Studies of Aerosol-Cloud Interactions with Observations and Cloud-Scale Simulations

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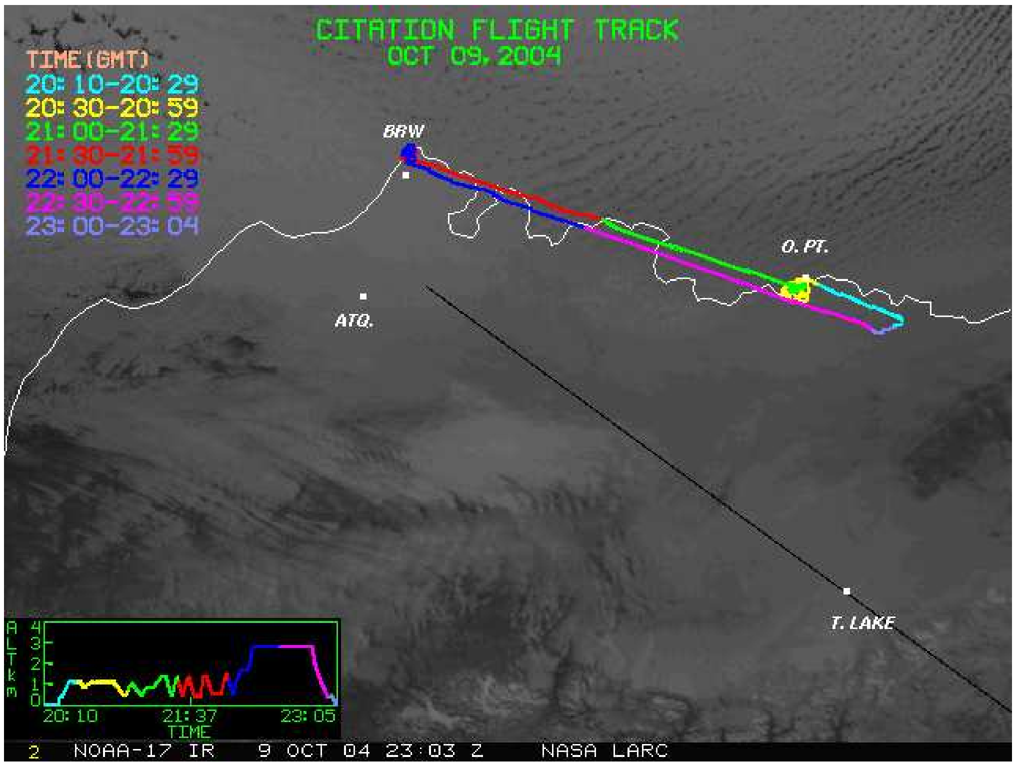
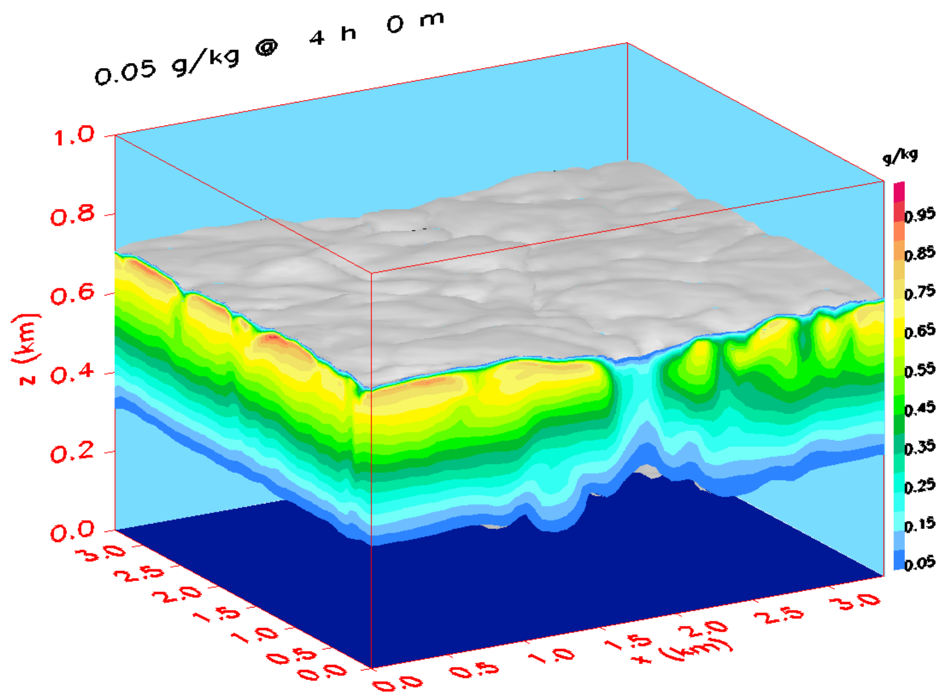
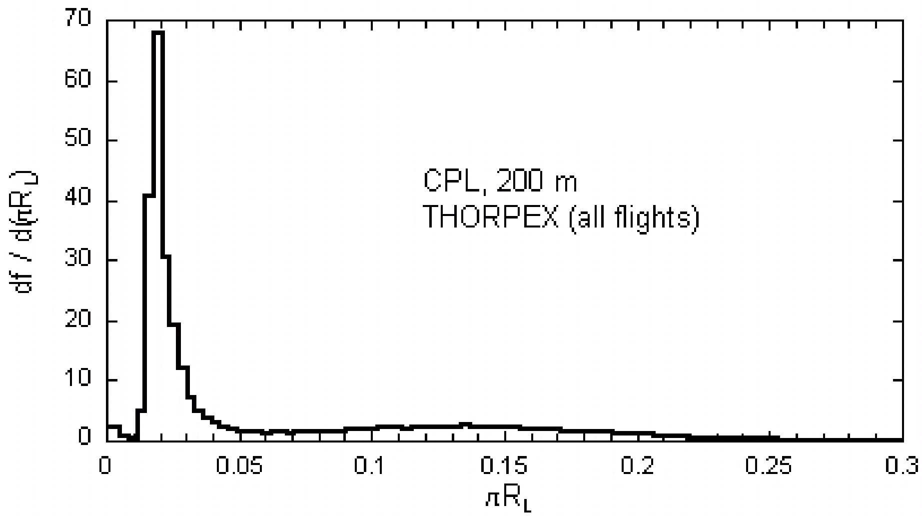
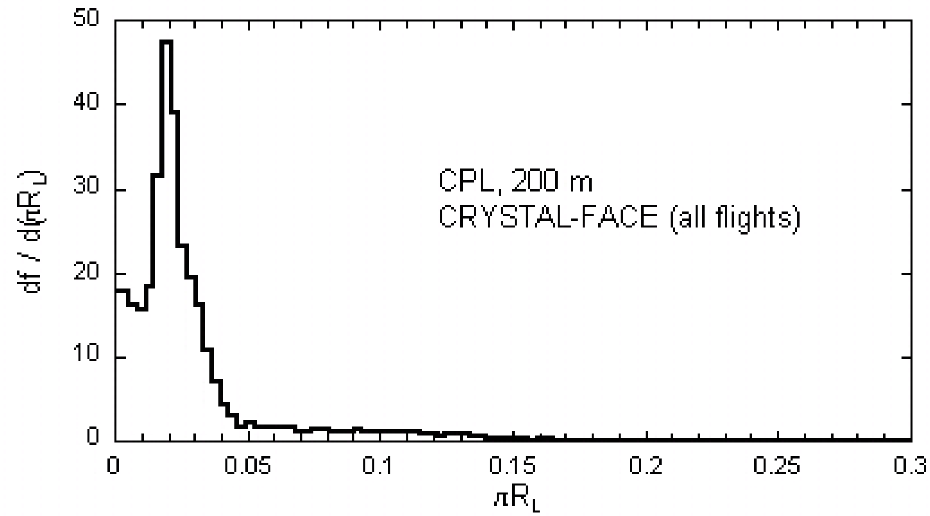


