Project 40
Quantifying Uncertainties in Predicting Aircraft Noise in Real-world Situations

Motivation and Objectives

- Improving the understanding of uncertainties for predicting aircraft noise in the current FAA modeling tools.
- Need to account for uncertainties in modeling of the aircraft noise (source), meteorological conditions (propagation path) and ground impedance, terrain profile (receiver).

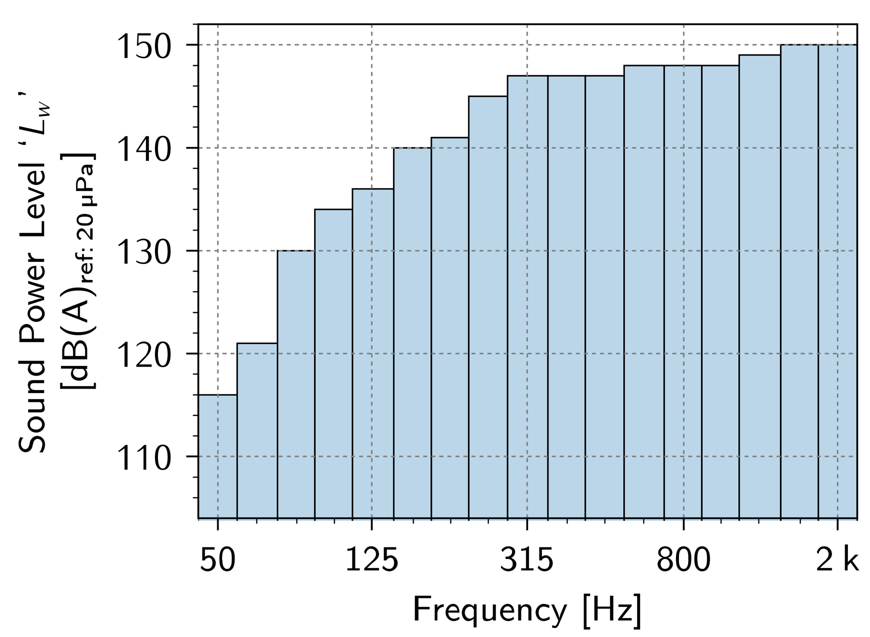
Approach

- Extending the approach shown by Wilson et al. (JASA, 2014)[1] to aircraft noise propagation.
- Using method of expected values and stochastic sampling technique along with a wide-angle CNPE method[3,4] to analyze the effect of uncertainties in the meteorological conditions on aircraft noise received near the ground.

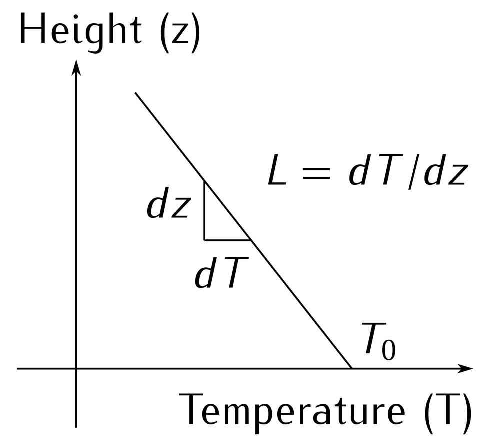
Input parameters

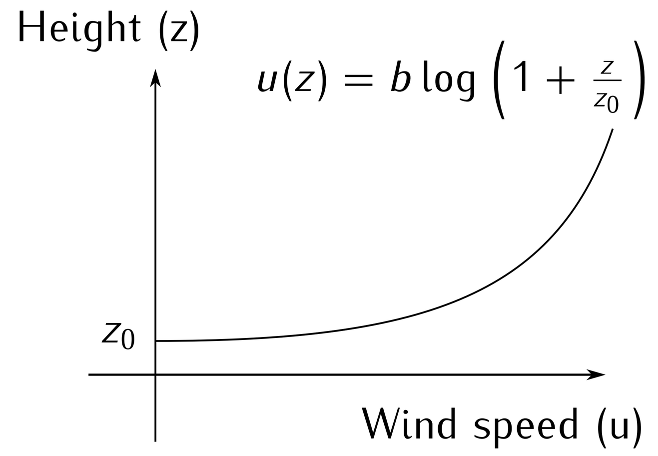
- Soft ground
- Aircraft altitudes: 1.0 km, 1.5 km, 2.0 km (typical for terminal area)
- Receiver height: 1.2 m

Aircraft: Boeing 777-300, max. thrust, departure setting[2]



