Cloud Report 1

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The image is of a small cloud mid-day with flatter, wispy clouds behind it. The focus of the image is this singular cloud, the defined edges of it bring interest of the shape the cloud is forming. The specific conditions in the atmosphere left this single cloud in this shape. Everything exists only because of the conditions that allow it to, and the intent of this photo is to reveal this idea of interdependence and then to analyze what those conditions were that formed this particular cloud on this day in Boulder, Colorado.

To further understand the atmosphere on this day, the skew-t diagram of a weather balloon going up in the atmosphere can be utilized.

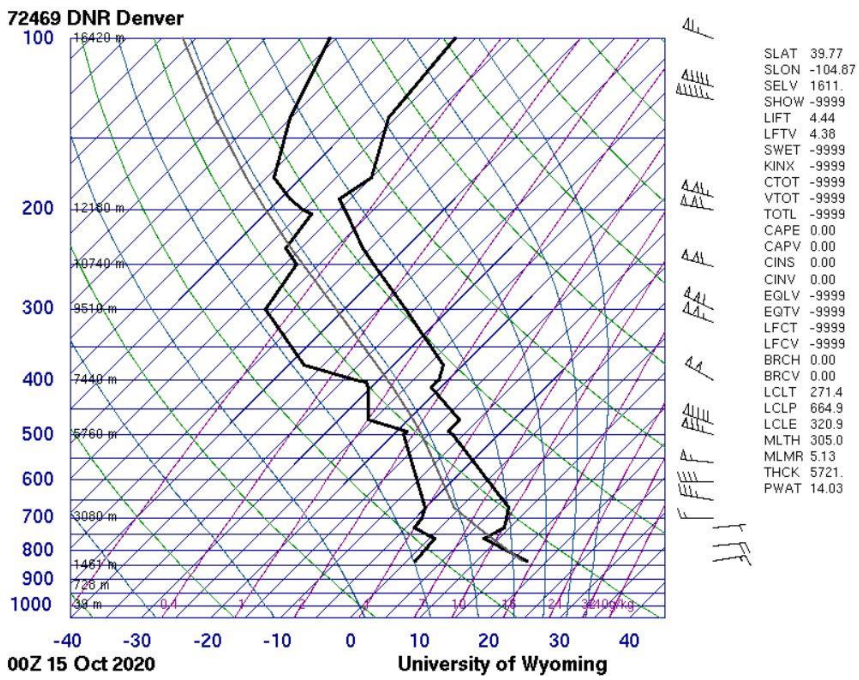

Figure 1, Skew-t at DIA 3 hours after the photo was taken

As seen in Figure 1, the CAPE on this day was zero, pointing to a conclusion that there was stability in the atmosphere on this day. Where the dewpoint temperature and true temperature pinch closer to on another, there is an indication of condensation and cloud formation. Here, there is a pinch at about 5760 m and at 12160 m. This gives an idea of the two clouds we can see in the photo's height. By the heights given and observation of the cloud's structure and placement regarding the foothills, the forefront, low cloud is a mountain wave cloud, or standing cumulus lenticularis and the wispy higher clouds are cirrostratus.

To further investigate weather systems and the flow in the atmosphere that made these clouds, a surface weather map can be analyzed.

