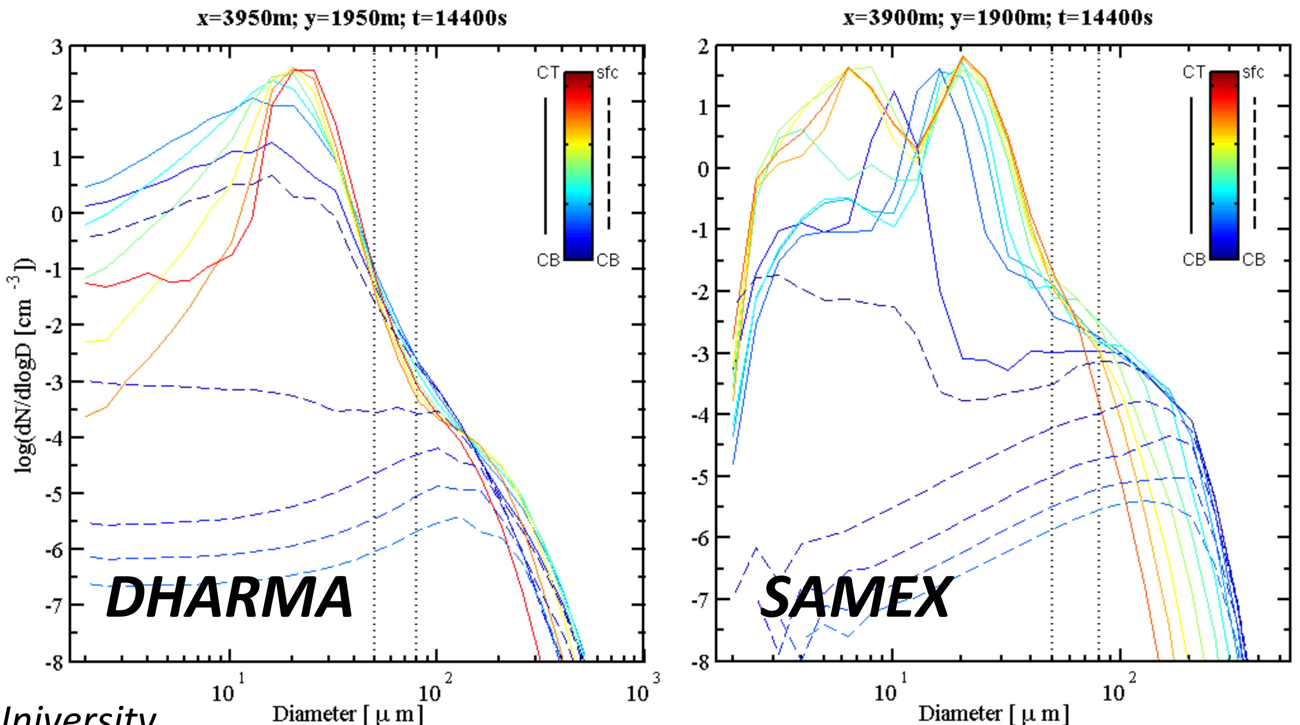
Observational constraint of drizzle properties and processes in LES with size-resolved microphysics: Use of Doppler cloud-radar moments and spectra

Is this drizzle realistic?



