Considerations for Designing an Numerical Experiment

Wei Wang

*Nansha, Guangdong, China*

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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
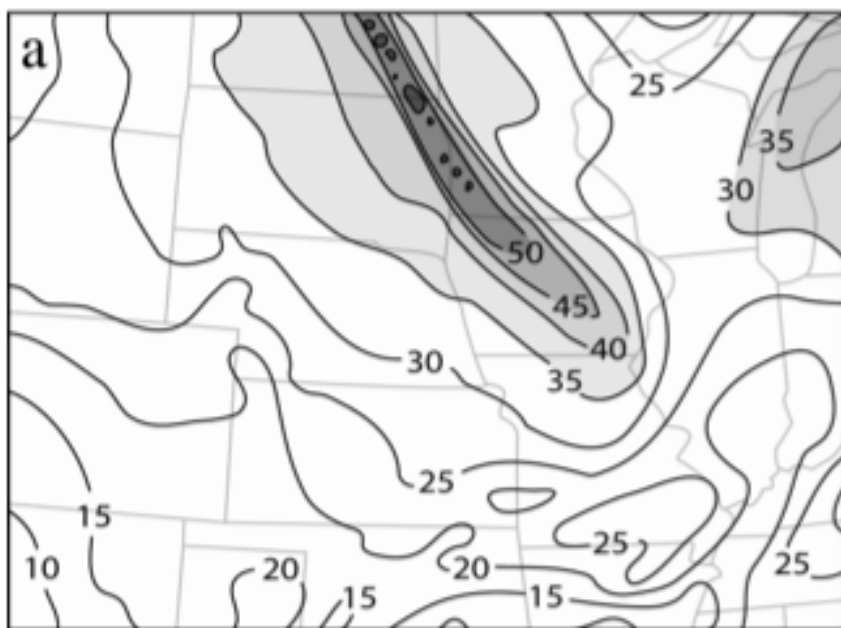 - Away from the area of interest
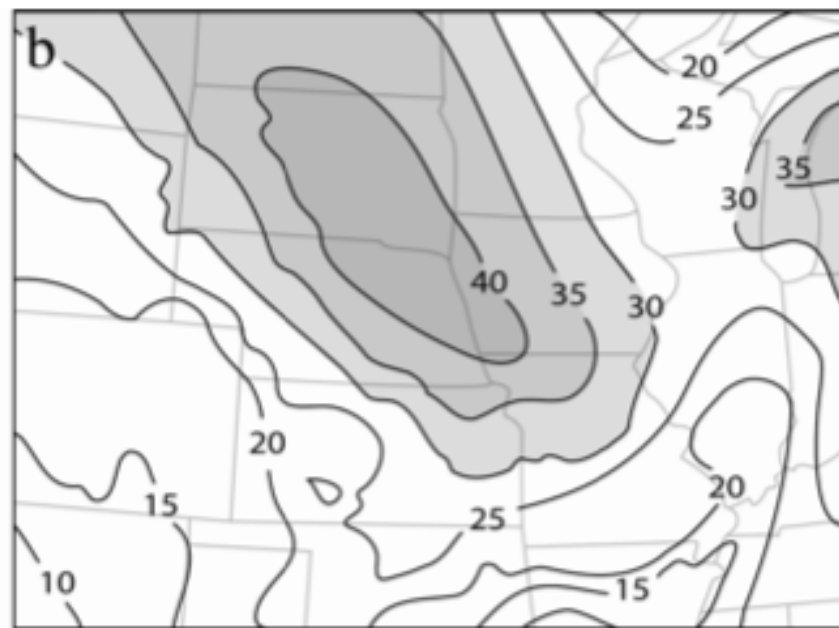
Note on Configuring Domains: Horizontal
