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Dependency of horizontal resolution on structure changes of atmospheric stratification in the 2015 Hiroshima heavy rainfall

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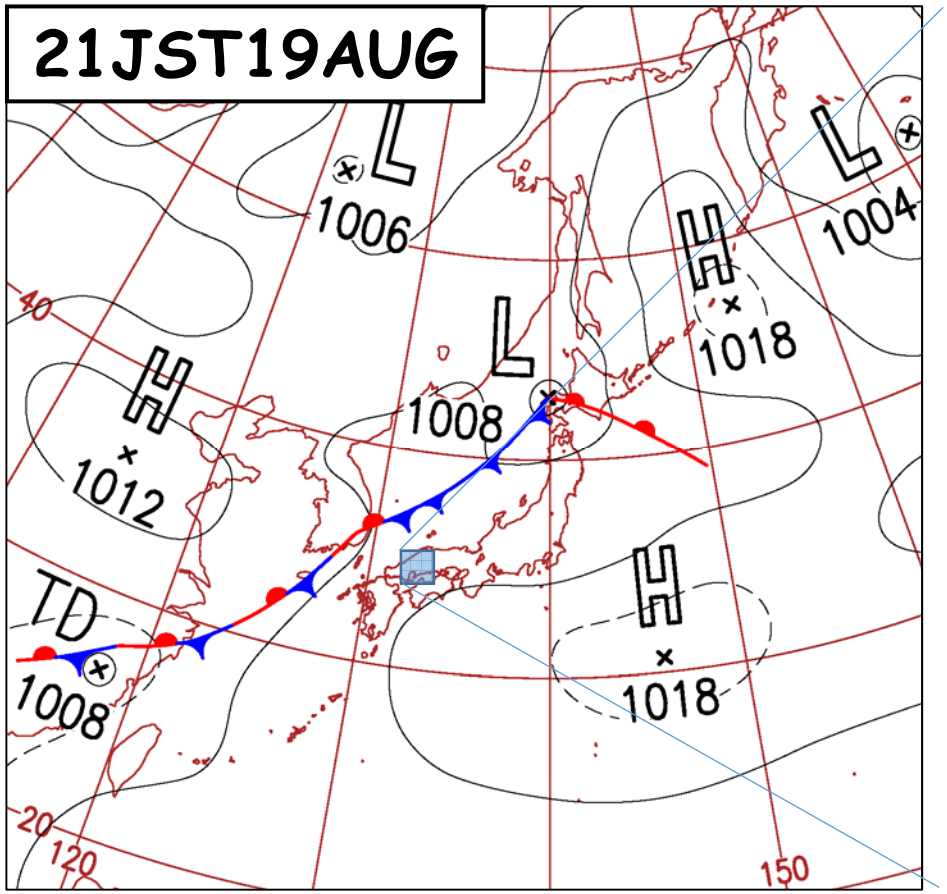
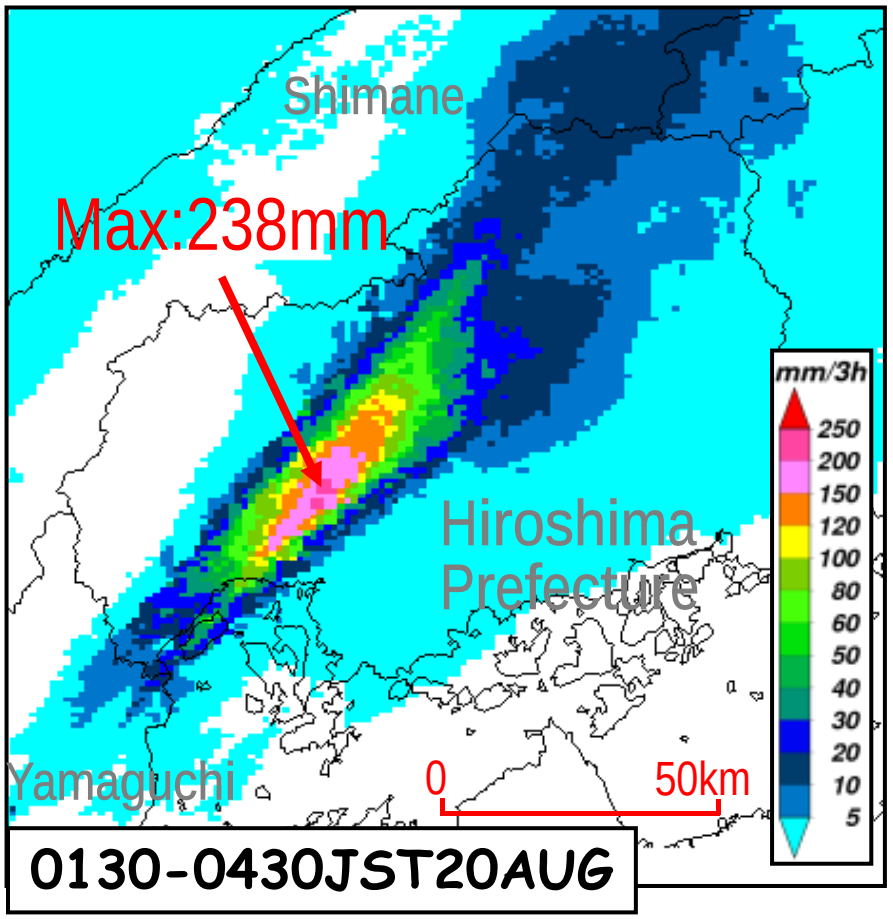
Weather condition and Rainfall distribution

