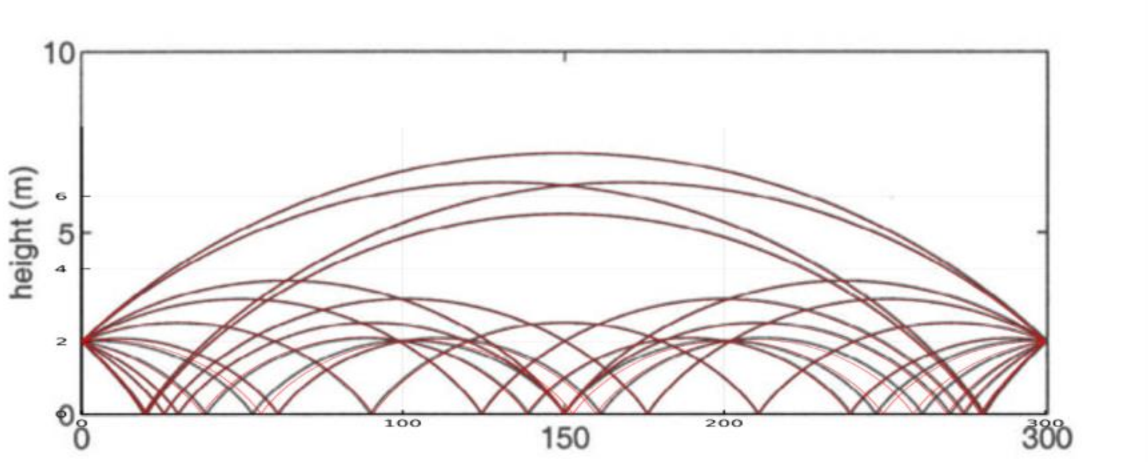
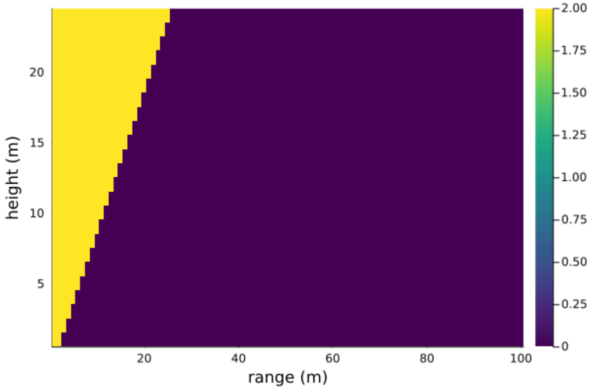


Beregning av veitrafikkstøy

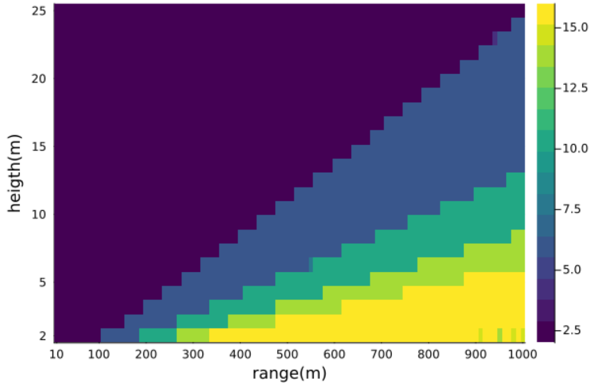
Parametrisk studie av antall lydbaner til mottakeren

Guillaume Dutilleux, Louise Berthier

NTNU/IE/IES/Akustikk

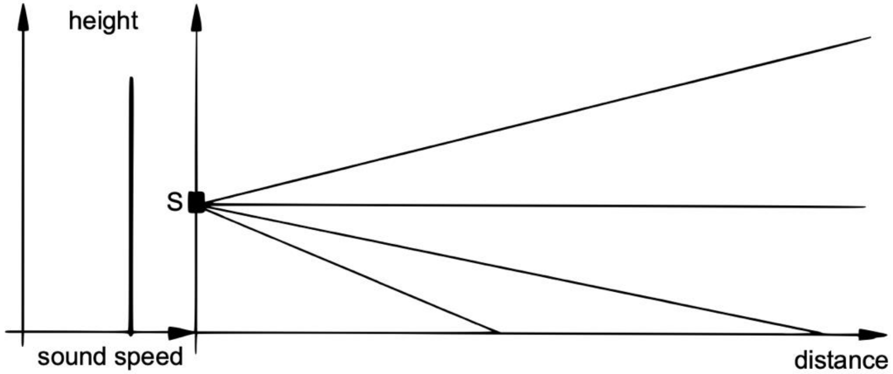


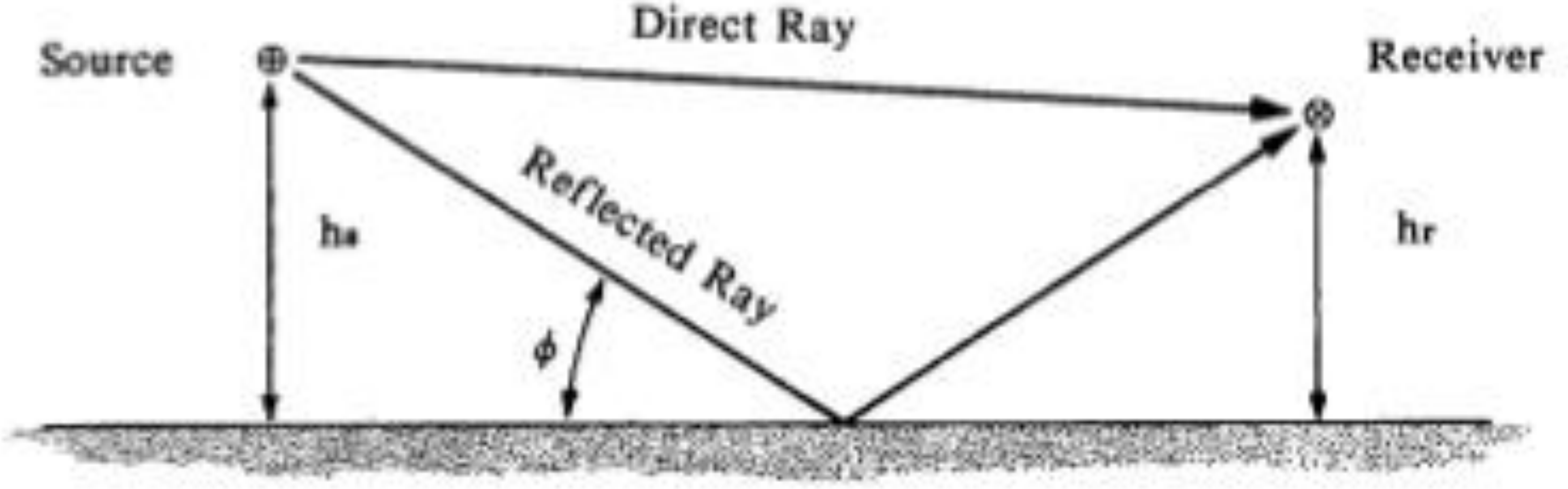
Kunnskap for en bedre verden



Er det nok med 2 lydbaner?