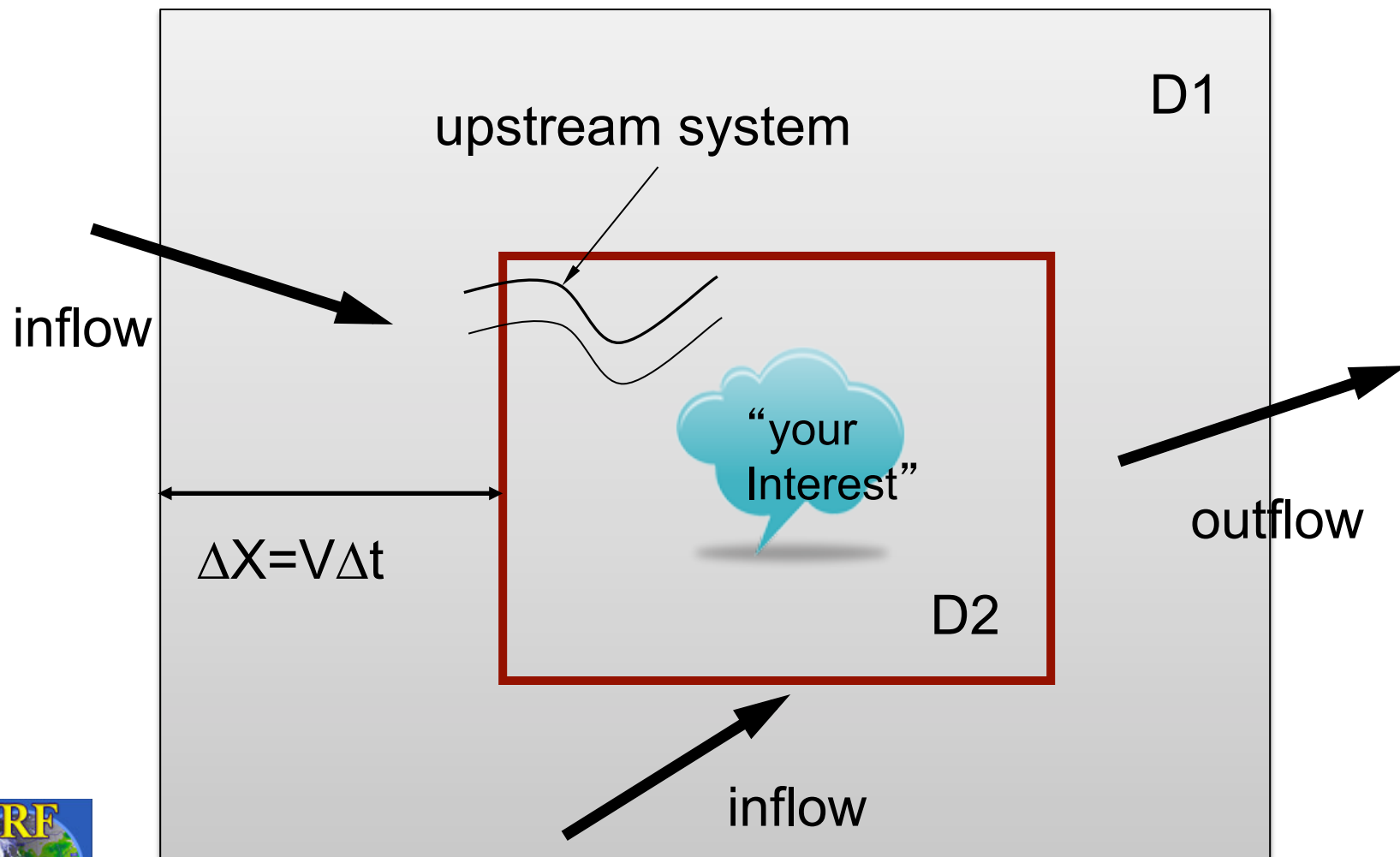
Note on Configuring Domains:
Effect of domain sizes
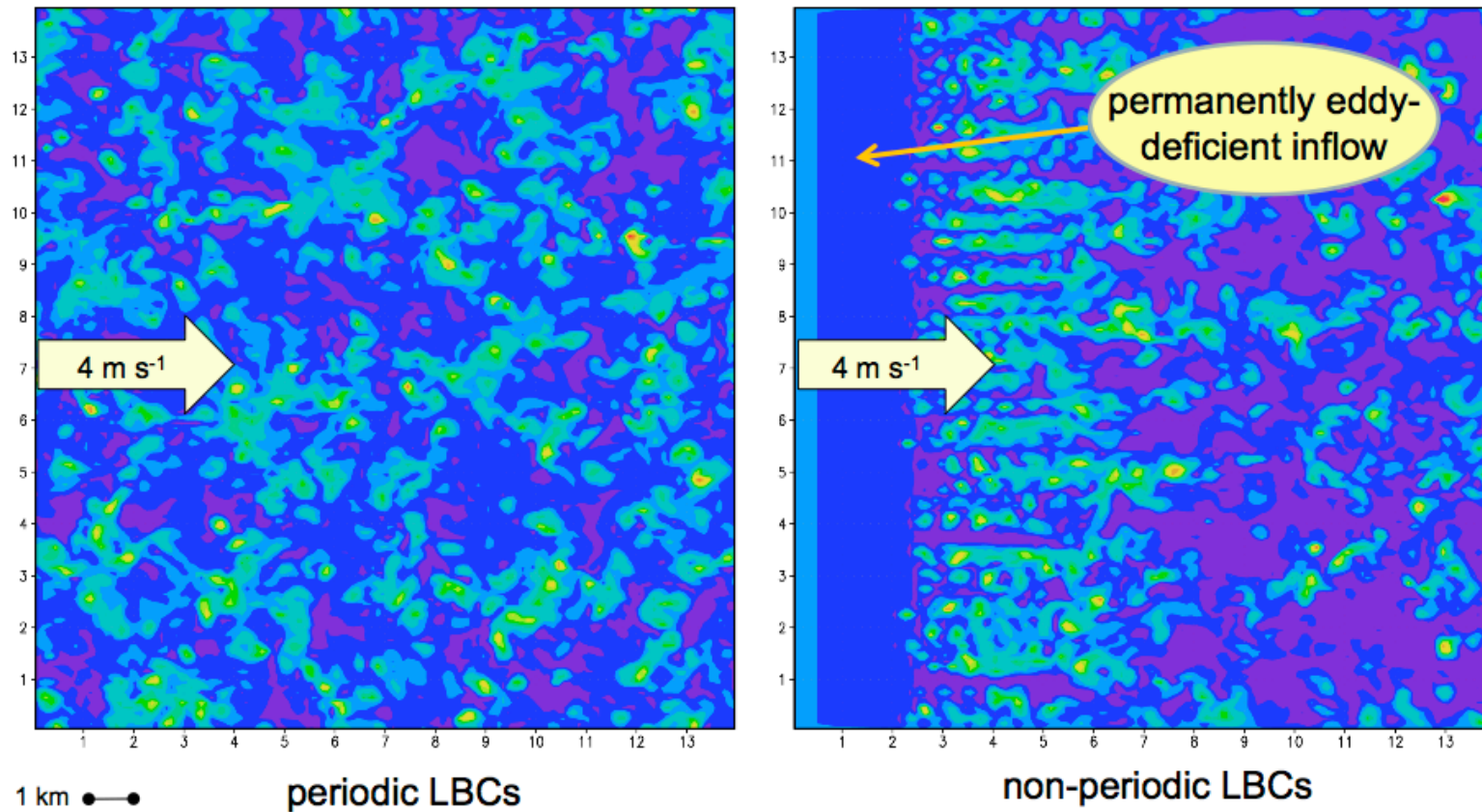
Large regional domain

