Preliminary Results from an Extended Cloud Object Simulator

Zach Eitzen (SSAI/NASA-LaRC)
Kuan-Man Xu (NASA-LaRC)
Takmeng Wong (NASA-LaRC)

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Introduction/Motivation

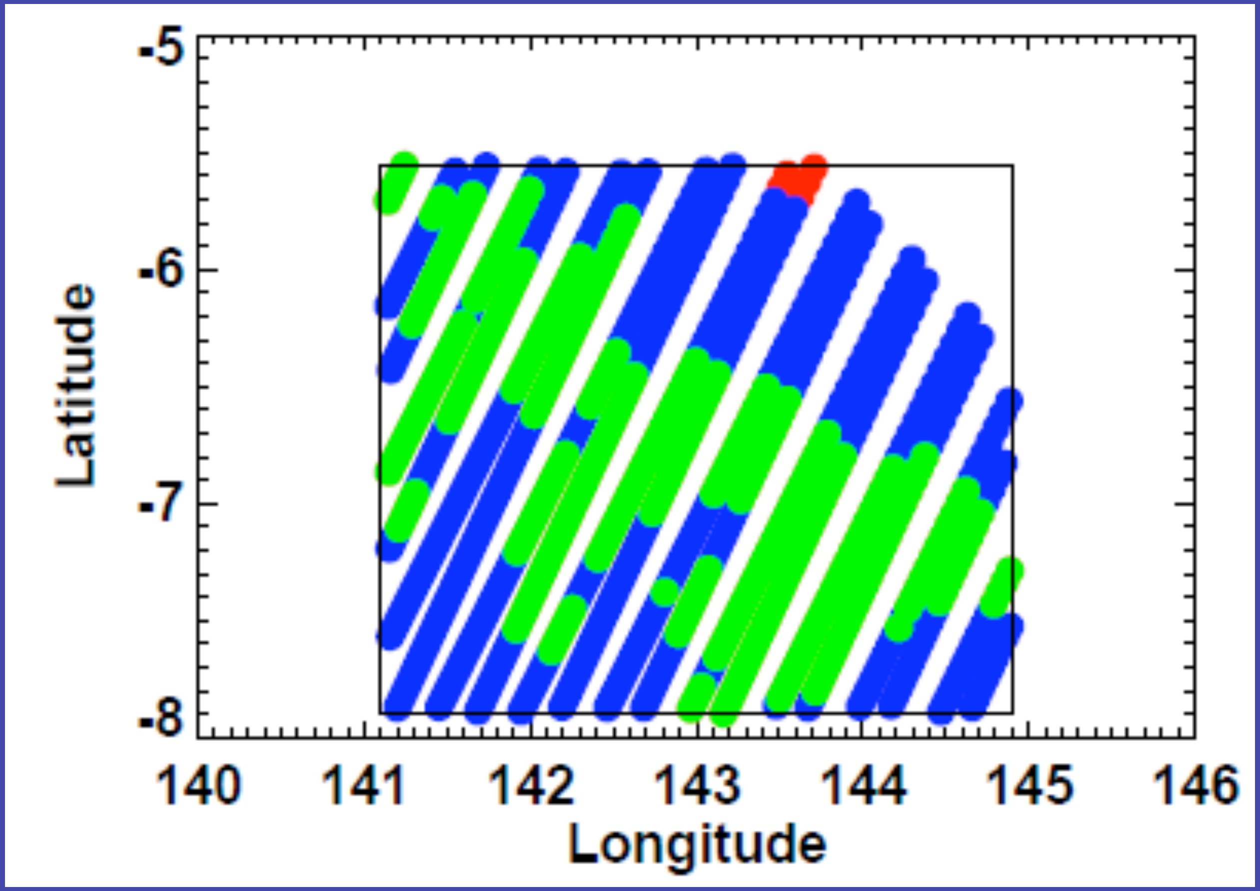
•Deep convective cloud objects are contiguous regions of overcast CERES satellite footprints with cloud top heights > 10 km and optical depths > 10.

