White Waves

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Clouds 2

Image description:

Cloud formations over the Rocky Mountains are some of the most beautiful and revealing in the western United States. Clouds can provide great insight into the fluid flows and dynamics present in the Troposphere. The primary purpose of this assignment is to capture a cloud image that not only reveals characteristics of the fluid dynamics present, but to capture one that is not commonly seen in an artistic and frame quality way. The motivation for this assignment came by way of previous cloud photographs submitted and an effort to capture an aspect of clouds and their behavior in the atmosphere that is not commonly obtained. It was determined that the best atmospheric conditions to fulfill these desires was to capture an image when the atmosphere is relatively stable, yet there is a potential storm front moving in or higher wind gusts that extend throughout the troposphere. These wind gust and weather systems result in more complex atmospheric conditions and therefore more interesting clouds in the winter months.

Method for capturing Phenomenon:

The image seen on the title page was taken in Broomfield Colorado. In addition the image was captured at approximately 7:00 a.m. on Monday, April, 9th. Prior to this date there were very few clouds present in the atmosphere yet after checking various weather reports, it was determined that the best cloud formations would occur early in the morning of the date the image was captured. In addition, during the Colorado winter months, the sky tends to be the most brilliant and bright in the hour following the sunrise and therefore provided the greatest contrast and detail in the cloud formations. This detail is heightened due to that fact that the sun is not directly over the clouds and therefore develops strong shadows on the cloud face, which adds depth and detail to the clouds lower visible section. The image is facing almost directly upwards towards the sky with a slight angle towards the east. This angle is approximated to be 80 degrees from the horizon.

Clouds and phenomenon:

Through anaylsis of not only the image but the skew-T plot as well, it has been determined that the cloud formations primarily present in the image are that of Cirrocumulus undulatus. This was determined by first looking at the image in which you see patches of small cloudlets at a relatively high altitude[2]. The clouds tend to have a grainy texture which is characterisitic of Cirrocumulus. They are undulatus given the wave formations running from left to right of the cover image. The initial height approximated was roughly 13000 meters (42700 feet) above sea level at a relative height of 11800 meters (38700 feet). This height was approximated at this value based off the fact that this cloud formations sparaticially ranged west to lie over the mountains. The clouds that were over the mountians were still extremely high and were estimated to be roughly 1.5 to 2 times higher then the highest visible mountain (Longs peak) at

an altitude of over 4300 meters (14000 ft). This higher atmospheric elevation is solidified when looking at the skew-T plot below (figure 1). From this plot it is evident that the two lines come closest at an absolute altitude of 12500 meters indicating the highest probability of cloud formation. This aligns with the Cirrocumulus cloud formation because they are primarily developed at elevations ranging from 5000-13000 meters[1]. The skew-T has another area in which the lines approach eachother at an absolute altitude of 4000 meters, yet given the observations made at the time the cover image was taken, no lower lying clouds were visible.

