Hands-on Training on Weather Radar QC

7-8th February 2018

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Guide map of the workshop

Weather radar

Basics and operation of weather radars — Day 1: 1

Hardware

- Install
- Calibration
- Maintenance

Day 1-2: 2

Advanced techniques

- Solid-state transmitter

Day 1-2: 2

Observation

- Obs. scheduling
- Quality control
- Sites composite

Day 2-4: 4,5

Advanced techniques

- Doppler velocity
- Accurate obs. using dual-pol

Day 4: 7

Application

- QPE&QPF

Day 4: 7

Advanced techniques

- Detecting mesocyclone
- Products derived from dual-pol obs.

Day 4: 7

- Weather summary

Day 5: 9

Regional radar network

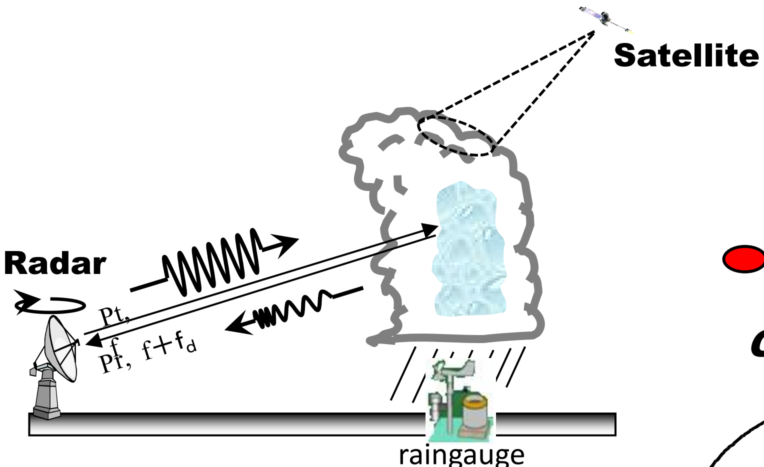
- Capacity development
- Data exchange
- Regional cooperation

Day 9: 12

Hands-on Training on Weather Radar QC

- Introduction of JMA Operational system (15min.)
- Quality control algorithms
  - Characteristics of non-precipitation echo (10min.)
  - JMA methods of Pseudo CAPPI process (15min.)
  - Statistical approach for QC (10min.)
- Hands on training (90min.)
  - Adjustment of elevation angle composite table
  - Making PCAPPI and Statistical data
  - Verification of the results

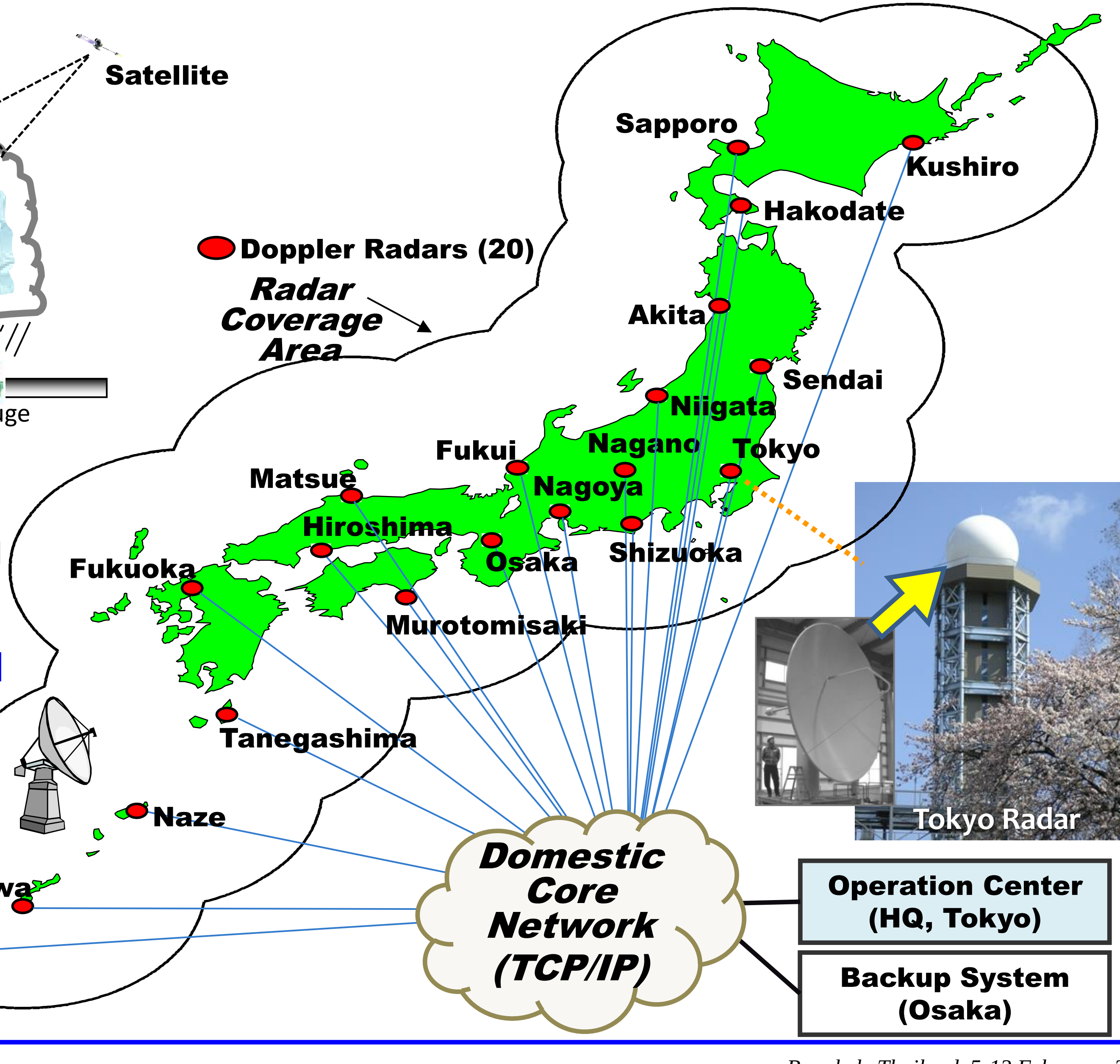
JMA's Weather Radar Network



C-band Radar observes reflected echo (precipitation drops) and Doppler Velocity.

Precipitation, Wind

Every 5 min.



JMA radar specifications

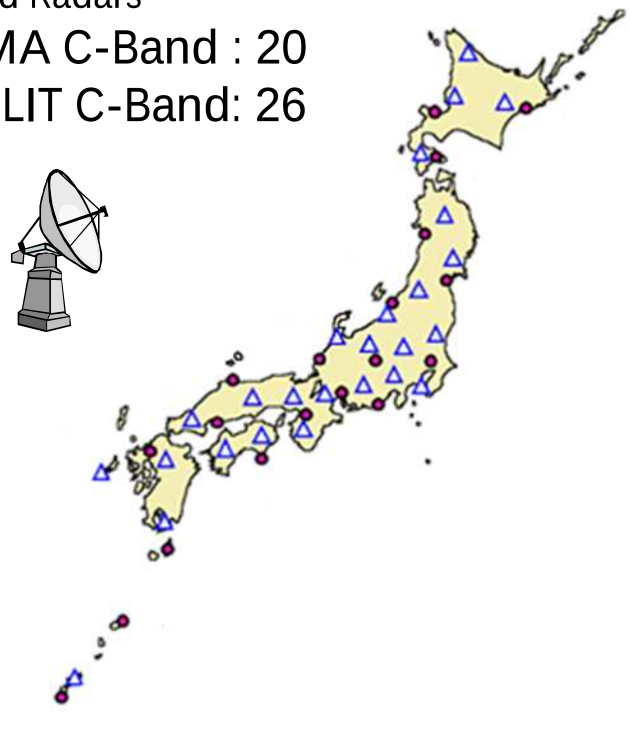
Frequency	5300〜5370 MHz (C-band)		
TX type	Klystron		
Peak Power	250 kW		
Pulse Width	2.5 μs	1.0 μs	
Pulse Repetition Frequency (PRF)	330 Hz	600/480 Hz	940/752 Hz
Antenna Diameter	4 m (Beam Width < 1.2 °)		
Maximum Range	Rainfall intensity : 400 km Doppler velocity : 250 km		

Nationwide Radar Composite Maps

C-band Radars

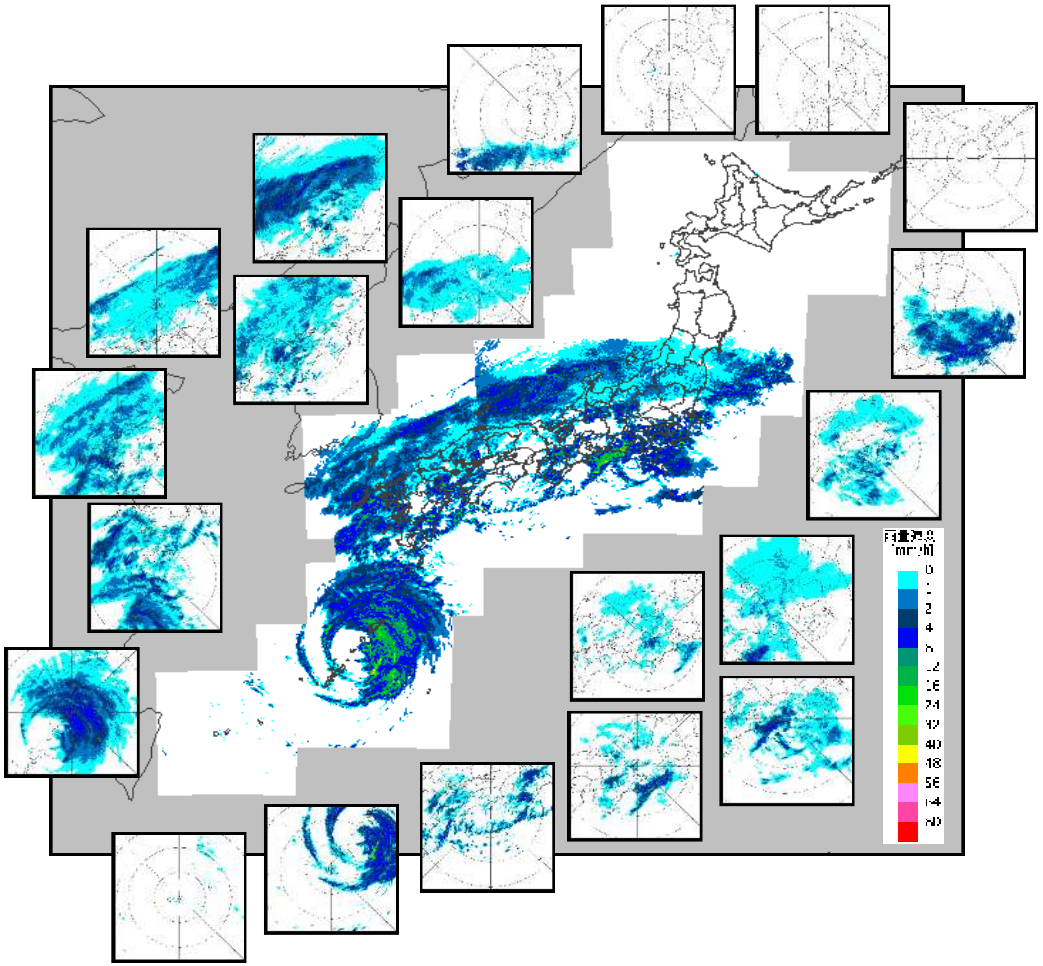
● JMA C-Band : 20

▲ MLIT C-Band: 26



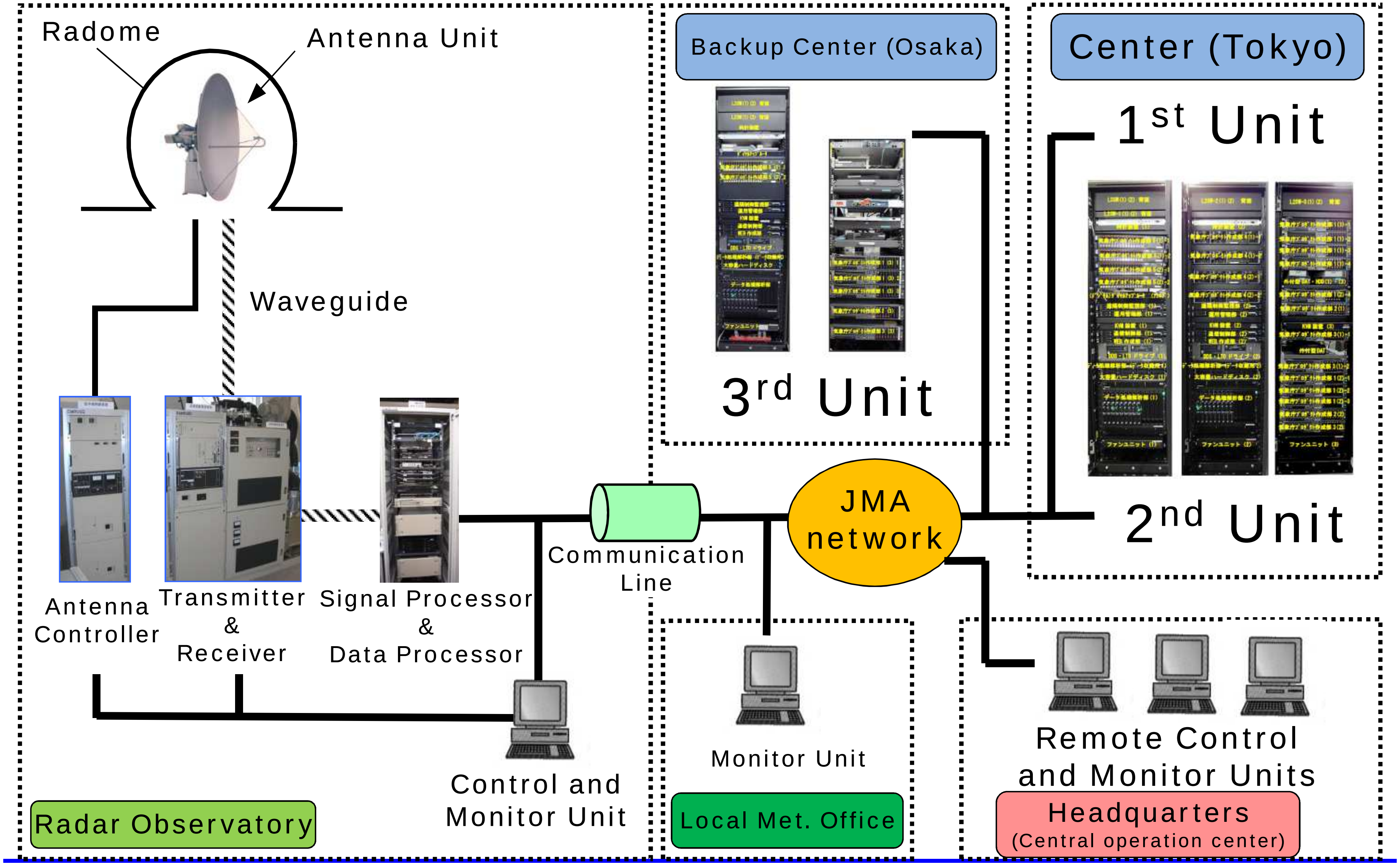
C-band Radar echo data (JMA, MLIT) are collected to the center system and integrated into a nationwide echo intensity composite map(every 5 minutes)

MLIT: Ministry of Land, Infrastructure, Transport and Tourism



for Monitoring / Nowcasting
Quantitative Precipitation
Estimation / Forecast (QPE/QPF) etc.

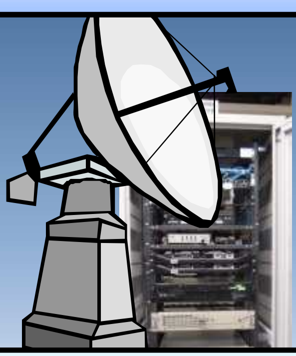
Radar network system



Automated QC on radar systems

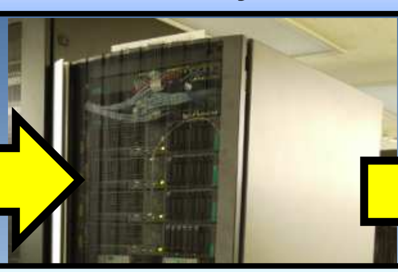
Data Flow

Radar sites



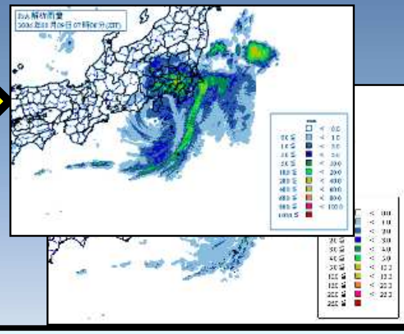
Raw data
- Reflectivity
- Velocity

Center System



- Raw data
- Composite map
- Meso-cyclone detection
- Another Products

Forecasting Product Systems



- QPE
- QPF

QC methods

Radar sites:

Side lobe Removal
Selective MTI
MTI map processing
Interference Removal
Sweep correlation
2nd-trip Echo Removal
etc

Center System:

Making products
QC on the PCAPPI process

Forecasting Product Systems:

QC at every product

Quality Control for radar composite

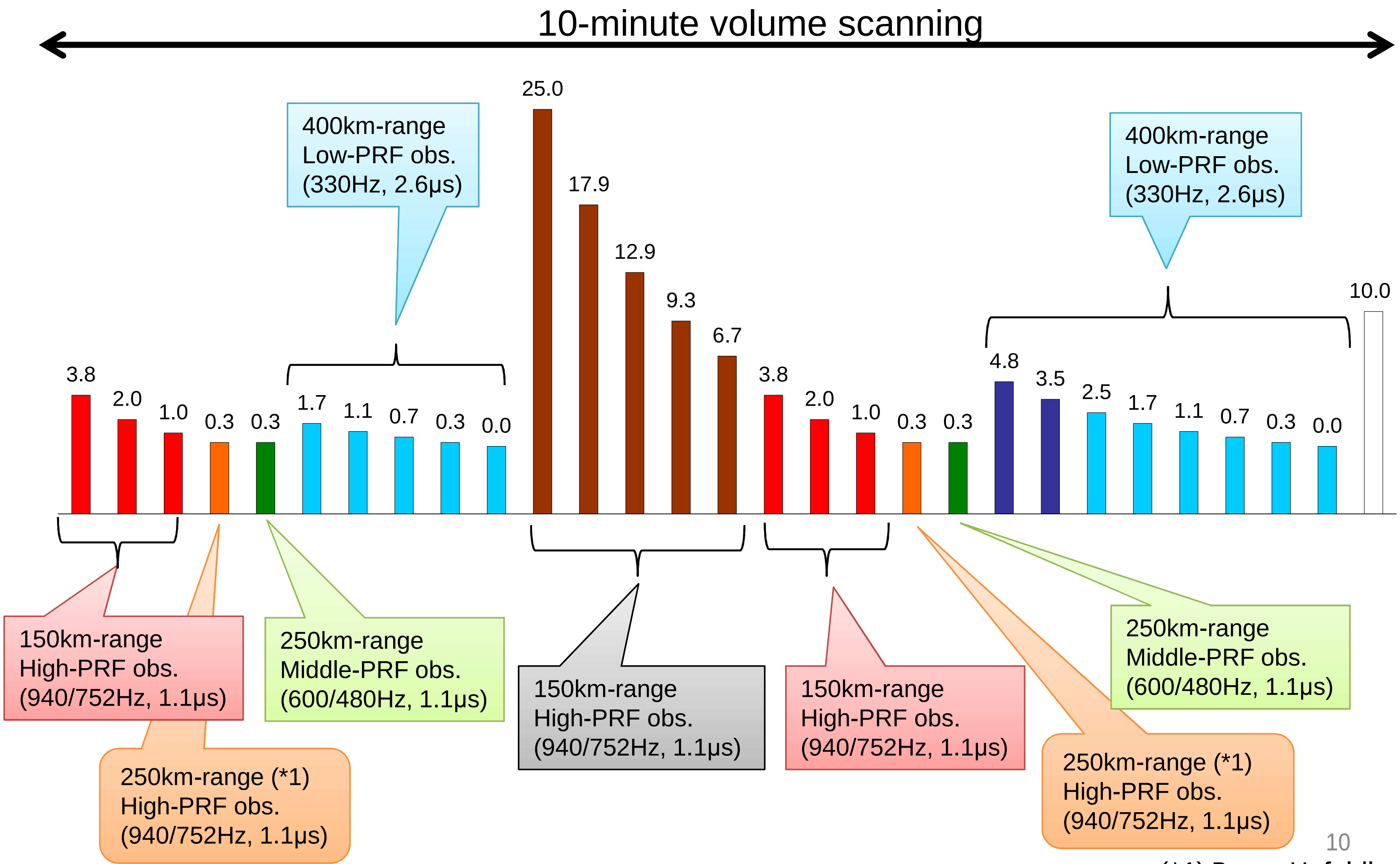
Basic concept of scanning schedule

- Precipitation
  - Low PRF, long pulse (330 Hz, 2.6 micro sec.)
    - long distance
    - Mainly precipitation
- Velocity
  - Dual High PRF, short pulse

    (940/752 Hz, 600/480 Hz , 1.1 micro sec.)
    - Short distance
    - Velocity range is large

Observation Scan Sequence

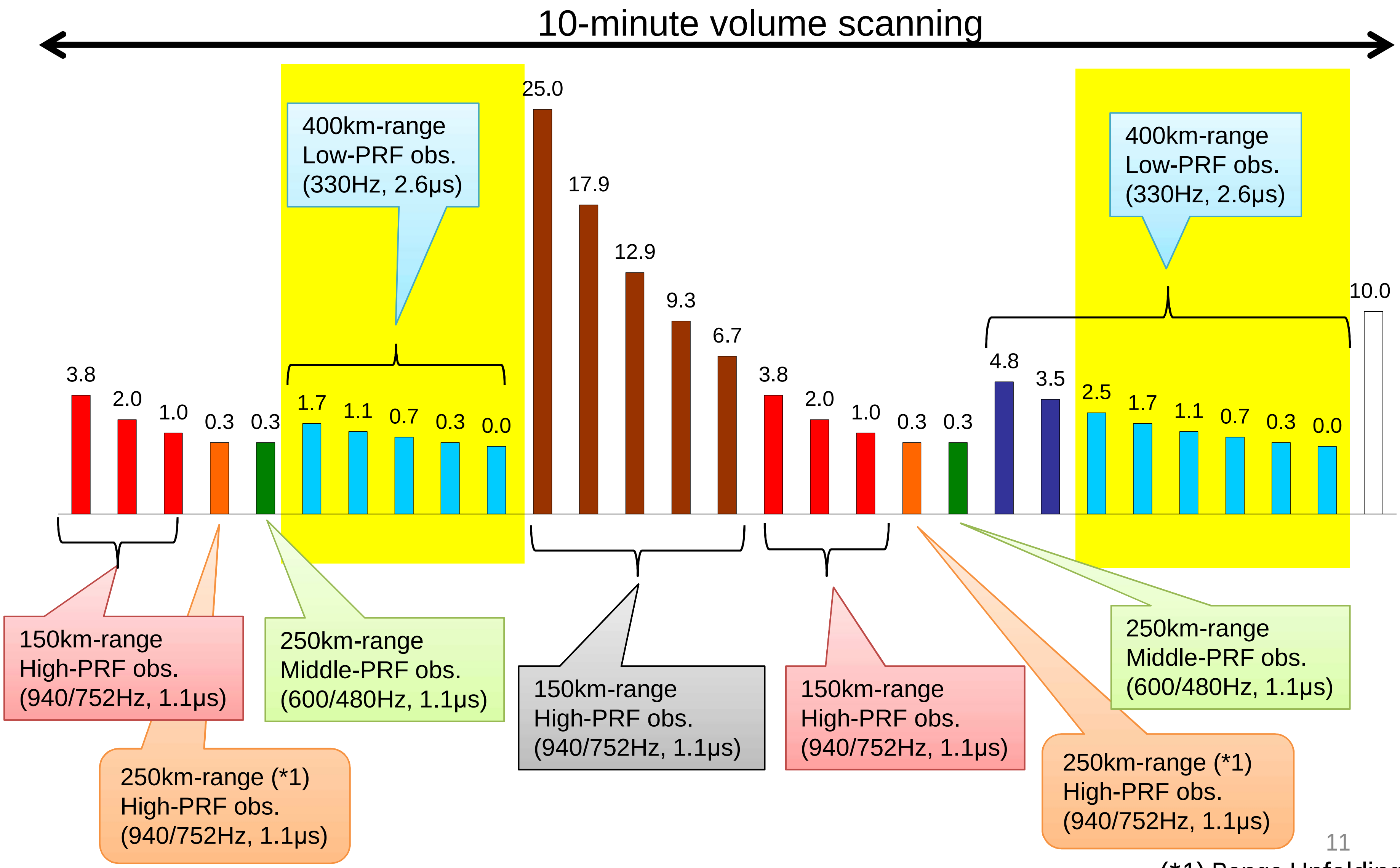
Example of Tokyo radar



(*1) Range Unfolding

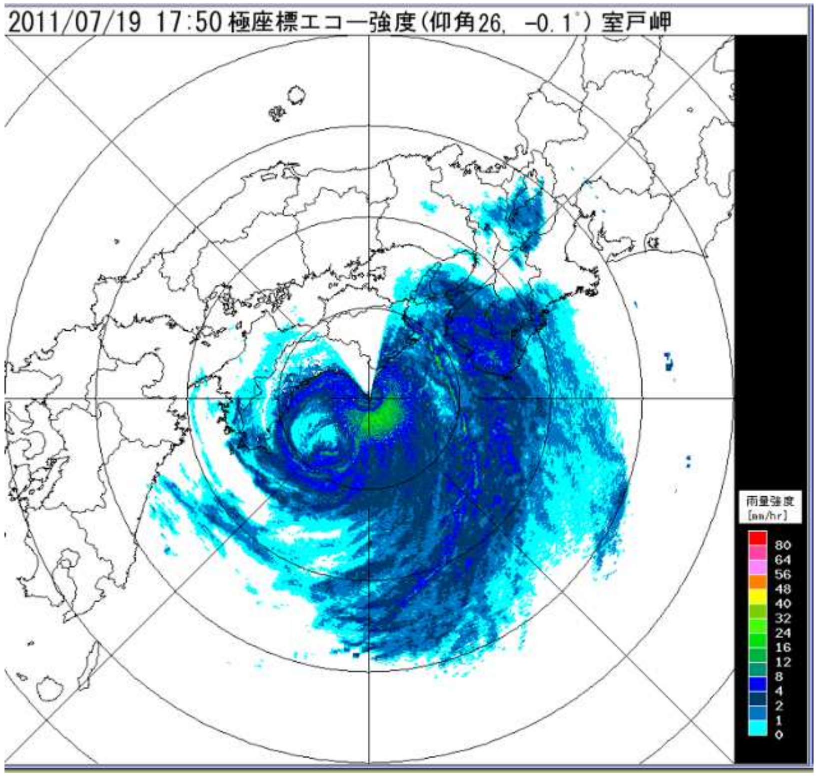
Observation Scan Sequence

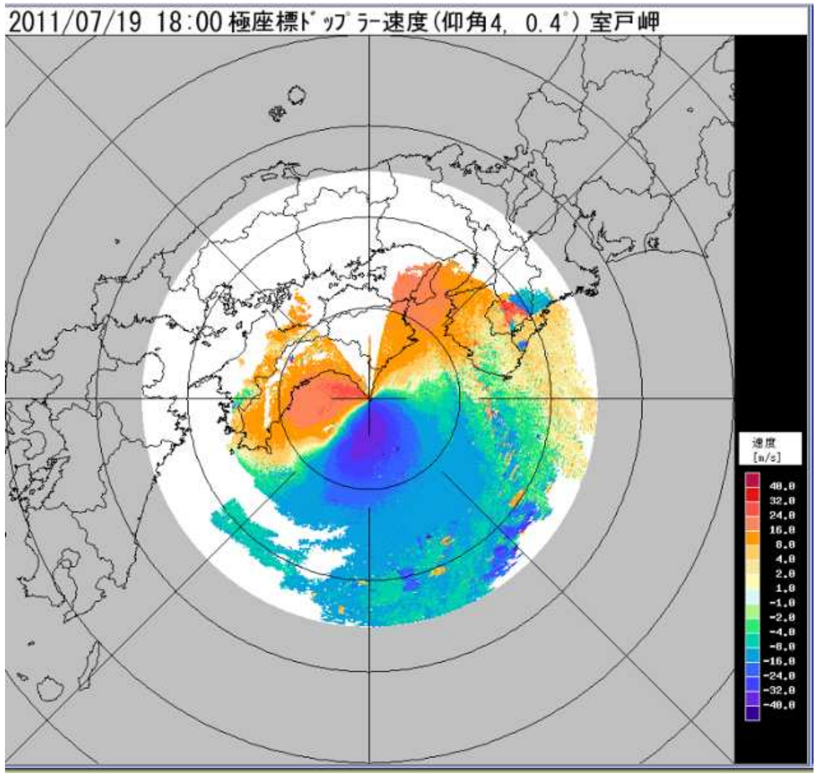
Example of Tokyo radar



(*1) Range Unfolding

Primary Data

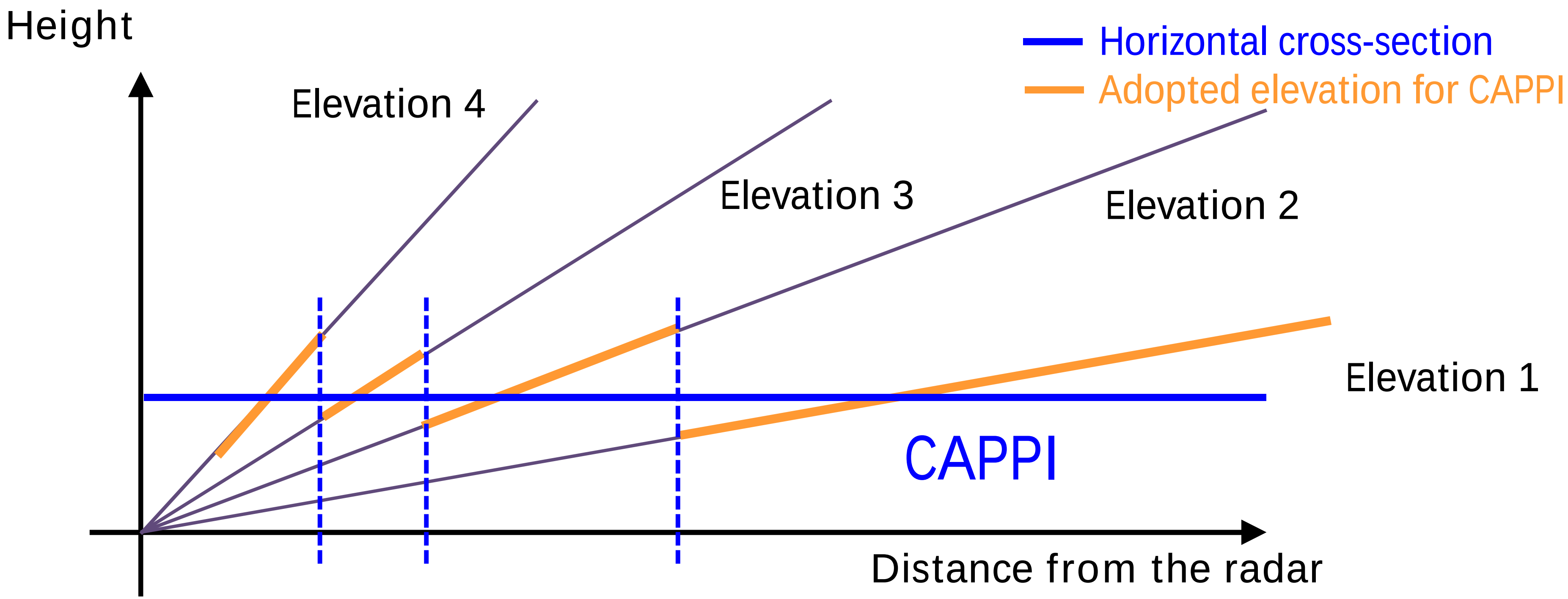




Data Type		Unit	Coordinates	Mesh Size	Area	Number of Mesh	Data Size (one mesh)	Data Format	Period
Each radar	Echo intensity	dBZ	Polar	250 m x 0.7 deg	400 km radius	8,192,000	1 byte	GRIB2	10 min
	Doppler Velocity	m/s	Polar	250 m x 0.7 deg	250 km or 150 km radius	512,000 or 307,200	1 byte	GRIB2	10 min

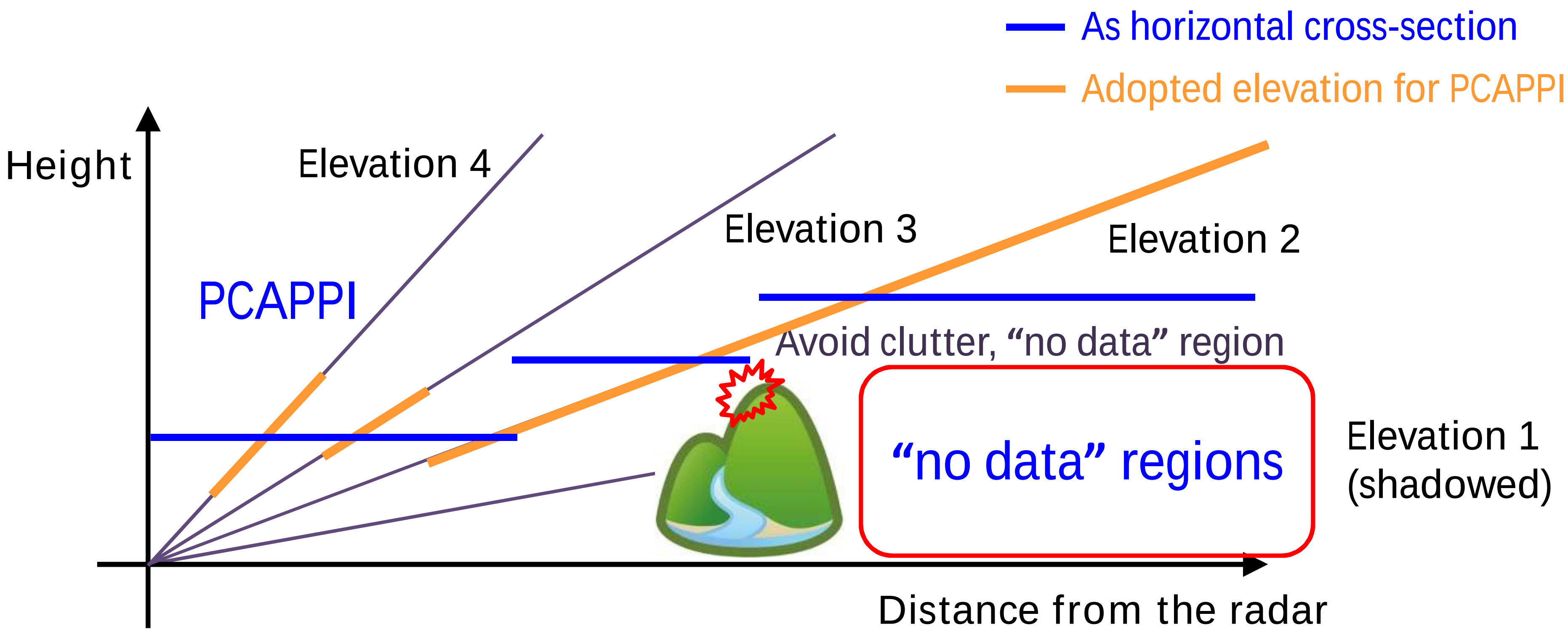
CAPPI

- CAPPI stands for Constant Altitude Plan Position Indicator.
- A horizontal cross-section display of a variable at a specified altitude.



