Comparison of Low-boom Predictions from Different Sonic Boom Propagation Codes

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Introduction

- **Follow-on to 3rd AIAA Sonic Boom Prediction Workshop held in January 2020***
  - Compare state of current prediction methods for shaped low booms
  - Explore effect of realistic atmospheric conditions
- **NASA and ONERA wanted to assess differences in more detail**
  - Propagation of near field signatures to the ground
  - Update results and compare additional parameters

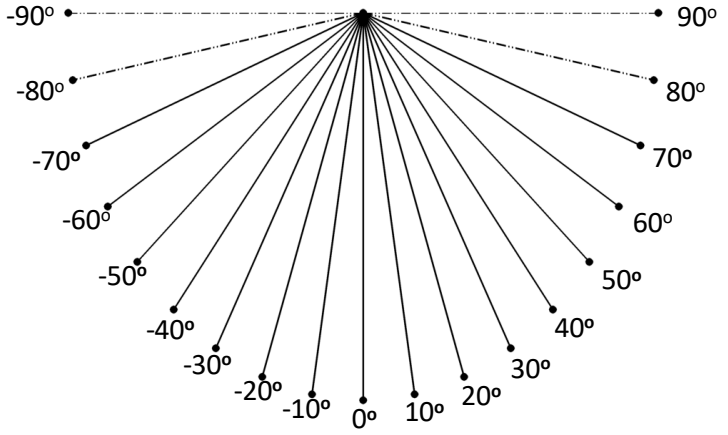
- **Describe observed differences and investigate possible causes of differences**
- **Propose recommendations for code refinements for both organizations**

*S. K. Rallabhandi and A. Loubeau. Summary of Propagation Cases of the Third AIAA Sonic Boom Prediction Workshop. AIAA SciTech, 2021.

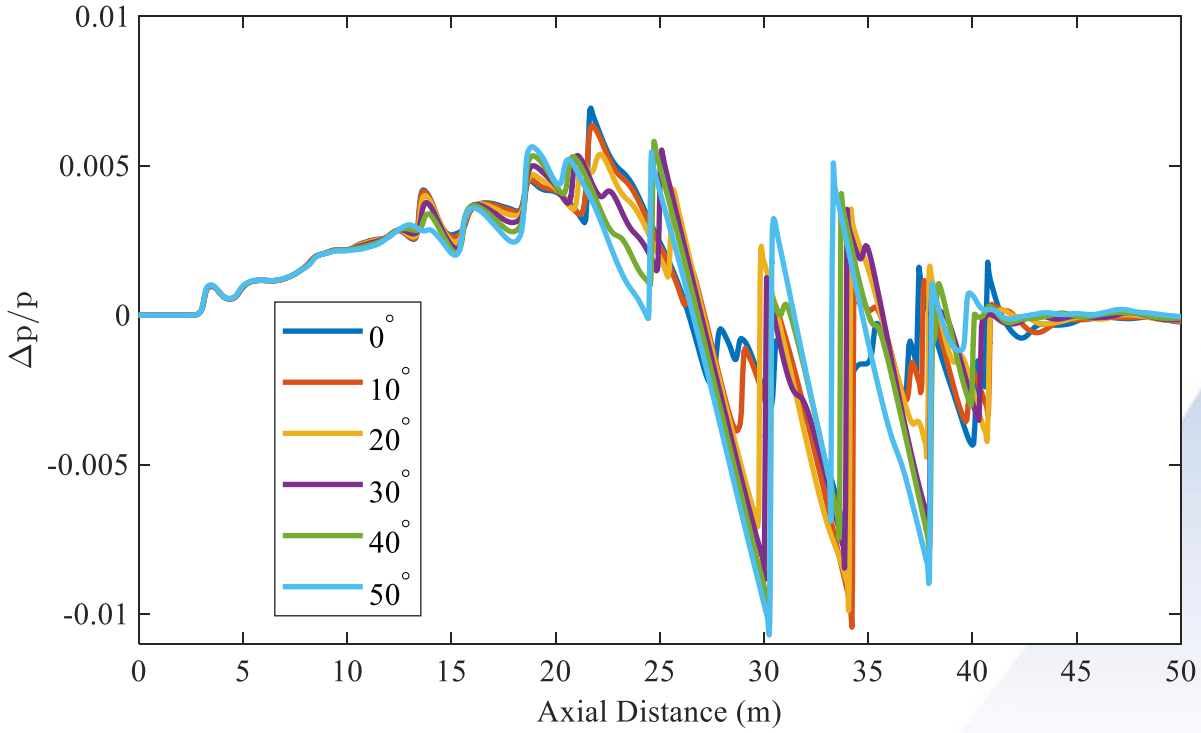
ONERA and NASA Sonic Boom Propagation Codes

- **ONERA**
  - Airbus code BANGV
- **NASA supports two codes**
  - sBOOM v2.82
  - PCBoom v6.7.2
- **All three codes include**
  - Geometrical acoustics ray tracing
  - Propagation along rays with numerical solutions to lossy Burgers equation
  - Effects of nonlinearity, atmospheric absorption/dispersion, geometrical spreading
- **Used NASA's metrics code to compute spectra and metrics for all three sets of results**