[Sétra, 2011]

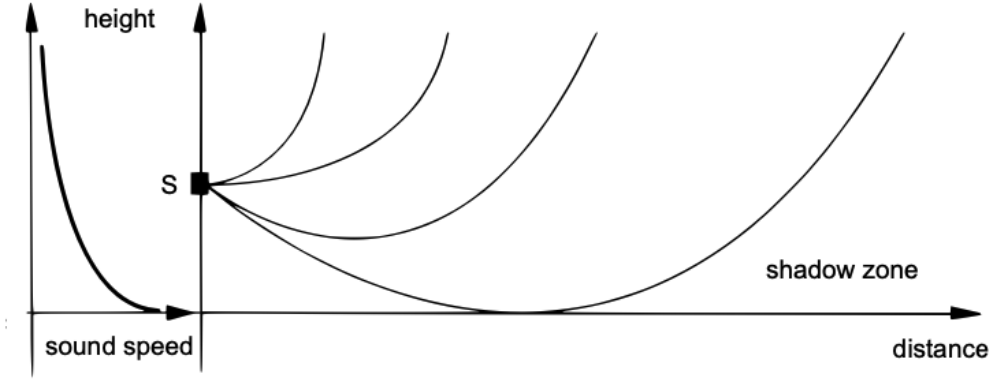


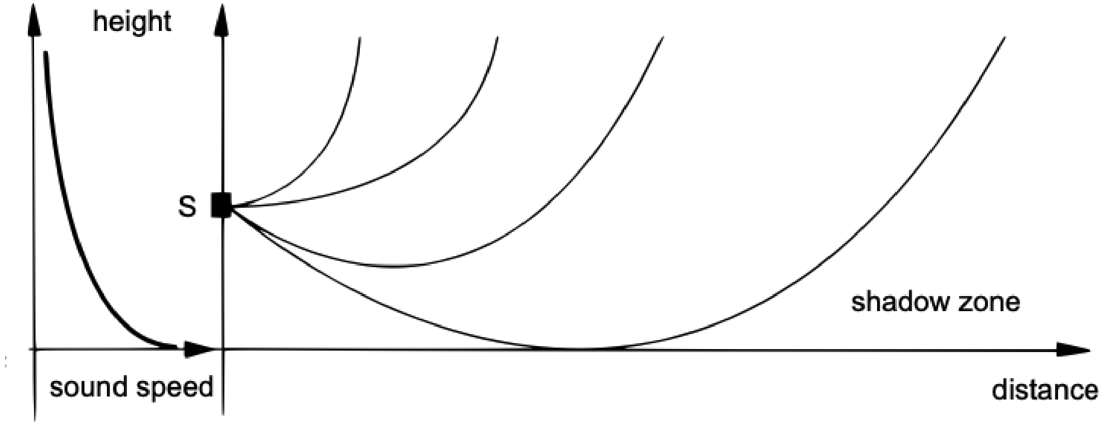


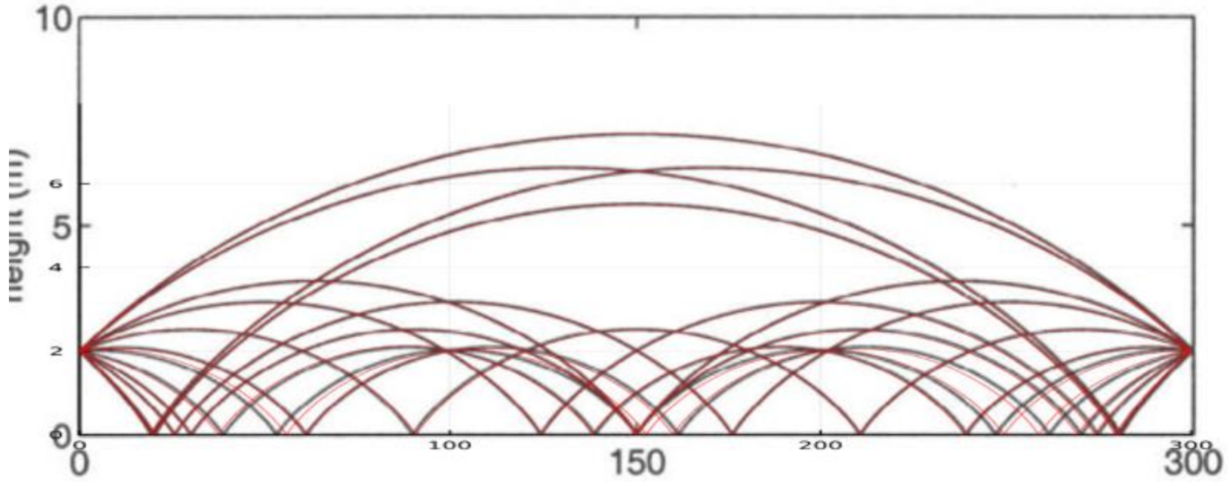
[Lamancusa]

Hva med gunstige værforhold?

[Sétra, 2011]

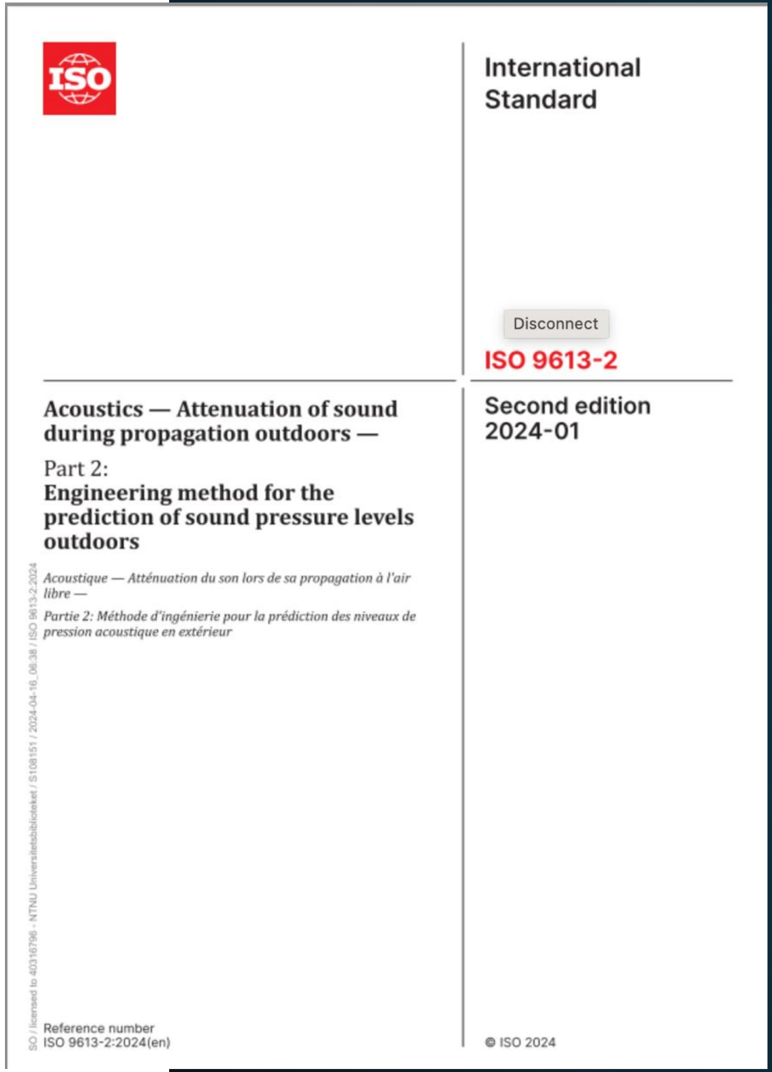






Hva dagens beregningsmetoder gjør

- ISO 9613-2:1996 : uklart for bakkedemping er basert på målinger
- Nord 96: se ISO 9613-2
- Nord 2000: korreksjon for flere refleksjoner
- Harmonoise : 1 bakkerefleksjon
- 2015/996/EC retningslinje :
    - Basert på NMPB 2008 / NF S 31-133:2011
    - semi-empirisk bakkedemping som »tar høyde for flere refleksjoner på bakken » [Dutilleux et al. 2010].


