Intercomparison of rainfall simulations using different bulk microphysical models

Yoshinori Yamada
Meteorological Research Institute, Tsukuba, Ibaraki, 305-0052, Japan
E-mail: yyamada@mri-jma.go.jp

Abstract

1. Introduction

High resolution numerical models are now available for the forecast and simulation of localized heavy rainfalls. It is not, however, so many studies focusing on the difference in the simulated precipitation fields depending on microphysical models. This paper presents an intercomparison of rainfall simulations using different three bulk models for a case of a catastrophic heavy rain fall event from 6th July, 2018 to 8th in the western part of Japan.

2. Outline of the experiments

Three bulk microphysical models are used in this study. Two of those are from Ikawa and Saito (1987) and Yamada (2016). Both models classify water substances into six species (water vapor, cloud water, rain, cloud ice, snow, and graupel), the latter is, however, more sophisticated and high in degree of freedom. In the rest (hereafter Y2018) of the models, water is categorized into five types of water vapor, cloud water, rain, "snow crystal", and graupel. The category of snow crystal includes pristine ice, snow, and rimed ice particles except for graupel. This classification resembles that in Morrison and Grabowski (2008), the category of graupel, however, remains because it is not suitable to represent a drop size distribution for an ensemble of snow crystals and graupels, both of which have very different properties. The ice phase model of Y2018 is similar to that in Yamada (2016).

The two-moment scheme of warm rain by Cohard and Pinty (2000) is employed. The analytical self-collection equation for rain drops (Verlinde and Cotton 1990) is used instead except for the model of Ikawa and Saito (1987).

The simulations are made using JMA-NHM (Saito et al. 2006) with a horizontal resolution of 0.5 km for a model domain of 450 km x 450 km centered at (132.66 E, 34.25 N). Number of vertical layers was 60, and the top of the model domain was set to 21.8 km. The model run started at the initial time of 06 UTC on Jul. 6 up to 6 hours. The initial and boundary conditions were supplied from the meso-analysis of Japan Meteorological Agency. The boundary layer model for the grey zone (Ito et al. 2015) was used. Two-moment ice phase models is used throughout, while warm rain model is either one- or two-moment.

3. Results

Figure 1 shows hourly rainfall at forecast hour = 4. All of the simulated rainfall fields represent a band-like precipitation pattern. The difference in the one- and the two-moment model of the warm phase brought about contrasts in the rainfall amounts. It is also found that the difference in the ice phase model does not bring about significant differences in the simulated rainfall amount for this heavy rainfall event.

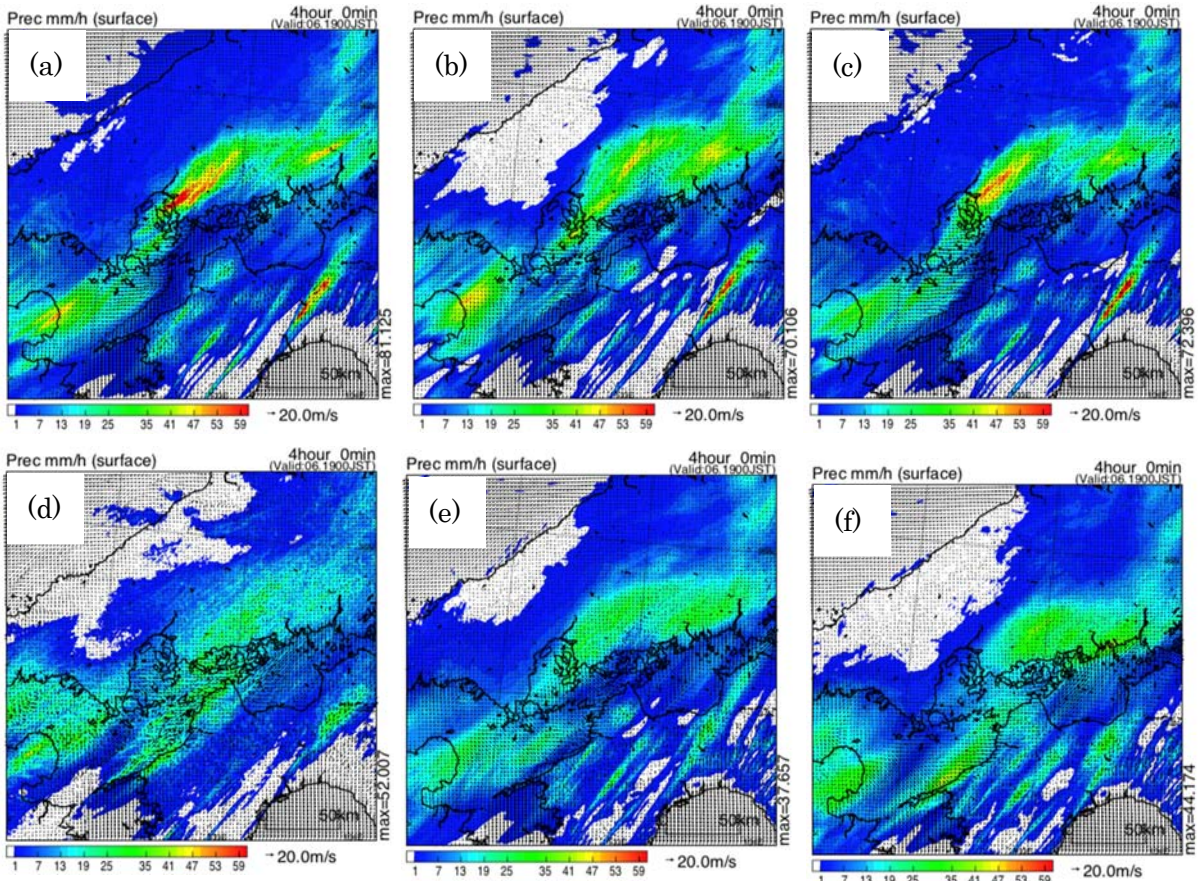

Fig. 1 Simulated hourly rainfall amount in mm. Upper panels: results using one-moment model of warm phase. (a): Ikawa and Saito, (b) Yamada (2016), (c) Y2018. Lower panel: results using two-moment model of warm phase. (d): Ikawa and Saito, (e) Yamada (2016), (f) Y2018.

References:

Ito, J., H. Niino, M. Nakanishi, and C.-H. Hoeng, 2015: An extension of the Mellor–Yamada model to the terra incognita zone for dry convective mixed layers in the free convection regime. *Bound.-Lay. Meteorol.*, **157**, 23-43.

Morrison, H. and W. W. Grabowski, 2008: A novel approach for representing ice microphysics in models: Description and tests using a kinematic framework. *J. Atmos. Sci.*, **65**, 1528 – 1548.

Saito, K., T. Fujita, Y. Yamada, J. Ishida, Y. Kumagai, K. Aranami, S. Ohmori, R. Nagasawa, S. Kumagai, C. Muroi, T. Kato, H. Eito, and Y. Yamazaki, 2006: The Operational JMA Nonhydrostatic Mesoscale Model. *Mon. Wea. Rev.*, **134**, 1266-1298.