S-Pol Data from DYNAMO

Example Signatures

Time to reflect and ruminate

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This report contains a few examples of interesting polarimetric signatures from DYNAMO

National Center for Atmospheric Research

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Contents

1 Sea Clutter

It is well known that for low grazing angles, i.e., low elevation angles for S-Pol, that in the mean $Z_H < Z_V$. Thus Z_{dr} will negative. The exact behavior of Z_{dr} depends on the roughness of the sea surface. Large waves and white caps will cause Zdr to be more “noisy”. For S-Pol at DYNAMO echoes from the sea in the lagoon area are typically always negative and appear as blue due to the standard color scale for Z_{dr} (differential reflectivity) from CIDD.

a *Case 1: Day Time, Clear Weather*

Figures 1 to 3 show S-Pol data for clear weather in the day at 0.5° elevation angle. The blue color scale for Z_{dr} is negative. The Addu Atoll is outlined with white lines and the reflectivity shows high power from ground clutter return. There are some small positive Z_{dr} spots (marked by red color scale). These echoes are likely due to bugs, birds and a few sea craft.

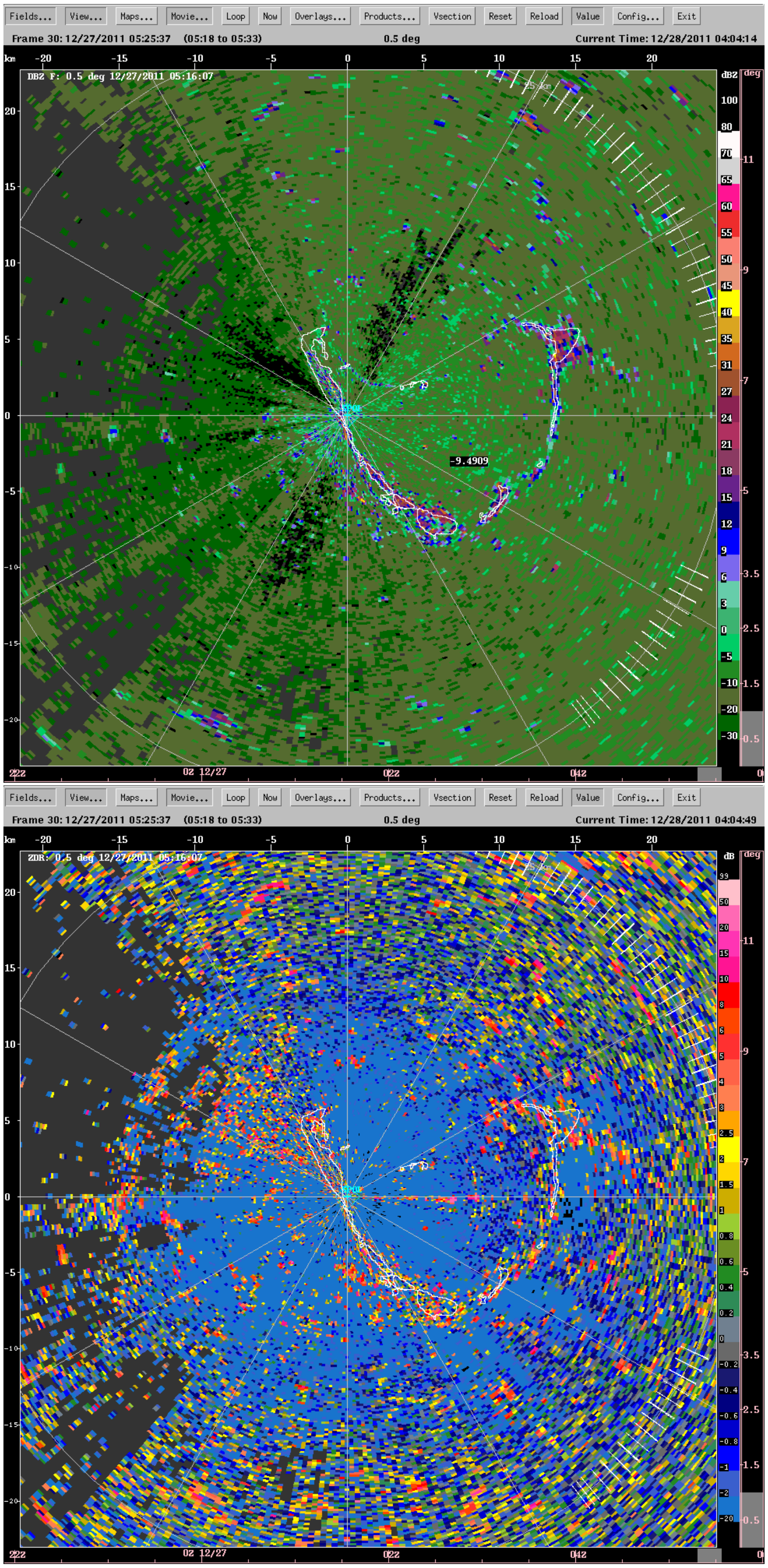

Figure 1: Sea clutter day time example. Z top, Z_{dr} bottom.

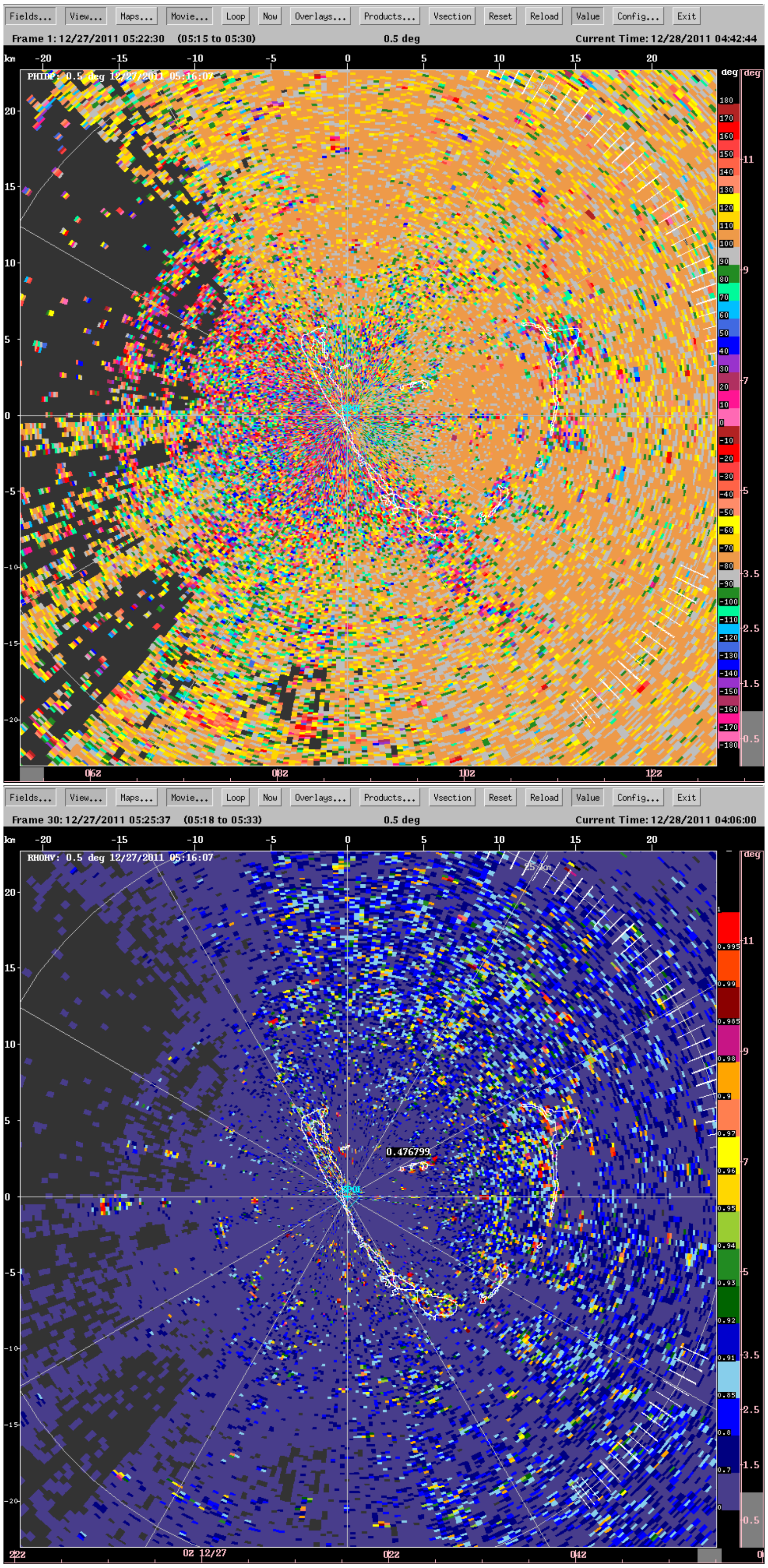

Figure 2: Sea clutter day time example. ϕ_{dp} top, ρ_{hv} bottom.

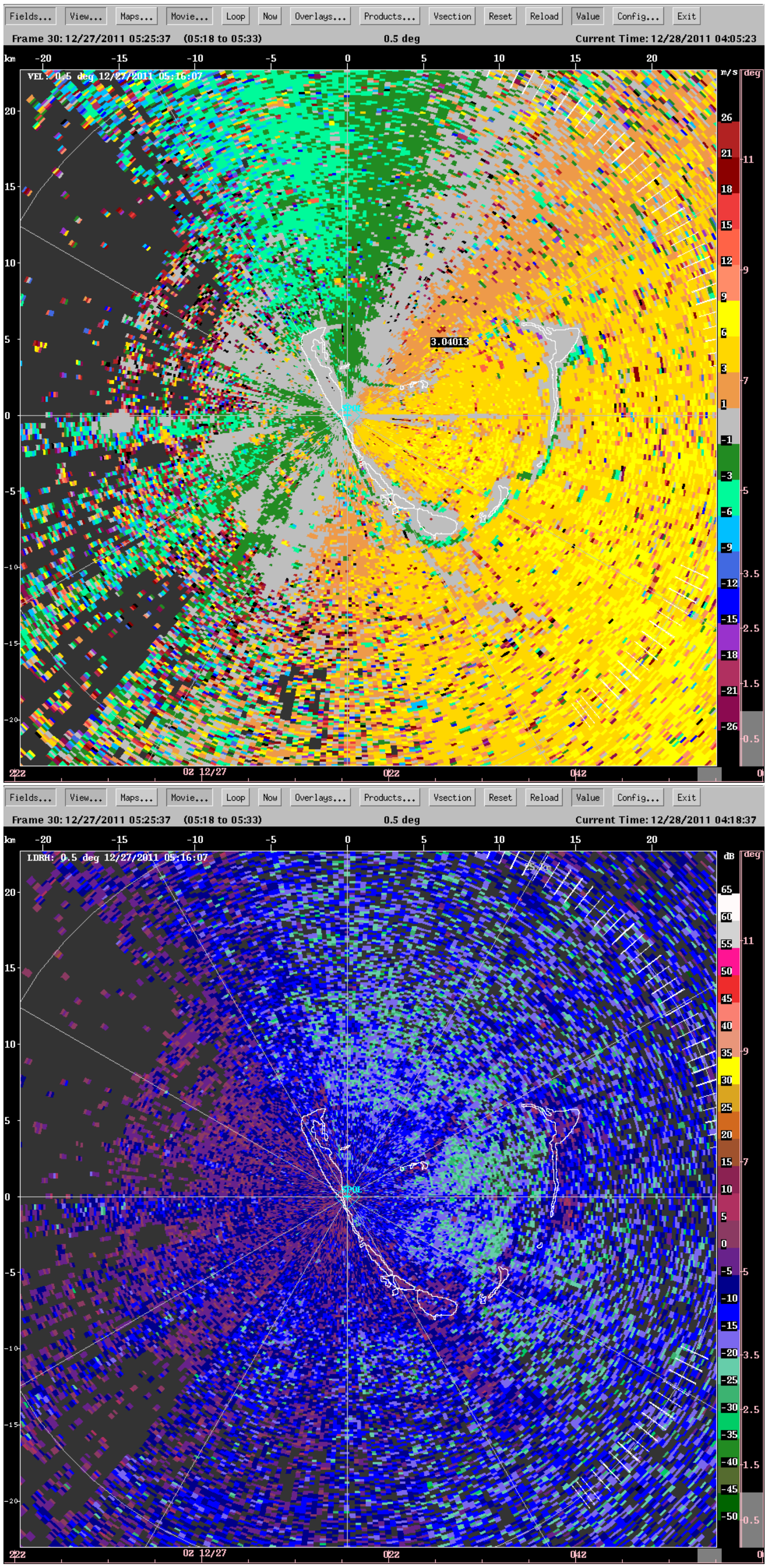

Figure 3: Sea clutter day time example. Velocity, top, LDR bottom.

b *Case 2: Night Time, Clear Weather*

Figures 4 to 6 show S-Pol data for clear weather at night at 0.5° elevation angle. There are far more positive Z_{dr} areas. These echoes are likely due to bugs and birds.

