The Aerosol Dependence of Ice Generation in Stratiform Mixed-phase Cloud as Observed from Remote Sensing

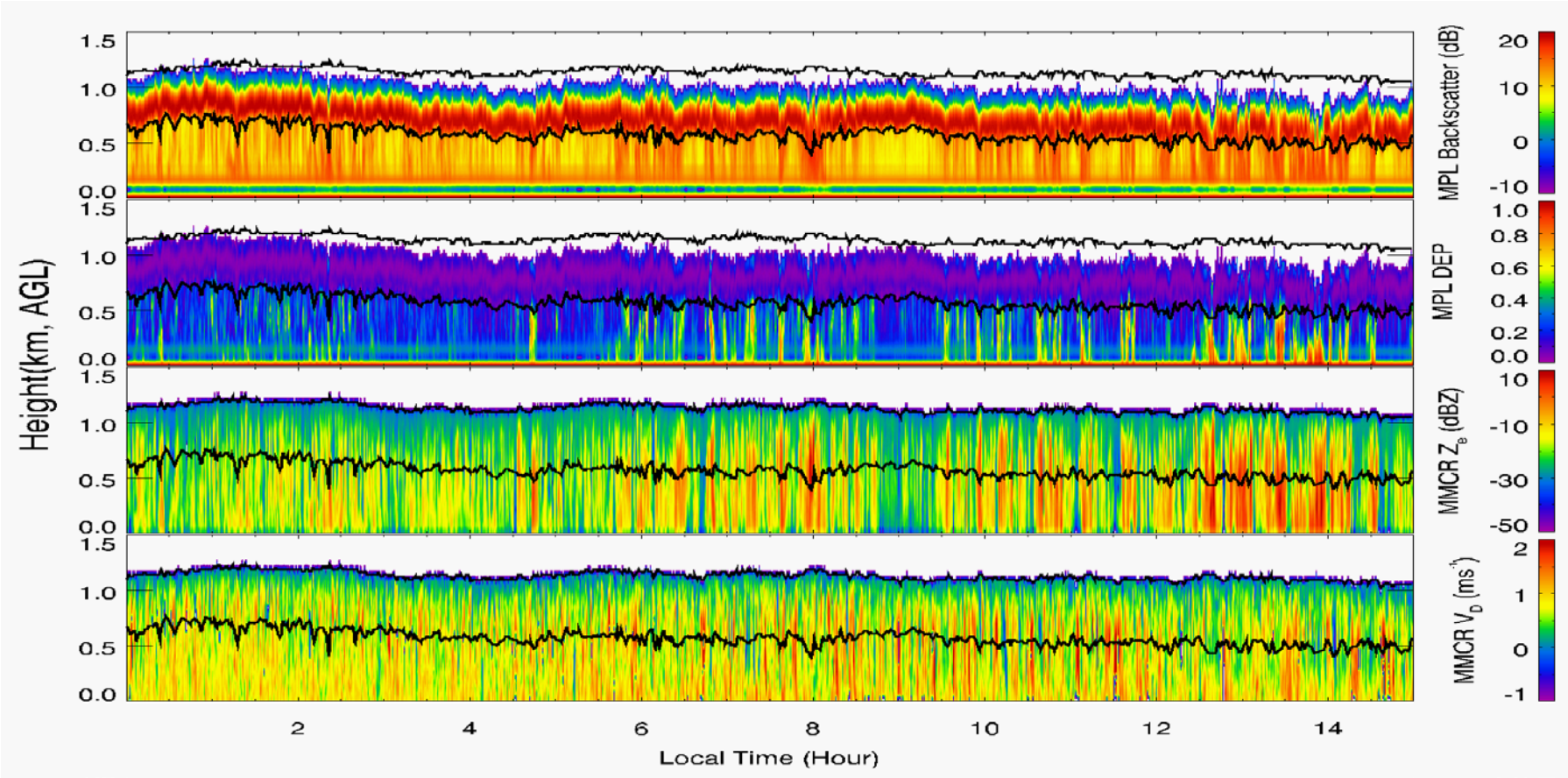
Zhien Wang, Damao Zhang, Tao Luo and Min Deng, *University of Wyoming*

Andy Heymsfield, *NCAR*

Jiwen Fan, *PNNL*

Dong Liu, *CAS*, *Hefei*, *China*

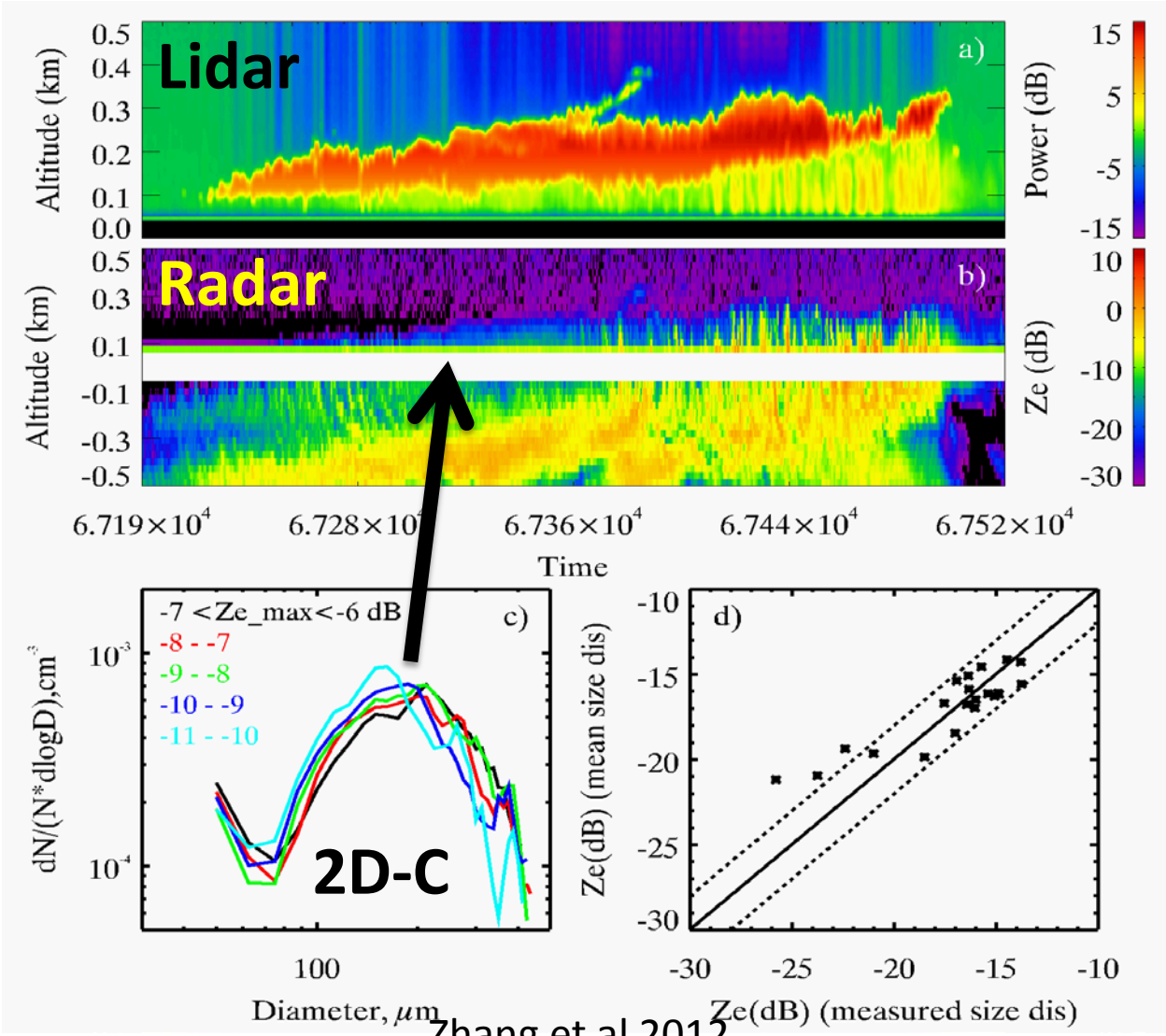
Stratiform Mixed-phase Clouds for Ice Generation Studies



