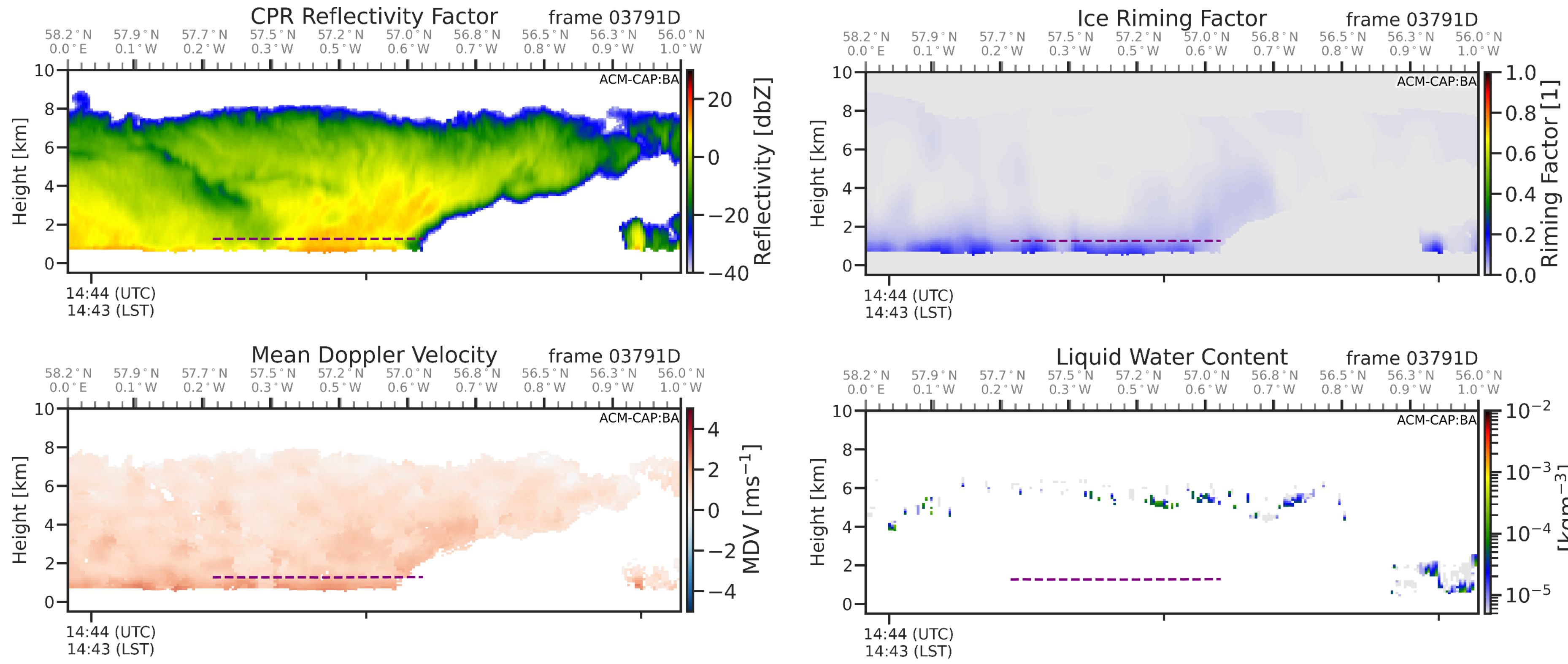


Aims

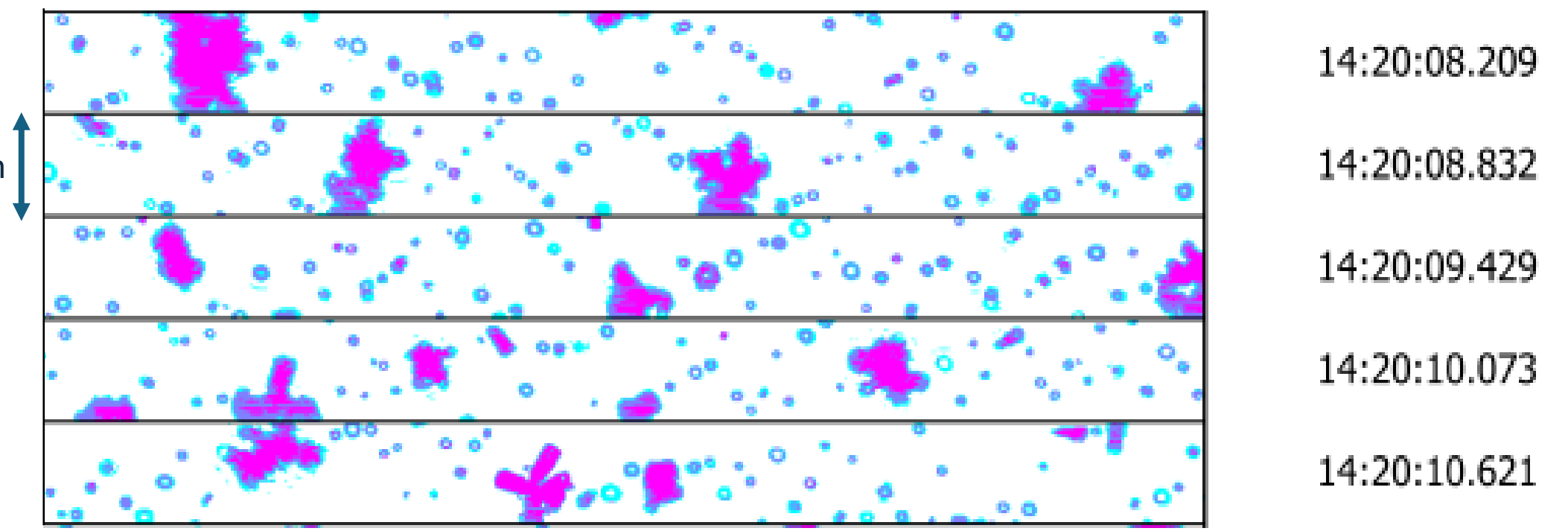
We evaluate EarthCARE's synergy product, ACM-CAP (ATLID-CPR-MSI Cloud Aerosol and Precipitation) using in-situ aircraft observations.

- With the presence of layer of supercooled liquid above the flight track, the lidar is attenuated, therefore just the CPR is used in the retrieval.
- Stratiform Cloud over the North-East of the UK on January 27th, 2025.

