NORTHERN HAIL PROJECT

2022 2023

ANNUAL REPORT

Western Engineering

CONTENTS

LAND ACKNOWLEDGMENT

The Northern Hail Project (NHP) and partner institutions acknowledge the use of indigenous ancestorial lands for research.
Western University is committed to strengthening and building relationships with indigenous communities across Canada. The following sections acknowledge the lands on which our research is conducted.

ALBERTA

Olds College is on the traditional territories of the Niitsitapi (Blackfoot) and the people of the Treaty 7 region in Southern Alberta, including the Siksika, the Piikani, the Kainai, the Tsuut'ina and the Stoney Nakoda First Nations. This area is also home to Mètis Nation of Alberta, Region III. The University of Alberta is located on the traditional territories of the Cree, Blackfoot, Métis, Nakota Sioux, Iroquois, Dene, and Ojibway/Saulteaux/Anishinaabe nations; lands that are now known as part of Treaties 6, 7, and 8 and homeland of the Métis. The city of Calgary is on the ancestral territory of the Blackfoot Confedecacy, made up of the Siksika, Piikani, Amskaapipiikani and Kainai First Nations; the Îethka Nakoda Wîcastabi First Nations, comprised of the Chiniki, Bearspaw, and Goodstoney First Nations; and the Tsuut'ina First Nation. The city of Calgary is also homeland to the historic Northwest Métis and to the Otipemisiwak Métis Government, Métis Nation Battle River Territory, Nose Hill Métis District 5 and Elbow Métis District 6.

ONTARIO

Western University is located in Dish With One Spoon Treaty Territory, the ancestral territory of the Anishinaabek, Haudenosaunee, Lūnaapéewak and Chonnonton Nations.

NORTHERN HAIL PROJECT: ABOUT US

The Northern Hail Project (NHP), founded in 2022 at Western University with seed funding provided by the University, is intended to reinvigorate hail research in Canada. Hail is becoming an increasingly costly problem, with escalating losses every year. This was exemplified by Canada's first billion-dollar hailstorm, which occurred in Calgary in June of 2020. The NHP represents the first major research effort on the subject of hail and hail impacts in Canada since the Alberta Hail Projected ended in 1985, nearly 40 years ago. Significant gaps in our understanding of hail remain, and these need to be addressed for Canada as a whole to respond to the escalating impacts from this hazard.

The NHP works to better detect the occurrence of damaging hail across Canada, improve forecasting and nowcasting techniques, and to support development of damage prevention and mitigation measures. Even fundamental considerations for hail damage, including understanding hailstone aerodynamics and how hail impacts result in differences in damage to important assets (e.g., buildings versus crops) remain under-explored. To improve preparedness and support critical decision making, the NHP studies both the historical and future climate of hail occurrence in Canada.

NORTHERN HAIL PROJECT: MISSION, VISION, OBJECTIVES

MISSION

To advance our understanding of the meteorology, climatology and impacts of damaging hail across Canada.

VISION

- That through our research, Canadians will become better informed and more resilient to the impacts from damaging hail.

- That resilience to hail impacts will be achieved through every step of the risk mitigation process, from improved climatology – knowing where and when damaging hail can occur – through to changes in forecasting and nowcasting techniques, and finally through enhanced building codes and infrastructure standards to increase asset resilience, including the challenges presented by a rapidly changing climate.

- The NHP will also help to train the next generation of severe weather scientists across Canada through unique opportunities and real-world experiences.

OBJECTIVES

1. Capture meteorological data associated with the occurrence of SCS and associated damaging hail (and wind-driven hail) events using a wide range of collection methods and instruments, including hail monitoring equipment, radar data, and field work;
2. Understand the aerodynamics of hailstones and its effect on fall speed;
3. Develop remote sensing and on-the-ground methods to conduct advanced hail damage assessments and field surveys, to determine impacts to the built (buildings and other infrastructure) and natural (crops, trees and forests) environments;
4. Identify and categorize all damaging hail events in Canada by integrating new data sources (including social media) to develop an observation-based hail climatology;
5. Better understand hailstorm environments, and in collaboration with Environment and Climate Change Canada, improve numerical models for forecasting, 'nowcasting' (forecasts out to one hour), and issuing warnings for damaging hail; and
6. Develop damaging hail hazard, vulnerability, and catastrophe models for Canada.

NORTHERN HAIL PROJECT: LEADERS' MESSAGE

Following the success of the Northern Tornadoes Project, the Northern Hail Project (NHP) was launched in the spring of 2022. This was made possible thanks to generous financial support from the University of Western Ontario as well as our successful application for five years' funding through an NSERC Alliance Grant.

The formation of the NHP marks the end of a nearly 40-year period with no dedicated hail research program in Canada. This renaissance comes at a time when we are seeing an acceleration in insured losses from hailstorms in Canada and against the backdrop of Canada's first billion-dollar hailstorm, which hit Calgary on 13 June 2020.

Our mandate is ambitious and requires capturing high-fidelity ground truth data. In the short term, we will focus on collecting hailstones within hailswaths, conducting forensic-level hail damage surveys, and documenting the extent of hailswaths using unmanned aerial vehicles (UAVs). In the long term, these ground truth data will feed into key applied scientific and decision support products such as building Canada's first comprehensive hail climatology, developing hail risk models, and improving our understanding of the atmospheric conditions that precede damaging hailstorms. The data will be used to develop new and improved radar tools for identifying hail in thunderstorms and providing reliable estimates of hail size on the ground. These data will also be used to validate state-of-the-art weather prediction models used to forecast severe thunderstorms. Ultimately, these advances in the science will allow for better hail warning systems. Additionally, forensic damage surveys of both agricultural land and urban areas will determine how urban infrastructure performs during hailstorms, as well as how people and crops are affected. The public and other stakeholders, such as emergency managers, will have access to our data through the NHP's open data portal.

This systematic approach to data collection, analysis, and interpretation will help create more resilient communities and infrastructure systems by identifying the communities and Indigenous reserved lands that are exposed to hailstorms and by studying how adverse impacts could be mitigated through proactive approaches. The national hail climatology will support improved risk and catastrophe models for the insurance sector and design professionals, and will assist with the mitigation of risk to renewable energy infrastructure that is sensitive to hail.

With the NHP firmly established and our first two summer field seasons complete, we are happy to present our first annual report for the years 2022 and 2023. The first two years of the project were a whirlwind of activity. The NHP was officially launched in April 2022, and on 1 June we already had our first team, comprising three members, in the field in Alberta collecting data.

During our first summer, we deployed a network of 30 hailpads in "Hail Alley". We were very lucky in that several hailpads were hit multiple times. Over 800 hailstones were collected and later processed. A major accomplishment in 2022 was when the team found Canada's new record largest hailstone near Markerville, Alberta. We were also pleasantly surprised at the great interest the media showed in our work.

The 2023 season saw a marked increase in the size of our team in Alberta, with ten members, as well as the formation of the new hail damage survey and UAV teams. We conducted our first forensic-level surveys on the prairies in 2023, and also conducted test flights of UAVs equipped with multi-spectral sensors, including a thermal sensor. We also expanded our hailpad network to 40 sites. We collected over 1,000 hailstones and conducted 10 forensic damage surveys. A major milestone was accomplished with the installation of Canada's first hail-monitoring network, comprising 19 stations, in the city of Calgary. This is one of a handful of such networks in the world. In a world first, we assisted Dr. Joshua Soderholm from the Australian Bureau of Meteorology in releasing a hailsonde into the updraft of a severe hailstorm.

The future of hail research in Canada has never looked brighter and we are excited to share the fruits of our labour in 2022 and 2023 with you in this report.

Julian Brimelow and Greg Kopp

NORTHERN HAIL PROJECT: IMPACT AT A GLANCE

During the NHP's pilot year, the team sampled 38 storms, collecting 55 bags of hail with three people and one vehicle in the field.

The following season in 2023, the team expanded to ten people and three vehicles. 23 storms were sampled, and 104 bags of hail were collected.

During the 2022 field season, the team documented and collected Canada's largest hailstone to date. This hailstone, found near Markerville, AB, had a maximum diameter of 12.3 cm and a mass of 292.7 g.

The NHP's network of 30 hail monitoring stations was installed in 2023, covering the city of Calgary and some areas to the north of the city.

A network of 34 (2022) and 40 (2023) hailpads was installed in "Hail Alley", covering over 400 km^2. Software to automate the analysis of impacted hailpads is being developed.

Ten undergraduate interns were trained and participated in data collection.

Over 1,300 hailstones collected in 2022 and 2023 were measured, weighed and photographed.

International collaboration and media interviews were conducted across both 2022 and 2023 seasons.

NORTHERN HAIL PROJECT: THE TEAM IN 2022 AND 2023

Leadership

NHP Executive Director
Dr. Julian Brimelow

ImpactWX Chair in Severe Storms Engineering
Prof. Gregory Kopp

Principle Investigators on the NSERC-Alliance Grant
Drs. Kopp, Brimelow, Sills, Hanesiak, Goda, Newson and Najafi.

Staff

Meteorological Observation Instrumentation
Dr. Connell Miller

Meteorological Research Staff
Simon Eng

Field Coordinators
Francis Lavigne Theriault (2022)
Devon Healy (2023)

Western Libraries
Liz Sutherland
Jordan Fuller

Students

Graduate Students
Sudesh Boodoo
Francis Lavigne Theriault

Field Project Interns

2022 – Mark Gartner, Chris Rattray.

2023 – Adan Ahmed, Sonia Baxby, Jordon Charlette, Ben Chernesky, Mark Gartner, Jay Lesyk, Peter Macdonald, and Madelaine Richer.

NORTHERN HAIL PROJECT: OUR PARTNERS

The NHP is proud to work with partners and funders in this research endeavour. These partners provide funding, research support and collaboration through grants, guidance and resource sharing. Western University partners with the University of Manitoba, York University, Pelmorex's The Weather Network, CatIQ and closely collaborates with Environment and Climate Change Canada and several Canadian and international universities and research centers on this Project.

University of Manitoba

CatIQ™ Catastrophe Indices and Quantification Inc. a PERILS company

The Weather Network

NSERC ALLIANCE - MITACS ACCELERATE PROGRAM

NSERC CRSNG Mitacs

Funding is provided through the NSERC Aliance - Mitacs Accelerate program.

INSTITUTE FOR CATASTROPHIC LOSS REDUCTION (ICLR)

Institute for Catastrophic Loss Reduction

Building resilient communities

The Institute for Catastrophic Loss Reduction (ICLR) provides core funding as well as guidance from member insurance companies on the current needs of the industry, including identifying priority gaps in research.

INSURANCE INSTITUTE FOR BUSINESS AND HOME SAFETY (IBHS)

Insurance Institute for Business & Home Safety®

The NHP is also working closely with the Insurance Institute for Business and Home Safety (IBHS), sharing ongoing research and collaborating on laboratory and field experimentation.

ENVIRONMENT AND CLIMATE CHANGE CANADA (ECCC)

Environment and Climate Change Canada

The NHP also recognizes partners and collaborators at Environment and Climate Change Canada's (ECCC) Science and Technology (S&T) Branch, specifically Daniel Michelson, Dominique Brunet, Bill Burrows, Sudesh Boodoo, and Jason Milbrandt.

WEATHERLOGICS AND INSTANT WEATHER

WEATHERLOGICS

Instant Weather™

The NHP has also closely partnered with WeatherLogics and Instant Weather (IW). These companies are on the leading edge of providing Canadians with improved forecast products and methods, and the NHP has been working with them to help develop these products as well as share critical information on severe weather events across Canada.

NORTHERN HAIL PROJECT: BACKGROUND

WHY STUDY HAIL?

