Microphysical Properties within Regions of Enhanced Dual-Frequency Ratio: Results from the 2022 Deployment

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1. Motivation

- Multi-frequency radar measurements can improve the retrieval of snowfall properties from satellite observations
- Dual-Frequency Ratio (DFR): Reflectivity difference between two radars operating at different frequencies
- Related to characteristic size D_m, used to retrieve particle size distribution (PSD) parameters, and influenced by microphysical processes

Research Questions

1. What can multi-frequency radar measurements tell us about the microphysics in snowstorms?
2. How are these observations related to banded precipitation structures?
3. **[NEW FOR 2022]** How do the preliminary results from the 2022 deployment compare to 2020?

2. Data & Methods

- W-band (CRS), Ku- and Ka-band (HIWRAP), X-band (EXRAD) reflectivity Z_e corrected for attenuation and matched to P-3 location
- Aircraft must be within 4 km and separated by no more than 3 min
- PSDs: 2D-S (0.15–1.4 mm, 10 µm resolution), HVPS (1.4–30 mm, 150 µm resolution) every 5 s
- Time-varying mass-dimension relationship for deriving bulk microphysical properties
- Variable DFR threshold used to investigate whether DFR related to precipitation structures (Fig. 1)

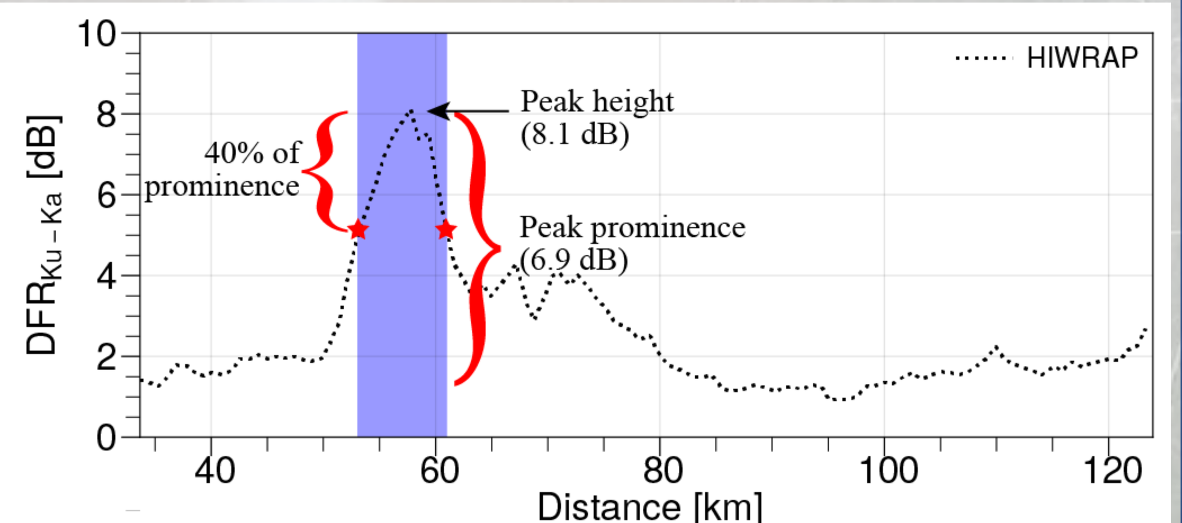

Fig. 1 Example of procedure used to detect prominently larger radar Ku- and Ka-band DFR (DFR_{Ku-Ka}) along the P-3 flight track.