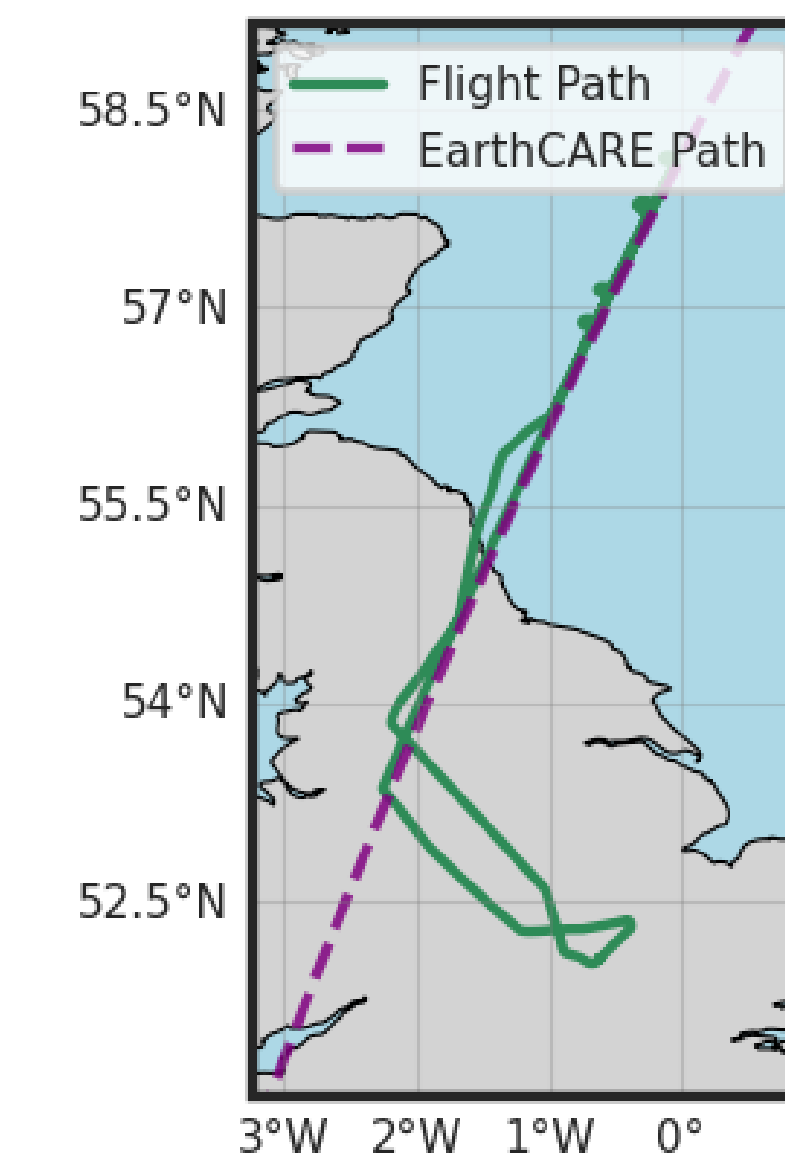


[Figure 1: EarthCARE's ACM-CAP retrievals of (a) CPR Reflectivity factor, (b) C-CD Best Estimate Sedimentation Velocity, (c) Ice Riming Factor and (d) LWC. Each with Flight track for Run 3 for VERIFY campaign flight 401 (purple dashed).]

