# Locally narrow droplet size distributions in stratocumulus clouds: Insights from ACE-ENA and LES

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U.S. DEPARTMENT OF ENERGY

**The representation of microphysical processes can strongly influence cloud-climate feedbacks in global climate models (e.g., Bodas-Salcedo et al., 2019). Cloud-radiative interaction is also modulated by aerosols via cloud microphysics, which is one of the major uncertainties in anthropogenic climate change (IPCC, 2013).**

-Confronting the Challenge of Modeling Cloud and Precipitation Microphysics,
Morrison, H., van Lier-Walqui, M., Fridlind, A. M., Grabowski, W. W., Harrington, J. Y., Hoose, C., et al., JAMES (2020)

**Regardless of their specific differences, bulk microphysics parameterizations have mostly followed a paradigm of two pillars. The first pillar assumes some analytical hydrometeor size distributions function such as the three parameter Gamma function to close the set of equations for predicting HSD moments.**

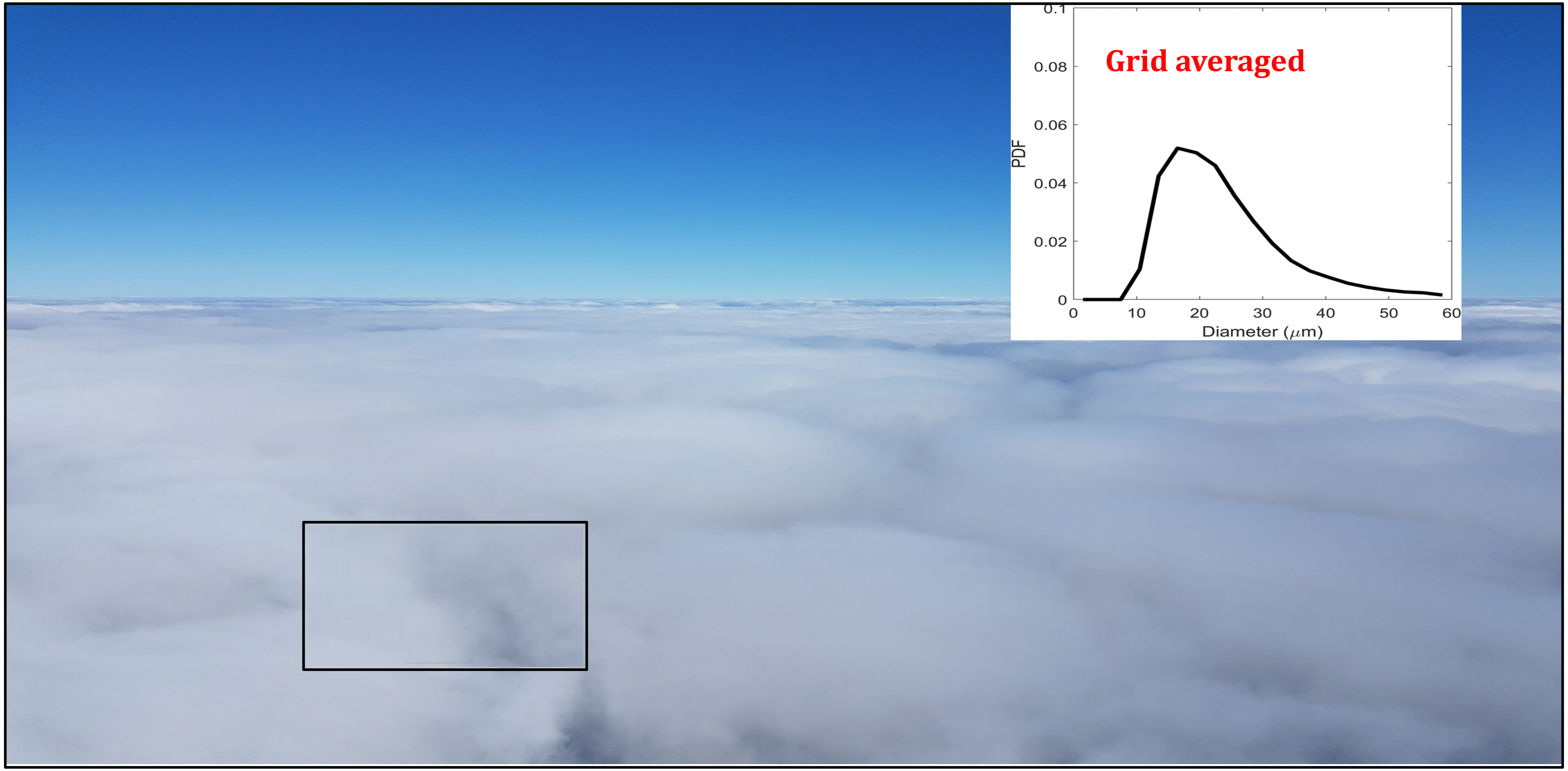
-Parameterization and Explicit Modeling of Cloud Microphysics: Approaches, Challenges, and Future Directions,
Liu, Y., Yau, MK., Shima, Si et al, Adv. Atmos. Sci(2023)

