Microphysical properties within regions of enhanced dual-frequency ratio during the IMPACTS field campaign

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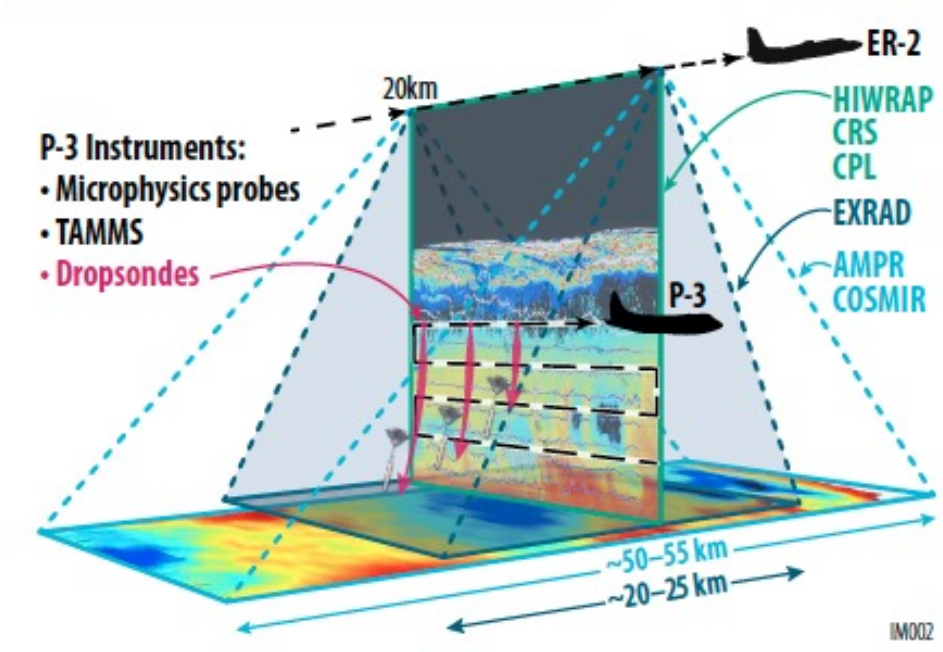
GOES-16 ABI Geocolor satellite image of the 29 January 2022 New England blizzard. Image source: NOAA/STAR.

Investigation of Microphysics & Precipitation for Atlantic-Coast Threatening Snowstorms

- 3-year NASA-funded project aimed to:
  - *Understand* dynamic, thermodynamic, microphysical processes associated with snowbands
  - *Apply* observations to improve modeling and remote sensing capabilities

