The Ottawa-Gatineau Tornado Outbreak: Observations from damage surveys following the storm

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Aaron Jaffe, BESc.

Northern Tornadoes Project

Faculty of Engineering
Western University
London, ON
Overview

• September 21\textsuperscript{st}, 2018 Ottawa Area Tornadoes
• Damage Assessment Tools
• Damage Survey
  • Dunrobin
  • Gatineau
  • Nepean
• Summary
September 21st Tornadoes

- Outbreak of 6 tornadoes
- 1 EF-3 tornado and 1 EF-2 tornado
- 4 other tornadoes categorized as EF-1
- 4 Tornadoes started in Ontario, 2 in Quebec

<table>
<thead>
<tr>
<th>EF Rating</th>
<th>EF-Scale Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>90-130</td>
</tr>
<tr>
<td>1</td>
<td>135-175</td>
</tr>
<tr>
<td>2</td>
<td>180-220</td>
</tr>
<tr>
<td>3</td>
<td>225-265</td>
</tr>
<tr>
<td>4</td>
<td>270-310</td>
</tr>
<tr>
<td>5</td>
<td>315+</td>
</tr>
</tbody>
</table>
## Event Summary

Preliminary Analysis – Sept. 21 Confirmed Tornadoes

<table>
<thead>
<tr>
<th>Start Time (Approx.)</th>
<th>Location(s)</th>
<th>Estimated Path Length</th>
<th>Estimated Max Width</th>
<th>Current EF Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:30 PM</td>
<td>Baskatong Reservoir</td>
<td>18 km</td>
<td></td>
<td>EF-1</td>
</tr>
<tr>
<td>3:50 PM</td>
<td>Otter Lake</td>
<td>11 km</td>
<td></td>
<td>EF-1</td>
</tr>
<tr>
<td>3:50 PM</td>
<td>Calabogie/White Lake</td>
<td>36 km</td>
<td></td>
<td>EF-1</td>
</tr>
<tr>
<td>4:30 PM</td>
<td>Kinburn/Dunrobin/Gatineau</td>
<td>49 km</td>
<td>1.3 km</td>
<td>EF-3</td>
</tr>
<tr>
<td>4:40 PM</td>
<td>Val-des-Bois</td>
<td>27 km</td>
<td></td>
<td>EF-1</td>
</tr>
<tr>
<td>5:50 PM</td>
<td>Nepean (Ottawa)</td>
<td>23 km</td>
<td>750 m</td>
<td>EF-2</td>
</tr>
</tbody>
</table>
Meteorology

Synoptic Conditions

Upper Air – 300 hPa

Upper Air – 500 hPa

21-Sep 19 UTC SPC Mesoanalysis

21-Sep 18 UTC WPC Analysis
Meteorology
Supercell Environment

- **SBCAPE ~2000 Jkg\(^{-1}\)** → Strong sustained updraft
- **CIN ~0 Jkg\(^{-1}\)** → Discrete supercells initiated ahead of front
- **Cold Front** → Storms initiated ahead of and along surface boundary and pressure trough
- **Upper Jet Exit Region** → Divergence aloft

**Lifting Mechanism**

- **Instability**
- **Moisture**
- **Wind shear**

**Severe Thunderstorms**

- **LCL ~750 m AGL** → Cloud base, supercell tornadoes typically 600-800 m AGL
- **EBS ~60 kt / 0.3 km SRH ~300-600 m\(^2\)s\(^{-2}\) / 0.1 km SRH ~300-500 m\(^2\)s\(^{-2}\)** → Upper and low level jets present, substantial wind shear for mesocyclone development, long-lived thunderstorms
Radar Observations

