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Observation of secondary ice production in clouds at low temperatures

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Supplementary Information

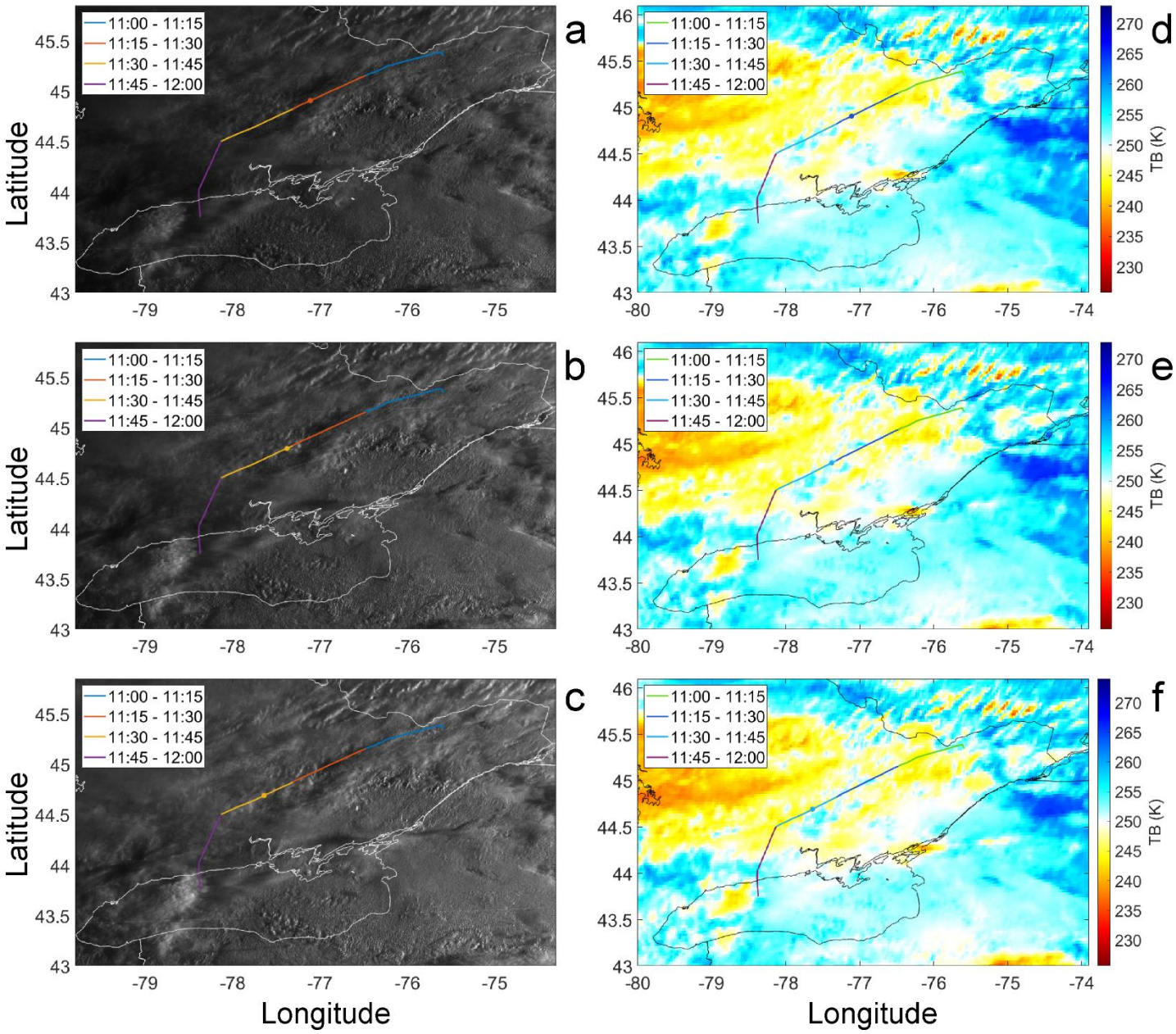

Figure S1. Satellite GOES-16 visible (a,b,c) and infrared (band 13, 10.8μm) (d,e,f) images corresponding to 11:27 UTC (a,d), 11:32 UTC (b,e) and 11:37 UTC (c,f) on 25 March 2017. Color lines indicate the flight track of the NRCC Convair-580. The dots indicate the positioning of the aircraft corresponding to the satellite imagery times.

