Cloud-I

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[Summary]

The report showing the weather in Boulder while cold front coming down from northwest high land driven by the high pressure center formed in mountains. The weather disturbance generates storms in Boulder and Denver area and cooled done the temperature. Figure-1 shows an amazing cumulonimbus with anvil head captured at 6:19 PM mountain time on October 7 2007 in Boulder, Colorado.

Figure-1. Cumulonimbus formed in Boulder on October 7 2007

[Geographic environment and macro meteorology]

The city of Boulder is located in Boulder Valley where the Rocky Mountain meets the Great Plains. The elevation of Boulder is 5430 feet (1655 m). East to Boulder belongs to Colorado piedmont which elevated from 750 m to ~ 1800 m. West to Boulder is mountain area which could be higher than 16000 feet (5000 m). Located at 40N, 105W in the westerly wind belt, most precipitation occurs during the winter and spring months brought by west wind from Pacific Ocean crossing mountains becoming a “high desert” climate.

During the winter starting from fall, polar maritime air masses formed in northern pacific brings cool and moist air all the way across rocky mountain arriving Colorado. While the cold air masses move through mountains, cold front lifts the warm air masses and form clouds and precipitation as shown in figure-2. It usually starts with foehn wind which dehydrated while move upslope and

warming adiabatically while going down slope. Before cumulonimbus and recitation happened in Boulder, the air temperature gets warmer because the strong, gusty, warm and dry winds blowing down from mountain. As shown in table-1, the weather in Boulder gets warm and windy before the storm and precipitation happened on Oct-7. After Oct-7, the cold air masses occupy the Boulder area and air temperature gets cooler.

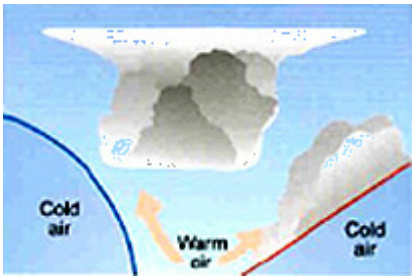

Figure-2. Cloud formation

Outdoors Weather Planner for
Boulder, CO (80302) *October*
[English | Metric]

Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue
2	3	4	5	6	7	8	9
OBSERVED	OBSERVED	OBSERVED	OBSERVED	OBSERVED	OBSERVED	OBSERVED	OBSERVED
Hi 74°F Lo 53°F	Hi 83°F Lo 50°F	Hi 84°F Lo 54°F	Hi 86°F Lo 51°F	Hi 84°F Lo 48°F	Hi 58°F Lo 39°F	Hi 74°F Lo 35°F	Hi 74°F Lo 45°F
Precip (in) 0in.	Precip (in) 0in.	Precip (in) 0in.	Precip (in) 0in.	Precip (in) 0in.	Precip (in) 0in.	Precip (in) 0in.	Precip (in) 0in.

Table-1. Temperature at Boulder in October 2007

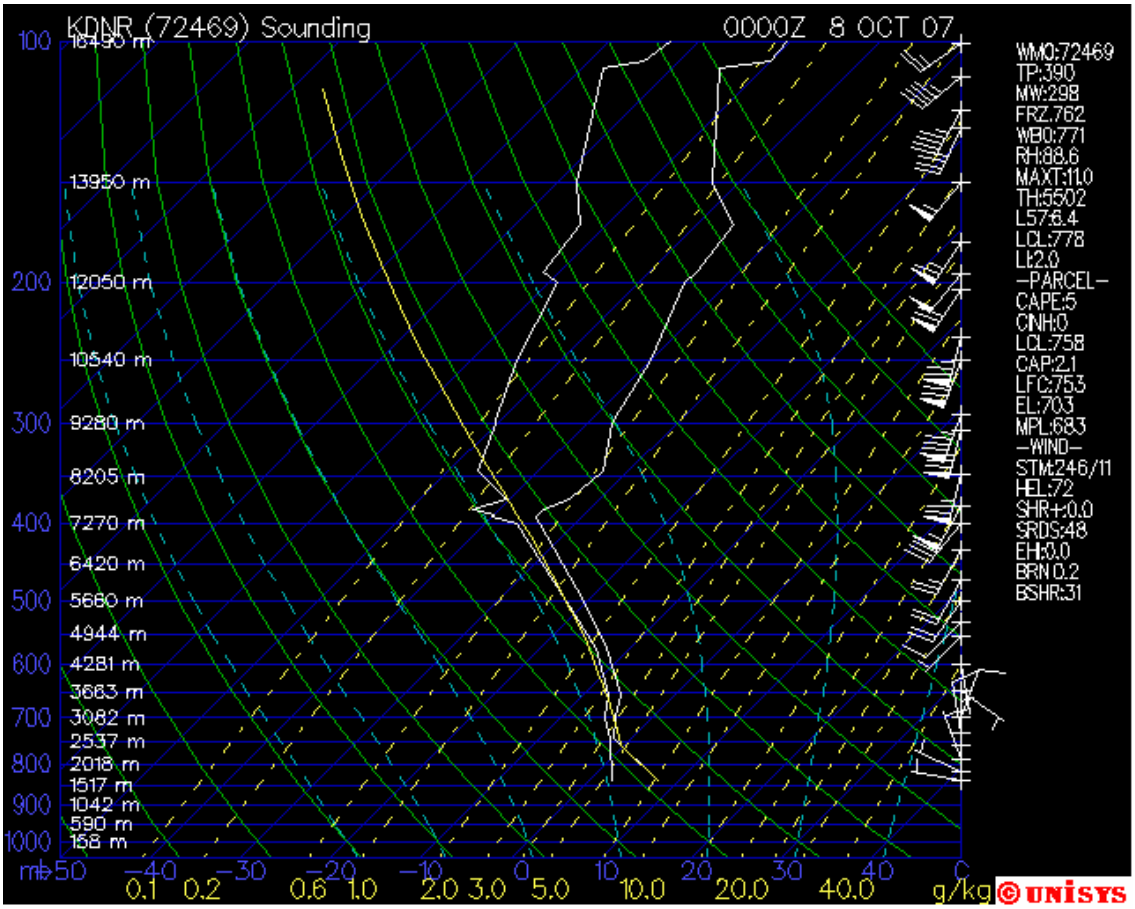

Figure-3. Skew-T plot observed in Denver at 6:00 PM on Oct. 7 2007.

