IDENTIFYING AND UNDERSTANDING UNCERTAINTIES IN A POLARIMETRIC SIMULATOR

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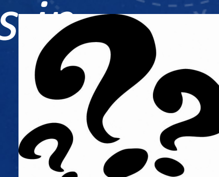
ASR PI MEETING

19 MARCH 2018 TYSON’S CORNER

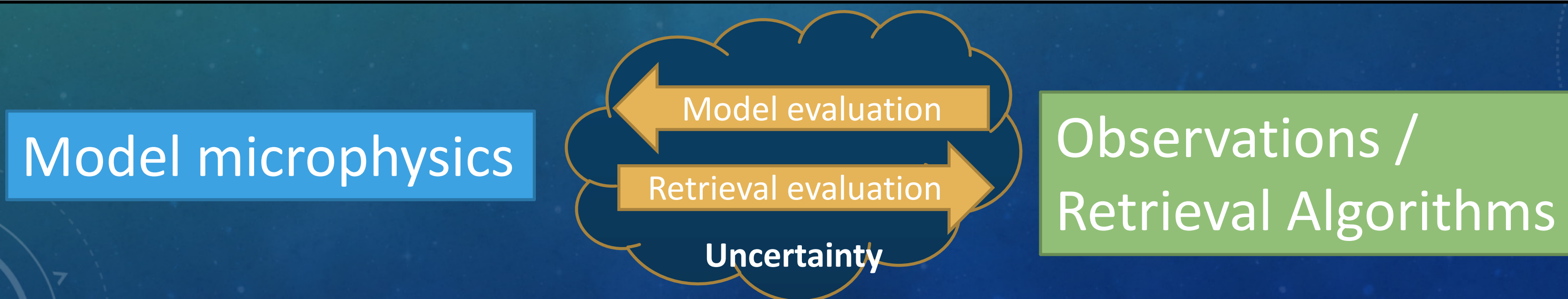
Science Questions Driving development of our Simulator

- *How do polarimetric radar signatures contrast in convective cores between land and ocean?*
  - *E.g. MC3E vs. TWP-ICE*
  - *What are the uncertainties of the radar retrievals?*
- *How well can sophisticated microphysics represent the land-ocean contrast of polarimetric signals and retrievals?*
  - *E.g. Bulk vs. Bin microphysical schemes*
- *What are the relative roles of thermodynamics and aerosols in convective invigoration, for land and ocean regions?*
- *How is DSD variability related to cloud microphysical processes?*
- *What is the impact of DSD assumptions on precipitation microphysics in CRMs?*



POLARRIS:
POLArimetric **R**adar **R**etrieval and **I**nstrument **S**imulator

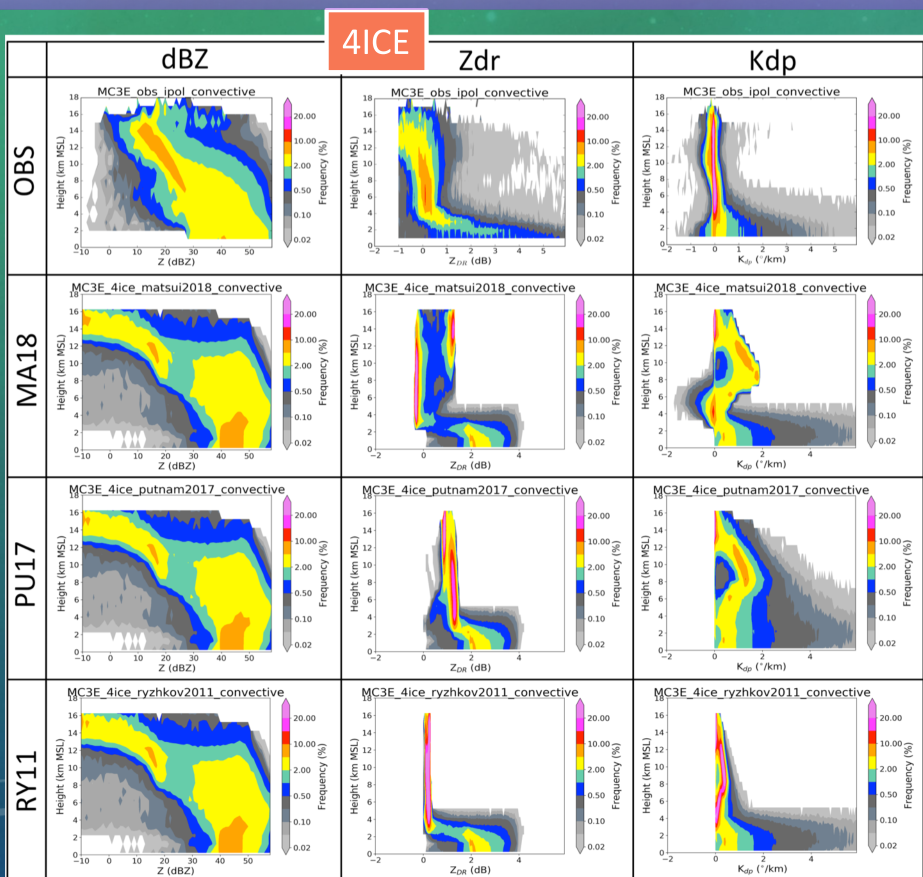
- Framework to put the model data and radar observations into **direct** comparison
- *POLARRIS-F*
  - Calculate the polarimetric radar moments from scattering calculations using model consistent microphysical assumptions + user assumptions + radar geometry
- *iPOLARRIS*
  - Apply the same retrievals to models output as radar analysis
    - HID, polarimetric rainfall estimation, dual-Doppler wind retrieval



