Impacts of double-moment bulk cloud microphysical scheme in tropical and midlatitude mesoscale convective system

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1.Cloud microphysical scheme

More accurate cloud microphysical scheme is required recently since cloud-resolving model is being applied to more larger and longer spatial and time scales. Double-moment scheme is one of the alternatives for improving cloud-resolving model (Morrison et al. 2005; Seifert & Beheng 2006). We developed single/double-moment cloud microphysical schemes and investigated impact of the double-moment scheme on various mesoscale convective systems.

Figure 1 shows conversion diagrams of water cycle cosidered in developed schemes. Existing paramerizations are mainly used, but condensation/deposition and double-moment descriptions follow to Morrison et al. (2005) and Seifert & Benehg (2006), respectively.

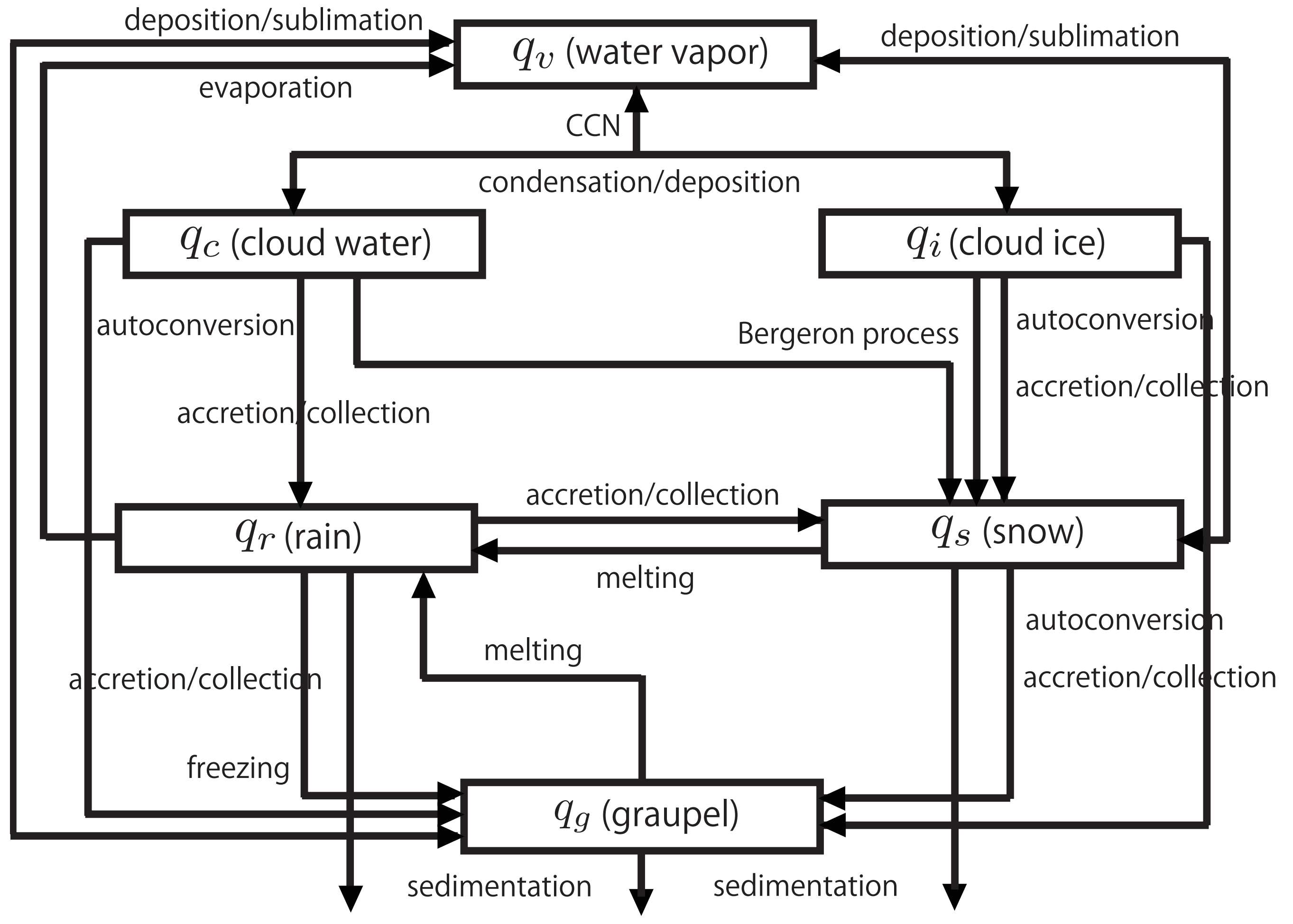

Fig.1 Conversion diagrams of developed single/double-moment schemes

Follwing investigations are conducted with comparing the results of 3-class single moment scheme (Grabowski 1998, refered to as GW3). Our single/double-moment schemes are refered to as MSW6 and MDW6, respectively, hereafter.

2.Squall line experiment

Squall line experiment in both tropical and midlatitude is performed in order to validate the schemes' basic capability for simulating deep convection. The schemes are implemented into dynamical core (Baba et al. 2010) of an atmospheric model. Experiment setups follows to Rederlsperger et al. (2000) and Kelmp & Weisman (1984) for midlatitude, respectively.

Radar reflectivites (Fig.2) show that our schemes successfully simulated squall line structure, and double-moment scheme also simulated trailing stratiform cloud after convective clouds as Hovmollerdiagram of precipiation for MDW6 shows moderate precipitation in downstream (Fig.3).