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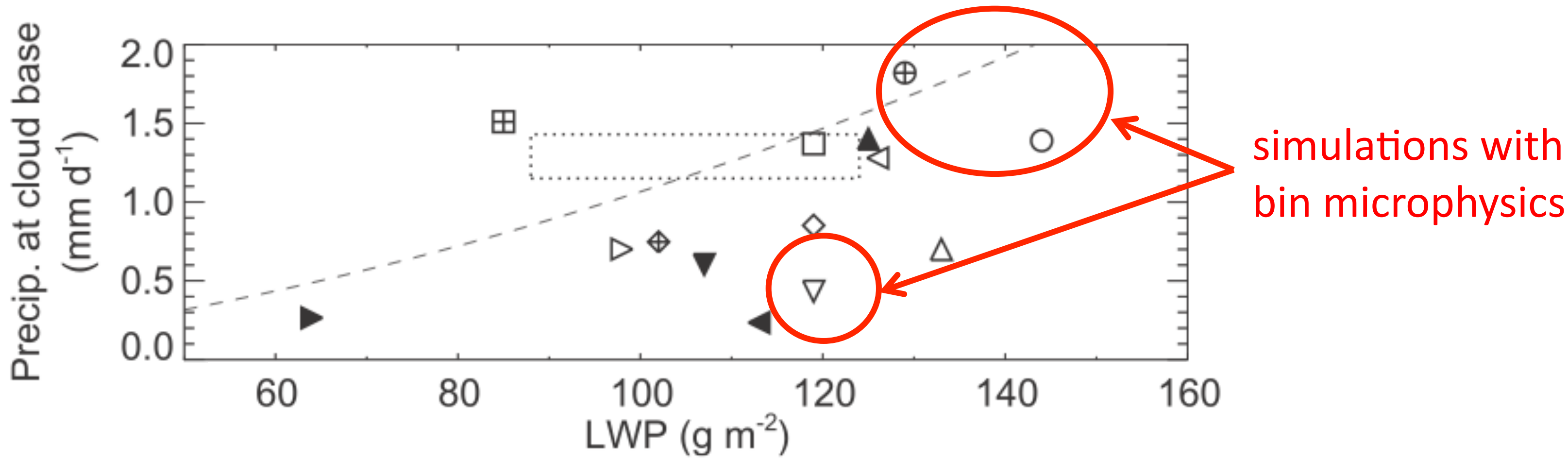
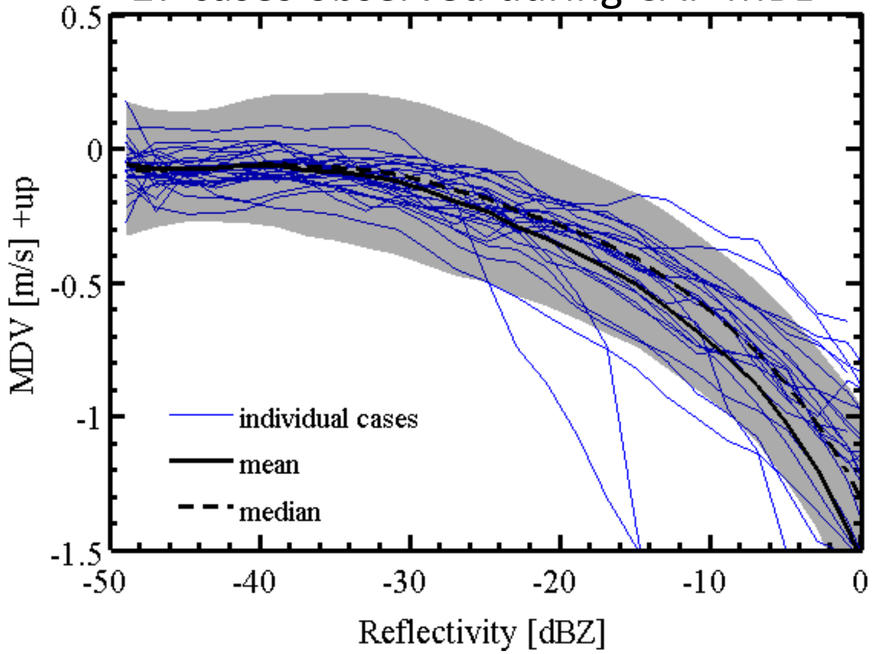
Motivation



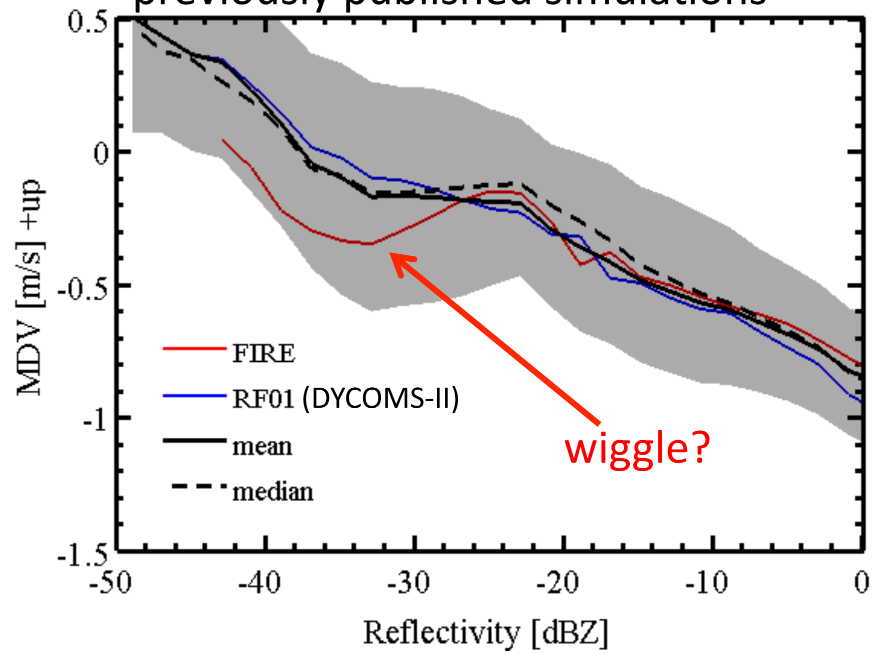
- drizzle modulates cloudy boundary layer evolution [e.g. Wood 2012]
- climate model drizzle parameterization has been based on a North Sea Sc LES case study "as a data source and benchmark" [e.g. Khairoutdinov and Kogan 2000, Gettelman and Morrison 2015]
- LES with size-resolved microphysics depend on uncertain collision-coalescence kernels and differing numerics [e.g. Ackerman et al. 2009]
- case studies difficult to constrain observationally (large spatiotemporal variability, sparse in situ measurements, inadequate LS forcing, etc.)

