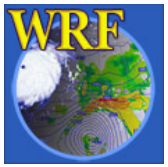
Boundary condition option for nests.

May change *relax_zone* and *spec_bdy_width* for ARW ***(spec_zone+relax_zone =spec_bdy_width)***



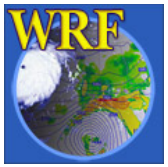
Other notes on namelists

- Use same physics options for all domains.
  - An exception is cumulus scheme. One may need to turn it off for a nest that has grid distance of a few kilometers.
- Also use same physics calling frequency (e.g. **`radt, cudt,`** etc.) in all domains.

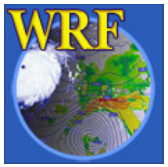


Where do I start?

- Always start with a *namelist* template provided in a test case directory, whether it is a ideal case, or real data case.
- Not all namelists are function of domains. If in doubt, check Registry.EM_COMMON, Registry.NMM and registry.io_boilerplate (look for string 'namelist').
- Use document to guide the modification of the namelist values:
  - run/README.namelist
  - User's Guide, Chapter 5



Running NMM Nested Case



Running NMM Nested Case

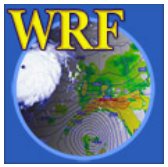
- Files available from WPS:

  met_nmm.d01.<date>

  geo_nmm_nest.l0*.nc,.. (multi files from **geogrid**)

- Link or copy WPS output files to the run directory:

```
cd test/nmm_real
ln -s ../../../WPS/met_nmm.d01.*   .
ln -s ../../../WPS/geo_nmm_nest.l0*   .
```



Running NMM Nested Case

- Edit **namelist.input** file for runtime options (set **max_dom >= 2** for a nest run)

- Run the real-data initialization program (MPI only):

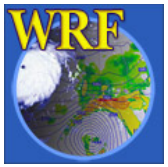
  mpirun -np *N* ./real_nmm.exe

- Successfully running this program will create model initial and boundary files:

  wrfinput_d01

  wrfbdy_d01

  geo_nmm_nest.l01.nc ← from geogrid



Running NMM Nested Case

- Run the model executable by typing (MPI only):

  `mpirun -np N ./wrf.exe`

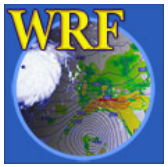
- Successfully running the model will create model *history* files, one for each domain:

  `wrfout_d01_2005-08-28_00:00:00`

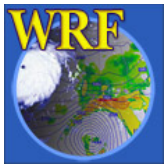
  `wrfout_d02_2005-08-28_00:00:00`

  And *restart* file if selected:

  `wrfrst_d01_<date>, wrfrst_d02_<date>`



Running ARW Nested Case



Running ARW Nested Case

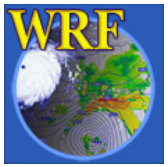
- Files available from WPS:

  met_em.d01.<*date*> (a few time periods)

  met_em.d02.<*date*> (at least one time period data)

- Link or copy WPS output files to the run directory:

```
cd test/em_real
ln -s ../../../WPS/met_em.* .
```



Running ARW Nested Case

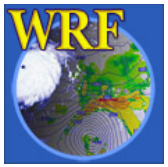
- Edit **`namelist.input`** file for runtime options (set **`max_dom >= 2`** in **`&domains`** for a nested run)

- Run the real-data initialization program:

  `./real.exe,` if compiled serially / SMP, or

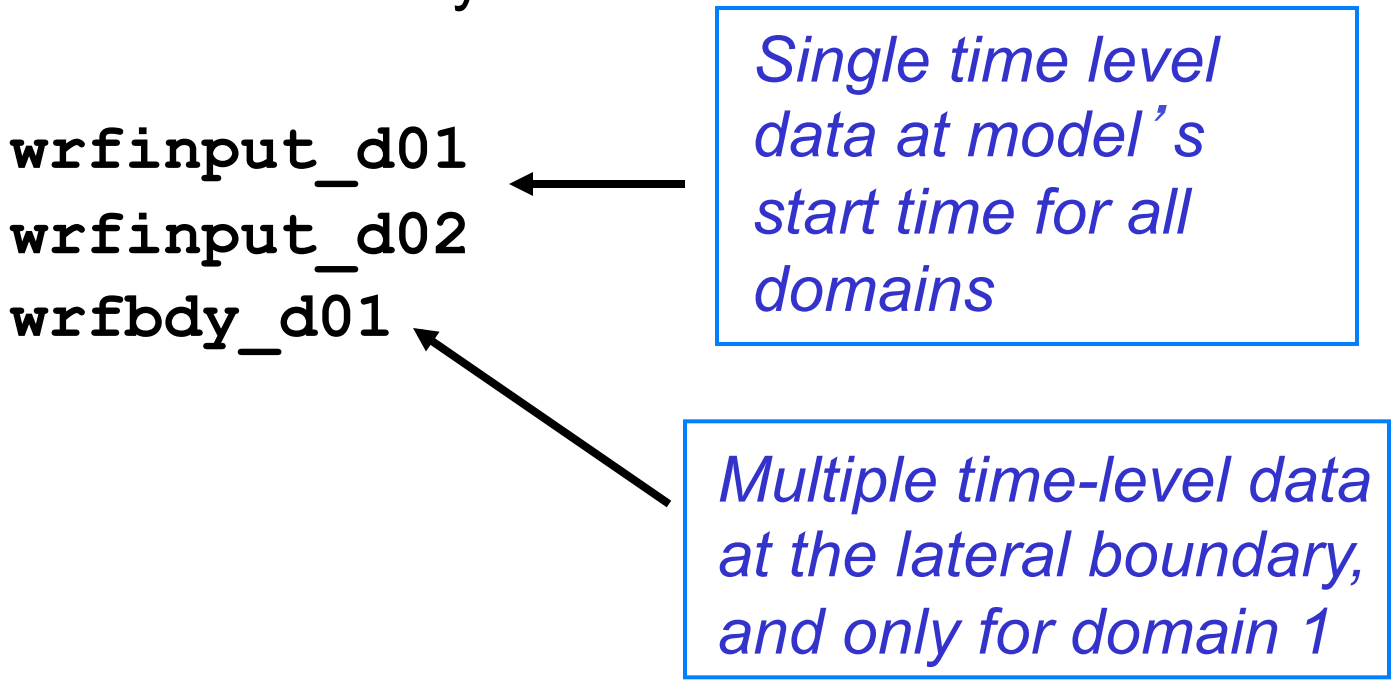
  `mpirun -np N ./real.exe,` for a MPI job

