Generation mechanisms of convections by gravity waves

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1. Introduction

Because convective storms sometime cause mudslides or floods, it is important to understand the generation and development mechanisms of the convections. In this study, the generation mechanisms of the convections by gravity waves (GWs) were investigated using the outputs of Non-hydrostatic model (NHM).

2. Ideal experiment of 2-dimensional model

To understand the generation process of convections, ideal experiments using 2-dimensional model was performed (Yamasaki and Seko, 1992). Typical profiles of temperature and humidity in the tropical atmosphere were used as the basic fields. Two sets of four babbles were placed in the domain of numerical model.

Figure 1 shows the temporal variations of vertical wind at z=1.2km and temperature at z=150 m. GWs were generated at the convections and propagated from the convections. Convection **F** was generated at the overlapped area of GWs from the convections **A** and **C**. Convection **F** was developed when GWs from the convections **B** and **E** arrived. Convection **J** was also generated when GW arrived from the convection **G**, and was developed when GW arrived from the convection **H**. When GW approached, temperature was decreased and relative humidity was increased (not shown). Updraft of GW and these changes caused by GWs are the favorable conditions for the generation and development of convections. There was no cold pool where convections **F** and **J** were generated. This distribution indicates that GW generates and develops the convections.

3. Generation mechanisms of convections by gravity waves

Numerical simulations using NHM were performed from the initial conditions produced from JRA25 data. Initial time was 12UTC 28 2008. Downscale experiments were further performed with the grid intervals of 5 km and 1 km.

Figure 2a shows the rainfall distribution reproduced by 5km-NHM. A convective band extending southeastward was generated at the eastern side of Sumatra Island. Figures 2b and 2c are the distributions of rainfall and temperature at P=1000hPa, reproduced by 1km-NHM. Convection **A** was generated on the eastern side of the convective band in the convergence zone of northwesterly and westerly flows (Fig. 2a). When convection **A** was generated, the cold pool did not exist near the convection **A**. The convections were generated at the eastern side of the band successively. Convections **B** at the southern side of the convective band were generated at the gradient zone of temperature. This gradient was the boundary of the cold pool, which was expanding eastward. This distribution suggests that the cold pool also contributed the generation of the convection. Figure 3 is the time sequence of vertical wind, temperature and dew-point deficit (T-Td) at P=950hPa along the broken line in Fig. 1b, which crossed the convection **A**. Convection **A** was generated at the weak updraft region along the eastern side of the band (dotted line in Fig. 3c), when GW was propagated from the east (broken line in Fig. 3a). When GW was propagated, temperature was decreased and dew-point deficit became smaller (Figs. 3b and 3d). The updraft of GW makes the atmosphere cooler and moister, which are favorable conditions for the generation and development of convections.

Figure 4 is the same as Fig. 3 except for the broken line in Fig. 2c, which crossed the convections **B**. Convections **B** were generated along the edge of the cold pool (dotted line in Fig. 4c). Low-level updraft was produced by the

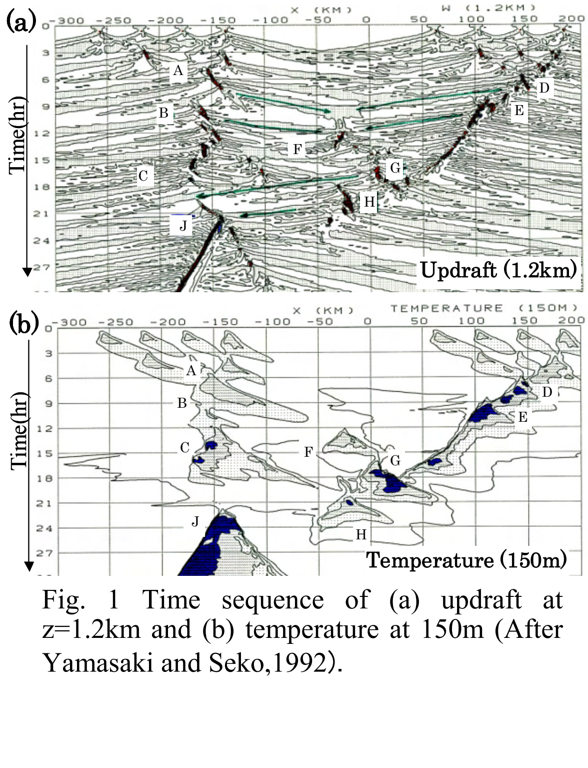


Fig. 1 Time sequence of (a) updraft at z=1.2km and (b) temperature at 150m (After Yamasaki and Seko,1992).

outflow of the cold pool. When the gravity wave from the western side overlapped the edge of cold pool, the convection was generated (broken line in Fig. 4a). These variations of temperature and dew-point deficit were also common with the convection A (Figs. 4b and 4d).

4. Summary

Updraft of GW makes the atmosphere cool and moistens. Updraft and these changes are favorable conditions for the generation of convections. When the weak convergence or weak cold pools exists, GW determines the generation point and timing of convection.