Ice generation in Convective clouds– a totally different animal; limited contribution from lidar and radar

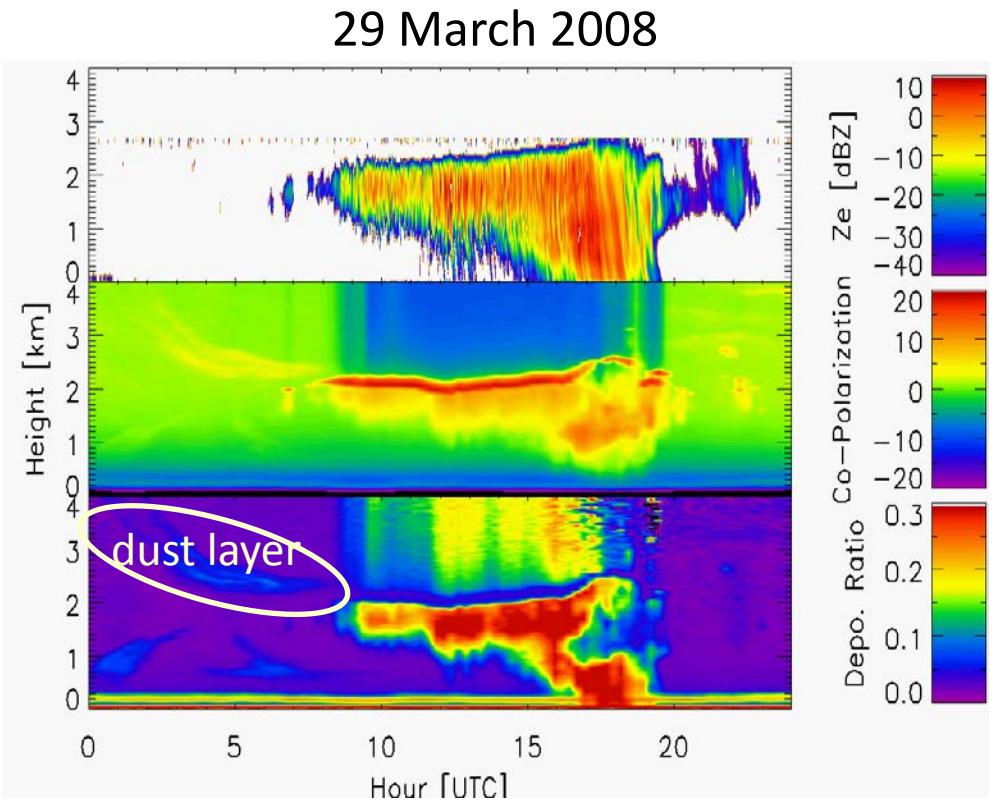
The Similarity of Ice Crystal Size Distribution in Similar Mid-level Stratiform Clouds

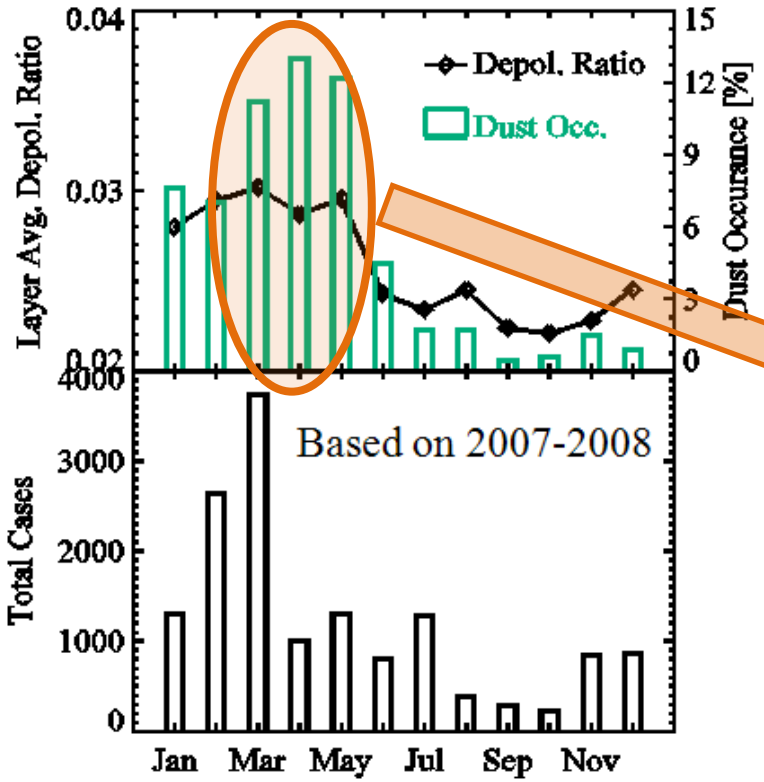
Similar clouds in terms of cloud top temperature (CTT) and LWP.

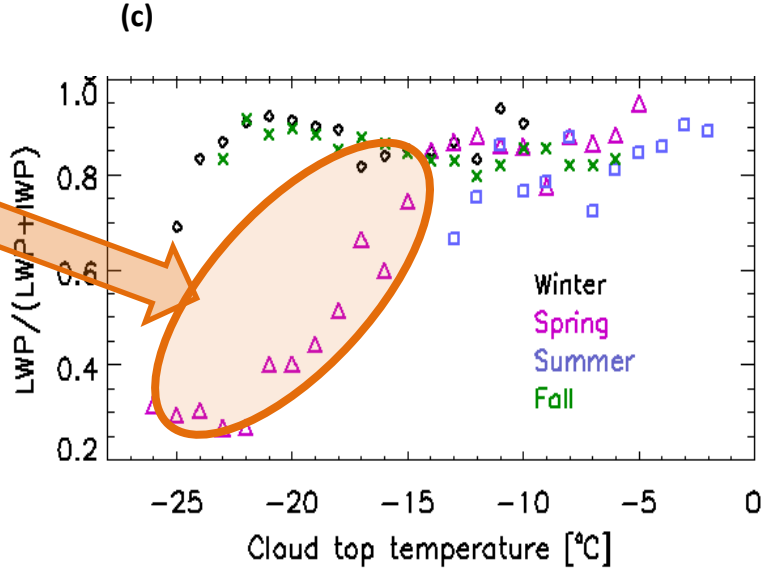


Zhang et al 2012

Spring time High Dust Occurrence is one of the potential reasons!