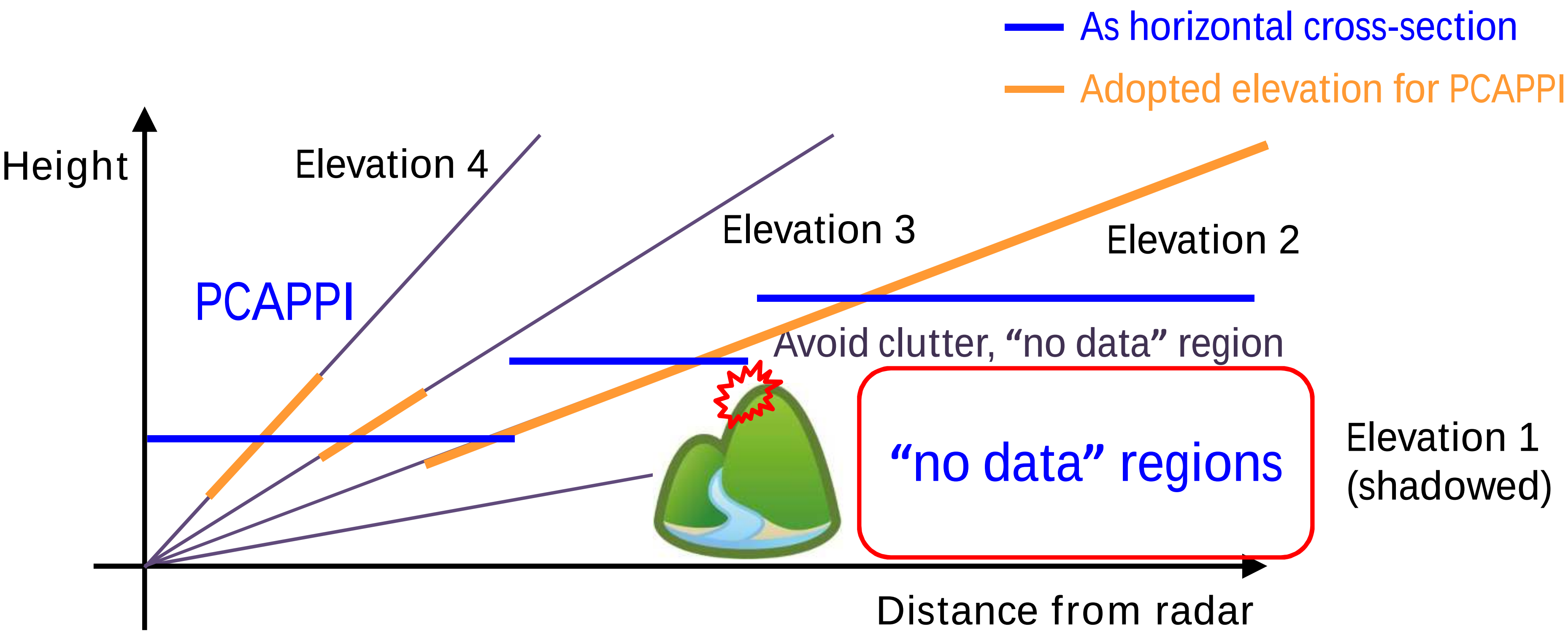
Pseudo CAPPI

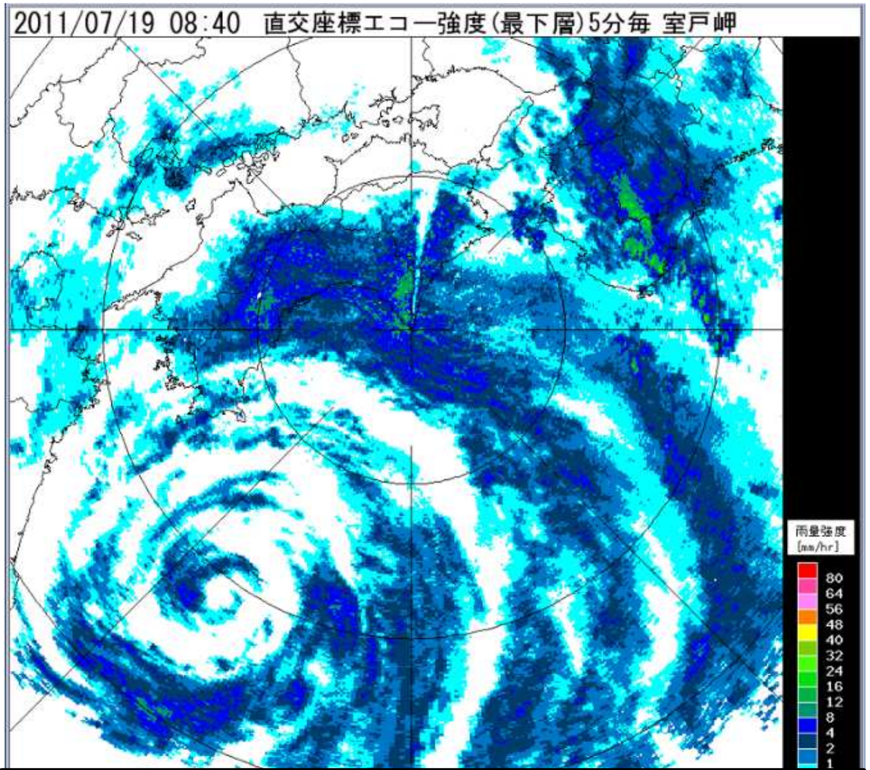
- The “no data” regions as seen in the CAPPI (close to and away from the radar with reference to the selected altitude) are filled with the data from the highest and the lowest elevations, respectively, in another form of CAPPI, called “Pseudo CAPPI”.



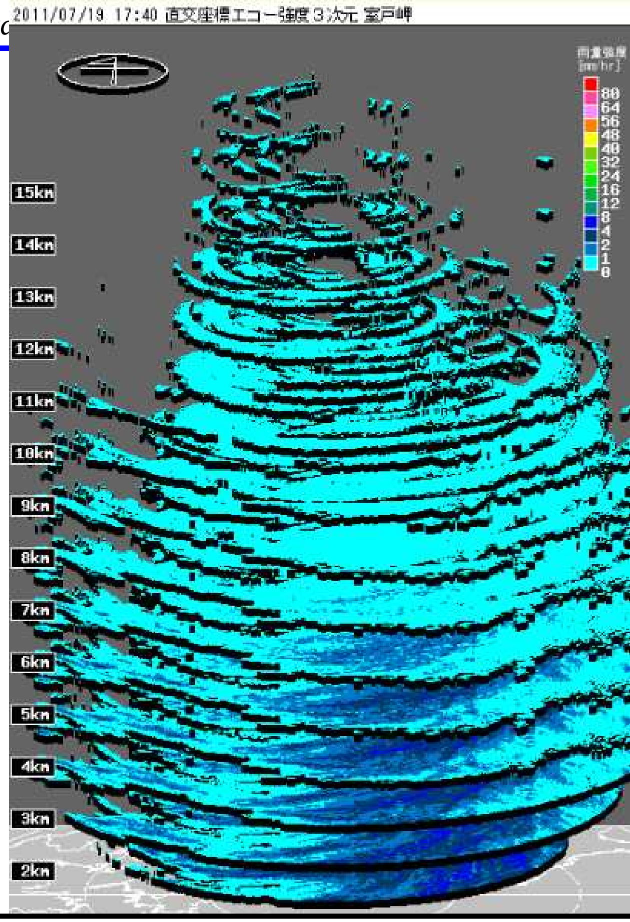
Pseudo CAPPI

- Topography and suitable observation elevation depend on the place of radar sites.
- Every radar requires this setting for every direction.
  This setting for JMA methods of PCAPPI is called "elevation angle composite table."





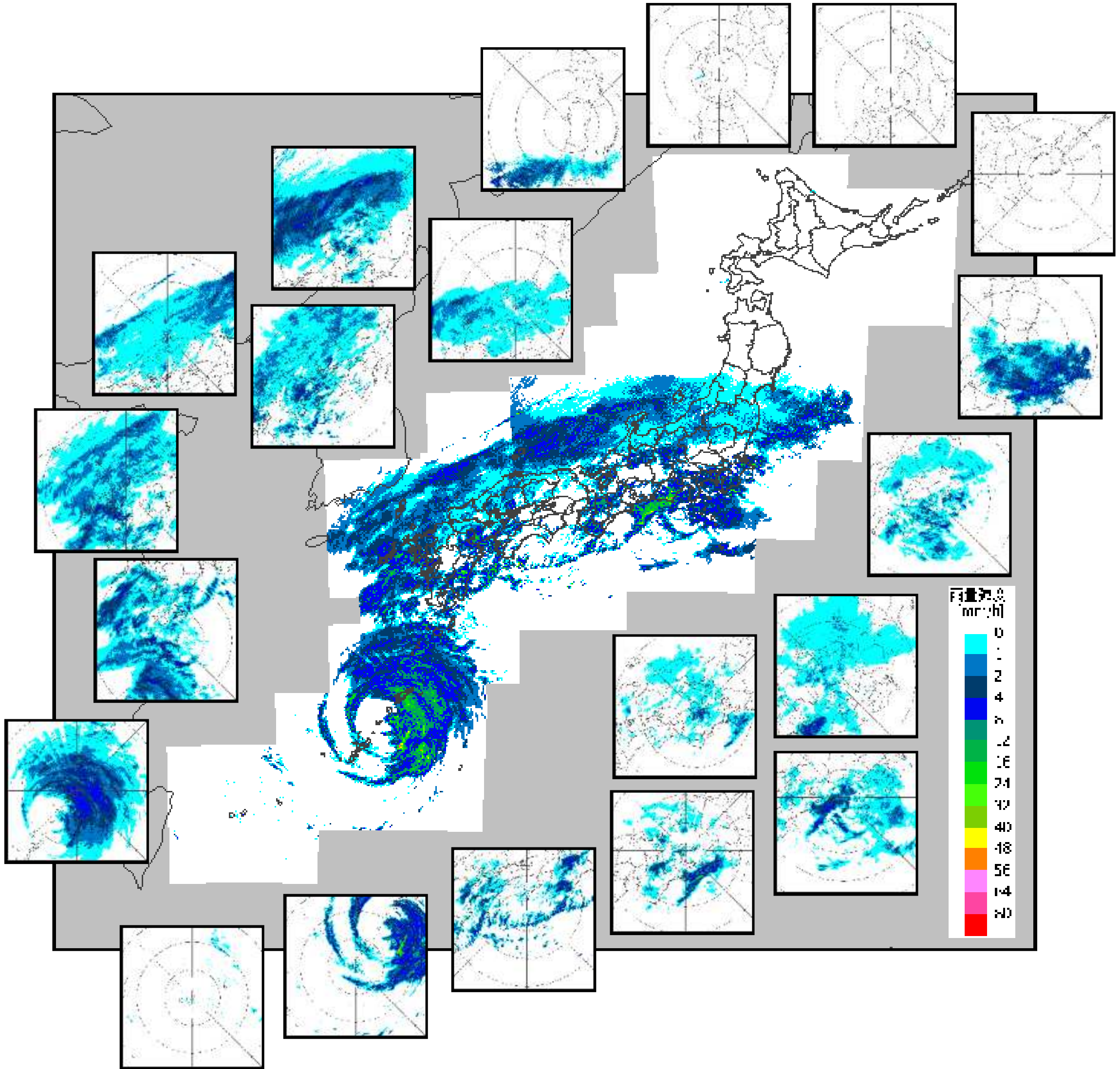
Pseudo CAPPI

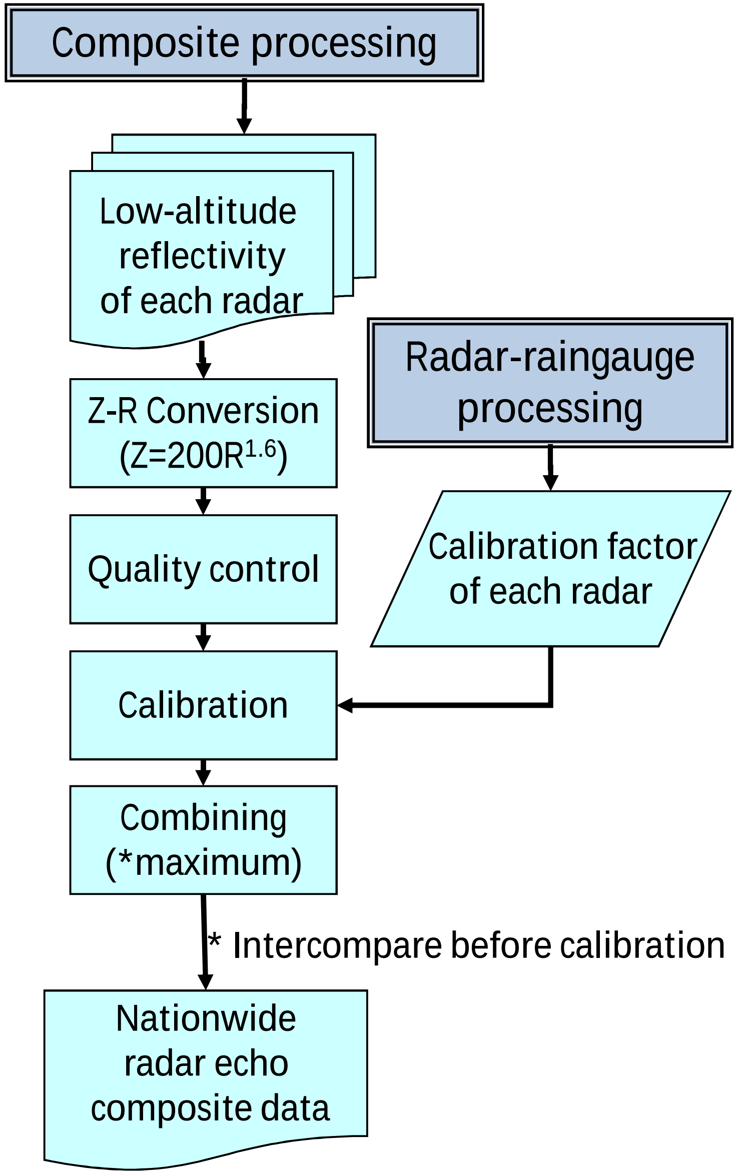


15 layers CAPPI

Data Type		Unit	Coordinates	Mesh Size	Area	Number of Mesh	Data Size (one mesh)	Data Format	Period
Each radar	Pseudo CAPPI	mm/hr	xy	1 x 1 km	500 x 500 km	250,000	1 byte	Radar IO	5 min
	CAPPI	dBZ	xy	1 x 1 km	500 x 500 km	250,000	1 byte	GRIB2	10 min

Nationwide Radar Composite Precipitation Intensity





All radar echo data are collected to the center system, and nationwide composite map is made.

Hands-on Training on Weather Radar QC

- Introduction of JMA Operational system
- Quality control algorithms
  - Characteristics of non-precipitation echo
  - JMA methods of Pseudo CAPPI process
  - Statistical approach for QC
- Hands on training
  - Adjustment of elevation angle composite table
  - Making PCAPPI and Statistical data
  - Verification of the results

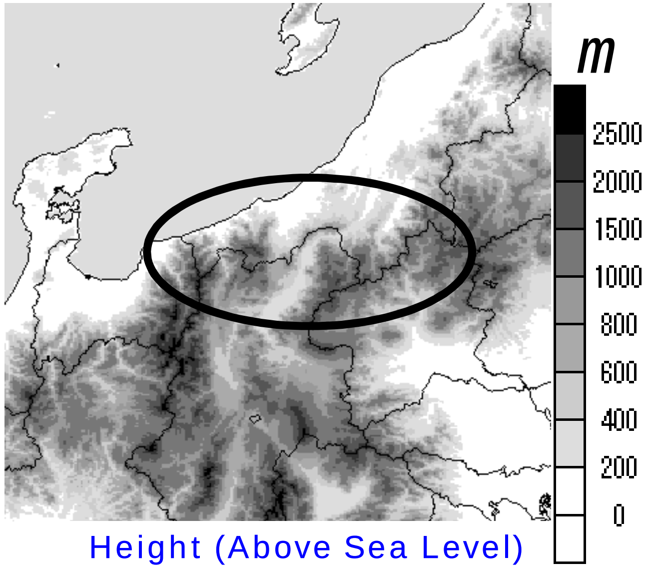
Ground clutter

- Echoes due to non-precipitation targets are known as clutter.
- Clutter can be the result of a variety of targets, including buildings, hills, mountains, aircraft and chaff.

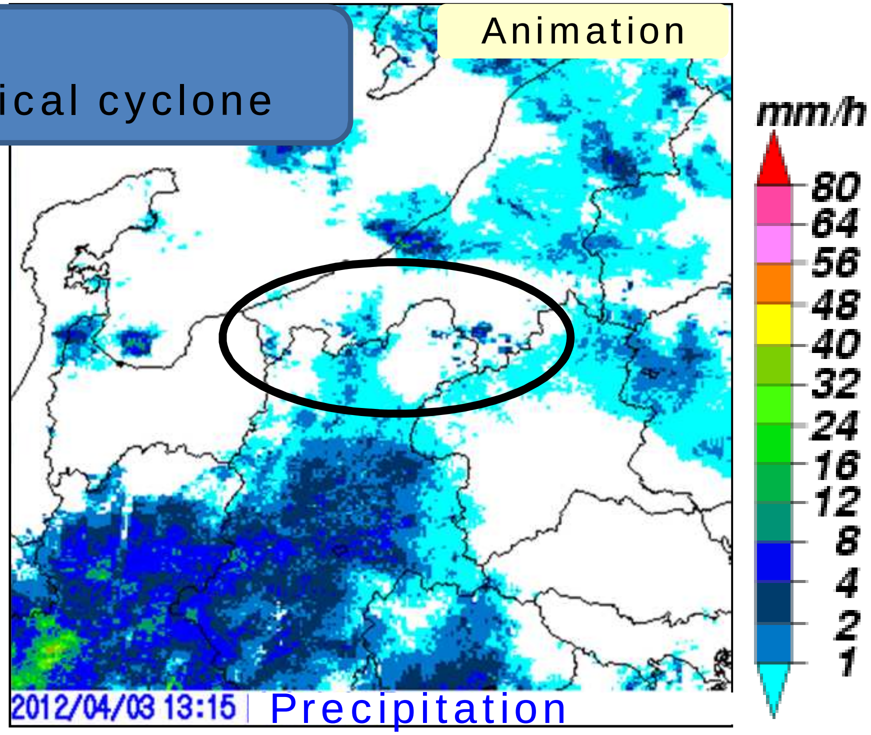
* WMO GUIDE TO METEOROLOGICAL INSTRUMENTS AND METHODS OF OBSERVATION WMO-No. 8 (2008 edition, Updated in 2010) Part II chapter 9 radar measurements

Example of remaining ground clutters

2012/APR/03
Rapidly developed extratropical cyclone



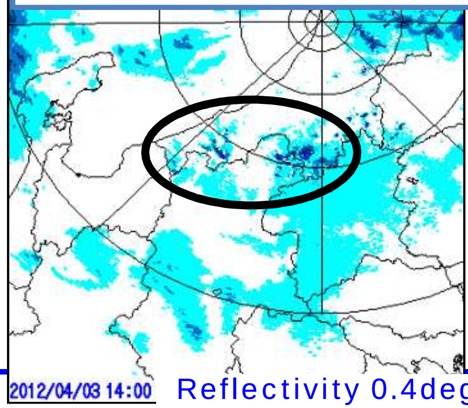
Height (Above Sea Level)



Precipitation

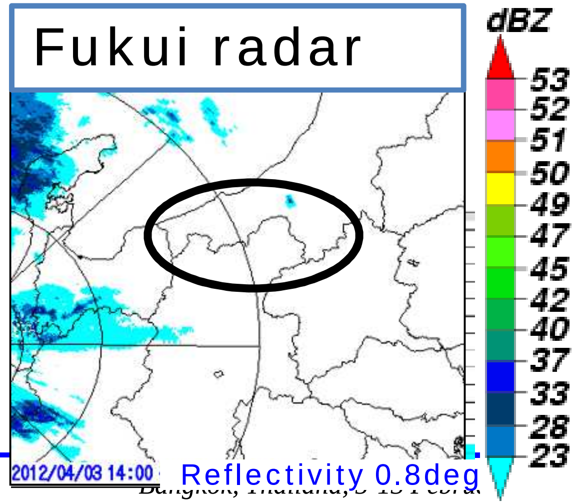
- With the passage of a low pressure system, storms occurred across the country. In such cases, ground clutters may not be completely removed. Careful monitoring is required because they do not indicate actual precipitation.

Niigata radar



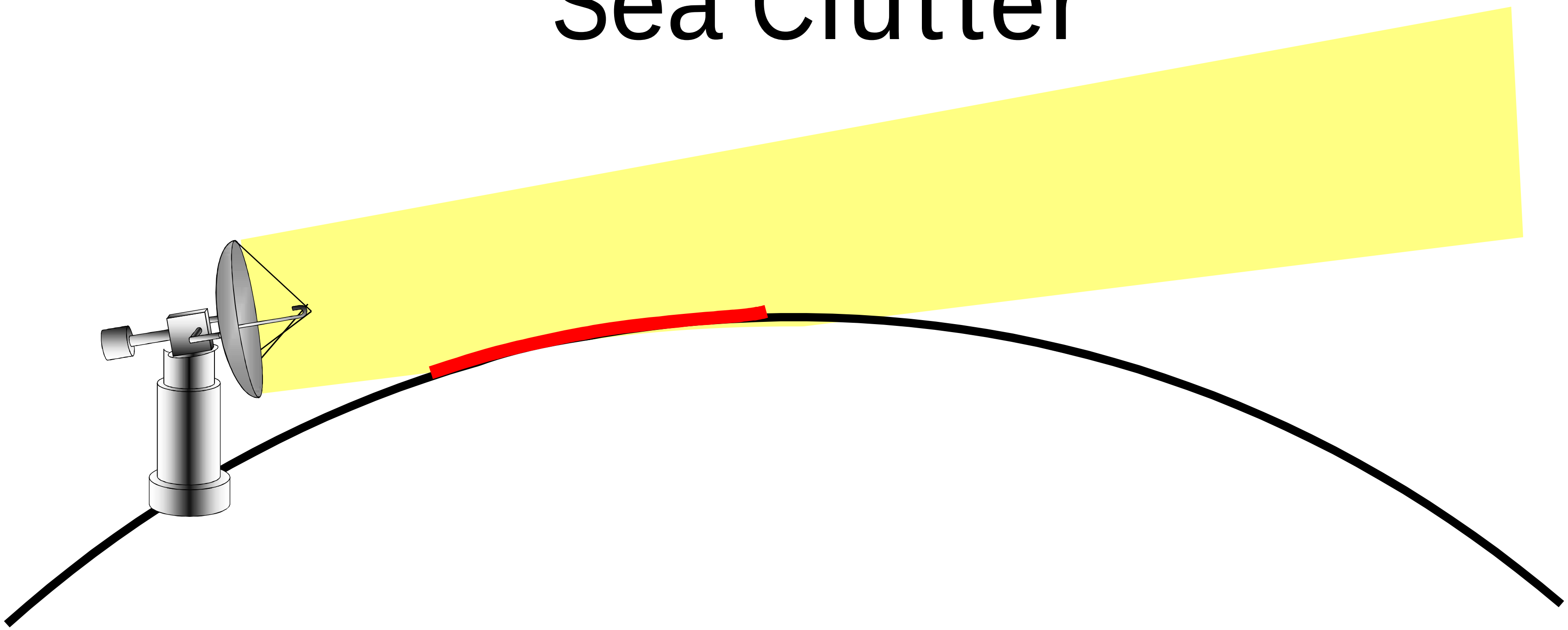
Reflectivity 0.4deg

Fukui radar



Reflectivity 0.8deg

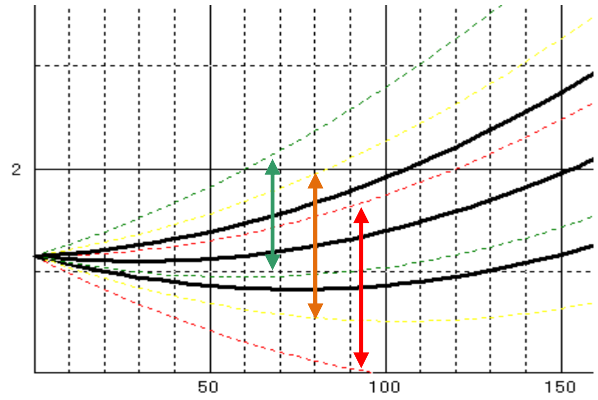
Sea Clutter



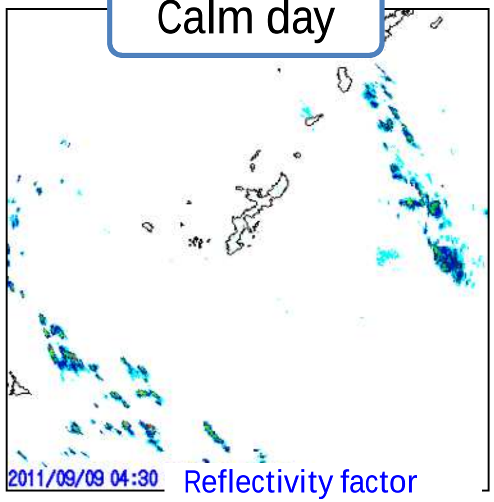
- Sea clutter is observed caused by sea wave or sea spray.
- Because of sea wave motion, suppression by MTI does not work well.
- For the elimination of usual sea clutters, the radar scans with high elevation angle are employed to produce the PCAPPI .

2011/08/04
Typhoon MUIFA (1011)

Sea clutter

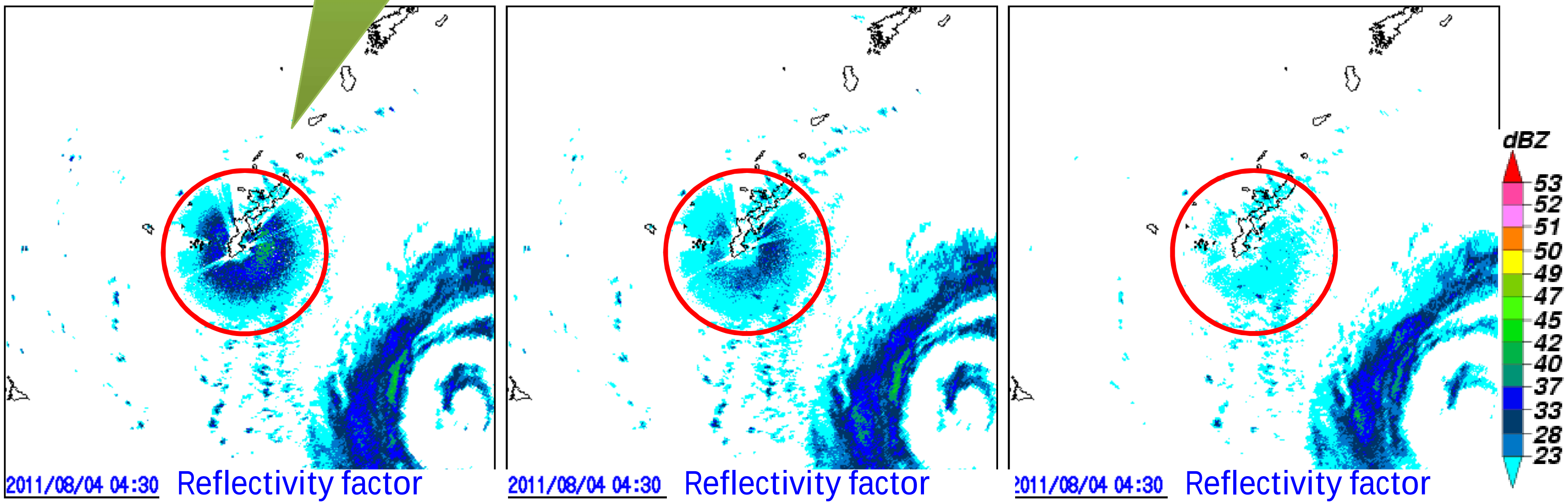


Calm day



Reflectivity factor 0.1deg

Okinawa radar



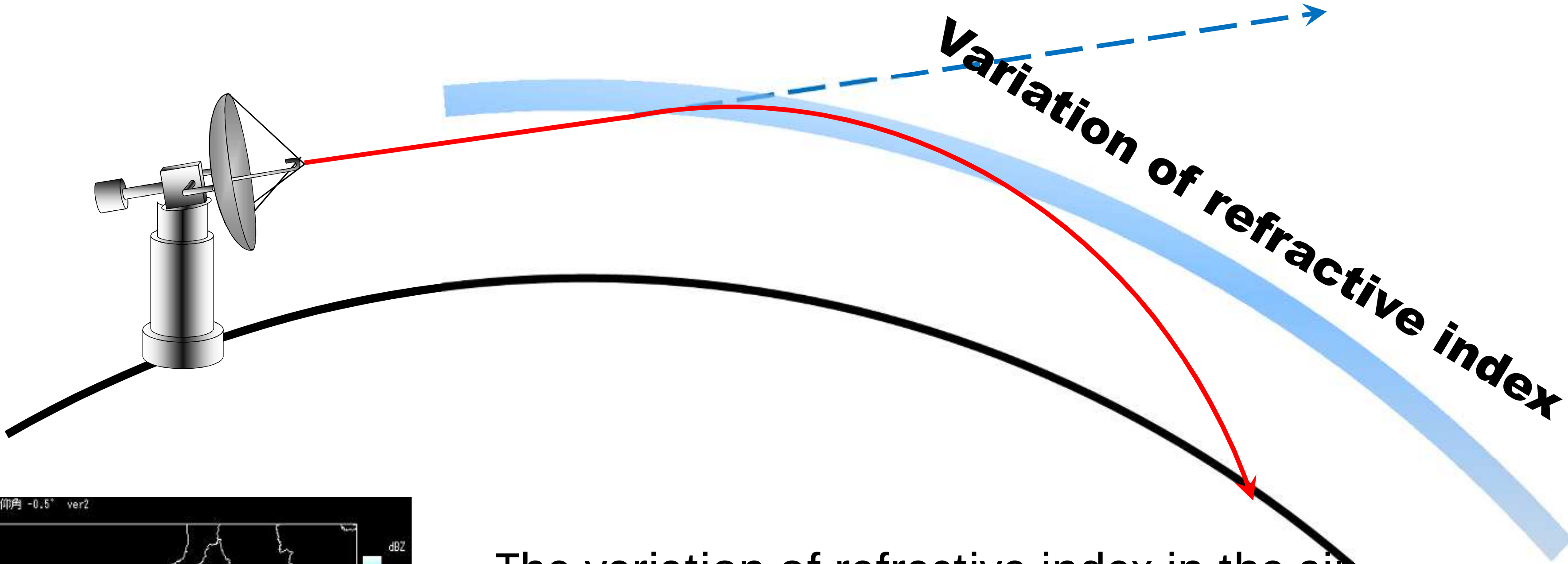
Reflectivity factor 0.1deg

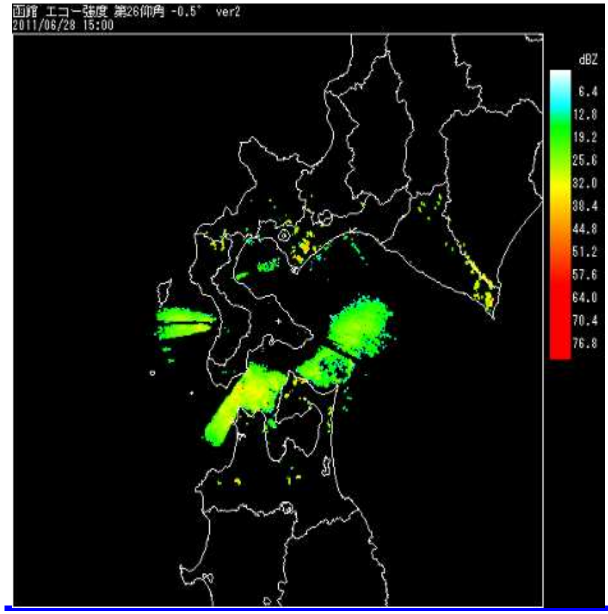
Reflectivity factor 0.2deg

Reflectivity factor 0.6deg

- In windy situations, the sea spray may be observed at low elevation angles.

Anomalous propagation



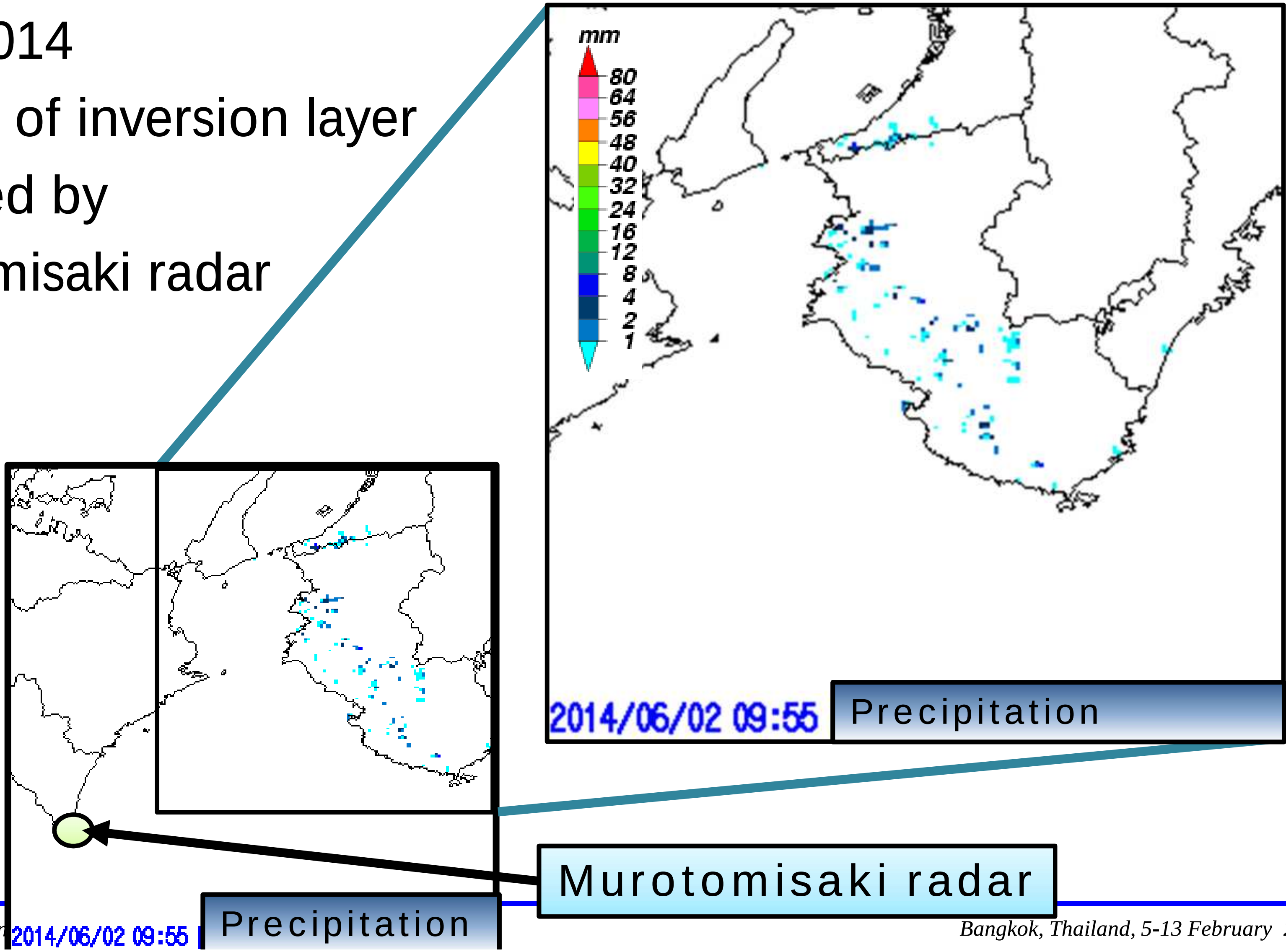


- The variation of refractive index in the air refracts the radar beam below. This kind of refraction is known as the anomalous propagation.
- The anomalous propagation produces some false echoes, in most cases as sea clutter.

