So, you want to run WRF?

12 steps toward improving the outcome

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Based on:

Warner, Thomas T., 2011: Quality Assurance in Atmospheric Modeling. *Bull. Amer. Meteor. Soc.*, 92, 1601–1610.

1. Clearly Define the Scientific or Practical Objective

Hypothesis to be tested?

How will you know whether you are successful?

Is this a fishing trip?

Do you really need WRF?

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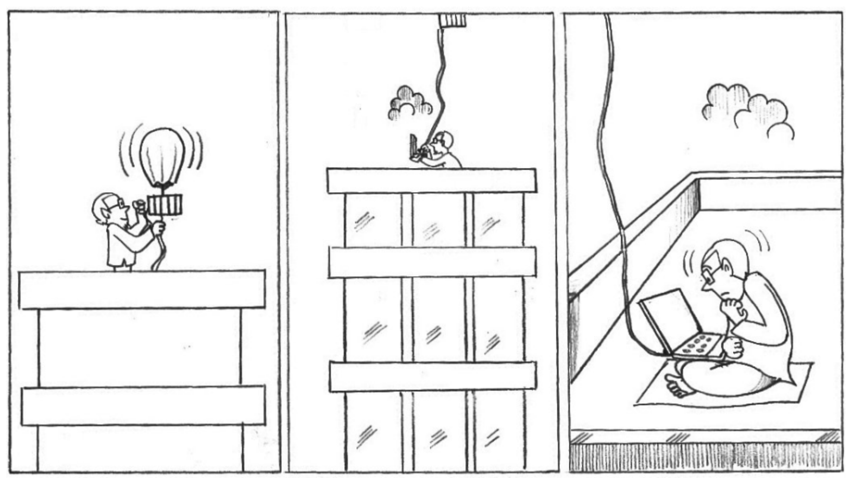
2. Identify and Develop a Physical Understanding of the Atmospheric Processes that must be Accurately Simulated.

- Necessary to design simulation(s) – what processes are important? (convection, radiation, cloud physics, snowcover, etc.)
- Necessary to judge efficacy of simulation
- Will generally require extensive literature review
- Not complete understanding – after all this may be the reason for the study – but enough to guide choices in methodology

3. Perform a Thorough Analysis of all Available Observations

- Increase familiarity with phenomena or processes under investigation
- Know how and where model results may be helpful
- Be better able to judge adequacy of simulations



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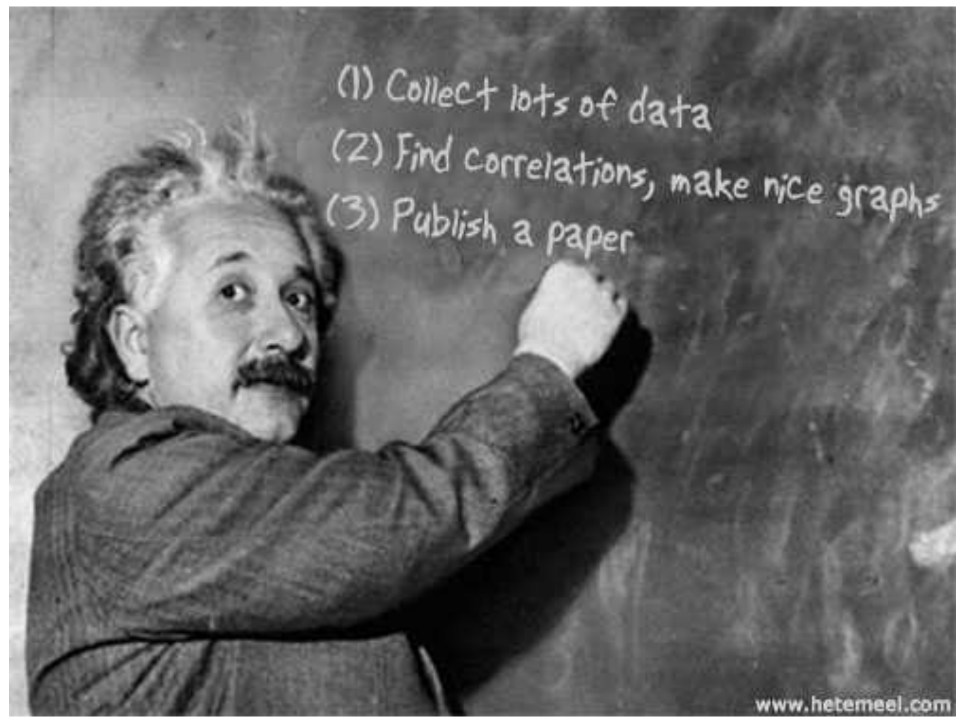
4. Prepare an Experimental Design

Case study? Which case? Is a real-case simulation the best strategy – or should it be idealized? Do we need a model at all?