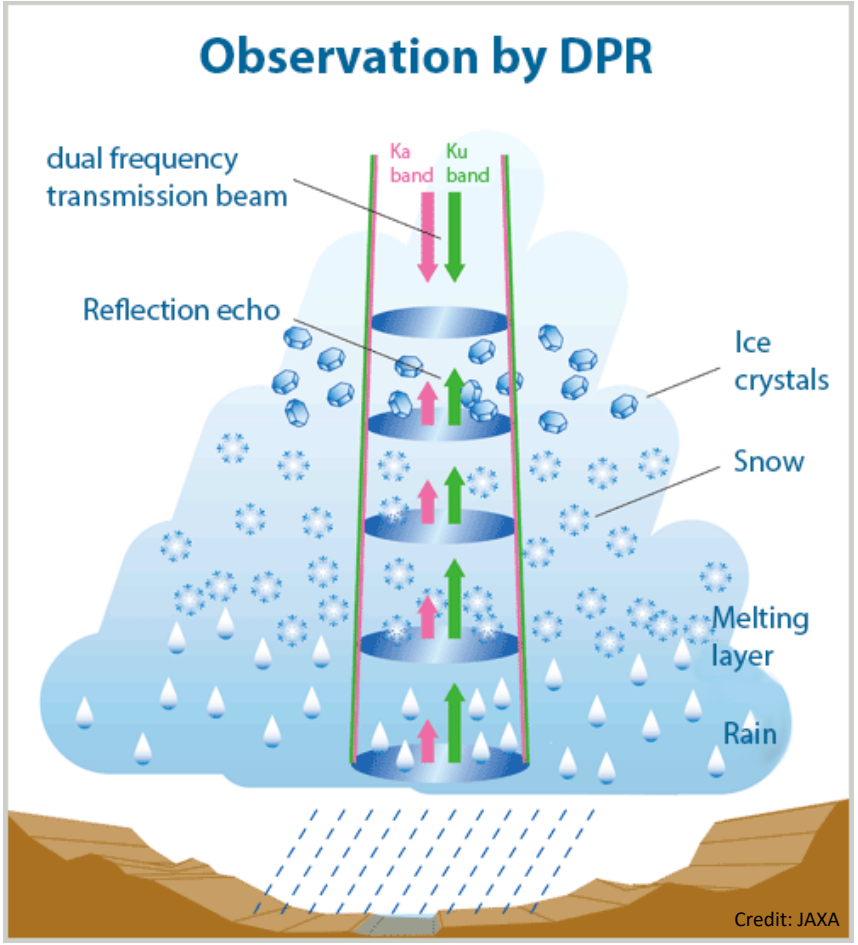


Goals for this talk:

1. What can multi-frequency radar measurements tell us about the microphysics in snowstorms?
2. How different are the microphysical and multi-frequency radar measurements between the winters sampled?

What can DFR tell us about microphysical properties?

- **DFR = Dual-frequency ratio**
- Typically involves 1+ frequencies in non-Rayleigh regime
- Related to particle size (D_m) and can be used to retrieve PSD parameters
- Can infer microphysical processes (e.g., aggregation)
- Focus for this talk: $DFR_{Ku\text{-}Ka}$

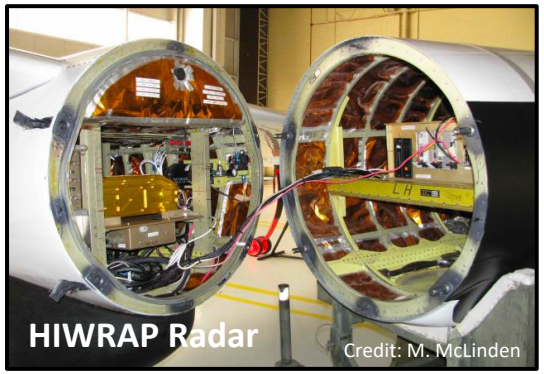


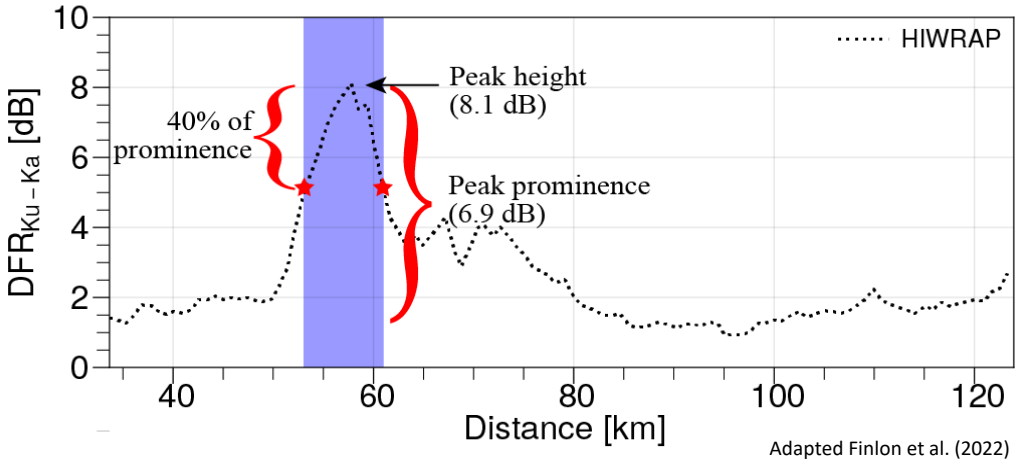
Defining regions of enhanced DFR

- Applies the technique outlined in Finlon et al. (2022)
- This talk uses IMPACTS data from all coordinated flights between NASA ER-2 and P-3

