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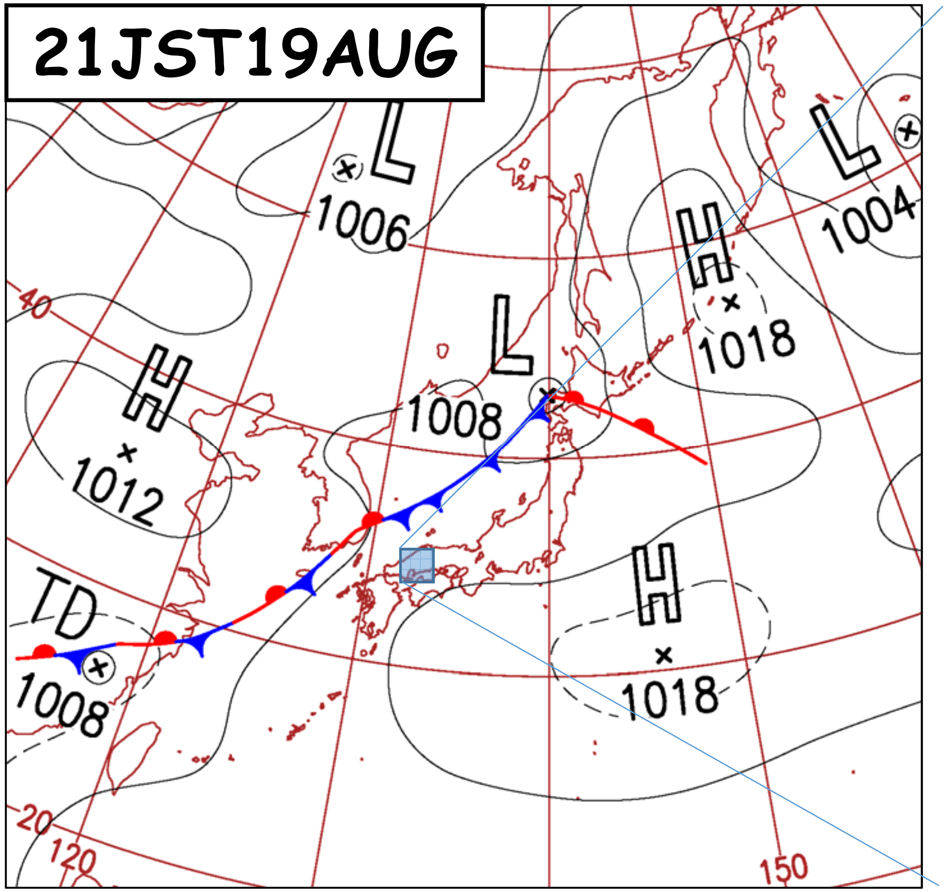
Influence of horizontal resolution on structure changes of atmospheric stratification in the 201~~5~~4 Hiroshima heavy rainfall

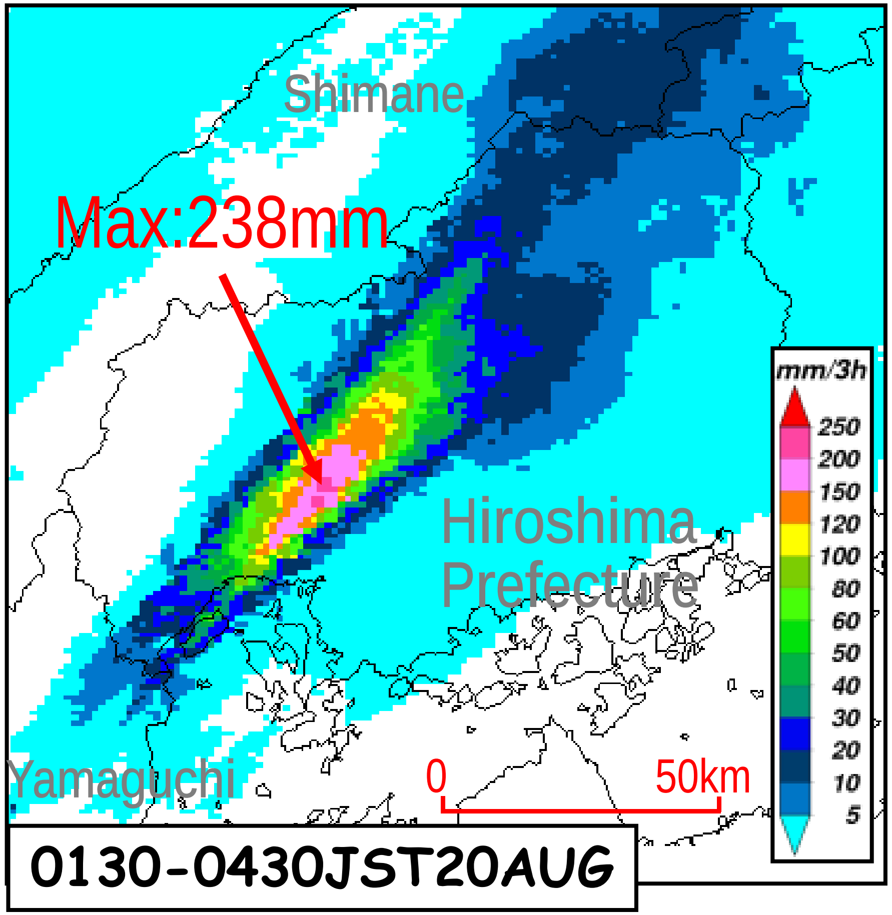
Teruyuki KATO
(Meteorological Research Institute, JMA,Japan)