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

model top

$\triangle Z$

Do not use large $\triangle Z$

($\triangle Z < 1000$ m)

$\triangle Z$

Z

✔

✖
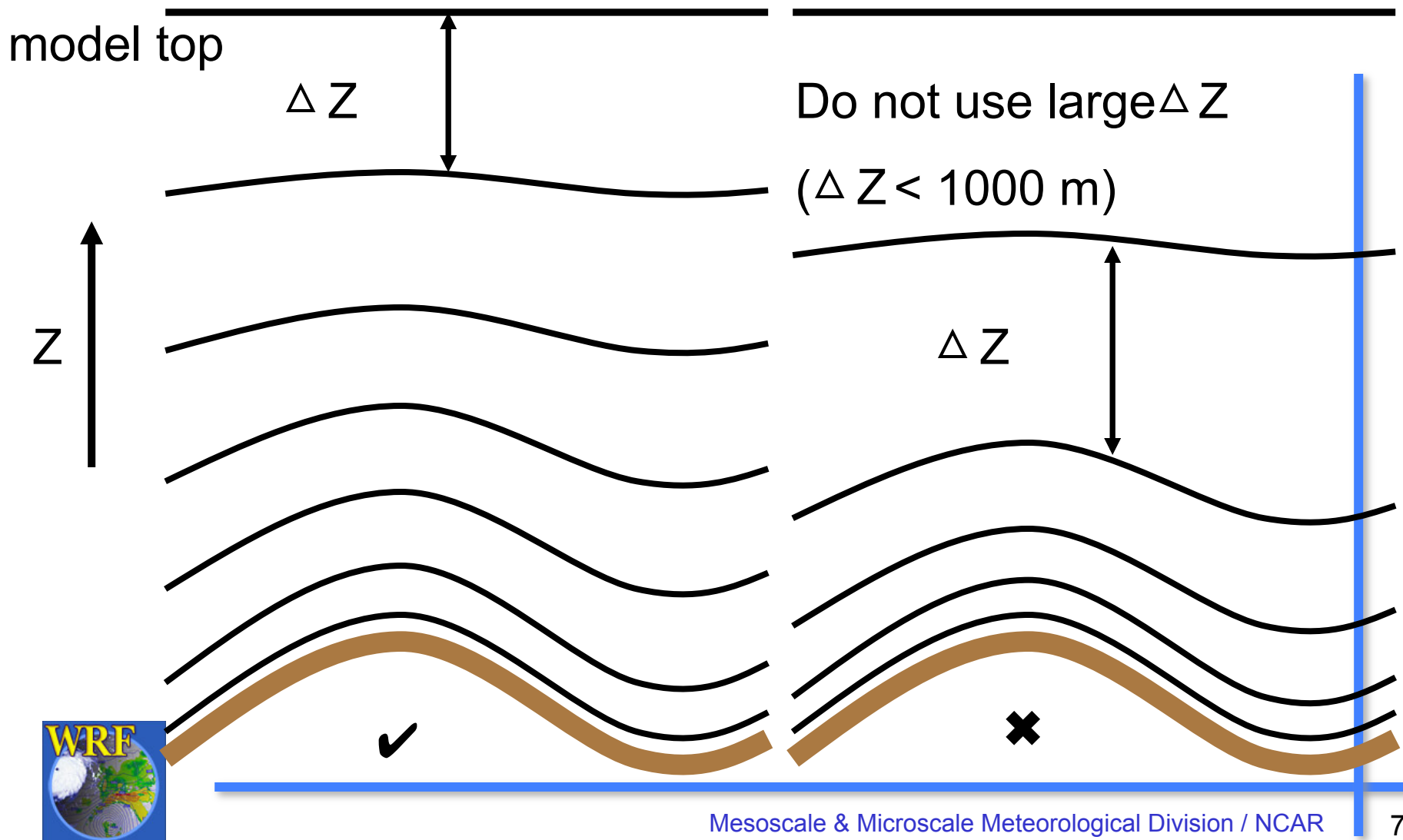
Domains

- ## 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 used in the model.

Nests:

- When should I use nests?

  Some of the reasons may be:
  - 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:

- ## Important to verify:

  - Knowing where model is biased can be very useful

- ## Verifying high-resolution model can be tricky:

  e.g. phase error, which punishes higher resolution
  model more

  - Neighborhood method more appropriate

A forecast example

-- What can we learn from this example?

Derecho forecast from NCAR's 2012 RT

Observed radar composite
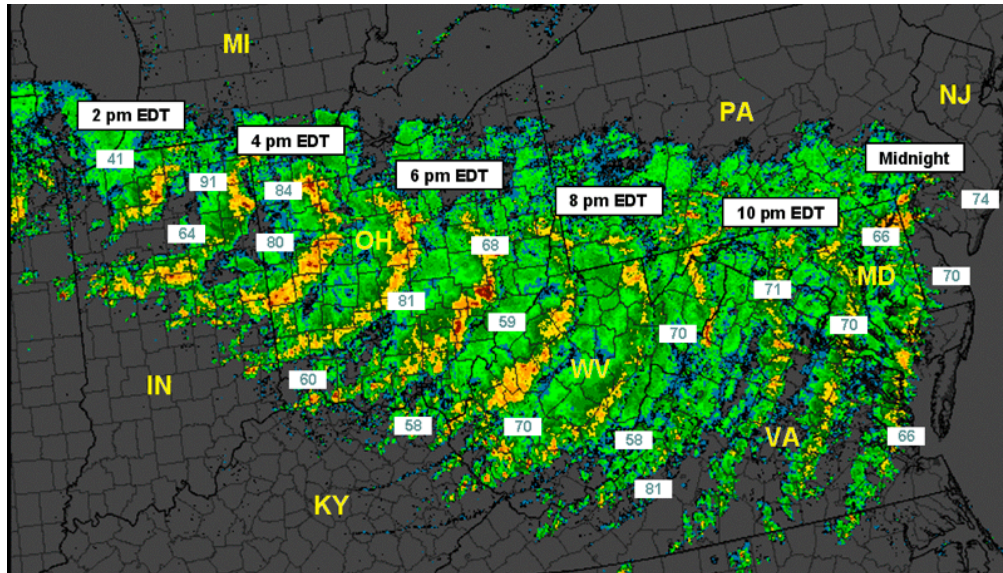
(from NOAA/SPC)

