Flow Visualization: Cloud Second

MCEN 5151: Flow Visualization

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I Introduction and Background

Flow visualization plays a pivotal role in the field of fluid dynamics, as it provides invaluable insights into the behavior of fluid movement. Additionally, many of these experiments can be conducted using easily accessible and cost-effective materials. This allows for captivating visual representations of the underlying physics without the need for modern laboratory equipment. However, experimental methods aren't the sole way of capturing these visuals as they naturally occur around us like clouds. According to Rangno, "a cloud is suspended particles of water or ice, or both, that are in sufficient concentrations to be visible"[1]. Clouds also come in many forms, each with unique properties and characteristics. Additionally, there is a bundle of resources that can be used to characterize clouds such as Skew-T charts which can provide information on altitude, pressure, temperature, and dew points. For this assignment, I successfully captured a cumulus and stratocumulus cloud in Washington D.C., and identified it through the use of a Skew-T chart as well as visual elements from the cloud itself.

II Geographical Notes

This photo was taken near the Washington Monument as I was walking down a path to get to the Lincoln Memorial. It was around 4:00 pm on November 9th, 2023, the weather was quite cool and I was facing South-West. The highest elevation in D.C. is about 125 meters above sea level and I took this picture at about a 60-degree angle from the horizontal.

Information	**Description**
Location	Near the Washington Monument in D.C.
Elevation	125 meters above sea level
Date and Time	November 9th, 2023 at 4:00 p.m.
Cardinal Direction	Facing South-West
Angle Above Horizontal	~60 degrees

Table 1: Useful Table of Information for My Image

III Cloud Physics

The clouds can be identified as cumulus and stratocumulus due to a few defining visual characteristics. To begin, according to the NOAA, cumulus clouds are "detached, generally dense clouds and with sharp outlines that develop vertically in the form of rising mounds, domes, or towers with bulging upper parts often resembling a cauliflower"[3]. Though my image does not necessarily depict them as cauliflower, but rather more like dirigibles, it still contains other defining features. These include being detached as the center of my image contains three of these clouds on their own. The NOAA also states that the "sunlit parts of these clouds are mostly brilliant white while their bases are relatively dark and horizontal"[3]. This is very apparent in my image as the underside of the cloud seems fairly flat and dark yet as you follow it vertically, it turns into a vibrant fluffy shape. These clouds also typically develop during a clear day due to diurnal convection, which is just the vertical movement of air due to temperature changes over the course of a day (Hot to Cold). They are also most prominent in the morning but dissolve away towards the evening which could explain why they are stretched out like airships as I took this image around 4:00 pm. Figure (1) below showcases a cropped version of the original photo to highlight the aforementioned cumulus clouds in more detail.

Figure 1: Cumulus Clouds of Orginal Photo

As for Stratocumulus clouds, they're quite similar to cumulus in terms of formation, however, they are quite visually different. According to the NOAA, stratocumulus clouds are "Gray or whitish patchy, sheet, or layered clouds that almost always have dark tessellations and rounded masses"[3]. Additionally, stratocumulus clouds tend to be non-fibrous and can appear both merged and non-merged. Comparing this description to Figure (2), the leftmost portion exhibits many of these characteristics.

Figure 2: Cumulus Clouds of Orginal Photo

By analyzing the Skew-T chart in Figure(3), it also supports the cloud types mentioned before. For some background, clouds will generally form when the temperature and dewpoint lines come in close contact. The chart provided has quite a few locations where this does happen, however as Cumulus and Stratocumulus clouds are low-level clouds, they will generally form below 2000 meters[2]. By looking at this point on the graph, the lines do get close to converging around this area and even touch at 100 meters. Additionally, both these clouds form within stable atmospheres which is dictated by the CAPE number in the chart. As this value is zero, this means that the atmosphere was stable during the time I took the picture and further supports how this graph can be representative of the clouds during this day.

