University of Wisconsin-Madison
ATM OCN 452
The Frontal Cyclone (4 cr)
Fall 2025

Meeting time and Location: T, Th 1:20 – 2:30,
1411 AOSS Building

Instructional Modality: Face-to-face

Credit allocation: Traditional Carnegie Definition - Six contact hours per week, with 4 additional HW hours each week

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

Office Hours: Wed. 1:20 – 3:20 (or by appointment)

T. A.: Libby Orr, 1421 Meteorology and Space Science
ljorr@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 Libby or me, you earn 2 additional points on your final grade.
- If you beat ***both*** Libby 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. 4	Introduction, Philosophy and Goals of 452, Review of Fundamental Physics	*Bjerknes and Solberg (1922)*
2	Sept. 9	Geostrophic Wind, Cons. of Mass, Force balance at sfc and aloft, effects of curvature	*Chapter 8.2*
2	Sept. 11	Hypsometric equation, thermal wind equation; Instabilities, Vertical structure of cyclones	
3	Sept. 16	Cyclone development, Energetics view of cyclone life cycle, definition of ageostrophic wind; Sutcliffe (1938), ageostrophic wind	*Orlanski and Sheldon (1995)* *Sutcliffe (1939)* *Chapters 8.2 and 6.1*
3	Sept. 18	Quasi-geostrophic ω-equation	*Sutcliffe (1947), Ch. 6.2*
4	Sept. 23	Trenberth form of the ω-equation	*Trenberth (1978), Ch.6*
4	Sept. 25	Exam 1 (material covered up to 9-23-25)	
5	Sept. 30	The "*geostrophic paradox*" and its resolution, the **Q**-vector	*Hoskins et al. (1978), Martin (1998), Ch. 6.4* Student Map Discussions begin
5	Oct. 2	Q-vector continued	" Case Study #1 introduced
6	Oct. 7	Introduction to fronts, frontal slope and frontal characteristics, relation of fronts to jets	*Chapter 7.1*

6	Oct. 9	Frontogenesis and deformation fields Frontogenesis and vertical circulations,	“
7	Oct. 14	Sutcliffe (1938), Sawyer-Eliassen	*Eliassen (1962), Ch. 7.2*
7	Oct. 16	Frontogenesis and vertical circulations, Sutcliffe (1938), Sawyer-Eliassen	*Martin (1999a), Ch. 7.2* *Eliassen (1962), Ch. 7.3* Case Study #1 due Case Study #2 intro
8	Oct. 21	Exam II (material up to 10-16-25)	
8	Oct. 23	Sawyer and Eliassen continued, upper-level Frontogenesis.	*Eliassen (1962), Ch. 7.3*
9	Oct. 28	Upper-level FG continued, upper FG and its effect on cyclogenesis	*Keyser and Shapiro (1986) sect. 2, Martin (2014), Ch. 7.4*
9	Oct. 30	Mechanisms for banded precipitation at fronts, CSI criteria and PV_e, adiabatic reduction of PV_e	*Martin et al. (1992), Ch. 7.5* Case Study #2 due
10	Nov. 4	Cyclogenesis, Petterssen’s Types A and B, Q-G Tendency equation	*Chapter 8.3*
10	Nov. 6	Q-G PV form of the Tendency equation, Applications	*Chapter 8.3*
11	Nov. 11	The role of diabatic effects in cyclogenesis, explosive cyclogenesis	*Uccellini (1989)* *Palmen Memorial Vol.,*
11	Nov. 13	Exam III (material through 11-11-25)	
12	Nov. 18	“Self-development”, cyclogenesis and frontogenesis as concurrent processes.	*Chapter 8.5*
12	Nov. 20	Introduction to potential vorticity, What is PV? Invertibility and Conservation	*Hoskins et al. (1985) sect. 1, Chs. 9.1 and 9.2*
13	Nov. 25	PV inversion diagnostics	
13	Nov. 27	Thanksgiving	

14	Dec. 2	Cyclogenesis from the PV perspective; mutual amplification of upper and lower anomalies	*Chapter 9.3*
14	Dec. 4	Interior PV anomalies; Diabatic effects and the PV paradigm. "Self development" from a PV perspective RESEARCH PAPERS DUE	*Chapter 9.4*
15	Dec. 9	PV distribution in upper-level fronts, role of tropopause deformation in cyclogenesis Diabatic influences on PV, examples The conceptual elegance of "PV thinking" Recent research on occluded cyclones	*Chapter 9.5* *Chapter 9.5* *Hoskins and Berrisford (1988) Martin (1999a), (1999b),* *Chapter 8.7*

FINAL EXAM: *Wednesday December17, 2025 7:45-9:45 AM*

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

AOS 452
Laboratory Outline
Fall 2025

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

1) Data Analysis and Interpretation

2) Forecasting and Weather Discussions

3) Acquisition of Computer Skills

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

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

Undertaking individual research projects requires 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.

We will also gain practice in putting together research work on weather systems with two mini case studies. The first (introduced on October 2 and due on October 16) will concentrate on helping you formalize your curiosity about a case we encounter together this fall. You will be required to pick an aspect of the case to consider for analysis; the frontal structure, the development of the SLP minimum, the precipitation distribution, etc. You will write a short (2 page) description of the case aspect of interest and illustrate it with a figure or two to provide a *synoptic description* of the case.

The second mini case study will be introduced on October 16 – it will be a continuation of your first study but in which you apply diagnostics to quantify aspects of the subject of interest related to this case. This analysis will also require a 2ish page write up (illustrated with a figure or two) that will be due on October 30. The combination of these two smaller assignments will get you ready for the final lab assignment described below.

Each INDIVIDUAL will pursue his/her own specialized research topic and write 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 THURSDAY DECEMBER 4!!!!

2) <u>FORECASTING</u>

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 <u>will</u>. 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).

Any student who beats either Prof. Martin or Libby 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.

<u>Map discussions</u> - The class will be split into groups of 2 for this component. Each group will be required to give two 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. Libby and I will conduct the discussions through most of September. 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) <u>COMPUTER SKILLS</u>

Throughout the term you will become familiar with GEMPAK and VIS-5D by doing exercises concerning the current weather. Your mini-case study work will incorporate what you have learned about these data analysis tools. **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.

Libby will provide you with a detailed LAB SYLLABUS

Last 2 lab periods (December 4 and 9) 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
(available for download on AOS 452 webpage)

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) Martin, J. E., 2014: Quasi-geostrophic diagnosis of the influence of vorticity advection on the development of upper level jet-front systems. *Quart. J. Roy. Meteor. Soc.*, **140**, 2658-2671.

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

12) *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.

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

14) *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.

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

COVID-19 REQUIREMENTS:

Students should continually monitor themselves for COVID-19 symptoms and get tested for the virus if they have symptoms or have been in close contact with someone with COVID-19. Student should reach out to instructors as soon as possible if they become ill or need to isolate or quarantine, in order to make alternate plans for how to proceed with the course. Students are strongly encouraged to communicate with their instructor concerning their illness and the anticipated extent of their absence from the course (either in-person or remote). The instructor will work with the student to provide alternative ways to complete the course work.

Academic Integrity: Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these previously listed acts are examples of misconduct which may result in disciplinary action. Examples of disciplinary action include, but is not limited to, failure on the assignment/course, written reprimand, disciplinary probation, suspension, or expulsion.

Diversity and Inclusion Statement: At UW-Madison, we value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals. These values will undergird the efforts we make together in this class.