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WEATHER & SOCIETY ADVISOR

A Study Group of The Interdisciplinary Centre on Climate Change IC3

The Reflection Pool

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If you have weather stories, ideas, photos or expertise that you would like to contribute to future newsletters, please contact Amber Silver at a2silver@uwaterloo.ca

UNIVERSITY OF WATERLOO

The summer of 2013 has been a record-breaking season for severe weather in Canada. In June, torrential rainfall caused serious flooding across wide swaths of southern and central Alberta that lasted for over three weeks. Preliminary damage estimates suggest that the cost of these floods could exceed $5 billion dollars, making it one of the costliest disasters in Canadian history. In June, an isolated storm that dropped over 120 mm of rain in parts of the Greater Toronto Area, which resulted in a flash flood that stranded motorists, disrupted public transportation, and caused substantial economic damages. Other parts of Ontario have also seen active weather this summer, with the fourteenth tornado of the season recently confirmed in Arthur, Ontario. Ontario typically experiences 12 tornadoes during the summer severe weather season, which extends from late April until early October. Severe storms also resulted in extensive wind damage in Kitchener-Waterloo, Cambridge, and other communities in southwestern Ontario.

This issue of the Canadian Weather and Society Advisor contains articles that crosscut a wide variety of issues pertaining to summer severe weather. The first article relates a Canada wide study on the performance of pervious concrete pavement, an issue of particular relevance for those individuals interested in the influence of Canada's freeze-thaw cycles on roads and highways. Next, an article on the role of storm chasers as weather spotters outlines the allure (and danger) of tornadic storms. A second article on storm chasing outlines the significant danger of lightning as a summer hazard in Canada, and the safety precautions that are necessary when chasing severe storms. Finally, in the Student Corner a Geography & Environmental Management student explains why she chose to examine Environment Canada's storm damage survey tool for her undergraduate thesis research.

We hope you enjoy reading the second quarterly edition of the Canadian Weather and Society Advisor.

Sincerely,

Jean Andrey, Brian Mills, Michelle Rutty, and Amber Silver

Pervious Concrete

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Pervious concrete pavement offers a sustainable solution to urban growth challenges by providing a stormwater management alternative. As noted in Figure 1, it is very permeable. The benefits of pervious concrete pavement are experienced by the environment and community. In order for pervious concrete pavement to have extensive use in Canada, maintenance needs must be understood and proven.

Figure 1: Pervious Concrete Pavement

Maintenance may not always be required but is often needed to maintain adequate performance of pervious concrete. The Centre for Pavement and Transportation Technology (CPATT) at the University of Waterloo, Cement Association of Canada and industry members have partnered to carry out a Canada wide study to evaluate the performance of pervious concrete pavement in the Canadian freeze-thaw climate. The study involved the design construction and monitoring of five sites across Canada. These are located in British Columbia, Ontario, and Québec, as noted in Figure 2. The combined laboratory and field evaluation allowed for direct improvements to the construction and design of these sections. As noted in Figure 3 and Figure 4, samples of pervious concrete are run through the laboratory and evaluated for freeze-thaw damage and they are exposed to typical maintenance to evaluate their long-term performance.

Figure 2: Field Site Locations

Maintenance methods have been evaluated at four of the five test sites that have been constructed across Canada in this project. In general, the results in indicate that it is essential to agitate the debris in the voids in order to remove as much as possible. This can be achieved by sweeping either with a stiff broom or street sweeper. Following sweeping, power-washing and vacuuming have both been found to be effective. Simply rinsing the surface using a garden hose has also improved the permeability of the field site. An important detail to note is that sites that start with a low permeability cannot generally be renewed to a high level of permeability.

Figure 3: Testing Freeze-thaw Durability of Pervious Concrete

Figure 4: Pervious Concrete Slabs

The following findings have been made on this project:

- The initial permeability of the pervious concrete pavement will depict future performance
- Permeability is not likely to be renewed to original condition
- Maintenance should be performed before the start of the freeze-thaw season to minimize raveling distress prompted by expansion of debris on the surface.

Dr. Susan Tighe is currently a Canada Research Chair in Pavement and Infrastructure Management, Director of Centre for Pavement and Transportation Technology (CPATT), Norman W. McLeod Professor in Sustainable Pavement Engineering and a Professor of Civil Engineering at the University of Waterloo. In 2007, she was named one of Canada's Top 40 Under 40 for her leadership and vision with respect to the Canadian Transportation Community. She is an author of over 300 technical publications in pavements and infrastructure and is involved in a number of research projects.