Approach

27 cases observed during CAP-MBL



previously published simulations



- 19-month CAP-MBL [Wood et al. 2015] W-band zenith Doppler cloud-radar data suggest statistical stability of drizzle properties
- case studies required to understand *causes, extent, relevance* of LES deviations from CAP-MBL data

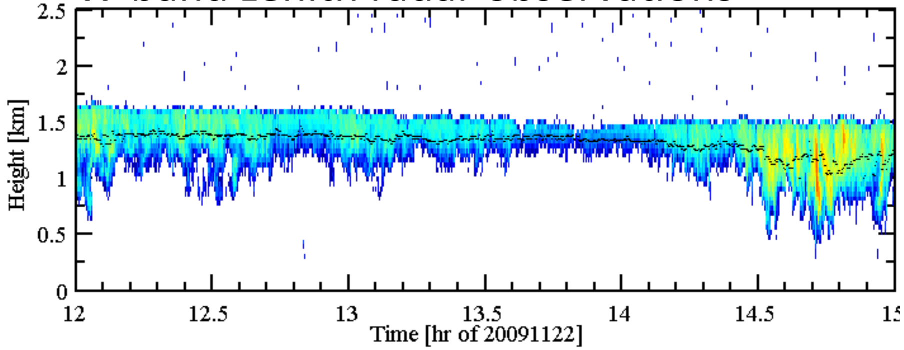
Sc case study (11/22/09): 2 LES/bin models

- initial sounding (11Z), fixed subsidence profile and SST, fixed/similarity surface fluxes, nudged horizontal winds

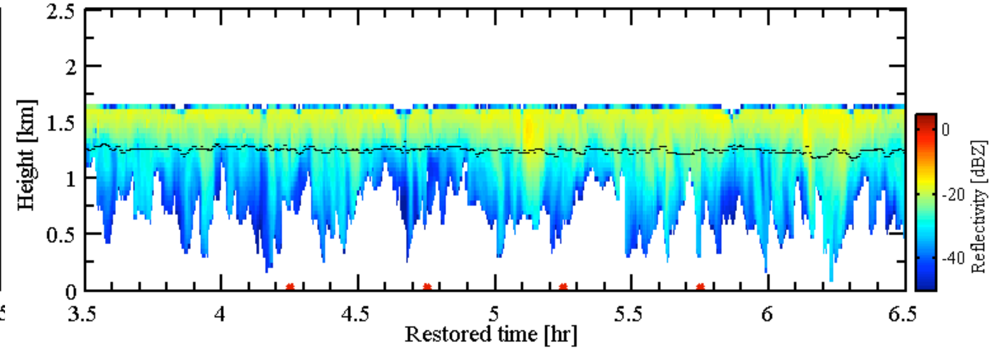
DHARMA	SAMEX
finite-difference dynamics scheme [Stevens et al. 2002]	finite-difference dynamics scheme [Khairoutdinov and Kogan 2003]
dynamic Smagorinsky sub-grid scale scheme [Kirkpatrick et al. 2006]	prognostic TKE sub-grid scale scheme [Deardorff 1980]
one-moment bin scheme	one-moment bin scheme
piecewise polynomial diffusional growth scheme [Colella and Woodward 1984]	semi-Lagrangian diffusional growth scheme [Kogan 1991]
implicit collision-coalescence conserves N and M [Jacobson et al. 1994]	Berry and Reinhard [1974]
Hall [1980] collision kernel	Hall [1980] collision kernel
Beard and Ochs [1984, 1995] coalescence efficiencies	coalescence efficiency = 1
diagnostic aerosol [Clark 1974]	prognostic aerosol (consumption)

