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Lightning Safety Efforts in Canada 2009 to 2015

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ABSTRACT

After adopting the lightning safety message “When Thunder Roars, GO INDOORS!” in 2010, Environment Canada has concentrated our efforts on three areas of lightning safety 1) lightning safety videos, 2) a new online lightning display entitled the “Canadian Lightning Danger Map” (CLDM), and 3) a real-time Lightning App for mobile devices. We have produced three bilingual lightning safety videos. The first video, entitled “Lightning Safety” is more general, aimed at debunking three misconceptions of lightning safety; 1) Lightning never strikes the same place twice, 2) Lightning only strikes under a storm cloud, and 3) Trees are safe hiding places from lightning. Our second video introduced the Canadian Lightning Danger Map (CLDM). The map uses information from recent lightning strikes to create high danger zones indicated in red. The danger zones help show where the lightning risk is greatest in the next 10 minutes. It doesn’t show the specific lightning strikes but does show the area when the next strike could occur, based on the current strike. The CLDM can be used in real-time on mobile phones. The CLDM is based on work done by Ron Holle. (Distances and Times Between Cloud-To-Ground Flashes in a Storm 2003). Our third video utilized a live-action, real-life scenario with a girls’ soccer team in a storm situation to emphasize how to use the CLDM. This video portrayed how a referee would use the CLDM to alert the players and clear them off the field to an appropriate shelter. It also shows four of the six ways lightning can kill or injure a person: direct strike, ground current, side flash and upward leaders. Most people believe it is the direct strike that causes the most serious injuries when in fact ground current and side flash cause the most deaths and injuries of any of the methods. These 3 videos were produced in both English and French. An added bonus of having produced the soccer-related video in French is that it would give it an opportunity for an international following in Europe and in French speaking African countries where the game is popular. Finally, a lightning app was built for use during the summer of 2015 in support of the FIFA Women’s World Cup and the 2015 Pan American Games hosted by Canada. The lightning app alerted sporting venue managers if lightning was moving into their area at specific distances from their venues. It showed the live lightning

strikes, the warning areas as well as action statements of what to do to keep safe, depending on how close lightning was to the location of interest. This presentation will highlight the soccer-based lightning safety video, the Canadian Lightning Danger Map, and the Lightning App.

Keywords—lightning safety, lightning messaging, lightning alerting, lightning risk, lightning safety videos

Lightning Safety Efforts in Canada 2009-2015

1. Introduction

Environment and Climate Change Canada (ECCC) developed their Canadian Lightning Detection Network (CLDN) in 1999 in conjunction with the United States’ Vaisala-hosted network. This combined network covers contiguous North America north of Mexico, including eastern areas of Alaska. As the data flowed in, lightning safety efforts were independently managed by each ECCC region in Canada. In 2009 a team from the National Service Office in Kelowna, British Columbia, took the reins of the CLDN and serious work began in consolidating and coordinating national lightning safety efforts.

2. “Lightning in Canada” Webpages

Dedicated national webpages for lightning, “*Lightning in Canada*”, went live on the ECCC website (www.ec.gc.ca) in 2010. The *Lightning in Canada* section included webpages on lightning safety, facts about lightning and lightning stories. Lightning safety videos were added over the years. In 2013 a new lightning display (Canadian Lightning Danger Map) replaced the original flash density maps. Most recently in 2015, a lightning app was tested and used during the FIFA Women’s Cup and the Pan American Games.

To promote the website for the summer of 2011, the CLDN team had a “banner” (top of page advertisement) placed on Weatheroffice (the live weather website of ECCC) that would draw people to the new webpages. The pages are now highlighted annually during Lightning Safety Week.

3. Lightning Safety Efforts

3.1 Lightning Safety Messaging

The first lightning safety effort was the adoption of the lightning safety message “When Thunder Roars, GO INDOORS!” in 2010. This was a change from the 30/30 rule that had been used since the 1990s. It was found that the first “30” of the 30/30 rule was often misunderstood by the public. The 30/30 rule was intended to count the number of seconds between seeing a flash of lightning and hearing thunder. One was to seek safe shelter **before** the count reached 30 seconds. However this was often not the case. People would wait until they counted at least 30 seconds before seeking shelter, which was then an unsafe practice. The lightning safety message “When Thunder Roars, GO INDOORS” provided an easier and safer message to promote.

