



Supplement of

In situ observation of riming in mixed-phase clouds using the PHIPS probe

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S1 - Habit overview during ACLOUD and SOCRATES campaign

Fig. S1 shows an overview of the different habits observed during the two campaigns in different temperature regimes. Note that during the first flight of SOCRATES, PHIPS was not recording images due to a laser malfunction, hence RF01 is excluded from the analysis. Fig. S2 shows an overview of the fraction of "normally" (blue), "epitaxially" rimed (red), and unrimed (yellow) ice crystals per habit of the ACLOUD and SOCRATES campaign.

S2 - Correlation histograms

In the following, we show the remaining correlation histograms of riming fraction (Fig. S3), surface riming degree (Fig. S4), fraction of epitaxial riming (Fig. S5) as well as one-sided riming (Fig. S6) with various meteorological parameters, including relative cloud height (Fig. S3d, 100% corresponds to cloud top, 0% to cloud base), CDP mean droplet diameter (Fig. S3g), relative humidity (RH, Fig. S3f), ambient vertical velocity relative to the aircraft (Fig. S3g) and HCR Doppler velocity, divided in stratiform (h) and convective cloud segments (i). Note that fraction of one-sided particles is considered to be a lower estimate, as not every particle is imaged clearly from both sides on the stereo images and it is thus not always possible to determine whether or not both sides are rimed. HCR and RH data are available for the SOCRATES campaign only.

S3 - Smallest rimed particle

Fig. S7 shows the smallest ice particle on which riming was observed as discussed in Sec. 3. It is a column that was observed during the SOCRATES campaign on flight RF12. It has an area equivalent diameter of $D_{im,A} = 116.1 \mu\text{m}$ and maximum dimension of $D_{im,max} = 193.7 \mu\text{m}$.

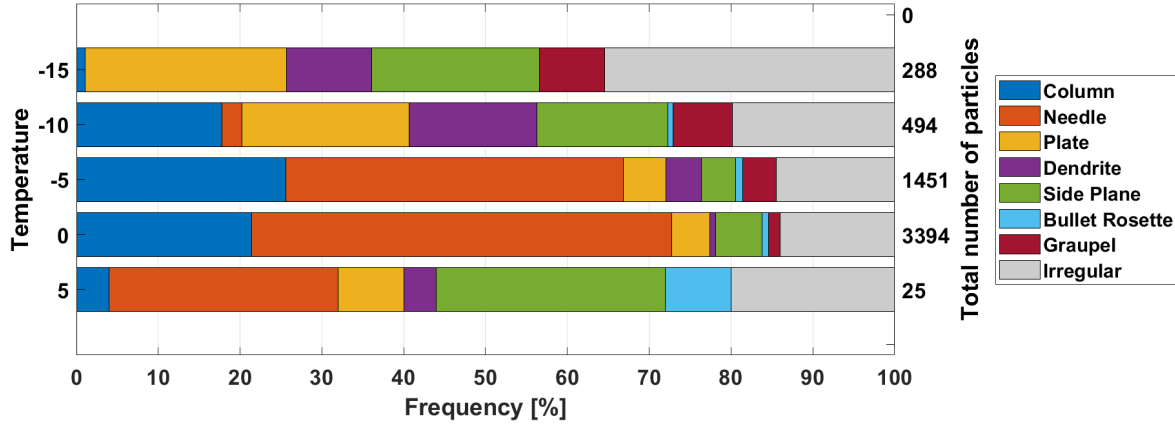


Figure S1. Overview of the habits of the manual classified particles of ACLOUD and SOCRATES in different temperature regimes $T \geq -17^\circ\text{C}$.