Sc case study (11/22/09): 2 LES/bin models

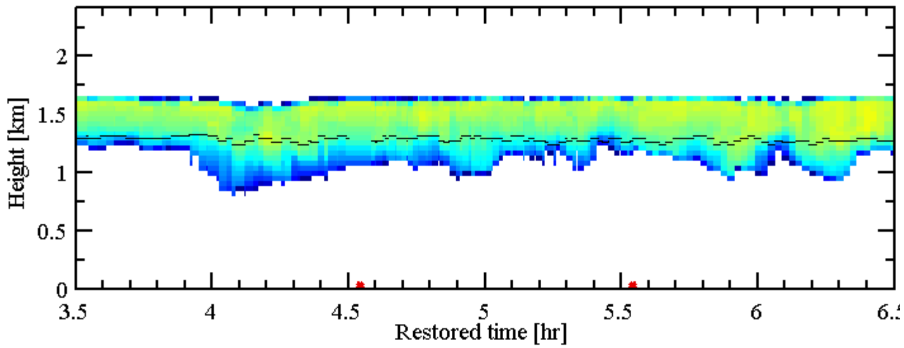
W-band zenith radar observations



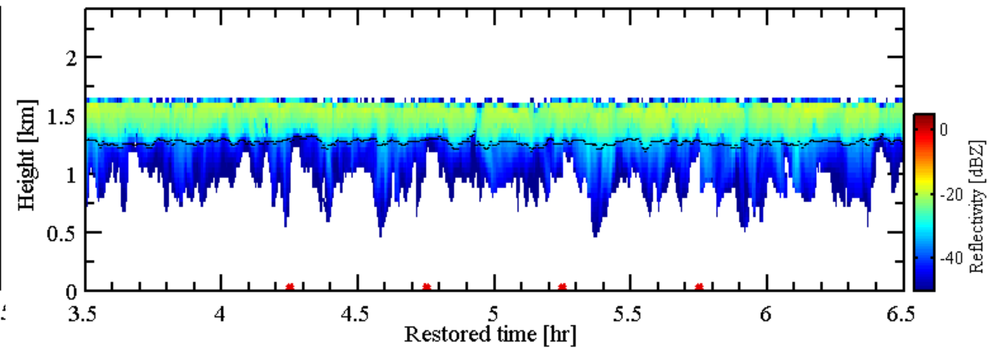
DHARMA with 130 cm^{-3} aerosol



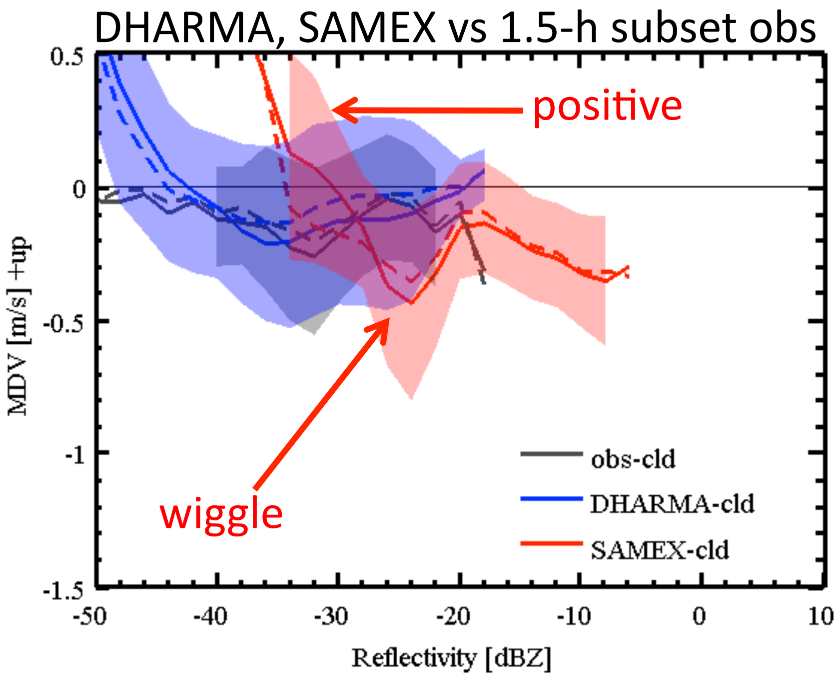