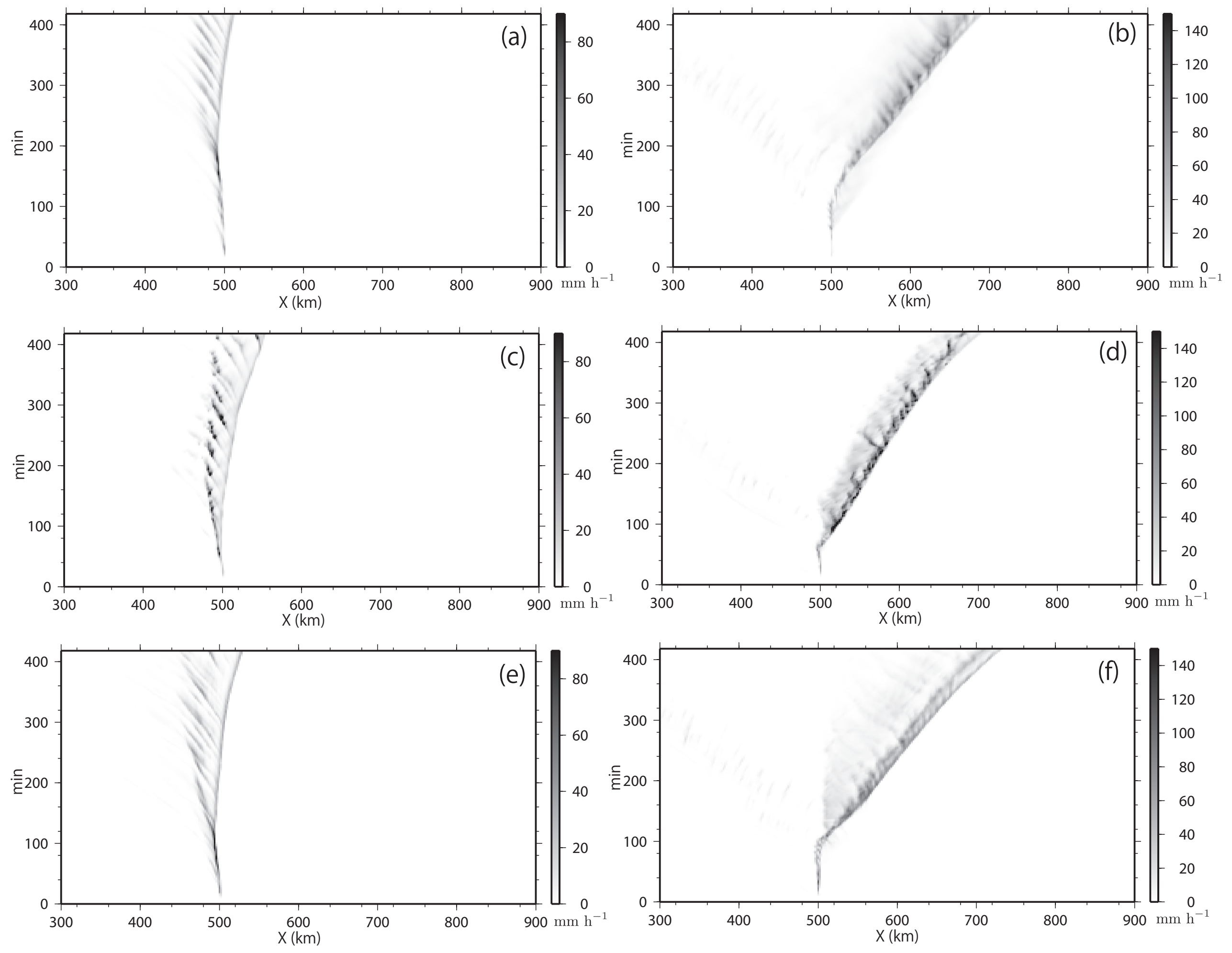

Fig.2 Hovmoller diagrams of precipitations (a), (b) GW3, (c),(d) MSW6, (e),(f) MDW6
Left and right figures show tropical and midlatitude squall lines, respectively.

