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Sonic Boom Propagation Predictions for AIAA SBPW3 (Orlando, FL, 2020)

Hao Shen
Boeing Research & Technology

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Introduction / Outline

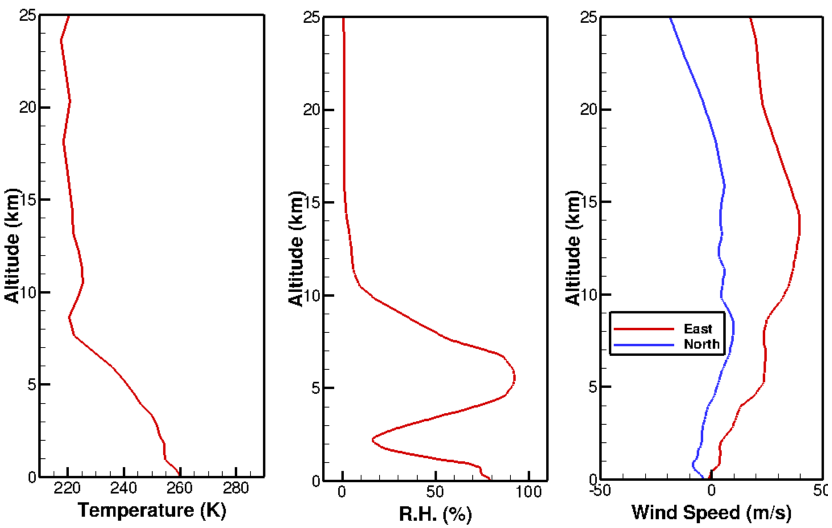
- Case descriptions
- General information for propagation codes
- Case 1 results and comparisons
- Case 2 results and comparisons
- Summary

Cases Analyzed

Case 1: NASA C25P

M = 1.6, Alt = 15760.0 m, Ground elevation = 264.069 m, Heading: East, R/L = 3.

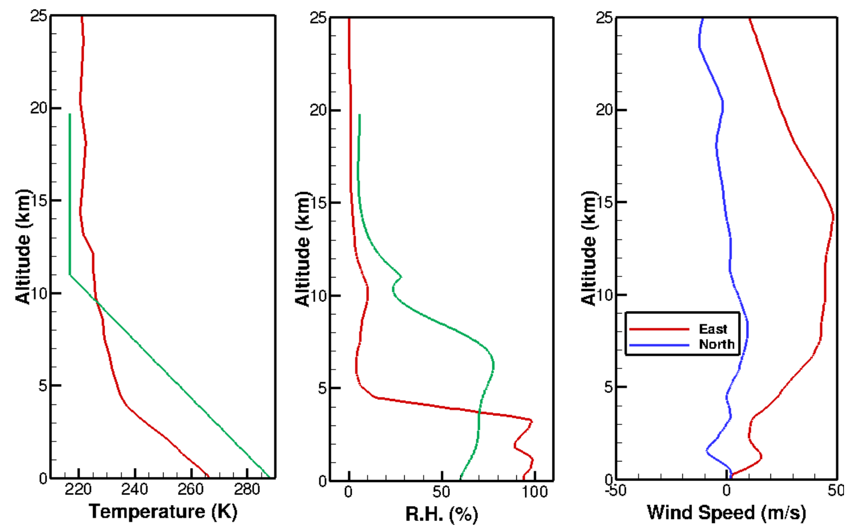
- Measured Atmosphere Profile (with wind)



Case 2: NASA C609

M = 1.4, Alt = 16459.2 m, Ground elevation = 110.011 m, Heading: East, R/L = 3.

- Measured Atmosphere Profile (with wind)
- Standard Day Atmosphere Profile (no wind)



Propagation Prediction Codes

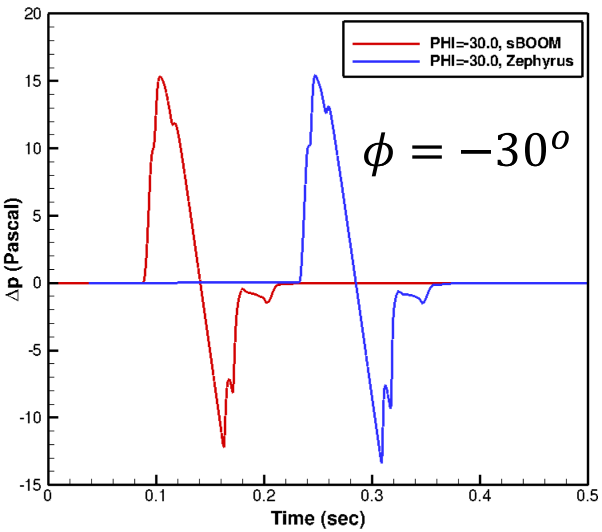
NASA sBOOM code (v2.81)

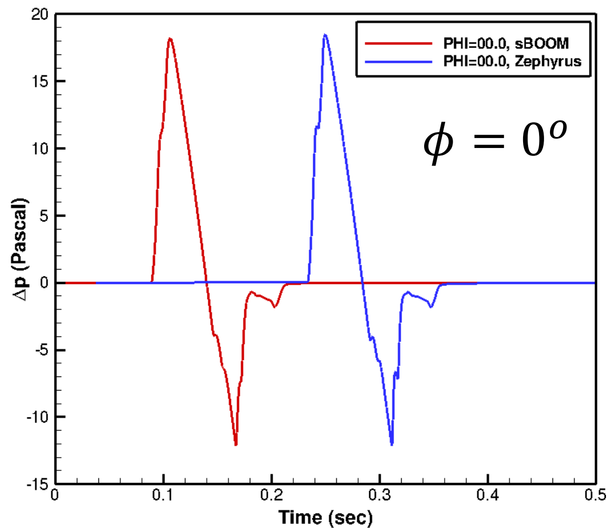
- Ray tube for propagation path
- Nonlinear lossy Burger's equation for signature propagation
- Attenuation with classical dissipation and molecular relaxation
- Noise metrics calculated internally
- Linux and Windows platforms
- Reference:
    - Sriram Rallabhandi, Advanced Sonic Boom Prediction Using the Augmented Burgers Equation, Journal of Aircraft, Vol. 48, No. 4, July-August 2011.