Ensemble of cases?

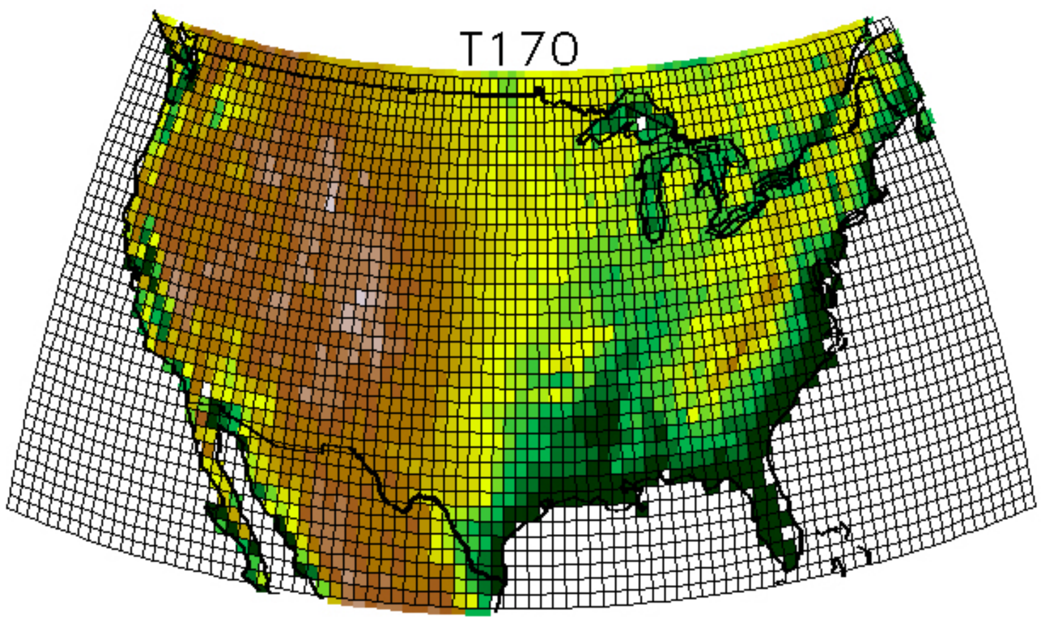
Process study?

How will verification be done?



5. Define the model configuration

- Domain – often has profound influence
- Resolution (horizontal and vertical)?