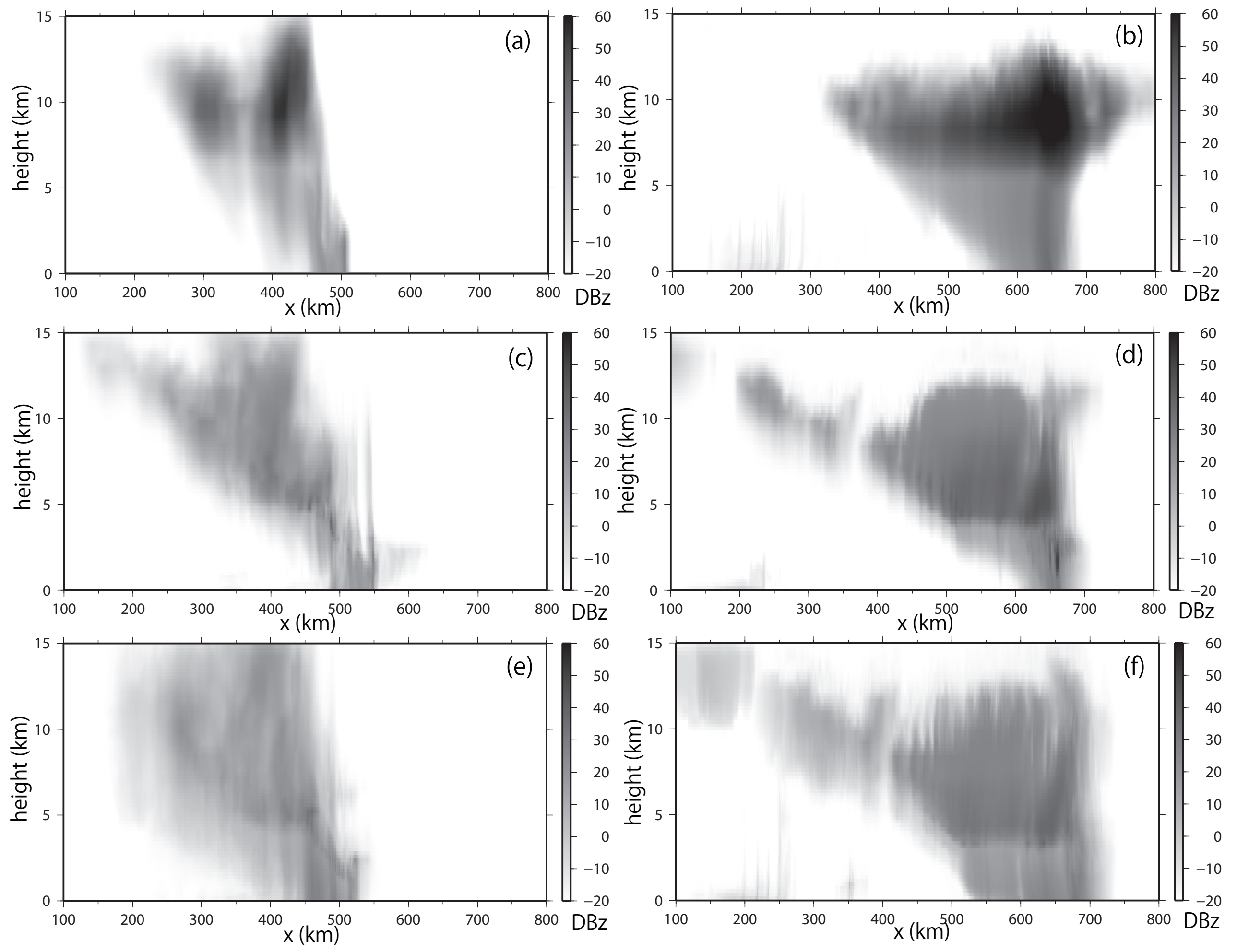

Fig.3 Radar reflectivity of simulated squall lines (a), (b) GW3, (c),(d) MSW6, (e),(f) MDW6
Left and right figures show tropical and midlatitude squall lines, respectively.

3.Radiative convective equilibrium

Long-term water and energy balance is required for the cloud mirophysical scheme. For the validation and to investigate effect of double-moment scheme on long-term integration radiative convective equilibrium tests are performed.

Comparisons of domain averaged temperature and precipitations indicates that increasing class of local intensity of scalar fluctuations (Fig.4). The double-moment decreases the maxima of the scalar fluctuations. Along with the fluctuations, time variations of the OLR/OSR differ by microphysical schemes (Fig.5). OLR/OSR of double-moment scheme much fluctuated due to the changable number density of water species. The average values of OLR/OSR are almost same between GW3 and MDW6 (OLR: 280 W/m2, OSR: 60 W/m2), however, the fluctions might have potential imact on long-term mesoscale convection.

