Generation mechanisms of convections by gravity waves

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Contents

1. Motivation

-I believe that it is important to understand the generation and development mechanisms of the convections because convective storms sometime cause mud slides or floods.

-Reducing the damage of disasters has always been top priority. Further investigation of the generation mechanisms of the convections is necessary.

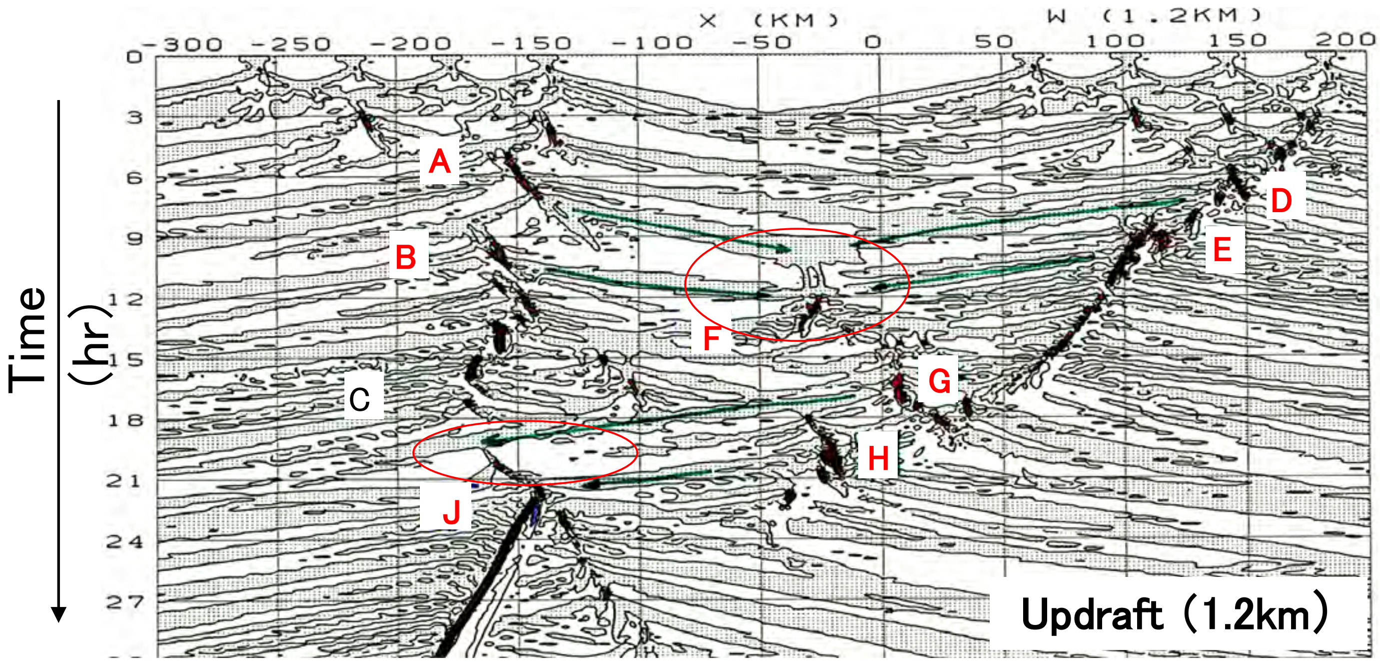
2. Ideal experiment of the 2-dimensional model

- To understand the generation process of convections, ideal experiments using the 2-dimensional model was performed by 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.

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).

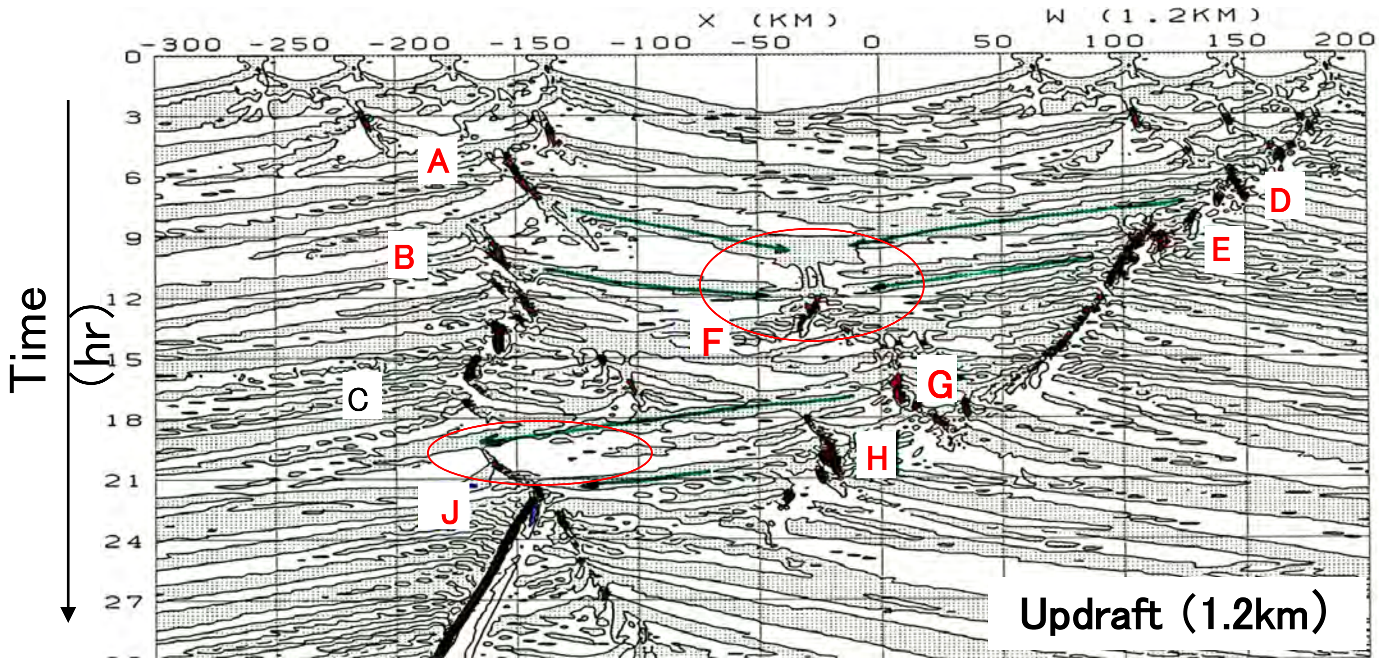
Temporal variations of vertical velocity at z=1.2km



Time sequence of updraft at z=1.2km (After Yamasaki and Seko,1992).

