Brief Update on University of Utah Research

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Acknowledgements for data and inspiration:

Greg McFarquhar, University of Illinois

J. Walter Strapp, Met Analytics Inc.

Delphine Leroy and Alfons Schwarzenboeck, CNRS/Université Blaise Pascal

Alexei Korolev and Mengistu Wolde, Environment Canada

Julien Delanoë, Laboratoire Atmosphère, Milieux, et Observations Spatiales

Alain Protat and Rodney Potts, Center for Australian Weather and Climate Research

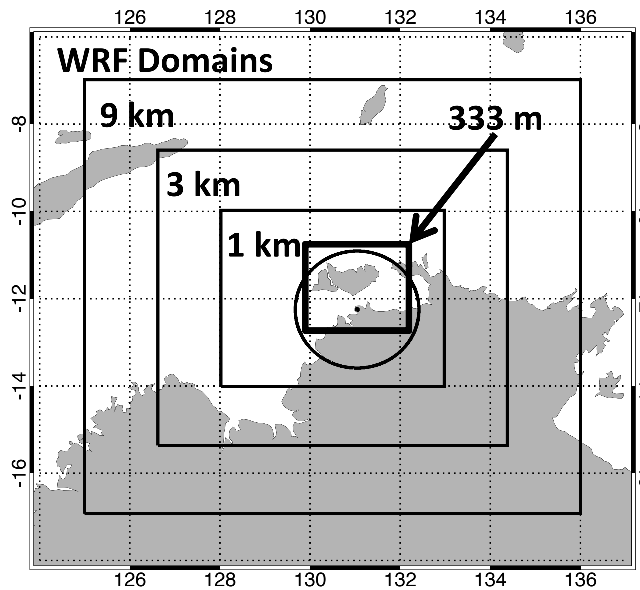
Validating cloud simulations with HAIC-HIWC observations

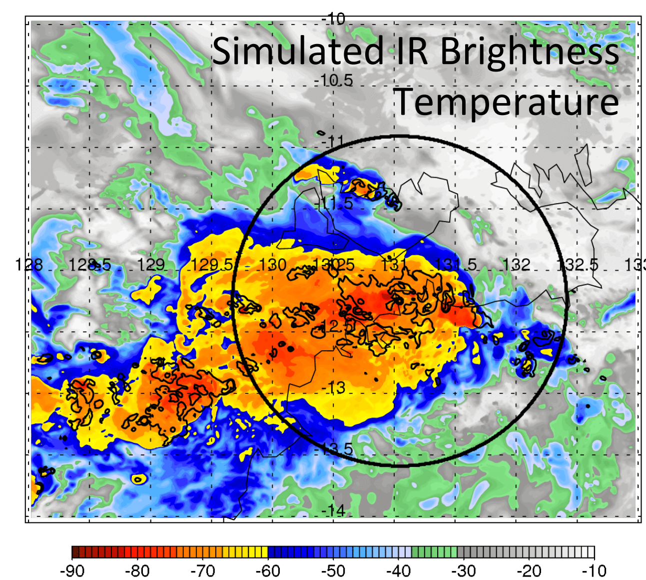
WRF V3.6.1 with 3 nested domains (9, 3, 1 km; 92 vertical levels) forced by ACCESS-R 12-km analyses

Simulated events: 23 Jan, 2-3 Feb, 7 Feb, and 18 Feb (varying success; 29 Jan attempted but failed)

Model output is compared with measurements from all 23 campaign flights with a focus on relationships between **updraft vertical velocity** (**w**), **temperature** (**T**), **total condensed water content** (**TWC**), and **mass diameters** (**10% MD, MMD, 90% MD**)

The results shown here are only for the **18 Feb event** and **1 km grid spacing**, but other events and a 333 m grid spacing run show similar results





Testing 3 very different and popular microphysics schemes

Bulk schemes

Predict bulk moments of PSDs represented by continuous functions (1-moment schemes predict 1 moment such as mass; 2-moment schemes typically predict mass and number)

More moments predicted is more realistic, but more computationally expensive

Bin schemes

Predict number of particles in discrete size bins

More realistic than bulk schemes, but far (10-50x) more computationally expensive

More realistic representation of microphysics does not necessarily mean more realistic cloud and precipitation simulations because microphysics remains poorly constrained by observations

