Analysis of Tropical Convective Systems with Extended Cloud Object Data from CERES

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Introduction/Motivation

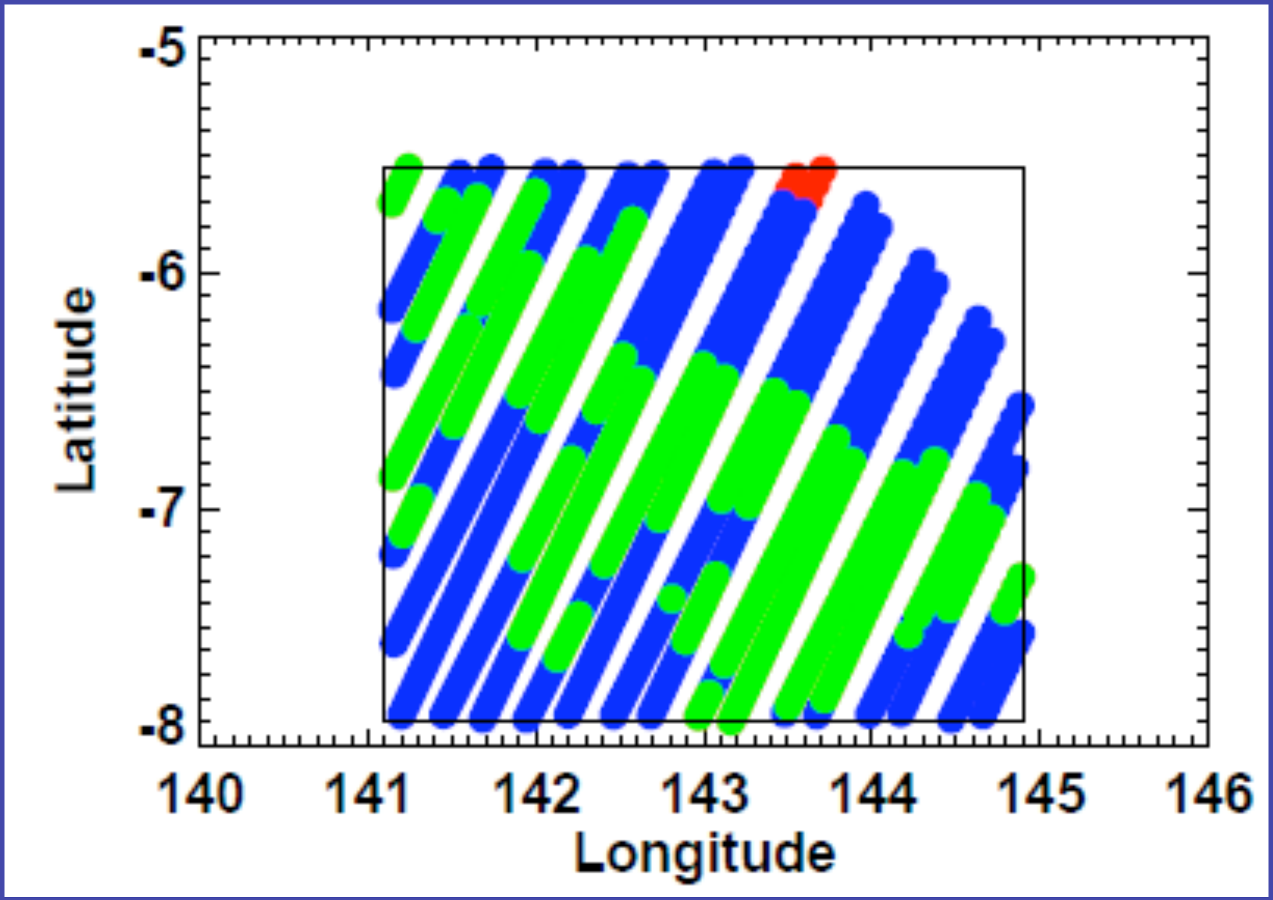
•Deep convective cloud objects are contiguous regions of overcast CERES satellite footprints with cloud top heights > 10 km and optical depths > 10. These data are from the tropical (25 S – 25 N) Pacific from Jan-Aug 1998.