- GWs were generated at the convections and propagated to both directions.
- 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.

Temporal variations of vertical velocity at z=1.2km

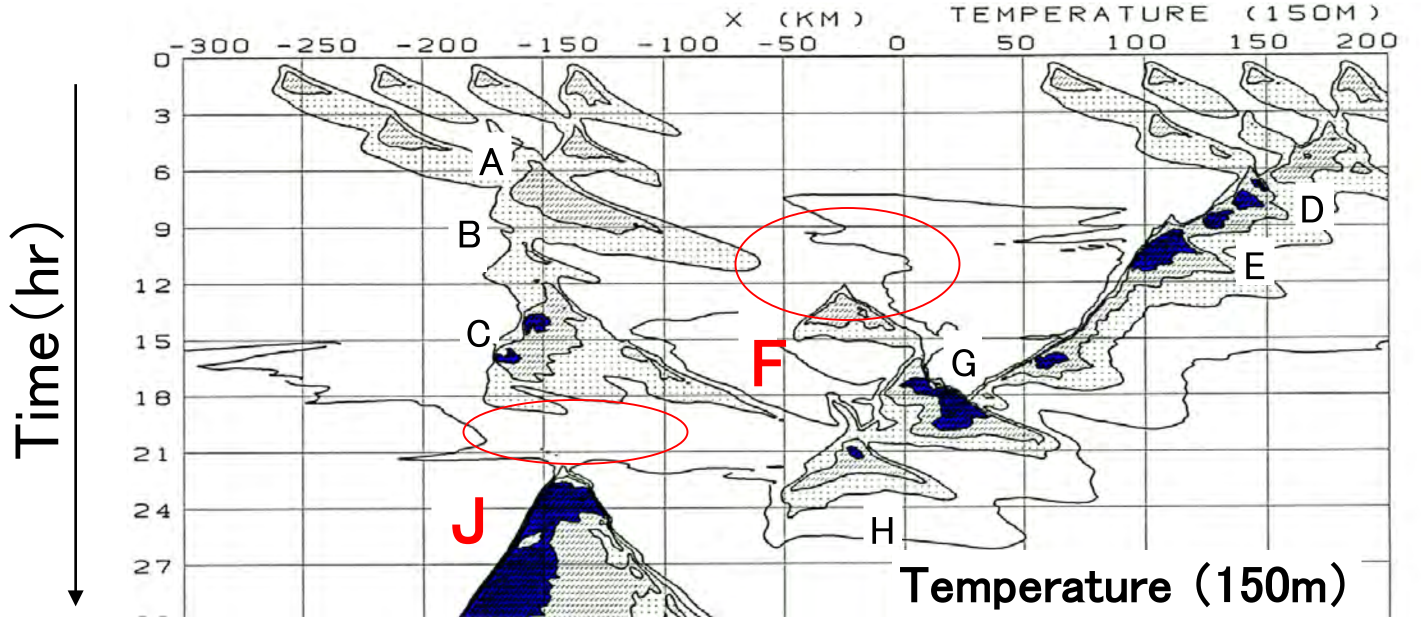


Time sequence of updraft at z=1.2km (After Yamasaki and Seko,1992）.

-Convection J was also generated when the GWs from the convection G arrived, and was developed when GW from the convection H arrived.

-When GWs approached, temperature was decreased and moistened (not shown). Updraft and these changes were caused by GWs and were favorable conditions for the generation of convections.

Temporal variations of temperature at z=150 m



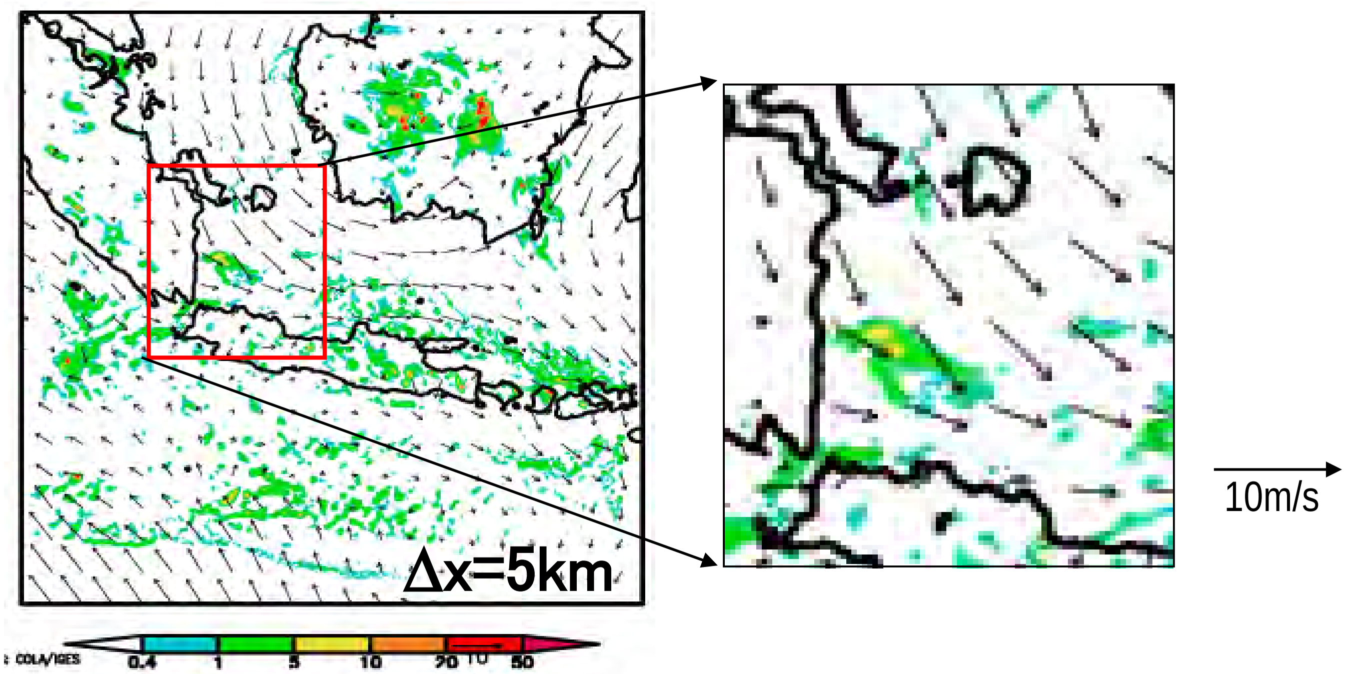
Time sequence of temperature at 150m (After Yamasaki and Seko,1992).

