P4.9 **SEVERE HAIL IMPACTS AND PREPAREDNESS**

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1. INTRODUCTION

Recent climatological study of severe hail in Finland (Tuovinen et al. 2009) shows that even on high latitudes hail can be a problem and cause injuries and locally considerable property damage. The database includes numerous events where up to 6 or 7 cm hailstones have been reported. Typically a yearly average of 10 severe-hail cases occur in Finland during 5 days between mid-June and mid-August, but the year-to-year variation is considerable.

Thanks to new approaches and e-mail hail survey project the number of observed cases annually has greatly increased lately (Tuovinen and Schultz 2010). For example, in 2010, 90 severe-hail cases occurred during 22 days and currently more than 400 severe hail reports are documented in the Finnish severe hail database. The motivation of this study is to find out what are typical large hail damage in Finland and define some guidance for public and authorities to mitigate hail impacts.

We studied media reports of the damage from 60 large-hail cases and two severe-hail outbreak cases in detail. In both parts, the data comes from the rescue operations of the Finnish Rescue Services and the statistics of paid compensations from the Finnish Motor Insurers´ Centers. The impact description is followed by general safety rules for public and severe-hail call-to-action statements.

The hail damage and its socioeconomic impacts are studied in detail for the 10 July 2006 severe-hail episode, one of the most violent severe-hail outbreaks in recent history in Finland. Another very fresh but more isolated example of large hail damage is from 8 August 2010. Both events were well documented and raised questions about society's vulnerability to severe hail.

To prepare the general public better for large hail events, we have taken new measures. Based on the observed impacts in Finland, and, in co-operation with the Emergency Services College, we have developed in this study hail storm general safety rules and call-to-action statements that can be included in warning messages.

2. IMPACTS OF HAIL STORMS

Regardless of size, hail can flatten crops (Fig. 1) or make roads hazardous to drive on with slippery conditions and rapidly decreasing visibility (Fig. 2). At least seven injuries and one death have been reported in traffic accidents caused by hail in Finland since 2006. It seems that most violent hail storms don't necessarily cause much road accidents as cells move rather quickly and aren't often able to accumulate troubling amount of hail on the ground to cause slippery conditions. Slow-moving or stationary hail cells with lot of 1–3 cm hail are in a better position to cause local traffic problems. Small hail may also cause flash floods in city areas, if hail accumulates to the ground blocking rain water sewing system.

Fig. 1. Hail damage at the wheat field 1 August 2008. Hail streaks can destroy field completely (Photo: Jaakko Holsti).

Based on damage caused by 60 separate severe-hail cases in Finland during the past 10 years (from the climatology by Tuovinen et al. (2009)), we have classified the typical reported damage for different hail sizes (Table 1). The impact of the hail is not solely dependent on hail size, but also on the duration of the hail fall and the accompanying winds (e.g. Parker et al. 2005). The most commonly reported hail damage in Finland includes broken plastic or glass shields and windows, and dented cars. Injuries caused by falling hailstones have been bruises, wounds or mild concussions. A hail impact damage chart (Table 1) shows similarities with other reported damage elsewhere (e.g. Hohl et al. 2002, Marshall et al. 2004, Webb et al. 2009).

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Fig. 2. Slippery road 1 August 2008 after 20-minute hail fall in Southern Finland. Road maintenance had to be called in for help as two kilometers of road became impassable. Radiation fog was also a risk for road safety (Photo: A-J Punkka).

TABLE 1: Hail impact damage chart for Finland.

