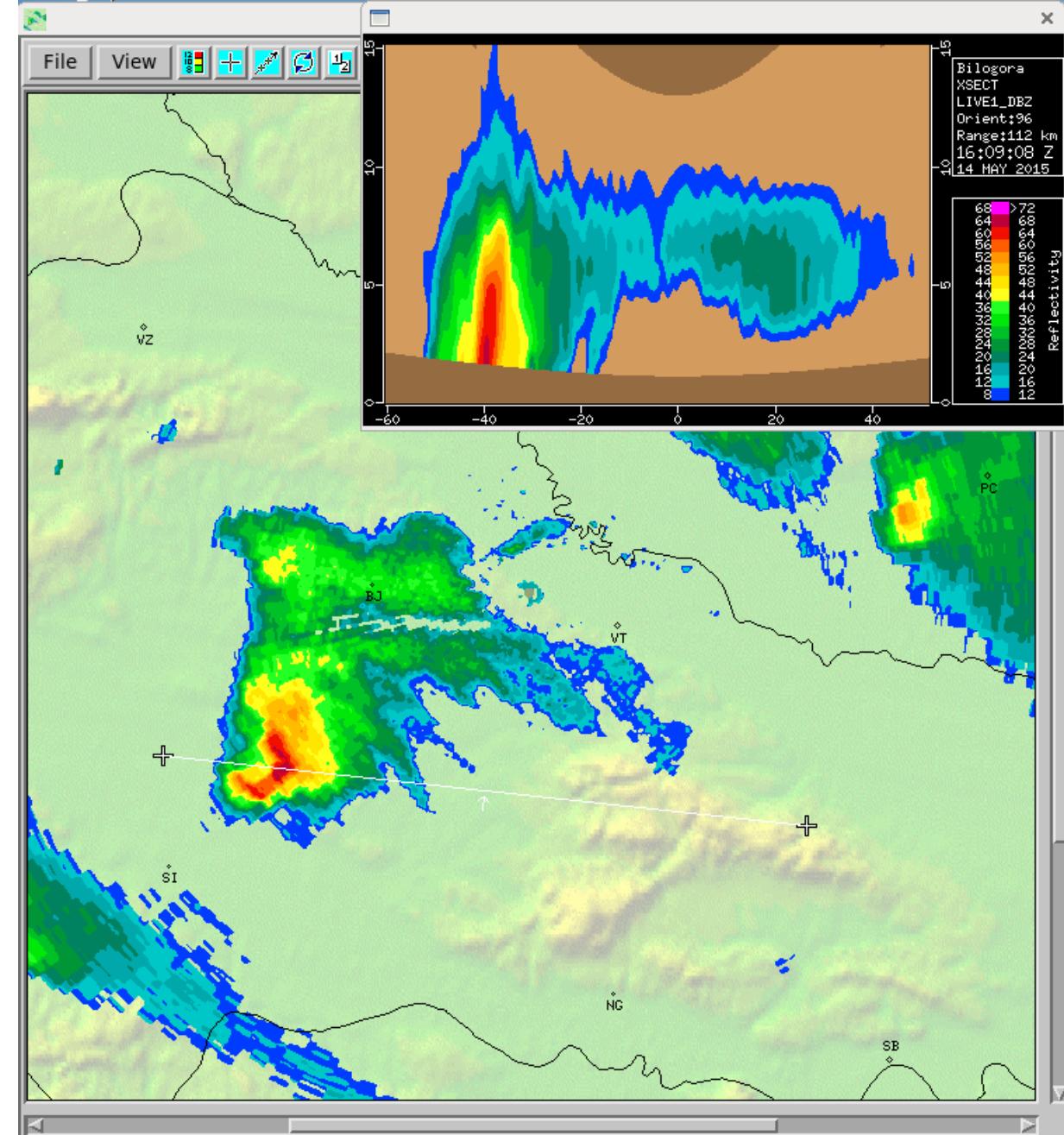


Meteorološki radari, pogreške i problemi mjerenja

Dr Bojan Lipovšćak

bojan@lipovscak.com
lipovscak@cirus.dhz.hr



Meteorološki radari

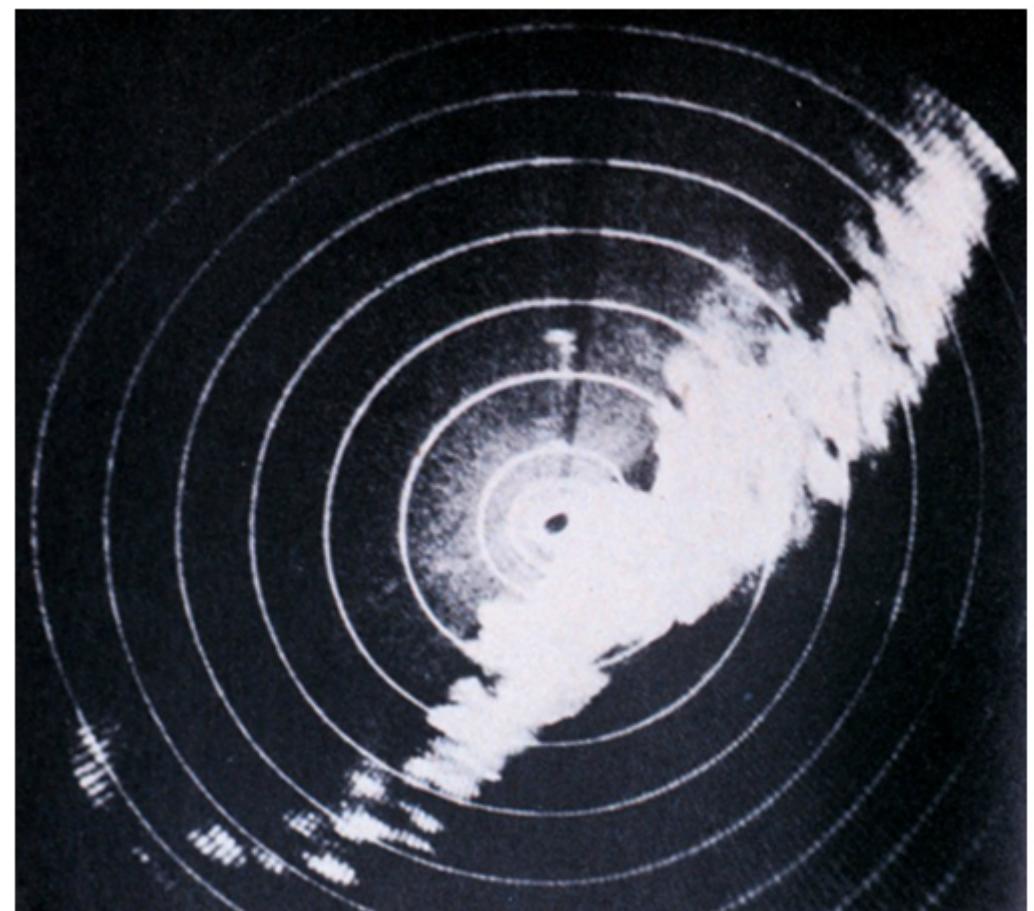
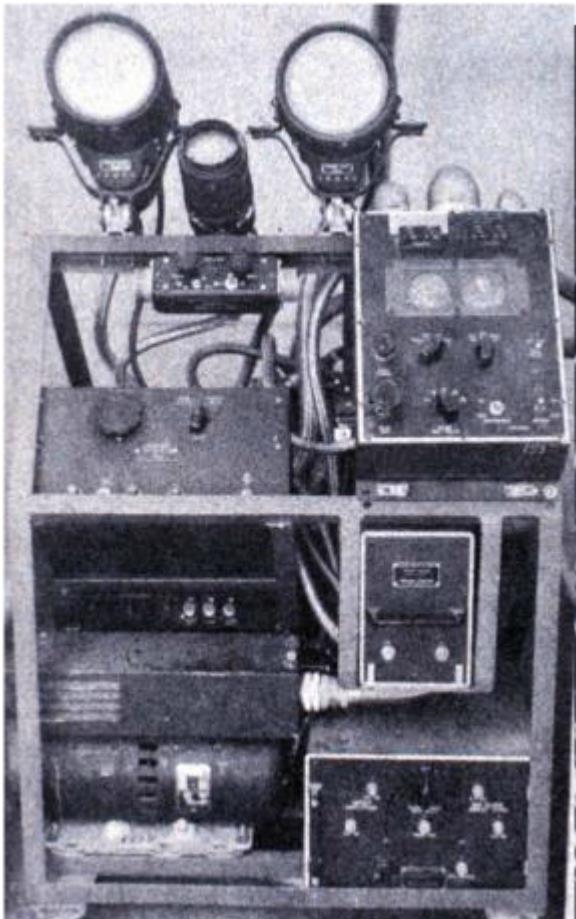
sadržaj

- radari
- smetnje
- geometrija
- problemi pri mjerenuju



RADAR

- RAdio Detection And Ranging.



RADAR

1865 J. C. Maxwell

1886 H. R. Hertz

1897 G. Marconi

1904 C. Hülsmeyer „Telemobiloskop”

1917 N. Tesla

1921 Magnetron A. W. Hull

1922 A. H. Taylor i L.C. Young drveni brod

1930 L. A. Hyland zrakoplov.

1931 W. A. S. Butement i P. E. Pollard brodski radar

1933 R. Kühnhold od 1938 proizvodi "Freya radar"

1935 R. A. Watson-Watt i A.F. Wilkins 10 km domet zrakoplovi

1936. Klystron - General Electric .

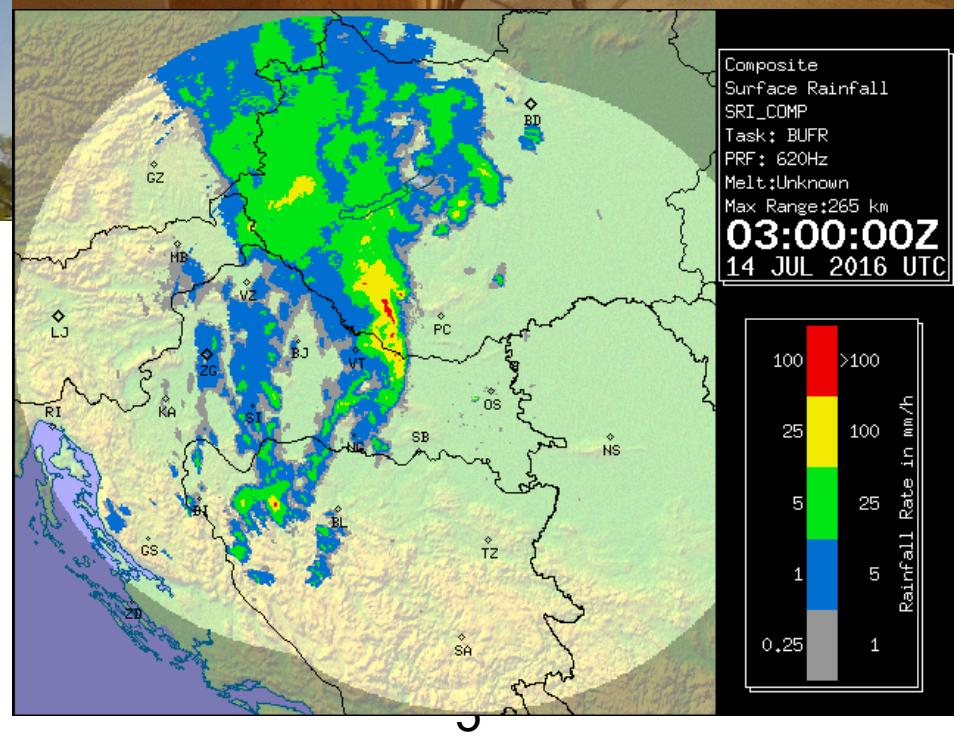
1939 T. Randall i H. A. Howard Boot radar na zrakoplov

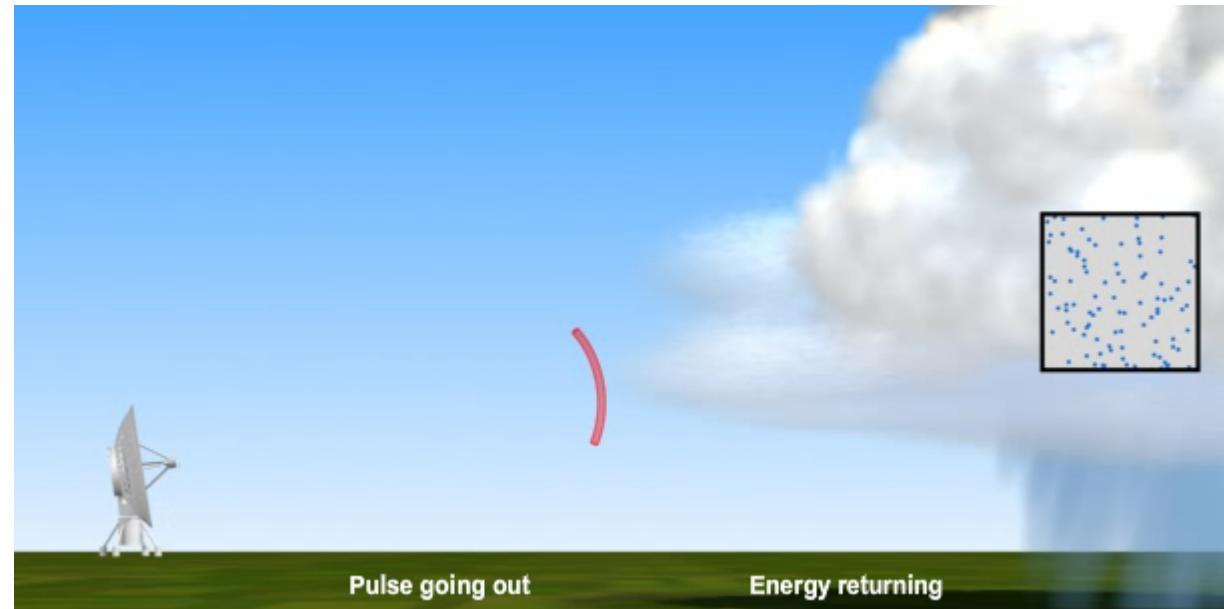
1940 radari





HAZ





radarski volumen = valjak

“Cone of silence”

short range

long range

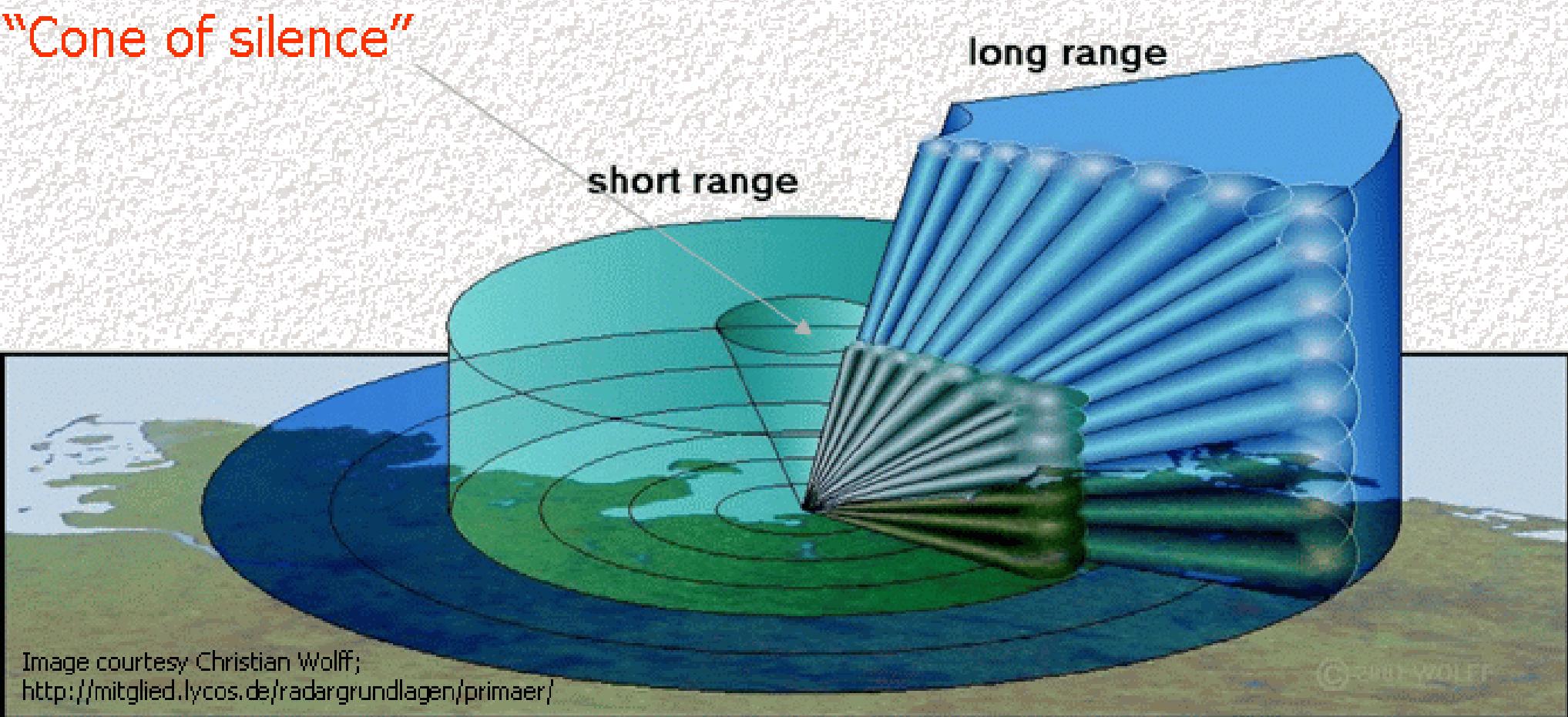
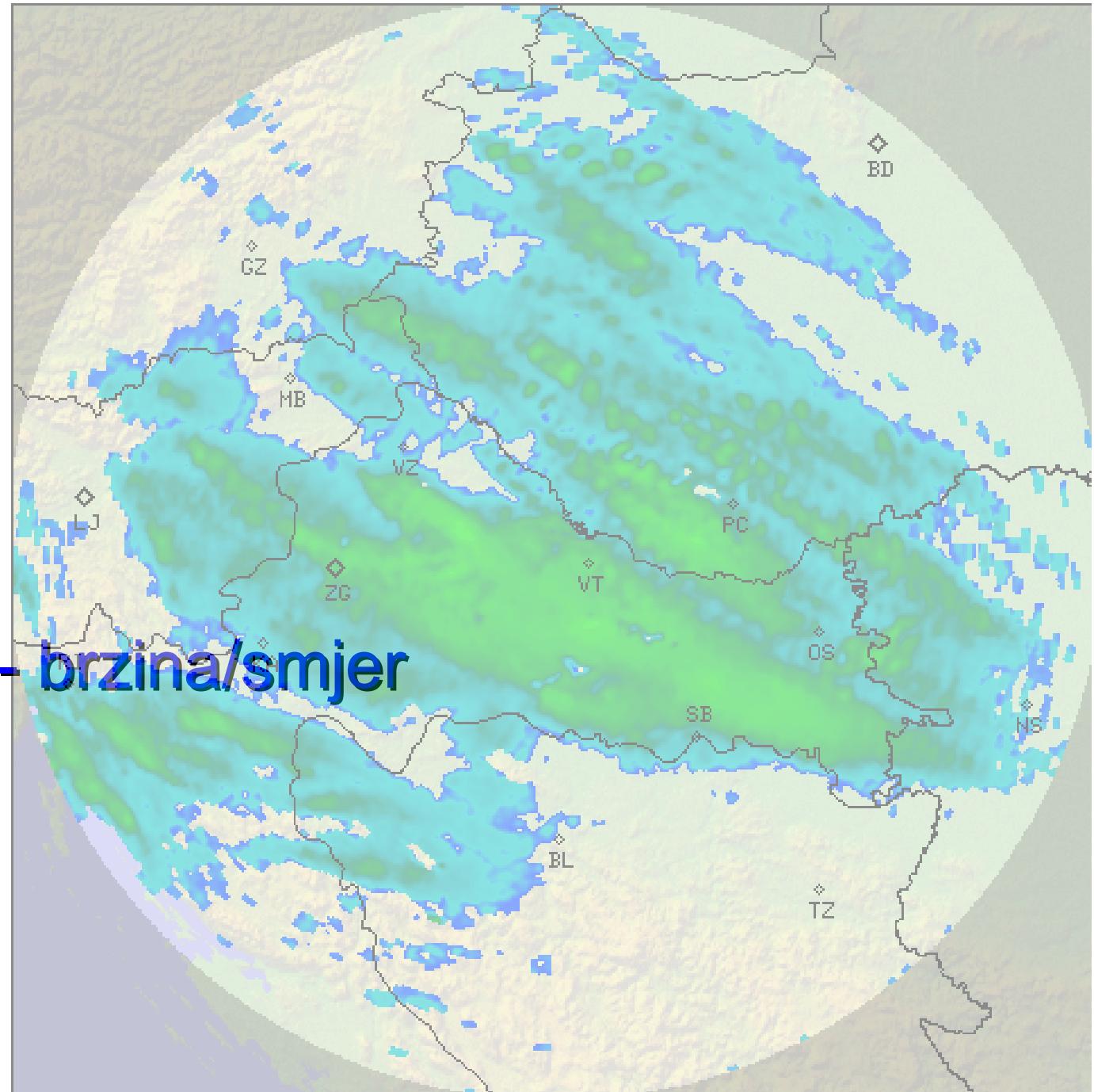


Image courtesy Christian Wolff;
<http://mitglied.lycos.de/radargrundlagen/primaer/>

© CHRISTIAN WOLFF

radar
meteorolog

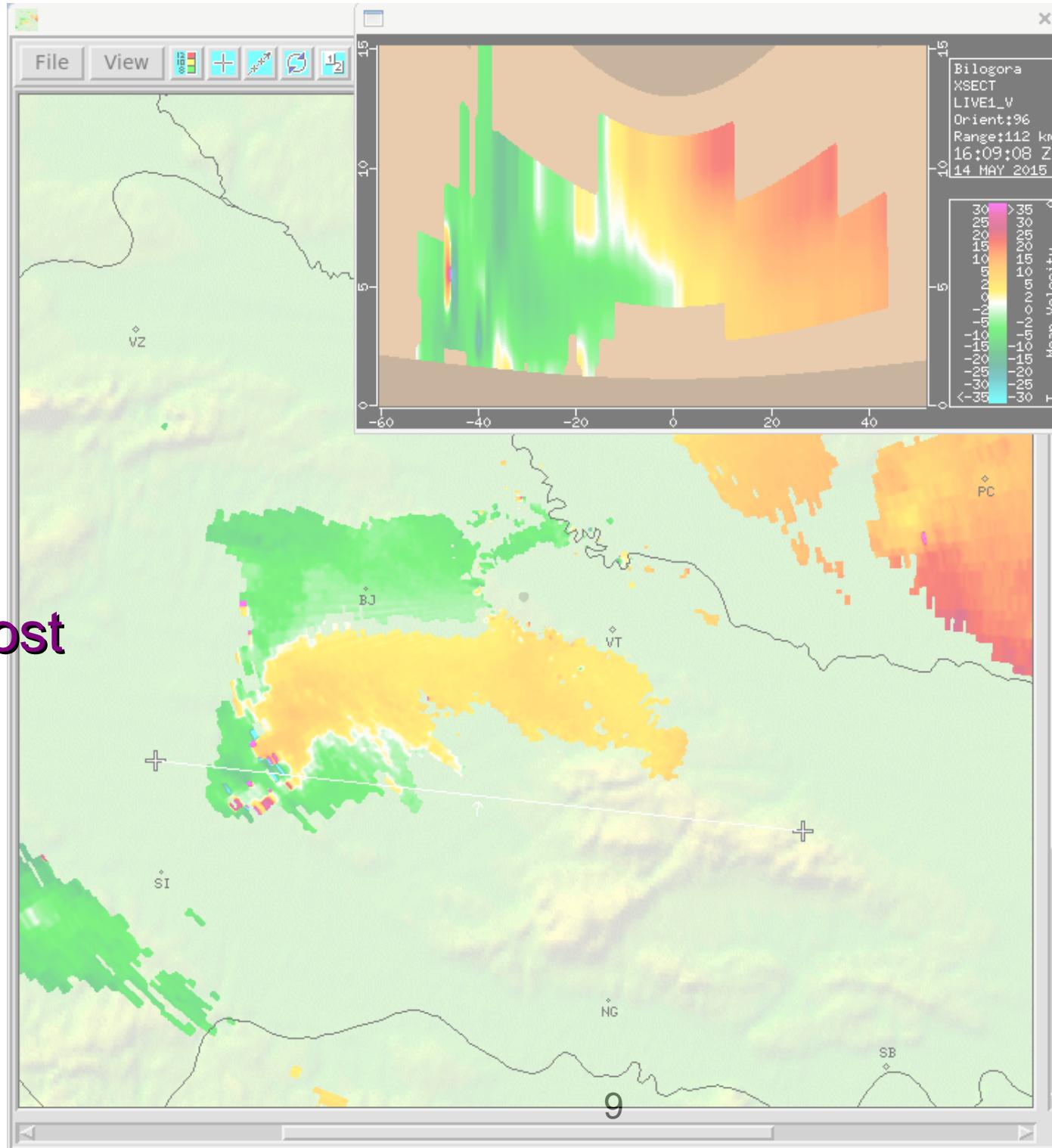
OBORINA
količina,
vrsta,
intenzitet,
položaj,
premještanje - brzina/smjer



radar meteorolog

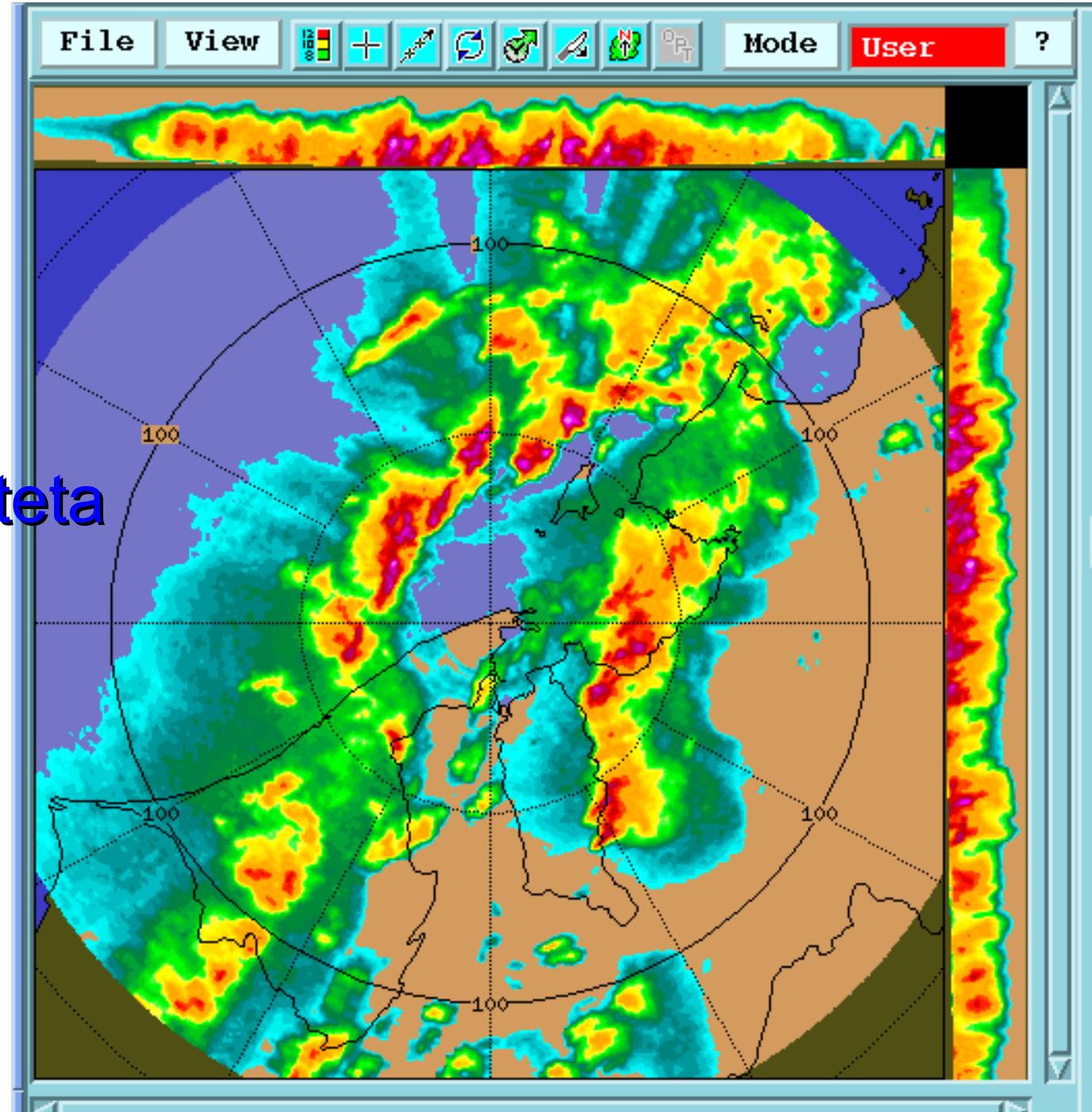
VJETAR
dopler brzina,
smjer,
visina,
rasprostranjenost
položaj

prema radaru!

