Reviewer 2 comments and response

We appreciate the reviewers insightful comments. We have tried to address them all carefully below in a point-by-point manner and believe the paper has been improved as a result.

Review Comment 1: Is there an operating range for the instrument? What is energy consumption as a function of ambient temperature? This would shed light on the requirements for deployments in different areas.

Response: The recommended operating range of the DEID for field experiments is from 104° C to 106° C for ambient temperatures ranging from -20° C to 20° C. At the Red Butte Canyon experimental site, the DEID was operated at 104° C for the entire experimental period between December 2019 and April 2020, with ambient temperatures ranging from -12° C to 10° C. At the Alta Collins site, the DEID was operated at 106° C for the entire experimental duration between October 2020 and April 2021, with ambient temperatures that varied from -20° C to 20° C. The DEID energy consumption is estimated using the following equation

$$Convective\ power\ loss\ = h_c A_p \vartriangle \mathrm{T},$$

where, h_c is the wind speed dependent convective heat transfer coefficient for air flow over flat aluminium plate, A_p is the area of the hotplate, $\vartriangle \mathrm{T}$ is temperature difference between hotplate and the ambient air. The rate of convective heat loss rate for a range of wind speeds and temperatures is given in figure R1.

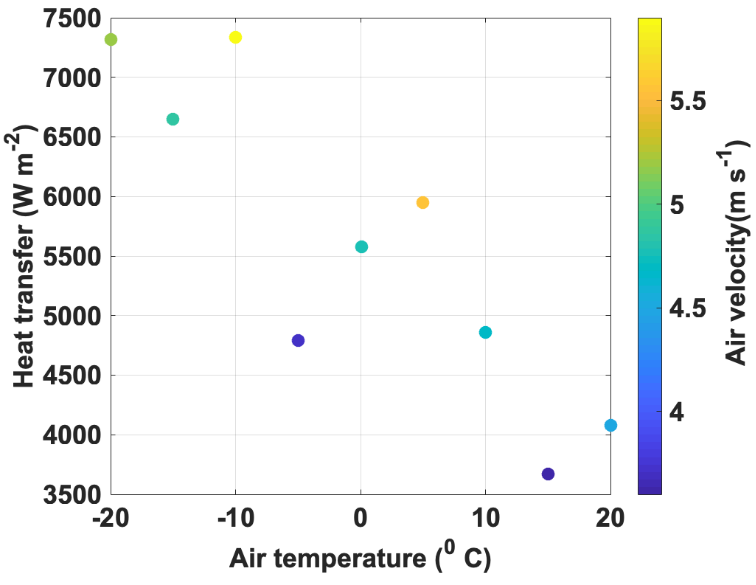

Figure R1. Rate of convective energy loss for different ambient temperature and wind speed.

Review Comment 2: What are the impacts of wind flow around the instrument for snow events? Since this is mentioned as a drawback of other instruments, should address. It seems like provided wind tunnel tests were focused on thermal effects of wind (this is good!). This should be pointed out at L295, otherwise reader could interpret this statement too far. The statement at L350+ about minimal interference with the camera seems like a stretch, but that's coming from someone that lives in a windy environment. I agree that a flat plate implies it is better than other platforms.

Response: At the Alta Collins site location, the DEID was collocated alongside instrumentation deployed at the long-running Collins Snow Study Plot (CLN), which is a well-protected snow study site located at the upper terminus of Little Cottonwood Canyon, averaging 1300 cm of snowfall annually and 17.4 days with at least 25 cm of snow per winter. The full record from CLN spans 41 years (January 1980–April 2021), and the last 21 seasons include a complete record of automated hourly precipitation observations (Alcott and Steenburgh 2010).

This site was chosen in part to avoid the additional measurement of windblown snow that would typically be lifted from exposed terrain features. However, we did not do anything to specifically avoid measuring lifted snow other than using this well-sheltered area along with keeping the plate surface elevated ~1.25 m above the ground surface. Lifting the plate to this height significantly reduces wind-blown effects even in non-sheltered areas (e.g., Naaim-Bouvet et al. 2014). Blowing snow is likely to have a distinct signature by way of particle clustering and size. In the current state, no distinction has been made between the characteristics of freefalling and lifted snow. If there is a flux of precipitation falling downward onto the plate, it will be measured whatever its origin.

