Deep convective cloud system size and structure across the global tropics and subtropics

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A new database of deep convective clouds

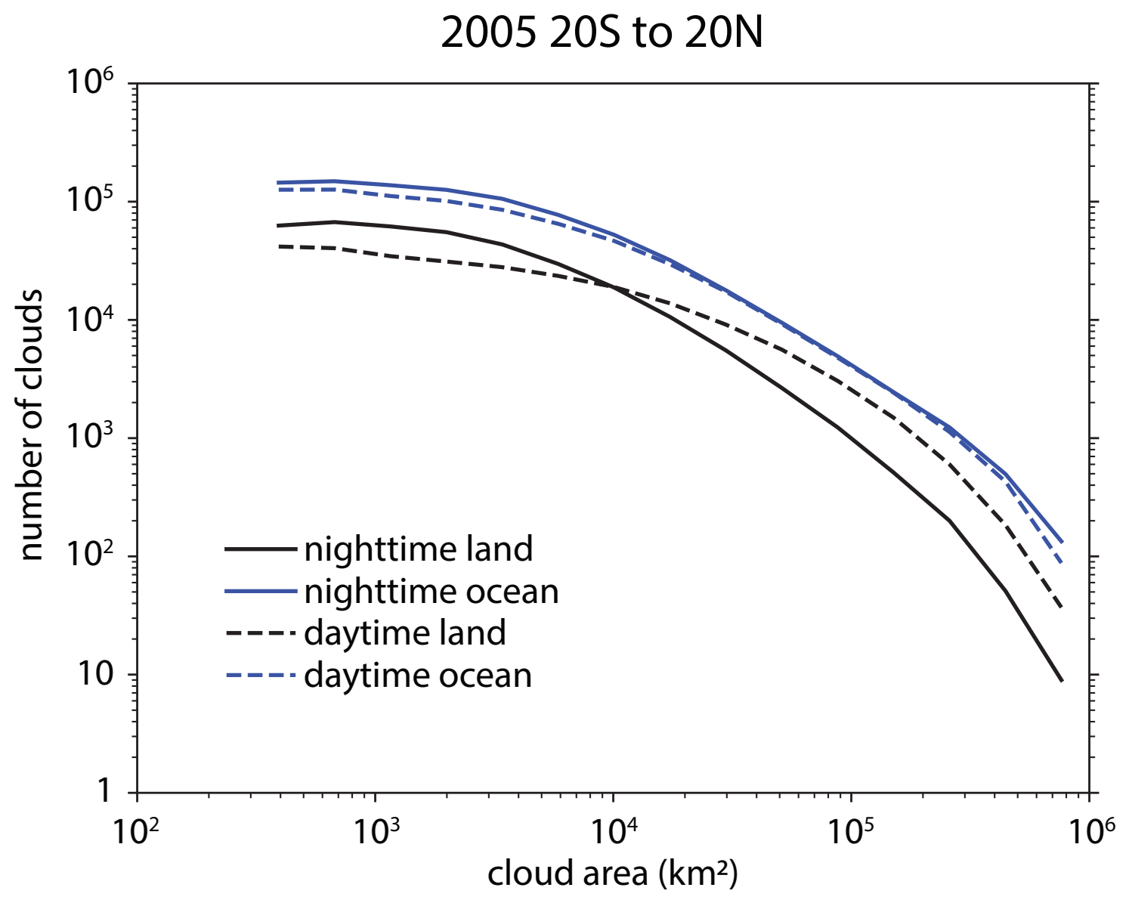
We apply an objective image processing algoritm to finely gridded infrared MODIS granules to identify individual deep convetive cloud systems. The result is a database of millions of convective cloud systems that includes metrics for the:

distribution of MODIS IR brightness temperature within cloud objects,
distribution of AMSR microwave brightness temperature within clouds,
profile of cloud particle effective radius,
CAPE and vertical shear of horizontal wind of the surrounding environment,
and aerosols in the surrounding environment.