Size	Impacts
≥1,5 cm/ long duration	- Slippery roads and poor visibility - Crop and plant damage
2–3 cm	- Occasional damage to car sheet metal
3–5 cm	- Scratches from sharp hail edges, bruises, swellings, and mild concussions for humans and animals - Damage to car sheet metal and windshields cracked - Tin roofs dented, felt roofs damaged, building windows broken, holes in plastic roof decks, paint comes off of exterior walls
5–7 cm	- Crushing for humans - Tile roofing broken, two-light frame windows broken
≥7 cm	- Car windshields completely broken, large dents in sheet metal

2.1 CASE 1: 10 July 2006

During 10 July, numerous splitting supercell storms swept through small cities and communities in the eastern Finland (Tuovinen 2007), producing hail up to 7-cm in diameter and damaging winds. The right-moving supercells were the strongest hail producers. Altogether, 8 different storms produced severe hail with over 50 individual reports of severe hail (Fig. 3).

These storms caused multimillion-euro property damage as over 1000 cars were damaged, and some were beyond repair. Also, numerous windows in buildings and tile roofs were shattered in the worst-hit areas. A few people were injured at the local athletics meeting when the sudden hail fall started. The total amount of the insured property losses was estimated to be 2–2.5 million euros. The Finnish Motor Insurers´ Centers statistics did not show an increase in the number of accidents in most of the affected provinces; except for one province where the number of accidents was double the average.

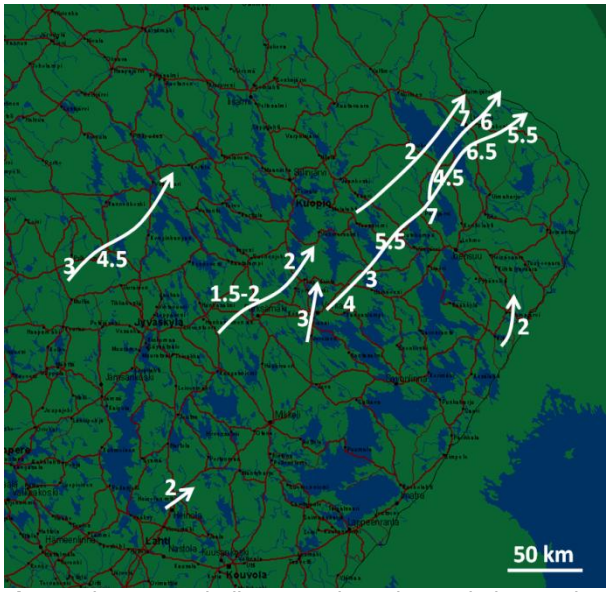

Fig. 3. The severe hailstorm trajectories and observed maximum hail sizes (cm) 10 July 2006.

2.2 CASE 2: 8 August 2010

On late afternoon and evening of 8 August 2010 severe storms, including several supercell thunderstorms, developed rapidly in Western Finland (Fig. 4). One of the storms started to produce very large hail even during the storm splitting stage and the right-mover continued doing so during its' several hours lifetime. Storms moved slowly over the small cities producing 4–7 cm hail for 10 minutes breaking windows, wind shields, hammering cars and roof sailings. Even tile roofs experienced damage. Hail grew into record size of 8 cm (Fig. 5), which has been observed in Finland only twice before (1968 and 2009). According to local newspaper (*Tyrvään Sanomat*), approximately 1500 cars were damaged with dents on the metal skin or wind shields. There were also numerous cars with completely busted wind shield and the damage was beyond repair. Additional damage was caused by downdrafts that downed trees and damaged building roofs. Estimated damage of 8 August hail storm was about 4.0 million euros.

