International Institute for Infrastructure Renewal and Reconstruction

Ready at a Moment's Notice

The Logistics of the Military and Emergency Preparedness

SCHULICH School of Engineering, University of Calgary

# Session 2: Emergency Response When an emergency occurs, how do we respond?.

## Modeling of the Mitigation Network for Natural Disasters Example: Prairie Tornadoes


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# What is a Disaster/Catastrophe/Calamity?

OXFORD ENGLISH DICTIONARY DEFINITION:

DISASTER: a sudden accident or a natural catastrophe that causes great damage or loss of life

CATASTROPHE: an event causing great and usually sudden damage or suffering; a disaster

CALAMITY: an event causing great and often sudden damage or distress; a disaster

# What is a Natural Disaster/Catastrophe/Calamity?

TRIAL DEFINITIONS:

| | |
|---|---|
| DISASTER: | a natural event that causes damage as well as distress, suffering and/or loss of life (e.g. Haiti earthquake, 2010)<br>CANADA: F3-5 tornadoes? |
| CATASTROPHE: | a disaster followed immediately by another disaster OR major infrastructure failure that cause significant damage and loss of life > x (e.g. Tsunda Trench earthquake + Indian Ocean Tsunami , 2004; OR Loma Prieta earthquake + collapse of Cypress Street Viaduct , 1989)<br>CANADA: Major flood + dam failure? |
| CALAMITY: | a disaster followed immediately by one or more disasters as well as major infrastructure failure that cause massive damage and loss of life >y (e.g. East Japan earthquake, tsunami and nuclear reactor failure, 2011)<br>CANADA: Cascadias fault earthquake + tsunami +? |
| END OF THE WORLD: | large asteroid strike (Chixculub asteroid, -65M years) |

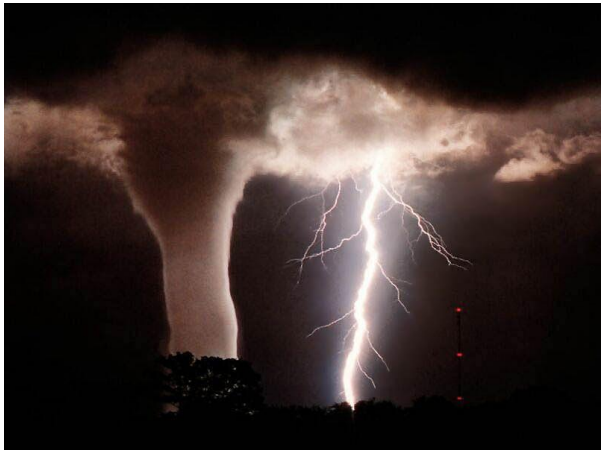
# DISASTER MITIGATION

- PRE DISASTER
- DURING DISASTER
- AFTER DISASTER

# DISASTER MITIGATION

- CONTINUOUS PRE – PLANNING
- INSTALLATION OF PLANS, “SAFEGUARDS”, DETECTION & WARNING SYSTEMS
- REAL-TIME MANAGEMENT
- IMMEDIATE & POST-DISASTER RESCUE
- MEDIUM TERM RECOVERY
- LONG TERM RECOVERY
- UPDATING OF “PRE-PLANNING” ACTIVITY
- *CULTURAL CHANGE*

