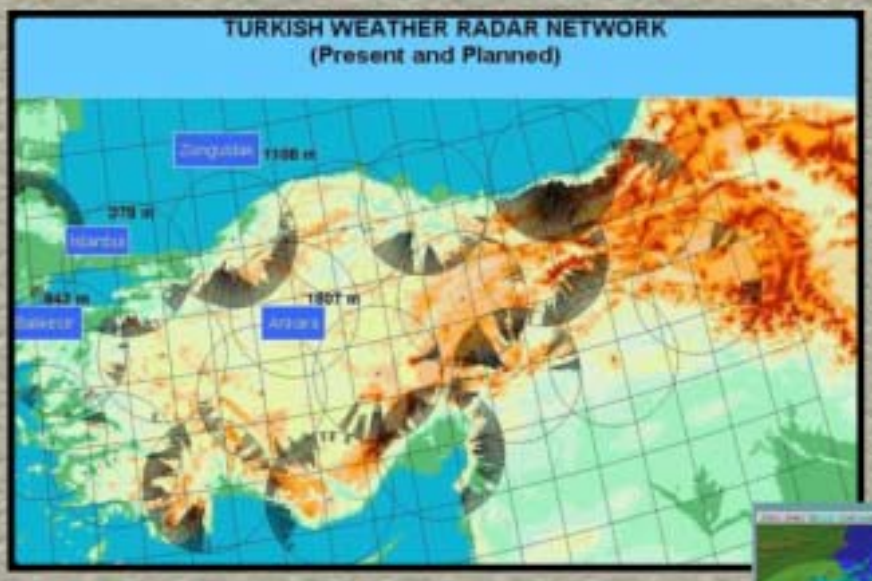
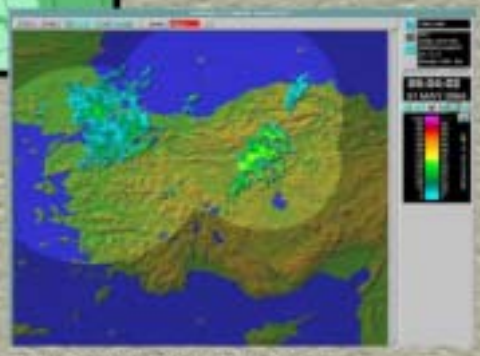
Detection of Zdr Abnormalities on Operational Polarimetric Radar in Turkish Weather Radar Network

- Turkish State Meteorological Service (TSMS) has four Weather Radars
- Three radars in operation since 2003:
  - C-Band, Klystron transmitter, Parabolic Antenna with a diameter of 7 m
  - Sigmet Software and Mitsubishi Hardware
- Polarimetric Radar in operation since 2001:
  - C-Band, Klystron transmitter, Dual Polarized with dual polarization switch, Parabolic Antenna with a diameter of 4.2 m
  - Rainbow Software and Gematronik Hardware





A Composite Image from Turkish Weather Radar Network

by Oguzhan Sireci

Differential reflectivity (ZDR):

Ratio between the reflectivity of a horizontal polarized pulse and the reflectivity of a vertical polarized pulse. ZDR depends on the asymmetry of the shape, the orientation and the falling behavior of the particles. ZDR is positive for oblate raindrops, zero or slightly negative for hail and graupel, and is strongly biased by differential attenuation during the passage of the radar pulse through heavy rainfall.

- Raindrops are not always spherical when they fall - especially the larger drops
- They tend to become more oblate
- So, the reflectivity would be larger if the wave were horizontally polarized, or Zh > Zv
  Define,

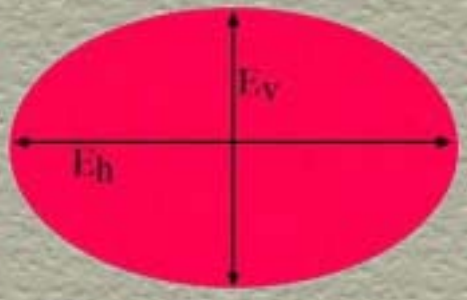
ZDR = differential reflectivity
= 10 log(Zh/Zv)

- ZDR is great for discriminating large drops from hail - hail tumbles randomly, looks like a spherical particle.
- So, ZDR for hail is about 0.
- ZDR for ice is about 0 as well.

Table 1. Values of polarimetric variables for precipitation types (from Doviak and Zrnić 1993).

