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Joint Simulator for Satellite Sensors
Joint-Simulator

An evaluation of NICAM using a ground-based 94 GHz Doppler radar over Tokyo

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EarthCARE modeling workshop 2022

Introduction

- Evaluation and improvement of the cloud properties in global non-hydrostatic models are important using satellite data. One of the methods is a radiance-based evaluation using satellite data and a satellite simulator (here Joint simulator, Hashino et al. 2013), which avoids making different settings of the microphysics between retrieval algorithms and NICAM.

- The satellite data with active sensors has a limitation to observe the specific case of cloud and precipitation systems. And it is needed to validate satellite observations using in-situ observation. There are intensive observation stations over the Kanto region.

- The ULTIMATE (ULTra sIte for Measuring Atmosphere of Tokyo metropolitan Environment) started to verify and improve high resolution numerical simulations based on these observation data last year. The improved simulations will be validate by the EarthCARE.

- I introduce the evaluation results of NICAM using a vertical pointing 94 GHz radar in NICT.

- I introduce the impact of microphysics on CFADs of Doppler velocity with consideration of errors like the EarthCARE CPR.

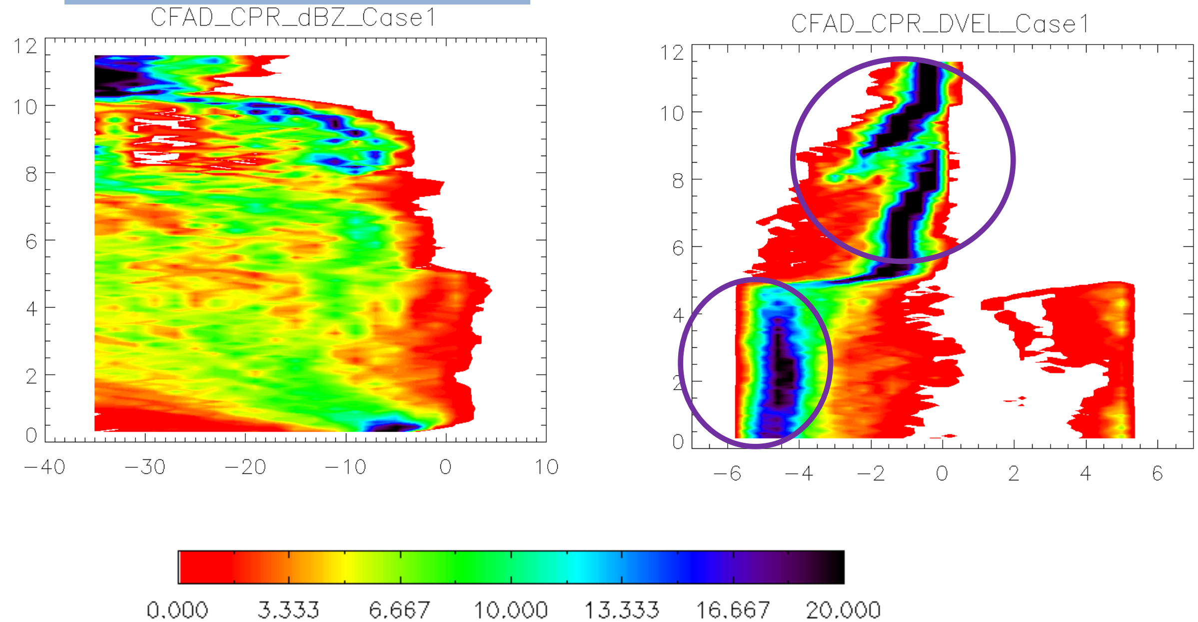
Evaluation using NICT 94 GHz CPR

Case1

NICT

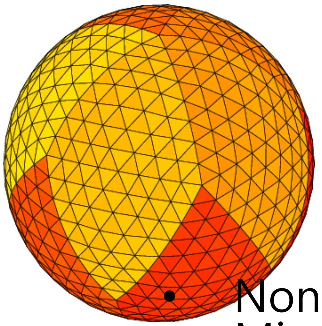
Radar Reflectivity

Doppler velocity

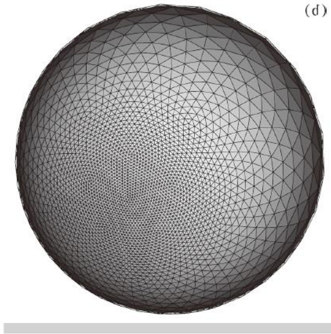


The data is provided in courtesy by NICT Ohno-san and Horie-san.

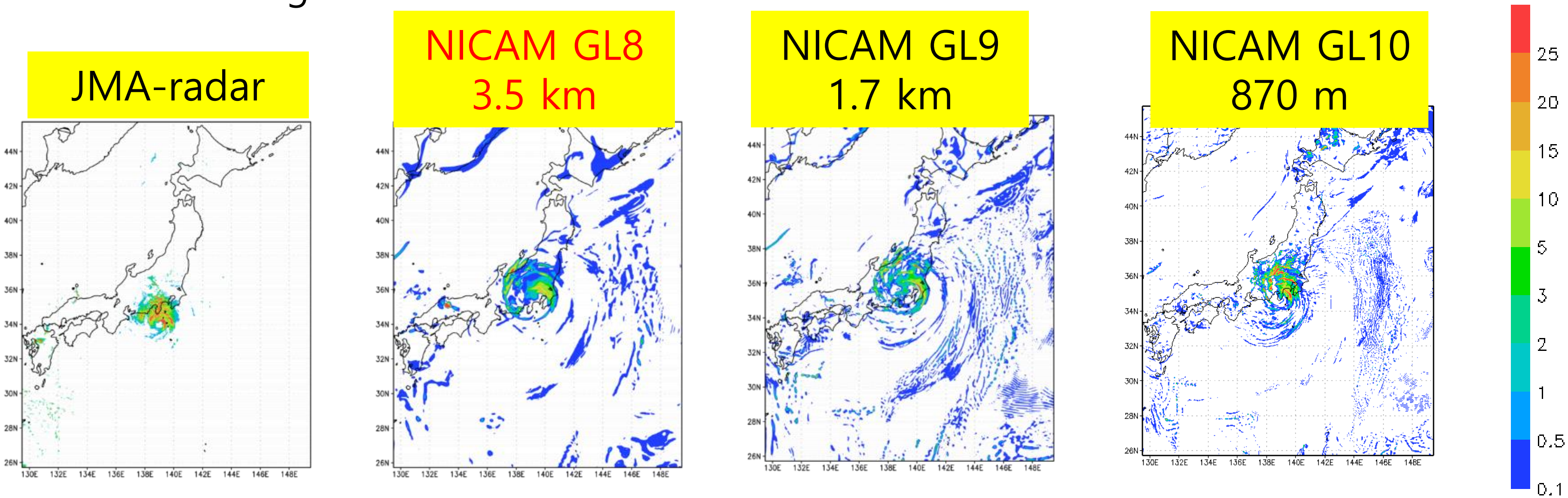
- Underestimation of radar reflectivity because of wet attenuation of CPR observation.
- Observed Doppler velocity is reliable.
- CFADs of Doppler velocity shows two modes of Doppler velocity for rain and ice hydrometeors.