International Standard

Disconnect

ISO 9613-2

Acoustics — Attenuation of sound during propagation outdoors —

Part 2:
Engineering method for the prediction of sound pressure levels outdoors

Acoustique — Atténuation du son lors de sa propagation à l'air libre —

Partie 2: Méthode d'ingénierie pour la prédiction des niveaux de pression acoustique en extérieur

Second edition
2024-01

Reference number
ISO 9613-2:2024(en)

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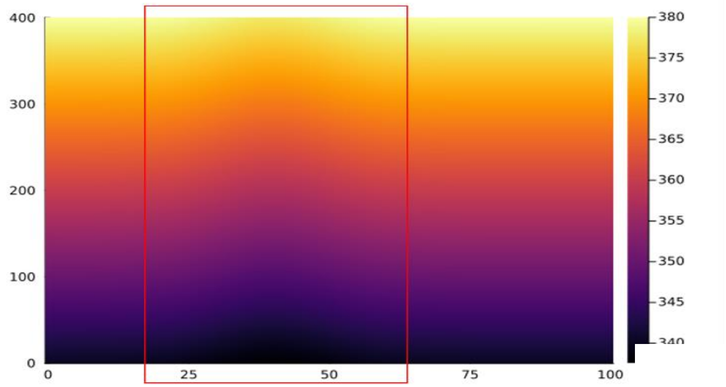
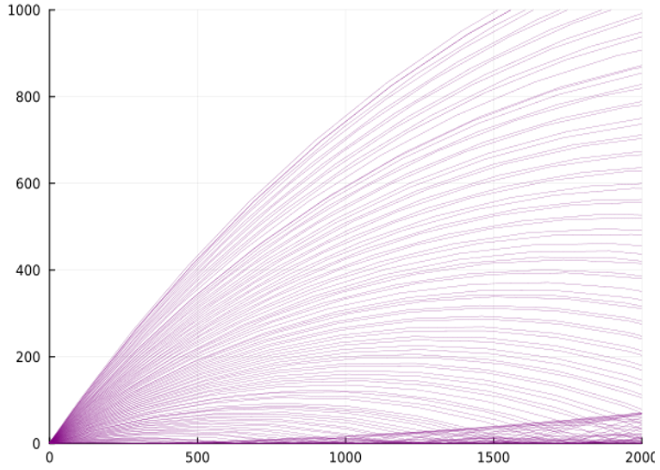
Problemstilling

- Undersøke hvordan antall lydbaner varierer mellom en kilde og en mottaker ved bruk av strålesporing som tar høyde for lydhastighetsprofil
- Antagelser
  - Trafikkstøy
  - Punktkilde
  - Flat bakke
  - Standardiserte WiSi værforhold (ISO 1996-2:2017)
- Parametre som tas i betraktning
  - Avstand fra kilden
  - Høyde over bakken

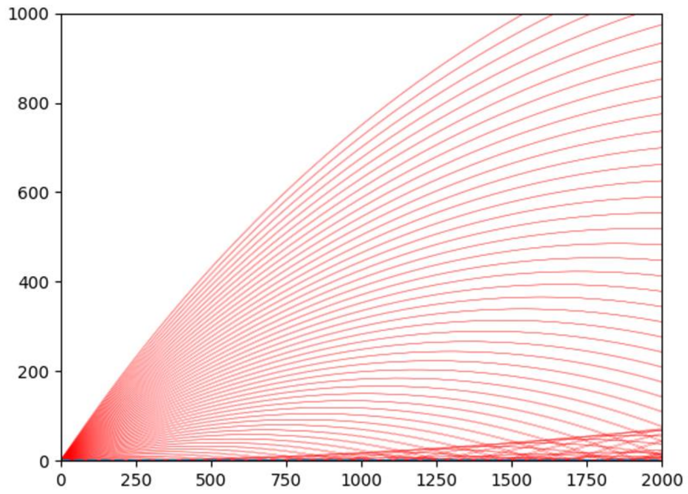
Analytisk strålesporing i Julia

Range-dependent sound speed



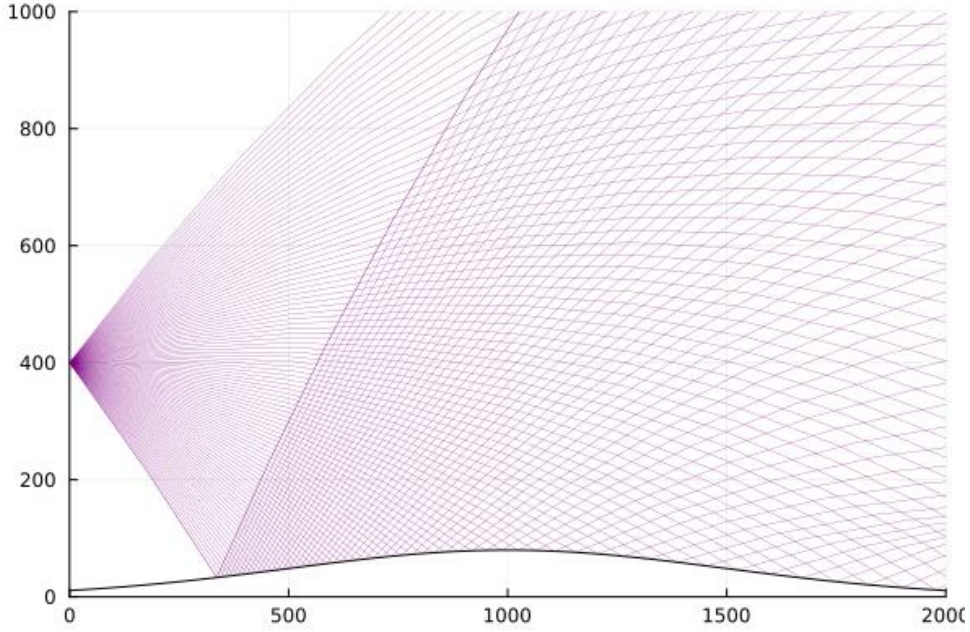


Range-dependent



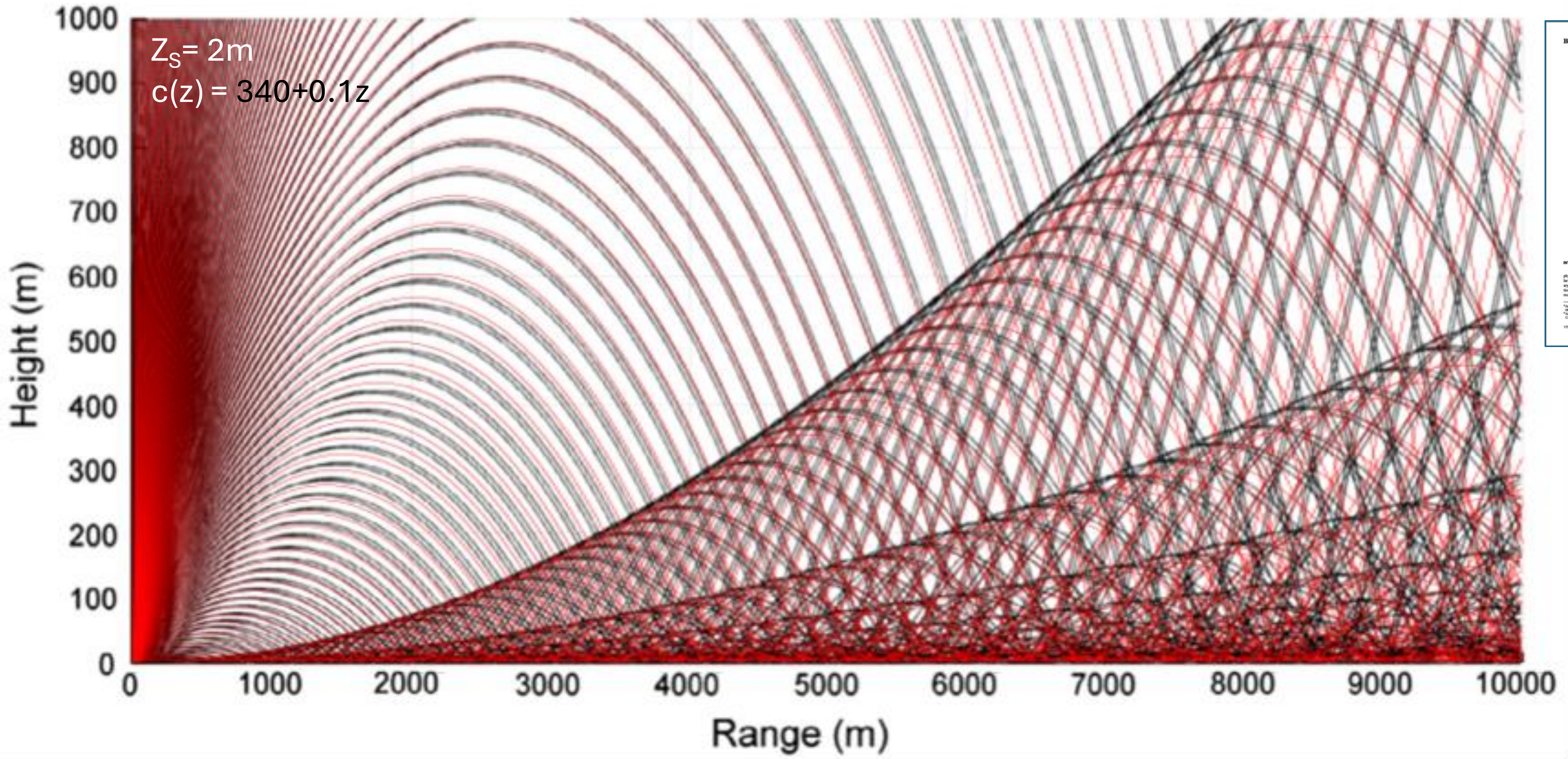
Range-independent

Non-flat ground



[Berthier, 2023]