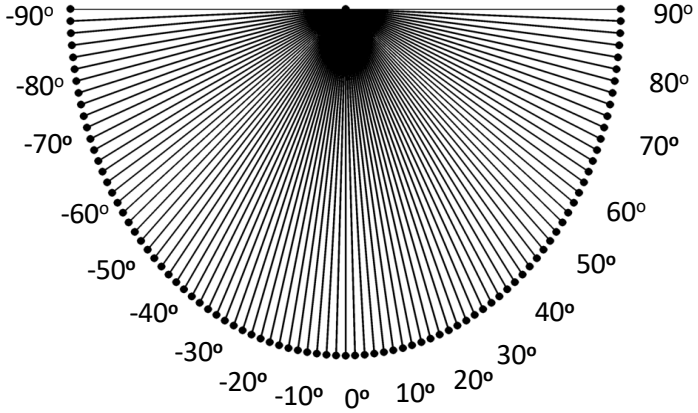
Case 1: NASA C25P



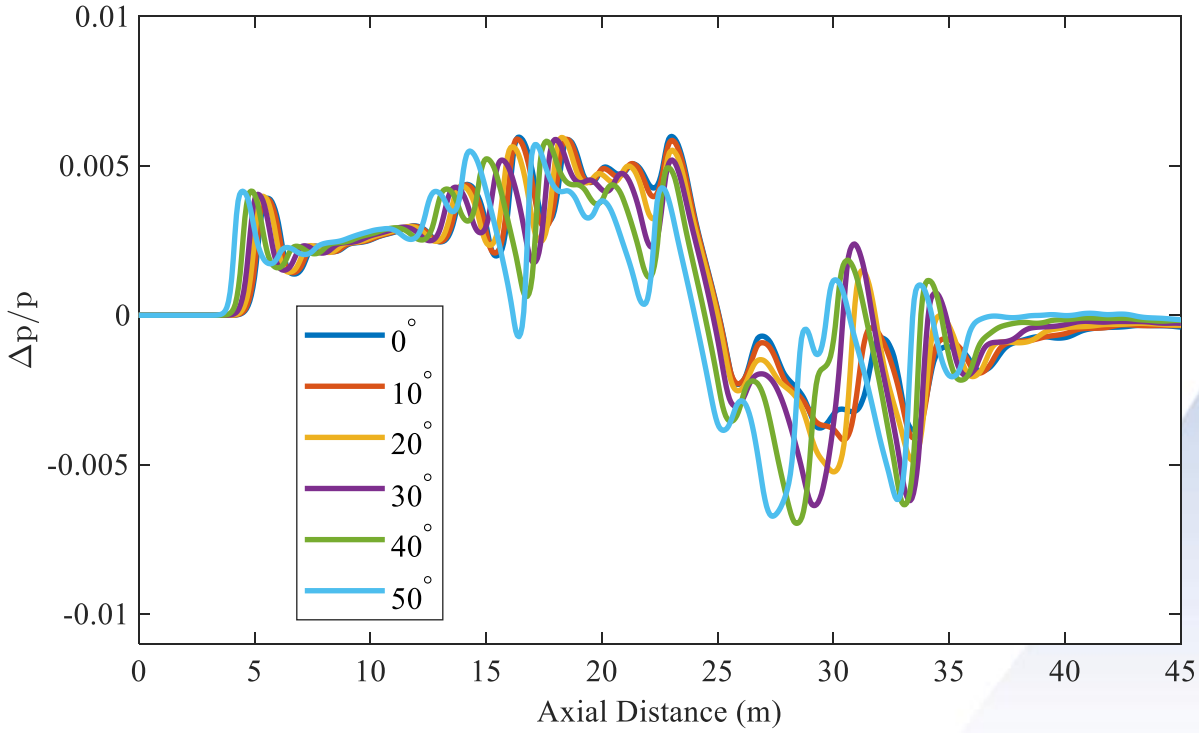
- NASA C25P powered low-boom demonstrator concept
- Flow Conditions: M=1.6, Altitude = 15760 m, R/L = 3.0, L = 33.53 m
- Near field provided from -90° to 90° in 10° increments



Case 2: NASA/LM X-59 C609



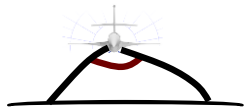
- **NASA-Lockheed Martin low-boom flight demonstration design: variant of X-59 QueSST**
- **Flow Conditions: M=1.4, Altitude = 16459.2 m , R/L = 3.0, L = 27.43 m**
- **Near field provided from -90° to 90° in 2° increments**



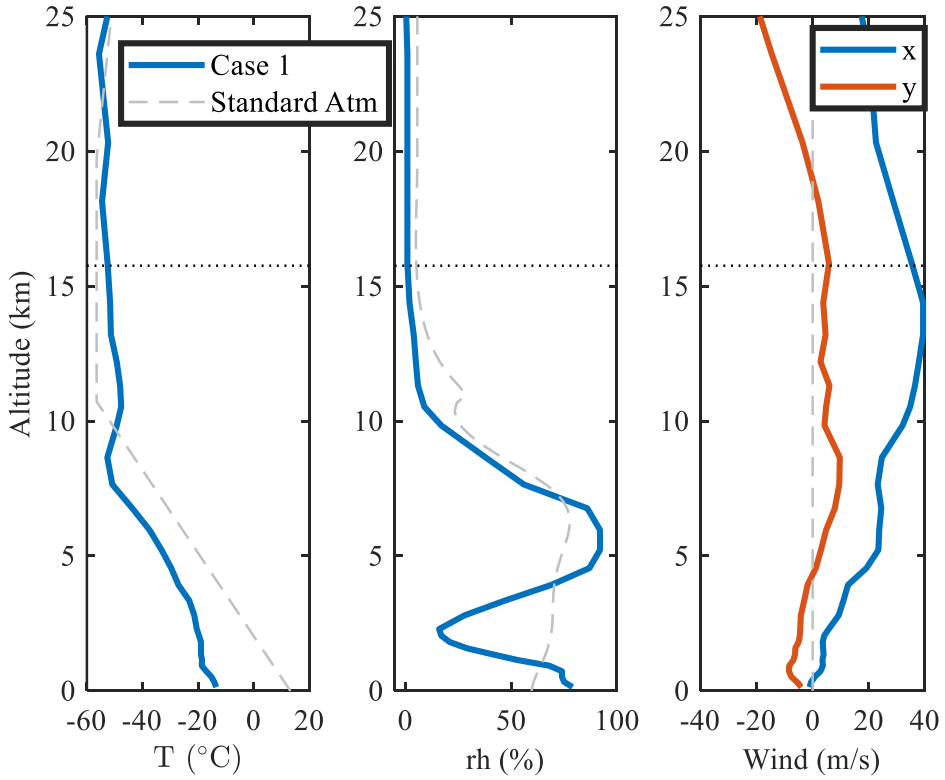
Atmospheric Profiles

- **Profiles selected from Climate Forecast System Reanalysis (CFSv2) database**
  - Realistic atmospheric profiles, including winds

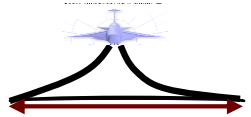
- **Case 1**



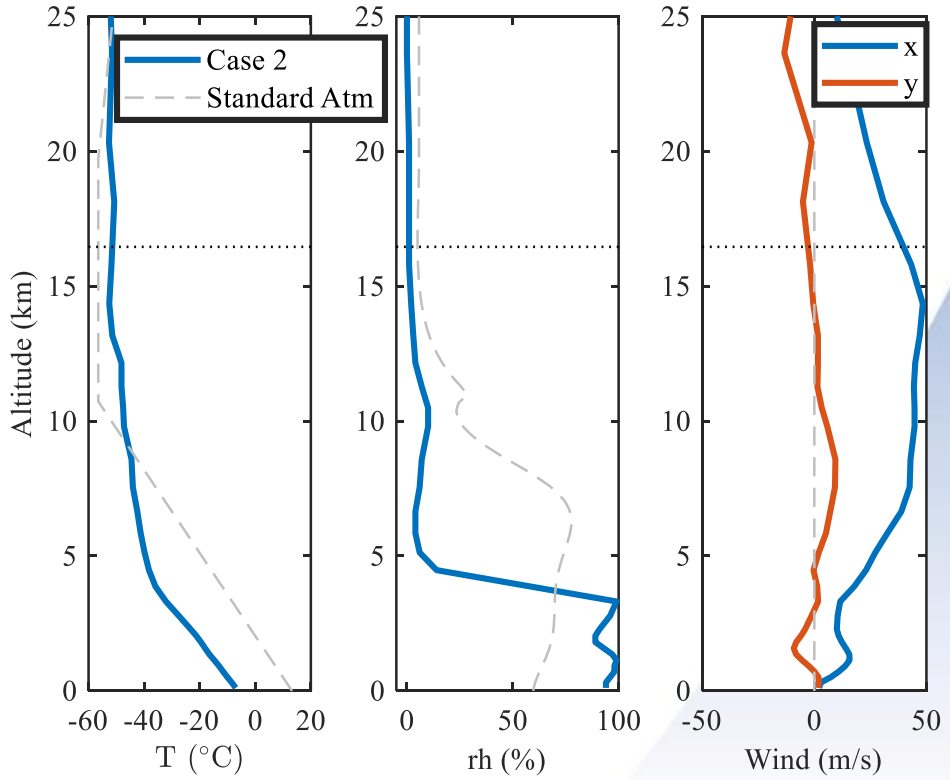
  - Wide carpet to maximize cut-off ray angles



