Tornadoes and Severe Weather Forecasting

ICLR
Friday Forum
June 8 2001

Outline

• Tornadoes
• Tornadoes formation
• Current Severe Weather Forecast Practices
• Future Forecasting/Nowcasting
  – Sydney 2000 Project

Tornadoes

Types
Classification

Tornado Classification

to be or not to be
Frequency by Class

Deaths by Class

Conditions for Big Storms

Tornado Climatology

Fronts and Weather
The Supercell

Other Severe Weather Features

Derechos

Gustfronts

Prefrontal Squalls

Microbursts
Microbursts & Airplanes

The Small Storms

Non-Supercell Tornadoes

Small Storms

Forecasting
- current practice

Upper Air Network

12 August 1991 Cloud Development along the Sea Breeze Front during an OF-Bace Flow Regime
Warning Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>Wind</td>
<td>Strong winds that cause mobility problems and possible damage to vegetation and structures.</td>
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<tr>
<td>Heavy Rainfall</td>
<td>Heavy or prolonged rainfall accumulating on a scale sufficient to cause local widespread flooding.</td>
</tr>
<tr>
<td>Thunderstorm</td>
<td>One or more of the following: strong winds causing mobility difficulty, damage to structures due to wind and hail, heavy rain that may cause local flooding and lightning.</td>
</tr>
<tr>
<td>Severe Weather</td>
<td>Presence of tornado(s), damaging hail, heavy rain, strong winds, life and property exposed to real threat, lightning.</td>
</tr>
<tr>
<td>Tornado</td>
<td>Public has real potential to be exposed to tornado(s).</td>
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</tbody>
</table>

Some Recent Canadian Tornadoes

Pine Lake

Doppler Signature

Which storm is severe?

Guelph Tornado
Williams Lake

Mesocyclone Detection
Apr 20 1996 Williams Lake Tornado

What’s Happening on the Ground?

The Future
Sydney 2000

- Algorithmic Severe Weather diagnosis of the atmosphere
- Nowcasting (0+) of convective initiation and precipitation
- Combined to form the World Weather Research Program Sydney 2000 Forecast Demonstration Project

Demonstrate precision forecasting in time and space.

Forecast Ability

Nowcasting

Observation based short-term forecasting
0 to 6/12/24 hours
0 hours mean knowing what is happening now
– diagnosis (eg of severe weather)
0+ hours mean predicting what is happening in the future
– prognosis
– extrapolation
The Players

<table>
<thead>
<tr>
<th>Participant</th>
<th>System</th>
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</thead>
<tbody>
<tr>
<td>UK Met Office</td>
<td>Nimrod - 6 hour nowcasts</td>
</tr>
<tr>
<td>UK Met Office</td>
<td>Gandolf - 3 hour nowcasts</td>
</tr>
<tr>
<td>Canada MSC</td>
<td>CARDS - 90 minutes, Severe Weather</td>
</tr>
<tr>
<td>US NCAR</td>
<td>Autonowcaster - 90 minutes, forecast convection</td>
</tr>
<tr>
<td>US NSSL</td>
<td>WDSS - Severe Weather</td>
</tr>
<tr>
<td>Australia</td>
<td>Sprog - 90 minutes, Polarization Radar</td>
</tr>
</tbody>
</table>

Clients

- Real time delivery of products to BOM forecasters and external clients to use in provision of weather services
- Targeted Impact Studies for Olympic Games

Nimrod 0 to 6 hrs Precip Nowcast

- Successor to FRONTIERS (Forecasting Rain Optimised using New Techniques of Interactively Enhanced Radar and Satellite data) from 1997
- Radar derived surface rain rate analysis
- Nowcast scheme combines object-oriented rainfall advection with NWP mesoscale rainfall prediction
- Inputs – synoptic observations, surface beam radar reflectivity, satellite, NWP mesoscale model outputs
- Nowcasts from 0-6 hours, 15 min. time step, 5 km resolution
- Products – instantaneous rain rate, 15 minute rain accumulation, precipitation type, wind gusts

Nowcasting methodology

- Extrapolation forecast, T+6 hours
- Merged forecast, T+6 hours
- Radar Cross-correlation
- Use NWP to evolve and fill in

Nimrod extrapolation and ‘merged’ forecasts

- Optimum forecast
- Mesoscale NWP forecast
- Forecast lead time

GANDOLF 0 to 3 hours Precip Nowcast

- Designed to improve nowcasts of convective rain
- Radar derived 3-D rain analysis
- Object-oriented nowcast scheme with conceptual life cycle model of convective cell
- Inputs – multi-beam / volumetric radar reflectivity, satellite, NWP mesoscale model outputs
- Nowcasts from 0-2 hours, 10 min. time step, 2 km resolution
- Products – instantaneous rain rate, 15 minute rain accumulation, storm / cell track, (hail diagnosis, peak convective wind gust)
Life cycle of a convective cell in the Object Oriented forecast scheme

- **d**: developing
- **m**: mature
- **M**: fully mature
- **E**: early dissipating
- **D**: dissipating

**Temperature (Celsius)**

- 10
- 20
- 30
- 40
- 50

**Birth Dissipation Life cycle (minutes)**

- 10 10 20 30 45 60

**Instantaneous Rainfall Forecast**

- 10 minute run cycle
- 2 km resolution
- T+10 – T+120 min. forecasts
- Cell evolution (interaction)

**Autonowcaster**

- Convective Initiation
- Using current weather observations combined with a computer-based numerical model, FUZZY LOGIC, thunderstorm motion and growth is forecast for the next hour.

**Adjoint Winds and Boundary Detection**

- Machine/Human Drawn

**Boundary = Convective Initiation**

- Example given for boundary relative low-level shear.

**Fuzzy Logic**

- Converts low-level shear to thunderstorm likelihood
Final Convective Development Product

Polarimetric Radar

September 2000: Hail detection with Polarization Radar

Example of hail collected near Hornby Park NSW

National Severe Storms Laboratory Warning Decision Support System - Severe Weather Only

Probability of tornadoes and severe storms

Time-height trend information from 130 million data points

One hour trend of storm parameters

Pop-up table alerting of rapidly growing storms

Table ranking the most severe storms

Detects storms and vortices and forecasts their movement.

Point Forecast

Our Reality

The Bureau of Meteorology’s CPOL Polarimetric Doppler Research Radar now located temporarily at Badgery’s Ck in support of the Sydney 2000 Project

The Canadian Atmospheric Environment has developed a system to detect the severity of individual thunderstorms. Hail, downbursts, rotating storm updrafts and other severe weather signatures are detected automatically using Doppler radar data from the Bureau of Meteorology site at Kurnell.

Rings show locations of microbursts on 19 January 2000

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Hail

Card

Our Reality
Summary

- Described the variety of Tornadoes
- Described the current thinking about how they are formed
- Described how severe weather forecasting is done
- Described other tornado-like severe winds
- Described where we are going in forecasting