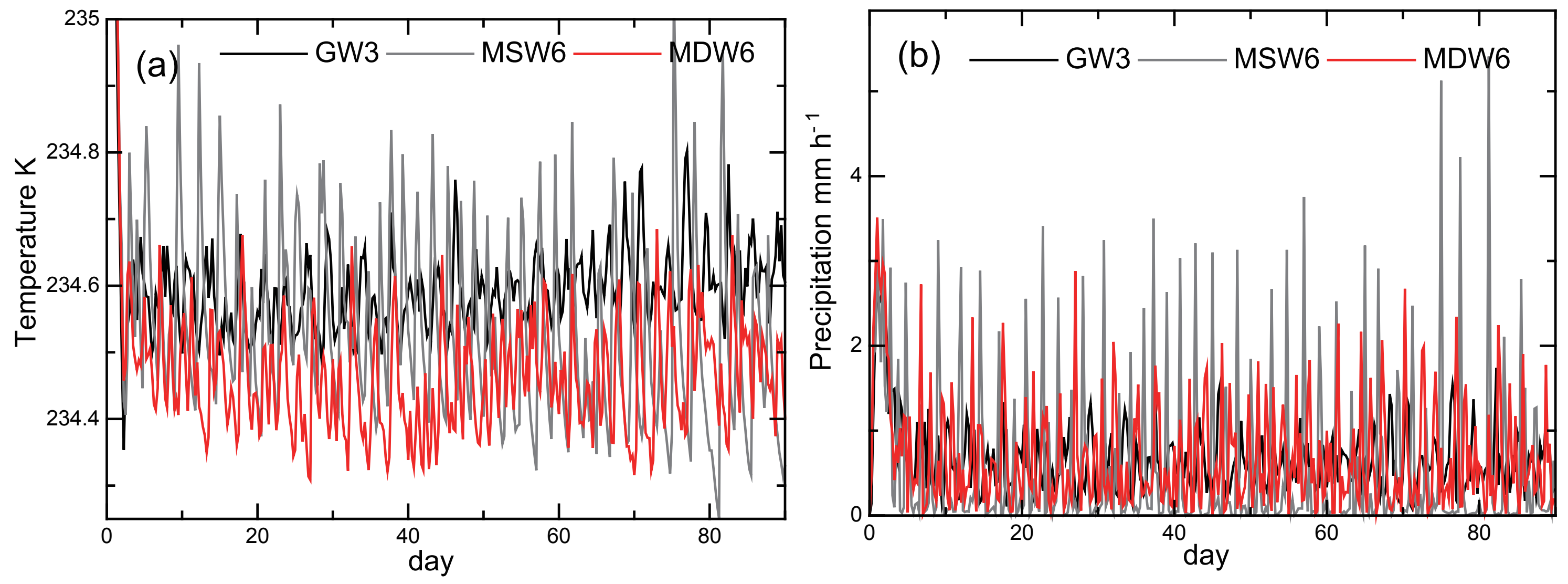

Fig.4 Time variations of domain averaged (a) column-integrated temperature and (b) precipitation.

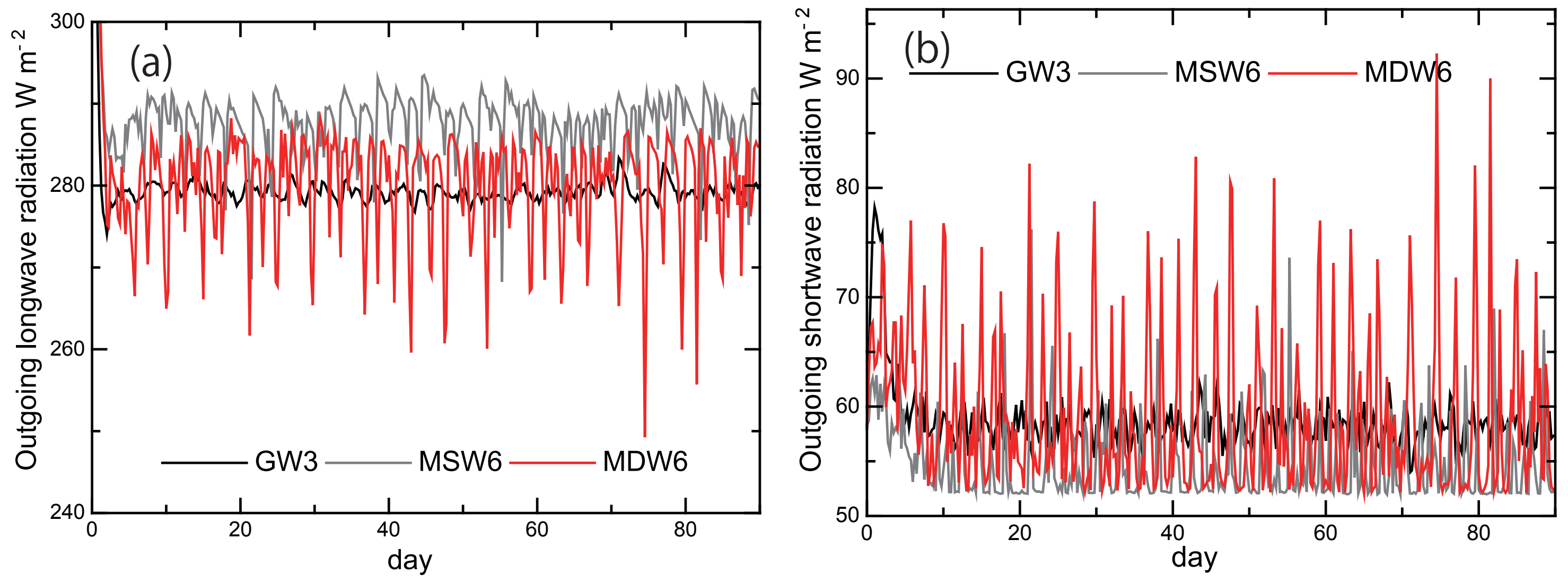

Fig.5 Time variations of domain averaged (a) OLR and (b) OSR.

4.TOGA COARE experiment

TOGA COARE experiment (Wu et al. 1998) is conducted to validate actual predictability of the MDW6. Hovmoller diagram of precipitation are presented (Fig.6). Eastward and westward moving precipitations are simulated as appeared in the observation. However, relative humidity of the model results shows deviation from observation (Fig.7). Further investigations for model setup and parameters are now being conducted.

