Wallops Flight Facility 2021-2022 Winter Snow Events: A Case Study Using Surface Instrumentation and Radars

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***Abstract*—We present a case study that showcases the analysis of four snowstorms that occurred during the winter season of 2021-2022 at Wallops Flight Facility. The study includes data collection and analysis from various instruments ranging from delicate optical, electronic, and mechanical surface instrumentation to state-of-the-art radars. Surface observations of geometrical and microphysical properties of winter precipitation coupled with radar scattering measurements and computations are crucial for the advancement of our understanding of snow events, numerical weather prediction models, and correct interpretation of data from the national network of weather radars.**

I. Introduction

This summary presents our studies of winter precipitation at the Global Precipitation Measurement (GPM) Precipitation Research Facility operated by NASA Goddard Space Flight Center Wallops Flight Facility (WFF) in Wallops Island, VA. This is a densely instrumented facility with a variety of instruments and radars, needed for the measurement of the physical properties of snow. Another feature of WFF, essential to our study, is its costal mid-latitude location, which experiences snowfall from so-called East Coast Winter Storms (Nor'easters) which can produce copious amounts of snowfall, freezing rain, and sleet. Our case study provides a better understanding of the Nor'easters and the physical properties of different winter precipitation such as size, shape, fall speed, and effective dielectric constant, which are all highly variable. Additionally, this improves our understanding of winter precipitation through radars and simultaneously advances complex numerical weather prediction models to help mitigate the impacts of Nor'easters and similar hazardous winter events.

II. Surface Instrumentation and Radars

We use a combination of instrumentation and radars to take advantage of the strengths of each instrument to validate and improve the results of others while gathering a more complete picture of the snowstorms. Surface instrumentation can be divided to instruments placed inside the Double Fence Inter-comparison Reference (DFIR) wind fence and outside. These instruments are camera based and can be used for hydrometeor classification [1]. Processed snowflake images can be used with scattering calculations to obtain radar measurable parameters, to be analyzed against measurements by collocated radars. Instruments inside include:

- SMAS - Snowflake Measurement and Analysis System, an in-house designed instrument at Colorado State University, containing seven high-resolution cameras for 3D reconstruction and measuring fall speeds [2]
- MASC - Multi-Angle Snowflake Camera, originally with 3 cameras, modified to have 5 cameras, for 3D reconstruction [3] and infrared sensors for fall speed [3]
- 2DVD - 2D-Video Disdrometer, gives two mutually orthogonal images of using line-scan cameras [3]
- 3D Ultrasonic Anemometer - gives 3D wind and temperature information at high temporal resolution

Figure 1. SMAS, MASC and 2DVD during deployment.

Instruments and radars outside other than another set of 3D Sonic Anemometer and 2DVD include:

- PIP - Precipitation Imaging Package, a video camera system that gives projected views in one plane.
- POSS - Precipitation Occurrence Sensor System, a bistatic Doppler radar that measures the reflectivity at X-band a few meters above the surface.
- NPOL - NASA Dual Polarimetric Radar, a scanning S-band radar with data at above 400 meters from surface.
- MRR - Micro Rain Radar, K-band continuous wave radar that is pointed upwards and measures particle size distributions and spectral power backscatter intensity.

III. Data Analysis and Study

During our deployment, we recorded a total of four snow events with Event 1 on January 2, 3, Event 2 on January 21, 22, Event 3 on January 28, 29, and Event 4 on February 13, 14. The dominant shapes recorded by the SMAS and MASC are Aggregate, Graupel-like, Germ, Plane, and Column (Fig. 2).

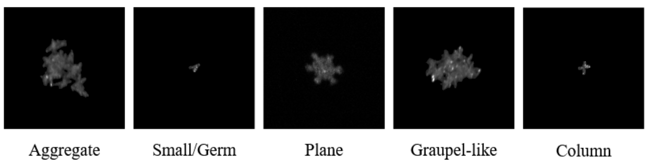

Figure 2. Examples of Snowflake Classes collected from SMAS and MASC.