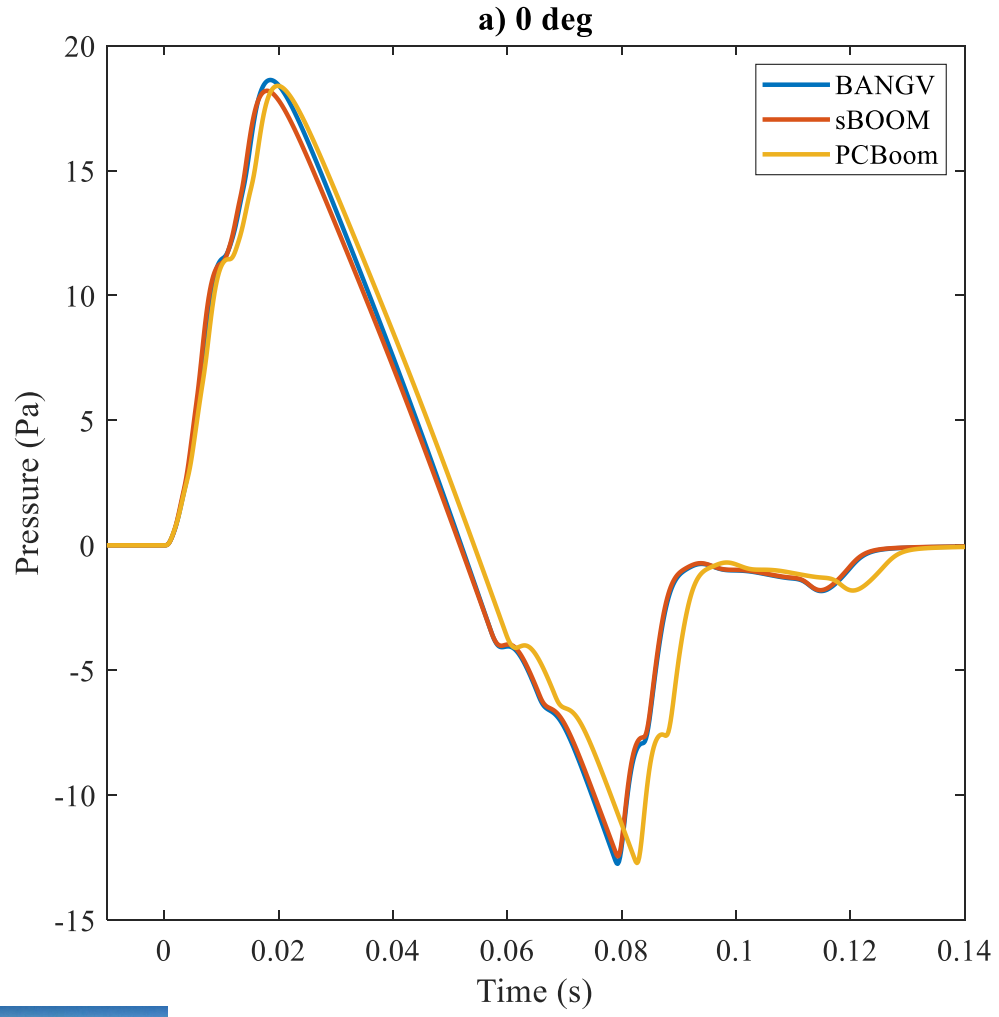
- **Case 2**

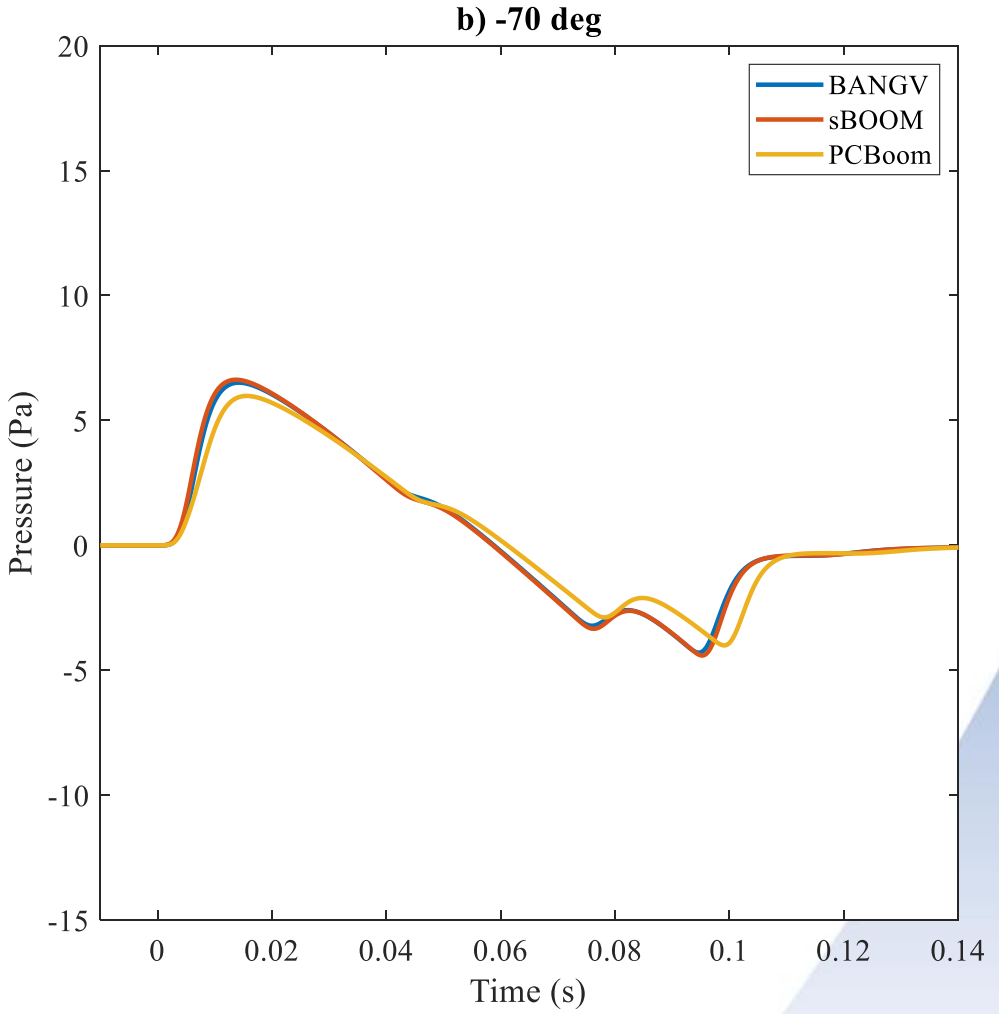


  - Wide carpet to maximize