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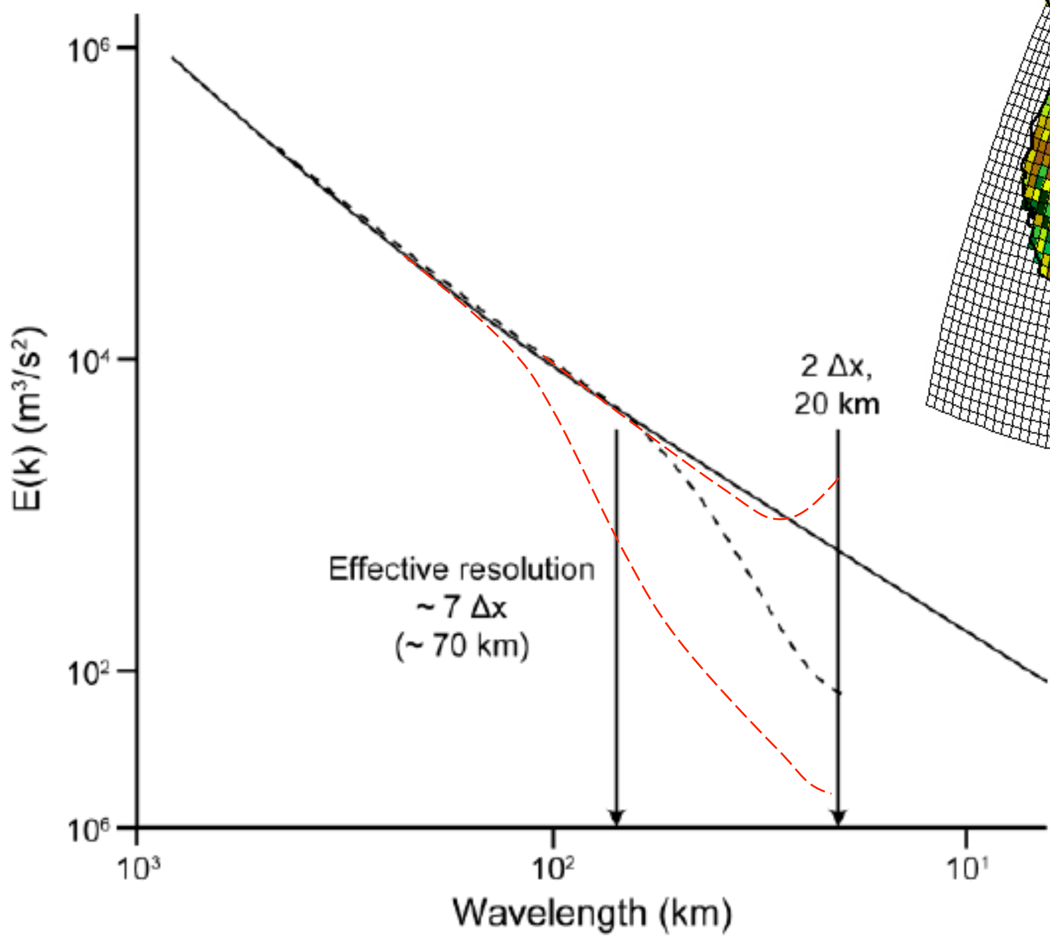
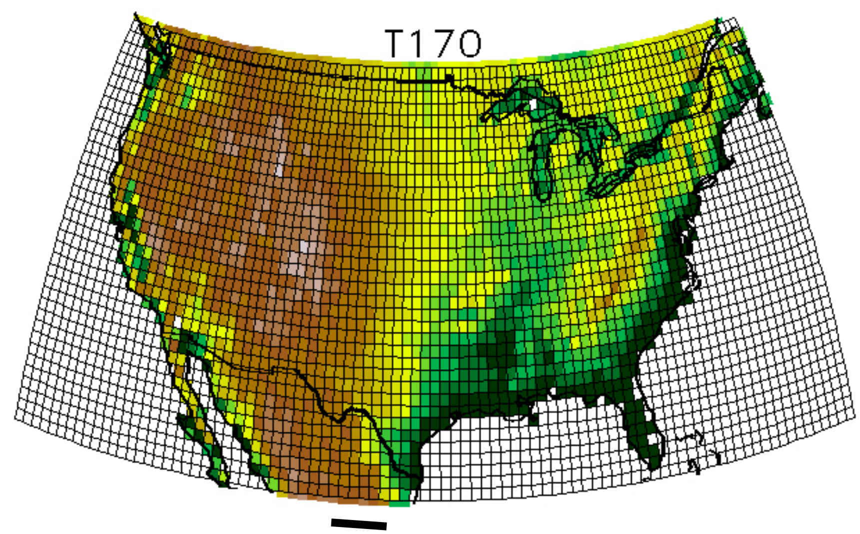
6. Choose Grid Spacing:

What do Models Resolve?





