Detecting severe storms using an RGB composite combining polarimetric radar parameters

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Introduction

Polarimetric radar moments such as **ZDR** and **CC (RhoHV)** provide valuable information on shape and homogeneity of scatterers inside a radar volume. They are, however, hard to interpret individually, and should at least be combined with **Z** for a proper interpretation. Since this involves switching between multiple radar moments and carefully judging overlap of signatures, we wondered whether this process can be simplified by combining these moments into an RGB.

Combining different channels into an RGB is well known in Satellite Meteorology. In Radar Meteorology, however, we know only a few informal experiments with RGBs, for example those shared by Trevor White on X in 2020. In our RGB we combine **Z**, **ZDR** and **CC** in such a way that it highlights various severe storm signatures.

RGB setup

Tornadic debris, large hail and **strong updrafts** are important phenomena to detect in radar imagery. They often have **distinct signatures** in **ZDR** and **CC** that distinguish them from surrounding echoes.

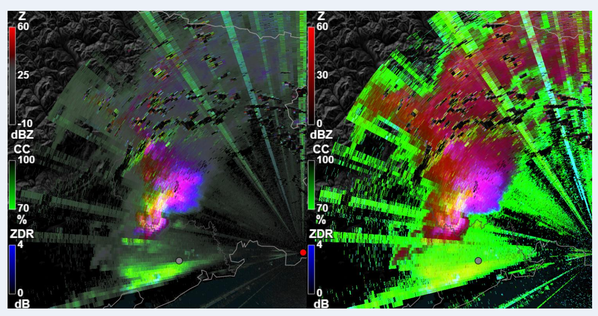
We want our RGB to highlight these signatures, which requires good contrast in the ranges of **Z, ZDR** and **CC** values that provide best discrimination. Additionally, we include an alpha channel, to de-emphasise regions of lower **Z**. Since not doing so resulted in the widespread green regions in the figure below (right).

The configuration is specified in the table and results in a setup where

- **red** provides good contrast from **moderate** to **high Z,**
- **green** highlights **low CC,**
- **blue** highlights **moderate** to **high ZDR,**
- **alpha de-emphasises** regions with **lower Z**.

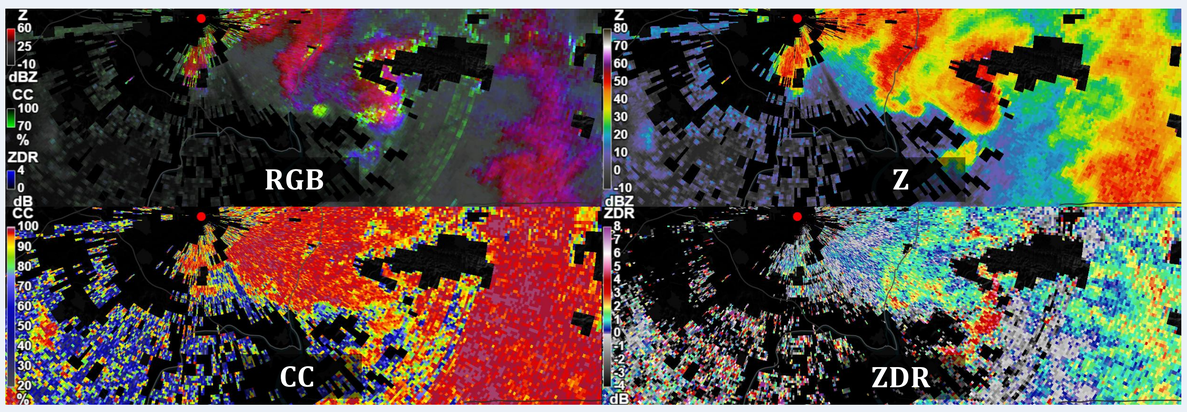
Z	Red	CC	Green	ZDR	Blue	Z	Alpha
						-10	0.05
						0	0.12
						10	0.22
						15	0.29
30	0	100	0	0	0	20	0.39
60	1	70	1	4	1	24	0.48
						28	0.58
						31	0.67
						34	0.77
						37	0.88
						40	1
dBZ		%		dB		dBZ	

Product values and corresponding RGBA values.