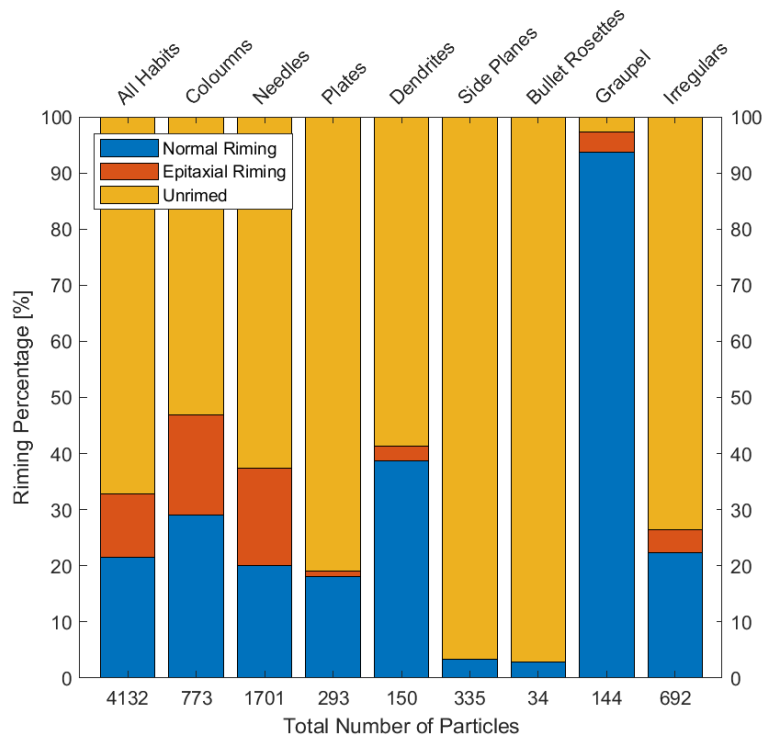


Figure S2. Overview of the fraction of "normally" (blue), "epitaxially" rimed (red), and unrimed (yellow) ice crystals per habit of the ACLOUD and SOCRATES campaign.

