Predictability of tornadoes in the Kanto region on 6 May 2012 based on assimilation of dense observations using the nested-LETKF system

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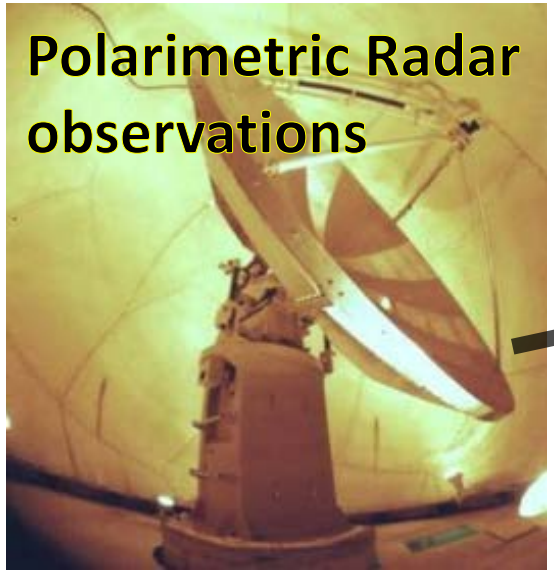
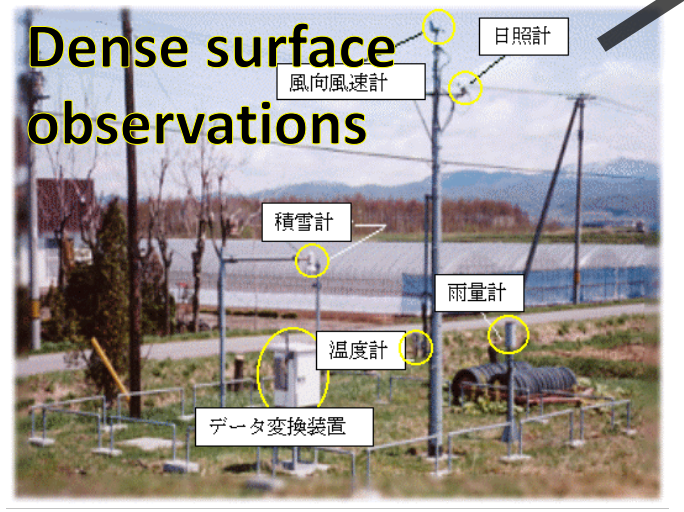
2015.3.9 Mon.

Outline of this study





アメダスの一例(北海道　美唄地域気象観測所)

assimilation

K-computer

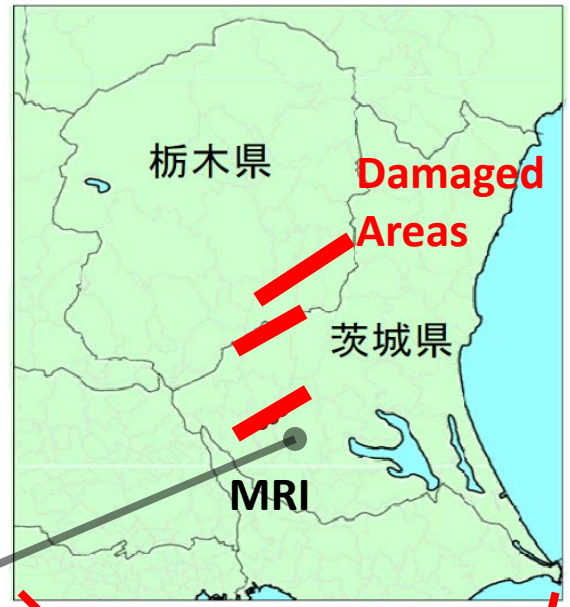
京

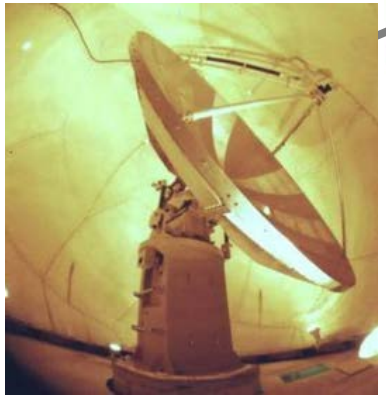
High-resolution numerical experiment

Tornadoes in 6 May 2012

3 tornadoes were generated almost simultaneously at 12:30 JST in 6 May 2012.

South one is estimated F3 (70-92 m/s)
- Damage length: 17km, width: 0.5km
- There were 1 killed, 37 injured, and 76 buildings completely destroyed



