Quality control of weather radar data by using dual-polarization

7 February 2018

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- Quality control using dual-pol data
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Principle of dual-polarization weather radar

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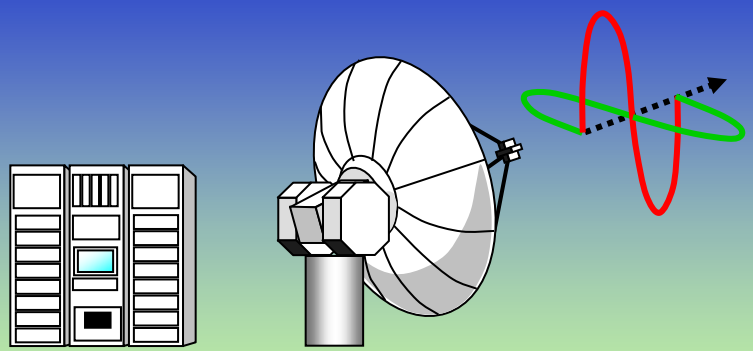
- Basic scheme of polarimetric radar
  - Quality control
  - Rain rate estimation
  - Hydrometer classification
- Dual-pol data
  - Zdr, ρhv, Φdp (Kdp)
  - Textures (S(Φdp))

Basic scheme of dual-pol radar

Merits:

- Quality control
- Rain rate estimation,
- Hydrometeor classification



Transmitting and receiving both horizontally (H) and vertically (V) polarized wave