Source: *Patrick Minnis, NASA/LaRC*



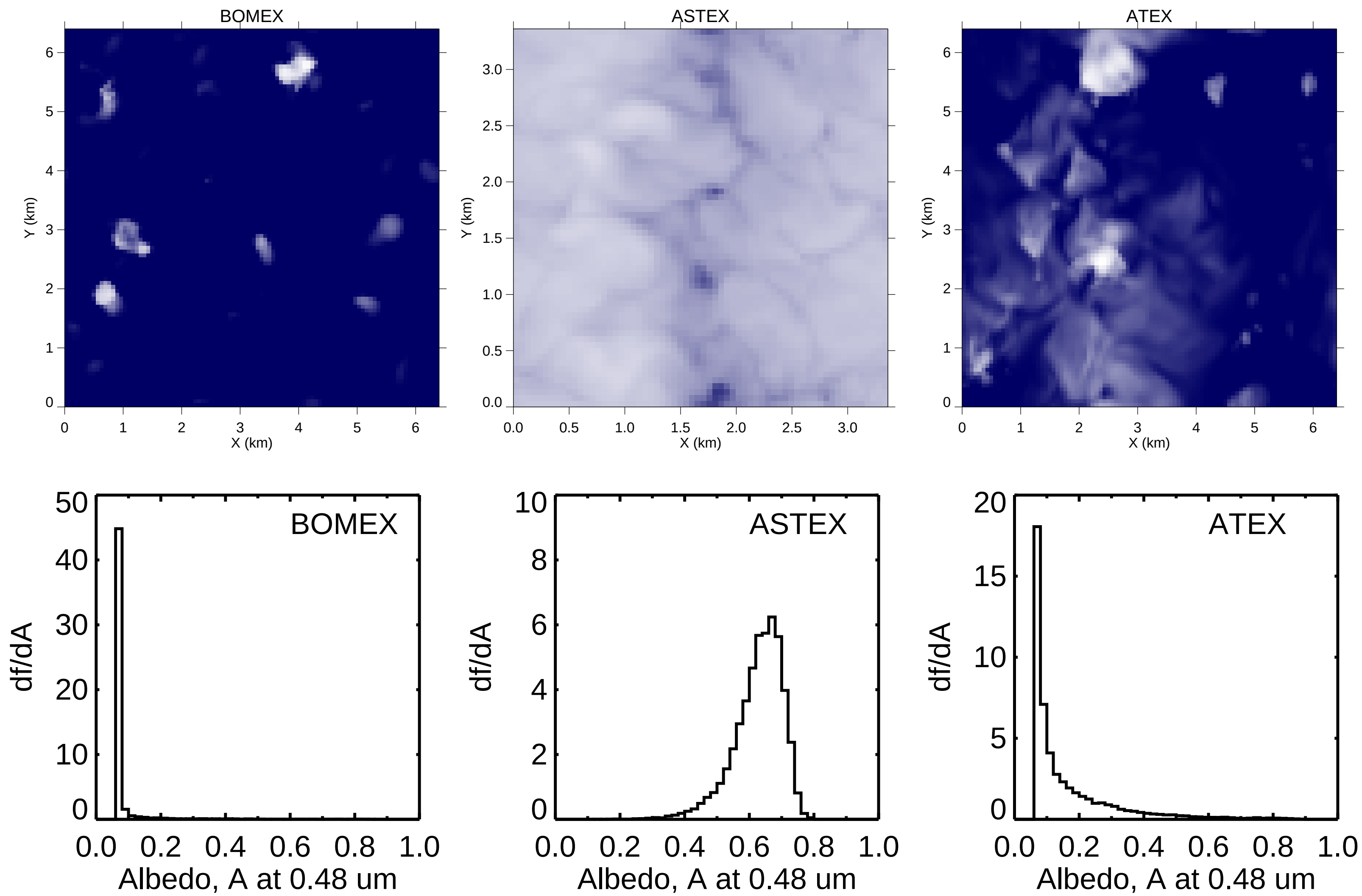
Distributions of Lidar Reflectivity Measured by Cloud Physics Lidar (CPL) over Marine Boundary Layer Warm Clouds