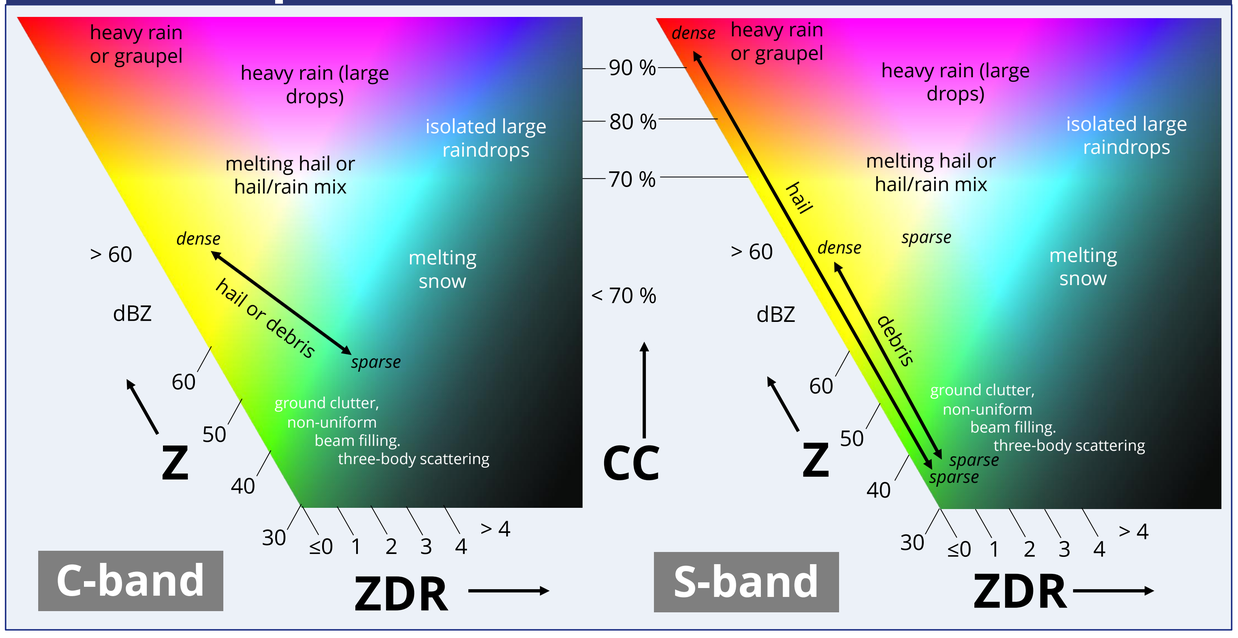
Our RGB with varying alpha (left) vs one with constant alpha=1 (right)

Linear interpolation occurs between the values in the table. Final displayed RGB values are given by $x_1 = a * (a * x_0 + 1 - a)$, where x_1 (x_0) represents the final (initial) RGB value, and a is alpha. Before display, alpha is set to 1.



RGB and its 3 individual components. The Tornadic Debris Signature (TDS) appears much clearer in the RGB.

