ATM OCN 452

The Frontal Cyclone

Fall 2011

Instructor: Dr. Jonathan E. Martin
1425A Meteorology and Space Science
jemarti1@wisc.edu
262-9845

Office Hours: Wed. 12:30 – 2:25 (or by appointment)

T. A.: Croix Christenson, 1405 Meteorology and Space Science
cchristenson@wisc.edu

Website: http://marrella.aos.wisc.edu/aos452/

Grading:		
Exams	3 @ 10% each	30%
Final Exam		15%
Final Laboratory Project		15%
Laboratory Exercises and Weather Discussions		40%

Additionally, participation in the Weather Forecasting Contest is ***mandatory.*** Performance cannot hurt your grade, but non-participation can!! For instance;

- For every missed forecast after 4 misses, you lose 1 pt on your final grade.
- If you beat Croix or me, you earn 2 additional points on your final grade.
- If you beat ***both*** Croix and me you earn 4 additional points on your final grade.

Required Text: *Mid-Latitude Atmospheric Dynamics: A First Course*
by Jonathan E,. Martin
and Assigned Readings (see syllabus)

Other References: Given with lectures. These additional references will consist of refereed scientific journal articles.

This course will require hard work and dedication. We will learn alot about the atmosphere and the weather at mid-latitudes during the course of the semester.

Syllabus

Week	Date	Topics	Reading
1	Sept. 6	Introduction, Philosophy and Goals of 452, Review of Fundamental Physics	*Bjerknes and Solberg (1922)*
1	Sept. 8	Geostrophic Wind, Cons. of Mass, Force balance at sfc and aloft, effects of curvature	
2	Sept. 13	Hypsometric equation, thermal wind equation; Instabilities, Vertical structure of cyclones	*Chapter 8.2*
2	Sept. 15	Cyclone development, Energetics view of cyclone life cycle, definition of ageostrophic wind; Sutcliffe (1938), ageostrophic wind	*Orlanski and Sheldon (1995)* *Sutcliffe (1938)* *Chapters 8.2 and 6.1*
3	Sept. 20	Quasi-geostrophic ω-equation	*Sutcliffe (1947), Ch. 6.2*
3	Sept. 22	Trenberth form of the ω-equation	*Trenberth (1978), Ch.6.3*
4	Sept. 27	The "*geostrophic paradox*" and its resolution, the **Q**-vector	*Hoskins et al. (1978), Ch. 6.4*
4	Sept. 29	Exam 1 (material covered up to 9-22-11)	
5	Oct. 4	The **Q**-vector (continued)	*Hoskins et al. (1978), Ch. 6.4*
5	Oct. 6	Introduction to fronts, frontal slope and frontal characteristics, relation of fronts to jets	*Chapter 7.1*
6	Oct. 11	Frontogenesis and deformation fields	*Chapter 7.1*
6	Oct. 13	Frontogenesis and deformation fields	*Chapter 7.1*

		Frontogenesis and vertical circulations, Sutcliffe (1938), Sawyer-Eliassen	*Eliassen (1962), Ch. 7.2*
7	Oct. 18	Quasi-geostrophic frontogenesis and the **Q**-vector	*Martin (1999a), Ch. 7.2*
7	Oct. 20	Sawyer and Eliassen continued, upper-level frontogenesis	*Eliassen (1962), Ch. 7.3*
8	Oct. 25	Exam II (material up to 10-18-11)	
8	Oct. 27	Upper-level FG continued, upper FG and its effect on cyclogenesis	*Keyser and Shapiro (1986) sect. 2, Ch. 7.4*
10	Nov. 1	Mechanisms for banded precipitation at fronts, CSI criteria and PV_e, adiabatic reduction of PV_e	*Martin et al. (1992), Ch. 7.5*
10	Nov. 3	Cyclogenesis, Petterssen's Types A and B, Q-G Tendency equation	*Chapter 8.3*
11	Nov. 8	Q-G PV form of the Tendency equation, applications	"
11	Nov. 10	The role of diabatic effects in cyclogenesis, explosive cyclogenesis	*Uccellini (1989) Palmen Memorial Vol., Chapter 8.5*
12	Nov. 15	"Self-development", cyclogenesis and frontogenesis as concurrent processes.	"
12	Nov. 17	Introduction to potential vorticity, What is PV? Invertibility and Conservation	*Hoskins et al. (1985) sect. 1, Chs. 9.1 and 9.2*
13	Nov. 22	Exam III (material through 11-15-11)	
13	Nov. 24	Thanksgiving Holiday	
14	Nov. 29	DOUBLE LECTURE Cyclogenesis from the PV perspective; mutual amplification of upper and lower anomalies. Interior PV anomalies; Diabatic effects and the PV paradigm.	*Chapter 9.3* *Chapter 9.4*
14	Dec. 1	DOUBLE LECTURE "Self development" from a PV perspective PV distribution in upper-level fronts, role of tropopause deformation in cyclogenesis	*Chapter 9.5*