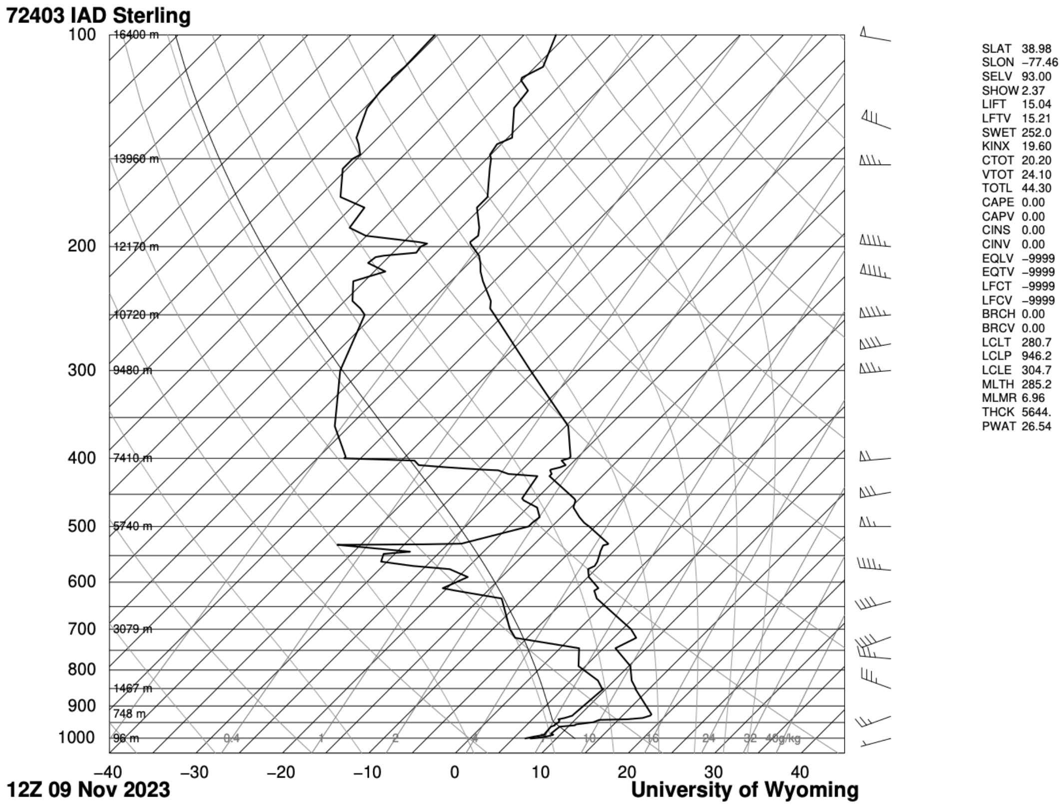

Figure 3: November 9th, 2023 Skew-T Chart (Sterling, VA)

IV Photographic and Visualization Techniques

There was very little photographic techniques used when capturing this photo as it wasn't as necessary in a non-experimental setting. The picture was taken in a landscape orientation to capture the wide range of clouds that I saw fully. Figure (4) showcases my original image alongside the edited version. One important note here is that the original image was taken on a rich contrast setting which could've provided additional lighting, hence why the middle and top right of the image are so vibrant.

(a) Original Photo

(b) Processed Photo

Figure 4: Original vs. Processed Photo

The original photo was captured on an iPhone 13 Pro which had a limited amount of adjustable settings compared to traditional cameras. This photo was taken with a focal length of 5.7 mm, an aperture of f/1.5, a shutter speed of $\frac{1}{567}$ and an ISO of 50. The pixels of the original image were 4032×3024 but sized down to 900x1300 for the edited version. The final image was then edited in Darktable but only cropped as I felt the lighting was already optimal and wanted to place more focus on the clouds rather than trees. This lighting also helped in identification as it highlighted many of their distinctive features such as textures.

V Conclusion

I believe the cloud image I took successfully showcases what a cumulus and stratocumulus cloud is despite having little processing. The image highlights many of the charcterisitcs of cumulus clouds, such as being fluffy, separated and having a contrast of light and dark regions. Similarly, the stratocumulus clouds showcase this as well but are much larger in size, patchy and are generally rounded. There are a few aspects of this photo I'm still unsure about such as questioning whether cropping out the trees entirely would improve the final image or is it necessary to keep them for context? I feel as if they provide a relative distance to the ground and support in identification of the cloud through height, but this may also obscure the fluid mechanics at work. Nonetheless, the experience of taking cloud photos during my trip to D.C. has given me the opportunity to see how they can vastly differ based on location. The opportunity to talk to Dr. Yang Tian during our critiques was also very informative about the cloud physics and helpful in identifying what my images captured. I look forward to using this knowledge beyond this class and in my future endeavours.

VI References

[1] Rangno, A. L. (2003, December 6). Clouds: Classification. Encyclopedia of Atmospheric Sciences. https://www.sciencedirect.com/science/article/pii/B0122270908001123

[2] Stratocumulus Clouds. Met Office. (n.d.-b). https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/clouds/low-level-clouds/stratocumulus

[3] Ten basic clouds | National Oceanic and Atmospheric Administration. (2023). https://www.noaa.gov/jetstream/clouds/ten-basic-clouds