

Horizontal Resolution Dependency of a Radiative-convective Equilibrium State of a Cloud System Resolving Model

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1. Introduction

- High-resolution cloud resolving simulations are expensive or impossible even using the Earth simulator.
- Representation of clouds largely depends on horizontal resolution as shown in Fig. 1 and sec. 3.

What are side-effects caused by lower horizontal resolutions in climate study ?

2. Experimental settings

Settings are basically following Tompkins and Craig (1998 and 1999).

- MRI/NPD-NHM (cloud resolving model of JMA)
- **Interactive radiation**
- **Fixed sea surface temperature: SST=302K**
- **No large scale forcing**
- Domain size: 200km x 200km x 28km
- 60days simulation: last 30 days are analyzed.
- **dx=2km, 4km, 8km** (dt=6, 12, 24s)
- additional runs (4km-LD, 4km-SD: diffusion is different)

3. Precipitation & clouds

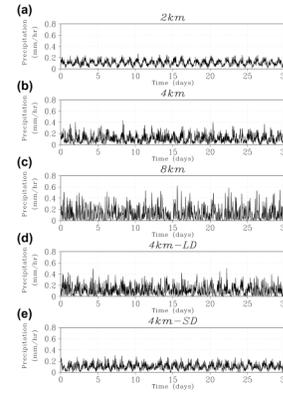


Fig. 2: Time-series of the domain-averaged precipitation rate.

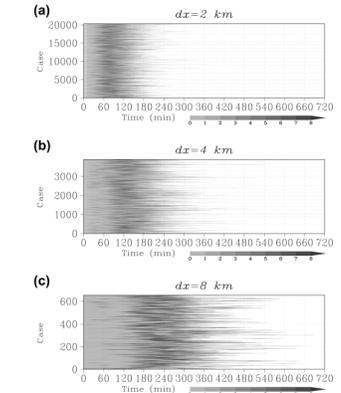


Fig. 3: Time-series of precipitation events. The ordinate is the number of precipitation events. The shade denotes the precipitation rate measured in mm/10min. It is assumed that clouds are almost standing.

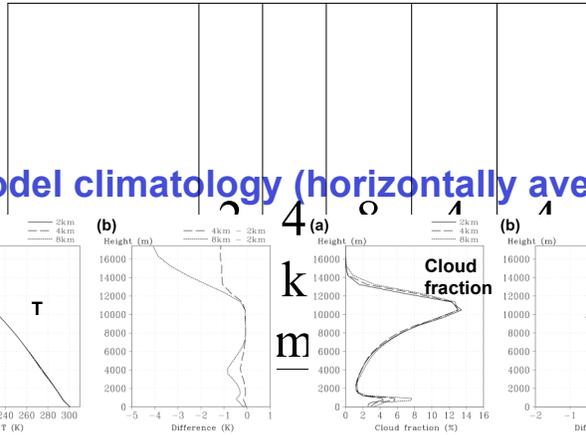
In lower horizontal resolution or with larger numerical diffusion, features of individual cloud are

- **slower development / longer lifetime** (Fig. 3)
- **larger horizontal size** (Fig. 1, Tab. 1)

features of convective activity are

- **smaller number of clouds in the domain** (Tab. 1)
- **sporadic development** (Fig. 2)
- **stronger activity** (Tab. 1)
- **slower response to the diurnal short-wave forcing** (not shown)

Table 1: Statistics of the surface precipitation.



4. Model climatology (horizontally averaged vertical profiles)

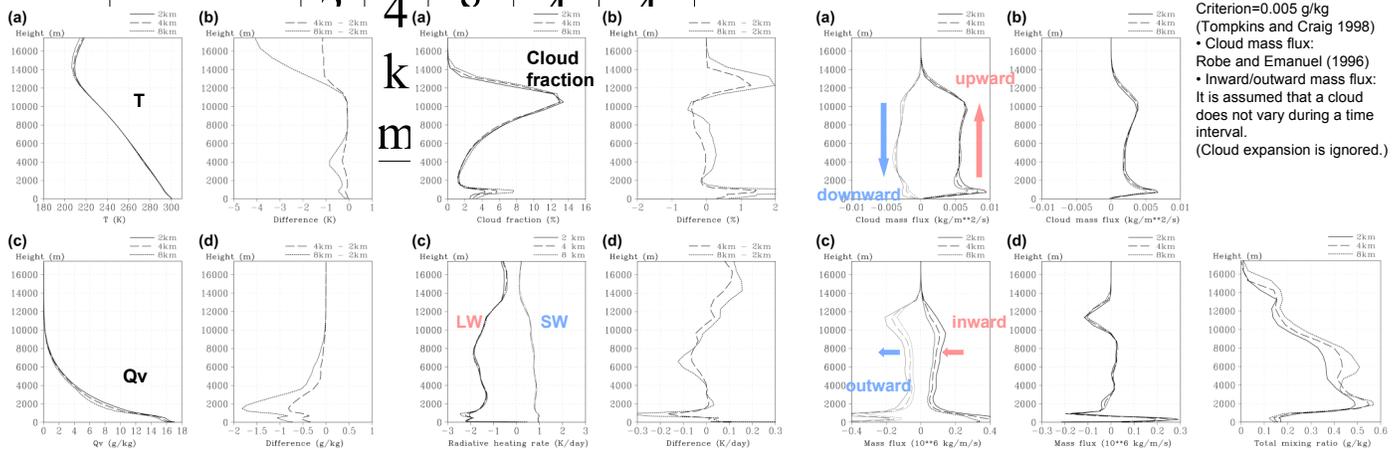


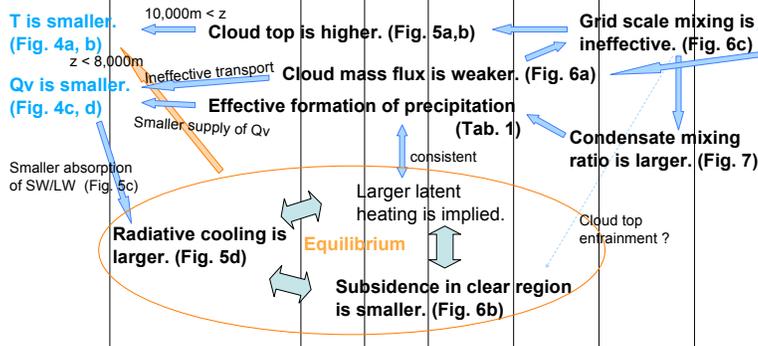
Fig. 4: (a) Temperature and (c) water vapor mixing ratio. (b), (d) Anomaly from 2km for each quantity.

Fig. 5: (a) Cloud fraction and (c) radiative heating rate. (b), (d) Anomaly from 2km.

Fig. 6: (a) Upward/downward cloud mass fluxes and (b) the net. (c) Total inward/outward horizontal mass fluxes and (d) the net.

Fig. 7: Total condensate mixing ratio.

In lower horizontal resolution ...



5. Conclusions

- In lower horizontal resolution, due to a stronger averaging implied,
 - the upward/downward cloud mass fluxes are weaker,
 - the grid scale mixing is ineffective.
- These can shift model climatology to be drier and cooler.
- A cloud scale parameterization is required in lower horizontal resolution as discussed by Jung and Arakawa (2004).
- Such parameterizations are required to compensate weaker cloud scale circulations.