Sammenlikning med (Attenborough, 1995)



Benchmark cases for outdoor sound propagation models

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The computational tools available for prediction of sound propagation through the atmosphere have increased dramatically during the past decade. The numerical techniques include analytical solutions for selected index of refraction profiles, ray trace techniques which include interaction with a complex impedance boundary, a Gaussian beam ray trace algorithm, and more sophisticated approximate solutions to the full wave equation; the fast field program (FFP) and the parabolic equation (PE) solutions. This large array of computational approaches raises questions concerning under what conditions the various approaches are reliable and concerns about possible errors in specific implementations. This paper presents comparisons of predictions from the several models assuming a complex impedance ground and four atmospheric conditions. For the cases studied, it was found that the FFP and PE algorithms agree to within numerical accuracy over the full range of conditions and agree with the analytical solutions where available. Comparisons to ray solutions define regimes where ray approaches can be used. There is no attempt to compare calculated transmission losses to measurements.

PACS numbers: 43.28.Fp, 43.20.Bi

INTRODUCTION

Propagation of sound outdoors involves a number of physical phenomena including geometric spreading, molecular absorption, reflection from a complex impedance boundary, refraction, diffraction, and scattering.[1] Accurate predictions of sound transmission loss (TL) from a source to a receiver must somehow account for all of these phenomena simultaneously. Although this goal is beyond current capabilities, a great deal of progress has been made in the past decade. Specifically, numerical techniques originally developed for applications in underwater acoustics have been modified for atmospheric predictions and new analytical results provide solutions for more realistic conditions. Some progress has been made toward including turbulence and terrain in the propagation models, but research on these aspects is still in progress.

Ray tracing has been a standard approach extensively used to predict outdoor sound levels in the presence of speed of sound gradients even though the mathematical conditions

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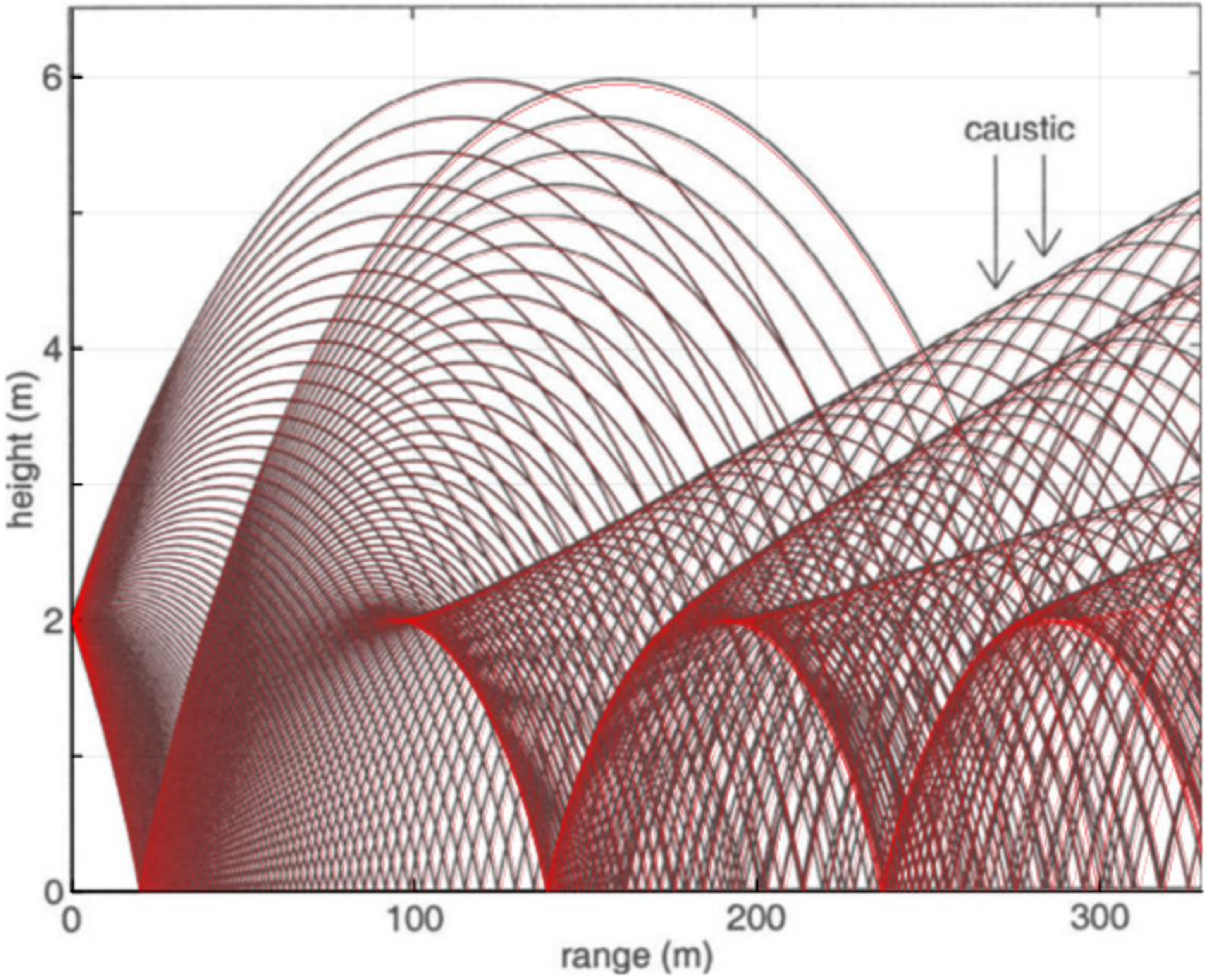
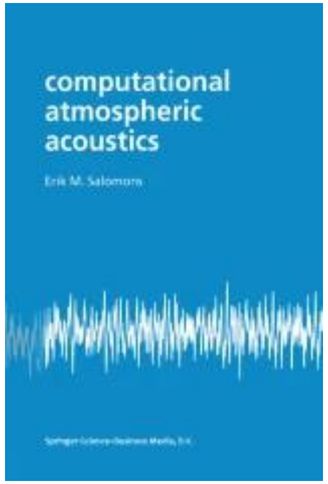
[b]Also with Université de Sherbrooke, Sherbrooke, Quebec J1K 2R1, Canada.

