Current Status and Future Plan of the implementation of Impact-based Forecasting at KMA

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Weather Impact Forecasts Team
Characteristics of climate and weather in Korea

• A small territory, but with a variety of severe weather
• Geographical environment and complex topography
  → Distinct seasons and big regional differences in weather
• 2-3 typhoons a year directly affect the peninsula
• Relatively big change in climate

Accurate and effective early weather warning system is necessary to prevent social and economic damages.
### Current warning system at KMA

#### Threshold-based Weather advisory/warning Service

<table>
<thead>
<tr>
<th>Advisory</th>
<th>Warning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strong wind</strong></td>
<td>Wind speed exceeding 21 m/s or wind speed of moment exceeding 25 m/s are expected on land. Wind speed exceeding 30 m/s are expected in mountain areas.</td>
</tr>
<tr>
<td><strong>Wind wave</strong></td>
<td>Wind of 14 m/s or more sustained for over 3 hours at sea or significant wave height is expected to be over 3 m.</td>
</tr>
<tr>
<td><strong>Heavy rain</strong></td>
<td>The precipitation for 6 hours is expected to be more than 70 mm or 1 hour precipitation for 12 hours to be over 110 mm.</td>
</tr>
<tr>
<td><strong>Heavy snow</strong></td>
<td>Snowfall is expected to be more than 5 cm in 24 hours.</td>
</tr>
<tr>
<td><strong>Dry air</strong></td>
<td>Effective humidity of less than 35% is expected for at least 2 days.</td>
</tr>
<tr>
<td><strong>Storm surge</strong></td>
<td>Sea level is expected to rise locally due to complex factors such as astronomical tides, typhoons, storms and low pressures, and to surpass the standard point to issue the advisory.</td>
</tr>
</tbody>
</table>
| **Cold wave** | When any of the following is expected between October and April:  
  1. Morning minimum temperatures are predicted to drop by more than 10° the previous day to below 3°C and to lower by 3°C compared to the climatological normal year.  
  2. Morning minimum temperatures of -12°C or less is expected for more than 2 days.  
  3. Serious damage is expected due to rapid temperature drop. |
| **Typhoon** | Strong wind, wind wave, heavy rain and storm surge are expected to reach advisory levels due to typhoon. |
| **Asian dust (HWANGSA)** | Hourly average dust (PM10) concentration is expected to exceed 400 μg/m³ or over 2 hours due to Asian dust. |
| **Heat wave** | Between June and September, the daily maximum temperature of more than 35°C is expected for over 2 days. |

*Note: In total, we are issuing warning for 11 elements.*
Case Study (Severe snow) Jeju International Airport (Jan. 23~25th, 2016)

Current severe weather warning system in KMA

Need for Impact forecasts

- The “weather impacts” can vary depending on time and place
- New forecast system should take into a consideration the expected social and economic impacts due to weather changes
Five Prerequisites for Successful IBFWS

**OBS**
develop agreements and standards for generating necessary impact data

**UIP**
provide ways for IBFWS users and providers to interact and improve the effectiveness of the Framework and its services

**CB**
support the systematic development of the institutions, infrastructure and human resources needed for effective IBFWS

**RMP**
Harness science capabilities and results to meet the needs of IBFWS

**SIS**
produce and distribute impact data and information according to the needs of users and to agreed standards

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**Impact-Based Forecasting and Warning Services (IBFWS)**

- **Observations & Monitoring**
- **User Interface Platform**
- **Research, Modeling and Prediction**
- **Capacity Building**
- **Service Information System**
OBS: based on new Technologies related to 4th Industrial Revolution

- National Disaster Reports (Traditional approach)
- Drone, CCTV
- Crowdsourcing Data Acquisition System (SNS)
- Citizen’s participation using emoticon (or infographics)

Interactive warning and data acquisition w/ graphics
OBS: People activity detection / tracking / understanding (Demo)

- Ex. of weather impact data acquisition system we are developing
- Multi-Person Tracking System using CCTV and AI
- Plan to use the system to build DB of how weather affects people’s activities

Courtesy of Korea University (Prof. Han-Seok KO)
Step 1
Early warning on High-Impact Weather
Based on the "Risk Matrix" approach

Impact Forecasts based on Risk Matrix

2016-2018

Step 2
Development of Hazard Impact Model
To link meteorological model with disaster model
(flood, heat wave etc.)