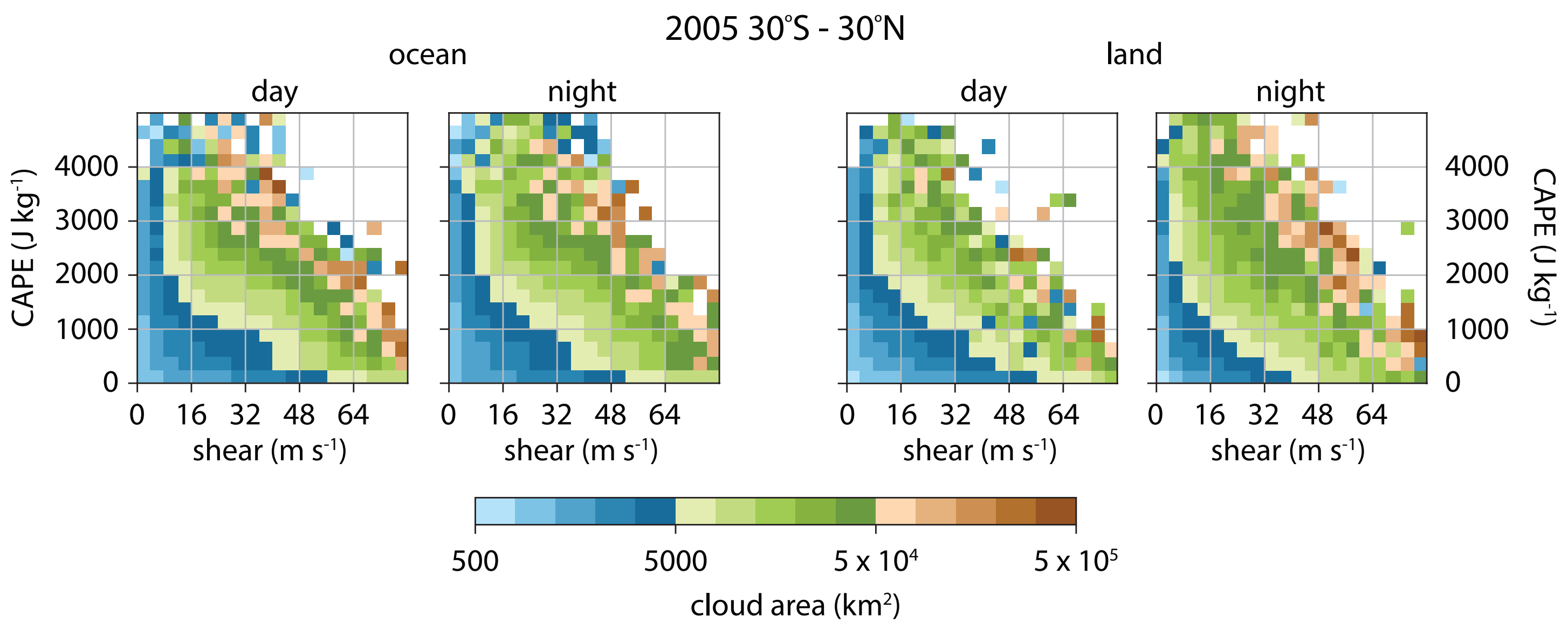
From which we seek indicators of:
the size distribution of clouds,
core/anvil structure,
cloud microphysical structure,
and the relation of these to CAPE, shear and aerosols.

