Impacts of dense and frequent surface observations on a sudden severe rainstorm forecast: A case of an isolated convective system

Data Assimilation Seminar

2016. 11. 24

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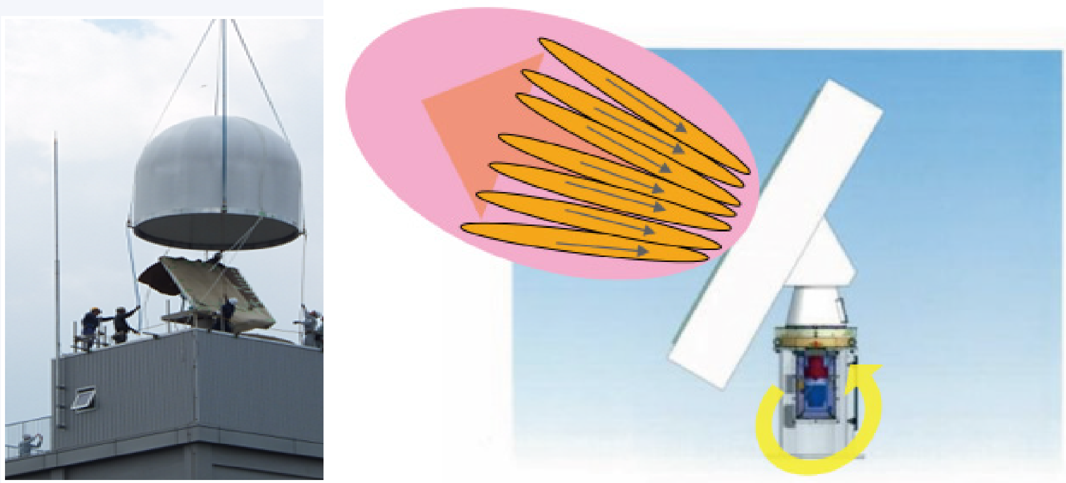
0.1 Introduction

CREST: Innovating "Big Data Assimilation" technology for revolutionizing very-short-range severe weather prediction

- We aim to innovate "Big Data Assimilation" technology for fully taking advantage of big data. *(Miyoshi et al. 2016; BAMS)*

⇒ High dense and frequency observation data is important.

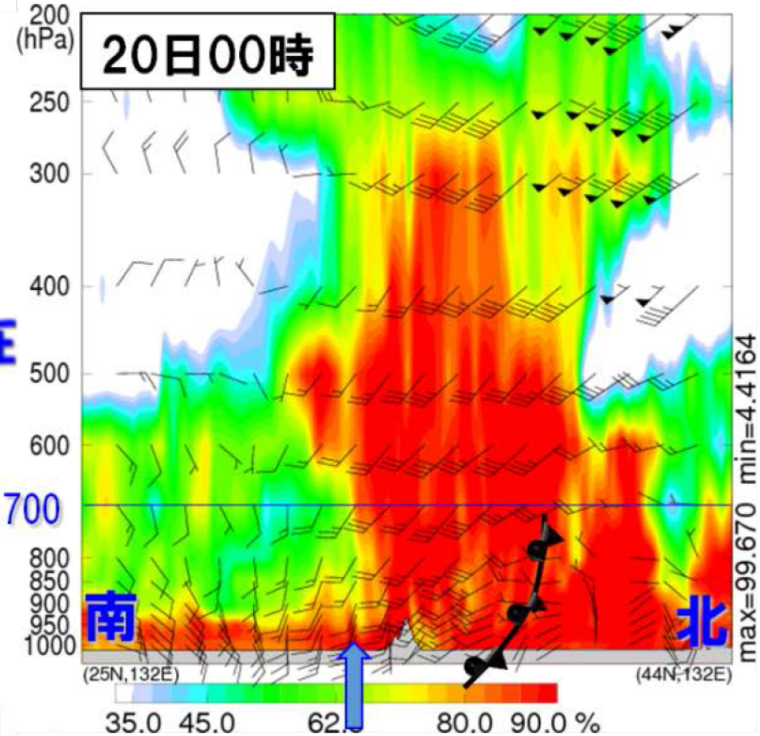
Phased Array Weather Radar (PAWR)



http://www.nict.go.jp/publication/NICT-News/1301/02.html より引用

0.2 Importance of atmospheric condition near surface

(Meteorological research institute press release)

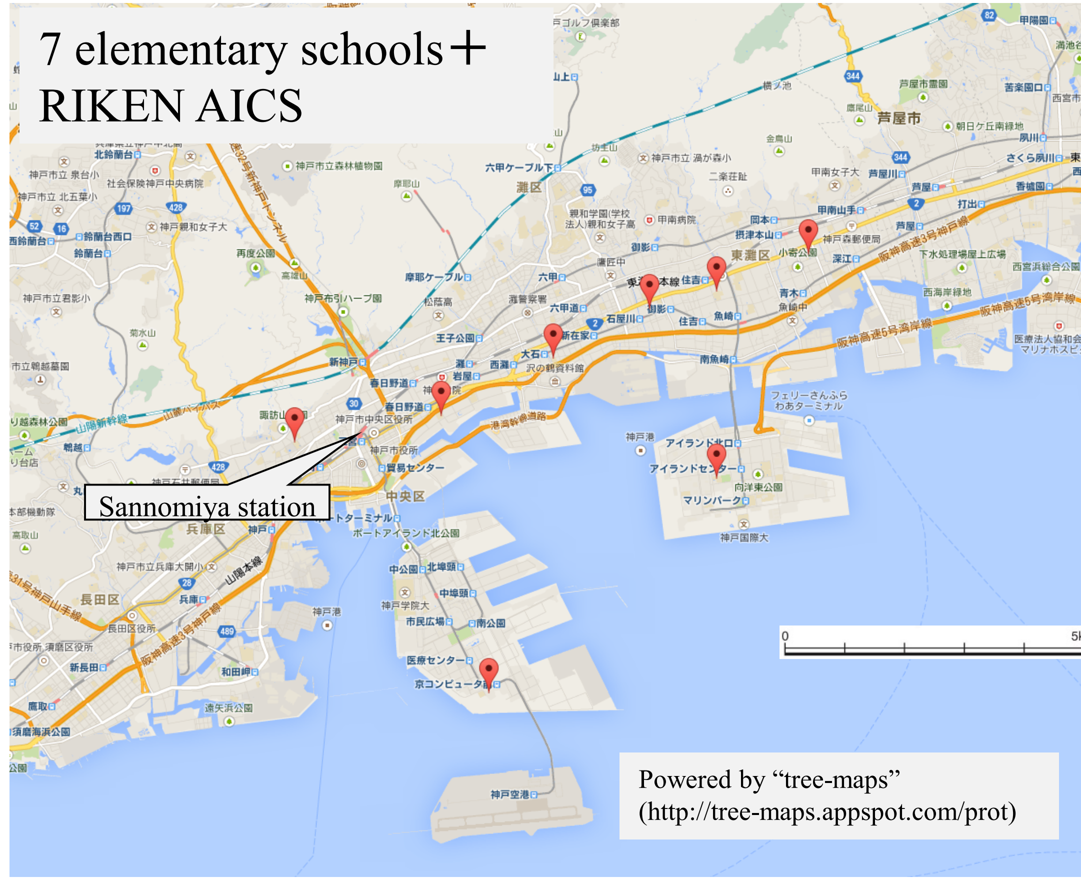


広島市付近

梅雨期にみられる大気構造・
大雨の発生位置が類似

Rich water vapor near surface

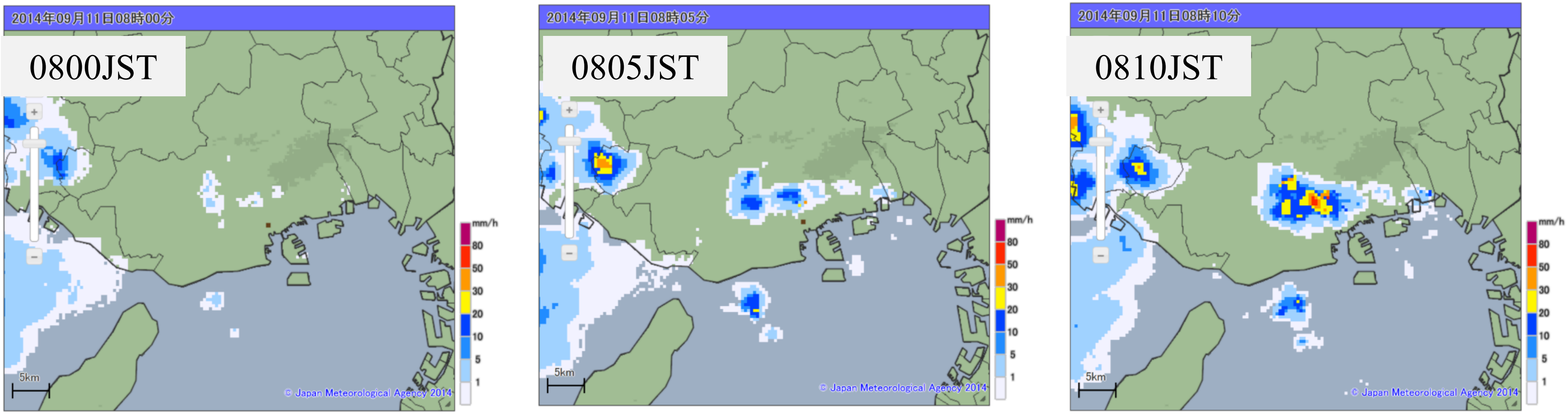
0.3 Original surface stations (POTEKA Ⅱ)



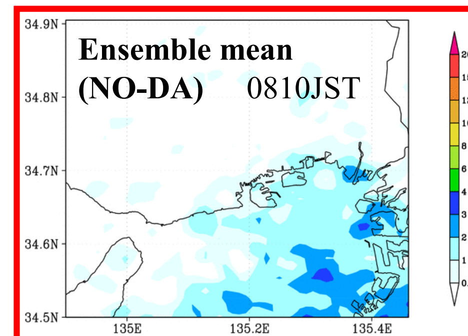
Observe every 30seconds

Wind direction [deg]	Temperature [℃]
Wind speed [m/s]	Pressure [hPa]
Relative humidity [%]	Rainfall sensitivity (0 / 1)
Radiation [W/m^2]	Rainfall amount [mm]

0.4 Sudden severe rainstorm event on Sep. 11, 2014

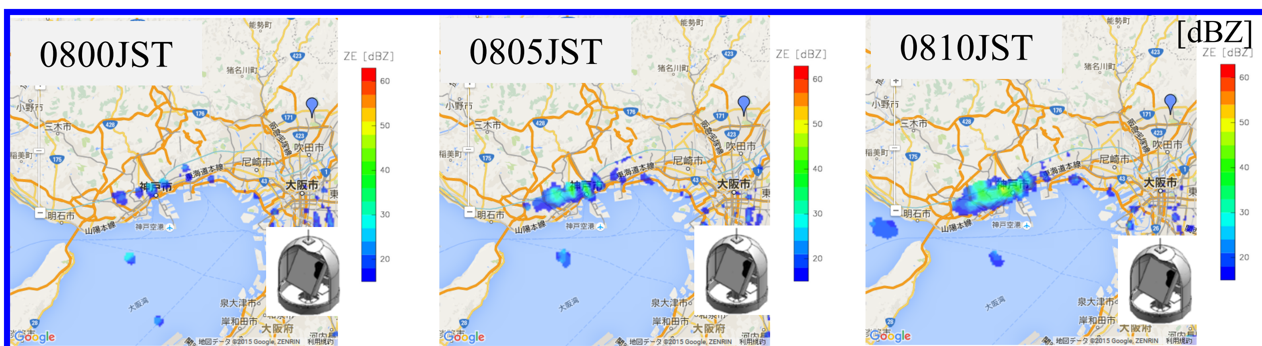


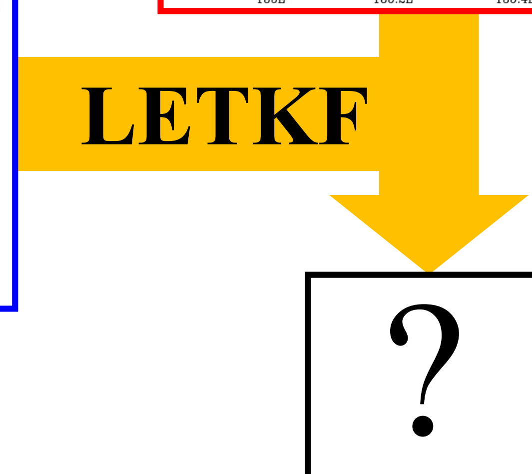
(High resolution nowcast by JMA : http://www.jma.go.jp/jp/highresorad/ より引用)



Phased array weather radar (2km elevation)

(http://pawr.nict.go.jp/)





0.5 Purposes in this study

- Target event: A sudden severe rainstorm by an isolated convection system on September 11, 2014.

- Performed NHM-LETKF (Miyoshi and Aranami 2006, Kunii 2014), with assimilating PAWR and surface observations (POTEKA II) every 30 seconds.

- Investigate impacts of dense and frequent surface observations on a sudden severe rainstorm forecast.

A series of the experiments

		Assimilated observation
1	**1-km** DA experiment	・PAWR
2	**1-km** DA experiments and forecasts (Comparison with observation data)	・PAWR ・PAWR+POTEKA(Not bias corrected) ・PAWR+POTEKA(Bias corrected)
3	**1-km** and **100-m** DA experiments (Comparison with resolution)	・PAWR
4	**100-m** DA experiments and forecasts (Comparison with observation data)	・PAWR ・PAWR+POTEKA(Bias corrected)

Models:

Forecasts: JMA-NHM *(Saito et al., 2001, 2006)*

DA-cycles: **NHM-LETKF** *(Miyoshi and Yamane 2006, Kunii 2014)*.

