ATMO 352: Severe Weather and Mesoscale Forecasting

Spring 2007

STUDY GUIDE – Final Exam, Part I only

Date: Monday, 05/07/07

Scope: *Part I*: Similar to earlier mid-term exams but covers last 1/3 of class. The study guide below covers specific material covered.
Part II: Severe forecasting exercise similar to recent labs and is thus comprehensive in nature. You will be asked to forecast the expected location of severe convective weather (i.e., tornado, hail, and/or straight line wind) during a specified period and provide a detailed forecast justification. Hard copy maps and soundings from a real world severe storm event over CONUS will be provided.

Time: 10:30 AM – 12:30 PM. Please arrive a few minutes early to allow time to hand out exam.
Part I: ≈ 1 hour
Part II: ≈ 1 hour

Location: O&M, Room 103

Type: Closed book and notes.
You must answer questions from both Parts I and II independently!

Form of Exam: Part I of the final exam will be a mixture of objective (e.g., multiple choice, true/false) and subjective (e.g., short answer/definition, problem solving) questions. A typical exam might include 1) multiple choice/true-false questions (10 minutes, 20%), 2) short answer questions (20 minutes, 40%), and 3) a problem solving question with sub-parts (20 minutes, 40%).
Part II will require you to make a regional Day-1 severe weather forecast (Convective Outlook). As in lab, you will mark the boxes on a provided map in which you expect severe weather to occur. Most importantly, you will provide a detailed (i.e., specific and quantitative) justification for your severe convective forecast using the techniques learned in class.

Material Covered:

- Lecture notes and web-page lecture materials from 04/16/07 to 04/30/07, inclusive (Chapters 5 and 6) including associated online reading assignments such as
  - UCAR MetEd module on "Severe Convection II: Mesoscale Convective Systems"

- Lab assignments #10-13, associated notes from lab, web-page lab materials, and lab reading assignments.

Instructional/Learning Objectives

1) Define and describe the forward flank downdraft (FFD) and rear flank downdraft (RFD) of supercells, including the physical processes responsible for them.
2) Identify likely locations of tornadoes relative to supercell structure.
3) Describe in detail the two "classical" theories of tornadogenesis in supercells. Explain key similarities and differences between the two theories (e.g., origin and role of the RFD).
4) Define streamwise vorticity physically. Describe the importance of streamwise vorticity in the development of tornadoes.
5) Define the storm relative helicity (SRH) both mathematically and physically. Identify the meteorological information required to calculate the SRH. List the units of SRH.
6) Describe the graphical definition (i.e., from a hodograph) of SRH. Evaluate the relative intensity of SRH between one hodograph and another.
7) Identify approximate ranges of SRH (both 0-1 km and 0-3 km) associated with tornadic environments.
8) Identify and describe the "classical" rule-of-thumb for estimating supercell storm motion.
9) Identify and describe the energy helicity index (EHI). List optimal values of EHI (both 0-1 km and 0-3 km) that differentiate non-tornadic supercells from tornadic supercells (i.e., significant tornadoes).
10) Identify optimal ranges of LCL and CIN associated with significant tornadic supercells.
11) Given various forecast scenarios described by a collection of sounding parameters, evaluate the potential for ordinary convection, non-tornadic supercells/large hail, and tornadic supercell storms.
12) Define and describe the origins of the dryline in the central United States. Explain the relationship of the dryline to the Miller Type I sounding.
13) In your own words, describe various means to identify the dryline in surface and remotely sensed meteorological data.
14) Given dewpoint, wind and pressure data, identify the likely location of the dryline. Identify (i.e., forecast) the likely region of convective initiation associated with the dryline.
15) Explain the importance of the dryline to the forecasting of severe storms, especially supercells.
16) Identify and describe the tornadogenesis process associated with most non-supercell tornadoes (e.g., land-spouts).
17) Identify key geographical locations in the United States associated with relatively high frequency of occurrence of non-supercell tornadoes and explain why they occur there.
18) Identify and describe the necessary conditions for hail formation.
19) Describe the role and importance of CAPE or updraft strength in the hail formation process. Describe the importance of freezing level height in hail occurrence on the ground.

20) Describe the 3-stage hail formation process in supercell storms. Be sure to define and explain the relevance of the stagnation point, the embryo curtain, the BWER, and the hail cascade in hail production within supercells.
21) Describe the hail formation process in multicell storms.
22) Identify and describe the vertically integrated liquid (VIL) both physically and mathematically. Explain how VIL is used as a radar nowcasting tool for severe convective weather and discuss its potential weakness in this regard.
23) Describe the differential reflectivity (Z_{dr}) both mathematically and physically. List typical ranges of Z_{dr} for rain, small hail, and large hail. Describe a polarimetric radar technique for identifying hail that utilizes both horizontal reflectivity (Z_h) and Z_{dr} (i.e., describe the "hail hole").
24) Identify the physical mechanisms responsible for severe straight-line wind events within convective storms.
25) Define downburst, macroburst, microburst, wet microburst, and dry microburst.
26) Describe key wind pattern differences between straight line and tornadic wind events. Explain why damage patterns associated with each type of event might be confused with each other.
27) Describe the conceptual model of the structure, evolution and characteristics of a typical microburst derived from damage assessment and Doppler radar data.
28) Explain the deleterious effects of microbursts on aviation.
29) Describe the role of lapse rate from cloud base to surface and rain water content or radar reflectivity on the formation of severe straight-line wind events. Explain how the presence of ice and melting might alter this relationship.
30) Explain how downdraft CAPE (DCAPE) might be used to forecast the potential for downbursts or severe straight-line winds. Alternatively, evaluate the relative downburst threat when given different values of DCAPE. Identify the physical mechanism associated with downbursts that is measured by DCAPE.
31) Given various combinations of lapse rate, precipitation type and amount (e.g., radar reflectivity), evaluate the potential for intense downdrafts and severe straight line winds.
32) Describe some typical differences in the environment of severe and non-severe squall lines.
33) Identify the component of the wind shear that exerts the most control over squall line intensity and longevity. Given different idealized shear vector and squall line orientations, evaluate/rank the squall lines according to longevity and intensity.
34) Identify and describe two archetypes of squall lines with trailing stratiform precipitation or mesoscale convective system (MCS). Identify the most likely location of severe weather in each type.
35) Describe the basic vertical structure of and flow field within a squall line with trailing stratiform precipitation or MCS, including the ascending front-to-rear flow, descending rear inflow, mesoscale updraft, and mesoscale downdraft.
36) Explain the dynamics behind the formation of a rear inflow jet (RIJ) within a MCS.
37) Describe (verbally and graphically) the morphology and evolution of a bow echo storm. Identify the most likely location of severe downburst winds and tornadoes within bow echo storms. Identify Doppler radar signatures associated with downbursts and tornadoes within bow echo storms.

38) Define a derecho and explain its relationship to the bow echo storm. Differentiate between serial and progressive derechos.
39) Identify and describe the synoptic environment of serial and progressive bow derechos. Differentiate between the synoptic environment of a supercell tornado outbreak and a serial derecho.
40) Identify the mesoscale meteorological conditions associated with bow echo storms and associated derechos (CAPE, shear, wind). Differentiate between the typical meteorological conditions associated with derechos during weak (synoptic) forcing (WF) and strong (synoptic) forcing (SF) events.
41) Explain how the differences in meteorological conditions associated with typical WF are SF derechos are consistent with the different physical mechanisms producing strong surface winds in each event type.