		The conceptual elegance of "PV thinking", useful in the forecast office??	*Hoskins and Berrisford (1988)*
15	Dec. 6	DOUBLE LAB	
15	Dec. 8	DOUBLE LAB	
16	Dec. 13	Recent research on occluded cyclones	*Martin (1999a), (1999b), Chapter 8.7*
16	Dec. 15	Recent research on occluded cyclones (cont.) Review for Final Exam	

FINAL EXAM: *7:25 p.m., Wednesday December 22, 2010*

This is a 2 hr exam and will be comprehensive but *NOT* nit-picky!

AOS 452
Laboratory Outline
Fall 2011

There are three primary component goals to the laboratory portion of the course, they are;

1) Data Analysis and Interpretation/Research Methods

2) Forecasting and Weather Discussions

3) Acquisition of Computer Skills

Each of these goals will be an integral part of the lab. A description of the plan for each is listed below.

1) <u>DATA ANALYSIS AND INTERPRETATION/RESEARCH METHODS</u>

We will begin by analyzing a surface and upper level chart INDIVIDUALLY to ensure that everyone gets experience doing both kinds of maps.

Then we will be analyzing a winter cyclone that affected the Midwest from 9-11 November 1998. We will analyze the majority of the cyclone life cycle beginning at 0000 UTC 9 November 1998 and ending at 0000 UTC 11 November 1998. The class will be split into 4 groups each with its own responsibilities.

GROUP 1 - sfc analyses at 12, 15, and 18 UTC 9 November <u>*as well as*</u> 850, 700, 500, and 300 mb at 12 UTC 9 November 1998.

GROUP 2 - sfc analyses at 21 UTC 9 November, 00, and 03 UTC 10 November *as well as* 850, 700, 500, and 300 mb at 00 UTC 10 November 1998.

GROUP 3 - sfc analyses at 06, 09, and 12 UTC 10 November *as well as* 850, 700, 500, and 300 mb at 12 UTC 10 November 1998.

GROUP 4 - sfc analyses at 15 and 21 UTC 10 November and 00 UTC 11 November *as well as* 850, 700, 500, and 300 mb at 00 UTC 11 November 1998.

The details concerning group responsibilities with regard to these analyses will be given in the lab.

After the hand analysis is completed (~2 to 3 weeks), we will turn our energies to GEMPAK, GARP and VIS-5D to answer dynamical questions posed by our thorough familiarity with the observed data. In this section of the lab, each group will be responsible for diagnosing the storm with respect to vertical motions, frontogenesis, cyclone structure etc. Each group will write up a DYNAMICAL description of the 12 h interval within which they are centered using hand analyses and computer diagnostics (from their own group and others when necessary). This paper will be 6-10 pages in length and will require figures to illustrate the points made in the text. (group presentations and write-ups are due TUES. NOVEMBER 8).

Each INDIVIDUAL then begins his/her own specialized research topic and writes an 8-12 page paper describing the results for a semester term project. The results must also be presented in an oral presentation at the end of the semester. THIS PAPER IS DUE AT THE BEGINNING OF LECTURE ON TUESDAY DECEMBER 13!!!!

I recognize that these assignments require that you learn something about research methods in our field. For that reason, we will devote a fair amount of time in the laboratory to helping you develop such skills. This will be accomplished by "mini-case studies" that will be coordinated by Croix and me. Beginning Sept. 20, we will devote 30 minutes (at least) of the lab period to presentation of an interesting case from the current, or nearly current, weather. We will model for you how we go about looking at it from a research perspective by discussing tools of analysis, interesting questions regarding the case, etc. This discussion will be on Tuesdays and on the subsequent Thursdays we will present a number of questions for you to consider about the case. We will assign groups of you responsibility for answering these questions with a due date of the written, illustrated and defended answer being the following Thursday. This semi-regular exercise will help you develop the research skills you need to successfully approach both the group case study and your individual case study work.

