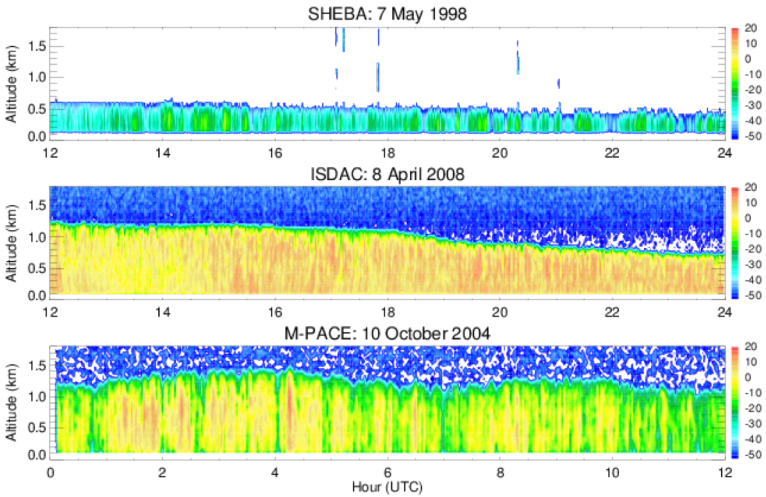
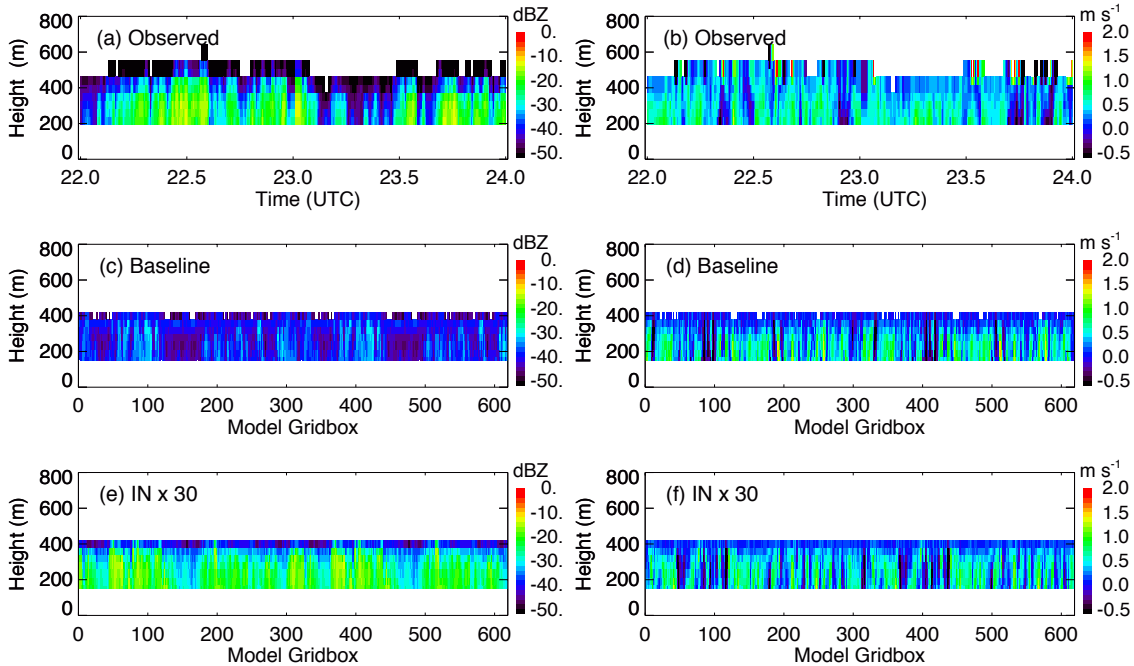
# Use of AWARE data to evaluate supercooled liquid and its context in a climate model




Fridlind and Ackerman
[ed. Andronache 2018]

Fridlind et al. [JAS 2012]




*Ann Fridlind[1], Katia Lamer[2], Andrew Ackerman[1], Maxwell Kelley[1], Daniel Knopf[3], Susanne Bauer[1], Jan Perlwitz[1,4]*

*[1]NASA GISS, [2]Penn. State Univ., [2]Stony Brook Univ., [4]Columbia Univ.*

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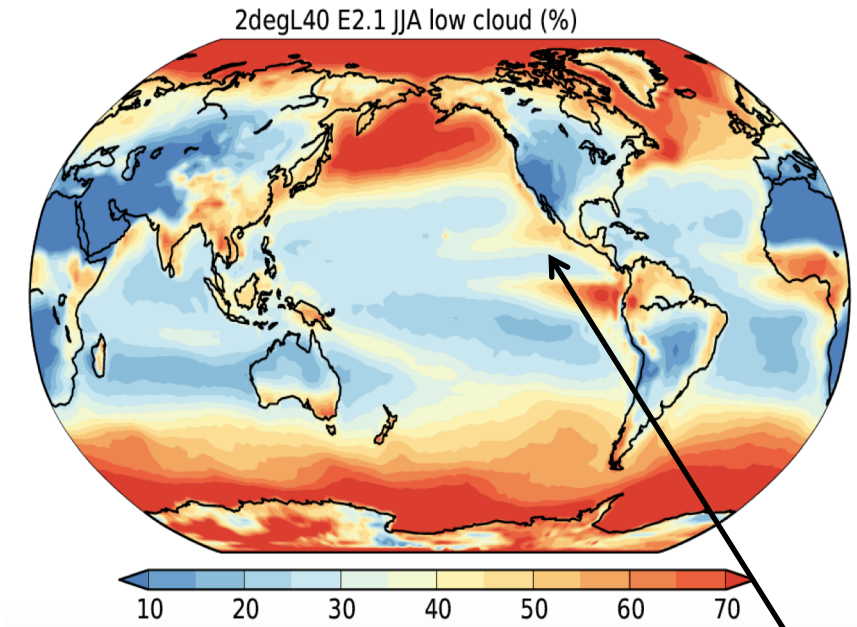
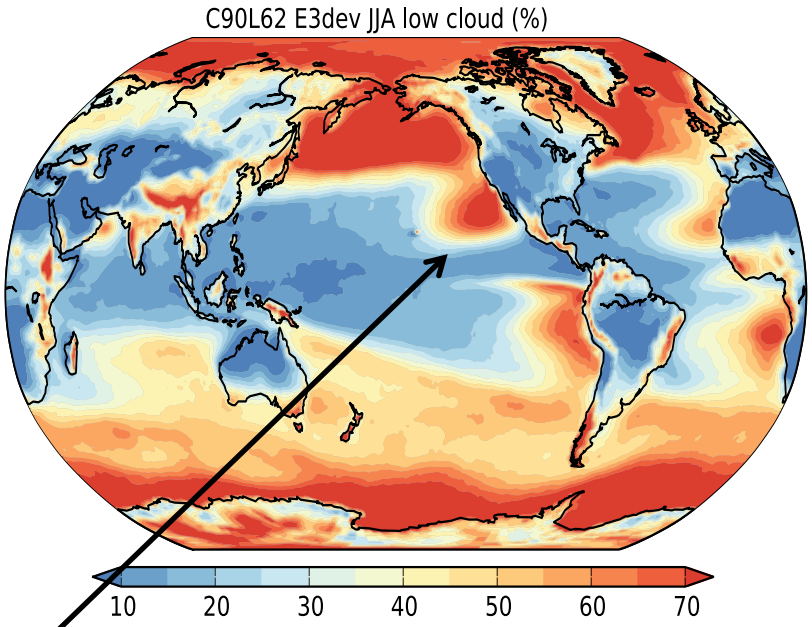
# Liquid-phase low cloud fraction

