Bulk Shear, SRH, Precipitable Water and More!

Adding to MetPy’s Convective CAPE-abilities

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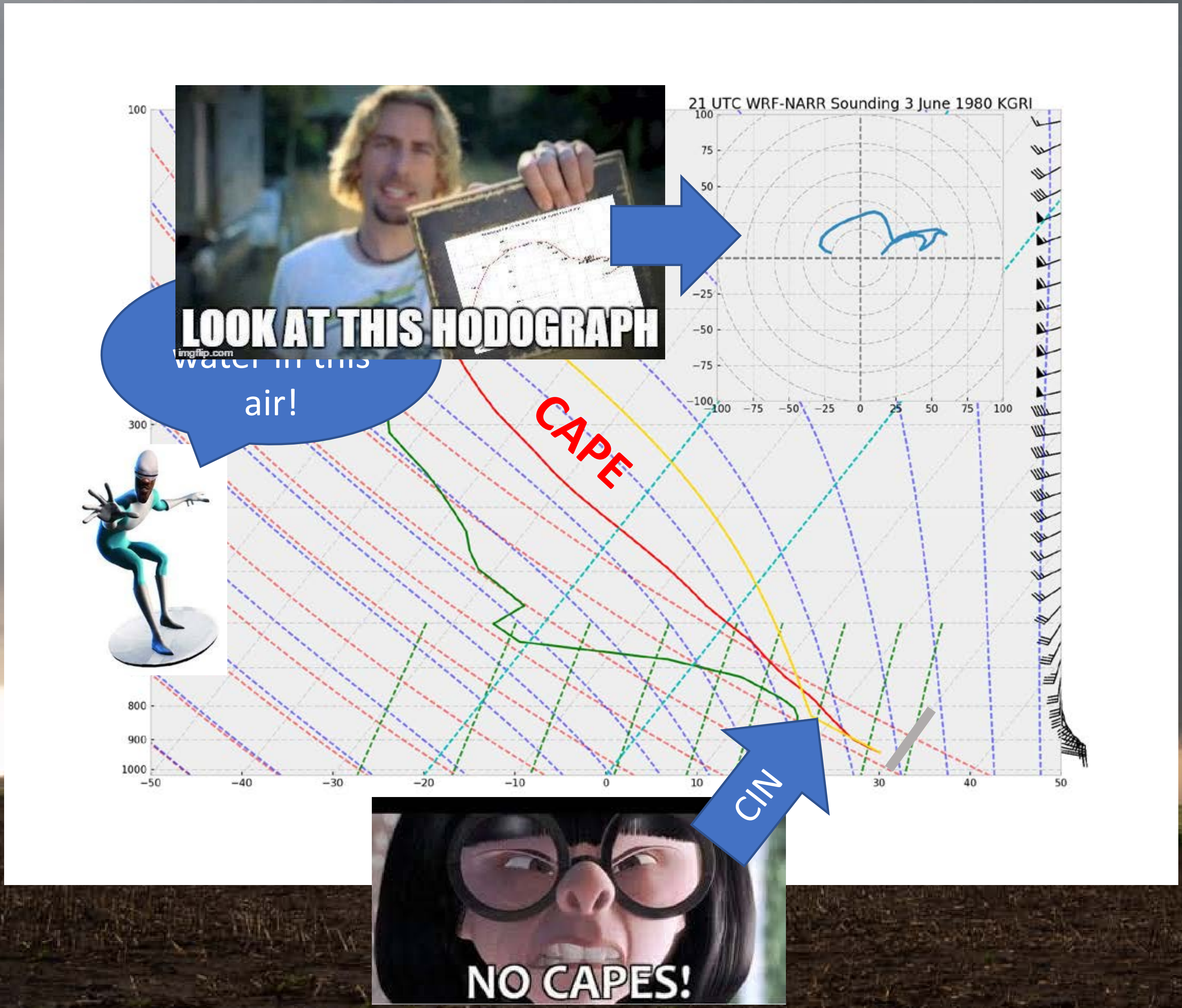
Intro to Skew-Ts and Sounding Parameters



