# 4. Weather radar Data Quality Control

## 4.1 Calibration

## 4.2 Noise reduction

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# 4. Weather radar Data Quality Control

4.1 Calibration

a. Calibration for radar equipment

was lectured by Mr. Inoue in the Session 2 “Weather Radar Maintenance”.

b. Calibration for quantitative Precipitation Estimation

will be lectured by Mr. Sakanashi in the Session 7.3 “QPE & QPF”.

4.2 Noise reduction

a. Noises (Error sources) on weather radar observation

b. Necessity and methods of noise reduction in weather radar observation

Will be lectured by Mr. Yamauchi and Mr. Hotta in the Session 5 “Hands-on Training on Weather Radar QC”.

# Error sources on weather radar observation

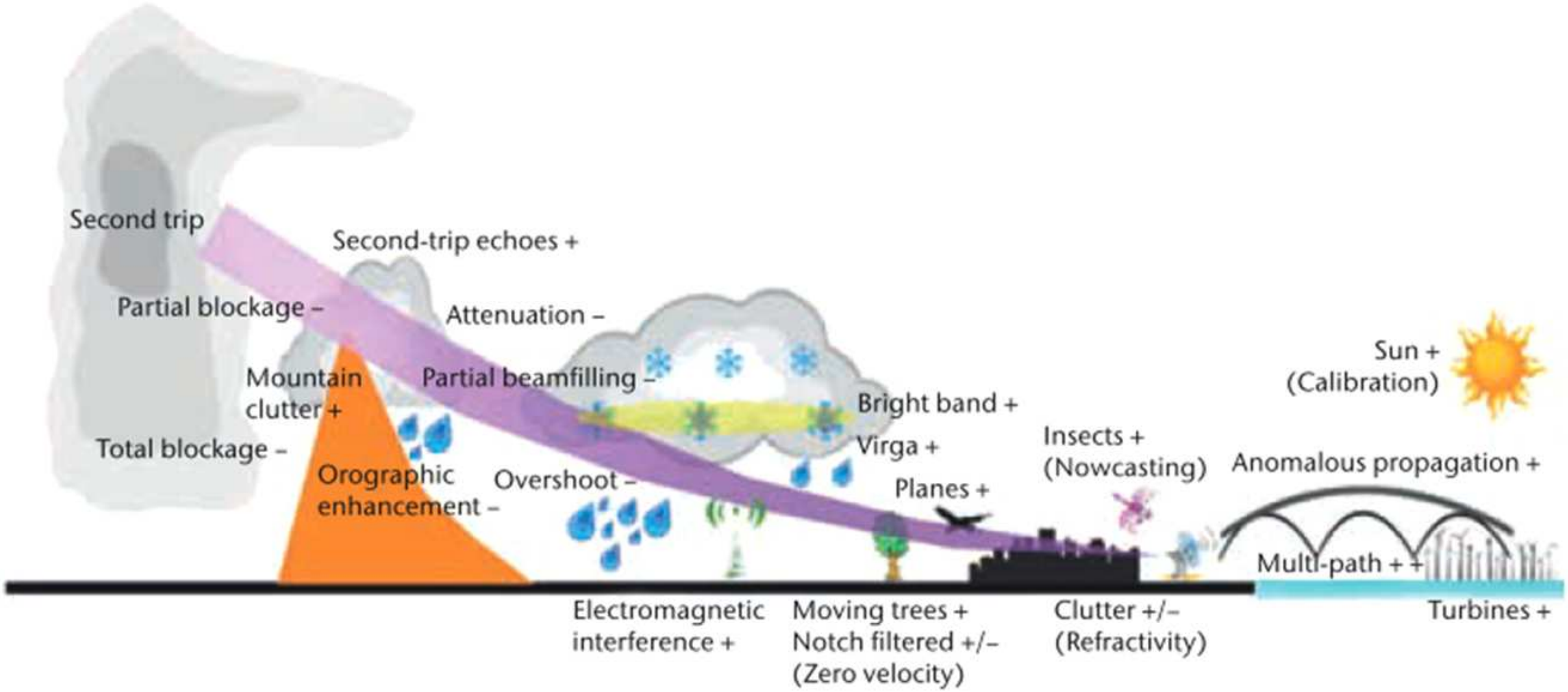



**Figure 7.2. The weather radar can detect many things besides weather targets. This schematic illustrates many of these features. The + or – signs indicate whether the radar reflectivity is augmented or diminished by the feature. These artefacts need to be removed for quantitative applications.**

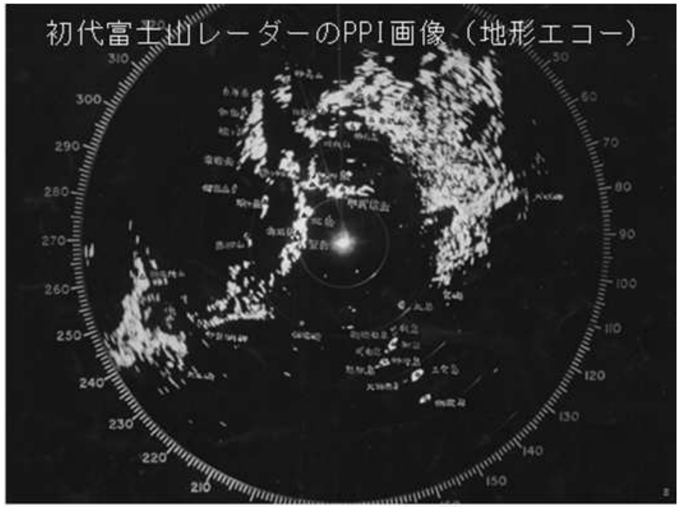
Source: Guide to Meteorological Instruments and Methods of Observation, 2014, WMO

