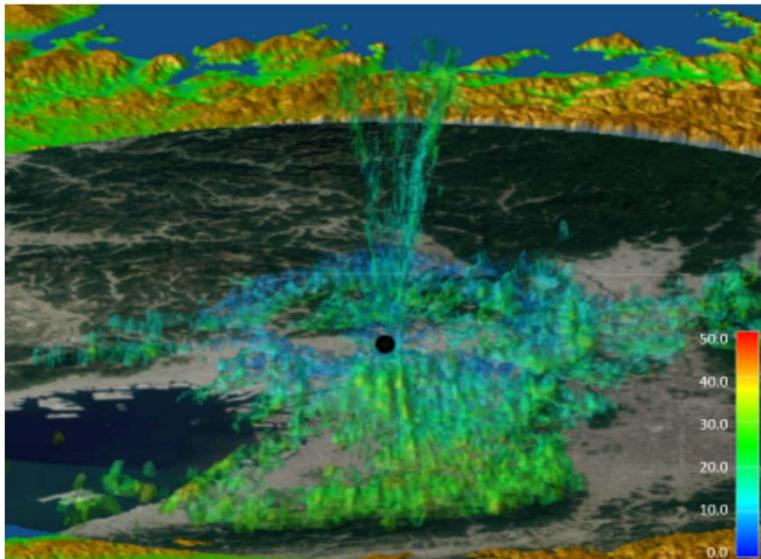


Real-time Quality Control of Phased Array Weather Radar Data Observed Every 30 Seconds



**Shinsuke Satoh, Fusako Isoda, Tetsuya Sano, Hiroshi Hanado (NICT),
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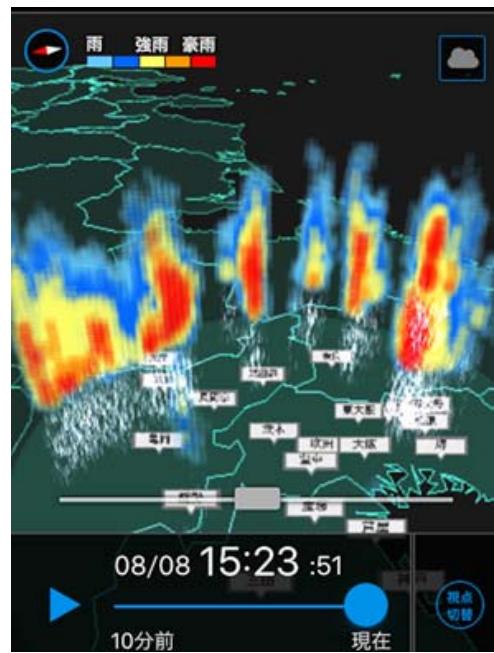
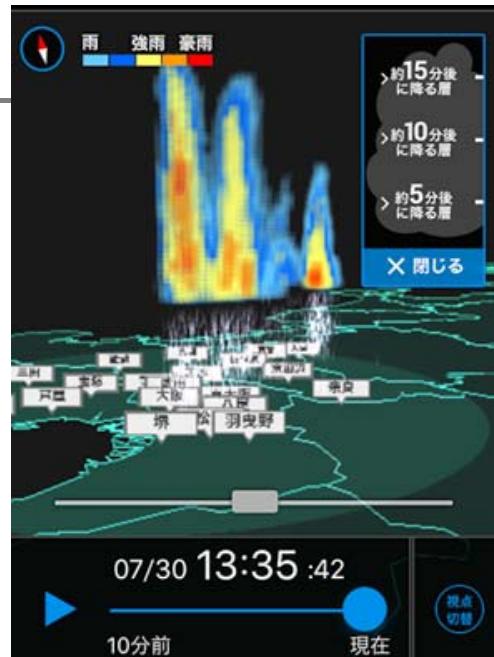
38th Conference on Radar Meteorology
@Chicago IL, 01 Sept. 2017

Introduction

The X-band (single-polarization) **Phased Array Weather Radar (PAWR)** measures 3D fine structure of precipitation with 100 m range and 100 EL angles every 30 seconds. The PAWR produces Big Data which is 100 times larger than traditional radar.

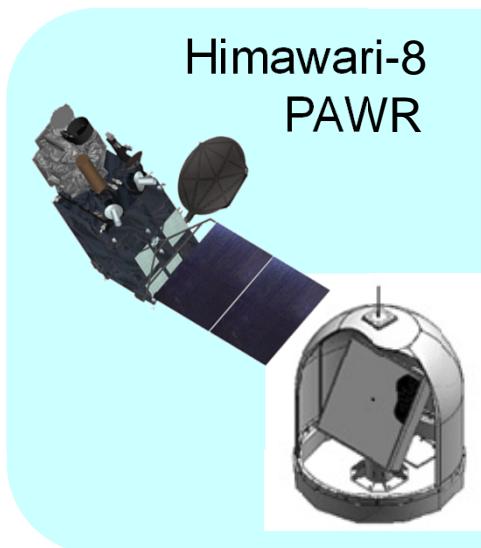
Real-time quality control (QC) processing of the PAWR data is essential for data assimilation and nowcasting for weather forecast. The real-time data is also published on a web-page (<http://pawr.nict.go.jp>) and is used in a smartphone application.

In this study, faster and general-purpose data QC algorithm is developed for use in real-time applications.



<http://pawr.life-ranger.jp>

“Big Data Assimilation” Revolutionizing Severe Weather Prediction (PI: Takemasa Miyoshi)



LETKF
Data Assimilation



NHM

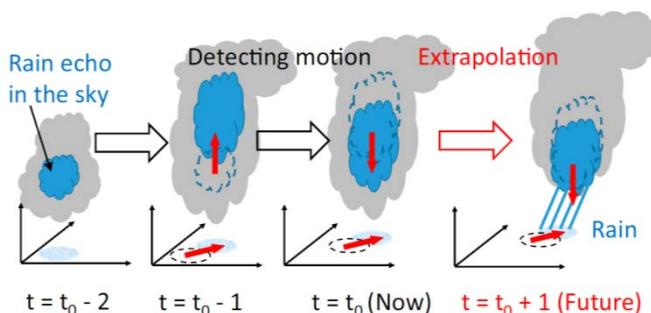
SCALE
Statistical Computing for Advanced Meteorology and Environment