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

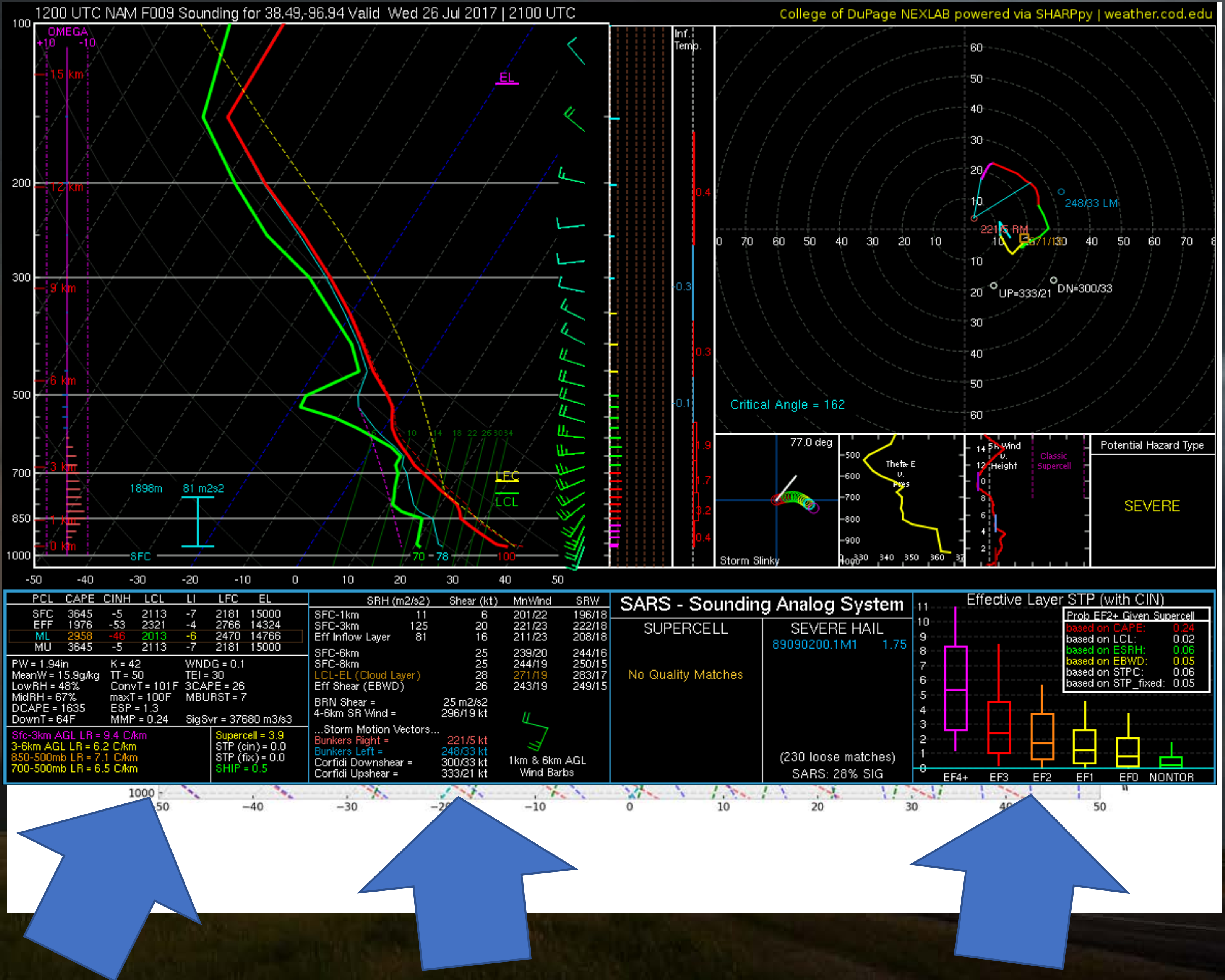
- Solid red line: temperature
- Solid green line: dewpoint
- Yellow line: lifted (surface) parcel temperature
- Area between parcel trace and temp:
  - CAPE (positive) / CIN (negative)

Hodograph

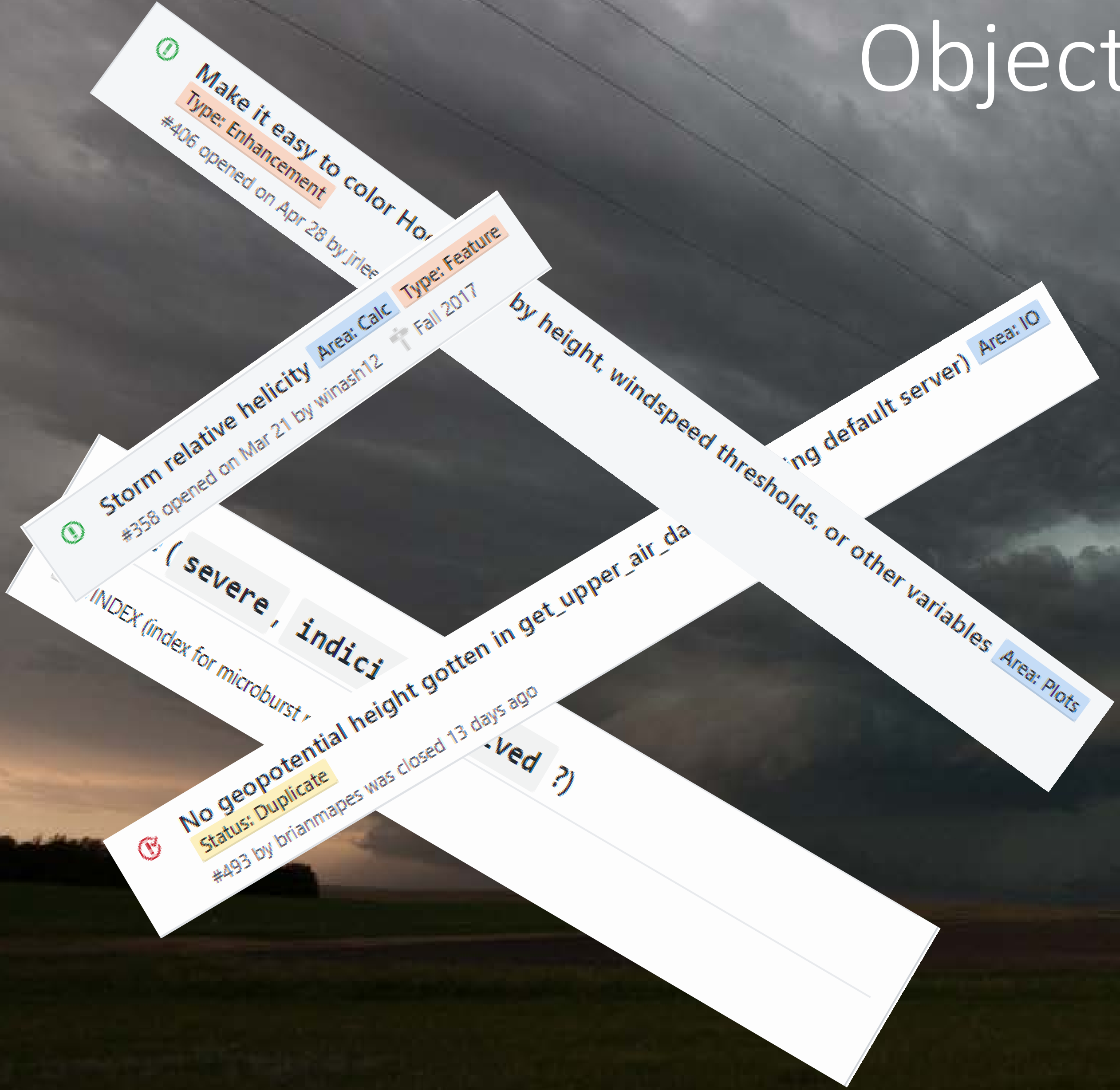
- Polar plot of wind speed and direction
- Area swept out by hodograph and storm motion vector: Storm-Relative Helicity