Forecast max-column reflectivity from 3 km model, starting from 1200 UTC June 29
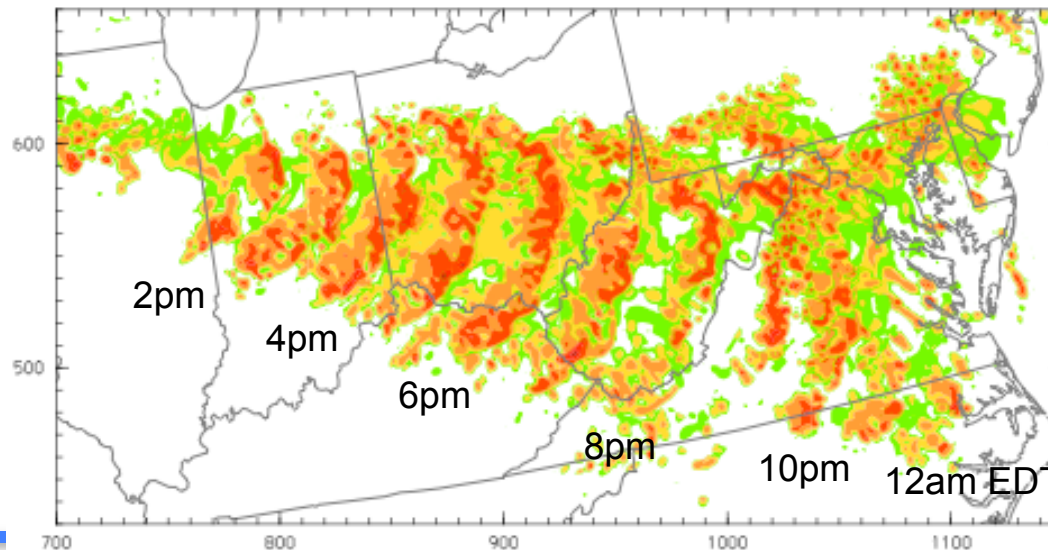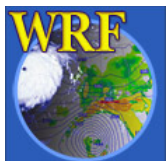
IC: Fully cycled analysis starting from late April using WRF-DART

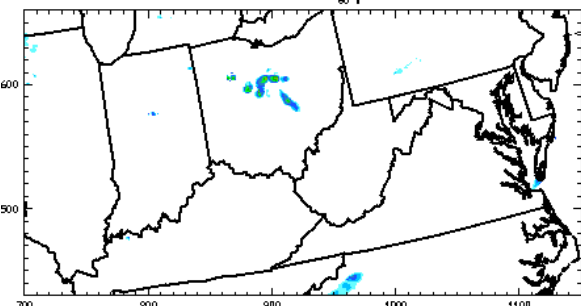Mesoscale & Microscale Meteorological Division / NCAR