Experiment design



- Nonhydrostatic Icosahedral Atmospheric Model
- Microphysics scheme : NSW6, NDW6
- Stretched grid system
- Turbulence scheme : MYNN2
- Land surface scheme : MATSIRO scheme
- Integration time : 2019. 09. 08. 00UTC – 10. 00UTC
- Initial data : NCEP FNL reanalysis data
- Horizontal resolution : g-level 8, g-level 9, g-level 10
- The minimum resolution: GL8 2.8 km, GL9 1.4 km, GL10, 700 m
- Time step : 15s, 5s, 2.5s
- Vertical gird number : 80



Precipitation distributions of three cases

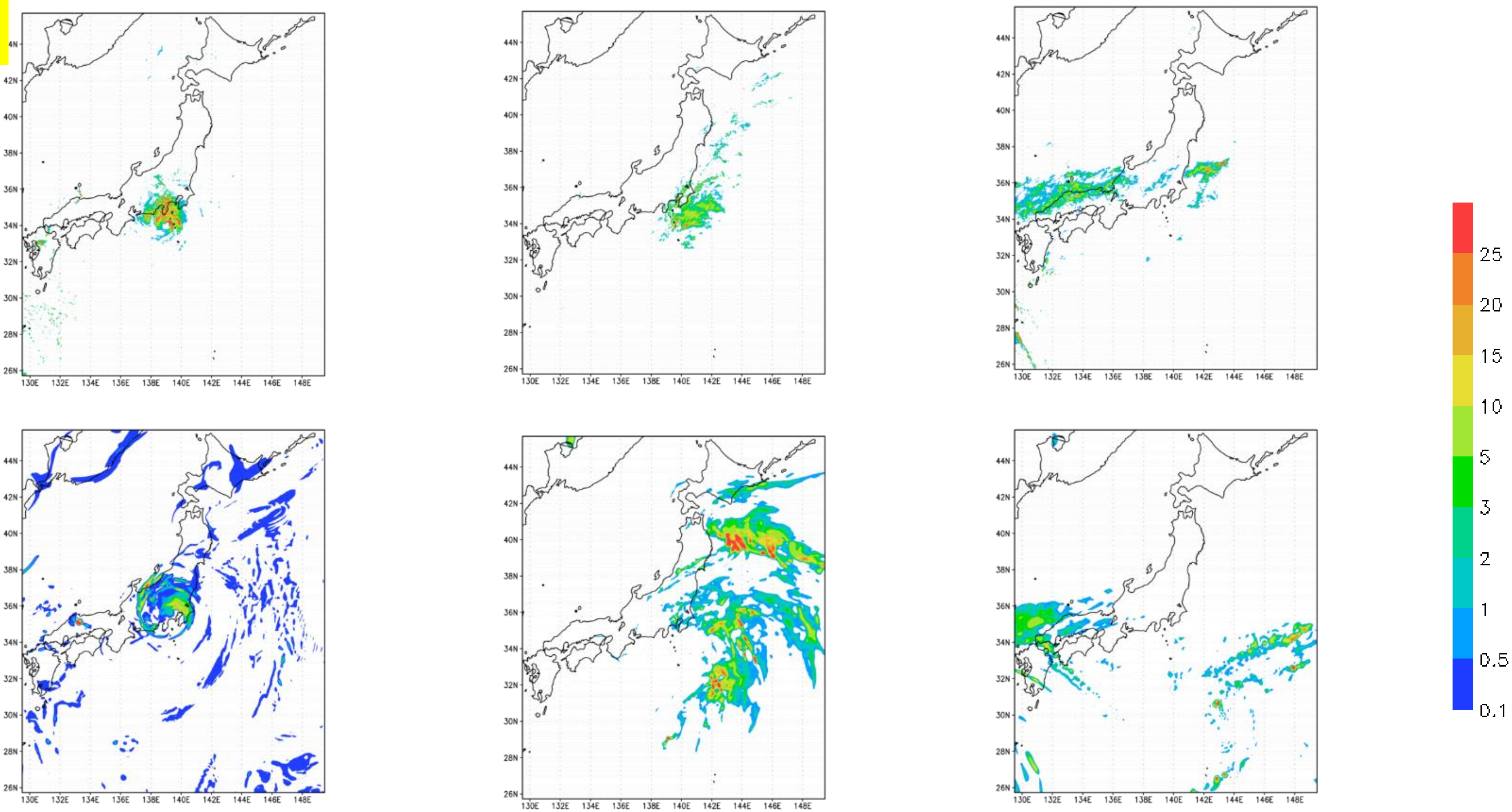
Case1
(Heavy precip.)

Case2
(medium precip.)

Case3
(weak precip.)

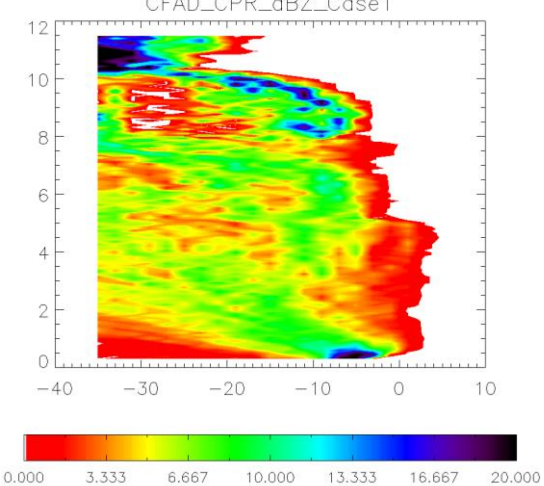
OBS.