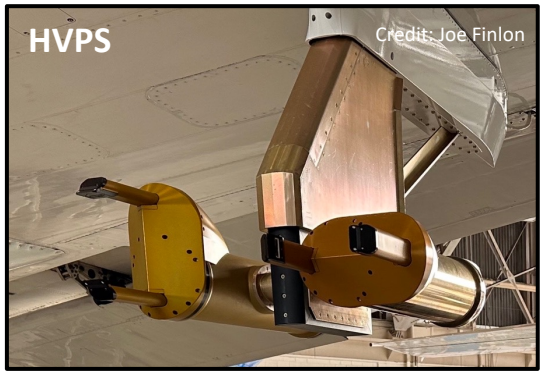
Defining regions of enhanced DFR

Goal: Investigate whether DFR of certain thresholds relate to precipitation structures (e.g., snowbands)



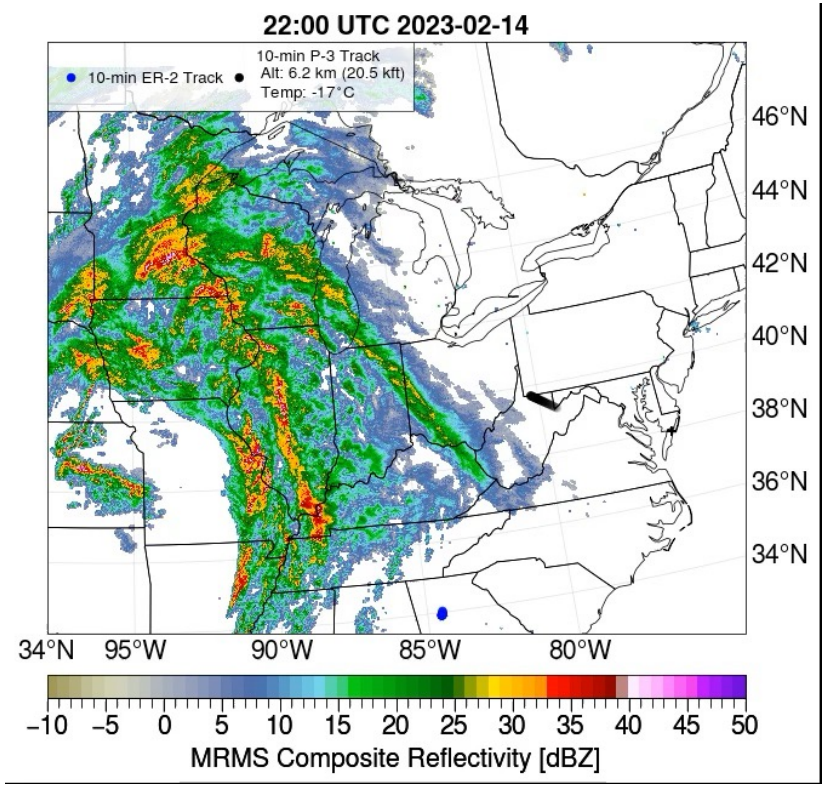


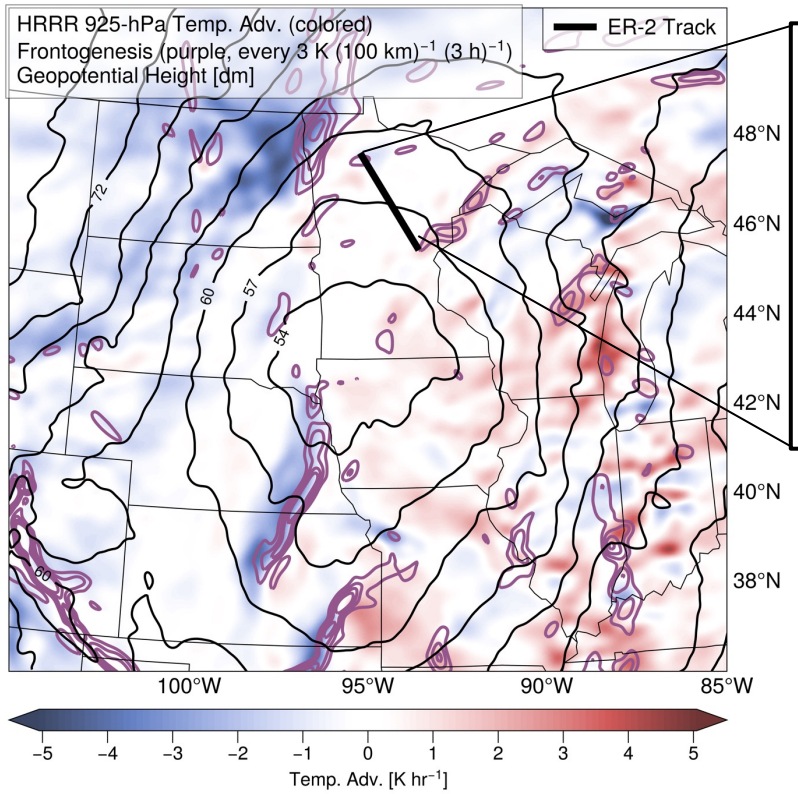
Adapted Finlon et al. (2022)