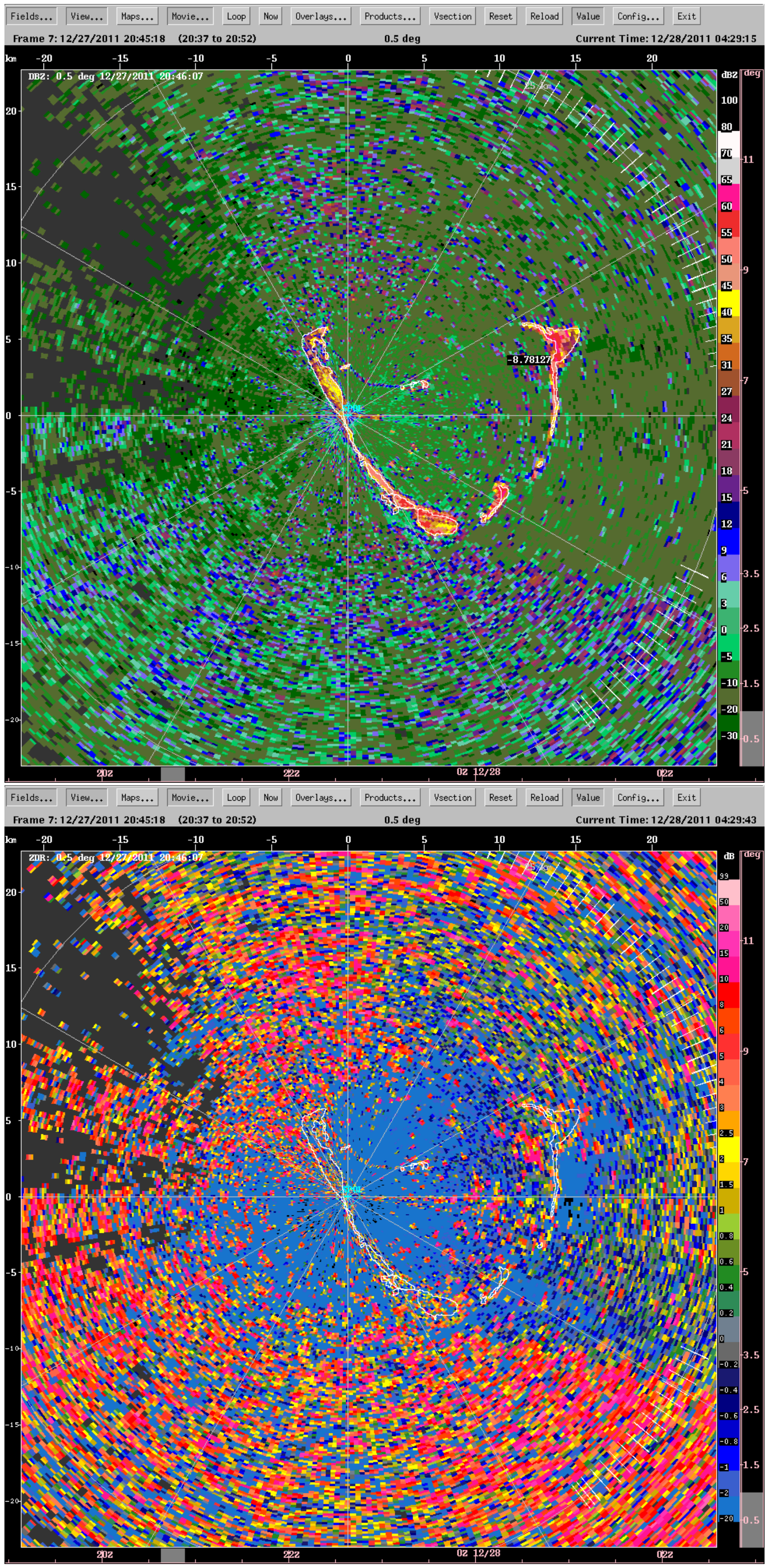

Figure 4: Sea clutter night time example. Z top, Z_{dr} bottom.

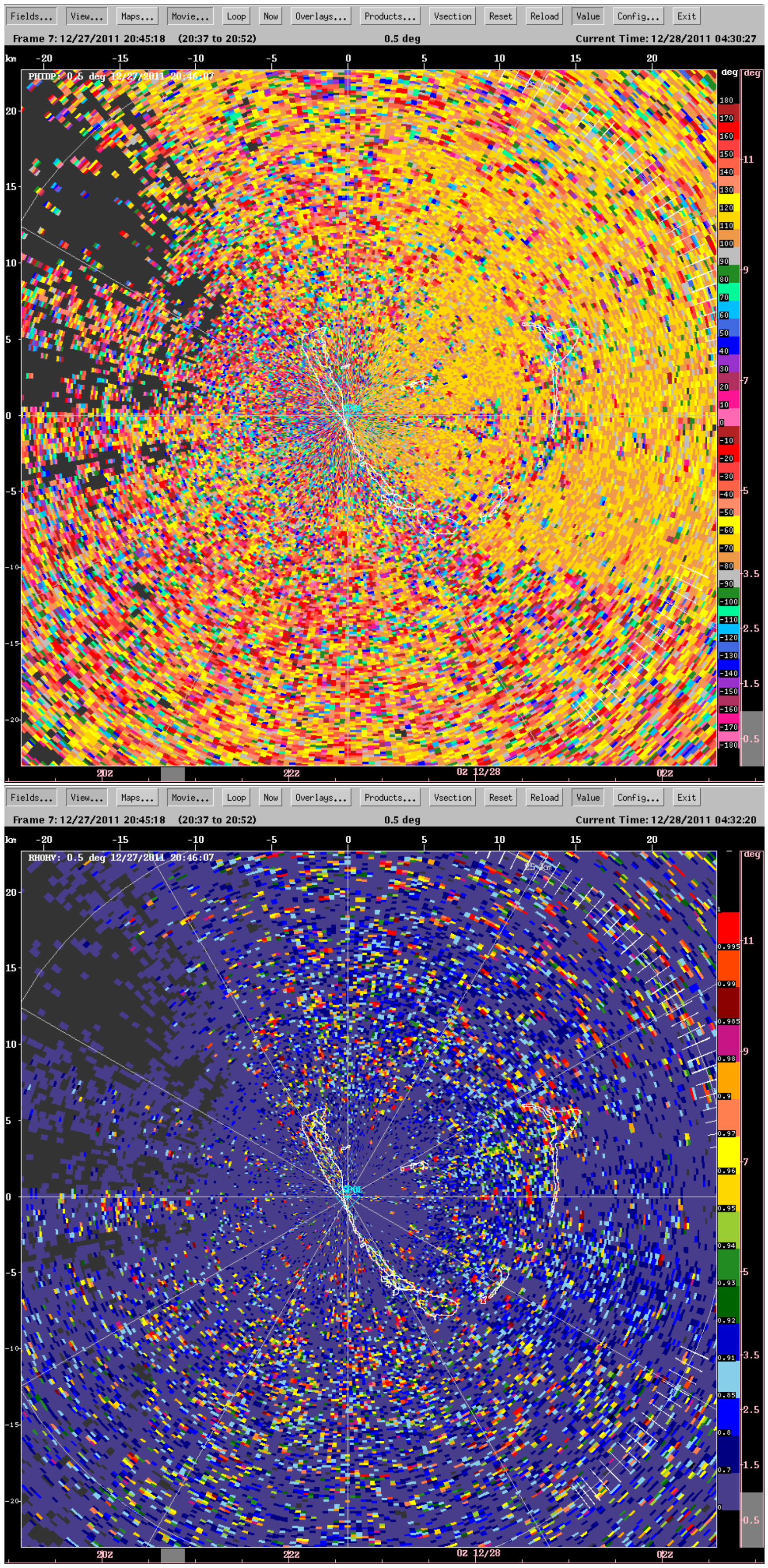

Figure 5: Sea clutter night time example. ϕ_{dp} top, ρ_{hv} bottom.

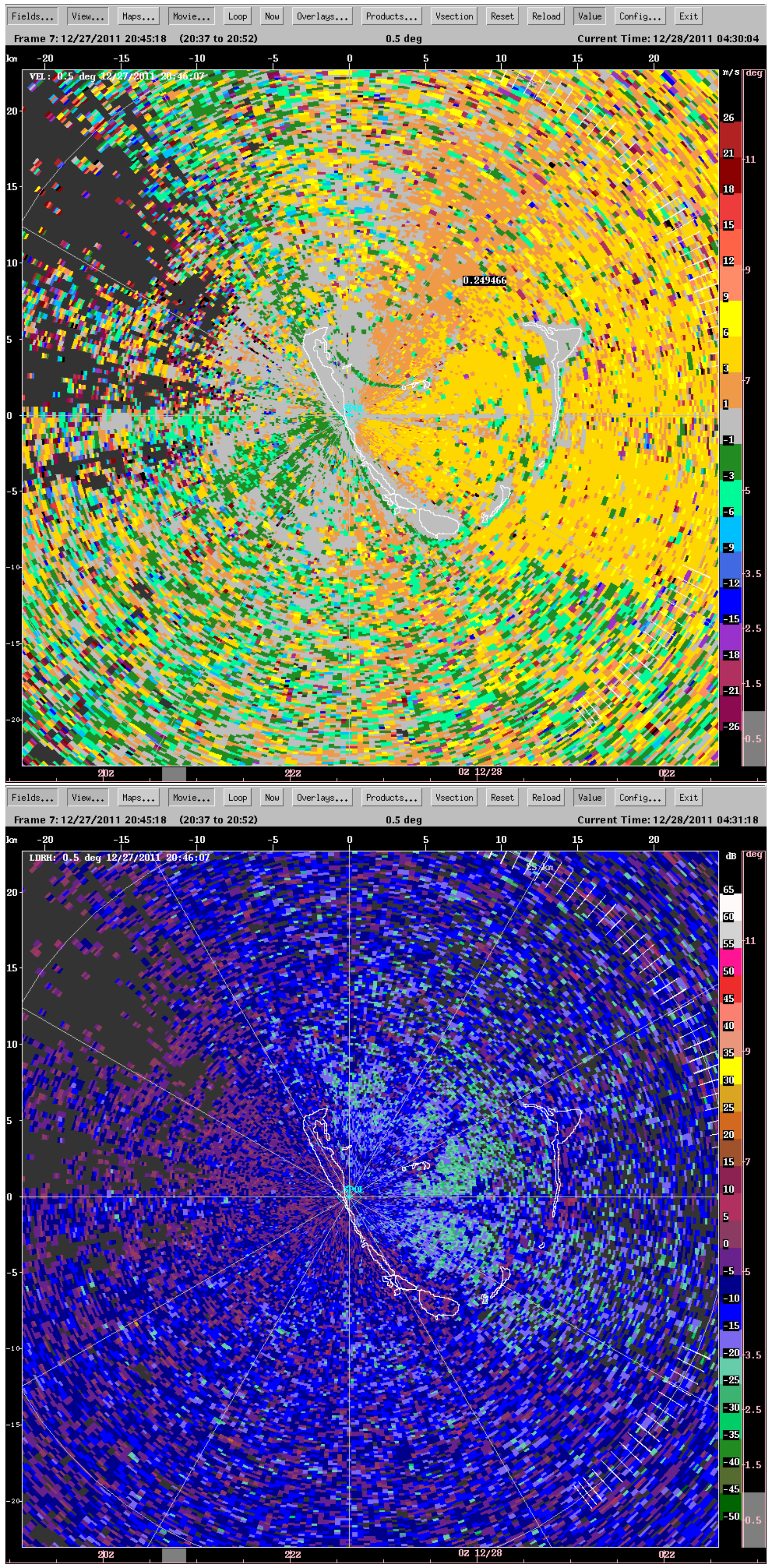

Figure 6: Sea clutter night time example. Velocity, top, LDR bottom.

c *Sea Clutter With Weather*

Figures 7 to 9 show an example of sea clutter mixed with precipitation echo. Notice the crescent shape of the beginning of the higher reflectivity at about 2 km from the radar to the north-north east. This is caused by waves breaking on the reef. In this case the higher reflectivities continue in range. Most of the time the higher reflectivities were limited to the reef break area causing the characteristic small crescent of higher reflectivities seen throughout DYNAMO. This case is interesting since 1) the higher reflectivities continue out in range and 2) precipitation echo is present also. The radar variables Z_{dr}, ϕ_{dp} and ρ_{hv} show a good separation of sea clutter echo from weather echo.

