Shattering on Cloud Particle Probe Tips: Lessons Learned from SPARTICUS

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Effects of Shattering on the 2D-S Methodology

- Two 2D-S Probes flown on the SPEC Learjet in SPARTICUS, one with Standard Tips and one with Modified Tips.
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- Measurements compared in Cumulus cloud containing only Cloud Drops (no shattering), and in Large Aggregates Precipitating from an Anvil.
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Methodology

- Two 2D-S Probes flown on the SPEC Learjet in SPARTICUS, one with Standard Tips and one with Modified Tips.
- Measurements compared in Cumulus cloud containing only Cloud Drops (no shattering), and in Large Aggregates Precipitating from an Anvil.

Results

- Modified Tips Reduce Effects of Shattering, but are not as Effective as Post Processing using Arrival Times and other Techniques to Remove Artifacts.
Comparison of Standard and Modified Probe Tips in Cumulus Containing only Cloud Drops

Learjet Cumulus Penetration with all Small Cloud Drops
Comparison of Standard and Modified Probe Tips in Anvil Precipitation

Learjet Anvil Penetration

2D-S Images with Standard Probe Tips

2D-S Images with Modified Probe Tips
Comparison of Shattering with Standard and Modified Tips

2D-S Standard Tips: No Arrival time Removal of Shattered Particles
Comparison of Shattering with Standard and Modified Tips

2D-S Standard Tips: No Arrival time Removal of Shattered Particles

2D-S Modified Tips: No Arrival time Removal of Shattered Particles
Comparison of Shattering with Standard and Modified Tips

2D-S Standard Tips: No Arrival time Removal of Shattered Particles

2D-S Modified Tips: No Arrival time Removal of Shattered Particles

2D-S Standard Tips: Shattered Particles Removed with Arrival Time Algorithm

Concentration \( \text{L}^{-1} \mu \text{m}^{-1} \)

Maximum Particle Dimension (\( \mu \text{m} \))
Comparison of Shattering with Standard and Modified Tips

- **2D-S Standard Tips**: No Arrival time Removal of Shattered Particles
- **2D-S Modified Tips**: No Arrival time Removal of Shattered Particles

**Concentration (L⁻¹ μm⁻¹)** vs. **Maximum Particle Dimension (μm)**
Scatterplots Showing Effectiveness of Standard and Modified Tips in Anvil Precipitation

2D-S with Standard Tips

2D-S with Modified Tips

Concentration of Ice < 100 μm (No. L⁻¹)

IWC of Ice Particles > 100 μm (g m⁻³)

Without Arrival Time Algorithm

With Arrival Time Algorithm (Y = 2114 X)

With Arrival Time Algorithm (Y = 367 X)
Combined FSSP, CPI and 2D-C Size Distributions (without Shattered Particles Removed) in Mid-Latitude Cirrus (Lawson et al. 2006)

-50 to -63 °C
-40 to -49 °C
-30 to -39 °C
Combined FSSP, CPI and 2D-C Size Distributions (without Shattered Particles Removed) in Mid-Latitude Cirrus (Lawson et al. 2006)

2D-S Size Distributions (with Shattered Particles Removed) in Mid-Latitude Cirrus (SPartICus)

-60 °C

-50 °C

-40 °C

-30 °C

846 L⁻¹

968 L⁻¹

2170 L⁻¹

2671 L⁻¹

366 L⁻¹

44 L⁻¹
SUMMARY of 2D-S Processing

- Modified Tips Reduce Effects of Shattering on the 2D-S Probe, but are not as Effective as Post Processing using Arrival Times and other Techniques to Remove Artifacts.

- This is Opposite to Korolev’s findings indicating that Modified Probe Tips are More Effective than Arrival Time Algorithm on the 2D-C and CIP Probes.
Brad Baker has been working on a Shattering Algorithm for the Fast FSSP. The Procedure Involves:

1) Noise Reduction
2) Shatter Reduction
3) Depth of Field Qualification
4) Transit Time Qualification

Transit Times Correlate well with Particle Size (for the first time), Resulting in a New Algorithm that has Dramatic Effects in some conditions.
Plot Showing how Particle Transit Time Correlates well with Particle Size (for the first time).
One Example of Aggressive Removal of Particles seen by the FFSSP as a Result of New Shattering and Transit Time Algorithm

Original FFSSP Size Distribution

Processed FFSSP Size Distribution
One Example of Agressive Removal of Particles seen by the FFSSP as a Result of New Shattering and Transit Time Algorithm

FFSSP Processing is a Work in Progress – Suggest Waiting to use Data Until More Work has been done.