CHARACTERIZATION OF UNCERTAINTIES

- Uncertainties in assumptions at the forward model level
    - Particle axis ratios, canting angles
- Model microphysics scheme assumptions (e.g. 4ICE vs. SBM)
    - Hydrometeor definitions
    - Rime fraction /density
    - PSD
  - ➢ *Propagation to the simulated variables*
  - ➢ *Propagation to retrievals (e.g. HID)*
- Uncertainties in retrieval algorithms
  - E.g. Hydormeteor Identification
    - MBFs
    - Fuzzy logic scoring (DOMINANT type)

CHARACTERIZATION OF UNCERTAINTIES: FORWARD MODEL



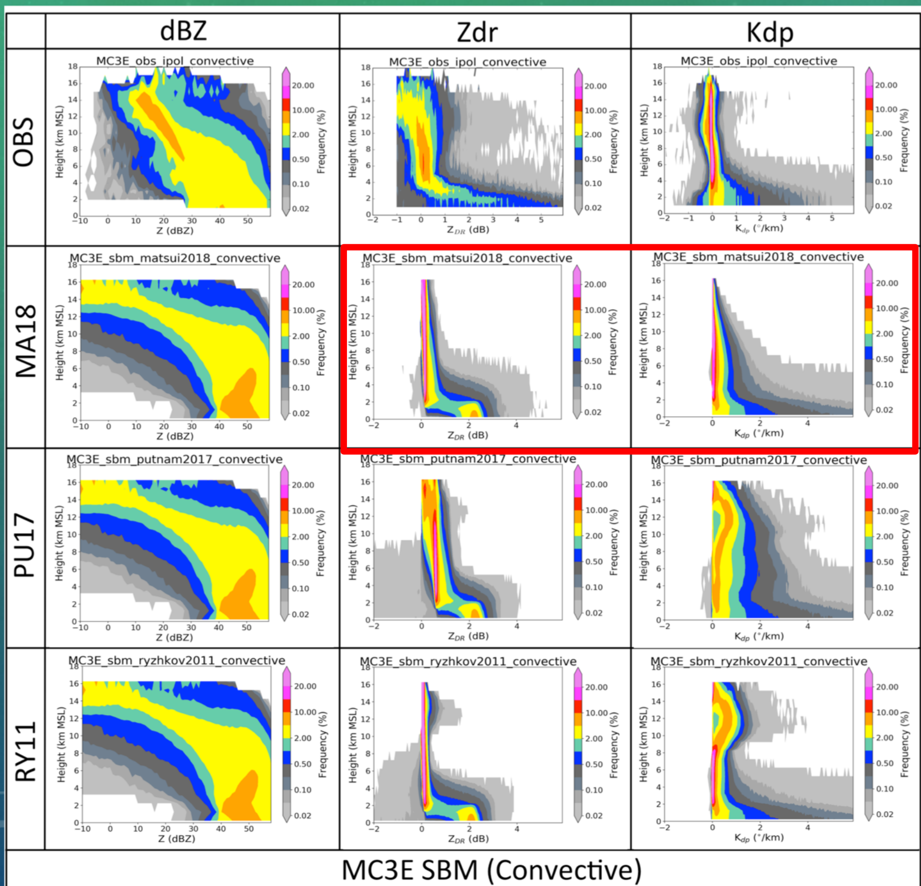
MC3E 4ICE (Convective)