Thompson: 1-moment cloud water, snow, and graupel; 2-moment cloud ice and rain

Morrison: 1-moment cloud water; 2-moment rain, cloud ice, snow, and graupel

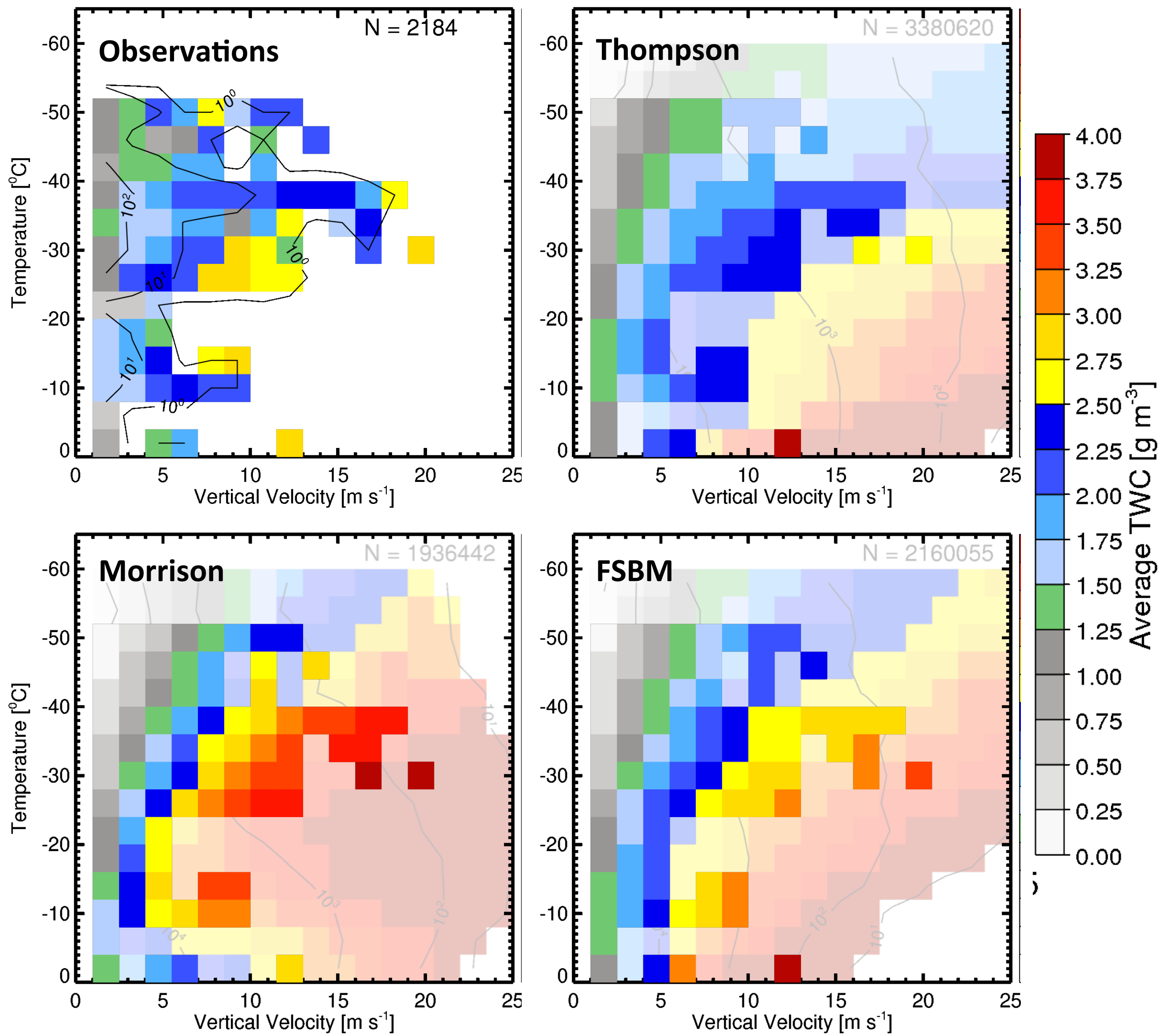
Fast SBM: 33 mass-doubling bins for aerosol, liquid, vapor-grown ice/aggregates, graupel