**Pinpoint (< 100-m resol.) forecast of
severe local weather by
updating 30 min forecast every 30 sec!**

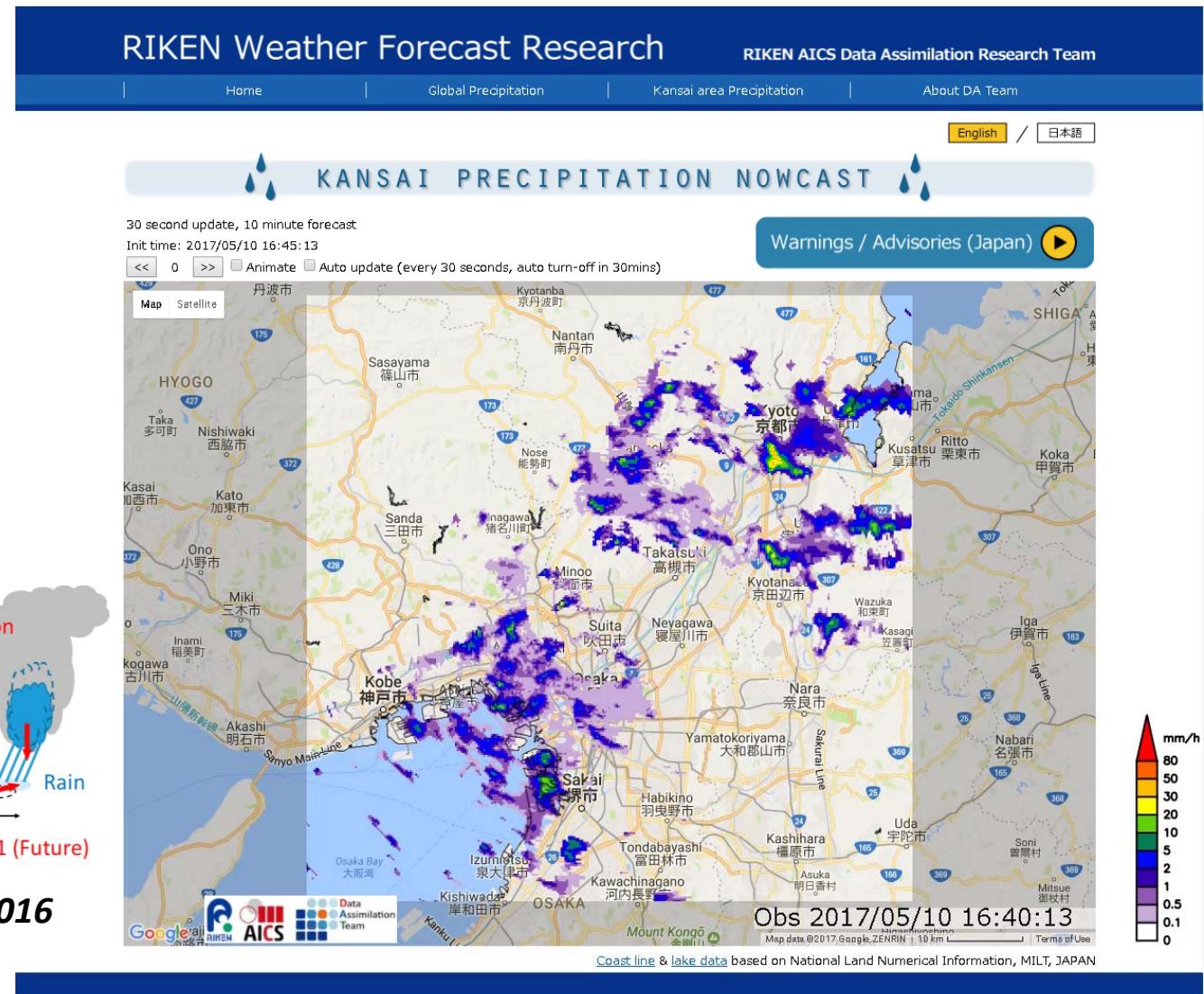
(Miyoshi et al. BAMS, 2016)

Real-time demonstration of 3D nowcasting

30-second update
nowcasting for 10
minutes started on
July 3, 2017.



Otsuka et al. Wea. Forecast, 2016



Request for faster QC algorithm

Data quality control (QC) such as clutter removal is essential in order to use PAWR observation data for data assimilation and nowcast.



The Ruiz's QC algorithm (SOLA, 2015) used for the BDA experiment requires calculation time of 40 seconds. However, it is necessary to develop a **faster** and **general-purpose** QC algorithm to perform real-time processing on the various observation data.

Perform QC calculation and data transfer within 10 seconds for 3D nowcast

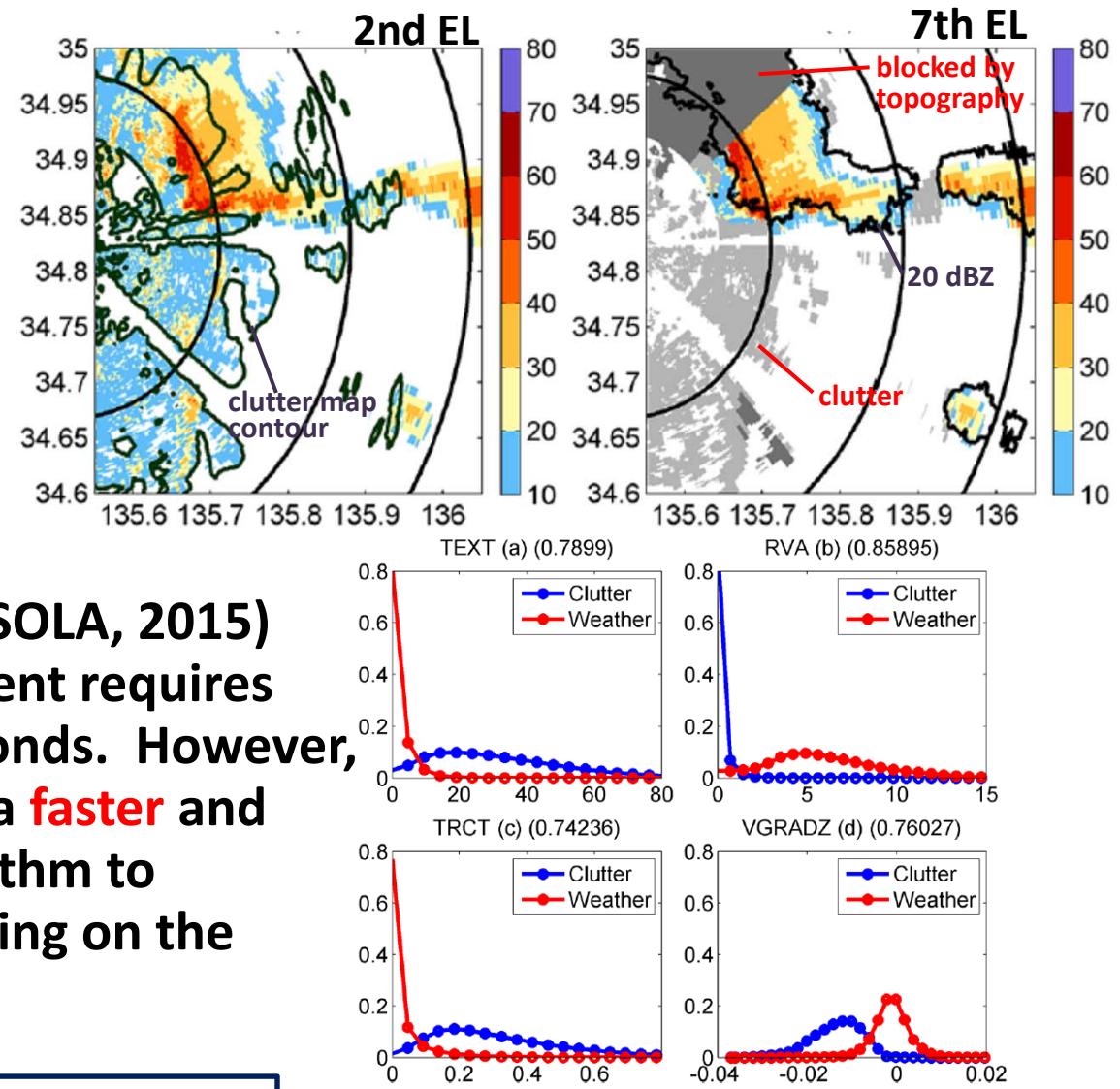
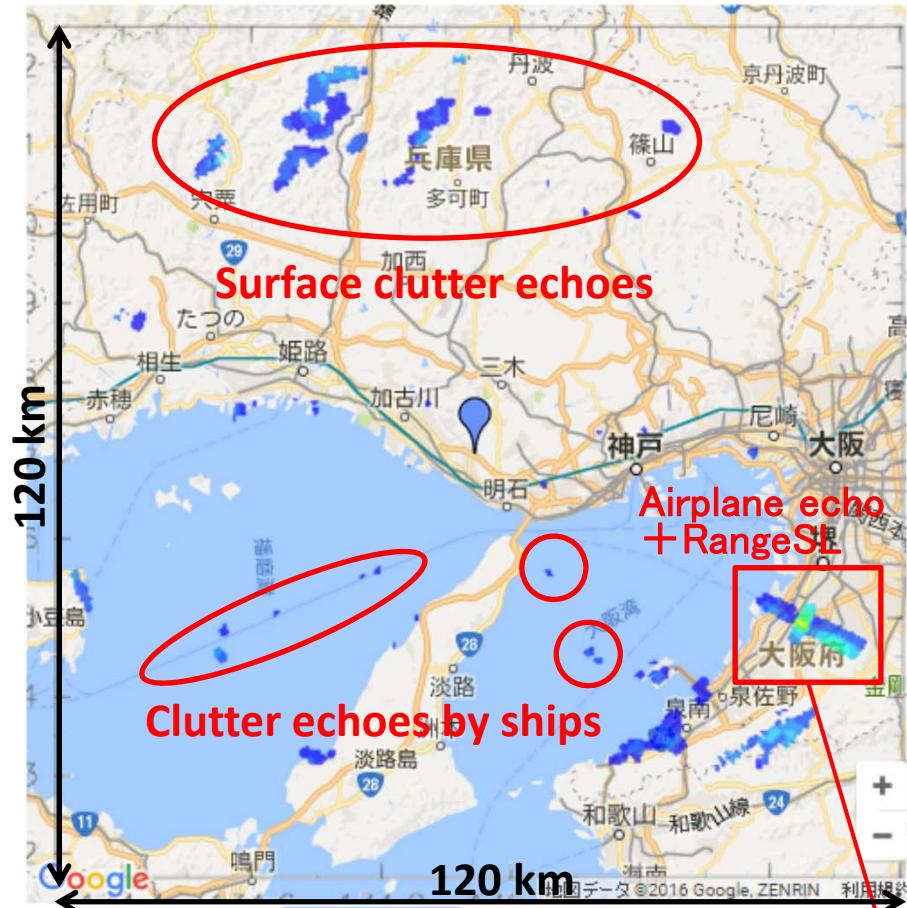