# Background

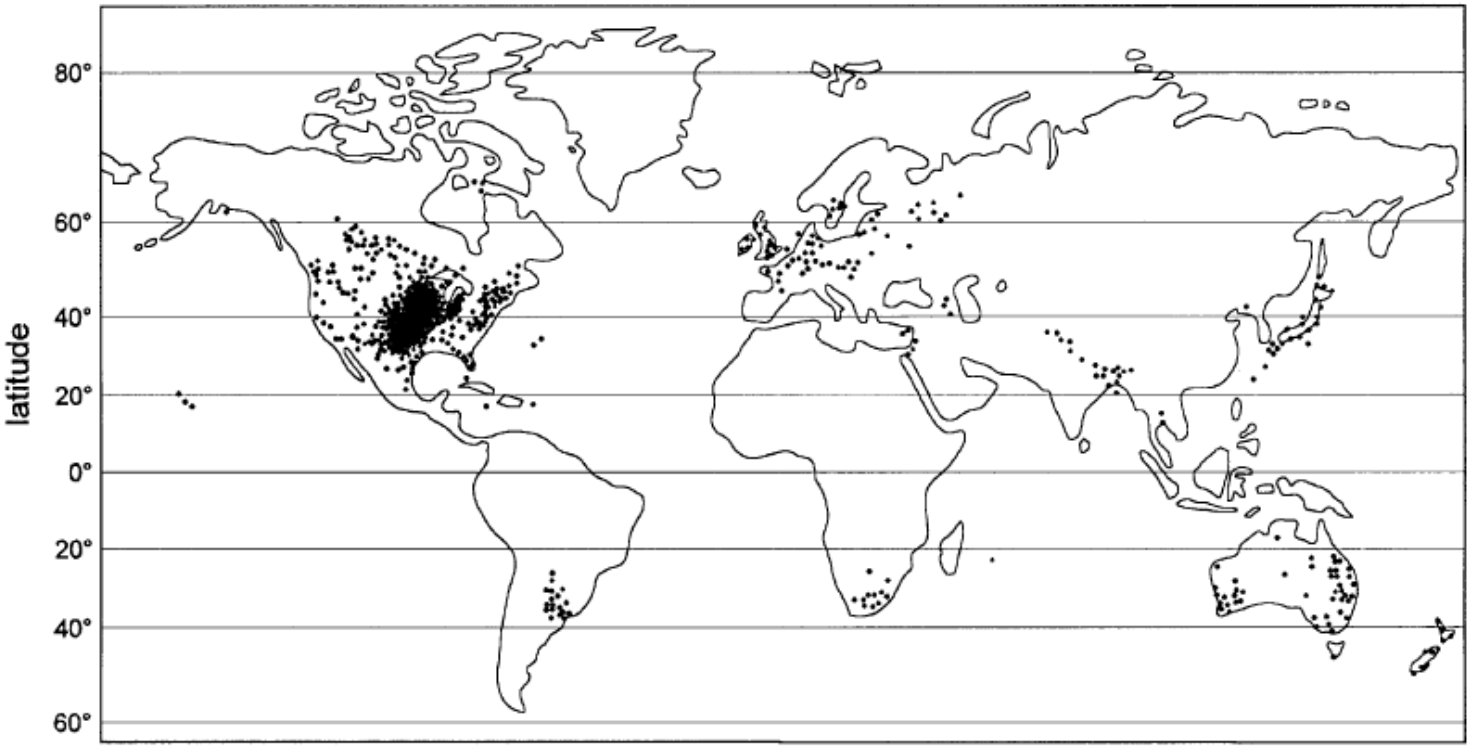


TORNADOES

# What is a Tornado

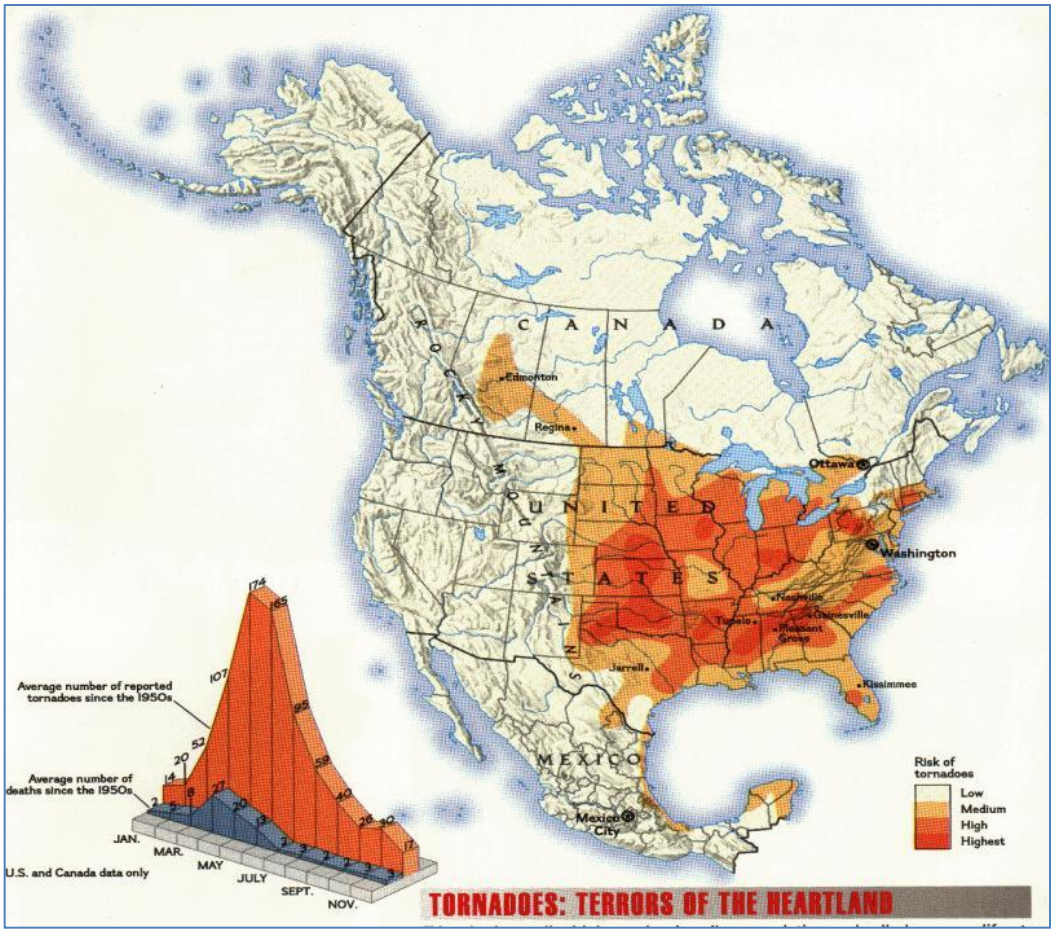
- A violently rotating column of air that extends from a thunderstorm cloud to the earth's surface
- Usually occurs where cold fronts clash with warm fronts
- Can move at speeds of 50-200 km/hour
- Localized and short-lived phenomenon
- Usually associated with black skies, strong winds, lightning, thunder and heavy rain or hail
- Has a high potential to create enormous damage to property and large number of deaths and injuries

# Worldwide Occurrence of Tornadoes




Source:(Goliger and Milford,1998)

