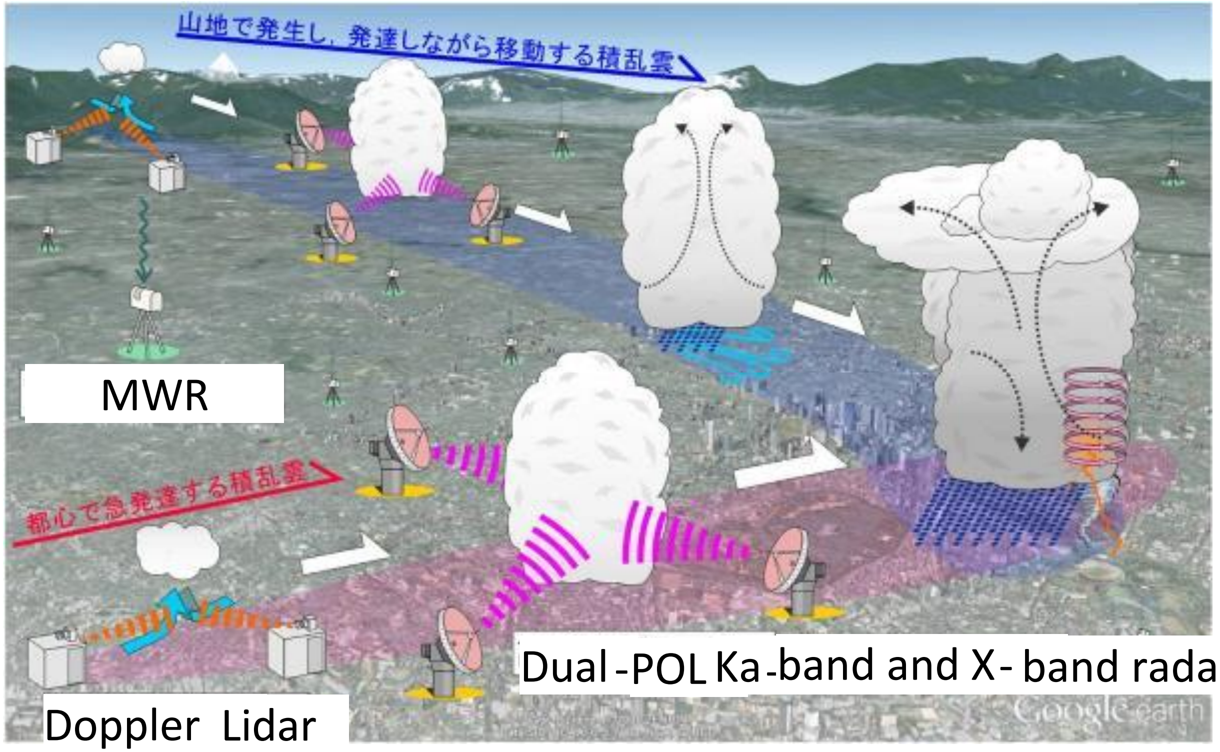
Concept of our PROJECT (FY2011 -2015) and our contribution to TOPROF

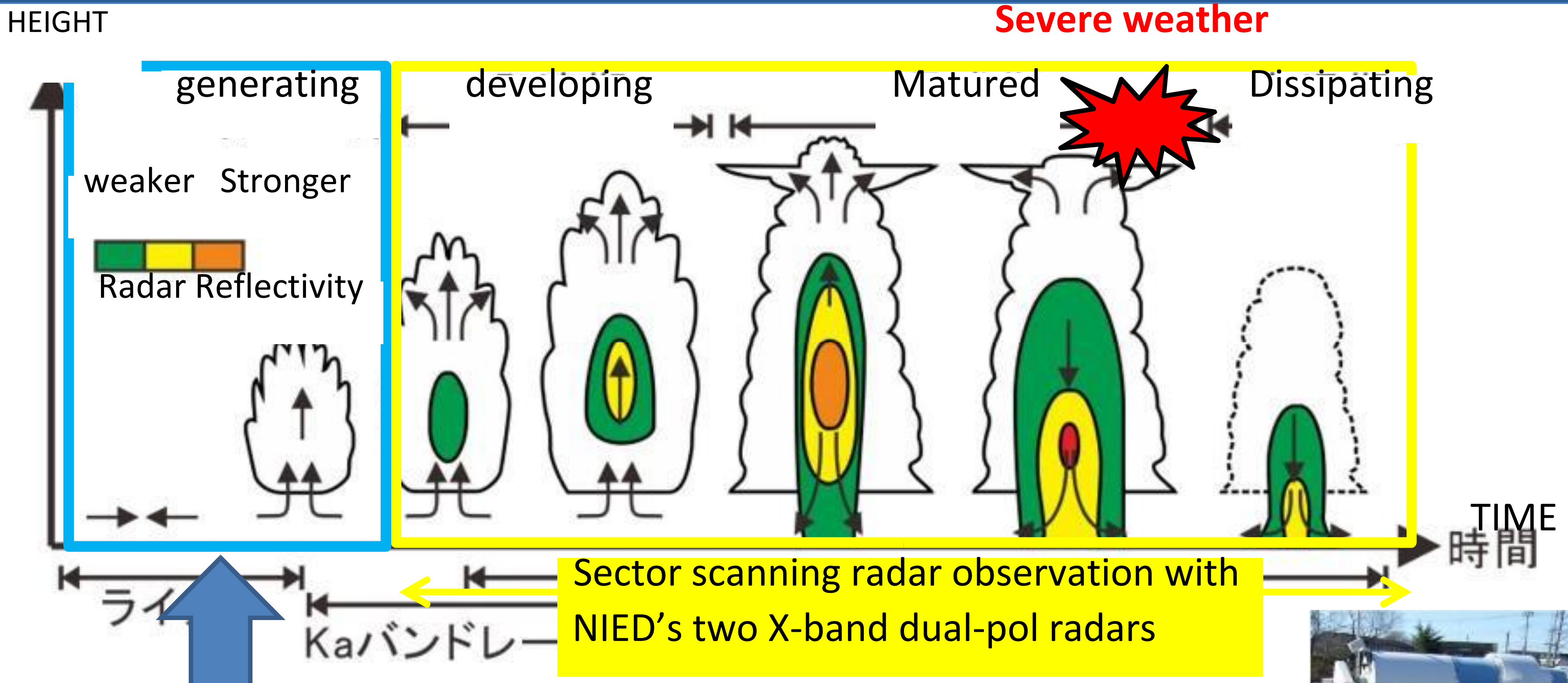


Shingo SHIMIZU

Observation network for Severe convection developed in TOKYO metropolitan region

National Research **I**nstitute for **E**arth Science and **D**isaster Prevention, Japan (**NIED**)

Concept of our PROJECT (FY2011-2015)
(LCbEx: Observation for Lifecycle of Cb Experiment)

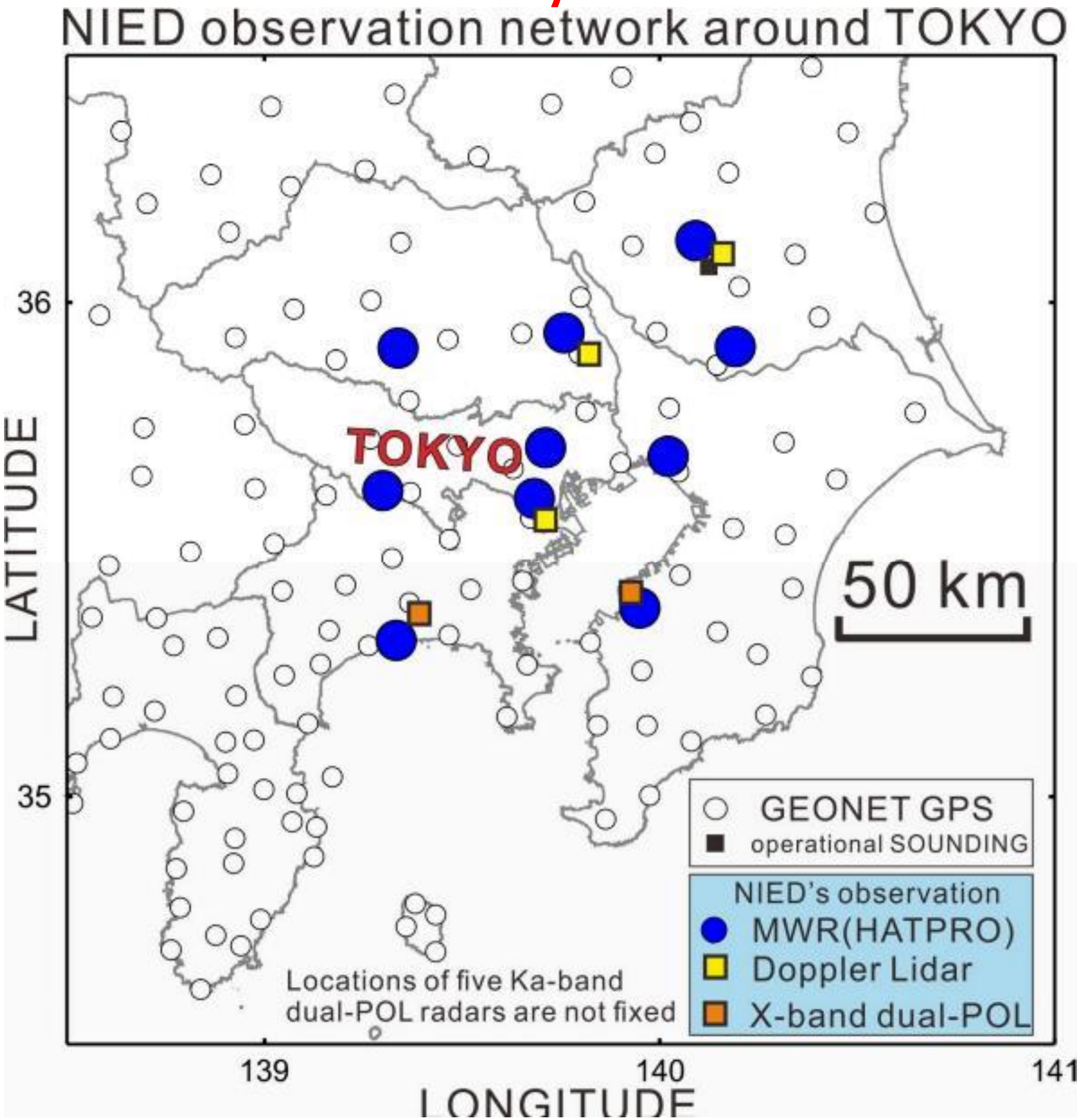


To detect developing stage of cumulonimbus.

- **three-Doppler lidars (maximum range is 30 km)**
- **five Ka-band dual-pol radar (maximum range is 30 km)**
- **10 microwave radiometers (MWRs) (RPG’s HATPRO)**

We have been developed 3DVAR-IAU assimilation system using X-band radar. Now we will upgrade the system to assimilate “lidar” and “MWR” data

Our high-density network of MWR Observation around Tokyo and Contribution to TOPROF



FY2014:
Development of
1DVAR assimilation for
MWR's brightness
Temperature, and
validation
Using sounding data

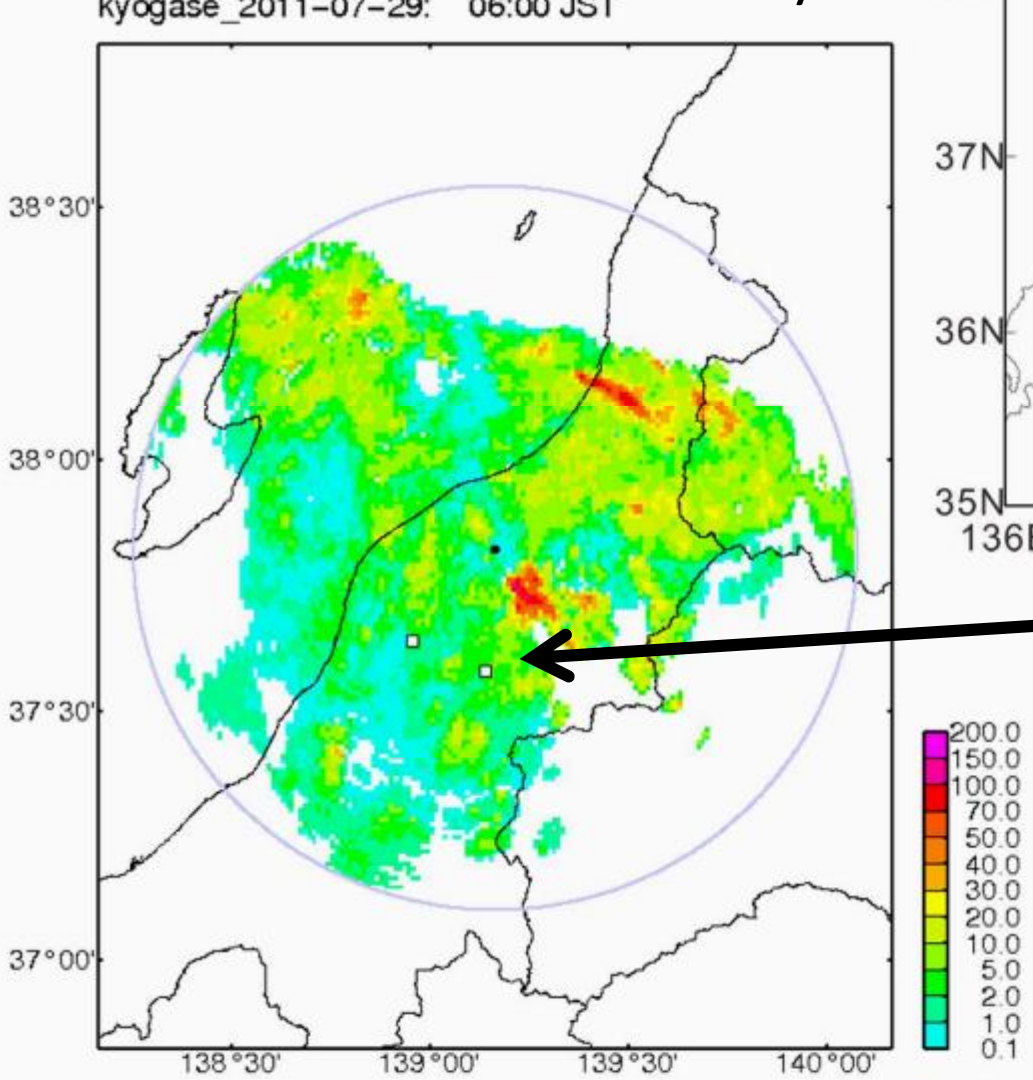
FY2015:
Development of
3DVAR-IAU assimilation
for MWR's brightness
Temperature

Ka-band and Doppler lidars
Will be used for validation
of liquid water profiling
GPS data is used for validation
of PW

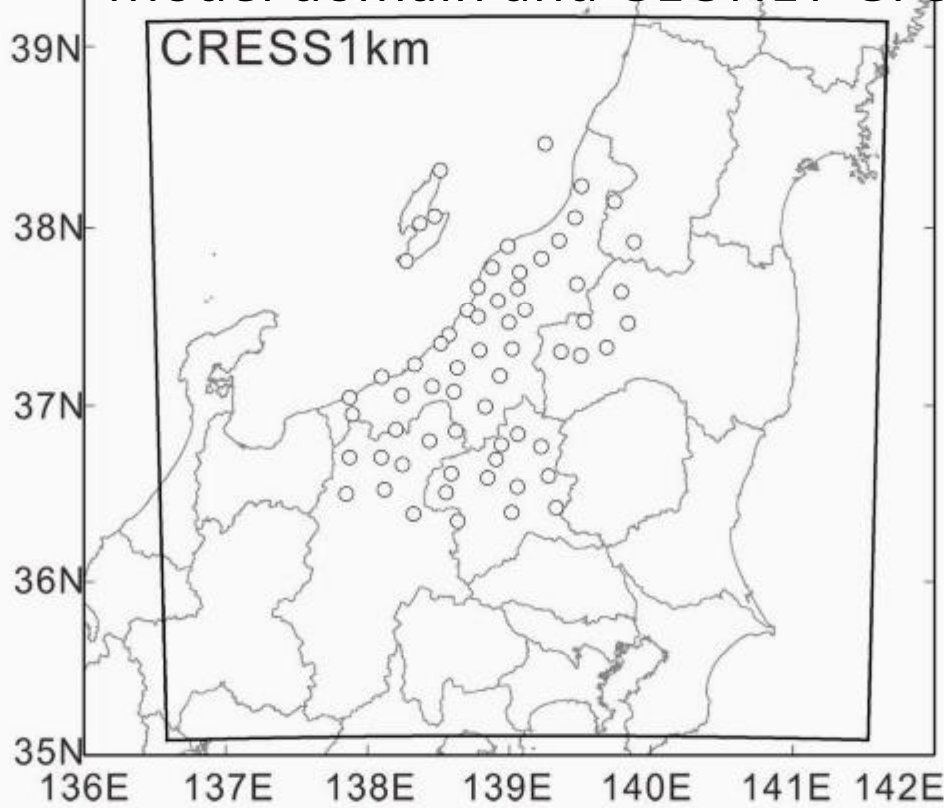
- **Basic equations: the non-hydrostatic and compressible equation system.**
- **Coordinate system: a terrain-following in a two or three dimensional domain.**
- **Spatial representation: finite difference method (Arakawa C grid in horizontal, Lorenz grid in vertical).**
- **Time integration: mode-splitting scheme (acoustic terms implicit in vertical)**
- **Ground model: *n*-layer 1-dim. thermal conductivity model.**
- **Ocean model: *n*-layer 1-dim. diffusion model.**
- **Surface process: bulk scheme (Louis scheme).**
- **Map projections: Lambert, Polar stereo, Mercator, Lat-lon.**
- **Parallel processing: inter-node: the Message Passing Interface (MPI) , intra-node: OpenMP. (CReSS showed high performance in Kei-super computer and Earth Simulator)**
- **Two-moment cold bulk scheme (option: warm bin scheme is available)**
- **NIED developed 3DVAR and Incremental Analysis Update scheme**