Ice crystal / Snow

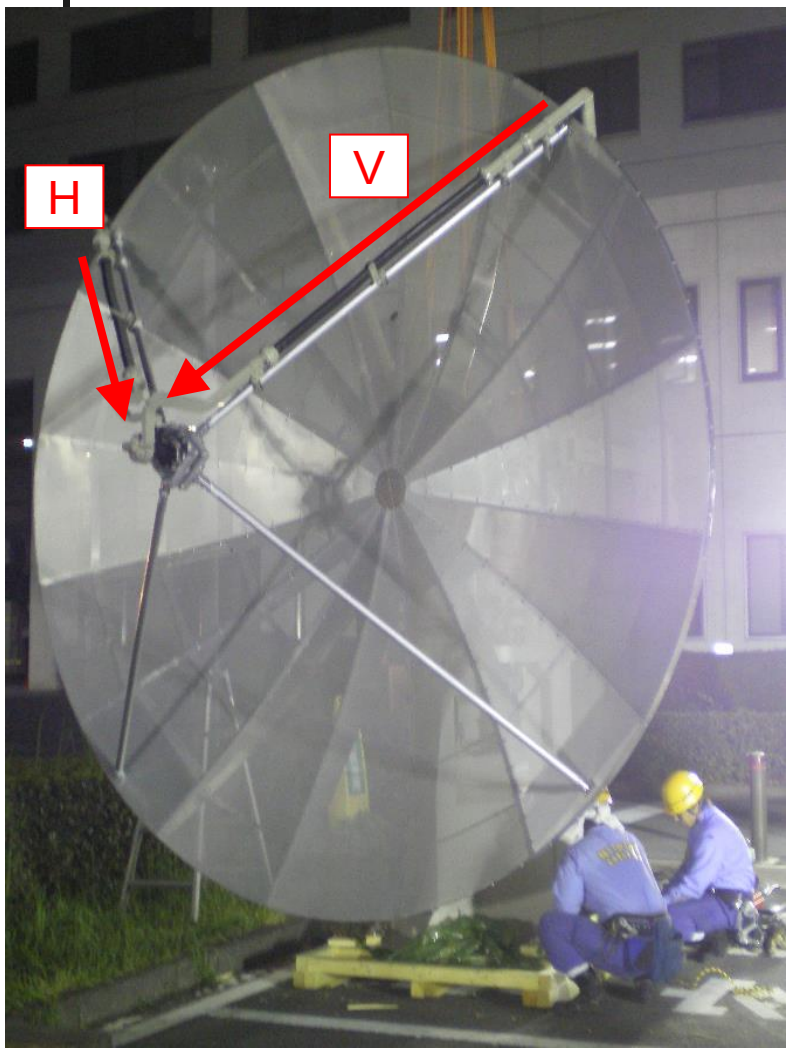

Graupel


Hail


Rain drop

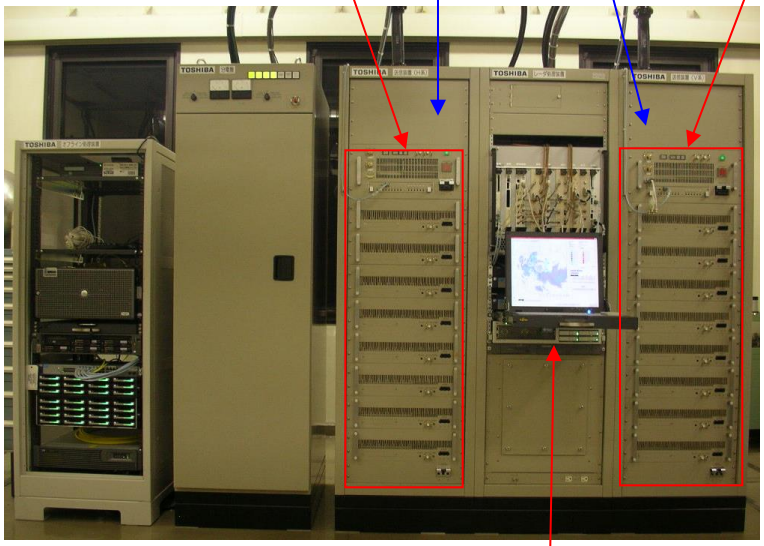

Large rain drop

Basic scheme of dual-pol radar



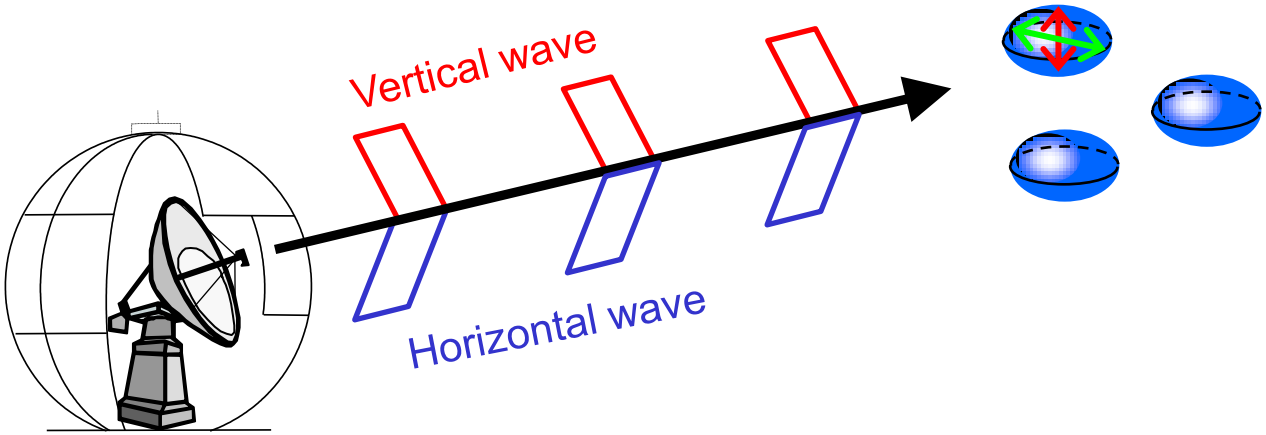
Antenna

- Two receivers for H & V
- Two transmitters or single transmitter which output wave is divided to H & V
- Isolation between H & V is crucially important

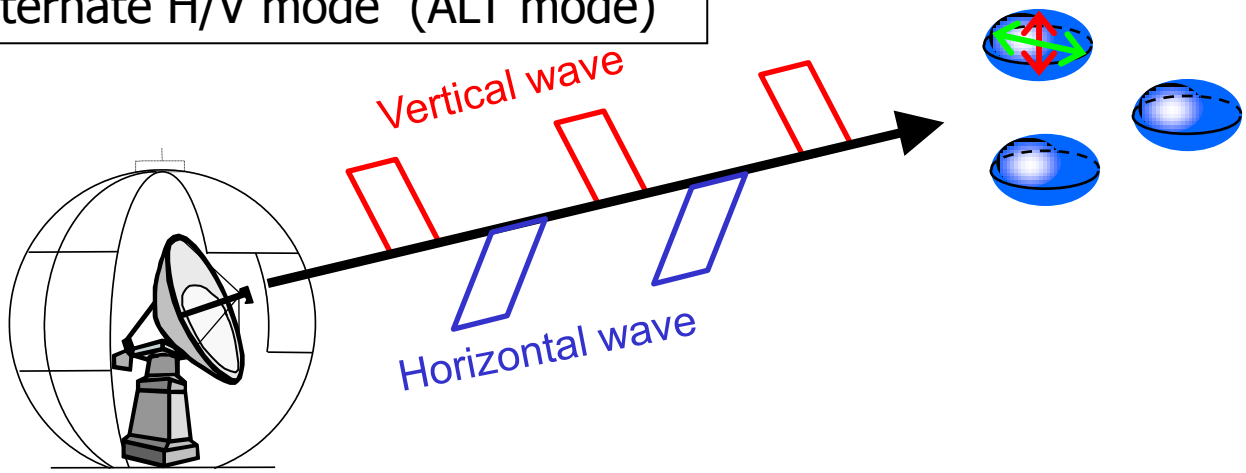


Two observation mode

Simultaneous Transmitting and Receiving mode (STAR or Hybrid mode)



Alternate H/V mode (ALT mode)



Dual-pol data

Conventional Doppler weather radar

Observed parameter
Reflectivity Z
Doppler velocity V
Velocity width W

&

Derived texture
S(Z)
S(V)
S(W)

+

Dual–polarization weather radar

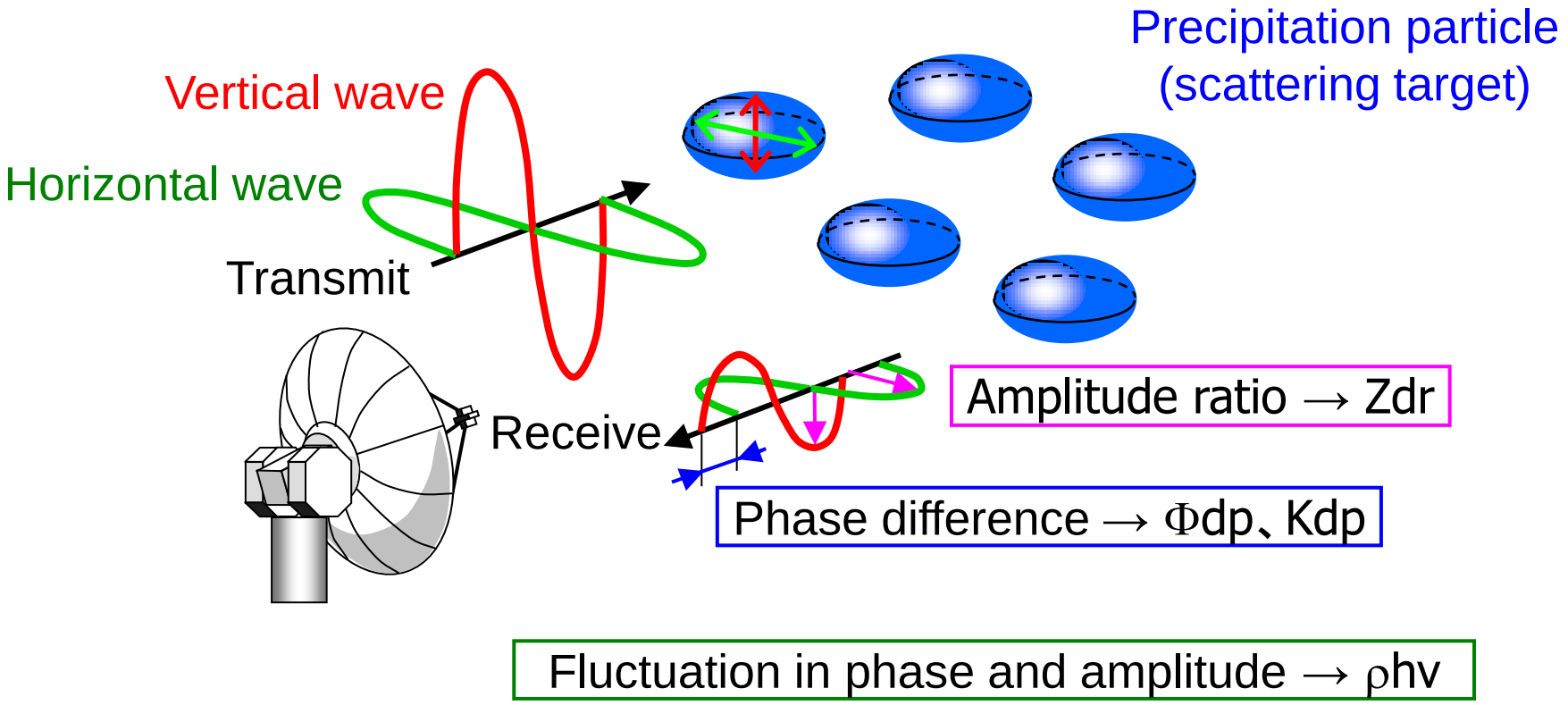
Observed parameter
Differential reflectivity Zdr
Correlation coefficient ρhv
Differential phase Φdp

