Data Format Documentation

Instrument: Two-dimensional video disdrometer (2dvd)

Overview:

During GCPEx, a 2dvd (compact version; Schönhuber et al. 2008) was deployed at each of the 5 ground sites (Table 1). The 2dvd was situated on a platform about 8 feet above ground within a wind abatement fence, which was constructed similar to a Double-Fence Intercomparison Reference (DFIR). The 2dvd data set contains both rain and snow observations. Processing of the 2dvd observations for snow was only conducted for a select number of significant snowfall events (see Table A.2). The 2dvd data set for snow consists of data processed using Joanneum Research's MAKE_SNO software (Schönhuber et al. 2008) as well as data processed via the camera "re-matching" method used by Huang et al. (2010). A brief description of the Huang et al. (2010) re-matching method is given in Appendix A.

Table 1. Locations of 2D-Video Disdrometers during GCPEx

2DVD	Site Name	Longitude	Latitude	Altitude (MSL)
SN25	Bob Morton	79°55'9.13"W	44°10'35.29"N	260 m
SN35	Steam Show	79°43'4.63"W	44°10'50.27"N	231 m
SN36	Sky Dive	79°38'25.02"W	44°14'16.30"N	236 m
SN37	CARE	79°46'50.11"W	44°13'59.45"N	251 m
SN38	Huronia	79°55'40.60"W	44°41'10.25"N	235 m

Data Organization:

The 2dvd data set is contained within daily tar archives. The daily archive is named with the following convention,

2dvd_[sn]_[campaign]_[site]_[latitude_longitude]_[date].tar

where [sn] = serial number of 2dvd instrument (e.g., sn35)
[campaign] = name of field campaign (e.g., gcpex)
[site] = site name
[latitude_longitude]=geographic location of instrument
(e.g., N363442.07_W0972640.90 is North 36°34'42.07" and West 97°26'40.90")
[date] = YYYYmmDD (e.g., 20110422)

and consists of binary and ASCII files containing information on each raindrop and snowflake sampled by both cameras.

The following files are contained within the tar archive and follow a similar naming convention as above except for the file extension:

- *.sno: compressed binary files preprocessed from the raw camera data using the MAKE_SNO software provided by Joanneum Research
    - contain information on individual hydrometeors
    - can be viewed graphically with VIEW_HYD software available from Joanneum Research (JR), the instrument manufacturer
    - decompression and data read possible with SNO2ASC program, available from data provider upon request
- *.shd: header file associated with *.sno file used by SNO2ASC and VIEW_HYD programs
- *.flakes.txt: ASCII file containing information on individual snowflakes identified by the MAKE_SNO software, which matches snowflakes imaged by each camera as long as its height measured by each camera is within a certain tolerance. (The exact details of MAKE_SNO are the proprietary information of JR).
- *.flakes_rematch.txt: ASCII file contains information on individual snowflakes identified by the re-match method of Huang et al. (2010)
- *.drops.txt: ASCII file containing information on individual hydrometeors

Note: Each daily tar archive may not contain all the above listed files. Only the tar archives associated with snowfall events listed in Table A.2 will include all the files.

File Format:

Level 2: MAKE_SNO files (*.sno and *.shd)

Format: compressed binary

Software: VIEW_HYD and SNO2ASC (available by request)

Level 2: flake-by-flake files created with MAKE_SNO (*.flakes.txt)

Format: ASCII

Format of each line (14 fields):
HH:mm:SS.ms, equivalent diameter (mm), volume (mm^3), fallspeed (m/s), cross-sectional area (mm^2), height of line (mm), height in Camera A (mm), height in Camera B (mm) , width in Camera A (mm), width in Camera B (mm), minimum pixel shawdowed in A (pixel #), maximum pixel shadowed in A (pixel #), minimum pixel shawdowed in B (pixel #), maximum pixel shadowed in B (pixel #)

Note: Both A & B Cameras contain 632 pixels.

Level 2: flake-by-flake files from Huang et al. rematch method (*.flakes_rematch.txt)

Format: ASCII

Format of each line: (10 fields)
Scan line of the day (n; see Appendix A), apparent diameter (D_{app}), fall speed (m/s), area shadowed in camera A (mm^2; A_1), area shadowed in camera A (mm^2; A_2), height of snowflake in camera A (mm; H_1), rectangular width of snowflake in camera A (mm; W_{r1}), height of snowflake in camera B (mm; H_2), rectangular width of snowflake in camera B (mm; W_{r2})
See Appendix A for definitions

Level 2: drop-by-drop files (*.drops.txt)

Format: ASCII

Format of each line:
HH:mm:SS.ms, equivalent diameter (mm), volume (mm^3), fall speed (m/s), oblateness$^{\#}$, cross-sectional area (mm^2), height in Camera A (mm), height in Camera B (mm) , width in Camera A (mm), width in Camera B (mm), minimum pixel shawdowed in A (pixel location), maximum pixel shadowed in A (pixel location), minimum pixel shawdowed in B (pixel location), maximum pixel shadowed in B (pixel location)

Note: Both A & B Cameras contain 632 pixels.