		Assimilated observation
1	**1-km** DA experiment	・PAWR
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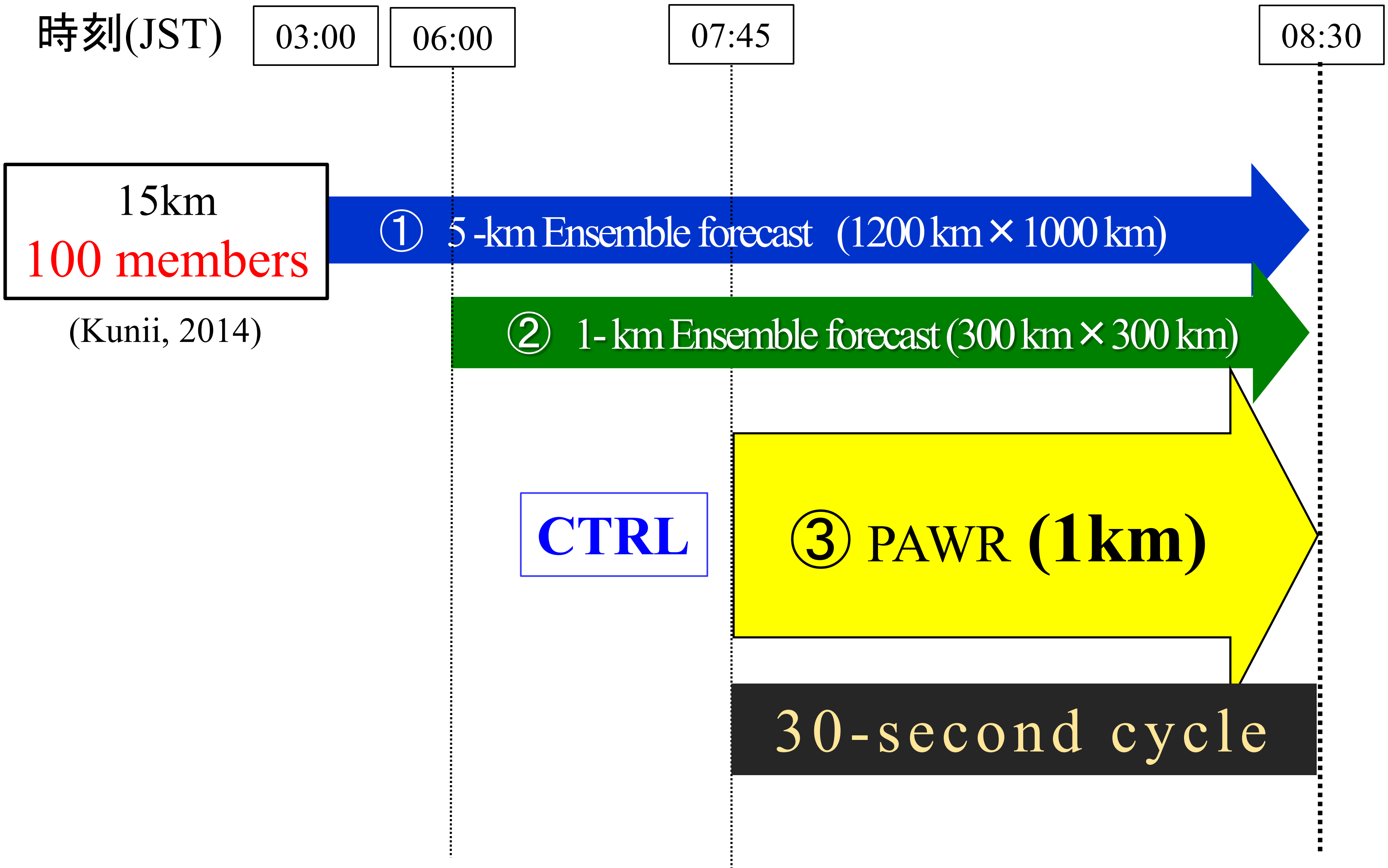
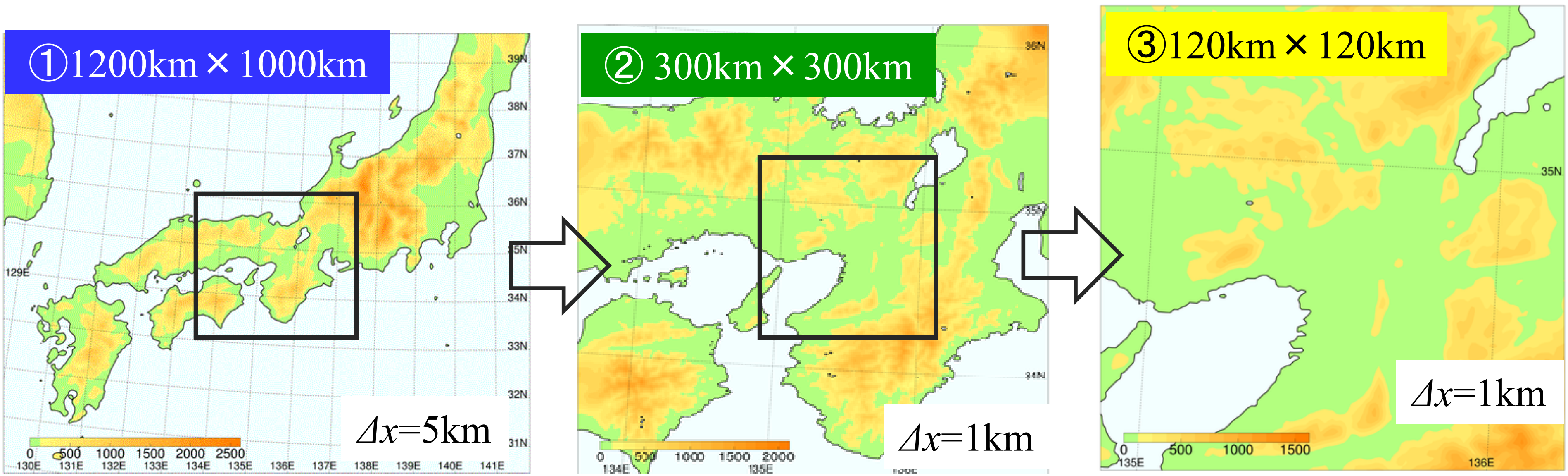
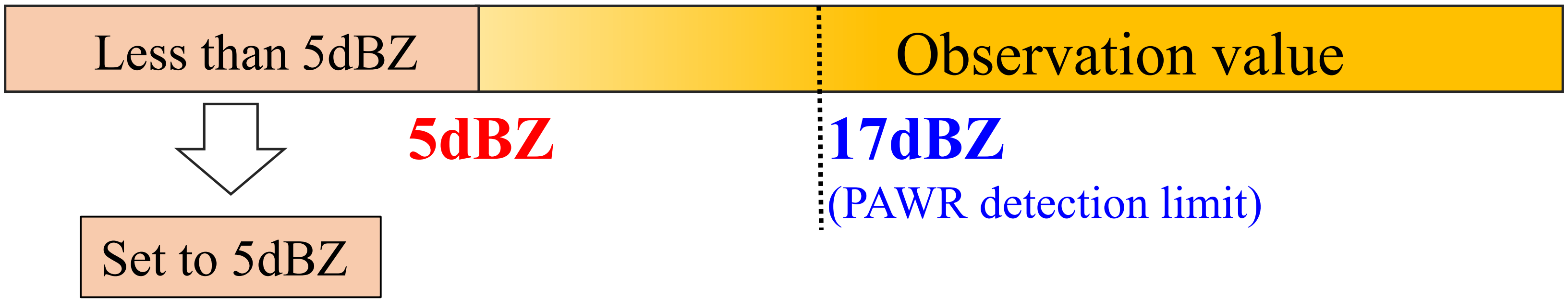
4	**100-m** DA experiments and forecasts (Comparison with observation data)	・PAWR ・PAWR+POTEKA(Bias corrected)

1.1 The workflow of DA experiments at **1-km resolution**




①1200km×1000km
Δx=5km
② 300km×300km
Δx=1km
③120km×120km
Δx=1km

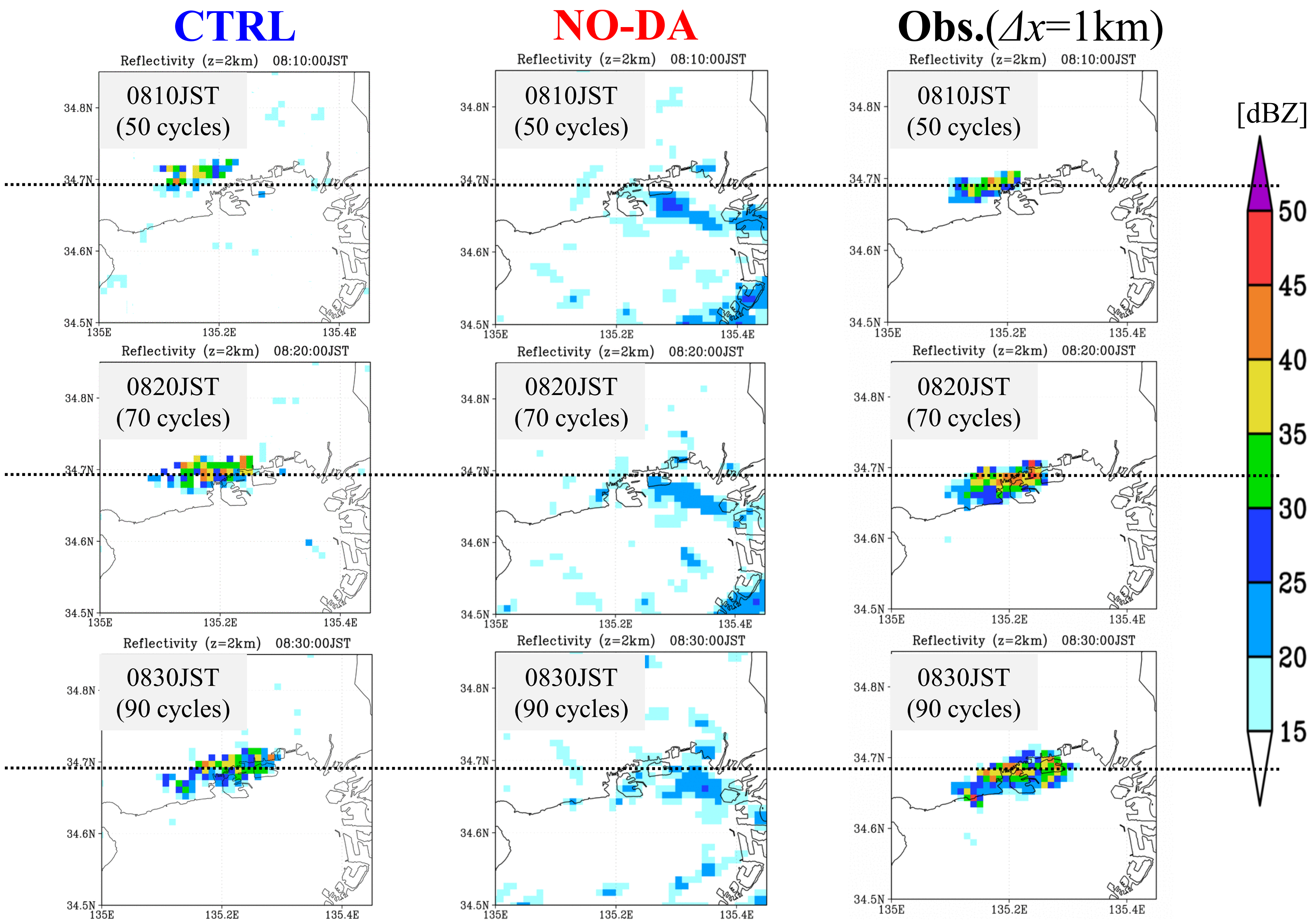
1.2 DA method for no precipitation



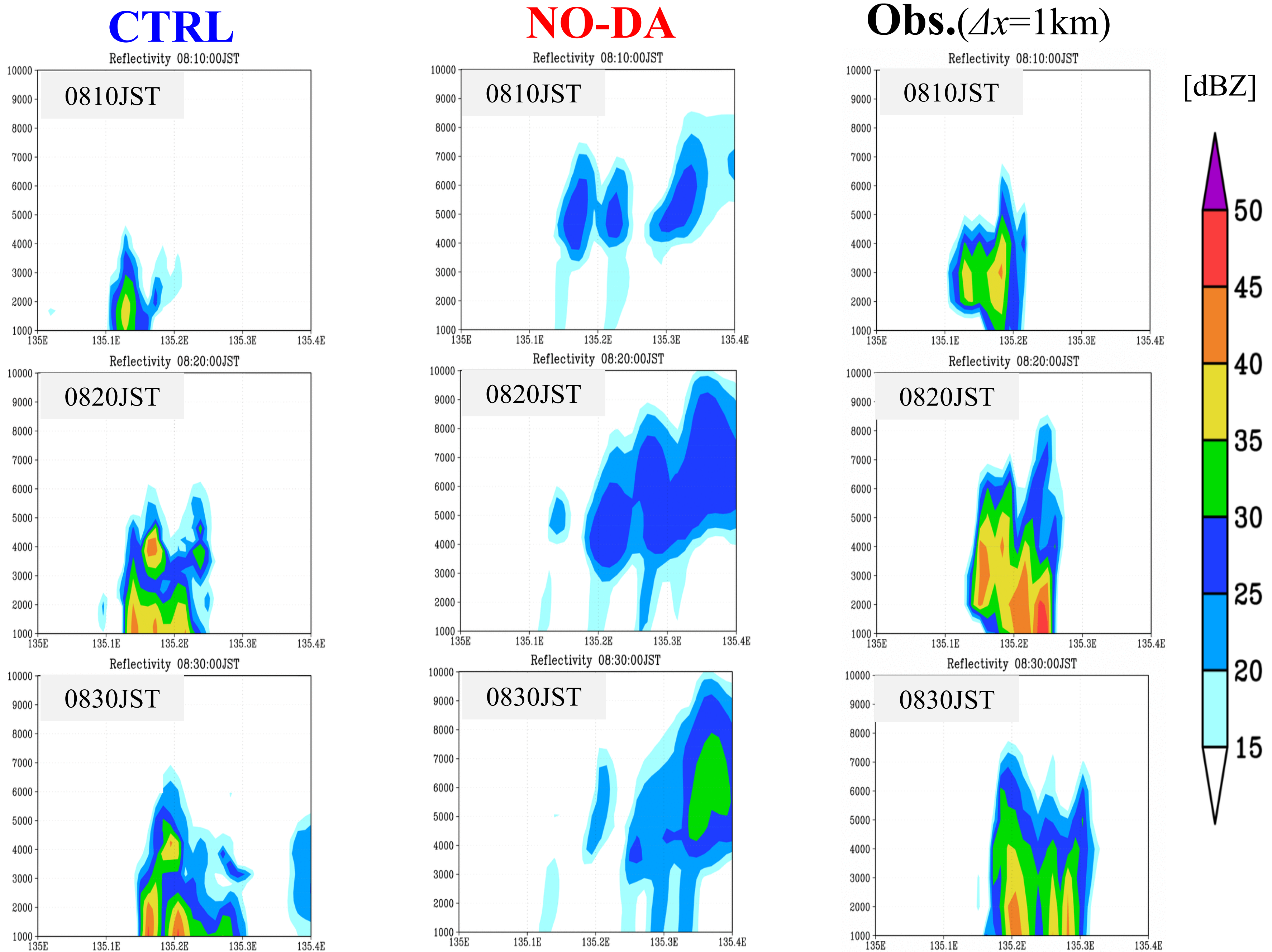
- Ref ≧ 5dBZ ⇒ Assimilated raw PAWR data
- Ref ＜ 5dBZ ⇒ Assimilated 5dBZ