EF-1 – Calabogie/White Lake, EF-3 – Kinburn/Dunrobin/Gatineau

- ~ 3:30 PM - Supercell structure visible west of Calabogie, continued to travel eastward for over 1.5 hrs (140+ km)
- ~3:50 PM - Tornado formed west of Calabogie and continued through to White Lake, dissipating by 4:25 PM
- ~4:35 PM - Second tornado formed SW of Kinburn, tracking NE directly through Dunrobin and across the Ottawa River into Gatineau
- ~5:10 PM – Tornado dissipates in Gatineau, supercell continues to track further to NE, storm structure weakens and rotation dissipates by 5:30 PM
Radar Observations
EF-2 – Nepean (Ottawa)

- ~5:00 PM – Storm cell develops SW of Ottawa near Carleton Place
- ~5:40 PM – Rotation detected as storm becomes small supercell near Kanata (~15 km SE of Dunrobin); continues to track NE for 30 min (~30 km)
- ~5:50 PM – Tornado formed west of Nepean (south of downtown Ottawa), quickly moving NE through mostly residential areas
- ~ 6:10 PM – Tornado dissipates and storm structure weakens and rotation dissipates
Event Summary
Preliminary Analysis – Sept. 21

- ECCC forecasters warned of potential for severe weather, including issuing Special Weather Statements one day prior to outbreak
- Through the afternoon and early evening of Sept. 21, several discrete supercells tracked through Eastern ON and Southern QC
  - Watches and warnings issued throughout the day as storms initiated ahead of the cold front in early afternoon
- Outbreak of six tornadoes touching down between 3:30 – 6:10 PM
  - No fatalities, 23 injuries reported
  - 2000+ dwellings (ranging from single-apartment units to detached single-family homes) damaged or destroyed
  - Significant damage to electrical infrastructure in urban areas, resulting in significant power outages lasting hours to days
- Ground damage surveys completed Sept. 22-24 in Eastern ON and Gatineau, QC
- Analysis of satellite imagery available on Sept. 24 confirmed 3 additional tornadoes in Quebec
Damage Assessment Overview
Survey Teams

• Northern Tornadoes Project Team
  • David Sills and Lesley Elliot (Environment Canada)
  • Emilio Hong and Aaron Jaffe (Western University)

• Environment Canada Team
  • Ontario Storm Prediction Center (OSPC)
  • Quebec Storm Prediction Center (QSPC)
Northern Tornadoes Project

• Identify and observe every tornado occurring in Canada
• Capture all information from these events
• Archive tornado data for public usage
Ground Survey Objectives

• Estimate bounds of the tornado
• Observe and document all possible observable damage
• Talk to witnesses for further details
• Analyze details of structures
Current Tools

• GPS cameras
• Aerial Surveys
• ArcGIS and Collector App
• Satellite imagery
• Drone imagery
Dunrobin
<table>
<thead>
<tr>
<th>DOD</th>
<th>Damage Description</th>
<th>EXP</th>
<th>LB</th>
<th>UB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Threshold of visible damage</td>
<td>105</td>
<td>85</td>
<td>130</td>
</tr>
<tr>
<td>2</td>
<td>Loss of roof covering material (up to 20%), gutters and/or awning; loss of vinyl or metal siding</td>
<td>125</td>
<td>100</td>
<td>155</td>
</tr>
<tr>
<td>3</td>
<td>Broken glass in doors and windows</td>
<td>155</td>
<td>125</td>
<td>185</td>
</tr>
<tr>
<td>4</td>
<td>Uplift of roof deck and loss of significant roof covering material (more than 20%); collapse of chimney; garage doors collapse inward; failure of porch or carport</td>
<td>155</td>
<td>130</td>
<td>185</td>
</tr>
<tr>
<td>5</td>
<td>Entire house shifts off foundation</td>
<td>195</td>
<td>165</td>
<td>225</td>
</tr>
<tr>
<td>6</td>
<td>Large sections of roof structure removed (more than 50%); most walls remain standing</td>
<td>195</td>
<td>165</td>
<td>230</td>
</tr>
<tr>
<td>7</td>
<td>Exterior walls collapsed</td>
<td>210</td>
<td>180</td>
<td>245</td>
</tr>
<tr>
<td>8</td>
<td>Most walls collapsed, except small interior rooms</td>
<td>245</td>
<td>205</td>
<td>285</td>
</tr>
<tr>
<td>9</td>
<td>All walls collapsed</td>
<td>275</td>
<td>230</td>
<td>320</td>
</tr>
<tr>
<td>10</td>
<td>Destruction of engineered and/or well-constructed residence; slab swept clean</td>
<td>320</td>
<td>265</td>
<td>355</td>
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*All wind speeds in km/h
Gatineau