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
  - <u>Only works on Python 2.7</u>



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

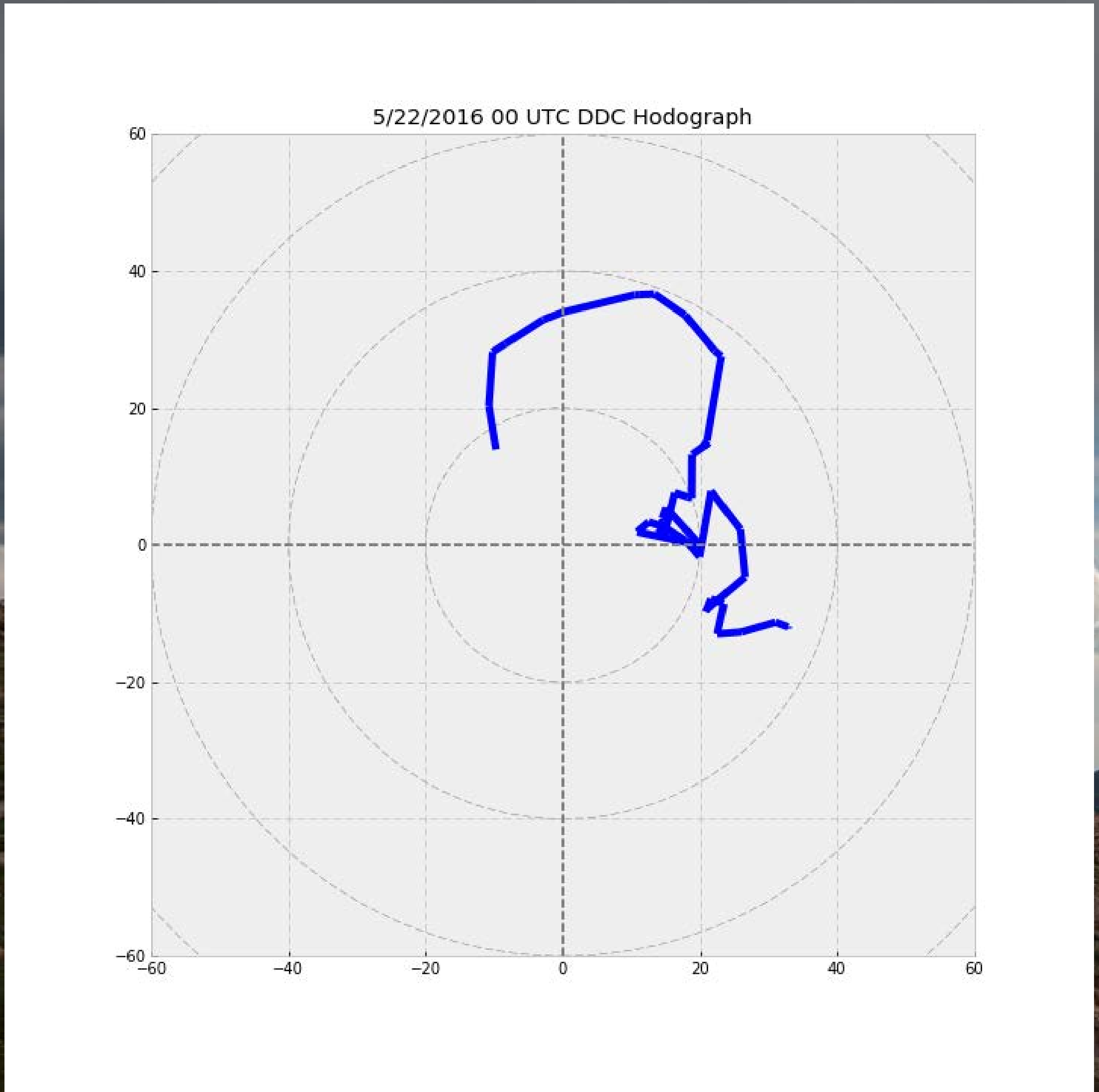
- Make get_upper_air_data bring in geopotential heights
- Fix miscellaneous things in LFC/EL
  - Ran into these errors throughout development
- Design functions to work with John’s get_layer and cape_cin definitions

