Atmospheric Sciences 5700
Mesoscale and Radar Meteorology
Spring 2025

Instructor: Steve Krueger
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Description: This course deals with the fundamental aspects of mesoscale and non-hydrostatic motions in the atmosphere. Such motions occur in the atmospheric boundary layer, in flow over mountains, in cumulus convection, mesoscale convective systems, lake effect snow, extratropical cyclones, and tropical cyclones. The course also describes how modern weather radars are used for the quantitative description and physical understanding of precipitating mesoscale systems. Whenever possible, we will undertake real-time examination of mesoscale events as they develop around the country.

Course Outcomes and Objectives: This course equips students with analytical and practical skills in mesoscale meteorology. Key learning outcomes include:

- **Scale Analysis**: Understand and derive simplified momentum equations for mesoscale and cumulus-scale motions.
- **Radar Meteorology**: Explain radar reflectivity, interpret Doppler velocity patterns, and understand the benefits of dual-polarization and longer-wavelength radars.
- **Boundary Layer and Convection**: Describe phenomena like lake-effect snow, drylines, mesoscale low-level jets, and sea breezes, including their roles in convection.
- **Convective Storms**: Analyze thunderstorm dynamics, life cycles, and the roles of CAPE and wind shear in storm severity and propagation.
- **Tornadoes**: Identify vorticity sources for supercell and non-supercell tornadoes.
- **Downdrafts and Bow Echoes**: Understand factors driving strong downdrafts, characteristics of bow echoes, and derechos.
- **Hail and Flash Floods**: Identify key factors in hail formation and meteorological conditions favoring flash floods.

- **Mountain Waves**: Analyze stationary gravity waves, wind shear effects, and the hydraulic jump theory for downslope windstorms.
- **Extratropical and Tropical Cyclones**: Describe mesoscale features like sting jets and rainbands, along with tropical cyclone formation, structure, and climatology.
- **Mesoscale Numerical Weather Prediction (NWP)**: Assess the roles of mesoscale models in severe storm forecasting.

This comprehensive framework emphasizes both theoretical understanding and practical applications in mesoscale meteorology.

Prerequisites: ATMOS 5100 Introduction to Atmospheric Dynamics; ATMOS 5300 Atmospheric Thermodynamics and Boundary Layer Processes

Classroom: WBB 820

Class hours: Tu Th 12:25 pm – 1:45 pm

Office hours Th 2:30 pm – 3:30 pm or by appointment. Email works well.

Holidays: (none)

Classes that will be rescheduled: Jan. 14, Jan. 21

Spring break (no class): March 11, 13

Midterm exam: Thursday, March 20

In-class report presentations: Tuesday, April 15, and Thursday, April 17

Last day of class: Tuesday, April 22

Final exam: Monday, April 28, 2025, 10:30 am – 12:30 pm

Course Requirements: The course grade will be determined from problem sets (35%), a mid-term exam (20%), a final exam (15%), a report (25%), and attendance (5%).

Grading Scale: The grading scale will be A or A-: ≥ 90; B-, B, or B+: 80-89; C-, C, or C+: 70-79; D-, D, or D+: 60-69; F: < 60.

Class policies: Students must take every exam with exceptions governed by University Policy. Plagiarizing, copying, cheating, or otherwise misrepresenting one's work will not be tolerated.

Missing class will not be penalized directly, but usually results in poor problem set and exam performance. Some course material that you are responsible for will only be presented during lectures (i.e., will not be found in the text or online notes).

Homework is due at the start of class on the due date, unless otherwise noted. *Late homework will generally not be accepted.*

University policies: Updated mandatory syllabus policies regarding the ADA Act, Safety at the U, Addressing Sexual Misconduct, and Academic Misconduct can be viewed at: https://cte.utah.edu/instructor-education/syllabus/institutional-policies.php

Required Textbook: *Mesoscale Meteorology in Midlatitudes* by Paul Markowski and Yvette Richardson.

Supplementary Textbook: *Radar Meteorology: A First Course* by Robert M. Rauber and Stephen W. Nesbitt. Highly recommended: comprehensive and clearly written. A must-have for anyone serious about radar meteorology.

Other Course Materials: The class web page includes links to notes, skew-T log p diagrams, and resources on forecasting convection.

Topics to be Covered (subject to modification):

1. Scale analysis; vertical momentum equation; buoyancy force (1 lecture)
2. Radar and its applications (2-3)
3. Lake effect snow (2-3)
4. Boundary layer phenomena (low-level jet, dry line, horizontal convective rolls, sea breeze)(1-2)
5. Convective storms (5)
6. Tornadoes (3)
7. Midterm exam (1)
8. Downbursts, bow echoes, derechoes (2)
9. Hail and lightning (1)

10. Flash floods (1)
11. Mountain waves and downslope windstorms (2)
12. Mesoscale aspects of extratropical cyclones (sting jets, rain bands, CSI) (1)
13. Tropical cyclones (1-2)
14. Mesoscale NWP (1)
15. Special topics (1-4)
16. Student reports (1)
17. Review (1)

Drop and Withdrawal dates:

- Last day to add or drop classes: **Friday, January 19.** (Students can drop classes through this date, and the courses will not appear on their transcripts.)
- Last day to withdraw from classes: **Friday, March 1.** (Students can withdraw from classes, but "W" will appear on their transcript for these courses.)