Weather condition and Rainfall distribution

Surface weather map



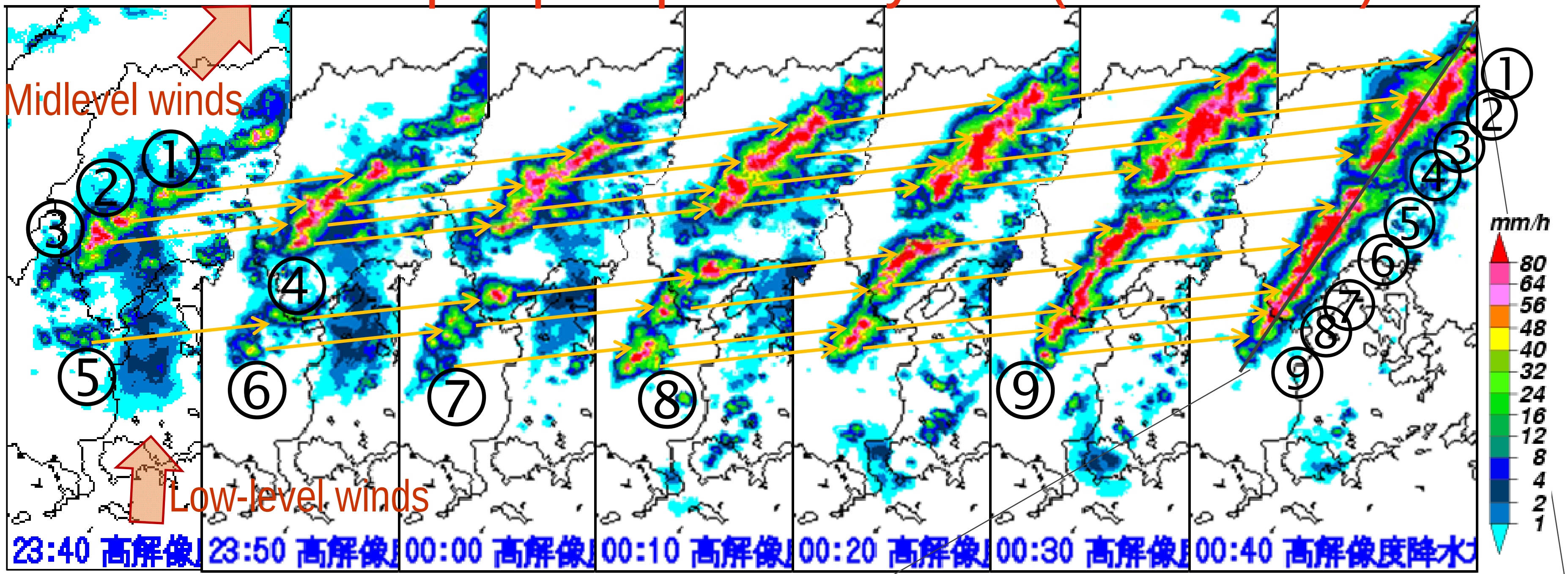
3-h precipitation amounts

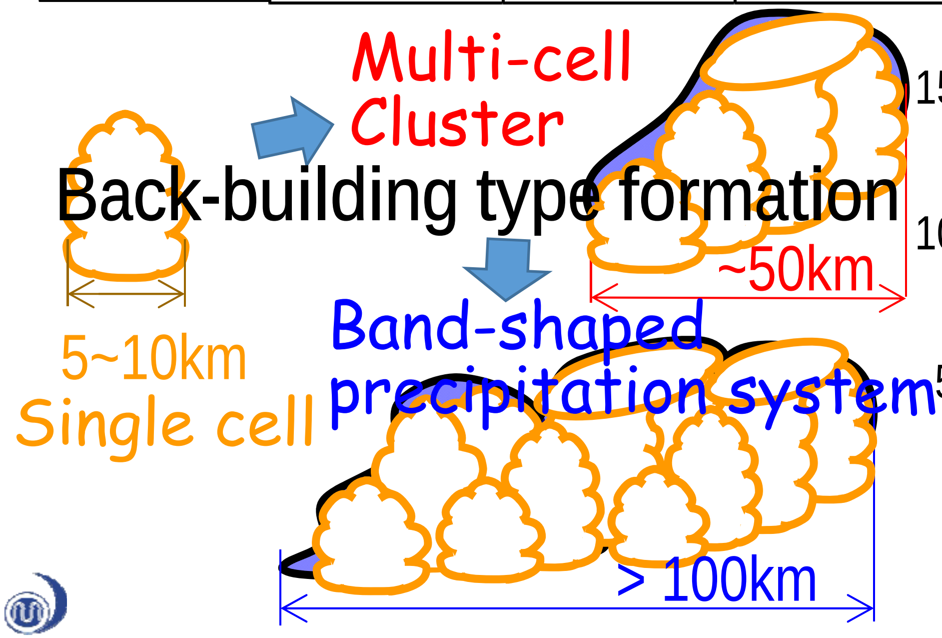


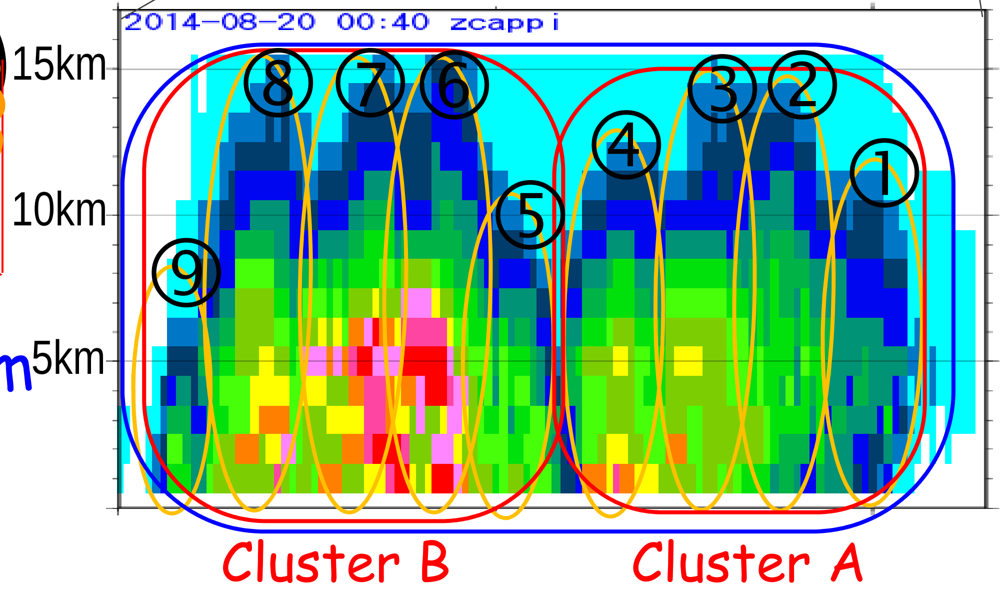
Heavy rainfall occurred ~300km south of stationary front.

Similar to heavy rainfall events observed in the rainy season of Japan.

Formation processes and structure of band-shaped precipitation system (cluster A&B)







Numerical model and experimental design

Model : JMANHM (Saito et al. 2006)

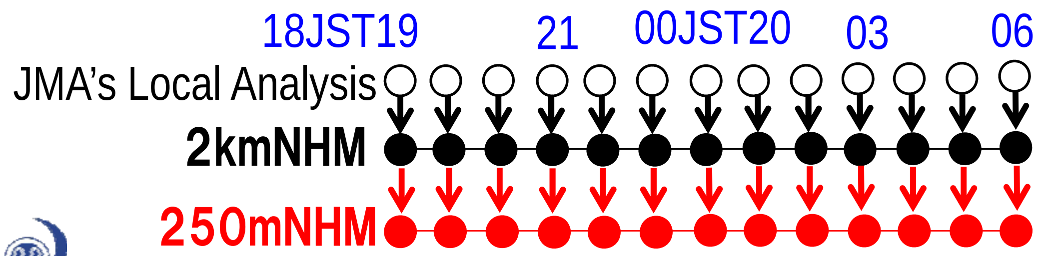
Dynamics:	Fully compressible equations with a map factor
Cloud physics:	Bulk-type with six water species (qv, qc, qr, qi, qs, qg)
Convection:	none
Turbulence:	MYNN scheme (Nakanishi and Niino 2006)
Surface flux:	Beljaars and Holtslag (1991)
Horizontal grid:	2km, 1km, 500m, 250 m

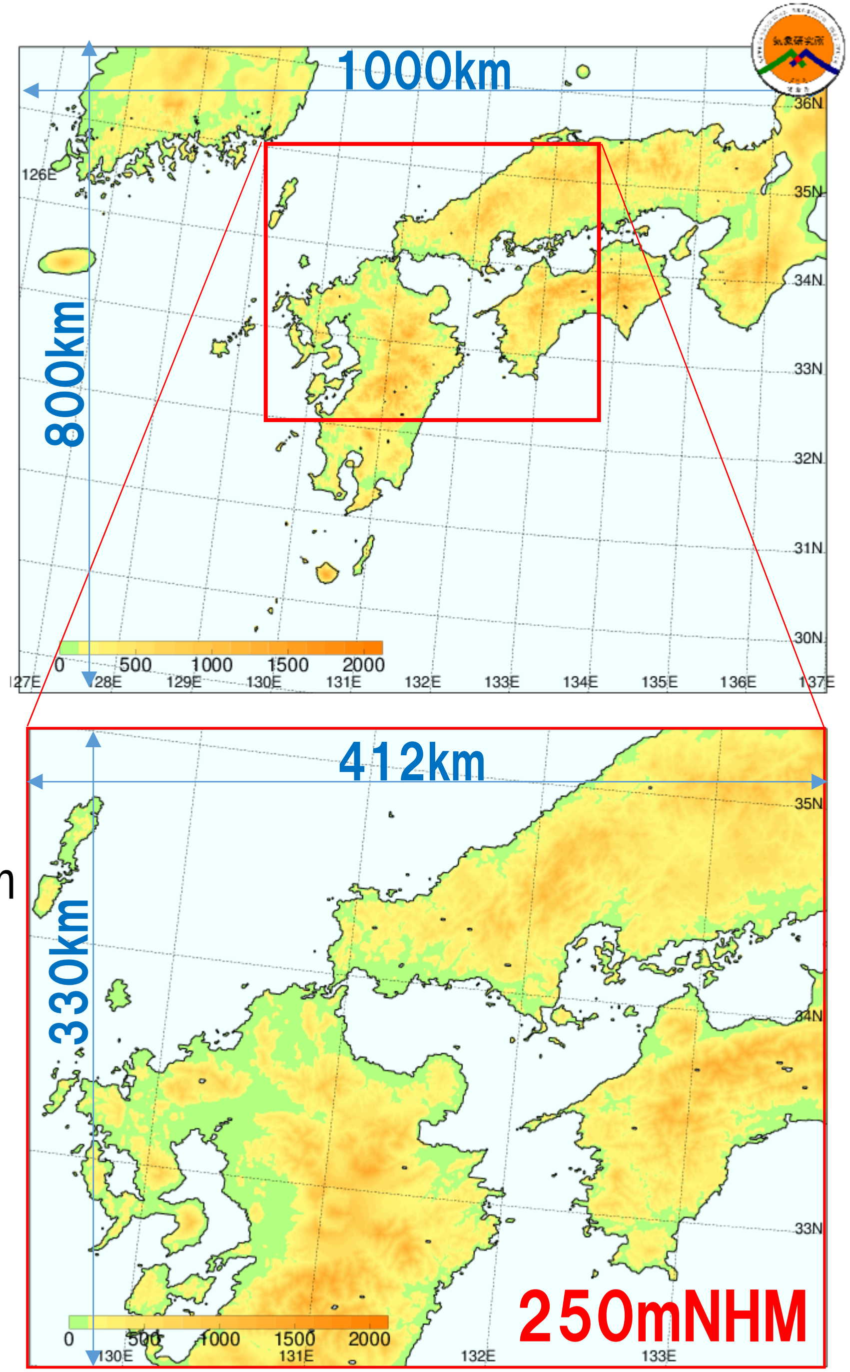
Initial/boundary data: Hourly JMA-Local analysis adopting a 3DVAR assimilation system, but for 250m