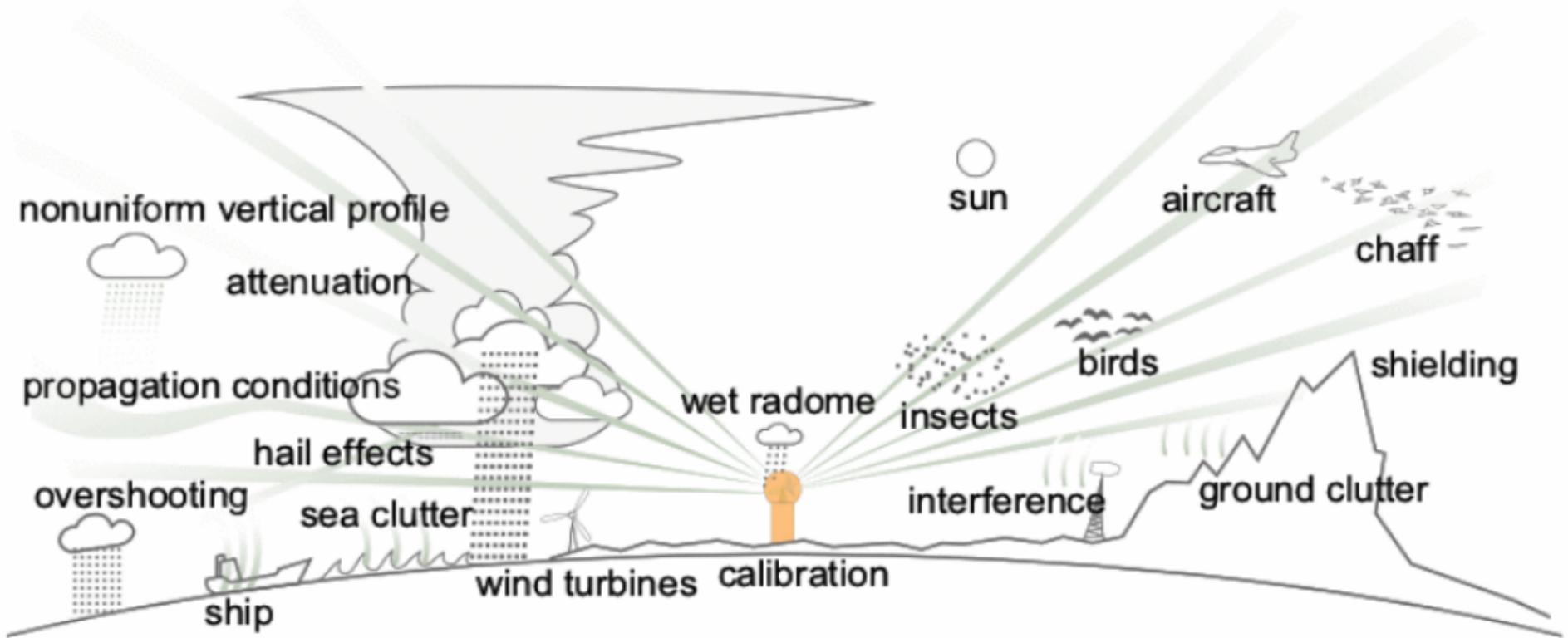


radar meteorolog POJAVE

hladna fronta
linija nestabiliteta
topla fronta
bright band
izolirani Cb
tornado



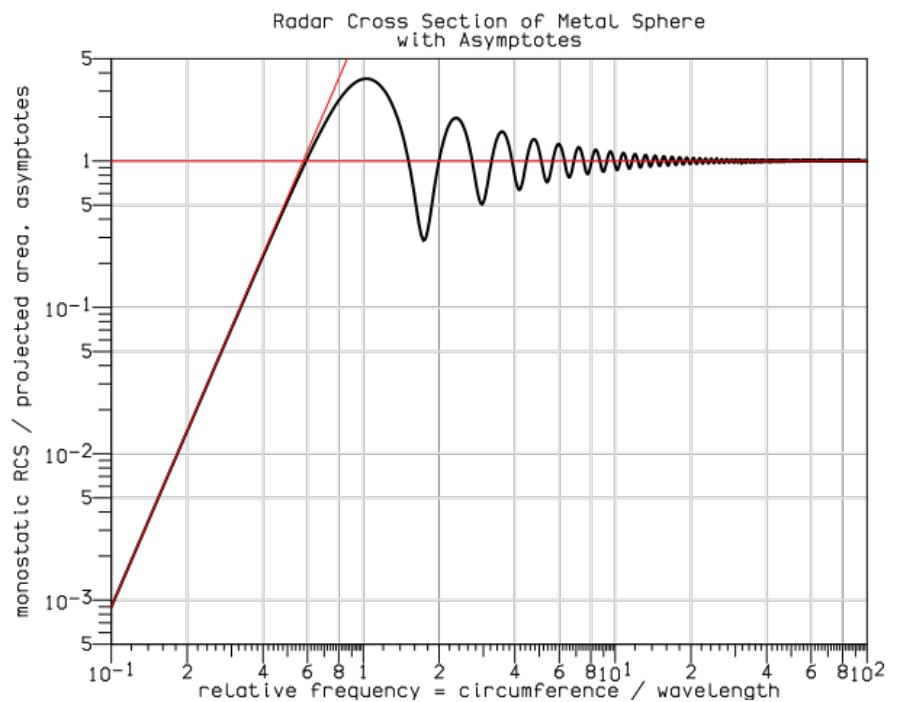
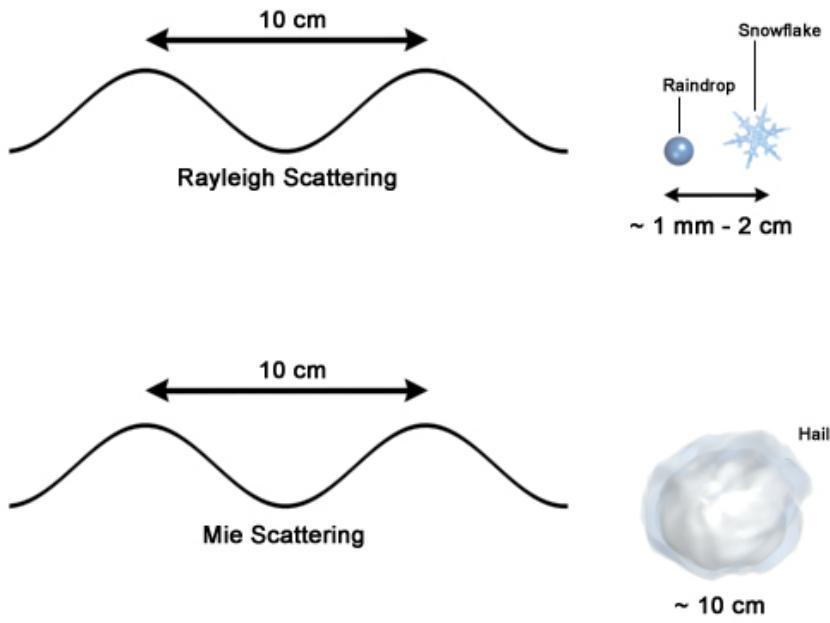
Na što sve treba misliti



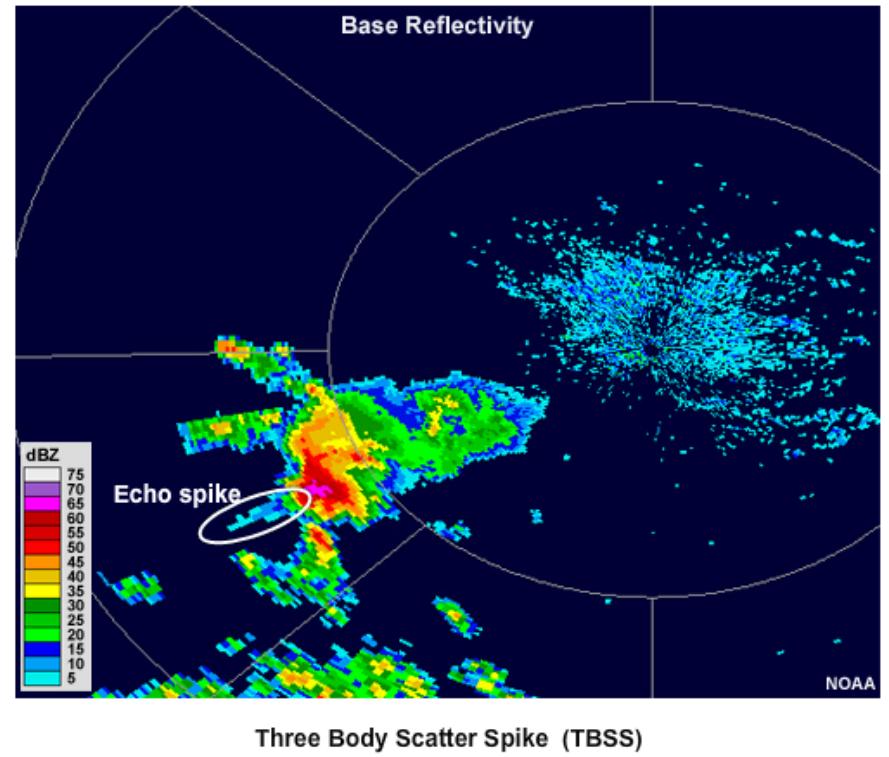
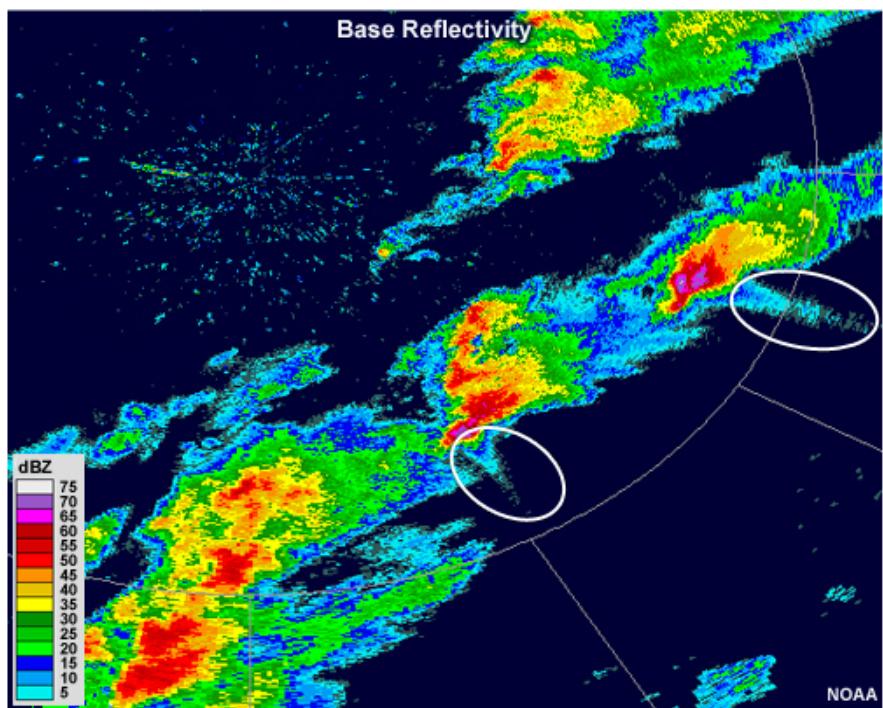
Daniel Michelson, SMHI

Raspršenje

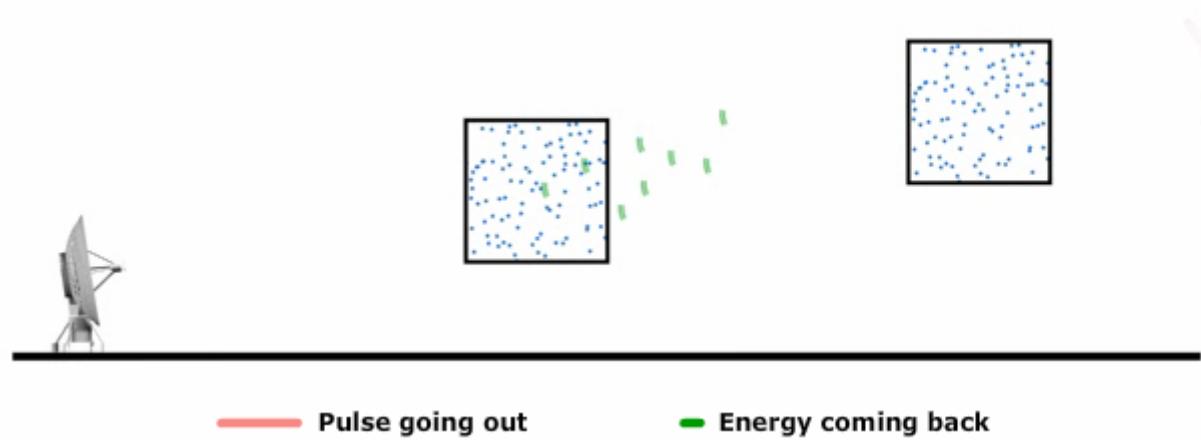
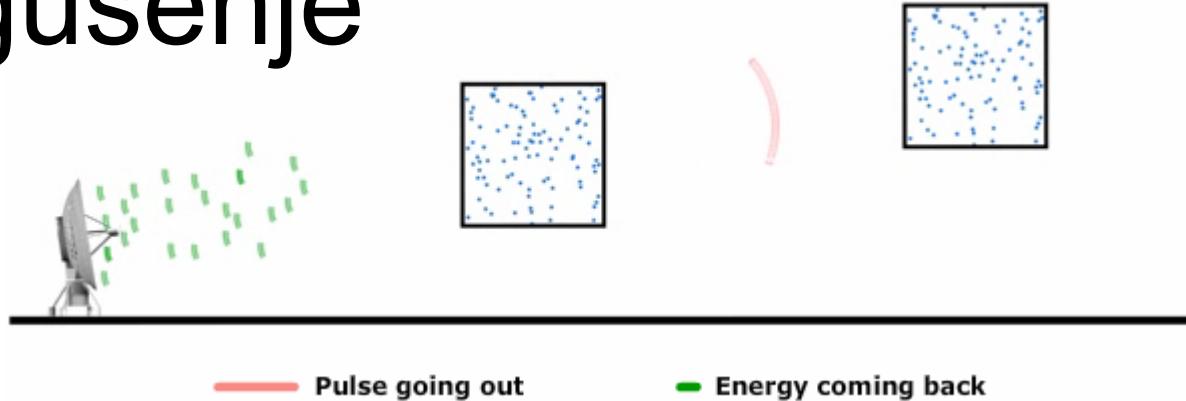
By Catslash - Own work, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=7134315>



tuča u Cb-u



gušenje



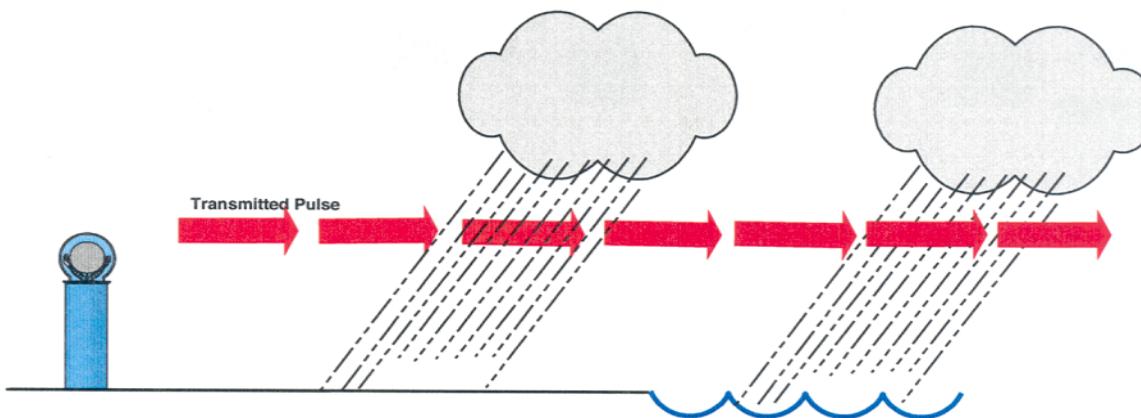


Figure 3a- Long Wavelengths Pass Through Precipitation And Produce No Useful Reflections

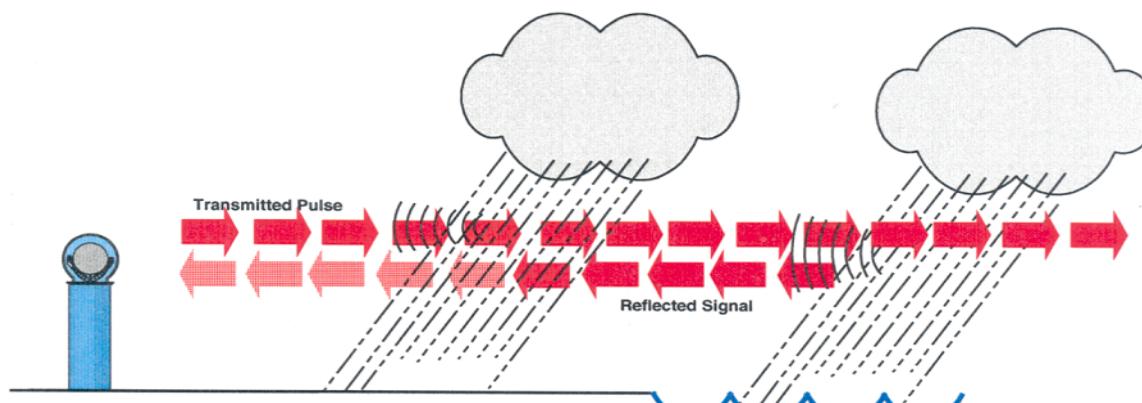


Figure 3b- Proper Wavelengths Pass Through Precipitation And Produce Useful Reflections

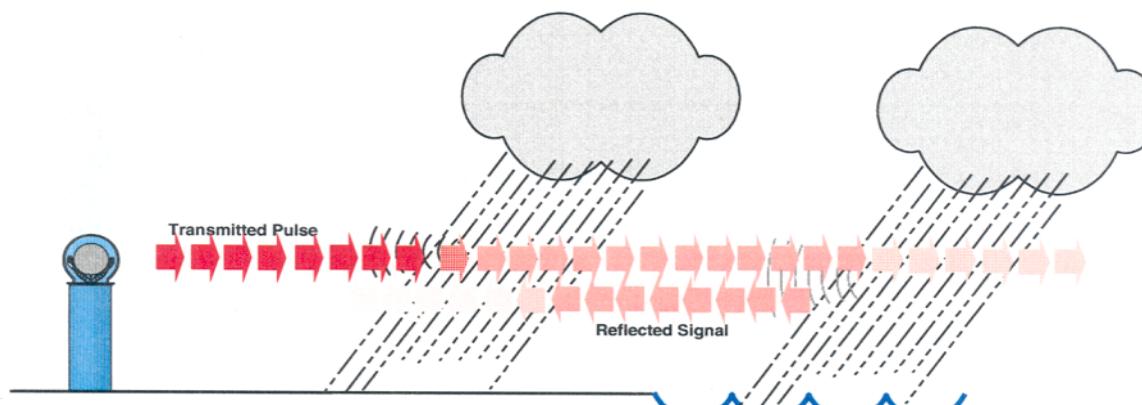
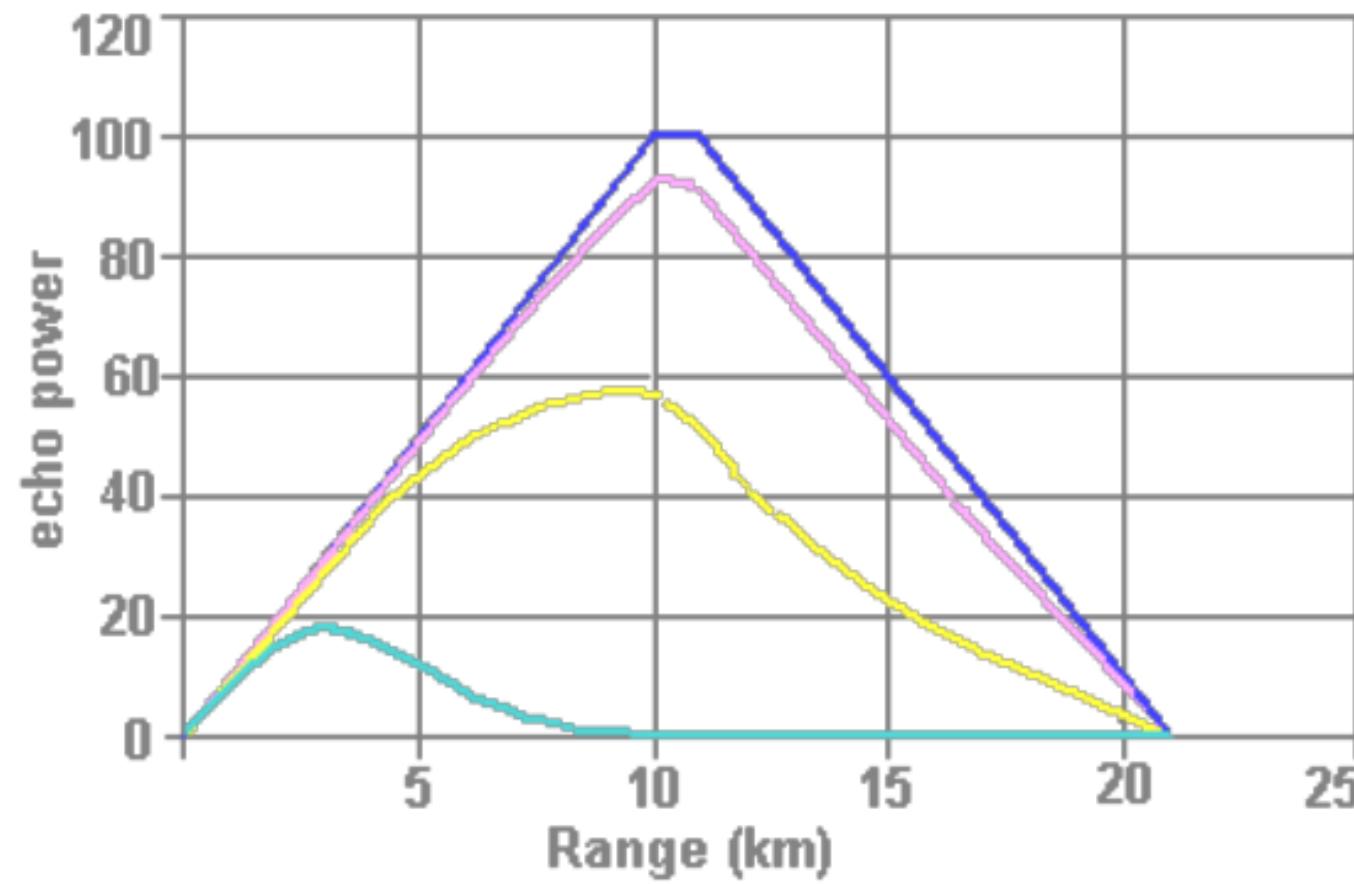
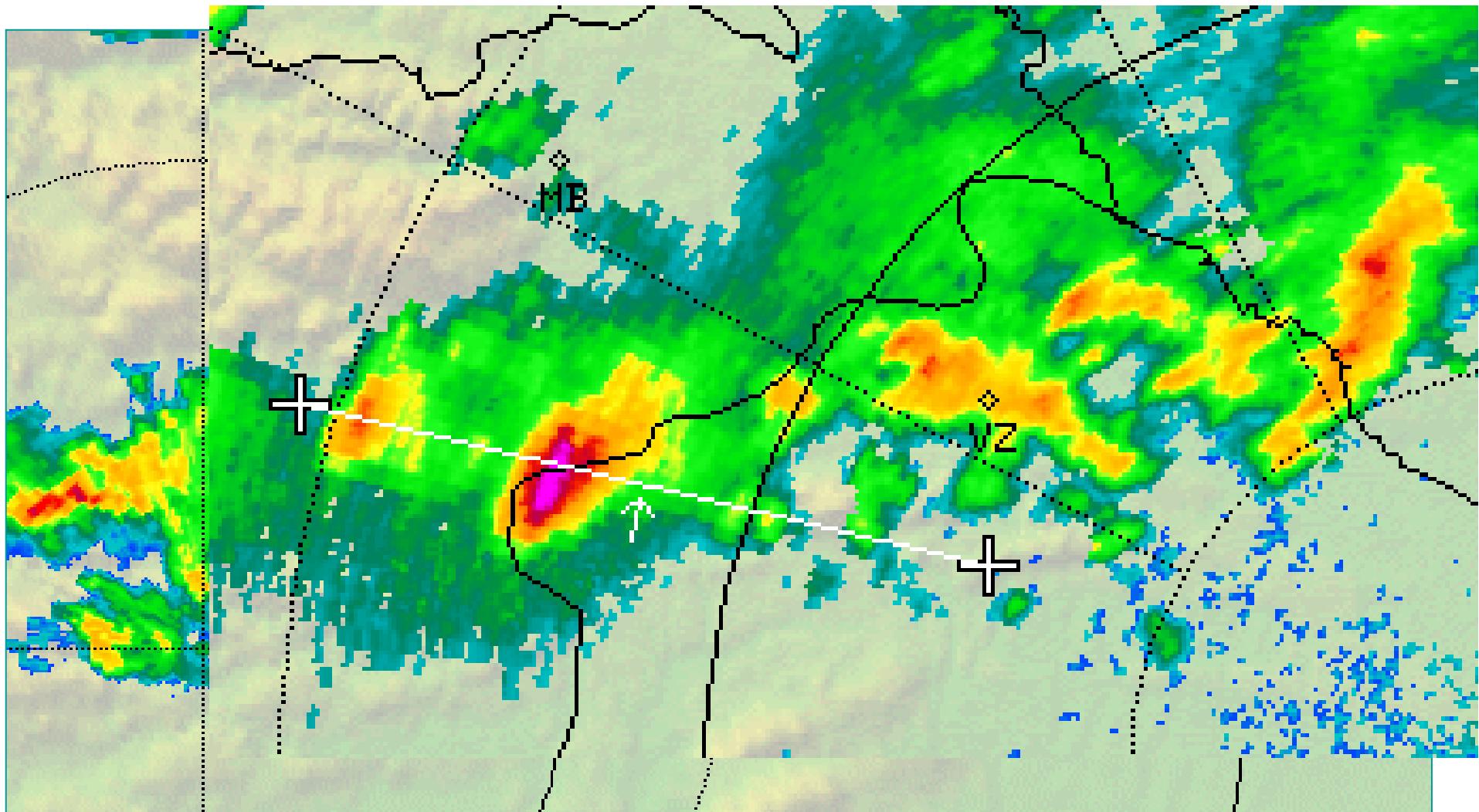