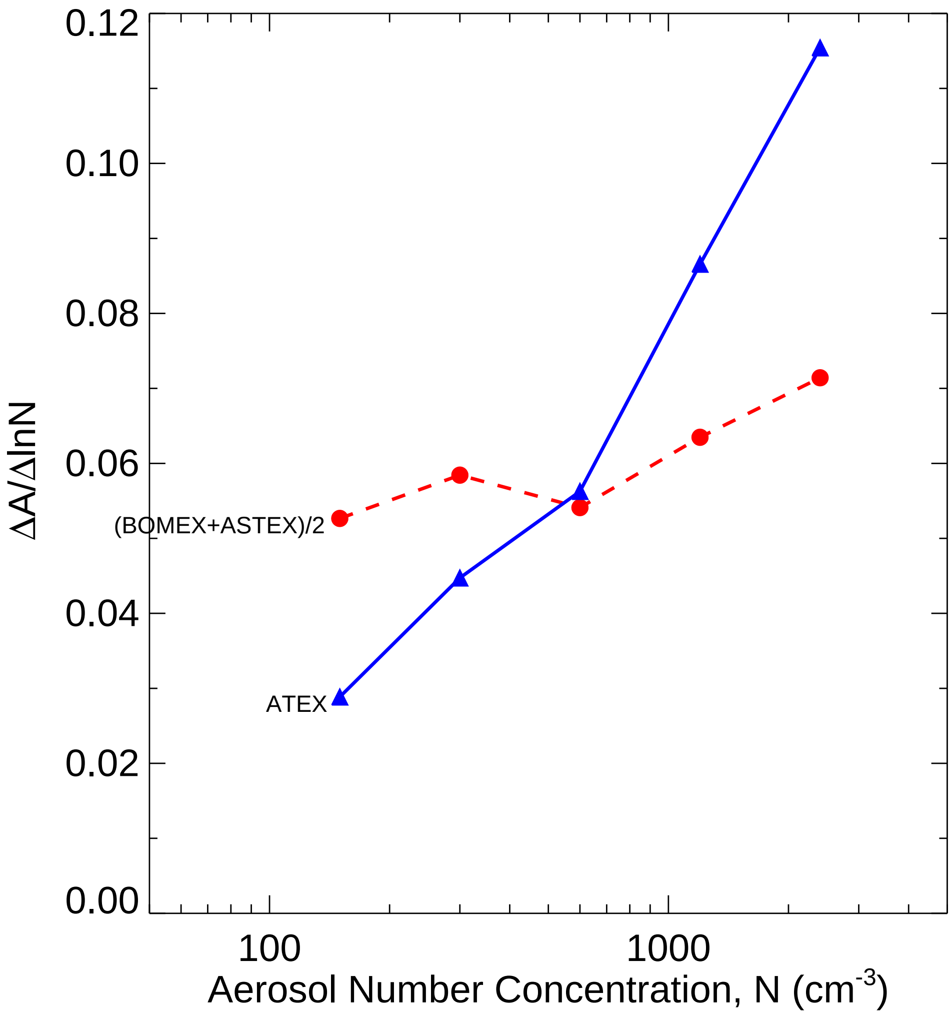
- Lidar reflectivity integrated over 0-5 km altitude
- Distribution does not show “Köhler gap” separating clouds from aerosol and gas
- Comparison by Tad Anderson et al. shows strong correlation between lidar reflectivity and colocated CERES albedo retrievals for warm clouds