(Aksoy et al. 2010)

1.3 Radar reflectivity at 2-km elevation (Analysis)



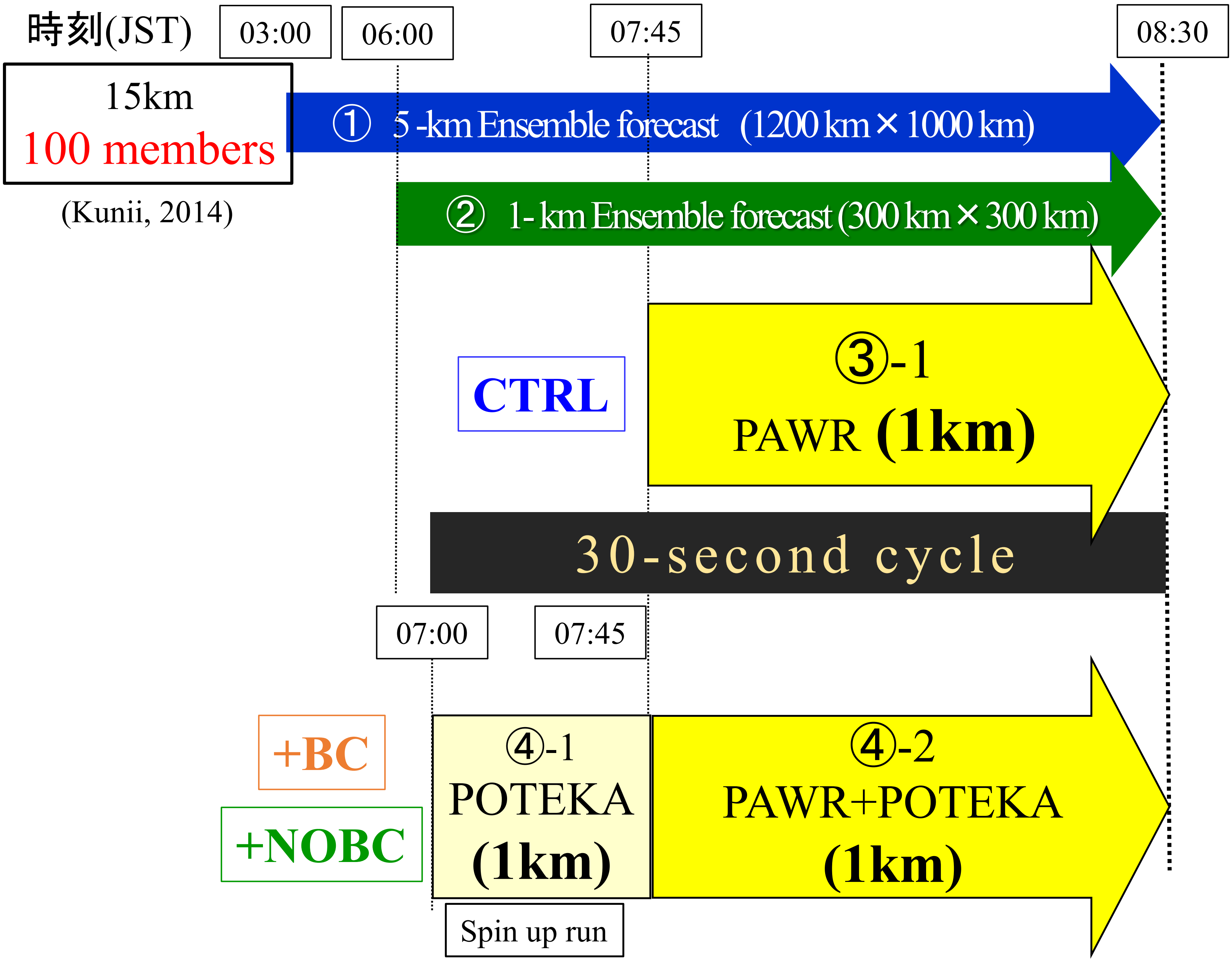
1.4 Vertical cross-section at 34.68N (Analysis)



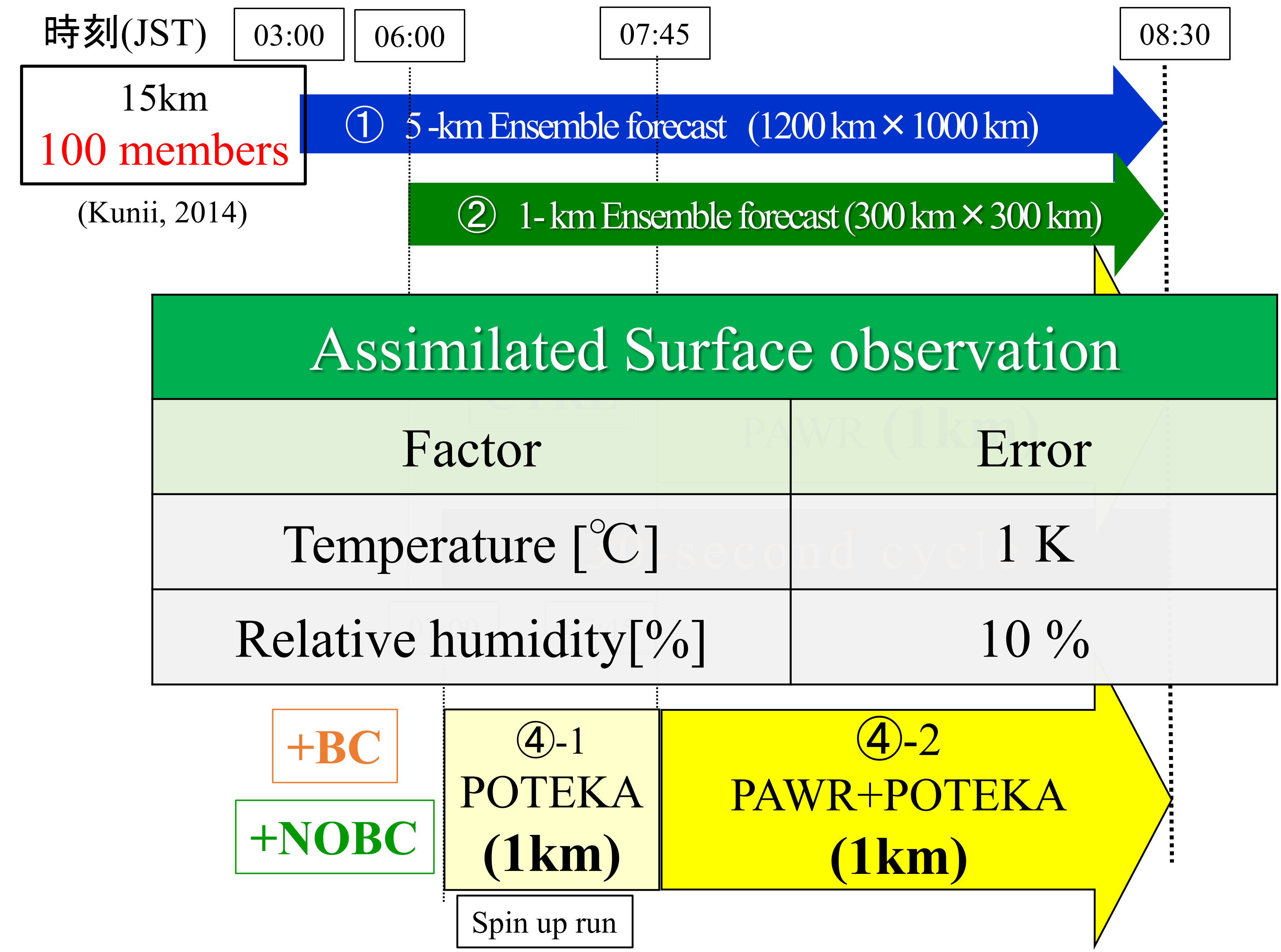
- Simulated a local severe rainstorm by an isolated convection system on September 11, 2014 by **1-km NHM-LETKF.**

		Assimilated observation
1	**1-km** DA experiment	・PAWR
2	**1-km** DA experiments and forecasts (Comparison with observation data)	・PAWR ・PAWR+POTEKA(No bias corrected) ・PAWR+POTEKA(Bias corrected)
3	**1-km** and **100-m** DA experiments (Comparison with resolution)	・PAWR
4	**100-m** DA experiments and forecasts (Comparison with observation data)	・PAWR ・PAWR+POTEKA(Bias corrected)

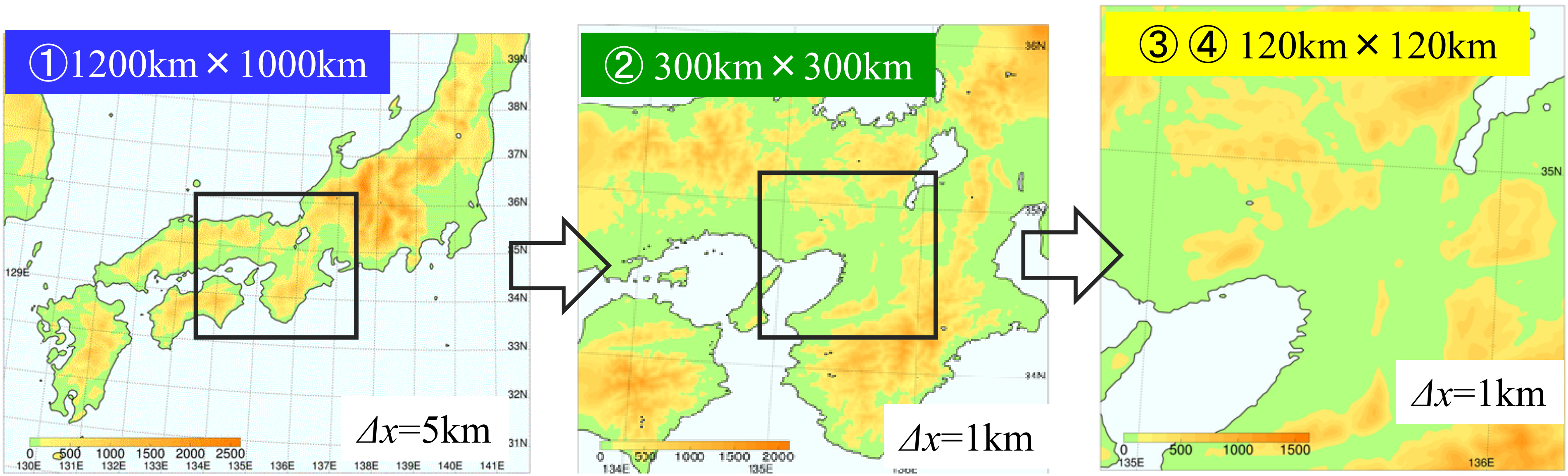
2.0 The workflow of DA experiments at 1-km resolution



2.0 The workflow of DA experiments at **1-km resolution**



Assimilated Surface observation	
Factor	Error
Temperature [℃]	1 K
Relative humidity[%]	10 %



①1200km×1000km
0 500 1000 1500 2000 2500
130E 131E 132E 133E 134E 135E 136E 137E 138E 139E 140E 141E
39N 38N 37N 36N 35N 34N 33N 32N 31N
129E
Δx=5km
② 300km×300km
0 500 1000 1500 2000
134E 135E
36N 35N 34N
Δx=1km
③ ④ 120km×120km
0 500 1000 1500
135E 136E
35N
Δx=1km

2.1 Bias correction for POTEKA II

- There is a significant bias in obs. by POTEKA Ⅱ

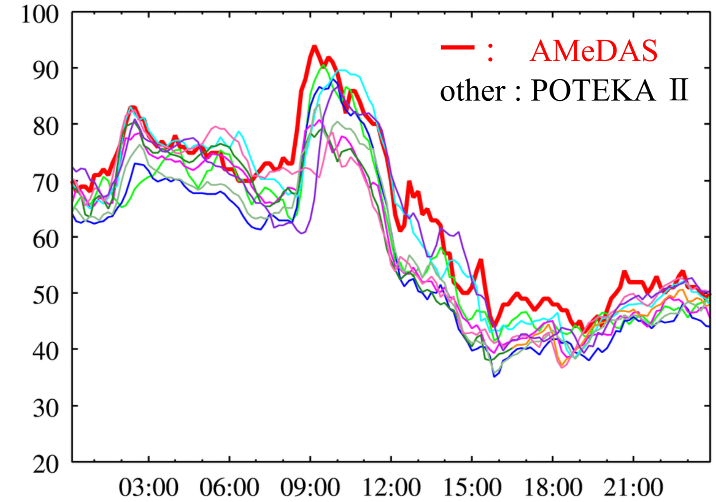
(Ex.) Relative humidity : Under estimated
Temperature : Over estimated

A bias correction method developed
with the Kobe observatory data
as the unbiased ground truth.