Mean total water content vs. w and T

1. Mean observed TWCs range from 1 to 3 g m^{-3} at most temperatures and increase with vertical velocity

2. Simulations produce equally high or higher TWCs for a given temperature and vertical velocity

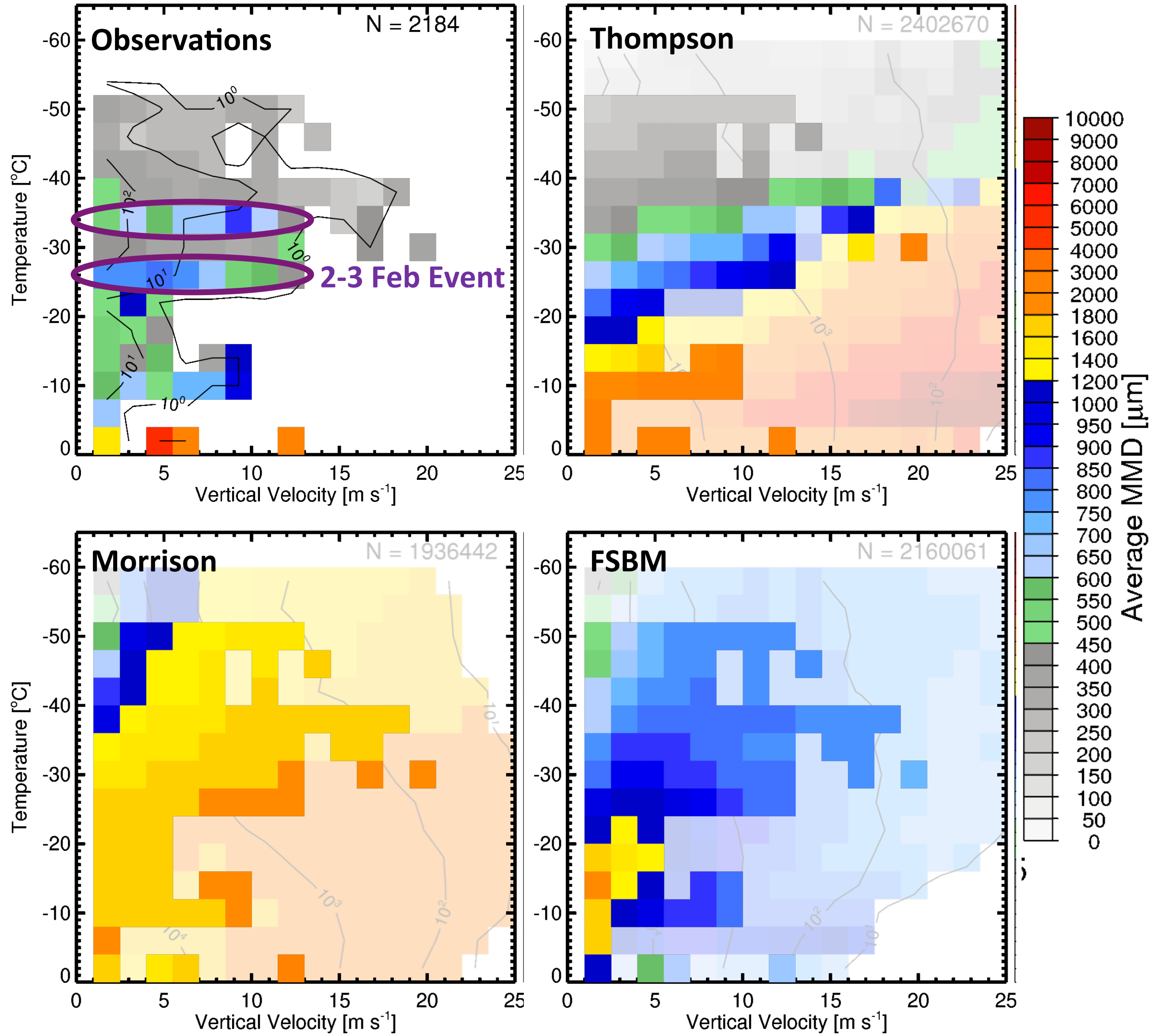
3. Observations are missing samples at warm temperatures in moderate-strong updrafts (lightning, high dBZ avoided by aircraft)



Mean hydrometeor MMD vs. w and T

1. Observed mean MMDs increase as vertical velocity increases at warm temperatures, but decrease with increasing vertical velocity at cold temperatures (only the FSBM bin scheme can reproduce this feature)