References

Yamasaki, M., and H. Seko, Effect of the gravity wave on the convections, 1992, Proceedings of Spring meeting of Meteorological Society of Japan, A108 (in Japanese).

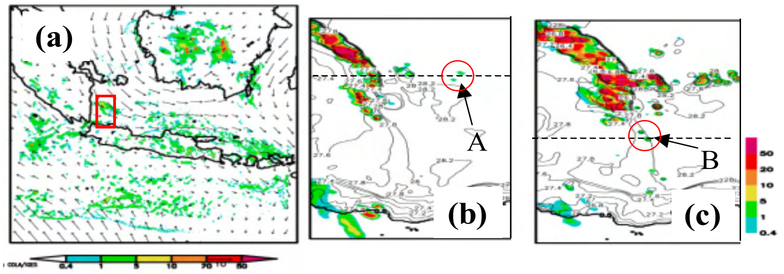
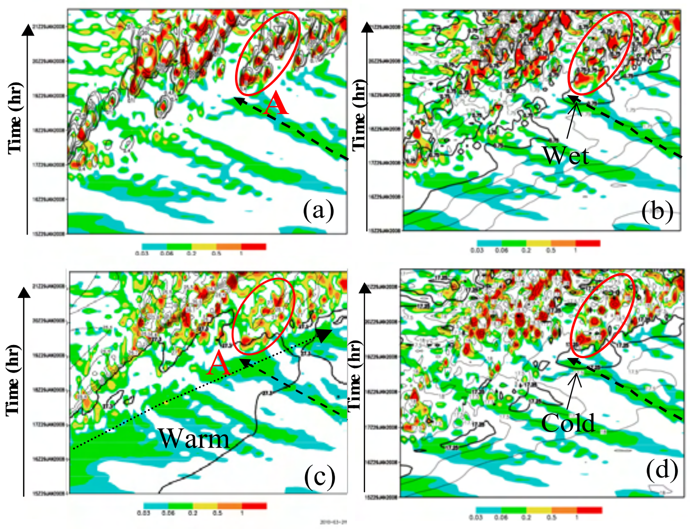


Fig. 2 (a) Rainfall region reproduced by 5km-NHM. Initial time is 18UTC 28 Jan. 2008. Rainfall region and temperature at 1000hPa at (b) 22:30UTC 29 and (c) 23:20UTC reproduced by 1km-NHM. Domains of (b) and (c) are indicated by rectangle in (a). Initial time of 1km-NHM is 15UTC 29.



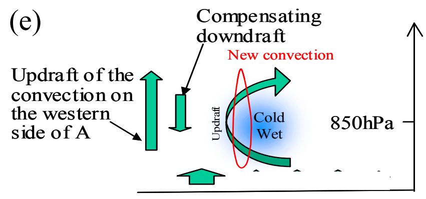
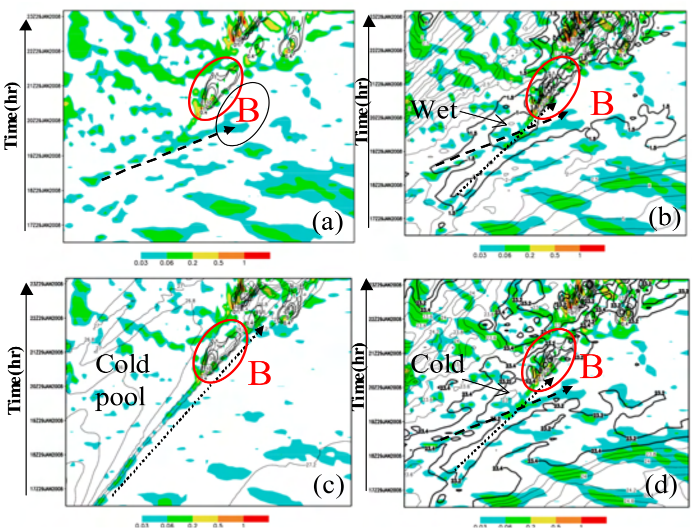


Fig. 3 Time variation of updraft (colored region) at (a, b and d) P=850hPa and (c) P=925hPa along the broken line in Fig. 2b and, (a) rainfall (b) dew-point deficit at P=850hPa, (c) temperature at P=1000hPa and (d) temperature at P=850hPa. (e) Schematic illustration of convections A.



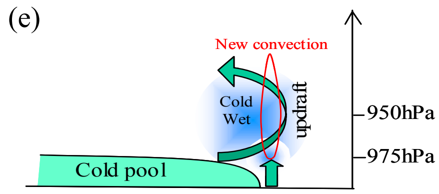


Fig. 4 Time variation of updraft (colored region) at (a, b and d) P=950hPa and (c) 975hPa along the broken line in Fig. 2c, (a) rainfall (b) dew-point deficit at P=950hPa, (c) temperature at P=1000hPa and (d) temperature at P=950hPa. (e) Schematic illustration of convections B.