Surface weather map



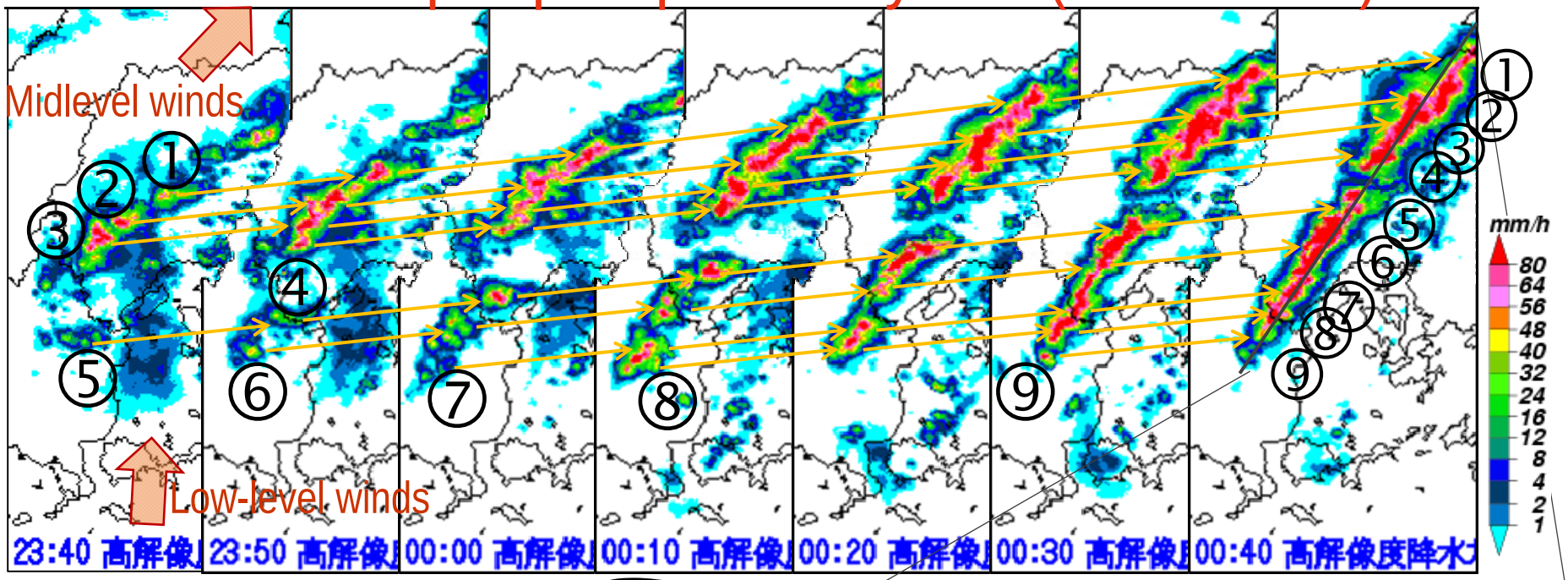
3-h precipitation amounts

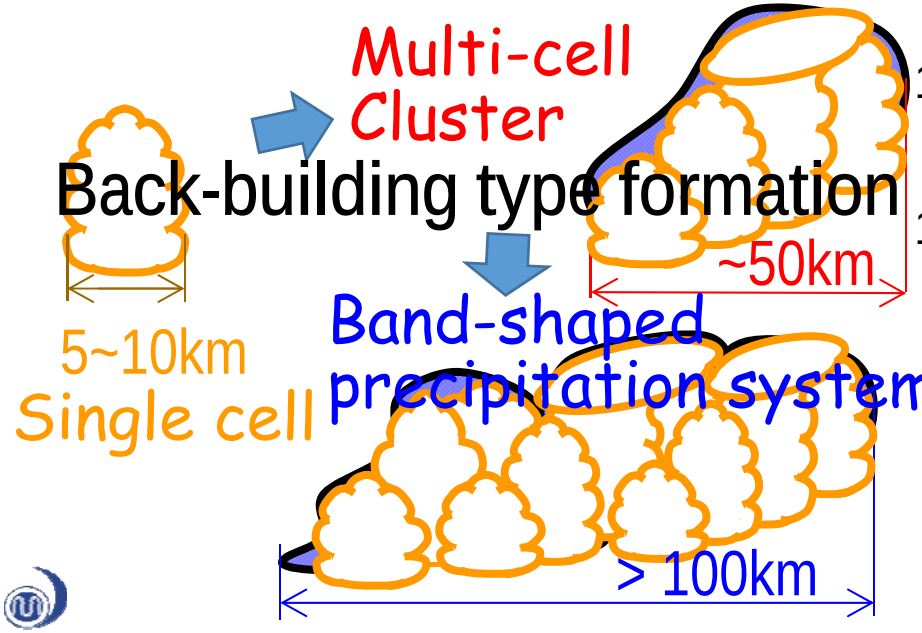


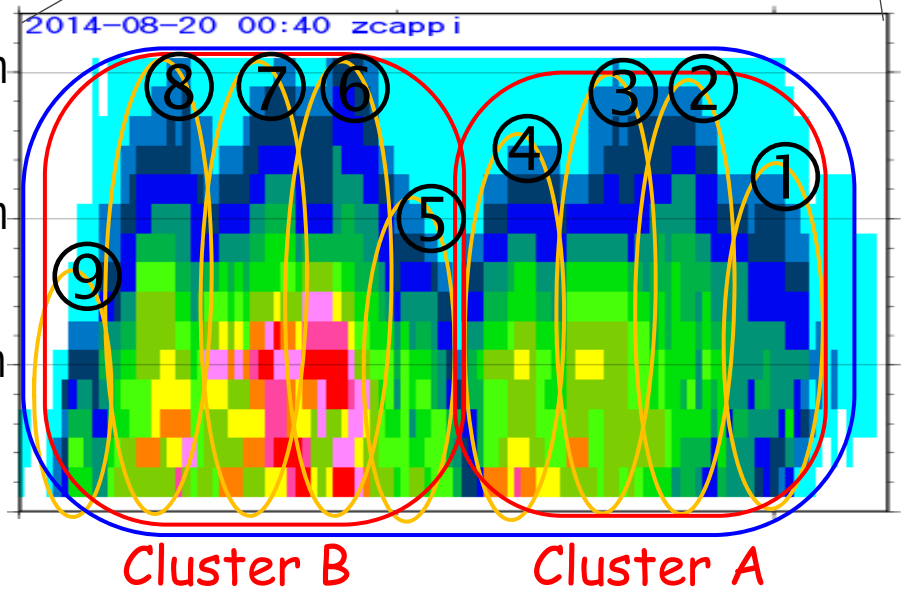
Heavy rainfall occurred ~300km south of stationary front.

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)

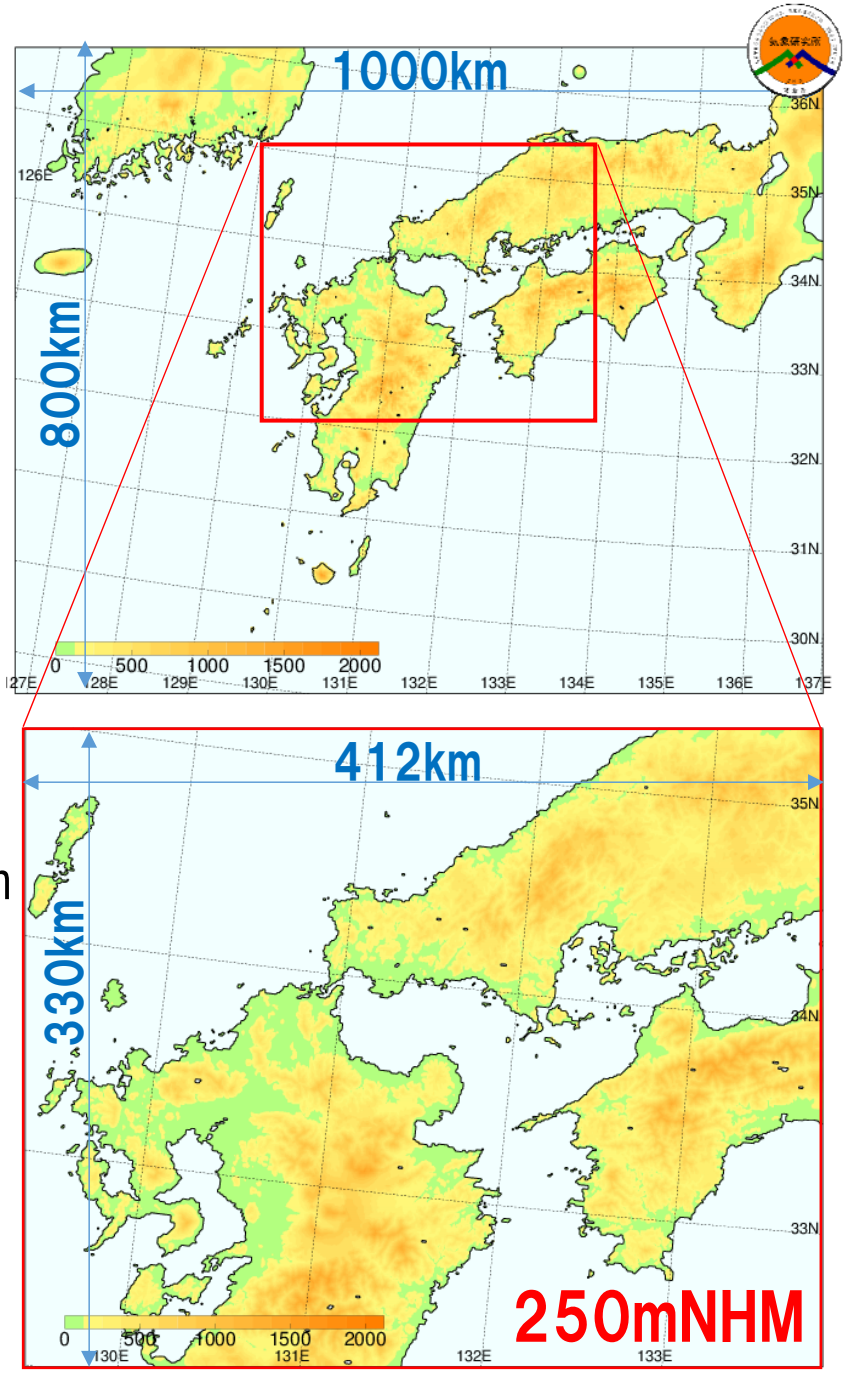
Surface flux: Beljaars and Holtslag (1991)

Horizontal grid: 2km, 1km, 500m, 250 m

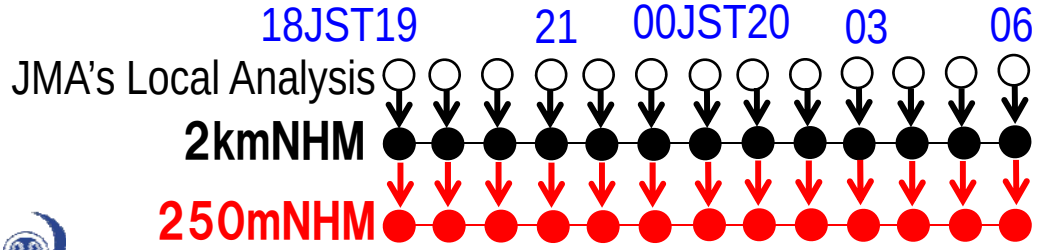
Initial/boundary data: Hourly JMA-Local analysis adopting a 3DVAR assimilation system, but for 250m