•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.

•Eitzen, Xu, and Wong (2009, J. Climate) analyzed “extended” cloud objects from CERES-TRMM observations, defined as those cloudy footprints which are included in a rectangle that is defined by the minimum and maximum latitude and longitude of the original cloud object.

•The concept behind a simulator is to approximate how a satellite would view an atmosphere with the physical properties specified by model output. Here, we apply the simulator to regions in which extended cloud objects are observed.

Example of an Extended Cloud Object



The footprints of the original cloud object are in green, Non-DC footprints are in blue, and DC footprints outside of the original object are in red.

Data

•97 large (effective diameter >300 km), 150 medium (D_{eff}=150-300 km), and 176 small (D_{eff}=100-150 km) extended cloud objects (ECOs) were observed by CERES-Terra in March 2000.

•Each of these ECOs was matched in time (within three hours) and space to a group of corresponding ERA-Interim reanalysis grid cells.

•Footprints and subcolumns with τ<1 are excluded from this analysis in order to minimize the effects of detection problems.

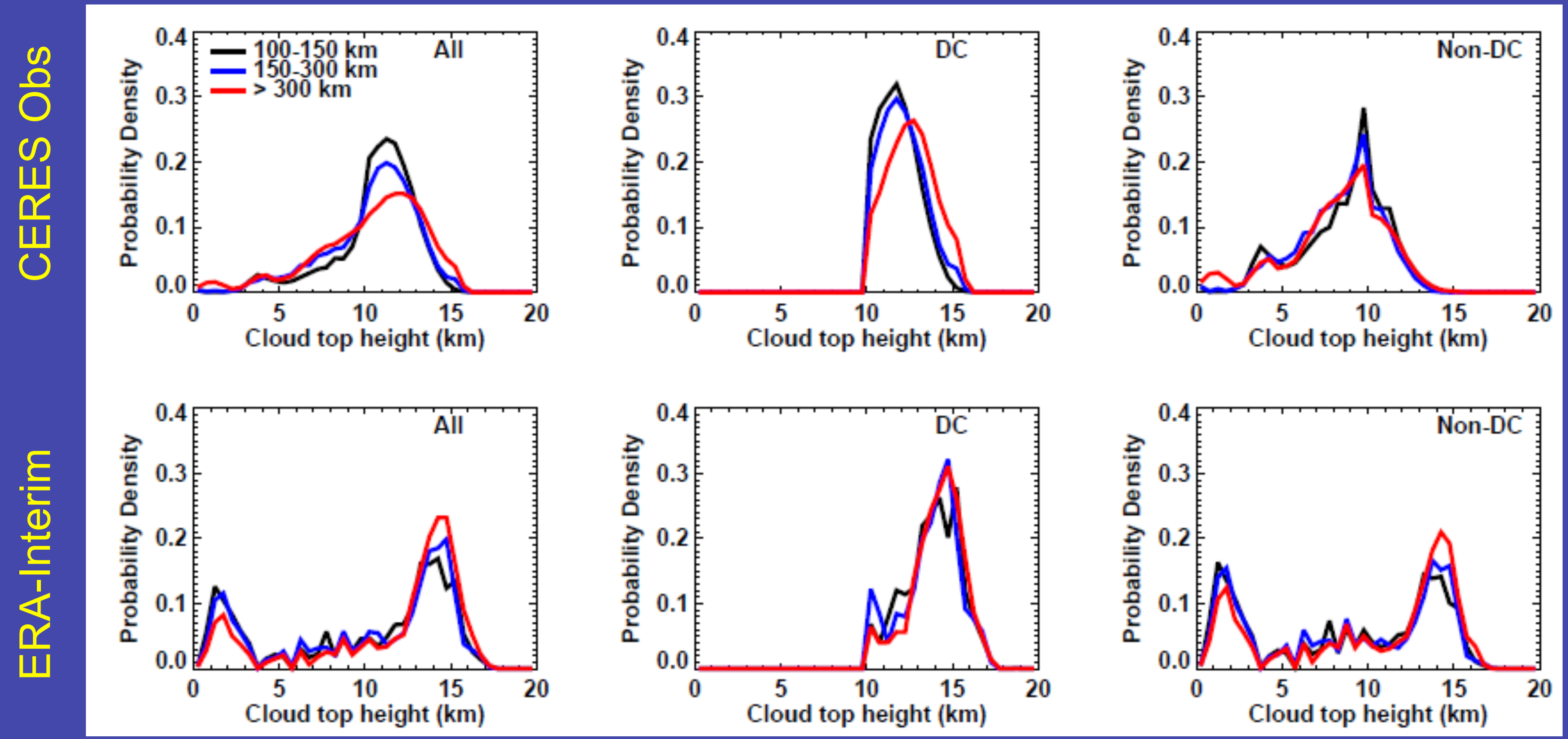
Simulator

- The ERA-Interim cells are much larger (1.5°×1.5°) than CERES-Terra footprints (~20 km), so the grid cells are split into subcolumns with a comparable area, similar to Xu (2009, Mon. Wea. Rev.).