IC F06 F09 F12

1800 UTC, 2 pm EDT 2100 UTC, 5 pm EDT 0000 UTC, 8 pm EDT
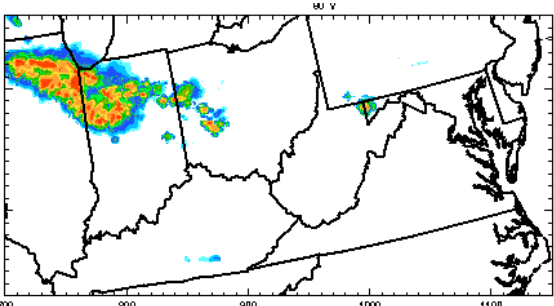
EnKF

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GFS

Mesoscale & Microscale Meteorological Division / NCAR
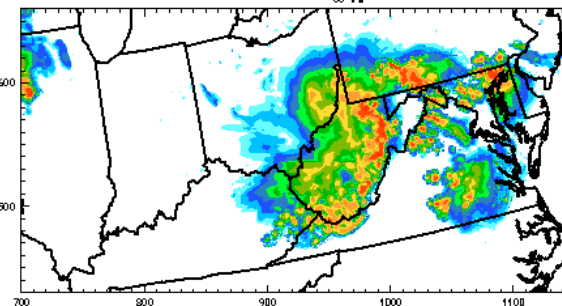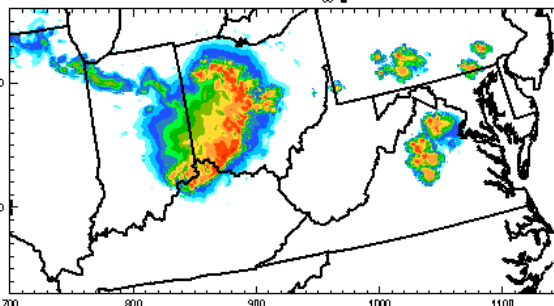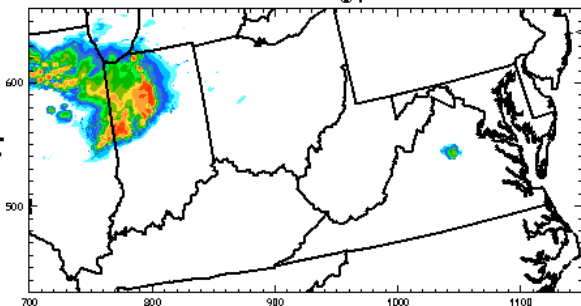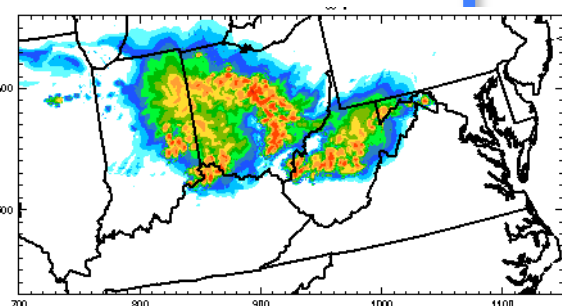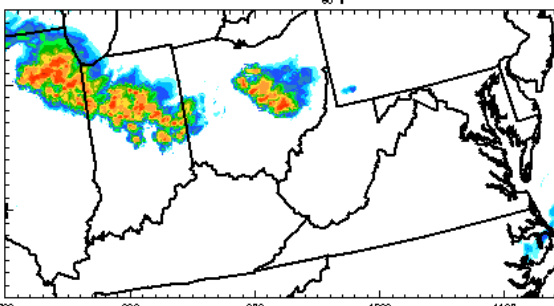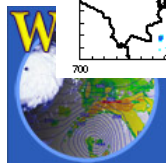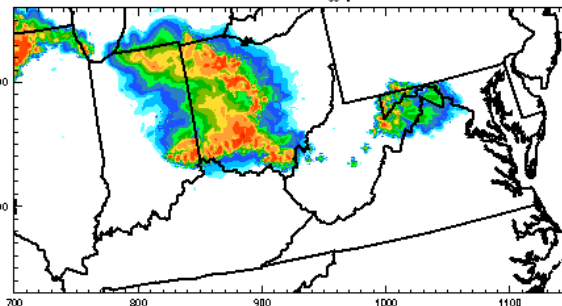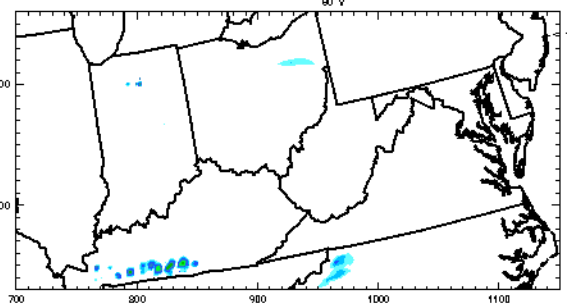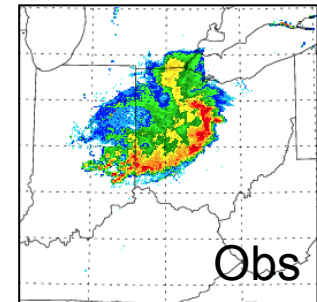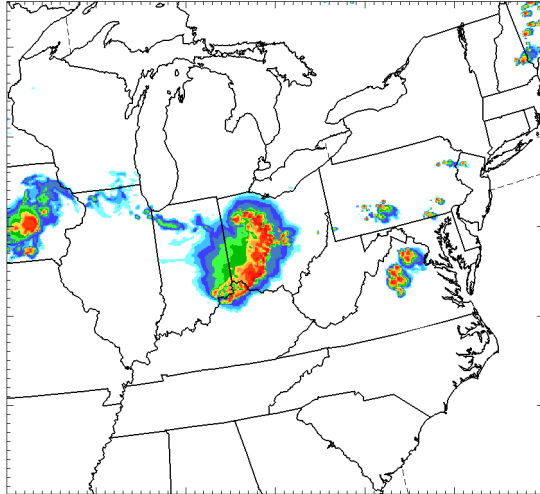
Sensitivity to physics and initial conditions:

29 June 2012
Derecho

Obs

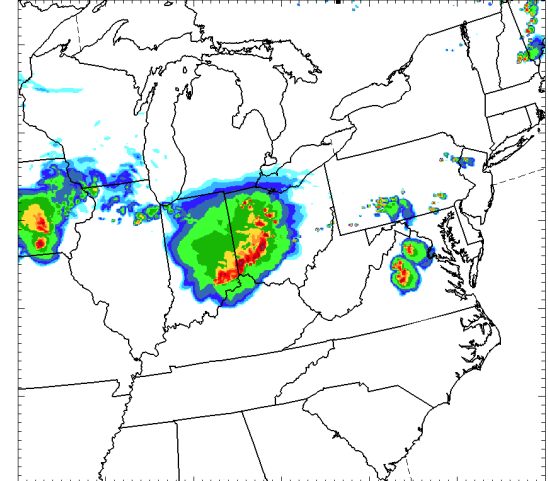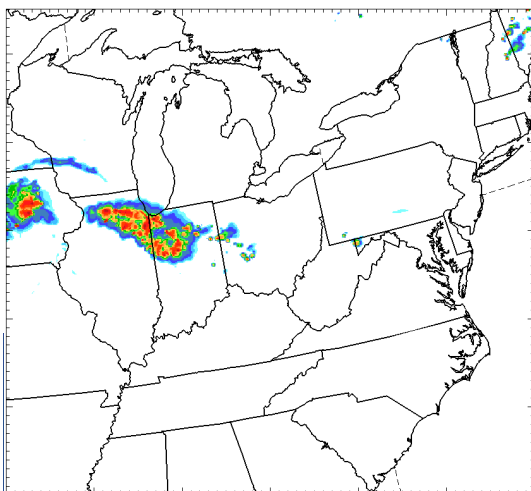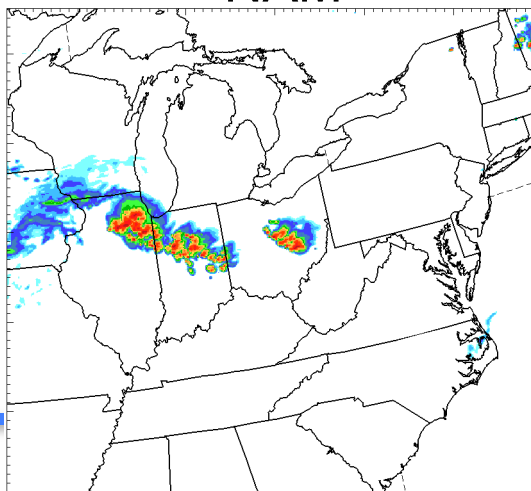### DART-Morrison-MYJ

DART-Morrison-YSU
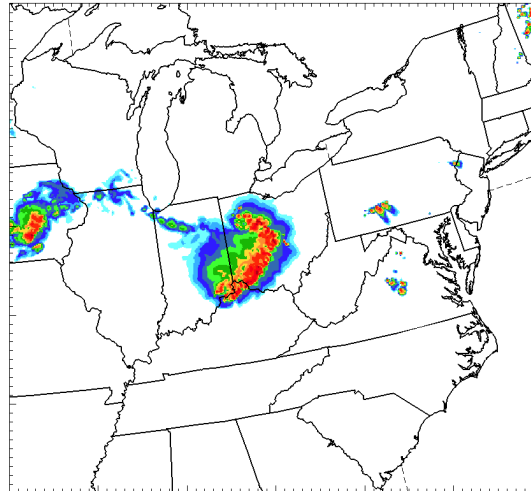
DART-Thompson-MYJ

GFS

NAM

RUC
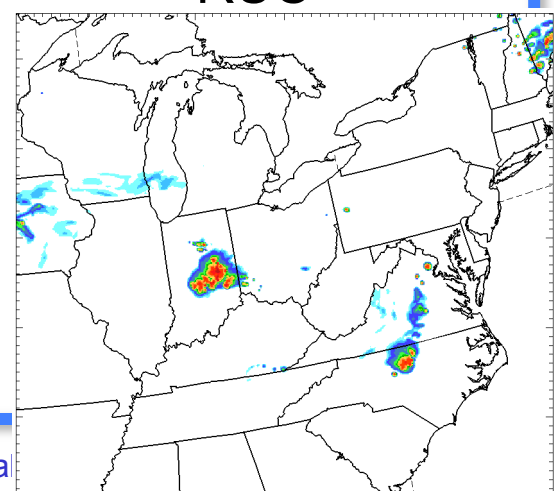
(From Weisman)