&

Derived texture
S(Zdr)
S(ρhv)
S(Φdp)

Spatial derivative
Specific differential phase Kdp

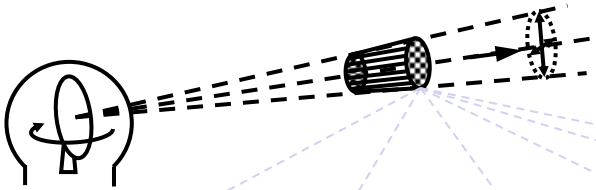
Dual-pol data



Zdr: Differential reflectivity

Courtesy of Mr. Umehara

- Z_{DR} : Shape of particle
  - Ratio between horizontal and vertical reflectivity factor.
  - Reflects aspect ratio of scattering targets.
  - Possible range of values : generally -4 to 10 (dB)
  - Useful for Rain rate estimation and hydrometeor classification

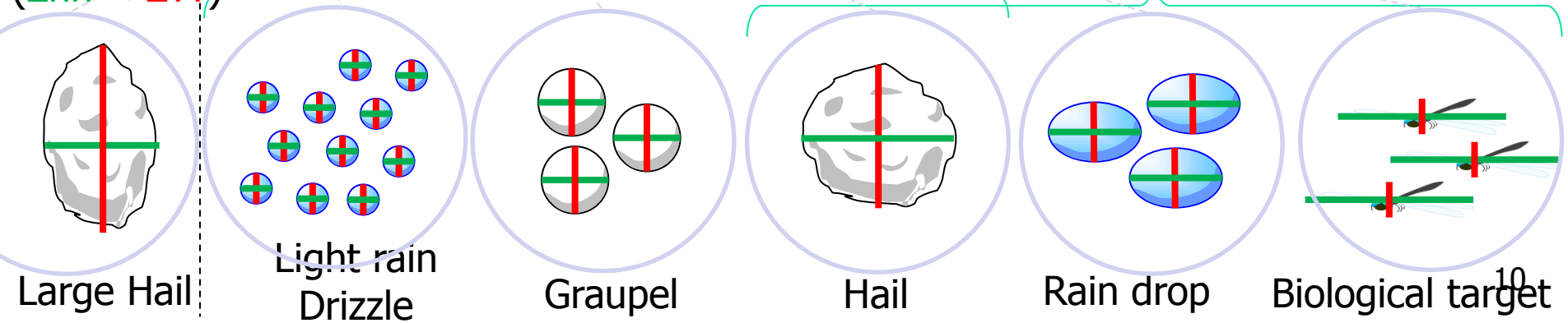


$$\mathrm{Zdr} = 10\log_{10}\left(\frac{Z_{hh}}{Z_{vv}}\right)$$

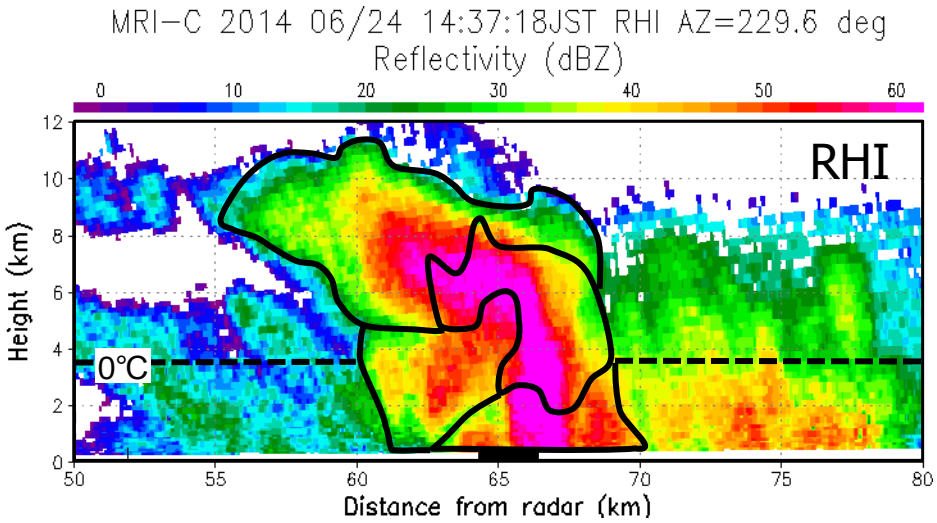
Negative (Zhh < Zvv)

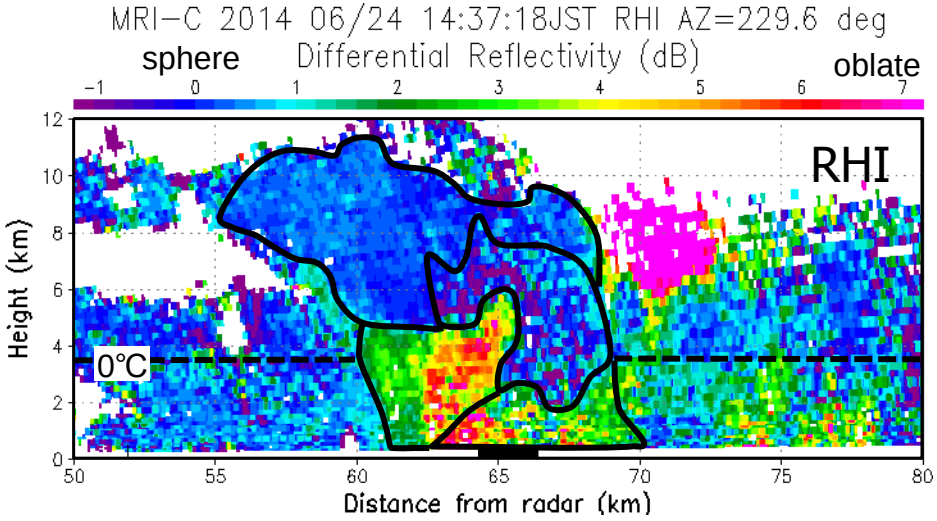
Close to zero (Zhh=Zvv)

