SID-2H Data Processing Software

April 2008 (updated Feb 2010)

Installation

The SID-2H data processing software requires the Interactive Data Language (IDL) software package, either as a full IDL distribution or the freely available IDL Virtual Machine.

Using a full IDL distribution:

1. Unzip the file “sid.zip” into a directory.
2. Add the directory to IDL's search path using the menus or by modifying the “!path” system variable.
3. Type “sid” at the command prompt to start the processing software.

Using the IDL Virtual Machine:

1. Start the virtual machine.
2. Choose the file “sid.sav” when prompted.

Data Processing

Type “sid” at the IDL command prompt to start the processing software, or choose the file “sid.sav” when prompted by the IDL Virtual Machine. The data processing window appears by default when the software is started. To process raw data:

1. Click on “Add file series...” and select the raw SID-2H files to be processed for the desired flight. The SID-2H data acquisition software automatically saves raw files in a numbered series. A new series is started each time the data acquisition is interrupted during a flight. Be sure to select at least one file from each series.
2. Enter the netCDF file that contains the NCAR G-V or C-130 flight level data. This is required to compute the sample volume from the aircraft's true air speed. If the file is not available, enter a default speed to use instead.
3. Select processing options:

- Averaging time: Enter an averaging interval of 1 second or greater.
- Size gain: This adjusts the calculated size of particles, and should be changed based on calibration data or comparisons with other probes.
- Minimum interarrival time: Select a threshold to avoid counting potentially shattered particles. The SID-2H probe does not measure particles with interarrival times less than 50 microseconds, so values smaller than this will have no effect on the processing.
- Saturation max: The number of detectors allowed to be saturated (at the maximum raw value of 2047) before the particle is rejected.
- Speed Rejection: This option turns on particle rejection by comparing the transit time of the particle to the air speed of the aircraft. If the computed 'speed' of the particle through the laser is not within a factor of 3 of the aircraft speed, then it is rejected. Noisy particles tend to have extremely high 'speeds'.
- Auto-leveling: A pre-processing feature that applies a correction to each of the 28 channels to ensure that the average particle is round.
- Peak: Select if the probe was configured with peak detectors. Integrating detectors were used prior to April 2010, and use a different particle sizing algorithm.

4. Select output options:
   - IDL “sav” file: Select to save data in IDL's proprietary format. This file records all processing options, processed data, and housekeeping data. This file is also required to view data with the IDL browser. See the file format section of this document for detailed information about this file.
   - NetCDF file: Select to save data in netCDF format. This will be a stand-alone file following NCAR/RAF conventions.
   - Appended netCDF file: Select to append the SID processed data to the aircraft netCDF file, rather than making a new file. The aircraft file is specified in the 'Aircraft Data' section.
   - Particle-by-Particle file: Creates an ASCII particle-by-particle file with detailed information on each particle processed. This file may grow to be very large. In order to make these files more manageable you will be prompted during processing to adjust the time range of printed particles.
   - Output directory: Change the location where these files will be written. Appended aircraft netCDF files will not be moved.

5. Click “BEGIN PROCESSING” to process the data.

Processing will take several minutes to hours depending on the amount of data. Once completed, a new file(s) containing the processed data will be saved with the naming convention “ddmmmyyyy_hhmmss_SID.dat”, “ddmmmyyyy_hhmmss_SID.nc”, or “ddmmmyyyy_hhmmss_SID.txt”.

Settings from a previously processed IDL file can be loaded under the “File / Load Settings” menu option. You can then make any changes to the processing options and reprocess the data. The old file will be overwritten unless a different output directory is selected.

Processing Details

Particle processing follows several steps: particle sizing, particle shape detection, particle rejection, and computation of bulk properties.

Particle sizing follows the method outlined in the document “Small Ice Detector” by P. Field. Briefly, the formula used is

$$r = a_{30} D_{0...27}^{0.53}$$

where r is particle radius, a_{30} is a user-adjustable coefficient, and D represents the mean value of all 28 detector values. In practice, the D values are modified by an adjustment to account for the current PMT gain, and an adjustment for transit time when integrating detectors are being used. If saturated detectors are allowed, D is also modified to account for the number of saturated detectors found in a given particle. See the program sid_size.pro for more details.

