The Diurnal Cycle of the Cloud Radiative Effect of Deep Convective Clouds over Africa from a Lagrangian Perspective

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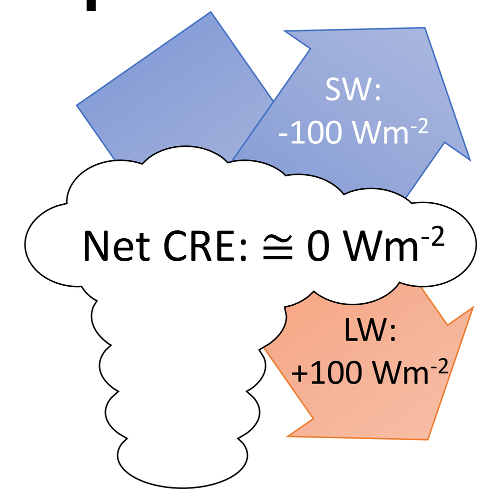
OSPP

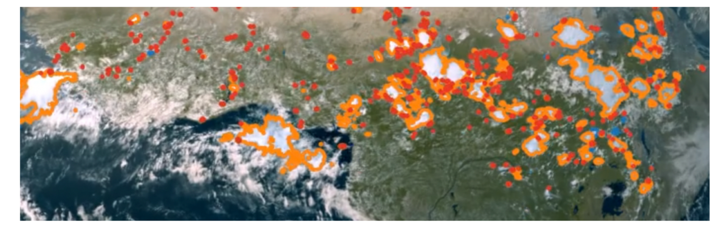
Graphical abstract:

(a)



a: Average tropical deep convective cloud (DCC) cloud radiative effect (CRE) is 0, despite large shortwave/longwave fluxes

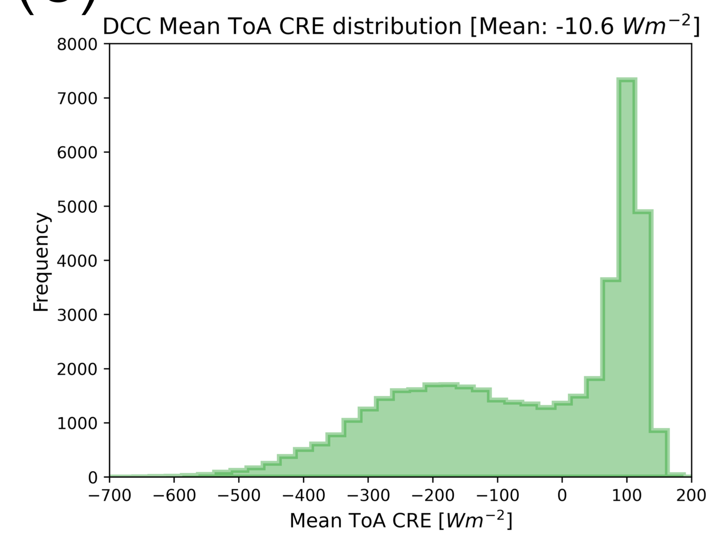
(b)



4 months
> 40 000 anvils
> 90 000 cores

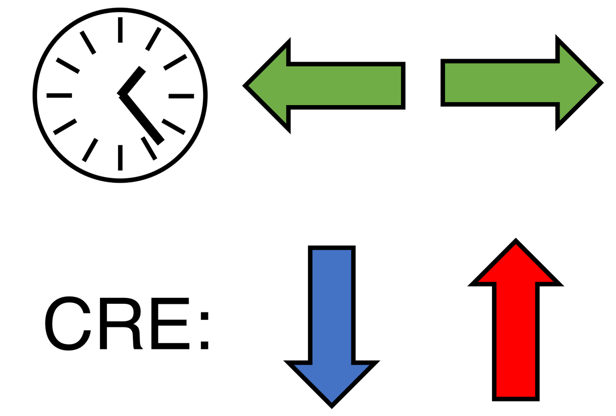
b: we track anvils and associated cores to study lifecycle and CRE

(c)



c: we find a bi-modal CRE distribution, with both peaks consisting of isolated DCCs, and long-lived systems in the center.