2. All schemes overestimate MMDs between -10 and -40°C, but there are large differences between the schemes

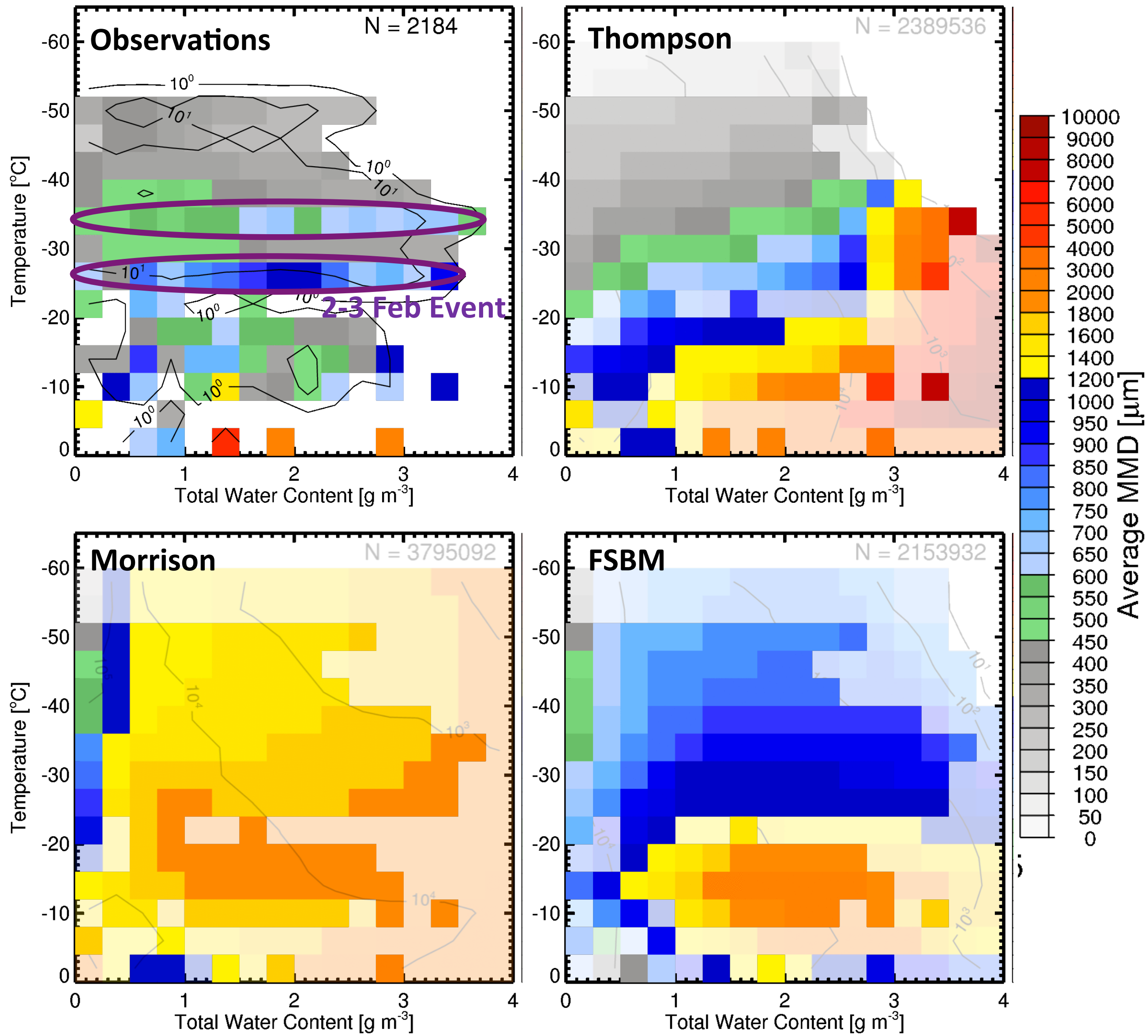


Mean hydrometeor MMD vs. TWC and T

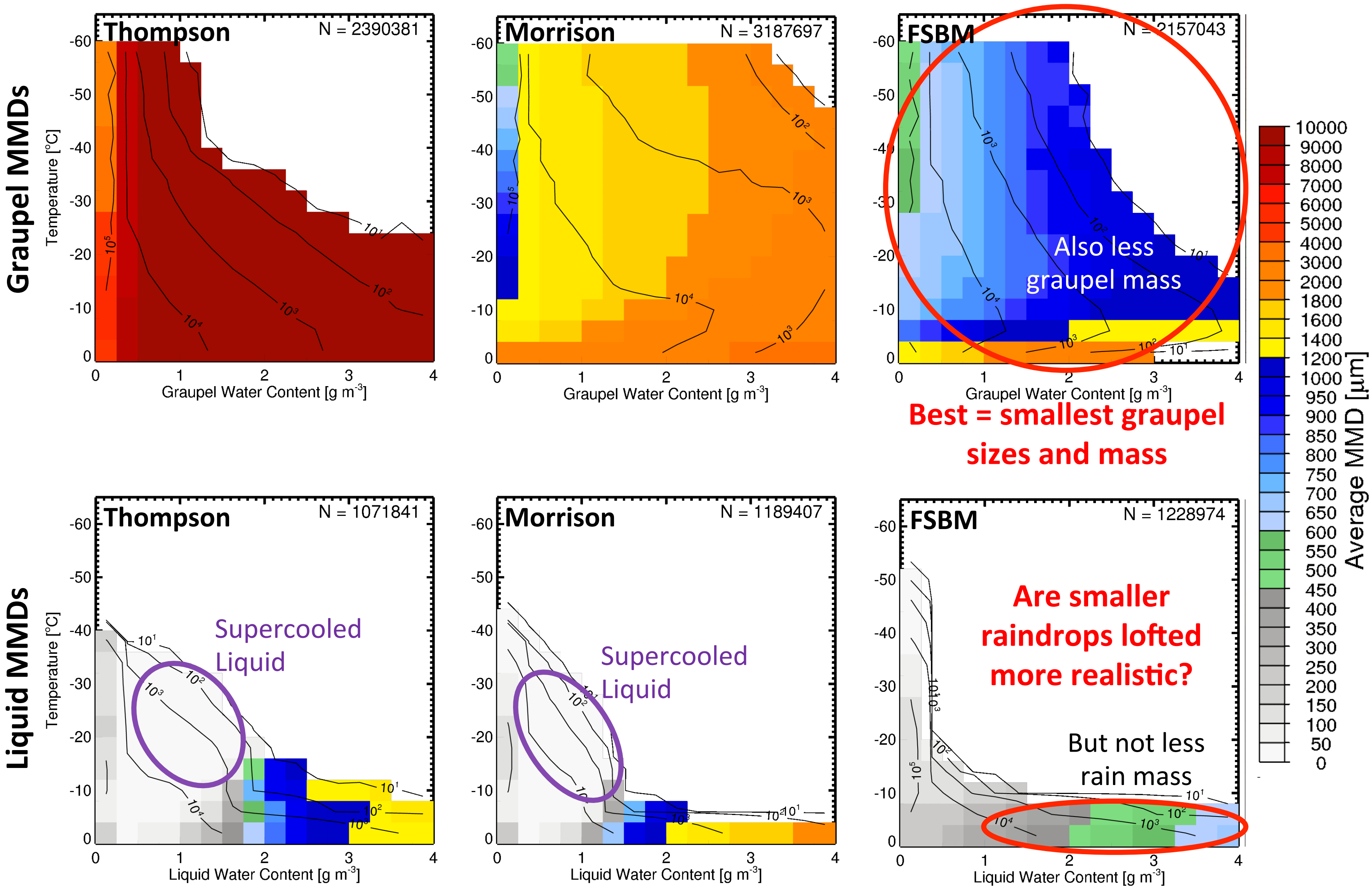
1. Observed MMDs are not correlated with TWC at warm temperatures (could be limited and biased sampling)

2. Observed correlations at cold temperatures depend on MCS type, but many systems show decreasing MMD with increasing TWC