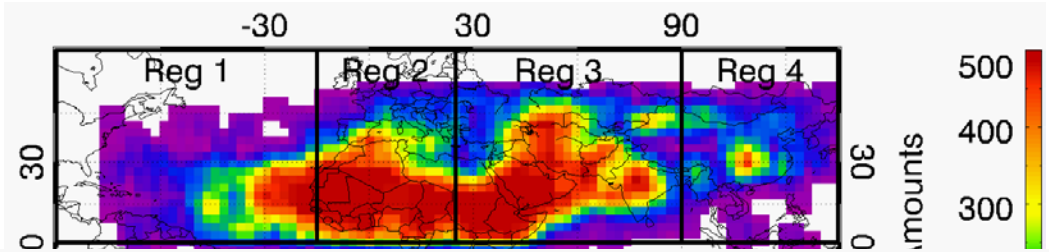


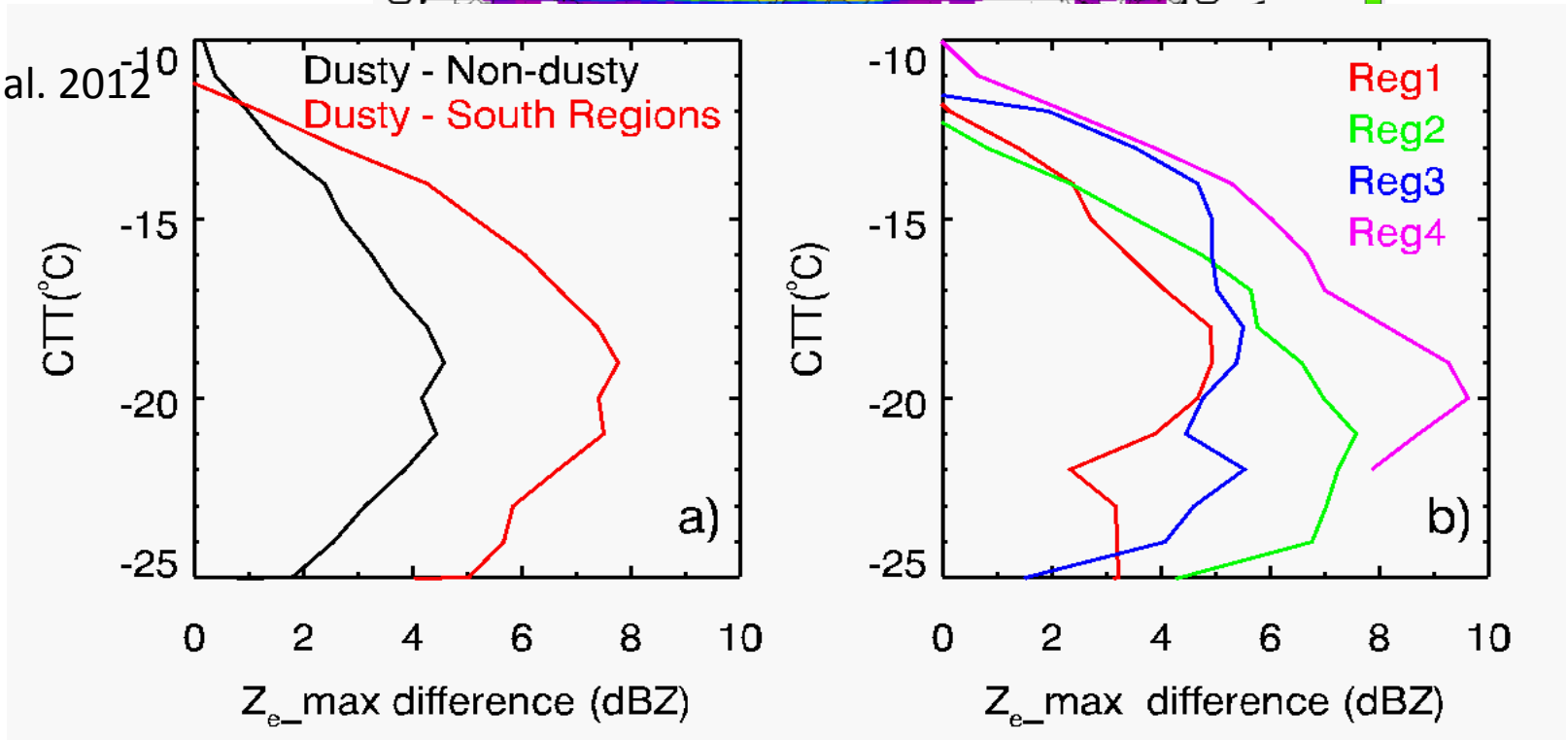




Regional Differences of the Dust Impact

Zhang et al. 2012





8 dBZ → factor of ~7

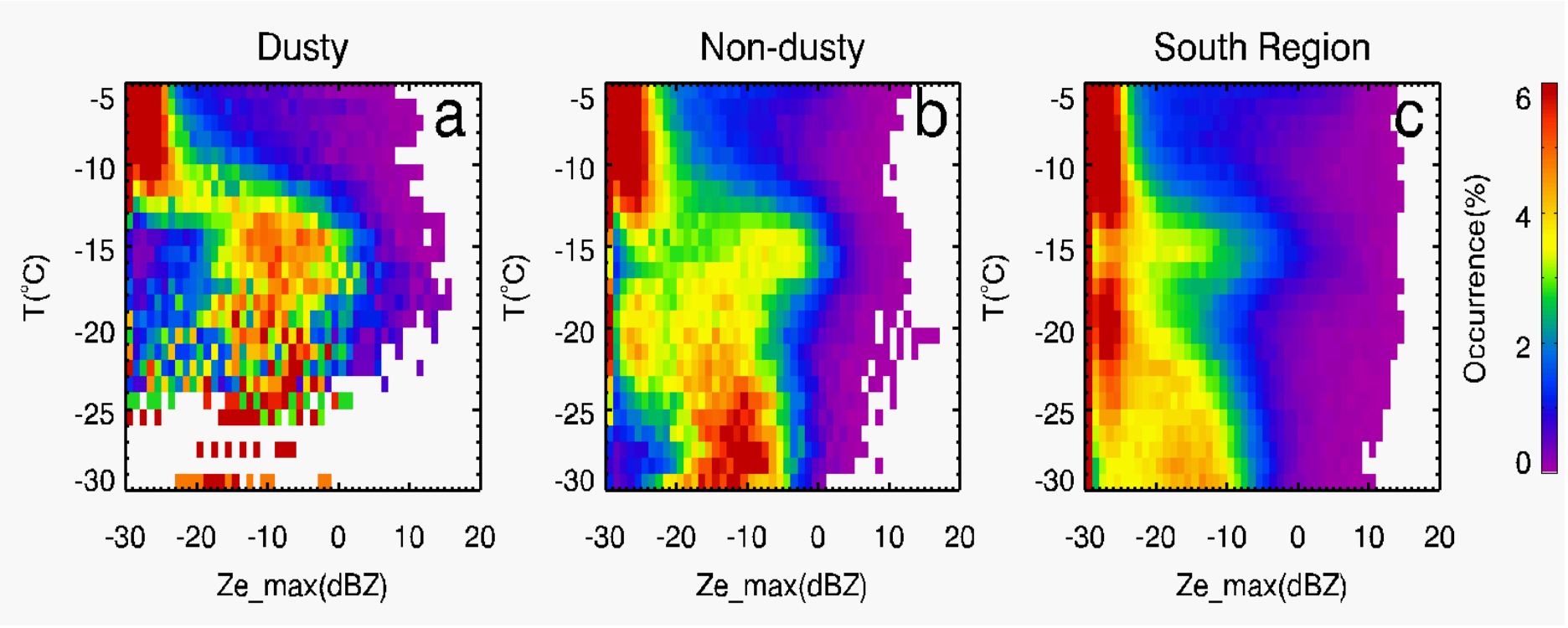
5 dBZ Peak difference!