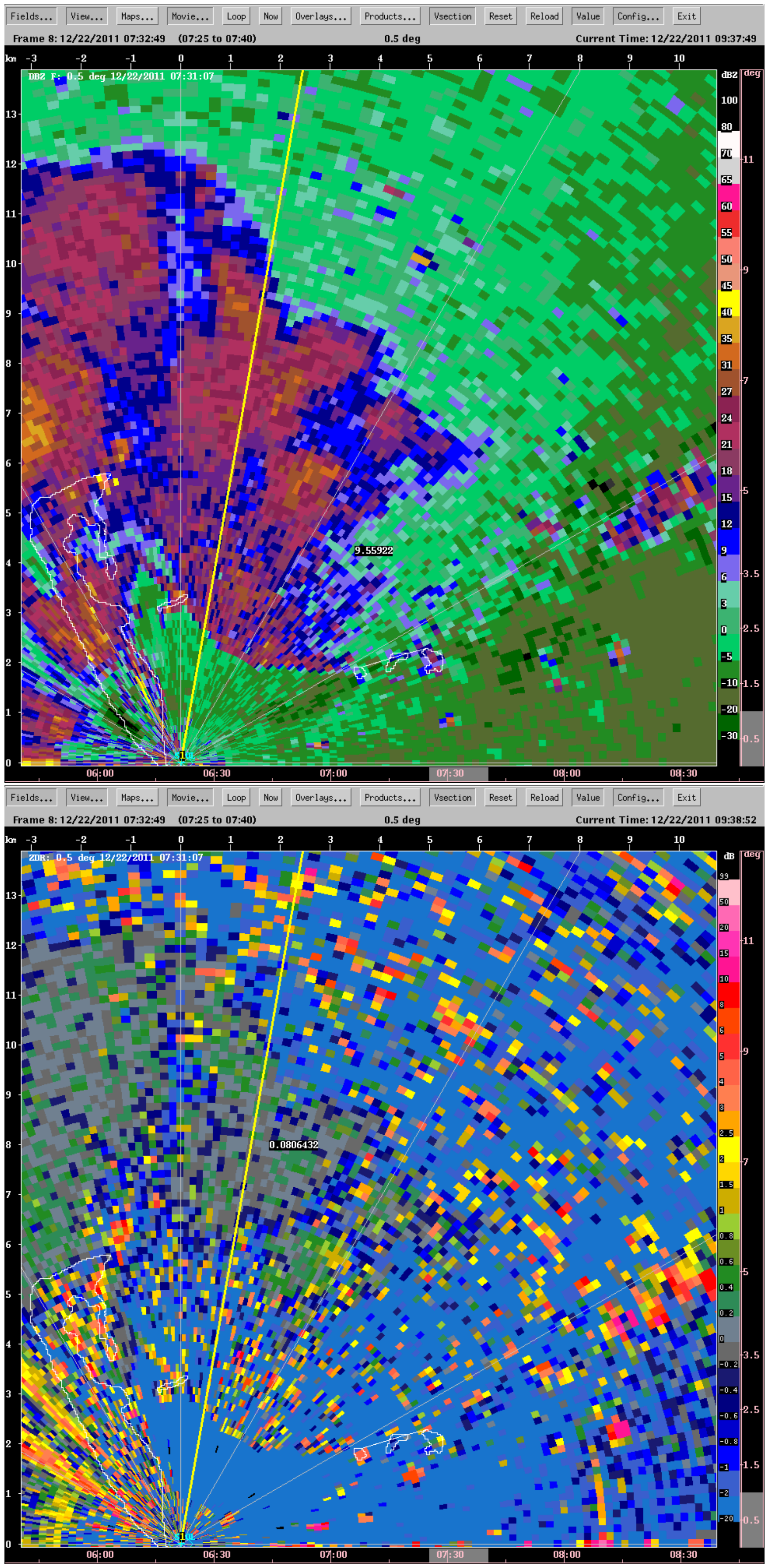

Figure 7: Sea clutter mixed with weather example. Z top, Z_{dr} bottom.

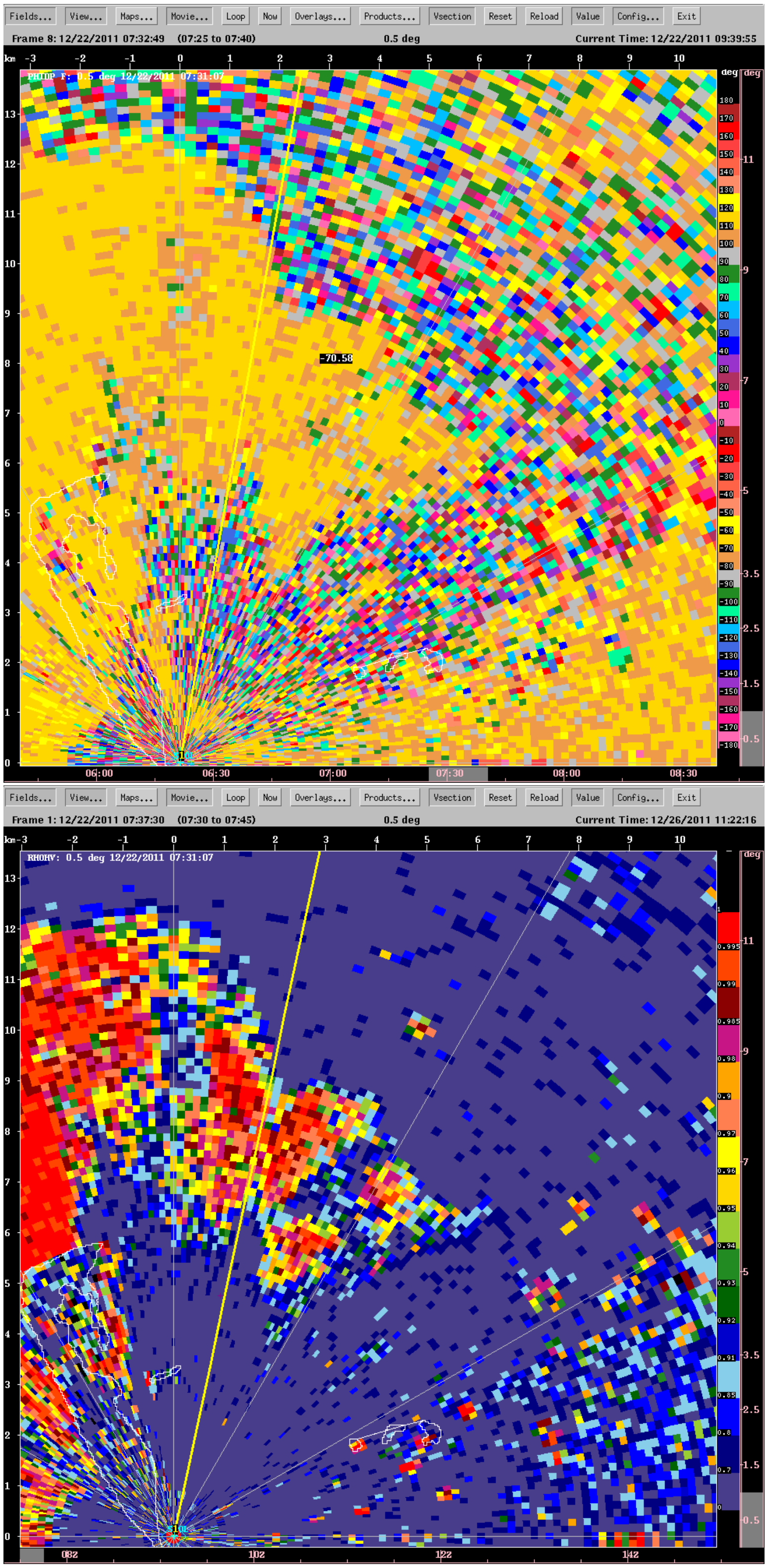

Figure 8: Sea clutter mixed with weather example. ϕ_{dp} top, ρ_{hv} bottom.

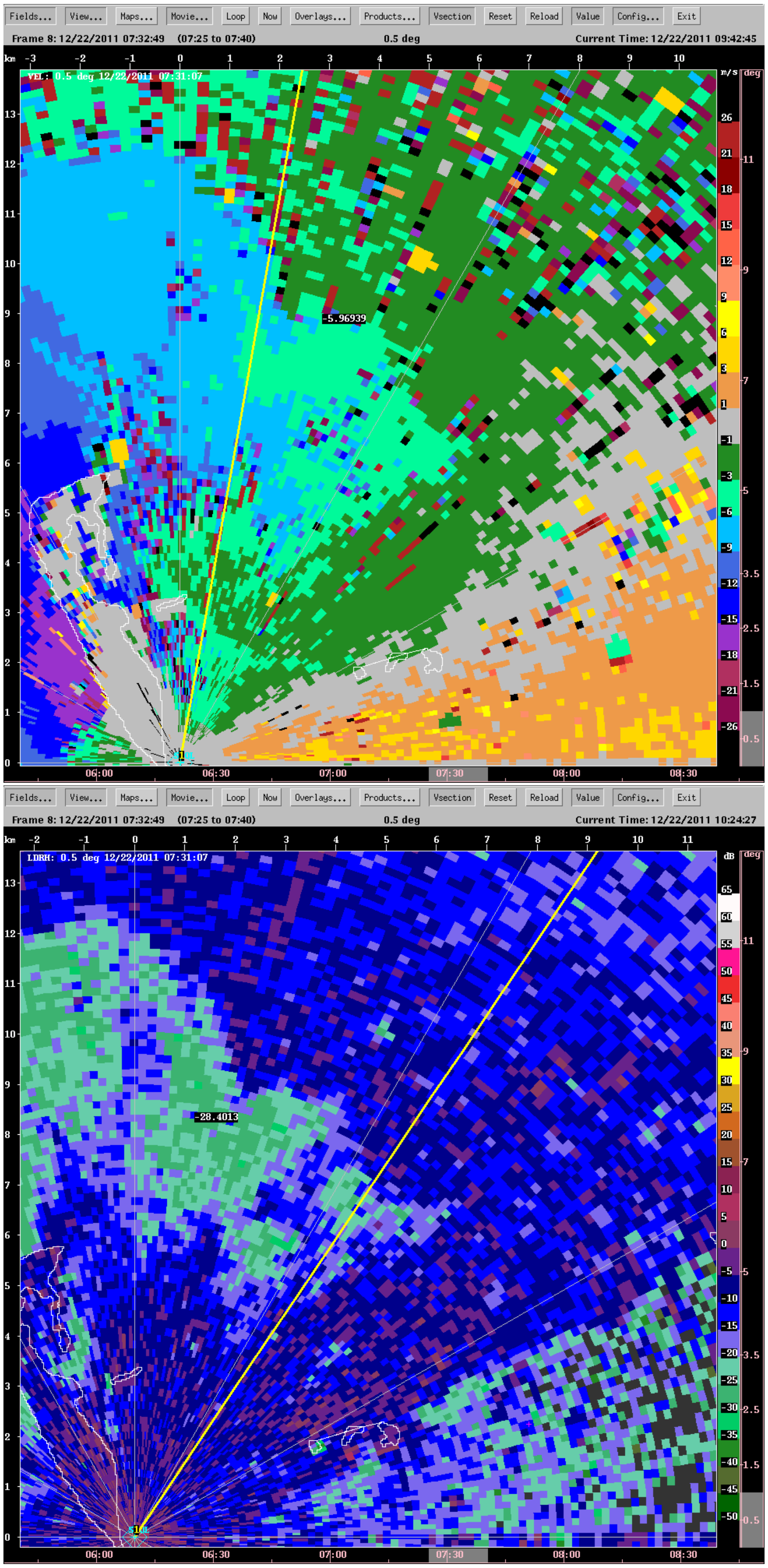

Figure 9: Sea clutter mixed with weather example. Velocity, top, LDR bottom.

2 Biological Echos

There was much biological echo seen by S-Pol as shown above in the sea clutter plots. The following are several interesting examples where the biological echoes formed lines in reflectivity.

a *Case 1*

The first case shows bugs and birds in a boundary that is also marked by convergence in the velocity signatures. These boundaries are typically marked by high Z_{dr}. Several other anomalies are pointed out in Figures 10 to 12.