3. Regions of Enhanced DFR at Flight Level

Example: 05 Feb 2020

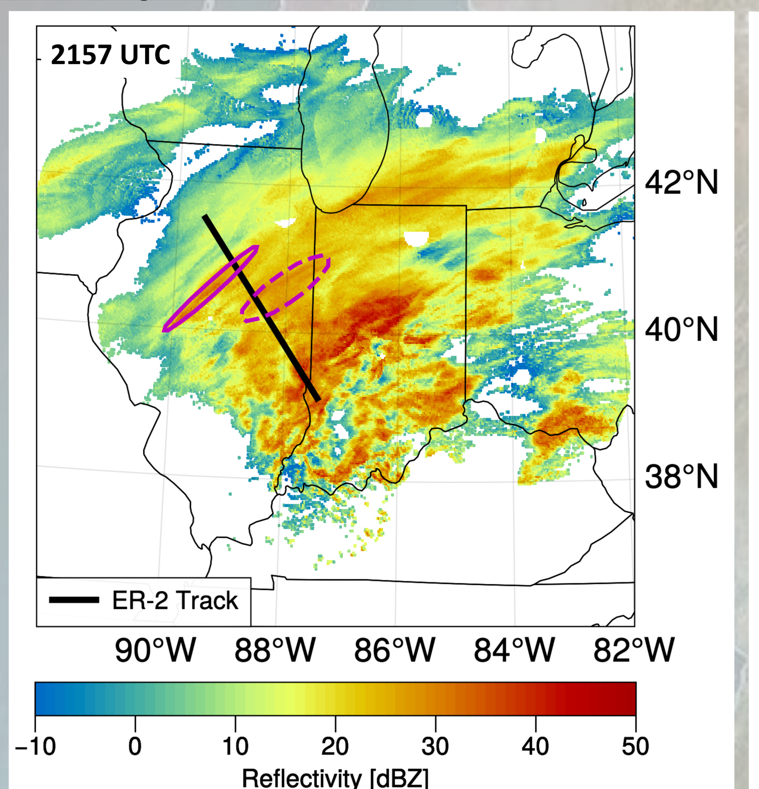

Fig. 2 2-km Z_e from NEXRAD mosaic valid at 2157 UTC 05 Feb 2020. ER-2 track in black and snowbands as magenta ovals.

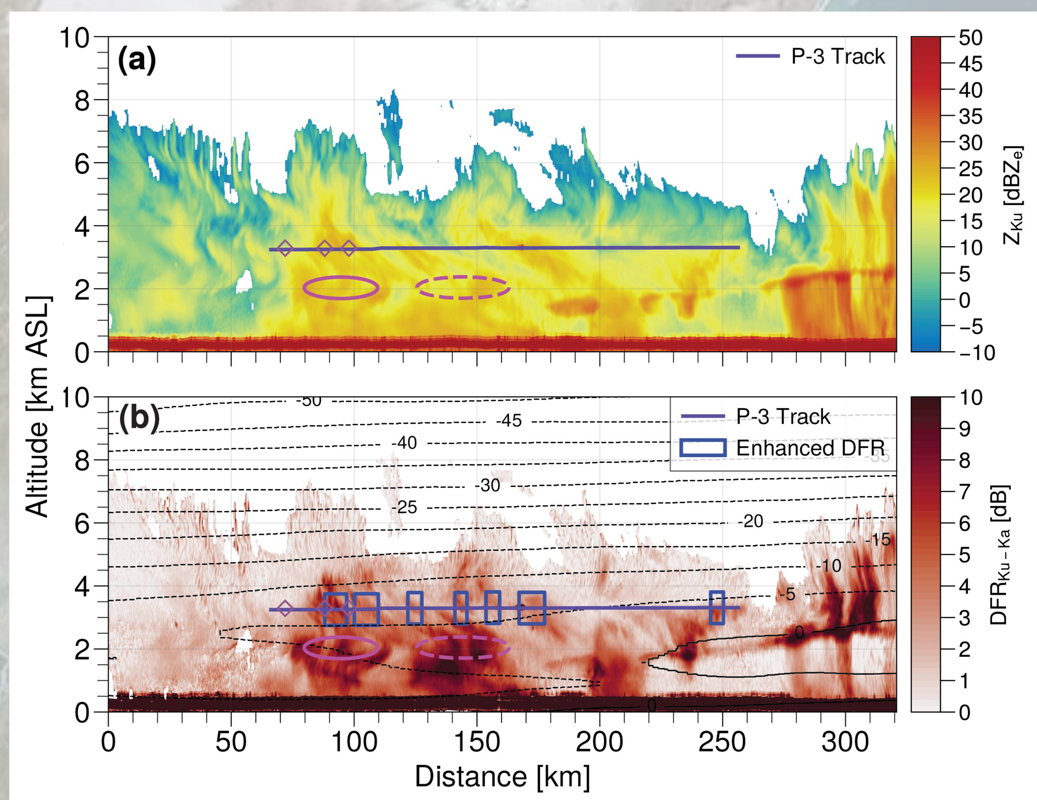

Fig. 3 HIWRAP cross-sections of (a) Z_{Ku} and (b) DFR_{Ku-Ka} for flight segment in Fig. 2. P-3 flight track (purple line), regions of enhanced DFR (blue boxes), and snowbands (magenta ovals) also shown.