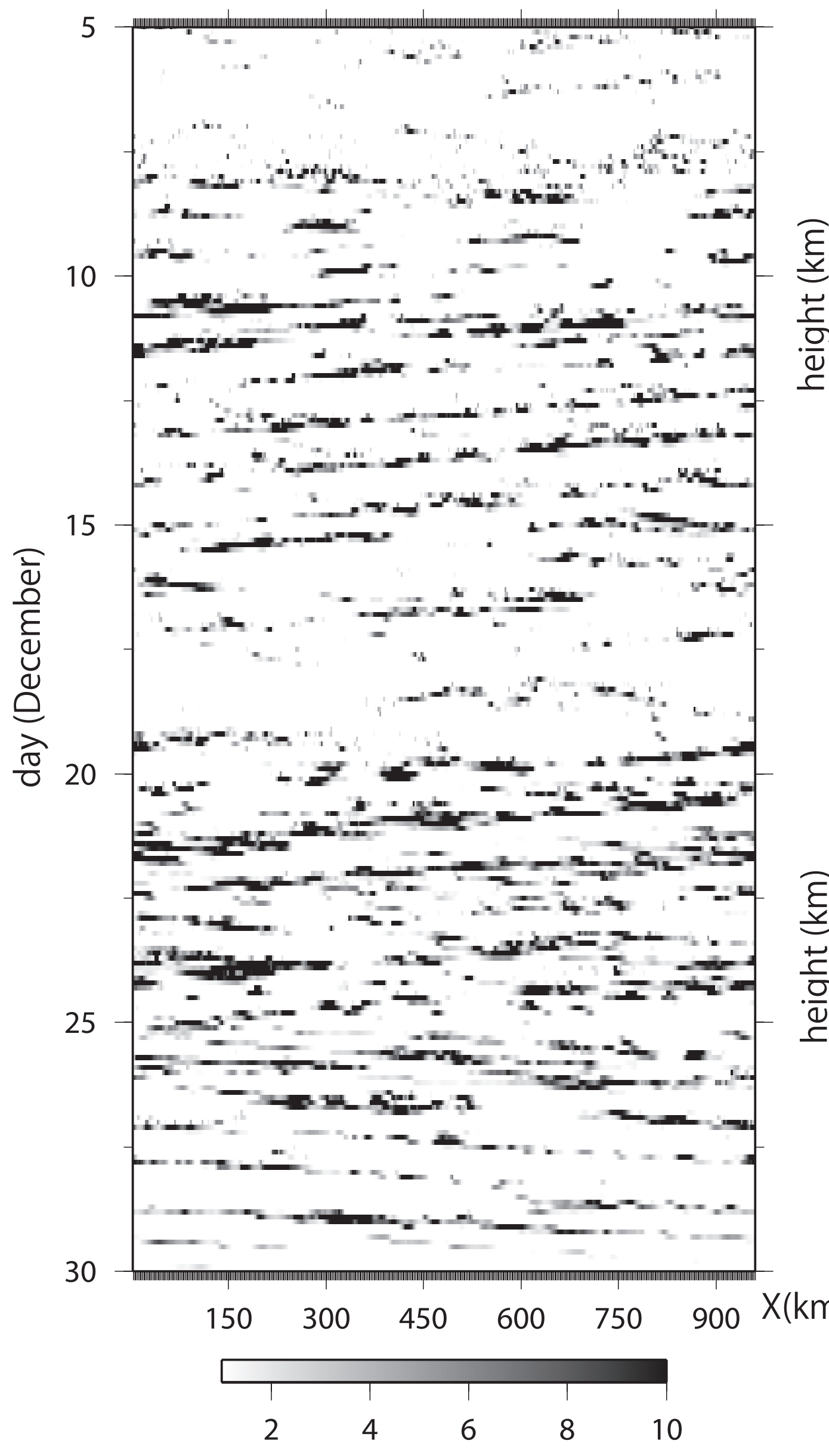

Fig.6 Hovmoller diagrams of precipitations obtained from TOGA COARE exp. using MDW6.