Marine Boundary Layer Warm Clouds: Simulated Albedo Distributions



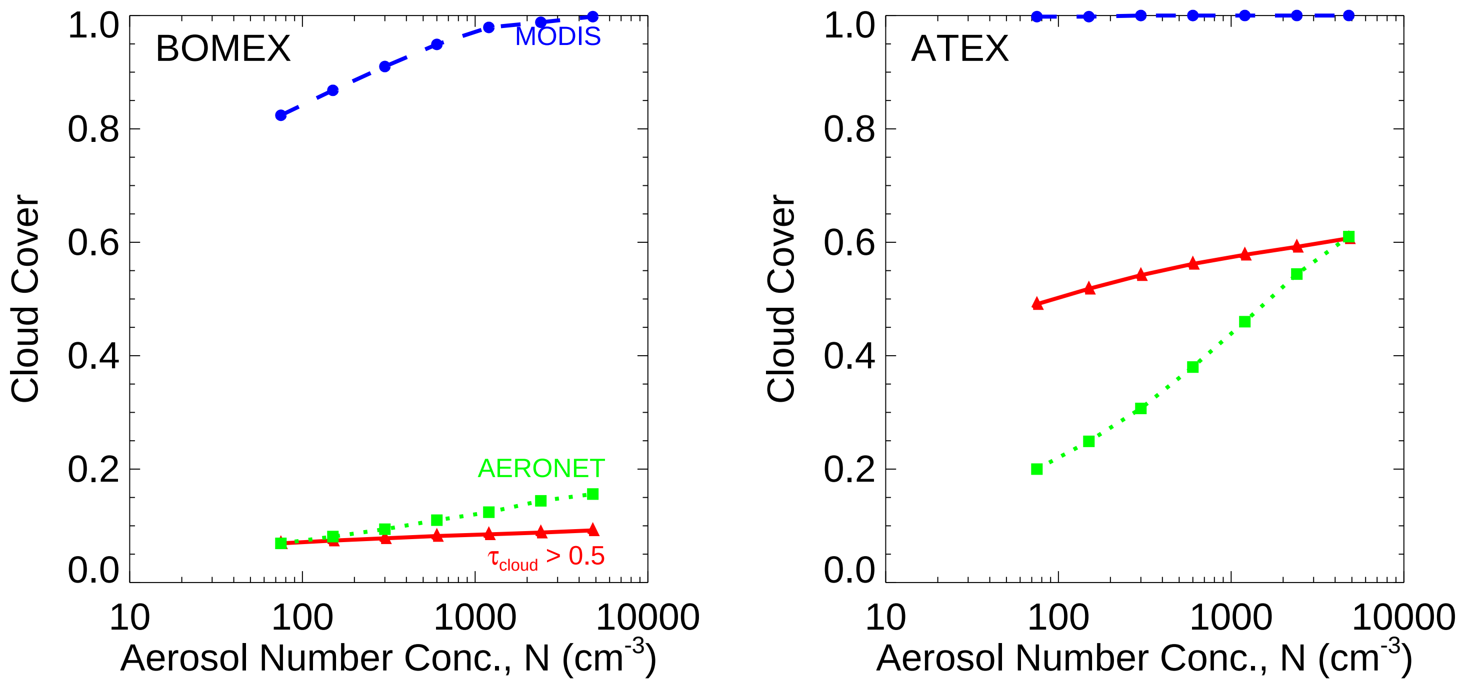
- Averaging nearly-clear and overcast looks nothing like broken sky cover distribution

Albedo Dependence on Aerosol Concentration for Broken Sky Cover



- Large-scale models combine clear and cloudy albedos for partly-cloudy skies
- Doing so can bias albedo dependence on N high or low