Hodograph Coloring

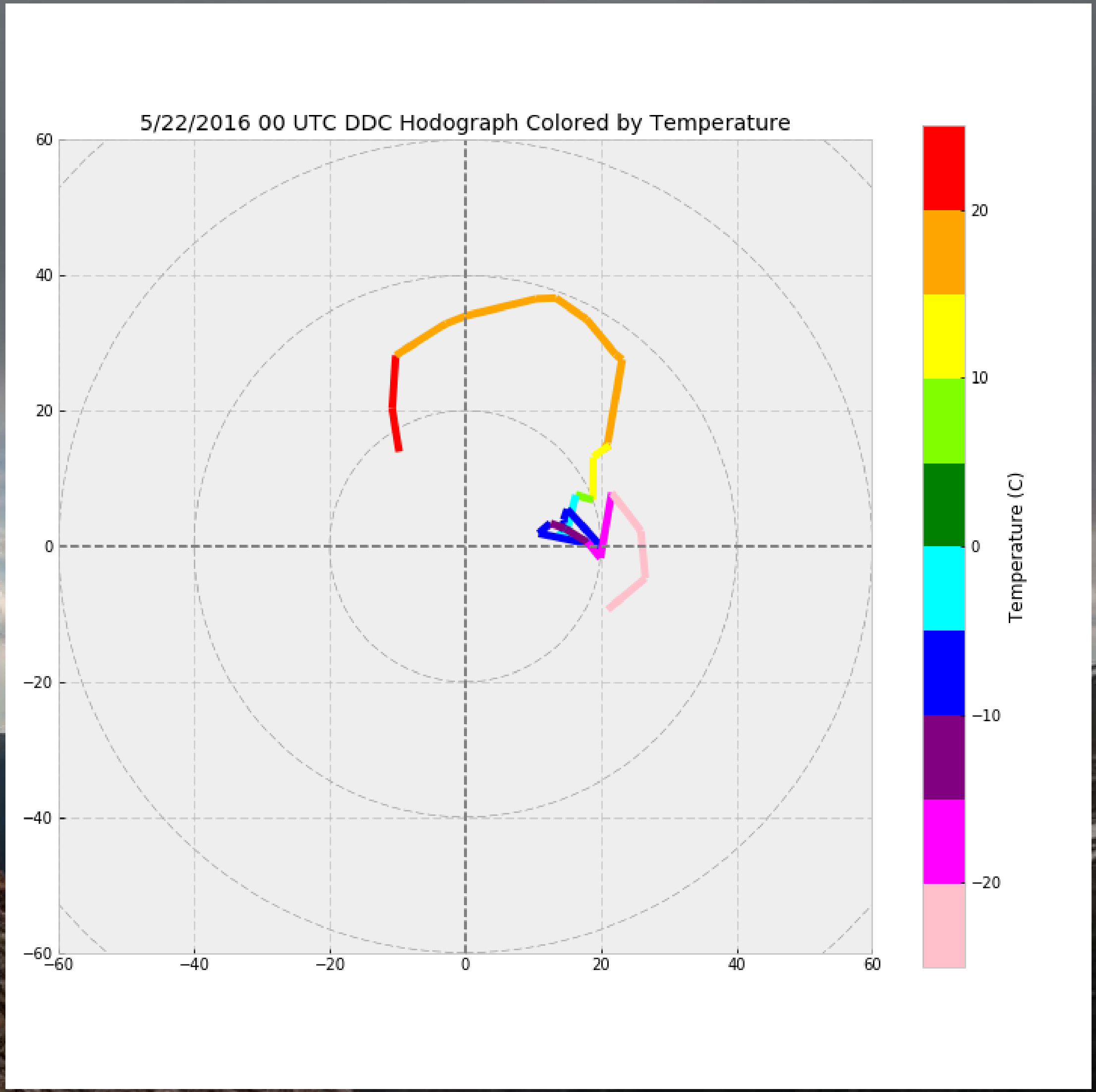
```
u, v, hgt = delete_masked_points(u, v, hgt)
cmap = mpl.colors.ListedColormap(colors)
bounds = np.asarray(bounds + hgt[0]) * bounds.units
interp_vert = interp(bounds, hgt, hgt, u, v)
inds = np.searchsorted(hgt.magnitude, bounds.magnitude)
u = np.insert(u.magnitude, inds, interp_vert[1].magnitude)
v = np.insert(v.magnitude, inds, interp_vert[2].magnitude)
hgt = np.insert(hgt.magnitude, inds, interp_vert[0].magnitude)
norm = mpl.colors.BoundaryNorm(bounds.magnitude, cmap.N)
cmap.set_over('none')
cmap.set_under('none')
kwargs['cmap'] = cmap
kwargs['norm'] = norm
line_args = self._form_line_args(kwargs)
lc = colored_line(u, v, hgt, **line_args)
self.ax.add_collection(lc)
return lc
```

- 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.

Result:



5/22/2016 00 UTC DDC Hodograph
60
40
20
0
−20
−40
−60
−60
−40
−20
0
20
40
60



5/22/2016 00 UTC DDC Hodograph Colored by Temperature
60
40
20
0
−20
−40
−60
−60
−40
−20
0
20
40
60
20
10
0
−10
−20
Temperature (C)

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

$$\frac{\int_0^d u * p \, dp}{\int_0^d p \, dp}$$

$$\sum^{N-1} [(u_{n+1} - c_x)(v_n - c_y) - (u_n - c_x)(v_{n+1} - c_y)]$$

```
pw = -1. * (np.trapz(w.magnitude, pres_layer.magnitude) * (w.units * pres_layer.units) /
        (g * rho_l))
```

```
u_mean = (np.trapz(layer_u * layer_p, x=layer_p) /
          np.trapz(layer_p, x=layer_p) * units('m/s'))
```