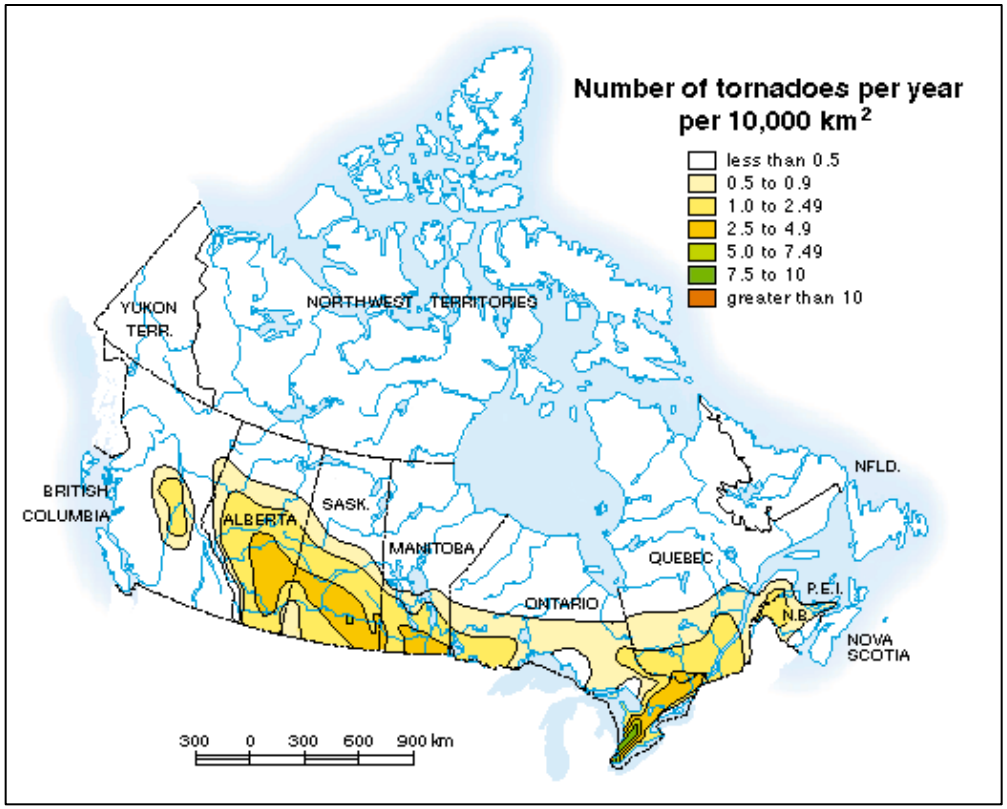
# Tornado Distribution in North America




Source: (Grosvenor et al, 1998)

# Tornado Contour Map in Canada

- Two main clusters of tornado-prone regions
- Approximately 36 tornadoes are reported on annually on average in the prairie region
- Disastrous impacts on highly populated, industrialized or agricultural areas




Source: Natural Resources Canada (2007)