-There were no cold pools where convections F and J were generated. This distribution supports that GWs generate and develop the convections.

3. Generation mechanisms of convections by gravity waves

- Numerical simulations of NHM with the grid interval of 20 km were performed.
- Initial and boundary conditions were produced from JRA25 data.
- Initial time was 12UTC 28 2008.
- Downscale experiments were performed with the grid intervals of 5 kms and 1 km.

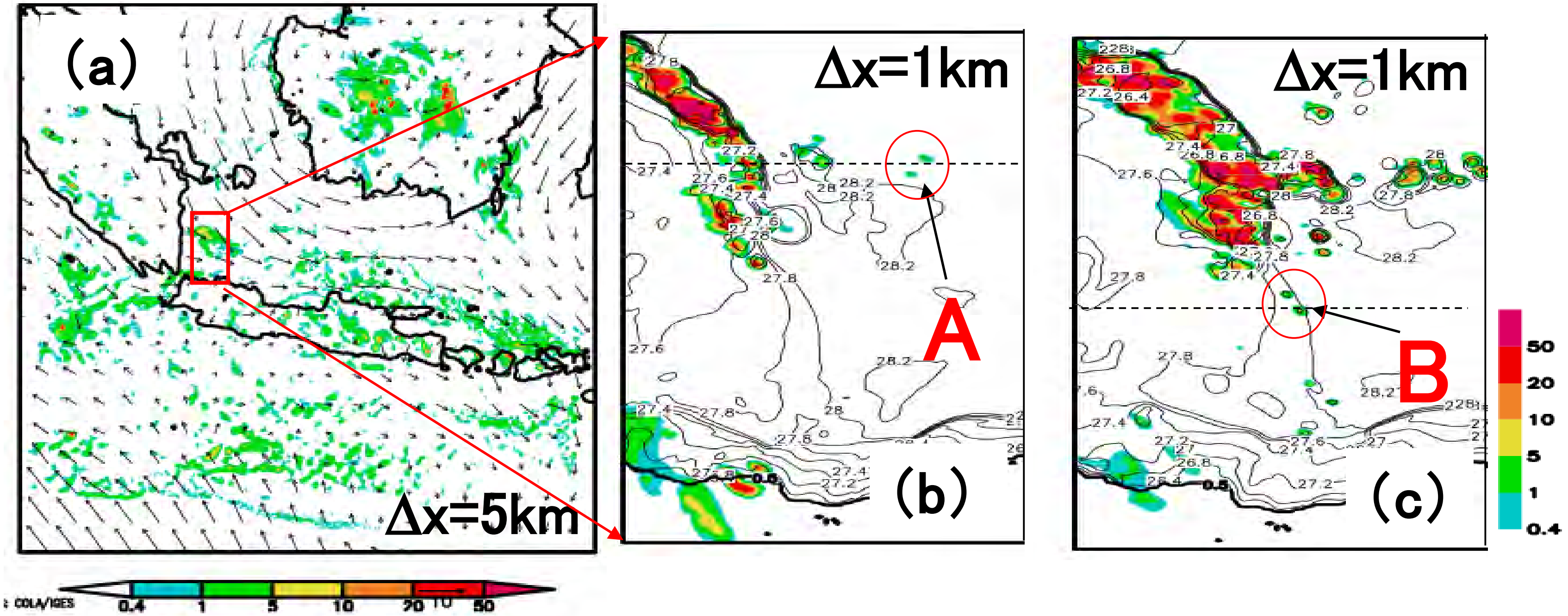
Rainfall distribution reproduced by 5km-NHM



Rainfall region reproduced by 5km-NHM. Initial time is 18UTC 28 Jan..

- A convective band that extended southeastward was generated at the eastern side of Sumatra island.
- Westerly and northwesterly flows were converged near the convective band.

