Introduction of NCDR’s early warning system for emergency response of hydrometeorological Hazards

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Extremely heavy rainfalls caused by typhoons, monsoons and Mei-Yu front often result in floods and landslide in both urban and rural areas.

Typhoon Herb 1996
Xangsane Typhoon 2000
Nari Typhoon 2001
Typhoon Mindulle 2004
Typhoon Aere 2004
Typhoon Kalmaegi 2008
Typhoon Sinlaku 2008
Typhoon Morakot 2009
Typhoon Fanapi 2010
OUTLINE

• Function and role of NCDR
• Disaster Monitoring
• Weather Forecast
• Disaster Prediction
• Integrated Platform

Function and Role of NCDR

National Science and Technology Center for Disaster Reduction
Enhancement of emergency support functions (ESFs) within CEOC

Central Emergency Operation Center (CEOC)

- Commander, Co-Commanders, Deputy Commanders
- Command Post
- Chief Staff Division
- News and Media Division
- Operation Division
- Administrative Division

Situation Assessment Group

- NCDR
- Water Resources Agency
- National Fire Agency
- Directorate General of Highways
- Office of Disaster Management
- Central Weather Bureau
- The Soil and Water Conservation Bureau

Purpose:
Integrate & provide most updated info and precaution notice for decision making

- Risk assessment
- Technology Support
- Hydro info. of river
- Dam and pumping station operation.
- Loss estimation,
  co-ordination and communication.
- Dynamic data of Typhoon.
- Potential streams of debris flow
  monitoring and warning
- Consultation
Since taking the emergency response to Typhoon Chebi in 2001, National Science and Technology Center for Disaster Reduction (NCDR) has been participating in and taking charge with the situation assessment in the Central Emergency Operation Center (CEOC).

During the operation of CEOC, NCDR staff has to take shifts, staying in the CEOC to assist the disaster response with information analysis. Since the precise analysis of important information is the key to help making the most appropriate disaster response decision, NCDR cooperates with Central Weather Bureau (CWB) and Typhoon and Flood Research Institute (TTFRI) to receive instant weather information.

To fulfill the needs for early warning, disaster monitoring, and information analysis, NCDR retrieves useful information from ensemble forecast and apply it on the warning system.

The framework of warning system for the disaster risk of typhoon and flood:

1. **Rainfall Warning**
   - Probability Model
   - High Risk Area

2. **Physical Model**
   - Scenario Simulation
   - Impacted Region and Scale

3. **Disaster Scale Estimation Method**
   - Scale and Scenario

4. **Emergency Operation**

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**Disaster Scale**

- Rainfall
  - Probability Model
  - Scenarios and Simulation
  - Impacted Region and Scale

- Physical Model
  - Scenario Simulation
  - Impacted Region and Scale

- Disaster Scale Estimation Method
  - Scale and Scenario

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**Risk**

- Rainfall Warning
  - Probability Model
  - High Risk Area

**Scenario**

- Physical Model
  - Scenario Simulation
  - Impacted Region and Scale

**Disaster Scale**

- Disaster Scale Estimation Method
  - Scale and Scenario

**Operation**

- Emergency Operation
Basic Concept of Early Warning and Emergency Response Operation

The early warning and emergency response operation for typhoon and heavy rainfall events consist of these three components:

= **Forecast** (Weather Forecast, Scenario Simulation) +

**Monitor** (instant disaster condition, disaster-related index) +

**Operation** (analysis, decision, announcement, local government operation)

Enhance the Capability for **Monitoring**

Disaster risk of weather events
Enhance the capability to monitor disaster risks of weather events

- Do research to understand the multiscale interaction that causes disastrous weather and climate events. Analyze both local and global natural hazard events to
  1. understand the multiscale meteorological conditions that cause the disaster, and
  2. To establish a check list for local disastrous weather event for disaster risk potential estimation.