As another point of evidence, the total SWE accumulation was compared with manual measurements from the Alta-Collins snow-study plot. A windshield was implemented around the manual bucket to increase catchment efficiency. The correlation between the DEID and the manual SWE measurement is 0.997 for 10 snow events.
At L295, it is now stated that DEID measurements are highly insensitive to the thermal impacts of winds.

Alcott, Trevor I., and W. James Steenburgh. "Snow-to-liquid ratio variability and prediction at a high-elevation site in Utah's Wasatch Mountains." *Weather and forecasting* 25.1 (2010): 323-337.

Naaim-Bouvet, Florence, et al. "Detection of snowfall occurrence during blowing snow events using photoelectric sensors." *Cold Regions Science and Technology* 106 (2014): 11-21.

Review Comment 3: My biggest concern with the paper is the missed opportunity to compare DEID to other common measurements. Take visibility for example... was there a forward scattering sensor on site? Provided that the instrument is sensitive to hydrometeors > 200μm, I presume there could be bias. What about MASC data? Would be great to see PDFs of select variables between the two systems. Statements like Line 310-312 could be backed up with MASC images.

Response: The DEID and MASC were both deployed at the Red Butte Canyon site. Unfortunately, there was no forward-scattering sensor at the site with which a visibility calculation could be compared. For a one hour period of measurement, used for comparing MASC and DEID measurements of hydrometeor maximum dimension D_{max}, the median values with lower and upper quartiles from the DEID and MASC are D_{max} = 2.77 [1.84 4.38] mm and D_{max} = 2.90 [1.93 4.89] mm respectively. The pdf is given in figure R2. A more extensive comparison between the MASC and DEID is addressed in the paper in review (Measurement report: Mass and Density of Individual Frozen Hydrometeors K Rees, D Singh, E Pardyjak, T Garrett - Atmospheric Chemistry and Physics Discussions, 2021).

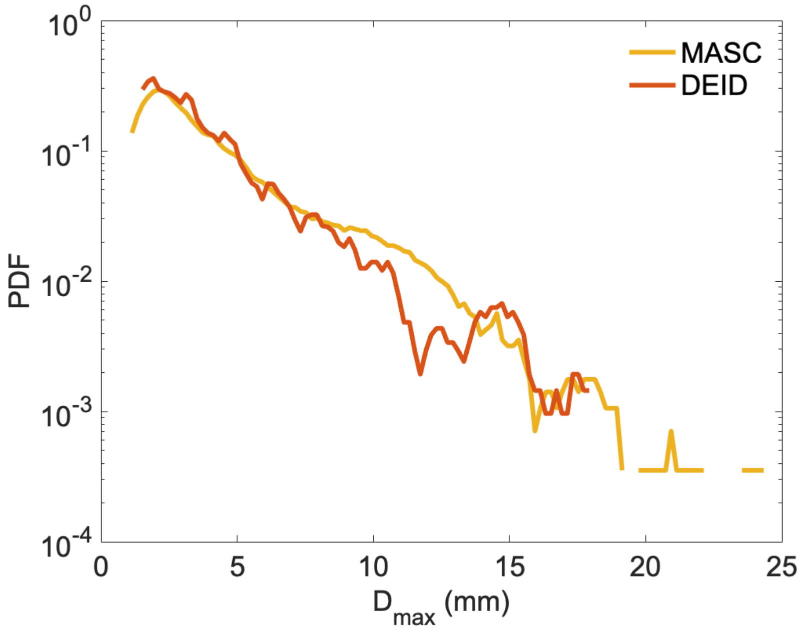

Figure R2. PDF of D_{max}. 2268 snowflakes are observed using DEID and 2093 snowflakes are observed using MASC in one hours duration on Jan 26, 2020 at Red Butte Canyon.

Review Comment 4: Can you explain the logic between sampling rates? Why was 12 Hz decided upon for field work? Precipitation rate is mentioned, but is this determined on the fly by input from other instruments? It's unclear how the range of 2-30Hz is related to the rates quoted in Section 2.2 that mentions tests up to 120 fps / 240 Hz.

