High-resolution Precipitation Observation Using Compact X-Band Weather Radar

January 5th, 2015
95th AMS Annual Meeting, Phoenix, Arizona
By FURUNO ELECTRIC CO., LTD
1. Introduction

2. Evaluations at a pin-point observation point
   - Evaluations and comparison of rainfall measurements between a radar and a rain gauge.

3. Evaluations on a basin basis
   - Evaluations and comparison of river stages between storm-water runoff simulation model and estimation by radar data.

4. Conclusions
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Backgrounds and motivations

- These days there are soaring numbers of extreme weathers in the world such as torrential rain, tornadoes and so on.
- Needs for observation of precipitation with high spatial and temporal resolutions are growing higher and higher.
Our solutions

- Dual Polarimetric Doppler Weather Radar to contribute to prediction of occurrence of rainstorms.
- High precision 3D meteorological monitoring.
- Classified as one of the smallest and lightest Weather Radar available in market. (as of June 2013)
Dual Polarimetric Radar System

- Prediction of extreme weather.
- Safe operation management of roads and railways.
- Counter plan for flooding, landslide, storm surge and inundation disasters.

**New type weather radar**
- **X-band (φ3.3m)**
- **Update cycle**: 30sec
- **Range**: 30km - 80km

**FURUNO (φ1.08m)**
- **Update cycle**: 50m
- **Range**: 50m - 250m

**Weather forecasting**
- Hurricane, Tropical cyclone

**Conventional weather radar**
- **C-band (φ7.0m)**
- **S-band (φ12.6m)**
- **Update cycle**: 30sec - 10min
- **Range**: 1km - 450km

φ : Radome diameter
# The main specifications

<table>
<thead>
<tr>
<th>Items</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating Frequency</strong></td>
<td>9 GHz band</td>
</tr>
<tr>
<td><strong>Beam Width</strong></td>
<td>2.7 degrees (both horizontal and vertical beams)</td>
</tr>
<tr>
<td><strong>Peak Output Power</strong></td>
<td>100 W (solid-state, both horizontal and vertical beams)</td>
</tr>
<tr>
<td><strong>Antenna Rotation Speed</strong></td>
<td>16 rpm max. (adjustable)</td>
</tr>
<tr>
<td><strong>Maximum Range</strong></td>
<td>Approx. 30 km</td>
</tr>
<tr>
<td><strong>Scan Modes</strong></td>
<td>PPI, CAPPI, RHI</td>
</tr>
<tr>
<td><strong>Communication Port</strong></td>
<td>LAN 100Base-TX x 1 port</td>
</tr>
<tr>
<td><strong>Power Supply</strong></td>
<td>100-240 VAC, single phase, 50/60 Hz</td>
</tr>
<tr>
<td><strong>Power Consumption</strong></td>
<td>650 W max.</td>
</tr>
<tr>
<td><strong>Radome Dimensions</strong></td>
<td>Diameter 1,086 mm x height 1,024 mm</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Approx. 65 kg</td>
</tr>
</tbody>
</table>

Kagoshima, Japan

**Gent, Belgium**
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Place and cases to be studied

Place: Kumamoto, Japan
Target: continuously heavy precipitation caused by linear rainbands in rainy season (Baiu), and other cases in spring and autumn.

Cases:
(1) 3, 6, 7, July, 2014: rainy season
(2) 21, 22, 27, June, 2014: rainy season
(3) 29 March, 2014
(4) 24, 25 October, 2013
Radar and rain gauge to be compared

- Comparing observed precipitation by radar with observed precipitation of the rain gauge.

**FURUNO radar**
- Elevation: 4.0 deg

Radar precipitation observed by every 1 min is accumulated during 10 min and compared with observed precipitation of the rain gauge.

**Rain gauge**
- Uto, Kumamoto,
- Lat: 32 deg 42.0 min
- Lon: 130 deg 39.4 min
- 17 km away from the radar

Used the map of The Geospatial Information Authority of Japan Digital Japan Portal Web Site.
Case 1:
12:30 pm, 6 July, 2014
Case of rainy season
Results: case 1

Case 1:
> 4 mm/10min: under-estimated
2-4 mm/10min: better

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Case 2:
3:30 pm, 21 June, 2014
Case of rainy season
Results: case 2

Case 2:

> 4 mm/10min: under-estimated

< 2 mm/10min: over-estimated
Results: case 3, 4

Case 3, 4: 
< 2 mm/10min : over-estimated
Evaluations at a pin-point observation point

- Amount of precipitation is more than 4 mm/10min: under-estimated
  - Because of signal attenuation due to heavy rain.
  - Multi-radar System could cover the signal attenuation effectively by arranging each radar system in optimal positions.

- Amount of precipitation is less than 2 mm/10min: over-estimated
  - Additional fine tuning for QPE parameters might be necessary.
  - Possibly due to error of the rain gauge.
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Syukugawa basin and a weather condition

Syukugawa basin

Used the map of The Geospatial Information Authority of Japan Digital Japan Portal Web Site.

Used storm-water runoff simulation model, GeoHyMoS
http://hywr.kuciv.kyoto-u.ac.jp/index-e.html

Time is local time (JST).

Case: 8-10 August, 2014
The Typhoon No.11 is approaching to the west part of Japan.
Radar observation 09:55 am, 10 Aug. 2014

Syukugawa basin

Radar-site 1
Radar-site 2

35 km

Precipitation
- 100 mm/h ~
- 50 ~ 100 mm/h
- 20 ~ 50 mm/h
- 10 ~ 20 mm/h
- 5 ~ 10 mm/h
- 1 ~ 5 mm/h
- 0.1 ~ 1 mm/h
- No data
A comparison of river stage between simulation and observation at Syukugawa River. The observation period starts from 3:00 pm, 8 Aug. and continues till 12:00 am, 11 Aug., 2014.
Prediction of precipitation is started from 3:00 am 9 Aug. and calculated till 30 min forward. Precipitation predicted by advection model is input into the model and river stage is calculated in the same way as observed one.
Prediction of precipitation is started from 9:30 am 10 Aug. and calculated till 30 min forward.
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Conclusions (1/2)

- **High spatial and temporal resolutions** of Furuno's radar, 50 m and 30 sec respectively lead to these good results.
  - This topnotch feature is first developed in this industry.

- **Evaluations at a pin-point observation point**
  - Rainfall observed by FURUNO radar is compared with rainfall measured by a rain gauge at a pin-point observation point.
  - In case amount of precipitation is more than 4 mm/10min, radar observation tends to under-estimate the precipitation because of signal attenuation.
  - Multi-radar System should be installed to avoid problems of shadowing areas due to buildings or strong signal attenuation due to heavy rain.
Conclusions (2/2)

◆ Evaluations on a basin basis

- The storm-water runoff simulation model, GeoHyMoS is applied to the calculation of river stage of Syukugawa River.
- Sudden increase of river stage is reproduced successfully from the observed precipitation as well as predicted one.
- In order to issue the early-warning of urban flood, combining the storm-water runoff simulation model and prediction data is one of the most effective methods.
Acknowledgement

- The research project is supervised by Professor Eiichi Nakakita of Kyoto University and Professor Satoru Oishi of Kobe University.
- Radar data of Kumamoto are provided by Japan Weather Association (JWA).

Thank you for your attention! 😊

http://www.furuno.com