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

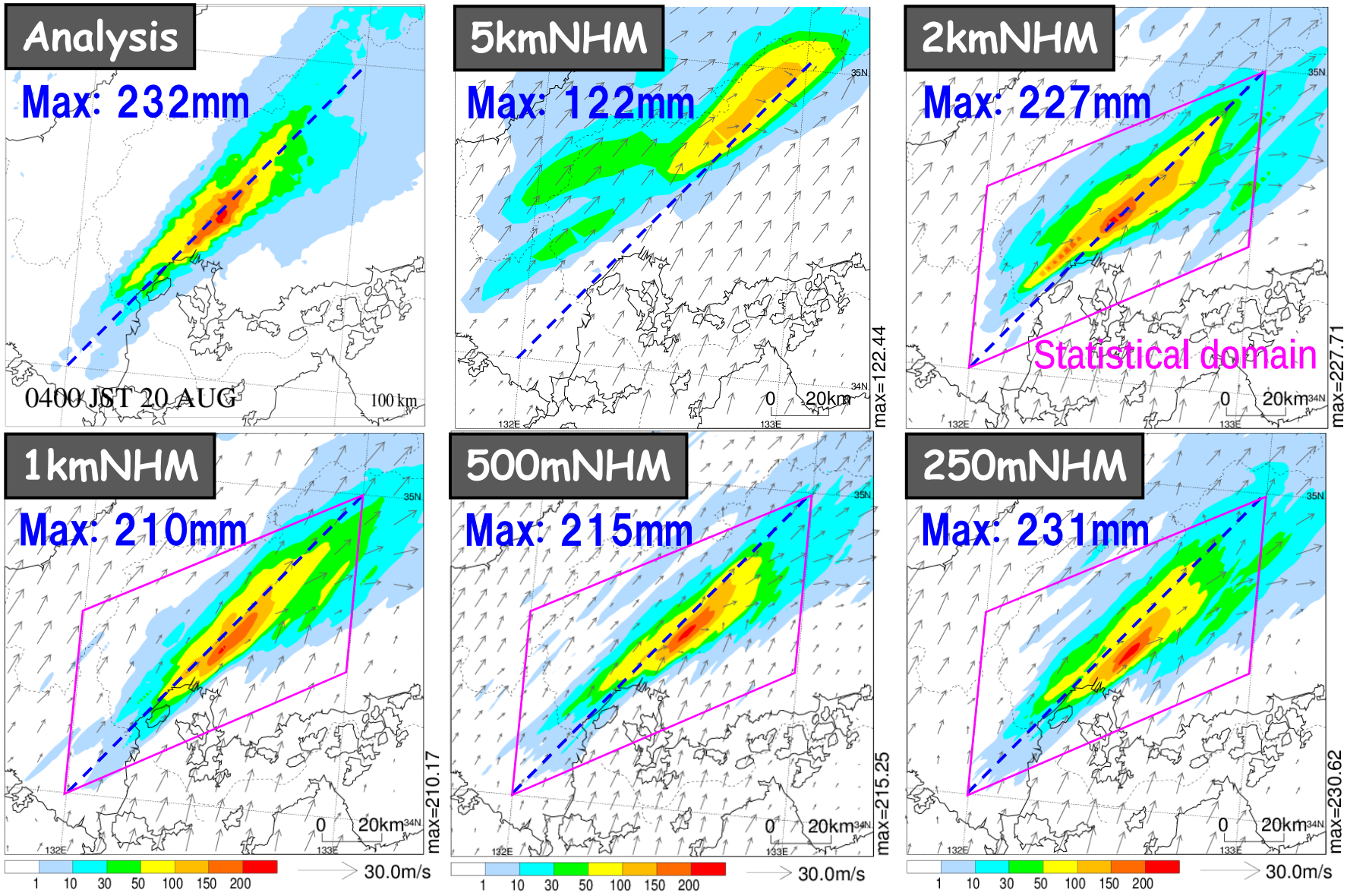
Water vapor diffusion for grids with w > 10 m/s



Design of 250mNHM run

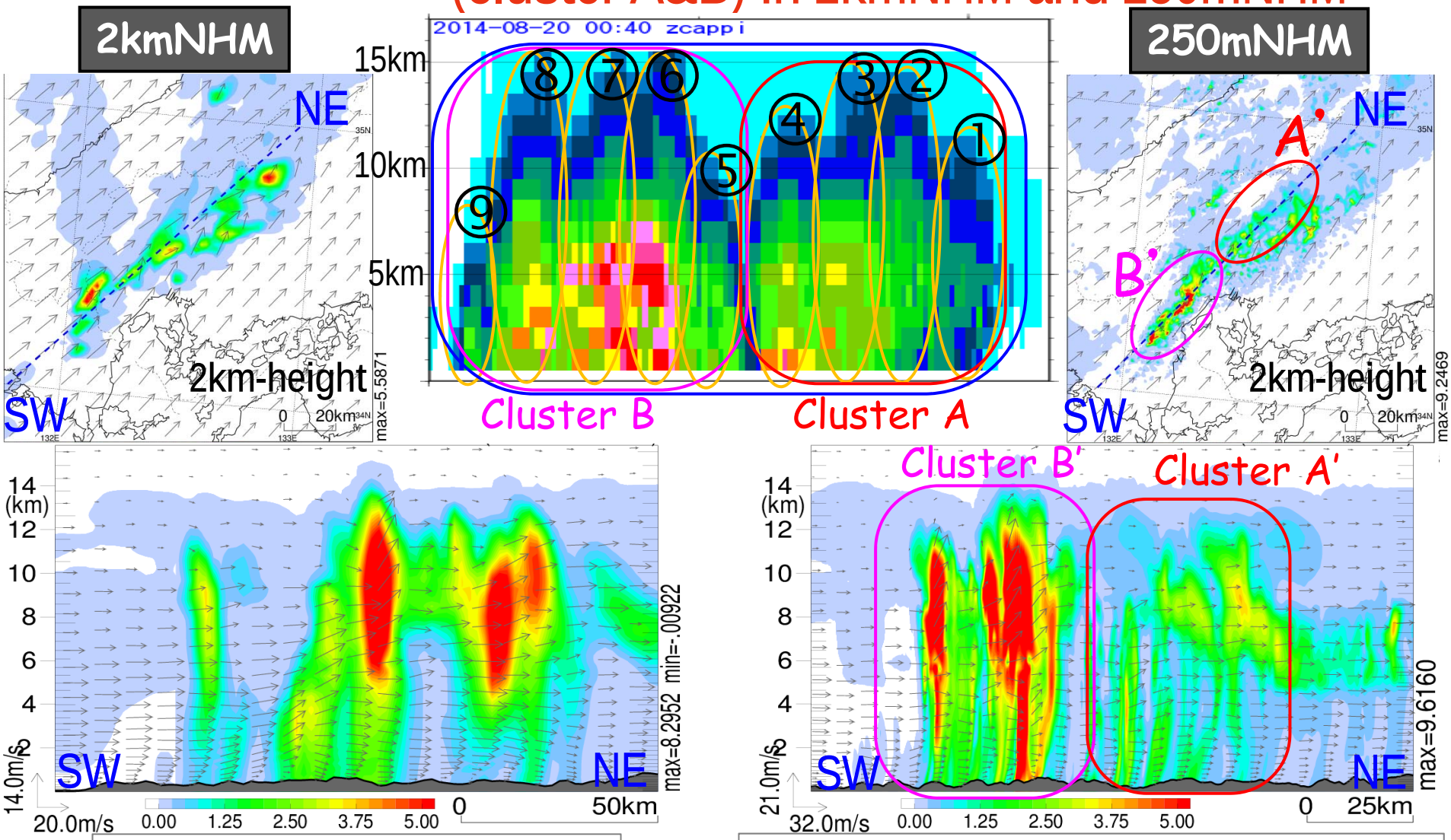


Results of 18JST19initial(3-houly accumulated rainfall at 04JST20)