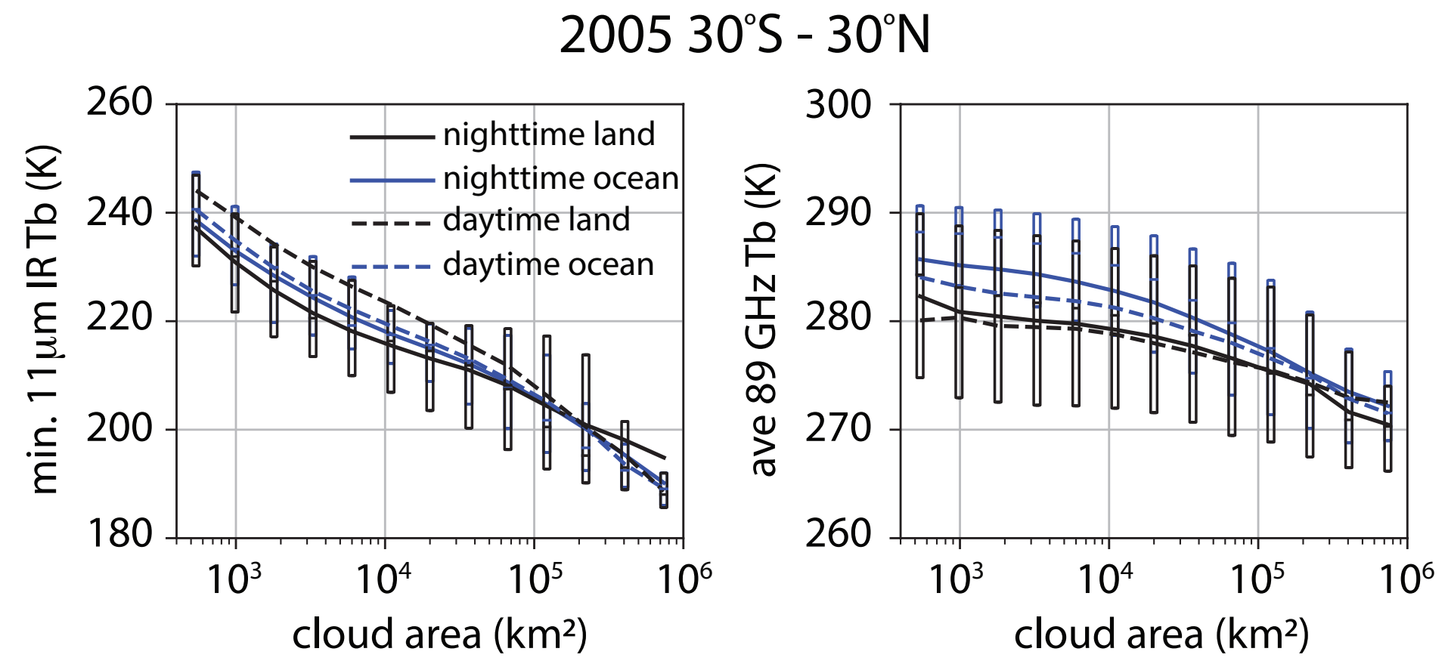
A full record from MODIS Terra (1999 - 2021) and Aqua (2003 - 2021) for the global tropics (20S - 20N), including close to 100 million deep convective cloud systems, will be available on the NASA Goddard DAAC later this summer.