# Ground clutter

Most troublesome noise against weather radars

Mt. Fuji Radar (1964-1999) at the elevation of 3,770 m

C-band Radar of JMA Meteorological Research Institute

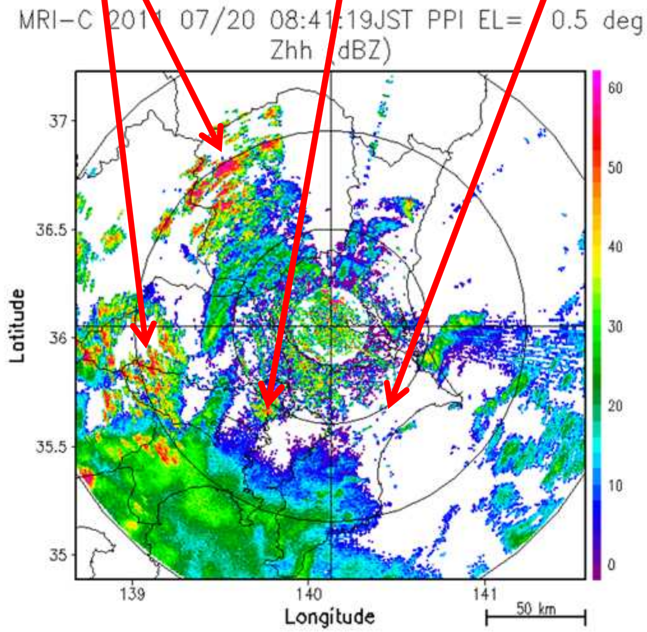




Ground clutter observed Mt. Radar

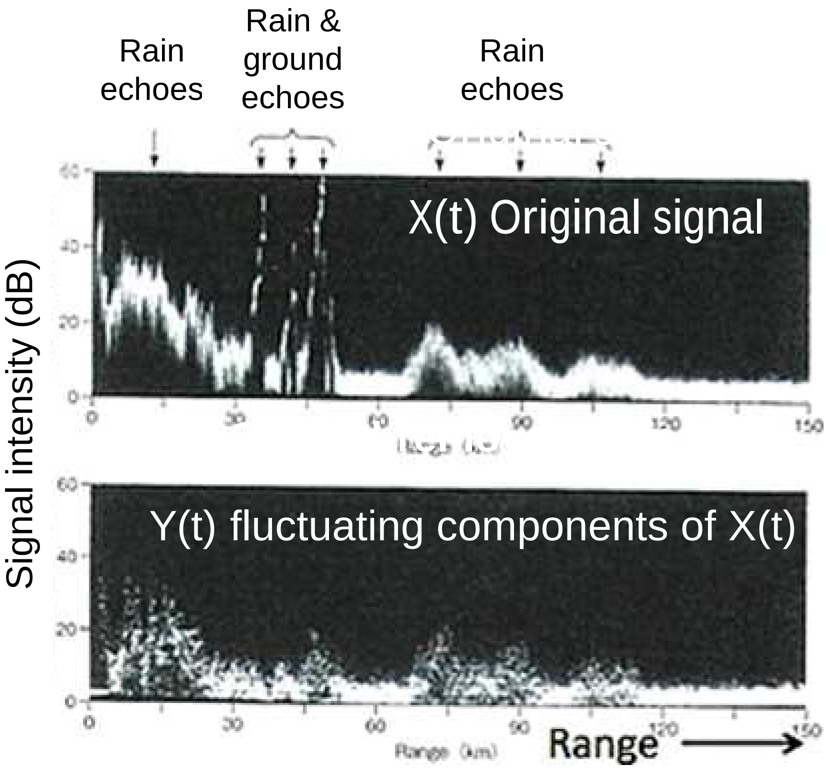
Buildings

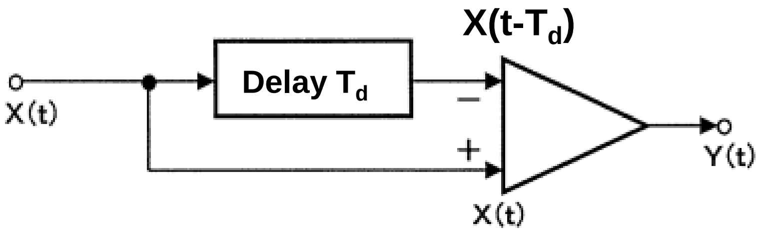
Mountains

Power lines

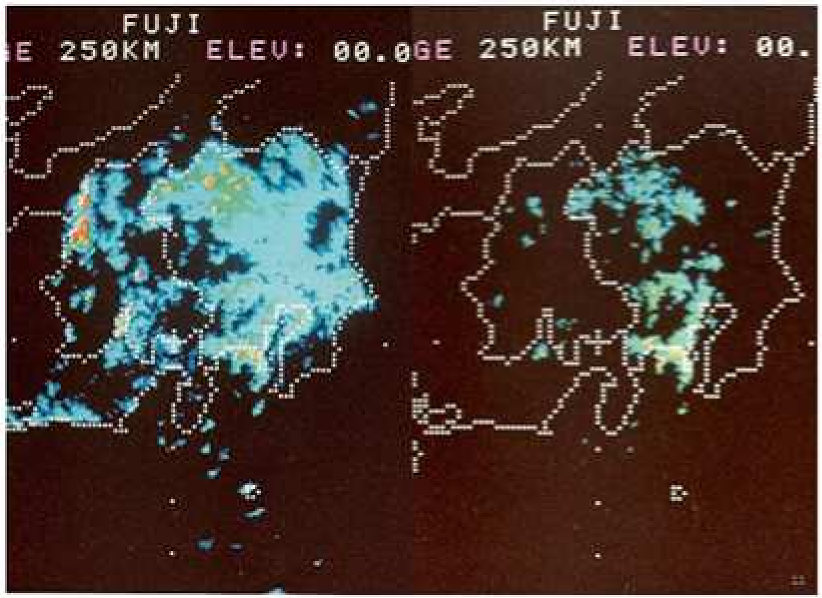


# Ground clutter remover
## - Non-coherent MTI for non-Doppler radars -

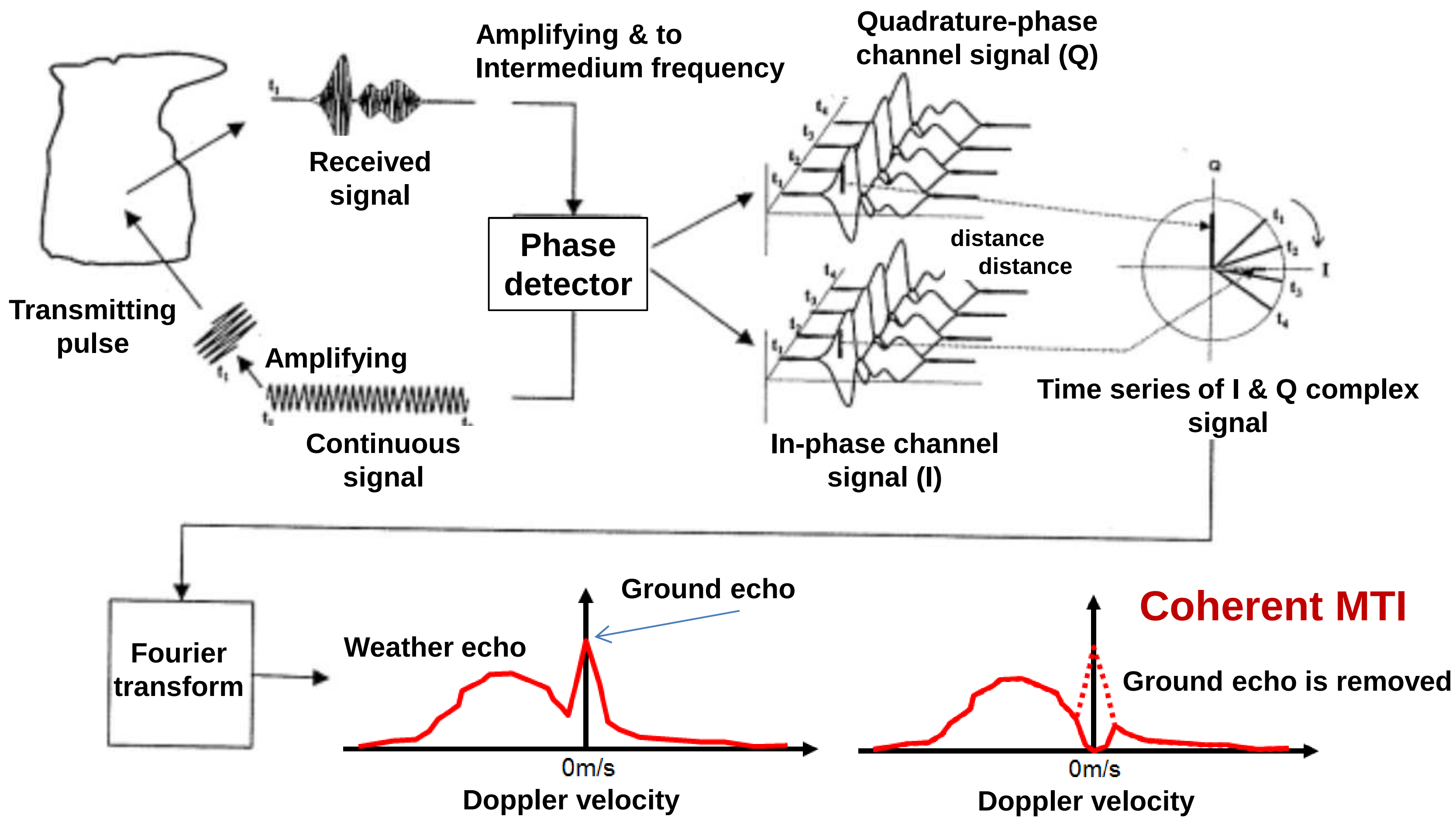


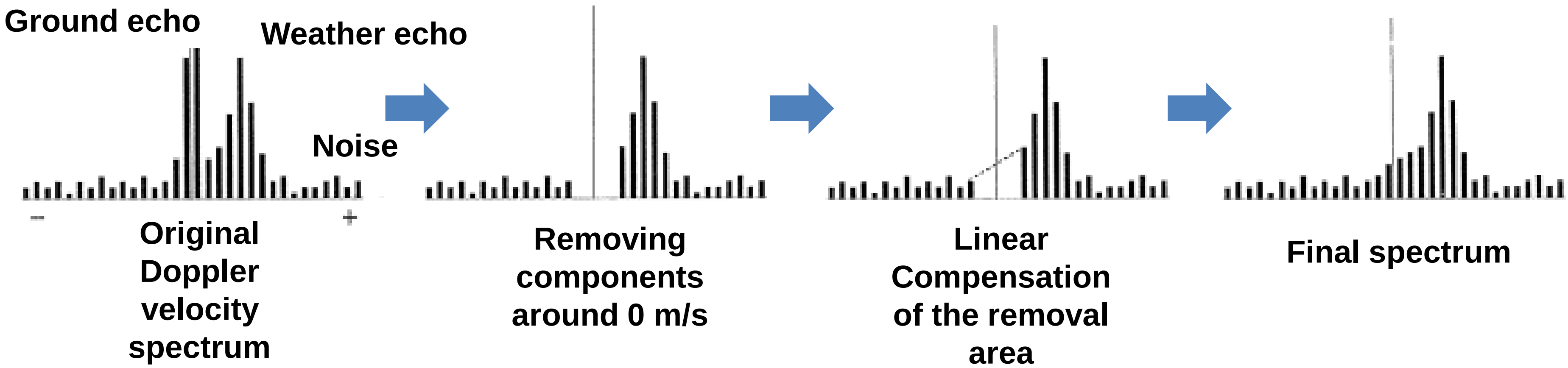

Non-Filtered Filtered

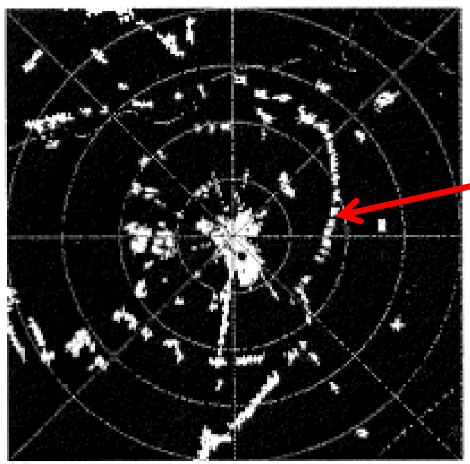


# Ground clutter remover
# - Coherent MTI for Doppler radars -

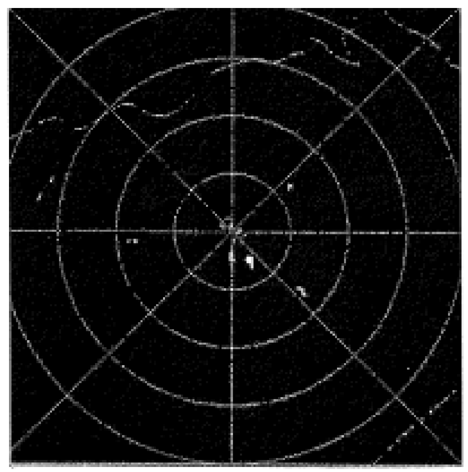


