

ATS730
Mesoscale Modeling
Spring Semester 2014

Meeting Times:

T/TH: 9-10:15am

Room: ATS 101

Instructor:

Susan C. van den Heever

Room 425

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Graduate Teaching Assistant:

Matthew Igel

Room 418

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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. The final project and the presentation of this project will constitute your entire course grade. The weekly programming assignments will not count directly towards your grade, however, they do form the basis of the simple mesoscale model, which will be used to conduct your final project and presentation. You will be asked to hand in the output from these homework assignments in order to check whether your model is on track.

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, technical manuals etc are available online at:
<http://reef.atmos.colostate.edu/~sue/vdhpge/login730.php>
- Graphical software (Grads, IDL, Matlab, Gnuplot, etc)
- Programming language (Fortran, C++) and compiler

Class Webpage

The webpage for this class may be found at:

<http://reef.atmos.colostate.edu/~sue/vdhpge/login730.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 Section 1.6 of the 2010 – 2011 General Catalog, found at

<http://www.catalog.colostate.edu/Content/files/2012/FrontPDF/1.6POLICIES.pdf>,

and the student conduct code (<http://www.conflictresolution.colostate.edu/conduct-code>).

Other information on academic integrity can be found on the Learning@CSU website (<http://learning.colostate.edu/integrity/index.cfm>). 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 <http://rds.colostate.edu/csuinto/accommodations.asp> for more information.

Tentative 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, nondimensional pressure	1
Chapter 4	Equation Simplification	Deep versus Shallow continuity, adiabatic, perturbation vertical pressure gradient, hydrostatics, steady state assumptions etc	2
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 <ul style="list-style-type: none"> • Advection <ul style="list-style-type: none"> ○ Difference Equations ○ Linear stability ○ Courant number ○ Forward-Upstream Differencing ○ Leapfrog ○ Adams-Bashford ○ Flux Correction • Subgrid-Scale Flux <ul style="list-style-type: none"> ○ Diffusion equation ○ Linear stability ○ Explicit versus Implicit schemes • Coriolis 	9

Chapter 9	Boundary and Initial Conditions	<ul style="list-style-type: none"> • PGF and Divergence Terms Diagnostic Equations Time Splitting Nonlinear Effects <ul style="list-style-type: none"> • Aliasing • Other Methods Grid and domain structure, stretched and moveable grids, staggering; top, lateral and bottom boundaries Lateral Boundary Conditions <ul style="list-style-type: none"> • Constant inflow, gradient outflow • Radiative • Sponge • Periodic • Larger-scale or analyzed Top Boundary Conditions <ul style="list-style-type: none"> • Rigid tops • Impervious • Porous lids • Absorbing layers 	2
Chapter 10	Coordinate Transformations	<p>Generalized vertical coordinate</p> <p>Isentropic</p> <p>Isobaric</p>	1
Chapter 11	Parameterization of Moist Thermodynamic Processes	<p>Terrain-following sigma forms</p> <ul style="list-style-type: none"> • Microphysics: bin and bulk microphysics, hydrometeor size distributions, single- and multi-moment schemes, representation of basic processes, autoconversion • Convection: convective adjustment, Kuo scheme 	9