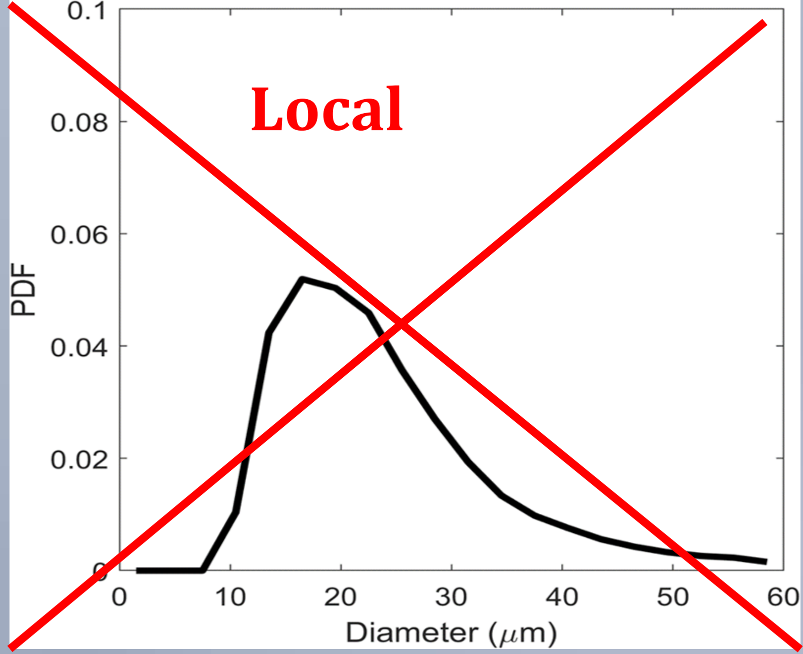
**For nonlinear process rates such as autoconversion and accretion, the grid-mean process rates calculated from the subgrid-scale variability do not equal the process rate calculated from the grid-mean value of x, i.e.,**

-Vertical dependence of horizontal variation of cloud microphysics: observations from the ACE-ENA field campaign and implications for warm-rain simulation in climate models
Z. Zhang et al, Atmos. Chem. Phys.(2021)

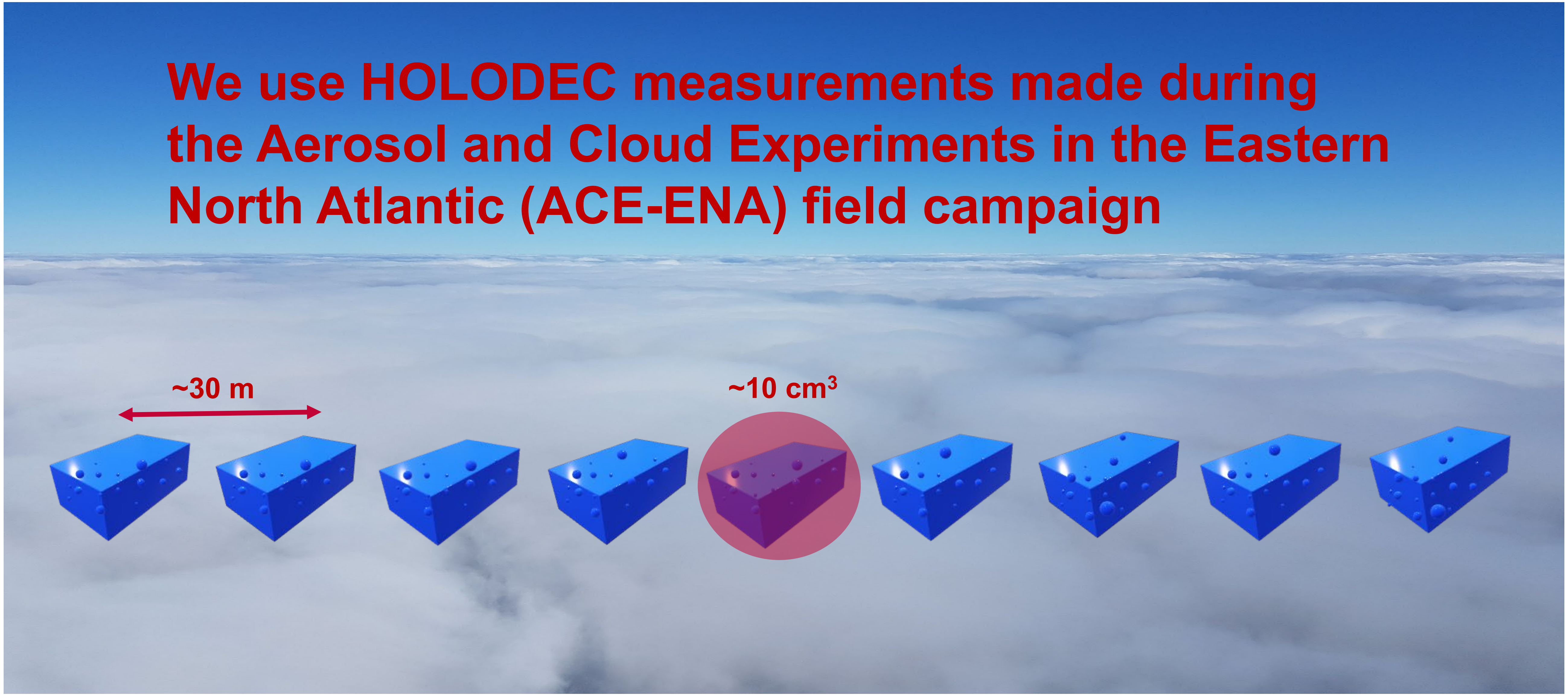
$$\langle f(x) \rangle \neq f(\langle x \rangle)$$