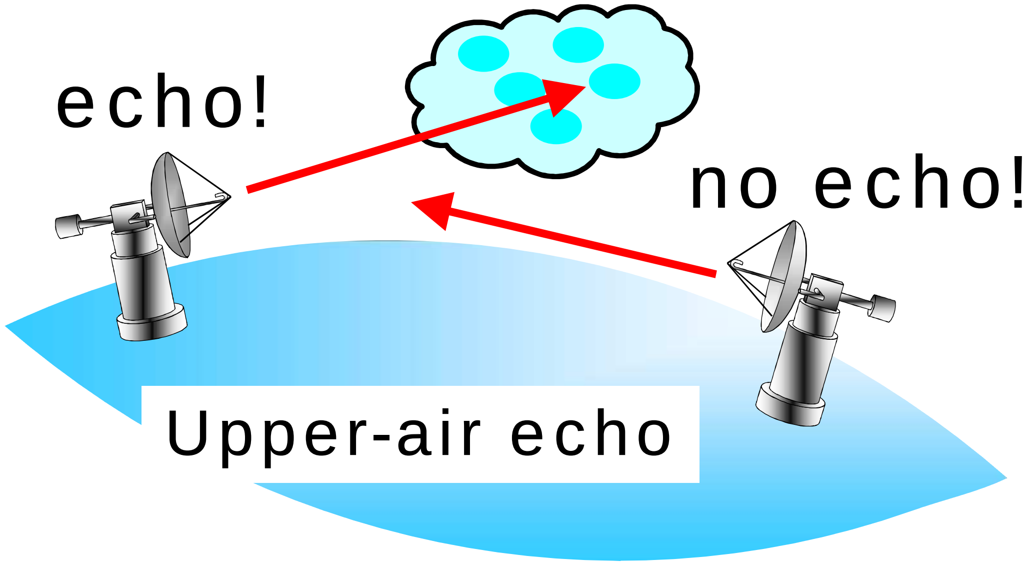
An example of non precipitation echo due to anomalous propagation

AP case of JMA radar

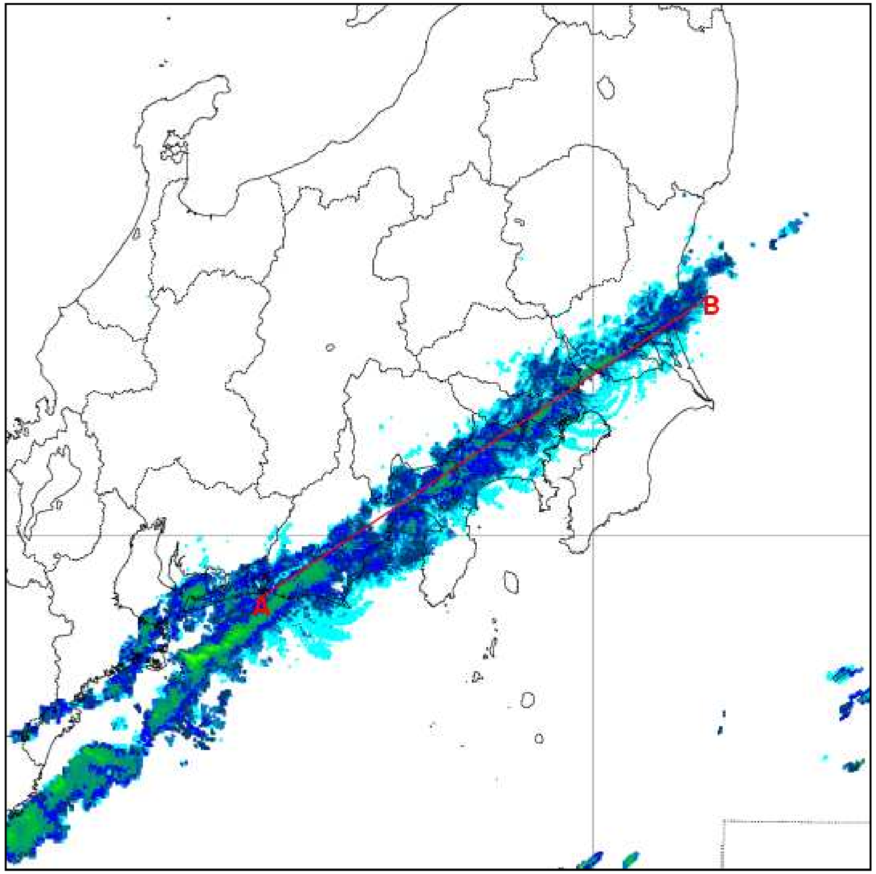
- Jun/2/2014
- Because of inversion layer
- Observed by Murotomisaki radar

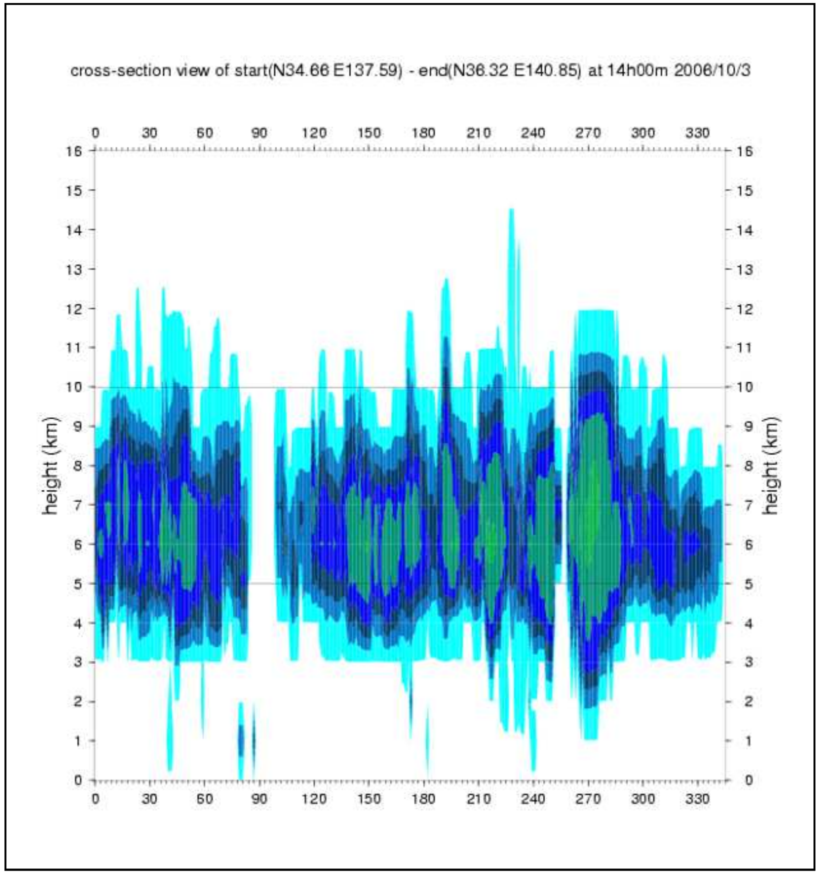


Echo at upper altitudes
- upper-air echoes -



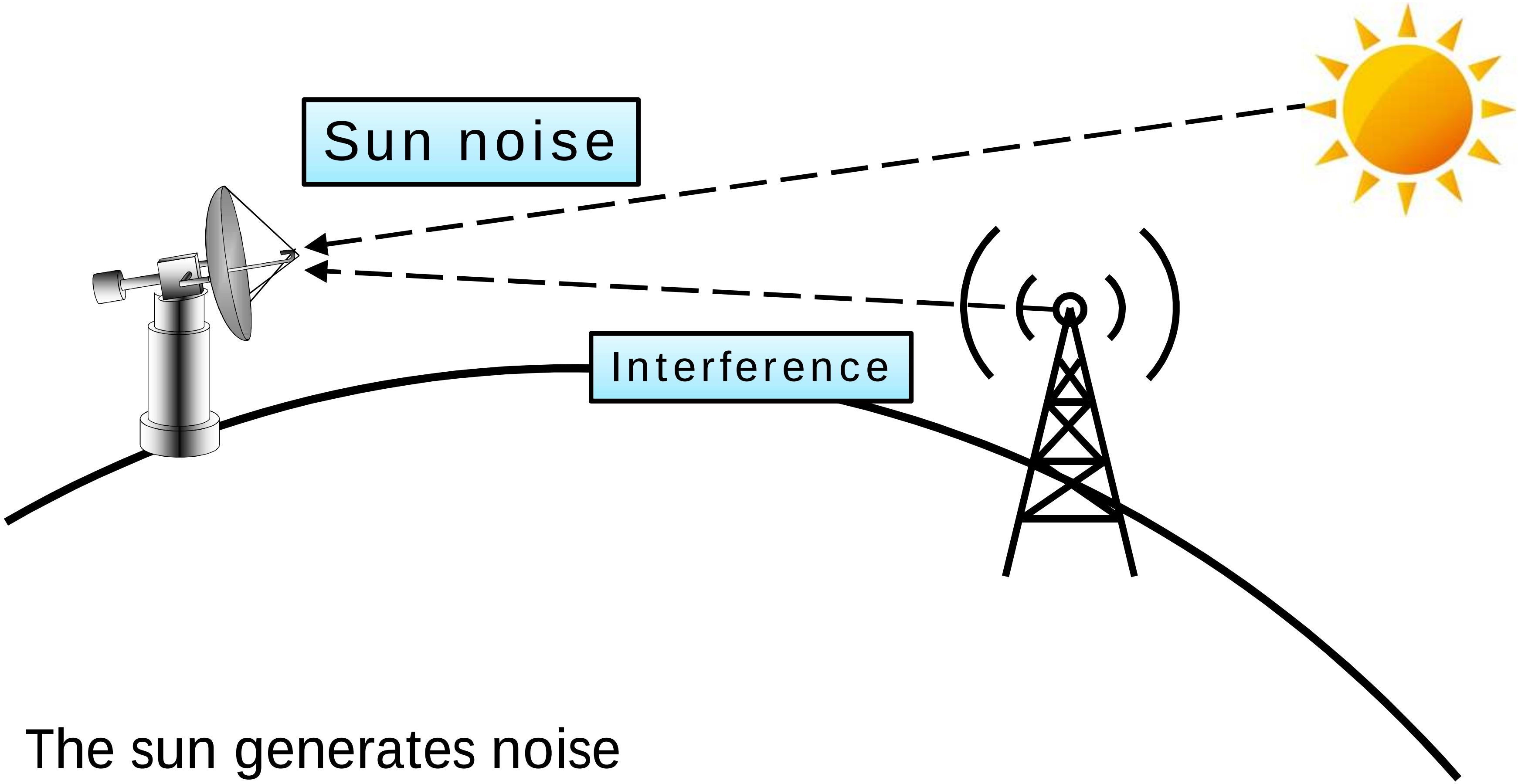
- The radar echo is sometimes observed only at upper altitudes.
- In this case, the liquid drop is completely vaporized during its falling, so precipitation don’t reaches the ground.





CAPPI image at an altitude of 6 km(left)
and cross section(right)

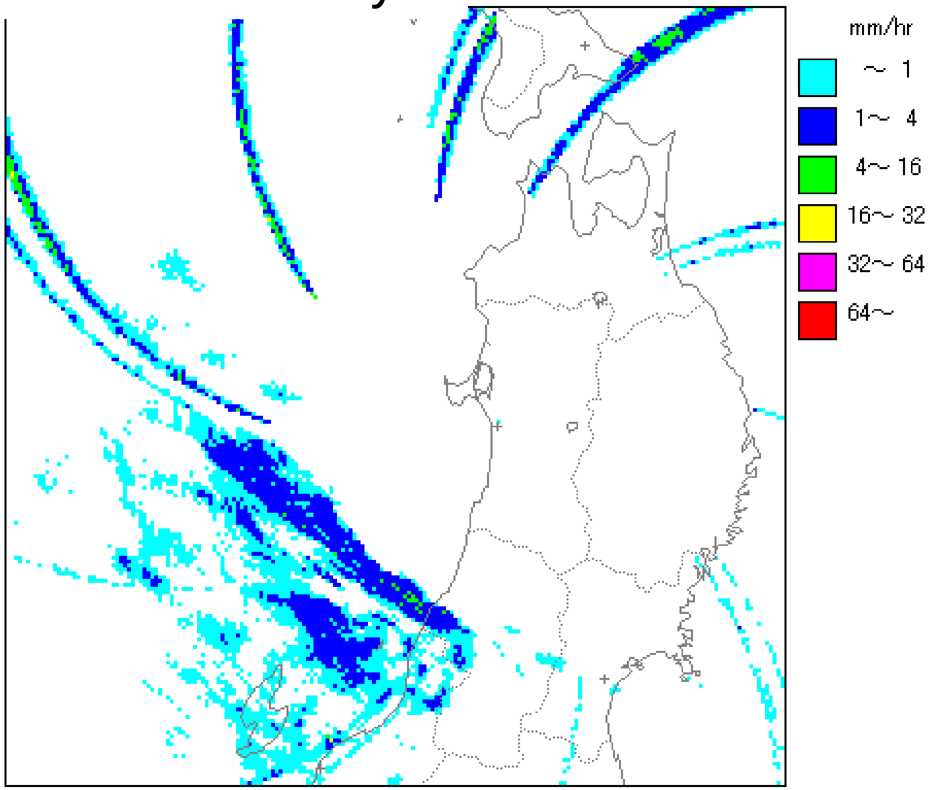
Various Types of Electromagnetic Noises



- The sun generates noise
- The interference comes from artefactual electromagnetic sources.

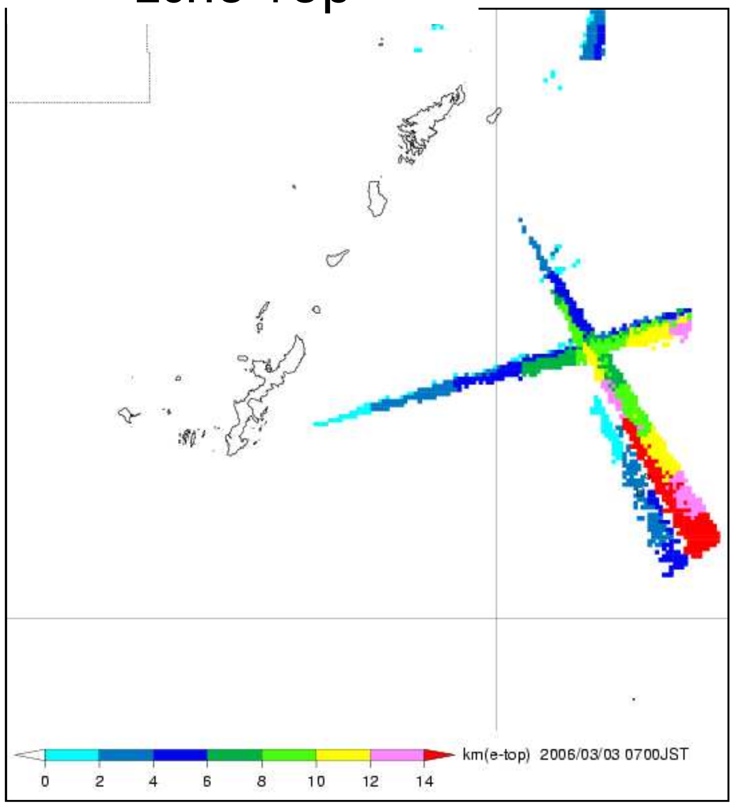
Examples of interference

Echo Intensity



Interference from another radar

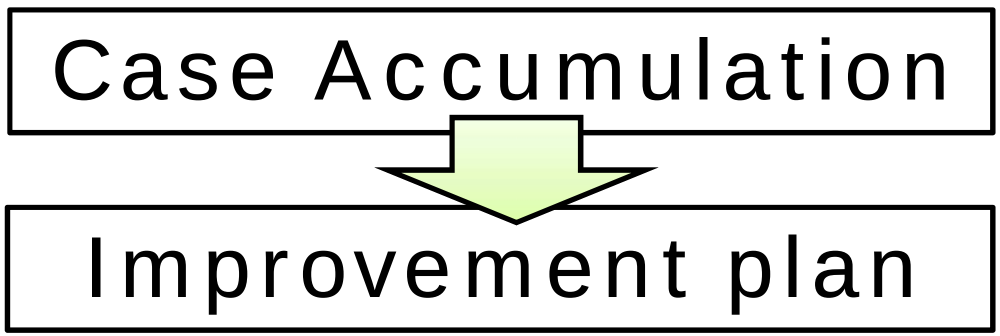
Echo Top



Interference from moving body

Importance of Case Accumulation

- It is important to accumulate cases of anomalous echo.
- It will be very useful for QC.
- The materials should include Meteorological information such as
  - *Weather charts*
  - *Various observations (AWS, sonde, satellite, radar…)*



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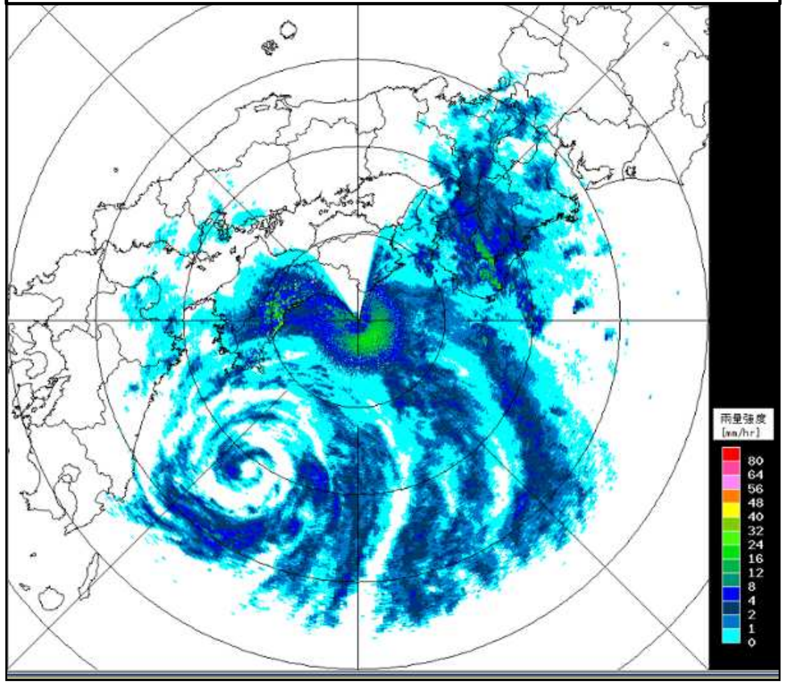
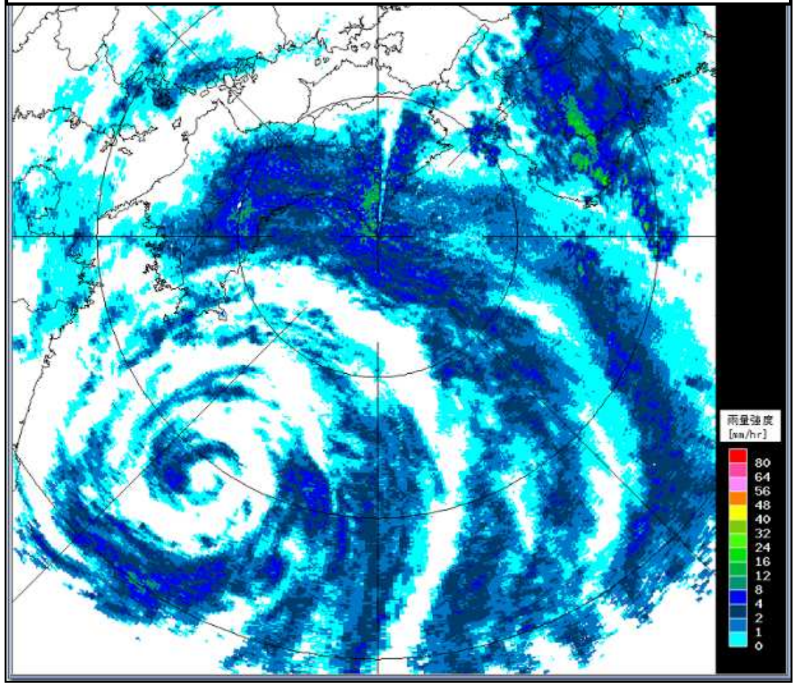
JMA way of Pseudo CAPPI

PPI at the elevation -0.1 degree



JMA way of Pseudo CAPPI

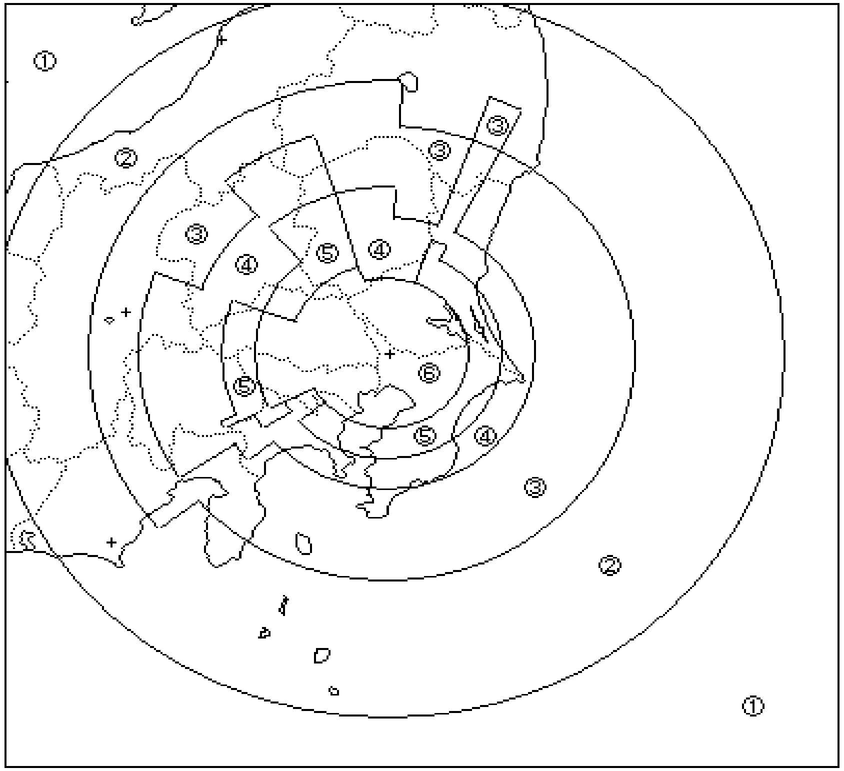


JMA methods of Pseudo CAPPI (PCAPPI); height is <u>about 2 km</u> by using several PPIs at low elevation angles.

This data <u>can remove</u> sea clutters and also ground clutters.

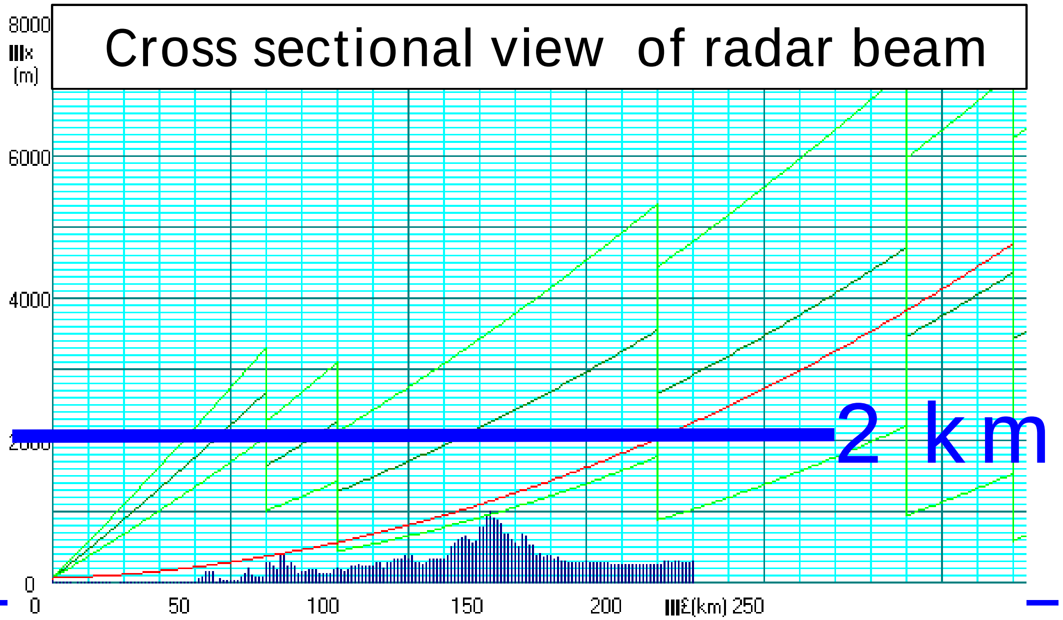
Elevation angle composite table

Elevation angle composite table is parameters
for making Quality Controlled CAPPI data

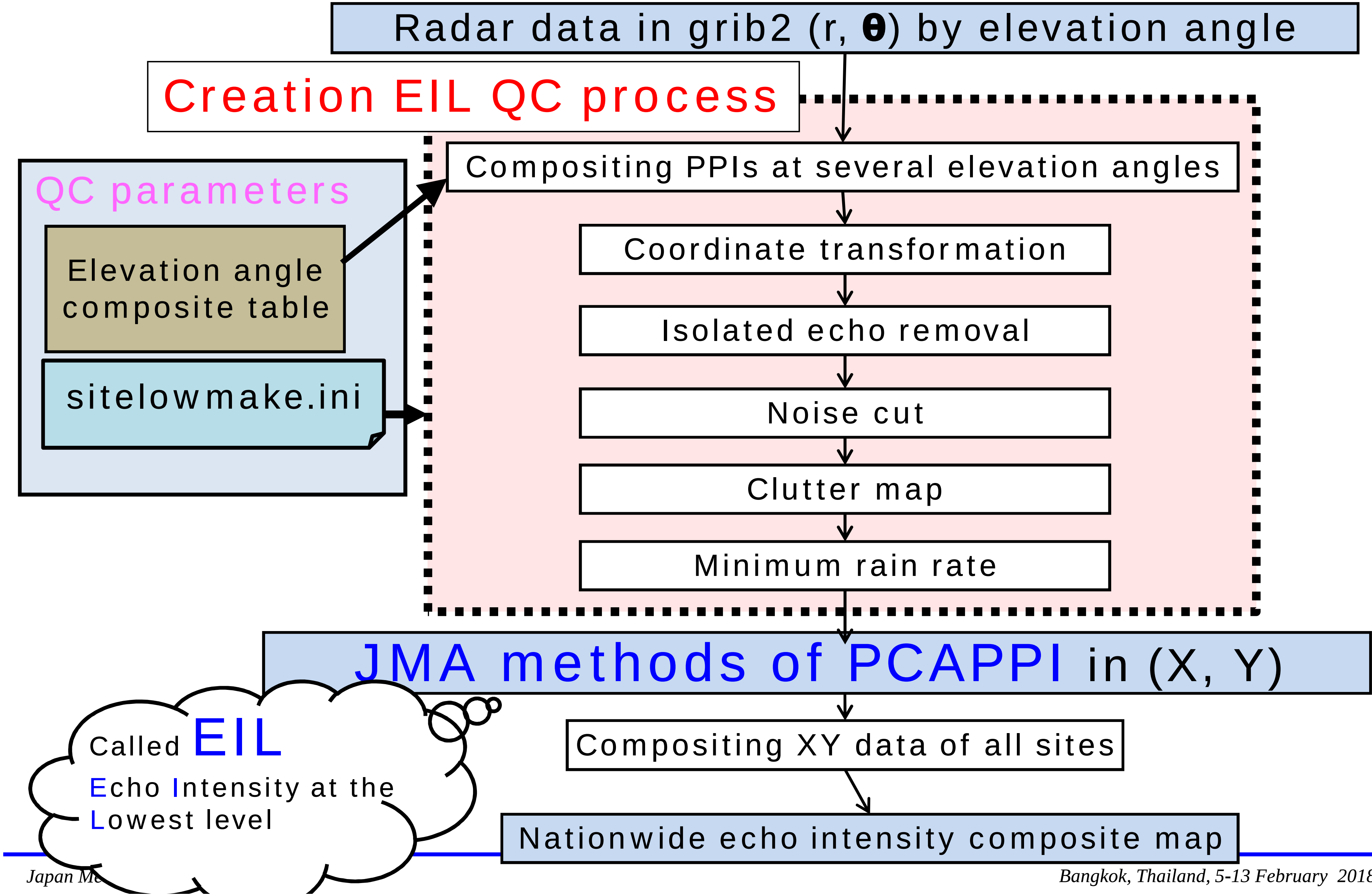


<Elevation>
(1) 0.0deg (2) 0.3deg (3) 0.7deg
(4) 1.1deg (5) 1.7deg (6) 2.5deg

- Selecting an optimal elevation angle located near 2 km altitude in each place
- Avoiding an effect of ground clutter



Data processing flow for PCAPPI



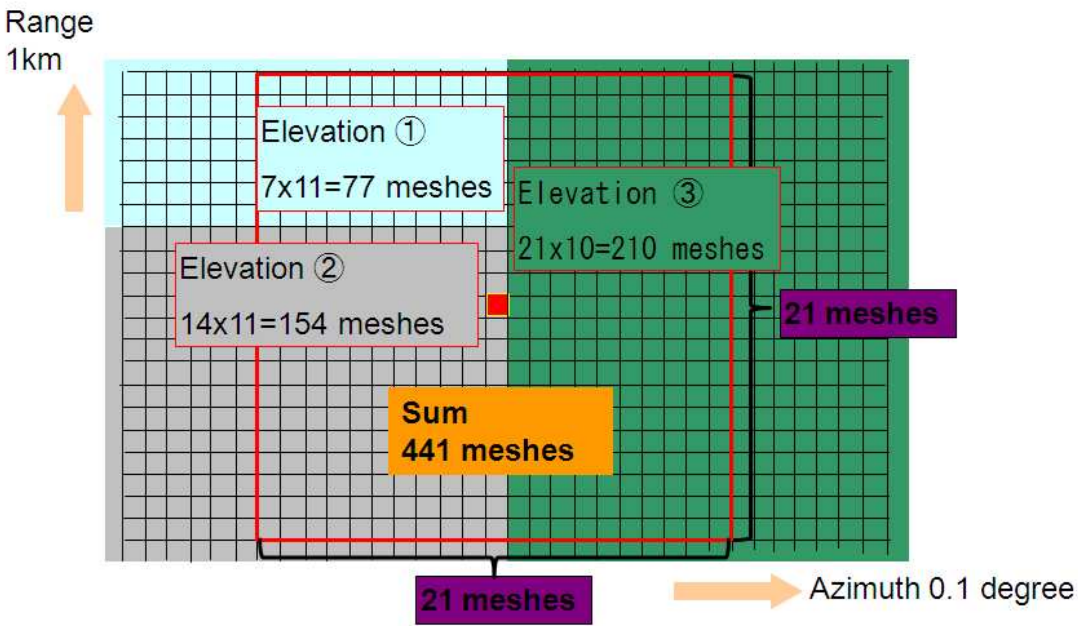
Parameters

Ex.)

```
[47695]
elangles=3.8,2,1.0,0.3,1.7,1.1,0.7,0.3,0.0,25.0,17.9,1
2.9,9.3,6.7,3.8,2.0,1.0,0.3,4.8,3.5,2.5,1.7,1.1,0.7,0.3,
0.0
use_angle_10a=0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,1,1,1,1,1,1
code=A5
ename=tokyo
offx=20
offy=20
n0=51.1
noise_cut=704
rain_cut=33
iso_window=5
iso_count=5
smooth_r=100
smooth_t=10
clut1_file=CLUT¥"aa¥"_00_1
clut1_type=3
clut1_wx=3
clut1_wy=3
clut1_count=0
clut2_file=
clut2_type=3
clut2_wx=0
clut2_wy=0
clut1_count=0
B=200
beta=1.6
```

sitelowmake.ini

Smoothing around border of composite table



Smoothing around border of elevation angles to avoid discontinuity at connection in elevation angle composite process.
The smoothing areas is 10km around border.
We count the number of meshes every angle, and use them as weight for the averaging intensities.
The left figure shows an example.

Elevation 1 is 77 meshes 30dBZ
Elevation 2 is 154 meshes 50dBZ
Elevation 3 is 210 meshes 35dBZ

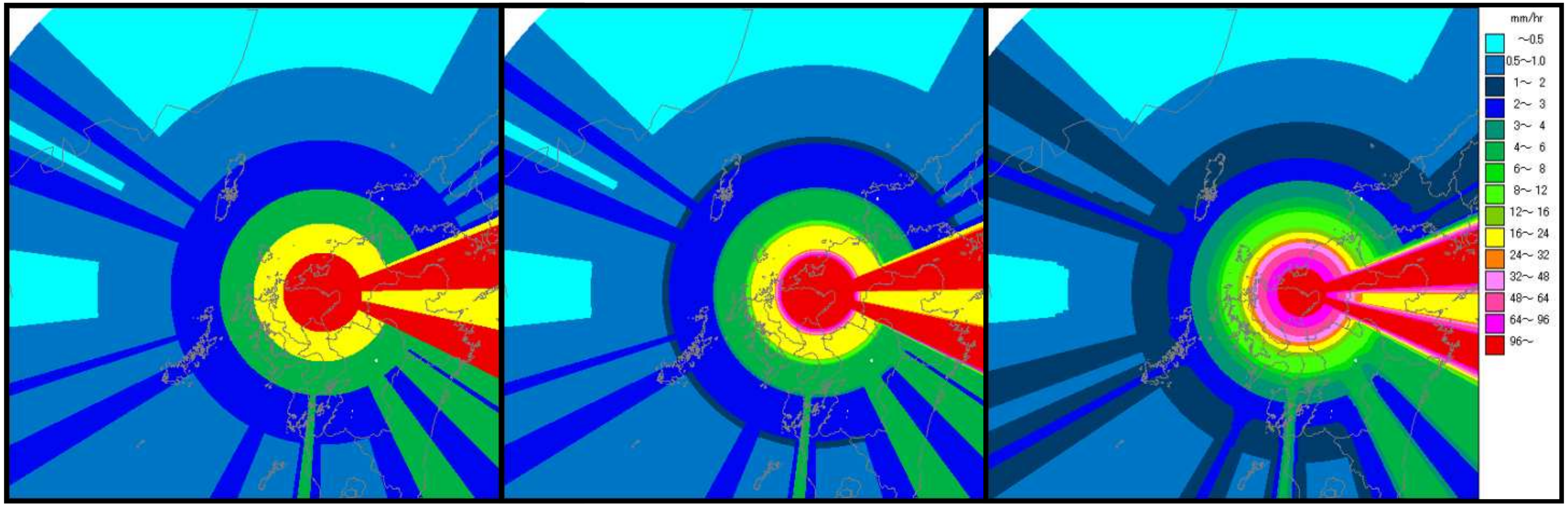
$$\text{Smoothed intensity} = \frac{77*10^{(30/10)} + 154*10^{(50/10)} + 210*10^{(35/10)}}{441} = 36601.08$$

Logarithmic value, 10 * log 36601.08 = **45.63** (dBZ)

Smoothing

Test

Without smoothing　After smoothing: 1　After smoothing: 2



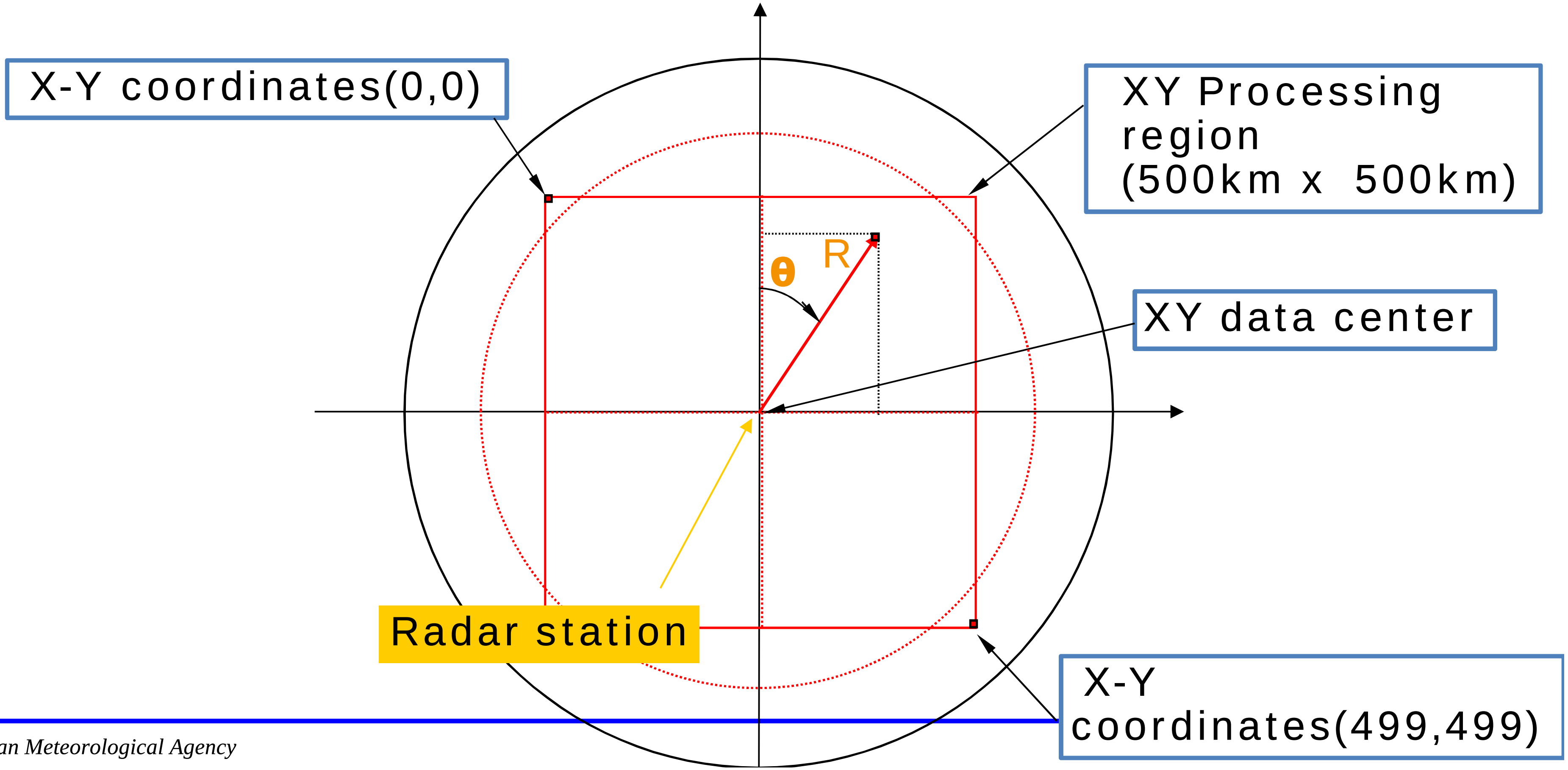
The weights are calculated
: 10 km in range direction
: 1 degree in azimuth direction

The weights are calculated
: 100 km in range direction
: 10 degree in azimuth direction

```
...
smooth_r=100    : range for smoothing (km*10)
smooth_t=10     : azimuth for smoothing (deg*10)
...
```

Transformation from Polar coordinates to X-Y coordinates

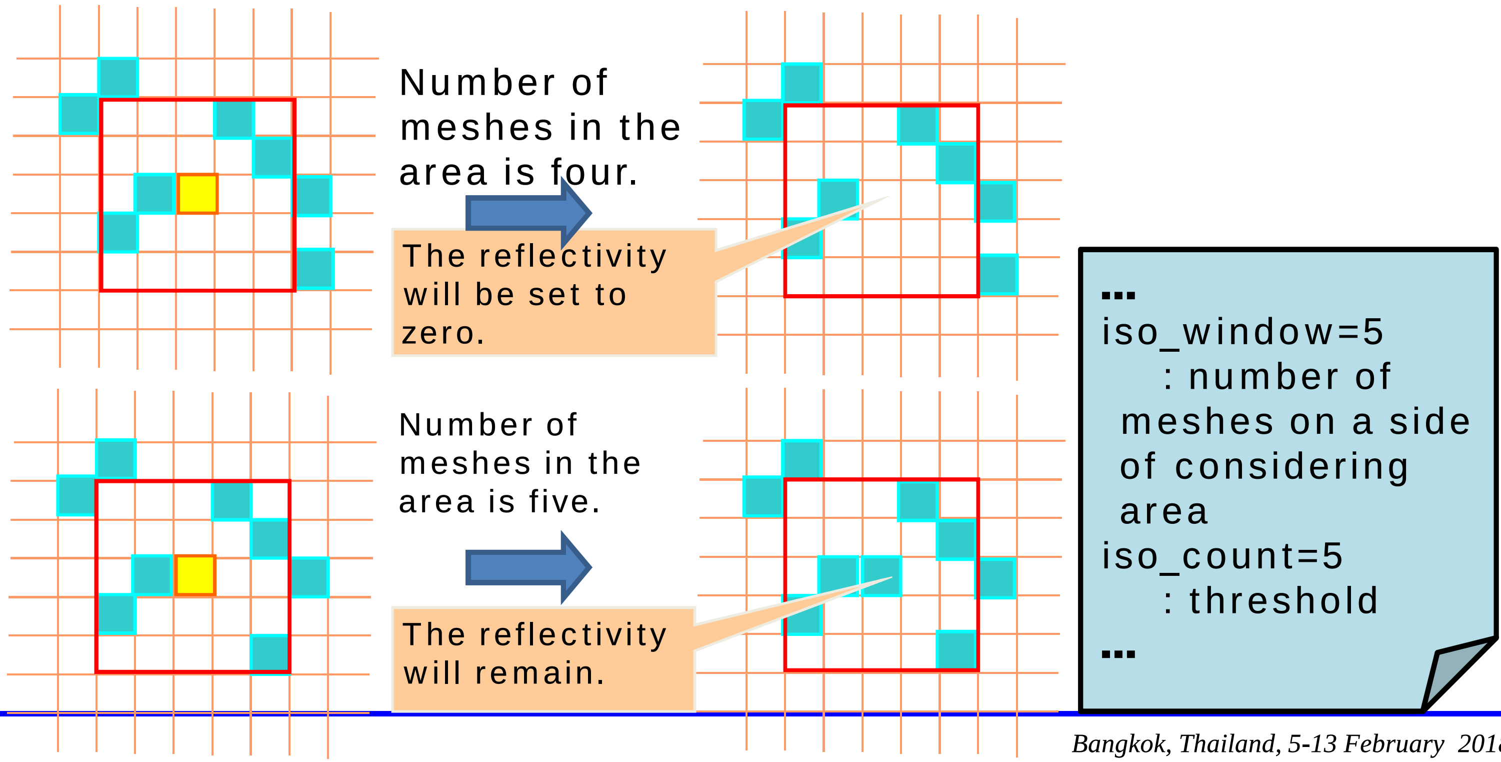
- Primary data (PPI in polar coordinate (R, θ, φ)) are transformed to X-Y coordinates(X, Y, φ) with a spatial resolution of 1km, and an area of 500km × 500km square X-Y coordinates.
- The nearest bin in polar coordinate is applied for each mesh in X-Y coordinate.
- This can reduce data size of huge primary data and make them be easier to use.



