Fire Dragon

Cumulus Fractus

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I. Objective

This image was captured for the Flow Visualization course's second "Cloud" project at the University of Colorado at Boulder with the objective of exemplifying an atmospheric condition via the detailed observation of clouds. In the heart of Pennsylvania, outside the borders of Philadelphia, overlooking the hills right across the river around sunset was the perfect scenery to accomplish this second assignment. The photograph illustrates a clear Cumulus Fractus cloud formation accompanied by winds flowing from the northwest with sustained average speeds of 9-13 mph (Fig 2)[4]. These cloud classifications and the atmospheric effects creating these formations will be investigated and discussed throughout this report to explain the conditions and dynamics of the image.

II. Discussion

This image was taken right outside the city of Philadelphia, standing northeast right of the Schuylkill River at about 6:10pm on March 24, 2011. Based on the March 25 00Z-sounding data in the Skew-T plot from Pittsburg, PA (Fig 1)[1], the classification of the cloud in the image can be explained. Even though the dewpoint profile (and a CAPE = 0) indicates a nearly stable atmosphere with mostly clear skies at higher altitudes, it also perfectly depicts, in concurrence with the temperature profiles, cloud formations at a height of about 4,500 ft above sea level during the evening of the date the image was captured. Thus, due to this measured altitude, the visible cloud formations fall into the low level Cumulus genera[2]. This image exemplifies these atmospheric conditions and also illustrates how visually impacting these formations can be at times.