- Preliminary version of ModelE3 (Ackerman, Cheng, Del Genio, Kelley)
  - turbulent mixing [Bretherton and Park 2009]
  - large-scale cloud fraction for liquid [Smith 1990], ice [Ballard and Wilson 1999]
  - large-scale two-moment microphysics [Gettelman and Morrison 2015]

**ModelE2.1, 2x2.5x40L**



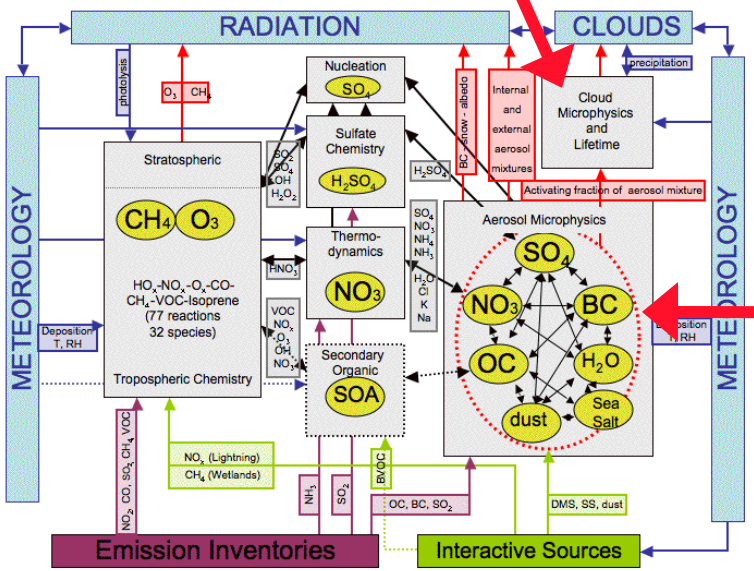

**ModelE3, C90x62L**




**liquid-phase stratiform clouds**

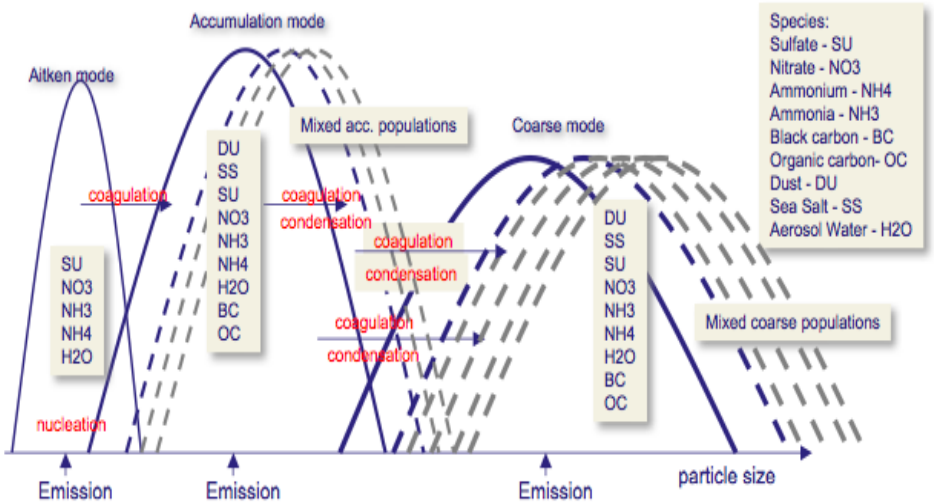
# ModelE3 gas and aerosol-phase chemistry

Droplet activation following
Adbul-Razzak et al. (1998)
and Abdul-Razzak and Ghan (2000)




