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QUALITY ASSURANCE IN ATMOSPHERIC MODELING

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Thesis

It is easy to run a model

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It is easy to run a model

but

It is NOT easy to run a model properly

What do we mean by "quality assurance" in this context?

- Understand weaknesses of models
- Make the best choices about model configuration for a specific application
- Thoroughly verify the model accuracy

Why is this an issue now?

Is the problem
becoming any worse?

A brief, recent history of NWP

- 25 years ago – most modelers were model developers at universities, or national laboratories, or weather services. All had atmospheric science degrees, with NWP courses.

A brief, recent history of NWP

- 10 years ago – community models become available, rapid increase begins in the number of model users.

A brief, recent history of NWP

- Now
  - There is a rapid growth in the use of atmospheric models for a wide variety of applications.
  - Many model users have not had an NWP course.
  - Sometimes model users do not even have a good knowledge of atmospheric processes.

Causes for the rapid growth in the use of models

- access to turn-key community models;
- online model documentation and short courses;
- declining costs of computing hardware;
- increasing accuracy of models;
- greater awareness of the value of model-generated weather and climate information;
- greater maturity of coupled secondary models that allow atmospheric forecasts to be used for prediction of floods, infectious-disease outbreaks, electric-power consumption, air-quality-related health warnings, etc.;
- the realization by every nation that it is being affected by climate change, and the resulting desire to perform climate downscaling to answer practical questions about future water resources, agricultural productivity, etc.;
- the use of atmospheric models by specialists from other scientific disciplines; and
- the maturation of science in developing countries.

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How can research and operational modeling practices can be improved?

The following list is of common shortcomings that need attention

1) Clearly define the scientific or practical objective of the modeling

- Write down the specific goals or questions to be answered

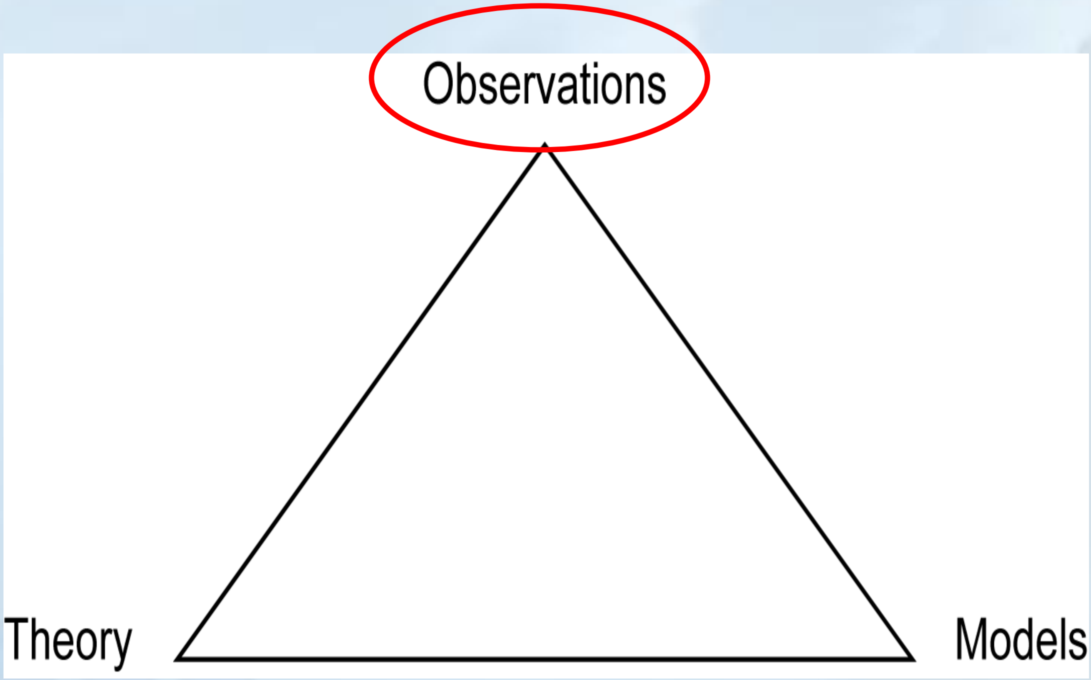
2) Prepare an experimental design

- List the experiments that will be performed – verification, sensitivity studies, etc.