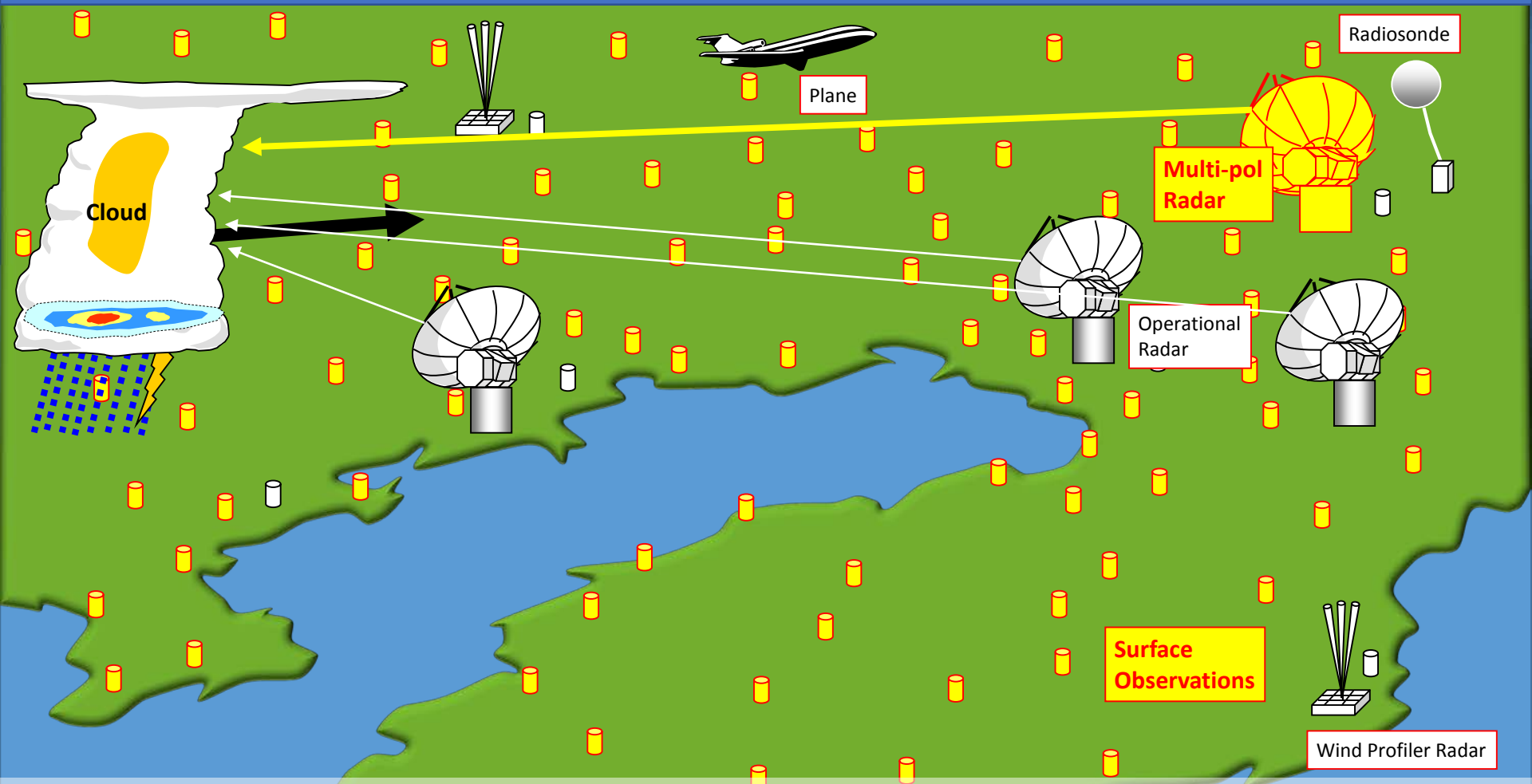


MRI advanced C-band solid-state polarimetric (MACS-POL) radar

In this study,

Reproducing vortices with assimilation of **Polarimetric Radar and surface observations**.

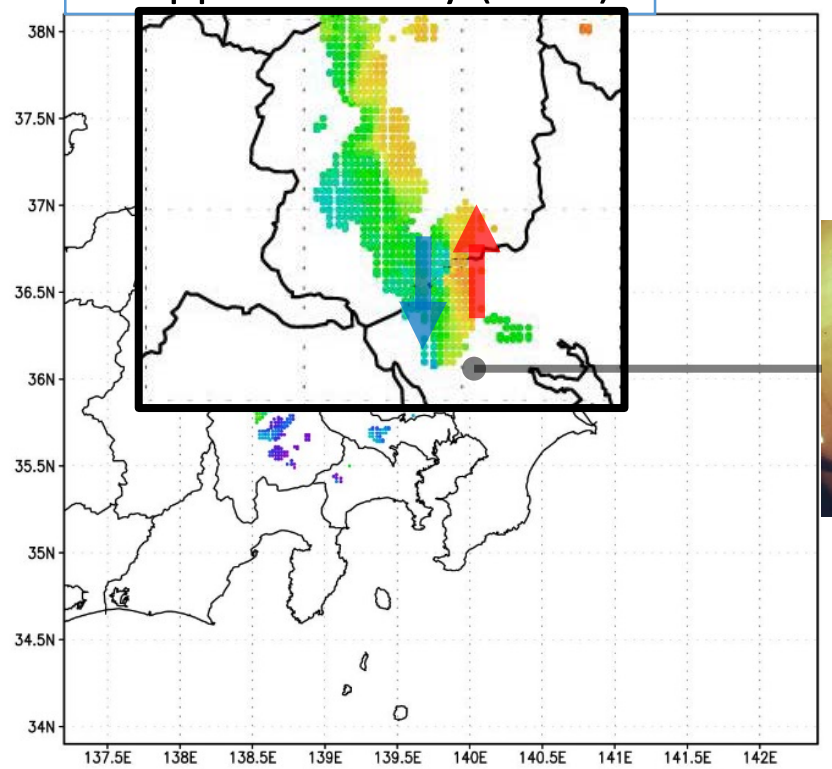
High-resolution observations

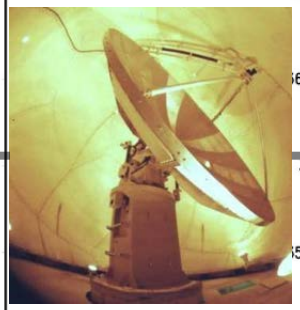


Surface observations from Japan Meteorological Agency (JMA) and NTT DOCOMO INC, and **Polarimetric Radar observations** from 2nd laboratory, Meteorological Satellite and Observation System Research Department, Meteorological Research Institute are used for this experiment except JMA operational observations.

MACS-POL Radar Observations

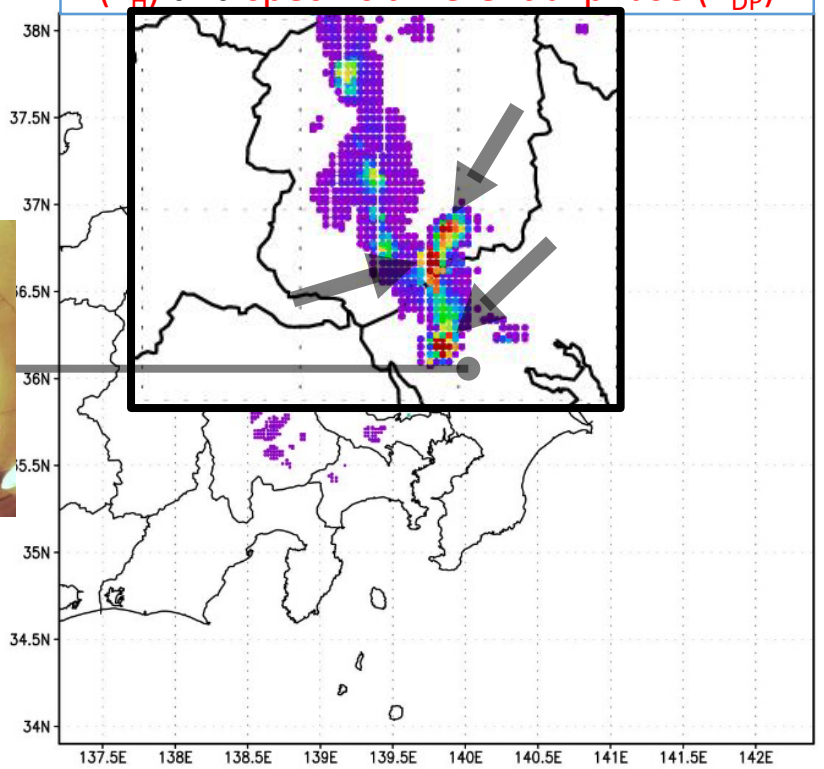
Doppler Velocity (m s^{-1})

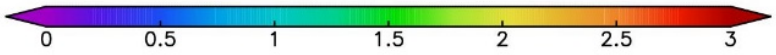




12:30 JST
EL=1.0°

Rain (g m^{-3}) estimated by reflectivity (Z_H) and specific differential phase (K_{DP})





3 peaks associated with 3 tornadoes were observed.

