



Clouds First

Tristan Brasov

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University of Colorado Boulder

MCEN 5151 Flow Visualization 002

Alto cumulus undulatus, September 27th, 2026, at 6:52 PM PDT, Manhattan Beach, CA

1 Context and Purpose

This photograph was taken for the Clouds First assignment in MCEN 5151 Flow Visualization at the University of Colorado Boulder. The intent with the image was to capture a cloud layer as best as possible, to show the air around it is moving, and to use the weather data from that evening to explain why the clouds formed the way they did. Visually, the goal was to catch the clouds just after sunset, when light from below picks out their texture in red and orange, and to keep the beach and lifeguard tower as a dark silhouette so that the sky carries the image. The final image shows a rippled sheet of alto cumulus undulatus high over the ocean, with a thin band of marine layer cloud sitting on the horizon beneath it. No one else assisted with this image.

2 Circumstances

The photo was taken from the beach in front of lifeguard tower 34 in Manhattan Beach, CA at 33°53'54" N, 118°25'08" W, and about 10 ft (3 m) above sea level, facing the Pacific Ocean at a compass heading of 240° southwest. It was taken on September 27th, 2026 at 6:52 PM PDT, 9 minutes after the 6:43 PM sunset. At that moment the sun was about 2.7° below the horizon at an azimuth of 268° [1], just past the right edge of the frame, so the clouds were lit from below and from the right. Additionally, the camera was aimed about 8° above the horizon. This follows from where the sea horizon sits in the

original frame, 80% of the way down. With the 32 mm focal length and the sensor's 22.3×14.9 mm size [2], the frame spans roughly 38° horizontally and 26° vertically [3]. It therefore covers headings from about 221° to 259° and angles from the horizon up to about 21° above it. Figure 1 labels the main features of the final image.

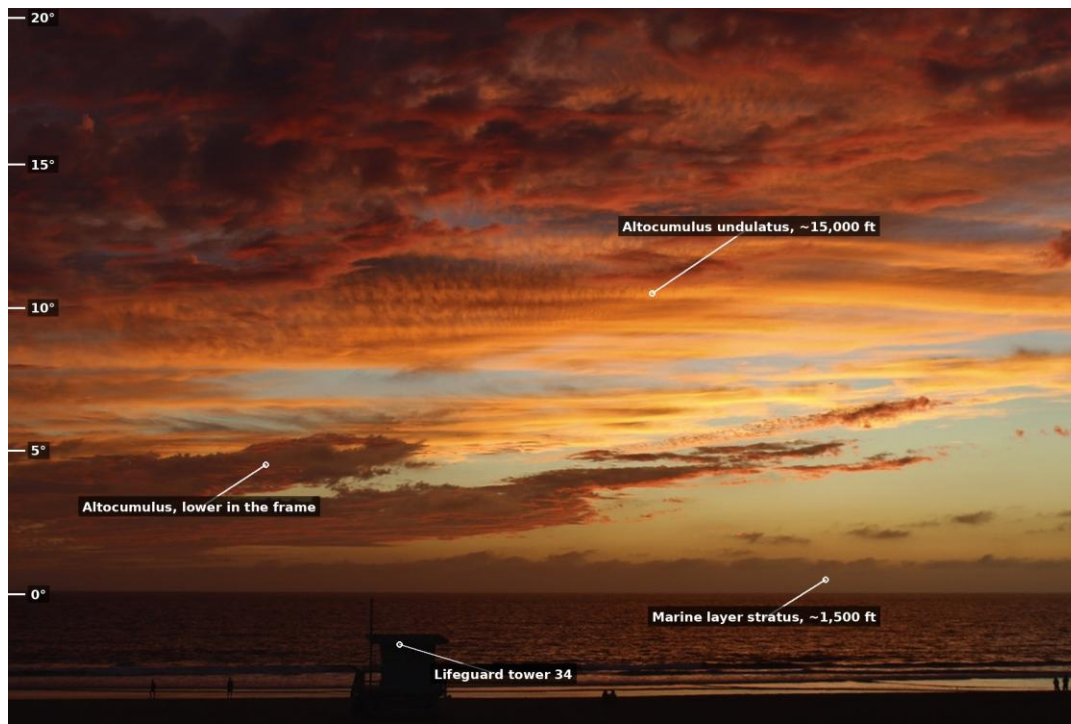


Figure 1. Final image with the cloud layers and angles above the horizon.

