**ATM 651 Lab: due Monday, Oct 26**

**Understanding vertical instability for moist convection**

Deep convection doesn't just happen randomly: it happens where all three *ingredients* are present: *instability, moisture, and initiation.* This *conserved-variables sounding plot* can show **lifted-parcel buoyancy** as the gap between red and green curves, for various parcels: *undilute* is the heavy vertical green line from the surface conserving h; *entraining* parcels in light green have their value of h drawn toward the blue curve by mixing in light green. That buoyancy force is the main driving force for convective clouds.

1. For this recent sounding at Miami, on an overcast day with pretty robust shallow convection beneath it, answer these questions:

Diagram

Description automatically generated A picture containing outdoor, grass, field, track

Description automatically generated

a. Express how the sounding corresponds to the cloudiness in the region: overcast, with deep convection not too far away, but with only shallow convection locally. Be specific about pressure layers of key features.

b. How much adiabatic upward displacement would be required to remove the cap at 750 mb by cooling the environmental T (that is, moving the red curve to the left of the vertical green curve)? If it occurred steadily over 6 hours, what value of omega (Pa/s) would suffice?

b. As an alternative form of destabilization from a., how many Joules per square meter of surface MSE flux would be required to bring a well-mixed boundary layer to the right of the SMSE overhang, so that the vertical green line from the surface would have no negative buoyancy? Sketch the small rectangle of blue ink you'd have to add from the surface, and multiply its width (in kJ/kg units) by its height (dp/g in kg m-2), remember hPa = 100 Pa.

c. How much water vapor would have to be added (say, due to horizontal advection from a more moist place nearby) to bring this air column to saturation at its current temperature profile? You may estimate it roughly, just by eye, geometrically, from the blue shaded area (equal to CVW) and the subsaturation or available water vapor capacity (the white area between blue and red curves).

2. The sounding for any balloon site on Earth can be generated with the notebook [here](https://colab.research.google.com/drive/1JLdE8at_807UXOTpOHXvvuEuMpipwcKT?usp=sharing)\*, for any sounding at http://www.weather.uwyo.edu/upperair/sounding.html. To operate the notebook, select "Runtime --> Run all". Errors will occur. Now select Runtime --> Restart runtime and run all. You should get an image like the one in the book chapter, or like the following. Once you have done that, you can navigate to the cell where the location "MFL", time, and label string are set. *Make sure you adjust all 3 for your new site and time so the label comes out correctly!* Shift-return your way downward from there until your plot appears.

\*https://colab.research.google.com/drive/1JLdE8at\_807UXOTpOHXvvuEuMpipwcKT?usp=sharing

a. Find moist convective situations of interest. Peruse the world's satellite imagery with https://go.nasa.gov/3ofF3RV or your favorite resource (zoom.earth a nice quick one) to help you choose balloon [launch sites](http://www.weather.uwyo.edu/upperair/sounding.html) with interesting moist convection prospects. Try to find (i) a moist tropical site, (ii) deep convection struggling with too little moisture over an unstable hot dry land area (like west Africa or southwestern Asia or the southwestern US in northern summer), (iii) a place with only modest-depth convective clouds (notice the *cloud top pressure* layer in the web site above, or use sunrise and sunset photos to see whether icy anvil clouds are present for the cumulus towers to cast shadows on). For each one, display the sounding and a photo and briefly discuss how they correspond, being specific about pressure levels of features (dry layers, moist layers, SMSE overhangs, etc). Is the surface point representative of a whole boundary layer, or is it special (like cold beneath a stable layer with large ds/dz at night)?

In one of your cases, adjust the parcel ensemble properties in the plotting function calls: perhaps more parcels, different entrainment rates, a narrower or wider distribution of initial h around the surface value the balloon happened to sample, etc., in order to better correspond to the satellite image.

b. Find 3 more diverse environments on Earth: be creative. Perhaps a deep well-mixed layer over a hot desert; a cold place with hardly any capacity for moisture in the column (small distance between black-red curves); a rainy place in midlatitudes with stable laminar-looking thick clouds (forced ascent making moist condensation but without vertical parcel buoyancy instabilities). Or anywhere you like. The whole world is there!

c. Meteorologist extra credit: Capture the corresponding skew-T from the Wyoming site. Explain to us how its features correspond to the conserved energy-mass plot.