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Effects of wind shear on cloud field organization

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In the presence of wind shear, convective cloud fields can organize themselves into larger structures than individual clouds, such as squall lines. Organization of the cloud field, whether caused by wind shear or otherwise, is not currently well represented in climate models.

In order to account for organization within a convective parameterization scheme, three aspects must be characterized and understood. First, the shear profile in a given climate model grid-column must be characterized. Second, the response of the cloud field to representative shear profiles is required. Third, the features of the cloud field response that will have an impact on the parametrization scheme must be identified and used to make modifications to the scheme. This presentation focuses on the second part, using high-resolution idealized simulations to investigate the response of cloud fields caused by varying the driving shear profiles. Particular attention is paid to ways in which the cloud field organization can be measured, how the statistics of the cloud field change and how the lifetimes of individual cloud cells change in the presence of shear.

We find that certain unidirectional shear profiles, known from observations to induce organization, also induce organization of the cloud field in our simulations. The degree of organization of the cloud field can be quantified, using a measure of organization at different spatial scales. The measure is based on a histogram of cloud-to-cloud distances. For our shear profiles, increasing the strength of shear is found to increase the degree and spatial scale of the organization. Additionally, when using a definition of convective cells that focuses on stronger cells than the average, the mean lifetime of cloud cells is seen to increase with increasing shear. The distribution of mass-flux per cloud is found to be well fitted by an exponential decrease for all shear profiles that have been investigated. With increasing shear, the number of stronger cells increases relative to the no shear case.

The findings are particularly well suited to modifying the stochastic Plant-Craig scheme, due to the scheme's representation of both the cloud lifetime and the convective mass-flux distribution. Both the lifetime and the mass-flux distribution (from which the random variables are sampled) can be generalized to become functions of the shear profile. Implementing these modifications will form the basis for future work.