Fig. 2. Conditional histogram for the parameters (a) TEXT, (b) RVA, (c) TRCT, and (d) VGRADZ. The parenthetical numbers on top of each panel indicate the discrimination index values.

Ruiz et al. SOLA, 2015

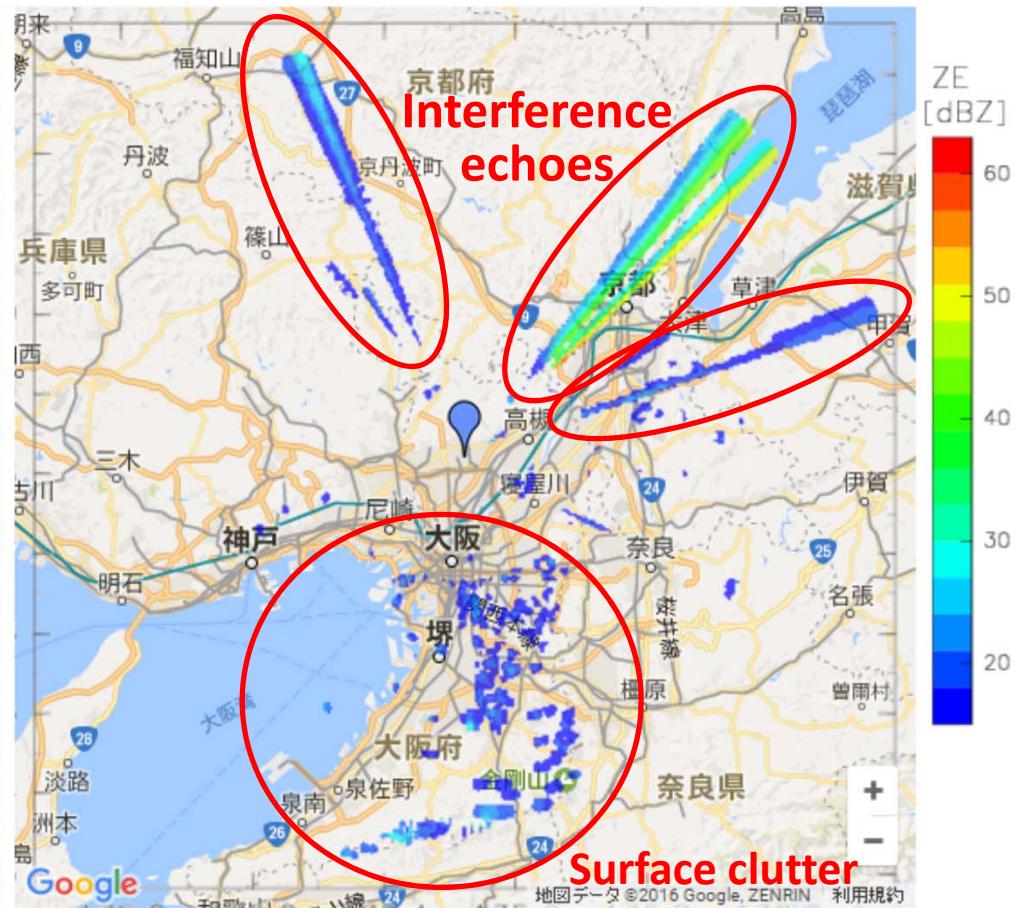
Clutter echoes and interference noise

2016/12/01 10:10:30



Kobe PAWR (fine weather)

2015/12/18 10:40:34



Suita PAWR (fine weather)

Add another data at
2016/12/01, 10:03:30

QC flag < 8 bit >

[0]Valid data, [1]Shadow, [2]Clutter possible, [3]Clutter certain,
[4]Noise, [5]RainAttn., [6]RangeSL, [7](Reserve)

- A new file of 1-byte QC flag data is provided in the same format of the same polar-coordinates as Ze and Vr data.
(e.g. 20150808-160021.all_**pawr_qcf.dat**, kobe_20150808160000_A08_**pawr_qcf.dat**)
- The QC flag file will be created in NICT Koganei in real-time (within 10 sec.)

< CONTENTS >

- [0] Valid data : if (Ze > -327.68 & Vr > -327.68) then (1)
- [1] Shadow : if (ASL(Dem) > beamHT using 4/3 equiv. earth radius) then (1)
- [2] Clutter possible (clutter map) : if (statistical Ze_PD > 20%) then (1)
- [3] Clutter certain : if (Ze_PD>20% & -1.5<Vr<1.5ms⁻¹ & ZeText > 3.0) then (1)
- [4] Noise (Interference) : if (rng_num > 500 & Ze_std/Ze_avg < 0.5) then (1)
- [5] Rain attenuation : if (Ze_inetg > 50 dBZ & delta_Ze < -2 dB/km) then (1)
- [6] Range Side Lobe :if (Ze > 40 dBZ & ZeText < 1.5 & ZrTextAz < 0.8) then (1)
- [7] (Reserve): future use (e.g. abnormal Vr., uncorrected aliased velocity)

Shadow flag and Stratiform rain echo

Compare DEM altitude (GSI 10m)
with radar beam height using equiv.
earth radius ($4/3 \times R$)