Isolated echo removal

- Removing the isolated echoes caused by ground clutter, ships and aircrafts.
  - In the 5×5 meshes, the number of meshes of which intensity is larger than zero is counted except of the target center mesh.
  - If the number is below a threshold, the intensity of the mesh is set to zero. If not , it will remain.

Ex.)
Threshold ＝5



Noise cut

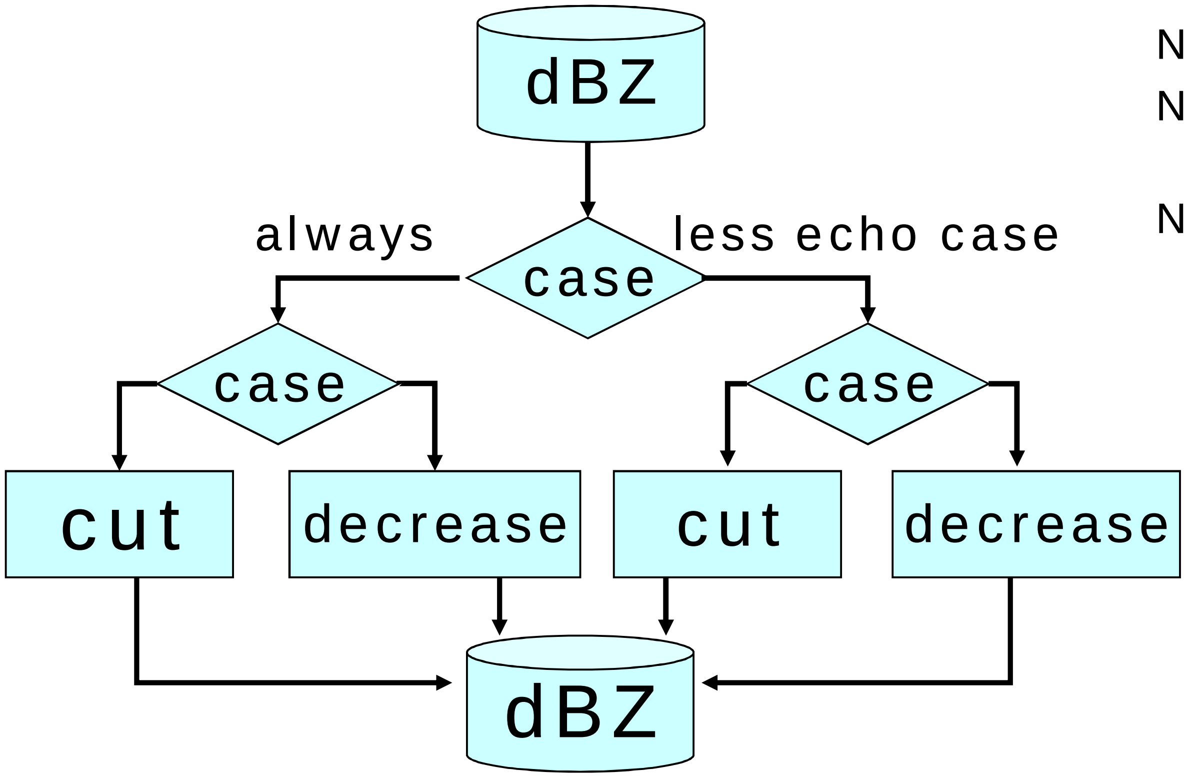
- In this process, echo intensities below a threshold are set to zero, i.e, No Echo.
- This threshold depends on each radar.

```
...
noise_cut=704       : threshold (dBZ*100)
...
```

Clutter map

Clutter map is used when process like MTI could not eliminated clutter.
A clutter map has thresholds to delete echoes or values from the observed echo intensities.

Nr = Ns + 10 * log(1 – 10 ^ ((Ng – Ns) / 10))

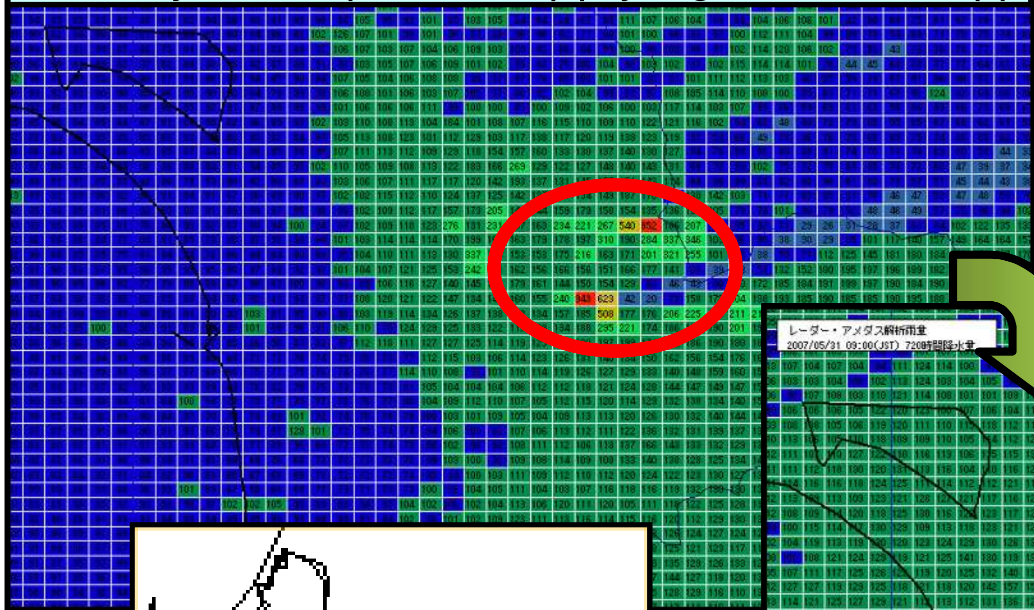


Ng：clutter map value(dBZ)
Ns：reflectivity before subtraction(dBZ)
Nr：reflectivity after subtraction(dBZ)

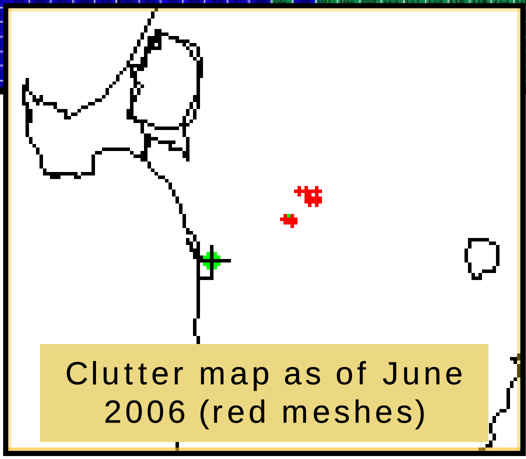
```
...
clut1_file=CLUT¥"aa¥"_00_1
clut1_type=3
clut1_wx=3
clut1_wy=3
clut1_count=0
...
```

Example of the impact of clutter map processing on QPE data

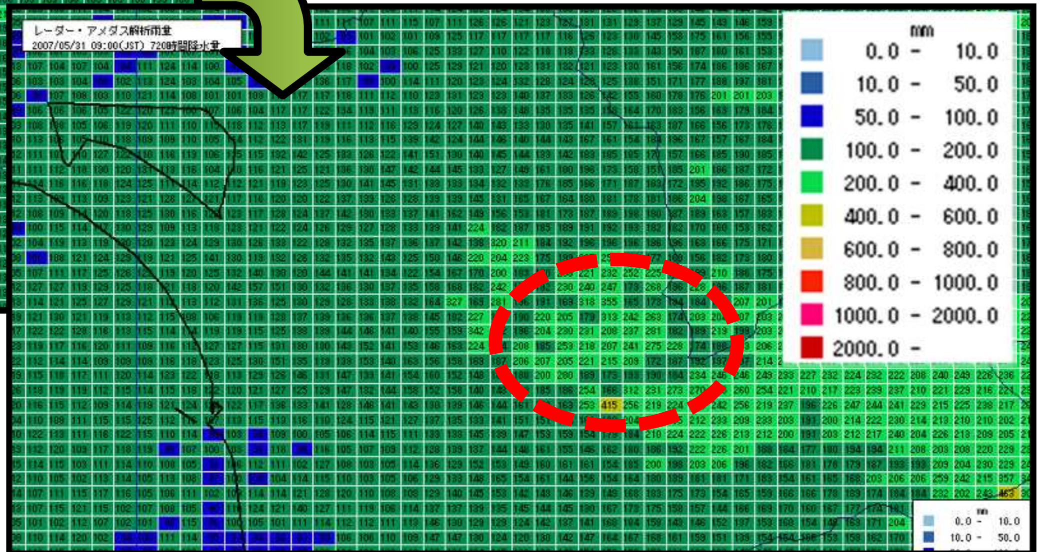
1-month accumulated QPE data for May 2006 (before applying clutter map)



We applied clutter map to meshes which shows extremely high value compared to the surrounding meshes decreased.



Clutter map as of June 2006 (red meshes)



1-month accumulated QPE data for May 2007 (after applying clutter map)

Quantitative Precipitation Estimate (QPE) : Radar/rain-gauge analyzed precipitation

Minimum rain-rate

- Minimum rain-rate is a process for cutting low level value after clutter map process.
- If the Nr is below a minimum rain-rate,
  the Nr is set to zero (No Echo)

※Nr：reflectivity after subtraction(dBZ)

```
…
rain_cut=33        : threshold (mm/h*100)
…
```

Features of each algorithm

Algorithm	Type	Advantage	Disadvantage
Elevation angle composite table	Selected angle Area:(r,theta)	Sea clutter Ground clutter	
Noise cut Minimum rain-rate	Low level cut Area : all	Low level noise	Low level echo
Clutter map	Level cut(set) Area : mesh	Ground clutter (enable to remove by MTI)	Remove precipitation echo (Labor for setting)

Summary of EIL process

- EIL process contains many quality control methods.
- In order to create Cartesian data with good quality (less clutter and less noise), we need to set various parameters adequately.
- Removing non-precipitation echo has a possibility also removing precipitation echo.

Hands-on Training on Weather Radar QC

- Introduction of JMA Operational system
- Quality control algorithms
  - Characteristics of non-precipitation echo
  - JMA methods of Pseudo CAPPI process
  - Statistical approach for QC
- Hands on training
  - Adjustment of elevation angle composite table
  - Making PCAPPI and Statistical data
  - Verification of the results

Statistical approach for QC

Statistical method is effective way to understand the quality of radar data.

JMA uses the statistics for quality control.

- Appearance count
- Summation

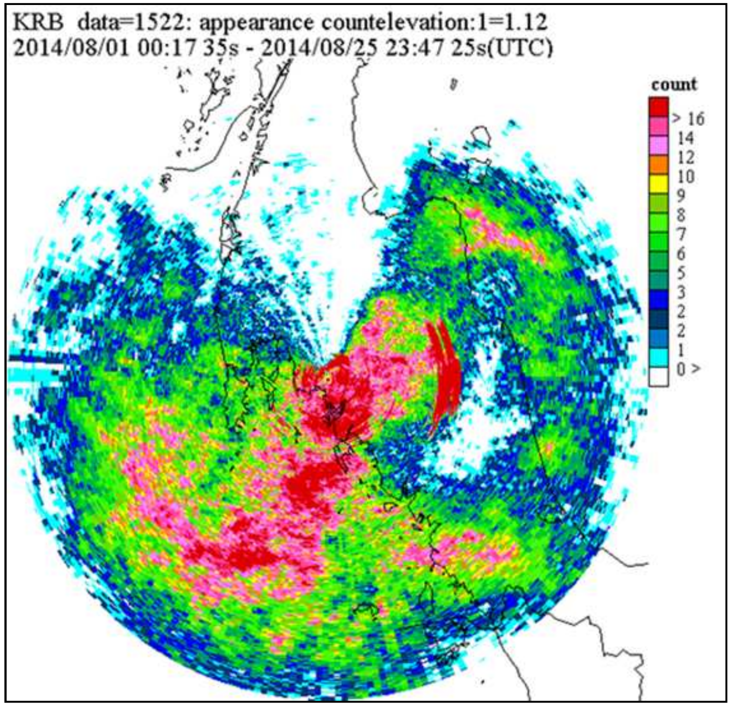
Make every sites, angles and lowest.(monthly)

Appearance Count

- Count over 1mm/h precipitation intensity calculated from dBZ, B, and beta.

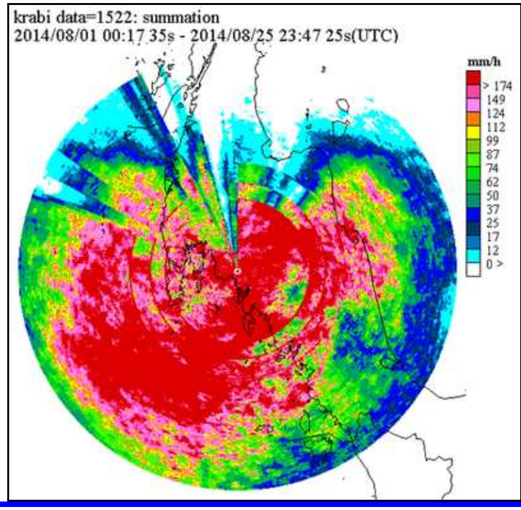
- The appearance clarifies

: continuous weak echoes



Summation

- Sum up precipitation from radar data.
- “Appearance count” can’t detect clutter or high intensity echo, but summation can detect these things.
- That would be clear using summation data.
- The summation of precipitation from clutter affects QPE.



Target

- Every elevation's observation

To understand the characteristics of observation at each elevation.

- EIL (Echo Intensity at the Lowest Level)

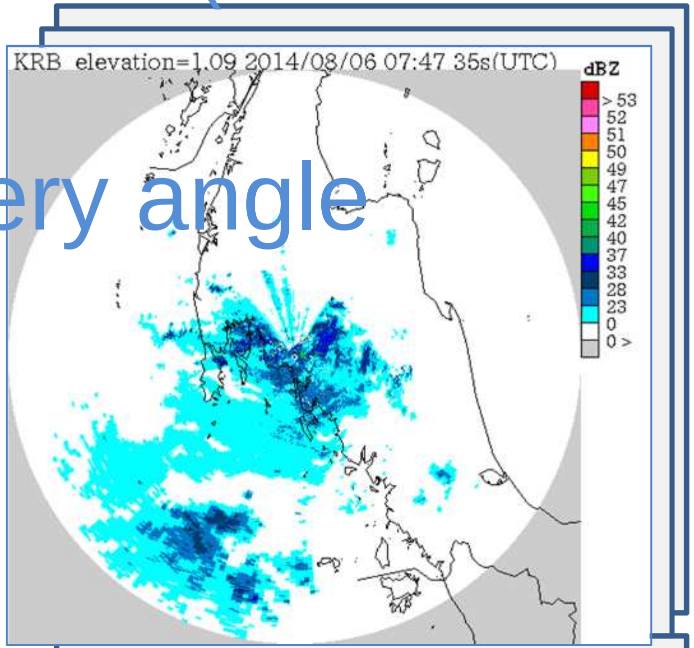
To understand the characteristics of products.

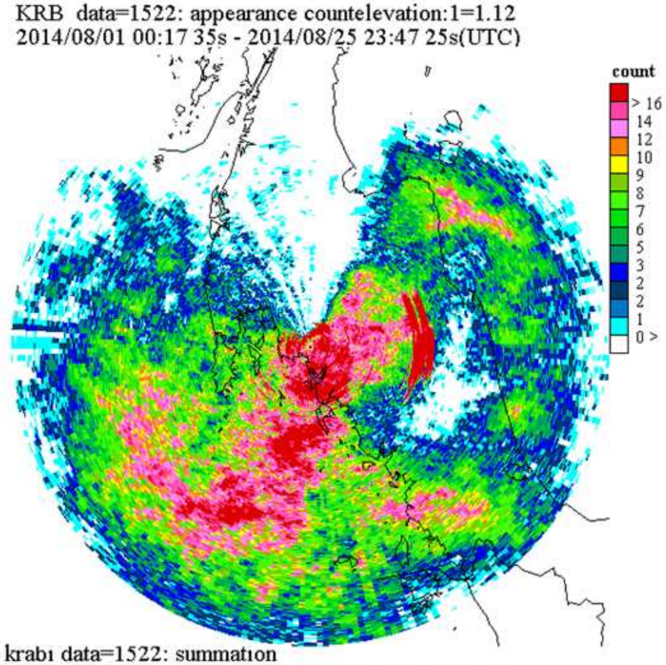
- Shadowed area
- Observable area
- Low quality area

Each Data(observation time)

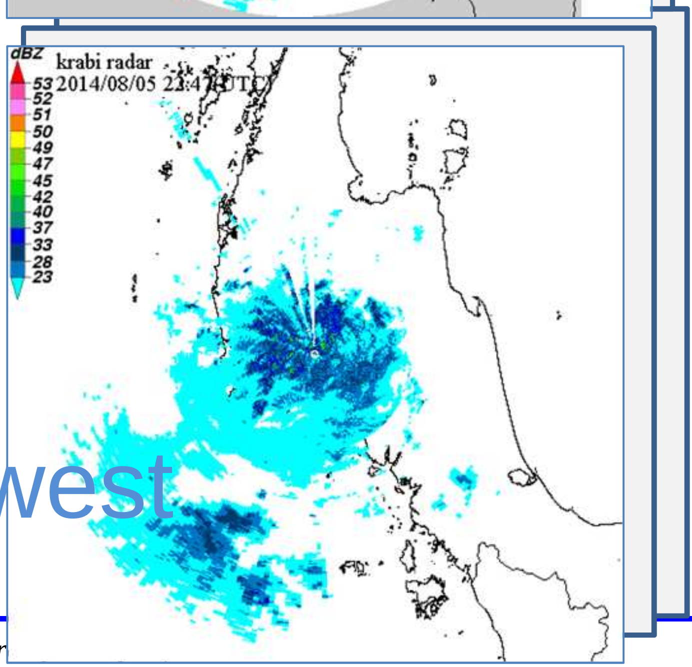
Statistical Data

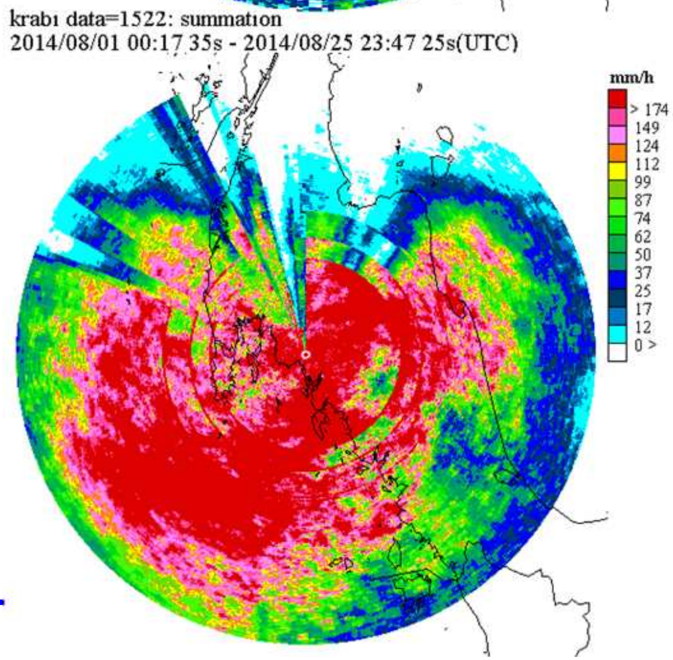
Every angle





Lowest





In Statistical program

- Use average instead of Summation
  - Equivalent (with using data count)

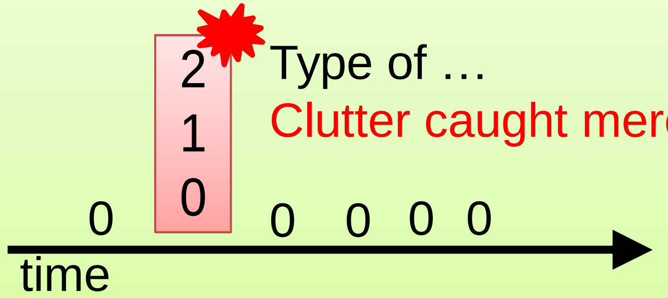
Summation = Average × Data count

How to detect clutter

Various type of clutter exists but …

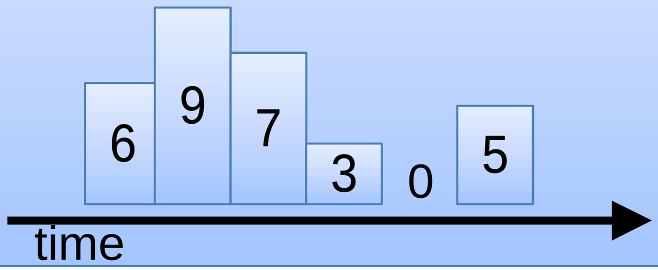
- Advantages
  - Average
    - Merely but strong
  - Appearance
    - Weak but continuous

Appearance = 1
Average = 35 suspicious



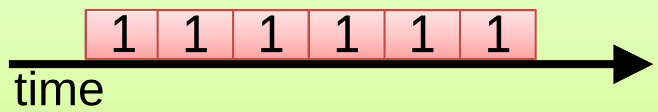
Type of …
Clutter caught merely but strong

Precipitation case is not so suspicious
Appearance = 6
Average = 5



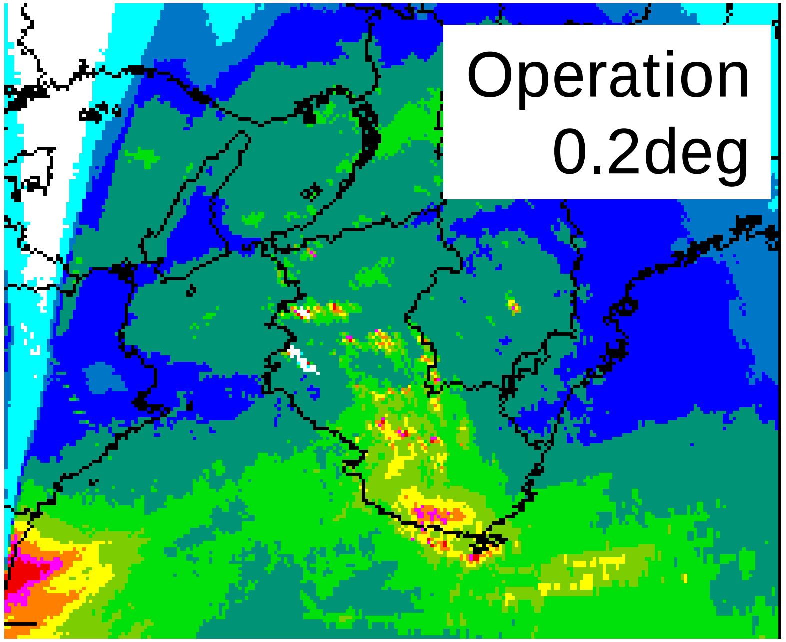
Appearance = 6
Average = 1
suspicious

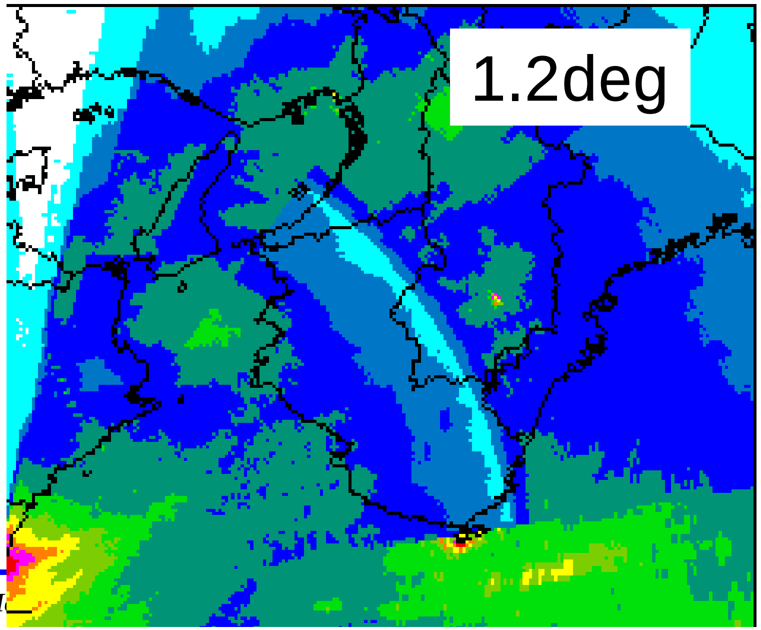
Type of …
Clutter caught weak but continuous

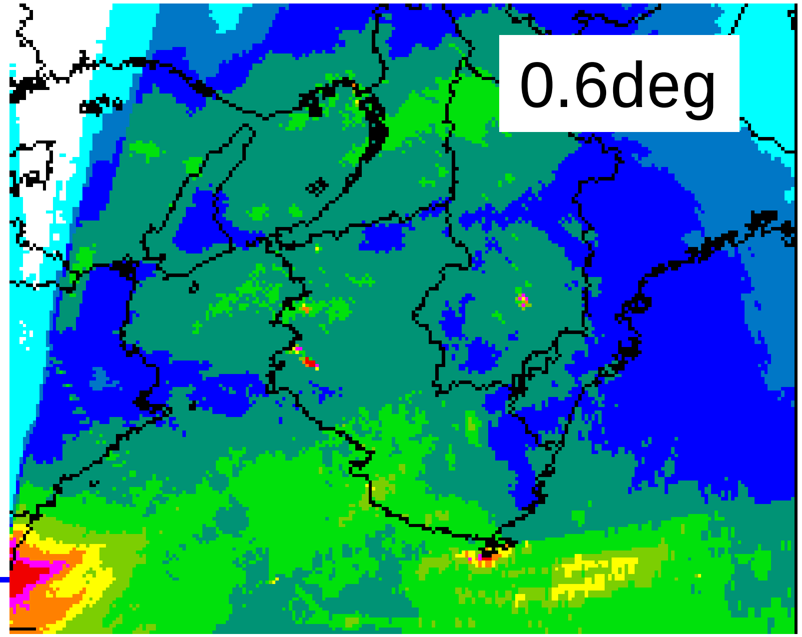


Summation Test of MUROTOMISAKI Radar May. 2014

- 0.2 deg is operation. (observational product)
- 0.6 deg test decrease the clutter.
- 1.2 deg test also decrease the clutter ,but decrease real precipitation echo.







Summary of Quality control

- Anomalous echo is too intense echoes compared with the actual precipitation area. Such as,
  - Ground clutter
  - Sea clutter
  - Anomalous propagation ... etc.
- Complete elimination is impossible by automatic processing
- System operators must check such echoes
- Case accumulation contributes to QC

Thank you for your attention !!

Hands-on Training on Weather Radar QC

- Introduction of JMA Operational system
- Quality control algorithm
  - Characteristics of non-precipitation echo
  - JMA methods of Pseudo CAPPI process
  - Statistical approach for QC
- Hands on training
  - Adjustment of elevation angle composite table
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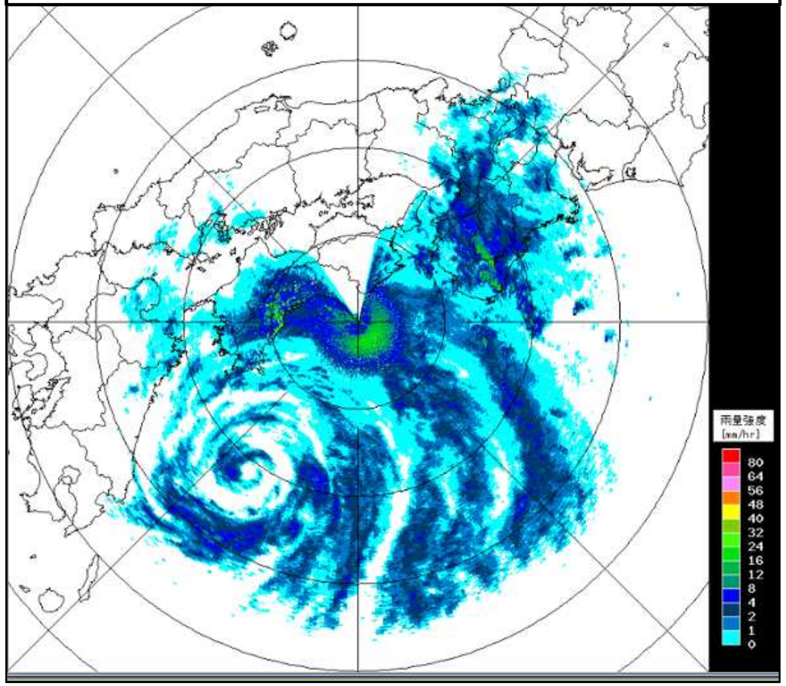
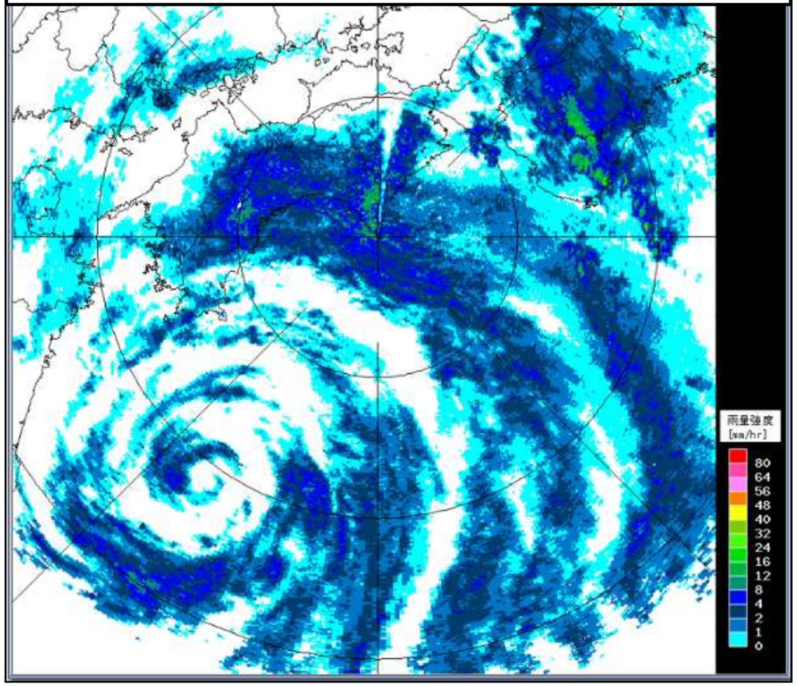
  - Verification of the results

JMA methods of Pseudo CAPPI

PPI at the elevation -0.1 degree



JMA methods of Pseudo CAPPI



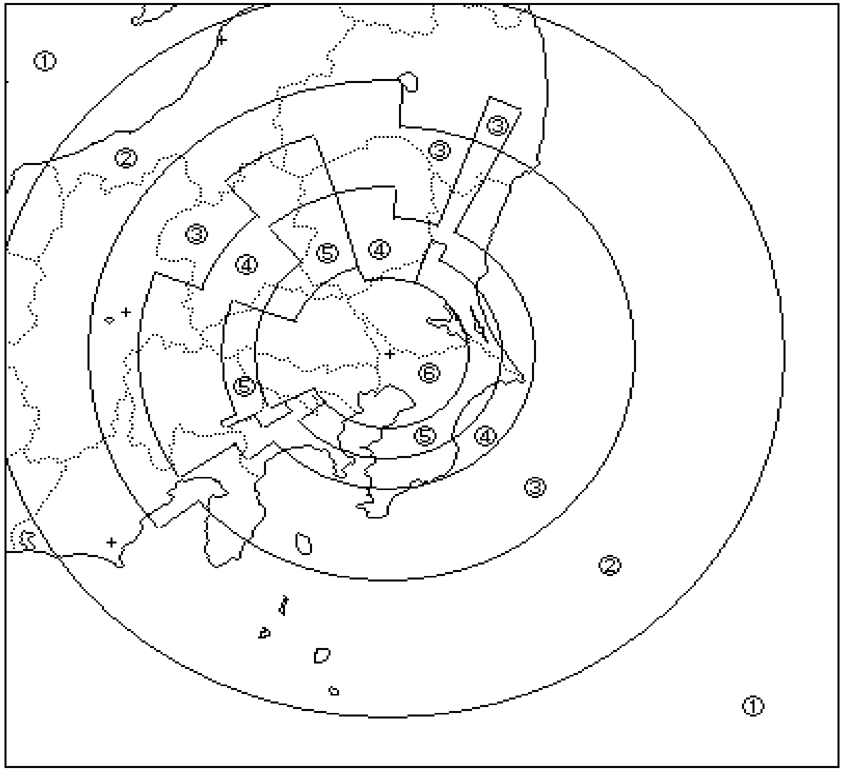
JMA methods of Pseudo CAPPI (PCAPPI); height is <u>about 2 km</u> by using several PPIs at low elevation angles.

This data <u>can remove</u> sea clutters and also ground clutters.

