METEOROLOGICAL ANALYSIS OF THE ROCKY MOUNTAIN NATIONAL PARK LIGHTNING FATALITIES OF 11 AND 12 JULY, 2014

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1. Introduction

On July 11, at 1:04 pm MDT (1904 UTC), A 42 year old female was struck and killed by lightning while hiking on Ute Trail, just below Trail Ridge Road in Rocky Mountain National Park (RMNP), Colorado. Seven other people in her hiking party were also injured by this flash (Fig. 1). On the following day, July 12, at 3:47 pm MDT (1547 UTC), tragedy struck once again in RMNP, when Gregory Cardwell, 52, was struck and killed while sightseeing at the Rainbow Curve Overlook on Trail Ridge Road. Three others were also injured (Fig. 2). This incident occurred only 1.75 miles (2.8 km) from the fatality that occurred the day before.

Since 2000, the National Weather Service (NWS) in Pueblo, CO has been analyzing the meteorology associated with lightning strike incidents in Colorado. The motivation for this research is twofold; first, we wish to accurately document the location of where people were located relative to the rain area when they were affected by a Cloud-to-Ground (CG) lightning flash and second, to observe how close previous CG lightning flashes were to the victim.

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In this paper, CG flash plots (time vs distance) for the two cases are shown, along with time lapse of radar data overlaid with CG stroke data. By examining these variables, we can observe the lightning frequency/trends immediately prior to the two fatalities and we can observe the precipitation characteristics of the storm at the fatality location.

2. Background

The lead author has now analyzed a total of 22 lightning casualty cases, some in considerable detail (NOAA 2015, Hodanish 2012, 2008, 2006). The first lightning casualty case occurred in 2000 (Hodanish et. al, 2004), while the two RMNP cases highlighted in this paper occurred in summer 2014. It should be noted that not every lightning flash which caused a casualty (fatality or injury) in Colorado during the last 15 years has been examined. The author of this paper is an operational meteorologist, and examines lightning casualty cases as time permits.

To determine which CG flash caused the casualty, two pieces of information are required. The first piece of information is acquiring the exact time when the lightning flash hit the victim, while the second piece of information is documenting the specific location where the victim was struck. Typically, the location of the victim is well

documented. Emergency responders will use GPS to mark the location of where the victim was found after being struck (this assumes the victim was not moved until the emergency medical authorities arrived). On the other hand, determining the exact time that a lightning flash incident occurred can be difficult, especially if it is only one victim and no other people were in the vicinity when the flash occurred. This is typically the case of lone hikers struck by lightning in the Colorado high country. With respect to the two RMNP cases highlighted in this paper, both the location and time of the incidences were well documented, as both lightning strike incidents were witnessed by several people.

In Hodanish (2006, 2008), the following definitions were used to define the frequency of CG lightning activity immediately prior to a flash that caused the lightning casualty:

Frequent CG activity: CG flash activity, averaged over a 5 minute time period and within 6 miles (9.7 km) of the casualty location, which was greater than or equal to 1.0 Flash per minute (Fl min^{-1})

Infrequent CG activity: CG flash activity, averaged over a 5 minute time period and within 6 miles (9.7 km) of the casualty location, which was less than 1.0 Fl min^{-1}

In this paper, these same definitions will be used. In the above definitions, the distance of 6 miles (9.7 km) was originally chosen because this is the distance in which people should be in safe shelter when lighting is occurring (30-30 lightning rule, AMS 2002). The flash rate values of < 1.0 Fl min^{-1} and >= 1.0 Fl min^{-1} were arbitrarily chosen.

Lightning data used in this study is from the North American Lighting Detection Network, operated by Vaisala.

3. Data Analysis

3.1 Time vs Distance Plots

In order to examine the lightning activity prior to the victims being struck, "time vs distance" lightning plots were created for the two RMNP cases (Fig. 3 and Fig. 4). In each plot, CG and In-Cloud (IC) activity within 10 miles and 30 minutes prior to the victim being struck are shown. The "0.00" on the abscissa indicates the time when the victim was struck. It should be noted that both plots show CG *stroke* data. Typically, a lighting flash consist of several strokes. These strokes which make up the lighting flash generally all occur within a split second, but can be a kilometer or two away from each other. In addition, IC lightning "pulses" (Holle et. al, 2014) are also shown along with the CG stroke data. The IC data is shown in order to observe if thunder from IC lightning was likely being heard prior to the fatal CG flash. These two plots show a "wide view" of the spatial and temporal aspects of the total lightning activity prior to the casualty occurring.