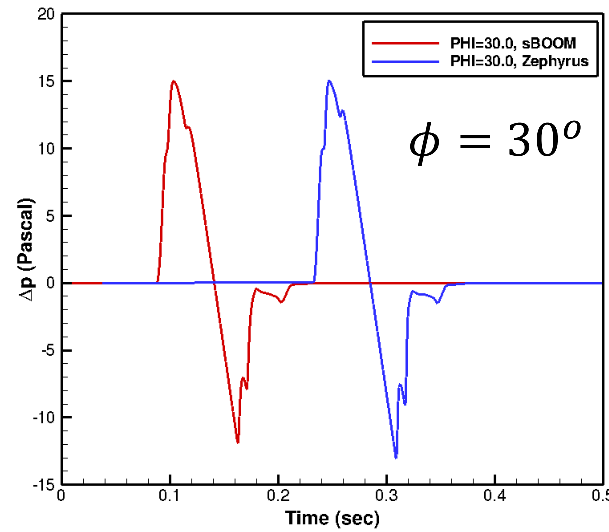
Boeing Zephyrus code (2001)

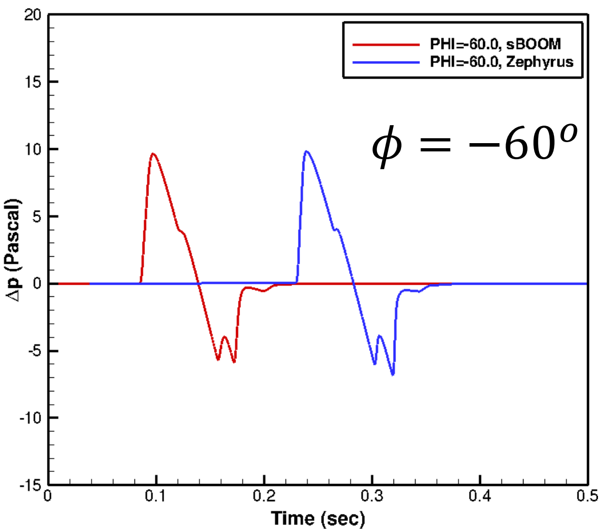
- Ray tube for propagation path
- Nonlinear lossy Burger's equation for signature propagation
- Attenuation with classical dissipation and molecular relaxation
- Noise metrics calculated externally (NASA LCASB)
- Windows platform
- Reference:
    - Leick Robinson (1992), A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere. The Journal of the Acoustical Society of America. doi: 10.1121/1.403061.

Case 1 Prediction – Ground Signatures



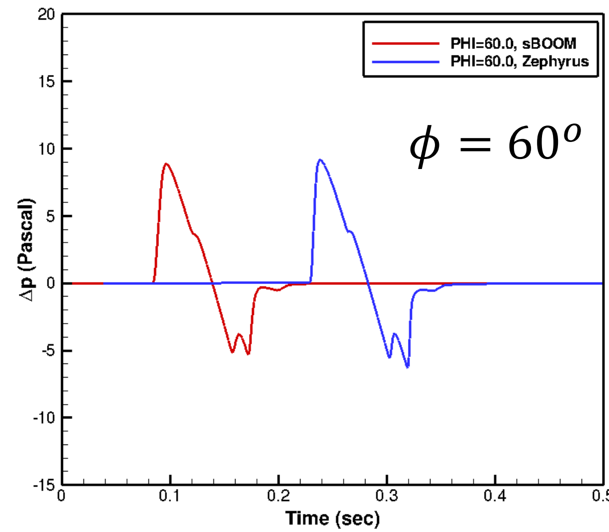




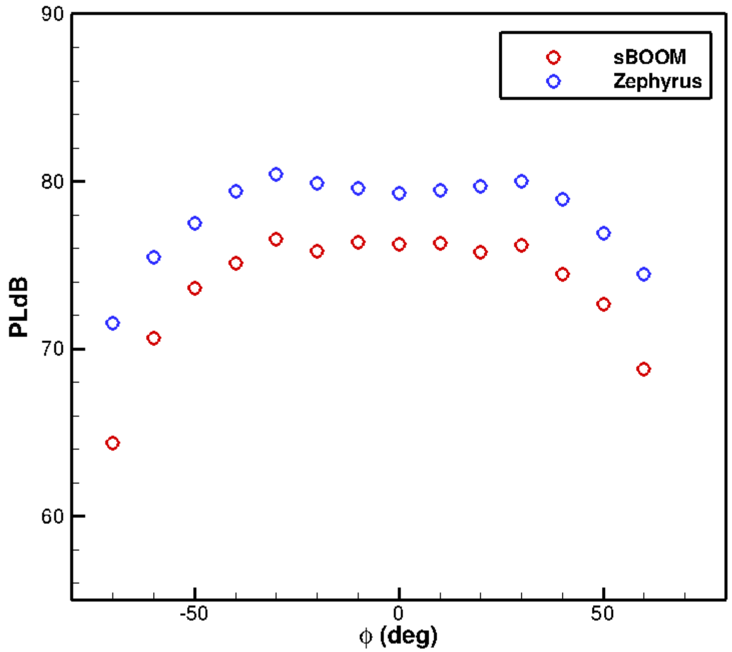


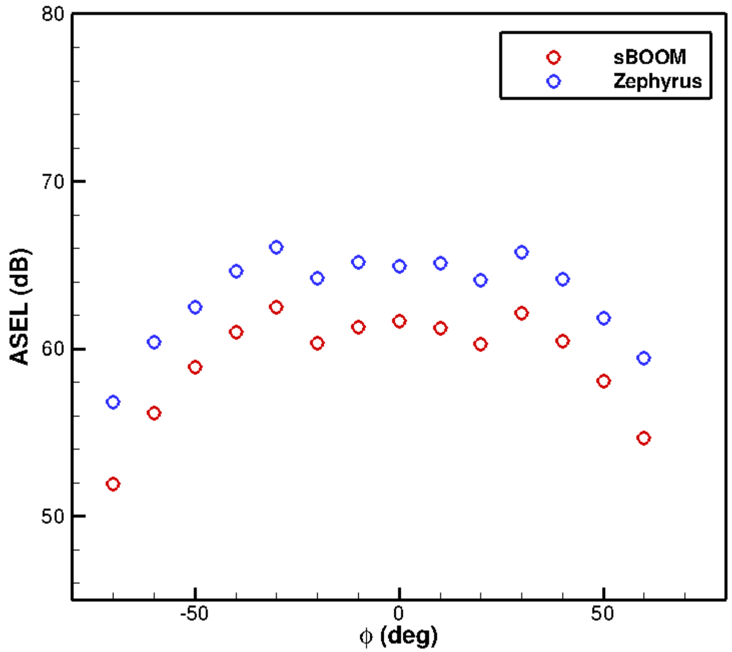
Ground signatures predicted by sBOOM and Zephyrus are in close agreement in terms of amplitude, overall rise time and shape.