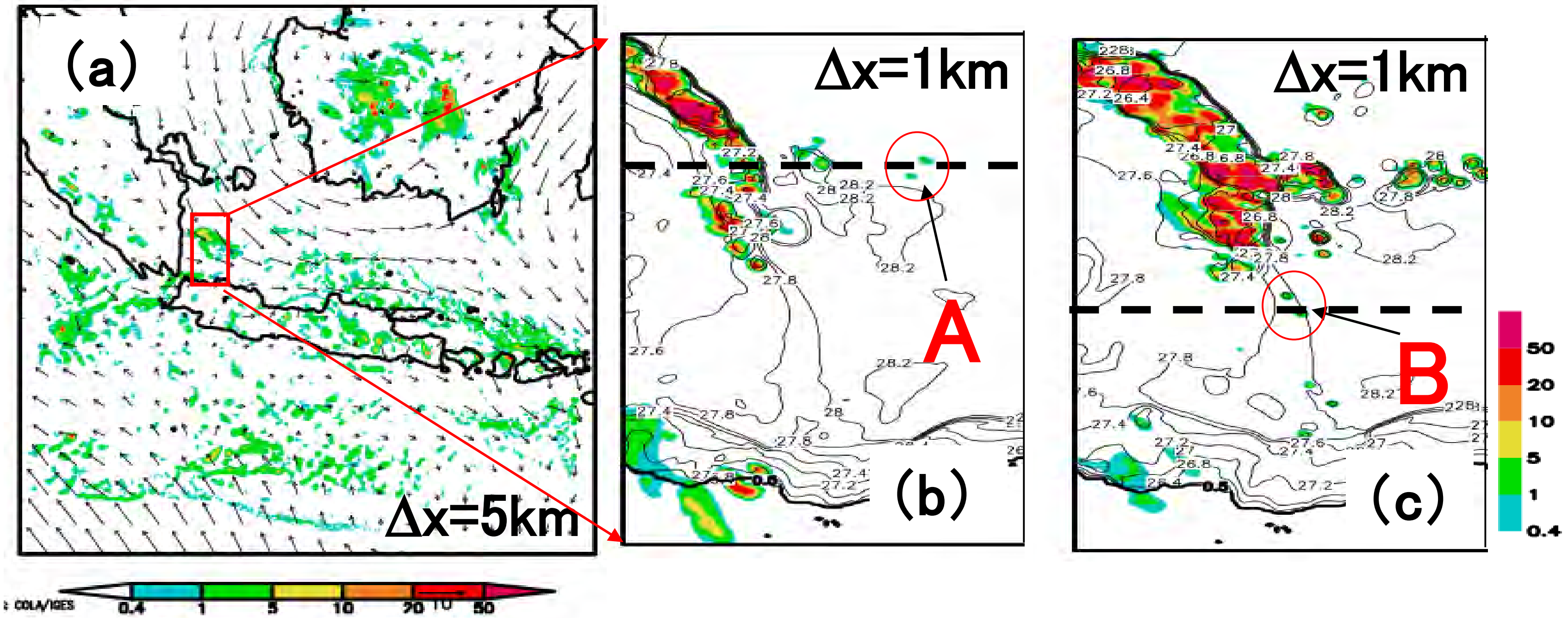
Rainfall and temperature distributions at P=1000hPa, reproduced by 1km-NHM



(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.

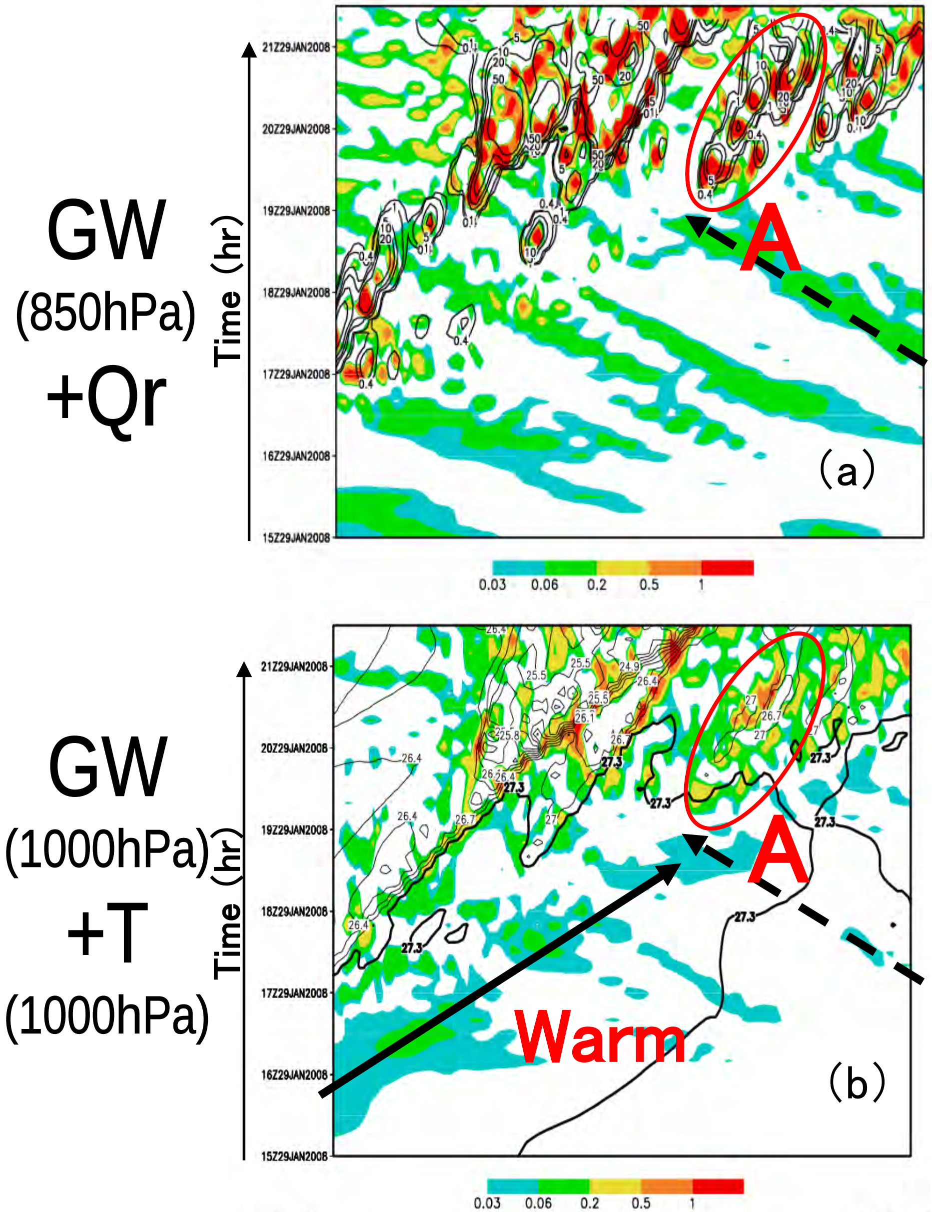
-Convections 'A' were successively generated on the eastern side of the convective band where cold pools did not exist.