Figure 3c- Short Wavelengths Are Absorbed By Precipitation And Produce No Useful Reflections

gušenje 20 km oblak s 100 mm/h
S, C, x band

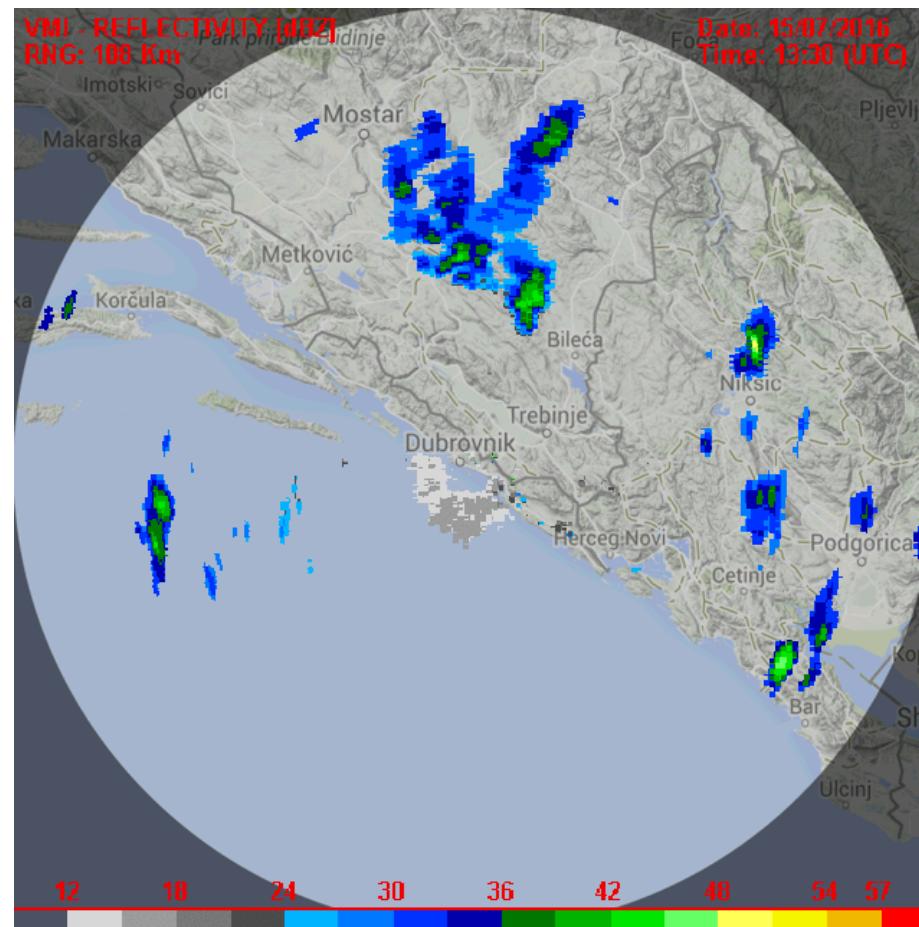
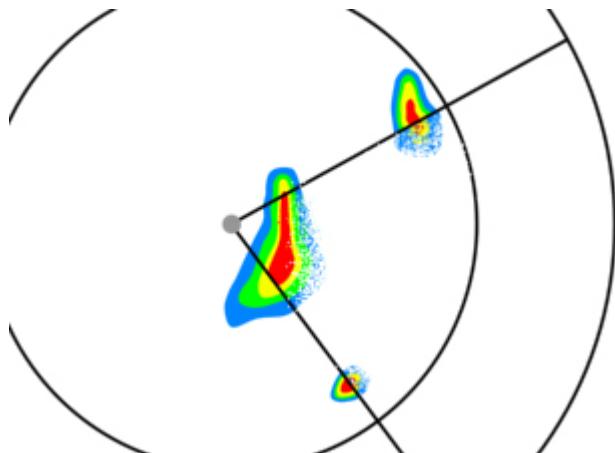




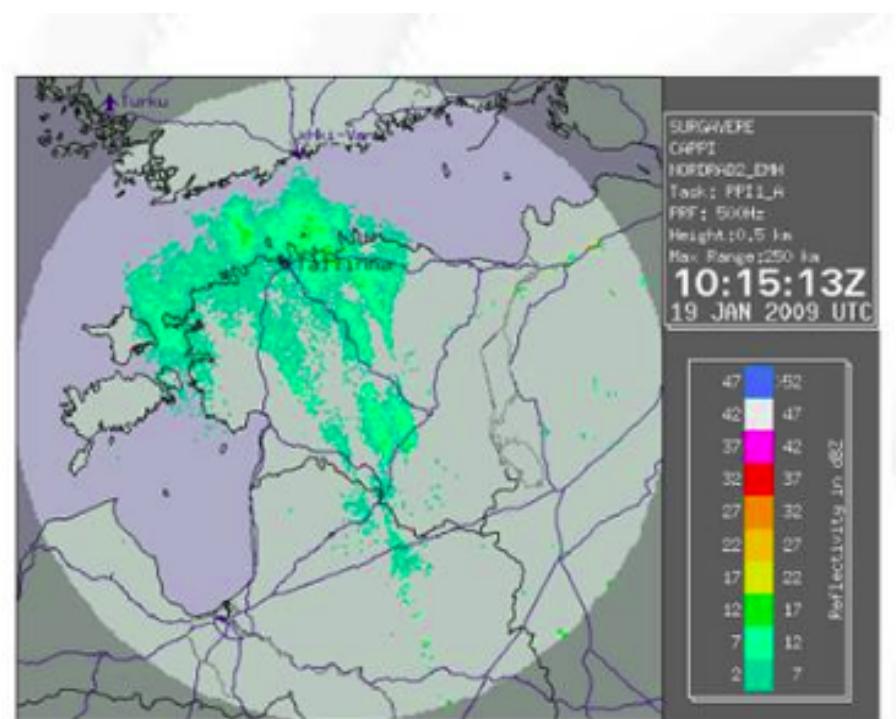
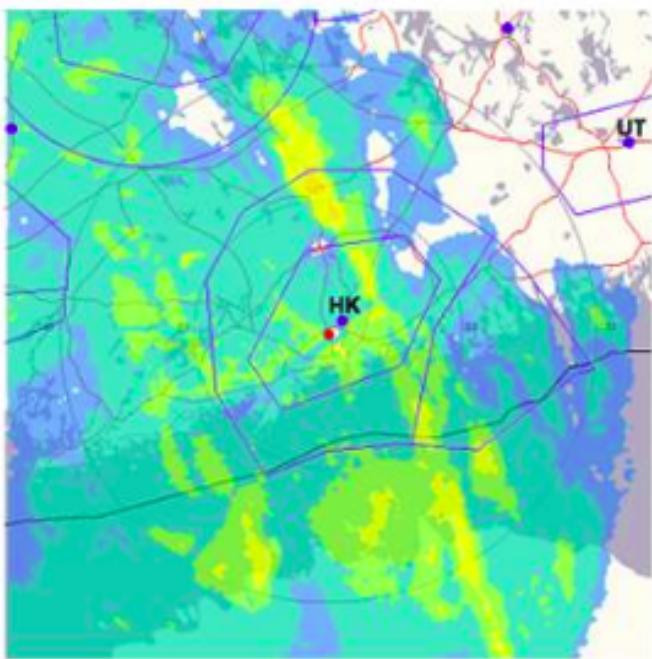
DHMZ 2017.

17

atenuacija x band



prikaz podataka



Elena Saltikoff, FMI

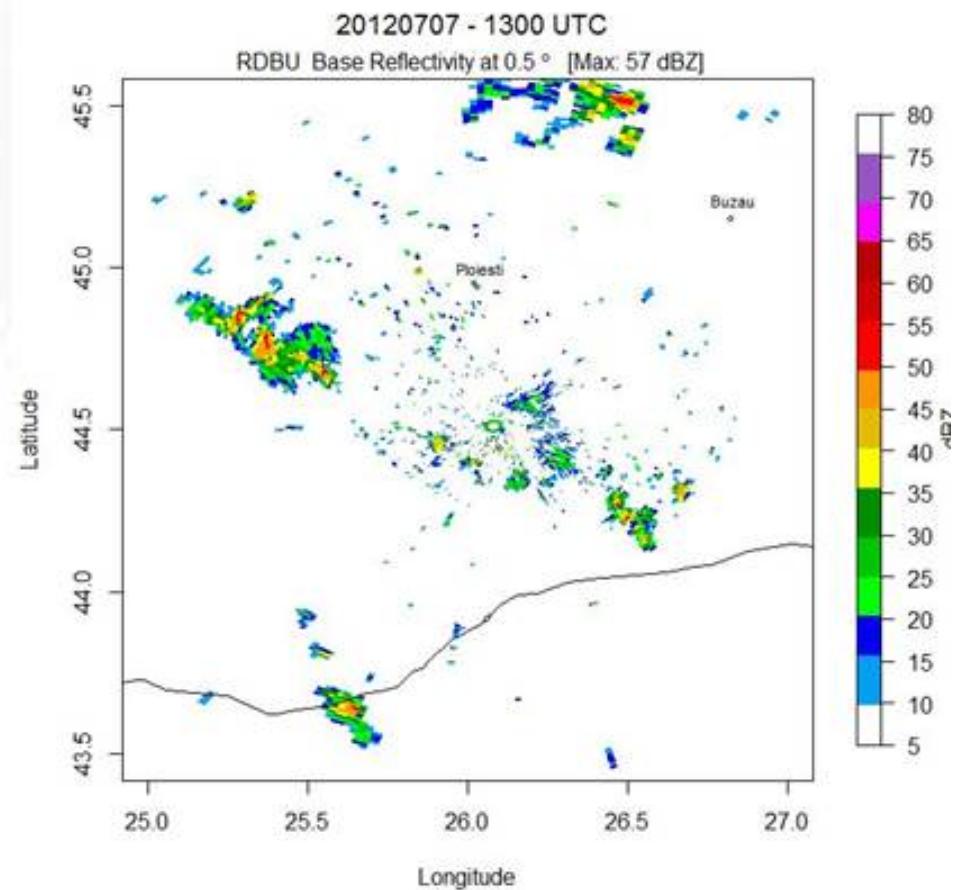
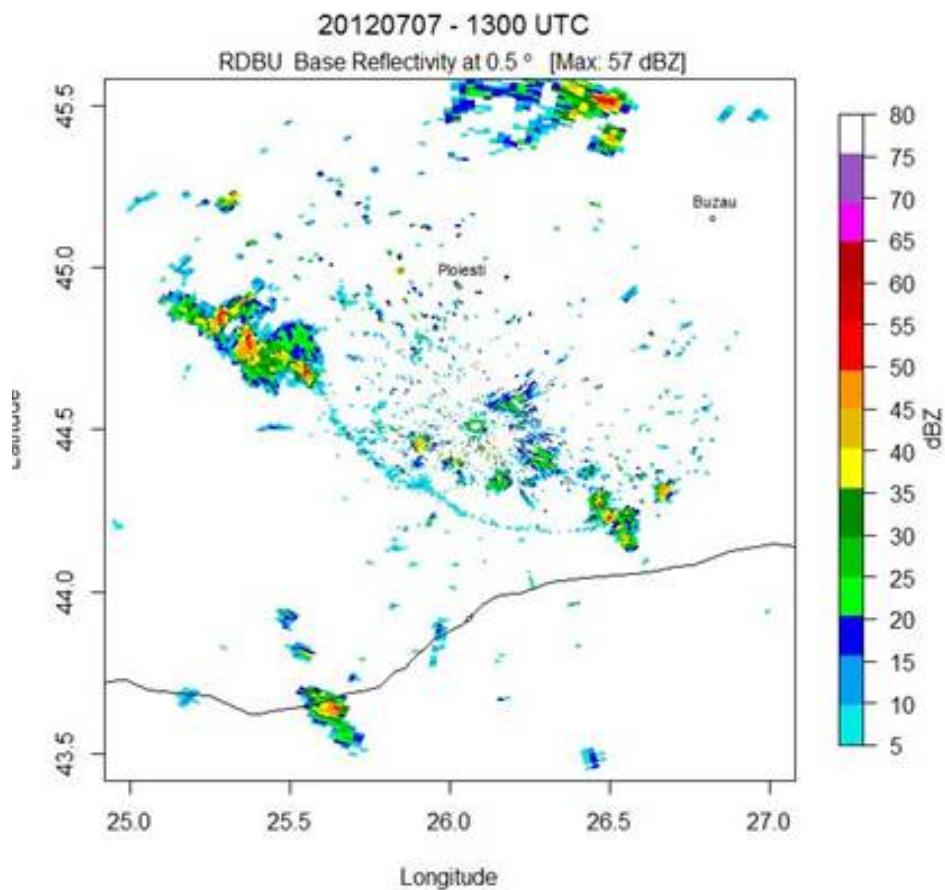
Sometimes, what you see on the radar display is NOT what is measured.

Minimum detectable signal --- Minimum displayed signal

Beware of artificial MDS!!!

The display of data may be thresholded, therefore some data may not be displayed!

5 dB znači puno

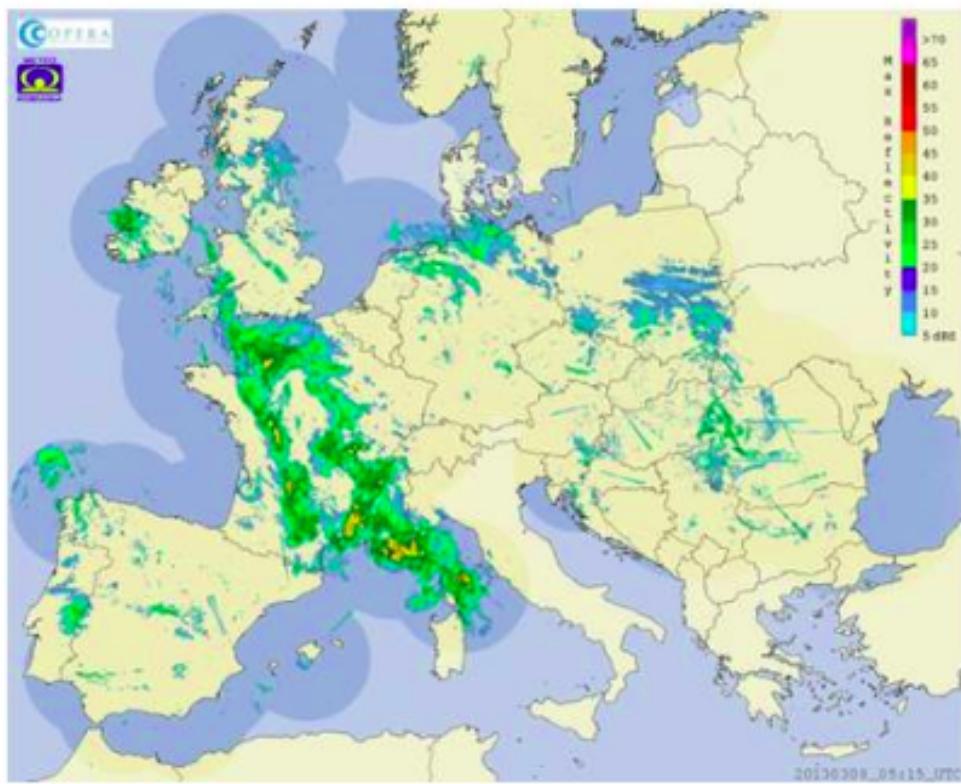


S-band: $Z=300R^{1.4}$

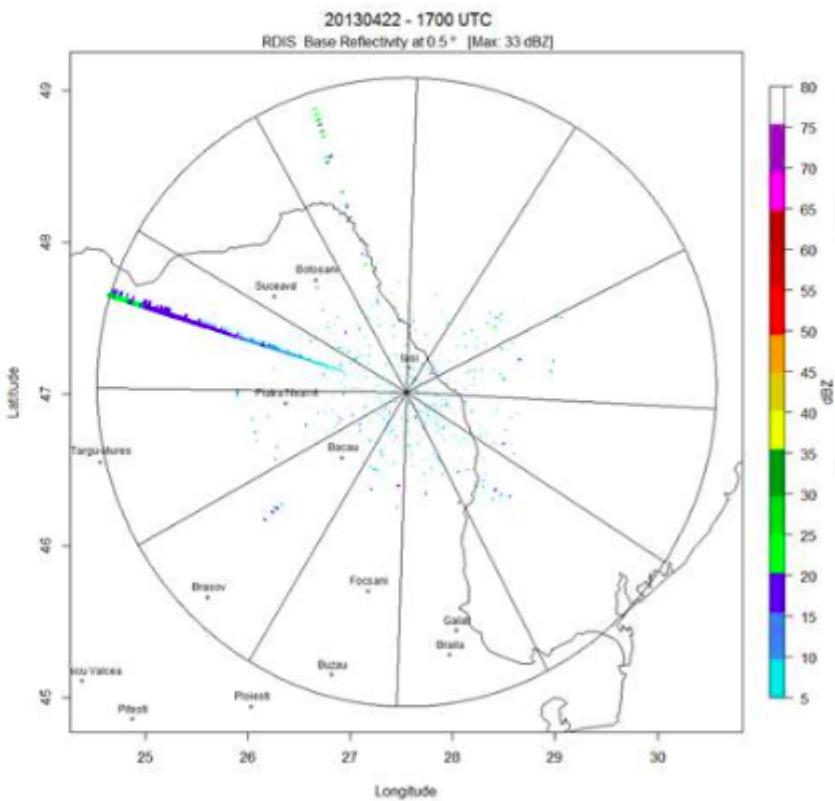
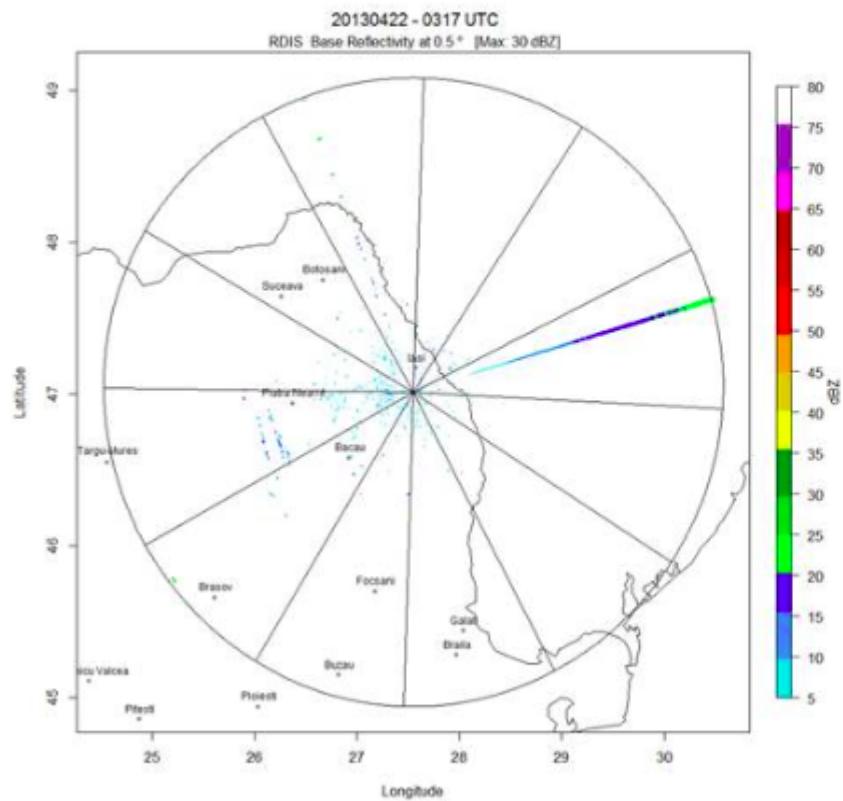
10 dBZ = 0.088 mm/h

HAZU 2017

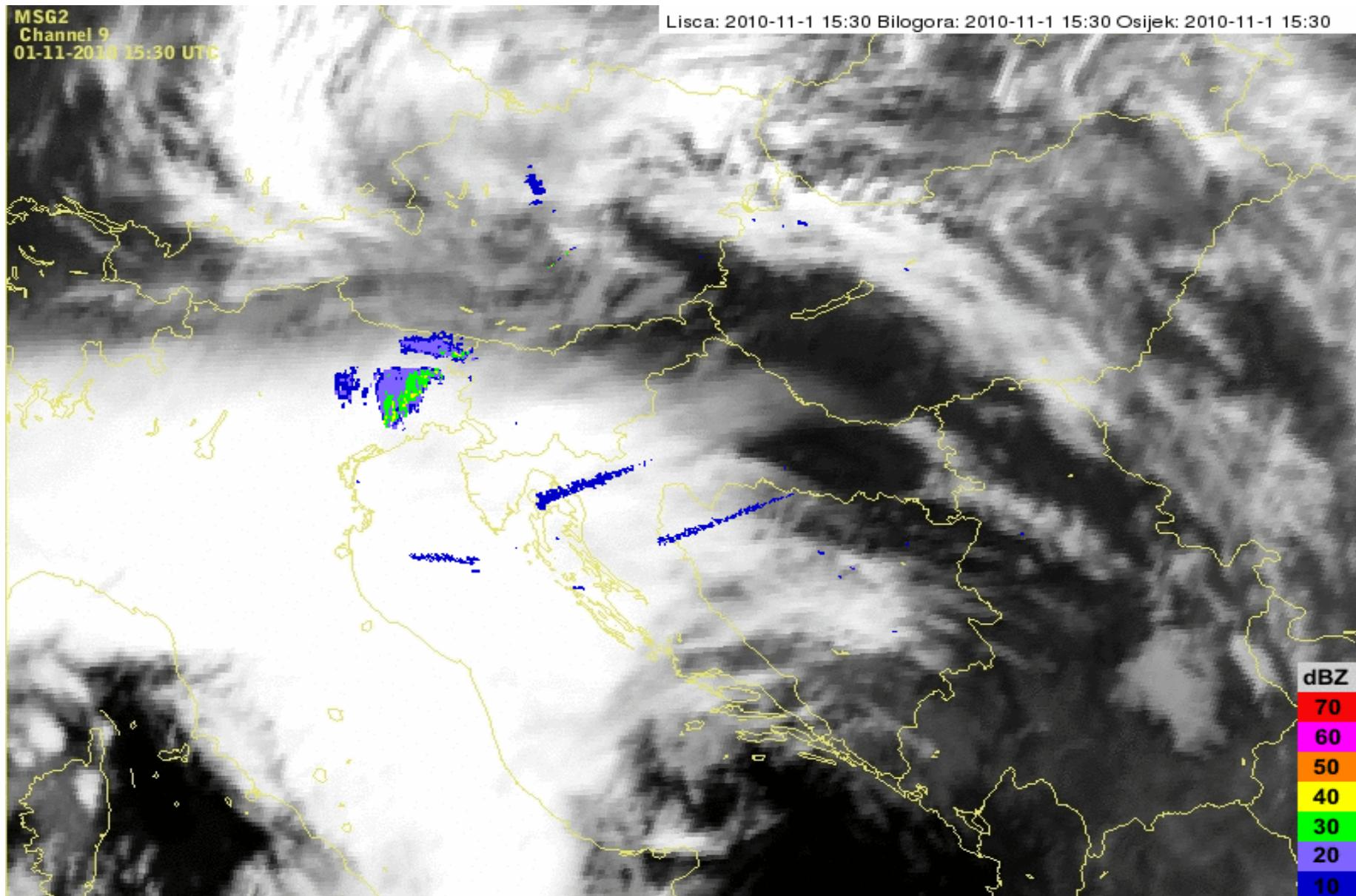
20



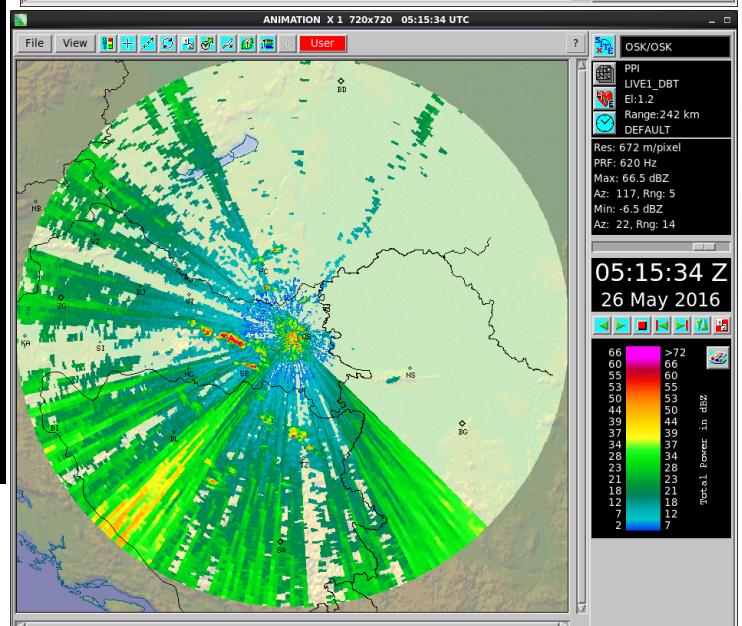
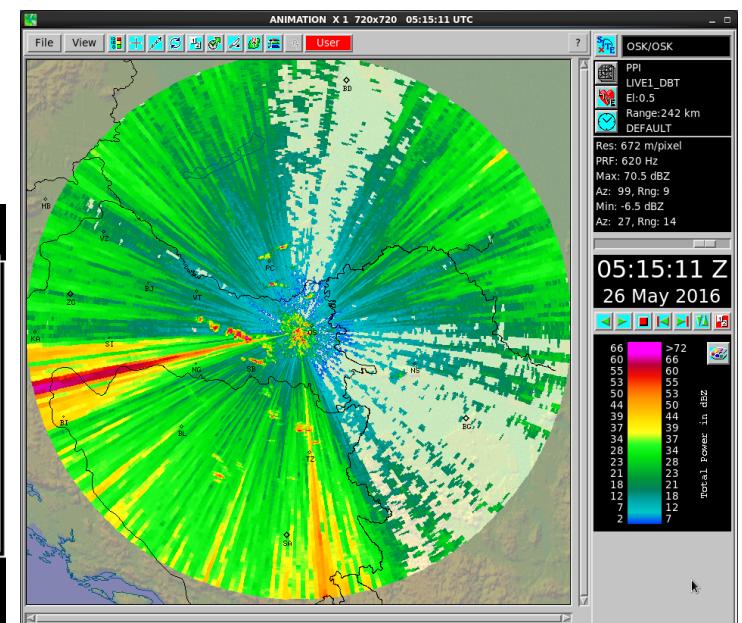
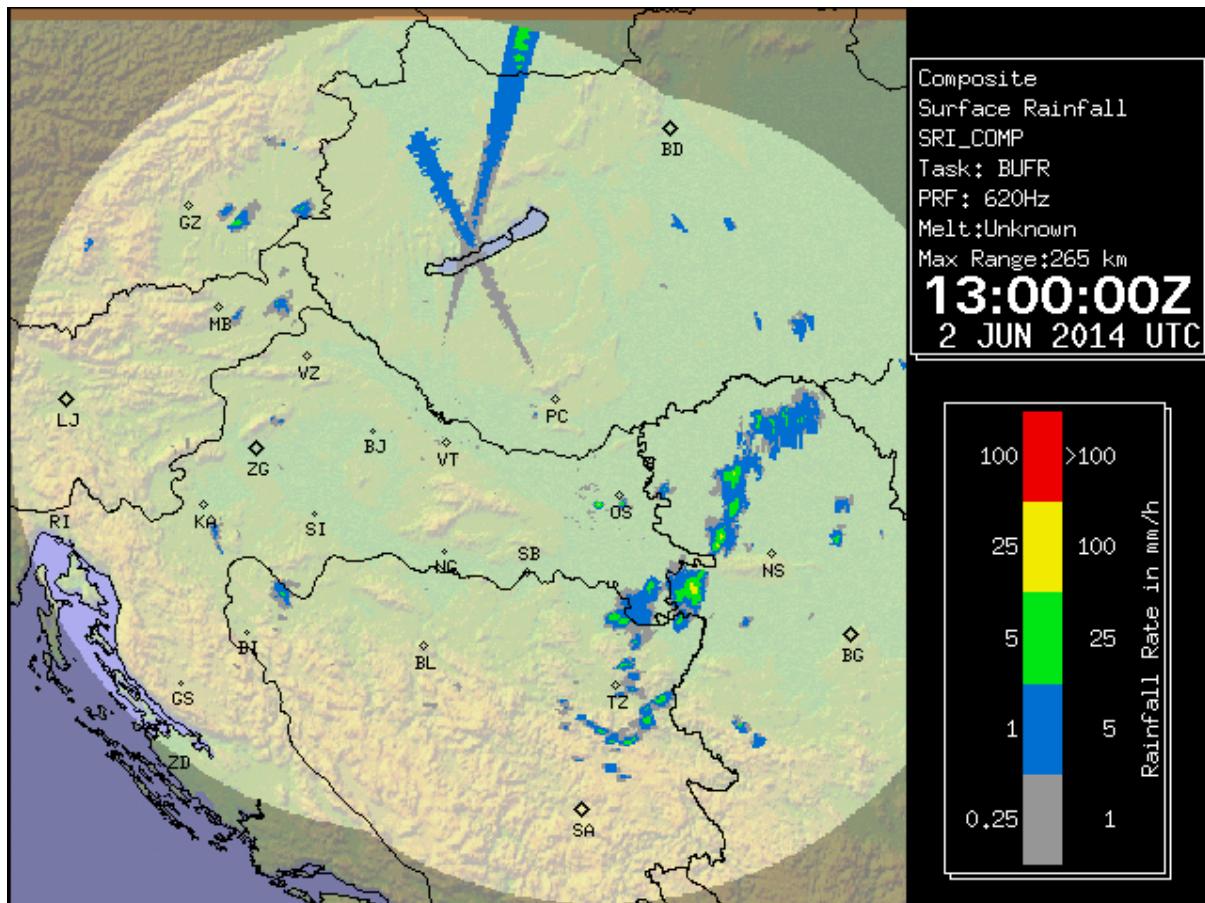
sunrise at 06:06 LT and on 69.9° azimuth
sunset at 20:11 LT and on 290.3° azimuth