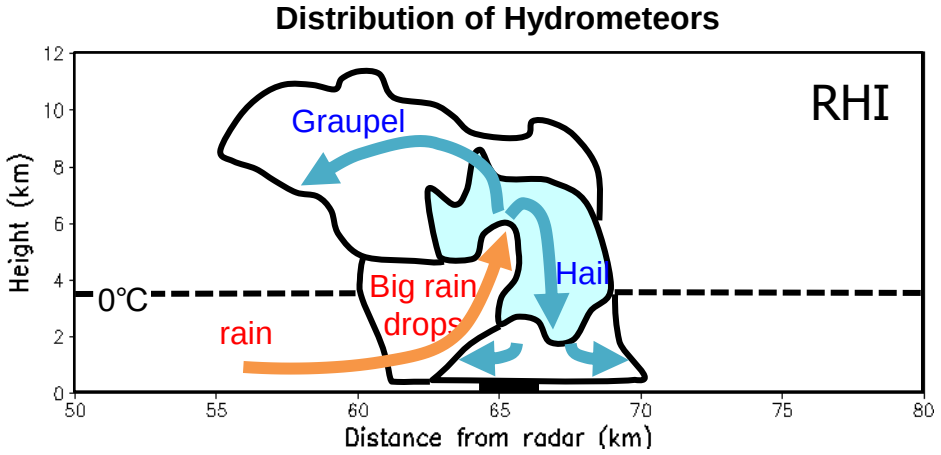
Positive (Zhh>Zvv)