Scale-dependent cloud properties



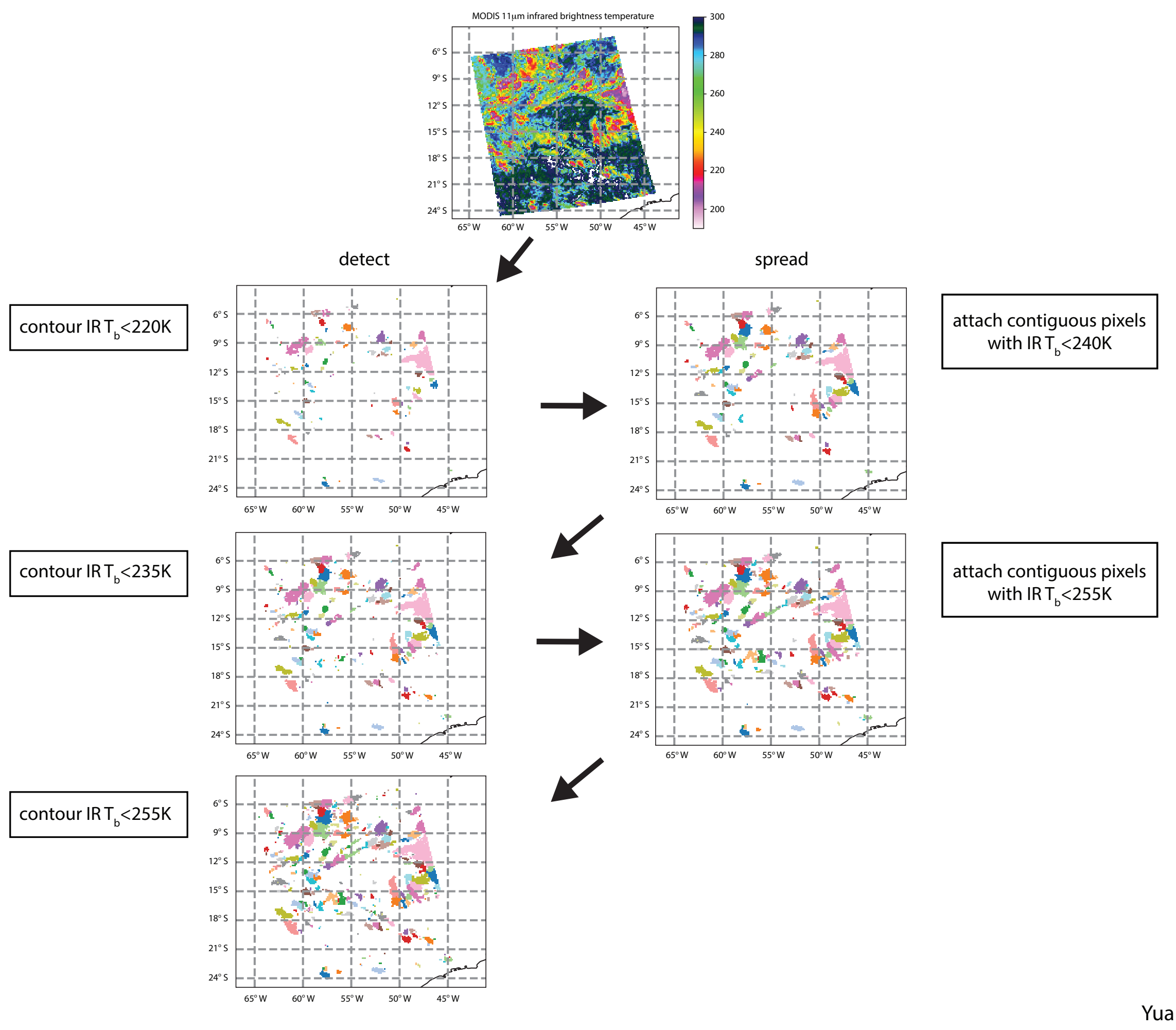
- Convective clouds span a range from a single grid-cell (~250 km² in this case) to nearly 10^6 km².
- The shape of the distribution is relatively robust to resolution of the gridded IR data (not shown).
- Convective cloud size increases systematically with both CAPE and shear.
- The CAPE/shear/size relationships vary greographically (not shown).





- The distributions of IR and microwave brightness temperatures provide some rough clues to the structural aspects of the cloud.
- The minimum IR brightness temperature indicates that the deepest cores of clouds are systematically colder for larger clouds, with stronger diurnal variation over land.
- Average 89 GHz brightness temperature is sensitive to the amount of vertically integrated precipitation-sized ice in the core and anvil stuctures of cloud systems.