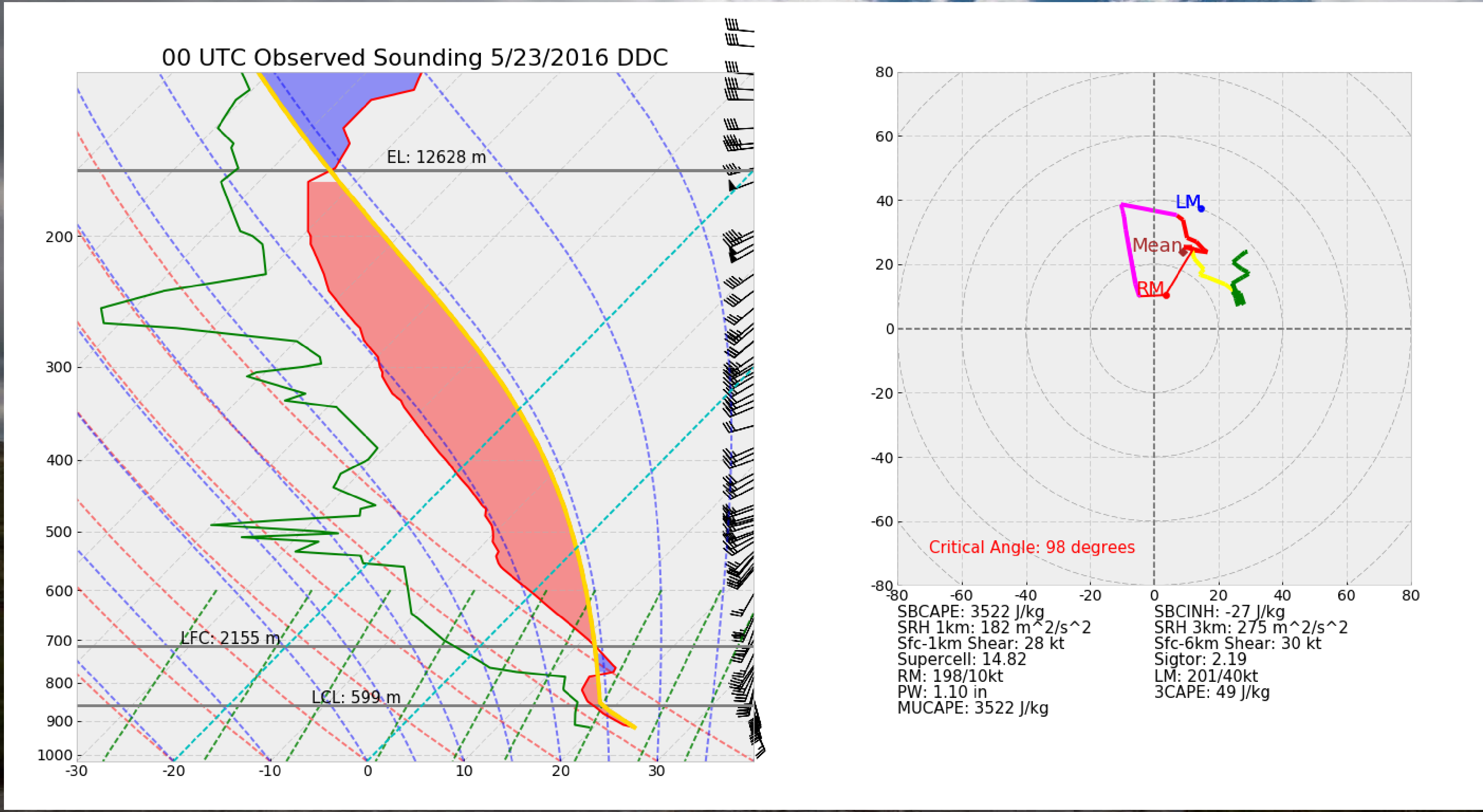
```
int_layers = sru[1:] * srv[:-1] - sru[:-1] * srv[1:]

p_srh = int_layers[int_layers.magnitude > 0.].sum()
n_srh = int_layers[int_layers.magnitude < 0.].sum()
```

Other Parameters

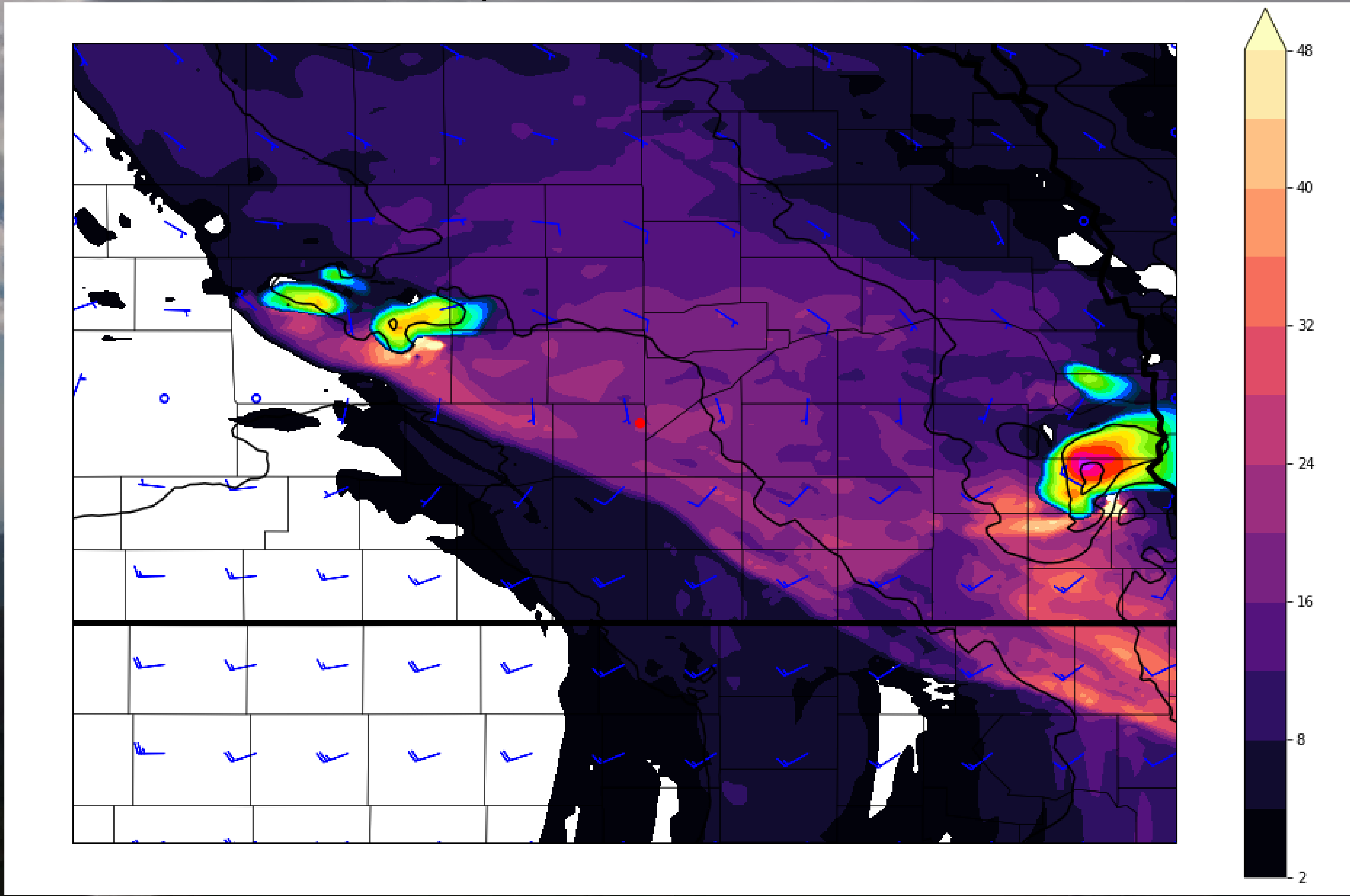
- Bunkers storm motion
- Bulk shear
- Supercell Composite
- Significant Tornado Parameter
- Critical Angle
- CAPE/CIN (John)
  - Variants: most unstable, sfc-3km
- Effective Layer (in development…)
- Haines Index (also in development…)