SAMEX with 260 cm^{-3} aerosol

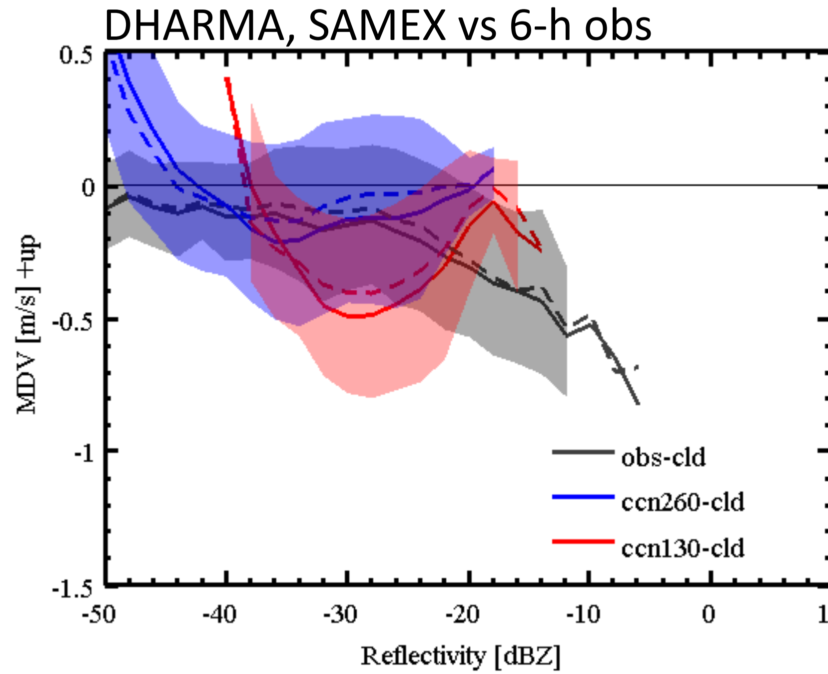


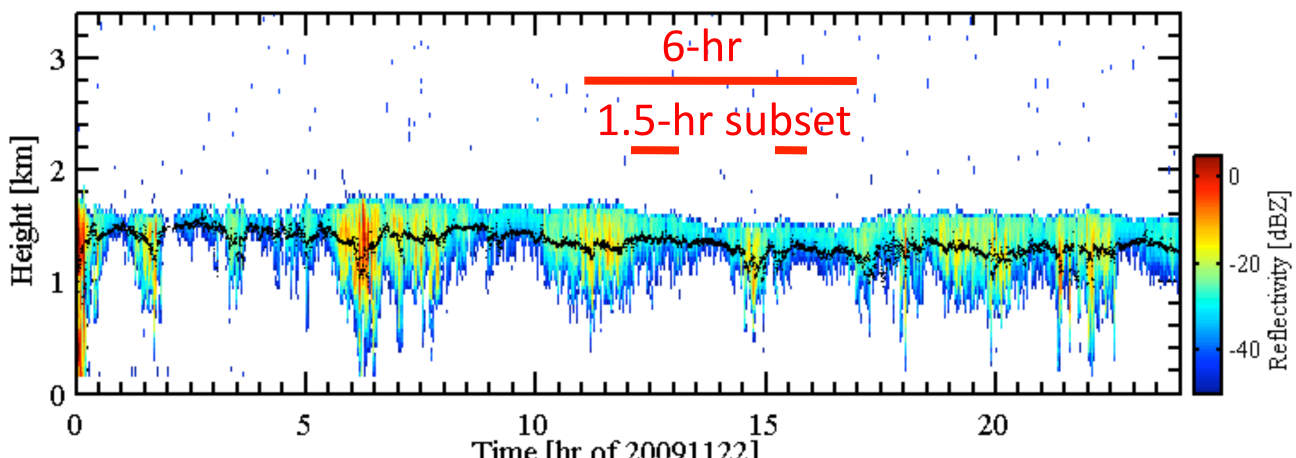
DHARMA with 260 cm^{-3} aerosol



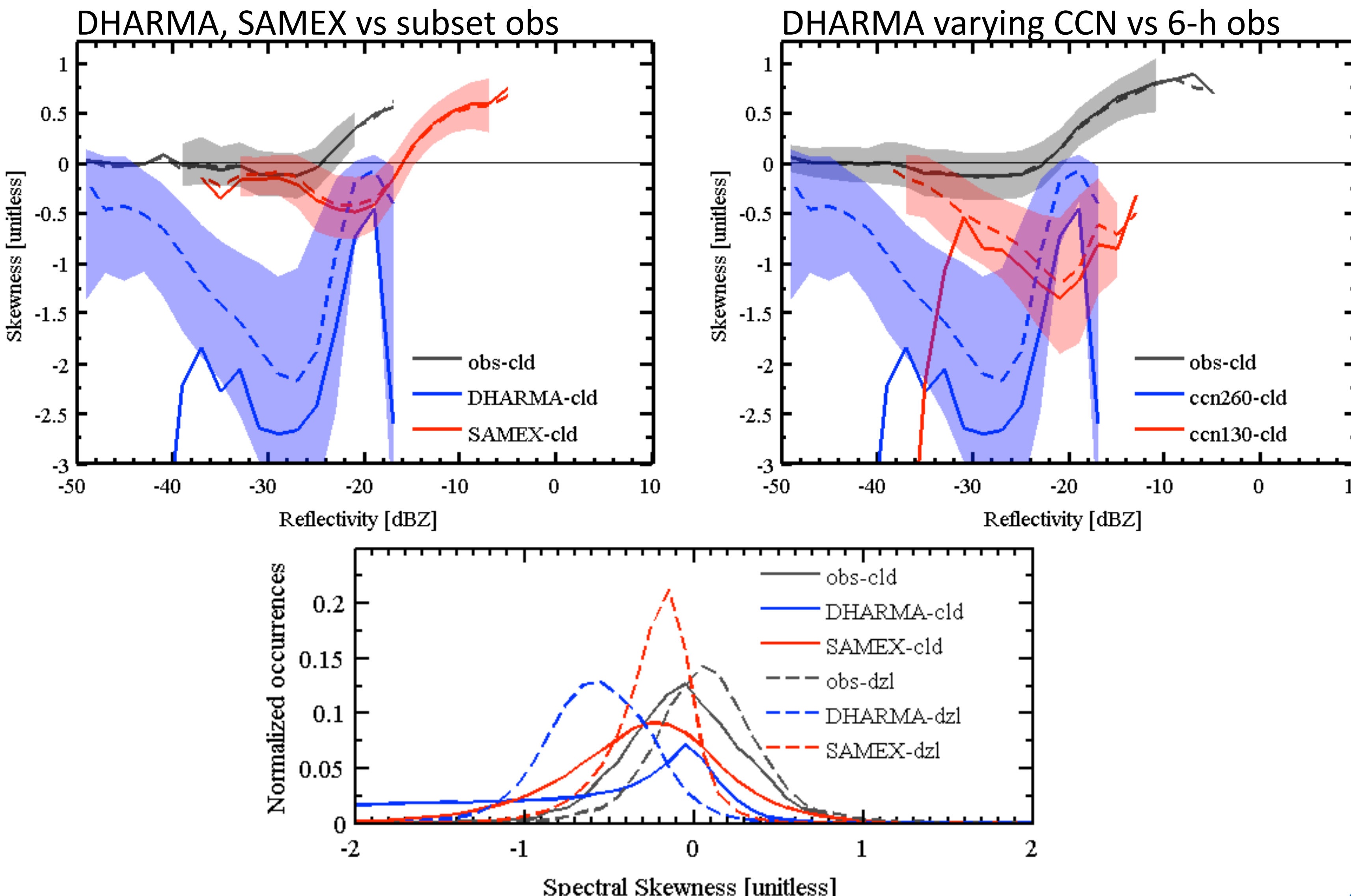
Results: Mean Doppler velocity vs reflectivity