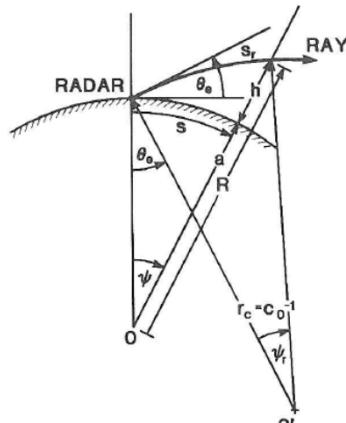
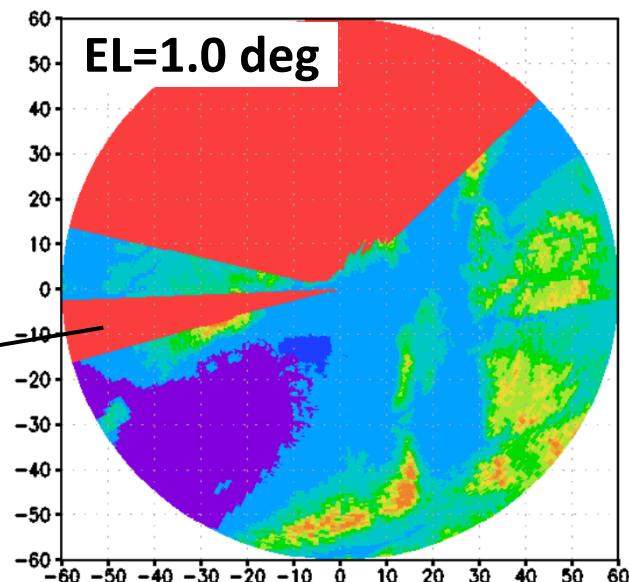
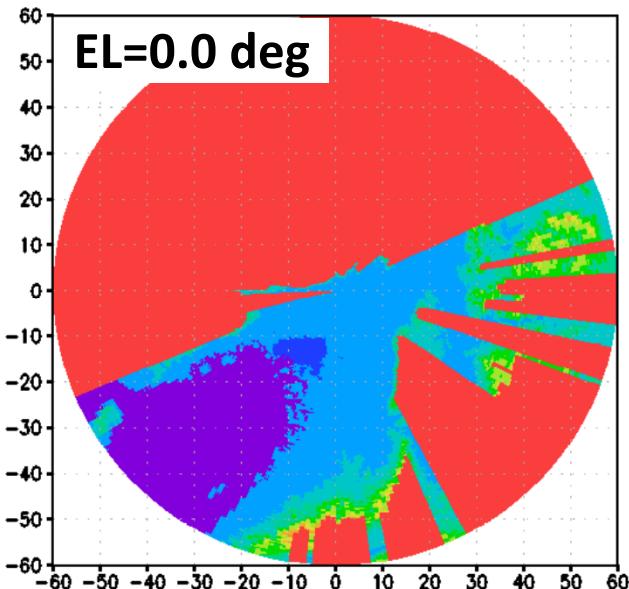
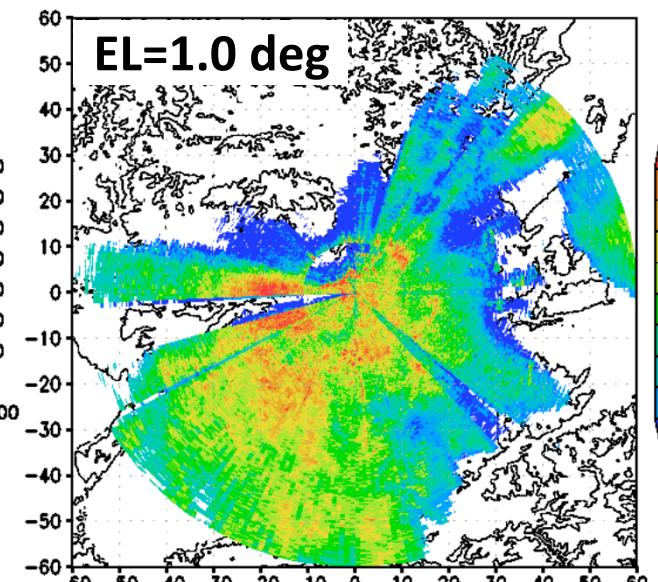
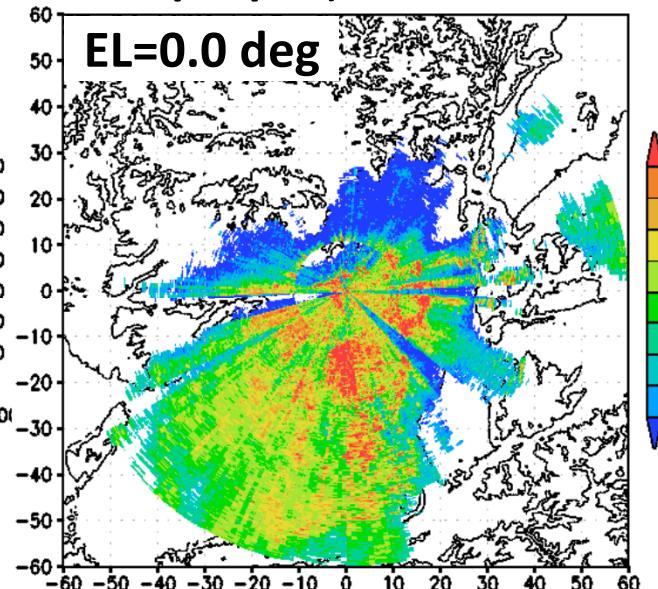


Fig. 2.5 Circular path of a ray in an atmosphere

Shadow of a
neighboring
building



2015/07/17, 08:30:19JST



Shadow of a neighboring building

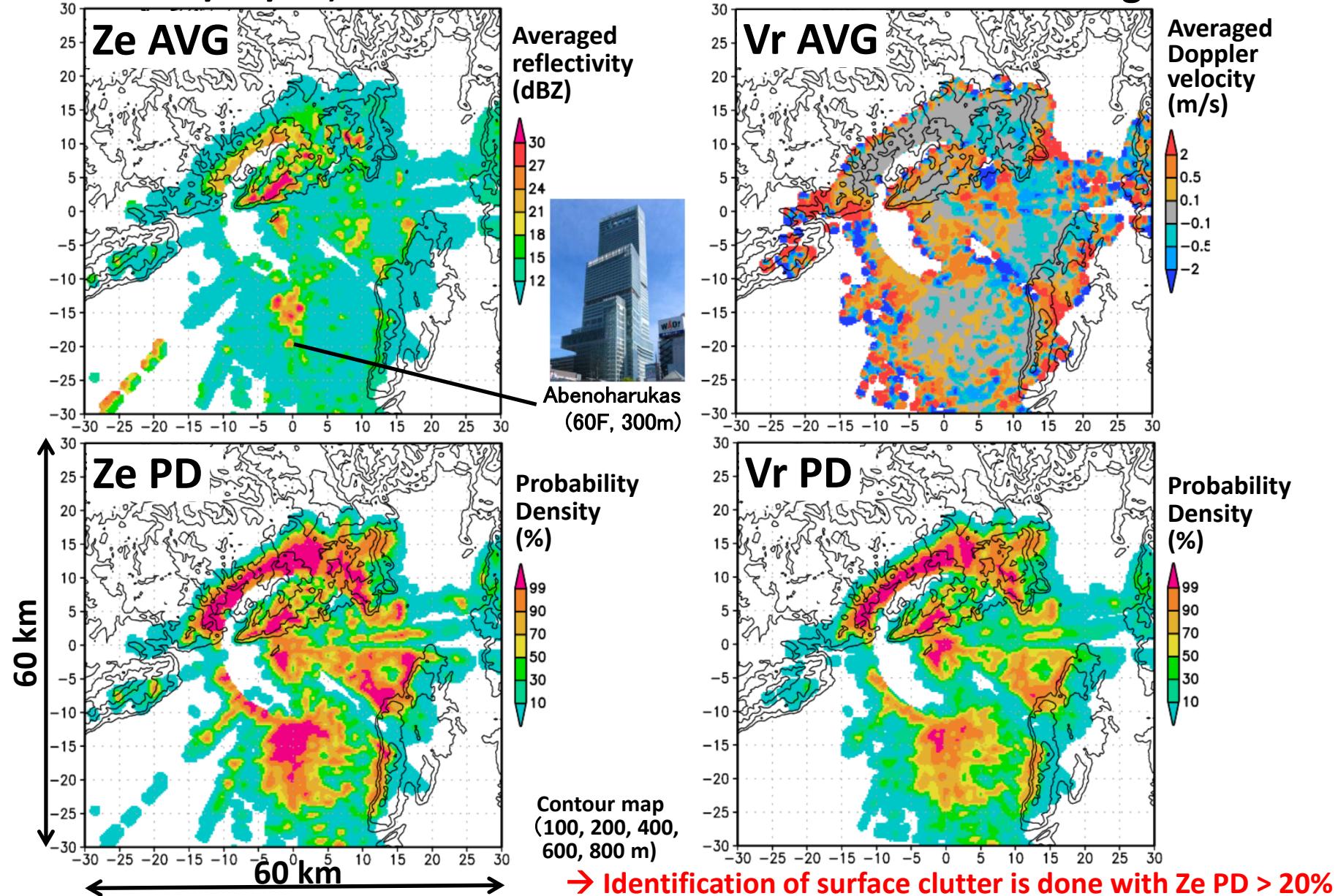
```
/* Building (GSE com-east)*/
if (i == 1 && 255.6 < az[k][j] && az[k][j] < 267.6){
    asldem = asl[jlat][ilon]+64.5;
}
```