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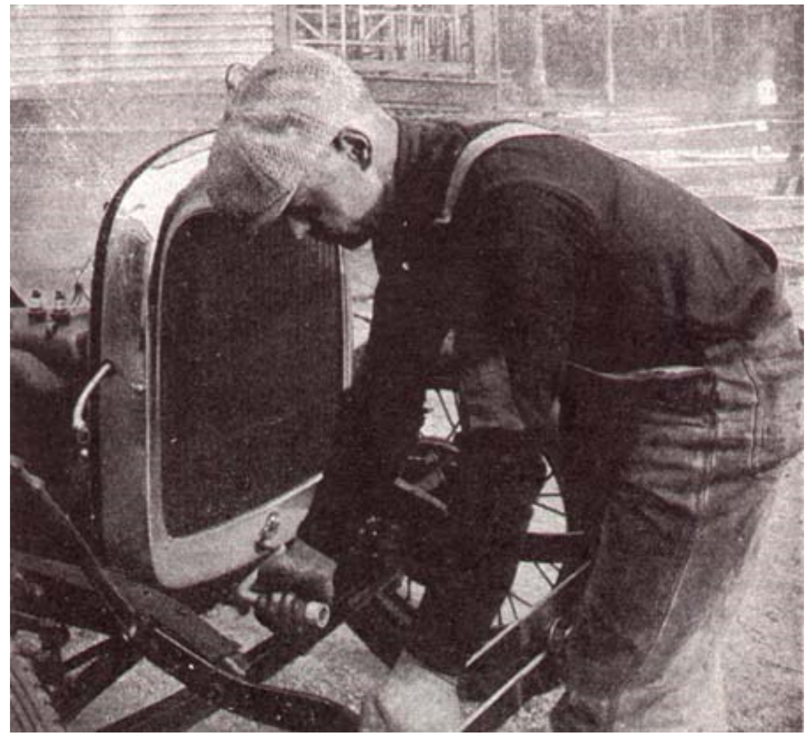
Filters in the model are often not discussed, but seriously affect the short-wavelength part of the spectrum

7. Choose time and method of initialization

- Interpolation from other model?
- Variational data assimilation?
- Ensemble data assimilation?
- What "spinup" is allowed?
- Knowledge of techniques?



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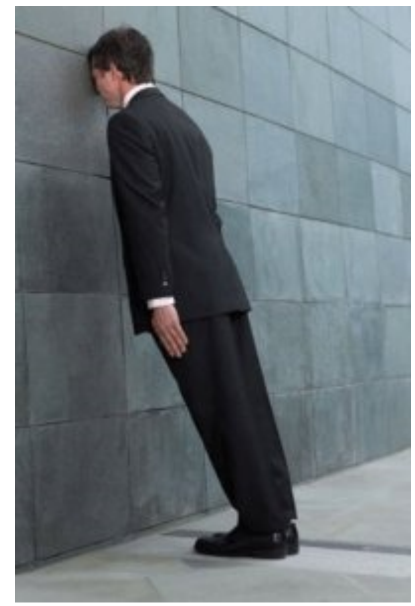
8. Evaluate sensitivity to lateral boundary locations and specification (if limited area)

- Tradeoff between large domain (computational cost) and small domain (determination of solution by boundaries
- Open or periodic (idealized)
- Quality of model/data on lateral boundaries



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Influence of Lateral Boundaries