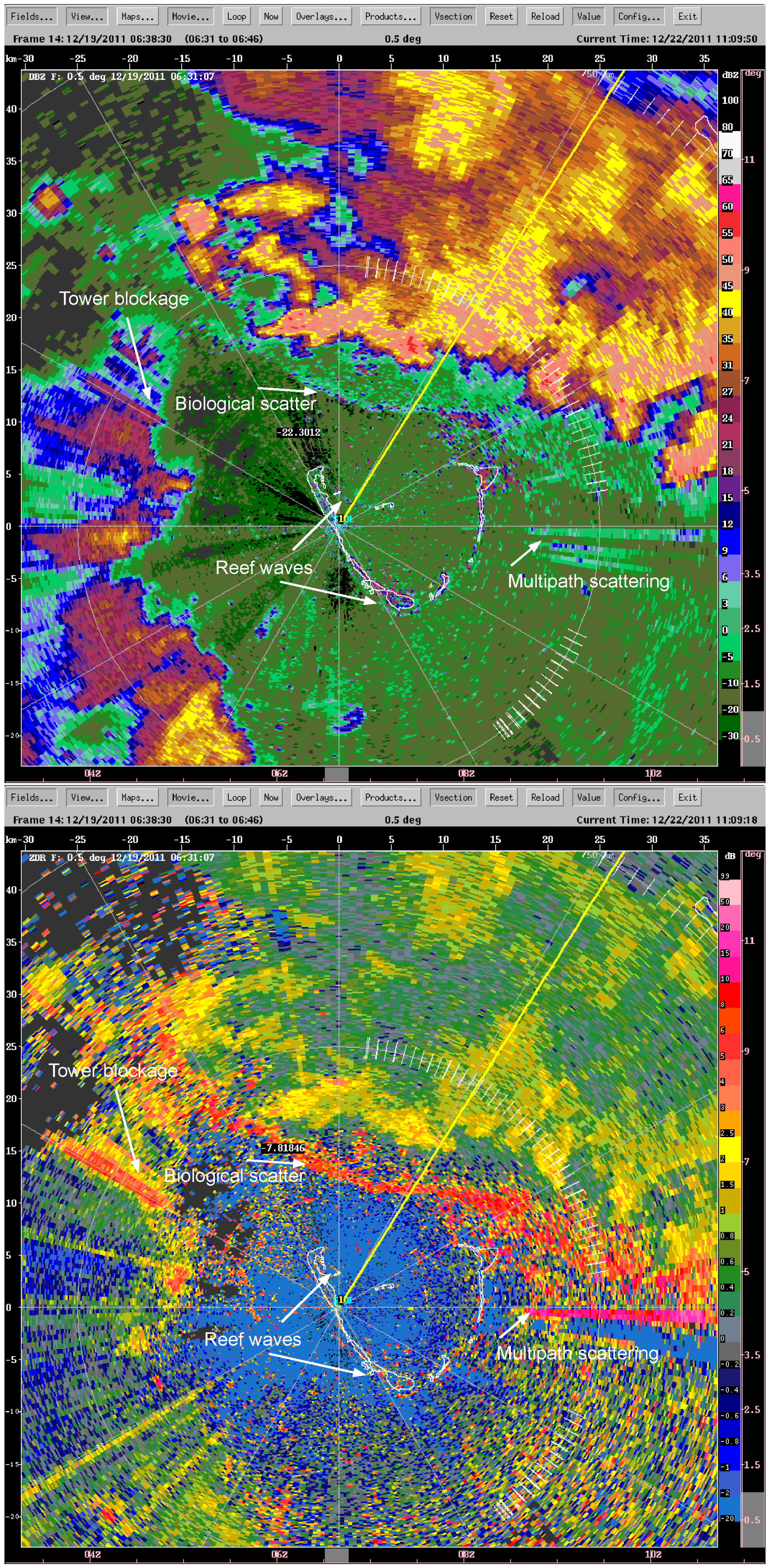

Figure 10: Biological echoes marked by positive Z_{dr} line. Top: Z; Bottom:Z_{dr}. Other echo anomalies are also pointed out in the plots.

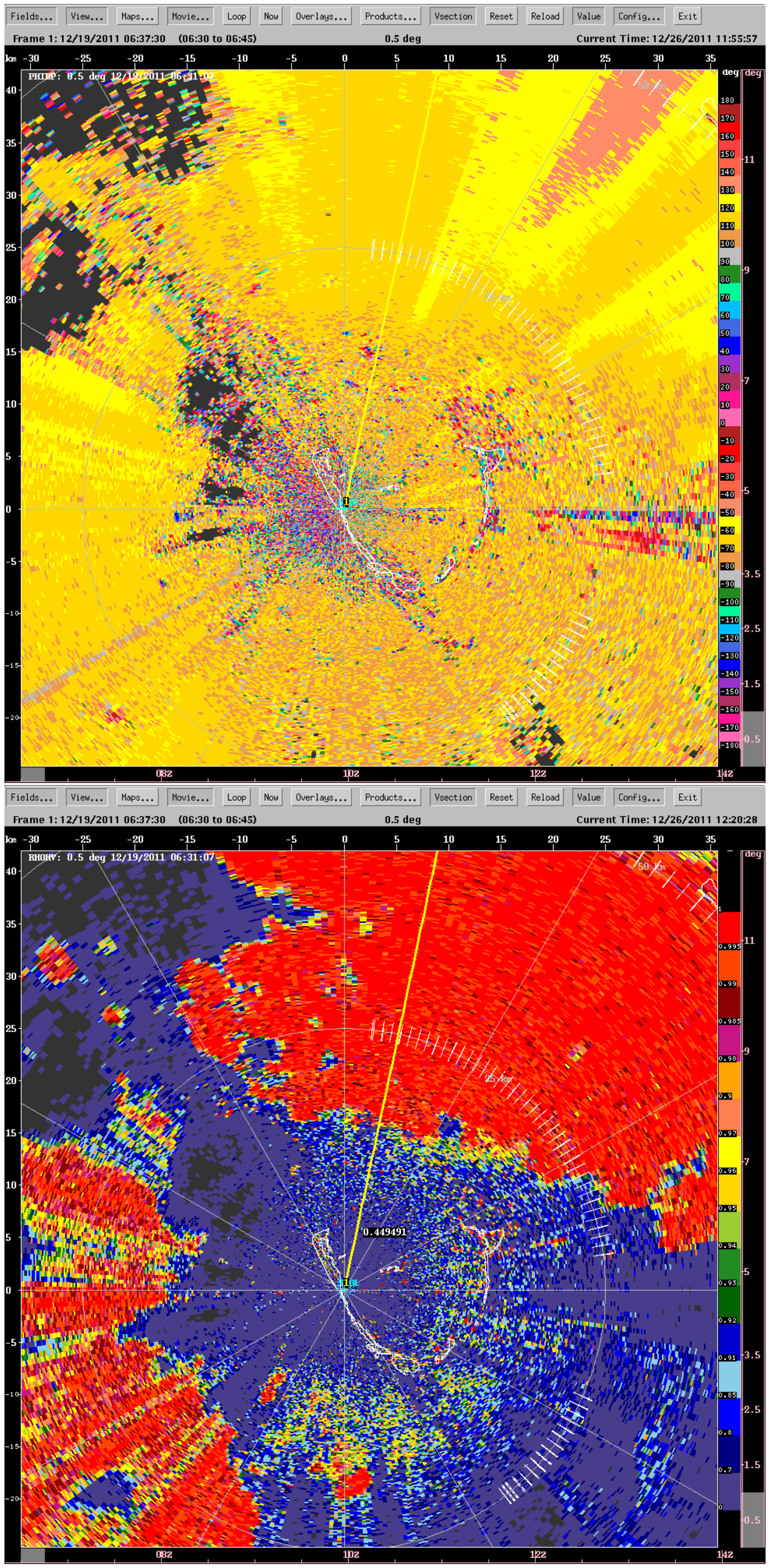

Figure 11: Biological echoes ϕ_{dp}, top, ρ_{hv} bottom. Other echo anomalies are also pointed out in the plots.

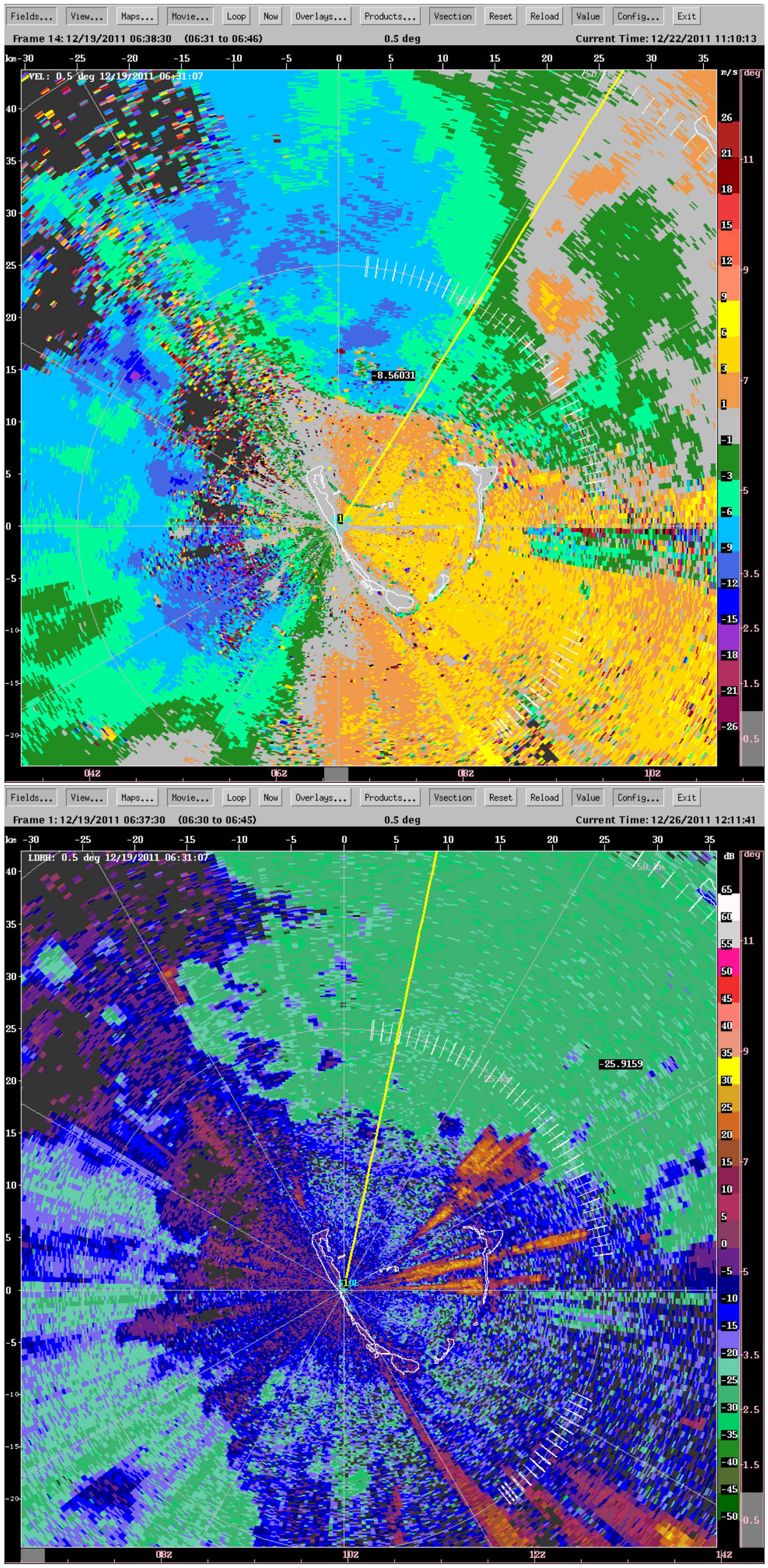

Figure 12: Biological echoes. Velocity, top, LDR bottom.

b *Case 2: Bird Echo*

Case 2 shows bird echo in Figures 13 to 15. The birds are flying at about 20 MPH into the wind. The ϕ_{dp} siginature shows significant phase shift at backscatter (Mie scattering) evidenced by noisy ϕ_{dp} along the bird-line.

