Cirrus and Cumulus Clouds

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Flow Visualization: The Physics and Art of Fluid Flow

Clouds First

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Fig 1. Wispy Cirrus and Fluffy Cumulus Clouds 09-05-2026

1. **Context and Purpose:**

The picture of *Wispy Cirrus and Fluffy Cumulus Clouds* [Fig. 1] was taken for the MCEN 5151 Flow Visualization Clouds First assignment. Flow Visualization is the process of making flow physics visible through a variety of techniques. In the atmosphere, clouds can be treated as particle tracers or markers, and we can learn a lot about weather and atmospheric conditions by observing clouds. Clouds both reveal atmospheric flows like winds, jet streams, and circulation patterns and are also shaped by the particular conditions of the flow they reveal. The image of the clouds depicted in Fig 1. was captured with the intent of using the cloud formations as a tool to understand the flow in the upper atmosphere. Another goal was to show how atmospheric dynamics generate coherent structures in the skies that manifest as beautiful and diversely textured clouds that are visible in our routine lives.

2. **Describe circumstances of the image:**

The process of taking a 'good' cloud photo involved trading a significant amount of doom scrolling between walks home from campus and mundane errands for looking upward. This photo was taken in East Boulder, Colorado at 10:35 am on September 5, 2026 facing west towards the Rocky Mountains. East Boulder is approximately 5 miles east of the Rocky Mountain Foothills, specifically the Flatirons. The photo was taken with an iPhone 7 angled at approximately 135 degrees from the earth surface.

3. **Cloud Layers and Weather**

The image depicts two different cloud layers and cloud types. Cirrus clouds dominate the higher cloud layer. The cirrus clouds are identified by their wispy and feathery outline and the delicate undulating curls. A small cluster of cumulus clouds can also be seen in the foreground's lower cloud layer[2]. The presence of these two different cloud types and distinct layers reveals some key details about the atmospheric flows occurring, which can be further understood by analyzing the Skew-T diagram from Grand Junction.

Although the bright blue sky alludes to a calm sunny day, the two cloud layers are signaling vastly different stability states. Looking at the Skew-T Plot (Fig 2.), we can estimate the lower cloud height to be at a pressure level of around 600hPa and the second cloud height to be around 320hPa. On the Skew-T plot these are the locations where the dew point temperature and the environmental temperature converge above the LCL. Using the Hypsometric Equation we can estimate the cloud height from the sounding's pressure and temperature readings [1].

$$z_{cloud} = z_{ground} + \frac{R_d}{g} T ln\left(\frac{P_1}{P_2}\right)$$

$$z_1 = 1655(m) + 29.27(m/K)\,(286K) ln\left(\frac{860hPa}{600hPa}\right) = 4,669\,m$$

$$z_2 = 1655(m) + 29.27(m/K)(256K) ln\left(\frac{860hPa}{320hPa}\right) = 9,063\,m$$

These numbers are well aligned with the height levels observed on the right hand vertical axis of the Skew-T. However, the second cloud height calculation, where the Cirrus clouds and jet

streams are forming, contains greater error because the assumption of hydrostatic balance on which the hypsometric equation is founded is disrupted by strong vertical motions [1].