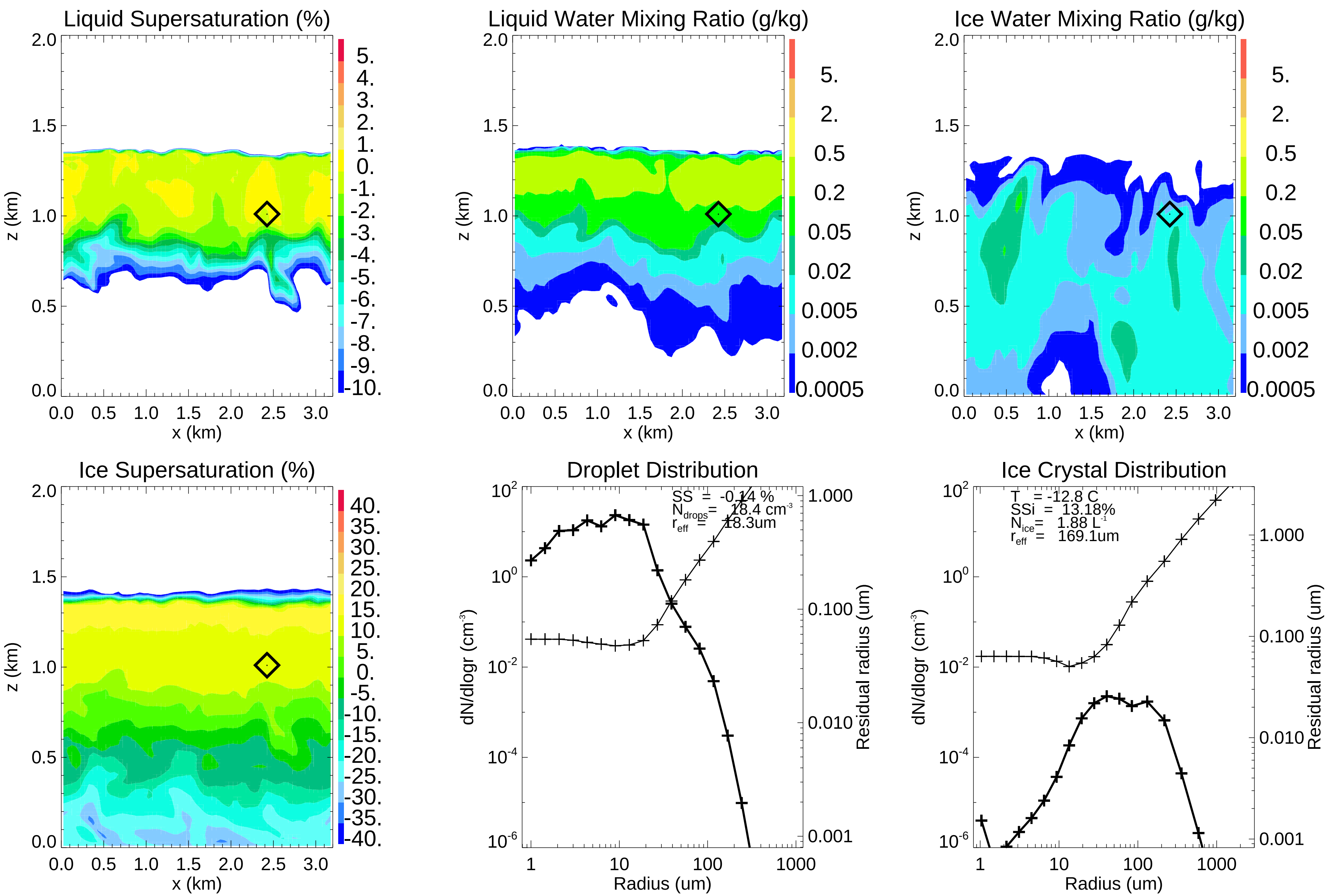
Emulation of MODIS and AERONET Cloud Filters



- Little to none of the cloud-free area survives MODIS filter used for aerosol retrievals $\Rightarrow$ aerosols actually colocated with clouds in correlation studies?