Numerical diffusion: 20min(linear), 10min(2D)

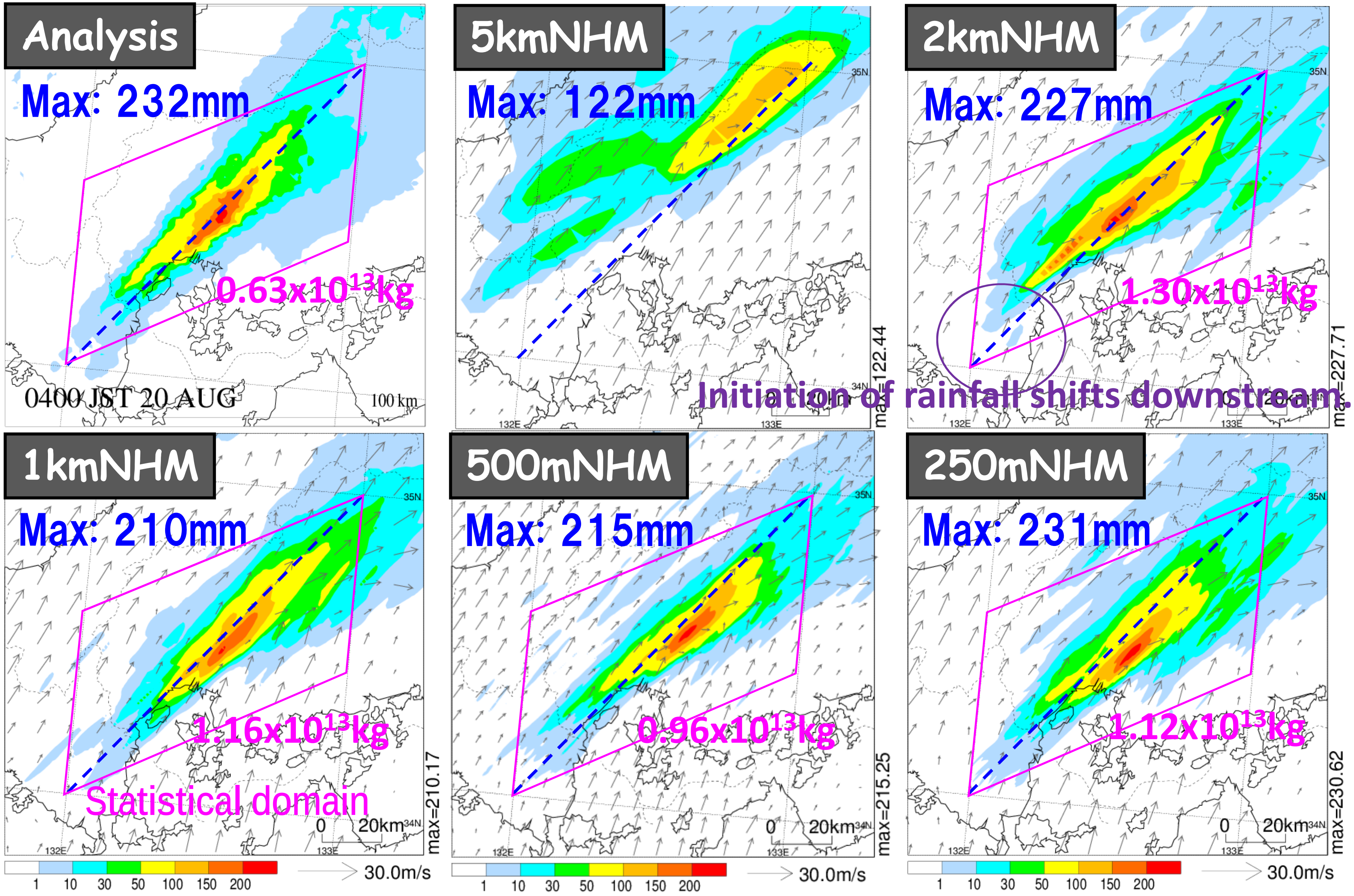
Water vapor diffusion for grids with w > 10 m/s

Design of 250mNHM run



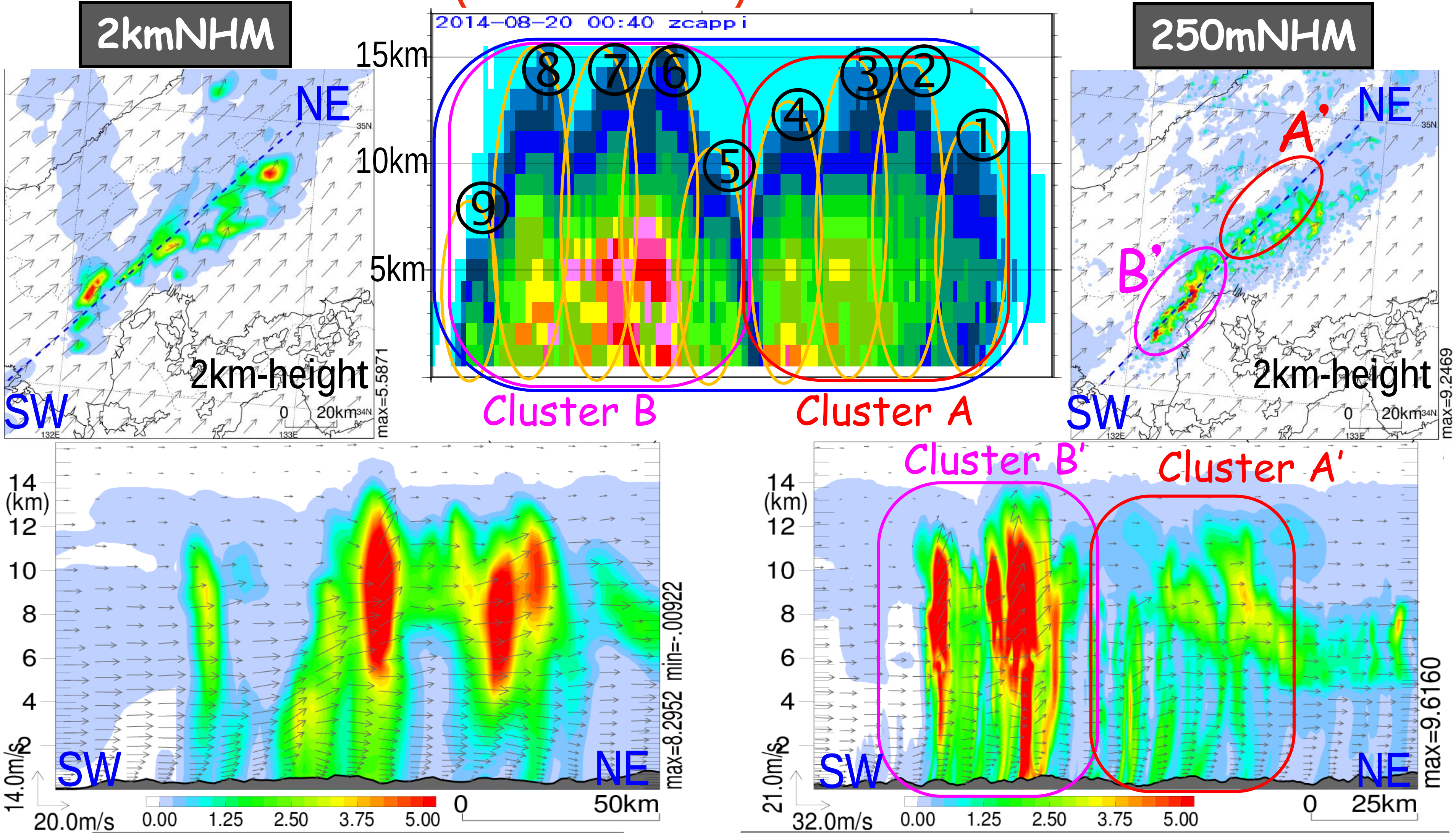


Results of 18JST19initial(3-houly accumulated rainfall at 04JST20)



In this case, resolution of two kilometer can reproduce a rainband.