The Northern Hail Project (NHP) addresses key data and knowledge gaps for hail and advances our understanding of hail occurrence, impacts and damages across Canada in order to, ultimately, develop/improve means for managing the associated risks and reducing our vulnerability to hail. A unique ambition of the NHP is to systematically capture all possible data related to damaging hail events across Canada using a wide range of methods and tools. Our approach will eventually enable us to assess the impacts of damaging hail events on infrastructure and people exposed to extreme weather-related hazards. The resulting databases, observational and analytical climatologies, and risk models for damaging hailstorms can be used for developing adaptation measures, which may be particularly beneficial for isolated and marginalized communities as well as urban centres.

PERSONNEL

As part of the NSERC Alliance - Mitacs Accelerate Grant, the NHP will train 55 highly qualified personnel, consisting of one Postdoctoral researcher, 10 doctoral students, seven master's students, and 37 summer research interns, offering them the hands-on experiences needed to fill gaps in industry related to the impacts and assessments of severe storms. Trainees will operate and deploy equipment, and gain valuable data analysis and coding skills. They will exploit the vast amount of measured data for maximum scientific and societal benefit. Collectively, trainees will acquire multi-disciplinary capabilities and experiences that position them for future opportunities dealing with extreme weather and its impacts.

DATA COLLECTION

The detection and characterization of damaging hail from hailstorms are essential to assess storms, understand hail growth mechanisms, improve forecasts, and mitigate damage. Detailed data on the occurrence, size distribution, shape, density, and hardness of hailstones are required for these purposes, as well as for assessing hail damage and the properties of hailswaths. There are significant data and knowledge gaps in our understanding of hail, hailswaths, and their variability across Canada, and around the world. The lack of hail data is a large part of this issue, with perhaps the most crucial component of hail research, determination of hailstone characteristics, having been neglected since the Alberta Hail Project ceased in 1985 (Sills and Joe 2019). Consequently, there is a critical need for high-quality hail data. There are multiple technical challenges: hailstones and hail swaths have a high spatial and temporal variability, and they can occur anywhere including inaccessible areas, and hail melts quickly (Brimelow 2018).

To capture detailed information, multiple mobile teams must be deployed to collect, measure, and preserve hailstones. Such techniques have been developed over the past decade in the United States for actively seeking out hailswaths, including projects SHAVE (Ortega et al. 2009) and HailStone (Blair et al. 2017).

Figure 1: Cross-section of a hailstone collected in 2023.

NORTHERN HAIL PROJECT: OPERATIONS

As of 2023, the NHP's field operations comprises of three separate teams, each with a unique goal that contributes to the NHP's overall objectives. The teams are based in Olds, Alberta but operates across a large part of the province (see Fig. 2). The teams deploy anywhere in this area to intercept hailstorms in real time. Appendices A and B show a list of missions conducted in 2022 and 2023.

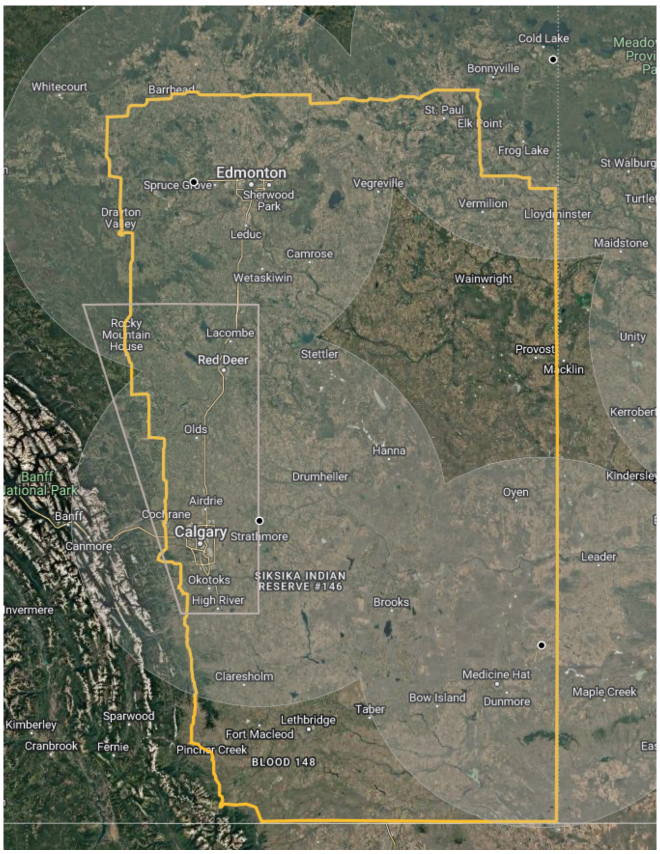


Figure 2: The NHP study area (yellow polygon).

HAILSWATH TEAM

The main duties of the Hailswath Team are to lead the mission, select sampling locations, determine the extent of the hailswath across a given transect, and to collect and preserve representative hail samples as soon as possible after hail has fallen.

The Hailswath Team attempts to sample hail in the most intense portion of the hailswath, while measuring the bounds of the entire swath (see Fig. 3). A 10 metre by 10 metre area is surveyed, with team members collecting a representative sample of stones, including not only the largest but also reflecting a variety of shapes and sizes. This sampling critical for understanding the various hailstone characteristics which can be found at individual locations under the same hailstorm. One team member enters data while the others collect samples, which are then bagged using sample codes and placed in portable freezers as soon as possible to reduce the impacts of melting. The Survey123 ArcGIS application is used to catalogue and geolocate hail sampling locations, using a form that records the time, location, maximum hail dimensions, and collection bag tracking codes, as well as imagery of the hailstones themselves for later analysis. During the 2023 storm season, all mission vehicles were equipped with freezers, increasing the available space for sample collection.

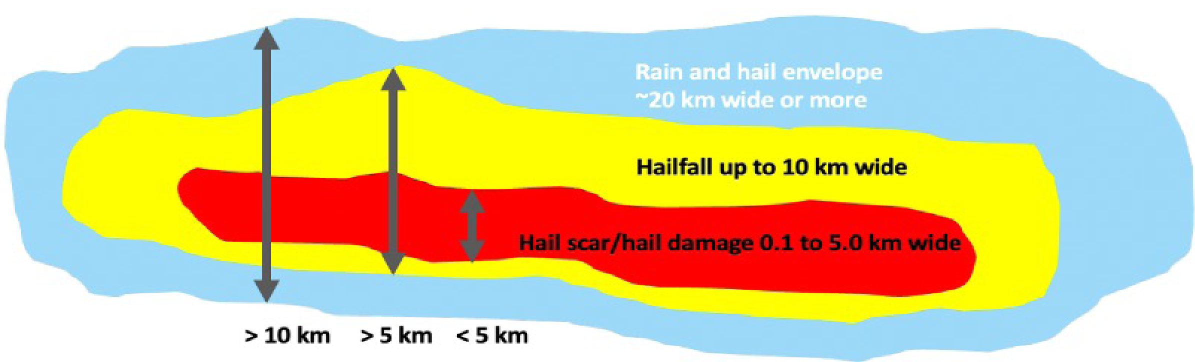


Figure 3: Schematic showing the idealized distribution of the precipitation swath from a convective storm. The Hailswath Team collects hail in the red area, though the bounds of the hailswath (yellow area) are identified when possible.

A NEW CANADIAN RECORD:
THE AUG 1ST, 2022 MARKERVILLE, AB HAILSTONE

During the NHP's first/pilot year of operations in the summer of 2022, the Hailswath Team intercepted a powerful storm that produced a large number of "giant" (i.e., 10 cm or larger) hailstones.

In the vicinity of the hamlet of Markerville, Alberta (located southwest of Red Deer, Alberta), the team collected a hailstone with a maximum diameter of 12.3 cm and a mass of 292.7 g, making it the largest hailstone on record in Canada. This exceeds the previous record set on August 27, 1973 near Cedoux, Saskatchewan of 11.4 cm and 290.0 g.

The storm went on to cause extreme damage to vehicles and crops, catching many motorists off guard along the Queen Elizabeth II Highway immediately north of Innisfail. Damage was so severe the hailstorm reportedly caused injuries to vehicle occupants, including a concussion and a broken rib (Doll, 2022). The storm continued, destroying a large area of agricultural crops for several kilometers east of the highway.

The IBHS rapid response team flew to Red Deer to scan the stone using a laser scanner (see Fig. 4), and also scanned multiple other hailstones in the NHP's collection. In total, 30 stones were scanned and added to an international hailstone database.

The NHP has subsequently acquired its own 3D scanning and printing equipment.

Figure 4: The Markerville, AB hailstone being scanned by the team from IBHS.

UAV TEAM

For the 2023 field operations season, a second team was added with a focus on collecting UAV data in the field. A suite of drones with a variety of payloads acted as a second mission vehicle, following the Hailswath Team and collecting UAV data in conjunction with the collection of hail samples. The suite of drones included:

- DJI M300 (Fig. 5) quadcopter with AgEagle (MicaSense) Altum-PT 6-Band sensor, carrying a high-resolution pan spectral sensor, a thermal sensor, and five (5) dedicated spectral sensors focusing on red, green, blue, red-Edge, and near-infrared.
- Two DJI Mavic 2 Pro quadcopters (not shown), one carrying a 20-megapixel visible spectrum camera, and a second with an additional near-infrared sensor.

From an operational perspective, UAVs are able to access areas otherwise difficult (or impossible) to reach by vehicle. This allows a comprehensive documentation of the hailswath's extent. The added benefit of the UAVs is that they can be used on "scouting" missions to guide the Hailswath Team to the core of the swath. The UAV imagery partially bridges the scale differences between ground observations and satellite imagery. See Appendix C for a list of UAV flights conducted by the field team in 2023.

Figure 5: DJI M300 UAV with multi-spectral camera.

Purpose

The research purpose of the UAV data collection is to determine what additional data can be gleaned from low-level flights over hailswaths. This includes testing and application of recently developed approaches for hail analysis, including determining maximum hail size and hail size distribution using high-resolution visual spectrum imagery (Soderholm et al. 2020), investigating crop and other important damage and impacts through imagery in the visible and infrared, and assessing information from derived products such as the normalized difference vegetation index (NDVI).

The UAV imagery is to be compared to the ground observations to determine what hailswath characteristics can be determined from an aerial perspective versus the results obtained from sample collection (e.g., detection of maximum hail size). Similar comparisons can be made between UAV and satellite imagery, particularly using common spectra, to understand differences in the spatial variability of hail and hail impact characteristics, including the detectability of such features when using different observation platforms collecting imagery at significantly different resolutions.

Experimentally, linking hail and hail impact characteristics by comparing them to imagery collected in different spectra (e.g., visible versus infrared imagery) is also critical in the search for potential indicators for rapid identification of hail damage potential. For example, there may be thresholds identified for imagery in the infrared or near-infrared spectrum that can be linked to potential damage to certain types of crops or other vegetation. The collection of follow-up imagery in the days or weeks after a hail event can again provide indicators which can be used to assess damage and impacts resulting from hail events by investigating any progressive changes in returned spectra across time.

DAMAGE SURVEY TEAM

Among the key components of the NHP's mandate include "understanding hailstone aerodynamics and damage potential" and "develop advanced methods for post-storm damage assessment". To this end, the NHP has begun regular post-storm forensic damage assessments (Figs. 6 and 7) for the purposes of improving our understanding of hail impacts to buildings, vehicles, crops, trees, and other built and natural assets. As of 2023, a dedicated Damage Survey Team was added to the NHP field operations. The data and findings from the forensic damage surveys will serve to improve our understanding of hail impacts, and aid in developing damage mitigation strategies and methods for reducing or eliminating hail damage to assets.