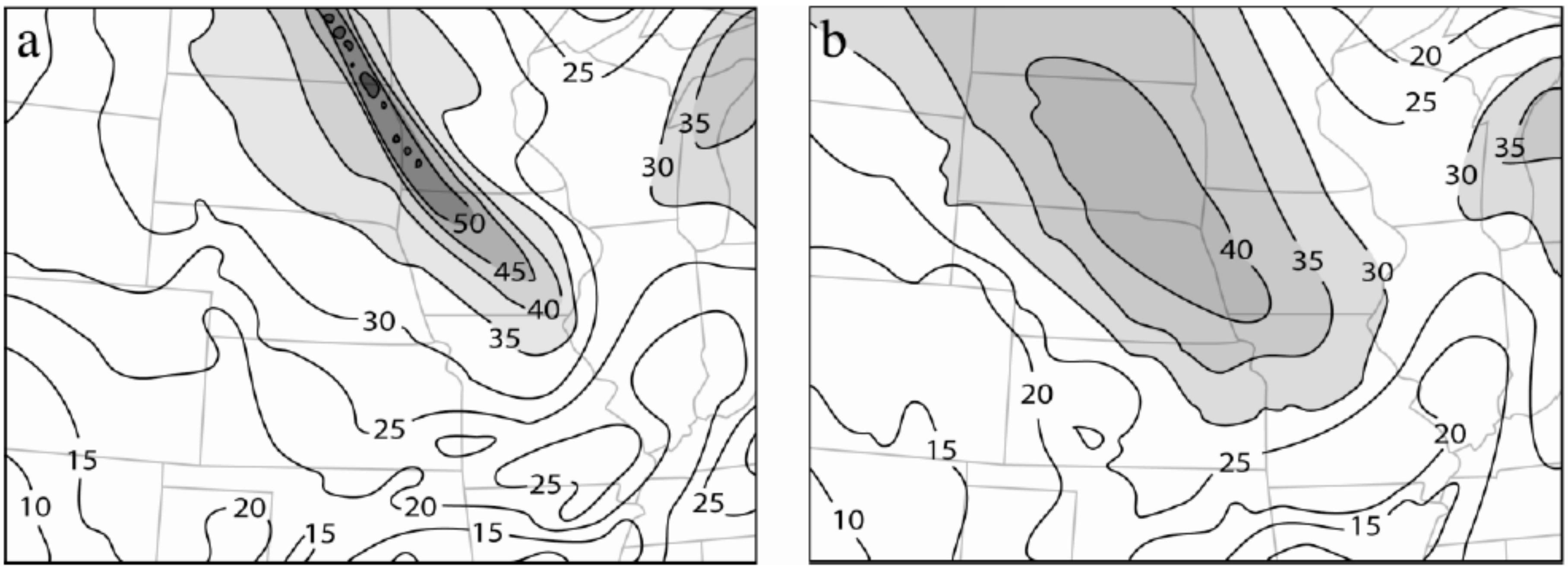


Figure. Twelve-hour simulations of 250-hPa winds (m s-1) from the 40-km grid increment Eta Model initialized at 1200 UTC 3 August 1992, based on experiments that used a large (a) and small (b) computational domain. The isotach interval is 5 m s-1. From Treadon and Peterson (1993).