3) Identify the processes that must be accurately simulated by the model.

- Based on a knowledge of the local meteorology, and the objectives
- This will help determine the model configuration – resolution, parameterizations, etc.
- Verification may be done in the context of specific important processes

4) Perform a thorough analysis of all observations before modeling



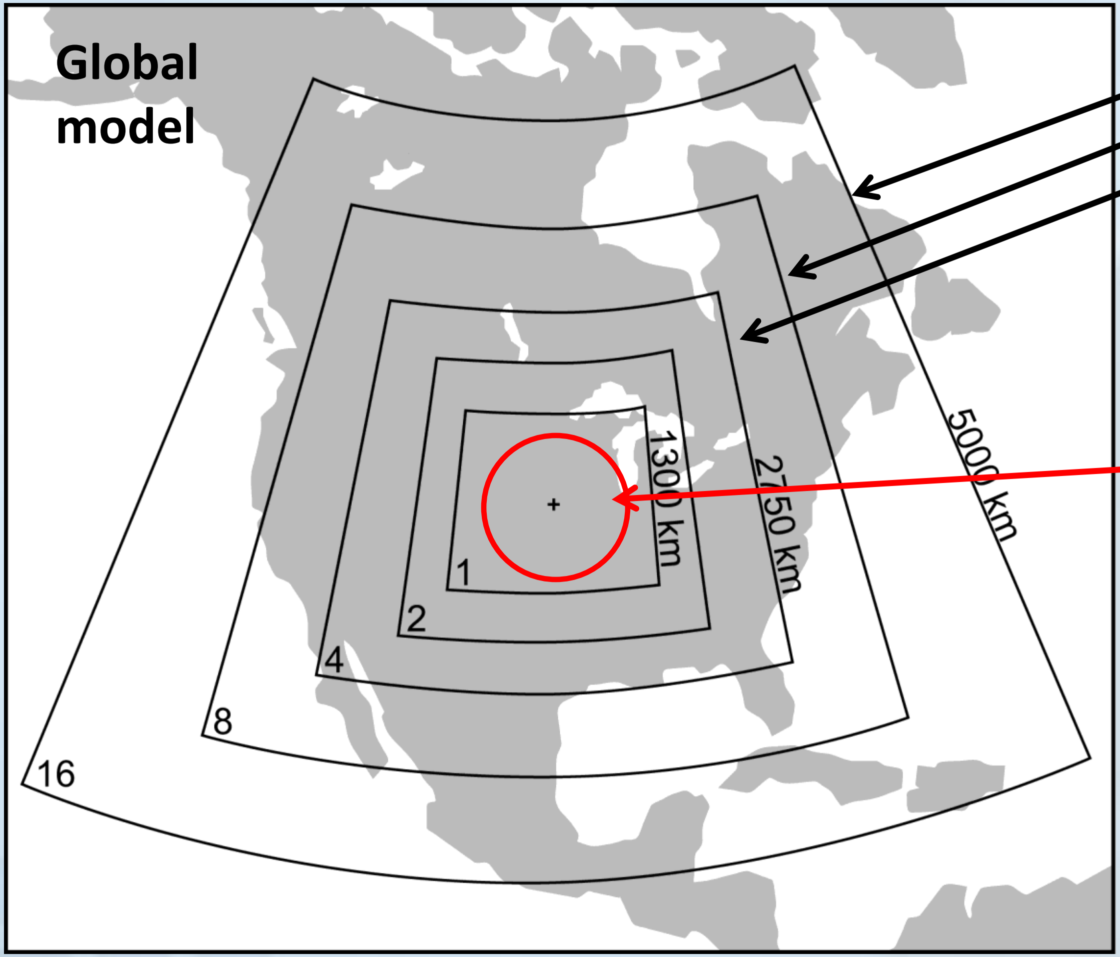
Why?