3DVAR assimilation Impact of GPS-derived Precipitable water

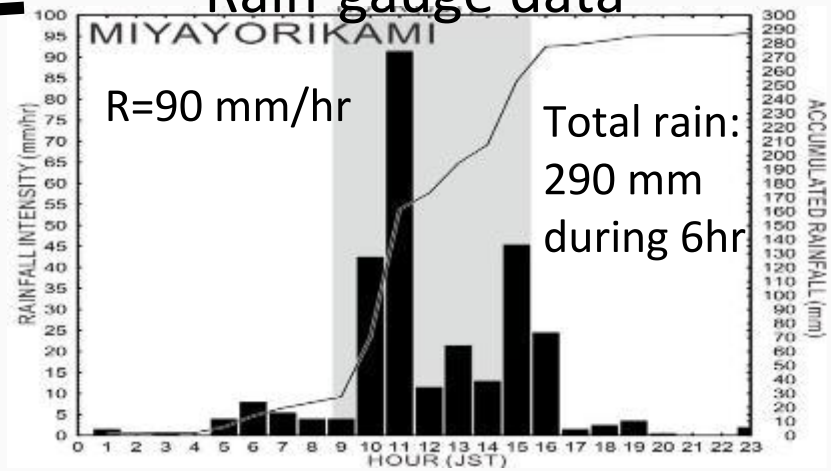
Observed Rainfall intensity



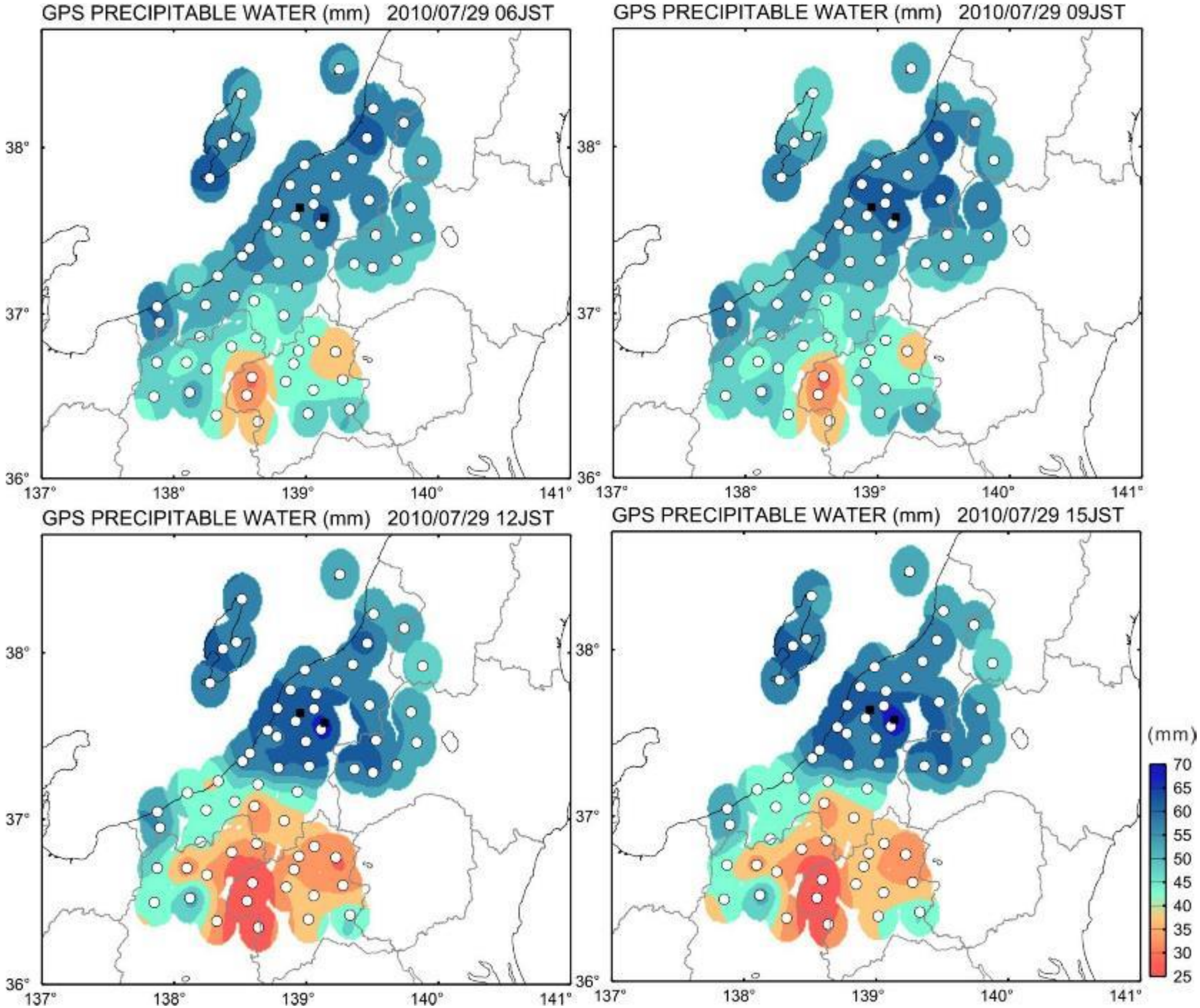
Model domain and GEONET-GPS



Rain-gauge data



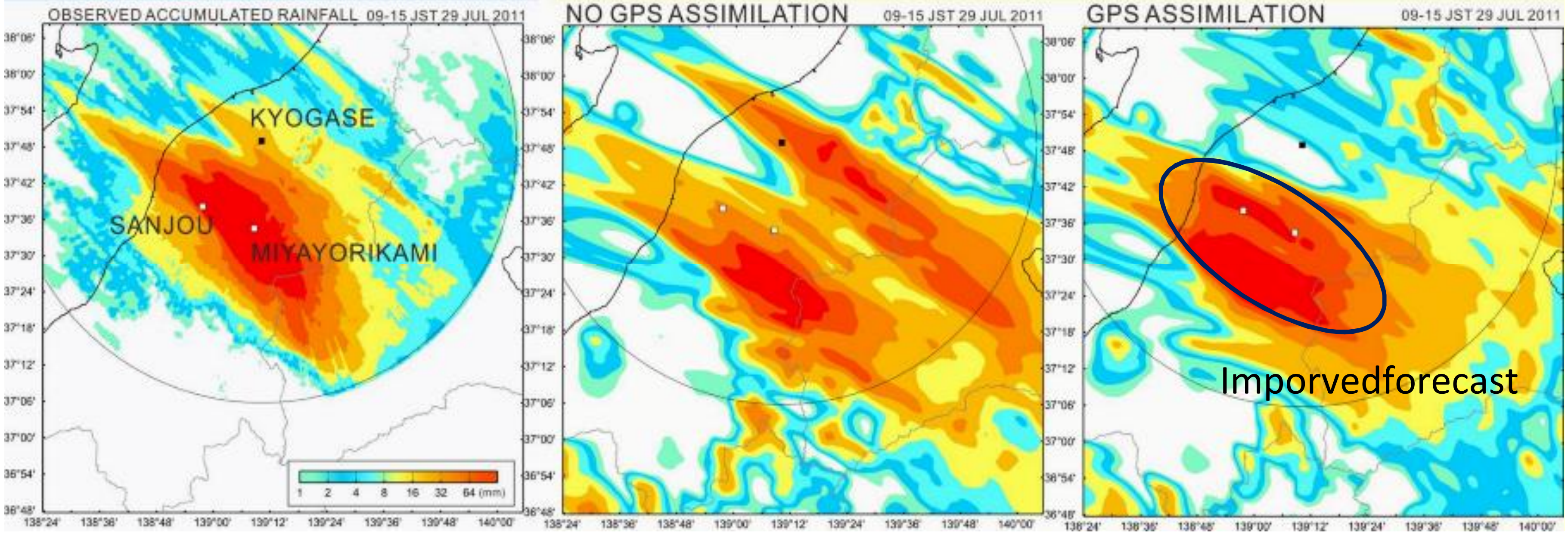
GPS
PW
Every
3h



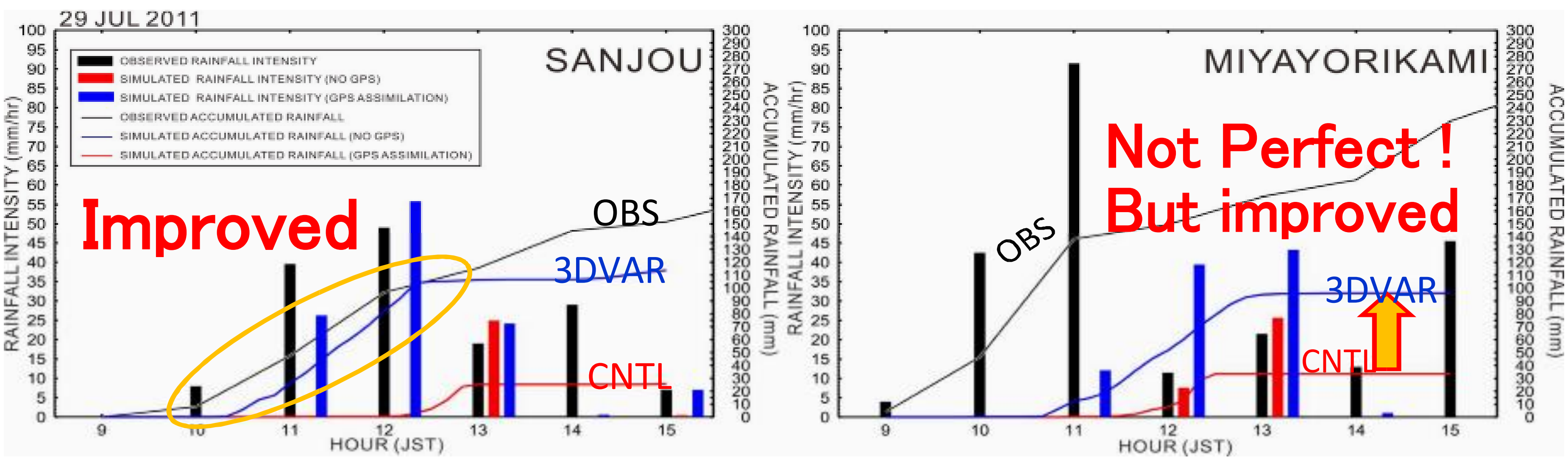
Observed rainfall amount
From 9 to 15 JST

Forecasted Rainfall amount from 9 to 15 JST

No GPS Assimilation | GPS Assimilation

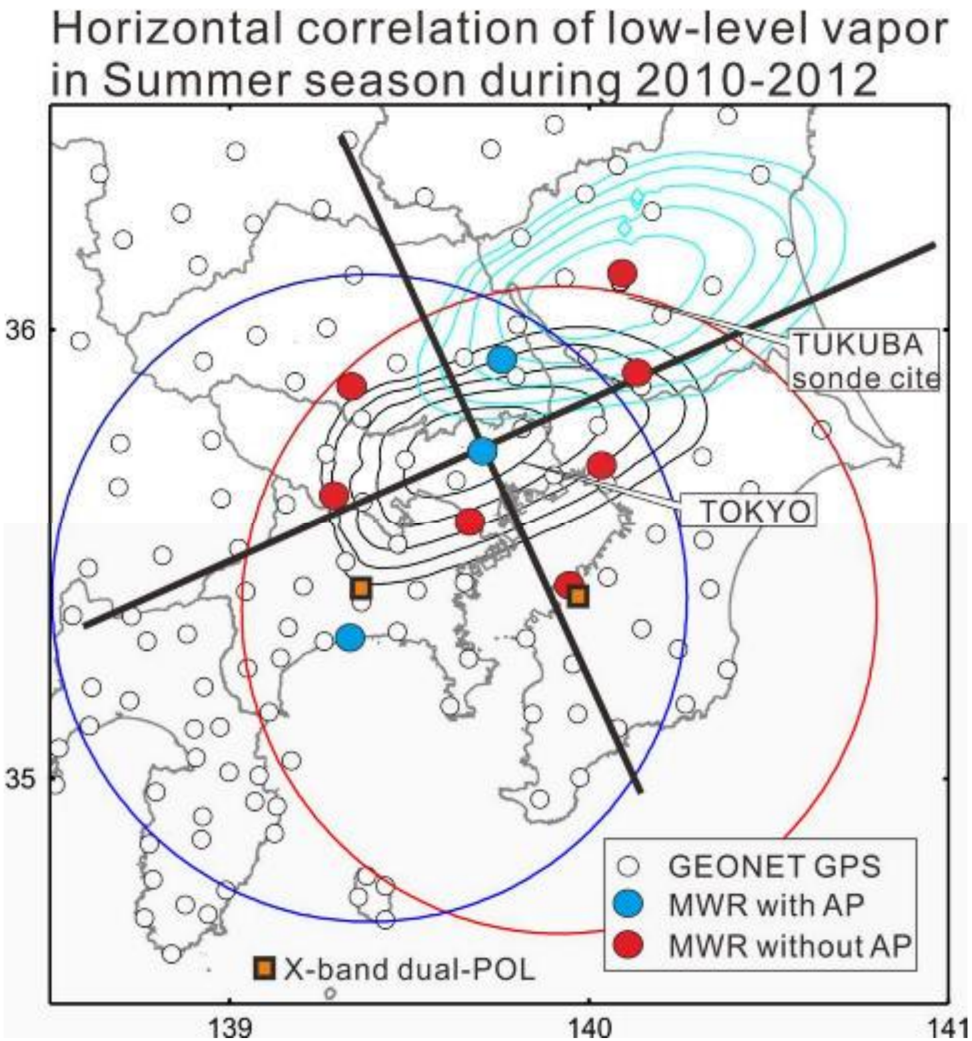


1hr Rainfall : Comparison between rain-gauge observation and forecast



GPS zenith delay is analyzed using IGS final orbit data (GAMIT software), but this is available after 2 weeks ! MWR provides accurate PW in real-time

NMC method is used to build background error covariance matrix for 3DVAR Scale length of Horizontal correlation of low-level vapor is investigated especially in summer season from 2010 to 2012.



One MWR is installed at a center of Tokyo metropolitan region.