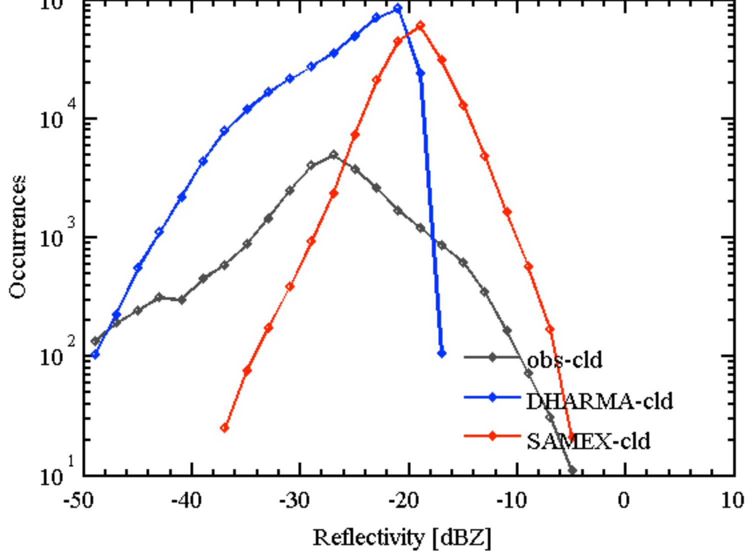




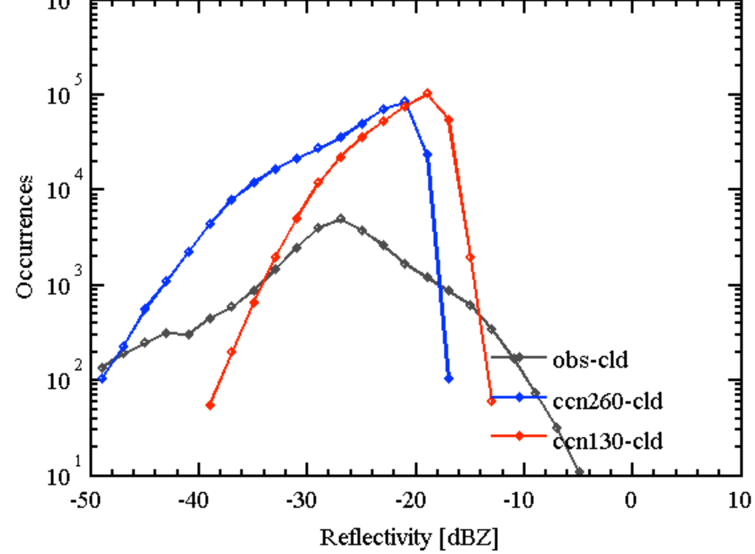
Results: Doppler velocity skewness vs reflectivity



