

Metric variability in a fine-resolution microphone array at NASA Quesst Mission Phase 2 Dry Run

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Introduction

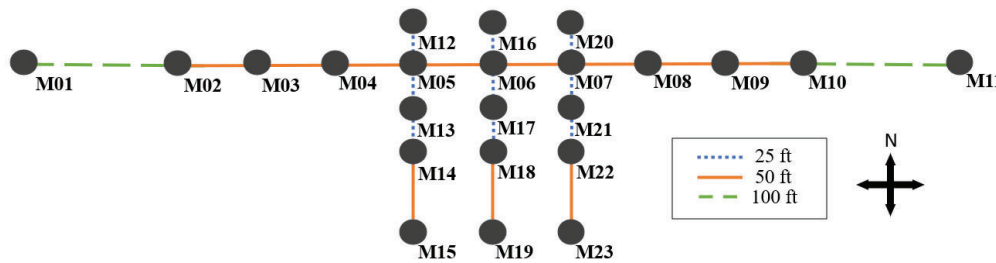
- NASA Quesst Mission
- ARray Instrumentation for Sonic Thump Observations in TurbuLence (ARISTOTLE)
 - Measure X-59 sonic “thumps”
 - Analyze variability due to atmospheric turbulence
 - What 2D spatial variability in sonic boom loudness was observed?
 - What is the relationship between loudness variability and turbulence or other variables?
 - How do the measurements compare to predictions?



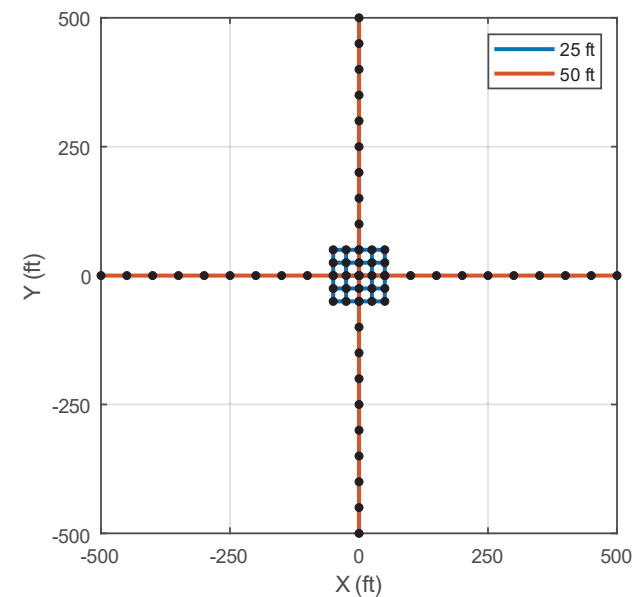
NASA

Array design

- ARISTOTLE Jr. at previous NASA flight test (CarpetDIEM III)
 - Limited dataset
 - 23-microphone, 2D array
 - Average PL range: 7.3 dB
 - Average σ_{PL} : 1.7 dB



- ARISTOTLE design
 - 1,000 ft x 1,000 ft
 - 25 ft and 50 ft spacing



NASA Quesst Phase 2 Dry Run

- Full-scale dry run with an F-15B
 - Flight planning
 - Instrument deployment
 - Data collection
 - Ground acoustic
 - Near, mid, and far field pressure signatures
 - Trajectory
 - Meteorological



NASA/Christopher LC Clark

ARISTOTLE at Quesst Phase 2 Dry Run

- 6 weeks
- 19 booms
- 4 flight maneuvers
- Ray elevation angle: 7 to 27°



ARISTOTLE at Quesst Phase 2 Dry Run

- Setup
 - 61 microphones
 - 3 microphone types
 - 5 data acquisition systems
 - Differential GPS
 - Longer-term deployment
 - Weather
 - Wildlife
 - Security