Elevation angle composite table

<u>Elevation angle composite table</u> is parameters for making Quality Controlled CAPPI data

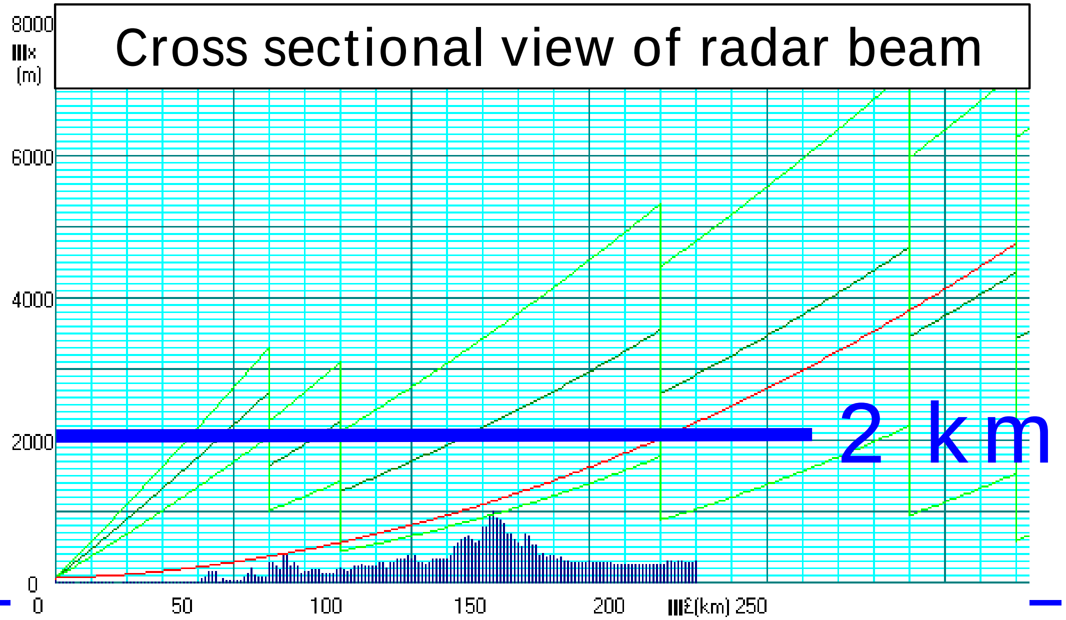
- Selecting an optimal elevation angle located near 2 km altitude in each place
- Reducing effect of ground clutter



<Elevation>

(1) 0.0deg (2) 0.3deg (3) 0.7deg

(4) 1.1deg (5) 1.7deg (6) 2.5deg



Targets of Hands-on training

- To experience benefits of JMA's Pseudo CAPPI process

  - By adjusting elevation angle composite table

- To realize importance of statistical data

  - By verifying statistical data

This practice will give answers to questions below;

- How PCAPPI process can improve data quality?
- How we find out a better way of QC with statistical data?

Adjustment of Composite Tables

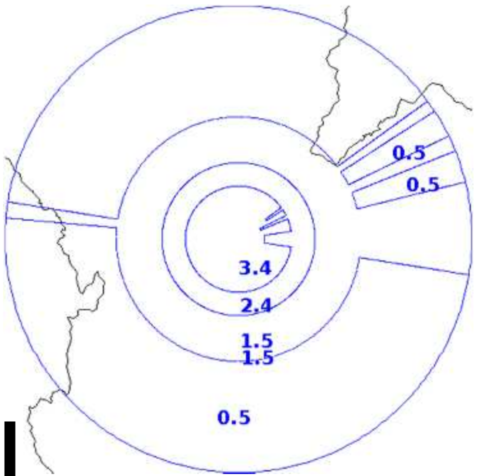
(2014 Aug, Phisanulok radar site)

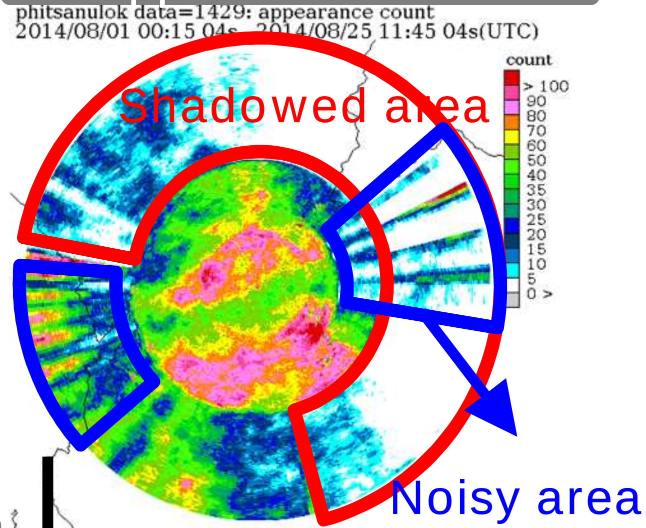
Composite table

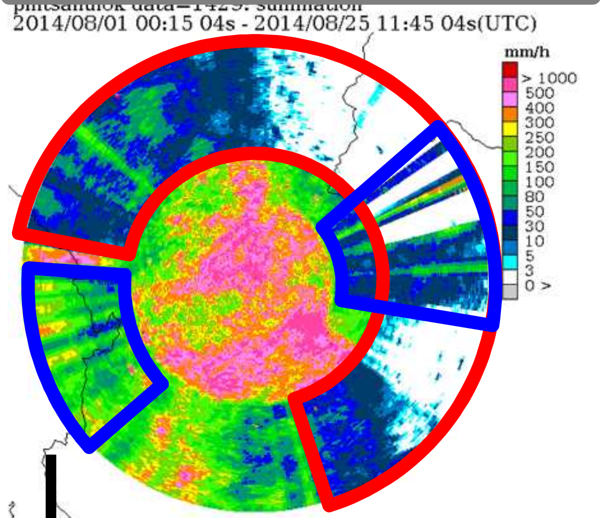
Statistical PCAPPI data

Appearance Count

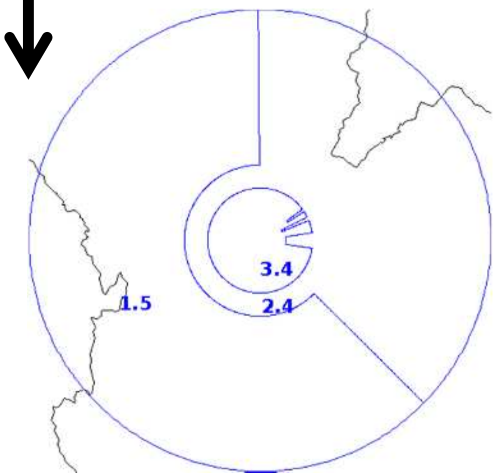
Summarized data

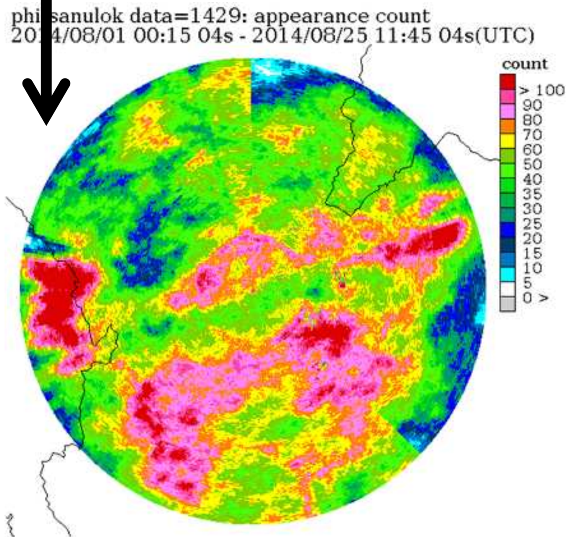


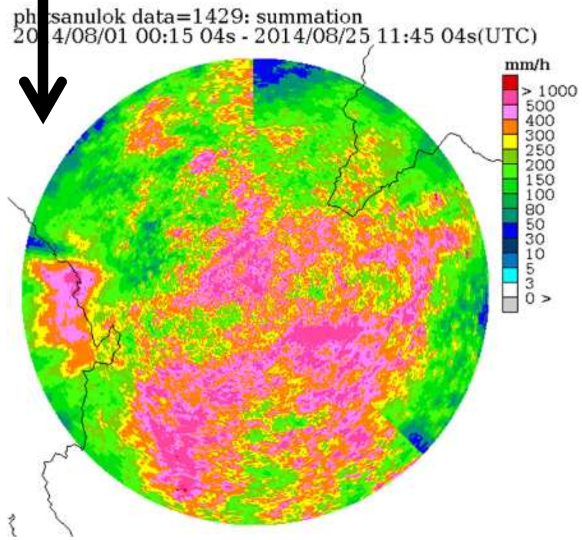




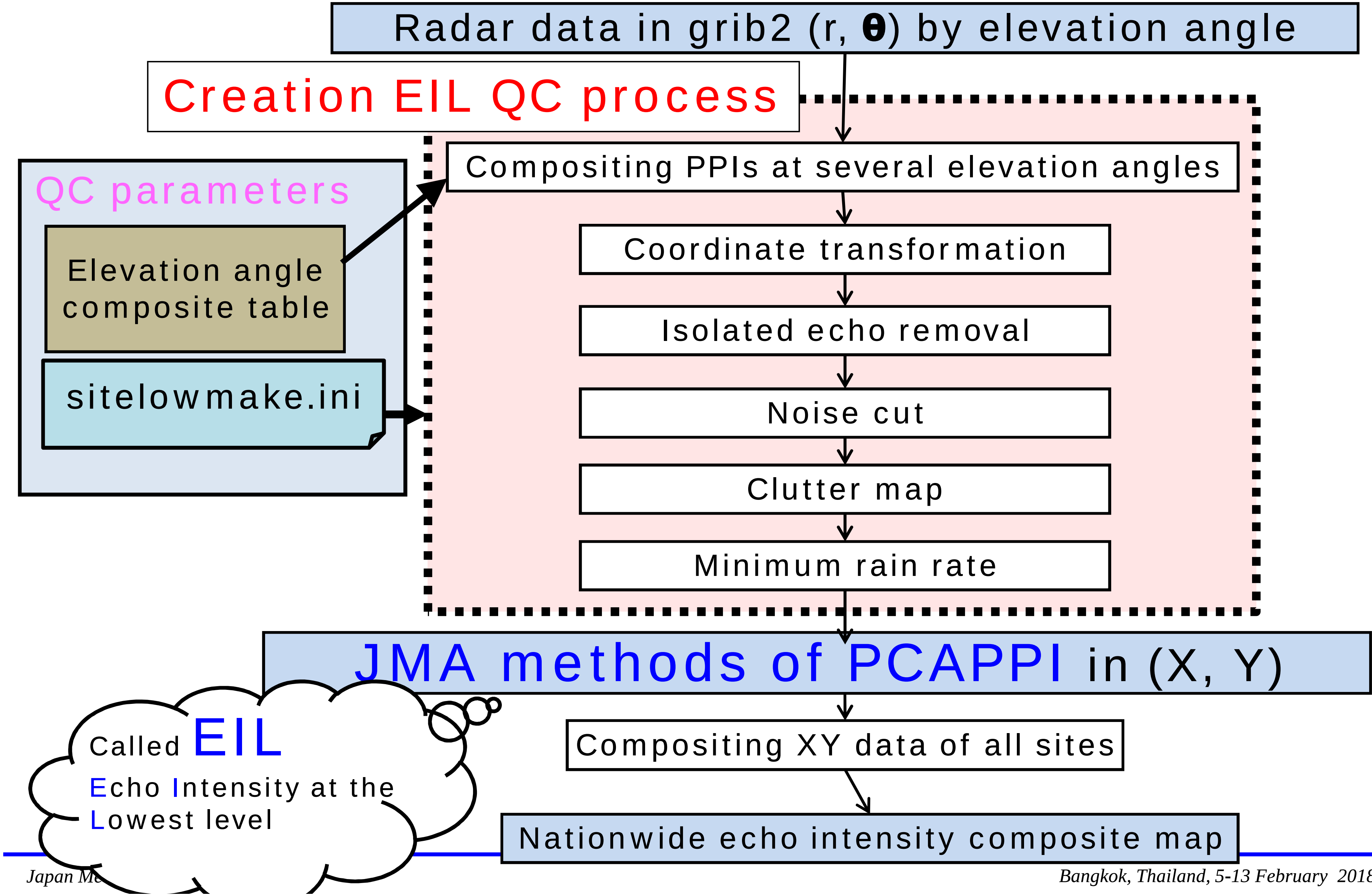
Adjusting Composite table





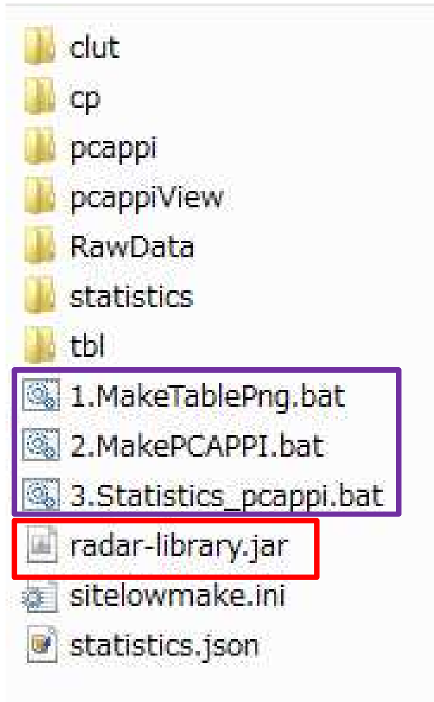


Data processing flow for PCAPPI

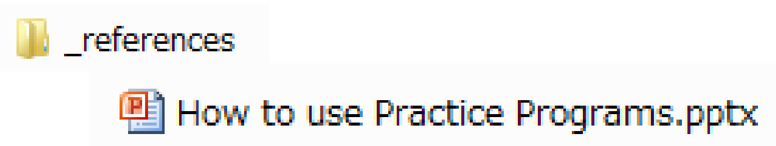


“radar-library.jar”

- Executable binary
- Written in java and Compressed in “jar” (Java ARchive)
- Contains decoding, encoding, data processing, coordinate transforming, and data viewing programs.
- Runnable in command for every purpose
- We use windows batch files today for simplicity.



- More information about this program is in…

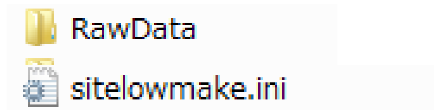


Radar data and parameter file

- Butterworth site RAW data (IRIS format)
- Data period : 1 day (17 Dec, 2014)
- Elevation angles for PPI : 0.0, 0.7, 1.5, 2.5

```
[Butterworth]
elangles=0.0,0.7,1.5,2.5
use_angle=1,1,1,1
code=BW
ename=Butterworth
offx=0
offy=0
n0=54.3
noise_cut=6
rain_cut=3
iso_window=5
iso_count=5
smooth_r=41
smooth_t=3
...
```

sitelowmake.ini



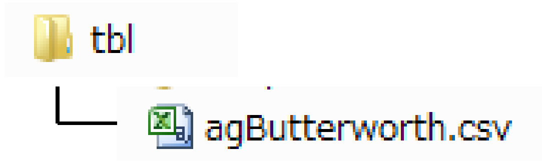
Composite table(CSV file)

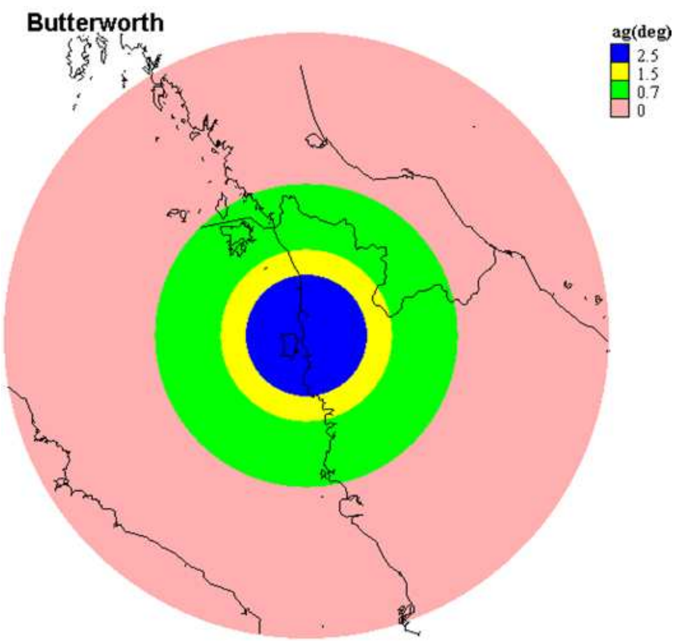
- Composite table shows angles used in each area.

agButterworth.csv(simple CAPPI)

```
360, 0, 2.5, 60, 1.5, 85, 0.7, 150, 0, 300
```

Azimuth(deg), Distance(km), Angle (deg)





- simple CSV(Comma-Separated Values)
- this file means…

  for 0-360 azimuth (for all around),

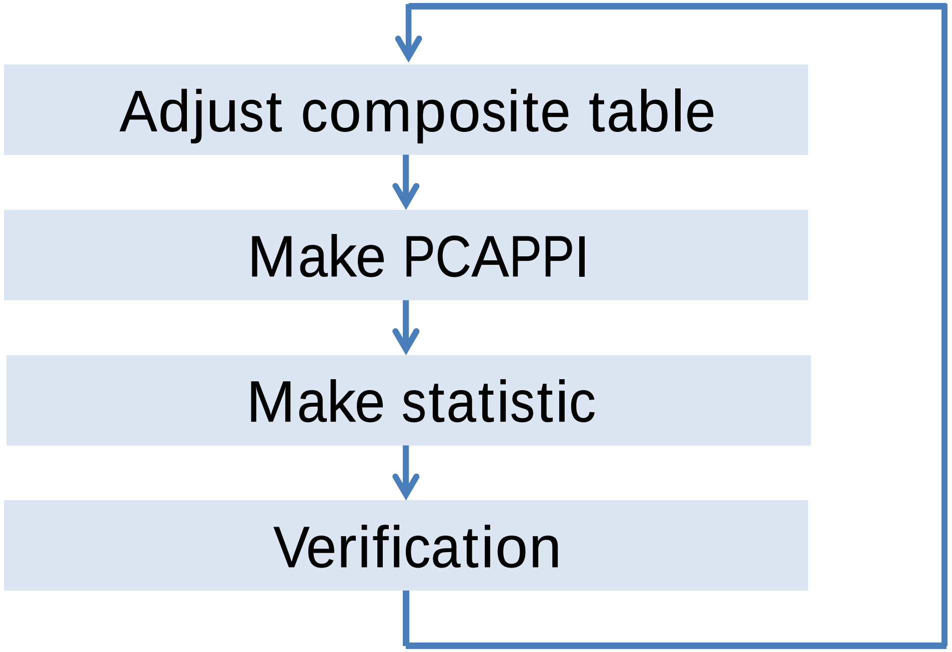
  use 2.5 angle PPI data for 0-60 km,

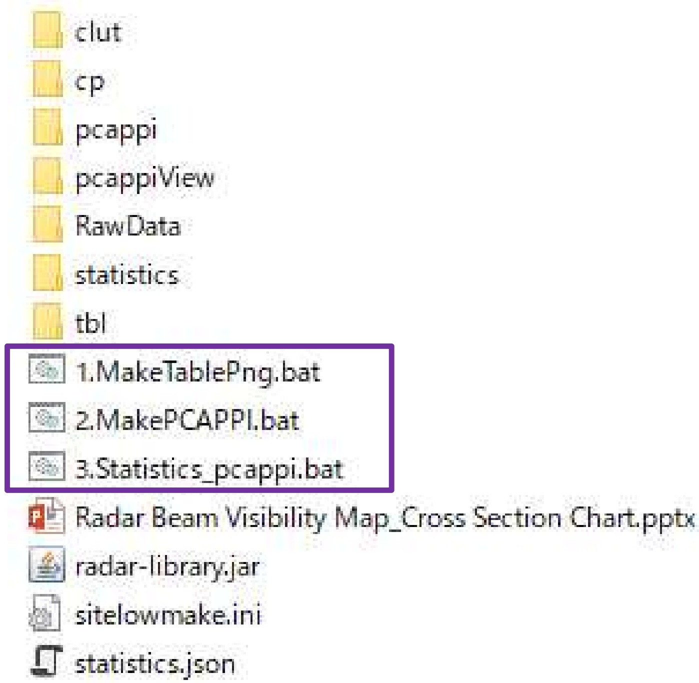
  use 1.5 angle PPI data for 60-85 km,

  use 0.7 angle PPI data for 85-150km,

  use 0.0 angle PPI data for 150-300km

Preparation: Operation check





- At first, We do operation check of these batch files.
- Please call JMA staff if you're in trouble.

1.MakeTablepng.bat

```
java -cp radar-library.jar PCAPPITableToPNG ./tbl/agButterworth.csv
```

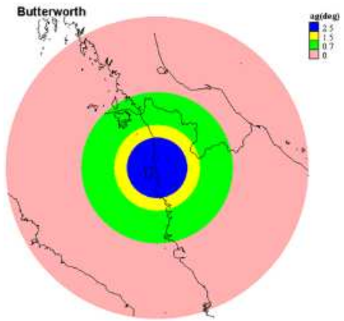
MakeTablepng.bat

classname

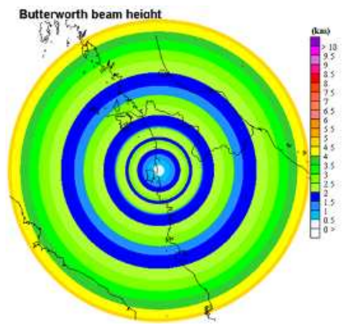
tbl
- agButterworth.csv
- agButterworth.csv.png
- agButterworth.csvBH.png

agButterworth.csv

↓ PCAPPITableToPNG

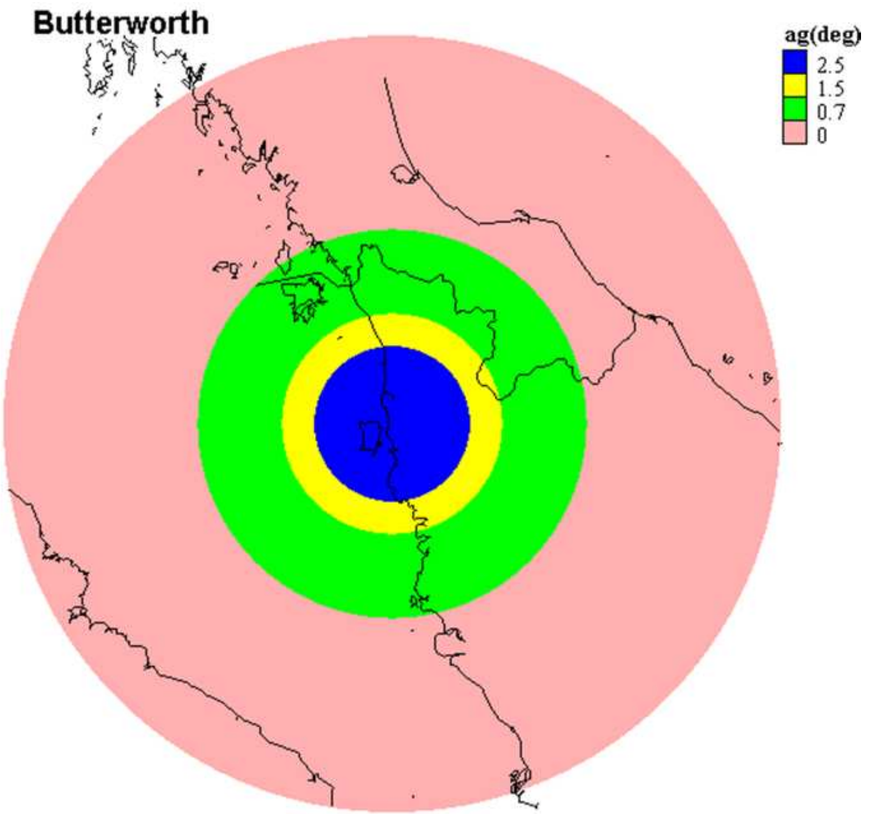


agButterworth.csv.png

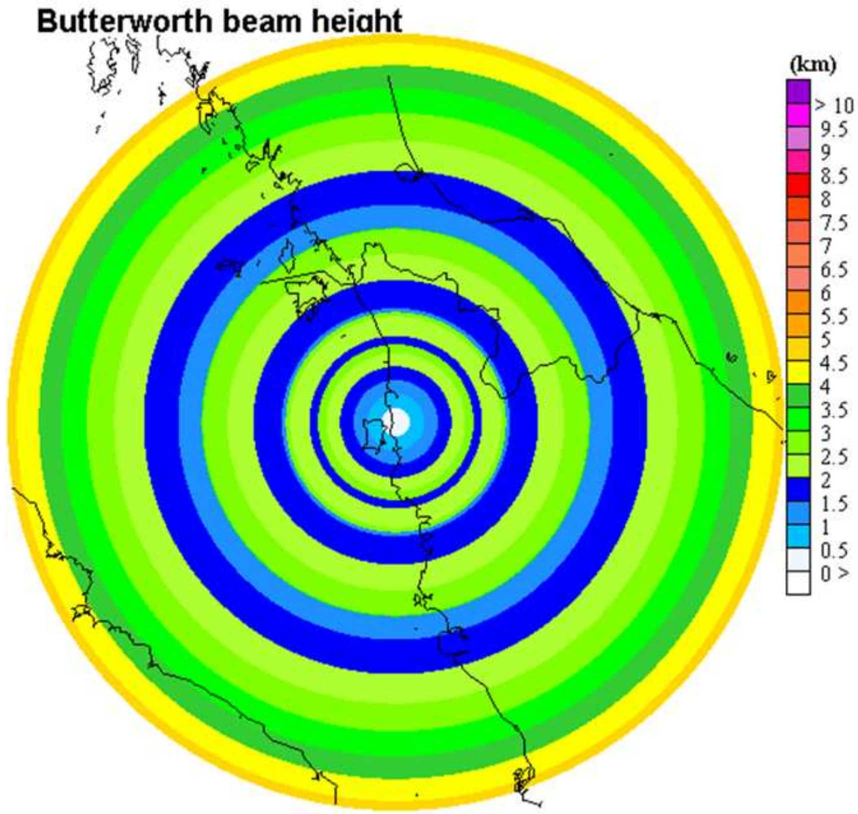


agButterworth.csvBH.png

Composite table: Simple CAPPI(2km)



Angle

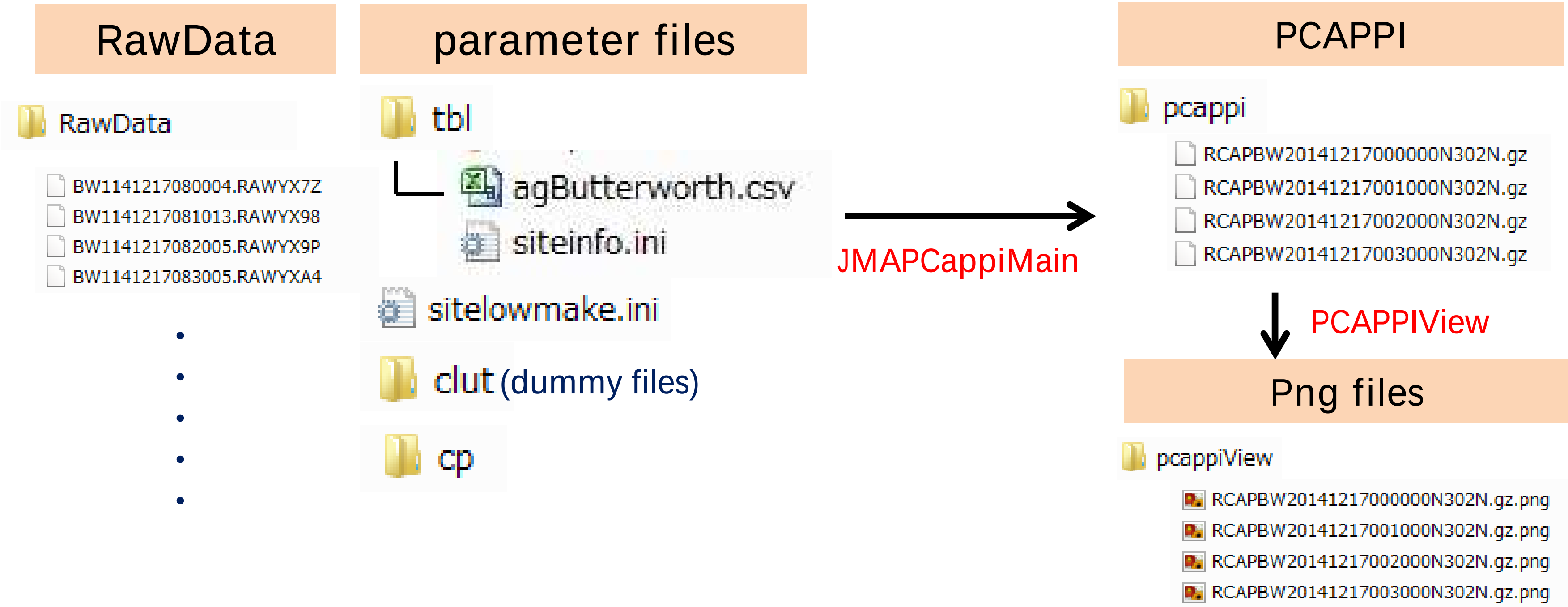


Beam Height

2.MakePCAPPI.bat

```
for %%i in (./RawData/BW*) do (
  java -cp radar-library.jar JMAPCappiMain -envfile=./sitelowmake.ini -tbldir=./tbl
-destdir=./pcappi/. -clutdir=./clut ./RawData/%%i -gz
)
for %%i in (./pcappi/*) do (
  java -cp radar-library.jar PCAPPIView ./pcappi/%%i -dest=./pcappiView/.
-colorPallet=./cp/dbz_color.txt
)
```

MakePCAPPI.bat



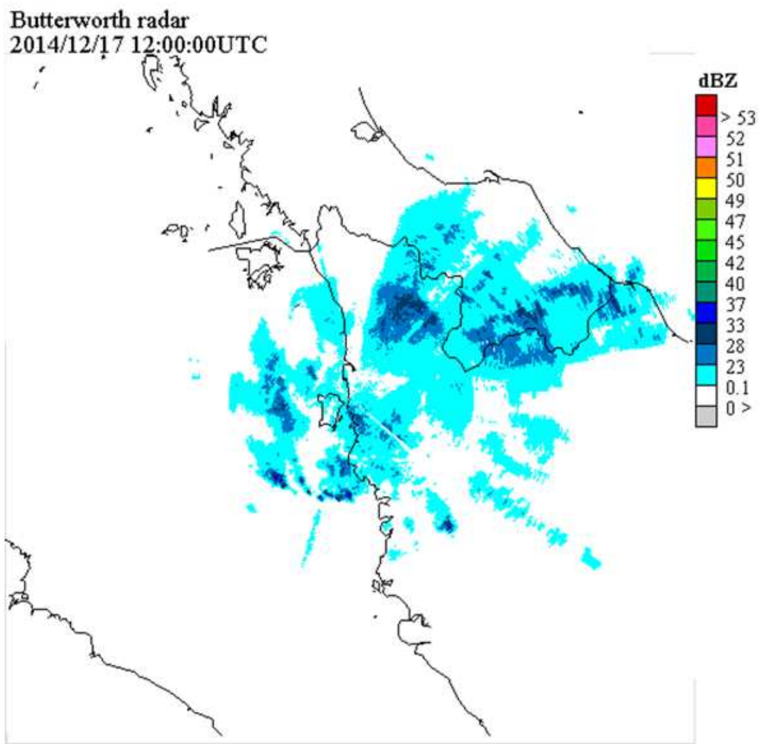
PCAPPI data

pcappi

Filename

- RCAPBW20141217000000N302N.gz
- RCAPBW20141217001000N302N.gz
- RCAPBW20141217002000N302N.gz
- RCAPBW20141217003000N302N.gz
- RCAPBW20141217004000N302N.gz
- RCAPBW20141217005000N302N.gz
- RCAPBW20141217010000N302N.gz
- RCAPBW20141217011000N302N.gz
- RCAPBW20141217012000N302N.gz

pcappiView



- Details of the format is in …

_references

JMAPCAPPIFormat.pptx

3.Statistics_pcappi.bat

```
java -cp radar-library.jar StatisticsMain -ini=statistics.json -name=pcappi -start=201412170000
-end=201412180000
java -cp radar-library.jar StatisticsView ./statistics/pcappi
```

Statistics_pcappi.bat

PCAPPI

pcappi

- RCAPBW20141217000000N302N.gz
- RCAPBW20141217001000N302N.gz
- RCAPBW20141217002000N302N.gz
- RCAPBW20141217003000N302N.gz

→ StatisticsMain

Statistics(csv)

statistics

- Butterworth_pcappi_201412170000_201412172350_Butterworth_APPEARANCE.csv
- Butterworth_pcappi_201412170000_201412172350_Butterworth_APPEARANCE_header.csv
- Butterworth_pcappi_201412170000_201412172350_Butterworth_AVERAGE.csv
- Butterworth_pcappi_201412170000_201412172350_Butterworth_AVERAGE_header.csv

⋮

↓ StatisticsView

parameter file

statistics.json

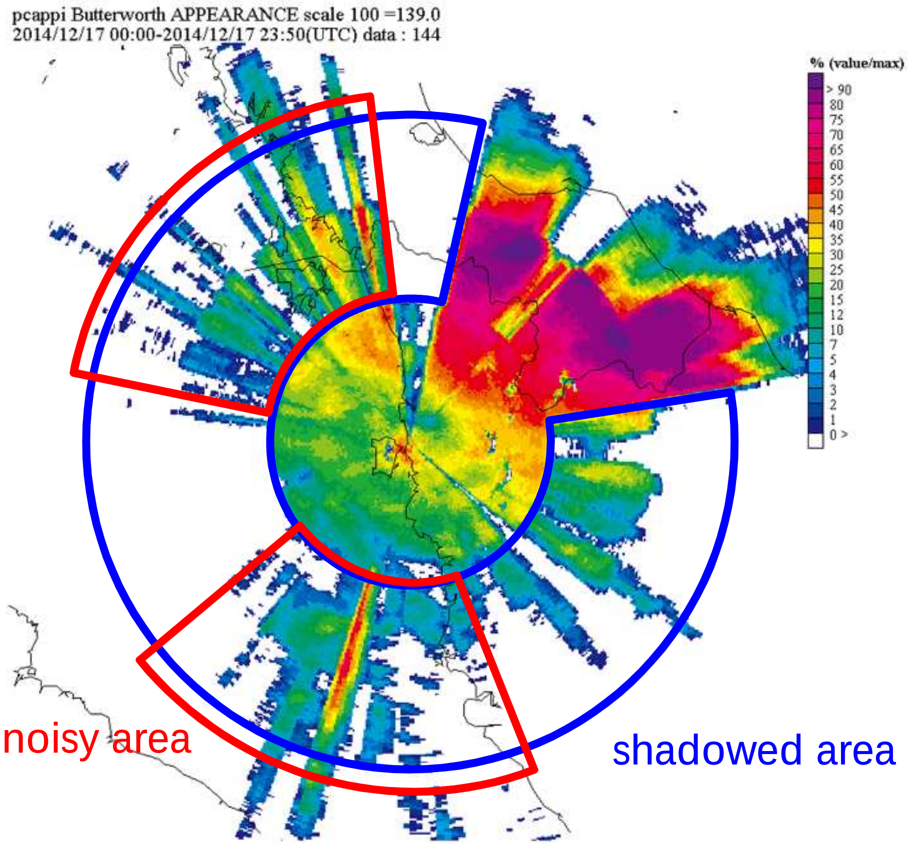
"filename":"./pcappi/RCAP.*'yyyyMMddHHmmss'N302N.gz",
"sek": "10",
"calculation": "DBZtoRAIN",
"outdir":"./statistics/pcappi/."}

Png files

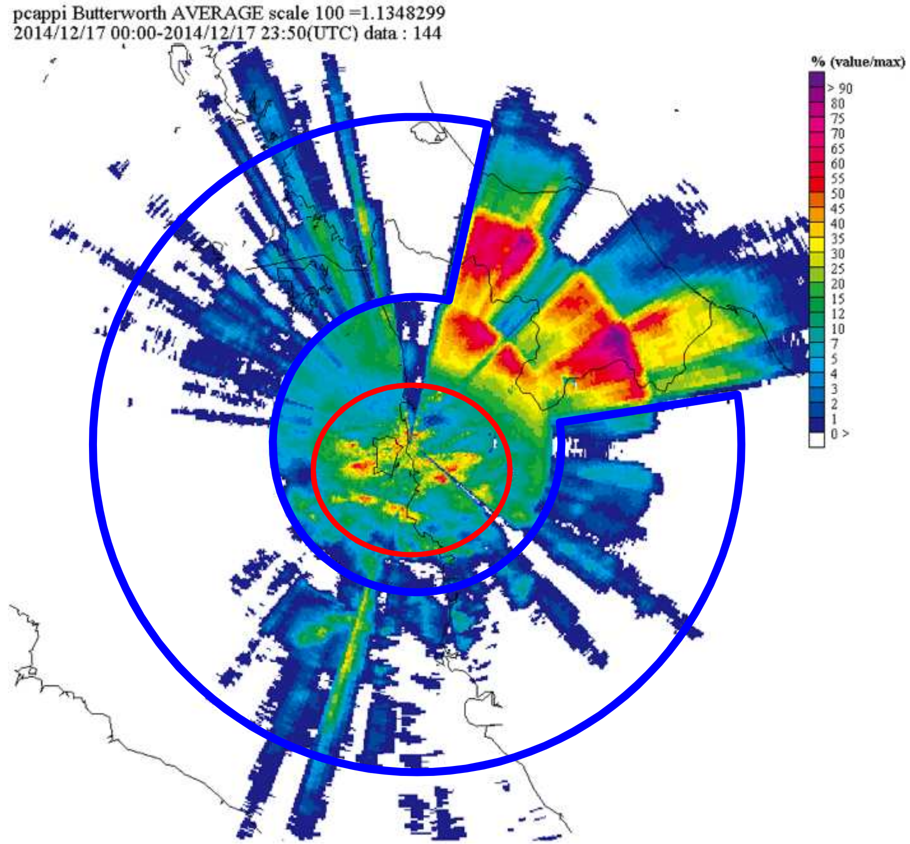
statistics

- Butterworth_pcappi_201412170000_201412172350_Butterworth_APPEARANCE_header.png
- Butterworth_pcappi_201412170000_201412172350_Butterworth_AVERAGE_header.png

Statistics: Simple CAPPI(2km)

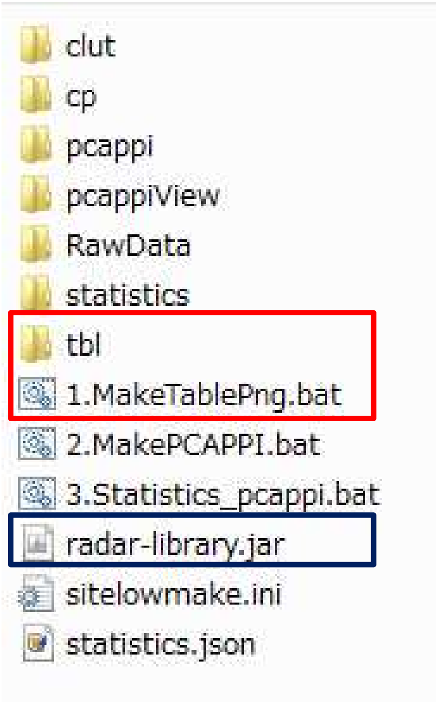


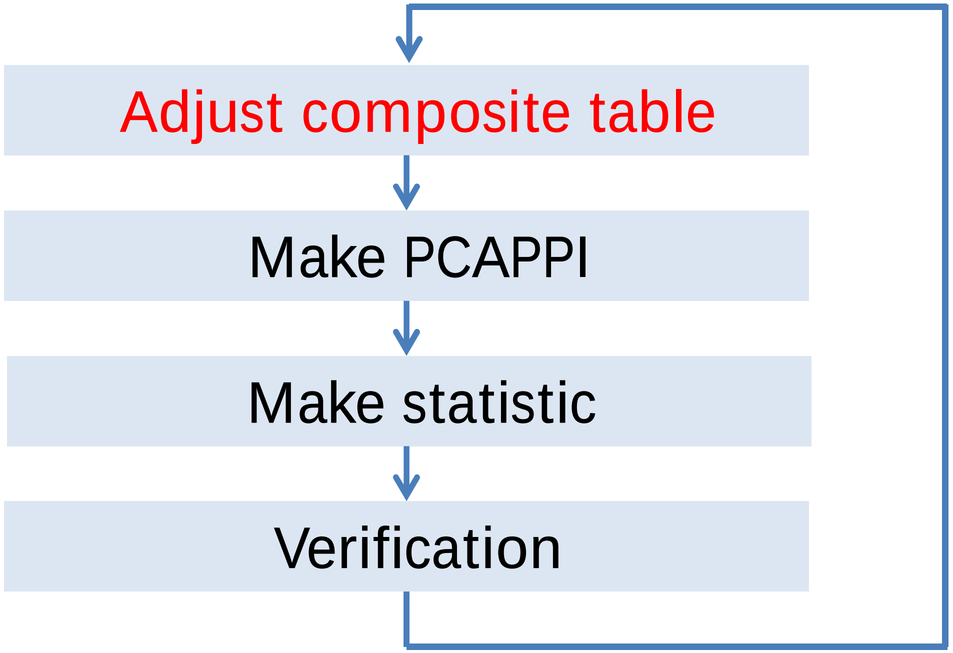
Appearance



Average

Flow of the practice





- Let`s adjust composite table to avoid obstacle.
- Radar Beam Visibility map and Cross Section Chart are useful.