6 MWRs are installed along the 95% of correlation coefficient contour

3MWRs are installed outside of the Contour (2 MWRs will observe Inflow moisture, 1 MWR is for Long-term validation with routine Sounding data at TSUKUBA)

What benefit we expect from TOPROF

Knowledge of several Microwave Radiometer retrieval methods
with its ambiguity information toward 1DVAR assimilation

Investigation on the potential of MWR assimilation system
Toward real-time operation forecast

Understanding on Cloud physics using MWR and Doppler lidar

What we can contribute to TOPROF

Feedback for the Validation of MWR retrieval by comparing GPS analysis
Especially for precipitable water

Feedback for the validation of MWR retrieval by comparing multiple
Ka-band radars and Liders for liquid water distribution

Another sample: Radar Assimilation using 3DVAR

Radar

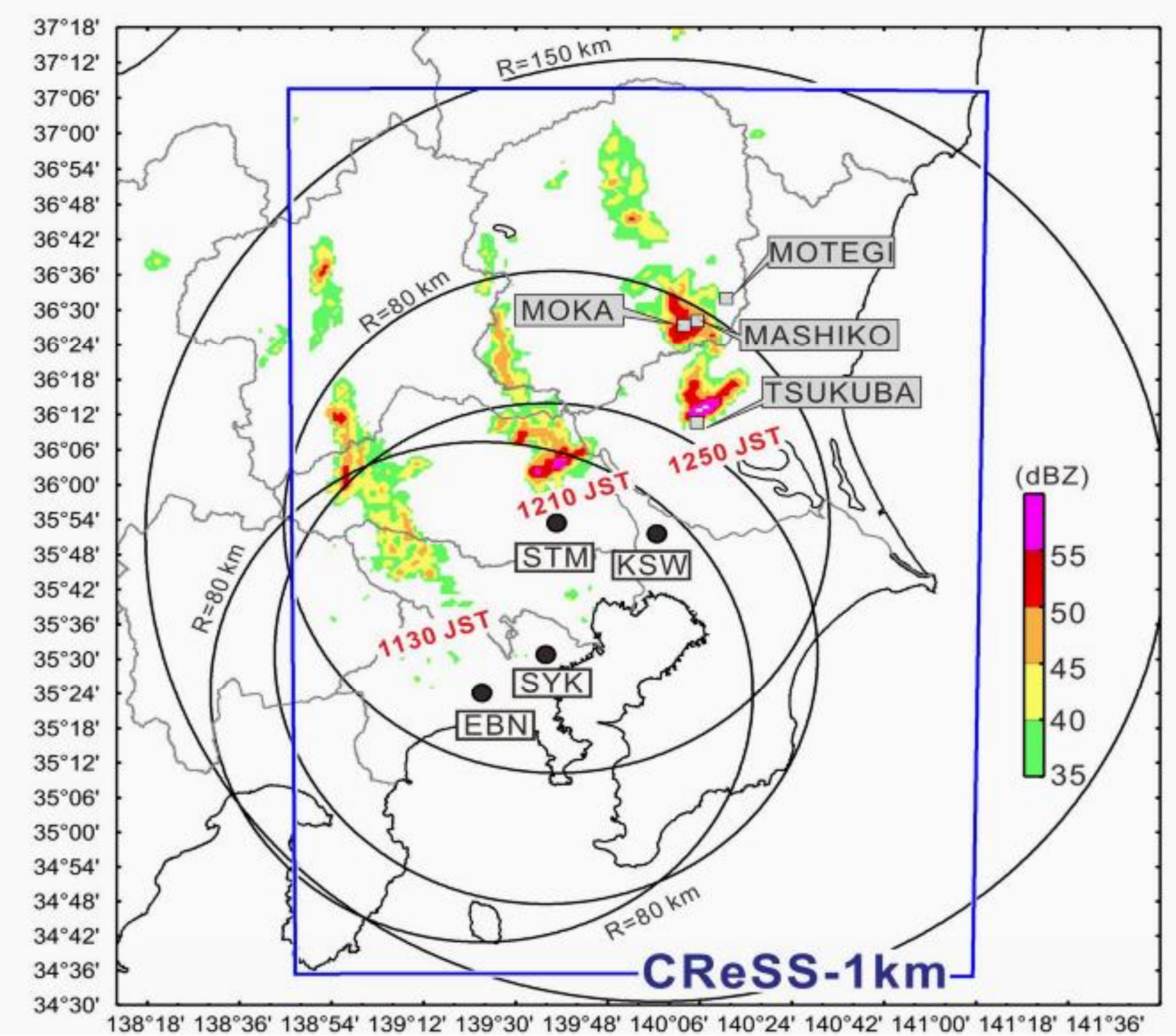
・NIED X-band
Dual-Pol (EBN)
(dt = 5 min)

・MLIT X-band
Dual-Pol (STM,SYK)
(dt = 5min)

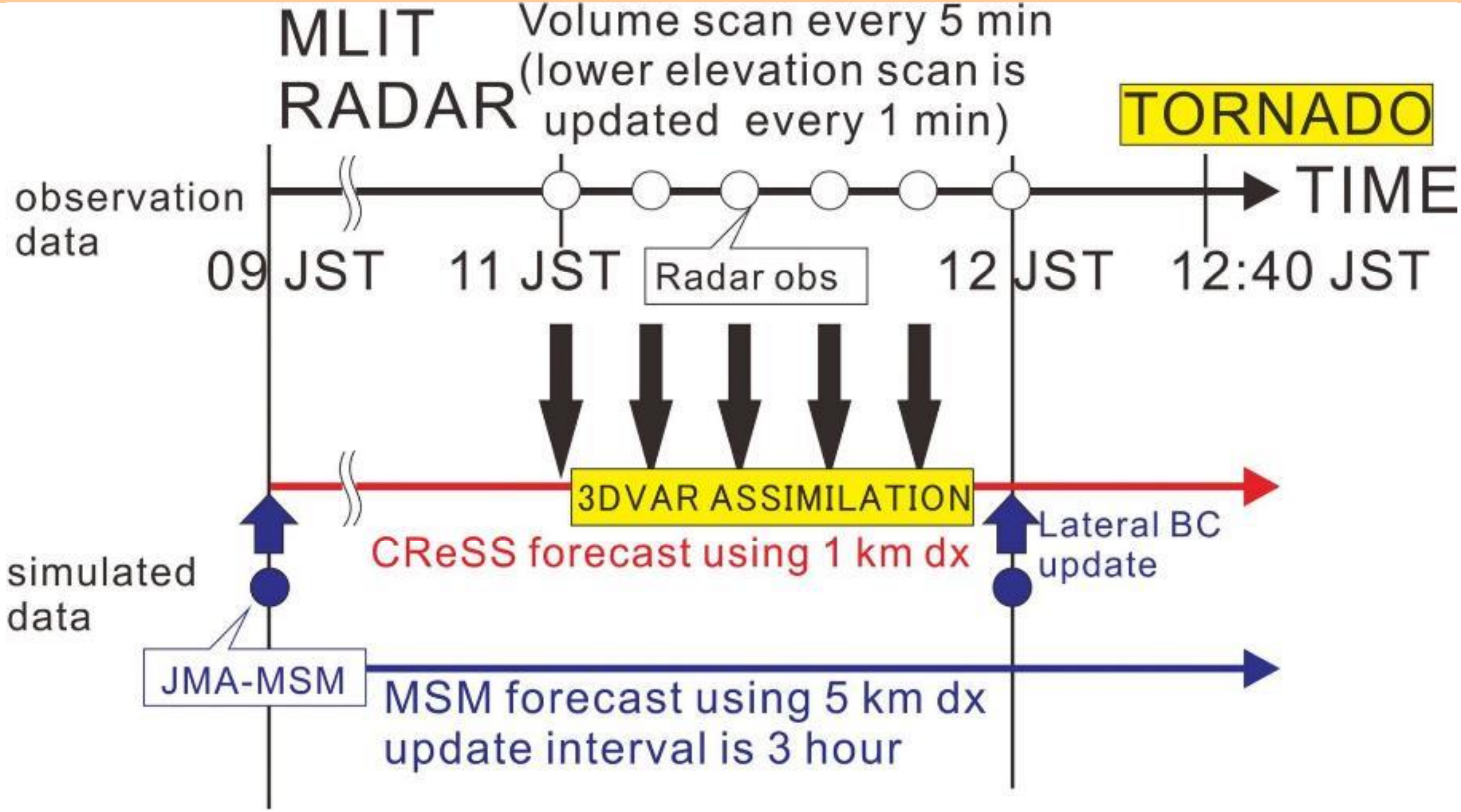
・JMA C-band (KSW)
Doppler
(dt = 10min)

Numerical model

・CReSS ver3.2
dx = 1 km
dz = 200-500m



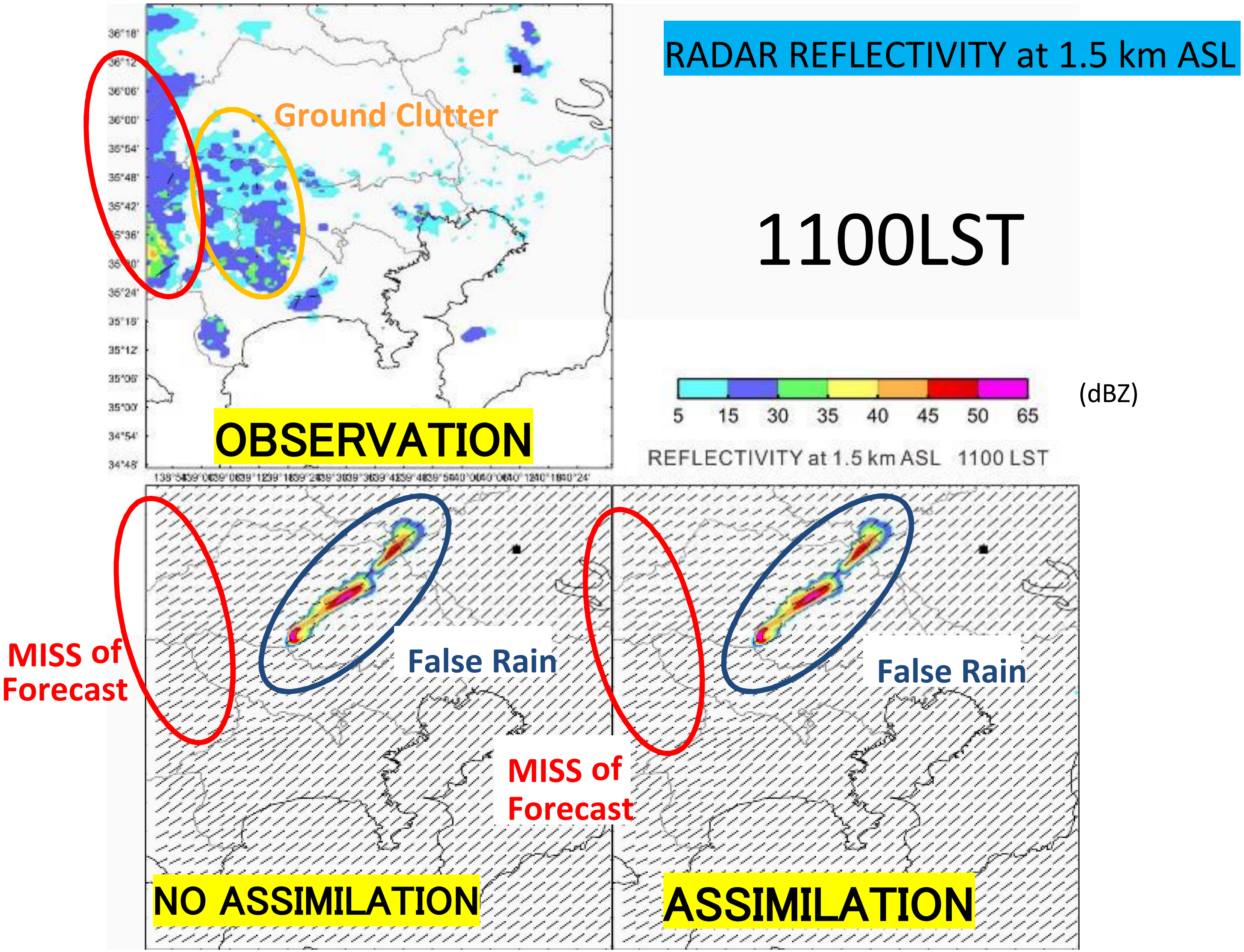
CReSS -3DVAR with Incremental Analysis Update (IAU)



CReSS3DVAR assimilates radial velocity from radar network every 5 min.

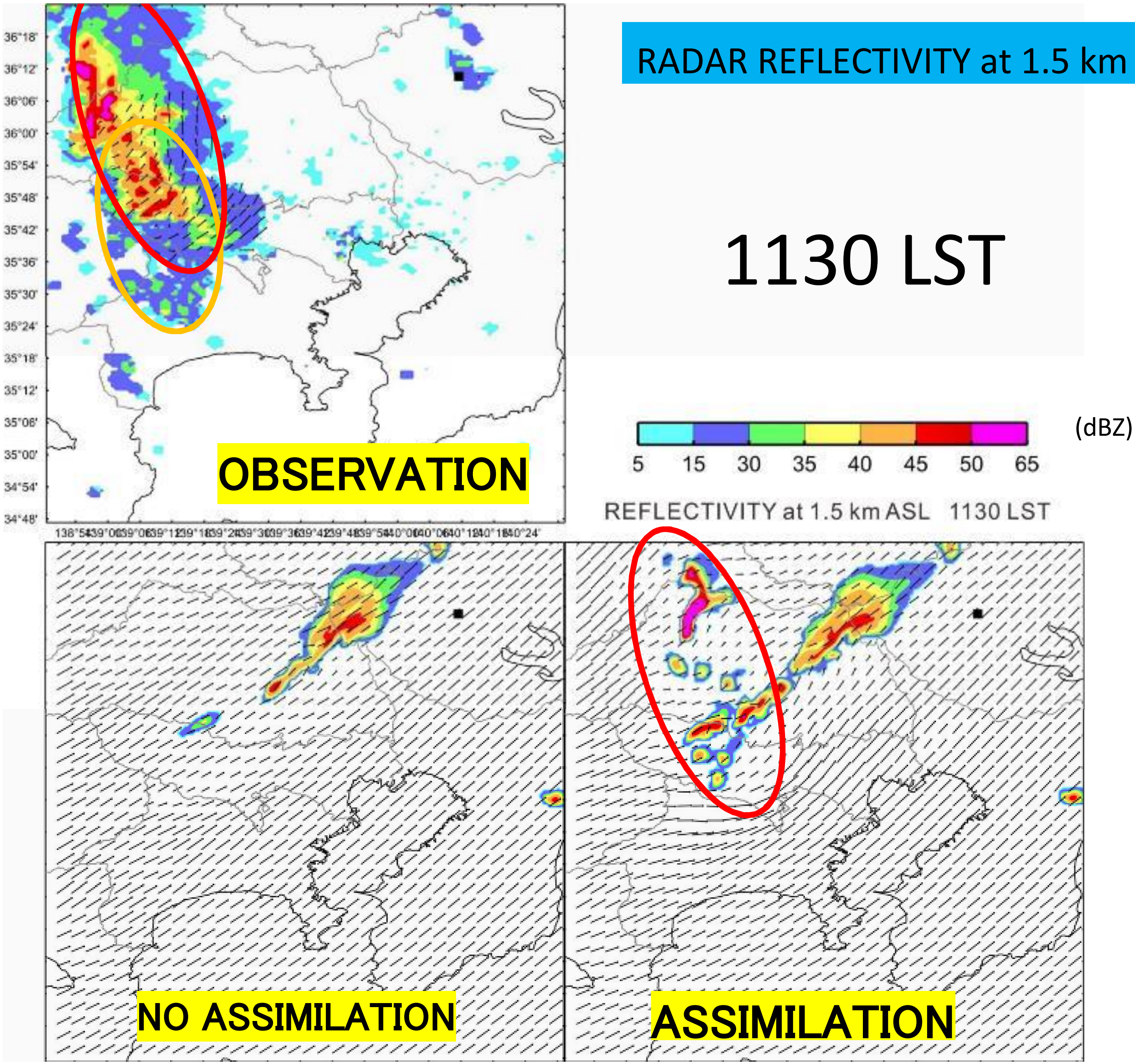
Increment of wind velocity is evaluated at the observation time.

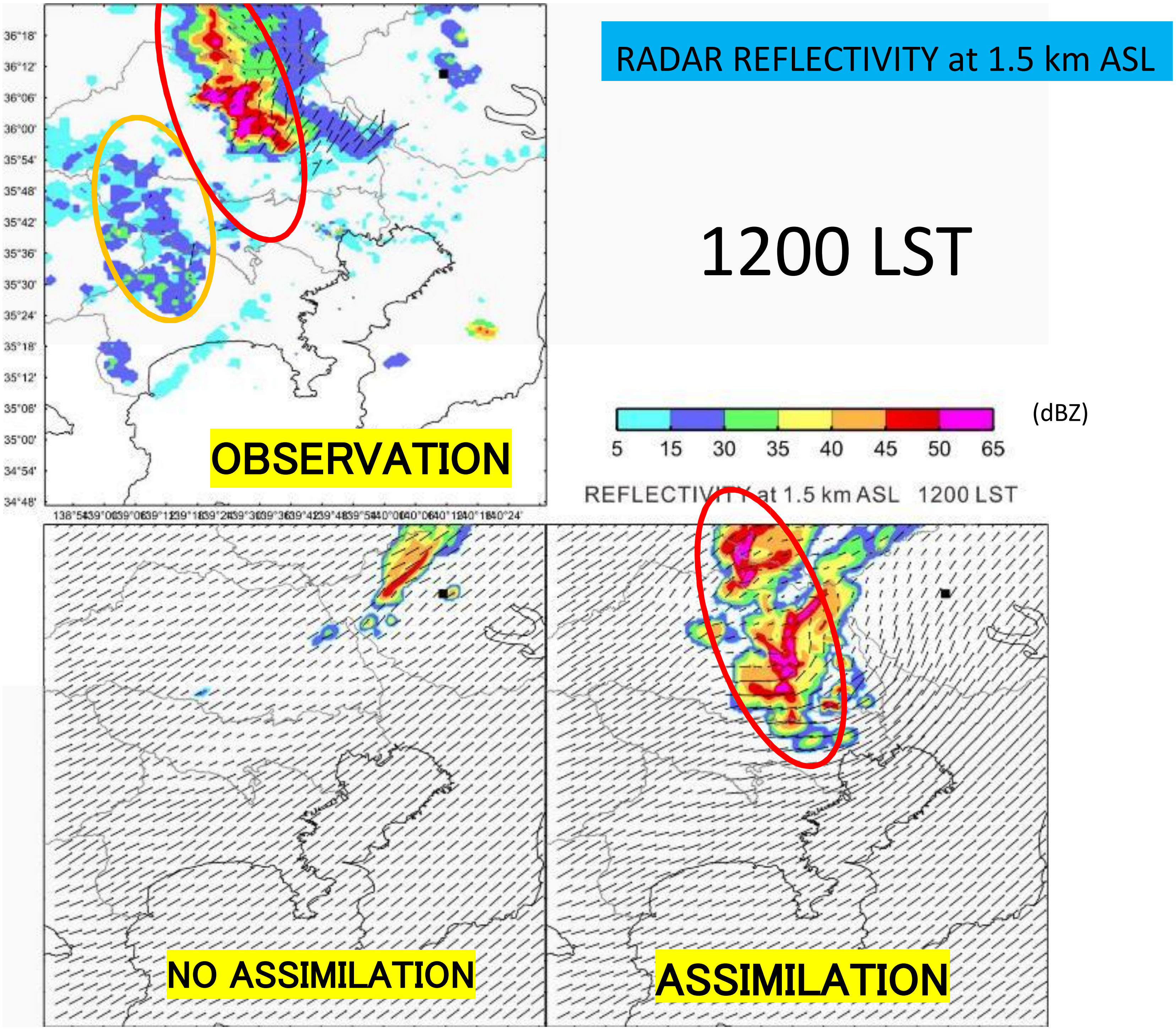
The incremental of wind velocity is assimilated using nudging scheme.