A portion of the time vs distance plots shown in Figs. 3 and 4 are highlighted in pink to emphasize the CG lightning activity which was occurring within 5 minutes and 6 miles of the casualty location. It is within

this temporal and spatial region in which CG flash rates are calculated to determine if the storms were producing frequent (>=1.0 Fl min^{-1}) or infrequent (<1.0 Fl min^{-1}) CG lightning activity.

For the Ute Trail case (Fig. 3), two CG flashes occurred within 6 miles and 5 minutes prior to the CG flash which caused the fatality. One CG flash, consisting of two strokes, occurred at 1901:41 UTC (184 seconds prior to the fatality) while the other flash, consisting of three strokes, occurred at 1904:45 UTC (41 seconds prior to the fatality). This gave an average CG flash rate of 0.4 Fl min^{-1} .

For the Rainbow Trail Overlook case (Fig. 4), no CG flashes occurred within 6 miles and 5 minutes prior to the CG flash which caused the fatality. Several IC flashes were identified, and occurred 3 to 5 miles away from the fatality location. The CG flash rate for this case was 0.0 Fl min^{-1}.

We now combine these two RMNP cases with the other 20 lightning casualty cases examined previously by the author (Hodanish 2012). Table 1 shows data for all 22 cases. Information includes the time of the flash which caused the casualty, the latitude and longitude where the victim(s) was(were) struck and the number of flashes/flash rates which occurred within 6 miles and 5 minutes prior to the flash which caused the casualty.

For two of the cases shown in Table 1 (case 17 and 18), the author was not confident in which flash actually caused the casualty, likewise flash rate statistics could not be calculated. For the other 20 cases, six (30%) had frequent CG activity (>=1 Fl min^{-1}), *while the other 12 cases (70%) had infrequent CG activity (<1.0 Fl min^{-1}).*

3.2 Radar/Lightning Time Lapse

Fig. 5 and Fig. 6 show a radar time lapse with the CG stroke and IC flash data overlaid for both of the RMNP cases. In each figure, a 10 mile range ring is shown, with the fatality occurring in the center of the ring. Only lightning which occurred within this ring is shown (this was done to match up with the distance/time plots shown in Figs. 3 and 4). Radar data is from KFTG WSR 88D located near the Denver International Airport, which is about ~65 NM east-southeast from the fatality locations. Data shown is 0.5^{o} base reflectivity imagery, and is shown in ~2 minutes increments. The time lapse lasts approximately 30 minutes. The looping ends around the time of the fatality.

The radar time lapse for the Ute Trail case (Fig 5) showed that a thunderstorm of moderate intensity was in progress 8 miles to the west of where the fatality occurred at the beginning of the time lapse (1834:06 UTC). As time progressed, this storm moved steadily to the east at about 15 mph. As the storm was just west of the location of where the fatality occurred, it began to produce CG strokes (See Fig 3). The flash which caused the fatality occurred at 1904:45 UTC. It is clear from this case that the hiking party knew of the lightning threat as the CG flashes were striking nearby and the storm was clearly visible from the west. News media reports confirmed that the hiking

party knew of the lightning threat but could not make it to safety in time.

The radar time lapse for the Rainbow Trail Overlook case (Fig 6) showed showers increasing over the region at the beginning of the time lapse (2115:57 UTC). As time progressed, the showers increased, moving to the east-southeast around 12 mph. One storm developed just northeast of where the fatality occurred around 2140:00 UTC. This storm rapidly intensified just to the east of the Rainbow Trail Overlook. At 2147:49 UTC, a CG flash came out of the far west core of the storm causing the fatality at the Rainbow Trail Overlook. Based off radar data, the man who was struck likely knew of the strong storm to his immediate east, as the scenic overlook overlooks the terrain to the east. From Figure 4, IC flashes were occurring, but they were located 4 to 6 miles to the north and occurred 2 to 4 minutes prior to the fatal flash. It is unknown if he heard thunder from these IC flashes. It was likely precipitating at the time of the fatality.