3. All schemes overpredict MMDs at relatively warm temperatures with increasing MMDs as temperature and TWC increase



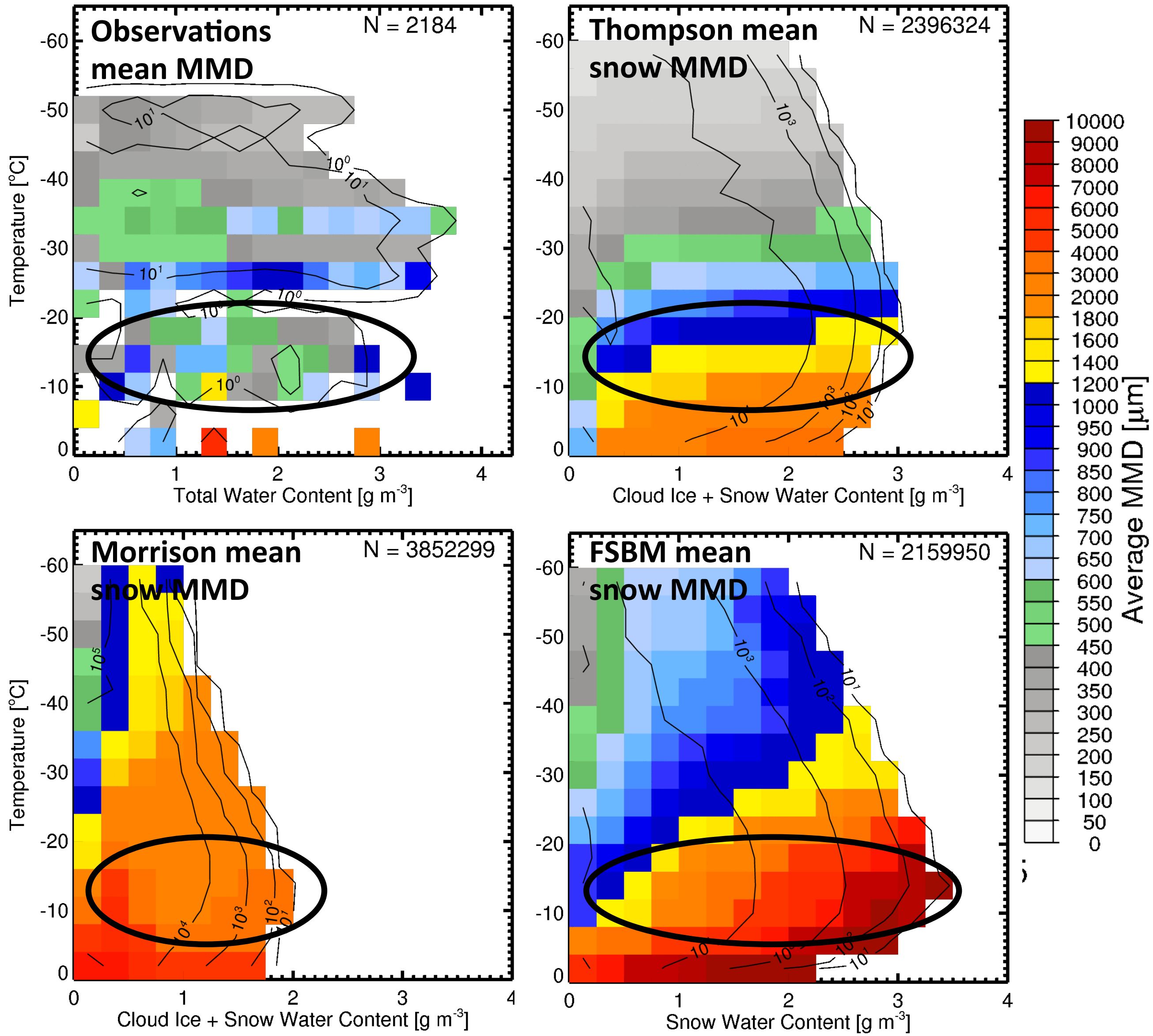
What causes the large differences between schemes?



Even ignoring graupel, there is a model snow size bias

1. All schemes produce snow particles that are too large, which biases simulated reflectivity and microphysical process rates

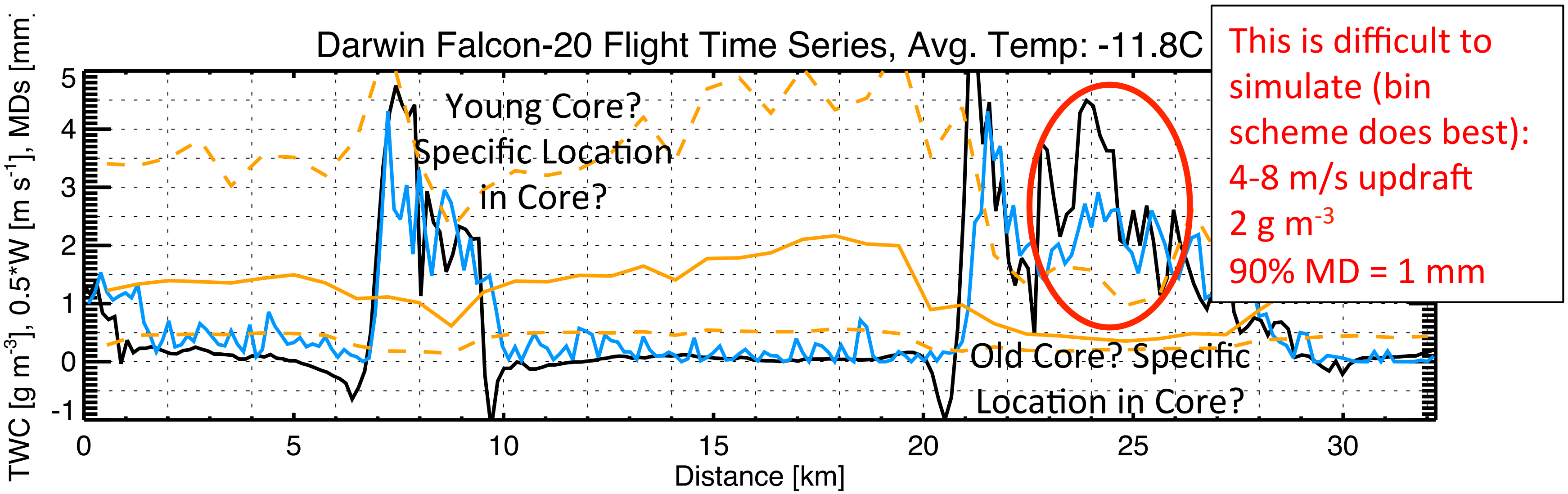
2. Much smaller observed sizes are potentially a result of skipping dendritic growth in updraft cores and/or collisional fracturing of entrained dendrites/aggregates from stratiform regions