# Tornado Warnings

- Warnings are the culmination of a sequence of actions ... that act to alert the public to a heightened probability of high-impact weather, minutes, hours or even days in advance" (Stensrud et al., 2009).

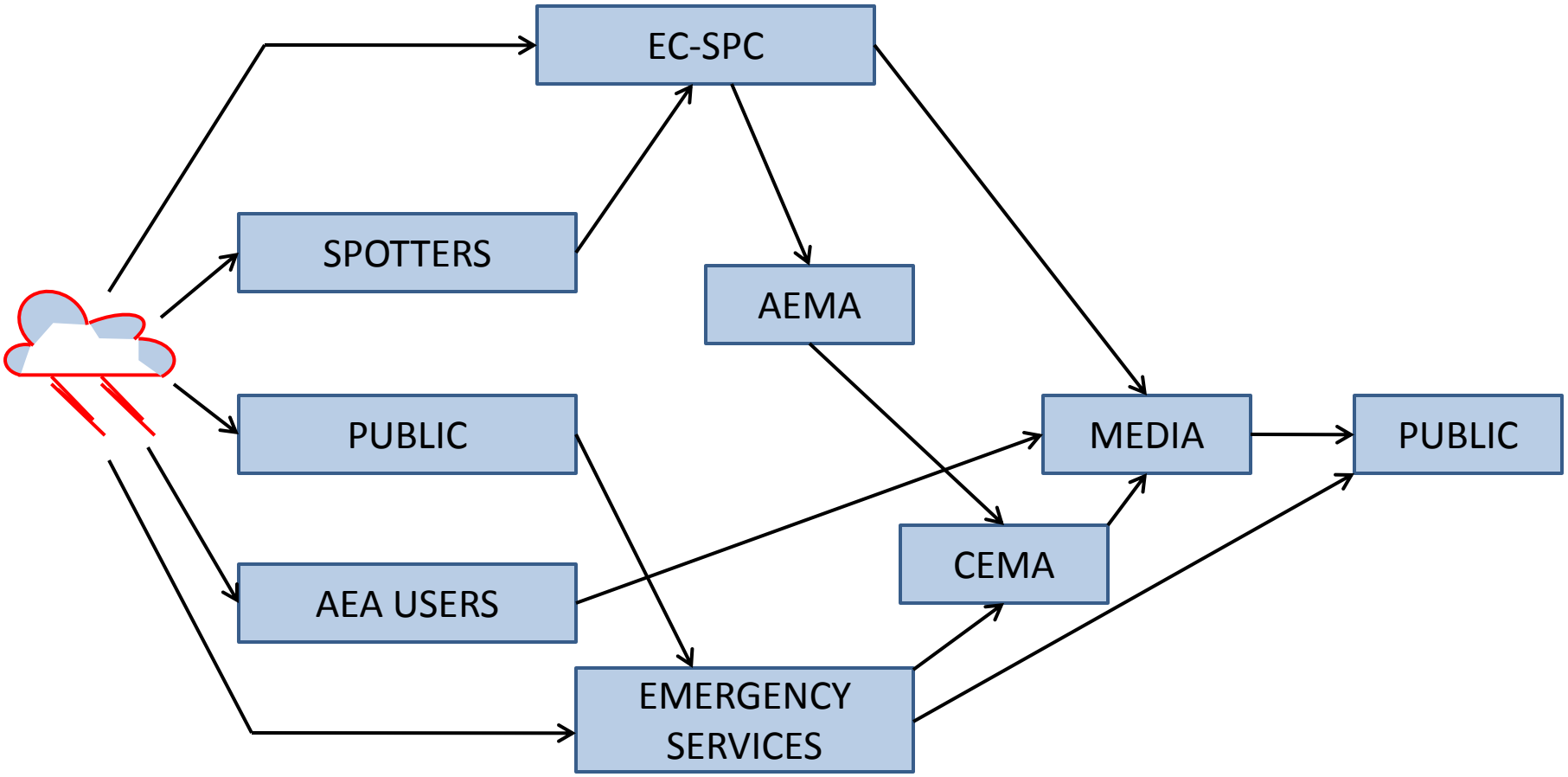
- Tornado warning is issued "when a tornado has been reported; or when there is evidence based on radar, or from a reliable spotter that a tornado is imminent"