[Micro meteorology]

Clouds form when rising air cools and the moisture in it condenses to form water droplets. If air becomes relatively warmer than surrounding air while lifting

and will continue to rise without any outside forces (self buoyant), this atmosphere turns to be unstable and highly possible to form cumulus or cumulonimbus as showed in picture (figure-1).

Figure-3 shows the skew-T in 6:00 PM mountain time on October 7, 2007. The atmosphere is neutral from 1580 m (surface level of Denver / Boulder area) to 2400 m. Around 2400 m high, the air starts to condensate (lifting condensation level/LCL). A strong lifting force happened from 2400 m to 2600 m, and the atmosphere became stable above 3000 m. Based on the Skew-T plot we can estimate the top of the cumulonimbus in the photo is around elevation 3000 m.

On the right hand side of skew-T plot also shows the wind profile at the time. The surface wind and higher level wind (>4000 m) are blowing eastward, however, the wind around 3000 ~ 3500 m is blowing westward. A jet stream is blowing eastward above 6000 m with 58-62 knots comparing to lower level wind with only 3-7 knots.

Figure-4 also shows the surface wind vector with eastward wind on the western Colorado and westward wind on the eastern Colorado. An enhanced infrared photo is shown in figure-5. A lot of clouds are formed on the eastern Colorado while blowing east wind on the surface.

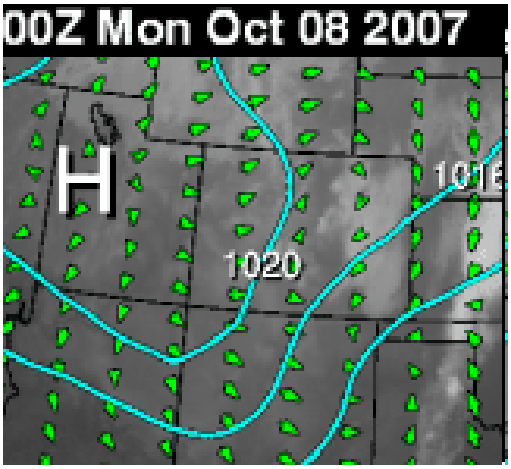

Figure-4. Surface wind vector map

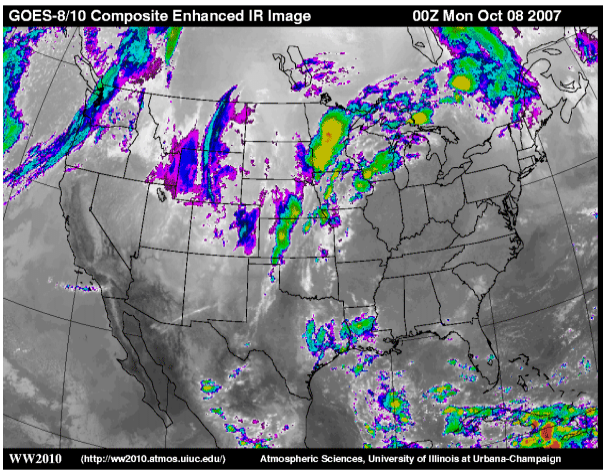

Figure-5. Enhance infrared map

Figure-6. Mechanism of storm formation on Oct. 7 2007 at Boulder, CO.

Concluded from figure-3 skew-T, figure-4 surface wind vector, and figure-5 clouds distributions, a micro meteorology mechanism can be presented in figure-6 as above. The strong, cold and moist west wind is blowing from the mountain area. Some of them blow down slope to Boulder/Denver area, and some is introduced by the backward turbulence because of dramatic elevation change in Front Range. Both cold air meets at Boulder/Denver region and lift up the warm air forming the stormy weather on October 7 2007.

[Photography environment]

The photo is shoot at Folsom street facing east with 15 degree angle. As the height estimated from skew-T is 3000 m above sea level (Boulder is ~1600 m above sea level), the distance can be calculated as 5.2 km.

[Camera setup]
Nikon D80 digital camera @2007/10/07 18:19:19.9
18-135 mm Nikker lens with warm filter and polarizer filter
Size of filed view: 2800 m x 1400 m (WxH)
Distance from the object to lens: 5.2 km
ISO 320 1/125 sec - F/5.6
Image Size: Large (3872 x 2592)
Focal Length: 70mm
No Flash
Photoshop processing: level adjusted

[Summary]

An amazing cumulonimbus with anvil head is captured on October 7, 2007. The structure of clouds in the photo shows strong flow lifting upward. Combining with weather data, we can conclude the atmosphere phenomena and mechanism happening during winter time while west wind blowing across the mountains.

[Reference]

[1] http://en.thinkexist.com/quotes/with/keyword/clouds
[2] http://imnh.isu.edu/digitalatlas/clima/imaging/clddev.htm
[3] http://www.wunderground.com/cgi-bin/findweather/
[4] http://www.csgnetwork.com/estcloudbasecalc.html
[5] http://weather.unisys.com/index.html
[6] http://www.atmos.uiuc.edu/weather/tree/viewer.pl?launch/irslp.
[7] http://www.vivoscuola.it/us/rsigpp3202/umidita/lezioni/form.htm