In Event 2, 0^{th} hour UTC of January 22, 2022, we analyzed the particle size distribution of the equivalent circle diameter of the snowflakes falling through the SMAS (Fig. 3). Results show that most snowflakes are small. Fig. 4 shows the fall speed analysis from MASC and MRR on Event 2, 8^{th} hour UTC of January 22, 2022. Fig. 4 shows that MASC observes a lower speed, which is due to some uncompensated wind turbulence effects. Fig. 5 shows the data from NPOL on Event 1 at 04:23 AM UTC on January 3, 2022. NPOL shows precipitation and reflectivity at ~120 km towards the south. The red color indicates wet snow.

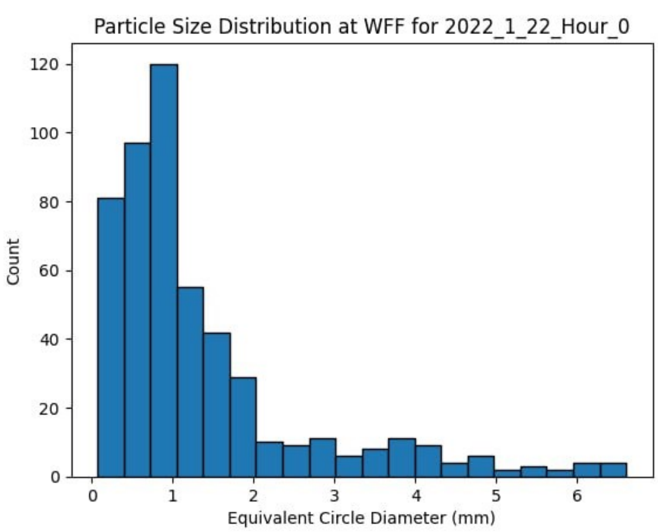

Figure 3. Equivalent Circle Diameter Particle Size Distribution by SMAS.

Acknowledgment

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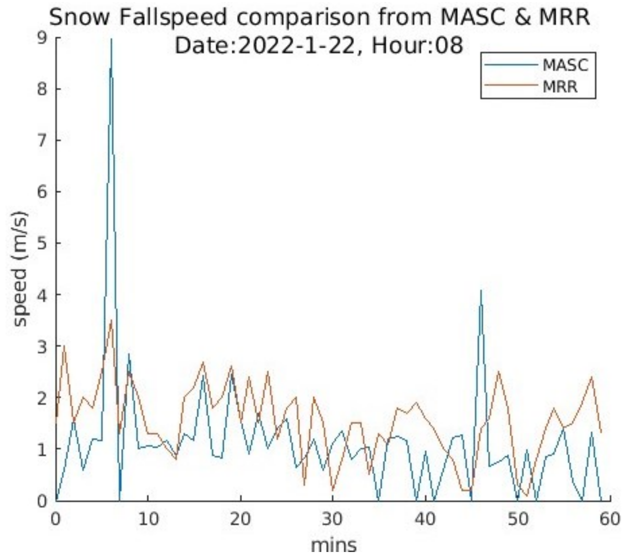

Figure 4. Snowflake fall speed measured by MASC and MRR

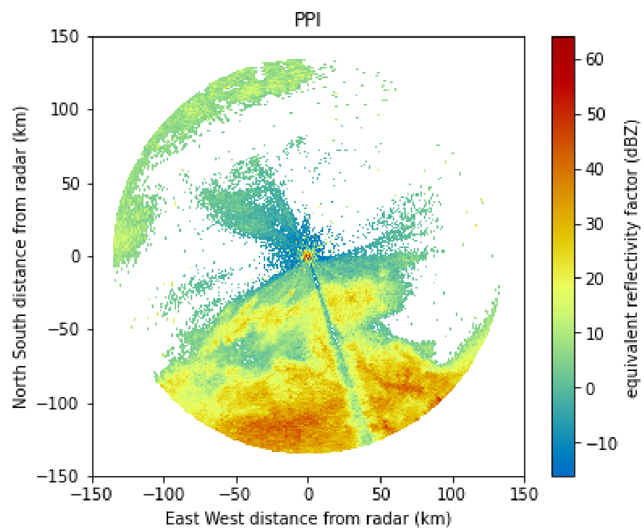

Figure 5. Plan Position Indicator (PPI) Scan from NPOL

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