Rainfall and temperature distributions at P=1000hPa, reproduced by 1km-NHM



(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.

- Next, time sequences along the broken lines are shown.

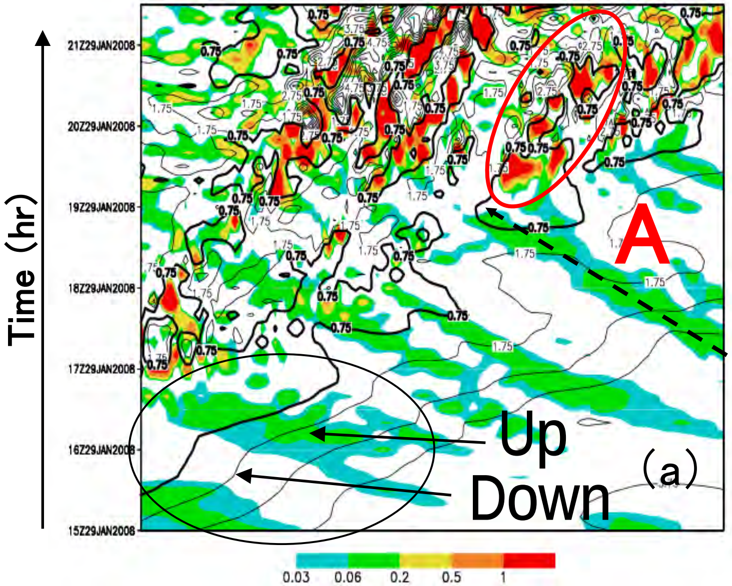


Time variation of updraft (colored region) at P=850hPa along the broken line in Fig. 2b, (a) rainfall and (b) temperature at P=1000hPa.

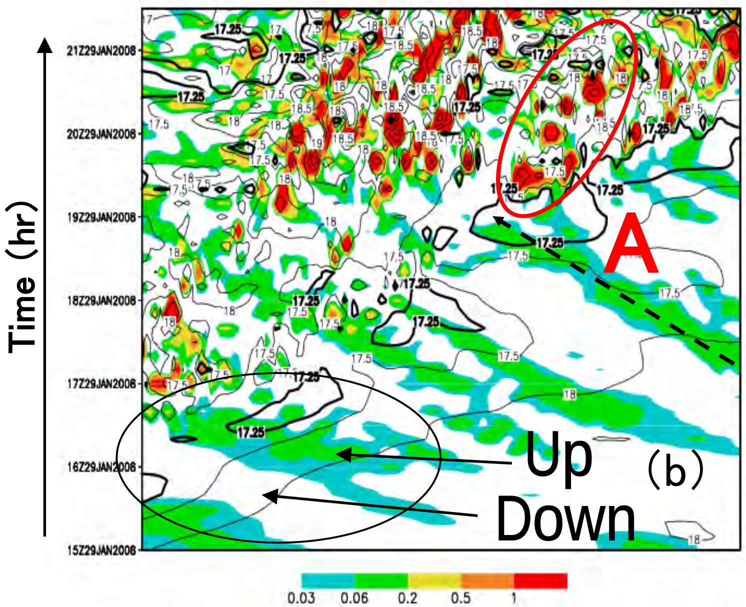
Time sequences of updraft and temperature at P= 1000hPa and 850hPa along the line that crosses the convections ‘A’.

- At 1000hPa, updraft produced by the convergence of westerly and northwesterly flows (solid arrow) was seen on the eastern side of the convections.
- These is no cold pools before the generation of convections ‘A’.
- Convections ‘A’ were generated when the updraft at 850hPa (broken arrow) was propagated from the east.

GW
(850hPa)
+T-Td
(dew-point deficit)
(850hPa)



GW
(850hPa)
+T
(850hPa)



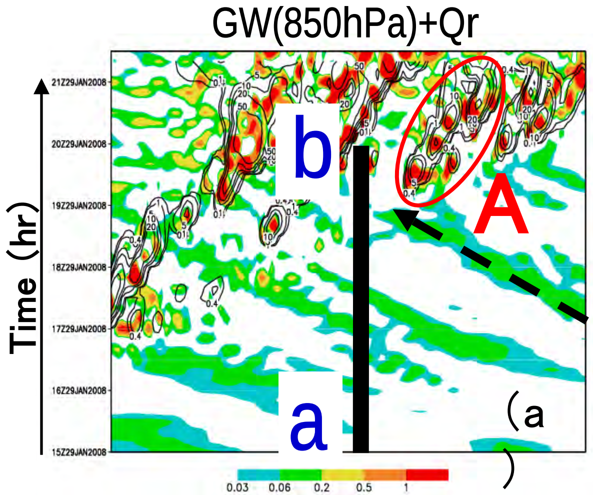
Time variation of updraft (colored region) at P=850hPa along the broken line in Fig. 2b, (a) dew-point deficit at P=850 hPa and (b) temperature at P=850hPa..

Time sequence of updraft and temperature and dew-point deficit (T-Td) at 850 hPa along the line, which crosses the convections ‘A’.