Shape detection is done with two methods, the asphericity factor and by discrete shape detection using Fourier transforms. The asphericity factor is computed following the same document which details the particle sizing method, and is a measure of the variation in detector response across the 28 elements. In general, round particles will have an asphericity factor below 2, while irregular particles may have asphericity factors as large as 40 or 50. Particles are categorized both by size and sphericity in this software, and 2-D histograms of the concentration of particles in both size and asphericity space can be viewed in the data browser.

Discrete shape detection uses Fourier transforms to identify strong modes in the frequency spectrum and assign a shape to the particle based on these modes. Particles that have no strong modes are classified as 'round' particles. These particles are recorded separately in the 'round' particle size distributions and related derived parameters. Particles that have a strong mode on wavenumber 1 are likely vignettes of out-of-focus particles and are rejected. Particles that have large values on higher wavenumbers (2 through 8) are classified as 'irregular' and recorded in the 'irregular' size distribution. The number of particles classified at each wavenumber are recorded in the 'BRANCH_COUNT' variable, and are used as a particle classification tool in the data browsers and recorded data. For example, particles with strong values on wavenumbers 2 or 4 may be columnar crystals, while those with strong values at wavenumber 6 may be classified as plates. See the program sid_size.pro for more details on the asphericity and Fourier methods.

Particle rejection is required to ensure reliable data. A number of criteria have been devised to remove poor or unreliable data. Each particle is individually checked for the following:

- At least 20 detectors have readings above zero
- Interarrival time is within expected range
- Particle size is within expected range
- Particles are roughly balanced around the center point
- The number of unsaturated detectors is high enough
- Particles have a measurable transit time
- If flagged, particles have a reasonable transit time based on aircraft speed
- The air speed was within expected range

All of the current rejection criteria can be found in the program sid_reject.pro.

Browsing Processed Data

Select "Other Actions / Browse Data" from the main window to enter the data browser. The browser may also be accessed directly from IDL command line by typing "sid_browse". Load a processed (*SID.dat) file under the "File / Load" menu to begin browsing.

Changing the viewing time:
The first 3 tabs (Distributions, Particles, and Timing) display data for a single time period, typically one second. To move forward one second, left-click anywhere on the main plot. To move backward one second, right-click on the main plot. The scroll wheel on a mouse may also be used to move forward or backward more rapidly. A blue indicator line shows the current position in a small concentration plot at the bottom of the screen. Left-click on the small concentration plot to directly access a new time period. A new time may also be typed into the text box at the bottom-left corner of the window in either 'hhmmss' or seconds-from-midnight format. Click the 'HMS' or 'SFM' label to toggle formats.

Size and asphericity distributions tab:
The default tab shows the normalized particle size distribution, the asphericity (Af)

distribution, and a colorized contour composite of these two distributions. Computed bulk values such as total number concentration, liquid water content (assuming water density), and mean diameter for the current time period are also displayed.

Particles tab:
The 'Particles' tab displays the scattering patterns of the particles recorded for each time period. *The original raw data files must be accessible in order to view this screen; the scattering patterns are not saved in the processed file.* In order to display the shape of the particles in a meaningful manner, they have all been displayed at the same size, and are arranged in 10 columns based on the mean of the *raw* scattering value. The particles with the smallest raw scattering values (0-200 raw units) are displayed in the leftmost column, and the particles with the largest raw scattering value (1800+) are displayed in the rightmost column. The center of each particle is indicated with a red marker, and the calculated size of each particle (microns) is printed next to this marker. The size of a particle depends on integration time as well as the scattering amplitude, so the printed particle sizes do not necessarily increase from left to right. A maximum of 10 particles are shown per column. In some instances there may be thousands of undisplayed particles.

Timing tab:
This tab shows the interarrival time and transit time distributions. Ideally, the interarrival time plot should have a shape resembling a Poisson distribution, and the transit time distribution should be very narrow.