RADAR REFLECTIVITY at 1.5 km ASL
1100LST
Ground Clutter
OBSERVATION
5 15 30 35 40 45 50 65
(dBZ)
REFLECTIVITY at 1.5 km ASL 1100 LST
MISS of Forecast
False Rain
NO ASSIMILATION
MISS of Forecast
False Rain
ASSIMILATION

RADAR REFLECTIVITY at 1.5 km ASL

1130 LST

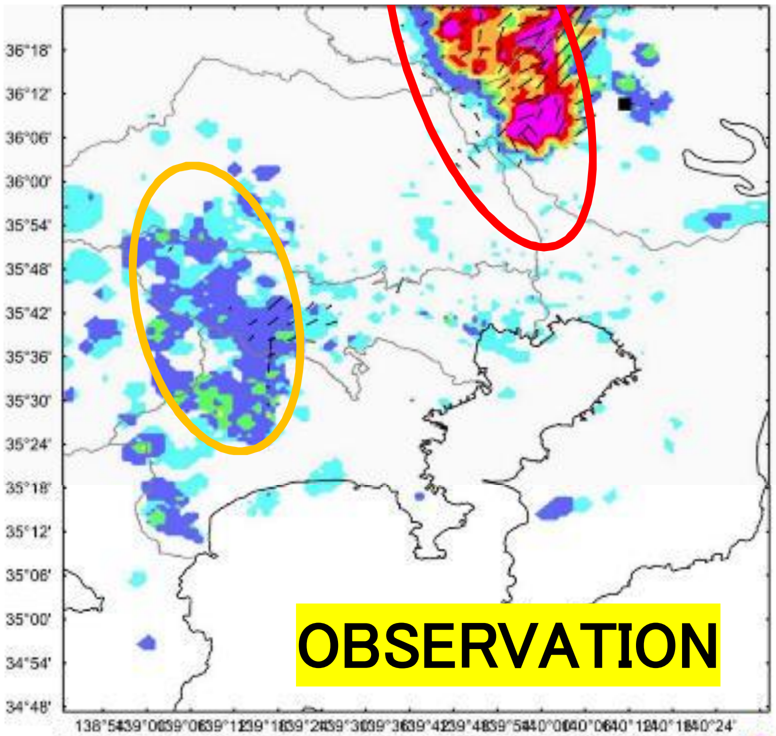


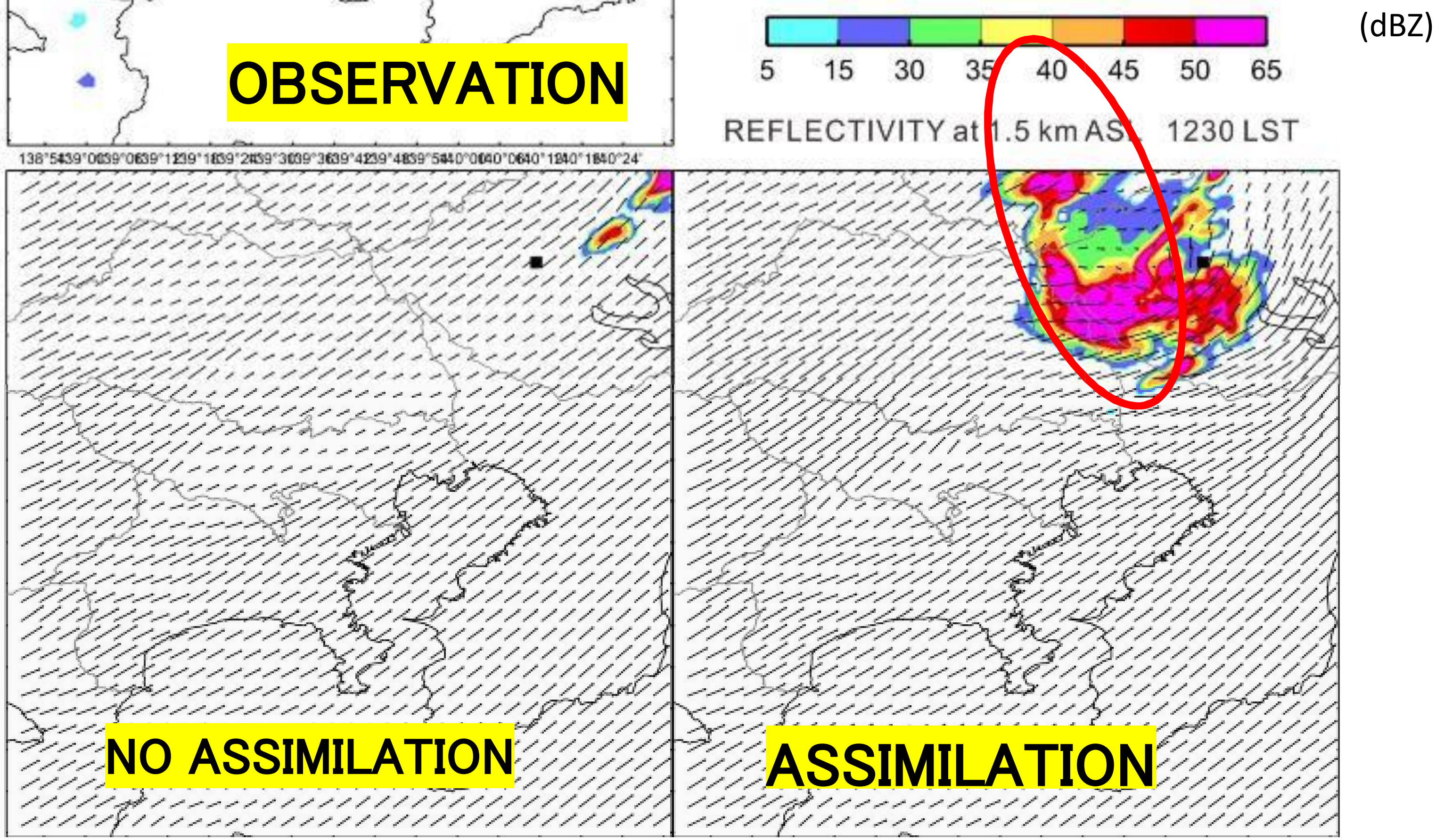


RADAR REFLECTIVITY at 1.5 km ASL
1200 LST
36°18'
36°12'
36°06'
36°00'
35°54'
35°48'
35°42'
35°36'
35°30'
35°24'
35°18'
35°12'
35°06'
35°00'
34°54'
34°48'
OBSERVATION
(dBZ)
5 15 30 35 40 45 50 65
REFLECTIVITY at 1.5 km ASL 1200 LST
NO ASSIMILATION
ASSIMILATION

RADAR REFLECTIVITY at 1.5 km ASL

1230 LST



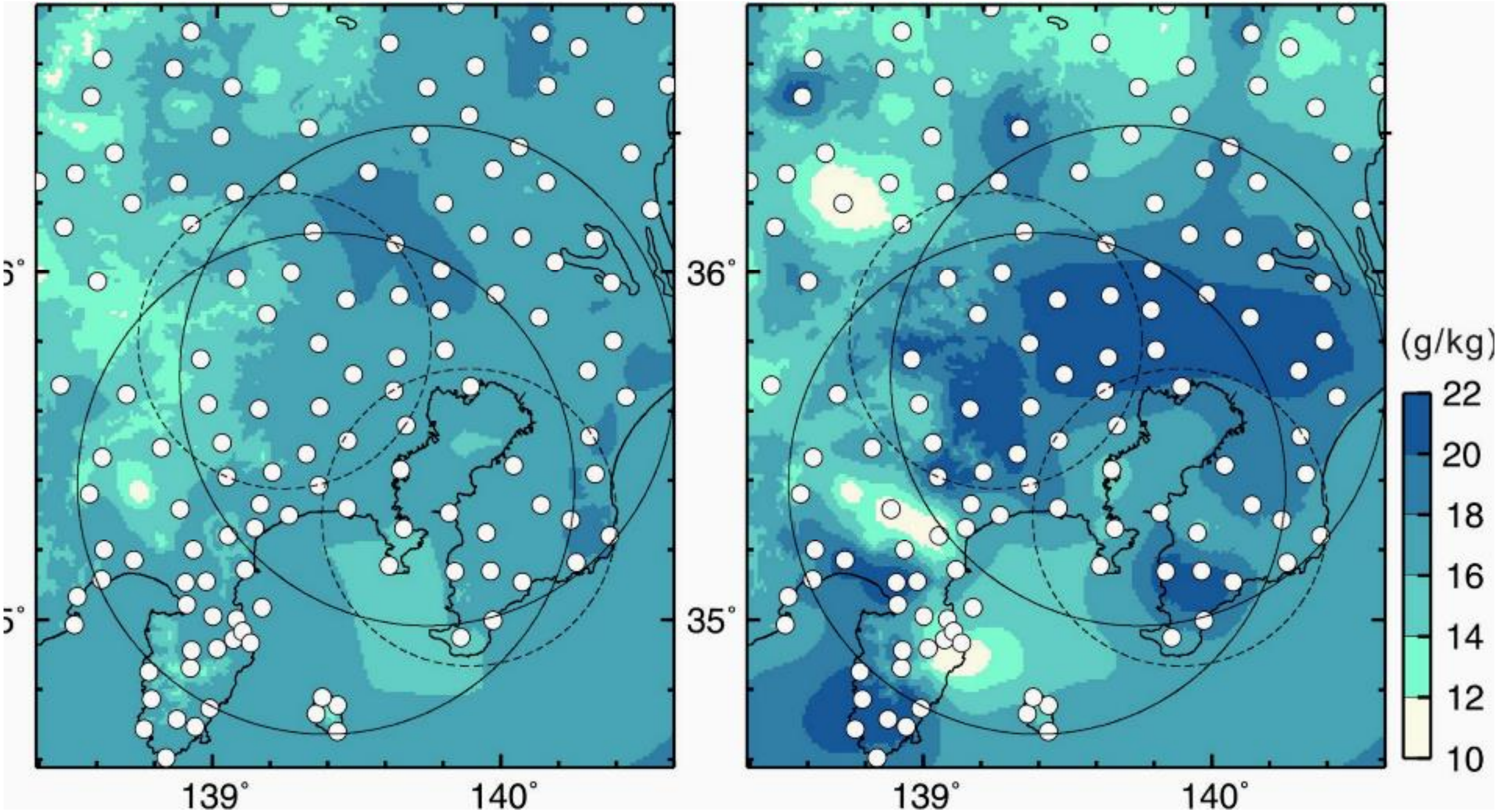


NIED developed 3DVAR-IAU scheme using radar and GPS data toward the real-time forecast heavy rainfall Summary of NIED's development

1) real-time QPE using Kdp from X-band dual-POL (Kim et al., 2012)
2) real-time 3D wind analysis using X-band radar network (XNET)
3) Nowcasting using convective-cell tracking (Shimizu et al., 2012)
4) real-time 3DVAR short-range forecast using radar and GPS wet zenith delay

To better forecast severe weather, we are now setting up ▪5 Ka-band dual-POL radar (Mitsubishi), ▪3 Doppler lidar (Mitsubishi) ▪10 Microwave radiometer (RPG) Around TOKYO metropolitan region

NIED 3DVAR Mixing ratio of vapor at a height of 100m



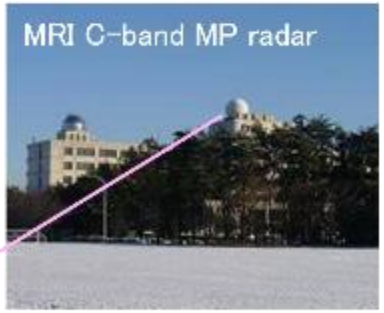
No Assimilation **3DVAR**

Real-time estimation of 3D wind in TOMACS

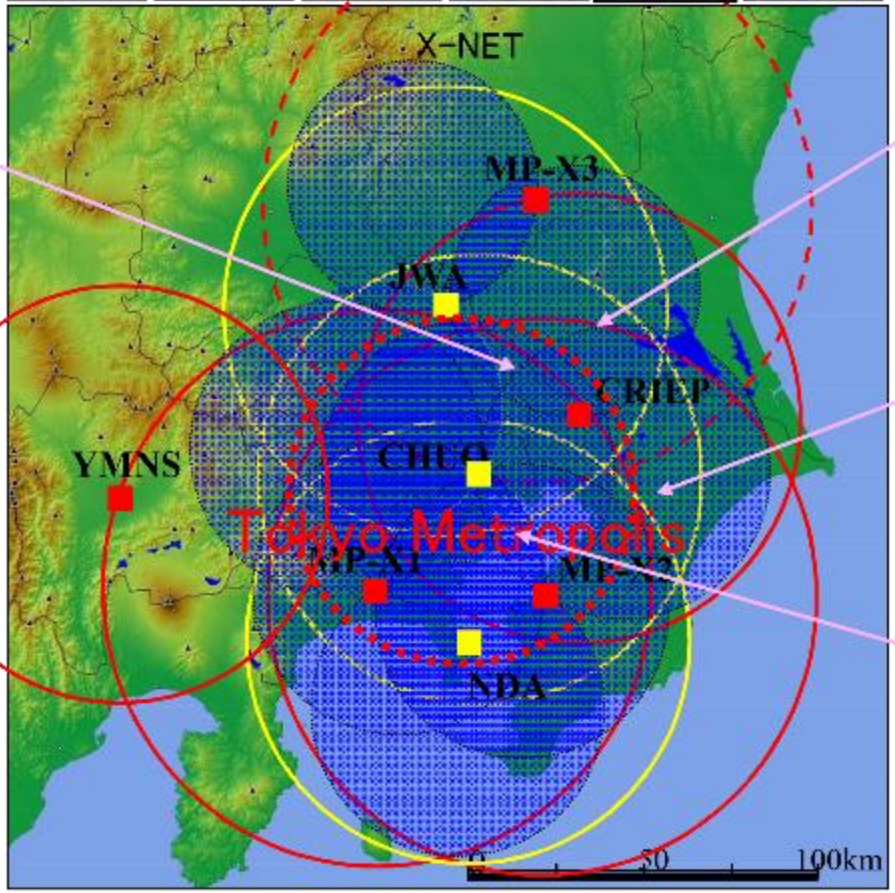
Research/operation weather radars concentrate in the Tokyo Metropolitan Area: X-NET(5 X-band MP radars and 3 Doppler radars), two X-band MP radars of River Bureau, MRI C-band MP radar and 3 JMA C-band operational Doppler radars.