$^{\#}$*Precise measurement of oblateness (i.e., axis ratio) may not be achieved during strong winds*

APPENDIX A: Re-matched snowflake data

Time

The time, T, (in UTC seconds of the day) at which each identified snowflake fell through the measurement area is obtained from the scan line number, n, of the day as

$$T = \frac{n}{T_p}$$

where the period of the cameras, T_p, is given by

$$T_p = \frac{1}{F}$$

with the line scanning frequency, F, of each 2dvd listed in Table A1.

Table A 1. Line scan frequency for each 2dvd.

	SN25	SN35	SN36	SN37	SN38
Frequency (Hz)	55172	55272	55272	55272	55272

Apparent Diameter

The apparent diameter is related to the shadow area, and is similar to the equivalent-volume diameter (D_{eq}) of a raindrop. The 2DVD measures the height ($H_{1,2;}$ see Figure A.1), the longest width of a scan line ($W_{max1,2}$ not shown in Figure A.1) and the shadow area ($A_{1,2}$). The rectangular width ($W_{r1,2}$; see FigureA.1) is distorted by horizontal movement of the particle and is not used in calculating apparent, V_{app},,

$$V_{app} = \frac{\pi}{6} D_{app}{}^{2} = \frac{V_{app1} + V_{app2}}{2}.$$

Here *we assume that the snowflake is an ellipsoid*. Generally, V_{app} will exceed the true volume of the snow flake (hence "apparent" volume). The D_{app} is not the same as the maximum dimension from a single projected view, such as that of aircraft 2D-imaging probes, although the two will be correlated. We believe that use of the two projected views provided by the 2DVD yields a better approximation to the "dimension" of the snow particle. The two orthogonal areas of the ellipsoid are forced to be equivalent to the shadow areas from the two cameras.

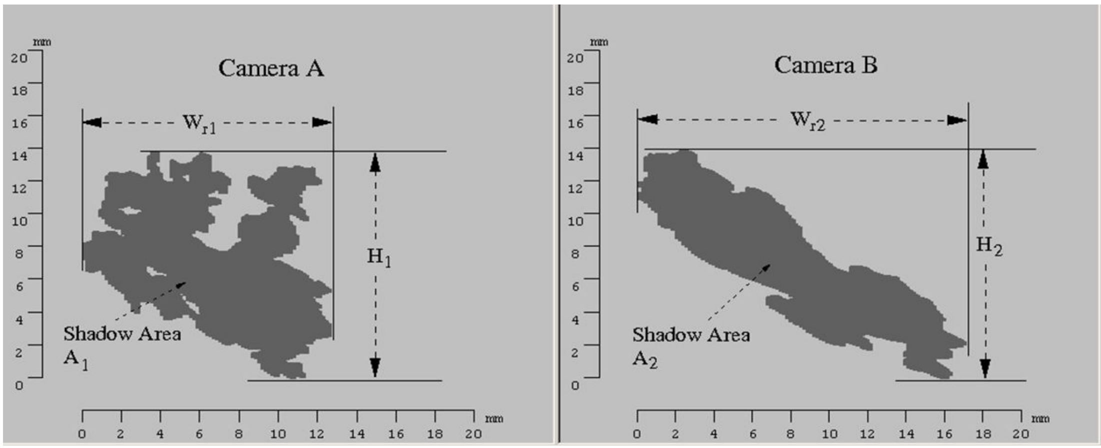

Figure A.1. An example snowflake image from the 2dvd (from Huang et al. 2010).

We define the V_{app1} as

$$V_{app1} = \frac{\pi}{6(H * W_1 * W_2)}$$

where $H = \sqrt{H_1 * H_2}$ and $W_{1,2} = \frac{4 * A_{1,2}}{\pi * H}$ (Note that theoretically $H_1 = H_2$), and V_{app2} as

$$V_{app2} = \frac{\pi}{6(HH * W_{\max 1} * W_{\max 2})}$$

were $HH = \sqrt{HH_1 * HH_2}$ and $HH_{1,2} = \frac{4 * A_{1,2}}{\pi * W_{\max 1,2}}$.

Adjustment to snow size distribution

Since the 2DVD must match two orthogonal views to measure the fall speed, the matching criteria results in some fraction of the total number of particles being rejected, thereby causing an underestimation of the number concentration (see Appendix A of Huang et al. 2010). Thus the measured snow size distribution (SSD) needs to be adjusted by a constant factor, γ, which is calculated from the following method.