# Do cloud droplet populations look the same at all scales ?

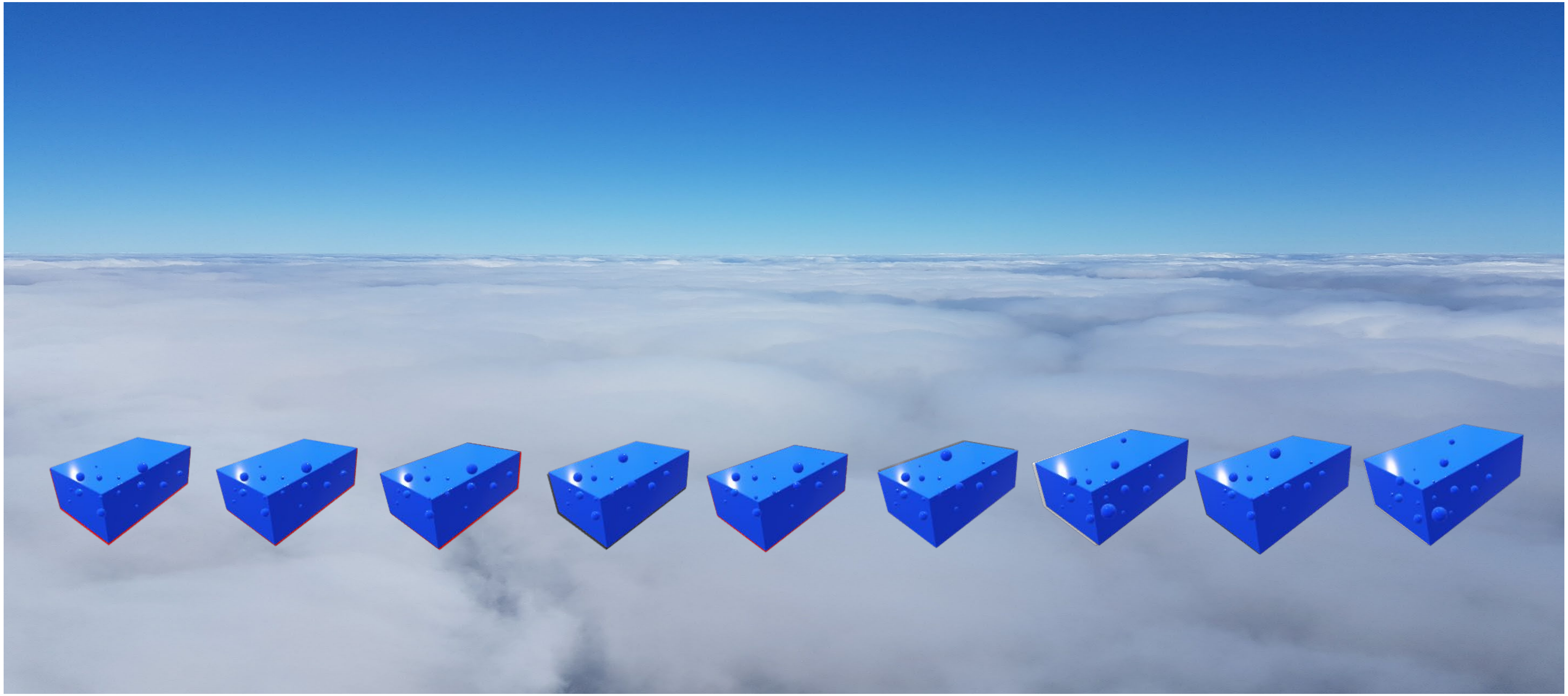



Local
PDF
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
Diameter (μm)