3 Cloud Study

Two cloud layers fill the frame. Most of the sky is a sheet of altocumulus, made of patches and rolls of cloud, generally with shading [4]. Across the middle of the frame, about 9 to 12° above the horizon, the sheet breaks into long, nearly parallel bands made of rows of small ripples. Elongated, broadly parallel elements like these define the undulatus variety [5]. Darker, lumpier altocumulus sits lower in the frame, about 3 to 6° above the horizon. A flat gray band of marine layer stratus lines the horizon itself, taking up only the lowest 1° of the frame.

The nearest weather station is Los Angeles International Airport (LAX), about 3 mi (5 km) north. Its 6:53 PM report, one minute after the photo, listed a few clouds at 1,500 ft (460 m), a scattered layer at 15,000 ft (4,570 m), another scattered layer at 25,000 ft (7,620 m), and a west wind of 8 kt [6]. The 1,500 ft layer is the marine layer, and the 15,000 ft layer matches the altocumulus. Since only few and scattered layers were reported, the rest of the sky was partly cloudy, not overcast. The day before was similar: at 6:53 PM on September 26th, LAX reported scattered cloud at 15,000 ft and broken cloud at 23,000 ft (7,010 m), and early that morning the marine layer had covered the airport at about 800 ft (240 m) [6]. LAX recorded no rain from September 24th to 29th, a high of 85°F (29°C) on the 27th, and light winds averaging 5 to 7 kt each day [6], so there was no sign of a front passing through. Seen 9 to 12° above the horizon, a layer at 15,000 ft is roughly 13 to 18 mi (21 to 29 km) away, so the ripples were well offshore. Figure 2 is the Skew-T from Vandenberg, CA (station 72393) at 00Z on September 28th, which is 5:00 PM PDT on September 27th, about two hours before the photo [7]. Vandenberg is about 135 mi (220 km) northwest of Manhattan Beach, and it was the closest sounding available, since the San Diego sounding was missing for that time. The values below were read from the plot to about $\pm 2^\circ\text{F}$ ($\pm 1^\circ\text{C}$).

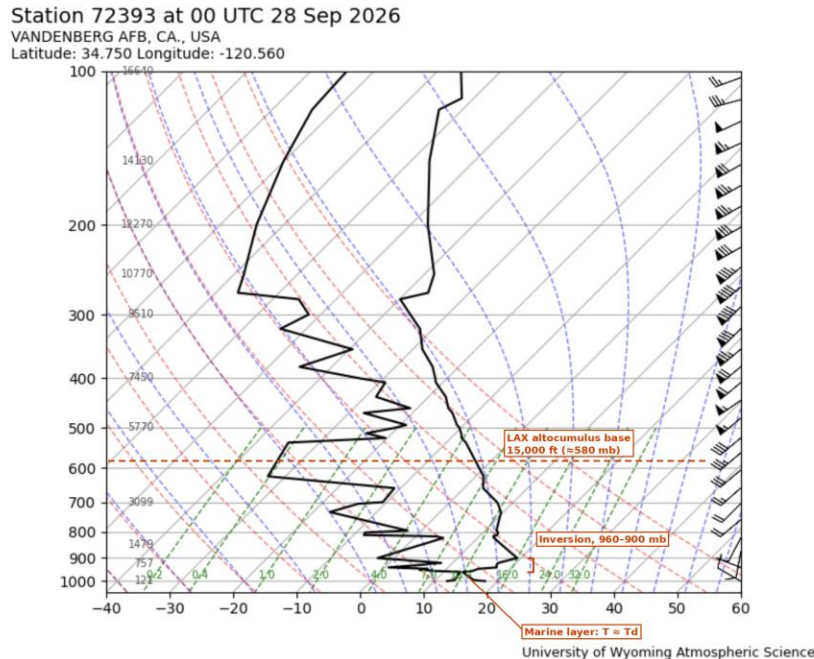


Figure 2. Skew-T for Vandenberg, CA (72393), 00Z September 28th, 2026, with the marine layer, the inversion, and the LAX altocumulus height marked.

The bottom of the sounding shows the marine layer. From the surface up to about 960 mb, or 1,500 ft (450 m), the temperature and dewpoint lines nearly touch, so that air is close to saturated. This is the gray band on the horizon, and its top agrees with the 1,500 ft cloud at LAX. Directly above it, the temperature rises with height instead of falling, from about 56 °F (13 °C) at 960 mb to 66 °F (19 °C) at 900 mb, or 3,250 ft (990 m), while the dewpoint drops to about 29 °F (−2 °C). This is a strong temperature inversion. An inversion is a stable layer, so the cool, moist marine air cannot mix upward through it and stays trapped beneath it as a flat layer of stratus [8, 9].