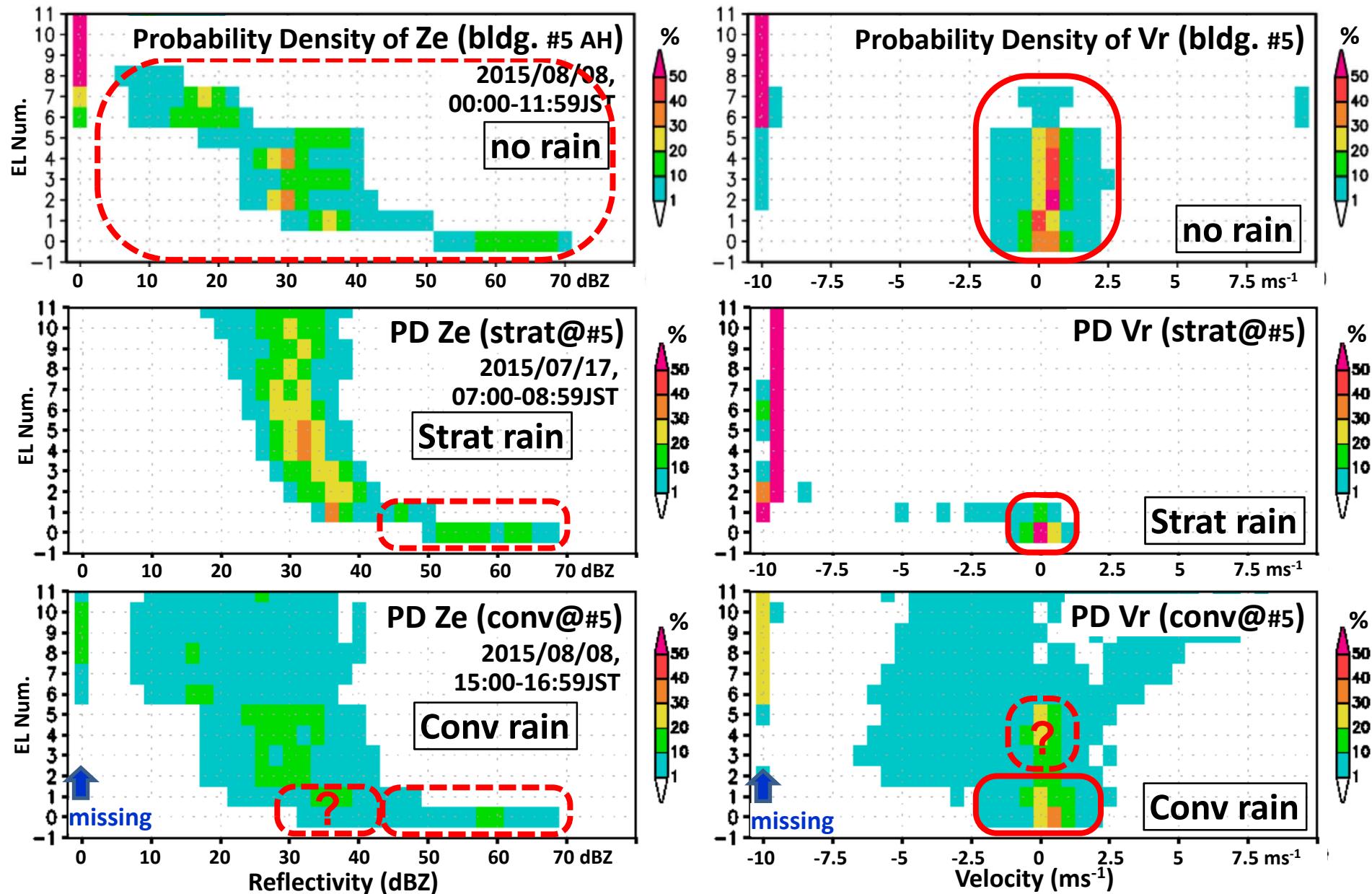
```
<consider beam width>
sinel=sin((el[k][j]+0.45)*RAD); /* consider half beam (diffraction)*/
cosel=cos((el[k][j]+0.45)*RAD);
sinaz=sin((az[k][j]+0.6)*RAD); /* because az[][] is the start angle */
cosaz=cos((az[k][j]+0.6)*RAD);
```

Statistics of surface clutter echoes (Ze & Vr)

2015/08/08, 00:00 – 12:00 JST (fine weather) , EL=2.0 deg



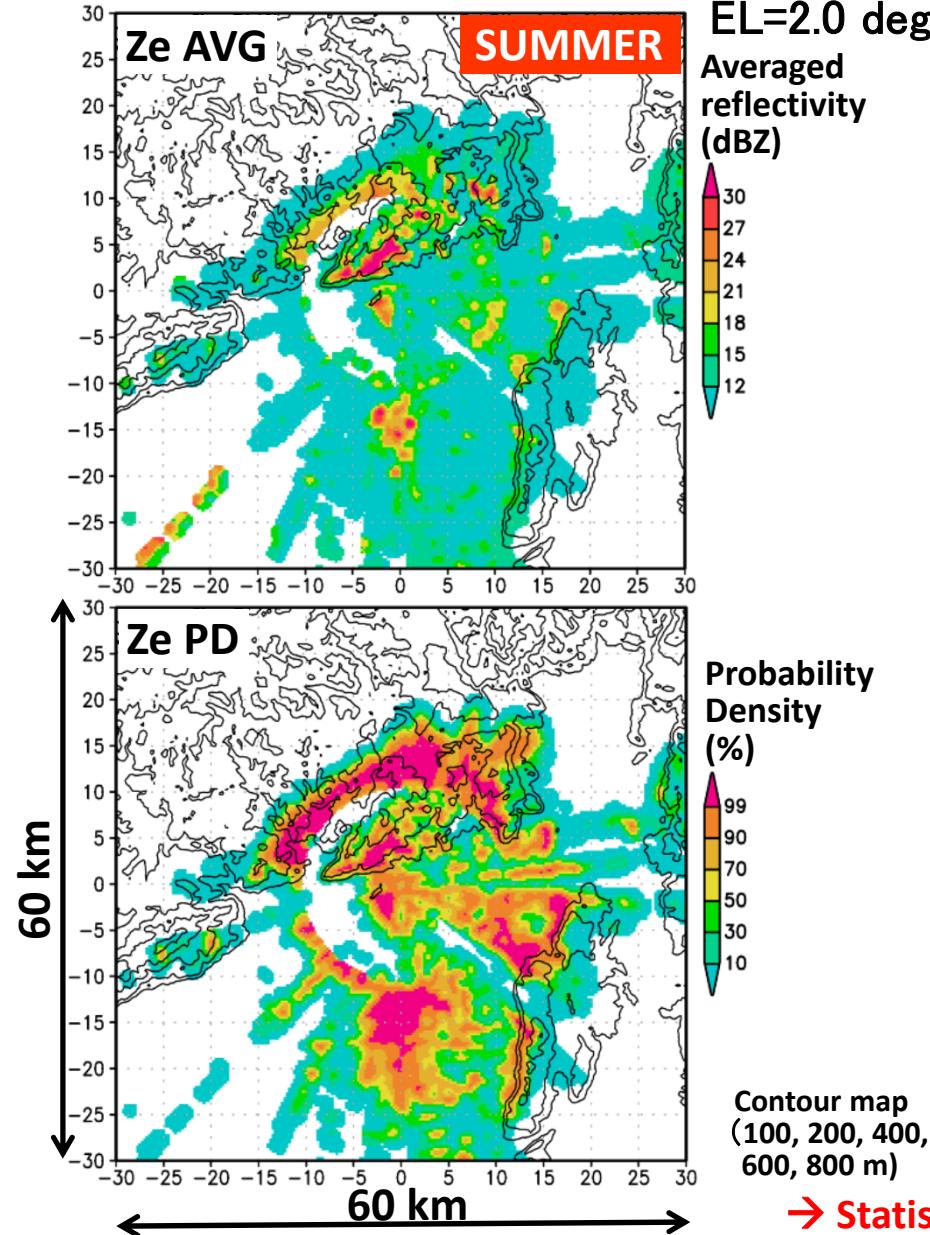
Vertical gradient of bldg vs rain echoes



