Measurement and Characterization of Winter Precipitation at MASCRAD Snow Field Site

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***Abstract*—We present our ongoing studies of winter precipitation using multi-angle snowflake camera (MASC), 2D-video disdrometer, computational electromagnetic scattering methods, and state-of-the-art polarimetric radars. The newly built and established MASCRAD (MASC + Radar) Snow Field Site is one of the currently best instrumented and most sophisticated field sites for winter precipitation measurements and analysis in the nation. We present and discuss MASCRAD measurements for the snow event on Nov 15, 2014 in La Salle, Colorado.**

I. INTRODUCTION

This summary presents our ongoing studies of winter precipitation using multi-angle snowflake camera (MASC) [1], 2D-video disdrometer (2DVD), higher order computational electromagnetic scattering methods, fully polarimetric data from state-of-the-art polarimetric radars, GPS advanced upper-air system sounding system, PLUVIO snow measuring gauge, and VAISALA weather station. The principal goal of these comprehensive studies, which we term the MASCRAD (MASC + Radar) project, is to establish a novel approach to characterization of winter precipitation and modeling of associated polarimetric radar observables, with a longer-term goal to significantly improve the radar-based quantitative precipitation estimation in stronger, more hazardous, winter events.

The newly built and established MASCRAD Field site with a double wind fence housing MASC, 2DVD, PLUVIO, and VAISALA instruments, as well as the collocated NCAR GAUS Sounding System trailer, covered, with high spatial and temporal resolutions and special scan strategies, by two state-of-the-art polarimetric weather radars, CSU-CHILL Radar and NCAR SPOL Radar, and supported by excellent geometrical and image processing and scattering modeling and computing capabilities, is one of the currently best instrumented and most sophisticated field sites for winter precipitation measurements and analysis in the nation. This is the first time real (measured) snowflake images are used with realistic scattering calculations, to obtain radar measurable parameters, which are then compared and analyzed against measurements by highly precise polarimetric radars.

II. MASCRAD EASTON SNOW FIELD SITE

We have established the MASCRAD Field Site at the Easton Valley View Airport, south of Greeley, in La Salle, Colorado, shown in Fig. 1. The site is fully operational and has performed well during the first snow storm (on Nov 15, 2014). We have built a 2/3-scaled double fence intercomparison reference (DFIR) wind shield at the Easton Field Site, for placement of the MASC (Fig. 2), 2DVD, PLUVIO, and VAISALA instruments, as well as a big heated weather-proof enclosure for the two computers running the MACS and the 2DVD and other accessories.

Specifically, our interest are storms that produce liquid equivalent snow amounts of at least 1 mm. At Easton site, we take any snow event, even light snow. We need snow events at a variety of surface temperatures, but colder ones are better. Also, it is important to have several cases of rain turning to wet snow, to dry snow. Ideally, we also would like to have freezing rain, ice pellets, sleet, re-freezing layer, etc.

We are also using the collocated NCAR GAUS (GPS Advanced Upper-Air System) Sounding System. The GAUS facility provides important high-resolution measurements of temperature, humidity, pressure, and winds. It is well-known, for example, that the vertical profile of wet-bulb temperature will constrain the type of precipitation at the surface.

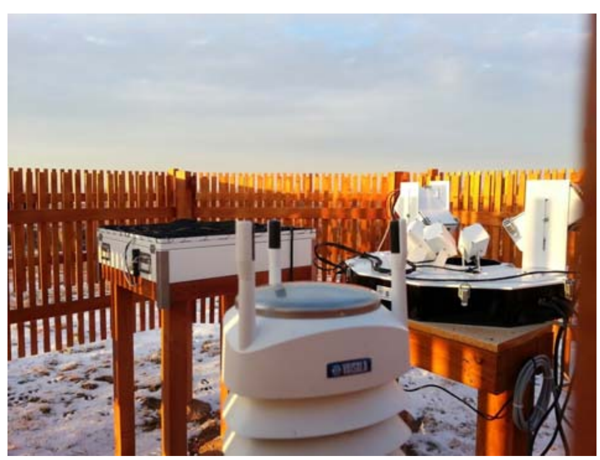

Fig.1. MASCRAD Snow Field Site; shown are 2DVD, VAISALA, and MASC instruments.

Fig. 2. Multi-Angle Snowflake Camera (MASC) at the MASCRAD Snow Field Site in Fig. 1.