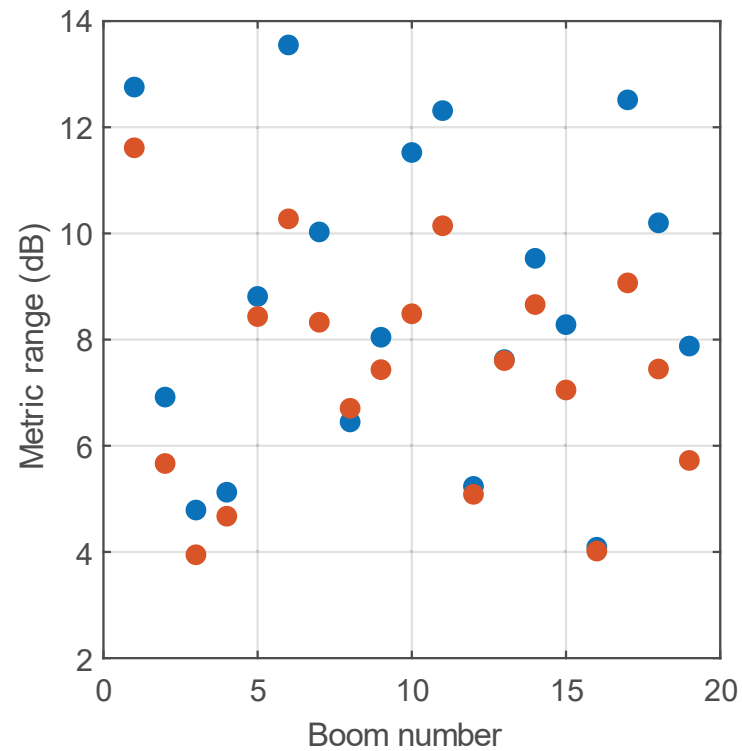
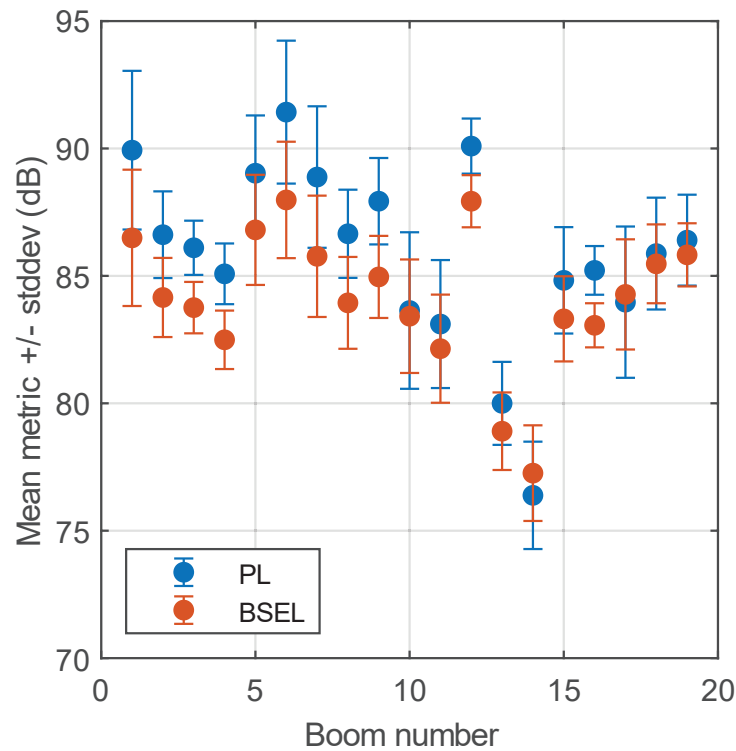


Weather

- **Surface weather**
 - **Temperature**
 - Mean: 29.8°C
 - Range: 20.4 to 35.7°C
 - **Humidity**
 - Mean: 27.2%
 - Range: 12.1 to 51.5%
 - **Wind speed and direction**
 - Mean: 2.1 m/s
 - Range: 0.0 to 5.3 m/s
 - Direction: mostly from the south