ground carpet width

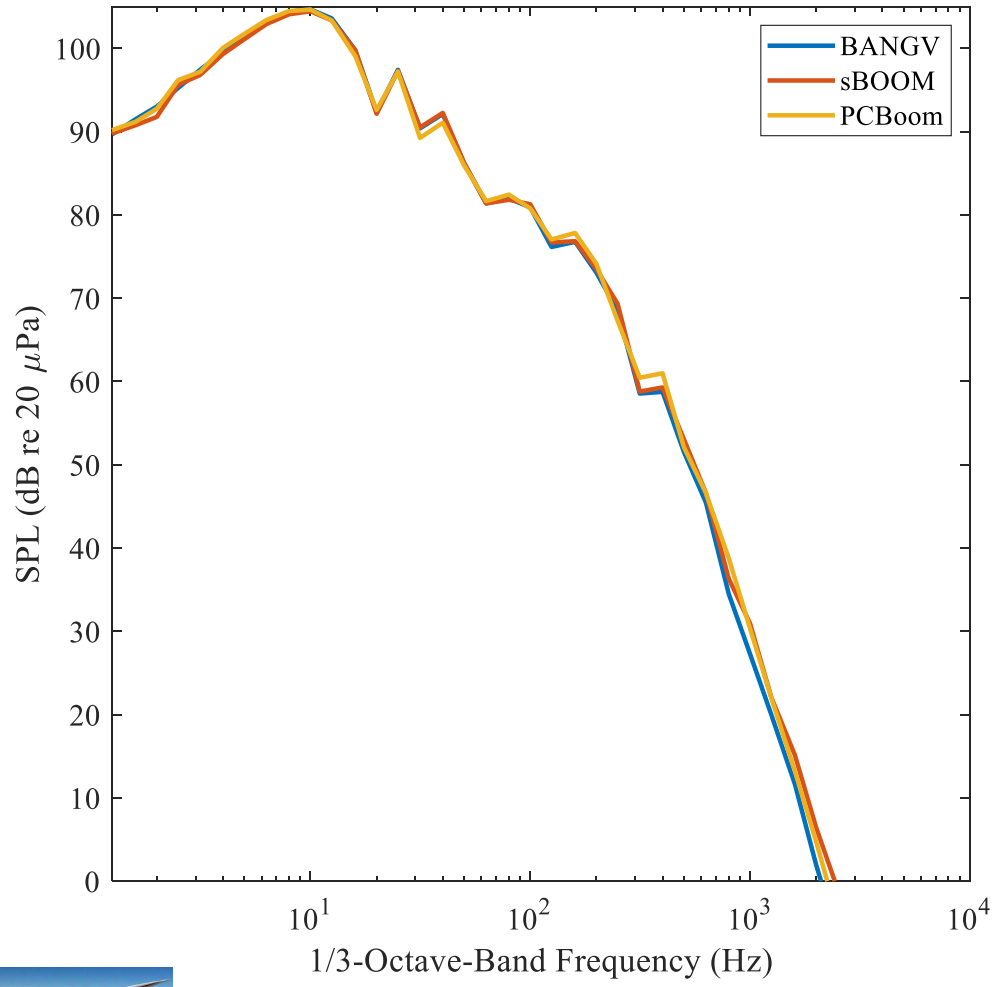


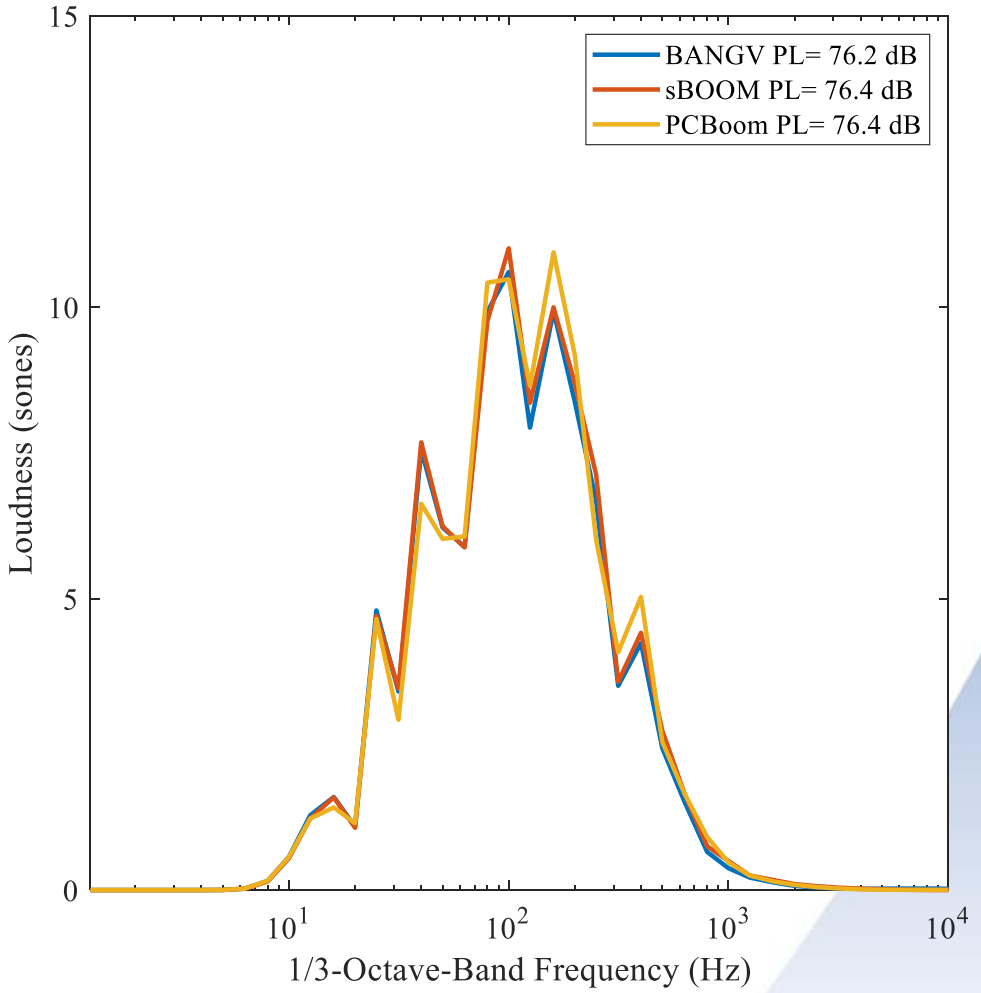
Case 1 Ground Waveforms