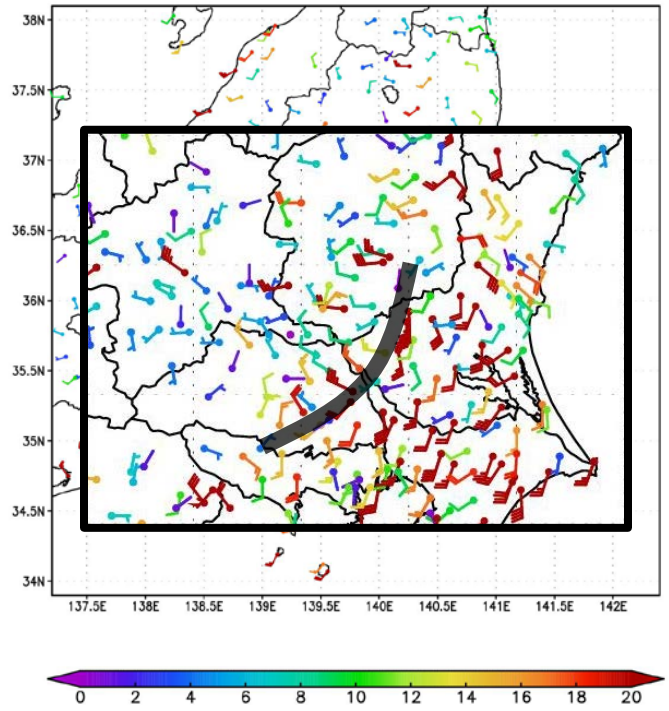
MACS-POL Radar data are from 2nd laboratory, Meteorological Satellite and Observation System Research Department, Meteorological Research Institute.

Surface Observations using AMeDAS and ESN

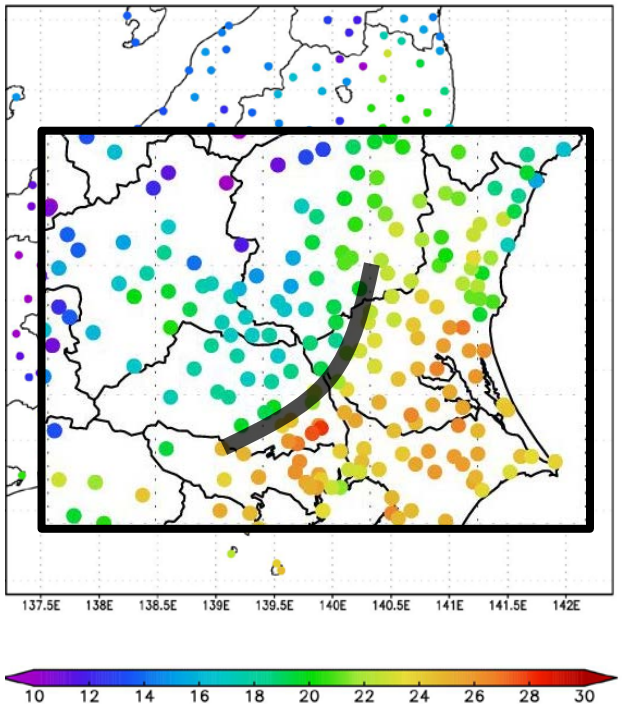
AMeDAS: Automated Meteorological Data Acquisition System
ESN: Environmental Sensor Network

12:30 JST
(Interval ～ 10km)

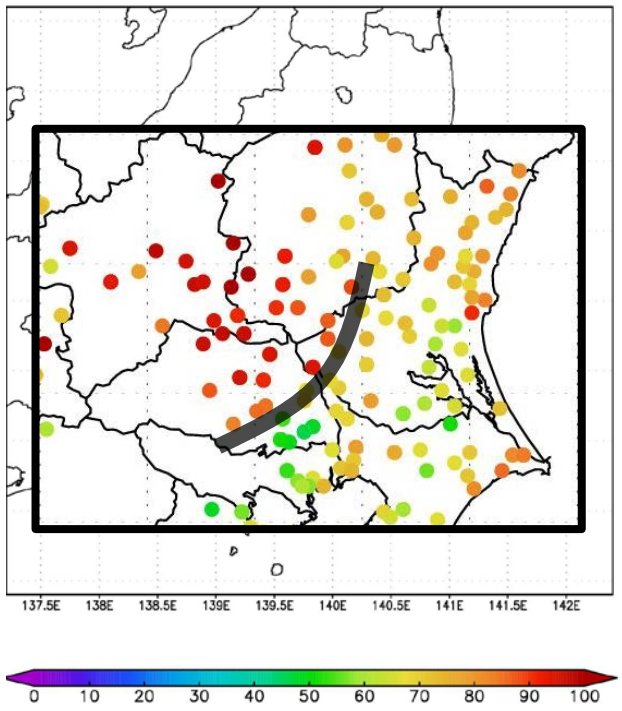
Horizontal Wind (m s^{-1})



Temperature (K)



Relative Humidity (%)