Above the inversion, the temperature falls by about 3.0 °F per 1,000 ft (1.7 °C per 1,000 ft) up to 700 mb, or 10,200 ft (3,100 m), and by about 3.6 °F per 1,000 ft (2.0 °C per 1,000 ft) from there to 500 mb, or 18,900 ft (5,770 m). Both rates fall between the saturated rate of about 2.7 °F per 1,000 ft (1.5 °C per 1,000 ft) and the dry rate of about 5.4 °F per 1,000 ft (3 °C per 1,000 ft). Air like this is stable as long as it stays unsaturated [8], and here the dewpoint stays far below the temperature through most of this range. A parcel of air pushed upward would cool at the dry rate, end up colder and denser than the air around it, and sink back, so the atmosphere was stable. On the Skew-T, the temperature line is more upright than the dry adiabats, which is what a stable layer looks like. Stable air is expected to form flat layers of clouds, and that is exactly what the image shows: every cloud is a flat or rippled layer, with no towering cumulus.

The 15,000 ft altocumulus base reported at LAX falls near 580 mb on the Skew-T, between the 500 and 600 mb lines (dashed line in Fig. 2). At Vandenberg that exact level is dry, and the closest moist layer sits a little higher, near 450 to 500 mb, or 18,900 to 21,500 ft (5,770 to 6,560 m). That difference is reasonable given the 135 mi and two hours between the sounding and the photo, so the LAX report is the better measure of the cloud height.

The wind barbs can explain the ripples. Winds aloft blew from the southwest and strengthened with height, from about 25 kt at 10,000 ft (700 mb) to about 40 kt near 15,000 ft and 55 kt at 18,900 ft (500 mb). When a stable layer is sheared like this, it can break into waves called billows, and cloud forms at the crest of each one [10]. The undulations in the altocumulus are most likely the visible trace of that shear.

4 Photographic Technique

The camera was a Canon EOS Rebel T100 digital SLR, handheld, with a Canon EF-S 18–55 mm f/3.5–5.6 III lens set to 32 mm (51 mm full-frame equivalent). The camera ran in the Landscape scene mode, which chose an aperture of f/7.1, a shutter speed of 1/60 s, and ISO 100, with evaluative (pattern) metering and 0 exposure compensation. The horizon was framed low so that the sky fills most of the image, and the focal length was set to fit both the ripple band and the tower in one frame. The original JPEG is 5184×3456 px, the sensor's full frame. As found in Section 2, the field of view is about $38^\circ \times 26^\circ$, and the ripple band was 13 to 18 mi (21 to 29 km) from the lens.

Post-processing was done in Apple Photos on macOS. The frame was cropped slightly, by about 3% on each edge, keeping the 3:2 shape, so the final image is 4892×3260 px. In the Light panel, Highlights was set to -0.29 to keep detail in the brightest yellow clouds, Brightness to -0.10 , Contrast to $+0.11$, and Black Point to -0.05 . In the Color panel, Saturation was set to $+0.06$ and Vibrance to $+0.20$. Definition, a local contrast control, was set to 0.40 to bring out the ripples. Exposure, Brilliance, Shadows, white balance, sharpening, noise reduction, and vignette were left untouched. Figure 3 compares the original and final images.



Figure 3. (a) The original frame, with the dashed box marking the region kept by the crop, and (b) the final image.

5 Image Dissection

The image captures two layers of a stable atmosphere: a marine layer held down near the ocean by a strong inversion, and a sheared altocumulus layer about 15,000 ft up whose ripples trace the wind shear. Both the scientific and visual intent were met. The ripple band across the middle is the strongest part of the image, and the low sunlight gives each element a lit edge and a shaded side, which is what makes the texture readable. The tower silhouette also gives the sky a sense of scale. The main weaknesses are the upper third, which is dark, loses detail in its darkest clouds, and pulls attention away from the ripples, and the marine layer band, which is thin and easy to miss. A tighter crop on the ripple band, or bracketed exposures to hold detail in both the bright and dark clouds, would have greatly helped.

The analysis rests on the following assumptions. (1) The cloud heights come from LAX, 3 mi away, not from the photo itself. (2) The Skew-T is from Vandenberg, 135 mi away and two hours earlier, and its values were read from the plot. (3) The angles assume an undistorted lens and use the sea horizon as 0° . (4) The compass heading is taken as displayed. The natural next steps would be to photograph the same sky from two places at once to measure its height directly, use a wider lens to show more of the sheet, and shoot a time-lapse to watch the billows form and move.

6 References

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