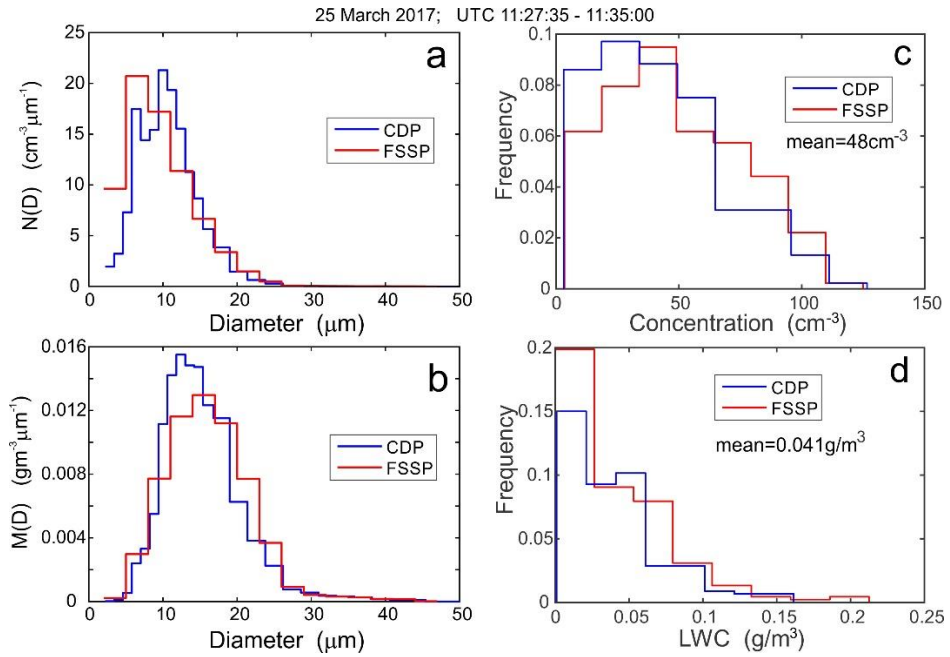

Figure S2. Average cloud droplet distributions of concentration (a) and mass (b), probability density functions of cloud droplet concentration (c) and LWC (d) measured by FSSP and CDP averaged over the cloud domain shown in Fig.1. The cloud segments with droplet number concentration N_{dr}<3cm^{-3} were not included in the statistics. The total length of mixed phase clouds is approximately 21.5km (192 one-second average points).