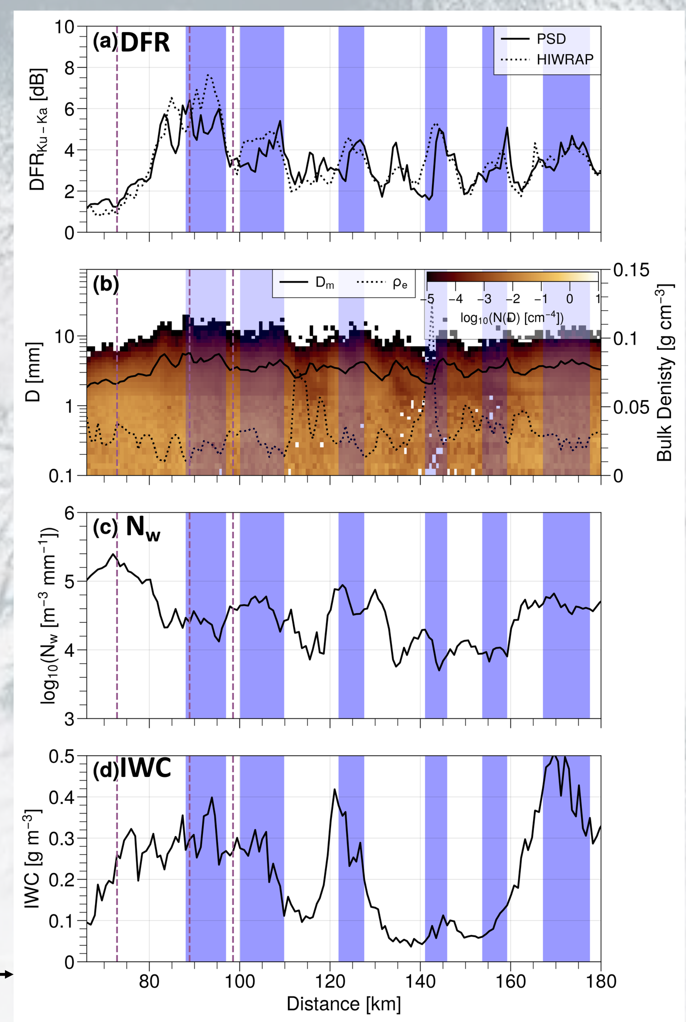

Fig. 4 Along-track DFR, D_m, ρ_e, N_w, IWC for the time period along the purple line in Fig. 3.

- ER-2 and P-3 sampled banded precipitation structures (Figs. 2, 3)
- Larger D_m, smaller ρ_e and N_w within regions of enhanced DFR consistent with an enhanced aggregation process (Fig. 4)
- Less dense particles and lower N_w → IWC may not be very large

4. IMPACTS Cases Analyzed

Date	Description	# Obs
25 Jan	Warm occluded front with generating cells	462
01 Feb	Warm oceanic frontal system over southern Atlantic with GPM overpass	185
05 Feb	Shallow frontal zone over Midwest with snowbands	678
07 Feb	Heavy snow in a rapidly deepening cyclone over NE	418
25 Feb	Generating cells with supercooled water in a NW sector of a Midwest Storm	585
19 Jan	Warm-frontal bands and generating cells in an Alberta Clipper in Canada	702
29 Jan	Departing strong nor’easter sampled over Plymouth, MA and southern ME	165
04 Feb	Cold front with freezing rain and snow over New England and NY	646
08 Feb	GPM overpass over low in the Gulf of Maine with snowbands NW of low	45
17 Feb	Deepening snowstorm over Chicago, IL	1134
19 Feb	Cold Alberta Clipper over Québec	139
	TOTAL	5159

Table 1 List of coordinated flights used in the DFR analysis and the number of 5-s collocated observations for each case.