  (EC, 2012).

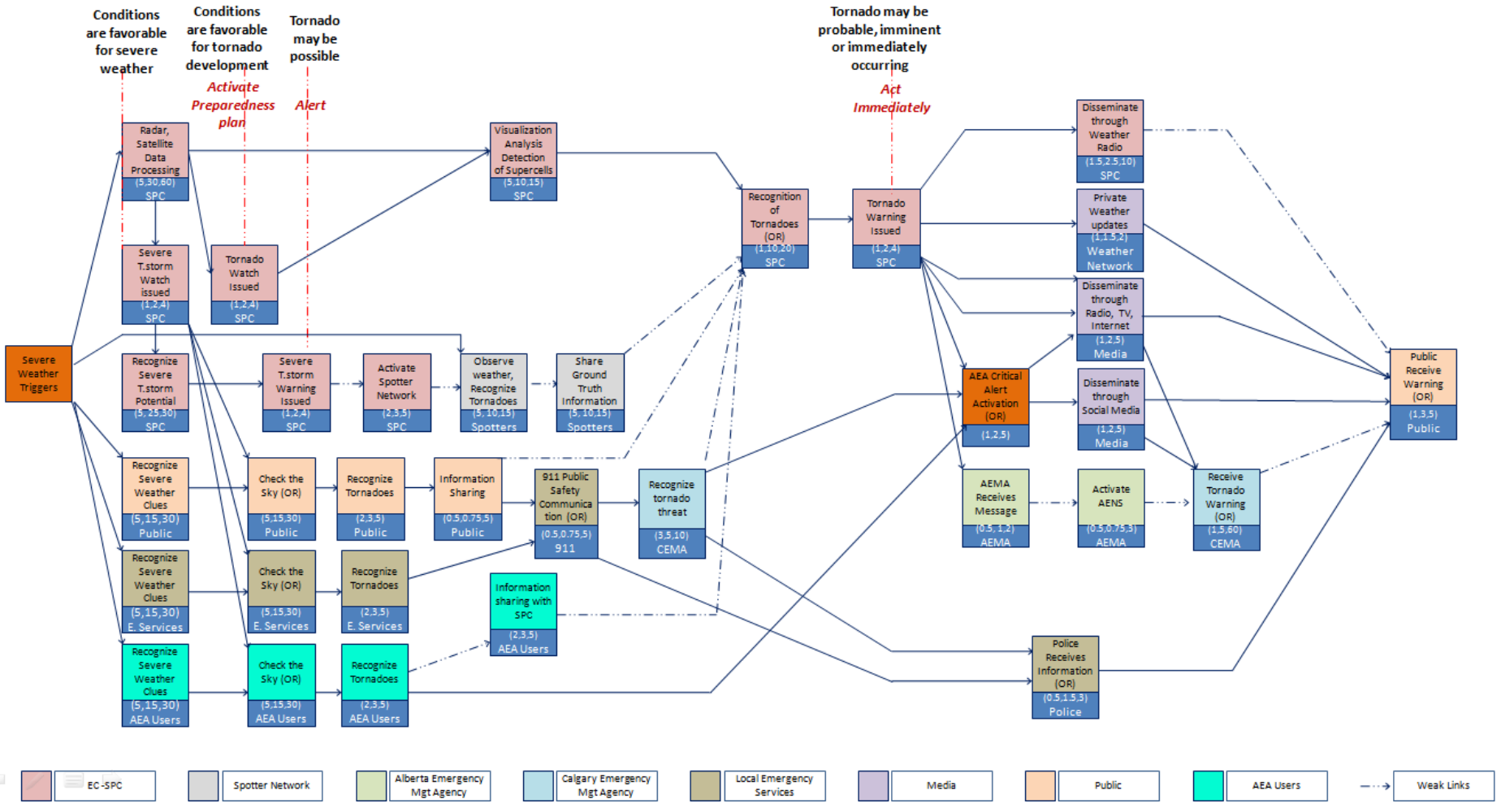
# Collaborating Partners

- Environment Canada –Prairie and Arctic Storm Prediction Centre
- Spotter Network
- Alberta Emergency Management Agency
- Alberta Emergency Alert –Authorized Users
- Calgary Emergency Management Agency
- Police, emergency services
- Local Radio and Television, Internet, Social networks
- Public

# Warning Partnerships



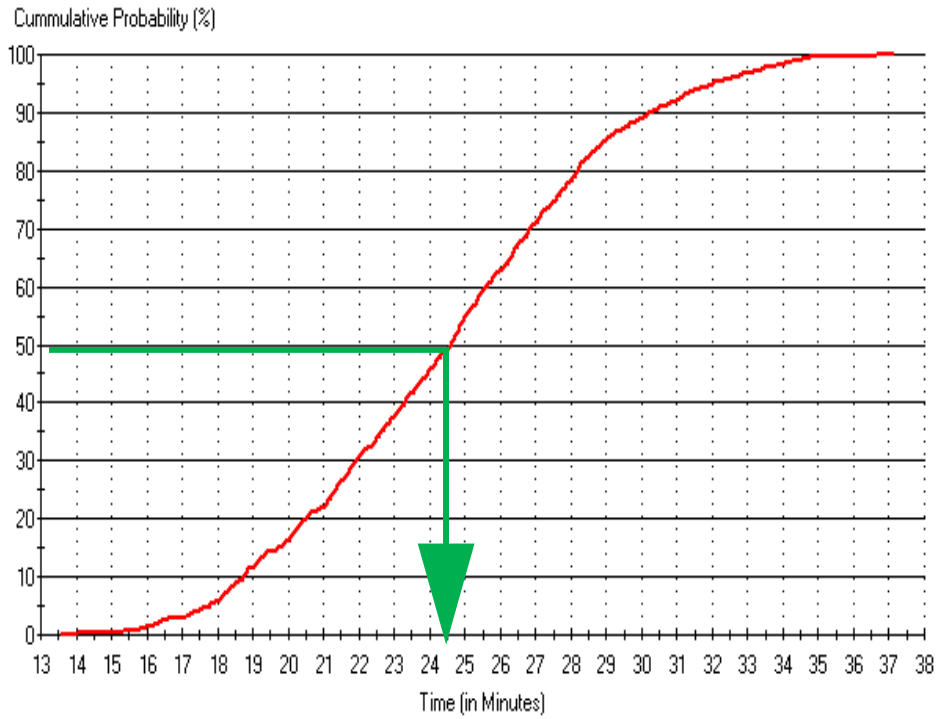
# Tornado Detection, Warning and Communication Network



# Simulation Output Results

- There is a 50% chance that tornado detection, warning and communication can be completed within 25 minutes or less.

- The maximum time predicted through simulation is about 37 minutes.