- The subcolumns are assigned a binary (0 or 1) cloud fraction at each vertical level using a cloud generator (Klein and Jakob 1999; Webb et al. 2001) with the maximum-random overlap assumption.
- The ice and liquid water contents from the ERA-Interim data are converted to optical depths, liquid/ice radii and IR emissivities following Benedetti and Janiskova (2008).
- In the near future, the LaRC version of the Fu-Liou code will be coupled with the simulator in order to compare CERES LW and SW fluxes.

Sensitivity to Size

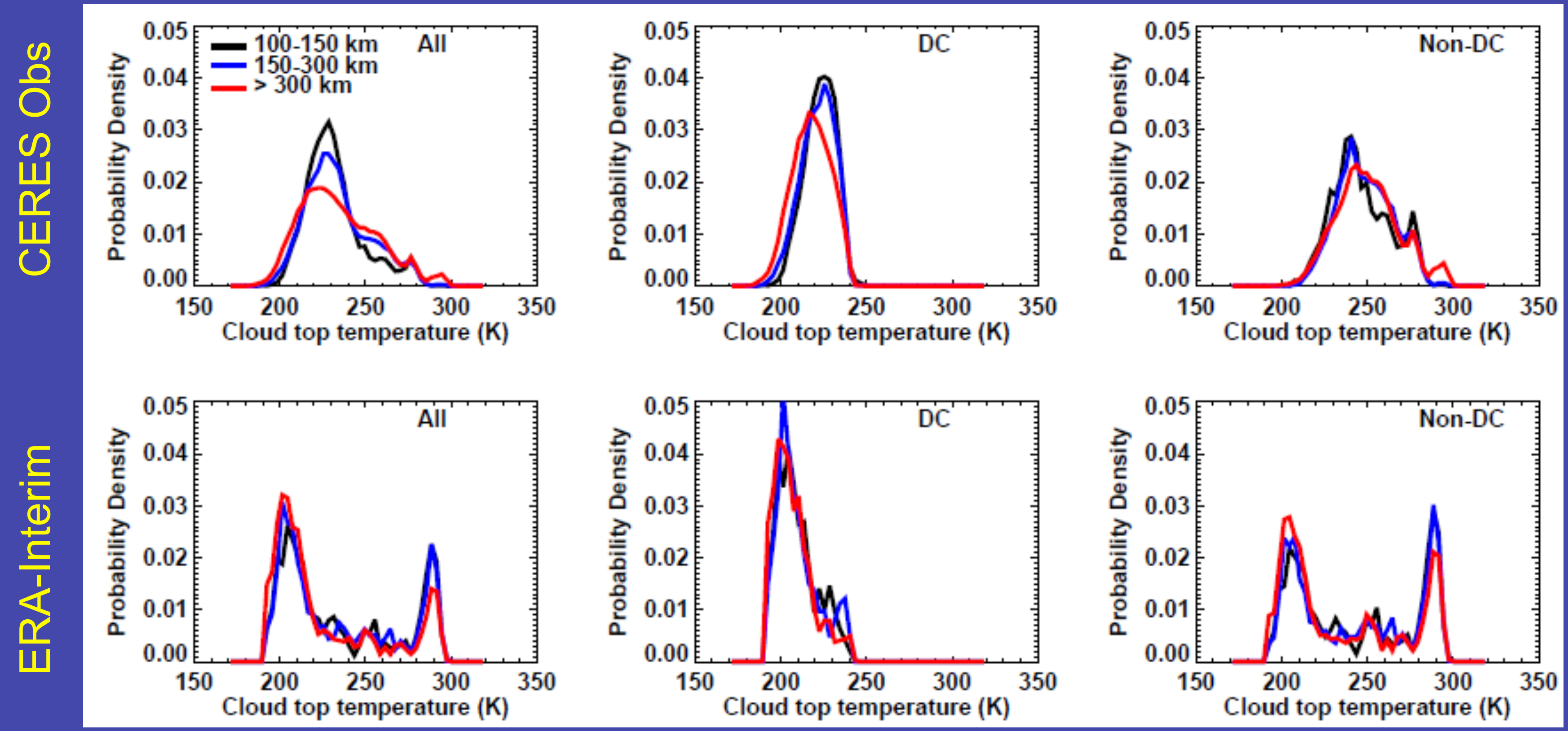
Size	CERES DC	CERES Non-DC	ERA-Interim DC	ERA-Interim Non-DC
> 300 km	45738 (50.2%)	45340 (49.8%)	21441 (33.6%)	42362 (66.4%)
150-300 km	13358 (55.4%)	10743 (44.6%)	6089 (25.1%)	18161 (74.9%)
100-150 km	5108 (62.3%)	3087 (37.7%)	3225 (22.6%)	11049 (77.4%)