BUT, there is an observational sampling bias

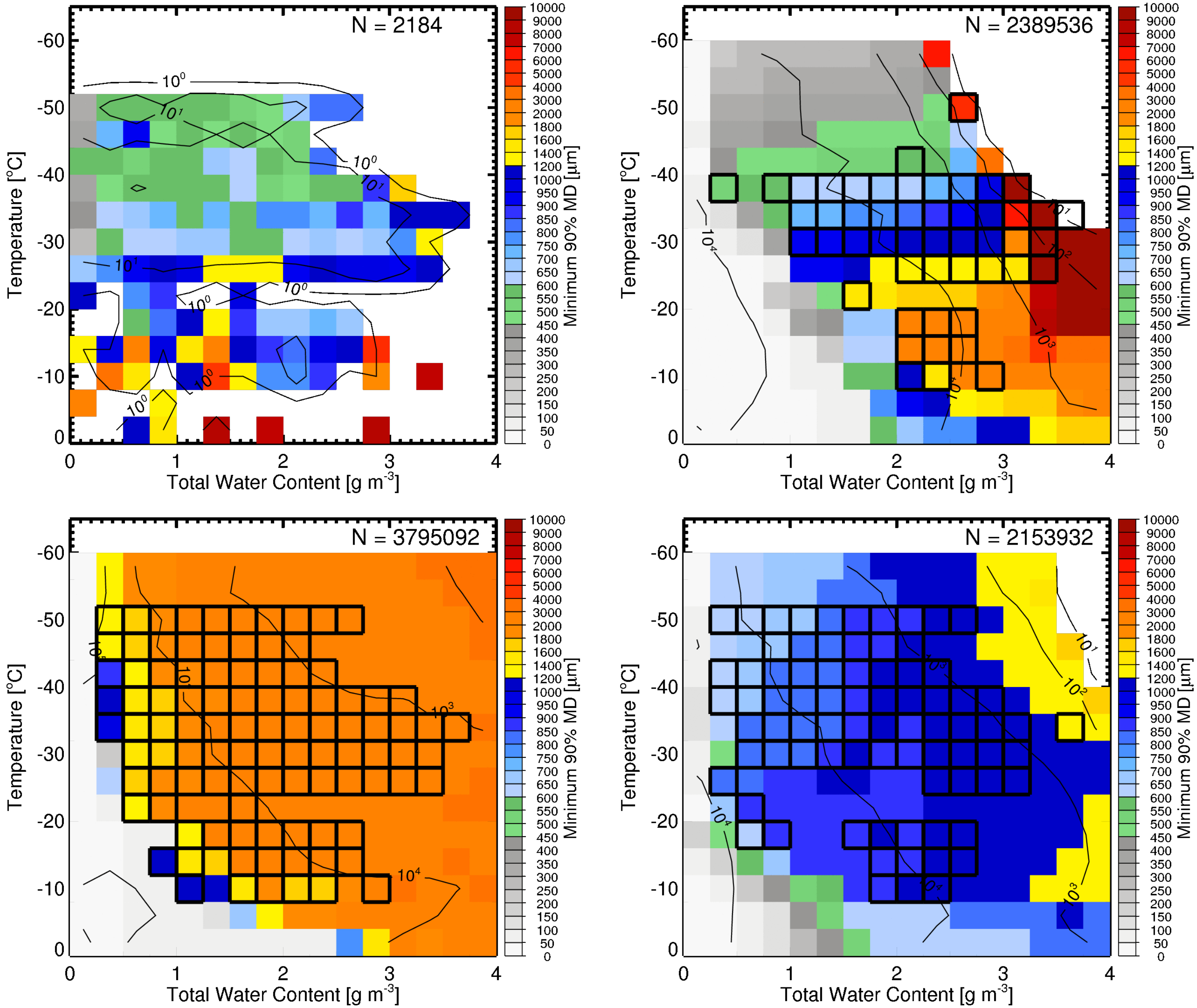
Convective cores with lightning or high reflectivity were avoided, so measurements are biased toward lesser liquid and graupel conditions

To counter this, we are focusing on observed properties that are not reproduced anywhere in simulations (e.g., 90% MDs at large TWCs in updrafts (below))