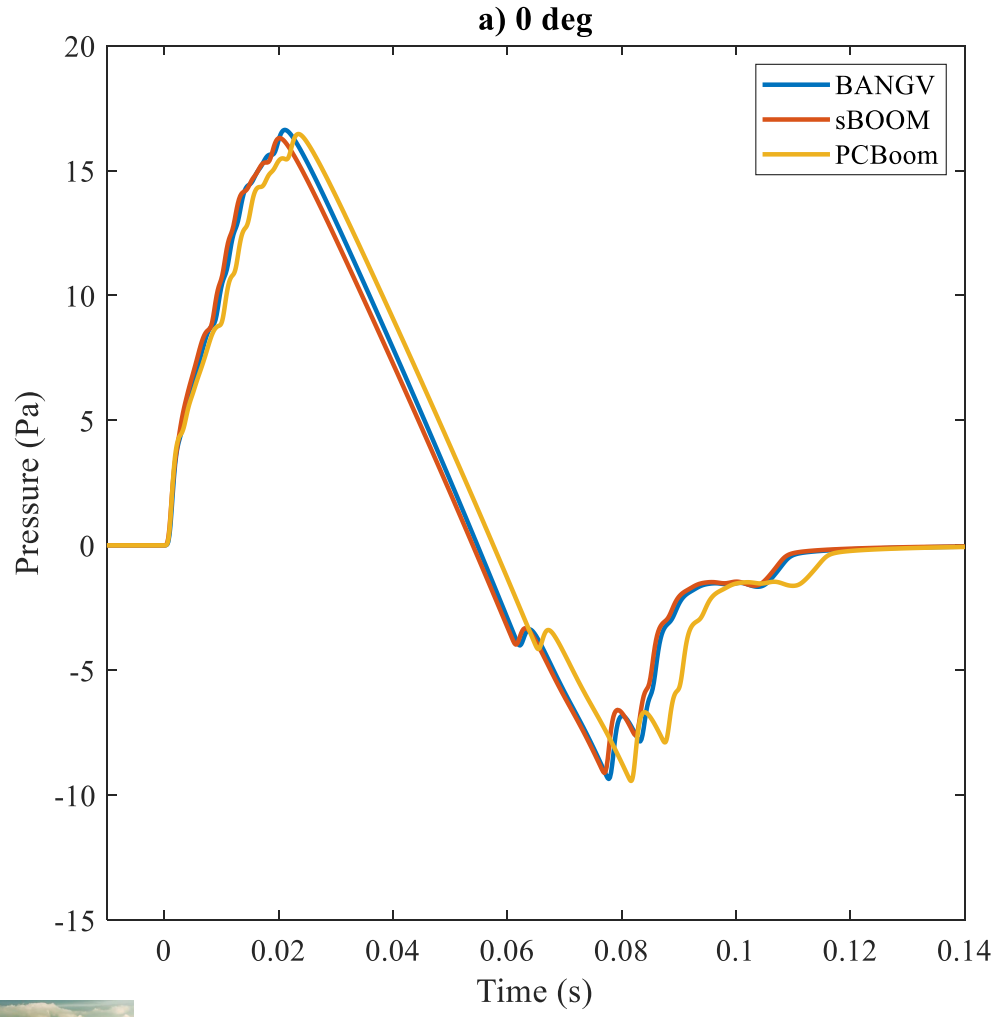


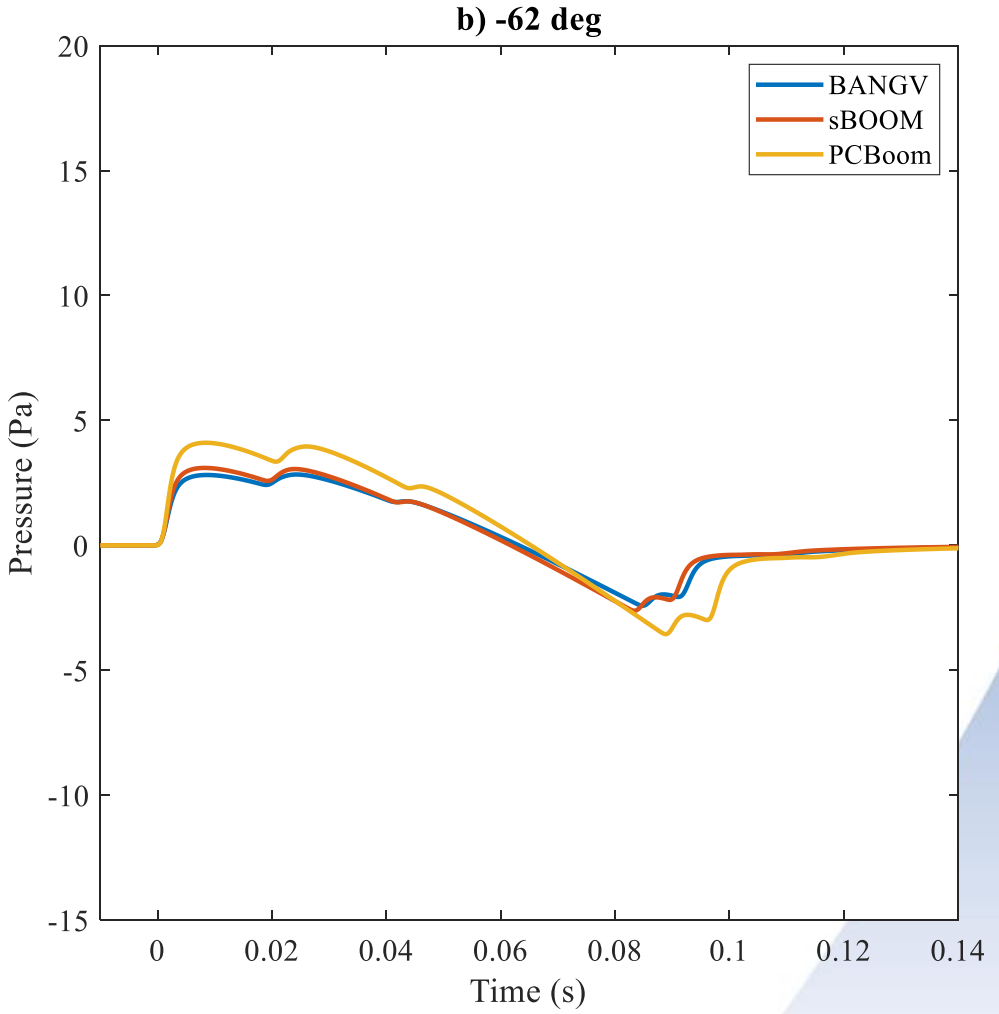
Case 1 Spectra (0 deg.)