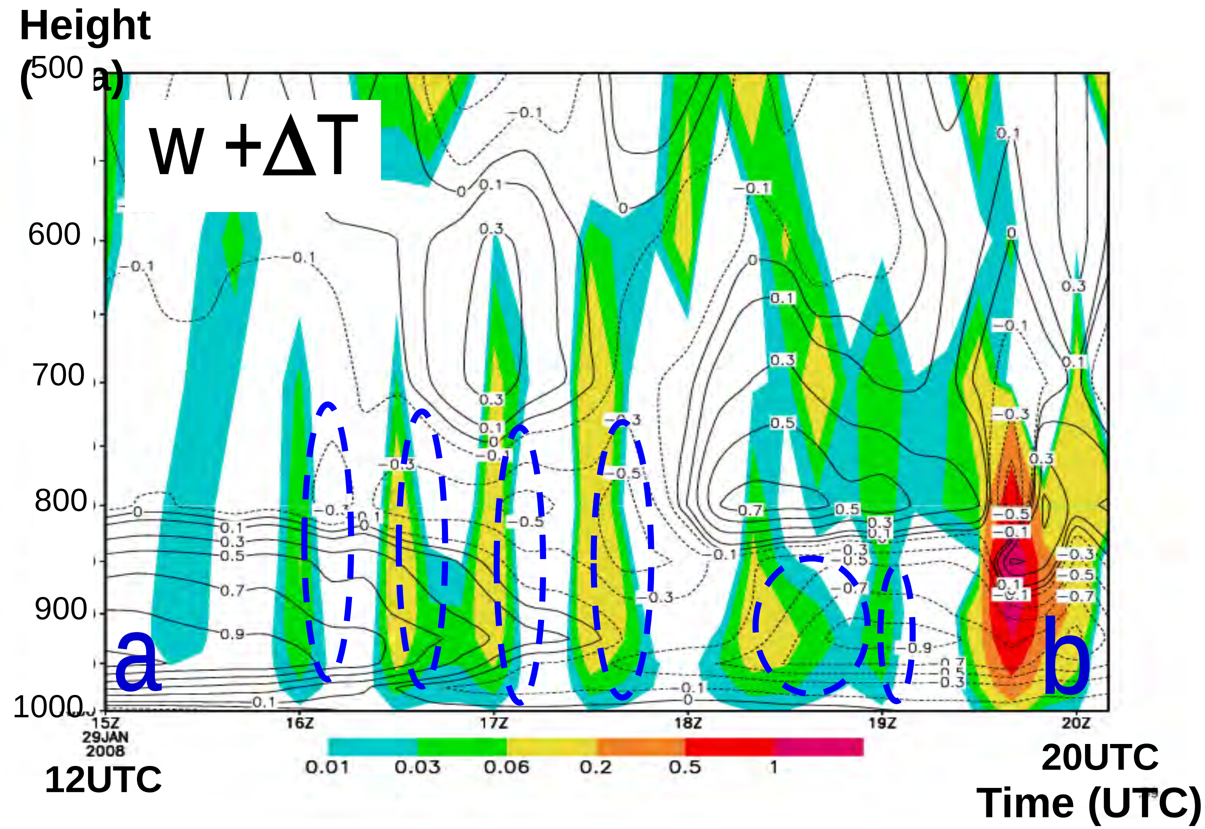
- Temperature was gradually decreased as time passed.
- Temperature was fluctuated when the updrafts were propagated from the east.

- The relation of temperature and updraft is checked by showing the vertical cross section.

Deviations of temperature and vertical velocity from the horizontal average



Time variation of updraft

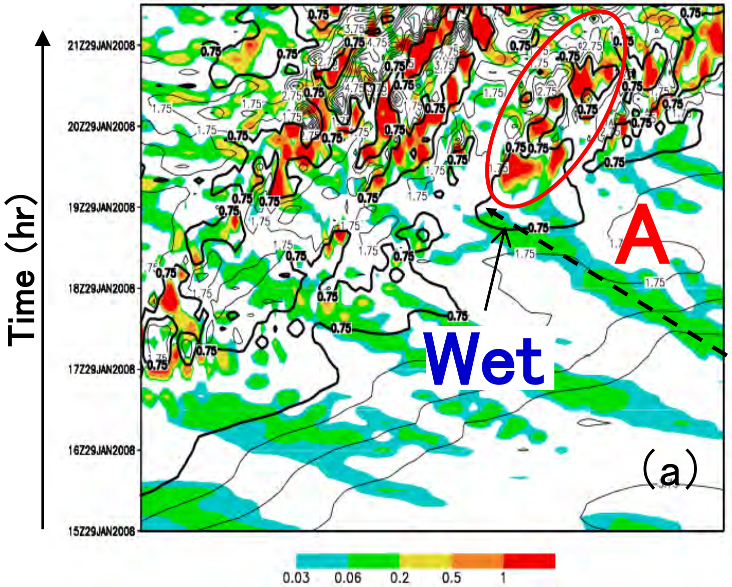


-Temperature was gradually decreased as time passed.

-Temperature was largely decreased after the passage of updraft.

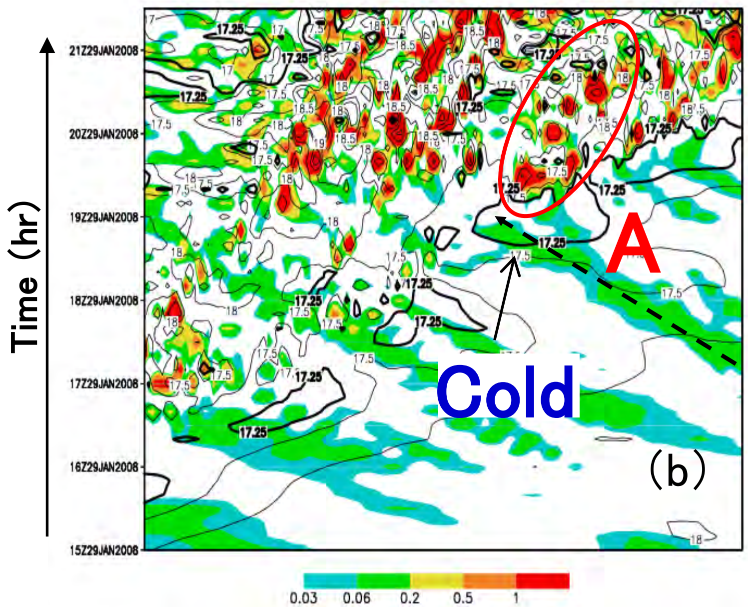
-This phase relation indicates that these deviations were produced by GWs.

