Interactions between radiation and convective organization

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Atmospheric moist convection (rainstorms made up of deep cumulus clouds) can organize on spatial scales from a few kilometres to thousands of kilometres, and on time scales from hours to weeks. Idealised models of radiative-convective equilibrium, as well as realistic simulations and observations of tropical convective phenomena such as the Madden-Julian Oscillation (MJO) and tropical cyclones, show that feedbacks between radiation, clouds, water vapour, and circulations can cause convective clouds to aggregate and organize on larger scales. For example, radiative cooling of the boundary-layer by shallow cumulus and warming by deep convective upper-level outflows ("anvil" clouds) have been found to promote larger-scale organization. Radiative interactions between convective cloud and the land-surface can also be important for convective organization; for example, models that represent too little shallow cumulus in the morning may overestimate solar heating of the land, leading to too early onset of deep convection. This raises important questions regarding the representation of convection in weather and climate models, such as:

1. What interactions between radiation, moisture, and cloud are important for convective organization and should be parameterised for a given model target grid scale?
2. Do aggregated conditions in parameterised-convection simulations have similar anvil cloud warming and boundary layer cooling as estimated from observations or as seen in high-resolution simulations?
3. To what extent do cloud biases in convective regions contribute to surface temperature biases that feed back on convective circulation biases in land regions with strong diurnal forcing or monsoon rainfall?

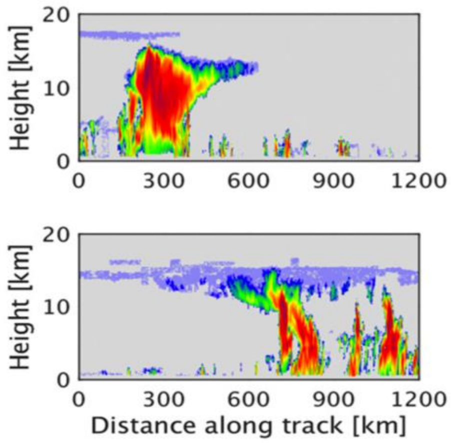

Figure 1: CloudSat reflectivities (with red colours being higher ice and/or liquid concentrations) along two different satellite overpasses with similar average rain rates: (upper panel) an example of organized convection, (lower panel) an example of less organized convection. Figure from Stein, T. H. M., C. E. Holloway, I. Tobin, and S. Bony, 2017: Observed relationships between cloud vertical structure and convective aggregation over tropical ocean. J. Climate, 30, 2187–2207.

For this PhD project, the student will undertake work leading to improvements in the representation of radiation interactions with convective organization in models. The work will involve analyses of high-resolution process model simulations as well as observations and coarser-resolution simulations. The student will work closely with scientists at the Met Office, Reading, and other universities as part of the NERC-Met Office ParaCon project, which seeks to make a step change in representing convective processes in models at important operational and climate scales.

Training opportunities:
The student will analyse high-resolution model analyses and interact with Met Office model development teams and other academics as part of the UK-wide ParaCon project.

Student profile:
This project would be suitable for students with a degree in physics, mathematics or a closely related environmental or physical science. Knowledge of python or a similar programming language is desirable.

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