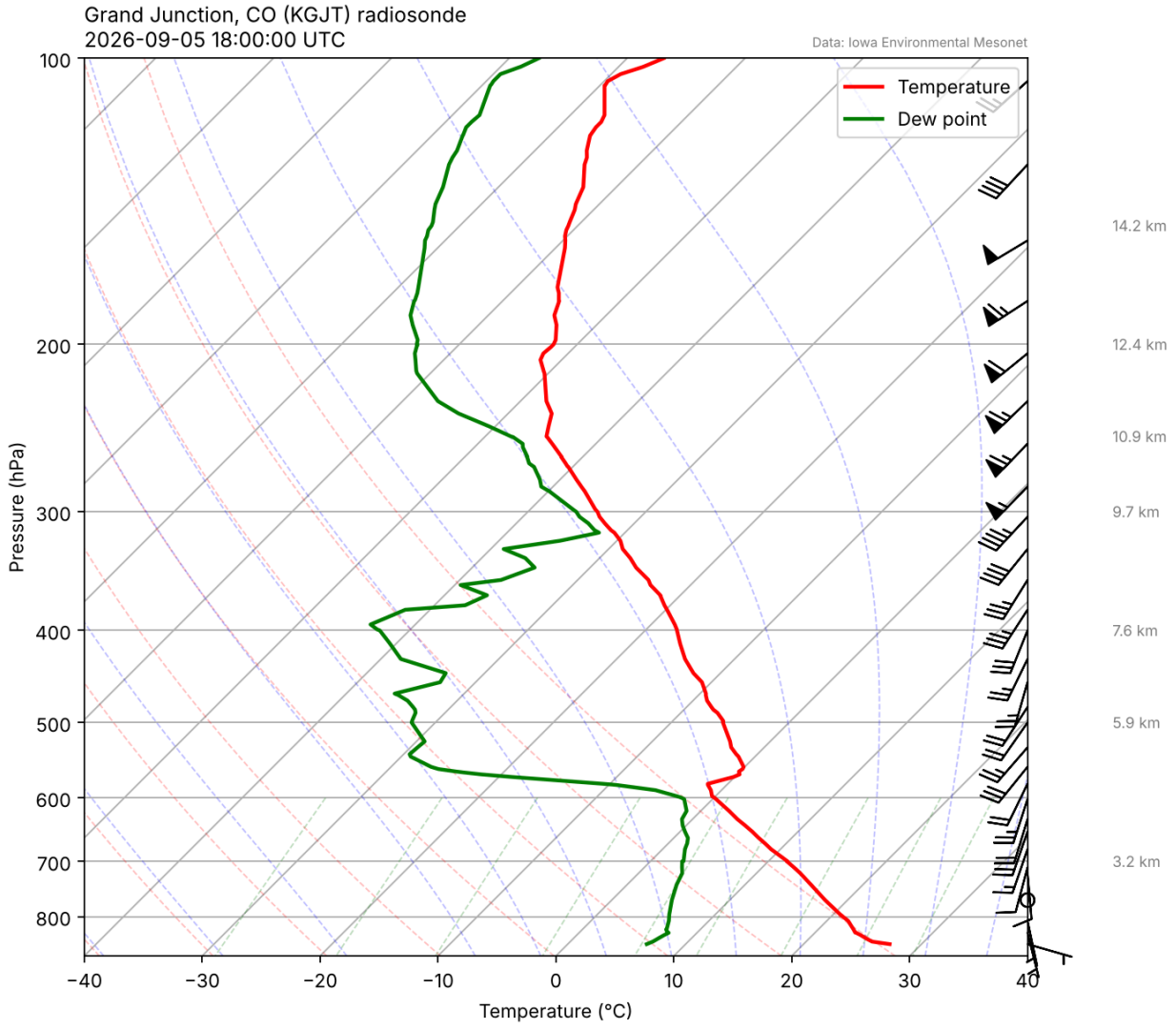


Fig 2. Skew-T from Grand Junction radiosonde (data from Iowa Mesonet) generated with MetPy [6][5]

Using the calculated cloud height and the change in temperature, we can determine local atmospheric stability for each cloud height based on the slope of the temperature reading, and the calculated environmental lapse rates. From the surface to the first cloud height at around 600hPa, the temperature changes approximately 9.2K/km, which sits between the dry adiabatic lapse rate, 9.8K/km and the moist adiabatic lapse rate, 5K/km. This means within this layer, the atmosphere is conditionally unstable. The sharp temperature inversion between 600 and 590hPa is the atmospheric boundary layer's capping inversion. This instability makes sense from an atmospheric dynamics perspective because at 10:35 am, the boundary layer is well-mixed and non-stationary as it is still developing while the sun rises and heats the surface [3].

Generally and especially above the capping inversion, in the deep convection zone, the atmosphere is strongly stable. The first cloud height, LCL, and LFC points are all densely packed on top of each other and the temperature above the capping inversion almost exactly parallels the moist adiabat until the next inversion. This implies that there is virtually no convective available potential energy (CAPE) and relatively little convective inhibition (CIN). When CIN is greater than CAPE, the atmosphere is stable and it is unlikely that storms will develop as the atmosphere's cap is too strong for air parcels to break into free convection. This also explains how two distinct cloud layers are formed in the image. In the lower unstable layer, cumulus humilis clouds sit just below the capping inversion in the mixed layer, where their vertical motion is suppressed. The stable cloud layer where the cirrus clouds sit however is between the boundary layer the tropopause, where particles are now fully saturated and ice crystals can form. When these ice crystals form they become heavier than the particles around them, drop, and are pushed out by shear currents and jet streams. This causes the virga effect, or the precipitation tail that forms the wispy tails of cirrus clouds [7].

The wind barbs on the Skew-T plot further support this cloud classification. Within the shallow developing boundary layer, the winds are fairly calm and consistent. Cumulus clouds typically form in low vertical shear profiles[4]. Cirrus clouds however require high shear and veer to stretch out into their delicate wispy features. As depicted in the right hand axis, the wind shear increases significantly with height around 9.7km. Low to moderate surface winds were recorded on September 5th from the KBJC airport weather station[8]. Overall the weather for the week of September 5 was characterized by calm winds, high temperatures above 88F, and very little scattered rainfall in the days following. Cirrus clouds can warn of incoming change in weather up to 48 hours in advance if there is an approaching warm front and the clouds develop into stratus clouds [2]. Wispy cirrus clouds aloft like these however hint that there is little likelihood of rain. With a strong cap in the atmosphere, a strong stability state, and little convection mixing the low level cumulus clouds with the winds aloft, these clouds are indicative of very dry conditions.

4. Photographic Technique:

The image was captured on an iPhone SE camera with automatic settings. At 10:30 am the sun is still climbing towards its peak and the cloud scene is front lit.

Table 1 - Camera and Image Details:

Setting	**Details**
Camera	Apple iPhone SE (3rd generation)
Lense	Main Camera - 26 mm f/1.8 12MP
Focal Length	28mm
Aperture	f/1.8

Shutter Speed	1/2525 s
ISO	32
Exposure Program	Auto, 0 EV
Original Image Dimensions	3024 x 4032 px
Final Image Dimensions	1200 x 1600 px



Fig 3. Original Image

Finally, the image was cropped from the original 3024 x 4032 px, as depicted in Fig 2, to 1200 x 1600 px to center the virga streak as the primary subject of the image.

5. Conclusions:

The image shows how atmospheric dynamics and weather conditions yield different cloud features. Notably, the image captures two distinct pressure levels in the atmosphere at which different clouds and different local stability states can be observed. Many fine details in the cloud textures were compromised due to lower camera quality. Future Cloud pictures should use digital cameras with which aperture and ISO settings can be adjusted. Additionally in the next cloud picture, I want to test more photo editing and post processing to further enhance the cloud details. The more interesting flow phenomena are revealed in the smaller details of the clouds like curls and hooks that show circulation. The image in Fig 1. shows some of these details and fluid phenomena. Most evident is the virga streak in the cirrus clouds, which is the primary subject of the picture. In the background there is also some evidence of buoyancy in the smaller curls and streaks of the cirrus clouds. These features show how shear, advection, and thermal convection more air parcels throughout the atmosphere and form clouds.

6. References and Citations

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