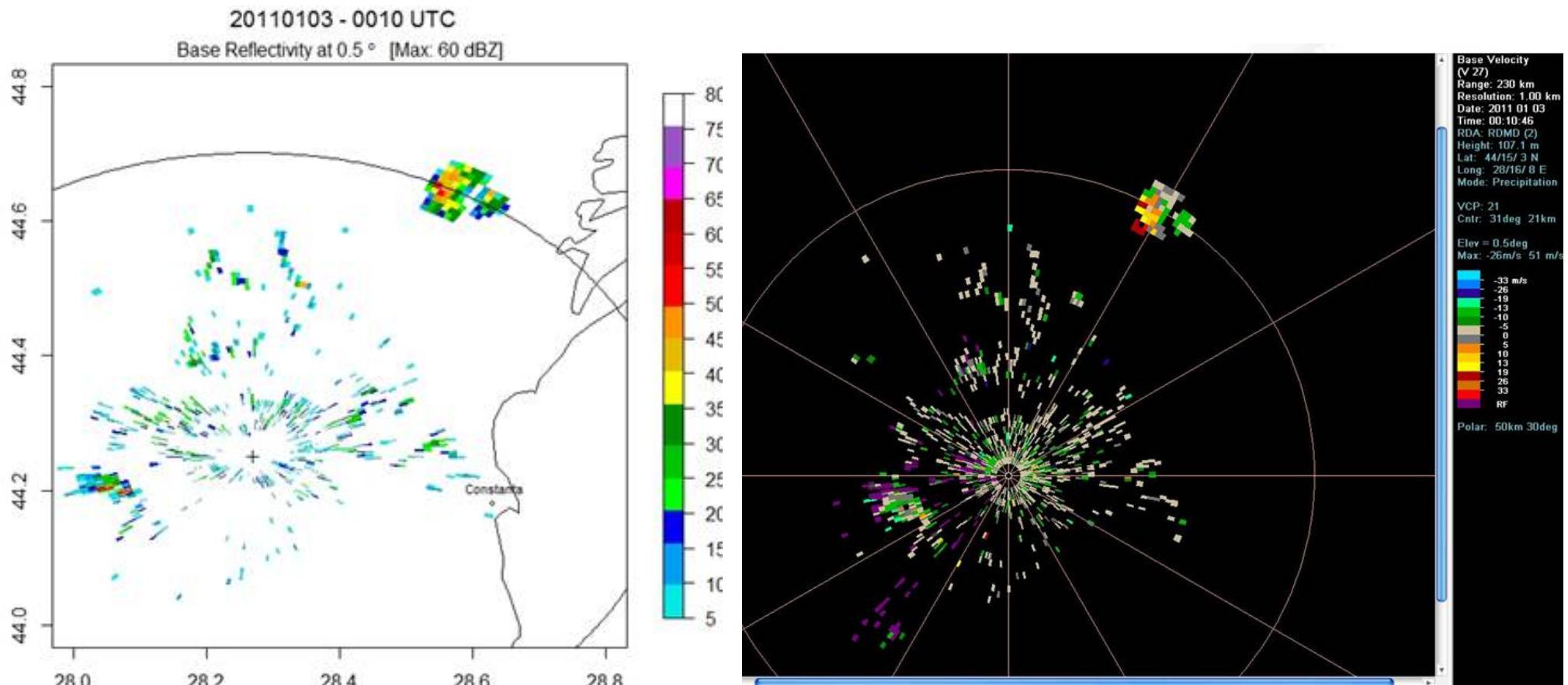
Sunce zalazi u 16:34



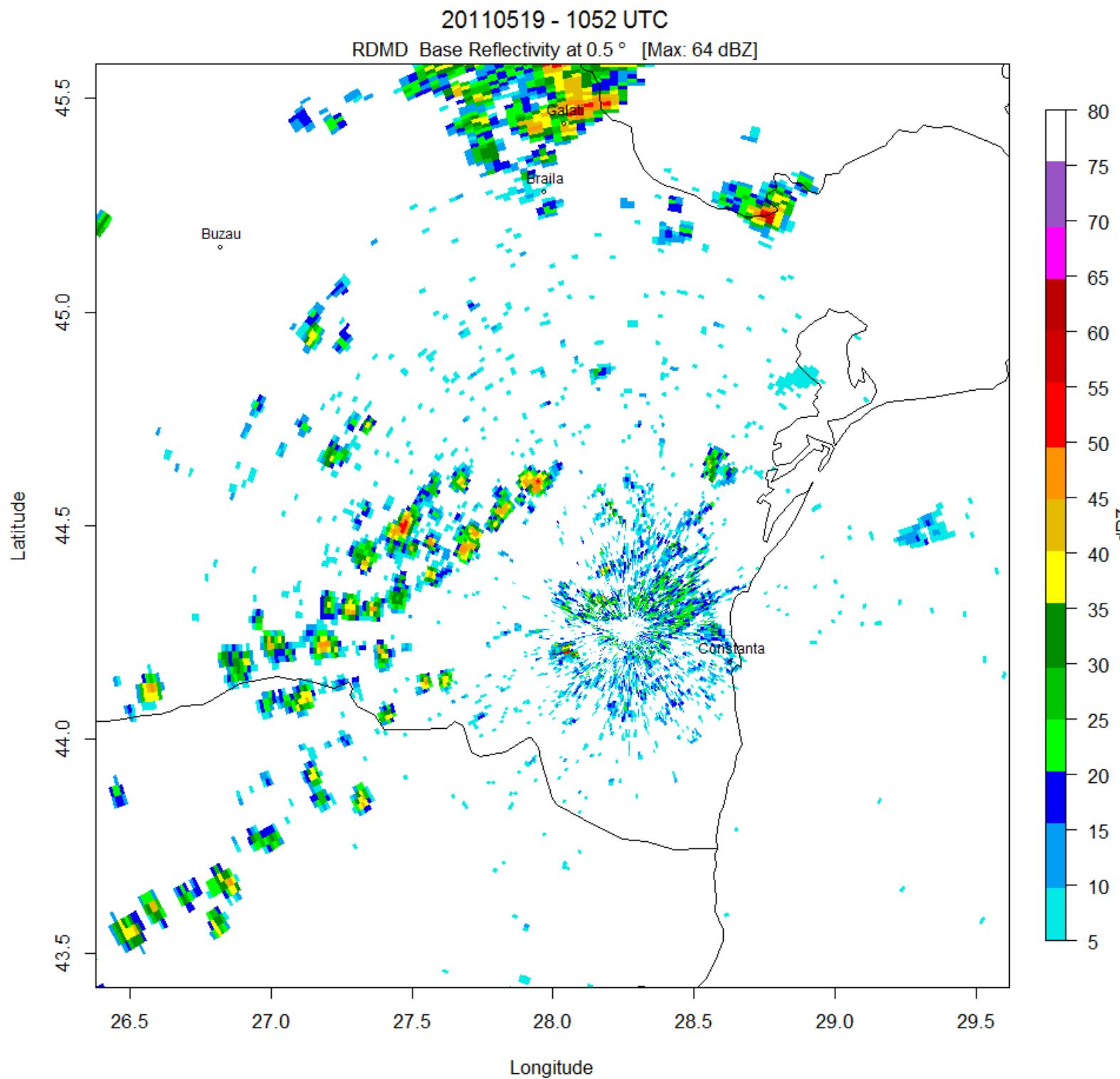
w - lan sunce, ili ??



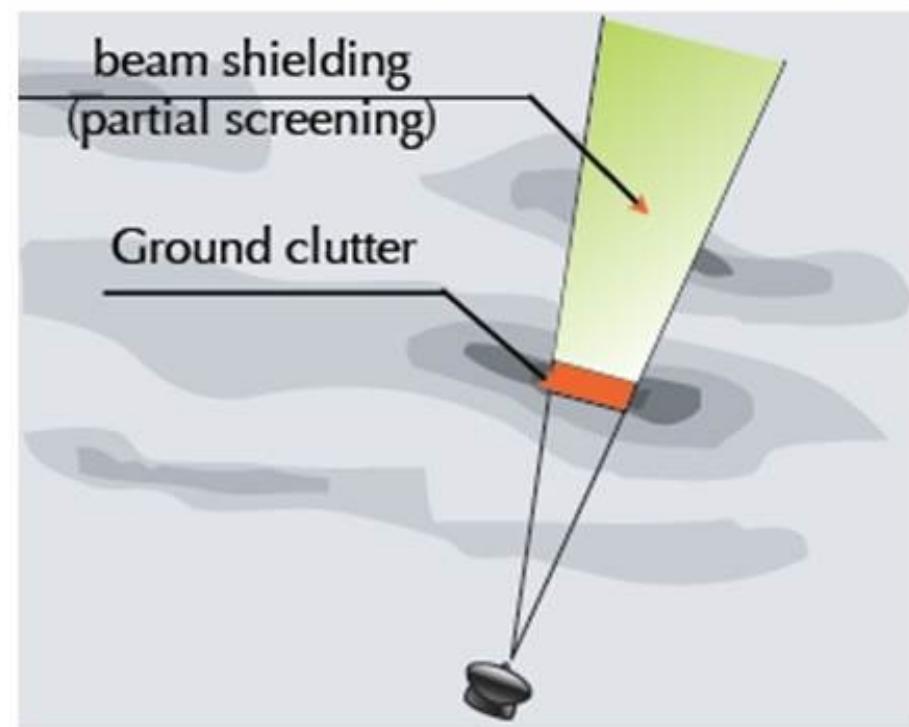
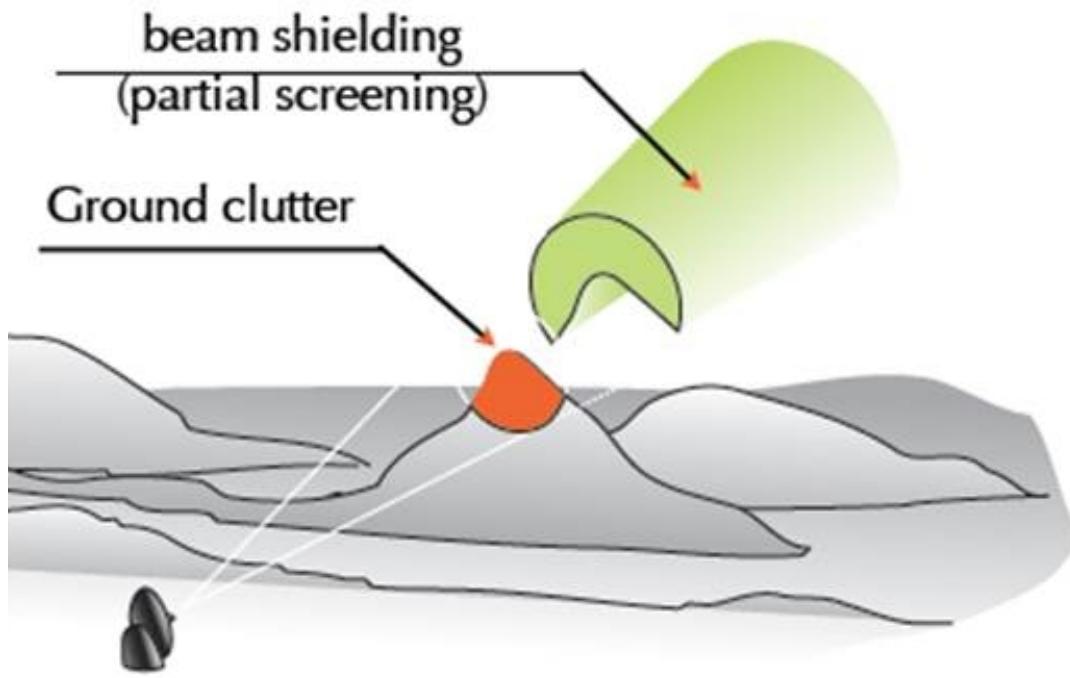
vjetroelektrane



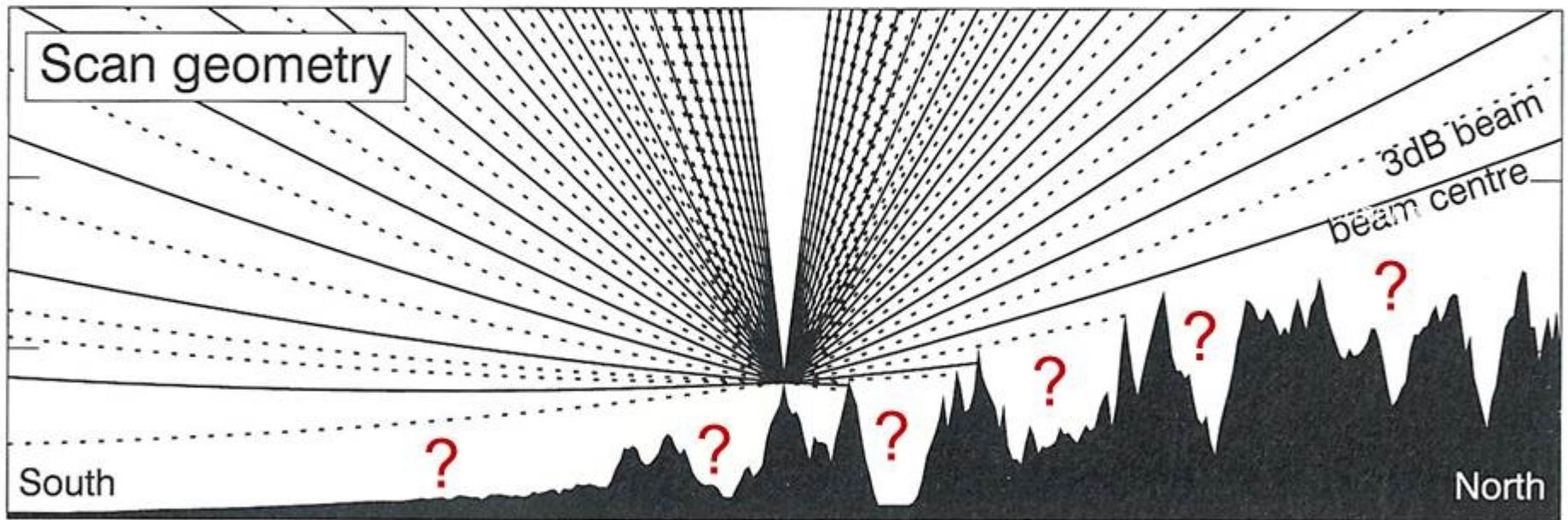
vjetroelektrane clutter



Beam shielding and blocking



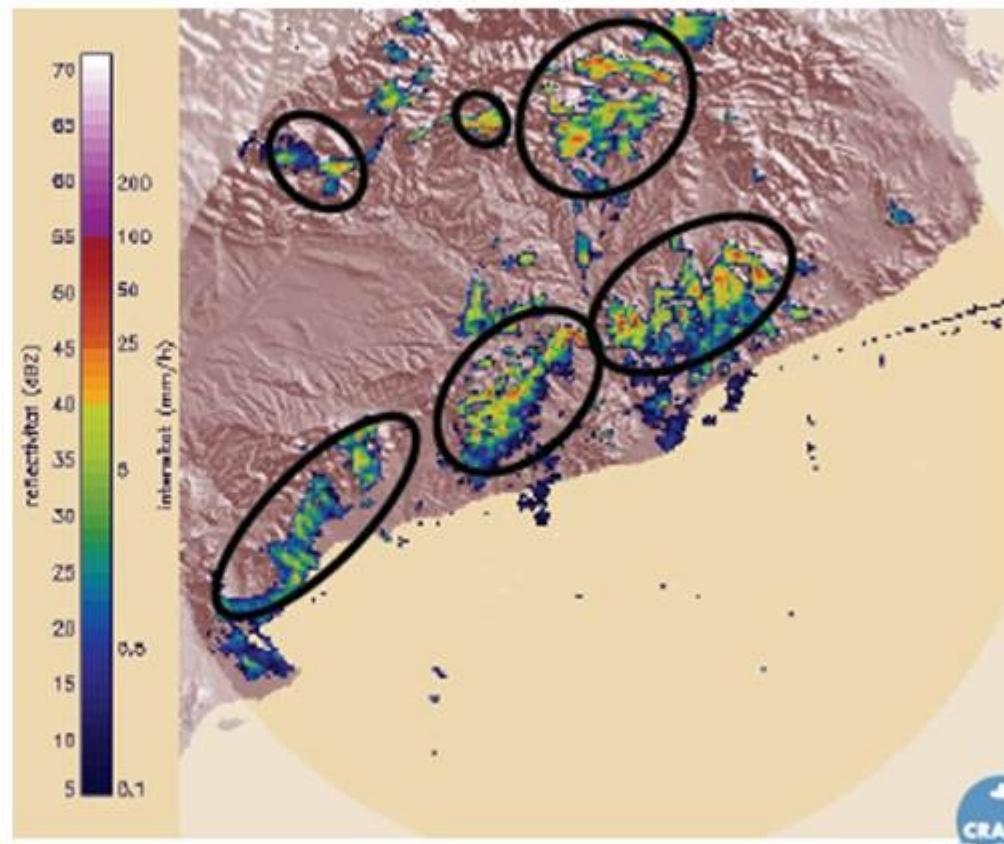
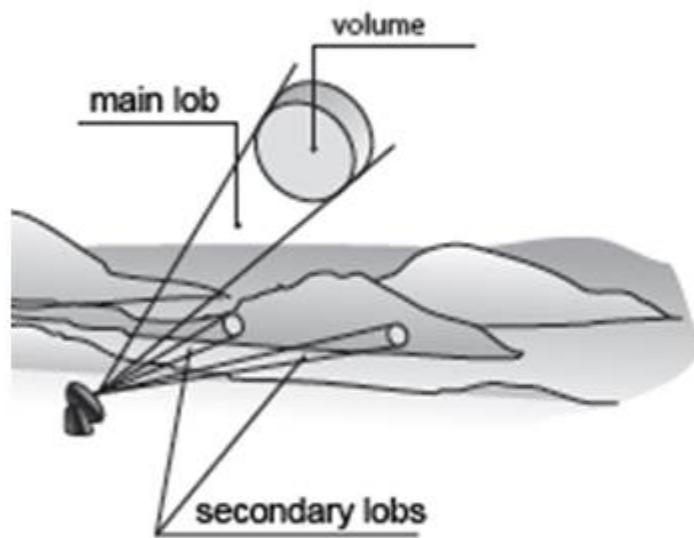
vrijeme u kotlinama ?



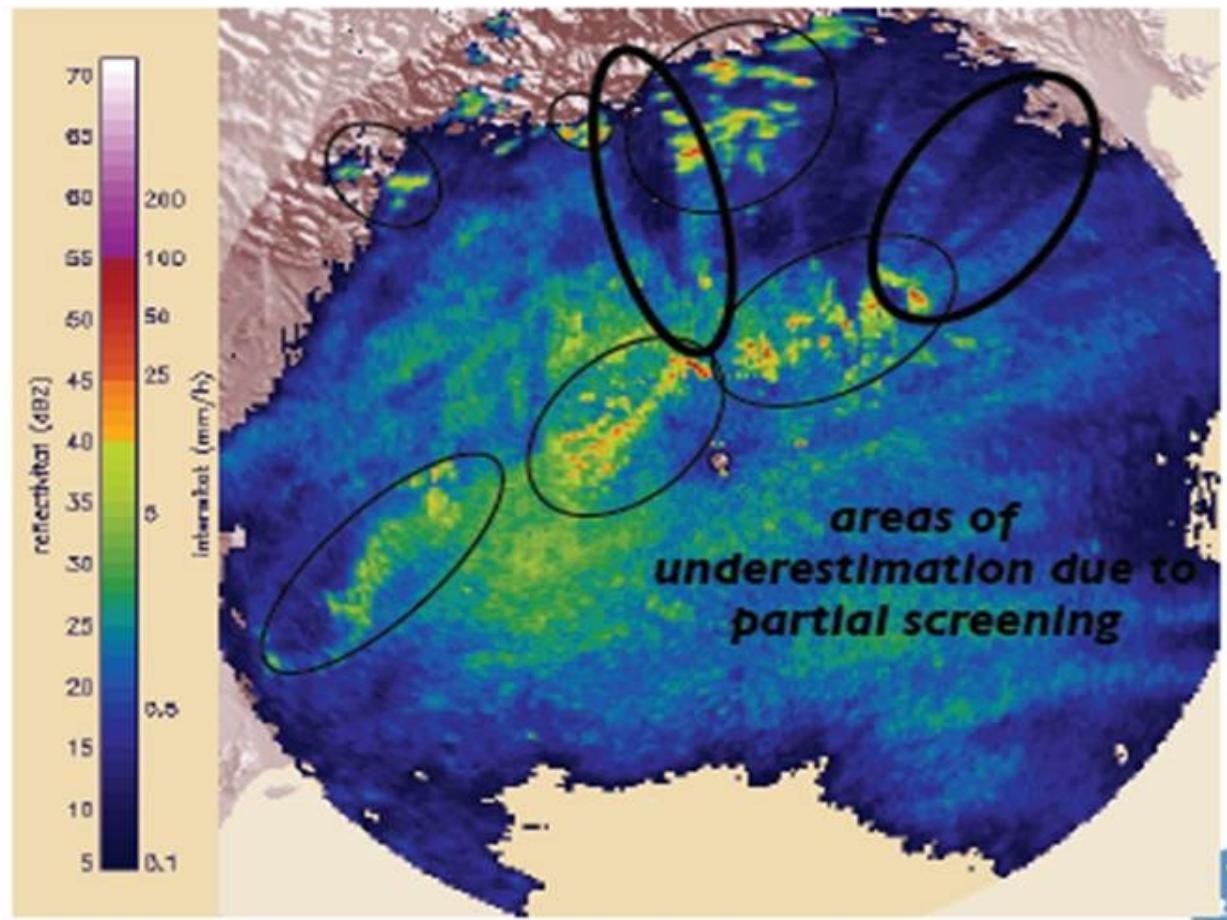
beam overshooting occurs close to the radar (valleys)