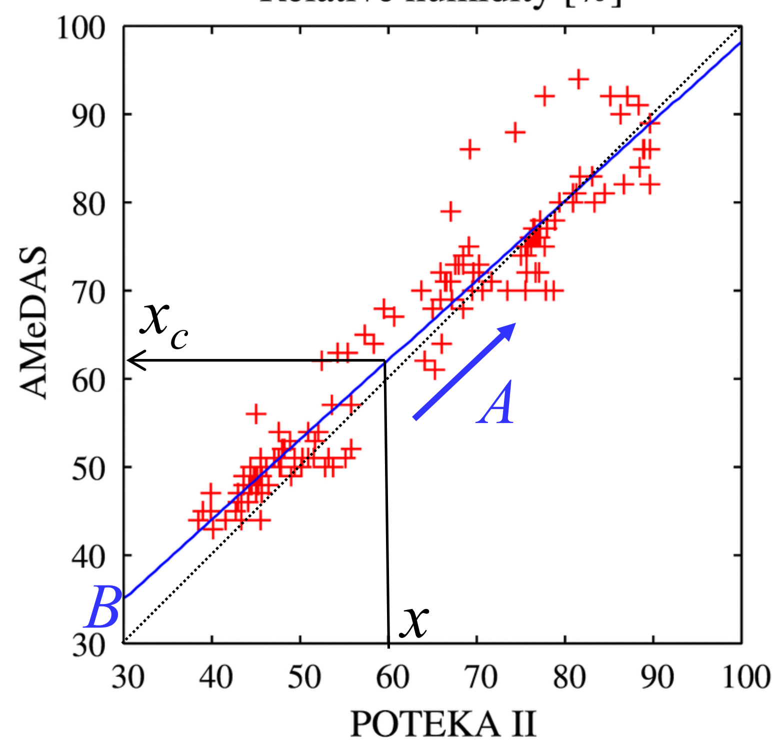
- Plot POTEKA Ⅱ (x) and Kobe observatory data (y)
- Calculate the gradient (A) and intercept(B) by least squares method.
- Calculate the corrected values (x_c) by following formula $x_c = Ax + B$

(Remark : x and y are 10 minutes averaged values)

- Original POTEKA Ⅱ data (x_{30}) : $x_{30} = x + x'$
- Corrected POTEKA II data (x_{c30}) : $x_{c30} = x_c + x'$

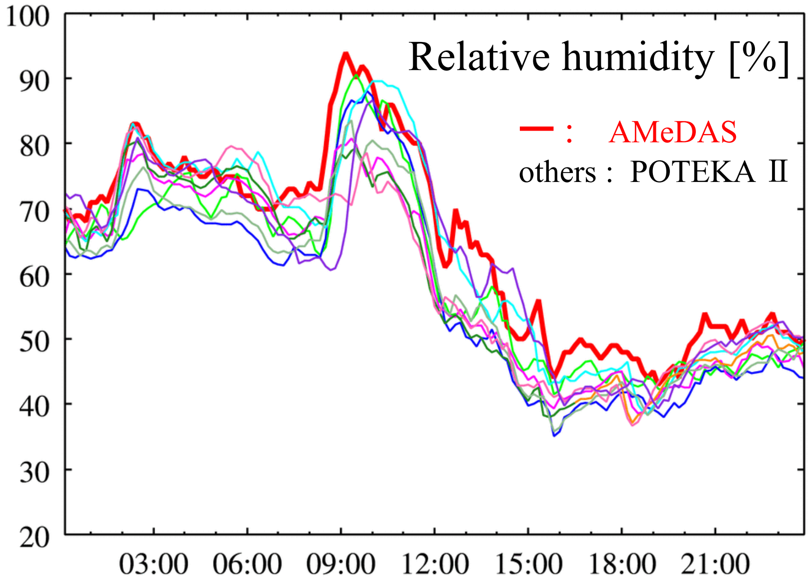


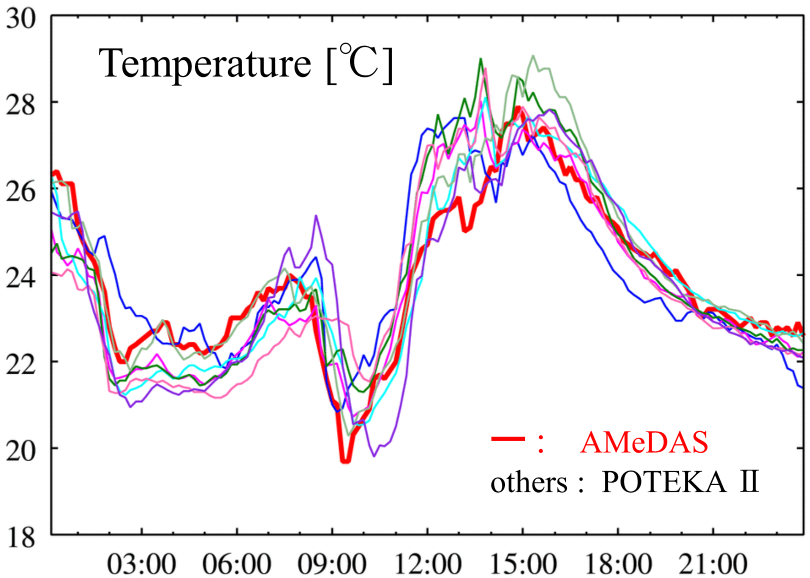
Relative humidity [%]