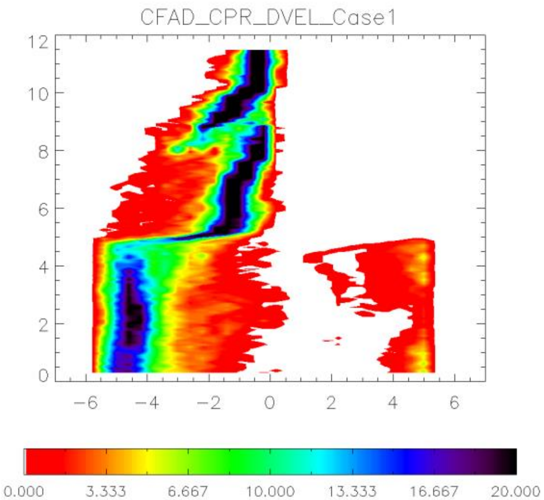
NICAM



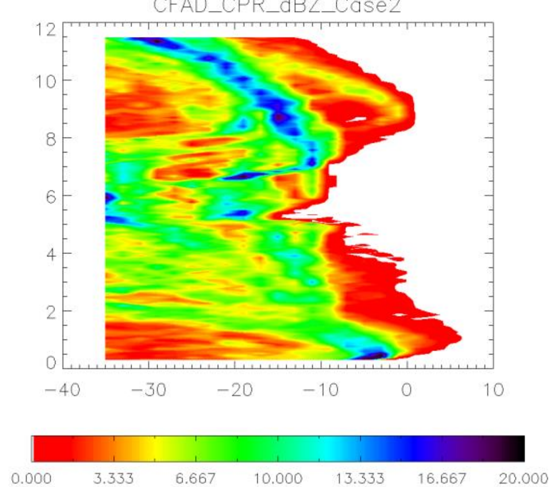
Observed CFADs of dBZ and Doppler velocity for three cases

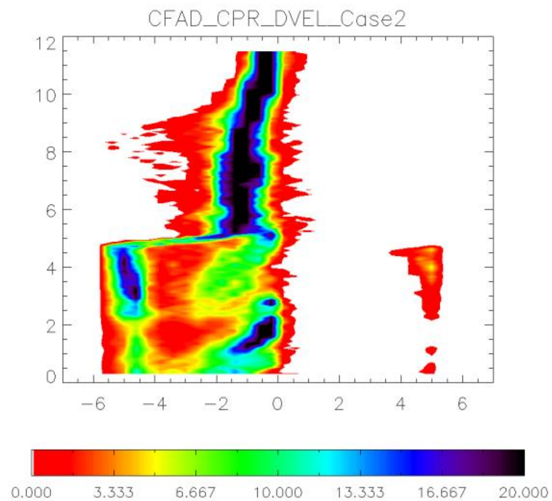
Case1
(Heavy precip.)



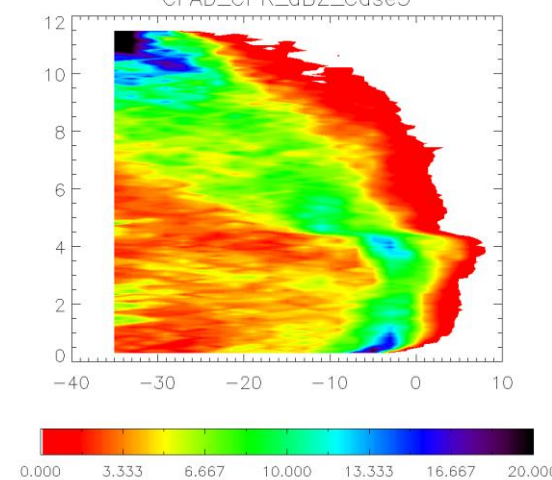


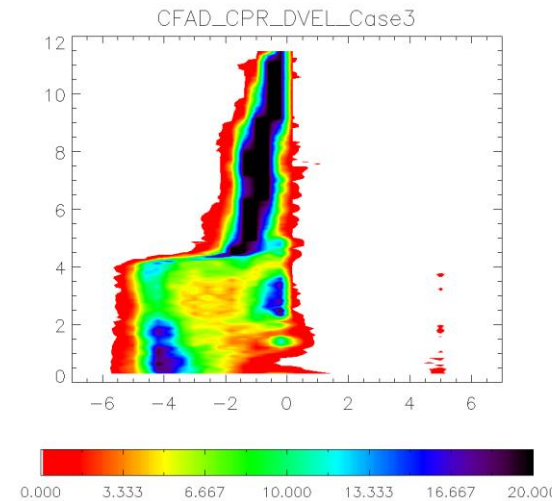
Case2
(medium precip.)



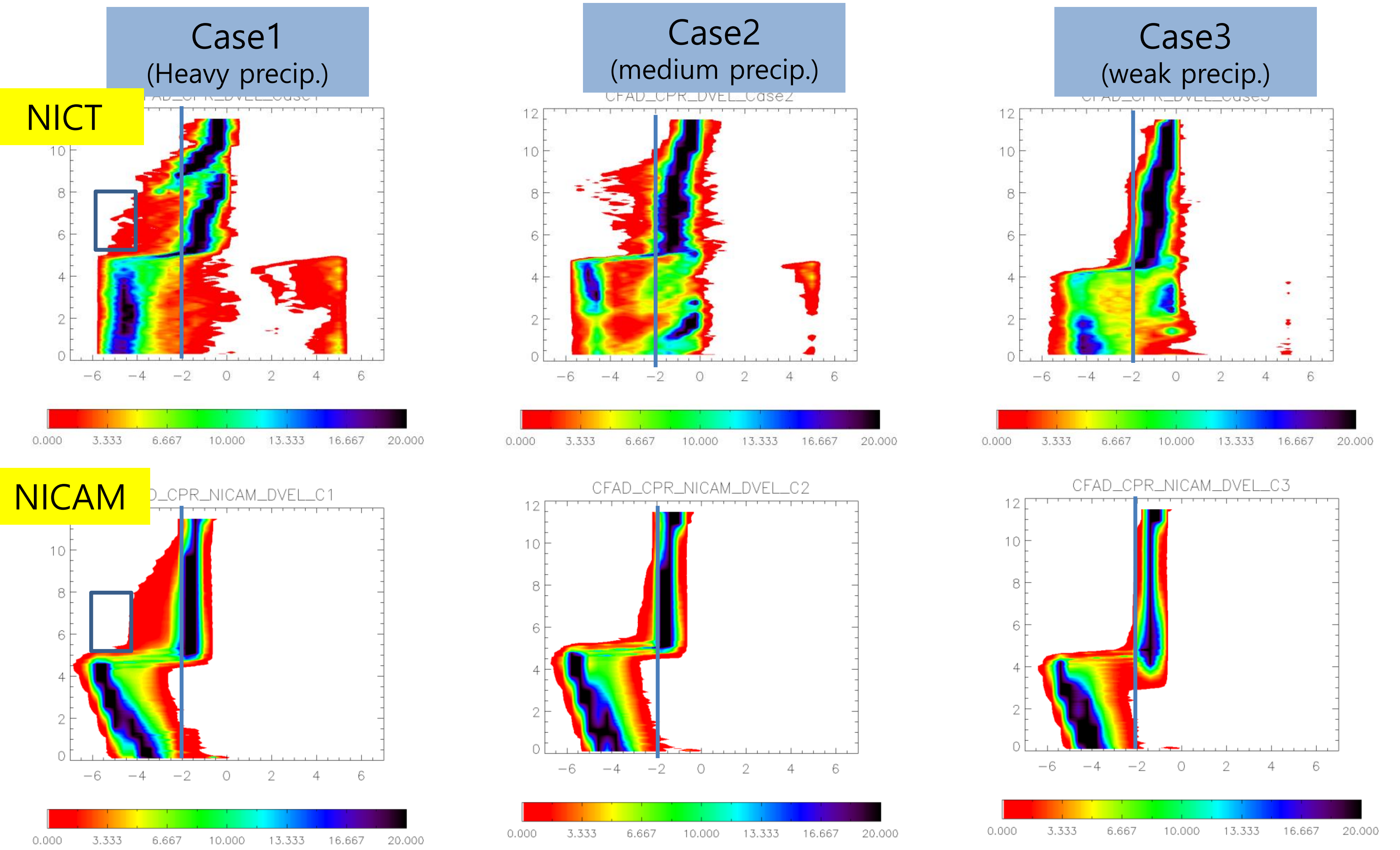


Case3
(weak precip.)