GW (850hPa) +T-Td (dew-point deficit) (850hPa)



Time sequences of updraft, temperature and dew-point deficit (T-Td) at 850 hPa along the broken line, which crossed the convections 'A'.

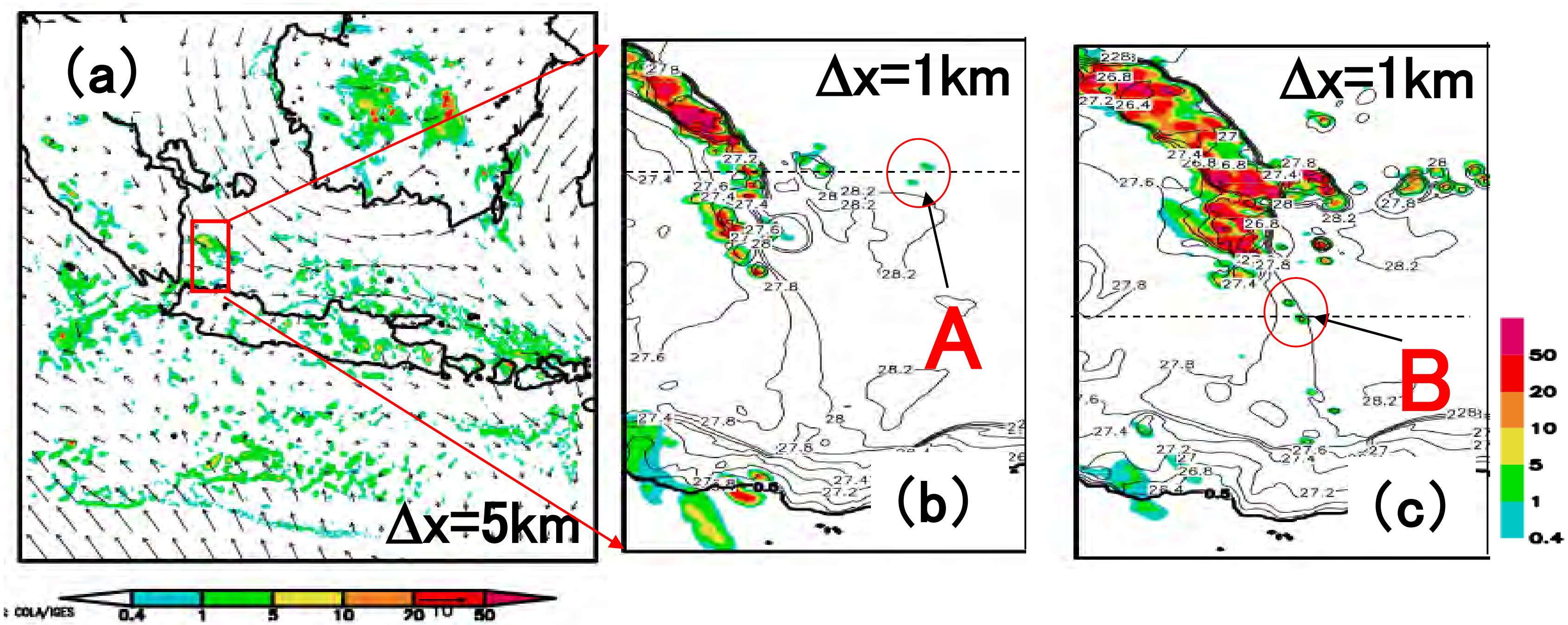
GW (850hPa) +T (850hPa)



Time variation of updraft (colored region) at P=850hPa along the broken line in Fig. 2b, (a) dew-point deficit at P=850 hPa and (b) temperature at P=850hPa..

- When the GW was propagated, temperature was decreased and the dew-point deficit became smaller.
- These changes are common to ones that explained with results of the 2-dimensional model.