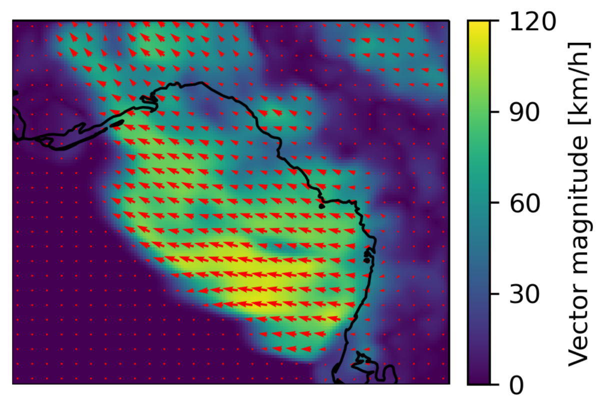
(d)



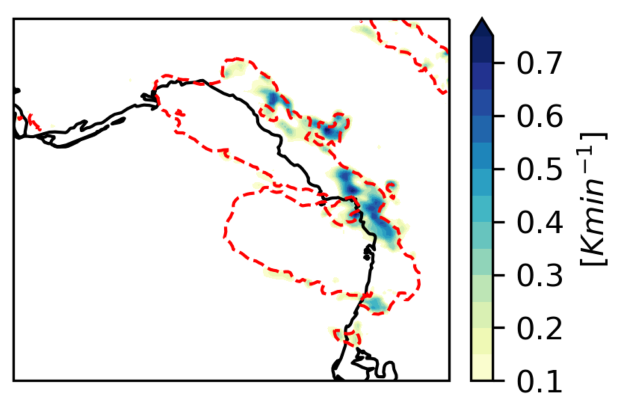
d: changes in the diurnal cycle strongly increase or decrease net CRE

Lifetime and time of initiation determine the cloud radiative effect distribution of deep convective clouds over Africa

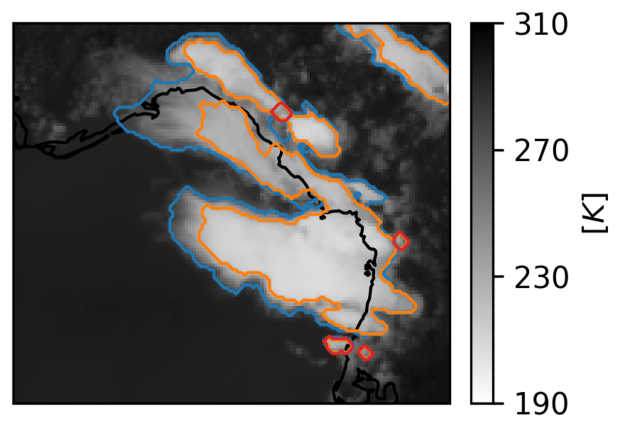
Method:



⬅ DCC motion is estimated using optical flow. These motion vectors are used to construct a semi-Lagrangian framework.



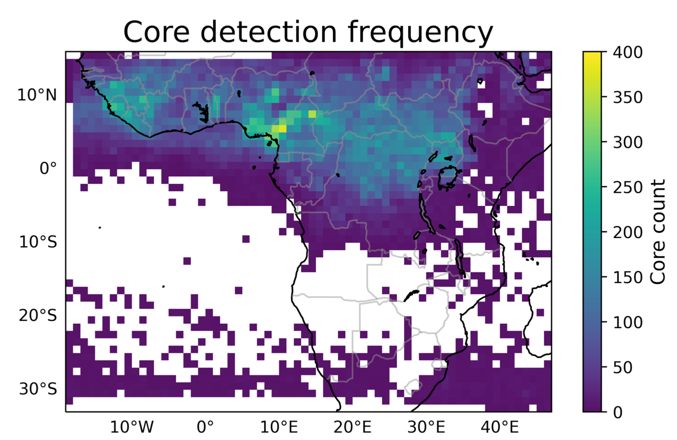
⬅ We detect cores where we observe a cloud top cooling by at least 8K in a 15 minute period, signifying intense convective growth.

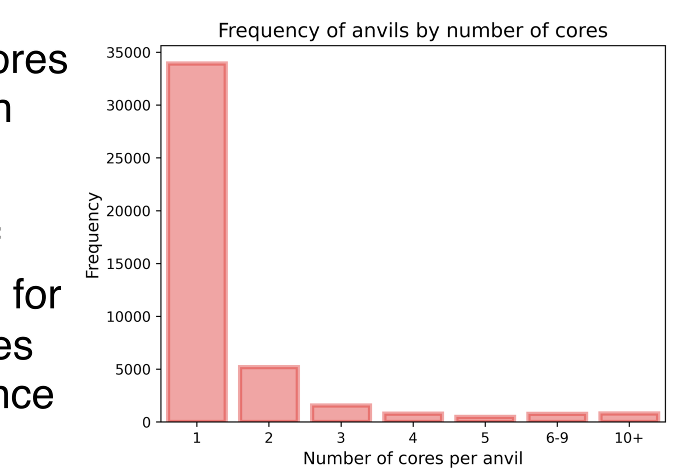


⬅ Associated anvil cloud regions are detected around the cores. Segmenting in both time and space, we detect anvils even after the core has dissipated.