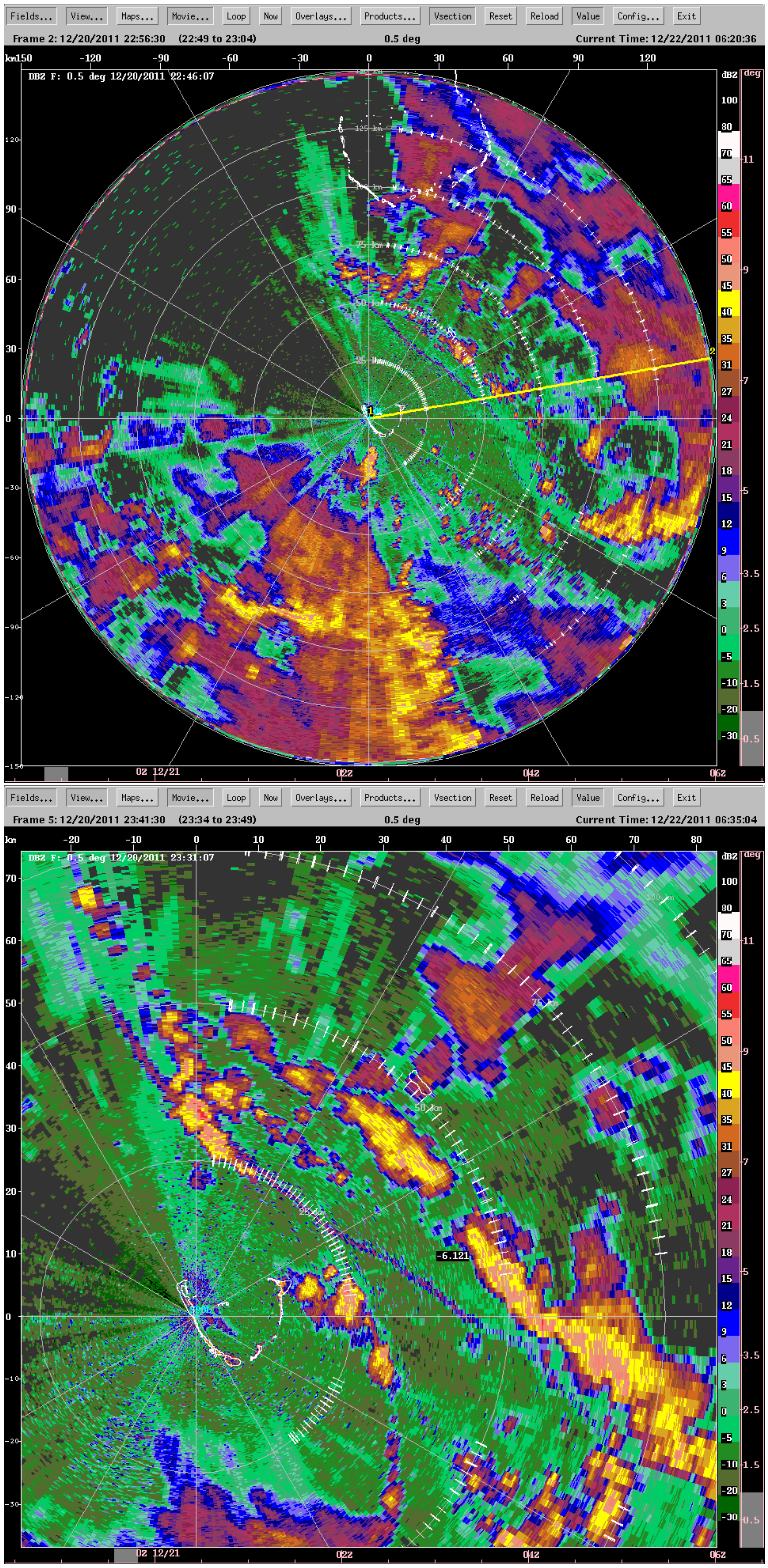

Figure 13: Bird echoes. Top Z out to 150 km,; Bottom: Z zoomed in on the bird line.

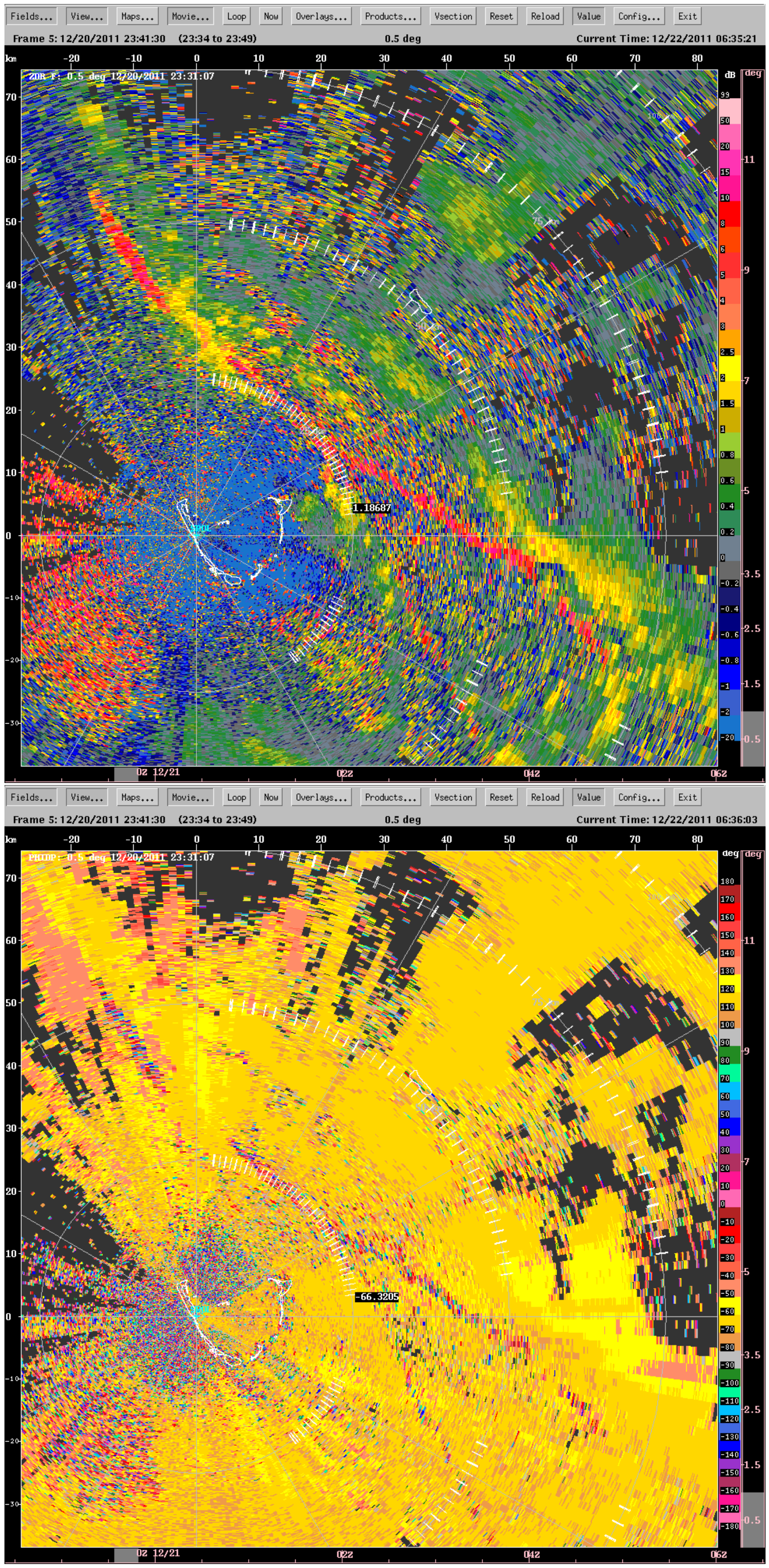

Figure 14: Bird echoes. Z_{dr}, top, ϕ_{dp} bottom. Note the noisy ϕ_{dp} along the bird-line cause by Mie scattering.

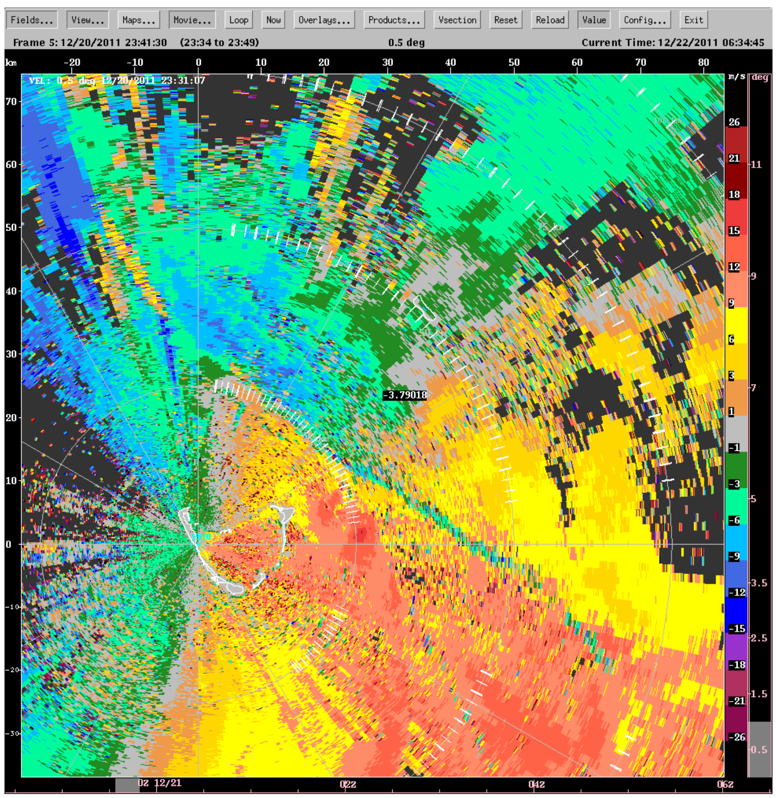

Figure 15: Bird echoes, radial velocity. Birds are flying against the wind at about 20 MPH. Bugs can not do this.

c *Biological Echo with Negative Z_{dr}.*

This case also shows a boundary echo associated with birds and bugs. The lefthand portion of the line appears to be dominated by bird and bug echo with high Z_{dr}. Interestingly, the right hand portion of the line has zero or negative Z_{dr}! The ϕ_{dp} shows significant and consistent phase different from the background phase. This is likely due to Mie scattering of the targets. Shown in Fig. 20 is a scattering cross section plot as a function of Deq (equivalent volumetric diameter). For the present case, the HH cross section is in one the local minima areas while the VV cross section is more toward one of the maxima thus giving negative Z_{dr}.

It seems that the biological scatterers are large and oriented in the vertical dimension.

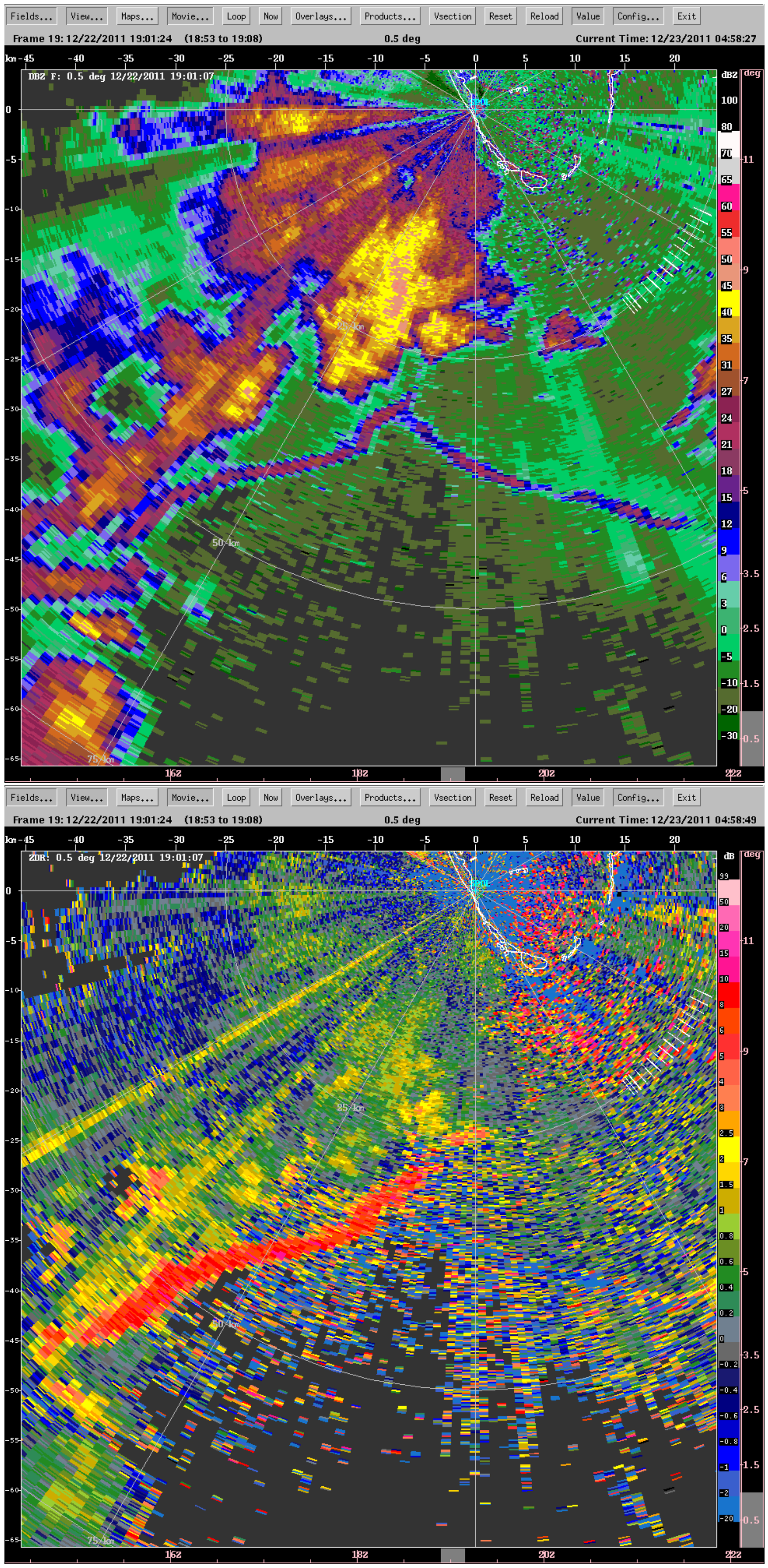

Figure 16: Biological echoes. Z, top, Z_{dr} bottom.