	RY11	PU17	MA18
Liquid (cloud & Rain)	A_{xis} = 0.9951+0.0251*D-0.03644*D^2 +0.005303*D^3-0.0002492*D^4 [Brandes et al. 2011] Type: quasi-Gaussian (Θ_{mean}= 0°, σ=1°)		
Ice (column)	A_{xis} = 2.0 Type: random		
Ice (plate)	A_{xis} = 0.35 Type: quasi-Gaussian (Θ_{mean}= 0°, σ=10°)		
Ice (dendrite)	A_{xis} = 0.125 Type: quasi-Gaussian (Θ_{mean}= 0°, σ=10°)		
Snow aggregate	A_{xis} = 0.8 Type: quasi-Gaussian (Θ_{mean}= 0°, σ=40°)	A_{xis} = 0.75 Type: quasi-Gaussian (Θ_{mean}= 0°, σ=20°)	A_{xis} = 0.592 Type: quasi-Gaussian (Θ_{mean}= 10°, σ=10°)
Graupel	A_{xis} =max(0.8, 1.-0.2*D) Type: quasi-Gaussian (Θ_{mean}= 0°, σ=40°)	A_{xis} = 0.75 Type: quasi-Gaussian (Θ_{mean}= 0°, σ=10°)	A_{xis} = 0.814 Type: quasi-Gaussian (Θ_{mean}= 20°, σ=10°)
Hail	A_{xis} max(0.8, 1.-0.2*D) Type: quasi-Gaussian (Θ_{mean}= 0°, σ=40°)	A_{xis} = 0.75 Type: quasi-Gaussian (Θ_{mean}= 0°, σ=10°)	A_{xis} = min(0.725, 0.897 - 0.0008D - 0.0002D^2) Type: quasi-Gaussian (Θ_{mean}= 90°, σ=10°)

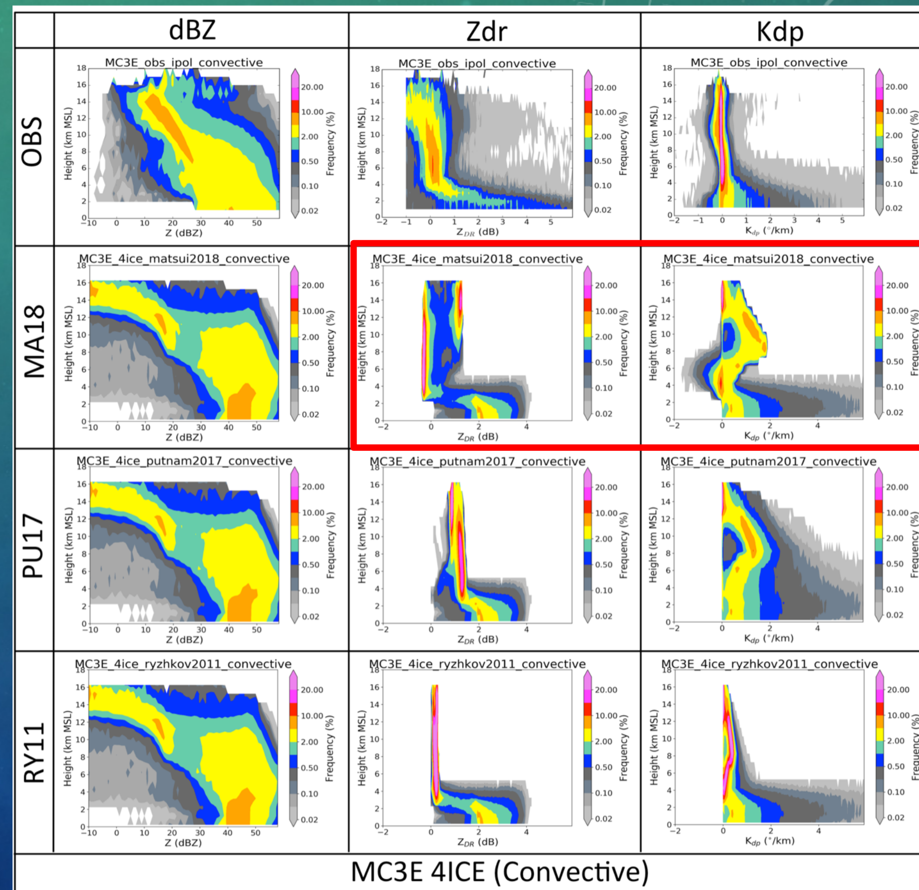
- Different sets of scattering assumptions (axis ratio, canting angle distribution), *none reproduce the observations*
- Assuming a single axis ratio (for a given hydrometeor type) across all size *significantly impacts the breadth of retrieved K_{dp} and Z_{dr} values*