# Warning Related Issues

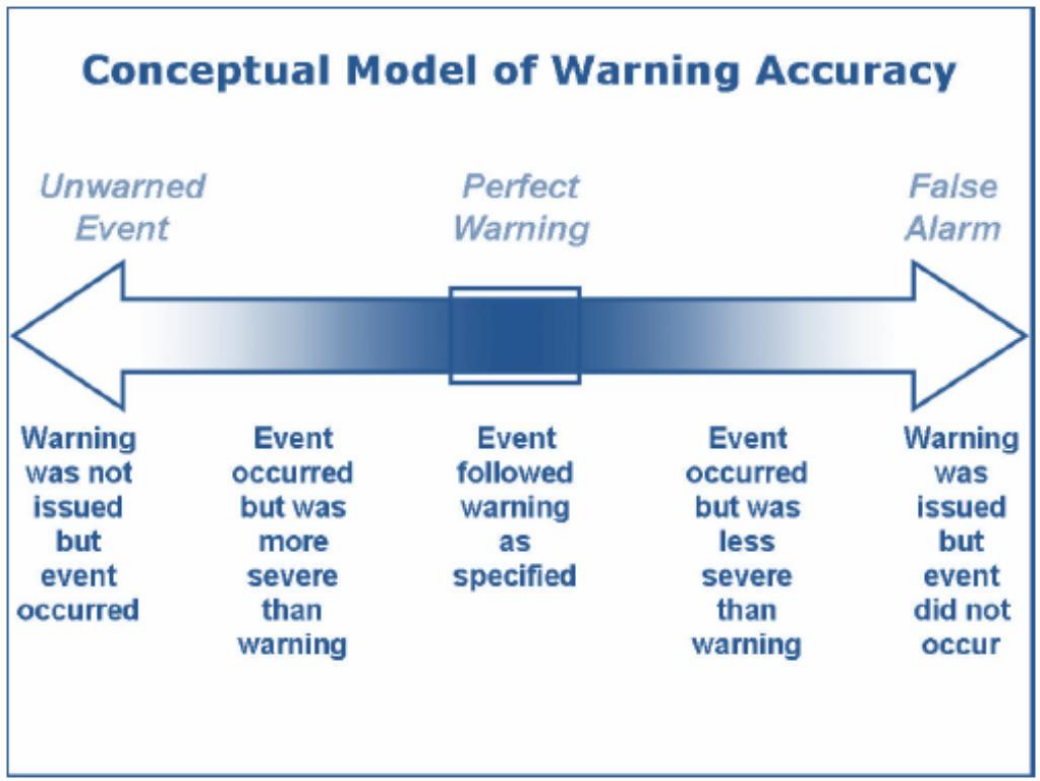
- Hard to predict
- Short warning lead times
- Uncertainty in predicting actual paths, size of forecast regions
- Warning for a large area although impacts are localized
- False warnings
- Missed events

# False Warnings

False warnings can be recognized as communications regarding tornado events that have been forecasted but not actually occurred.

| | Tornado | No Tornado |
|---|---|---|
| Warning Given | True Warning | False Warning |
| No Warning Given | Missed Event | Status Quo |

# Conceptual Model of Warning Accuracy




Source: Barnes et al. (2007)

