Bulk Shear, SRH, Precipitable Water and More!

Adding to MetPy’s Convective CAPE-abilities

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Intro to Skew-Ts and Sounding Parameters

**Plot**
- Grey lines: constant temperature (skewed!)
- Red dashed lines: constant potential temperature (isentropes)
- Blue dashed lines: moist adiabats
- Green dashed lines: constant mixing ratio
- Vertical coordinate: pressure, logged

**Data**
- Solid red line: temperature
- Solid green line: dewpoint
- Yellow line: lifted (surface) parcel temperature
- Area between parcel trace and temp:
  - CAPE (positive) / CIN (negative)

**Hodograph**
- Polar plot of wind speed and direction
- Area swept out by hodograph and storm motion vector: Storm-Relative Helicity

There is no water in this air!
Current Plotting Options

- MetPy: Plots this-
  - Great SkewT, but missing some functionality...

- SharpPy (or NSHARP):
  - Fantastic-looking SkewTs with loads of convective parameters
  - Not very easily customizable, functions for individual parameters don’t easily stand alone, includes cumbersome unit assumptions
  - Only works on Python 2.7
Objectives

• Put together a group of functions for MetPy capable of calculating various sounding indices, both for individual soundings and (someday) for gridded data.

• Add some improvements to Metpy’s Skew-T/Hodograph plotting in response to some feature requests.

• Make some other miscellaneous improvements to make this possible.
First Steps

• Make get_upper_air_data bring in geopotential heights
• Fix miscellaneous things in LFC/EL
  • Ran into these errors throughout development
• Design functions to work with John’s get_layer and cape_cin definitions
Hodograph Coloring

- Coloring a hodograph over user-selected height ranges posed a problem: the heights the user selects are often not at an actual observation point
  - Solution: use interpolation and searchsorted to find and insert these heights and their corresponding winds into the data
- Use the user-given bounds and colors to set up a custom colormap to color the hodograph with.
Integration Fun!

- Several important sounding parameters require integration.
- Must be approached differently depending on the parameter, since we may or may not have what we need to integrate.
  - storm-relative helicity
  - precipitable water
  - mean pressure-weighted wind

\[
\begin{align*}
\int u \cdot p \, dp \\
\int p \, dp
\end{align*}
\]

\[
\sum_{N-1} \left[ (u_{n+1} - u_n - y) \cdot (v_{n+1} - v_n - x)(v_{n+1} - c_y) \right]
\]

\[
pw = -1 \cdot (\text{np.trapz}(w\,\text{magnitude}, \text{pres_layer.magnitudes}) \times (w\,\text{units} \times \text{pres_layer.units}) / (g \times rho_1))
\]

\[
u\_\text{mean} = (\text{np.trapz}(\text{layer}_u \times \text{layer}_p, x=\text{layer}_p) / \text{np.trapz}(\text{layer}_p, x=\text{layer}_p) \times \text{units}(\text{'m/s'})
\]

\[
\text{int_layers} = sru[1:1] \times \text{srv}[:-1] - sru[:-1] \times \text{srv}[1:]
\]

\[
p\_\text{srh} = \text{int_layers}[\text{int_layers.magnitudes} > 0].\text{sum()}
\]

\[
m\_\text{srh} = \text{int_layers}[\text{int_layers.magnitudes} < 0].\text{sum()}
\]
Other Parameters

- Bunkers storm motion
- Bulk shear
- Supercell Composite
- Significant Tornado Parameter
- Critical Angle
- CAPE/CIN (John)
  - Variants: most unstable, sfc-3km
- Effective Layer (in development...)
- Haines Index (also in development...)
(Un)finished Product
Gridded Data

WRF-NARR Reflectivity, Bunkers Storm Motion, and Supercell Composite 6/3/1980 23 UTC
Gridded Data

WRF-NARR Reflectivity, Bunkers Storm Motion, and Significant Tornado Parameter 6/3/1980 23 UTC
Gridded Data

Reflectivity and Critical Angle
Gridded Data
Next Steps

• Add more parameters!
  • Use effective layer function to calculate parameters over an effective layer
  • Add downdraft CAPE and functions to calculate the indices which depend on it.
• Improve interactivity of sounding plotter
• Make parameter calculations run faster on gridded data
Predicting supercell motion using a new hodograph technique. Wea. Forecasting, 15, 61–79.

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