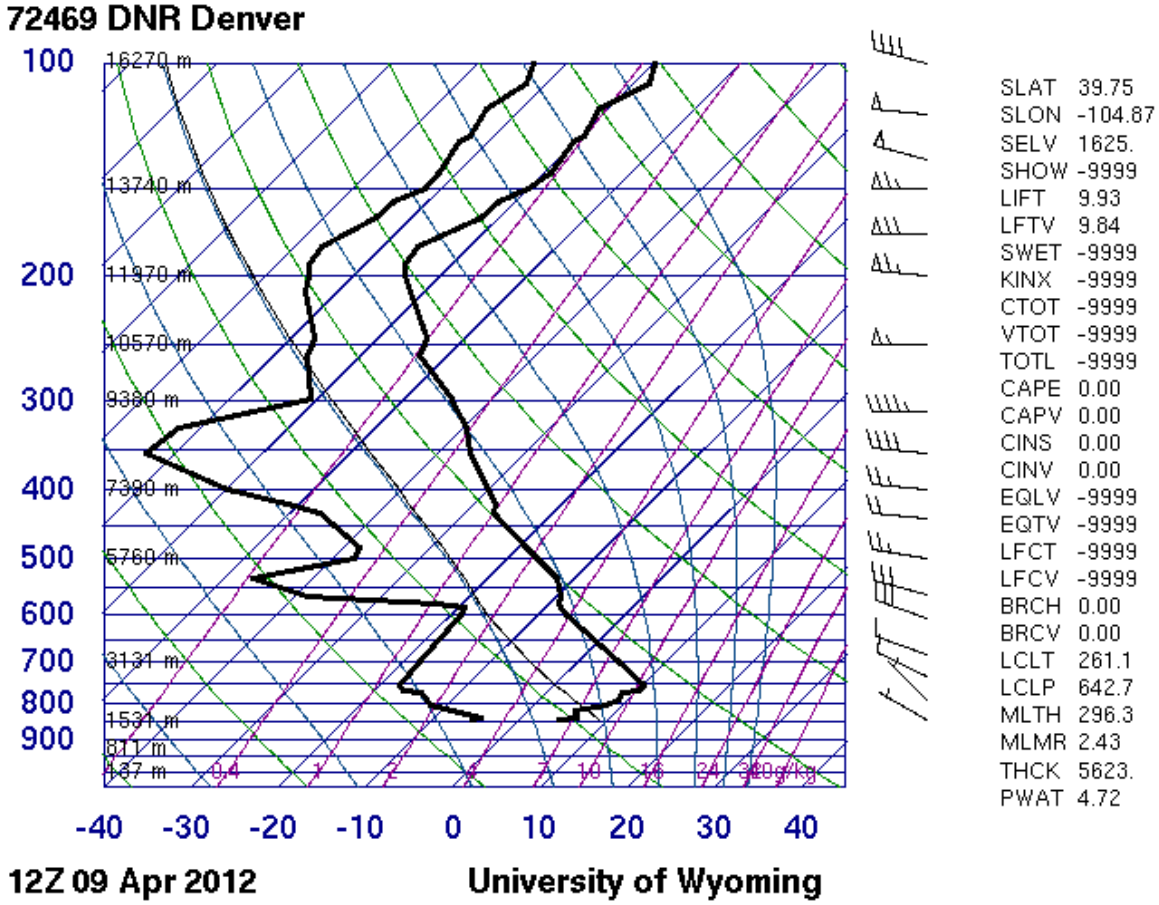

Figure 1: February 14th 6 a.m. Skew-T plot[3]

There was no rain or snow on the day the image was taken, yet it was forcast that there would be slight winds and it was approximated to have a 50 percent chance of rain the following day. This accounts for the wave forms generated in the clouds that were most likely developed by gravitation waves combining with the resonant frequency of the wind present at the time the photograph was taken. In additon, these wave formations can be developed and visually heightened given the fact that individual waves commonly overlap and combine into a larger wave form[4]. Though relatively breezy, the air in the

atmosphere is considered stable which is evident when looking at the CAPE value of the skew-T plot. The CAPE value is zero which indicates complete stability of the air in the atmosphere. Thought the CAPE value was zero, it is estimated that there were pockets of slight instability at the elevation of the clouds given that in the image there are two sets of waves that appear to intersect at the larger wave forms. The multiple wave generation at various angles is commonly a indication that there is minor instability present in that area of the atmosphere, yet overall the atmosphere as a whole is classified as stable. The waves present in the image developed rather rapidly yet travelled a significant distance before the wave form was difused at the clouds merged.

Photographic technique:

The photographic technique used to make this image was limited due to the use of a Kodak Easyshare Z981 which is in essence a point and shoot camera. The camera saves its pictures in a digital format with a pixel quality of 14.1 megapixels. Though the camera has the option to adjust the exposure time and ISO the two cannot be adjusted at the same time. For the case of taking an image of the bright sky it was decided to keep the ISO at the 400 pre-set value and adjust the shutter speed. A faster shutter speed of 1/600 was utilized given the relatively fast speed of the cloud caused by the wind gusts in the atmosphere. Though the field of view size is hard to approximate given the large height of the cloud formation, it can be approximated when you consider that the pixel size of the final image of 3928 by 2021 pixels combined with the estimate relative height of 11800 meters and a photographic angle or 80 degree from the horizon. This information can be used to approximate the size of the cloud because in the image the cloud fills the frame in both height and width. Using this information combined with the geometric tangent relation, it is determined that the width of the cloud is roughly 15300 meters wide by 7870 meters in height. This height is determined when you consider that the ratio of height to width is 51 percent so therefore the height is 51 percent smaller than that of the width. In addition since the cloud was nearly overhead, the distance from the camera to the cloud formation is slightly above its vertical height. Through Pythagorean theorem it was determined that this distance is approximately 14000 meters.

There was very little post processing done to the image due to the fact that the intent was to capture the cloud formation in a natural form without extensive editing. The image was simply cropped and edited to sharpen the image slightly while avoiding potential grainy formation. The original image pixel size is 4288 pixels wide and 3216 pixels in height and after cropping the image size is 3928 pixels wide and 2021 pixels in height. In addition the contrast and sharpness was increased slightly to increase the definition of the waveforms present.

Conclusions:

Overall, the intention of the image was achieved given the fact that the Cirrocumulus undulates cloud formations are relatively rare especially in Colorado. It clearly demonstrates the waveform phenomenon as well as shows multiple waves merging and combining into one larger wave formation. My favorite aspect of this image is the fact that there are two different waveforms present yet, as mentioned above, combine and form a larger wave. One thing I dislike about the image is the fact that the sky is not as radiantly blue as my previous cloud image submission. I think the blue gradient adds good contrast to the overall photograph, yet given the fluid dynamics and flows present in the image, the bright blue nature of the sky was sacrificed to heighten the visualization of the wave phenomenon. One question I have developed after creating this image how exactly these two individual waves form in such varied directions? If I were to attempt to capture this atmospheric phenomenon again, I would like to create a time lapse so the viewers can see the wave forms merge into the large combined wave. Overall I have continued to gain greater understanding of the physics present in the atmosphere and cloud formations and have increased my appreciation for the natural beauty they present.

Bibliography:

[1] "Cirrocumulus." *Windows to the Universe*. National Earth Science Teachers Association. Web. 01 Mar. 2012. <http://www.windows2universe.org/earth/Atmosphere/clouds/altocumulus.html>.

[2]The Cloud Collector's Reference Â» Stephen Burt." *The Cloud Collector's Reference Â» Stephen Burt*. Web. 12 Apr. 2012. <http://cloudappreciationsociety.org/collecting/stephen-burt2/>.

[3]"72496 DNR Denver Skew-T." *Wyoming Weather Web*. Web. 12 Apr. 2012. <http://weather.uwyo.edu/cgi-bin/sounding?region=naconf>.

[4]"Cirrocumulus Undulatus." *Wikipedia*. Wikimedia Foundation, 04 Dec. 2012. Web. 10 Apr. 2012. <http://en.wikipedia.org/wiki/Cirrocumulus_undulatus>.