4 Discussion and Findings

The two people who were struck and killed by lightning in Rocky Mountain National Park were struck by storms that were producing infrequent lighting activity (i.e., <1.0 Fl min^{-1} averaged over 5 minute time period and within 6 miles of the fatality location). The storm that caused the fatality on Ute Trail was producing flash rates of 0.4 Fl min^{-1}, while the storm that produced the fatal flash at the Rainbow Trail Overlook produced no CG flashes.

Combining the two RMNP cases with the other 20 cases examined by Hodanish 2012, it is observed that 70 percent of storms that cause casualties in Colorado have flash rates that are less than 1.0 Fl min^{-1}.

Radar analysis of the two RMNP cases indicated that precipitation was occurring at the time of the fatality. For the Ute Trail case, the hiking party knew of the lightning threat, but could not reach shelter in time. For the Rainbow Trail case, the man who was struck likely knew of the heavy precipitation off to his immediate east. It is unknown if he heard thunder from IC flashes which occurred 2 to 4 minutes prior to the fatal lightning flash.

More information regarding lightning casualty studies can be found on the NOAA/NWS Pueblo Colorado Lightning Resource Page located at:

http://www.weather.gov/pub/lightning

Then click on “lightning casualty case studies”.

5. Acknowledgments

The authors would like to thank the following folks who assisted in this study: Jennifer Stark, NWS Pueblo, CO; Ron Holle, Vaisala; John Jensenius, NWS Gray, ME; Bill Rhoeder, private meteorologist; William Brooks, Vaisala; Dr J. Stano, SPoRT, Huntsville, AL and Kyle Patterson, RMNP PIO.

6 References

American Meteorological Society, 2002: Lightning safety awareness statement. AMS website: http://www.ametsoc.org/POLICY/lightningpolicy_2002.html

Hodanish, S. J., 2006: Meteorological case studies of lightning strike victims in Colorado. 86th Annual AMS conference, Atlanta GA, Amer. Meteor. Soc

Hodanish, S. J. 2008: Meteorological case studies of lightning strike victims in Colorado - An Update. 89th AMS conference, Phoenix, AZ. Amer. Meteor. Soc.

Hodanish, S. J., 2012: Meteorological case studies of lighting strike victims in Colorado. International Lightning Meteorology Conference, Vaisala. Broomfield, CO.

Hodanish, S.J., Holle, R., and D. Lindsey. 2004: A small updraft producing a fatal lightning flash. *Weather and Forecasting*, **19**, pp 627-632.

Holle, R. L., N. W. S. Demetriades and A. Nag. 2014; Lightning warnings with NLDN cloud and cloud-to-ground lightning data. 2014 International Conference on Lightning Protection, Shanghai, China.

NOAA 2015: Colorado Lightning Casualties: Case Studies, HTML document: http://www.crh.noaa.gov/pub/?n=/ltg/case_studies_index.php.