9. Define the most appropriate physical parameterizations.

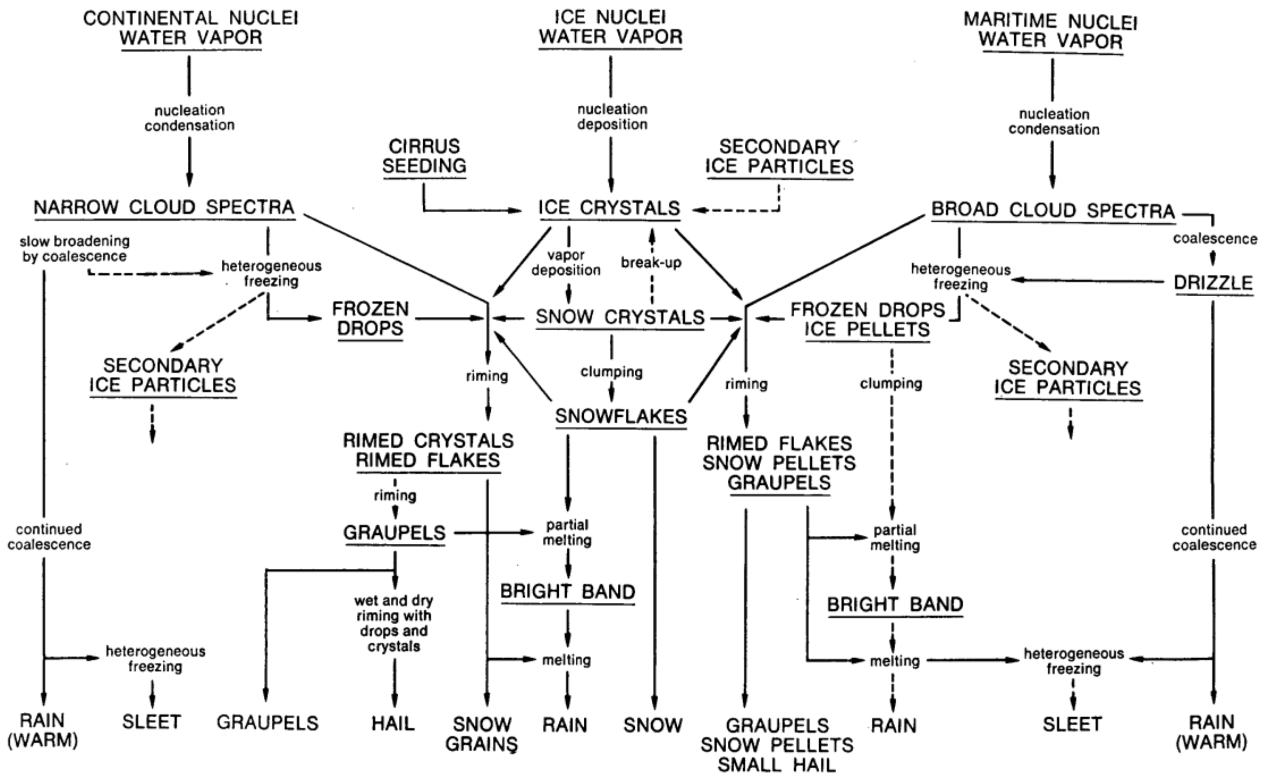


FIG. 1. The major types of precipitation elements, and the physical processes through which they originate and grow, are shown in this flow diagram (Braham, University of Chicago). Computer