Urs Germann

bočne latice



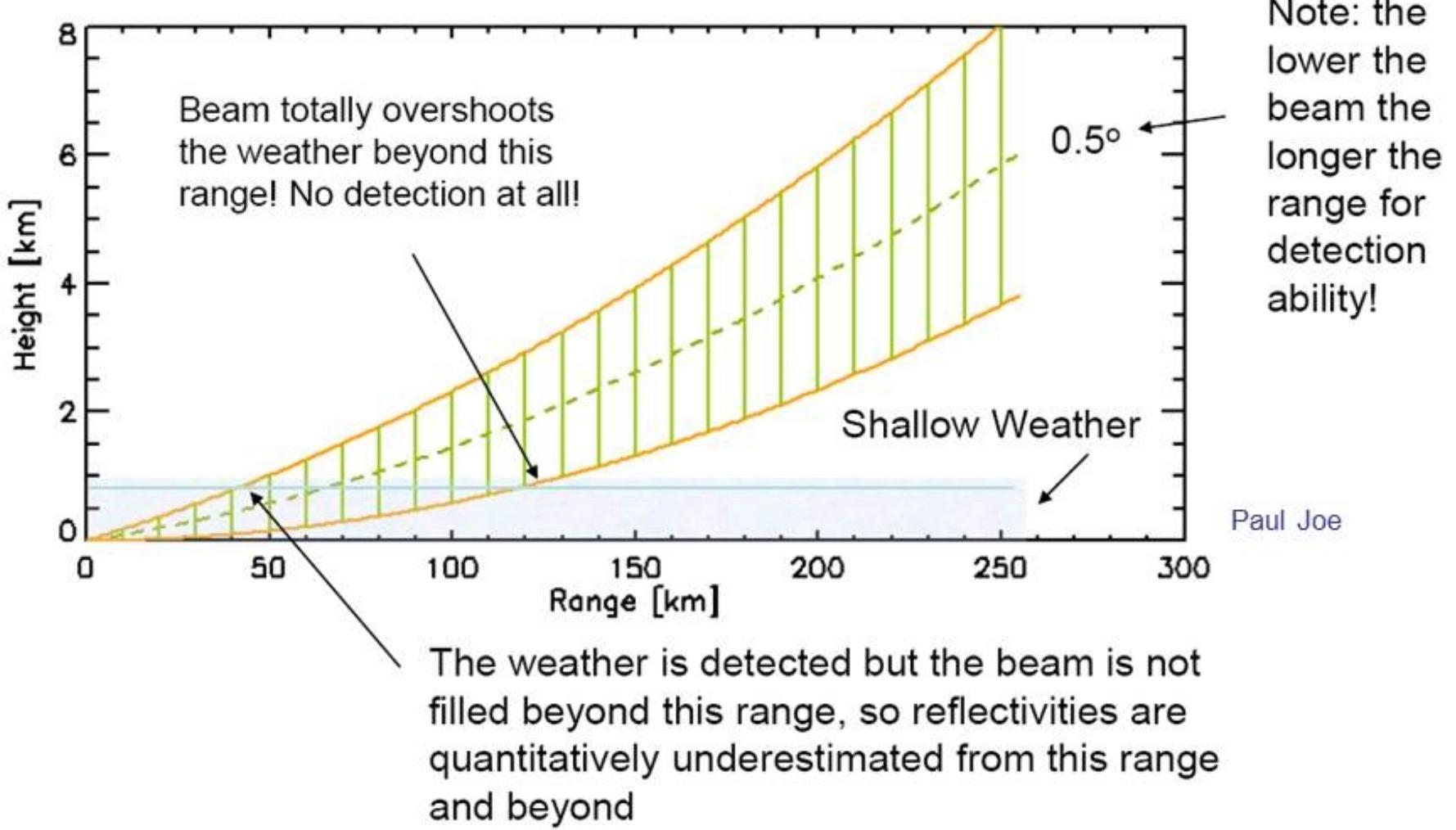
blokiranje, sjene, stalni odrazi



zemlja je okrugla

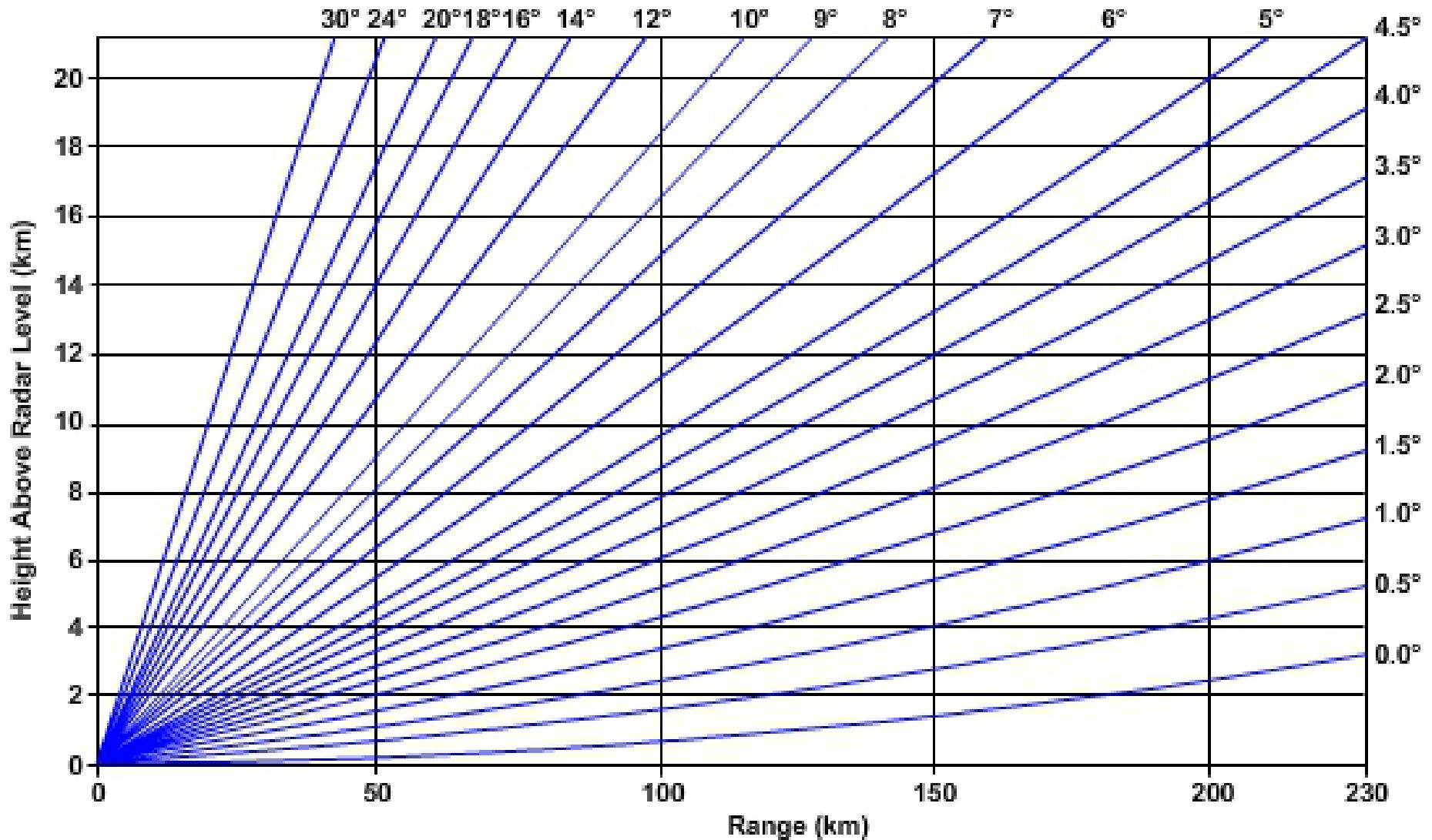


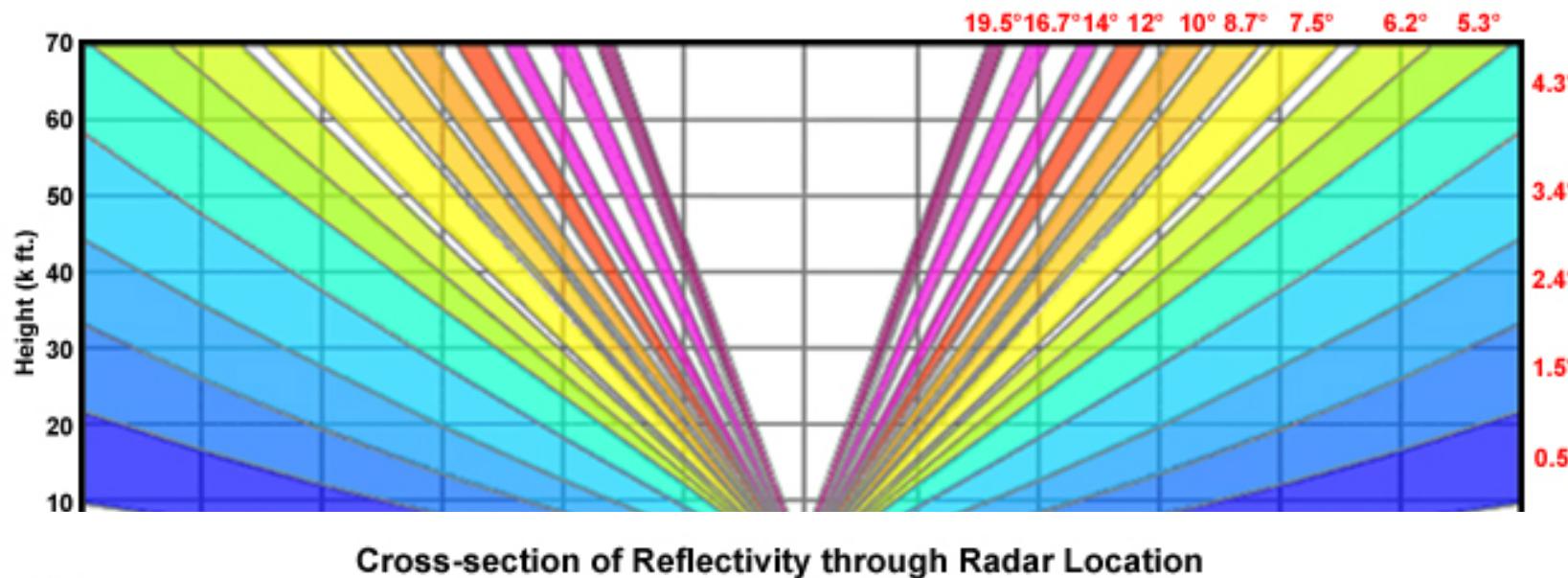
Distance effects - overshooting



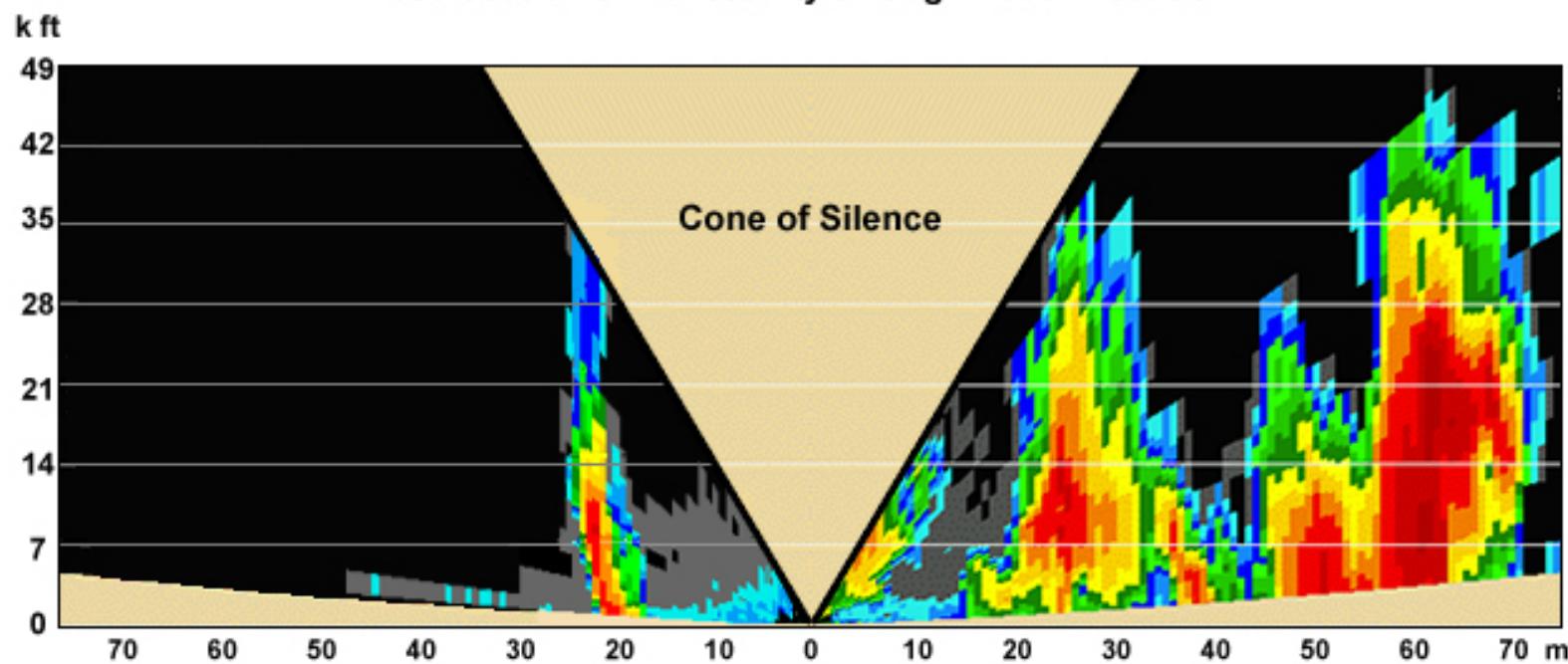
explanation for seasonal coverage variations (shallow wintertime precipitation)

Height Above the Ground of Radar Sample as a Function of Range

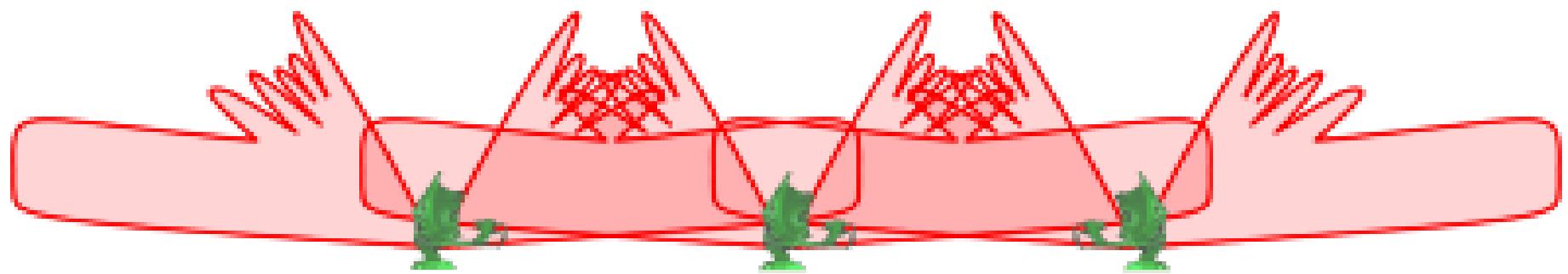




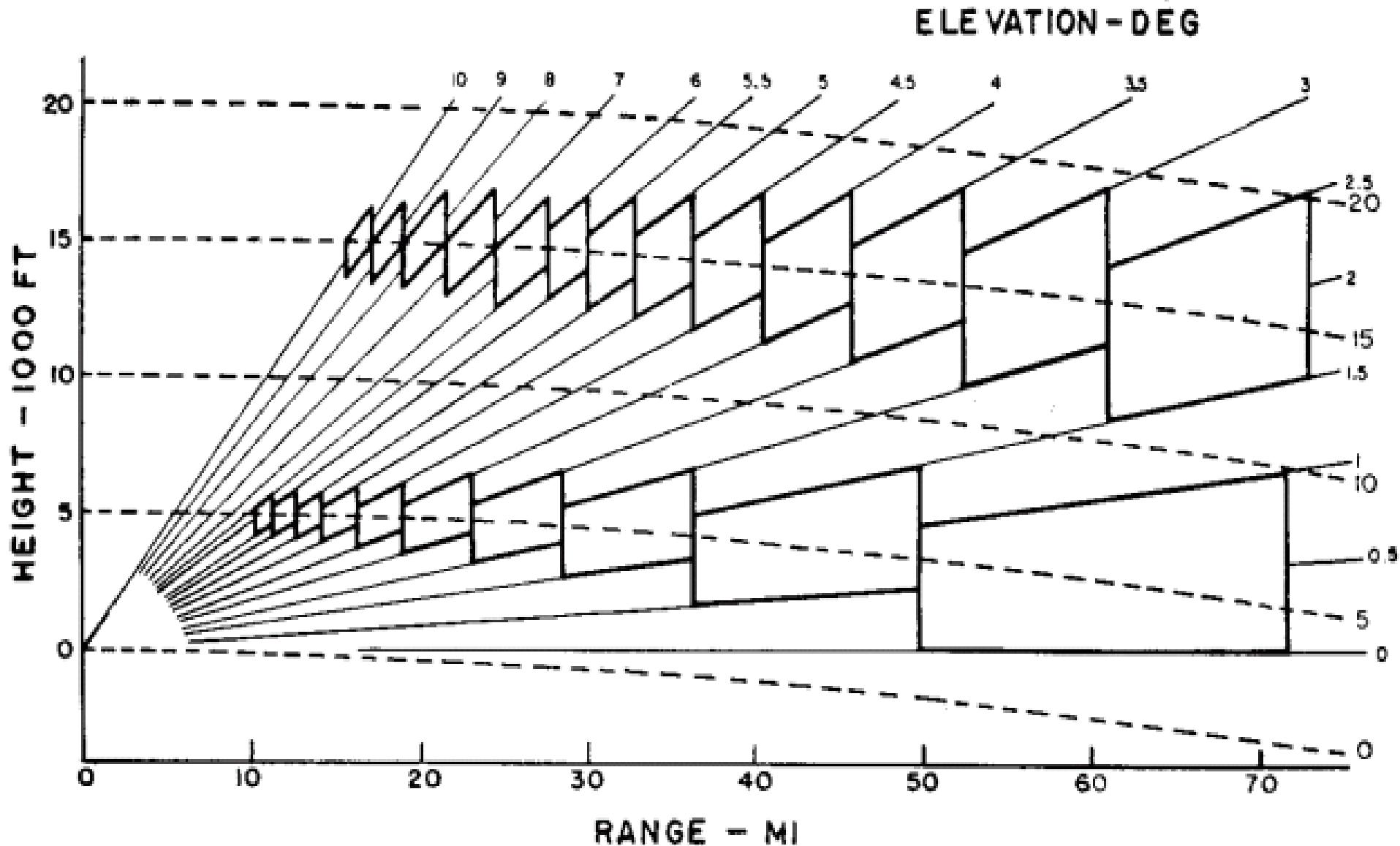
Cross-section of Reflectivity through Radar Location



mreža radara

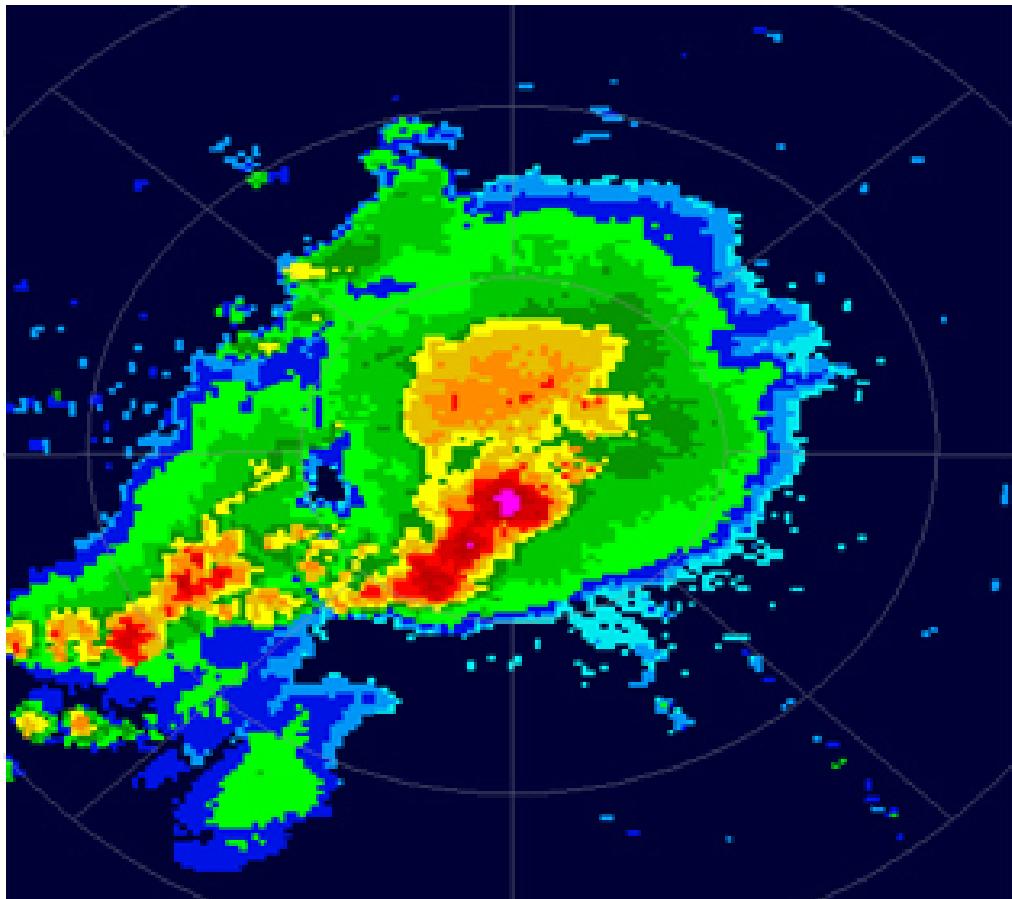


cappi

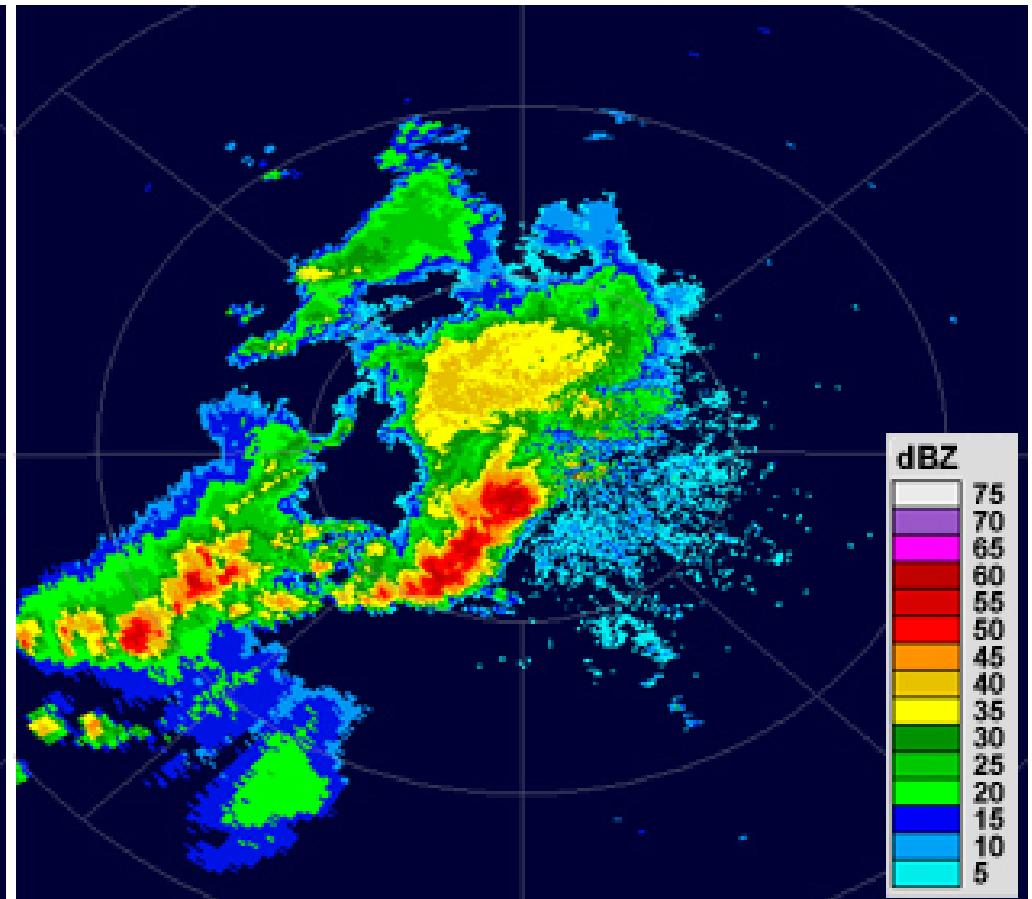


capii

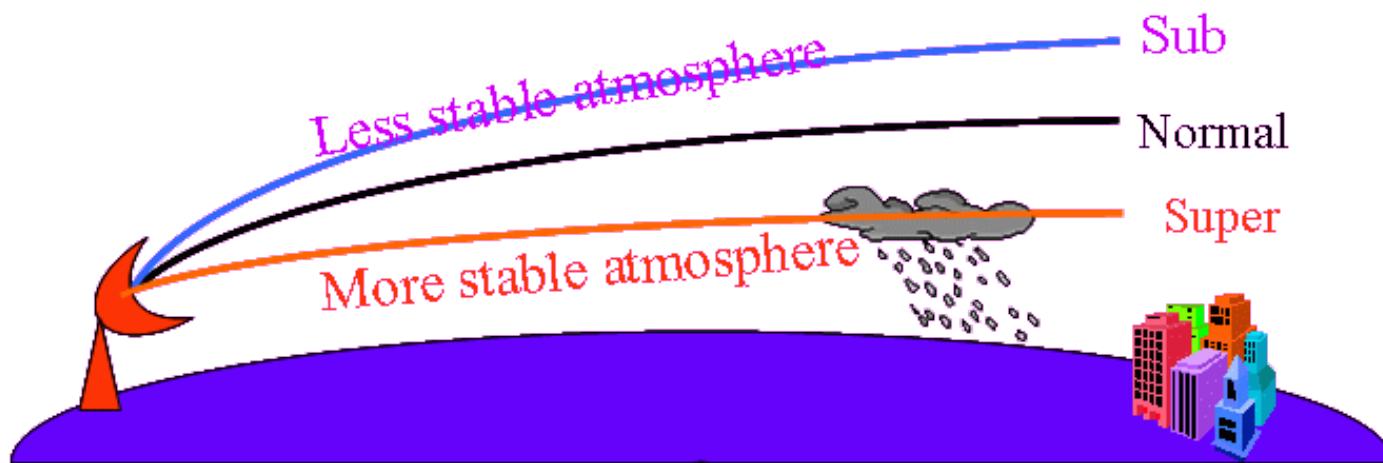
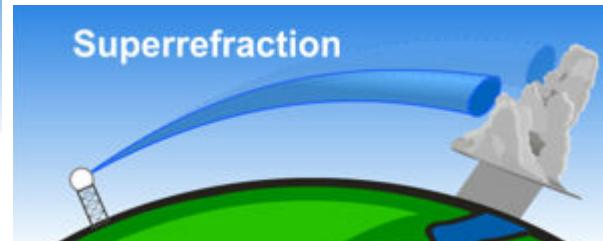
Composite Reflectivity



Base Reflectivity

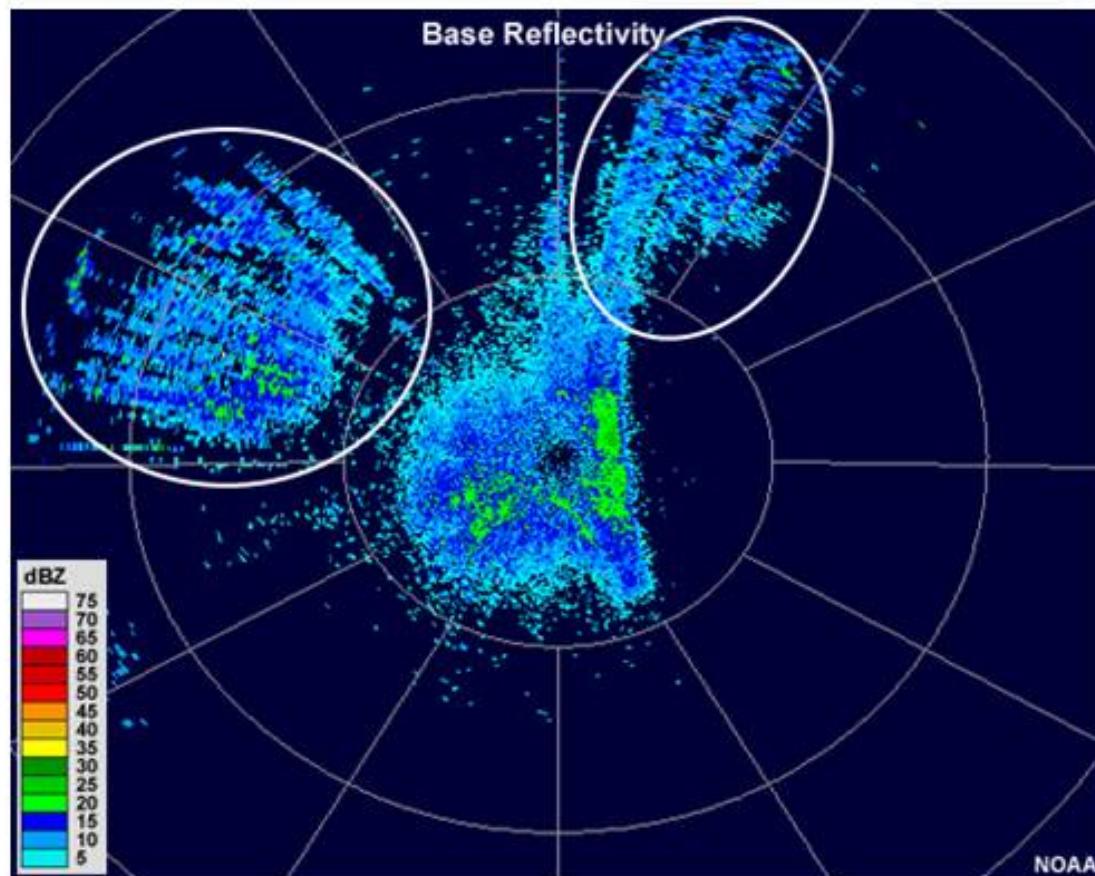


svojstva atmosfere



Anomalous propagation:

Anomalous propagation most commonly occurs when sharp inversions in the lower troposphere bend radar beams downward as they travel away from the radar. This phenomenon may cause a widespread cluttered appearance at the ground, or only certain features, such as local hilltops or buildings, may be intercepted.