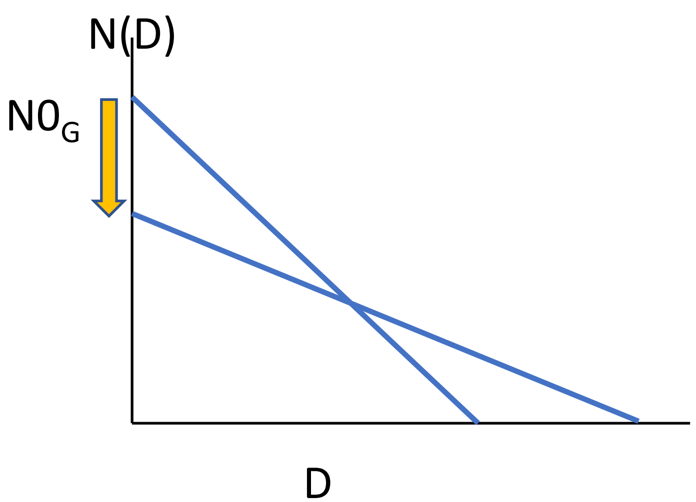


CFADs of Doppler velocity between observation and NICAM



The sensitivity tests of NSW6 about the process of graupel

Increases of graupel size

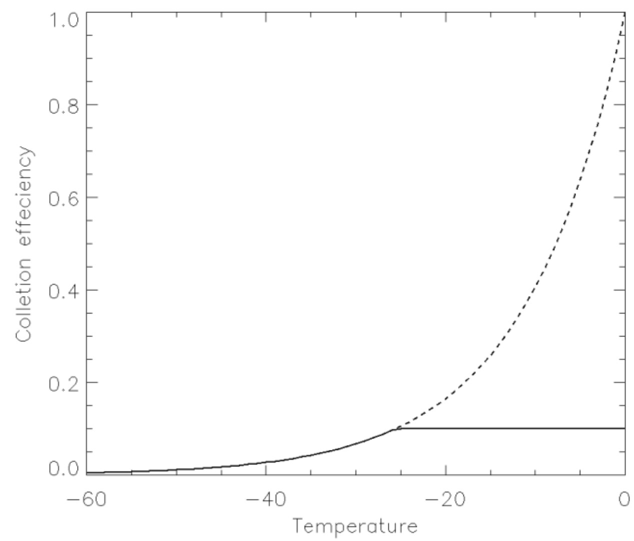


$N(D)=N0_G*\exp(-\lambda*D)$

Decrease of $N0_G$

$N0_G$ = 4.0E8 → 4.0E7 → 4.0E6

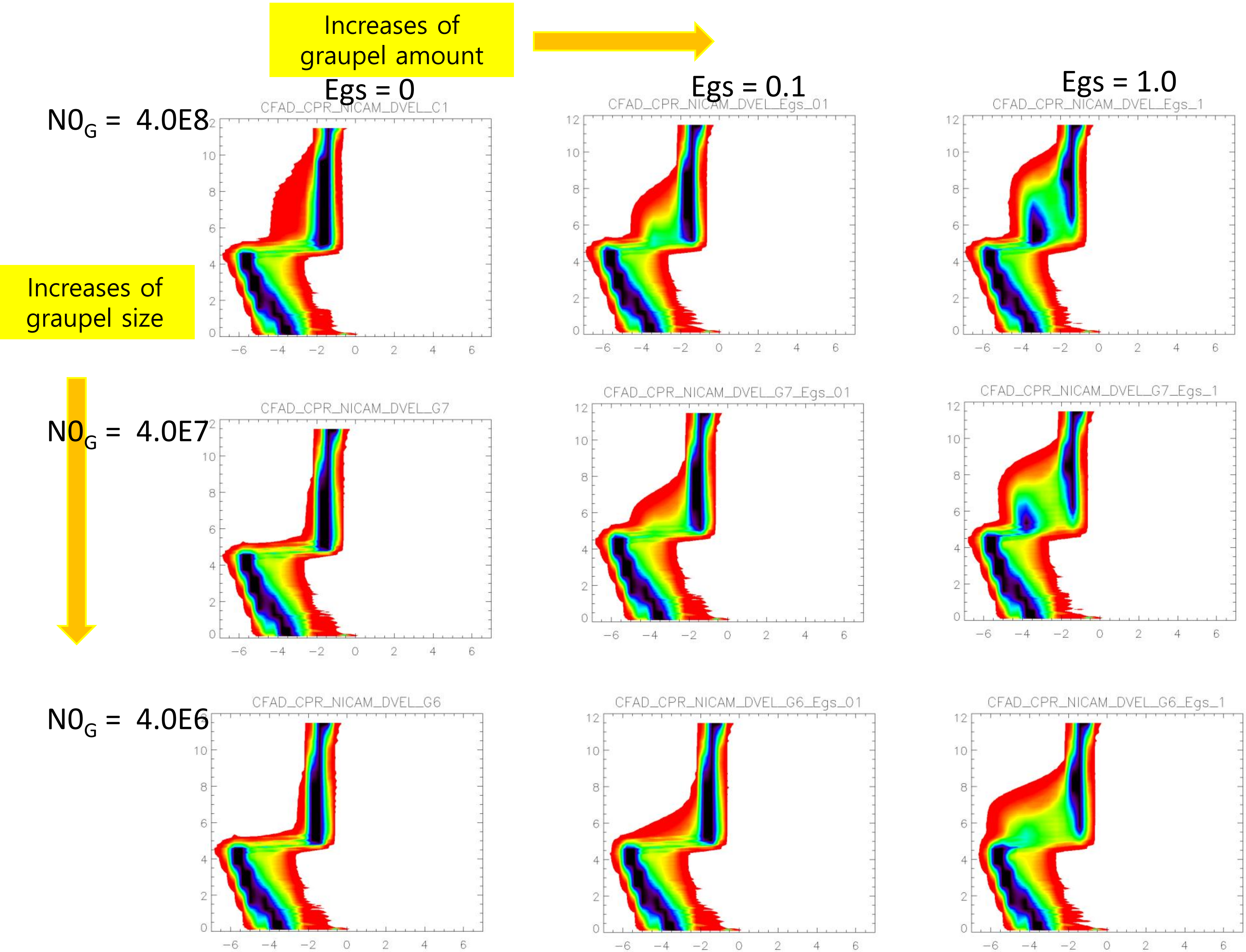
Increases of graupel amount



Accretion rate of snow by graupel

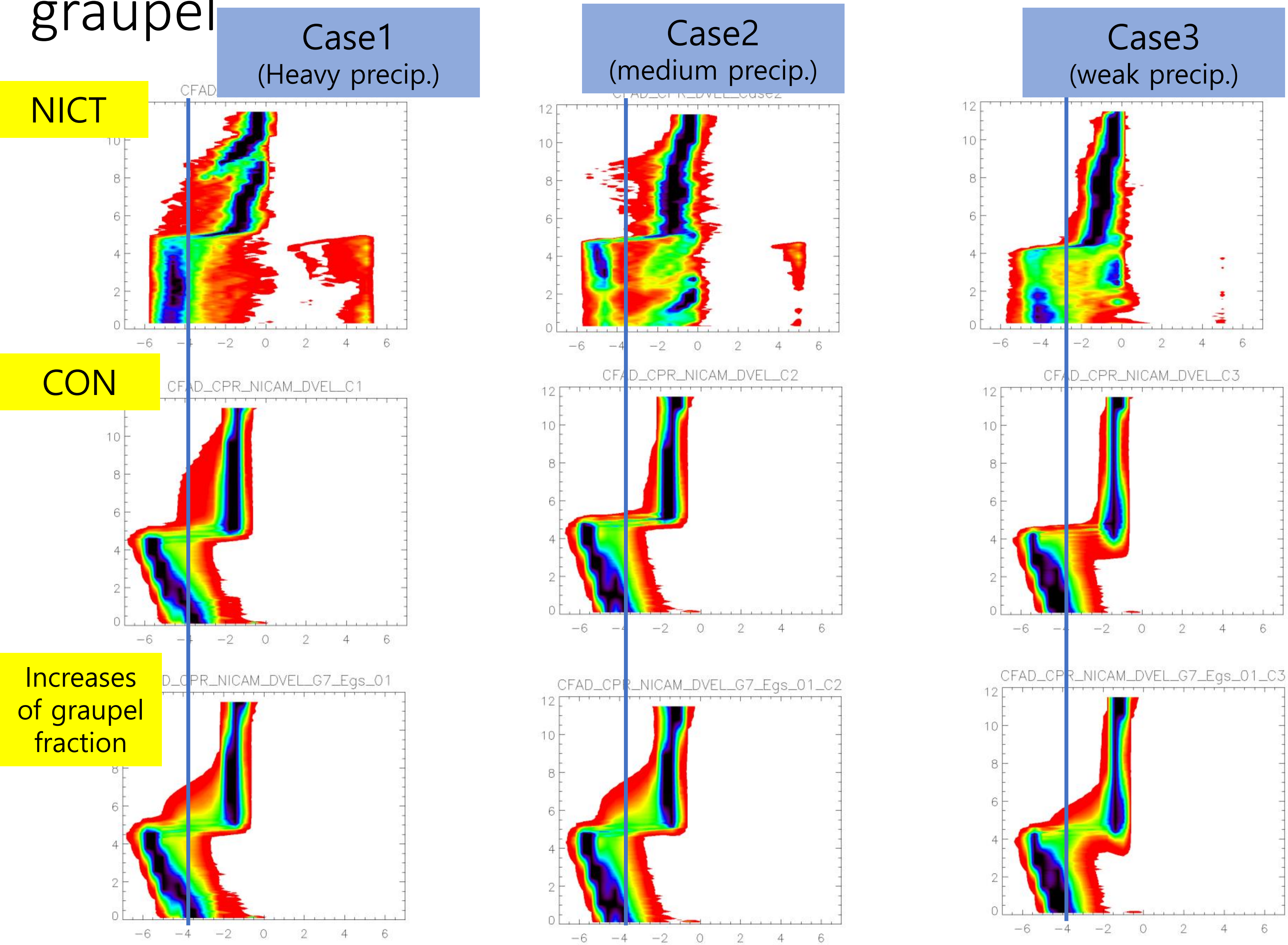