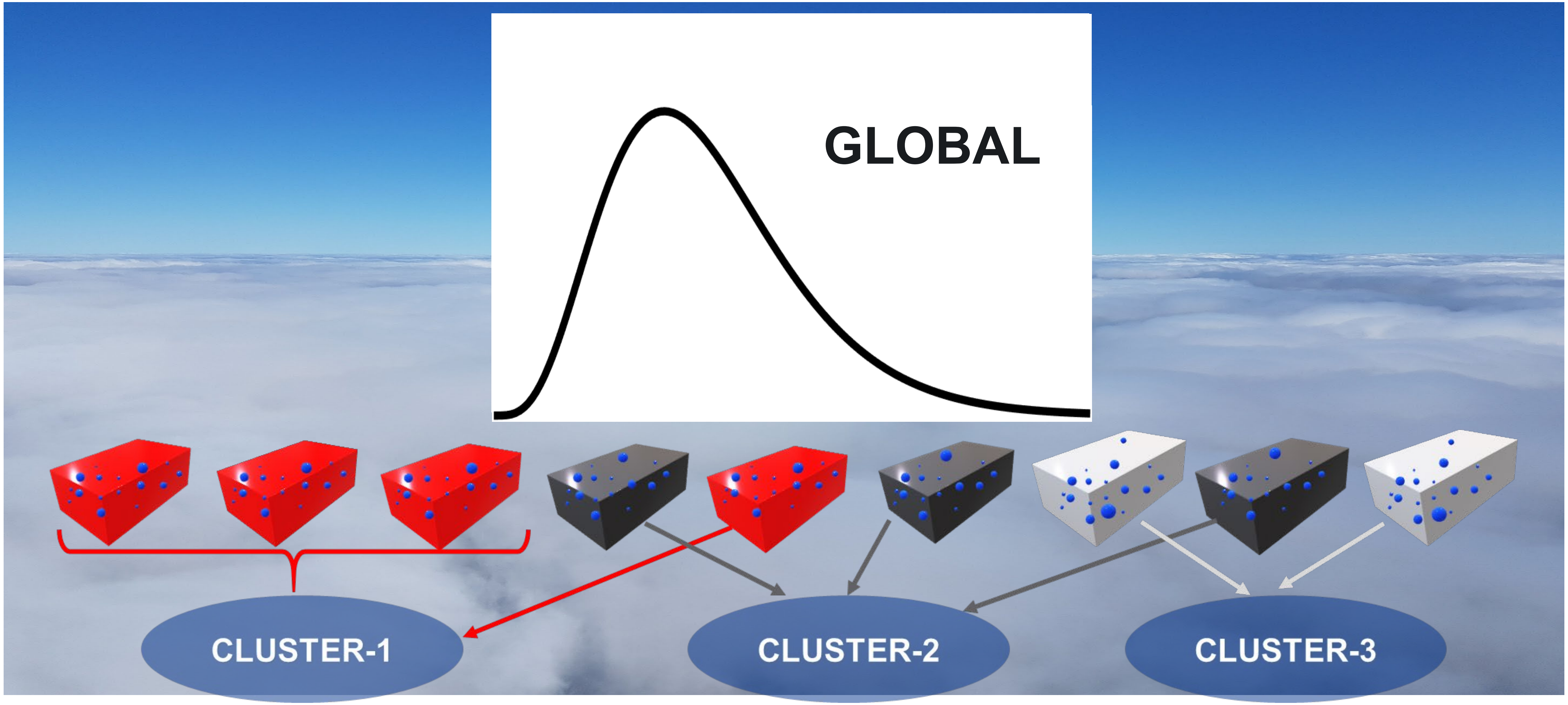
# Holographic Detector for Clouds  takes localized size distribution measurements as it cuts through a cloud



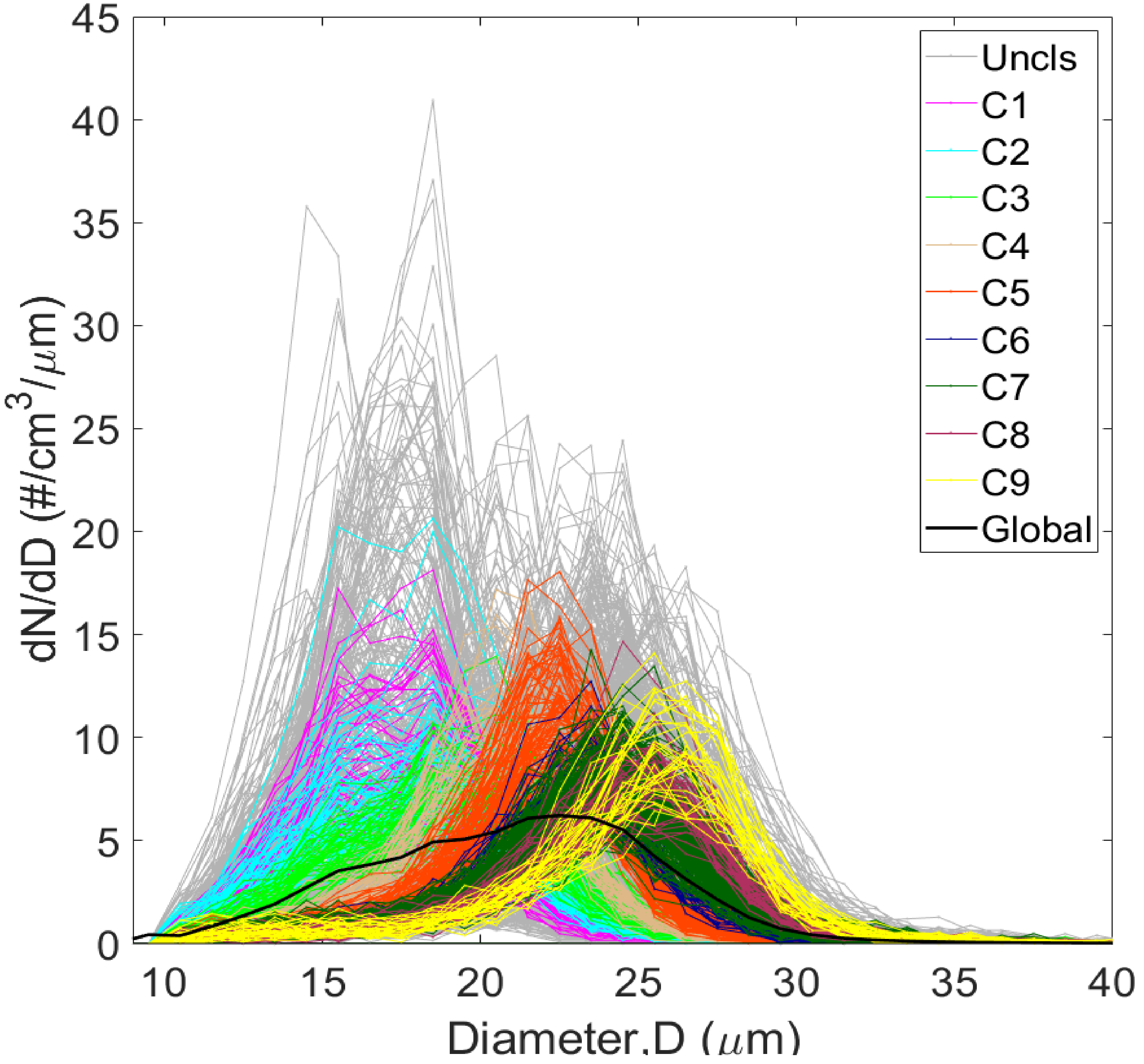
# What size distribution shapes can we expect in a cloud?