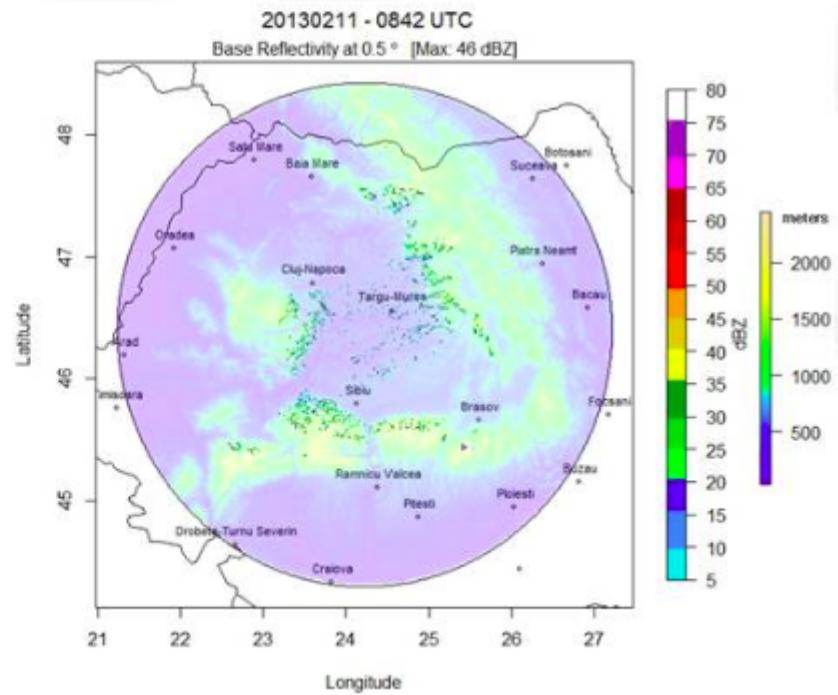
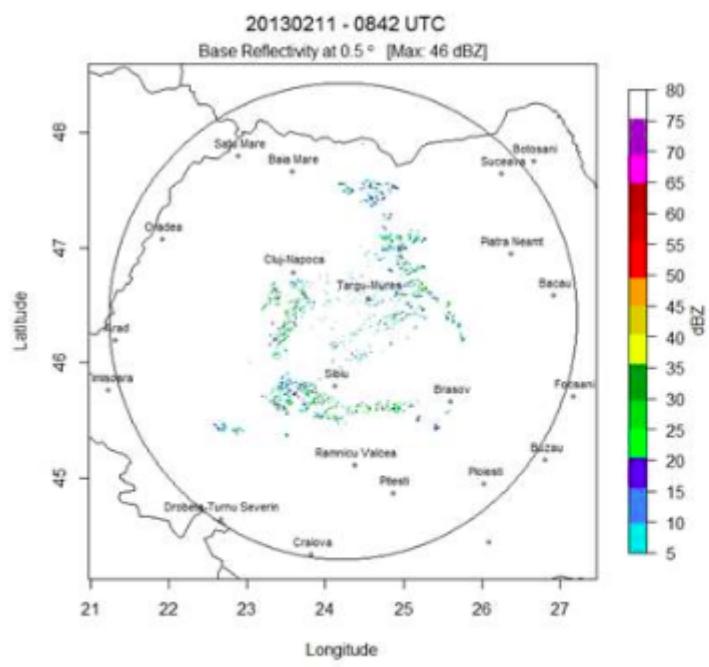


ground clutter (nered)

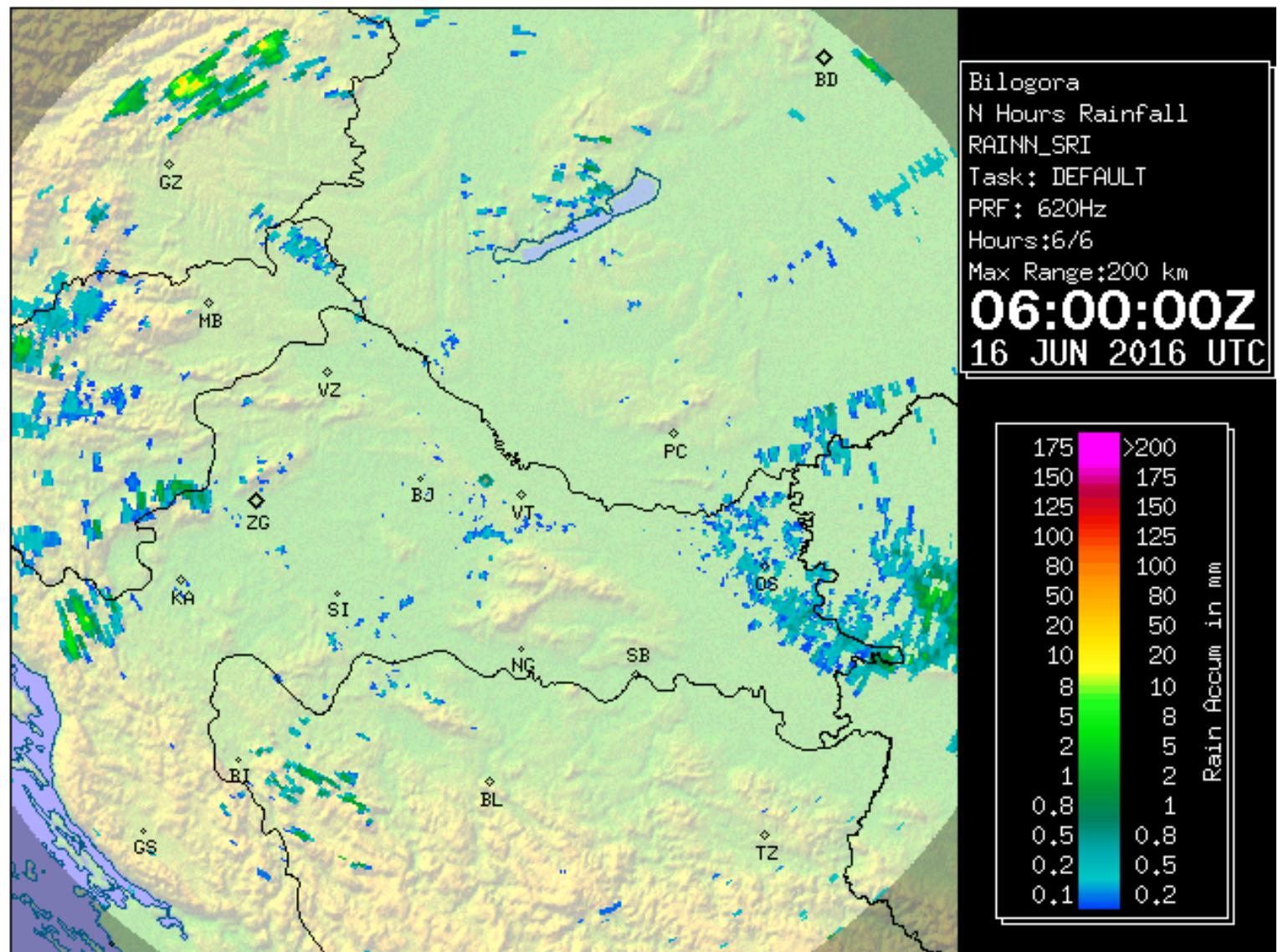
Radar signal is reflected from mountains, buildings, trees, ...

Because these targets are not moving, GC can be identified and removed with Doppler filters.

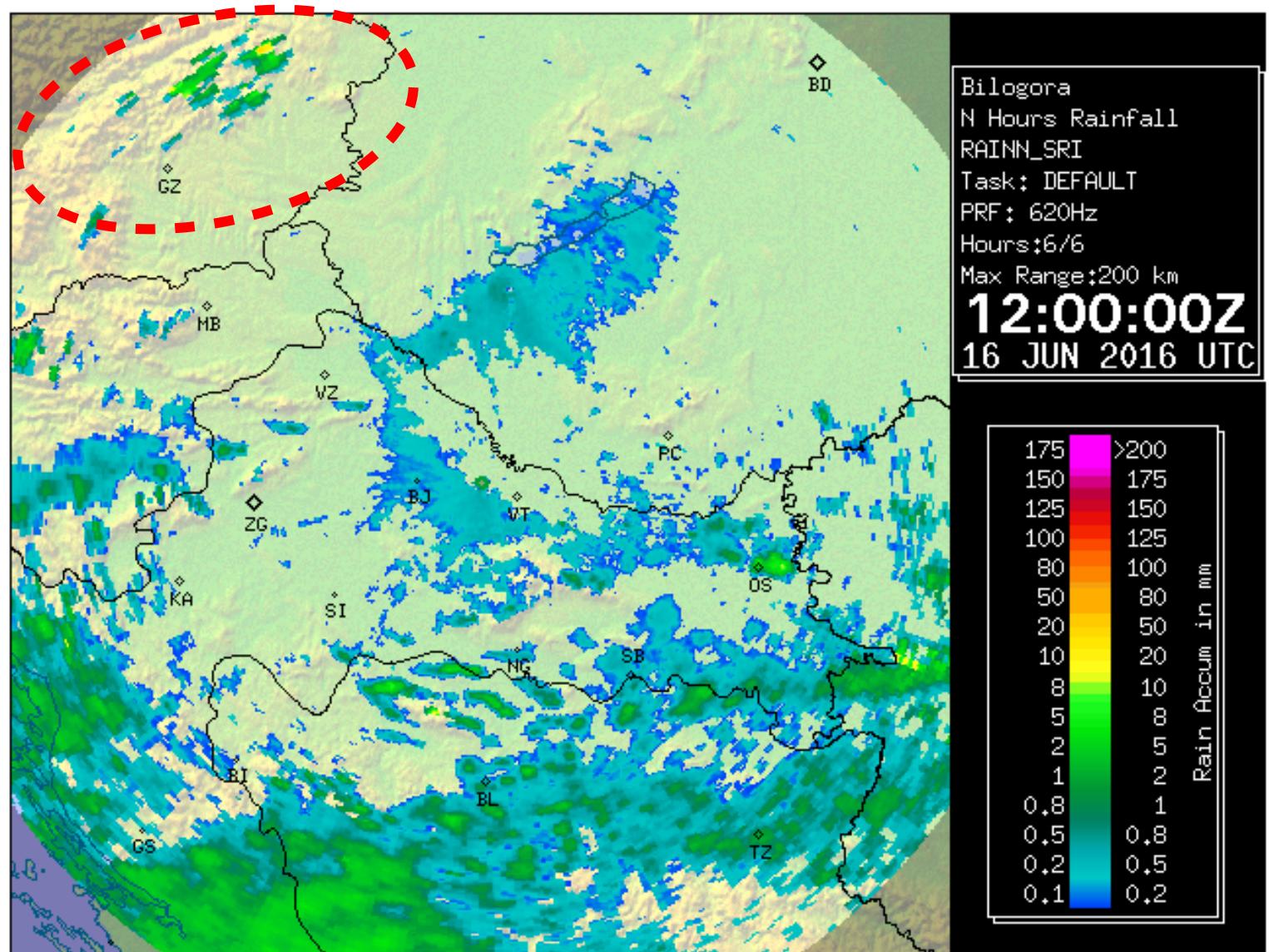
Remaining GC after data processing is called *residual ground clutter*.



ground clutter

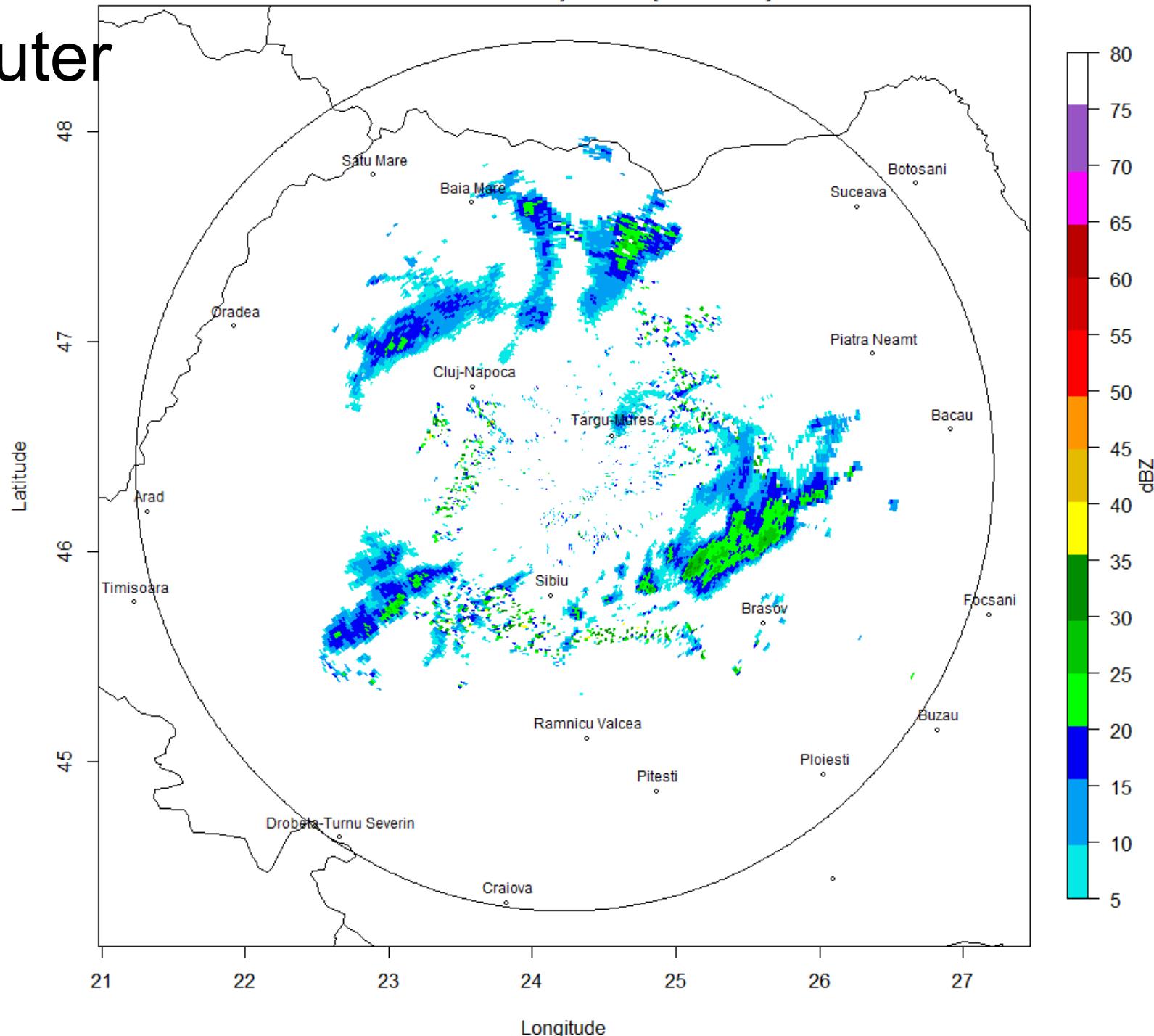


ground clutter rain 6/6

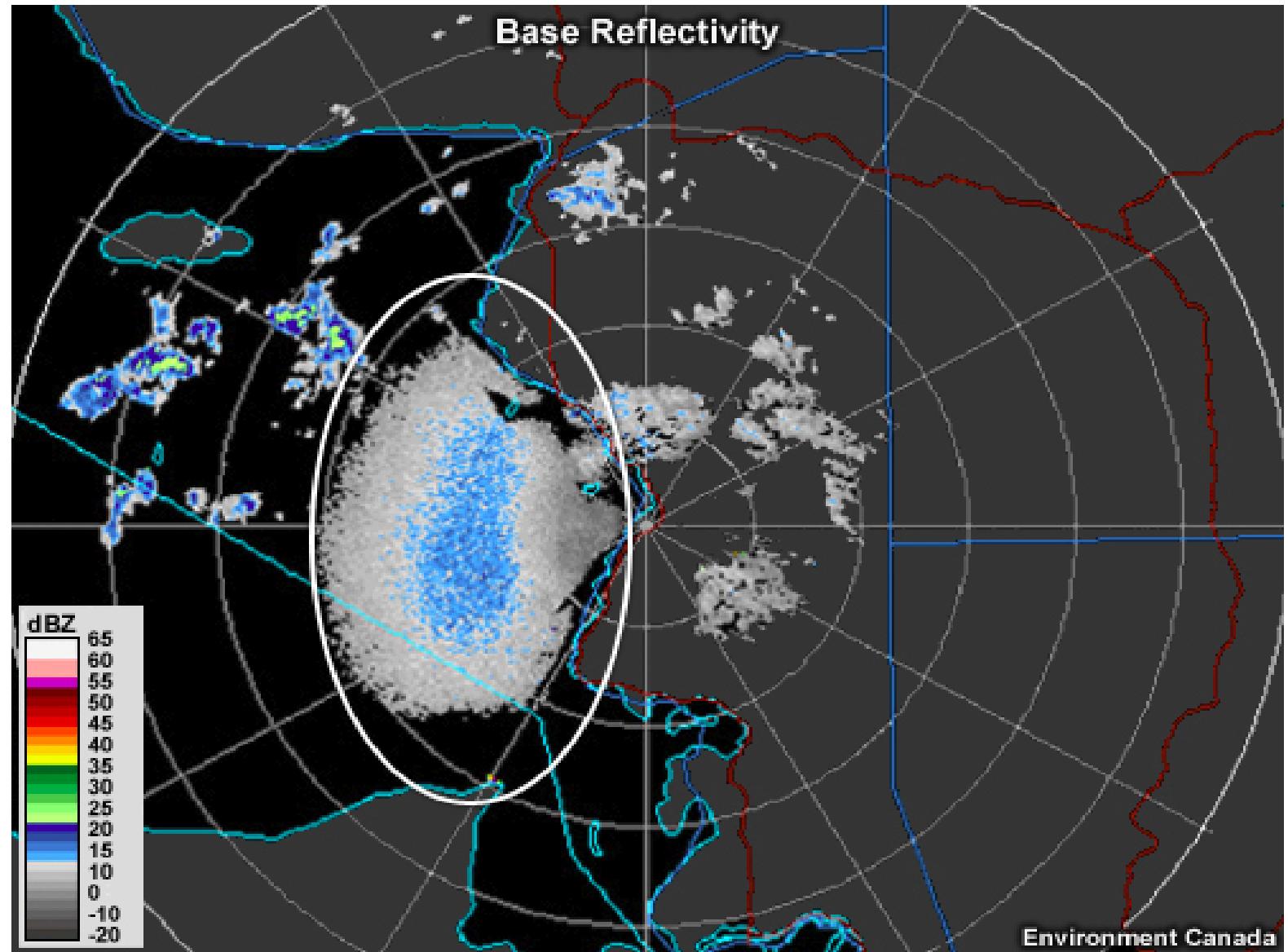


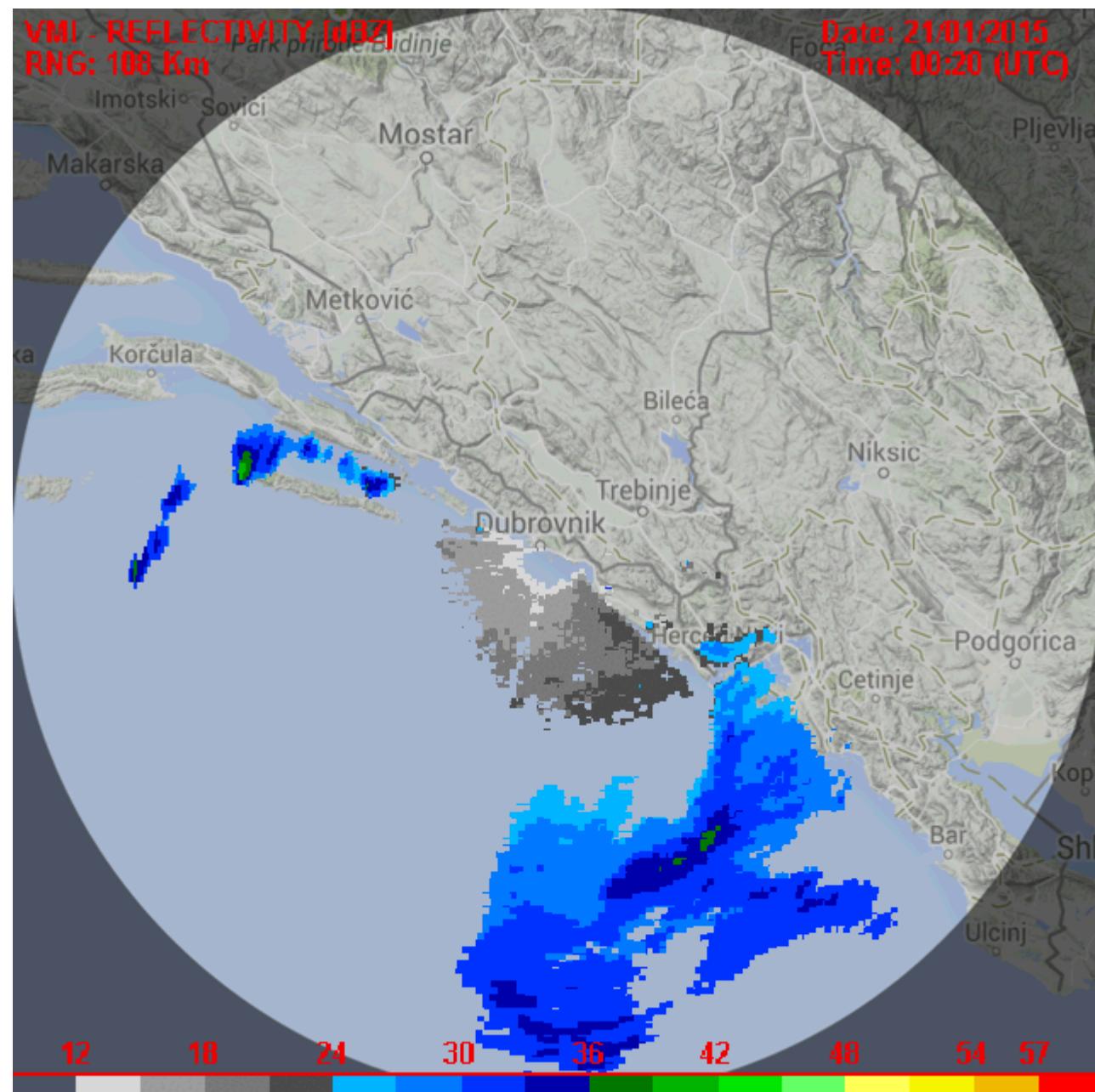
20130220 - 0805 UTC
RDBB Base Reflectivity at 0.5° [Max: 44 dBZ]