Upcoming Opportunities and Events

- 2 Graduate Student Fellowships offered by the Marine Environmental Observation Prediction and Response Network (MEOPAR) Network of Excellence. http://meopar.ca/opportunities/memorial-university-graduate-student-fellowships-available/

- University of Waterloo, Faculty of Environment's 2013 TD Walter Bean Lecture in the Environment: A Delicate Balance: Fighting poverty in the age of climate change. 2, October 2013. Waterloo, Ontario. https://uwaterloo.ca/environment/events/tdwalterbean

- American Meteorological Society's 10th Symposium on Fire and Forest Meteorology, 15-17 October 2013. Bowling Green, Kentucky, USA. http://www.ametsoc.org/meet/fainst/201310fireforest.html

- The Center for International Governance Innovation's The Public Life of Climate Change: The First 25 Years. 24, October 2013. Waterloo, Ontario. http://www.cigionline.org/events/public-life-of-climate-change-first-25-years

- 1st International Workshop on Landslides in Sensitive Clays, 28-30 October 2013 at Laval University, Quebec City. http://www.iwlsc.ca/

- 10th Annual Canadian Risk and Hazards Network Symposium, 5-8 November 2013. Regina, Saskatchewan. http://crhnet2013.mhrisk.ca/

- Canadian Water and Wastewater Association Climate Change Workshop, 27-30 November 2013. Ottawa, Ontario. http://www.cwwa.ca/windowonottawa_e.asp

- The World Weather Open Science Conference, 15-21 August 2014. Montreal, Quebec. http://www.wwosc2014.org/

Environment Canada's Weather radio program is an automated warning delivery service that provides continuous, location-specific broadcasts of weather information whenever severe weather poses a risk for your region. For more information on the program or for information on obtaining a weather radio, please visit: http://www.ec.gc.ca/**weatheradio**

Ask a Professional: A Day in the Life of a Storm Chaser

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Patricia specializes in natural hazards and risk assessment. She has been a storm spotter and chaser in both Ontario and the US for over 13 years.

My path to emergency management began with a strong interest in severe weather and public safety. While various hazards are part of my duties, severe weather is a major focus. My hobby as an experienced storm chaser has given me additional perspective on the public safety issues surrounding tornadoes. I did not actually intend to become a storm chaser but living close to tornado alley at the time, inspired me to become a SKYWARN spotter. Overtime I discovered a talent for pinpointing potential tornadic activity, and I began to head out to observe storms to provide information to SKYWARN and CANWARN.

Tornadoes are a spectacular natural vision, but their danger must never be underestimated. Being a storm chaser requires a high level of awareness of the situation and safety, a willingness to stay well away from the danger zones resulting in less dramatic photographs and video, being willing to stay on the phone with CANWARN, extensive knowledge about storms, and a willingness to help those who may have been impacted.

Trained spotters are vital for warning systems. While indicators that a tornado is possible may be visible on radar, the tornado itself is not. Storm spotters confirm the presence, direction and damage potential, and provide crucial information to meteorologists. Most storm chasers are storm spotters. Since they actually pursue severe weather, they are more likely to have greater experience identifying weather features correctly (although there are exceptions).

Chasing has gained considerable exposure in recent years due to media, both traditional and social. While this has increased information provided to warning agencies and increased public awareness of severe weather, it has also fuelled popular misconceptions. These misconceptions could place inexperienced chasers and the public at risk if videos and photographs taken by storm chasers are not put into context.

Figure 1: Photo is an example of a tornado taken in Nebraska that does not have a 'classic' funnel

Without proper context, never assume that video or photo sources have the necessary experience or even take proper safety precautions. There is no certification process; anyone can call themselves a storm chaser. This has resulted in a number of images taken while under considerably dangerous conditions (such as directly under a rotating wall cloud). This can cause incorrect assumptions regarding the safety of conditions similar to those seen in various images. It is also important to remember that the use of zoom lenses is common, and safety is paramount.

Experienced storm chasers know storm structure and the locations of the most dangerous conditions, and are mindful that conditions can change suddenly. Even stopped a safe distance from a developing tornado multiple escape routes are planned. It is also not always obvious in media that the storm chaser is not (and should never be) in the path of the tornado. Tornadoes can move fast and this is a risk not worth taking, especially since these storms can create numerous other hazards, like lightning, damaging winds, flooded roads due to intense rainfall and hail.

Always be aware of dangers severe weather poses. Media only shows half the story, and remember that safety is paramount.

Lightning as a Summer Hazard

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David is a professional photographer and storm chaser based out of Niagara Falls, Ontario.