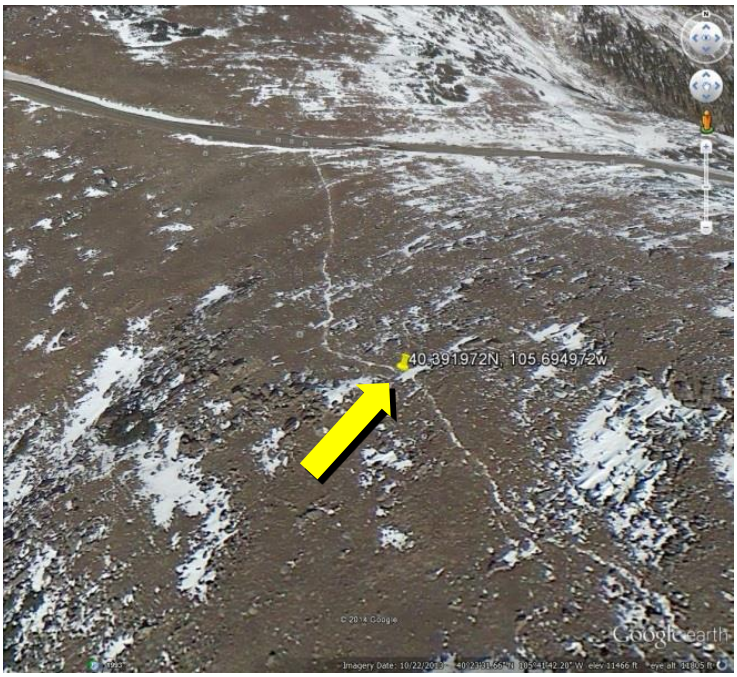

Figure 1. Location of the Ute Trail fatality in Rocky Mountain National Park. Elevation was 11,478 feet (3498 meters). Image from Google.

Figure 2. Location of the Rainbow Overlook fatality in Rocky Mountain National Park. Elevation was 10,815 feet (3,296 meters). Image from Google.

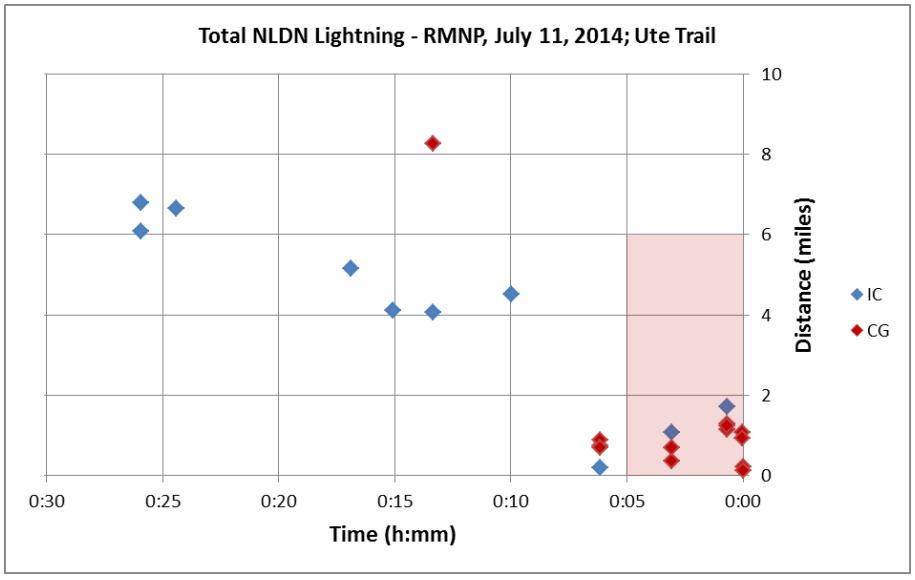

Figure 3. Time vs distance plot for the Ute Trail lightning fatality case in Rocky Mountain National Park on July 11th, 2014. The plot shows the total lightning activity within 10 miles and 30 minutes leading up to the fatality. Blue diamonds represent in-cloud flashes ("pulses"), while the red diamonds represent the CG stroke data. The pink shaded area highlights the lightning activity within the 5 minutes and 6 miles prior to the fatality occurring. "0:00" represents the time of the fatality (the fatality occurred at 1904:45 UTC (1:04:45 PM MDT)). Lightning data from Vaisala.