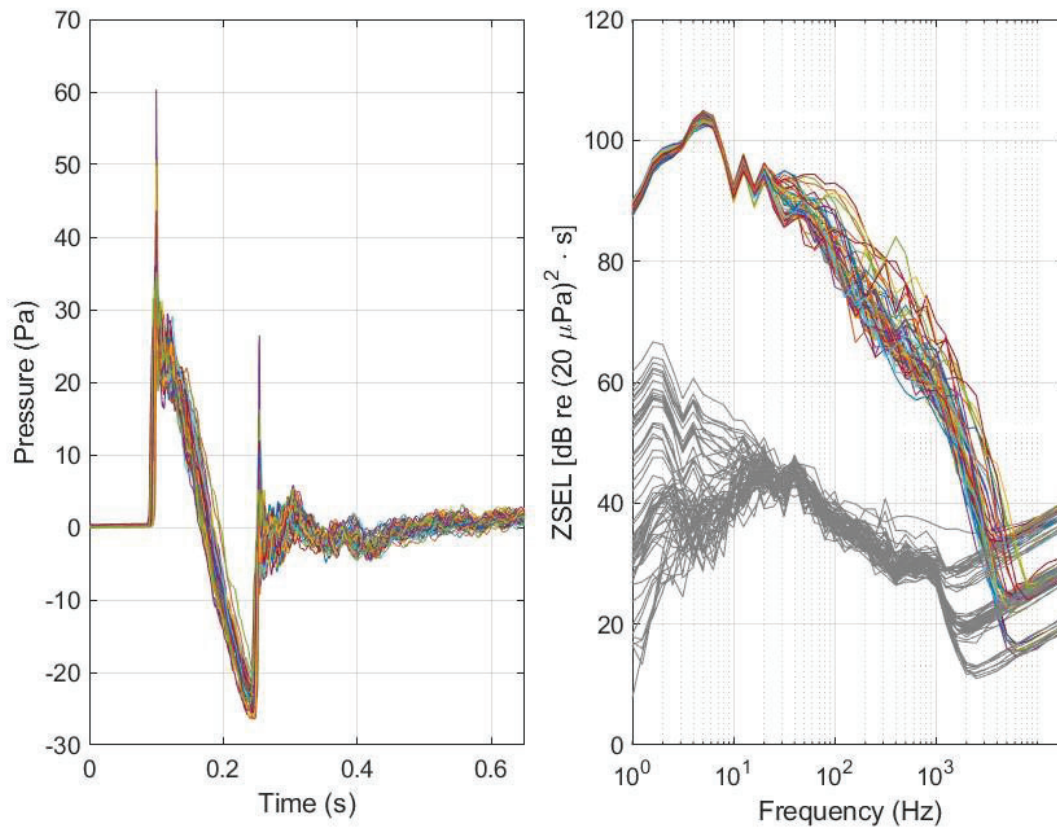
Summary of acoustic measurements



Examples

- Largest σ_{PL}
 - Booms 1 and 10
- Largest PL range
 - Boom 6
- Smallest σ_{PL} and PL range
 - Boom 16

