WORLD METEOROLOGICAL ORGANIZATION
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JOINT MEETING OF
CBS EXPERT TEAM ON SURFACE-BASED REMOTELY-SENSED OBSERVATIONS
(Second Session)
AND
CIMO EXPERT TEAM ON OPERATIONAL REMOTE SENSING
(First Session)

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RADAR WIND PROFILERS

Quality and Interference Issues

Analysis of the impact of wind turbines on weather radar observation

(Submitted by Yoshihisa Kimata)

Summary and Purpose of Document

The document presents currently analyzed impact of wind turbines on weather radar observation in JMA.

ACTION PROPOSED

The meeting is invited to note the information contained in this document.

Analysis of the impact of wind turbines on weather radar observation

Currently analyzed impact of wind turbines on weather radar observation in JMA is briefly presented for the joint CIMO/CBS expert team on Operational Remote-Sensing, Geneva, December 2011.

1. Current situation of wind farms in Japan

As of in March 2010, 1683 wind turbines are at work (http://www.nedo.go.jp/library/fuuryoku/pdf/02_dounyuu_suii.pdf, in Japanese) and the number of Wind Farms (hereafter, “WF”) has been increasing year by year. The location environments of these WFs are much diverse. Some WFs are located along the coasts and others are along the ridges, and they are distributed in all over Japan. Therefore, many WFs are running in open areas and may interfere with weather radar observations.

2. Characteristics of Wind Turbine Clutter

The Wind Turbine Clutter (hereafter, “WTC”) cannot be removed by the MTI filter because the working turbines have non-zero Doppler velocity and are not identified as stationary targets by weather radars.

Figure 1 shows an example of difference between the spectrum of ground clutter with and without WTC. Distribution of spectral power density is spread due to working wind turbines of the a WF.

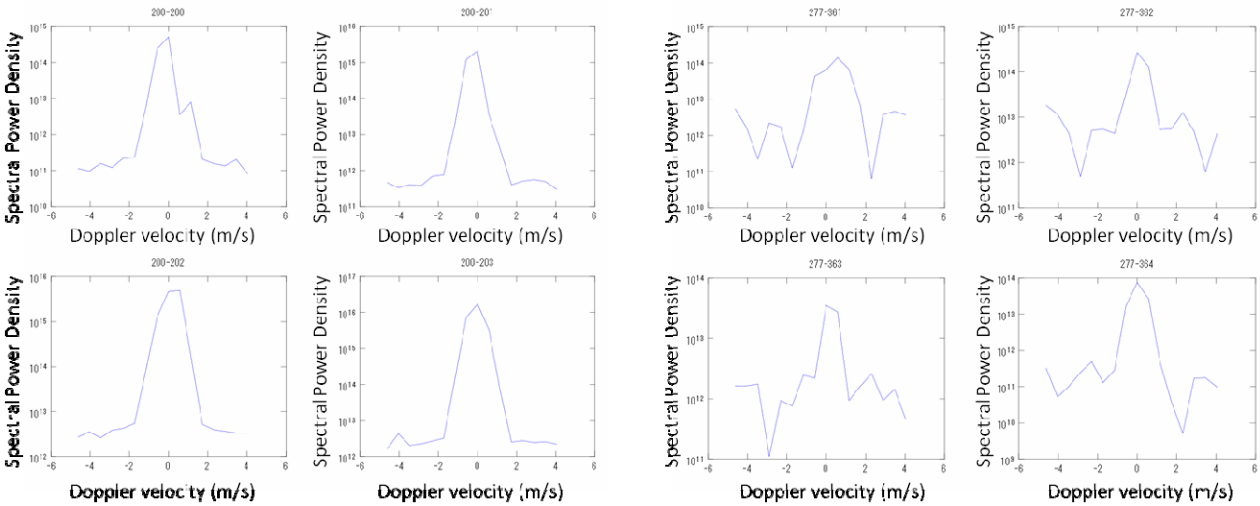

Fig.1 Spectrum of Ground Clutter and Wind Turbine Clutter

3. Data processing to remove Wind Turbine Clutter

Figure 2 shows briefly the data processing flow in JMA to produce a nationwide radar rain-rate composite map, which is a radar product of 1 km mesh-size to be used to monitor rain and snowfall distributions, tropical cyclones, precipitation related to meso-scale severe weathers etc.. Among these processing sequences, the following 2 measures are effectively functioning to eliminate the interference of WTC from the radar product.

3.1 Compositing PPIs at several elevation angles (Quasi-CAPPI) to avoid WTC

Japan is surrounded by seas and its topographic features are very much complicated. Therefore, sea clutter suppression is one of the vital technology as well as ground clutter suppression to

produce a clutter-free rain-rate composite map, and in order to well cover the surface of low altitude over the complicated mountain regions, the simply produced CAPPI is not appropriate in Japan.

JMA produces a Quasi-CAPPI near the ground, approximately 2 km above the ground level, by compositing several PPIs at low elevation angles. To produce the Quasi-CAPPI, the elevation angle to be used is defined for each mesh. These elevation angles are fundamentally selected so that the center of the radar beam passes at a height of about 2km above the ground over clutter free areas. However, over clutter influenced areas, a higher elevation angle is selected to avoid sea clutters or high level mountains. Therefore, the data of Quasi-CAPPI contains much less sea clutters and covers better over mountain regions than that of simple CAPPI. In addition, Quasi-CAPPI is also applicable to avoid WTCs.