4’7’’

Sammenlikning med (Salomons, 2001)

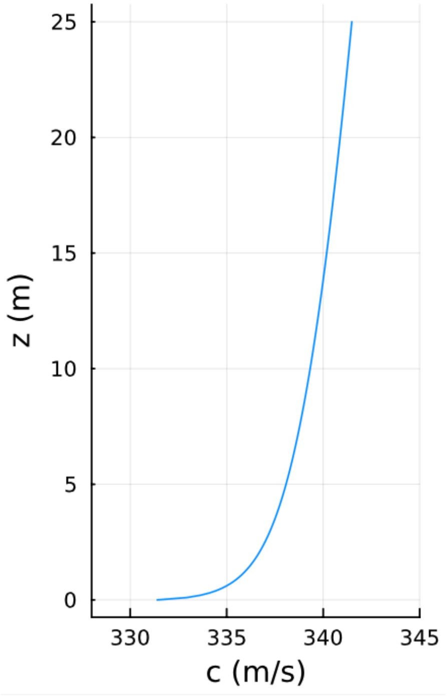


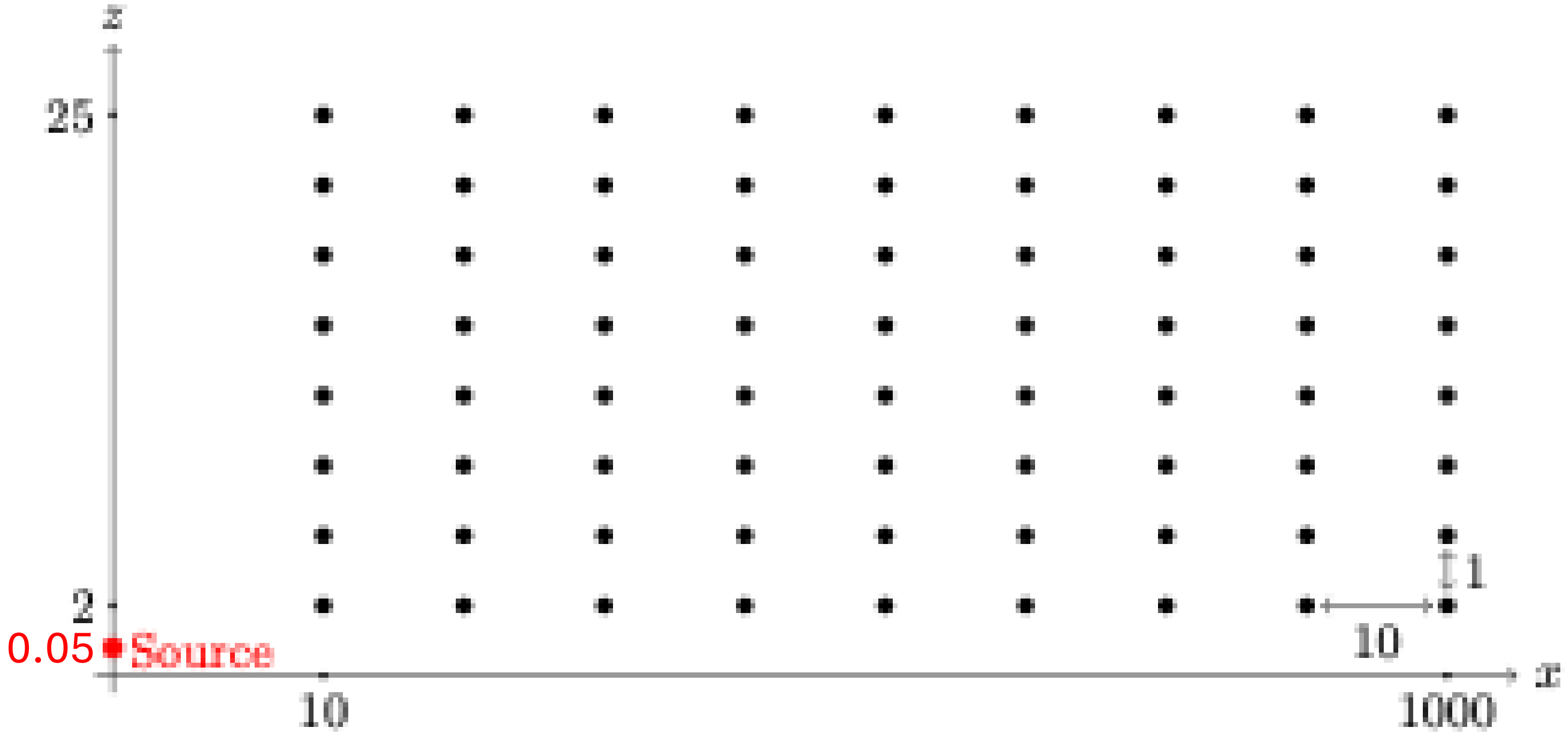


z_S = 2 m

$c(z) = 340 + \ln(1+z/0.1)$

Parametrisk studie





Standardiserte værforhold

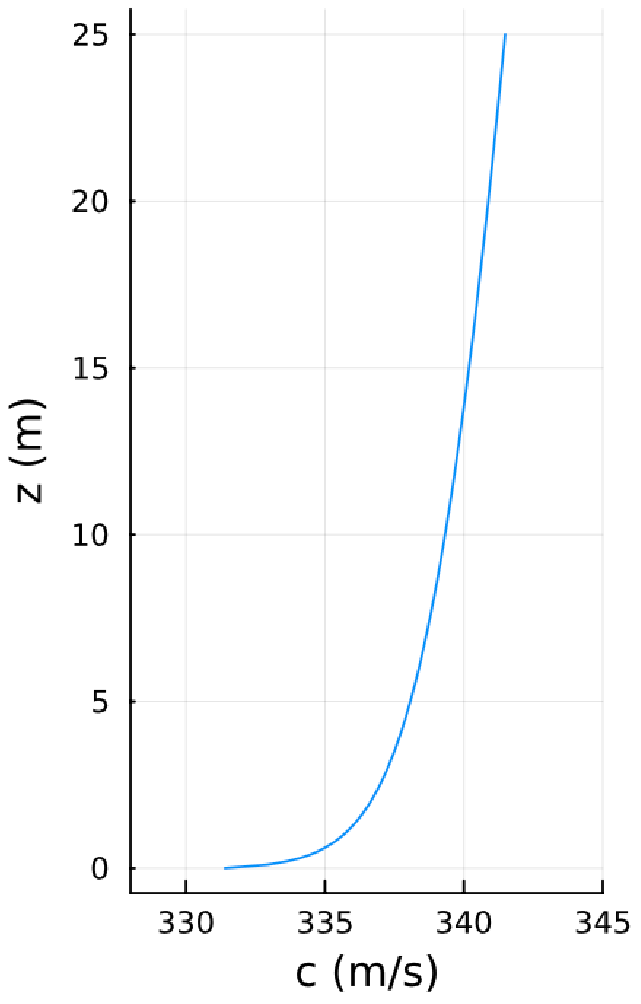


Table A.2 — Inverse Monin-Obukhov length, $1/L$, as a function of wind speed (W) and stability class (S)

$1/L$, m^{-1}	S1	S2	S3	S4	S5
	Day 0/8–2/8	**Day 3/8–5/8**	**Day 6/8–8/8**	**Night 5/8–8/8**	**Night 0/8–4/8**
W1: 0 m/s to 1 m/s	−0,08	−0,05	0	0,04	0,06
W2: 1 m/s to 3 m/s	−0,05	−0,02	0	0,02	0,04
W3: 3 m/s to 6 m/s	−0,02	−0,01	0	0,01	0,02
W4: 6 m/s to 10 m/s	−0,01	0	0	0	0,01
W5: >10 m/s	0	0	0	0	0
X/8 indicates ratio of cloud cover of the sky.					

Table A.1 — Friction velocity for different wind speed classes

	u_* m/s
W1: 0 m/s to 1 m/s	0
W2: 1 m/s to 3 m/s	0,13
W3: 3 m/s to 6 m/s	0,3
W4: 6 m/s to 10 m/s	0,53
W5: >10 m/s	0,87