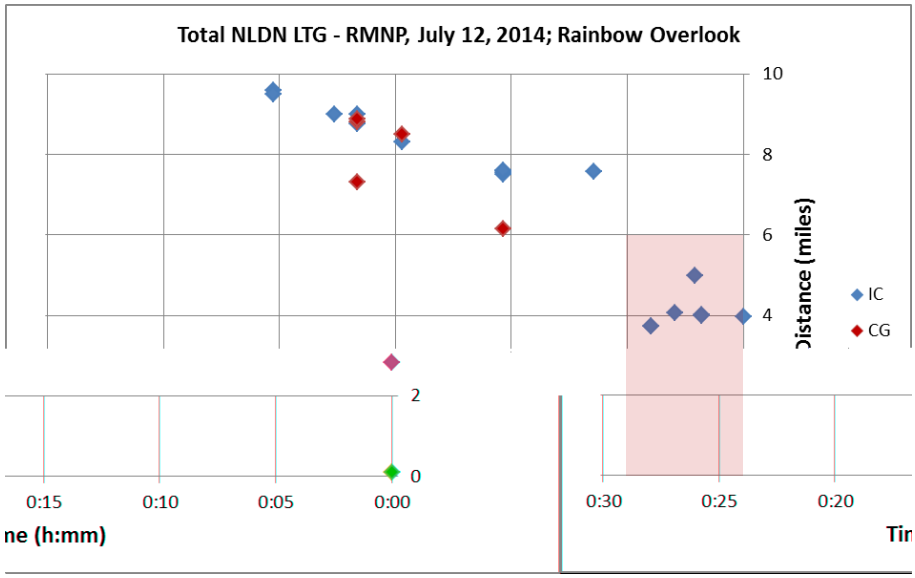

Figure 4. Time vs distance plot for the Rainbow Overlook lightning fatality case in Rocky Mountain National Park on July 12th, 2014. The plot shows the total lightning activity within 10 miles and 30 minutes leading up to the fatality. Blue diamonds represent in-cloud flashes ("pulses"), while the red diamonds represent the CG stroke data. The pink shaded area highlights the lightning activity within the 5 minutes and 6 miles prior to the fatality occurring. "0:00" represents the time of the fatality (the fatality occurred at 2147:49UTC (3:47:49 PM MDT)). Lightning data from Vaisala.