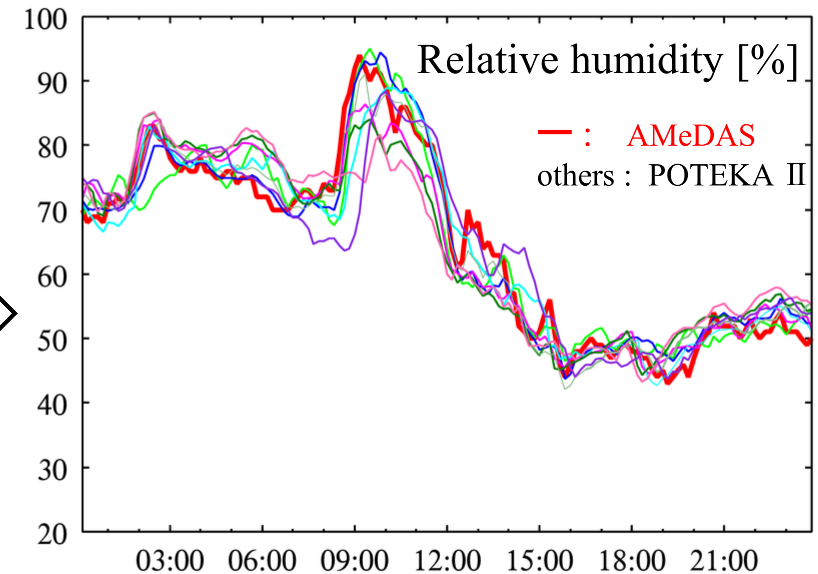
2.2 The results of bias correction

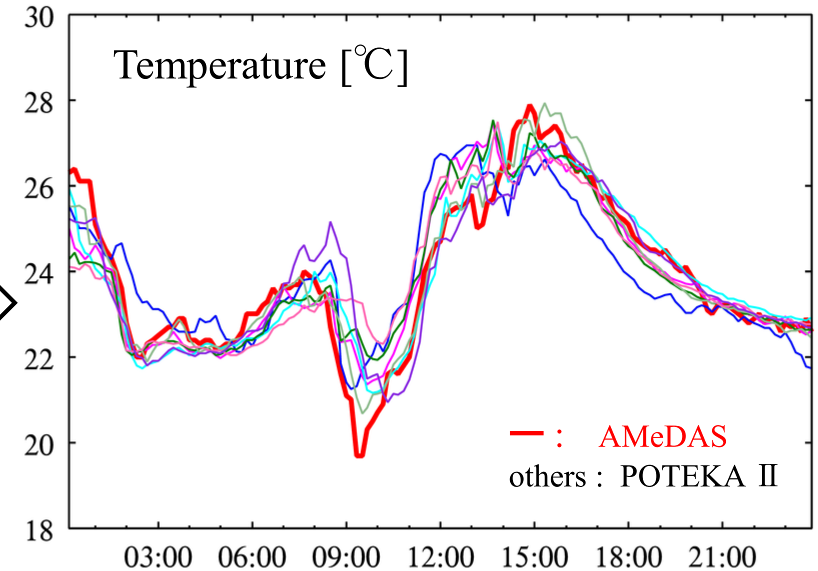
Before correction



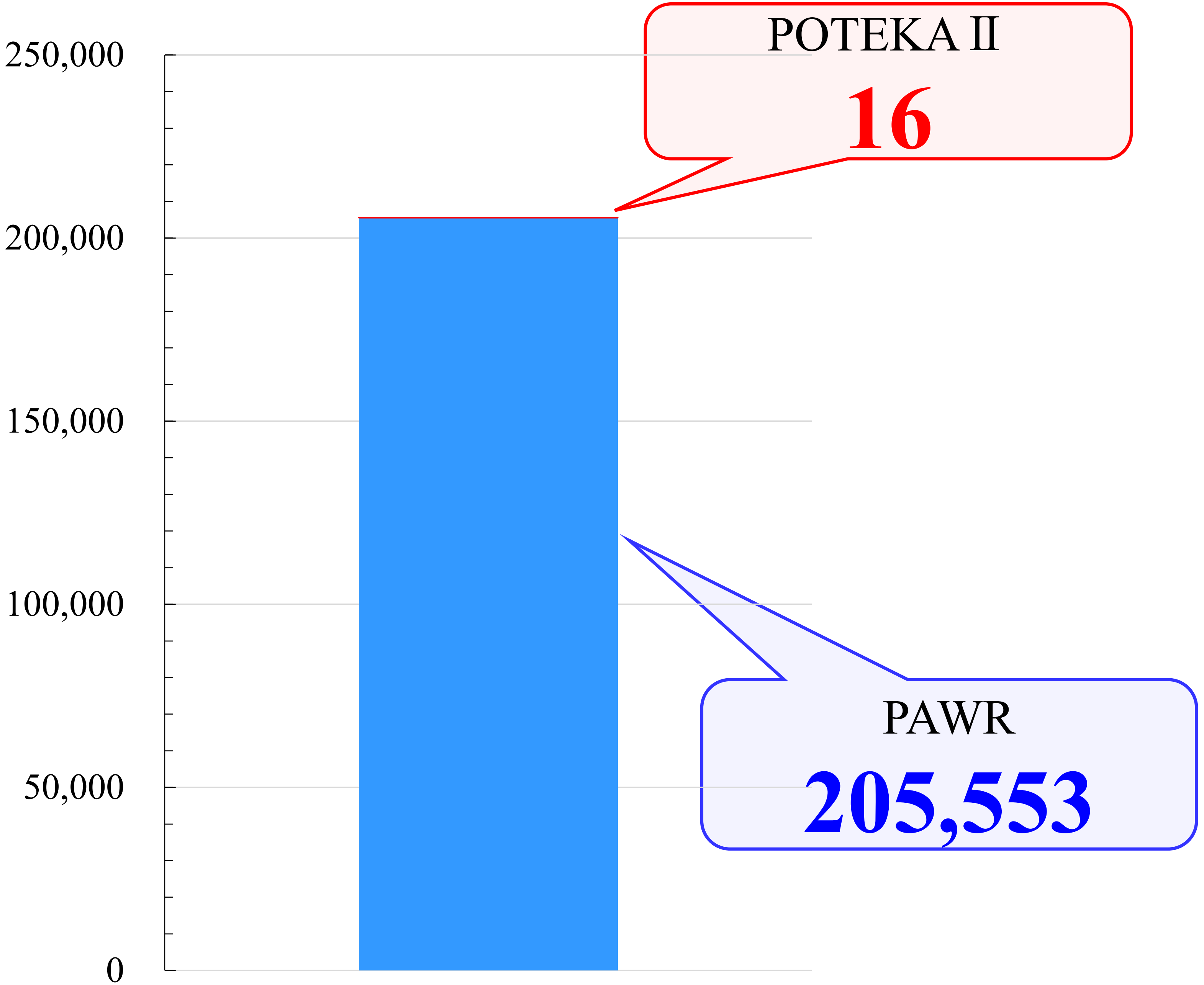


After correction

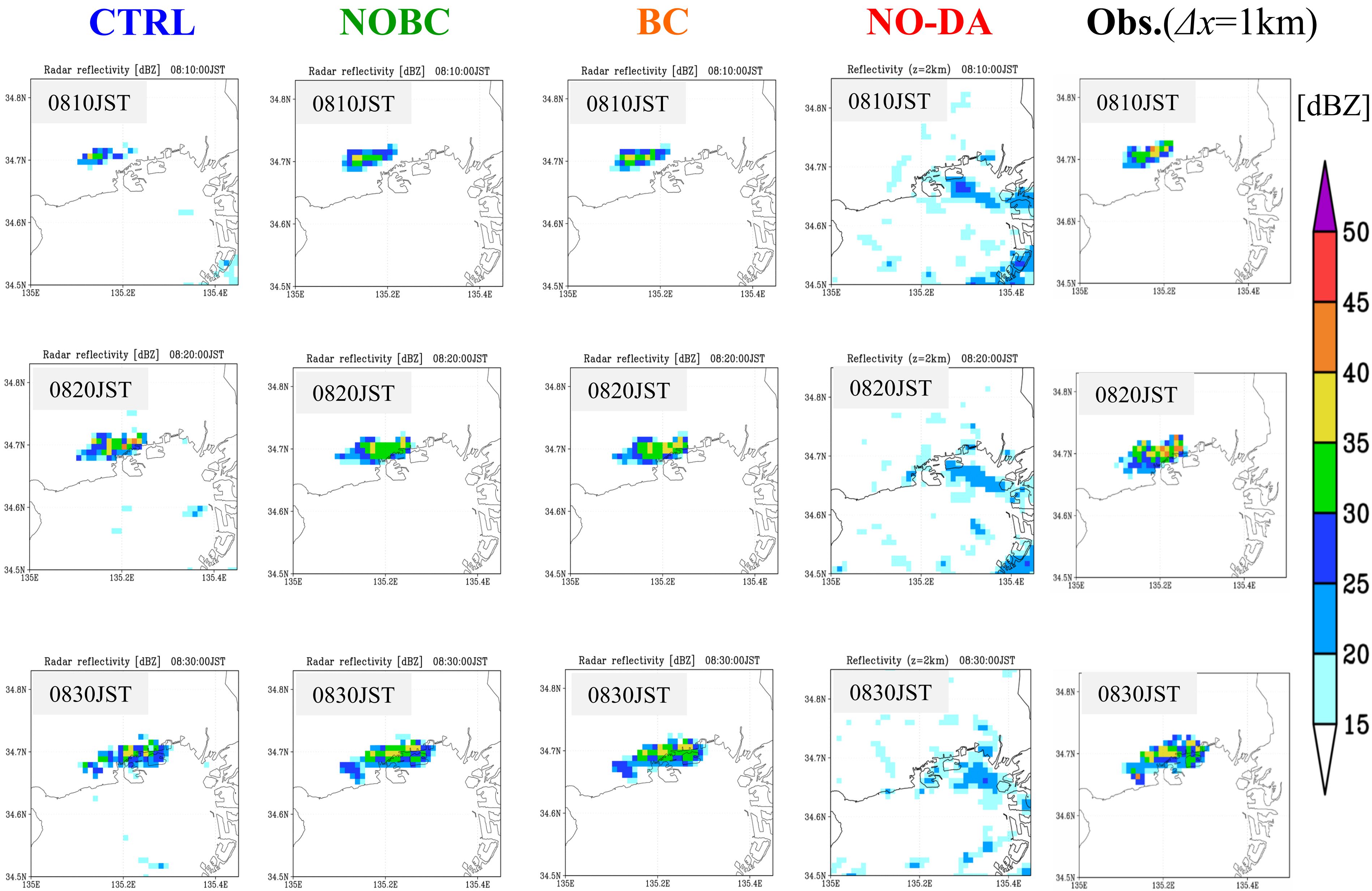




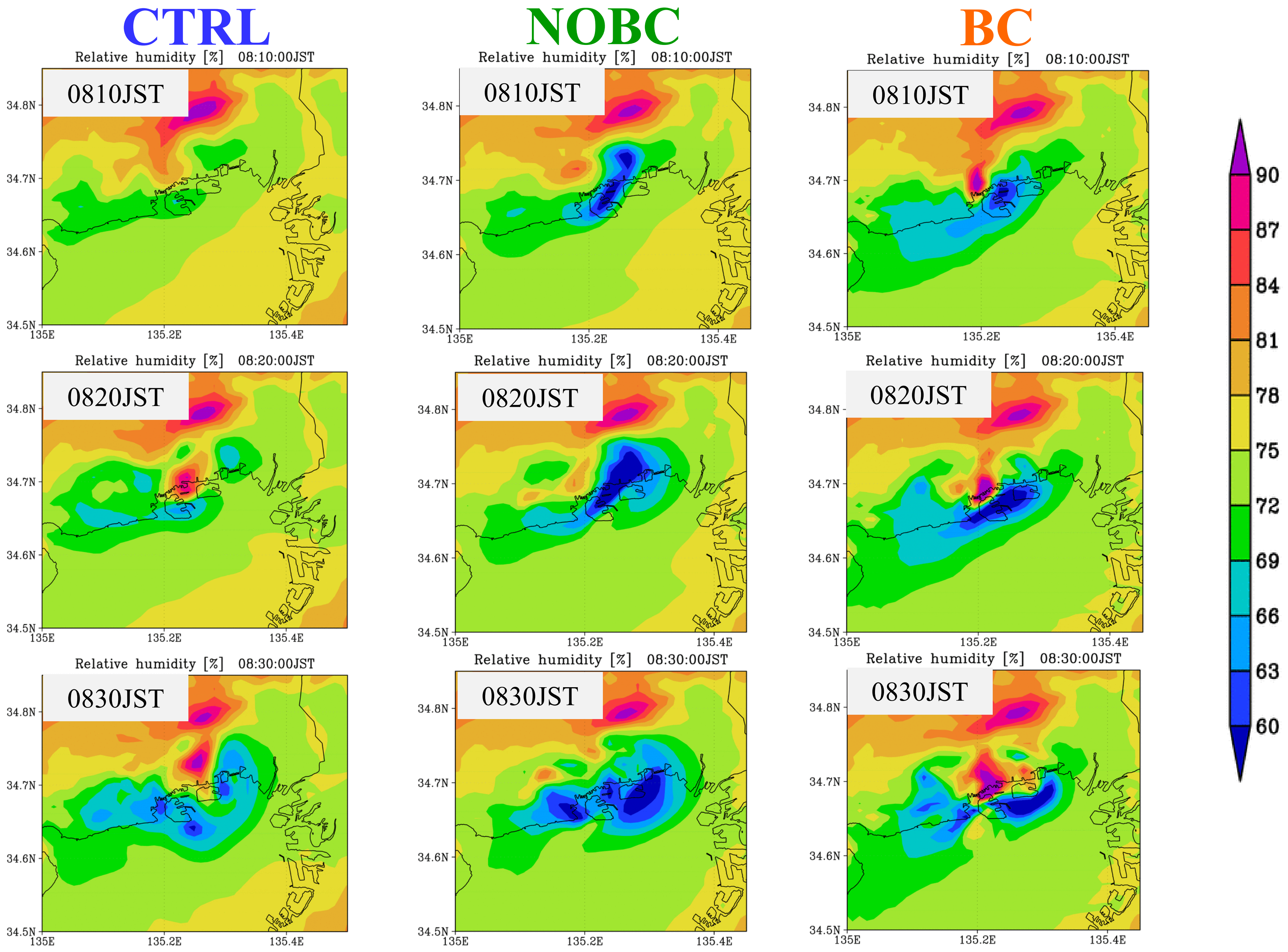
2.3 The amount of observations in a DA cycle



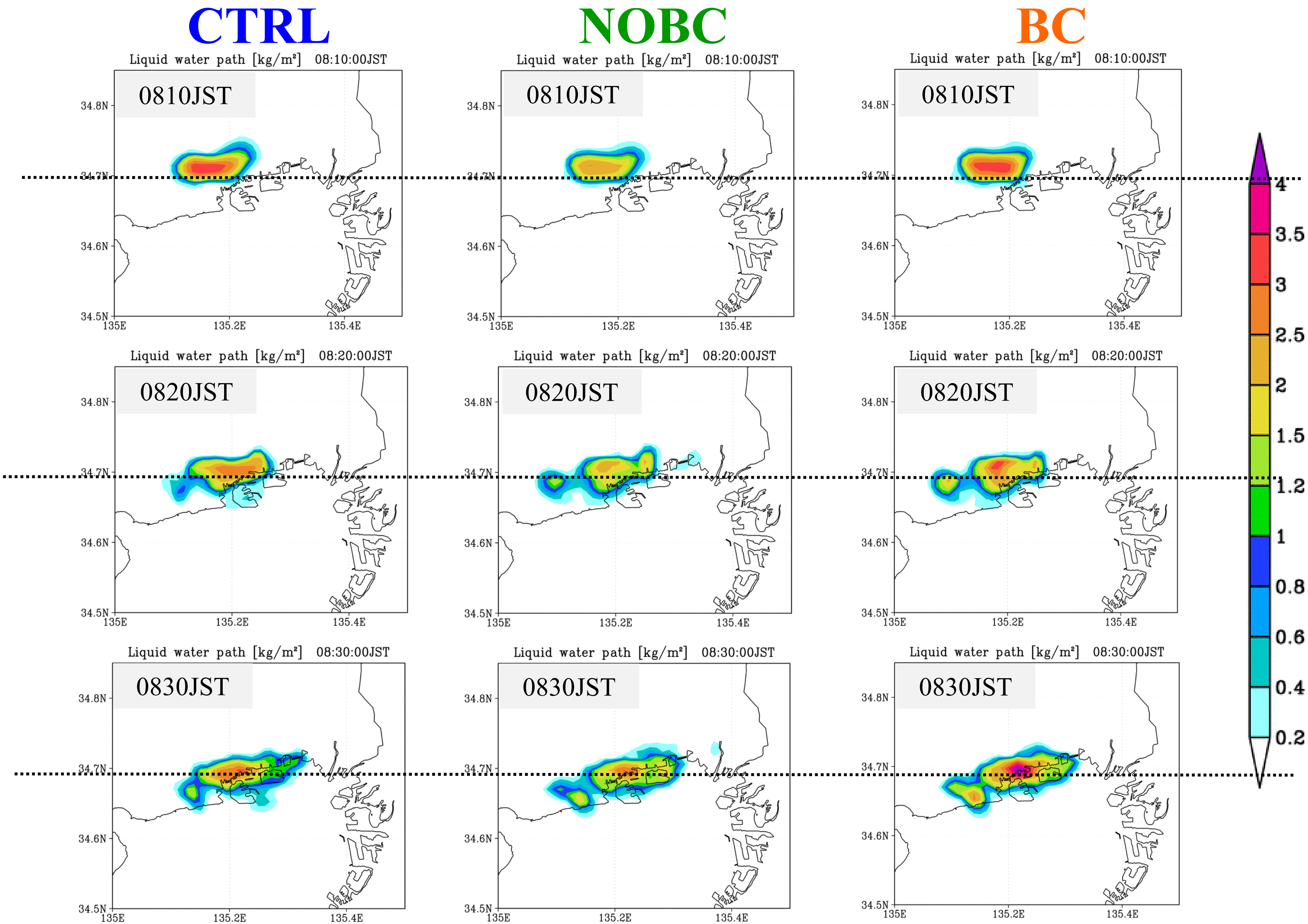
2.4 Radar reflectivity at 2-km elevation (Analysis)



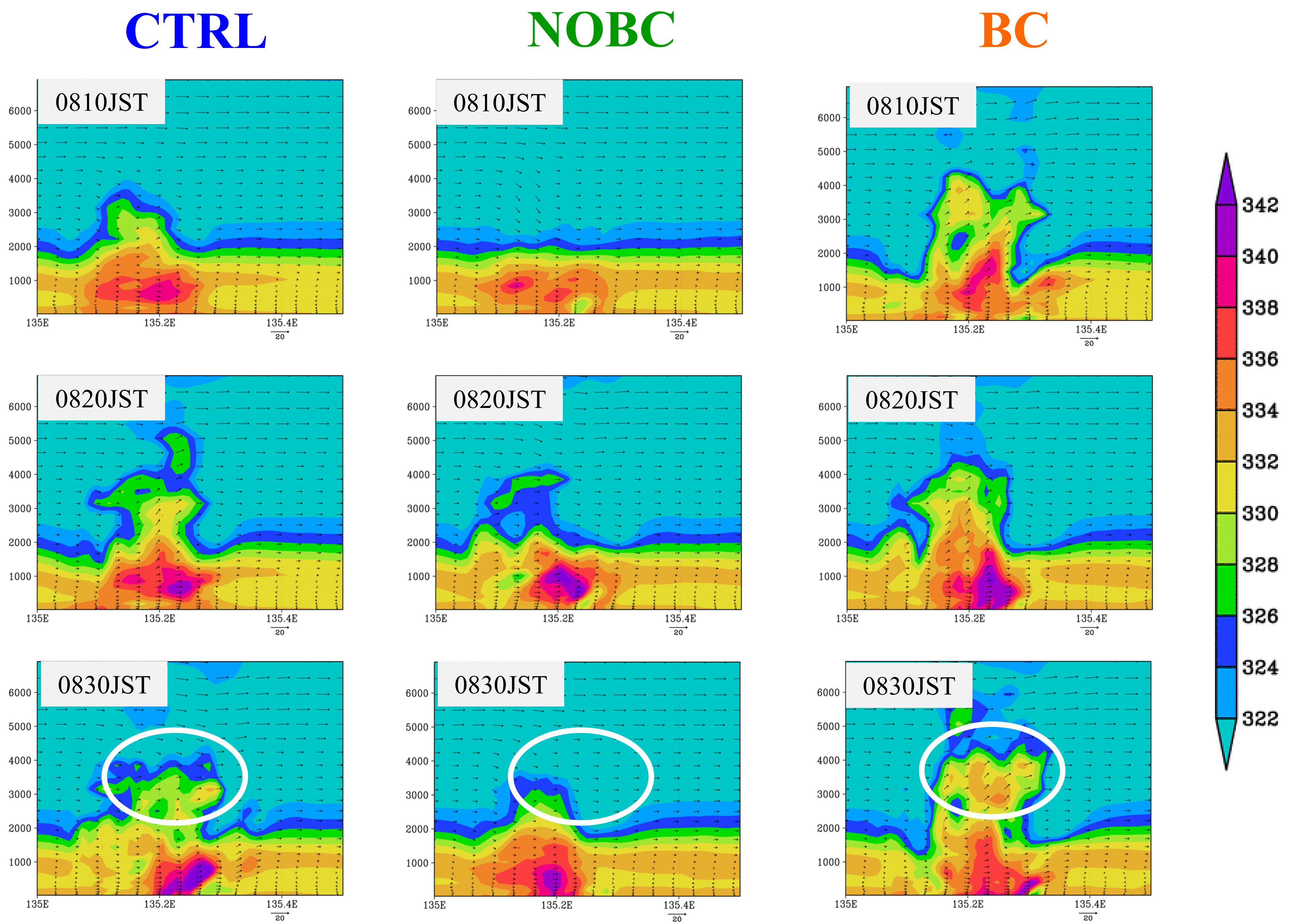
2.5 Surface relative humidity [%] (Analysis)