Maximum collection efficiency (Egs)

Egs = 0 → 0.1 (solid) → 1 (dotted)

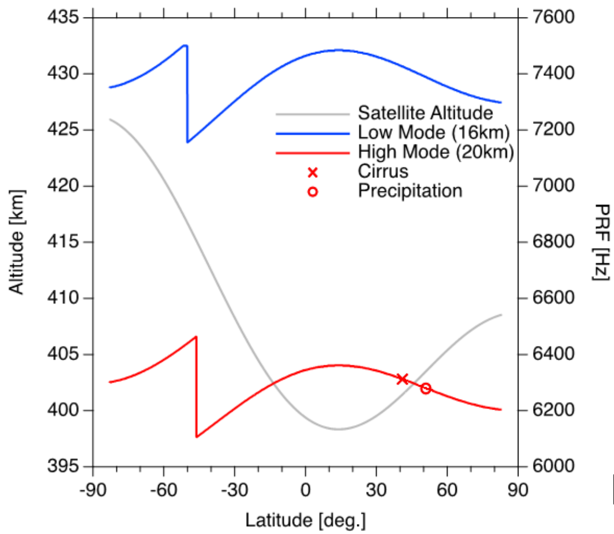


Increases of graupel amount
Egs = 0
Egs = 0.1
Egs = 1.0
Increases of graupel size
N0G = 4.0E8
N0G = 4.0E7
N0G = 4.0E6
CFAD_CPR_NICAM_DVEL_C1
CFAD_CPR_NICAM_DVEL_Egs_01
CFAD_CPR_NICAM_DVEL_Egs_1
CFAD_CPR_NICAM_DVEL_G7
CFAD_CPR_NICAM_DVEL_G7_Egs_01
CFAD_CPR_NICAM_DVEL_G7_Egs_1
CFAD_CPR_NICAM_DVEL_G6
CFAD_CPR_NICAM_DVEL_G6_Egs_01
CFAD_CPR_NICAM_DVEL_G6_Egs_1