•The modeling studies of Eitzen and Xu (2005, JGR) and Luo et al. (2007, JAS) have shown that comparisons of simulated and observed ensembles of deep convective cloud objects can result in the identification of problems with models, and solutions can be tested against observations.

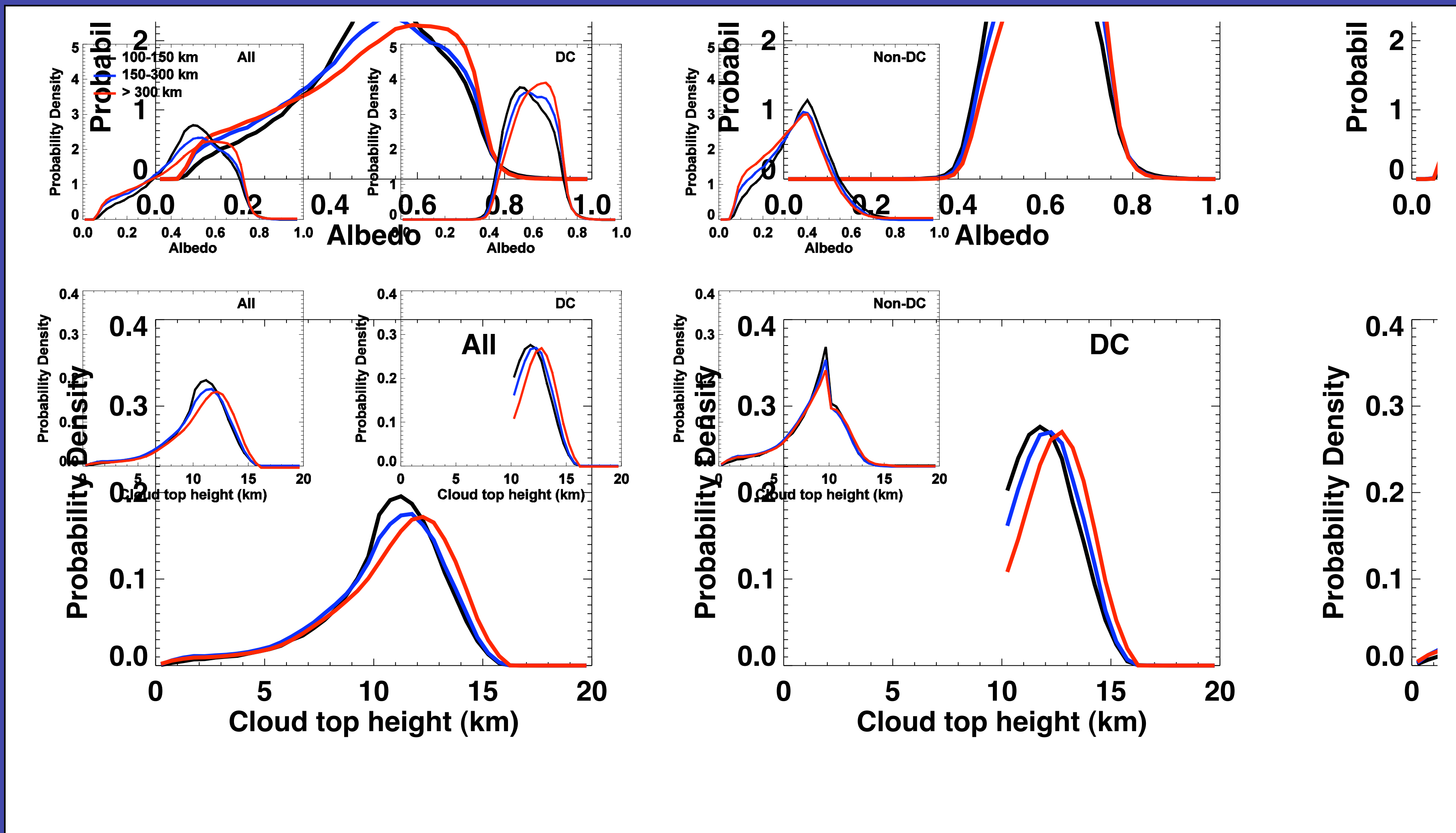
•In Eitzen and Xu (2008, JAS), simulations of ensembles showed that the “deep convective (DC)” and “non-DC” model columns did not change with SST in the same way, with simulated albedo nearly unchanged with SST for DC columns, but decreasing with SST for non-DC columns.