2.6 Liquid water path [kg/m^2] (Analysis)

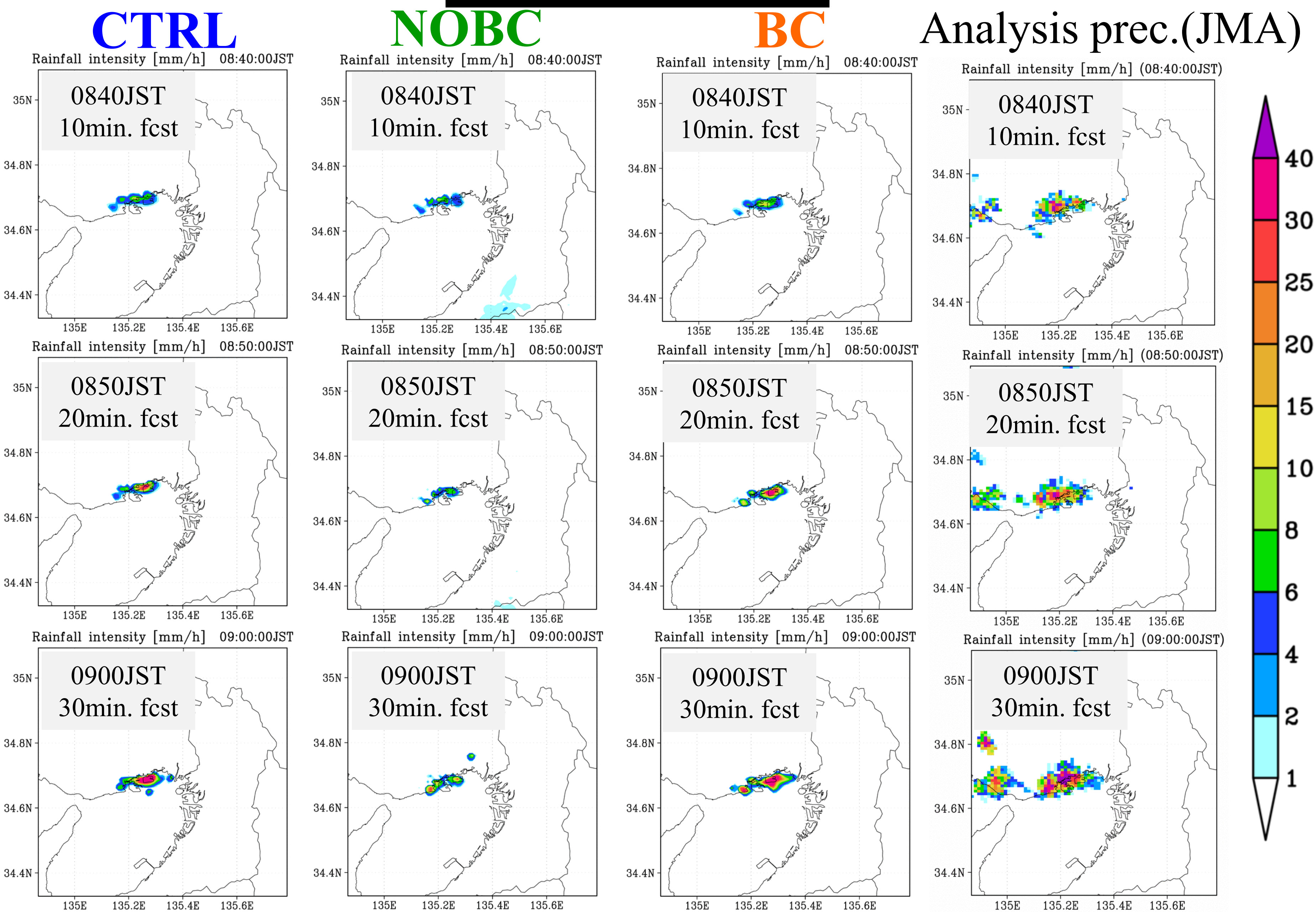


2.7 Equivalent potential temperature[K] (34.695N) (Analysis)



2.8 Surface rainfall amount in forecast experiments (Δx=1km)

Initial time: 0830 JST

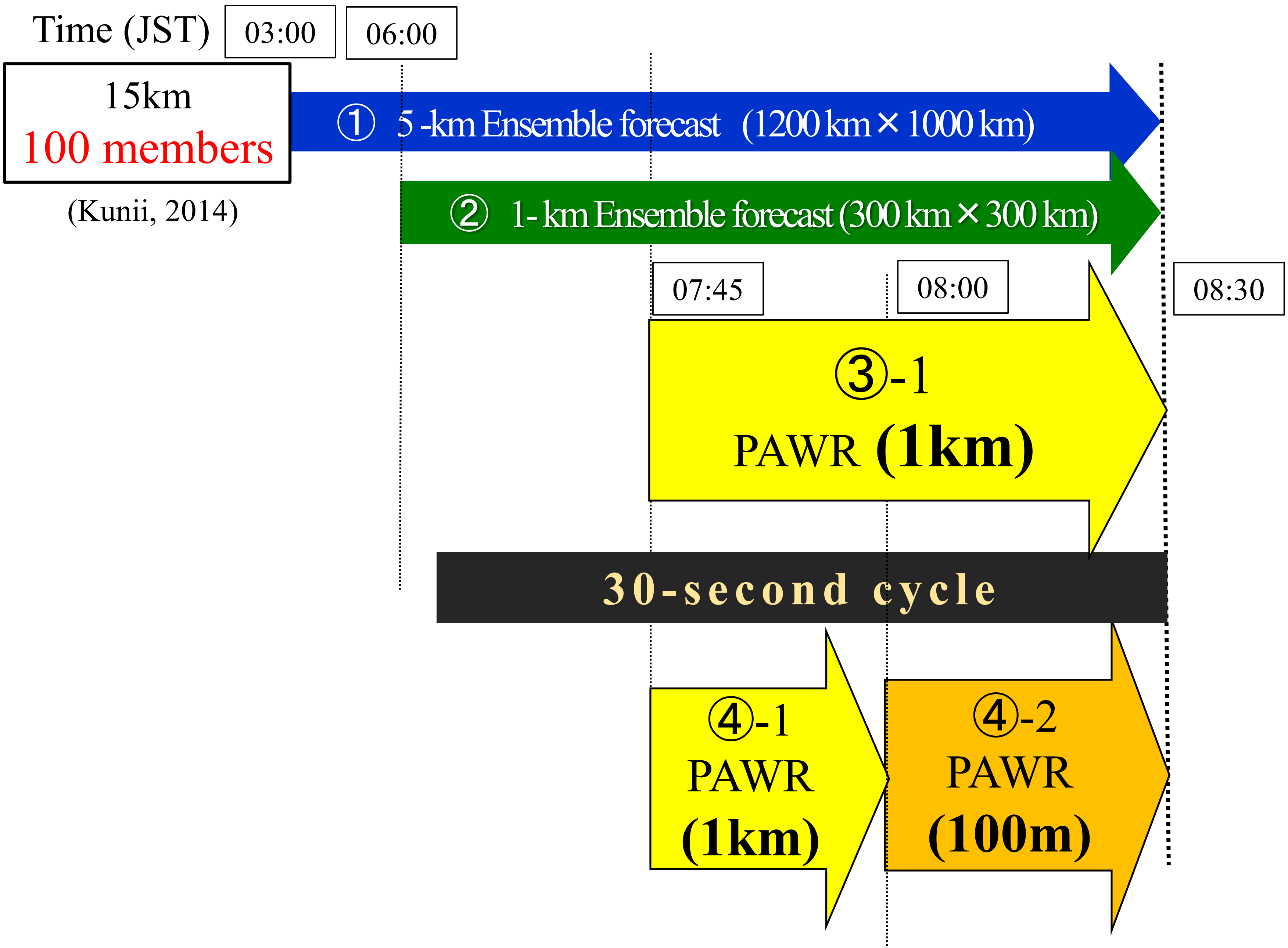


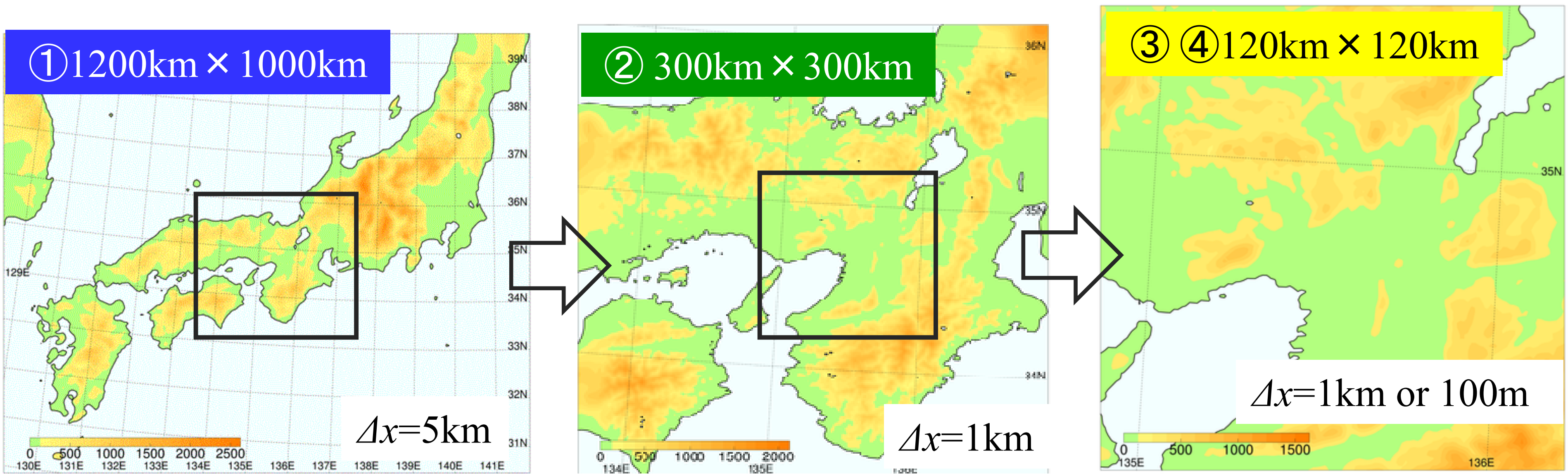
- Simple bias correction algorism was developed.

- Surface data assimilation contributed to **improve RH, LWP and rainfall intensity.**

		Assimilated observation
1	**1-km** DA experiment	・PAWR
2	**1-km** DA experiments and forecasts (Comparison with observation data)	・PAWR ・PAWR+POTEKA(No bias corrected) ・PAWR+POTEKA(Bias corrected)
3	**1-km** and **100-m** DA experiments (Comparison with resolution)	・PAWR
4	**100-m** DA experiments and forecasts (Comparison with observation data)	・PAWR ・PAWR+POTEKA(Bias corrected)