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

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

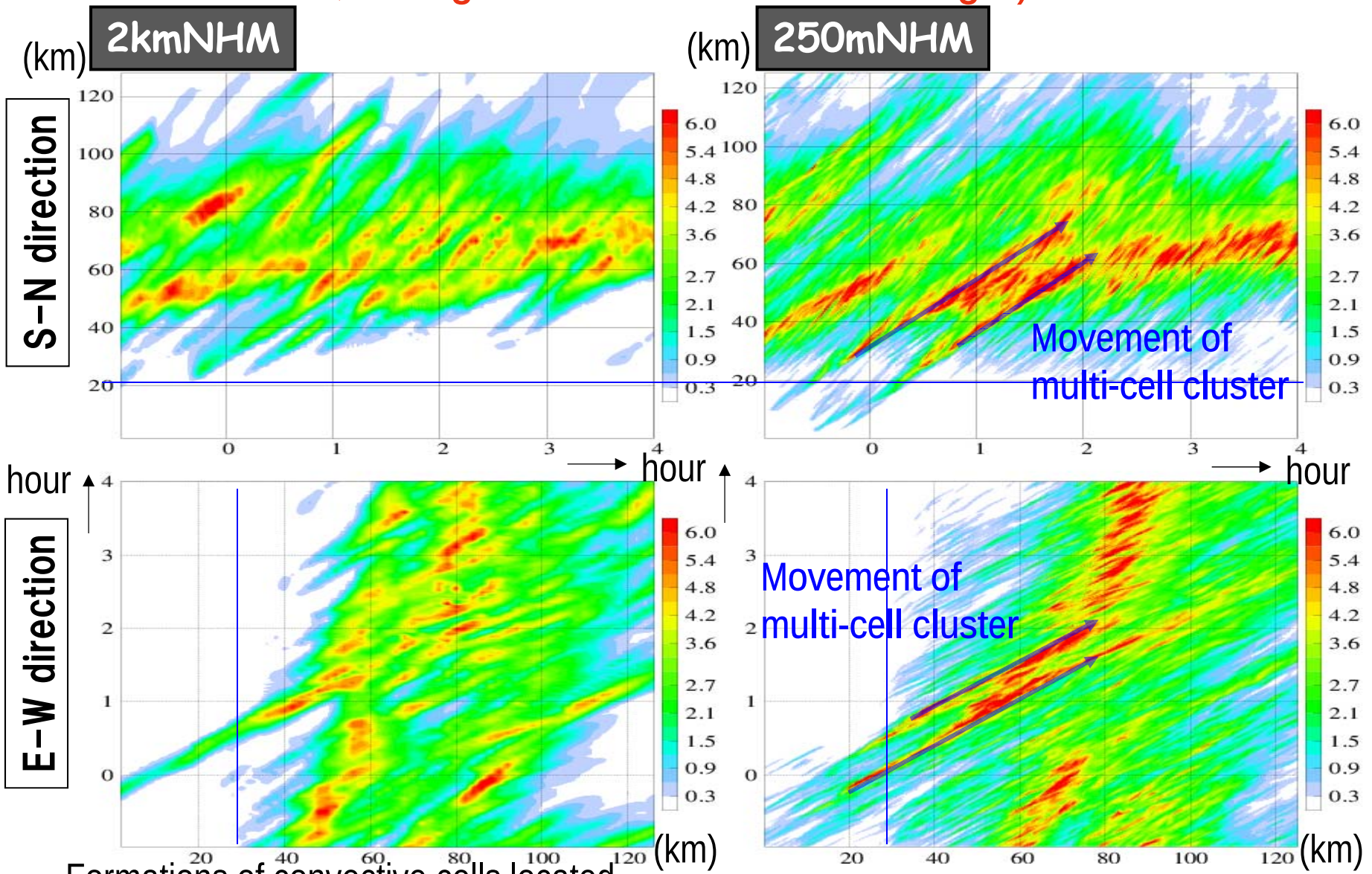


Cell's size is overestimated.

Cluster's structure is well reproduced.

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

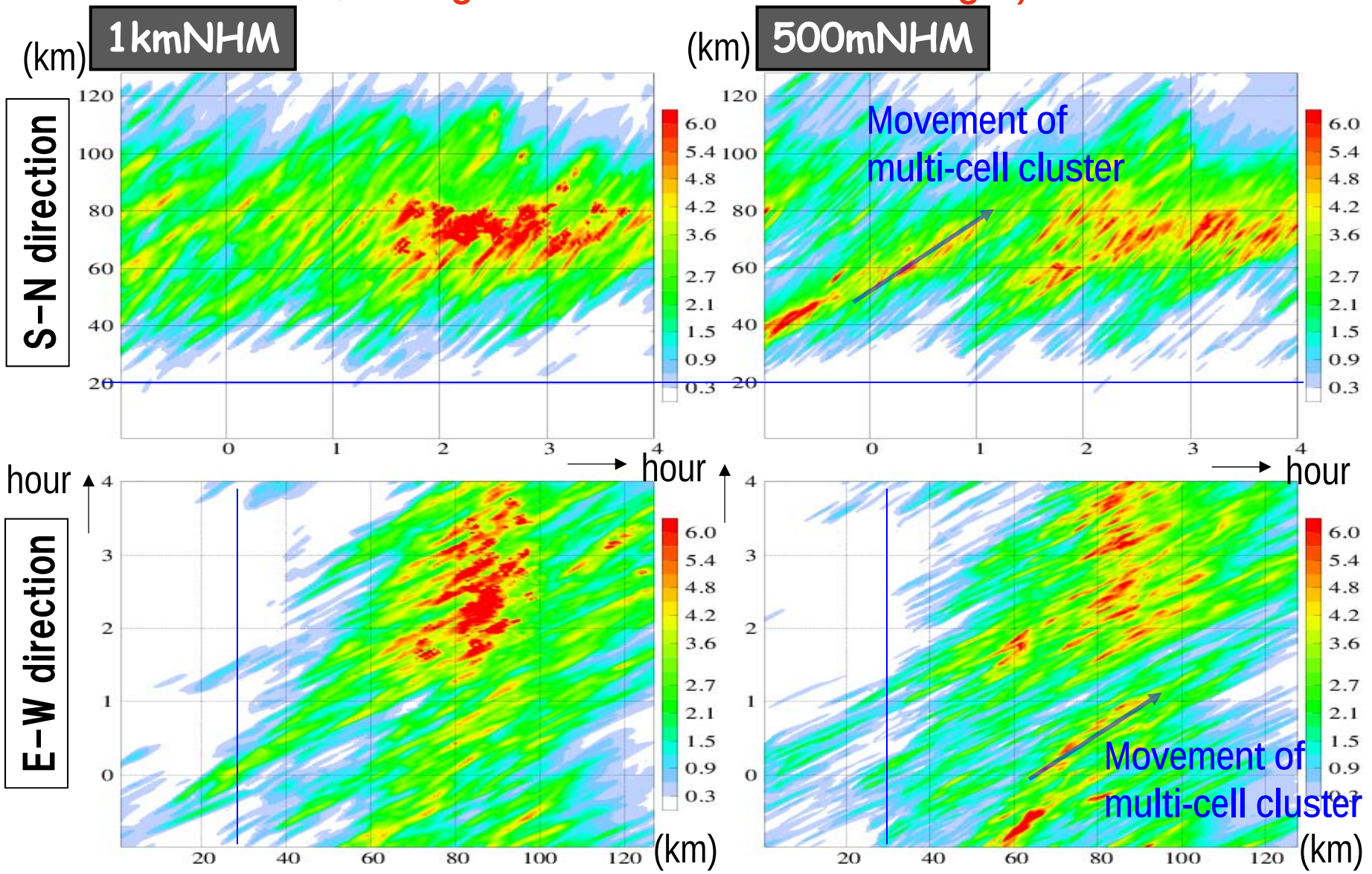
Reproductibity of movement of convective cells
（Mixing ratio of rain at a 466m height)



Formations of convective cells located on the downstream side than 250mNHM.