	Z_h (dBZ)	Z_{DR} (dB)	ρ_{hv}	K_{DP} (°km^{-1})	LDR (dB)
Drizzle	< 25	0	>0.99	0	<-24
Rain	25 to 60	.3 to 4	>0.97	0 to 10	-27 to -24
Dry snow	< 35	0 to .3	>0.99	0 to 0.5	<-24
Dense snow	< 25	0 to 3	>0.93	0 to 1	-25 to -24
Wet snow	< 45	0 to 3	0.8 to 0.93	0 to 2	-13 to -18
Dry graupel	40 to 50	-0.3 to 1	>0.99	-0.3 to 0.3	< -20
Wet graupel	40 to 55	-0.3 to 3	>0.99	-0.3 to 2	-20 to -25
Wet hail (< 2 cm)	50 to 60	-0.3 to 0.3	>0.93	-0.3 to 0.3	<-20
Wet hail (> 2 cm)	55 to 70	<-0.3	>0.96	-1 to 1	-10 to -13
Rain/hail	50 to 70	-1 to 1	>0.89	0 to 10	-10 to -20

Bigger Rain Drops Become More Obtale



Depends on axis ratio

oblate : ZDR > 0

prolate : ZDR < 0

For drops: ZDR ~ drop size (0 - 4 dB)

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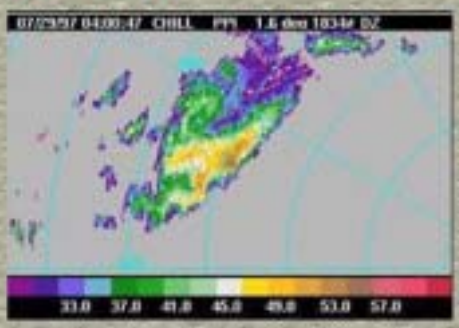
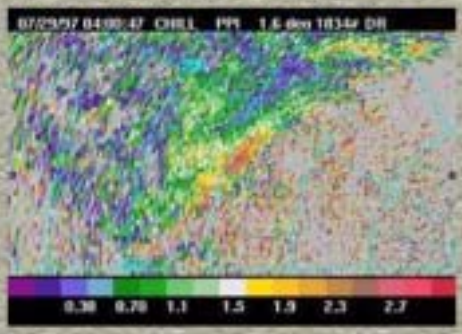
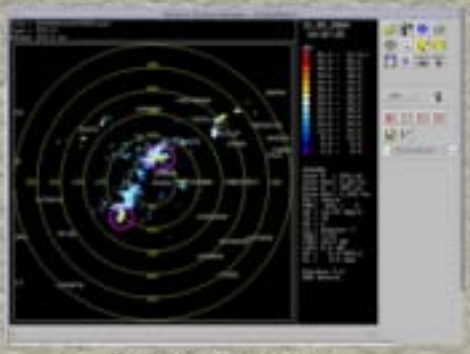
Some Zdr samples from an operational polarimetric radar:



The frame shows the radar reflectivity factor (Z) in units of dBZ from a polarimetric radar. Notice that the maximum reflectivity is about 55 dBZ, a typical lower limit for hail contaminated returns. No hail was observed during the storm.

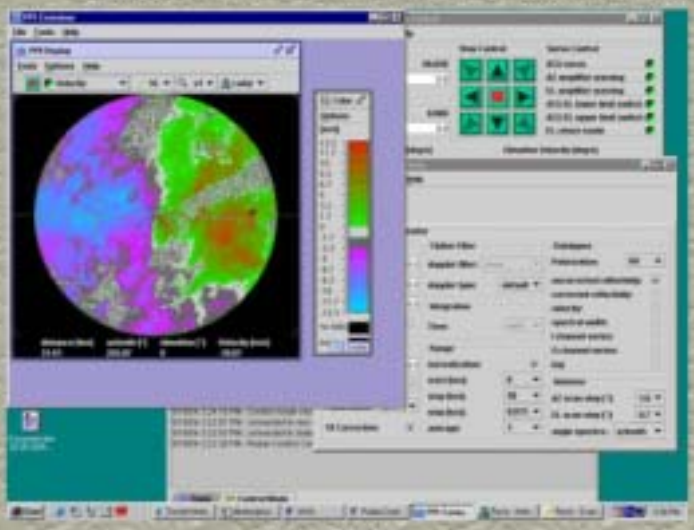


The image shows the differential reflectivity (Zdr) which is the difference between the reflectivity factors observed at horizontal polarization and vertical polarization. High values of Zdr indicate large raindrops within the pulse volume. The high differential reflectivity values (>2.5) associated with the high reflectivity regions indicate significant numbers of large raindrops.