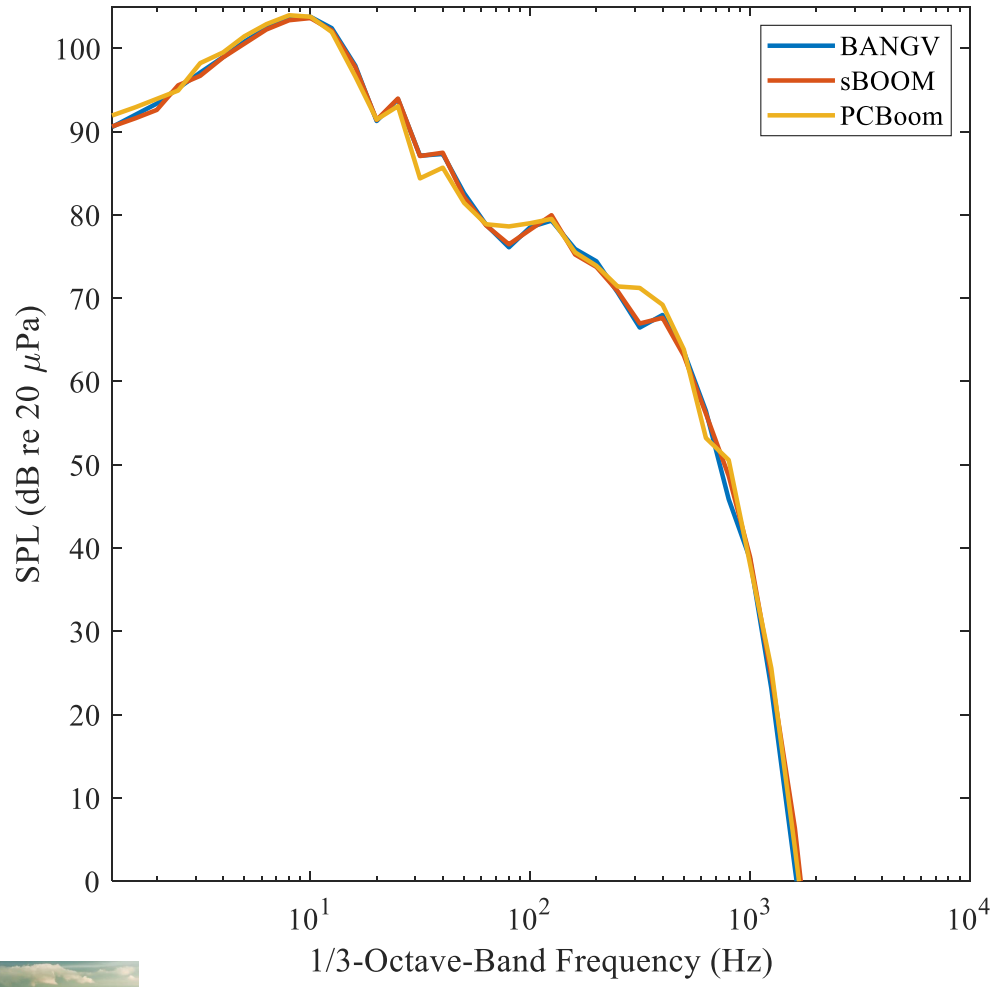


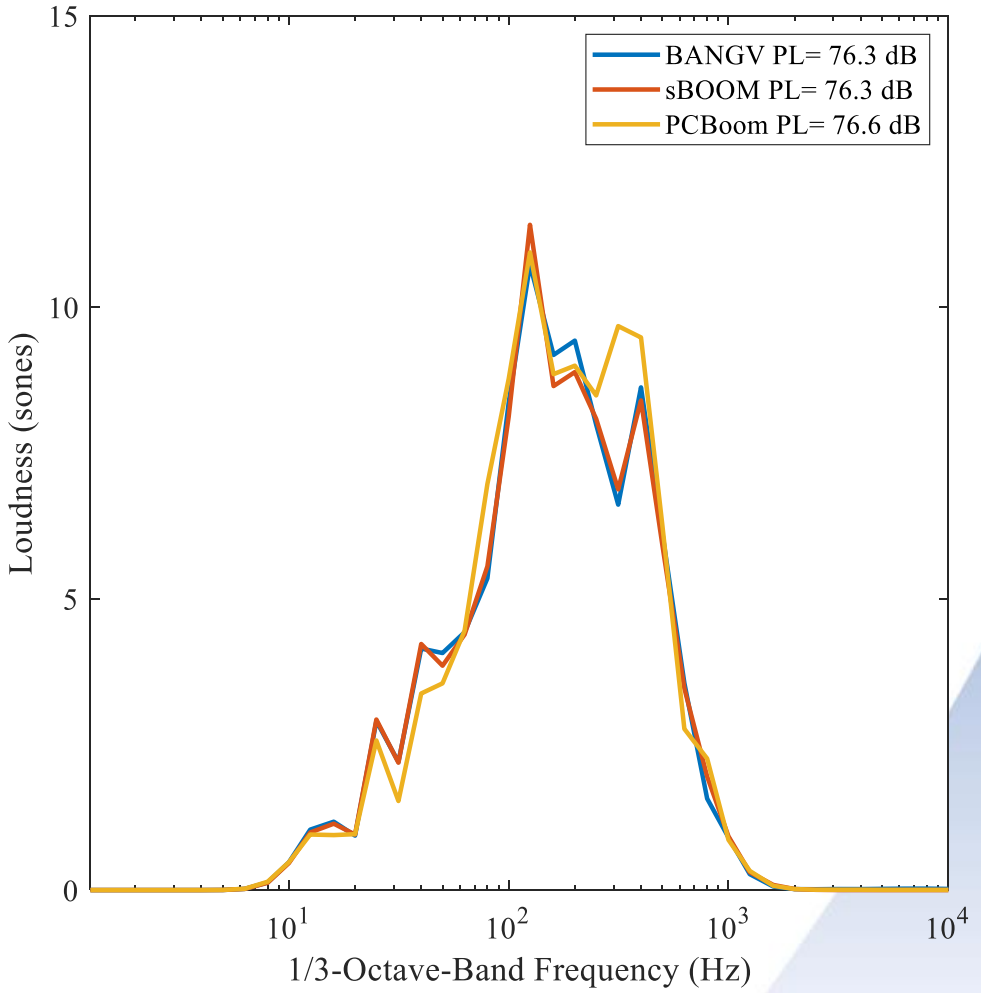
Case 2 Ground Waveforms