Differences exist in small details



Case 1 Prediction – Loudness Metrics

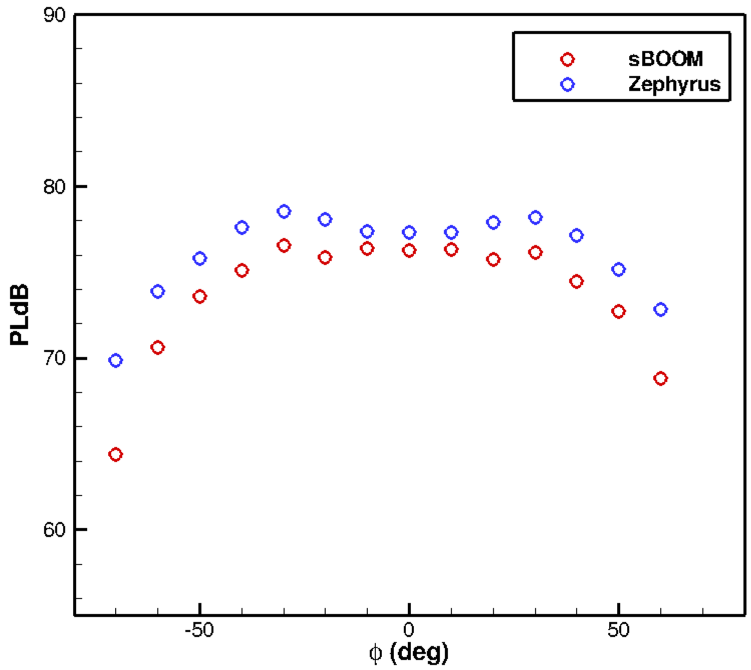


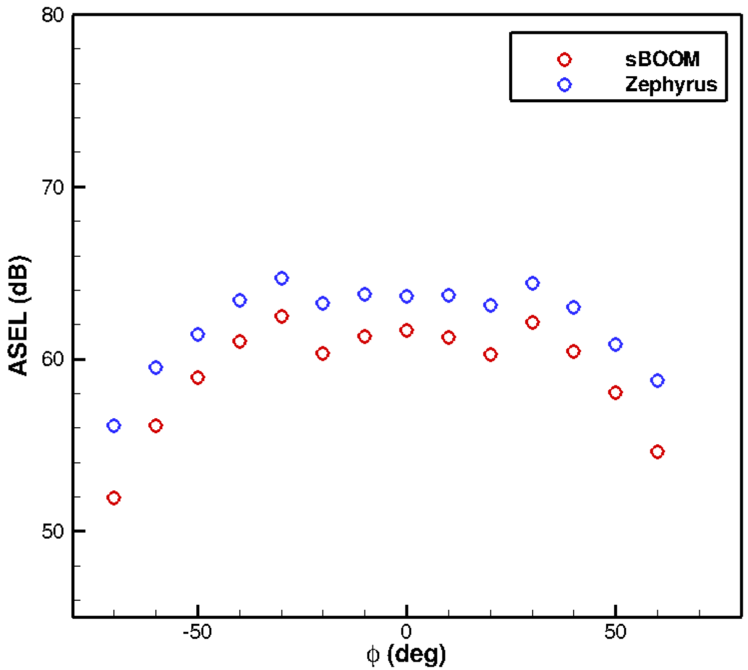


- Difference in loudness predictions: 3-4 PLdB
- Relatively large compared to previous experiences
- Caused by non-uniform and under sampled Zephyrus output

Case 1 Prediction – Loudness Metrics

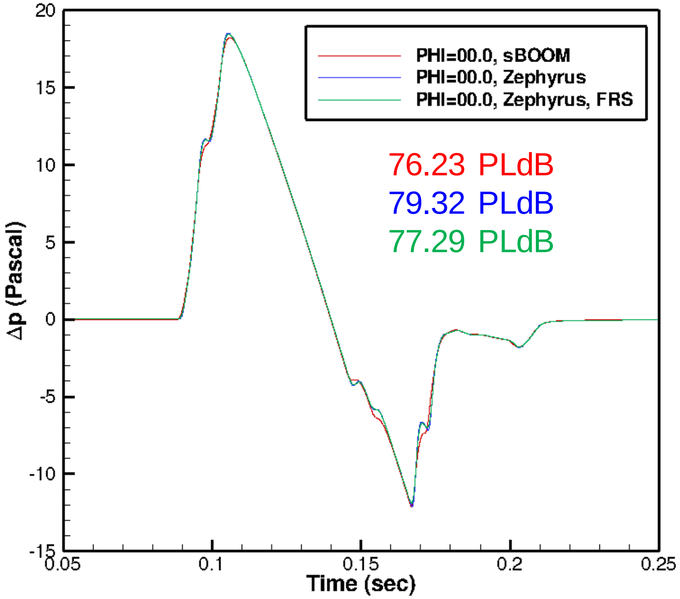
Using filtered resampling for Zephyrus results