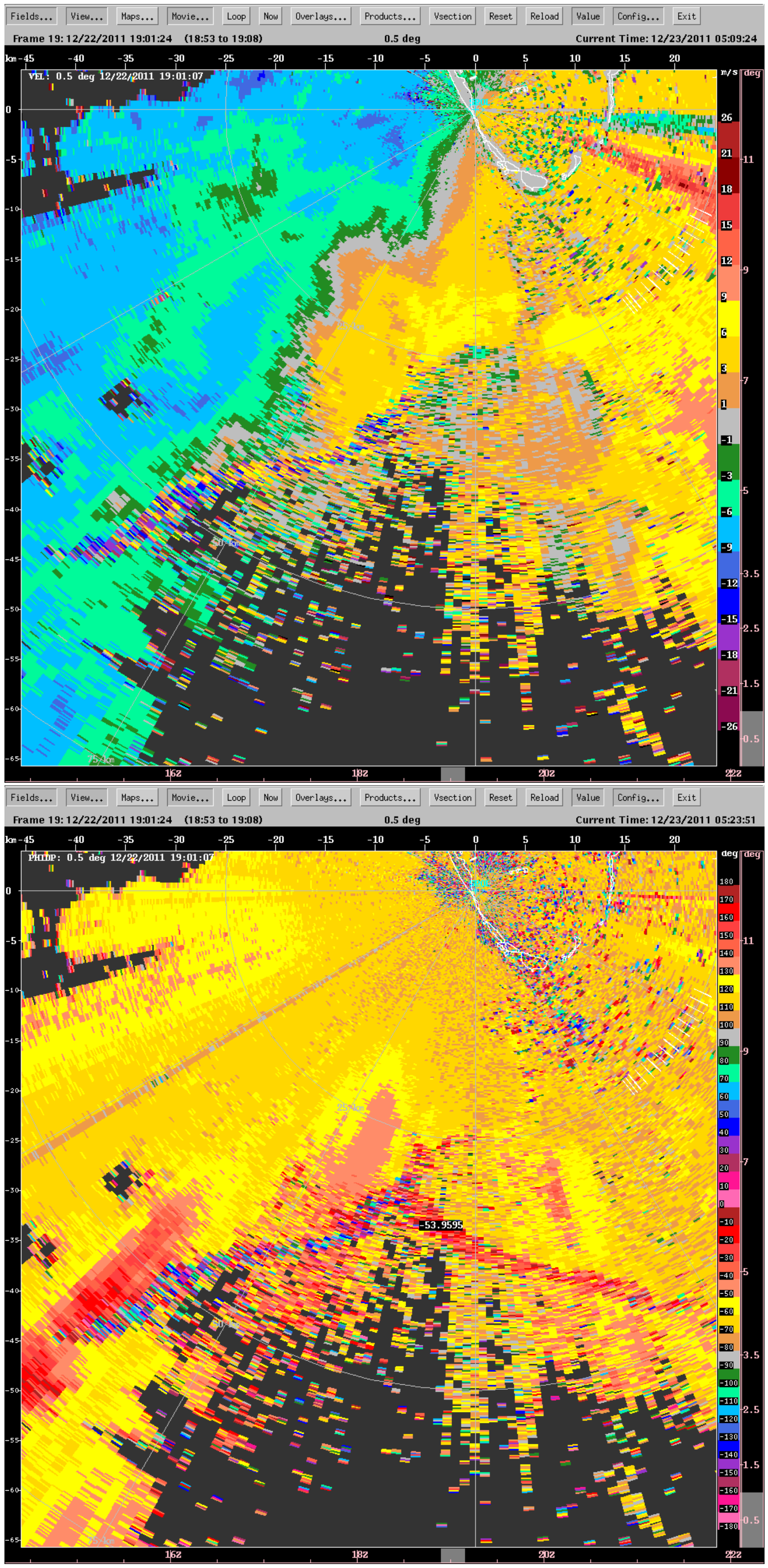

Figure 17: Biological echoes. Velocity, top, ϕ_{dp} bottom.

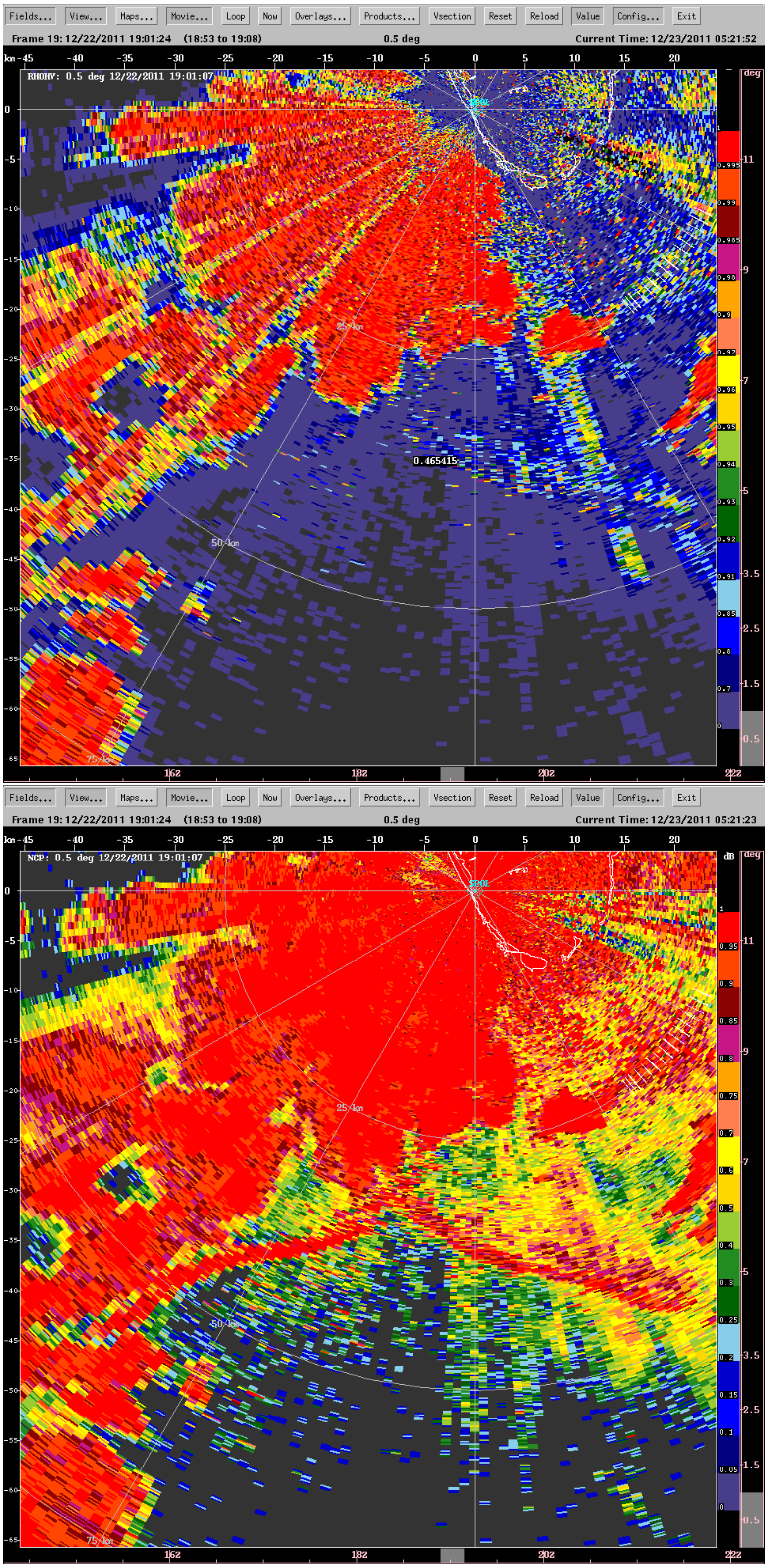

Figure 18: Biological echoes. ρ_{hv}, top; NCP, bottom.

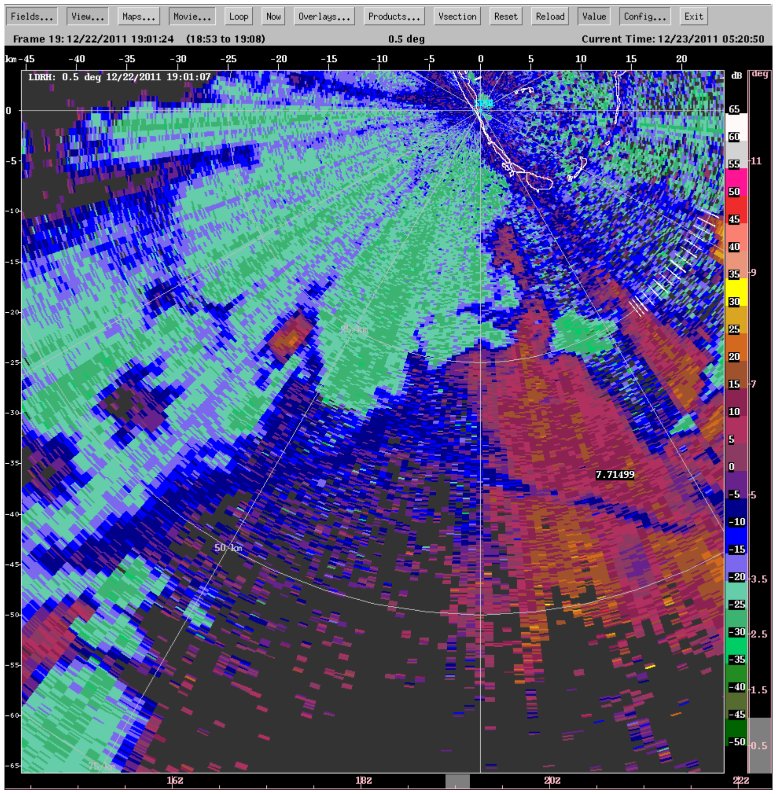

Figure 19: Biological echoes. LDR.

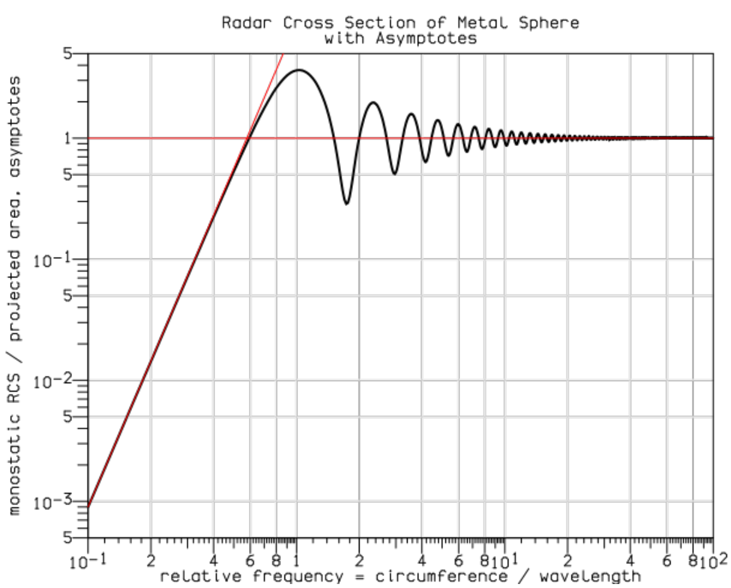

Figure 20: Back scatter cross section for spheres.