Meteorological conditions and uncertainty

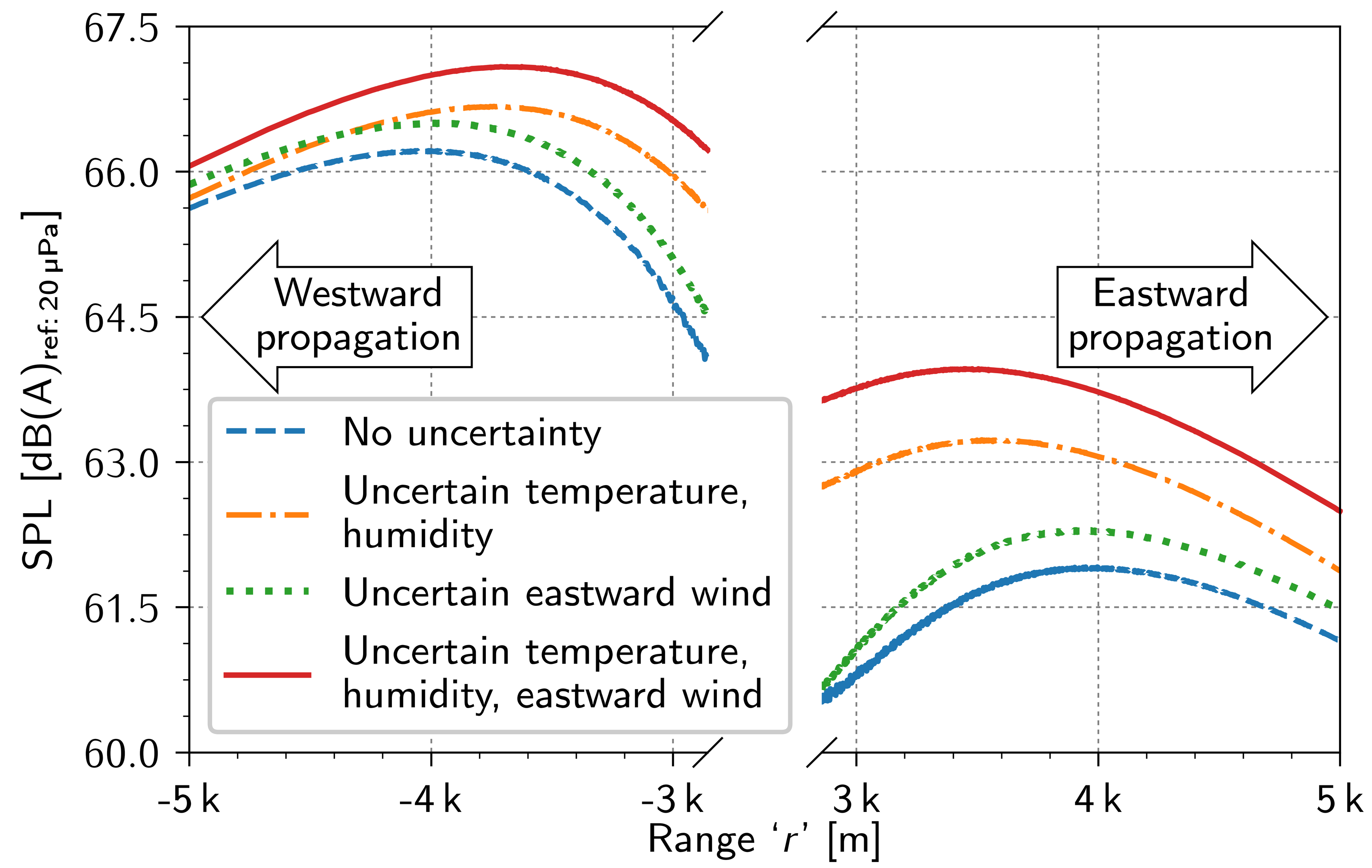




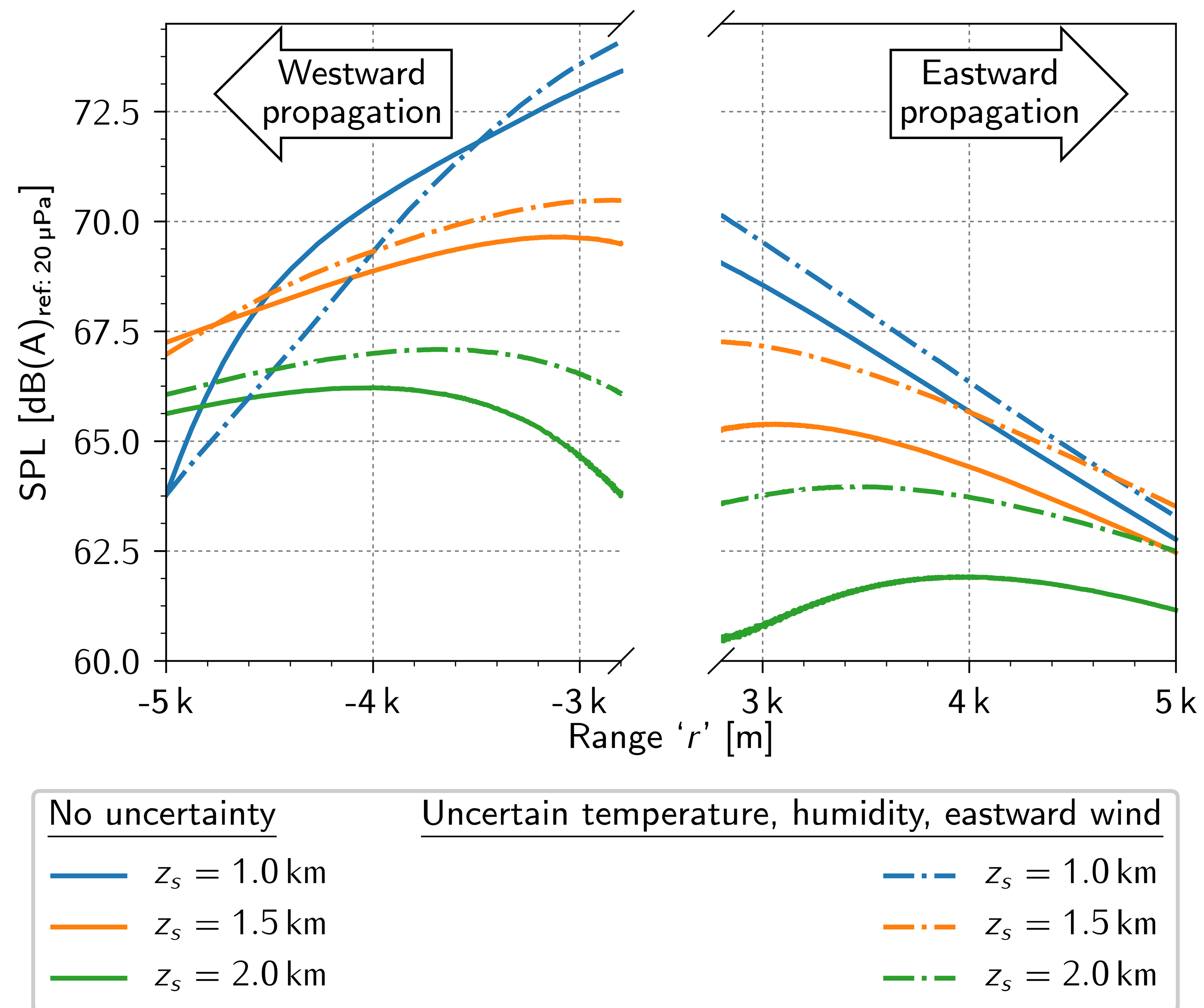
Parameter	Mean (μ)	Std. deviation (σ)
Temperature at the ground 'T_0' [°C]	-3	3.7
Lapse rate 'L' [°C/km]	-4	1.5
Parameter 'b' in the wind profile [m/s]	1.1	0.6
Relative humidity 'r_h' [%]	85	4.5

Results[5]

Results for aircraft altitude 2 km



Comparing cases of increasing aircraft altitude



Discussion

- The overall approach shown by Wilson et al. (2014)[1] seems to be adaptable to aircraft noise propagation.
- Variation of meteorological parameters around their mean values does have a net effect on the expected SPLs.
- Uncertainty in temperature profile seems to have a stronger influence on the received SPLs as compared to the effect of uncertainty in the wind profile.
- Effect of meteorological uncertainties increases as the aircraft altitude increases (more vertical propagation).
- Effect of meteorological uncertainties decreases with increasing horizontal distance of propagation (atmospheric absorption dominates).

Next Steps

- Using ray tracing and integrated calculation methods for faster computations and to overcome the angle limitation of PE methods.
- Analyzing the effect of uncertainties on sound exposure levels.
- Using probability density functions based on real world weather data instead of assuming a symmetric distribution (Gaussian) of uncertainties.
- Using advanced stochastic sampling techniques such as importance sampling, adaptive importance sampling (to reduce computation time).

References

1. Wilson, D. Keith, et al. "Description and quantification of uncertainty in outdoor sound propagation calculations." The Journal of the Acoustical Society of America 136 (3) 1013-1028 (2014).
2. K. Poulain, "Numerical propagation of aircraft en route noise," Master's thesis, The Pennsylvania State.
3. M. West, K. Gilbert, and R. Sack, "A tutorial on the parabolic equation (PE) model used for long range sound.
4. Salomons, Erik M. "Computational atmospheric acoustics." Springer Science & Business Media, 2012.
5. Patankar, H. P., and Sparrow, V. W. "Quantifying the effect of uncertainty in meteorological conditions on aircraft noise propagation." 47th International Congress and Exposition on Noise Control Engineering, INTER-NOISE 2018.

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