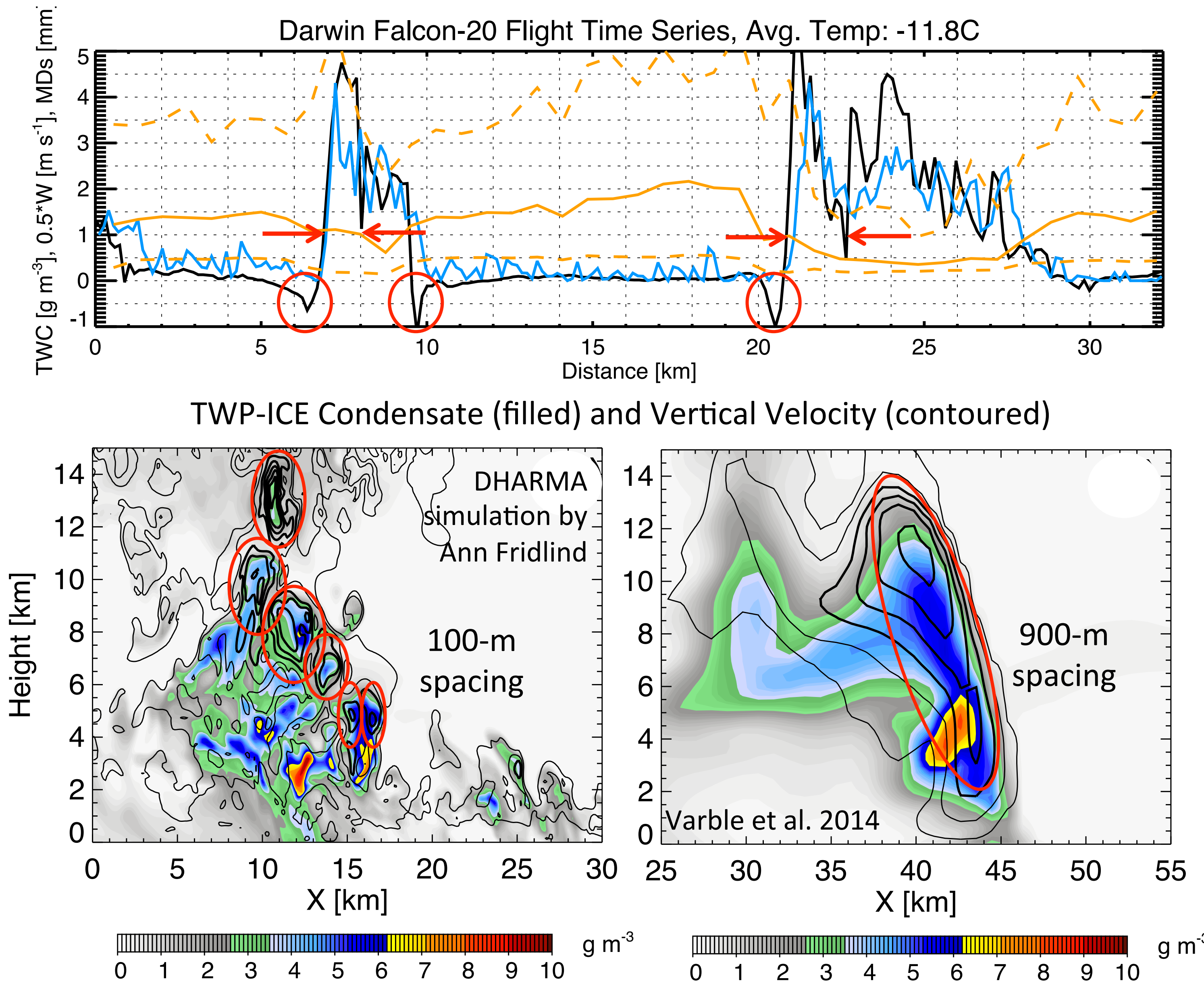


Excessive cloud droplets lower simulated MMDs and increase integral radii, making comparisons with observations difficult. Information on LWC would be very helpful, perhaps just an upper limit on LWC to ensure that significant liquid is not present.

Updraft 90% mass diameter observations not simulated



Rare flight observations in drafts can also validate structure



Future Work

1. Investigate causes for microphysics scheme differences
2. Potentially incorporate LWC information and RASTA IWC and vertical motion retrievals
3. Incorporate Cayenne observations, especially between 0 and -15°C with contextual X-band reflectivity

   Usage of D_{eq} with mass SD and vertical motion retrievals similar to Falcon data are crucial for extending comparisons