The Polarimetric Characteristics of Chaff Using the WSR-88D Network

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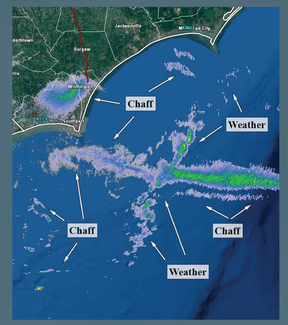
Introduction

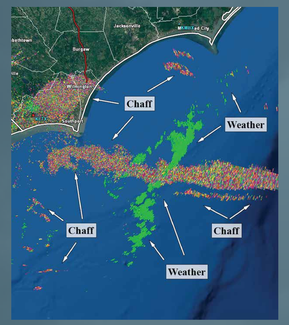
Chaff is a radar countermeasure typically used by the military in training exercises around the United States. Due to its resonant cut lengths on the order of centimeters, chaff appears prominently on the S-band WSR-88D radars. Chaff returns tend to look similar to weather echoes in the reflectivity factor and radial velocity fields, and can masquerade as clutter, stratiform precipitation, or deep convection to the radar operator or radar algorithms. Knowledge of chaff characteristics, specifically in the polarimetric estimates, is useful to radar users and automated algorithms to discriminate between chaff and weather echoes.

Chaff as a Radar Target

- False weather returns cause issues for radar users
- Mixed weather and chaff is problematic
- Mixed cases can be discerned via differential reflectivity (Z_{DR}), cross-correlation coefficient (ρ_{HV}), and differential phase (Φ_{DP})

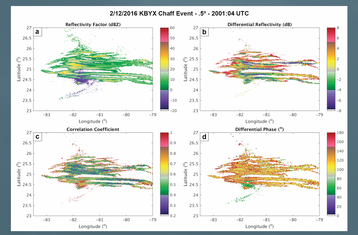


Reflectivity Factor



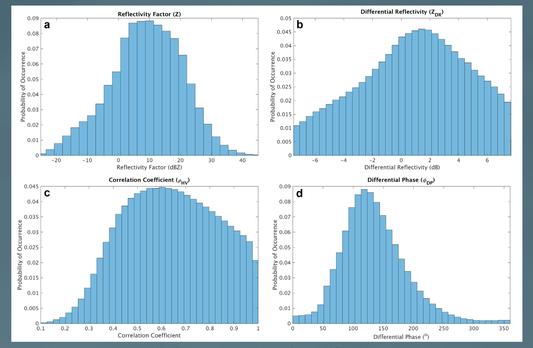
Differential Phase

X-band Chaff Strands and Clumps

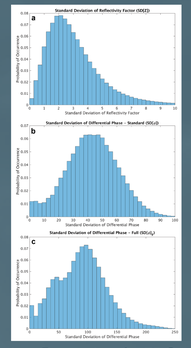


East-West-Oriented Chaff Clouds as Seen by the KBYX WSR-88D on 12 February 2016

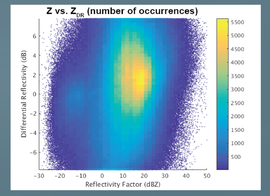
Statistical Properties of Chaff



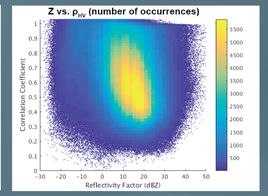
Z, Z_{DR}, ρ_{HV}, and Φ_{DP} for 75 Cases



Texture Parameters for 75 Cases



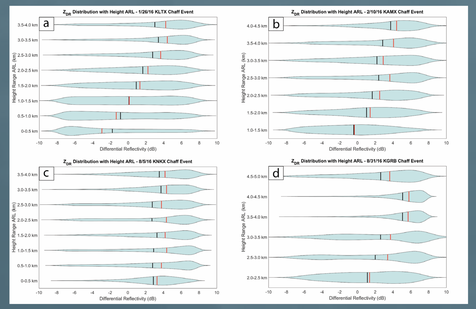
Z vs. Z_{DR} for 75 Cases



Z vs. ρ_{HV} for 75 Cases

- 2.2 million data points across 75 cases in 2016
- Collected via manual human truthing
- 33 different WSR-88Ds

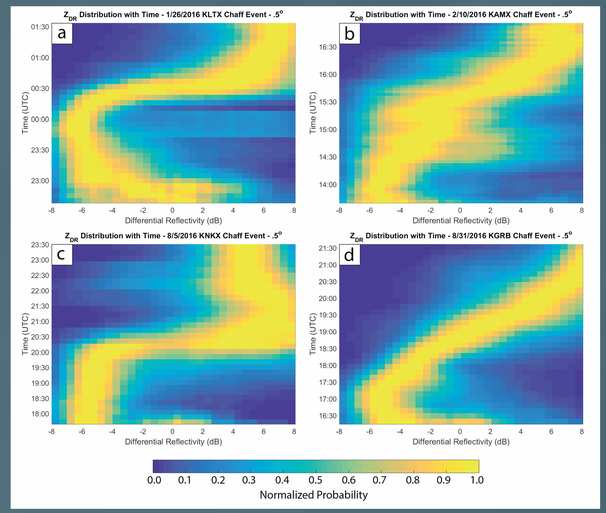
Z_{DR} Distributions by Height



Violin Plots of Z_{DR} Distribution for 4 Cases

- Compared to previous studies, significantly more negative Z_{DR} was seen in this dataset
- The negative Z_{DR} was concentrated in the lower atmosphere and earlier in fallout
- A combination of electrical, mechanical, and size-sorting mechanisms are postulated to contribute to the non-trivial amount of negative Z_{DR}

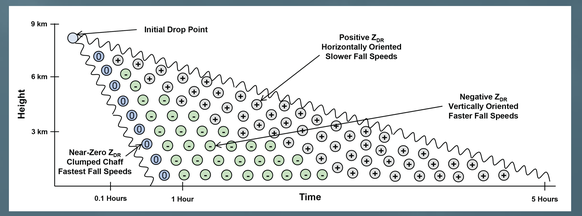
Z_{DR} Dynamics during Chaff Fallout



Z_{DR} Distribution in Time at the Base Elevation for 4 Cases

Z_{DR} Fallout Concept and Summary

- A comprehensive chaff database was used to determine quantitative properties
- A significant amount of negative Z_{DR} was observed
- Observations in time and height have led to hypotheses regarding negative Z_{DR}



Z_{DR} fallout concept. Clumps (near-zero Z_{DR}) fall out first, followed by vertically oriented fibers, and finally horizontally oriented fibers

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