

Vertical winds recovered from high time-resolution multiple-Doppler wind synthesis

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1. Introduction

Vertical motions in the atmosphere are closely related to the activity of clouds, and cloud-related natural hazards, and so on. Regardless of their importance, their actual condition, however, still remains unknown because the difficulties in the direct reliable measurements. Past determination of vertical winds in precipitation systems have been mostly relied on the conventional multiple-Doppler radar analysis (e.g., Ray et al. 1980). A more advancing method called MUSCAT (Bousquet and Chong 1998; Chong and Bousquet 2001) significantly improved the accuracy in the determined wind components, especially in the vertical winds, by overcoming the deficiencies in the conventional approach. The discrepancies of the MUSCAT-derived vertical wind components from the true values are not clear yet.

Apart from the Doppler radar analysis, numerical simulations of convective clouds can be made at high spatial resolutions. For example, Ito et al. (2021) has conducted idealized experiments with horizontal spacings down to 100 m for a case of torrential rainfall. It is uncertain that whether the magnitudes of the simulated vertical velocities in their study really occurred in clouds. More studies are indispensable to understand the vertical winds in the atmosphere. This paper presents the vertical winds at 30-second intervals derived from dual phased array weather radar (PAWR) Doppler radar analysis.

2. Wind recovery from dual-PAWR analysis

Three-dimensional wind retrieval at 30-second time resolution was made by employing MUSCAT permitting to the analysis over a complex terrain (e.g., Chong and Cosma 2000). The data fit form proposed by Yamada (2013) was adopted. The horizontal and vertical resolutions are set equal to 0.5 km and 0.3 km, respectively, with the lowest height of 0.3 km above sea surface. The orography data was made by the digital elevation model (10m grid) provided by the Geospatial Information Authority of Japan so that its spatial resolution is consistent with that of the wind recovery.

3. Time change in the updrafts in the updraft core

Figure 1 indicates time change in the mean updrafts (downdrafts) in an updraft (downdraft) core for a relatively active convective clouds occurred on Aug. 29, 2019 over and around the Osaka Bay, Japan. The mean values are computed using five values from the largest at each height. It is apparent that their time evolution is quite rapid. In addition, The magnitude of updrafts and downdrafts are comparable. Large downdrafts were analyzed in the cloud.

Second example comes from a precipitation system of relatively weak convective activity passed over the Osaka Bay on Jul. 11, 2019. An excellent reproducibility of this precipitation system by the non-hydrostatic model of the Japan Meteorological Agency with the same horizontal resolution as that of the wind restitution gave an good opportunity for an inter-comparison of radar- and model-derived vertical winds over the sea. The 0.5-km resolution model was conducted, using the nesting technique, by a subsequent execution of a 5-km and 2-km resolution models. Since the heights of the wind recovery and the model do not usually coincide, the vertical winds from the two results were compared at the nearest proximity heights. It was found that the magnitudes and the occurrence frequencies were similar for updrafts and downdrafts (Fig. 2).

4. Summary

It appears necessary to accumulate dual-PAWR analysis and to make mutual comparisons among vertical winds derived and estimated by various methods to advance the knowledge of vertical winds.

Acknowledgements

This research is supported by JSPS KAKENHI Grant Number JP19H00815 for the project entitled "Clarification of generating mechanisms of cloud-related severe phenomena over diverse surfaces by advanced methods and the improvement of their short-range forecasts".

Keywords: dual-PAWR wind synthesis, High time-resolution three-dimensional wind recovery over a complex terrain from MUSCAT, Inter-comparison of vertical winds derived from dual-PAWR analysis and high-resolution numerical model

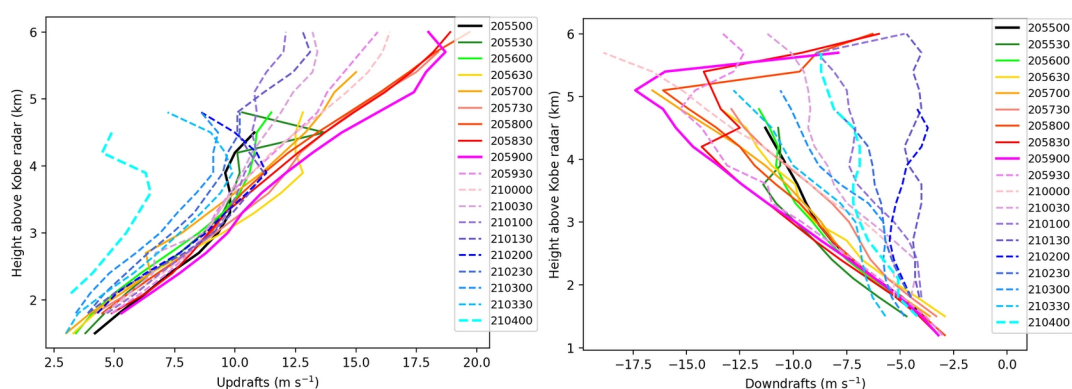


Fig. 1: Vertical profiles of vertical winds at 30-second intervals from 2055:00 JST to 2104:00 JST. Left: Updrafts. Right: Downdrafts.

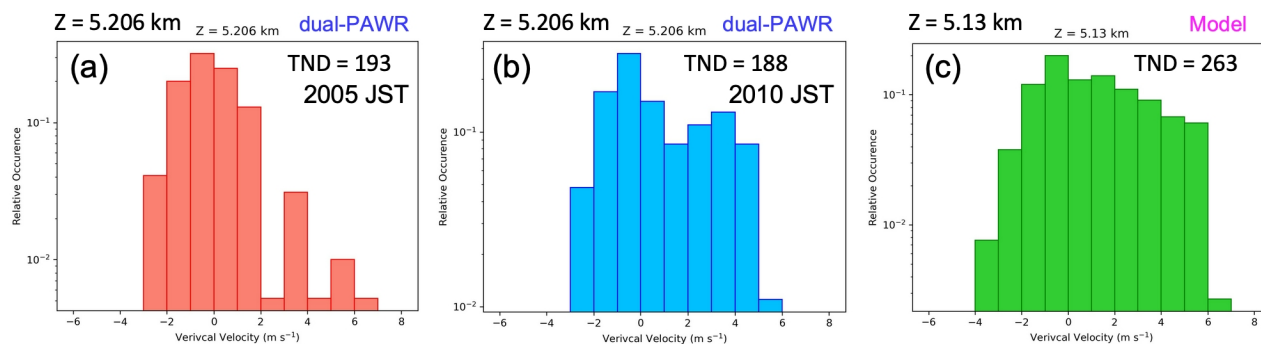


Fig. 2 Intercomparison of vertical winds derived from dual-PAWR analysis and a high-resolution numerical model. The abscissa is the vertical velocity in m s⁻¹ and the ordinate indicates the relative occurrence of vertical winds at 5.206 km (for radar) and 5.13 km (for model) above sea surface. "TND" is the total number of data. (Left and Middle): Relative occurrence derived from dual-PAWR analysis. (Right): Relative occurrence from numerical model.