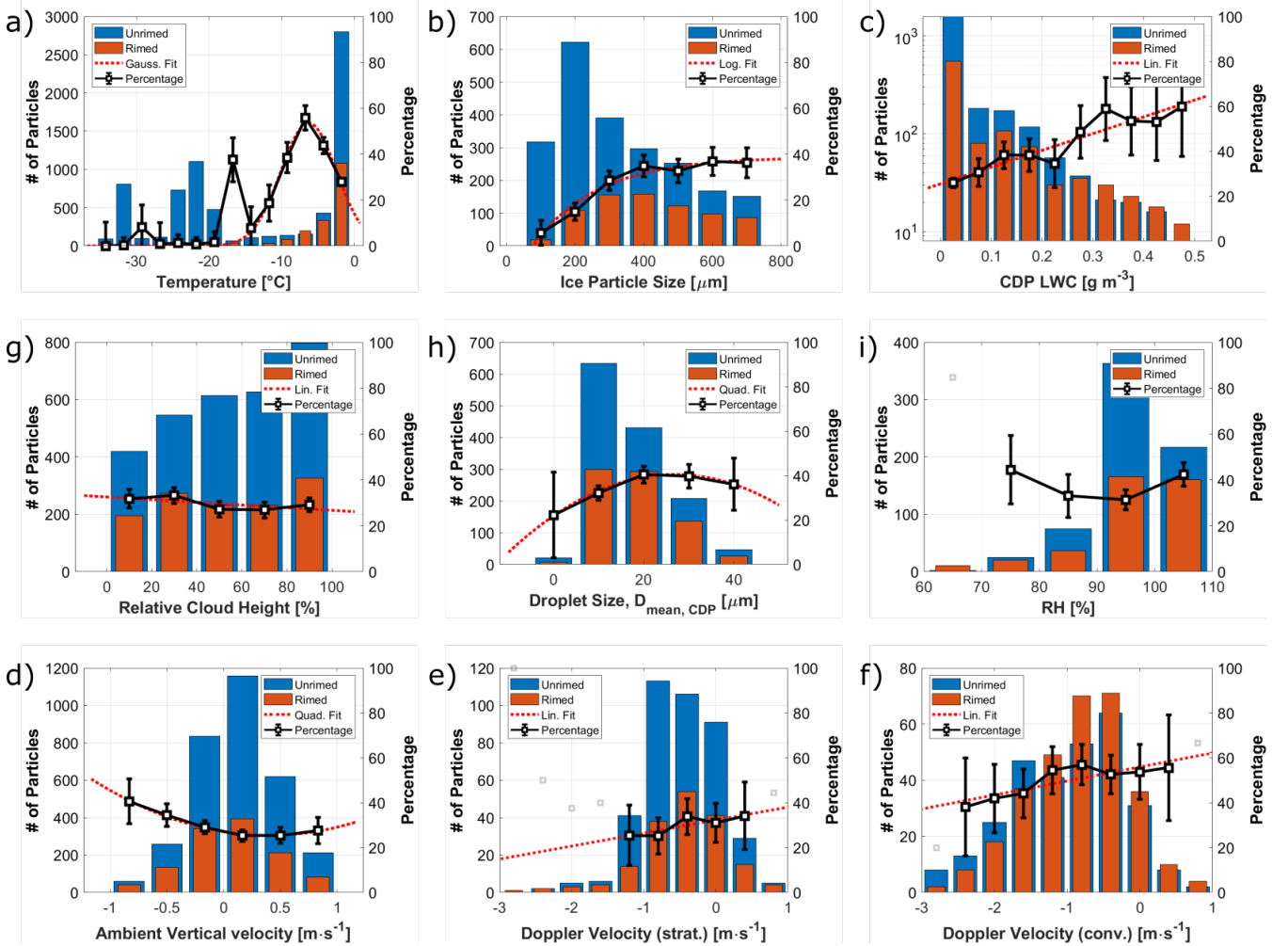


Figure S3. Histograms showing the absolute number of classified unrimed (blue) and rimed (red) particles during ACLOUD and SOCRATES as well as the relative percentage ($n_{\text{rimed}}/n_{\text{all}}$, black, right axis) in correlation with different ambient parameters: Temperature (a), area-eq. diameter of the underlying ice particle measured by PHIPS (b), CDP LWC (c), relative cloud height (d), CDP mean droplet diameter (e), relative humidity (f), ambient vertical velocity (g) and HCR Doppler velocity, divided in stratiform (h) and convective cloud segments (i). The red dotted line shows a fit to the percentage values. The statistical uncertainty bars correspond to the number of particles per bin ($n^{-1/2}$). Only bins with $n \geq 20$ are considered for the fits. Others are shown in grey.