CHARACTERIZATION OF UNCERTAINTIES: MICROPHYSICAL SCHEME

SBM

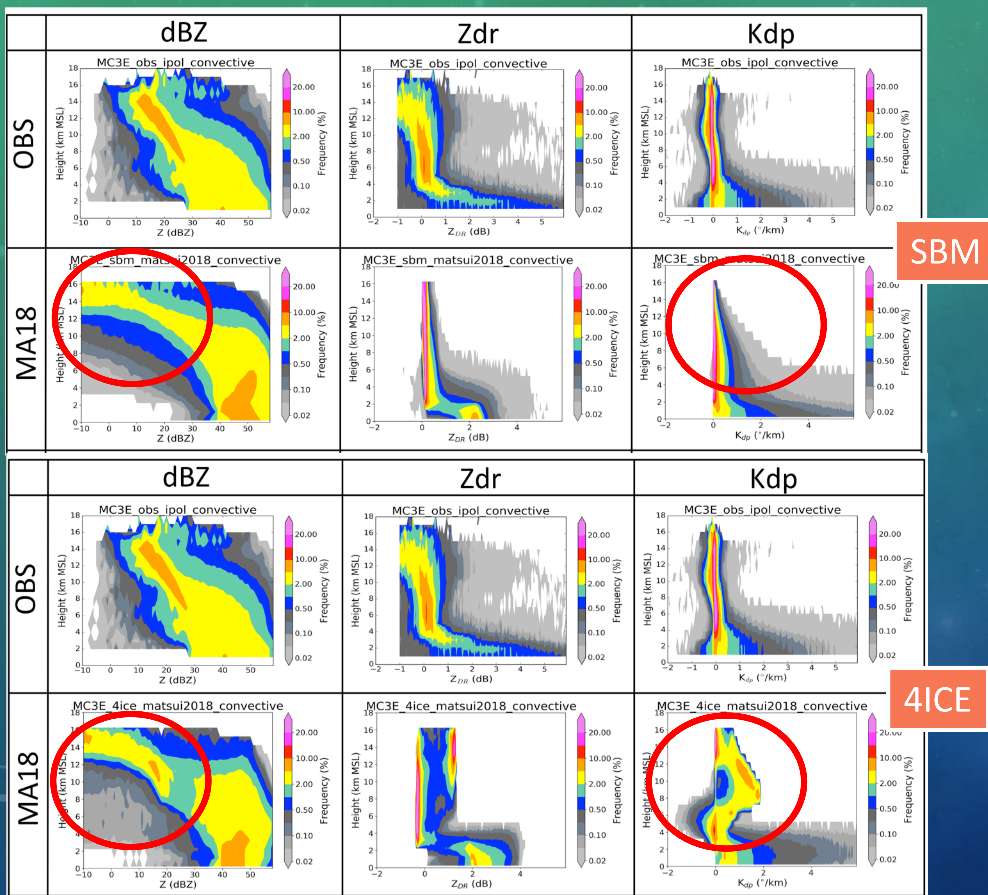


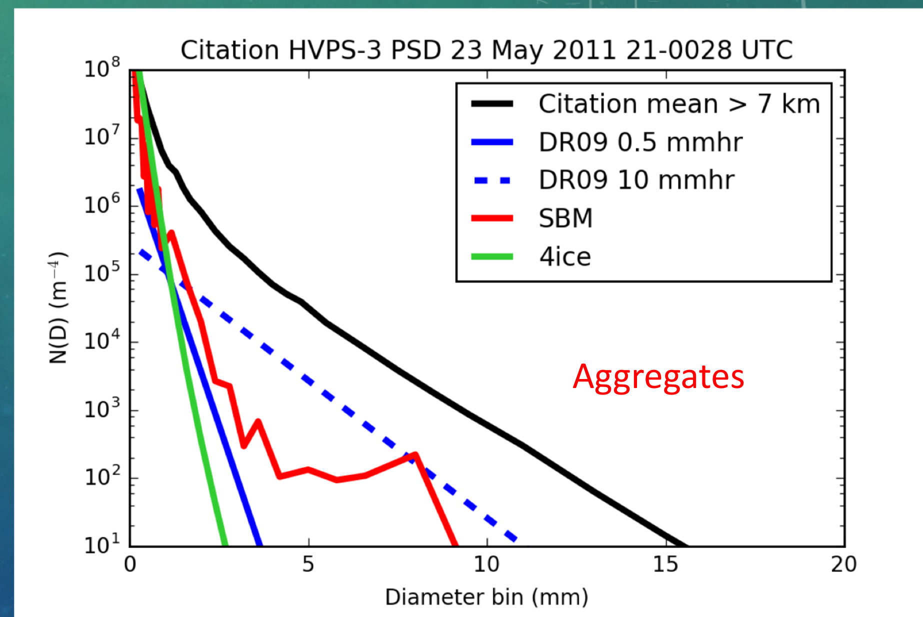
4ICE



K_{dp} and Z_{dr} have markedly different responses to microphysics scheme

