Using airborne measurements to evaluate HRRR forecasts of freezing drizzle aloft: results from the WINTRE-MIX field campaign

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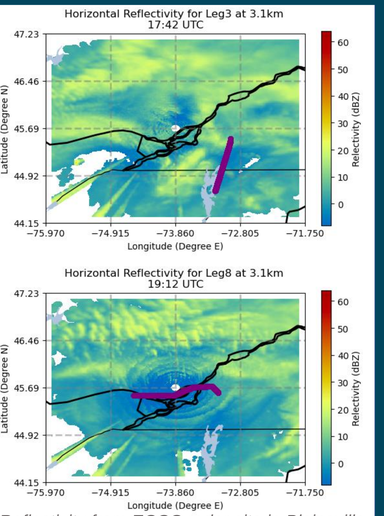
Motivation

Scenarios of supercooled large drop (SLD) icing poses a challenge for numerical weather models due to difficulties accurately predicting atmospheric and microphysical conditions (Jensen et al. 2023). The Winter Precipitation Type Research Multi-scale Experiment (WINTRE-MIX) conducted research flights onboard the National Research Council of Canada (NRC) Convair-580 aircraft to collect data to evaluate and improve numerical forecasts of precipitation type (Minder et al. 2023). A unique microphysical environment was observed by scientists during the first flight of intensive observing period 9 (IOP9) with widespread freezing drizzle (FZDZ) observed in cloud with cloud top temperatures as cold as -15ºC. Leg 0, Leg 3 and Leg 8 are emphasized due to observations of icing.



Reflectivity from ECCC radar site in Blainsville taken at average altitude for each leg. Flight path is shown in purple

Ice accumulated on the Nevzorov probe on the wing of the Convair-580 following IOP9 flight 1.

Goal

Evaluate HRRR forecasts of freezing drizzle aloft to compare to observations made on board the Convair-580 during the first flight of IOP9.

Methods

Aircraft

- Cloud droplet probe (CDP)
- Nevzorov hot-wire probe
- Rosemount Icing Detector
- 2D-Stero probe (2D-S)
- NRC W-band airborne radar (NAW)

Data resampled on 30-second averages (excluding NAW)

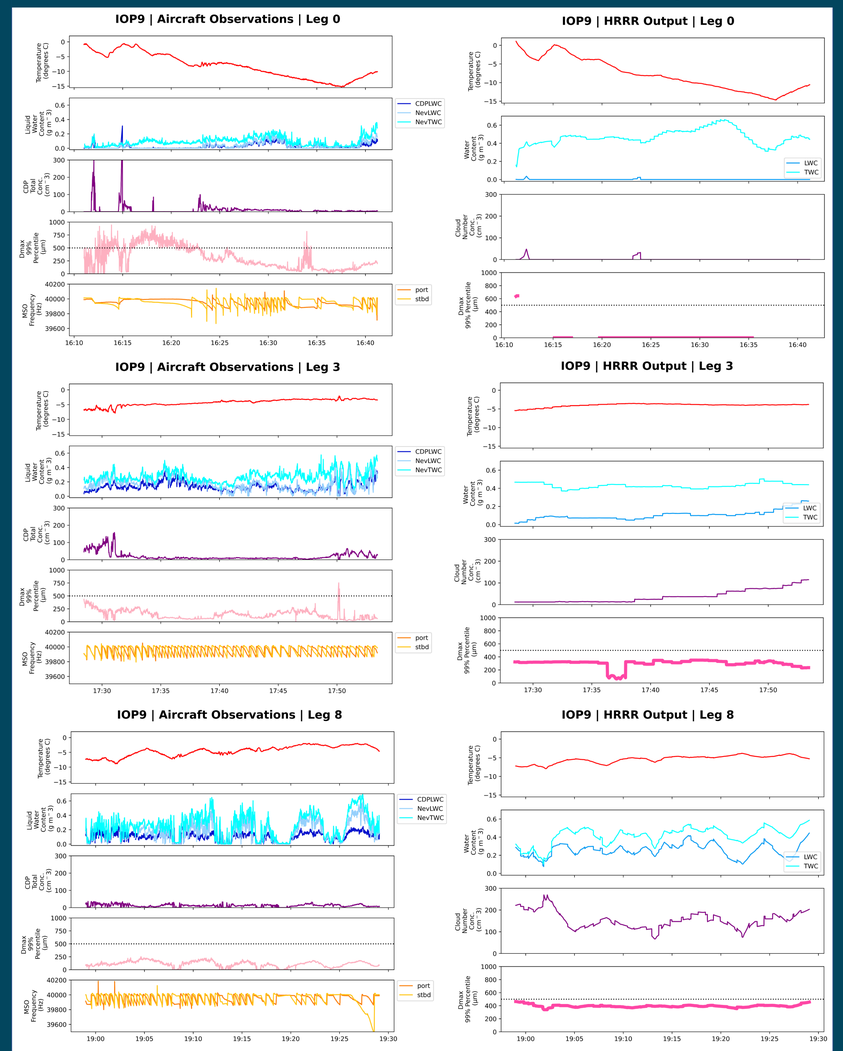
HRRR

- HRRR forecasts were initialized at 1200 UTC 7 March 2022
- Four forecast hours (fh04-fh08) were examined coinciding with research flight