Resolution Differences: simulated max winds

3 km results

over 80 mph

2pm 4pm 6pm 8pm 10pm 12am
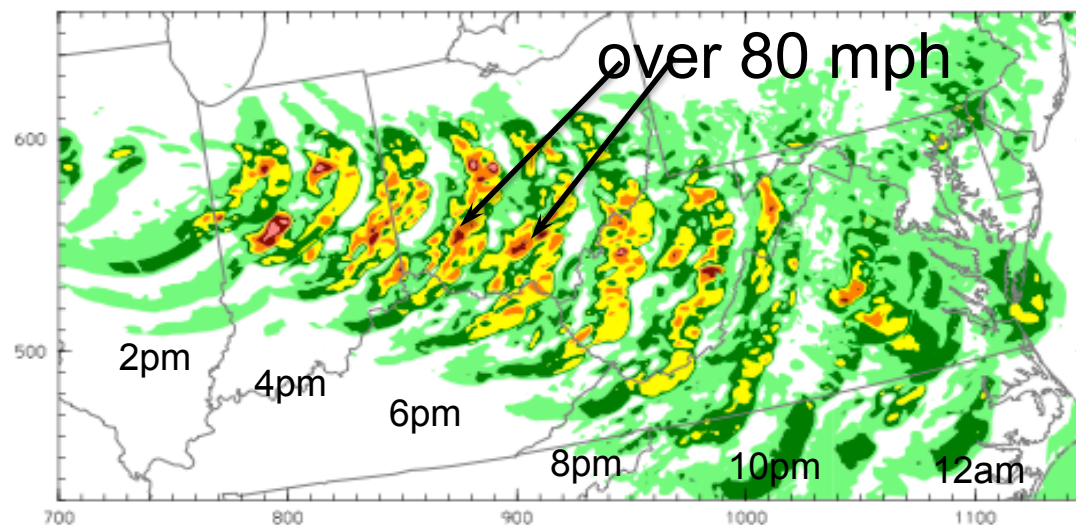
15 km results

NCAR Real-time Forecast Domain (2013)

15 km

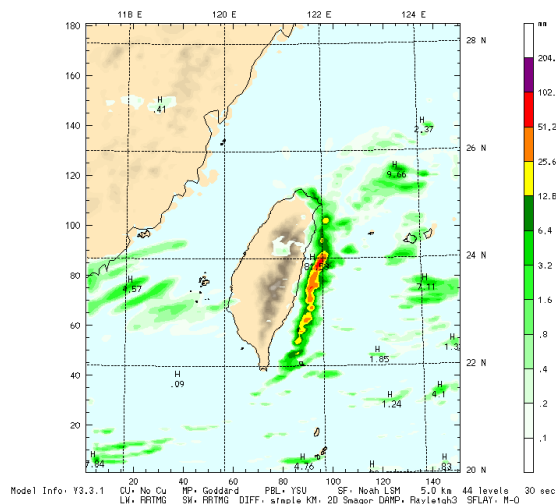3 km

What this case show:

- Initial conditions are important
- Different initial conditions will likely give different solutions
- Compared to model runs using different physics options, changing initial conditions is likely to have larger impact
- Model resolution matters

An example of nest feedback
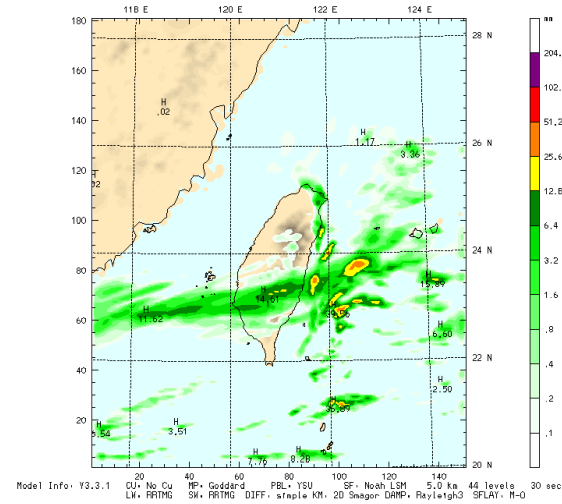
feedback = 0   feedback = 1

60-h forecast of the 6-h rainfall for the period ending
18 UTC 6 May 2014 (courtesy of J. Bresch)

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

- *"WRF Advanced usage and Best Practices" by
  Dudhia and Wang:*
  http://www2.mmm.ucar.edu/wrf/users/workshops/
  WS2014/ppts/best_prac_wrf.pdf (next talk)

References:

Numerical Weather and Climate Prediction, 2011. By Thomas Warner, *Cambridge University Press*.

Warner, T., 2011. Quality assurance in atmospheric modeling. *Bull. Amer. Met. Soc. Dec. issue, p1601 – 1611.*

Stensrud, D., 2007. Parameterization Schemes: Keys to Understanding Numerical Weather Prediction Models. *Cambridge University Press*.

Haltiner G. and R. Williams, 1980. Numerical Prediction and Dynamic Meteorology. *Wiley*.