•Thus, we introduce “extended” cloud objects, defined as those cloudy footprints which are included in a rectangle that is defined by the minimum and maximum latitude and longitude of the contiguous cloud object.

Example of an ECO

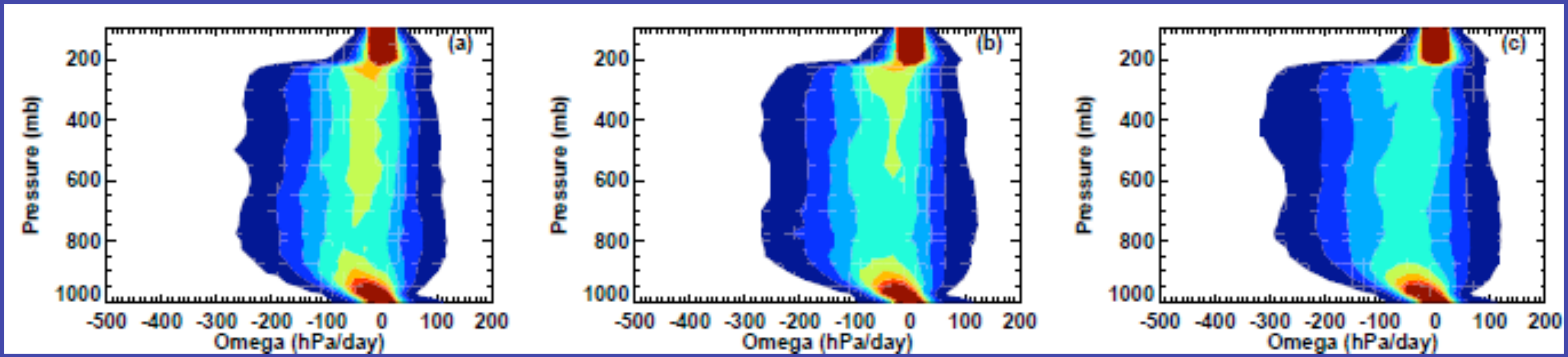


Changes in cloud properties with object size



Changes in cloud properties with object size

Large cloud objects tend to have higher cloud tops due to stronger large-scale upward motion, as shown in these contoured frequency diagrams of omega from ECMWF-Interim data.

