

SYLLABUS

ATMS 597R: Special Topics in Atmospheric Sciences Advanced Mesoscale Modeling with the Weather Research and Forecasting (WRF) Model

Meeting time: MWF 1:00-1:50 PM in ASB Room 109

Instructor: Assistant Professor Steve Nesbitt, ASB Room 203, 244-3740,
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Course goals

This course is designed to teach you to become a knowledgeable user of the Weather Research and Forecasting (WRF) regional model in a supercomputing environment. By the end of this course, you will have working knowledge of configuration, data set preparation, running, post processing, and analyzing the output from the model in idealized and "real data" simulations and forecasts. We will examine the sensitivity of model simulations to boundary conditions, land surface and boundary layer schemes, cloud microphysics and radiation, and if time allows, apply spectral nudging, verification, and data assimilation techniques.

Online resources

Class web page: <http://www.atmos.uiuc.edu/~snesebitt/ATMS597R>

Class wiki: <https://wiki.cites.uiuc.edu/wiki/display/atms597r>

Class e-mail discussion board: ATMS597P@LISTSERV.ILLINOIS.EDU; This is where to go for help first and will constitute the first contact for office hours, if necessary.

Computing resources

This course has use of a 30,000-wall clock hour education grant from the National Center for Supercomputing Applications (NCSA). Each of you has or will be given an account on cobalt.ncsa.uiuc.edu for running simulations via batch scripts – this machine is a large Silicon Graphics linux supercomputer. While 30,000 hours seems like a lot of resources in this class, it is far from an infinite resource. I will design the experiments so that they do not require a large amount of resources, but you will have to be careful not to be careless with the allotted computer time. I can see how many hours each of you uses, so be sure to do test runs, etc. if long computing times are anticipated. If you have your own resources, you are free to use those as well (manabe, NCSA, or other computer or account).

We are limited as to the number of computers in Room 109. If you can bring a laptop to class every day, that would be very helpful.

Note on programming skills to be used in this course

If you are not comfortable with UNIX shell operations and scripting, this course will provide some background in using these tools for the course as well as your research. In addition, you will modify codes in FORTRAN 77/90 programs, as well as compile, link, and run the WRF model, which is written in FORTRAN and C. Post processing will involve use of the NCAR Command Language (NCL). Examples will be given in class in each of these computing skills and one major goal of this course is to make sure that all students are up to speed on these basic computing skills. Students that are not very familiar with these tools may expect to spend a significant time debugging errors, especially at the beginning. Ask your fellow more experienced students for help, but becoming a good programmer requires you to be able to debug code yourself.

Course outline

August/September

1. Introduction/Course logistics – UNIX basics, logging in to NCSA
2. Mesoscale modeling primer
 - a. Introduction to regional Numerical Weather Prediction
 - b. Theoretical basis for the WRF model – Advanced Research (NCAR) version 3.2
 - c. Modeling mesoscale phenomena: Issues and solutions
 - d. Parameterizations in mesoscale models (introduction)
 - e. Designing an experiment with a mesoscale model (desired simulation vs. available resources)
 - f. **Selection of class project hypothesis (due 27 September)**
3. The WRF model (practical aspects) – *supercell test case project*
 - a. Software infrastructure
 - b. Configuration/Compilation
 - c. The “namelist”
 - d. Running the model in batch mode; single vs. flavors of parallel processing
 - e. Quick-look viewing of model output
 - f. When things go bad; how to tell and what to do
4. Idealized modeling with WRF (ideal.exe/wrf.exe) – *bell-shaped hill test case*
 - a. Specifying/modifying input data
 - b. Modifying initialization code
 - c. Impact of domain sizes, horizontal/vertical resolution, boundary condition specification, physics options
 - d. Visualizing output in NCL

October

5. Preparation of datasets for simulations/forecasts (WRF Pre-processing System) – *3D simulation project*

- a. Designing and preparing real data simulations (GUI and script approaches)
- b. Preparing geographic datasets (terrain/land use)
- c. Atmospheric initialization/boundary condition data
6. "Real data" modeling with WRF (real.exe/wrf.exe)
 - a. Issues: Boundary conditions, spin-up time
 - b. Visualizing output in NCLE
 - c. Impact of domain sizes, horizontal/vertical resolution, boundary condition specification, physics options
 - d. **Status updates on class project**
7. Parameterizations – *parameterization project*
 - a. Surface parameterizations
 - b. Boundary layer parameterization
 - c. Microphysical parameterization
 - d. Convective parameterization
 - e. Radiative parameterization

November/December

8. Advanced topics
 - a. Spectral and observational nudging
 - b. Issues in tropical cyclone simulation
 - c. 3D and 4D VAR data assimilation
 - d. Model Evaluation/Verification Tools
9. Class workshops on class project

Texts

- Material from the WRF Users web page, including the Technical Description and Users Guide documents, available for free download.
- *Parameterization Schemes: Keys to Understanding Numerical Weather Prediction Models* by David J. Stensrud. Cambridge University Press, available from many places including the University Bookstore.

Grading

Since you are all graduate students, the grading and evaluation in this course will be informal. You will be given a grade based on your homework projects (50%) and your class project (50%).

Homework

There will be 3 homework projects during this course where you will be asked to do specific exercises with WRF. You will prepare a report on your findings and submit these assignments electronically via the class wiki to the instructor.

Class project

The last 1/3 of the course will be dedicated to a class project that ideally will be part of your thesis or dissertation or on a topic of interest to you. The topic, selected by you, will be a scientific hypothesis that you want to test using WRF. Your topic selection will be due on 27 September in the form of a 2-page single spaced abstract, uploaded to the class wiki. The abstract should list your hypothesis, justification, technical approach, and anticipated computational effort (CPU hours). The instructor will give you feedback on the scope, level of detail, and feasibility of your project. Starting in mid-November, we will rotate through each class member's project each week to give the class a glimpse as to your progress and results. Final reports on your class project will be due on your project on Monday, December 13 at noon, and will be submitted on the course wiki. Grading will be based on the completeness, comprehensiveness, and ability to address your project goals.