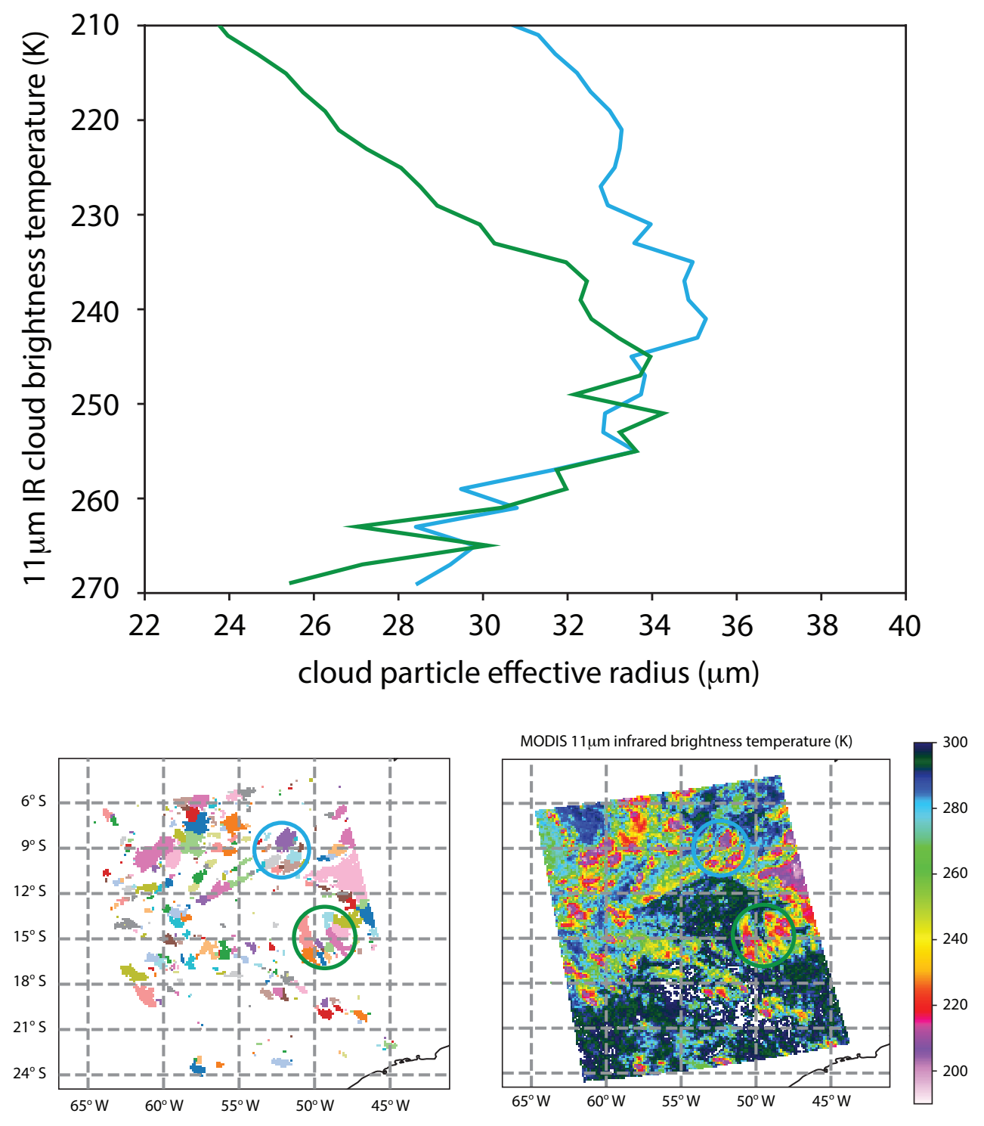
Detect and spread algorithm



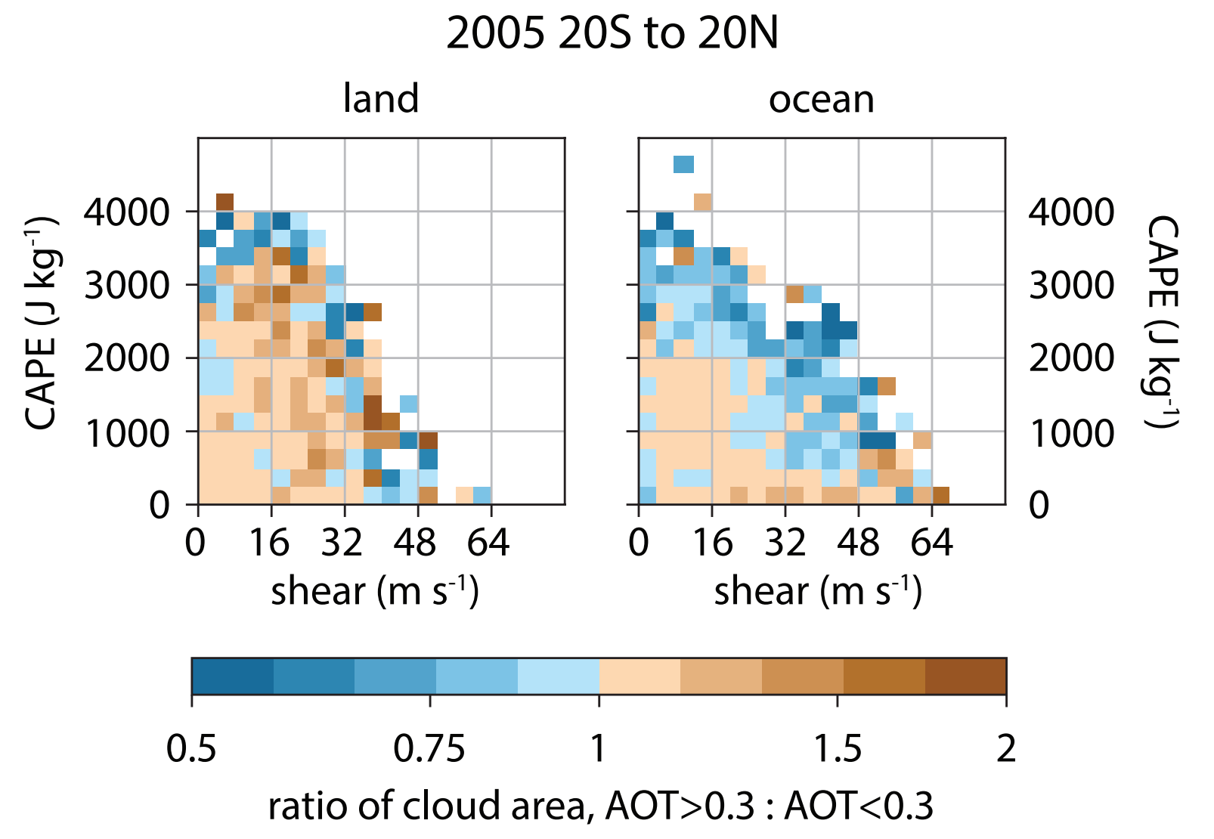
- We apply the "detect and spread" algorithm (Boer and Ramanathan, 1997) to infrared (IR) brightness temperatures from MODIS to identify the convective core of cloud systems and attached the associated anvil cloudiness.
- An itertative detect process identifies the deepest cloud systems first, and attaches their associated anvils before moving on to cloud systems with warmer cores.
- Thresholds are chosen as in Roca and Ramanathan (2000) to capture core/anvil structures as individual cloud system structures. Extended thin cirrus is not included with this choice of thresholds. MODIS IR and AMSR-E microwave data are gridded on a common 0.125° lat/lon grid prior to applying the detect and spread algorithm.
- Profiles of cloud drop effective radius are constructed for each cloud as in Yuan et al. (2010) [not shown here on this poster].

Boer, E.R. and Ramanathan, V., 1997. Lagrangian approach for deriving cloud characteristics from satellite observations and its implications to cloud parameterization. J. Geophys. Res., 102(D17).
Roca, R. and Ramanathan, V., 2000. Scale dependence of monsoonal convective systems over the Indian Ocean. J. Climate, 13(7).
Yuan, T., et al., 2010. Estimating glaciation temperature of deep convective clouds with remote sensing data. Geophys. Res. Lett., 37(8).