Boom 1: largest σ_{PL}

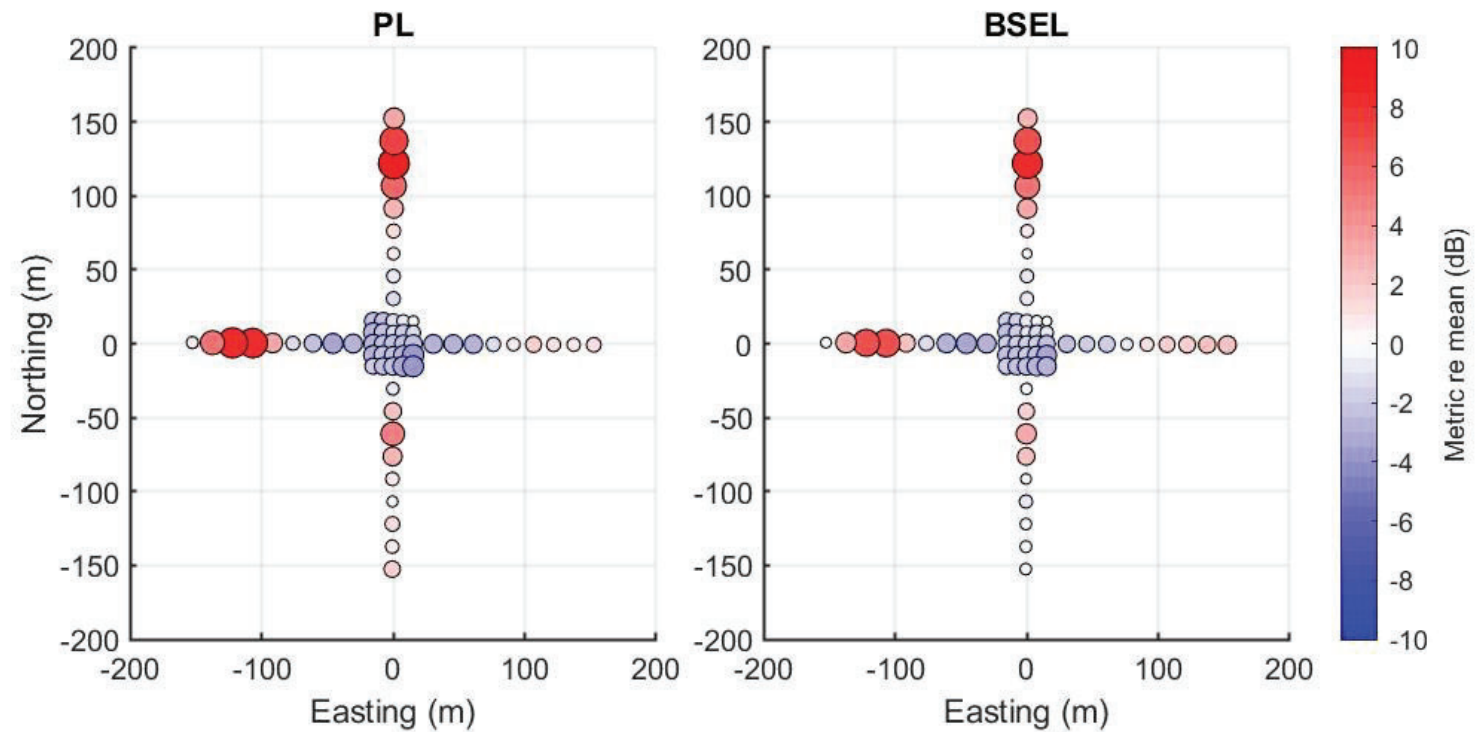


Measured spectrum: color
Ambient spectrum: gray

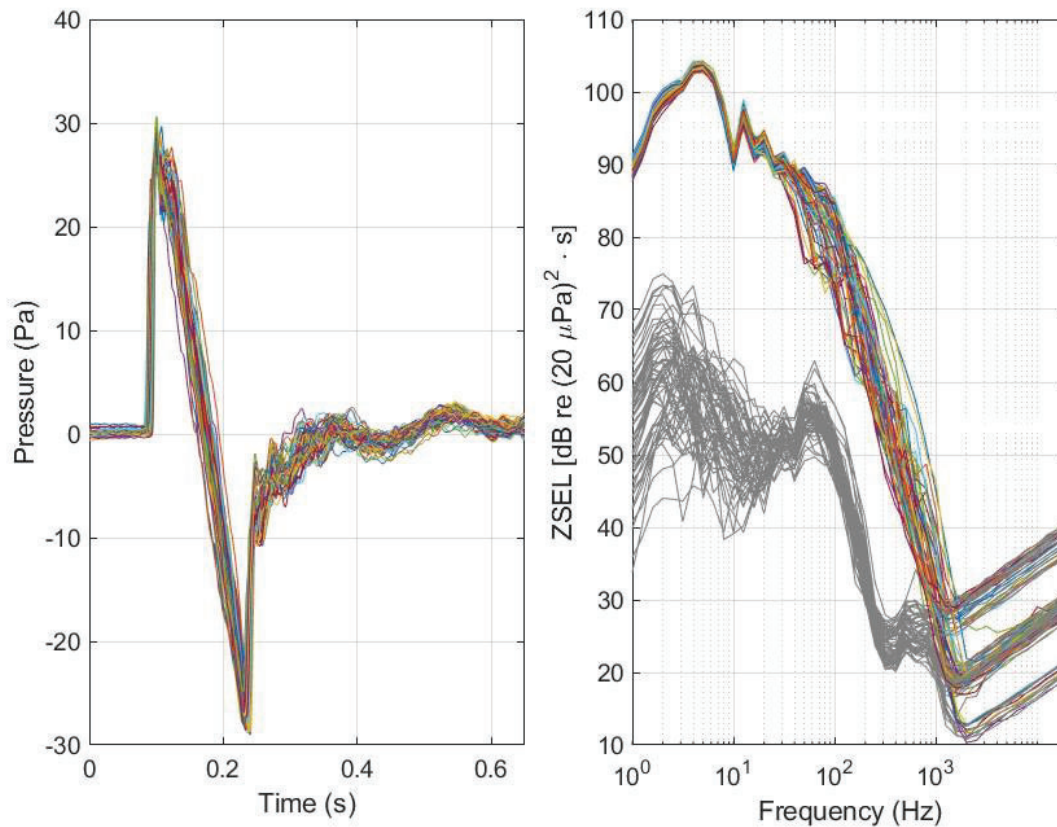
Turbulence flight
June 3 at 7:28 am
Temperature: 20.6°C
Relative humidity: 49.7%
Wind: 0.0 m/s