# MATRIX

## Aerosol Microphysical Model based on the Methods of Moments
## Bauer et al. ACP 2008



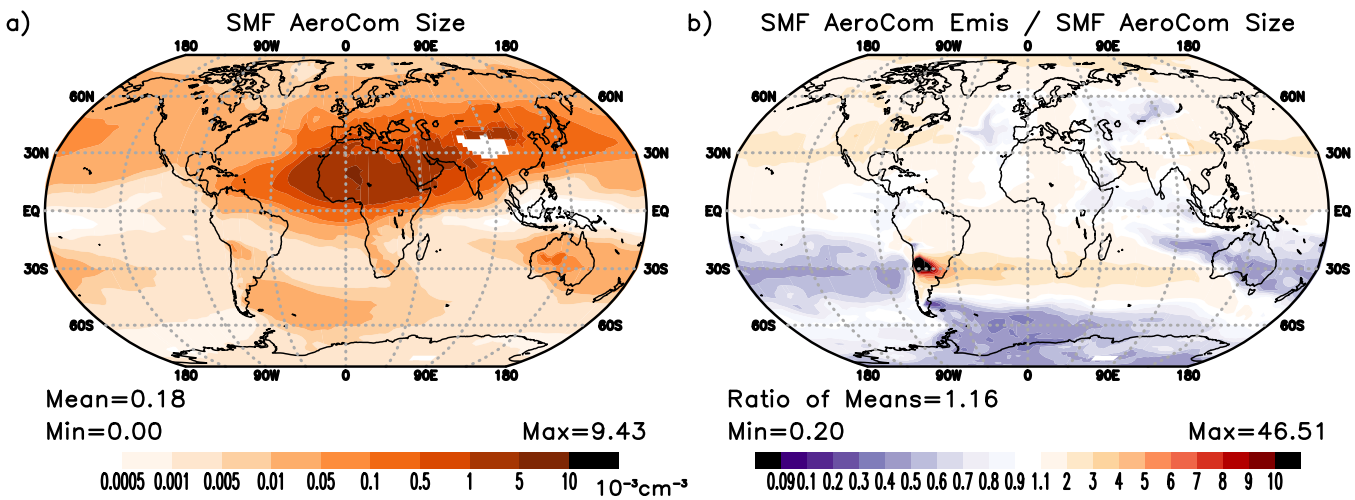

Bauer et al., Atmos. Chem. Phys. 8, 6603-6635, 2008
Bauer et al., Atmos. Chem. Phys., 10, 7439-7456, 2010
Gao et al. Geosci. Model Dev., 10, 751-764, 2017

# ModelE3 off-line INP calculations

- feldspar $N_{INP}(T)$ @ 600 mb using an active site scheme [cf. Atkinson et al. 2013]
- inform MATRIX single dust type

Knopf et al.
Poster 168 Tues@3:30
Perlwitz et al. [in prep.]