Reproductivity of band-shaped precipitation system (cluster A&B) in 2kmNHM and 250mNHM

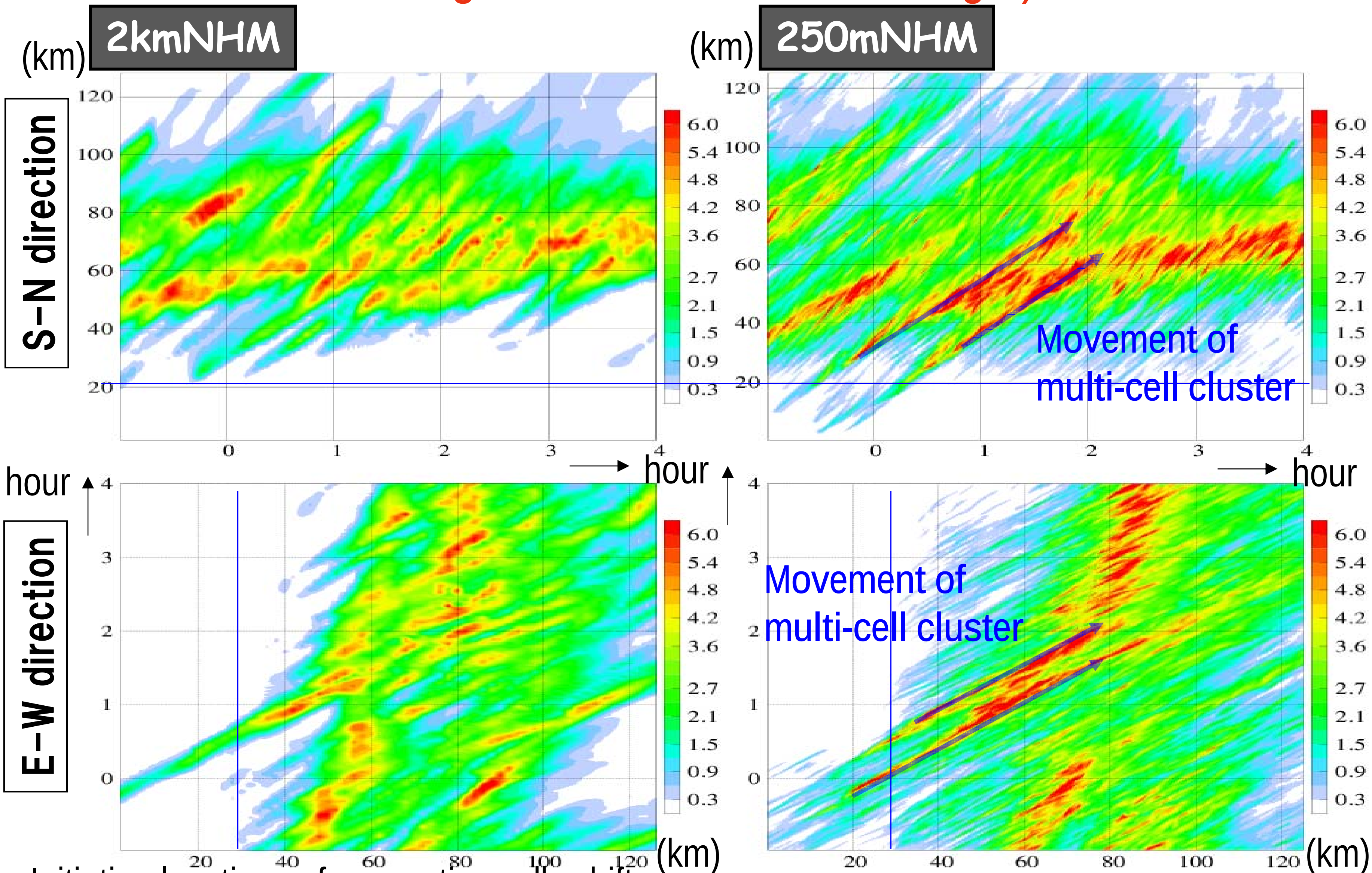


Cell's size is overestimated.

Cluster's structure is well reproduced.

250m resolution is necessary to reproduce the structure of multi-cell clusters.

Reproductibity of movement of convective cells
(Mixing ratio of rain at a 466m height)

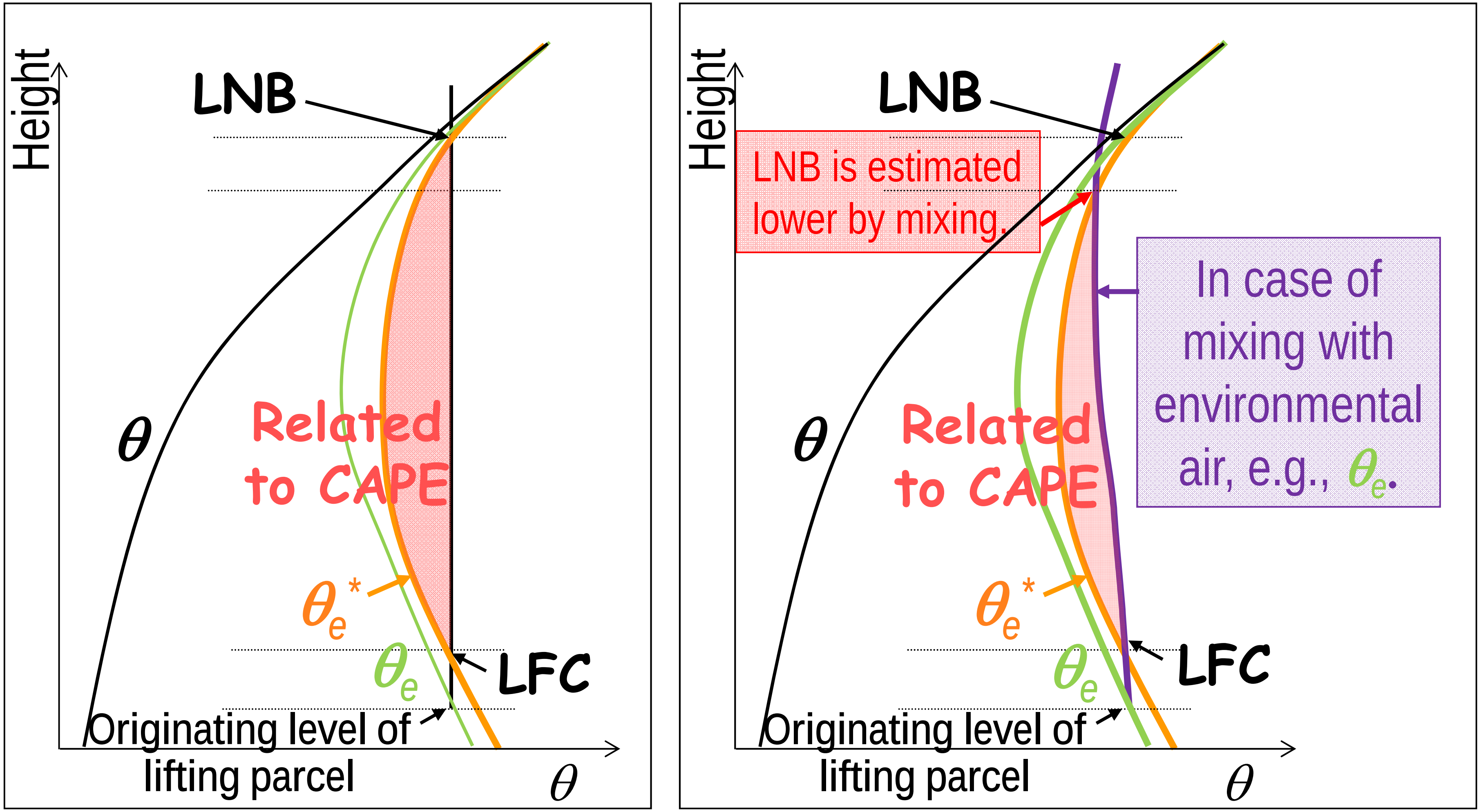


Initiation locations of convective cells shift on the downstream side, compared with 250mNHM.