models of some of these processes have been developed although inadequate basic knowledge about process kinetics has tended to restrict their application.

Braham, 1974, BAMS

Different Schemes, Different Results

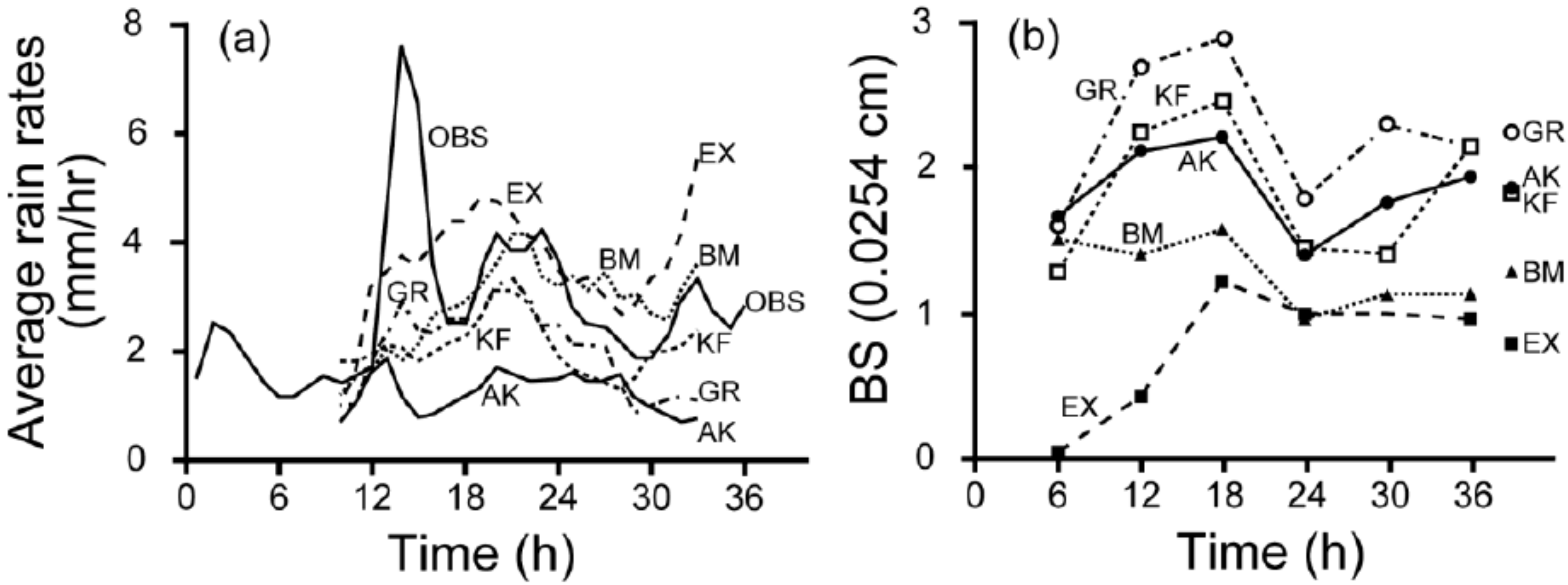
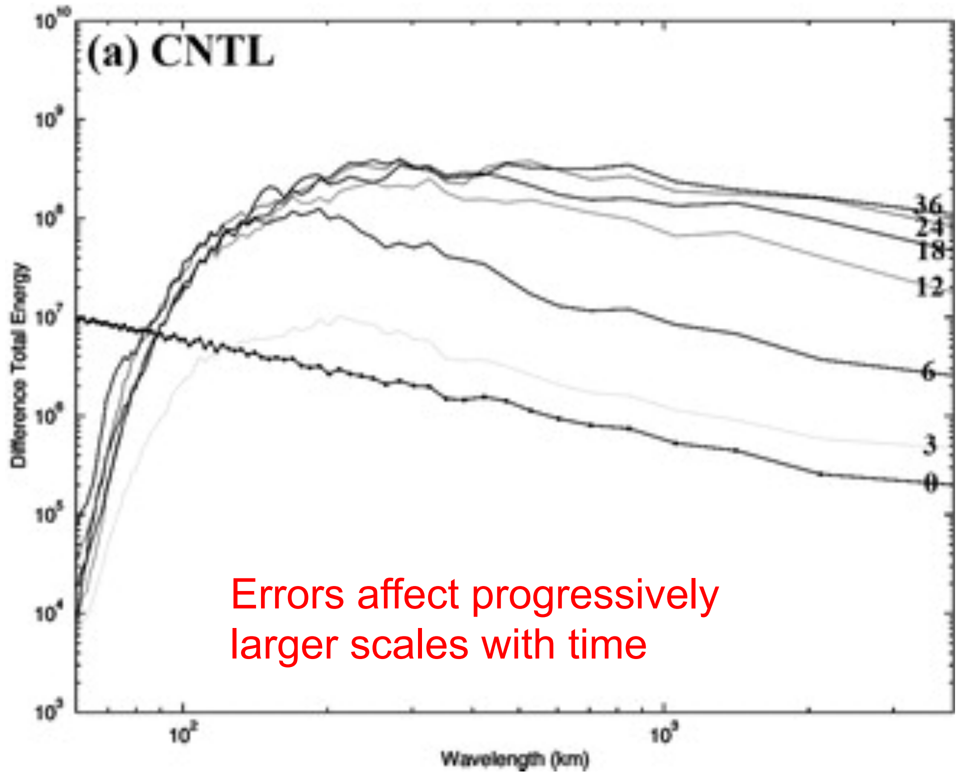