2018-2019

Step 3
Operational Impact Forecasts Services

2020~

Road Map for the implementation of IBFWS at KMA

Risk = Hazard x Vulnerability x Exposure
In order to determine the impact or the level of risk for each area in Korea, we utilized experiences and expertise of retired KMA forecasters and former disaster-prevention officers. Using the information they have provided, we have calculated the regional risk thresholds we currently use as shown here for strong wind and heavy rain.

<table>
<thead>
<tr>
<th>Region</th>
<th>Strong Wind</th>
<th>Heavy Rain</th>
</tr>
</thead>
<tbody>
<tr>
<td>5m/s</td>
<td>8m/s</td>
<td>12m/s</td>
</tr>
<tr>
<td>7m/s</td>
<td>10m/s</td>
<td>15m/s</td>
</tr>
<tr>
<td>8m/s</td>
<td>12m/s</td>
<td>16m/s</td>
</tr>
</tbody>
</table>

**Regional Risk Threshold**: (a) strong wind, (b) heavy rain
**RMP: Ensemble Outputs → Probabilistic Forecasting**

- Probabilistic forecasting by calibrating the results from ECMWF Global Ensemble and UM Global and Local Ensemble
- To improve the precision of forecasting the likelihood of severe weather.

**Calibration of ECMWF ENS Outputs**

<table>
<thead>
<tr>
<th>Precipitation Thresholds</th>
<th>+1 day prediction</th>
<th>+1~5 day prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>10mm/6hr</td>
<td>12mm</td>
<td>12mm</td>
</tr>
<tr>
<td>20mm/6hr</td>
<td>18mm</td>
<td>20mm</td>
</tr>
<tr>
<td>30mm/6hr</td>
<td>24mm</td>
<td>27mm</td>
</tr>
<tr>
<td>40mm/6hr</td>
<td>28mm</td>
<td>32mm</td>
</tr>
<tr>
<td>50mm/6hr</td>
<td>35mm</td>
<td>40mm</td>
</tr>
</tbody>
</table>

Calibrated Precipitation thresholds of ECMWF ENS during the summer of 2013 through 2015 over South Korea
Heat Wave Impact Model
that incorporate with demographic and GIS information
Storm Surge Flood Model
that estimates property damages
SIS: Web-based Supporting System for forecasters and users

Setting Impact Thresholds for each region in Korea

Impact-based Warning Statement

Impact DB(Library)
Visualization of Flood Impact Model

to help communicating the weather impact to end-users

RMP: VR/AR visualization of weather impacts

Impact Forecasts
UIP and CB: Pilot projects of user-oriented services and Training

Cooperation with decision makers in local governments

Pilot Project on IBFWS in Asia: “International Workshop”

- **(Purpose)** to promote the concept of multi-hazard impact-based forecasts including the role of future forecasters to identify associated training needs in the Region.
Key Points of this talk

- Through KMA’s experiences, we realized that risk-matrix approach can potentially be used for user-specific applications and decision making - but it needs the more accurate ensemble outputs and suitable thresholds.

- Building partnership with stakeholders is also the main key for the success. It is absolutely necessary to collaborate with social scientists and staffs involved in the partnership. The results should be shared.

- Hazard Impact Modelling is challenging but ultimately it can prove to be impactful in decision making.

- We need to focus on the collection of impact DB. For this, studies that enhance the usability of new technologies such as IoT (CCTV, Drone etc), Big Data, AI should be actively pursued in the future.

- In order for the IBFWS to succeed, collaboration between academia and government is very important at National level.

- At Regional and Global Level,

"Let’s work Together!!!"
GAM SA HAM NI DA!
(Thank you very much!)

Thank you for your attention!
Any Questions and Comments?

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Impact-based forecast: Typhoon ‘CHABA’, 4~5 Oct. ‘16

Impact forecast & Disaster distribution

Storm Surge, Strong wind, Flooding..

Impact-based Typhoon warning

(a) Impact–based warning for strong wind
(−2day)

(b) Impact–based warning for heavy rain
(−2day)

Typhoon warning in current KMA’s forecasting System based on Observations

(c) KMA’s typhoon warning issued on the D–day

(d) Areas damaged by Typhoon CHABA in Korea
Impact Forecasts based on Risk Matrix

Risk = Hazard x Vulnerability x Exposure