(a) Z_e_max differences between dusty, non-dusty and 'South Regions' MSCs in terms of CTT; (b) Z_e_max differences between dusty and 'South Regions' MSCs for the four sub-regions.

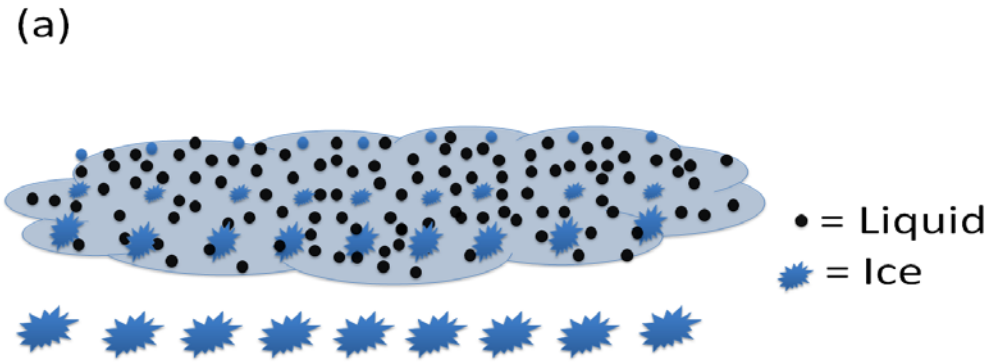
Relative variation is not enough!

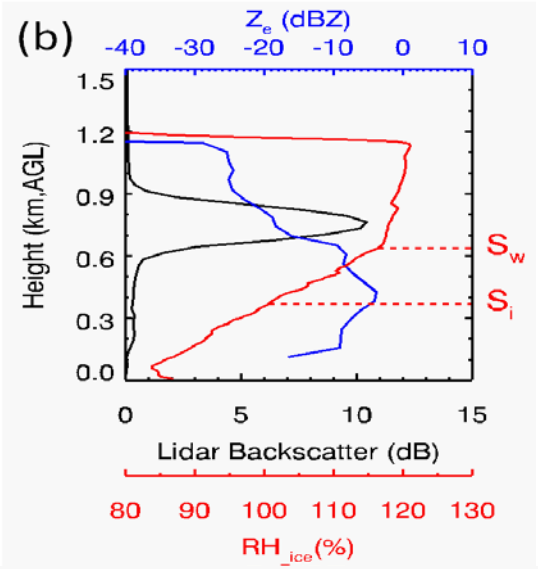
Ze_max → N_ice

Link N_ice with aerosols

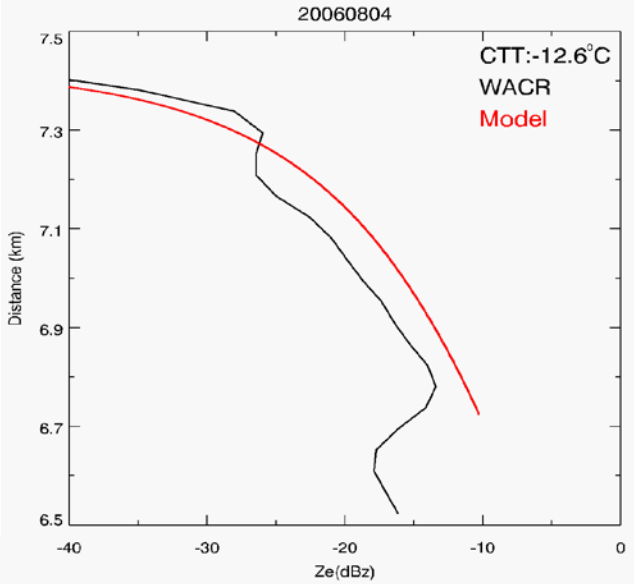


A simple ice growth model in stratiform mixed-phase clouds





- **Temperature dependent shapes**
- **Shape and size dependent falling speed**
- **Thermodynamic environment conditions determined by cloud top temperature and LWP**
- **Given vertical velocity**
- **Diffusion growth and riming growth**

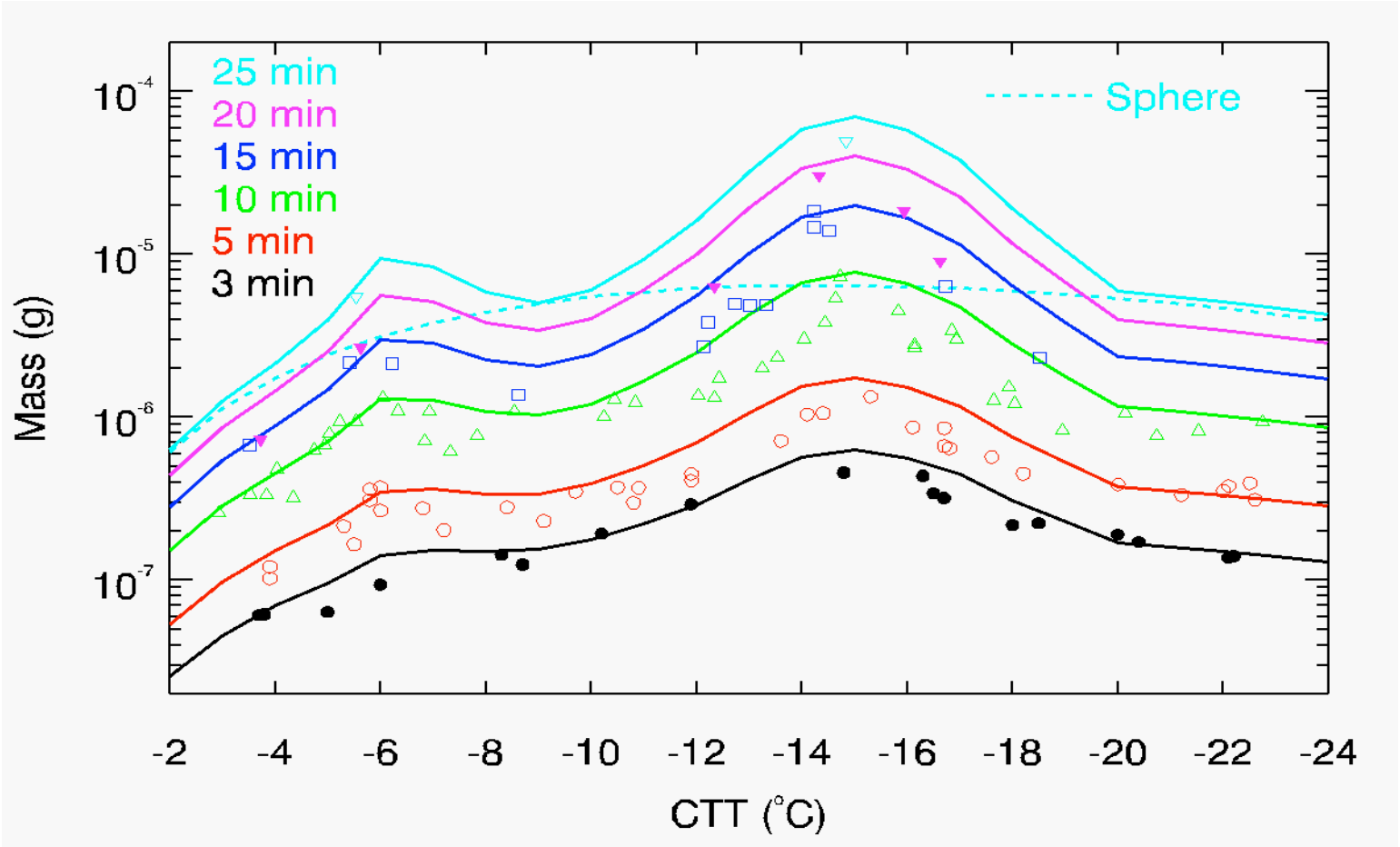


Two-step evaluations

- Evaluate modeled Ze profile – can we model the growth of ice crystals in stratiform mixed-phase clouds?