Detectors tab:
This is a diagnostic window to assist with the evaluation of probe and detector performance throughout an entire flight. The upper plot shows the frequency of appearance of raw detector values, after they have been adjusted for their known offsets and biases. Click on any of the 28 detector indicators to overlay a plot for a single detector's histogram. The lower plot shows the average shape of the particles for each of the raw detector divisions used in the 'Particles' tab. For example, the dark blue line shows the average shape of low-amplitude (less than 200 raw units) particles, and the red line shows the average shape of high-amplitude particles. The heavy white line is the average for all particles.

Time series tab:
This window displays time series plots of derived parameters and housekeeping data. Two plots are available, and the value to be plotted on each can be changed with the drop-down menus. The start and end times can be selected from the small concentration reference plot at

the bottom of the screen. Left click to move the green indicator and set a new start time, and right click to move the red indicator and set a new stop time. The selection can be fine-tuned by clicking on the main (large) plots: left click to set a new start point at the current cursor position and right-click to set a new stop point at the current cursor position.

Saving plots:
Click the "Create PNG" button on any screen to save the current plot(s) to a PNG image. It will be saved in the directory where the processed file is located.

File properties:
The options used to process the file are accessed from the "File / Properties" menu. Detector offsets, gains, and a log of events recorded by the SID-2H data acquisition system are also displayed here.

Exporting Data

The processed data can be exported to a netCDF file for use in other plotting or data visualization applications. Select "Other Actions / Export Data" from the main window to enter the data exporter. The exporter may also be accessed directly from IDL command line by typing "sid_export".

Processed Data File Format

Processed data is saved in a raw data file using IDL's save/restore format. This file can be used directly for analysis beyond the capabilities of the Data Browser. Type "restore, xxxx_SID.dat" at the IDL command prompt to load the data into the IDL workspace. Once loaded, all data will be available in a structure named "data". The structure has a number of tags with processed information, and three sub-structures named op, mux, and units. Descriptions of the data are in the table below. *Units for each of these can be viewed in the 'units' sub-structure by typing 'help, data.units, /st' at the IDL command prompt.*

Variable	**Description**

OP	A sub-structure containing the processing options.
OP.FN_ORIG	The original filenames entered into the GUI.
OP.RATE	Averaging interval.
OP.SIZEGAIN	Gain for particle sizing.
OP.INTTHRESHOLD	Minimum interarrival time required to accept a particle.
OP.PTHFILE	netCDF file which contains true air speed data.
OP.TEXTFILE	Flag for creating a particle-by-particle file.
OP.FIXEDTAS	Fixed air speed to use if pthfile is unavailable.
OP.AUTOLEVEL	Flag for auto-leveling of detectors.
OP.OUTDIR	Output directory.
OP.MAXSATURATED	Maximum number of detector allowed to be saturated.
OP.TASTAG	netCDF tag for true air speed
OP.FN	Filenames that pass data integrity test.
MUX	A sub-structure containing housekeeping data recorded by the multiplexer.
MUX.TDETECTOR	Detector temperature, raw units (divide by -40.739 for C)
MUX.TLASER	Laser temperature, raw units.
MUX.TLASERCONTROL	Laser controller temperature, raw units.
MUX.TFPGAAMBIENT	FPGA Ambient temperature, raw units.
MUX.THEADHEATER	Head heater temperature, raw units.
MUX.THEADAMBIENT	Heat ambient temperature, raw units.
MUX.LASERPOWERMON	Laser power monitor, mV.
MUX.TLASERPOWERMON	Laser power monitor temperature, raw units.
UNITS	A sub-structure containing the units of the derived parameters.
TIME	Time in seconds from midnight UTC on the date specified in 'DATE'.
DATE	Date at data acquisition start.
DATE_PROCESSED	Date and time of processing.