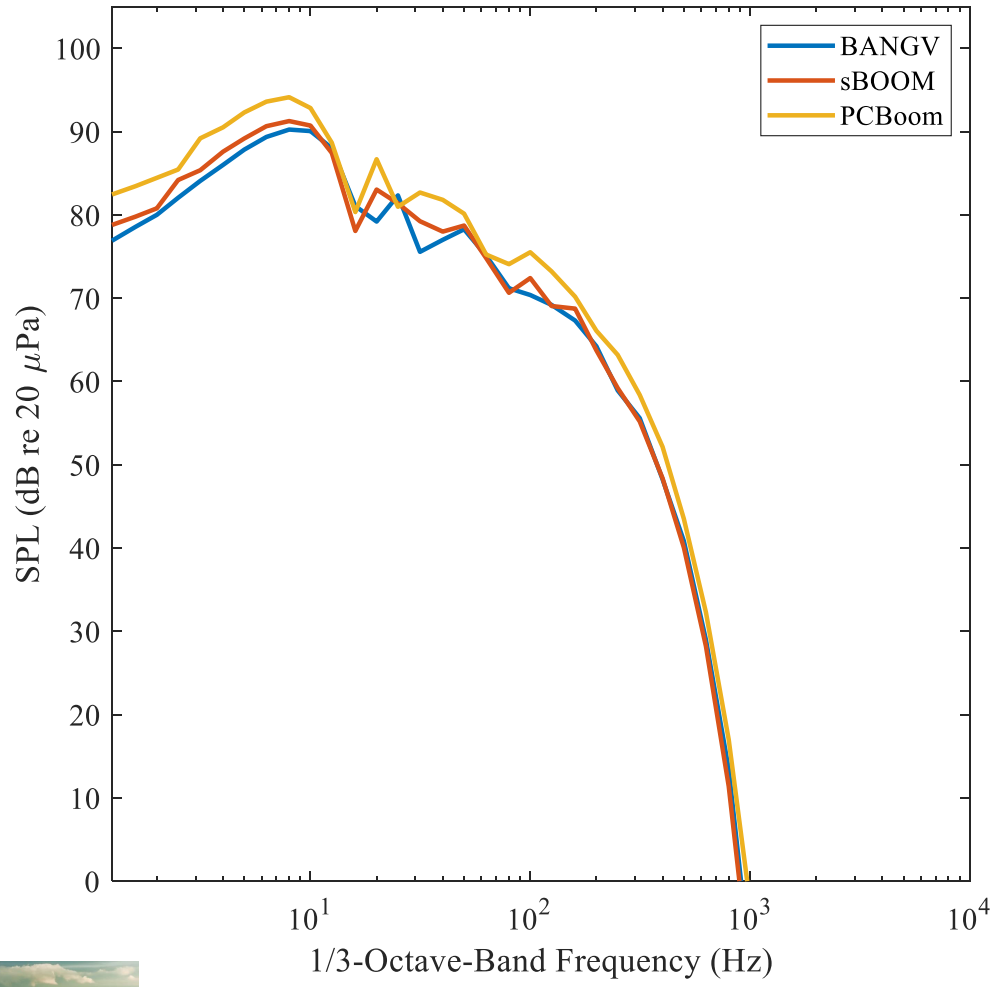


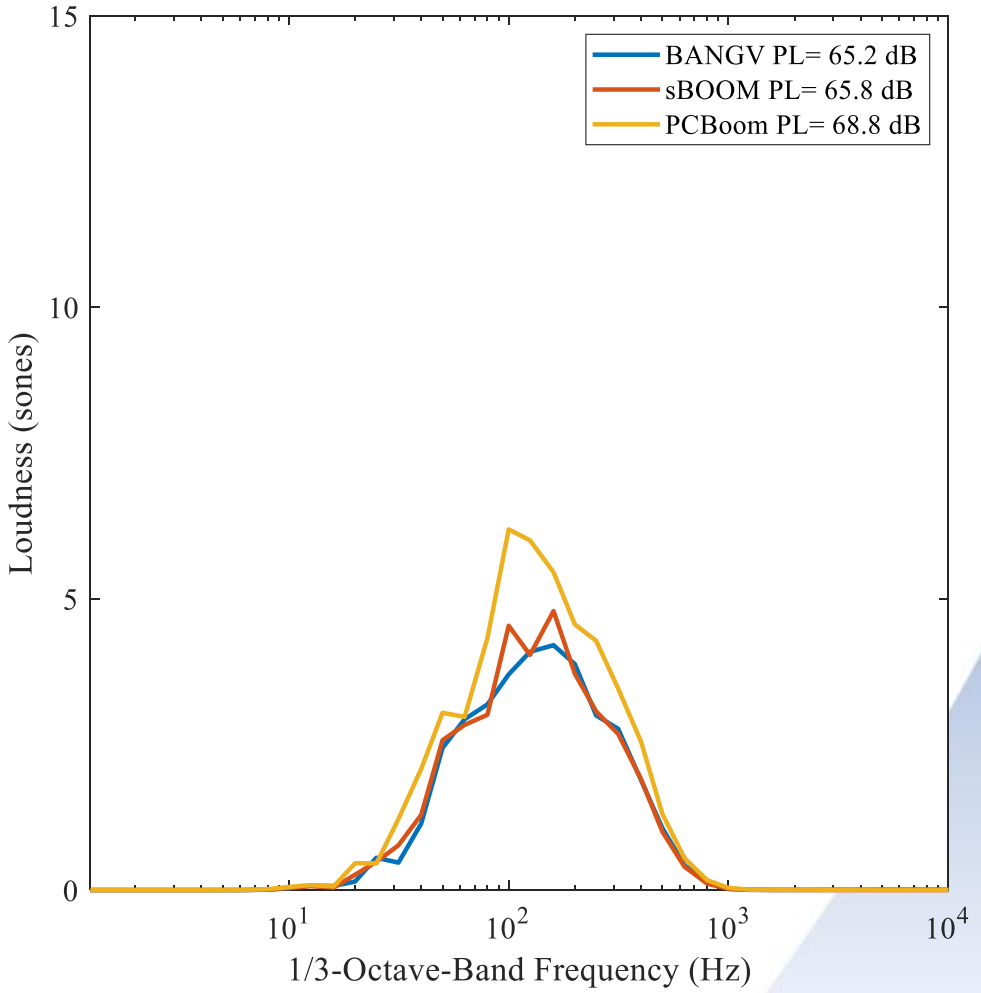
Case 2 Spectra (0 deg.)