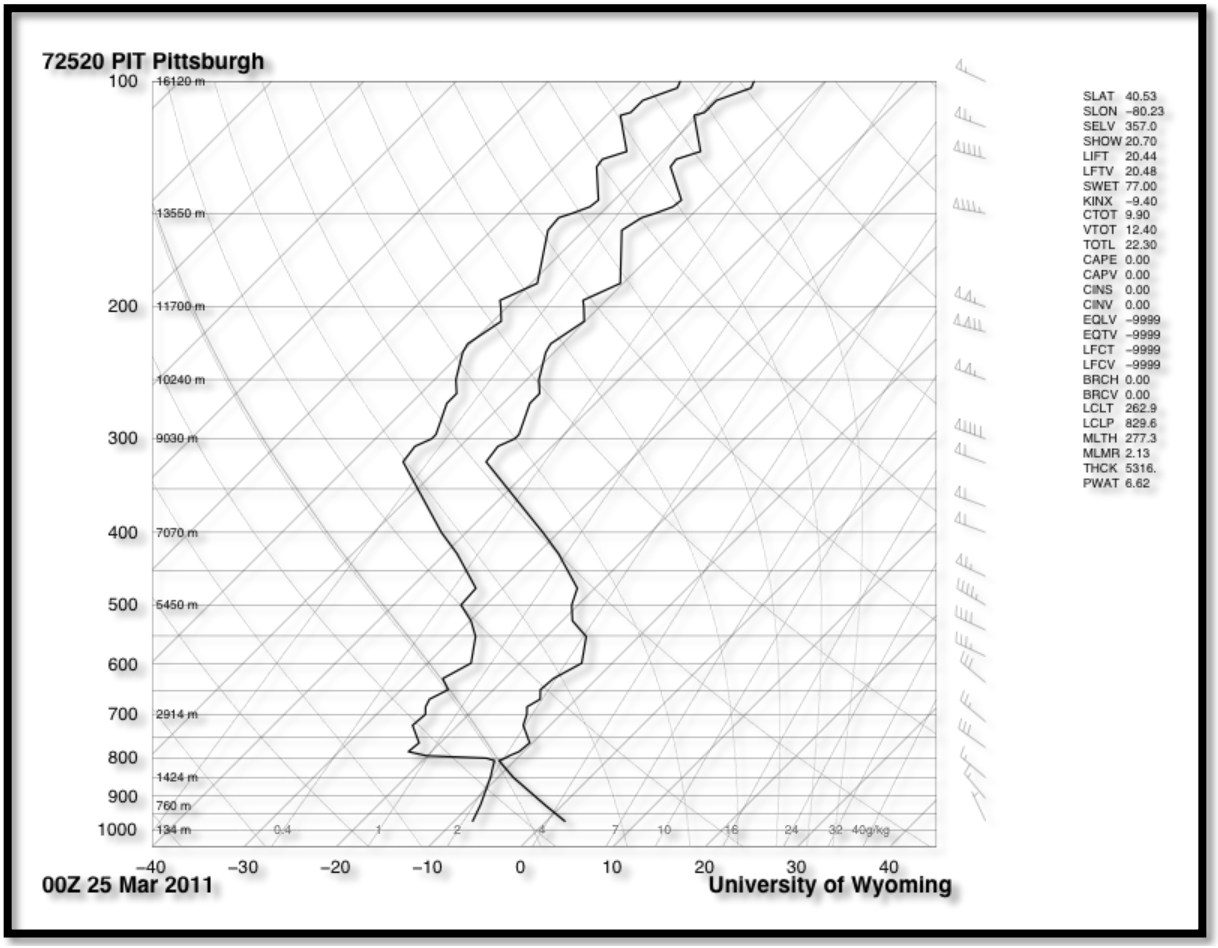

Figure 1: Skew-T Plot for Pittsburg, PA on March 25, 2011. Skew-T plot was recorded at roughly 10:00am of the next day[1].

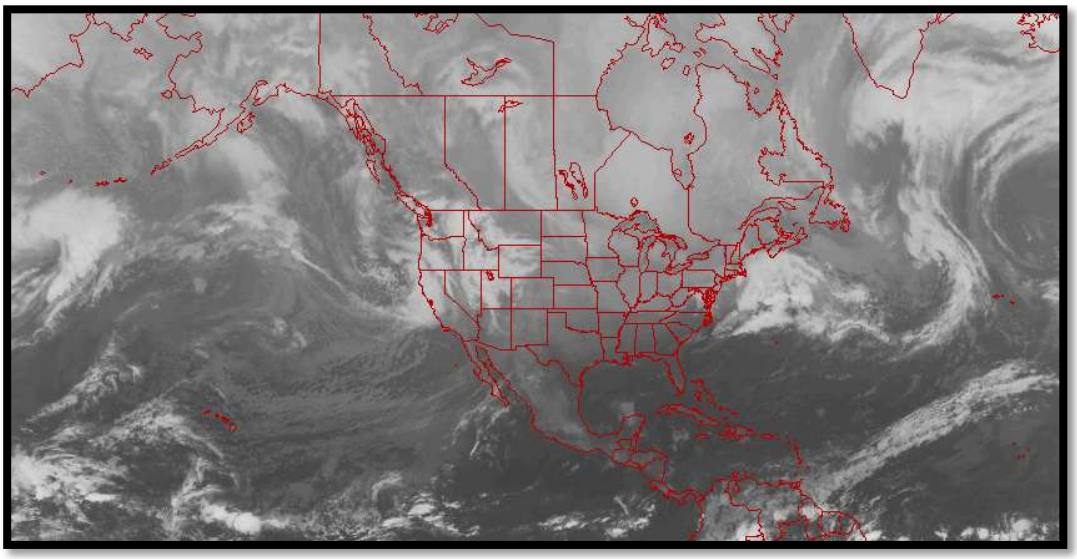

Figure 2: Satellite Map of N. America portrays the visible, infrared and water vapor. Shows cloud formations and movement of these due to winds. These images are generated by geostationary satellites orbiting 22,000 miles above the equator looking at the US[4].

The aforementioned Cumulus cloud captured in this image has a ragged shape, placing it in the Fractus species. Cumulus Fractus clouds are named for their ragged-edged features and mist type appearance, typified by the right top cloud in the image, at times. These clouds typically form as detached clouds, as the name "fractus" ("part" in Latin) describes them. These clouds form anywhere at 1,000-5,000 ft[2], placing this particular cloud in the higher regime of ~ 4,500 ft, as shown by the Skew-T plot. Cumulus Fractus clouds usually from in two ways: (1) in fair weather as raising pockets of warm air rises and condenses or (2) by being shed by larger cumulonimbus clouds after a rain storm. One essential quality of clouds, greatly illustrated in Cumulus Fractus clouds, is their constant transitioning of formation and deformation into different atmospheric exemplifications. Cumulus Fractus clouds are perfect candidates for the visualization of this transitioning phenomenon due to the fact that as they make their way across the sky, the moist air they contain tends to evaporate into the surrounding dry air, deteriorating and changing at fast rates. In this image, the "Fire Dragon" formation, with help from the setting sun light rays, vanished in a matter of minutes.