JMA Kashiwa C-band Doppler radar

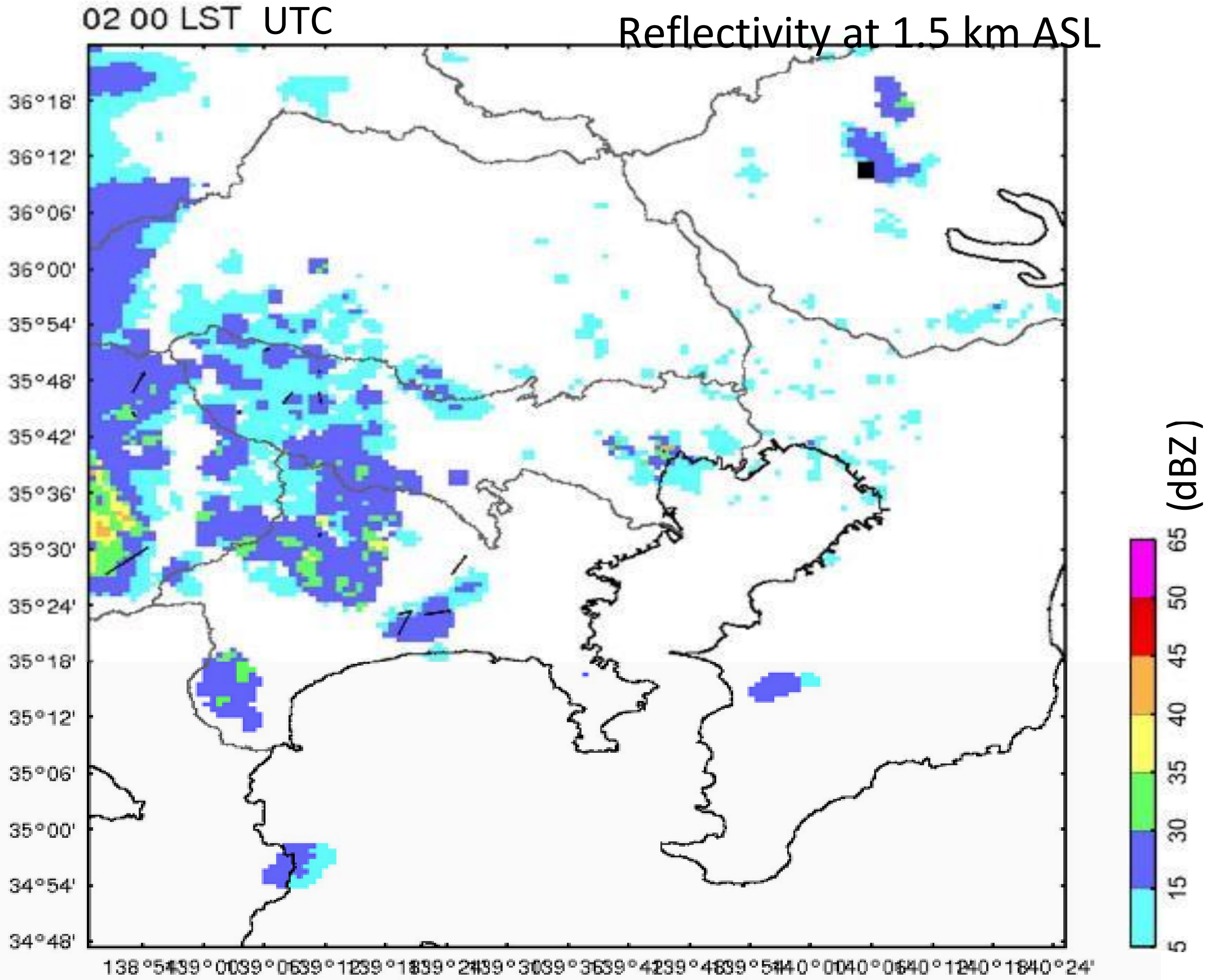


JMA Narita Airport C-band Doppler radar

M. Maki of NIED and X-NET Group

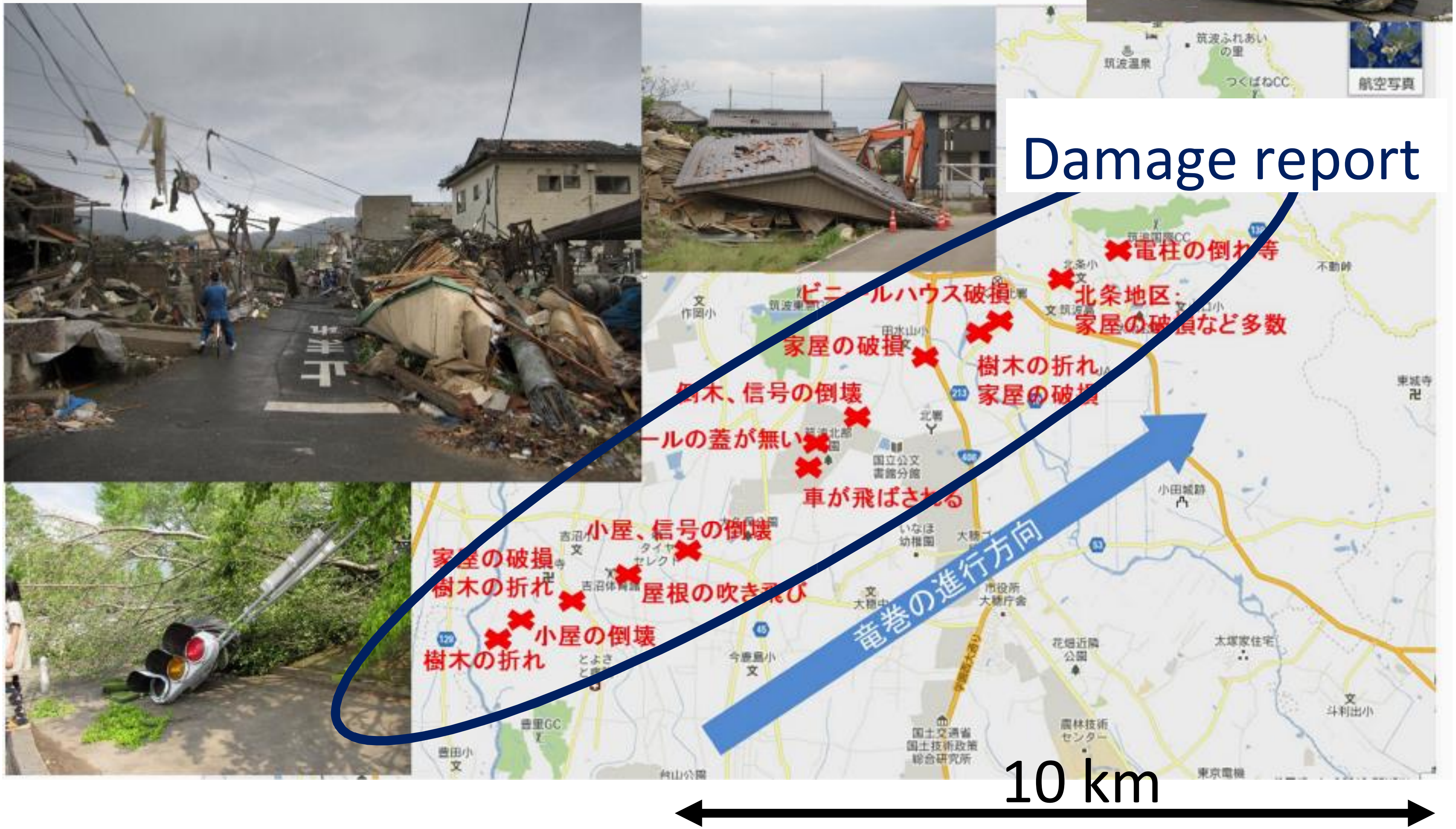
JMA Haneda Airport C-band Doppler radar

Real-Time 3D wind analysis using X-NET



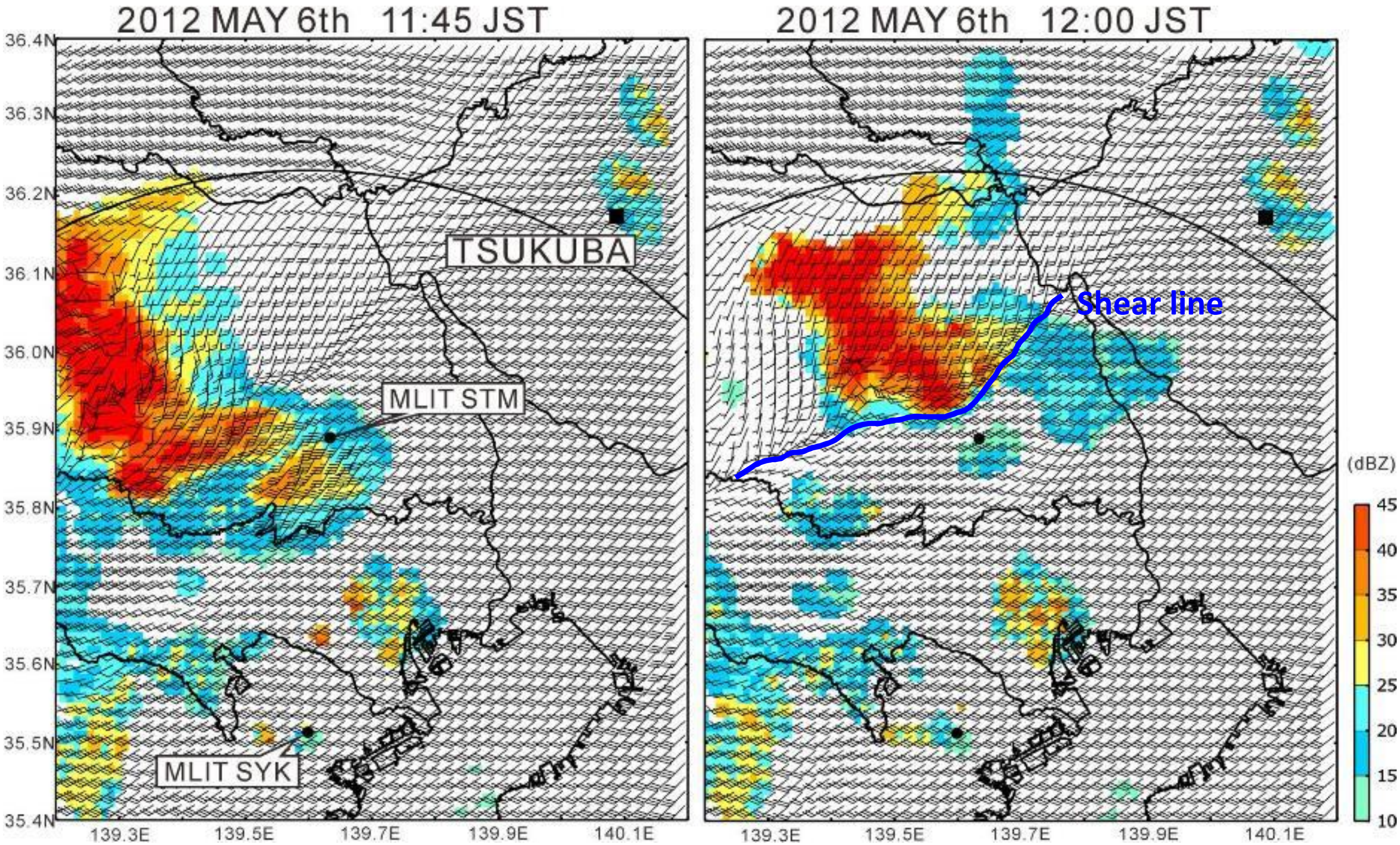
Tornado damage on May 6th 2012 in Tsukuba

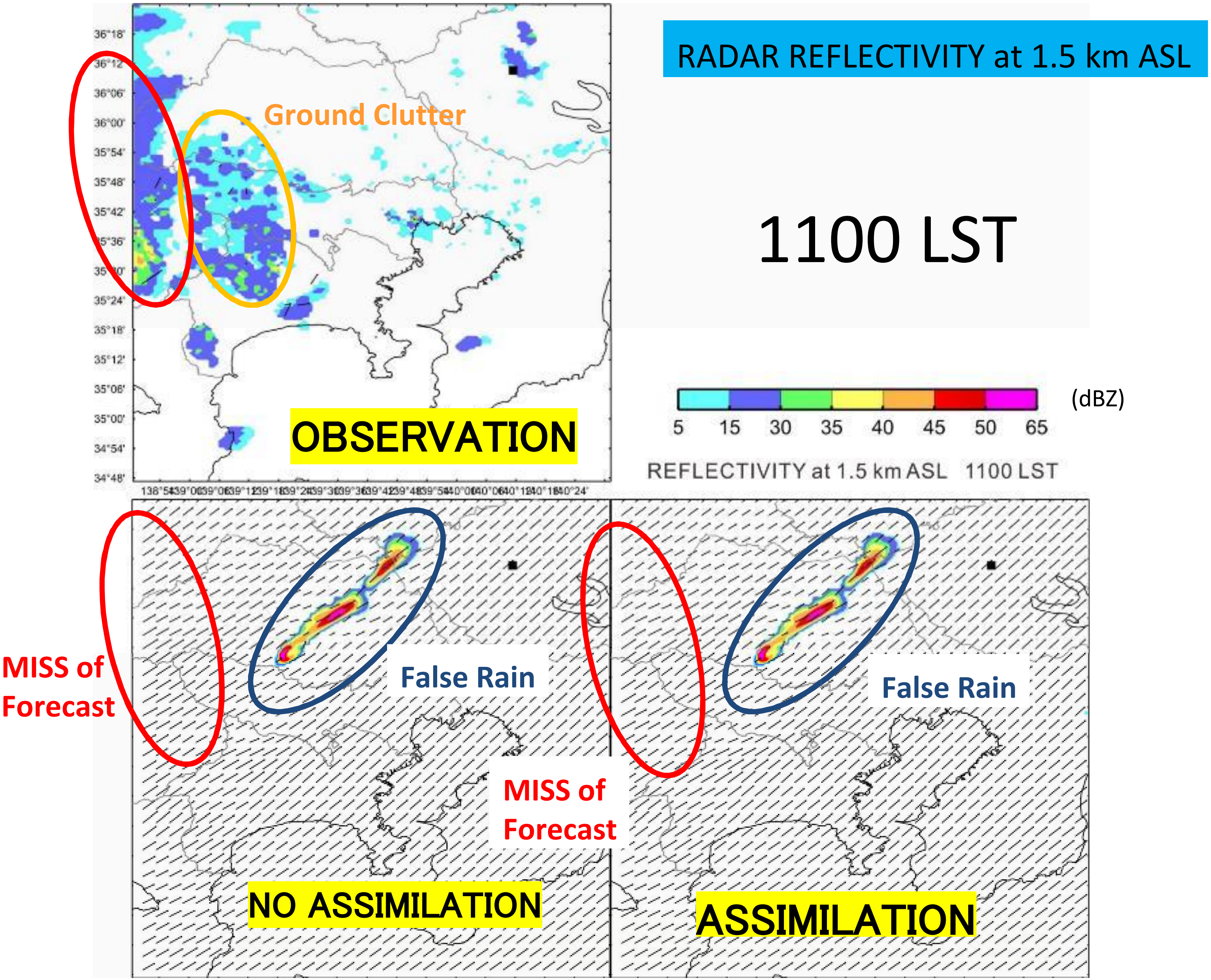
The most severe Tornado damage (Fujita scale was F3) in Japan was observed on 6th May 2012 . More than 30 people was injured, and a 14 year's-old boy was killed. The tornado path length was 17 km.

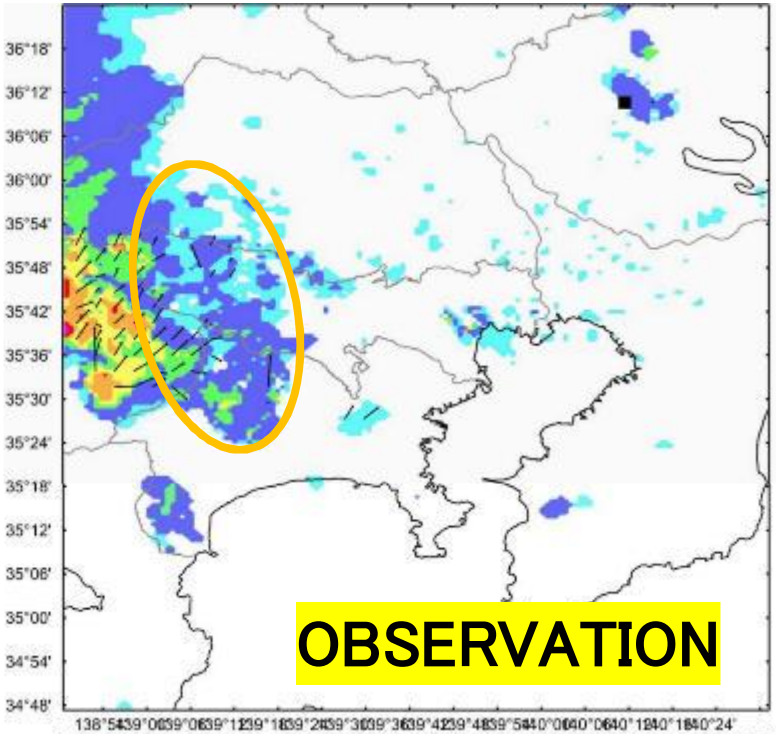


Objective analysis (3DVAR) for wind field at a height of 1km

Radar reflectivity and analyzed wind field by 3DVAR-IAU

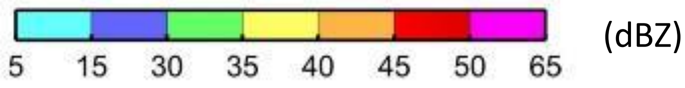



RADAR REFLECTIVITY at 1.5 km ASL
1100 LST
Ground Clutter
OBSERVATION
(dBZ)
5
15
30
35
40
45
50
65
REFLECTIVITY at 1.5 km ASL 1100 LST
MISS of Forecast
False Rain
MISS of Forecast
False Rain
NO ASSIMILATION
ASSIMILATION