FAAM VERIFY Flight 401



[Figure 2: CIP 15 Images for time of Run 3 from FAAM's aircraft. Large ice crystals show signs of riming. Small drizzle drops present]

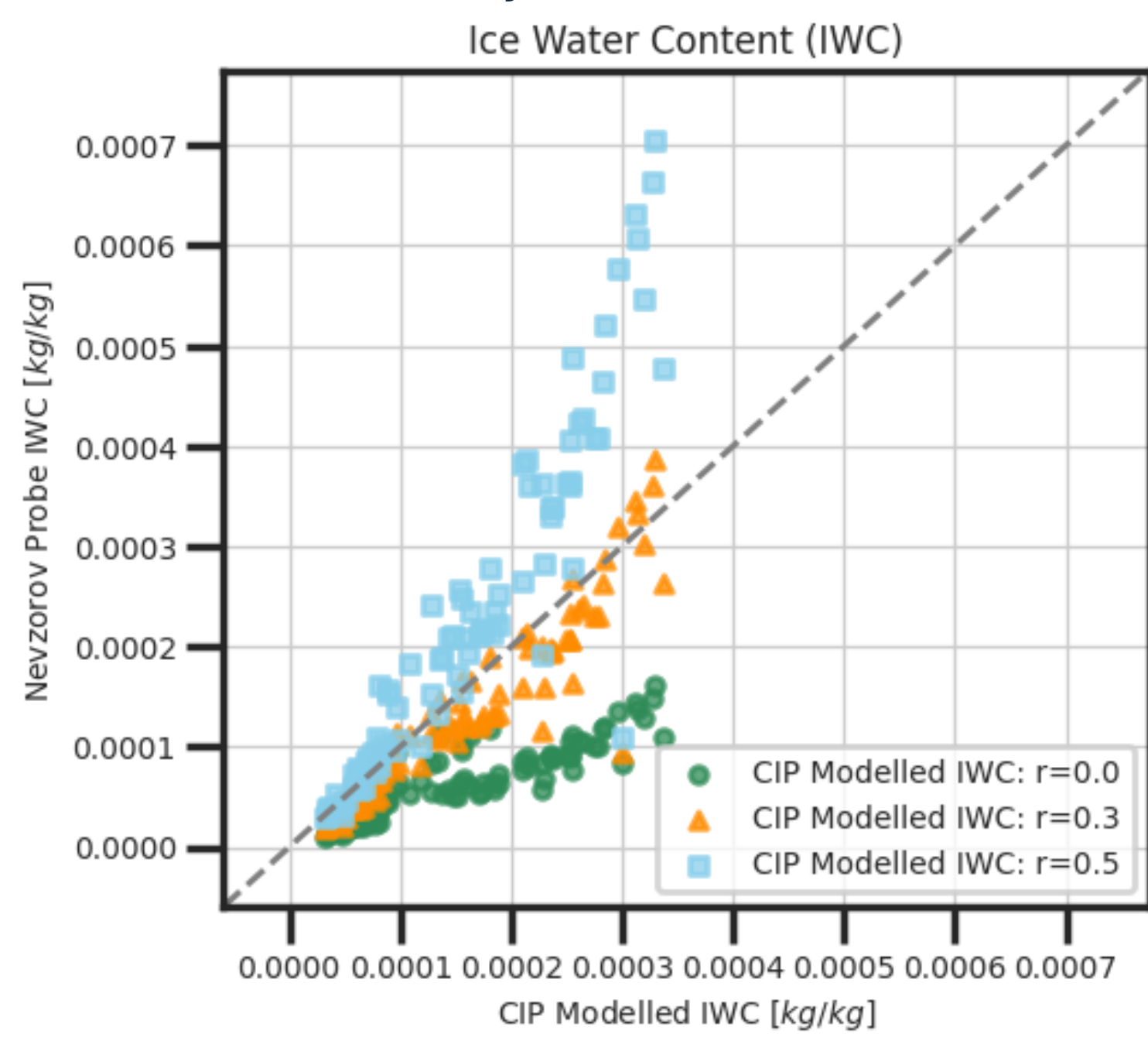


[Figure 3: Flight Track for VERIFY 401 (green), EarthCARE Track (purple)]