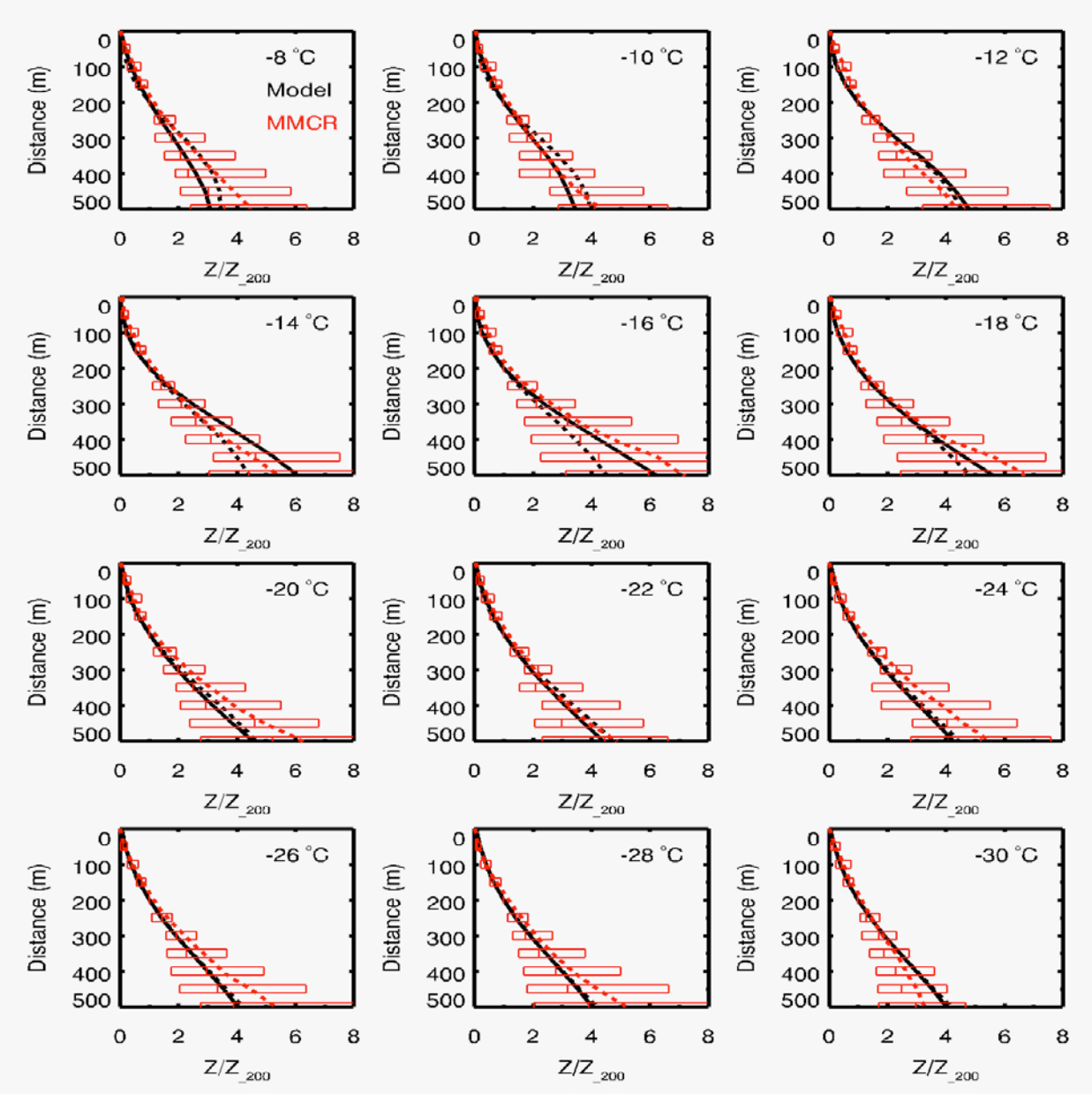
- Compare retrieved ice concentration with in situ observations

Limited lab data for evaluation

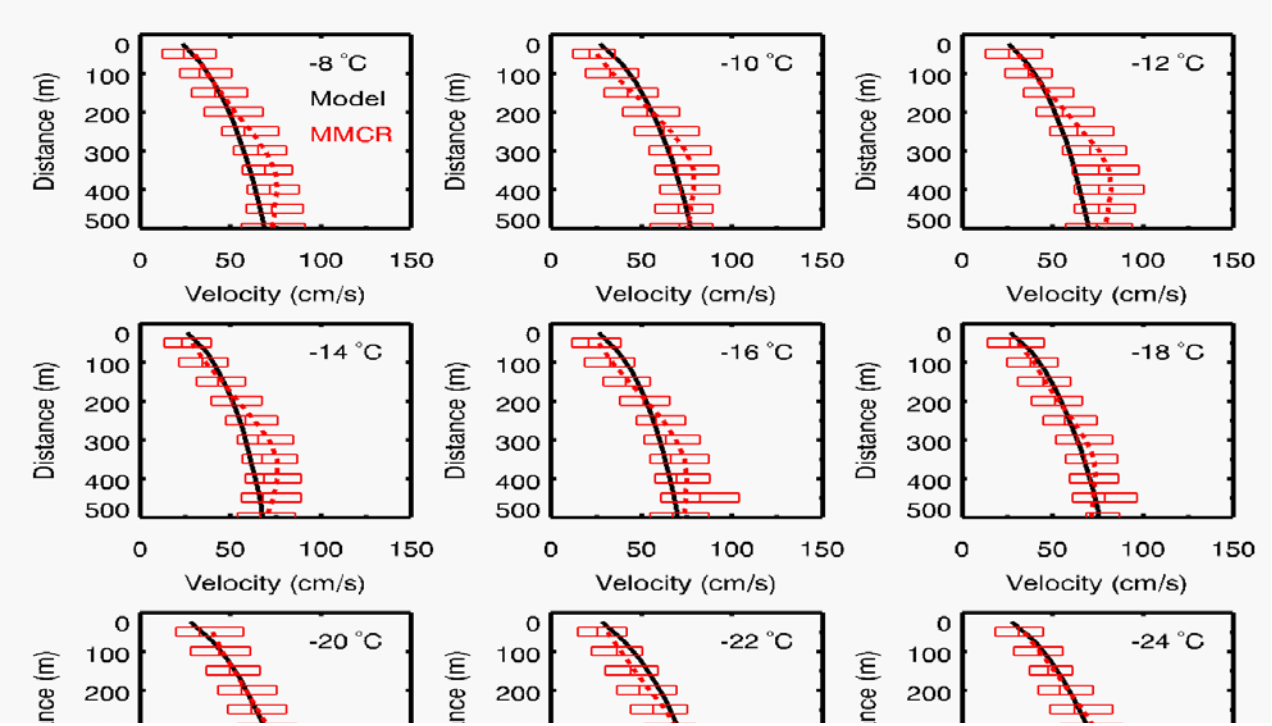


Wind tunnel measurements from *Takahashi et al [1991]* are plotted with different signs for comparisons .