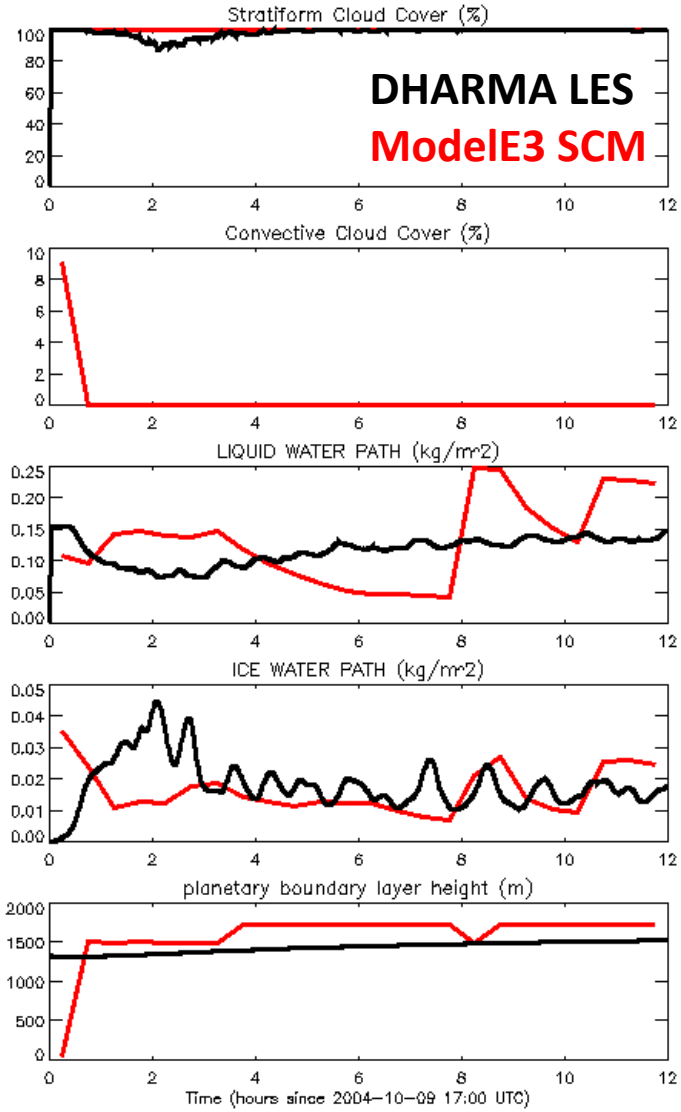
## ModelE2.1, 40L



# ModelE3 SCM versus LES

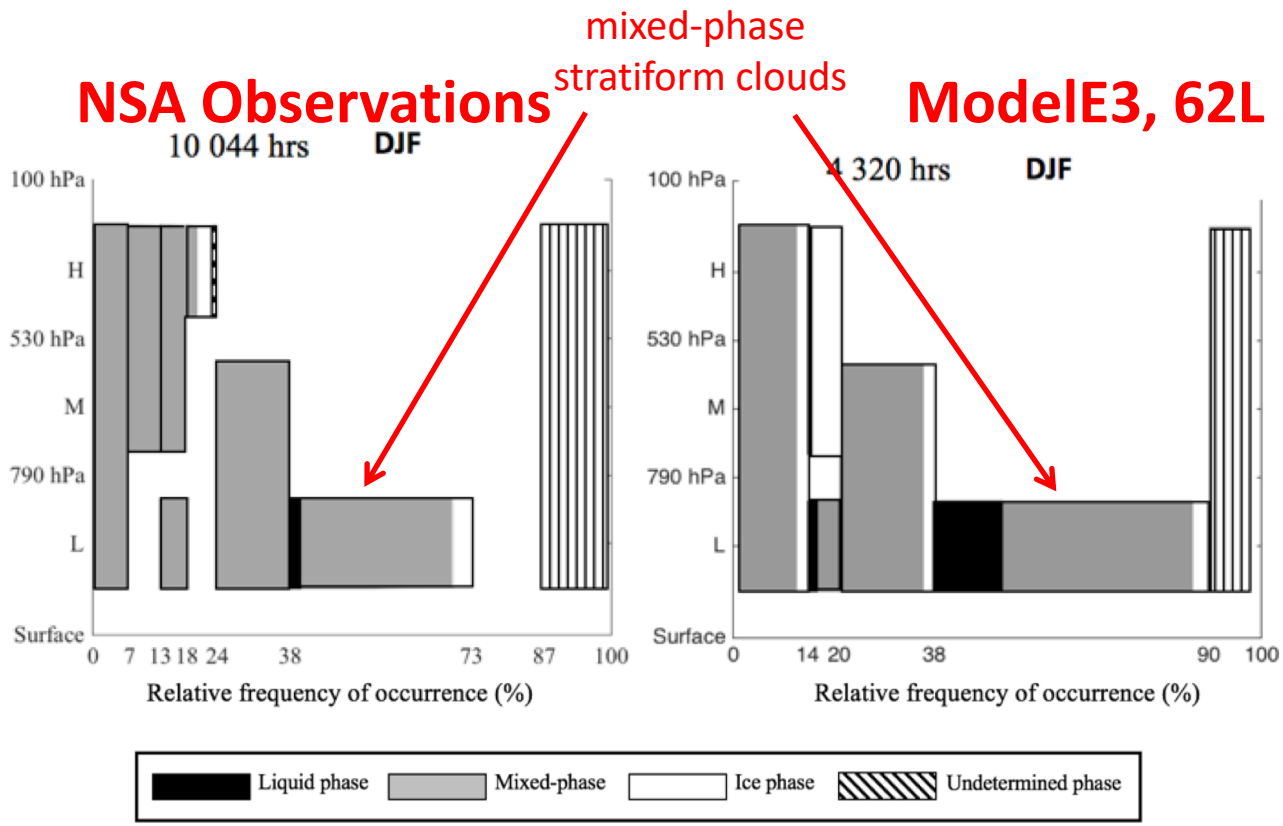
- M-PACE case [Klein et al. 2009]
  - reasonable behavior
  - liquid-phase boundary layer is big challenge!

**ModelE3, 62L**



# Mixed-phase low cloud occurrence frequency at NSA

- Preliminary version of ModelE3
  - immersion freezing [Bigg 1953] of cloud and rain drops
  - contact freezing [Young 1974] of cloud drops
  - aerosol freezing with prescribed cloud ice concentration (100/L) and $RHI_{crit}$ following Kärcher and Lohmann [2002]
  - convective detrainment glaciated at 0°C



# Ground-based forward simulator for phase

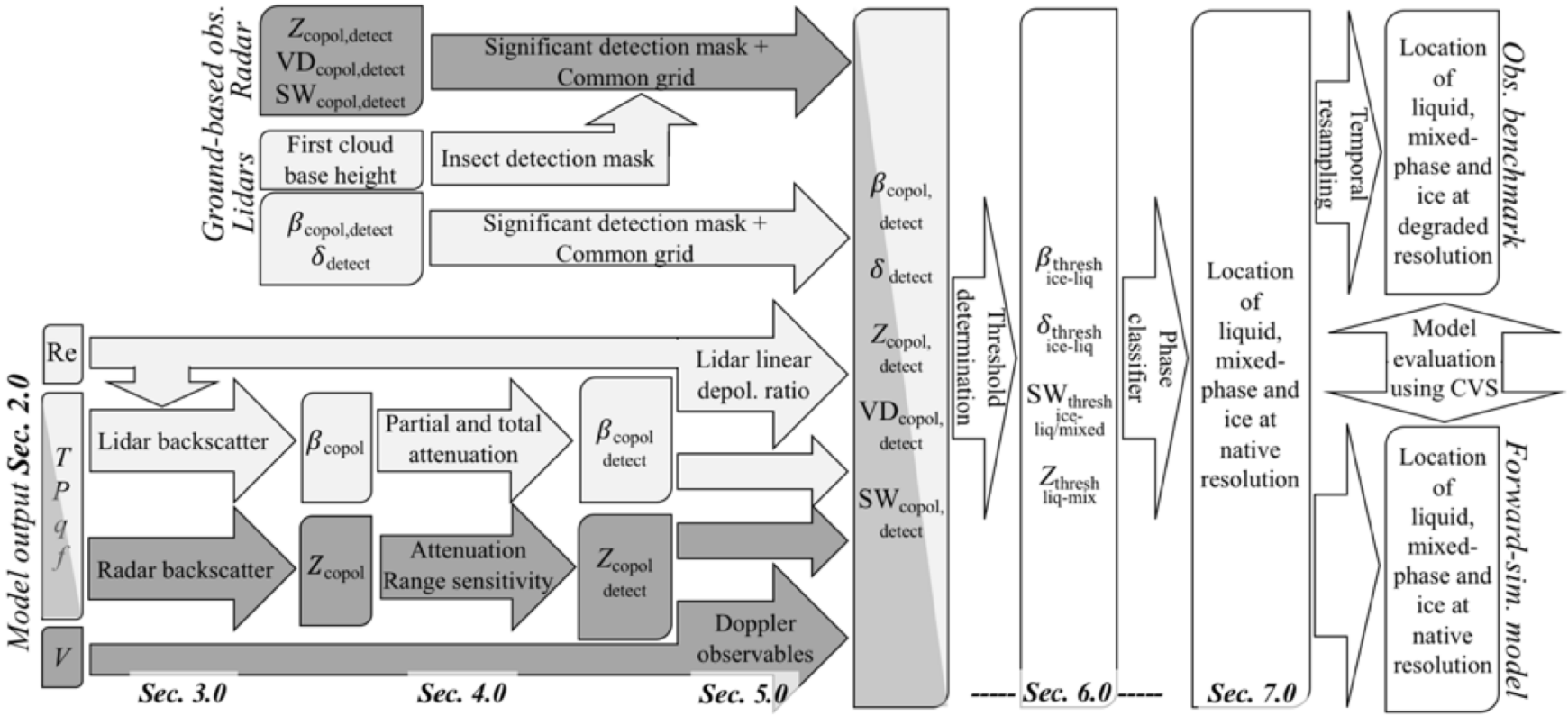



Fig. 1. (GO)²-SIM framework. (GO)²-SIM treats/emulates two types of remote sensors: 35 GHz Doppler radars (dark gray shading) and 532 nm polarimetric lidars (light gray shading). It then tunes and applies a common phase-classification algorithm (white boxes) to both observed (upper section) and forward-simulated (bottom section) fields (latter demonstrated here). Use of results to enable GCM hydrometeor phase evaluation using the cloud vertical structure (CVS) approach will be demonstrated in follow-on work.