3.2 French Translation Challenges

As Canada is a bilingual country, an official French translation was needed for the lightning safety phrase. There were a couple of possible iterations of the lightning safety message in French. The initial message on the website was: “Lorsque le tonnerre se met à gronder, il faut vous abriter!” [When thunder begins to rumble, we must take shelter]. This was found to be too cumbersome and hard to remember. A second attempt, “Lorsque le tonnerre gronde, cherchez refuge!” [When thunder roars, seek refuge] was then tried. With help from French teachers and colleagues a third and final official French translation for “When Thunder Roars GO INDOORS!” became, “Quand le tonnerre gronde, RENTREZ VITE!” [When thunder roars, go indoors/ inside fast] in 2011.

3.3 Messaging – Focusing on the Kids

“Lightning safety is best taught just before the start of the local lightning season” (Roeder et al; 2011). In Canada the lightning season is considered to be from late May to early September but lightning strikes are seen on the West and East coasts through the winter. July is the month with the most lightning detected.

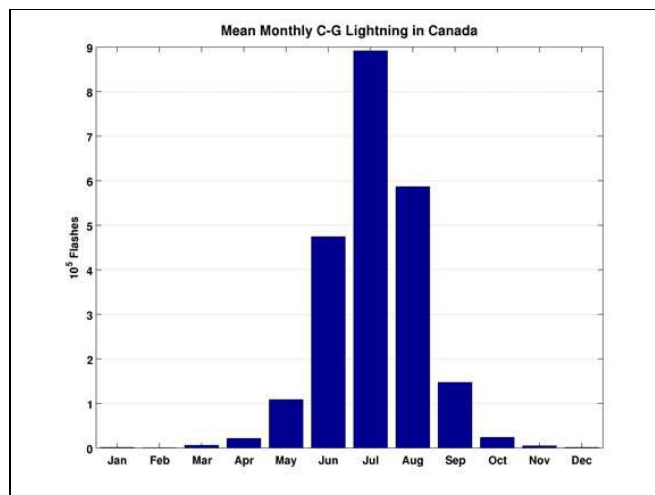


Figure 1. Mean Monthly Cloud to Ground Lightning in Canada

As can be seen by comparing Figure 1 and Figure 2, the amount of lightning in July coincides with the most lightning-related injuries and fatalities.

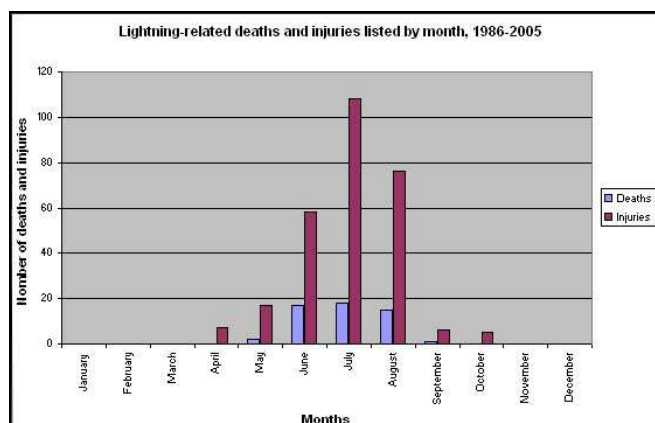


Figure 2. Lightning related deaths and injuries in Canada listed by month 1986-2005

“Children are sometimes much better at lightning safety than adults who may be distracted by their work, recreational activity or their use of electronic devices” (MA Cooper, RL Holle 2010). Teaching children is one of the most effective methods in lightning safety education (Roeder 2011). By promoting the lightning safety saying “When thunder roars, GO INDOORS!” to young children, it is the hope they will remember this phrase for years to come, like adults and childhood nursery rhymes.

