Constructing Three-Dimensional Multiple-Radar Reflectivity Mosaics over China

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Instruction

Doppler weather radar is an important and effective instrument to observe precipitation at regional scale. The weather surveillance Doppler (WSR-88D) network in the United States (US) has played an important role in weather service such as issuing warnings for severe precipitation storms (e.g., tornado and hurricane) and flash floods. The Multi-Radar and Multi-Sensor (MRMS) system developed by National Severe Storms Laboratory (NSSL) at National Oceanic and Atmospheric Administration has been proved to be a great success in integrating observations of all available weather radars across the US. The MRMS provides real-time quantitative precipitation estimation (QPE) products and quantitative precipitation forecasts (QPF).

The core of the MRMS is a three-dimensional multi-radar reflectivity mosaic from which all the radar-related products are derived.

China has set up a dense weather Doppler radar network with total 216 radars across mainland China by 2014, which is called China New Generation Weather Radar (CINRAD). In addition, there is one weather radar jointly ventured by Zhuhai City and Macao, and located southwest of Macao, and one weather radar in Hong Kong, and 6 weather radars in Taiwan (Fig. 1). The dense radar network and the advent of the effective data compression and high speed internet transportation make feasible the real-time China radar mosaic and QPE system over China mainland (CMQ). Such system will provide scientific community and the public with high temporal and spatial resolution QPE products which is critical in hydrologic modeling and forecasting to issue warning for flood and extreme precipitation storm monitoring like typhoon and tornado.

Study Region

The study region is the whole continuous mainland China. As an experiment, data from Zhuhai radar near Macao in southern China and another two radars in Yancheng and Lianyungang are used to conduct three-dimension reflectivity mosaicking.

Methodology

The scheme of three-dimensional radar reflectivity proposed by Zhang et al. (2005) are used on the multi-radar observations. Vertical Interpolation(VI), and Vertical and Horizontal Interpolation (VHI) are two popular approaches to construct three-dimensional radar reflectivity based on single radar observation. It is proved that the vertical interpolation(VI) approach is suitable for most situations, and the VHI approach preserves more of the continuous nature of brightband layer and avoids ring-shaped artifacts in the analysis.

For a grid cell c, the reflectivity analysis at t can be computed based on observations from its two adjacent radar bins below and above, i.e. b and c as shown in Fig. 2. Let $\theta_b$, $\theta_a$, $\theta_c$ be the elevation angles of the radar bins a and b, and the grid cell c, the reflectivity analysis for grid cell c, $f_c$ can be computed with Eq. (1-3):

$$\begin{align*}
    w_1 &= \frac{(\theta_c - \theta_a) / (\theta_a - \theta_b)}{1} \\
    w_2 &= \frac{(\theta_c - \theta_b) / (\theta_c - \theta_a)}{1} \\
    f_c &= \frac{(w_1 + w_2) f_a}{w_1 + w_2}
\end{align*}$$

To mosaic the reflectivity from single radar, the analysis reflectivity $f_a$ can be obtained based on steep weighting function in Eq. 3 with Eq. (4):

$$f_a(t) = \sum_{m=1}^{M} a_m f(t-m)$$

Results

For the VI scheme, the reflectivity analysis from Zhuhai radar at UTC201405082005 is shown in Fig. 4. The reflectivity analysis from Yancheng radar at UTC201606230600 is shown in Fig. 5.

Conclusion

The VI scheme is computationally effective to construct three-dimensional radar (3D) reflectivity. The mosaicking with steep weighting function gives promising smooth reflectivity between adjacent radars. The 3D reflectivity mosaics lays a foundation stone for QPE and other radar products in future.