Generation of Merged Radar-Lidar Data Products during the IMPACTS 2020 Field Campaign

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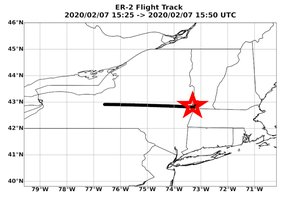
Objectives

- Develop ER-2 based radar-lidar merged data products that can both supplement and create added value to the source data.
- Visualize overall storm structure and hydrometeors with two approaches.
  - Normalized
  - Power conversion (lidar -> radar dB)
- Development of ER-2 based microphysical property product retrievals from depolarization data.
  - Potential hydrometeor retrievals
    - Precipitation phase
    - Crystal habit
    - Particle size
  - Supervised machine learning-based approach
- Evaluate ER-2 hydrometeor properties assuming P-3 in-situ data as truth

Datasets

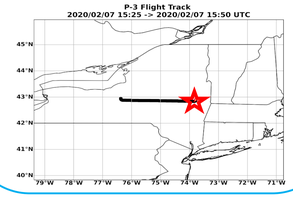
High Altitude ER-2 Data (Level 1B)

- Ka-band – HIWRAP (35.5 GHz)
- Ku-band – HIWRAP (13.6 GHz)
- W-band – CRS (94 GHz)
- X-band – EXRAD (9.4 GHz)
- Lidar – CPL (1064, 532 nm)

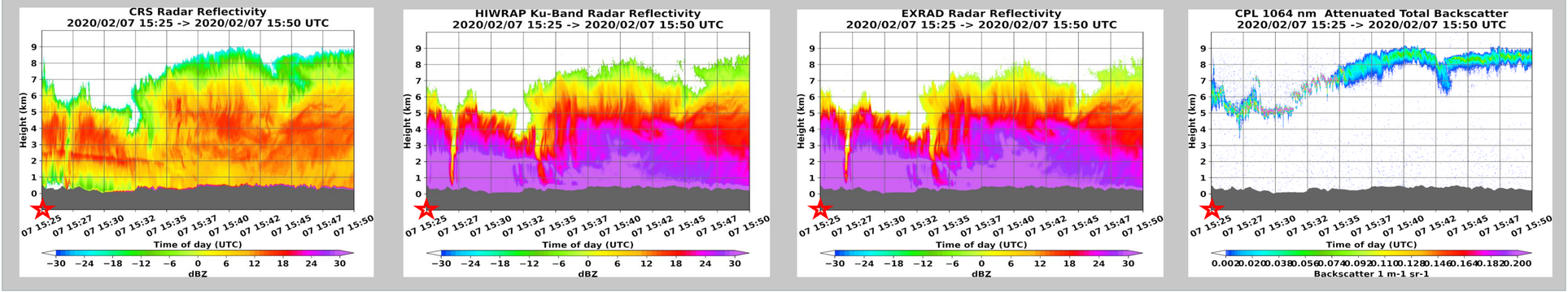


In-situ P-3 Orion Data

- Wisper, RICE – Cloud and Ice Water Content
- HVPS, Hawkeye – Particle Size Distribution

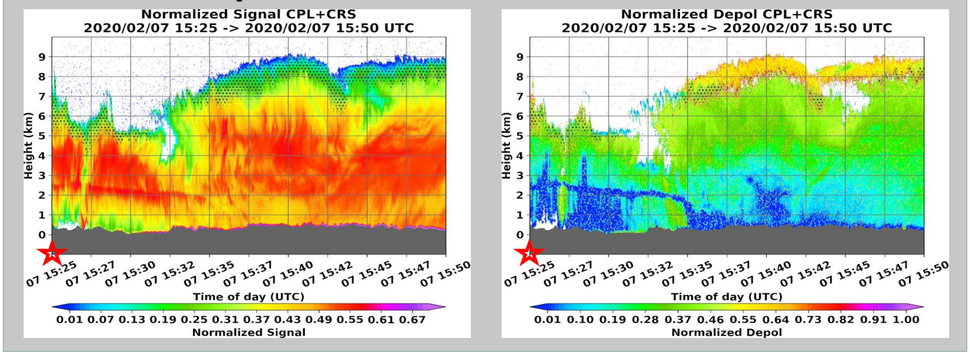


Raw Data Inputs (Radar Reflectivity, Attenuated Total Backscatter)