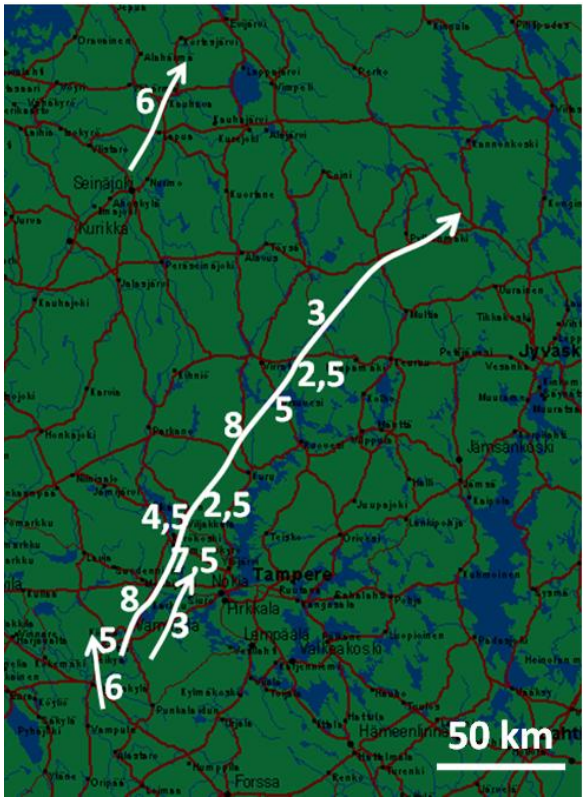

Fig. 4. The severe hailstorm trajectories and observed maximum hail sizes (cm) 8 August 2010.

Fig. 5. Baseball-sized hailstone 8 August 2010 in Western Finland (Photo: H-M Sariluoto).

3. HAIL PREPAREDNESS

Hail preparedness in Finland includes severe weather outlooks (Punkka and Rauhala 2010) which are distributed to civil protection authorities and key infrastructure partners like electricity companies and for both road and railway administration up to 48 hours before large hail events. Based on severe weather outlook user survey (Punkka and Rauhala 2010), although large hail is quite a rare event in one single place in Finland, more than half of the outlook users think that large hail has large impact on their operations.

When large hail producing thunderstorms are expected in the following 24 h, a severe thunderstorm warning is issued. In case of imminent weather disaster, Finnish Meteorological Institute may issue an official emergency announcement that, by law, is published immediately in all radio and television stations (Rauhala and Schultz 2009). Additionally, one of the warning forecaster's duties is to inform the in duty operator of Traffic Management Centre for possible traffic problems related to slow-moving hail storms. Road users can be warned of slippery road surfaces via road traffic statement that is read instantly on the nationwide radio channel.

The new preparedness measures developed in this study are the general safety rules and call-to-action statements. General safety rules (Table 2) aim primarily to protect lives, but secondarily also to prevent property and environmental damage. They are distributed in written format on web pages, brochures or in books to be studied before onset of the event.

Call-to-action statements (Table 3) should provide localized guidance on what to do in response to the forecast (Troutman et al. 2001), although only a few European countries surveyed said that they included such statements in their severe thunderstorm warning message sent to the public (Rauhala and Schultz 2009). The purpose of the call-to-action statements is to save lives, and they are intended to be used only when the threat is imminent. The aim is to keep them as compact and clear as possible so that they are easily understandable when heard on the radio. Two levels of statements have been developed to highlight the possibility of extremely dangerous events (Smith 2000).

TABLE 2: General safety rules.

Before the event
- Drive carefully; hail can produce poor driving conditions.
- Don't go boating.
- Cover roof windows.
- Close the doors and windows.
- Cover garden furniture and other property outside.
- Keep pets and cattle inside.
- Drive car to garage.

During the event
- Move indoors away from windows and glass roofing.
- Tents, lightly built structures or plastic roof decks are not safe.
- If outside, take cover. Cover particularly your head. Hail can cause scratches and crushing for humans and animals.
- If driving, take into account other traffic – do not park your car so that it dangers the road safety. If you stop by the road side, use emergency signal. Hail can produce poor visibility, slippery roads and damage the wind shield.

After the event
- Avoid non-necessary travel. Look out for tree branches on the road. Hail can produce slippery road conditions.
- If you don't need help, help the neighbor.
- Check roof structures and windows.
- Clean the rain water system if blocked.

TABLE 3: Thunderstorm hail call-to-action statements for Finland.

Large hail	
General	Move indoors away from windows and glass roofing.
Extremely dangerous situation	This is a very dangerous situation. Large hail can cause crushing and wounds. Move immediately indoors away from windows and glass roofing.

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