2400 mottakere
x 25 værforhold
= 60000 beregninger av antall lydbaner

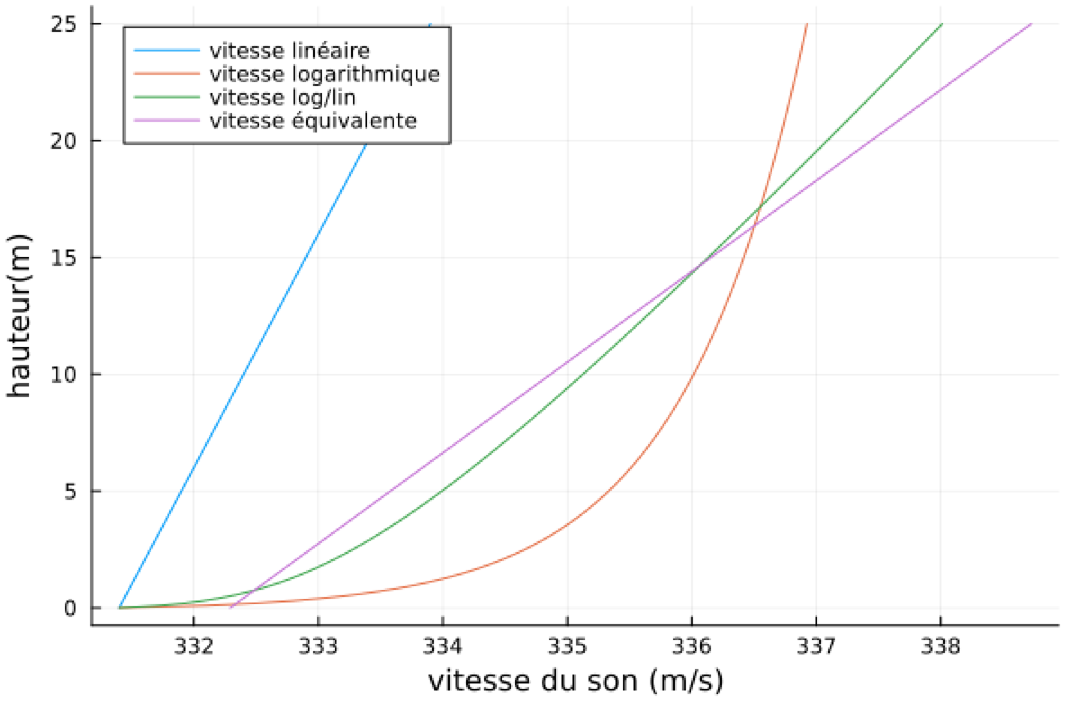
Table A.3 — Temperature scale T_* as a function of wind speed (W) and stability class (S)

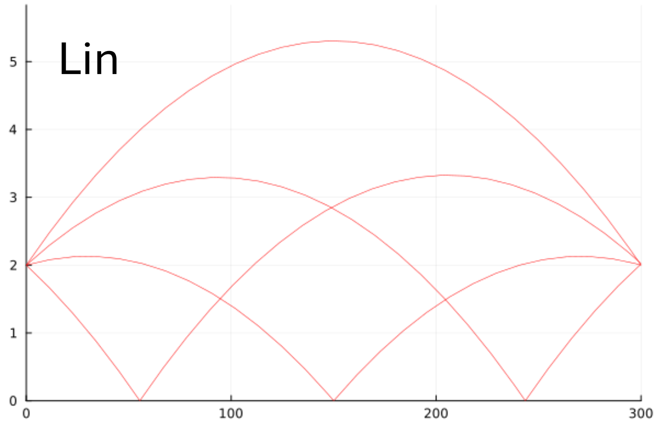
T_*, K	S1	S2	S3	S4	S5
	Day 0/8–2/8	**Day 3/8–5/8**	**Day 6/8–8/8**	**Night 5/8–8/8**	**Night 0/8–4/8**
W1: 0 m/s to 1 m/s	−0,4	−0,2	0	0,2	0,4
W2: 1 m/s to 3 m/s	−0,2	−0,1	0	0,1	0,2
W3: 3 m/s to 6 m/s	−0,1	−0,05	0	0,05	0,1
W4: 6 m/s to 10 m/s	−0,05	0	0	0	0,05
W5: >10 m/s	0	0	0	0	0
X/8 indicates ratio of cloud cover of the sky.					

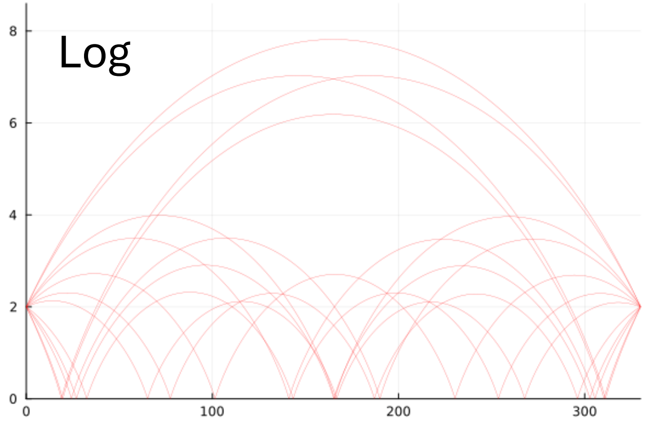
[ISO 1996-2:2017]