$\sigma_{PL} = 3.1$ dB
PL range = 12.8 dB

Boom 1: largest σ_{PL}



Boom 10: largest σ_{PL}

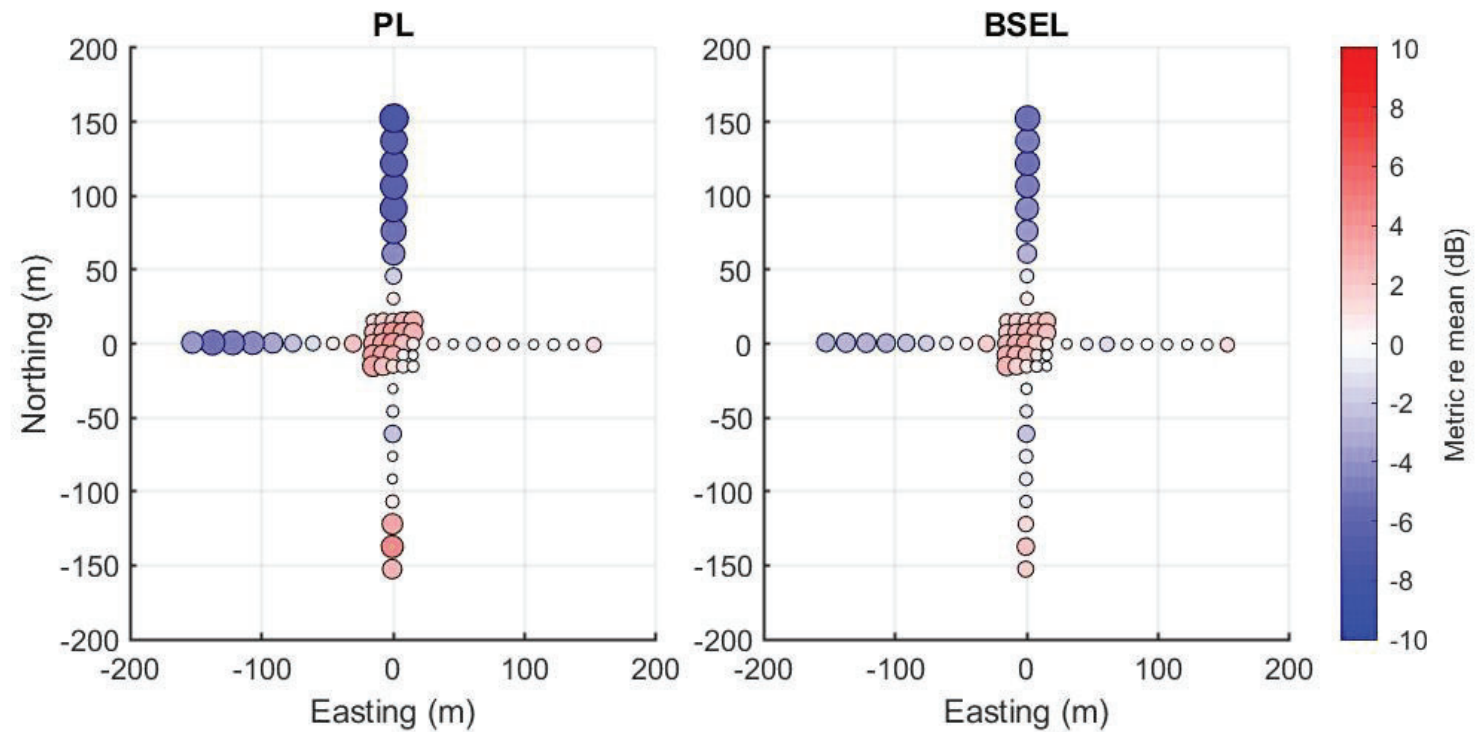


Measured spectrum: color
Ambient spectrum: gray

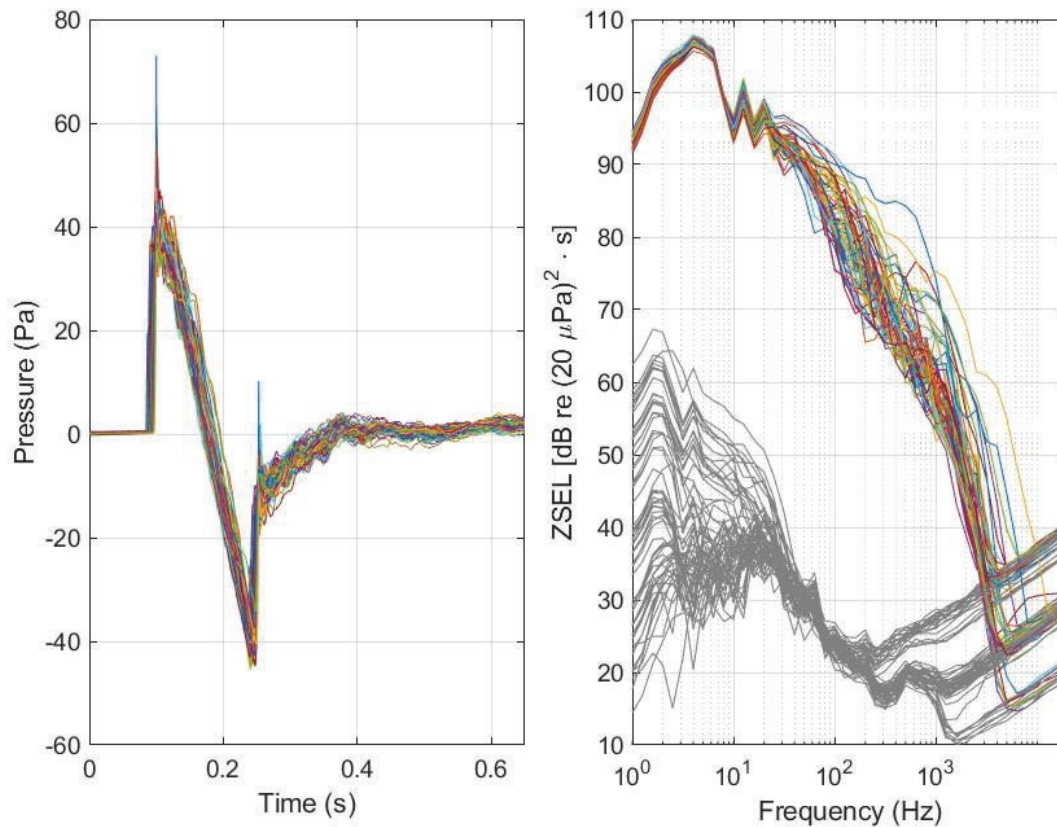
Near-field flight
June 11 at 9:49 am
Temperature: 30.9°C
Relative humidity: 29.5%
Wind: 5.3 m/s Southwest