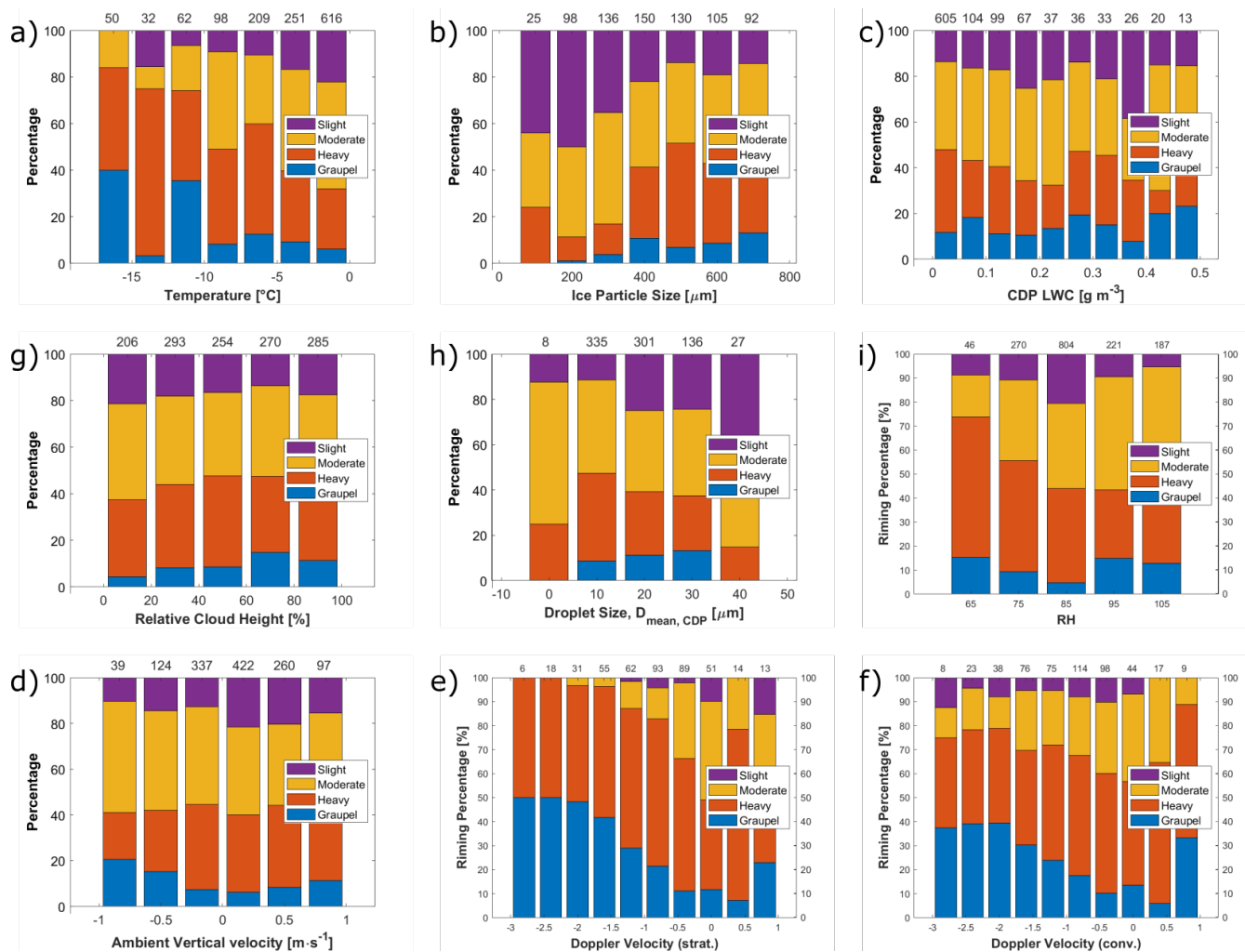


Figure S4. Correlation of surface riming degree with ambient parameters similar to Fig. S3. HCR data (d) is only available for SOCRATES.