Movements of multi-cell cluster are clear.

Atmospheric stabilization by moist convection

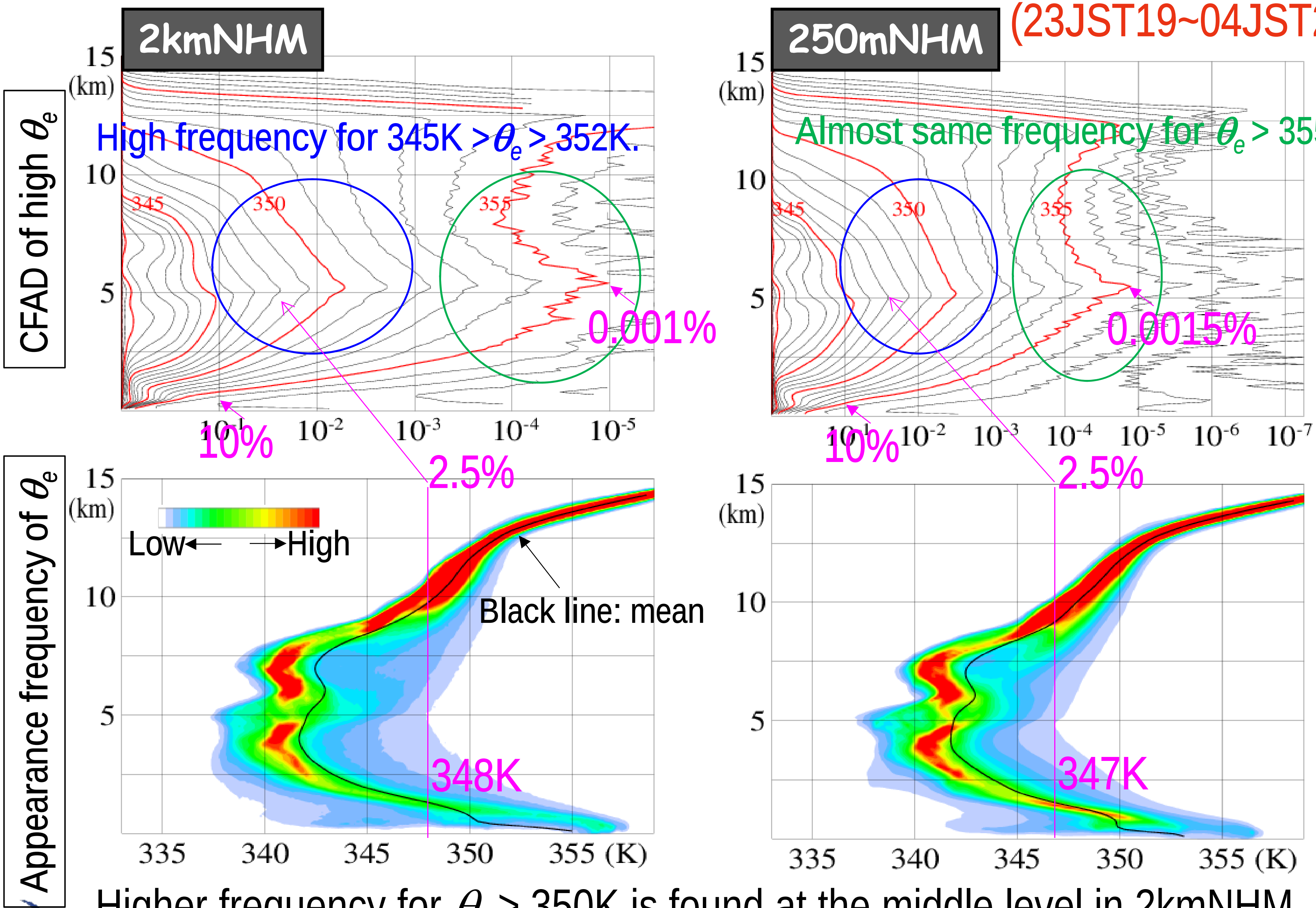
Middle-level θ_e becomes close to low-level values.



In Kain-Fritsch scheme, atmospheric instability is relaxed to reduce CAPE to 15% of original state.

Appearance frequency of atmospheric structure (θ_e profiles)

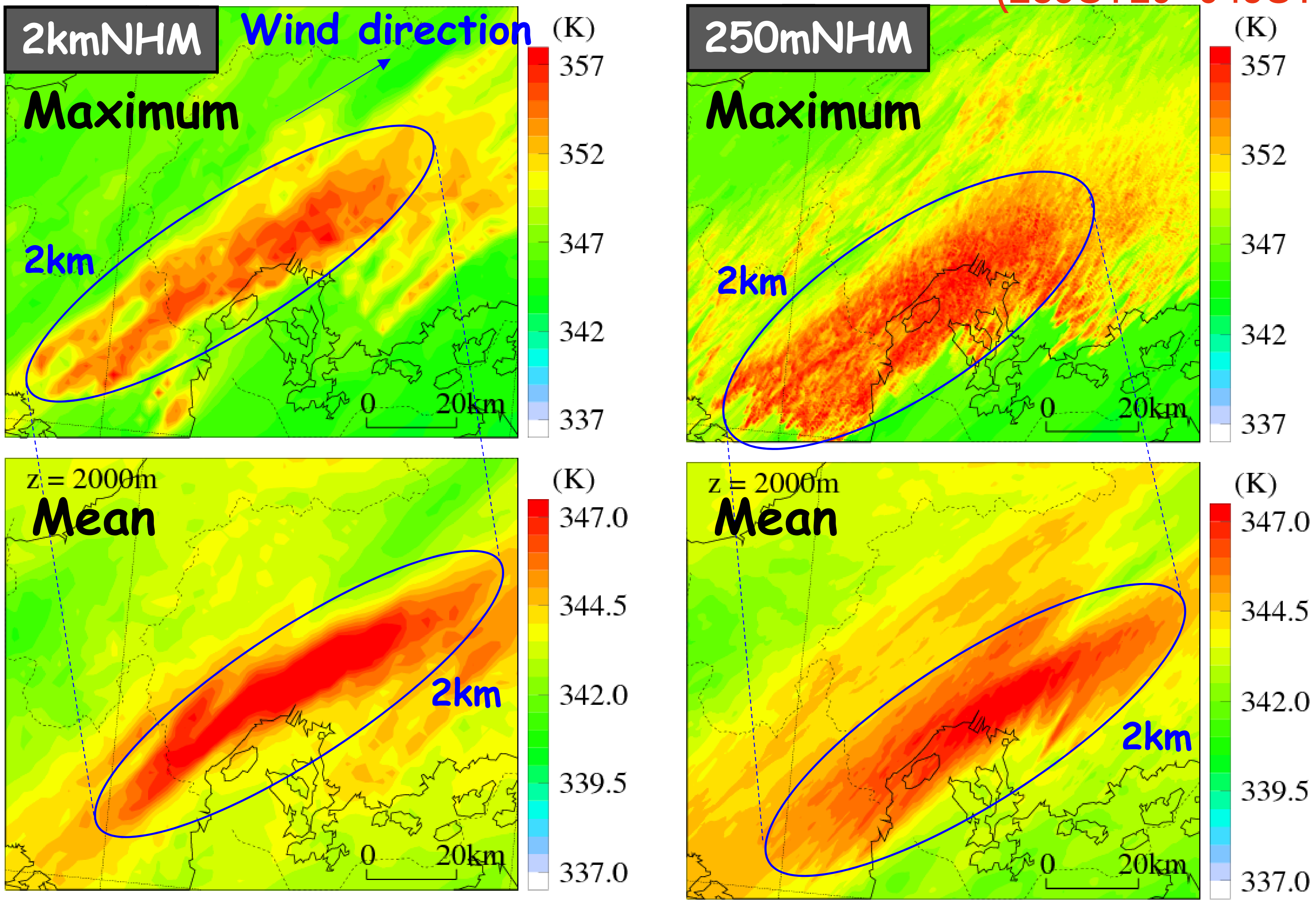
(23JST19~04JST20)



Higher frequency for θ_e > 350K is found at the middle level in 2kmNHM.