Jones, W. K. et al (2023), A semi-Lagrangian method for detecting and tracking deep convective clouds in geostationary satellite observations, AMT, 16, 1043–1059
https://doi.org/10.5194/amt-16-1043-2023

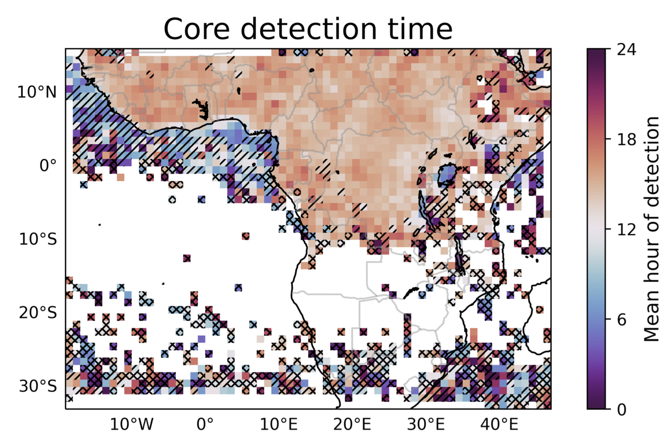
Lifecycle:



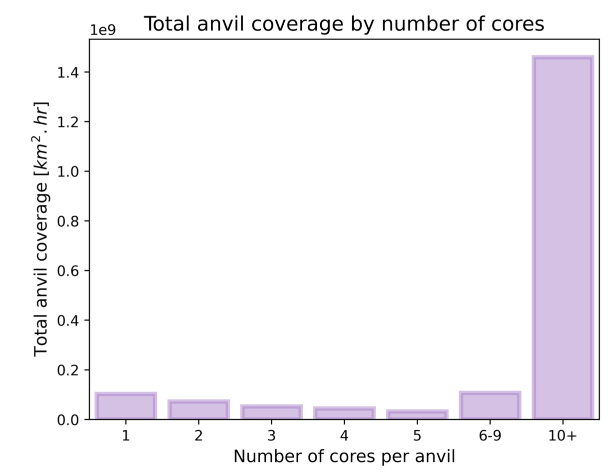


⬅ Number of cores detected in each 1x1° grid box

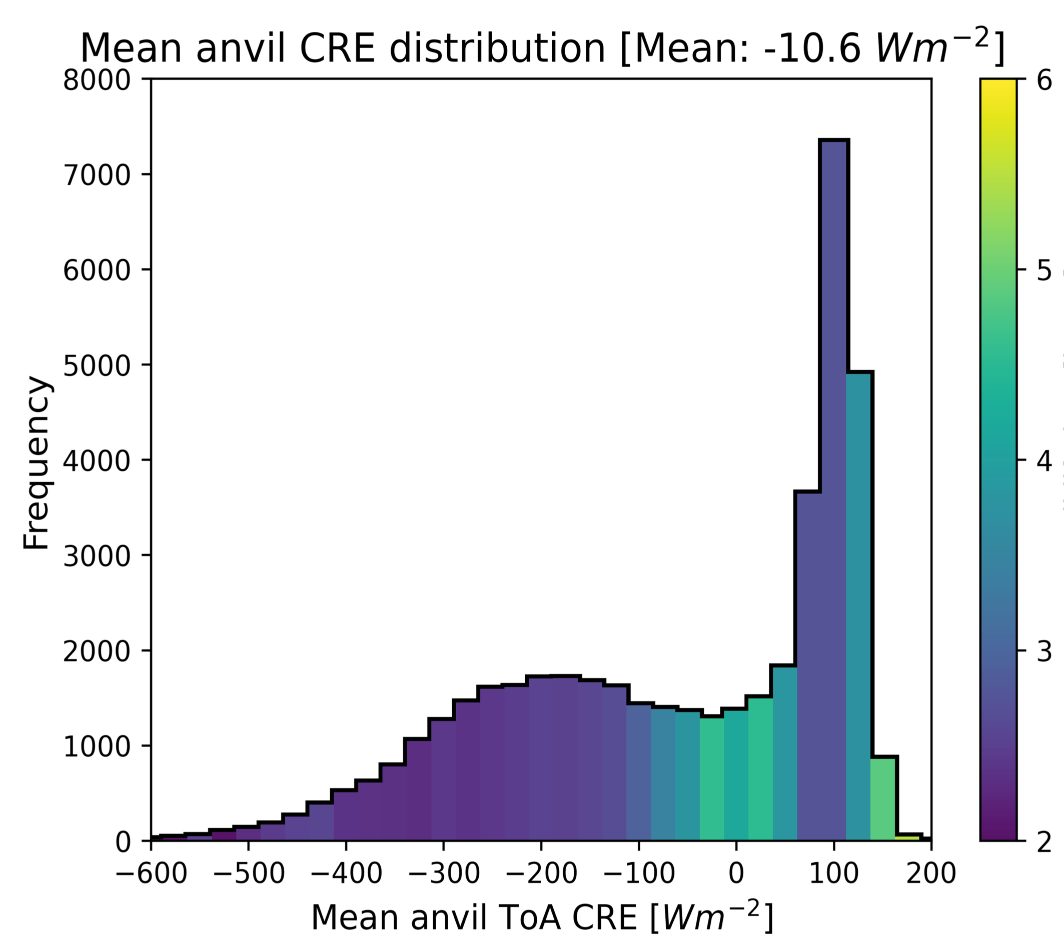
↙ Mean time of day of detection for cores. Grid boxes with large variance are shown with hatching