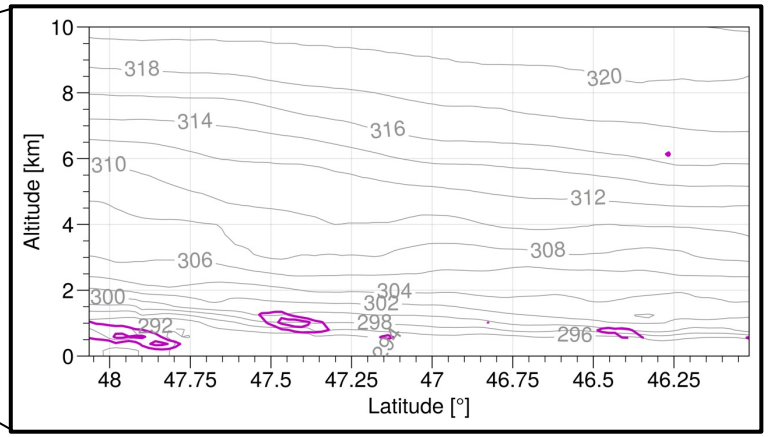


Radar matching algorithm determines radar Z_e along P-3 track → Identify regions of enhanced DFR where DFR signal at P-3 location ≥ 40% of peak prominence → Evaluate PSD parameters and bulk properties within and outside of enhanced DFR regions

