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Diurnal signals in flower cloud organization in the upstream Tradewind regions during EUREC4A

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Tradewind shallow cumulus clouds cover vast areas of the subtropical oceans, and are associated with various modes of mesoscale organization. During the EUREC4A field campaign in the subtropical Atlantic in early 2020, unique in-situ and remote sensing measurements were made that allow characterization of Trade wind cloud organization as well as the large-scale environment in which this phenomenon takes place. But how exactly the boundary layer transitions from upstream stratocumulus to the observed organized fair-weather cumulus in downstream areas is still not fully understood, and requires additional information on processes taking place far upstream. To gain insight and fill this data gap, in this study high-resolution Lagrangian simulations are conducted for selected EUREC4A days. The simulations follow the transitioning low-level air mass for multiple days as it approaches Barbados, covering at least three full diurnal cycles. The mean state in the simulations is evaluated against observational data. Sensitivity experiments on domain size are conducted, suggesting that mesoscale organization converges above 100x100 km2. The simulation for 2 February 2020 features well-defined flowers in upstream regions. Interestingly, the occurrence and duration of these flower periods follow a well-defined diurnal cycle. The flower clouds are also associated with distinct mesoscale patterns in thermodynamic state. To gain further insight, various metrics are used to quantify the mesoscale patterns. We find that the organization is expressed as a distinct, well-defined isolated mode in the 2D power spectrum of thermodynamic state. A novel metric called 'SGAP' is defined to capture this behaviour, expressing the degree of organization as the spectral area above an unorganized baseline state. SGAP is then combined with cross-sectional analyses of dynamics and heat budget terms in the LES to establish which mechanism is responsible for forming and dissipating the flower structures during the diurnal cycle.

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