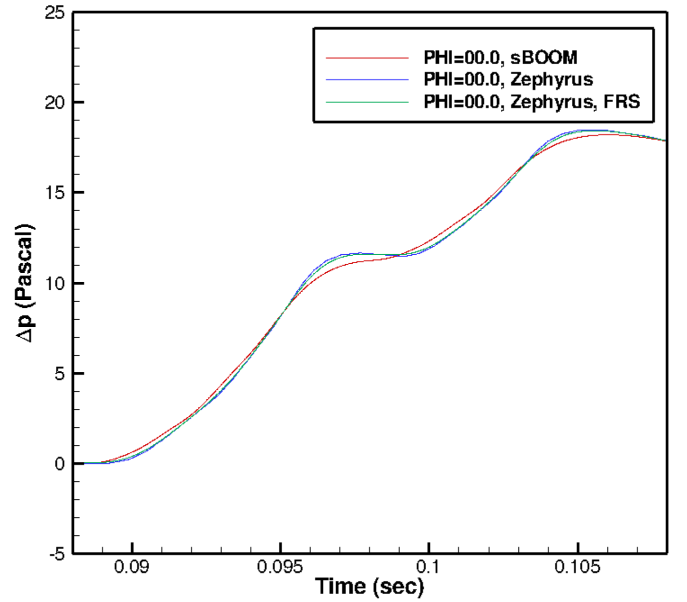


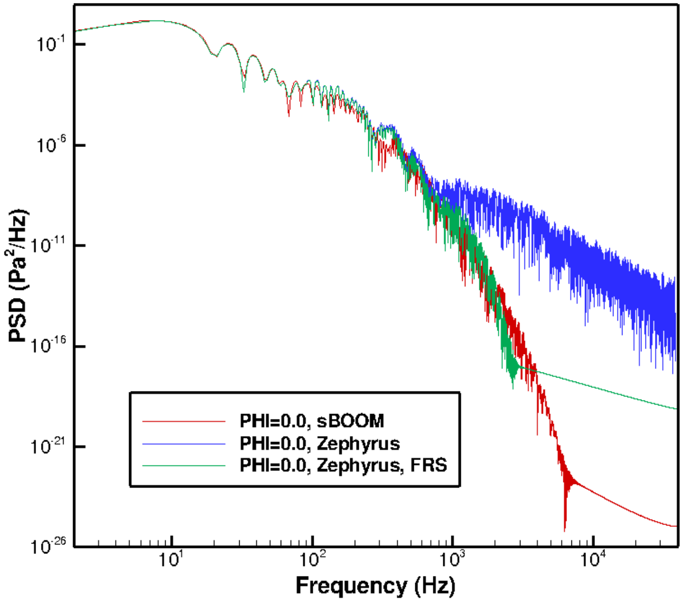


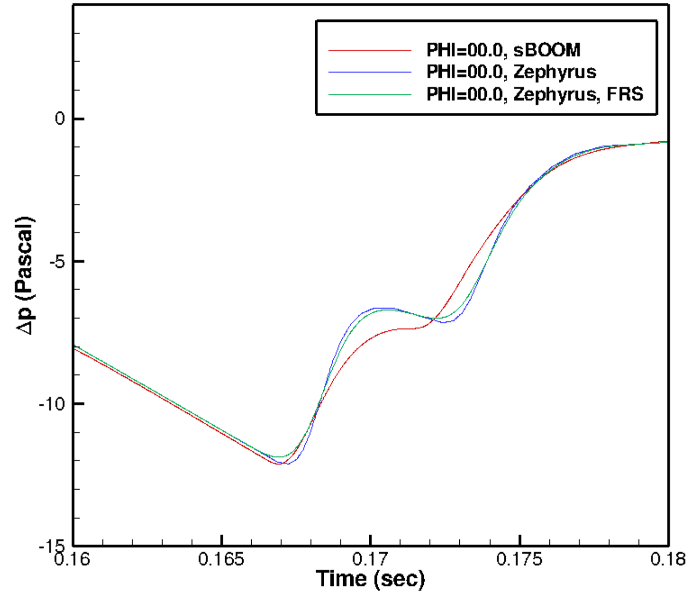
- Filtered resampling reduced the difference to: 1-2 PLdB

Case 1 Prediction – PLdB Differences

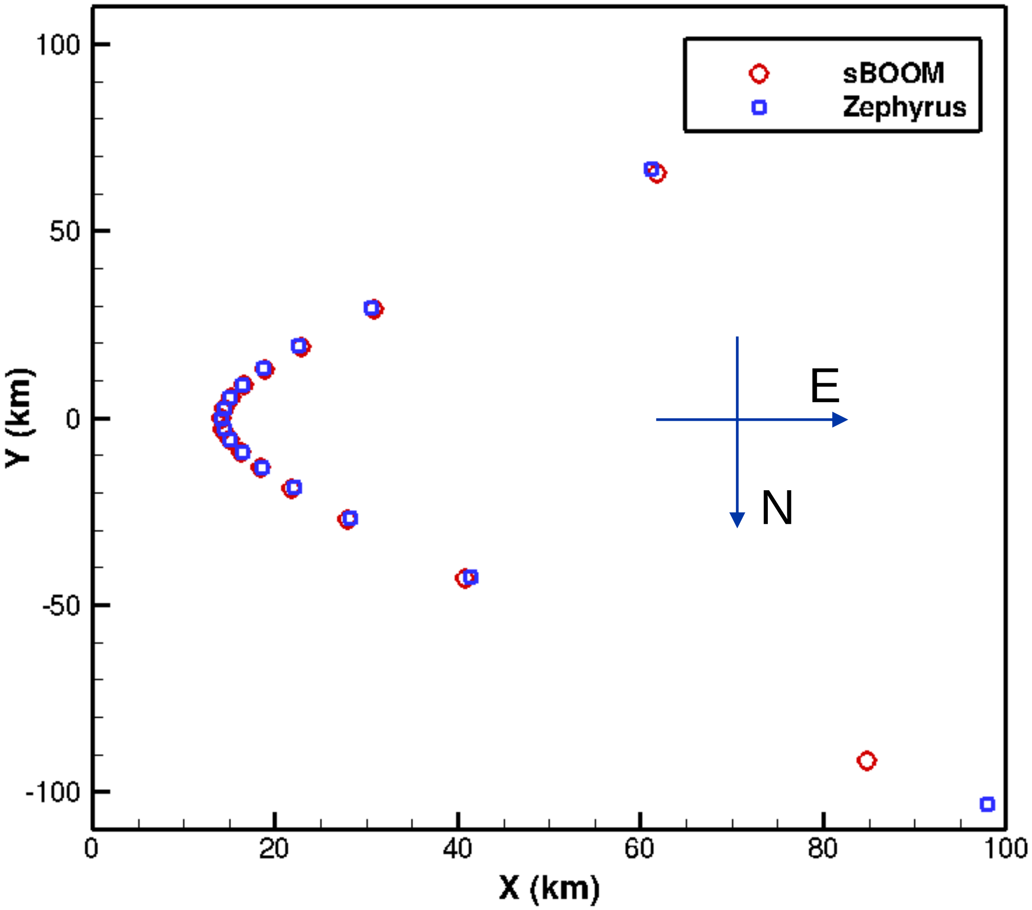








Case 1 Prediction – Ground Interception



Lateral Cutoff:

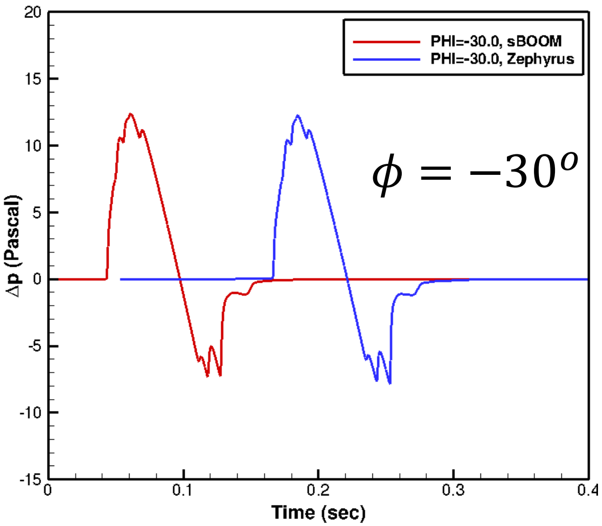
sBOOM:

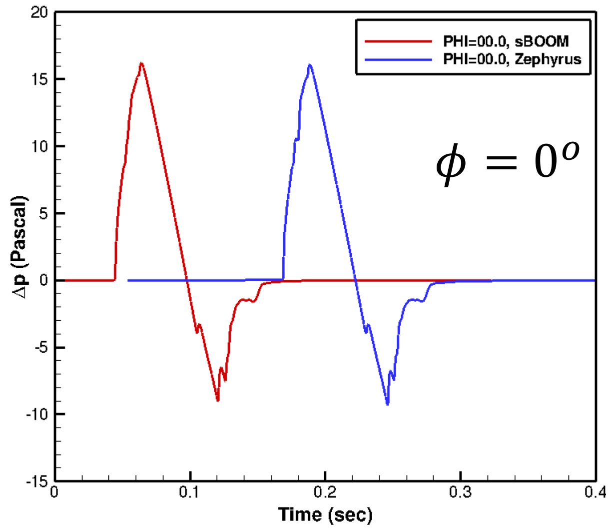
- $\phi = -78.40$, x=84720m, y=-91460m
- $\phi = \ \ 69.11$, x=61690m, y=65525m

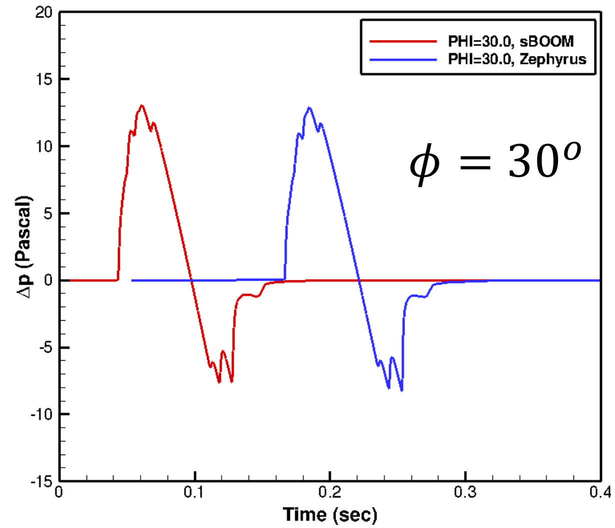
Zephyrus:

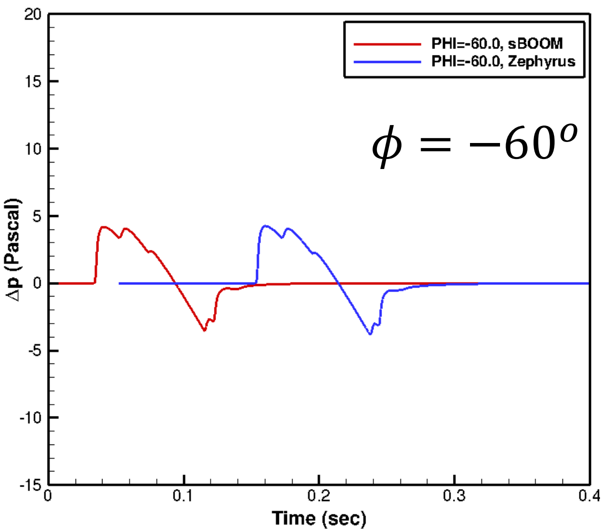
- $\phi = -78.50$, x=97864m, y=-103109m
- $\phi = \ \ 68.80$, x=61169m, y=66505m