CHARACTERIZATION OF UNCERTAINTIES: MICROPHYSICAL SCHEME





- 4ICE much narrower distribution of ice
- Small reflectivities

CHARACTERIZATION OF UNCERTAINTIES: IMPACT ON RETRIEVALS

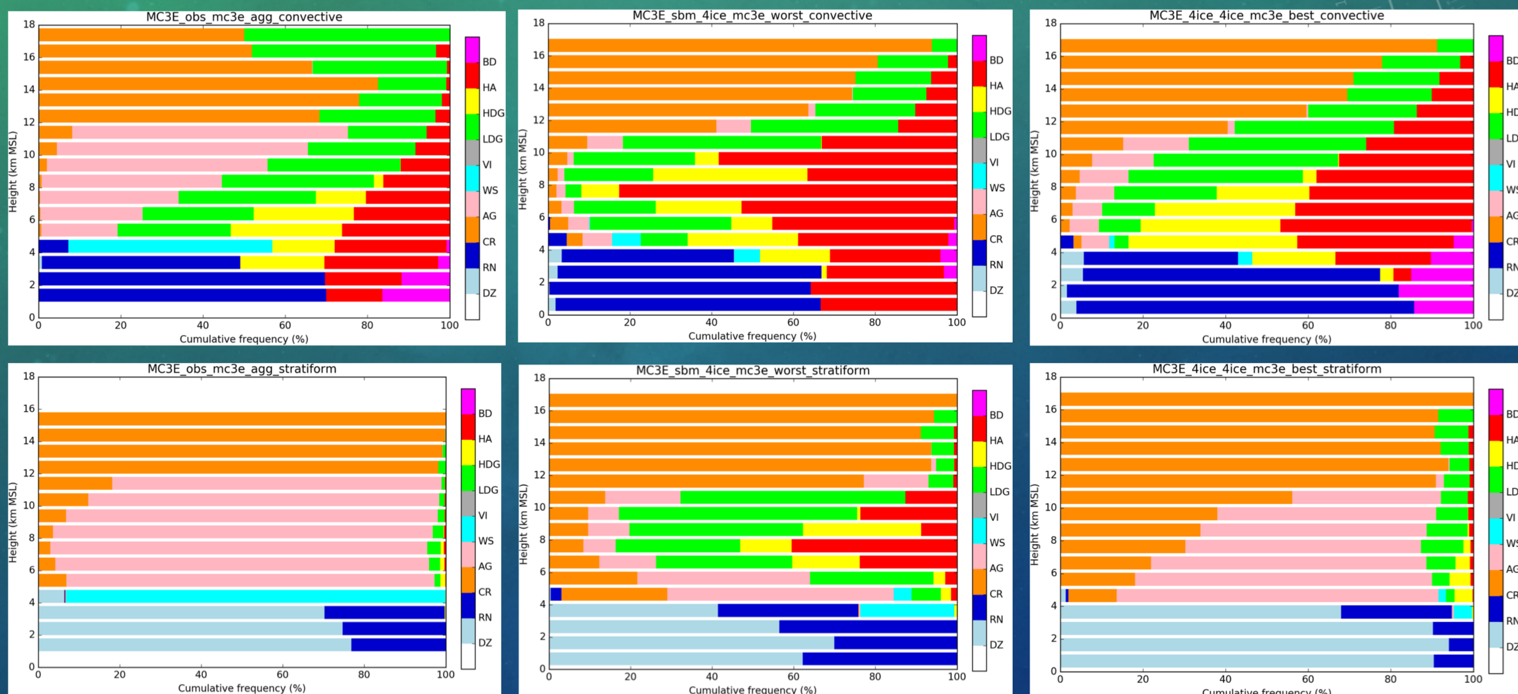
Observations (CSAPR)