- From FAAM's VERIFY Campaign, we use flight 401, in which supercooled liquid water is present seen in the CIP images (above). We evaluate how the ACM-CAP product captures the microphysical processes such as riming.
- For cases of riming, we expect an increase in fall velocity due to the increased density of ice particles as the supercooled liquid freezes and infills the open geometry of ice particle.

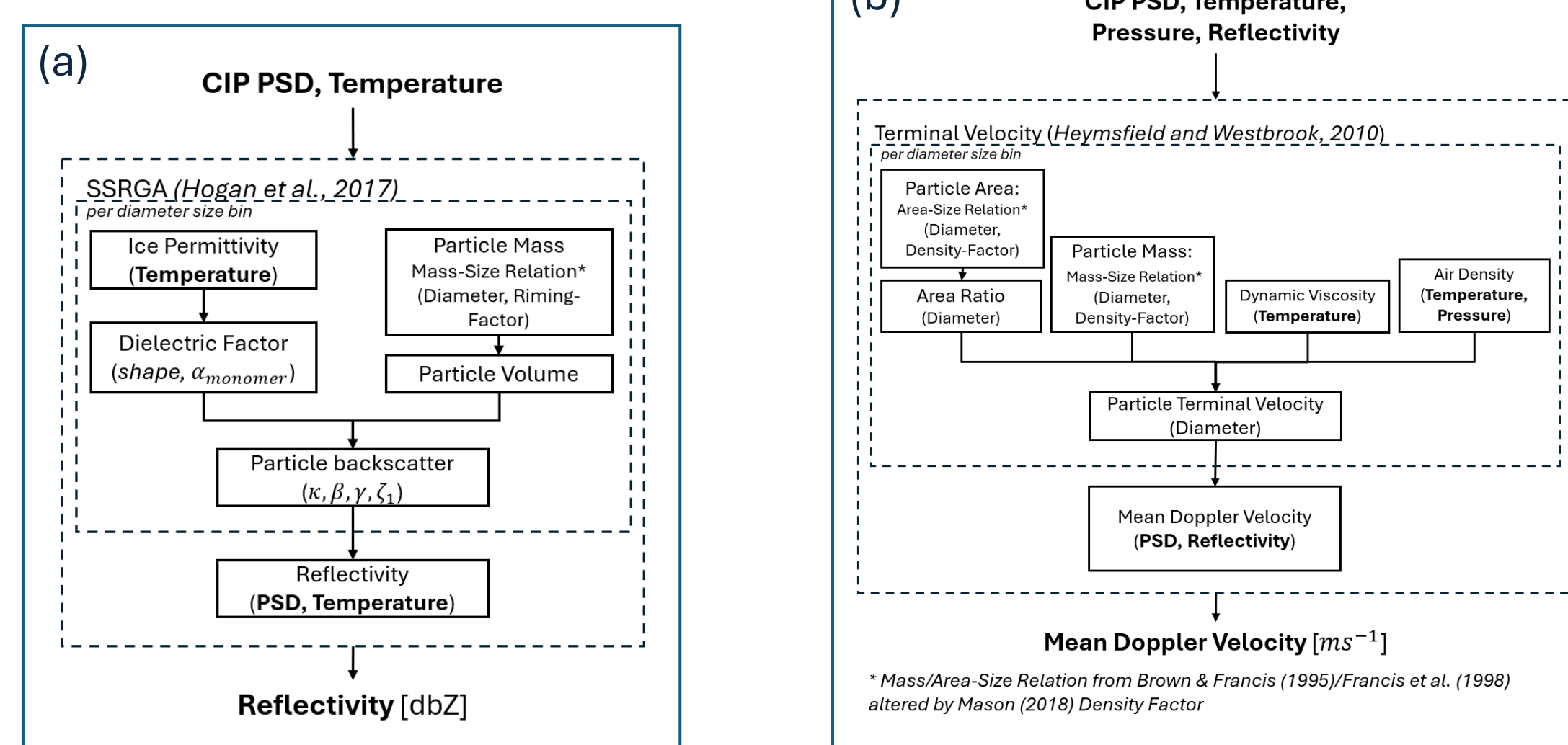
Density Factor