3.1 Resolution dependence in the DA experiment



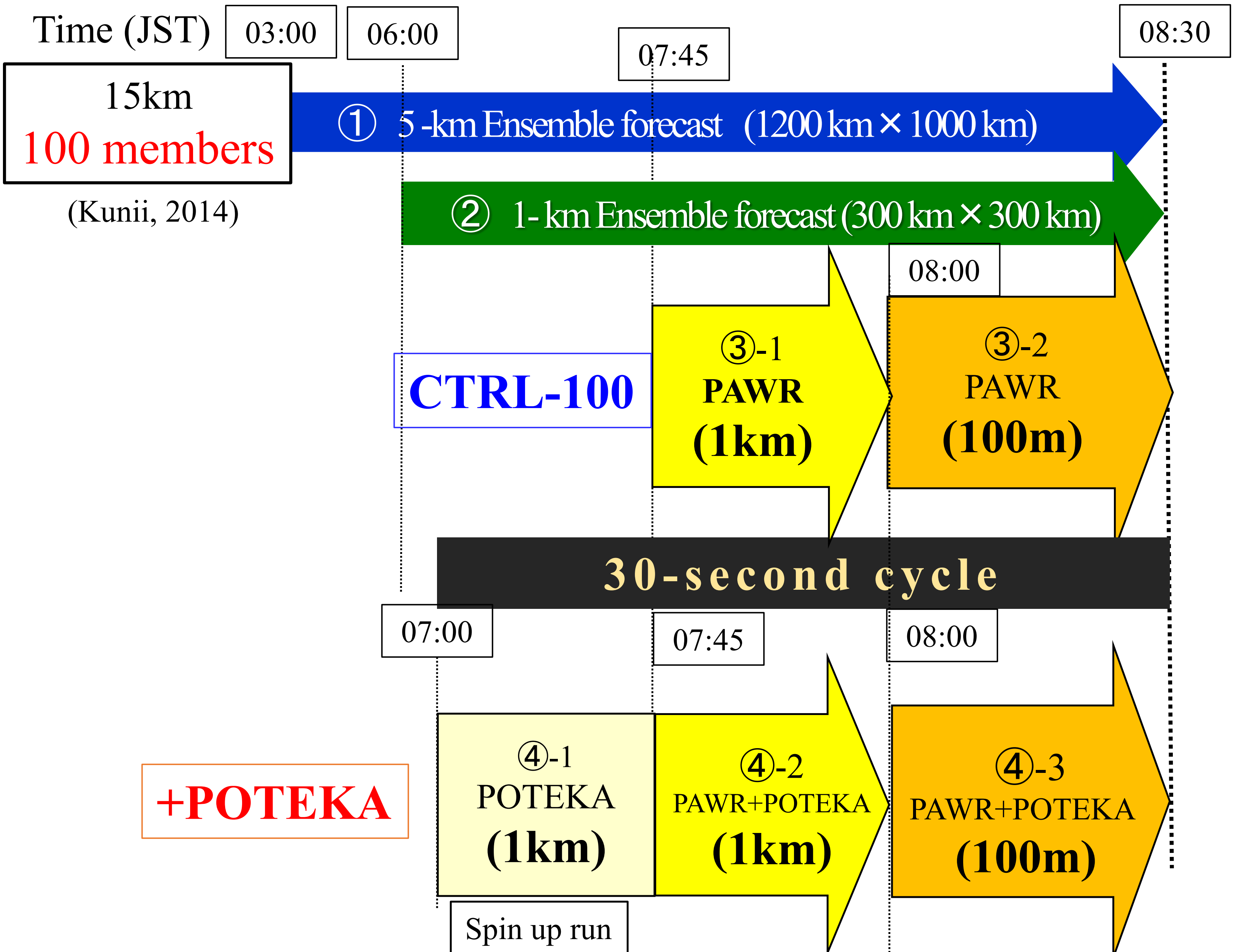


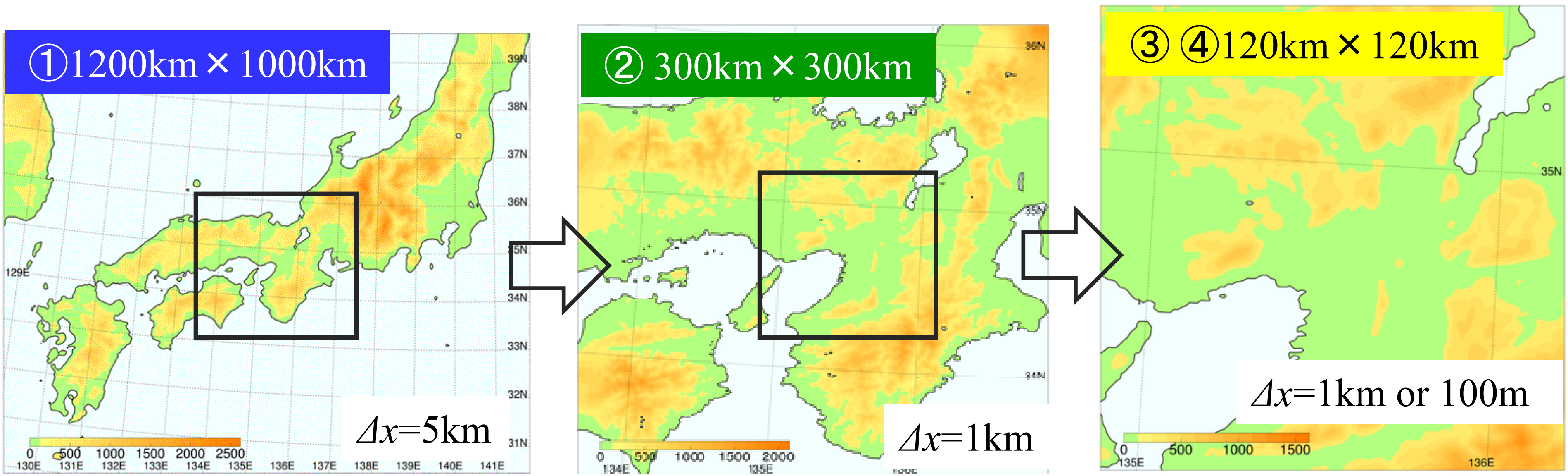
①1200km × 1000km
Δx=5km
② 300km × 300km
Δx=1km
③ ④120km × 120km
Δx=1km or 100m

- DA experiment at **100-m resolution** was performed, and the active convective system was simulated in detail.

		Assimilated observation
1	**1-km** DA experiment	・PAWR
2	**1-km** DA experiments and forecasts (Comparison with observation data)	・PAWR ・PAWR+POTEKA(No bias corrected) ・PAWR+POTEKA(Bias corrected)
3	**1-km** and **100-m** DA experiments (Comparison with resolution)	・PAWR
4	**100-m** DA experiments and forecasts (Comparison with observation data)	・PAWR ・PAWR+POTEKA(Bias corrected)

4.1 The workflow of DA experiments at 100-m resolution




①1200km × 1000km
Δx=5km
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Δx=1km
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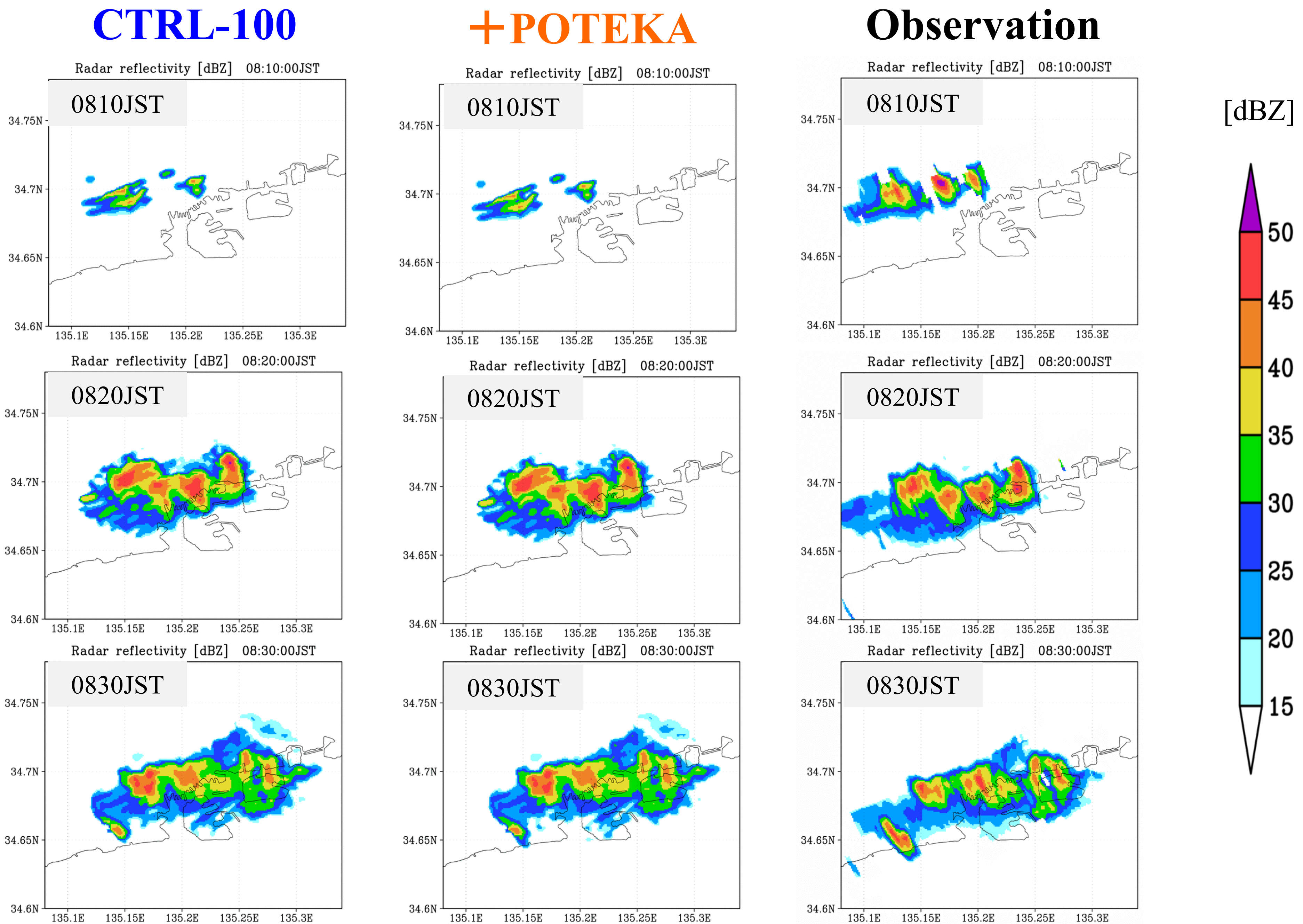
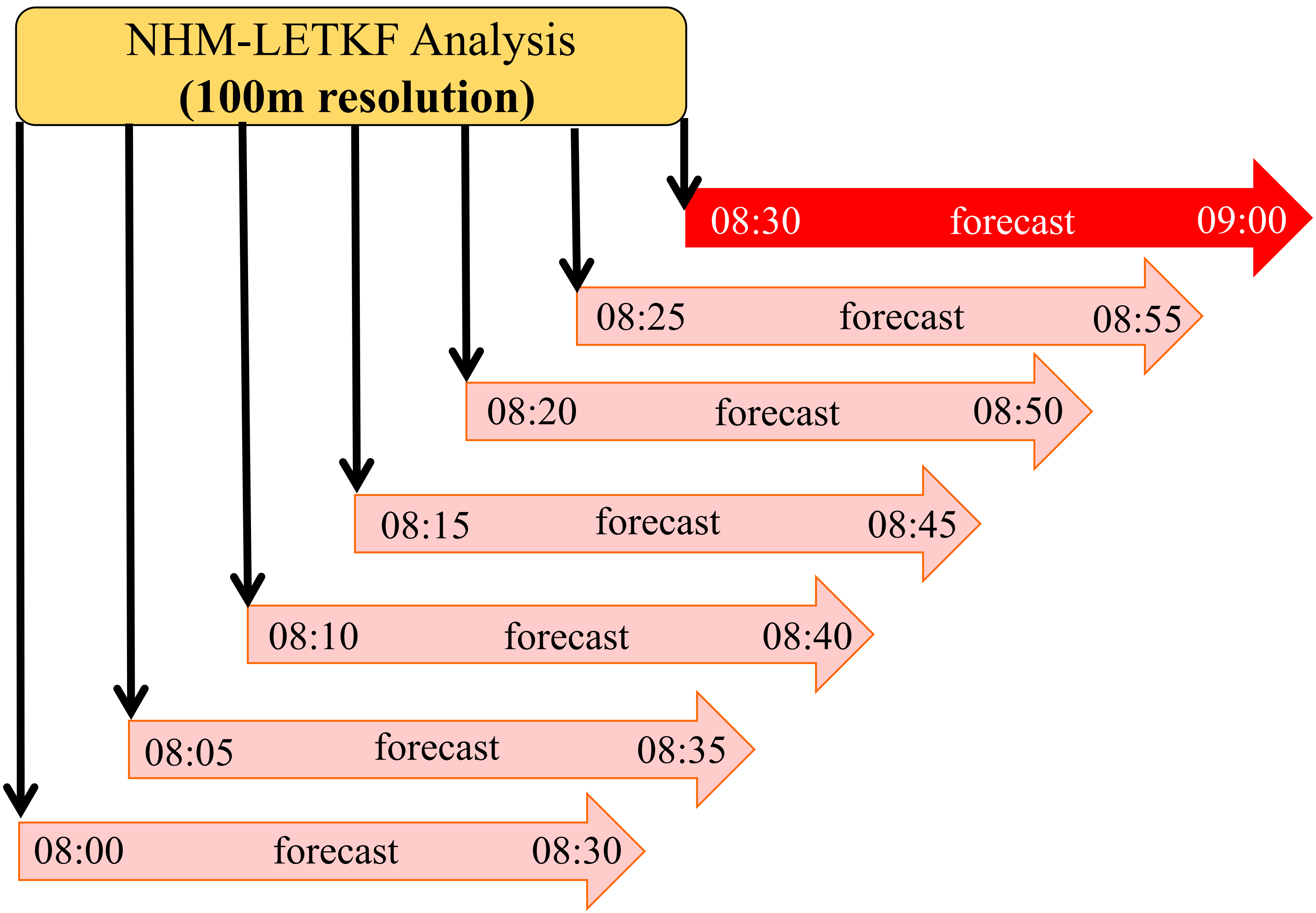
Δx=1km or 100m

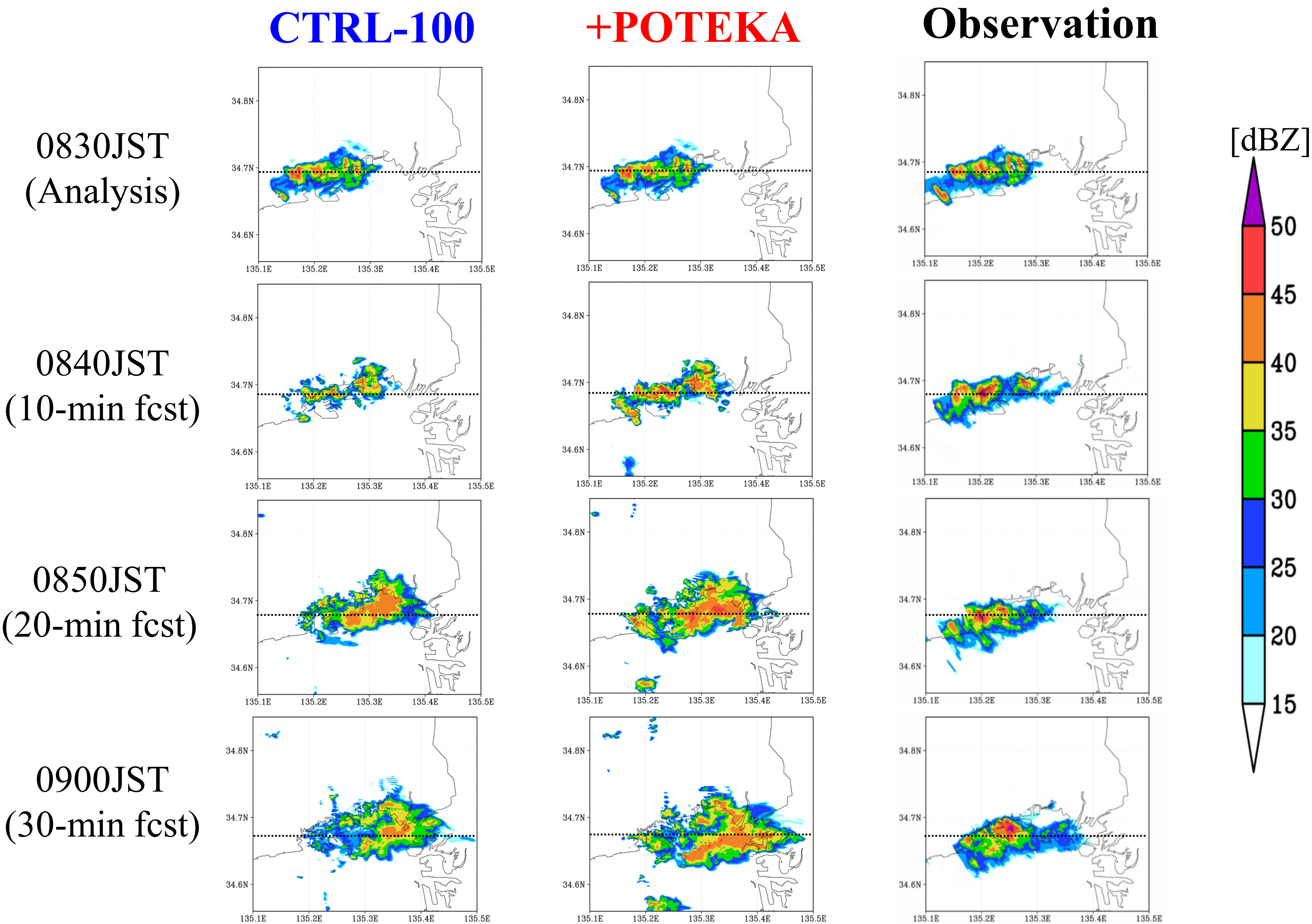
4.2 Radar reflectivity at 2-km elevation (Analysis)



