FSSP Data Processing Comparison

By David Delene
University of North Dakota
This FSSP-100 has the Signal Processing Package (SPP) upgrade to the FSSP-100 probe. This package replaces original PMS electronics with modern high-speed circuitry.
The beam splitter divides the scattered light onto two photodetectors.

One photodetector is optically masked to not receive scattered light from near the laser beam’s center of focus.

Droplets are rejected as being out of the depth of field when the signal from the masked detector exceeds that from the unmasked detector.

*FSSP schematic is taken from Dye and Baumgarnder, [1984]*
Sample Volume = TAS*DOF*BD*(Tc/Ts)

TAS – Aircraft True Air Speed (~100 m/s)
DOF – FSSP Depth of Field (~2.9 mm)
BD – Laser Beam Diameter (~0.2 mm)
Tc – Number of Droplets Sized (Total Counts)
Ts – Number of Droplets within the DOF (Total Strobes)
The effective laser beam diameter is the fraction of the total diameter where droplets are within the laser beam long enough so they can be sized.

A running average of droplet transit time through the beam is maintained. If the droplet time within the laser beam is less than the average, it is rejected from sizing but included in the running average.
The velocity acceptance ratio is based on the ratio of total FSSP counts to total FSSP strobes at 10 Hz from the second flight on January 10, 2008. Dye and Baumgarnder [1984] state that the theoretical velocity acceptance ratio is 62%.
Coincidence and Dead Time Corrections

\[ cf = \frac{1}{1 - 0.73 \times F_a} \]

\( cf \) – Correction factor

\( F_a \) – Activity Fraction

The 0.73 constant is an empirical factor found from computer simulations which takes into account particles which are still in the beam at the end of a reset delay period. This factor is described by Baumgardner [1983] and Baumgardner et al [1985].

What should be used for SPP upgraded probe?
The FSSP is calibrated to determine the instruments depth of field, laser beam diameter, and channel size boundaries. The channel counts obtained from measurements on beads of known size are used to determine the FSSP channel boundaries.
FSSP Mie Function is taken from Dye. and Baumgarnder, [1984]
January 29, 2008 FSSP calibration check at 8:40:28 using 15 µm beads.
### 2007/2008 Saudi Arabia

**FSSP SN 1947-0281-60 (WMI) Calibration Checks**

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### FSSP SN 6702-0789-126 (NRL) Calibration Checks

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February 3, 2008 Assignment

• Compare the M300 real time processing of FSSP number concentration data with the post-processed FSSP number concentration data.

• Use the January 10, 2008 flights for comparison.

• Present results on March 5, March 9, 2008 at 1:00 p.m.

• Mark it on the calendar, “FSSP Data Processing Comparison”
<table>
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<th>Processing Method</th>
<th>M300 Play Back</th>
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<td>Bead Size Calibration</td>
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<td>Depth of Field (Range 0)</td>
<td>*2.33 mm</td>
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*Measured on serial number 1947-0281-60 by Dennis Afseth on December 5, 2007 in Riyadh.
FSSP Total Droplet Concentration

Comparison of the M300 real-time data processing method (x-axis) and UND post-processing method. All 1 Hz average data from the second flight on January 10, 2008 are used for this comparison.

Is this reasonable?
Comparison of the M300 real-time data processing method (x-axis) and UND post-processing method after fixing bead fraction problem. All 1 Hz average data from the second flight on January 10, 2008 are used for this comparison. Include Beam Fraction correction but not coincidence and dead time corrections.
Limitations of the M300 as a Scientific Data Processing System

• The M300 does not have a robust Software Development Environment.
  • The formula table is a difficult and time consuming programming environment.
  • Proprietary Development Environment
    • Limited ability to test software.
• The M300 is not a modular data processing environment.
• Limited to only current and past values.
• Closed source code.
• Difficult to automate data reprocessing.
Conclusions

• The M300 is a very good data acquisition system, but not a very good data processing system.

• The “real time” and “post processing” methods disagree and this disagreement needs to be resolved.

• Well calibrated instruments and validated software is critical for the scientific evaluation of measurements.
Future Work (Assignment)

• Use the information presented in this presentation, the M300 real-time ASCII data files (08_01_10_13_34_12.m300.raw and 08_01_10_13_34_12.probes.raw), the post-processing ASCII data files (08_01_10_13_34_12.sau_comb and 08_01_10_13_34_12.conc.spp_fssp.1Hz 08_01_10_13_34_12.conc.spp_fssp.raw).

• Present results on March 23, 2008 at 1:00 p.m.

• Mark it on the calendar, “Cloud Liquid Water Measurements”
Any Questions?
Cloud Liquid Water Comparison

Slope = 3.5272

Liquid Water Content [g/m³] vs. SppLWCM300 [g/m³]
The velocity acceptance ratio is based on the ratio of total FSSP counts to total FSSP strobes. Dye and Baumgarnder [1984] state that the theoretical velocity acceptance ratio is 62%.
Liquid Water Content Calculation

The amount of liquid water for a given volume of air may be determined through mass integration of the cloud droplet distribution.

\[
LWC = \left( \frac{\Pi}{6} \right) \rho_w \sum_{i=1}^{m} N_i d_i^3
\]

- \( \rho_w \) – Density of Water
- \( N_i \) – Concentration of droplets in size channel \( i \)
- \( d_i \) – Droplet diameter in size channel \( i \)
- \( m \) – Total number of channels