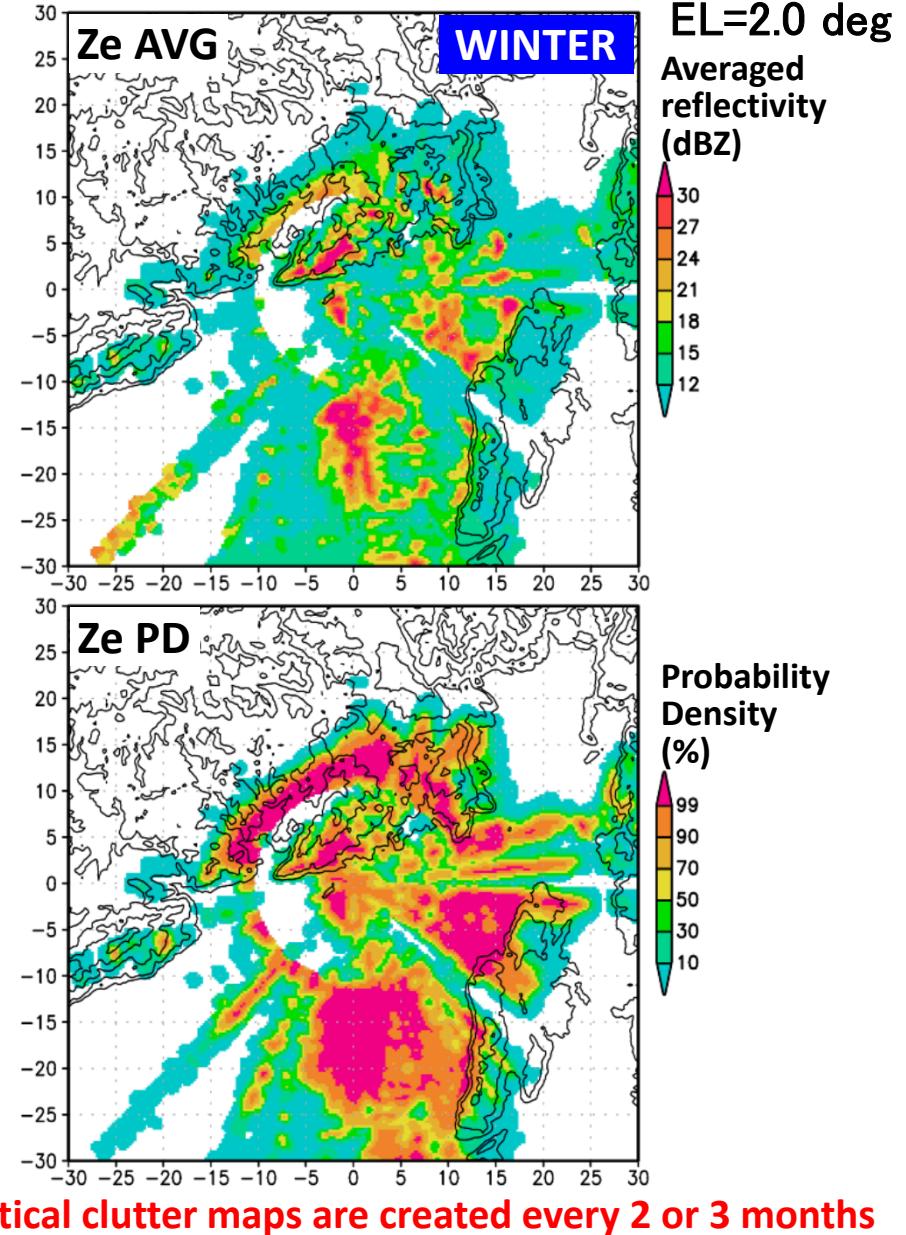
→ Vertical gradient information is not used anyway...

Seasonal variation of surface clutter (Ze)

