ATS730
Mesoscale Modeling
Spring Semester 2020

Meeting Times:
M/W: 9-10:15am
Room: 212B ACRC

Instructor:
Susan C. van den Heever
Room 425
Email: sue@atmos.colostate.edu

Teaching Assistant
Leah Grant
Room 426
Email: Leah.Grant@colostate.edu
Office Hours: Wednesday 2-3pm

Course Description:
The primary goal of ATS730 is to present the development of the basic equations used in mesoscale models, as well as the various methods by which we solve these equations. Emphasis will be on the equations and methodology of solution, rather than on actual simulations of mesoscale phenomena or the evaluation of specific mesoscale models. These goals will be achieved through lectures in class, background reading and various programming assignments, the end result of which will be the construction of a *simple moist physics mesoscale model*. This simple mesoscale model will then be used for a final project and presentation. The course consists of two 75-minute classes a week during which the basic course content will be taught and discussions focusing on the results of the programming assignments will be held. Notes and homework assignments are based in varying degrees on notes by Fovell (2005) and Pielke (2002), and on development, research and experience gained in the van den Heever modeling group.

Grading:
No exams will be held for this class. Approximately 9 weekly programming assignments and a final project (which you will present at the end of the semester) will constitute your entire course grade, contributing 10% and 90%, respectively. The weekly programming assignments form the basis of the mesoscale model being built in class. Each week builds on the code developed the previous week. The model you develop needs to be used to conduct final project and presentation, and hence it is very important to ensure that you complete each of your weekly assignments in a timely manner. You will be asked to hand in the output from these homework assignments in order to check whether your model is on track. Late homework assignments will be penalized 20% per day beyond the assignment deadline.

Required Reading and other Tools / Skills

- Mesoscale Meteorological Modeling 2nd Edition by Roger Pielke (2002)
- Class Notes based on Pielke (2002), Fovell (2005), COMET modules, and technical manuals are available online at: https://vandenheever.atmos.colostate.edu/vdhpage/ats730/ats730.php
- Graphical software (Grads, IDL, MatLab, Gnuplot, etc)
- Basic fortran programming skills
- You will be provided with an account on the van den Heever clusters in which to build, compile and run your model.

Class Webpage

The webpage for this class may be found at:
https://vandenheever.atmos.colostate.edu/vdhpage/ats730/ats730.php
Class notes, homework sets and general announcements can be found at this site.

Academic Integrity:

All students are subject to the policies regarding academic integrity found in the 2019 – 2020 General Catalog, found at http://catalog.colostate.edu/general-catalog/policies/, and the student conduct code (https://resolutioncenter.colostate.edu/student-conduct-code). Examples of academic dishonesty can be found in these sources. At a minimum, violations will result in a grading penalty in this course and a report to the Office of Conflict Resolution and Student Conduct Services.

Special Needs:

Please see the instructor during the first two weeks of the semester, if you have special learning needs that should be accommodated in this class, and refer to https://disabilitycenter.colostate.edu/ for more information.

Course Outline:

Chapter	Topic	Subtopics	~# Classes
Chapter 1	**Introduction**		1
Chapter 2	**Tools**	Taylor Series, Lagrangian vs Eulerian, Tensor Notation	1
Chapter 3	**Basic Conservation Equations**	Conservation equations, virtual temperature, non-dimensional pressure	1
Chapter 4	**Equation Simplification**	Deep versus shallow continuity, adiabatic, perturbation vertical pressure gradient, hydrostatics, steady state assumptions etc	3
Chapter 5	**Equation Averaging**	Limits, resolution, scale separation, Reynold's assumption, turbulence, closure problems, flux forms, hydrostatic versus nonhydrostatic, diagnostic equation for nonhydrostatic pressure, conservation equations and the Exner function	1
Chapter 6	**Waves and Mesoscale Models**	Perturbation method, acoustic waves, gravity waves	2
Chapter 7	**Derivation of the Fully Compressible Model Framework**	Pressure gradient acceleration terms, advantage of π over p, pressure tendency equation, fully compressible equations	1

Chapter 8	**Methods of Solution**	Finite Difference Schemes
		• Advection
		    o Difference Equations
		    o Linear stability
		    o Courant number
		    o Forward-Upstream Differencing
		    o Leapfrog
		    o Adams-Bashford
		    o Flux Correction
			8

Chapter	Topic	Subtopics	~# Classes

Chapter 8 (cont)	**Methods of Solution (cont)**	• Subgrid-Scale Flux
		  ○ Diffusion equation
		  ○ Linear stability
		  ○ Explicit versus Implicit schemes
		• Coriolis
		• PGF and Divergence Terms
		• Diagnostic Equations
		• Time Splitting
		• Nonlinear Effects
		• Aliasing
		• Other Methods	

Chapter 9	**Boundary and Initial Conditions**	Grid and domain structure, stretched and moveable grids, staggering; top, lateral and bottom boundaries Lateral Boundary Conditions • Constant inflow, gradient outflow • Radiative • Sponge • Periodic • Larger-scale or analyzed Top Boundary Conditions • Rigid tops • Impervious • Porous lids • Absorbing layers	2
Chapter 10	**Coordinate Transformations**	Generalized vertical coordinate • Isentropic • Isobaric • Terrain-following sigma	1
Chapter 11	**Parameterization of Moist Thermodynamic Processes**	• Microphysics: bin and bulk microphysics, hydrometeor size distributions, single- and multi-moment schemes, representation of basic processes, autoconversion • Convection: convective adjustment, Kuo scheme	9