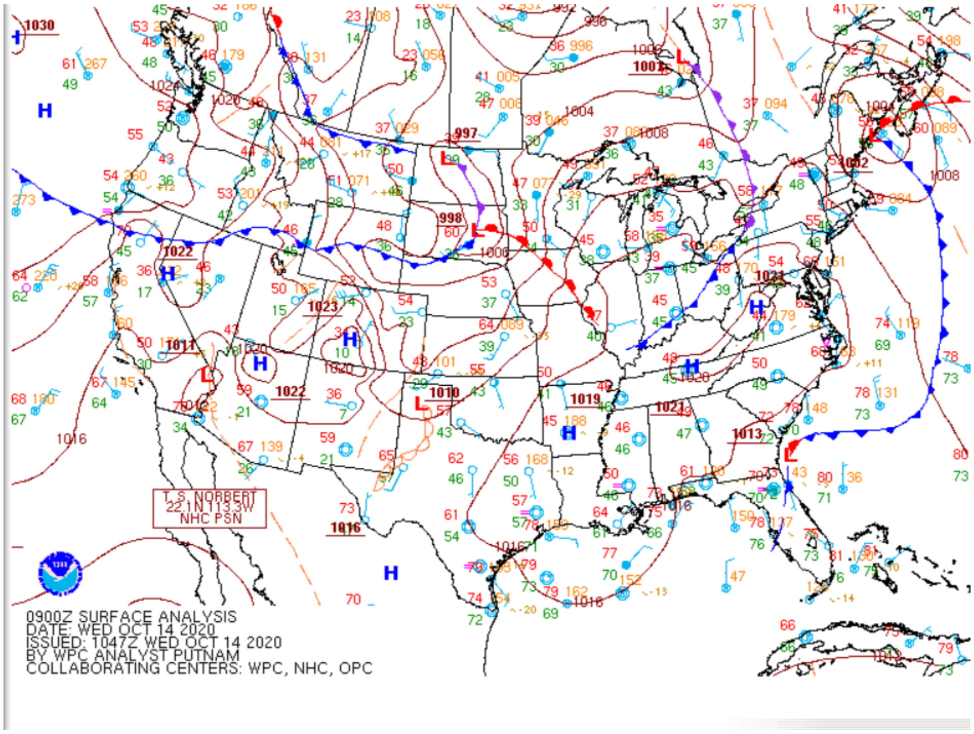

Figure 2, Surface map thirty minutes before the photo

The pressure gradient force across the surface can be found by applying the Navier-Stokes equation. With the Navier Stokes simplified to exclude viscous forces, for this circumstance, the pressure gradient force equation is:

$$\frac{\overrightarrow{F_{PG}}}{\mathrm{m}} = \frac{-1}{\rho}\left(\frac{\partial \mathrm{P}}{\partial \mathrm{x}}\hat{\imath} + \frac{\partial \mathrm{P}}{\partial \mathrm{y}}\hat{\jmath} + \frac{\partial \mathrm{P}}{\partial \mathrm{z}}\hat{\mathrm{k}}\right) \qquad (1)$$

Due to limitations of analyzing the pressure in the x and y pane on this surface map, I will assume that there is no vertical wind. This is somewhat flawed, as rising air is what causes the formation of clouds, but in mid-latitude weather systems vertical motion is minimal. The pressure gradient in the x and y plane of the surface provides insight on weather systems moving in. The partial derivatives in the equation will be analyzed simply by the change in pressure given the isobars and how far those isobars are from one another. The vertical border of Colorado is assumed to be 444 km for scaling purposes.

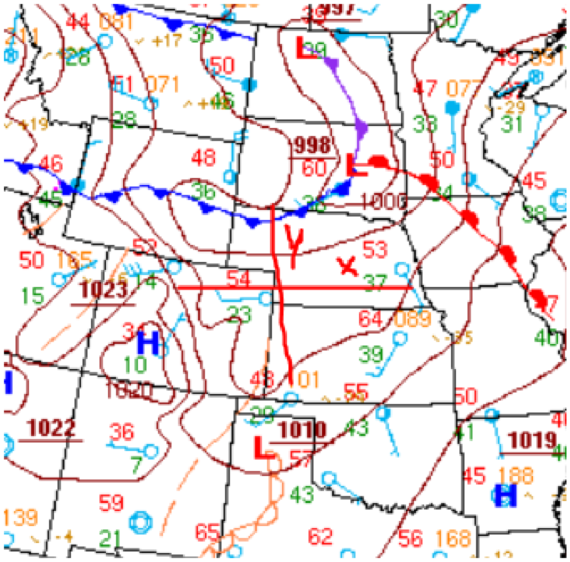

Figure 3, the x and y distances between isobars

The ΔX given the scale is about 800 km and ΔY is about 600km. The change in pressure along the x axis is -8 hPa and the change in pressure along the y axis is -10 hPa. To find the density in Denver for this equation, the R of dry air of 287 J/kg*K was used. The pressure of 1004 hPa and temperature of 54^{o}F or 285.37K was used.