"Worst" Assumptions

"Best" Assumptions

Convective

Stratiform



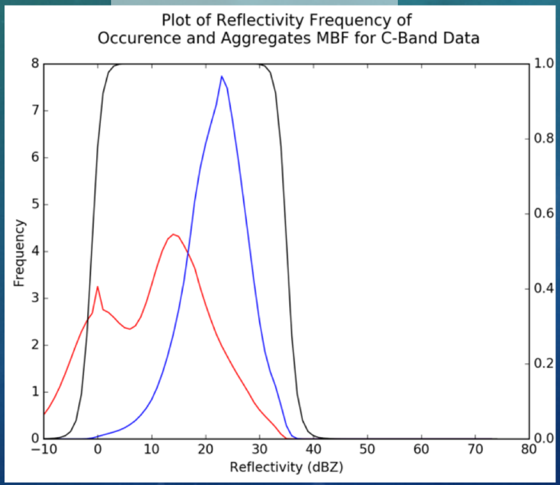
Assumptions can impact the amount of hail, graupel, and aggregates in the retrievals

CHARACTERIZATION OF UNCERTAINTIES: RETRIEVAL INPUT

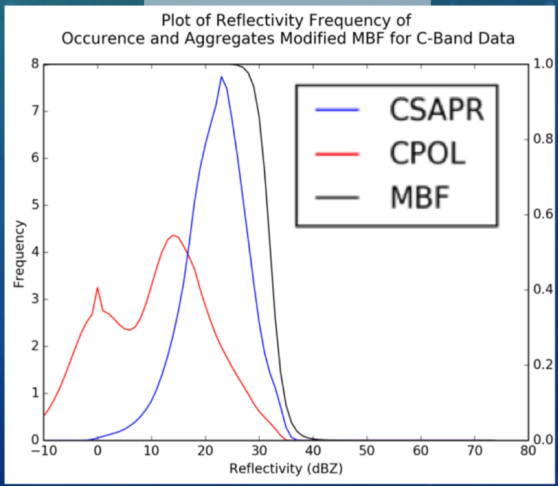
- HID Membership Beta Functions
  - How much does the resulting HID change based on MBF modification?
  - Using C-band radar observations from a tropical location (CPOL Darwin) and mid-latitude location (CSAPR MC3E), *all* variables for all ten hydrometeor types were adjusted