Case Study – 14 Feb 2023 Snowstorm over Minnesota with banded precipitation

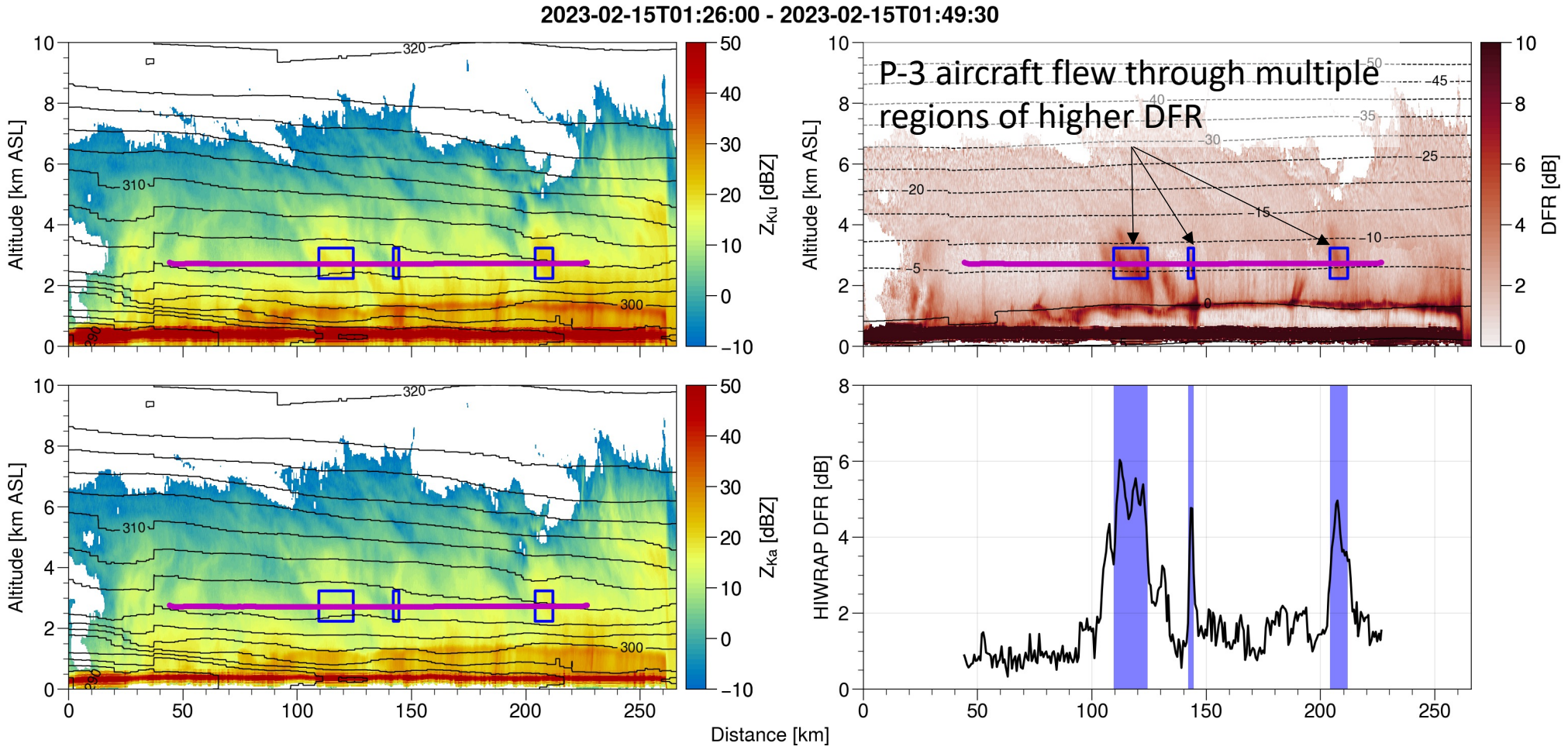




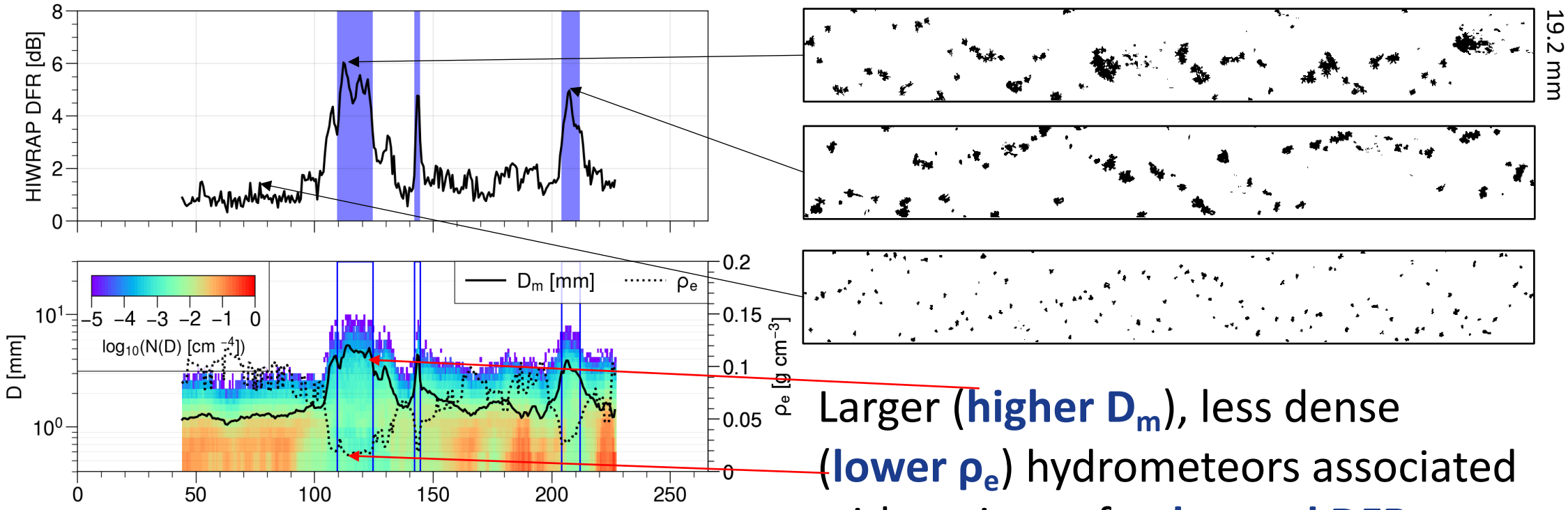


Featured a deepening low pressure system with multiple snowbands

