Announcements

Subject:	A practical introduction to numerical modeling of the atmosphere.
Text:	Class notes, available at the class website: http://kiwi.atmos.colostate.edu/group/dave/at604.html
Course grade:	1/4 on homework, 1/4 on each of two midterms (closed book, in class), and 1/4 on final (closed book, in class) The final will emphasize the latter part of the course, and will be held during finals week.
Access to instructor:	As you may know, I have posted office hours, but students in this class are welcome to come to me with questions any time, provided only that I am not actually busy with someone else.
Teaching assistant:	We are fortunate to have Jonathan Vigh as a TA for this course. He will grade the homework and will be available to answer questions on a schedule which he will make known to you. He may also organized other activities, which will be announced separately.
Computing:	Some of the homework will involve writing computer programs, plotting results, etc.You can use any computing language or plotting software you want. Although you are certainly encouraged to ask questions about the homework, neither I nor the TA will help with debugging your programs.
Auditing:	Auditing is permitted, provided that you audit officially by filling out the appropriate form. Auditors are required to attend class but are not required to hand in homeworks or take exams. Keep in mind, however, that, like skiing or swimming or bicycling, numerical modeling is learned largely by doing.
Schedule:	Classes will be missed occasionally. A calendar will be distributed.

General References

Arakawa, A., 1988: Finite-difference methods in climate modeling. *Physically-based modelling and simulation of climate and climatic change - Part I*, M. E. Schlesinger (ed.), 79-168.

Arfken, G., 1985: *Mathematical methods for physicists*. Academic Press, 985 pp.

Chang, J., 1977: General circulation models of the atmosphere. *Meth. Comp. Phys.*, **17**, Academic Press, 337 pp.

Durran, D. R., 1999: *Numerical methods for wave equations in geophysical fluid dynamics*. Springer, 465 pp.

Haltiner, G. J., and R. T. Williams, 1980: *Numerical prediction and dynamic meteorology*. J. Wiley and Sons, 477 pp.

Kalnay, E., 2003: *Atmospheric modeling, data assimilation, and predictability*. Cambridge Univ. Press, 341 pp.

Manabe, S., ed., 1985: Issues in atmospheric and oceanic modeling, Part A: Climate dynamics. *Adv. in Geophys.*, **28**, 591 pp.

Manabe, S., ed., 1985: Issues in atmospheric and oceanic modeling, Part B: Weather dynamics. *Adv. in Geophys.*, **28**, 432 pp.

Mesinger, F., and A. Arakawa, 1976: Numerical methods used in atmospheric models. *GARP Publ. Ser. No. 17*, 64 pp.

Randall, D. A., Ed., 2000: *General Circulation Model Development. Past, Present, and Future*. Academic Press, 807 pp.

Richtmeyer, R. D., and K. W. Morton, 1967: *Difference methods for initial value problems*. Wiley Interscience Publishers, New York, 405 pp.

Washington, W. M., and C. L. Parkinson, 1986: *An introduction to three-dimensional climate modeling*. University Science Books, Mill Valley, New York, 422 pp.

Preface

The purpose of this course is to provide an introduction to the methods used in numerical modeling of the atmosphere. The ideas presented are relevant to both large-scale and small-scale models.

Numerical modeling is one of several approaches to the study of the atmosphere. The others are observational studies of the real atmosphere through field measurements and remote sensing, laboratory studies, and theoretical studies. Each of these four approaches has both strengths and weaknesses. In particular, both numerical modeling and theory involve approximations. In theoretical work, the approximations often involve extreme idealizations, e.g. a dry atmosphere on a beta plane, but on the other hand solutions can sometimes be obtained in closed form with a pencil and paper. In numerical modeling, less idealization is needed, but in most cases no closed form solution is possible. Both theoreticians and numerical modelers make mistakes, from time to time, so both types of work are subject to errors in the old-fashioned human sense.

Perhaps the most serious weakness of numerical modeling, as a research approach, is that it is possible to run a numerical model built by someone else without having the foggiest idea how the model works or what its limitations are. Unfortunately, this kind of thing happens all the time, and the problem is becoming more serious in this era of "community" models with large user groups. One of the purposes of this course is to make it less likely that you, the students, will use a model without having any understanding of it.

This introductory survey of numerical methods in the atmospheric sciences is designed to be a practical, "how to" course, which also conveys sufficient understanding so that after completing the course students are able to design numerical schemes with useful properties, and to understand the properties of schemes that they may encounter out there in the world.

The first version of these notes, put together in 1991, was heavily based on the class notes developed by Prof. A. Arakawa at UCLA, as they existed in the early 1970s, and this influence is still apparent in the current version, particularly in Chapters 2 and 3. A lot of additional material has been incorporated, mainly reflecting developments in the field since the 1970s. The explanations and problems have also been considerably revised and updated.

The teaching assistants for this course have made major improvements in the material and its presentation, in addition to their help with the homework and with questions outside of class.

I have learned a lot by extending and refining these notes, and also through questions and feedback from the students. The course has certainly benefitted

considerably from such student input.

Finally, Michelle McDaniel has spent countless hours patiently assisting in the production of these notes. She created the formatting that you see, and organized the notes into a “book.”