Application to other cases using the tunning of graupel



The simulation results with Doppler errors like EarthCARE CPR using J-SIM



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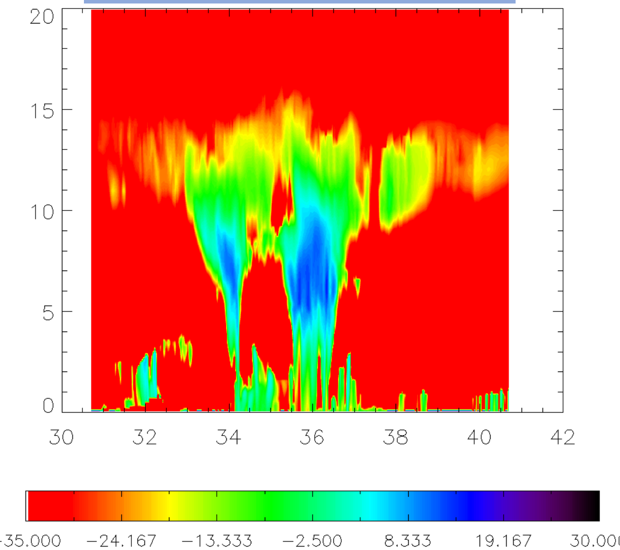
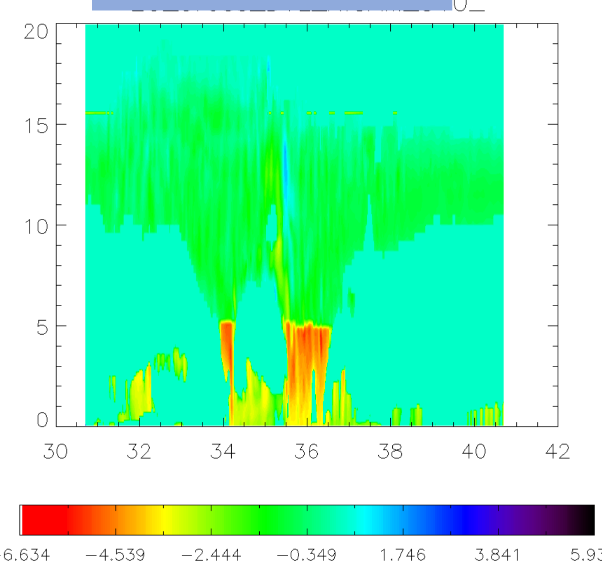
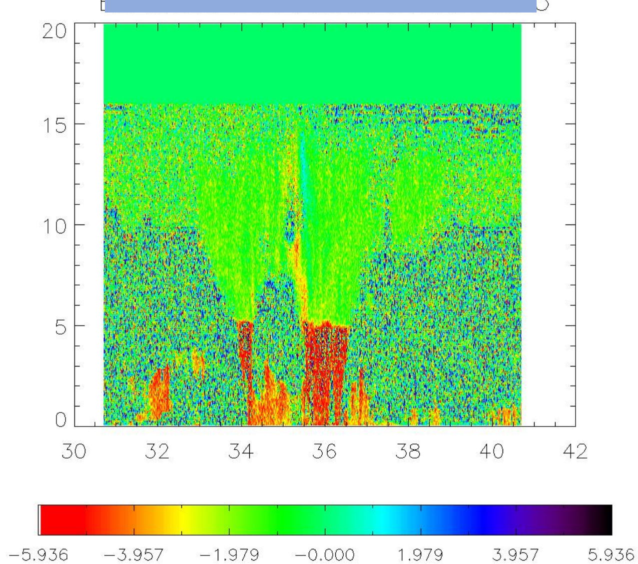
Radar reflectivity



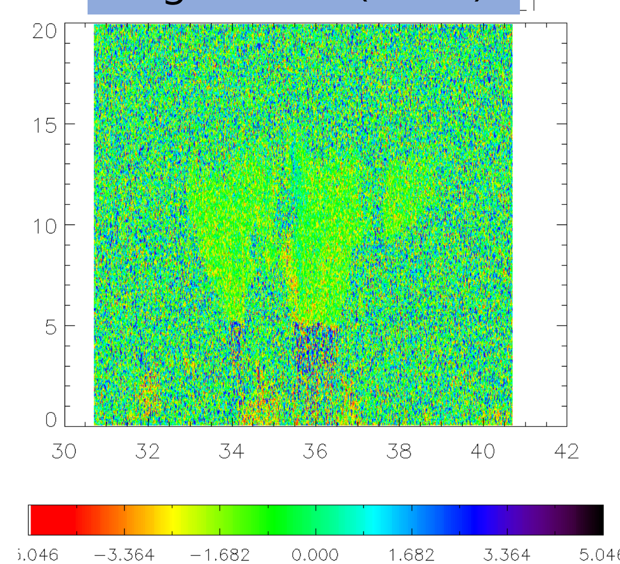
Without errors



Low mode (16km)

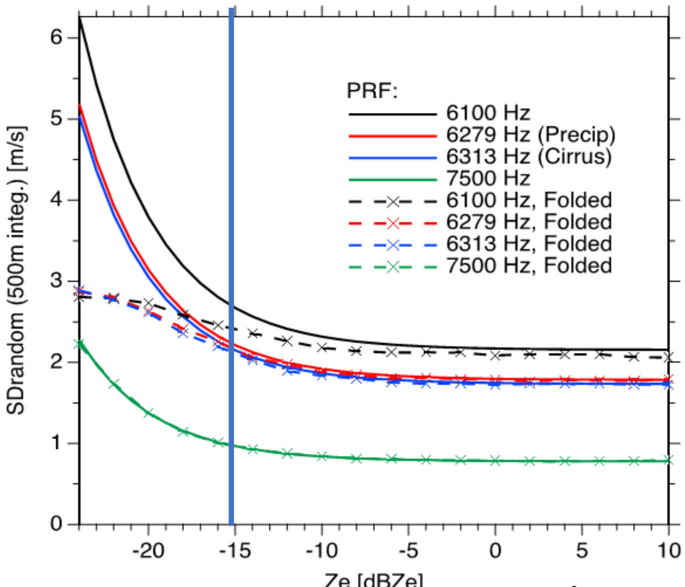


High mode (20km)



Tests using simulated Doppler velocity like ECARE CPR (Low mode) for Case 1

Without errors
(dBZ > -36.)