d *Bogus Biological Echoes*

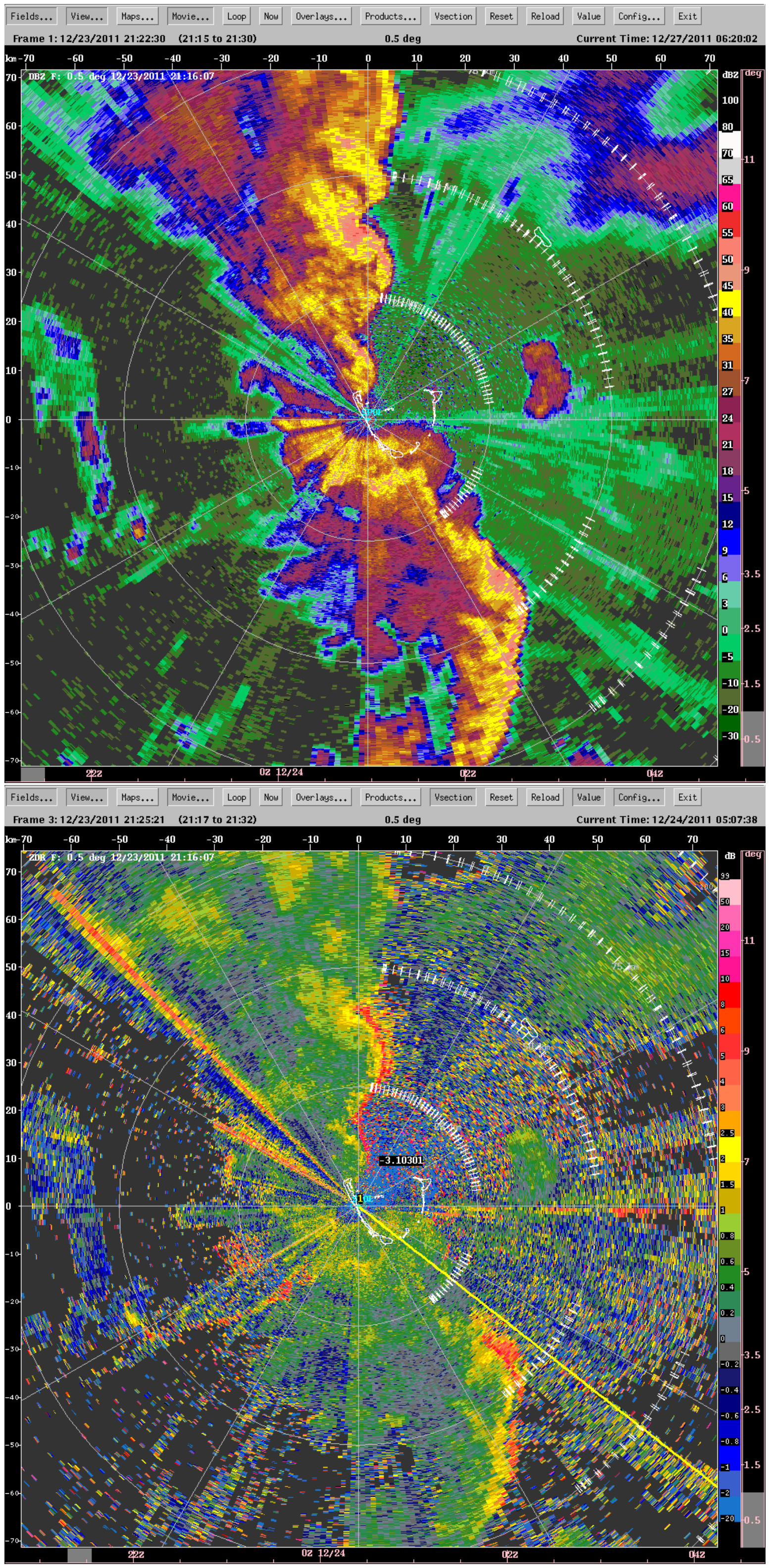

Figure 21: Sidelobe artifacts masquerading as biologicals scatter. Biological echoes. $0.5°$ elevation. Z, top, Z_{dr} bottom.

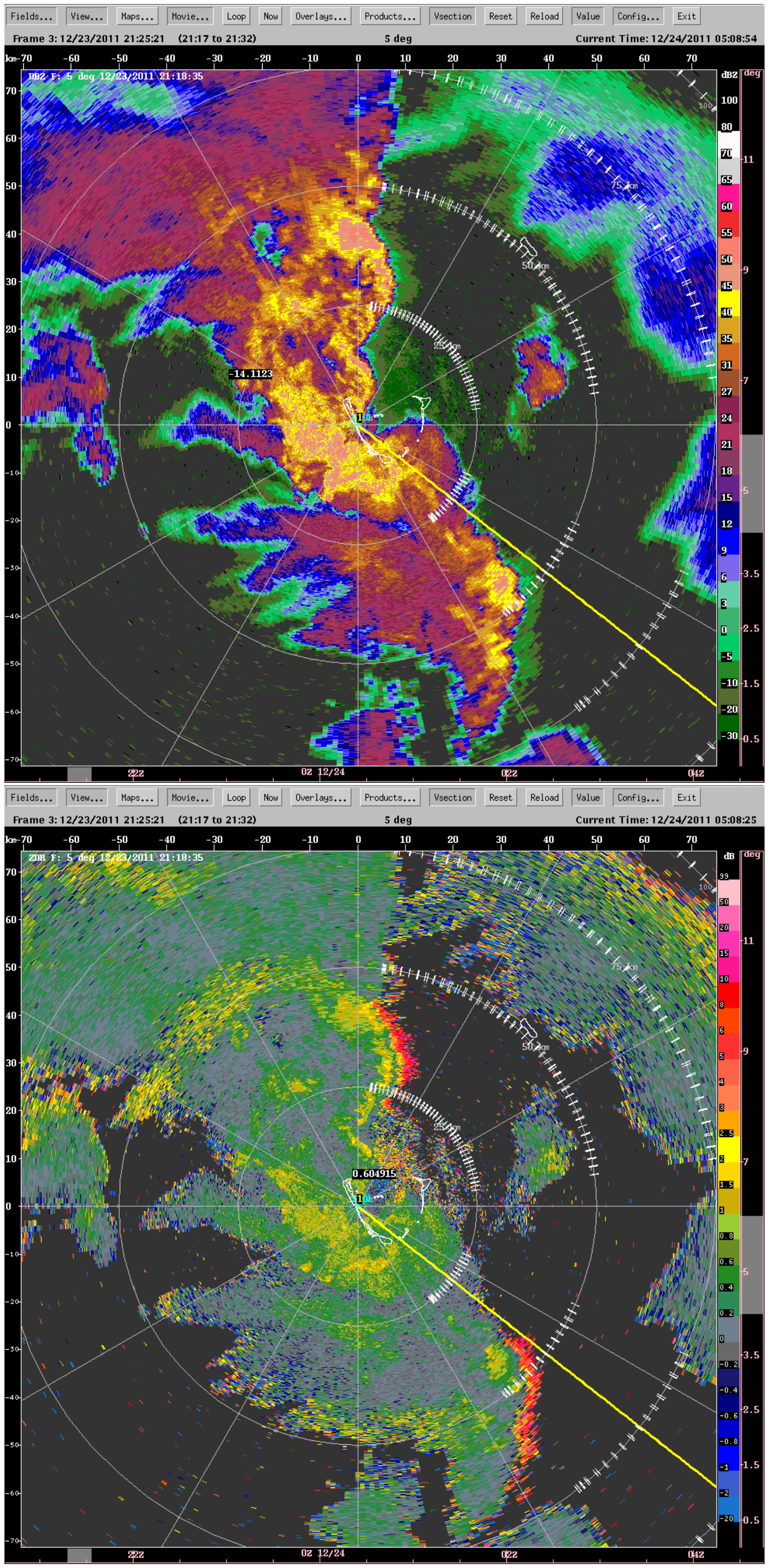

Figure 22: Sidelobe artifacts masquerading as biologicals scatter. The elevation angle is5°. Z, top; Z_{dr}, bottom. Biological scatter is not likely at these higher elevation. The high Z_{dr}s (red/pink colors) are due to non-matched H and V antenna pattern sidelobes.

3 Tower Attenuation

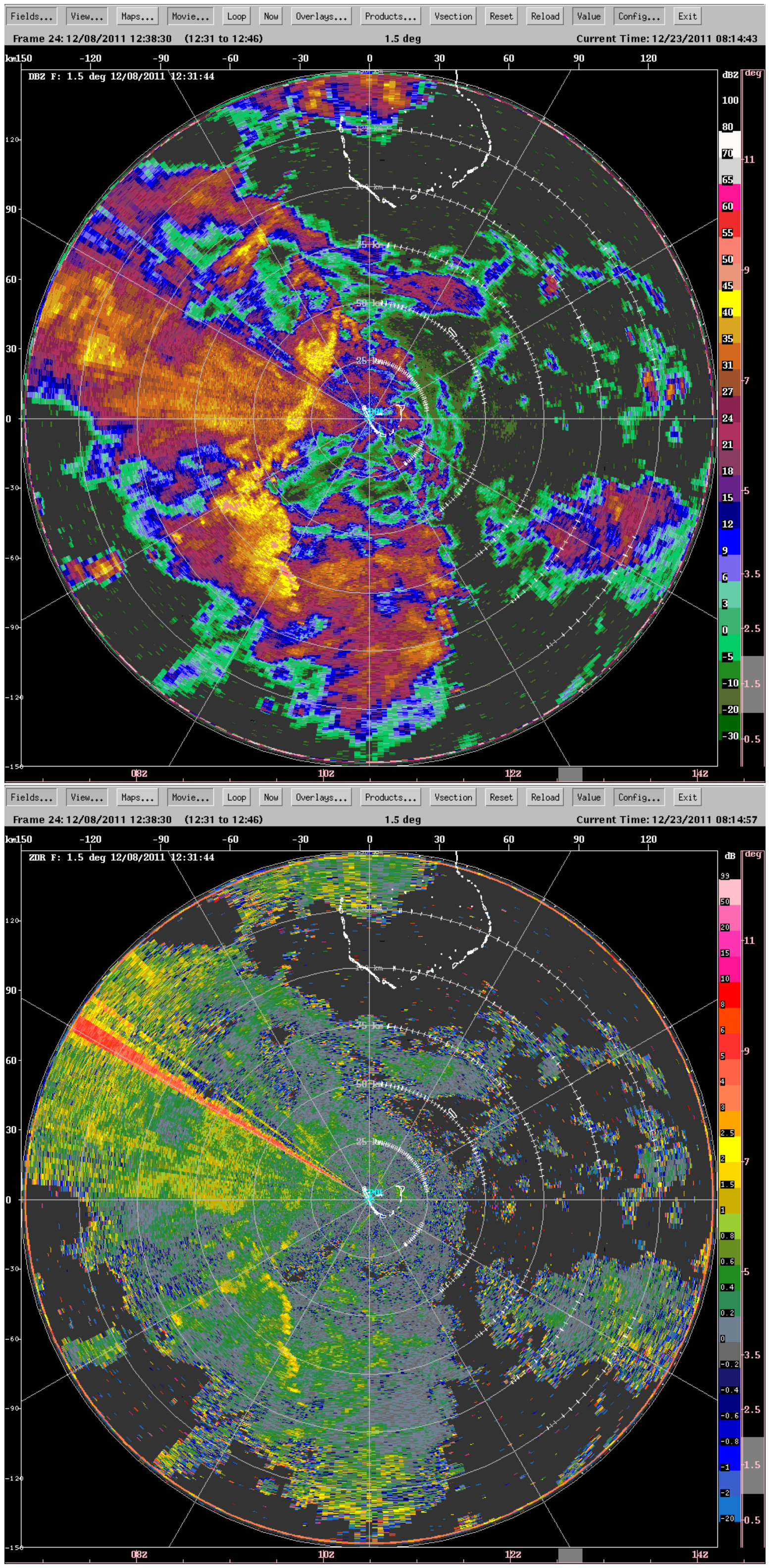

Figure 23: The high Z_{dr} streak to the north-west is due to differential attenuation/scattering by the tower close to the radar shown in Fig. 24. The streak is only seen when there is precipitation echo in that radial.

Figure 24: The tower close to S-Pol along the 300° radial.

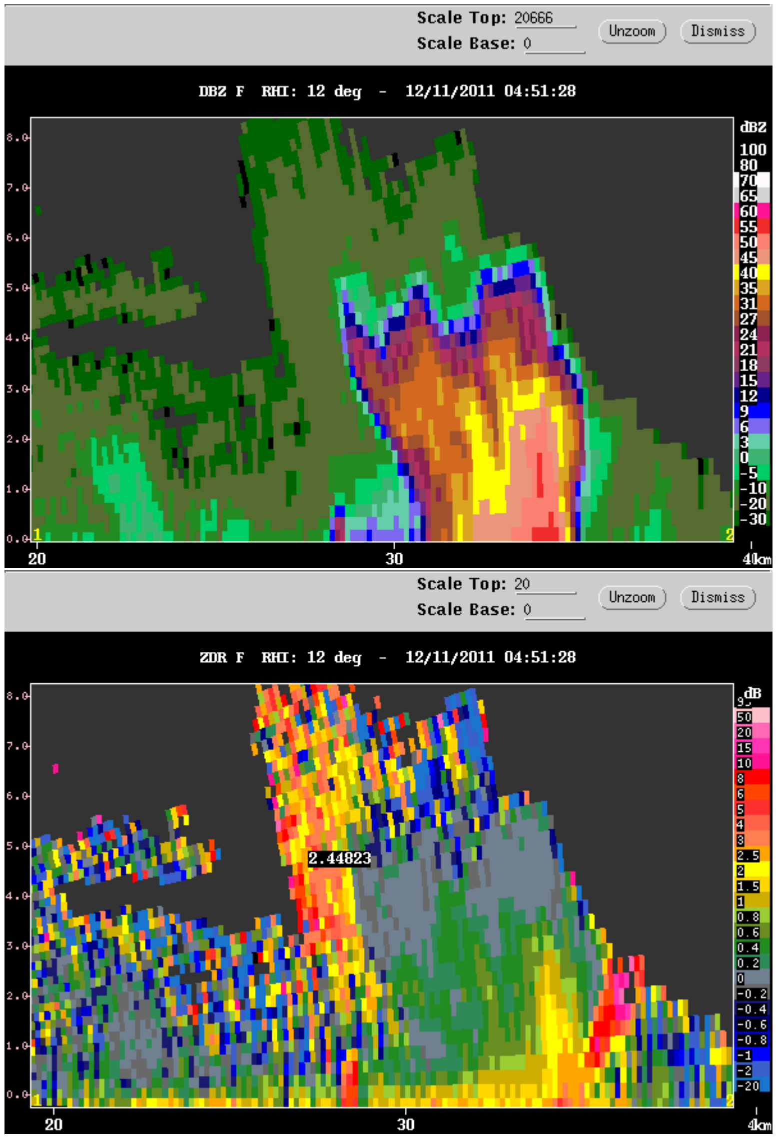

Figure 25: Three-body scattering. Z, top, Z_{dr} bottom.