Lamer et al. [in prep.]

# Ground-based forward simulator for phase

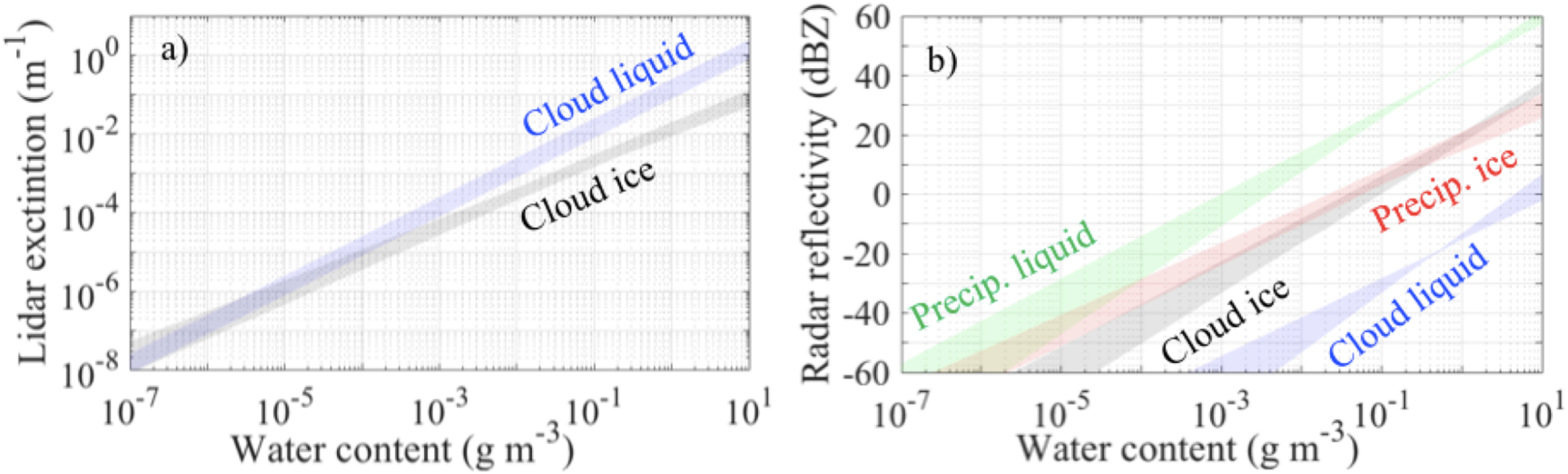
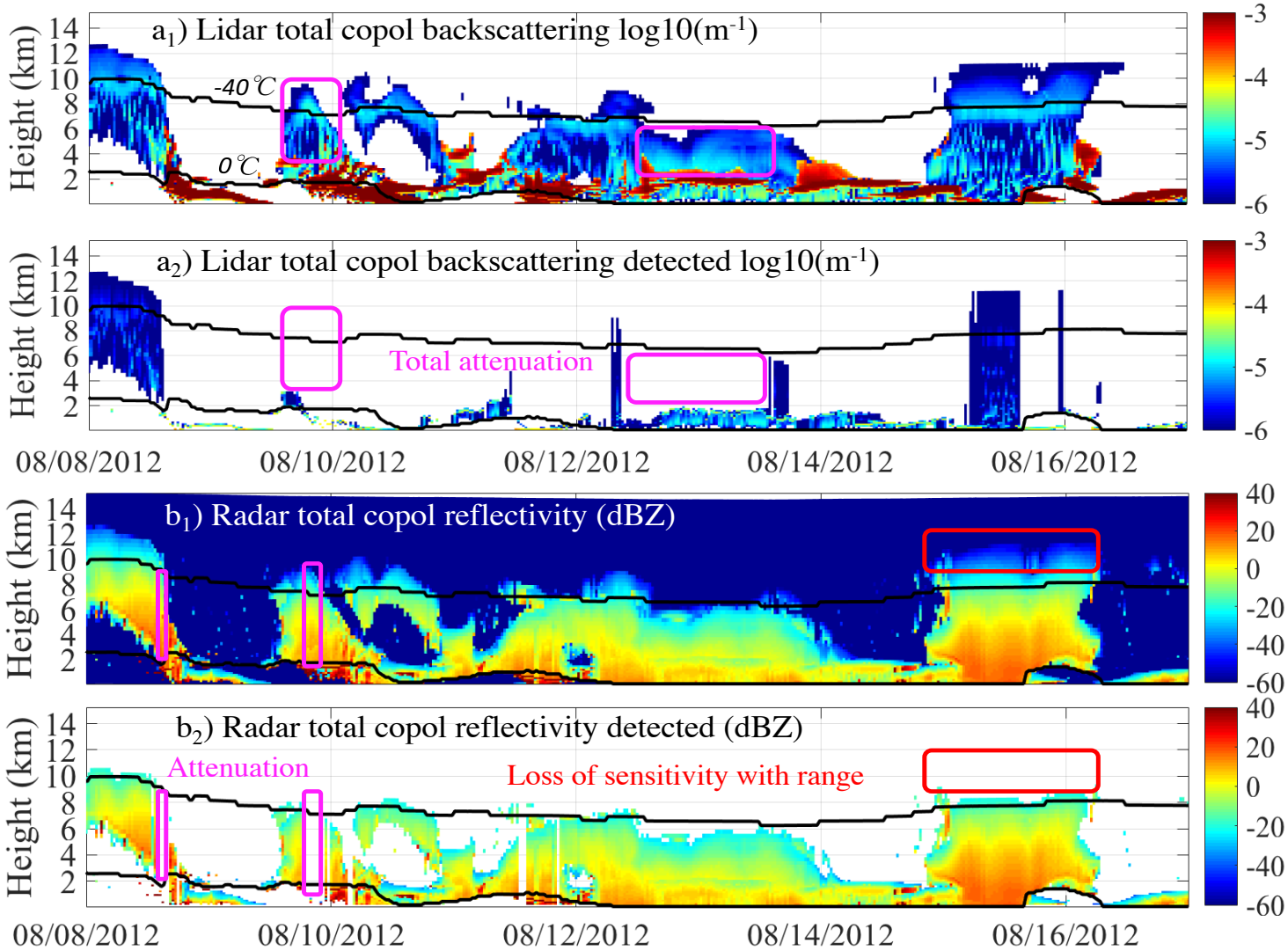



