So, you want to run WRF?

12 steps toward improving the outcome

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Based on:

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?
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
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)?
6. Choose Grid Spacing:
What do Models Resolve?

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
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.
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 rainfall rate 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

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

Wind speed

Distance

- Observed jet
- Forecast jet

1 High res
2 Medium res
3 Coarse res
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.