# Characteristic drop size distributions when combined give the averaged gamma like distribution



# Individual local cloud size distributions are narrow when compared to the segment-averaged global distribution and have distinct modes

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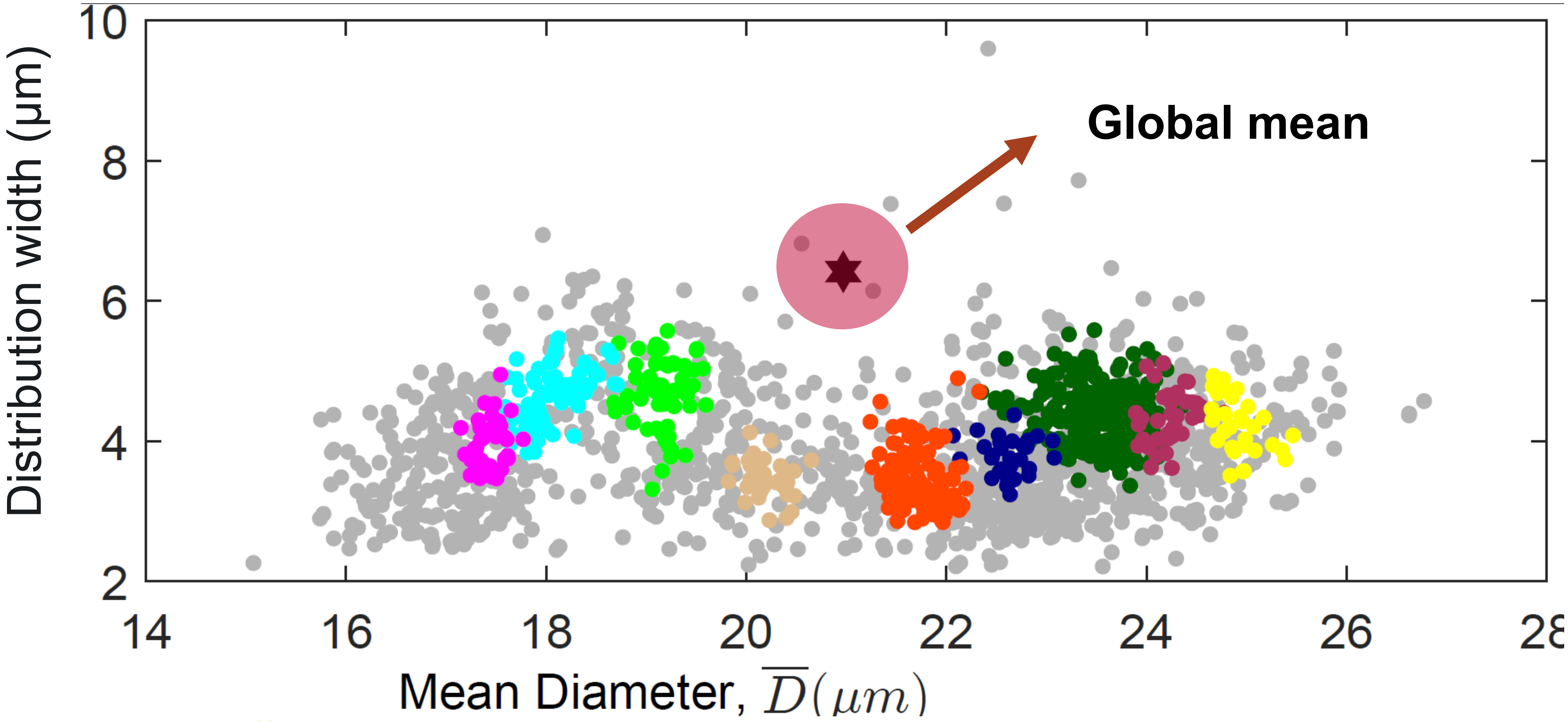
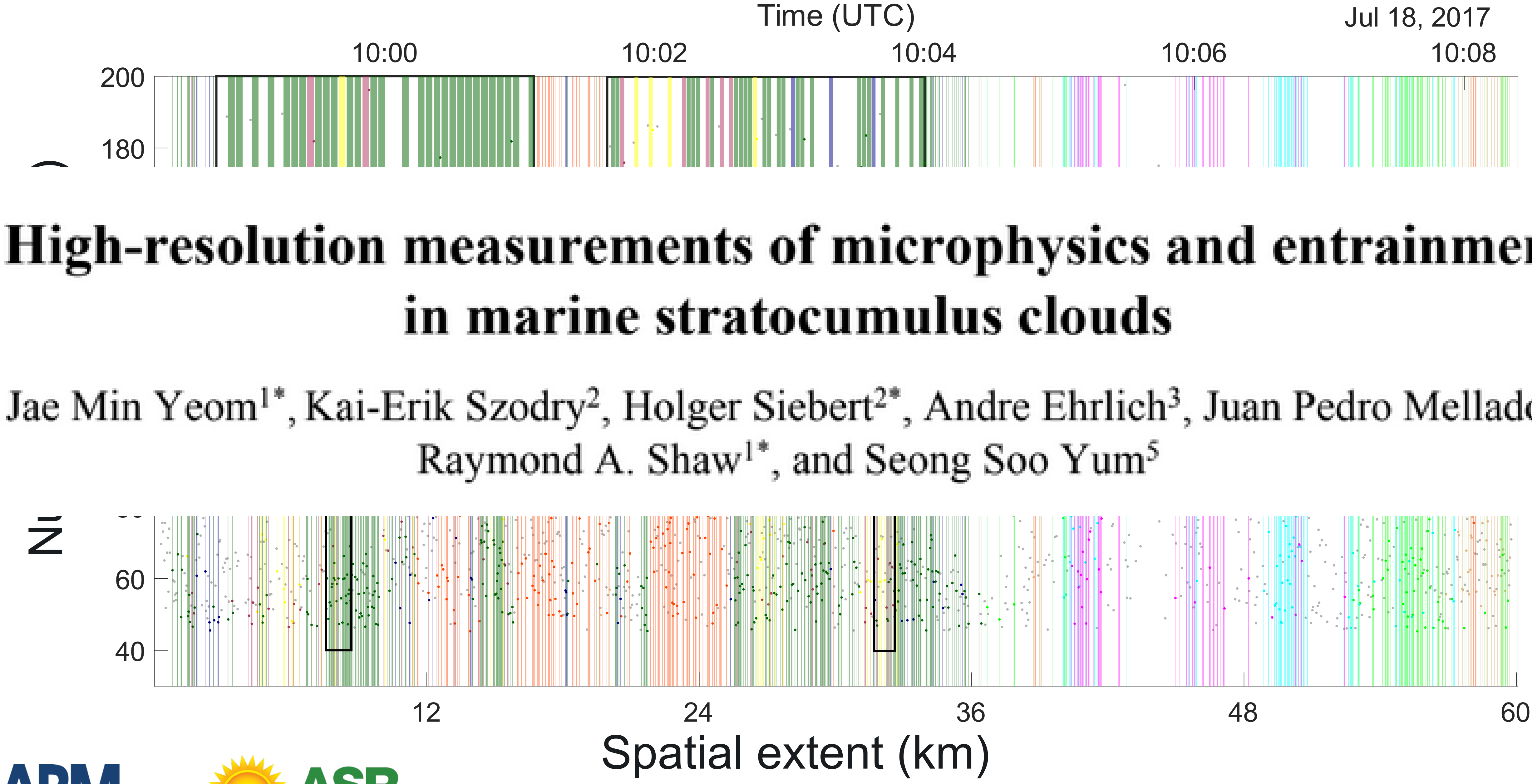
# The global mean and width are not representative of cloud structures at small scales