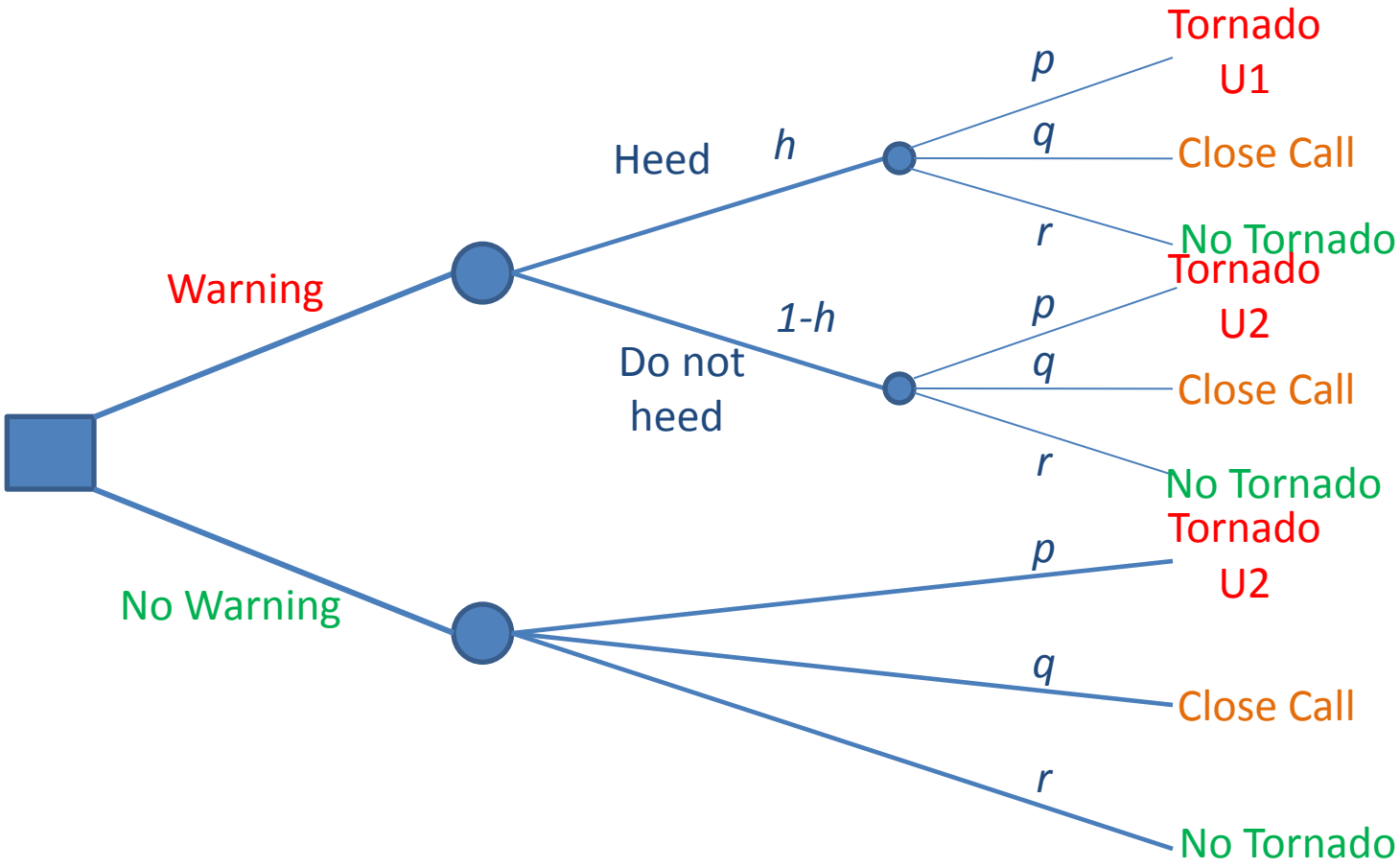

- Instead of having a yes-no categorization of warnings, this spectrum is used to demonstrate the range of accuracy of warnings.

# Probability of False Warnings

| Year | Number of tornado warnings | Joint occurrence of a tornado and a warning issuance | Number of false warnings |
|---|---|---|---|
| 2010 | 190 | 8 | 182 |
| 2011 | 76 | 7 | 69 |
| Total | 266 | 15 | 251 |

- Individual tornado occurrence reports were compared with the tornado warning records to determine the joint occurrence of a tornado and a warning issuance.
- Absence of such an intersection for a warning is counted as a false warning record.
- False warning probability 251/266 = 94.3%

# Warning Decision Tree for a Tornado




$E(W) = hp(U1)+(1-h)p(U2)$;  $E(NW)=p(U2)$

# Conclusion

- We must prepare even for events that have not occurred in millennia.
- Systems in place to mitigate disaster impacts are very complex and involve multiple federal/provincial/local agencies.
- “Dry runs” of disaster mitigation systems are costly and may not always highlight weaknesses.
- Modeling the current mitigation network and Monte Carlo simulation provides an economical tool for assessing its reliability and pin pointing deficiencies.

# Acknowledgements


- Calgary Emergency Management Agency (CEMA)
  - Chief Bruce Burrell
- NSERC
- Schulich School of Engineering, University of Calgary
- Association of Professional Engineers and Geoscientists of Alberta (APEGA)
- Van Horne Institute