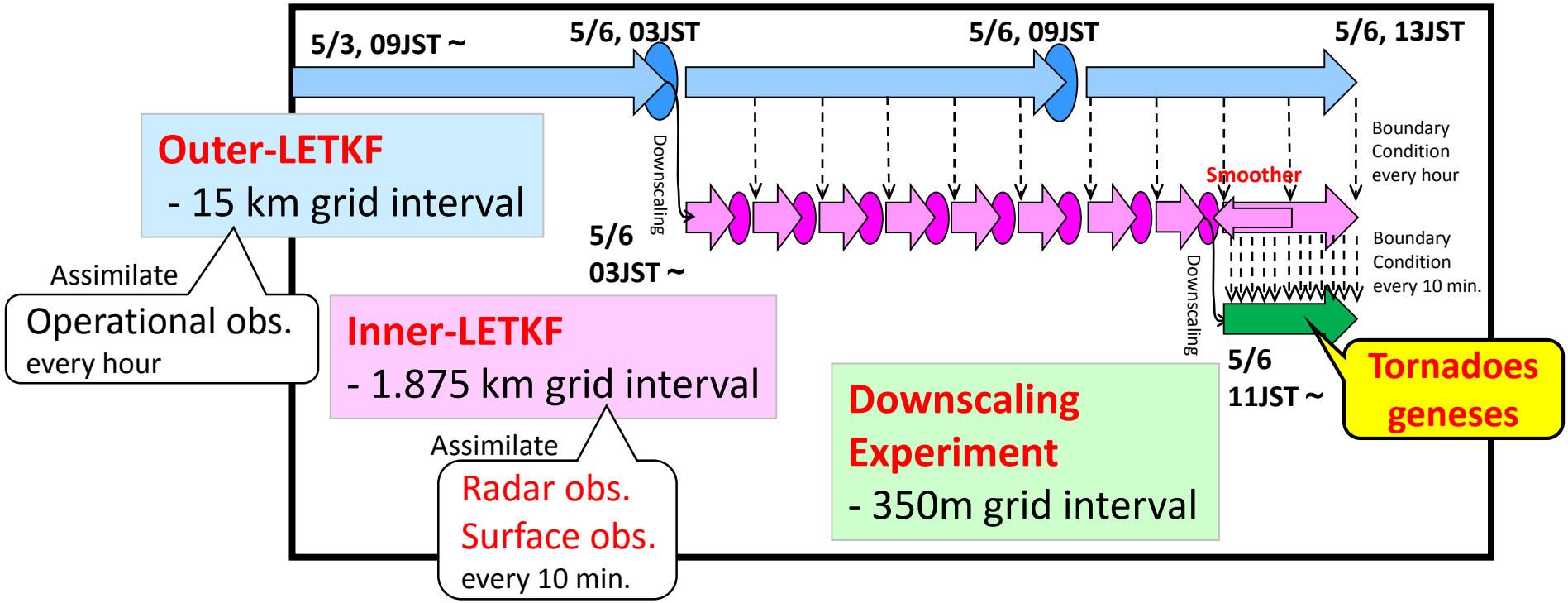


The shear line was observed well.

AMeDAS data are from Japan Meteorological Agency, and ESN data are from NTT DOCOMO INC.

Outline of Nested-LETKF system

Arrows: Ensemble experiment, Ellipses: LETKF analyses



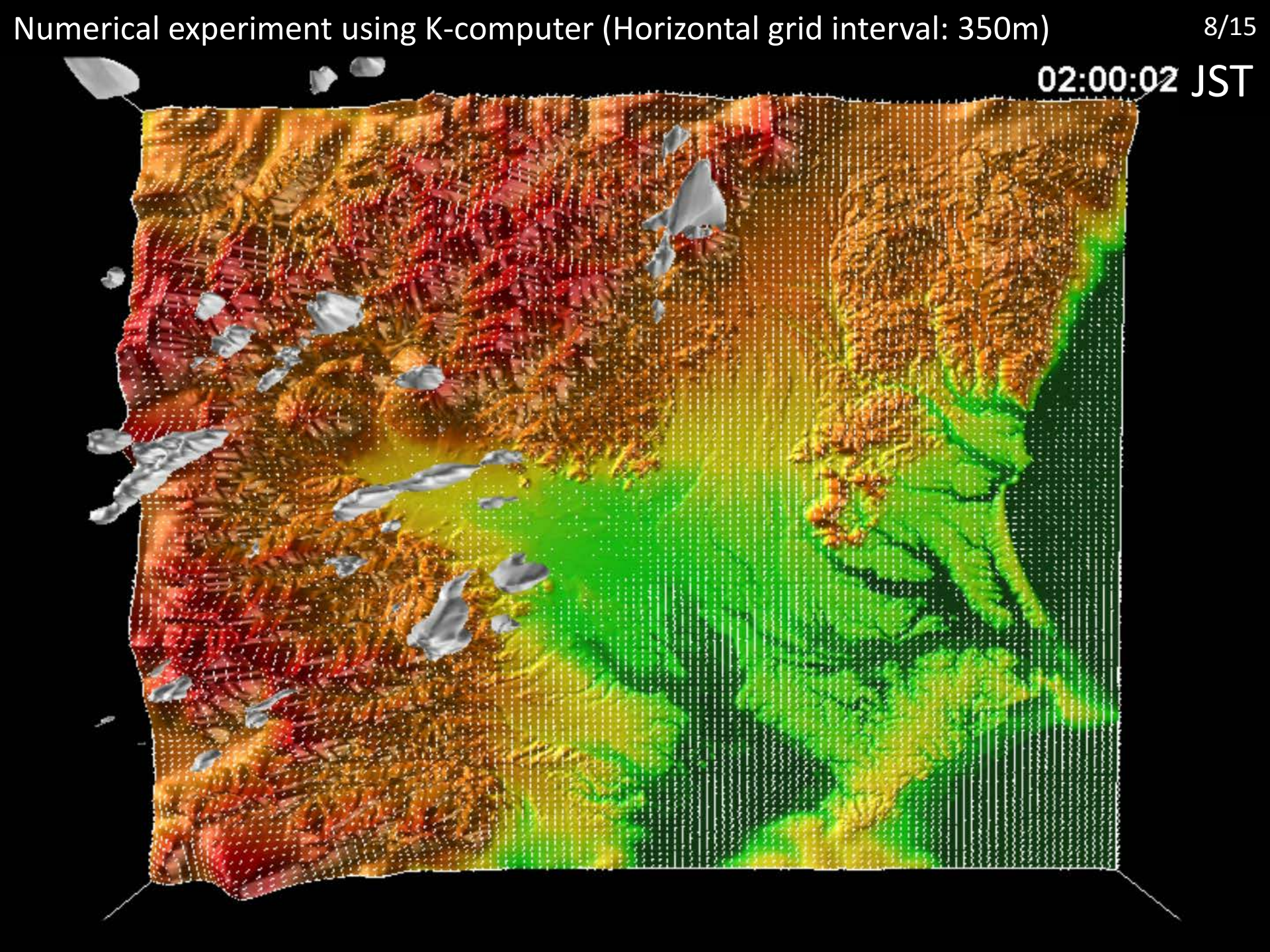
Number of ensemble members: 32

Operational obs.: Surface (pressure), Radiosondes (wind, temperature, humidity), Planes (wind, temperature), Radars (Doppler wind, humidity) and Wind profiler radars (wind)

Radar obs.: Doppler wind observed by MACS-POL and operational 3 radars
Rainwater estimated from K_{DP} and Z_H of MACS-POL radar

Surface obs.: Surface Wind, temperature and humidity observed by AMeDAS and ESN

Numerical experiment using K-computer (Horizontal grid interval: 350m)