III. Snow Event on 15 Nov 2014

For collection of CHILL and SPOL radar data for the MASCRAD project, special scan strategies have been implemented for both radars focused on high spatial and temporal resolutions over the Easton site. For CHILL, the dual-transmitter PRFs were increased to 1000 Hz each. In alternating pulse mode the effective PRF is 2000 Hz to enable coherent processing gain to extract weak cross-polar signal from noise (improving LDR detection). All data over the Easton site are being acquired in time series mode (I + jQ) in addition to conventional covariance products. The scan strategy over Easton includes 3 fixed pointing beams with dwell of 20 s each, 2 RHIs, 1 low elevation angle PPI sweep and 1 VAD scan. This cycle repeats every 4 min. The SPOL radar (PRF = 1000 Hz; alternating mode using fast polarization switch) scans include PPI sectors at 7 elevation angles (60 degree sector centered at Easton) along with 2 RHIs. Time series data are archived routinely.

Our first use of the CHILL Radar was on Nov 15, 2014. We started tacking a storm coming from west of Greeley at 10:00 a.m. until it was over the Easton site at 10:20 a.m. and then switched the radar to the Easton schedule to start collecting data. The MASC was being monitored during this storm and images being collected were immediately compared to the radar data coming in from CHILL. Multiple RHI, PPI, and Point scans were collected over the Easton site. We continued collecting data from both CHILL and MASC until the storm completely passed over at 3 p.m. Fig. 3 shows Virtual CHILL (VCHILL) displays of the RHI images taken from two different Z_{dr} regimes. It was observed that aggregates were predominant at the 17:18 UTC time, with near 0 dB Z_{dr}. The more positive near-surface Z_{dr} around 18:29 UTC were due to the presence of more individual, non-aggregated planar crystals. These radar observations matched well with observations from the MASC.

Fig. 4 shows a set of three high-resolution images of a snowflake collected by the MASC during the snow storm on 15 Nov 2014. We then perform 3D shape reconstruction of snowflakes from the MASC photographs using the visual hull image processing method, and convert these shapes into meshes of quadrilateral patches suitable for electromagnetic scattering modeling and analysis [2]. By calculation of the "particle-by-particle" scattering matrices, we obtain realistic simulations of the radar observables [3], which are then compared against radar measurements.

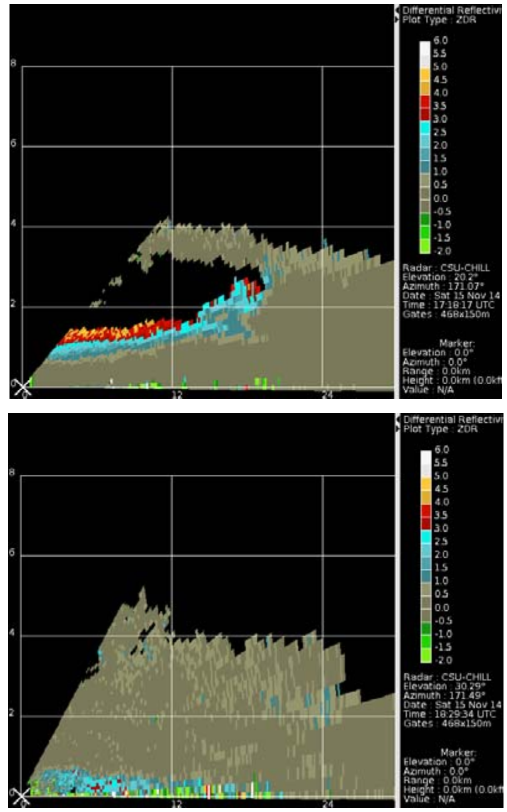

Fig. 3. VCHILL displays of RHI Z_{dr} scans by CHILL Radar from 15 Nov 2014 event at two different times, 17:18 and 18:29 UTC. The azimuth angle is toward the Easton site.

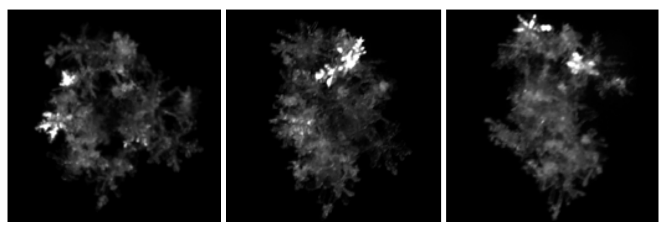

Fig. 4. Set of three high-resolution images of a snowflake collected by three cameras of the MASC during the snow event on 15 Nov 2014, at the MASCRAD Easton Field Site.

Acknowledgement

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References

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