Zdr: Differential reflectivity

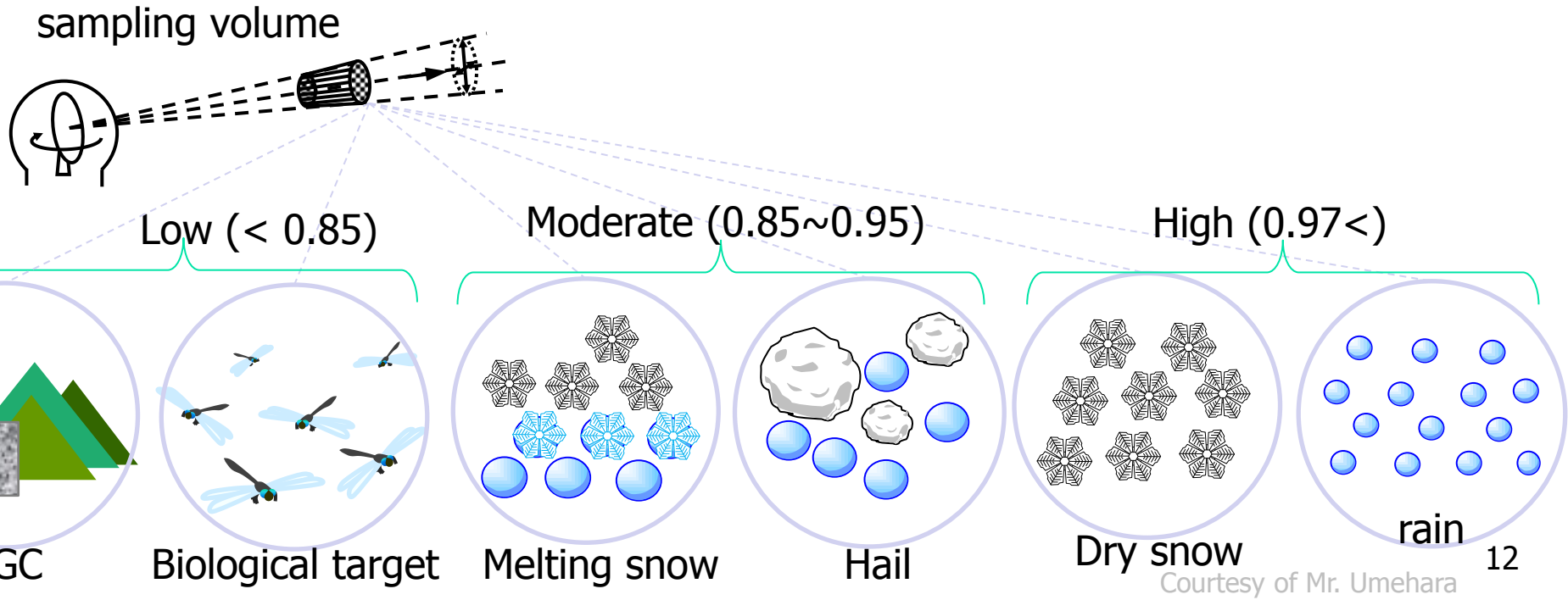






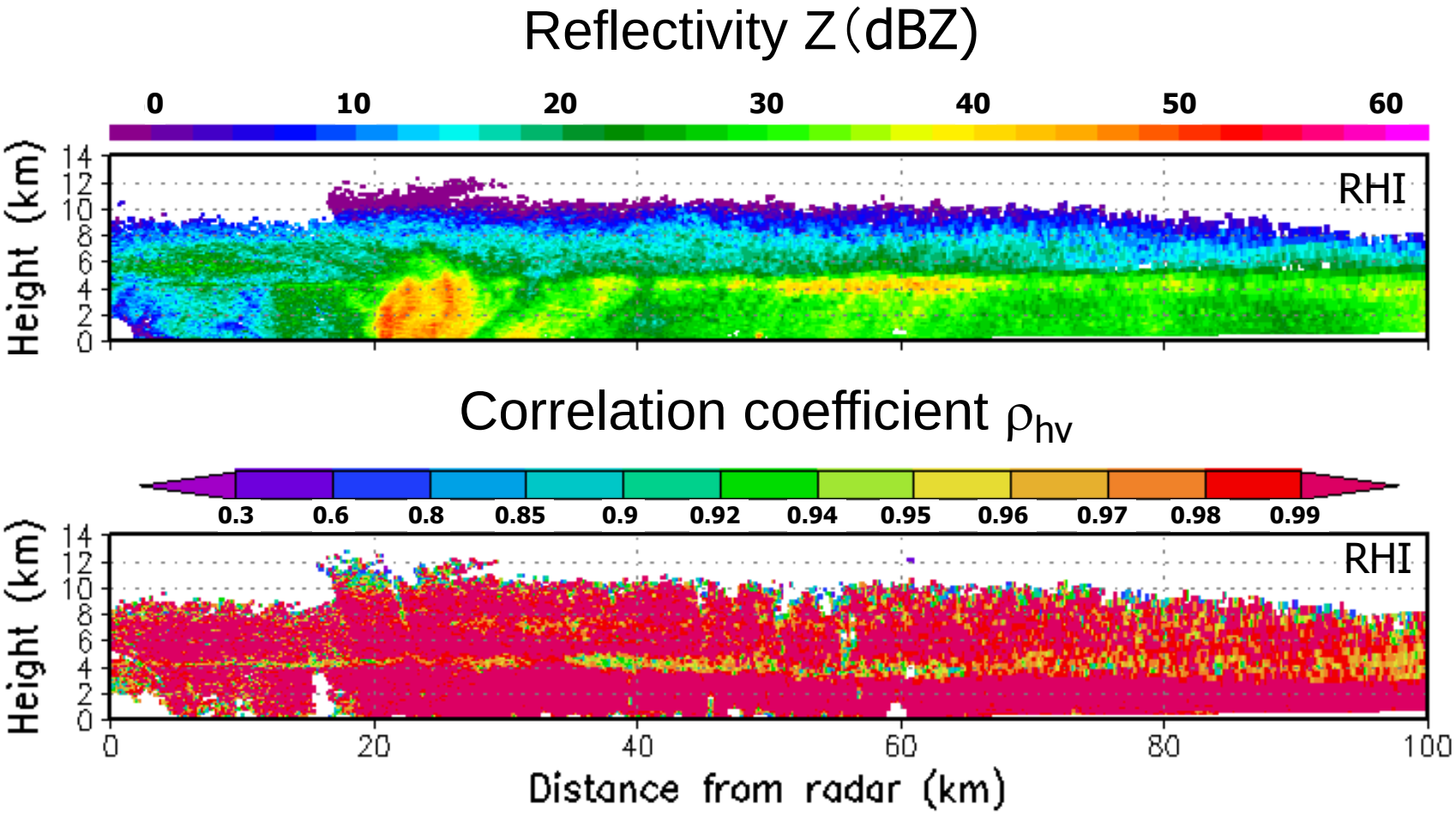
ρhv: Correlation coefficient

- ρ_{hv}: Diversity in shape
  - Correlation coefficient between horizontal and vertical signal.
  - Reflects diversity of scattering targets within a bin.
  - Possible range of values : 0 to 1 (none units)
  - Useful for hydrometeor classification and QC



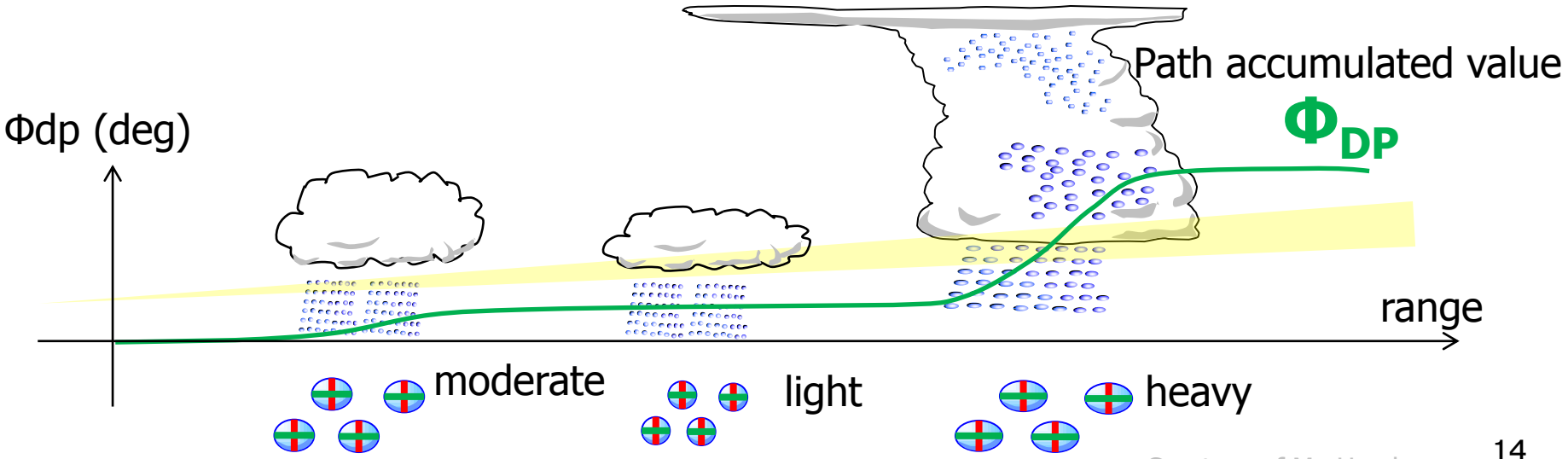
Courtesy of Mr. Umehara

ρhv：Correlation coefficient



Φdp: Differential phase

- Φ_{DP}: Rain rate / Water content
  - Phase difference between horizontal and vertical signals.
  - Reflects aspect ratios of precipitation particles on the beam path.
  - Possible range of values : folded in -180 to180 deg (0 – 360 deg)
  - In weather echo, monotonically increasing with range (continuous)
  - Not affected by rain attenuation