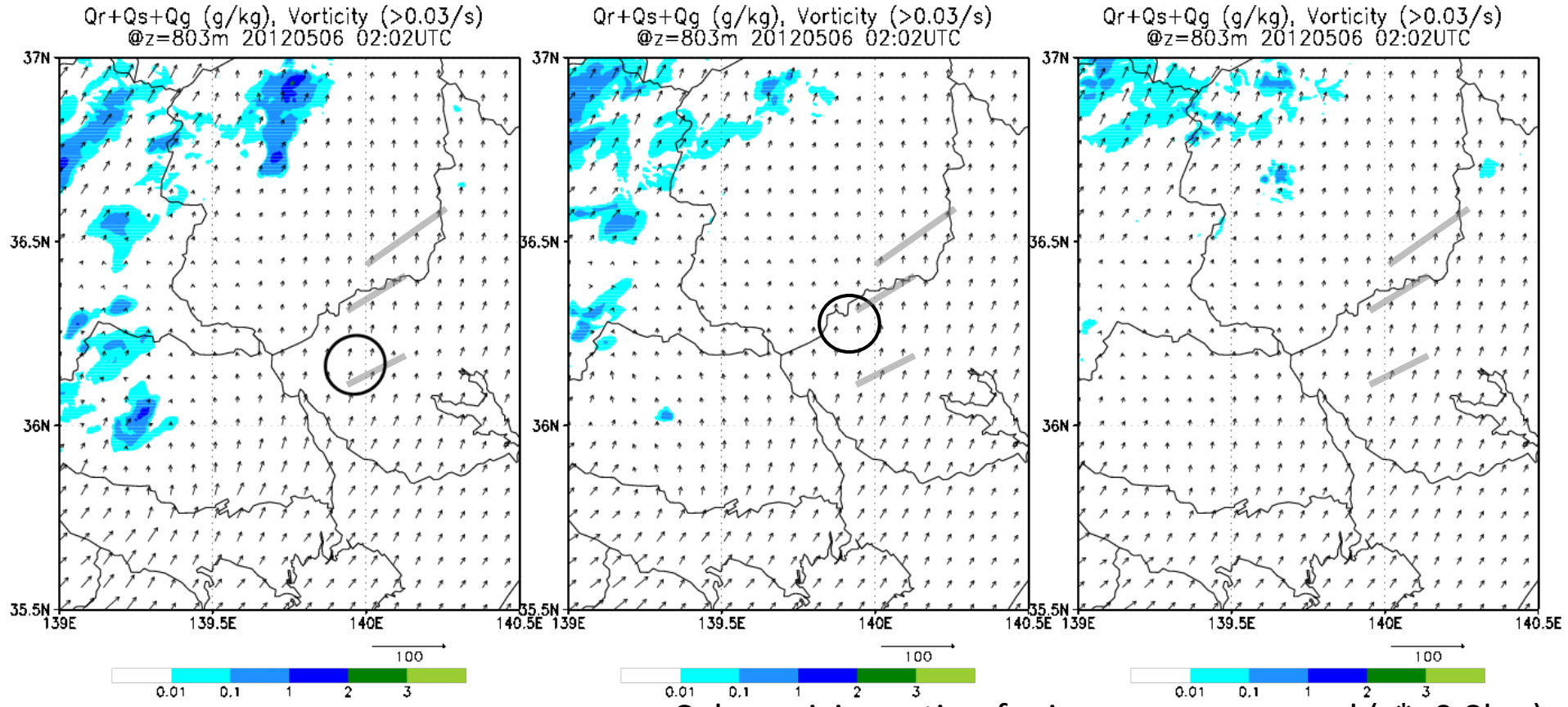


Impact of assimilation of dense observations

CTL

Surface obs. are not assimilated

Radar obs. are not assimilated



Path of the vortex is improved

Color: mixing ratio of rain + snow + graupel (z*=0.8km)

Arrows: horizontal wind (z*=0.8km)

Gray lines: damage area by real tornadoes

Red points in circles: relative vorticity > 0.03/s

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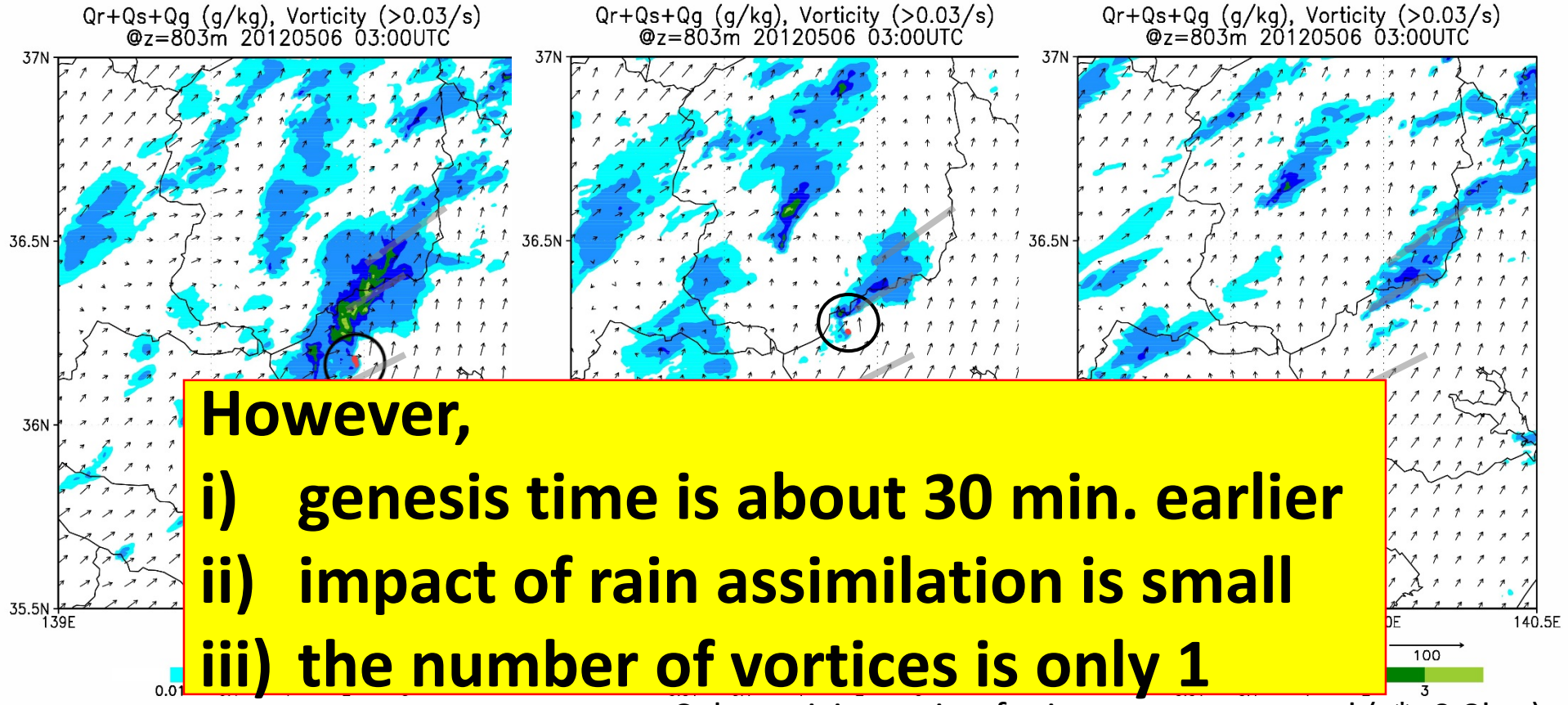