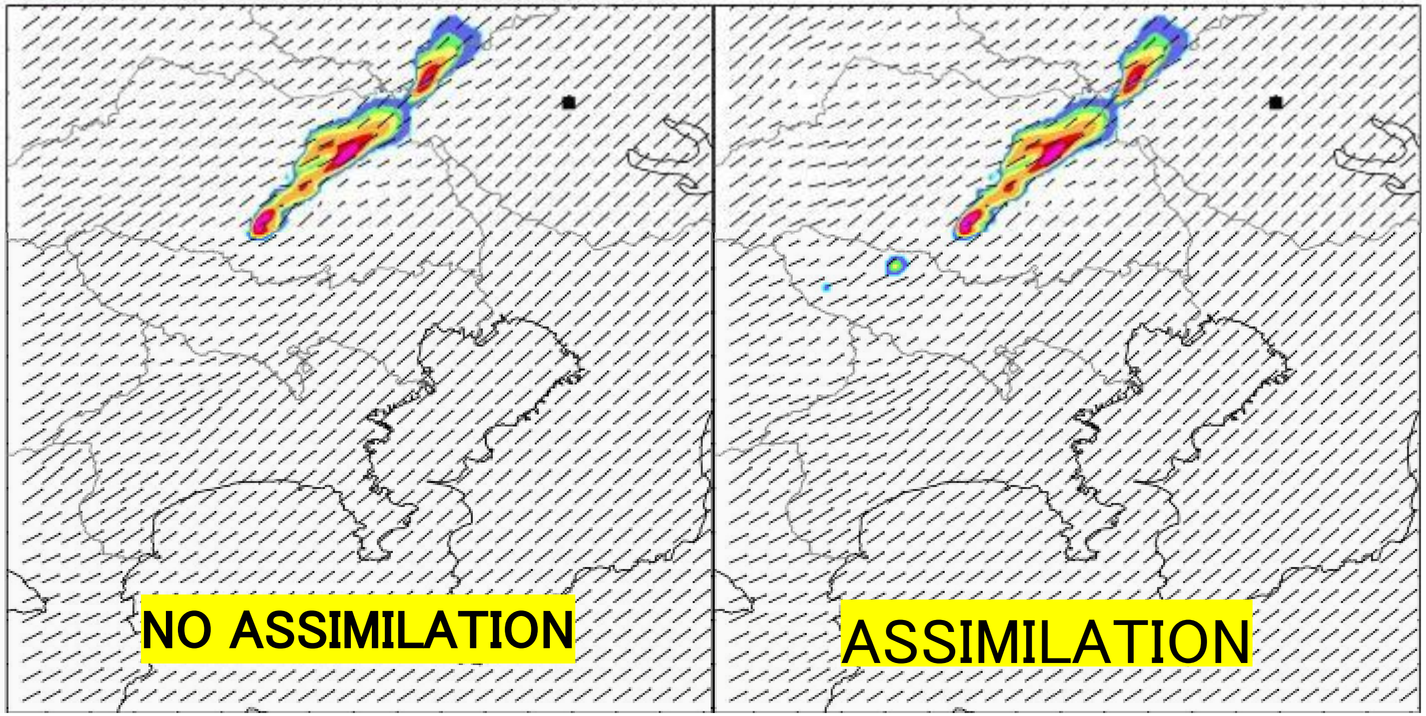


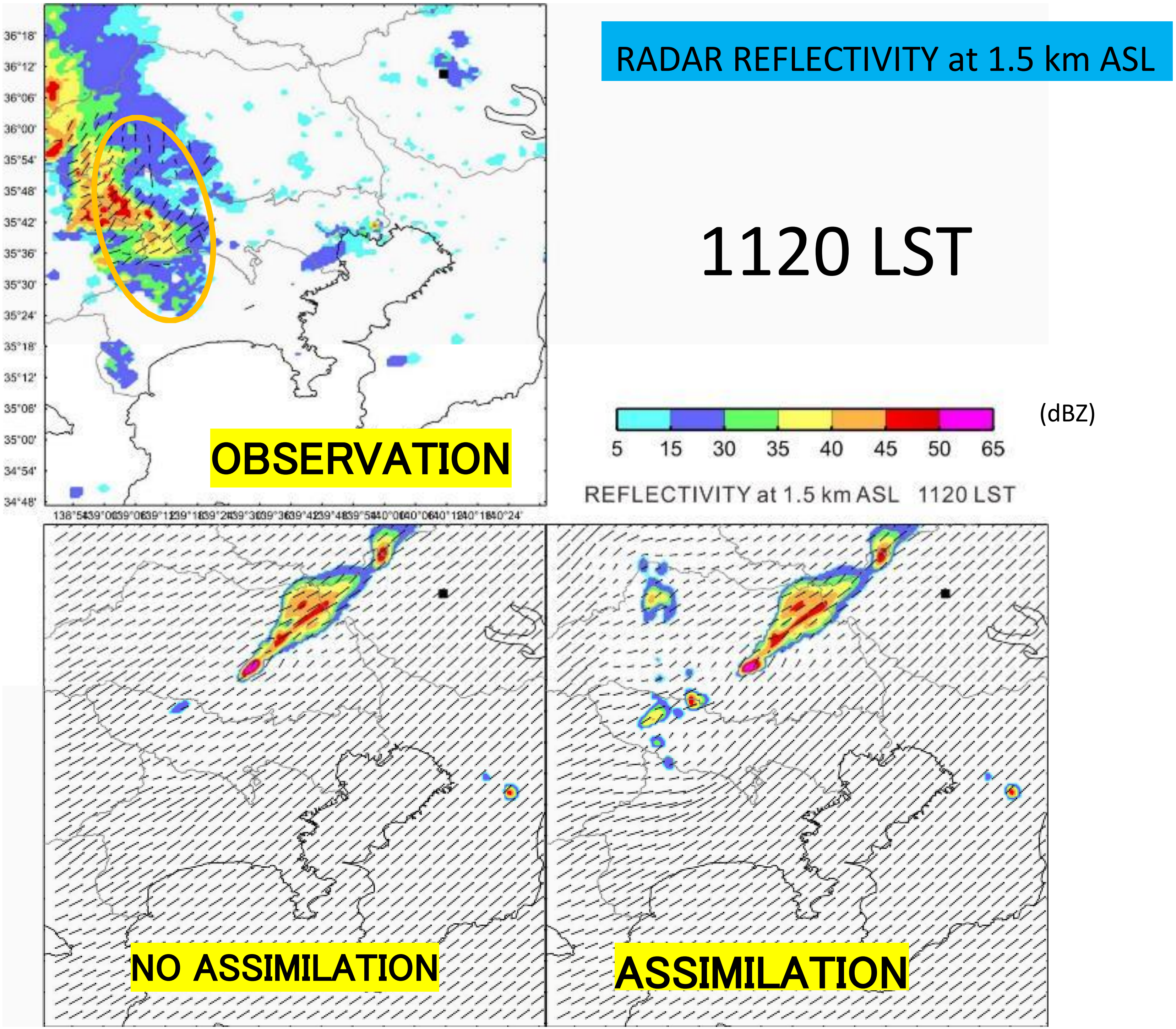
RADAR REFLECTIVITY at 1.5 km ASL

1110 LST



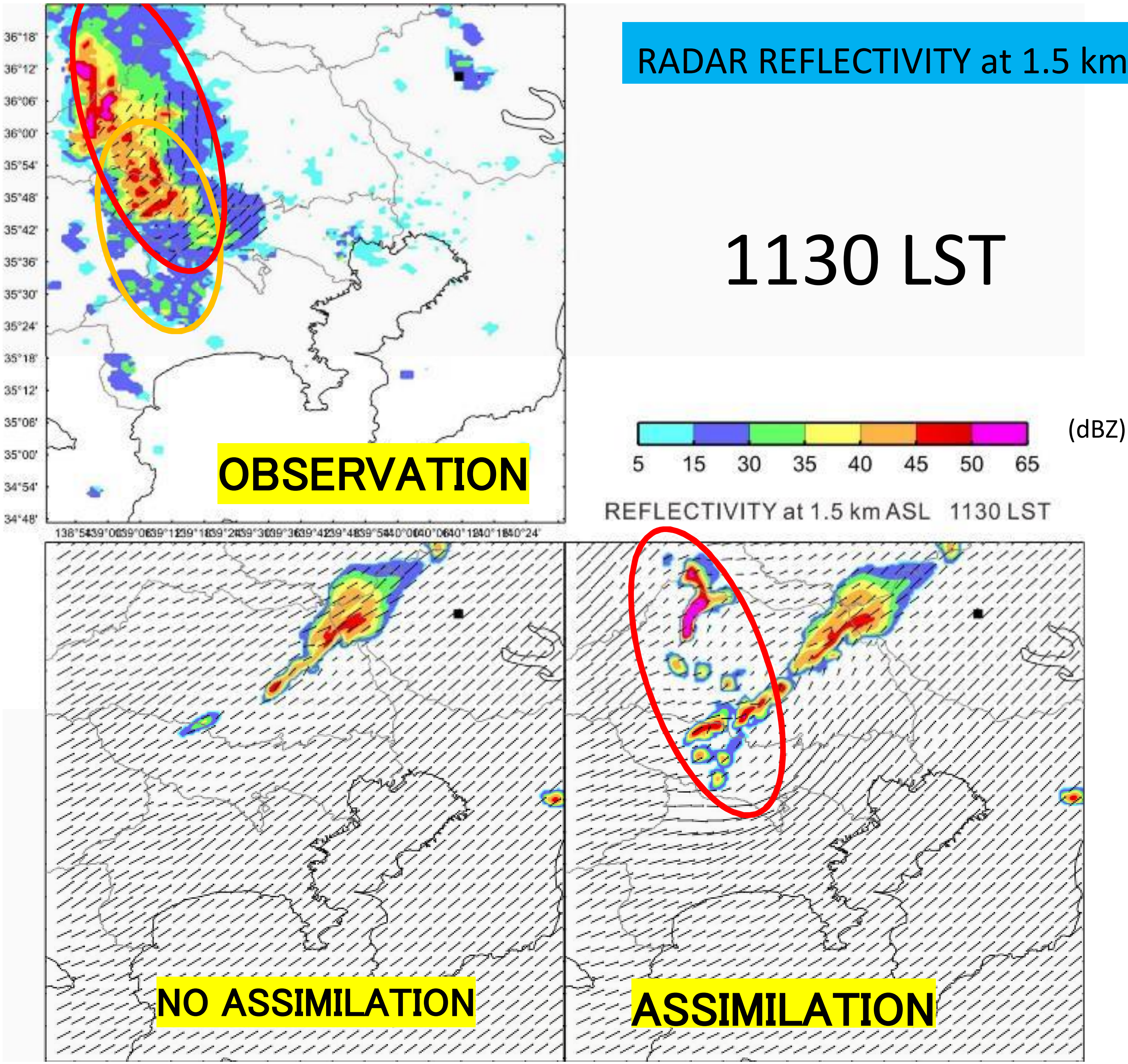
REFLECTIVITY at 1.5 km ASL 1110 LST

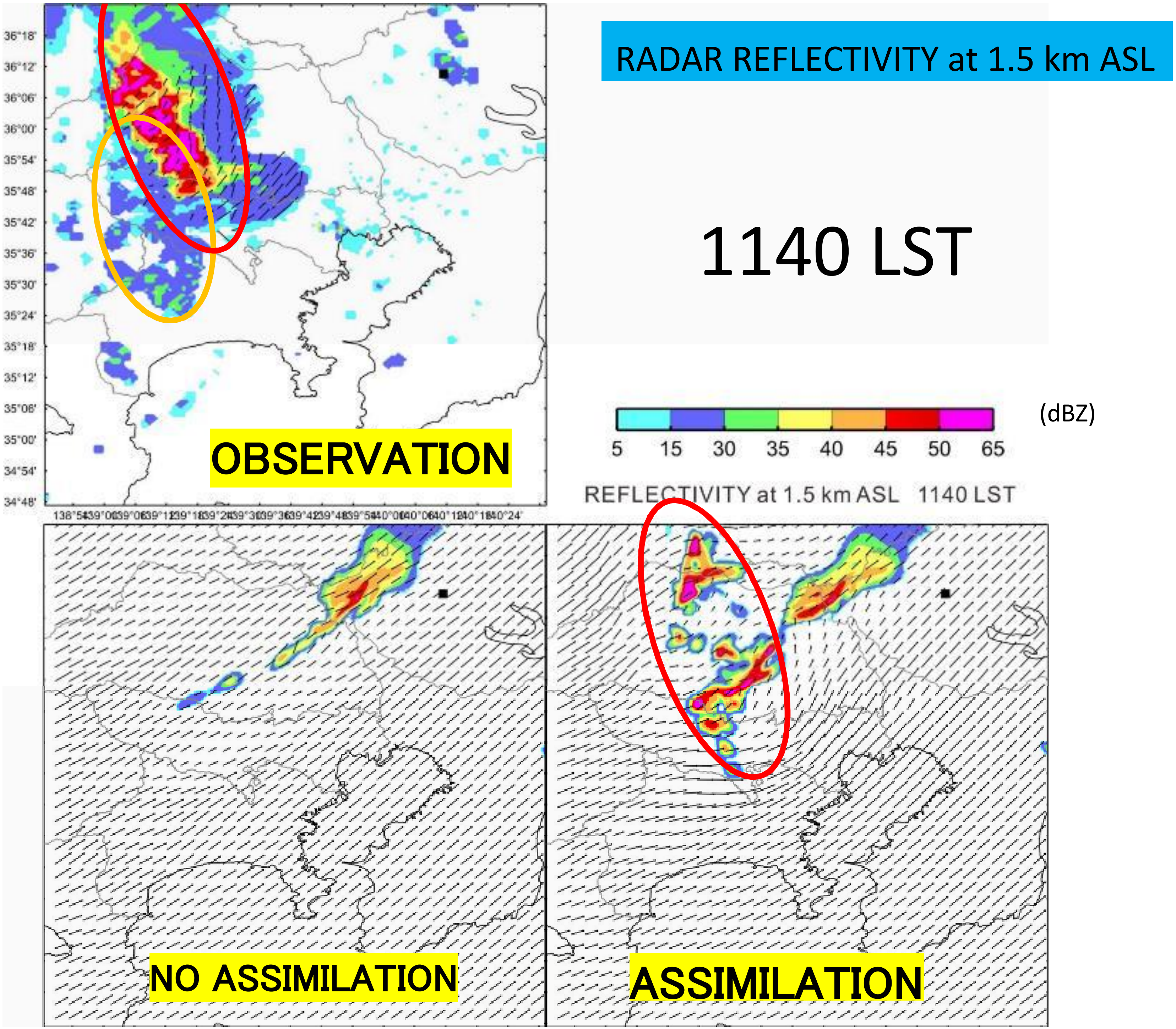



RADAR REFLECTIVITY at 1.5 km ASL
1120 LST
36°18'
36°12'
36°06'
36°00'
35°54'
35°48'
35°42'
35°36'
35°30'
35°24'
35°18'
35°12'
35°06'
35°00'
34°54'
34°48'
OBSERVATION
5 15 30 35 40 45 50 65
(dBZ)
REFLECTIVITY at 1.5 km ASL 1120 LST
NO ASSIMILATION
ASSIMILATION

RADAR REFLECTIVITY at 1.5 km ASL

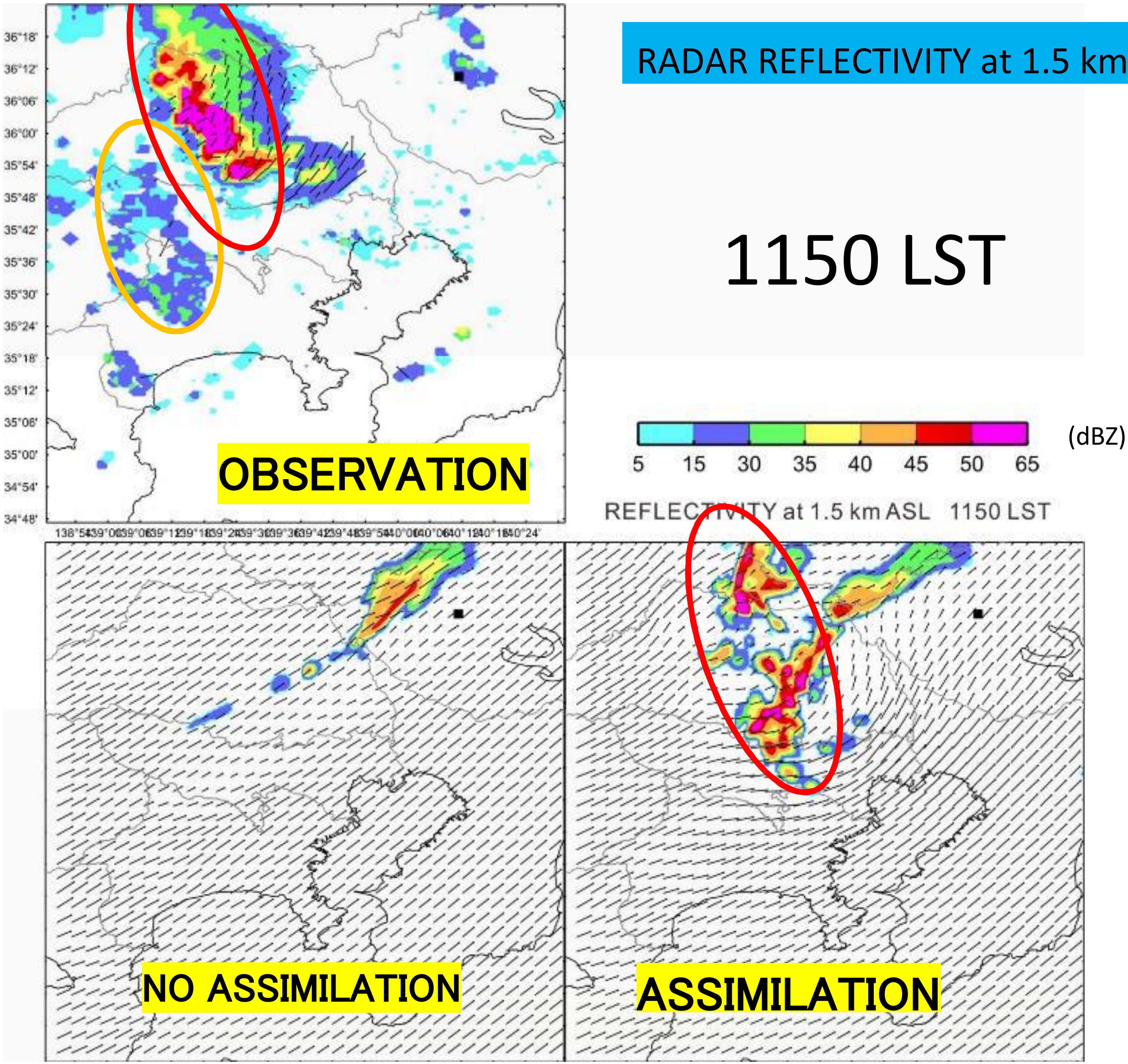
1130 LST




RADAR REFLECTIVITY at 1.5 km ASL
1140 LST
OBSERVATION
36°18'
36°12'
36°06'
36°00'
35°54'
35°48'
35°42'
35°36'
35°30'
35°24'
35°18'
35°12'
35°06'
35°00'
34°54'
34°48'
5 15 30 35 40 45 50 65
(dBZ)
REFLECTIVITY at 1.5 km ASL 1140 LST
NO ASSIMILATION
ASSIMILATION