$$\rho = \frac{\mathrm{P}}{\mathrm{R_d T}} = \frac{1004*10^2\mathrm{Pa}}{287\frac{\mathrm{J}}{\mathrm{kg*K}}*285.37\mathrm{K}} = \quad 1.23\,\frac{\mathrm{kg}}{\mathrm{m}^3} \tag{2}$$

Given all these components, the pressure gradient force per unit mass comes out to $0.00081\hat{\imath}\,\frac{\mathrm{N}}{\mathrm{s}^2} + 0.00135\hat{\jmath}\,\frac{\mathrm{N}}{\mathrm{s}^2}$. This is moderately high pressure gradient force, which is line with the higher wind speeds both at the surface and especially in the atmosphere. This gives the direction of general wind flow. On the surface map, the low-pressure center is Northeast of Colorado. Based off the $\frac{\overrightarrow{F_{PG}}}{\mathrm{m}}$, the motion around this low-pressure point is counterclockwise. A warm front has just passed through Colorado, and the warm front is following it, but has yet to reach Colorado at the time of the photo. Counterclockwise flow is indicative of convergence and veering in the atmosphere for the Northern Hemisphere. Convergence is what leads to storms, so the conditions here are some that if they continued it would lead to a storm.

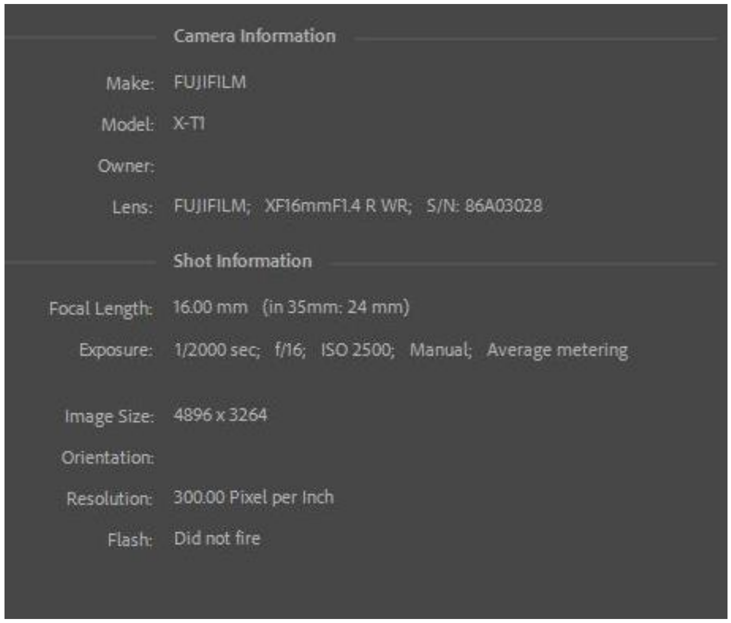

Figure 4, Specs of camera settings for photo

The camera was estimated to be around 5000m from the photo. The focal length of the lens used is 16mm. So, the subject was very far from the focal length. The Fujifilm X-T1 that this photo was taken with allows for a maximum resolution of 4896 x 3264 pixels. The shutter speed was 1/2000 sec, ISO was set to 2500 and the F-stop was set to f/16. These all let to balance of light, depth of field, and ability to focus on the cloud. In Photoshop, the image was edited through making the transfer curve steeper in the bottom left, adding contrast. To make the background a bluer, the blue cure was steepened in the lower left, bringing more blue into the shadows and darker colors.

The image reveals the interdependence of what is in the atmosphere, for all that must be present to make this one small cloud. The image fulfilled my intent and displayed the physics I wanted to go into. In the future, the image could further investigate clouds by accompanying images of the sky throughout the day. More context of what came before and after would add to the intent of interdependence.

Works Cited

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