- Horizontal and vertical interpolations to aircraft position
- Diagnostic calculations performed following methods used in Tessendorf et al. (2021)

Compare datasets

Observation and Model Trend Comparison

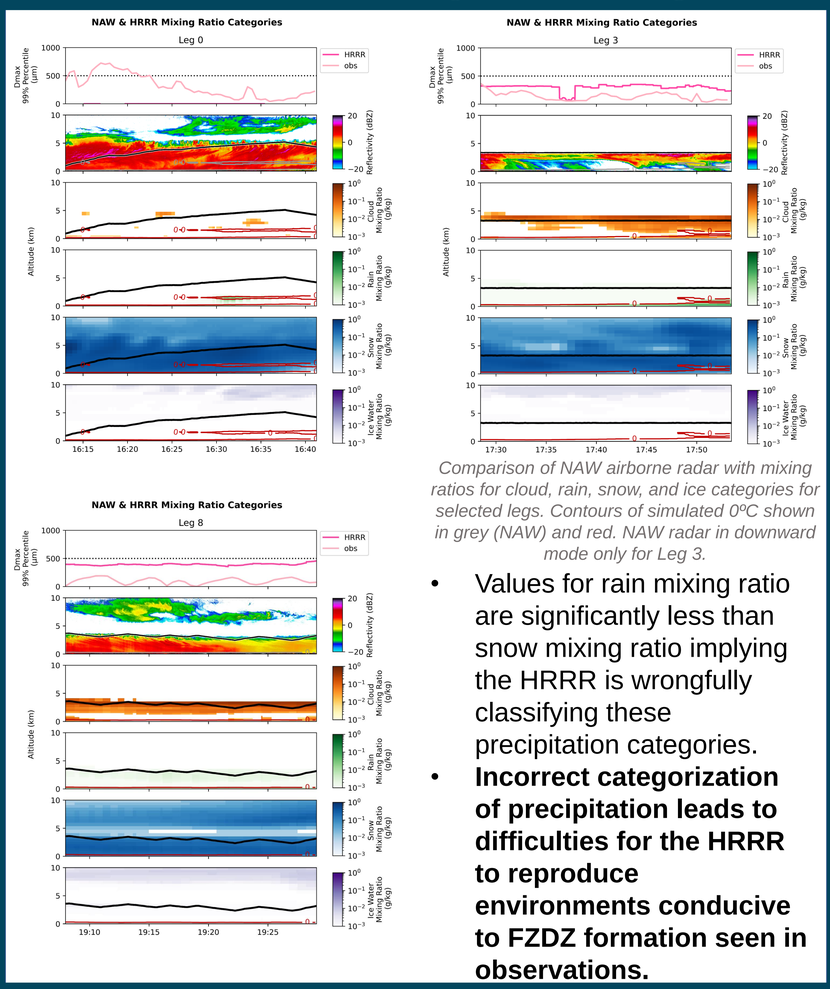


Timeseries of selected legs of IOP9. Timeseries were constructed for all legs of flight.

Timeseries of HRRR output for selected legs of IOP9 interpolated to aircraft position.

- We hypothesize that the HRRR will struggle to capture SLD formation at colder cloud top temperatures.
- The HRRR adequately models liquid water content (LWC) compared to observations but overestimates total water content (TWC) implying the model is anticipating a greater amount of ice (IWC = TWC - LWC).
- The HRRR tends to overestimate cloud number concentration when compared to observations.
- **The HRRR generally predicts the correct category of SLD using the 500 μm Dmax threshold (Tessendorf et al. 2021), however, values of Dmax tend to deviate significantly between observations and model output.**

NAW and HRRR Mixing Ratio Categories



Comparison of NAW airborne radar with mixing ratios for cloud, rain, snow, and ice categories for selected legs. Contours of simulated 0ºC shown in grey (NAW) and red. NAW radar in downward mode only for Leg 3.

- Values for rain mixing ratio are significantly less than snow mixing ratio implying the HRRR is wrongfully classifying these precipitation categories.
- **Incorrect categorization of precipitation leads to difficulties for the HRRR to reproduce environments conducive to FZDZ formation seen in observations.**

Ongoing and Future Work

Conduct numerical weather simulations to explore how modifying the microphysics scheme will affect the comparison between the observations made and the HRRR output.

References

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