- Using Mason et al. (2018) density factor, which scales the mass-size and area-size parametrisation from Brown and Francis (1995) and Francis (1998) to denser solid spheres, i.e. graupel, we determine a density/riming factor by comparing the Nevzorov Probe's ice water content (IWC) to a calculated IWC using CIP PSD and a mass-size relation with different density factor.



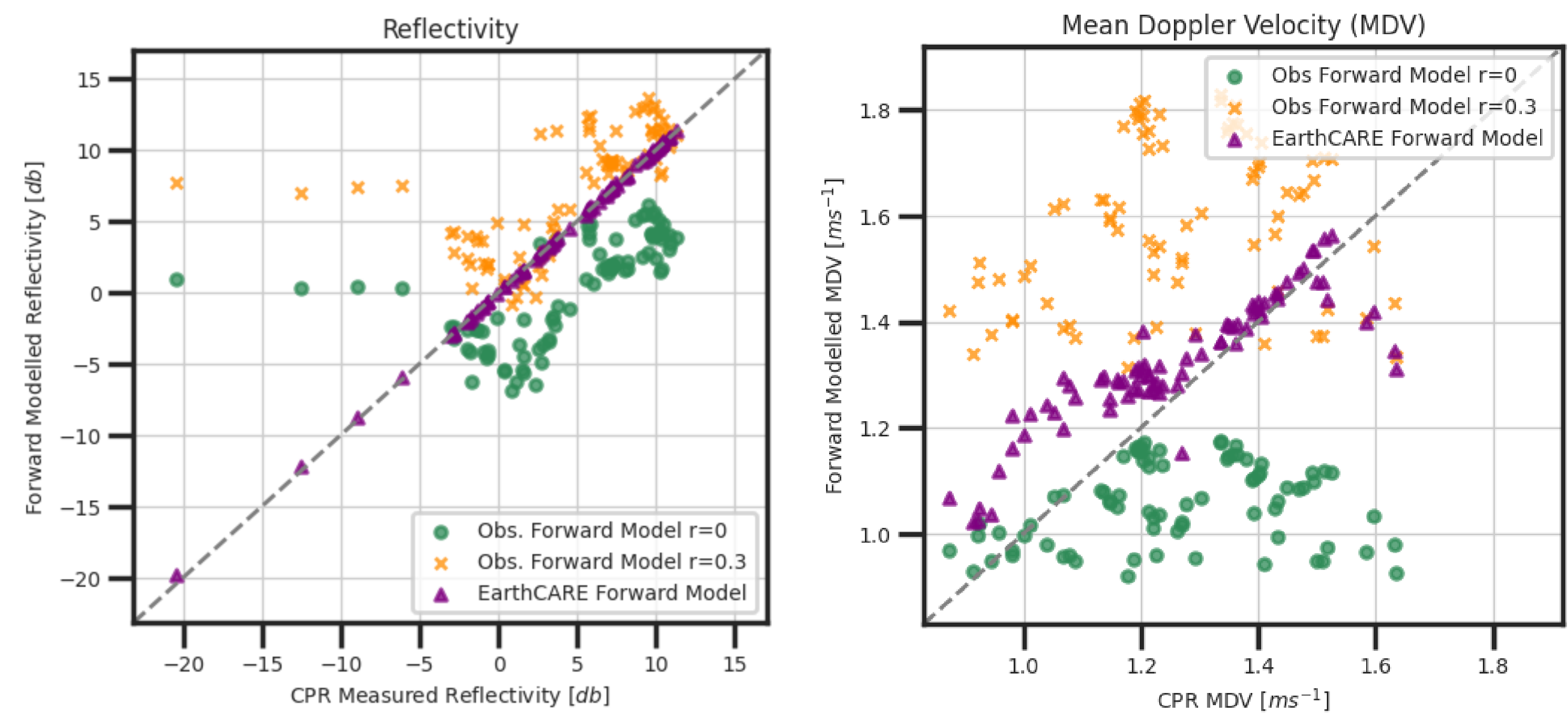
[Figure 4: Matching CIP PSD calculated IWC using Mason (2018) density factor, r , to alter the mass-size relation to model denser rimed particles]