  where ***N*** is the number of processors requested



Running ARW Nested Case

- Successfully running this program will create model initial and boundary files:



Running ARW Nested Case

- Run the model executable by typing:

  `./wrf.exe >& wrf.out &`

  or

  `mpirun -np N ./wrf.exe &`

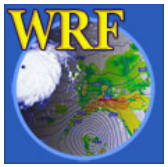
- Successfully running the model will create model *history* files, one for each domain:

  `wrfout_d01_2005-08-28_00:00:00`

  `wrfout_d02_2005-08-28_00:00:00`

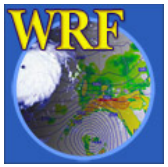
  And *restart* file if **`restart_interval`** is smaller than the integration time:

  `wrfrst_d01_<date>, wrfrst_d02_<date>`



Moving Nest Case (ARW only)

- The main reason for using this option is to run the model economically.
- Must choose correct compile options when creating **`configure.wrf`** file
  - Choose preset move, or vortex following
- Other options are controlled by the namelists.
- Can do specified move, and automatic vortex tracking (for tropical cyclone application).
- All nest domains can move, but driven by the innermost nest



Specified Moving Case

- namelists in **`&domains`**:

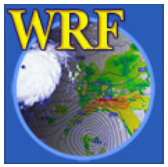
  `num_moves, move_id, move_interval,`
  `move_cd_x, move_cd_y`

  ➔ nest can only move one parent-grid-cell at a time.

  i.e., `move_cd_x = 1, -1,` or `0`

- Also specify initial nest location:

  `i_parent_start, j_parent_start`



Automatic Moving Case

- Tropical cyclone applications only.
- Works better for well developed storms.
- Namelists in **`&domains`**:

  `vortex_interval` (default 15 min)

  `max_vortex_speed` (default 40 m/s)

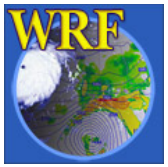
  `corral_dist` (default 8 coarse grid cells)

  `track_level` (default 50000 Pa)

  `time_to_move` (default is 0 h for all nests)

- Also specify initial nest location

  `i_parent_start, j_parent_start`

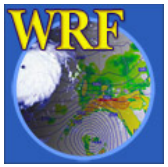


One-way Nesting: Two separate runs

Less common option:

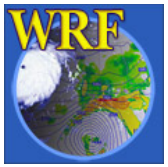
- Prepare data as if one were to run a two-way nested case up to program real;
- Run WRF model for coarsest domain first. Should output model frequently (e.g. hourly);
- Use program **`ndown.exe`**, together with coarsest domain model output and nest domain wrfinput file, to generate wrfinput and wrfbdy file for the next model run;
- Run WRF model for the second domain.

(Also see Chapter 5, pages 15 - 17)



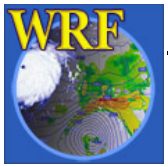
Summary

- Two-way, without nest input files (ARW) (**`input_from_file=.f.`**)
- Two-way, with nest input files (NMM and ARW) (**`input_from_file =.t.`**)
- Two-way, with static nest input only (ARW) (**`input_from_file=.t., fine_input_stream=2`**)
- One-way, *concurrent* run (**`feedback =0`**) (NMM/ARW)
- One-way, *separate* runs (treated like two single-domain runs, with ***`ndown`***) (ARW)
- Two-way, specified moving nest run (ARW)
- Two-way, automatic vortex tracking run (ARW, also possible in NMM)



Notes about Nesting

- When should I use nests?
  - Input data resolution is too coarse (for example, some reanalysis data: NNRP, NCEP2, climate model data)
  - 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: boundary conditions from external sources are typically 3 – 6 hourly, while nested boundary conditions are in minutes (coarse domain time step)
  - There isn't sufficient computing resources
- Nest domain sizes should not be too small
  - No less than 100x100
  - Avoid boundary zones that are about 10 grid point wide
  - Avoid 'sweeping' effect from lateral boundaries
  - Avoid placing nest boundaries over high mountains



References

- Information on compiling and running WRF with nests, and a more extensive list of namelist options and their definition / explanation can be found in the ARW and NMM User's Guide, Chapter 5
- Start with namelist templates in `test/` directory, and refer to namelist used for different applications on pages 5-25 – 27 for ARW
- Practice with online tutorial, and in the class.