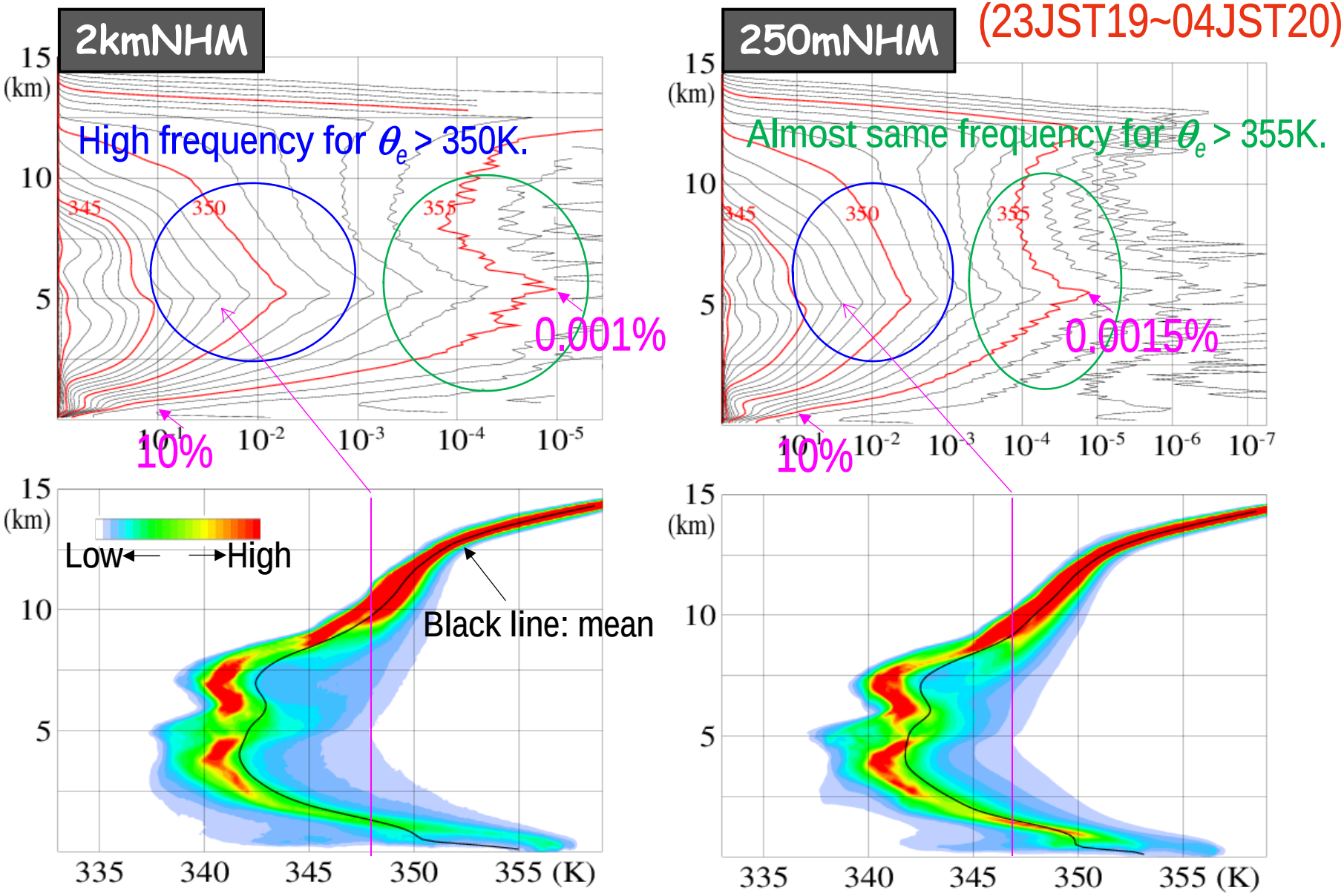
Movements of multi-cell cluster are clear.

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



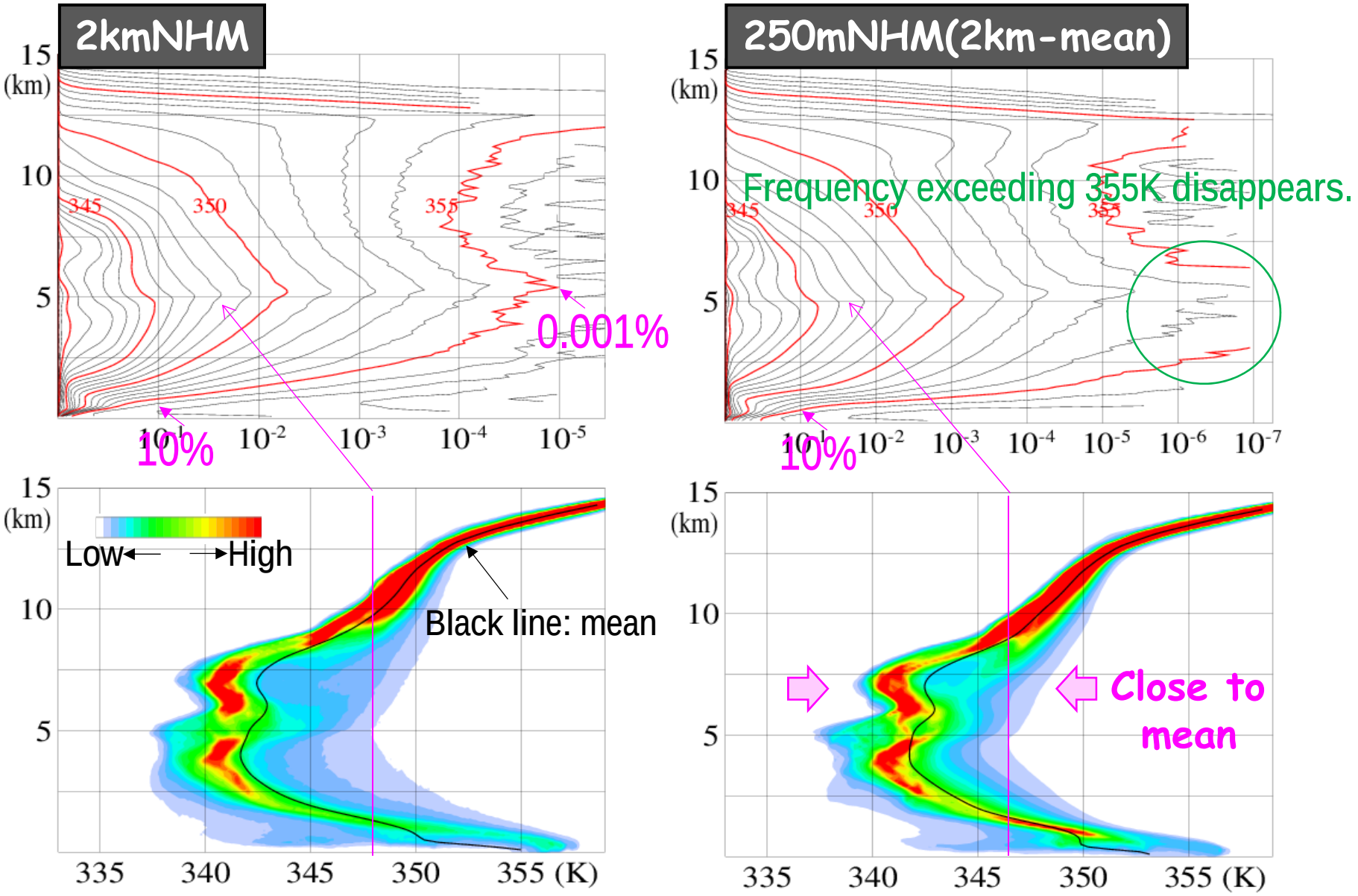
Movements of multi-cell cluster are not so clear.

Appearance frequency of atmospheric structure and θ_e (23JST19~04JST20)



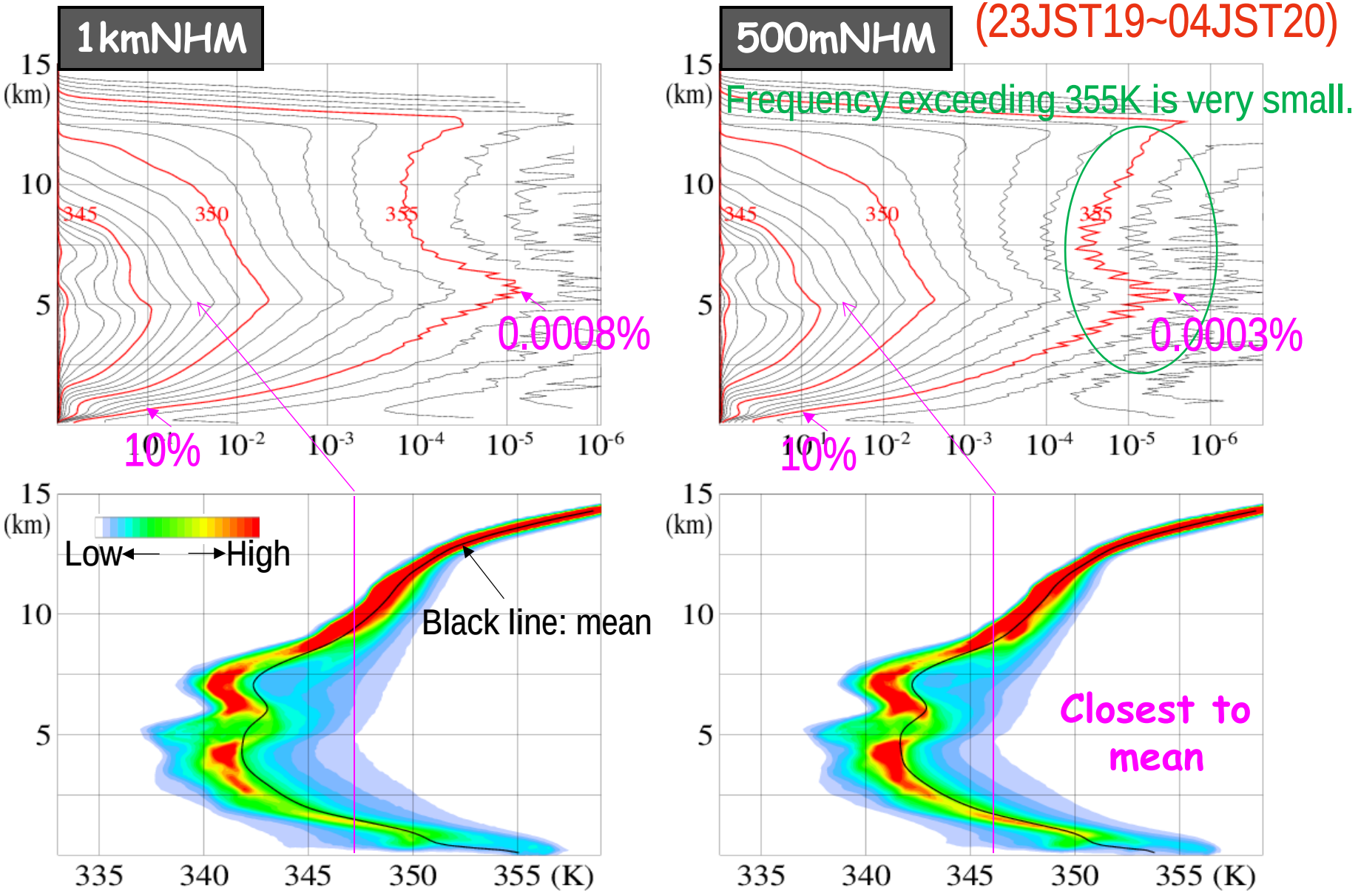
Higher frequency for θ_e > 350K is found at the middle level in 2kmNHM.