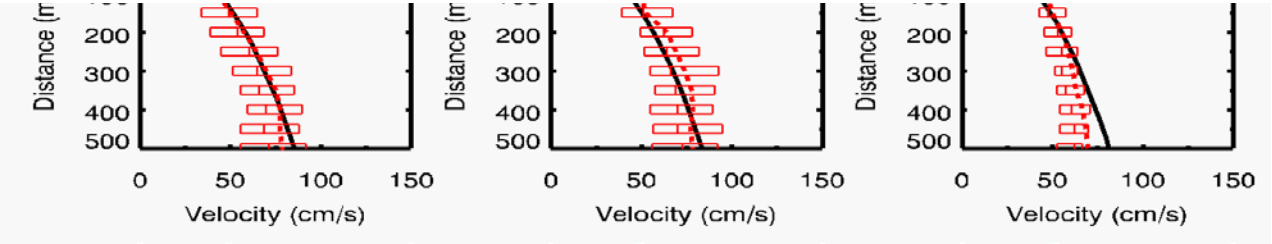
Ze Comparison with MMCR Data at NSA



Doppler Velocity Comparison with MMCR Data at NSA

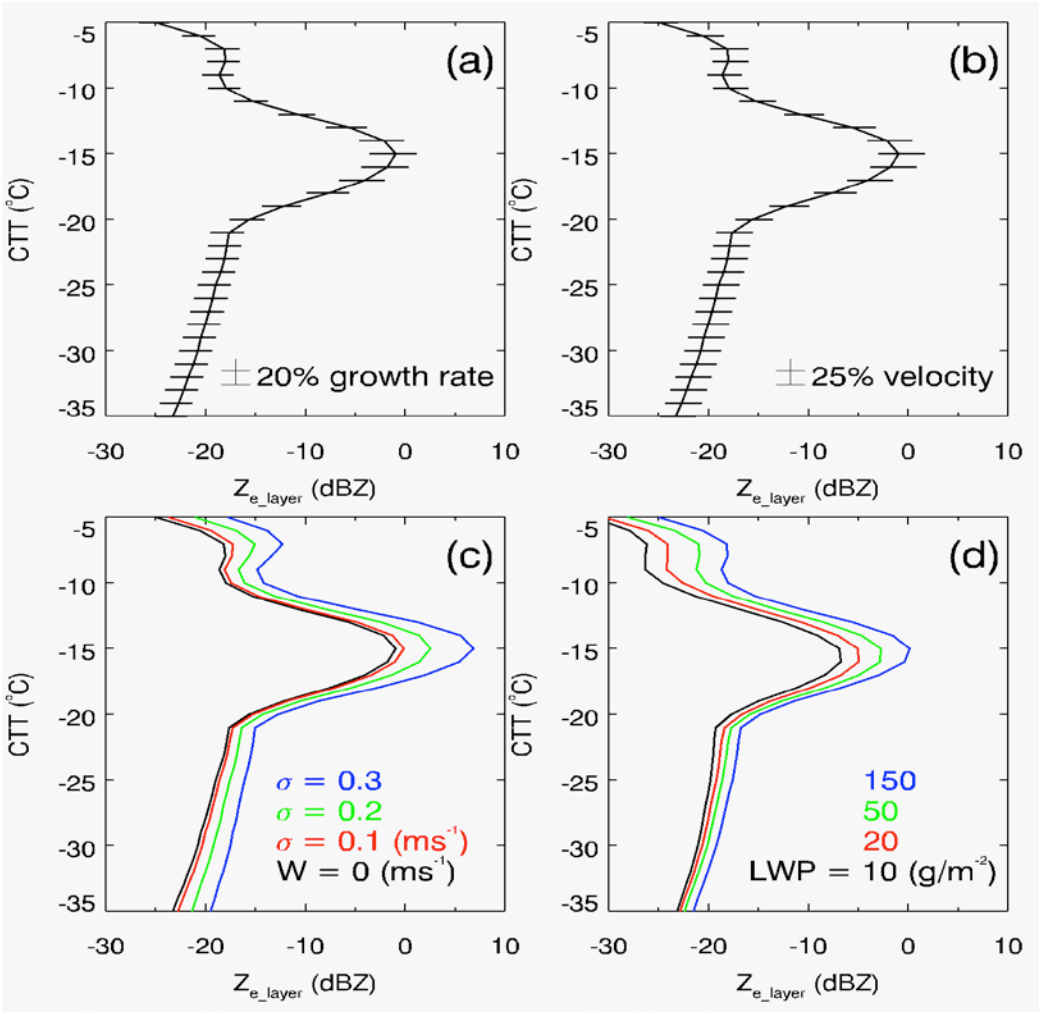


Model simulations compare well with MMCR observations statistically.

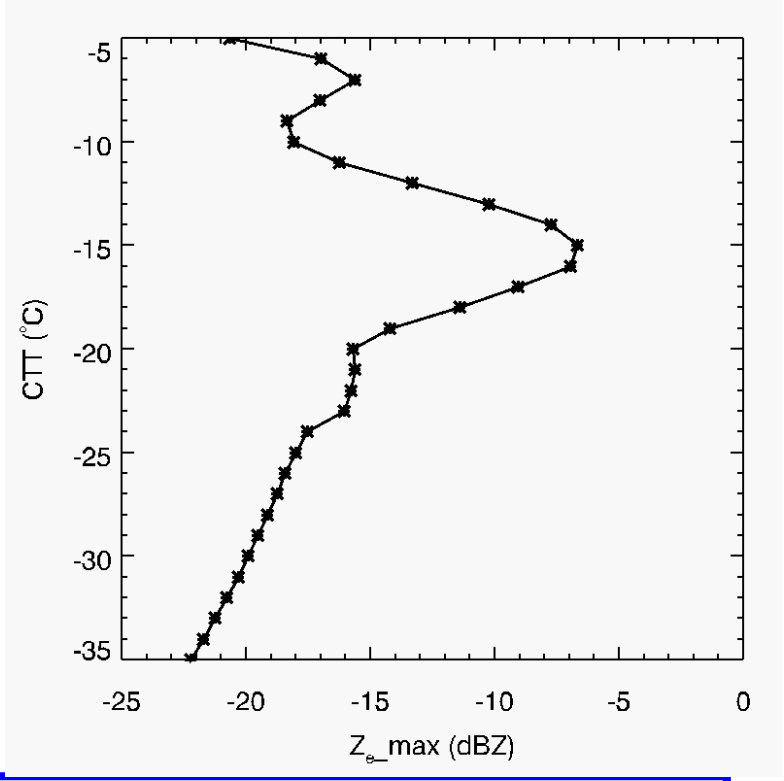


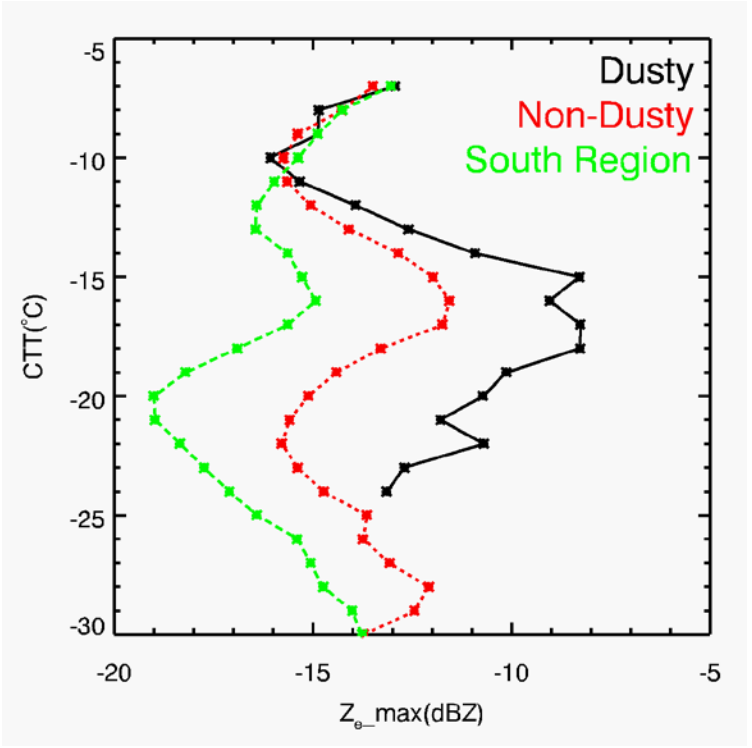
Sensitivities to Input Parameters

- Use in situ observations to better set updraft speed distributions.
- LWP as an input of the retrieval.



