GEOL-G 474 – Topics in Atmospheric Science
Spring 2017 – Indiana University

Topic: Mesoscale Meteorology

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Contents

1. Overview

Course outcome for students: Students who participate in the course fully will be able to describe mesoscale phenomena in both qualitative and quantitative terms, including their causes, development, and effects, imparting an appreciation for nature and its impact on our lives.

In this course, it is my goal to provide students with a foundation in the processes that govern atmospheric phenomena at the mesoscale. The course will include a treatment of both dynamic and thermodynamic forcings for selected phenomena. Through application of this knowledge, **students will be demonstrate the critical thinking and problem-solving skills expected of seniors in the atmospheric science program at IU.**

2. What is the Mesoscale?

Much of the "sensible weather" we experience is produced by mesoscale phenomena. Broadly speaking, the *mesoscale* includes the range of atmospheric flows larger than those dominated by turbulence and smaller than those that are essentially in geostrophic balance. To be precise, Orlanski (1975) defined the *mesoscale* as motions on spatial scales from 2 to 2000 km. Very few simplifications to the equations of motion are permitted at the mesoscale; hence it is often one of the most challenging – and most rewarding – study areas for scientists and students.

3. Course Outline

Using mesoscale phenomena as a common theme, our course includes rigorous study of:
- the fundamental principles of atmospheric fluid dynamics and thermodynamics;
- the dynamical processes that operate in the atmosphere; and
- the laws of motion and the so-called primitive equations.

The final list of topics will be tailored based on student interest.

Tentative Topic List

(Book chapter references given in parentheses)

1. Primitive equations of motion
- Definition of the mesoscale (Ch. 1)
- Distinctions between mesoscale and other atmospheric phenomena
- The primitive equations & scale analysis (early Ch. 2)

2. Basic updraft and downdraft dynamics
- fundamentals of buoyancy
- review CAPE, CIN, soundings, conditional instability (2.6, 3.1) [*brief -- covered extensively in G340, G332, & G339*]
- airmass thunderstorms are a good starting point (8.1, 8.2)
- contributions to W (i.e., dw/dt; 2.3, 10.2)
- Chapter 4 of Kessler: Basic Thunderstorm Energetics and Thermodynamics

3. Cloud microphysics
- the role of latent heat in instability, CAPE, and cloud growth
- review of the growth and nucleation of cloud droplets (ref. 10.3 and 10.4) [*brief – covered in G332*]

4. Synoptic and mesoscale processes (5.2, Ch. 7)

- drylines (5.2) and turbulent mixing in the boundary layer
- ingredients for strong, persistent storms [*brief -- covered extensively in G109 & G339*]
- climatology of these ingredients [*brief -- covered extensively in G339 & G437*]
- atmospheric conditioning mechanisms
- Chapter 5 of Kessler: Thunderstorms in the Synoptic Setting

5. Supercell storms (8.4)
- hodographs (2.7)
- the pressure perturbation equation (2.5)
- storm splitting

6. Mesoscale circulations
- Sea breezes and circulation theory (5.4)
- Great Plains Low Level Jet (4.5)
- MCS and squall lines (8.3, Ch. 9)
- cold pool propagation (5.3)
- RKW theory

Choose N of these:

Tornadoes (10.1)
- dynamic pipe effect
- baroclinic generation of vorticity along FFD and RFD

Hurricanes (handouts)

Non-hurricane rain/flood events (10.4, handouts)
- hydrology/hydrometeorology of flooding

Mountain meteorology
- Orographic precipitation
- Numerical weather prediction in complex terrain
- Wind systems (diurnal; downslope windstorms)

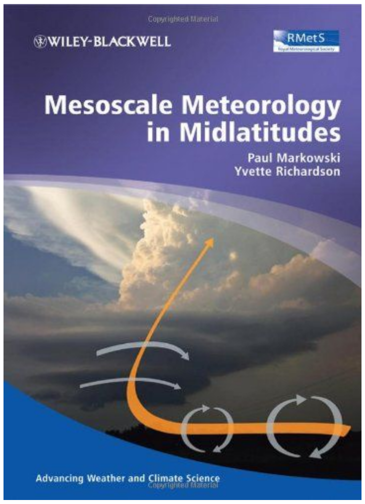
4. Prerequisites

In most atmospheric science and meteorology programs across the country, the Mesoscale Meteorology course is revered as a "capstone" type of experience – requiring summary and integration of the student's body of knowledge acquired through all previous courses in the program – and it will be treated as such here at IU. As a result, *these prerequisites must be enforced.*

- Official: GEOL-G 340/532 or GEOG-G 304 or GEOL-G 332 or equivalent, or similar upper division physical science coursework or experience
- Official: Differential and integral calculus (e.g., M211 and M212)
- Official: Calculus-based physics (e.g., P221)
- Unofficial: Basic "programming" and data visualization ability (Excel should suffice)

5. Text

Mesoscale Meteorology in Midlatitudes, by Markowski and Richardson.



This text is available electronically through the IU Library at no charge to students. If this were to change, however, I will change the required text. Also keep handy the errata for the Markowski text--every book has errors.

Occasional reading supplements may be provided from:
- *Storm and Cloud Dynamics*, by Cotton, Bryan, and van den Heever [*PDF available for free via IU Library*]
- *Cloud Dynamics,* by Houze [*PDF available for free via IU Library*]
- *Severe Convective Storms and Tornadoes*, 2012, by Bluestein [*PDF available for free via IU Library*]
- *Severe Convective Storms*, the 2002 AMS Monograph
- *Mesoscale-Convective Processes in the Atmosphere*, by Trapp
- *Thunderstorm Morphology and Dynamics,* AMS monograph edited by Kessler

6. Assessment

- Midterm and comprehensive final exam
    - Weighted either 25%/25% or 10%/40%, whichever is most beneficial to each student (but *not* 40%/10%)
    - Proposed midterm date: last class before spring break
    - Mandatory final exam date and time: Thursday 4 May, 10:15 a.m.
- Bi- or tri-weekly quantitative homework assignments (30%)
- Research Review activities (20%)

7. Research Review

One of the requirements of work in the sciences is that you are able to report on and explain the significance of current research about topics of interest to you. For this component of the course, the deliverables are:

- A 6-page, AMS conference style report (an example will be provided);
- An oral presentation to be given during the last week or two of classes; and
- An 11” x 17” “mini-poster” suitable for an audience of scientists, e.g., traffic on the 4th floor hallway of the Geological Sciences Building.

We will endure both a “proposal” phase and a “peer review” phase on your written work, so that your final report is of the highest possible quality. Each of the three elements of this research review will be weighted equally for this part of the course grade. More details will be given in the first two weeks of class.

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