Analysis of precipitation characteristics in marine boundary layer cellular convective clouds in the Eastern North Atlantic

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Extended Abstract

Despite their important role in the global radiative energy budget, marine boundary layer (MBL) clouds are not well represented in today's climate models. MBL clouds are responsible for energy and moisture transfer between the atmosphere and the ocean. The global energy balance is driven by incoming shortwave solar radiation and outgoing longwave infrared radiation. The low-lying stratiform clouds in the MBL reflect more shortwave solar radiation than the underlying ocean, which will have a cooling effect on the global energy budget. However, because they are so low in altitude, the temperature of the clouds is similar to that of the surface, so they do not significantly impact the infrared portion of the energy balance. Because of this significant impact on the radiative energy budget, there is a need for improved understanding of the processes that drive the lifecycle of these cloud systems (Wood et al. 2016). The improved understanding of these processes can then be used to develop better parameterizations of the relevant physics in climate models, and subsequently improved climate simulations.

Low-level MBL clouds are often organized into cellular patterns at the mesoscale (5-100 km). Two main types of mesoscale cellular convection (MCC) organization in the MBL are open and closed cells (Wood et al. 2006). These different cloud organization regimes have

significantly different impacts on the radiative energy balance, and feedbacks related to the hydrological cycle and atmospheric aerosol budgets. Open cell clouds consist of large rings of narrow cumulus clouds with clear skies (or thin stratocumulus) in the middle. Radar observations shows the cellular organization of precipitation with open spaces in between. Closed cell clouds consist of thick centers of stratiform clouds with narrowing or clearing on the edges.

In this study, we investigate differences in precipitation properties between these two MCC types, towards gaining a better understand understanding of the processes that cause and maintain the organization. To analyze the precipitation data, we determine and compare the observed histograms of 5-minute surface rain rate (mm/hr), the intercept parameter N_w ($1/m^3$ mm) for an assumed exponential rain drop size distribution, median volume drop diameter (D_0) (mm), and liquid water content (LWC) (g/m^3) for observed cases of each MCC type. It was hypothesized that these precipitation properties will vary for the different MCC regimes. The closed cell clouds were found to have smaller drop sizes and lower rain rate than open cell clouds, which had larger drop sizes and higher rain rates, but for shorter periods of time. The distribution of 5-minute rain rate of open cell cases peaked at a higher rain rate than that of the closed cell cases. Correspondingly, the LWC of open cell cases is greater than those in the closed cell cases. Beyond the locations of distribution peaks, both open and closed cell distributions extend over the full range of observed rain rate and LWC values. The distribution of N_w for open cell cases peaks at a lower value than the closed cell cases, while the distribution of D_0 for open cell precipitation peaks at a larger value than that for closed cell precipitation. We found a clear difference in precipitation properties between open cell MCC and closed cell MCC. Consider a short burst of pouring rain every few hours (with some clear skies in between), vs. an overcast, drizzly day. Open cell MCC clouds tended to have bursts of fewer, but larger, raindrops. Closed cell MCC tended to have more, smaller raindrops throughout the day. This project helped us to further understand the differences in precipitation characteristics of different types of cloud mesoscale organization and raises more questions about the differences between open and closed cell clouds and their behavior.