Examining snowflake relationships by analyzing data from two different field instruments

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Introduction

- Precipitation forecasts are highly dependent on hydrometeor mass and density which are highly uncertain and difficult to measure
- New instrument, called the Differential Emissivity Imaging Disdrometer (DEID), measures the mass and density of **individual** snowflakes
- Multi-Angle Snowflake Camera (MASC) takes high quality photos of snowflakes and obtains various measurements for individual snowflakes

These two instruments were deployed alongside a weather station in Alta, UT during winter 2023-2024.

Here, we compare individual snowflake parameters measured by the two, as well as observe density trends with temperature and relative humidity

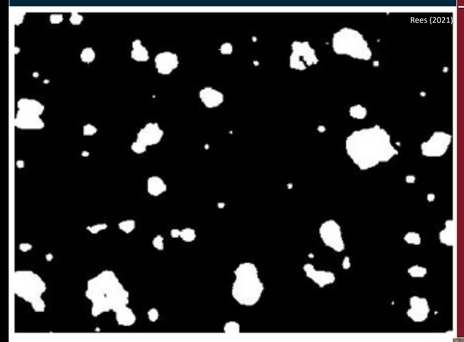
Methods

Differential Emissivity Imaging Disdrometer (DEID)

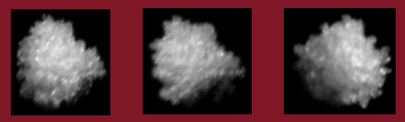
- Determines mass from each particle's evaporation time and diameter by assuming conservation of energy (Singh 2021)

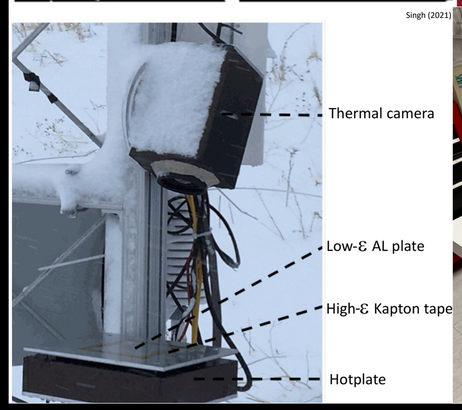
Multi-Angle Snowflake Camera (MASC)

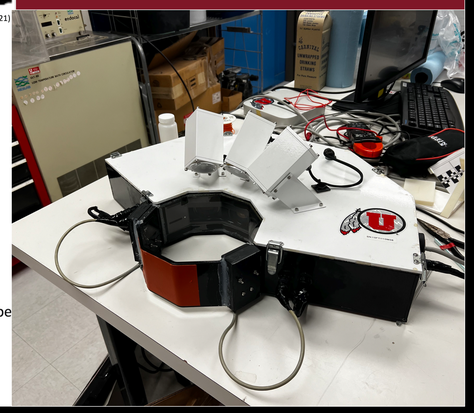
- Uses 3 cameras 36° apart to create a 3D visual of snowflakes
- Used alongside the DEID for data comparison



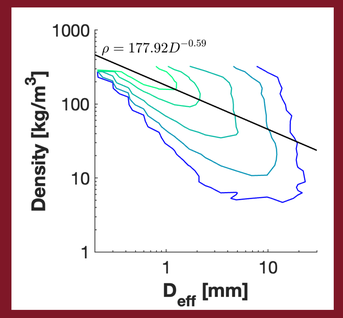
MASC Triplet







Results



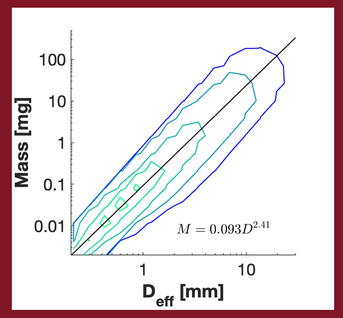
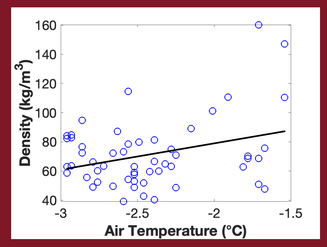
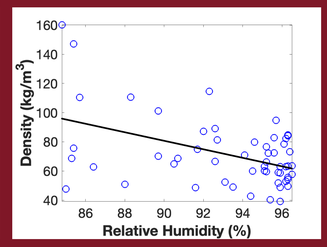


Figure 1. Density-Diameter and Mass-Diameter relationships based on DEID measurements. The exponents generally coincide with previous studies, as Rees et al. (2021) found a range from 2.17 to 2.73 for mass-diameter and -1.28 to -0.48 for density-diameter. Locatelli & Hobbs (1974) found a range of 1.4 to 3.0 for mass-diameter. Therefore, the exponents found during this project support those from Rees et al. (2021), but exceed the values obtained in Locatelli & Hobbs (1974), specifically the values obtained for densely rimed hydrometeors and aggregates.

Figure 2. Relationship between density (as measured by the DEID), air temperature, and relative humidity. All points represent 10 minute averages.





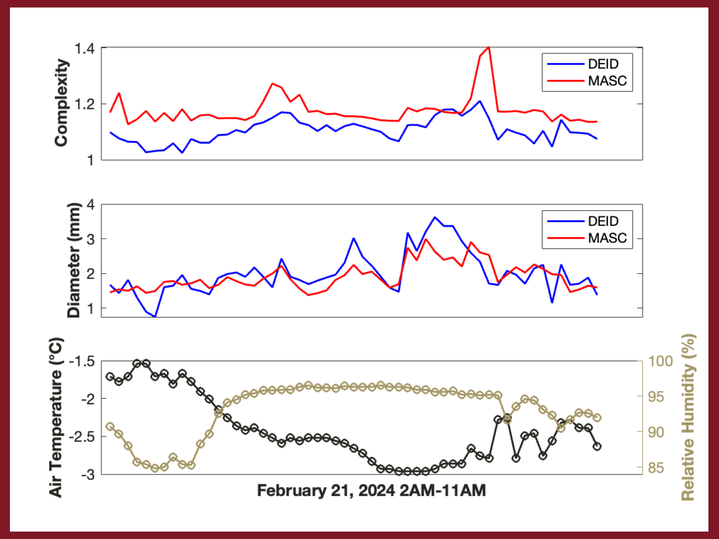


Figure 3. Time series displaying how snowflake complexity and diameter change over time for both instruments, demonstrating good agreement between the two. The last time series shows how air temperature and relative humidity changed over time during the study period.

Conclusions

- Observed density-diameter and mass-diameter relationships support findings from previous studies
- As expected, measured snowflake density increases with temperature and decreases with relative humidity, but more studies with longer timescales are needed
- Observations of 10-minute averaged complexity and diameter are consistent between the MASC and DEID.

References

Locatelli & Hobbs (1974) *J. Geophys. Res.*
Rees et al. (2021) *Atmos. Chem. Phys.*
Singh et al. (2021) *Atmos. Meas. Tech*

Acknowledgements

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