Effective Use of Information on Hazardous Winds Associated with Severe Storms

Kunio Sakurai
Director-General of Forecast Department
Japan Meteorological Agency
Prologue: Example of tornado disaster with Typhoon: September 17, 2006

Nobeoka, Miyazaki Prefecture
Length 7.5 km, Maximum width 300 m
3 people killed, 143 injured
79 buildings completely destroyed,
348 partially destroyed

Hyuga, Miyazaki Prefecture
Length 2.0 km, Maximum width 200 m
7 people injured
1 building completely destroyed,
9 partially destroyed

* Statistics include damages by typhoon itself.
Contents

• Part I
  – Outline of information on hazardous winds associated with severe storms
    • Tornado Watch
    • Hazardous Wind Nowcast
  – Techniques for forecasting of hazardous winds
  – Example of tornado and issued information

• Part II
  – Accuracy of Tornado Watch
  – How to convey the risk and How to utilize the information
    • Designing information in collaboration with users
    • How to effectively use the Tornado Watch
Part I

Outline of Information on Hazardous Winds Associated with Severe Storm

Techniques for forecasting of hazardous winds
Tornado Watch No.1
Issued by Miyazaki Local Meteorological Observatory at 12:07 Sep. 18, 2008

There is a risk that a hazardous wind may occur in Miyazaki prefecture. Tornados occur under cumulonimbus. When there is a sign of thunderstorm, protect yourself in solid structures.

This information remains in effect for one hour after issued. Target areas: Miyazaki, Nishinan-Kushima, Miyakonojyo, Kobayashi-ebino, Saito-Takanabe

* The information is issued only in Japanese. This is translated into English as reference.
Hazardous Wind Nowcast (2010~)

Issued every 10 minutes in GPV format with 10 km resolution, which includes an analysis and forecasts up to one hour.

Two categories:
- **Higher probability of tornadoes (7%)**
  - = more missed events (70%)
- **Slight probability of tornadoes (2%)**
  - = less missed events (10%)
Techniques for forecasting of hazardous winds

Potential indices using NWP

Radar echo intensity

Hazardous wind index

Detection of mesocyclones using Doppler radar

Prediction of hazardous wind occurrence based on the left two methods

Tornado Watch
Step 1. Potential indices using NWP

Predict the atmospheric condition in which cumulonimbi (super cells) are likely to be generated.

→ Tornadoes are generally associated with a cumulonimbus (super cell)

Calculate potential indices using atmospheric instability and vertical shear, such as Energy Helicity Index (product of CAPE by SReH)

High potential for hazardous wind can be predicted one day before.
Step 2. Hazardous Wind Index based on NWP indices and radar reflectivity observations

Predict probability of hazardous winds
← Hazardous winds likely occur when cumulonimbus is generated in high EHI area.

How to calculate the Index?

Formulate an expression to calculate the Hazardous Wind Index using regression analysis, with
- objective variable:
  Hazardous wind occurs (1) or not (0)
- explanatory variable:
  Potential Indices calculated by NWP and radar echo (intensity and height)

→ calculate Hazardous Wind Index (HWI) every 10 minutes.
Doppler radar cannot detect tornados, because their size is too small. Doppler radar can detect Mesocyclones, which exists in the parent cloud of a tornado, and their size is about 10 km in diameter.

### How to detect mesocyclones?

pick out wind patterns which are similar to a mesocyclone, and compare the wind field with the vorticity field of an ideal mesocyclone.
Criteria for issuing the Watch

For a grid point A;

① The hazardous wind index exceeds a threshold within the circle with 100-km radius centered the target point A in the last one hour.
② A mesocyclone is presently detected at A.

When the above two conditions are satisfied at the same time, a hazardous wind is probable at A. → Tornado Watch is issued.

Another criterion: two conditions below are satisfied at the same time
① A mesocyclone is detected within the circle with 100-km radius centered the target point A in the last one hour.
② Hazardous wind index presently exceeds a threshold at A. is also adopted.
An Example of Tornado Watch issued on Aug. 28, 2008

Mesocyclone was detected.

Hazardous wind index exceeded a threshold.

Tornado Watch was issued at 19:05 JST.

There occurred a tornado at 20:00 JST.
Dissemination of the information

JMA Headquarters

Mass media such as TV and radio

Private weather companies

Manufacturing companies

Weather Information including Tornado W.