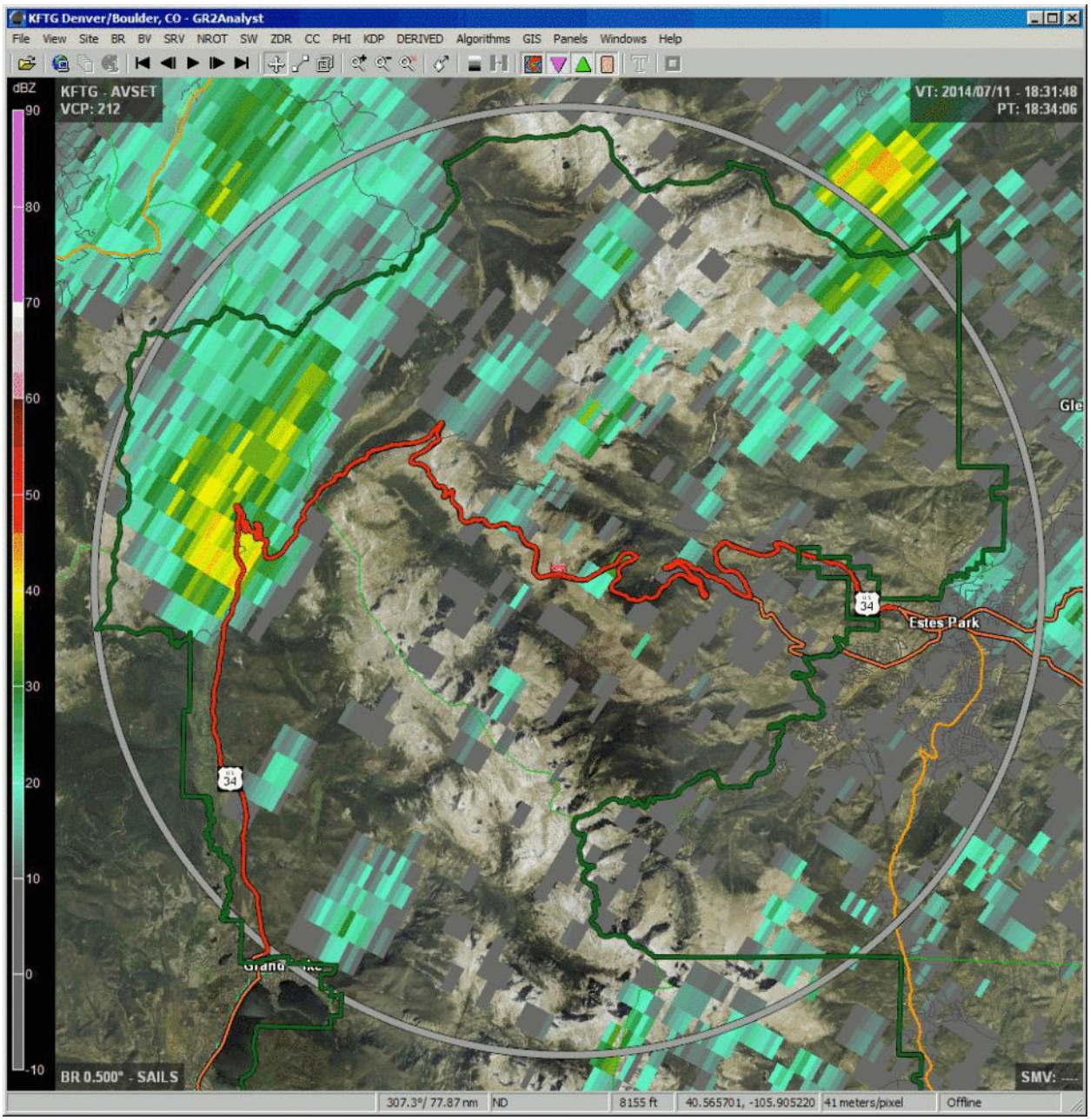

Figure 5. Image of the radar loop for the Ute Trail case. Go to:

http://www.crh.noaa.gov/Image/pub/ltg2/2014_07_11_RMNP_Ute/2014_07_11_RMNP_075s.gif

to see the radar loop.