Figure 4. Average rainfall rate, for a spring-season convective event (a), based on observations (OBS) and for five simulations that used different treatments for the convection - four different parameterizations, and no parameterization (EX). Also depicted is the rainfallrate bias score averaged for three warm-season convective events (b), again for each of the four parameterizations and for the use of no parameterization. The four convective parameterizations were the Grell (GR), Kain-Fritsch (KF), Betts-Miller (BM), and Anthes-Kuo (AK) schemes. Adapted from Wang and Seaman (1997).

Selecting Model Physics

- Many options = more opportunities and more work
- No substitution for testing multiple options for a particular application
  - A given set of physics will perform differently depending on domain size, location, initialization and phenomenon of interest.
  - Certain combinations better tested than others, but still no guarantee of performance
- Choices will also depend on verification metric
- Cycling WRF is a good way to uncover biases in physics
- What do you think would be most helpful?

10. Understand the limits to predictability of the phenomenon being studied

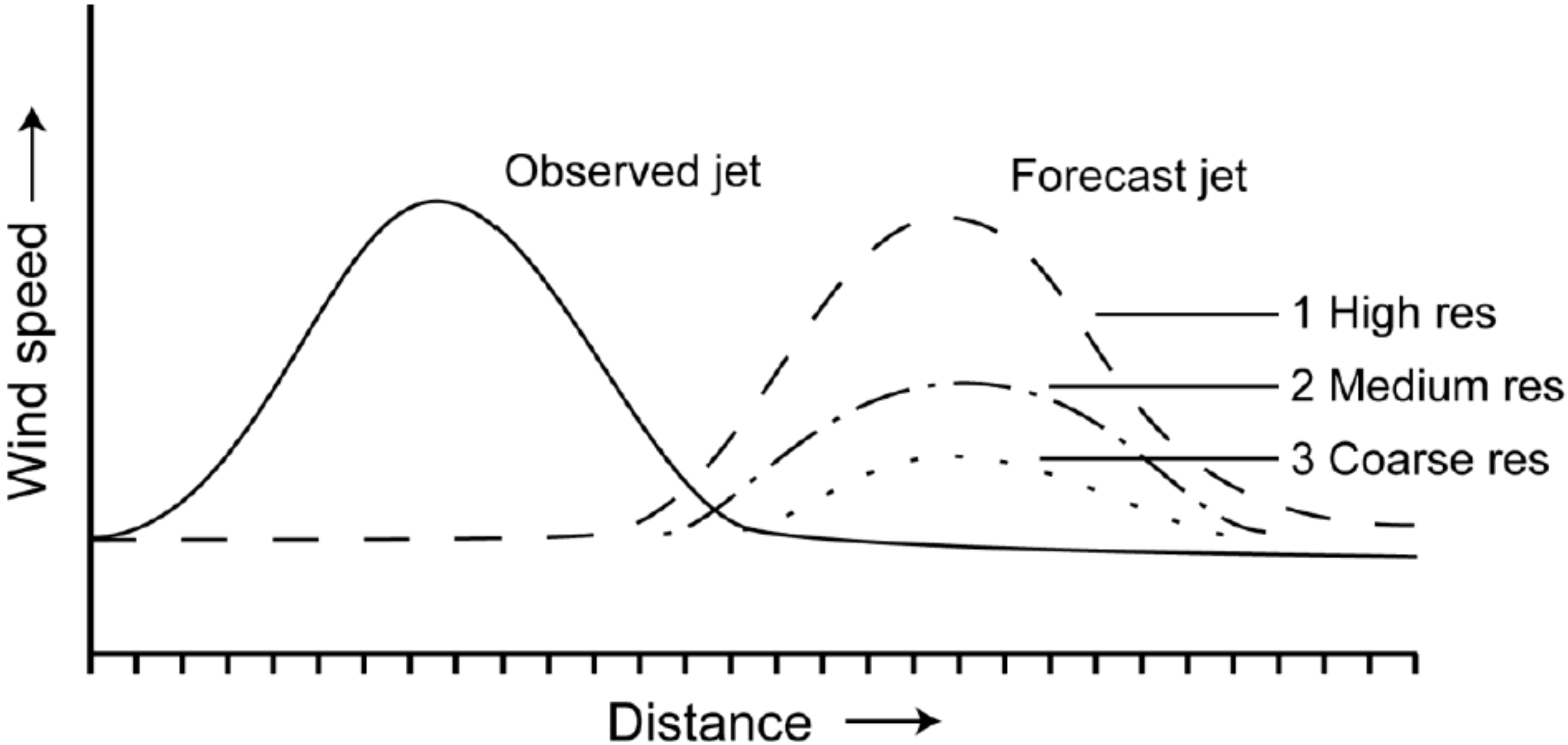


Zhang, Fuqing, Naifang Bei, Richard Rotunno, Chris Snyder, Craig C. Epifanio, 2007: Mesoscale Predictability of Moist Baroclinic Waves: Convection-Permitting Experiments and Multistage Error Growth Dynamics. *J. Atmos. Sci.*, **64**, 3579–3594.

11. Establish a verification plan before the model is run and perform a thorough verification, using appropriate metrics, of the model solution using all available observations.

- Why before? Because verification method may dictate model output
- Importance?
  - Confidence in model use (process study or forecast)
  - Quantify strengths and weaknesses
  - Assure "right answer for right reason."
- Choose appropriate verification metrics

Beware of Verification Metrics



12. Use good coding practices and well-documented software

- Will new code be developed? Black-box vs. white-box testing
- Be able to repeat your results (because you will probably have to)
- Upgrades to community codes – use newest version?
  - Latest version could have major bugs
  - Does upgrade affect reproducibility?

Conclusions

- Research models are tools, and like any tool, must be used properly
- Modeler should be as familiar with observations as the model
- More planning and preparation of simulations leads to shorter (and better) duration of studies
- It is entirely possible to set out to do a modeling study and never run the model.