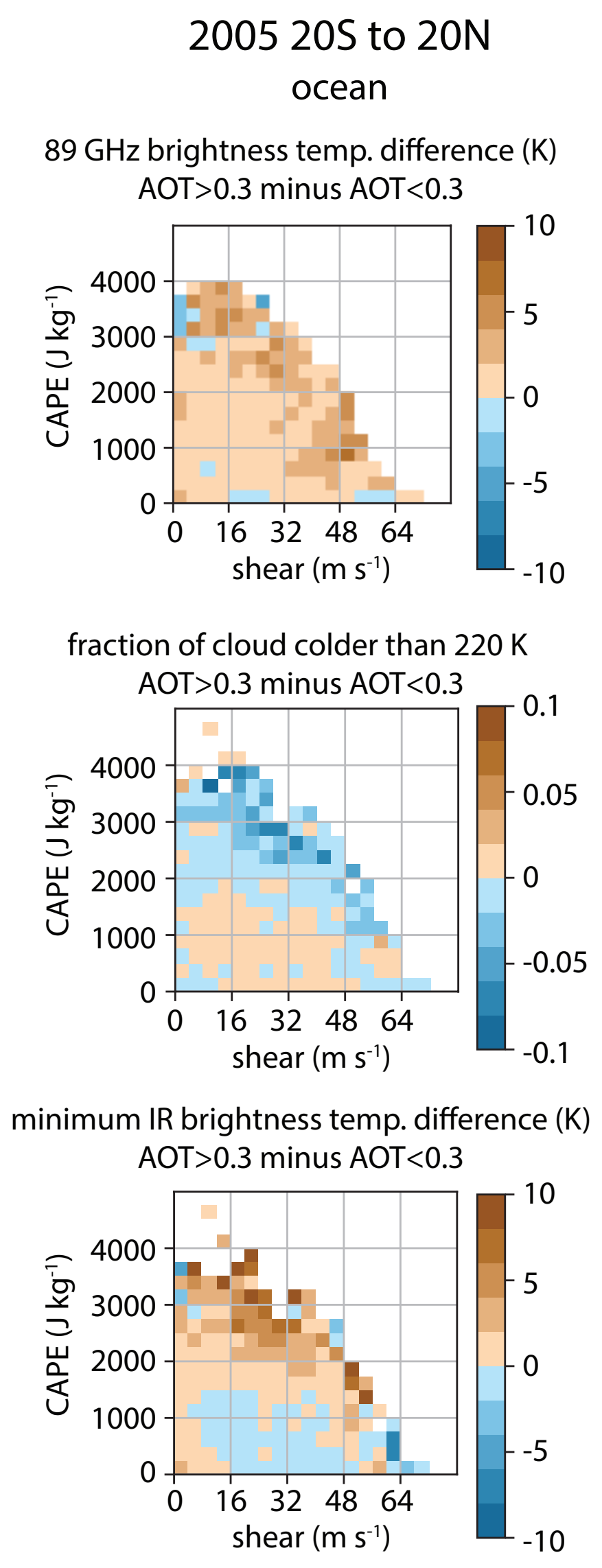
Applications



- Construction of composite profiles of particle effective radius from clusters of deep convective clouds.



- Since CAPE and shear strongly influence cloud size, we control for these in exploring aerosol impacts on the spatial coverage of convective cloudiness.
- There are land/ocean contrasts in whether clouds are larger or smaller under high aerosol optical thickness (AOT) or low AOT.
- Smaller clouds over the ocean under high AOT, CAPE and shear environments coincide with other structural differences.



Summary

- A new database of deep convective clouds over the global tropics will be available soon on the NASA Goddard DAAC at:
  doi: 10.5067/HXRNU4HCIPA6 for MODIS Terra and
  doi: 10.5067/0Y3M8IO4XKG5 for MODIS Aqua.
- Preprint of dataset description at:
  https://doi.org/10.5194/amt-2023-6

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- The database links the horizontal scales of core/anvil convective structures to indicators of cloud microphysics and the environment in which the cloud is developing.
- Potential applications include evaluation of model-simulated concvective clouds, examination of the linkages between convective-scale cloud processes and regional radiative forcing by clouds, and exploring impacts of aerosol variability on convective cloud structure and coverage.