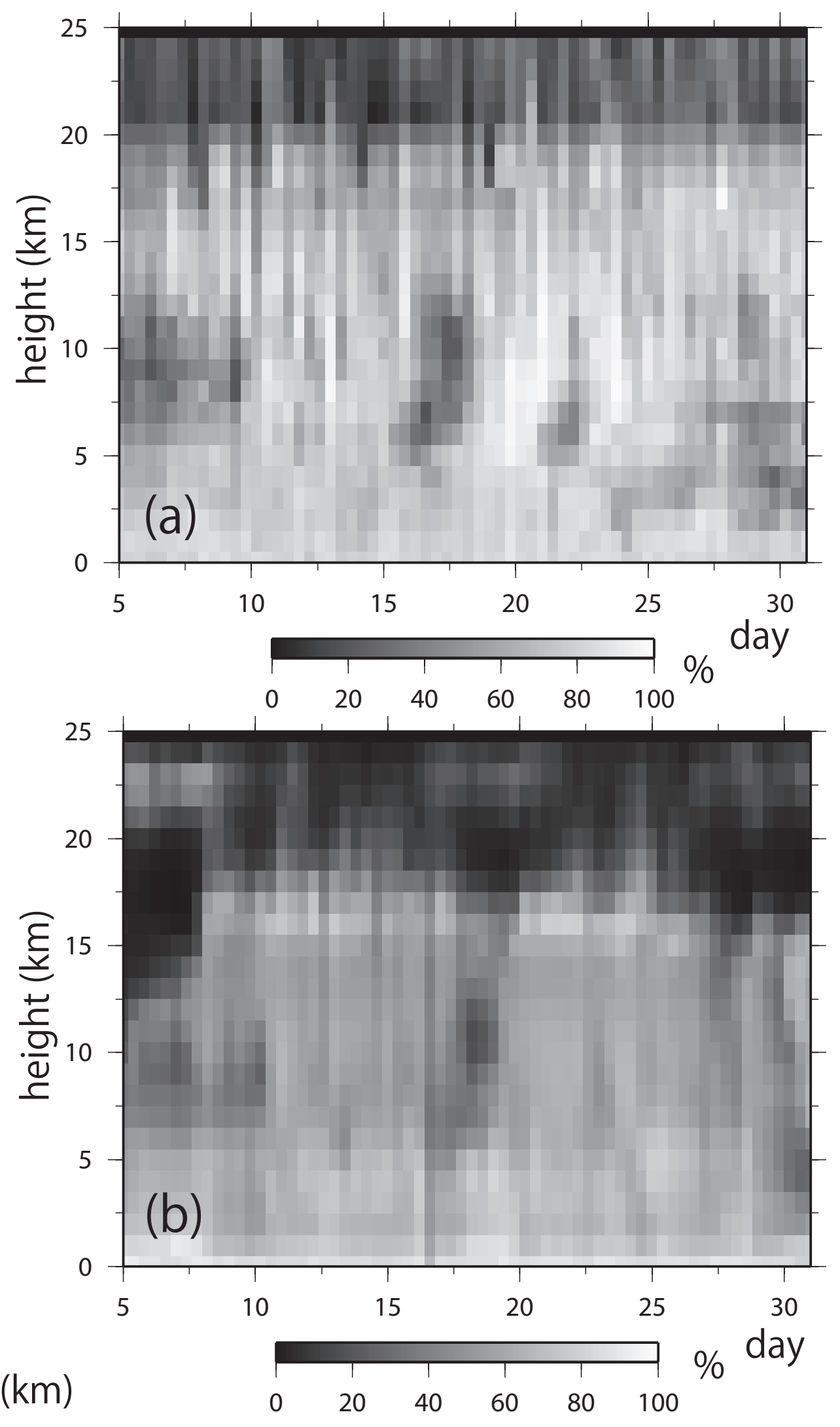

Fig.7 Comparisons of time variations of relative humidity. (a) OBS and (b) model result.

5.Summary and conclusion

Single/double-moment cloud microphysical schemes are developed. 2D squall line experiment reveals that the schemes are able to simulate typical features of tropical and midlatitude squall lines. Radiative-convective equilibrium test indicates that developed schemes can achieve quasi-steady state but double-moment effect appears as OLR/OSR fluctuaions. Finally, TOGA COARE experiment is coducted, however, some differences are found compared to observation. Further investigations for model setup and parameteres are required.

References

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