# Ground clutter remover
# - Coherent MTI for Doppler radars -



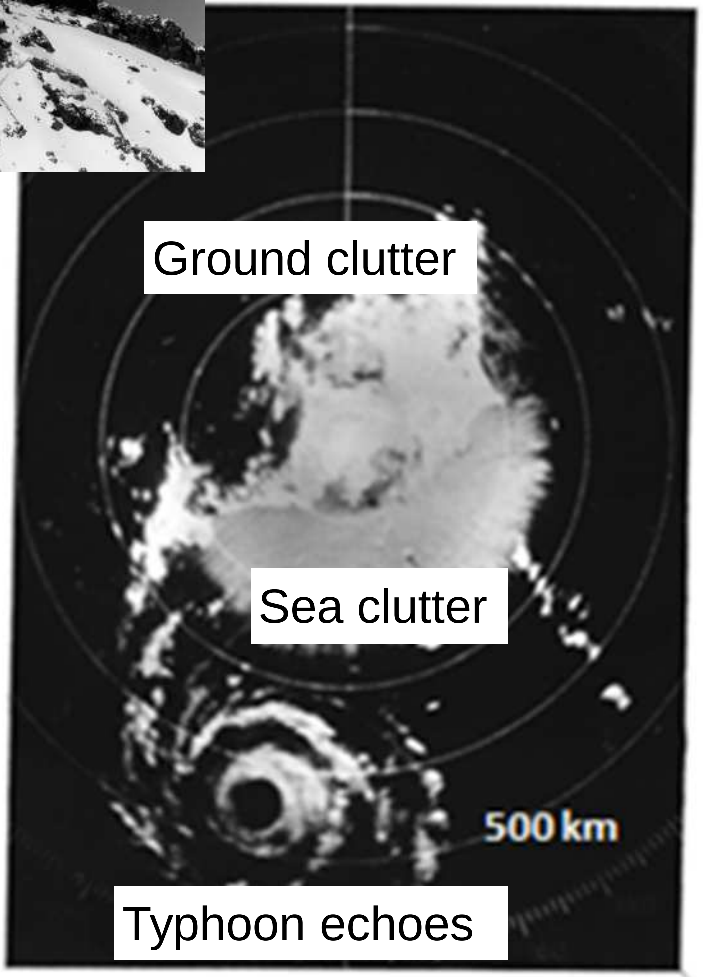



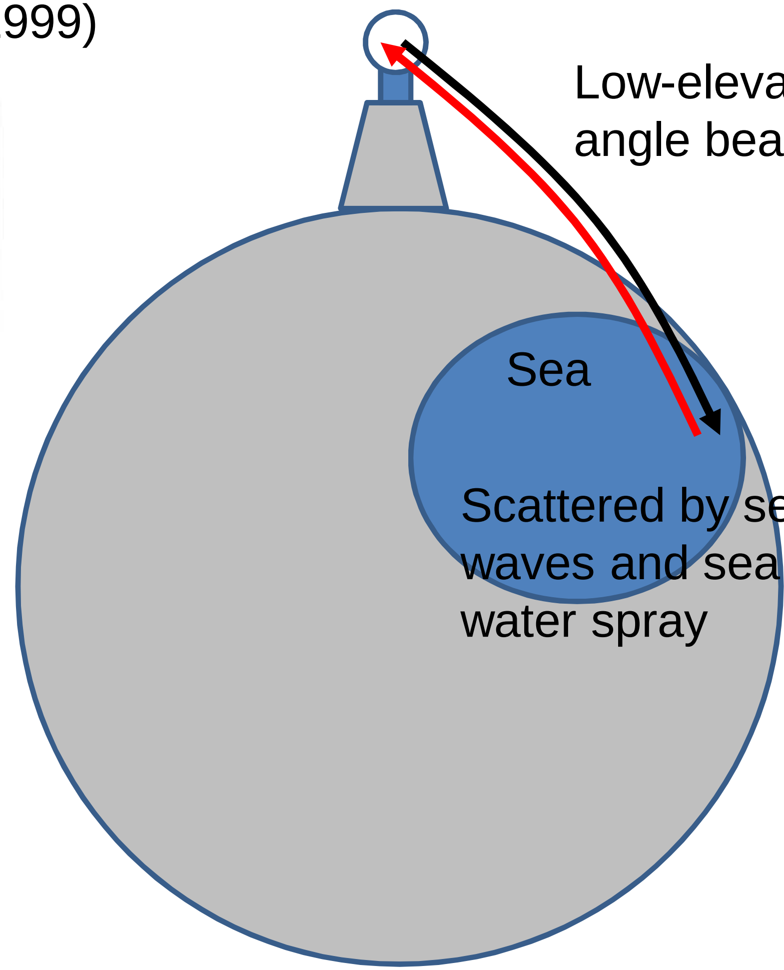
Power line towers



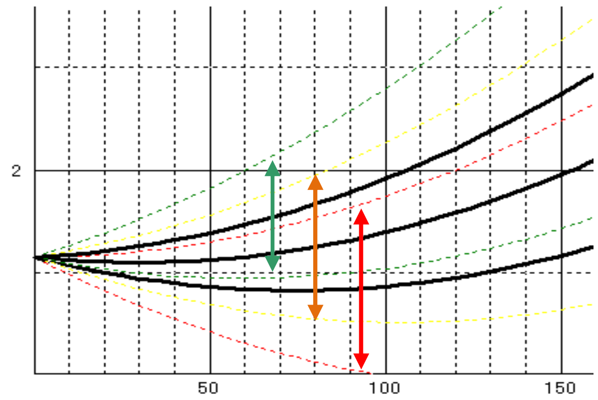
# Sea clutter

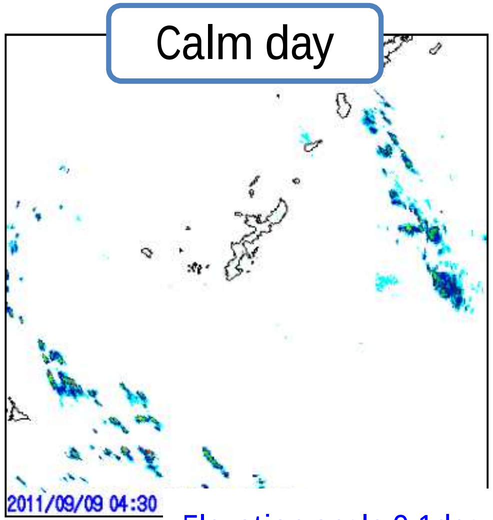
Mt. Fuji Radar (1964-1999)



# Sea clutter

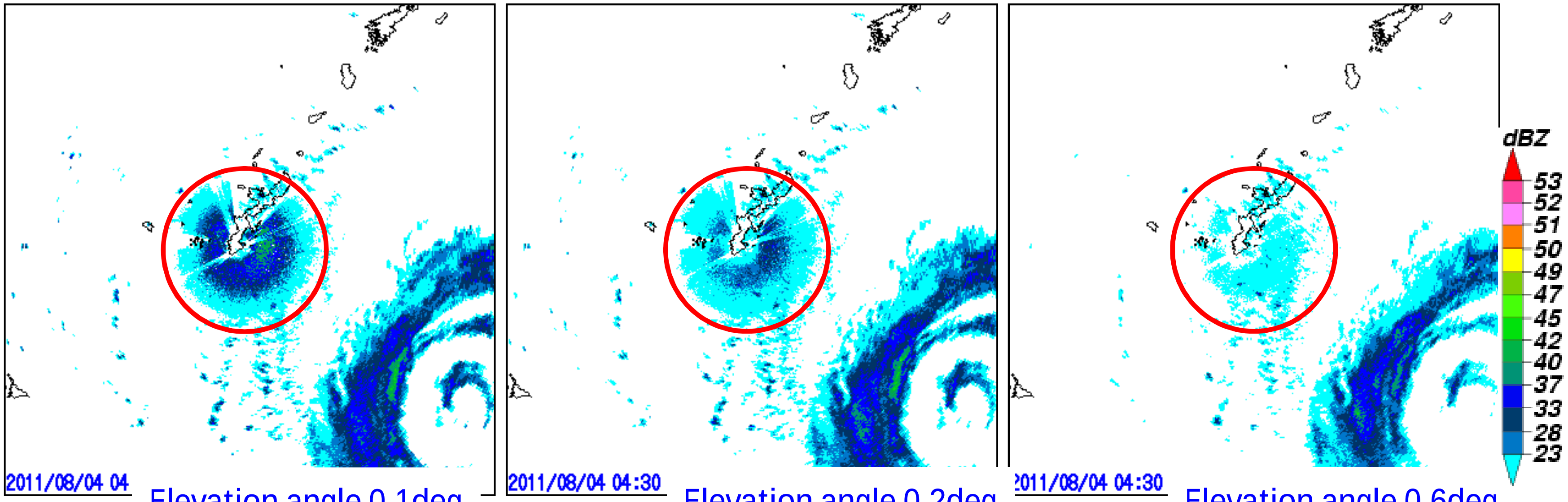



Elevation angle 0.1deg

2011/08/04
Typhoon MUIFA (1011)

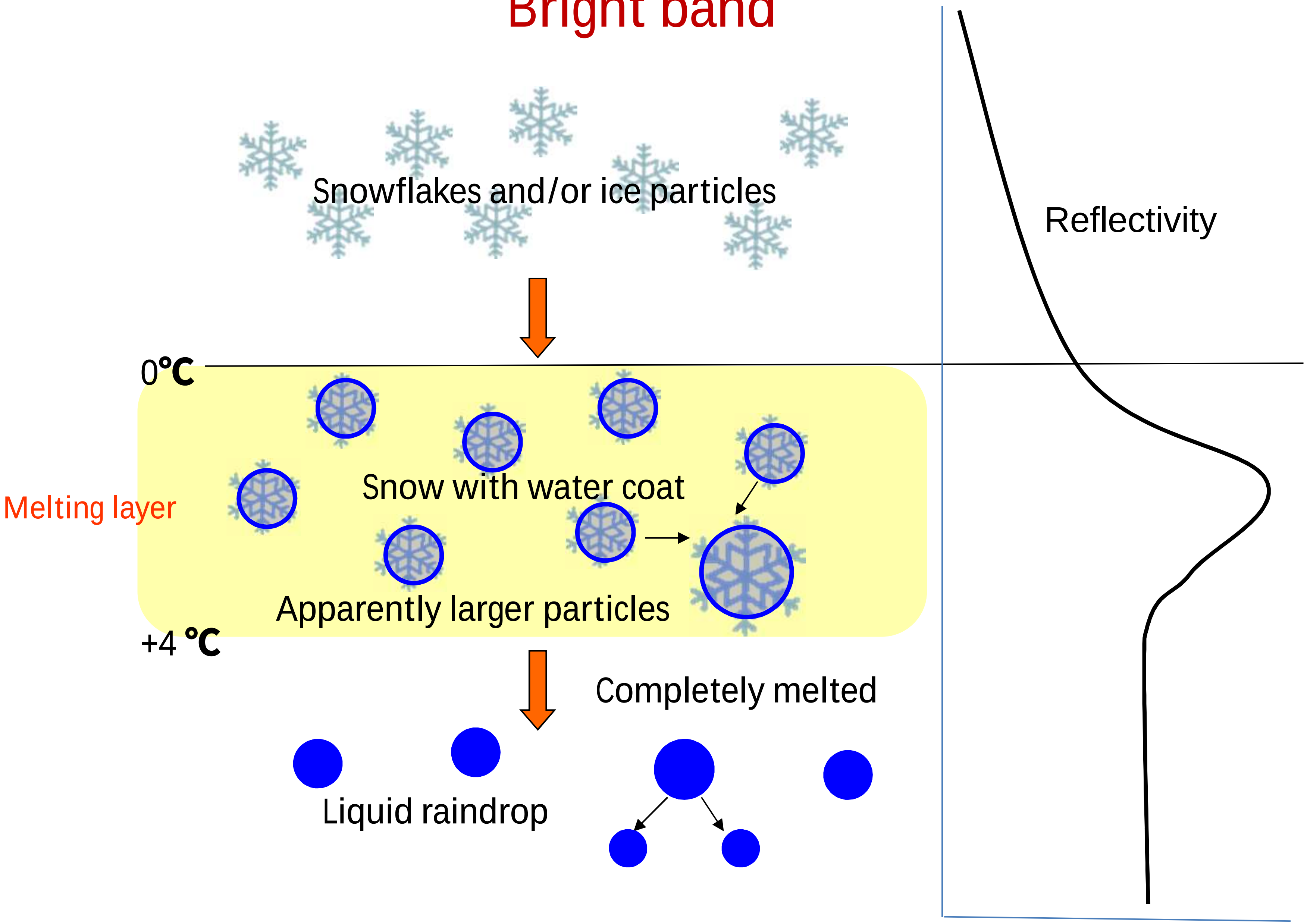
Okinawa radar




Elevation angle 0.1deg Elevation angle 0.2deg Elevation angle 0.6deg

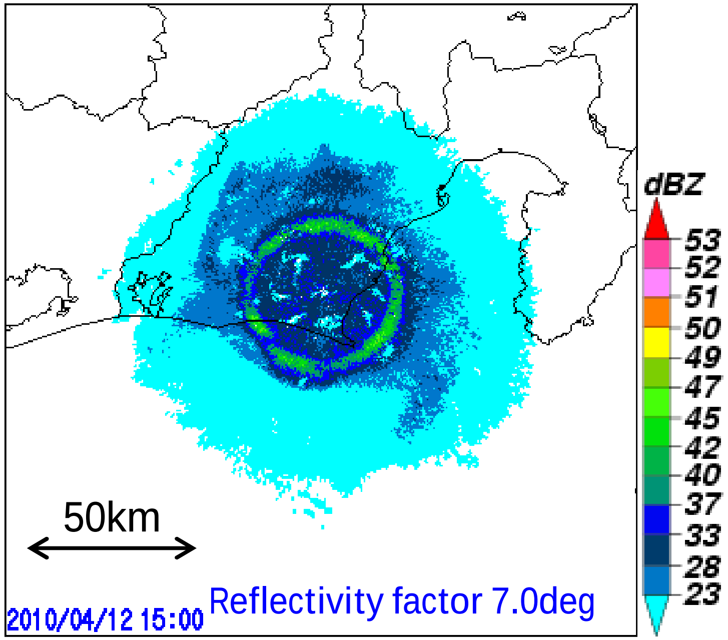
- In windy situations, the sea spray may be observed at low elevation angles.