Fig. 3. a) Lidar extinction as a function of water content in the form of cloud liquid (blue) or cloud ice (black). b) Radar co-polar reflectivity as a function of water content in the form of cloud liquid (blue), cloud ice (black), precipitating liquid (green) or precipitating ice (red). Spread emerges from using multiple differing empirical relationships (listed in Table 1) and from variability in the 1-year ModelE3 output (including the effects of varying temperature and effective radii).

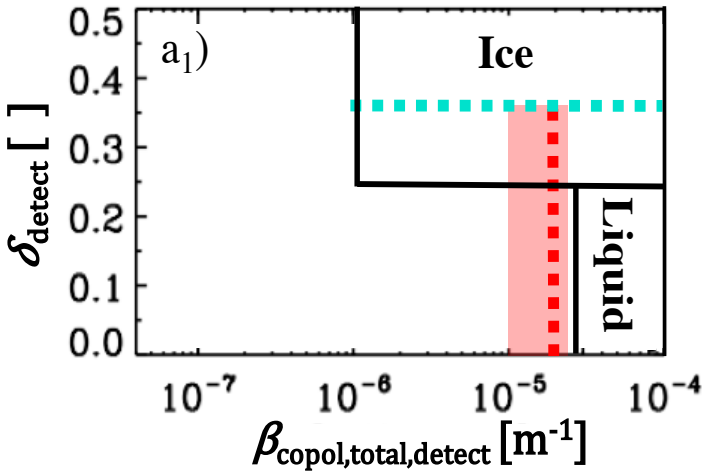
Lamer et al. [in prep.]

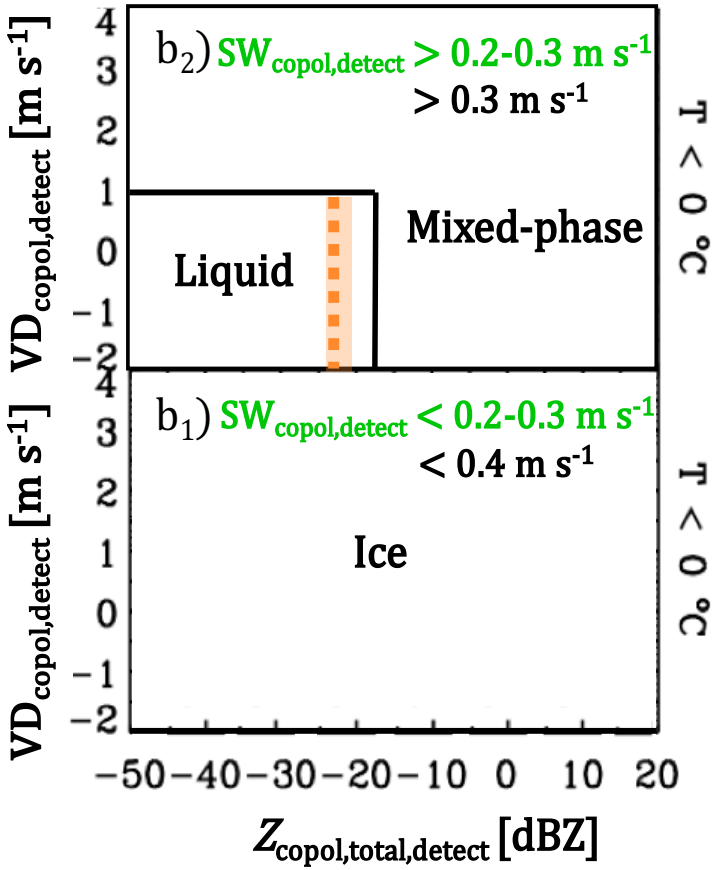
# Ground-based forward simulator for phase




Lamer et al. [in prep.]