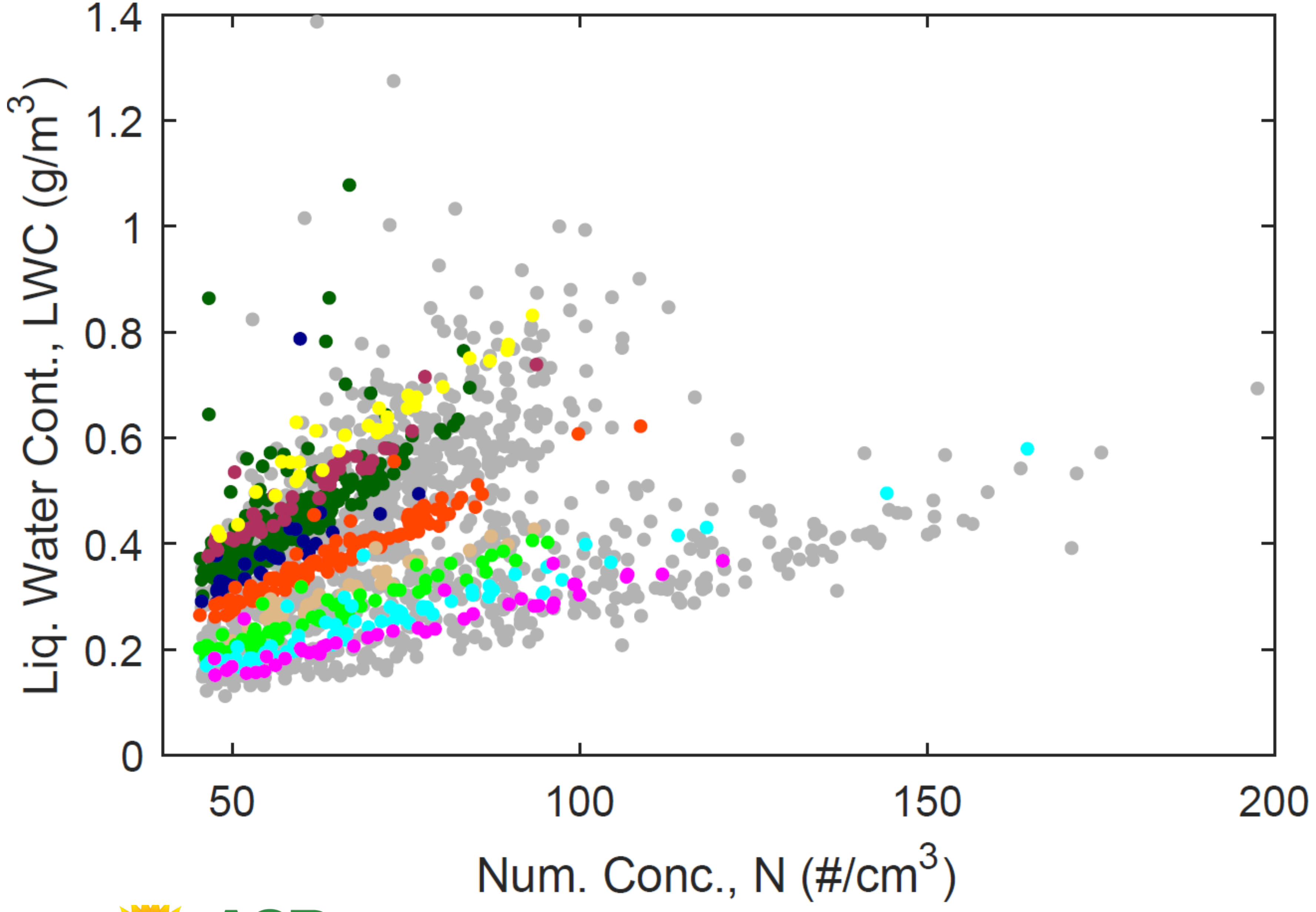
# These characteristic distributions tend to occur in blocks of successive holograms usually of order 1s to 10s of km