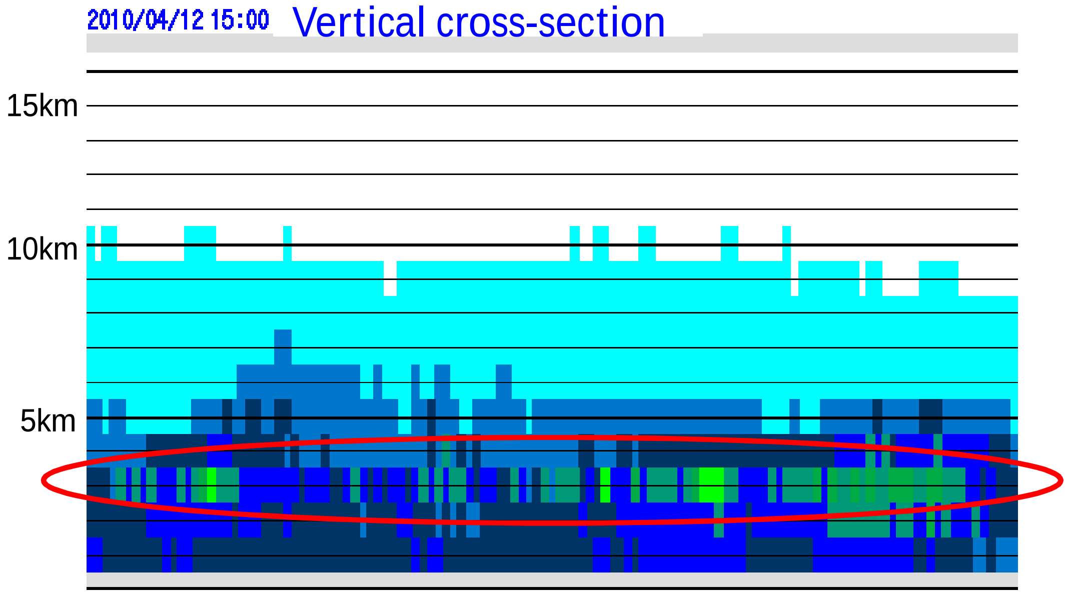
# Bright band


Snowflakes and/or ice particles
Reflectivity
0℃
Melting layer
Snow with water coat
Apparently larger particles
+4 ℃
Completely melted
Liquid raindrop

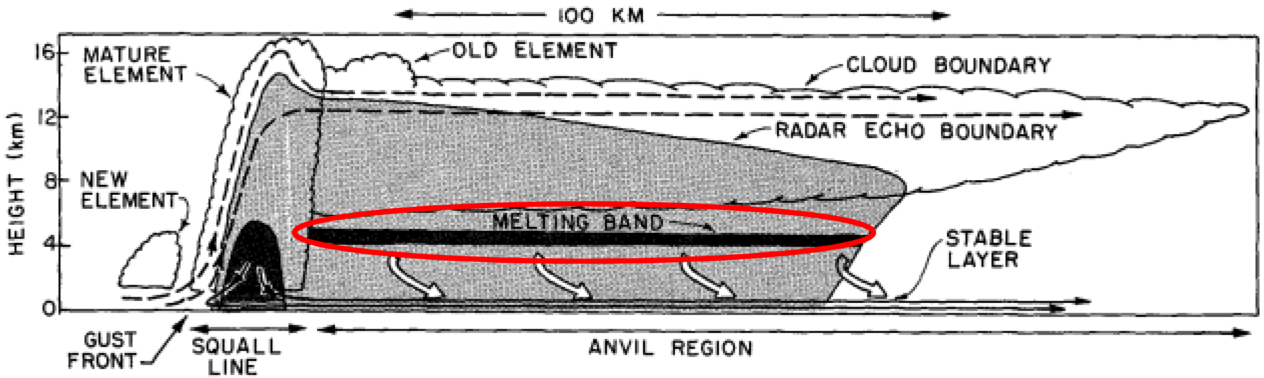
# Bright band

JMA Shizuoka radar

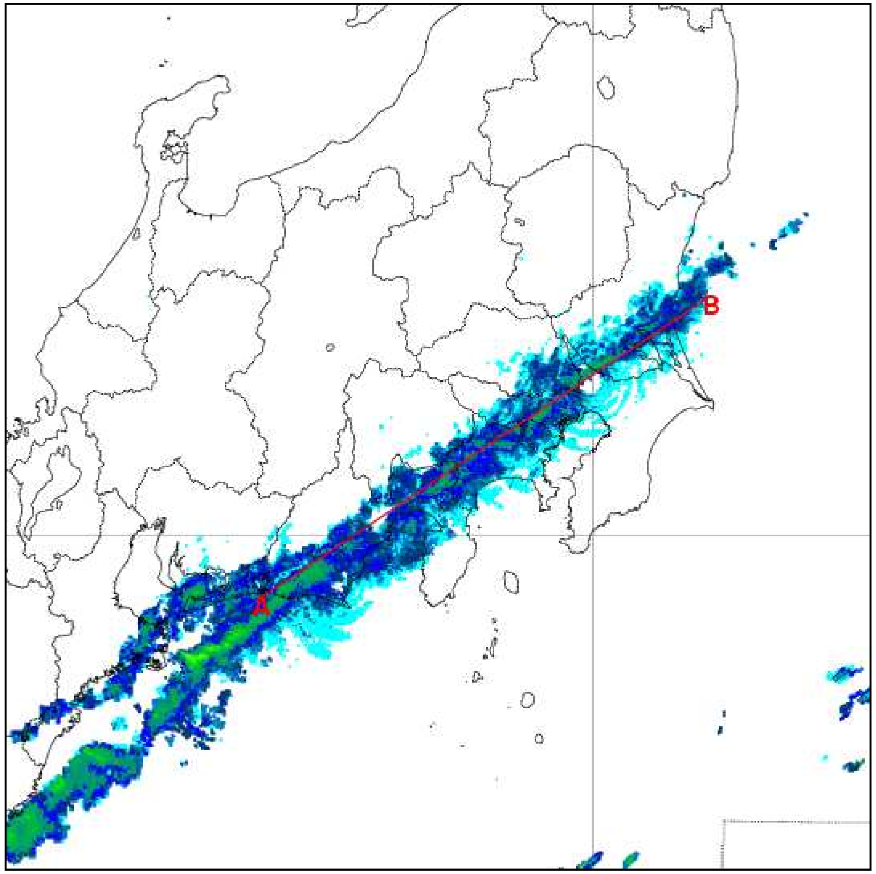


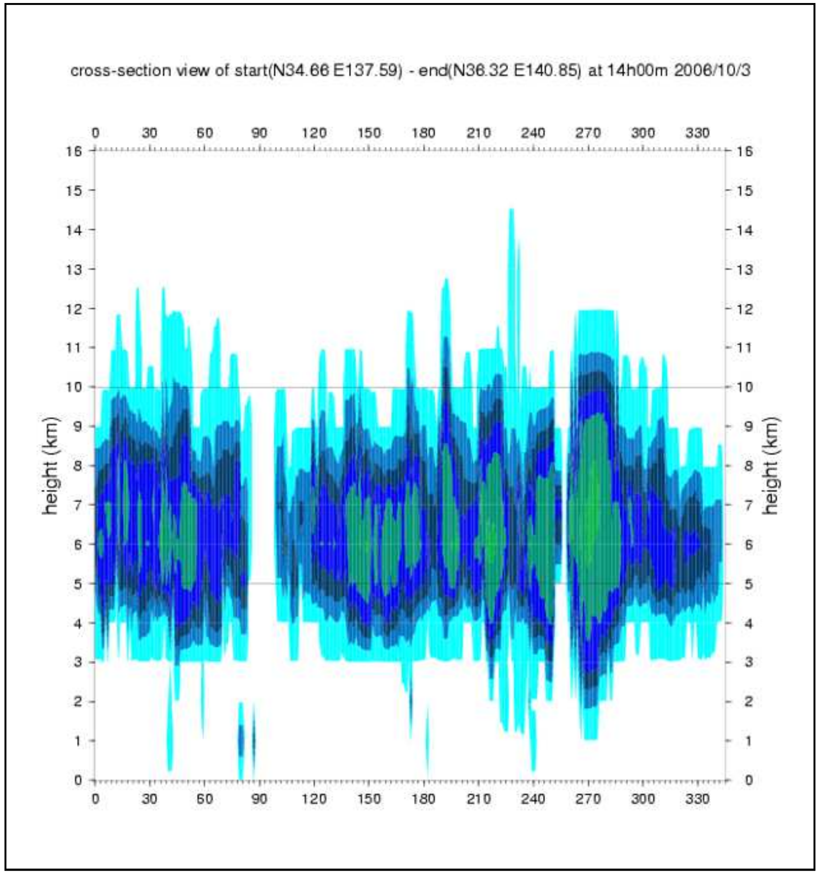

Vertical cross-section a tropical squall line (Houze, 1977)



# Precipitation aloft




Reflectivity at the level of 6 km




Cross section A - B

# Side lobe

## - Antenna pattern of a parabolic antenna -

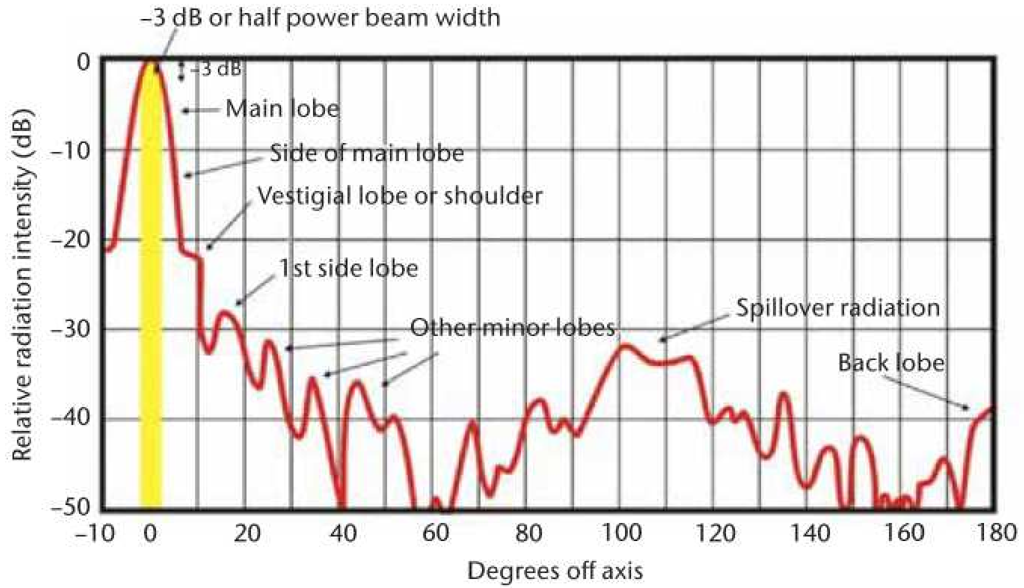



Figure 7.8. A generic antenna radiation pattern. Note that the antenna beam widtl typically defined at the half power (50% or –3 dB) points. If the target is highly reflec power is emitted and received on the side of the main lobe and the other side lobe

Source: Guide to Meteorological Instruments and Methods of Observation, 2014, WMO