(Un)finished Product



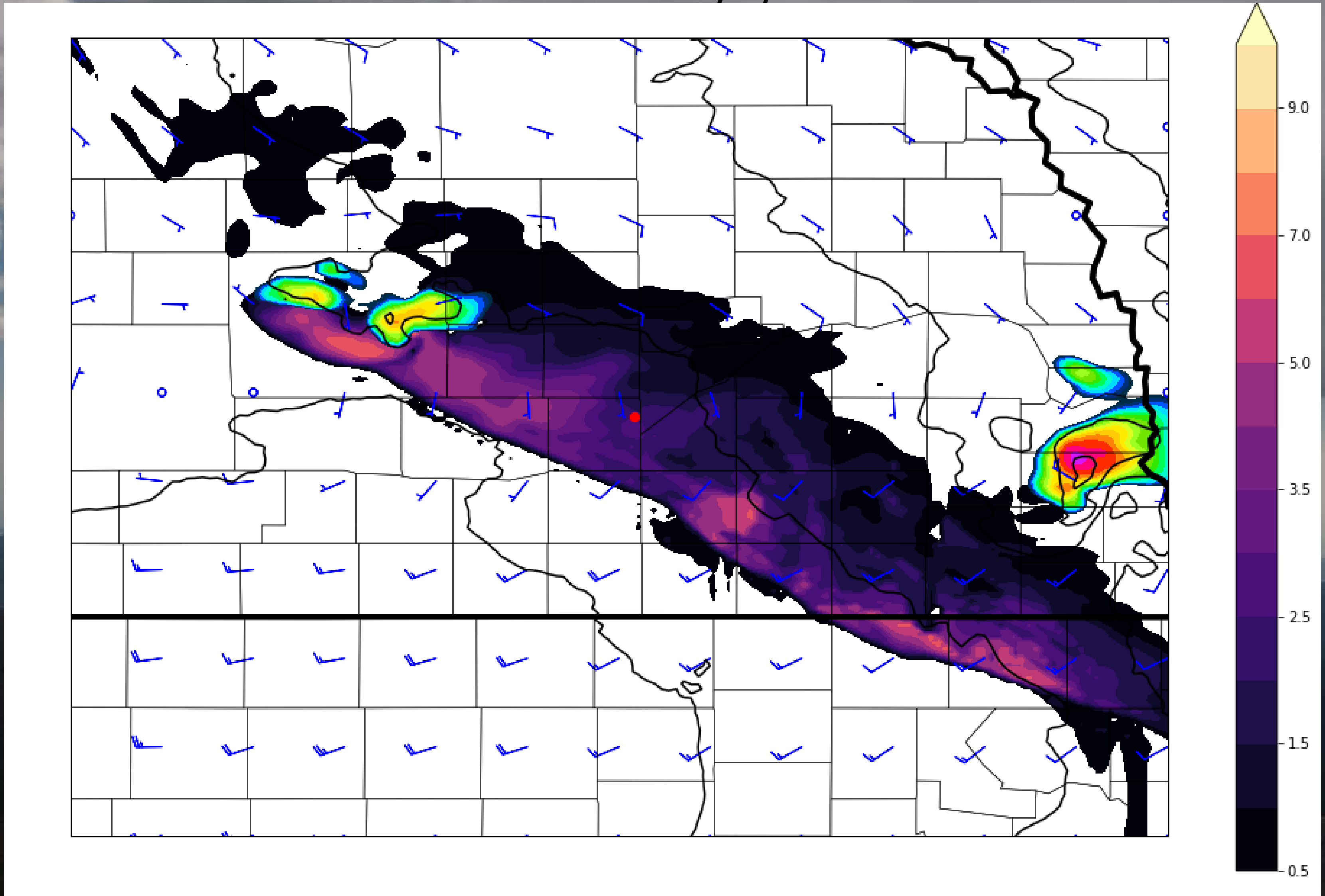
Gridded Data

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

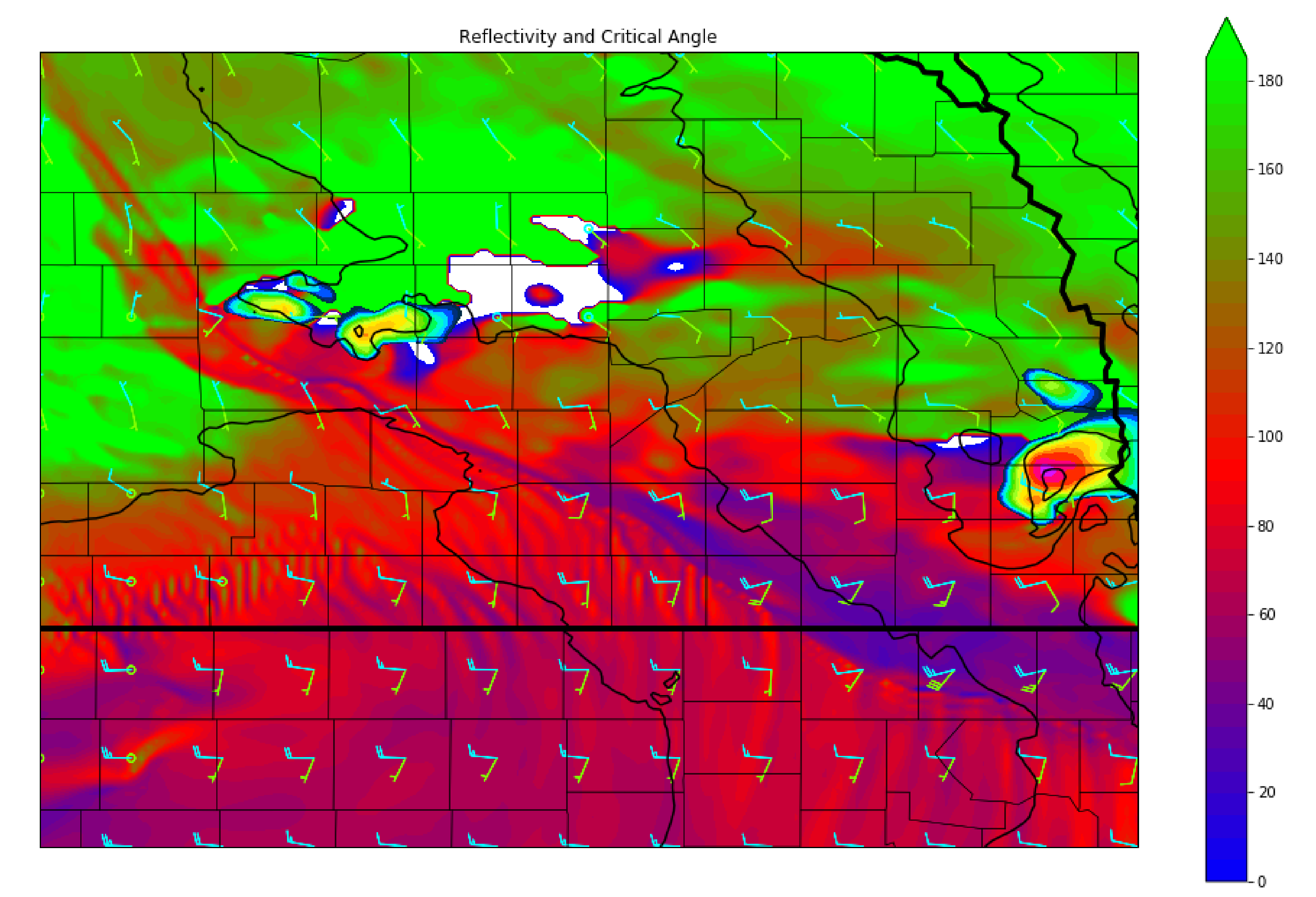