Cloud top height



All clouds DC clouds Non-DC clouds

Cloud top temperature



All clouds

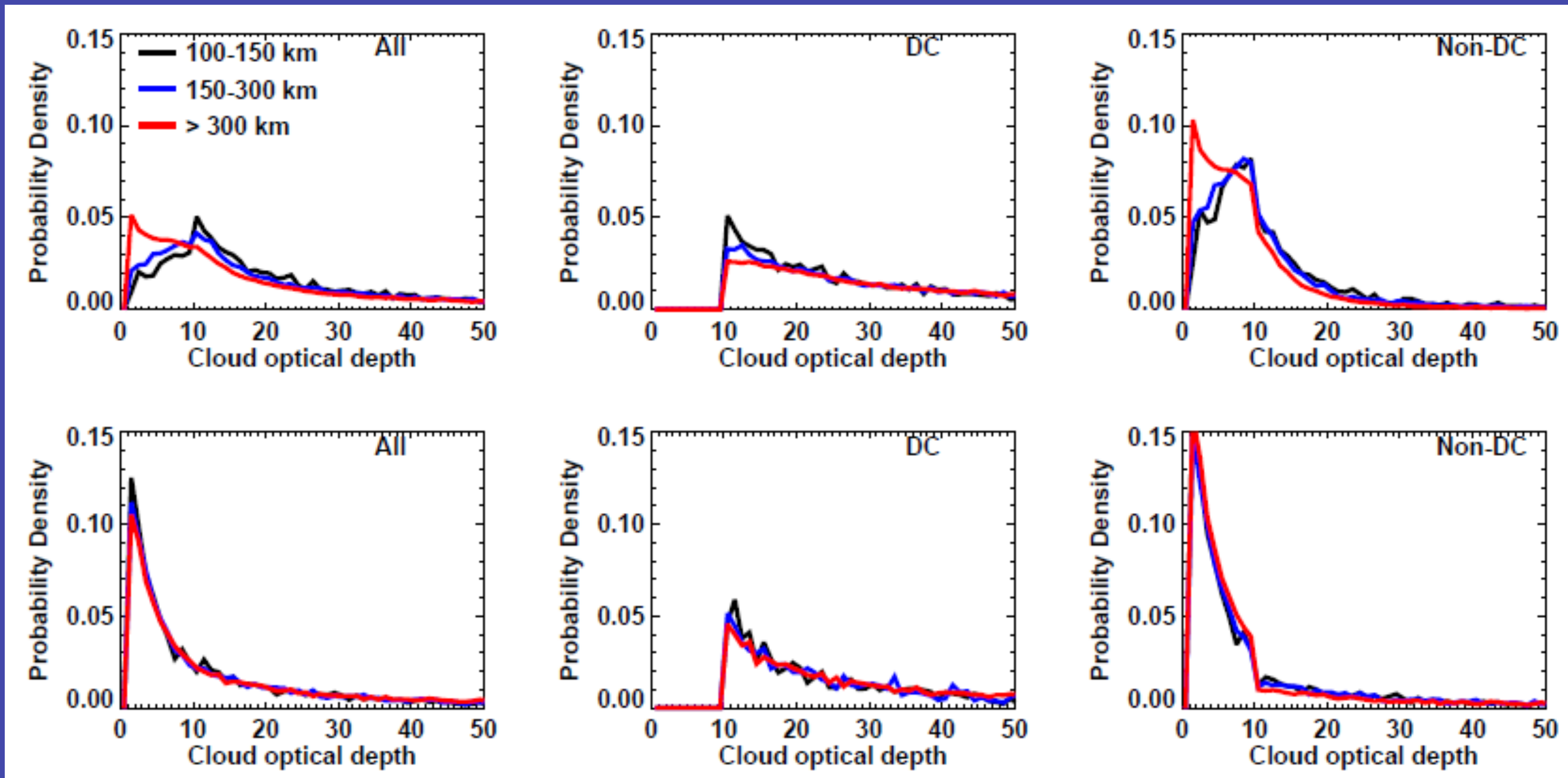
DC clouds

Non-DC clouds

Cloud optical depth

CERES Obs

ERA-Interim

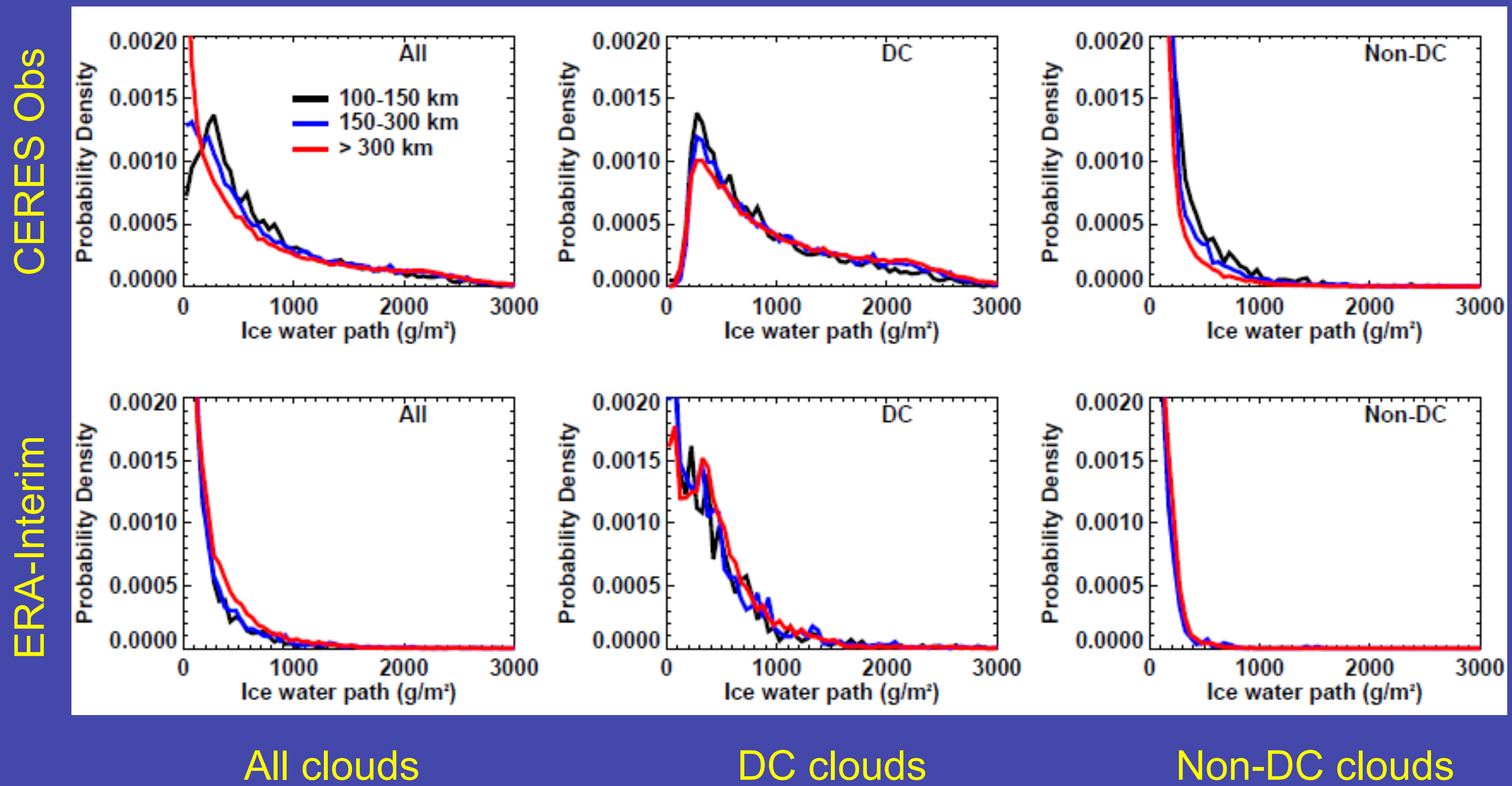