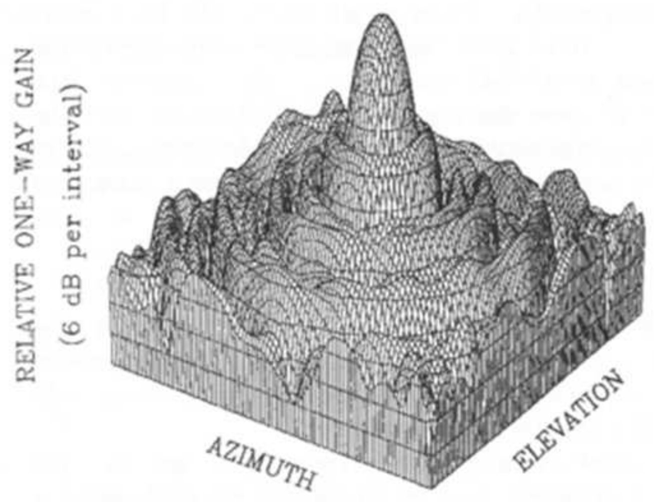
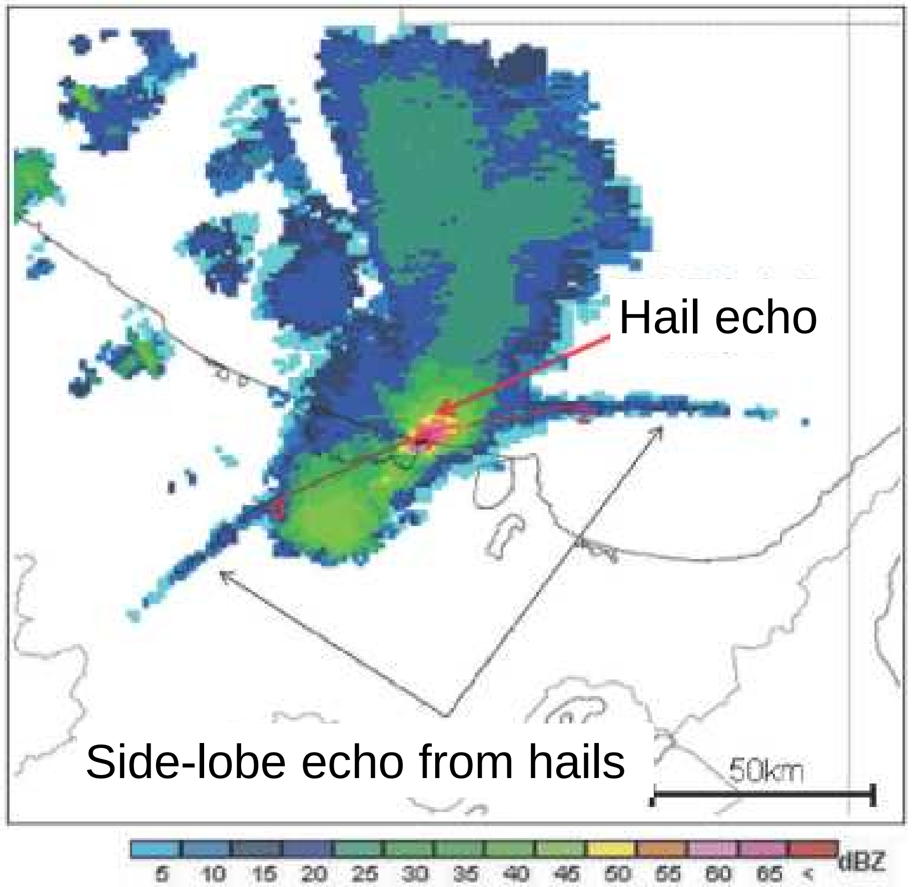



*Figure 2.9 Antenna beam pattern of the NCAR CP2 X-band antenna. The elevation and azimuth angles extend about 5° either side of the mainlobe (0.1° per interval for both elevation and azimuth). The horizontal contours are at 6-dB intervals. From Rinehart and Frush, 1983.*

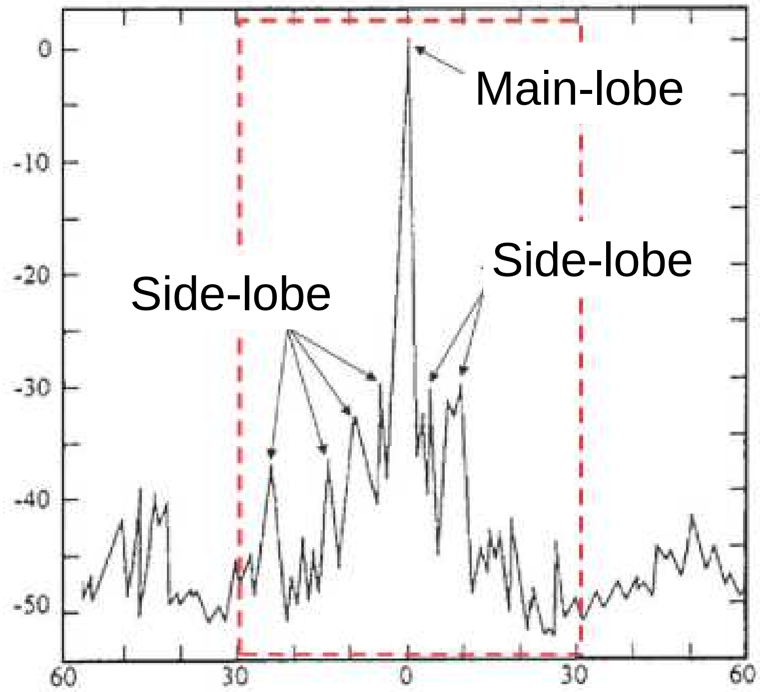
Source: Radar for meteorologist : Rinehart, 1999

# Side lobe echo

## - Pseudo weather echo coming rom hails -

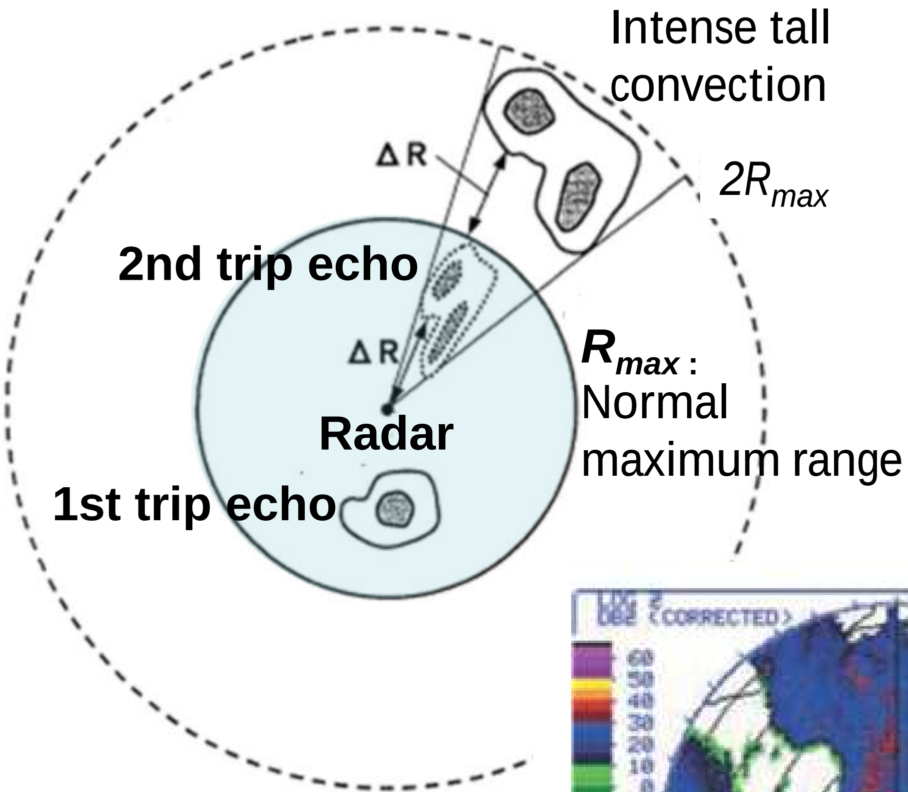



JMA Kushiro Radar 14:28 LST 28 June 2006
Uchida et al. (2010)




Beam patter of JMA Kushiro Radar

# Second trip echo




- **1st trip echo: true echo in the maximum range**
- **2nd trip echo: false echo out of the maximum range**

$R_{max} = C / 2PRF$

$R_{max}$ :Maximum range

C: Light speed (3 x $10^6$ km)

PRF: Pulse repetition Frequency

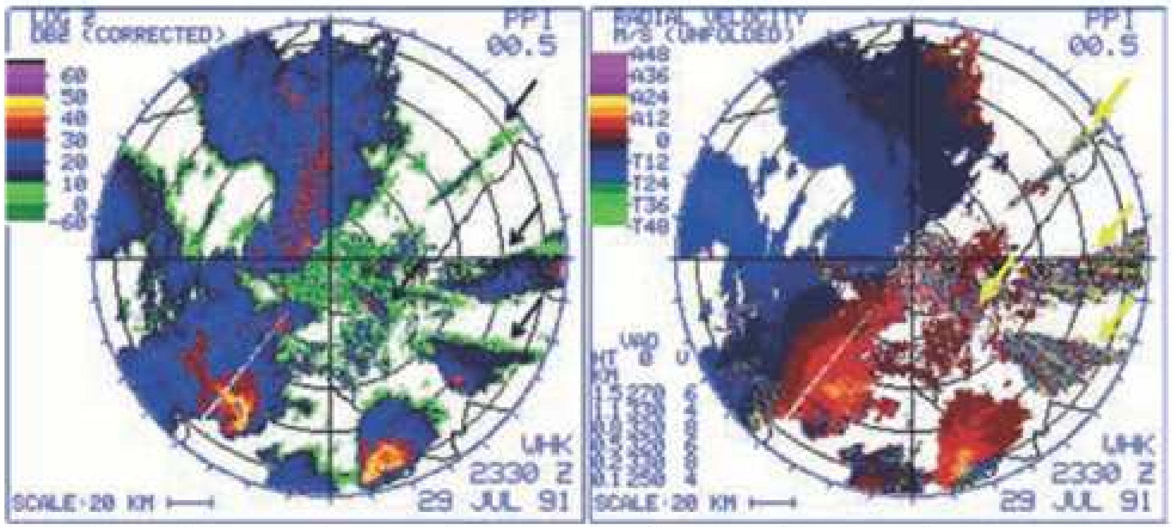
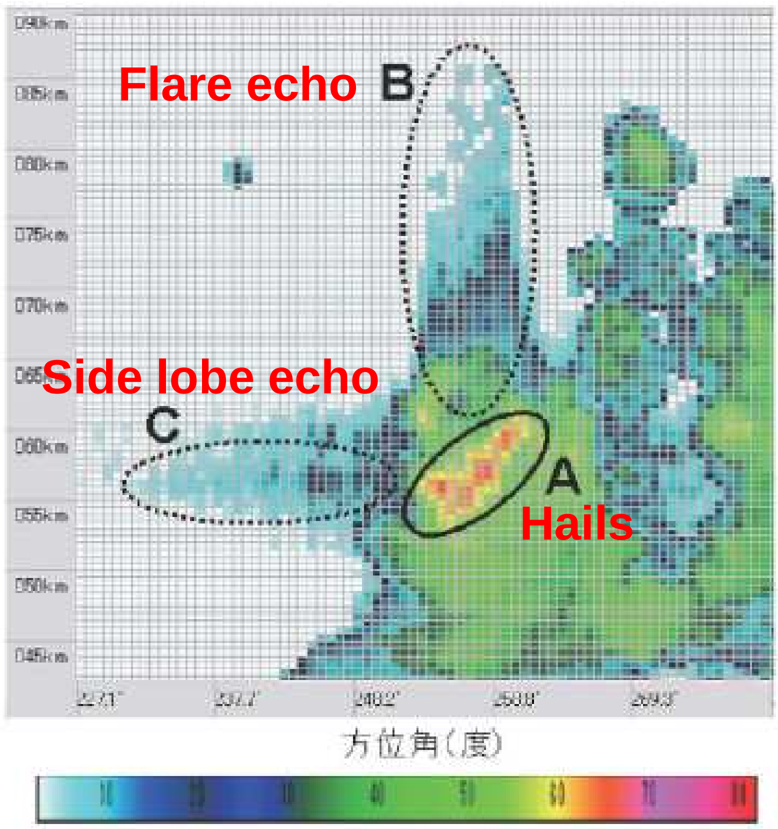


