This study (Qu et al.) investigates the impact of secondary ice production (SIP) on the cloud microphysics and dynamics under mid-latitude winter conditions based on numerical weather prediction (NWP) simulations. Two flights from the 2019 In-Cloud ICing and Large-drop Experiment (ICICLE) field campaign were selected for model evaluations. SIP processes, the Hallett-Mossop (HM) and fragmentation of freezing drops (FFD), are parameterized and examined in the model simulations. The study finds that SIP is important for high ice water content (HIWC) production in strong convective conditions, whereas it has a less impact in stratiform conditions. The interaction between the two SIP mechanisms is also important for the modeled cloud microphysics.

General comments

The results of contrasting the importance of SIP for convective and stratiform conditions through comparison with *in situ* ICICLE observations are interesting. However, the manuscript can be significantly improved by considering the following points:

1. Description of cloud microphysics in model parameterizations be improved (see detailed comment below).
2. Primary ice nucleation and role of it for model simulations.
3. Role of other SIP mechanisms (e.g., ice-ice collision breakup) for model simulations.

Specific comments

Line 26: "influencing the energy balance and hydrological cycle on both regional and global scales". Please provide some citations, e.g., Zhao and Liu GRL 2021, among others.

Line 92: "(PSD)"?

Line 99: "sizes of ice and liquid particles, ice and liquid water content (LWC) were calculated from PSDs measured by particle probes". How do you separate liquid from ice particles to calculate LWC and IWC?

Line 102: "asses"? should be "assess".

Figure 1: "The red rectangle". Shall it be "orange rectangle"?

Section 3.2. Description of cloud microphysics parameterizations should be improved.

How is ice nucleation parameterization represented in the model? how about aerosols and CCN treated in the model?
Line 130: "four ice categories". What are these four ice categories?
Line 131: "PSD". No need to redefine it as it is defined above.
Line 133: "liquid ice mass"?
Line 156: "Liquid "cloud droplets" are defined as having a diameter smaller than 50 µm, while "rain drops" have a diameter exceeding this threshold". How does P3 treat liquid-phase hydrometeors in P3?

Equation (3): What are the units of these variables?

Line 180. Considering the large uncertainty of the FFD parameterization, can you test another parameterization Phillips et al. 2018?

Line 186: model experiments “one with only HMr (based on ice collected rain drops, excluding collected rain used for FFD), one with only FFD”. These two experiments have never been discussed later and listed in Table 1.

Line 211: “ice number concentration (Ni)”. Can you give the size range of ice?

Figure 3: The unit of Ni seems not correct. Same for Ni in Figure 12.

Line 259-261. “These results indicate that under freezing conditions with an abundant supply of supercooled rain, the initiation of the FFD process is highly dependent on the rate of the HM process, or potentially any SIP processes which could provide sufficient amount of small ice particles.” It is interesting to see the interactions between SIPs. How about SIP and primary ice nucleation interactions?

Line 266: “based at simulation 510 min simulation time”? The sentence is not correct (two simulations).

Line 390: “in this stratiform 390 case Ni is primarily governed by the homogeneous freezing process, with SIP playing a relatively less important role. Ice particles with high number concentrations, formed through homogeneous freezing above 7 km, fall and eventually increase Ni values at lower altitudes.” Can you provide evidence? how about heterogeneous ice nucleation?

Line 450: “However, even with SIP, the PSD is not yet perfectly captured. Further studies are needed to enhance the accuracy of ice particle size distribution representation.” Can you give some explanations?

Conclusions and perspectives section: please add some discussions on primary ice nucleation and other SIP processes and role of them for model simulations.