All clouds

DC clouds

Non-DC clouds

Ice water path



Sensitivity to SST

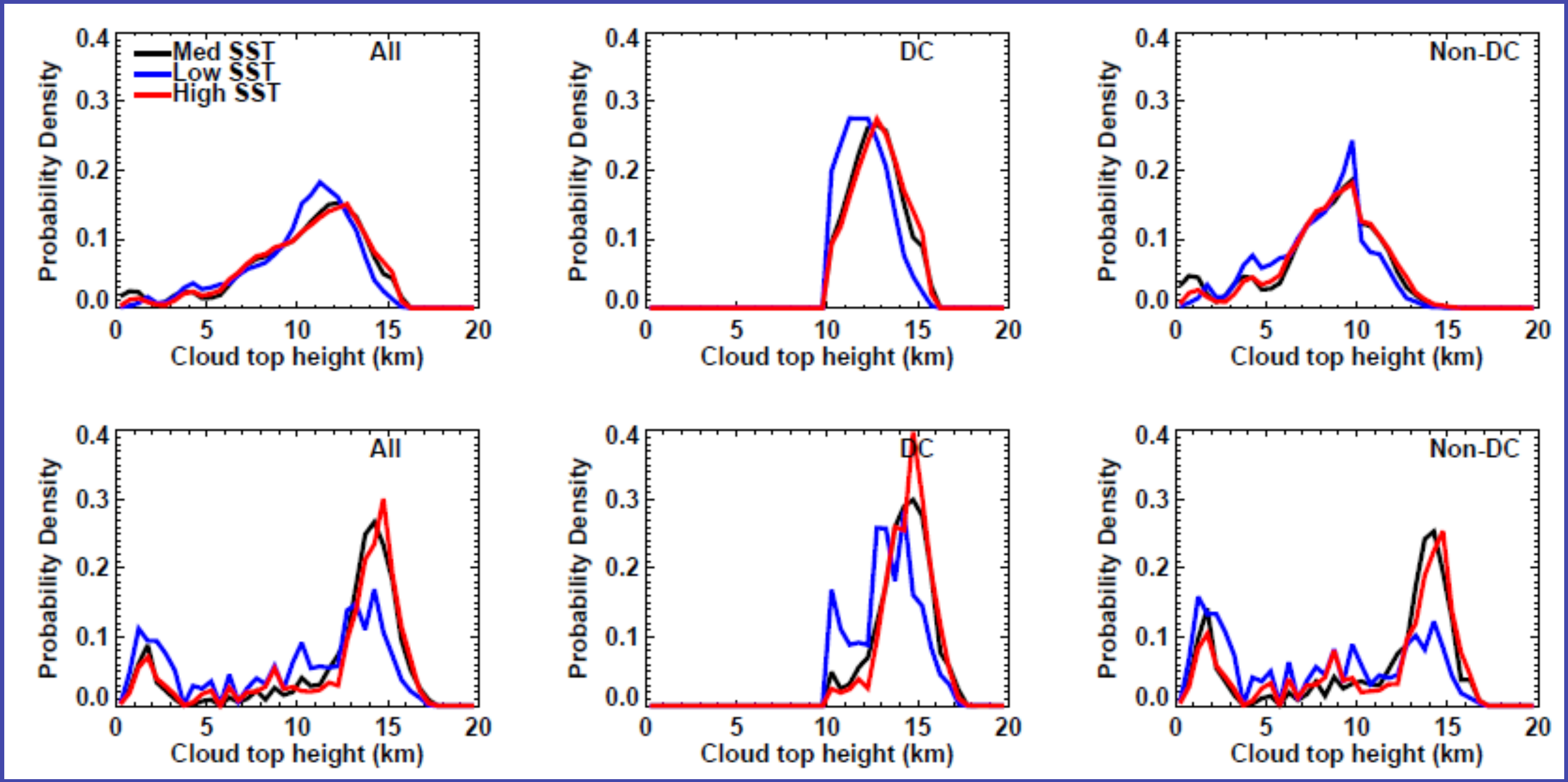
- The 97 large cloud objects were split into three groups of 32-33 objects with low, medium and high SSTs

SST	CERES DC	CERES Non-DC	ERA-Interim DC	ERA-Interim Non-DC
High (>302.2 K)	17864 (48.5%)	18947 (51.5%)	8424 (32.6%)	17452 (67.4%)
Medium (301.3-302.2 K)	16359 (49.7%)	16560 (50.3%)	8711 (37.5%)	14539 (62.5%)
Low (<301.3 K)	11515 (53.9%)	9833 (46.1%)	4306 (29.3%)	10371 (70.7%)