Assume that snow falls uniformly over the instrument. Then, the theoretical number of snowflakes falling through the virtual measuring area divided by the theoretical number of snowflakes falling in the scan area of each camera (shown in Figure A.2) should be equal to the ratio of these two areas as:

$$\frac{theoretical\,\#\,of\;snowflakes\,in\,virtual\,measurement\,area}{theoretical\,\#\,of\;snowflakes\,in\,scan\,area\,of\;one\,camera} = \frac{100}{250} = 0.4$$

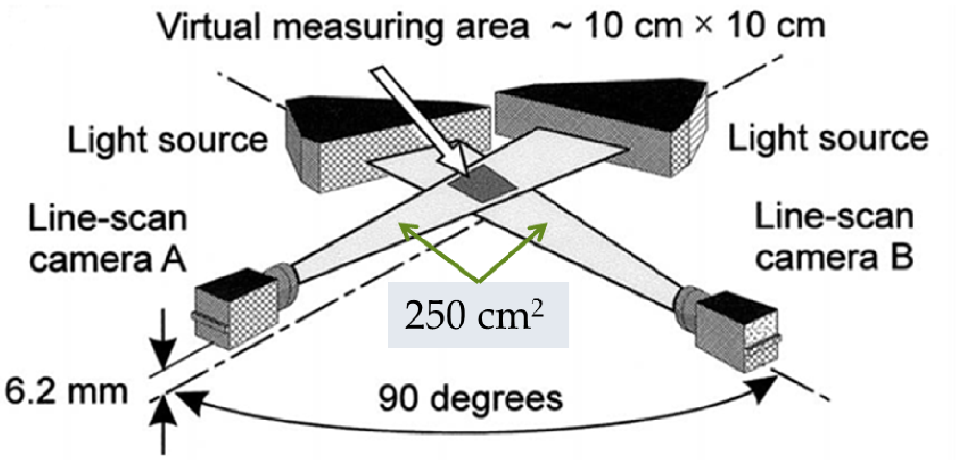

Figure A 2. Measurement principle of the 2dvd (from Kruger and Krajewski 2002) showing the the virtual measurement area ($100 cm^2$) relative to the larger single camera measuring areas ($250\ cm^2$).

Therefore, the SSD-adjustment factor γ is derived as:

$$\gamma = \frac{0.4 * (\#of\ snowflakes\ actually\ counted\ in\ scan\ area\ of\ one\ camera)}{\#\ of\ matched\ snowflakes\ in\ virtual\ measurement\ area}$$

The adjusted concentration in each size channel, $N(D_i)$, is defined as:

$$N(D_i) = \gamma * N_m(D_i)$$

where $N_m(D_i)$ is the SSD calculated from the measured snowflakes in each size channel and γ is assumed constant. In essence, the "raw" or unadjusted SSD is simply scaled by the factor γ. Table A.2 provides the γ values calculated from the dataset collected during GCPEx.

Table A 2. Number concentration adjustment factors, γ, calculated from the 2dvd dataset collected during GCPEx.

Case	SN25	SN35	SN36	SN37	SN38
21-Dec-2012	1.07	N/A	1.00	1.00	1.00
30-Dec-2012	N/A	N/A	1.86	1.48	1.79
18-Jan-2012	N/A	2.14	1.42	1.36	1.49
19-Jan-2012	1.09	2.48	1.63	1.01	3.78
30-Jan-2012	1.02	1.43	1.33	1.24	1.37
11-Feb-2012	1.25	1.71	N/A	1.24	1.59
12-Feb-2012	1.69	2.00	N/A	1.67	1.58
18-Feb-2012	1.35	1.53	1.00	1.09	X

N/A: no data collected; X: camera files may be repaired by 2dvd manufacturer

The accuracy of this re-adjustment method is unknown at present but “spot” checks with the snow video imager (aka SVI) for some for events during the Light Precipitation Validation Experiment (LPVEX), which took place around Helsinki, Finland during the Fall of 2010, have shown good agreement between the SSDs from the two instruments.

Note: The rematched “snowflake” files contain the fall speed and apparent diameter, D_{app}, for each particle, which can be used to estimate a fall speed versus D_{app} power law. However, we have not yet derived the density versus D_{app} power law for each GCPEx event since this is still a research topic under evaluation (see Huang et al. 2011).

References

Huang, Gwo-Jong, V. N. Bringi, Robert Cifelli, David Hudak, W. A. Petersen, 2010: A Methodology to Derive Radar Reflectivity–Liquid Equivalent Snow Rate Relations Using C-Band Radar and a 2D Video Disdrometer. *J. Atmos. Oceanic Technol.*, **27**, 637–651. doi: http://dx.doi.org/10.1175/2009JTECHA1284.1

———, V. N. Bringi, W. A. Petersen, L. Carey, C. J. Schultz, and P. N. Gatlin, 2011: Case Study of a Winter Precipitation Event using Three 2D-video disdrometers and ARMOR Radar, 35th Conf. on Radar Meteor., Pittsburgh, PA, P13.203, [available online at https://ams.confex.com/ams/35Radar/webprogram/Paper191883.html]

Kruger, Anton, Witold F. Krajewski, 2002: Two-Dimensional Video Disdrometer: A Description. *J. Atmos. Oceanic Technol.*, **19**, 602–617. doi: http://dx.doi.org/10.1175/1520-0426(2002)019<0602:TDVDAD>2.0.CO;2

Schönhuber, M., G. Lammer, and W. L. Randeu, 2008: The 2D-video-distrometer. *Precipitation: Advances in Measurement, Estimation and Prediction,* S. C. Michaelides, Ed., Springer, 3–31.