Appearance frequency of atmospheric structure and θ_e



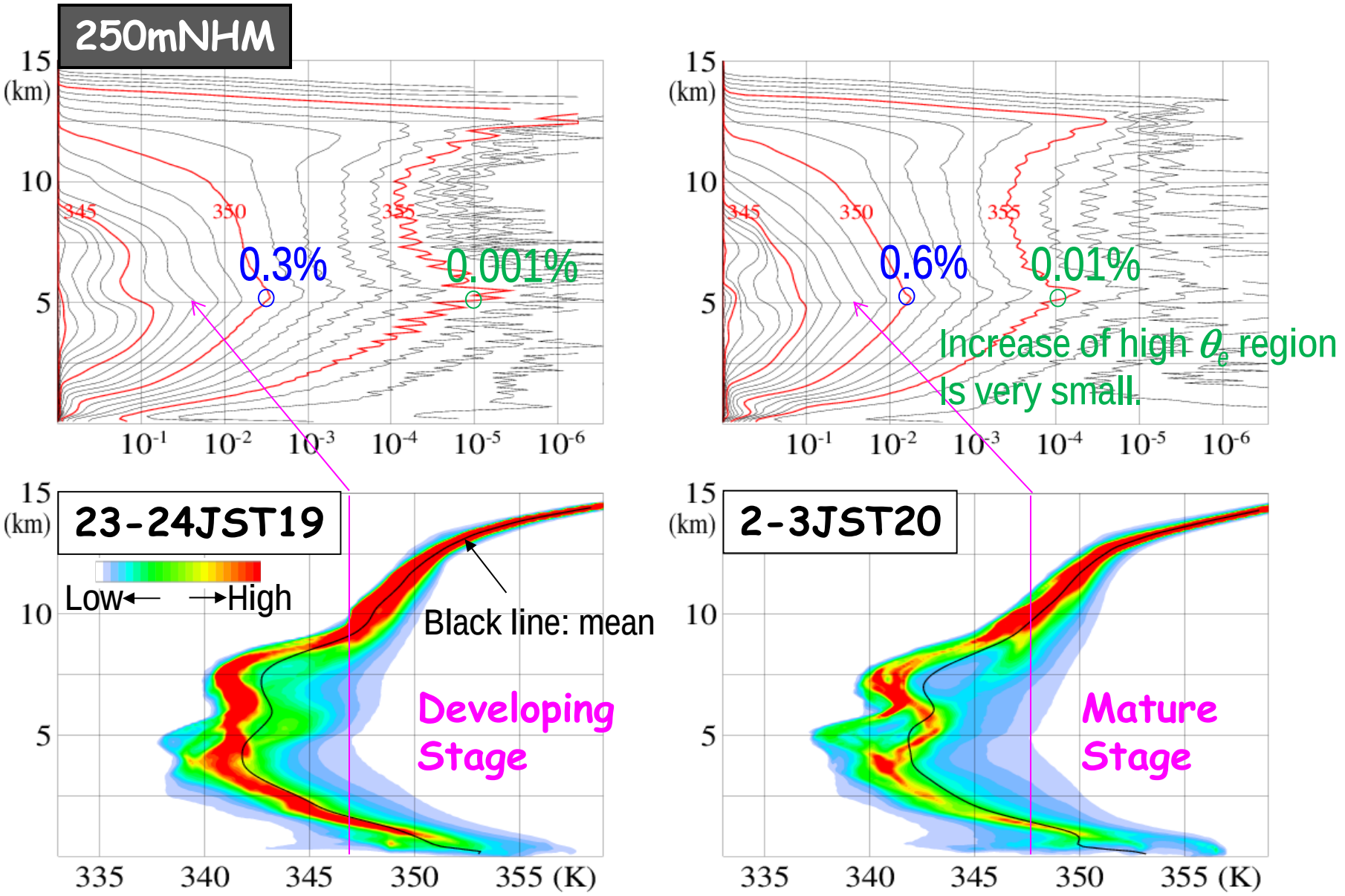
Distributions do not become close to 2kmNHM by averaging. ⇦ Opposite effect

Appearance frequency of atmospheric structure and θ_e (23JST19~04JST20)



θ_e is distributed close to mean in comparison with 2km/250mNHM.

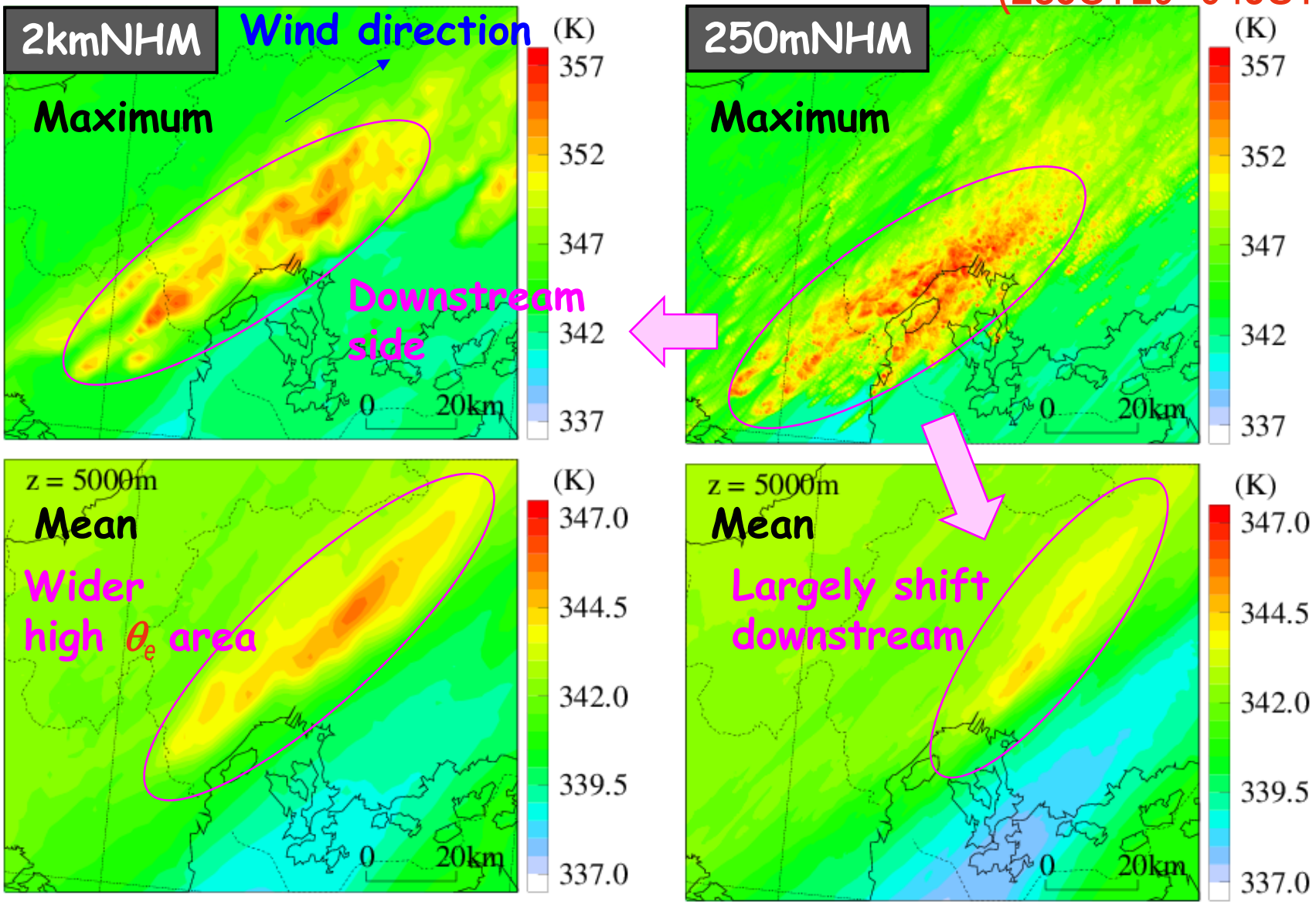
Time change of atmospheric structure and θ_e



Stratification is little changed by convective activities.