➡ Due to their large area and long lifetime, multi-core systems dominate the total anvil coverage, despite being few in number

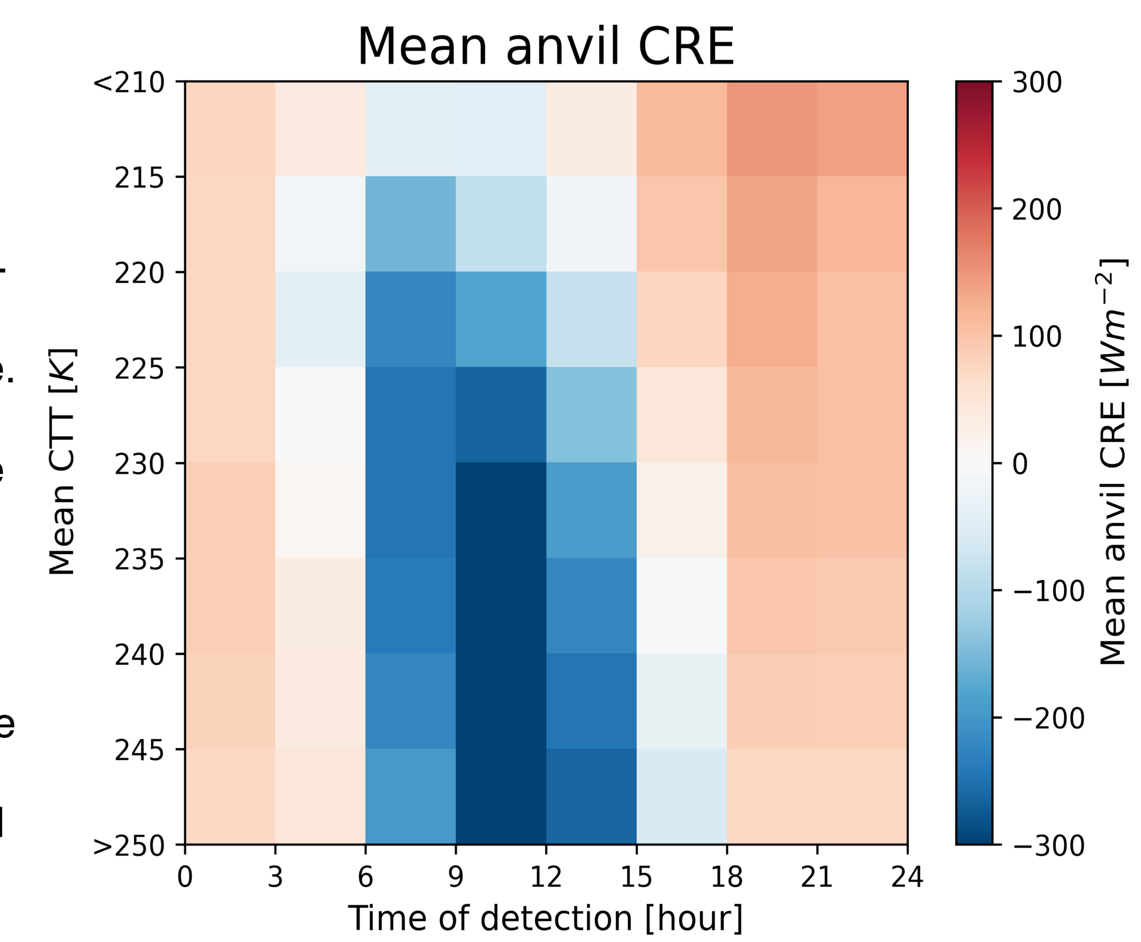


Radiative Effect:



⬅ Mean anvil CRE has a bimodal distribution, with both peaks consisting of isolated, short lived DCCs. Long-lived DCCs occur in the center or warm extreme. The negative mean is due to a cold bias in the radiative flux dataset

➡ Comparing the time of detection and CTT shows that for all but the coldest (and longest lived) DCCs, the diurnal cycle plays a major role in anvil CRE



Summary:

The distribution of tropical DCC CRE is determined by the shortwave CRE of isolated, short-lived DCCs occurring during the day- and nighttime. Changes to the diurnal cycle of convection – e.g. due to changing temperature or aerosol radiative effects – may lead to shifts in the overall CRE balance.

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