However,

i) genesis time is about 30 min. earlier

ii) impact of rain assimilation is small

iii) the number of vortices is only 1

Path of the vortex is improved

Color: mixing ratio of rain + snow + graupel (z*=0.8km)
Arrows: horizontal wind (z*=0.8km)
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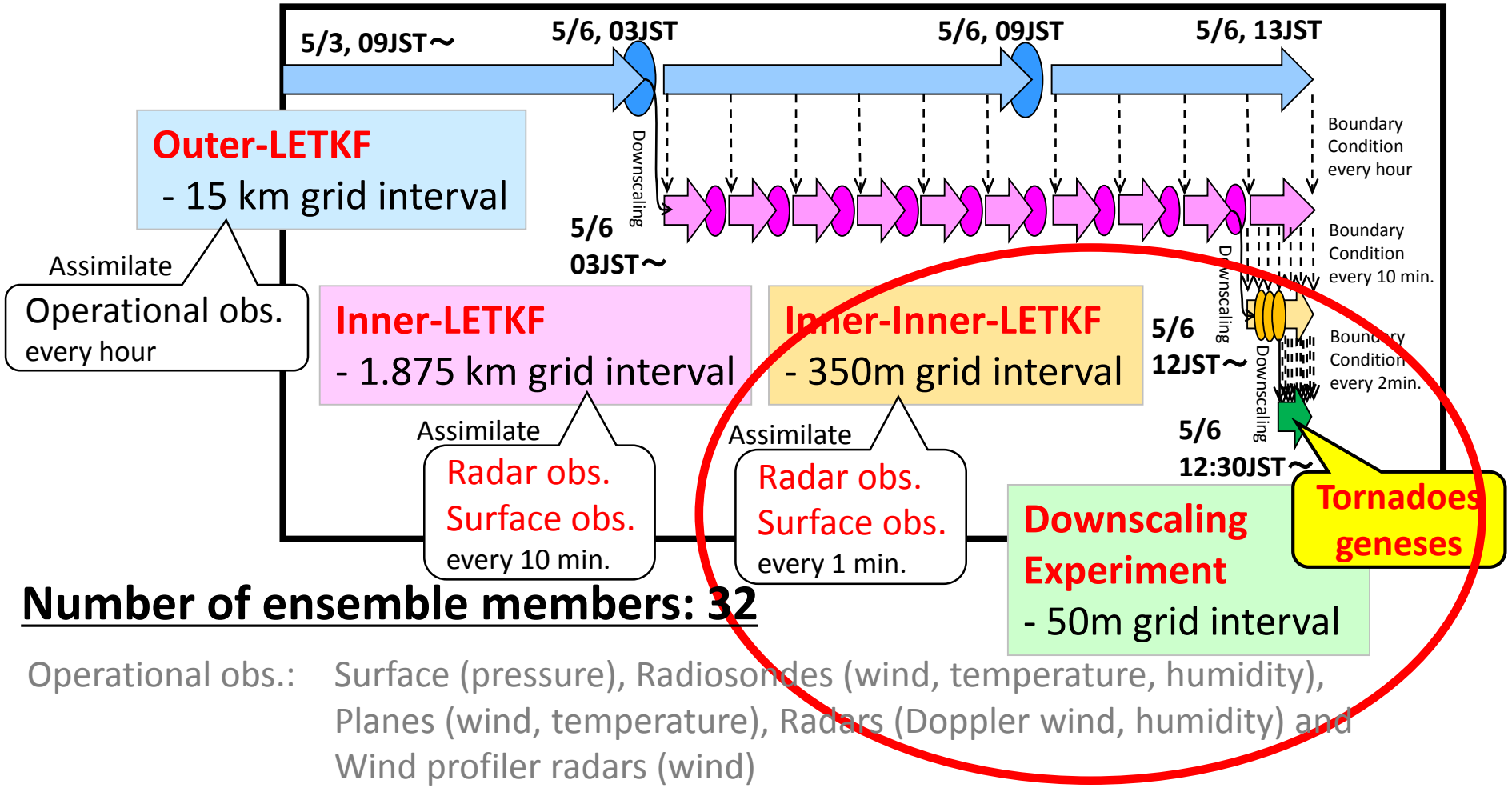