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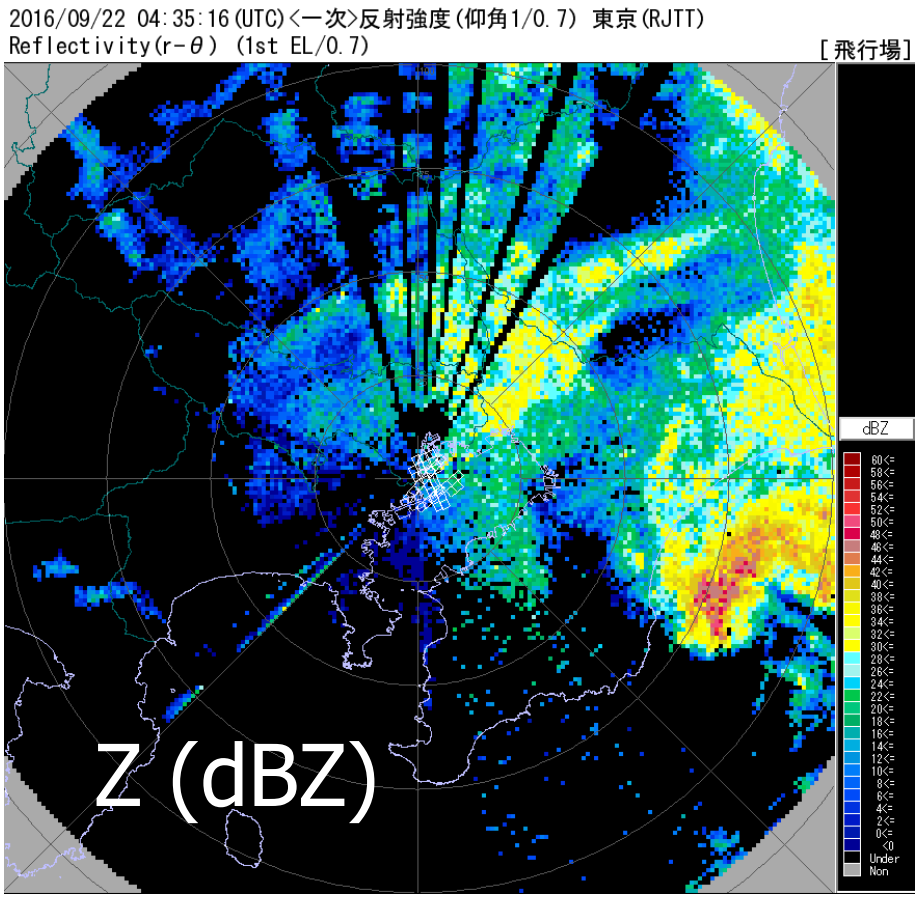
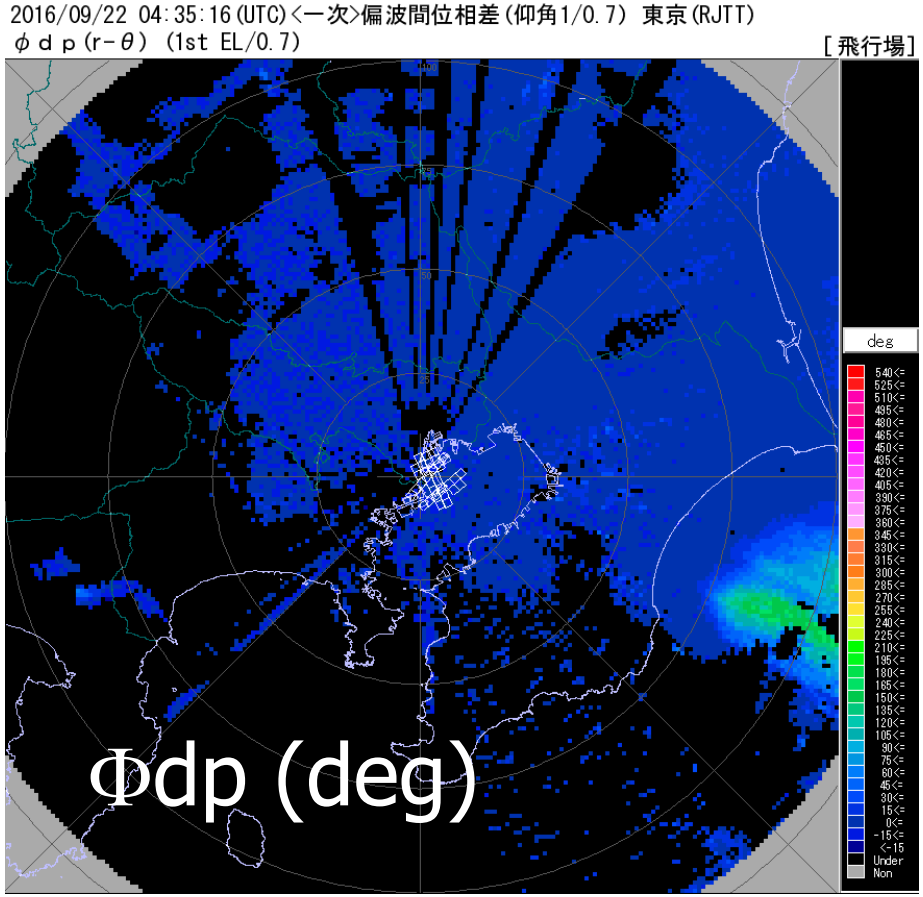
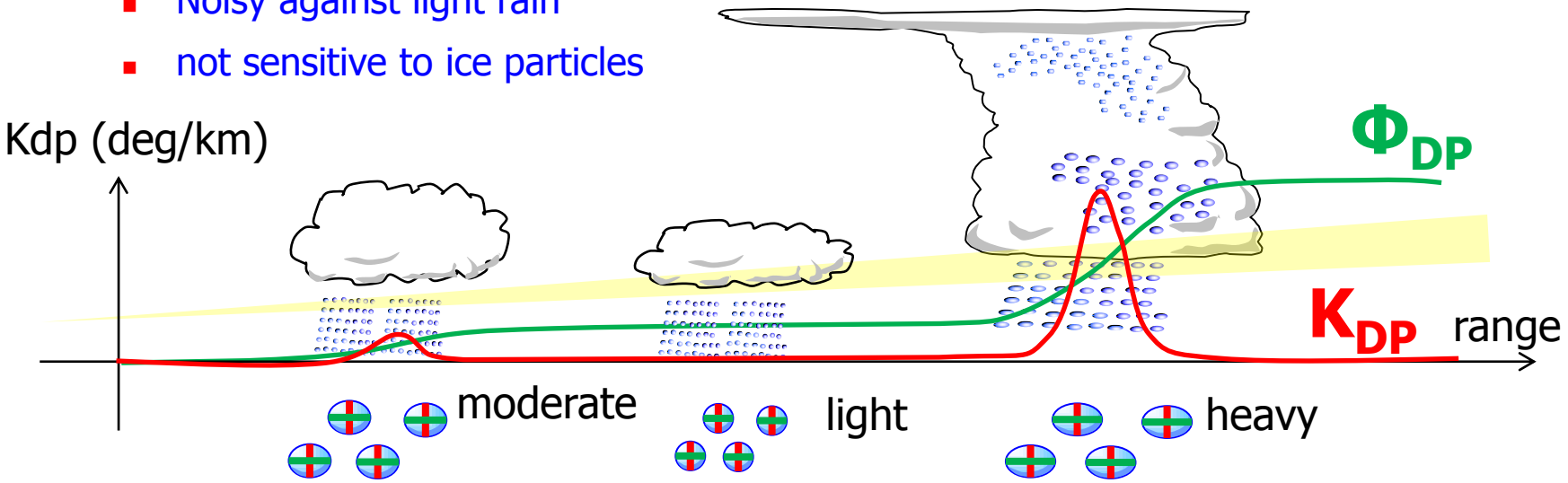
Φdp: Differential phase