ground clutter

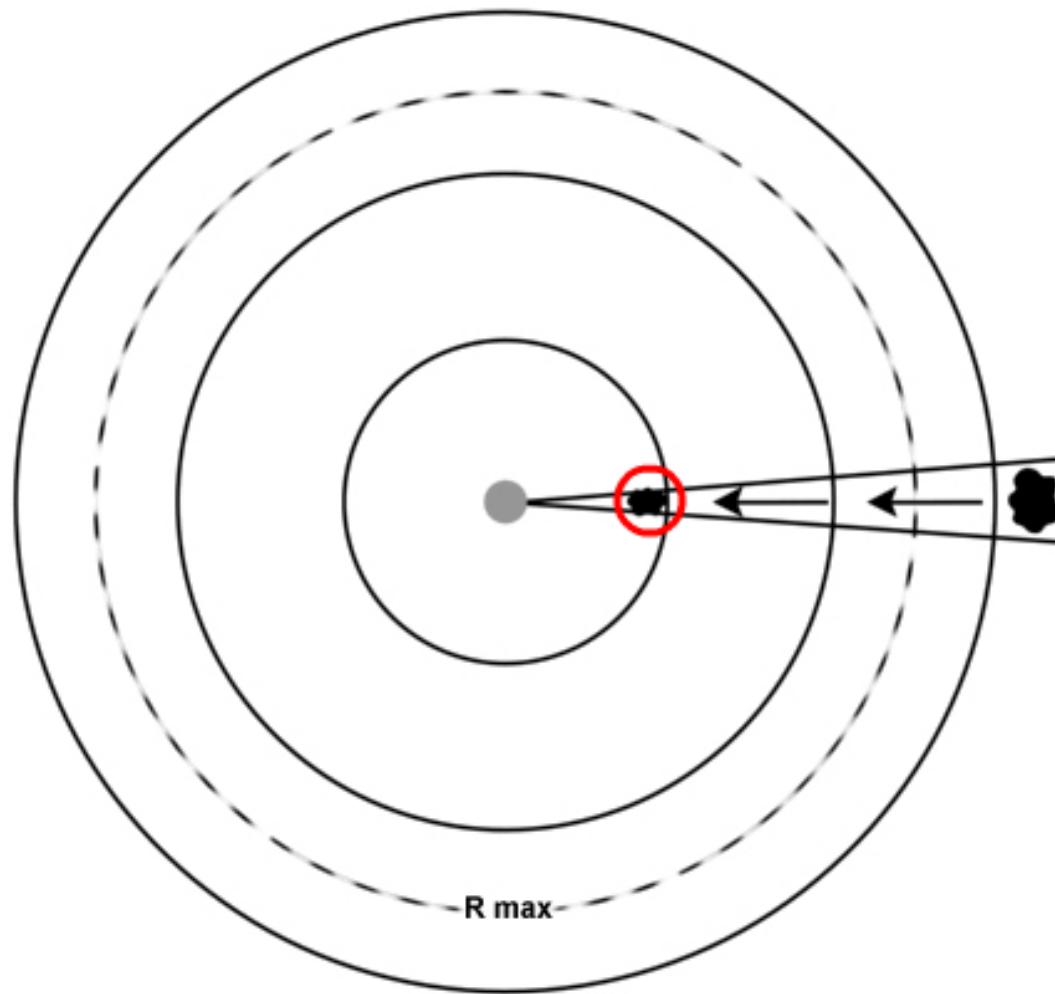


sea clutter

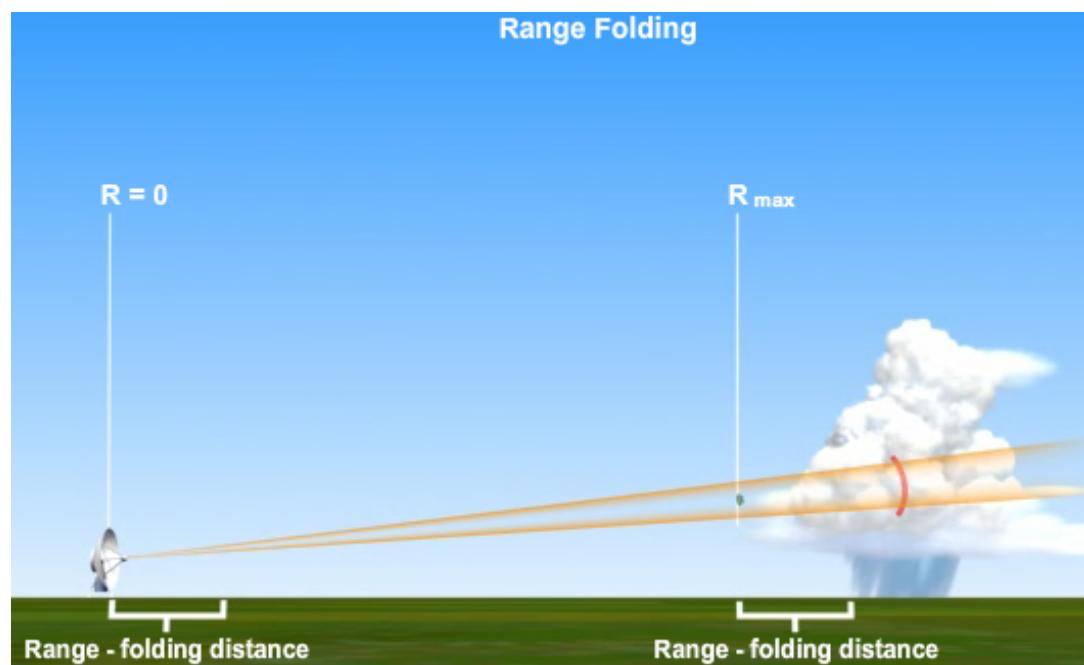
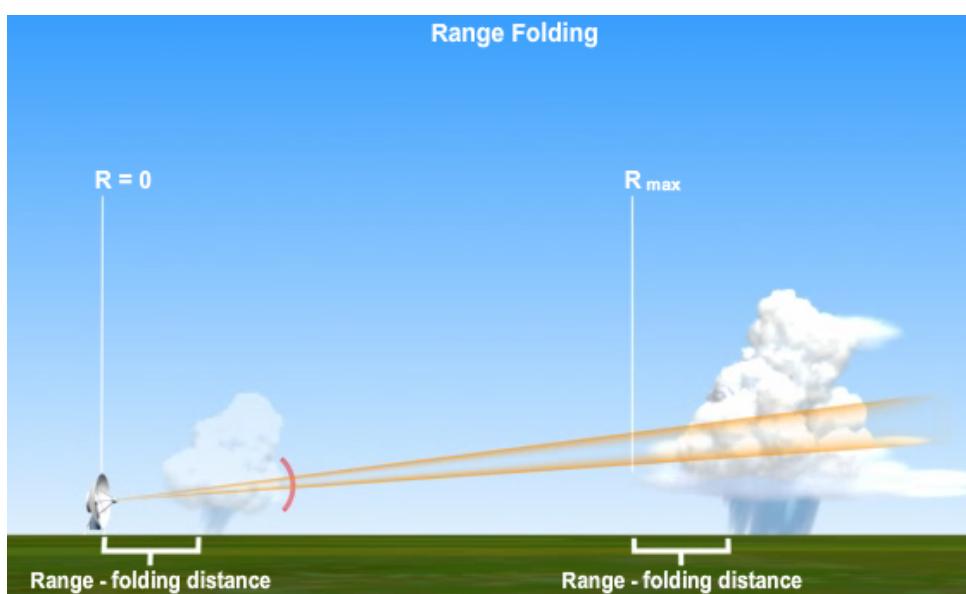
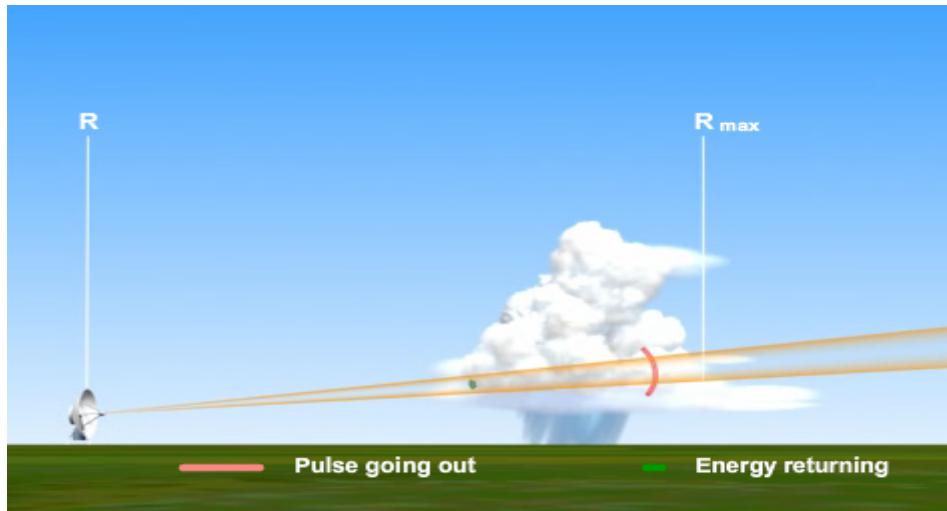




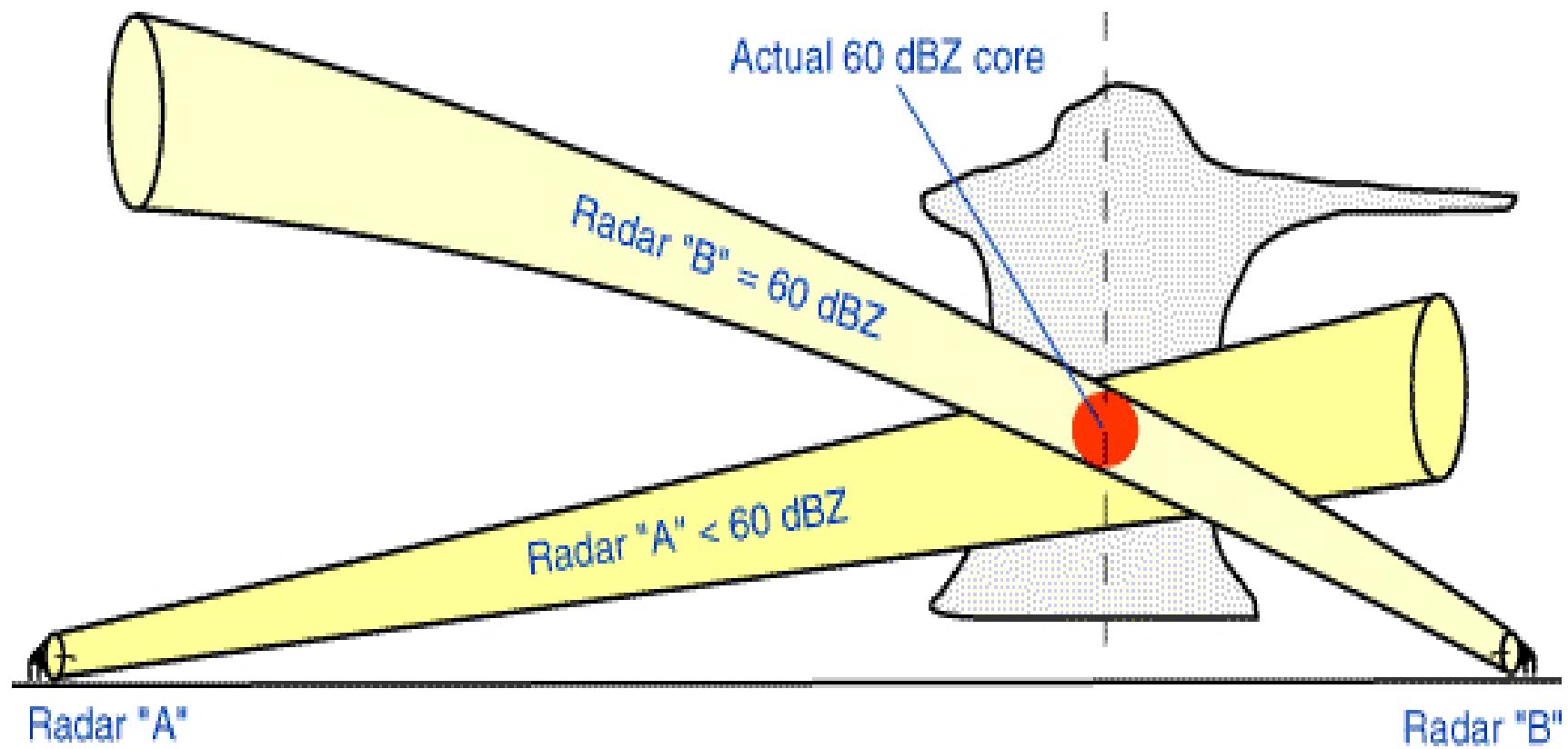
lažni odraz



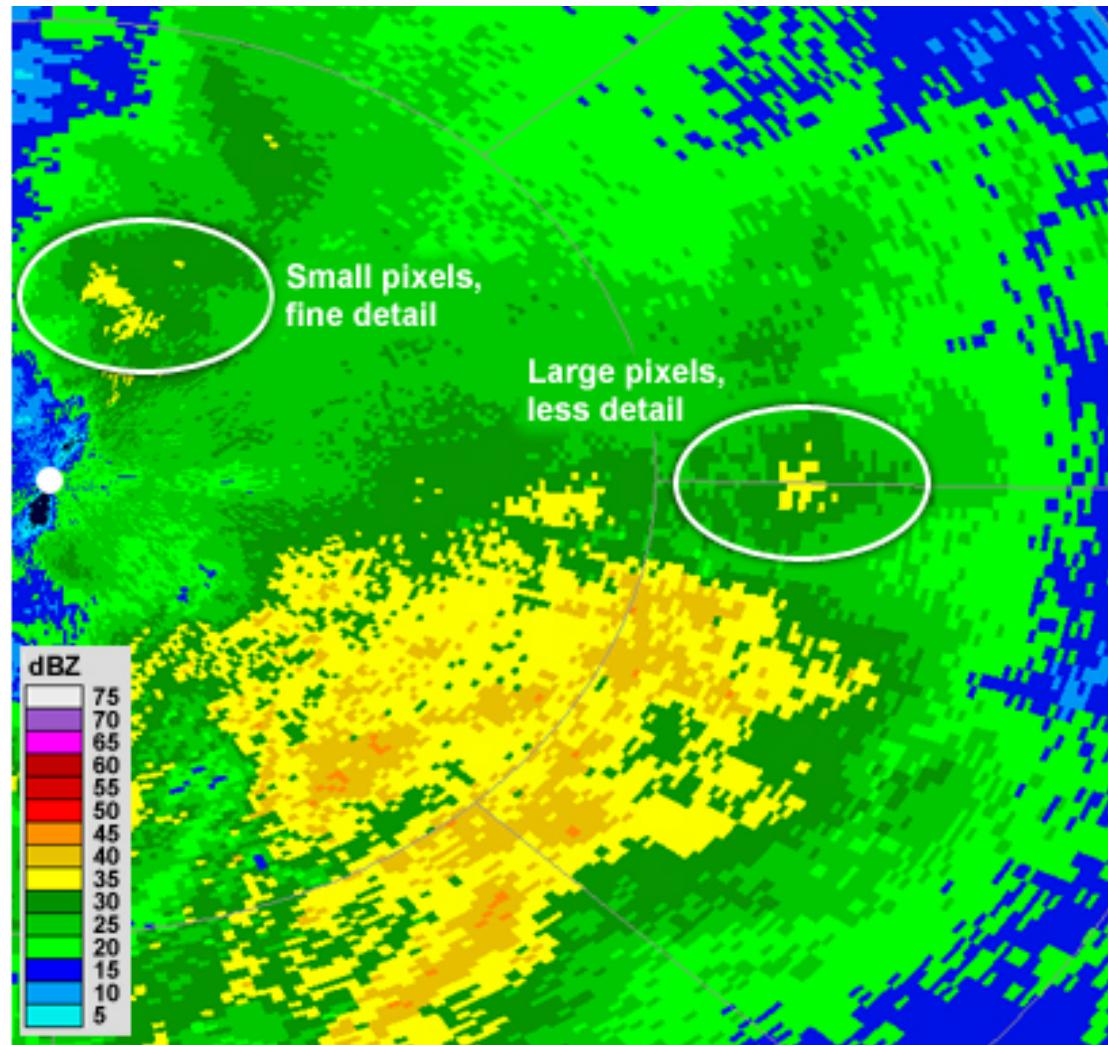
udaljenost

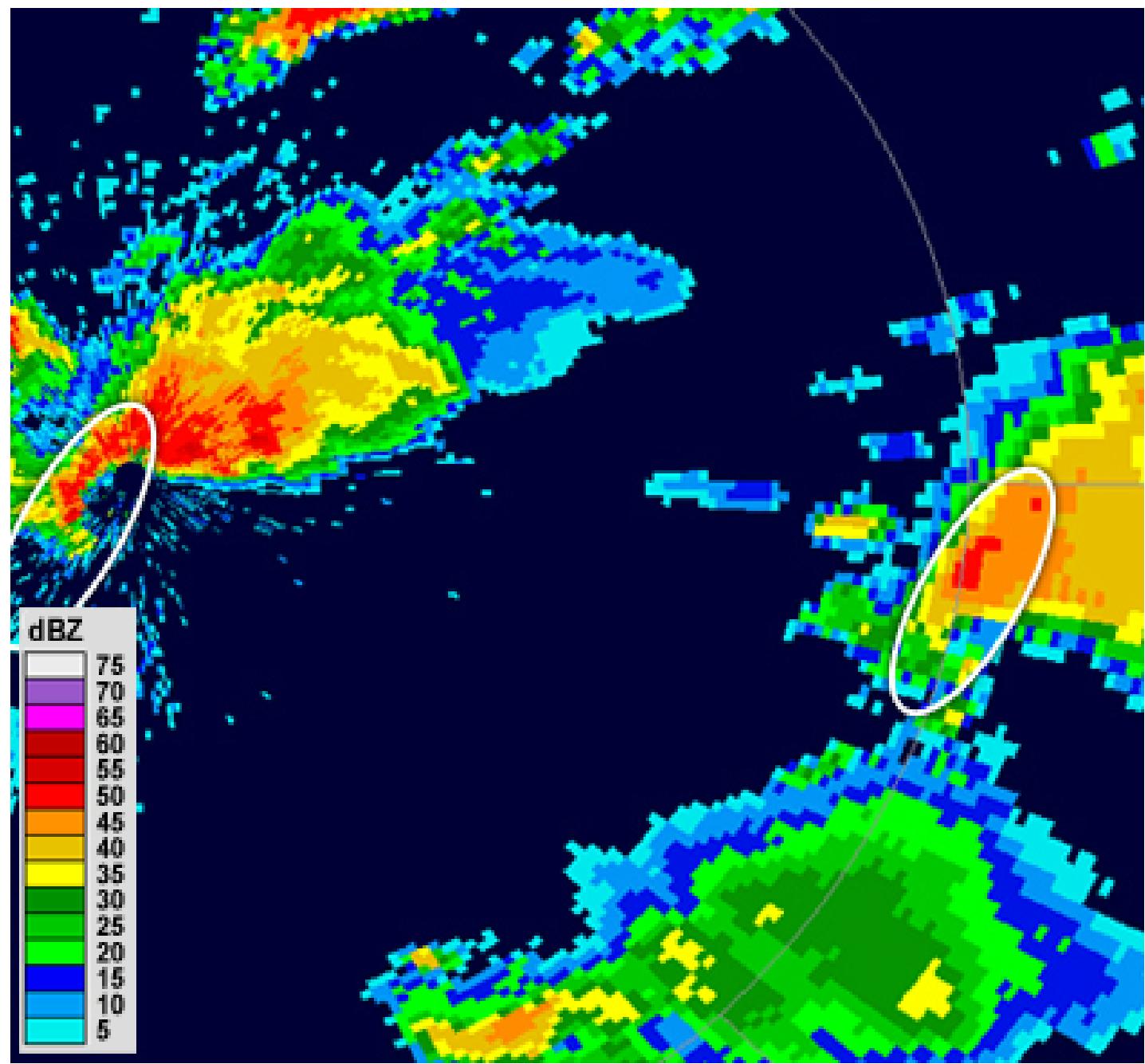


šířina snopa



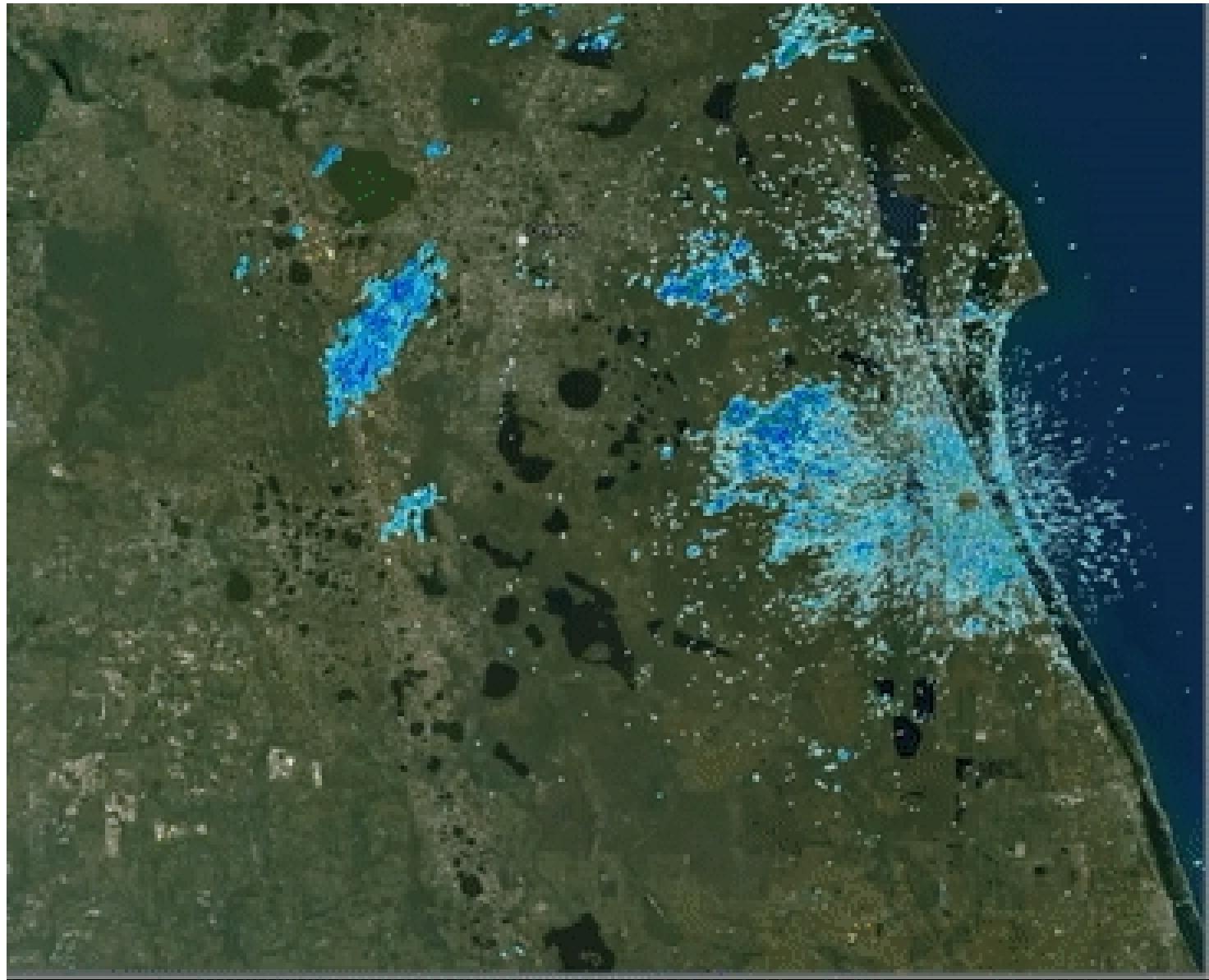
geometrija udaljenost od radara





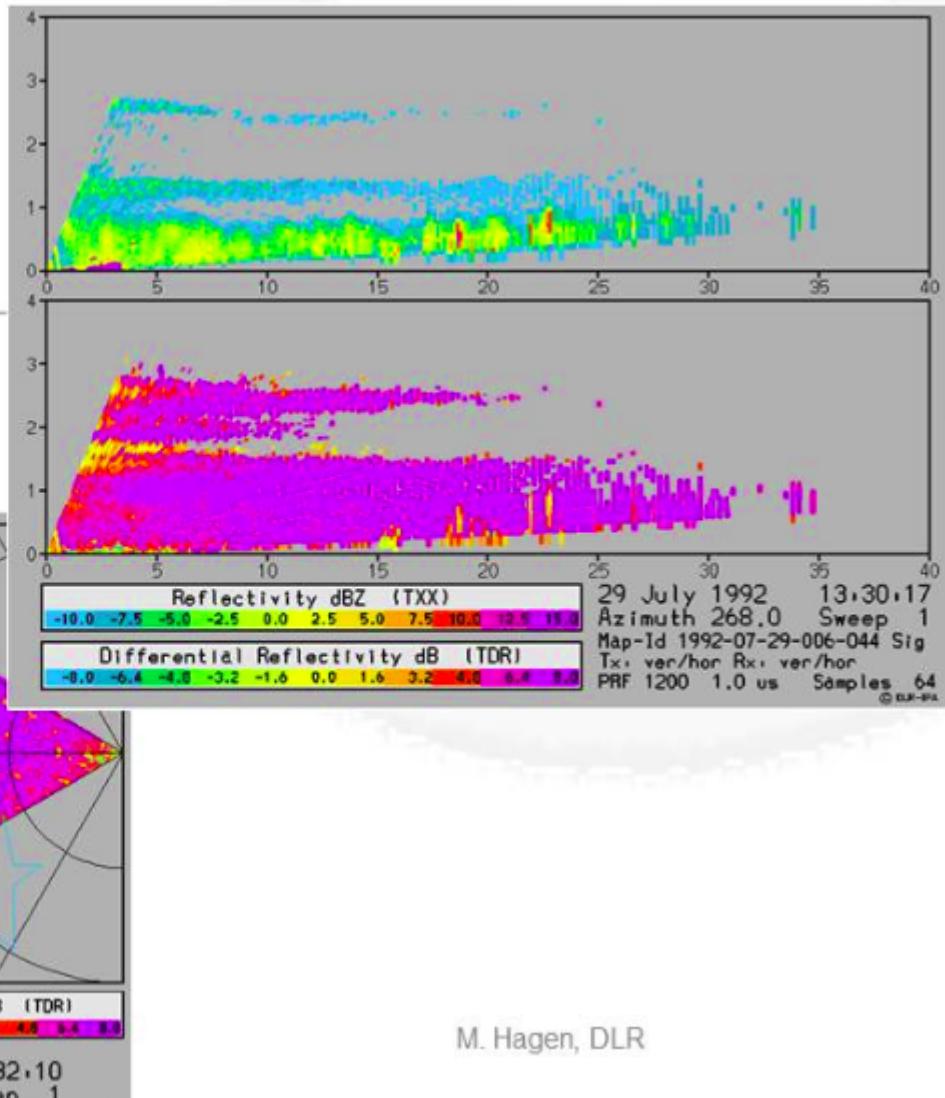
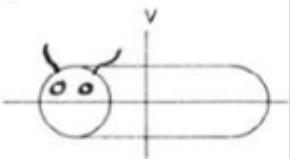
HAZU 2017

ptice

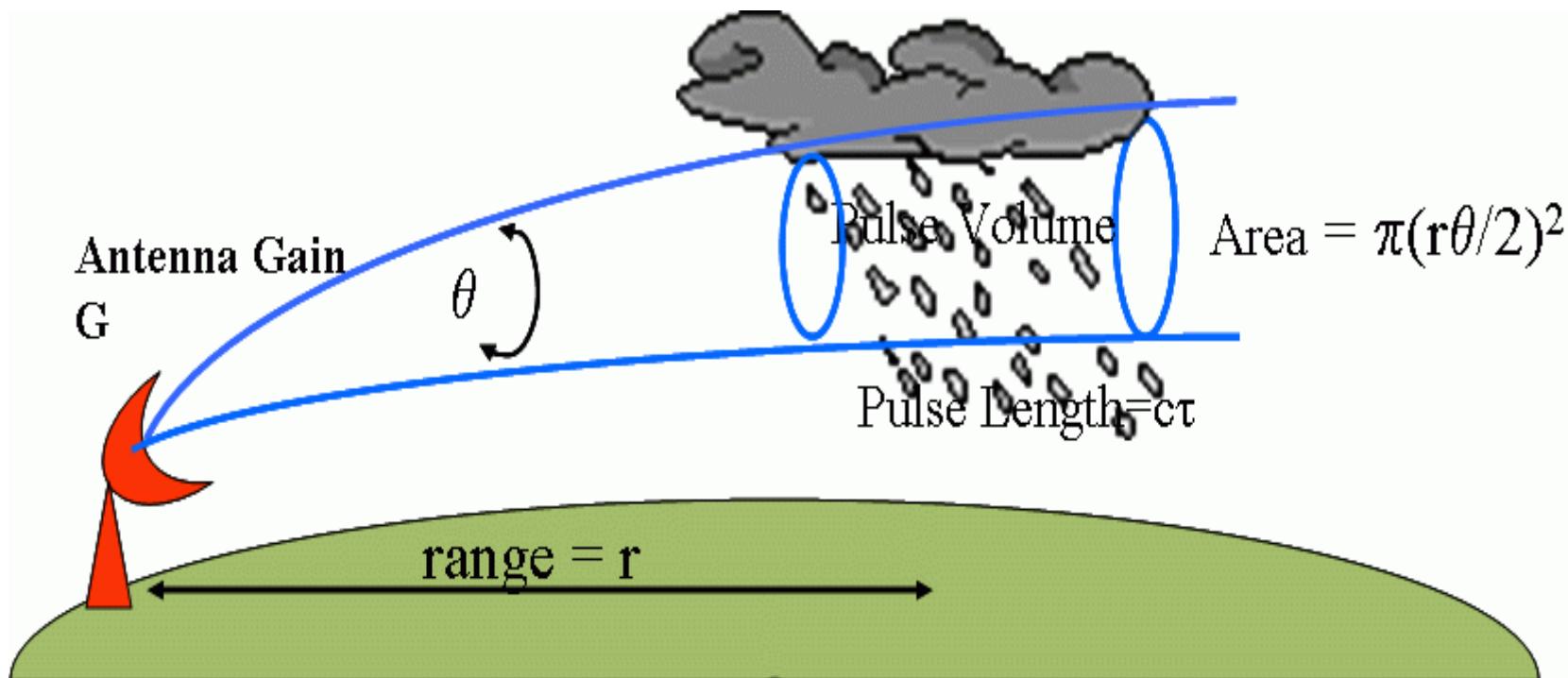


Insects:

- small size (2 – 5 mm),
low concentration
=> low Z
- elongated body
=> ZDR > 5 dB
high ρ_{HV}