Case 2 Meas. Atm. Prediction – Ground Signatures



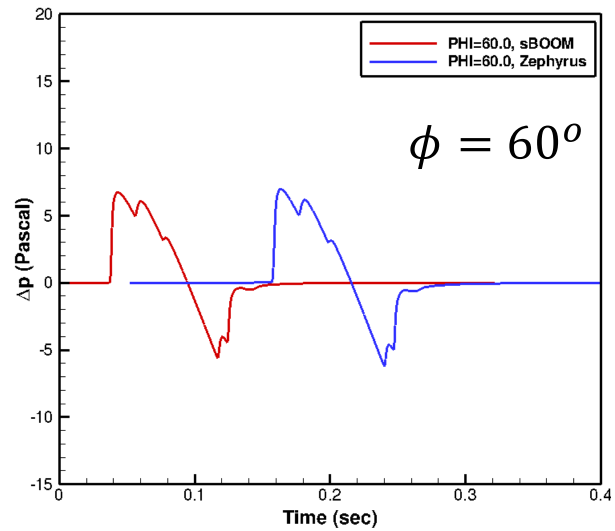




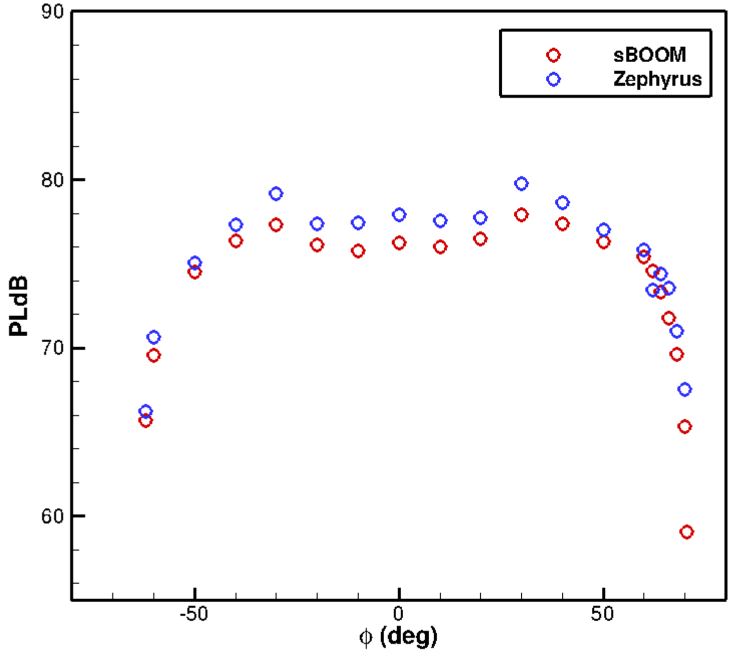


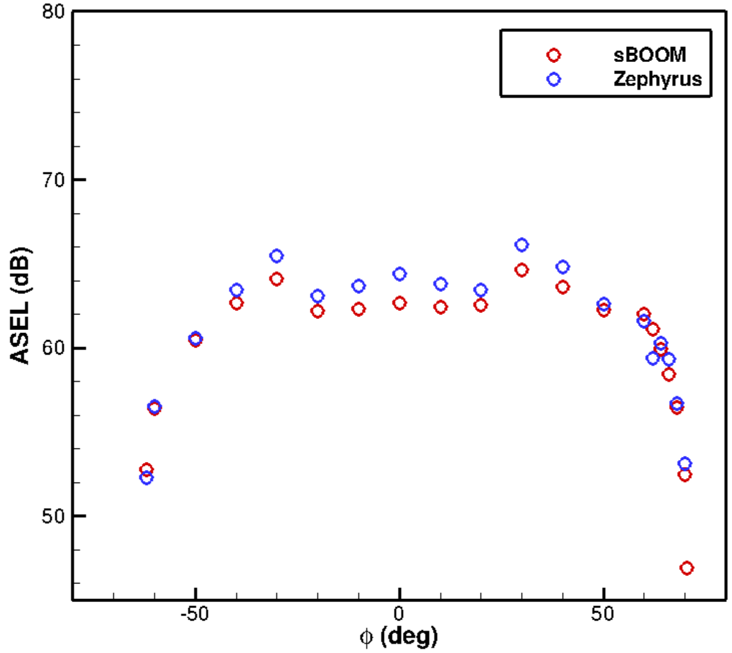
Ground signatures predicted by sBOOM and Zephyrus are in close agreement in terms of amplitude, overall rise time and shape.

Differences exist in small details



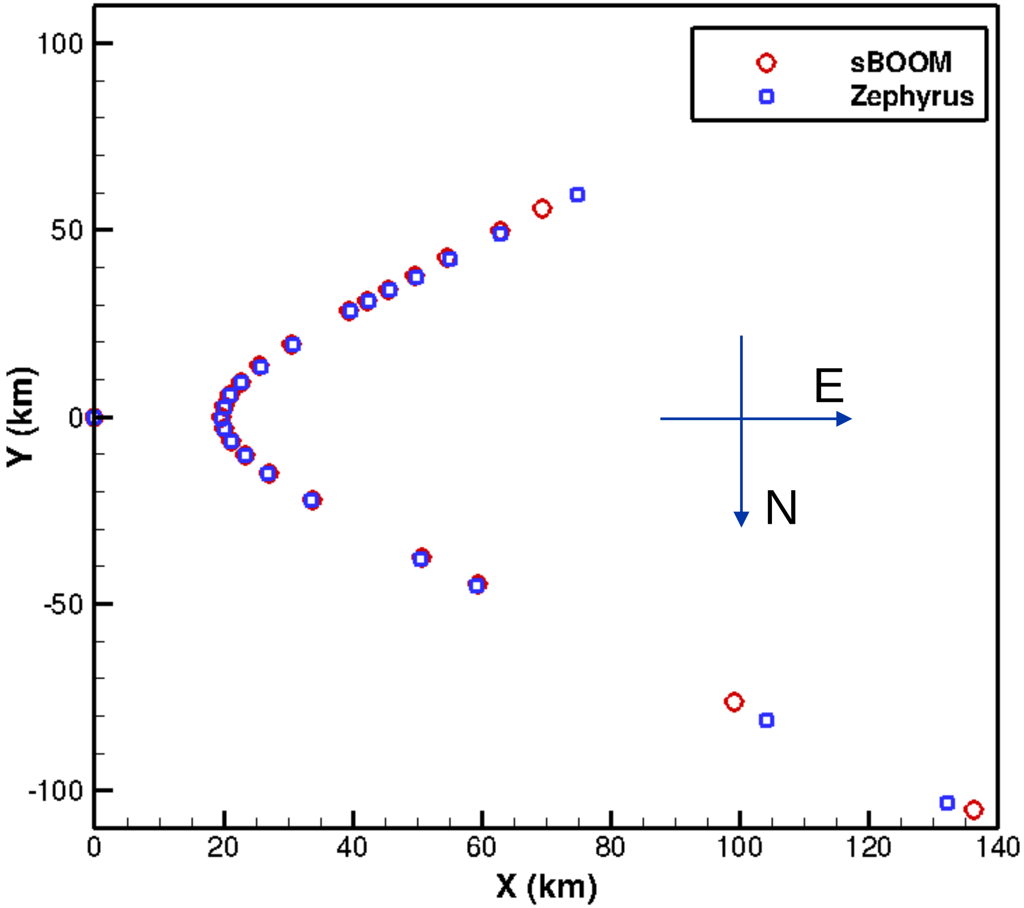
Case 2 Meas. Atm. Prediction – Loudness Metrics