Cumulus clouds usually form vertically on top of one another reaching altitudes of notable extent, however their base is always formed at lower heights. The smallest (in vertical length) of the cumulus vertical cloud extensions are known as Cumulus Humilis, which is partly what we see in this image. However, what we see are fractions (described by the part of the name "fractus") of these known Cumulus Humilis configurations. The fractions, or Cumulus Fractus, depicted in the image posses a vertical extent of about 3,000 ft with a lifetime of 10-30 min, which explains their fast transitioning and formation as they move across the sky. Considering an average vertical velocity of ~ 9 ft s^{-1}, the time scale for a parcel to enter the cloud base and exit the cloud top is of the order of

$$T = 3{,}000 \text{ ft}/9 \text{ ft s}^{-1} = 333 \text{ s} \approx 5.5 \text{ min}$$

The liquid-water content of small cumuli rarely exceeds 1.0 g m^{-3} and is typically ~ 0.3 g m^{-3}. Hence, with such short time scales and low liquid-water contents, precipitation in Cumulus Fractus clouds is unlikely to occur[3].

This image not only exemplifies the atmospheric conditions of that specific date, but it also makes tribute to the beauty and power of nature when physical dynamics such as the atmosphere, the rays of the sun and these mist formations are combined. This Cumulus Fractus' rapid changes, mixed with the refraction of the

sun's rays and winds creates a magical sequence depicted below (once again, this sequence illustrates the lifecycle of this type of clouds):

Frame 1: Mar 24, 2011 @ 6:10 PM **Frame 2: Mar 24, 2011 @ 6:11 PM** **Frame 3: Mar 24, 2011 @ 6:12 PM**

III. Photography

The photograph of the cloud formations was collected using a Canon EOS Rebel T1i, digital SLR, with a final image resolution of pixel dimension [X: 4752, Y: 2478]. The field of view of the clouds composition is in the order of 3,655ft x 4,000ft, giving a spatial resolution of approximately 1.3ft/pixel. The camera was set to manual operation to appropriately adjust the exposure, shutter speed, and aperture according to what was needed for the image. The lens focal length used was 55 mm, an intermediate value, to focus on the desired clouds and details and capture as much of the cloud formation (fire dragon) in the respective field of view. The image was exposed with an aperture value of f/14, a shutter speed of 1/160 sec, and a low ISO speed rating of 200 without having the flash fired to prevent granulation from over exposure. The original image was exposed enough that not many lighting adjustments were made, however the contrast and saturation were increased to about 20% of the original output to highlight the sun's lighting on the clouds to create that sense of fire seen in the image. The cropping tool was utilized to remove a portion of the tree boundary from the bottom of the image and unnecessary sky space at the top. All these adjustments were made using Photoshop.

IV. Conclusion

After closely analyzing the atmospheric condition readings and weather dynamics for the specific day this image was captured, it can be concluded that the subjected cloud formations can be classified as Cumulus Fractus.

Having taken this photograph opened my eyes to the realization of the amazing figures (or fantasies) these natural formations, with the combination of atmospheric factors, can produce. Photographing this configuration was an incredible experience due to the short lifetime of this particular type and specie of cloud; in a matter of minutes this cloud formation changed exposing a visualization of quick changes due to water evaporation from this mist of clouds into the dry air. As the sun set behind the hills and the cumuli fractus clouds moved across the sky, this fire dragon formation was produced. The dragon formed, it threw fire for exactly 2 minutes and then vanished; 2 minutes of amazement and complete indulgence of pure beauty and imagination.

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[1] AMS Glossary. American Meteorolgy Society. Web. 26 Feb. 2010. <http://amsglossary.allenpress.com/glossary/search?id=mountain-wave-cloud1>.

[2] Met Office, National Meteorological Library and Archive, Clouds 1 (2007).

[3] W. R. Cotton, G. Bryan and S. C. van den Heever, Storm and Cloud Dynamics, International Geophysics Series Vol. 99

[4] Unisys Weather, Image and Map Archive. 12 Feb. 2011 <http://weather.unisys.com/archive/index.php>