**High-resolution measurements of microphysics and entrainment in marine stratocumulus clouds**


Jae Min Yeom[1*], Kai-Erik Szodry[2], Holger Siebert[2*], Andre Ehrlich[3], Juan Pedro Mellado[4], Raymond A. Shaw[1*], and Seong Soo Yum[5]

# The linear reduction in liquid water content with number concentration suggests predominance of dilution by inhomogeneous mixing.




**LWC~ N x d$^3$**

**The slope is proportional to the mean diameter of the droplet size distribution**

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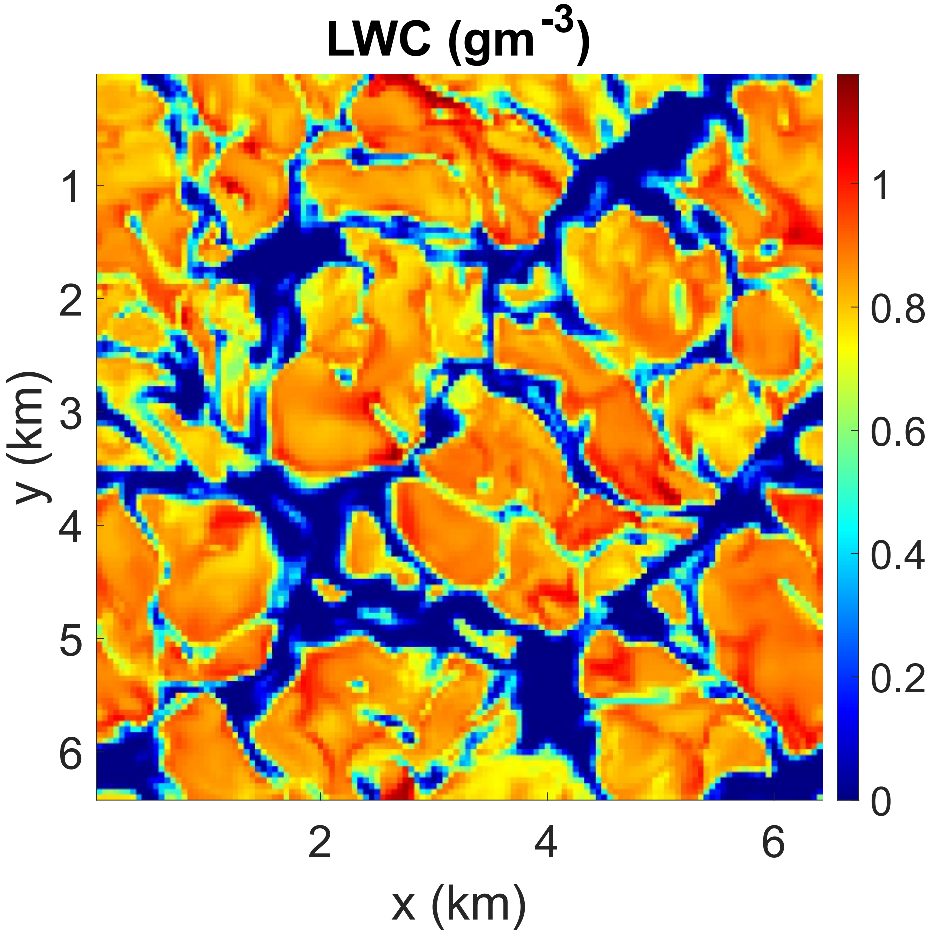
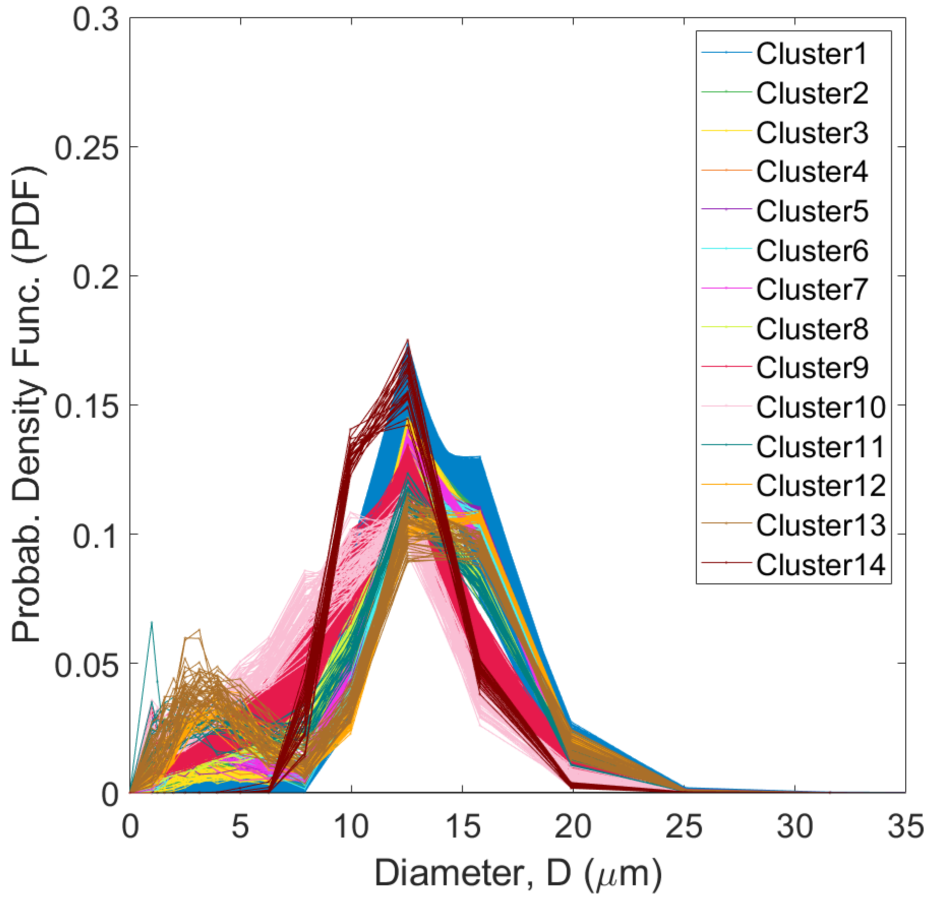
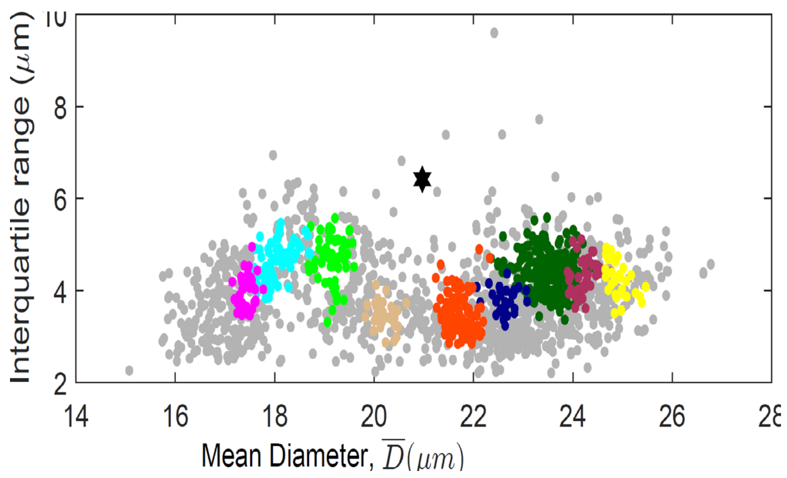
# Characteristic distribution shapes are also found for LES simulations(preliminary), however large-scale structure observed in ACE-ENA is notably absent

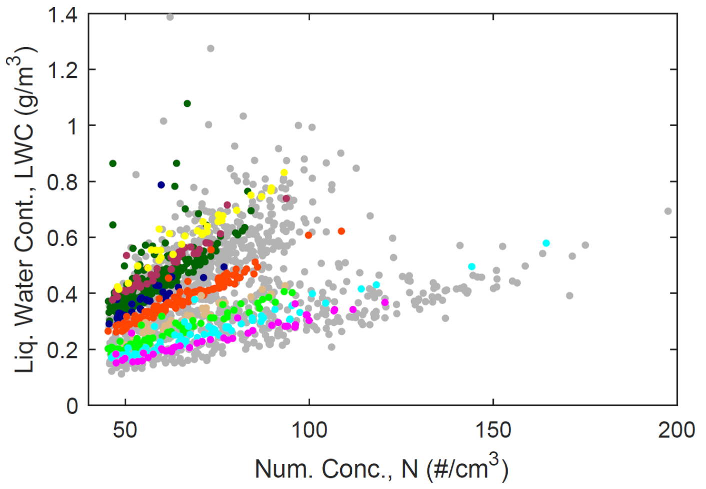


# Take home points

**Microphysical rates (like collision - coalescence) depend on local cloud properties, but the size distributions at that scale are always narrow. This implies that correlations not only in cloud droplet number concentration, but also droplet size distribution shape have to be accounted for in coarse resolution models.**




**The characteristic distributions tend to occur in spatial blocks of varying extent, usually of order 1s to 10s of km scaling with the size of the largest eddy.**
**These blocks may point to cloud parcels with common microphysical history that have been inhomogeneously mixed.**

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