Forward Modelling



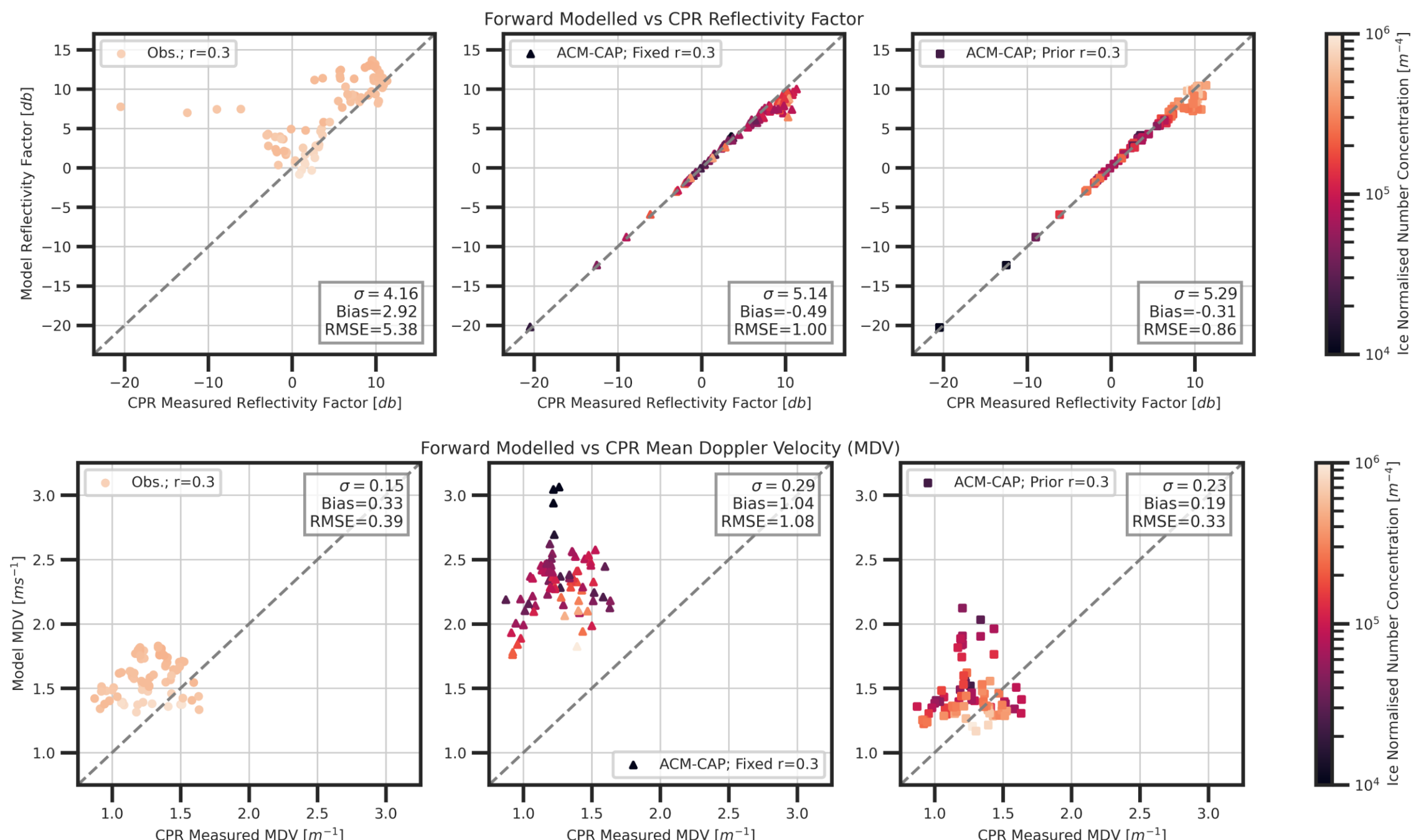
- With the current baseline, reflectivity is well captured. MDV is generally modelled well also.