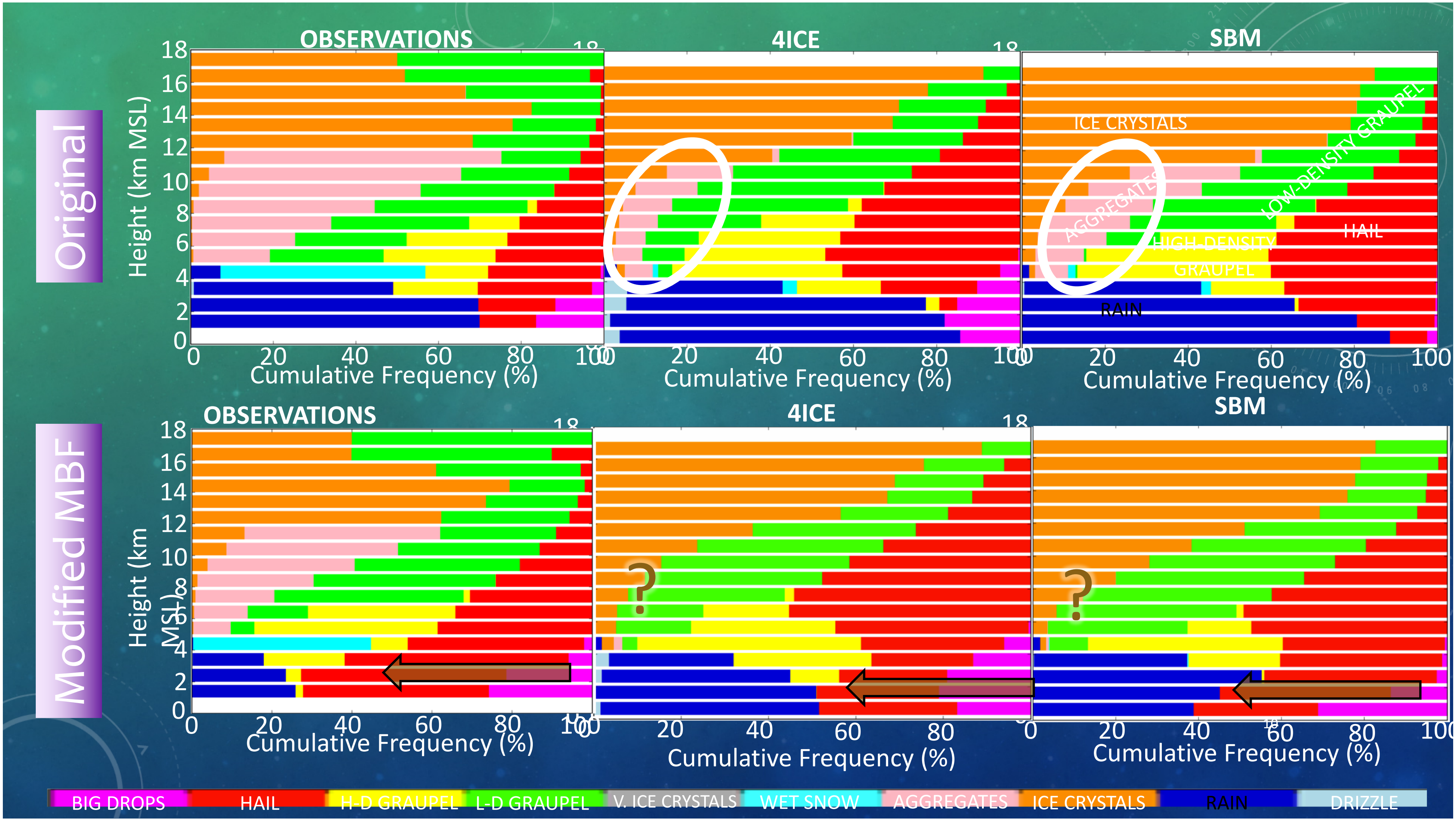
ORIGINAL MBFs

AGGREGATES



MODIFIED MBFs

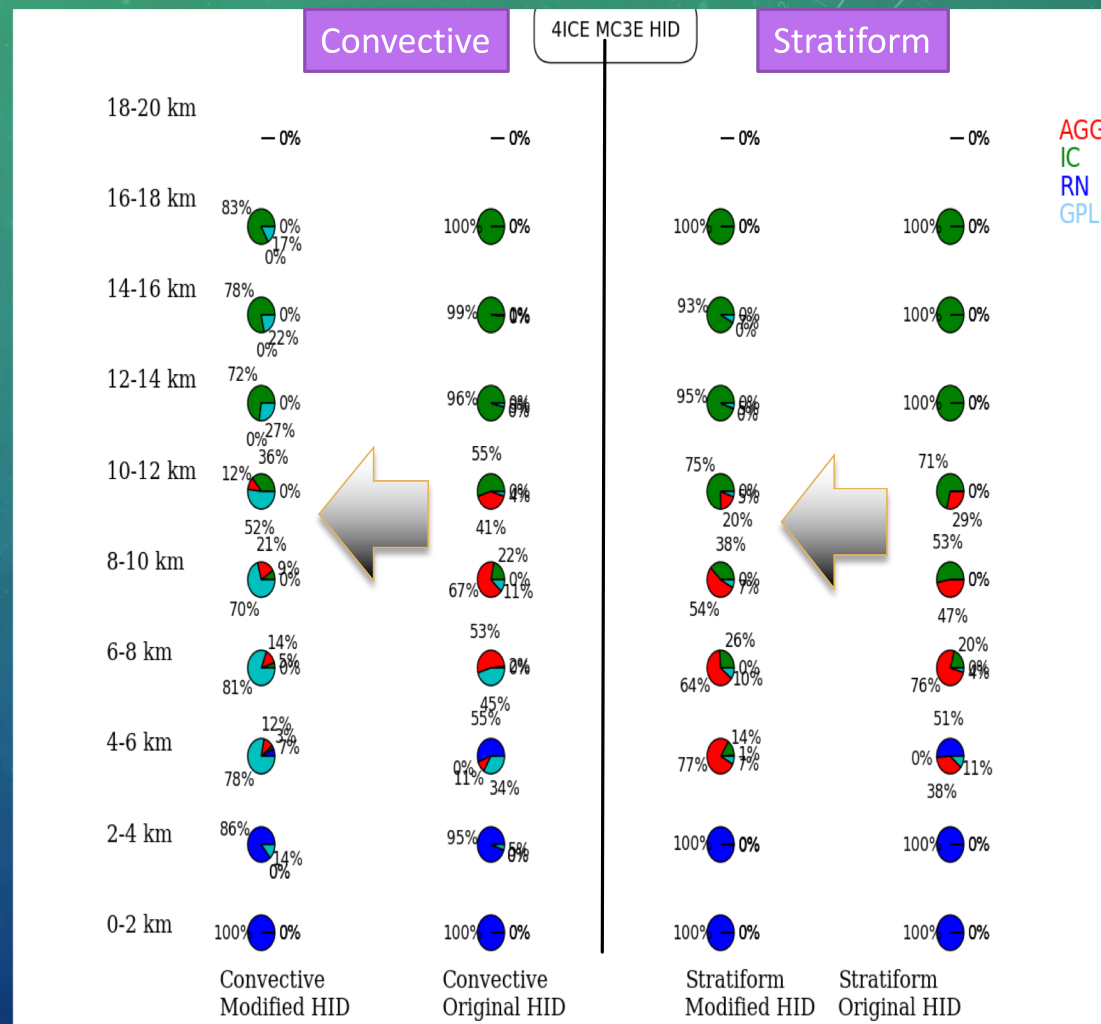




Original
Modified MBF
OBSERVATIONS
4ICE
SBM
Height (km MSL)
Cumulative Frequency (%)
ICE CRYSTALS
AGGREGATES
LOW-DENSITY GRAUPEL
HIGH-DENSITY GRAUPEL
HAIL
RAIN
?
BIG DROPS
HAIL
H-D GRAUPEL
L-D GRAUPEL
V. ICE CRYSTALS
WET SNOW
AGGREGATES
ICE CRYSTALS
RAIN
DRIZZLE

CHARACTERIZATION OF UNCERTAINTIES: RETRIEVAL INPUT

- Decrease AGG – turn into graupel
- Are these changes more or less than assuptions in forward model or microphysics scheme?



UNCERTAINTIES: CHALLENGING BUT CRITICAL

- A polarimetric radar simulator such as POLARRIS has many layers of complexity
- Although it is nearly impossible to quantify all sources of uncertainty, it is critical to identify and understand them
- These come at several levels:
  - Model microphysical parameterizations (assumed PSD, density, sizes, hydrometeor classes)
  - Forward model assumptions (canting angle, axis ratio, density, particle types)
  - Applied Retrievals (e.g. hydrometeor identification, rainfall retrievals, wind retrieval)
- *Does one dominate over the others?*
- *Can we reduce any areas of uncertainty?*
  - *More observations of particle DSDs, fall modes, shapes, densities, etc.*
- *How to quantify and represent in final 'products'?*

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