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METR 4433 – Mesoscale Meteorology
Spring 2017

Study Guide for Exam #1

Below are listed the principal topics, concepts, and capabilities for which you will be responsible on the first exam. The absence of a topic from this sheet does NOT imply that it will be absent from the exam!

Definitions of Mesoscale

1. Be able to explain various approaches (e.g., dynamical, phenomenological) for defining atmospheric "scales" (e.g., synoptic, meso, storm).
2. Understand the atmospheric energy spectrum and its role in helping define the mesoscale.
3. Be able to explain the concept of energy cascade and its role in the atmosphere.
4. Be able to explain how the mesoscale differs dynamically from other scales in the atmosphere.
5. Be able to perform a scale analysis of the equations of motion and know the principal time and space scales for planetary, synoptic, meso- and storm-scale motions.

Linear Perturbation Theory and Gravity Waves

1. Understand the physical and mathematical differences between a linear and nonlinear operator, like advection, or a physical system, like a cloud growing in a conditionally stable atmosphere.
2. Understand the term "nonlinear steepening" and its origin in nonlinear advection.
3. Understand and be able to explain the concept of an eigenvalue.
4. Understand how nonlinear processes involve feedback or, in the case of waves, involve creating multiple waves from a single one.
5. Be able to list and explain the physical relevance of all steps and assumptions associated with linear perturbation theory as applied to wave motion.
6. Be able to work with complex exponential functions and know their relationship, in the context of waves, to the more standard sine and cosine formulations (see handout).
7. Be able to define basic states, and perturbations from them, as directed, and then use them to linearize a set of nonlinear equations. You will NOT be expected to come up with a list of equations that describe a particular type of wave, though you may be asked to explain why a given set of equations is appropriate for representing various pure wave types.
8. Be able to derive the frequency equation, or dispersion relationship, for both internal and external gravity waves.
9. Understand the difference between internal and external gravity waves.
10. Understand the buoyancy frequency and its relevance in gravity waves.

11. Understand how the orientation of internal gravity waves affects their frequency relative to the intrinsic buoyancy frequency.
12. Understand the conditions of vertical stratification in which internal gravity/buoyancy waves occur.
13. Know and be able to explain the Boussinesq approximation.
14. Understand the concept of a wavenumber vector and how it relates to wave propagation and wave structure.
15. Be able to compute numerical values of phase speed for all wave types using order of magnitude estimates for relevant physical quantities.

<u>Mountain Wave Dynamics</u>

16. Know the general characteristics of mountain waves and the conditions necessary for their formation.
17. Be able to explain the Froude number both physically (i.e., its role in mountain wave dynamics) and mathematically.
18. Understand the concept of linear perturbation theory and how it is applied to mountain waves.
19. Be able to define mathematically and explain the buoyancy frequency.
20. Be able to Linearize the equations governing mountain waves and derive the dispersion relation.
21. Given the dispersion relation for mountain waves, be able to explain wave characteristics (e.g., vertically propagating, trapped, evanescent).

Necessary Equations Will be Provided on the Exam