Kdp: Specific differential phase

- K_{DP}: Rain rate / Water content
  - Change of Φ_{DP} in a unit distance
  - Reflects aspect ratios of precipitation particles on the beam path.
  - Possible range of values : generally -2 to 10 (deg/km)
  - Not affected by rain attenuation
  - Useful for rainfall rate estimation (especially for heavy rain)
  - Noisy against light rain
  - not sensitive to ice particles



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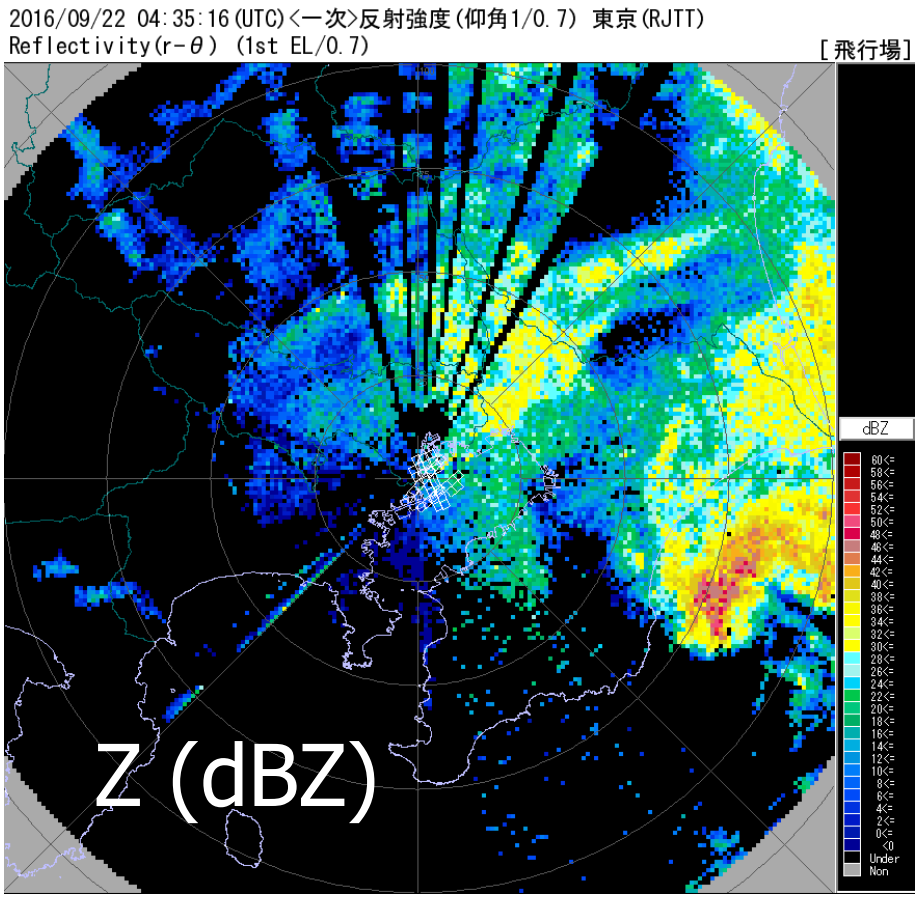
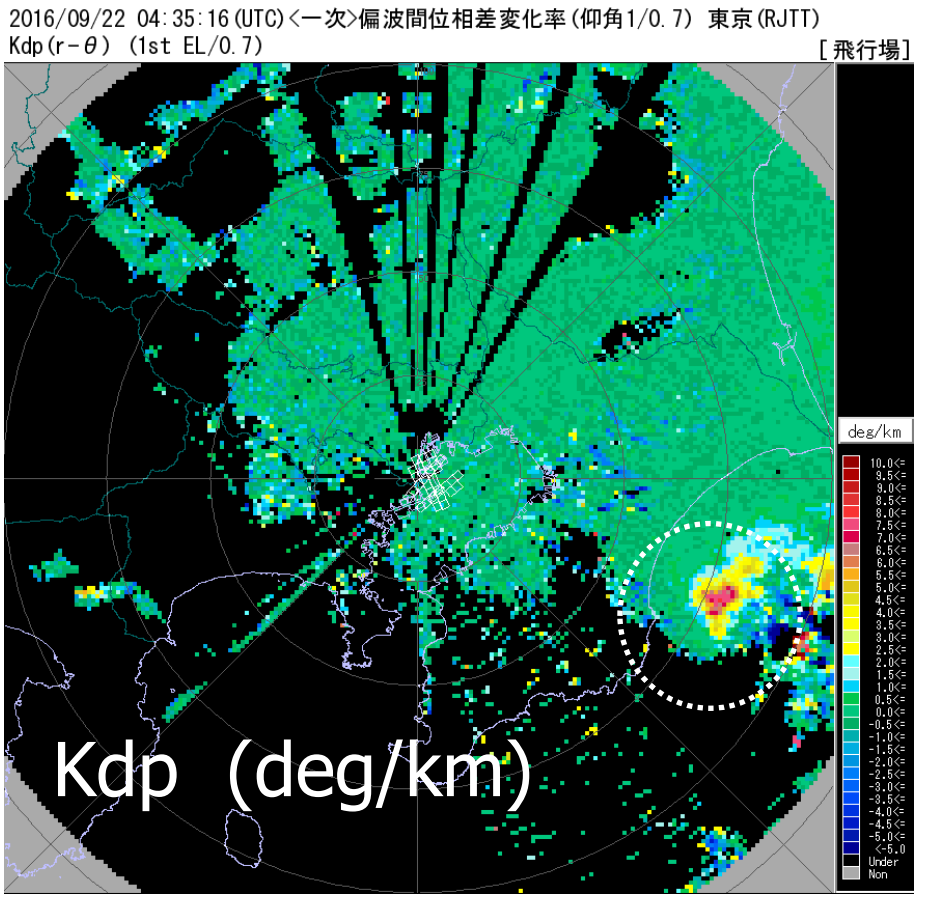
Kdp: Specific differential phase

