DEVELOPMENT OF SPACEBORNE RADAR SIMULATOR BY NICT AND JAXA USING JMA CLOUD-RESOLVING MODEL

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1. INTRODUCTION

We are developing synthetic radar data toward a simulation of the Global Precipitation Measurement (GPM) dual-frequency precipitation radar (DPR) for contribution to the DPR algorithm development. We utilize a cloud-resolving model by the Japan Meteorological Agency (JMA-NHM), and the satellite radar simulation algorithm by the National Institute of Information and Communications Technology (NICT) and the Japan Aerospace Exploration Agency (JAXA) named as the Integrated Satellite Observation Simulator for Radar (ISOSIM-Radar). It is necessary to validate the developed synthetic data. In this study, we report the diagnosis of the JMA-NHM with reference to the TRMM Precipitation Radar (PR) and CloudSat Cloud Profiling Radar (CPR) using the ISOSIM-Radar from the view of comparisons of cloud microphysics schemes of the JMA-NHM.

2. EXPERIMENTAL DESIGN

The JMA-NHM is a nonhydrostatic mesoscale model developed by the Japan Meteorological Agency (JMA) ([1], [2]). Here, observed rainfall systems are simulated with one-way double nested domains having horizontal grid sizes of 5 km (outer) and 2 km (inner). Data used here are from the inner domain only. We tested three kinds of cloud microphysics schemes of the JMA-NHM, that is, IS1, IS2, and FH. The IS1 and IS2 schemes are explicit three-ice bulk microphysics schemes [1] based on [3]. The differences between IS1 and IS2 are forecasts of number concentrations of snow and graupel in the IS2 [4]. The newly developed FH scheme is fundamentally different from the others and an explicit four-ice bulk microphysics scheme [5] based on [6] and [7].

The ISOSIM-Radar simulates received power data in a field of view of the space-borne radar with consideration to a scan angle of the radar ([8], [9]). The received power data are computed with gaseous and hydrometeor attenuations taken into account. The backscattering and extinction coefficients are calculated assuming the Mie approximation for all species. The dielectric constants for solid particles are computed by the Maxwell-Garnett model [10]. Particle size distributions are treated in accordance with those of the JMA-NHM. We are trying to incorporate the melting layer model into the ISOSIM-Radar, but the current results are not calculated with it.

We examined a case of an intersection with the TRMM PR and the CloudSat CPR on 6th April 2008 over sea surface in the south of Kyushu Island of Japan. The CloudSat passed over first at 132.61E and 27.97N and the TRMM passed over 6 minutes later. The passage time of the TRMM PR is 4:41UTC. At that time, a precipitation system of an extratropical cyclone over a stationary front was observed there. Here, we examined data with scan numbers 3691-3760 on the TRMM orbit number 59200 and with scan numbers 21325- 21774 on the CloudSat orbit number 10322.

3. RESULTS

A forward calculation of the radar equation is applied to the JMA-NHM data by the ISOSIM-Radar. Figures 1 show received power data at 13.8GHz averaged on the scan numbers 3709-3721. Freezing level heights of the target precipitation system are about 4.2km. The simulated received power data are similar below the freezing level with data observed by the PR, while they are smaller, in particular, for the scan angles of 13-17 degrees. The simulated data in the liquid layer of the FH scheme are underestimated most among those of three schemes. For the altitudes above the freezing level, the simulated values of the IS1 and the IS2 are much larger than the observed values, while the values of the FH are well-corresponding to those of the observation. In the FH scheme, the mean mixing ratio of the snow is less than that of the IS2 and mean number concentration of snow is more than that of the IS2. Smaller mean diameter of a particle is connected with less mixing ratio and more number concentration. As a result, it leads to decreased received power related to the snow. The overestimation of the received power data reduced around 10 km altitudes in the IS2 simulation in comparison with the IS1 simulation. This suggests that prognostic number concentrations are more effective in high altitudes and constant number concentrations can lead to the overestimation of the snow there.

4. SUMMARY

We are developing synthetic radar data toward a simulation of the DPR for the contribution to the algorithm development. In this study, we examined the diagnosis of cloud microphysics schemes of the JMA-NHM with reference to the PR and the CPR using the ISOSIM-Radar. The validation results using the PR data indicated that the overestimation of frozen particles found in the IS1 and IS2 schemes is heavily reduced in the FH scheme. The overestimation of the received power data reduced around 10 km altitudes in the IS2 simulation in comparison with the IS1 simulation by the prognostic number concentration of the snow.