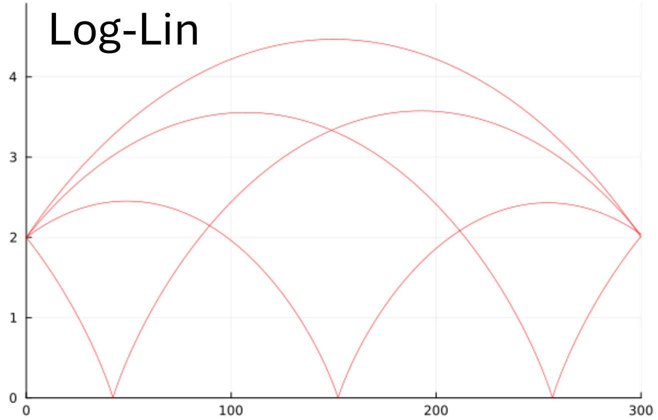
Linearisert lydhastighetsprofil

- For høye beregningstider med logaritmisk profil

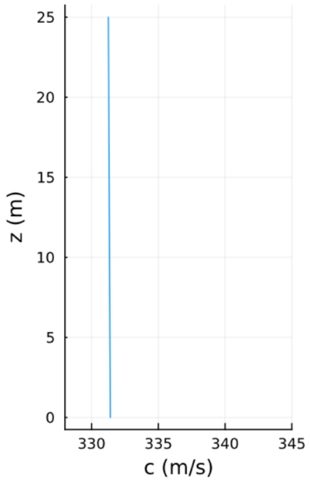


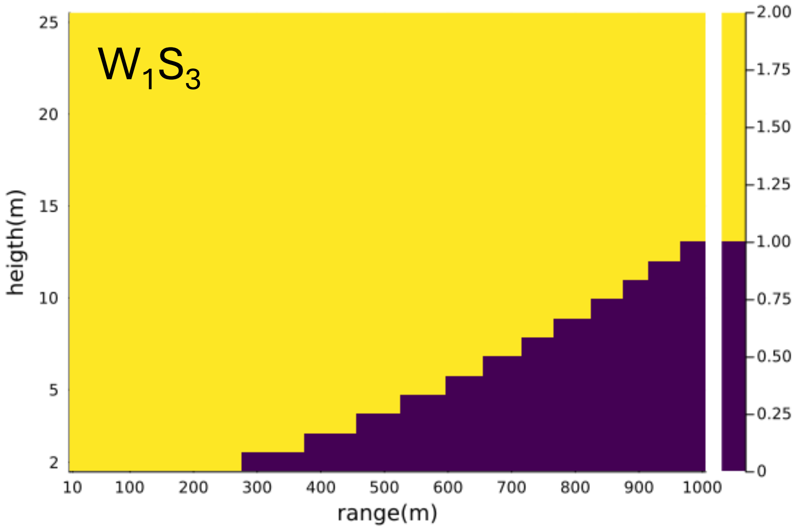


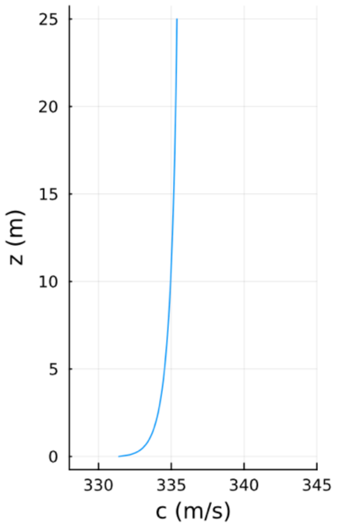


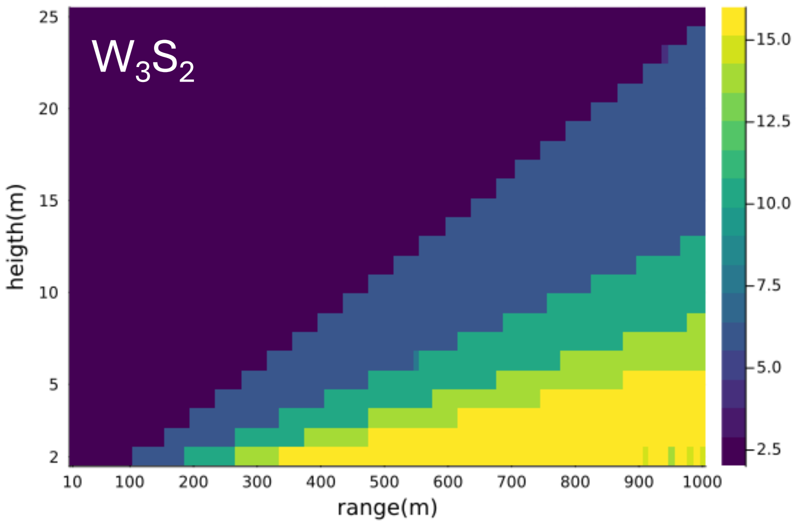


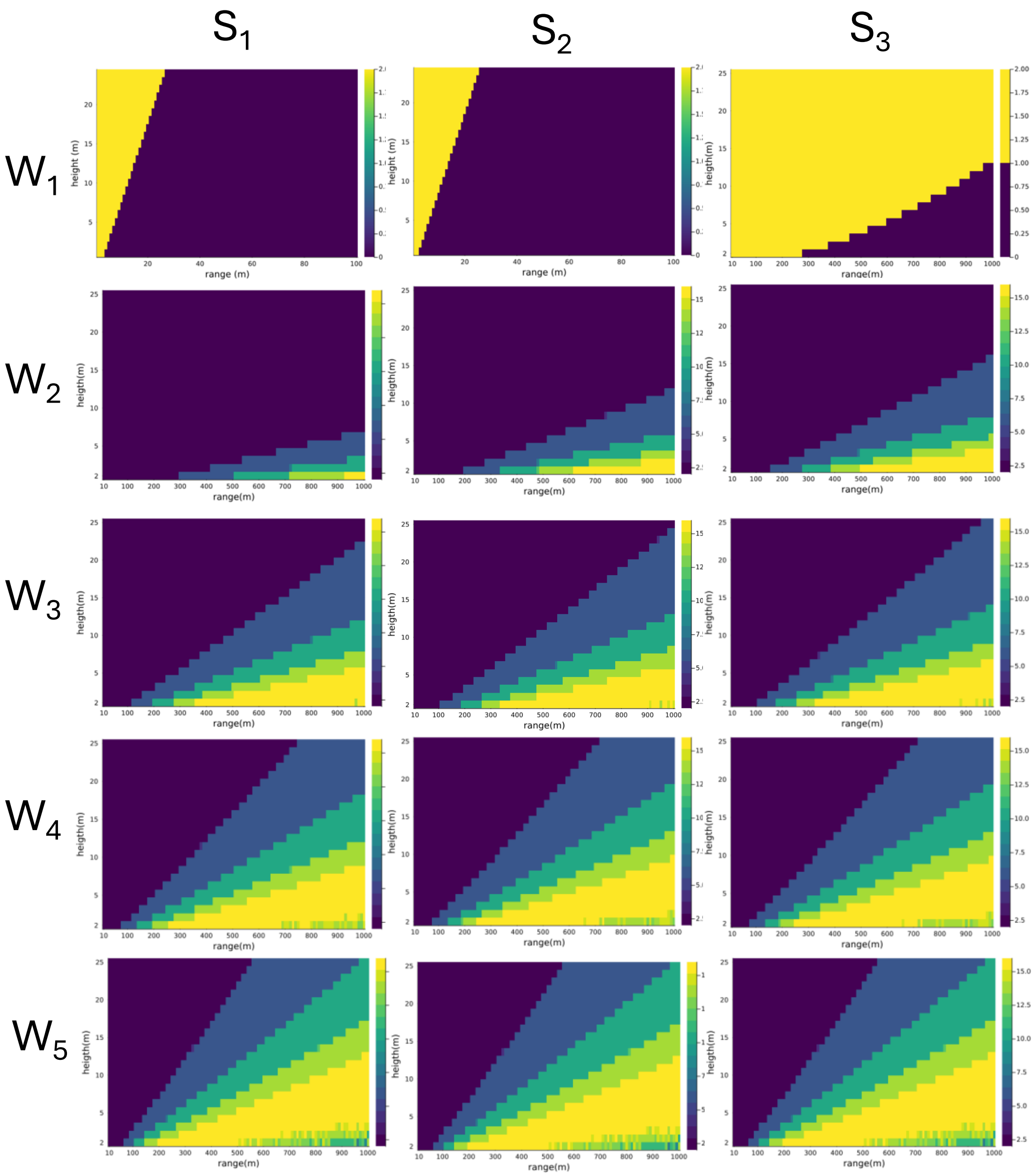
Resultater - dagtid



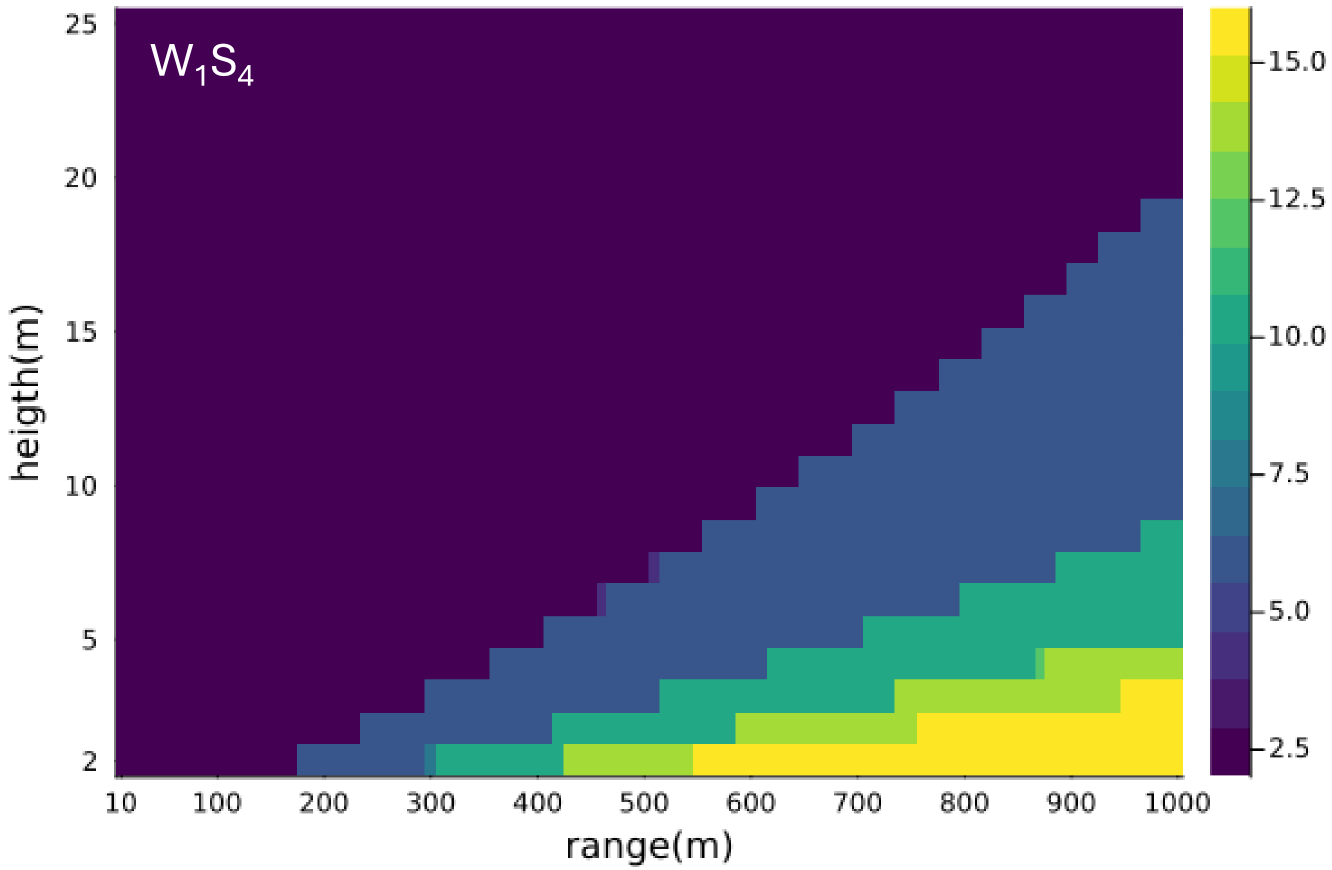


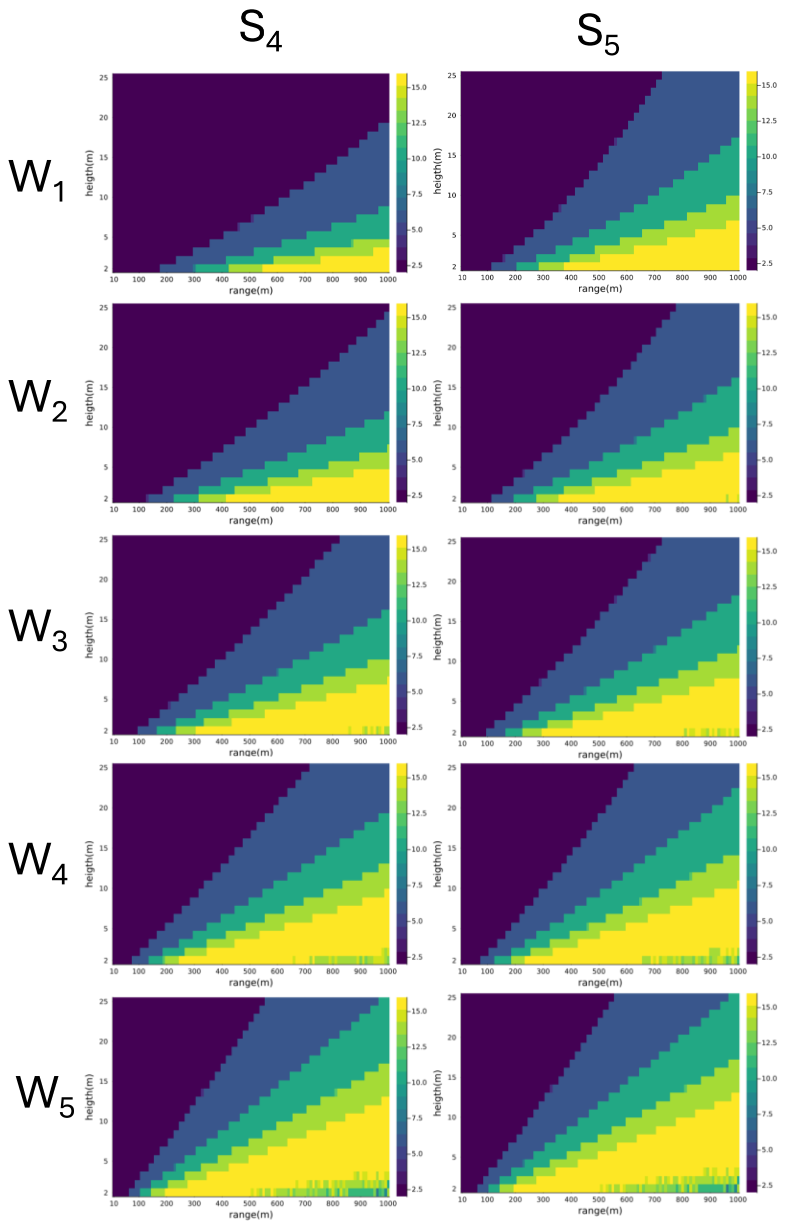






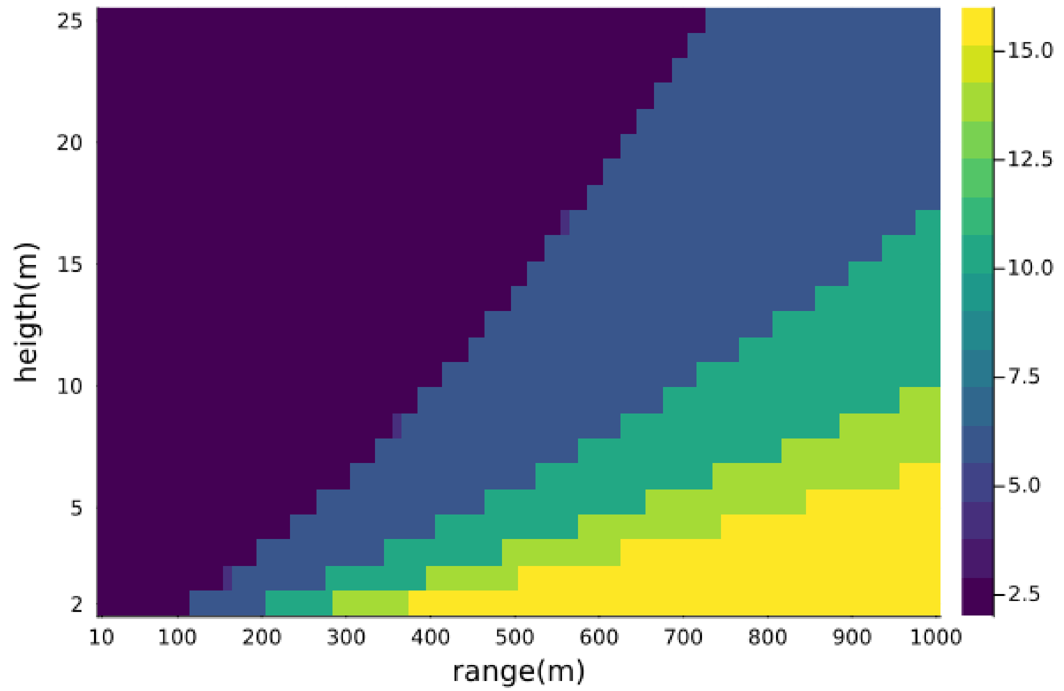