Rainfall and temperature distributions at P=1000hPa, reproduced by 1km-NHM



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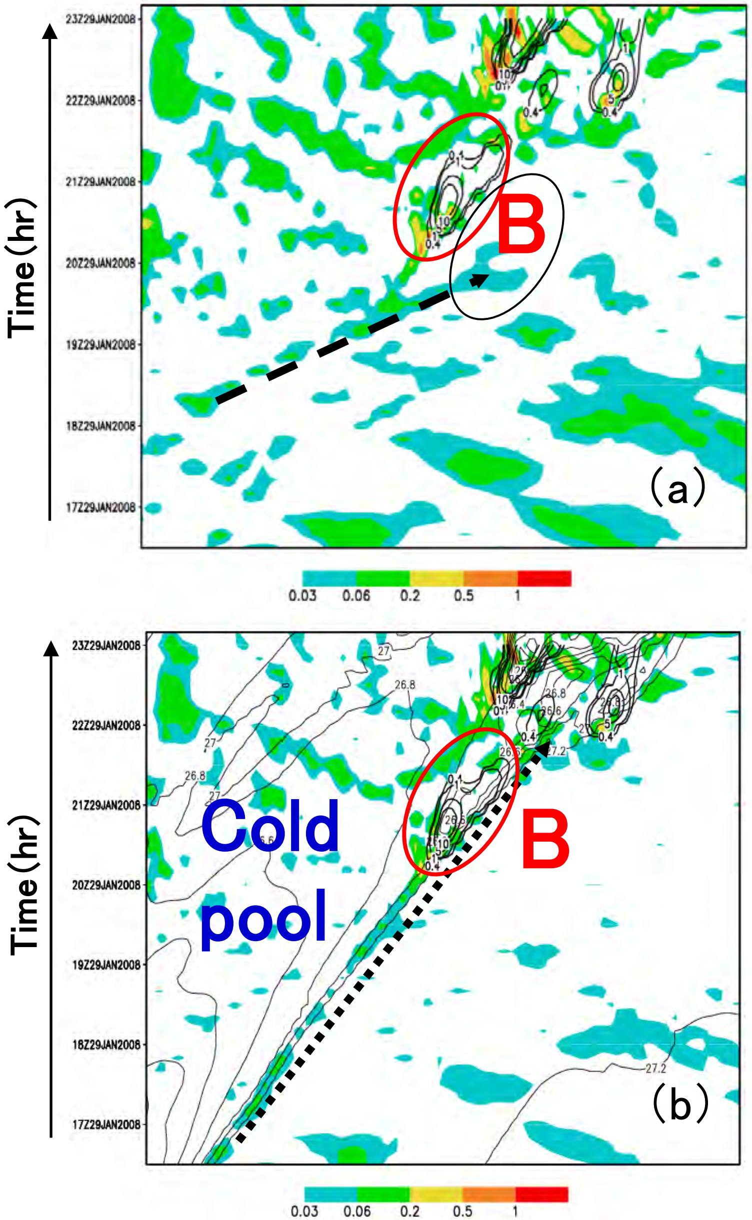
-Convections 'B' were generated on the large gradient zone of temperature.

GW
(950hPa)
+Qr

GW
(975hPa)
+T
(1000hPa)

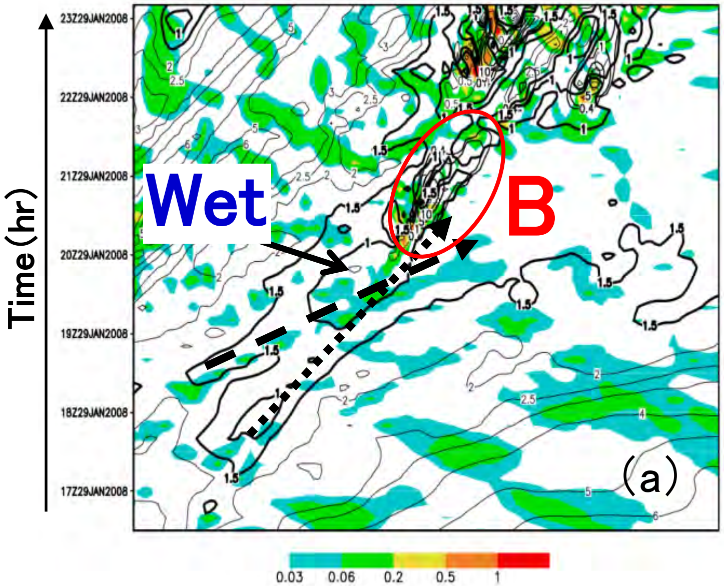


Time variation of updraft (colored region) at (a) P=950 hPa and (b) 975hPa along the line, (a) rainfall and (b) temperature at P=1000hPa.

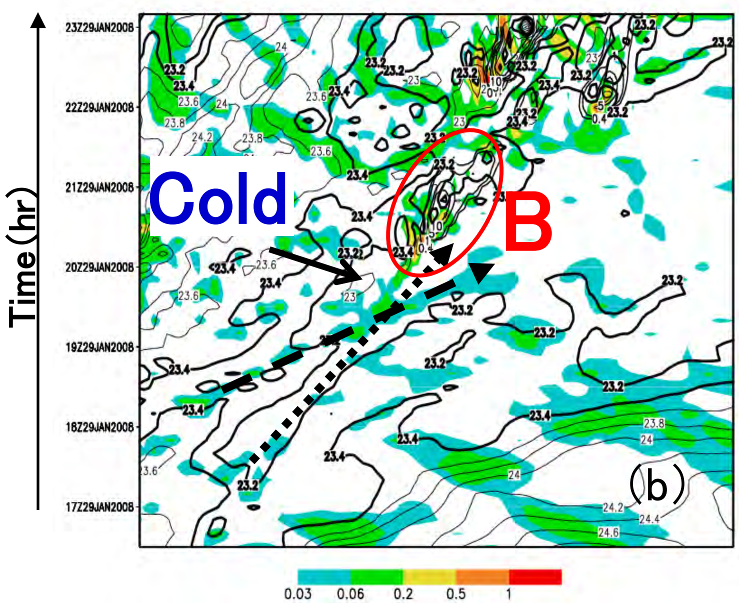
Time sequences of updraft and temperature at P=1000 hPa and 950hPa along the broken line, which crossed the convections 'B'.

- Convection 'B' was generated along the edge of the cold pool.
- Low-level updraft was produced by the outflow of the cold pool.
- When the GW from the western side overlapped the edge of cold pool, the convention 'B' was generated.

GW
(950hPa)
+T-Td
(dew-point deficit)
(950hPa)



GW
(950hPa)
+T
(950hPa)



Time variation of updraft (colored region) at P=950 hPa along the broken line, (a) dew-point deficit and (b) temperature at P=950hPa..

Time sequences of updraft and temperature at P=1000 hPa and 950hPa along the broken line, which crossed the convections ‘B’.

- When GW was propagated, temperature was decreased and dew-point deficit became smaller.
- These variations of temperature and dew-point deficit were common with those of the convections ‘A’.

4. Summary

-Updraft of GWs makes the atmosphere cool and moist. Updraft and these changes generated the convections in this study.

-The generation point and timing of the convection was influenced by GW. When the cold pool was weak, GW influenced the generation point and timing of convection.

Thank you for your attention.