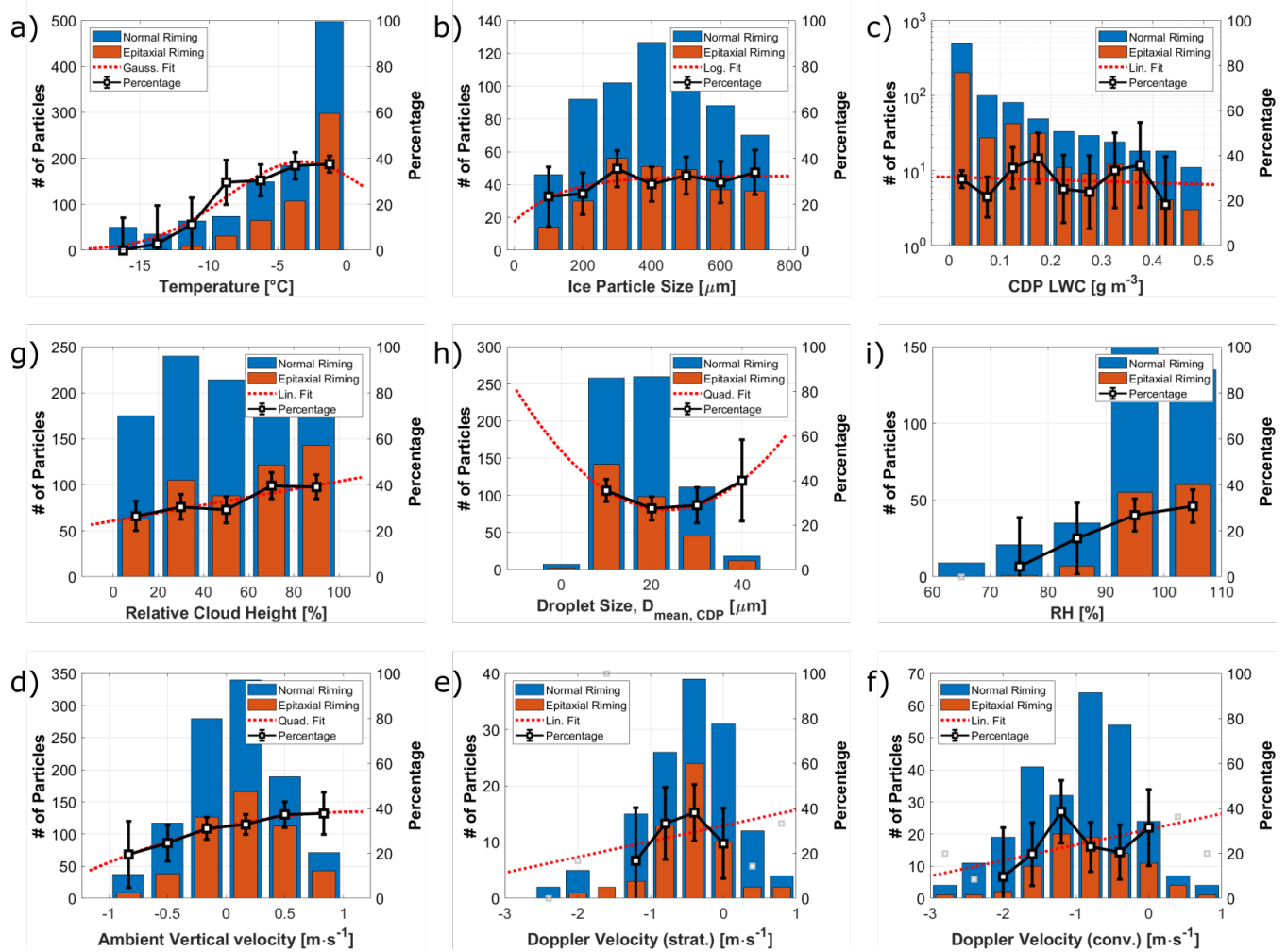


Figure S5. Correlation of the fraction of normally and epitaxially rimed particles with ambient parameters similar to Fig. S3. HCR data (d) is only available for SOCRATES.