$\sigma_{PL} = 3.1$ dB
PL range = 11.5 dB

Boom 10: largest σ_{PL}



Boom 6: largest PL range

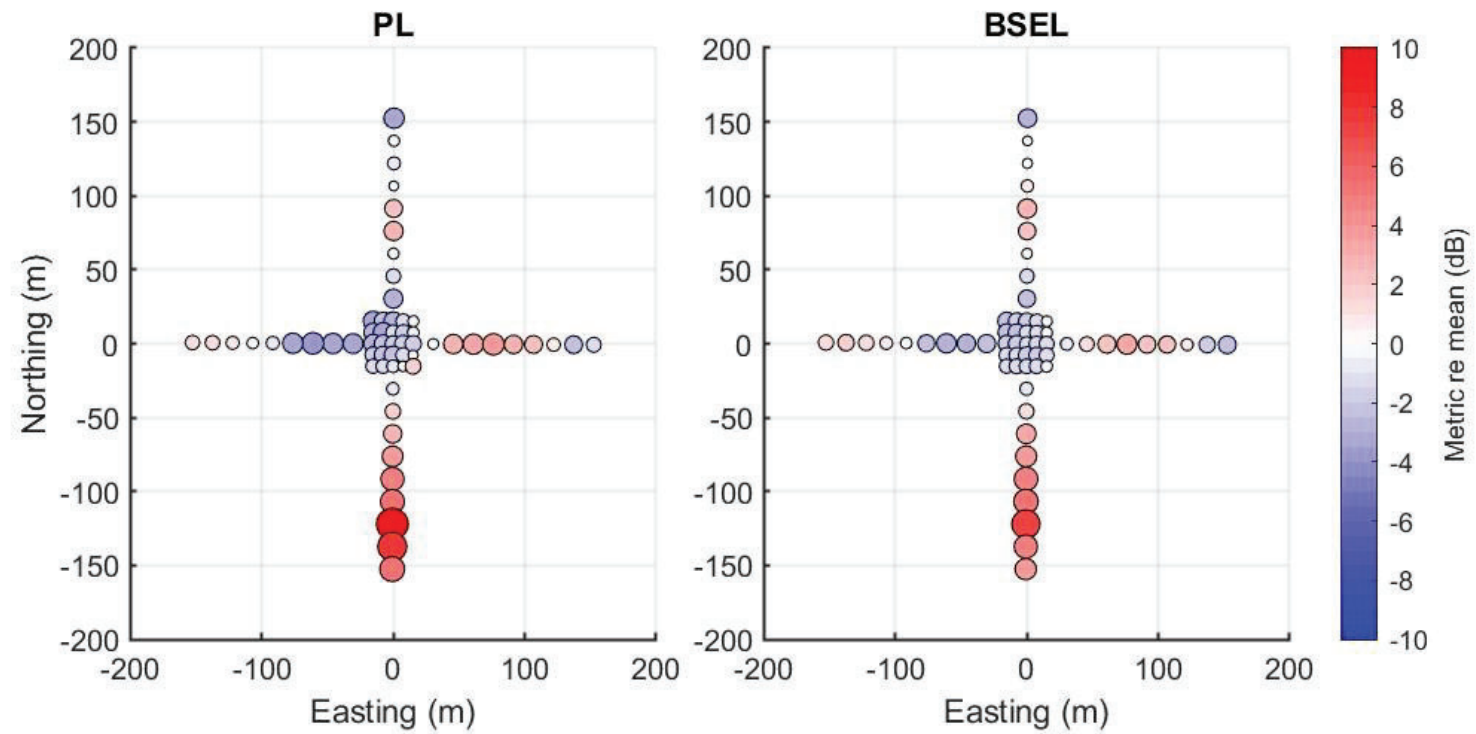


Measured spectrum: color
Ambient spectrum: gray

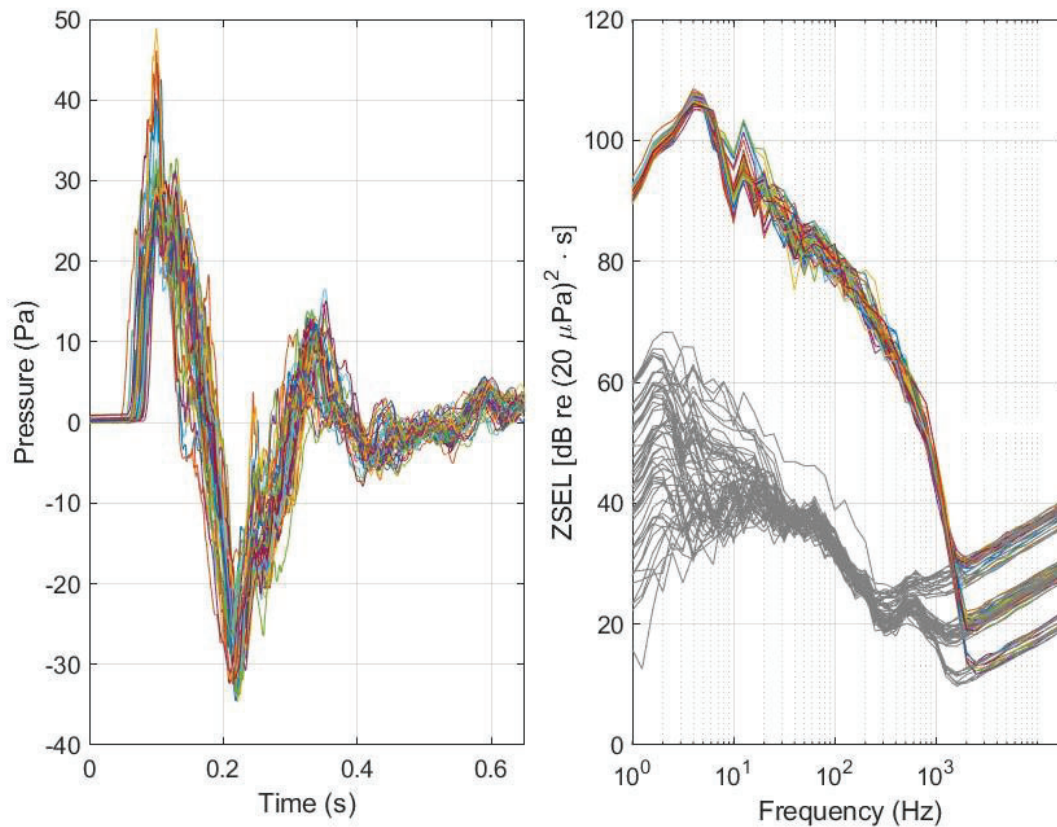
Turbulence flight
June 6 at 10:17 am
Temperature: 28.5°C
Relative humidity: 33.0%
Wind: 0.9 m/s Southeast