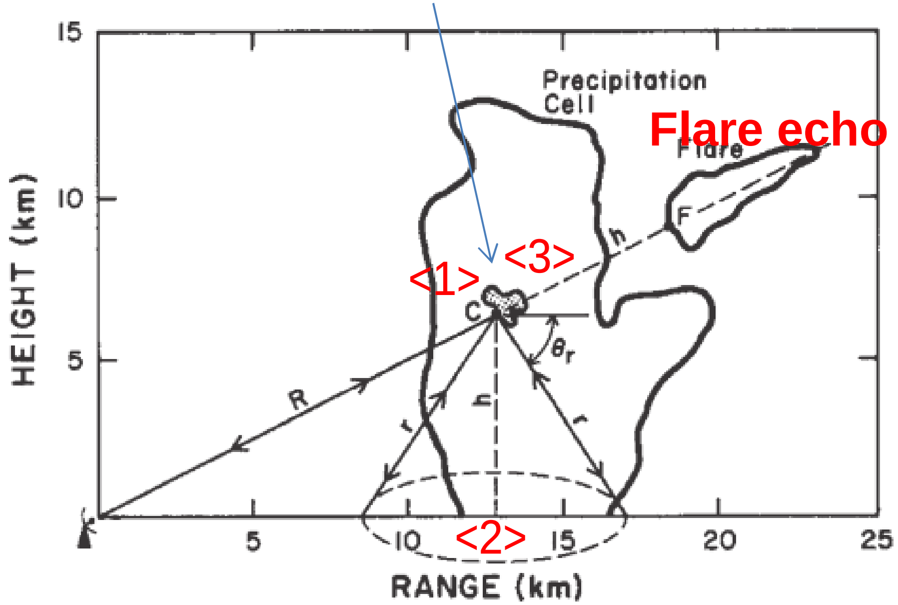

Figure 7.12. An example of second-trip echoes in reflectivity (left) and radial velocity (right) for a magnetron radar

Source: Guide to Meteorological Instruments and Methods of Observation, 2014, WMO

# Three-body scatter spike due to hails




Intense target for radars: **hails**




(Wilson and Reum 1988)

# Artificial non-precipitation target:

## - air planes, chaff, wind turbine, sky lift -

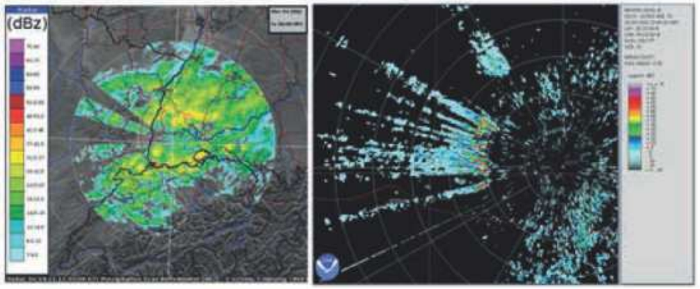



**Figure 7.23. The image on the left (courtesy of Deutscher Wetterdienst) shows blocking (west of the radar) by wind turbines, and the image on the right shows interference and multiple scattering effects of the turbines (courtesy of the National Oceanic and Atmospheric Administration).**

Source: Guide to Meteorological Instruments and Methods of Observation, 2014, WMO

| *Range* | *Potential impact* | *Guideline* |
|---|---|---|
| 0–5 km | The wind turbine may completely or partially block the radar and can result in significant loss of data that cannot be recovered. | Definite impact zone: Wind turbines should not be installed in this zone. |
| 5–20 km | Multiple reflection and multi-path scattering can create false echoes and multiple elevations. Doppler velocity measurements may be compromised by rotating blades. | Moderate impact zone: Terrain effects will be a factor. Analysis and consultation is recommended. Reorientation or resiting of individual turbines may reduce or mitigate the impact. |
| 20–45 km | Generally visible on the lowest elevation scan groundlike echoes will be observed in reflectivity Doppler velocities may be compromised by rotating blades. | Low impact zone: Notification is recommended. |
| > 45 km | Generally not observed in the data but can be visible due to propagation conditions. | Intermittent impact zone: Notification is recommended. |

# Natural non-precipitation target:
# - birds -

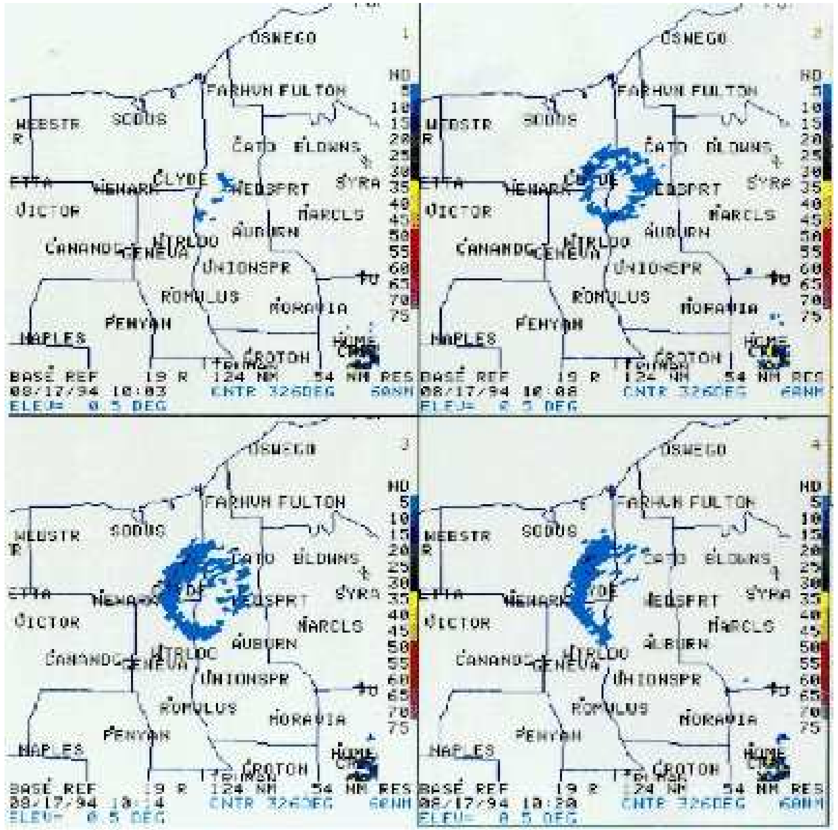


**Figure 1 - Ring shaped radar echo detected by doppler radar at NWSO Binghamton on 17 August 1994. Time of images are 1003Z, 1008Z, 1014Z, and 1020Z from top left to lower right, respectively.**

http://www.weather.gov/images/bgm/research/birds1997/fig2a1.jpg

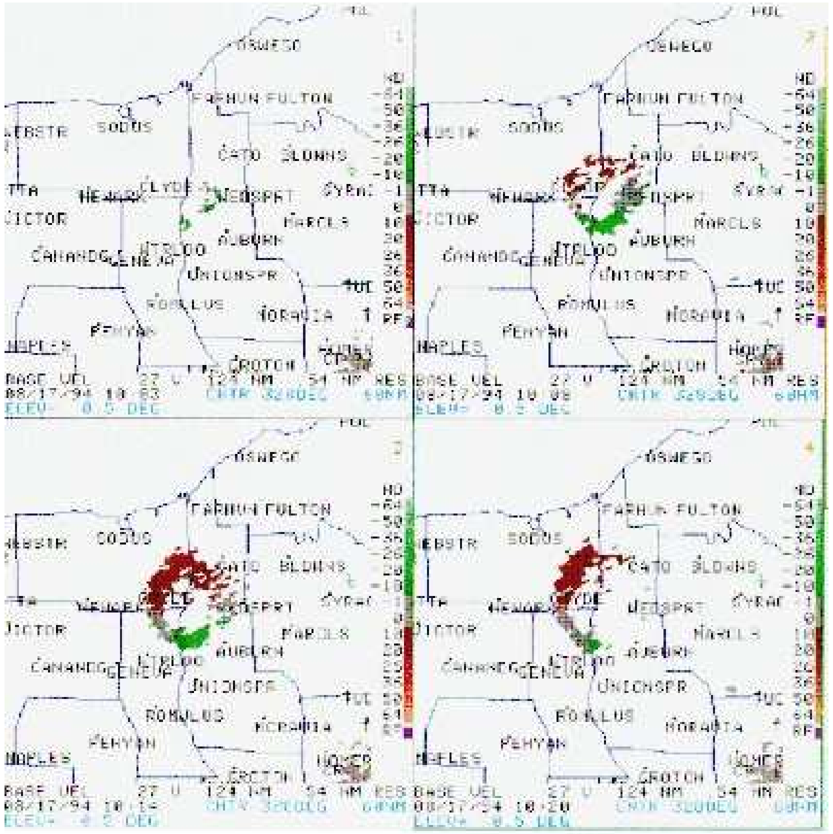


**Figure 2 - Divergent velocity signature of birds over Montezuma NWR detected by doppler radar at NWSO Binghamton on 17 August 1994. Red represent velocities away from the radar and green represents velocities toward the radar. Time of images are 1003Z, 1008Z, 1014Z, and 1020Z from top left to lower right, respectively.**