Gridded Data

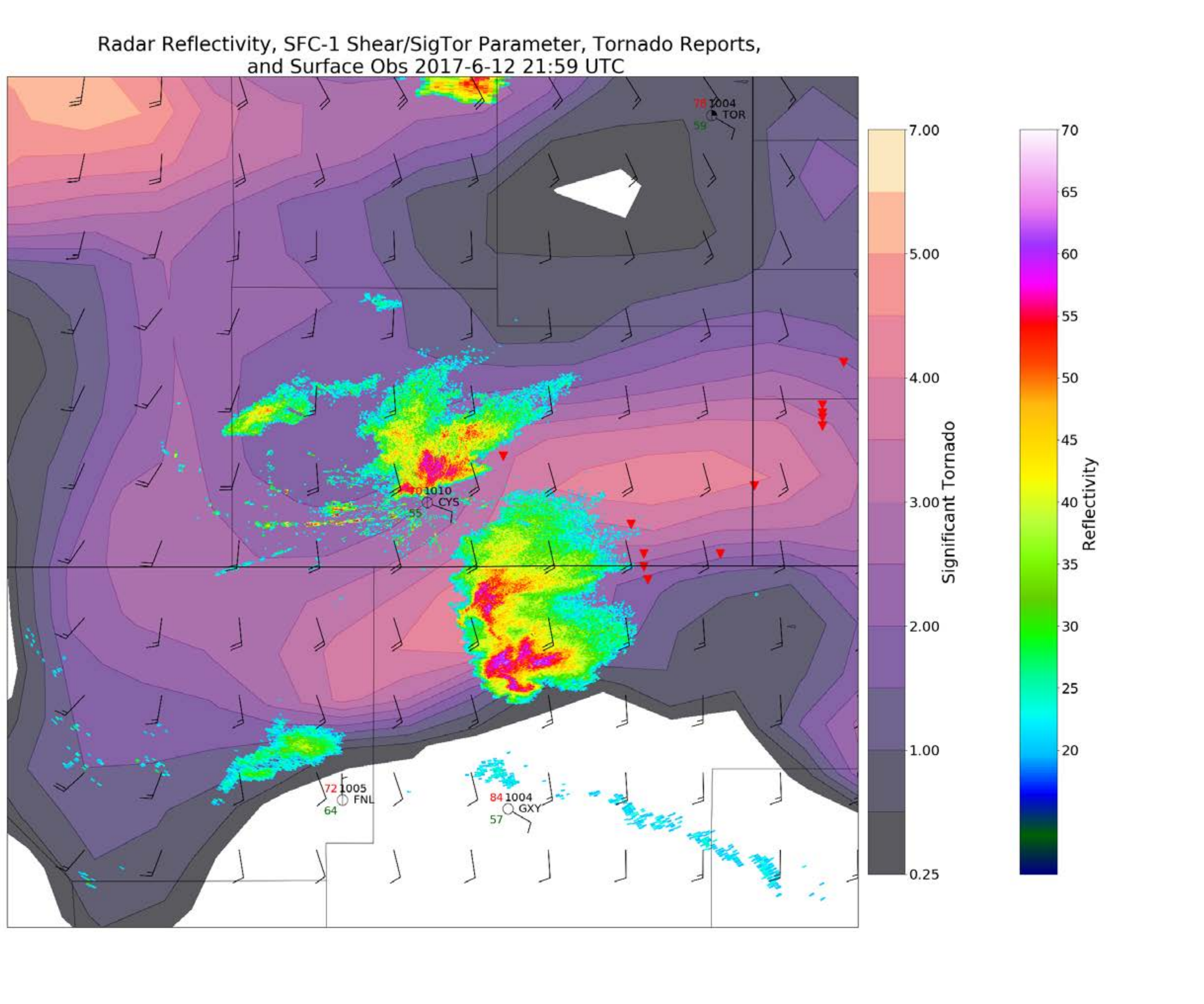
WRF-NARR Reflectivity, Bunkers Storm Motion, and Significant Tornado Parameter 6/3/1980 23 UTC



