HOMEWORK 1
METR 5403/4403: Applications of Meteorological Theory to Severe-Thunderstorm Forecasting
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Due: Monday, February 13, 2017 at the beginning of class

Instructions: STATE ALL ASSUMPTIONS. CARRY THROUGH ALL UNITS OF ALL PROBLEMS TO EACH SOLUTION'S END. YOU MAY WORK WITH OTHERS; EACH SUBMITTED SOLUTION WILL BE UNIQUE.

Problem 1: Consider a surface cyclone downstream of an attendant mid-level cyclonic-flow maximum corresponding to a positively tilted shortwave trough, and consider a surface cyclone downstream of an equivalent mid-level cyclonic-flow maximum corresponding to a negatively tilted shortwave trough. In both cases, assume convection develops within the warm sector. In which case would mid-level lapse rates and vertical shear characterizing the warm-sector convective environment be more likely support organized, severe convection? Justify your answer with illustrations.

Problem 2: Suppose that two mid-level shortwave troughs with identical height/flow patterns traverse two different air masses and related different thermodynamic stratifications: (a) a continental polar air mass underlying warmer air aloft, and (b) deep, dry, well mixed profiles subject to downslope-flow-enhanced warming/drying in the lee of the Rockies. Which case, if any, would yield stronger surface cyclogenesis? Why?

Problem 3: Consider a low-level, meso-α-scale boundary that is associated with an extratropical cyclone. Consider two points that lie along a mutual latitude that orthogonally intersects the boundary, and are spaced 10 km apart. Assume that winds are easterly at 5 $m\ s^{-1}$ east of the boundary and westerly at the same speed to the west of the boundary.

(a) What is a typical order of magnitude of vertical velocity associated with large-scale vertical motion surrounding an extratropical cyclone?

(b) Assuming an LFC at 1 km AGL, how long would it take for a parcel of air to ascend from the surface to the LFC using the vertical velocity specified in part (a)?

(c) Now, consider the velocity fields in the problem statement above, associated with the boundary. Assuming the impermeability boundary condition at the Earth's surface, what is the vertical velocity at the LFC at 1 km AGL?

(d) Using the vertical velocity associated with the low-level boundary calculated in part (c), how long would it take for a parcel of air rooted at the Earth's surface to ascend to the LFC?

(e) In a brief essay, describe the relationship between large-scale ascent, surface boundaries, and the development of convection in relation to parts (a)-(d) above. (HINT: Consider typical temporal scales associated with the development of surface-based convection. Is it the lift at large scales that is directly responsible for surface-based convection?)

Problem 4: On the following analyzed surface chart (part of the Unified Surface Analysis), use the manually analyzed features (e.g., tropical waves, fronts, etc.) and observations to identify areas of vertical motion. In particular, outline areas of implied low-level ascent and subsidence, using the letter A to indicate ascent and the letter S to indicate subsidence. Place a number next to each of the marked letters and then provide *concise* explanations justifying the sign of vertical motion.