Survey Triggers

The initial focus of the damage assessments has been on severely damaging hailstorms. A preliminary set of "Go/No Go" criteria was developed to help guide the decision on whether or not to conduct a damage survey. A damage survey was conducted if one or more of the following criteria was met:

- Damage to occupied buildings resulted in breach of building envelope, including complete hail penetration of windows, siding or roofing, and/or severe damage to siding and/or roofing resulting in water penetration.
- Large, clearly visible hail scar due to vegetation/crop/forest damage on visible satellite imagery.
- 100% crop loss reported by two or more farms and/or reported in social or news media at multiple locations along a hail swath.
- Damage to multiple vehicles resulting in broken/destroyed windows or severe body damage requiring repair.

The final decision to execute a damage survey is then made through discussion and consensus among the research team. The team has also conducted a small number of surveys on events which do not meet these criteria, both as a means of testing these criteria and assessing damage for events at the lower end of the damage intensity spectrum. As we continue to refine methods for damage surveys, these criteria will continue to evolve.

Figure 6: NHP team member holding a reference object to hail damage to residential siding.

Figure 7: NHP team member surveying an area for crop/grass damage.

Purpose

The main purpose of a forensic damage survey is to collect detailed information on the type and severity of damage. This information is used to:

- Document the range of damage, including damage to buildings, crops, vehicles, critical infrastructure, and trees.
- Document evidence of the peak severity of the hailstorm, including the maximum hail size and the hailfall density (i.e., number of hailstones per square meter).
- Document any human (or animal) injuries or casualties.
- Define the area affected, including damage boundaries of the extent of the hail damage.
- Document the sequence of events leading to impacts.
- Provide information for direct inter-comparison between remote sensing and other observation platforms and products.
- Inform response/adaptation measures which can be used to prevent or reduce impacts from hail events.

This information is then used to improve our understanding of the kinetic energy required to generate damage, and the risks and vulnerabilities of existing buildings/infrastructure to hail damage, as well as to begin to develop response strategies.

Methods

When an event is identified and a Damage Survey Team is assigned, impacts data are collected via social and news media. Area residents may be contacted to obtain further details, including permissions for site access or scheduling of on-site interviews. After arriving on site, the team plans and executes a ground survey, using a grid search (see Fig. 8) as well as community canvassing (i.e., door knocks) to collect detailed impacts information at multiple individual properties. Fig. 8 demonstrates the grid search method.

Properties X_1 and X_2 indicate locations where contacts have already been made prior to executing of the damage survey. A survey route (yellow arrows) is then followed with the purposes of locating the outer boundaries of the hail damage (dashed orange lines), as well as locating the regions of worst damage within the core of the path and identifying additional properties for on-site data collection. Damage data are captured using photographs on the ground and imagery (phots and video) from a UAV. The team also interviews as many eyewitnesses as possible.

Figure 8 (a): The start of a grid search pattern based on eyewitness locations X_1 and X_2. Orange dashed lines represent the boundaries of damage.

Figure 8 (b): a completed grid search pattern based on eyewitness locations X_1 and X_2. Orange dashed lines represent the boundaries of damage.

In many cases, one or more residents will have also saved hail samples in their freezers. When available, these are weighed and all three axes are measured, and key information relating to these samples (e.g., time-to-collection after hailfall, melting due to rain, etc.) is also recorded.

FIELD OPERATIONS

Weather Forecasting

Regardless of the likelihood of a mission, there are daily morning all-hands forecast discussion meetings throughout the field operations period. These meetings are to discuss any potential operations or other work slated to occur that day, as well as to discuss details of any activities, including anything from administrative elements through to social activities.

The process and methods for forecasting have evolved throughout the first two field seasons. Currently, a long-term (five-day) forecast is issued with the intent to identify potential periods of field operations and down-days activities in the coming week. During daily morning briefings, a Day 2 (i.e., next day) forecast is discussed, which serves two purposes. The first is to indicate to the team whether they need to prepare for field operations the following day. The second is to provide an initial idea of the potential chase target location for the following day. Day 2 hail forecasts are also produced by NTP/NHP meteorologists through the summer months and are referenced during the morning forecast discussion. In the evening, if conditions the following day remain favourable for operations, a notice is sent out to the team by the Field Coordinator to indicate that the following day will be an operations day. Mission target selection is then discussed and completed during the Day 1 forecast discussion, described below.

Mission Day

Mission days begin with the regular daily morning briefing, but with a focus on discussing field operations strategy for that day. The initial mission target location, as well as the expected timing and progression of conditions, are discussed.

Depending on timing and availability, two teams – the Hailswath and UAV teams – will be deployed, with the Field Coordinator seated in the Hailswath vehicle and acting as the mission lead. Depending on availability, the Damage Survey Team will occasionally be deployed in operations to act as a second hailstone sample collection team.

The teams then leave for the mission target to await storm initiation, adjusting their position based on where storms initiate, as well as on how they behave and whether there are other small-scale weather factors which may play a role in affecting storm activity. These small-scale weather features are often subtle and only become evident a few hours prior to storm initiation, for example, “outflow boundaries” generated by earlier thunderstorm activity.

Approach Strategy

Storm selection is generally based on selecting the most severe storm that is within reach of the chase team, is located over an area with good roads and is safe to intercept. The teams follow storms on the southern flank from a safe distance before intercepting the hail swath behind the storm when it is appropriate to do so. Depending on storm behaviour, road access and other factors, the team may sample the same storm multiple times during a mission or sample multiple storms. Depending on mission goals, sampling strategies may be modified. For example, a large proportion of hail sampled in 2022 and 2023 originated from supercell thunderstorms. A goal of the 2024 field season will be to sample hailstones from other storm types.

Figure 9: View from an NHP field vehicle of a hailswath.

NORTHERN HAIL PROJECT: OPERATIONS SUMMARY

By the end of 2023, the NHP had conducted 35 missions to investigate hail on the ground in Alberta (Table 1 below). Of these, 20 were undertaken in 2022 and 15 in 2023. For the first field season, there were only three team members and only hailswath intercept missions were conducted. In 2023, the number of team members increased to 10, with three teams— a Hailswath Team, a UAV Team and a Damage Survey Team.

The team sampled 38 storms in 2022 and 23 storms in 2023. Despite fewer hailstorms being sampled in 2023, many more hail samples were collected (104 bags versus 55 in 2022) on account of a modified sampling strategy. This new strategy involved the Damage Survey Team participating in the collection of hail when they were available. On these days, they would leap-frog along the swath in tandem with the Hailswath Team. The average time between when radar indicated hail reached the ground and when the team collected samples was about 22 minutes for both years. Unfavourable storm conditions in 2023 meant that the three teams drove ~16,000 km versus ~20,000 km by one team in 2022. These distances include mileage for maintaining the hailpad network. Tables in the Appendix A and Appendix B provides a summary of the missions for each year.

Table 1: Summary of NHP field team statistics for 2022 and 2023.

	2022	2023
Missions	20	15
Storms Sampled	38	23
Bags of Hail Collected	55	104
Mean Time to Collection (min)	23	22
Field Vehicles	1	3
Distance Driven (km)	~20,000	~16,000
People in the Field	3	8

WEATHER CONDITIONS

Weather conditions play a key role in determining how many days the teams go on missions during the summer. In 2022, the prevailing weather conditions were more favourable overall than in 2023. This is reflected in the rainfall percentile maps in Figs. 10 and 11. Specifically, Fig. 10 shows that other than small areas of below normal precipitation near Edmonton and Calgary in 2022, most of Alberta (and the prairies) received near-to above-normal rainfall. The favourable conditions are also reflected in lightning flash density anomaly maps (not shown), with near-to above-normal lightning activity over most of the prairies, with west-central Alberta being especially active for thunderstorm activity.

In contrast, in 2023, most of the prairies experienced moderate to very low rainfall amounts, with drought conditions affecting a large portion of the region (Fig. 11). The exception to this was the Peace Country and central Alberta, where near-record rainfall amounts were recorded. The lightning flash density anomaly maps (not shown) indicates that thunderstorm activity was below average over most of the prairie provinces in 2023, with the largest deficits over central Alberta and far southern Saskatchewan.

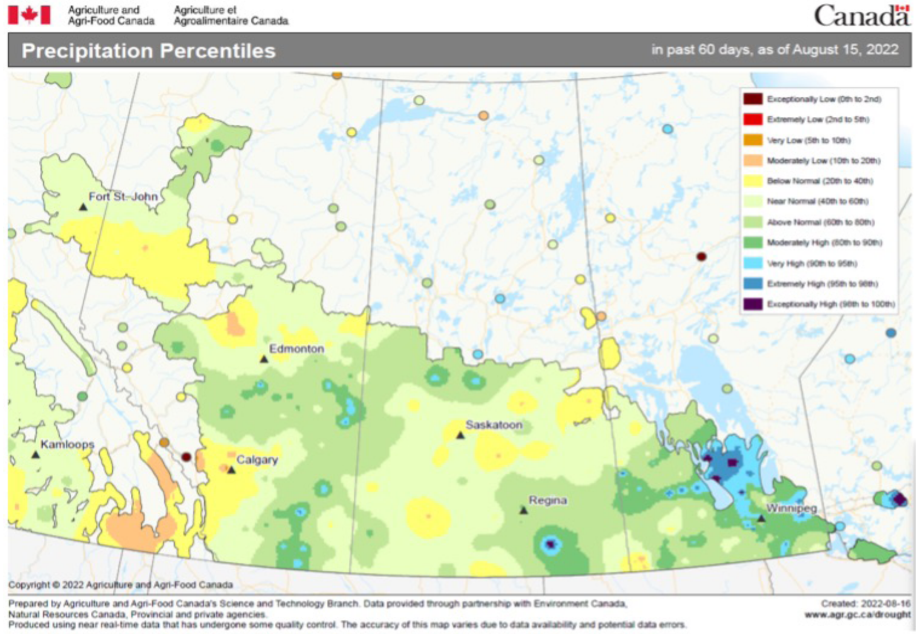


Figure 10: Precipitation percentiles observed on the Canadian prairies between mid-June and mid-August (most active storm period) in 2022.

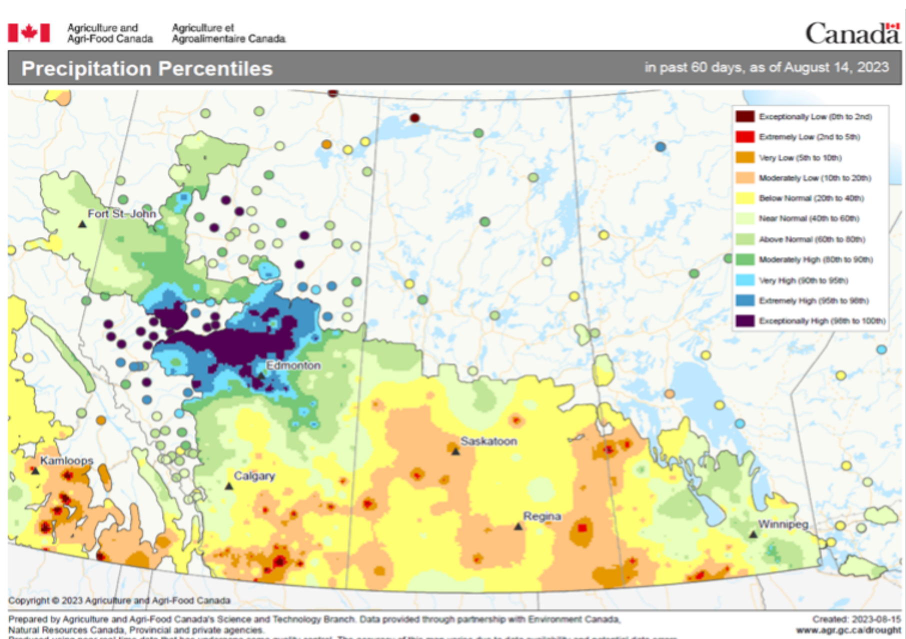


Figure 11: Precipitation percentiles observed on the Canadian prairies between mid-June and mid-August (most active storm period) in 2023.