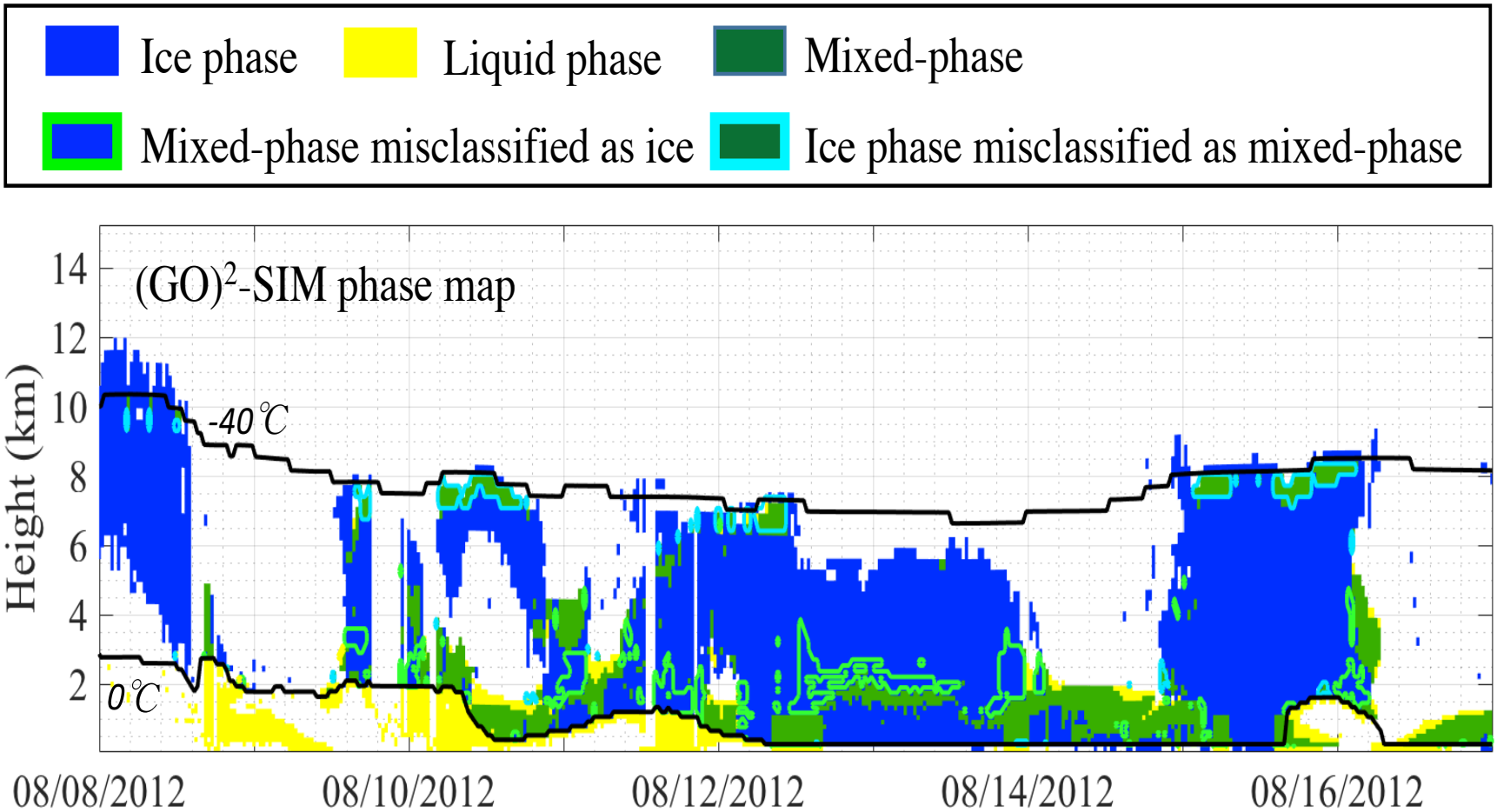
# Ground-based forward simulator for phase




Lamer et al. [in prep.] following Shupe [2007]

# Ground-based forward simulator for phase




Lamer et al. [in prep.]

# Ground-based forward simulator for phase

a) Determined using ModelE Output Mixing Ratio

| | Liquid | Mixed-phase | Ice | Total hydrometeors Simulated |
|---|---|---|---|---|
| Frequency of occurrence (%) | 1 | 60 | 39 | 42 |

b) Determined using Fixed Thresholds modified from *Shupe* [2007]

| | Liquid | | | Mixed-phase | | | Ice | | | Total Hydrometeors Retrieved | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Median | | ½ IQR | Median | | ½ IQR | Median | | ½ IQR | Median | | ½ IQR |
| Frequency of occurrence (%) | 9 | ± | 0 | 14 | ± | 3 | 74 | ± | 4 | 78 | ± | 2 |
| Wrong (%) | 0 | ± | 0 | 0 | ± | 0 | 0 | ± | 0 | 1 | ± | 0 |
| Missed (%) | 0 | ± | 0 | | | | 1 | ± | 0 | 1 | ± | 0 |
| Questionable (%) | 0 | ± | 0 | | | | 6 | ± | 1 | 6 | ± | 1 |
| Total error (%) | | | | | | | | | | 7 | ± | 1 |

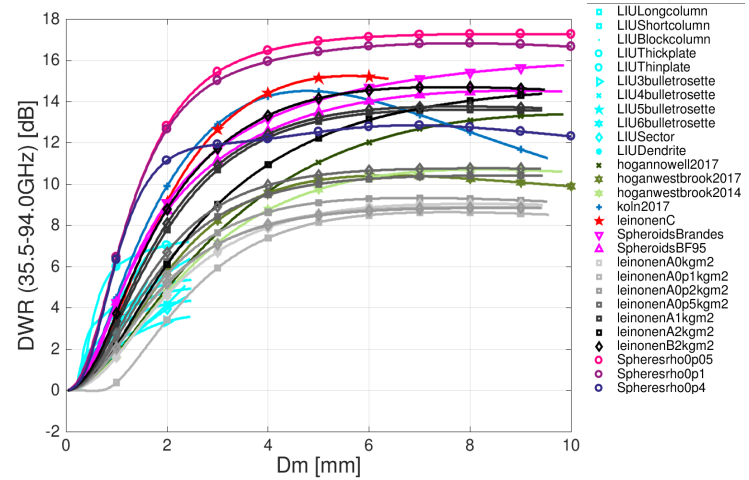
c) Determined Using Flexible Objective Thresholds from model output mixing-ratio

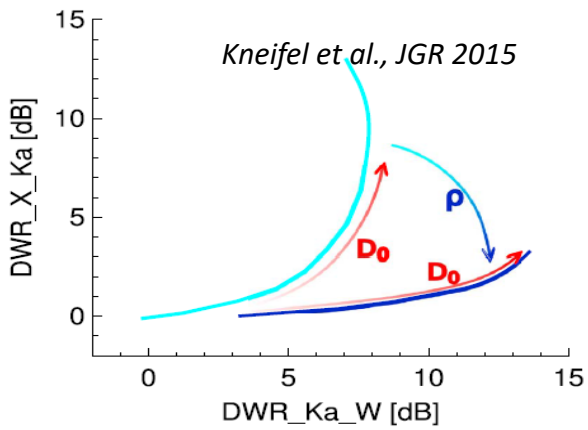
| | Liquid | | | Mixed-phase | | | Ice | | | Total Hydrometeors Retrieved | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Median | | ½ IQR | Median | | ½ IQR | Median | | ½ IQR | Median | | ½ IQR |
| Frequency of occurrence (%) | 8 | ± | 1 | 20 | ± | 2 | 71 | ± | 3 | 78 | ± | 2 |
| Wrong (%) | 0 | ± | 0 | 1 | ± | 0 | 0 | ± | 0 | 2 | ± | 0 |
| Missed (%) | 0 | ± | 0 | | | | 1 | ± | 0 | 2 | ± | 0 |
| Questionable (%) | 0 | ± | 0 | | | | 4 | ± | 1 | 4 | ± | 1 |
| Total error (%) | | | | | | | | | | 6 | ± | 1 |

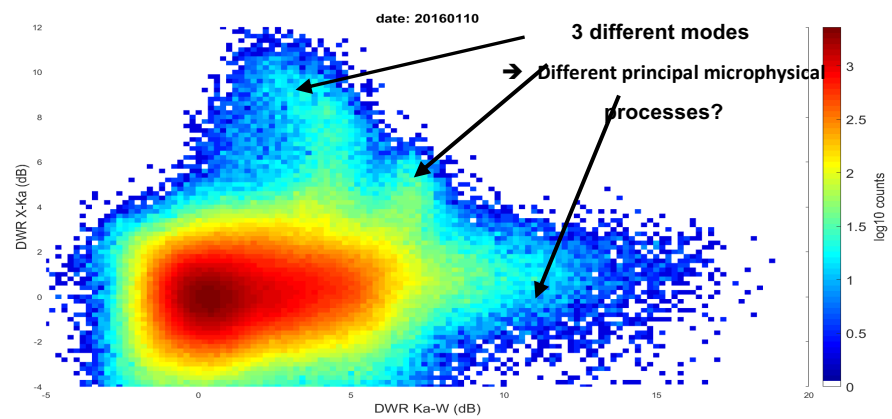
Lamer et al. [in prep.]

# AWARE project plan

- Hire a post-doc (www.giss.nasa.gov/employment)
- Deeper evaluation of cloud properties and context during AWARE
  - application of $(GO)^2$-SIM to ModelE simulations and observations (cloud occurrence, phase)
  - comparison of observed and simulated CCN spectra
  - analysis of PBL and free tropospheric thermodynamics
  - conditional evaluation of ice properties (Ka-W) and active processes (Ka-W-X)
  - two LES case studies to refine approach



# Modeling strategy

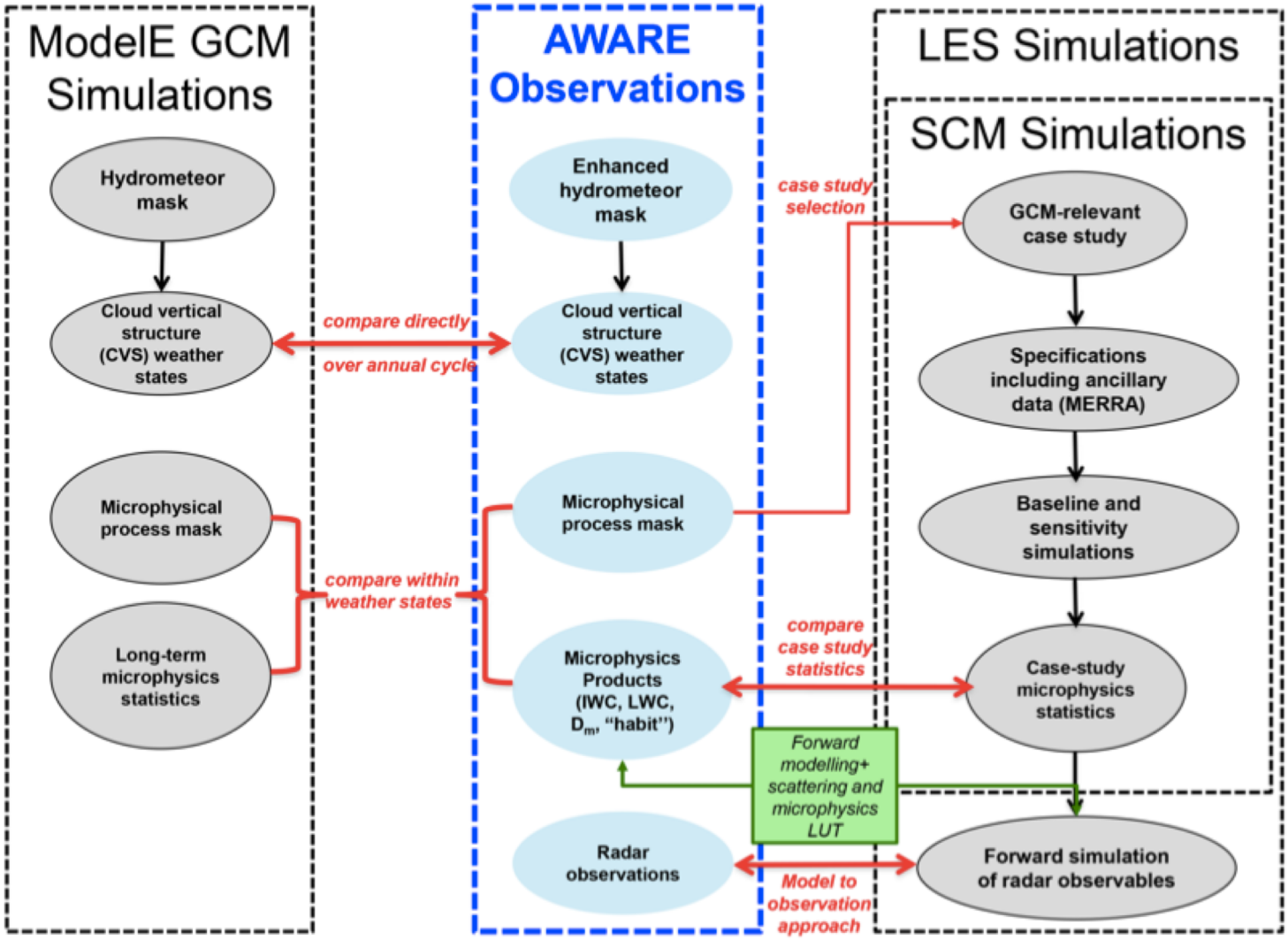



Fig. 1: Diagram illustrating the simulation and observation deliverables that will be generated. Model and retrieval scheme improvements will constitute improved agreement at comparison points.