Lightning safety tattoos and stickers were developed and printed with the help of the Sky Watchers program of Environment Canada in 2011. They are distributed to the Warning Preparedness Meteorologists (WPMs) as well as

schools and summer camps on an as needed basis and are proving very popular.

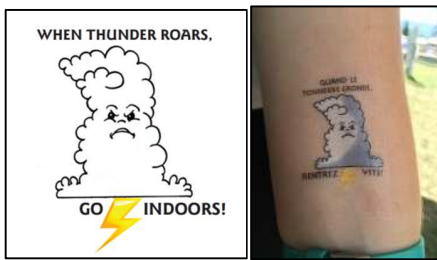


Figure 3. Samples of tattoo and tattoo transferred to arm.

With these factors in mind and with schools still in session, the middle of June was targeted for the national Lightning Safety campaign.

3.4 Lightning Safety Day – Week

Initially Lightning Safety Day was to be in conjunction with Severe Weather Week in May that would highlight a type of severe weather each day of the week. However, as of 2011 it was decided to have a specific Lightning Safety day annually in June instead. Due to technical issues, ECCC website banners had to be posted for no shorter than a one week's duration, so as a result the Canadian media thought it would be Lightning Safety Week, not just a day. This mirrors the situation in the USA where they do have an entire lightning safety week highlighted.

There was great interest from the media, including radio, television and newspapers, all wanting lightning safety-related interviews. The respective regional ECCC Warning Preparedness Meteorologists did most of these media interviews.

Since 2011 Lightning Safety Week has been scheduled during the second full week of June, when lightning safety can be promoted through the schools and fresh in the minds of the media and the general public heading into the season.

3.5 Internal Education

In Canada the Warning Preparedness Meteorologists (WPMs) do almost all of the media interviews, speak with emergency managers, and brief weather watchers. To ensure the lightning safety messaging was broadcast consistently, the CLDN team contacted the WPMs across Canada to review the changes to the messaging in the fall of 2010. Following that initial call, a yearly spring teleconference/webinar was then instituted to bring the WPMs up to date with what was new in the lightning field or in lightning safety messaging. With their input the lightning safety web pages evolved as did the lightning safety week.

4. Canadian Lightning Danger Map



Figure 4. Sample – Canadian Lightning Danger Map

In 2011 the CLDN group decided to develop and implement a new approach to lightning strike maps and lightning safety. At that time the Canadian lightning strike map was a low resolution flash density map which was updated hourly at 25 minutes past the hour. The goal was to provide not just lightning strikes on a map, but something that would convince Canadians that (perceived) non-severe storms are as great or a greater threat as severe storms. To affect lightning-risk behaviour change and protective action, the Canadian Lightning Danger Map (CLDM) was developed in 2012.

The CLDM was based on work by Ron Holle, Martin Murphy and Raul Lopez (Distances and Times between Cloud-To-Ground Flashes in a Storm, 2003). Holle identified that the majority of fatalities occur when lightning frequency was diminished. It has been documented that as many as two thirds of lightning strike victims are killed outside the peak of a storm. The CLDM shows where a strike has occurred but also an area where the next lightning strike could occur, to highlight the danger zone.

The CLDM officially replaced the flash density maps on May 15, 2013. A fact sheet explaining the CLDM and a video showing how to use the new maps effectively were made available on the *Lightning in Canada* webpage. Numerous complaints were received with the replacement of the old flash density product. The most frequent complaint was that the CLDM did not show the frequency of the flashes. People preferred the flash density maps which gave a sense of severity of the strikes. They thought that if the lightning strikes were severe the strikes would be more of a threat than isolated storms. More work had to be done to convince Canadians non-severe storms were just as dangerous as severe

storms when it came to lightning strikes. It only takes one lightning strike to change your life.

It was disheartening to receive so many complaints. A few compliments were received as the maps provided near real-time lightning strike information compared to the flash density maps. It wasn't until the maps were animated in May 2014 that more positive feedback was received. People liked to see where the lightning storm was tracking as it provided useful information for their decision-making.