4 Three-Body Scattering

The 3-body signal path is as follows: radar to rain drops to sea surface to rain drops to radar. Three-body scatter typically occurs over land when large hail is present. Here large rain drops interact with the sea surface. The sea surface is general more reflective than land so that 3-body scattering can be seen over water bodies with smaller precipitation particles. Three-body scattering is most evident in RHIs.

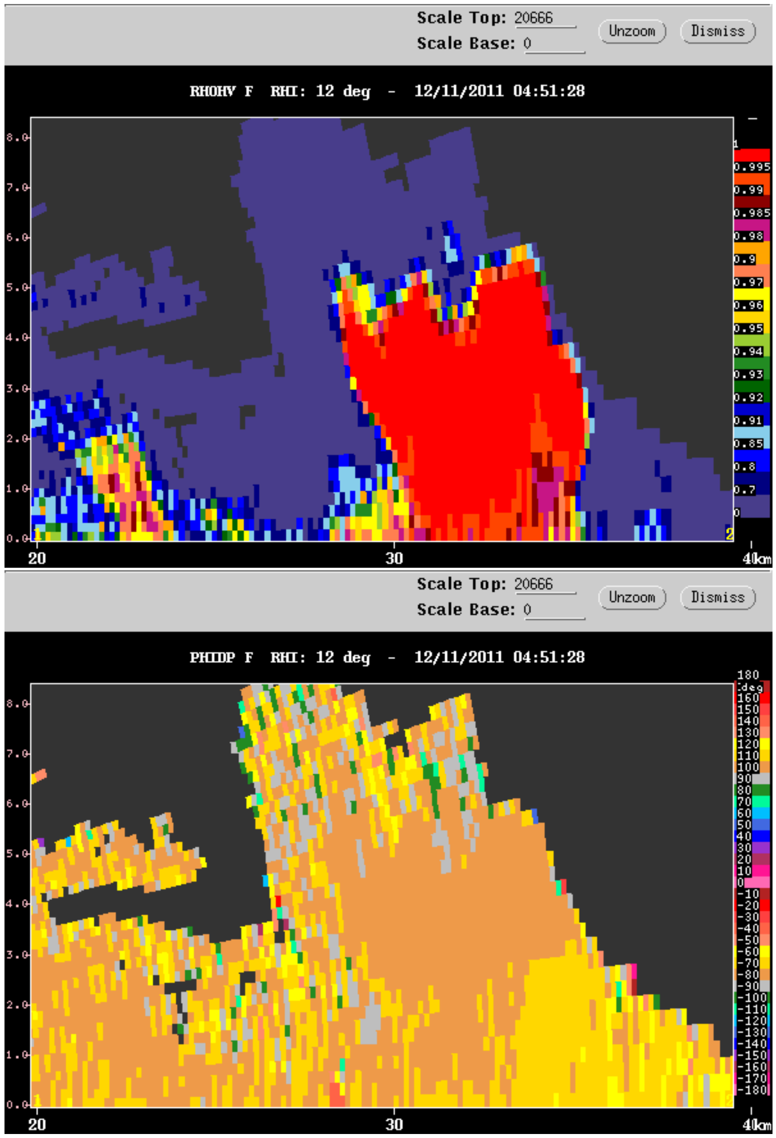

Figure 26: Three-body scattering. ρhv, top, ϕ_{dp} bottom.

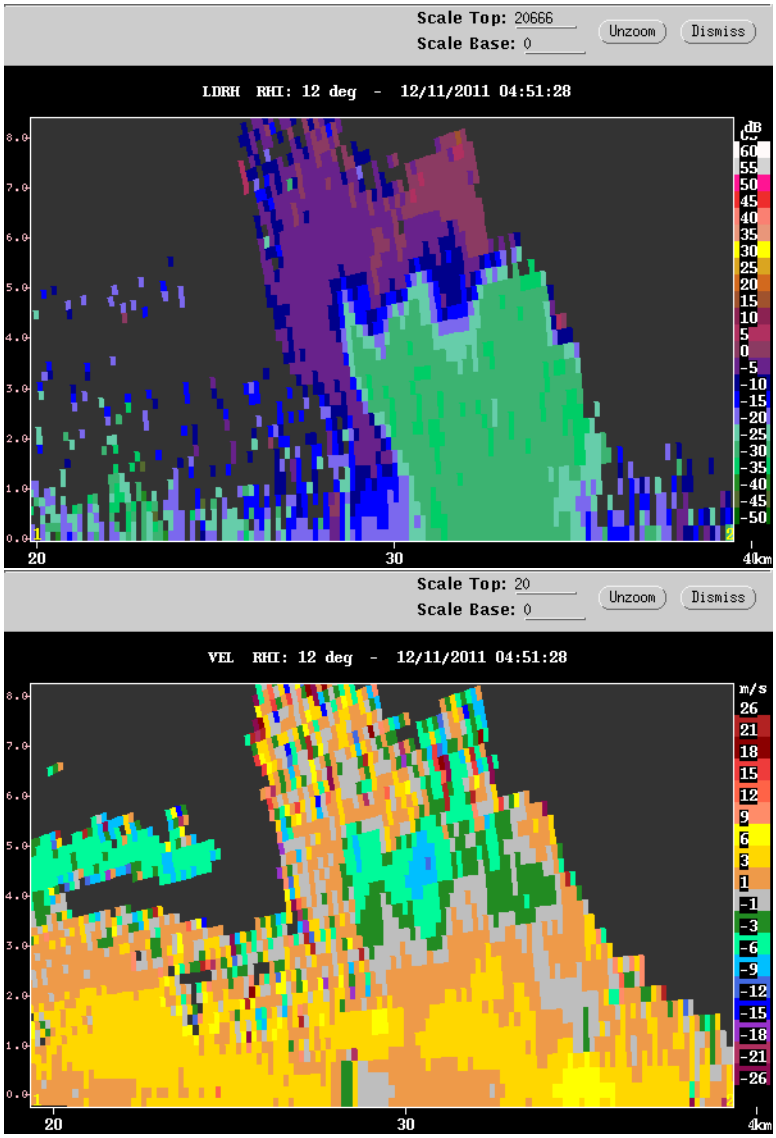

Figure 27: Three-body scattering. LDR, top. Velocity, bottom.

5 High Z_{dr} in Low Reflectivity Ice

Many times very high Z_{dr} (5^+ dB) in low reflectivity ice was observed during DYNAMO. No other possible bias sources are apparent and thus these signatures appear meteorological. Figure 28 show such a region in the southwest sector of S-Pol.

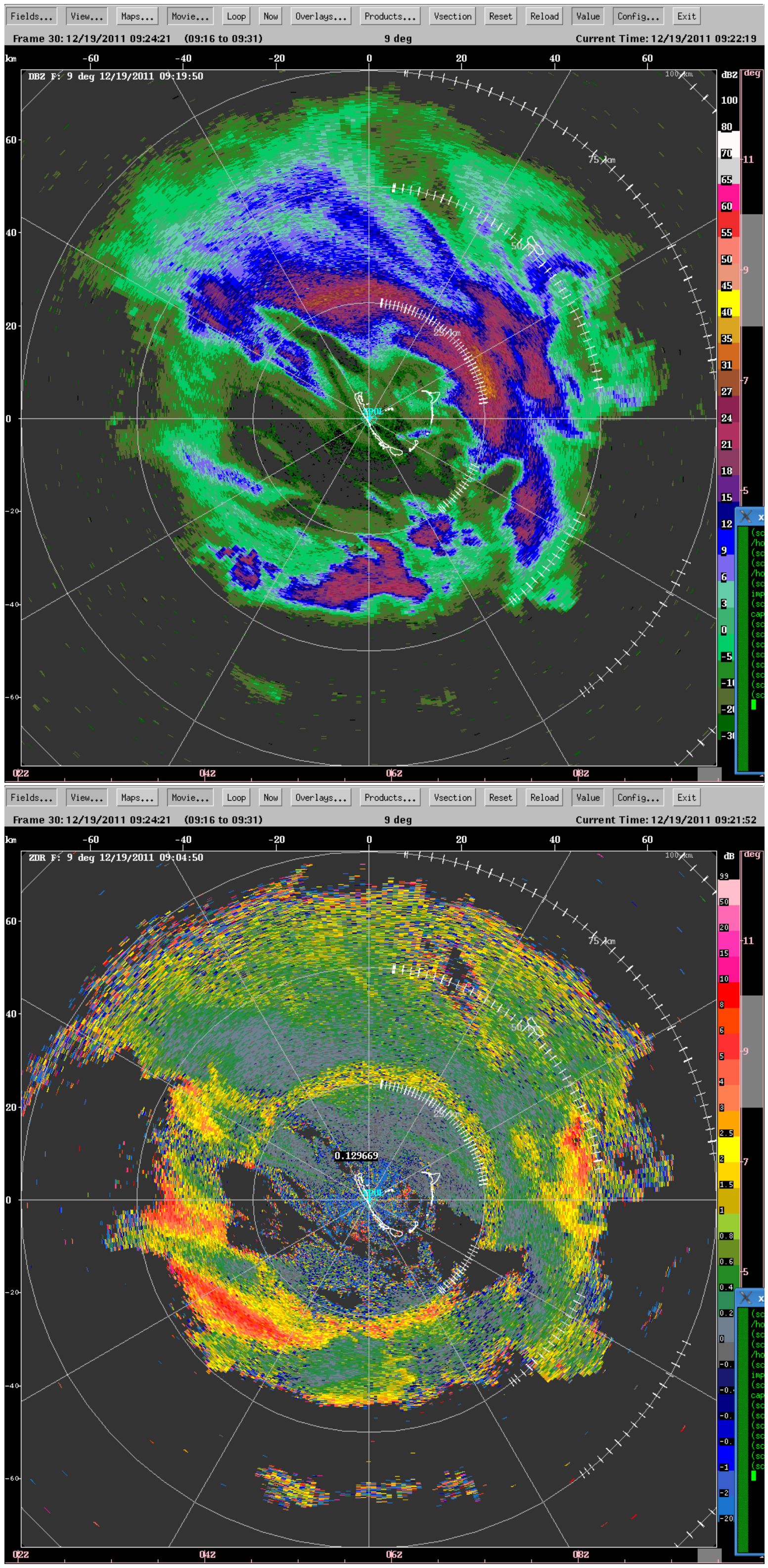

Figure 28: High Z_{dr} in low reflectivity ice. Elevation angle is 11°

6 Multipath Scattering from the Dock Area

Figures 7 to 9 show some multipath scattering that is likely caused by the towers in the dock area east of S-Pol. Figures 6 shows two pictures of these towers approximately as S-Pol sees them. The center of the S-Pol beam, at 0.5° elevation is about 35 feet. The beam width is about 15 feet at 300 m range. These multipath echoes are very low reflectivity and only occur when ptrecipitaion is in S-Pol's viewing area. The velocity signature nearly always mimics the velocity to the *west* of the radar. The signal path appears to be: radar to towers to precipitation in S-Pol's westerns hemisphere to the towers and back to the radar. Note the 3 elevated multipath reflectivity streaks which seem to correspond to the 3 of the towers in Fig. 6. When precipitation is present in these radial, the Z_{dr} streaks no longeer appear. Thus, the scattering mechanism here is distinctly different from that due to the high tower to the east of S-Pol discussed above.

Figure 29: The lighting towers at the dock area just east of S-Pol.

Acknowledgment Thanks to all the people that made S-Pol at DYNAMO a success!