- You need to understand the processes that you will be modeling in order to configure the model (e.g., DX, DZ).
- You may think that you know about all of the important prevailing processes, but assume that you don’t.
- The sooner you start running the model, the longer a study will take.

5) Define the required horizontal and vertical resolutions of the model based on knowledge of the typical length scales of the (above established) specific processes that must be simulated well.

6) For limited-area models, run test simulations to evaluate the sensitivity of the model solution to the computational-domain size (i.e., lateral-boundary location).

Choice of lateral-boundary condition placement

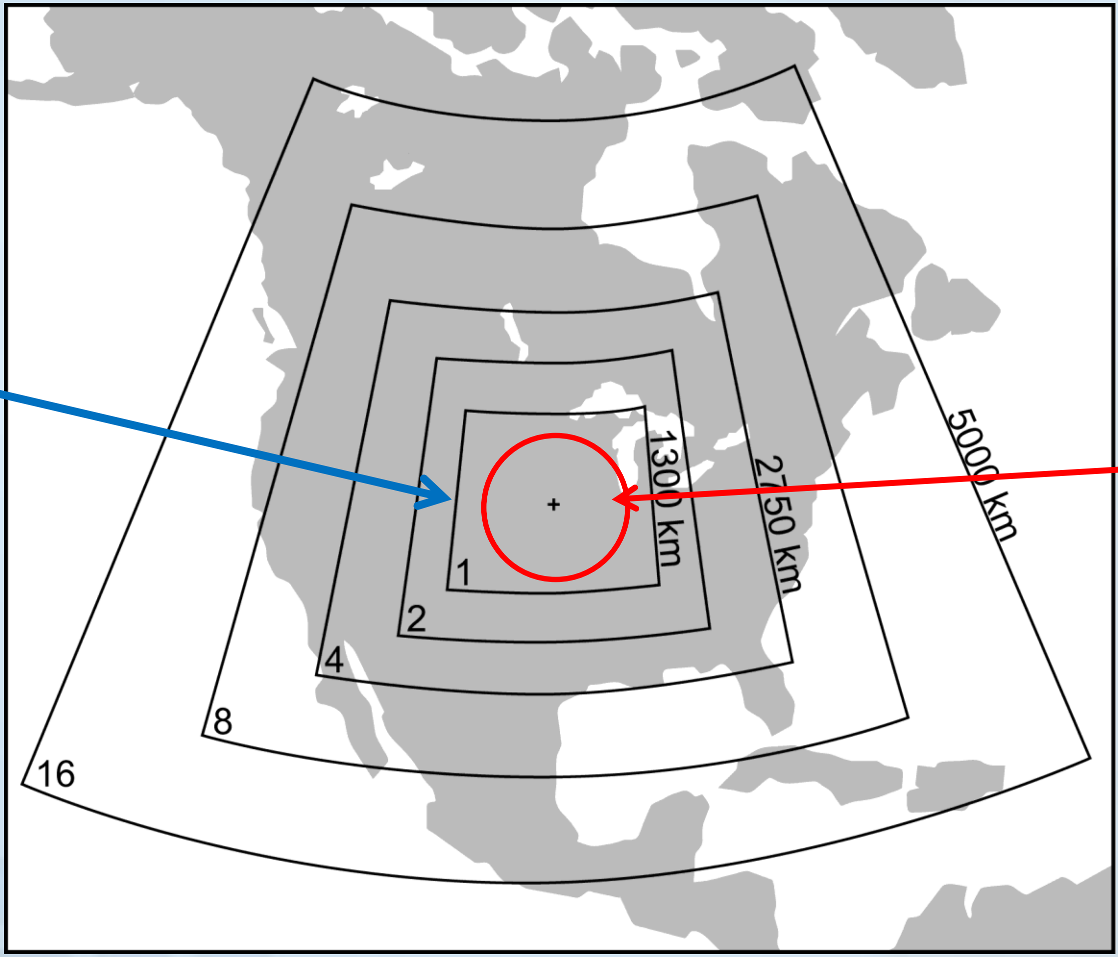


Possible choices for regional model grids

Study area

Choice of lateral-boundary condition placement

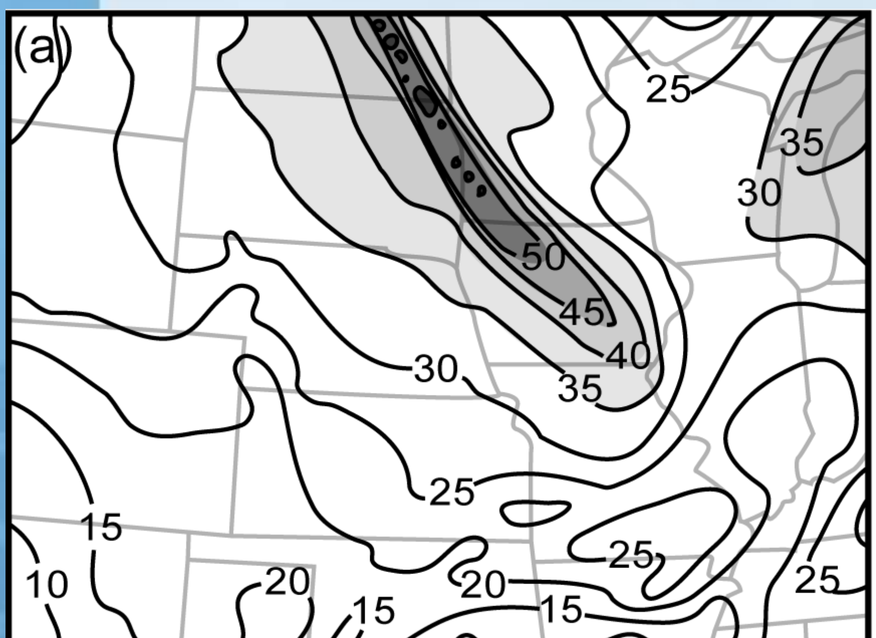