DISDROMETER NETWORK

One of the first major projects undertaken by the NHP was to deploy a network of hail monitoring stations in Calgary and "Hail Alley". The design, logistics and deployment of the network were undertaken in close coordination with the City of Calgary and ICLR. The network was largely complete by May 2023, with the last two stations deployed in early June. In total, 19 stations were deployed in Calgary. The network collected its first summer's worth of data in 2023 and, moving forward, will continue to collect valuable information on hail and weather conditions in this hail-prone region.

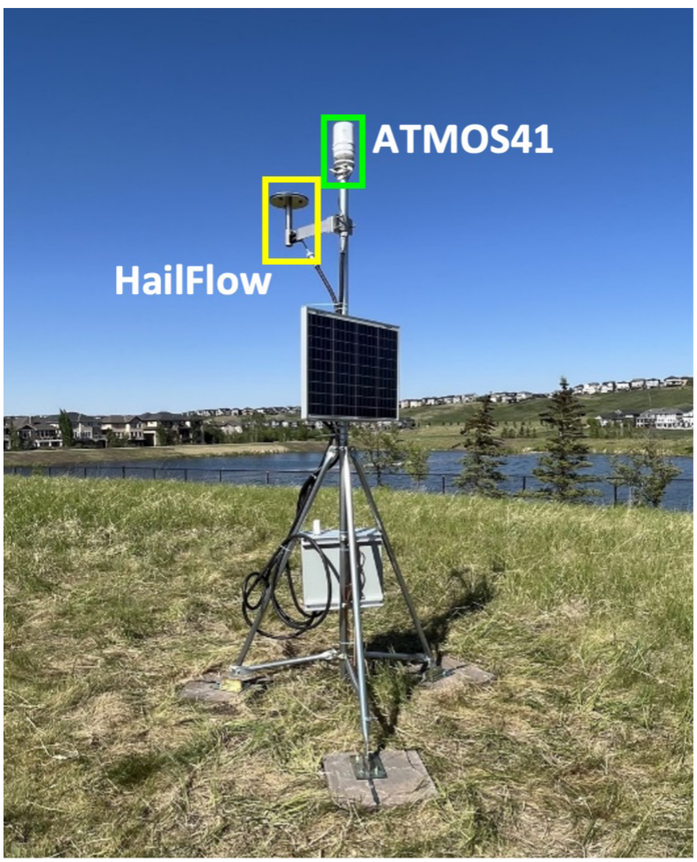


Figure 12: One of the hail-monitoring stations (located at Symons Valley) in the Calgary network. See text for details.

Each hail-monitoring station consists of two sensors (Fig. 12): a hail disdrometer (HailFlow, ISAW) and an all-in-one weather station (ATMOS41, METER Group). The hail disdrometer consists of a piezoelectric sensor mounted below two circular metal plates (measuring 20 cm across) that are separated by a rubber spacer. The instrument measures the number of hail impacts, the number of impacts per second and the percentage of strikes in 5-mm size bins (from 5 mm to 80 mm). The ATMOS41 measures wind speed and direction (using an ultrasonic anemometer), temperature, humidity, solar radiation, pressure, and precipitation. The sensors are mounted on a tripod and located about 3 m above the ground. The stations are powered by a solar a panel and data are transmitted over the cellular network. Data are transmitted every 10 minutes to a server in London, Ontario, for dissemination on a public-facing data portal. In contrast, most federal and provincial weather stations (e.g., Calgary International Airport) report data only once every hour.

The hail-monitoring data will serve multiple purposes: i) capturing the occurrence and severity of hail across Calgary, ii) validating existing and new radar algorithms for detecting the presence of hail and estimating hail size, iii) quantifying the extent and severity of damage following hailstorms, and iv) lastly, using data from the stations for an early warning system for when hailstorms are approaching the city from the north, west and south.

Calgary Hail Monitoring Network

On account of the high spatial variability of hailfall, a dense network of stations was required to provide useful coverage across Calgary. The number of stations required to provide complete coverage (~1 km spacing) would be prohibitively expensive, so a trade-off was required. Ultimately, 19 stations were installed across the city (Fig. 13), with coverage for residential and commercial areas made a priority. The mean nearest neighbour distance of the current network configuration is 5.4 km, with a station density of one station per 40 km^2. Most stations are located at fire halls or ponds.

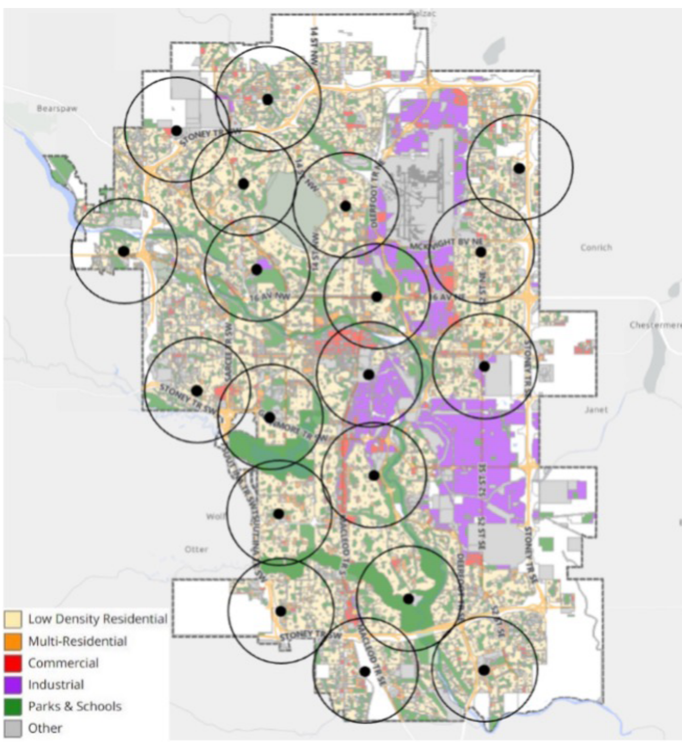


Figure 13: Locations of the disdrometer stations overlaid on primary land-use areas across Calgary. The black circles have a radius of 3 km and indicate the approximate area for which the station data are representative. Source: City of Calgary

Stations Outside of Calgary

Eight stations were installed in “Hail Alley” northwest of Calgary in 2023. These stations were installed at Airdrie, Olds Farm, Carstairs (between Didsbury and Carstairs), Water Valley, Dickson Dam, Nier, Sundre, and Hespero. To verify the ATMOS41 weather station, three stations were located adjacent to standard weather stations: a fully equipped station at Olds Farm and Nier, and a weighing rain gauge at Dickson Dam. The stations at Nier and Sundre were not operational in 2023 due to technical issues. These stations will be operational for the 2024 season.

Figure 14: Locations of the eight disdrometer stations outside of Calgary in 2023. The stations at Nier (12 km NW of Airdrie) and Sundre were not operational due to technical issues. Supersites are indicated by red pins.

Supersites

Three supersite stations (Fig. 16) were deployed in 2023 at Water Valley, Dickson Dam and Hespero (northernmost station in Fig. 14). A supersite consists of a hail-monitoring station, supplemented by a hailpad and a motion activated trail camera (with cellular connection) staring down on a blue foam pad. The camera is solar powered. The purposes of the supersites are twofold: (i) test the motion-triggered cellular cameras for collecting images of hail falling on the ground; and (ii) collect independent hail data to validate the HailFlow sensor (via comparison with the hailpad and camera data). The trail cameras were found to be very reliable, with 100% uptime during the summer of 2023. Their ability to provide real-time data at intervals of less than a minute is especially helpful. Fig. 16 (right) shows an image collected during a hailstorm at Water Valley on 30 July 2023.

Results

For the purposes of our analysis, we define a hail event as being a 10-minute period when at least two hail strikes of 5-10 mm (or larger) are recorded. The amount of hail activity detected by the network is impressive given that the sampling area of the disdrometers is 20 cm across and that, collectively, the sampling area of all the disdrometers in Calgary (surface area of over 800 km^2) is only 0.6 m^2 or $6x10^{-7}$ km^2. All but two of the 16 operational stations in Calgary detected hail. Despite the unfavourable storm conditions, the network collected data for 66 hail events, with over 2,800 hail strikes recorded (Fig. 15). Twelve severe hail events (i.e., disdrometers indicated hail of at least 20 mm in diameter) were identified. The largest hail detected by the network was 40-45 mm in far-northwestern Calgary on 6 July. As expected for a 10-min sampling interval, the most common duration for hail events was less than 10 minutes. The longest time for which hail was reported in consecutive reporting intervals was 50 minutes (i.e., five consecutive observation intervals when hail strikes were recorded). The busiest day for the network was on 17 July when 12 stations were hit by hail. This was associated with a strong line of thunderstorms that moved across the area. Over the entire 2023 season, the highest hail strike rates detected by the disdrometers were less than five strikes per second; the disdrometers can record up to 25 hail strikes per second.

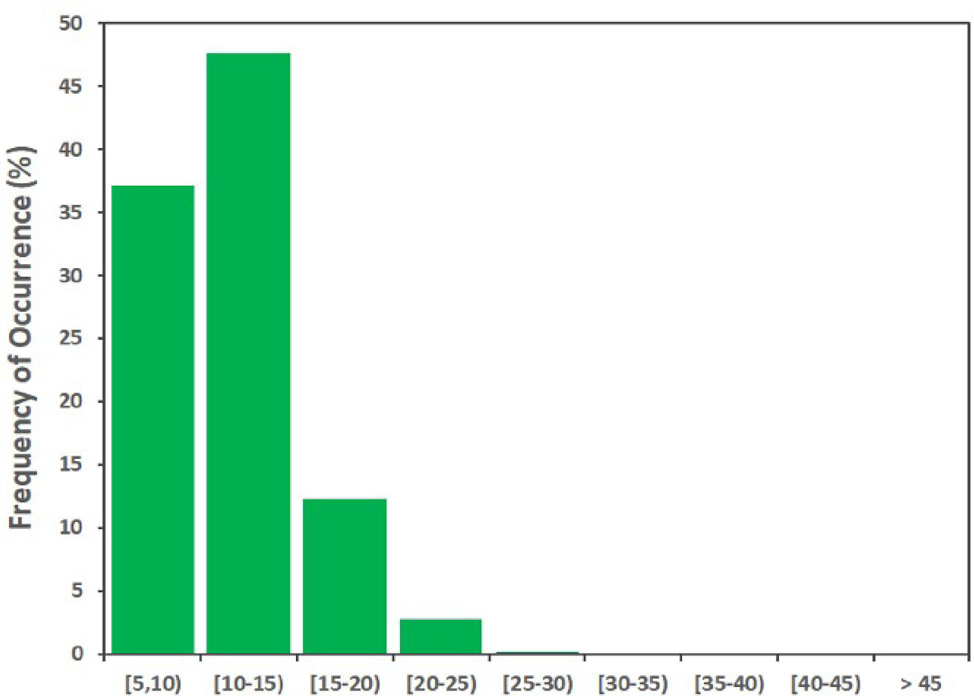
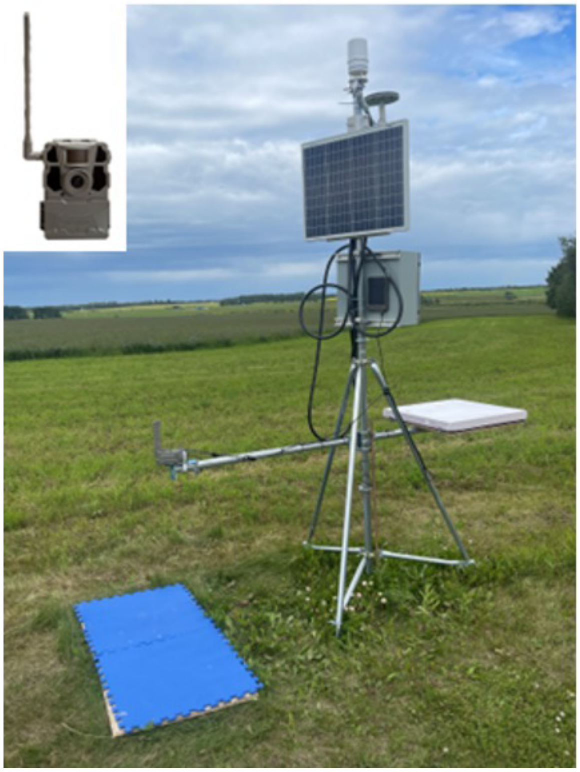


Figure 15: Hail-size distribution for the disdrometers in Calgary for 2023. An exponential distribution is evident, which is what we would expect for hail. Over 84% of the hail strikes were for hail between 5 and 15 mm, with severe hail strikes accounting for only 3% of all the hails strikes.