Response: Higher frame rates were used to validate aspects of particle detection and the melting rates etc. and a lower rate (12 Hz) was used in field observations. To determine a thermal camera frame rate that would capture the widest possible range of hydrometeor types , an experiment was performed during a snow event at Red-Butte Canyon on 25 March 2020. The thermal camera was operated at a frequency of 60 Hz with the plate temperature set to 104° C. The total mass of hydrometeors was estimated using two different algorithms, from the total mass in each frame, a summation of the mass of each particle. The difference in total mass between the two algorithms can arise due to rejection of hydrometeors with an evaporation time less than three consecutive frames or from incomplete evaporation at the end of sample period. A period with a length of three frames (0.25 sec) was selected as a minimum for performing an accurate mass measurement. The total mass of hydrometeors that fell on the hotplate within half an hour was calculated using sampling frequencies of 1, 2, 3, 6, 10, 12, 15, 20, 30, and 60 Hz and shown in Figure R4. Using the frame-by-frame method the calculated total mass at 12 Hz frequency is 99.82 % of the total mass calculated at 60 Hz, so it is this method that is used for SWE accumulation calculations. Using the particle-by-particle method the calculated total mass at 12 Hz frequency is 94.79 % of the total mass calculated at 60 Hz. Sampling at 60 Hz could also be done, but it is less practical operationally.

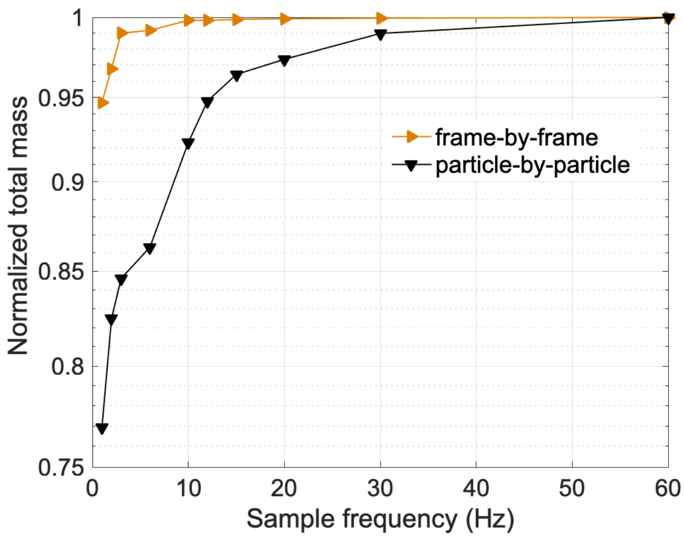

Figure R4. Normalized total mass that is total mass at different frequency divided by total mass at highest frequency is plotted against sample frequency.

Review Comment 5: What are the computing requirements like? It was unclear whether the imagery is processed in real-time or not, and if so, what type of resources are needed.

Response: For a ~ 1.2 Mpixels camera resolution, the processing time for each frame is approximately 0.015 sec. The average size of the data for a one-hour period is 1.3 Gb and the associated processing time is approximately 11 minutes. Selecting a frame rate of 12 Hz, in part, assures that the DEID can operate as a real-time instrument. Hence, the 12 Hz represents a cost benefit balance between accuracy of the measurement and time and storage costs.

Review Comment 6: Figure 12: Is there any significance to the width of the heavy/light snow columns? It seems like these could be broadened.

Response: Figure 12 is modified.

Minor comments:

Line 25: Might be worth highlighting the challenges of other instruments for snow/wind? See associated references that could be added to this section.

Parsivel:

Battaglia, A., Rustemeier, E., Tokay, A., Blahak, U., & Simmer, C. (2010). PARSIVEL Snow Observations: A Critical Assessment. *Journal of Atmospheric and Oceanic Technology*, *27*(2), 333–344. https://doi.org/10.1175/2009JTECHA1332.1

Loeb, N. and A. Kennedy, 2021: Blowing Snow at McMurdo Station, Antarctica During the AWARE Field Campaign: Surface and Ceilometer Observations. *J. Geophys. Res. Atmos.*, 126, e2020JD033935.

MASC:

Fitch, K. E., Hang, C., Talaei, A., and Garrett, T. J., 2020: Arctic observations and numerical simulations of surface wind effects on Multi-Angle Snowflake Camera measurements, Atmos. Meas. Tech., 14, 1127–1142.

Response: Added

Figure 4 caption: water droplets or water and ice droplets?

Response: In wind tunnel, only water droplet was used.

L230: Is there an extra – before Collins?

Response: Corrected

L235: Please clarify- what is a sample referring to if there were 2000 snowflakes or rain drops contained within? I think this is answered at L358... just make sure this is clarified earlier on.

Response: For each trial, 2000 snowflakes/raindrops were collected during continuous precipitation and the sample collection time varied from about 5 to15 minutes.