STARTTIME	Time at data acquisition start.
STOPTIME	Time at data acquisition stop.
ENDBINS	Size bin end-points.
MIDBINS	Size bin mid-points.
SPEC1D	Counts per size bin in a [time, size bin] array.
SPEC2D	Counts per bin in a [time, size bin, asphericity bin] array.
CONC1D	Normalized particle concentration in a [time, size bin] array.
AREA	Total projected area assuming spherical particles.
LWC	Liquid water content assuming spherical liquid particles.
MVD	Median volume diameter.
MND	Mean number-weighted diameter.
NT	Total particle concentration.
SPEC_ROUND	The same as SPEC1D, but for round particles only.
CONC_ROUND	The same as CONC1D, but for round particles only.
AREA_ROUND	The same as AREA, but for round particles only.
LWC_ROUND	The same as LWC, but for round particles only.
MVD_ROUND	The same as MVD, but for round particles only.
MND_ROUND	The same as MND, but for round particles only.
NT_ROUND	The same as NT, but for round particles only.
SPEC_IRREG	The same as SPEC1D, but for irregular particles only.
CONC_IRREG	The same as CONC1D, but for irregular particles only.
AREA_IRREG	The same as AREA, but for irregular particles only.
LWC_IRREG	The same as LWC, but for irregular particles only.
MVD_IRREG	The same as MVD, but for irregular particles only.
MND_IRREG	The same as MND, but for irregular particles only.
NT_IRREG	The same as NT, but for irregular particles only.
INTENDBINS	Interarrival bin end-points.
INTMIDBINS	Interarrival bin mid-points.

INTSPEC	Counts per interarrival bin in a [time, interarrival bin] array.
BRANCH_COUNT	Counts of accepted particles by the number of 'branches' computed using a Fourier transform. 0=round, 1=off-center, 2=two-branches, etc. Can be used for habit identification, e.g. columns usually have 2 or 4 branches, plates have 6, etc.
AFMIDBINS	Asphericity bin mid-points.
AFSPEC	Counts per asphericity bin in a [time, asphericity bin] array.
MEANAF	Mean number-weighted asphericity.
TRANSITTIME	Mean transit time.
SPEED	Mean particle speed based on transit time and laser depth.
MISSED	The number of 'missed' particles reported.
MISSEDHIST	A histogram of the number of 'missed' particles reported per event.
ACCEPT_COUNT	The number of particles accepted.
REJECT_COUNT	The number of particles rejected.
REJECT_REASON	A [time, 8] array with the number of particles rejected for each reason:
	0: unused
	1: not enough detectors with non-negative values.
	2: out of interarrival time bin range.
	3: out of size bin range.
	4: unused
	5: too many saturated detectors (according to op.maxsaturated)
	6: unusually long or short transit time.
	7: unknown air speed, or unusually slow air speed (< 20 m/s)
TAS	True air speed used for concentration calculations.

SA	Sample area used for concentration calculations.
ACTIVETIME	Time probe was available for recording.
TOTALSCATTER	A [20, 28] array with the cumulative sum of scattering values per detector for 20 scattering amplitude ranges. The ranges are 1% of the mean scatter (0-2047).
TOFMIDBINS	Transit time bin mid-points.
TOFSPEC	Counts per transit time bin in a [time, transit time bin] array.
PMTGAIN	The photomultiplier gain setting.
DETOFFSET	Default detector offset values used for detector normalization.
DETGAIN	Default detector gain values used for detector normalization.
AUTOOFFSET	Automatically generated offset values used for detector normalization.
AUTOGAIN	Automatically generated gain values used for detector normalization.
DETHIST	A histogram of normalized scattering values [0-2500] for each detector.
FIRSTI	Index of particle within the first block for the first particle in time period.
FIRSTBLOCK	Block number containing the first particle in time period.
BLOCKPOINTER	File pointers to particle blocks.
FILENUM	File number for each of the particle blocks.
LARGETRIGGER	Large trigger setting.
SMALLTRIGGER	Small trigger setting.
NTDEAD	Total concentration computed using missed particles during dead time.
EVENTINDEX	Time index for events recorded by the acquisition system.
EVENTTYPE	Event type for each event.
EVENTSTRING	Event string for each event.

TBSPEC1D	The same as SPEC1D, but using time-based sizing.
TBCONC1D	The same as CONC1D, but using time-based sizing.
TBENDBINS	Bin endpoints used for time-based sizing.
TBMIDBINS	Bin midpoints used for time-based sizing.