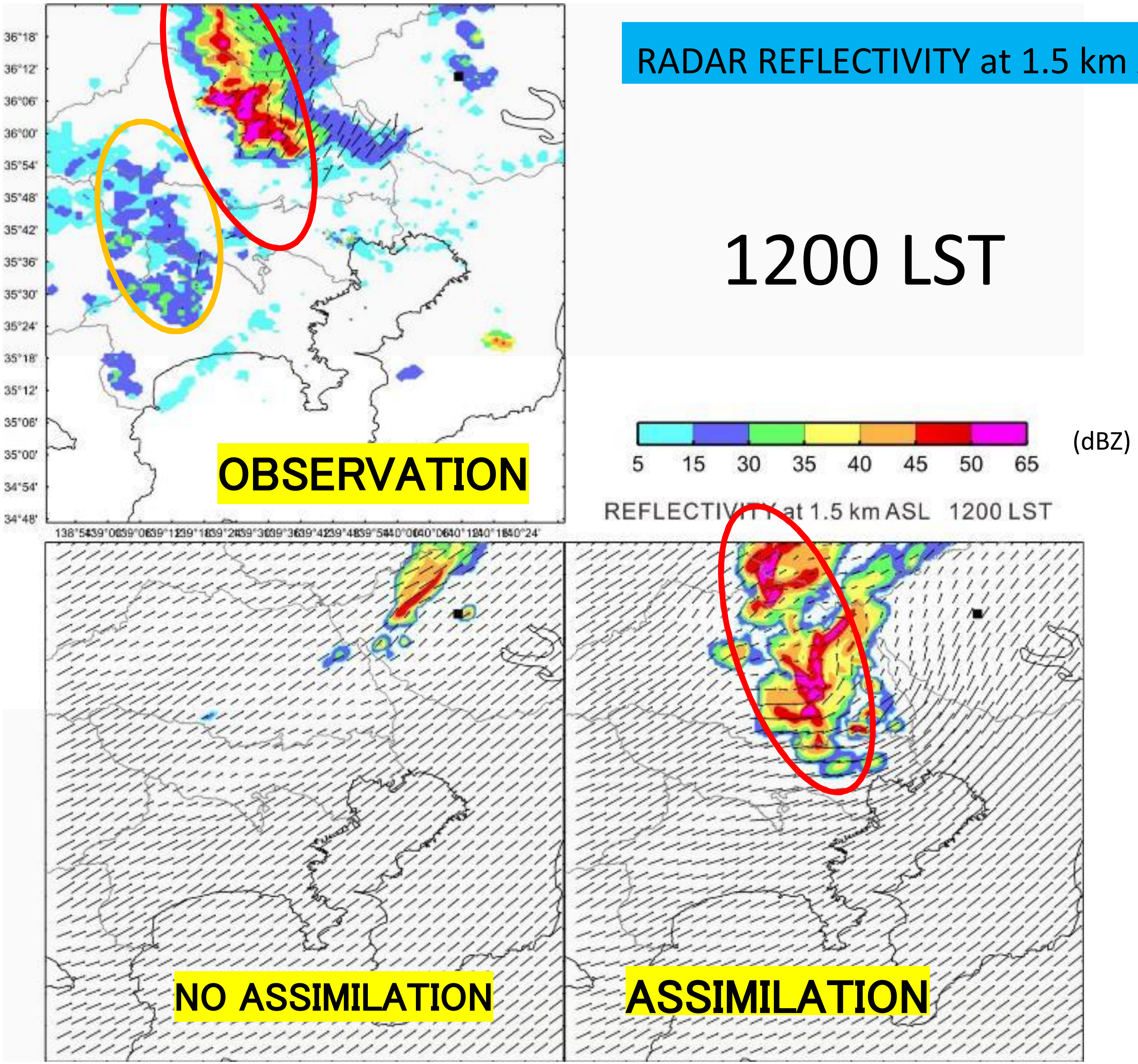
RADAR REFLECTIVITY at 1.5 km ASL

1150 LST



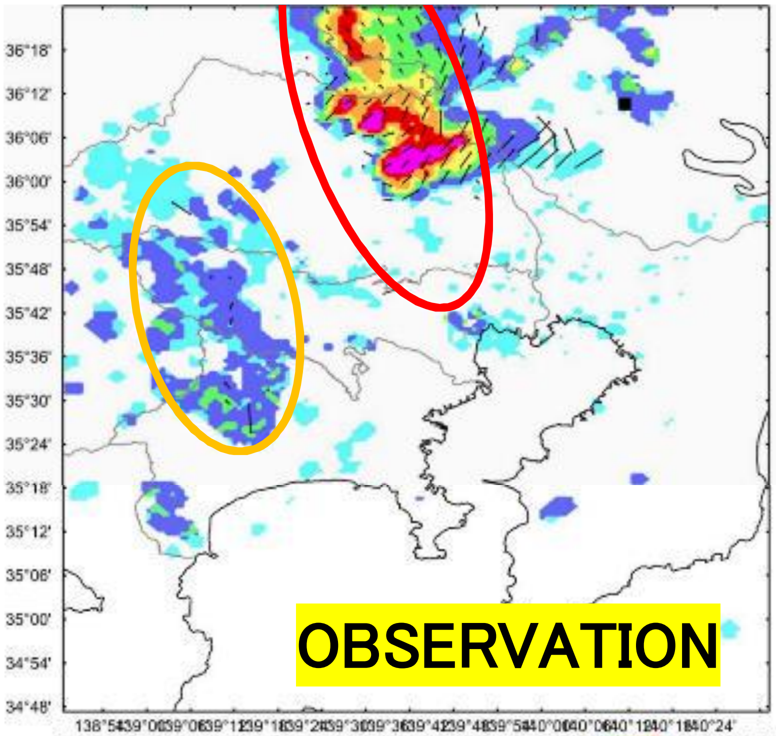
RADAR REFLECTIVITY at 1.5 km ASL

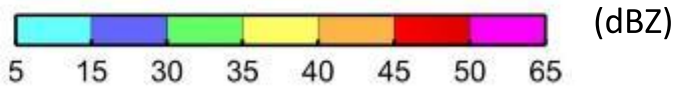
1200 LST

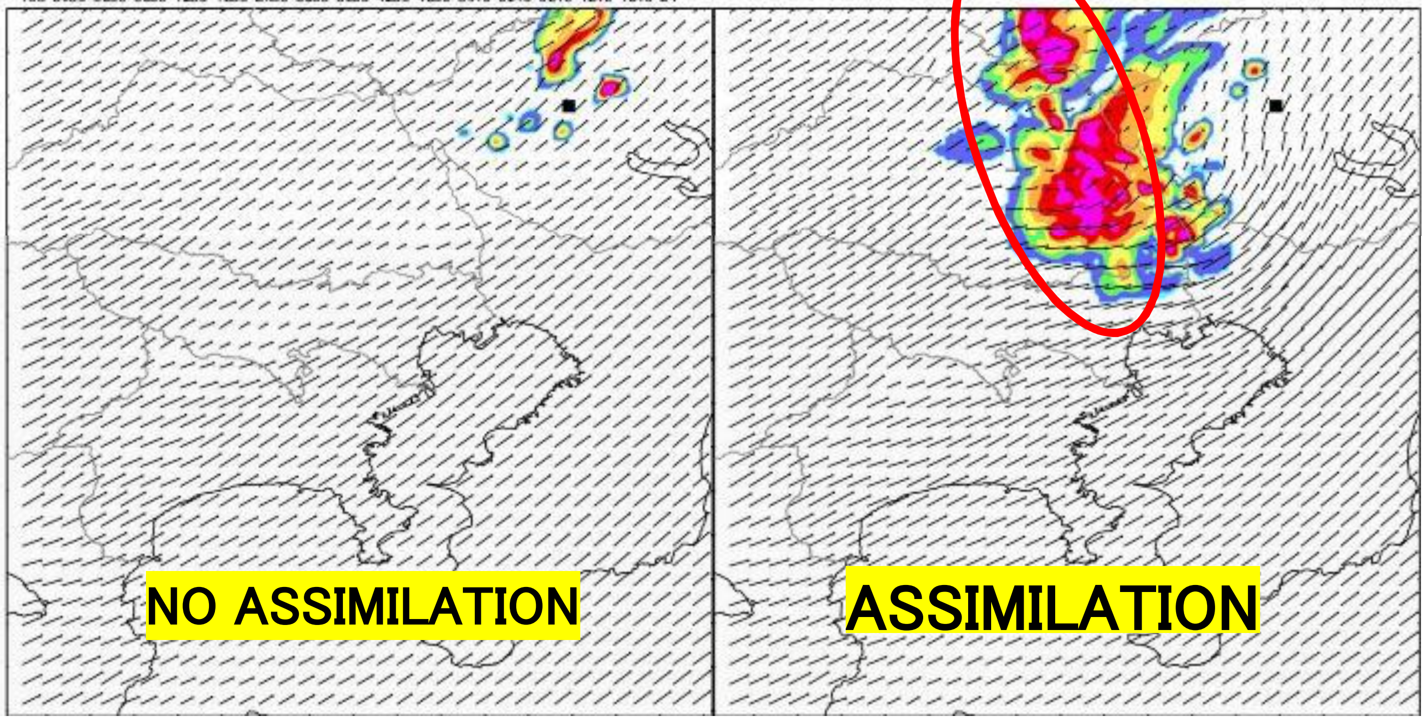


RADAR REFLECTIVITY at 1.5 km ASL

1210 LST

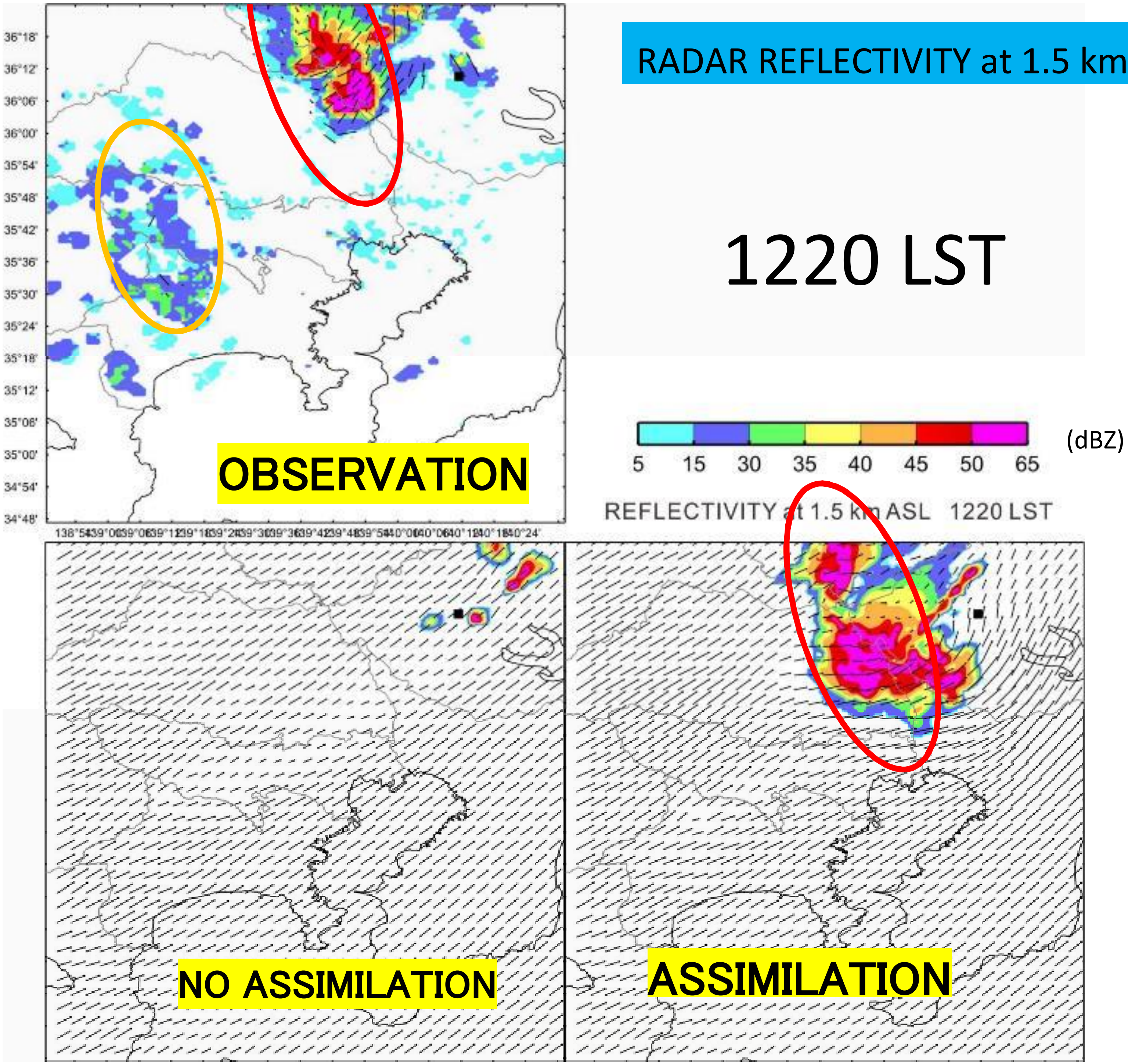


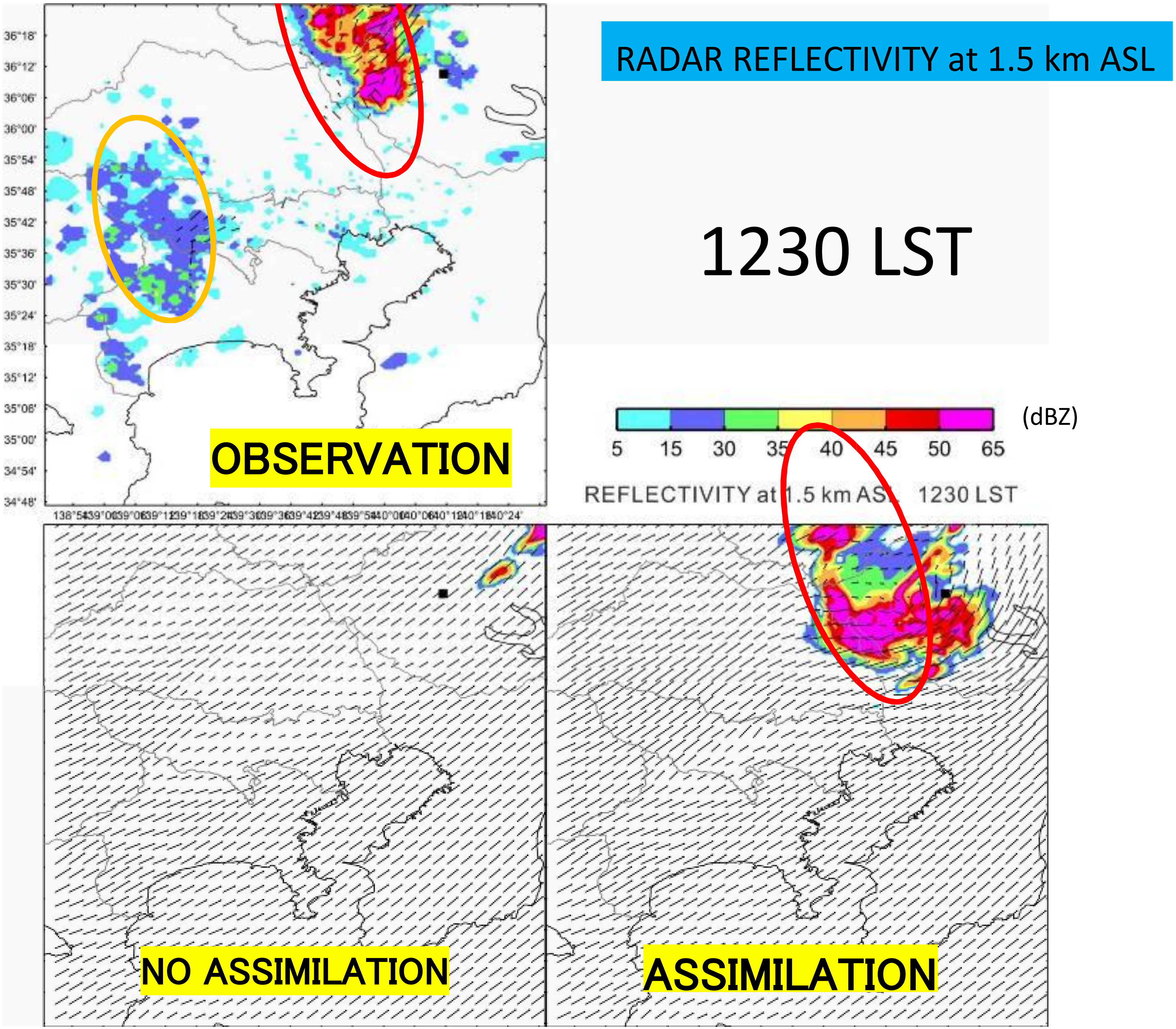




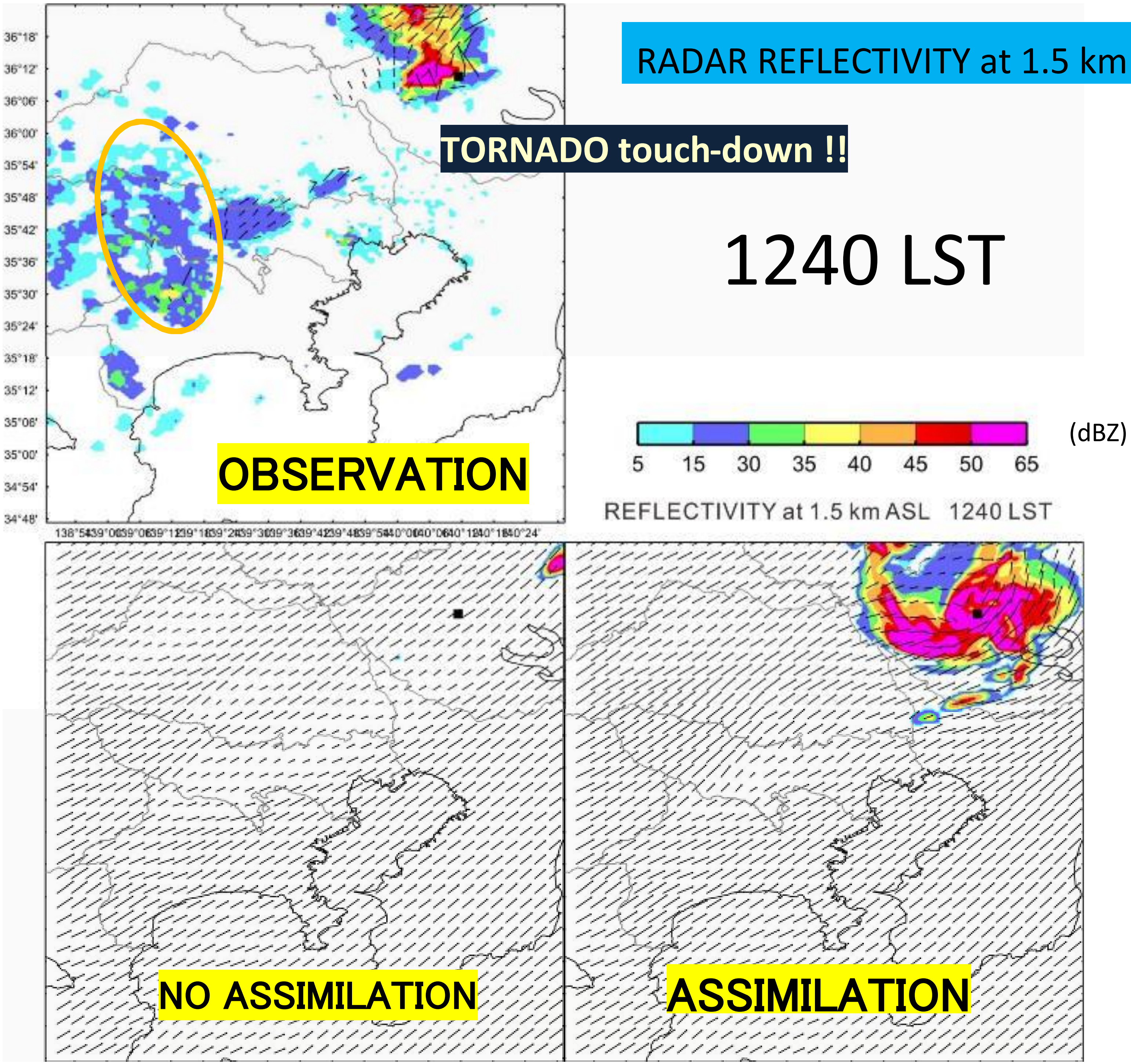
RADAR REFLECTIVITY at 1.5 km ASL

1220 LST



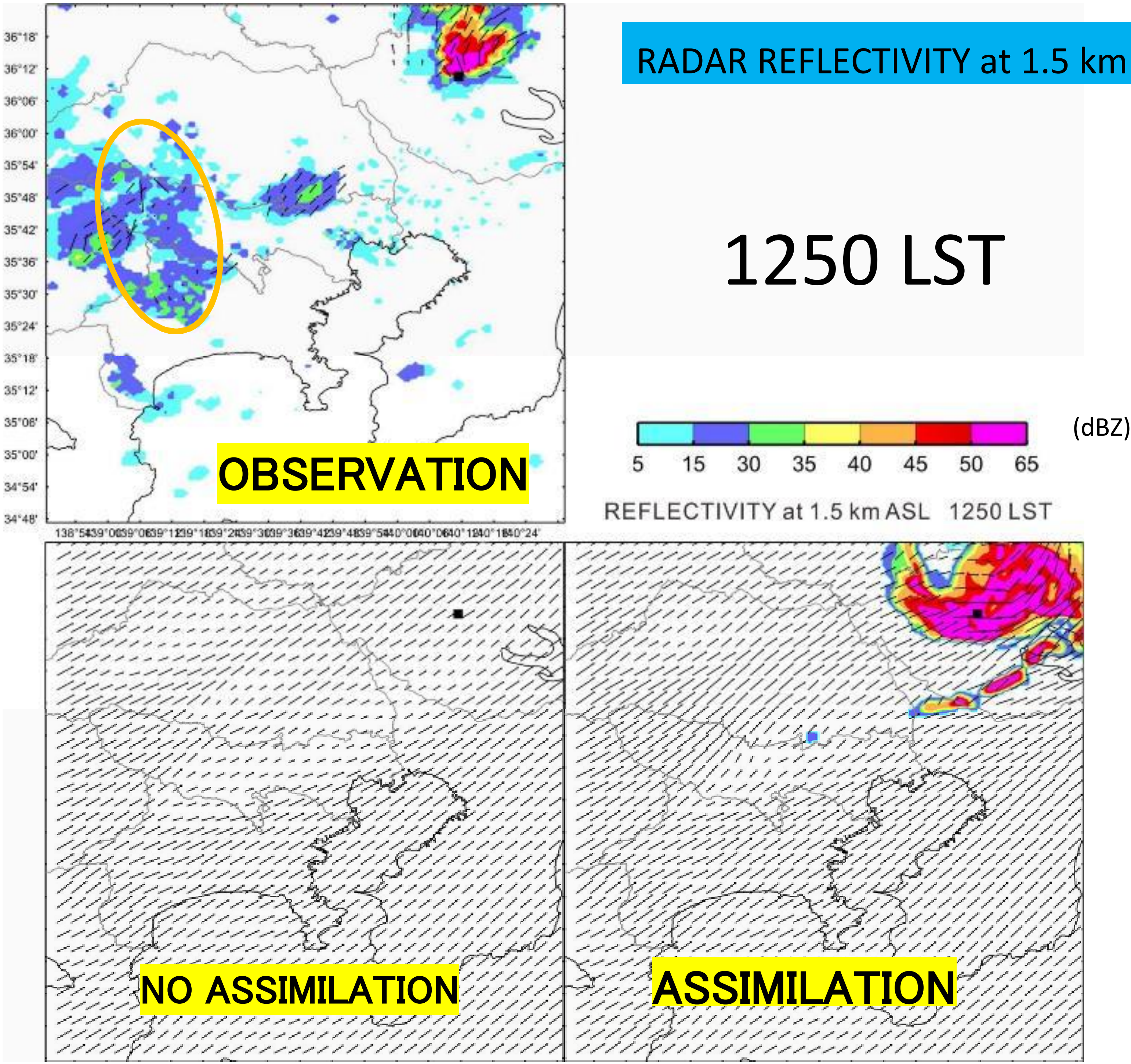

RADAR REFLECTIVITY at 1.5 km ASL
1230 LST
OBSERVATION