Maximum/mean θ_e distribution at 2km height

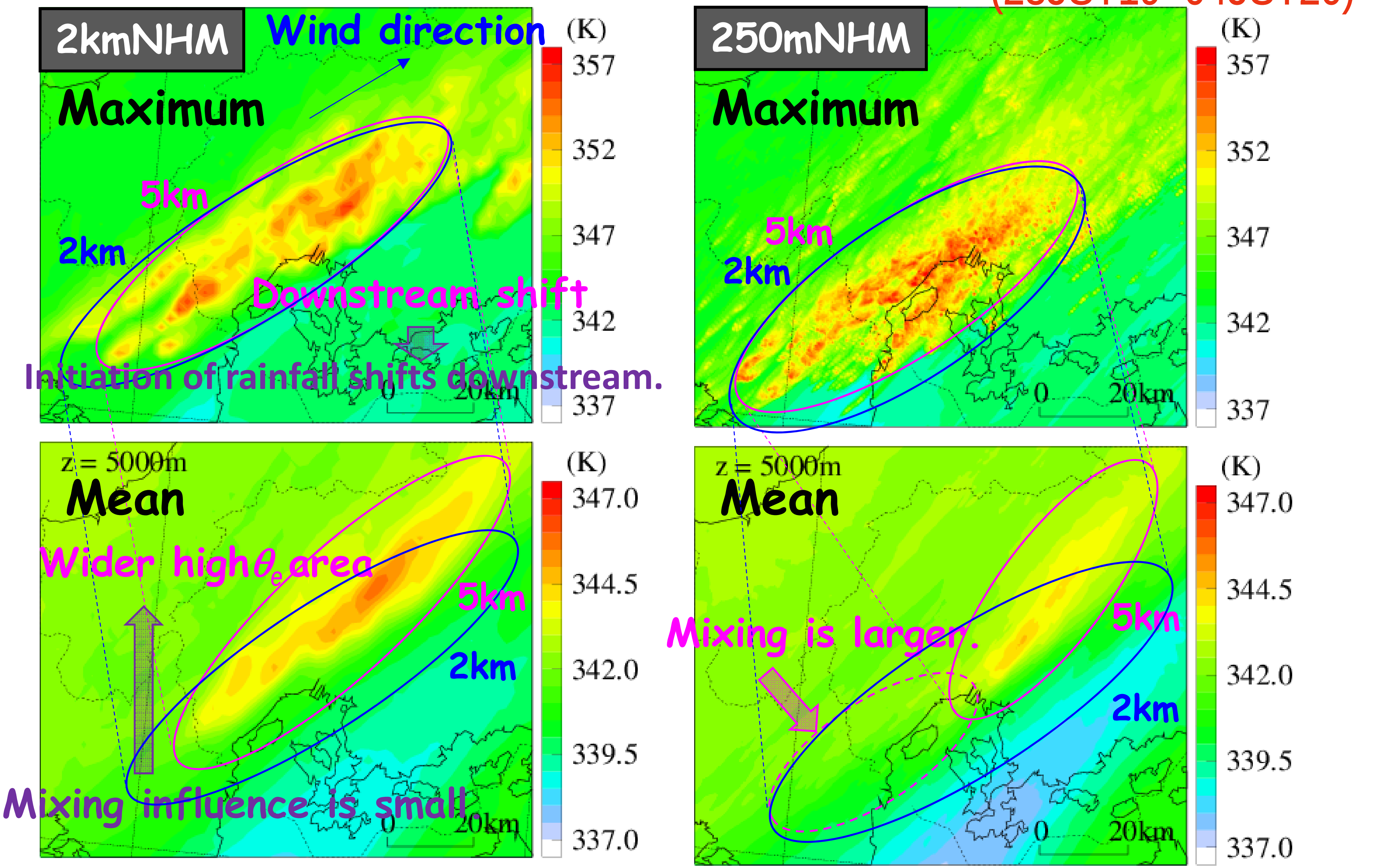
(23JST19~04JST20)



Little differences between 2kmNHM and 5kmNHM.

Maximum/mean θ_e distribution at 5km height

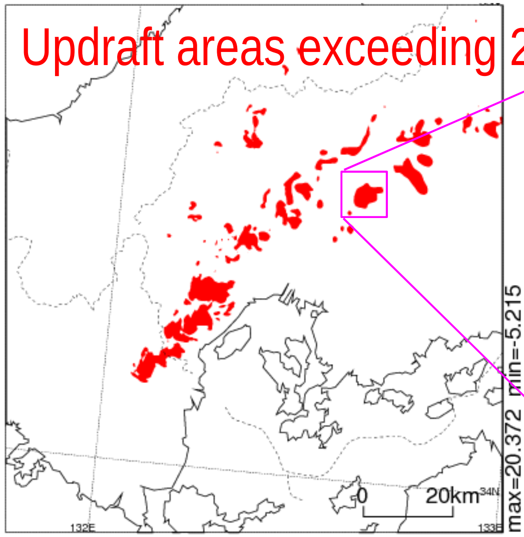
(23JST19~04JST20)

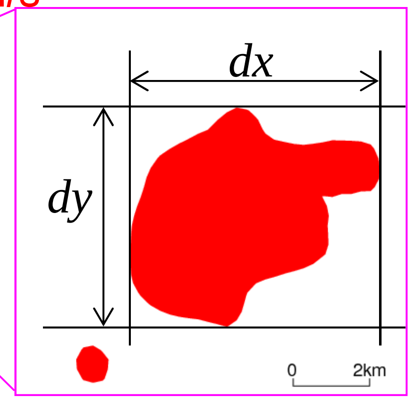


Wider high θ_e area is found in 2kmNHM even at 5km, but vanishes in 250mNHM.

Updraft core size in moist convection

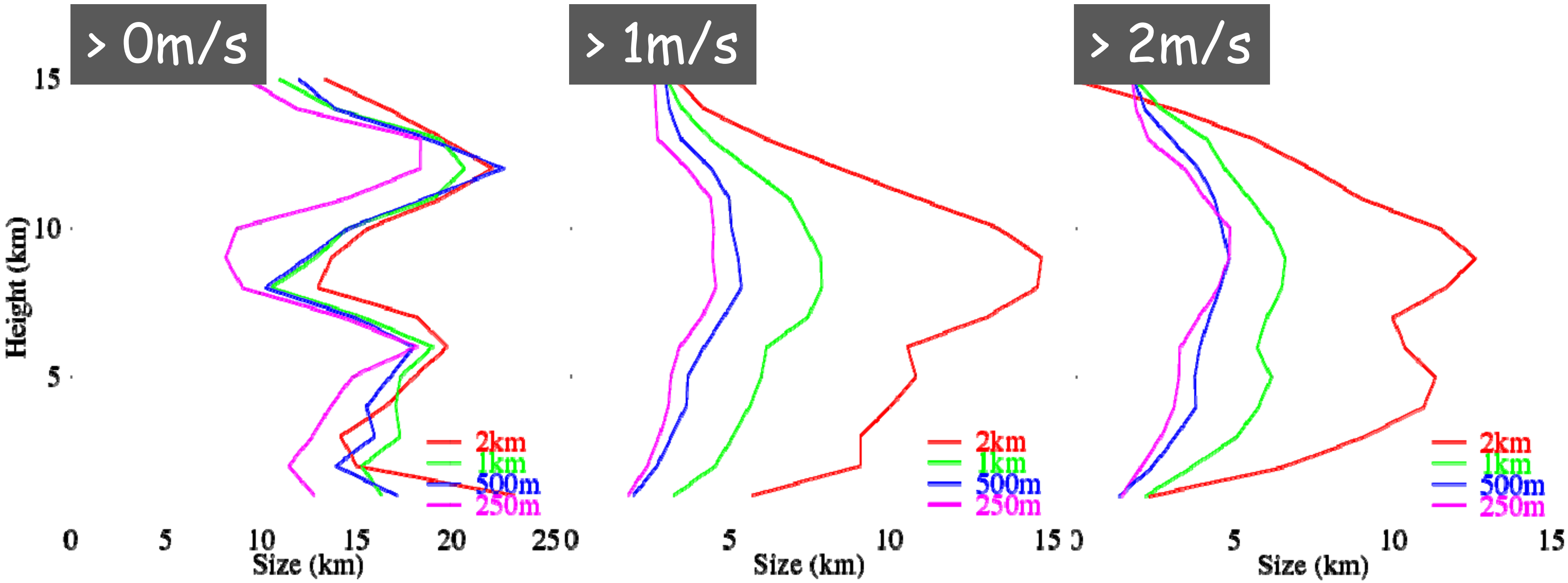
- Almost the same size for resolution ≤ 500m
- Core size becomes bigger with height below 10 km.