$\sigma_{PL} = 2.8$ dB
PL range = 13.6 dB

Boom 6: largest PL range



Boom 16: smallest σ_{PL} and PL range

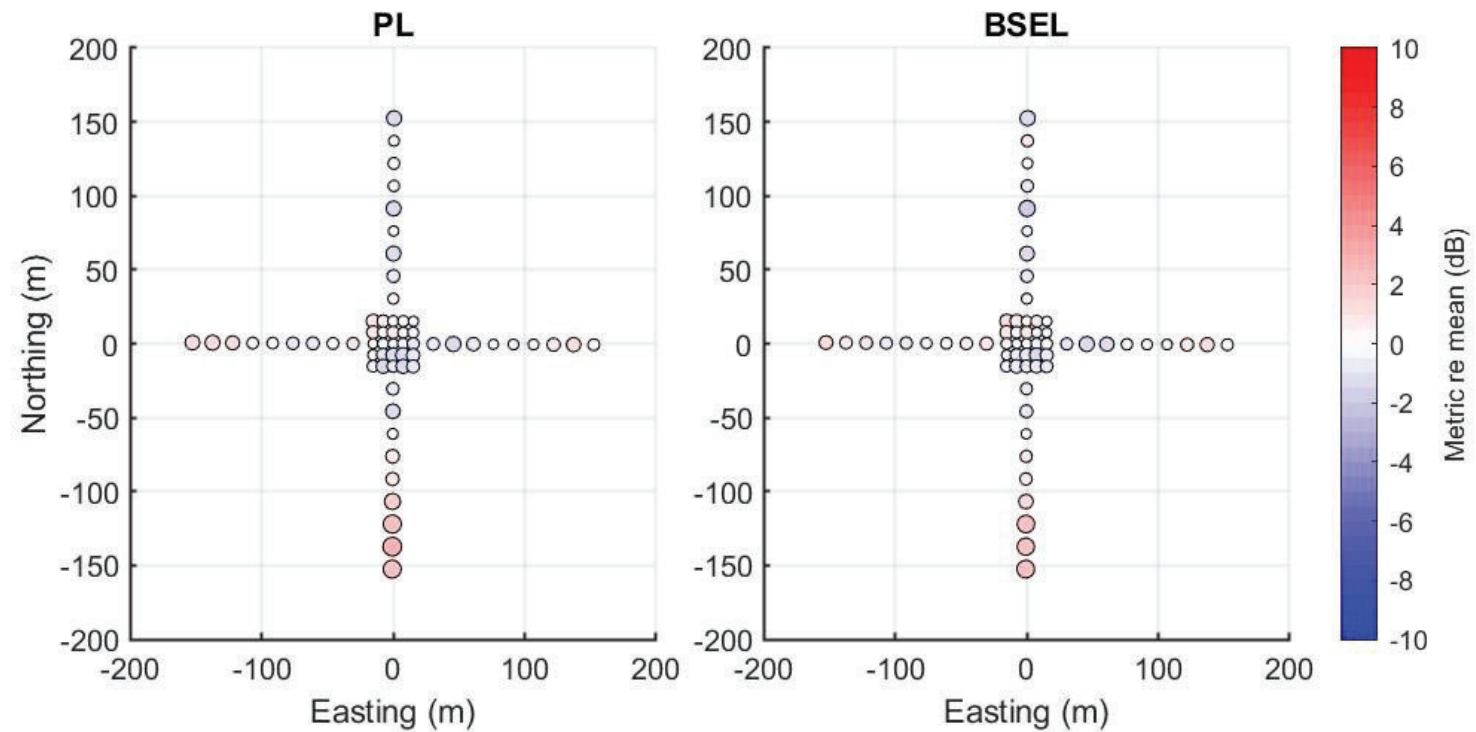


Measured spectrum: color
Ambient spectrum: gray

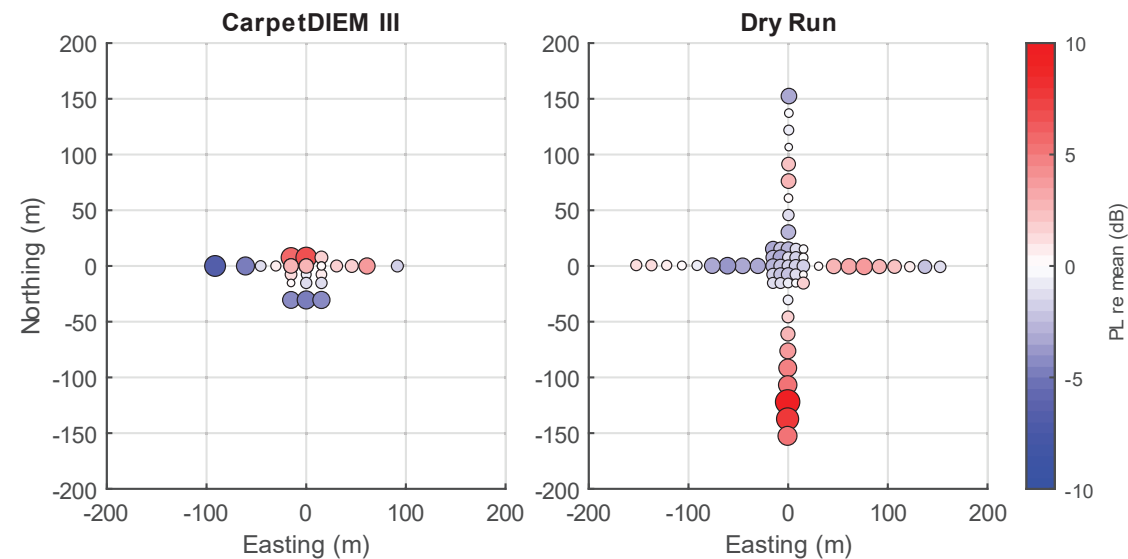
Near-field flight
July 2 at 12:37 pm
Temperature: 33.0°C
Relative humidity: 19.8%
Wind: 2.4 m/s East

$\sigma_{PL} = 1.0$ dB
PL range = 4.1 dB

Boom 16: smallest σ_{PL} and PL range



Comparison to CarpetDIEM III



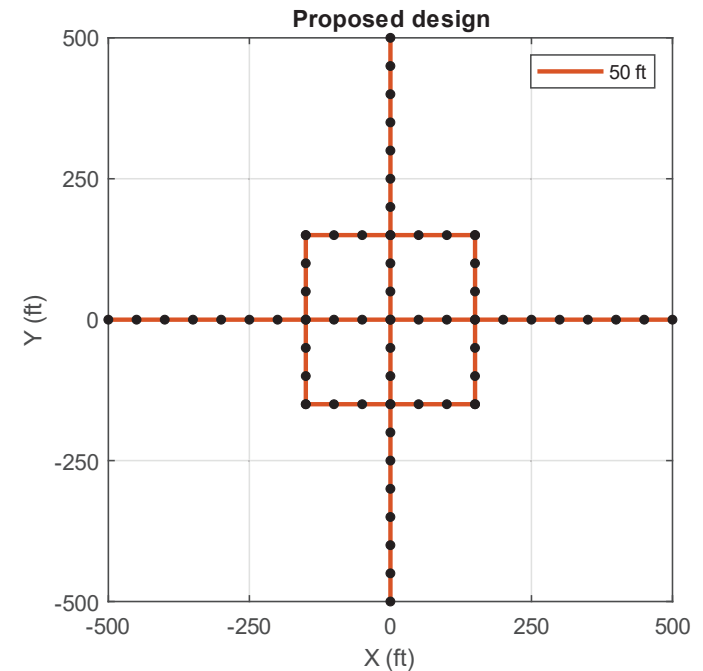
	CarpetDIEM III	Dry Run
σ_{PL}	0.9 to 3.4 dB	1.0 to 3.1 dB
σ_{BSEL}	0.5 to 2.4 dB	0.9 to 2.7 dB
PL range	3.6 to 17.2 dB	4.1 to 13.6 dB
BSEL range	2.3 to 8.7 dB	3.9 to 11.6 dB

Conclusions

- Observed PL variability
 - σ_{PL} : 1.0 to 3.1 dB
 - PL range: 4.1 to 13.6 dB
 - σ_{PL} and σ_{BSEL} are similar to the values from CarpetDIEM III
- 25 ft spacing was not necessary to capture variability in metrics
- Repeating regions of loud and quiet were not captured for each boom

Conclusions

- Observed PL variability
 - σ_{PL} : 1.0 to 3.1 dB
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Next steps

- What is the relationship between loudness variability and turbulence or other variables?
 - Receive data from NASA
 - Meteorology
 - Analyze weather balloon data
 - Calculate turbulence parameters from sonic anemometer data
 - Calculate atmospheric boundary layer height from ceilometer and weather balloon data
 - Trajectory
- How do the measurements compare to predictions?
 - Compare measurements to model predictions
 - PCBoom
 - KZKFourier turbulence model