WRF Nesting: Set Up and Run

Wei Wang
NCAR/MMM
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Outline

- General comments
- Nest namelist options
- Running WRF with nests
  - two-way nesting
  - moving nest
  - 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:
  - **`real.exe`** – *executable to create IC/BC*
  - **`wrf.exe`** – *executable for model integration*
  - **`ndown.exe`** – *utility program for one-way nesting*
  - **`tc.exe`** – *utility program for TC bogusing*

- If you are working with real data, be sure that files for *nest* domains from WPS are generated:
  - **`met_em.d01.<date>`**, **`met_em.d0*.<date>`**
    (* terrain, static land data are in the nested files)

Steps to Run (same as before)

1. cd to *run/* or one of the *test case* directories
2. Move or link 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*
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.
- Nest-specific namelist options will be explained next.

Important to note:

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

Nest namelist Options

namelist record `&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,
frames_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:

```
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. .

```
state real ht  ij  misc  1 - i012rhdus "HGT" "Terrain Height" "m"
```

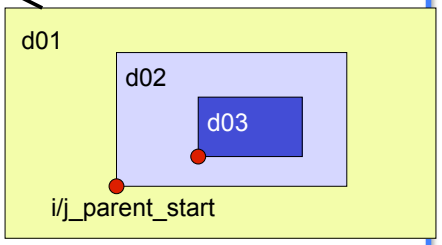

namelist record &domains

```
max_dom   = 3,
e_we      = 74, 112,94,
e_sn      = 61, 97, 91,
e_vert    = 30, 30, 30,
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 set in WPS



&domains

```
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 (3 and 5 are recommended), and *time step ratio* can be different from grid ratio.
- Grid distance is in meters, even for lat/lon map projection.

&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.

namelist record **&bdy_control**

```
spec_bdy_width = 5, (10)
spec_zone      = 1,
relax_zone     = 4, (9)
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*** ***(spec_zone + relax_zone = spec_bdy_width)***

* Wider boundary zone may work better for coarser driving data

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 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 Nested Case

Running a Nested Case

- Files available from WPS:

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

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

  (* terrain, static land data are in the nested files)
- Move or link WPS output files to the run directory:

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

Running a 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 a Nested Case

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

wrfinput_d01 ← *Single time level data at model's start time for all domains*

wrfinput_d02

…

wrfbdy_d01 ← *Multiple time-level data at the lateral boundary, for domain 1 only*

Running a 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

- 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 coarse/ parent 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 - 19)

Summary

- Two-way, without nest input files (**`input_from_file=.f.; feedback = 1`**)
- Two-way, with nest input files (**`input_from_file =.t.; feedback = 1`**)
- Two-way, with static nest input only (**`input_from_file=.t., fine_input_stream=2`**)
- One-way, *concurrent* run (**`feedback =0`**)
- One-way, *separate* runs (treated like two single-domain runs, with ***`ndown`***)
- Two-way, specified moving nest run
- Two-way, automatic vortex tracking run

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 which 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 User's Guide, Chapter 5
- Start with namelist templates in **`test/`** directory, and refer to namelist used for different applications on pages 5-33 – 35 in the User's Guide
- Practice with online tutorial, and in the class.