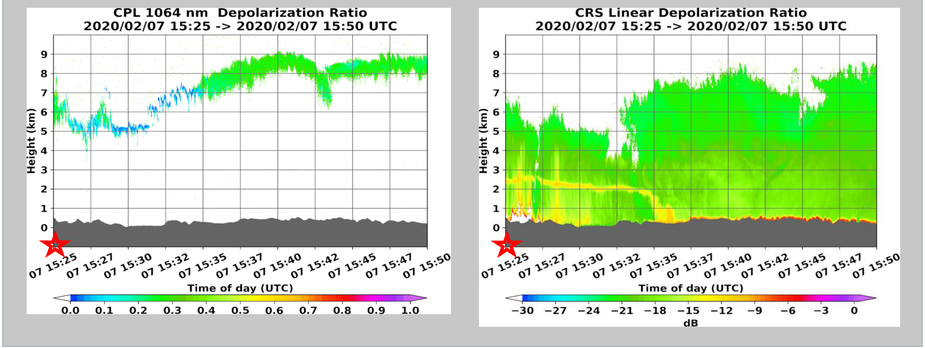


Temporal Averaging + Vertical Interpolation → **Normalization** / **Power Conversion (dB)**

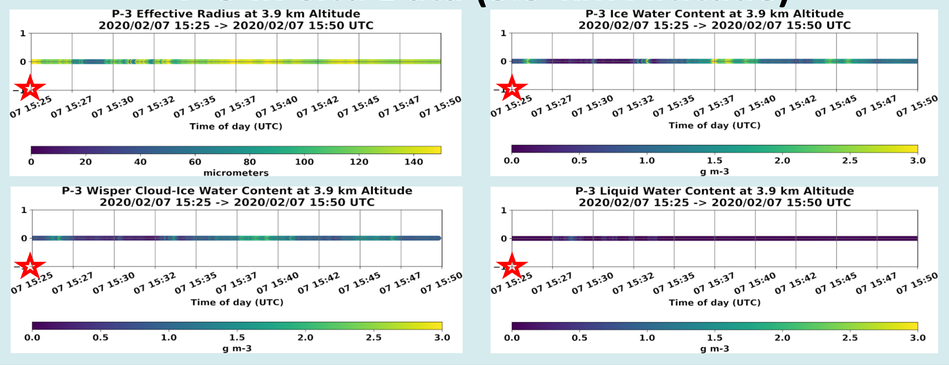
Composite Normalized Data Products



Raw Data Inputs (Depolarization)



P-3 In-situ Data (3.9-km Altitude)



Discussion of Figures

- All data, figures, and processes shown within the grey boxes depict an overall flow diagram of our data processing algorithm, which starts from the raw ER-2 level 1B data products and ends with the production of our normalized, composite figures (power conversion still under development).
  - All shown data is from a coincident ER-2/P-3 overpass (1525 – 1550 UTC 7 Feb. 2020) over central New York State flying from east to west.
  - All data within the grey boxes originates from ER-2 radar and lidar data, whereas data in the blue box is from the P-3 cloud probes.
- The February 7th IMPACTS mission targeted an intense, north-south oriented precipitation band located in the northwestern quadrant of a rapidly intensifying wintertime cyclone moving over the Delmarva Peninsula.
- Raw radar and lidar data show a pronounced increase in echo top height, change in cloud particle phase (liquid to ice), and a sharp decline in bright band height (radar only) as the aircraft transitioned from the warm sector and into the cold sector of the stationary front around 1535 UTC.
- Normalized ER-2 radar-lidar products provide a more complete picture of storm structure because these composite figures include data from both highly sensitive and quickly attenuated datasets and also those with lower sensitivity threshold and reduced attenuation.
- The normalized signal figures show considerably higher (~1 km) cloud top heights than seen in any radar products due to CPL's higher sensitivity.
- Higher values of normalized depolarization (brighter colors) denote an increased probability of ice-phase particles, which is an assumption that is shown to be consistent with P-3 liquid and ice water content measurements at 3.9 km.

Summary

- We have further refined our method for generating composite normalized data products from ER-2 Level 1B datasets.
  - The algorithm now supports all four of GSFC's high-altitude radars and the CPL lidar.
  - Dataset composites can now be mixed and matched to include any combination of radar and lidar data.
  - Our latest innovation is to apply normalized depolarization products with goal of achieving remote detection of hydrometeor properties (i.e., cloud/droplet particle phase, crystal habit, particle size, etc.)
- Compositing various products offers advantage of mitigating individual sensitivity and attenuation limitations of individual products to obtain a more complete illustration of storm structure.
- Favorable initial comparisons between the P-3 cloud probe measurements and the ER-2 depolarization retrievals show promise that the remote retrieval of hydrometeor properties is possible from the ER-2, but more work is needed.
- On-going work will continue use both the ER-2 and P-3 datasets to determine the potentially applications of radar-lidar composite products, generate power conversion-based composite products, and train a supervised machine learning model to make probabilistic predictions of cloud/droplet particle properties using ER-2 data only.