# Natural non-precipitation target:
# - volcano ash -

Source: NNN

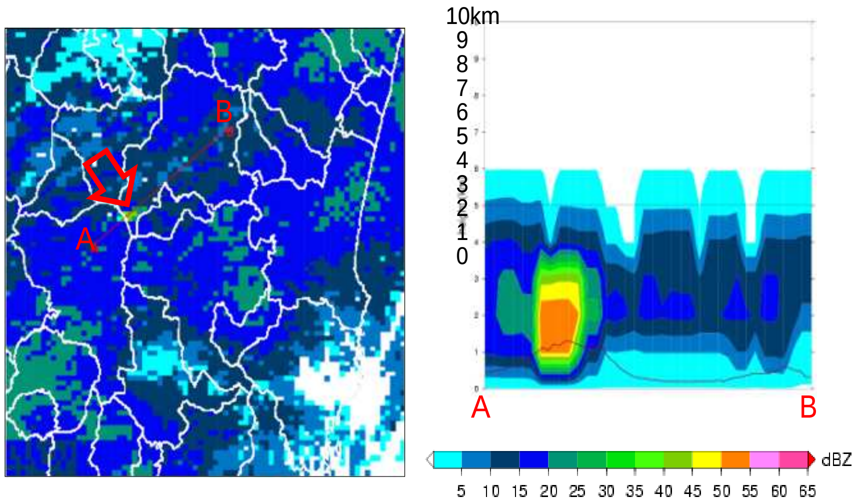
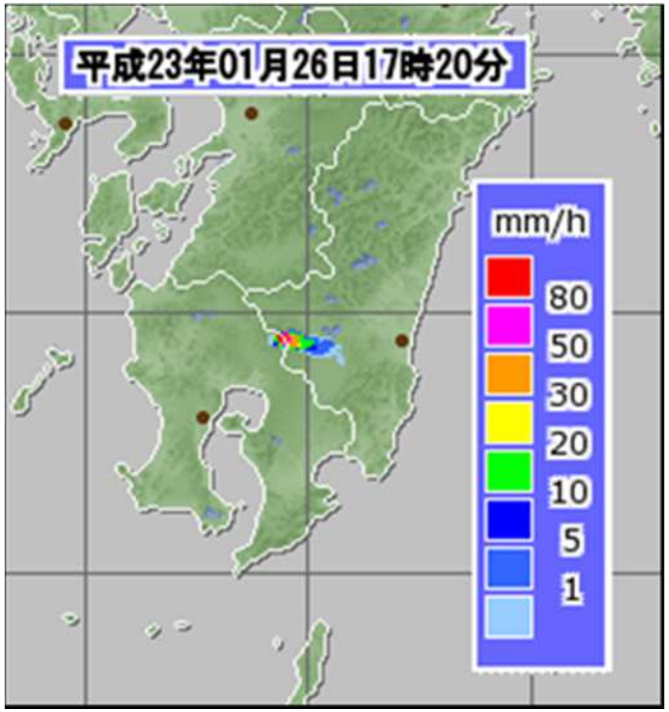
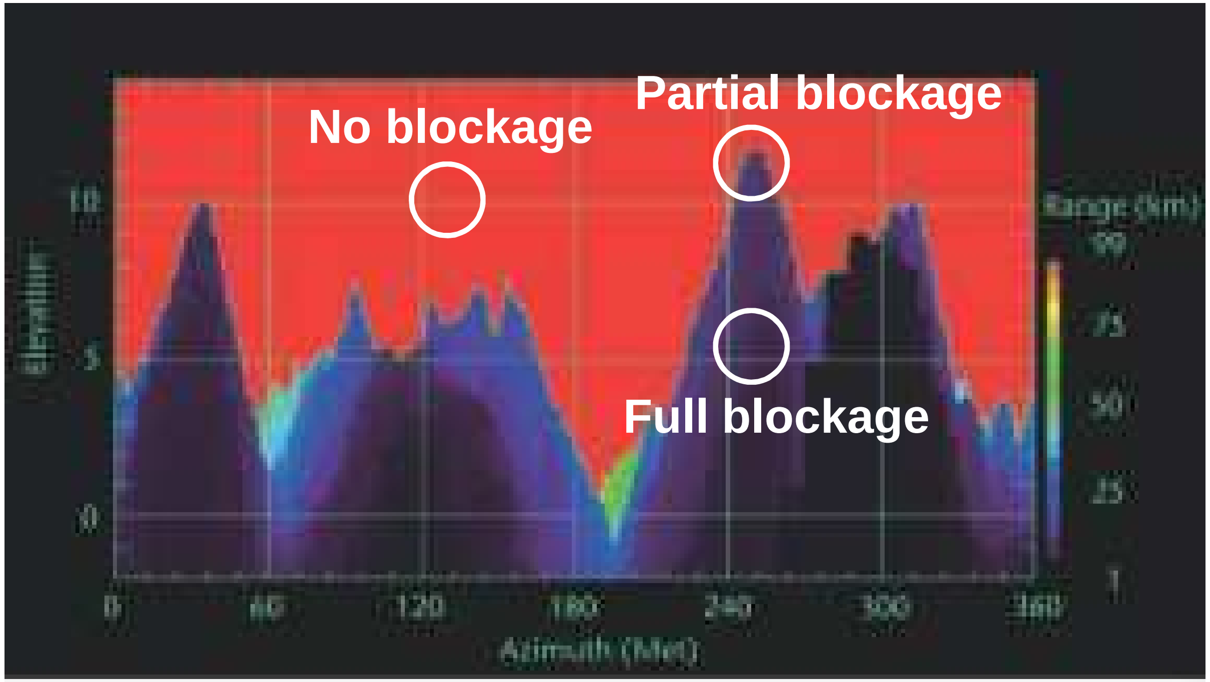



**図3. 層状エコーと噴煙エコーが混在する事例**
(2011/02/14 05:00-10**新燃岳噴火**)
**左**:3 km CAPPI, **右**:A-B**間鉛直断面**




Source: JMA

# Beam blockage due to mountains/buildings

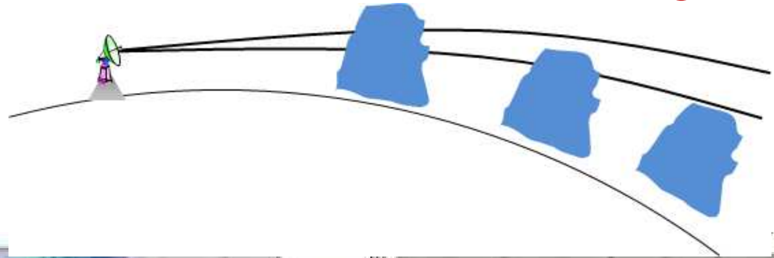



Partial blockage of a radar beam makes reduction of beam width $\theta$ , and then leads the fault reflectivity measurement.

**Reduced due to blockages**

$$P_r = \frac{\pi^3 P_t G^2 h \theta^2 |K|^2 \Sigma D^6}{1024 \log_e 2\, r^2 \lambda^2} \cdot 10^{-0.1L} \cdot 10^{-0.2 k_g \cdot r}$$

# Lack of beam filling



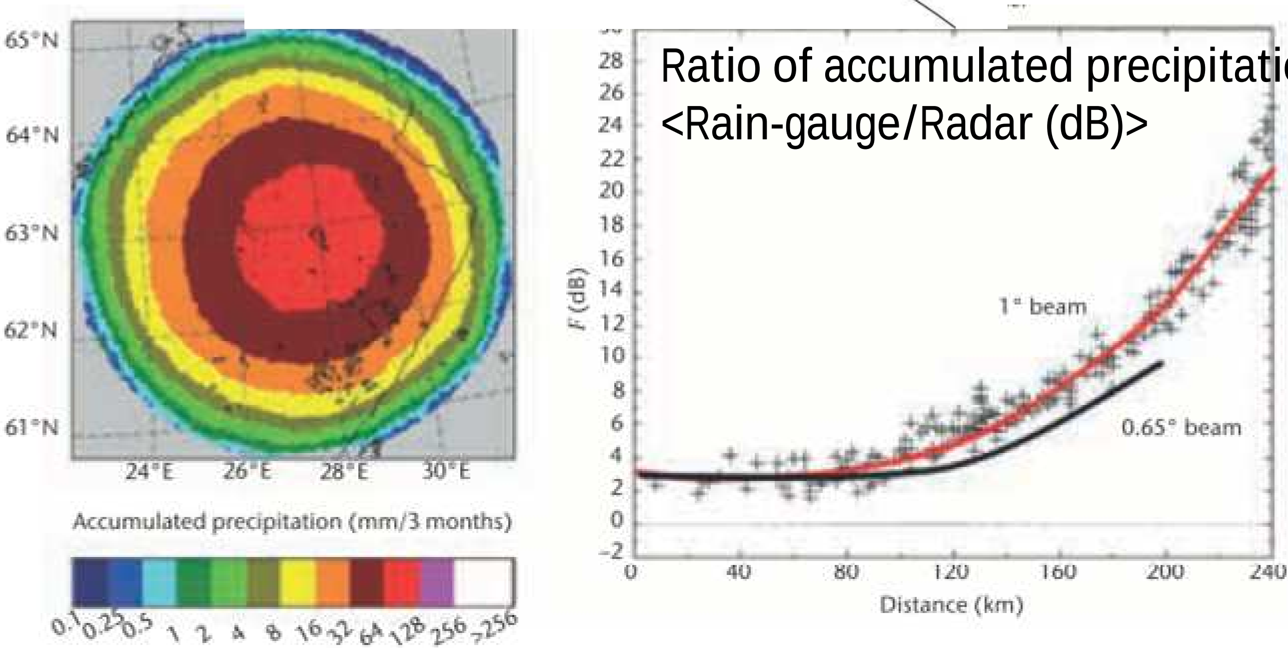



**Figure 7.33. This shows an accumulation of radar-derived precipitation over a winter season. The annular pattern is primarily due to the lack of beam filling at long ranges for shallow winter weather systems. The right image shows how this is reflected as a range bias with the radar–gauge comparisons (figure courtesy of Daniel Michelson of the Swedish Meteorological and Hydrological Institute using data from the Finnish Meteorological Institute).**

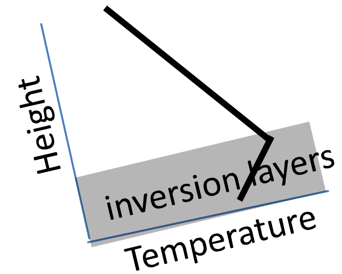
Source: Guide to Meteorological Instruments and Methods of Observation, 2014, WMO

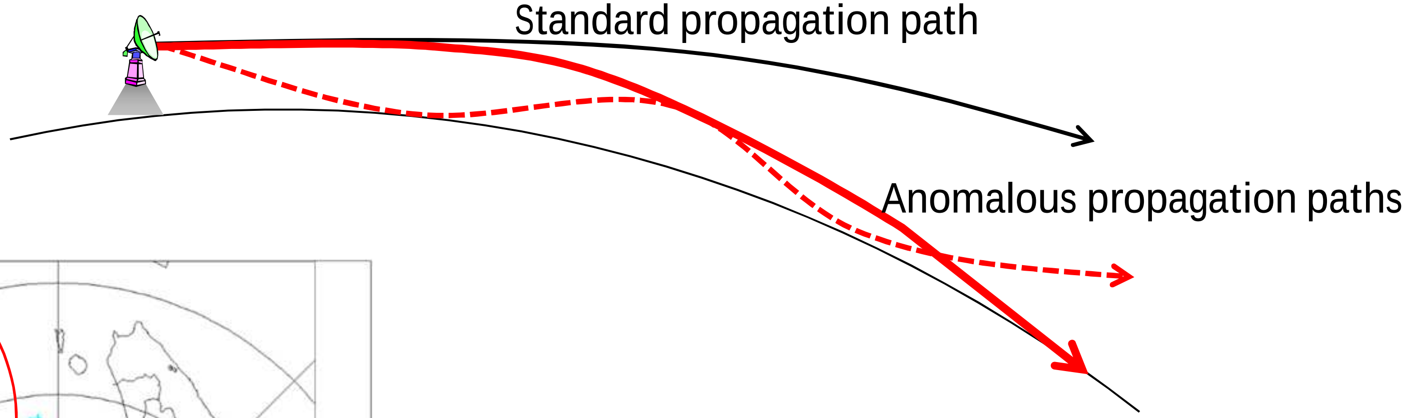
# Anomalous propagation: super-refraction, ducting

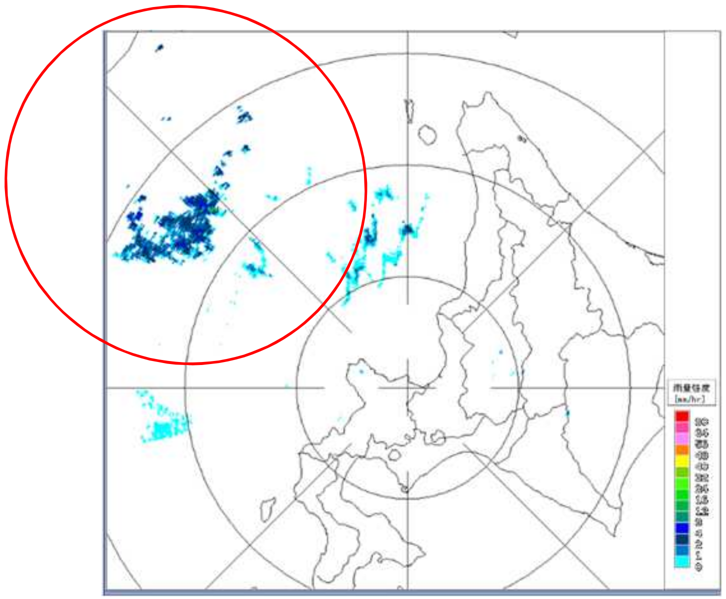
The propagation passage is greatly changed by certain causes; mainly by inversion layers near the surface and anomalous vertical profile of the refractive index of the air.

⇒ Radio waves propagate and finally hit the surface.

⇒ Radio waves are trapped in the layer and propagate longer distance.