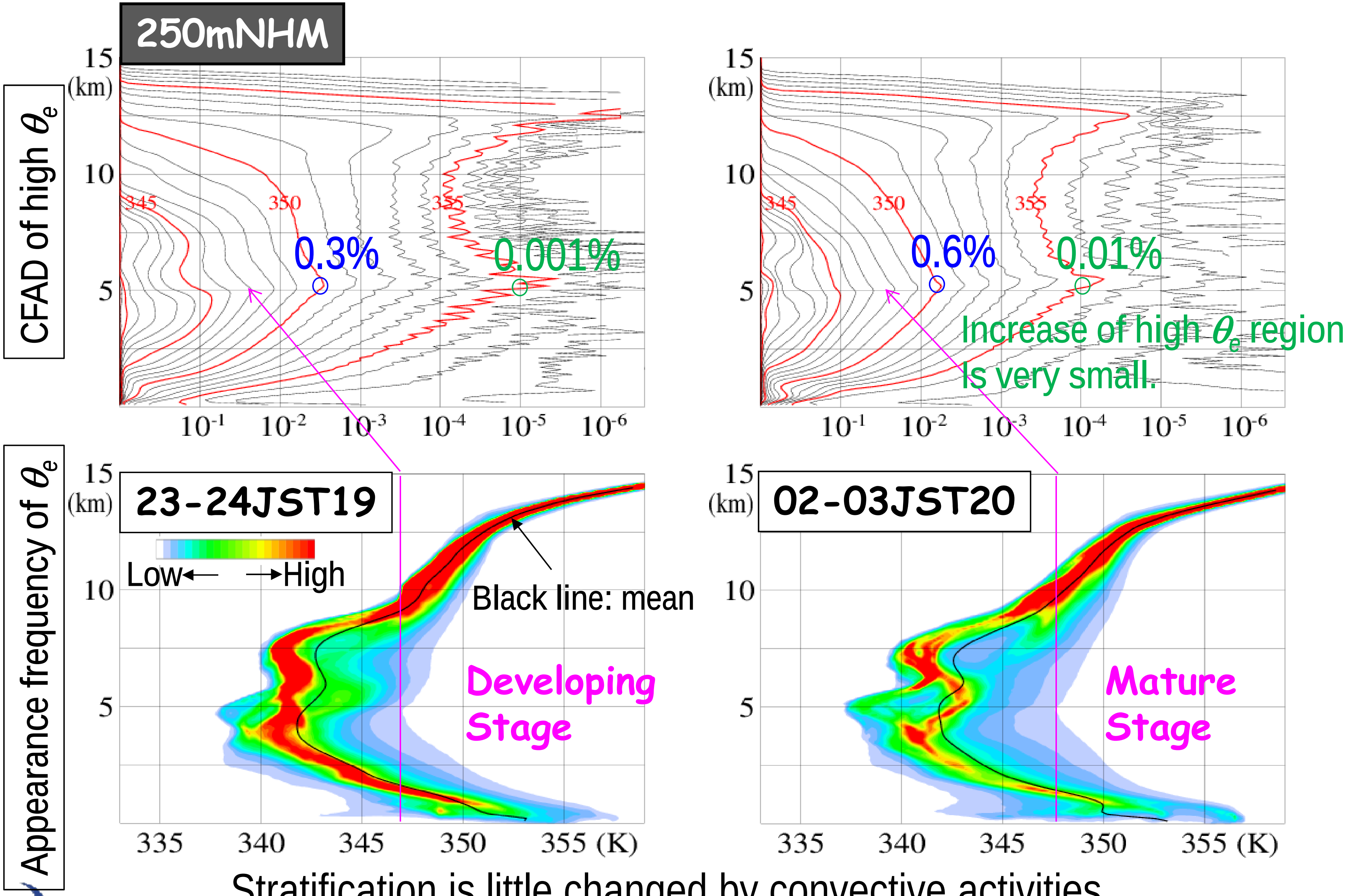


Core size is defined as $\sqrt{dx \times dy}$.

Mean size of updraft cores , estimated using every 1-min output for 4 hours.



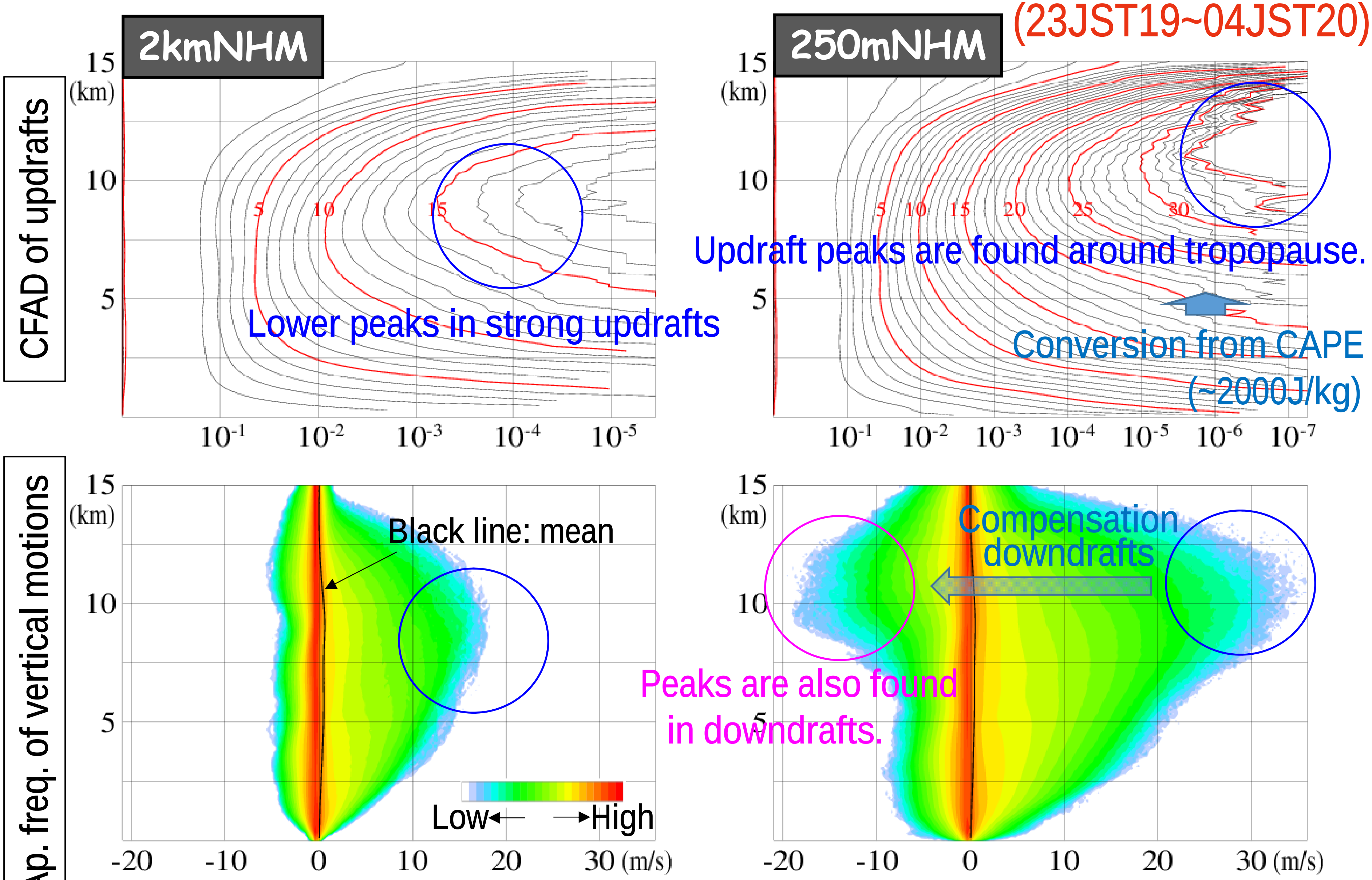
Time change of atmospheric structure (θ_e profiles)



Stratification is little changed by convective activities.