Cloud top height

CERES Obs

ERA-Interim



All clouds

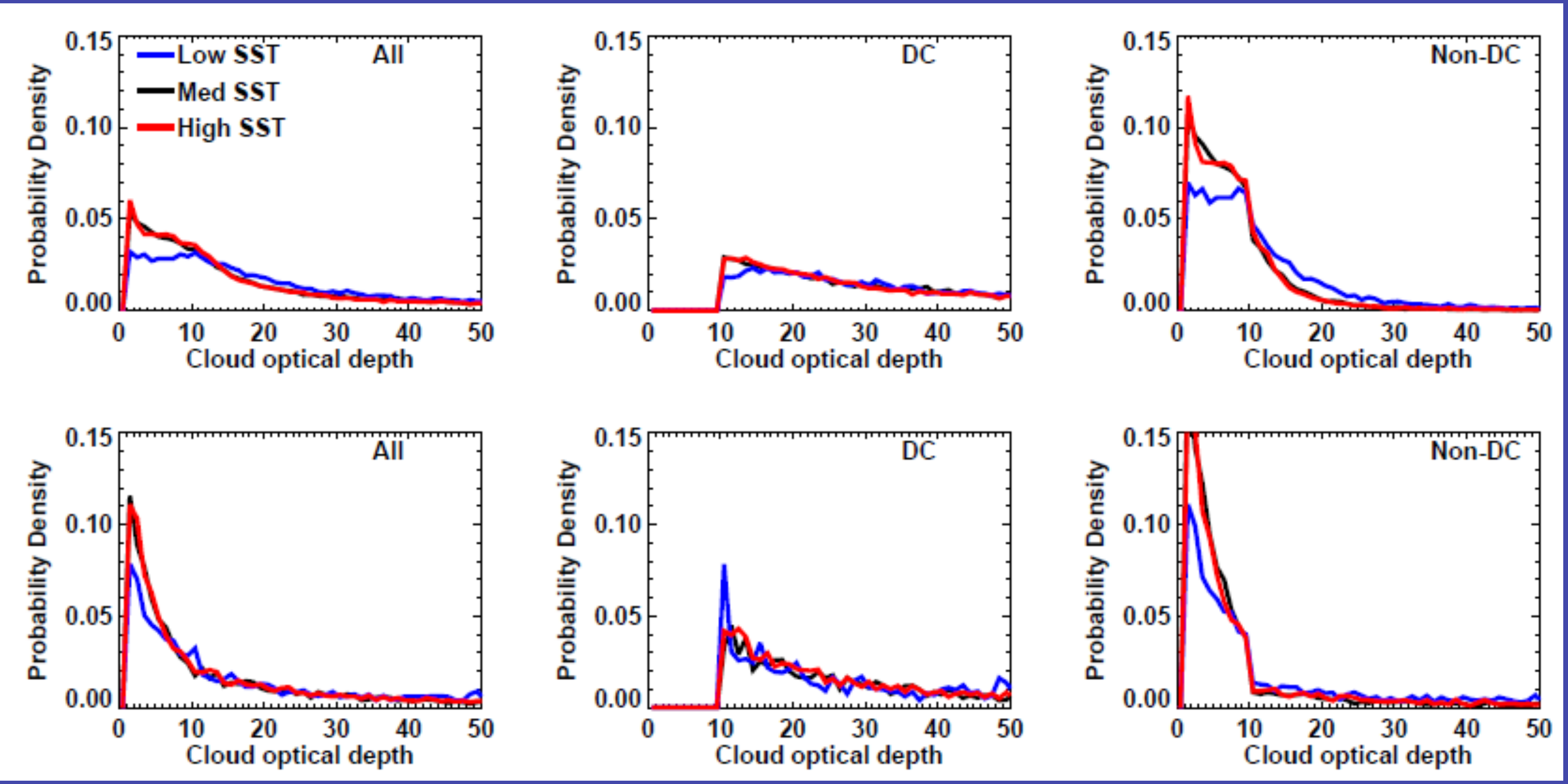
DC clouds

Non-DC clouds

Cloud optical depth

CERES Obs

ERA-Interim



All clouds

DC clouds

Non-DC clouds

Summary

•The ERA-Interim reanalysis generally simulated a smaller fraction of DC subcolumns than is observed for all size and SSTs examined here.

•As ECO size increases, the observed DC clouds have higher optical depths and have higher cloud top heights. The ERA-Interim DC cloud tops are generally higher than those observed, and do not change much with size.

•Observed 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). ERA-Interim non-DC optical depths and ice water paths do not change as much with size.

•As SST increases, observed DC cloud top heights increase and the optical depth slightly increases. However, there is a decrease in non-DC optical depths, with more thin anvils. There is an asymmetry in the SST response, with more changes in cloud properties between low and medium SSTs than medium and high SSTs. The ERA-Interim data also has lower optical depths among non-DC subcolumns as SST increases.

Future Work

- Expand data period to two years of Terra observations and ERA-Interim reanalysis data, using full-resolution ERA data (approximately 0.7°×0.7°).
- Use LaRC version of Fu-Liou radiative transfer model to obtain subcolumn SW and LW radiative fluxes and compare them to CERES observations.
- Examine joint distributions of some pairs of cloud/radiative properties.