Enhance the capability of monitoring disaster risks of weather events

- Build up the system of disaster risk monitoring with multiscale meteorological phenomena. The multiscale meteorological condition monitoring includes the climate scale (e.g. Monsoon, ENSO, MJO), synoptic scale (e.g. Typhoon, High, Low, Front) and Mesoscale phenomena.

The automatic meteorological data collection, analysis, and diagram plotting strengthens the disaster risk monitoring and managing.
Instant Rainfall Evolution Analysis

Analyze the rainfall evolution and intensity to estimate the disaster risk

### 1. 6 hours accumulated rainfall

**1 hour**

- **Rainfall Scale Index (RSI)**
  - Considered the local rainfall characteristic, the rainfall warning threshold and historical rainfall record, to standardize the rainfall. (courtesy of DPRI)
  - RSI enhances the capability of monitoring disasters.

#### Rainfall Scale Index (RSI)

\[
RSI = \frac{r - r_{thr}}{r_{max} - r_{thr}}
\]

- **Threshold(for warning)**
- **History Rainfall Max.**

### 3. 24 hours accumulated rainfall

**3 hours**

- **High Risk Rainfall**
- **Flood Risk**
- **Slopeland Risk**

### Enhance the capability of monitoring disaster risks of weather events

- **Rainfall Scale Index (RSI)** considers the local rainfall characteristic, the rainfall warning threshold and historical rainfall record, to standardize the rainfall. (courtesy of DPRI) RSI enhances the capability of monitoring disasters.

Monitor the disaster with different lead time rainfall information, include 1HR, 3HR, 6HR, 12HR, and 24HR.
Enhance the capability of monitoring disaster risks of weather events

**Rainfall Scale Index (RSI)** considers the local rainfall characteristic, the rainfall warning threshold and historical rainfall record, to standardize the rainfall. (courtesy of DPRI)

<table>
<thead>
<tr>
<th>Long-Term (24-72 hours)</th>
<th>Short-Term (6-12 hours)</th>
<th>Very Short-Term (1-3 hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2009 Typhoon Morakot</strong></td>
<td><strong>2010 Typhoon Fanapi</strong></td>
<td><strong>20120611 heavy Rainfall</strong></td>
</tr>
<tr>
<td>24 hours Accumulated Rainfall</td>
<td>6 hours Accumulated Rainfall</td>
<td>3 hours Rainfall &gt; 200 mm</td>
</tr>
<tr>
<td>RSI close to the maximum historical record</td>
<td>RSI close to the maximum historical record</td>
<td>RSI &gt; 2.0 exceed the maximum historical record</td>
</tr>
</tbody>
</table>

**Strengthen the Quantitative Precipitation Forecasts (QPF) Technique**
Strengthen the **Quantitative Precipitation Forecasts (QPF) Technique**

- The numerical weather prediction (NWP) technique has been developed in NCDR since 2006. The routine weather forecast products are generated by the WRF model runs.

- To improve the capability of QPF, NCDR has taken the following steps.
  1. Used higher resolution terrain data
  2. Developed radar data assimilation technique
  3. Evaluated QPF’s performances.

**Real time forecast**

**Strengthen the Quantitative Precipitation Forecasts Technique**

- NCDR has developed the QPF technique for the Typhoon emergency operation for the central government.
  1. Analyze disaster risk from the predicted typhoon tracks of CWB and other meteorological operation centers (e.g. JTWC, JAM, CMA et al.)
  2. Decide the worst risk scenario with the predicted typhoon track to estimate the QPF.
The QPF technique which fulfills the needs of emergency operation has been provided to CWB’s weather forecast operation center. Base on this technique, CWB cooperated with NCDR to further develop the advanced ETQPF (Ensemble Typhoon Quantitative Precipitation Forecast System).

Integrated Ensemble Forecast from CWB, TTFRI and NCDR

Receiving instant ensemble forecast from CWB and TTFRI for advanced rainfall prediction analysis.
Forecast from
- CWB
- TTFRI
- NCDR

- 45组系集成员
- 即時預報得分評估
- 系集成員群組平均

綜合得分
得分區間

CWB
TTFRI
TTFRI/TC
GROUP MEAN
Ensemble Mean for **Township Scale Forecast**

Use the rainfall observation and rainfall ensemble forecast to estimate future rainfall risk and calculate the disaster potential.