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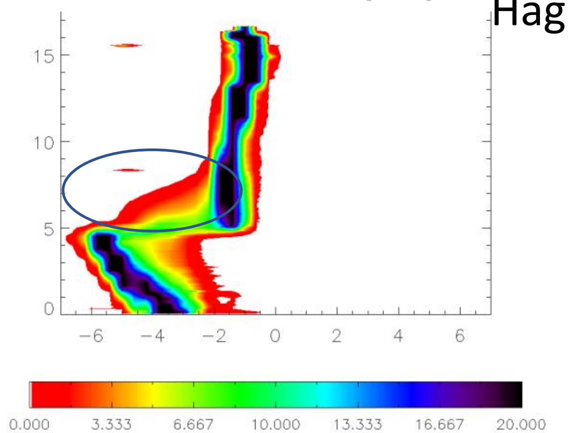
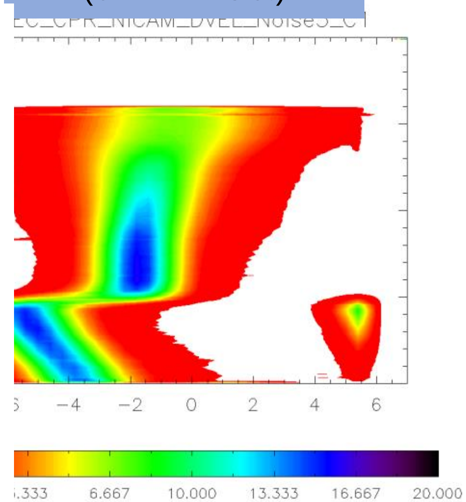
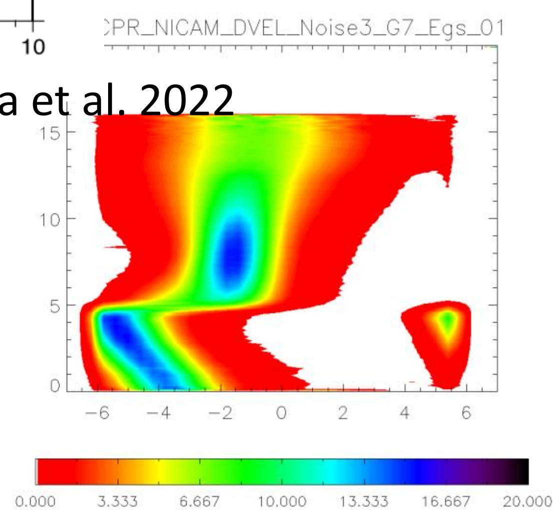
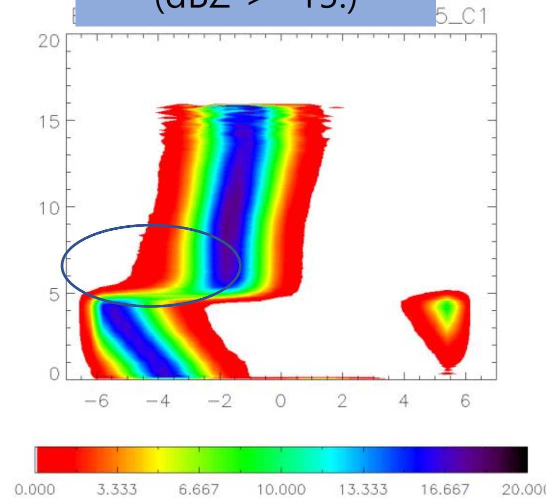


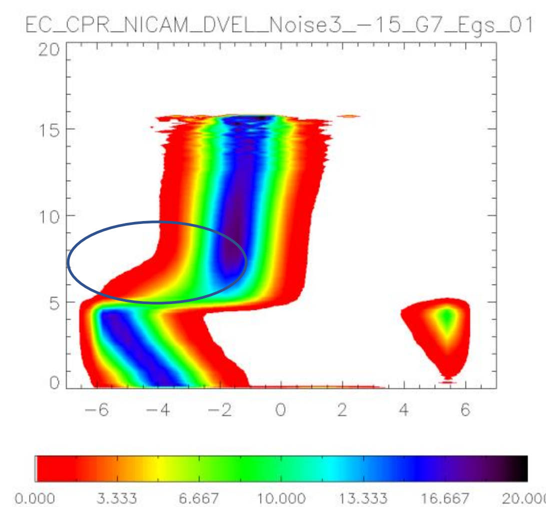
With errors
(dBZ > -36.)



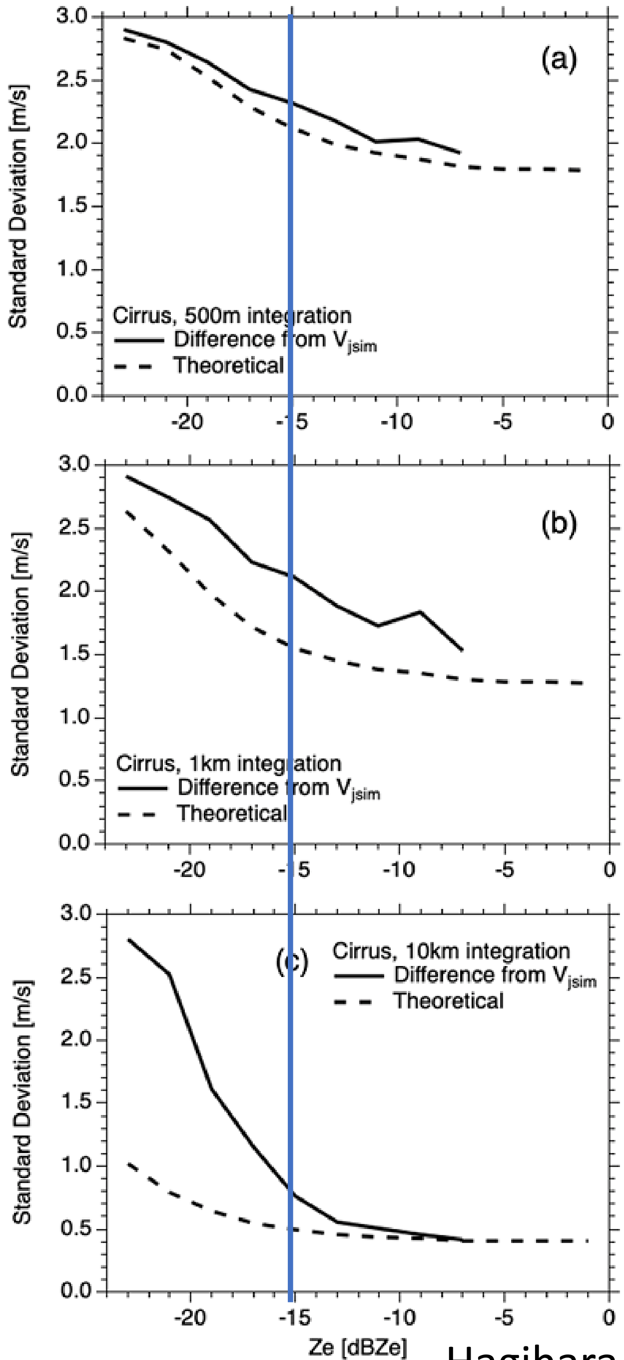


With errors
(dBZ > -15.)