• Same tornado that caused EF3 damage in Dunrobin crossed the Ottawa River and caused significant damage in Gatineau, QC

• 14 injured, 2 severely

• 215 buildings damaged or destroyed

• 100,000 residents without power
Gatineau

- Map shows damage locations and areas surveyed
- Surveyed area of 800x400 metres
- EF3 damage with maximum wind speeds around 240 km/h
Gatineau
Low-Rise Apartment Buildings
### Low-Rise Apartment Buildings

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<td>155</td>
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<tr>
<td>2</td>
<td>Loss of roof covering (up to 20%)</td>
<td>160</td>
<td>130</td>
<td>195</td>
</tr>
<tr>
<td>3</td>
<td>Uplift of roof decking; significant loss of roof covering (more than 20%)</td>
<td>200</td>
<td>170</td>
<td>235</td>
</tr>
<tr>
<td>4</td>
<td>Uplift or collapse of roof structure leaving most walls standing</td>
<td>220</td>
<td>195</td>
<td>255</td>
</tr>
<tr>
<td>5</td>
<td>Most top story walls collapsed</td>
<td>255</td>
<td>220</td>
<td>295</td>
</tr>
<tr>
<td>6</td>
<td>Almost total destruction of top two stories</td>
<td>290</td>
<td>250</td>
<td>330</td>
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https://www.google.com/maps
Low-Rise Apartment Buildings
Low-Rise Apartment Buildings
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Low-Rise Apartment Buildings
Vehicles
Residential Structures
Residential Structures
Mid-Rise Apartment Buildings
Mid-Rise Apartment Buildings
Nepean

• Second powerful tornado from the outbreak hit Ottawa suburb of Nepean

• Several hundred homes damaged

• Widespread power outages
Nepean

• Tornado path length: 23 km
• Tornado path width: 750 m
• EF2 damage with maximum wind speeds around 200 km/h
Drone Usage

https://www.dji.com/mavic-air
Bells Corners
Arlington Woods
Arlington Woods
Arlington Woods
Arlington Woods
Greenbank Road
Greenbank Road

https://www.cbc.ca/news/canada/ottawa
Craig Henry
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Craig Henry
Tanglewood
Tanglewood
Tanglewood

• Repairs to the Tanglewood Hydro One power substation that was largely responsible for the Ottawa-Gatineau power outages is expected to take weeks

https://twitter.com/hydroottawa/status
Main Findings

• Damage surveying of the Nepean tracks and thresholds for the Kinburn-Dunrobin-Gatineau storms
• Signs leading to EF-3 categorization in Dunrobin from surrounding structures
• Nepean damage survey and the documentation of hundreds of buildings in the neighbourhood
• 2 nail connections in Gatineau and the resulting failures due to these connections
What we learned

• Challenges of getting on site and accessing all points
• Drone no-fly zones and the flying restrictions
• How to spend our time surveying
• Coordination of different teams and parties
Moving Forward

• Aerial surveys to be conducted for the damage tracks and study of the resulting tracks
• Data basing the information and storing for archiving purposes
• Engineering analysis of structures such as engineered structures, house failures and debris flow patterns
• Tree fall and the patterns for tornado paths.
Acknowledgements

• Northern Tornadoes Projects Team
  • Gregory Kopp (Western University) and David Sills (Environment Canada)
  • Lesley Elliot
  • Sarah Stevenson and Connell Miller
  • Western Libraries

• Environment Canada teams

• Institute for Catastrophic Loss Reduction
Thank You