Resultater - natttid

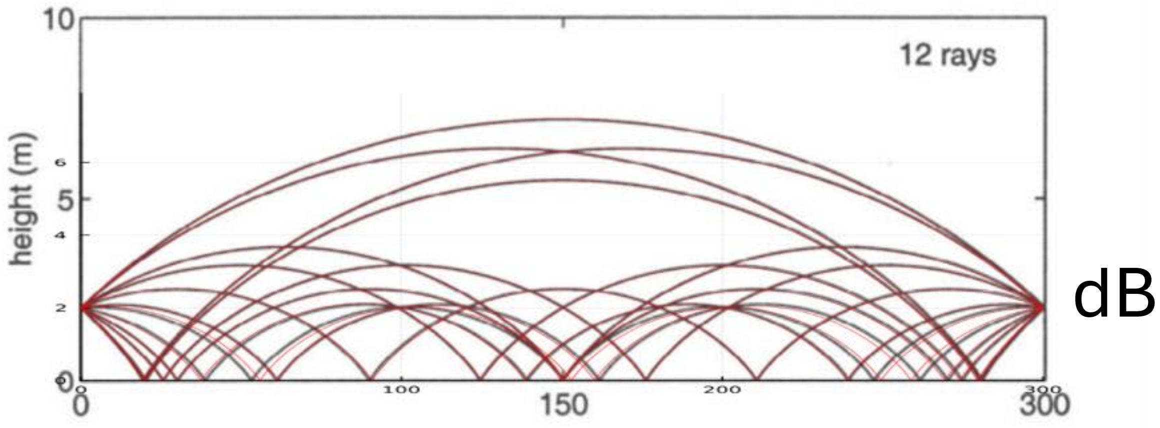




Konklusjon

- For støy fra veitrafikk
- Bruk av avansert strålespøring ift standardiserte beregninsmetoder selv om profilen ble linearisert
- Antallet lydbaner er ofte høyere enn 2
  - Øker når mottakeren er nær bakken
  - Øker med avstand fra lydkilden
  - Antallet kan nå 15
- Veien videre: hvor mange lydbaner bidrar til lydnivået i praksis?
  - Utvikling av strålesporingskoden





dB?