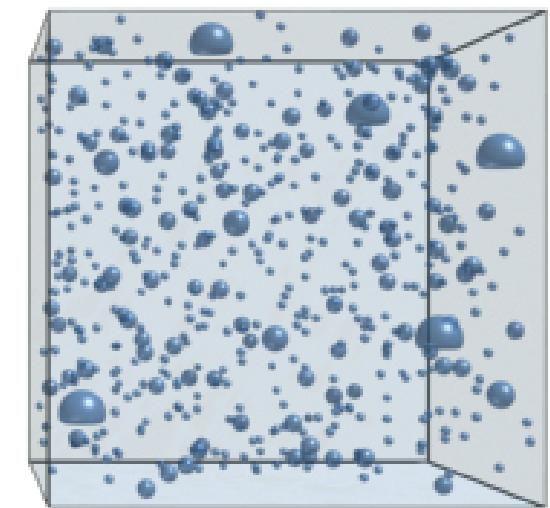
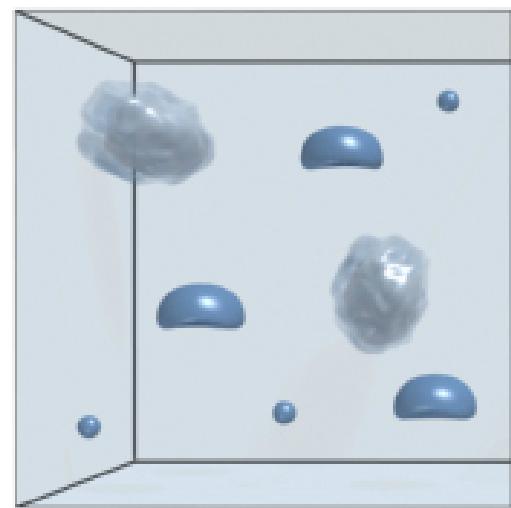


M. Hagen, DLR

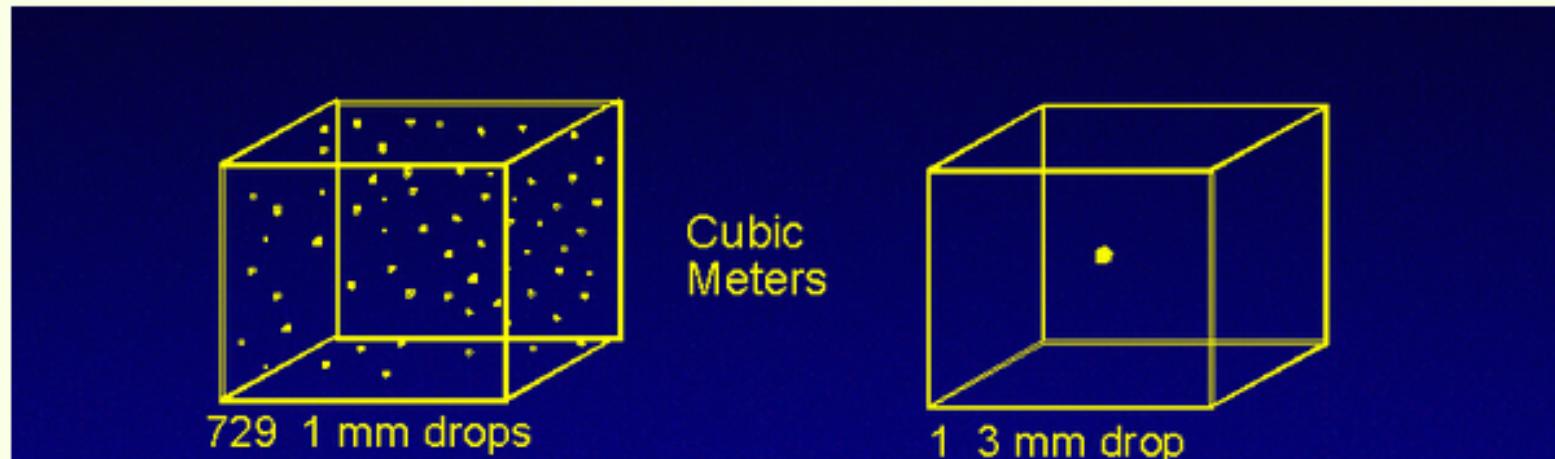


$$Z = \sum_{i=1}^n D_i^6$$

Raindrop diameter (D)—Units of millimeters
 Volume—Units of cubic meters
 Radar Reflectivity Factor (Z)—Units of mm^6/m^3

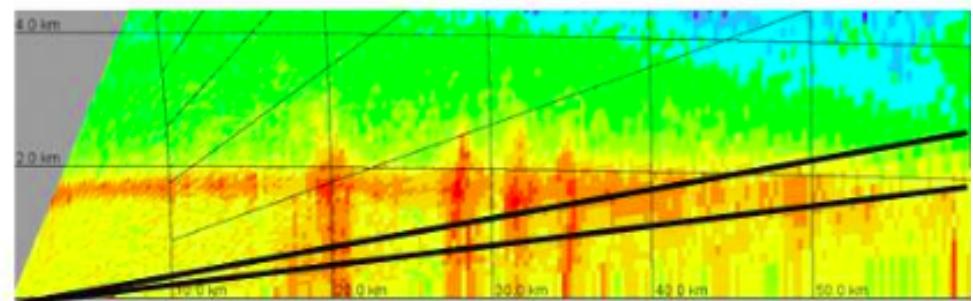
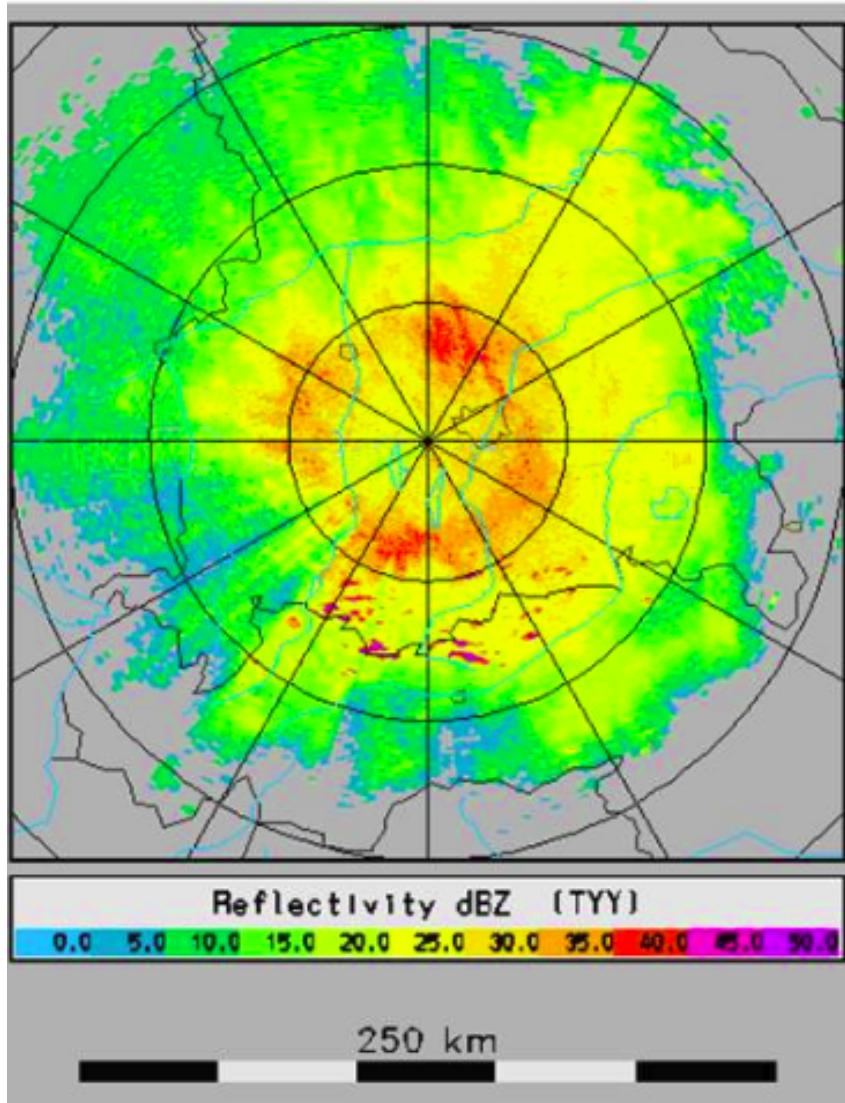


Danger of using fixed Z-R relationships

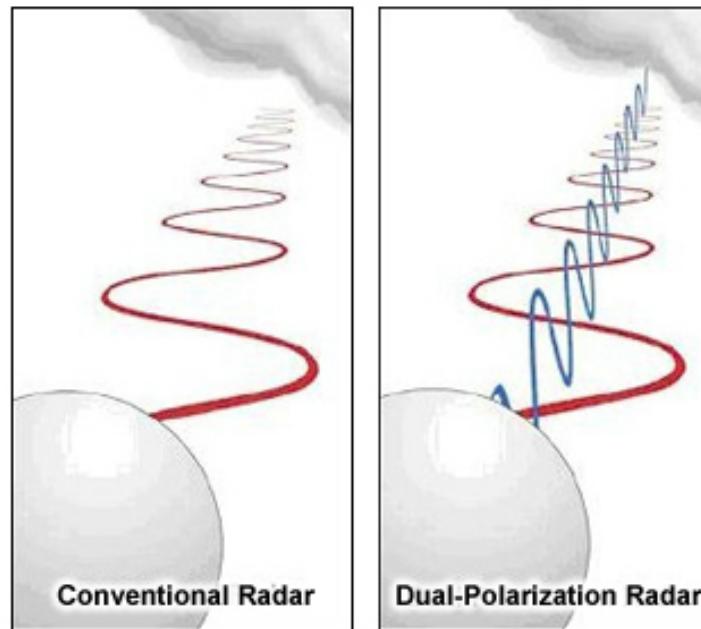


In both cases the measured reflectivity is $\text{mm}^3/\text{m}^3 \rightarrow 29 \text{ dBZ}$

svjetla nit - bright band



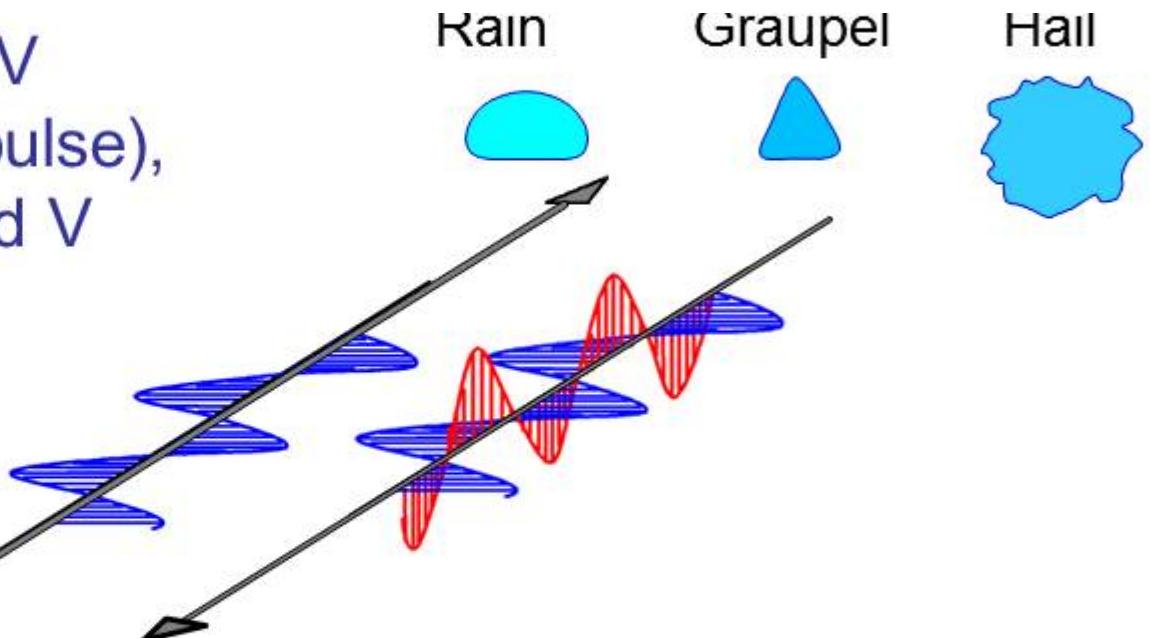
dual pol



Cloud and precipitation particles have different shape, phase, size, and falling behaviour



alternating H and V
transmit (pulse to pulse),
simultaneous H and V
receive



- expensive and sensitive switch required
- can measure full scattering matrix (research radars)

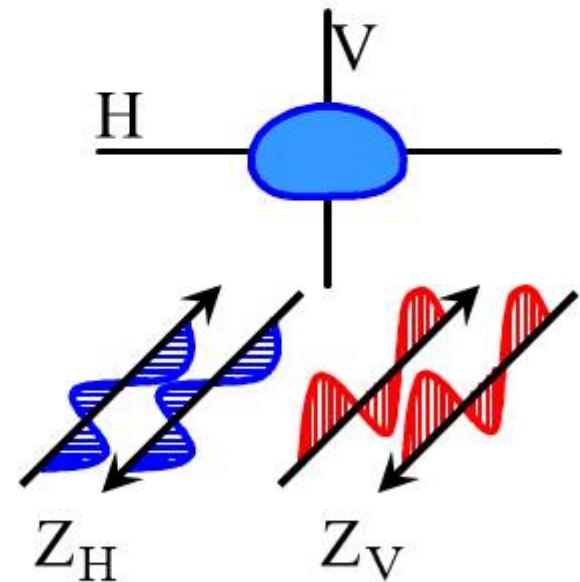
Differential Reflectivity (ZDR)

Differential reflectivity is the ratio between horizontal and vertical reflectivity factor

$$ZDR = 10 \log\left(\frac{z_H}{z_V}\right) \quad \text{or} \quad ZDR = z_H - z_V \quad \text{unit dB}$$

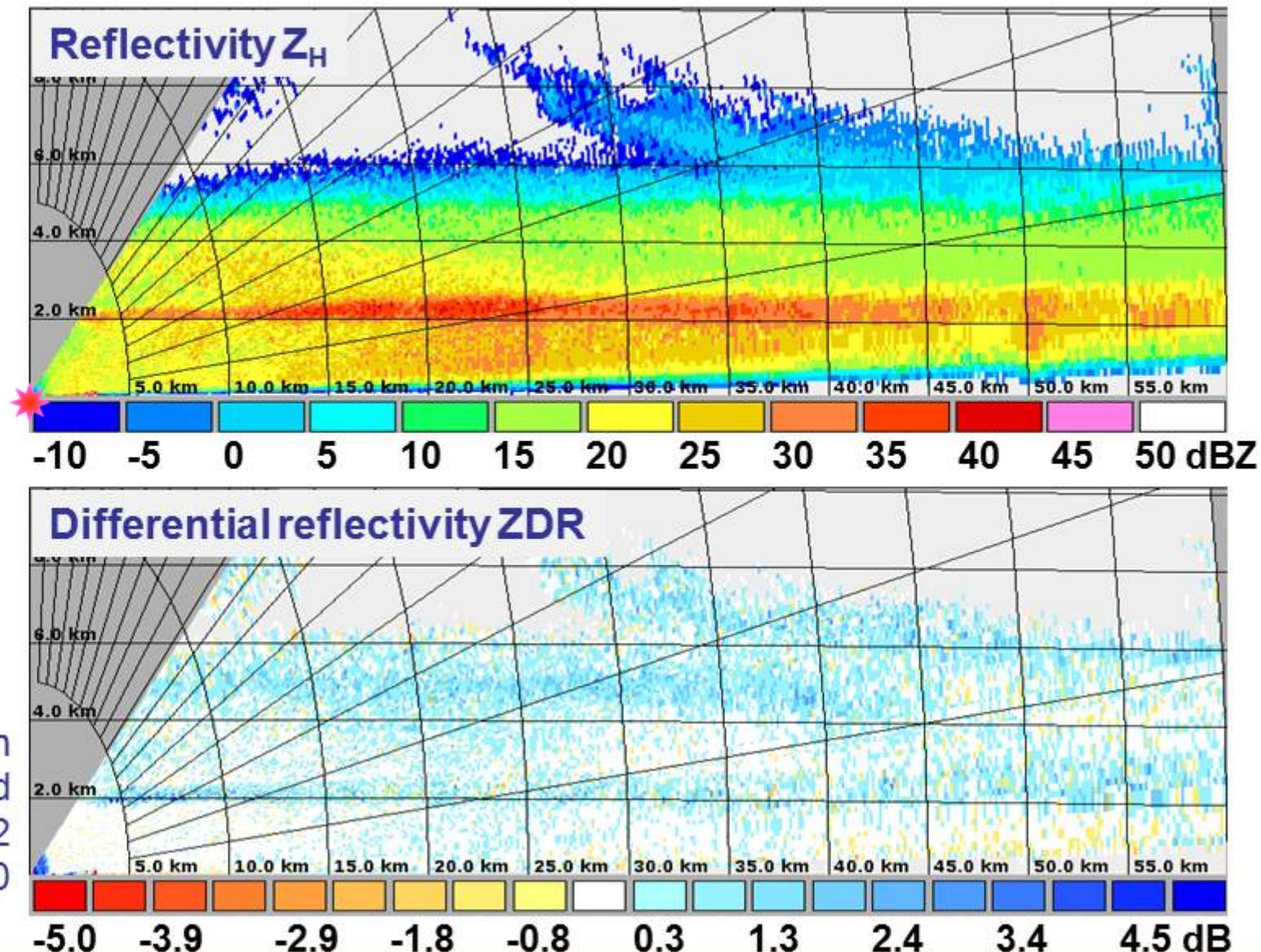
using z_H, z_V in $\text{mm}^6 \text{ m}^3$, or Z_H, Z_V in dBZ.

- ZDR depends on particle shape, orientation and falling behaviour.
- positives ZDR is caused by oblate particles falling orientated parallel to the polarization basis.
- ZDR is weighted with reflectivity.



Differential Reflectivity (ZDR)

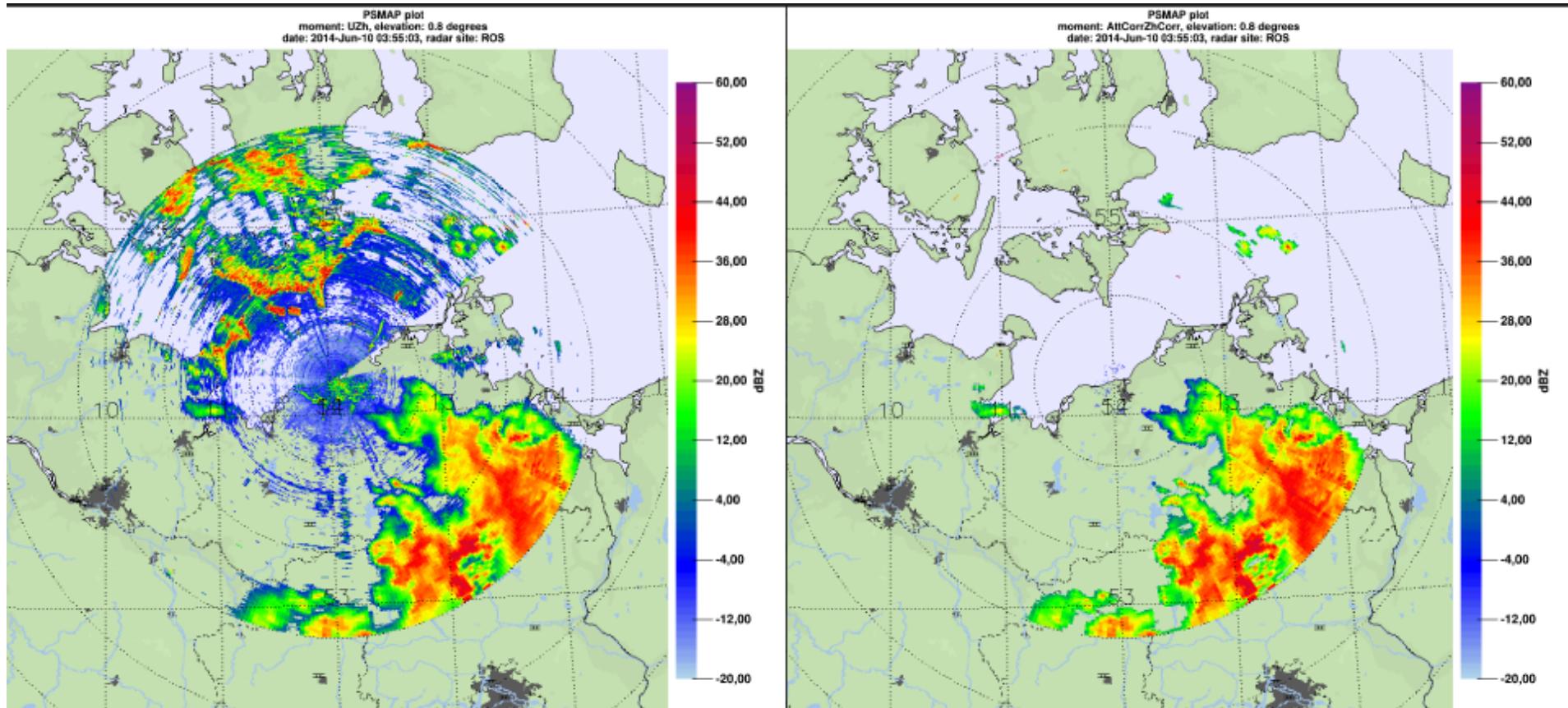
Indication
for oblate
particles
falling
horizontally
orientated



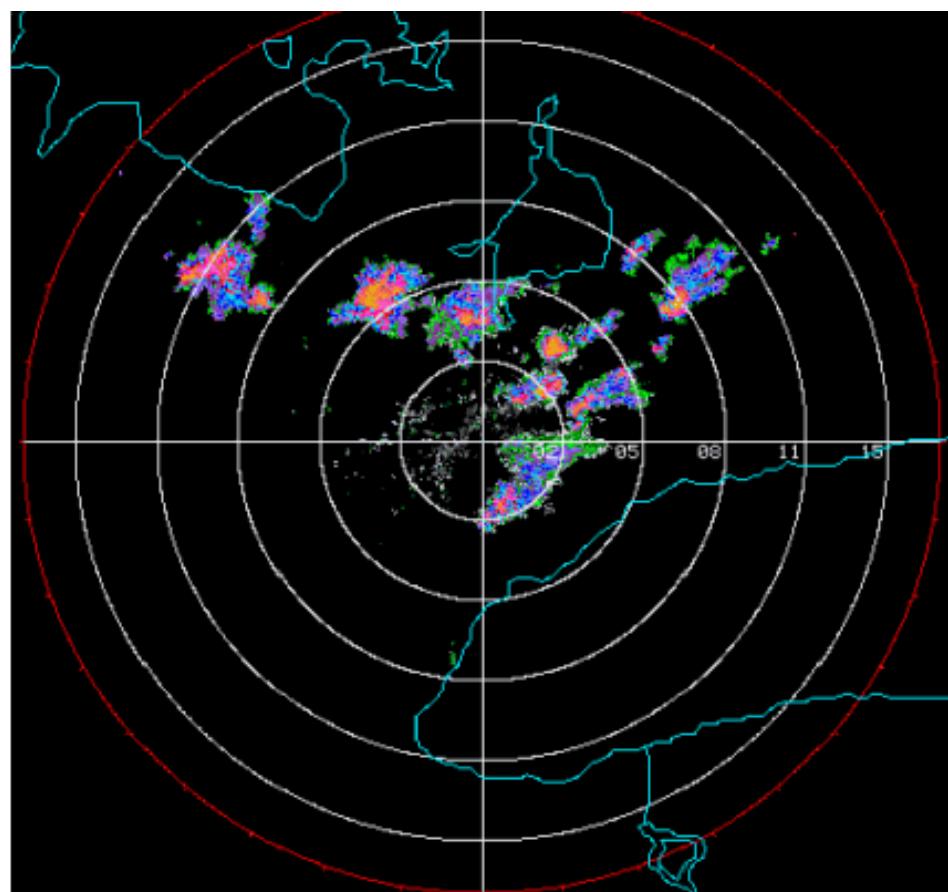
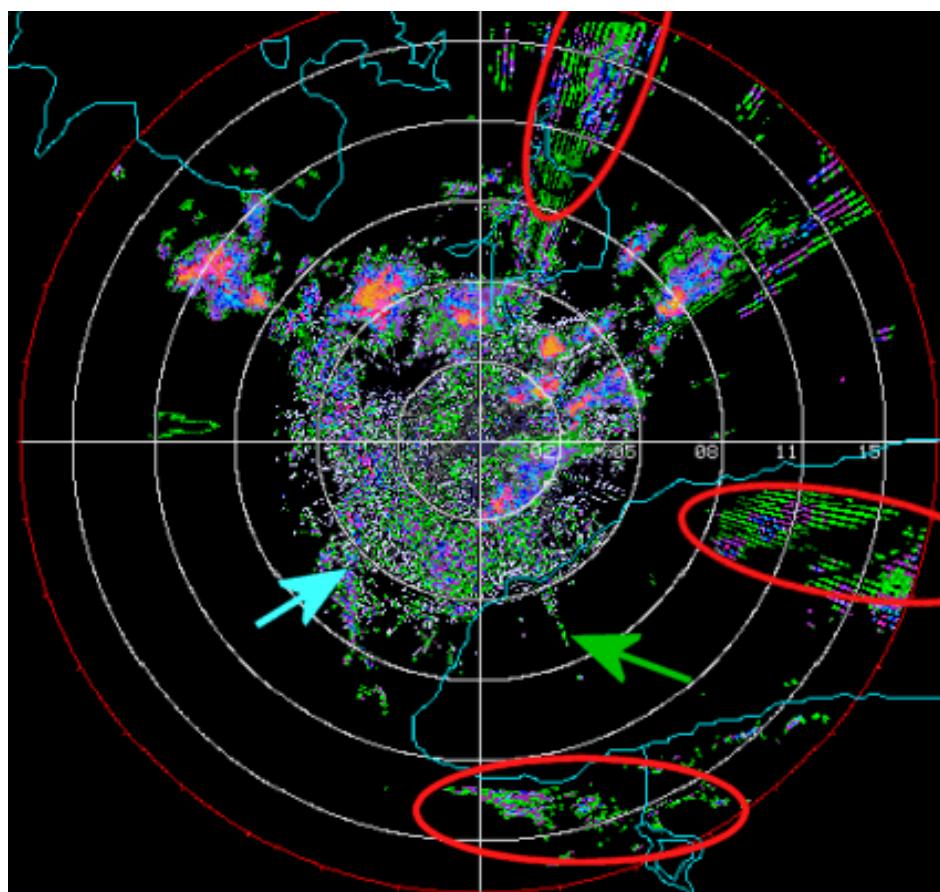
RHI scan
Poldirad
11 July 1992
11:10

Echo class				
	ECHO		EXTERNAL	
	("true" echo, ie. back-scattered pulses)	192-223	(signal not from the radar)	
	LOCATED (correctly located wrt applied geometrical model)	0-127		
PASSIVE (not moving actively; drifting)		0-63		
PRECIPITATION (hydrometeors)	0-47	48-63	64-127	192-223
<i>rain, sleet, snow, hail, graupel drizzle</i>	<i>debris</i>	<i>insects(slow)</i>	<i>ground clutter</i>	<i>second trip</i>
		<i>chaff</i>	<i>birds, bats</i>	<i>specular</i>
			<i>insects(fast)</i>	<i>flare echo</i>
			<i>aircraft, ships</i>	<i>noise</i>
			<i>buildings, masts</i>	<i>jamming</i>
			<i>wind turbines</i>	

QA



QA



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