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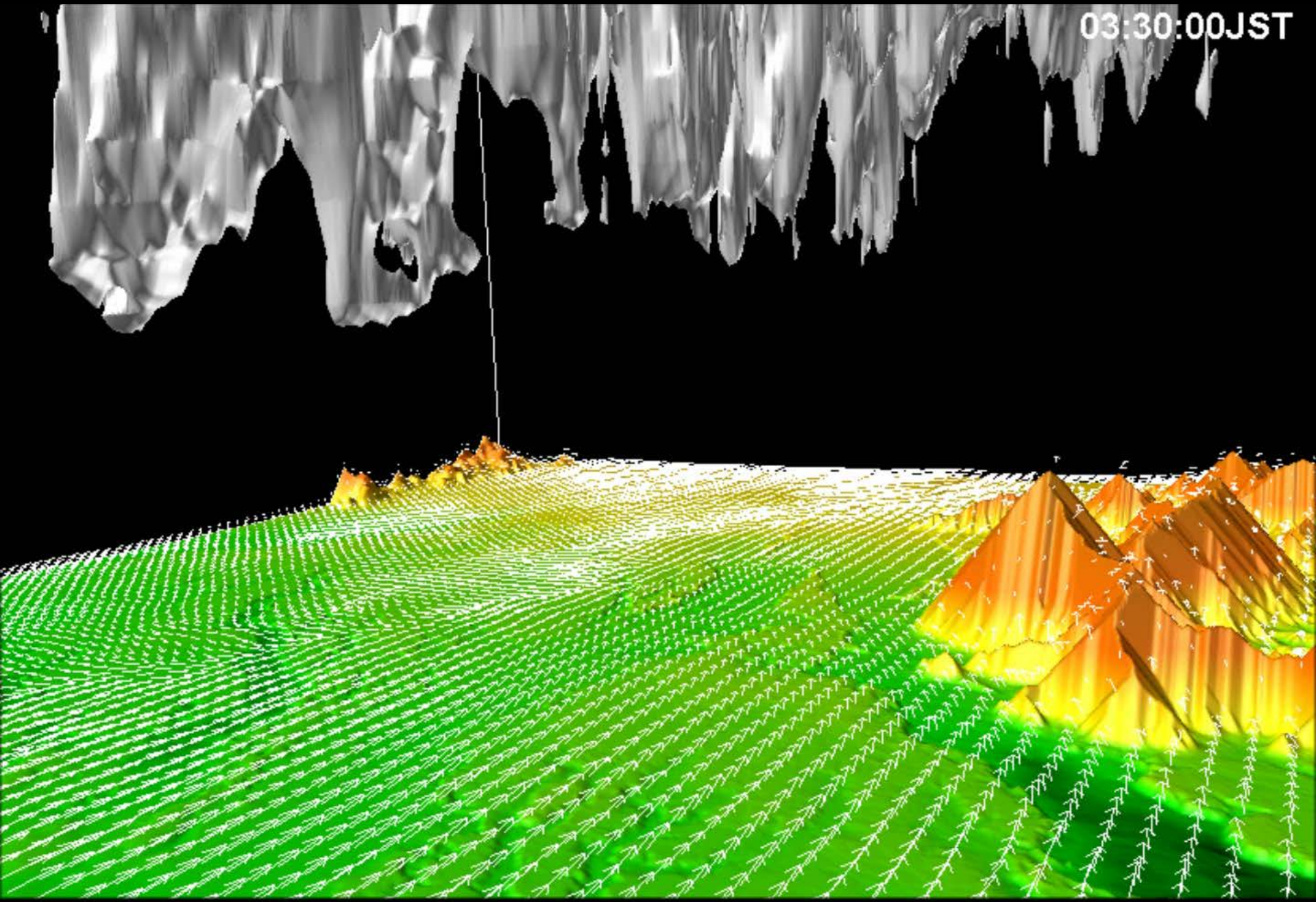
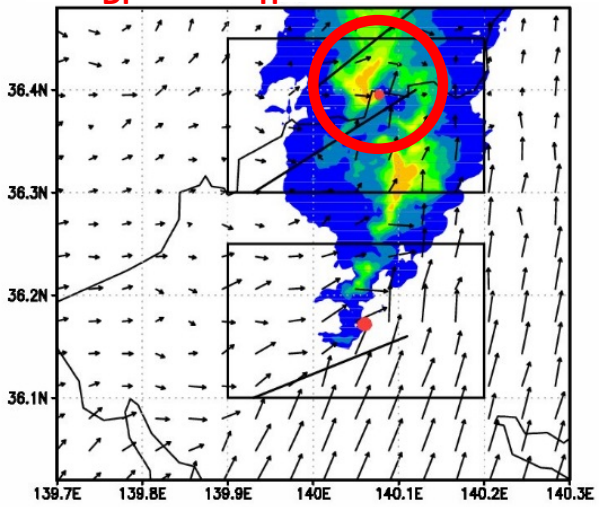
Numerical experiment using K-computer (Horizontal grid interval: 50m)

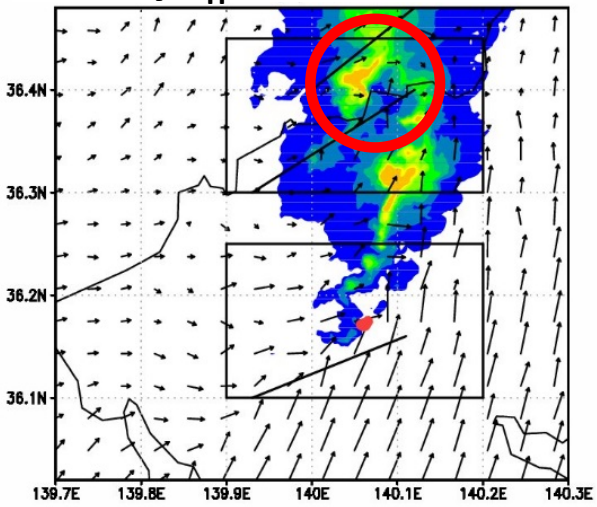


Impact of assimilation of Multi-pol information

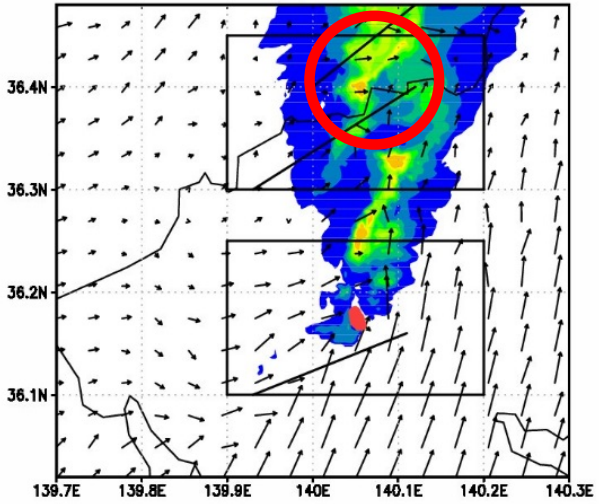
Rainwater estimated from K_{DP} and Z_H is assimilated

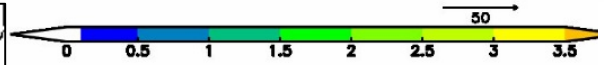


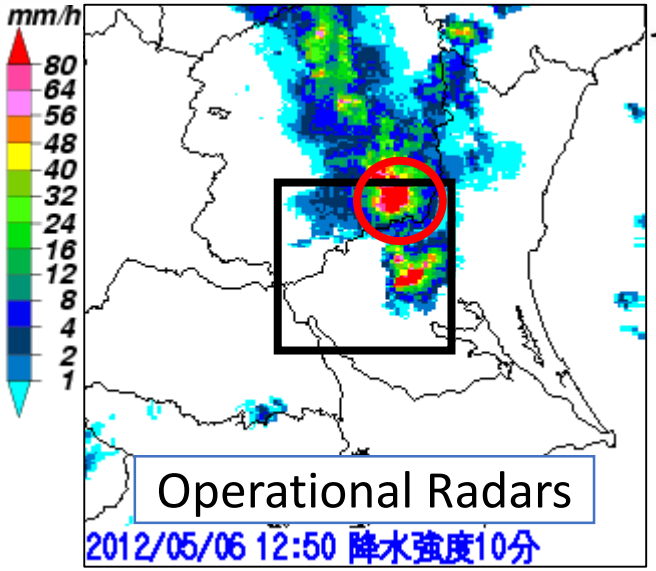
Rainwater estimated from only Z_H is assimilated