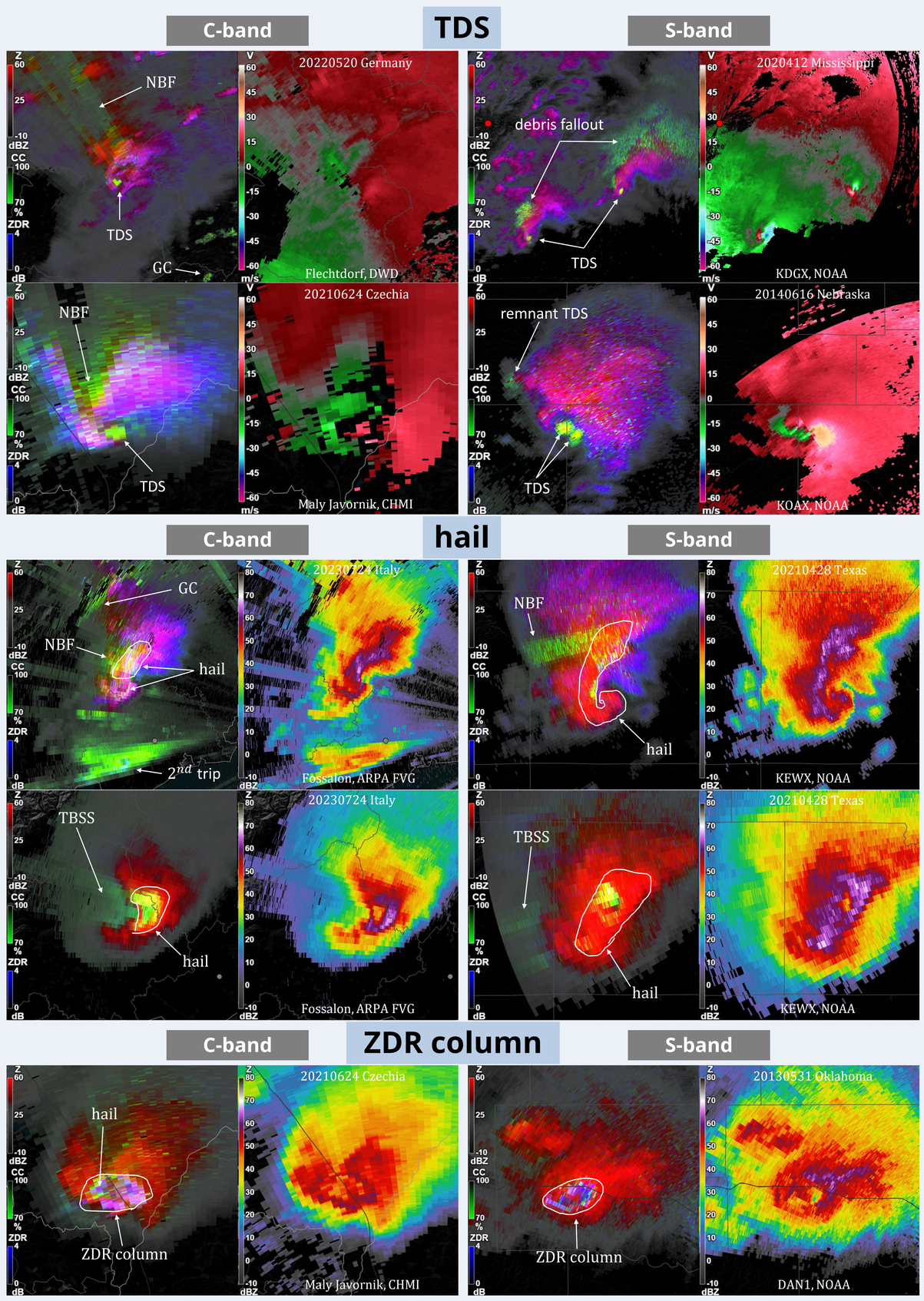
RGB interpretation



RGB examples

RGB signatures for various phenomena are shown below, with a focus on TDSes, hail and strong updrafts (ZDR columns). The acronyms in the figures refer to:

- **NBF: Nonuniform Beam Filling**
- **GC: Ground Clutter**
- **TDS: Tornadic Debris Signature**
- **TBSS: Three-Body Scatter Spike (“hail spike”)**



Conclusion

We created a polarimetric radar RGB with a configuration that highlights tornadic debris, hail and strong updrafts. These phenomena usually appear clearer in the RGB than in individual products. We think that the RGB can make polarimetric products more accessible to forecasters, as well as be a valuable tool for researchers who study polarimetric signatures in detail. Our ESSL Testbeds will provide an opportunity to evaluate its potential in quasi-operational practice.

We note, however, that ground clutter and second-trip echoes can distract from more interesting phenomena. Sufficient filtering (but not too aggressive) of the individual products is therefore recommended before creating the RGB.

Acknowledgements

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