3.2 Clutter Map to remove WTC

To remove clutters, such as mountains and the WTCs, which cannot be eliminated in the previous processes, JMA uses a filtering measure called “Clutter Map” , in which the intensity defined in the Clutter Map is subtracted from observed reflectivity (Figure 3) of each mesh.

The “Clutter Map” is so highly effective that precipitation echo is removed together with the WTCs. The filter pierces a hole in the radar data, but the hole is filled up by neighboring radar data. So far, JMA does not have serious problems in practical use of composite radar data and QPE in Japan.

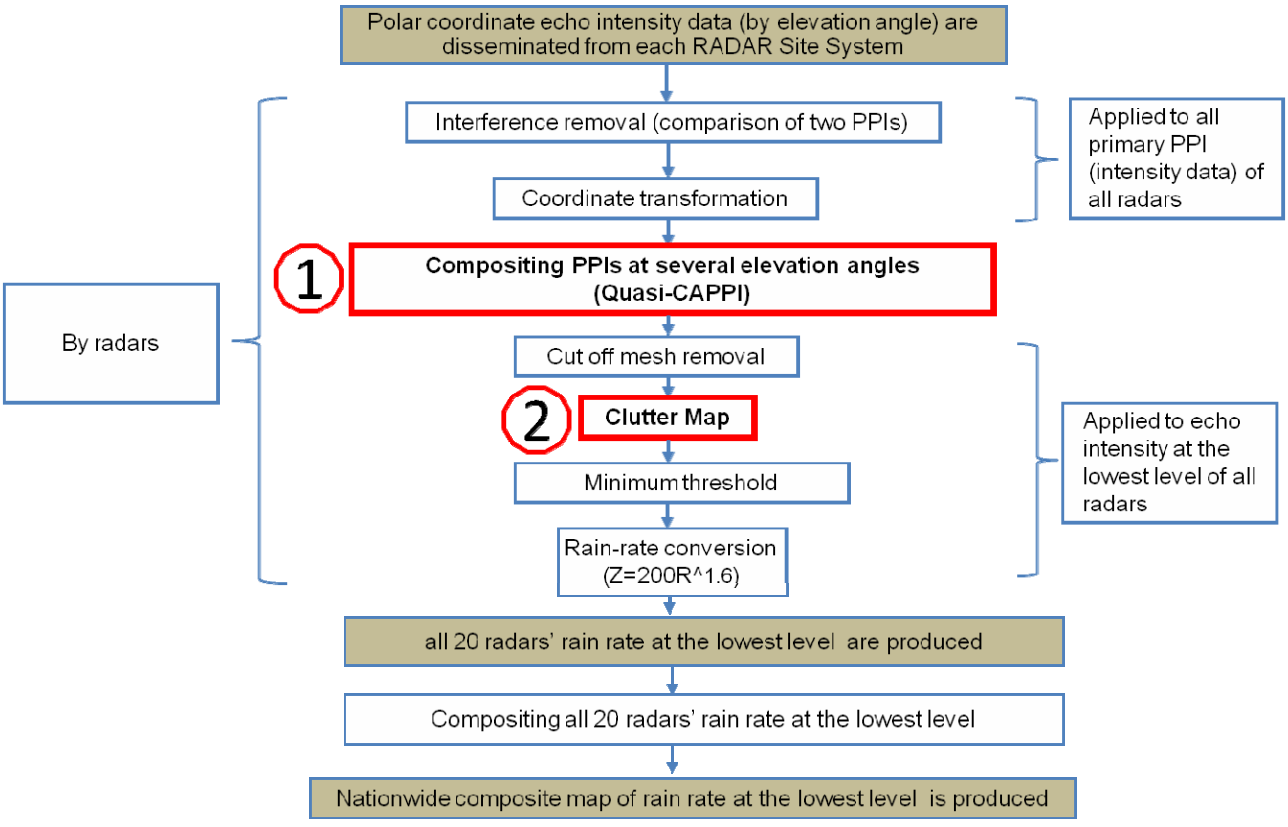

Fig.2 JMA data processing flow to produce nationwide radar rain-rate composite map

$$N_r = N_s + 10\log\left(1 - 10^{\wedge}\frac{N_g - N_s}{10}\right)$$

Ng：clutter map value(dBZ), Ns：reflectivity before subtraction(dBZ),
Nr：reflectivity after subtraction(dBZ)　※If Ng >= Ns then Nr will be 0

Fig.3 The equation of Clutter Map subtraction

4. Summary

- Number of Wind farms is rapidly increasing all over Japan

- Doppler Spectrum is spread by Wind Turbine Clutter (WTC), and therefore WTC is not filtered out as ground clutter by the MTI filter

- The following two measures applied on JMA radar data processing are effectively functioning to eliminate the interference of WTCs from the radar product

  “Compositing PPIs at several elevation angles (Quasi-CAPPI)” to avoid WTC,
  “Clutter Map” to remove WTC

- So far, JMA does not have serious problems in practical use of composite radar data and QPE in Japan

- Further research and review would be needed to make clear how WTC affect to other processing in JMA (ex. meso-cyclone detection)