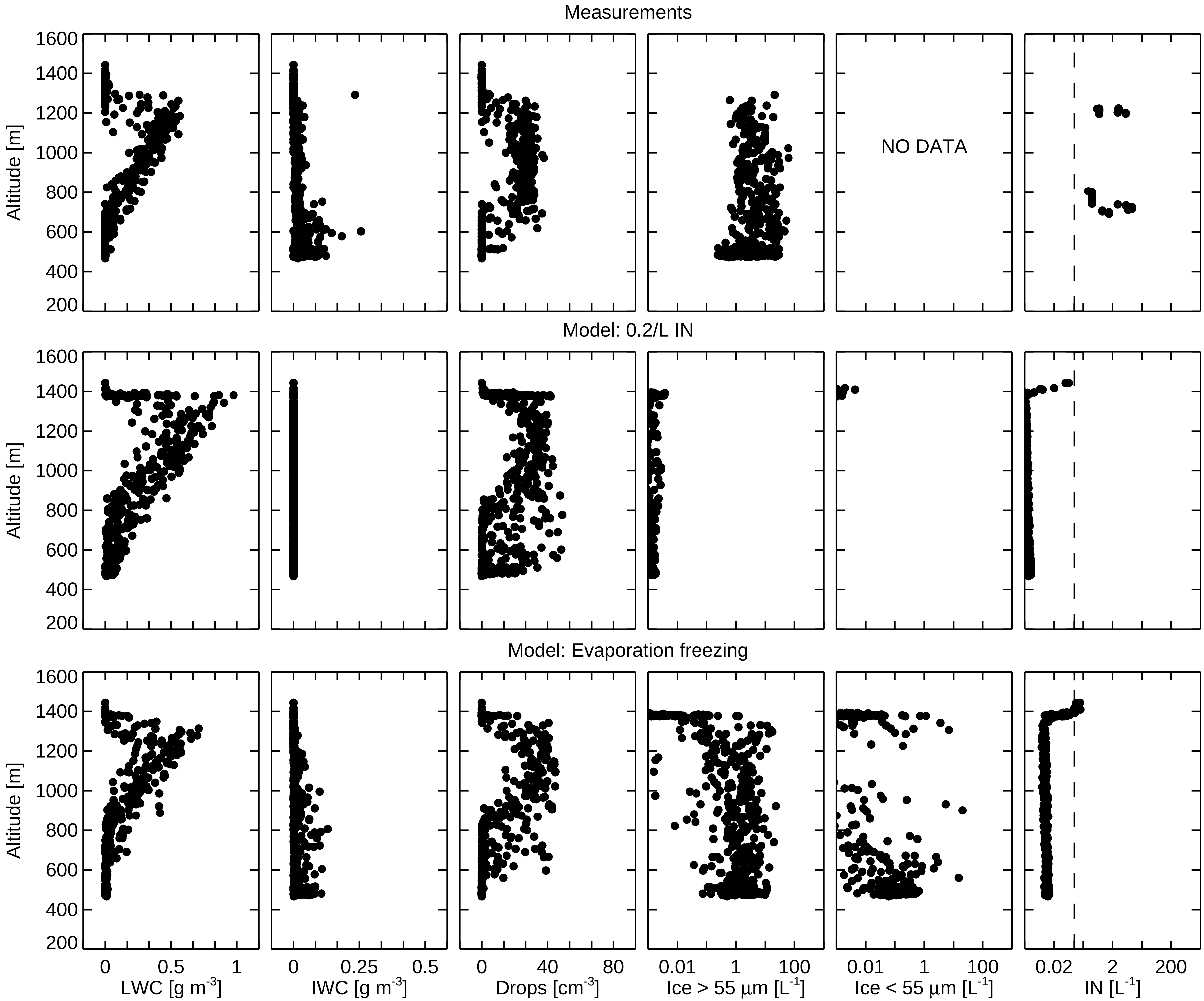
- Cloud cover dependence on aerosol exaggerated using AERONET filter, which mistakes thickening haze for increasing cloudiness