Max/mean distributions of θ_e at 5km height

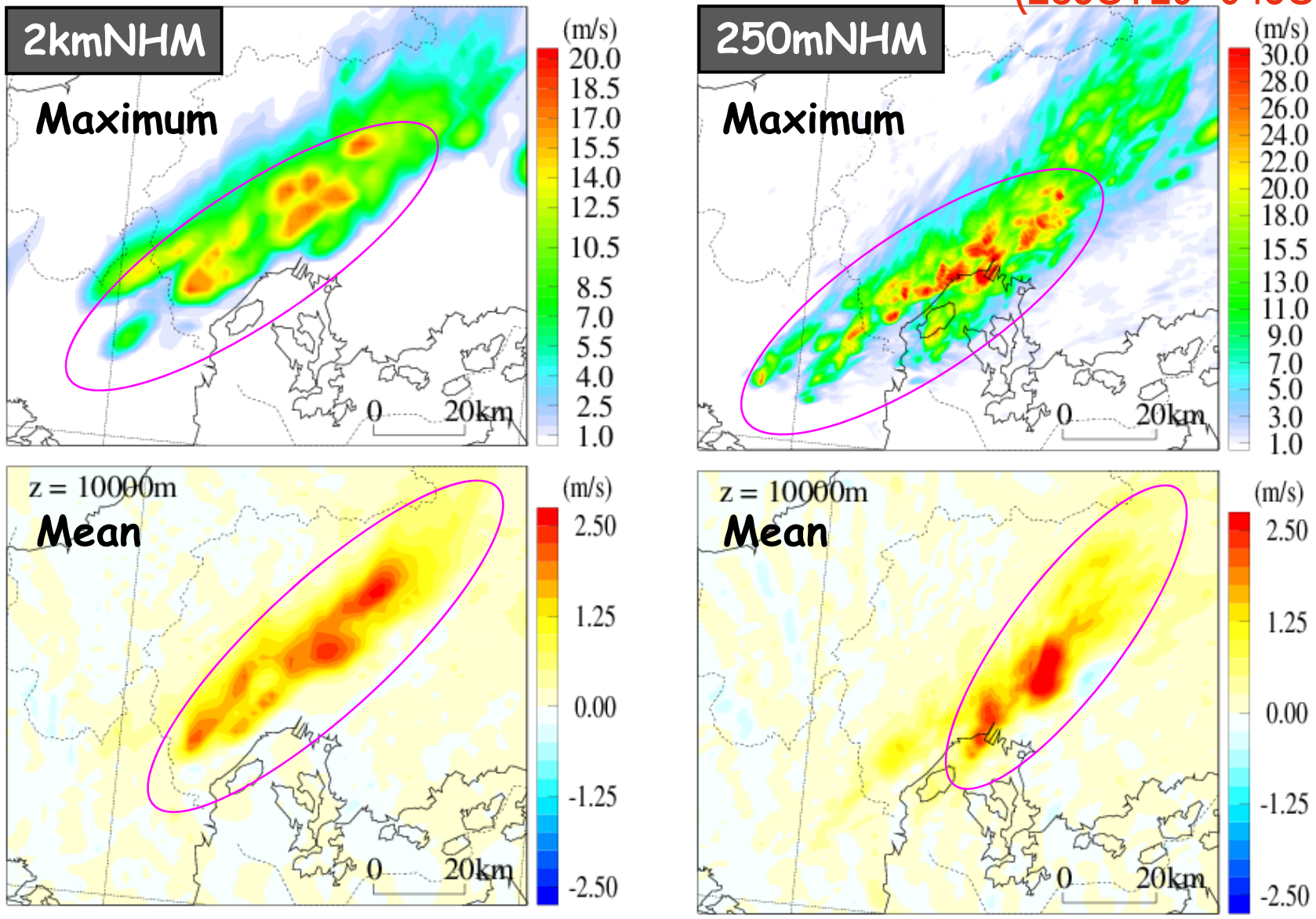
(23JST19~04JST20)



Shift of high θ_e areas is not so large.

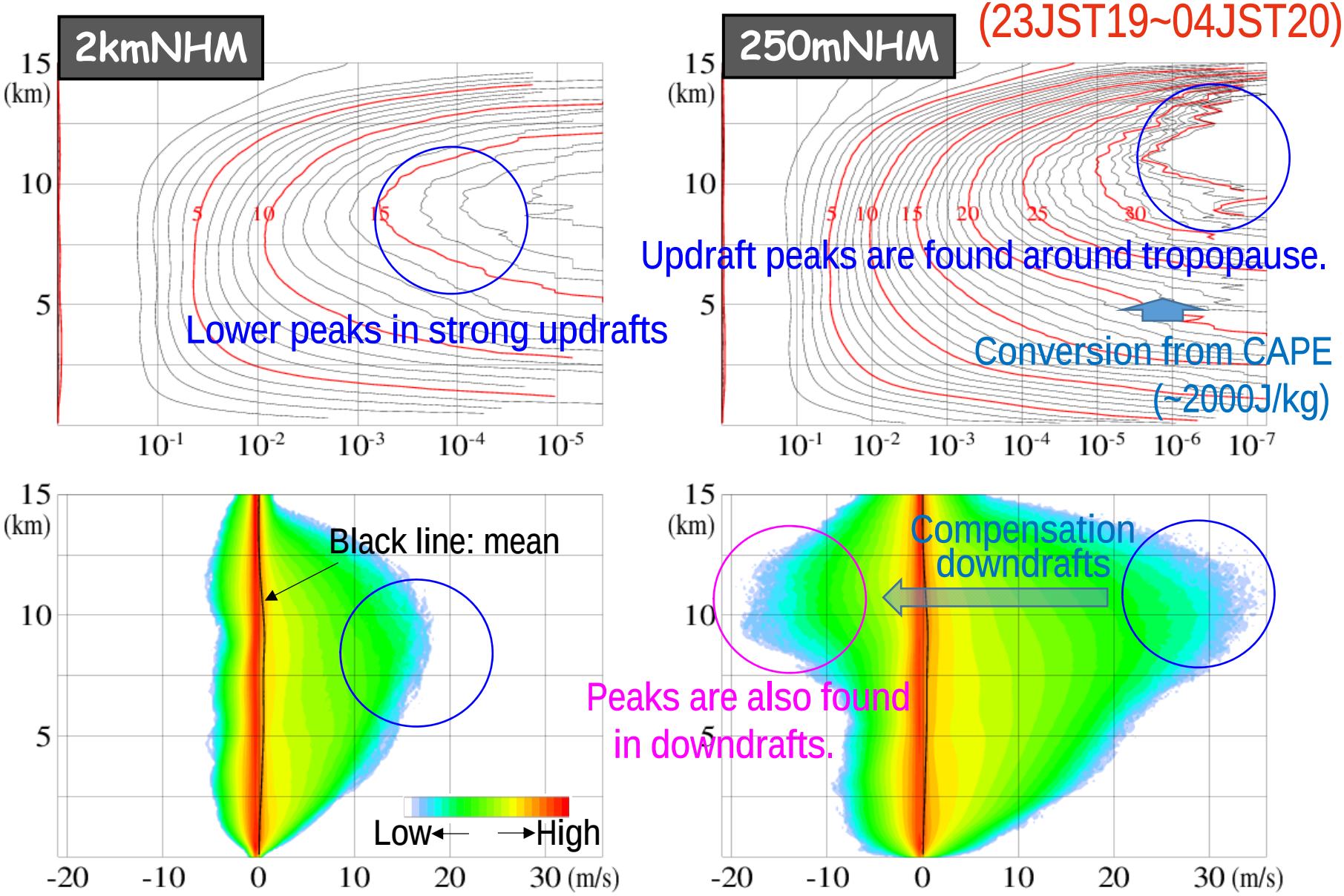
High θ_e areas largely shift downstream in mean.