As the CLDM product evolves it is hoped that update times can be reduced, and that the size of the radii of the alerting circles will also be reduced. This will better inform the Canadian public where the lightning danger exists.

5. Lightning Safety Videos

After attending the 2010 International Lightning Detection Conference/ International Lightning Meteorology Conference (ILDC/ILMC), the CLDN group brainstormed ideas on how to promote lightning safety. Besides the Lightning Safety Week and general education by the WPMs, an idea of producing lightning safety videos was decided upon. Three videos were proposed: 1. Debunking the lightning safety myths; 2. Highlighting lightning safety at a soccer game; 3. Telling personal stories of lightning strike victims and survivors.

As of 2016, the first two videos have been filmed as well as a video entitled "How to use the Canadian Lightning Danger Map".

5.1 Lightning Safety Video #1- Debunking three misconceptions regarding lightning safety

English:<http://www.ec.gc.ca/foudre-lightning/default.asp?lang=En&n=19A02AD8-1>

French:<http://www.ec.gc.ca/foudre-lightning/default.asp?lang=Fr&n=19A02AD8-1>

This was the CLDN team's first foray into video production. It took over a year from conception to filming of the video. In hindsight this video was the shortest turn-around time of all of the lightning safety videos to date. A few of the lessons learned from this were: ensure you have approvals from the highest level of management from the beginning; ensure you have your communications department involved from the beginning; have a deadline, but build in some flex time in case of unforeseen circumstances.

The video concentrated on three myths of Lightning Safety. The myths that were used in the video were based upon the good work of Ron Holle, Mary Ann Cooper and William Roeder and the rest of the Lightning Safety Group in the USA. It was thought that by highlighting three lightning myths, it would bring attention to some falsely assumed beliefs. These are: 1. Lightning never strikes the same place twice. 2.

Lightning only strikes under a storm cloud. 3. Trees are safe sheltering place from lightning.

We used our WPMs as the spokespeople for the respective language versions of the video. While visuals played, they stated facts and dispelled myths about lightning safety.

Myth #1 Lightning never strikes the same place twice. Many people may believe this, so to prove this was false we showed animation of the CN tower being struck several times. The voiceover states that the CN tower gets struck by lightning an average of 75 times per year.

Myth #2 Lightning only strikes under a storm cloud. Many people run for cover when it's raining but don't take action if there's only thunder and lightning. We wanted to show that you are in danger not only when you are under the thunderstorm cloud but also as much as 16 km away from it. We showed an image of lightning striking well beyond the area where it was raining. The announcer stated that in fact 2/3rd of lightning victims get struck either ahead or behind a thunderstorm.

Myth #3 Trees are safe hiding places from lightning. Often people run under a tree to avoid getting wet. However in a thunderstorm, standing under a tree actually increases your risk of being injured or killed. The voiceover states that trees are not safe places, and the video shows to go into a house or car.

We concluded the video with the lightning safety message "When thunder roars, GO INDOORS!" or in French, "Quand le tonnerre gronde, RENTREZ VITE!"

Not only was this EC's first video but also the first time EC used social media to promote lightning safety or in fact any severe weather. Messages were posted on the EC corporate Facebook and Twitter accounts, along with the video being posted to YouTube and of course the *Lightning in Canada* part of the EC website.

5.2 Lightning Safety Video #2 - Lightning Safety on the Soccer Field

English:<http://www.ec.gc.ca/foudre-lightning/default.asp?lang=En&n=54B219E5-1>

French:<http://www.ec.gc.ca/foudre-lightning/default.asp?lang=Fr&n=54B219E5-1>

YouTube <https://www.youtube.com/watch?v=PtgVBPXuUac>

The largest jump in per capita lightning deaths is from children 0-9 years old to youths 10-19 years old. This is presumed to be due to youth doing more outdoor activities without adult supervision along with a lack of awareness of the lightning threat and/or more risk-taking behavior in adolescence (Roeder, Cooper et al, 2011).