Probably the choice of most modelers



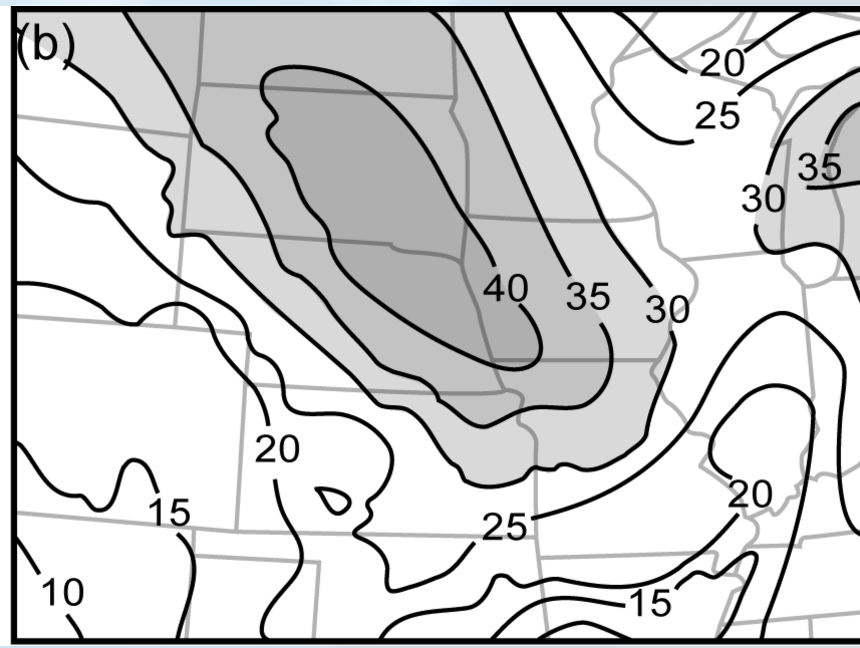
Study area

Example of the sensitivity of model solution to location of LBCs

Largest domain

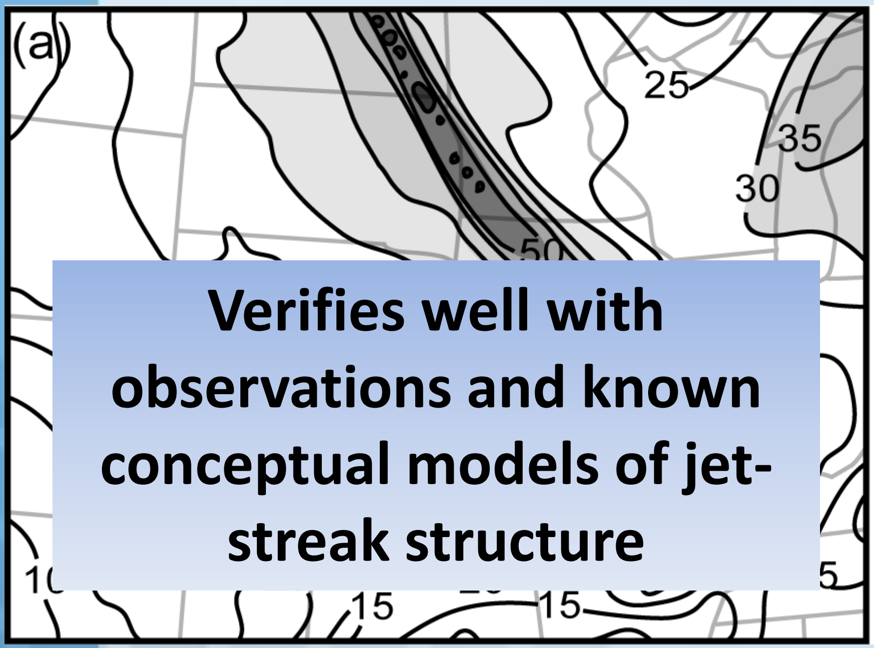


Smallest domain



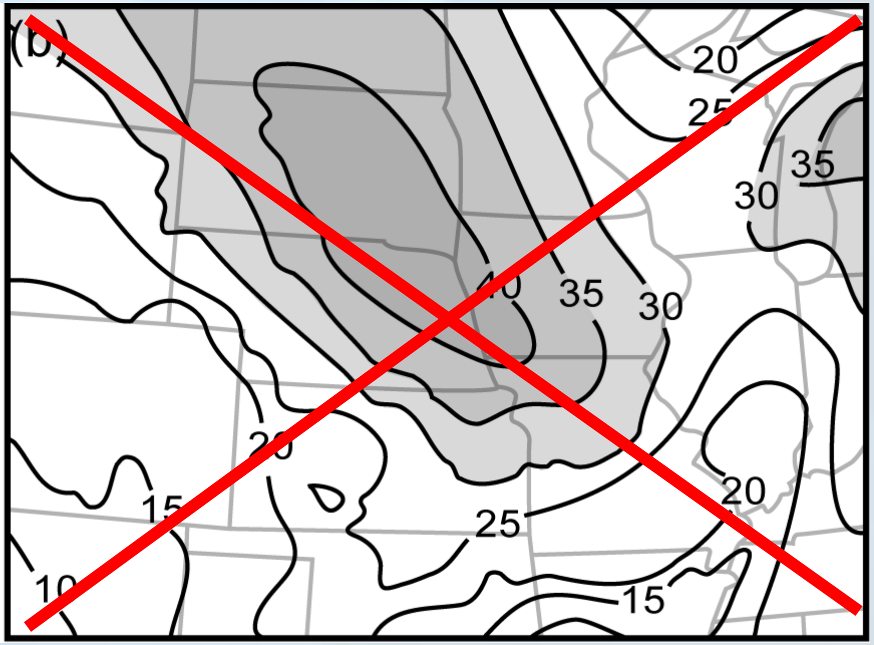
Example of the sensitivity of model solution to location of LBCs

Largest domain



Verifies well with observations and known conceptual models of jet-streak structure