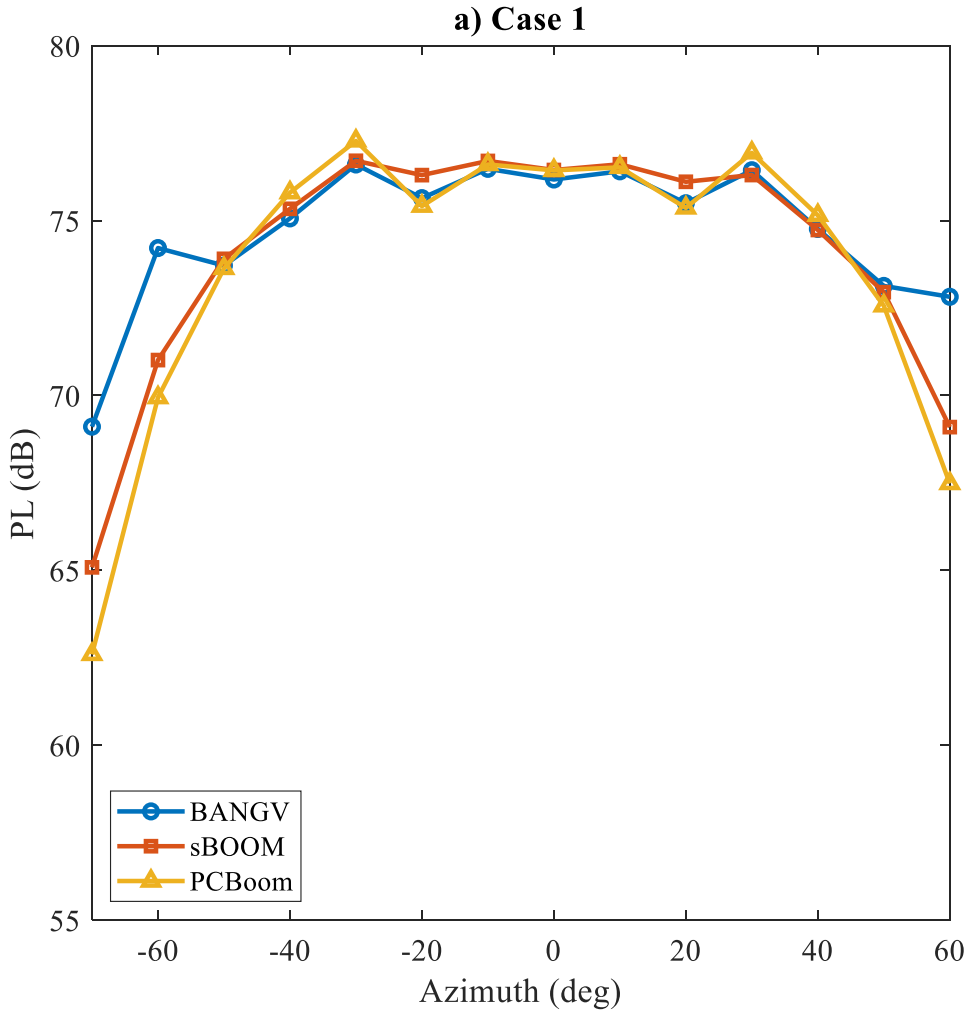


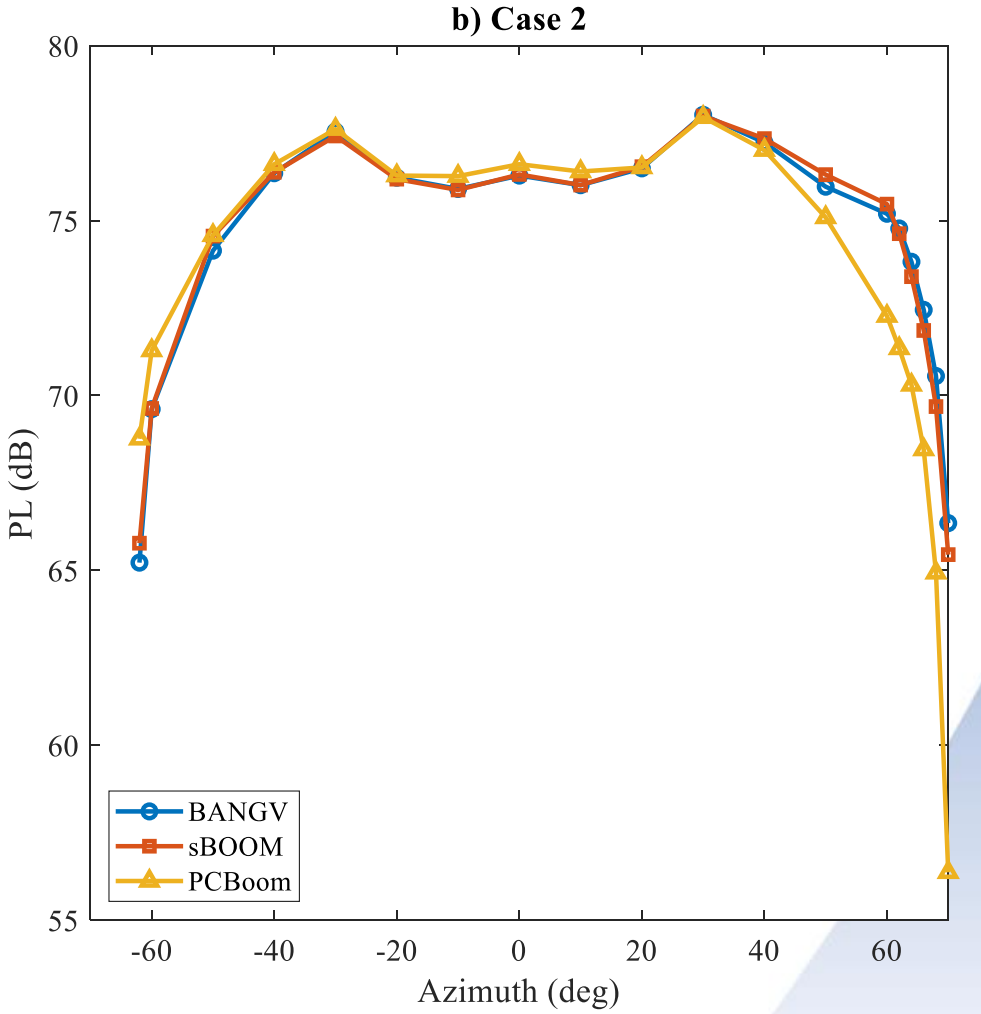
Case 2 Spectra (-62 deg.)





PL Carpet


a) Case 1
80
75
70
65
60
55
PL (dB)
-60
-40
-20
0
20
40
60
Azimuth (deg)
BANGV
sBOOM
PCBoom


b) Case 2
80
75
70
65
60
55
PL (dB)
-60
-40
-20
0
20
40
60
Azimuth (deg)
BANGV
sBOOM
PCBoom

Near Field Starting Signatures

- **Differing assumptions on incorporating wind effects in transition from near field CFD frame of reference to geometrical acoustics frame of reference**
  - Affects initialization of ray trajectories and pressure-time history at the origin of these rays
  - Issue not resolved yet

- **In this comparison, used consistent methodology for extracting starting signatures**
  - Improved agreement between ground predictions

Summary

- **Ray paths generally very consistent between different implementations**
- **Most loudness predictions are tightly spaced across center of the primary carpet**
  - Differences in PL < 1 dB
  - Despite slight differences in waveform length
- **Spread increases at locations further off-track**
  - Differences in PL up to 10 dB
  - Loudness predictions questionable near edges of the lateral carpet
  - Longer ray paths are more affected by atmosphere
- **Good opportunity for identifying potential items for further development**
  - Discussion continues on starting signature issue with new simpler test cases
  - Paper includes discussion of additional parameters, such as ray paths and cut-off ray angles

Acknowledgments

- **Will Doebler (NASA) – atmospheric profiles**