

MEA 443 SYNOPTIC WEATHER ANALYSIS AND FORECASTING

Fall 2009 Midterm Exam Review Summary

This sheet summarizes the most important concepts for the midterm exam. However, there is no guarantee that 100% of the exam material is represented on this sheet, and there are topics on this sheet that may not be covered on the exam. Expect to see several of these topics represented on the exam (Wednesday, 7 October).

Exam format: There may be a few quantitative calculations so **bring your calculators**. There will be a variety of question formats, including short-answer, multiple choice, derivation of equations (given starting points, etc.) and lots of physical interpretation and application of the material from lecture to both idealized and actual data.

- 1.) Be sure to review the handouts covering the basic meteorological variables and their physical significance. For example, given a vertical profile of potential temperature, be able to identify mixed layers (and the depth of the Planetary Boundary Layer). Know how stability can be determined from a profile of temperature or potential temperature.
- 2.) Know the mathematical definition, physical significance, and meteorological importance of vorticity. For instance, why do we mostly concern ourselves with the vertical component? Given a weather map, be able to use “finite difference” techniques to compute the sign or numerical value of the vorticity at any given location. Expect to identify regions of large or small shear and curvature vorticity, given a plot of geopotential height or wind.
- 3.) Be sure you can identify and interpret each of the terms in the vorticity equation. For simplified situations, be prepared to discuss processes that govern vorticity, and how it evolves with time.
- 4.) An important applications of the vorticity equation involved Rossby waves. Know the basic mechanism of these waves, and what processes govern their movement. For a real-data example, be able to compute the Rossby wave phase speed. Know the assumptions that went into the Rossby-wave phase speed equation that we developed. Where did that equation come from?
- 5.) Be sure to have a solid understanding of how the hypsometric equation relates to weather system structure. Why do midlatitude cyclones tend to tilt westward with height? How does the structure of a hurricane compare to that of an extratropical cyclone?
- 6.) Know the thermal wind material. For example, be able to demonstrate that a backing wind is associated with cold advection. Be able to use thermal wind arguments to explain changes in wind speed with height above and below the jet stream core, etc. How does the thermal advection relate to forcing vertical air motion? Expect to apply the thermal wind relation to do something useful in a real-data situation.
- 7.) What are the main assumptions that go into the QG system? Which of these assumptions are the most restrictive? For which types of weather system might QG theory be irrelevant?
- 8.) If the QG system of equations is really less accurate than the “full” primitive equation system, then what is the purpose of using it?

- 9.) Be prepared for some sort of short derivation, for example, derive the QG omega or height-tendency equation from the thermodynamic and vorticity equations. You will be given the starting and ending equations... no need to memorize! You will likely be asked a simple math problem relating to natural logarithms, exponential functions, or basic calculus.
- 10.) Given a weather map or overlay of weather maps, be able to recognize
- a.) the sign of vorticity or thermal advections, etc.
 - b.) regions of veering or backing in vertical profiles,
 - c.) regions of veering or backing from an overlay of height at different levels.
- 11.) For the QG omega and height-tendency equations, be able to recognize **and interpret** each of the terms, and be able to relate them to things plotted on weather maps.
- 12.) Physically, what is the QG vertical motion? What “purpose” does it serve? Given a diagram of a jet entrance or exit (in either hemisphere) be able to deduce the sense of the ageostrophic circulation that would accompany the flow.
- 13.) What are the advantages of the Q-vector form of the omega equation relative to the traditional form?
- 14.) Be able to compute Q-vectors from a weather map (given the Q-vector expression), and indicate where rising or sinking motion would be expected.
- 15.) Given a set of maps, be able to apply QG reasoning to make and defend a basic weather forecast (e.g., precipitation forecast).
- 16.) For the QG height-tendency equation, be able to apply it to explain the evolution of upper waves, and surface cyclones and anticyclones. Why is it the *differential* thermal advection that matters? Physically, how does the diabatic term lead to height rises and falls? What type of height tendency would we expect in different synoptic settings (e.g., above a developing hurricane, behind a strong cold front, etc.)
- 17.) What is the QGPV? Why is PV useful in the first place? What are 2 useful properties of PV, and how can it help our understanding of atmospheric dynamics?
- 18.) How does the PV relate to the QG height-tendency equation?
- 19.) Be prepared to discuss how PV non-conservation can provide information about the dynamics (and predictability) of a given weather system.
- 20.) Know the basic characteristics of the main U.S. operational models such as the GFS and NAM. Which model might be a better choice in a given situation?

- 21.) How can the vorticity equation be used to explain the observation that cyclones tend to form along fronts? How does the vorticity equation “work” to explain the vorticity tendency as a function of time?
- 22.) Be able to explain the basic cyclone climatology from a physical-process perspective.
- 23.) Know the “mechanism” of cyclogenesis from several different viewpoints, including the vorticity equation, height-tendency equation, and pressure-tendency view.
- 24.) There will be some representation of forecasting material on the exam, as it relates to the earlier material.
- 25.) Know “type A” vs. “type B” cyclogenesis (Miller vs. Petterssen); what is the role of the upper trough in cyclone development?
- 26.) What is meant by the term cyclone “self development”? Given some data, could you recognize this process? What can you look for to see if it is active?
- 27.) What process ultimately limits self development? What conditions weaken or enhance this limitation? How does stability affect this process?
- 28.) Know the basic energetics of cyclones. What are the energy sources? How does trough axis tilt factor into storm development? Given some data, can you determine the sign of the barotropic or baroclinic energy conversion? [If we get to this on Tuesday.]
- 29.) Given some data from a real case, be able to apply the tools learned in class to make a prediction about the subsequent evolution of the system.
- 30.) Know the basic premise behind isentropic analysis. Understand why it is advantageous to use potential temperature as a vertical coordinate, and know what complications can arise from this.
- 31.) Why do we call lines of constant potential temperature “isentropes”?
- 32.) Given an isentropic map, you should be able to identify regions of isentropic uplift or subsidence.
- 33.) What is the “frozen wave approximation”? Be prepared to compute and interpret the *storm-relative* isentropic flow.