JMA Homepage

Direct transmission to disaster management organizations by dedicated line and internet

Public through Internet

Local governments, Municipalities

Disaster management organizations

Message super-imposed on TV

“Tornado Watch was issued in Gunma Prefecture. Watch out tornados and strong winds.”
Part II

Accuracy of Tornado Watch
How to Convey the Risk
How to Utilize the Information
What is needed other than technical improvements?

- Even with the latest techniques, the accuracy of tornado prediction is rather low. (see statistics shown next)
- Even with technical and instrumental improvements, it is difficult to dramatically improve the accuracy.

→ need another attempts to enhance the effectiveness of the information, for example...
- Designing information in collaboration with users
- Provide a guideline about how to use the information
- Raising public awareness about Tornado Watch
In general, tornados are small in spatial and temporal scale in Japan. → It is very difficult to forecast hazardous winds with high accuracy.

*Hit rate is about 30%, false alarm rate is about 90%.

Number of times
Tornado Watch was issued: 141
Number of hazardous winds events observed: 51 (▲)
Number of observed events warned by Tornado Watch in advance: 13 (○)

Hit rate (Probability of Detection): $\frac{13}{51} = 25.5\%$
False alarm rate: $\frac{128}{141} = 90.8\%$

How to enhance the effectiveness of the information?
How to convey the risk?
Designing information in collaboration with users

• Set up an advisory committee composed of professors of meteorology, sociology and risk management, and media people and asked for advice on information contents and how to convey the risk of hazardous winds.

• Sought opinions from potential users such as construction firms, schools, railway companies

Outcomes from the discussion

▶ Name of the information
  The word *tornado* should be included, because this word draws people’s attention for its risk, while the information of downbursts and gust fronts is also included.

▶ Valid time period of the Watch
  Indication of the valid time period of the Watch (one hour) helps to understand exactly when people should pay attention to severe weather.

▶ Support this service
  The JMA should provide the information, even if the accuracy is rather low; the information can save people’s lives when used properly.
Watch the sky

Tornado Watch is issued

Watch the sky

If there is no sign of thunderstorm, particular actions are not required.

If there is a sign of thunderstorm, you should protect yourself in a solid structure.

How to utilize the Watch?
Developing a guideline

Basic concept of required action

Only by paying more attention to the weather condition, we can reduce risk of damage to human life, without taking refuge in vain too frequently.
### Possible Scenario

#### 1 - 0.5 day before
Weather information referring to tornado, as a prior notice.

#### A few hours before

- **Thunderstorm advisory**
- **Tornado Watch**

#### 0 - 1 hour before

- **Tornado occurs**

---

**Weather explanation based on the latest radar observation** (weather company)

**When there is a sign of approaching a cumulonimbus and thunderstorm,**
**protect yourself inside a solid structure and take security measures with other people. Watch out for lightning, hail, and heavy rain as well as tornados.**

**I should close windows, curtains, and shutters before the storm...**

**Transportation Operation**

**Take security measures based on the latest weather observation such as radar echo.**

**Take necessary action well in advance where it takes time to make people evacuate.**

**If there is a sign, protect yourself inside a solid structure.**

**Watch out Up in the sky**

Radio  TV  Cell phone  Internet  Online system
Raising public awareness is a key issue to prevent disaster caused by hazardous winds.

- published and distributed a brochure, which includes
  - Meaning of the information issued by JMA
  - Required action to the information to guard yourself
  - Understanding the tornado
- gave lectures to media people, local government staff in charge of risk management.
- TV and radio programs to introduce this information and how to use.

* This brochure is published only in Japanese.
Summary and Conclusion

• As a countermeasure for disasters caused by severe storms, the JMA started issuing the Tornado Watch in 2008, and is planning to provide Hazardous Wind Nowcast in 2010, using new prediction techniques.

• Accurate observation and prediction of severe storms is technically challenging, because their spatial and temporal scale is small in Japan.

• The JMA have made attempts to enhance the effectiveness of this information; asking for advice to an advisory committee and potential users, developing a guideline about how to use the information, and raising public awareness about this information.

• We can increase the value of disaster prevention information by collaboration with users and mass media, in addition to technical improvements; the JMA is willing to share our knowledge and experience we have gained from our attempts with RA-II Members.