Simulations of Marine Boundary Layer Mixed-Phase Clouds

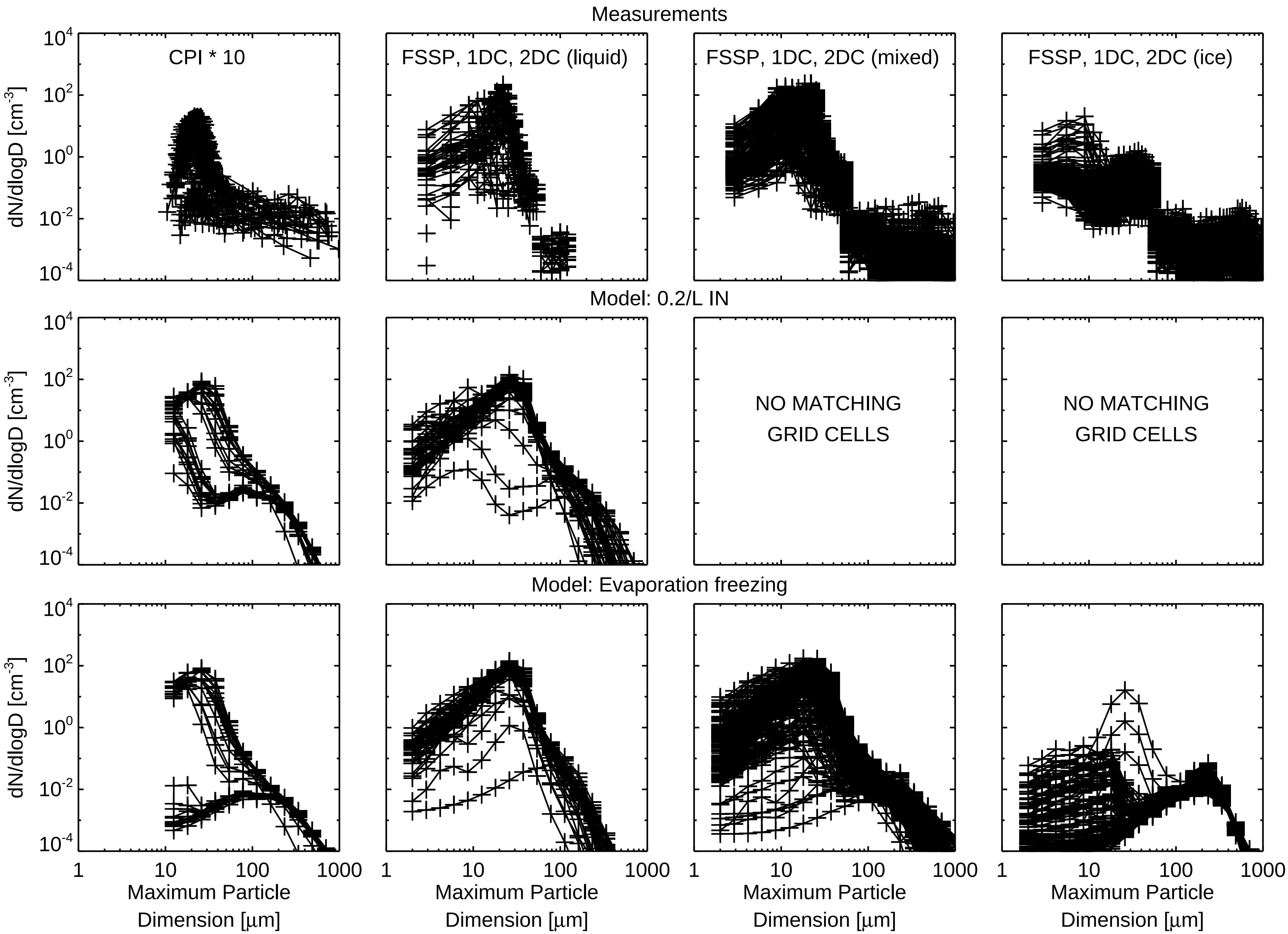


Model Description: Ice Formation

Mechanism	Temp, C	Supersat	Dependence	Description
Primary modes				
contact	$-4 > T > -14$	—	$f_{lin}(T)$	drop + $IN_{aer} \rightarrow$ ice
condensation	$-8 > T > -22$	$S_w < S$	$f_{lin}(T)$	$IN_{aer} \rightarrow$ ice
deposition	$-10 > T$	$S_i < S < 0.3$	$f_{exp}(S)$	$IN_{aer} \rightarrow$ ice
immersion	$-10 > T > -24$	—	$f_{lin}(T)$	drop + $IN_{drop} \rightarrow$ ice
Multiplication				
rime-splintering	$-3 > T > -8$	—	$f_{lin}(T)$	crystal per 250 collisions
drop shattering	$0 > T$	—	$D_{drop} > 50\ \mu m$	multiplication factor = 2
ice fragmentation	$0 > T$	—	$f_{lin}(\Delta mom^2)$	up to 20–60 fragments
Other processes				
evaporation nuclei	$0 > T$	$S < S_w$	—	$1/10^4$ drops $\rightarrow IN_{aer}$
charge enhancement	$0 > T$	—	$f(D_{drop})$	drop charge retained
evaporation freezing	$0 > T$	$S < S_w$	—	‘some’ drops ‘just freeze’



Measurements
Model: 0.2/L IN
Model: Evaporation freezing
NO DATA
Altitude [m]
200
400
600
800
1000
1200
1400
1600
0
0.5
1
LWC [g m^{-3}]
0
0.25
0.5
IWC [g m^{-3}]
0
40
80
Drops [cm^{-3}]
0.01
1
100
Ice > 55 μm [L^{-1}]
0.01
1
100
Ice < 55 μm [L^{-1}]
0.02
2
200
IN [L^{-1}]



Measurements
CPI * 10
FSSP, 1DC, 2DC (liquid)
FSSP, 1DC, 2DC (mixed)
FSSP, 1DC, 2DC (ice)
Model: 0.2/L IN
NO MATCHING GRID CELLS
NO MATCHING GRID CELLS
Model: Evaporation freezing
dN/dlogD [cm⁻³]
Maximum Particle Dimension [μm]
1
10
100
1000