Overview of Midterm Exam #1
METR 4403/5403 – Spring 2024

The first midterm exam will include mostly the synoptic and mesoscale aspects, including lectures up to Feb 19th, i.e., the first 9 lectures.

When and where:
Wednesday March 6 10am-11:15am in NWC 1350.
Review session: Monday March 4 10-11:15am in class.

Format:
- Closed notes (like traditional in-class exam), closed everything (e.g., phones, etc.).
- Everyone is expected to take exam in person in NWC 1350 (except for very special situations)
- Several multiple choices, fill-in-the-blank, or true-false questions.
- 3-4 multipart questions.
- No calculations. There may be simple derivations starting from equations given. A list of equations will be provided to you on last page of exam.

Materials needed:
- Pencils. You may find color pencils to be helpful as well. Paper will be provided.

Topics we covered:
1. **Lecture topic 1: Introduction to convection**
   a. Four key ingredients (instability, lift, moisture, shear)
   b. Instability (EML climatology and advection)
   c. Lift (synoptic QG source/jet streaks; mesoscale front/outflow/dryline)
   d. Moisture (BL moisture large and deep; return flow; vertical mixing; evapotranspiration)
   e. Vertical wind shear (synoptic influences; deepening cyclones; jet streaks; LLJ; lee cyclogenesis)

2. **Lecture topic 2: Skew-T Diagram and Parcel Theory**
   a. Parcel theory. It's assumptions.
   b. Skew-T diagrams
   c. Theoretical maximum velocity based on parcel theory/Skew-T diagram.
   d. Factors ignored by parcel theory that can cause it to over-estimate maximum vertical velocity
   e. Key levels and quantities associated with Skew-T. Different kinds of CAPE

3. **Lecture topic 3: Change of Lapse Rate**
   a. Virtual temperature effects
   b. Effects of boundary layer mixing, moisture transport on CAPE/CIN.
   c. Lapse rate tendency equation (know how the terms in the equations work). How they affect stability

4. **Lecture topic 4: Quasi-Geostrophic Height Tendency Equation, Frontogenesis, Jet Streak**
   a. Given that QG height tendency equation, be able to interpret terms in the equation
   b. Know how the vorticity advection term works to change geopotential height at different levels within trough-ridge systems, and able to apply the knowledge.

c. Know how the differential temperature/thermal advection term works to change geopotential height at different levels within trough-ridge systems, and able to apply the knowledge.
d. Know how diabatic heating can cause height change at different levels.
e. Which term is responsible for propagation and which is responsible for intensity change?

5. **Lecture topic 5: Quasi-Geostrophic Omega Equation**
    a. QG approximation and geostrophic/thermal wind balance
    b. Given the Omega equation, be able to interpret terms in the equation
    c. Know how the differential absolute vorticity advection term works to produce vertical motion at different parts of mid-level trough-ridge systems, and near upper-level jet streak, and able to apply the knowledge.
    d. Know how thermal advection term works to produce vertical motion at different parts of mid-level trough-ridge systems, and able to apply the knowledge.

6. **Lecture topic 7: Synoptic Exercise**

7. **Lecture topics 8, Vertical wind shear**
    a. Sources of vertical wind shear (geostrophic and ageostrophic, Ekman spiral)
    b. Influence on convection
    c. How to measure? Bulk wind differences. Effective inflow layer.
    d. Effective bulk shear. What layer to use to calculate?
    e. How to forecast vertical wind shear change?

8. **Lecture topics 9-10: Hodographs and related concepts/quantities**
    a. Hodographs – be able to plot them
    b. Layer vertical wind shear vector and horizontal vorticity based on hodographs
    c. Straight and curved hodographs, the direction of curvature.
    d. Storm relative wind vectors on hodographs
    e. Streamwise and cross-wise vorticity
    f. Significance of streamwise vorticity in updraft development
    g. Helicity
    h. Storm-relative wind vectors and storm-relative helicity
    i. Environmental storm-relative helicity (SRH) over different depth
    j. Graphic representation of SRH on hodograph