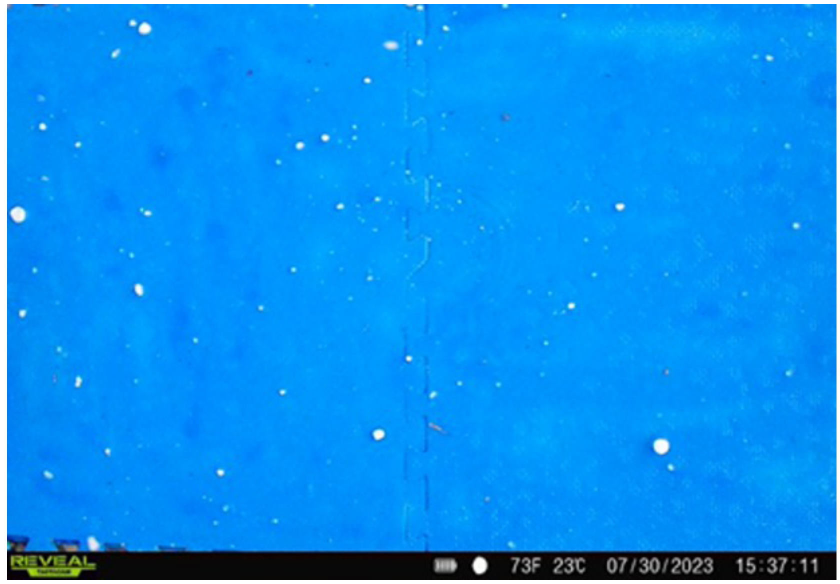


Figure 16: (Left): Example of a hail-monitoring supersite station at Hespero. Downward-facing camera is on the boom on the left-hand side, and the extruded foam hailpad is on the right-hand side. (Top): Hailstones captured by the camera at Water Valley. The largest hail-stones in this image are about 17 mm across.

HAILPAD NETWORK

Hailpads have been used for many decades to monitor hail activity and they continue to be useful for hail research. The NHP is using data from hailpads to:

- Validate both old and new radar-based hail algorithms and hail metrics,
- Validate numerical model output,
- Map the spatial distribution and frequency of hail in “Hail Alley”, and
- Improve our understanding of hail-size distributions.

Hailpad data collected at selected disdrometer sites will also be critical for validating the Hailflow disdrometers used in the Calgary network.

The hailpads are made of extruded foam that measure 61 cm by 61 cm and 5.1 cm thick. The foam is painted with a thin white latex paint to prevent UV light from degrading the foam. The foam is attached to a wooden base which is then mounted to a fence post (Fig. 17). In 2022 the there were 34 hailpads in the network, this was increased to 40 in 2023. The hailpad locations are shown in Fig. 18. About 50% of the hailpad locations in the 2022 network were relocated slightly based on feedback from the field team, primarily for safety.The hailpads are placed in a north-south staggered grid so as to increase the likelihood of capturing storms as they move from west to east. Hailpads are spaced approximately 3.2 km apart in the north-south direction and 6.4 km in the east-west direction. Three hailpads were located outside of the static network: one each at the Water Valley and Hespero supersites and another next to traffic weather station on Queen Elizabeth Highway II near Bowden.

Figure 17: Example of a hailpad deployed in the network.

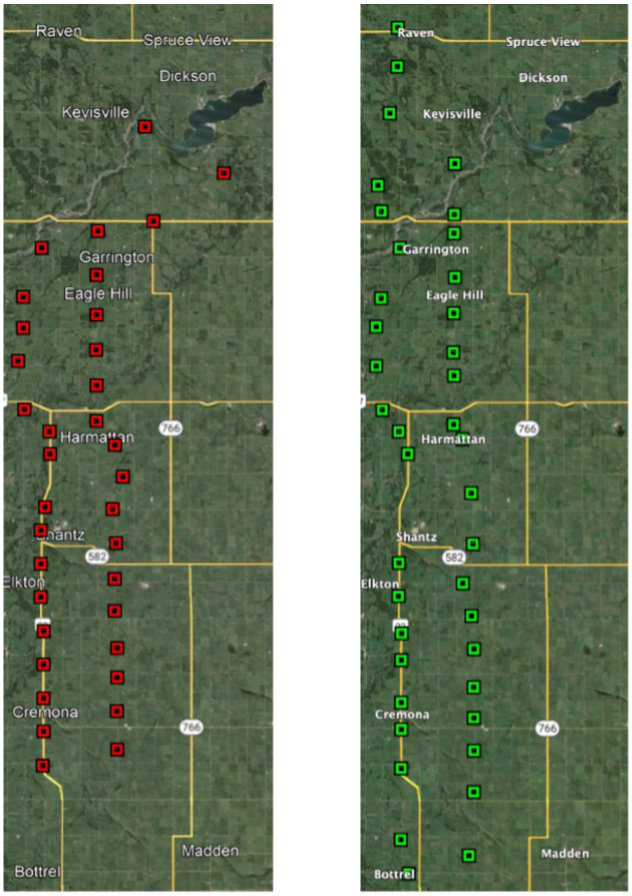


Figure 18: Locations of hailpads in the static network in 2022 (left-hand side) and in 2023 (right-hand side).

Figure 19: Examples of hailpads hit by hail in 2023. (TL) Large number of small hailstones (~5-7 mm), (TR) Some larger stones (10-15 mm) mixed with many small hailstones, (BL) Random assortment of 10-15 mm hailstones, (BR) A “saturated” hailpad that was hit by many hailstones, some of which were severe.

In 2023, the network was ~75 km long (north-south) and covered ~415 km^2, with a station density of one station per 10.5 km^2. This is a slightly higher density than that of the 2022 network (one station per 11.0 km^2) when the network extended 57 km north-south and covered ~380 km^2. Maintaining the hailpad network is labour intensive and time consuming because it is a manual process and requires time to drive between locations. Consequently, we have determined that the NHP field team can maintain a maximum of 40 hailpads moving forward.

A new, slightly softer, Foamular foam was tested in 2023 (compressive modulus of 1350 psi versus 2000 psi). Hailpads using the two foams were placed side-by-side at a subset of sites to allow for comparisons to be made. Analysis will be undertaken during the winter of 2023-2024. Examples of what hailpads hit by hail look like are provided in Fig. 19. These pictures illustrate the difficulty of analyzing hailpads. Specifically, they show the large number of dents that need to be identified and sized, that very few of the dents are spherical, and that there can be a significant number of dents that overlap each other.

Inspection of the hailpads indicates that 93 pads were hit by hail in 2022, compared to 57 hailpads in 2023. In 2022, the network was hit by hail on 18 days. Only one hailpad was not hit by hail in 2022 and one site was hit by hail on seven separate days. In contrast, 11 pads were not hit by hail in 2023, and one site was hit by hail four times. It is estimated that the size of hail detected by the network in 2023 ranged from ~5 mm to ~30 mm. To determine how effective the network was at capturing hail events, the NHP will collect hail reports and radar data (within a two to three km radius) of the hailpads. Hail reports will be sourced from NHP hailswath intercept missions, social media, ECCC and WeatherLogics. Depending on the type of radar data being used, data will be sourced from the InstantWeather app, the Multi-Radar Multi-Sensor product (NOAA) and ECCC.

NORTHERN HAIL PROJECT: RESEARCH

The NHP represents a rebirth of research on damaging hail in Canada. It is the first research initiative focused on hail occurrence since the Alberta Hail Project ended operations in 1985, nearly 40 years ago. The research described in this section covers a wide range of topics related to mitigating impacts from hail in Canada.

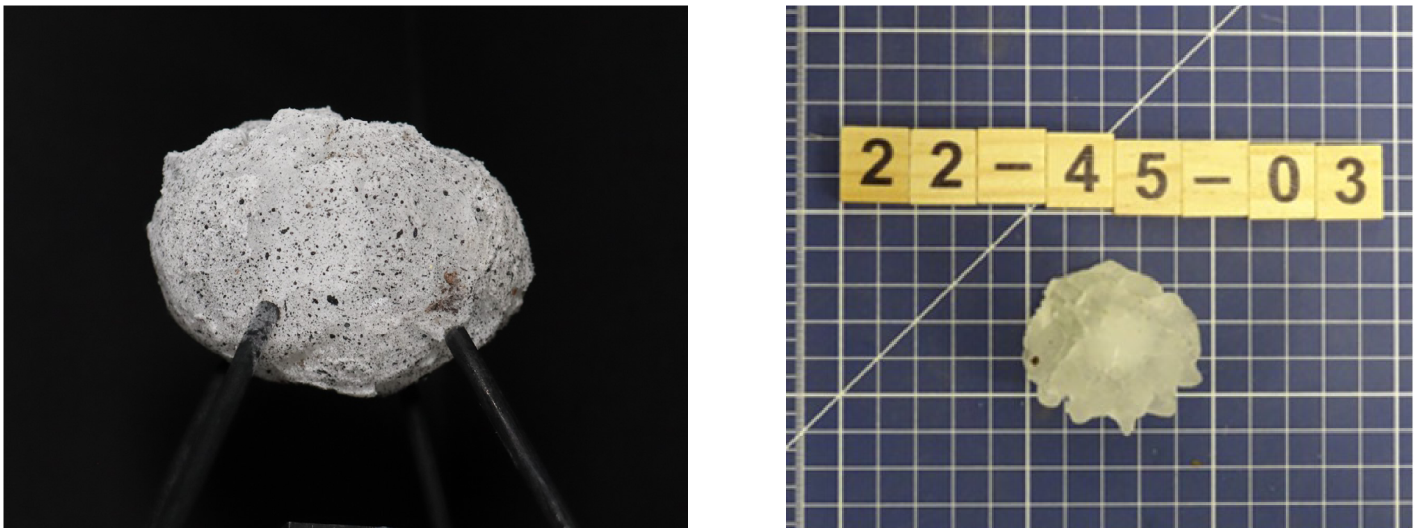


Figure 20: Two examples of the more than 1,000 hailstones that have been catalogued to date. Each square in the right image is 1 cm x 1 cm

HAILSTONE SAMPLE ANALYSIS

The hailswath intercept missions have been successful and we estimate that over 2,500 hailstones were collected during the first two field seasons. The hailstones are stored in cold rooms (-20 ˚C or lower) in sealed bags until they can be processed.