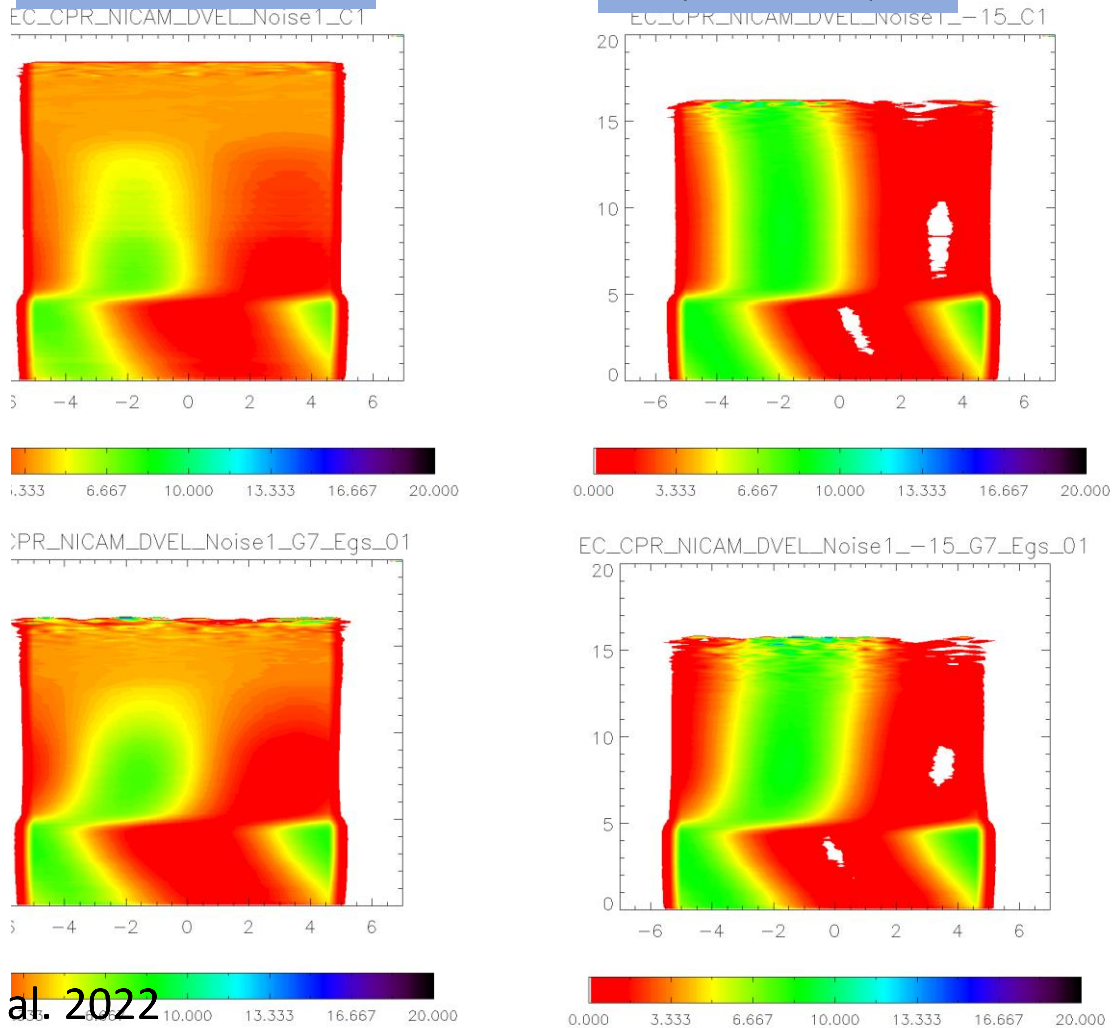


ed Doppler velocity like
ıode) for Case 1



With errors
(dBZ > -36.)

With errors
(dBZ > -15.)



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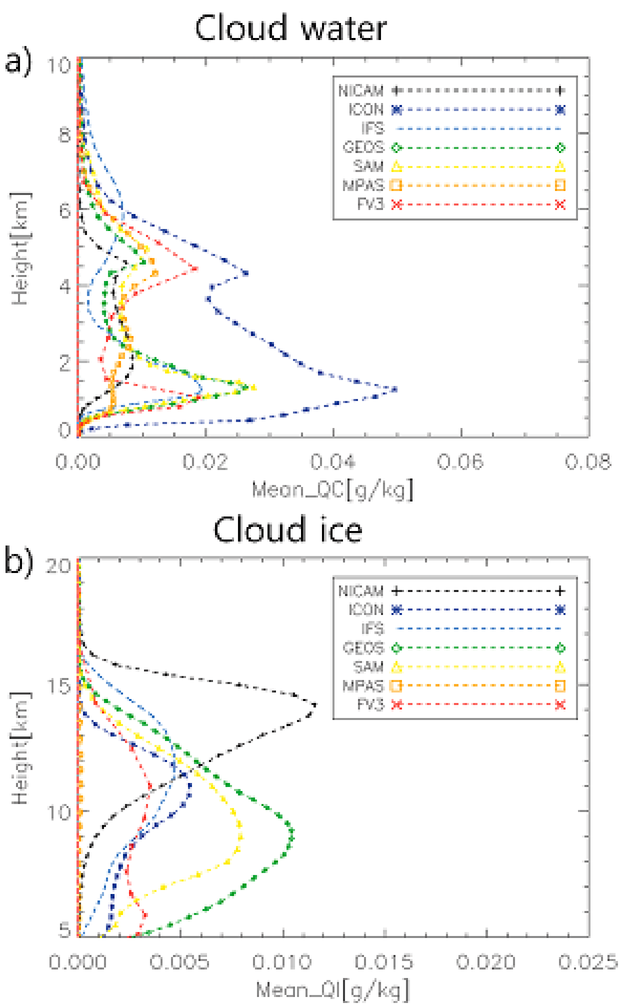
The DYAMOND (DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains) project: Stevens et al. (2019, PEPS)

- The DYAMOND project is the intercomparison of global high-resolution simulations with less than 5 km horizontal resolution.
- We investigated Cloud properties of DYAMOND data over the Atlantic. Roh et al. (2021, JMSJ)



The definition of cloud water and cloud ice are different each model.

When we compare the vertical profiles of ice hydrometeors, we need the same criterion each model.

The only radar reflectivity have limitation.

Radar reflectivity: the size and ice water content for snow and graupel
Doppler velocity: the density of ice hydrometeor (graupel, snow)
Lidar: sensitive to small ice particles.

Summary

- We evaluated NICAM using NICT CPR over Tokyo.
- The present version of NSW6 shows underestimation of the fraction of graupel for a tropical cyclone case.
- The change of the interceptor parameter of graupel (increase of graupel size) deceases minimum Doppler velocity above the melting layer.
- As an increase of collection efficiency of snow and graupel, the fraction of Doppler velocity less than -3 m/s increases between 6 and 8 km.
- We compared the results with the simulated Doppler velocity like the EarhCARE CPR using Joint simulator.
- The low mode (high PRFs) shows are consistent with the results of NICT results.
- The EarthCARE product is useful to intercompare vertical distributions of ice hydrometeors of GSRMs.

Thank you