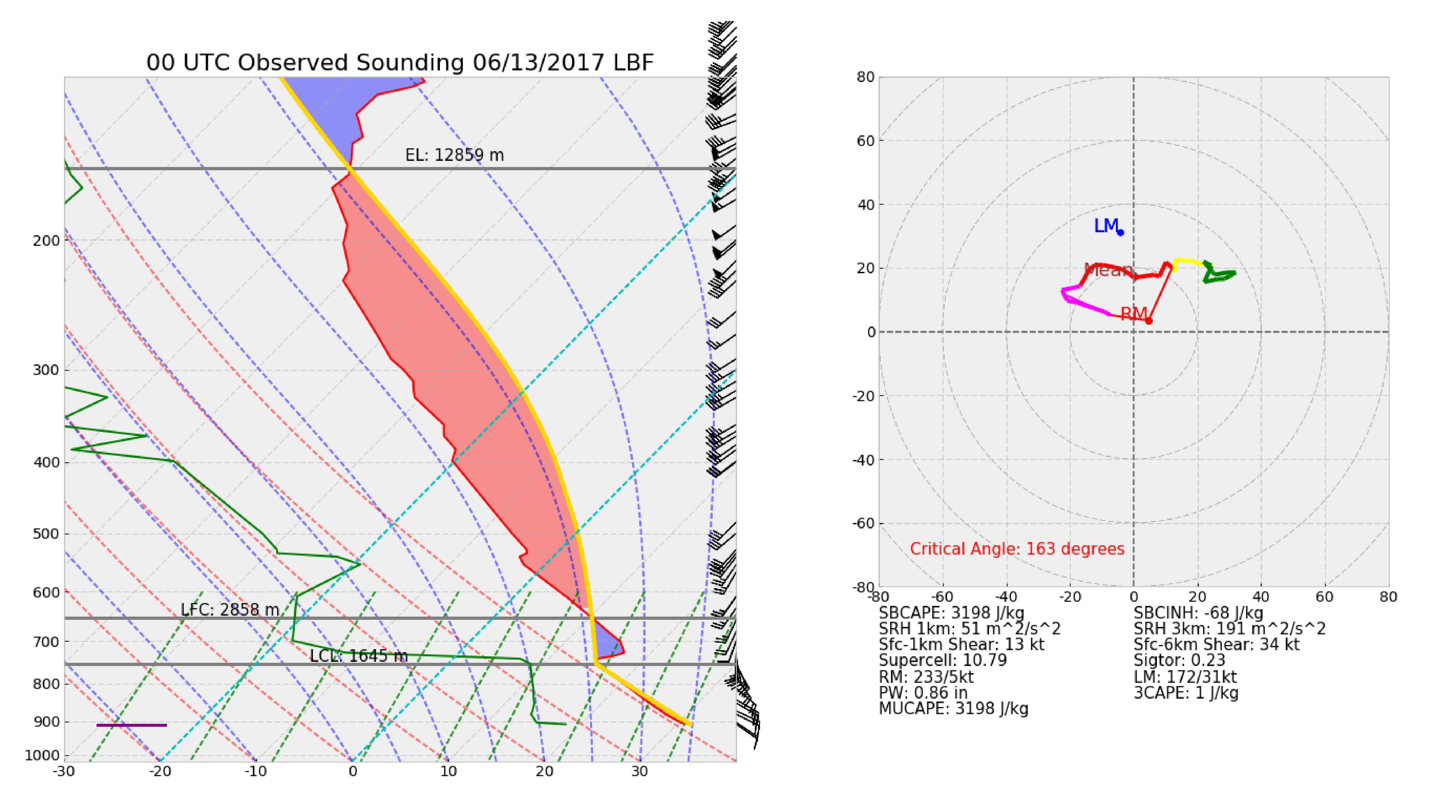
Gridded Data



Gridded Data



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

References

Bunkers, M. J., B. A. Klimowski, J. W. Zeitler, R. L. Thompson, and M. L. Weisman, 2000: Predicting supercell motion using a new hodograph technique. Wea. Forecasting, 15, 61–79.

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