14 Feb 2023 HIWRAP radar cross section



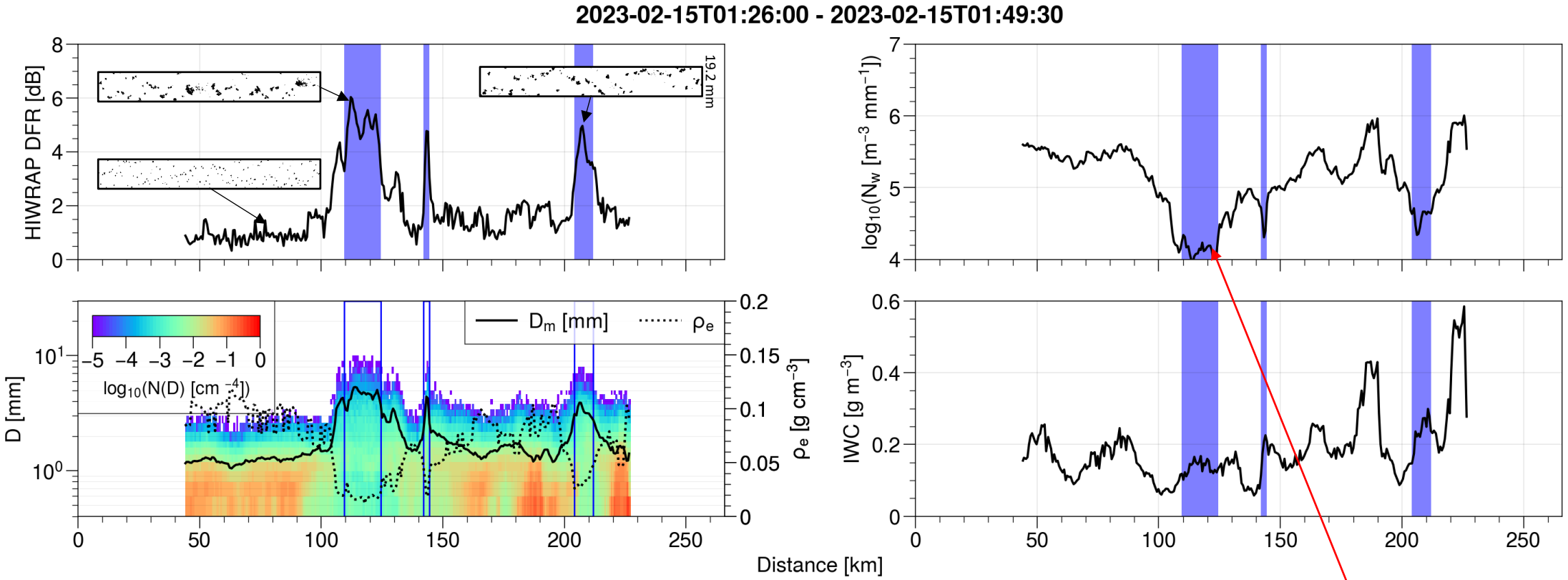
14 Feb 2023 in-situ microphysics



Larger (**higher D_m**), less dense (**lower ρ_e**) hydrometeors associated with regions of **enhanced DFR**

Shown: HVPS data only (no 2D-S)