During the winter of 2023-2024, students at the University of Alberta catalogued each hailstone from the 2022 field season. This involved three steps for each hailstone. i) measuring three axes, ii) weighing the hailstone, and iii) taking a photograph looking vertically downwards with the hailstone's maximum cross-sectional area visible (see Fig. 20). For each bag, up to two stones deemed to be representative of other stones in the bag were selected, plus a stone that was clearly dissimilar to the other hailstones. Over 800 hailstones were catalogued for 2022 and at the time of writing, almost 500 hailstones have already been catalogued for 2023.

Figure 21: Example of a hailstone being measured in the field. Once measured, the hailstone will be stored for further processing.

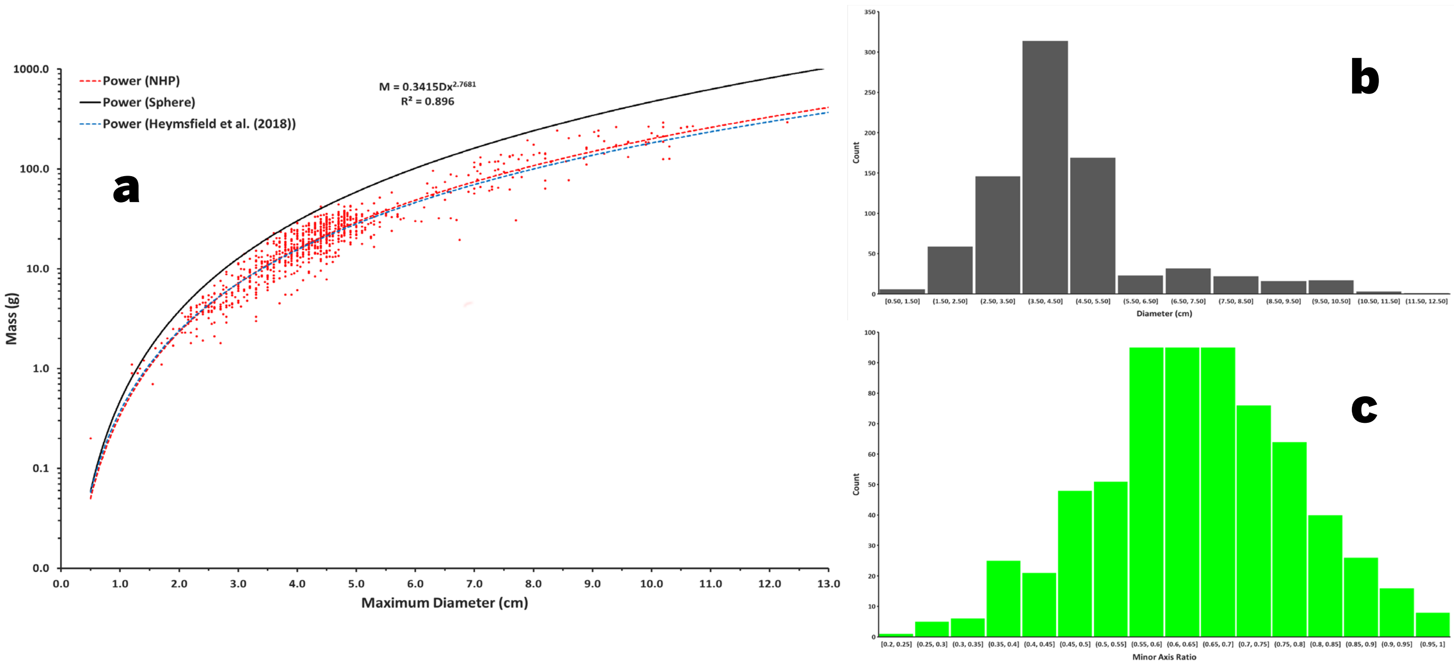


Figure 22: Results from the analysis of 808 hailstones collected in 2022. (a) Mass versus maximum diameter (Dmax) curves for spherical hailstones, those collected by the NHP, and as described in Heymsfield et al. (2018). (b) Histogram of maximum hail diameters in 0.5 cm size bins, (c) histogram of the axis ratio (minimum to maximum diameter) for 726 hailstones.

Fig. 22 provides some key metrics for the hailstones. In panel (a) the mass of each hailstone versus its maximum dimension is shown. The best fit curve (power law) for these data is similar to that obtained in the analysis of over 3,000 stones as summarized in Heymsfield et al. (2014). A histogram showing the hail-size distribution is shown in panel (b). Here a couple of key details are revealed. First, we over-sampled hail between 3.5 and 5.0 cm, and under-sampled hail < 3.5 and > 5 cm. For hail, this histogram should show the frequency decreasing exponentially with size.

This peculiar distribution of collected stones is probably attributable to the fact that collecting smaller hail before it melts is difficult and that hail > 5 cm in diameter is rare over “Hail Alley”. Additionally, it is known that supercell storms have a propensity to produce golfball or larger hail (Blair et al. 2017) and the team may have favoured sampling these storms because they are long lived, and their movement is fairly predictable.

The aspect ratio (ratio of minimum axis to the maximum axis) of our hailstone collection, shown in panel (c), is very similar to that found for other hailstone collections in the scientific literature. Specifically, the modal axis ratio in our data is 0.60 to 0.65, compared to 0.63 reported in Shedd et al. (2021) for over 1,500 hailstones collected in the USA.

Figure 23: Example of a hailstone being measured in the field.

CT Scans

The NHP collaborated with the Permafrost ArChives Science (PACS) Laboratory at the University of Alberta to scan several of the large hailstones collected during the Markerville event. This is only the second time that hailstones have been scanned using this technique. Data were captured using a helical scan with a Nikon XTH 225 ST industrial computed tomography micro-CT scanner (Roustaei et al. 2024). The hailstones were stacked vertically in a styrofoam container, with dry ice placed vertically above the samples to prevent melting during scanning. The scans were conducted using various settings with the reflection target source at 85 to 140 Kv (125 to 200 µa), an exposure time of 4 to 8 frames per second and voxel (3D volume representing pixel resolution and slice thickness) sizes from 25 to 60 µm. Images of the scans were converted into three-dimensional grey-scale volumes and then analyzed using Dragonfly 2022 image processing software (Roustaei et al. 2024). The CT scans allowed us the unique ability to "see" inside the hailstones and examine the 3D structure of the stone in unprecedented detail without having to cut the hailstone. These data can also be used to estimate the size of air pockets and air bubbles in the hailstones, which indicate the type of growth and which can also be used to determine the density of the ice.

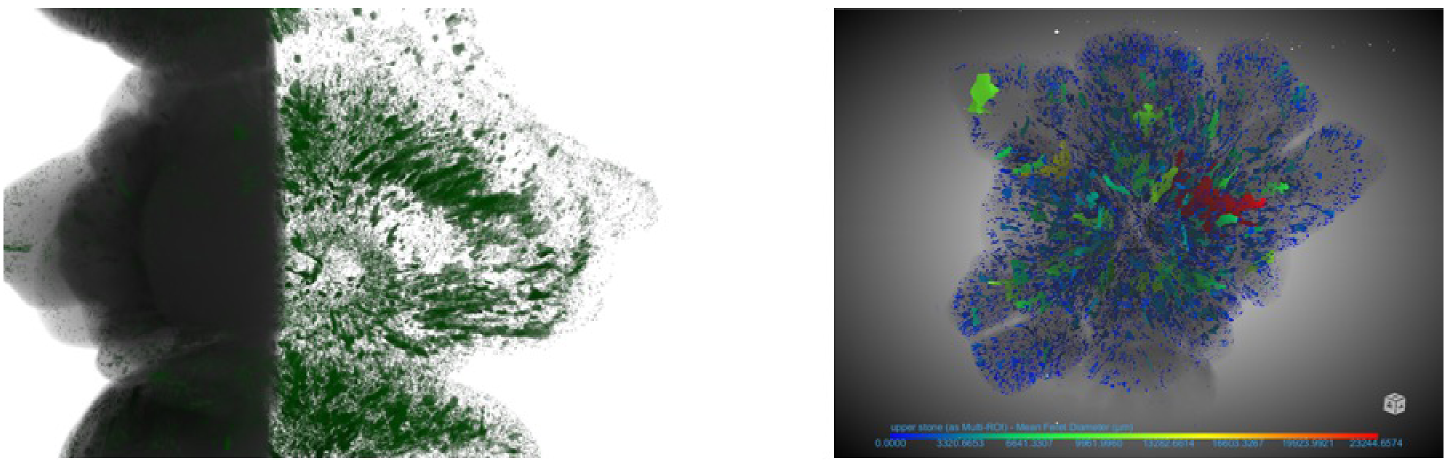


Figure 24: Examples of analysis from the computed tomography scan of hail collected on the day of the Markerville hailstorm. (left) Green areas indicate higher porosity (more bubbles) and clear areas lower porosity (fewer bubbles). (right) Feret diameter of cavities in a scanned hailstone.

AUTOMATED HAILPAD ANALYSIS

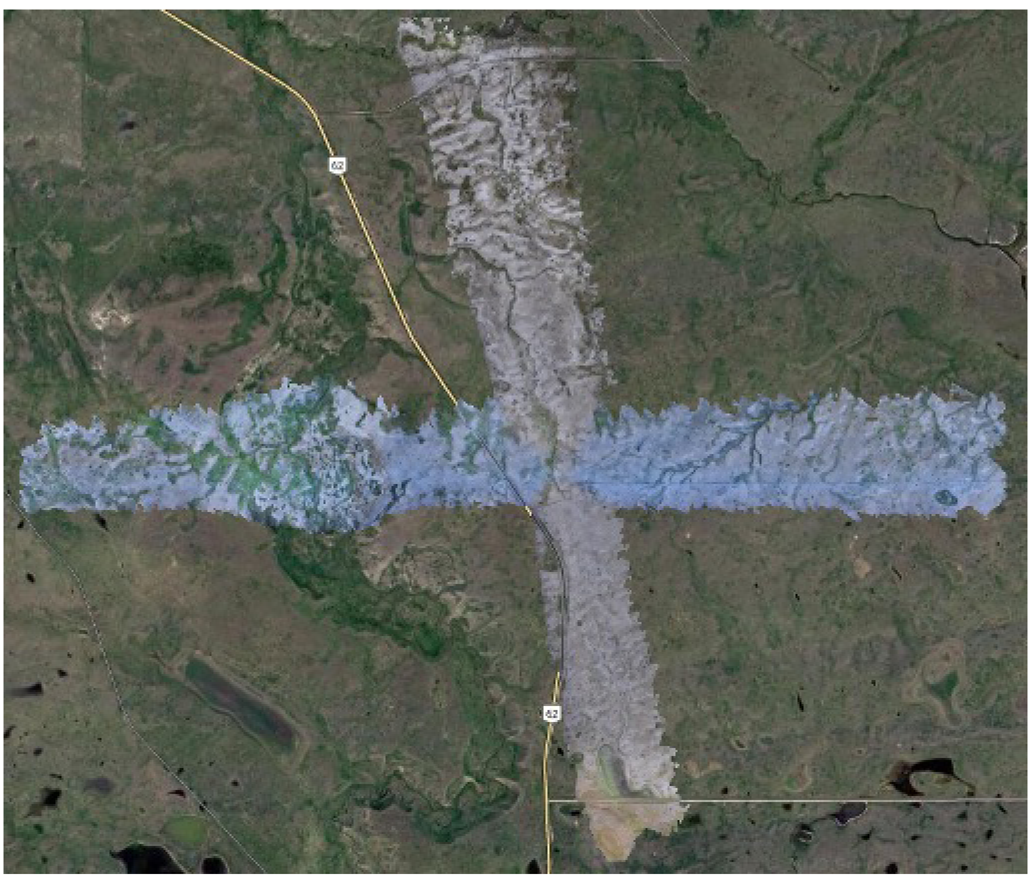
Almost 160 hailpads from 2022 and 2023 are ready to be analyzed. A student at Western University is developing an automated analysis technique to objectively extract hail count and size information from the hailpads. One option that is being considered is to scan each hailpad using a 3D scanner and then use machine learning and computer vision techniques to extract information about the number, size and depth/ volume of hail dents (Fig. 25a). If we can reliably retrieve depth information, we may be able to infer both the size and impact velocity of hailstones.