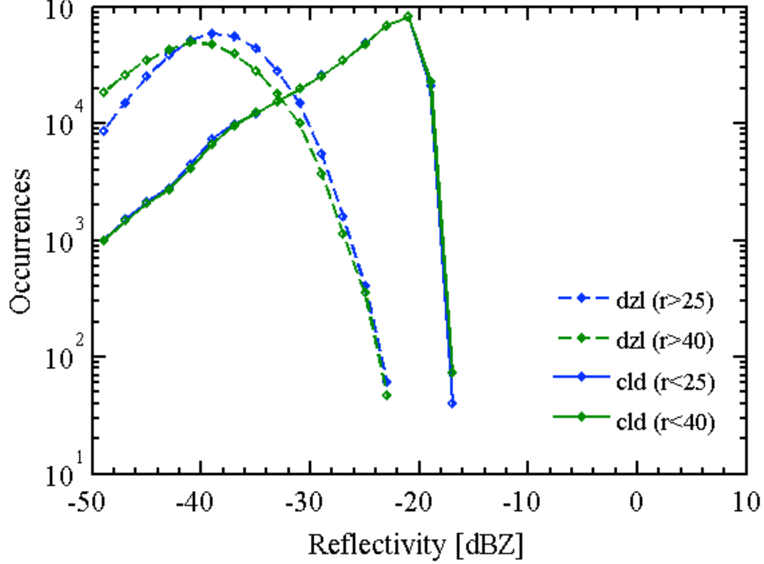
DHARMA, SAMEX vs 6-hr obs



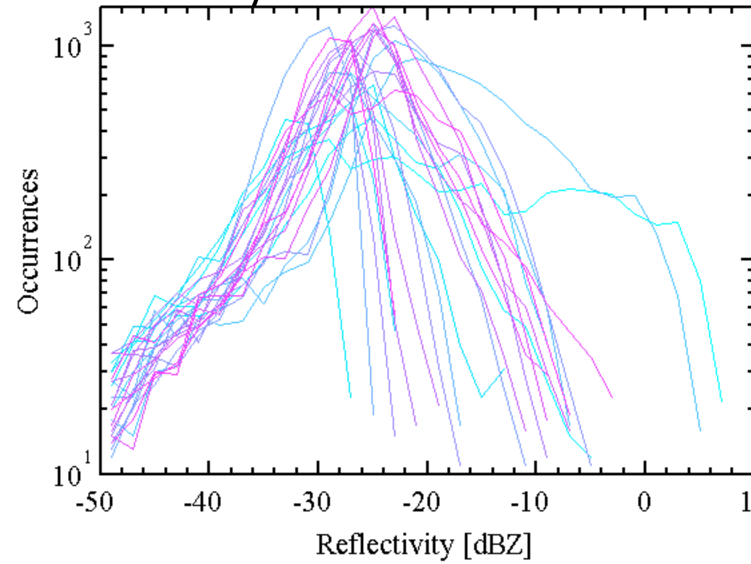
DHARMA with varying CCN



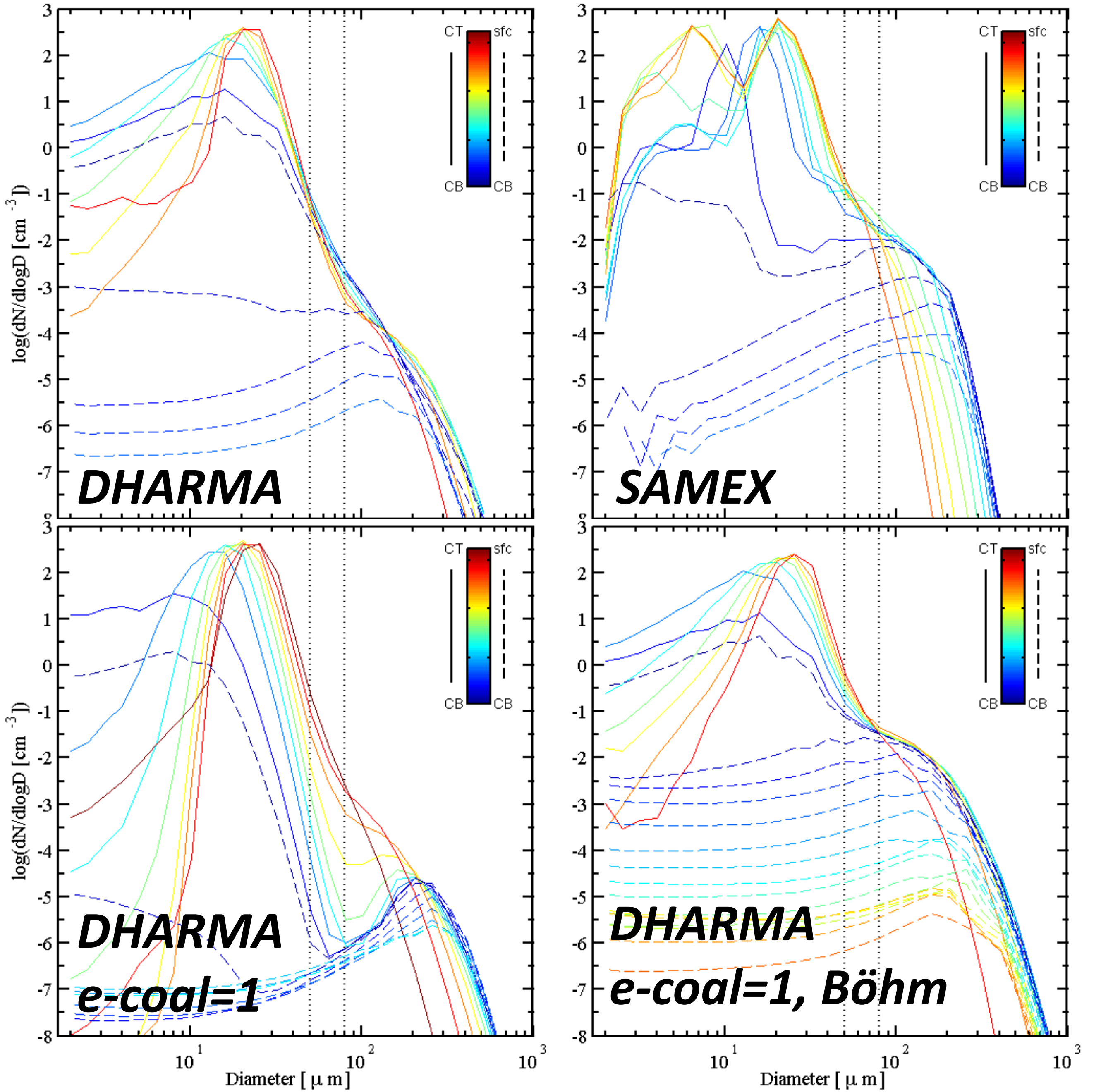
DHARMA drizzle and cloud



hourly obs



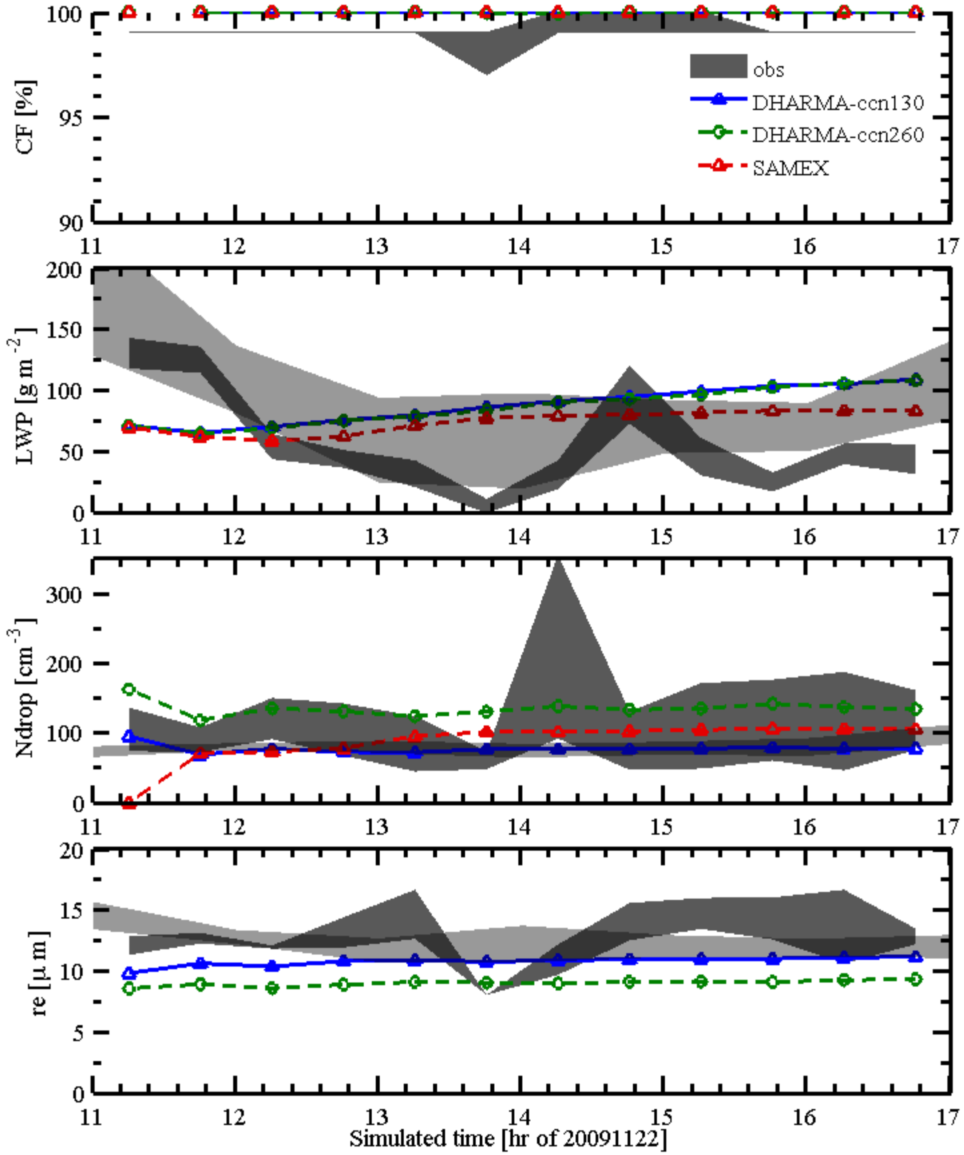
Future work: test kernels, numerics

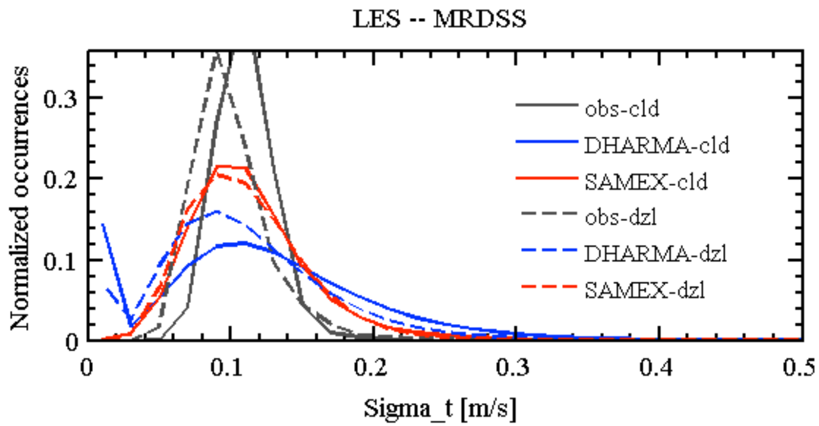


Conclusions

- both SAMEX and DHARMA exhibit upward MDV in the limit of low reflectivity and local MDV minima (wiggles) not observed
- DHARMA produces unrealistic negative DV skewness (sparse concentrations of large drizzle); SAMEX less so, but neither DHARMA nor SAMEX produce 0 mean drizzle skewness
- SAMEX makes more, smaller drizzle and high-Z cloud whereas DHARMA makes less, larger drizzle and low-Z cloud; but both SAMEX and DHARMA drizzle peak with similar Z (–20 dBZ) higher than observed (<–25 dBZ)
- simulated features depend on specified aerosol (poorly constrained in CAP-MBL observations)
- with more work (kernels, numerics, budgets), promising approach to improve evaluation of LES with bin microphysics, parameterization development and evaluation

Sc case study (11/22/09): 2 LES/bin models





CAP-MBL aerosol properties