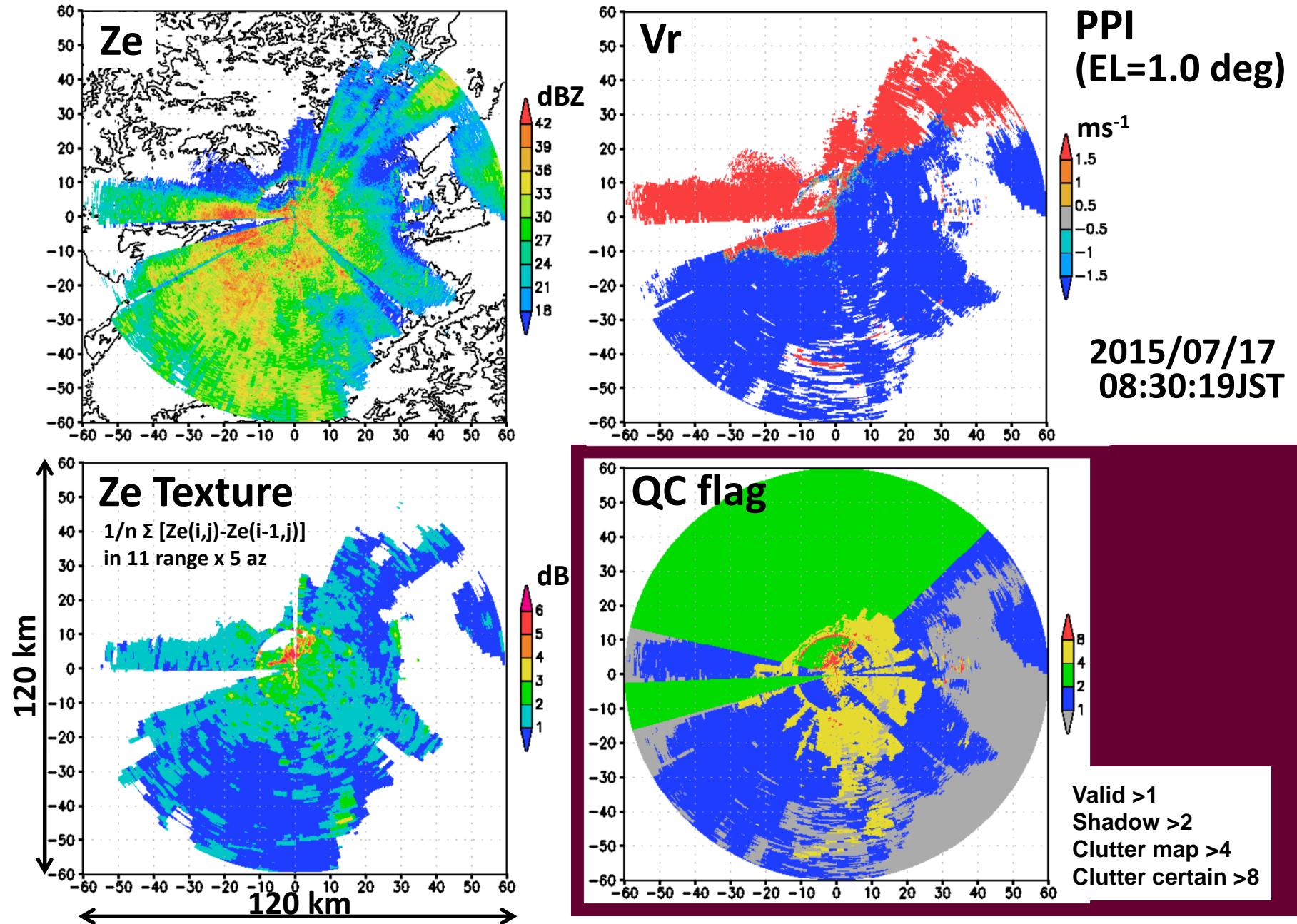
2015/08/08, 00:00 – 12:00 JST



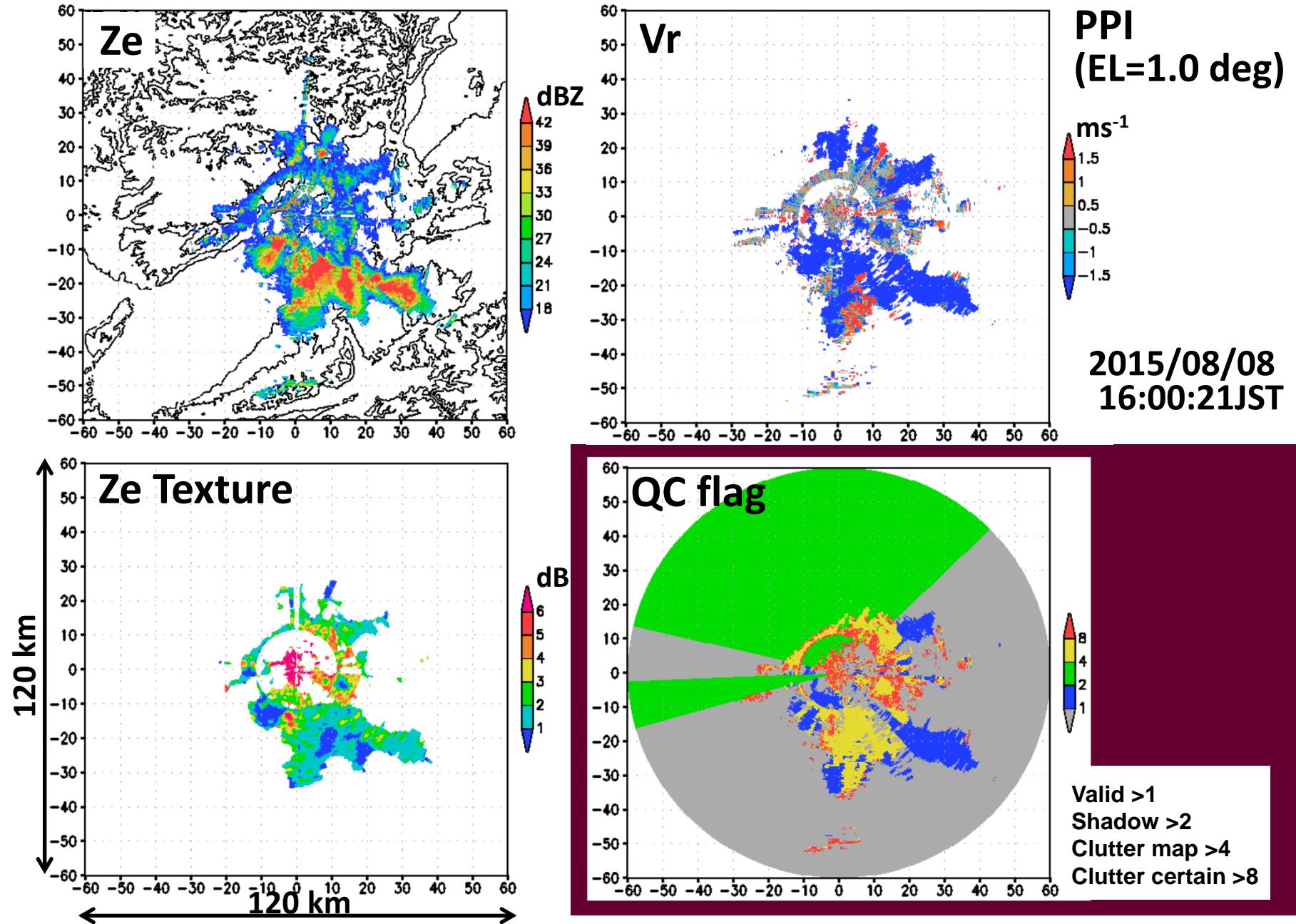
2016/01/26, 00:00 – 12:00 JST



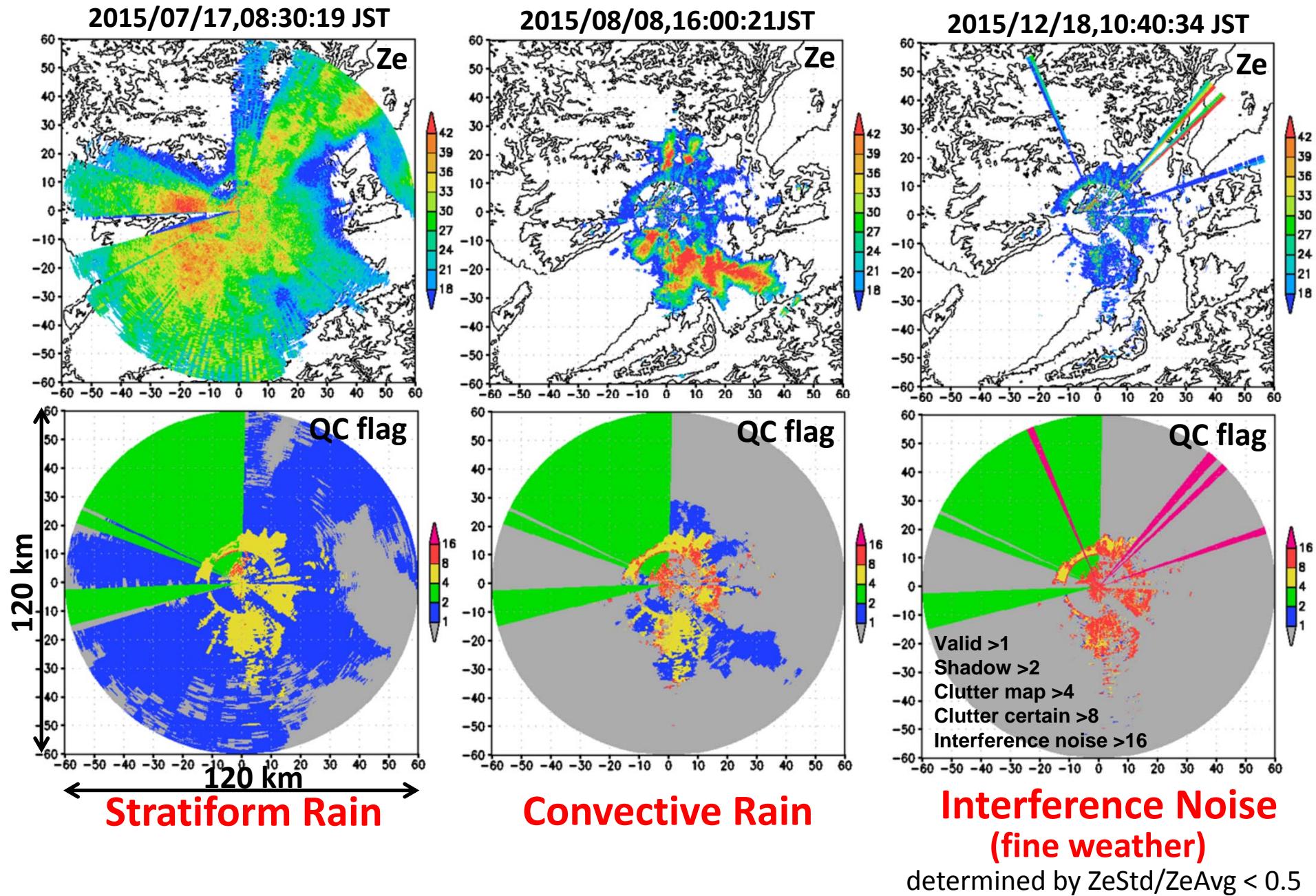
QC flag of Stratiform Rain echo



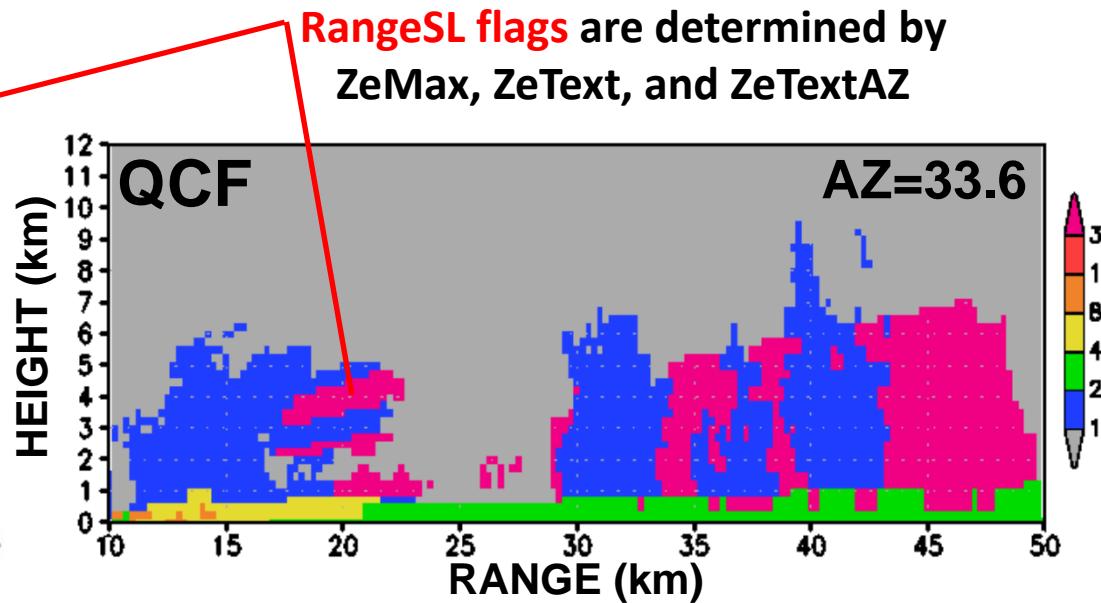
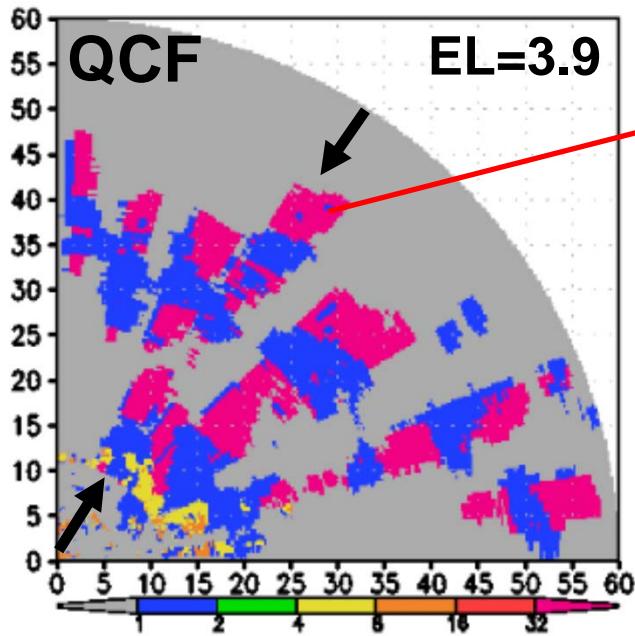
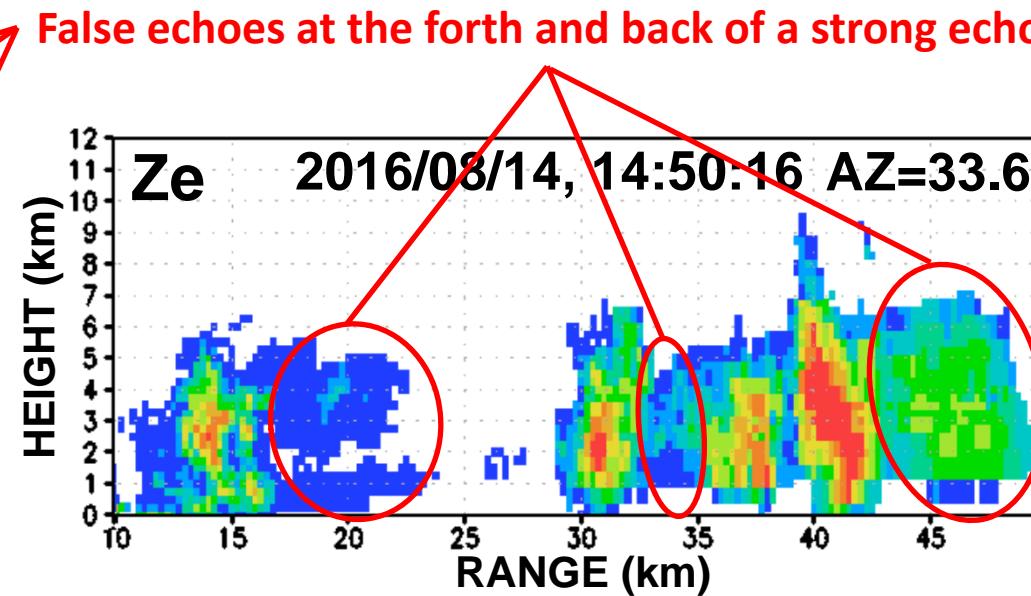
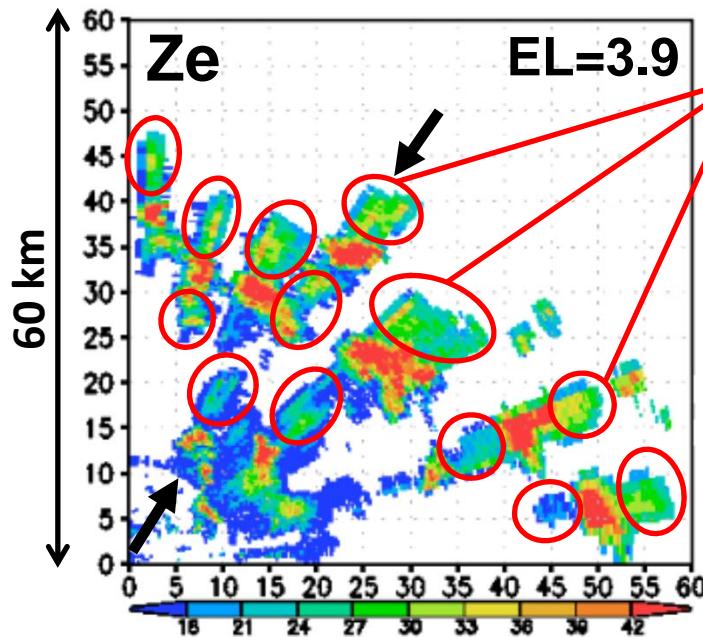
QC flag of Convective Rain echo



Ze and QC flag in PPIs (EL=2.0 deg)



Range side-lobe contamination



Computation time for creating QC flag

```
< Convective case >
## Input file: 20150808-154021.all.10000000.dat, 20150808-154021.all.20000000.dat
## date & time: 2015/8/8, 15:40:21 – 2015/8/8, 15:40:51
## data_size=379200, elnum=110, aznum=300, rnum=600 lat=34.82, lon=135.52, alt=119.0

# Total           real time = 10.000  proc time = 8.890
# Total make qc flag real time = 6.000  proc time = 5.660
# Input data read: real time = 1.000  proc time = 0.420
# Calc Ze_ave, rinteg: real time = 0.000  proc time = 0.170
# Calc Ze_texture: real time = 4.000  proc time = 3.870
# Make QC flag: real time = 1.000  proc time = 1.180
# Output QC flag: real time = 0.000  proc time = 0.020
# PPI make & output real time = 4.000  proc time = 3.230

real 0m9.186s      user 0m8.343s      sys 0m0.555s
```

This is the result of
using single a CPU core,
which enables faster
calculation by parallel