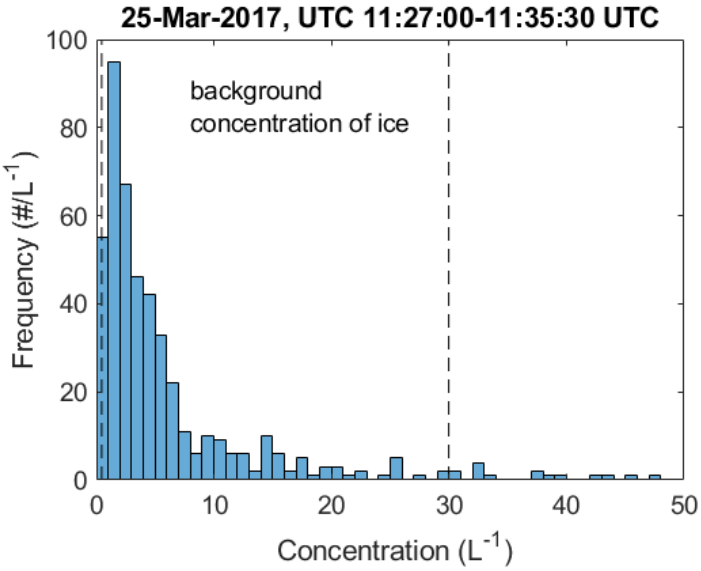

Figure S3. Probability density function of ice particle concentration measured by 2DS in the cloud segment shown in Fig.1 excluding cloud segments 1-3 (Fig.1a). Clouds with ice particle concentration with N<10^{-3} L^{-1} were not considered. The vertical dashed lines indicate 5 (left) and 95 (right) percentiles of the ice particle concentration.

Calculation of the rate of droplet freezing.

Calculation of the ice production was performed based on Bigg's equation of the rate of the cloud droplet freezing, i.e.,

$$\frac{dN_{ice}(i)}{dt} = aCN_{dr}(i)m_{dr}(i)\exp(-bT_C) \quad \text{(S1)}$$

where N_{dr} and m_{dr} are the concentration and mass of droplets of *i*-th size category, respectively, and N_{ice} is the concentration of ice particles formed due to freezing of the droplets of the *i*-th category, T_C is the air temperature in °C, and a=10^{-4} $s^{-1}g^{-1}$, b=0.66°C^{-1}, C=1 are constants.

Integrating Eq.S1 over the droplet size distribution yields:

$$\frac{dN_{ice}}{dt} = \sum_i aCN_{dr}(i)m_{dr}(i)\exp(-bT_C) = aCW\exp(-bT_C) \quad \text{(S2)}$$

where W is LWC.

Integration of Eq.S2 over the droplet size distribution shown in Fig.S2a gives the rate of the droplet freezing $dN_{ice}/dt \approx$ 0.3 $L^{-1}s^{-1}$ (Fig.S4).

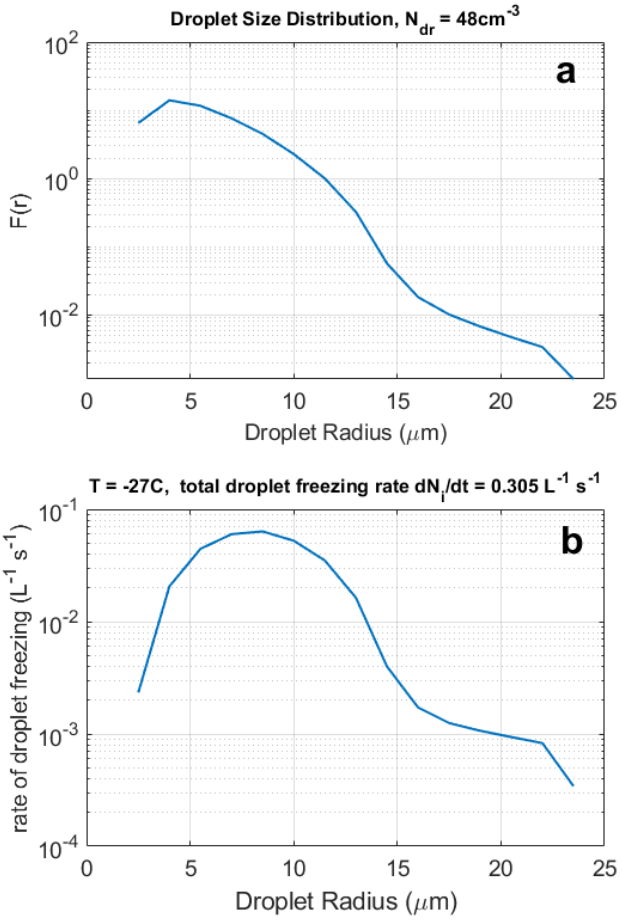

Figure S4. (a) Droplet size distribution (same as in Fig.S2a). (b) Distribution of the rates of droplet freezing corresponding to the droplet size distribution in (a) and T_C=-27°C.