Appearance frequency of vertical/strong upward motions

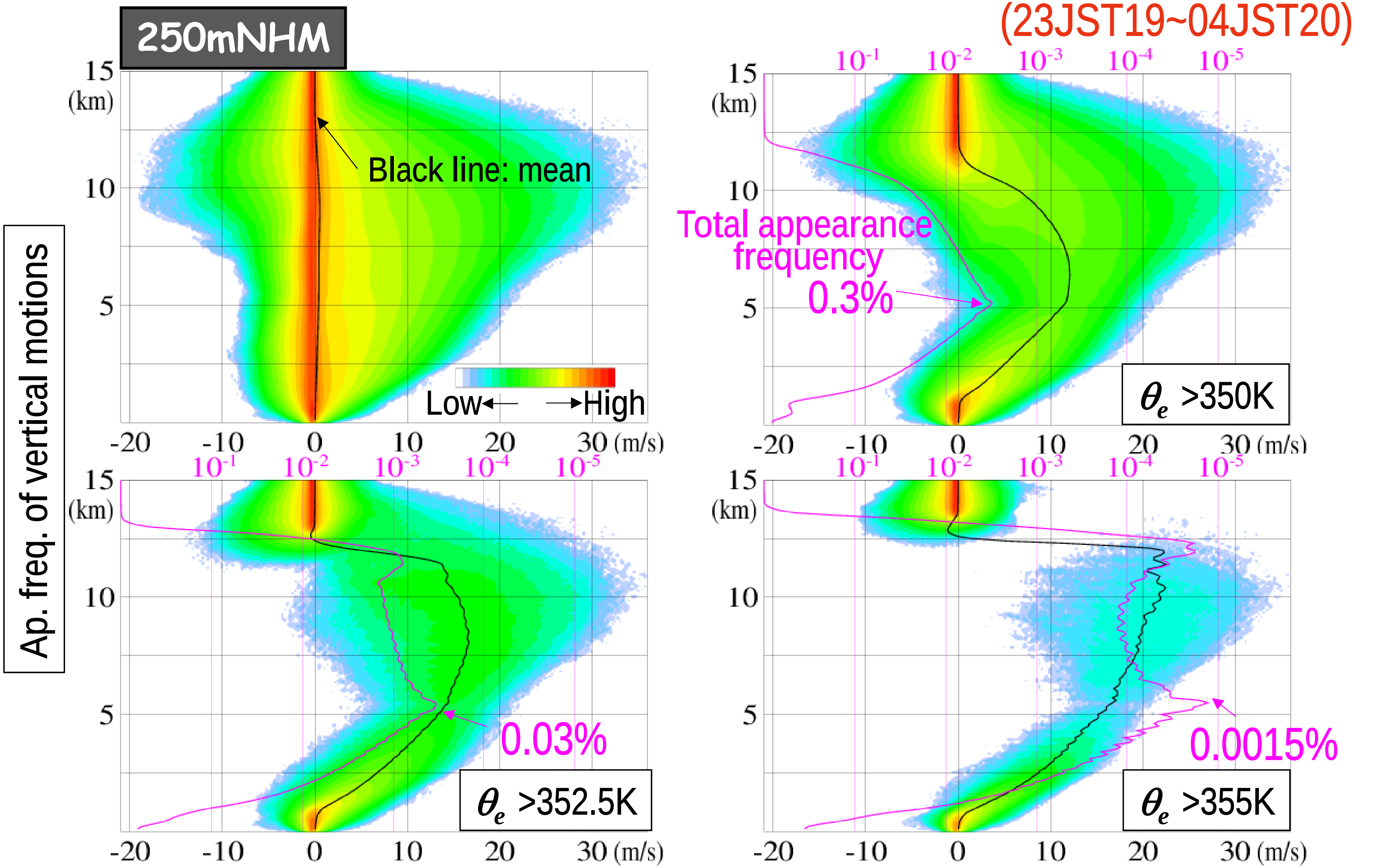
(23JST19~04JST20)



Differences are found in peak heights of upward motions, as well as intensity.

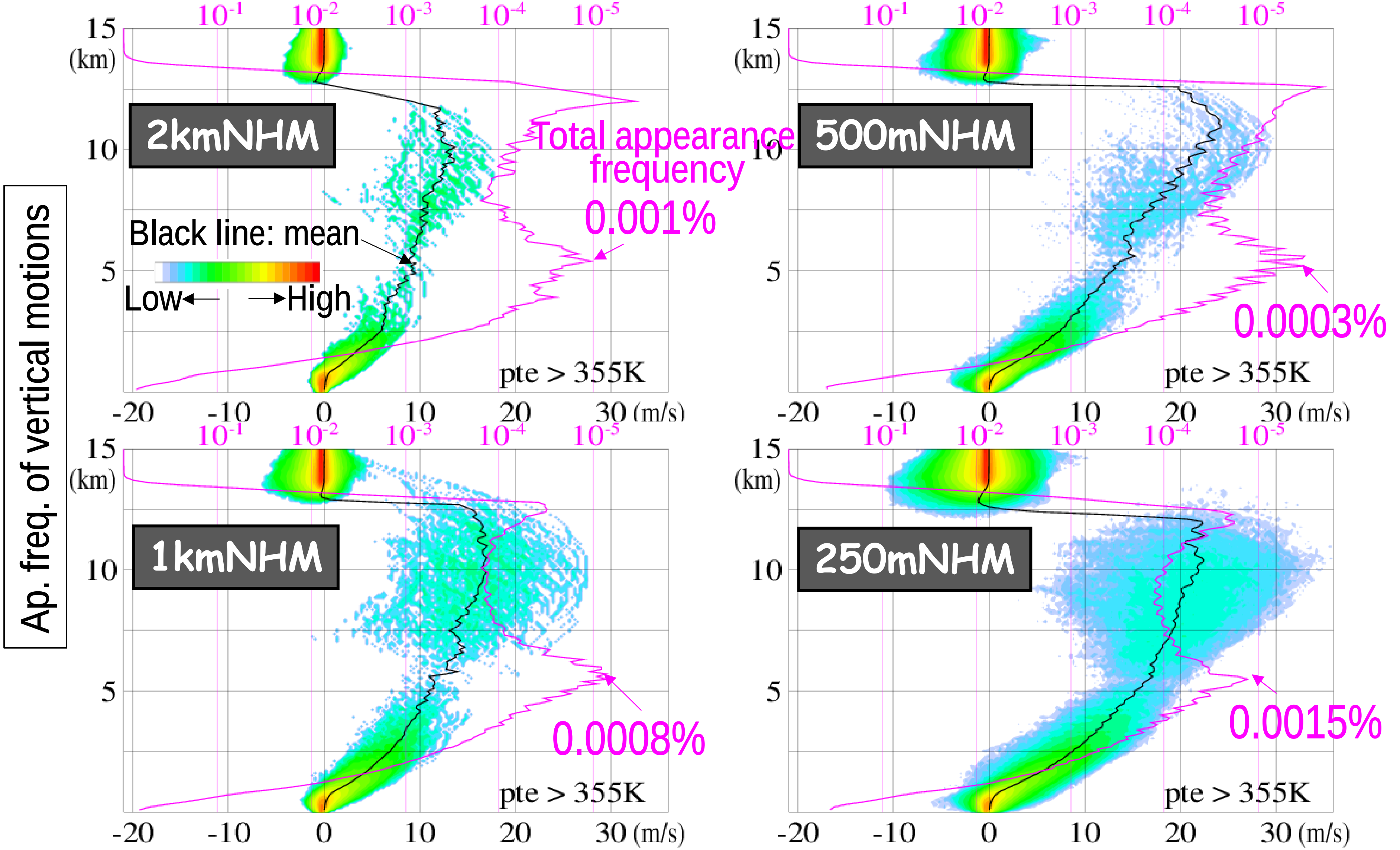
Appearance frequency of vertical motions in high θ_e regions

(23JST19~04JST20)



Acceleration regions of updrafts with conserving θ_e are very narrow.

Appearance frequency of vertical motions in grids with θ_e>355K
(23JST19~04JST20)



Even low resolution can represent the acceleration of updrafts with conserving θ_e.

Influence of horizontal resolution on structure changes of atmospheric stratification

- Even 2kmNHM can successfully reproduce a band-shaped rainfall area, but not structures of the precipitation system.
- For the reproduction, 250mNHM is necessary.

- Higher frequency for high θ_e appears at mid-level in 2kmNHM.

  ⇑ Bigger updraft cores and smaller influence of mixing

- Weaker updrafts in 2kmNHM ⇒ initiation of rainfall downstream.

- Acceleration regions of updrafts with conserving θ_e are very narrow, which is found even in 2kmNHM, but their intensity.

  ⇓ which could be found in case of large vertical shear?

Stratification is little changed by convective activities.