[Figure 5: Forward model presented here (a) and (b) to model the reflectivity factor and MDV from FAAM measurements (including CIP 15 and CIP 100 particle size distribution (PSD)) (green for density factor $r=0$, orange for density factor $r=0.3$, and ACM-CAP (purple))]

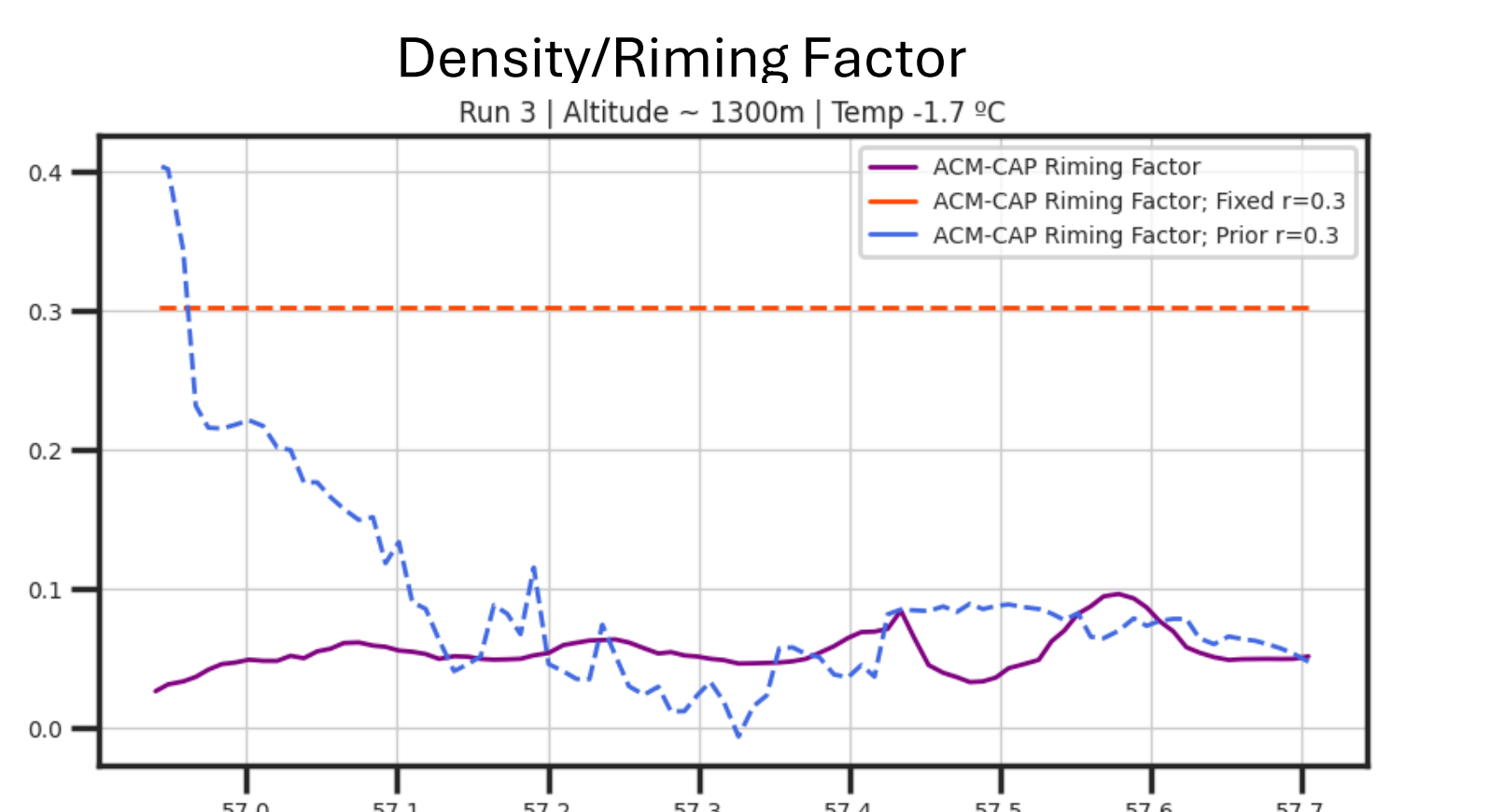


Reprocessed Retrievals

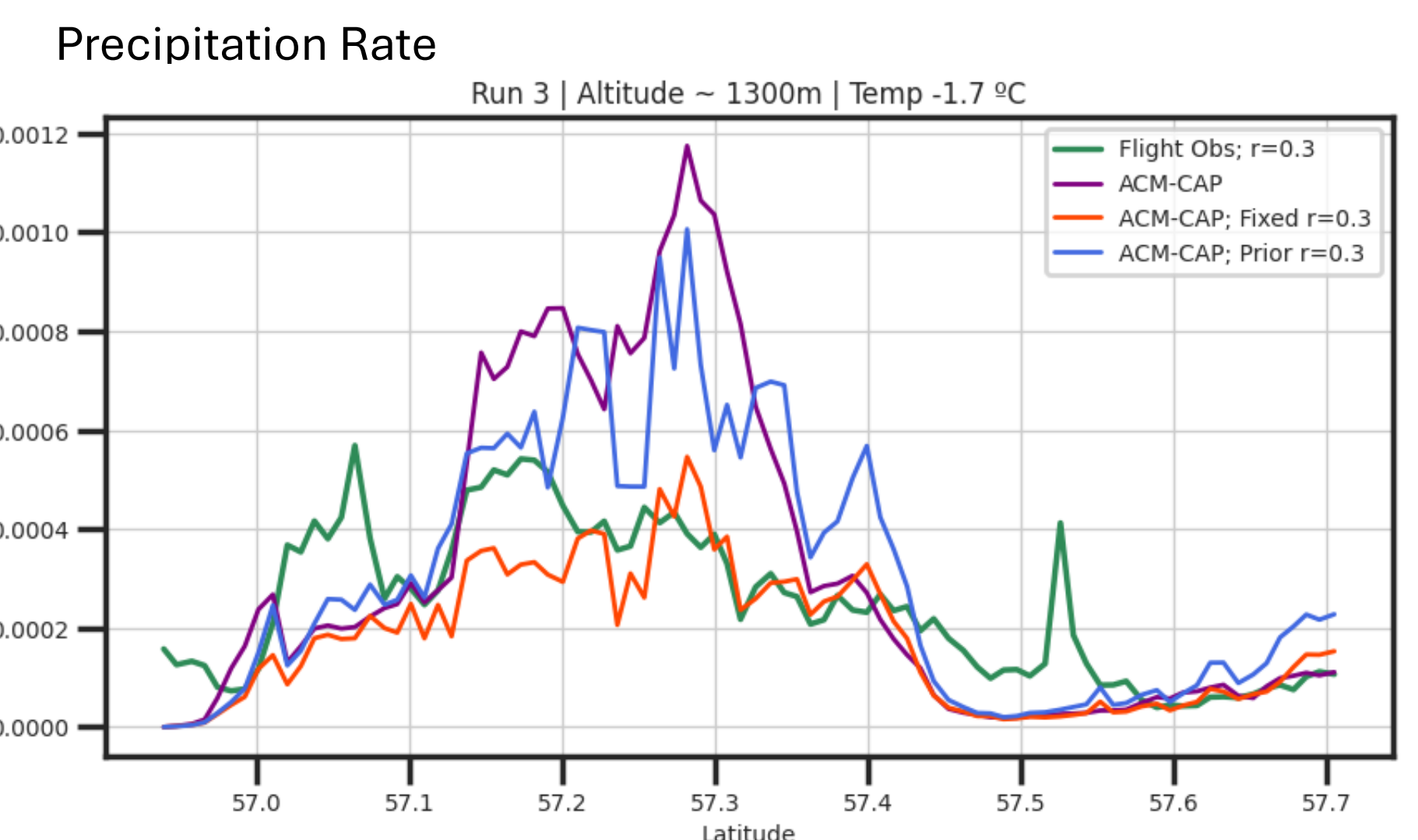
- To analyse ACM-CAP with increased riming to match observations, we set the prior for riming factor to $r=0.3$ within the retrieval algorithm. We also run the retrieval fixing the riming factor at $r=0.3$.
- While we see an improvement in local precipitation rate, closer to in-situ observations for higher density factors, the forward modelled MDV shows deviation in accuracy from the case with no prior or set value.



[Figure 6: Forward Modelled variables compared to C-CD measured reflectivity and MDV. Coloured using Ice normalised number concentrated; measured for flight obs, retrieved for ACM-CAP]



[Figure 7: Density/Riming Factors for each ACM-CAP retrieval along the flight-track]



[Figure 8: Local Precipitation Rate, calculated using IWC and fall-speed along flight track]

Further Work

- Quantify uncertainty in both the in-situ and satellite observations.
- More observations needed to better analyse cases of riming and particles with higher density.

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References: Brown & Francis, 1995; doi: 10.1175/1520-0426(1995)012<0410:IMOTIW>2.0.CO;2
 Francis et al., 1998; doi:10.1002/qj.49712454812
 Heymsfield & Westbrook (2010); doi: 10.1175/2010JAS3379.1
 Mason et al. (2018); doi: 10.1029/2018JD028603