computation (MPI)

```
< Stratiform case >
## Input file: 20150717-083019.all.10000000.dat, 20150717-083019.all.20000000.dat
## date & time: 2015/7/17, 8:30:19 – 2015/7/17, 8:30:48
## data_size=379200, elnum=110, aznum=300, rnum=600 lat=34.82, lon=135.52, alt=119.0

# Total           real time = 11.000  proc time = 11.400
# Total make qc flag real time = 7.000  proc time = 7.890
# Input data read: real time = 0.000  proc time = 0.550
# Calc Ze_ave, rinteg: real time = 1.000  proc time = 0.500
# Calc Ze_texture: real time = 5.000  proc time = 5.250
# Make QC flag: real time = 1.000  proc time = 1.570
# Output QC flag: real time = 0.000  proc time = 0.020
# PPI make & output real time = 4.000  proc time = 3.510

Real 0m11.704s      user 0m10.241s      sys 0m1.190s
```

Summary

- The X-band phased array weather radar (PAWR) produces 3D big data (100 m, 100 EL angles) every 30 seconds. The real-time data QC is essential for data assimilation and nowcasting.
- The statistical features of surface clutter echoes in both clear and rainy days were investigated to use for surface clutter removal.
- 8-bit QC flag in the radar coordinates was designed. It includes shadow, surface clutter, interference noise, range side-lobe contamination etc.
- The QC flag in both stratiform and convective echo was verified. The computation time for creating the QC flags was within 10 seconds.