Considerations for Designing an Numerical Experiment

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Domains

- In general,
  - IC is more important for simulations of a few days;
  - BC is more important for longer simulations.

- How large do they need to be?
  - Should not be too small, otherwise solution will be determined by forcing data
  - No less than 100x100 (at least 10 grid points are in the boundary zone)

- Where to place my lateral boundaries?
  - Avoid steep topography
  - Away from my interest
Note on Configuring Domains: Horizontal

\[ \Delta X = V \Delta t \]

inflow

upstream system

outflow

“your Interest”
Note on Configuring Domains: Effect of domain sizes

Large regional domain

Smaller regional domain

(From Warner, 2011)
Note on Configuring Domains: Effect of lateral boundary conditions

From Gaudet et al. WRF Users’ Workshop 2012, talk 3.5
Domains

- How many vertical levels should I use?
  - At least 30 or more levels for model top at 50 mb
  - 50 mb model top is recommended
  - Vertical grid distance should not be larger than 1000 m:
    - Radiation, microphysics, less accurate lateral BC
  - Related to horizontal grid size too: if finer horizontal grid size is used, consider adding a few more levels in the vertical
  - Make sure $dz < dx$
Note on Configuring Domains:

Vertical levels

Do not use large $\Delta Z$

($\Delta Z < 1000$ m)
Domains

- Consider the placement of your domains:
  - What map projection to use?
  - Check the range of the map scale factor after running `geogrid`
    - Values should be close to 1

* Placement of the domain will affect the time step you can use in the model
Nests:

- When should I use nests?
  - Input data resolution is too coarse
  - Input data may not be adequate as LBC
  - There isn’t sufficient computing resources

- Nest domain sizes should not be too small;
- Nest boundary should be kept away from coarse domain boundary, and steep topography.
- If you use a nest, do not save on coarse domain – it’s cheap (and may scale better when using large number of processors)
Input Data

• Check land data:
  e.g. landuse: does it represent my area well?

• Know about the data: how good are the data?
  – Forecast data
  – Reanalysis data
  – Climate model data

• How frequent do I need to have boundary conditions?
  – More frequent is better

* Good data will go a long way to ensure good outcome.
Model Options

• What do I start with?
  – What other people have success with?
    • References, papers
    • Consider well-tested options first
  – Simple options first:
    For example,
    • Graupel may not be important if dx >> 10 km
    • mixed layer ocean model may not be needed if the modeled track isn’t correct
    • Use analyses from weather centers before trying to create your own (via either obsgrid or DA) for both initial and lateral boundary conditions
    • Single domain first, before using many nests
Model Options

– Choose physics for appropriate grid sizes
  • Use a cumulus scheme if grid size > 10 km
  • A cumulus scheme isn’t needed when grid size < 4 km
  • Avoid grid sizes 5 – 10 km
  • Use a PBL for grid size > 500 m
  • Use LES options for grid size < 100 m

– Consider other options:
  For example,
  • Upper level damping over topography
  • Gravity-wave drag if resolution is coarse
  • Slope effect on radiation when grid size < 2 km
Verification:

• What to verify?
  – 500 mb height, or surface precipitation?

• Verifying high-resolution model can be tricky:
  e.g. phase error, which punishes higher resolution model more
  – Neighborhood method more appropriate
Derecho forecast from NCAR’s 2012 RT

Observed radar composite

Forecast max-column reflectivity at 3 km, starting from 1200 UTC June 29

IC: Fully cycled analysis starting from late April using WRF-DART

(from NOAA/SPC)
Sensitivity to physics and initial conditions:

DART-Morrison-MYJ

DART-Morrison-YSU

DART-Thompson-MYJ

GFS

NAM

RUC

(From Weisman)
Resolution Differences: simulated max winds

3 km results

15 km results

over 80 mph
NCAR Real-time Forecast Domain (2013)

15 km

3 km
**Bottomline..**

- Model results can be affected by many choices:
  - Domain configuration, both horizontal and vertical;
  - Input data;
  - Initial and lateral boundary conditions.

- Model has limitations:
  - Physics: biases, may not represent certain process well, etc.
  - Limitation of the lateral boundaries

- **Always check the output after each program**
Other Best Practice Reading:

- “12 steps toward improving the outcome” by C. Davis: http://www2.mmm.ucar.edu/wrf/users/workshops/WS2012/ppts/discussion1.pdf
References:


