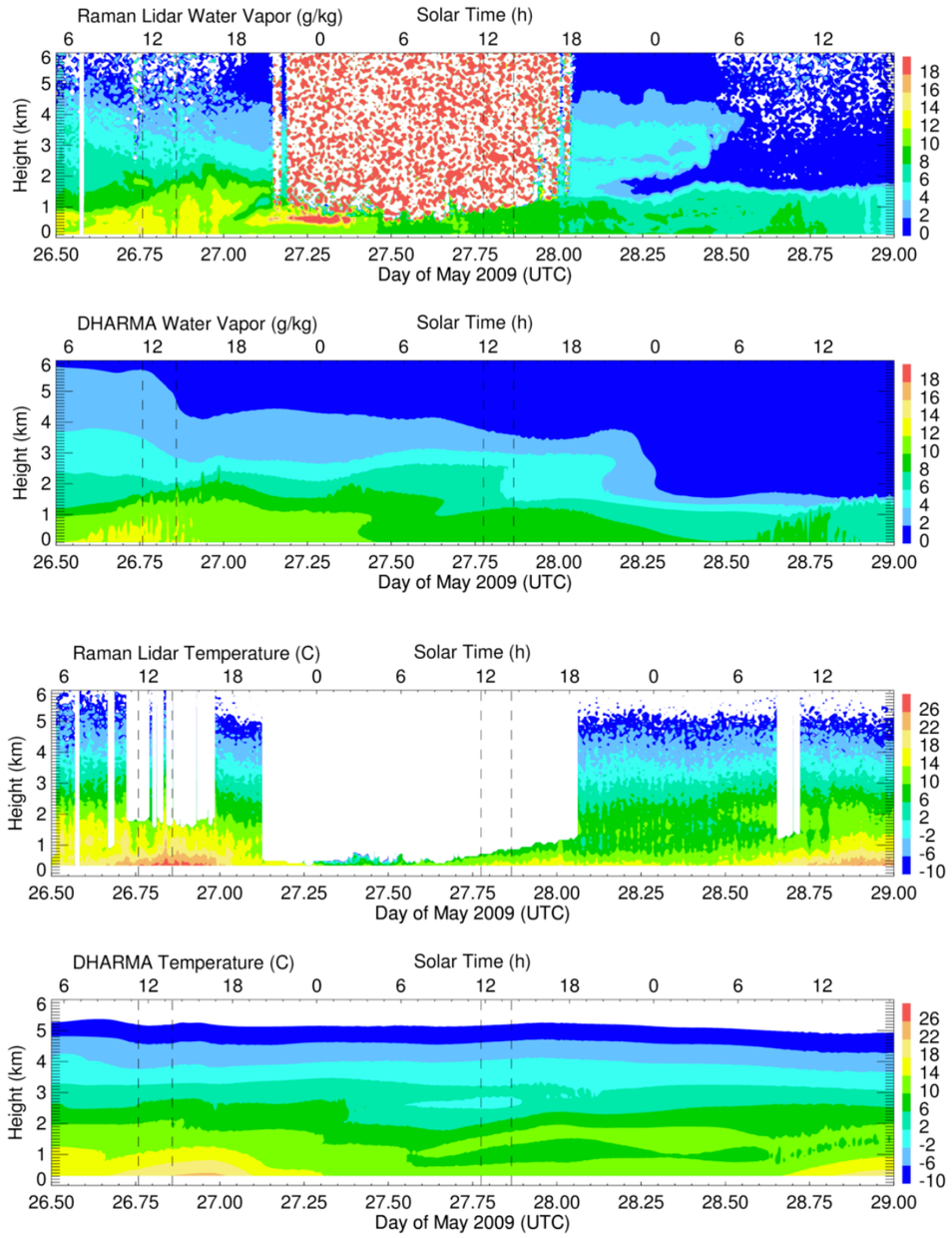
Question for ARM CPMSG:

Given scientific focus areas that are important to DOE objectives and relevant to ARM measurements, are there subtopics where ARM has strong potential to contribute but is not reaching that potential for various possible reasons?

ARM Cloud and Precipitation Measurements and Science Group: Jim Mather, Ann Fridlind, Nitin Bharadwaj, Christine Chiu, Scott Collis, Jennifer Comstock, Scott Giangrande, Hanna Goss, Nicki Hickmon, Mike Jensen, Matt Kumjian, Paytsar Muradyan, Rob Newsom, Alyssa Sockol, Matthew Sturm, Adam Thiesen

1. Boundary layer structure and near-cloud dynamics

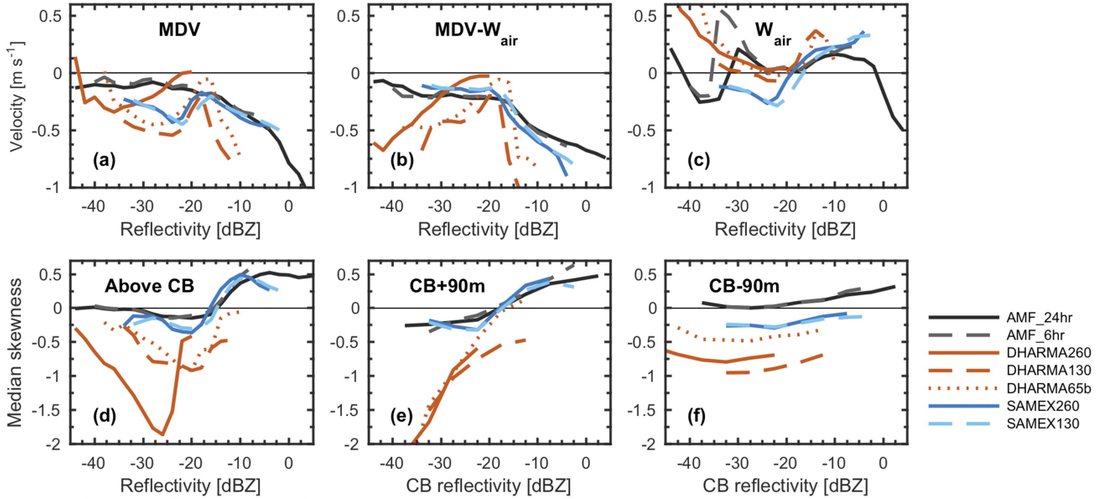
- PBL behavior is diverse across models (from LES to GCM), difficult to robustly evaluate (satellite data and high-frequency soundings lacking)
- strengths
  - long-term data sets with high spatial and temporal near-surface resolution: Doppler lidar, ceilometer, Raman lidar retrievals of WVMR and T, polarimetric radar
  - extensive ancillary data sets: soundings, surface met network, sfc fluxes, soil moisture, LASSO simulations
- barriers?
  - PBL height and structure are difficult to robustly define (multiple products differ), and data sets can be difficult to harmonize
  - coastal and island locations not ideal, and Oklahoma not as flat as Wangara (e.g., drainage flows; not an issue for near-cloud dynamics)



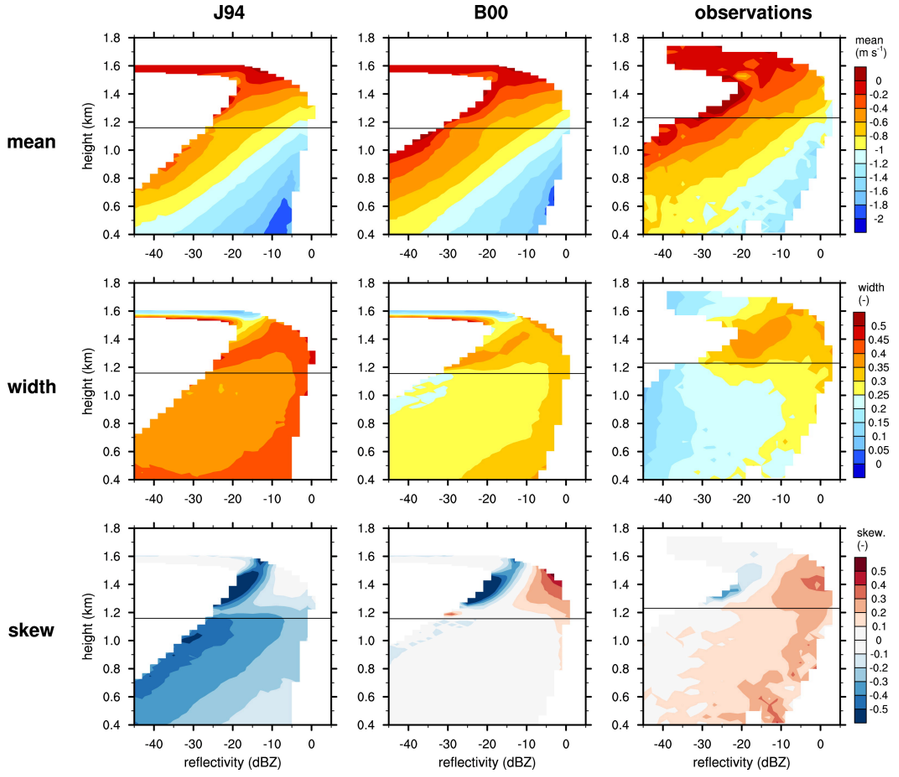
Raman lidar retrievals vs DHARMA LES at SGP (unpublished)

2. Shallow warm cloud precipitation formation and structure

- large uncertainty in model precipitation processes (LES to GCM), models difficult to robustly constrain
- strengths
  - long-term data sets: Doppler radar, MWR, Doppler lidar at ENA
  - colocated data: lidar-detected cloud base height
- barriers?
  - lack of robust droplet number concentration retrievals? or is column average adequate?
  - large-scale advective tendencies variable, very hard to constrain?
  - Oklahoma consistently high-aerosol? NSA CCN data quality issues? ENA poorly coupled?
  - progress requires expanding 1D view to 3D?



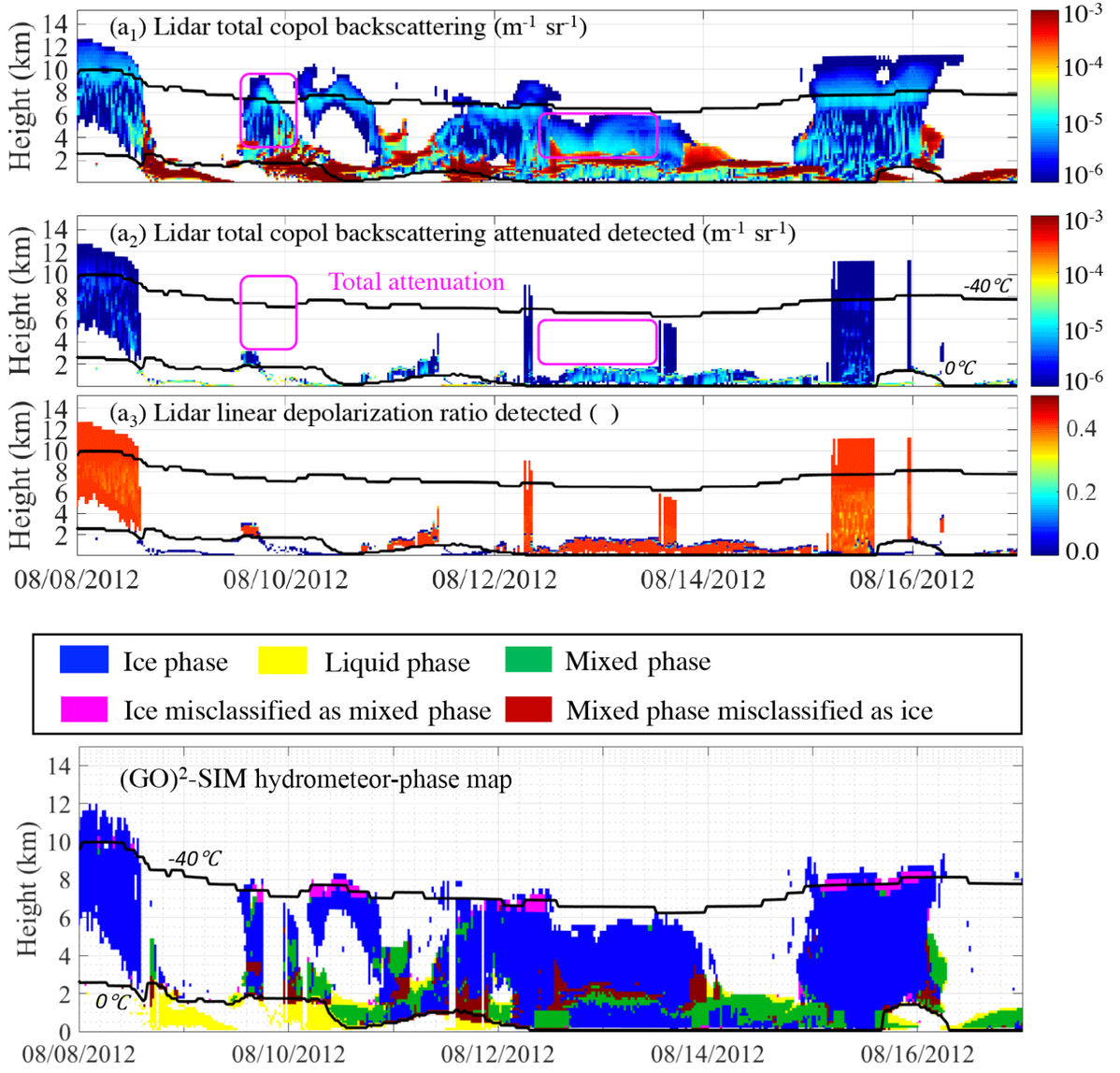
W-band Doppler spectra vs DHARMA and SAM LES results at ENA (Rémillard et al. JAMC 2017)



W-band Doppler spectra vs improved DHARMA LES (Lee et al. JAS 2019)

3. Hydrometeor phase evaluation in climate models

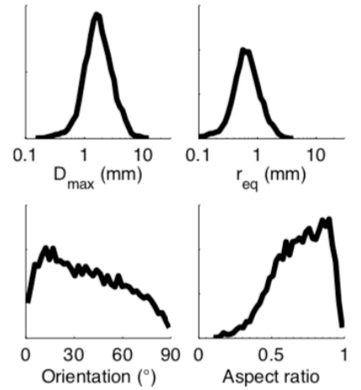
- GCMs very poorly predict supercooled water, and hard to evaluate well (e.g., Δz = 500 m in CALIPSO data)
- strengths
  - long-term data sets: KAZR and depolarization lidar at NSA
  - colocated data: soundings, surface met and radiative fluxes
- barriers?
  - requires a GCM forward simulation approach and unique processing of multiple data?
  - models without prognostic precipitation may be limited to an evaluation of first detectable liquid layer base?



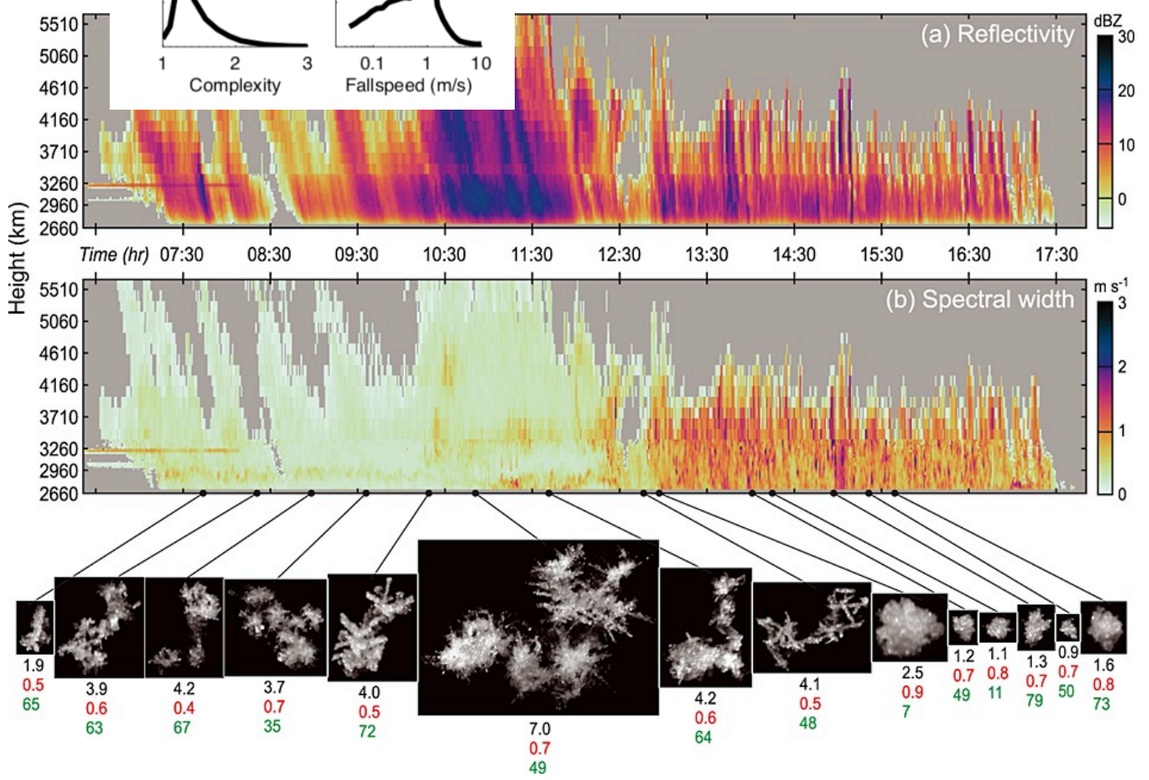
Hydrometeor phase forward-simulated from GISS ModelE3 climate model at NSA (Lamer et al. GMD 2018)

4. Ice properties and processes

- complexity of coupled ice properties and processes usually remains simplified in both LES–GCM models, retrievals
- strengths
  - upcoming collocated data sets with sensitivity to ice properties: KAZR, MASC, XSACR, polarimetric Ka-W-SACR2, Geonor, LPMS, snow depth at NSA
  - colocated data: depolarization lidar, soundings, albedo
- barriers?
  - key instrument for robust analyses are recently upgraded (e.g., MASC fence), have not been colocated?
  - robust methods for handling ice property complexity in both retrievals and models not yet in hand? progress expected



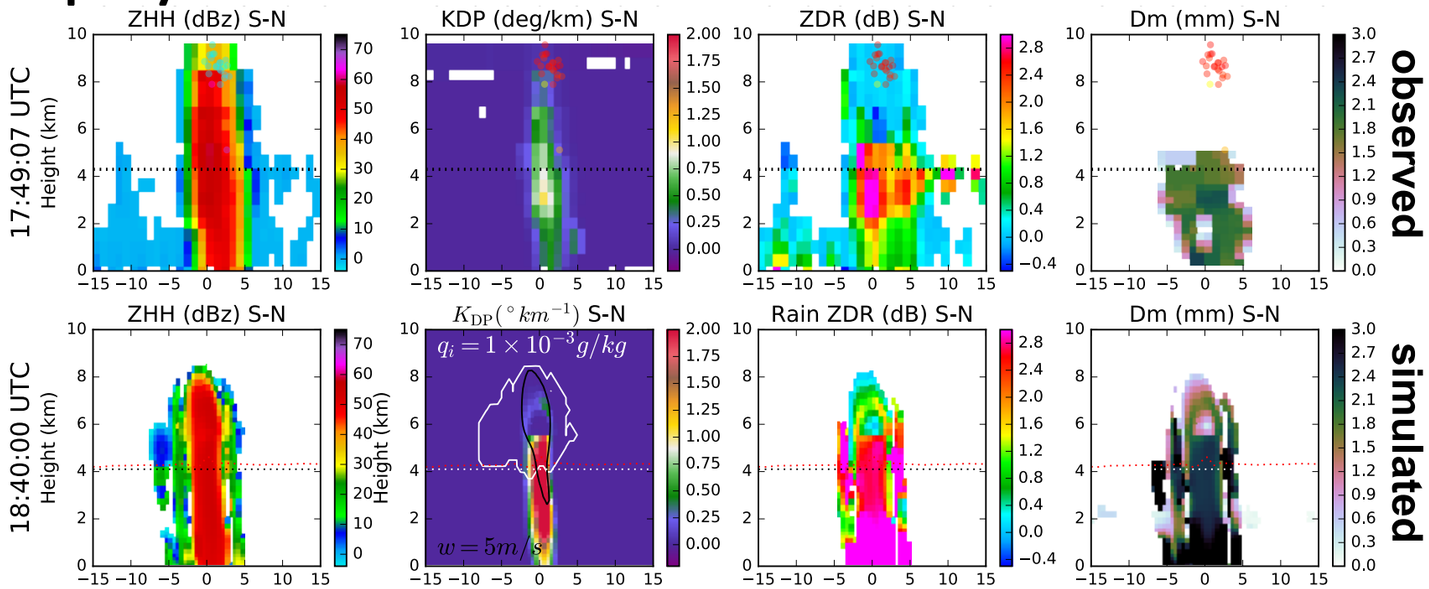
Example MASC data at Alta, UT (Garrett et al. 2012)



Example MASC data at Alta, UT (Garrett et al. 2015)

5. Coupled dynamics and microphysics of deep convection

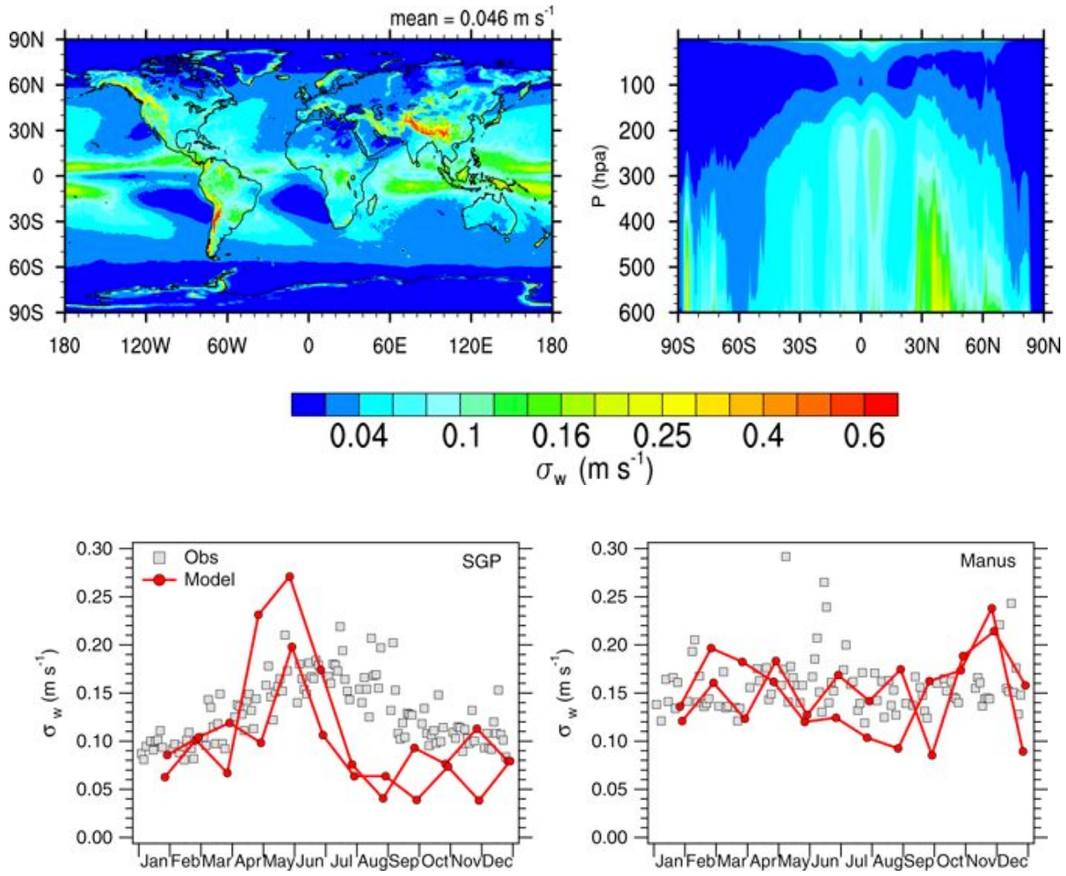
- complexity of coupled convective microphysics and dynamics remains poorly understood, very difficult to well observe
- strengths
  - short-term calibrated data sets with unique sensitivity to microphysics and dynamics: C-SAPR and X-SAPRs (SGP network recently successfully demonstrated in rapid-scan mode)
  - colocated data: NEXRAD S-band, soundings, continuous ground-based aerosol data at SGP
- barriers?
  - integration of modeling and multi-instrument 4D data sets is non-trivial?
  - multi-Doppler wind vector and microphysics property retrievals (e.g. rain DSD parameters) arguably remain on bloody part of cutting edge?
  - rapid scanning requires supervision or automated tracking (latter under development)



Houston example motivating upcoming TRACER field campaign (Fridlind et al. AMT 2019)

6. Cirrus dynamics and microphysics

- cirrus formation mechanisms remain poorly understood, in part owing to scarce observations of driving gravity wave dynamics
- strengths
  - long-term data sets with unique sensitivity to vertical wind speed in-cloud: KAZR at all sites
  - colocated data: soundings, lidar
- barriers?
  - vertical wind speed retrievals may not be operational, further development required?
  - climate models not yet including prognostic schemes for gravity wave contributions to vertical wind speed variance?



In-cirrus vertical wind speed variance from 7-km GEOS-5 "Nature Run" compared with SGP and Manus retrievals (Barahona et al. Sci. Rep. 2017)

Summary and questions

- What are subtopics where ARM has strong potential to contribute more?
  - boundary layer structure (SGP) • shallow warm cloud precip (ENA)
  - hydrometeor phase evaluation (NSA) • ice properties/processes (NSA)
  - deep convection (SGP) • cirrus dynamics/microphysics • others?
- Are there specific barriers to progress over a five-year time frame that key investments could feasibly address?
- Are *you* encountering any specific barriers to progress?
- Do you see areas where you could be engaged in lowering barriers?

- Feedback welcomed
  - web form <INSERT> • talk to us (co-chairs or members) • Thursday Breakout Session 6: How ARM Meets the Needs of ASR Science Goals/Panel Discussion led by Shaocheng Xie and Jennifer Comstock