It can also be noted that adults may not necessarily take action if lightning is in the area. However, if they are responsible for their children or a team then they are more likely to take appropriate safe action.

We decided to film the video with female soccer players as the FIFA Women's World Cup was being played in Canada June/July 2015. We thought this would make an appropriate video for that time.

The video of Lightning Safety on the Soccer Field was a concept born from the untimely deaths of two soccer players in Canada due to lightning. We also wanted to highlight and show the methods of injury that can occur during a lightning strike or while the surrounding air is being electrically charged. A common misconception is that people believe a direct lightning strike causes the most fatalities. However it has been shown (Cooper 2010) that there are six ways of being injured or killed by lightning. These are by ground current, side flash, contact, upward leaders, direct strike, and blunt trauma. Ground current and side flash make up the highest percentage of people killed or injured. The video shows four of the six methods of injury. By showing that it is not just a direct strike that could injure or kill someone, it is the authors' hope that the soccer players, coaches and referees will take safe action before a lightning strike occurs.

If a storm is approaching, many people take shelter under a tree to get out of the rain. Many soccer fields are lined with trees so the video also makes note to not take shelter under trees. Players, coaches, and/or fans would expose themselves to ground current through the roots and side flash from the trunk of the tree.

The video shows how the CLDM could be used in a real life situation. Most people are able to access the Weatheroffice website on their phones and therefore would be able access the CLDM. This video shows good safety practices by using the CLDM, and includes the factors in communicating risk in a real life scenario. These include:

- Words that attract the attention and indicate the nature and level of the hazard
- Signals used to remind people to go indoors: the visual map of CLDM showing lightning strikes as red circles and the auditory signal of the "thunder roars"
- The consequences of the being exposed to the hazard: how you can be struck or affected by strikes
- Instructions to avoid the consequences of being exposed to the hazard: take shelter in car or building

The video was well received in the Lightning Safety community. Compliments came in from many locations including the USA and Africa. It was thought that this video could be used in other communities and would help people visualize the ways that people can be injured or killed by

lightning. Each year this video will be promoted and shown to the outdoor sports community in an effort to increase lightning safety awareness.

5.3 Lightning Safety video: How to use the Canadian Lightning Danger Map (CLDM)

English:<http://www.ec.gc.ca/foudre-lightning/default.asp?lang=En&n=1EC15260-1>

French:<http://www.ec.gc.ca/foudre-lightning/default.asp?lang=Fr&n=1EC15260-1>

To communicate to the public the change from flash density maps to the CLDM it was decided to develop an explanatory video. The video introduces the CLDM and shows where to find the new map. (Editor's note: the CLDM is now easily found from a link on the City pages of the Weatheroffice website). The CLDM uses information from a recent lightning strike to create high danger zones. These danger zones are red circle-like areas. If there is a red circle over your location you are in a high danger zone.

Again the video ended with the lightning safety message "When thunder roars, GO INDOORS!" or in French "Quand le tonnerre gronde, RENTREZ VITE!"

Social media was used to promote the CLDM video. Messages were posted on Facebook, and Twitter along with the video being posted to YouTube as well as our website. At the time of filming, the link to the CLDM was located under the Alerts menu and therefore was not easily found. There is now a direct link to the CLDM on the City pages of the Weatheroffice website. With the addition of animation to the CLDM, it is believed that more people have accepted this new tool to warn them of the risk of lightning strikes.

6. Mobile Lightning App

A mobile lightning app was built for the Meteorological Service of Canada to monitor outdoor venues during the FIFA 2015 Women's World Cup and the 2015 Toronto Pan American (PanAm) Games. The app allowed venue managers to monitor, in real time, lightning activity in the vicinity of their venue in real time and helped them with their decision making regarding athlete and audience safety. As part of a limited trial the app also included sites of major Canadian airports and Meteorological Service of Canada offices.

6.1 Features

The app was built on a user-centric principle. Users were able to choose a "Location of Interest" that they wished to monitor which was placed at the centre of the map. The app would update immediately when turned on or when a new Location of Interest was chosen. Once on, the app would then update every 60 seconds thereafter. Real time lightning strikes were plotted on the map showing users exactly where the lightning was in relation to them. Strikes would fade out over time giving users of a general idea of how current or old they were.

