Observations of Chain Aggregates in Florida Cirrus Cloud Anvils on 3 August 2019 during CAPEEx19

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ABSTRACT

Elongated chain-like aggregates have been observed in cirrus cloud anvils produced by electrified thunderstorms. Cloud chamber experiments have also been able to generate chain aggregates while applying strong electric fields (> 60 kV m^{-1}) to environments with ice crystal concentrations between 3.0 x 10^6 – 4.0 x 10^6 m^{-3} and over a range of temperatures. While it is believed that electric fields are important for chain aggregate formation, exactly where and how the chain aggregation process occurs with thunderstorm is not well understood, which inhibits inclusion in cloud models. Not having chain aggregates in models causes inaccuracies to cloud radiative transfer properties. Furthermore, chain aggregates are important to consider for supersonic flight.

To better understand the chain aggregation process, the North Dakota Citation II Research Aircraft sampled convection-induced, cirrus cloud anvils during the 3 August 2019 CapeEx19 field project flight. The aircraft flight's in-situ observations are analyzed to determine the degree that chain aggregation is occurring within cirrus cloud anvils. While chain aggregation is likely occurring in multiple locations; the in-situ, cirrus anvil observations indicate that the highest concentrations of chain aggregates are close to the storm core and the chain aggregate concentrations decrease away from the storm core. The observed chain aggregates contain individual crystal elements that grow under different temperature regimes and approximately 90 percent of the chain aggregates lack the presence of any rimed ice. Electric field observations indicate stronger electric fields closer to the storm core (on the order of 10^1 kV m^{-1}), which suggests that the chain aggregates observed near the storm core may have formed within the storm core, likely above regions of high concentrations of supercooled liquid water. However, the relative chain aggregate concentration with respect to non-chain aggregates ($RCAC_{N\text{-}C}$) increases away from the storm core (up to a certain distance), which supports the hypothesis that the chain aggregation process is occurring in the cirrus anvil region. However, further away from the storm core the electric fields are low which inhibits the idea that chain aggregation is continuing in the cirrus anvil region.

Analysis of additional flights that transect through the convective core would be useful to see if higher concentrations of chain aggregates (rimed and un-rimed) are observed. Analysis of all the CapeEx19 research flights would be useful to determine the variability of chain aggregates away from the convective cores. Moreover, to help understand the chain aggregation process in the cirrus anvil region, additional cloud chamber experiments would be beneficial to test if chain aggregation can occur using electric fields < 60 kV m^{-1} at temperatures colder than -30 °C.