Rainwater is not assimilated







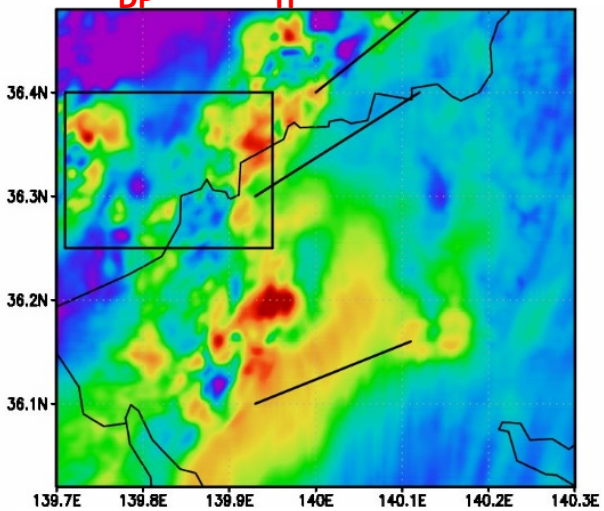
12:46JST forecast (z*=0.5km)
(initial: 12:30JST)

Color: mixing ratio of rain (g/kg)
Arrows: horizontal wind
Red points: vorticity>0.03/s
(calculated in 350m grids)

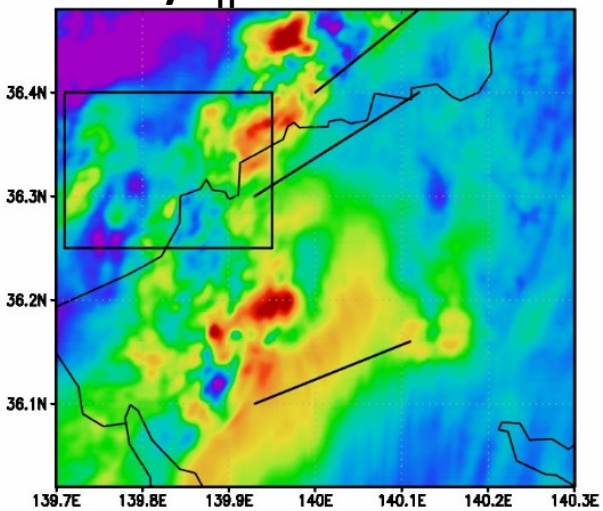
North rain is reproduced well because of rainwater assimilation

Low-level water vapor in the initial state (12:30JST)

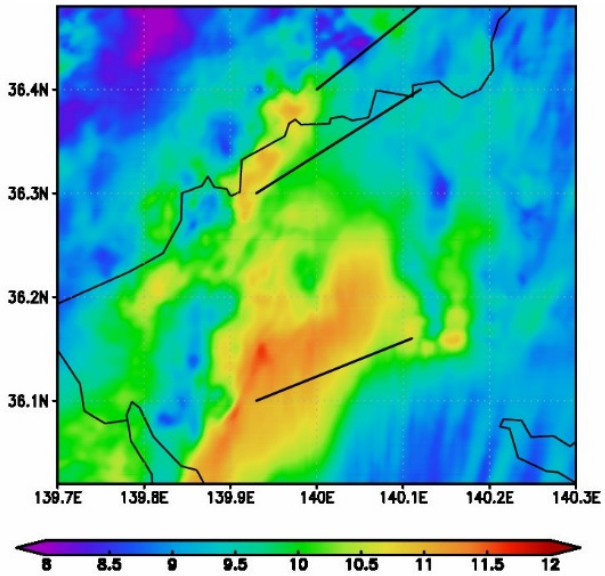
Rainwater estimated from K_{DP} and Z_H is assimilated



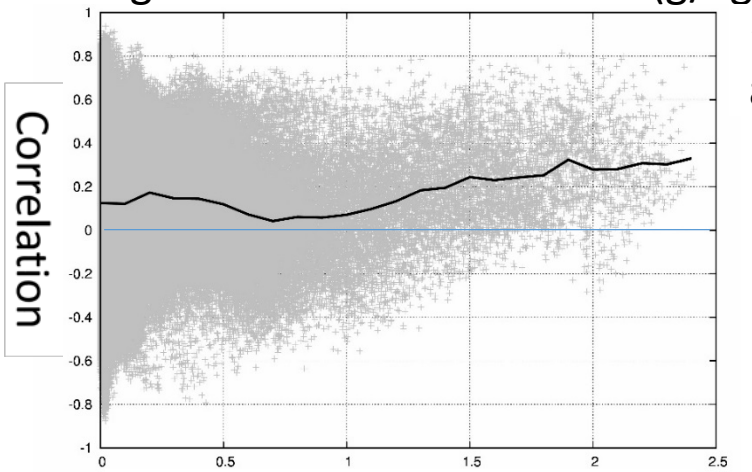
Rainwater estimated from only Z_H is assimilated



Rainwater is not assimilated



↑ Mixing ratio of the water vapor averaged in z*<1km in 12:30JST (g/kg)



← Correlation between the mixing ratio of water vapor and that of rain at each grid points in z*<1km in 12:30JST

Positive correlation between low-level water vapor and rain

↓

Low-level water vapor increased in the heavy rain region in LETKF analysis.

Summary

- Dense observations (below) were assimilated with the Nested-LETKF system in the case of tornadoes in May 6, 2012
  - Radar radial wind and rain estimated from Z_H and K_{DP}
  - Horizontal wind, temperature and humidity on the surface

- Realistic vortices are reproduced due to these data assimilation
  - Correction of low-level water vapor was important for reproducing vortices and rain.
  - Multi-pol information is also useful to make reproduction of rain better

- In the future, we plan to perform assimilation experiments in the other cases

This study is supported by “HPCI Strategic Program for Innovation Research Field3” (ID: hp120282, hp130012, hp140220) and “Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities(TOMACS)”. The downscaling experiment was performed using K-computer.