14 Feb 2023 in-situ microphysics



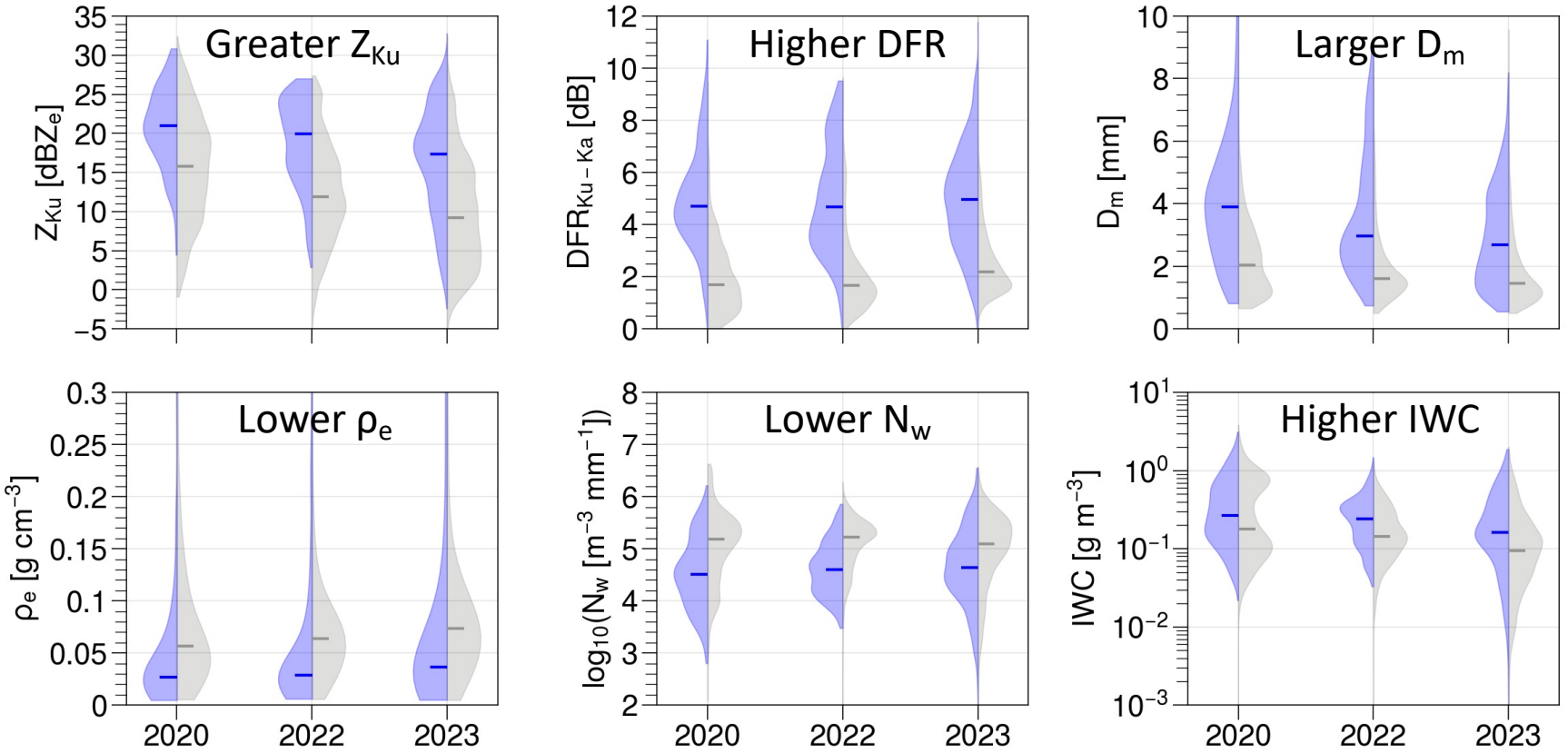
Enhanced DFR regions: Lower concentration of small particles (**lower N_w**) may be attributed to **aggregation**

DFR influence on microphysical properties

Ehanced DFR Regions

- Larger D_m (63%)
- Lower N_w (11%)
- Lower ρ_e (73%)
- Higher IWC* (47%)

*IWC % difference less for events when 2D-S + HVPS used



Summary & Key Points

- Variability in cloud properties linked to crystal growth processes, shown in multi-frequency radar measurements as prominently higher DFR
- **Enhanced DFR regions:** Larger D_m, smaller ρ_e and N_w → larger aggregates

Future Work:

1. Objectively identify snowbands to evaluate their relationship to enhanced DFR regions
2. Use 2D-S + HVPS data to verify results

References & Data Sources

- 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.*, **79**, 2773–2795, https://doi.org/10.1175/JAS-D-21-0311.1.
- McMurdie, L. A., and Coauthors, 2022: Chasing Snowstorms: The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) Campaign. Bull. Amer. Meteor. Soc., 103, E1243–E1269, https://doi.org/10.1175/BAMS-D-20-0246.1.

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Data Sources:

- 2020 & 2022 data publicly available at the NASA GHRC http://doi.org/10.5067/IMPACTS/DATA101
- HIWRAP: http://har.gsfc.nasa.gov
- HVPS: https://atmos.uw.edu/~jfinlon/impacts/data/hvps/

Credit: Stephen Nicholls

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