The 2013 storm season has been one of the most impressive Brian Chapman and I have seen and experienced in our 13 years of storm chasing in Ontario, although, the number of tornadoes is right on pace for the yearly average. Super-cells have been numerous all across the region. This season we have seen everything from rotating wall-clouds, funnel clouds, tornadoes, flooding, golf-ball sized hail, and including the main cause of damage across Ontario: intense straight-line winds. Despite the severe weather we have had this year, we have been fortunate that there have been no deaths in Ontario as a result. There is one more element of danger that comes with every thunderstorm that hits our province that is often over-looked and that element is lightning. Environment Canada doesn't issue severe thunderstorm watches for storms that just produce lightning because if they did, they would likely have a watch in place every day during the summer, whether it be in the southern, northern or eastern part of our province. People would then become numb to it and ignore the watches on days that have all the severe ingredients in place, namely lightning, hail, strong winds and possible tornadoes. My main focus since I have started storm chasing has been to capture lightning and share my experiences to inform people when a storm could produce lightning, how to recognize it and how to stay as safe as possible.

They say the odds of being struck by lightning are one in a million. That being said, I believe the odds increase when around and under a thunderstorm. July is the month that sees the most lightning across not just Ontario but the rest of Canada as well. The increase in lightning coincides with hot and humid air-masses that cover most of Canada during this month. July 2013 was no exception across Ontario. This was one of the worst seasons I've seen for storms located in one area and often producing lightning landing distances of 15 to 20 kilometres away from the storm centre. This is known as out-of-the-blue lightning. I have watched these occurrences on radar as well as in person. It makes documenting a storm a lot more difficult when you have to watch for lightning so far away from the storm. I had one of my closest calls this season while photographing a storm on the edge of Beamsville, Ontario. While we watched the storm hit between Stoney Creek and Grimsby, we saw lightning strike in Beamsville, roughly 20 kilometres away from the rain-core. I had just set up the video camera and was getting ready to get back into my vehicle when lightning struck behind us within 100 metres. This was the closest call I have ever experienced while outside of the car. I do 90% of my lightning photos from inside the car. The remainder are done when storms are a great distance away.

Figure 1: A lightning strike from the Ontario severe weather outbreak that hit on July 19, 2013.

There are three main types of lightning that we can see during a thunderstorm. One is intra-cloud (IC) where lightning strikes from one part of the cumulonimbus and strikes a different section of it. The second is cloud-to-cloud (CTC) where lightning travels from one storm cell to another storm without striking the ground. The third type which actually affects us on the earth's surface is cloud-to-ground (CTG). Out of these three forms of lightning, cloud-to-ground lightning is the most studied because it is the easiest to view. Even though cloud-to-cloud and intra-cloud lightning are more common, they're more difficult to see which makes them more challenging to study.

There are two variations of cloud-to-ground lightning. One is the negatively charged CTG and the other is the far more powerful positively charged CTG. Thankfully, the positively charged lightning is a lot less common than the negatively charged bolt. The positively charged CTG starts in the highest part of a thunderstorm and has the farthest reach out of any single strike. It is the type that can occur when you have a clear blue sky over head and still have lightning strike you, which is why it is called out-of-the-blue. It is generally recommended that you stay in a

shelter until 30 minutes after you hear the last rumble of thunder because of the distance lightning can reach.

Figure 2: On the left of this photo is a positive lightning strike. To the right is the more common negative strike.

Figure 3: The above photo shows intra-cloud lightning over Lake Ontario.

Figure 4: Cloud-to-Cloud Lightning over Stoney Creek, Ontario

One of the early warning signs of possibly being targeted by lightning is if you have a sudden nauseous feeling when there is a storm in the vicinity. Another sign is if your hair starts to stand up straight. Even though I use this method, it is still not a great warning or 100 percent reliable. Most lightning strikes without warning, which is why I am often in the car before the storm gets too close. I have had one experience in my lifetime where, thankfully, we did get a warning and it picked a different target a distance away from where people were gathered. This happened while waiting for a storm to pass during a break in a game of baseball. My team-mate's hair started to stand straight up right beside me. I was 12 at the time. My dad, who was one of the coaches, quickly noticed this and told us and everyone else to get into their vehicles. Lightning struck just on the other side of the arena complex and the thunder was instantaneous. It was an incredibly bright flash and came out of the back end of the storm, which is where, most often than not, the positively charged lightning strikes originate.