This would be a significant advancement in the information that we can extract from hailpads. This process will also require a manual analysis of hailpads to train the algorithm. To ensure uniform calibration, energy-matching drop tests (using steel spheres) for the new and old foams will be conducted. The energy-matching method involves dropping a steel sphere from a height that results in it hitting the hailpad with the same impact energy as a hailstone of equivalent diameter falling at terminal velocity. One can then use this information to develop an empirical relationship that relates the size of dents in the foam to the hail size. This method was developed in the 1970s and is still in use to

Ice, however, is elastic and hailstones are not perfect spheres. To investigate the limitations of using inelastic steel spheres for calibration, we plan to launch lab-manufactured hailstones (that have a similar shape, density and structural integrity as natural hailstones) at foam hailpads to extend the calibration data set. To do this, we are collaborating with the Insurance Institute of Business and Home Safety (IBHS) at their lab facilities in South Carolina. Dents in the foam using this method will be more realistic than those made using steel spheres and should allow for more accurate analysis of the hailpads. Results from both approaches will be compared and contrasted.

UAV DATA COLLECTION AND ANALYSIS

The goal of the UAV data collection by NHP field operations will be to develop methods to collect high-resolution data using a UAV equipped with advanced multi-spectral cameras and a thermal imager. The UAV will complete transects across hailswaths to measure the variability of hail properties (Fig. 25b). Furthermore, return flights over the same affected areas over the following days to weeks will facilitate an analysis of how crops respond to a variety of hail concentrations and sizes.



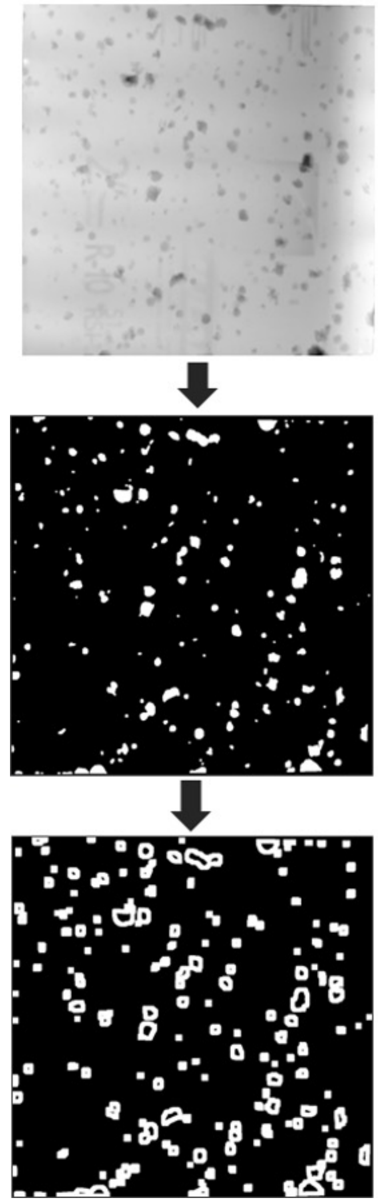


Figure 25a: (top) Preliminary analysis of a test hailpad. The image begins as a rendering from a 3D laser scan. It is processed to identify dents, and refined using a depth threshold to remove noise. Lastly, a watershed algorithm is applied.

Figure 25b: (left) Orthomosaic of transects made along and across the hailswath intercepted near Whisky Gap Alberta on 29 July 2023.

HAIL DAMAGE/IMPACT MECHANISMS

Damage survey information is vital to addressing the engineering component of the NHP's research goals. Significant differences in material, vehicle, and crop impacts have already been identified from these assessments, and improvements in hailstorm characterization (e.g., maximum hail size, hailfall depth and size distribution) have also been gleaned.

Residential Cladding and Building Envelope Performance Evaluation

Key analysis results will focus on the development of so-called "impact thresholds". These are defined as the threshold intensity at which a hazard generates damage to infrastructure, vehicles or vegetation. For hail, this includes thresholds for window failures, roof damage resulting in water penetration, and so on. Multiple damage thresholds - representing different tiers of impact severity - can exist for the same damaged surface. For example, did vehicle damage consist of minor and repairable body damage or destruction of windows and body and roof panels? These thresholds are critical for risk assessment and risk modelling of the hail hazard, and their absence represents and important gap in hail risk science that the NHP will be addressing.

Based on these findings, as well as previous research efforts internationally, the NHP is developing a position paper that will outline the needed information for the development of an internationally applicable hailstorm intensity scale. Scales have been previously developed (TORRO H Scale for example), but these have not been widely adopted internationally, and they may not fully capture all of the hail and hailstorm factors (and associated uncertainty) that are critical to characterizing the damage potential of hail events. These gaps demonstrate the need for the NHP's research on a hail intensity scale.

HAIL FORECASTING AND NOWCASTING

The NHP, through the forecasting process for field operations and damage survey preparation, as well as through analysis of high impact events, is developing and testing methods for improved hail forecasting and nowcasting techniques. This includes testing hail-size forecasting techniques (Fig.26), and the evaluation of radar signatures which are traditionally used to identify potentially damaging hailstorms for nowcasting. Evaluations are based on ground-truth data obtained from field operations, damage surveys and social and news media reports.

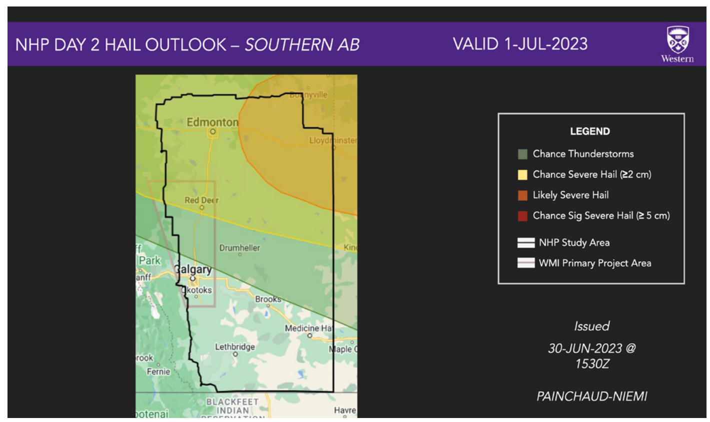


Figure 26: Day 2 hail outlook prepared for the NHP field team.

The NHP is also engaged in research that aims to improve hail detection and hail sizes estimated from operational weather radar data, by leveraging polarimetric variables from the new Canadian S-band radar network. Polarimetric enhancements and better-quality controlled reflectivity data are expected to improve the single-polarization algorithms for detecting hail and estimating hail size. Furthermore, adding new polarimetric hail signatures from key dual-polarization variables above the radar-derived freezing level are expected to improve the detection of occurrence and size of hail. A key outcome is the anticipated improvement to the widely used Maximum Expected Size of Hail (MESH) product.

HAILSWATH MAPPING

Since 2022, the NHP has been identifying and mapping hailswaths across Canada using radar-derived MESH (Maximum Estimated Size of Hail) products. This process is one step towards building a complete hail climatology for Canada. For 2022, the MRMS (Multi-Radar/Multi-Sensor System) MESH product was used to identify hailswaths, and in 2023 and beyond, the MESH product was derived from ECCC data. Hailswaths are identified and measured (length and width) based on a set of criteria, before they are plotted, similar to those seen in Fig. 27. Over 1,400 hailswaths have been identified, with 469 in 2022 and 954 in 2023. Many hailswaths have exceeded 300 km in length, with one hailswath on July 21, 2023 being over 500 km long!

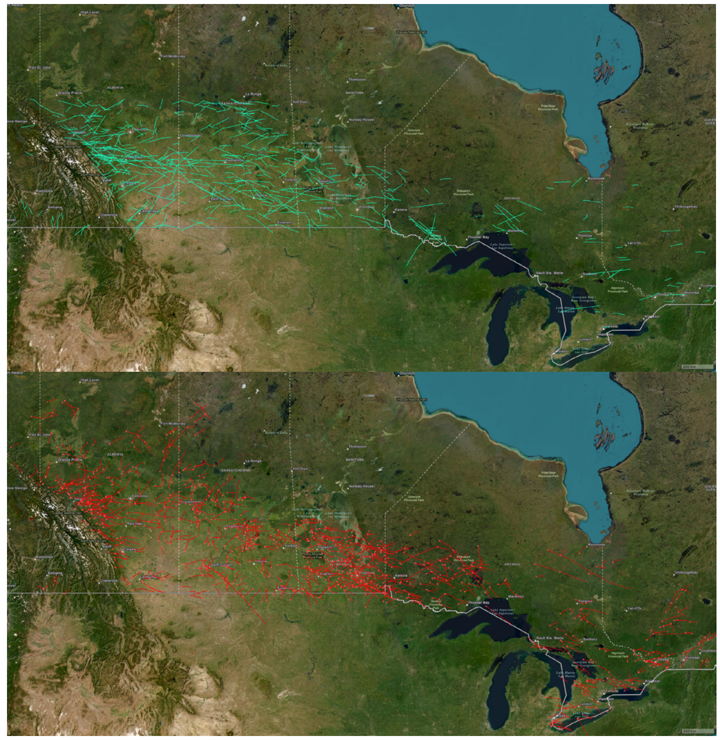


Figure 27: Mapped hailswaths for 2022 (top) and 2023 (bottom).

INTERNATIONAL COLLABORATION

In-situ observations of hailstorms along trajectories have only now become possible thanks to the miniaturization of electronics. The Hailsonde, which exploits the unique design and functionality of microsondes to provide in-situ observations in the hail growth region has been developed by Dr. Joshua Soderholm at the Bureau of Meteorology in Australia. The first successful Hailsonde observations in the supercooled region of a hailstorm were achieved on 24 July 2023 in a collaboration between Dr. Soderholm and the NHP. Two Hailsondes (Fig. 28) were launched four minutes apart into a supercell near Caroline, Alberta. The storm produced large hail exceeding 60 mm in maximum dimension during the flight. Both probes measured updraft speeds exceeding 37 m s^{-1} during balloon-assisted ascent, and, after the balloons detached, the probes continued to ascend to almost 8,000 m AMSL. Despite following very similar trajectories, the sondes experienced different growth regimes, highlighting the sensitivity of hail growth to even subtle changes in temperature and moisture along the hailstone's trajectory.

Figure 28: Dr. Joshua Soderholm holding the Hailsonde equipment.

NORTHERN HAIL PROJECT: MEDIA AND CONFERENCES

MEDIA

The NHP has appeared in many media pieces and has presented research and findings at various conferences. Some media pieces and conference appearances are shown below.