From Maximum Z_e to Ice Number Concentration





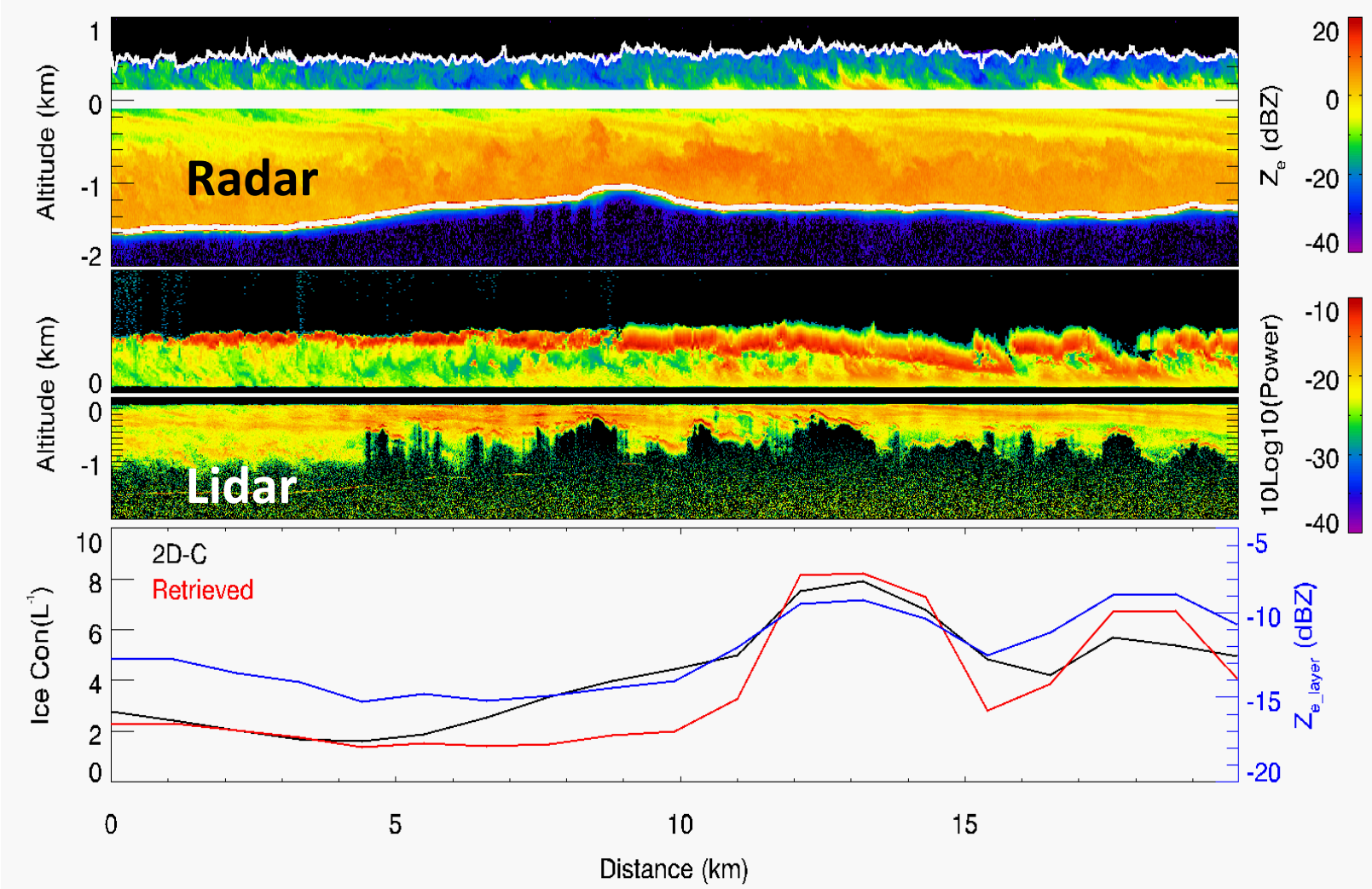
Modeled Z_e with 1 per liter ice concentration

Observed Z_e

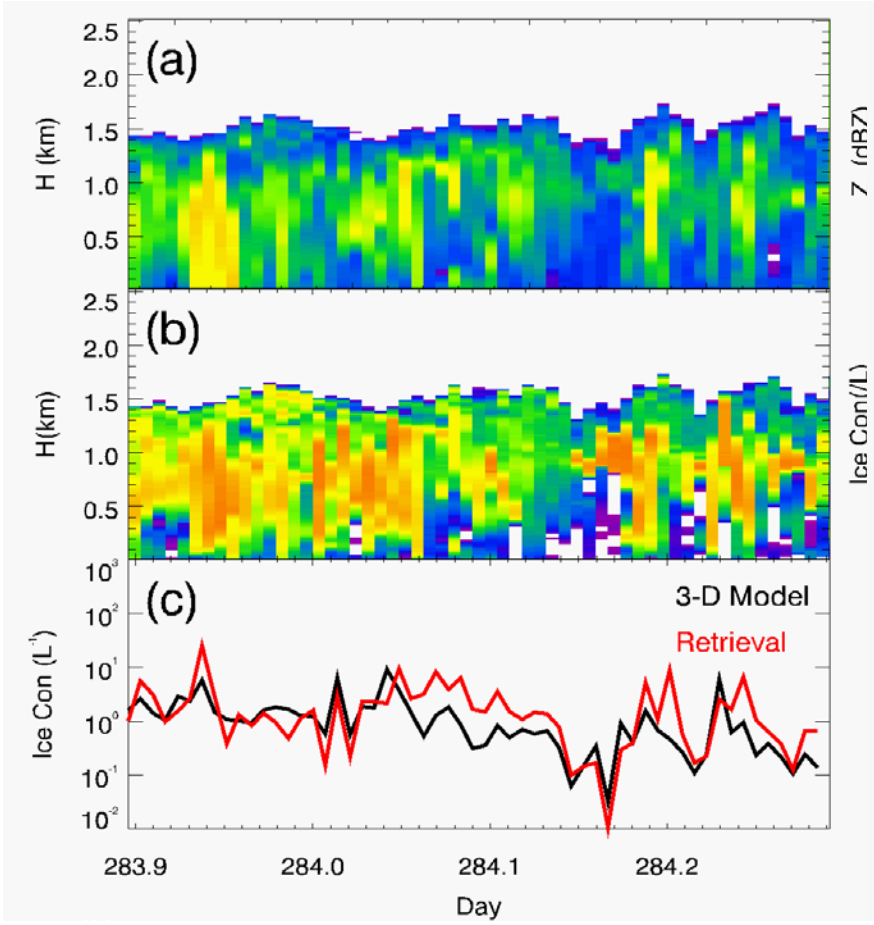
?