Radar Beam Visibility Map and Cross Section Chart

- In this case(azimuth= 0.0 deg, 0.0deg means due north),

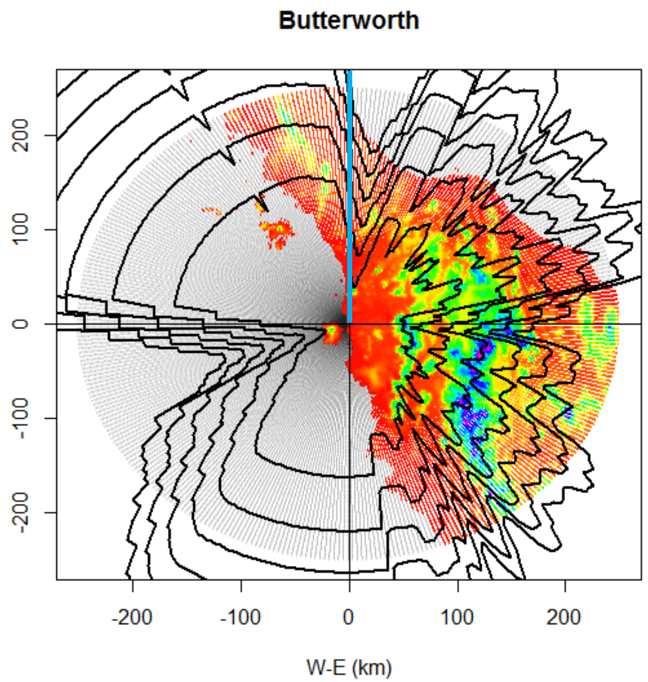
  we should not use 0.0 degree angle data because the beam is blocked.

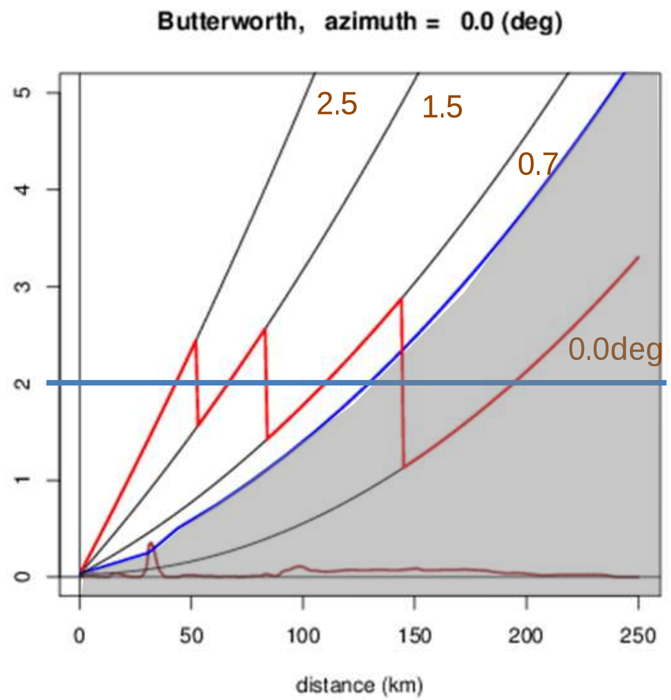
Map

Color:
- altitude
  - warm is low
  - cold is high

Gray:
- sea

Black:
- ranges of radar beam visibility at heights of 1 km, 2km … from inside





Cross section

Black:
- radar beams for each elevation angles

Red:
- beams for cappi(2km), land surface ignored

Blue:
- limitation of radar beam visibility

Brown:
- land surface

How to avoid obstacles

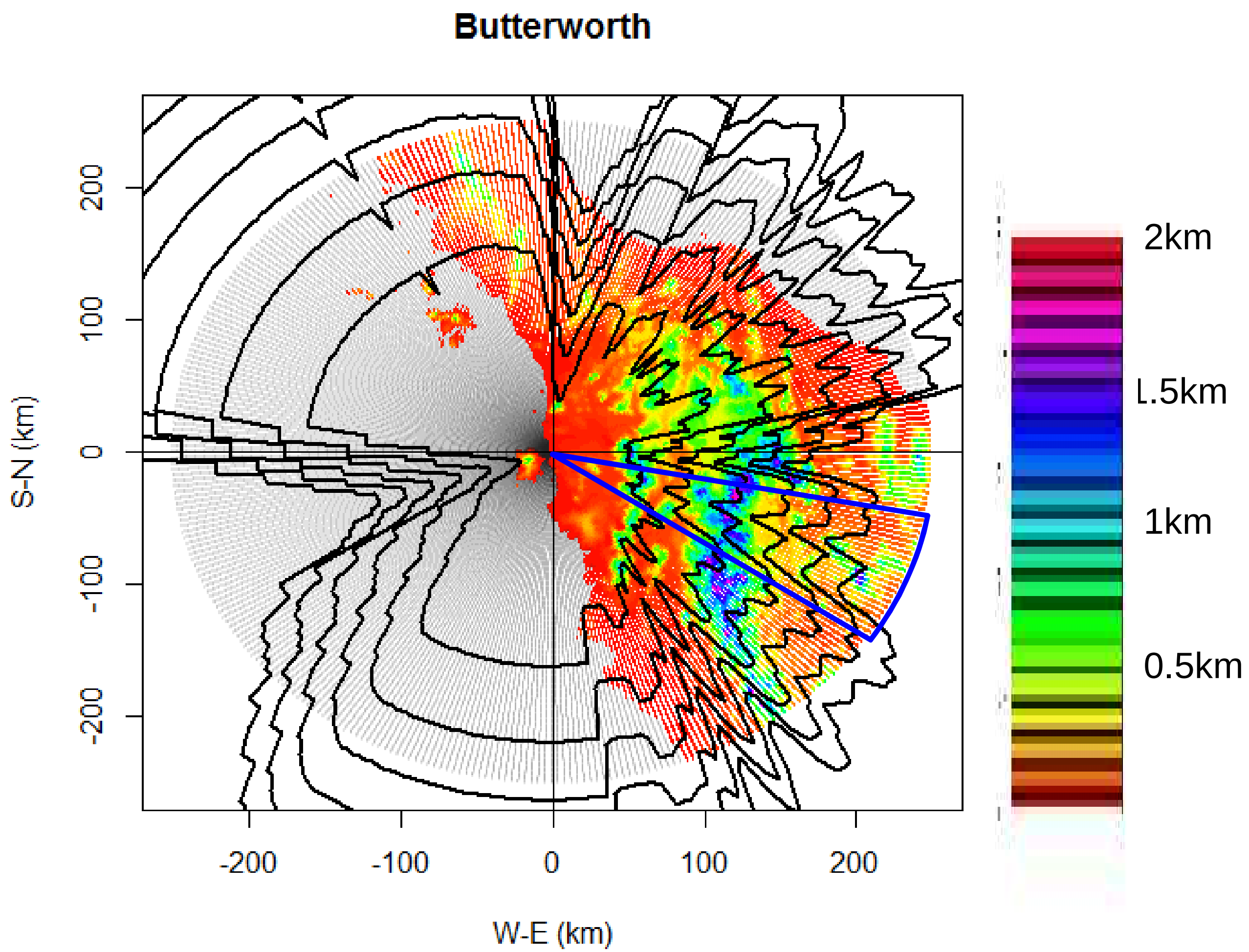
- Check the beam blockage with cross section chart
  - Beams below the limitation line(blue line) are blocked by land surface.
  - We should not use the angle which beam is blocked.

- Edit composite table (agButterworth.csv)
  - Adopt the higher angle instead of the angle which beam is blocked.

- Edited composite table will give us more better PCAPPI data.

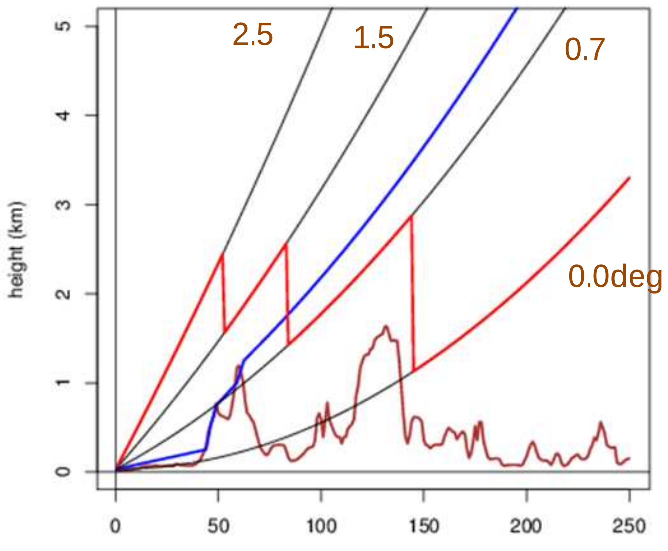
- Let's try with me.

Check the beam blockage

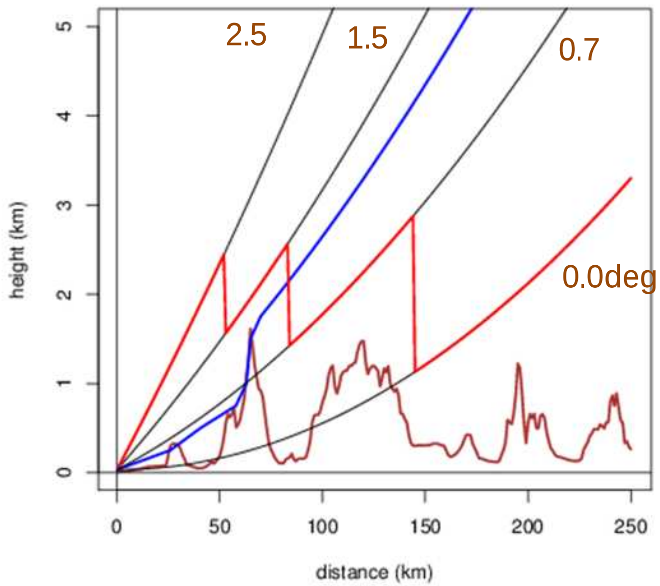


- We focus on south eastern part.

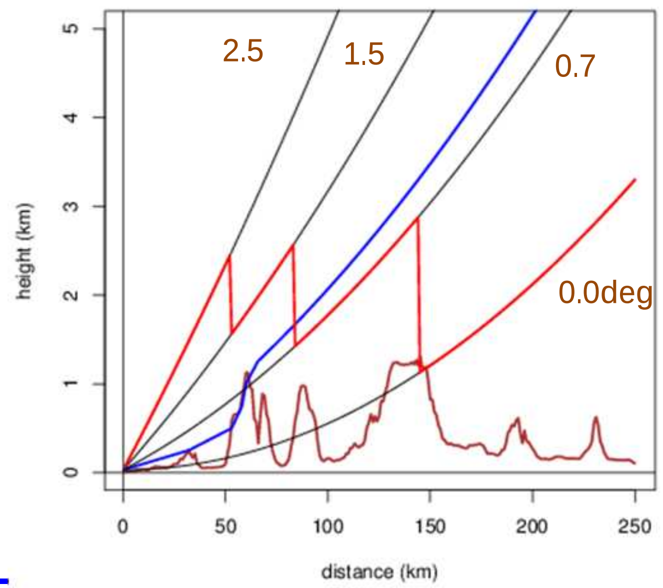
azimuth = 100 deg



azimuth = 110 deg



azimuth = 120 deg



- In 100 – 120 degree azimuth, We should not use ? angle PPI data.

Exercise 1

tbl
Exercise_1
agButterworth.csv

100	0	2.5	60	1.5	85	0.7	150	0	300
120									
360	0	2.5	60	1.5	85	0.7	150	0	300

Azimuth(deg), Distance(km), Angle (deg)

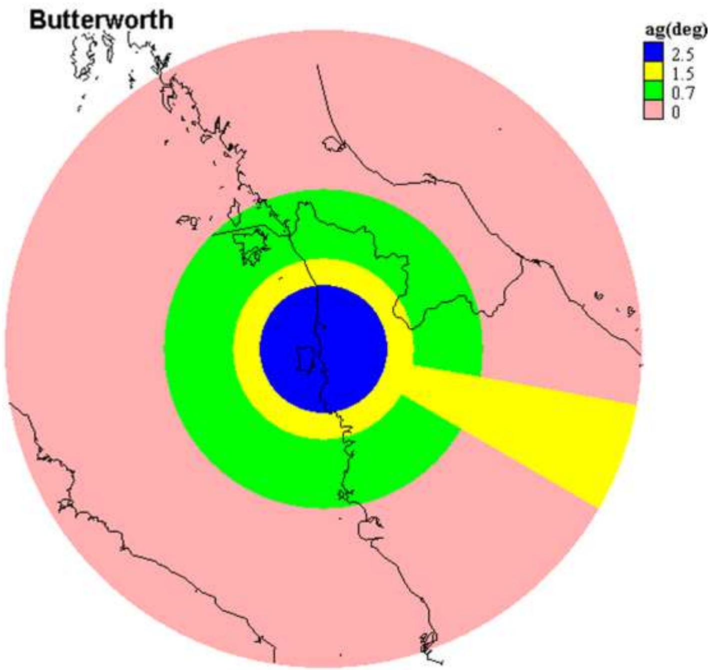
- Fill in the blanks and complete composite table.
- If you finished, then copy this file to upper folder, and overwrite the old table.

Edited composite table

agButterworth.csv(modified)

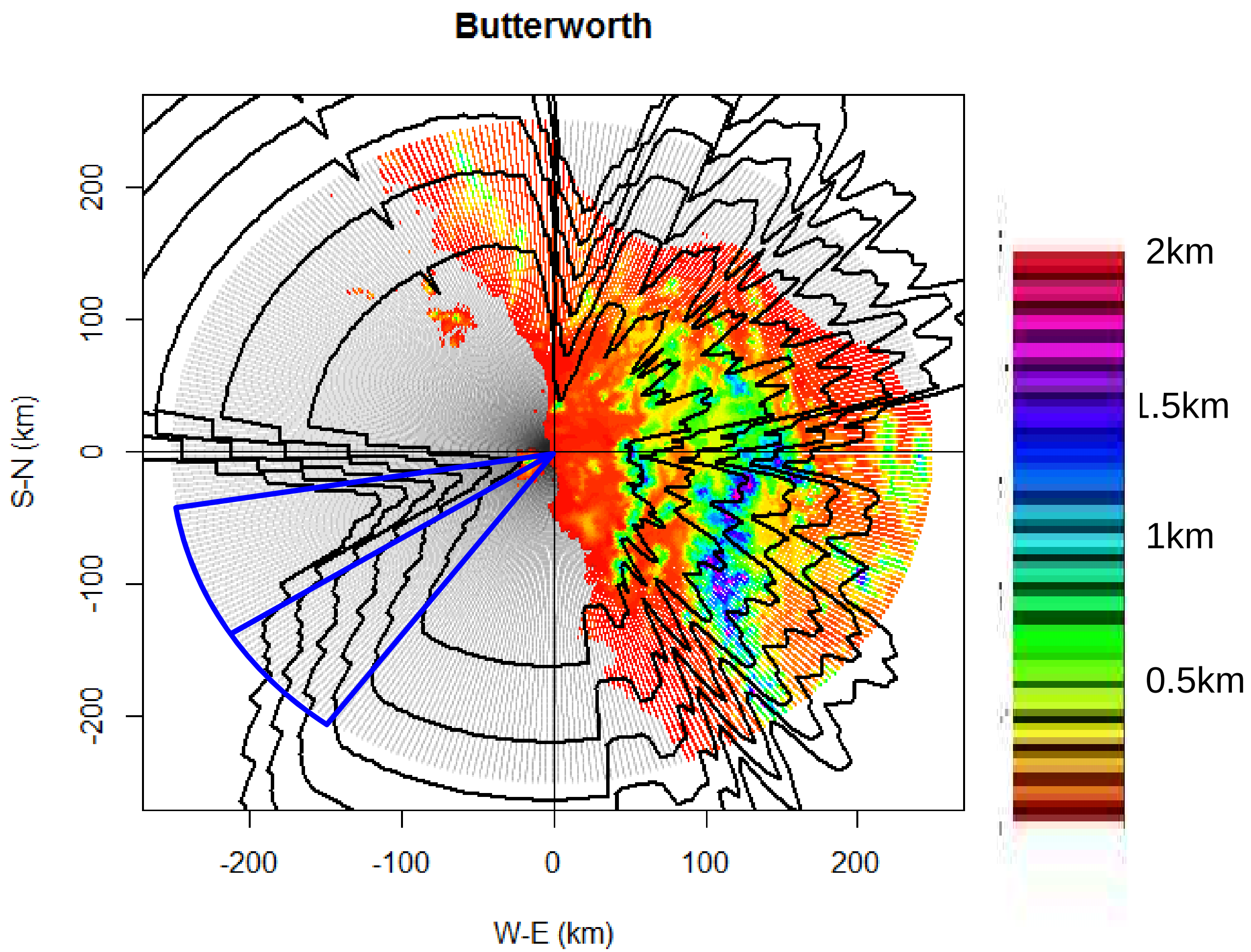
```
100, 0, 2.5, 60, 1.5, 85, 0.7, 150, 0, 300
120, 0, 2.5, 60, 1.5, 300
360, 0, 2.5, 60, 1.5, 85, 0.7, 150, 0, 300
```

Azimuth(deg), Distance(km), Angle (deg)



- Edit agButterworth.csv and execute MakeTablepng.bat, then you can check your table by png file .
- In this case, I added lines to stop using 0.7 and 0.0 angle data for 100-120 azimuth.

Check the beam blockage



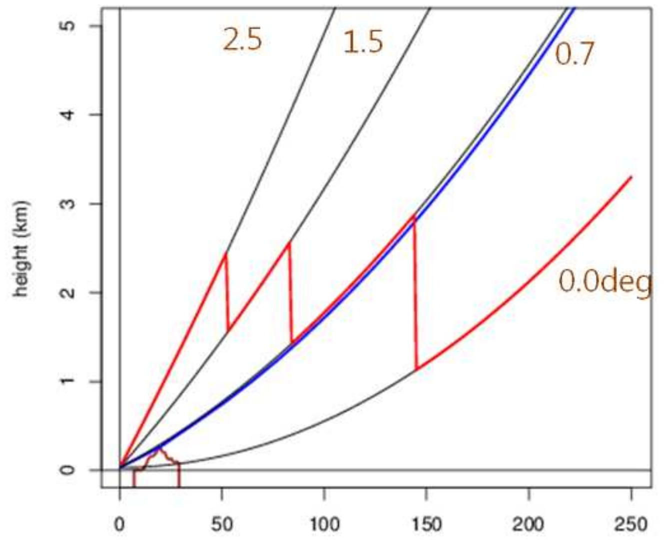
- Next, We focus on south western part.

Exercise 2

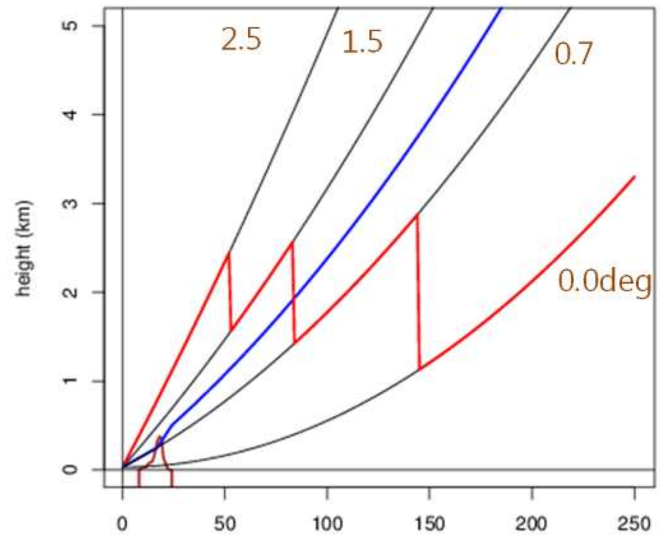
- tbl
  - Exercise_2
    - agButterworth.csv

20	0	2.5	60	1.5	300				
80	0	2.5	60	1.5	85	0.7	300		
100	0	2.5	300						
120	0	2.5	60	1.5	300				
170	0	2.5	60	1.5	85	0.7	300		
210	0	2.5	60	1.5	85	0.7	150	0	300
220	0	2.5	60	1.5	85	0.7	300		
240									
260									
270	0	2.5	60	1.5	85	0.7	300		
350	0	2.5	60	1.5	85	0.7	150	0	300
360	0	2.5	60	1.5	85	0.7	300		

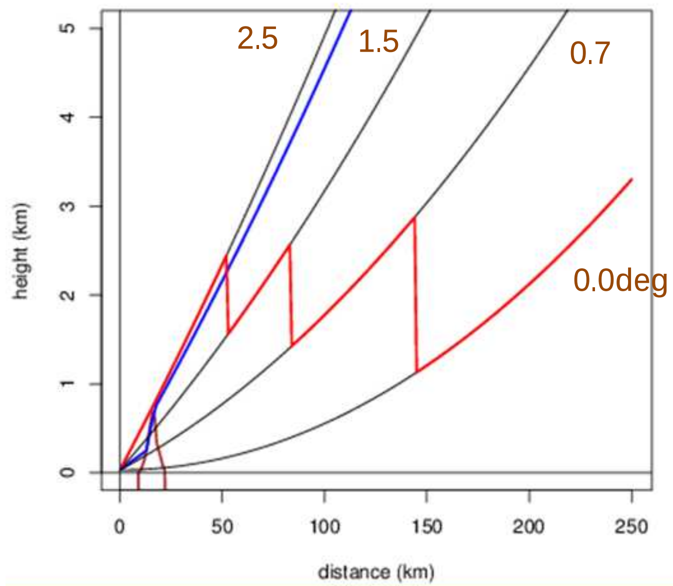
azimuth = 230 deg



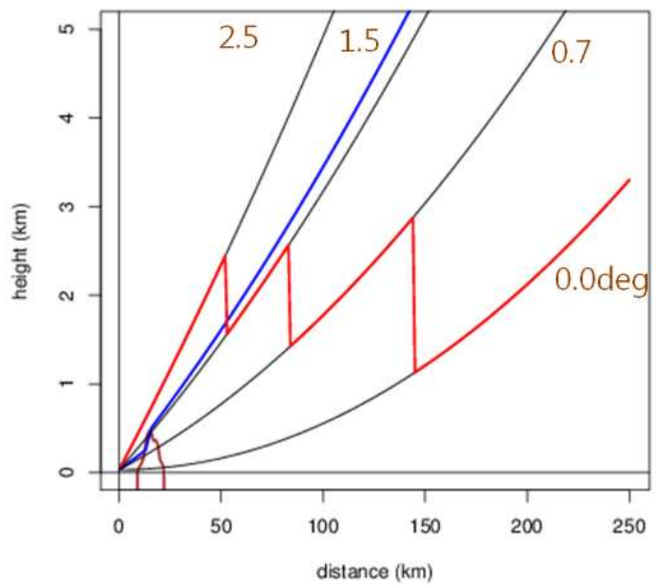
azimuth = 240 deg



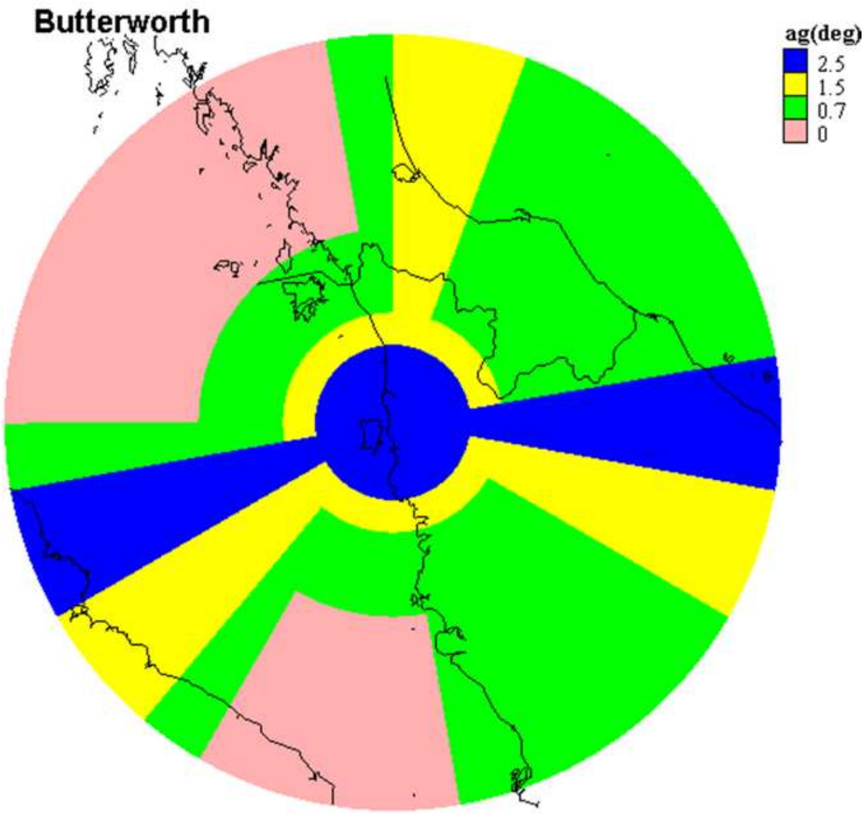
azimuth = 250 deg



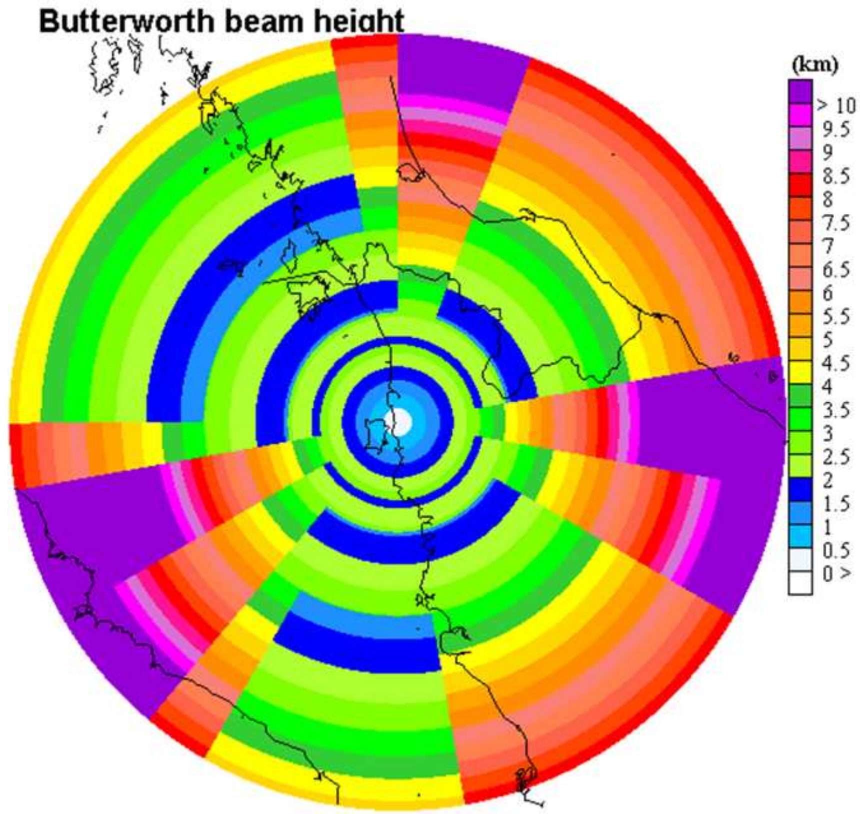
azimuth = 260 deg



Composite table(considered obstacle)

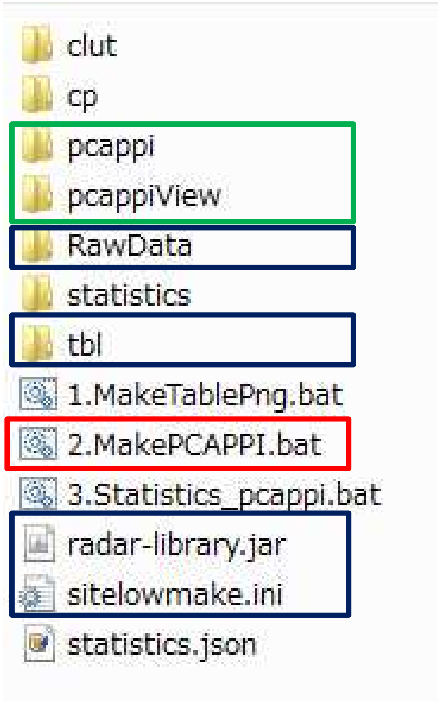


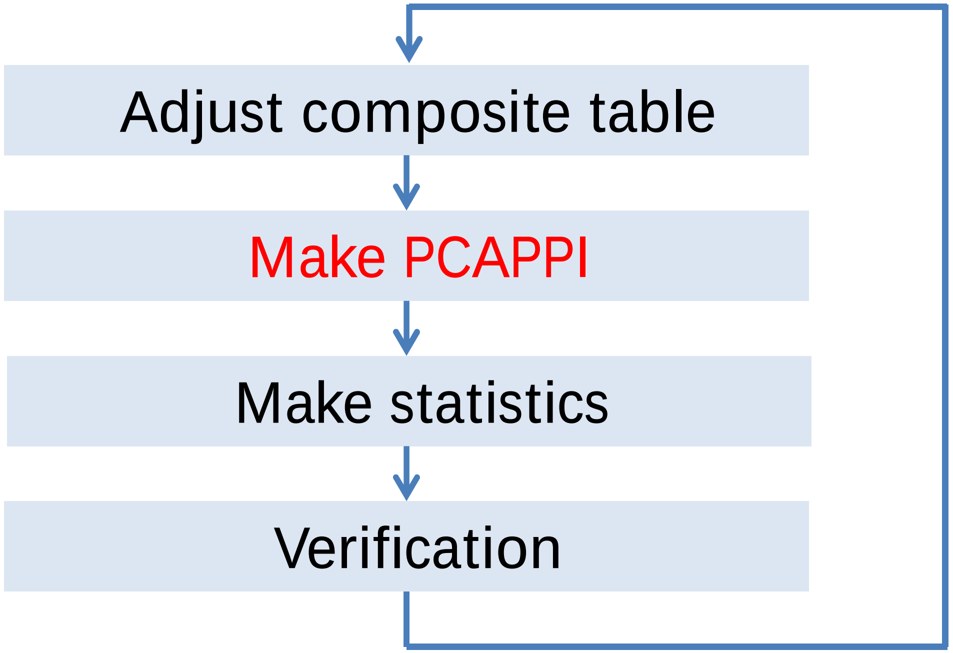
Angle



Beam Height

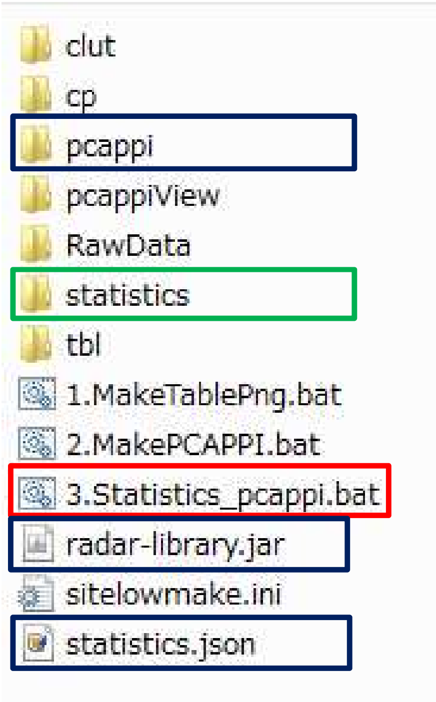
Flow of the practice

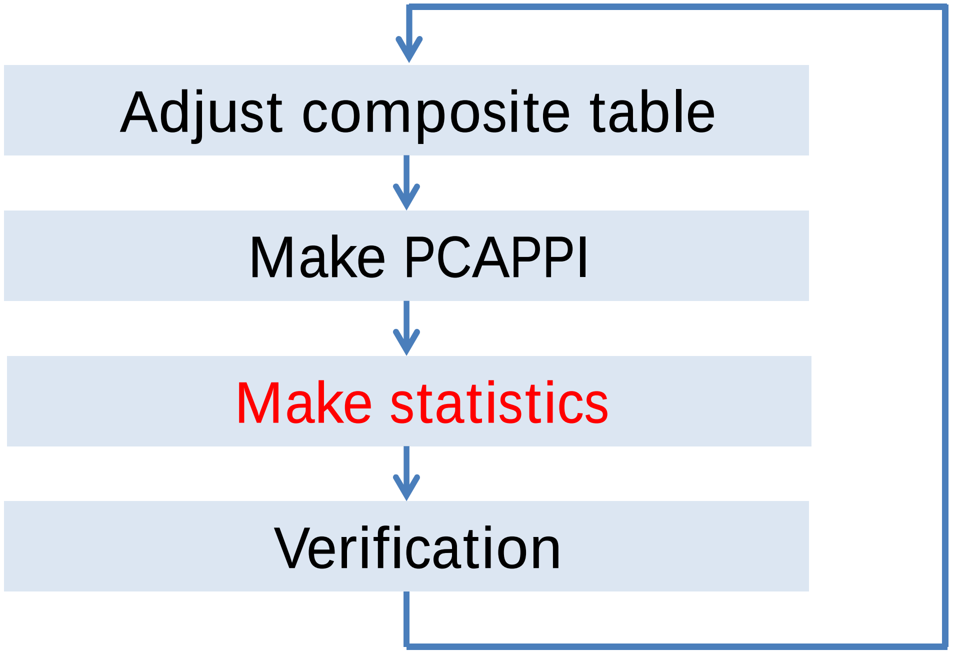




- Let's make PCAPPI by new composite table.