- Difference in loudness predictions: ~1 PLdB

Case 2 Meas. Atm. Prediction – Ground Interception

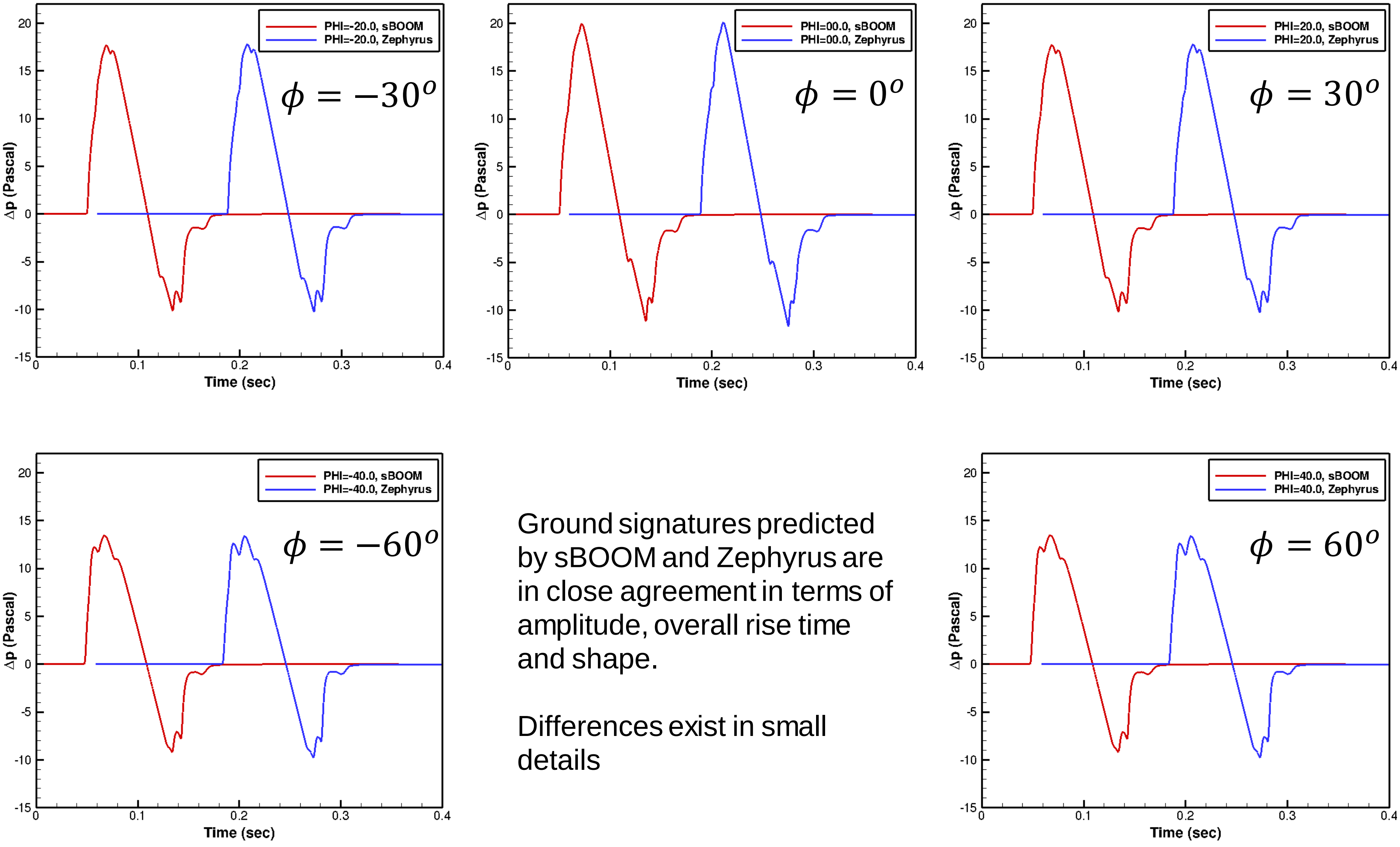


Lateral Cutoff:

sBOOM:
- $\phi = -64.07$, x=136164m, y=-105074m
- $\phi = 70.49$, x=69420m, y=55631m

Zephyrus:
- $\phi = -64.06$, x=132007m, y=-103100m
- $\phi = 70.70$, x=74709m, y=59557m