5. Bulk Microphysical Comparison

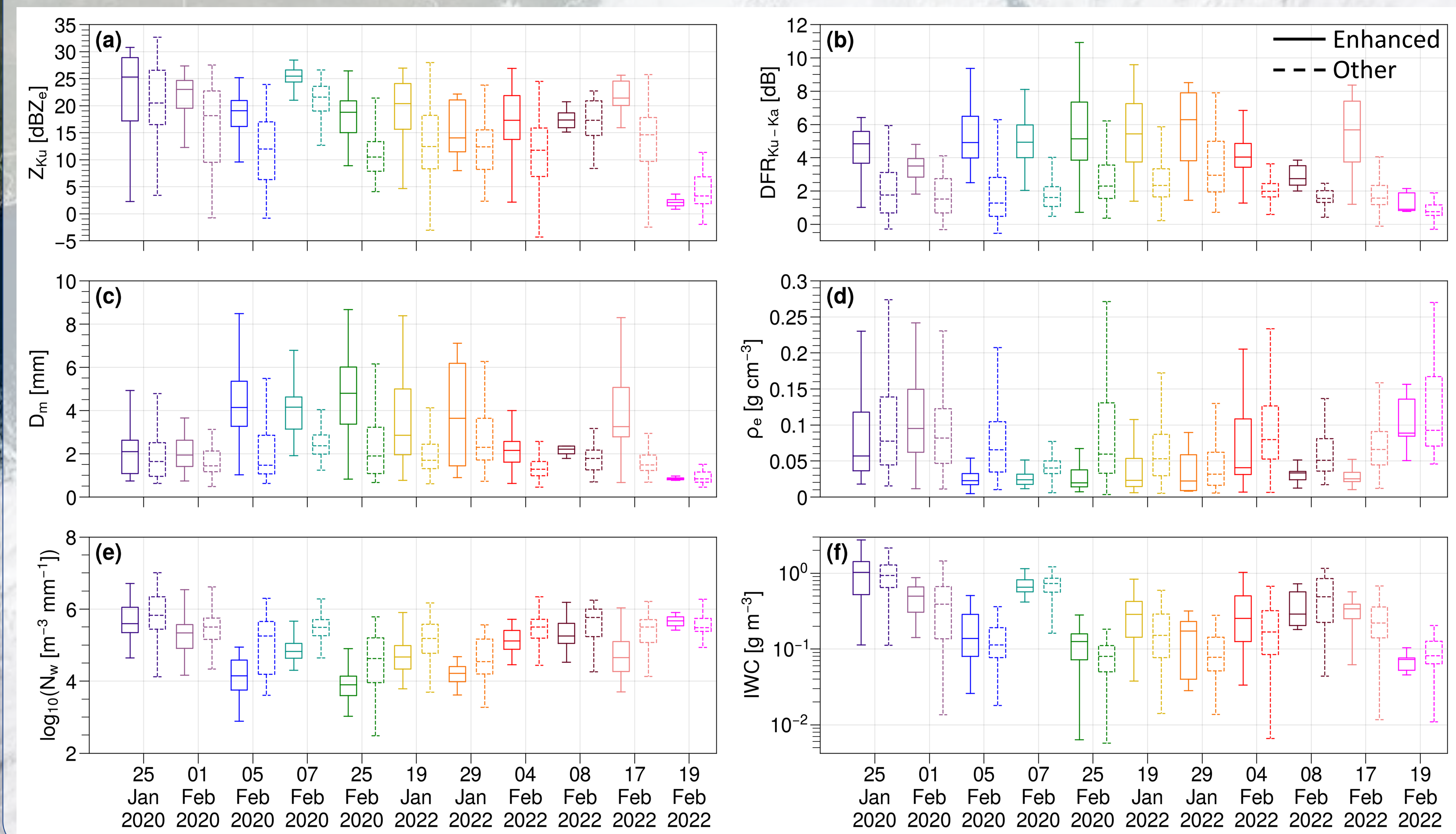

Fig. 5 Boxplots of (a) HIWRAP Z_{Ku}, (b) HIWRAP DFR_{Ku-Ka}, (c) D_m, (d) ρ_e, (e) $\log_{10}(N_w)$, and (f) IWC for regions within (solid) and outside of (dashed) enhanced DFR for each coordinated flight.

2022 vs. 2020

Similar results in regions of enhanced DFR:

- Larger D_m
- Lower ρ_e and N_w
- Less change in IWC

% Difference (Enhanced vs. Other)

	2020 Only (Finlon et al. 2022)	2020 + 2022
D_m	58.0%	59.8%
ρ_e	-36.6%	-32.7%
N_w	-74.2%	-79.3%
IWC	-0.9	12.9%

6. Summary & Future Work

- Preliminary results promising and suggest conclusions from Finlon et al. (2022) may hold for cases sampled during 2022 deployment
- Further QC of radar data (i.e., absolute calibration) and microphysics data (i.e., shattering removal) from 2022 deployment are needed
- Running neural network radar retrievals on 2022 cases may add further insight to the microphysics and how they relate to banded precipitation structures

References

Finlon, J. A., L. A. McMurdie, and R. J. Chase, 2022: Investigation of Microphysical Properties within Regions of Enhanced Dual-Frequency Ratio During the IMPACTS Field Campaign. *J. Atmos. Sci.* (published online ahead of print 2022), https://doi.org/10.1175/JAS-D-21-0311.1.

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