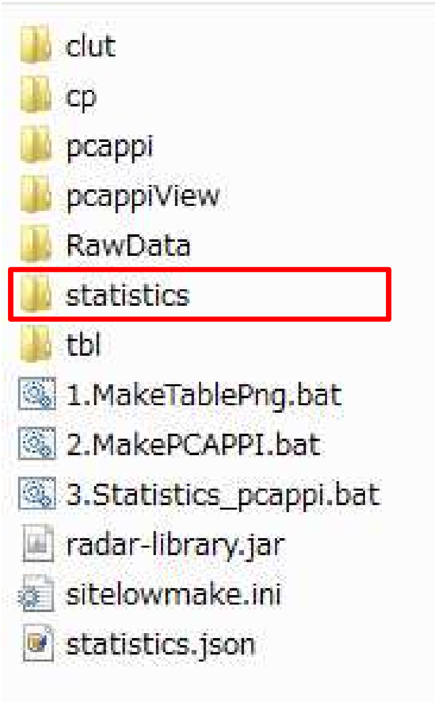
Flow of the practice

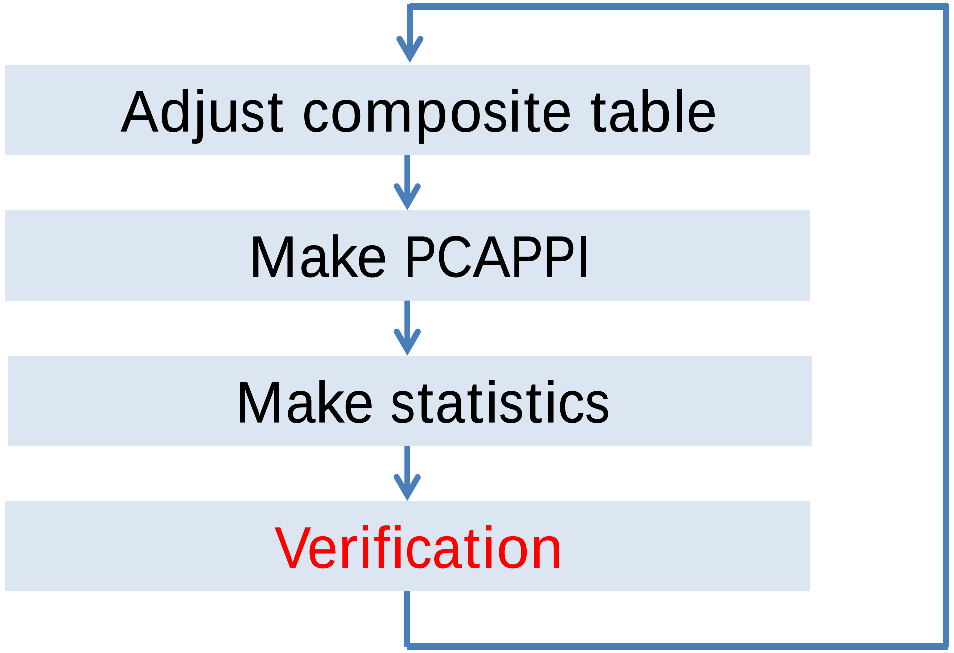




- Next, To make statistical data, Execute Statistics_pcappi again.

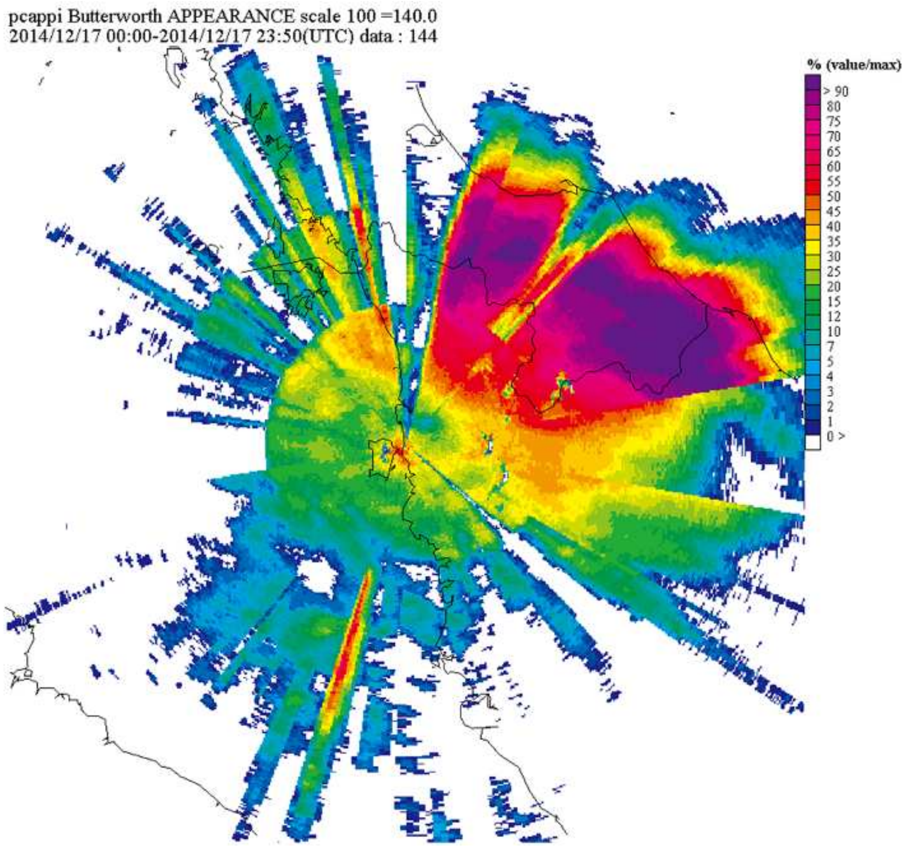
Flow of the practice



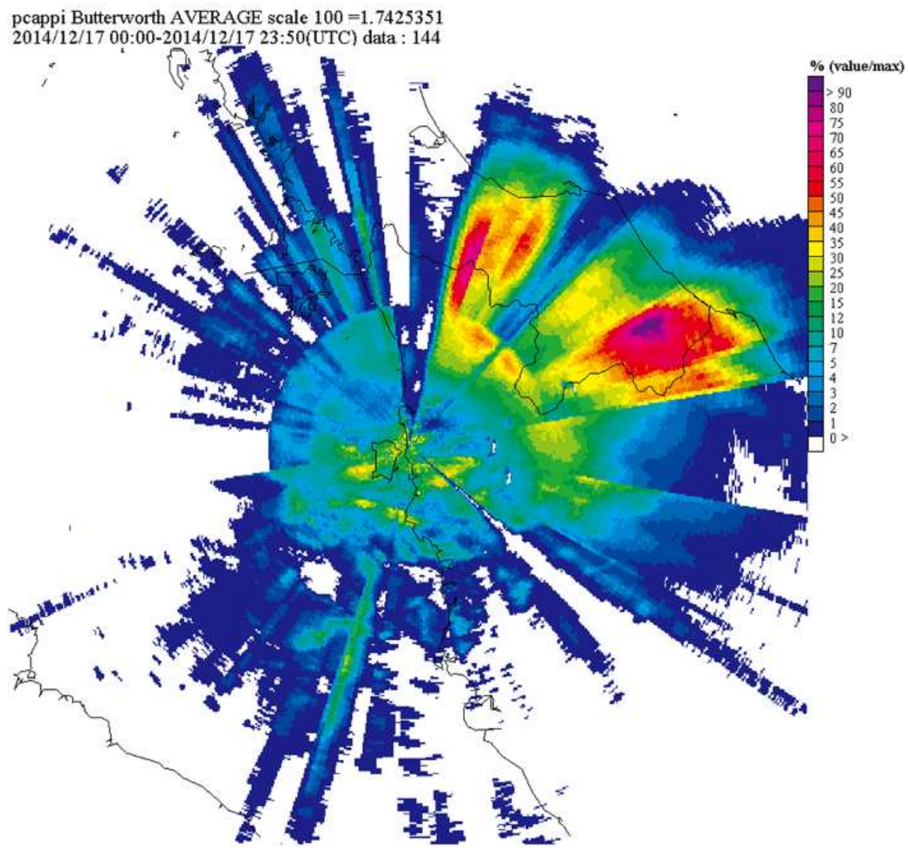


- Verify the result of statistics from remade PCAPPI.
- It is important to verify the adjusted data.
- Because , there might be a case in which the adjusted affect might have low quality data.

Statistics: PCAPPI (considered obstacle)

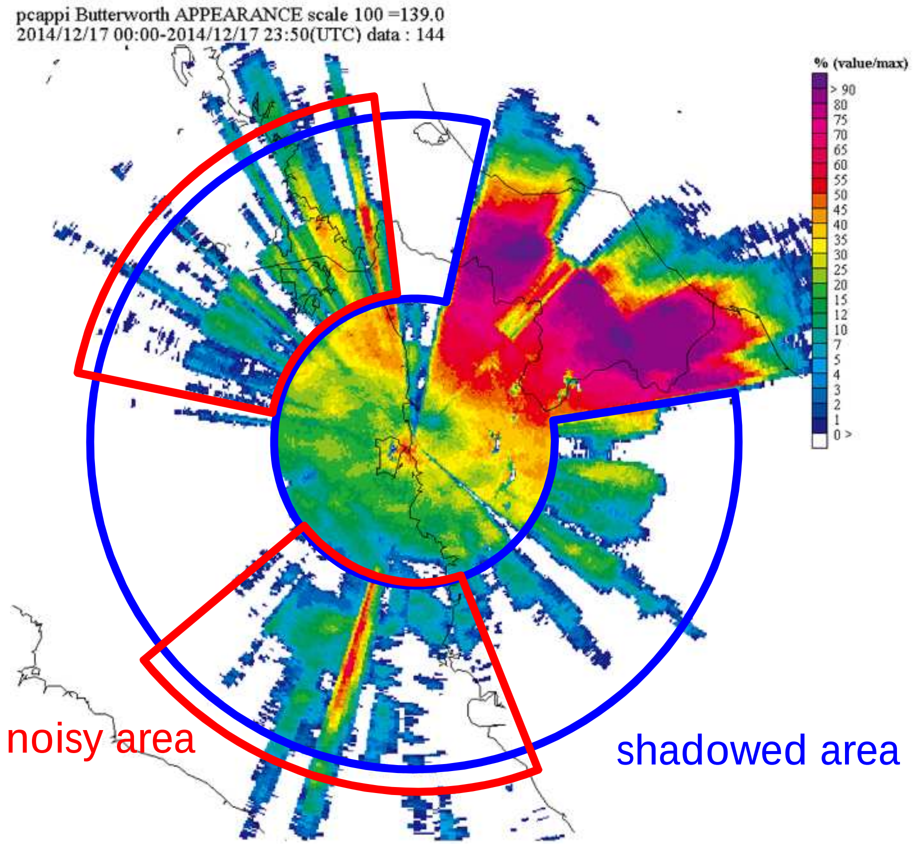


Appearance

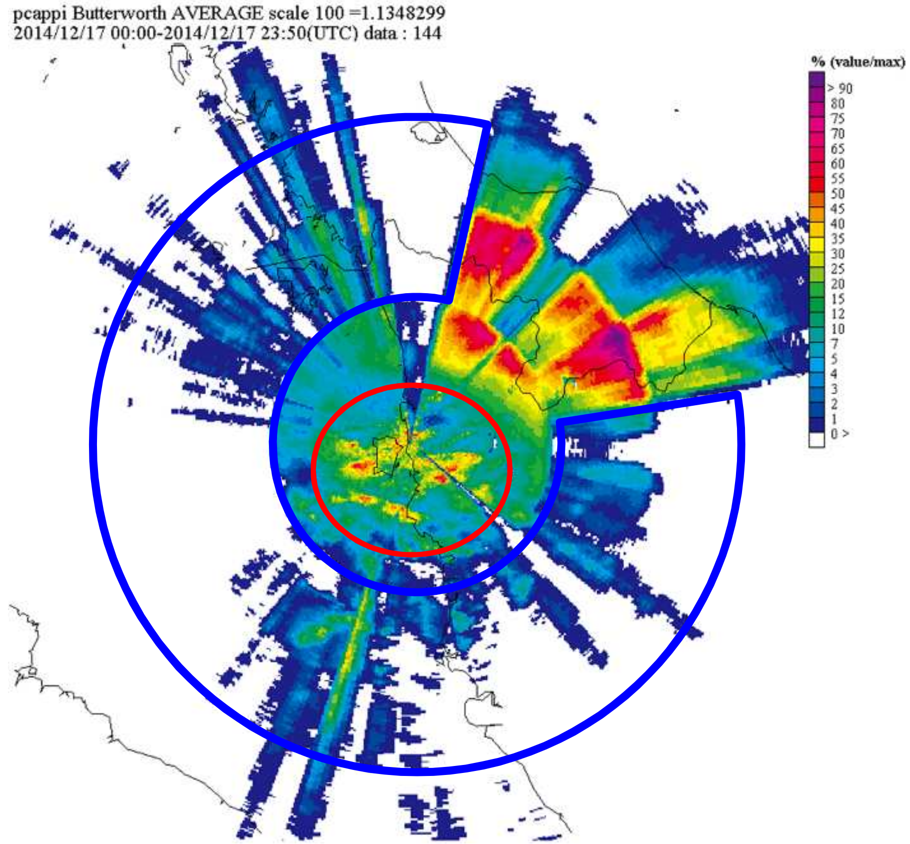


Average

Statistics: Simple CAPPI (2km)

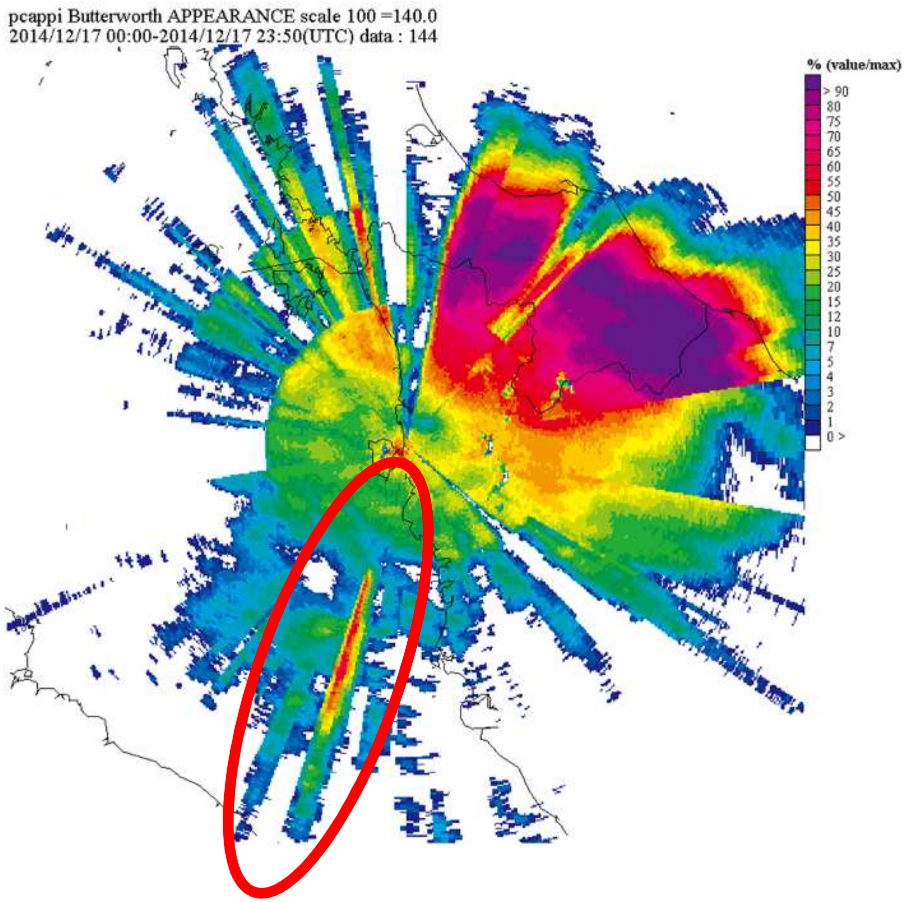


Appearance

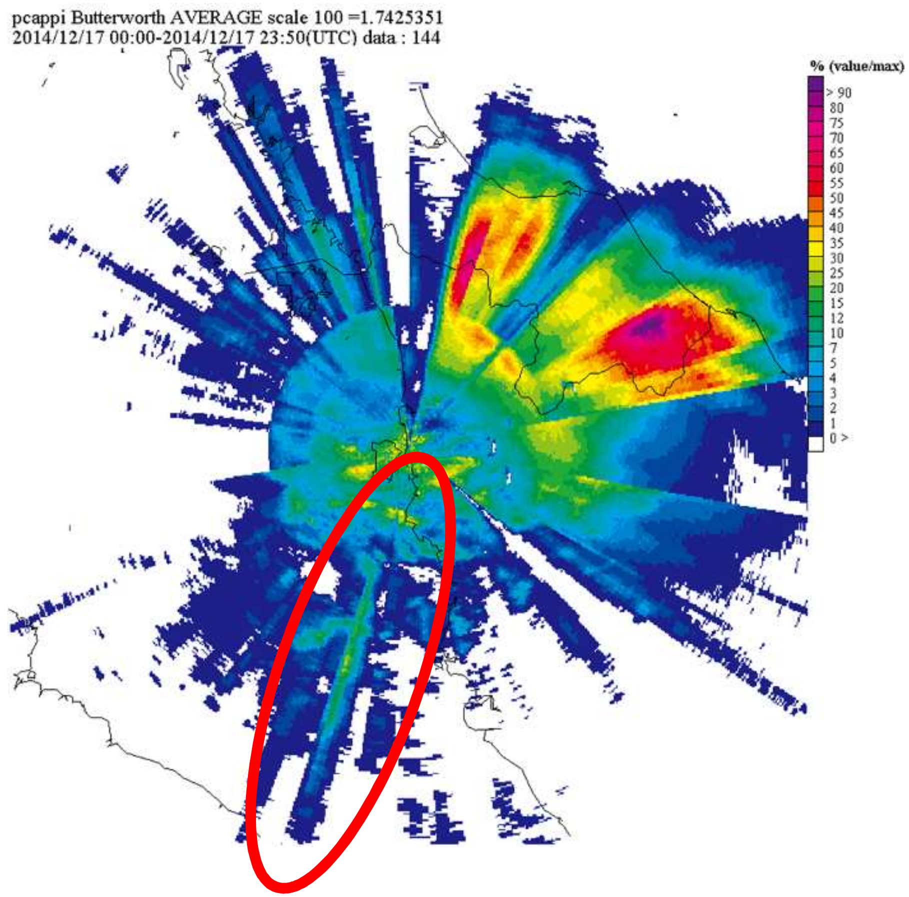


Average

Statistics: PCAPPI (considered obstacle)

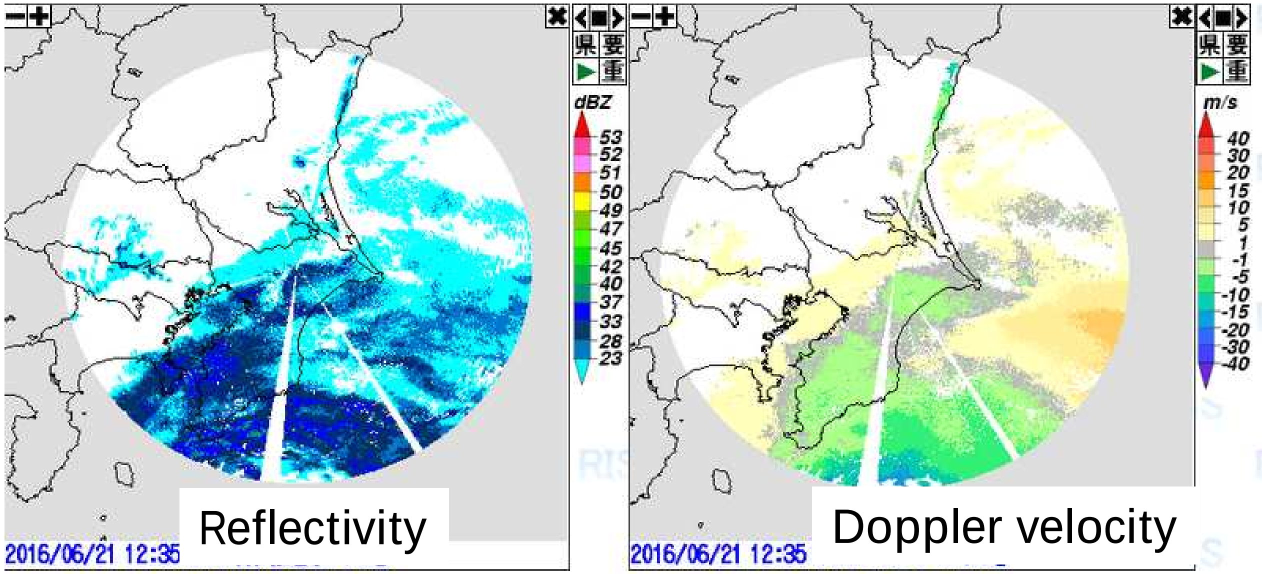


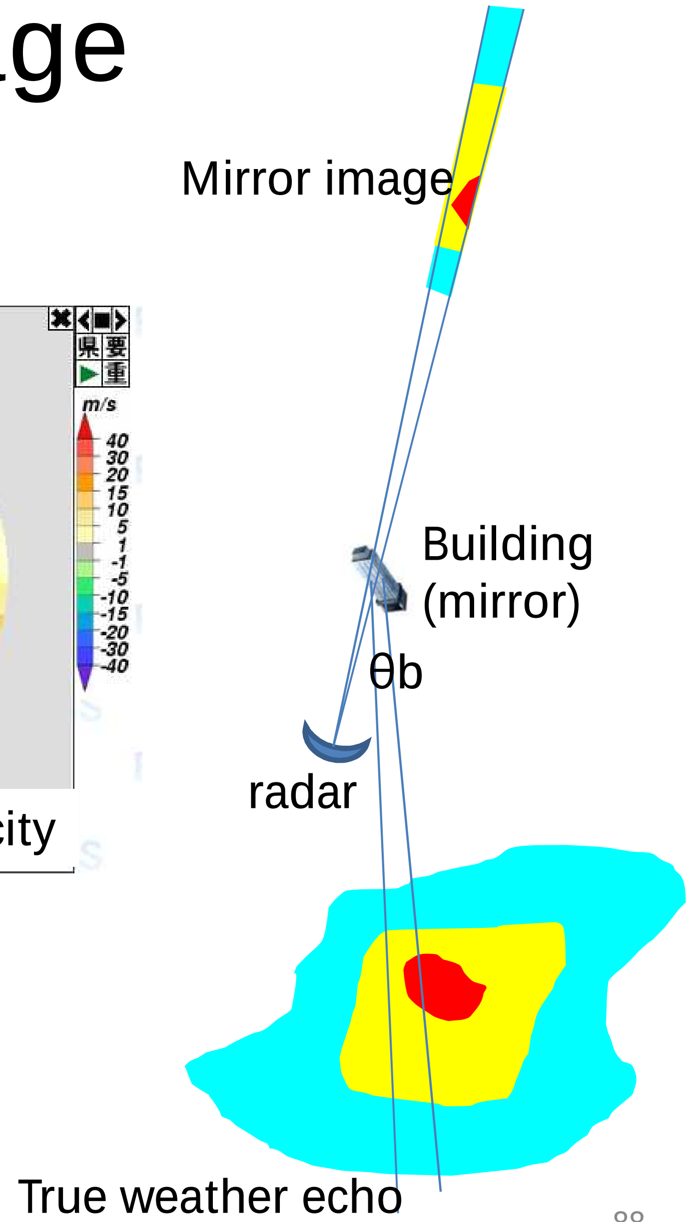
Appearance



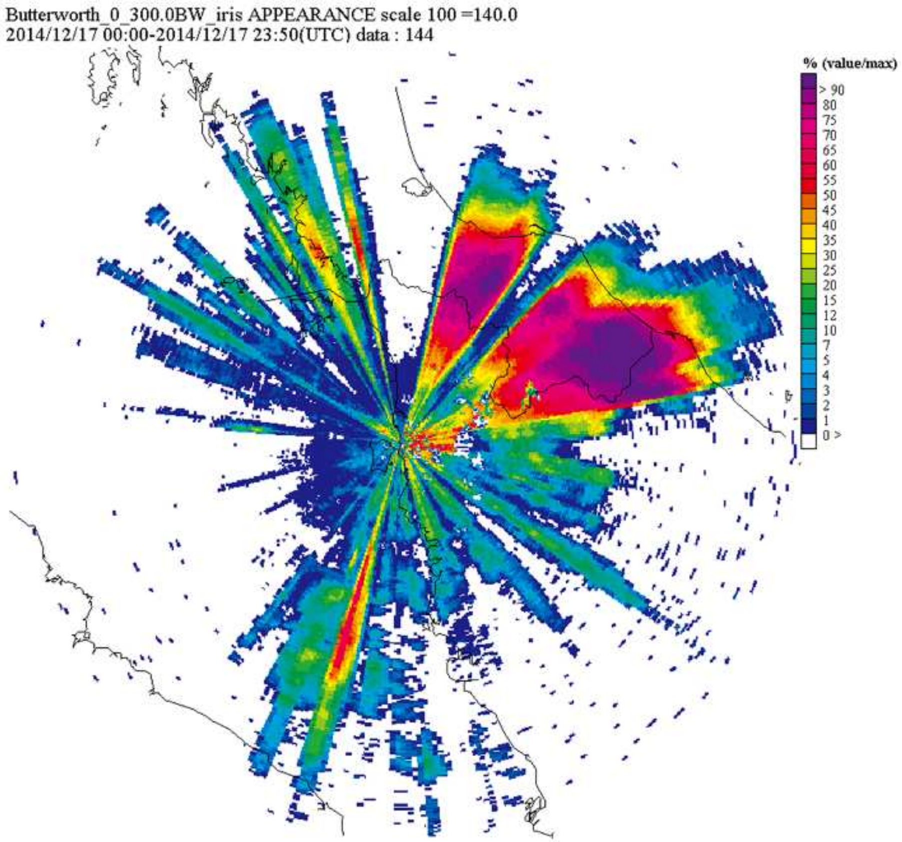
Average

Mirror image

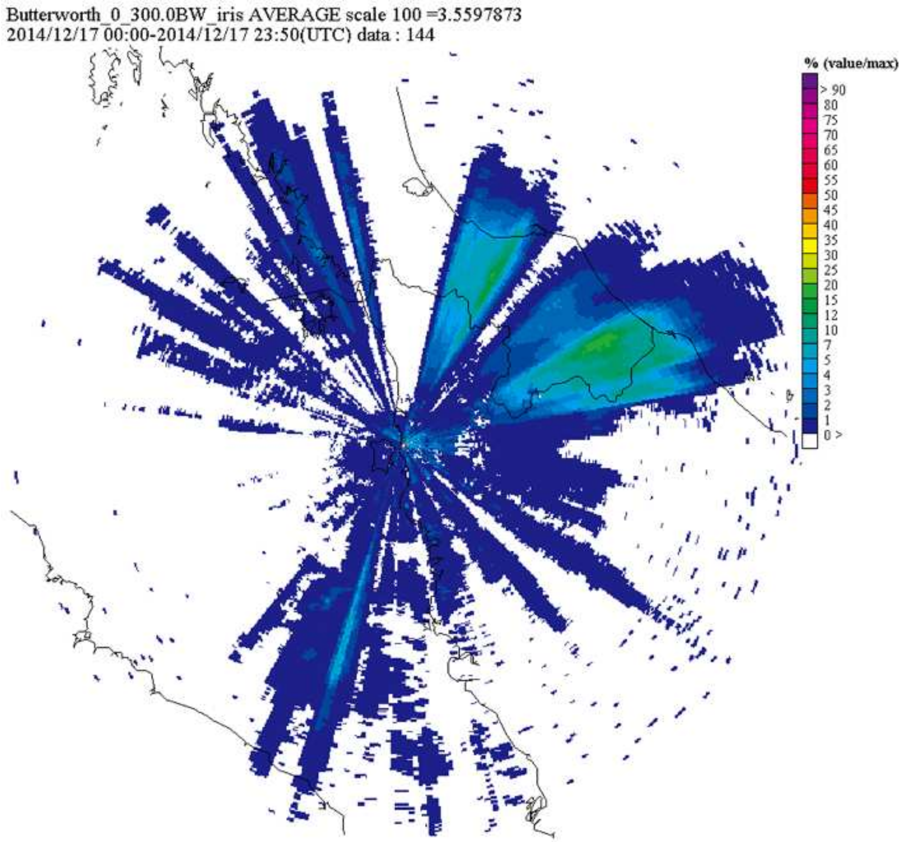




Raw Data Statistics(0.0deg)

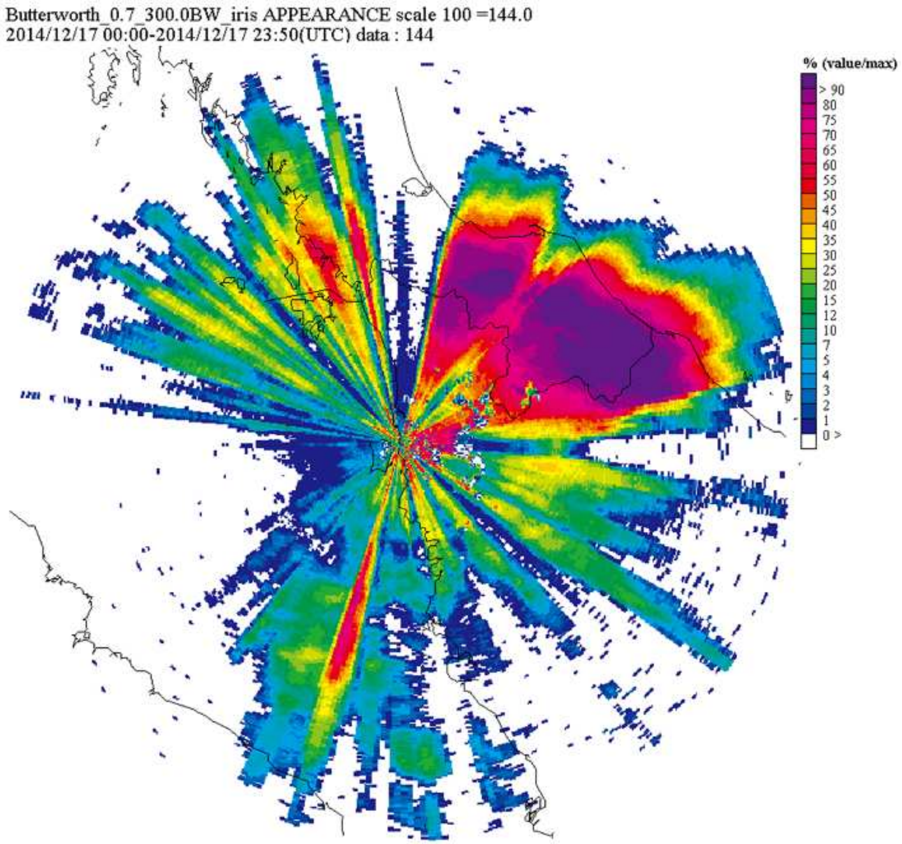


Appearance

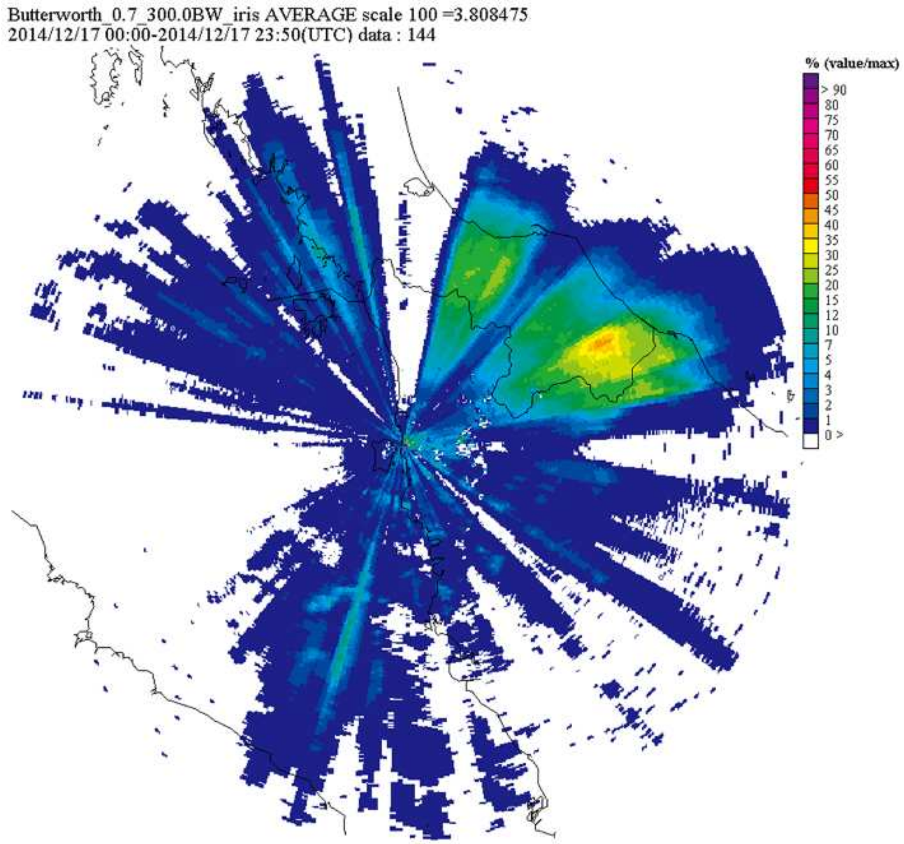


Average

Raw Data Statistics(0.7deg)