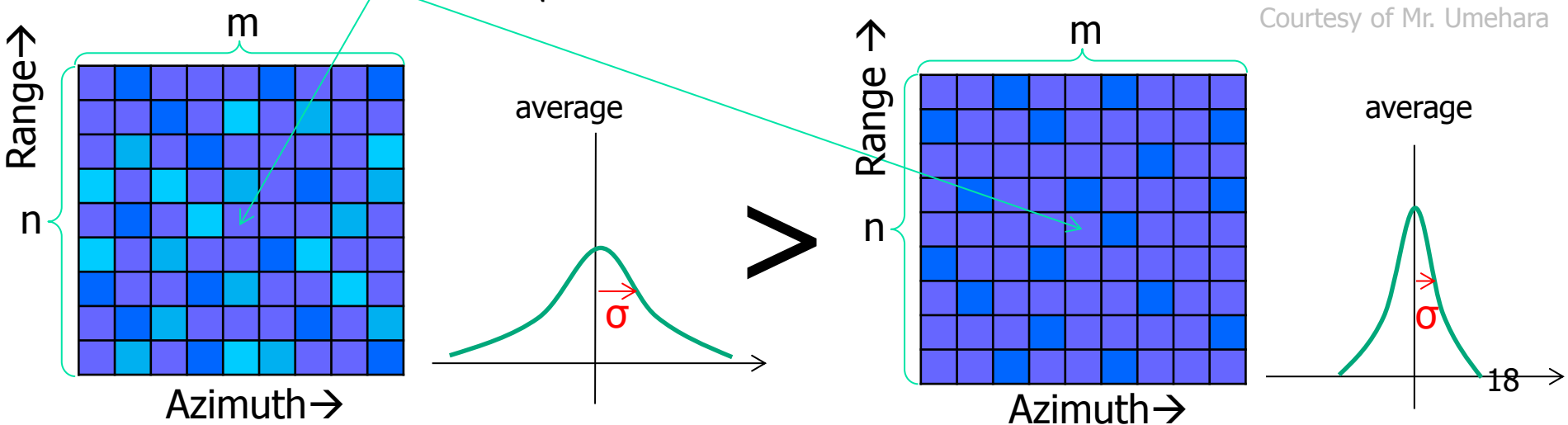




Textures of dual-pol data

- Texture : Spatial Fluctuation
  - Generally defined as standard deviation parameters
  - Reflects the roughness of the value distribution
  - Reflects the characteristics of targets (depends on parameter)
  - Useful for QC and hydrometeor classification

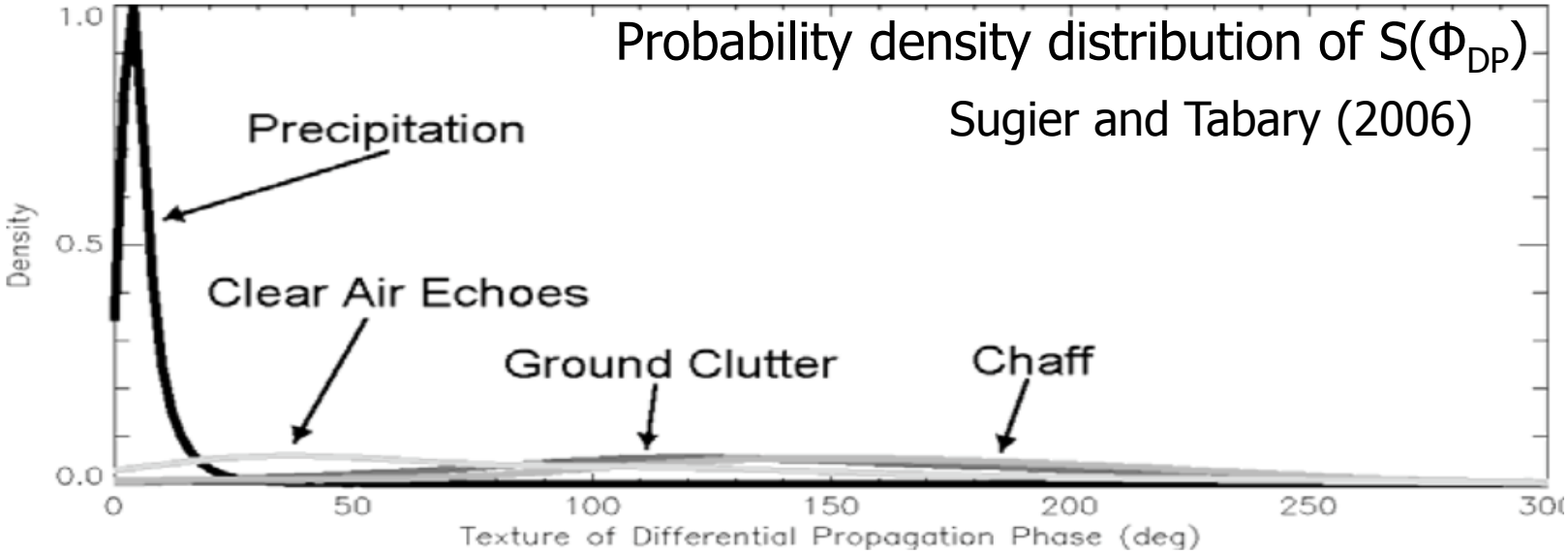
$$Texture(X_{a,b}) = \sqrt{\frac{\sum_{i=-(m-1)/2}^{(m-1)/2} \sum_{j=-(n-1)/2}^{(n-1)/2} \left(X_{a,b} - X_{a+i,b+j}\right)^2}{mn}}$$



Courtesy of Mr. Umehara

$S(\Phi_{DP})$: textures of Φ_{DP}

- $S(\Phi_{DP})$: Standard deviation of Φ_{DP}
  - Reflects sparseness or non-uniformity of scattering targets within sampling volume
  - Possible range of values : larger than 0
  - Can clearly indicates precipitation echo
  - Useful for hydrometeor classification and QC



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Dual-pol data

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