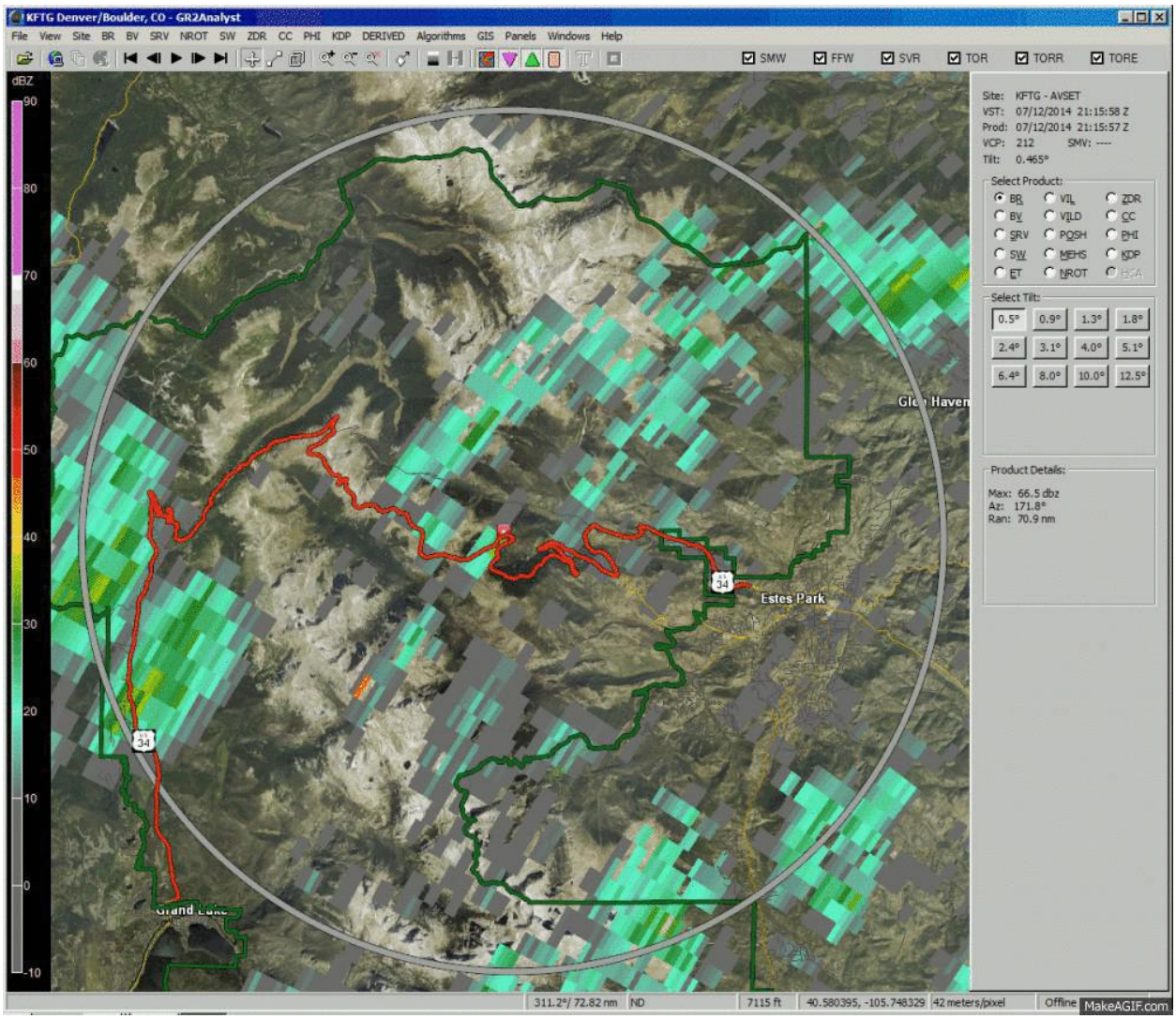

Figure 6. Image of the radar loop for the Rainbow Trail Overlook case. Go to:

http://www.crh.noaa.gov/Image/pub/ltg2/2014_07_12_RMNP_Rainbow/2014_Jul_12_RMNP_loop_075s.gif

to see the radar loop.

Table 1. Case number (#), date, general location, time of the flash which likely caused the casualty, latitude/longitude of strike victims' location and CG flash rates within 5 minutes/6 miles prior to the flash which caused the casualty.

Case #	Date yymmdd	General Location	Time of Casualty (UTC) hhmm:ss	Latitude /Longitude of victims' location	#flashes/5min, (fl/min)
1	000725	Pikes Peak	1856:54	38.8417, -105.0425	0/5 min, (0.0 fl/min)
2	030727	Crestone	2236:13	37.9900, -105.6250	10/5 min, (2.0 fl/min)
3	030824	Lake George	2246:24	38.9650, -105.3355	5/5 min, (1.0 fl/min)
4	030824	Redcone Pass	2126:20	39.5317, -105.8217	1/5 min, (0.2 fl/min)
5	040529	Littleton	1842:40	39.6000, -105.1200	0/5 min, (0.0 fl/min)
6	040619	Kremmling	2045:49	40.0665, -106.3936	5/5 min, (1.0 fl/min)
7	040707	Arvada	0012:37	39.8333, -105.1300	1/5 min, (0.2 fl/min)
8	040801	Breckenridge	2038:06	39.4730, -105.9550	7/5 min, (1.4 fl/min)
9	050723	Pueblo	2359:59	38.2886, -104.5778	2/5 min, (0.4 fl/min)
10	050906	Rocky Ford	0007:00	37.9970, -103.7287	0/5 min, (0.0 fl/min)
11	060621	Jeffco	2311:20	39.8763, -105.0639	0/5 min, (0.0 fl/min)
12	060719	Colo Sprgs (COS)	2352:15	38.9055, -104.7720	1/5 min, (0.2 fl/min)
13	060719	Woodland	2329:01	38.9928, -105.0575	4/5 min, (0.8 fl/min)
14	070902	Oldstage	0052:29	38.7415, -104.9116	9/5 min, (1.8 fl/min)
15	080703	Bear Basin	2242:11	38.1716, -105.2940	4/5 min, (0.8 fl/min)
16	080724	CSU, Ft Collins	0118:15	40.5739, -105.0816	40/5 min, (8.0 f/lmin)
17	080724	Mineral (Contdvd)	Unknown	37.9508, -107.0315	could not be determined
18	090606	Evans	Unknown	40.3788, -104.7366	could not be determined
19	100612	Brown Canyon	2212:38	38.6800, -106.0920	0/5 min, (0.0 fl/min
20	110831	Hermit Lake	2151:58	38.0900, -105.6320	1/5 min, (0.2 fl/min
21	140711	Ute Trail (RMNP)	1904:45	40.3901, -105.6945	2/5 min, (0.4 fl/min)
22	140711	Rainbow overook (RMNP)	2147:49	40.4006, -105.6620	0.0 min, (0.0 fl/min)