Max/mean distributions of vertical motions at 10km height (23JST19~04JST20)



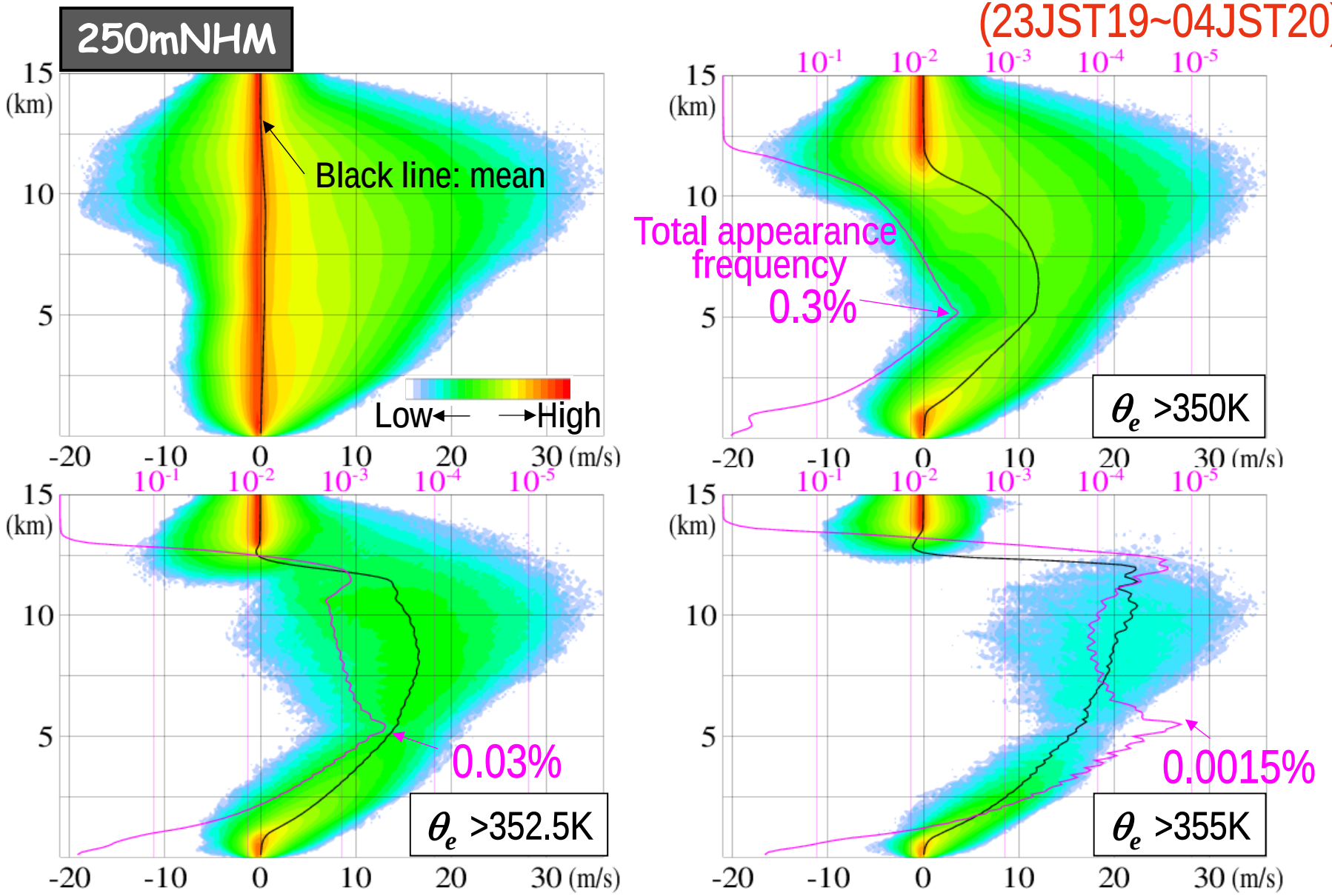
High correlations are found in distributions between θ_e and updrafts.

Appearance frequency of vertical/strong upward motions (23JST19~04JST20)



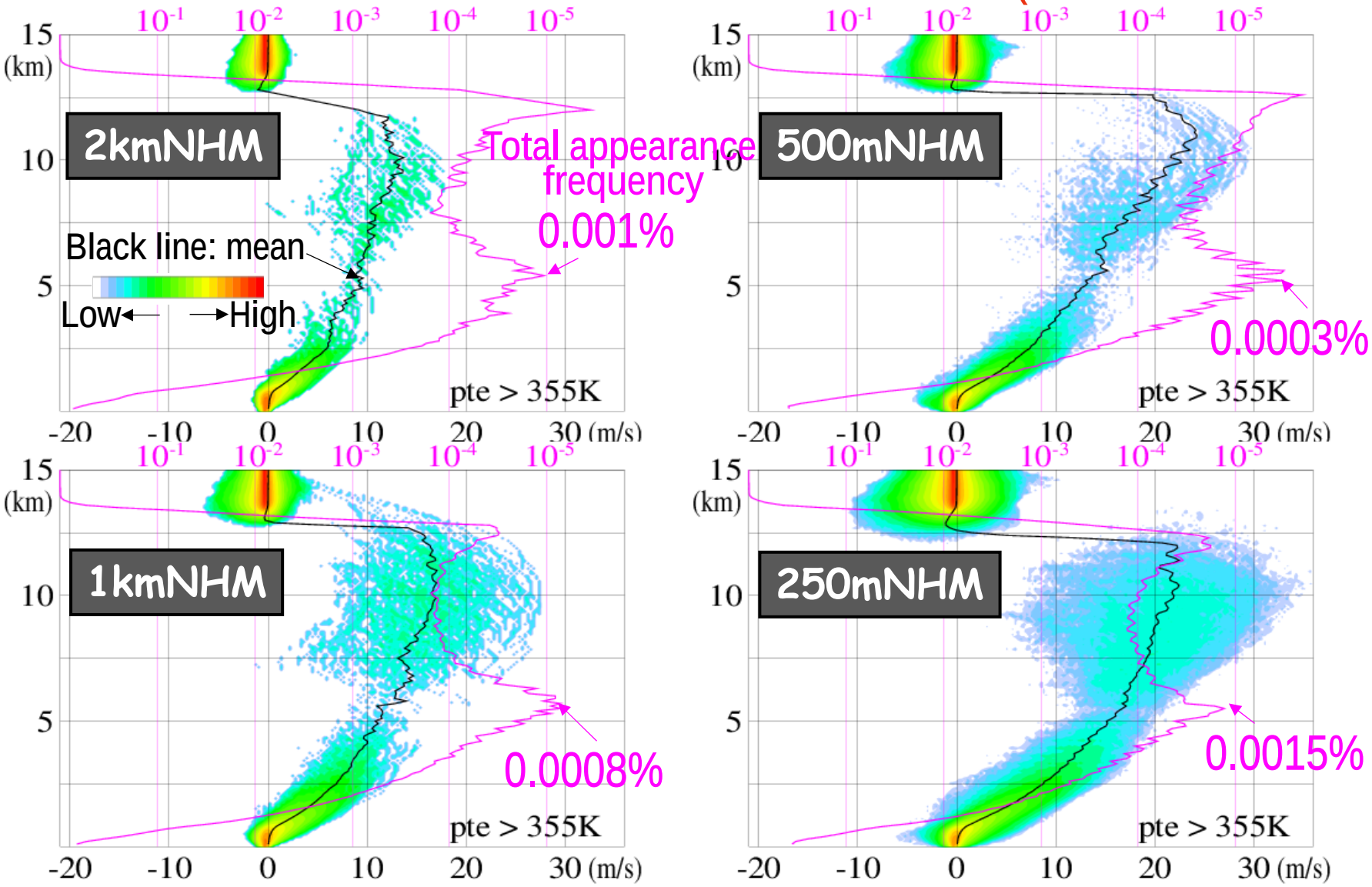
Differences are found in peak heights of upward motions, as well as intensity.

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.

Dependency of horizontal resolution on structure changes of atmospheric stratification

① Even 2kmNHM can successfully reproduce a band-shaped rainfall area, but not structures of the precipitation system.

② For the reproduction, 250mNHM is necessary.

③ Weaker updrafts shift rainfall areas downstream in 2kmNHM.

④ Higher appearance frequency for θ_e > 350K is found at the middle level in 2kmNHM, but grids with θ_e > 355K are found almost equal to that in 250mNHM.

⑤ Acceleration regions of updrafts with conserving θ_e are very narrow, which is found even in 2kmNHM, but their intensity.

Stratification is little changed by convective activities.