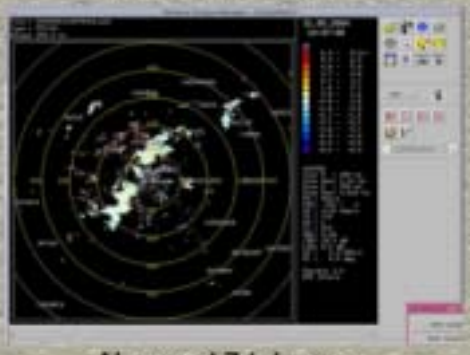


Reflectivity Image

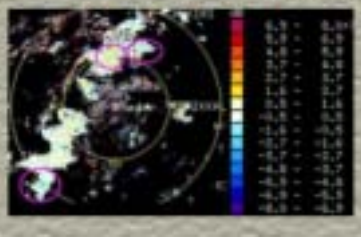
Before checking Zdr values, Velocity(V) and Reflectivity(Z) images in our Polarimetric Radar seem normal.



Velocity Image



Abnormal Zdr Image



Bigger Zdr values should have been observed in marked areas which have heavy rain

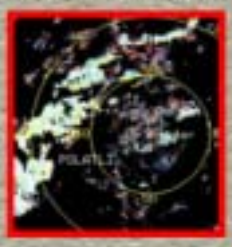
by Oguzhan Sireci

- Normally, Zdr Values should change in 0-4 dBm range in rainy areas.

For small rain drops and hail, Zdr values should be ~0dBm and should be around 0-4dBm for big rain drops. This value depends on the shape of the drop. In normal conditions, Zdr becomes negative for clutter and ice crystal.

Abnormality Symptoms determined on the product

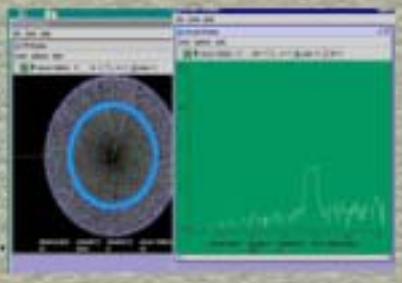
- In the area of rain echos, Zdr values changes almost randomly between -5dBm to +6 dBm.
- In received images, plus and minus values have been observed as one inside another.
- The transitions observed in Zdr values are not so logical and meaningful.
- Zdr values upper than 5dBm are almost impossible practically

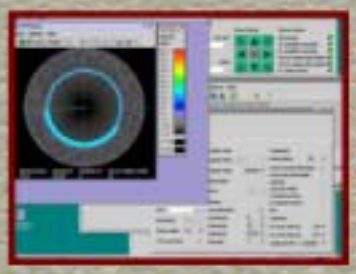


Another abnormal Zdr image

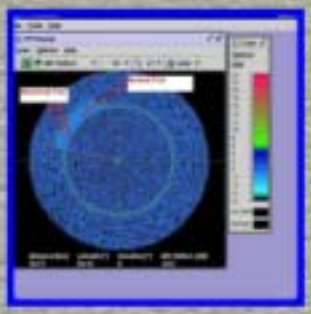
To be able to analyse problem in detail,a pulsed signal was applied to the receiver

F=5625MHz, Delay=100µsec (15km) signal was applied, and that signal was examined in ppi and ascope as reflectivity(Z).



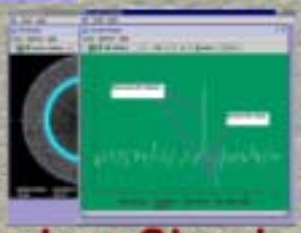


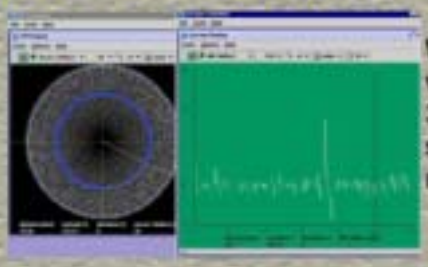
If width of the applied signal changed, it could have been observed in ppi as expected



Signal observed as -0.57dB in Differential Mode. Normally this value should have been 0 dBm. But this value was stable and caused by difference of attenuations of two seperate waveguide, so it is compensated as Zdr balance from software.
Fluctuates at the both side of the applied signal were very high in positive and negative side. If width of the signal getting narrow, only this abnormal signals remained.

Abnormalities at both edge of the signal could be observed more clearly in ascope





When applied pulse width decreased to 3 µsec only abnormal signals (spikes) remained.

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