Calgary

Ontario researchers choose Alberta's 'hailstorm alley' as site for 5-year study

Massive Calgary hail storm happened 2 years ago on June 13, 2020

Taylor Simmons · CBC News · Posted: Jun 14, 2022 9:14 AM EDT | Last Updated: June 14, 2022

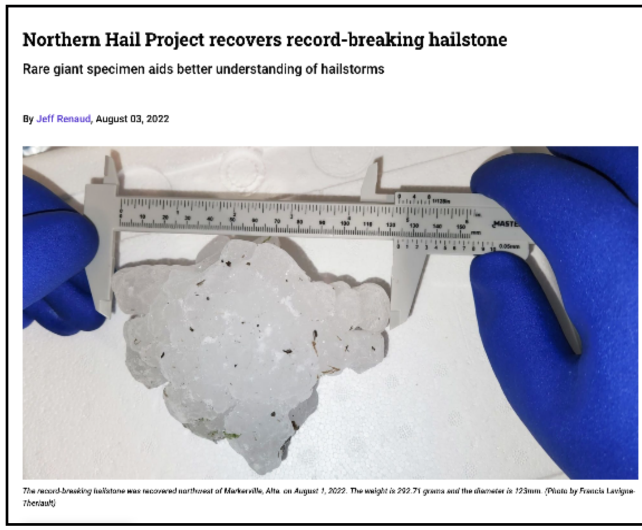
Researchers with the Northern Hail Project set up hailpads in the foothills of Alberta. (Reports2NHP/Twitter)


Calgary 'the place to be' for hail researchers expanding project in second year of study

Western University group installs 20 new monitoring stations, triples roster of researchers working on the ground in Calgary area

Michael Rodriguez

Published Jul 20, 2023 • Last updated Jul 20, 2023 • 3 minute read


Northern Hail Project recovers record-breaking hailstone

Rare giant specimen aids better understanding of hailstorms

By Jeff Renaud, August 03, 2022

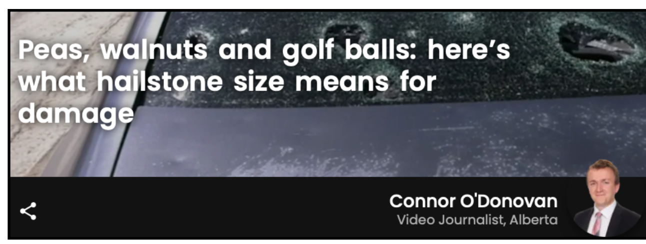
The record-breaking hailstone was recovered northwest of Markerville, Alta. on August 1, 2022. The weight is 292.71 grams and the diameter is 123mm. (Photo by Francis Lavigne-Theriault)


Calgary

19 new monitoring stations in Calgary to aid defense against hailstorms

Researchers say data will improve forecasting, help mitigate damage

Jonathon Sharp · CBC News · Posted: Jul 21, 2023 2:56 PM EDT | Last Updated: July 21, 2023



CONFERENCES

- **2nd North American Workshop on Hail and Hailstorms**, September 20–22, 2022, Boulder, CO
- **AMS Severe Local Storms Conference (SLS)**, Oct 24–28, 2022, Santa Fe, NM
- **International Conference on Wind Engineering (ICWE)**, August 27–31, 2023, Florence, Italy
- **Canadian Meteorological and Oceanographic Society (CMOS) Congress 2023**, May 28–June 1, 2023, St. Johns, NL
- **11th European Conference on Severe Storms**, May 8–12, 2023, Bucharest, Romania

NORTHERN HAIL PROJECT: FUTURE DIRECTIONS

Following a successful pilot season in 2022 and the growth of the field team in 2023, the NHP will continue to advance our knowledge of the meteorology, climatology and impacts of damaging hail across Canada into 2024 and beyond.

In 2024, the NHP field team will return to the project area in Alberta to collect hail, document hailswaths from the ground and from the air, and conduct forensic-level hail damage surveys. Now with a solid foundation, the 2024 field team will focus on expanding data collection to include collecting smaller hail and conducting more UAV flights. This will be achieved by focusing on collecting hail from a variety of storm types and being closer to the storm before intercepting. Damage survey efforts will be expanded to cover all of Canada, leading to a wealth of information on different types of hail damage. These data will contribute to continued development of a hail damage intensity scale in collaboration with international partners.

The documentation and analysis of hailstones collected in 2023 will continue into 2024, as will the majority of research started in 2022 or 2023.

The NHP's disdrometer network will remain operational across "Hail Alley". New supersite locations will be added involving new cameras and a different collection board beneath the cameras. The hailpad network will also remain in place for 2024, passively collecting hail size and intensity information during hailstorms.

Forecast methods will be refined and tested in further hail seasons, while hail reports collected from partners and social media will act to validate these methods and contribute to the development of Canada's hail climatology.

NORTHERN HAIL PROJECT: ACKNOWLEDGEMENTS

The Northern Hail Project would first like to acknowledge our main funders, including the Institute for Catastrophic Loss Reduction (ICLR) and their associated member companies. Funding for internships and graduate positions is provided by the Natural Sciences and Engineering Research Council of Canada (NSERC) and Mitacs through the NSERC Alliance - Mitacs Accelerate program. Initial seed funding for the NHP was provided directly by Western University, through the Strategic Priorities fund.

The City of Calgary, in particular Dustin Lockwood, Hydraulic Modelling Technologist, has been critical in the development and deployment of the disdrometer network across the city. Similarly, Fire Chief Kevin Miller from the Cremona and District Emergency Services, Cliff Skocdopole, Kevin Challoner from Sundre High School and the Alberta Government, David Clarke and Dennis Rollag, generously provided sites for our hail-monitoring supersites. We are also grateful to Corriena Fox from the Town of Carstairs and Mandeep Dhaliwal from the Calgary Region Airshed Zone for providing us space to install stations.

The University of Alberta (U of A) Canadian Ice Core Lab (CICL), in particular Director Dr. Alison Criscitiello and Ice Core Laboratory Analyst Dr. Anne Myers, as well as the Permafrost ArChive Science (PACS) lab (Joel Pumple and Jordan Harvey), led by Dr. Duane Froese, generously provided laboratory time and equipment as well as coordination, support and storage space for NHPs large collection of hail sample. Students Juanita Sandoval Ortiz and Jarod McLeay, supported by the U of A, worked diligently for months processing and analysing hail samples.

Red Deer College (2022) and Olds College (2023) provided housing, laboratory access and an overall base of operations for the NHP field operations campaigns.

We also wish to thank the many land-owners who kindly volunteered to host hailpads on their properties, as well as people who provided access to property and information for damage surveys.

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NORTHERN HAIL PROJECT: APPENDIX A
2022 HAILSWATH INTERCEPT MISSIONS

Mission No.	Date	Location(s)	No. of Data Points
1	June 5, 2022	Armada, AB	5
2	June 8, 2022	Strachan, AB	4
3	June 12, 2022	Hussar, AB	9
4	June 19, 2022	Haynes, AB Prentiss, AB	4
5	June 22, 2022	Olds, AB	15
6	June 23, 2022	Altario, AB	3
7	June 28, 2022	Rocky Mountain House, AB	23
8	July 1, 2022	Innisfail, AB Pine Lake, AB Huxley, AB Lousana, AB Red Deer, AB	22
9	July 5, 2022	Donalda, AB Galahad, AB Talbot, AB Brownfield, AB	9
10	July 7, 2022	Bergen, AB Shantz, AB	13
11	July 8, 2022	Innisfail, AB Maskwacis, AB	8
12	July 9, 2022	Markerville, AB Red Deer, AB	18
13	July 15, 2022	Drayton Valley, AB	4
14	July 16, 2022	Sundre, AB Red Deer, AB Markerville, AB	13
15	July 22, 2022	Cochrane, AB	11
16	July 30, 2022	Cremona, AB	2
17	July 31, 2022	Condor, AB	10
18	August 1, 2022	Condor, AB Stratchan, AB	11
19	August 4, 2022	Hussar, AB	4
20	August 14, 2022	Birchcliffe, AB	2

NORTHERN HAIL PROJECT: APPENDIX B
2023 HAILSWATH INTERCEPT MISSIONS

Mission No.	Date	Location(s)	No. of Data Points
1	June 12, 2023	Rainbow, AB	5
2	June 16, 2023	Red Deer, AB	3
3	June 17, 2023	Rocky Mountain House, AB	6
4	June 25, 2023	Pine Lake, AB Delburne, AB Red Deer, AB	8
5	June 30, 2023	Alder Flats, AB Buck Lake, AB Rimbey, AB Rocky Mountain House, AB	11
6	July 1, 2023	Carstairs, AB Didsbury, AB Shantz, AB Acme, AB	13
7	July 10, 2023	Didsbury, AB	6
8	July 17, 2023	Bergen, AB Cremona, AB Carstairs, AB	10
9	July 22, 2023	Burnstick Lake, AB	1
10	July 24, 2023	Brazeau Dam, AB	7
11	July 28, 2023	Turner Valley, AB	5
12	July 30, 2023	Whisky Gap, AB	3
13	July 30, 2023	Cow Lake, AB Strachan, AB Drayton Valley, AB	9
14	July 31, 2023	Bearberry, AB Bergen, AB Sundre, AB Caroline, AB	38
15	August 3, 2023	Brazeau Dam, AB	2

NORTHERN HAIL PROJECT: APPENDIX C
2023 UAV FLIGHTS

Date	Location(s)	Notes
June 25, 2022	Pine Lake, AB	Mavic quadcopter flight over hailswath and crops.
July 16, 2022	Bergen, AB	UAV flight over hailswath and crops.
July 22, 2023	Burnstick Lake, AB	UAV flight over crops.
July 23, 2023	Brazeau Dam, AB	UAV flight over hailswath.
July 27, 2023	Turner Valley, AB	UAV flight over crops.
July 29, 2023	Whisky Gap, AB	UAV orthomosaic flight over hailswath and crops.
July 30, 2023	Drayton Valley, AB Rocky Mountain House, AB	UAV flight of hailswath and crops.
July 31, 2023	Caroline, AB	UAV flight over crops

NORTHERN HAIL PROJECT: APPENDIX D
COMPLETED HAIL DAMAGE SURVEYS

Date	Location(s)	Notes
June 19, 2022	Wapella/Langbank, SK	NTP team conducted point ground damage surveys of hail impacts for long-tracked hail event.
July 16, 2022	Ponoka, AB	First detailed damage survey of significant hail event, conducted along ~60 km by ~5 km wide portion of track. Multiple reports of building envelope breaches due to hail as well as 100% crop losses to all crop types.
June 7, 2023	Oak River and Rivers, MB	Survey conducted following reports of significant building impacts in Oak River. ~40 km long portion of track surveyed over two days, including tour of Oak River provided by Deputy Reeve.
July 1, 2023	Didsbury, AB; Killam, AB	2 Events - Survey of town of Didsbury conducted following reports of hail up to 80 mm in diameter accompanying violent tornadic supercell. Damage in and around Killam assessed following reports of significant siding damage and broken windows across the community.
July 20, 2023	London, ON	Damage survey conducted to document lower damaging threshold hail case. Portions of western and northern London suffered vehicle and garden damage, but absence of siding and window damage.
July 31, 2023	Horburg/Caroline, AB	Samples from the storm were collected by the Field Operations team. Surveys indicated large wind-driven hail at higher-elevation locations, with less severe damage and smaller hail indicated at lower elevations near the end of the track.
July 26, 2023	Selkirk/Rennie MB; Eagle Lake MB	2 Events – Survey of Selkirk to Rennie track showing transition from hail to wind-driven hail from same storm cell. Separate survey conducted in Eagle Lake area. Damage in Selkirk area confirmed go/no go criteria regarding presence (or lack thereof) of hail damage to crops on visible satellite imagery following event.
August 3, 2023	Lindsay, ON	Multi-hazard event – survey initiated following reports of combined large hail, wind and extreme rainfall impacts affecting most of city of Lindsay as well as surrounding agricultural areas.
August 12, 2023	Port Bolster/Pefferlaw, ON	Survey conducted following numerous reports of extremely large (i.e., tennis ball to baseball) accompanying tornado-warned storm.