5 15 30 35 40 45 50 65
(dBZ)
REFLECTIVITY at 1.5 km ASL 1230 LST
NO ASSIMILATION
ASSIMILATION

RADAR REFLECTIVITY at 1.5 km ASL

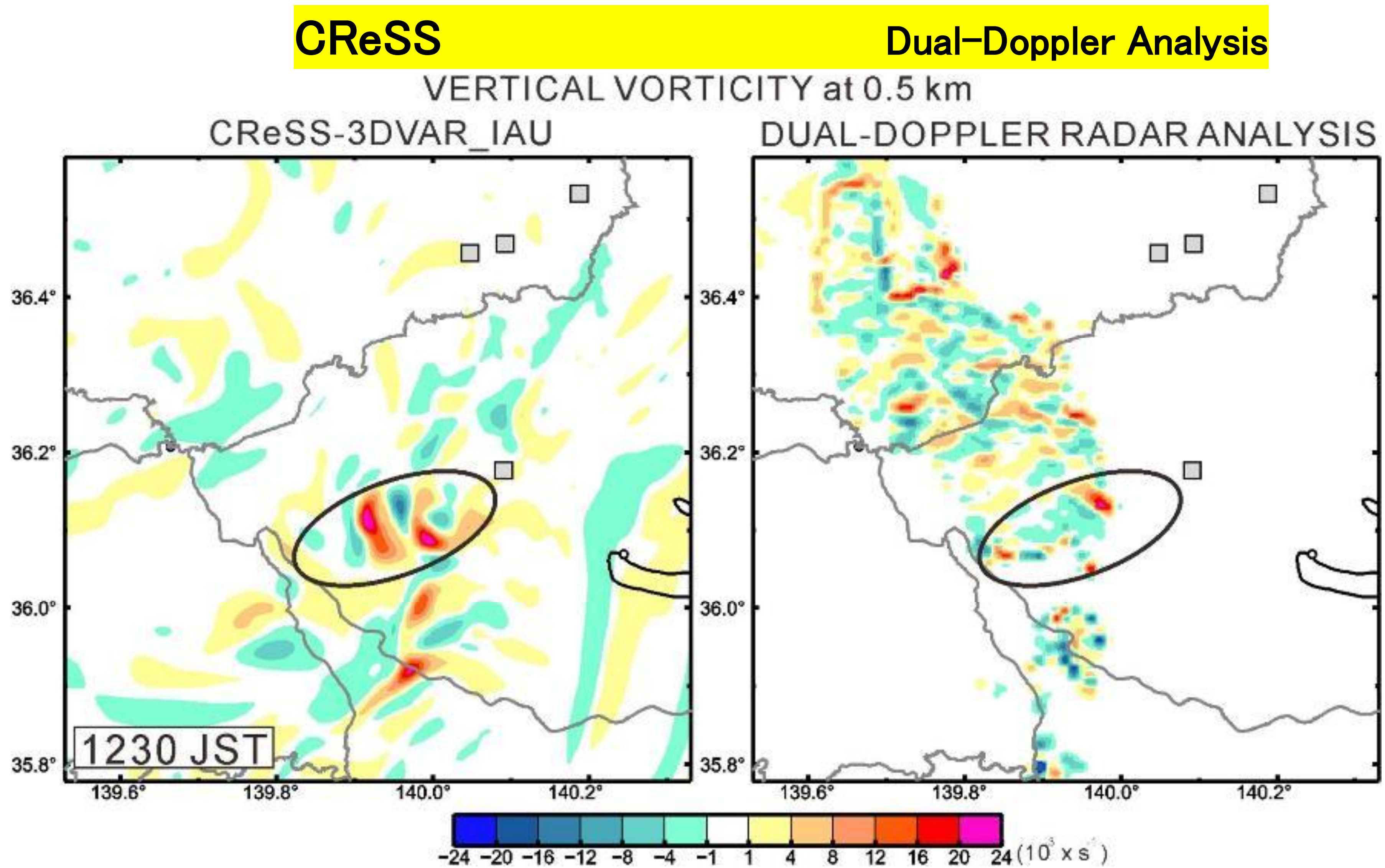


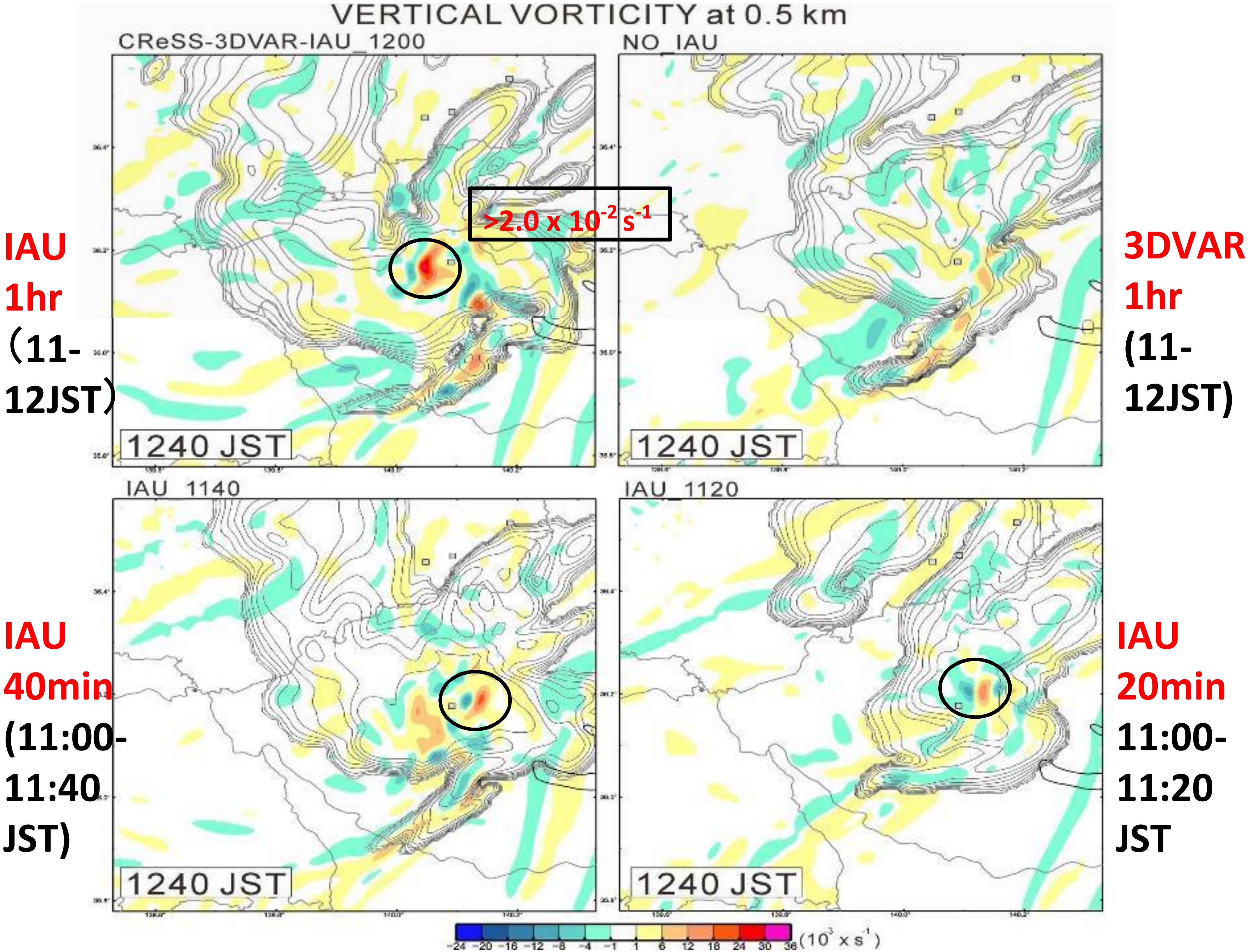
RADAR REFLECTIVITY at 1.5 km ASL

1250 LST



Vertical vorticity at a height of 0.5 km at 1230 JST





VERTICAL VORTICITY at 0.5 km
CReSS-3DVAR-IAU_1200
NO_IAU
>2.0 x 10-2 s-1
IAU
1hr
（11-
12JST）
3DVAR
1hr
(11-
12JST)
1240 JST
IAU_1140
IAU_1120
IAU
40min
(11:00-
11:40
JST)
IAU
20min
11:00-
11:20
JST
-24 -20 -16 -12 -8 -4 -1 1 6 12 18 24 30 36
(10-3 x s-1)