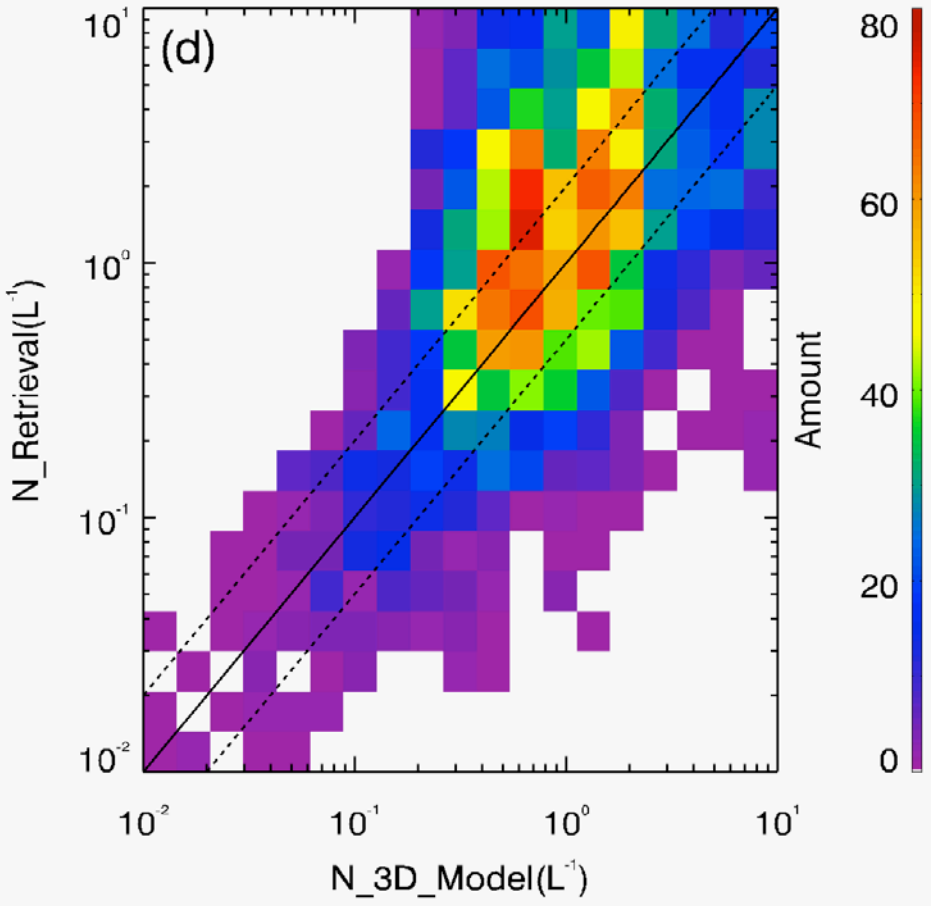
Ice concentration in stratiform clouds globally!

Comparison retrievals with in situ measurements



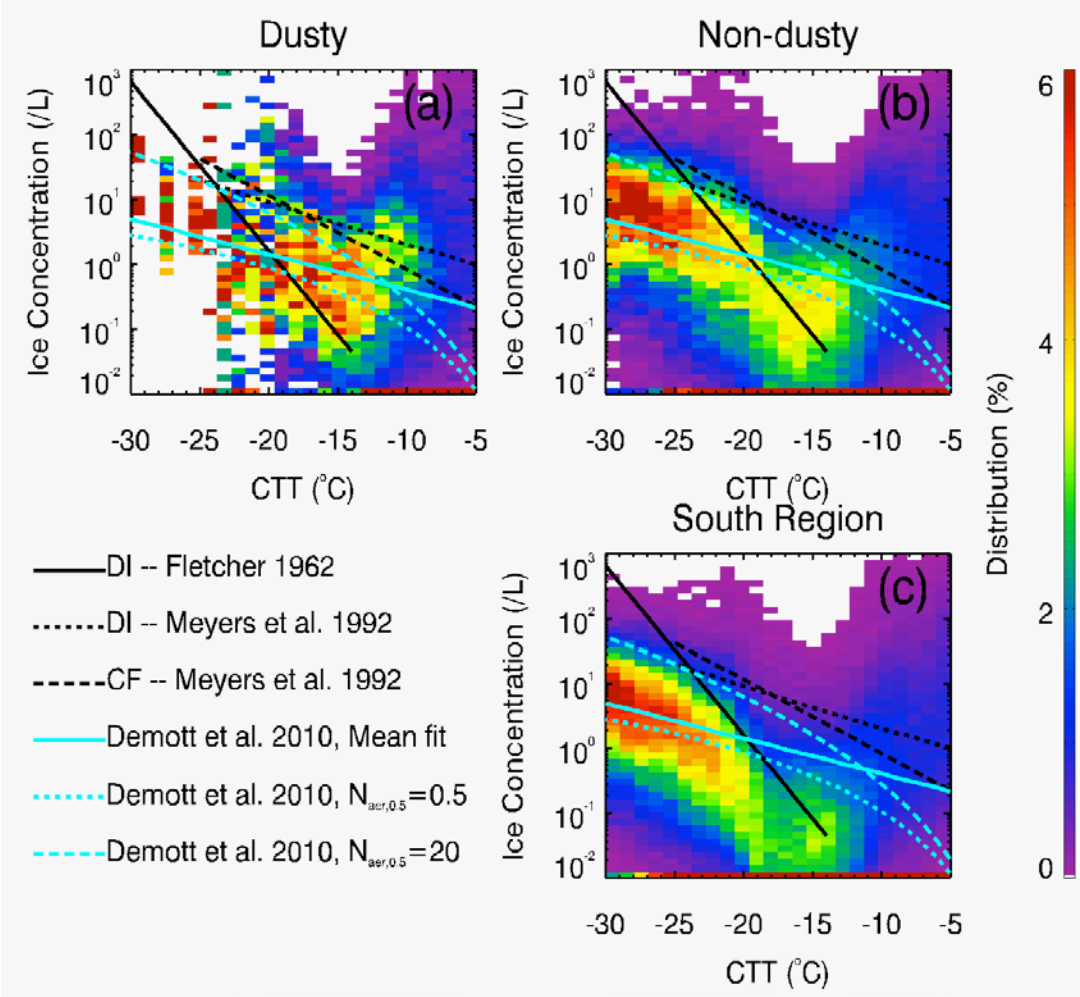
Using 3D Model Simulations for Evaluation





N_ice in Dusty and Non-dusty middle-level Stratiform Mixed-phase Clouds (SMCs)

- At warm CTT (-20 - -15 ºC), dusty SMCs has 2-5 times higher N_ice than non-dusty and ‘South Regions’.
- N_ice for dusty SMCs compare well with DeMott (2010) IN parameterization; while N_ice for non-dusty and ‘South Regions’ SMCs lower than most of previous IN parameterizations statistically.



Summary

1. An algorithm is developed to retrieve ice concentration in **stratiform** mixed-phase clouds
2. Evaluations with in situ collocated measurements and 3-D bin microphysical model simulations indicate a statistical uncertainty about a factor of 2.
3. The algorithm will be applied to long-term ARM observations at the NSA and satellite global measurements to provide a large ice concentration dataset.