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**Disaster Prediction and Risk Analysis**

High resolution Slope–Stability, Inundation model and Probability Model
Combine observed and predicted rainfall as the effective rainfall for probability models to calculate probability of landslide and flooding in the next 1~2 days.

### Landslide Probability

<table>
<thead>
<tr>
<th>Observation Rainfall</th>
<th>Forecast Rainfall</th>
<th>Accumulated Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBS +3 hr FST</td>
<td>+6 hr FST</td>
<td>+9 hr FST +12 hr FST +15 hr FST +18 hr FST</td>
</tr>
</tbody>
</table>

### Effective Rainfall

### Risk Probability and Affected Population

**User Interface for manual Control**

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**Rainfall**

**Flooding Probability**

**Affected Population**

**Affected population in Township Scale**
Two-Dimensional Inundation Model

The inundation potential map for township scale warning

The river basin simulation and prediction for 2-D inundation physical model

The Current design of real-time prediction:

- **200m x 200m** grid mesh
- Run in distributed computing environment
- Up to **50** basin domain in Chinese Taipei
- Total computing time is approximately **3 hours**
- Prediction is updated every 3 hours

Transient Rainfall Infiltration and Grid-based Regional Slope-Stability Analysis ─ TRIGRS

- Require high resolution of model grid for slopeland analysis
- Need to analyze time-dependent rainfall infiltration by updating observation and prediction rainfall each hour
- Real-time and quick prediction of shallow landslide potential

USGS TRIGRS
2-D physical model
Physical model application for disaster risk analysis

Analyze the prediction of physical models and combine that with the landuse category information to obtain the possible disaster scenario.

Flood Area of each Landuse categories

Slopend Safety Index predicted by TRIGRS model

Integrated Platform

NCDR WATCH SYSTEM and DECISION SUPPORTING SYSTEM
NCDR Weather and Climate Monitoring System

http://watch.ncdr.nat.gov.tw

◆ All products are uploaded to the web site for Emergency Operation

CEOC disaster response with information analysis

Capability of exporting data into different formats

To fulfill the needs during emergency response operation, data can be exported into following formats.

◆ Grid data
◆ GIS format (Shapefile、township data)
◆ Google Earth format (KML、KMZ)
Create a information sharing and integration platform – Decision supporting system

- Integrate the disaster spatial information, visualized as an Operation Map, and it could provide instant disaster condition effectively.

Information Display Modules developed by NCDR

- Weather information
- Slopeland
- Flood
The new version of the integrated platform for Decision supporting system

In order to satisfy the requirements of disaster early warning for typhoon and heavy rainfall, the instant weather information and ensemble weather forecast were used to develop the early warning technology for flood and landslide disaster. Attempts have also been made to assess the social impact and economic loss.

Currently, the weather monitoring index, instant rainfall evolution analysis, rainfall scale index, township scale application of ensemble forecast and disaster risk probability are already developed. Through a display platform, the NCDR Weather and Climate Monitor website, these information can be used to monitor the disastrous weather instantly.

Some important weather and warning information are uploaded onto the Decision Support System, which is developed by NCDR and is already open to governmental emergency response units to help the disaster response decision-making process more effectively.
Summary

The disaster prevention require delicate operation. Not only collecting and analyzing data but also increasing the accuracy of observation and prediction is needed.

Currently, the weather, flood and slopeland models are too rough for township scale disaster risk analysis. It is difficult for the models to resolve the real terrain distribution and land slope and go a step further to make an acceptable prediction.

By increasing model grid resolution and importing ensemble forecast method for flood and slope models, it could satisfy the requirement of disaster prevention. However, it will need huge computing resources to support the calculation.

The integrated “Cloud” platform might allows us to effectively do the mapping and use the computing resources safely.

THE END

Thank You