Case 2 STD. Atm. Prediction – Ground Signatures



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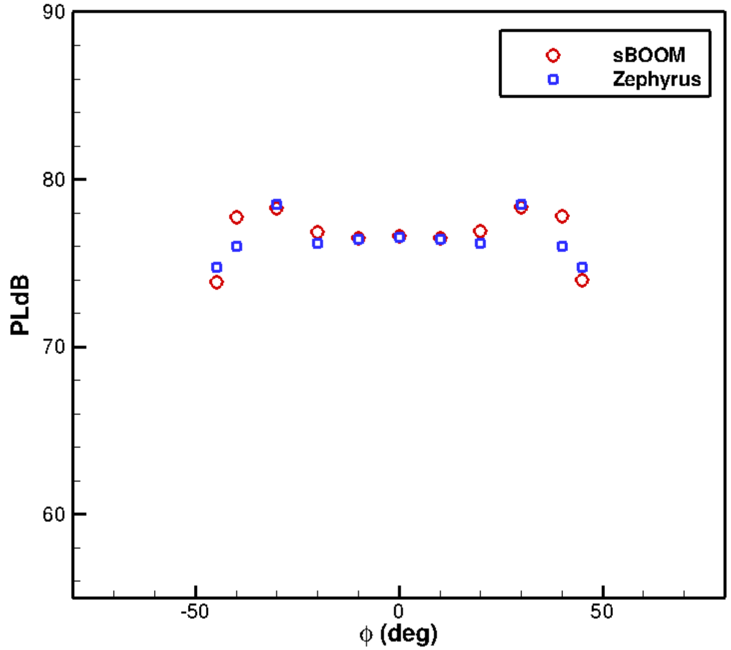
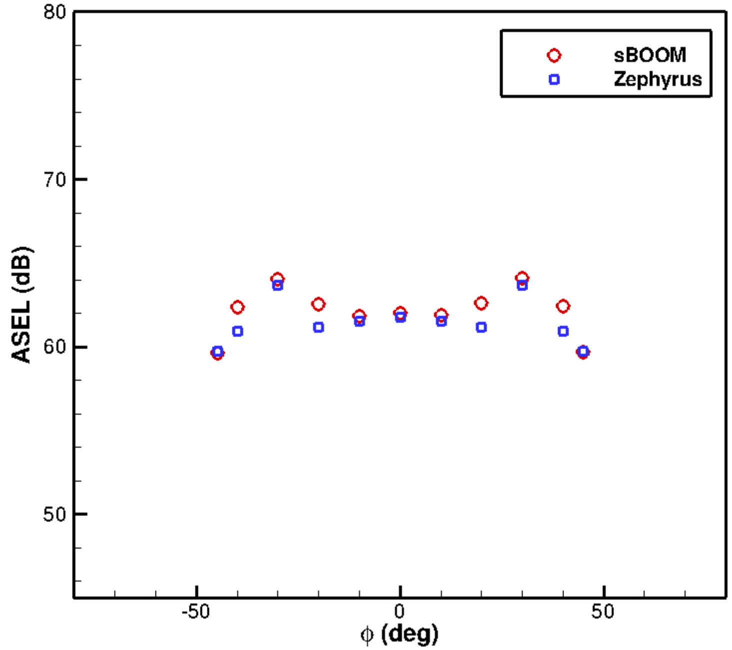
Differences exist in small details

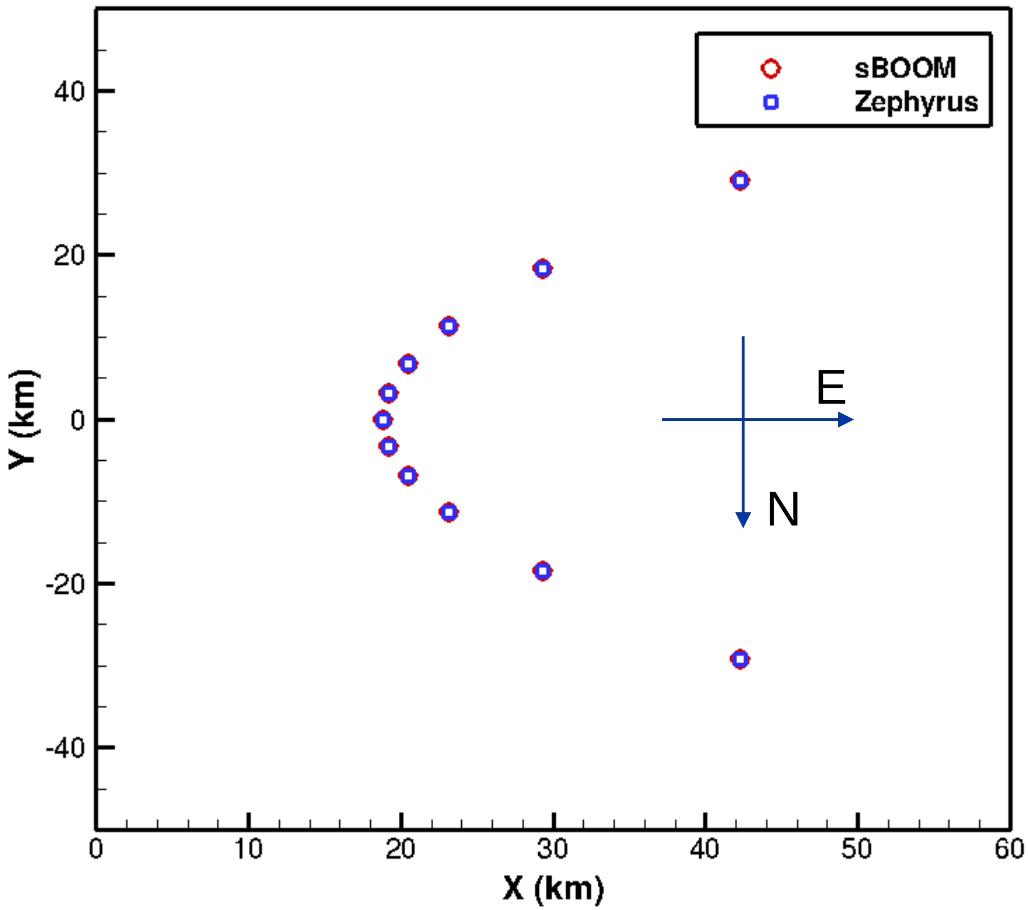
Case 2 STD. Atm. Prediction – Loudness Metrics





- Difference in loudness predictions: ~1 PLdB

Case 2 STD. Atm. Prediction – Ground Interception



Lateral Cutoff:

sBOOM:

- $\phi = -44.85$, x=42242m, y=-29189m
- $\phi = \ \ 44.85$, x=42242m, y=29189m

Zephyrus:

- $\phi = -44.84$, x=42213m, y=-29165m
- $\phi = \ \ 44.84$, x=42213m, y=29165m

Summary

- Cases 1 and 2 are analyzed using NASA sBOOM and Boeing Zephyrus codes.
- Overall ground signature amplitude, rise time and shape predicted by sBOOM and Zephyrus are very close to each other for both cases.
- Acoustical ray path ground interception and boom carpet edge predicted by sBOOM and Zephyrus are very close to each other for the two cases.
- For Case 1, loudness levels for sBOOM predictions and Zephyrus predictions with linear resampling are different between 3 to 4 PLdB. With filtered resampling on Zephyrus predictions the difference drops to 1 to 2 PLdB.
- For Case 2, loudness levels predicted from sBOOM and Zephyrus ground signatures are very close to each other.
- Modifications in Zephyrus output options and numerical control is needed for more reliable comparisons.

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