Smallest domain



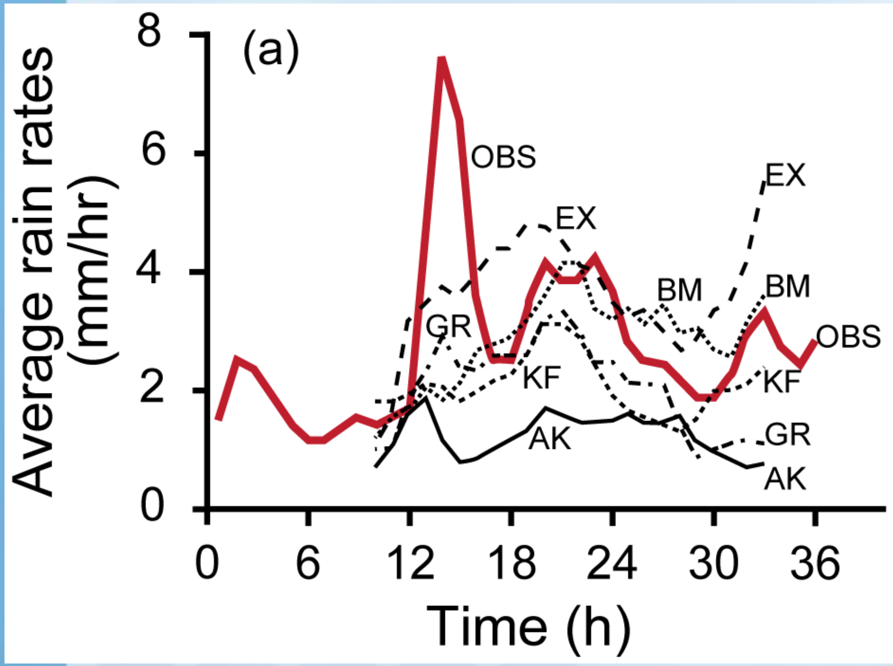
6) Estimate the most appropriate physical-process parameterizations for your needs.

(convective precipitation,
radiation,
cloud microphysics,
boundary layer turbulence)

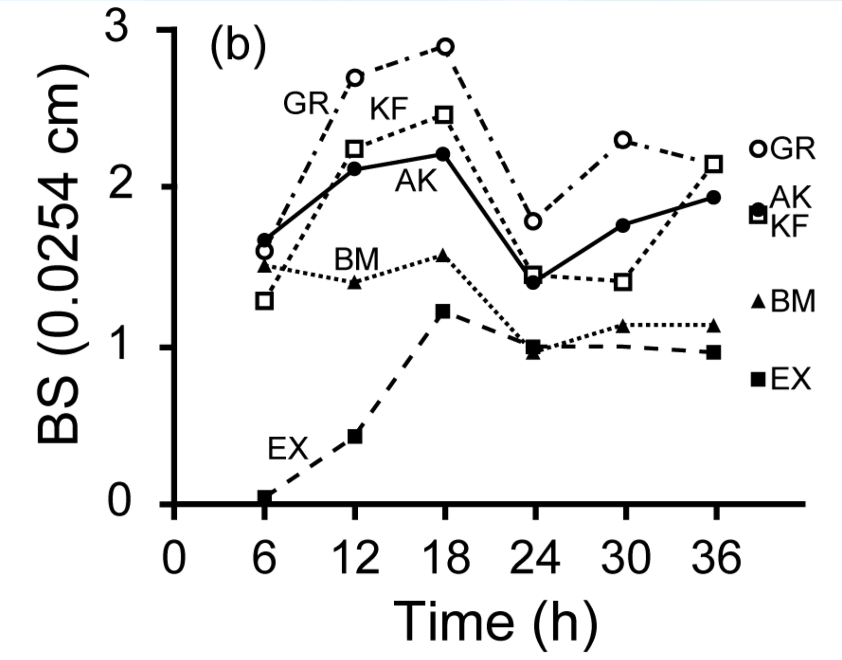
- Why: Parameterization performance depends on
  - geographic area
  - weather regime
  - season
  - grid resolution
- Recommendation:
  - Don’t simply use the default parameterizations in a model.
  - Review the literature for what has worked best for other modelers for the region, etc.
  - Test at least a few different, reasonable options.

Example sensitivity to convective parameterizations

Grid-total predicted and observed precip



BIAS – grid total precip



Parameterizations = GR, KF, AK, BM

No Parameterization = EX

7) Perform a thorough verification of the model solution using all available observations.

Thank you