Comment on amt-2021-26
Anonymous Referee #1

The manuscript by Libby Koolik and co-authors provides a thorough description of the novel SPIDER inlet, which can discriminate interstitial aerosol particles, cloud droplet and ice crystal residuals in ambient mixed-phase clouds. SPIDER uses a combination of a large pumped-counterflow-virtual-impactor (rejection of interstitial aerosol particles) and a droplet evaporation section and a PCVI (rejection of droplet residuals), which allows that only ice crystal are transmitted in the system. A set of laboratory experiments is conducted to verify the transmission of ice particles in the main sample flow of SPIDER, and the rejection of interstitial aerosol particles and cloud droplets. The rejected unactivated aerosol particles and the cloud droplet residuals can thereby still be measured in the pump flows of the PCVIs. The SPIDER inlet was also successfully tested in a field campaign during in-cloud conditions, measuring the size distribution ice crystal residuals.

Only a few of such ice-selective inlets exist worldwide, therefore the novel SPIDER inlet is an enrichment for the field of mixed-phase cloud research.

The manuscript is generally well written, and I only have the following minor comments.

General comments:

- The citation in the introduction needs to be improved. Often references are repeated and sometimes not specific enough, or not appropriate. See specific comments below.
- Transmission efficiencies: As you claim that the SPIDER inlet is able to sample simultaneously interstitial aerosol particle, droplet residuals, and ice crystal residuals, it
would be needed to address the transmission efficiencies for the different channels. To my understanding this can be retrieved from the existing measurements.

- No particles smaller than the lower size limits of the OPC/OPS (~0.3 µm) were measured. Hiranuma et al. (2016) used a condensation particle counter to address the question of transmission of small particles in the different channels. In my opinion, such measurements can help to verify that e.g. no small aerosol particles or small evaporated cloud droplets are able to be transmitted in the droplet or ice channel, respectively. Further, such measurements can also be used for transmission efficiency measurements at the interstitial aerosol channel. This is rather a recommendation for future work and does not imply that new measurements need to be presented in this manuscript.

- Ice crystal residuals and cloud droplet residuals are not necessarily only INPs and CCNs, respectively, as cloud droplets can also contain scavenged particles and ice residuals can also contain droplet residuals due impact from secondary ice crystal formation (e.g. see discussion in Kamphus et al., 2010). Based on your statement in the introduction (lines 67 – 70) and in the conclusions (lines 290 – 291), you should be more specific about what ice residuals and cloud droplet residuals are when you sample them with SPIDER. Are you truly only measuring INPs and CCNs?

Specific comments

- Abstract: I suggest to give the size range of ice particles which can be analyzed with SPIDER.
- Lines 26 – 28: I assume that the most important criteria about the Storm Peak Laboratory campaign was that you were able to sample ambient supercooled clouds, which I would mention here.
- Lines 29 – 30: „Possible design improvements of SPIDER are also suggested“, are you referring here to using more robust OPCs or OPCs with a higher resolution? It is not clear to me what those design improvements would be.
- Lines 33 – 34: „Mixed-phase clouds are important factors in aviation and climate (Shupe et al., 2008)“, please add more and also more recent literature, as e.g. Lohmann et al. (2017), McCoy et al. (2016).
- Lines 38 – 40: „Mixed-phase clouds are particularly complicated because the partitioning of phases is critical in assessing these effects (Atkinson et al., 2013; Hirst et al., 2001; Korolev et al., 2003; Shupe et al., 2006).“ Atkinson et al. (2013) was not investigating this specific research question; also, there is more and also more recent literature about this, e.g. Korolev et al. (2017), Tan and Storelvmo et al. (2019), just to name a few.
- Lines 41 – 43: „This has resulted in a global effort to study these clouds (Abel et al., 2014; Davis et al., 2007a; Hiranuma et al., 2016; Kupiszewski et al., 2015; Mertes et al., 2007; Patade et al., 2016).“ Also here, include more recent studies, e.g. Lohmann et al. (2017), Lowenthal et al. (2019), Schmidt et al. (2017), Ramelli et al. (2021), Ruiz-Donoso et al. (2020).
- Lines 45 – 46: „At this saturation aqueous droplets are the favored state and particles that activate are termed cloud condensation nuclei (CCN) (Lohmann and Hoose, 2009; Wang et al., 2012).“ Those references are not specifically investigating warm cloud activation. I recommend to change the references to e.g. Pruppacher and Klett (1997).
- Lines 42 – 49: „Ice can form homogeneously, via spontaneous nucleation of ice in a solution droplet, at temperatures below -40°C (Atkinson et al., 2013; Kamphus et al., 2010; Korolev et al., 2003; Storelvmo et al., 2008; Verheggen et al., 2007; Wang et al., 2012).“ None of those publications focus on homogeneous freezing of solution
The author contributions is missing
Figure 4: There is no panel (c)
Figure 7: Please indicate that this is the transmission efficiency from the PCVI
Figure 8 (and related discussion in the text): Another important parameter for the description of these timeseries would be the ambient temperature, which one could relate to the nucleation temperature of ice crystals in the cloud. More, on 2019-01-21 at ~ 18:30, ice crystal concentrations are as high as 0.03 cm-3, which is a relative high
INP concentration at temperatures < -20°C (the lower limit of ambient temperature, as I understand from line 240). Thus, is this an indication for an impact of sampling ice crystals formed by secondary processes?

Figure 9 (panels c, d): Also here, are your measurements impacted by secondary ice crystal production in the smaller size bins? It is quite surprising that the concentration of ice crystal residuals increase towards smaller sizes.

**Editorial comments:**

- Line 92: Please introduce the abbreviation „SPIDER“, since it is the first time using it in the main text.
- Line 93: Please introduce the abbreviation „L-PCVI“.
- Line 222: The abbreviation for INP was introduced earlier.
- Lines 304 – 305: Remove those test citations.
- I suggest to either use supersaturation or relative humidity with respect to water (especially in the droplet evaporation chamber section).
- As the abbreviation for ammonium sulfate (AS) is only used a few times in the manuscript I suggest to use the full name.
- The resolution of Figures 3, 4, 8, and 9 can be improved.

**References**


Hoose, C., and Möhler, O.: Heterogeneous ice nucleation on atmospheric aerosols: a review of results from laboratory experiments, Atmos. Chem. Phys., 12, 9817 - 9854, 10.5194/acp-12-9817-2012, 2012.