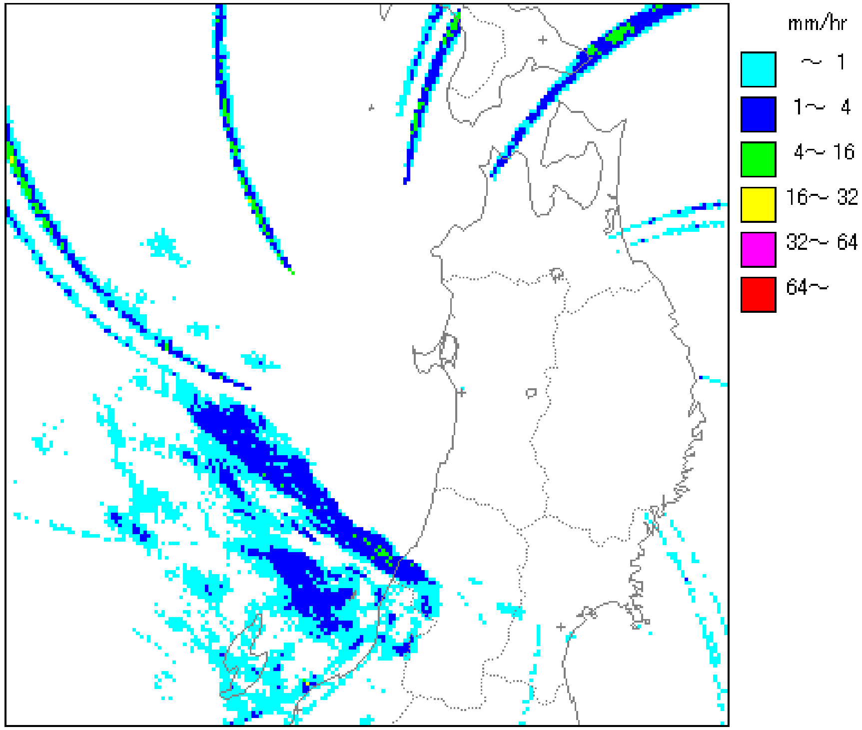
AP echo observed by Sapporo radar
Sep. 8, 2011 16:50(JST)

Causes of inversion layer

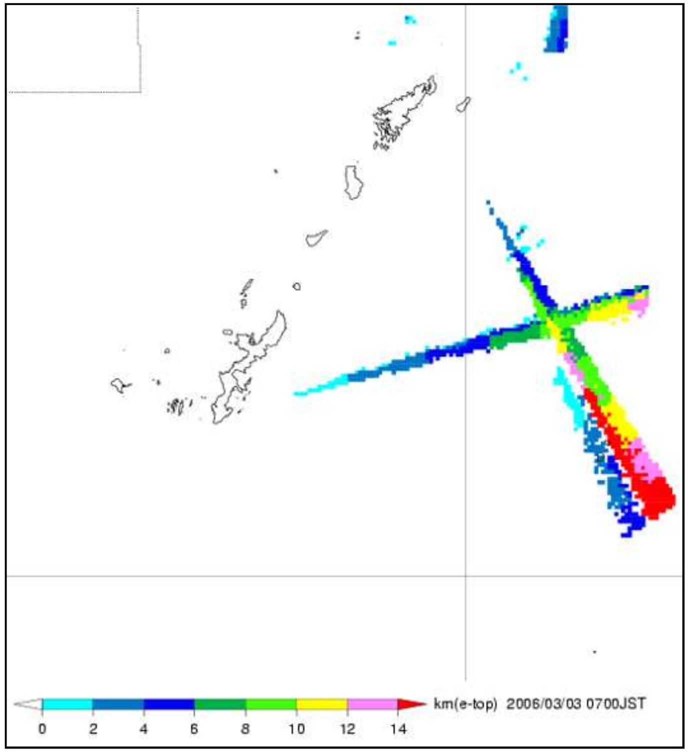
- ◯ Cold air advection near the surface
- ◯ Night cooling of the surface
- ◯ Down motion of air-mass
- ◯ Passage of a weather front
- ◯ Fog layer


22

# Electromagnetic interference




Interference with another rotating radar




Interference with continuous radio waves

# Interference with Radio Local Area Networks (RLANs)

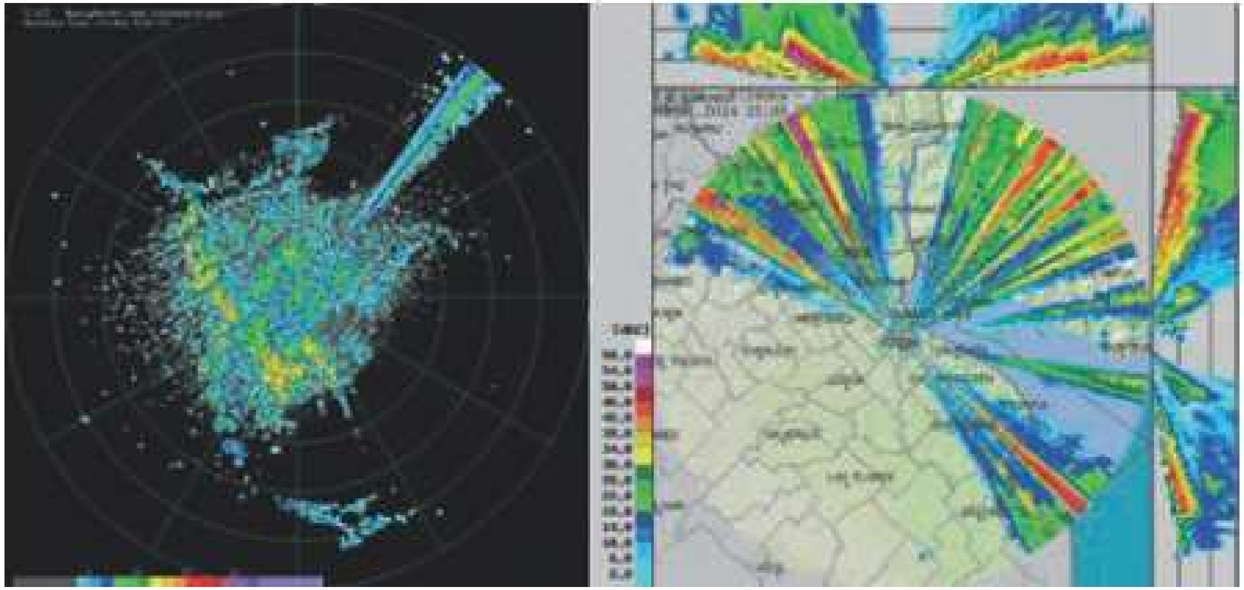


Figure 7.19. The image on the left demonstrates the type of expected interference from a Radio Local Area Network located 6.4 km away at 0.42° elevation angle. The image on the right is from an operational weather radar, courtesy of Claudia Campetella of the Servicio Meteorológico Nacional (Argentina).

Source: Guide to Meteorological Instruments and Methods of Observation, 2014, WMO

# Interference with Radio Local Area Networks (RLANs)

Electromagnetic interference from other radars or devices, such as Radio Local Area Networks (RLANs), is becoming increasingly significant, requiring substantial diligence to protect against it. Interference among adjacent radars is mitigated through the use of slightly different frequencies (but still in the same band) with appropriate filters on the transmitter and receiver.

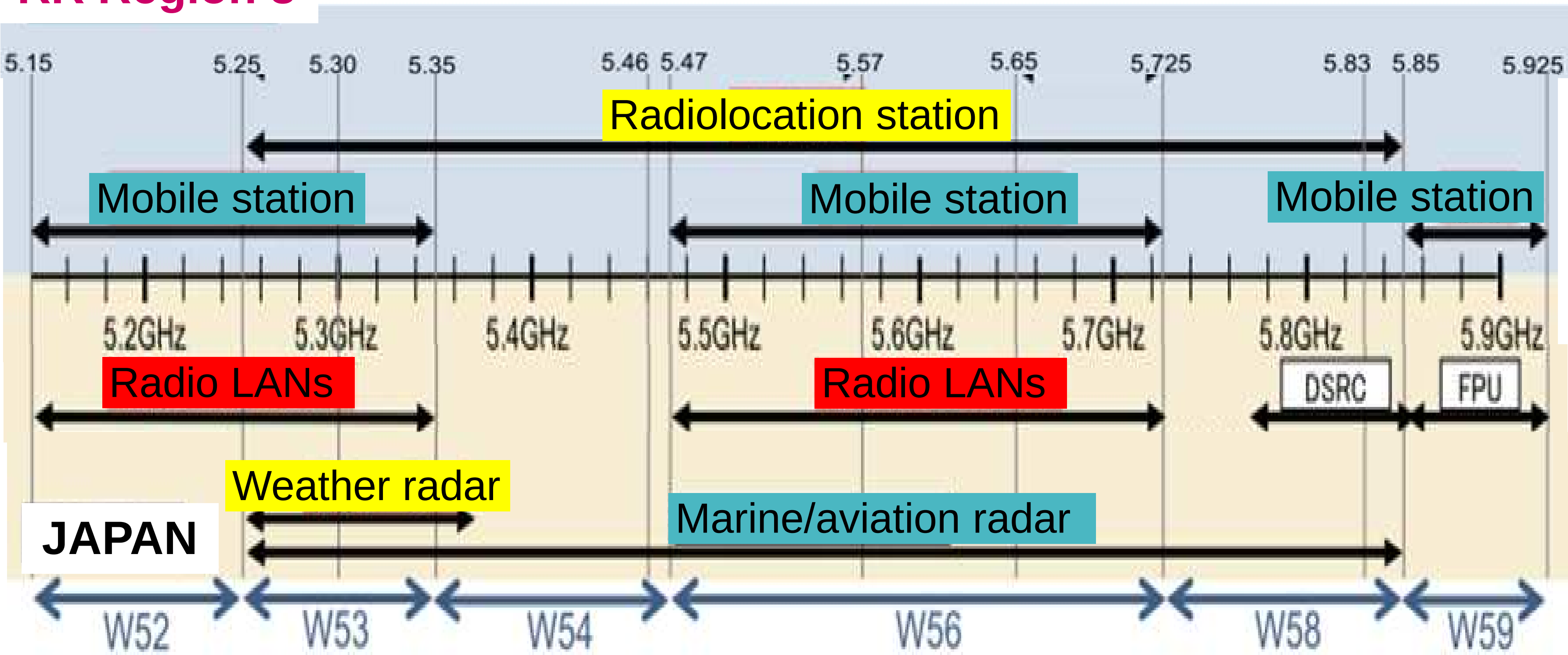
There may be occasional interference from airborne and ground-based C band radars using the same frequency.

Use of the electromagnetic spectrum is determined by agreement and managed through the International Telecommunication Union. At the World Radiocommunication Conference 2003, the C band frequencies were opened up to the telecommunication industry on a regulated secondary non-interfering non-licensed basis to be shared with the meteorological community. In order to be non-interfering, the RLAN devices are supposed to implement Dynamic Frequency Selection, which is designed to vacate a C band channel if a weather radar is detected. However, the algorithms used to detect the weather radar are not sufficient to prevent interference before they vacate the channel. The Doppler spectra of RLAN signals appear as white noise and can be removed with adaptive noise techniques. However, they increase the noise level and reduce the sensitivity of the weather radar where the RLAN is detected. WMO has issued guidance statements relating to the co-use of the C band frequencies.

Source: Guide to Meteorological Instruments and Methods of Observation, 2014, WMO

# Simplified
# Radio Regulations of International Telecommunication Union (RR ITU) around C-band weather radars

RR Region 3




- Radio LANs must monitor weather radar signal at the first one minute of their operation.
- If weather radar signal is received during their operation, radio LANs must shift their frequency bands.

# Thank you

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