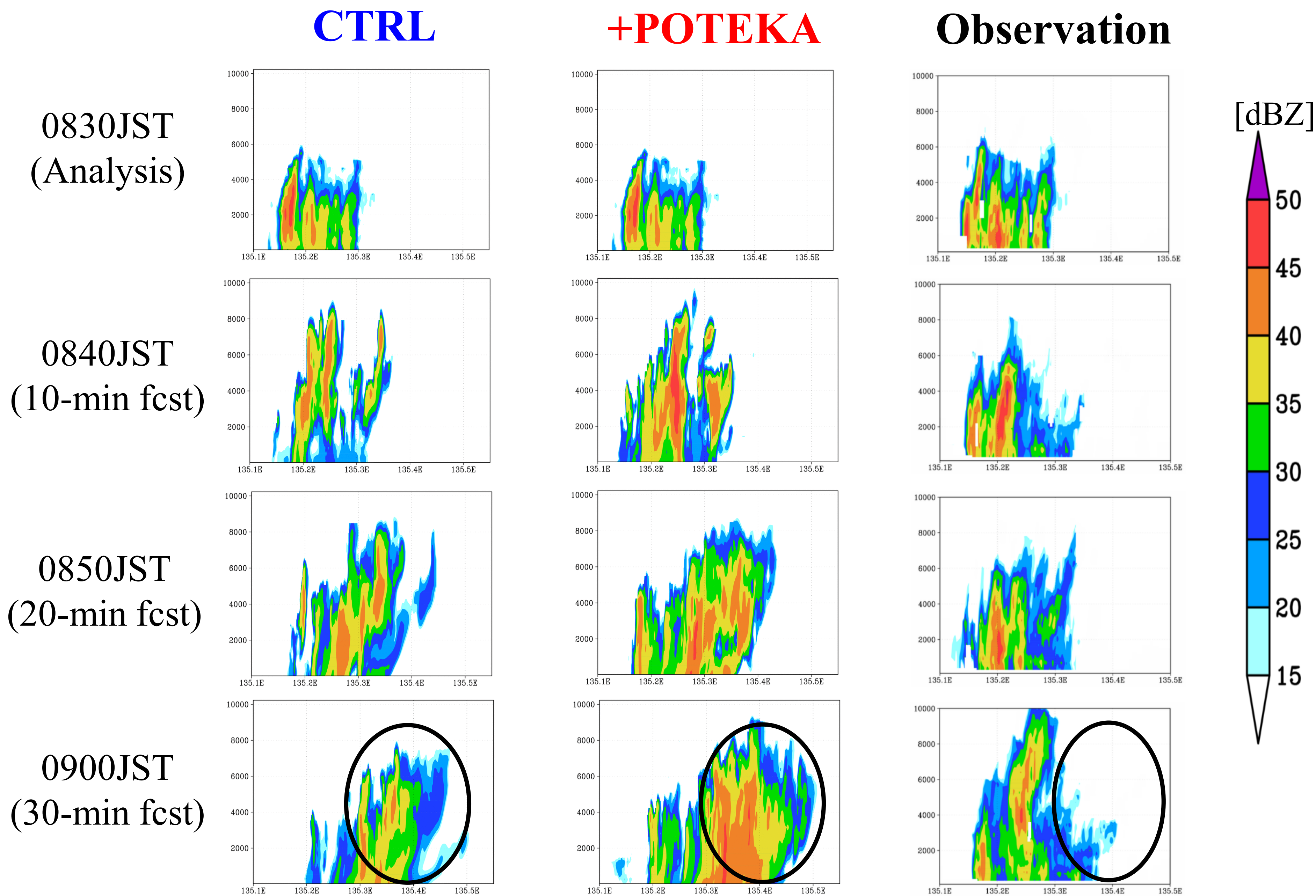
4.3 Workflow of the forecast experiments



4.4 Radar reflectivity (2-km elevation): Initial: 0830 JST



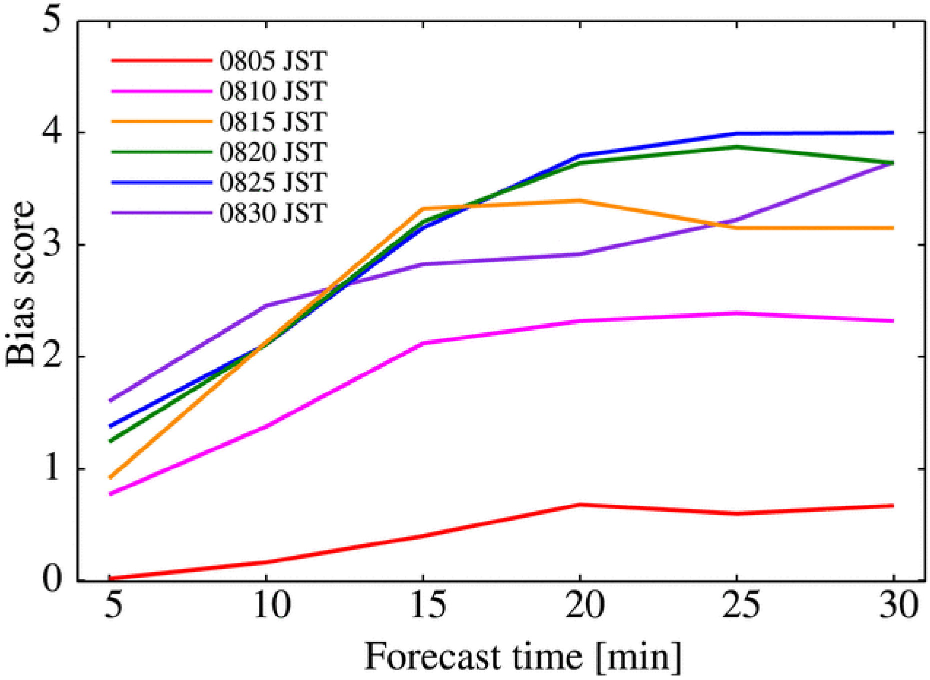
4.5 Vertical cross section : Initial: 0830 JST



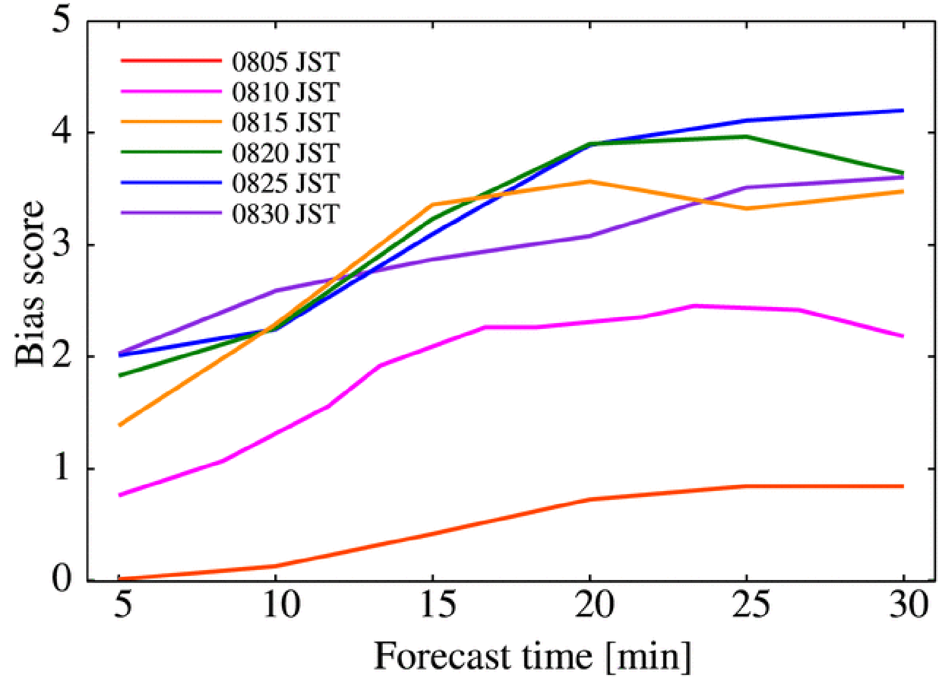
4.6 Bias score in forecasts

- Elevation 2km
- Threshold 25dBZ

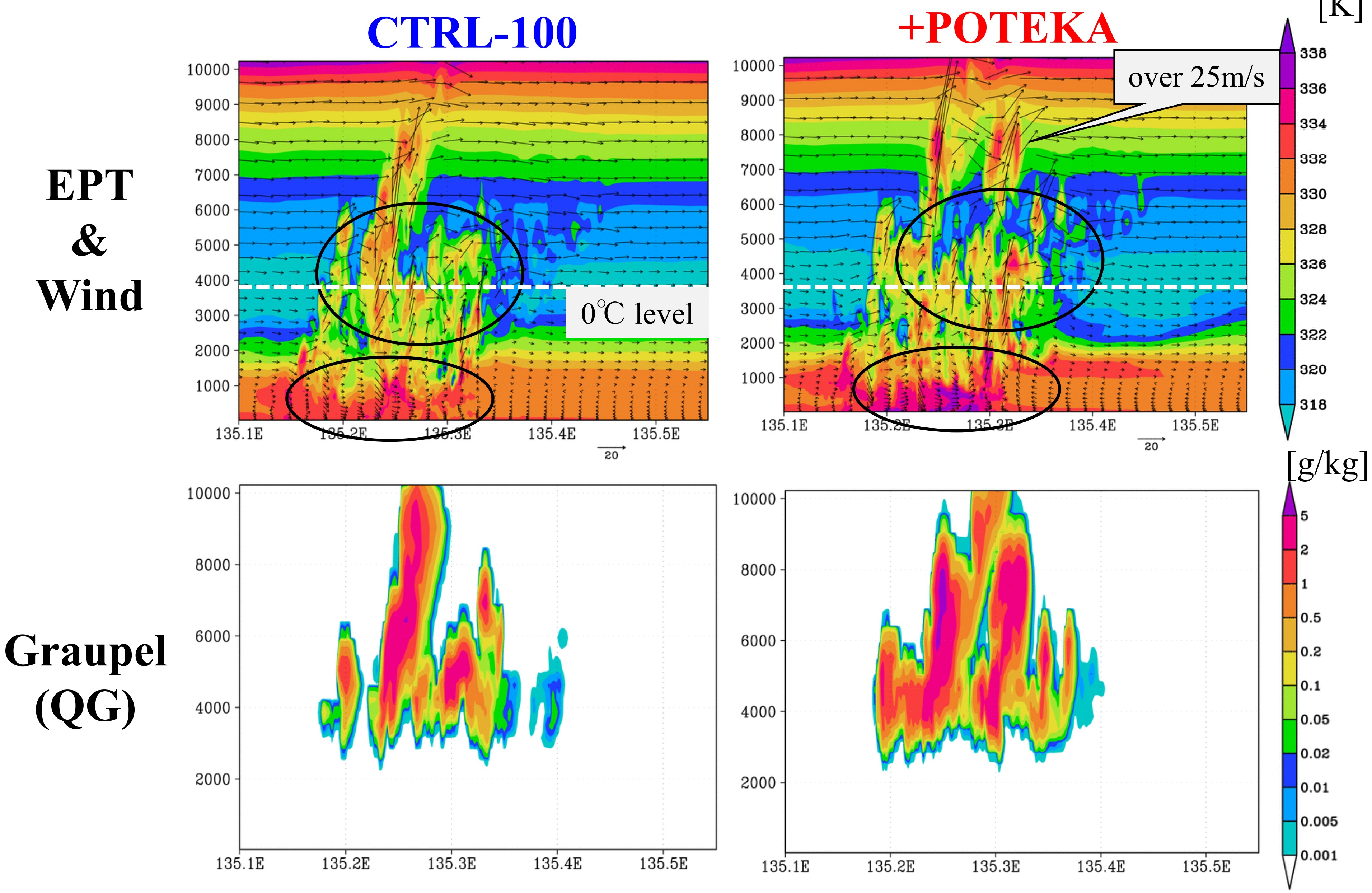
CTRL-100



+POTEKA



4.7 Vertical cross-section in 10-min. forecast (Initial 0830JST, 34.69N)



5. Summary

- We performed and succeeded 30-seconds update LETKF cycles with PAWR and surface observations.
- Reproduced a local severe rainstorm by an isolated convection system on September 11, 2014.
- Bias corrected surface DA contributed to improve rainfall forecast.
- In forecasts, it remains some issues.

Thank you for your attention !