Circles at a radius of 10 km and 25 km were overlaid on the map as part of a two stage alerting process. The 10 km ring was chosen to approximate the 30/30 rule of lightning safety. It takes 30 seconds for sound to travel a distance of 10 km, the distance which is typically seen as the limit of thunder being audible. The 25 km radius was chosen to alert users that lightning was generally in the area. A counter displayed the number of strikes that were visible on the display. This helped users determine whether lightning activity was intensifying or decreasing, but more importantly it was a means of engaging the user, giving them a reason to come back and check the display to see what was going on.

6.2 Safety Messaging

Alerting messages appeared on screen when lightning was detected within either of the two circles. As can be seen in Figure 5, a *Caution* message was displayed when lightning was detected between 10 and 25 km of the Location of Interest. The message indicated that lightning was nearby and asked that users be prepared to move to safe shelter should lightning approach within 10 km. A *Danger* message was displayed when Lightning was detected within 10 km of the Location of Interest. The message asked users to move immediately to safe shelter which was defined as building or metal roofed automobile and to remain there for 30 minutes until the last rumble of thunder. The issuing of a *Danger* message started a 30 minute countdown timer. The timer would reset to 30 minutes if a new lightning strike was observed within 10 km of the Location of Interest. If no further lightning was observed within 10 km of the Location of Interest, the time would countdown to zero and the *Danger* message was replaced with a *Safe* Message. A *Safe* message was displayed when no lightning was observed or if observed lightning was more than 25 km from the Location of Interest. Users were able to configure their device to vibrate or tone when lightning was observed.

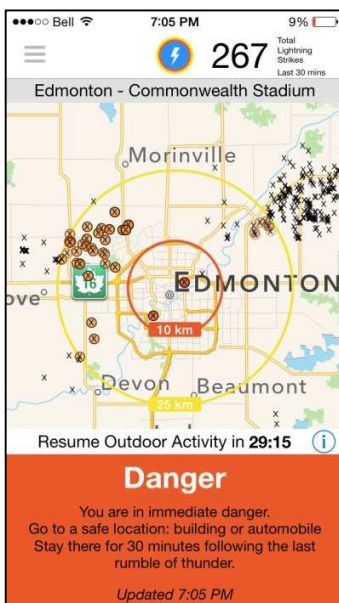


Figure 5. Canadian Lightning App Display

6.3 User Reaction

Users were generally pleased with the app. They appreciated the display of actual lightning strikes which they could see relative to their own location rather than having the chance of lightning expressed as a probability or some other synthetic measure. Venue managers at the Pan Am Games said that it did indeed help them with their decision making. Users at airports pointed out they have shorter return-to-activity times, but that the countdown timer aided them in tailoring their decision making to their own standards and needs.

Environment and Climate Change Canada (ECCC) hopes to have a lightning app accessible to the emergency management community in the future. Ongoing efforts for promoting lightning safety will occur through WPMs and ECCC's annual Lightning Safety Week.

7. Conclusion

Lightning safety efforts have developed over the past six years since the national CLDN team took over. The CLDN team built a well-respected website, produced three lightning safety videos and developed a new map interface that shows the danger of lightning strikes. In addition to internal and external education efforts, a lightning app was developed for select clients of the FIFA World Cup and the Pan American games. Lightning safety awareness has increased but more work still needs to be done to prevent deaths and injuries in Canada from lightning.

8. Acknowledgments

The ECCC lightning safety program and messaging was developed with the help of Vaisala and the US Lightning Safety group especially Ron Holle, Mary Anne Cooper, and William Roeder. Special mention should be made to Environment and Climate Change Canada colleagues Brian Mills for his assessment of lightning related injuries and fatalities in Canada, Matt MacDonald and Rene Heroux for their help in developing the lightning safety videos and Lisa Vitols for her recommendations as a social scientist pertaining to lightning safety and messaging.

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