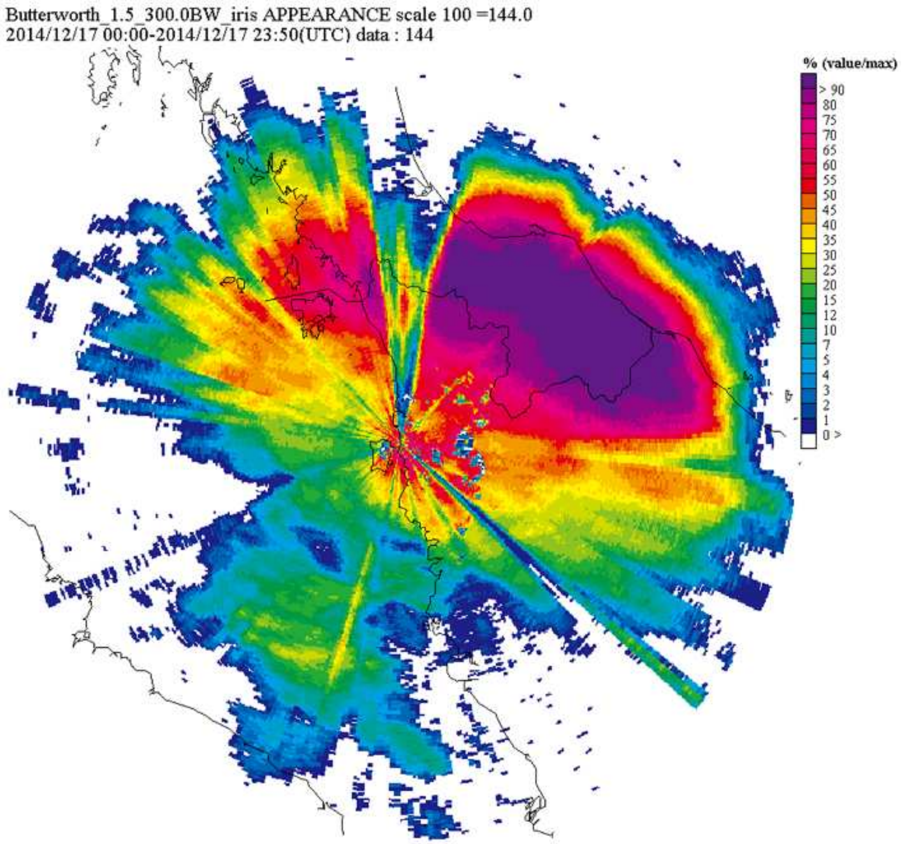


Appearance

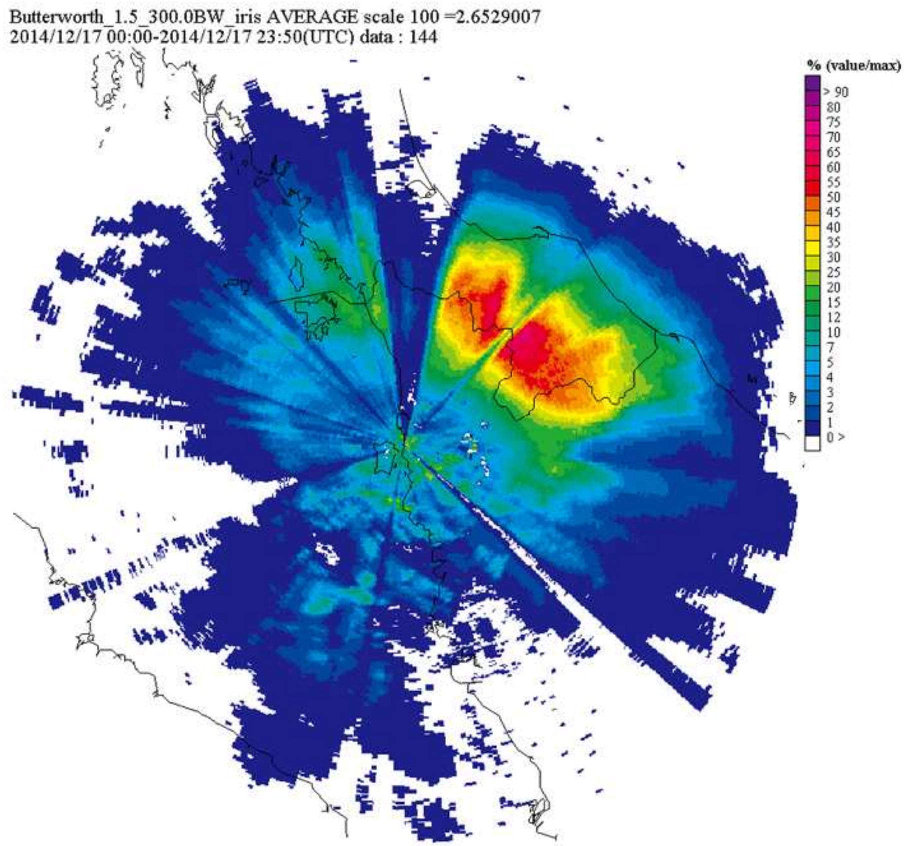


Average

Raw Data Statistics(1.5deg)

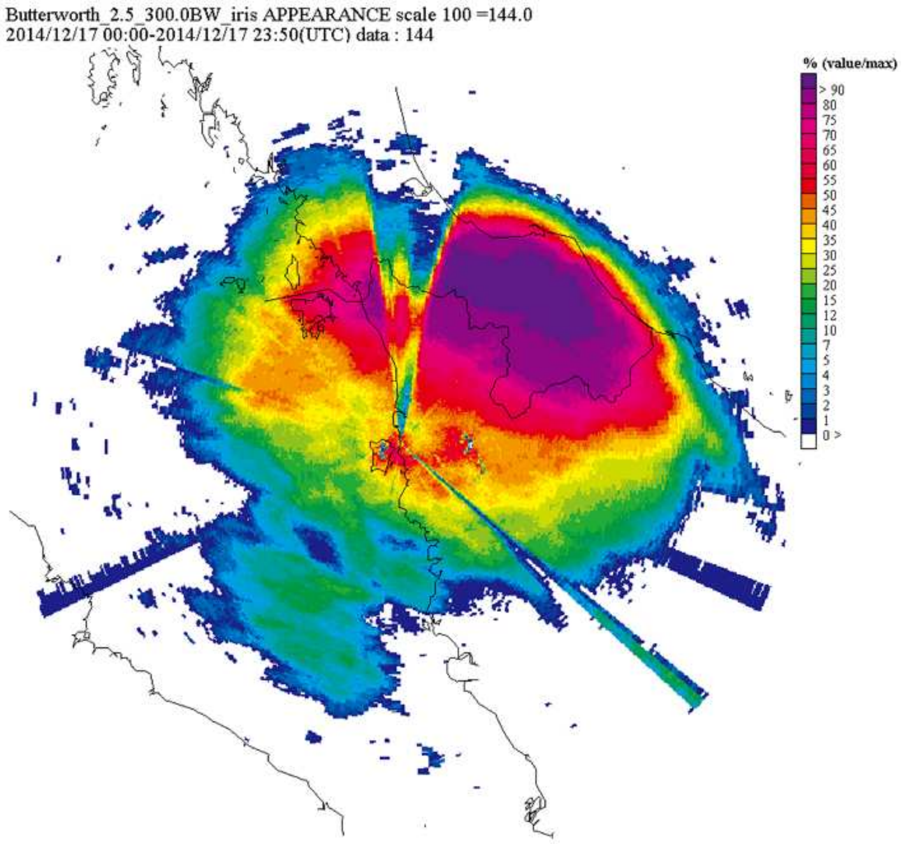


Appearance

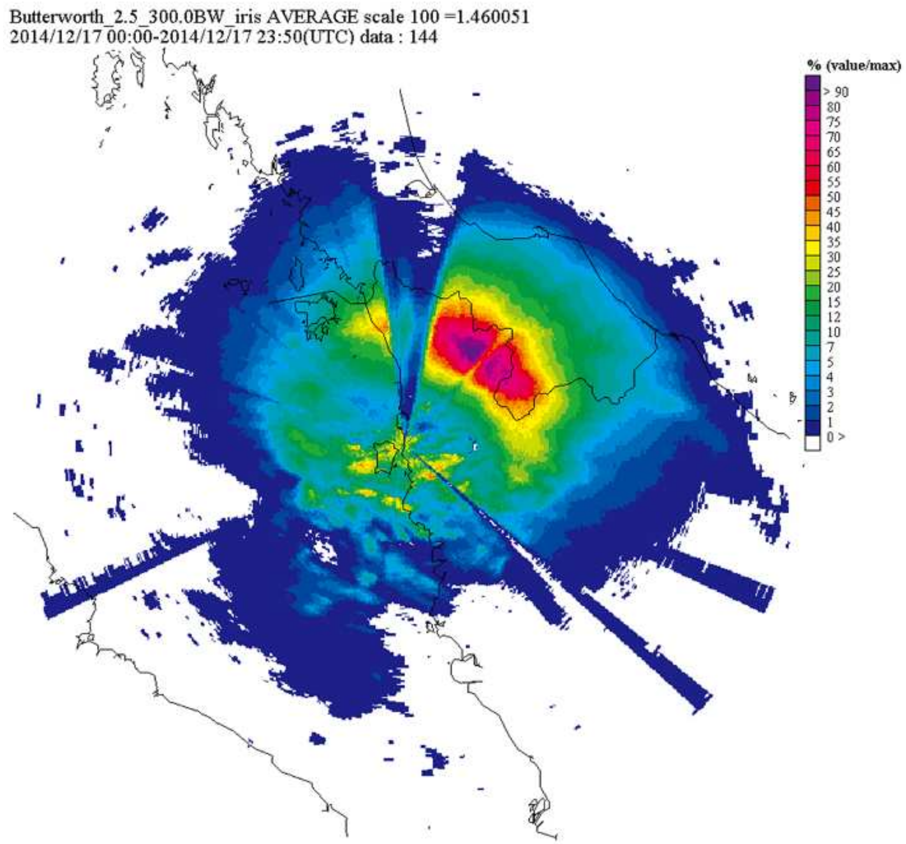


Average

Raw Data Statistics(2.5deg)

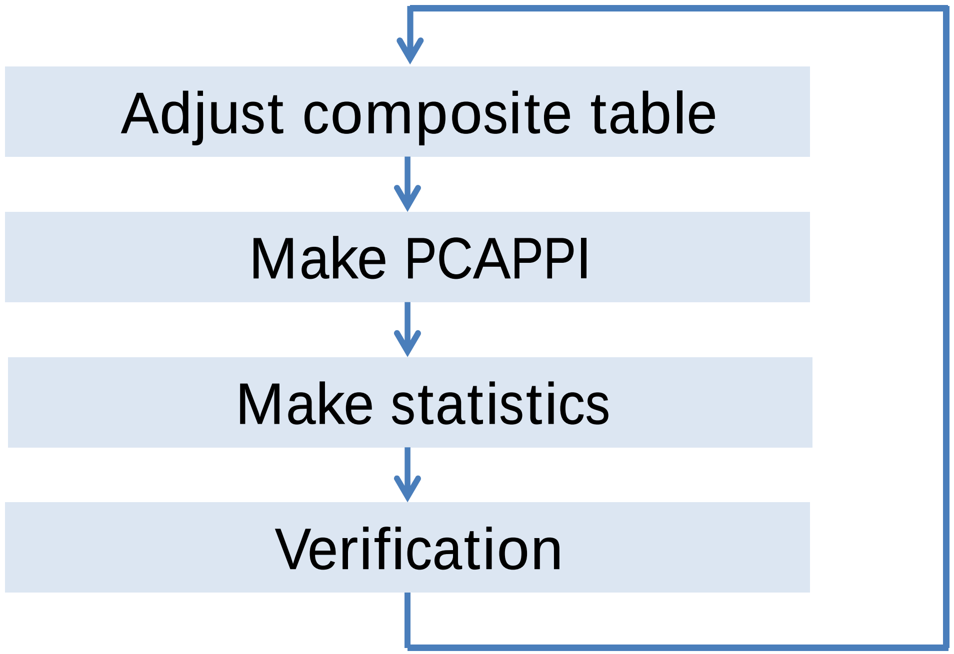


Appearance



Average

Next Challenge: Avoid mirror-image

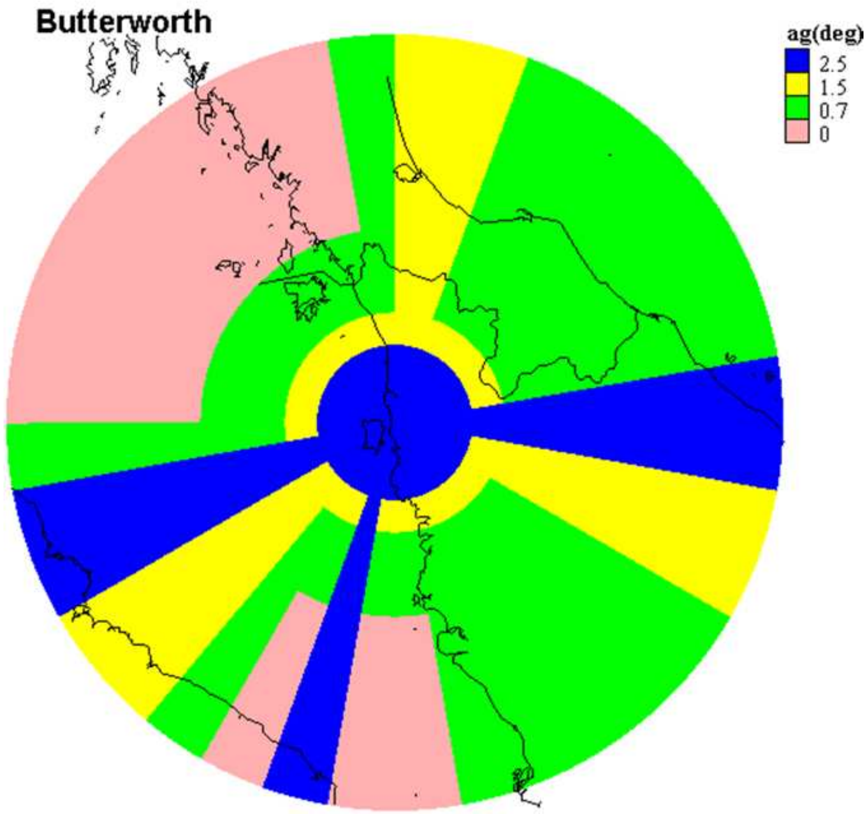


- Statistical data revealed that PCAPPI is partly contaminated by mirror-image.
- To remove mirror-image, let's adjust composite table again.

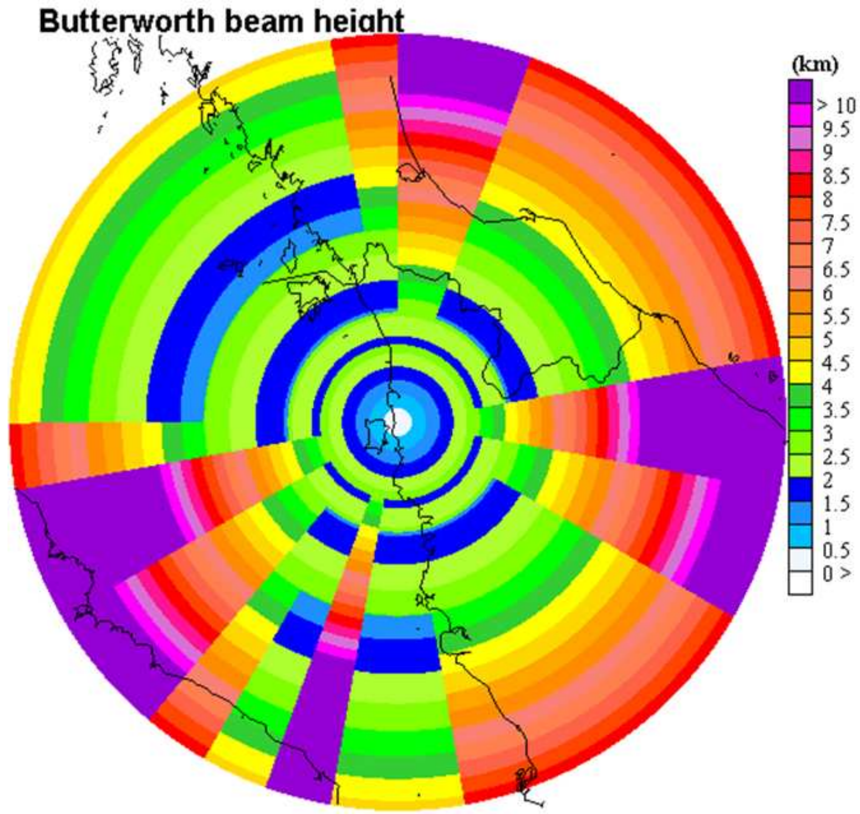
Exercise 3

20	0	2.5	60	1.5	300				
80	0	2.5	60	1.5	85	0.7	300		
100	0	2.5	300						
120	0	2.5	60	1.5	300				
170	0	2.5	60	1.5	85	0.7	300		
190	0	2.5	60	1.5	85	0.7	150	0	300
200									
210	0	2.5	60	1.5	85	0.7	150	0	300
220	0	2.5	60	1.5	85	0.7	300		
240	0	2.5	60	1.5	300				
260	0	2.5	300						
270	0	2.5	60	1.5	85	0.7	300		
350	0	2.5	60	1.5	85	0.7	150	0	300
360	0	2.5	60	1.5	85	0.7	300		

Composite table: PCAPPI (avoid mirror-image)

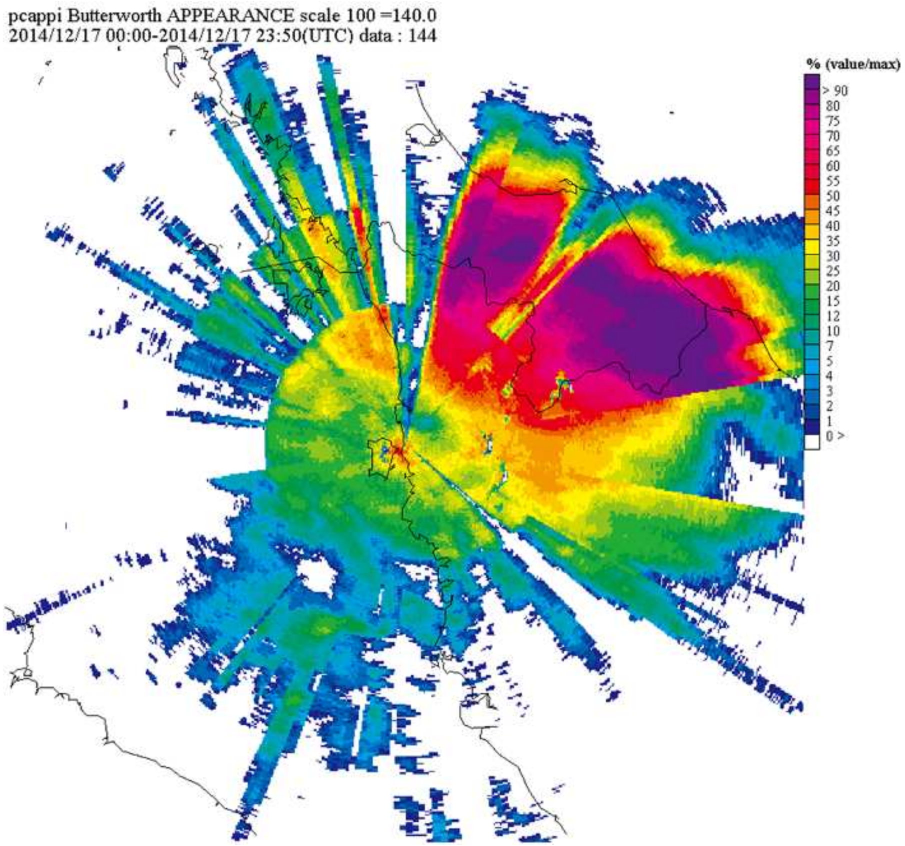


Angle

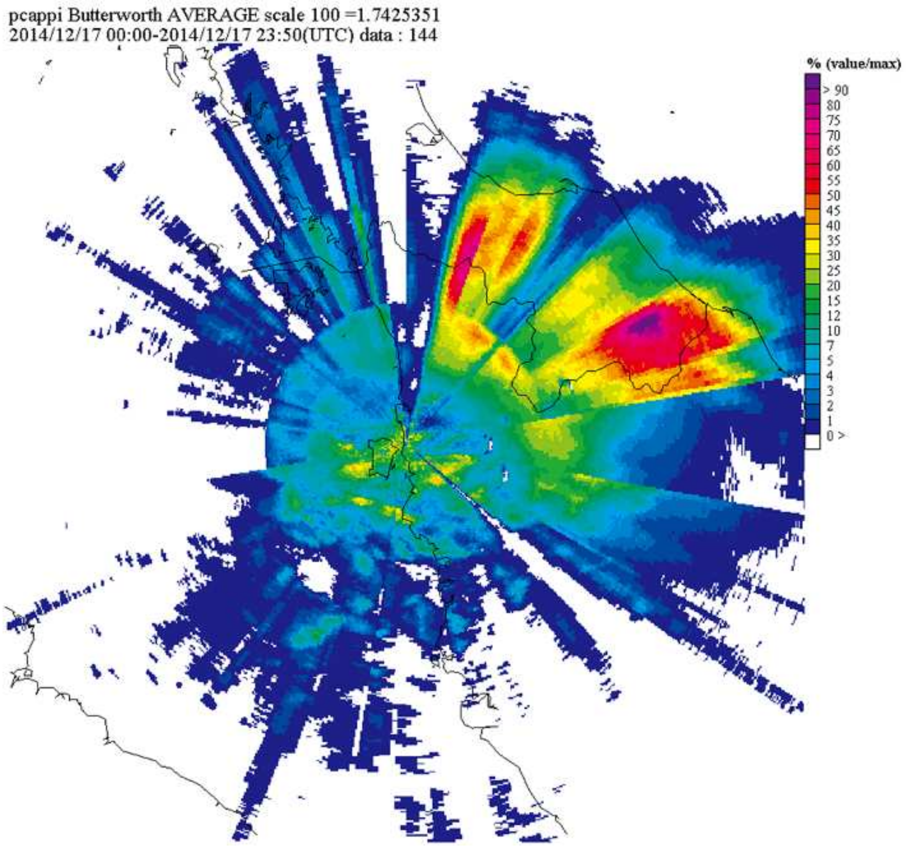


Beam Height

Statistics: PCAPPI(avoid mirror-image)



Appearance



Average

Result

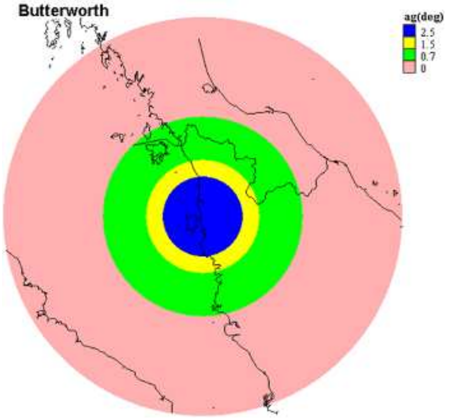
Composite table

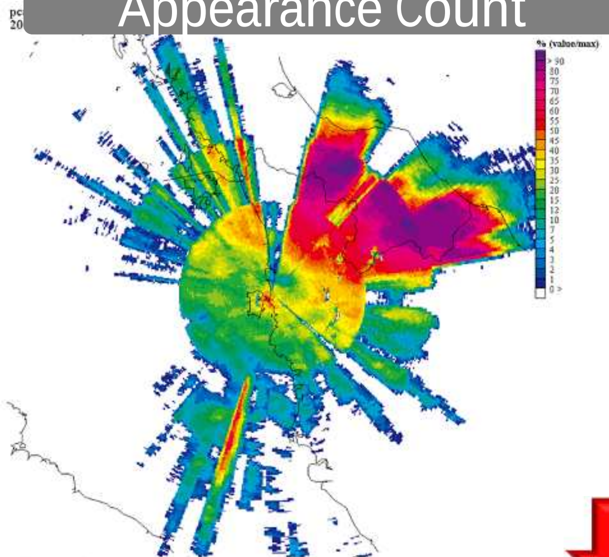
Statistical PCAPPI data

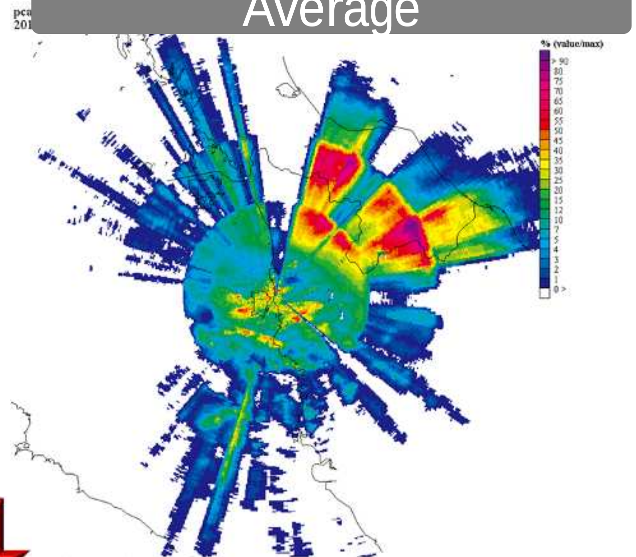
Appearance Count

Average

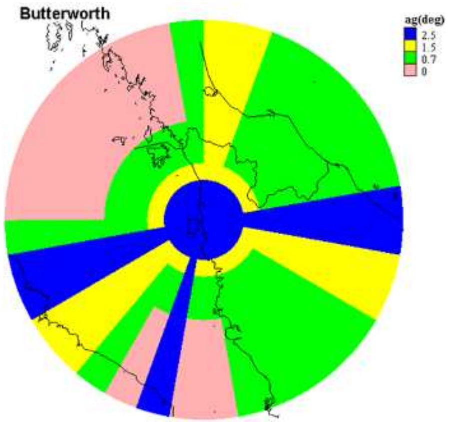
Before

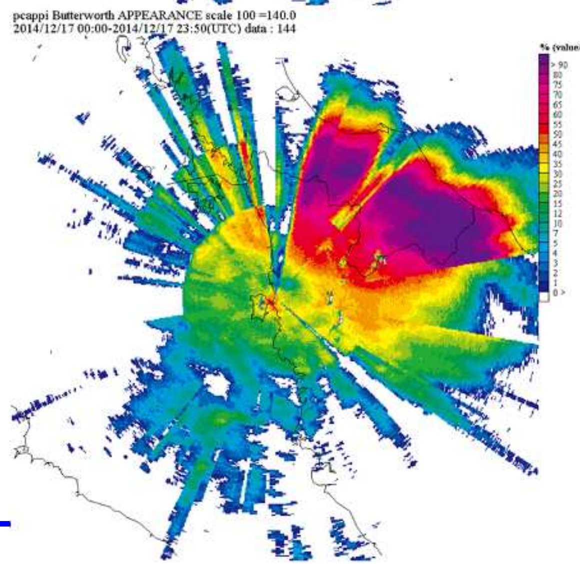


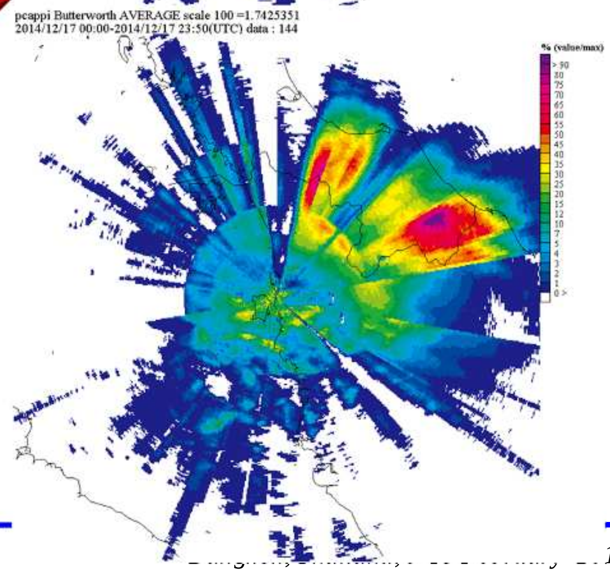




After

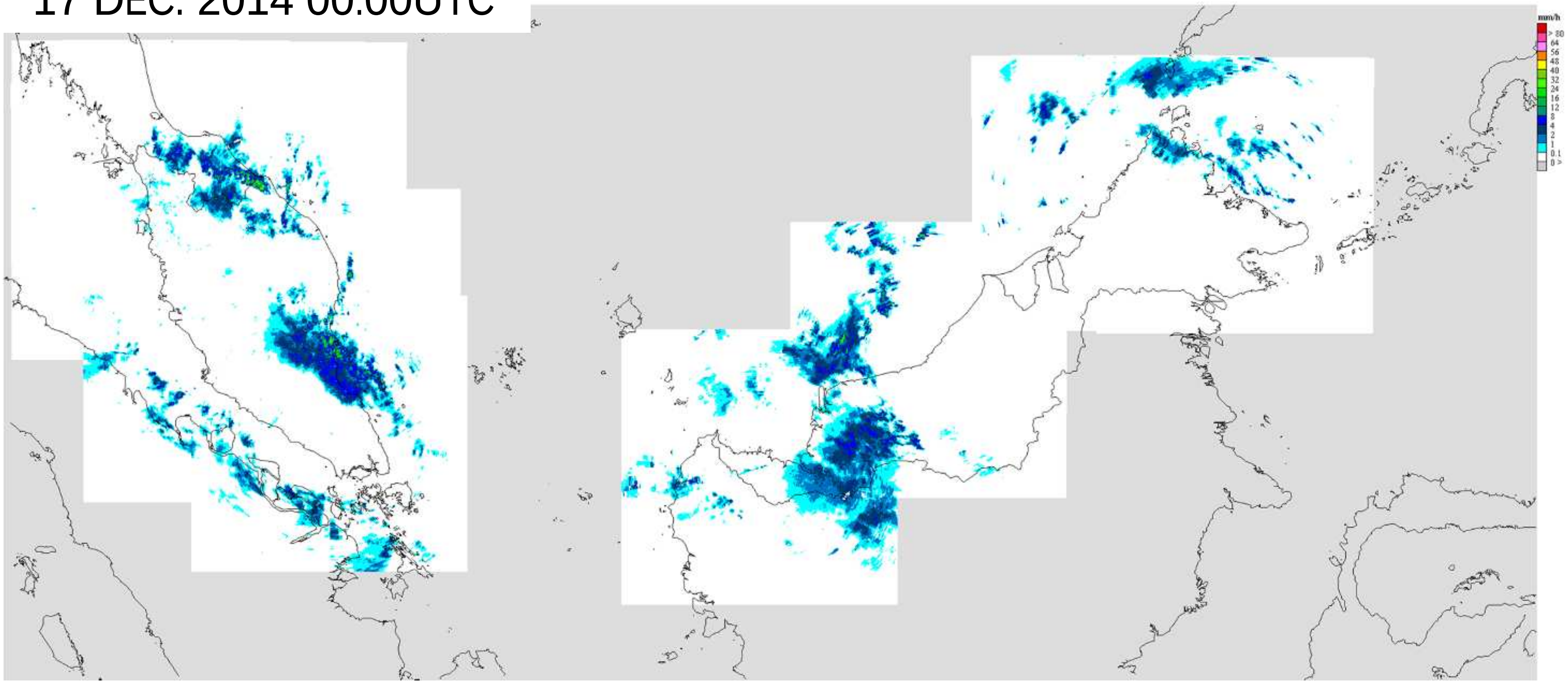






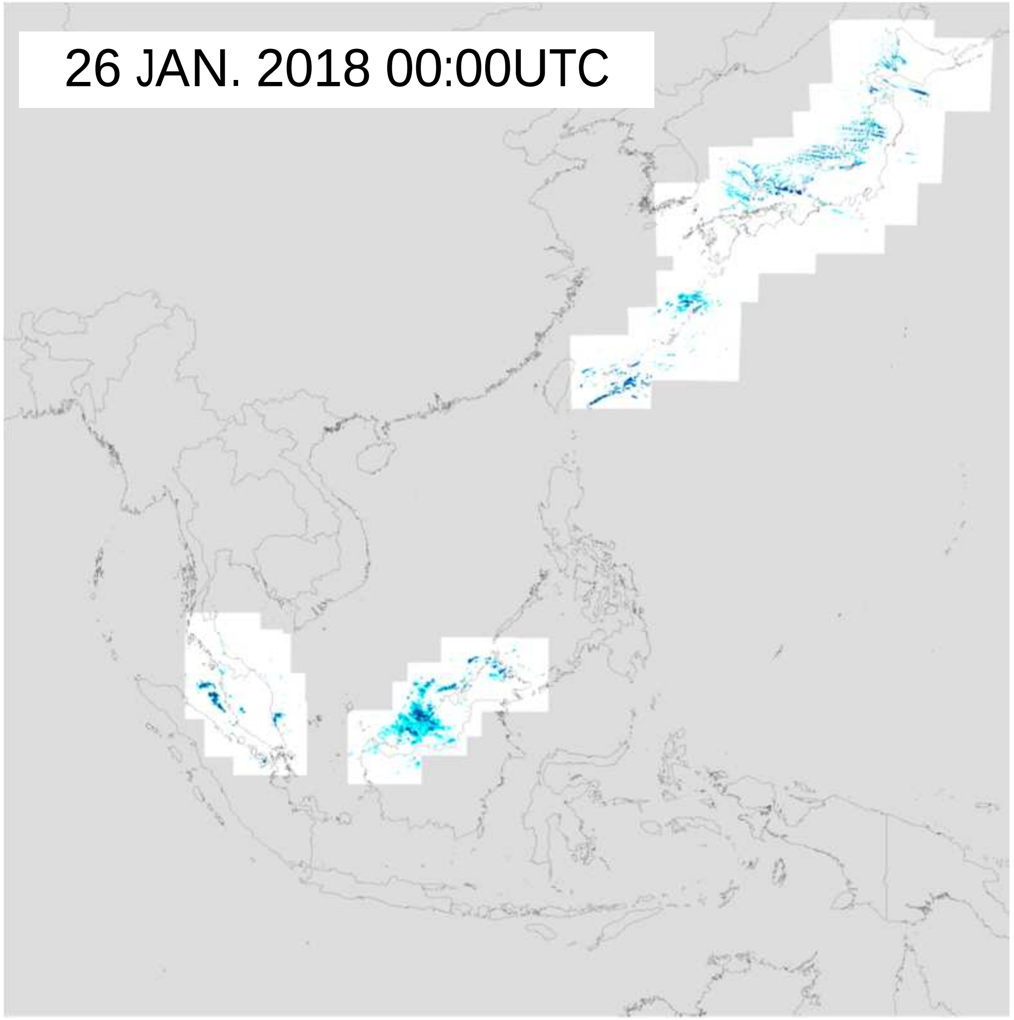
National composite map

17 DEC. 2014 00:00UTC

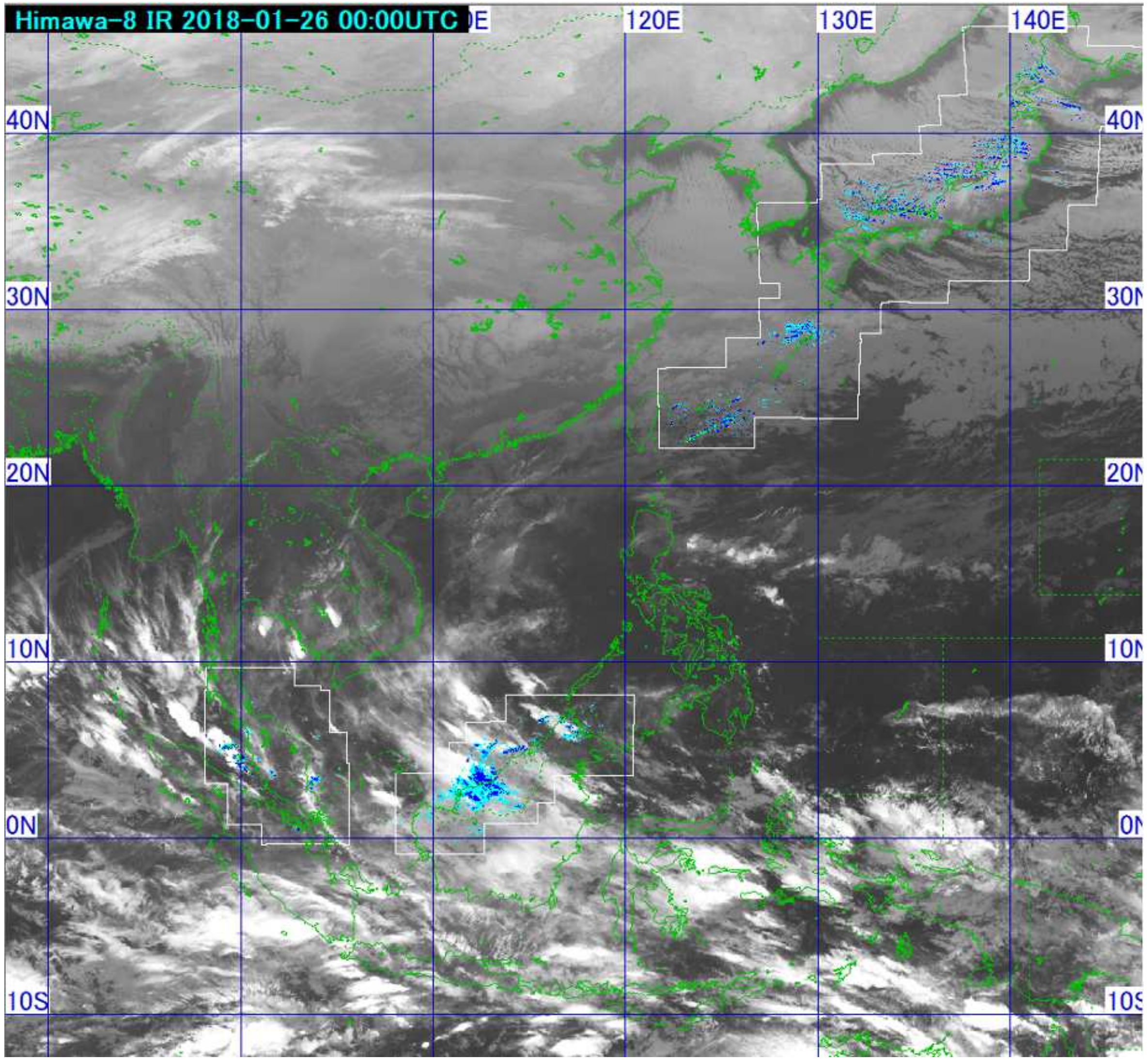


- Quality of composite map depends on quality of each radar's EIL.

International Radar Composite Imagery



With Satellite Image



Summary

- In order to create Cartesian data with good quality (less clutter and less noise), we need various processes.
- However, it is impossible to completely eliminate anomalous echoes by automatic processing.
- Radar data quality control should be done through whole radar systems.
- Accumulation and careful investigation of radar data will improve QC results.

Thank you for your attention !!