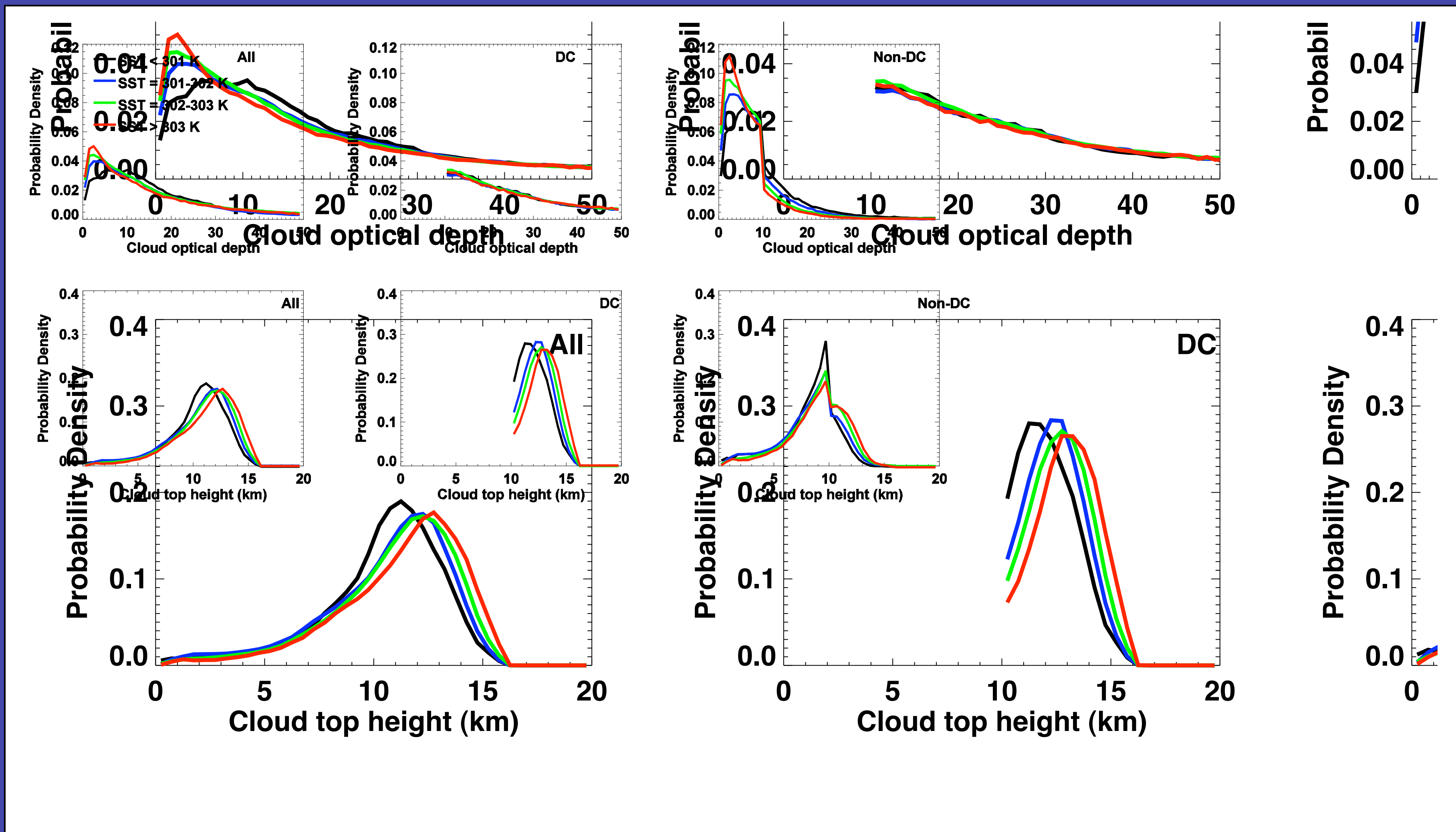


100-150 km

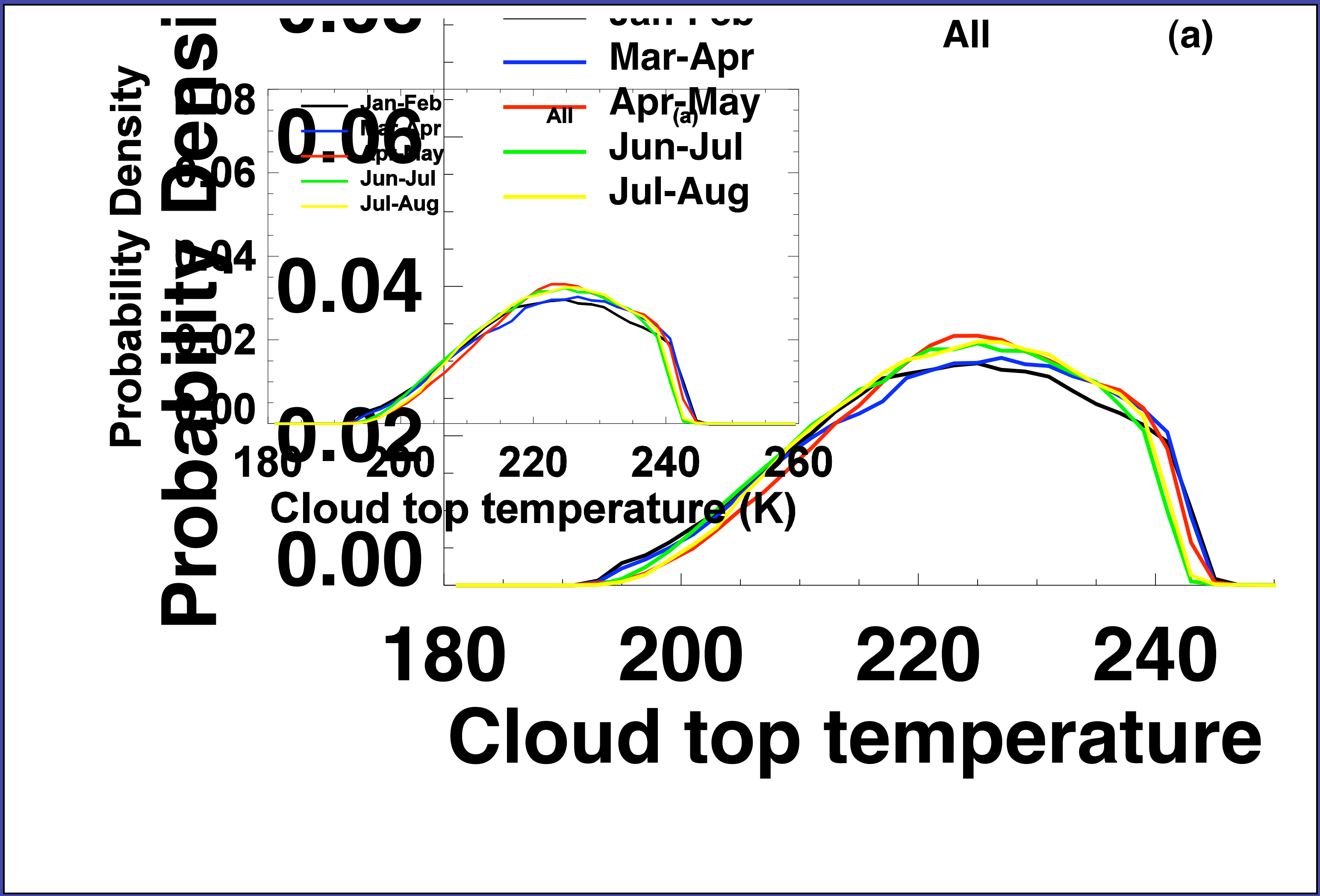
150-300 km

> 300 km

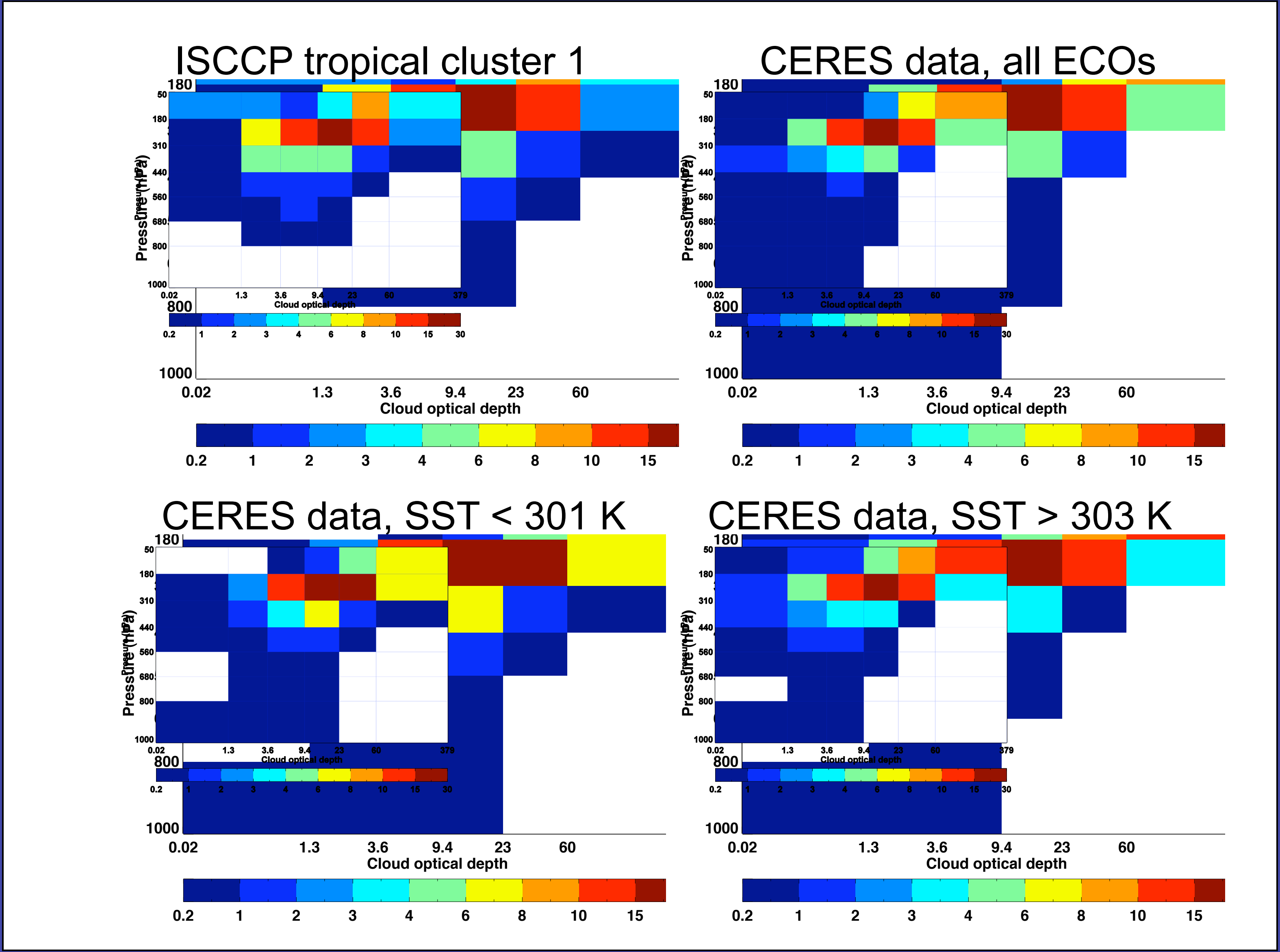
Changes in properties with SST



Fixed Anvil Temperature hypothesis



Joint distributions of p_c and τ



Conclusions

•As ECO size increases, DC clouds are more reflective and have higher cloud top heights due to increased large-scale upward motion.

•The non-DC clouds are less reflective and generally have similar cloud top heights as size increases. This may be because larger convective systems have longer lifetimes (Machado et al. 1998), allowing more thin cirrus to evolve (Luo and Rossow 2004).

•As SST increases, DC cloud top heights increase and the albedo slightly increases. However, there is a decrease in non-DC albedos, with more thin anvils. This is consistent with Del Genio and Kovari (2002), who found that the fraction of updraft water that goes into detrainment decreases with SST.

•Cloud top temperature distributions remain stable even though SST changes, supporting the fixed anvil temperature hypothesis of Hartmann and Larson (2002).

•The joint distribution of pc and t is quite similar to that of the “deep convective” cluster identified by Rossow et al. (2005).