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6. REFERENCES

[1] Ikawa, M. and K. Saito, "Description of a nonhydrostatic model developed at the Forecast Research Department of the MRI". *Tech. Rep. MRI*, 28, 238 pp., 1991.
[2] 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, The operational JMA nonhydrostatic model. *Mon. Wea. Rev.*, 134, 1266-1298., 2006.
[3] Lin, Y. H., R. D. Farley, and H. D. Orville, "Bulk parameterization of the snow field in a cloud model". *J. Climate Appl. Meteor.*, 22, 1065-1092, 1983.
[4] Eito, H., and K. Aonashi, "Verification of Hydrometeor Properties Simulated by a Cloud-Resolving Model Using a Passive Microwave Satellite and Ground-Based Radar Observations for a Rainfall System Associated with the Baiu Front". *J. Meteor. Soc. Japan*, 87A, 425-446, 2009.
[5] Hashimoto, A., "Introduction to the 4-ICE cloud microphysics scheme". *Separate volume of annual report of NPD*, 54, 93-97, 2008. (in Japanese).
[6] Cohard, J. M. and J. P. Pinty, "A comprehensive two-moment warm microphysical bulk scheme. Part I: Description and tests". *Quart. J. Roy. Meteor.Soc.*, 126, 1815–1842, 2000.
[7] Ferrier, B. S., "A double-moment multiple-phase four-class bulk ice scheme. Part I: Description". *J. Atmos. Sci.*, 51, 249-280, 1994.
[8] Oouchi K., S. Satoh, T. Iguchi, Y. Ohsaki, K. Mizutani, S. Ishii, M. Sasano, H. Okamoto, and H. Ishihara, "Development of the Integrated Satellite Observation Simulator (ISOSIM)". *Proc. 23rd ISTS*, 2141-2144, 2002.
[9] Kubota, T., H. Eito, T. Iguchi, H. Hanado, K. Aonashi, S. Shimizu, N. Yoshida, R. Oki, "Preliminary results of satellite radar simulator using cloud-resolving model by the Japan Meteorological Agency", *Proc. EarthCARE Workshop 2009*, 201-206, 2009.
[10] Bohren, C. F. and L. J. Battan, "Radar Backscattering of Microwaves by Spongy Ice Spheres". *J. Atmos. Sci.*, 39, 11,2623–2628, 1982.

7. BIBLIOGRAPHY

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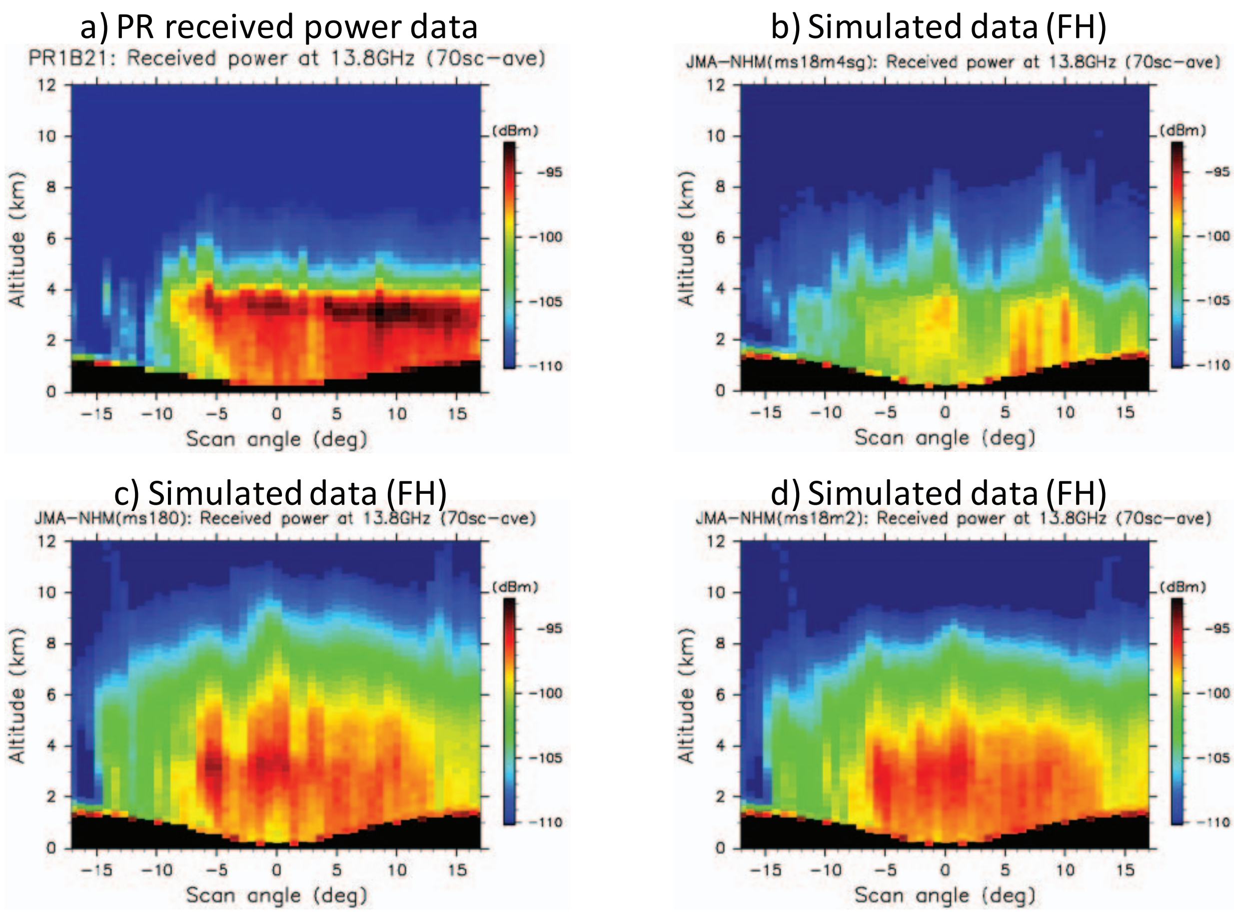

Figure 1: Received power data at 13.8GHz averaged on the scan numbers 3709-3721. (a) Observed data by the TRMM PR, (b) simulated data of the FH, (c) simulated data of the IS1, and (d) simulated data of the IS2.