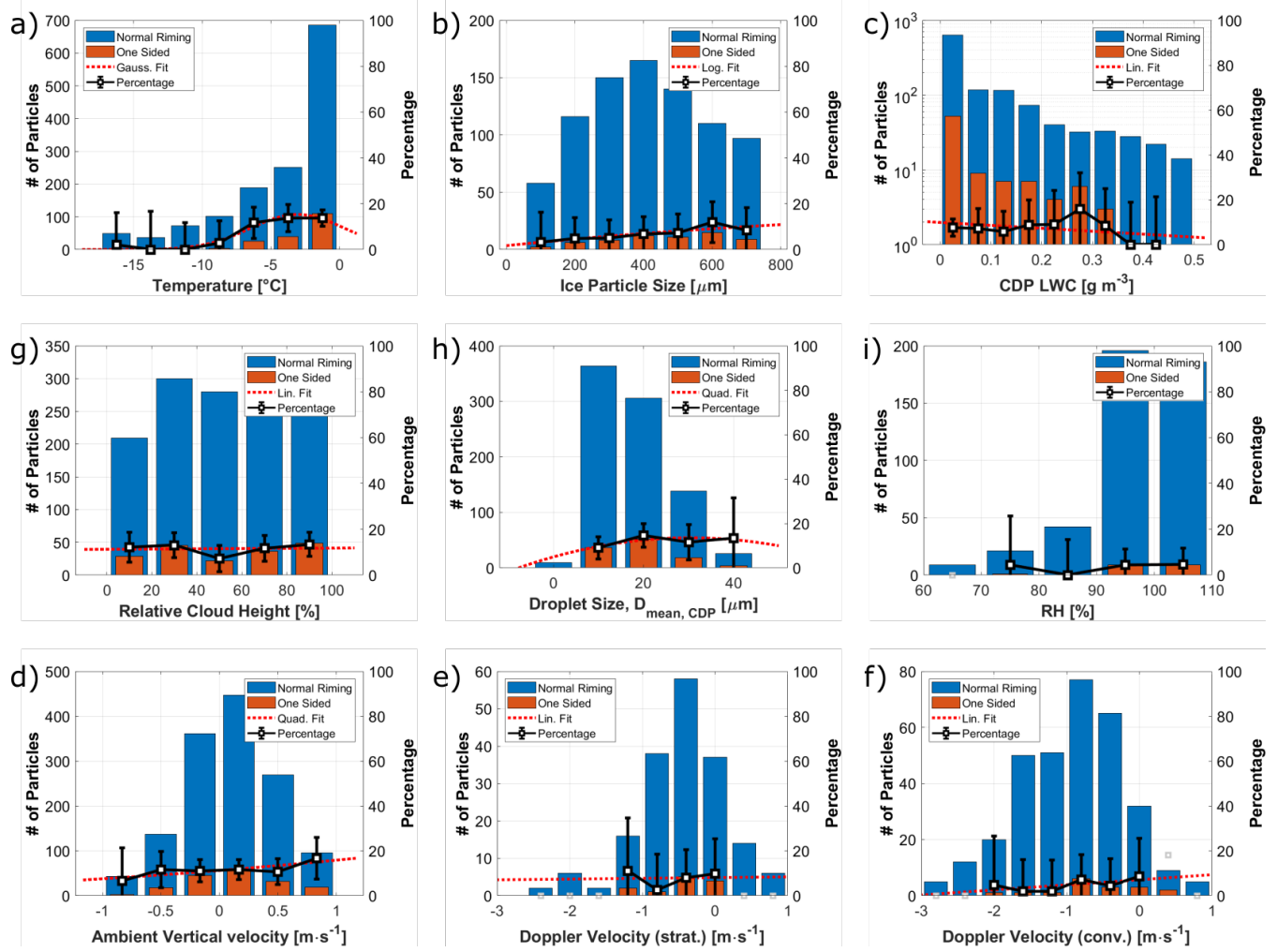


Figure S6. Correlation of the fraction of one-sided rimed particles with ambient parameters similar to Fig. S3.

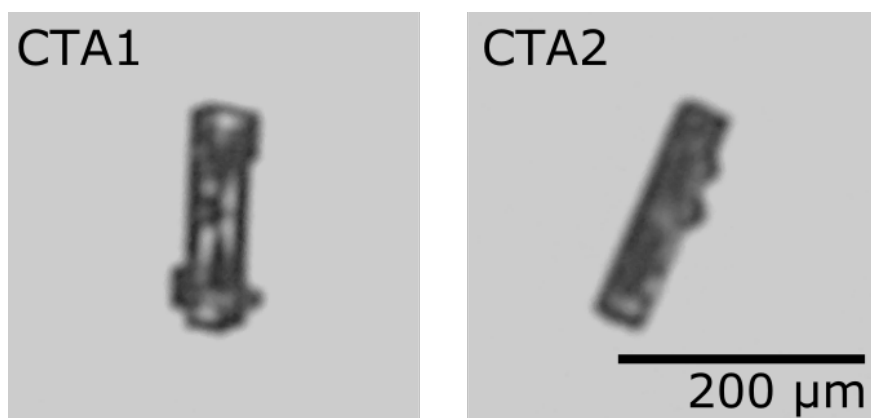


Figure S7. Stereo image of one of the smallest particles that is conclusively classified as riming and showed no indication of shattering had an area equivalent diameter of $D_{im,A} = 116.1 \mu\text{m}$ and maximum dimension of $D_{im,max} = 193.7 \mu\text{m}$ (SOCRATES, RF12, #217).