2) FORECASTING

Every student will be required to participate in the Weather Forecasting Contest. Your performance in the contest will have no bearing on your grade, however, your approach to it will. Every student will be required to keep a forecasting journal in which a short verbal description of the coming day will be written along with yesterday's verification and your

previous day's forecast (when applicable). At the end of each 2-week period, each student will be required to submit these journal pages for evaluation of their completeness.

Any student who beats either Prof. Martin or Croix in the contest will receive a bonus of 2 points on their final average. If any student beats BOTH of us in the contest, that student will receive 4 extra points.

Map discussions - The class will be split into groups of 2 for this component. Each group will be required to give four extended map discussions concerning the current and forecast weather. These discussions will include a synopsis and diagnosis of the current weather and a forecast through the coming 36 hours. Croix and I will conduct the discussions through September 15. The remaining discussions will be handled by the students. Students *not* delivering a given map discussion are required to participate and will be responsible for evaluating the delivering couple's performance.

3) COMPUTER SKILLS

Throughout the term you will become familiar with GEMPAK, GARP and VIS-5D by doing exercises concerning the current weather. By late September or so, after you've acquired these skills, we'll give you the 9-11 November 1998 data in GEMPAK and VIS-5D. **Each student will also be responsible for constructing a World Wide Web page, connected to the class homepage, which can be used during map discussions and for preparation of forecasts for the NCWFC.** We will discuss this more as the course moves forward.

Croix will provide you with a detailed LAB SYLLABUS

Last 2 lab periods (December 13 and 15) will be occupied with individual term projects presentations. These presentation will be 12 minutes in length; 9 minutes for presentation, 3 for questions.

AOS 452 Supplemental Reading List (distributed 9-6-11)

1) Bjerknes, J., and H. Solberg, 1922: Life cycle of cyclones and the polar front theory of atmospheric circulation. *Geofys. Publ.*, **3**(1), 1-18.

2) Orlanski, I. , and J. P. Sheldon, 1995: Stages in the energetics of baroclinic systems. *Tellus*, **47A**, 605-628.

3) Sutcliffe, R. C., 1939: Cyclonic and anticyclonic development. *Quart. J. Roy. Meteor. Soc.*, **65**, 518-524.

4) Sutcliffe, R. C., 1947: A contribution to the problem of development. *Quart. J. Roy. Meteor. Soc.*, **73**, 370-383.

5) *Trenberth, K. E., 1978: On the interpretation of the diagnostic quasi-geostrophic omega equation. *Mon. Wea. Rev.*, **106**, 131-137.

6) Hoskins, B. J., I. Draghici, and H. C. Davies, 1978: A new look at the ω-equation. *Quart. J. Roy. Meteor. Soc.*, **104**, 31-38.

7) *Martin, J. E., 1998: On the deformation term in the quasi-geostrophic omega equation. *Mon. Wea. Rev.*, **126**, 2000-2007.

8) Eliassen, A., 1962: On the vertical circulation in frontal zones. *Geofys. Publ.*, **24**, 147-160.

9) *Keyser, D., and M. A. Shapiro, 1986: A review of the structure and dynamics of upper-level frontal zones. *Mon. Wea. Rev.*, **114**, 452-496. (only 452-474 required)

10) Uccellini, L. W., 1990: Processes Contributing to the Rapid Development of Extratropical Cyclones, in *Extratropical Cyclones: The Erik Palmen Memorial Volume*, C. W. Newton and E.O. Holopainen, Eds., *Amer. Met. Soc.*, 1990, pp.81-105.

11) Hoskins, B. J., M. E. McIntyre, and A. W. Robertson, 1985: On the use and significance of isentropic potential vorticity maps. *Quart. J. Roy. Meteor. Soc.*, **111**, 877-946.

12) Hoskins, B. J., and P. Berrisford, 1988: A potential vorticity perspective of the storm of 15-16 October 1987. *Weather*, **43**, 122-129.

13) *Martin, J. E., 1999a: Quasi-geostrophic forcing of ascent in the occluded sector of cyclones and the trowal airstream. *Mon. Wea. Rev.*, **127**, 70-88.

14) *Martin, J. E., 1999b: The separate roles of geostrophic vorticity and deformation in the mid-latitude occlusion process. *Mon. Wea. Rev.*, **127**, 2404-2418.

* available for downloading as PDFs on AOS 452 website