When lightning is in your area, the best place to be is indoors, whether it be in a car with the windows up or in a house. While in a house, it is important to stay away from windows, or anything plugged into electrical outlets. It is recommended to also avoid running the tap or taking a shower during a storm because the electrical current from a strike can travel through the pipes. I recently heard of a woman running water in the sink when lightning struck and she felt a weird sensation go through her body. She went to bed that night and woke up the next day with the whole right side of her body paralyzed. Most of us now have wireless phones but back in the days when landlines were the norm, individuals were killed in their homes by lightning charges travelling through the phone lines, connecting with anyone talking on the phone at the time. My great-grandparents used to live in a house on a hill and it was not uncommon for their phone to be blown off the wall during a thunderstorm due to lightning. The electrical wiring in homes is one of the easiest routes for lightning to follow. My neighbour's house was struck by lightning and he said it hit every electrical outlet in the living-room.

A portion of my work requires me to be out in thunderstorms but I do take every safety precaution I can. I have had lightning strike three times within 20 metres of the car. All three times, I was in the car with the windows up. That being said, I realize mother nature is unpredictable, which is why I continually research new ways to look after safety in the field.

The day before this article was to be sent in on August 8, 2013, something amazing happened for our storm team. We documented our first ever tornado. It touched down just east of Arthur, one of three confirmed tornadoes on that day in Ontario. I can use the word amazing because no one was hurt and it led to some beautiful photographs. It was rated an EF-0 by Environment Canada with winds ranging between 90 to 130 kilometres an hour.

Student Corner: Undergraduate Research on Severe Weather

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Sara is an undergraduate student at the University of Waterloo who has studied Geomatics and physical geography over the last four years. She also has a keen interest in severe weather and its impacts on society.

Weather is a topic that anyone can relate to. It's used as an ice-breaker in conversations; you don't have to be an expert to discuss it, and it affects Canadians every single day. Decisions are made about the weather - what am I going to wear? Is it a good day to spend outdoors? Do I have to cancel my plans because of extreme weather conditions? The conversations that people have with each other about their weather experiences is what initially got me interested in weather, climate and society. My interest continued to grow after learning about extreme weather events, how people are affected by them and how decisions are made in response to these events in class.

Tornados have always been a favourite of mine; to talk about, learn about and watch. Many people have a fascination with tornados and chase them just for the thrill of it. They're a mysterious occurrence; often difficult to predict and track, leaving behind a path of destruction. When I was deciding on a topic for my fourth year thesis, I decided that I'd like to choose one that I haven't really had the opportunity to explore in the courses offered at UW and one that I'm really interested in. So what better research topic than that of tornados? I decided to conduct research on the visual storm damage assessment tool that is utilised by Environment Canada to determine the occurrence of a tornado and its magnitude, and classify it according to the Enhanced Fujita Scale. Knowledge about how this tool is implemented by Environment Canada is not well known, thus providing an excellent opportunity for me to research it and educate myself and others about it.

My research methods involve qualitative interviews with professionals who are involved with using the tool, as well as observing, first-hand, the implementation of the tool at sites in Southern Ontario recently damaged by severe weather (hopefully a tornado!). This is an exciting topic because it allows me to conduct field research (depending on the occurrence of severe events during the summer of 2013), meet professionals who I share an interest with, and learn more about how severe weather (specifically tornados) impacts Canadians.

Worth Reading

Jeuring J and Becken S. 2013. Tourists and severe weather--An exploration of the role of 'Locus of Responsibility' in protective behaviour decisions. *Tourism Management* **37**: 193-202.

Cheng VYS, Arhonditsis GB, Sills DML, Auld H, Shephard MW, Gough WA, and Klaassen J. 2013. Probability of tornado occurrence across Canada. *Journal of Climate* **e-View**: doi: 10.1175/JCLI-D-13-00093.1.

Durage SW, Wirasinghe SC, and Ruwanpura J. 2013. Comparison of the Canadian and the US tornado detection warning systems. *Natural Hazards* **66**: 117-137.

Stevens MR and Hanschka S. 2013. Multi-level governance of flood hazards: the case of municipal flood bylaws in British Columbia, Canada. *Natural Hazards Review* **e-View**: 10.1061/(ASCE)NH.1527-6996.0000116

Henderson SB, Wan V, and Kosatsky T. 2013. Differences in heat-related mortality across four ecological regions with diverse urban, rural and remote populations in British Columbia. *Health & Place* **23**: 48-53.

Nelson AL, Vorstenbosch V, and Anthony MM. 2013. Assessing fear of storms and severe weather: validation of the Storm Fear Questionnaire (SFQ). *Journal of Psychopathyology and Behavioural Assessment* **e-View**: 10.1007/s10862-013-9370-5.

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